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Tulare Lake Subbasin Groundwater Sustainability Plan

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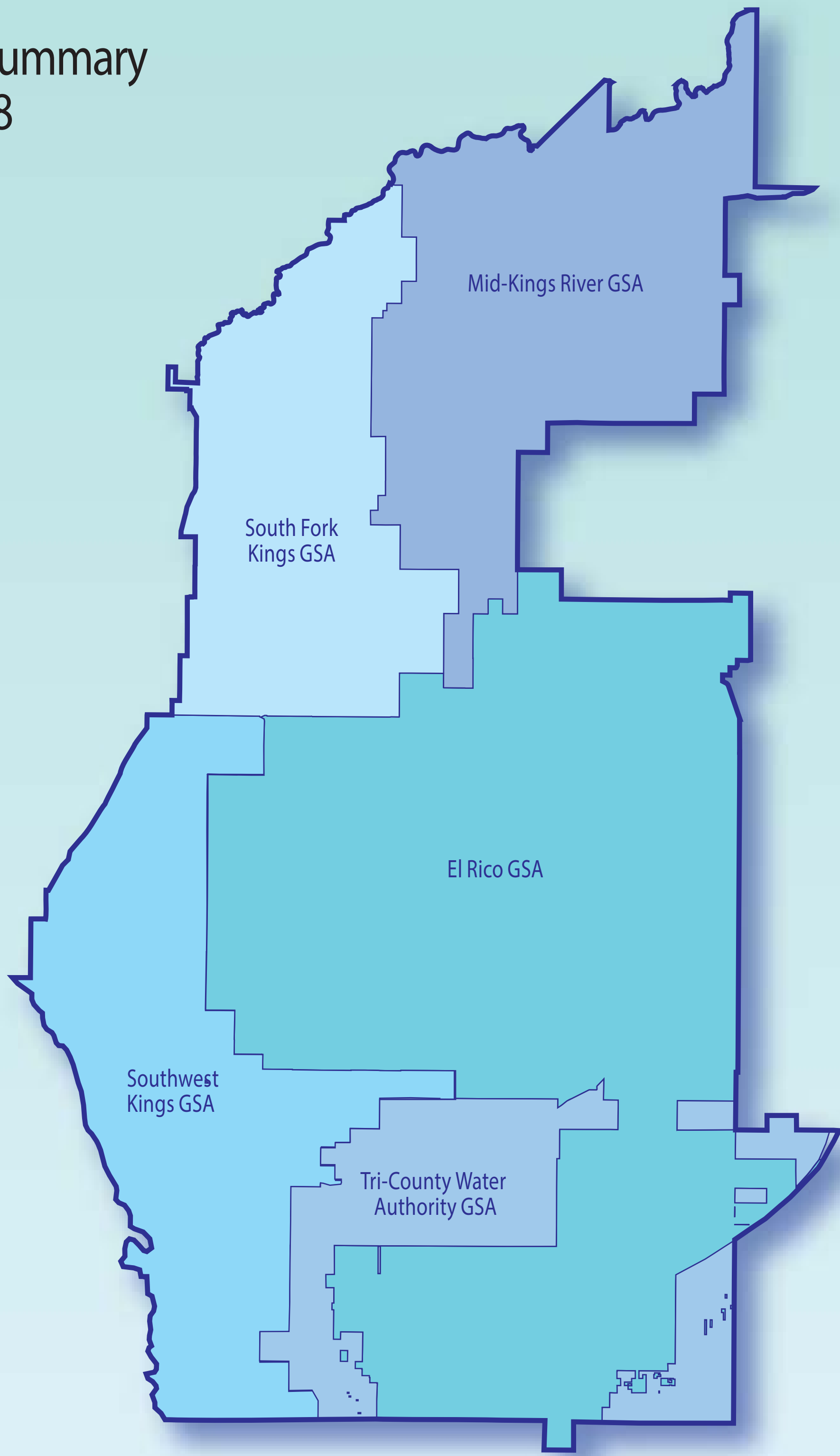

MID-KINGS RIVER GROUNDWATER SUSTAINABILITY AGENCY
South Fork Kings Groundwater Sustainability Agency
ER El Rico GSA
SWK Southwest Kings Groundwater Sustainability Agency
TRI-COUNTY WATER AUTHORITY

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ACRONYMS AND ABBREVIATIONS

%	Percent
§	Section
µm/sec	micrometers per second
µS/cm	microsiemens per centimeter
A-Clay	A perched unconfined aquifer exists above a locally extensive clay layer
AF	acre-feet
AF/Y	acre-feet per year
AGR	agricultural uses
AMSL	above mean sea level
ASR	Aquifer Storage and Recovery
bgs	below ground surface
BLM	Bureau of Land Management
BMP	Best Management Practice
BPA	Basin Plan Amendment
Caltrans	California Department of Transportation
CASGEM	California Statewide Groundwater Elevation Monitoring
C-Clay	A semi-confined aquifer is present above a locally extensive clay layer
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CGPS	Continuous Global Positioning System
CSD	Community Service(s) District
CVHM	Central Valley Hydrologic Model
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CV-SALTS	Central Valley Salinity Alternatives for Long-term Sustainability
CVSRN	Central Valley Spatial Reference Network
DAC	Disadvantaged Community

DDW	Division of Drinking Water
DMS	Data Management System
DOF	Department of Finance
DPR	Department of Pesticide Regulation
DQO	Data Quality Objective
DTSC	Department of Toxic Substances Control
DWR	California Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection Program
EC	electrical conductivity
E-Clay or Corcoran Clay	A fully confined aquifer exists below a regionally extensive clay layer
EPA	United States Environmental Protection Agency
ETc	Crop evapotranspiration
ft	foot/feet
ft/d	foot per day
GAMA	Groundwater Ambient Monitoring and Assessment Program
GDE	Groundwater Dependent Ecosystem
GIS	Geographic Information System
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HCM	Hydrogeologic Conceptual Model
HS	Health and Safety
ID	Irrigation District
ILRP	Irrigated Lands Regulatory Program
InSAR	Interferometric Synthetic Aperture Radar
ITRC	Cal Poly Irrigation Training & Research Center
KCWD	Kings County Water District
KDWCD	Kaweah Delta Water Conservation District
KRCD	Kings River Conservation District
KRFMP	Kings River Fisheries Management Program
KRWA	Kings River Water Association
KRWQC	Kings River Water Quality Coalition
K_{sat}	saturated hydraulic conductivity
LiDAR	Light Detection and Ranging

LU	Land Use
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
MKR	Mid-Kings River
MO	measurable objective
MSL	mean seal level
MT	minimum threshold
MUN	municipal or domestic water supplies
NASA	National Aeronautics and Space Administration
NCCAG	Natural Communities Commonly Associated with Groundwater”
PBO	Plate Boundary Observatory
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PUD	Public Utility District
PVC	polyvinyl chloride
RC	Resource Conservation
RD	Reclamation District
RMS	representative monitoring site
RWQCB	Regional Water Quality Control Board
SFK	South Fork Kings
SGMA	Sustainable Groundwater Management Act of 2014
SJRRP	San Joaquin River Restoration Program
SJVAPCD	San Joaquin Valley Air Pollution Control District
SMARA	Surface Mining and Reclamation Act
SOPAC	Scripps Orbit and Permanent Array Center
SR	State Route
Subbasin	Tulare Lake Subbasin
SURF	Surface Water Database
SWP	State Water Project
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resources Control Board
TCWA	Tri-County Water Authority
TDS	Total Dissolved Solids
TLBWSD	Tulare Lake Basin Water Storage District

TNC	The Nature Conservancy
TV	television
U.S.	United States
UNAVCO	University Navigation Satellite Timing and Ranging Consortium
USACE	United States Army Corps of Engineering
USBR	United States Bureau of Reclamation
USDA	United States Department of Agriculture
USGS	United States Geological Survey
UWMP	Urban Water Management Plan
VOC	volatile organic chemical
WCR	Well Completion Report
WD	Water District
WHPA	Wellhead Protection Area
WWQC	Westside Water Quality Coalition
WWTP	waste water treatment plant

EXECUTIVE SUMMARY

23 CCR §354.4 *Each Plan shall include the following general information: (a) An executive summary written in plain language that provides an overview of the Plan and Description of Groundwater conditions in the basin.*

This Groundwater Sustainability Plan (GSP) was developed pursuant to the Sustainable Groundwater Management Act of 2014 (SGMA). GSPs are required under SGMA to bring the Tulare Lake Subbasin (Subbasin) into groundwater sustainability by 2040. Under SGMA, Groundwater Sustainability Agencies (GSAs) were created in groundwater subbasins to develop and implement GSPs for the subbasin.

1.0 Introduction

Chapter 1, *Introduction*, provides the Subbasin overview and sustainability goal and information regarding the organization, management, and legal authority of the Groundwater Sustainability Agencies (GSAs).

1.1 Overview and Purpose of the Groundwater Sustainability Plan

The Subbasin is located within the southern portion of the San Joaquin Valley in the Central Valley of California (Figure ES-1). The Subbasin (Basin No. 5-22-12) is classified as a high-priority subbasin by the California Department of Water Resources (DWR) and is one of 21 basins and subbasins identified by DWR as critically overdrafted (DWR 2019a). Five local GSAs, the Mid-Kings River (MKR), South Fork Kings (SFK), Southwest Kings (SWK), El Rico (ER), and the Tri-County Water Authority (TCWA) GSAs, cooperatively developed this GSP to address the management of current and future groundwater use within the Subbasin to achieve sustainability (Figure ES-2).

The goal of the GSP is to reach Subbasin-wide groundwater sustainability within 20 years of the GSP's implementation (DWR 2019b). The GSP will be reevaluated and updated, at a minimum, every five years (2025, 2030, 2035, and 2040) to revise, as necessary, sustainability goals and management criteria, monitoring, and implementation of groundwater projects and management strategies.

1.2 Organization and Management Structure of the GSAs

The five participating GSAs collaboratively developed this single GSP for Subbasin under an Interim Operating Agreement (Appendix F). The Interim Operating Agreement establishes mechanisms to ensure collaboration and coordination throughout the Subbasin. Each GSA was formed by local member agencies that are represented as stakeholders on each GSA Board of

Directors. The Boards of Directors and their technical teams have collected and organized data from experienced groundwater consultants as well as sought feedback from groundwater users within the GSA boundaries through each SGMA phase (see Stakeholder Engagement and Communication Plan in Appendix B).

2.0 Plan Area

Chapter 2, *Plan Area*, specifies the geographic extent of the GSP including but not limited to jurisdictional boundaries, existing land uses and land use policies, identification of water resource types, density of wells, and location of communities dependent on groundwater in the Subbasin.

2.1 Summary of Jurisdictional Areas and Other Features

The Plan area is mostly located within Kings County, with small portions in Tulare and Kern counties. The groundwater basin covers approximately 837 square miles (535,869 acres) (DWR 2016b). The land overlying the Subbasin has a population of 125,907 (2010) and density of 150 persons per square mile. A major portion of the Subbasin's population works in the agricultural production industry. The GSAs vary in acreage and location within the GSP area (Figure ES-2).

Mid-Kings River Groundwater Sustainability Agency

The MKR GSA covers approximately 152 square miles (±97,400 acres) and is located in the northeastern portion of the Subbasin (Figure ES-2) (DWR 2019d). The public and private agencies within the MKR GSA include the Kings County Water District (WD), the City of Hanford, and Kings County. Surface water delivery entities within this area are the Riverside Ditch Company, the Peoples Ditch Company, the Settlers Ditch Company, the Last Chance Water Ditch Company, the New Deal Ditch Company, and the Lone Oak Ditch Company. The primary industries are agriculture and food processing. The primary industry within the MKR GSA is agriculture. Other industries within the boundary include food processing, as well as warehousing and distribution, and commerce industry that is standard in a community of approximately 60,000 people (e.g., automotive shops, supermarkets, etc.).

South Fork Kings Groundwater Sustainability Agency

The SFK GSA covers approximately 111 square miles (±71,300 acres) and is located in the northwestern part of the Subbasin (Figure ES-2) (DWR 2019d). The public and private agencies within the SFK GSA include the City of Lemoore, Kings County, Empire West Side Irrigation District (ID), Stratford ID, Stratford Public Utility District, Lemoore Canal and Irrigation Company, John Heinlen Mutual Water Company, and Jacob Rancho Water Company. The primary industries within the SFK GSA are agriculture and food processing.

<u>**Southwest Kings Groundwater Sustainability Agency**</u>

The SWK GSA covers approximately 140.6 square miles (±93,100 acres) and is located in the western portion of the Subbasin (Figure ES-2). The public and private agencies within the SWK GSA are Dudley Ridge WD, Tulare Lake Reclamation District (RD) #761, Kettleman City Community Service District (CSD), Tulare Lake Basin Water Storage District (TLBWSD), and Kings County. Due to the poor yield and poor quality of the groundwater within the SWK GSA, only a minimal quantity of groundwater is pumped within the GSA. Groundwater levels, water quality, and subsidence are maintained at current levels. The primary industries within the GSA are agriculture, oil production, and commercial usage specific to Kettleman City.

<u>**El Rico Groundwater Sustainability Agency**</u>

The ER GSA covers approximately 357 square miles (±228,400 acres) and is located in the center of the Subbasin (Figure ES-2) (DWR 2019d). The public and private agencies within the ER GSA are the City of Corcoran, Kings County, Alpaugh ID, Melga WD, Lovelace RD, Salyer WD, Corcoran ID, Tulare Lake Drainage District, and the TLBWSD. The primary industry within the ER GSA is agriculture. Other industries within the boundary include food processing, as well as warehousing and distribution, and commerce industry that is standard in a community of approximately 10,000 people (e.g., automotive shops, supermarkets, etc.).

<u>**Tri-County Water Authority Groundwater Sustainability Agency**</u>

The TCWA GSA is a collective group of local water agencies dedicated to monitoring and regulating groundwater in the Tulare Lake Hydrologic Region. The TCWA GSA covers approximately 170.0 square miles (±108,800 acres) in the Tulare Lake and Tule subbasins (Figure ES-2) (DWR 2019d). Approximately 75.19 square miles (±48,100 acres) of the GSA's area is located within the southeastern portion of the Subbasin. The primary industry within the TCWA GSA is almost entirely agriculture.

2.2 Water Resource Monitoring and Management Programs

<u>**Monitoring and Management Programs**</u>

<u>*Groundwater Level Monitoring*</u>

The California Statewide Groundwater Elevation Monitoring (CASGEM) Program tracks long-term groundwater elevation trends throughout California. The Kings River Conservation District (KRCD) is the local agency that monitors groundwater levels within the Plan area.

Groundwater Extraction Monitoring

It is not known how many private wells are metered nor if any existing groundwater extraction monitoring programs are in place. Potential future groundwater monitoring policies are discussed in Chapter 5, *Monitoring Network*.

Groundwater Quality Monitoring

See Chapter 5, *Monitoring Network*, for information on groundwater quality monitoring within the Subbasin.

Land Surface Subsidence Monitoring

Land subsidence has been measured for many years throughout the Central Valley. The Plan area contains various local monitoring networks, which can be utilized to survey existing benchmarks to measure subsidence. See Chapter 5, *Monitoring Network*, for further information regarding subsidence in the Plan area.

Surface Water Monitoring

Kings River Water Association monitors surface water in the Kings River and the associated watershed including seasonal snowpack, reservoir stage, reservoir inflow and outflow, Kings River flows, and Kings River diversions. The Friant Water Authority monitors San Joaquin River's water delivered through the Friant-Kern Canal. The Kaweah and St. Johns Rivers Association monitors Kaweah River water flows and deliveries, and the St. John's River that reaches the Subbasin via Cross Creek and Tule River. DWR and TLBWSD monitor the State Water Project (SWP) and the Kings River flows that enter the Subbasin.

Irrigated Lands Regulatory Program

The Irrigated Lands Regulatory Program (ILRP) was initiated in 2003 to address pollutant discharges to surface water and groundwater from commercially irrigated lands. The program is administered by the Central Valley Regional Water Quality Control Board (RWQCB).

GSP Monitoring and Management Plans

The individual water entities located within the Plan area will be responsible for continuing to collect data for any current monitoring or management plan. The monitoring program is described further in Chapter 5, *Monitoring Network*.

Impacts to Operational Flexibility

Regulatory Decisions and Agreements

Regulatory monitoring and management programs outside the boundaries of the Subbasin have limited the operational flexibility and management of the Subbasin by reducing the Central Valley Project (CVP) and SWP delivery amounts, which include the following:

- **1992 Central Valley Project Improvement Act (CVPIA)**: Enactment of the CVPIA mandated changes in the CVP and reallocation of water supplies and reductions in pumping, particularly for the protection, restoration, and enhancement of fish and wildlife. Water supplies in the Plan area have been reduced as a result of the CVPIA.

- **2007 Biological (Wanger) Decision:** A federal decision found that United States Bureau of Reclamation (USBR) did not consider evidence that fish, including salmon and delta smelt, would be harmed by increased water exports for the Sacramento-San Joaquin Delta. The result of this curtailed SWP and CVP pumping from the Delta, reducing overall supplies to the Subbasin.

Places of Use

Agencies use of water from Kings River, Kaweah River, Tule River, SWP, and CVP are restricted to the place of use defined by their water rights. This GSP will not alter these agreements.

Contaminant Plumes

Water quality for individual monitoring wells can be found from Geotracker (SWRCB 2019a).

Kings River Fisheries Management Program

The Kings River Fisheries Management Program (KRFMP) includes numerous measures to benefit the Kings River fisheries, including year-round flows, improved temperature control, and additional monitoring. The local water entities have already adjusted agricultural operations to adapt to the KRFMP.

Conjunctive Use Programs

Conjunctive use is the coordinated and planned management of surface and groundwater resources to maximize their efficient use. Conjunctive use is utilized to improve water supply reliability and environmental conditions, reduce groundwater overdraft and land subsidence, and to protect water quality.

Relation to General Plans

Every county and city in California is required to develop and adopt a General Plan (California Government Code, §65350-65362). Six general plans are in effect within the boundaries of the

Subbasin, each of which were adopted prior to creation of the local GSAs and preparation of the GSP. The Plan area also includes four community plans within unincorporated areas (Table 2-3).

Impact of GSP on Water Demands

The General Plans of the counties of Kings, Tulare, and Kern, as well as the cities of Hanford, Lemoore, and Corcoran, make assumptions for both rural and urban development. Urban Water Management Plans prepared for the cities of Lemoore, Hanford, and Corcoran address assumed land use changes and growth rates. This GSP may use the land use change assumptions identified in the General Plans as well as other information for forecasting the anticipated water budget.

Impact of GSP on Water Supply Assumptions within Land Use Plans

Kern County General Plan
There are no anticipated impacts on Kern County lands within the Subbasin. The total Kern County land area within the Subbasin is 360 acres (Kern County 2009).

Kings County General Plan
Future projections from the Department of Finance expect the population to reach 181,218 by the year 2035 (DOF 2019). The primary water supply goal in this plan is for reliable and cost-effective infrastructure systems that permit the county to sustainably manage its diverse water resources and agricultural needs, secure additional water, and accommodate for future urban growth (Kings County 2010).

Tulare County General Plan
Tulare County's General Plan 2030 Update developed goals and policies to encourage sustainable groundwater management, such as to develop additional water sources, implement water conservation, and encourage demand management measures for residential, commercial, and industrial indoor and outdoor water uses in all new urban development (Tulare County 2012).

City of Hanford General Plan
The Land Use, Transportation, Water Resources, and Public Facilities sections of the City of Hanford's General Plan discuss various topics including water supply. The primary water supply goal in the plan is to maintain reliable and cost-effective infrastructure systems that permit the city to sustainably manage its diverse water resources and needs.

City of Lemoore General Plan
The City of Lemoore General Plan policies are geared towards preserving environmental resources such as open space, prime farmland, wetlands, special species, water resources, air quality, and other elements of value to Lemoore residents. If the city grows

at the anticipated rate, demand will exceed the supply available from existing wells. There is no restriction on the number of wells the City of Lemoore may drill within city boundaries. Water quality maintenance is a more considerable challenge to meeting water demand than water quality for the City of Lemoore (City of Lemoore 2015).

City of Corcoran General Plan

The Land Use, Circulation, Safety, Conservation and Open Space, Air Quality, and Public Services and Facilities sections of the City of Corcoran's General Plan discuss various topics including water supply. The General Plan's primary water supply goal is to protect natural resources including groundwater, soils, and air quality in an effort to meet the needs of present and future generations (City of Corcoran 2014).

Permitting Process for New or Replacement Wells

In California, local jurisdictions with the authority to adopt a local well ordinance that meets or exceeds DWR Well Standards have regulatory authority over well construction, alteration, and destruction activities (DWR 2019a). After the submittal of the GSP, California Water Code §10725 - §10726.9 describes the authoritative power by the GSAs, including but not limited to imposing spacing requirements on new groundwater well construction, imposing operating regulations on existing groundwater wells, and controlling groundwater extractions. The GSA may use the powers described in the above code to provide the maximum degree of local control and flexibility consistent with sustainability goals described in the GSP.

Land Use Plans outside the Basin

In general, all future land use changes will need to consider the net groundwater impact to neighboring basins, and updates to agency General Plans will need to consider GSPs and the responsibility of each member and participating agency. GSPs for neighboring basins will be evaluated during the GSP review process. Coordination between subbasins is required as part of GSP implementation.

2.3 Additional GSP Components

Wellhead Protection

A Wellhead Protection Area is defined by the Safe Drinking Water Act Amendment of 1986 as "the surface and subsurface area surrounding a water well or wellfield supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield" (100 U.S. Code. 764). Municipal and agricultural wells constructed by the GSA member agencies are designed and constructed in accordance with DWR Bulletins 74-81 and 74-90. A permit is required from the applicable county prior to construction of a new well within the GSA's area. In addition, the GSA member agencies encourage landowners to follow the same standard for privately owned wells.

Migration of Contaminated Groundwater

Groundwater contamination can be human-induced or caused by naturally occurring processes and chemicals. Sources of groundwater contamination can include irrigation, dairy production, pesticide applications, septic tanks, industrial sources, stormwater runoff, disposal sites, and improperly constructed wells.

Databases provide information and data on known groundwater contamination, planned and current corrective actions, investigations into groundwater contamination, and groundwater quality from select water supply and monitoring wells are maintained by the State Water Resources Control Board (SWRCB), Department of Toxic Substances Control, California Department of Pesticide Regulation, and the Groundwater Ambient Monitoring and Assessment Program (GAMA).

Well Abandonment/Well Destruction Program

Well abandonment generally includes properly capping and locking a well that has not been used in over a year. Well destruction includes completely filling in a well in accordance with standard procedures listed in Section 23 of DWR Bulletin 74-81 (DWR 1981). DWR Bulletin 74-90 includes a revision in Section 23, for Subsection A and B, from Bulletin 74-81 (DWR 1991).

Replenishment of Groundwater Extractions

Groundwater replenishment occurs naturally through rainfall, rainfall runoff, and stream/river seepage and through intentional means, including deep percolation of crop and landscape irrigation, wastewater effluent percolation, and intentional recharge. The primary local water sources for groundwater replenishment in the Plan area include precipitation, Kings River, Kaweah River, Tule River, Deer Creek, Poso Creek, and various smaller local streams and an extensive network of irrigation canals.

Well Construction Policies

Proper well construction is necessary to ensure reliability, longevity, and protection of groundwater resources from contamination. All of the GSA member agencies follow state standards when constructing municipal and agricultural wells (DWR 1991).

Groundwater Projects

The GSA member agencies in general developed their own projects to help meet their water demands and will develop additional future projects to meet sustainability. Developing groundwater recharge and banking projects is considered key to stabilizing groundwater levels. The GSA will also support measures to identify funding and implement regional projects that help the region achieve groundwater sustainability.

Efficient Water Management Practices

Water conservation has been and will continue to be an important tool in local water management, as well as a key strategy in achieving sustainable groundwater management. All the GSA member agencies engage in some form of water conservation including water use restrictions, water metering, education, and tiered rates.

Relationships with State and Federal Agencies

From a regulatory standpoint, the GSAs have numerous relationships with state and federal agencies related to water supply, water quality, and water management. Relationships unique to the region include those with entities managing the Kings River and Pine Flat Dam. The Kings River provides the majority of surface water used in the area. Kings River water is impounded by Pine Flat Dam, which is owned and operated by the United States Army Corps of Engineers (USACE) (Kings County 2002). The GSA member agencies work with the USACE and SWRCB to oversee and manage their Kings River water as needed. The local agencies also developed and continue to implement the KRFMP in partnership with the CDFW.

Land Use Planning

Each of the local member agencies and water entities of the Subbasin's GSAs have an interest in land use planning policies and how they relate to the use of available water supplies.

Groundwater Dependent Ecosystems

The Nature Conservancy (TNC) worked with DWR to identify Groundwater Dependent Ecosystems (GDE) throughout the state. TNC primarily used vegetative indicators and applied them to historical aerial imagery. Imagery was cross-referenced with CASGEM well levels to identify possible GDEs. The data used in GDE identification pre-dates the baseline year of 2015, so all land use changes in the interim period may not be included. Such areas have been delineated within the Subbasin, but currently have not been confirmed.

2.4 Notice and Communication

Formation of GSAs

Representatives from cities, counties, WDs, IDs, CSDs, and private water companies participated in the formation of the GSAs. Additionally, landowners, Disadvantaged Community representatives, and industry representatives were present at GSA formation meetings.

Implementation of the GSP

SGMA implementation at the GSA level begins as DWR is reviewing this GSP. During the implementation phase, communication and engagement efforts focus on educational and informational awareness of the requirements and processes for reaching groundwater sustainability as set forth in the submitted GSP.

Decision-Making Process

Each of the five GSAs within the Subbasin operate under an Interim Operating Agreement (effective September 1, 2017) to facilitate coordination and management actions (Appendix F). The Interim Operating Agreement is categorized as a legal agreement and ensures communication and coordination of the data and methodologies used by each GSA in developing the GSPs within the Subbasin for several factors, including groundwater elevation and extraction data, surface water supply, total water use, change in groundwater storage, water budget, total water use, and sustainable yield.

Beneficial Uses and Users

The GSAs shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing a GSP (California Water Code, §10723.2).

Opportunities for Public Engagement

The GSAs within the Subbasin developed a joint Communication and Engagement Plan to address how stakeholders within the individual GSA boundaries were engaged which will continue to be utilized through the GSP implementation phases. The Communication and Engagement Plan describes various elements, including public meetings and workshops, printed communication, digital communication, media coverage, and stakeholder surveys.

Interbasin Communications

Subbasin GSAs and technical consultants met with surrounding subbasins throughout the development of the GSP to discuss how to achieve sustainability on a regional level, develop interbasin agreements, and share data when possible.

3.0 Basin Setting

The Subbasin is located primarily in Kings County in the Tulare Lake Hydrologic Region of the San Joaquin Valley. Topography in the Subbasin slopes inward towards the center of the valley. The former Tulare Lake occupies this portion of the Subbasin. Chapter 3 of the GSP discusses the hydrogeologic conceptual model (HCM), groundwater conditions, the water budget, and management areas for the Subbasin.

3.1 Hydrogeologic Conceptual Model

The HCM provides a general understanding of the physical setting, characteristics, and processes that govern groundwater occurrence and movement within the Subbasin (DWR 2016c).

Geographic Setting

The Subbasin is located primarily in Kings County in the Tulare Lake Hydrologic Region of the San Joaquin Valley, California (Figure ES-1). The Subbasin covers an area of approximately 535,869 acres or about 837 square miles (DWR 2016b). It is boardered by the Kings Subbasin to the north, the Kaweah Subbasin to the northeast, the Tule Subbasin to the southeast, the Kern County Subbasin to the south, the Kettleman Plain Subbasin to the southwest, and the Westside Subbasin to the northwest. The San Joaquin Valley boardered on the west by the Coast Ranges and on the east by the Sierra Nevada Mountains (Figure ES-1).

The climate in the Subbasin is semi-arid, characterized by hot, dry summers and cool moist winters and is classified as a semi-arid climate (BSk to BSh under the Köppen climate classification), usually found within continental interiors some distance from large bodies of water. The topography of the Subbasin is generally low sloping inward from all directions toward the center of Tulare Lake. Land use in the Subbasin and surrounding areas is predominately agricultural with three primary urban areas of the cities of Hanford, Lemoore, and Corcoran.

Soil texture varies across the Subbasin. Clayey soils dominate in the Tulare Lake area. Loam and sandy loam soils border the clayey soils and are the predominant soils to the east of the lake, including areas of the Tule and Kaweah rivers watersheds; to the west, along the eastern flanks of Kettleman Hills and the Coast Ranges; and to the north and northeast, including along the Kings River watershed.

Stream flow in rivers, streams, and surface water conveyances (canals) is a significant source of groundwater recharge throughout the Subbasin by direct infiltration to the subsurface and from deep percolation where surface water is applied for agricultural irrigation. Major rivers supplying water to the Subbasin include the Kings, Kaweah, Tule, and Kern rivers. Streams emanating from the southern Sierra Nevada Mountains and the Coast Ranges are typically ephemeral and do not reach any major water course or surface impoundment in the Subbasin.

Extensive water supply delivery systems have been developed over the past 160 years within the Subbasin to move surface water supplies for irrigation, flood control, and land reclamation.

Currently, at least 34 conveyance systems (rivers, streams, canals, and diversions) are available to deliver surface water to the Subbasin. The only water generated within the Subbasin is from pumped groundwater. Pumped groundwater may be used for direct irrigation on nearby agricultural lands or piped into municipal or agricultural water delivery systems.

Water is imported into the Subbasin using facilities of the SWP located to the west and the CVP. The California Aqueduct is operated and maintained by DWR. The Friant-Kern Canal is operated and maintained by the Friant Water Authority and is used to convey water from the San Joaquin River to Kern County. The Friant-Kern Canal crosses the Kings River about 10 miles west of Pine Flat Dam, where water can be released into the River. This water can be delivered to the Subbasin through a series of canals along the Kings River and its distributaries.

Hydrogeologic Setting

During the late-Pliocene and early-Pleistocene, the terrestrial Tulare Formation was deposited as sediments, which were eroded and shed from the rising mountains into the subsiding San Joaquin Valley. Throughout much of the Valley, Tertiary-Quaternary sediments filled the basin with a mixture of sands, silts, and clays, which were deposited on alluvial fans and along the San Joaquin Basin axis by the rivers and streams emanating from the adjoining mountains.

Large-scale lacustrine deposits accumulated in the shallow lakes that developed as a result of the internal drainage. During this time, the lacustrine Corcoran Clay (E-Clay of Croft 1972) accumulated to thicknesses of as much as 300. Additionally, thick deposits of lacustrine sediments have accumulated in Tulare Lake.

The Tulare Formation is generally regarded as the most important water-bearing formation in the southern San Joaquin Valley. The Tulare Formation comprises unconsolidated clay, silt, sand, and gravel, as well as poorly consolidated sandstones and conglomerated deposited by streams and rivers emanating primarily from the Sierra Nevada and Coast Ranges.

Groundwater flow in the Subbasin has historically been influenced by five significant bounding conditions, including: Kettleman Hills on the southwest; Kings River alluvial fan on the northeast; Arroyo Pasajero fan on the northwest; Tulare Lake clay beds in the central portion of the subbasin; and the Kaweah and Tule River alluvial fans on the east.

Tulare Lake Lacustrine Deposits (Clay Plug)

The lacustrine deposits of the ancestral and former Tulare Lake are potentially the most significant controlling factor for groundwater movement in the central portion of the Subbasin. The horizontal and vertical extent of these continuous fine-grained lacustrine deposits is called the “clay plug.” Although some of the clays and sand stringers are saturated, they do not produce enough water to have been developed for groundwater extraction.

The water quality method and it was used to define the bottom of the Subbasin. Within the Subbasin, water quality of 3,000 milligrams per liter total dissolved solids (TDS), typically found at depths greater than 3,000 feet below ground surface (bgs), defines the bottom of the Subbasin using this methodology for this GSP.

Principal Groundwater Aquifers and Aquitards

Groundwater beneath the Subbasin occurs primarily in the coarser-grained Sierran sediment deposits of the alluvial fans of the Kings, Kaweah, and Tule rivers, as well as the fans of the lesser streams that drain from the Sierra Nevada Mountains into the southeastern portion of the Subbasin. On the west side of the Subbasin, some sediments may have Coast Ranges origin. The Corcoran Clay underlies most of the Subbasin, which essentially subdivides the Subbasin into two aquifer systems, an unconfined to semi-confined aquifer system above the Corcoran Clay and a confined aquifer system below the Corcoran Clay.

Fine-grained lacustrine, marsh and flood deposits underlie the valley trough and floor and were deposited in lacustrine or marsh environments (Croft 1972). These fine-grained units are critically important in the hydrology of the basin in that they restrict the downward movement of water and act as aquitards. The Corcoran Clay or E-Clay is the most extensive aquitard in the San Joaquin Valley. The low permeability of the Corcoran Clay makes it an effective aquitard. It has sharp vertical boundaries and shows up well on borehole geophysical electric logs.

Groundwater Recharge and Discharge

Groundwater recharge in the Subbasin occurs primarily by two methods: (1) infiltration of surface water from the Kings River and unlined conveyances, and (2) infiltration of applied water for irrigation of crops. Intentional recharge also occurs within the Subbasin by percolating surface water through storage ponds and old river channels. Most surface water entering the Subbasin is consumptively used or retained due to the internal drainage within the Subbasin.

Groundwater discharge in the Subbasin is predominantly by groundwater extraction along the eastern and northern portions of the Subbasin where water quality and well yields are higher than near Tulare Lake.

Primary Uses of Each Aquifer

Primary groundwater uses within the Subbasin include domestic, municipal, agricultural, and industrial. Domestic pumping is primarily from the upper unconfined and semiconfined aquifer because it is easier to access and typically has sufficient yield for domestic purposes. Municipal pumping of groundwater occurs in the cities of Hanford, Lemoore, and Corcoran and the communities of Armona and Stratford (Table 3-4). Wells for municipal purposes are typically in the deeper portions of the unconfined and semiconfined aquifer and sometimes reach into the confined aquifer. Most of the agricultural pumping in the Subbasin and in adjoining subbasins is from deep wells constructed above and below the Corcoran Clay.

3.2 Groundwater Conditions

This section contains information related to historical and current groundwater conditions necessary to understand the characteristics of groundwater flow within the Subbasin, groundwater quality, and the water budget. Subsidence is also discussed.

Groundwater Flow

Historically, groundwater movement in the Subbasin was dominated by recharge of surface water on the alluvial fans of the rivers and streams emanating from the Sierra Nevada Mountains and by the discharge sinks created by evaporation from Tulare Lake and evapotranspiration created by the swamps and marshes along the periphery of the Lake. By 1952, groundwater development had altered the potentiometric surface such that distinct pumping cones of depression had developed in the unconfined upper aquifer east of the Subbasin beneath the Kaweah and Tule River fans and within the Subbasin on the Kings River fan near Hanford (Davis et al. 1959). In 2016, groundwater cones of depression in the unconfined upper aquifer were apparent east of the Subbasin with groundwater elevations having declined 100 to more than 200 feet from the 1952 data. The groundwater cones of depression peripheral to the Subbasin changed the natural prevailing direction of groundwater flow from west-southwest toward Tulare Lake, to east, northeast, and southeast away from Tulare Lake.

Vertical Groundwater Gradients

Vertical groundwater gradients between the upper unconfined aquifer and the confined aquifer separated by the Corcoran Clay are spatially and temporally variable. Prior to widespread groundwater development, there was an upward gradient from the confined aquifer to the unconfined aquifer (including artesian conditions) beneath much of the Subbasin. As agriculture was developed, pumping from below the Corcoran Clay eventually resulted in a downward gradient beneath much of the Subbasin.

Groundwater Storage Estimates

There is an estimated at 20.5 million acre-feet (AF) of groundwater in storage in the unconfined aquifer zone. The confined aquifer has an estimated at 60.4 million AF of groundwater in storage.

Total groundwater in storage is approximately 80.9 million AF as of 2016. Overall there has been a loss of storage of about 3.84 million AF from the unconfined aquifer, a storage gain of about 1.53 million AF in the confined aquifer, resulting in a combined total loss of about 2.31 million AF between 1990 and 2016.

Groundwater Quality

Water quality geochemistry varies in groundwater beneath the San Joaquin Valley. Historically, on the west side of the valley, groundwater was always high in sulfate compared to groundwater on the east side of the valley. Near the center of the valley, groundwater had a mixed character, also being high in alkalis. The difference in chemical characteristics of the groundwater was attributed to the source area for the sediments in which the groundwater was contained. On the west side, deposits were derived from marine sedimentary rocks with high proportions of sulfur-rich minerals (such as gypsum), whereas on the east side, deposits were derived from granitic rocks with high proportions of silicates. Near the center of the valley and around the historical Tulare Lake, groundwater contained higher proportions of chloride. TDS measurements in groundwater were greater on the west side than the east.

TDS has increased in most groundwater in the San Joaquin Valley over the past 100 years. However, the spatial distribution of the TDS and individual cation-anion makeup of the groundwater still reflect the geologic provenance of the containing sediments as well as the chemical characteristics of the recharge water. The greatest TDS increases in the Tulare Lake area were in the shallow portions (i.e., unconfined to semiconfined) of the aquifer.

In general, chemicals of concern that affect water quality in the Subbasin include salinity (TDS), arsenic, nitrate, and volatile organic chemicals.

Land Subsidence

Land subsidence due to groundwater withdrawals and associated drawdown has been well documented and has affected significant areas of the San Joaquin Valley since the 1920s, including the Subbasin (Wood 2017). Between 1926 and 1970, there was approximately 4 feet of cumulative subsidence near Corcoran, 4 to 6 feet of subsidence near Hanford, and as much as 12 feet of subsidence near Pixley. Following the completion of the SWP and CVP, surface water became more readily available in the San Joaquin Valley and groundwater extraction was reduced and groundwater levels recovered. As a result, subsidence due to groundwater withdrawal was temporarily slowed or stopped.

Groundwater pumping has since increased in the San Joaquin Valley in the past 10 to 25 years due to several factors including the planting of permanent crops and a reduction of available imported surface water. Subsidence in the San Joaquin Valley was exacerbated during a moderate to severe drought from 2007 through 2009, and a severe to exceptional drought from 2012 through 2016. A Jet Propulsion Laboratory study of subsidence between June 2007 and December 2010 indicated subsidence rates were as high as 8.5 inches per year near Corcoran (Farr et al. 2015). A more recent study by the Jet Propulsion Laboratory indicted subsidence rates accelerated in some areas during the recent drought, with annual subsidence rates of 1 to 1.5 feet near Corcoran in 2015-2016 (Farr et al. 2017).

Interconnected Surface Water and Groundwater Systems

Prior to development in the late 1800s and early 1900s, groundwater and surface waters were interconnected around the Subbasin, resulting in extensive wetlands, a nearly persistent Tulare Lake, and notable artesian aquifers indicating strong upward groundwater gradients. Groundwater levels were near the ground surface beneath much of the Subbasin, and as streams and rivers flowed from the Sierra Nevada foothills and Coast Ranges towards Tulare Lake, they geographically transitioned from losing streams which recharged underlying groundwater into gaining streams that benefit from groundwater discharge.

During development, the four major rivers draining into Tulare Lake were dammed, and Tulare Lake itself was able to be reclaimed due to upstream irrigation demands. As a result, most streams and rivers draining into Tulare Lake became disconnected from the regional unconfined aquifer system.

3.3 Water Budget Information

This section provides a quantitative description of the water budget for the Subbasin including an account of the inflows, outflows, and changes in storage in the Subbasin aquifer system over time.

Inflows

Inflows consist of:

- Precipitation
- Surface Water Diversions
- Imported Groundwater Supply
- Lake Bottom Water Storage
- Intentional Recharge
- River and Canal Seepage

- Wastewater Treatment Plant Discharge
- Subbasin Boundary Groundwater Inflows

During the 1990-2016 period, estimated total inflow ranged from 1,070,860 AF (2015) to 2,203,450 AF(1990) and averaged about 1,584,140 acre-feet per year (AF/Y).

Outflows

Outflows consist of:

- Evapotranspiration
- Municipal Pumping Demand
- Agricultural Pumping Demand
- Agricultural Drains
- Subbasin Boundary Groundwater Outflows

In the 1990-2016 period, estimated total outflow ranged from 1,529,580 AF (2015) to 2,783,110 AF (1990) and averaged about 1,968,130 AF/Y.

Annual Change in Groundwater Storage

The annual change in storage (or overdraft) was estimated for the study period 1990-2016 and for the period 1998-2010, which represents a period of “normal hydrology” where Kings River flows were close to the 50-year historical average. During the 1990-2016 period, the estimated annual change in storage in the Subbasin ranged from -392,280 AF (2015) to 361,230 AF (2011) and averaged about -85,690 AF/Y over this 26-year period. During the 1998-2010 “normal hydrology” period, the estimated annual change in storage in the Subbasin ranged from -296,280 AF (2008) to 220,649 AF (2006) and averaged about –73,760 AF/Y over this 13-year period.

Estimate of Sustainable Yield

During the 1998-2010 “normal hydrology” period, the difference between average groundwater pumping (-348,700 AF/Y) and average net recharge (335,360 AF/Y) differed by only about -13,340 AF/Y. During this same period, the estimated overdraft due to pumping in the Subbasin averaged about -49,480 AF/Y (net subsurface interbasin outflows due to pumping in other subbasins account for the other -24,290 AF/Y of overdraft). If agricultural pumping in the Subbasin were reduced by an average of 49,480 AF/Y to about -299,220 AF/Y, the net change in storage should be close to zero or possibly positive. Hence, the current estimate of long-term sustainable yield for agricultural pumping is approximately -299,220 AF/Y over the historical average of 310,792 acres of irrigated land in the Subbasin.

Projected Water Budget

The projected water budget for the Subbasin represents a hypothetical forecast for the 54-year period from 2017 through 2070 based on an assumed “normal hydrology” period and estimated future climate change impacts. This forecast provides the Subbasin’s GSAs with a tool to allow flexibility in groundwater management and planning of sustainability projects. The projected water budget is based on current baseline conditions of groundwater and surface water supply, water demand, and aquifer response to allow for implementation of groundwater management and projects implemented under the GSP. Groundwater modeling of the forecast conditions will be used to evaluate long-term groundwater flow trends, change in storage, and long-term groundwater sustainability under different forecast conditions and proposed groundwater sustainability projects conducted by individual GSAs.

3.4 Management Areas

In order to facilitate implementation of the GSP, management areas have been created for the Subbasin. There are five Primary Management Areas and two Secondary Management Areas. Each of these types of management areas are described in the following sections.

Primary Management Areas

Primary Management Areas have been formed from each of the five GSAs (Figure ES-2). The formation of Primary Management Areas will facilitate data management and assist with the implementation and management of the GSP. Furthermore, each GSA has unique surface water and groundwater allocations and usage, and they are best positioned to develop Best Management Practices and development of groundwater sustainability projects.

Secondary Management Areas

Two Secondary Management Areas have been formed for the Subbasin (Figure ES-2). These two Secondary Management Areas are different from the Primary Management Areas and each other due to distinctly different groundwater conditions in each area. These two areas are the Clay Plug (Management Area A) and the Southwest Poor Quality Groundwater Secondary Management Area (Management Area B).

4.0 Sustainable Management Criteria

The SGMA defines sustainable groundwater management as the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results. The avoidance of undesirable results is important to the success of GSP implementation.

Sustainable management criteria include:

- Sustainability Goal
- Undesirable Results
- Minimum Thresholds (MTs)
- Measurable Objectives (MOs)

These criteria for the Subbasin were developed through the assessment of sustainability indicators. The indicators are measured at representative monitoring sites (RMSs) in each management area of the Subbasin.

Sustainability indicators are the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, become undesirable results. Under SGMA, sustainability indicators are: chronic lowering of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded water quality, land subsidence, and depletions of interconnected surface water. In the Subbasin, there is sufficient evidence to eliminate two of the sustainability indicators from further consideration – seawater intrusion and depletion of interconnected surface waters.

4.1 Sustainability Goal

The goal of this GSP is to sustainably manage groundwater resources and continue to provide an adequate water supply for existing beneficial uses and users in accordance with county and city general plans while meeting established MOs to maintain a sustainable groundwater yield. To achieve the goals outlined in the GSP, a combination of measures, including continued management practices and monitoring will be implemented over the next 20 years and continued thereafter. Additional surface water supply and infrastructure projects will be a crucial component of augmenting groundwater supplies. Management actions also will be implemented.

4.2 Undesirable Results

Undesirable results occur when groundwater conditions within the Subbasin result in significant and unreasonable impacts to a sustainability indicator. The potential for undesirable results occurring in the Subbasin for all four of the sustainability indicators can be traced back to events, statewide policies, and natural causes that have occurred outside of the Subbasin and/or by entities not associated with the GSAs and others in the Subbasin. Reductions in historical allocations of surface water by federal, state, and judicial authorities have resulted in a need for the overlying Subbasin's population and enterprises to find additional viable water sources, which has resulted in an increased reliance on groundwater in this Subbasin.

The following are some examples of reductions to surface water supplies historically available within the Subbasin:

- The SWP and CVP water delivery reductions through the CVPIA (circa1992)
- Biological Opinions (circa 2007)
- The San Joaquin River Restoration program (circa 2010)

Additionally, Subbasin-wide effects to groundwater supplies may result from the following:

- Climate Change
- Changing Crop Patterns
- Subbasin Groundwater Outflows
- Increased Urbanization

These events, statewide policies, and impacts that have occurred outside of the Subbasin, by entities not associated with the GSAs, and/or out the GSAs control have resulted in an increase in groundwater pumping throughout the Subbasin.

Groundwater Levels

Certain areas show long-term decline in groundwater levels, which if not addressed, may eventually lead to a reduction in usable groundwater supplies. Given the 60- to 300-foot depth to groundwater relative to the approximately 3,000-foot-deep aquifer, it is understood that long-term declines could continue for many years before developing a situation that would truly be significant and unreasonable. Lowering groundwater levels can result in the following main impacts, the degree to which will determine if the conditions of lower groundwater levels are significant and unreasonable: water well problems, land subsidence, and deterioration of groundwater quality.

Groundwater Storage

Groundwater storage is the capacity of the underground to store water. As previously stated, there is an estimated at 20.5 million AF of groundwater in storage in the unconfined aquifer zone. The confined aquifer has an estimated at 60.4 million AF of groundwater in storage. Total groundwater is storage is approximately 80.9 million AF as of 2016. Annual changes occurred in groundwater storage from 1990 through 2016 in the upper and lower aquifer zones for each GSA area. Overall there has been a net loss of storage of about 2.31 million AF between 1990 and 2016.

Land Subsidence

Land subsidence is the lowering of the land-surface elevation from changes that take place underground. Common causes of land subsidence from human activity are pumping water, oil, and gas from underground reservoirs; dissolution of limestone aquifers (sinkholes); collapse of underground mines; drainage of organic soils; and initial wetting of dry soils (hydrocompaction) (Leake 2016). The majority of subsidence in the San Joaquin Valley has occurred due to groundwater extraction from below the Corcoran Clay layer, present at depths of 100 to 500 feet bgs, resulting in compaction and eventual subsidence in and below the Corcoran Clay layer (Ireland et al. 1984, Faunt et al. 2009).

The undesirable results related to land subsidence will be the significant loss of functionality of a critical infrastructure or facility, so the feature cannot be operated as designed, requiring either retrofitting or replacement to a point that is economically unfeasible. Potential impacts include:

- Raising flood control levees to mitigate subsidence
- Raising railroads tracks to mitigate flooding impacts related to subsidence
- Re-grading canals, including the California Aqueduct, to address grade changes related to subsidence
- Flooding of major roads and highways

The one critical infrastructure location in the Subbasin is roughly 17 miles of California Aqueduct alignment. Significant impacts to the conveyance capacity of this facility related to land subsidence caused in the Subbasin will be viewed as significant and unreasonable undesirable results. Fortunately, there does not appear to be significant subsidence along this alignment. The GSAs understand this to be related to the limited amount of groundwater pumping in that area.

Groundwater Quality

Water quality degradation has been linked to anthropogenic activities, and can result from pumping activities, as well as the known migration of contaminant plumes. Groundwater quality is currently comprehensively monitored in the Subbasin by regulatory agencies. These agencies rely on existing regulations and policies to define undesirable results related to the deterioration of groundwater quality. The agencies and coalitions include the ILRP, GAMA, RWQCB, Central Valley Salinity Alternatives for Long-term Sustainability Program (CV-SALTS), and cities and communities within the Subbasin.

4.3 Minimum Thresholds

MTs quantify groundwater conditions for each applicable sustainability indicator at each RMS. Measurements will be made at the RMSs for each sustainability indicator to determine whether an undesirable result is occurring in the Subbasin.

Groundwater Levels

The process for establishing the MTs for the groundwater levels sustainability indicator for the Subbasin is based on the following concepts, each of which was developed using the information developed for the HCM and as described in other portions of the GSP.

1. Groundwater levels in the Subbasin generally are declining, though at different rates at different locations in the Subbasin .
   - The groundwater level declines have been effectively managed by the GSA member agencies. The rate and degree to which groundwater levels have declined have not been significant and unreasonable.
2. The continued decline of groundwater levels in the Subbasin may result in impacts to beneficial uses and users that are significant and unreasonable, or undesirable. If this were to occur, the GSAs may not be able to manage and/or mitigate the effects to the beneficial uses and users of groundwater and therefore the effects may then become significant and unreasonable (i.e., undesirable results).
2. The GSAs of the Subbasin will be implementing projects and management actions designed to reduce the rate of groundwater level decline in the Subbasin and eventually stabilize groundwater levels into the future.
   - Implementation of the projects and management actions by the GSAs is anticipated to begin in 2020 and be completed by 2035.
3. The results of forecast simulations using the calibrated groundwater model indicate that the implementation of the projects and management actions by the GSAs proposed in this GSP will begin to reduce the rate of groundwater level decline in the Subbasin by 2035 and will stabilize groundwater levels by 2040. This will mitigate potential future undesirable results.

Groundwater Storage

The MT for the groundwater storage sustainability indicator in the Subbasin is the calculated change in storage using the methodology described in Chapter 5 and using the groundwater level sustainability indicator MTs at the RMSs.

Land Subsidence

The process for establishing the MTs for the land subsidence sustainability indicator for the Subbasin was based on groundwater model simulations with implementation effort and without, each of which was developed using the information developed for the HCM and as described in other portions of the GSP. The methodology of developing the MTs for subsidence is described in Chapter 5.

Groundwater Quality

Existing groundwater quality conditions will be considered as a baseline. The GSAs will not be responsible for existing groundwater quality concerns; MTs will be determined as described by the agencies and coalitions which include ILRP, GAMA, RWQCB, CV-SALTS, and cities and communities within the Subbasin for the various constituents they monitor. The basic authority of the GSAs is to locally determine the sustainable amount of groundwater that can be pumped and to manage the transition from the current groundwater usage to a groundwater usage that is sustainable.

Definition of a Minimum Threshold Exceedance

The MTs quantify groundwater conditions for each applicable sustainability indicator at each RMS. Undesirable results may occur in the Subbasin related to a specific sustainability indicator if the MT numeric values are exceeded for that indicator, as defined below.

- The lowering of groundwater levels is considered significant and unreasonable if pumping of groundwater elevations decline below the proposed MT at 45 percent (%) of the RMSs over a consecutive three-year period.

- Undesirable results may occur to groundwater storage when the volume of groundwater extracted causes groundwater levels to exceed the MT in more than 45% of all monitored wells within a consecutive three-year period.

- Undesirable results may occur due to land subsidence the MT is exceeded at either of the two RMSs.

- Data gathered by the agencies and coalitions will be reviewed and considered for the potential degradation of water quality caused by the implementation of this GSP and this GSP's projects and management actions.

4.4 Measurable Objectives

MOs, including interim milestones in increments of five years, have been established 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.

Groundwater Levels

The process for establishing the MOs for the groundwater levels sustainability indicator is described in detail in the description for establishing MTs.

Groundwater Storage

The MO for the groundwater storage sustainability indicator in the Subbasin is the calculated change in storage using the groundwater level sustainability indicator MOs at the RMSs.

Land Subsidence

The process for describing the MOs for the land subsidence sustainability indicator is described in detail in the description for establishing MTs.

Groundwater Quality

Existing groundwater conditions will be considered as a baseline. The GSAs will not be responsible for existing groundwater quality concerns; degradation beyond existing groundwater quality conditions will be the MO. MOs will be monitored by the agencies and coalitions.

Path to Achieve and Maintain the Sustainability Goal

Interim milestones for the groundwater levels sustainability indicator were calculated at five-year intervals with project and management action implementation. The MO for groundwater storage change and subsidence were also set with five-year interim milestones. It is the intent of the GSAs to develop and implement projects and management actions by 2035, sufficient to mitigate long-term overdraft. The path to achieve the sustainability goal is continued monitoring of the data collected from the coalitions and agencies listed in this chapter at each milestone.

5.0 Monitoring Network

SGMA requires each subbasin to establish a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term groundwater trends and related surface conditions and to evaluate changes in the Sustainability Indicators.

5.1 Description of Monitoring Network

The monitoring network for the Subbasin comprises existing and proposed RMS locations. The groundwater level RMS locations as discussed below are by aquifer zone. The land subsidence RMS locations consist of the existing land subsidence monitoring locations in the Subbasin and the general areas where future extensometers may be added. The groundwater quality RMS monitoring network is composed of wells currently sampled by the local cities/municipalities/small community systems and the Kings River Water Quality Coalition (KRWQC) ILRP.

The aquifer is divided into three aquifer zones for groundwater level monitoring:

1. The A zone is the shallow portion of the aquifer above the A-Clay and in areas where shallow groundwater is present outside of the A-Clay.
2. The B zone is the unconfined portion of the aquifer above the E-Clay or Corcoran Clay and below the A-Clay where the A-Clay is present.
3. The C zone is the confined portion of the aquifer below the E-Clay.

There are areas in the Subbasin where groundwater is not used due to poor water quality and/or, in the clay plug, non-productive strata. Portions of the Subbasin where groundwater pumping does not occur are not proposed to be actively monitored at this time. These areas overlay portions of ER, TCWA, and SWK GSAs.

Monitoring Network Objectives

The objectives of the various monitoring programs include the following:

- Establish baseline groundwater levels and groundwater quality and record long-term trends going forward;
- Use data gathered to generate information for water resources evaluations and annual changes in water budget components;
- Determine the direction of groundwater flow;
- Provide comparable data from various locales within the Subbasin;

- Demonstrate progress toward achieving MOs, interim milestones, and MTs described in the GSP as they relate to the Sustainable Management Criteria; and
- Develop the data to evaluate impacts to the beneficial uses or users of groundwater.

Design Criteria

New monitoring locations will be developed, and existing networks enhanced, where necessary, using an approach similar to the Data Quality Objective (DQO) process to guide the GSAs site selection. The DQO process follows the United States Environmental Protection Agency Guidance on Systematic Planning Using the Data Quality Objective Process (EPA 2006).

Overview of Existing Programs

Government agencies and private entities currently have existing programs in place that monitor groundwater levels, groundwater quality, and land subsidence. These programs will be utilized for future data collection and will be coordinated with SGMA monitoring requirements. If data from these sources becomes unavailable in the future, the monitoring network will be modified to monitor for the appropriate sustainability indicator.

Overview of Proposed Facilities

Proposed facilities for the groundwater level network include 95 monitoring wells (or existing wells that monitor a specific aquifer zone) at 34 locations in the Subbasin. The proposed monitoring wells may be necessary if existing wells cannot be identified to fill spatial data gaps in the network.

Two extensometers are initially proposed to be located in the vicinity of Corcoran and an area south of Lemoore. If funding or other agreements are made for the construction of the proposed extensometers, the locations will be refined by the GSA(s) at that time based on up-to-date subsidence maps and benchmark data.

Groundwater Levels

Groundwater level monitoring has occurred in most areas of the Subbasin on a semi-annual basis since the 1950s. Kings County WD, KRCD, Corcoran ID, DWR, USBR, and private landowners have measured and/or are currently measuring groundwater levels as part of existing monitoring programs. These agencies will continue monitoring semi-annually for future data collection and may expand, as needed, to comply with SGMA monitoring requirements.

The proposed RMS monitoring network, when built-out, will include a density of RMSs of up to two wells for the B zone (above the E-Clay) and C zone (below the E-Clay), and one well for the

A zone (above the A-Clay where it is present) for the 36-square mile Townships wholly in the Subbasin.

Groundwater Storage

Groundwater level contour maps will be prepared and estimates of annual storage change will be evaluated by comparing current year seasonal high contour sets to previous year seasonal high contours sets which are then multiplied by specific yield values. The storage change monitoring network is the same as the water level monitoring network. RMS well locations are linked to specific aquifer zones, and as such, data from these wells will be weighted heavier than wells without construction information. It should be noted that even though a well may not have construction information, the data can still be used in constructing water level maps if the data is consistent with water levels from RMS wells.

Groundwater Quality

The Subbasin is relying on already existing groundwater quality monitoring programs. Groundwater quality monitoring may supplement, as needed, groundwater quality monitoring currently under the oversight of an existing regulatory agency or groundwater quality coalition.

Land Subsidence

For land subsidence, the existing CVSRN CGPS in the area will be used as RMSs for the Subbasin. Additional land subsidence data can be gathered to evaluate subsidence across the Subbasin. These data will be evaluated annually and if subsidence rates approach MOs at the nearest CGPS station, then additional RMSs may be added as determined by the GSA. Two extensometers are proposed in areas of known subsidence, pending funding or collaboration with DWR or the USGS.

The Subbasin is included in areas monitored for subsidence by regional water agencies or the state and federal governments. Measurement and monitoring for land subsidence is performed by USGS, KRCD, KDWCD, USACE, UNAVCO, and various private contractors. Interagency efforts between the USGS, the U.S. Coast and Geodetic Survey (now the National Geodetic Survey), and DWR resulted in an intensive series of investigations that identified and characterized subsidence in the San Joaquin Valley. National Aeronautics and Space Administration also measures subsidence in the Central Valley and has maps on their website that show the subsidence for defined periods.

Consistency with Standards

The data gathered through the monitoring networks will be consistent with the standards identified in 23 CCR §352.4 related to GSPs.

5.2 Monitoring Protocols for Data Collection and Monitoring

The DQO process will be used to develop monitoring protocols that assist in meeting MOs and sustainability goals of this GSP (EPA 2006). Groundwater level, groundwater quality (if the GSAs participate in groundwater quality monitoring), and land subsidence monitoring will generally follow the protocols identified in the DWR Best Management Practices for the Sustainable Management of Groundwater - Monitoring Protocols, Standards, and Sites (DWR 2016f). Monitoring Protocols will be reviewed at least every five years as part of the periodic evaluation of the GSP and updated as needed. The GSAs may develop standard monitoring forms in the future if deemed necessary.

5.3 Representative Monitoring

DWR has referred to representative monitoring as utilizing a subset of sites in a management area. The GSP has developed a monitoring network of RMS wells where MOs, MTs and interim milestones are defined in further detail in Section 4.4 and 4.5, *Minimum Thresholds* and *Measurable Objectives*. Groundwater conditions can vary substantially across the Subbasin and the use of a small number of representative wells in the Subbasin is not practical to cover such a large area with varying conditions. The network will strive to fill data gaps with existing wells that have well construction information and historical groundwater level data. Proposed monitoring sites may include clustered wells, if existing wells cannot be identified and used, that will be able to provide data for different aquifer zones at a single location.

5.4 Assessment and Improvement of Monitoring Network

Groundwater Levels

The CASGEM Groundwater Elevation Monitoring Guidelines (DWR 2010) were used to estimate the density of RMS wells needed for the Subbasin per the DWR's Best Management Practices for the Sustainable Management of Groundwater - Monitoring Networks and Identification of Data Gaps (DWR 2016e). As feasible, the GSAs will evaluate the RMS network and make adjustments as needed over time. Groundwater levels will be measured in October for seasonal low conditions and in February to April for the seasonal high conditions depending on the GSA. Currently, there are spatial data gaps throughout the Subbasin. Spatial data gaps are primarily in the southern/southwestern region of the Subbasin where groundwater is not used due to poor water quality, and in the lakebed area due to lack of productive strata and poor water quality.

Most of the wells monitored in unincorporated areas are privately owned. As such, well construction information, including depth and perforated interval, are not available for most of these wells. While these wells may not provide ideal data points, they will continue to be monitored even if well construction data is collected which indicates the well is a composite well (perforated across multiple aquifer zones, in the Subbasin usually across the Corcoran Clay).

The RMS groundwater level network has data gaps, such as missing construction or partial construction information for some RMS wells. The goal is to have accurate well construction information for RMS wells monitored for groundwater level that currently lack construction information within five years of plan implementation.

Groundwater Storage

Groundwater storage change will be calculated using groundwater level contour maps from seasonal high groundwater conditions of successive years. Groundwater storage calculations are largely dependent on the groundwater level monitoring network. Collection of well attribute information described above will also benefit groundwater storage change evaluations. In addition, groundwater released from clays due to subsidence will also be evaluated annually from data collected from the land subsidence monitoring network.

Annual groundwater storage changes by each GSA will be calculated so individual GSAs can evaluate progress towards meeting MOs. The data used to estimate storage change will be the water level data collected from the water level networks. The most significant data gaps in the groundwater storage change monitoring network include Information on well construction aquifer characteristics, and shallow groundwater level data near rivers, creeks, and canal systems. Other data gaps in the groundwater storage network are the same as in the groundwater level monitoring network, as described above, since storage change is dependent on changes in groundwater levels.

Water Quality

Several programs already operate with the directive of groundwater quality standards. The GSAs desire to use existing groundwater quality sampling programs for tracking of groundwater quality. The monitoring frequency is dependent on those existing monitoring schedules. Groundwater quality associated with projects and management actions will be monitored appropriately.

There are no known data gaps in monitoring groundwater quality within the Subbasin. Additional monitoring may be triggered through evaluation of the existing data from the agencies and coalitions, and in conjunction and collaboration with the agencies or coalitions, on a case-by-case basis.

Groundwater quality monitoring site selection is driven, in part, by the location of city/municipal and other community well locations. As well, the KRWQC-ILRP has several well locations north of the clay plug. At this time, the Subbasin GSAs are proposing not to sample for groundwater quality in de-designated areas which includes Secondary Management Areas A and B. Locations of future groundwater quality sampling will likely be from monitoring wells that are constructed with funds from state or federal programs in data gap areas. As described above, the Subbasin GSAs would like to work collaboratively with the agencies currently performing groundwater quality monitoring.

Land Subsidence

There are presently no known depth-discrete subsidence monitoring facilities (i.e., extensometers that can measure subsidence in specific portions of the aquifer) within the Subbasin. It is believed that the majority of subsidence occurs from compaction of clays. Extensometers would provide the data needed to differentiate subsidence at specific depth intervals. These data would be used to validate which portions of the aquifer are experiencing the most subsidence.

Land subsidence in the Subbasin is monitored through agency and government land subsidence surveying programs. The data generated by these programs are considered adequate both spatially and temporally as InSAR/LiDAR mapping covers the entire Subbasin. However, individual GSAs may develop subsidence monitoring programs as needed that may include surveys of wells, or measurement of pumping water levels in deep wells in known subsidence areas.

5.5 Data Storage and Reporting

The monitoring programs within the GSAs will be coordinated within the Subbasin. RMS well locations, construction, and groundwater level data are shared or will be shared by the different GSAs. Similarly, data reported to DWR will be collected and reported in a consistent format. GSP development and implementation will depend on the Data Management System's (DMS) ability to support GSP activities. The DMS shall also allow for upload and storage of information.

5.6 Data and Reporting Standards

Table 5-8 provides the data and reporting standards for the GSP. The standards are prescribed for identification and coordinates of monitoring sites, well identification and construction information, maps, and hydrographs.

6.0 Projects and Management Actions to Achieve Sustainability

The GSAs have developed the projects and management actions described in this chapter. Once the GSP is approved, the projects and management actions previously selected by each GSA will be advanced and implemented. Projects and management actions will be implemented in the most effective manner to create a sustainable yield for each sustainability indicator, as applicable. Costs for implementing each project was developed using information from previous projects in the Subbasin area.

Management actions are generally programs or policies developed with the objective of management through reducing water demand, improving water data gathering, and/or protecting water quality. Management actions listed in this chapter are conceptual. Each GSA will utilize this list, or other options as they may arise, to further develop and refine their own management actions as needed to achieve sustainability.

6.1 Water Supply

The Subbasin receives surface water from the SWP, the USBR's CVP, the Kings River, the Kaweah River, and the Tule River. Furthermore, flood waters occur from controlled and uncontrolled streams including the Kings River, Kaweah River, Tule River, Deer Creek, White River, Kern River, and Poso Creek. The timing and volume of surface water supply varies depending on the magnitude of the water year. In addition, each GSA is proposing to use their members' existing contracts and rights for surface water as access to import more surface water into the Subbasin.

6.2 Projects

The following project types are reviewed in Chapter 6 and provide options being considered by the GSAs and their respective partner agencies for use in implementation of this GSP. Potential projects that may be utilized by the GSAs and partners include:

- Construction of new and modification of existing conveyance facilities;
- Above-ground surface water storage projects;
- Recharge basins and/or water banking in or out of the Subbasin;
- On-farm flooding; and
- Aquifer Storage and Recovery (ASR).

Potential projects are listed and described in Table 6-1.

<u>Conveyance Facilities Modifications and Construction of New Facilities</u>
Modifications or improvements to existing facilities can be completed to increase conveyance efficiency and allow for greater flow capacity. Improvements of an existing system could also increase the delivery area or delivery efficiency. Total capacity may also be increased with the construction of new conveyance systems such as canals, check structures, and additional turnouts, to allow for surface water delivery to new areas. By providing a larger service area, more acreage would be able to use surface water, thus reducing the demand on groundwater

pumping. It is anticipated that throughout the Subbasin, existing facilities will be improved by reshaping of existing canals, modification of canal control structures, and canal lining. Canal lining would prevent seepage losses and increase the total usable water volume. Conveyance construction and improvements will support other proposed projects in the area.

Above-Ground Surface Water Storage

Above-ground storage basins can be constructed for the purpose of capturing and retaining more surface water for direct irrigation purposes. Controlled surface water storage on the valley floor would allow users to more effectively utilize each water year's available surface water. All surface water diversions into and out of the storage basins would be measured appropriately. Groundwater pumping should decrease in direct correlation to the additional volume of surface water captured and stored in the new facilities. Additionally, if the storage basin were to replace an agricultural field, demand reduction would occur within the footprint of the designated storage basin.

Recharge Basins/Water Banking

Recharge basins could be built with the purpose of recharging water into the aquifer system with the intent of extraction later on. By recharging water in wet years, groundwater levels will improve, creating a buffer storage volume that could be extracted during periods of dryness or drought. Recharge basins would be constructed in areas containing soils associated with high infiltration rates; therefore, potential recharge volume realized is dependent upon the size of the recharge basin and the availability of flood water. These types of facilities are anticipated to be located in the northerly (SFK and MKR GSAs) and easterly portions (ER GSA) of the Subbasin due to coarser-grained soil profiles.

On-Farm Recharge

On-farm recharge is a form of groundwater recharge performed by flooding an existing agricultural production field. Potential locations for on-farm recharge will be determined by areas containing soil profiles with high infiltration potential. It will be up to each GSA to determine the most favorable locations and decide on a minimum acreage size designated for this type of project. Voluntary participation from the landowners and their delivery facilities will be utilized as part of the project. In this effort, existing local wells will recover recharge supplies.

Aquifer Storage and Recovery

ASR is an intentional recharge method utilizing direct injection of surface water into an aquifer for later recovery, usually through the use of wells. ASR well sites would be selected to directly store water in certain geologic zones for later recovery or to stabilize groundwater levels to arrest subsidence. Voluntary participation from landowners with appropriate facilities will be coordinated with the individual GSAs as funding becomes available.

6.3 Management Actions

Management actions represent options available to GSAs that will help support them in the sustainable management of groundwater. Each GSA has the flexibility to choose a list of actions that they believe will be pursued and will independently develop the policies to meet the needs of their area for achieving sustainable management. The management actions will be chosen by each GSA after the implementation of this GSP. Possible management actions are listed and described in Table 6-1. Examples of potential management actions include, but are not limited to the following:

Policies

- Voluntary fallowing programs

Outreach

- Education of groundwater use

Assessment

- Pumping fees for groundwater allocation exceedances
- Pumping fees for groundwater extractions

Groundwater Allocation

- Development of GSA level groundwater allocation
- Development of landowner groundwater allocation
- Groundwater marketing and trade
- Operation and management of groundwater extractions

New Development

- Require new developments (non-de minimis extractors) to prove sustainable water supplies if land use conversion is not a conservation measure

Monitoring and Reporting

- Flood flows (spills into the Subbasin), including Tule River, Deer Creek, Cross-Creeks and Kings River
- Registration of extraction facilities
- Require self-reporting of groundwater extraction, water level, and water quality data

- Require well flowmeters, sounding tubes, and water quality sample ports for new well construction

Existing Surface Water Contracts

- Flood flows (spills into the Subbasin), including Tule River, Deer Creek, and Cross-Creeks

7.0 Plan Implementation

Upon submittal of the GSP to DWR, GSP implementation will commence in the Subbasin. The GSAs will continue their efforts to engage the public and secure the necessary funding to successfully monitor and manage groundwater resources to avoid future undesirable results related to groundwater usage in the Subbasin. This GSP works in tandem with authorities of numerous agencies with the goal to coordinate activities in the region for the effective management of groundwater resources.

7.1 Estimate of GSP Implementation Costs

GSAs and member agencies will coordinate and implement the actions outlined in this GSP. As such, the implementation is anticipated to be performed by multiple agencies. To identify implementation costs, a draft structure of cost has been suggested and is included below:

- Regular/Ongoing SGMA Compliance Activities,
- GSP Five-Year Update,
- Plans to Fill Data Gaps,
- Projects, and
- Management Actions.

Table 7-1 lists estimated costs to develop each component of the GSP.

7.2 Schedule for Implementation

Implementation of the GSP will result in the sustainable yield of groundwater resources in the Subbasin by year 2040. Some areas within the Subbasin have existing projects. The schedule of projects and management actions are outlined below. At each five-year interim milestone, updates to the schedule will occur, as applicable, dependent on achievement of MO for each applicable sustainability indicator. Possible steps involved in the schedule of implementation include:

- Improved efforts to monitor across the Subbasin
- Begin identification of management actions through policy development
- Seek grant funding through available opportunities
- Establish project funding for some GSAs
- Develop program for voluntary fallowing
- Expansion of programs, projects and bringing new projects on-line
- If necessary, implement Management Actions relating to demand reduction

Based on the model timeline for projects to come on line:

- 2020-2025-Yield 50,000 AF, average 8,333 AF/Y
- 2026-2030-Yield 0 AF, average 0 AF/Y
- 2031-2035-Yield 660,000 AF, average 132,000 AF/Y
- 2036-2040-Yield 380,000 AF, average 76,000 AF/Y
- 2020-2040 Yield 68,125 AF/Y annual average

7.3 Mid-Kings River Groundwater Sustainability Agency

The MKR GSA is primarily a partnership between Kings County WD, the City of Hanford, and the County of Kings. The City of Hanford has developed and maintained municipal drinking water facilities for its residents for many decades. The Kings County WD has developed facilities and programs to address surface and groundwater conditions in its service area since the 1950s. The partnership of these three agencies provides a combination of resources and experience that will significant aid in SGMA implementation.

Projects

New Recharge Basins
The MKR GSAs plan to develop new recharge basins is conceptual and will be adaptive based on the productivity of facilities, the long-term availability of local wet year supplies and progress during the implementation period.

Partnership with Kings County WD
As an agency, Kings County WD has slightly different goals and a separate budget to take on efforts that address surface and groundwater conditions in almost all the MKR GSA area. The MKR GSA will work cooperatively with Kings County WD to develop the other needed basin facilities as well.

System Improvements
Kings County WD is evaluating their existing facilities used to recharge groundwater (roughly 1,100 acres) and deliver available surface water and developing projects to improve existing facilities.

Conservation Measures
The MKR GSA is aware of many different efforts by local growers to transition from current irrigation methods to more efficient irrigation systems. Some of these efforts are sprinklers, drip irrigation, and the use of drip tape (subsurface irrigation). While these methods do not change the amount that crops need to use to grow, they will reduce the amount lost to evaporation and the amount lost past the root zone.

Management Actions

Meter Requirements
The MKR GSA currently views that requiring the registration of all wells and the use of flow meters will dramatically improve the areas understanding of the most significant water balance components.

Pumping Restrictions
Currently it is believed that the historic amount of groundwater overdraft in the MKR GSA area can be addressed with new projects and programs developed through the Implementation period. However, if long-term increased demands and/or reduced surface water availability is experienced, the MKR GSA will consider implementing groundwater pumping restrictions.

Voluntary Fallowing
In the MKR GSA area there is a mixture of permanent and row crops grown in the agricultural areas. The MKR GSA Board plans to develop a program to work with row crop growers that would annually lease their property to reduce groundwater pumping in the area.

On-Farm Recharge
The MKR GSA is aware of landowners interested in on-farm recharge in the area. This effort will be continually evaluated to try to take advantage of the recharge capacity of existing fields.

Others
The MKR GSA plans to continually evaluate potential opportunities and pursue efforts that address GSA priorities with the least impact on local landowners. As the

Implementation period begins, the MKR GSA expects to learn many things over time and the hope is that this learning will help target efforts to be more and more effective.

Financing

The MKR GSA has contracted for consultant services related to GSA funding for implementation efforts and plans to hold a Proposition 218 election in 2020. Current plans are to develop a land based assessment for GSA administrative costs and a groundwater pumping charge to develop needed projects.

7.4 South Fork Kings Groundwater Sustainability Agency

SFK GSA encompasses 71,310 acres in the western portion of the Subbasin.

Projects

Recharge Basins

The SFK GSA will consider investment in surface recharge projects being proposed in MKR GSA and other GSA’s north and east of the Subbasin that are tributary to the Kings River.

ASR

SFK GSA has initiated a pilot study to determine the efficacy of ASR and has applied for a CEQA exemption to pilot test an ASR well in 2020. Subject to a successful pilot test and approvals from the RWQCB and Division of Drinking Water, SFK GSA would then develop a program that would enable individual landowners to develop and initiate ASR operations when they have access to surface water suitable for underground injection.

Management Actions

Groundwater Monitoring Program

SFK GSA’s groundwater level monitoring program will be generally implemented in accordance with this plan. Over time, the SFK GSA intends to rely solely on actual observed water levels rather than model results to establish progress towards sustainable pumping and avoidance of undesirable results.

Measurement of Groundwater Pumping

SFK GSA will initiate a measurement program to monitor groundwater pumping in the SFK GSA. The program will utilize a combination of metering at individual wells, remote sensing of cropping patterns, and grower surveys to determine crop type, irrigation sources, irrigation practices, and groundwater use.

Groundwater Accounting System

The SFK GSA will begin developing an accounting system that will link the measured pumping volumes with projects and policies to achieve overdraft reduction, sustainable yield, and avoidance of undesirable results.

Groundwater Pumping Fees

The SFK GSA will begin developing a fee structure for groundwater users.

Demand Reduction Program

The SFK GSA intends to initiate a program to reduce demand for groundwater. The elements of SFK GSA's demand reduction program may be as follows:

1. Enhancement of surface water delivery and on-farm efficiency improvement;
2. Seasonal cropping and dryland farming program; and
3. Land retirement or long-term fallowing contracts.

Financing

The SFK GSA is currently financed through a maximum assessment of $9.80 per acre that was approved through a Proposition 218 election in 2017 and the assessment will sunset in 2023. SFK GSA will establish a financing program that actively seeks out grants and funding partnerships that can implement the projects and management actions outlined in the GSP.

7.5 Southwest Kings Groundwater Sustainability Agency

The average annual storage change for the SWK GSA is estimated to be in surplus, thus projects to mitigate overdraft are not currently needed in this GSA. No projects have been determined at this time. Management actions may be determined at a later time and will be based upon annual monitoring results. The SWK GSA is applying for Proposition 1 Technical Support Services grant funding to offset some of the capital improvement costs associated with the development of new monitoring wells to fill existing data gaps in the monitoring network.

7.6 Tri-County Water Authority Groundwater Sustainability Agency

TCWA is a Joint Powers Authority created between local agencies cooperatively working towards groundwater sustainability by establishing a GSA between Angiola WD, Deer Creek Storm Water District, W. H. Wilbur Reclamation District, and Kings County. TCWA intends to manage groundwater within its boundaries in the Tulare Lake Hydrologic Region to accomplish the goals set forth in the GSP.

Projects

The Liberty Project is a water storage project on about 20 sections (roughly 20 x 640 acres = 12,800 acres) of private lands within Angiola WD and Kings County. This project will enable the capture and temporary storage of winter/spring flows from the Fresno Slough, Fresno ID, Mercy Springs, the Kings, Tule and Kaweah rivers, SWP Article 21, and CVP 215 waters. The project will be built in phases and will ultimately be capable of 94,000 acre-feet of surface storage. The stored water will be used in-lieu of groundwater pumping and for aquifer recharge.

Management Actions

TCWA has acted to implement certain management strategies immediately and has recognized the ability to develop additional actions and strategies over the 20-year implementation period. Management actions will be reviewed and revised by the TCWA Board of Directors at the five-year milestones to ensure sustainability is reached.

TCWA will implement its agricultural supply well metering program in 2020. To address overdraft conditions, a demand reduction of groundwater pumping may be implemented by TCWA.

7.7 El Rico Groundwater Sustainability Agency

The ER GSA and technical advisors have developed the projects and management actions described in Chapter 6. Once the GSP is approved, the projects and management actions previously selected are proposed to be advanced and implemented. Each GSA proposes their method to achieve sustainability, utilizing a combination of projects and management actions. Section 6.5, *GSA Sustainable Methods*, describes the mix of projects and management actions chosen by the GSA to meet the goals.

7.8 Identify Funding Alternatives

The Subbasin GSAs successfully pursued grant funding to help develop the GSP. A number of the GSAs have already passed Proposition 218 elections, which secured funds to generate sufficient revenue for the initial preparation of the GSP and initial GSA administrative functions. The annual operational costs have begun and are used to fund Agency operations and activities required by SGMA, including retaining consulting firms and legal counsel to provide oversight and lead the various agencies through the steps for SGMA compliance. Expenses consist of administrative support, GSP development, and GSP implementation. GSP development and GSA administrative costs are ongoing.

7.9 Data Management System

In development of this GSP, the five GSAs have developed a groundwater model that has been calibrated to estimate future scenarios. The DMS plans to build on existing data inputs in the groundwater model and develop a more formalized approach to collecting and capturing the data. As stated in Chapter 5, *Monitoring Network*, future data will be gathered to develop annual reports, as well as provide necessary information for future and ongoing update to the groundwater models at five-year intervals upon GSP implementation. The DMS that will be used is a geographical relational database that will include information on water levels, surface water diversions, land elevation measurements, and water quality testing. The DMS will allow the GSAs to share data and store the necessary information for annual reporting.

The DMS will be on local servers and data will be transmitted annually to develop a compiled repository for data analysis for the Subbasin's groundwater, as well as to allow for preparation of annual reports.

7.10 Annual Reporting

The GSAs will provide the Plan Manager the required information of groundwater levels, extraction volume, surface water use, total water use, groundwater storage changes and progress of GSP implementation for the Annual Report in accordance with the timelines required to meet the April 1st deadline each year.

7.11 Periodic Evaluations

The annual report will include updates or changes to the GSP or policy changes by the GSA's. Certain components of the GSP may be re-evaluated more frequently than every five years, if deemed necessary. This may occur, for example, if sustainability goals are not adequately met, additional data is acquired, or priorities are altered. Those results will be incorporated into the GSP when it is resubmitted to DWR every five years.

In addition, the annual report will provide an assessment to DWR in accordance with the regulatory requirements, at least every five years. The assessment will include and provide an update on progress in achieving sustainability including current groundwater conditions, status of projects or management actions, evaluation of undesirable results relating to MOs and MTs, changes in monitoring network, summary of enforcement or legal actions, and agency coordination efforts in accordance with 23 CCR §356.4.

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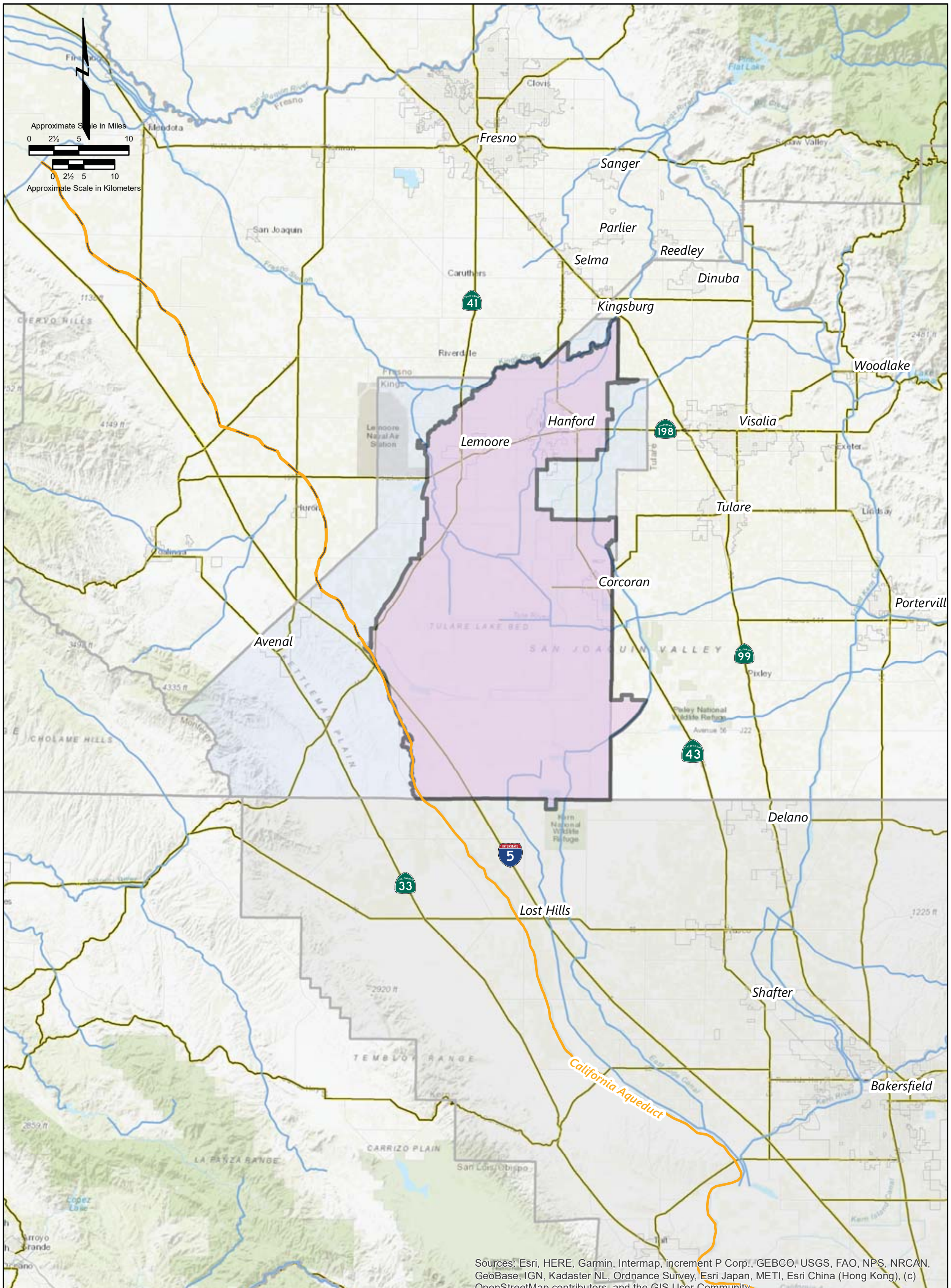

Explanation

Rivers[1]	
Federal Central Valley Project Infrastructure(CVP)	
State Water Project Infrastructure (SWP)	
Joint Federal/State	
All Counties, US (TIGER/Line2016)	
Cities2015	
Subbasin boundary	

Notes:
1. Surface water data taken from ESRI World Hydro Basemap

Regional Location of Tulare Lake Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 1/10/2020 | Project No.: FR18161220

Figure **ES-1**

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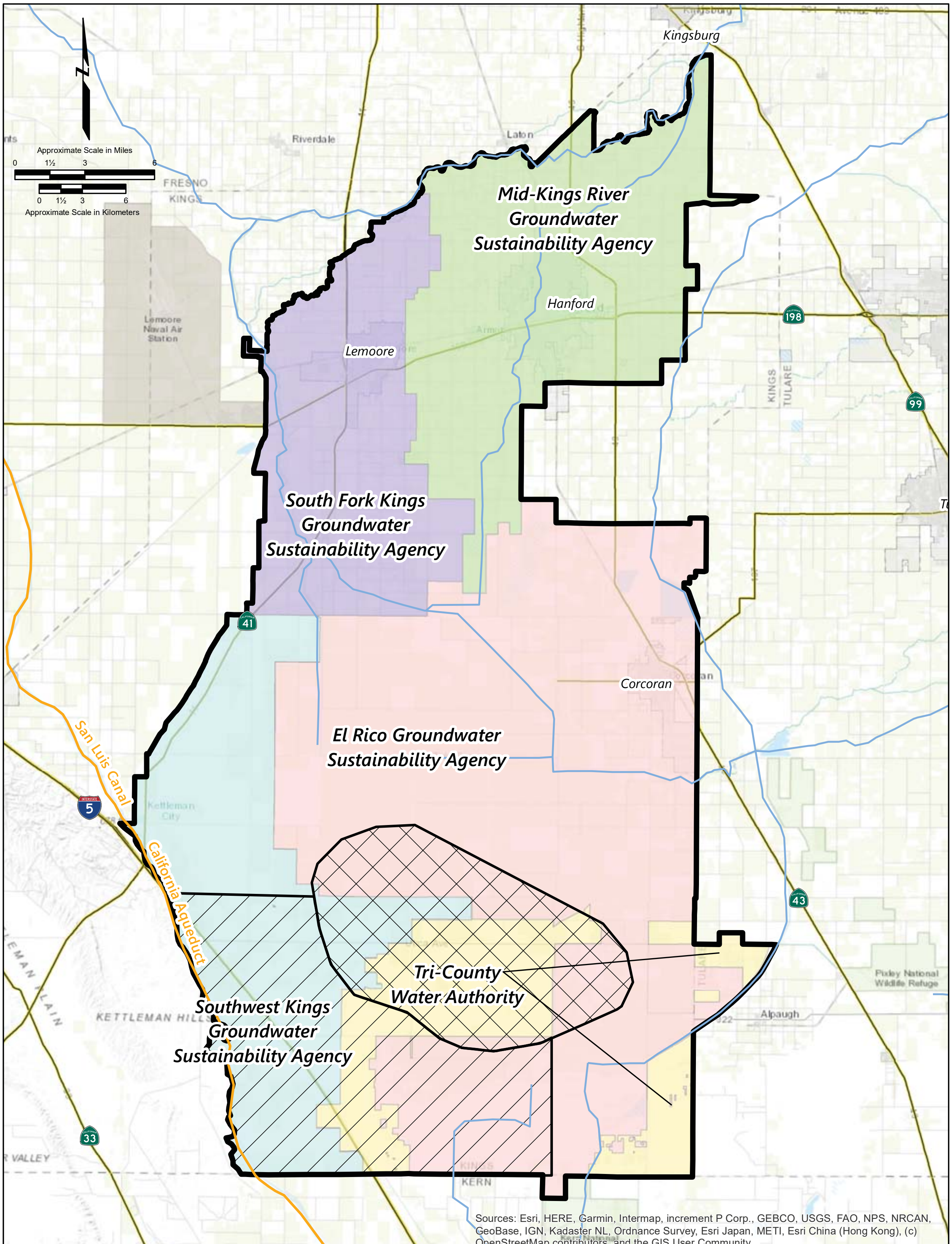


Explanation

- Rivers[1]
- Edmund G. Brown California Aqueduct
- Subbasin boundary
- Cities2015
- Estimated extent of clay plug below E-clay
- Southwest Poor Quality Groundwater

Groundwater Sustainability Agencies (GSAs)

- El Rico GSA
- Mid-Kings River GSA
- South Fork Kings GSA
- Southwest Kings GSA
- Tri-County Water Authority GSA

Notes:
1. Surface water data taken from ESRI World Hydro Basemap

GSAs within the Tulare Lake Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/10/2020	Project No.: FR18161220
		Figure **ES-2**

1.0 INTRODUCTION

Key Features of SGMA
▶ **Senate Bill 1168 -** Requires the sustainable management of groundwater basins for long-term reliability and economic, social, and environmental benefits for future uses
▶ **Senate Bill 1319 -** Authorizes State Water Resources Control Board intervention to remedy a mismanaged groundwater basin
▶ **Assembly Bill 1739 -** Establishes criteria for sustainable management of groundwater and authorizes DWR to establish best management practices for groundwater management

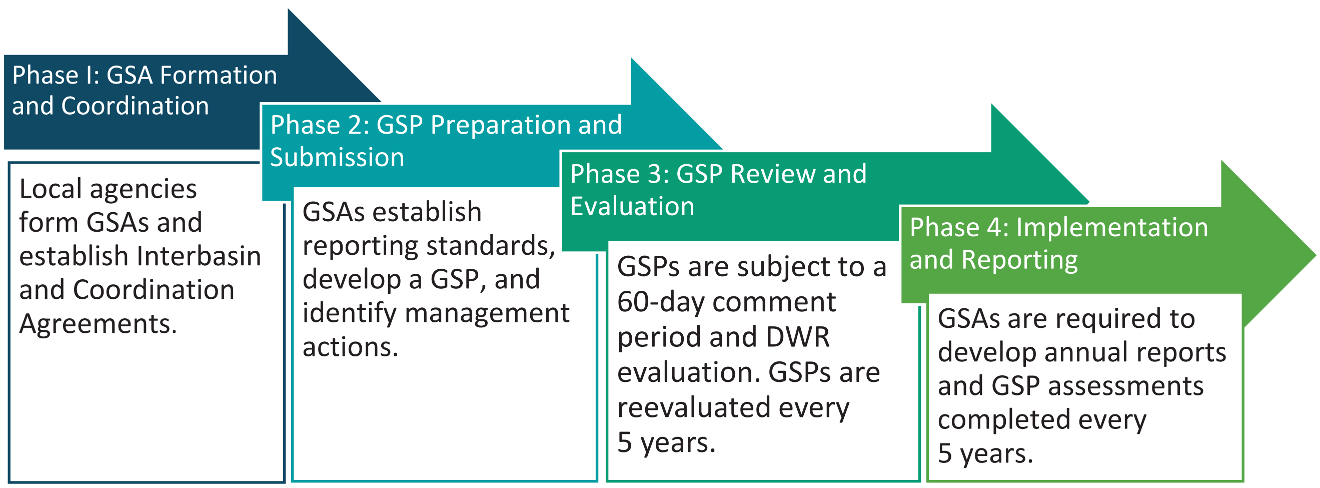
The legislative intent of the Sustainable Groundwater Management Act of 2014 (SGMA) is to sustainably manage California's groundwater basins. SGMA gives authority to local agencies to form Groundwater Sustainability Agencies (GSAs) and to manage groundwater basins to reach long-term groundwater sustainability through the preparation and implementation of Groundwater Sustainability Plans (GSPs) (California Water Code, §10720-10737.8). The adoption of SGMA established California's first comprehensive framework for sustainable management of groundwater basins through local agency coordination. SGMA expands the role of the California Department of Water Resources (DWR) to enforce local implementation of sustainable groundwater management practices through the review and approval of GSPs and allows for State Water Resources Control Board (SWRCB) intervention if groundwater basins do not meet sustainability requirements.

DWR Statewide Bulletin 118 Report describes regional groundwater occurrence, defines California groundwater basin boundaries, identifies basins that are subject to critical conditions of groundwater overdraft, and establishes basin priority (California Water Code, §12924). California's 515 groundwater basins are classified into four categories; high-, medium-, low, or very low-priority based on conditions identified in the California Water Code, §10933(b). Conditions include the population and irrigated acreage overlying the subbasin, the degree to which the population relies on groundwater as their primary source of water, and exceedance of sustainable yield (DWR 2019b). Basin prioritization also considers any documented impacts on groundwater within the subbasin, including overdraft, subsidence, saline intrusion, water quality degradation, or other adverse impacts on local habitat and streamflows. A subbasin is subject to critical conditions of overdraft when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts (DWR 2019b).

The Tulare Lake Subbasin (Subbasin) is identified as high priority by DWR and is one of twenty-one basins considered to be in a critically-overdrafted condition (DWR 2019a). Five participating

GSAs in the Subbasin have coordinated to develop this comprehensive GSP in compliance with SGMA: Mid-Kings River (MKR), El Rico (ER), South Fork Kings (SFK), Southwest Kings (SWK), and Tri-County Water Authority (TCWA) (Appendix F). The GSAs are committed to continued coordination and compliance with annual and five-year reporting requirements during the implementation of their GSP.

Subbasins subject to critical conditions of overdraft are classified as medium-and high-priority basins under the above criteria and require the preparation and adoption of GSPs (California Water Code, §10720.7). Each GSP is required to set long-term sustainability goals as well as "interim milestones" in increments of 5 years that represent measurable groundwater conditions and target values. Data collection and annual reporting to DWR is also required to ensure conformance with SGMA following GSP adoption, to the maximum extent feasible (California Water Code, §10720.1). The GSPs therefore must be reevaluated and updated, at a minimum, every 5 years (2025, 2030, 2035, and 2040) to provide refinements to the GSPs and allow for revised management.



1.1 Subbasin Overview

The Subbasin (Basin No. 5-022.12) consists of 837 square miles (535,869 acres) in the southern region of San Joaquin Valley Groundwater Basin, within Kings County. The Kings, Kaweah, Tule, and Kern Rivers within the southern portion of the San Joaquin Valley flow into the Tulare drainage subbasin (DWR 2006). The Subbasin is bounded to the south by the Kern County Groundwater Subbasin (5-022.14), to the east by the Tule Groundwater Subbasin (5-022.13) and the Kaweah Groundwater Subbasin (5-022.11), to the north by the Kings Groundwater Subbasin (5-022.08), and the west by the Westside Groundwater Subbasin (5-022.09). The southern half of the Subbasin consists of lands in the historically present Tulare Lake bed in Kings County (DWR 2016b).

The land overlying the Subbasin has a population of 125,907 (2010) and density of 150 persons per square mile (DWR 2019a; US Census Bureau 2018). Agriculture is one of the top three industries in Kings County, and a significant portion of the Subbasin population is involved in all facets of agricultural production (DWR 2019c). As one of the primary industries, agriculture is the largest source of employment in the County.

1.2 Purpose of the Groundwater Sustainability Plan

SGMA requires GSAs for high- and medium-priority basins to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge and expects subbasins to reach sustainability within 20 years of GSP implementation (DWR 2019c). GSAs establish minimum sustainability thresholds, measurable objectives, and long-term planning strategies through GSP development to achieve SGMA requirements (California Water Code, §10720; 10727). GSPs must identify the existing physical setting of the groundwater basin and assess groundwater levels to inform management actions and measurable sustainability goals (California Water Code, §10727.2).

The Subbasin GSP establishes how GSAs will monitor groundwater and use the data results to improve groundwater conditions in the basin. DWR defines sustainable groundwater management as the management and use of groundwater in a manner that can be maintained

King's County is ranked the 10th largest agricultural production county in California. Top commodities include milk, cattle, cotton, almonds, pistachios, and tomatoes (Kings County Agricultural Commissioner 2017).

The Tulare Lake Subbasin contains approximately 251,994 irrigated acres of agricultural land. Approximately 50% of irrigation supplies are met by pumping groundwater (DWR 2019c).

during the planning and implementation horizon without causing undesirable results (California Water Code, §10721 [v]). Undesirable results under SGMA are defined as:

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply
- Significant and unreasonable reduction of groundwater storage

- Significant and unreasonable sea water intrusion
- Significant and unreasonable degraded water quality including the migration of containment plumes that impair water supplies
- Significant and unreasonable land subsidence that substantially interferes with surface land uses
- Surface water depletions that have significant and unreasonable adverse impacts on beneficial uses of surface water.

The DWR GSP Emergency Regulations establish the requirements of GSP preparation and implementation in medium-and high-priority designated basins (Table 1-1; DWR 2016a).

1.3 Sustainability Goal

23 CCR §354.24 *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.*

1.3.1 Goal Description

This GSP aims to manage groundwater resources to continue to provide an adequate water supply for existing beneficial uses and users in accordance with counties and cities general plans while meeting established measurable objectives to maintain a sustainable yield. This goal aims to continue to provide adequate water supply for existing beneficial uses and users while ensuring the future, sustainable use of groundwater. Additionally, the sustainability goal works as a tool for managing groundwater, basin-wide, on a long-term basis to protect quality of life through the continuation of existing economic industries in the area including but not limited to agriculture.

GSAs in the Subbasin will work collectively to manage groundwater resources in the Subbasin, develop sustainability projects, and implement management actions, where appropriate. Section 3.2, *Groundwater Conditions*, provides insight to current and historical groundwater conditions, as well as a model for a 50-year forecast water budget to quantify groundwater level stability. Historic and hydrologic modeling estimates were used to develop a sustainable yield, which aims to stabilize forecasted groundwater levels. This goal was established in a manner that is transparent to the public and stakeholders to ensure the local population has a voice in the development of the programs. With the implementation of management actions and projects, as well as the continued interim monitoring and reassessment of activities, groundwater levels will be maintained at levels that will not create undesirable results.

1.3.2 Discussion of Measures

To achieve the goals outlined in the GSP, a combination of measures, including continued management practices and monitoring will be implemented over the next 20 years and continued thereafter. Additional surface water supply and infrastructure projects will be a crucial component of the supply system in diverting these waters to areas that provide the most benefit for offsetting the use of groundwater. Management actions will be implemented to help mitigate overdraft based on the demand from beneficial uses and users. Projects and management actions are discussed in further detail in Chapter 6, including a general timeline on when implementation will take place. When combined with consistent monitoring practices for each of the sustainability indicators, the GSAs will coordinate how individual GSAs pursue sustainability on a Subbasin level.

1.3.3 Explanation of How the Goal Will be Achieved in 20 Years

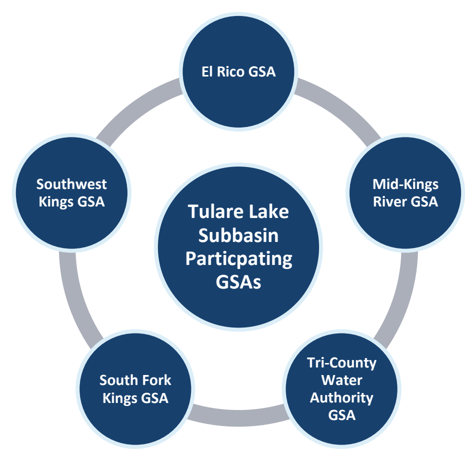
The goal of this Subbasin will be achieved in the next 20 years by the following:

- Understanding the existing condition’s interaction with future conditions;
- Analyzing and identifying the effects of existing management actions on the Subbasin;
- Implementing this GSP and its associated measures including project and management actions to halt and avoid future undesirable results;
- Collaborating between agencies to achieve goals and protect beneficial uses; and
- Assessing at each five-year interim milestone implemented project and management action’s successes and challenges.

1.4 Groundwater Sustainability Agency Information

23 CCR § 354.6(a) *The name and mailing address of the Agency.*

Five participating GSAs comprise the Subbasin: MKR, ER, SFK, SWK, and TCWA (Table 1-2). These GSAs have the authority and responsibility to sustainably manage the Subbasin under SGMA (California Water Code, §10723).



1.4.1 Organization and Management Structure of the GSA(s)

23 CCR § 354.6(b) *The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.*

The five participating GSAs collaboratively developed this single GSP for Subbasin under an Interim Operating Agreement (Appendix F). Each GSA was formed by local member agencies that represent stakeholders on the GSA Board of Directors (Table 1-3). The Board of Directors and technical teams will collect and organize data from experienced consultants as well as seek feedback from groundwater users within the GSA boundaries through each SGMA phase (Appendix B). The GSA decision-making process is divided into various organization's roles. Below includes a description of each organization's responsibilities:

- **Subbasin Management Team-** Each GSA has a representative on the team who worked collaboratively to jointly develop this GSP and manage groundwater in the basin.
- **Board of Directors-** Adopts policies in regard to the development and implementation of the participating GSAs and the GSP.
- **Stakeholder/Advisory Committees-** Makes recommendations to the Board of Directors and technical consultants based on feedback from stakeholders to ensure this GSP accounts for representative local interests of all beneficial users. The committees work to encourage active involvement of a diverse, social, cultural, and economic elements of each GSA's population. Not all participating GSAs elected to have stakeholder/advisory committees.

1.4.2 Legal Authority of the GSA(s)

23 CCR § 354.6(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.*

SGMA delegates the responsibility and authority to sustainably manage groundwater to local agencies through adoption and implementation of a GSP in medium-or high-priority basins (California Water Code, §10720). SGMA provides "local [GSAs] with the authority and the technical and financial assistance necessary to sustainably manage groundwater" (California Water Code, §10720.1). GSAs have regulatory authority including but not limited to adoption of regulations, conduction of investigations, and requirement of registered groundwater extraction facilities to sustainability manage groundwater within the basin (California Water Code, §10725). The five participating GSAs overlying Subbasin are coordinating to develop one comprehensive GSP (California Water Code §10723[a]). Each GSA overlies a portion of the Subbasin (DWR Bulletin 118, Basin No. 5-022.12). The five GSAs have established an Interim Operating Agreement to ensure coordination in developing and implementing the GSP.

The Subbasin is designated as a high-priority basin and therefore requires preparation of a GSP that will achieve groundwater sustainability in the basin within 20 years of implementation (California Water Code, §10720.7; 10727.2[b]). GSAs are required to lead communication, outreach, and engagement efforts within the basin and develop and implement a GSP on a basin-wide scale to sustainable manage groundwater at the local level.

1.4.3 Estimated Cost of Implementing the GSP and the GSA's Approach to Meet Costs

23 CCR § 354.6(e) An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.

The costs for implementing the GSP fall into a number of categories. The first is past and current planning functions. The GSAs have been for several years advancing development of the GSP and it has cost a significant amount of money. The historic and current planning functions have been broken down by the GSAs by a proportionate cost breakdown identified in Table 1-4. Applying this methodology to the past and present planning functions has resulted in an annual cost to the Subbasin of roughly $400,000. This is shown in Table 1-5. Implementation of the plan consists of annual ongoing and planning functions as well as implementation of projects and management actions. These estimated costs are shown on Table 1-6.

Some of the past costs have been paid for with grants from the State of California and for that the GSAs are grateful. There is opportunity to pursue additional grants and the GSAs fully intend to pursue additional grants that may become available. For the remainder of the ongoing costs and project financing for projects the local users will look to each of the GSA's constituency. Each GSA is responsible to its local area to identify the means in which to pay for the improvements and the level and detail to which management actions will be implemented. It is clear that each of the GSAs intend to implement projects to mitigate the overdraft and become sustainable. Management actions are identified as a possible tool and will be developed if the GSAs are unable to reach sustainability through the development of projects.

1.5 Interim Operating Agreement

Each of the five GSAs within the Subbasin operate under an Interim Operating Agreement (effective September 1, 2017) to facilitate coordination and management actions (Appendix F). SGMA expects local agencies to collaborate on a subbasin-wide scale and a combination of GSAs may be formed using a "joint powers agreement, a memorandum of agreement, or other legal agreement" (California Water Code, §10723 [b]). The Interim Operating Agreement is categorized as a legal agreement and ensures communication and coordination of the data and methodologies used by each GSA in developing the GSPs within the Subbasin for several factors, including groundwater elevation and extraction data, surface water supply, total water use, change in groundwater storage, water budget, total water use, and sustainable yield. Each GSA entered the Interim Operating Agreement to set forth their mutual intent to develop a single GSP for the Subbasin and authorize research and data collection required for the GSP according to a mutually agreeable timeline. Under this agreement, the GSAs agree to utilize their best efforts in preparing the GSP. Additionally, the SWK GSA and SFK GSA have a data sharing agreement with the Westlands Water District.

1.6 Groundwater Sustainability Plan Organization

The Subbasin GSP is organized as follows:

- **The Executive Summary** provides a summary overview of this GSP and a description of groundwater conditions at the basin, including management strategies and implementation actions.
- **Chapter 1. Introduction:** Includes the purpose of the GSP under SGMA to sustainably manage groundwater, the sustainability goals, the specifics of the participating GSAs, and the outline of the organization to this GSP.
- **Chapter 2. Plan Area:** Specifies the geographic extent of the GSP including but not limited to jurisdictional boundaries, existing land uses and land use policies, identification of water resources types, density of wells, and location of communities dependent on groundwater in the Subbasin.
- **Chapter 3. Basin Setting:** Describes the physical setting and characteristics of the current Subbasin conditions relevant to the GSP, including a Hydrogeologic Conceptional Model of the basin conditions, current and historic groundwater conditions, management areas, and a water budget.
- **Chapter 4. Sustainable Management Criteria:** Establishes criteria for sustainable groundwater management in the Subbasin, including how the GSAs will characterize undesirable results, and minimum thresholds and measurable objectives for the sustainability indictors.
- **Chapter 5. Monitoring Network:** Describes the GSP’s monitoring network to collect sufficient data on groundwater conditions and to assess the plan’s implementation through monitoring protocols on data collection and an established management system.
- **Chapter 6. Projects and Management Actions:** Outlines the project and management actions of the GSAs to meet the sustainability goal of the basin in a manner that can be maintained.
- **Chapter 7. Plan Implementation:** Consists of estimated GSP implementation costs, funding sources, GSP implementation schedule, and a plan for annual reporting and evaluation.

- **Chapter 8. References:** Includes a list of all references used to develop the GSP.
- **Appendices:** Includes additional information including but not limited to GSA contact information, the Interim Operating Agreement, Communication and Engagement Plan, Hydrogeologic Models, and the GSP checklist.

2.0 PLAN AREA

> ***23 CCR §354.8*** *Each Plan shall include a description of the geographic areas covered, including the following information:*
> - *One or more maps of the basin that depict the following, as applicable:*
> - *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.*
> - *Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.*
> - *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.*
> - *Existing land use designations and the identification of water use sector and water source type.*
> - *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.*

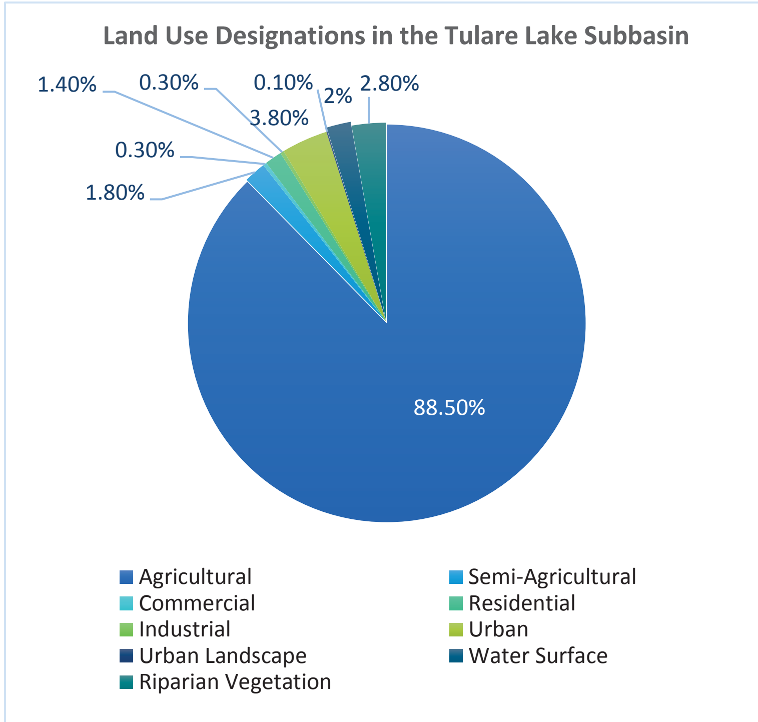
The Tulare Lake Subbasin (Subbasin) is located within the southern portion of the San Joaquin Valley Basin in the Central Valley of California. The Subbasin is defined under Department of Water Resources (DWR) Bulletin 118 as a high-priority basin (Basin No. 5-22.012). The Subbasin covers approximately 837 square miles (535,869 acres) including portions of the Kings, Kern, and Tulare counties (DWR 2016b). The five Groundwater Sustainability Agencies (GSAs) located within the Subbasin are the Mid-Kings River (MKR), South Fork Kings (SFK), Southwest Kings (SWK), El Rico (ER), and Tri-County Water Authority (TCWA) (Figure 2-1). There is no overlap among the GSAs and there are no adjudicated areas in the groundwater basin.

Tulare Lake Subbasin Prioritization Factors

- **Area:** ~837 square miles (535,869 acres)
- **Population (2010):** ~125,907
- **Projected Population Growth (2030):** ~176,446
- **Population Density:** ~150 persons/ square mile
- **Public Supply Wells:** ~75
- **Total Wells:** ~9,380
- **Irrigated Acres:** ~251,994
- **Groundwater Supply:** ~50% of water supplies
- **Total Storage Capacity:** ~17.1 million acre-feet (AF)

Source: DWR 2019b.

There are 28 total water management entities in the Subbasin GSA Plan area (Plan area) that have signed on as members of GSAs (Figure 2-3 through Figure 2-7). Federal lands located within the Plan area include Bureau of Land Management (BLM) parcels and administrative offices, the Santa Rosa Rancheria lands owned by the Bureau of Indian Affairs, and portions of the California Aqueduct regulated by the United States Bureau of Reclamation (USBR) (BLM 2019). State lands include the California State Prison Corcoran, Avenal State Prison, California Judicial Council courthouses, California Department of Transportation (Caltrans) storage facilities, portions of the Coastal and California Aqueducts regulated by DWR, State Routes 41, 198, and 43 and Interstate 5 (DGS 2019). Future planned development of these thoroughfares includes expansion to allow for additional vehicle capacity. A portion of the proposed California High Speed Rail alignment traverses portions of the MKR and ER GSAs (Figure 2-8; Figure 2-10) (High-Speed Rail Authority 2019). Tribal lands located within the Plan area include the Santa Rosa Indian Community of the Santa Rosa Rancheria (DWR 2017a).



Land uses within the Plan area were surveyed by DWR in 2014, with additional surveys for Kings, Kern, and Tulare Counties in 2003, 2006, and 2007, respectively (Figure 2-8 through Figure 2-12). The Plan area is primarily comprised of agricultural and urban land use designations. Agriculture accounts for the largest percentage of land use in the Subbasin (Table 2-1). The primary land use designations for urban land are residential, commercial, and industrial, with groundwater being the main source of water (Table 2-2; DWR 2017a).

The Subbasin is supplied by surface water from the Kings River, the Tule River, the Kaweah and St. John's Rivers, and unregulated streams including Deer Creek and Poso Creek, the California Aqueduct, and the Friant-Kern Canal. High precipitation rain events also convey natural surface water flows to the Plan area from Cottonwood Creek and Deer Creek. In 1995, DWR estimated the total groundwater storage capacity of the basin to be 17.1 million acre-feet (AF) to a depth of 300 feet, and 82.5 million AF to the base of fresh groundwater (DWR 2016b).

Figure 2-2 is a map of well density in the GSA area. There are an estimated 9,380 known wells within the Plan area, based on DWR continuous well records starting from 1940 (DWR 2019c). These records exclude test wells and recently drilled wells which have not been reported to DWR as of 2018. Any wells that have been decommissioned without issuance of a Kings County permit are mapped as active. DWR did not have information readily available to sort the wells based on domestic or irrigation use. The map does not necessarily show where pumping is concentrated since there is no differentiation between the different well uses.

2.1 Summary of Jurisdictional Areas and Other Features

23 CCR §354.8(b) *A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.*

2.1.1 Groundwater Sustainability Plan (GSP) Area

The Plan area includes the jurisdictional boundaries of the MKR, SFK, SWK, TCWA, and ER GSAs (Figure 2-1). The majority of the Plan area is located within Kings County, with small areas in Tulare and Kern Counties. The Kings Subbasin is the northern boundary of the Plan area, with the Westside and Kettleman Plains Subbasins on the western boundary, the Kaweah and Tule Subbasins to the East, and Kern County Subbasin to the south (DWR 2019d). The Plan area is comprised of five GSAs and 28 entities, which are described further below. Water use sector and water source type vary by agency (Table 2-2). Many private domestic and private community wells are used in rural and semi-rural areas throughout the Subbasin.

2.1.2 Mid-Kings River Groundwater Sustainability Agency

The MKR GSA covers approximately 152 square miles (±97,400 acres) and is located in the northeastern portion of the Subbasin (Figure 2-3) (DWR 2019d). The public and private agencies within the MKR GSA include the Kings County Water District WD, the City of Hanford, and Kings County. Surface water delivery entities within this area are the Riverside Ditch Company, the Lemoore Canal and Irrigation Company, the Peoples Ditch Company, the Settlers Ditch Company, the Last Chance Water Ditch Company, the New Deal Ditch Company, the Lone Oak Ditch Company, and the Lakeside Ditch Company. The primary industry within the MKR GSA is agriculture. Other industries within the boundary include food processing, as well as warehousing and distribution, and commerce industry that is standard in a community of approximately 60,000 people (e.g., automotive shops, supermarkets, etc.).

2.1.2.1 <u>Kings County Water District</u>

Formed in the 1950s, the Kings County WD area is approximately 223 square miles (±143,000 acres) in northeastern Kings County in the central portion of the San Joaquin Valley. Surface water is obtained from the Kings River and Kaweah and St. John’s Rivers through ditch company stock ownership. Kings County WD owns ditch stock for Kings River supplies in Lemoore Canal and Irrigation Company, Peoples Ditch Company, Settlers Ditch Company, and the Last Chance Water Ditch Company and ditch stock for Kaweah River supplies from Lakeside Ditch Company. Kings County WD also purchases surplus water from the Friant Division of the Central Valley Project (CVP), when available. There are numerous intentional recharge basins located in the Kings County WD, including the Apex Ranch Conjunctive Use Project, which is a groundwater bank that uses 50 acres of dry Kings River channel as a recharge area (Kings CWD 2011). Kings County WD is also responsible for managing flood water deliveries to the Old Kings River channel – a former river channel which is delivered wet year supplies through Peoples Ditch.

2.1.2.2 Kings County

Kings County, founded in 1893, is located on the western side of California's San Joaquin Valley. Kings County covers an area of approximately 1,391 square miles (890,240 acres), 1,024 square miles (±655,132 acres) of which are dedicated to harvested crops and other agricultural uses (Kings County 2019). U.S. Census Bureau estimates Kings County has a population of 151,336 as of 2018 (U.S. Census Bureau 2018) and is the 10th largest agricultural production county in the state, grossing over two billion dollars in 2017. Top commodities produced in Kings County include cattle, milk, cotton, pistachios, almonds, tomatoes, and grapes.

2.1.2.3 City of Hanford

The City of Hanford, incorporated in 1891, is located 30 miles southeast of Fresno in northern Kings County. The City of Hanford encompasses approximately 25 square miles (16,000 acres) and has a population of over 55,000. The sole source of water for the City of Hanford is groundwater, currently delivering 11,640 AF per year (AF/yr). The City of Hanford operates a wastewater treatment facility that discharges treated wastewater to percolation ponds or to farmlands for irrigation purposes (City of Hanford 2011).

2.1.2.4 Peoples Ditch Company

The Peoples Ditch Company, organized in 1873, is a pre-1914 water right holder on the Kings River that delivers water to the MKR and ER GSAs. Peoples Ditch Company's main canal system is located within the MKR GSA. The Peoples Ditch diversion off the Kings River is just upstream of Peoples Weir, south of Kingsburg. Peoples Ditch Company controls a portion of the storable volume behind Pine Flat Dam. The City of Hanford and Peoples Ditch Company have agreements regarding stormwater conveyance to Peoples Ditch and maintenance of facilities through the City of Hanford (City of Hanford 2017). Surface water diversions for Peoples Ditch Company average over 144,400 AF/yr over the last 100+ years of record (DWR 2012).

2.1.2.5 Last Chance Water Ditch Company

Last Chance Water Ditch Company, established in 1873, is a pre-1914 water right holder on the Kings River. The Last Chance Main Canal system and side ditches are located in the Hanford-Armona area in the central San Joaquin Valley. The Last Chance Main Canal diversion off the Kings River is just upstream of the Last Chance Weir, northeast of the 12th Avenue and Elder Avenue intersection. Last Chance Water Ditch Company controls a portion of the storable volume behind

Pine Flat Dam, and surface water diversions for the company average over 62,200 AF/yr over the last 60+ years of record (KRCD 2009).

2.1.2.6 Santa Rosa Rancheria

The Santa Rosa Rancheria community is comprised of approximately 700 residents. The Rancheria encompasses 2.8 square miles (±1,800 acres) within Kings County. The Rancheria relies on groundwater pumping for the majority of its water consumption (DWR 2019b).

2.1.2.7 Armona Community Services District

Armona Community Services District (CSD) serves the unincorporated community of Armona in Kings County. Armona CSD operates two groundwater wells that supply the population of 3,200 residents with 600 AF/yr (Armona CSD 2015). Recent discussions with Armona CSD staff in November of 2019 suggest the population has increased to 4,150 (Armona CSD 2019).

2.1.2.8 Home Garden Community Services District

Home Garden CSD serves the unincorporated community of Home Garden in Kings County. Groundwater wells provide water for 1,700 residents of the community (Home Garden CSD 2015).

2.1.2.9 Settlers Ditch Company

Settlers Ditch Company stock is a derivative of Peoples Ditch Company stock. In contrast, the Settlers Ditch Company has a separate Board of Directors and the ditch system is not viewed as part of Peoples Ditch Main Canal. Settlers Ditch delivery system is east of Hanford and generally north of Highway 198 (Kings CWD 2011).

2.1.2.10 New Deal Ditch Company

The New Deal Ditch Company holds a dry ditch stock, which gives access to deliver other stock water supplies through the New Deal Ditch. The New Deal Ditch begins at the end of the Peoples Ditch near the basin southwest of the 12th Avenue and Houston Avenue intersection. The New Deal Ditch generally delivers surface water to Peoples Ditch Company within part of the Kings County WD service area (Kings CWD 2011).

2.1.2.11 Lakeside Irrigation Water District

Lakeside Irrigation WD was formed in 1962 and its 31,991 acre service area is almost entirely within Kings County WD. Lakeside Irrigation WD has roughly the norther third of its service area in the Subbasin and the MKR GSA, while the southern two-thirds is in the Kaweah Subbasin and the Greater Kaweah GSA. There are 56 miles of open ditch in the Lakeside system as well as 10 recharge/regulation basins.

Lakeside Ditch Company, established in 1874, is a pre-1914 water right holder on the Kaweah River. The Lakeside canal system is located in the area southeast of Hanford in the central San Joaquin Valley. The Lakeside diversion off the Kaweah River is northeast of the 5th Avenue and Grangeville Boulevard intersection, just east of the Lakeland Canal. Kings County WD is a Lakeside Ditch Company stock holder as is Lakeside Irrigation WD.

2.1.3 South Fork Kings Groundwater Sustainability Agency

The SFK GSA covers approximately 111 square miles (±71,313 acres) and is located in the northwestern part of the Subbasin (Figure 2-4) (DWR 2019d). The public and private agencies within the SFK GSA include the City of Lemoore, Kings County, Empire Westside Irrigation District (ID), Stratford ID, Stratford Public Utility District (PUD), Company, Lemoore Canal and Irrigation Company, John Heinlen Mutual Water Company, and Jacob Rancho Water Company. The primary industries within the SFK GSA are agriculture and food processing (Appendix B).

2.1.3.1 City of Lemoore

The City of Lemoore, incorporated in 1900, lies within the northern portion of Kings County. The City of Lemoore encompasses an area of 6.82 square miles (±4,371 acres) and includes over 25,000 residents. Water supplies are approximately 8,300 AF/yr, with groundwater acting as the sole source for the City of Lemoore. The majority of water deliveries are metered. The City of Lemoore operates a wastewater treatment plant where treated wastewater is delivered to local farms for agricultural use (City of Lemoore 2015).

2.1.3.2 Empire Westside Irrigation District

Empire Westside ID was formed in 1931 and is a Kings River member unit. Its service area of 6,400 acres stretches from northwest to southwest of Stratford in Kings County. Empire Westside ID has a storage share of the Kings River of 13,000 AF and is a State Water Project Contractor (KRCD 2009).

2.1.3.3 Stratford Irrigation District

Stratford ID was formed in 1916 and is a Kings River member unit. Its service area is near Stratford in Kings County and encompasses 9,800 acres. Stratford ID has a storage share of the Kings River of 11,000 AF (KRCD 2009).

2.1.3.4 Stratford Public Utility District

Stratford PUD serves a population of 1,300 in the unincorporated community of Stratford within Kings County. Stratford PUD operates three groundwater wells that serve 340 metered service connections (Kings County 2015).

2.1.3.5 Lemoore Canal and Irrigation Company

Lemoore Canal and Irrigation Company was established in 1870. As a mutual water company, it serves the stockholders of the Lemoore area. The Company encompasses 52,300 acres and has a storage share of the Kings River of 100,000 AF (KRCD 2009).

2.1.3.6 John Heinlen Mutual Water Company

The John Heinlen Mutual Water Company serves an area of 13,100 acres near Lemoore in Kings County. The Company has a storage share of 10,000 AF of the Kings River (KRCD 2009).

2.1.3.7 Jacob Rancho Water Company

Jacob Rancho Water Company is a private water company operating within the SFK GSA.

2.1.4 Southwest Kings Groundwater Sustainability Agency

The SWK GSA covers approximately 140.6 square miles (±90,000 acres) and is located in the western portion of the Subbasin (Figure 2-5). The public and private agencies within the SWK GSA are Dudley Ridge WD, Tulare Lake Reclamation District (RD) #761, Kettleman City CSD, and Tulare Lake Basin Water Storage District (TLBWSD). Due to the poor yield and poor quality of the groundwater within the SWK GSA, only a minimal quantity of groundwater is pumped within the GSA. Groundwater levels, water quality, and subsidence are maintained at current levels. The primary industries within the GSA are agriculture, oil production, and commercial usage specific to Kettleman City (Appendix B).

2.1.4.1 Tulare Lake Basin Water Storage District

TLBWSD, formed in 1926, is located in Kings and Tulare Counties. TLBWSD has a service area of 296.88 square miles (±190,000 acres). TLBWSD obtains surface water from the Kings River, with supplemental deliveries from the Tule and Kaweah Rivers and the State Water Project (SWP). In a representative year, TLBWSD delivers approximately 324,400 AF (Tulare Lake Basin Water Storage District 2015).

2.1.4.2 Dudley Ridge Water District

Dudley Ridge WD, organized in 1963, is located in Kings County south of Kettleman City. Dudley Ridge WD services agricultural lands and encompasses an area of 58.77 square miles (±37,615 acres). Dudley Ridge WD water supply consists of water from the SWP and local transfers. Dudley Ridge WD does not use local groundwater due to low yields and poor quality. However, landowners within Dudley Ridge WD now import groundwater from the Angiola ID well field in Tulare County through canals across the Tulare Lake Bed. The annual water use for the Dudley Ridge WD is approximately 45,000 AF (Dudley Ridge WD 2012).

2.1.4.3 Tulare Lake Reclamation District #761

Tulare Lake RD #761 is located in the central San Joaquin Valley. Its boundaries primarily lie within the TLBWSD and encompass approximately 54.69 square miles (±35,000 acres). Tulare Lake RD #761 averages annual deliveries of approximately 24,500 AF from the Kings River (DWR 2012).

2.1.4.4 Kettleman City Community Service District

Kettleman City CSD serves a population of approximately 1,500 residents in the unincorporated community of Kettleman City. Historically, Kettleman City CSD has provided approximately 315 AF/yr from groundwater wells (Kettleman City CSD 2009). The CSD will now rely on surface water from their new Surface Water Treatment Facility. Their groundwater wells will now only be used as a back-up emergency supply

2.1.5 El Rico Groundwater Sustainability Agency

The ER GSA covers approximately 357 square miles (±228,400 acres) and is located in the center of the Subbasin (Figure 2-6) (DWR 2019d). The public and private agencies within the El Rio GSA are the City of Corcoran, Kings County, Alpaugh ID, Melga WD, Lovelace RD, Salyer WD, Corcoran ID, Tulare Lake Drainage District, and the TLBWSD. The primary industry within the ER GSA is agriculture. Other industries within the boundary include food processing, as well as warehousing and distribution, and commerce industry that is standard in a community of approximately 10,000 people (e.g., automotive shops, supermarkets, etc.) (Appendix B).

2.1.5.1 City of Corcoran

The City of Corcoran, incorporated in 1914, lies on the eastern side of Kings County. The City of Corcoran has a population of approximately 22,215 and encompasses approximately 7.5 square miles (4,800 acres). The City of Corcoran relies on groundwater to supply its residents with approximately 5,000 AF/yr of domestic water supply (City of Corcoran 2014).

2.1.5.2 Tulare Lake Basin Water Storage District

TLBWSD, formed in 1926, is located in Kings and Tulare Counties. TLBWSD has a service area of 296.88 square miles (±190,000 acres). TLBWSD obtains surface water from the Kings River, with supplemental deliveries from the Tule and Kaweah Rivers and the SWP. In a representative year, TLBWSD delivers approximately 324,400 AF (Tulare Lake Basin Water Storage District 2015).

2.1.5.3 Alpaugh Irrigation District

The Alpaugh ID was formed in 1915 and encompasses approximately 15.625 square miles (±10,000 acres). It is located on the southeastern edge of the Subbasin and is within the ER GSA. Alpaugh ID relies mostly on groundwater for its deliveries, operating 18 wells with the capability to deliver approximately 4,000 AF/yr. Alpaugh ID is a subcontractor with Tulare County for up to 100 AF/yr of CVP water. Alpaugh ID does not have other surface water contracts but utilizes small allotments of flood waters in the Homeland Canal (USBR 2018).

2.1.5.4 Corcoran Irrigation District

Corcoran ID was formed in 1919 to provide irrigation water to land within its boundaries. Corcoran ID encompasses approximately 34.38 square miles (±22,000 acres). Corcoran ID obtains most of its surface water from the Kings River, with supplemental deliveries from the Kaweah and St. John's Rivers and USBR Section 215 water (Irrigation Training and Research Center 2008).

2.1.5.5 Lovelace Reclamation District #739739

Lovelace RD #739739 encompasses approximately 9.22 square miles (±5,900 acres) located north of TLBWSD. Lovelace RD's primary function is flood control (DWR 2012).

2.1.5.6 Salyer Water District

Salyer WD is located in and around the TLBWSD. Salyer WD encompasses approximately 16.25 square miles (±10,400 acres) (DWR 2012).

2.1.5.7 Tulare Lake Drainage District

Tulare Lake Drainage District is a California Drainage District located in Kings, Tulare, and Kern Counties.

2.1.5.8 Melga Water District

Melga WD was formed in 1953 and encompasses approximately 117.19 square miles (±75,000 acres) mostly within the TLBWSD. Surface water supplies are obtained from the SWP and Kings River with periodic availability from the Kaweah and Tule Rivers (DWR 2012).

2.1.6 Tri-County Water Authority Groundwater Sustainability Agency

The TCWA GSA is a collective group of local water agencies dedicated to monitoring and regulating groundwater in the Tulare Lake Hydrologic Region. The TCWA GSA covers approximately 170.0 square miles (±108,800 acres) in the Tulare Lake and Tule Subbasins (Figure 2-7) (DWR 2019d). Approximately 75.19 square miles (±48,120 acres) of the GSA's area is located within the southeastern portion of the Subbasin. The primary industry within the TCWA GSA is almost entirely agriculture (Appendix B).

2.1.6.1 Tulare County

Tulare County, formed in 1852, encompasses approximately 4,839 square miles (±3,096,950 acres) and is located south of Fresno County. As of the 2010 census, the population was 442,179 (U.S. Census Bureau 2018; Tulare County 2019).

2.1.6.2 Kings County

Kings County, founded in 1893, is located on the western side of California's San Joaquin Valley. Kings County covers an area of approximately 1,391 square miles (890,240 acres). U.S. Census Bureau estimates Kings County has a population of 151,336 as of 2018 (U.S. Census Bureau 2018). Federal lands located within the Plan area include BLM parcels and administrative offices, the Santa Rosa Rancheria lands owned by the Bureau of Indian Affairs, and portions of the California Aqueduct regulated by the USBR (BLM 2019)

2.1.6.3 Angiola Water District

Angiola WD, formed in 1957, is an agency within the TCWA GSA. Irrigation wells within the area are mostly owned by the Angiola WD. Groundwater pumping supplements the fluctuating surface water supplies sourced from SWP, CVP, Kings River, Tule River, Deer Creek, and floodwaters from Tulare Lake (DWR 2012).

2.1.6.4 Atwell Island Water District

Atwell Island WD encompasses approximately 11.1 square miles (±7,100 acres). Atwell Island WD delivers surface water supplies from subcontracts with the County of Tulare of up to 50 AF/yr. Atwell Island WD does not operate any groundwater wells or recharge facilities (DWR 2012).

2.1.6.5 W.H. Wilbur Reclamation District #825

According to databasin website, W.H. Wilbur RD #825 is located within the TCWA GSA.

2.1.6.6 Deer Creek Storm Water District

According to Local Agency Formation Commission website for Tulare County, Deer Creek Storm WD is located within the TCWA GSA.

2.2 Water Resources Monitoring and Management Programs

2.2.1 Monitoring and Management Programs

> ***23 CCR §354.8(c)*** *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.*

2.2.1.1 Groundwater Level Monitoring

The California Statewide Groundwater Elevation Monitoring (CASGEM) Program tracks long-term groundwater elevation trends throughout California. The Kings River Conservation District (KRCD) is the local agency that monitors groundwater levels within the Plan area. KRCD facilitates collaboration between local monitoring entities and DWR. The data is collected twice a year, in the spring and the fall (DWR 2012).

Kings County WD monitors groundwater levels on a regional scale and has monitored the groundwater since the 1950s. Kings County WD collects water level data from up to 280 wells in the spring and fall (Kings CWD 2011).

2.2.1.2 Groundwater Extraction Monitoring

It is not known how many private wells are metered nor if any existing groundwater extraction monitoring programs are in place. Potential future groundwater monitoring policies are discussed in Chapter 5, *Monitoring Network*.

2.2.1.3 Groundwater Quality Monitoring

See Chapter 5, *Monitoring Network,* for information on groundwater quality monitoring within the Subbasin and see Chapter 4, *Sustainable Management Criteria*, for existing groundwater quality monitoring.

2.2.1.4 Land Surface Subsidence Monitoring

Land subsidence has been measured for many years throughout the Central Valley. The Plan area contains various local monitoring networks, which can be utilized to survey existing benchmarks to measure subsidence. The United States Geological Survey (USGS), National Aeronautics and Space Administration (NASA), and KRCD also measure subsidence in the Central Valley. DWR commissioned NASA's Jet Propulsion Laboratory to utilize airborne and satellite radar data to measure ongoing land subsidence throughout California and produce maps showing how subsidence varies seasonally and regionally. USGS and NASA have published maps on their websites that show the subsidence monitoring results for a defined time period (USGS 2019; NASA 2017). KRCD also has a 7-mile grid that monitors new and existing benchmarks for land subsidence. Caltrans has a benchmark correction control network with historic elevation updates showing ground movement within the Subbasin at various locations. See Chapter 5, *Monitoring Network,* for further information regarding subsidence in the Plan area.

2.2.1.5 Surface Water Monitoring

Kings River Water Association (KRWA) monitors surface water in the Kings River and the associated watershed including seasonal snowpack, reservoir stage, reservoir inflow and outflow, Kings River flows, and Kings River diversions. The Friant Water Authority monitors San Joaquin River's water delivered through the Friant-Kern Canal. The Kaweah and St. Johns Rivers Association monitors Kaweah River water flows and deliveries, and the St. John's River that reaches the Subbasin via Cross Creek and Tule River. DWR and TLBWSD monitor the SWP and the Kings River flows that enter the Subbasin.

2.2.1.6 Irrigated Lands Regulatory Program

According to the Waterboards website, the Irrigated Lands Regulatory Program (ILRP) was initiated in 2003 to address pollutant discharges to surface water and groundwater from commercially irrigated lands. The primary purpose of the ILRP is to address key pollutants of concern including salinity, nitrates, and pesticides introduced through runoff or infiltration of irrigation water and stormwater. Surface water quality has been monitored for several years, and in the future, groundwater quality will be monitored. The program is administered by the Central Valley Regional Water Quality Control Board (RWQCB).

Under the ILRP rules, agricultural crop growers may form "third party" coalitions to assist with required monitoring, reporting, and education requirements for irrigated agriculture. The Kings River Water Quality Coalition (KRWQC) was established in 2009 as a Joint Powers Agency to combine resources and regional efforts to comply with the regulatory requirements of the ILRP. The KRWQC area and supplemental areas cover most of the Plan area (KRWQC 2016). The Westside Water Quality Coalition (WWQC) was formed in 2013 as part of the ILRP. Dudley Ridge WD is within the boundaries of the WWQC (WWQC 2019). Regional information on surface and groundwater quality is available from the individual coalitions.

2.2.1.7 GSP Monitoring and Management Plans

The individual water entities located within the Plan area will be responsible for continuing to collect data for any current monitoring or management plan. The monitoring program is described further in Chapter 5, *Monitoring Network*.

2.2.2 Impacts to Operational Flexibility

23 CCR §354.8(d) *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.*

2.2.2.1 Regulatory Decisions and Agreements

Regulatory monitoring and management programs outside the boundaries of the Subbasin have limited the operational flexibility and management of the Subbasin, by reducing the CVP and SWP delivery amounts, which include the following:

- **1992 Central Valley Project Improvement Act (CVPIA)**: The CVPIA is a multipurpose federal water legislation providing for water resource management throughout the western United States (U.S.). Enactment of the CVPIA mandated changes in the CVP and reallocation of water supplies and reductions in pumping, particularly for the protection, restoration, and enhancement of fish and wildlife. Water supplies in the Plan area have been reduced as a result of the CVPIA. Supplies were impacted due to pumping restrictions within the Delta and development of refuge supplies from previously available contract supplies, which led to decreased allocations for Mid-Valley Canal and Cross Valley Canal contracts.
- **2007 Wanger Decision:** A federal decision found that USBR did not consider evidence that fish, including salmon and delta smelt, would be harmed by increased water exports for the Sacramento-San Joaquin Delta. The result of this curtailed SWP and CVP pumping from the Delta, reducing overall supplies to the Subbasin.

2.2.2.2 Places of Use

Agencies use of water from Kings River, SWP, and CVP are restricted to the place of use defined by their water rights. This GSP will not alter these agreements.

2.2.2.3 Contaminant Plumes

Water quality for individual monitoring wells can be found from Geotracker (SWRCB 2019a). See Chapter 3, *Basin Setting,* for more information on water quality in the Subbasin.

2.2.2.4 Kings River Fisheries Management Program

A partnership has been forged between KRCD, the KRWA, and the California Department of Fish and Wildlife (CDFW) to create the Kings River Fisheries Management Program (KRFMP). This program includes numerous measures to benefit the Kings River fisheries, including year-round flows, improved temperature control, and additional monitoring. However, this comes at the expense of some operational flexibility for Kings River water users. The Kings River provides the majority of the surface water used in the Subbasin area (KRFMP 1999).

Several requirements are placed on Pine Flat Reservoir and Kings River operations, as a part of the program. These include maintaining a minimum of 100,000 AF in Pine Flat Reservoir, temperature control pool (10 percent [%] of the reservoir's capacity), and October through March minimum fish flow releases below Pine Flat Dam (KRFMP 1999).

The local water entities have already adjusted agricultural operations to adapt to the KRFMP. In the future, additional recharge and banking facilities could help the program to further adapt by providing a place to store Kings River waters when supply exceeds irrigation demands.

2.2.3 Conjunctive Use Programs

23 CCR §354.8(e) *A description of conjunctive use programs in the basin.*

> ***Conjunctive Use*** *is the deliberate combined use of groundwater and surface water, which involves actively managing the aquifer systems as an underground reservoir.*

Conjunctive use is the coordinated and planned management of surface and groundwater resources to maximize their efficient use. Conjunctive use is utilized to improve water supply reliability and environmental conditions, reduce groundwater overdraft and land subsidence, and to protect water quality. Conjunctive use can include using surface water when it is available and relying on groundwater when surface water supplies may run out seasonally or are limited during droughts. Conjunctive use also includes cyclic storage where surplus surface waters are recharged during wet years and groundwater is pumped during dry periods.

Surface water is also used for groundwater banking (recharge) in areas that allow surface water to be stored in the aquifer for use at a later date. Kings County WD operates numerous recharge basins within its district. Within Kings County WD, the Apex Ranch Conjunctive Use Project uses 50 acres of dry Kings River channel as a recharge area. Alpaugh ID has storage ponds that provide incidental recharge (Kings CWD 2011). Corcoran ID operates percolation basins with a 10,000 AF capacity capable of recharging 200 AF/day (DWR 2012). The City of Corcoran has an agreement with Corcoran ID to discharge stormwater into their ditch network for the purpose of recharge (City of Corcoran 2014). Additionally, the City of Hanford has a very similar agreement with Peoples Ditch Company.

2.3 Relation to General Plans

2.3.1 Summary of General Plans/Other Land Use Plans

23 CCR §354.8(f) *A plain language description of the land use elements or topic categories of applicable general plans that include the following: A summary of general plans and other land use plans governing the basin.*

Every county and city in California is required to develop and adopt a General Plan (California Government Code, §65350-65362). A General Plan is a comprehensive long-term plan for development of the county or city, which consists of a statement of development policies and identifies objectives, principles, standards, and proposals for the area. To an extent, a General Plan acts as a "blueprint" for development.

The General Plan must contain seven state-mandated elements; however, any additional elements the legislative body of the county or city wishes to adopt can be included. The seven mandated elements are: Land Use, Circulation, Housing, Noise, Open Space, Conservation, and Safety. The General Plan may be adopted in any form deemed appropriate or convenient by the legislative body of the county or city, including the combining of elements. Within the Plan area, agencies with jurisdiction over land uses have adopted General Plans (Table 2-3).

As noted in Section 2.1.6.6, a relatively small portion of the ER GSA extends into Kern County. The extension consists of 640 acres and is a portion of a 1,080-acre parcel (Figure 2-11), used as evaporation ponds and owned by the Tulare Lake Drainage District. It is considered unlikely that any Kern County General Plan policies have any practical relevance to the Plan area.

2.3.2 Impact of GSP on Water Demands

23 CCR §354.8(f)(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.*

All of the General Plans in the Plan area were adopted prior to the development of the GSA and this GSP; therefore, the General Plans did not consider the impacts of this GSP's implementation.

The General Plans of Kings, Tulare, and Kern County, as well as the City of Hanford, Lemoore, and Corcoran make assumptions for both rural and urban development. Urban Water Management Plans (UWMPs) prepared for the City of Lemoore, Hanford, and Corcoran address assumed land use changes and growth rates. This GSP may use the land use change assumptions identified in the General Plans as well as other information for forecasting the anticipated water budget, described later in this GSP. See Chapter 3, *Basin Setting,* for more information.

2.3.3 Impact of GSP on Water Supply Assumptions within Land Use Plans

23 CCR §354.8(f)(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.*

There are six General Plans within the Plan area. The counties of Kings, Kern and Tulare and cities of Lemoore, Hanford, and Corcoran each possess a General Plan. The General Plan sections that cover the effect of the water supply are summarized below. Impacts due to implementation of the Plan vary and planning efforts will continue to be coordinated, with each entity and their respective plan to be updated at the five-year milestones.

2.3.3.1 County of Kern General Plan

There are no anticipated impacts on Kern County lands within the Subbasin. The total Kern County land area within the Subbasin is 360 acres (Kern County 2009).

2.3.3.2 Kings County General Plan

Kings County ranks as the seventh fastest-growing county in population in California. The estimated 2018 population of Kings County was 151,366 (U.S. Census Bureau 2018). Future projections from the Department of Finance (DOF) expect the population to reach 181,218 by the year 2035 (DOF 2019). The Land Use (LU), Resource Conservation (RC), and Health and Safety (HS) sections of the Kings County General Plan discuss various topics including water supply. The primary water supply goal in this plan is for reliable and cost-effective infrastructure systems that permit the County to sustainably manage its diverse water resources and agricultural needs, secure additional water, and accommodate for future urban growth (Kings County 2010).

2.3.3.3 County of Tulare General Plan

Tulare County's General Plan 2030 Update developed goals and policies to encourage sustainable groundwater management, such as to develop additional water sources, implement water conservation, and encourage demand management measures for residential, commercial, and industrial indoor and outdoor water uses in all new urban development (Tulare County 2012).

2.3.3.4 City of Hanford General Plan

The Land Use, Transportation, Water Resources, and Public Facilities sections of the City of Hanford's General Plan discuss various topics including water supply. U.S. Census Bureau estimated the 2018 population to be 56,910 (U.S. Census Bureau 2018), City of Hanford staff suggest the population has increased to approximately 58,000 (City of Hanford 2019), which accounts for approximately 37% of the population of Kings County. The 2016 General Plan anticipates the population to increase to 90,000 by 2035. The annual gross water use in 2015 was 11,640 AF or 188 gallons per capita per day. The General Plan's 2020 urban water use targets 179 gallons per capita per day, which is intended to be maintained through the 2035 plan horizon. The anticipated gross annual water use by 2035 can be expected to be 18,045 AF (City of Hanford 2011). The primary water supply goal in the plan is to maintain reliable and cost-effective infrastructure systems that permit the City to sustainably manage its diverse water resources and needs.

2.3.3.5 City of Lemoore General Plan

The City of Lemoore General Plan policies are geared towards preserving environmental resources such as open space, prime farmland, wetlands, special species, water resources, air quality, and other elements of value to Lemoore residents. The estimated 2018 population of Lemoore was 26,474 (U.S. Census Bureau 2018). Sufficient land was allocated in the General Plan to accommodate for future population projections, which are expected to reach 48,250 by 2030. According to the 2005 City of Lemoore UWMP, the City of Lemoore's 2005 maximum day demand was approximately 12.8 million gallons per day, which is well within the current supply capacity of 19.2 million gallons per day. If the City grows at the anticipated rate, demand will exceed the supply available from existing wells. Since Lemoore is not located within an adjudicated water basin, there is no restriction on the number of wells the City of Lemoore may drill within City boundaries. Water quality maintenance is a more considerable challenge to meeting water demand than water quality for the City of Lemoore (City of Lemoore 2015).

2.3.3.6 City of Corcoran General Plan

The Land Use, Circulation, Safety, Conservation and Open Space, Air Quality, and Public Services and Facilities sections of the City of Corcoran's General Plan discuss various topics including water supply. U.S. Census Bureau estimated the 2018 total population of Corcoran to be 21,676 (U.S. Census Bureau 2018). By 2030, the population is expected to reach 26,888. The City of Corcoran's entire water supply is provided by local groundwater. The average daily demand in 2010 was 5.9 million gallons per day. Projected daily demand in 2030 is expected to increase to 5.5 million gallons per day, so projected water use targets a 20% use reduction. The General

Plan's primary water supply goal is to protect natural resources including groundwater, soils, and air quality in an effort to meet the needs of present and future generations (City of Corcoran 2014).

2.3.4 Permitting Process for New or Replacement Wells

23 CCR §354.8(f)(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.*

In California, local jurisdictions with the authority to adopt a local well ordinance that meets or exceeds DWR Well Standards have regulatory authority over well construction, alteration, and destruction activities (DWR 2019a). After the submittal of the GSP, California Water Code §10725 - §10726.9 describes the authoritative power by the GSAs, including but not limited to imposing spacing requirements on new groundwater well construction, imposing operating regulations on existing groundwater wells, and controlling groundwater extractions. The GSA may use the powers described in the above code to provide the maximum degree of local control and flexibility consistent with sustainability goals described in the GSP.

2.3.4.1 Kings County

The Kings County General Plan Resource Conservation Policy A1.6.3 states the following regarding well installations:

- *Protect groundwater by enforcing the requirements for installation of wells in conformity with the California Water Code, the Kings County Well Ordinance, and other pertinent state and local requirements.*

Kings County adheres to DWR Well Standards guidelines for the construction of groundwater wells that are intended to protect the groundwater quality and reduce the adverse effects caused by improper well construction (DWR 1981; DWR 1991). Kings County has the sole authority for establishing and enforcing the standards for construction and deconstruction of water wells. In accordance with the California Water Code §13801, Kings County Ordinance No. 587 has provisions that require permits for well construction, reconstruction and deepening, with oversight provided by the County's Health or Building Officials, and stipulates that no person shall dig, bore, drill, deepen, modify, repair, or destroy a well, cathodic protection well, observation well, monitoring well or any other excavation that may intersect groundwater without first applying for and receiving a permit unless exempted by law (Kings County 2000; 2001). The permittee is required to complete the work authorized by the permit within 180 days of the date of issuance of the permit.

Installation of domestic supply wells in Kings County must follow separate guidelines and regulations. Domestic wells installation requires completion of necessary permits, California Environmental Quality Act (CEQA) review, DWR and Drinking Water Source Assessment and Protection Program (DWSAP), and site and well inspections. A well is not to discharge into the water distribution system until the above documents have been submitted to the Division Office and a field inspection of the well installation has been made by Kings County Environmental Health Services (Kings County Public Health Department 2009).

2.3.4.2 County of Kern

Kern County stipulates the contractor as the responsible party to construct, deepen, or reconstruct an agricultural well in accordance with Kern County Ordinance Code, §14.08 (Kern County 2019). In addition, the contractor must also meet standards set by DWR, with the exception of modifications by updated DWR revisions (DWR 1981; DWR 1991). The responsibility lies with the owner to ensure the following have been included and completed:

- Install surface slab
- Implement watertight sanitary seal
- Use of approved backflow protection device (chemigation, air gap)
- Use of down-turned, screened casing air vent
- Disinfection of access/sounding tube
- Unthreaded sample tap installation
- Approved Flow Meter-NSF 61 installed
- Collection of water samples from the well to conduct a Water Quality Analysis for Arsenic Fluoride, Ethylene dibromide, Dibromo chloropropane and Gross Alpha

The Water Quality Analysis test must be performed by a state-certified laboratory. Final approval cannot be issued until all water quality tests have been received by Kern County and the surface construction features have been approved by Kern County Public Health Services Department 2018 (Kern County 2018).

2.3.4.3 County of Tulare

Tulare County approved a water well ordinance in September 2017 (Tulare County Ordinance Code, Part IV. Health, Safety and Sanitation, Chapter 13. Construction of Wells) that addresses agricultural and domestic water wells. Well construction, destruction, and setback requirements have been altered under Tulare County Ordinance Code Part IV Chapter 13 (Tulare County 2017). This ordinance places restrictions on the drilling of new wells on previously non-irrigated land where the land has not had a well or has not had surface water in the past. Tulare County Environmental Health Services Division is responsible for the permitting and enforcement within the portion of the Subbasin in Tulare County. Tulare County Ordinance Code Part IV Chapter 13, Article 3 stipulates the following:

- *Except as otherwise provided in sections 4-13-1250 and 4-13-1255 of this Article, it shall be unlawful for any person to construct, deepen, reconstruct or destroy any well, or soil boring, or cause any of those acts to be done, unless a permit has first been issued to him or to the person on whose behalf the work is undertaken. The Tulare County Health Officer may prescribe conditions if he determines that they are required to prevent contamination or pollution of underground waters. Permit conditions are appealable pursuant to section 4-13-1275 of this Article. A well permit shall be valid for six (6) months from the date of issuance.*

2.3.5 Land Use Plans Outside the Basin

23 CCR §354.8(f)(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.*

In general, all future land use changes will need to consider the net groundwater impact to neighboring basins, and updates to agency General Plans will need to consider GSPs and the responsibility of each member and participating agency. GSPs for neighboring basins will be evaluated during the GSP review process. Coordination between subbasins is required as part of GSP implementation. A discussion of some potential management actions, including policy changes are described in Chapter 6, *Projects and Management Actions*.

Relevant land use plans for Kern and Tulare counties are discussed in Section 2.3.3, *Impact of GSP on Water Supply Assumptions within Land Use Plans*. There are no nearby cities that have land use plans.

2.3.5.1 Fresno County General Plan

The Public Facilities and Services section of the Fresno County General Plan discusses general public facilities and services; funding; water supply and delivery; wastewater collection, treatment, and disposal; storm drainage and flood control; and numerous other services (Fresno County 2000). The goal of the water supply and delivery section is to ensure the availability of an adequate and safe water supply for domestic and agricultural consumption. The relevant policies are listed below:

- Policy PF-C.12 - The County shall approve new development only if an adequate sustainable water supply to serve such development is demonstrated.

- Policy PF-C.13 - In those areas identified as having severe groundwater level declines or limited groundwater availability, the County shall limit development to uses that do not have high water usage or that can be served by a surface water supply.
- Policy PF-C.23 - The County shall regulate the transfer of groundwater for use outside of Fresno County. The regulation shall extend to the substitution of groundwater for transferred surface water.
- Policy PF-C.26 - The County shall encourage the use of reclaimed water where economically, environmentally, and technically feasible.

2.4 Additional GSP Elements

23 CCR §354.8(g) *A description of any of the additional Plan elements included in the Water Code Section 10727.4 that the Agency determines to be appropriate.*

2.4.1 Saline Water Intrusion

Saline (or brackish) water intrusion is the induced migration of saline water into a freshwater aquifer system. Saline water intrusion is typically observed in coastal aquifers where over-pumping of the freshwater aquifer causes salt water from the ocean to encroach inland, contaminating the fresh water aquifer. The Subbasin is approximately 70 miles from the Pacific Ocean, and the potential for adverse impacts of saline intrusion in the Subbasin are considered low.

2.4.2 Wellhead Protection

A Wellhead Protection Area (WHPA) is defined by the Safe Drinking Water Act Amendment of 1986 as “the surface and subsurface area surrounding a water well or wellfield supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield” (100 U.S. Code. 764). The WHPA may also be the recharge area that provides the water to a well or wellfield. Unlike surface watersheds that can be easily determined from topography, WHPAs can vary in size and shape depending on subsurface geologic conditions, the direction of groundwater flow, pumping rates, and aquifer characteristics.

According to the EPA website, the Federal Wellhead Protection Program was established by Section 1428 of the Safe Drinking Water Act Amendments of 1986. The purpose of the program is to protect groundwater sources of public drinking water supplies from contamination, thereby eliminating the need for costly treatment to meet drinking water standards. The program is based on the concept that the development and application of land use controls, usually applied at the local level, and other preventative measures can protect groundwater.

According to the Safe Drinking Water Act, states may be delegated primary implementation and enforcement authority for the drinking water program. To date, California has no State-mandated program and relies on local agencies to plan and implement programs. Wellhead Protection Programs are not regulatory in nature, nor do they address specific sources. They are designed to focus on the management of the resource rather than control a limited set of activities or contaminant sources.

Contaminants from the surface can enter an improperly designed or constructed well along the outside edge of the well casing or directly through openings in the wellhead. A well is also the direct supply source to the customer, and such contaminants entering the well could then be pumped out and discharged directly into the distribution system. Essential to any wellhead protection program is proper well design, construction, and site grading to prevent intrusion of contaminants into the well from surface sources.

Wellhead protection is performed primarily during design and can include requiring annular seals at the well surface, providing adequate drainage around wells, constructing wells at high locations, and avoiding well locations that may be subject to nearby contaminated flows. Wellhead protection is required for potable water supplies and is not generally required, but is still recommended, for agricultural wells.

Municipal and agricultural wells constructed by the GSA member agencies are designed and constructed in accordance with DWR Bulletins 74-81 and 74-90. A permit is required from the applicable county prior to construction of a new well within the GSA's area. In addition, the GSA member agencies encourage landowners to follow the same standard for privately owned wells. Specifications pertaining to wellhead protection include (DWR 1981; DWR 1991):

- Methods for sealing the well from intrusion of surface contaminants;
- Covering or protecting the boring at the end of each day from potential pollution sources or vandalism; and
- Site grading to assure drainage is away from the wellhead.

2.4.3 Migration of Contaminated Groundwater

Groundwater contamination can be human-induced or caused by naturally occurring processes and chemicals. Sources of groundwater contamination can include irrigation, dairy production, pesticide applications, septic tanks, industrial sources, stormwater runoff, and disposal sites. Contamination can also spread through improperly constructed wells that provide a connection between two aquifers or improperly abandoned/destroyed wells that provide a direct conduit of contaminants to aquifers.

The following databases provide information and data on known groundwater contamination, planned and current corrective actions, investigations into groundwater contamination, and groundwater quality from select water supply and monitoring wells.

2.4.3.1 State Water Resources Control Board

The State Water Resources Control Board (SWRCB) maintains an online database that identifies known contamination cleanup sites, known leaking underground storage tanks, and permitted underground storage tanks. The online database contains records of investigation and actions related to site cleanup activities (SWRCB 2019a).

2.4.3.2 Department of Toxic Substance Control

The State of California Department of Toxic Substances Control (DTSC) provides an online database with access to detailed information on permitted hazardous waste sites, corrective action facilities, as well as existing site cleanup information. Information available through the online database includes investigation, cleanup, permitting, and/or corrective actions that are planned, being conducted, or have been completed under DTSC's oversight (DTSC 2019).

2.4.3.3 California Department of Pesticide Regulation

The California Department of Pesticide Regulation (DPR) maintains a Surface Water Database (SURF) containing data from a wide variety of environmental monitoring studies designed to test for the presence or absence of pesticides in California surface waters. As part of DPR's effort to provide public access to pesticide information, this database provides access to data from DPR's SURF (DPR 2019).

2.4.3.4 Groundwater Ambient Monitoring and Assessment Program

The SWRCB Groundwater Ambient Monitoring and Assessment (GAMA) program collects data by testing untreated raw water for naturally occurring and man-made chemicals and compiles all of the data into a publicly accessible online database (SWRCB 2019b).

2.4.4 Well Abandonment/Well Destruction Program

Well abandonment generally includes properly capping and locking a well that has not been used in over a year. Well destruction includes completely filling in a well in accordance with standard procedures listed in Section 23 of DWR Bulletin 74-81 (DWR 1981). DWR Bulletin 74-90 includes a revision in Section 23, for Subsection A and B, from Bulletin 74-81 (DWR 1991). The following revision is stated for Subsection A, Item 1:

DWR's Bulletin 74-90 establishes California Well Standards, which states:

A monitoring well or exploration hole subject to these requirements that is no longer useful, permanently inactive or "abandoned" must be properly destroyed to:

- Ensure the quality of groundwater is protected, and;
- Eliminate a possible physical hazard to humans and animals.

- *<u>Obstructions</u>. The well shall be cleaned, as needed, so that all undesirable materials, including obstructions to filling and sealing, debris, oil from oil-lubricated pumps, or pollutants and contaminants that could interfere with well destruction are removed for disposal. The enforcing agency shall be notified as soon as possible if pollutants and contaminants are known or suspected to be in a well to be destroyed. Well destruction operations may then proceed only at the approval of the enforcing agency. The enforcing agency should be contacted to determine requirements for proper disposal of materials removed from a well to be destroyed.*

The following revision from DWR Bulletin 74-90 states for Subsection B:

- *<u>Wells situated in unconsolidated material in an unconfined groundwater zone.</u> In all cases the upper 20 feet of the well shall be sealed with suitable sealing material and the remainder of the well shall be filled with suitable fill or sealing material from Bulletin 74-81.*

The remainder of Section 23 from DWR Bulletin 74-81 is unchanged.

Proper well destruction and abandonment are necessary to protect groundwater resources and public safety. Improperly abandoned or destroyed wells can provide a conduit for surface or near-surface contaminants to reach the groundwater. In addition, undesired mixing of water with different chemical qualities from different strata can occur in improperly destroyed wells.

The administration of a well construction, abandonment, and destruction program has been delegated to the counties by the California State legislature. Kings County requires that wells be abandoned according to State standards documented in DWR Bulletins 74-81 and 74-90. Due to staff and funding limitations, enforcement of the well abandonment policies is limited.

2.4.5 Replenishment of Groundwater Extractions

Replenishment of groundwater is an important technique in management of a groundwater supply to mitigate groundwater overdraft. Groundwater replenishment occurs naturally through rainfall, rainfall runoff, and stream/river seepage and through intentional means, including deep percolation of crop and landscape irrigation, wastewater effluent percolation, and intentional recharge. The primary local water sources for groundwater replenishment in the Plan area include precipitation, Kings River, Kaweah River, Tule River, Deer Creek, Poso Creek, and various smaller local streams. For more information, refer to Section 2.2.3, *Conjunctive Use Programs*, of the GSP.

Primary groundwater replenishment sources in the Plan area:

- Kings River
- Kaweah River
- Tule River
- Deer Creek
- Poso Creek
- Precipitation
- Various smaller streams

2.4.6 Well Construction Policies

Proper well construction is necessary to ensure reliability, longevity, and protection of groundwater resources from contamination. All of the GSA member agencies follow state standards when constructing municipal and agricultural wells (DWR 1991). Kings County has adopted a well construction permitting program consistent with state well standards to help assure proper construction of private wells. Kings County maintains records of all wells drilled in the Plan area.

State well standards address annular seals, surface features, well development, water quality testing and various other topics (DWR 1991). Well construction policies intended to ensure proper wellhead protection are discussed in Section 2.4.2, *Wellhead Protection*.

2.4.7 Groundwater Projects

The GSA member agencies in general developed their own projects to help meet their water demands and will develop additional future projects to meet sustainability. Developing groundwater recharge and banking projects is considered key to stabilizing groundwater levels. Chapter 6, *Project and Management Actions to Achieve Sustainability*, provides descriptions, estimated costs, and estimated yield for numerous proposed projects.

The GSA will also support measures to identify funding and implement regional projects that help the region achieve groundwater sustainability. This can include recharge projects that take advantage of local areas conducive to recharge and areas where recharge provides the most benefit to the GSA. This can reduce the burden for certain agencies from having to recharge within their boundaries if they do not have suitable land or soils.

2.4.8 Efficient Water Management Practices

Water conservation has been and will continue to be an important tool in local water management, as well as a key strategy in achieving sustainable groundwater management. All the GSA member agencies engage in some form of water conservation including water use restrictions, water metering, education, tiered rates, etc. These water conservation programs were tested during the 2014-2015 drought, which included state-mandated urban water restrictions for the first time. Details of water conservation programs can be found in various documents, such as individual UWMPs (City of Corcoran 2017; City of Lemoore 2015; City of Hanford 2011). Existing efficient water management practices include recycled water use and high efficiency irrigation practices.

2.4.9 Relationships with State and Federal Agencies

From a regulatory standpoint, the GSAs have numerous relationships with state and federal agencies related to water supply, water quality, and water management. Relationships that are common to all water agencies, such as regulation of municipal water by the California Division of Drinking Water (DDW), are not discussed here. Many of the GSA member agencies receive grants from various agencies for water-related projects. Grants are obtained from agencies including but not limited to DWR, SWRCB, and USBR. The GSA member agencies work closely with these state and federal agencies to track grant programs and administer and implement grant contracts. Relationships unique to the region are summarized below.

2.4.9.1 Kings River Water

The Kings River provides the majority of surface water used in the area. Kings River water is impounded by Pine Flat Dam, which is owned and operated by the United States Army Corps of Engineers (USACE) (Kings County 2002). The water rights permits were obtained from the SWRCB; however, allocation and management of water is largely controlled by the KRWA. The GSA member agencies work with the USACE and SWRCB to oversee and manage their Kings River water as needed. The local agencies also developed and continue to implement the KRFMP in partnership with the CDFW.

2.4.10 Land Use Planning

Land use policies are documented in various reports, such as General Plans, specific land use plans, and plans for proposed developments. Updating some of these plans is a multi-year process and not all plan updates can be fully completed concurrently with the GSP development. These land use plans are expected to be modified gradually over time to be consistent with the goals and objectives of this GSP. Some smaller communities rely on county policies and have no formal land use. Land use is shown in Figures 2-8 through 2-12.

Each of the local member agencies and water entities of the Subbasin's GSAs have an interest in land use planning policies and how they will impact their continued development and water supplies.

The following GSA member agencies have direct land use planning authority:

- Kings County
- Kern County
- Tulare County
- City of Corcoran
- City of Hanford
- City of Lemoore

2.4.11 Impacts on Groundwater Dependent Ecosystems

The Nature Conservancy (TNC) worked with DWR to identify Groundwater Dependent Ecosystems (GDE) throughout the state. TNC primarily used vegetative indicators and applied them to historical aerial imagery. Imagery was cross-referenced with CASGEM well levels to identify possible GDEs. The data used in GDE identification pre-dates the baseline year of 2015, so all land use changes in the interim period may not be included. Given the depth to groundwater throughout the Subbasin, it is believed that no GDEs exist.

2.5 Notice and Communication

Stakeholders gathered monthly to develop the recommended GSA formation governance structure for the Subbasin. Representatives from cities, counties, WDs, IDs, CSDs, and private water companies participated in the formation of the GSAs. Additionally, landowners, Disadvantaged Community (DAC) representatives, and industry representatives were present at GSA formation meetings.

2.5.1 Implementation of the GSP

SGMA implementation at the GSA level begins as DWR is reviewing this GSP. During the implementation phase, communication and engagement efforts focus on educational and informational awareness of the requirements and processes for reaching groundwater sustainability as set forth in the submitted GSP. Active involvement of all stakeholders is encouraged during implementation, and public notices are required for any public meetings, as well as prior to imposing or increasing any fees. Public outreach is also completed by the individual GSAs with collaborative efforts subbasin-wide when target audiences span more than one GSA boundary.

2.5.2 Decision-Making Process

> ***23 CCR §354.10 (d)*** *A communication section of the Plan that includes the following:*
> - *An explanation of the Agency's decision-making process.*

Each of the five GSAs within the Subbasin operate under an Interim Operating Agreement (effective September 1, 2017) to facilitate coordination and management actions (Appendix F). The Interim Operating Agreement is categorized as a legal agreement and ensures communication and coordination of the data and methodologies used by each GSA in developing the GSPs within the Subbasin for several factors, including groundwater elevation and extraction data, surface water supply, total water use, change in groundwater storage, water budget, total water use, and sustainable yield. The governing body of the GSP consists of a single authorized representative from each of the five member GSAs. Significant decisions require a unanimous vote of the representatives, while less significant decisions only require a four-fifths vote.

The Subbasin GSAs' decision-making process is broken down by the roles of the Subbasin management team, their respective Board of Directors, and any Stakeholder/Advisory Committees. The roles of the boards and GSA entities are outlined below.

- **Subbasin Management Team –** Comprised of a representative from each of the five GSAs working collaboratively to jointly manage groundwater within the Subbasin and to develop a GSP. These individuals met on a monthly and then bi-weekly basis throughout the GSP development and public review phases.
- **Boards of Directors –** Adopts general policies regarding development and implementation of the individual GSAs and the GSP.
- **Stakeholder/Advisory Committees –** Represents all beneficial uses and users of groundwater within the individual GSA boundaries and makes recommendations to the Boards of Directors and technical consultants regarding feedback from stakeholders to account for local interests. Not all GSAs have Stakeholder/Advisory Committees, and while allowed within SGMA, these committees are not required.

2.5.3 Beneficial Uses and Users

> ***23 CCR §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 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.*
> - *A list of public meetings at which the Plan was discussed or considered by the Agency.*
> - *Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.*

The GSAs shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing a GSP (California Water Code, §10723.2). The interests of all beneficial uses and users of groundwater within the Subbasin by GSA are identified in Table 2-4. Engagement with groundwater users occurs in the following phases of the development and implementation of the GSP:

2.5.4 Opportunities for Public Engagement

> ***23 CCR §354.10 (d)(2)*** *Identification of opportunities for public engagement and a discussion of how public input and response will be used.*

Stakeholder Key Interests related to groundwater include:

- Drinking Water
- Domestic, everyday usage
- Agriculture – farming, dairy, and livestock
- Industrial (food processing)
- Recreational

The GSAs within the Subbasin developed a joint Communication and Engagement Plan to address how stakeholders within the individual GSA boundaries were engaged through stakeholder education, opportunities for input, and public review during GSP development and implementation (Appendix B). Stakeholders were invited to public meetings through distribution of meeting notices to the Subbasin GSAs' district and member agency distribution lists, community organizations' contact lists, and press releases and public service announcements. Press releases were distributed to local media outlets announcing the meeting dates, times and locations. Local community organizations, such as the Kings County Farm Bureau, were asked to distribute meeting notices via email to their membership/contact lists. Public meetings held during the preparation and submission phase of the GSP were geared towards an overview of the SGMA, the GSP development process, stakeholders' expectations of public review and implementation, distribution of stakeholder surveys and solicitation of stakeholder input, and question/answer sessions. This segment of public meetings gave stakeholders an opportunity to be involved in GSP development and share their thoughts and concerns.

2.5.4.1 Communication & Outreach Methods

There were a variety of opportunities, venues, and methods for the Subbasin's GSAs to connect with and engage stakeholders throughout GSA formation, GSP development, GSP review, which will continue to be utilized through the GSP implementation phases.

Printed Communication

Printed materials incorporated the visual imagery established through individual GSA branding efforts and was tailored for specific means of communication throughout the phases of GSP development, public review, and implementation. Printed materials were also translated into Spanish, when necessary for diverse stakeholder education.

- **Fliers –** Fliers designed and tailored for stakeholder audiences, encompassed infographics and text with key messages that were pertinent for the appropriate phase of GSP development. Distribution was via GSA-website posting, direct mail, email, and direct distribution as handouts throughout communities, GSA, and Subbasin-wide outreach meetings. For outreach to DACs/Severely Disadvantaged Communities, fliers were available in both English and Spanish languages.
- **Letter Correspondence –** When letter correspondence was necessary, particularly during the public review and implementation phases, letters were distributed via email and/or direct mail. Letters included pertinent facts and explanations communicated to specific stakeholder groups.
- **Presentation Materials –** PowerPoint presentations were utilized at educational/outreach public meetings. For a consistent Subbasin-wide message, a draft presentation was developed for the GSP development and public review phases, with placeholder slides for GSAs to update with GSA-specific information. Handouts of presentations were distributed to stakeholders in attendance, emailed to the Interested Parties list, and/or posted on individual GSAs' websites for stakeholders to access, particularly if they were unable to attend.

Digital Communication

Digital communication outlets were also designed to incorporate the Subbasin GSAs' branding and was a significant means of communication through the GSP development and public review phases and will continue during the implementation phase.

- **Websites –** Public meeting notices, agendas, and minutes of the Board of Directors and Stakeholder/Advisory Committee meetings were posted on the individual GSAs' websites. These websites serve as integral resources for stakeholders within the Subbasin boundary. Electronic files of printed materials, presentations and other educational resources, and direct links to stakeholder surveys (English and Spanish versions) were also accessible via the websites. Websites will be maintained throughout the implementation phase of this GSP. This serves as a way for stakeholders to easily educate themselves on the GSP process and phases.
- **Interested Parties List –** As required by SGMA §10723.4 "Maintenance of Interested Persons List," the Subbasin's GSAs maintain contact lists and regularly distribute emails to those who have expressed interest in the GSAs' progress. These emails consist of meeting notices and other documents that are pertinent to the Subbasin GSAs and their communication efforts. This process will continue through the GSP implementation phase.
- **Email Blasts –** Email blasts for meeting notices, stakeholder surveys, public review notices, and other crucial information were coordinated with community organizations and stakeholder groups by utilizing their distribution lists. Examples of these organizations are Kings County Farm Bureau and water/irrigation districts within the individual GSAs' boundaries.

Media Coverage

Press releases were written and distributed to the media list of local newspaper publications. These press releases focused on notification of public engagement opportunities, such as targeted stakeholder meetings, public review/comment processes and opportunities. Press releases will continue during GSP implementation for meetings and notifications.

Stakeholder Surveys

Stakeholder surveys were used for the deliberate polling of stakeholders to give them a direct voice in the GSP development phase. The SFK and SWK GSAs circulated physical surveys, while the remaining three GSAs conducted verbal surveys through one-on-one discussions with stakeholders within their GSA boundaries. For the GSAs who administered physical stakeholder surveys, they developed both online and printed versions of their surveys. Survey links were posted as Google Forms on the individual GSAs' websites and were utilized in email blasts to the Interested Parties Lists. Hardcopies were also available for distribution throughout the respective GSA. Feedback received from the surveys was taken into consideration during the development of the GSP.

2.5.5 Encouraging Active Involvement

> ***23 CCR §354.10(d)*** *A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of population within the basin.*
> - *The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.*

Through Stakeholder Committees and, in some instances an Advisory Committee, GSAs are able to encourage the active involvement of diverse social, cultural, and economic elements of the population within the Subbasin prior to and during the development and implementation of this GSP. Printed materials are tailored for specific means of communication throughout the phases of the GSP development, public review, and implementation. As stated above, printed materials are translated into Spanish. Fliers, fact sheets, letter correspondence, presentation materials stakeholder surveys, and newsletters are the forms of printed communication between the public and GSAs. Digital communication and media coverage serve as an additional means of communication between the public and GSAs. During this GSP's implementation, specific stakeholders are informed of upcoming compliance requirements. Addresses of the area's property owners within the GSAs' boundaries can be obtained through Kings County. Meetings were held in a range of areas within the Subbasin to encourage attendance.

2.5.5.1 Subbasin Public Meetings

Public meetings to ensure equitable community access occurred within each GSA throughout the GSP's phases. Each GSA provided a list of previous and ongoing public meetings to track the effectiveness of outreach efforts (Appendix B).

2.5.6 Interbasin Communications

Subbasin GSAs and technical consultants met with surrounding subbasins throughout the development of the GSP to discuss how to achieve sustainability on a regional level, develop interbasin agreements, and share data when possible. A list of interbasin communications is included in Appendix B.

3.0 BASIN SETTING

> **23 CCR §354.12** *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.*

Key Features of the Tulare Lake Subbasin

- **Area:** ~837 square miles (535,869 acres)
- **Population (2010):** ~125,907
- **Projected Population Growth (2030):** ~176,446
- **Population Density:** ~150 persons/ square mile
- **Public Supply Wells:** ~75
- **Total Wells:** ~9,380
- **Irrigated Acres:** ~251,994
- **Groundwater Supply:** ~50% of water supplies
- **Total Storage Capacity:** ~17.1 million acre-feet

Source: DWR 2019b

The Tulare Lake Subbasin (Subbasin) is located primarily in Kings County in the Tulare Lake Hydrologic Region of the San Joaquin Valley. The San Joaquin Valley is relatively flat and elongates to the northwest and is bounded on the west by the Coast Ranges and on the east by the Sierra Nevada Mountain Range. The Subbasin is located in the south-central portion of the greater San Joaquin Valley. Topography in the Subbasin slopes inward towards the center of the valley. The former Tulare Lake occupies this portion of the Subbasin. Land use in the Subbasin and surrounding areas is predominately agricultural with localized urban areas of Hanford, Lemoore, and Corcoran. This chapter discusses the hydrogeologic conceptual model (HCM), groundwater conditions, the water budget, and management areas for the Subbasin.

The HCM, discussed in Section 3.1, acts as a sustainable groundwater management tool for the Subbasin's Groundwater Sustainability Agencies (GSAs) and provides a basis for the numerical groundwater flow model developed for the Subbasin (Appendix D). The HCM includes a description of the geographic, geologic and hydrogeologic setting, and a discussion of data gaps and uncertainties associated with the HCM.

Groundwater conditions, provided in Section 3.2, include current and historical groundwater conditions in support of the Groundwater Sustainability Plan (GSP) to ensure historical and present challenges are adequately described. The groundwater conditions section includes a description of current and historical groundwater conditions, current and potential subsidence in the Subbasin, a summary of groundwater quality, interconnected surface and groundwater systems, and groundwater dependent ecosystems.

The water budget, discussed in Section 3.3, provides a quantitative description of the historical, current, and 50-year projected inflows and outflows of the Subbasin. Additionally, the water budget will be used to develop an estimate of existing overdraft in the Subbasin and establish baseline conditions for the purpose of understanding future water supply reliability and for development of sustainable management actions and projects within the Subbasin. The historical water budget was used to develop and calibrate a numerical groundwater model of the Subbasin (Appendix D) and develop a 50-year forecast of future conditions, assuming normal hydrologic conditions adjusted for estimated climate change. The forecast model will be used as a planning tool to evaluate overdraft, develop sustainable management projects, and to evaluate management practices and projects' abilities to meet measurable objectives to avoid undesirable results.

Additionally, management areas, discussed in Section 3.4, have been delineated to facilitate data management and GSP implementation.

3.1 Hydrogeologic Conceptual Model

23 CCR §354.14(a) *Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterize the physical components and interaction of the surface water and groundwater systems in the basin.*

The HCM provides a general understanding of the physical setting, characteristics, and processes that govern groundwater occurrence and movement within the Subbasin (DWR 2016c). It comprises a compilation of available information to portray the geographic setting, regional geology, basin geometry, water quality, and consumptive water uses (municipal, agricultural, and industrial) in the Subbasin. The HCM looks at the groundwater and surface water interactions and assesses the inflows and outflows to and from the Subbasin. Subbasin boundaries are often a combination of physical and political boundaries, so subbasin boundaries often do not reflect the actual physical hydrologic boundaries of an area. Thus, the area of study in an HCM is often larger than the designated subbasin boundaries. The HCM also provides the foundation for the numerical groundwater model, delineating the boundary conditions, the hydrogeologic layers, and the model domain needed to provide an accurate representation of the groundwater flow system.

3.1.1 Geographic Setting

The Subbasin is located primarily in Kings County in the Tulare Lake Hydrologic Region of the San Joaquin Valley, California (Figure 3-1). The Subbasin covers an area of approximately 535,869 acres or about 837 square miles (DWR 2016b). The Subbasin contains five GSAs: El Rico (ER), Mid-Kings River (MKR), Southwest Kings (SWK), South Fork Kings (SFK), and Tri-County Water Authority(TCWA) (Figure 3-2). It is bounded by the Kings Subbasin to the north, the Kaweah Subbasin to the northeast, the Tule Subbasin to the southeast, the Kern County Subbasin to the south, the Kettleman Plain Subbasin to the southwest, and the Westside Subbasin to the northwest (Figure 3-3).

The San Joaquin Valley is relatively flat and is oriented in a northwest-southeast direction and is bounded on the west by the Coast Ranges and on the east by the Sierra Nevada Mountains (Figure 3-4).

Flow from the rivers and streams of the Sierra Nevada Mountains are largely regulated by a series of dams and reservoirs, which capture runoff from winter precipitation. Most of the runoff falls as snow in the adjoining highlands. The flow from the reservoirs is fed into man-made canals and modified streambeds that carry surface water primarily to agricultural users (Figure 3-5).

3.1.1.1 Climate

The climate in the Subbasin is semi-arid, characterized by hot, dry summers and cool moist winters and is classified as a semi-arid climate (BSk to BSh under the Köppen climate classification), usually found within continental interiors some distance from large bodies of water. The wet season occurs from November through March with 80 percent (%) of precipitation falling during this season. The valley floor often receives little to no rainfall in the summer months. Precipitation typically occurs from storms that move in from the northwest off the Pacific Ocean. Occasionally storms from the southwest, which contain warm sub-tropical moisture, can produce heavy rains.

Historical annual precipitation records over a span of 118 years have been recorded by the Hanford weather station. The Hanford weather station is located in the northern portion of the Subbasin where precipitation averages 8.28 inches per year. From 1899 to 2017, rainfall has ranged from a minimum of 3.37 inches in 1947 to a maximum of 15.57 inches in 1983 (NOAA 2019) (Table 3-1). Monthly precipitation in the area ranges between 0.00 and 6.69 inches per month. Typically, precipitation decreases from northeast to southwest across the Subbasin due to the rain shadow of the Coast Ranges. Figure 3-6 provides a map of the 30-year average annual precipitation across the Subbasin from January 1989 through December 2010 using the Parameter-elevation Regressions on Independent Slopes Model (PRISM) database, maintained by the Oregon State University (PRISM 2018).

3.1.1.2 Topography

The topography of the Subbasin is generally low sloping inward from all directions toward the center of Tulare Lake (Figure 3-7). From the northeast edge to the center of Tulare Lake, ground surface elevations range from about 292 to 188 feet above mean sea level (AMSL). The highest elevations within the Subbasin of approximately 405 feet AMSL occur along the northeast flank of Kettleman Hills. Drainage within the Subbasin is internal flowing toward Tulare Lake.

3.1.1.3 Land Use

Land use in the Subbasin and surrounding areas is predominately agricultural with three primary urban areas of the cities of Hanford, Lemoore, and Corcoran. Land use was evaluated using California Department of Water Resources (DWR) land use maps for 1990 through 2006 and annual United States Department of Agriculture (USDA) CropScape maps from 2006 through 2016 (DWR 2016d; USDA 2016). These maps were provided in Geographic Information System (GIS) formats, allowing for aggregation of similar land uses to simplify analysis. A total of 24 land uses were identified and evaluated (Table 3-2). Land use maps for eight different time periods between 1990 and 2016 are presented in Figures 3-8a to 3-8d.

Between 1990 and 2016, the 535,869-acre Subbasin had an average of approximately 61% of its surface area or 342,400 acres of crops, 7,490 acres of riparian land or land covered by water, 140,540 acres of fallow or undeveloped forest land, 9 acres of industrial parks, and about 22,860 acres of urban areas (Figures 3-8a to 3-8d; Table 3-2) (Wood 2018). The mix of crops grown, and the areas of fallow lands has changed over time as agricultural practices changed in response to agricultural markets and water conditions. During the 2010-2015 drought, fallowed acreage increased while riparian, cotton, and pasture acreage all decreased (Figures 3-8a to 3-8d) (Table 3-2) (Wood 2018). Cotton showed the most change with a decrease of more than 100,000 acres (approximately 46%) between 1996 and 2015. The data also show an overall increase in permanent crops over time, with substantial increases (about 52,260 acres or 250%) in almonds, stone fruit, and pistachios from 1995 to 2016.

3.1.1.4 Soils

Many soil surveys have been conducted across the Subbasin by the USDA Natural Resources Conservation Service (NRCS 2018). The surveyed areas may have been mapped at different times, at different scales, and with varying levels of detail, occasionally resulting in abrupt soil survey area boundaries and incomplete data sets.

Soil texture is interrelated with groundwater flows as it affects water holding capacity and vertical water movement through the soil profile. Soil textural classifications vary across the Subbasin. Clayey soils are dominant in the interior of the Subbasin, corresponding with Tulare Lake (Figure 3-9) (Soil Survey Staff 2018).

Clayey soils dominate in the Tulare Lake area. Loam and sandy loam soils border the clayey soils and are the predominant soils to the east of the lake, including areas of the Tule and Kaweah rivers watersheds; to the west, along the eastern flanks of Kettleman Hills and the Coast Ranges; and to the north and northeast, including along the Kings River watershed.

Salts in soil are commonly sourced from parent rock and can be a result of evapotranspiration concentrating salt within irrigation water. The saturated hydraulic conductivity (K_{sat}) of a soil affects a saturated soil's ability to move water through soil pore spaces under a hydraulic gradient. K_{sat} is very low in the lake of the Subbasin (Figure 3-10), ranging only from 0.0-10.0 micrometers per second (µm/sec) (NRCS 2018). These clay soils tend substantially limit percolation and basin recharge in this area. As the soil textures become coarser (sandier), the conductivity tends to improve. The K_{sat} increases north of the lake, in the Kings River watershed, to 10.0-40.0 µm/sec. Similar conductivities are also present in alluvial fan channels emanating from the Kettleman Hills and Sierra Nevada Mountain ranges.

Some soil profiles in the area contain natural levels of salts.

3.1.1.5 Rivers, Streams, and Tulare Lake

Stream flow in rivers, streams, and surface water conveyances (canals) is a significant source of groundwater recharge throughout the Subbasin by direct infiltration to the subsurface and from deep percolation where surface water is applied for agricultural irrigation. The modern-day surface water conveyances that supply the Subbasin are primarily described as follows (Figure 3-5):

Kings River

The Kings River is the one of the largest sources of surface water supply to the Subbasin, contributing most of the surface runoff in the Subbasin. The Kings River is a 133-mile long river with a watershed of approximately 1,500 square miles above Pine Flat Dam (USBR 2003). It is the largest river draining the southern Sierra Nevada Mountains with headwaters in and around Kings Canyon National Park. The Kings River has three main tributaries, the North Fork, Middle Fork and South Fork. The flow of the North Fork is regulated by several dams, Courtright and Wishon Reservoirs, used to generate hydroelectric power. Pine Flat Dam at a maximum elevation of approximately 952 feet in the foothills of the Sierra Nevada Mountains captures the controlled flow from the North Fork as well as well as the combined unregulated flow from the South and Middle Forks and the controlled flow from the North Fork of the Kings River (USBR 2003). The dam is owned by the United States Army Corps of Engineers (USACE) and has a maximum capacity of about 1,000,000 acre-feet (AF) of water (KRCD and KRWA 2009). The primary purpose of the dam is flood control and secondary purposes include irrigation, hydroelectric power generation, and recreation. The flow in the Kings River below Pine the Flat Dam is controlled by the dam and distributed into various canals and distributary channels by diversion structures described in Section 3.1.1.6.

Kaweah River

The Kaweah River is located in Tulare County and drains the high Sierra Nevada Mountains, with headwaters in Sequoia National Park. Above Lake Kaweah, the main stem of the Kaweah River is about 33 miles long with a drainage area of about 561 square miles (SCE 2016). Prior to stream regulation, the main trunk of the Kaweah River historically flowed southwestward entering the San Joaquin Valley near Lemon Cove. The river separated into several distributary channels forming the alluvial plain known as the Kaweah Delta, upon reaching the edge of the valley. During periods of high flow, these channels historically carried sufficient water to reach Tulare Lake.

In the 1920s, weirs were built at McKay's Point to partition water into the St. Johns and Kaweah rivers (KDWCD 2018). In 1962, the USACE constructed Terminus Dam to provide flood control for the cities and lands below the dam. In 2004, six fuse gates were installed on the dam to raise the lake level by 21 feet and increase the capacity of Kaweah Lake to about 185,000 AF (IWP and DC 2004). In addition to flood control, the dam and reservoir also provide irrigation water for agriculture on the Kaweah Delta (KDWCD 2018). Below the dam, most of the flow is controlled by a network of diversions, canals, and improved distributary channels. During below average rainfall years, minimal, if any, water reaches the Tulare Lake; however, during years with average to above average runoff, water from the Kaweah River system has reached the Tulare Lake and is stored or used for irrigation in ER GSA. The primary purpose of the dam is flood control and secondary purposes include irrigation, hydroelectric power generation, and recreation.

Tule River

The Tule River is located in Tulare County and drains highlands in the southern Sierra Nevada Mountains. The Tule River has three main tributaries, the North Fork, Middle Fork, and South Fork, with a maximum length of about 28 miles at the North Fork and below the confluence of Middle Fork, as well as a drainage area of about 390 square miles above Lake Success (USACE 2017). The Tule River below Porterville splits into two main channels. Eventually, these channels merge again downstream and flow into the Tulare Lake, south of Corcoran. By the early 1900s many diversions were constructed to move water into irrigation ditches that spread across the Tule River fan. Lake Success was constructed primarily for flood control purposes and has a capacity of about 82,000 AF (https://www.spk.usace.army.mil/Locations/Sacramento-District-Parks/Success-Lake). Since the lake's construction, the Tule River flows to the Tulare Lake on average and above average rainfall years, and Tule River water is stored or used for irrigation.

The primary purpose of the dam is flood control and secondary purposes include irrigation, hydroelectric power generation, and recreation.

Kern River

The Kern River is located in Kern County and drains the southern slopes of the Sierra Nevada Mountains. The Kern River was dammed by Isabella Dam in 1953. Occasionally, during times of very high runoff, the Kern River could flow into the Tulare Lake and the water is stored or used for irrigation in Tulare Lake Basin Water Storage District. The primary purpose of the dam is flood control and secondary purposes include irrigation and recreation.

Streams of the Tulare Lake Subbasin

Streams emanating from the southern Sierra Nevada Mountains, south of the Tule River, drain lower elevations and more arid areas of the Sierra Nevada Mountains. These streams, White River, Deer, Mill, Cottonwood, Dry, and Poso Creeks, typically lose their discharge to percolation into the alluvial fans before entering the Tulare Lake. Currently, most of these streams have diversions on them, which channel their flows to delivery systems for irrigation. Cottonwood and Dry Creeks contribute to the Kaweah River system and add supplies to the Subbasin in wet years. Dry Creek's runoff is accounted for in the Kaweah River system. Poso Creek has few diversions for irrigation and remains important in and near Tulare Lake. These streams account for a small percentage of the runoff delivered into the Subbasin.

Streams emanating from the Coast Ranges are typically ephemeral and do not reach any major water course or surface impoundment in the Subbasin.

Tulare Lake

Currently, a system of open canals and pumping systems allow for the efficient distribution of irrigation water throughout the area.

3.1.1.6 Water Supply Delivery System

Extensive water supply delivery systems have been developed over the past 160 years within the Subbasin to move surface water supplies for irrigation, flood control, and land reclamation. Currently, at least 34 conveyance systems (rivers, streams, canals, and diversions) are available to deliver surface water to the Subbasin (Figure 3-5). The only water generated within the Subbasin is from pumped groundwater. Pumped groundwater may be used for direct irrigation on nearby agricultural lands or piped into municipal or agricultural water delivery systems. Much of the land within the Subbasin has associated water rights to the Kings, Kaweah, and Tule rivers as well as some of the minor streams of the Subbasin. These water allocations are supplied by the many irrigation and water districts within the Subbasin.

Water is imported into the Subbasin using facilities of the State Water Project (SWP) located to the west and the Central Valley Project (CVP). The California Aqueduct is operated and maintained by DWR. The California Aqueduct originates in the southwestern corner of the Sacramento-San Joaquin Delta and runs down the west side of the San Joaquin Valley and over the Tehachapi Mountains into southern California. Water from the California Aqueduct can be turned out at Lateral A, which delivers water to the Subbasin at or above the Empire Weir No. 2. This water can be distributed to the Subbasin through the series of canals below the Empire Weir No. 2.

The Friant-Kern Canal is operated and maintained by the Friant Water Authority and is used to convey water from the San Joaquin River to Kern County. The canal originates at Friant Dam, which is operated by the United States Bureau of Reclamation. The Friant-Kern Canal flows southeasterly along the western flank of the Sierra Nevada foothills through Fresno, Tulare, and Kern counties. The Friant-Kern Canal crosses the Kings River about 10 miles west of Pine Flat Dam, where water can be released into the river. This water can be delivered to the Subbasin through a series of canals along the Kings River and its distributaries.

3.1.2 Geologic Setting

The Subbasin is located in the south-central portion of the greater San Joaquin Valley. The major geologic features of this portion of the San Joaquin Valley are the San Andreas Fault, the Garlock Fault, and the three bounding mountain ranges: the Coast Ranges to the west, the Sierra Nevada Mountains to the east, and the Tehachapi and San Emigdio Mountains to the south (Figure 3-12). The San Joaquin Valley elongates to the northwest and stretches approximately 250 miles from the Sacramento-San Joaquin delta on the north to the Tehachapi and San Emigdio Mountains on the south. The valley is filled with marine and continental sedimentary rocks that are more than 30,000 feet in total thickness.

3.1.3 Geologic Structure

The geologic structure of the San Joaquin Valley is complex and has evolved considerably through geologic time. The San Joaquin Valley was formed generally as a structural trough subsiding between two uplifts: the tectonically-driven tilted block of the Sierra Nevada Mountains and the folded and faulted mountains of the Coast Ranges. The axis of the trough is asymmetrical, with the deepest portion of the trough closer to the Coast Ranges. The southern Sierra block forms the eastern limb of the valley syncline or trough (Bartow 1991). It is a southwest-plunging ridge of basement rock, primarily Mesozoic plutonics, upon which has accumulated more than 10,000 feet of Tertiary sediments in the vicinity of the Subbasin.

The west-side fold belt runs along the western portion of the Subbasin and comprises the low-lying portion of the eastern Coast Ranges (Figure 3-12). The fold belt is characterized by Cenozoic sedimentary rocks that have been deformed by thrust faults. The fold belt formed adjacent and subparallel to the San Andreas Fault, a major strike-slip transform fault between the North American and Pacific plates. These sedimentary rocks dip steeply beneath the San Joaquin Valley to the east and are found at depths of more than 3,000 feet below the Valley floor. The Kettleman Hills on the west side of the Subbasin are part of the west-side fold belt.

3.1.4 Basin Development

During late Mesozoic and early Cenozoic time, much of the current San Joaquin Valley was part of a forearc basin that was open to the Pacific Ocean allowing deep marine sediment deposition into the San Joaquin basin (Bartow 1991). As plate boundaries shifted and movement along the San Andreas Fault began in the late Miocene, the San Joaquin Basin west of the fault was beginning to close off creating an extensive inland sea. During the Pliocene, marine sediments of the Etchegoin Formation and the primarily marine San Joaquin Formation were deposited in the shallowing sea bottom of the basin.

During the late-Pliocene and early-Pleistocene, the terrestrial Tulare Formation was deposited as sediments, which were eroded and shed from the rising mountains into the subsiding San Joaquin Valley. As the San Joaquin Valley evolved during the Pleistocene, the tilting of the Sierran block and the push from the thrust belts on the west side aided in the subsidence of the Valley trough. Throughout much of the valley, Tertiary-Quaternary sediments filled the basin with a mixture of sands, silts, and clays, which were deposited on alluvial fans and along the San Joaquin Basin axis by the rivers and streams emanating from the adjoining mountains.

The periodic glacial and wet Pleistocene climate produced times when the sediment loads from the mountains exceeded the subsidence rate in the Valley creating aggrading alluvial fans that cut off the flow of the San Joaquin Valley rivers to the sea (Atwater et al. 1986). Large-scale lacustrine deposits accumulated in the shallow lakes that developed as a result of the internal drainage. Corcoran Lake appears to have covered most of the Valley during the mid-Pleistocene (Bartow 1991) from about present-day Stockton to Bakersfield and roughly from Interstate 5 to State Route (SR) 99 (Figure 3-13). During this time, the lacustrine Corcoran Clay (E-Clay of Croft 1972) accumulated to thicknesses of as much as 300 feet (Figure 3-14a-c). Additionally, thick deposits of lacustrine sediments have accumulated in Tulare Lake. Due to the anomalously rapid tectonic subsidence in the Tulare Lake area and the internal drainage from the Kings, Kaweah, and Tule rivers, as well as early-on the Kern River into the lake, thick lacustrine deposits in addition to the Corcoran Clay have accumulated beneath the Tulare Lake. The total thickness of the Tulare Lake clays, including the Corcoran Clay, is more than 3,000 feet as labeled as QTf on Figure 3-14a-c.

3.1.5 Stratigraphy

Table 3-3 is a generalized stratigraphic column for the Subbasin. It represents a synthesis of stratigraphic descriptions from published reports for the area (Davis et al. 1959; Hilton et al. 1963; Croft and Gordon 1968; Loomis 1990; and Wood 2018). Stratigraphic units and their importance to groundwater occurrence and movement are described below.

3.1.5.1 Basement Complex

The basement complex beneath the Subbasin comprises primarily Sierran plutonic and metamorphic rocks, while the western margin of the basin is underlain primarily by Coast Ranges ophiolite (Scheirer 2007). The depth to the basement complex ranges from about 6,000 feet on the eastern margin of the Valley to about 30,000 feet below ground surface (bgs) on the western margin (Scheirer 2007). The depth to basement complex is such that the basement rocks do not affect the usable groundwater beneath the Subbasin.

3.1.5.2 Miocene and Pre-Miocene Sedimentary Deposits

The Miocene and pre-Miocene sedimentary deposits are found deep below the Subbasin and have been encountered in deep exploration borings drilled for oil and gas deposits. The water contained in these deposits is saline or the depth to these deposits are such that that they do not affect the usable groundwater beneath the Subbasin with the exception of the Santa Margarita Formation to the east.

The Santa Margarita Formation is a gray sandstone of upper Miocene age that is present at a depth of about 1,100 feet bgs beneath Terra Bella (Hilton et al. 1963). The formation dips steeply to the west and is about 4,300 feet deep near SR 99 at Earlimart. The Santa Margarita Formation has been tapped as an aquifer in the area from Terra Bella to Richgrove, about 25 miles east of the eastern Subbasin boundary. The Santa Margarita Formation is separated from the usable groundwater in the Plio-Pleistocene Tulare Formation by about 2,000 to 3,000 feet of mostly fine-grained marine deposits of the Pliocene San Joaquin and Etchegoin Formations. Groundwater in the Santa Margarita Formation increases in salinity content to the west and the approximate position of the saline to freshwater interface is about 20 miles east of the Subbasin. Thus, the Santa Margarita is likely too deep and too saline to yield usable groundwater beneath the Subbasin for usage.

3.1.5.3 Upper Miocene to Pliocene Etchegoin

The Etchegoin Formation is a shallow water marine formation of upper Miocene and early Pliocene age that crops out in the Kettleman Hills west of the Subbasin. The Etchegoin Formation comprises silty and clayey sands, sandy silt, silty clay, blue sandstone, and conglomeratic sandstone (Woodring et al. 1940). The Etchegoin dips steeply to the east from the Kettleman Hills. Deep exploratory borings for oil and gas have encountered the Etchegoin beneath the Subbasin at depths of 3,500 to 4,000 feet bgs. Geophysical logs indicate that water in the Etchegoin Formation is saline and its groundwater is unusable beneath the Subbasin.

3.1.5.4 Pliocene San Joaquin Formation

The San Joaquin Formation is a shallow marine formation of mid-to-upper Pliocene age that also contains some near-shore continental deposits. It comprises a basal conglomerate member and overlying thin beds of poorly-sorted, fine-grained sandstone amongst thick beds of siltstone and claystone (Loomis 1990; Woodring et al. 1940). The formation crops out in the Kettleman Hills and dips steeply to the east beneath the Subbasin.

In the Kettleman Hills area, the top of the San Joaquin Formation is conformable with the overlying Tulare Formation and is marked by the uppermost Mya zone, which is described as a transition from marine deposits (Mya fossils) to continental deposits (Tulare Formation) of lake, swamp, and stream origin (Woodring et al. 1940). In the Kettleman Hills area, monitoring wells indicate the sandstones within the San Joaquin Formation contain saline water and do not yield sufficient water to be classified as an aquifer (Wood 2018). The formation is in contact with the base of the Tulare Formation beneath the Subbasin, with the contact typically about 3,000 feet bgs (Page 1983). The San Joaquin Formation is considered too deep and too saline to yield usable groundwater beneath the Subbasin.

3.1.5.5 Pliocene-Pleistocene Tulare Formation – Continental Deposits

The Tulare Formation is generally regarded as the most important water-bearing formation in the southern San Joaquin Valley. The Tulare Formation is a continental deposit that overlies the San Joaquin Formation and has been assigned to the upper Pliocene and Pleistocene epochs. It has been described mostly by investigators on the west side of the valley, where it crops out in the west-side fold belt anticlines. The type section is generally taken to be the Kettleman Hills, where 1,700 to 3,500 feet of the Tulare Formation have been described on the east and west flanks of North Dome, respectively (Woodring et al. 1940). Other investigators, particularly on the east side of the valley, have described continental deposits, primarily of Sierran origin, that are time-correlative with the Tulare Formation such as the Kern River, Laguna, Turlock Lake, Riverbank, and Modesto formations (Lettis and Unruh 1991).

The Tulare Formation is defined as the uppermost continental deposits deformed by the west-side fold belts (Woodring et al. 1940). This was relatively clear in the Kettleman Hills area; however, in other west-side folds (e.g., Lost Hills), the quaternary alluvium has also been deformed as uplift continues into the Holocene. In the Tulare Lake area, the east side Plio-Pleistocene deposits that overlie the San Joaquin Formation with the Tulare Formation are mapped (Page 1983). In the subsurface, because of textural and depositional similarities, it is difficult to separate recent alluvial deposits from sediments of the Tulare Formation (Davis et al. 1959). Based on existing research in the Tulare Lake area, the Tulare Formation in this report is considered an ongoing sequence of Plio-Pleistocene continental deposits above the San Joaquin Formation that continue to be deposited today in the Holocene period. These deposits can be subdivided into Sierra and Coast Range origins. Each source area contributes different grain sizes and mineralogy that will affect potential well yields and groundwater quality. They also can be subdivided by lacustrine units, older alluvium, and younger alluvium. The different units has a bearing on groundwater occurrence and movement.

The Tulare Formation comprises unconsolidated clay, silt, sand, and gravel, as well as poorly consolidated sandstones and conglomerates. These sediments have been deposited by streams and rivers emanating primarily from the Sierra Nevada and Coast Ranges. The Coast Ranges are composed of gypsiferous marine shales, sandstones and volcanic rocks, sediments sourced from the Coast Ranges, which are generally gypsiferous, typically finer-grained, and contain more angular lithic fragments than Sierran sediments (Page 1983). The granitic source rocks of the Sierra yield sediments with abundant quartz, feldspars, and micas, and are typically coarser-grained and more rounded than the Coast Ranges sediments. Thus, areas of the Subbasin comprised of Sierran sediments tend to have greater water storage capacity due to higher levels of porosity than areas comprised of sediments from the Coast Ranges.

Sedimentary facies of the Tulare formation range from mid-to-distal alluvial fan deposits, marsh deposits, lacustrine deposits, overbank and flood deposits, and fluvial deltaic deposits entering Tulare Lake, and terrestrial shoreline deposits. In terms of depositional environments for the Tulare Formation, the Subbasin is dominated by the lacustrine environment of Tulare Lake in the southern portion of the Subbasin (Figures 3-14a-c). In the northern portion, the depositional environment is dominated by mid-to-distal alluvial fan deposits of the Kings River. The northwestern corner of the Subbasin contains a strip of basin deposits along the South Kings River, west of Lemoore and Stratford. To the east of the Subbasin, the depositional environment comprises mid-to-distal alluvial fan deposits of the Kaweah and Tule rivers.

3.1.6 Lateral Basin Boundaries and Geologic Features Affecting Groundwater Flow

Groundwater flow in the Subbasin has historically been influenced by five significant bounding conditions, including: Kettleman Hills on the southwest, Kings River alluvial fan on the northeast, Arroyo Pasajero fan on the northwest, Tulare Lake clay beds in the central portion of the Subbasin, and the Kaweah and Tule River alluvial fans on the east (Figure 3-15).

3.1.6.1 Kettleman Hills Anticline

The Kettleman Hills anticlinal structure is located on the southwest edge of the Subbasin (Figure 3-15). The Kettleman Hills anticline exposes the late Miocene-Pliocene Etchegoin Formation along its axis, with the younger San Joaquin and Tulare Formations exposed along its flanks. To the west, these formations dip steeply beneath the Kettleman Plain, where the Tulare Formation reaches an estimated thickness of 4,000 feet (Stewart 1946). Groundwater recharge to the Subbasin from direct infiltration on the Kettleman Hills is almost non-existent due to low precipitation, low relief of the Hills, and minimal eastern exposure of the Tulare Formation. The lack of groundwater recharge is evident due to the lack of development of significant alluvial fans on the east side of the Hills. Inter-basin movement of groundwater from the Kettleman Plain to the Subbasin is blocked by the synclinal structure of the Kettleman Plain and the anticlinal structure of the Kettleman Hills, which places thousands of feet of steeply dipping marine claystones and siltstones between the Tulare Formation beneath the Kettleman Plain and the Tulare Formation beneath the San Joaquin Valley. Additionally, the Tulare Formation has been eroded off the tops of each of the Kettleman domes and the San Joaquin Formation exposed in the gaps between the domes, essentially leaving no connection between the Tulare Formation on either side of the Kettleman Hills. Hence there is little or no groundwater flow between the Kettleman Hills and the Subbasin.

3.1.6.2 Kings River Fan

The Kings River alluvial fan extends northward from the Tulare Lake to beyond the northeastern boundary of the Subbasin (Figure 3-15). The fan deposits comprise a series of sand beds and intervening silty to clayey layers with paleosol interludes. Coarser deposits are present higher on the fan north and east of the Subbasin and finer deposits are more prevalent toward the distal end of the fan, within the Subbasin near the center of the valley. Where the historical Kings River entered Tulare Lake, the depositional environment changed from fluvial and alluvial to deltaic, with the sandier beds interfingering with finer lacustrine deposits within the lake. The Kings River, which forms the northern boundary of the Subbasin, appears to provide persistent recharge to the fan deposits along its course. Because of the size of the Kings River drainage area and the magnitude of its flows, the Kings River fan typically contains thicker and coarser sediments than the fans of the lesser Kaweah and Tule Rivers. The fan below the Subbasin is divided into upper and lower aquifers by the Corcoran Clay, which stretches east to west across the fan beneath the Subbasin, extending up fan to about SR 99 (Figures 3-14a-b). The Corcoran Clay layer often has very limited transmissivity and can confine lower aquifers beneath this layer while also preventing or limiting percolation of water from upper aquifers into lower aquifers. The Kings River alluvial fan is a significant source of groundwater inflow and outflow to/from the northern portion of the Subbasin.

3.1.6.3 Los Gatos Creek and Arroyo Pasajero Fan

Los Gatos Creek emanates from the Diablo Range, which is a part of the Coast Ranges, west of Coalinga and grades eastward toward the valley floor. Although the Los Gatos Creek fan is not within the Subbasin, it borders the Subbasin to the northwest (Figure 3-15). The creek is ephemeral and creek flows only reach the valley floor and areas near the Subbasin during periods of extremely high precipitation. As such, there is little or no groundwater flow between the Los Gatos Creek and the Subbasin.

The Los Gatos Creek fan has prograded eastward during the wetter climates of the Pleistocene. Coast Range sediments extend perhaps 15 to 18 miles into the Valley and to a depth of several hundred feet above the Corcoran Clay (Croft 1972; Miller et al. 1971). Another lobe of the Coast Range sediments lies beneath the Corcoran Clay and also extends approximately 15 to 18 miles into the Valley. These sediments comprise sands, silts, and clays of relatively fine-grained textures (Meade 1967). Additionally, sands from the Diablo Range consist of darker minerals and contain more lithic fragments. Grains are subounded to subangular andesite, serpentinite, and chert with some weathered mica flakes. Below the Coast Range sediments are described as floodplain and deltaic/lacustrine deposits of Sierran origin (Miller et al. 1971). The Sierran deposits are described as lighter in color and micaceous, primarily biotite with more than 25% feldspars (Meade 1967). These Sierran deposits extend down to the top of the San Joaquin Formation marking the base of the Tulare Formation.

Groundwater in the Coast Range sediments show a distinct sulfate type of water derived from the marine formations from which the sediments originated (Davis and Coplen 1989). This contrasts with the bicarbonate-type water typical of the Sierran sediments. The total dissolved solids (TDS) of the Coast Range sediments are also typically higher than the Sierran sediments. Wells on the Los Gatos Creek fan typically tap the Sierran deposits below the Corcoran Clay.

3.1.6.4 Tulare Lake Lacustrine Deposits (Clay Plug)

The lacustrine deposits of the ancestral and former Tulare Lake are potentially the most significant controlling factor for groundwater movement in the central portion of the Subbasin. The center of the Tulare Lake depositional system is elongate from northwest to southeast with continuous lacustrine deposits extending like down through the interior portions of the lake to the top of the San Joaquin Formation, which beneath the Subbasin is 2,600 to 3,000 feet bgs (Figures 3-14a-c). The area with continuous lacustrine sediments from the surface to the underlying San Joaquin Formation is roughly 23 miles long by 12 miles wide (Figure 3-15). The horizontal and vertical extent of these continuous fine-grained lacustrine deposits is called the "clay plug." The lacustrine deposits are primarily silts and clays with occasional interbedded fine sands. The deposits are under reduced conditions in nearly all locations where coring has occurred, which indicates little, if any, subaerial contact or oxygenated water since the sediments were emplaced (Miller et al. 1971). Although some of the clays and sand stringers are saturated, they do not produce enough water to have been developed for groundwater extraction. Near the northern, southern, and eastern peripheries of the lacustrine plug, coarser deposits interfinger with the fine-grained sediments. Coarser and more transgressive sediments are present on the eastern, Sierran periphery compared to the western, Coast Range periphery. Where present, the clay plug acts as a barrier to groundwater flow beneath the Subbasin.

3.1.6.5 Kaweah and Tule River Fans

The Kaweah and Tule River fan sediments to the east of the Subbasin have similar deposition to the sediments beneath the Kings River fan; however, they are not as laterally extensive and appear to be thinner and more interbedded than the Kings River deposits (Figure 3-15). Near the toe of the Kaweah and Tule River fans, deposits become more deltaic and interbed with the lacustrine deposits of the Tulare Lake. Similarly, to the Kings River fan deposits, the Kaweah and Tule River fans below the Subbasin are divided into upper and lower aquifers by the Corcoran Clay, which stretches east to west across the fan beneath the Subbasin, extending up fan to the area of SR 99 (Figure 3-14b). The Kaweah and Tule River fan deposits comprise well graded course Sierran sediments with ample water storage capacity and have been extensively developed for groundwater extraction east of Tulare Lake and the Subbasin. The Kaweah and Tule River fans are a significant source of groundwater inflow and outflow to/from the eastern portion of the Subbasin.

3.1.7 Definable Bottom of the Basin

The DWR published Best Management Practices (BMPs) for HCMs for the sustainable management of groundwater (DWR 2016c). Identifying a definable bottom of the Subbasin is one key step in addressing the issue of total basin water storage, as well as the depth to which water can feasibly be extracted. In their section on “Definable Bottom of the Basin,” DWR noted “several different techniques or types of existing information can be used in the evaluation of the definable bottom of the basin and extent of fresh water.” One method would be to define the base of the water-bearing formations below which no significant groundwater movement occurs, such as the depth to bedrock or some other low permeability formation. A second method would be to evaluate the chemistry of the groundwater beneath the basin vertically and then map the elevation at which the groundwater exceeded a pre-determined criterion for fresh water.

The criteria for fresh water, however, is inconsistent in that it has been defined as a TDS content at approximately 2,000 milligrams per liter (mg/L), 3,000 mg/L, and 10,000 mg/L by various sources (Page 1973; RWQCB 2015; and 49 Code of Federal Regulations 146.4) Additionally, in their BMPs (DWR 2016c), DWR noted they will be constructing a freshwater map for the Central Valley that assumes the base of fresh water is defined by California’s secondary maximum contaminant level recommendation of 1,000 mg/L. Because of these inconsistencies, the definable bottom of the basin will be discussed below using two different methods.

3.1.7.1 Geologic Method

A case can be made, on a geologic basis, to define the bottom of the Subbasin at the base of the Tulare Formation, above the underlying San Joaquin Formation. The Tulare Formation is a continental deposit that includes sediments deposited in the San Joaquin Basin from the Pliocene to the present. The Tulare Formation is the primary groundwater aquifer for the southern San Joaquin Valley, including the Subbasin. The Tulare Formation overlies the San Joaquin Formation, a predominantly marine formation comprising significant thicknesses of claystone and siltstone along with minor beds of fine-grained sandstone, which contain brackish water (Wood 2018). Sandstone beds are of low permeability and do not yield sufficient water to be considered an aquifer or a suitable source for agricultural or municipal uses. Even if some sandstone beds contained water that might meet water quality criteria, they are of low permeability and do not yield sufficient water to be considered an aquifer (Wood 2018). Thus, the contact between the Tulare Formation and the underlying San Joaquin Formation would fit the definition for a geologic barrier to groundwater flow under DWR criteria.

The contact between the Tulare Formation and the San Joaquin Formation was previously mapped as the top of the upper Mya zone near the central and southern portions of the Subbasin (Figure 3-16) (Page 1981; Page 1983). Sources included identifications of the upper Mya zone in well logs from 292 oil and gas exploratory borings as well as structure contour maps and geologic sections done for oil and gas fields in the area. These data show that the approximately water bearing depth of the Tulare Formation ranges from about 4,000 feet bgs near the axis of the San Joaquin syncline, which lies to the east of the Kettleman Hills to approximately 2,500 feet bgs near the southeastern corner of Kings County. The study's map did not extend into the northern portion of the Subbasin, so the contact between the Tulare and San Joaquin Formations has been estimated from oil and gas exploration wells in the area (Wood 2018). The depth to the base of the Tulare Formation in the northern portion of the Subbasin ranges from 2,700 to 2,200 feet bgs, rising to the north (Figure 3-16). Near the City of Corcoran, the depth of the Tulare Formation is greater at approximately 3,400 feet bgs.

Studies have shown that portions of the Tulare Formation do not yield groundwater that meets water quality criteria for beneficial uses, particularly in and surrounding the Tulare Lake. These criteria are examined in detail in the following section.

3.1.7.2 Water Quality Method

Several potential criteria exist for determining the extent of fresh water in a groundwater basin; however, the criteria adopted by the California Regional Water Quality Control Board (RWQCB), Central Valley Region, appears to be the most appropriate for the Subbasin. The RWQCB is the state agency that has been charged with adopting and enforcing water quality control plans, or basin plans, to protect state waters. The Subbasin is within the boundaries of the Tulare Lake Hydrologic Region (Figure 3-1) as defined by the RWQCB and therefore subject to the Tulare Lake Basin Plan (Basin Plan).

The Basin Plan describes designated beneficial uses of groundwater to be protected, water quality objectives to protect those uses, and a program for implementation to achieve the objectives (RWQCB 2015). Beneficial uses of groundwater in the Tulare Lake Hydrologic Region include municipal, agricultural, and industrial. The Basin Plan incorporates the Sources of Drinking Water Policy Resolution No. 88-63, adopted by the State Water Resources Control Board (SWRCB), which states all surface and ground waters of the State are considered to be suitable, or potentially suitable for municipal or domestic water supplies (MUN) with the exception of water that has a TDS exceeding 3,000 mg/L and is additionally not reasonably expected by the RWQCB to supply a public water system (SWRCB 2006). Regarding agricultural uses (AGR), the Basin Plan is not explicit to the numerical criteria for determining beneficial use; however, the Basin Plan contains a narrative regarding an exception to the AGR designation if pollution by natural processes or human activity is documented that cannot be reasonably treated by BMPs or economically achievable treatment practices to achieve water quality suitable for agricultural uses.

In 2014, the Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS), a stakeholder group that was created to develop a comprehensive Salt and Nitrate Management Plan for the Central Valley, identified a need to define the salinity-related requirements for the protection of both the MUN and AGR beneficial uses. This evolved into the development of a technical information and environmental and economic analysis in support of a MUN and AGR beneficial use evaluation project for a portion of the historical Tulare Lake (RWQCB 2017). A beneficial use evaluation report was submitted on behalf of CV-SALTS proposing portions of the groundwater body beneath the historical Tulare Lake be de-designated for MUN and AGR beneficial uses (KDSA et al. 2015). The evaluation report affirmed the criteria for exemption from MUN to be a TDS of 3,000 mg/L. CV-SALTS has also provided a literature review, which affirmed guidelines that stated only the most salt-tolerant crops may be sustainably irrigated with water exceeding 3,000 microsiemens per centimeter (µS/cm) or less (a TDS of about 2,000 mg/L) (CV-SALTS 2013; Ayers and Westcot 1985). As part of the literature review, CV-SALTS also identified acceptable salt levels for livestock watering to be water with an electrical conductivity (EC) of 5,000 µS/cm or less (a TDS of about 3,000 mg/L).

The RWQCB adopted the preferred alternative for MUN beneficial use de-designation to be the application of the Sources of Drinking Water Policy exception 1a, where water quality exceeds an EC of 5,000 µS/cm (RWQCB 2017). The report further proposed the preferred alternative for AGR beneficial use de-designation be based on a 5,000 µS/cm EC threshold value (3,000 mg/L) taken from the Canadian Council of Ministers for the Environment for all classes of livestock (CCME 2007). These criteria were accepted by the RWQCB (Resolution R5-2017-0032) on April 6, 2017, and adopted by the SWRCB (Resolution No. 2017-0048) on September 6, 2017.

Based on the body of work by CV-SALTS and the regulatory acceptance of the criteria for de-designation of MUN and AGR of an EC of 5,000 µS/cm (approximately 3,000 mg/L TDS), the criteria for determining the extent of fresh groundwater in the Subbasin was set at 3,000 mg/L TDS. Within the Subbasin, water quality of 3,000 mg/L TDS, typically found at depths greater than 3,000 feet bgs, could define the bottom of the Subbasin using this methodology for this GSP.

3.1.8 Hydrogeologic Setting: Principal Groundwater Aquifers and Aquitards

The current hydrogeology of the Subbasin is complex in that the only physical boundaries are the Kettleman Hills on the southwestern edge and the Kings River on the northeastern edge of the Subbasin. The remaining edges of the Subbasin are based on political boundaries and water management areas, and the actual physical water-bearing formations of the Subbasin extend into these adjacent areas. Groundwater beneath the Subbasin occurs primarily in the coarser-grained Sierran sediment deposits of the alluvial fans of the Kings, Kaweah, and Tule rivers, as well as the fans of the lesser streams that drain from the Sierra Nevada Mountains into the southeastern portion of the Subbasin. A study conducted in the 1960s subdivided the coarser-grained deposits into three units, older and younger alluvium and undifferentiated continental deposits (Croft and Gordon 1968). These deposits are primarily Sierran in origin and were deposited during the Quaternary period by the major stream channels emanating from the Sierra Nevada Mountains. On the west side of the Subbasin, some sediments may have Coast Ranges origin, but the axis of Tulare Lake is close to the Kettleman Hills and its finer-grained sediments, which leaves little room for potentially coarser-grained Coast Ranges sediment deposition on the west side. The Corcoran Clay underlies most of the Subbasin, which essentially subdivides the Subbasin into two aquifer systems, an unconfined to semi-confined aquifer system above the Corcoran Clay and a confined aquifer system below the Corcoran Clay.

The younger alluvium is generally thinner than the older alluvium and is present in current stream channels and as a veneer over the older alluvium as the deposits stretch to the west. The younger alluvium is primarily arkosic and is considered of Holocene age. It occurs entirely above the Corcoran Clay and is unconfined. In places, it may contain groundwater perched above any one of a number of relatively continuous clay layers.

The older alluvium is widespread throughout the San Joaquin Valley and represents deposition from both the Coast Ranges on the west side of the Valley and the Sierra Nevada Mountains on the east. The older alluvium is generally identified by its stratigraphic position on terraces of the major rivers, though as mentioned earlier, there is no current method to differentiate it in the subsurface from the Tulare Formation. The older alluvium is considered Pleistocene to Holocene in age and it is typically bifurcated by the Corcoran Clay such that groundwater contained in the older alluvium may be either confined or unconfined.

Beneath the older alluvium are the undifferentiated continental deposits, which beneath the Subbasin are Sierran in origin. The deposits are beneath the Corcoran Clay, and as such, groundwater contained in the undifferentiated Tulare Formation is all confined.

Lacustrine deposits have been identified in the Subbasin principally beneath the Tulare Lake. Geologic cross sections illustrate the thick and continuous nature of these clay deposits beneath the lake (Croft 1972; Croft and Gordon 1968; Davis et al. 1959). Additionally, six individual lacustrine clays were identified in the subsurface and had sufficient lateral extent to be considered important in affecting groundwater movement (Croft 1972). These clays were identified in geophysical logs and named the A- through F-Clays, with the E-Clay being equivalent to the Corcoran Clay. Though the A- through D-Clays may be important locally in restricting downward movement of groundwater, Corcoran Clay or E-clay is the most significant (KDSA et al. 2015). The Corcoran Clay has been identified beneath Tulare Lake and extends beyond the

Subbasin in all directions except for a small area in the northeast corner of the Subbasin (Croft 1972).

Marsh and flood basin deposits are found typically near the modern axis of the San Joaquin Valley, along the distal reaches of the streams in the southern Valley. These deposits comprise silts and clays that can be relatively thick in some locations creating local areas of perched groundwater.

For purposes of monitoring, as described in Chapter 5, the aquifers are divided into three aquifer zones:

- The A zone is the shallow portion of the aquifer above the A-Clay and in areas where shallow groundwater is present outside of the A-Clay,
- The B zone is the unconfined portion of the aquifer above the E-Clay or Corcoran Clay and below the A-Clay where the A-Clay is present, and
- The C zone is the confined portion of the aquifer below the E-Clay.

The main aquifers and aquitards are described in greater detail in the following sections.

3.1.8.1 Unconfined Aquifer

The unconfined and semi-confined upper portions of the regional freshwater aquifer are found above the Corcoran Clay. This upper portion of the regional freshwater aquifer is generally comprised of coarse- to medium-grained sediments (i.e., sand and gravel) with silt and clay interbeds. The depth to first groundwater beneath a large portion of the Subbasin is less than 15 feet bgs in a zone situated above the A-Clay (Figure 3-17).

Groundwater within the rest of the Subbasin and surrounding areas are typically found between depths of 30 and 250 feet bgs, depending on location and the season or year when the water levels are measured. The shallow groundwater areas typically have poor water quality, and the shallow soils require drainage to grow crops (KDSA et al. 2015) (Figure 3-17). In areas where groundwater is below 15 feet, the shallow unconfined aquifer is subject to large swings in water levels due to groundwater recharge, which occurs primarily along stream channels, unlined surface water conveyances, and artificial recharge basins. In thicker sections of the unconfined aquifer, pumping for agricultural uses may create significant drawdown of the water table during the irrigation season and under prolonged drought conditions. Nearer the Tulare Lake, where the upper aquifer is substantially interbedded with lacustrine deposits, the groundwater producing zones are thinner and become increasingly finer-grained limiting groundwater withdrawals to primarily relatively low demand domestic uses.

3.1.8.2 Confined Aquifer

The sediments below the Corcoran Clay comprise the lower confined portion of the regional freshwater aquifer. This lower portion of the regional freshwater aquifer is generally comprised of clay, silt, sand, and gravel (Page 1983).

Few maps are available showing groundwater elevations in the confined aquifer beneath the Subbasin and surrounding areas (Harder and Van de Water 2017). In fall 1998 and 1999, groundwater was at an elevation of about 100 feet below mean sea level (MSL) at a depth of about 300 feet bgs near Corcoran, decreasing in elevation to the south towards an apparent pumping center near Alpaugh. The coarser and thicker sections of sediments below the Corcoran Clay lend themselves to development of higher capacity wells that withdraw groundwater for municipal and agricultural uses. However, the limited extent of highly productive fresh groundwater aquifers within the boundary of the Subbasin, generally along the coarse-grained sediments within the alluvial fans (e.g., Kings River fan), concentrates these wells in the eastern portion of the Subbasin and in adjoining subbasins to the east, beyond the finer-grained deltaic and lacustrine deposits grading into the Tulare Lake. Because of the effectiveness of the Corcoran Clay as an aquitard, recharge to the confined aquifer likely occurs primarily in the upper portions of the alluvial fans beyond the Corcoran Clay's eastern extent.

The sediments within the southern portion of the Tulare Lake consist of a thick, continuous sequence of clays, forming a clay plug. There are no significant production wells within the clay plug due to the fine-grained nature of the sediments; however, there may be a few stock watering wells in this area.

3.1.8.3 Aquitards

Fine-grained lacustrine, marsh and flood deposits underlie the Valley trough and floor and were deposited in lacustrine or marsh environments (Croft 1972). These fine-grained units are critically important in the hydrology of the basin in that they restrict the downward movement of water and act as aquitards. These nearly impermeable gypsiferous fine sand, silt and organic clay deposits are more than 3,000 feet thick beneath parts of Tulare Lake and spread out laterally and interfinger with the coarser sediments found along the basin margins (Croft 1972; Page 1983). The clayey or silty clay units interbedded within the Tulare Formation are designated by letters A through F (Croft 1972). The A-, C- and E-Clay units are the primary fine-grained units underlying significant portions of the Subbasin and can isolate different waters and bounds the freshwater aquifers. However, beneath Tulare Lake, these individual clay units are not distinguishable from the other clay deposits that form the massive clay plug beneath the center of the lake (KDSA et al. 2015).

A-Clay

The A-Clay is a dark greenish gray or blue, organic clay found approximately 60 feet bgs in the Tulare Lake area (KDSA et al. 2015). A-Clay is approximately 10 to 60 feet in thickness and in some places a sand lens separates the A-Clay into an upper and lower unit (Croft 1972). However, due to similarities in the sedimentary deposits beneath Tulare Lake, A-Clay was not able to be positively identified in all areas (Page 1983). Outside of Tulare Lake area and near rivers and streams, groundwater above the A-Clay can be an important source of shallow groundwater for domestic and limited AGR uses. In Tulare Lake area, groundwater above the A-Clay is typically too saline for MUN or AGR usage and has been exempted from MUN and AGR beneficial use (RWQCB 2017). The delineated lateral extent of the A-Clay is shown in Figure 3-17 delineated by Croft (1972) and Page (1983) is shown on Figure 3-14a-c and Figure 3-17 (Croft 1972; Page 1983).

C-Clay

The C-Clay consists of yellowish-brown to bluish-gray silty-clay and is found approximately 230 feet bgs in the Tulare Lake area (KDSA et al. 2015). The C-Clay is about 10 feet thick and is structurally warped and folded (Croft 1972). C-Clay could not be positively identified beneath Tulare Lake in previous studies (Page 1983). Outside of the Tulare Lake area, most of the groundwater production from public supply wells is from wells that tap water below the C-Clay (KDSA et al. 2015). In the Tulare Lake area, groundwater above the C-Clay is typically too saline for MUN or AGR usage (RWQCB 2017) and has been exempted from MUN and AGR beneficial use. The delineated lateral extent of the C-Clay is shown on Figure 3-18 and in cross sections A to A’, B to B’, and C to C’ (Figures 3-14 a-c) (Croft 1972; Page 1983).

Corcoran Clay (E-Clay)

The Corcoran Clay is the most extensive aquitard in the San Joaquin Valley. The Corcoran Clay is composed of dark-greenish gray, mainly diatomaceous, silt, clay, silty clay, clayey silt and sand that was deposited in a lake that occupied the San Joaquin Valley (Croft 1972). The lateral extent and depth of the Corcoran Clay is shown on Figure 3-19a and its thickness on Figure 3-19b. The Corcoran Clay is warped into a major, asymmetric, northwest trending syncline that has been additionally deformed with smaller, subordinate folds.

Recently, a detailed evaluation of the presence of the Corcoran Clay beneath Tulare Lake area was undertaken in support of a de-designation of beneficial uses for groundwater beneath this lake area (KDSA et al. 2015). This study identified the Corcoran Clay as being present at depths of about 400 to more than 800 feet bgs throughout the Subbasin. Within the clay plug itself, due to the continuous fine-grained lacustrine nature of the sediments, similar to that of the Corcoran

Clay, the Corcoran Clay cannot be delineated. The low permeability of the Corcoran Clay makes it an effective aquitard. It has sharp vertical boundaries and shows up well on borehole geophysical electric logs. The Corcoran Clay appears to extend out to the east of the Subbasin near SR 99. On the west, it rises sharply with the Tulare and underlying San Joaquin Formations. E-clay is more difficult to recognize as it approaches the west-side fold belts. Geophysical well logs indicate that the Corcoran Clay, although the largest single confining bed in the Subbasin, constitutes only a small percentage of the total cumulative thickness of clay layers in the unconsolidated sediments beneath the Tulare Lake clay plug.

3.1.9 Hydraulic Parameters

Two significant hydraulic parameters for groundwater resources are hydraulic conductivity and storage coefficient. The hydraulic conductivity is directly proportional to the rate at which groundwater will move under a unit hydraulic gradient. The storage coefficient is the amount of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit head change. When referring to an unconfined aquifer, the storage coefficient is called the specific yield and is related to the amount of water drained from the pore spaces in the aquifer and given as a percent of the total volume of the aquifer material. For a confined aquifer, the amount of water released is derived from limited compressibility of the water and primarily by the compression of the aquifer. No drainage of the water pores is involved.

A method referred to as "*yield factor*" was utilized to approximate relative permeability, also known as hydraulic conductivity (Croft and Gordon 1968). The yield factor is equal to 100 times the specific capacity of a pumping well divided by the thickness of saturated material penetrated by the well (Croft and Gordon 1968). Specific capacity is calculated by dividing the discharge from the well by the amount of drawdown created by pumping. The study used pump-efficiency tests supplied by Pacific Gas and Electric Company and Southern California Edison Company to calculate the specific capacities of numerous wells in the Tulare Lake area. These data were compiled and indicated increasing yield factor or permeability moving away from Tulare Lake, largely related to the increasing coarseness of sediments further removed from the lacustrine fine-grained sediments within the lake (Figure 3-20).

Specific yields have been estimated for various areas of the San Joaquin Valley based on average grain size in the unconfined aquifers (Davis et al. 1964). On the Kings River alluvial fan, the specific yield was estimated to be 14.1%. On the Kaweah and Tule River fans, specific yield was estimated to be 9.5%. The storage coefficient for the confined aquifer has not been estimated specifically for the area within the Subbasin; however, a method is provided for estimating storage coefficient by multiplying the thickness of the confined aquifer in feet by a factor of 1×10^{-4} (Lohman 1972).

In support of the Central Valley Hydrologic Model (CVHM), scientists from the United States Geological Survey (USGS) developed a geologic texture model to describe the coarseness or fineness of basin-fill materials that make up the hydrogeologic system and used this model to estimate hydraulic properties including hydraulic conductivity and storage properties for every cell in the CVHM model grid (Faunt, ed. 2009) (Figure 3-21). Hydraulic conductivities derived from these texture models would range from approximately 1 foot per day (ft/d) to about 70 ft/d. Specific yields estimated for the CVHM ranged from 9% to 40% and varied based on the percentage of coarse-grained deposits with higher specific yields from coarser-grained deposits. The specific storage (storage coefficients divided by the thickness of the unit) ranged from 1.4×10^{-4} per foot (ft) for inelastic aquifers, 1.0×10^{-6} per ft for coarse-grained elastic aquifers, and 4.5×10^{-6} per ft for fine-grained elastic aquifers. The compressibility of water is estimated to be 1.4×10^{-6} per ft and must be added to the specific storage of the matrix to determine the confined specific storage.

3.1.10 Groundwater Recharge and Discharge

Groundwater recharge in the Subbasin occurs primarily by two methods: (1) infiltration of surface water from the Kings River and unlined conveyances, and (2) infiltration of applied water for irrigation of crops. Recharge from infiltration of direct precipitation is minor owing to the low annual rainfall and the predominance of fine-grained surface soils. Some recharge enters the Subbasin by subsurface flow from adjoining subbasins; however, this is a minor component as most pumping for irrigation lie to the north and east of the Subbasin due to the more favorable hydraulic properties of the sediments outside of the Subbasin. Intentional recharge also occurs within the Subbasin by percolating surface water through storage ponds and old river channels, though the magnitude of this component is small compared to the groundwater demand in the Subbasin. Most surface water entering the Subbasin is consumptively used or retained due to the internal drainage within the Subbasin.

Groundwater discharge in the Subbasin is predominantly by groundwater extraction along the eastern and northern portions of the Subbasin where water quality and well yields are higher than near Tulare Lake. Some discharge is impacted by direct soil evaporation and evapotranspiration, particularly in areas where groundwater is less than 10 feet bgs. Additionally, some discharge occurs by tile drains in agricultural areas that have high groundwater levels to lower the groundwater table to below the root zone to sustain agriculture. Groundwater discharge also occurs by subsurface movement of groundwater from the Subbasin toward adjoining subbasins. Potential groundwater recharge based on soil classification and potential groundwater extraction based on subsurface sediment texture varies (Figure 3-22).

3.1.11 Primary Uses of Each Aquifer

The upper unconfined and semiconfined aquifer and the lower confined aquifer are sometimes used for different purposes based on economics and water quality. Primary groundwater uses within the Subbasin include domestic, municipal, agricultural, and industrial.

3.1.11.1 Domestic Pumping

Domestic pumping is primarily from the upper unconfined and semiconfined aquifer because it is easier to access and typically has sufficient yield for domestic purposes.

3.1.11.2 Municipal Pumping

Municipal pumping of groundwater occurs in the Subbasin by the cities of Hanford, Lemoore, Stratford, and Corcoran (Table 3-4). Wells for municipal purposes are typically in the deeper portions of the unconfined and semiconfined aquifer and sometimes reach into the confined aquifer. Municipal uses require larger sustained yields than domestic uses; therefore, municipal pumping looks to deeper zones with longer well screens than domestic wells. The municipal pumping demand varies seasonally, peaking in the summer months.

3.1.11.3 Agricultural Pumping

Agricultural pumping requires large quantities of water and water quality not impacted by elevated TDS, chloride, and boron concentrations. The requisite quantity and quality can be achieved by drilling into the deeper portions of the upper aquifer and below the Corcoran Clay into the lower confined aquifer. Thus, most of the agricultural pumping in the Subbasin and in adjoining subbasins is from deep wells.

3.1.11.4 Industrial Water Pumping

Industrial use depends on application. Groundwater used to provide steam for power generation or heating needs to contain low TDS and may require treatment. Some industrial use such as dust control may not be dependent on water quality.

3.1.12 Uncertainty and Data Gaps

The HCM is being used to characterize groundwater conditions in the Subbasin and to provide the basis and assumptions used to construct and run the groundwater model. The groundwater model is being used to estimate changes over time in groundwater levels, flow directions, and storage given a set of inflows (precipitation, surface water, underflow in, etc.) and outflows (evapotranspiration, pumping, underflow out, etc.). Prior to SGMA, there were no requirements to manage or report groundwater usage. As a result, most water supply entities do not know the location, construction, and pumping history of many pumping wells within their jurisdiction. Although depth to groundwater measurements are collected periodically from many wells, the lack of well construction data makes it difficult to interpret the data. Furthermore, most of these entities often do not have a good historical accounting of which parcels have received surface waters and at what rates. Hence, these inputs and outputs need to be approximated by other means than direct measurement.

The data utilized for the HCM and subsequently the construction and calibration of the groundwater model were provided by various private parties, public agencies, and data extracted from existing numerical models of the area.

Much of the hydrologic data used in the HCM and to construct and calibrate the groundwater model are based on estimates or inferred from multiple data sources. As noted above, most water suppliers do not know the historical delivery of surface water to various parcels within their jurisdiction. Hence, it was necessary to assume that all irrigated parcels received some surface water allotment. Likewise, the location, construction, and pumping history of most of the irrigation wells in the Subbasin are not known. Hypothetical irrigation well locations were assumed to be distributed with relatively uniform spacing across the model domain. The hypothetical irrigation wells were also assumed to have completion intervals and frequency similar to that of a small subset of wells with known constructions. Hypothetical irrigation well pumping was estimated based on a water balance method using estimated agricultural demand based on reported crop type minus the assumed distribution of surface water supplies. While these simplifying assumptions and estimates are reasonable given the sparseness of measurements, they add uncertainty to the HCM and the groundwater model.

Overtime, under SGMA, more accurate data regarding well construction, water level measurement, spatial and temporal groundwater pumping, and surface water deliveries should be collected and utilized to update the HCM and the groundwater models of the Subbasin. As the HCM and the groundwater model are updated with actual measurement instead of estimates, the HCM and the groundwater model will become more useful tools for managing groundwater in the Subbasin.

3.2 Groundwater Conditions

23 CCR §354.16 *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…*

This section contains information related to historical and current groundwater conditions necessary to understand the characteristics of groundwater flow within the Subbasin, groundwater quality, and the water budget. Subsidence and its overall effect on groundwater storage, surface and groundwater interactions, and groundwater dependent ecosystems is also discussed.

3.2.1 Historical Changes in Groundwater Flow

Historically, groundwater movement in the Subbasin was dominated by recharge of surface water on the alluvial fans of the rivers and streams emanating from the Sierra Nevada Mountains and by the discharge sinks created by evaporation from Tulare Lake and evapotranspiration created by the swamps and marshes along the periphery of the Lake. Maps of unconfined groundwater conditions in the San Joaquin Valley between 1905 to 1907 (Figure 3-23) showed groundwater flow converging on the Tulare Lake bottom and confined flowing wells (artesian) in the Subbasin along the center of the valley and as far east as Goshen, Tulare, and Pixley (Mendenhall et al. 1916). Water levels indicated groundwater recharge on the Kings, Kaweah, and Tule River fans.

By 1952, groundwater development had altered the potentiometric surface such that distinct pumping cones of depression had developed in the unconfined upper aquifer east of the Subbasin beneath the Kaweah and Tule River fans and within the Subbasin on the Kings River fan near Hanford (Figure 3-24) (Davis et al. 1959). These groundwater depressions interrupted the through flow of groundwater from the alluvial fans west of the Sierra Nevada Mountains to the Tulare Lake area.

In 2016, groundwater cones of depression in the unconfined upper aquifer were apparent east of the Subbasin with groundwater elevations having declined 100 to more than 200 feet from the 1952 data (Figure 3-25). Based on available groundwater elevation data, the groundwater cones of depression peripheral to the Subbasin changed the natural prevailing direction of groundwater flow from west-southwest toward Tulare Lake, to east, northeast, and southeast away from Tulare Lake.

There were insufficient data available for confined aquifer only wells to prepare potentiometric surface maps for the confined aquifer system.

3.2.2 Recent Groundwater Elevation Data and Flow

In 1990, the DWR mapped groundwater levels in the unconfined aquifer at an elevation of about 260 feet AMSL near Kingsburg, decreasing toward the Tulare Lake bottom (Figure 3-26). Groundwater elevations beneath Hanford were about 170 feet AMSL and about 140 feet AMSL near Corcoran. There were several groundwater cones of depression in the water table near Hanford, north and south of Corcoran, and around Alpaugh. The Kings River appears to be a natural groundwater divide, a losing stream that provides a significant source of groundwater recharge to the unconfined aquifer. In general, groundwater flowed into the Subbasin from the Kings, Kaweah, and Tule subbasins and out of the Subbasin to the Westside Subbasin to the west-northwest (Figure 3-26).

In 1995, groundwater in the unconfined aquifer was at an elevation of about 260 feet AMSL near Kingsburg, decreasing toward the Tulare Lake bottom (Figure 3-26). Groundwater elevations beneath Hanford were about 150 feet AMSL and about 110 feet AMSL near Corcoran. By 1995, the cones of depression in the water table between Hanford and Corcoran had merged into a single large depression. The Kings River continued to be a natural groundwater divide. In general, groundwater flowed into the Subbasin from the Kings, Kaweah, and Tule subbasins and out of the Subbasin to the Westside Subbasin.

In 2000, groundwater in the unconfined aquifer was at an elevation of about 250 feet AMSL near Kingsburg, decreasing toward the Tulare Lake bottom (Figure 3-26). Groundwater elevations beneath Hanford were about 150 feet AMSL and less than 100 feet AMSL near Corcoran. The Kings River continued to be a natural groundwater divide. In general, groundwater flowed into the Subbasin from the Kings and Kaweah subbasins and out of the Subbasin to Tule and Westside subbasins.

In 2005, groundwater in the unconfined aquifer was at an elevation of about 260 feet AMSL near Kingsburg, decreasing toward the Tulare Lake bottom. Groundwater elevations beneath Hanford were about 140 feet AMSL, about 10 feet lower than in 2000. No data were collected in the Corcoran area (Figure 3-27). Throughout the Subbasin, groundwater levels had declined about 10 feet or greater than in 2000, during a period of average rainfall. The Kings River continued to be a natural groundwater divide. In general, groundwater flowed into the Subbasin from the Kings, Kaweah, and Tule subbasins and out of the Subbasin to the Westside Subbasin.

In 2010, groundwater in the unconfined aquifer was at an elevation of about 250 feet AMSL near Kingsburg, decreasing toward the Tulare Lake bottom. Groundwater elevations beneath Hanford were about 130 feet AMSL, and less than 10 feet AMSL near Corcoran (Figure 3-27). Throughout the Subbasin, groundwater levels had further declined about 10 feet or more feet since 2005. The Kings River continued to be a natural groundwater divide. In general, groundwater flowed into the Subbasin from the Kings, Kaweah, and Tule subbasins and out of the Subbasin to the Westside Subbasin.

In 2016, after roughly five years of severe drought, groundwater in the unconfined aquifer was at an elevation of about 230 feet AMSL near Kingsburg, decreasing toward the Tulare Lake bottom. In the Hanford area, groundwater levels were about 110 feet AMSL, about 20 feet lower than in 2010 (Figure 3-27). Cones of depression in the water table west, north, and southeast of Corcoran had deepened to -40 feet AMSL. In general, groundwater flowed into the Subbasin from the Kings and Kaweah subbasins and out of the Subbasin to the Tule and Westside subbasins.

Wells with groundwater monitoring records are shown in Figure 3-28a. The hydrographs for these wells were evaluated to look at seasonal trends. Hydrographs for representative wells with unknown construction, wells completed in the unconfined aquifer, and wells completed in the confined aquifer are shown on Figures 3-28b-d.

3.2.3 Vertical Groundwater Gradients

Vertical groundwater gradients between the upper unconfined aquifer and the confined aquifer separated by the Corcoran Clay are spatially and temporally variable. Prior to widespread groundwater development, there was an upward gradient from the confined aquifer to the unconfined aquifer (including artesian conditions) beneath much of the Subbasin (Figure 3-23). As agriculture was developed, pumping from below the Corcoran Clay eventually resulted in a downward gradient beneath much of the Subbasin. Pumping from a confined aquifer (which is a function of the storage coefficient) will often result in a larger change in head compared to pumping from an unconfined aquifer (which is a function of the specific yield) for the same volume of pumping. This is because the specific yield is typically several times larger than storage coefficient. Due to the different yield factors and the seasonal nature of agricultural pumping, groundwater levels in the confined aquifer tend to decrease much more than in the unconfined aquifer during the summer months, increasing the vertical gradients. As a result, vertical gradients tend to show a large range seasonally. As of December 2016, vertical gradients range between approximately 0.0 to 0.504 ft/ft (0.0 to 50 ft/100 ft) downward.

3.2.4 Groundwater Storage Estimates

Groundwater storage is the capacity of an aquifer system to yield groundwater. The amount of groundwater in storage (i.e., groundwater volume) is a function of the saturated thickness of the aquifer, the area of the aquifer, and the storage coefficients of an aquifer, which is the specific yield for unconfined aquifers and specific storage for confined aquifers. The specific yield of the Subbasin's aquifer system above the E-Clay (Corcoran Clay) ranges from 0.01 to 0.3 (unconfined), while the specific storage ranges between $1x10^{-5}$/ft and $4.5x10^{-2}$/ft for semi-confined intervals above the E-Clay (Wood 2018). The specific storage of confined sediments below the Corcoran Clay ranges between $2.5x10^{-7}$/ft and $1.25x10^{-3}$/ft (Wood 2018).

The Subbasin groundwater model and DWR estimates were used to calculate groundwater in storage for the principal aquifers (unconfined above the E-Clay and confined below the E-Clay) within the Subbasin boundaries based on 2016 conditions. The unconfined aquifer has an average specific yield of 8.5% (DWR, 2006) and an average saturated thickness of 451 feet over the 535,869 acres of the Subbasin. This yields an estimated at 20.5 million AF of groundwater in storage in the unconfined aquifer zone. The confined aquifer has an estimated average specific yield of 4.91% and an average saturated thickness of 2,294 feet over the 535,869 acres of the Subbasin. This yields an estimated 60.4 million AF of groundwater in storage in the confined aquifer zone. Total estimated groundwater in storage as of 2016 is approximately 80.9 million AF, slightly less than the DWR estimate of 82.5 million AF as of 1995 (DWR, 2006).

The groundwater model was also used to estimate the overall change in groundwater storage over the model calibration period of 1990 to 2016 for the unconfined and confined aquifers. Change in groundwater storage over time is a function of the change in hydraulic head of the aquifer, the aquifer area, and the storage coefficients. Groundwater storage can be negatively impacted by decreasing groundwater head and an overall reduction of the aquifers area resulting from declining groundwater.

Annual changes occurred in groundwater storage from 1990 through 2016 in the upper and lower aquifer zones for each GSA area (Figures 3-29a and b). Overall there has been a loss of storage of about 3.84 million AF from the unconfined aquifer, a storage gain of about 1.53 million AF in the confined aquifer, and a total loss of about 2.31 million AF between 1990 and 2016.

Permanent loss of groundwater storage capacity occurs when dewatering of an aquifer results in compression of sediments also known as subsidence due to loss of hydrostatic pore pressure that formerly offset compressional loading of the sediment overburden. Compaction of sediments permanently reduces effective porosity of an aquifer thus reducing overall aquifer storability. Between 1990 and 2016, the average subsidence across the Subbasin was approximately 1.42 feet with most of the compaction probably occurring in the fine-grained sediments within the confined aquifer. Assuming that the reduction in effective porosity of the fine-grained sediments is about 4.91%, then an average of 1.42 feet of subsidence (compaction) over the 535,869 acres of the Subbasin would result in a permanent loss of groundwater storage capacity beneath the Subbasin on the order of 37,360 AF, or approximately 0.05% of the total groundwater in storage in 2016.

3.2.5 Groundwater Quality

Water quality geochemistry varies in groundwater beneath the San Joaquin Valley (Mendenhall et al. 1916). On the west side of the valley, groundwater was always high in sulfate compared to groundwater on the east side of the valley. Near the center of the valley, groundwater had a mixed character, also being high in alkalis. Most of the water sampled represented essentially pre-development conditions. The difference in chemical characteristics of the groundwater was attributed to the source area for the sediments in which the groundwater was contained (Mendenhall et al. 1916). On the west side, deposits were derived from marine sedimentary rocks with high proportions of sulfur-rich minerals (such as gypsum), whereas on the east side, deposits were derived from granitic rocks with high proportions of silicates. Near the center of the Valley and around the historical Tulare Lake, groundwater contained higher proportions of chloride. It was also noted that TDS measurements in groundwater were greater on the west side than the east.

These findings were confirmed by an additional study in 1956, which concluded groundwater quality is markedly different vertically than horizontally (Davis et al. 1959). The increase in groundwater development between the initial and secondary reports resulted in the latter study subdividing groundwater into unconfined and semiconfined waters that have generally free communication with land surface, the fresh water confined beneath the Corcoran Clay, and brackish and saline marine connate waters that occur at depth beneath the useful aquifers throughout most of the Valley. These studies reported the confined fresh groundwater had lower TDS and a higher percentage of sodium than the unconfined or semi-confined aquifer. The differences between groundwater (carbonate) and west groundwater (sulfate) continued into the 1950s. The groundwater beneath the axial trough was highly variable because of evaporative concentration, variable mixing of east and west groundwater, and recharge of surface water along stream courses of Sierran rivers.

In 2018, a study undertook a comparison of historical groundwater quality data from the historical report of 1916 and modern samples from 1993-2015 to quantify anthropogenic contributions to salinity changes in groundwater quality (Hansen et al. 2018). Findings indicate TDS had increased in most groundwater in the San Joaquin Valley over the past 100 years. However, the spatial distribution of the TDS and individual cation-anion makeup of the groundwater still reflect the geologic provenance of the containing sediments as well as the chemical characteristics of the recharge water. The greatest TDS increases in the Tulare Lake area and eastward were in the shallow portions (i.e., unconfined to semiconfined) of the aquifer.

Excluding water above the A-Clay, the historical data did not indicate any substantial differences in TDS between shallow and deep groundwater. Modern increases in TDS in the shallower groundwater were hypothesized to be due to land usage, which is primarily agricultural in this area (Hansen et al. 2018). The changes to individual cations and anions suggest dissolution of silicate minerals possibly caused by increases in carbonic acid in the soil zone due to agricultural practices. An increase in bicarbonate concentrations were the highest contributor to increases in TDS over the past 100 years. Migration of higher TDS water to deeper portions of the unconfined/semiconfined aquifer was postulated to be the result of high rates of agricultural pumping, along with more limited municipal pumping creating downward vertical movement from upper to lower portions of the upper aquifer. Only limited changes to the TDS and chemical makeup of the lower, confined aquifer were apparent, assuming that the historical chemistry reflected both native conditions for both the upper and lower aquifers (Hansen et al. 2018).

Deep groundwater near the boundary of the continental deposits and the Tertiary marine deposits (San Joaquin Formation) has been estimated to exhibit TDS upwards of 2,000 mg/L based on limited groundwater samples and interpretation of geophysical logs of deep borings. This water represents saline connate water contained or adjacent to the marine deposits.

The SWRCB maintains a database of water quality data (GeoTracker) collected from various state regulatory programs, the USGS, and the University of California Davis Nitrate Study. These datasets were obtained for the Subbasin to gain a general overview of water quality. In general, chemicals of concern that generally affect water quality in the San Joaquin Valley were screened including naturally occurring and anthropomorphic. These included salinity (TDS), arsenic, nitrate, and volatile organic chemicals (VOCs). Figure 3-30 shows the area-wide distribution of TDS in groundwater. Figure 3-31 shows the distribution of arsenic in groundwater. Figure 3-32 shows the distribution of nitrate in groundwater, and Figure 3-33 shows the distribution of VOCs in groundwater.

South of Stratford and Corcoran, groundwater quality diminishes, and portions of the Tulare Lakebed have been de-designated as not suitable for municipal, domestic, agricultural irrigation, and stock watering supply (RWQCB 2017). The primary constituents of concern for the de-designated areas included boron, chloride, sodium, salinity (EC), and TDS (RWQCB 2017). Prior to amendment of the Water Quality Control Plan for the de-designation of MUN and AGR use of groundwater in areas of poor water quality in the Subbasin, characterization studies were conducted to evaluate the potential for the migration of poor water quality from the de-designated areas or the capture of poor quality water by wells near the de-designated area (KDSA et. al. 2015). The results of these characterization studies are summarized in RWQCB Resolution R5-2017-0032 as follows: basin-wide groundwater flows to the center of the Tulare Lakebed, poor water quality is present in a shallow saline aquifer above the Corcoran Clay, and better water quality is present in the aquifer located below the Corcoran Clay.

Data Gap: The available data from GeoTracker and other public sources generally do not distinguish groundwater quality by aquifer zone. Therefore, the depth intervals for water quality data presented in Figures discussed above are unknown and represent a data gap. Well completion data should be reviewed to potentially identify completion intervals for the reported wells, and subsequent water quality samples should only be collected from wells with known construction.

3.2.6 Land Subsidence

Alluvial aquifer systems including those found in the San Joaquin Valley typically consist of a granular mineral skeleton of sand, silt, and clay, and pore-spaces filled with water (LSCE 2014). When water is withdrawn (i.e., pumped) from an aquifer, the fluid pressure in the pore space, also known as pore pressure, is reduced and the weight of the overlying materials must be increasingly supported by the granular mineral skeleton of the aquifer system. As the pressure on the granular skeleton including effective stress increases, some compression of the aquifer system skeleton may occur causing elastic deformation. When the effective stress exceeds the previous maximum effect stress on the aquifer skeleton (pre-consolidation stress) then some rearrangement of the mineral grains, typically clays, may occur and result in permanent compaction resulting in inelastic deformation. For individual thin clay lenses, the amount of compaction is relatively small. However, the combined compaction of many clay lenses within an aquifer system can result in significant subsidence at the ground surface.

Land subsidence due to groundwater withdrawals and associated drawdown has been well documented and has affected significant areas of the San Joaquin Valley since the 1920s, including the Subbasin (Wood 2017). Between 1926 and 1970, there was approximately 4 feet of cumulative subsidence near Corcoran, 4 to 6 feet of subsidence near Hanford, and as much as 12 feet of subsidence near Pixley (Figure 3-34). Following the completion of the SWP and CVP, surface water became more readily available in the San Joaquin Valley and groundwater extraction was reduced and groundwater levels recovered. As a result, subsidence due to groundwater withdrawal was temporarily slowed or stopped.

Groundwater pumping has since increased in the San Joaquin Valley in the past 10 to 25 years due to several factors including the planting of permanent crops and a reduction of available imported surface water. At the same time, some existing wells were deepened or the pumps were lowered, and new wells were installed into deep, previously un-pumped and unconsolidated portions of the confined aquifer beneath the Corcoran Clay. Pumping from the confined aquifer eventually exceeded the pre-consolidation stress of the aquifer system, resulting in the resumption and acceleration of compaction of the fine-grained sediments in the confine aquifer system and associated subsidence at the land surface.

Subsidence in the San Joaquin Valley was exacerbated during a moderate to severe drought from 2007 through 2009 and a severe to exceptional drought from 2012 through 2016. A Jet Propulsion Laboratory study of subsidence between June 2007 and December 2010 indicated subsidence rates were as high as 8.5 inches per year near Corcoran (Farr et al. 2015) (Figure 3-35a). A more recent study by Jet Propulsion Laboratory indicted subsidence rates accelerated in some areas during the recent drought, with annual subsidence rates of 1 to 1.5 feet near Corcoran in 2015-2016 (Farr et al. 2017) (Figure 3-35b).

Groundwater pumping and drawdown and consequent subsidence are anticipated to continue until withdrawals from the deep confined aquifer can be managed so that sustainable groundwater pumping is achieved. Most of the aquifer compaction is inelastic, so subsidence is mostly irreversible even if groundwater pumping decreases and groundwater level recover.

3.2.7 Surface Water Systems

The established surface water system is described in detail in Section 3.1.1.5. The historical conditions of surface water flow have been significantly altered by irrigation demand and flood control/reclamation projects since the turn of the 20th century. In pre-development in the 1800s, runoff from the southern Sierra Nevada Mountains south of the San Joaquin River south to Kern River collected in three terminal lakes: Tulare Lake, Kern Lake, and Buena Vista Lake. This internal drainage configuration created vast regions of adjoining Tule marshes and riparian woodland wetlands. Tulare Lake in the 1870s was reported to have an area of approximately 446,000 acres or 697 square miles and an elevation of about 200 feet AMSL (BCI 1874). The surface area of Tulare Lake was about 505,000 acres or 790 square miles at its highest overflow level of 216 feet AMSL. The lake level and its aerial extent fluctuated during wet and dry periods.

Prior to development, Tulare Lake received runoff from the major and minor streams of the Southern Sierra Nevada described in Section 3.1.1.5. Tulare Lake also received overflow from Buena Vista Lake which in turn received overflow from Kern Lake (Figure 3-36). The major rivers formed broad deltaic and alluvial fans as they flowed from the Sierra Nevada foothills into the San Joaquin Valley, creating multiple distributary channels and sloughs that shifted periodically, especially during flooding events.

Natural hydrology of the Subbasin has been altered over the last century for flood control, irrigation, land reclamation, and water conservation priorities. Concerns about flood control and water supplies resulted in the construction of Pine Flat Dam on the Kings River, Terminus Dam on the Kaweah River, Success Dam on the Tule River, and Isabella Dam on the Kern River. The modern-day surface water conveyances that supply the Subbasin are primarily man-made canals and streambeds.

3.2.8 Interconnected Surface Water and Groundwater Systems

Prior to development in the late 1800s and early 1900s, groundwater and surface waters were interconnected around the Subbasin, resulting in extensive wetlands, a nearly persistent Tulare Lake, and notable artesian aquifers indicating strong upward groundwater gradients (Figure 3-23 and 3-36). Groundwater levels were near the ground surface beneath much of the Subbasin, and as streams and rivers flowed from the Sierra Nevada foothills and Coast Ranges towards Tulare Lake, they geographically transitioned from losing streams which recharged underlying groundwater to into gaining streams which benefit from groundwater discharge (Figure 3-37).

During development, the four major rivers draining into Tulare Lake were dammed, and Tulare Lake itself was able to be reclaimed due to upstream irrigation demands. As a result, most streams and rivers draining into Tulare Lake became disconnected from the regional unconfined aquifer system. The 1952 potentiometric surface maps show the Kings River was a losing stream from the Sierra Nevada foothills to where it crossed SR 198 (Figure 3-24). South of SR 198 and north of Tulare Lake, groundwater contours converge indicating the lower reach of the Kings River may have gained water due to groundwater discharge. The Tule and Kaweah rivers were losing streams in 1952. Potentiometric surface maps from 1990 show that the Kings, Kaweah, and Tule rivers are all losing streams (Figure 3-26).

In the past 160 years, the expanded use of surface water and groundwater extraction have resulted in a significant lowering of the regional water table, causing isolation of surface waters from groundwater beneath most of the Subbasin. Shallow, perched groundwater often is present in the vicinity of surface water conveyances and below recharge facilities; however, these shallow zones are disconnected from the regional unconfined aquifer. Other localized shallow perched zones may exist elsewhere in the Subbasin, but these are not considered a significant source of groundwater.

Though surface water is not connected to groundwater in the Subbasin, shallow groundwater near the Kings River potentially responds to changes in river flows. As described in Chapter 5, the GSP monitoring plan recognizes that a data gap exists in this area to be filled with a shallow monitoring well. Data from shallow wells in this area, once they become available, will be evaluated to better understand the relationship between shallow groundwater above the A-Clay, flows in the Kings River, and shallow groundwater use. The need for additional monitoring of shallow groundwater in the future in this area will be evaluated by the GSAs.

3.2.8.1 Groundwater Dependent Ecosystems

Groundwater Dependent Ecosystems (GDEs) are ecosystems that rely upon shallow groundwater for their sustainability. Depletion of groundwater and lowering of the water table has detrimental effects on GDE existence. GDEs differ from surface water dependent wetlands because they are sustained by natural surface water or artificially conveyed surface water. In some instances, such as the Kern Wildlife Refuge at the southern border of the Subbasin, a wetland may be artificially maintained by conveyed surface water delivery and deep groundwater pumping. Historically, the

Tulare Lake region appears to have supported a mix of both GDEs and surface water dependent wetlands (Figure 3-37), which were mostly eliminated when upstream water diversions and impoundments drained the lake.

Remaining GDEs within the Subbasin were evaluated using the California Natural Resources Agency DWR Open Data "*Natural Communities Commonly Associated with Groundwater*" (NCCAG) database. The database contains two habitat indicators that could indicate the presence of GDEs: (1) wetland features commonly associated with surface expression of groundwater under natural unmodified conditions, and (2) vegetation types (phreatophytes) commonly associated with the subsurface presence of groundwater. It should be noted that this dataset does not represent DWRs determination of a GDE. However, it can be used as an initial screening tool for identifying GDEs within the Subbasin.

Figure 3-38 shows the distribution of remaining wetland features that could be associated with groundwater. Note how few wetlands remain compared to pre-development (Figure 3-37). The remaining wetland consists of semi-permanent/seasonally flooded lake shore wetlands; semi-permanent/seasonally flooded or saturated marsh land; and riparian seasonally or permanently flooded wetlands. The NCCAG database identified 23 species of phreatophytes and five vegetative habitats within the Subbasin that could be associated with GDEs (Figure 3-38). All listed wetlands and phreatophyte areas within ER GSA are not GDE's due to the lack of groundwater in the listed areas.

Most of these vegetation types/plant species are associated with riparian habitat that rely on percolation of imported surface water. Salt tolerant phreatophytes such as iodine bush, quail bush, alkali bulrush, curlyton knotweed, hardstem bulrush, shrubby seepweed, spinescale, alkali goldenbush, and tamarisk can be found in the alkali sink or in brackish water marsh habitat. These plants are typically found in areas of shallow perched groundwater with high salinity (Figure 3-38). The lateral extent of shallow perched groundwater is dependent on available recharge associated with surface water conveyances, occasional flood events, agricultural irrigation, evapotranspiration, and land reclamation in areas where tile subsurface drains have been installed. The subsurface tile drains have controlled groundwater elevations by subsurface drainage.

It is anticipated that the existing imported surface water supplies into the Subbasin will continue unabated into the foreseeable future and may even increase as additional water supply projects are developed. Hence leakage from the surface water conveyances will continue to seasonally recharge shallow groundwater in the vicinity of the existing riparian phreatophytes.

Limited studies have shown that groundwater pumping from the principal unconfined aquifer system in the immediate vicinity of the Kings River may induce limited drawdown (i.e., leakage) of shallow groundwater above the A-Clay into the regional aquifer system (P&P, 2009). The studies indicate that increased pumping does not significantly increase leakage, suggesting that the leakage rate primarily dependent based on the vertical conductivity of the A-Clay. It is anticipated that the groundwater pumping from the unconfined aquifer in the vicinity of existing riparian phreatophytes will not increase in the foreseeable future and may even decrease as additional water supply projects are developed. Hence, the combined effects of steady or increased surface water supplies and steady or decreased groundwater pumping in the vicinity of the existing riparian phreatophytes are not likely to adversely impact the availability of shallow groundwater in the vicinity of the existing riparian phreatophyte areas.

3.3 Water Budget Information

23 CCR §354.18(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.*

This section provides a quantitative description of the water budget for the Subbasin including an account of the inflows, outflows, and changes in storage in the Subbasin aquifer system over time. This includes historical, current, and projected water budget and the changes in the Subbasin's storage. Within a subbasin, if total outflows exceed total inflows, both groundwater levels and groundwater in storage will decline, and the subbasin may be considered in a state of overdraft. When inflows and outflows are in balance, both groundwater levels and groundwater in storage will remain stable over time. Safe Yield is that volume of groundwater that may be utilized within a subbasin without long-term overdraft.

The historical water budget information will be utilized to estimate future conditions related to supply, demand, hydrology, and surface water supply reliability to construct a baseline forecast to understand future projected conditions and for development of management actions and projects.

As discussed more fully in Section 3.3.7.1, agriculture in the Subbasin is primarily dependent on surface water deliveries from the Kings River system, not precipitation. The annual surface water deliveries from the Kings River system to the Subbasin for the period 1966 through 2016 were used to calculate the long-term average surface water deliveries of approximately 627,710 acre-feet per year (AF/Y) without the 2012-2016 drought years. Within the 1990-2016 study period, the 1998-2010 interval has average surface water diversions of approximately 620,630 AF, very close to the long-term average of 627,710 AF/Y (excluding the drought years). Hence, the 13-year period from 1998 through 2010 may be considered a cycle of "normal hydrology" where the average Kings River surface water deliveries are near the long-term mean. The 1998-2010 "normal hydrology" period includes 1 average, 6 above-average, and 6 below-average surface water delivery years.

3.3.1 Inflows, Outflows, and Change in Storage

The Subbasin's water budget describes the inflows to and outflows from the Subbasin's hydrogeologic system. Inflow and outflow can occur from the hydraulic boundaries of the system, from various sources within the model domain such as inflow from adjacent subbasins, rainfall, lakes, and seepage from rivers and canals, and from the exit points such as wells, drainage systems, or outflow to adjacent subbasins. The boundaries, sources, and sinks identified within the model domain are discussed below.

3.3.1.1 Inflows

Inflows consist of precipitation, surface water diversions for irrigation, imported groundwater, lakebed storage, intentional recharge, seepage from streams and conveyances, and groundwater inflow from adjacent subbasins.

Precipitation

Precipitation can be a significant source of water to the Subbasin and surrounding area in wet years. Given the large areal extent of the Subbasin and surrounding area, it was determined using a single weather station to estimate precipitation would be inadequate to represent the entire Subbasin. Instead, the PRISM database maintained by the Oregon State University was used to estimate monthly precipitation from January 1990 through December 2016 across the Subbasin (Figure 3-39). The PRISM database contains monthly total precipitation for the entire United States using a 4-kilometer grid. The monthly precipitation values are statistically derived values based on local weather stations and corrections for topographic variations. The monthly precipitation data were summed by Subbasin area to estimate the potential annual precipitation volume (Figure 3-39).

Not all rainfall is available for use by crops – some falls on impervious surface, some is taken up by dry soils, some is intercepted by foliage and evaporates before it can infiltrate, and some deep percolates and recharges groundwater. Monthly effective precipitation was calculated by multiplying the monthly PRISM data sets by the Precipitation / Effective Precipitation ratios presented in the Food and Agriculture Organization 56 (Allen et al. 1998) (Table 3-1, Figure 3-40). Effective precipitation varies annually in the Subbasin (Figure 3-39). Between 1990 and 2016, the estimated volume of effective precipitation not utilized by crops (i.e., deep percolated) ranged from 430 AF in a dry year (2013) to 80,580 AF in a wet year (2010) and averaged approximately 23,700 AF/Y within the Subbasin.

Data Gap: The volume of effective precipitation utilized by crops, taken-up by soil, and deep percolated needs to be quantified across the Subbasin based on soil types and crops grown.

Surface Water Diversions

Surface water diversions from external sources are another significant source of water to the Subbasin. There are 34 rivers, streams, canals, and diversions entering and within the Subbasin that have recorded diversions (Figure 3-5). Surface water delivery and diversion records within the Subbasin for the past 50-years were obtained via direct contacts with the various GSAs and member water management agencies within the GSAs (Table 3-5). Between 1966 and 2016, surface water diversions ranged from 107,210 AF in a dry year (2015) to 1,056,880 AF in a wet year (1982) and averaged approximately 590,700 AF/Y of water across the Subbasin (Table 3-5). If the drought years of 2012-2016 are ignored, the long-term average is approximately 627,710 AF/Y.

Between 1990 and 2016, surface water diversions ranged from 107,210 AF in a dry year (2015) to 1,038,050 AF in a wet year (1996) and averaged approximately 559,440 AF/Y of water across the Subbasin (Table 3-5).

The surface water diversions are not delivered uniformly across the Subbasin and are highly variable by GSA with most surface water diversion going to the ER GSA and least amount of surface water going to TCWA GSA (Figure 3-41).

Data Gap: The volume of surface water delivered needs to be better quantified by parcel and GSA by month across the Subbasin.

Imported Groundwater Supply

One unique feature of the Subbasin is the importation of groundwater supplies from adjacent subbasins. Interests within the ER and TCWA GSAs operate well fields in the adjacent Tule Subbasin and import the pumped groundwater into the Subbasin as an additional water supply. Between 1990 and 2016, ER GSA operated up to 52 wells in the Creighton Ranch well field, which delivered up to 68,730 AF in a dry year (2014) and as little as 0 AF in wet years (1996-1999) and averaged approximately 39,320 AF/Y in non-wet years. The TCWA GSA operated up to 51 wells in the Angiola Water District (WD) well field, which delivered groundwater to SWK GSA and TCWA GSA lands in the Tulare Lake Subbasin (about 60%) and to TCWA GSA lands in Tule Subbasin (about 40%). Between 1990 and 2016, the Angiola WD well field delivered up to 23,100 AF in a dry year (2009) and as little as 0 AF in wet years (1996-1999) and averaged approximately 15,950 AF/Y in non-wet years (Figure 3-42).

Data Gap: The volume of groundwater imported and applied needs to be better quantified by parcel and GSA by month across the Subbasin.

Lake Bottom Water Storage

Another unique feature of the Subbasin is the utilization of certain portions of the historical lake for storage of surface water inflows, including flood waters. This stored surface water is used as an irrigation supply, thereby reducing long-term demand for groundwater. Tulare Lake storage is occurring mostly in the ER GSA management area and also in a small area of the TCWA GSA. There is no Tulare Lake storage in MKR GSA, SWK GSA, or SFK GSA areas.

Lake storage facilities have the capacity to store approximately 70,000 AF at any given time. During flood events, as an example of conjunctive use, some fields can be flooded allowing for the storage of significant volumes of water, in some years up to 450,000 AF in the ER GSA management area (Figure 3-42). When available, the storage water is typically utilized to supplement surface water deliveries in lieu of groundwater pumping.

Data Gap: The volume of water stored in surface impoundments and applied as surface water needs to be better quantified by parcel and GSA by month across the Subbasin.

Intentional Recharge

Groundwater recharge in the Subbasin also occurs from intentional percolation of surface water in storage ponds and water banks. Kings County WD has performed intermittent intentional recharge operation in 25 basins totaling about 720 acres throughout the MKR GSA when water is available. Kings County WD also has operated a water bank on the Old Kings River channel since 2002. Approximately 73,600 AF of water has been recharged over this 17-year period via percolation through approximately 150 acres of ponds (Figure 3-43), and approximately 48,500 AF have been recovered utilizing five recovery wells since 2002. This leaves a positive balance of approximately 25,100 AF in the aquifer system as of 2016.

As part of a lawsuit settlement, Kings County WD has been infiltrating Kings River flood waters along the Old Kings River channel since the 1940s (referred to as Condition 8 water). Condition 8 water is surface water that naturally would have infiltrated along an approximately 7.75-mile reach of the Old Kings River channel during high river flow years had the river not been diverted for irrigation. Between 1990 and 2016, Condition 8 recharge has ranged from as little as 0 AF in most years and as much as 36,800 AF in flood years (1995) and averaged approximately 30,370 AF/Y in wet years (Figure 3-43).

The Corcoran Irrigation District also owns and operates nine percolation basins totaling about 2,760 acres. Estimated percolation rates are about 0.25 ft/d. A review of aerial photographs suggests only one or two basins are typically utilized each year between March and September when surface water is available, percolating an estimated average of 23,500 AF/Y (Figure 3-43). During wet years, as much as 147,700 AF of water has been estimated to be percolated using these percolation basins.

In the Chamberlain Ranch area (ER GSA), 640 acres has been utilized for percolation basins. In 2017, approximately 5,000 AF was recharged.

Immediately adjacent to the eastern boundary of the ER GSA in the Tule Subbasin, there are recharge basins that are operated by ER GSA landowners. These recharge facilities are covered by a neighboring GSP.

Data Gap: The volume of intentional recharge needs to be better quantified by recharge facility by month across the Subbasin.

River and Canal Seepage

Seepage losses from river and canals provide another source of water to the Subbasin and surrounding areas. There are over 290 miles of major streams and canals within the Subbasin, in addition to many more miles of small distribution ditches on individual farms. Most of the stream and canals are unlined and can have significant seepage losses. Ownership of canal and river seepage is to be determined. There are a few anecdotal reports of seepage rates along a few reaches of some rivers and canals, but there are no known available seepage tests along the majority of the river and canal reaches in the Subbasin. Hence, river and canal seepage estimates are based on the calibrated groundwater model.

Between 1990 and 2016, seepage loss from rivers and streams are estimated to range between 60,440 AF in a dry year (2015) to 231,840 AF in a wet year (1993) and average approximately 141,360 AF/Y (Figure 3-44). Most of the seepage loss occurs on the Kings River in the MKR GSA and in the ER GSA (outside of the clay plug area) due to its size and number of canals delivering surface water to the GSA. The TCWA GSA management area has the lowest amount of seepage loss.

Data Gap: The volume of river and canal leakage needs to be better quantified by various river and canal reaches across the Subbasin.

Wastewater Treatment Plant Discharge

There are a number of small to mid-sized wastewater treatment plants (WWTPs) throughout the Subbasin operated by, including but not limited to, various cities, municipalities, the Department of Defense, Native American facilities, and manufacturing plants. At most of the WWTPs, treated wastewater is discharged into seepage ponds, used as recycled water, or utilized for irrigation by local farmers. The ratio of WWTP seepage to re-use is not well documented and needs further investigation.

Data Gap: The ratio of WWTP seepage to re-use is not well documented and needs further investigation. The volume of monthly WWTP seepage reaching groundwater needs to be better quantified by WWTP pond across the Subbasin.

Subbasin Boundary Groundwater Inflows

The Subbasin is located within the larger Tulare Lake Hydrologic Region and, except for the Kettleman Hills bordering the southwest potion of the Subbasin, the remaining Subbasin boundaries represent political not hydrogeological boundaries. As such. groundwater is free to move across political boundaries into or out of the Subbasin. Groundwater inflows represent groundwater entering the Subbasin across its boundary from adjacent subbasins. Groundwater flowing into the Subbasin is considered a net gain of groundwater and has the potential to increase available storage with the Subbasin (Table 3-6a). Total inflow into the Subbasin ranges from about 83,220 AF (2011) to 181,210 AF(1990) and averaged about 118,310 AF/Y (Figure 3-45). The highest inflows are from the Kings (197,84 AF/Y) and Kern (24,910 AF/Y) subbasins. The inflow from the Kern Subbasin is misleading in that most of the groundwater from the Kern Subbasin is entering through the southeast corner of the Subbasin and then flowing out into the Tule Subbasin.

In the Upper Aquifer, inflow into the Subbasin ranges from about 32,180 AF (2011) to 60,940 AF (1990) and averages about 43,980 AF/Y (Table 3-6b). In the Lower Aquifer, inflow into the Subbasin ranges from about 51,040 AF (2011) to 120,270 AF (1990) and averages about 74,330 AF/Y (Table 3-6c).

Total Subbasin Inflows

Total inflows into the Subbasin consists of precipitation, surface water imports, groundwater imports, applied pond storage (flood waters), intentional recharge, seepage losses from surface water conveyances, seepage losses from WWTPs, and subsurface inflows from surrounding subbasins. During the 1990-2016 period, estimated total inflow ranged from 1,070,860 AF (2015) to 2,203,450 AF(1990) and averages about 1,584,140 AF/Y. Water balance inflows are summarized annually on Table 3-7 by Land Surface Water Budget and Subsurface Water Budget. The Subsurface Water Budget is further divided by Upper and Lower Aquifer zones for groundwater pumping, interbasin flow, and change is storage.

3.3.1.2 Outflows

Outflows consist of evapotranspiration, agricultural pumping, municipal pumping, agricultural drains, and groundwater outflow to adjacent subbasins. Litigation is pending regarding the outflow of surface water from the Subbasin.

Evapotranspiration

Crop evapotranspiration (ETc) is the largest outflow of water from the Subbasin. ETc varies seasonally and by crop type, typically peaking during the summer months (ITRC 2003). DWR crop data sets from 1995, 1998, and 2006 were used to estimate crop acreage on a 40-acre spacing from 1990 to 2006 throughout the Subbasin. Starting in 2007, CropScape started producing annual estimates of crop acreage on a 40-acre spacing. Annual crop demand was calculated for each crop type on a 40-acre basis as follows:

Annual Crop Acreage (acres) * Annual Crop ETc (feet/yr) = ET_Demand (AF/Y)

Note some crop types do not receive irrigation water and have zero crop irrigation demand (Table 3-8). Crop irrigation demand, also referred to as farm demand was calculated as follows to account for this variable:

(Crop ET-Demand (AF/Y) – Effective Precipitation (AF/Y)) / Irrigation Efficiency (percent) = Farm Demand (AF/Y)

Between 1990 and 2016, the total farm irrigation demand in the Subbasin ranged from approximately 624,650 AF (2015) to 1,232,450 AF (1999), with an average crop irrigation demand of approximately 1,018,560 AF/Y over this 26-year period (Table 3-6a) (Figure 3-46). As shown in the DWR and CropScape data sets, the mix of crops grown and fallow lands has changed over time as agricultural practices were altered. A chart of annual crop demand shows total crop water demand has generally decreased since 2000 (Table 3-8). For example, cotton showed the most change with a decrease of near 50% between 1995 and 2016. Annualized tables and charts of crop demand for the Subbasin’s GSAs are presented in the Model Report in Appendix D.

Data Gap: Crop distribution maps are not available for all years of the study period and those that are available may not capture double cropping or multi-cropping areas. Likewise, estimating ET demand based on typical crop evapotranspiration (ETc) data and assumed irrigation efficiencies may lead to errors in estimated demand. Better quantification of monthly Farm Demand is needed on a parcel and GSA basis across the Subbasin.

Municipal Pumping Demand

Municipal pumping of groundwater occurs in the Subbasin by the communities of Hanford, Lemoore, Armona, Stratford, and Corcoran (Table 3-4). Between 1990 and 2016, reported municipal pumping has ranged from 9,110 AF (1991) to 26,700 AF (2002) and averaged 14,910 AF/Y over this 26-year period (Figure 3-47). The municipal pumping demand varies seasonally, peaking in the summer months.

Agricultural Pumping Demand

Agricultural pumping is typically not recorded over much of California, including the Subbasin. However, agricultural pumping demand on a 40-acre spacing can be estimated as follows:

Farm Demand (AF/Y) – Surface Water Deliveries (AF/Y) = Un-Met Demand (AF/Y)

Un-Met Demand (AF/Y) – Return Flows (AF/Y) – Lake Bottom Water Storage (AF/Y) = Ag_Pumping Demand (AF/Y)

Where: Return Flows are recycled unused surface water
Lake Bottom Water Storage is surface water deliveries or flood waters stored in ponds

The Agricultural Pumping Demand per 40-acre spacing can then be summarized by each GSA (Figure 3-47). Although this simple water balance approach does not account for the areal distribution of surface water diversions or farm delivery requirements, it does provide a reasonable estimate of agricultural pumping in the Subbasin and GSA-specific scale. Based on this analysis, pumping demand in the Subbasin from 1990 through 2016 has ranged from 77,680 AF (2011) to 618,840 AF (1990) and averaged 318,410 AF/Y over this 26-year period (Table 3-6a, Figure 3-47).

In the Upper Aquifer, estimated pumping in the Subbasin ranges from about 126,310 AF (2011) to 363,970 AF (1990) and averages about 246,814 AF/Y (Table 3-6b). In the Lower Aquifer, estimated pumping in the Subbasin ranges from about zero AF (2011) to 254,870 AF (1990) and averages about 134,595 AF/Y (Table 3-6c).

Data Gap: The lack of accurate data regarding the location, completion intervals, and monthly pumping data for most agricultural water supply wells is likely the most significant data gap in the Subbasin. Accurate information regarding the location, completion intervals, and monthly pumping for the agricultural supply wells in the Subbasin would eliminate the need to estimate agricultural pumping based on assumed crop demand and would significantly reduce uncertainty in the Subbasin water balance. Better quantification of monthly agricultural pumping is needed on a parcel and GSA basis across the Subbasin.

Agricultural Drains

Agricultural drains are used beneath several areas of the Subbasin to keep soil from becoming waterlogged in the root zone by return flows. Typically, a tile or French drain system is used with tiles buried approximately 4 to 6 feet bgs draining to sumps. Subsurface drainage collected in the sumps is pumped via pipeline to evaporation basins. Locations vary of subsurface drains and evaporation basins within the Subbasin (Figure 3-22). Agricultural drainage volume were not available and were estimated with a numerical model. Between 1990 and 2016, estimated groundwater withdrawal from agricultural drains ranged from 0 to about 20,850 AF (2004), and averaged 5,720 AF/Y. These estimates may be low. Most of the agricultural drainage is occurring in the ER and TCWA GSAs (Figure 3-48). Between 1990 and 2016, the ER GSA estimated agricultural drain withdrawals ranged from 0 to 20,590 AF (2004) and averaged about 5,440 AF/Y. The TCWA GSAs groundwater withdrawals from drains ranged from about 0 to 1,190 AF (2008) and averaged about 54 AF/Y. Table 3-6a shows the contribution of agricultural drainage to the overall water balance.

Data Gap: The use and operation of agricultural drains in the Subbasin is not well documented and needs further investigation. The volume of monthly drain discharge needs to be better quantified by GSA across the Subbasin.

Subbasin Boundary Groundwater Outflows

The Subbasin is located within the larger Tulare Lake Hydrologic Region, and with the exception of the Kettleman Hills bordering the southwest portion of the Subbasin. Groundwater outflows represent groundwater exiting the Subbasin across its boundary in to adjacent subbasins. Groundwater flowing out of the Subbasin is considered a net loss of groundwater and has the potential to reduce available storage with the Subbasin (Table 3-6a) (Figure 3-49). Outflow from the Subbasin ranges from about 111,280 AF (1990) to 160,350 (2016) AF, and averaged 136,520 AF/Y. The largest outflows are to the Kaweah, Kings, and Tule subbasins.

In the Upper Aquifer, outflow from the Subbasin ranged from about 42,520 AF (1993) to 60,070 AF (2016) and averaged about 43,980 AF/Y (Table 3-6b). In the Lower Aquifer, outflow from the Subbasin ranged from about 58,790 AF (1990) to 100,470 AF (2014) and averaged about 86,980 AF/Y (Table 3-6c).

Total Subbasin Outflows

Total outflows into the Subbasin consists of evapotranspiration, well pumping, agricultural drains, and subsurface outflows to surrounding subbasins. During the 1990-2016 period, estimated total outflow ranged from 1,529,580 AF (2015) to 2,783,110 AF (1990) and averaged about 1,968,130 AF/Y. Water balance outflows are summarized annually on Table 3-7 by Land

Surface Water Budget and Subsurface Water Budget. The Subsurface Water Budget is further divided by Upper and Lower Aquifer zones for groundwater pumping, interbasin flow, and change is storage.

3.3.2 Annual Change in Groundwater Storage

Change in groundwater storage within an aquifer is the difference between the sum of the inflows and the sum of the outflows. An increase in aquifer storage results when the sum of the inflows exceeds the sum of the outflows. Conversely, a decrease in storage results when the sum of the outflows exceeds the sum of the inflows. When inflows equal outflows, no change in storage occurs. With a large basin such as the Subbasin, localized variability in the inflows verses the outflows may occur in areas where groundwater storage increases during a specific water year while conversely in other areas a decrease in storage may occur within the Subbasin. An example of this variability could be attributed to areas where recharge basins may be located as opposed to areas where heavy groundwater pumping may be occurring. During the 1990-2016 period, estimated total annual change in storage in the Subbasin storage ranged from -392,280 AF (2015) to 361,230 AF (2011) and averaged about -85,690 AF/Y over this 26-year period (Table 3-6a, Figure 3-29a).

In the Upper Aquifer, estimated total annual change in storage in the Subbasin ranged from about -392,440 AF (1990) to 197,340 AF (2011) and averaged about -142,210 AF/Y (Table 3-6b, Figure 3-29b). In the Lower Aquifer, estimated total annual change in storage in the Subbasin ranged from about -113,050 AF (2014) to 275,064 AF (1993) and averaged about 56,520 AF/Y (Table 3-6c, Figure 3-29c).

3.3.3 Quantification of Overdraft

As defined by DWR, overdraft occurs where the average annual amount of groundwater extraction exceeds the long-term average annual supply of replenishment to the basin (DWR 2016b). Effects of overdraft can include land subsidence, groundwater depletion, and degradation of water quality and/or chronic lowering of groundwater levels. DWR Bulletin 118 defines critical overdraft as "*when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts*" (DWR 2016b).

The Subbasin sits at the lowest point of the Tulare Lake Hydrologic Region and receives both surface water inflows from several streams including Kings River, Kaweah River, St. Johns River, Tule River, and Deer Creek as well as the SWP. Nonetheless in some years, especially during extended drought cycles (e.g., 2012-2016), agricultural water demand exceeds the surface water inflows. This has led to the drilling of wells to develop groundwater resources to fulfill unmet water demand. Under recent historical conditions the average annual outflow exceeded the average annual inflow.

Overdraft is estimated using the historical water balance record beginning at the time when the net change in storage became negative, lasting over a period with no significant recovery in storage. As discussed in Sections 3.3.1.1 and 3.3.7.1, the period 1998-2010 represents a “normal hydrology period” with average surface water deliveries that were close to the long-term average surface water deliveries not counting the 2012-2016 drought. As such, the 1998-2010 period is a better for estimating the long-term “normal hydrology” than the 1990-2016 period which includes the exceptional drought.

Estimated overdraft (change in storage) was calculated over the Normal Hydrology Period of 1998 to 2010 and ranged from -296,280 AF (2008) to 220,649 AF (2006) and averaged about –73,760 AF/Y over this 13 year period (Table 3-6a, Figure 3-50a).

In the Upper Aquifer, estimated overdraft in the Subbasin was calculated over the Normal Hydrology Baseline Period of 1998 to 2010 and ranged from about -222,720 AF (2001) to 117,740 AF (2006) and averaged about -103,180 AF/Y (Table 3-6b, Figure 3-50b). In the Lower Aquifer, estimated overdraft over the Normal Hydrology Baseline Period ranged from about -85,580 AF (2008) to 136,360 AF (1998) and averaged about 29,410 AF/Y (Table 3-6c, Figure 3-50c). The Subbasin has been divided into management areas consisting of individual GSAs to quantify overdraft in each GSA area. The overall change in storage within the Subbasin and individual GSA management areas was calculated using the groundwater model. Table 3-6a-c and Figures 3-50a-c shows the annualized amount of overdraft in each GSA management area and the Subbasin for the total aquifer system, upper aquifer, and, lower aquifer.

3.3.4 Estimate of Sustainable Yield

Sustainable Yield is defined as the maximum quantity of water calculated over long-term conditions in the Subbasin including any temporary excess that can be withdrawn over a period of time without causing an undesirable result. Sustainability indicators are evaluated to determine when significant and unreasonable results occur indicating an exceedance in sustainable groundwater yields within the basin.

As presented in Chapter 4, the primary undesirable results of concern in the Subbasin are chronic lowering of groundwater levels, loss of groundwater storage, and subsidence. These undesirable results are all reflected in some way through the change in groundwater storage in the Subbasin.

Hence, an estimate of sustainable yield has been developed by examining the causes and magnitude of changes in storage in the Subbasin.

As shown on Land Surface Water Budget (Table 3-7), the estimated applied pumped groundwater for irrigation for the 1998-2010 "normal hydrology" period averaged about -348,700 AF/Y. During the same period, the Subsurface Water Budget (Table 3-7) indicates that the total estimated deep percolation (deep infiltration of applied water, stream leakage, and intentional recharge) averaged about 335,360 AF/Y. This is a difference of only -13,340 AF/Y. In other words, net recharges off-sets about 96% of total groundwater pumped for irrigation from the Subbasin. Hence, within the Subbasin, net recharge and net agricultural pumping are in near balance.

The Subsurface Water Budget also shows that during the 1998-2010 "normal hydrology" period net subsurface interbasin outflows from the Subbasin averaged about -24,290 AF/Y or about 33% of the average change in storage (i.e., overdraft) in the Subbasin of about 73,770 AF/Y (Table 3-7). The outflows can be attributed to increased groundwater pumping in the surrounding subbasins, which is beyond the control of the GSAs in the Subbasin. Hence, the overdraft in the Subbasin during the 1998-2010 "normal hydrology" period resulting from actions within the Subbasin is approximately -49,480 AF/Y (-73,770 AF/Y + 24,290 AF/Y).

As indicated above, during the 1998-2010 "normal hydrology" the difference between average applied groundwater for irrigation (-348,700 AF/Y) and average net recharge (335,360 AF/Y) differs by only about -13,340 AF/Y. During this same period, the estimated overdraft due to agricultural pumping in the Subbasin averaged about -49,480 AF/Y. If agricultural pumping were reduced by an average of 49,480 AF/Y to about -299,220 AF/Y, the net change in storage should be close to zero or possibly positive. Hence, the current estimate of long-term sustainable yield for agricultural pumping is approximately -299,220 AF/Y over the historical average of 310,792 acres of irrigated land (Table 3-2) in the Subbasin.

3.3.5 Current Water Budget

The current water budget is represented by the last full calendar year (2016) in which data are available. Estimated values for 2016 include: farm demand 67,794 AF, surface water supply 227,760 AF, imported groundwater 70,860 AF, pumping groundwater 428,423 AF, net recharge 154,700 AF, and net interbasin flow of -58,250 AF. Total outflows of -588,770 exceed total inflows of 256,800 AF, resulting in a change in storage of -294,320 AF. The current water budget for this period is summarized on Table 3-7 by Land Surface Water Budget and Subsurface Water Budget. The subsurface water budget is further divided by Upper and Lower Aquifer zones for groundwater pumping, interbasin flow, and change is storage.

3.3.6 Historical Water Budget

The historical water budget for the Subbasin covers a period of 27 years extending back to 1990 and is based on the set of available data records. Precipitation records span a period from 1899 to 2017 (Table 3-1). Evapotranspiration from the nearest California Irrigation Management Information System station covers a period of October 1982 through 2018. Surface water delivery data from the SWP is available since 1966, and GSA surface water delivery data on their canal systems are available since 1990. State and Tulare County land use records are available from 1990 to 2006 updated at 5-year intervals. USDA CropScape annual cropland data are available from 2007 to 2017. Groundwater pumping demand is based on both records of municipal pumping and projected rates of agricultural pumping as described in Section 3.3.1.2 from 1990 to the present. The historical water budget has been discussed in previous Sections 3.3.1 through 3.3.4 and is summarized annually on Table 3-7 for land surface water budget and subsurface water budget. The Subsurface Water Budget is further divided by Upper and Lower Aquifer zones for groundwater pumping, interbasin flow, and change in storage.

Subbasin inflows and outflows are calculated in the calibrated groundwater model based on general head boundary conditions that include groundwater elevations and groundwater flux. These are estimated based on historical groundwater elevations measured in wells at or near the Subbasin boundary and estimates of aquifer hydraulic parameters such as hydraulic conductivity, aquifer thickness.

Historical change in storage as described in Section 3.3.2 is the net difference between the inflows and the outflows. Change in storage is summarized annually on Table 3-7 by Subsurface Water Budget. The Subsurface Water Budget is further divided by Upper and Lower Aquifer zones for groundwater pumping, interbasin flow, and change is storage.

3.3.6.1 Historical Demands and Sustainability

Historical water conditions that affect sustainable yields include: (1) population growth in urban centers, 2) changes in agricultural demand, and 3) availability of surface water. Average agricultural water demand comprises 96% of total water use within the Subbasin, while urban use comprises 4%. Surface water deliveries have varied over time with a peak of 1,036,880 AF in 1996 to a low of 107,070 AF in 2015.

A review of U.S. Census Bureau data indicates the Kings County area exhibited a population of 151,336 as of 2018 (U.S. Census Bureau 2018) with a growth of approximately 48,632 people between 1990 and 2017, with most growth occurring in the Hanford-Lemoore area. The major urban areas saw increases in population of 25,602 people in Hanford, 12,733 people in Lemoore, and 8,471 people in Corcoran, accounting for 96% of the population growth in Kings County. These communities rely solely on groundwater for water supply. Estimates of urban pumping within the GSP area increased from 9,370 AF in 1990 to 18,410 AF in 2013 (Table 3-4). Reported urban pumping decreased during 2014-2016 in response to the drought.

Historical annual agricultural pumping demand of groundwater within the Subbasin is an estimated parameter dependent on several water balance components. It is dependent on crop type and the amount of row crops fallowed in a given year due to limited availability of surface water resources or economic circumstance. Historical agricultural pumping demand is calculated based on crop coefficient multiplied by reference evapotranspiration yielding crop evapotranspiration. Farm water demand is crop evapotranspiration minus effective precipitation divided by the irrigation efficiency of the irrigation method. Agricultural pumping is farm water demand minus applied surface water minus imported groundwater. Different crop types have different water requirements and changes in cropping pattern affect the amount of agricultural demand within the Subbasin. Historical crop demand is shown in tables and graphs in the Model Report in Appendix D. As shown by the tables and graphs, overall groundwater usage for agriculture has remained the top water user in the Subbasin and has varied over time since 1990 due surface water availability, climatic conditions, and other factors.

Heavy groundwater demand is directly associated with years of limited surface water supply. Fallowing of row crops during drought years offsets this increased demand to some extent. The relationship between available surface water deliveries, groundwater pumping, and crop demand impacts the water budget (Figure 3-51).

3.3.7 Projected Water Budget

The projected water budget for the Subbasin represents a hypothetical forecast for the 54-year period from 2017 through 2070 based on an assumed “normal hydrology” period and estimated future climate change impacts. This forecast provides the Subbasin’s GSAs with a tool to allow flexibility in groundwater management and planning of sustainability projects. The projected water budget is based on current baseline conditions of groundwater and surface water supply, water demand, and aquifer response to allow for implementation of groundwater management and projects implemented under the GSP. Groundwater modeling of the forecast conditions will be used to evaluate long-term groundwater flow trends, change in storage, and long-term groundwater sustainability under different forecast conditions and proposed groundwater sustainability projects conducted by individual GSAs.

Increases in urban population increased demand for groundwater resources within these communities. The estimated 2018 population of Kings County of 151,366 is expected to reach

181,218 by the year 2035 (DOF 2019). Continued urban population growth will likely increase the demand on groundwater resources. Some of the increase in urban demand will be offset by the conversion of agricultural land into housing; however, urban demand will continue to incrementally increase water demand unless future aggressive water conservation is implemented. Additional surface water sources or improved management of groundwater resources (e.g., increased recharge) could help offset increased urban water demand. Municipal pumping was assumed to increase slowly from about 25,060 AF (2017) to about 30,160 AF (2070).

Data Gap: Better estimates of urban demand growth should be developed for the forecast models.

3.3.7.1 Establishment of the Normal Hydrology Baseline Period

Long-term precipitation records are often used to evaluate hydrologic cycles for watersheds and subbasins. Typically, the cumulative departure from the long-term mean precipitation is used to evaluate hydrologic trends. Periods where the cumulative departure starts and ends near the long-term mean are often considered a “normal” cycle. This approach is appropriate to use where the hydrologic cycle is dominated by precipitation. However, agriculture in the Subbasin is primarily dependent on surface water supplies not precipitation. Surface water deliveries to the Subbasin is dominated by deliveries from the Kings River system. The Kings River flows are managed by Pine Flat dam, so surface water deliveries on the Kings River do not necessary follow precipitation. For example, annual precipitation in the City of Hanford was 15.13 inches and 9.16 inches during 2010 and 2011, respectively. However, surface water deliveries from the Kings River were the reverse, at 706,100 AF and 1,037,100 AF during 2010 and 2011, respectively.

The Kings River surface water deliveries are the largest and most consistent source of surface water to the subbasin. There are occasional surface water (or flood water) deliveries to the Subbasin from the Kaweah River, St. Johns River, Tule River, Deer Creek, and the SWP, but these are relatively small compared to the Kings River deliveries. Therefore, surface water deliveries from the Kings River were used to evaluate the long-term hydrology of the Subbasin.

Annual surface water deliveries from the Kings River system to the Subbasin for the period 1966 through 2016 were used to calculate the long-term average surface water deliveries of approximately 590,700 AF/Y including the recent drought years. A plot of the annual surface water deliveries and cumulative departure shows that Kings River hydrology and associated water deliveries fluctuate widely depending upon snow pack and rainfall (Figure 3-52). As discussed in Sections 3.3.1.1 and 3.3.7.1, the period 1998-2010 represents a “normal hydrology baseline period” with average surface water diversions of approximately 620,630 AF, close to the long-term average of 627,710 AF/Y without the 2012-2016 drought years. The cumulative departure from average surface water deliveries shows, although the period between

1994 and 2016 starts and ends at the long-term mean, it would not be considered a “normal hydrology” period because it includes a part of an exceptional drought from 2012 to 2015 (Figure 3-52). Instead, a downward offset of the historical cumulative departure shows the 13-year period from 1998 through 2010 represents a period of “normal hydrology baseline period ” cycle where the average is near the long-term mean (Figure 3-52).The 1998-2010 baseline period includes 1 average, 6 above-average, and 6 below-average surface water delivery years (Figure 3-52).

3.3.7.2 Normal Hydrology Forecast Period

During the 13-year 1998-2010 normal hydrology baseline period, Kings River surface water deliveries averaged about 620,633 AF/Y, just slightly below (1.13%) the 50-year long-term average of 627,710 AF/Y not including the 2012-2016 drought. These historical surface water deliveries used for the forecast were reduced to account for the permanent transfer of some SWP contracts out of the Subbasin.

The resulting 13-year “normal hydrology” cycle was used to create a 54-year forecast of future Kings River hydrology from 2017 through 2070. When the forecast was constructed in mid-2018, 2017 was already a known “wet” year with about 170% of Kings River flow, and 2018 was shaping up to be a relatively normal year. Hence, the 2017-2070 forecast was constructed using 2011 and 2010 as analogs for the 2017 and 2018 hydrology. The 13-year “normal hydrology” cycle was then repeated four times to complete the 54-year forecast (Figure 3-52).

3.3.7.3 Climate Change

The DWR provides guidance on how to incorporate climate change into hydrology forecasts. There are two basic approaches that have been used to simulate climate change in water resource modeling: (1) transient analysis and (2) climate period analysis (DWR 2018).

In a transient analysis, the climate change signal strengthens incrementally over time. In general, years further into the future are warmer than years closer to the beginning of the simulation, and the most severe changes to climate tend to occur toward the later years of the simulation. In California, where monthly precipitation variability is extreme, transient analysis can be difficult to interpret. In a transient analysis, monthly variability can completely obscure the climate change signal because each year of the simulation has both monthly variability and a climate change signal, making it difficult to determine which is causing shifts in precipitation.

In a climate period analysis, climate change is modeled as a shift from a baseline condition, usually historically observed climate where every year or month of the simulation it is shifted in a way that represents the climate change signal at a future 30-year climate period. Climate period analysis provides advantages in this situation because it isolates the climate change signal independent of the monthly variability signal. In a climate period analysis, monthly variability is based on the reference period from which change is being measured, meaning that all differences between the future simulation and the reference period are the result of the climate change signal alone.

Climate period analysis was utilized to modify the 54-year forecast of “normal hydrology” to account for future climate change. The 2017-2070 forecast incorporates climate period analysis using the 2030 and 2070 monthly change factors (CNRA 2018) for each forecast analog month (Figure 3-52). The 2030 monthly change factors were applied to the forecast months January 2017 through December 2030. The 2070 monthly change factors were applied to the forecast months January 2031 through December 2070. There is a notable increase in magnitude of the 2070 change factors compared to the 2030 change factors. This tends to result in wetter wet-periods and dryer dry-periods compared to the 2030 change factors. However, the 2070 climate change factors tend to average just 0.999 or just below average while the 2030 climate change factors tend to average about 1.011 times higher than average. As a result, the 2030 climate change factors tend to have a greater impact on long-term forecasts than do the 2070 climate change factors.

A chart of forecast Kings River surface water deliveries shows a comparison of annual normal forecasts, annual normal forecast with climate change, and the difference in annual surface water deliveries between the with- and without-climate change forecasts (Figure 3-52). The figure shows future climate change may, using the DWR mandated assumptions, result in more Kings River flows in some years, and less flow in other years compared to the baseline conditions.

3.3.7.4 54-Year Forecast Hydrology with Climate Change

The climate change factors were also applied to 54-year forecasts of monthly inflows (effective precipitation, SWP surface water deliveries, lake storage, and canal and river seepage) and outflows (agricultural demand) for the “normal hydrology” forecast. Outflows due to agricultural demand were based on current cropping patterns and account for maturing of young permanent tree crops and the replanting of tree crops on a 25-year cycle (except pistachios, which have a life span approaching 100 years). This methodology allows for the fallowing and replanting of non-permanent crops due to historical response of available surface waters.

3.4 Management Areas

> **23 CCR §354.20(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. (b) 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.*
>
> *(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.*
>
> *(3) The level of monitoring and analysis appropriate for each management area.*
>
> *(4) An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.*
>
> *(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.*

In order to facilitate implementation of the GSP, management areas have been created for the Subbasin. There are five Primary Management Areas and two Secondary Management Areas. Each of these types of management areas are described in the following sections.

3.4.1 Primary Management Areas

Primary Management Areas have been formed from each of the five GSAs. (Figure 3-53). The formation of Primary Management Areas will facilitate data management and assist with the implementation and management of the GSP. Furthermore, each GSA has unique surface water and groundwater allocations and usage, and they are best positioned to develop BMPs and development of groundwater sustainability projects.

Minimum thresholds and measurable objectives developed for each GSA management area described in Chapter 4 will be based on the groundwater conditions within each individual GSA management area.

Groundwater data collected from each GSA will be entered into a Data Management System to facilitate analysis of measurable objectives and undesirable results. A groundwater model has been developed for the Subbasin and adjacent areas to assist sustainable groundwater management in and between individual GSAs. Each GSA will coordinate with adjacent GSAs and adjacent subbasins to monitor within the San Joaquin Valley Basin if undesirable results in the adjacent managements areas are being contributed to by activities within that GSAs management area. The GSAs will coordinate corrective action, if necessary.

3.4.2 Secondary Management Areas

Two Secondary Management Areas have been formed for the Subbasin (Figure 3-53). These two Secondary Management Areas are different from the Primary Management Areas and each other due to distinctly different groundwater conditions in each area. These two areas are the Clay Plug (Management Area A) and the Southwest Poor Quality Groundwater Secondary Management Area (Management Area B).

3.4.2.1 Clay Plug

The Tulare Lake clay layers are a significant controlling factor for groundwater movement in the Subbasin. The clay plug does not transmit groundwater and is a hydrologic “dead” zone. As such, the area has never been developed for groundwater extraction. The southern portion of Tulare Lake deposition is made up of continuous lacustrine deposits extending like a tap root through the interior portions of the lake to the top of the San Joaquin Formation, which is 2,600 to 3,000 feet bgs (Figures 3-14a-c). The area with continuous lacustrine sediments from the surface to the underlying San Joaquin Formation is roughly 23 miles long by 12 miles wide. These sediments of continuous lacustrine deposits is called the clay plug. The clay plug does not transmit groundwater and is a hydrologic “dead” zone. As such, the area has never been developed for groundwater extraction.

Prior to amendment of the Water Quality Control Plan for the de-designation of MUN and AGR use of groundwater in areas of poor water quality in the Subbasin, characterization studies were conducted to evaluate the potential for the migration of poor water quality from the de-designated areas or the capture of poor quality water by wells near the de-designated area (KDSA et. al. 2015). The results of these characterization studies are summarized in RWQCB Resolution R5-2017-0032 as follows: basin-wide groundwater flows to the center of the Tulare Lakebed, poor water quality is present in a shallow saline aquifer above the Corcoran Clay, and better water quality is present in the aquifer located below the Corcoran Clay.

A zone-of-capture analysis was also completed that determined if areas outside of the proposed de-designated areas could extract groundwater from within the de-designated area. The results indicated that wells near the horizontal boundary would not draw water from within the proposed de-designated area nor influence groundwater flow direction (RWQCB 2017b). The characterization studies and the zone-of-capture analyses confirmed that no active wells in the fringe areas will draw water within the proposed de-designation area zone nor be impacted by groundwater from within the proposed de-designated zone.

Because this area, due to its historical depositional environment, is isolated from the regional groundwater flow regime in the Subbasin, it is being treated differently than other areas for monitoring purposes and the establishment of compliance points.

3.4.2.2 Southwest Poor Quality Groundwater

As described in Section 3.2.5 and shown on Figure 3-30, groundwater in the southwest corner of the Subbasin contains very high TDS concentrations. The groundwater in this area has poor water quality and limited supply. This is evidenced by that fact that there are no agricultural wells in the area, and due to the lack of water supply development, it is being treated differently than other areas for monitoring purposes and the establishment of compliance points.

Professional Declaration

Chapter 3.0 – Basin Setting was prepared in general conformance with §354.12 of the water code either by and/or under the direct supervision of the appropriate professional as indicated herein.

William V. Pipes, PG
Principal Geologist

4.0 SUSTAINABLE MANAGEMENT CRITERIA

23 CCR §354.22 *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.*

The Sustainable Groundwater Management Act (SGMA) defines sustainable groundwater management as the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results. The avoidance of undesirable results is important to the success of Groundwater Sustainability Plan (GSP) implementation. Development of the sustainable management criteria for the Tulare Lake Subbasin (Subbasin) was based on available information and data developed for the Hydrogeologic Conceptual Model (HCM), the characterization of groundwater conditions, and the water budget (DWR 2017b).

Sustainable management criteria include:

- Sustainability Goal
- Undesirable Results
- Minimum Thresholds (MTs)
- Measurable Objectives (MOs)

These criteria for the Subbasin were developed through the assessment of sustainability indicators and the identification of significant and unreasonable conditions for each of the indicators. The indicators are measured at representative monitoring sites in each management area of the Subbasin.

Sustainability Indicators

Sustainability indicators are the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, become undesirable results. Under SGMA, sustainability indicators and the undesirable results that can occur for each indicator, are:

- Chronic lowering of ***groundwater levels*** indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon.
- Significant and unreasonable reduction of ***groundwater storage***.
- Significant and unreasonable ***seawater intrusion***.
- Significant and unreasonable degraded ***water quality***, including the migration of contaminant plumes that impair water supplies.

- Significant and unreasonable **land subsidence** that substantially interferes with surface land uses.
- Depletions of ***interconnected surface water*** that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

While the default position under SGMA for GSAs is that all six sustainability indicators apply to a basin, SGMA allows for a sustainability indicator to not apply in a basin, based on evidence that the indicator does not exist and could not occur. In the Subbasin, there is sufficient evidence to eliminate two of the sustainability indicators from further consideration – seawater intrusion and depletion of interconnected surface waters. The evidence for eliminating these two indicators is presented in Chapter 3. The remainder of this chapter will address the other four sustainability indicators.

Management Areas

Differences in jurisdictional boundaries, water use, water source type, geology, and/or aquifer characteristics indicate that the use of management areas within the Subbasin may facilitate the sustainable management of groundwater in the subbasin. Although, the hydrogeologic conceptual model, water budget, and notice and communication activities for these areas are consistent across the entire GSP area. These management areas are presented in Chapter 3.

Representative Monitoring Sites

Representative monitoring sites (RMSs) are where MTs and MOs are set and monitored. RMSs can be used for one sustainability indicator or multiple sustainability indicators. The location, type, and monitoring of the RMSs selected for the Subbasin are described in detail in Chapter 5.

4.1 Sustainability Goal

> **23 CCR §354.24** *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.*

4.1.1 Goal Description

The goal of this GSP is to manage groundwater resources to continue to provide an adequate water supply for existing beneficial uses and users while meeting established MOs to maintain a sustainable groundwater yield. This goal will continue to provide adequate water supply for existing beneficial uses and users while ensuring the future sustainable use of groundwater. Additionally, the sustainability goal works as a tool for managing groundwater, basin-wide, on a long-term basis to protect quality of life through the continuation of existing economic industries in the area, including but not limited to agriculture.

The Groundwater Sustainability Agencies (GSAs) in the Subbasin will work collectively to manage groundwater resources in the Subbasin, develop sustainability projects, and implement management actions, where appropriate. Historical and hydrologic modeling estimates were used to estimate the sustainable yield, which would stabilize forecasted groundwater levels. This goal was established in a manner that is transparent to the public and stakeholders to ensure the local population has a voice in the development of the programs. With the implementation of management actions and projects, as well as the continued interim monitoring and reassessment of activities, stable groundwater levels will be achieved by 2040 and then maintained in to the future at levels that will not create undesirable results.

4.1.2 Discussion of Measures

To achieve the goals outlined in the GSP, a combination of measures, including continued management practices and monitoring will be implemented over the next 20 years and continued thereafter. Additional surface water supply and infrastructure projects will be a crucial component of augmenting groundwater supplies. Management actions also will be implemented. Projects and management actions are discussed in further detail in Chapter 6 and their implementation is described in Chapter 7. When combined with regular monitoring for each of the sustainability indicators, the GSAs will coordinate how they pursue sustainability in the Subbasin.

4.1.3 Explanation of How the Goal will be Achieved in 20 Years

The sustainability goals of this Subbasin will be achieved in the next 20 years by:

- Understanding the interaction between existing and future conditions;
- Analyzing and identifying the effects of existing management actions on the Subbasin;
- Implementing this GSP and its associated measures including projects and management actions to halt and avoid future undesirable results;
- Collaborating between agencies to achieve goals and protect beneficial uses; and
- Assessing at interim milestones (at five-year intervals) the successes and challenges of the implemented projects and management actions.

4.2 Undesirable Results

> **23 CCR §354.26(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.*

Undesirable results occur when groundwater conditions within the Subbasin result in significant and unreasonable impacts to a sustainability indicator. The following sections describe the undesirable results for each sustainability indicator and how undesirable results potentially could affect the beneficial uses and users of groundwater in the Subbasin.

4.2.1 Identification of Undesirable Results

The potential for undesirable results occurring in the Subbasin for all four of the sustainability indicators can be traced back to events, statewide policies, and natural causes that have occurred outside of the Subbasin and/or by entities not associated with the GSAs and others in the Subbasin. Reductions in historical allocations of surface water by federal, state, and judicial authorities have resulted in a need for the overlying Subbasin population and enterprises to find additional viable water sources, which has resulted in an increased reliance on groundwater in this Subbasin.

The following are some examples of reductions in surface water supplies historically available within the Subbasin. The reductions total approximately 2,155,000 acre-feet per year (AF/Y) of surface water:

- The State Water Project (SWP) and Central Valley Project (CVP) water delivery reductions through the Central Valley Project Improvement Act (circa 1992) have resulted in:
  - a decrease of SWP deliveries to the Subbasin by an average of 600,000 AF/Y;
  - decreased pumping due to Fall X-2 restrictions by an average of 300,000 AF on the SWP;
  - a decrease of CVP San Luis Unit deliveries by an average of 780,000 AF/Y;
  - a decrease of diversions of about 400,000 AF/Y due to Oroville releases that cannot be pumped into the SWP; and
  - unallocated project yield being developed into contracted supplies (Cross-Valley Contracts and Mid-Valley Canal efforts).
- Biological Opinions (circa 2007) have resulted in:
  - a decrease of SWP deliveries by an average 240,000 AF/Y; and
  - a decrease of CVP San Luis Unit deliveries by an average of 325,000 AF/Y.
- The San Joaquin River Restoration program (circa 2010) has resulted in:
  - reduced deliveries from the Friant Division CVP by an average 210,000 AF/Y.

Additionally, Subbasin-wide effects to groundwater supplies may result from the following:

- Climate Change
    - Information developed by California Department of Water Resources (DWR) suggests that warmer conditions could lead to more rain and/or earlier snow melt runoff (DWR 2017b).
    - Studies indicate increased temperatures could result in higher evapotranspiration rates, which could increase demand.
- Changing Crop Patterns
    - An increase in conversions from annual crops to permanent crops with a higher and more constant water demand could result in an increase in groundwater demand, assuming the same number of acres are irrigated.
- Subbasin Groundwater Outflows
- Increased Urbanization
    - Increases in land use for cities and communities in areas not currently irrigated could result in an increase in demand in certain GSAs.

These events, statewide policies, and natural causes that have occurred outside of the Subbasin, by entities not associated with the GSAs, and/or out the GSAs control, have resulted in an increase in groundwater pumping throughout the Subbasin. The potential for undesirable results to occur for each sustainability indicator due to this increase in pumping is described in the following sections.

4.2.1.1 Groundwater Levels

Based on collected data in the Subbasin, certain areas show long-term decline in groundwater levels, which if not addressed, may eventually lead to a reduction in usable groundwater supplies. Given the 60- to 300-foot depth to groundwater relative to the approximately 3,000-foot-deep freshwater aquifer, it is understood that long-term declines could continue for many years before developing a situation that would truly be significant and unreasonable.

Measurements of groundwater depths and respective elevations in water wells have been collected intermittently across the Subbasin since the early 1900s as discussed in Chapter 3. In the 1940s, pumping began to alter natural groundwater flow conditions, so local groundwater depressions developed. Between 1952 and the end of a five-year drought in 2016, these cones of depression had spread, resulting in groundwater elevation declines from 100 feet to more than 200 feet from 1952 data. The 2016 groundwater elevations are mostly available for the northern third of the GSP area and ranges from approximately 220 feet above mean sea level (MSL) in the very northern end of the GSP area to approximately -120 feet below MSL northwest of the City of Corcoran. Groundwater pumping in the east and central portions of the GSP area, as well as pumping in the neighboring subbasins, has contributed to groundwater level decline, which in turn has contributed to higher energy costs and well deepening.

Lowering groundwater levels can result in the following main impacts, the degree to which will determine if the conditions of lower groundwater levels are significant and unreasonable:

- Water well problems
- Subsidence
- Deterioration of groundwater quality

Water Well Problems

Declining groundwater levels have three main effects on water wells. First, as the depth to water increases, the water must be lifted higher to reach the land surface. As the lift distance increases, so does the energy required to drive the pump. Thus, power costs increase as groundwater levels decline. Depending on the use of the water and the energy costs, it may no longer be economically feasible to use water for a given purpose. Second, groundwater levels may decline below the bottom of existing pumps, necessitating the expense of lowering the pump, deepening the well, or drilling a deeper replacement well. Third, the yield of the well may decline below usable rates.

Land Subsidence

Land subsidence is “a gradual settling or sudden sinking of the Earth’s surface owing to subsurface movement of earth materials.” Though several different earth processes can cause subsidence, more than 80 percent (%) of the subsidence in the United States is related to the withdrawal of groundwater (Galloway and others, 1999).

Deterioration of Groundwater Quality

Under natural conditions the boundary between freshwater and saltwater tends to be relatively stable, but pumping can cause saltwater to migrate, resulting in saltwater contamination of the water supply. In inland aquifers, withdrawal of good-quality water from the upper parts of the aquifers can allow underlying saline water to move upward and degrade water quality. Additionally, where ground water is pumped from an aquifer, surface water of poor or differing quality may be drawn into the aquifer. This can degrade the water quality of the aquifer directly or mobilize naturally occurring contaminants in the aquifer.

4.2.1.2 Groundwater Storage

The amount of groundwater in storage (i.e., groundwater volume) is a function of the saturated thickness of the aquifer, the area of the aquifer, and the storage coefficients of an aquifer, which is the specific yield for unconfined aquifers and specific storage for confined aquifers.

The Subbasin groundwater model and DWR estimates were used to calculate groundwater in storage for the principal aquifers (unconfined above the E-Clay and confined below the E-Clay) within the Subbasin boundaries based on 2016 conditions. Total estimated groundwater in storage as of 2016 is approximately 80.9 million AF, slightly less than the DWR estimate of 82.5 million AF as of 1995 (DWR, 2006).

Annual changes occurred in groundwater storage from 1990 through 2016 in the upper and lower aquifer zones for each GSA area. Overall there has been a loss of storage of about 3.84 million AF from the unconfined aquifer, a storage gain of about 1.53 million AF in the confined aquifer, and a total loss of about 2.31 million AF between 1990 and 2016.

Permanent loss of groundwater storage capacity (i.e., subsidence) occurs when dewatering of an aquifer results in compression of sediments due to loss of hydrostatic pore pressure that formerly offset compressional loading of the sediment overburden. Compaction of sediments permanently reduces effective porosity of an aquifer thus reducing overall aquifer storability. Between 1990 and 2016, the permanent loss of groundwater storage capacity beneath the Subbasin was estimated to be on the order of 37,360 AF, or approximately 0.05% of the total groundwater in storage in 2016.

4.2.1.3 Land Subsidence

Land subsidence is the lowering of the land-surface elevation from changes that take place underground. Common causes of land subsidence from human activity are pumping water, oil, and gas from underground reservoirs; dissolution of limestone aquifers (sinkholes); collapse of underground mines; drainage of organic soils; and initial wetting of dry soils (hydrocompaction) (Leake 2016). The majority of subsidence in the San Joaquin Valley has occurred due to groundwater extraction from below the Corcoran Clay layer, present at depths of 100 to 500 feet below ground surface, resulting in compaction and eventual subsidence in and below the Corcoran Clay layer (Ireland et al. 1984; Faunt et al. 2009).

Land subsidence due to groundwater withdrawals and associated drawdown has been well documented and has affected significant areas of the San Joaquin Valley since the 1920s, including the Subbasin (Wood 2017). Between 1926 and 1970, there was approximately 4 feet of cumulative subsidence near Corcoran, 4 to 6 feet of subsidence near Hanford, and as much as

12 feet of subsidence near Pixley (Figure 3-34). Following the completion of the SWP and CVP, surface water became more readily available in the San Joaquin Valley and groundwater extraction was reduced and groundwater levels recovered. As a result, subsidence due to groundwater withdrawal was temporarily slowed or stopped. However, groundwater pumping has since increased in the San Joaquin Valley in the past 10 to 25 years due to several factors. Pumping from the confined aquifer eventually exceeded the pre-consolidation stress of the aquifer system, resulting in the resumption and acceleration of compaction of the fine-grained sediments in the confined aquifer system and associated subsidence at the land surface. Subsidence in the San Joaquin Valley was exacerbated during a moderate to severe drought from 2007 through 2009 and a severe to exceptional drought from 2012 through 2016.

Computer modeling was performed to forecast subsidence resulting from groundwater elevation lowering through 2040 with two scenarios. Scenario 1 does not utilize projects and management actions, and Scenario 2 includes the implementation of projects and management actions. The two scenarios were compared to illustrate the potential reduction in subsidence in the Subbasin with the implementation of projects and management actions. The areas with the largest simulated subsidence are on the western boundary of the South Fork Kings (SFK) GSA and the northeastern boundary of the El Rico GSA (Figure 4-1)

The undesirable results related to land subsidence will be the significant loss of functionality of a critical infrastructure or facility, so the feature(s) cannot be operated as designed, requiring either retrofitting or replacement to a point that is economically unfeasible. Modeled subsidence data was used to estimate future subsidence through the implementation period. Due to inelastic soil behavior, subsidence is mostly irreversible even if groundwater pumping decreases and groundwater levels recover. Potential impacts include:

- Raising flood control levees to mitigate subsidence;
- Raising railroads tracks to mitigate flooding impacts related to subsidence;
- Re-grading canals, including the SWP Aqueduct, to address grade changes related to subsidence; and
- Flooding of major roads and highways.

The one critical infrastructure location in the Subbasin is roughly 17 miles of California Aqueduct alignment. Significant impacts to the conveyance capacity of this facility related to land subsidence caused in the Subbasin will be viewed as significant and unreasonable undesirable results. Fortunately, there does not appear to be significant subsidence along this alignment. The GSAs understand this to be related to the limited amount of groundwater pumping in that area.

The California Aqueduct boarders the Subbasin, from approximately Kettleman City and south along the western boundary of Southwest Kings GSA adjacent to the alluvial groundwater basin (Figure 4-1). A recent subsidence map covering the period from May 2015 to September 2016 as processed by the Jet Propulsion Laboratory shows minimal subsidence in this area. This is the same general location of Interstate 5 in the Subbasin, which has experienced minimal subsidence over the same period as well. Forecast simulations show that subsidence in this area are projected to continue to be minimal.

The GSAs will continue to collect and evaluate subsidence data from subsidence monitoring locations along the area of the California Aqueduct and Interstate 5, even though it does not appear that subsidence along these facilities where they abut the Subbasin is problematic.

4.2.1.4 Groundwater Quality

Water quality degradation has been linked to some anthropogenic activities (see Chapter 3) and can result from pumping activities. Groundwater pumping may result in water quality degradation due to the migration of contaminant plumes. Additionally, in some areas pumping from deep wells has caused naturally occurring soil contaminants (arsenic, uranium) to leach out and dissolve into groundwater, which may cause undesirable results.

There are no known anthropogenic contaminant plumes within the Subbasin; however, elevated concentrations of total dissolved solids (TDS) and chloride in groundwater have been known to exist in some areas of the western Subbasin since the early 1900s. TDS is considered to have increased over the past 100 years. Additionally, groundwater water quality typically varies with depth above and below the Corcoran Clay. Beneath many portions of the Subbasin, TDS is lower beneath the Corcoran Clay.

Groundwater quality is currently comprehensively monitored in the Subbasin by regulatory agencies. These agencies rely on existing regulations and policies to define undesirable results related to the deterioration of groundwater quality. The agencies and coalitions include the Irrigated Lands Regulatory Program (ILRP), Groundwater Ambient Monitoring and Assessment Program (GAMA), Regional Water Quality Control Board (RWQCB), Central Valley Salinity Alternatives for Long-term Sustainability Program (CV-SALTS), and cities and communities within the Subbasin.

See the following links for additional information on the exceedance categories and monitoring schedules:

- ILRP - https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/
- GAMA - https://www.waterboards.ca.gov/gama/
- RWQCB - https://www.waterboards.ca.gov/
- CV-SALTS - https://www.waterboards.ca.gov/centralvalley/water_issues/salinity/

In Secondary Management Areas A and B, the agricultural uses (AGR) and municipal uses (MUN) of groundwater have been delisted within the Basin Plan (SWRCB R5-2017-0032) and currently are not required to be monitored according to the RWQCB and the Tulare Lake Basin Plan Amendment unless projects are proposed that would trigger monitoring in this area.

4.2.2 Potential Effects to Beneficial Uses and Users

4.2.2.1 Groundwater Levels

Undesirable results related to groundwater level declines in the Subbasin could diminish groundwater supplies for agricultural, municipal, industrial, and domestic needs. Agriculture is the main economic enterprise of the Subbasin, so effective management of groundwater for sustainable future use is critical to the continuation of current economic interests that add value to the Subbasin's communities.

Decreases in groundwater levels will continue to increase the energy needed for pumping. Continued groundwater level declines have the potential to cause some wells to become dry, requiring deepening and/or replacement to reach groundwater. Continued groundwater level declines could also force some well owners to lower or replace existing pumps if the existing well casing is not sufficiently deep. Although all of these potential impacts can be mitigated technically, they are considered significant undesirable results due to the expense involved.

4.2.2.2 Groundwater Storage

Decreases in groundwater levels also result in a decrease of groundwater in storage. Decreases of groundwater in storage could reach the point that agricultural and municipal water users would have a decreased capacity to access adequate groundwater during times of prolonged drought. This would be a significant undesirable result.

4.2.2.3 Land Subsidence

Land subsidence has the potential to cause damage to infrastructure which could result in hazards to public health and safety. Examples of infrastructure that have the potential to be impacted by subsidence include:

- Canals
- Levees
- Pipelines
- Bridges
- Private and public property
- Streets and highways
- Railroads
- Utility infrastructure
- Groundwater wells

While subsidence impacts to various facilities have been identified throughout the Subbasin, it currently doesn't appear that the impacts are significant and unreasonable. Nor does there appear to be significant subsidence issues in the area along the California Aqueduct within the Subbasin boundary (see Section 4.1.4.3).

4.2.2.4 Groundwater Quality

Should undesirable results occur with respect to groundwater quality, the amount of useable groundwater in the Subbasin could be reduced. If treatment is not possible, this degradation could affect the groundwater supplies for agricultural, municipal, industrial, and domestic needs. Additional costs would be incurred as some treatment costs could be necessary, some supply wells may have to be deepened or their pumps lowered, new wells may have to be drilled, and yields may be reduced. Also, should undesirable results occur with respect to groundwater quality, the amount of useable groundwater in storage may be reduced.

4.3 Minimum Thresholds

> **23 CCR §354.28** (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.*

This section describes the MTs established for the sustainability indicators applicable in the Subbasin: groundwater levels, groundwater storage, land subsidence, and groundwater quality.

The MTs quantify groundwater conditions for each applicable sustainability indicator at each RMS. Undesirable results may occur in the Subbasin related to a specific sustainability indicator if the MT numeric values are exceeded for that indicator, as defined in Section 4.3.3.

The MTs for each of these indicators are described in the following section. The measurement and monitoring of MTs, the definition of an exceedance that may result in undesirable results, and the potential effects on beneficial uses and users of groundwater are described in subsequent sections.

4.3.1 Description of the Minimum Thresholds

The information in this section provides a description of the processes to establish the MTs at each of the RMSs. The MT at each RMS is listed in Table 4-1.

4.3.1.1 Groundwater Levels

The process for establishing the MTs for the groundwater levels sustainability indicator for the Subbasin is based on the information developed for the HCM and as described in other portions of the GSP.

1. Groundwater levels in the Subbasin generally are declining, though at different rates at different locations in the Subbasin (Chapter 3, Section 3.2.2).
    - The groundwater level declines have been effectively managed by the GSA member agencies. The rate and degree to which groundwater levels have declined over the long-term have not been significant and unreasonable (Chapter 4, Section 4.2).
2. The GSAs of the Subbasin will be implementing projects and management actions designed to reduce the rate of groundwater level decline in the Subbasin and eventually stabilize groundwater levels into the future (Chapter 6).
    - Implementation of the projects and management actions by the GSAs is anticipated to begin in 2025 and be completed by 2035 (Chapter 7).
3. The results of forecast simulations using the calibrated groundwater model indicate that the implementation of the projects and management actions by the GSAs proposed in this GSP will begin to reduce the rate of groundwater level decline in the Subbasin by 2035 and will stabilize groundwater levels by 2040.

Using the above as a guide, MTs for the groundwater levels sustainability indicator in the Subbasin were established as follows:

1. Groundwater level changes in the Subbasin in the future were forecasted using the groundwater model starting from 2016 levels at each of the RMSs. The groundwater model assumed:
    - Lands that were fallowed during the 2011-2016 drought were brought back into production using historical cropping patterns.
    - Lands that were converted to permanent crops during the drought were assumed to remain in permanent crops.
    - Water use, surface water deliveries, etc., in the Subbasin generally remained the same into the future.
    - The "normal" hydrologic cycle, as described in Chapter 3, Section 3.3.7.1.
    - No projects or management actions were implemented.
2. The average forecasted water level in July 2035 at each RMS was selected as the MO in 2040 at each RMS.
3. The MT at each RMS was then selected as being the water level one standard deviation below the 2040 MO or 50 feet, whichever was greater.
4. The groundwater model was then used to simulate water level changes in the Subbasin into the future with the projects and management actions described in Chapter 6 and implemented using the above schedule.
5. The simulation results indicated that with the projects and management actions implemented, the MOs at nearly all the RMSs are achieved by 2040.

An example hydrograph illustrating this process is shown on Figure 4-2. Given the variability of groundwater conditions throughout the Subbasin, example hydrographs illustrating this process at locations within each GSA are shown on Figures 4-3 through 4-7. Hydrographs at all the RMSs generated from the groundwater model, showing the MTs, MOs, and stabilized groundwater levels by 2040, are presented in Appendix G. The MO, MT, and 5-year Milestones at each RMS are listed in Table 4-1.

4.3.1.2 Groundwater Storage

The estimated amount of groundwater in storage in the Subbasin above the base of fresh groundwater is roughly 82.5 million AF (DWR 2016b) while groundwater use in the Subbasin is in overdraft by an average of roughly 0.07 million AF/Y. Although the reductions in groundwater storage will be addressed through the GSP implementation period, the long-term regional overdraft could continue for many years without significant risk to the beneficial uses and users of groundwater in the Subbasin.

The MT for the groundwater storage sustainability indicator in the Subbasin is the calculated change in storage using the groundwater level sustainability indicator MTs at the RMSs. Groundwater level contour maps will be prepared and estimates of annual storage change will be calculated by comparing current year seasonal high to the previous year seasonal high groundwater contour sets. The resulting change in head will then then be multiplied by specific yield values to estimate change in storage.

4.3.1.3 Land Subsidence

The process for establishing the MTs for the land subsidence sustainability indicator for the Subbasin is based on the following concepts, each of which was developed using the information developed for the HCM and as described in other portions of the GSP.

1. Land subsidence in the Subbasin generally is occurring, though at different rates at different locations in the Subbasin (Chapter 3, Section 3.2.2).
    - Land subsidence has been effectively managed by the GSA member agencies. The rate and degree to which subsidence has occurred have not been significant and unreasonable (Chapter 4, Section 4.2).
2. Continued land subsidence in the Subbasin may result in impacts to beneficial uses and users that are significant and unreasonable, or undesirable (Chapter 4, Section 4.2). If this were to occur, the GSAs may not be able to manage and/or mitigate the effects to infrastructure and land use.
3. The GSAs of the Subbasin will be implementing projects and management actions designed to reduce the rate of land subsidence in the Subbasin and eventually stabilize land subsidence into the future (Chapter 6).
    - Implementation of the projects and management actions by the GSAs is anticipated to begin in 2025 and be completed by 2035 (Chapter 7).
4. The results of forecast simulations using the calibrated groundwater model indicate that the implementation of the projects and management actions by the GSAs proposed in this GSP will reduce the rate of land subsidence in the Subbasin by 2035 and land subsidence will subsequently stabilize within the Subbasin.

Using the above as a guide, MTs for the land subsidence sustainability indicator in the Subbasin were established as follows:

1. Land subsidence in the Subbasin in the future was forecasted using the groundwater model starting from 2016 levels. The groundwater model assumed:

   a. Lands that were fallowed during the 2011-2016 drought were brought back into production using historical cropping patterns.
   b. Lands that were converted to permanent crops during the drought were assumed to remain in permanent crops.
   c. Water use, surface water deliveries, etc., in the Subbasin generally remained the same into the future.
   d. The "normal" hydrologic cycle, as described in Chapter 3, Section 3.3.7.1.
   e. No projects or management actions implemented.
2. The average forecasted subsidence in July 2035 at each RMS was selected as the MO in 2040 at each RMS.
3. Given that subsidence will continue to occur following implementation of the GSP; i.e., there will be a lag before positive benefits accrue, the MT at each land subsidence RMS was selected as being the maximum cumulative land subsidence simulated within the model domain in 2070.
4. The groundwater model was then used to simulate land subsidence in the Subbasin into the future with projects and management actions implemented using the above schedule.
   a. The simulation results indicated that with the projects and management actions, the MOs at the RMSs are achieved by 2040.

The MO and MT for land subsidence at each RMS are shown in Tables 4-2 and 4-3.

4.3.1.4 Groundwater Quality

Groundwater quality in the northern portion of the Subbasin encompassing the Mid-Kings River GSA and SFK GSA is generally excellent for irrigation and satisfactory for MUN and industrial use (KCWD 2011). South of Stratford and Corcoran and portions of the Tulare Lakebed have been delisted for MUN and AGR beneficial use. Shallow groundwater contamination from fuel hydrocarbons, chemicals, or solvents are localized in the urbanized areas of Lemoore and Hanford and some smaller communities. Limited regional data are available for determining current nutrient concentrations based on groundwater depth and location. Shallow groundwater can have elevated concentrations of nitrates and TDS, but the majority of the region is generally below California Maximum Contaminant Levels (MCLs).

Existing groundwater conditions will be considered as a baseline. The GSAs will not be responsible for existing groundwater quality concerns; MTs will be determined as described by the agencies and coalitions which include ILRP, GAMA, RWQCB, CV-SALTS, and cities and communities within the Subbasin for the various constituents they monitor.

Data will be gathered from the above-mentioned agencies and coalitions. Should there be data and consensus from agencies and coalitions indicating a need to address degraded groundwater quality, the GSAs will implement monitoring to supplement the existing programs. The determination of monitoring will be on a case-by-case basis.

The basic authority of the GSAs is to locally determine the sustainable amount of groundwater that can be pumped and to manage the transition from the current groundwater usage to a groundwater usage that is sustainable. Federal and state agencies provide direct oversight of groundwater quality and set their own appropriate thresholds such as MCLs for drinking water at the point of use. These will be utilized by the Subbasin for MOs and MTs. For these reasons, the local GSAs will focus on groundwater quality issues that are related to groundwater pumping and GSP implementation rather than on issues related to existing contamination.

4.3.2 Measurement of Minimum Thresholds

Measurements will be made at the RMSs for each sustainability indicator to determine whether an undesirable result is occurring in the Subbasin.

4.3.2.1 Groundwater Levels

Groundwater elevations will be monitored at each RMS, and contour maps will be generated with the available data to show the groundwater elevations throughout the Subbasin. For more information regarding wells and RMSs in the monitoring network, refer to Chapter 5, *Monitoring Network*.

4.3.2.2 Groundwater Storage

Groundwater elevations will be monitored and contour maps will be generated to calculate groundwater storage change and will be updated every five years. For more information regarding the wells in the monitoring network, refer to Chapter 5, *Monitoring Network*.

4.3.2.3 Land Subsidence

Measurement of land subsidence will be done semi-annually. For more information on the monitoring network, refer to Chapter 5, *Monitoring Network*. While there are only two subsidence RMS locations for the Subbasin in the Monitoring Network, the Subbasin is working to establish a broader network in the future. Discussions are underway with a few agencies (Kings River Conservation District, Kaweah Delta Water Conservation District, DWR along California Aqueduct) related to established networks that could provide broader monitoring coverage.

4.3.2.4 Groundwater Quality

MTs will follow the state, federal, and local standards related to the relevant sustainability indicators set by the coalitions. Water quality data will be obtained from the below-mentioned coalitions and agencies:

- ILRP
- GAMA
- RWQCB
- CV-SALTS

4.3.3 Definition of a Minimum Threshold Exceedance

The MTs quantify groundwater conditions for each applicable sustainability indicator at each RMS. Undesirable results may occur in the Subbasin related to a specific sustainability indicator if the MT numeric values are exceeded for that indicator, as defined in the following sections.

4.3.3.1 Groundwater Levels

The lowering of groundwater levels is considered significant and unreasonable if pumping of groundwater elevations decline below the proposed MT at 45% of the RMSs over a consecutive three-year period. Groundwater levels exceeding the MT would trigger a series of actions and measures as described in Chapter 6, *Projects and Management Actions,* which would include projects and policy implementation.

4.3.3.2 Groundwater Storage

The loss of groundwater in storage calculated when groundwater levels exceed the MT in more than 45% of all monitored wells within a consecutive three-year period will be considered significant and unreasonable.

4.3.3.3 Land Subsidence

The majority of the Subbasin has some subsidence but it has not caused undesirable results, or the subsidence has been mitigated. Should land subsidence exceed the MTs at either or both of the RMSs, the subsidence will be considered significant and unreasonable. At this point, the GSAs will evaluate the cause of the subsidence. If subsidence originates from outside the GSP area, the impacted GSAs will coordinate with relevant GSAs in the other subbasins to address the issue. There is an understanding that there is subsidence in areas adjacent to the Subbasin and efforts will be made to determine if conditions outside the Subbasin are creating impacts within the Subbasin.

4.3.3.4 Groundwater Quality

If groundwater quality degrades from the baseline established when this GSP is implemented to the point where it is exceeding regulatory standards, the data gathered by the agencies and coalitions will be reviewed and evaluated as to the cause of the degradation. If it can be shown that the degradation of water quality was caused by the implementation of this GSP, the GSAs will coordinate with the agencies and coalitions to design an appropriate response.

4.3.4 Potential Effects to Beneficial Uses and Users

4.3.4.1 Groundwater Levels

Due to the timely process of infrastructure development and program implementation, and variability in hydrology and the availability of flood water, groundwater levels are expected to continue to decrease in the next several years before programs have a positive effect on the stabilization of groundwater levels.

Decreases in groundwater levels will continue to increase the energy needed for pumping. If MTs are reached some wells may become dry, requiring deepening and/or replacement to reach groundwater. Groundwater level declines below the MTs could also force some well owners to lower or replace existing pumps if the existing well casing is sufficiently deep. Although all of these potential impacts can be mitigated.

4.3.4.2 Groundwater Storage

Some decline of groundwater in storage has and is likely to continue to occur in the Subbasin. The MTs for groundwater storage recognizes both the need to address groundwater storage and the needed timeframe to substantially reduce the rate of depletion. The MTs will require the implementation of management actions with the goal of demand reduction and/or the inclusion of additional water supply. Additional information on projects and policies are defined in Chapter 6, *Projects and Management Actions*.

4.3.4.3 Land Subsidence

Some level of subsidence has occurred in the Subbasin. The MTs for subsidence recognizes both the need to address subsidence and the needed timeframe to substantially reduce its rate. The impact on water uses and users should decrease as projects and management actions are implemented. GSAs in the Subbasin will need to regularly review and consider data that evaluate whether undesirable conditions exist and the impacted GSAs will need to act to mitigate the significant and unreasonable impact.

4.3.4.4 Groundwater Quality

If groundwater quality conditions deteriorate to MT levels, the situation will be investigated and monitored and addressed in coordination with other agencies responsible for groundwater quality concerns. Treatment of supplies might be necessary or agricultural producers may experience a decrease in crop yield and/or crop quality. Poorer quality applied water could cause a buildup of inorganic constituents (salts) in the surface soil layers. MUN and urban use may experience a higher cost to treat water to the appropriate MCLs. However, groundwater quality will not be significantly and unreasonably impacted by implementation of this GSP.

4.4 Measurable Objectives

23 CCR §354.30 *(a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin with 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.*

This section describes the measurable objectives established for the Subbasin, including interim milestones in increments of five years, to achieve the sustainability goal within 20 years of GSP implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

4.4.1 Description of Measurable Objectives

4.4.1.1 Groundwater Levels

The process for establishing the MOs and MTs for the groundwater levels sustainability indicator is described in detail in Section 4.3.1. The process of establishing the MOs is summarized below. The MO at each RMS is listed in Table 4-1.

Using the concepts described in Section 4.3.1.1, MOs for the groundwater levels sustainability indicator in the Subbasin were established as follows:

1. Groundwater level changes in the Subbasin in the future were forecasted using the groundwater model starting from 2016 levels at each of the RMSs. The groundwater model assumed:
    a. Lands were fallowed during the 2011-2016 drought were brought back into production using historical cropping patterns.
    b. Lands that were converted to permanent crops during the drought were assumed to remain in permanent crops.

   c. Water use, surface water deliveries, etc. in the Subbasin generally remained the same into the future.
   d. The "normal" hydrologic cycle, as described in Chapter 3, Section 3.3.7.1.
   e. No projects or management actions were implemented.
2. The average forecasted groundwater level in July 2035 at each RMS was selected as the MO in 2040 at each RMS.
3. The groundwater model was then used to simulate water level changes in the Subbasin into the future with the projects and management actions described in Chapter 6 and implemented using the above schedule.
4. The simulation results indicated that with the projects and management actions implemented, the MOs at nearly all the RMSs are achieved by 2040.

An example hydrograph illustrating this process is shown on Figure 4-2. Given the variability of groundwater conditions throughout the Subbasin, example hydrographs illustrating this process at locations within each GSA are shown on Figures 4-3 through 4-7. Hydrographs at all the RMSs generated from the groundwater model, showing the MTs, MOs, and stabilized groundwater levels by 2040, are presented in Appendix G. The MO, MT, and 5-year Milestones at each RMS are listed in Table 4-1.

4.4.1.2 Groundwater Storage

The MO for the groundwater storage sustainability indicator in the Subbasin is the calculated change in storage using the groundwater level sustainability indicator MOs at the RMSs. Groundwater level contour maps will be prepared and estimates of annual storage change will be calculated by comparing current year seasonal high to the previous year seasonal high groundwater contour sets. The resulting change in head will then then be multiplied by specific yield values to estimate change in storage.

4.4.1.3 Land Subsidence

Using the concepts described in Section 4.3.1.3, MOs for the land subsidence sustainability indicator in the Subbasin were established as follows:

1. The average forecasted subsidence in July 2035 at each RMS was selected as the MO in 2040 at each RMS.
2. The groundwater model was then used to simulate land subsidence in the Subbasin into the future with projects and management actions implemented using the above schedule.

a. The simulation results indicated that with the projects and management actions, the MOs at the RMSs are achieved by 2040.

The MO and MT for land subsidence at each RMS are shown in Tables 4-2 and 4-3.

4.4.1.4 Groundwater Quality

Existing groundwater conditions will be considered as a baseline. The GSAs will not be responsible for existing groundwater quality concerns; degradation beyond existing groundwater quality conditions will be the MO. MOs will be monitored by the agencies and coalitions. The GSA will not be responsible for water quality issues currently being addressed by each responsible agency or coalition, nor will the GSAs be responsible for water quality issues associated with influences other than water quality issues associated with implementation of this GSP. Within the Subbasin, no correlation has been found between water quality and groundwater levels.

4.4.2 Operational Flexibility

4.4.2.1 Groundwater Levels

Operational flexibility is the difference between the MO and MT. It allows for periods of drought and seasonal variation, which are deemed reasonable to the GSAs in the Subbasin while operating under a normal hydrologic water supply period. The operational flexibilities for each of the RMS locations with sustainability criteria are shown on the hydrographs. Operational flexibility has also been considered in how the MT exceedance was established (Section 4.3.3)

The operational flexibilities for each of the RMS locations with sustainability criteria are shown on the hydrographs in Appendix G.

4.4.2.2 Groundwater Storage

Groundwater storage operational flexibility is based on an average, allowing room for expected reductions in groundwater storage in below normal hydrologic periods and increases in groundwater storage in hydrologic wet periods. The path to achieve MOs also relies on the coordination effort with the surrounding subbasins and/or GSAs.

The MO for groundwater storage change was set with five-year interim milestones. It is the intent of the GSAs to develop and implement projects and management actions by 2035, sufficient to mitigate long-term overdraft. Proposed projects may increase water supply while some management actions may decrease water demand. Projects and management actions may be adjusted over the implementation period in response to conditions driven by the courts, climate, and hydrology that speed or retard the goals of this GSP from being met.

4.4.2.3 Land Subsidence

For the Subbasin, the operational flexibility is minimal since subsidence is mostly irreversible, and the goal is to decrease the rate of subsidence.

4.4.2.4 Groundwater Quality

Each coalition and agency listed above has regulations that provide landowners compliance alternatives and allows continued operations.

4.4.3 Path to Achieve and Maintain the Sustainability Goal

4.4.3.1 Groundwater Levels

The MO at 2040 for each of the RMSs was selected from the forecasted modeling data. Mitigation of current groundwater elevation decline will be achieved by implementing projects and management actions through the implementation period. The projects will utilize existing and potential additional water supply and programs implemented can decrease water demand. Programs may be adjusted over the implementation period in response to conditions and if GSP MOs are not being met. Each subsequent five-year milestone measurement period may contain modifications to the MO and MT or contain additional measures or actions to achieve the MO elevation or groundwater depth by 2040 and beyond.

Table 4-1 lists the MO, MT, and 5-year Milestones at each RMS location with program implementation.

4.4.3.2 Groundwater Storage

The Subbasin has access to very strong surface water resources and millions of AF of stored groundwater. Current water budget evaluations estimate that the Subbasins overdraft is an average of roughly 73,770 AF/Y. The path to achieve and maintain sustainability will be to develop planned projects that can use more of the wet year surface water available to parties in the Subbasin so that the areas long-term overdraft is mitigated. The Subbasin will also pursue many management actions to better measure the amount of groundwater being pumped, monitor changing conditions and address various SGMA related Subbasin issues. The projects developed and planned by parties within the Subbasin appear to yield more than what is needed to address the areas overdraft on an average annual basis. However, like many other subbasins, the Tulare Lake Subbasin will only be able to achieve sustainability if their neighboring subbasins address the overdraft conditions in their areas as well.

The MO for groundwater storage change was set with five-year interim milestones. It is the intent of the GSAs to develop and implement projects and management actions by 2035, sufficient to mitigate long-term overdraft. Proposed projects may increase water supply while some management actions may decrease water demand. Projects and management actions may be adjusted over the implementation period in response to conditions driven by the courts, climate, and hydrology that speed or retard the goals of this GSP from being met.

4.4.3.3 Land Subsidence

The path to sustainability on subsidence is through the development of projects and implementation of management actions that lead to stabilized groundwater levels which thereby diminishes the need to develop deeper wells. Similar to previous periods when subsidence was minimized or arrested, additional surface water was made usable and actions were taken to stabilize groundwater levels.

Tables 4-2 and 4-3 illustrate modeled subsidence in feet, located at the two RMSs, both of which are owned by the State of California Department of Transportation (Caltrans). One is located in the Caltrans maintenance yard in the City of Lemoore, and the other is located on the west side of State Route 43, just north of the City of Corcoran. There may also be observation of the impacts on facilities. It is possible that subsidence may continue on its current trend until projects and management actions are implemented.

The 17-mile alignment of the California Aqueduct within the Subbasin is viewed as critical infrastructure and will have very little operational flexibility related to subsidence understood to be caused within the Subbasin. However, as previously stated, recent data has indicated that there is no significant subsidence occurring in that area.

4.4.3.4 Groundwater Quality

The path to achieve the sustainability goal is continued monitoring and evaluation of the data collected from the coalitions and agencies listed in this chapter at each milestone.

5.0 MONITORING NETWORK

> **23 CCR §354.34(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.*

This chapter describes the existing and proposed monitoring networks as proposed by the Tulare Lake Subbasin (Subbasin) Groundwater Sustainability Agencies (GSAs). Data collected from the monitoring network will be evaluated for short-term, seasonal, and long-term trends for the following sustainability groundwater indicators: groundwater levels, related surface conditions (i.e., land subsidence), and groundwater quality. Information collected through the Subbasin's monitoring network will support the implementation of this Groundwater Sustainability Plan (GSP).

The Sustainable Groundwater Management Act (SGMA) requires each subbasin to establish a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term groundwater trends and related surface conditions (23 California Code of Regulations [CCR] §354.34). A comprehensive monitoring network is essential to evaluate GSP implementation and measure progress towards groundwater sustainability. The sustainability indicators necessary to comply with SGMA monitoring and reporting requirements include chronic lowering of groundwater levels, reduction of groundwater storage, degraded water quality, land subsidence, seawater intrusion and depletions of interconnected surface water.

While the default position under SGMA for GSAs is that all six sustainability indicators apply to a basin, SGMA allows for a sustainability indicator to not apply in a basin, based on evidence that the indicator does not exist and could not occur. In the Subbasin, there is sufficient evidence to eliminate two of the sustainability indicators from further consideration – seawater intrusion and depletion of interconnected surface waters. The evidence for eliminating these two indicators is presented in Chapter 3.

The adequacy of the monitoring network is described for each sustainability indicator, as well as the quantitative values for the minimum thresholds (MTs), measurable objectives (MOs), and interim milestones. This chapter also includes a review of each monitoring network for monitoring frequency and density, identification of data gaps, plans to fill data gaps, and hydrogeologic rationale for future site selection. Consistent data collection and reporting standards will be incorporated into the network for reliable and accurate data. This information will be reviewed and evaluated during each five-year assessment. Monitoring programs for sustainability indicators are described, including the proposed monitoring strategies in compliance with SGMA, adequacy and scientific rationale, and history for each monitoring program.

5.1 Description of Monitoring Network

23 CCR §354.34(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.

The number of existing and proposed representative monitoring site (RMS) locations are summarized by GSA and Sustainability Indicator in Table 5-1. The groundwater level RMS locations as discussed below are shown by aquifer zone, in Figures 5-1 to 5-3. Figure 5-4 shows the existing land subsidence monitoring locations in the Subbasin and the general areas where future extensometers may be added. The groundwater quality RMS monitoring network is composed of wells currently sampled by the local cities/municipalities/small community systems, and the Kings River Water Quality Coalition (KRWQC)-Irrigated Lands Regulatory Program (ILRP) (Figure 5-5). Table 5-2 through Table 5-6 summarize the RMS locations by GSA as shown on Figures 5-1 through 5-5. Tables 5-2 through 5-6 identify the location, type of facility (well, well cluster, extensometer, etc.), existing monitoring program, sustainability indicators monitored, data collection frequency, and aquifer zone monitored. MOs, interim milestones, and MTs for groundwater levels and land subsidence are defined for both existing RMS locations and general areas where groundwater RMS locations are proposed to fill data gaps. Groundwater level RMS (existing and proposed) locations are distributed across the Subbasin in areas where groundwater is used and by aquifer zone (discussed below). This vertical and horizontal distribution of groundwater level RMSs will allow the GSAs to develop the data needed to evaluate groundwater conditions in the various aquifer zones, discussed below, and will be used to inform the Subbasin GSAs as to plan progress in meeting MOs, interim milestones, and MTs.

Due to the complexity of the hydrogeologic setting in the Subbasin as discussed in Section 3.1, *Hydrogeologic Conceptual Model*, the aquifer is divided into three aquifer zones for groundwater level monitoring:

- The A zone is the shallow portion of the aquifer above the A-Clay and in areas where shallow groundwater is present outside of the A-Clay (Figure 5-1).
- The B zone is the unconfined portion of the aquifer above the E-Clay (Corcoran Clay) and below the A-Clay where the A-Clay is present (Figure 5-2).

- The C zone is the confined portion of the aquifer below the E-Clay (Figure 5-3).

The groundwater level monitoring network also considers the Tulare Lake Basin Plan Amendment (BPA) in areas de-designated for municipal (MUN) and agricultural (AGR) uses (see Chapter 3, Sections 3.1.7.2, *Water Quality Method*, and 3.1.8.3, *Aquitards*, and Section 5.4.3, *Water Quality*, below for more details). Groundwater monitoring in those areas and aquifer zones is not proposed as decided by the GSAs that overly this area. These areas are Secondary Management Area A and Secondary Management Area B (Figures 5-1 to 5-5). Other sites are monitored for groundwater levels in the Subbasin and provide additional data to prepare groundwater level maps. These locations are not RMSs and the GSAs desire to keep these data private.

The C-Clay is another lacustrine clay between the A-Clay and the E-Clay; therefore, it is in the B zone (see Figure 3-17 for a map of the C-Clay and Section 3.1.8.3, *Aquitards*, for details on the various lacustrine clays layers). Most of the groundwater production from public supply wells near the lakebed is from wells that tap water below the C-Clay (KDSA et al. 2015). Water above the C-Clay in the clay plug area is typically too saline for MUN or AGR usage and has been exempted from MUN and AGR beneficial use (RWQCB 2017a). The Subbasin GSAs will evaluate groundwater level data where the C-Clay is present, and if future groundwater data indicates a need to separate out portion(s) of the aquifer in certain areas between the C- and E-Clays as another aquifer zone, the GSAs may do so at a that time.

There are areas in the Subbasin where groundwater is not used due to poor water quality and/or, in the clay plug, non-productive strata. Portions of the Subbasin where groundwater pumping does not occur are not proposed to be actively monitored at this time, as described further in Chapter 3, *Basin Setting*. These areas overlay portions of El Rico (ER), Tri-County Water Authority (TCWA), and Southwest Kings (SWK) GSAs. These GSAs desire to seek funding and work collaboratively with state, federal and other potential funding sources to construct monitoring facilities in Secondary Management Areas A and B (Figures 5-1 to 5-5). If monitoring facilities in these areas are constructed, they will be added to the monitoring network. Secondary Management Areas A and B are in the areas de-designated for AGR and MUN use and currently are not required to have new monitoring for water quality according to the Regional Water Quality Control Board (RWQCB), Tulare Lake BPA unless projects are proposed in these areas that would trigger new monitoring (see Chapter 3, Sections 3.1.7.2, *Water Quality Method*, and 3.1.8.3, *Aquitards*, and Section 5.4.3, *Water Quality*, below). In this event, these facilities could be incorporated into the monitoring network for SGMA.

South Fork Kings Groundwater Sustainability Agency

The groundwater level monitoring network for the South Fork Kings (SFK) GSA consists of three A-zone RMS wells and two areas for proposed shallow RMS wells (Figures 5-1 to 5-3; Tables 5-1 and 5-3). The three A-zone RMS locations are dedicated monitoring wells installed and monitored by Kings River Conservation District (KRCD). The GSA Groundwater Level RMS network also includes several other wells consisting of monitoring, agricultural, and municipal wells (Figures 5-1 to 5-3). Three of the RMS locations are based on existing monitoring well clusters (eight total wells) installed by the KRCD. SFK GSA will pursue existing wells to fill data gap areas. If existing wells cannot be found to monitor a given aquifer zone in a data gap area, the GSA will seek funding to install dedicated monitoring wells in data gap areas.

Mid-Kings River Groundwater Sustainability Agency

Mid-Kings River (MKR) GSA intends to include abandoned, unused, or idle wells in the monitoring network as they become available and data can be collected on which aquifer zone a given well monitors. In the event that a given well is not perforated to monitor a specific aquifer zone, then MKR GSA would install dedicated monitoring well(s) or use an existing well if one can be found to monitor that zone (Figures 5-1 to 5-3; Tables 5-1 and 5-2). MKR GSA has six dedicated monitoring wells owned by Kings County Water District (WD). The Kings County WD dedicated monitoring wells will continue to be monitored and will be used as RMSs. The long-term plan for MKR GSA is to develop roughly seven more dedicated monitoring locations that would be used as RMSs. The Kings County WD also has a groundwater monitoring network that relies on existing agricultural wells. Kings County WD intends to continue monitoring those wells to continue the historic record that has been developed. The MKR GSA will evaluate water levels from these wells (some are perforated in a single aquifer but many are composite wells) to understand the relationship of water level in these wells to water level data from wells that are known to monitor a specific aquifer zone.

Southwest Kings and Tri-County Water Authority Groundwater Sustainability Agencies

SWK and TCWA will concentrate their efforts to include existing or abandoned/idle wells with known construction information to minimize the need to build dedicated monitoring wells (Figures 5-1 to 5-3; Tables 5-1, 5-3, and 5-6).

El Rico Groundwater Sustainability Agency

ER GSA will include existing wells in the monitoring network and only construct dedicated monitoring wells as a last resort. About 104 wells in ER GSA are measured for water level including wells monitored by Corcoran Irrigation District (ID) and private landowners (Figures 5-1 to 5-3; Tables 5-1 and 5-5). Most Corcoran ID wells and 99 of the private wells in the ER GSA have pumping records (Appendix D, Table D2-4). Wells in the ER GSA are mostly perforated below the Corcoran Clay in the C zone; however, some are perforated above the Corcoran Clay in the B zone (Table 5-5).

5.1.1 Monitoring Network Objectives

> **23 CCR §354.34(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 effects 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.*

The objectives of the various monitoring programs include the following:

- Establish baseline groundwater levels and groundwater quality and record long-term trends going forward;
- Use data gathered to generate information for water resources evaluations and annual changes in water budget components;
- Determine the direction of groundwater flow;
- Provide comparable data from various locales within the Subbasin;
- Demonstrate progress toward achieving measurable objectives, interim milestones, and minimum thresholds described in the GSP as they relate to the Sustainable Management Criteria; and
- Develop the data to evaluate impacts to the beneficial uses or users of groundwater.

The path to achieving the objectives of the monitoring network includes collecting and evaluating the data needed for the Subbasin GSAs to monitor the Subbasin's progress in meeting MOs, interim milestones, and MTs relative to groundwater conditions and impacts to beneficial users of groundwater. The data collected through the monitoring network will also help quantify changes in the water budget components.

Groundwater level monitoring, groundwater storage estimations, and groundwater quality monitoring will utilize existing monitoring, irrigation, municipal, industrial, domestic, and proposed monitoring wells for RMSs. Below is a summary of the Subbasin GSA's planned monitoring networks. Monitoring is not proposed in areas outside of the Subbasin. Data sharing agreements are being developed or will be developed with adjacent groundwater subbasins in order to evaluate boundary conditions. Currently, the SFK GSA has a data sharing agreement with North Fork Kings GSA. SFK and SWK GSAs have data sharing agreements with Westlands WD.

5.1.2 Design Criteria

New monitoring locations will be developed and existing networks enhanced, when necessary, using an approach similar to the Data Quality Objective (DQO) process to guide the GSAs site selection. The DQO process follows the U.S. Environmental Protection Agency (EPA) Guidance on Systematic Planning Using the Data Quality Objective Process (EPA 2006). The DQO process is also outlined in the California Department of Water Resources (DWR) Best Management Practices for the Sustainable Management of Groundwater - Monitoring Networks and Identification of Data Gaps (DWR 2016e) and Monitoring Protocols, Standards, and Sites (DWR 2016f). While the DQO process was not developed specifically to guide the selection of new monitoring locations under SGMA, it does provide a repeatable process for site selection and evaluation so that the GSAs approach site selection in a similar manner.

The dedicated monitoring wells to be installed above the A-Clay or above the E-Clay in the Subbasin are recommended to be 4-inch Schedule 80 polyvinyl chloride (PVC) casings. Deep monitoring wells installed below the E-Clay are recommended to be 5- or 6-inch Schedule 80 PVC casings. This will ensure that representative water quality samples may be collected at these locations. Additional groundwater quality information will be collected and reviewed from agencies and entities currently monitoring for groundwater quality. Monitoring wells constructed in subsiding areas or deep monitoring wells extending below the Corcoran Clay may need to be designed with compression sections to help avoid collapse of the casings as decided by the individual GSA. Blank casing sections should be steel instead of PVC and casing centralizers should be installed. If abandoned wells are included in monitoring networks they need to be re-developed prior to beginning data collection to ensure they are not plugged and to remove any accumulated downhole equipment lubricant (oil), if present. Groundwater level data collected from these wells would need to be evaluated annually to ensure they continue to provide valid data. If the collected data appears to deviate from nearby wells in the same aquifer zone the wells will need to be re-developed as needed. Abandoned wells may not be included in the groundwater quality monitoring network as they will likely not have pumps in them, and evacuating enough volume to properly purge the well prior to sampling, using low-flow pumps, would not be cost effective.

Chapter 4, *Sustainable Management Criteria,* details the MTs, MOs, and interim milestones applicable to each sustainability indicator.

5.1.3 Overview of Existing Programs

Government agencies and private entities currently have existing programs in place that monitor groundwater levels, groundwater quality, and land subsidence. These programs will be utilized for future data collection and will be coordinated with SGMA monitoring requirements. If data from these sources becomes unavailable in the future, the monitoring network will be modified to monitor for the appropriate sustainability indicator. Below are the various programs currently in place that will be described further in Sections 5.1.5 to 5.1.8.

Groundwater Levels

- Kings County WD
- Apex Ranch
- KRCD
- California Statewide Groundwater Elevation Monitoring (CASGEM)
- Municipal monitoring programs
- Corcoran ID
- Private landowners in parts of ER GSA

Groundwater Quality

- Municipal public supply wells monitoring programs
- Groundwater Ambient Monitoring and Assessment Program
- ILRP
- Central Valley Salinity Alternatives for Long-term Sustainability
- Groundwater monitoring at sites with RWQCB wastewater discharge requirements
- Groundwater monitoring at subsurface drainage evaporation ponds

Land Subsidence

- United States Geological Survey (USGS) Monitoring
- National Aeronautics and Space Administration (NASA) Monitoring
- Central Valley Spatial Reference Network (CVSRN) Continuous Global Positioning System (CGPS) Stations
- KRCD network
- Kaweah Delta Water Conservation District (KDWCD) benchmarks
- California Aqueduct subsidence monitoring benchmarks

- University Navigation Satellite Timing and Ranging Consortium (UNAVCO)
- National Geodetic Survey (formerly U.S. Coast and Geodetic Survey)
- United States Army Corps of Engineering (USACE)

Existing facilities that are not associated with an existing program include private wells for AGR or domestic use. Including these wells in the existing monitoring networks will be the responsibility of the individual GSA.

5.1.4 Overview of Proposed Facilities

Proposed facilities for the groundwater level network include 34 monitoring wells (or existing wells that monitor a specific aquifer zone) to fill existing data gap areas (Figures 5-1 through 5-3). The two proposed extensometers are initially proposed to be located in the vicinity of Corcoran and an area south of Lemoore (Figure 5-4). If funding or other agreements are made for the construction of the proposed extensometers, the locations will be refined by the GSA(s) at that time based on up-to-date subsidence maps and benchmark data. The proposed monitoring wells may be necessary if existing wells cannot be identified to fill spatial data gaps in the network. There are three general types of data gaps to consider for monitoring networks.

- Temporal: Insufficient frequency of monitoring. For instance, data may be available from a well only in the fall since it is rarely idle in the spring. In addition, a privately owned well may have sporadic access due to locked security fencing, roaming dogs, change in ownership, etc. Going forward, wells in the monitoring network will be measured at a minimum in October for the seasonal low and in February through April for the seasonal high, as determined by the GSA, which will mitigate temporal inconsistencies.
- Spatial: Insufficient number or density of monitoring sites in a specific area.
- Insufficient quality of data: Data may be available but be of poor or questionable accuracy. Inaccurate data may at times be worse than no data, since it could lead to incorrect assumptions or biases. The data may not appear consistent with other data in the area, or with past readings at the monitoring site. The monitoring site may not meet all the desired criteria to provide reliable data, such as having information on well perforation depth, etc. Well location information on Well Construction Reports is often inaccurate (making it difficult or uncertain to match wells with their well logs), and these wells will need to be field located.

5.1.5 Groundwater Levels

Groundwater level monitoring has occurred in most areas of the Subbasin on a semi-annual basis since the 1950s (Provost & Pritchard 2011; WRIME 2005). Kings County WD, KRCD, Corcoran ID, DWR, and the United States Bureau of Reclamation (USBR) and private landowners have measured and/or are currently measuring groundwater levels as part of existing monitoring programs. Well logs and construction information are not available for all of these wells but as described in Section 5.4.1.2*, supplemental well construction data may be collected in the future*. Since 2009, DWR has also asked local agencies to collect and report groundwater level data under the CASGEM program. Kings County WD, KRCD, and Tulare Lake bed water agencies participate in CASGEM and report groundwater level data on a semi-annual basis (Provost & Pritchard 2011; DWR 2010; Summers Engineering 2012; WRIME 2005). These agencies will continue monitoring semi-annually for future data collection and may expand, as needed, to comply with SGMA monitoring requirements. Each agency will monitor groundwater levels in October and a minimum of 90 days later in February through April each year to provide consistency in the timing of measurements. Groundwater level data collection protocols will follow methods in the DWR's Best Management Practices for the Sustainable Management of Groundwater - Monitoring Protocols, Standards, and Sites (DWR 2016f).

RMS groundwater level locations have MOs to gauge the effectiveness of plan implementation measures and evaluate MTs that define undesirable results in the Subbasin. The proposed RMS monitoring network, when built-out, will include a density of RMSs of up to two wells for the B zone (above the E-Clay) and C zone (below the E-Clay), and one well for the A zone (above the A-Clay where it is present) for the 36-square mile Townships wholly in the Subbasin where the GSAs desire to monitor (Figures 5-1 to 5-3). Generally, if more than about half of a Township is within the Subbasin, RMS well densities were kept the same as for those Townships wholly in the Subbasin. Greater RMS well densities are focused around concentrated pumping areas and cities including Hanford, Lemoore, Corcoran and unincorporated communities. Data on the depth and perforated intervals of the monitoring wells or existing wells is required according to SGMA guidelines unless the GSA can demonstrate that such information is not needed to understand and manage groundwater in the Subbasin. The GSAs plan to obtain additional construction information on wells in the monitoring networks that lack well construction information. Some of the wells in the monitoring network do not have consistent measurements for consecutive years throughout their operational life for numerous reasons including lack of access, breaks in well casings, wells running during data collection, damaged or broken well sounding equipment, oil in the casings fouling of sounding equipment, bees, and other unforeseen circumstances. The GSAs will work with landowners to alleviate these issues as possible and include redundancy in the monitoring networks when feasible. Groundwater levels will be measured in the monitoring network wells each, as described above, in October and February through April. The timing of water level data collection will be coordinated between the GSAs so that the data is collected in as short a period as practicable.

Groundwater levels are measured in the various networks and types of wells including:

- Kings County WD: The Kings County WD encompasses a land area of approximately 143,000 acres between Tulare Lake Subbasin and Kaweah Subbasin. Water level measurements are taken semi-annually on average from 255 wells in both the spring and fall. The Kings County WD's monitoring program is divided into two distinct monitoring programs: (1) Apex Ranch Conjunctive Use Project Monitoring Program and (2) a district-wide monitoring program. The Kings County WD began routinely measuring groundwater levels district-wide in the 1950s. The district-wide data collection effort also includes data sharing with adjacent districts and groundwater basins and evaluates groundwater levels above the A-Clay and above the E-Clay.
- Apex Ranch Conjunctive Use Project Monitoring Program: The monitoring network consists of 40 to 45 off-site and on-site, agricultural, domestic, and dedicated monitoring wells. Several of the monitoring wells, both on site and off site, are equipped with data loggers that allow for data collection at set intervals and flexibility in the frequency that the data can be collected. These data are continuously recorded throughout the year.
- KRCD: Current groundwater level monitoring program includes semi-annual groundwater level measurements (WRIME 2005). KRCD also samples wells for the KRWQC-ILRP Groundwater Trend Monitoring.
- Corcoran ID: The Corcoran ID monitors water level elevation in approximately 74 wells in the Subbasin. Based on available data it appears that about 45 percent (%) of these wells are perforated above the Corcoran Clay in the B zone and about 55% are perforated below the Corcoran Clay in the C zone. Most Corcoran ID wells have some pumping records. The number of wells pumped in Corcoran ID can change from year to year.
- CASGEM Wells: DWR collects groundwater levels reported by local agencies and reports them through the CASGEM program. There are currently 17 CASGEM wells in the Subbasin.
- Municipal Wells: Most municipal wells are available for water level and/or water quality monitoring in Hanford, Lemoore, Corcoran, Armona, Home Garden, Kettleman City, Stratford, and others.
- Private Wells in ER GSA: There are approximately 99 private wells in ER GSA with reported historical pumping records and construction information, and 30 wells with some water level data. Of the 30 wells with water level data, 8 appear to be B zone (above the Corcoran Clay) and 22 appear to be perforated below the Corcoran Clay in the C zone.
- Wells in Adjacent GSAs: Groundwater level data from adjoining subbasins will also be collected through data sharing agreements to help provide better interpretation of GSA boundary flow conditions. Long-term agreements still need to be prepared to collect/share data with other subbasins.

5.1.6 Groundwater Storage

A groundwater model was originally developed for the Subbasin in 2017-2018 and further refined in 2019 (Appendix D). The groundwater model was used to estimate the overall annual change in groundwater storage over the model calibration period of 1996 to 2016 for the unconfined and confined portions of the aquifer. The groundwater model calculates the change in groundwater storage over time using the change in hydraulic head of the aquifer, and the assumed storage coefficients or specific yield of the dewatered sediments.

In the future, for annual reporting, groundwater level contour maps will be prepared and estimates of annual storage change will be calculated by comparing current year seasonal high to the previous year seasonal high groundwater contour sets. The resulting change in head will then then be multiplied by specific yield values (see Section 3.1.9) to estimate change in storage.

The storage change monitoring network is the same as the water level monitoring network. RMS well locations are linked to specific aquifer zones, and as such, data from these wells will be weighted heavier than wells without construction information. It should be noted that even though a well may not have construction information, the data can still be used in constructing water level maps if the data is consistent with water levels from RMS wells.

5.1.7 Groundwater Quality

The Subbasin is relying on already existing groundwater quality monitoring programs. Groundwater quality monitoring may supplement, as needed, groundwater quality monitoring currently under the oversight of an existing regulatory agency or groundwater quality coalition. See Section 3.2.5 for more information on existing groundwater quality monitoring in the Subbasin.

5.1.8 Land Subsidence

For land subsidence, the existing CVSRN CGPS in the area will be used as RMSs for the Subbasin. Additional land subsidence data can be gathered from the entities listed in Section 5.1.3 to evaluate subsidence across the Subbasin. These data will be evaluated annually and if subsidence rates approach MOs at the nearest CGPS station, then additional RMSs may be added as determined by the GSA. The GSAs are exploring partnership opportunities with KRCD or other similar entities to potentially expand the land subsidence monitoring network in the Subbasin. Two extensometers are proposed in areas of known subsidence, pending funding or collaboration with DWR or the USGS. Regional-based Light Detection and Ranging (LiDAR) subsidence maps may also be evaluated to identify areas of subsidence, in areas where there are no current benchmarks. As funding opportunities become available, additional subsidence monitoring facilities may include extensometers for depth discrete subsidence monitoring near or in the areas shown on Figure 5-4.

Land subsidence is discussed in further detail in Section 3.2.6, *Land Subsidence*. The Subbasin is included in areas monitored for subsidence by regional water agencies or the state and federal governments. Measurement and monitoring for land subsidence is performed by USGS, KRCD, USACE, UNAVCO, and various private contractors. Interagency efforts between the USGS, the U.S. Coast and Geodetic Survey (now the National Geodetic Survey), and DWR resulted in an intensive series of investigations that identified and characterized subsidence in the San Joaquin Valley. NASA also measures subsidence in the Central Valley and has maps on their website that show the subsidence for defined periods (NASA n.d.).

Surface land subsidence caused by excessive groundwater withdrawals that has the potential to impact critical infrastructure is identified as the sustainability indicator for land subsidence by the Subbasin GSAs, see C 4. Potential critical infrastructure currently in the Subbasin, as defined by the GSAs is listed in Section 4.3.2. Plans for infrastructure currently in the design stage can be adjusted to accommodate expected continued subsidence, for example, the California High-Speed Rail (LSCE, Borchers and Carpenter 2014). Individual GSAs may work with the other agencies/authorities to mitigate potential effects of subsidence, if needed. Deep groundwater pumping adaptive management programs or policies will be determined as needed by the GSA.

The California Aqueduct borders the Subbasin from about Kettleman City and south along the western boundary of SWK GSA adjacent to the alluvial groundwater basin. The GSAs will continue to collect and evaluate subsidence data from subsidence monitoring locations along the area of the California Aqueduct and Interstate 5.

The GSAs have initially defined MOs, interim milestones, and MTs for subsidence in the Subbasin at two CVSRN-CGPS stations: LEMA and CORC. see Chapter 4, Table 4-2a,b for the Sustainable Management Criteria at the LEMA CGPS location, and Chapter 4, Table 4-3a,b for the Sustainable Management Criteria for the CORC CGPS location.

5.1.9 Consistency with Standards

> **23 CCR §354.34(g)** *Each Plan shall describe the following information about the monitoring network:*
> *(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.*

The data gathered through the monitoring networks will be consistent with the standards identified in 23 CCR §352.4 related to Groundwater Sustainability Plans. The main topics of 23 CCR §352.4 are outlined below:

- Data reporting units (water volumes including surface water deliveries, estimates of groundwater pumping, etc., reported in acre-feet [AF], etc.)
- Monitoring site information (site identification number, description of site location, etc.)
- Well information reporting (CASGEM well identification number or other unique identifier, measuring point elevation, casing perforations, etc.)
- Map standards (data layers, shapefiles, geodatabases submitted in accordance with the procedures described in Article 4 of the SGMA regulations – Procedural issues related to submission of plans and public comment to those plans, etc.)
- Hydrograph requirements (hydrographs shall use the same datum and scaling to the greatest extent practical, etc.). Hydrographs will also be plotted showing depth to water as well as groundwater elevation.

5.2 Monitoring Protocols for Data Collection and Monitoring

> **23 CCR §352.2** *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.*
>
> **23 CCR §354.40** *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.*

The DQO process will be used to develop monitoring protocols that assist in meeting MOs and sustainability goals of this GSP (EPA 2006). The DQO process includes the following:

- State the problem;
- Identify the goal;
- Identify the inputs;
- Define the boundaries of the area/issue being studied;
- Develop an analytical approach;

- Specify performance or acceptance criteria; and
- Develop a plan for obtaining data.

Groundwater level, groundwater quality (if the GSAs participate in groundwater quality monitoring), and land subsidence monitoring will generally follow the protocols identified in the DWR Best Management Practices for the Sustainable Management of Groundwater - Monitoring Protocols, Standards, and Sites (DWR 2016f). Monitoring Protocols will be reviewed at least every five years as part of the periodic evaluation of the GSP and updated as needed. The GSAs may develop standard monitoring forms in the future if deemed necessary.

The following comments and exceptions to the Best Management Practices (BMPs) should be noted:

- SGMA regulations require that groundwater levels be measured to the nearest 0.1-foot. The BMP suggests measurements to the nearest 0.01-foot; however, this is not practical for many measurement methods. In addition, this level of accuracy would have little value since groundwater contours maps typically have 10- or 20-foot intervals, and storage calculations are based on groundwater levels rounded to the nearest foot. The accuracy of groundwater level measurements will vary based on the well type and condition. For instance, if significant oil is found in an agricultural well then readings to the nearest foot are likely the best one can achieve. As well, a methodology will need to be developed to keep track of the amount of oil in these wells, and if possible, have the oil removed when the pump is removed for other reasons.
- Water level data will be collected and sounding equipment maintained using standard operating procedures. When feasible well sounding equipment will be dedicated for either irrigation or domestic wells.
- Wells will be surveyed to a horizontal accuracy of 0.5 foot, preferably to 0.1 foot or less.
- In subsiding areas periodic measurements may be required to determine the elevations of the measuring points for measured wells. Individual GSAs may develop subsidence monitoring programs as needed.
- Unique well identifiers will be labeled on all public wells, and on private wells if permission is granted.
- The BMPs state that static groundwater elevation measurements should be taken preferably within a one- to two-week period. This is likely not feasible due to the large number of wells in the Subbasin and the differing seasonal high groundwater conditions by GSA. As described above, for semi-annual (two times per year) monitoring, measurements are to be taken in October for the seasonal low groundwater condition and February through April for the seasonal high groundwater condition depending on the GSA. In addition, where groundwater quality and funding allows, individual GSAs

may install data loggers in wells, most likely in dedicated monitoring wells and a select subset of existing wells.

- If a vacuum or pressure release is observed, then water level measurements will be measured every five minutes until they have stabilized.
- In the field, water level measurements will be compared to previous records; if there is a significant difference, then the measurement will be verified by measuring the well to double-check the measurement. If there is a reason that the person measuring the well can determine for why the measurement is inconsistent, it will be noted.
- For water quality monitoring (if or when the GSAs perform water quality sampling), field parameters for pH, electrical conductivity, and temperature will only be collected when required for the parameter being monitored. Determining if a well has been purged adequately may be ascertained by calculating a run time before sampling. For irrigation wells, samples will be taken when the well has been running long enough that an adequate volume has been removed (typically 3 to 5 well bore volumes and field parameters are stable).

5.3 Representative Monitoring

23 CCR §354.36 *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…
(c) The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.

DWR has referred to representative monitoring as utilizing a subset of sites in a management area. The GSP has developed a monitoring network of RMS wells where MOs, MTs, and interim milestones are defined in further detail in Section 4.4 and 4.5, *Minimum Thresholds* and *Measurable Objectives*. Groundwater conditions can vary substantially across the Subbasin and the use of a small number of representative wells in the Subbasin is not practical to cover such a large area with varying conditions. The network will strive to fill data gaps with existing wells that have well construction information and historical groundwater level data. Proposed monitoring sites may include clustered wells, if existing wells cannot be identified and used, that will be able to provide data for different aquifer zones at a single location.

The GSP does not plan to use groundwater elevations as a proxy for monitoring other sustainability indicators. As noted, groundwater elevations will be used as a critical component of groundwater storage change estimation, but the groundwater elevation monitoring will not replace or be used as a proxy for storage change estimations.

The GSAs will rely on the distribution of existing subsidence monitoring points coupled with the regional-based subsidence mapping to sufficiently cover the Subbasin, initially, and that the two CGPS stations (LEMA and CORC) are generally located in potentially viable subsidence RMS locations.

5.4 Assessment and Improvement of Monitoring Network

23 CCR §354.34(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.

This section reviews and evaluates the adequacy of the monitoring network, identifies data gaps, and describes methods to fill data gaps.

5.4.1 Groundwater Levels

5.4.1.1 Monitoring Frequency and Density

The CASGEM Groundwater Elevation Monitoring Guidelines (DWR 2010) were used to estimate the density of RMS wells needed for the Subbasin per the DWR's Best Management Practices for the Sustainable Management of Groundwater - Monitoring Networks and Identification of Data Gaps (DWR 2016e). The Subbasin GSAs collect water level data from more wells than the density requirements for RMSs as discussed below. The density of RMS wells outlined here is meant to meet the density requirements in the DWR Best Management Practices for the Sustainable Management of Groundwater - Monitoring Networks and Identification of Data Gaps (DWR 2016e), but data may continue to be collected from the various networks at higher densities needed to prepare groundwater contour maps. As feasible, the GSAs will evaluate the RMS network and make adjustments as needed over time.

CASGEM guidelines (DWR 2012) reference the Hopkins and Anderson (Hopkins 2016) approach which incorporates a relative well density based on the amount of groundwater used within a given area (DWR 2016e). The densities range from 1 well per 100 square miles to 1 well per 25 square miles, based on the quantity of groundwater pumped. A minimum density of 1 well per 25 square miles is recommended for basins pumping over 10,000 AF of groundwater per year per 100 square miles. Groundwater use varies throughout the Subbasin with many areas currently exceeding 10,000 AF/year per 100 square miles. As a result, a well density of approximately 1 RMS well per 25 square miles will be used. For this evaluation, well density is tracked per 36-square mile Township, which results in about 1.5 wells per Township. A more practical value of 2 wells per Township per aquifer zone is adopted resulting in a density of about 1 RMS well per 18 square miles. The RMS well density above the A-Clay and in areas of shallow groundwater outside of the A-Clay is recommended to be 1 well per Township because groundwater use is estimated to be less than the amount needed for a 2 well per Township density. Areas that have little to no pumping (de-designated areas or poor strata for groundwater production in the Tulare Lakebed area; reference Section 3.1.7.2, *Water Quality Method*, for more information), may have 0 to 1 well per Township. In general, each proposed RMS monitoring site, assuming a dedicated monitoring well is constructed if an existing well cannot be found for a given aquifer zone, will include monitoring above the A-Clay (where it is present and is used as a major water source), and above and below the Corcoran Clay where it is present. When economically feasible and practical, and existing wells cannot be identified for use, dedicated monitoring wells will be installed. Use of dataloggers will be evaluated by the GSAs on a case by case bases. It should be noted that the use of data loggers in areas of the Subbasin that have poor groundwater quality can be problematic and, as mentioned above, use of data loggers will be evaluated on a case-by-case basis by the GSAs.

Monitoring sites include RMS wells, which are defined as wells with reliable access during semi-annual water levels readings each year, known information on the well depth and perforated interval (or the GSA is reasonably certain of which aquifer zone a given wells is perforated in), and have adequate depth to accommodate seasonal fluctuations. Wells that do not meet these guidelines may be maintained in the network as monitoring locations, as they can still provide useful information. Well construction information on these wells may be obtained in the future, and assigned to a specific aquifer zone, if applicable. Regardless of the how these wells are constructed, water level data will continue to be collected in them to continue the record and provide valuable operational information for the well owner.

If more frequent data collection is required to demonstrate progress toward sustainability, monitor impacts to beneficial use of groundwater, monitor groundwater levels more closely, and/or quantify annual or seasonal changes in groundwater conditions, then the GSAs will re-evaluate the monitoring network and make changes as appropriate. Use of data loggers will be on a case-by-case basis as evaluated by the GSA. Data loggers, when they work successfully, can provide valuable data to evaluate short-term, seasonal, and long-term trends.

Groundwater levels will be measured in October for seasonal low conditions and in February to April for the seasonal high conditions depending on the GSA. The February through April water level measurements are designed to capture the recovery of groundwater levels after a seasonal period of minimal demand. The October measurement would capture a period after peak irrigation and summertime peak urban demands have declined, thereby showing the cumulative impacts on the groundwater basin before the seasonal winter and spring recovery has taken place.

5.4.1.2 Identification of Data Gaps

> **23 CCR §354.38** *(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:*
> *The location and reason for data gaps in the monitoring network.*
> *Local issues and circumstances that limit or prevent monitoring.*

Lack of Pumping Data

Most groundwater users have not kept track of how much water they have pumped or have not disclosed how much they have pumped. The GSA boards are considering direct measurement of groundwater options which may include flow meters.

Temporal Data Gaps

Some of the current wells used for data collection have not been measured consistently year after year, and therefore, temporal data gaps exist ranging from one year to over a decade. The GSAs designed a data collection program that assures semi-annual data collection. The GSAs' future monitoring efforts will increase the reliability of groundwater level readings given their importance to active management and compliance documentation. If a water level reading cannot be taken at a given well, the reason will be documented. The individual GSAs will determine if or when additional attempts will be made to collect that data. Temporal adjustments may be made for the different aquifer zones or in certain areas. For example, semi-annual water level readings in above the A-Clay wells is probably sufficient to capture seasonal and long-term trends in most of that aquifer zone because water levels in the aquifer are relatively stable in most of the area. Near the Kings River it may be desirable to collect more frequent data from above the A-Clay to better understand the relationship between the river and shallow groundwater. As well, in areas where there is more pumping from below the E-Clay, it may be desirable to collect data more frequently due to relatively rapid changes in head pressure in confined aquifers. More frequent data may also be needed from the aquifer above the E-Clay in areas where it is the main aquifer in which wells are perforated. The need to collect more frequent data and from which aquifer zone will be evaluated by the individual GSA.

Spatial Data Gaps

Currently, there are spatial data gaps throughout the Subbasin. Spatial data gaps are primarily in the southern/southwestern region of the Subbasin where groundwater is not used due to poor water quality, and in the lakebed area due to lack of productive strata and poor water quality. These areas are delineated as Secondary Management Area A and Secondary Management Area B (Figures 5-1 to 5-5). Consequently, groundwater levels are unknown for most of this area and minimal monitoring sites are proposed there to fill this data gap, since groundwater is not a resource that needs to be managed in this area to the benefit of the overlaying landowners. There are active wells east of the Tulare lake area clay plug, and RMS wells are located in these areas. In other areas of the Subbasin, data gaps are primarily due to the lack of known well construction. There are also spatial data gaps in the northern portion of the Subbasin, primarily related to well distribution in the various aquifer zones (Figures 5-1 to 5-3). Since the aquifer above the A-Clay (the A zone) is not used as a primary water source in most of the Subbasin, the spatial coverage does not have to be as dense as the more heavily pumped portions of the aquifer; i.e., the B zone above the Corcoran Clay and the C zone below the Corcoran Clay).

Insufficient Quality of Data

Currently, most of the wells monitored in unincorporated areas are privately owned. Specific well construction information, including depth and perforated interval, are not programmed into the model for most of these wells. While these wells may not provide ideal data points, they will continue to be monitored even if well construction data is collected which indicates the well is a composite well (perforated across multiple aquifer zones, in the Subbasin usually across the Corcoran Clay). Many well owners and water management agencies find this data relevant to their operations, and while these wells may not be compliant for SGMA reporting, data may continue to be collected from them as decided by the GSAs. Collecting well construction information is especially important throughout the Subbasin which is underlain, to a large extent, by the Corcoran Clay layer and other smaller aquitards. It is still desirable to know wells construction information, and if a Well Completion Report (WCR) is not available, other methods, including television (TV)/video surveys or sonic logs can be used to determine well construction. Once a well's construction is known, the aquifer zone(s) it is perforated in can be confirmed. When funding allows and an existing well cannot be found to monitor a specific aquifer zone, dedicated monitoring wells may be installed at targeted depths and perforated intervals to fill spatial data gaps.

5.4.1.3 Plans to Fill Data Gaps

> **23 CCR §354.38(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.*

The RMS groundwater level network has data gaps, such as missing construction or partial construction information for some RMS wells. The goal is to have accurate well construction information for RMS wells monitored for groundwater level that currently lack construction information within 5 years of plan implementation if possible. Well construction information will be needed for at least 5 existing A-zone wells, 1 existing B-zone well, and 7 existing C-zone wells. As well, as shown on Figures 5-1 to 5-3, there are 3 A-zone areas with data gaps, 12 B-zone areas with data gaps, and 18 C-zone areas with data gaps that need to be filled to achieve the RMS well density of 2 wells per Township for the B and C aquifer zones, and one well per Township density in the A zone. The GSAs prefer to fill the areas with data gaps with existing wells, if possible, but will construct dedicated monitoring wells as funding becomes available. These data gaps can be filled using the four alternatives below:

- **Collect Well Completion Reports.** WCRs will provide the needed information if a WCR can be positively linked to a well. These could be collected from the landowner or DWR; however, several challenges exist since so many have been drilled in the area and location information in the reports can be inaccurate. However, WCRs for private wells may not always be available to the GSAs.
- **Perform a video inspection of wells to obtain construction information.** A video inspection or TV survey can be performed on desired wells to determine the total depth and perforated interval. Video inspections can be performed when the pump is pulled for other reasons. As well, the GSAs can work with well owners to obtain existing videos or TV surveys. Recognize that video inspection would not provide information on the aquifer material.
- **Replace monitor point with an alternate private well:** Private wells without construction information could be replaced with another existing well with available well construction information. This may be simpler and less costly than a video inspection. However, changing monitoring well locations is not always desirable, since it is preferred to continue measurements in wells that have a long period of record (i.e., many years of groundwater level data).
- **Construct a dedicated monitoring well:** Dedicated monitoring wells are relatively expensive to construct, and their installation will depend on available funding. Dedicated monitoring wells will only be constructed if an existing private well cannot be found.

For those GSAs that do not have known construction for some of the wells in their RMS monitoring networks, they will either collect construction information on wells lacking well construction information by 2025, or will fill the gaps with monitoring sites with complete data.

The proposed dedicated monitoring wells, if an existing well cannot be found, will be nested (multiple casings installed in a single borehole) or clustered monitoring wells (multiple wells located close together). It is probable that with the recommended casing diameters, most multi-depth zone monitoring wells will need to be clustered as opposed to nested. This allows for monitoring groundwater levels at different aquifer zones at a single location or in close proximity to each other for clustered wells.

In the event that an existing RMS well becomes unavailable for water level monitoring, existing wells that monitor the same aquifer zone will need to be found and added to the network, or a dedicated monitoring well will need to be constructed. As well, an individual GSA may decide to continue to collect well construction information and allow monitoring of additional wells so that the water level monitoring network has redundant wells that meet the criteria for an RMS well. GSAs that develop and maintain a working list or an inventory of wells available for monitoring may choose to add these as RMS wells to increase RMS density. Water levels will be collected in these wells during the semi-annual water level monitoring events so that if an existing RMS well is no longer available for monitoring, an alternate well is readily available for use in the RMS water level network. Developing an inventory of wells additional to the RMS wells, and whether or when to add these wells to the RMS water level network will be decided by the individual GSAs.

5.4.1.4 Site Selection

> **23 CCR §354.34(g)** *Each Plan shall describe the following information about the monitoring network:*
> *(1) Scientific rationale for the monitoring site selection process.*

The scientific rationale for the groundwater level monitoring network includes the following:

- Existing wells with known construction information were preferentially selected for RMS wells.
- Other wells have over 20 years of water level data and are useful for long-term evaluations even though they may reflect multiple aquifer zones. These wells will continue to be monitored as this information is important to users of groundwater.
- The RMS network density follows the guidelines from DWRs' Best Management Practices for the Sustainable Management of Groundwater - Monitoring Networks and Identification of Data Gaps (DWR 2016e) to determine the RMS density.

The following scientific rationale will be used to add new RMS wells:

- Add wells, whenever necessary to maintain a minimum RMS monitoring well density.
- Avoid wells perforated across multiple aquifer zones for RMS wells, especially wells penetrating the Corcoran Clay and/or the A-Clay.

- Select wells that have access during semi-annual water level readings, preferably wells that do not have gates or access issues.
- Select sites for dedicated monitoring wells as far as possible from existing active wells.
- Active wells are preferred over idle or unused wells.
- Select wells with available construction information (i.e., depth, perforated interval).
- Select existing wells over constructing monitoring wells where feasible.

If data for a specific monitoring site is lacking, other wells in the vicinity which have the desired attributes, if available, can be added to increase the monitoring network's scope and breadth.

Figures 5-1 through 5-3 show existing RMS wells and areas that need additional RMS wells to fill data gap areas. As mentioned above, the GSAs will endeavor to fill data gaps with existing wells that meet the criteria above for an RMS monitoring point or will construct dedicated monitoring wells if funding is available.

5.4.2 Groundwater Storage

Groundwater storage change will be calculated using groundwater level contour maps from seasonal high groundwater conditions of successive years. Groundwater storage calculations are largely dependent on the groundwater level monitoring network. Collection of well attribute information described above will also benefit groundwater storage change evaluations. In addition, groundwater released from clays due to subsidence will also be evaluated annually from data collected from the land subsidence monitoring network.

5.4.2.1 Monitoring Frequency and Density

Annual groundwater storage changes by each GSA will be calculated so individual GSAs can evaluate progress towards meeting MOs. The data used to estimate storage change will be the water level data collected from the water level networks. This data will be collected, as mentioned above, at a minimum every October and February through April. In addition, also as discussed above, the GSAs will continue to collect data at more wells than the RMSs. This additional data will be used in conjunction with data from the RMSs to prepare groundwater contour maps which are then used to estimate storage change. The individual GSA storage change information will be aggregated for reporting to the DWR for the Subbasin as a whole.

5.4.2.2 *Identification of Data Gaps*

The most significant data gaps in the groundwater storage change monitoring network include:

- Information on well construction related to understanding groundwater pumping from the different aquifer zones;
- Aquifer characteristics of storativity, specific yield, and hydraulic conductivity/ transmissivity to better define the amount of groundwater in saturated aquifers, annual storage change, and boundary flows;
- Shallow groundwater level data near rivers, creeks, and canal systems to characterize recharge;
- Groundwater levels from wells with known construction along the Subbasin boundary that could better characterize groundwater flows in and out of the Subbasin, especially in the B and C zones;
- The amount of groundwater being released through subsidence and how that relates to changes in groundwater storage; and
- The amount of water released from clays due to subsidence.

Other data gaps in the groundwater storage network are the same as in the groundwater level monitoring network, as described above, since storage change is dependent on changes in groundwater levels.

5.4.2.3 *Plans to Fill Data Gaps*

Data gaps in the storage change monitoring network will be filled as data gaps in the groundwater level network, as discussed in Section 5.2, *Monitoring Protocols for Data Collection and Monitoring*, are filled.

- **Groundwater Pumping.** There are areas of the Subbasin where not all wells have flow meters and, therefore, no record of the amount of groundwater pumping exists. The estimates of groundwater pumping included in this GSP, in many areas, are developed based on assumptions of how much crops require for ideal irrigation and then subtracting out effective precipitation and applied surface water. GSAs in the Subbasin plan to monitor groundwater pumping directly in the future to better understand this key water balance component. Also, the lack of construction information on many wells has led to a gap in understanding how much water is being pumped from each aquifer zone. Some actual pumping data plus estimates are being used for modelling purposes. Only after the construction of wells in the Subbasin is better understood, then the amounts being pumped from each aquifer zone can begin to be managed.
- **Coordination with Adjacent Subbasins.** The Subbasin is surrounded by five other critically overdrafted subbasins. Coordination with adjacent subbasins and the

development of additional groundwater level monitoring facilities will be needed along the edge of the Subbasin to more accurately estimate the amount of groundwater flow in and out of the subbasins. From the groundwater modeling evaluations, it is clear that if conditions in adjacent subbasins don't improve, it will impact the ability of the Subbasin to achieve sustainability.

- **Recharge/Conveyance Loss Measurements.** There are many surface water right holders in the Subbasin that are partnering with local GSAs. The current measuring facilities on rivers, creeks and canals have been developed for surface water delivery and flood control purposes. Developing new measuring locations in order to refine information on recharge and conveyance losses will be important for water budgets and change in storage estimates. Local GSAs will work with their partners to develop new facilities as needed.
- **Aquifer Characteristics.** Estimates are currently being made about the specific yield or storativity of aquifers in the Subbasin. The GSAs will implement requirements relating to the development of new wells to develop a broader understanding of the variability of aquifer parameters throughout the Subbasin. This broader understanding will over time help refine estimates of groundwater in storage and groundwater flows.
- **Geology.** The current hydrogeologic conceptual model (HCM) for the Subbasin is based on the most current scientific information, but that information is limited. Much of the work that USGS and others have done on mapping the most significant geologic/ hydrogeologic features in the Subbasin are from evaluations of oil wells or water wells. Data from these wells, especially electric logs, are useful in developing an understanding of the subsurface at that location, but this data may not be available at a sufficient density to fill gaps in the HCM for an area of over half a million acres. New technologies may be able to fill in some of the missing information and provide a more accurate or complete HCM for the Subbasin. It is hoped that grant funding may be available for this type of effort or that the state develops this information on behalf of its groundwater basins to improve its understanding of this important resource.

5.4.2.4 Site Selection

The site selection process for wells in the storage change monitoring network used the same criteria as the groundwater levels monitoring network. The same criteria as outlined in Section 5.1.3, *Design Criteria*, may be used to add additional wells into the storage change monitoring network as the water level monitoring network is the same.

5.4.3 Groundwater Quality

Several programs already operate with the directive of groundwater quality standards. Groundwater quality associated with projects and management actions will be monitored appropriately. A more detailed groundwater quality assessment for the Subbasin is provided in Section 3.2.5, *Groundwater Quality*.

5.4.3.1 Monitoring Frequency and Density

The GSAs desire to use existing groundwater quality sampling programs for tracking of groundwater quality. Figure 5-5 shows the relative density of groundwater quality well locations. The monitoring frequency is dependent on those existing monitoring schedules. In general city/municipal wells are sampled quarterly but the frequency of sampling can vary significantly for different constituents and can also vary considerably from well to well. Sampling schedules for city/municipal and other community system wells are determined by the SWRCB Division of Drinking Water. The KRWQC-ILRP samples annually. Data, reports, and/or pertinent evaluations from the various programs will be retrieved annually.

5.4.3.2 Identification of Data Gaps

There are currently no data gaps in monitoring groundwater quality within the Subbasin. Additional monitoring will be triggered through evaluation of the existing data from the agencies and coalitions, and in conjunction and collaboration with the agencies or coalitions, on a case-by-case case basis.

5.4.3.3 Site Selection

Groundwater quality monitoring site selection is driven, in part, by the location of city/municipal and other community well locations. As well, the KRWQC-ILRP has several well locations north of the clay plug. At this time, the Subbasin GSAs are proposing not to sample for groundwater quality in de-designated areas which includes Secondary Management Areas A and B. Locations of future groundwater quality sampling will likely be from monitoring wells that are constructed with funds from state or federal programs in data gap areas. As described above, the Subbasin GSAs would like to work collaboratively with the agencies currently performing groundwater quality monitoring.

5.4.4 Land Subsidence

The Subbasin land subsidence monitoring network will utilize data and subsidence evaluations from a variety of agencies including USGS, NASA, UNAVCO, CVSRN, KRCD, and KDWCD to verify areas of subsidence. Current DWR subsidence monitoring along the California Aqueduct is in cooperation with the USGS (Sneed, Brandt, and Solt 2018). If data from these sources becomes unavailable in the future, a new or expanded monitoring network may be established to monitor land subsidence. The agencies and methods used for measuring subsidence are discussed below.

5.4.4.1 USGS Monitoring Network

A land subsidence monitoring network consisting of 31 extensometers was installed in the 1950s to quantify subsidence occurring in the San Joaquin Valley. This monitoring did not target the Tulare Lake bed area. By the 1980s, the land subsidence monitoring efforts decreased. Since then, a new monitoring network has been developed. The new network includes refurbished extensometers from the old network, CGPS stations, and use of Interferometric Synthetic Aperture Radar (InSAR). The USGS network does not have an extensometer in the Subbasin. Below is a description of the various methods used in the USGS Monitoring Network.

- **Extensometers.** Extensometers measure changes in the length of an object. As the surrounding soils move, or in the case of land subsidence fine grained soils compact, the distances between reference points change, which allows for continuous measurement of subsidence. Extensometers provide data for specific depth intervals in the subsurface where compaction of clays is occurring as well as the amount. These data are considered necessary to enable future predictions and mitigation of land subsidence. Extensometers are costly to install and require frequent maintenance and calibration.
- **InSAR.** During the last decade, the USGS and other groups have been using data from radar emitting satellites referred to as InSAR. This form of remote sensing compares radar images from each pass of an InSAR satellite over a study area to determine changes in the elevation of the land surface (USGS, 2017). InSAR has a relative accuracy within fractions of an inch.
- **LiDAR.** DWR and USBR utilize LiDAR coupled with land elevation surveys to monitor subsidence. LiDAR utilizes a laser device that is flown above the Earth's surface. The accuracy of LIDAR is known to be less than a tenth (1/10th) of a foot as measured in root-mean-square deviation and very similar to that of surveying.

5.4.4.2 NASA Monitoring Network

NASA obtains subsidence data by comparing satellite images of Earth's surface over time. For the last few years, InSAR observations from satellite and aircraft have been used to produce the subsidence maps (NASA n.d.). More information can be found on the California Open Data Portal under NASA JPL InSAR Subsidence Data (California Open Data Portal 2019).

5.4.4.3 Continuous Global Positioning System Stations

The CGPS stations provide daily horizontal and vertical data, with records starting as early as 2004. One CGPS station is located south of Kettleman City. The Plate Boundary Observatory (PBO) and the Scripps Orbit and Permanent Array Center (SOPAC) upload and process data from the network of CGPS stations and produce graphs depicting the horizontal and vertical change in a point's location through time. More Information on CGPS stations can be found at the UNAVCO website (UNAVCO 2019).

5.4.4.4 Central Valley Spatial Reference Network

The California Department of Transportation's Central Region has developed a network that is comprised of CGPS stations that are permanently in place and operate continuously. These stations are known as the CVSRN. The network has stations along highway corridors to provide real time corrections for surveyors and data that can also be post-processed as well. Two CVSRN stations are located within the Subbasin near Corcoran and Highway 43, and Lemoore and Highway 198. In addition, PBO CGPS stations will be included in the CVSRN network in the future. The network was not designed to monitor subsidence, but the network is used by a variety of disciplines which benefit from the data collected at the stations (Caltrans 2019).

5.4.4.5 Kings River Conservation District

KRCD monitors a network of new and existing benchmarks, targeting a density of approximately 7 miles, where possible. Figure 5-4 shows the locations of the benchmarks in their monitoring system (Thiede 2016).

5.4.4.6 Kaweah Delta Water Conservation District

KDWCD has a subsidence monitoring program with one benchmark monument in the Subbasin in the MKR GSA (Figure 5-4). KDWCD surveys the benchmark monuments twice a year in February and September.

5.4.5 Monitoring Frequency and Density

The subsidence monitoring network is surveyed annually in the Subbasin. Subsidence change will generally be reported by GSA. Subsidence occurs on a regional scale with varying degrees occurring throughout the Subbasin.

5.4.6 Identification of Data Gaps

There is presently no known depth-discrete subsidence monitoring facilities (i.e., extensometers which can measure subsidence in specific portions of the aquifer) within the Subbasin. It is believed that the majority of subsidence occurs from compaction of clays. Extensometers would provide the data needed to differentiate subsidence at specific depth intervals. This data would be used to validate which portions of the aquifer are experiencing the most subsidence. In addition to the regional-based LiDAR/InSAR subsidence maps, the groundwater model developed for the Subbasin has previously been used as a tool to estimate where subsidence may occur in the future as the GSAs determine where projects will be implemented and if pumping patterns change in the future. Westside, Kern County, and Tule subbasins have extensometers that are monitored by the USGS. Extensometers have a relative accuracy of approximately 1/100th of a foot and can provide information on which part of the aquifer is subsiding. When funding permits, proposed depth-discrete subsidence monitoring extensometers, in the vicinity of the greatest subsidence would be useful to evaluate depth-discrete subsidence. If and when depth-discrete monitoring becomes possible, the GSAs will pursue information on surface subsidence, groundwater pumping per well, surveys of well head elevations as needed, aquifer characteristics, and well construction to develop a scientific view of the zones and areas that can be managed to avoid subsidence.

5.4.7 Site Selection

Land subsidence in the Subbasin is monitored through agency and government land subsidence surveying programs. The data generated by these programs are considered adequate both spatially and temporally as InSAR/LiDAR mapping covers the entire Subbasin, and because the area is closely monitored due to existing subsidence. However, individual GSAs may develop subsidence monitoring programs as needed that may include surveys of wells, or measurement of pumping water levels in deep wells in known subsidence areas. The regional InSAR/LiDAR maps will be used to identify these areas.

If additional monitoring locations are added, such as the proposed extensometers, the following scientific rationale will be used:

- Add stable benchmark sites that can be easily accessed and surveyed.
- Add sites where the ground surface is unlikely to be modified by future construction and will remain undisturbed.

5.5 Data Storage and Reporting

> **23 CCR §352.6** *Each Agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the Plan and monitoring of the basin.*

The monitoring programs within the GSAs will be coordinated within the Subbasin. RMS well locations, construction, and groundwater level data are shared or will be shared amongst the different GSAs. In addition, the monitoring programs described in this Chapter were reviewed by the GSAs and will be consistent throughout the Subbasin. Similarly, data reported to DWR will be collected and reported in a consistent format. GSP development and implementation will depend on the Data Management System's (DMS) ability to support GSP activities. The DMS shall also allow for upload and storage of information.

The GSAs have a consultant to develop a DMS to store and retrieve the necessary information for annual reporting. This database standardizes the basin-wide collection of data. The GSAs have been provided data templates which allows them to collect and enter the necessary information in a standardized format for integration into the DMS. The DMS is a repository for data storage and will be used to help generate the required information for annual reporting for the Subbasin. Some features in the DMS are linked to a Geographic Information System (GIS) when applicable (i.e., monitoring locations, crop boundaries and groundwater contours). A schematic of the DMS structure showing the DMS table relationships is included as Figure 5-6.

The DMS includes information on monitoring sites related to the Sustainable Management Criteria. The data will be subject to several levels of quality control; first, when the GSA representatives enter the data, and again when the consultant evaluates the data when preparing annual reports, and a third level when the results are reviewed by the GSAs. The DMS for the Subbasin shall be secure and will be able to generate information to support reporting as requested by the GSAs. Standardized data-entry data templates will help stakeholders organize their data so that it transfers to the DMS efficiently to reduce the amount of time spent on data entry and quality control.

The DMS will include the necessary elements required by the regulations, including:

- Well location and construction information (where available)
- Water level readings and hydrographs including water year type
- Seasonal groundwater elevation contours
- Estimated groundwater extraction by category
- Total water use by source
- Estimate of groundwater storage change, including maps and tables
- Graph with Water Year type, Groundwater Use, Annual and Cumulative Storage Change
- Subsidence Monitoring Locations

Figure 5-7 shows some examples of tables and associated fields in the DMS. The DMS table fields allow for addition of required or needed fields. The data can be combined to generate the required information for annual reporting. For example, total water use by source would be combined using information from the groundwater extraction and surface water usage tables. Additional items may be added to the DMS in the future as needed or required.

Data will be obtained by each GSA and submitted to the consultant for inclusion in the DMS. The required data will be aggregated and summarized for reporting to DWR. Groundwater contours will be prepared outside of the DMS using GIS analysis because of the need to evaluate the integrity of the data and generate a static contour set that has been reviewed for quality assurance and should not change once approved. Groundwater storage calculations are also performed outside of the DMS, then the results of those calculations will be uploaded to the DMS for annual reporting. Groundwater use by sector estimates, surface water deliveries by diversion point, intentional recharge, and land use data will be prepared by the GSAs using the data-entry data templates and then uploaded to the DMS for annual reporting and evaluations of trends. Surface water delivery records are maintained by the surface water agencies in separate systems already, and that data is collected by each GSA and provided to the DMS as an aggregate total by GSA. A description of how the DMS addresses required elements of a DMS and annual reporting requirements listed in the Table 5-7. The GSAs may choose to have their own separate system for additional analysis.

5.6 Data and Reporting Standards

23 CCR §352.4 Data and Reporting Standards
a) The following reporting standards apply to all categories of information required of a plan.
b) Monitoring sites shall include the following:
....c) The following standards apply to wells:
....d) Maps submitted to the Department shall meet the following requirements:
....e) Hydrographs submitted to the Department shall meet the following standards:

Table 5-8 lists the reporting standards that will be used for implementation of the GSP.

The monitoring sites will include the following information:

1. A unique site identification number and narrative description of the site location.
2. A description of the type of monitoring, type of measurement taken, and monitoring frequency.
3. Location, elevation of the ground surface, and identification and description of the reference point.
4. A description of the standards used to install the monitoring site. Sites that do not conform to best management practices shall be identified and the nature of the divergence from best management practices described.

The following standards will apply to all wells:

1. Wells used to monitor groundwater conditions installed during GSP implementation will be constructed according to applicable construction standards, and the following information in both tabular and geodatabase-compatible shapefile form will be provided:
    a. CASGEM well identification number. If a CASGEM well identification number has not been issued, appropriate well information shall be entered on forms made available by the Department, as described in Section 353.2.

b. Well location, elevation of the ground surface and reference point, including a description of the reference point.

c. A description of the well use, such as public supply, irrigation, domestic, monitoring, or other type of well, whether the well is active or inactive, and whether the well is a single, clustered, nested, or other type of well.

d. Casing perforations, borehole depth, and total well depth.

e. Well completion reports, if available, from which the names of private owners have been redacted.

f. Geophysical logs, well construction diagrams, or other relevant information, if available.

g. Identification of principal aquifers monitored.

h. Other relevant well construction information, such as well capacity, casing diameter, or casing modifications, as available.

2. For GSP wells that lack casing perforations, borehole depth, or total well depth information to monitor groundwater conditions, a schedule for acquiring monitoring wells with the necessary information, or a demonstration to DWR that such information is not necessary to understand and manage groundwater in the basin, will be provided.
3. Well information used to develop the basin setting will be maintained in the DMS.

Maps submitted to the DWR will have the following:

1. Data layers, shapefiles, geodatabases, and other information provided with each map, will be submitted electronically to the DWR in accordance with SGMA-prescribed procedures.
2. The maps will be clearly labeled and will contain a level of detail to ensure that the map is informative and useful.
3. The datum will be clearly identified on the maps or in an associated legend.

Hydrographs submitted to the DWR will:

1. Be submitted electronically to the DWR in accordance with SGMA-prescribed procedures.
2. Include a unique site identification number and the ground surface elevation for each site.
3. Use the same datum and scaling to the greatest extent practical.

6.0 PROJECTS AND MANAGEMENT ACTIONS TO ACHIEVE SUSTAINABILITY

23 CCR §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 time-table 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 information and 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.*

6.1 Introduction

The member agencies and technical advisors have developed the projects and management actions described in this chapter. Once the Groundwater Sustainability Plan (GSP) is approved, the projects and management actions previously selected by each Groundwater Sustainability Agency (GSA) will be advanced and implemented. Each GSA proposed their method to achieve sustainability utilizing a combination of projects and management actions. Section 6.5, *GSA Sustainable Methods*, describes the mix of projects and management actions chosen by each GSA to meet sustainability.

Water supply is based on historically available water and forecasted water use, which is based on information from member agencies and best available data. Historical water supply was obtained from each agency in the Tulare Lake Subbasin (Subbasin) and includes surface water and groundwater.

Projects and management actions are supported by the best available science and data. They are proposed and will be implemented in the most effective manner toward creating a sustainable yield for each sustainability indicator, as applicable. Costs for implementing each project was developed using information from previous projects in the Subbasin area and is in a unit of cost format in Section 6.3, *Projects*, of this chapter. Due to data gaps, there is a level of uncertainty associated with the Subbasin and additional efforts are needed to further develop the projects and management actions.

Management actions are generally programs or policies developed with the objective of management through reducing water demand, improving water data gathering, and/or protecting water quality. Management actions listed in this chapter are conceptual. Each GSA will utilize this list, or other options as they may arise, to further develop and refine their own management actions as needed to achieve sustainability.

Implementation and reporting will begin once the GSP is submitted by January 31, 2020. Even while the California Department of Water Resources is reviewing the GSP, Sustainable Groundwater Management Act (SGMA) implementation at the GSA level must begin. During the implementation phase, communication and engagement efforts will be shifted to educational and informational awareness of the requirements and processes for reaching groundwater sustainability as set forth in the submitted GSP. Active involvement of all stakeholders will be encouraged during this phase, and Public notices will be provided for any public meetings and, prior to imposing any fees. Public outreach for this phase will also be completed by the individual GSAs with collaborative Subbasin-wide efforts when target audiences span more than one GSA boundary.

The GSAs view projects and management criteria as a long-term implementation effort. The criteria that triggered the implementation plan was the adoption of SGMA and chronic overdraft in the Subbasin. Implementation will begin with the adoption of this GSP and as the need arises for each type of project to attain groundwater sustainability by 2040. An example of implementation information of each project type within the Subbasin is noted in Table 6-5, column Circumstances of Implementation of this chapter. Each GSA will decide what projects are best suited for their area and what policy will be developed.

6.2 Water Supply

The Subbasin is served by the State Water Project (SWP), the United States Bureau of Reclamation Central Valley Project (CVP), the Kings River, the Kaweah River, and the Tule River, as described in Section 3.4, *Management Areas*. Furthermore, flood waters occur from controlled and uncontrolled streams including the Kings River, Kaweah River, Tule River, Deer Creek, White River, Kern River, and Poso Creek. The timing and volume of surface water supply varies depending on the magnitude of the water year.

6.2.1 Kings River Supplies

The Kings River, like all southern Sierra Nevada streams, is prone to extreme annual swings in runoff, which is directly related to mountain precipitation (Kings River Water Association 2004). The River's historically lowest runoff event was approximately 391,700 acre-feet (AF) from 1923 to 1924. In contrast, the 1982 to 1983 water year produced a record runoff of 4,476,400 AF.

Pine Flat reservoir feeds into the Kings River and has a storage capacity of approximately 1,000,000 AF. The volume of flood control storage space is determined by the United States Army Corps of Engineers (USACE) Reservoir Regulation Manual. On average, flood releases generally occur every three to four years and, in some instances, consecutively. Channel losses and fishery management periodically affect delivery flexibility through restrictions in water supply to the Subbasin (Tulare Lake Basin Water Storage District 2013). It is anticipated that surface water supplies from the Kings River will be the main source for projects advanced by the GSAs to achieve sustainability, which include storage, banking, recharge, and continuation of fully appropriated stream status.

6.2.2 Kaweah River Supplies

The Kaweah River flows are controlled by Terminus Dam, creating a reservoir with the purpose of providing flood protection and storage for irrigation. Terminus Dam has a storage capacity of approximately 185,600 AF (KDWCD 2017). Flood control storage space is determined by the USACE Reservoir Regulation Manual, which contains a flood control diagram that is used from November 1 to March 1. There are rights holders within the Subbasin, and during times of heavy runoff, flood water is released causing higher than average flows. Depending on irrigation demand and the season, portions of this flood water will reach the Subbasin.

6.2.3 Tule River Supplies

Tule River water rights holders within the Subbasin and flood water can empty into the Subbasin in times of runoff. Tule River flows are controlled by Success Dam, approximately 35 miles east of Corcoran. Success Dam, operated by the USACE, provides flood control and irrigation water storage by creating a reservoir with a total storage capacity of approximately 82,300 AF (Tule River Basin 2015). The Success Reservoir is operated by USACE, who is undertaking a project to expand storage to 112,000 AF in 2022-2023.

6.2.4 Deer Creek

Deer Creek rights holders are present in the Subbasin.

6.2.5 White River

White River has no rights holders. Flood flows occasionally occur in the Subbasin.

6.2.6 Poso Creek

There are no rights holders in the Subbasin. Flood flows occasionally occur in the Subbasin.

6.2.7 Kern River

Kern River has rights holders in the Subbasin, but the water has been contracted to the Kern County Water Agency. Flood flows may pass into the Subbasin.

6.2.8 State Water Project Supplies

There are multiple SWP contractors in the Subbasin. SWP supplies have regulatory restrictions (e.g., Endangered Species Act and Water Quality Control Plan) that result in delivery reductions, which reduces surface water reliability (Tulare Lake Basin Water Storage District 2013). Surface water supply allocations to the Subbasin vary based on water year type, hydrology conditions in the San Francisco Bay Delta, and regulatory restrictions.

6.2.9 Central Valley Project Supplies

The CVP has long-term agreements to supply water to more than 250 contractors in 29 of California’s 58 counties. Kaweah Delta Water Conservation District is the only long-term Friant Division contractor in the Subbasin, but there are several other non-long-term contractors that have diverted water via transfers and exchanges.

6.2.10 Import of Additional Supplies

Each GSA is proposing to use their existing contract and rights for surface water as access to import more surface water into the Subbasin.

6.3 Projects

Projects reviewed in this chapter provide options to each of the GSAs and their respective partner agencies to use in implementation of this GSP, which is discussed in Chapter 7, *Implementation*. Each project and the potential yield were included in the modeling process; results are represented in Appendix G, *Representative Monitoring Site Forecast Hydrographs*. The milestones based on the measurable objectives (MOs) and minimum thresholds (MTs) are included in Table 4-1. Potential projects that may be utilized by the GSAs and partners include:

- Construction of new and modification of existing conveyance facilities;
- Above-ground surface water storage projects;
- Recharge basins and/or water banking in or out of the Subbasin;
- On-farm flooding; and
- Aquifer Storage and Recovery (ASR).

6.3.1 Conveyance Facilities Modifications and Construction of New Facilities

Modifications or improvements to existing facilities can be completed to increase conveyance efficiency and allow for greater flow capacity. Improvements of an existing system could increase the delivery area or delivery efficiency. Total capacity may also be increased with the construction of new conveyance systems, such as canals, check structures, and additional turnouts, to allow for surface water delivery to new areas. By providing a larger service area, more acreage would be able to use surface water, thus reducing the demand on groundwater pumping. It is anticipated that throughout the Subbasin, existing facilities will be improved by reshaping of existing canals, modification of canal control structures, and canal lining. Canal lining would prevent seepage losses and increase the total usable water volume. Conveyance construction and improvements will support other proposed projects in the area.

6.3.1.1 Location

Project locations will be identified by each GSA and their respective partners within their area as soon as the need arises and funding is available.

6.3.1.2 Project Objectives

The main objective of this project type is to increase the conveyance capacity or efficiency of the surface water distribution systems, allowing for increased surface water supplies. This project will decrease reliance on groundwater and help to maintain groundwater levels and storage. A direct relationship exists between the volume of additional surface water that can be delivered to a site and reduction in groundwater pumping. This objective will be achieved by improving the existing system, constructing new facilities (e.g., canals, pipelines, and pump stations) to increase the delivery service area, and constructing new water management structures to manage deliveries in the expanded water delivery area. All water flows that are delivered to the Subbasin will be measured appropriately.

6.3.1.3 Project Benefits and Water Reliability

Project benefits include:

- Decreased reliance on groundwater pumping;
- Increased diversion capability or efficiency at existing points of delivery; and
- Diversion in upper reaches of the Subbasin to provide flood flexibility to the lower reaches of the Subbasin.

Historically, flood releases occur every three to four years with some years being consecutive flood-release years, as discussed above in Section 6.2, *Water Supply.* This project may also be used in normal years when water is available for purchase. With implementation of the SGMA, it is anticipated that surface water management by other water rights holders will also change and the available volume of surface water may decrease. However, based on historical data, the reliability and availability of flood-release water is considered effective for the purposes of this project type.

6.3.1.4 Project Ownership

The project would be owned and managed by the local water agencies where the project will be constructed. GSAs may be involved in funding and coordinating these efforts to improve water balance conditions within the GSA service areas.

6.3.1.5 Project Cost Estimate/Acre-Foot of Yield

Although no detailed cost estimate has been prepared, preliminary estimates of typical project component costs are:

- New Canal Excavation: Approximately $45 per linear foot; assumes 8 feet deep, with a capacity of 400 cubic feet per second (cfs)
- Excavate/widen existing canal: Approximately $20 per linear foot; assumes 6 feet deep to increase capacity
- New weirs or check structures: Varies from $50,000 to $500,000 based on placement

- Pump Station: Varies from $500,000 for a 100-cfs pump station to $3,000,000 for a 500-cfs pump station (includes cost of pumps, concrete structure, and electrical work); design would be in accordance with the Hydraulic Institute's guidelines;
- Piping or concrete lining of canals: about $1-3 million per mile for a large canal.

The yield of this type of project will be determined based on the designated delivery rates. The yield will be developed as projects are identified and funding becomes available.

6.3.1.6 Circumstances of Implementation

GSAs in the Subbasin have the flexibility to choose which types of projects and management actions to pursue in attaining sustainable management. Not all projects or management actions will be pursued. Decisions regarding projects and policies will depend on conditions and management of the GSA at the board level. Should this type of project be deemed appropriate and necessary, it will be considered an integral part of the overall effort to reach sustainability. The selection of check structures and turnouts, willing participants, and the availability of funding are circumstances considered necessary to project implementation.

6.3.1.7 Project Status and Schedule

No project schedule has been determined. Some GSAs need to secure funding to begin the planning and implementation of this project. It is expected, once funding is secured, it could take from one to five years to complete a project including meeting environmental compliance.

6.3.1.8 Permitting and Regulatory Process

Each project may require a permitting evaluation and compliance with California Environmental Quality Act (CEQA) requirements. This process will be performed, as required, once the projects have been selected. If construction is going to disturb more than 5 acres, a Storm Water Pollution Prevention Plan (SWPPP) may be necessary as well.

6.3.1.9 Legal Authority

The legal authority to acquire land, grants, water rights, etc., and to operate and maintain such facilities for the purposes of carrying out the provisions of SGMA is given to GSAs by the State of California in Division 6 of the Water Code (§10726.2). Each of the GSAs may need to acquire new surface water rights or work with agencies within their boundaries that have existing rights. GSAs will likely provide funding and coordination support for this type of project.

6.3.2 Above-Ground Surface Water Storage

Above-ground storage basins will be constructed for the purpose of capturing and retaining more surface water for direct irrigation purposes. Controlled surface water storage on the valley floor would allow beneficial users to more effectively utilize each water year's available surface water. All surface water diversions into and out of the storage basins will be measured appropriately. Groundwater pumping should decrease in direct correlation to the additional volume of surface water captured and stored in the new facilities. Additionally, if the storage basin were to replace an agricultural field, demand reduction would occur within the footprint of the designated storage basin.

6.3.2.1 Location

Prospective project locations will be identified by each GSA as funding becomes available. Surface water storage basins are likely to be in locations containing a soil profile with higher clay content, due to its hydraulic properties for draining slowly. The location will likely be determined based on areas that have rights to surface water, and higher consideration will likely be given to areas near existing distribution infrastructure.

6.3.2.2 Project Objectives

The main objective of this project type is to increase surface water diversion and accordingly reduce groundwater pumping. Reducing the average annual volume of groundwater pumping will allow the GSAs to meet the MOs set in Chapter 4.0, *Sustainable Management Criteria*, for groundwater levels and groundwater storage change.

6.3.2.3 Project Benefits and Water Reliability

Project benefits include:

- Increased conjunctive use, such as water diversion to help meet irrigation demand;
- Additional storage capacity on the valley floor and below the major reservoirs (Pine Flat, Success, Terminus, and Isabella), affording more opportunity to capture and redistribute surface water supplies; and
- Flood protection to the Subbasin by increasing the controlled storage areas.

Historically, flood releases occur on average every three to five years, with some years being consecutive flood-release years from the eastern watershed areas. These projects may also be used in normal years when water is available for purchase. With implementation of SGMA, it is anticipated that surface water management by other water rights holders will also change and the available volume of surface water may decrease.

6.3.2.4 Project Cost Estimate/Acre-Foot of Yield

Although no detailed cost estimate has been prepared, a preliminary engineer's opinion of estimated project cost is approximately $25,000 to $40,000 per acre to construct a storage project. This estimated cost includes land purchase, construction of storage basins, and inlet and outlet structures with flow measurement devices. The estimated project cost assumes the earthwork for excavation and compaction will balance and there will be no need for excess material export.

The yield of this project will be determined based on the designated acreage. For example, if constructed on farmland, a basin with a bottom area of 100 acres and a 5-foot depth will generate approximately 500 AF of storage. Additionally, agricultural demand reduction of approximately 3.0 AF per acre (based on approximate average evapotranspiration demand of alfalfa) results in a reduction of about 300 AF of annual demand.

6.3.2.5 Circumstances of Implementation

GSAs in the Subbasin have the flexibility to choose which types of projects and management actions they would like to pursue in attaining sustainable management. Not all projects or management actions will be pursued; decisions regarding projects and policies will depend on conditions and management of the GSA at the board level. Should this type of project be deemed appropriate and necessary, it will be considered an integral piece of the overall effort to reach sustainability. Accordingly, finding a low infiltration site (clay soils area), willing participants, and the availability of funding are circumstances considered necessary to its implementation.

6.3.2.6 Project Status and Schedule

No project schedule has been determined. Some GSAs need to secure funding to begin the planning and implementation of a project. Once funding is secured, it is expected that it could take up to three years to complete a water storage project including environmental compliance. Benefits would be realized when a flood event occurs.

6.3.2.7 Permitting and Regulatory Process

To implement an above-ground water storage project, the following permits and regulatory procedures required include, but are not limited to, the following:

- CEQA
- SWPPP
- Mosquito Abatement – for operation of an open body of water that could host vectors
- Surface Mining and Reclamation Act (SMARA)
- San Joaquin Valley Air Pollution Control District (SJVAPCD) – for preparation of a Dust Control Plan for construction with disturbs a surface area of 5 acres or more
- County Grading Permit (at a minimum county notification)
- Other permit requirements based on findings from biological or cultural studies

6.3.2.8 Legal Authority

The legal authority to acquire land, grants, water rights, etc., and to operate and maintain such facilities for the purposes of carrying out the provisions of SGMA is given to GSAs by the State of California in Division 6 the Water Code (§10726.2). Each of the GSAs may need to acquire new surface water rights or work with agencies or private parties within their boundaries that have existing rights.

6.3.3 Recharge Basins/Water Banking

Recharge basins will be built with the purpose of recharging water into the aquifer system with the intent of extraction later on. By recharging water in wet years, groundwater levels will improve, creating a buffer storage volume, or a water bank, that may be extracted during periods of dryness or drought. Recharge basins will be constructed in areas containing soils associated with high infiltration rates; therefore, potential recharge volume realized is dependent upon the size of the recharge basin and the availability of flood water. Infiltration rates are anticipated to vary from 0.35 AF per acre per day to 1.5 AF per acre per day. Existing wells in the area will be used for extraction of the stored water. Furthermore, demand reduction of approximately 3.0 AF per acre per year is also associated with this type facility due to the removal of agricultural lands. These types of facilities are anticipated to be located in the northerly (South Fork Kings [SFK] GSA and Mid-Kings River [MKR] GSA) and easterly portions (El Rico [ER] GSA) of the Subbasin due to coarser-grained soil profiles.

6.3.3.1 Location

Project location will be identified by each GSA and their associated partner agencies as funding becomes available and based on where the most benefit may be realized. Location of projects will be determined based on the infiltration potential of certain soil profile zones, groundwater levels, and groundwater quality within the Subbasin.

6.3.3.2 Project Objectives

The project objective is to capture additional surface water and recharge it into the aquifer for storage and later recovery. This objective will help to maintain groundwater levels for neighboring landowners so that dry-year groundwater pumping will not cause levels to fall below MTs set in Sustainable Management Criteria. This project will also benefit the MO for groundwater storage change. To quantitatively measure the project objective, all water flows that are delivered to the project site will be measured and beneficial recharge will be estimated after accounting for any system losses to determine the allowable recovery volume to be used in later years.

6.3.3.3 Project Benefits and Water Reliability

Project Benefits include:

- Increased groundwater storage in wet years, for use in later years;
- Operational flexibility in dry years;
- Increased groundwater levels and groundwater storage, thus avoiding increased costs for pumping; and
- Potential for improvement of groundwater quality by recharging with higher quality surface water.

Historically, flood releases occur every three to five years with some years being consecutive flood-release years. This project may also be used in normal years when water is available for purchase. With implementation of SGMA, it is anticipated that surface water management by other water rights holders will also change and the available volume of surface water may decrease. However, based on historical data, the reliability and availability of flood-release water is considered good for the purposes of this project type.

6.3.3.4 Management of Groundwater Extractions and Recharge

Agreements between the involved parties will need to be formed on a project-by-project basis for decisions on ownership and operation. Policy for accounting of groundwater extraction and recharge as it pertains to intentional recharge projects has not yet been defined; however, flow into the recharge basin will be measured and accounted for in extractions.

6.3.3.5 Project Cost Estimate/Acre-Foot of Yield

Although no detailed cost estimate has been prepared, a preliminary engineer's opinion of estimated project construction cost is approximately $30,000 to $50,000 per acre. This estimated cost includes land purchase, construction of basin, inlet structures, and installation of flow measurement devices. Limited excavation is assumed, due to balancing the levee compaction volume with extraction. Detailed soils investigations are recommended, and in some cases, the project may require deep ripping to remove clay layers, which could increase the project cost.

The yield of this project will be determined based on the designated acreage and availability of flood water. For example, an infiltration basin with a bottom area of 100 acres and an infiltration rate of 0.35 AF per acre per day would generate approximately 35 AF per acre per day of recharge, plus a reduction in annual water demand would occur at approximately 3.0 AF per acre if the basin replaced productive agricultural land.

6.3.3.6 Circumstances of Implementation

GSAs in the Subbasin have the flexibility to choose which types of projects and management actions they would like to pursue in attaining sustainable management. Not all projects or management actions will be pursued; decisions regarding projects and policies will depend on conditions and management of the GSA at the board level. Should this type of project be deemed appropriate and necessary, it will be considered an integral part of the overall effort to reach sustainability. Selecting a high infiltration area (sandy soils profile), finding willing participants, and the availability of funding are necessary circumstances to consider implementation of this type of project.

6.3.3.7 Project Status and Schedule

No project schedule has been determined. Some GSAs need to secure funding to begin planning and implementation of this type of project. It is expected, once funding is secured, it could take up to three years to complete this type of project, including environmental compliance.

6.3.3.8 Permitting and Regulatory Process

It is anticipated that the following permits and regulatory procedures may be required to implement this project:

- CEQA
- SMARA
- SWPPP
- SJVAPCD
- Mosquito Abatement
- County Grading Permit (at a minimum county notification)
- Other permit requirements based on findings from biological or cultural studies

6.3.3.9 Legal Authority

The legal authority to acquire land, grants, water rights, etc. and to operate and maintain such facilities for the purposes of carrying out the provisions of SGMA is given to GSAs by the State of California in Division 6 the Water Code (§10726.2). Each of the GSAs may need to acquire new surface water rights or work with agencies within their boundaries that have existing rights.

6.3.4 On-Farm Recharge

On-farm recharge is a form of groundwater recharge performed by flooding an existing agricultural production field. Potential locations for on-farm recharge will be determined by areas containing soil profiles with high infiltration potential. Additionally, on-farm flooding is limited by fertilization and crop type. Leaching of fertilizer chemicals into the groundwater system is not favorable, and some crops are more tolerant of saturated soils for longer periods of time than others. Alfalfa is well suited to on-farm flooding due to its ability to be inundated for long periods of time, and permanent crop types that are suitable for on-farm flooding during the dormancy period include vineyards, pistachios, and olives. It will be up to each GSA to determine the most favorable locations and decide on a minimum acreage size designated for this type of project. Voluntary participation from the landowners and their delivery facilities will be utilized as part of the project. In this effort, existing local wells will recover recharge supplies.

6.3.4.1 Location

Projects location will be identified by each GSA, partner agencies, and landowners based on most favorable conditions. As previously discussed, locations will be selected based on best potential benefits realized from certain soil profiles and existing cropped lands.

6.3.4.2 Project Objectives

The main objective of this project type is to reduce chronic lowering of groundwater water levels by providing a space where recharge can occur in off-season months of irrigation. To quantitatively measure the project objective, all water flows that are delivered to the project site will be measured through a metering device and beneficial recharge will be estimated after accounting for any system losses to determine the allowable recovery volume. Groundwater levels in the surrounding area will be compared to historical levels to observe the benefit of this project type on groundwater levels and storage.

6.3.4.3 Project Benefits and Water Reliability

Projects benefits include:

- Increased groundwater storage for recovery in later years;
- During wet years, additional use of flood water for recharge will provide greater flood control operation flexibility; and
- Increased groundwater levels and groundwater storage, thus avoiding increased costs for pumping;

Historically, flood releases occur every three to five years with some years being consecutive flood-release years. This project may also be used in normal years when water is available for purchase. With implementation of SGMA, it is anticipated that surface water management by other water rights holders will also change and the available volume of surface water may decrease. However, based on historical data, the reliability and availability of flood-release water is considered good for the purposes of this project type.

6.3.4.4 Management of Groundwater Extractions and Recharge

This project may be owned and managed by the GSA and their partner, if any, where constructed. Policy for groundwater extraction and recharge as it pertains to on-farm recharge projects has not yet been defined; however, flow into the recharge basin will be measured and accounted for in extractions.

6.3.4.5 Project Cost Estimate/Acre-Foot of Yield

Although no detailed cost estimate has been prepared, a preliminary engineer's opinion of probable project cost is approximately $500 to $1,000 per acre to implement. This estimated cost assumes that the landowner voluntarily enters into a land use agreement or easement. Limited to no excavation will occur within the designated land. Cost does include the purchase of flow measurement devices.

The yield of this project will be determined based on the designated acreage and the local recharge rate. For example, a 100-acre section of land with an infiltration rate of 0.35 AF per acre per day will yield 35 AF per day. No agricultural land will be taken out of production for this type of project.

6.3.4.6 Circumstances of Implementation

GSAs in the Subbasin have the flexibility to choose which types of projects and management actions they would like to pursue in attaining sustainable management. Not all projects or management actions will be pursued; decisions regarding projects and policies will depend on conditions and management of the GSA at the board level. Should this type of project be deemed appropriate and necessary, it will be considered an integral part of the overall effort to reach sustainability. Selecting an area with high infiltration potential (sandy soils area), appropriate crop type, willing participants, and availability of funding are circumstances considered necessary to the implementation of this project type.

6.3.4.7 Project Status and Schedule

No project schedule has been determined. Some GSAs need to secure funding to begin the planning and implementation of this project. It is expected, once funding is secured, that preparation of the policy could take a year to complete. The physical diversion of surface water can happen immediately following implementation of policy using existing distribution facilities. The schedule of actual operation may vary based on location, since some permanent crops can only be flooded during dormancy.

6.3.4.8 Permitting and Regulatory Process

- Land use agreements

6.3.4.9 Legal Authority

The legal authority to acquire land, grants, water rights, etc., and to operate and maintain such facilities for the purposes of carrying out the provisions of SGMA is given to GSAs by the State of California in Division 6 the Water Code (§10726.2). However, in this case, the GSA is not interested in owning the land, only providing the coordination to achieve project goals. Each of the GSAs may need to acquire new surface water rights or work with agencies within their boundaries that have existing rights. Agreements with landowners will be required to use their lands for recharge.

6.3.5 Aquifer Storage and Recovery

ASR is the intentional recharge by utilizing direct injection of surface water into an aquifer for later recovery, usually through the use of wells. ASR well sites will be selected to directly store water in certain geologic zones for later recovery or to stabilize groundwater levels to inhibit subsidence.

6.3.5.1 Location

Project locations, if feasible, will be identified by individual GSAs as funding becomes available. The areas outside the Subbasin (e.g. Westlands Water District GSA) are proposing ASR as part of their GSP.

6.3.5.2 Project Objectives

The main objective of this project is to reduce chronic lowering of groundwater levels and reduce subsidence by directly storing surplus water in the unconfined or confined aquifer. The objective will be measured by metering all water flows that are delivered to the project site appropriately.

6.3.5.3 Project Benefits and Water Reliability

Projects benefits include:

- Surplus water storage in the aquifer and subsequent recovery when there is demand;
- During wet years, utilization of flood flows, providing further flood protection; and
- Stabilization of groundwater levels to reduce subsidence rates.

Historically, flood releases occur every three to five years with some years being consecutive flood-release years. This project may also be used in normal years when water is available for purchase. With implementation of SGMA, it is anticipated that surface water management by other water rights holders will also change and the available volume of surface water may decrease. However, based on historical data, the reliability and availability of flood-release water is considered good for the purposes of this project type. This project would increase groundwater reliability and sustainability.

6.3.5.4 Management of Groundwater Extractions and Recharge

This project would be owned by landowners using their existing wells for ASR and managed by the GSA or partner agency where implemented. Policy for groundwater extraction and recharge as it pertains to ASR projects has not yet been defined. Landowners would have to enter into contracts with the GSA to allow for use of these private facilities.

6.3.5.5 Project Cost Estimate/Acre-Foot of Yield

Although no detailed cost estimate has been prepared, a preliminary engineer’s opinion of probable project cost is approximately $250,000 to $500,000 per well to construct. This estimated cost assumes that the owner of the well will enter into an easement and or use agreement with the GSA for use of the well. A flow measurement device will be needed.

The yield of this project will be determined based on the designated number of wells. For example, utilizing 100 wells at an estimated storage rate of 4 AF per day per well will generate approximately 400 AF of storage per day.

6.3.5.6 Circumstances of Implementation

If determined cost-effective, ASR projects will be considered as part of the overall effort to reach sustainability. These facilities are expected to be used in areas where surface soils are clays and are underlain by clay zones such as the A-, C-, and E-Clays. The selection of wells, willing participants, and the availability of funding are circumstances considered necessary to this project's implementation.

6.3.5.7 Project Status and Schedule

No project schedule has been determined. It is expected that, once funding is secured, it could take up to five years to complete this project, including environmental compliance.

6.3.5.8 Permitting and Regulatory Process

It is anticipated that the following permits and regulatory procedures will be required to implement this project:

- CEQA
- Compliance with the United States Environmental Protection Agency (EPA)
- Compliance with the Regional Water Quality Control Board (RWQCB)
- Local Agency Compliance
- Division of Drinking Water (DDW)

6.3.5.9 Legal Authority

GSAs were given the authority to "perform any act necessary or proper to carry out the purposes of [SGMA]" including the adoption of rules, regulations, ordinances, and resolutions that pertain to this GSP. Chapter 5 of Division 6 of the California Water Code lays out the rest of the powers and authorities given to GSAs. Each of the GSAs may need to acquire new surface water rights or work with agencies within their boundaries that have existing rights. Agreements with landowners will be required to use their wells for recharge.

6.4 Management Actions

Management actions represent example management options available to GSAs that will help support them in the sustainable management of groundwater. Each GSA has the flexibility to choose a list of actions that they believe will be pursued and will independently develop the policies to meet the needs of their area for achieving sustainable management. The management actions will be chosen by each GSA after the implementation of this GSP. Examples of potential management actions include, but are not limited to, the following:

- Projects Policies
  - Voluntary fallowing programs
  - Above-ground surface water storage projects
  - Infiltration basins (utilizing flood flows, purchased and exchanged waters)
  - On-farm recharge (utilizing existing cropped and uncropped lands to infiltrate water, mainly during dormant seasons, for recovery in a dry period)
  - ASR
  - Conveyance facilities modifications
- Outreach
  - Education of groundwater use
- Assessment
  - Pumping fees for groundwater allocation exceedances
  - Pumping fees for groundwater extractions
- Groundwater Allocation
  - Development of GSA level groundwater allocation
  - Development of landowner groundwater allocation
  - Groundwater marketing and trade
  - Operation and management of groundwater extractions
- New Development
  - Require new developments (non-de minimis extractors) to prove sustainable water supplies if land use conversion is not a conservation measure
- Monitoring and Reporting
  - Flood flows (spills into the Subbasin), including Tule River, Deer Creek, Cross Creek and Kings River

- Registration of extraction facilities
- Require self-reporting of groundwater extraction, water level, and water quality data
- Require well flowmeters, sounding tubes, and water quality sample ports for new well construction

- Existing Surface Water Contracts
  - Flood flows (spills into the Subbasin), including Tule River, Deer Creek, and Cross Creek

6.5 GSA Sustainable Methods

Based upon work documented previously, each GSA has an estimated annual storage change target to meet to be sustainable, based upon best available data and groundwater model results. This section identifies the projects and management action targets envisioned to achieve sustainability. These preliminary amounts will be reevaluated, and conditions monitored while efforts are implemented. This will allow the GSA to compare the anticipated versus resulting change in groundwater levels, as well as other sustainability criteria to determine if additional measures need to be employed to achieve sustainability.

6.5.1 Mid-Kings River Groundwater Sustainability Agency

The average annual storage change for the MKR GSA is estimated at negative 28,490 AF. The MKR GSA plans to pursue improvements to existing basins in the area, improvement to conveyance systems and expanded surface water delivery system, a voluntary annual fallowing program, and recharge basin development. Table 6-1 summarizes the combination of projects and management actions that are proposed to offset the change in storage to achieve sustainability within the GSA boundary. Demand reduction for dedicated lands for infiltration ponds are included in the Annual Yield column of the table below. An average annual value of 3.0 AF per acre of demand reduction will be used. The estimated annualized blended costs for this type of project, assuming a 20-year funding period and 4 percent (%) interest, is approximately $85/AF. Additional costs are expected for operational costs.

6.5.2 South Fork Kings Groundwater Sustainability Agency

The average annual storage change for the SFK GSA is estimated at a negative 37,840 AF. Table 6-2 summarizes the combination of projects and management actions that are proposed to offset the change in storage to achieve sustainability within the GSA boundary. Demand reduction costs will be determined once the policy has been developed by the GSA board. It is unknown at this time if the GSA will fund the demand reduction program by charging farmers in the GSA or whether an allocation program will be implemented allowing growers to manage their water allocations and requiring individual decisions on cropping and water use. The estimated costs for the entire ASR project are listed in Table 6-2.

6.5.3 Southwest Kings Groundwater Sustainability Agency

The average annual storage change for the Southwest Kings (SWK) GSA is estimated at positive 10,820 AF (surplus), thus projects to mitigate overdraft are not currently needed in this GSA. No projects have been determined at this time. Management actions may be determined at a later time and will be based upon annual monitoring results. A management area is also identified in this region. Should development of groundwater be accomplished in the management area, a set of criteria would be employed to identify the quantity of groundwater pumping and monitoring of groundwater levels. The SWK GSA has indicated to the other GSAs in the Subbasin that it would be interested in financially participating in projects elsewhere in the Subbasin if doing so would affordably increase the water supply to the SWK GSA.

6.5.4 El Rico Groundwater Sustainability Agency

The average annual storage change for the ER GSA is estimated at negative 20,810 AF. Table 6-3 summarizes the combination of projects and management actions that are proposed to offset the change in storage to achieve sustainability within the GSA boundary. Demand reduction for dedicated lands for infiltration ponds are included in the Average Annual Yield column of Table 6-3. An average annual value of 3.0 AF per acre of demand reduction will be used. Demand reduction is assumed to consist of crop fallowing in dry years. Since crop rotation and fallowing is assumed to be accomplished by growers within the GSA, no costs are associated with this farm practice. The estimated annual cost for the capital facilities associated with storage are estimated at $330/AF based upon a 20-year funding period and 4% interest.

6.5.5 Tri-County Water Authority Groundwater Sustainability Agency

The average annual storage change for the Tri-County Water Authority (TCWA) GSA is estimated at surplus 2,560 AF. Although in surplus, Table 6-4 summarizes the combination of projects and management actions that are proposed to further secure the positive change in storage to maintain sustainability within the GSA boundary. Demand reduction for dedicated lands for infiltration ponds are included in the Average Annual Yield column of Table 6-4. An average annual value of 3.0 AF per acre of demand reduction will be used. Demand reduction costs will be determined once the policy has been developed by the GSA. The proposed schedule for demand reduction in the TCWA GSA is a 10% reduction by the year 2025 and an additional reduction by the year 2030.

7.0 PLAN IMPLEMENTATION

Upon California Department of Water Resources (DWR's) approval of this Groundwater Sustainability Plan (GSP), GSP implementation will commence in the Tulare Lake Subbasin (Subbasin). The Groundwater Sustainability Agencies (GSAs) will continue their efforts to engage the public and secure the necessary funding to successfully monitor and manage groundwater resources within the Plan Area to avoid future undesirable results related to groundwater usage in the Subbasin. GSAs' ongoing efforts to coordinate with a diverse range of stakeholders and beneficial users works to improve the Subbasin's monitoring networks. This GSP works in tandem with authorities of numerous agencies with the goal to coordinate activities in the region for the effective management of groundwater resources. Table 6-5 are examples of policies that can be adopted by the GSAs. At this time, the GSAs have not adopted polices listed in Table 6-5 due to time constraints and lack of funding.

7.1 Estimate of GSP Implementation Costs

23 CCR §354.6 *Agency Information. 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:*
(e) An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.

The Subbasin's GSP was developed by the five GSAs within the Subbasin as a singular document to address groundwater overdraft. GSAs and member agencies will coordinate and implement the actions outlined in this GSP. As such, the implementation is anticipated to be performed by multiple agencies. To identify implementation costs, a draft structure of cost has been suggested and is included below:

1. Regular/Ongoing Sustainable Groundwater Management Act (SGMA) Compliance Activities;
2. GSP Five-Year Update;
3. Plans to Fill Data Gaps;
4. Projects; and
5. Management Actions.

Table 6-5 lists estimated costs to develop each project.

7.2 Schedule for Implementation

> **23 CCR §350.4** *General Principles. Consistent with the State's interest in groundwater sustainability through local management, the following general principles shall guide the Department in the implementation of these regulations.*
> *(f) A Plan will be evaluated, and its implementation assessed, consistent with the objective that a basin be sustainably managed within 20 years of Plan implementation without adversely affecting the ability of an adjacent basin to implement its Plan or achieve and maintain its sustainability goal over the planning and implementation horizon.*

Implementation of the GSP will result in the sustainable yield of groundwater resources in the Subbasin by year 2040. Some areas within the Subbasin have existing projects, which will continue to contribute to the Subbasin's groundwater sustainability. These projects are included in the groundwater model (Appendix D) but will not be shown on the schedule. The schedule of projects and management actions are outlined below. At each five-year interim milestone, updates to the schedule will occur, as applicable, dependent on achievement of Measurable Objectives (MO) for each applicable sustainability indicator. The list below demonstrates how 1,090,000 acre-feet (AF) of yield will be generated over the 20-year implementation period.

- 2020-2025-Yield 50,000 AF
  - Improved efforts to monitor across the Subbasin
  - Begin identification of management actions through policy development
  - Seek grant funding through available opportunities
  - Establish project funding for some GSAs
  - Develop program for voluntary fallowing
  - Bring on-line first projects
  - Evaluation of long-term climate change impacts over the last five years and their effects on GSP implementation
- 2026-2031-Yield 330,000 AF
  - Seek grant funding through available opportunities
  - Establish project funding for other GSAs
  - Expansion of programs, projects and bringing new projects on-line
  - If climate change impacts are significant, implement Management Actions relating to demand reduction
  - Evaluation of long-term climate change impacts over the last five years and their effects on GSP implementation
- 2032-2035-Yield 330,000 AF
  - Seek grant funding through available opportunities
  - Establish project funding for any remaining GSAs
  - Expansion of programs, projects and bringing new projects on-line,
  - If climate change impacts are significant, implement Management Actions relating to demand reduction

- 2036-2040-Yield 380,000 AF
    - Seek grant funding through available opportunities
    - Expansion of programs and projects
    - If climate change impacts are significant, implement Management Actions relating to demand reduction

7.2.1 Mid-Kings River Groundwater Sustainability Agency

7.2.1.1 Background

The Mid-Kings River (MKR) GSA is primarily a partnership between Kings County Water District (WD) and the City of Hanford. The City of Hanford has developed and maintained municipal drinking water facilities for its residents for many decades. The Kings County WD has developed facilities and programs to address surface and groundwater conditions in its service area since the 1950s. The partnership of these two agencies provides a combination of resources and experience that will significantly aid in SGMA implementation.

The MKR GSA area is crisscrossed with many different existing rivers, creeks, sloughs, ditches, canals and water delivery facilities. Kings County WD is a stockholder in Peoples Ditch Company, Settlers Ditch Company, Last Chance Water Ditch Company, Lakeside Ditch Company and Lemoore Irrigation and Canal Company. The stock associated with these water right holders provides the Kings County WD with yield from local rivers, conveyance through their distribution systems. Kings County WD annually “rents” the available stock water supplies to growers in their service area to be put to beneficial use. Also, available wet-year water is delivered to many existing basins, creeks and sloughs for groundwater recharge.

Kings County WD is an agency that has developed many different basin facilities in their service area (around 1,100 acres) in order to increase groundwater recharge during wet years. Kings County WD is also the agency responsible under State Board Decision 1290 for delivering wet year surface water in a former Kings River channel called the Old River for groundwater recharge. In 2002, Kings County WD also developed a groundwater bank at Apex Ranch that has the capacity to recharge and recover significant amounts of wet-year water.

The MKR GSA currently views that the long-term average of roughly 28,000-32,000 acre-feet per year (AF/Y) of overdraft is occurring in the service area.

7.2.1.2 <u>Projects</u>

New Recharge Basins

The MKR GSA currently views that roughly 1,500 acres of additional recharge basins need to be developed to address the historic groundwater overdraft. There are many discussions that need to be had related to who is responsible for the overdraft in the area, but currently the MKR GSA Board views this target as reasonable. The effort to build new recharge basins relates to the availability of sandy soils in the MKR GSA area, the availability of flood water supplies and the existence of surface water delivery facilities. Also, based on reasonable local assumptions, MKR GSA staff estimated that the development of new recharge basins could be five to ten times more effective per acre than fallowing efforts.

The MKR GSA's plan to develop new recharge basins is conceptual and will be adaptive based on the productivity of facilities, the long-term availability of local wet year supplies and progress during the implementation period. Generally, the plan is to develop several 40- to 80-acre recharge basins across the MKR GSA area near existing canals on very sandy properties. Recharge efforts are planned to be spread throughout the service area so that benefits are more connected to areas of groundwater use. The MKR GSA's desire is to work with willing landowners to acquire the properties and work with local material suppliers to excavate the sandy basin material.

Partnership with Kings County WD

As an agency, Kings County WD has slightly different goals and a separate budget to take on efforts that address surface and groundwater conditions in almost all the MKR GSA area. This has been challenging to segregate these similar efforts, but it is currently believed that the Kings County WD plans to take on local system improvements and the development of roughly 500 acres of new recharge basins through the Implementation period. However, given that Kings County WD has existing access to surface water supplies, the MKR GSA believes it is wise to work cooperatively with Kings County WD to develop the other needed basin facilities as well.

Consistent with this, Kings County WD is currently in the process of developing two different basin sites as well as investigating several others. The 80-acre Esajian Basin site along 7th Avenue between Dover and Excelsior Avenues had been identified as a very desirable recharge facility site in previous District studies. The District acquired the property earlier this year, went through the California Environmental Quality Act (CEQA) process, obtained permits for the construction, and construction has recently begun. It is expected that the new Esajian Basin facility will be put into service in 2020 or 2021.

The 30-acre Griswold basin site is north of Dover Avenue and just east of Highway 43. The Kings County WD has owned this property for several years and is currently in the planning stage of developing this new basin project. Soil explorations have been conducted across the property and have confirmed desirable characteristics for a new recharge basin. It is expected that the new Griswold Basin facility could be put into service in 2021 or 2022.

System Improvements

As SGMA implementation approaches, most surface and groundwater management entities are reconsidering their existing facilities in light of the new requirements for sustainable groundwater use by 2040. Consistent with this, Kings County WD is evaluating the current facilities used to recharge groundwater (roughly 1,100 acres) and deliver available surface water and developing projects to improve existing facilities. Most of the efforts currently identified relate to existing recharge basins and optimizing their diversion capacities given recent flood water availability periods. Other efforts may involve the modification of existing canal systems to remove current restrictions and allow for greater flows to be conveyed.

Conservation Measures

The MKR GSA is aware of many different efforts by local growers to transition from current irrigation methods to more efficient irrigation systems. Some of these efforts are sprinklers, drip irrigation, and the use of drip tape (subsurface irrigation). While these methods do not change the amount that crops need to use to grow, they will reduce the amount lost to evaporation and the amount lost past the root zone.

7.2.1.3 Programs

Voluntary Fallowing

In the MKR GSA area there is a mixture of permanent and row crops grown in the agricultural areas. The MKR GSA Board plans to develop a program to work with row crop growers that would annually lease their property to reduce groundwater pumping in the area. The details of this program are currently under development, but the developing program is thought of similarly to past Cotton Programs run by the United States Department of Agriculture. The MKR GSA reason for developing the program is to create a tool that could be used in drought times when recharge basins don’t provide benefits.

On-Farm Recharge

The MKR GSA is aware of landowners interested in on-farm recharge in the area. This effort will be continually evaluated to try to take advantage of the recharge capacity of existing fields. This will be pursued to the extent that the MKR GSA can partner with local growers on recharge efforts that are beneficial to groundwater resources and the grower's crops.

7.2.1.4 Management Actions

Meter Requirements

One of the most significant data gaps in the MKR GSA area is direct measurement of pumped groundwater from most wells. These records are available from public agencies, but generally not from private parties. The MKR GSA currently views that requiring the registration of all wells and the use of flow meters will dramatically improve the areas understanding of the most significant water balance components.

Pumping Restrictions

Currently it is believed that the historical amount of groundwater overdraft in the MKR GSA area can be addressed with new projects and programs developed through the Implementation period. However, it is acknowledged that there are significant data gaps that need to be filled before more accurate evaluations can be made and that the demand for wet-year water on local river systems will increase due to SGMA implementation. Also, evaluations of state-required potential future climate change scenarios indicate that agricultural crops demands could increase if crop evapotranspiration directly corresponds to increased temperatures. The MKR GSA will monitor these various situations and conditions and adapt MKR GSA efforts accordingly.

If long-term increased demands and/or reduced surface water availability is experienced, the MKR GSA will consider implementing groundwater pumping restrictions. There are many complicated issues with this kind of limitation and the MKR GSA plans to evaluate these prior to the implementation of such strategy. However, the current understanding is that the implementation of groundwater pumping restrictions would effectively require landowners to farm less ground without compensation for fallowed lands.

Others

The MKR GSA plans to continually evaluate potential opportunities and pursue efforts that address GSA priorities with the least impact on local landowners. As the Implementation period begins, the MKR GSA expects to learn many things over time and the hope is that this learning will help target efforts to be more and more effective.

7.2.1.5 Funding

Joint Powers Authority Member Support

The MKR GSA is currently a joint powers authority formed in 2016 whose participating agencies are Kings County, the City of Hanford and Kings County WD. These agencies currently have a cost sharing agreement that has been sustaining GSA efforts to date.

Estimated Implementation Costs

Estimated implementation costs for the GSP are based on a number of assumptions that will continue to be evaluated, adjusted, and refined over the implementation period. It is currently assumed that Kings County WD will be developing 500 acres of recharge basins in the area so that the MKR GSA will need to develop 1,000 acres. Based on assumed land purchase costs, earthwork costs, structure costs and costs for design and permitting, it was estimated that the planned effort could cost roughly $3,000,000 per year over the implementation period. It appears that if this effort is supported through groundwater pumping charges, that roughly $20 per acre-foot would be sufficient to fund the effort. However, the MKR GSA is still currently evaluating the potential revenue structure for GSA efforts and will hopefully conduct a Proposition 218 election in spring 2020.

Implementation Funding Plan

The MKR GSA is currently working with a consultant to develop a plan for GSA funding potentially through a land-based assessment and a groundwater pumping charge. The current view is that the land-based assessment would be used to sustain GSA administration while the groundwater pumping charge would be used to fund GSA projects. The use of the groundwater pumping charge is hoped to connect the amount of groundwater use to groundwater overdraft and the need for the GSA projects. MKR GSA consultants are working on developing documentation to support a local election on the funding scheme thought to be scheduled for spring 2020.

Grant Funds

The MKR GSA plans to pursue available grant fund opportunities that facilitate development of water management or monitoring facilities or allow for the study of data gap topics. Kings County WD has been successful in many competitive grant programs in the past. Grant programs through the DWR and the United States Bureau of Reclamation are planned to be regularly monitored for opportunities that might match the GSAs efforts.

7.2.2 South Fork Kings Groundwater Sustainability Agency

This section summarizes the approach that the South Fork Kings (SFK) GSA will take in implementing this GSP. It outlines specific technical issues, management actions, timelines, and funding approaches that the GSA proposes to implement starting in 2020.

7.2.2.1 Background

SFK GSA encompasses 71,310 acres in the western portion of the Subbasin. The hydrogeology of the SFK GSA differs somewhat from the surrounding Tulare Lake Subbasin GSA's in that there are three generally recognized aquifer zones:

1. A perched unconfined aquifer exists above a locally extensive clay layer (A-Clay). This aquifer is used for domestic and irrigation supply. Water quality varies from excellent (near the South Fork Kings River) to poor based on salt content (in areas toward the lake bottom near Stratford). The perched unconfined aquifer is on the order of 50-100 feet thick with a depth to water of near ground surface to 50 feet. There are insufficient data available to characterize whether and to what degree the perched aquifer is interconnected with surface water.

2. A semi-confined aquifer is present above a locally extensive clay layer (C-Clay). There are several thin, discontinuous clay layers between the A-Clay and the C-Clay that create variable and semi-confined conditions in this aquifer zone. Water quality is generally good in the semi-confined aquifer. The semi-confined aquifer is on the order of 500 to 600 feet thick with a depth to water of 100 to 250 feet. This aquifer is used primarily for irrigation, though there are a number of domestic wells completed in this aquifer. Many of the irrigation wells there are completed in both the semi-confined and the confined aquifer below the Corcoran clay. Domestic wells are typically completed in the upper portion of the semi-confined aquifer. Many wells in the semi-confined aquifer show declining water levels consistent with the deep confined wells. However, depending on the location and screen interval, some wells show limited decline in water-level. There are insufficient data available to characterize whether and to what extent the semi-confined aquifer is interconnected with the perched aquifer and/or surface water.

3. A fully confined aquifer exists below a regionally extensive clay layer (E-Clay or Corcoran Clay). The E-Clay is present at a depth of about 600 feet in the SFK GSA. This aquifer is used primarily for irrigation, but the City of Lemoore also uses this aquifer for its municipal supply. The confined aquifer is approximately 1,500 to 2,000 feet thick with a depth to water of around 200 to 500 feet. Many irrigation wells in this aquifer are completed in

both the semi-confined and underlying confined aquifer. Virtually all wells completed below the E-Clay show declining water levels. The degree to which interconnection of the semi-confined and confined aquifers via individual well completions contributes to a “regional” interconnection between the two aquifers is unknown. Recharge to the confined aquifer occurs outside the boundaries of the SFK GSA, and the groundwater levels in the confined aquifer are affected by both local pumping and the regional response to pumping and recharge across the entire Subbasin, including adjacent subbasins. Storage in this aquifer is represented by two storage concepts: the confined “specific storage” and the drainable porosity or “specific yield”. Confined storage represents the pressurized groundwater that causes water levels to rise above the Corcoran Clay confining layer. Because it represents pressure head, the volume of water in specific storage is relatively low. Drainable porosity represents the volume of groundwater that exists within the aquifer sediment matrix. The volume of storage as drainable porosity cannot be increased when water levels are above the elevation of the confining layer. As more water is added to a confined aquifer, confined storage increases, and water levels increase further above the confining layer. To reduce the volume of storage in drainable porosity, confined storage needs to decline such that water levels decline toward the confining layer. When this occurs, the structure of the confining layer changes. The confining layer essentially gets “squeezed”, which then causes subsidence at the ground surface. The amount of storage that can be taken out of drainable porosity in a confined aquifer is therefore related to the amount of associated subsidence.

7.2.2.2 Local Water Balance, Overdraft and Sustainable Yield

The water balance for the entire Tulare Lake Subbasin is described in the basin setting chapter of this GSP, local water budgets for individual GSAs have not been prepared. For the initial implementation period, SFK GSA will operate under the assumption that there is a baseline average long-term pumping volume range of about 85,000 to 140,000 AF/Y and a long-term groundwater overdraft of about 38,000 AF/Y. By subtraction, this implies a sustainable pumping yield range of about 60,000 to 100,000 AF/Y. SFK GSA’s projects and management actions will be developed, monitored and initially evaluated relative to these targets. However, there are uncertainties in the magnitude of pumping, interconnectedness between SFKGSA aquifer zones, inflows, and other outflows associated with activity both within and outside the SFK GSA jurisdictional boundary that have not yet been resolved. These issues will be revisited and addressed over the next five years through additional data collection and analysis. As more data are collected, the estimated SFK GSA overdraft, SFK GSA sustainable pumping yield, and potential for undesirable results will be refined and revised as appropriate.

7.2.2.3 Groundwater Monitoring Program

SFK GSA's groundwater level monitoring program will be generally implemented in accordance with Chapter 5 of this plan. The locations and completion intervals of the monitoring network are adequate to describe and monitor groundwater sustainability in the SFK GSA. As noted in Chapter 5, some of the monitoring thresholds for specific wells have been established based on modeling results. In the SFK GSA, there are water level data that differs from the modeling results on which the targets presented in Chapter 5 are based. SFK GSA will revise the minimum thresholds in cases where there is a difference between the actual observed water level and the modeled water level used to develop those thresholds, this effort will be part of adaptive management and can be done during the GSP update. Over time, the SFK GSA intends to rely solely on actual observed water levels rather than model results to establish progress towards sustainable pumping and avoidance of undesirable results. SFK GSA will coordinate with the Westside Subbasin on monitoring and minimum threshold differences. Because two different models were used to simulate groundwater conditions on the boundary between SFK GSA and Westside GSA, future coordination regarding boundary flows will be based primarily on data and, if necessary, focused groundwater analysis along the boundary. In addition, SFK GSA will initiate a focused investigation of perched aquifer zones and their relationship to adjacent surface waters and the underlying semi-confined aquifer.

7.2.2.4 Measurement of Groundwater Pumping

SFK GSA will initiate a measurement program to monitor groundwater pumping in the SFK GSA. The program will utilize a combination of metering at individual wells, monitoring of surface water delivery, remote sensing of cropping patterns, and grower surveys to determine crop type, irrigation sources, irrigation practices, and groundwater use. An initial survey will be sent to each parcel owner in the spring of 2020 to initiate the program and determine land cover, water use patterns, and pumping well distribution on individual parcels within the SFK GSA. Depending on the results of this survey, the SFK GSA will structure a program to deploy or calibrate flow meters, establish baseline cropping patterns, and assess the accuracy of water use based on remotely sensed measurements in the SFK GSA. The data will be maintained in a publicly accessible GIS database that will restrict the identity of individual parcels and owners and aggregate groundwater pumping and crop-type to a uniform grid. At this time, the SFK GSA is planning to encourage, but not require meters, sounding tubes, and water quality sampling ports on all wells. Kings County Building Division will be engaged to modify the water well ordinance (Ordinance No. 587) to coordinate well permitting with the GSP.

7.2.2.5 Groundwater Accounting System

After the program for measurement of groundwater pumping has been established (see Section 7.7.4), SFK GSA will begin developing an accounting system that will link the measured pumping volumes with projects and policies to achieve overdraft reduction, sustainable yield, and avoidance of undesirable results. The details of this system are still being evaluated but could range from a simple annual reporting of groundwater pumping quantities to a more comprehensive accounting and allocation system that is tied to acreage, land use classification, crop/soil type, and/or irrigation efficiency. A white paper on potential accounting approaches will be developed in the summer of 2020, after the initial pumping survey. Integration of the SMCs, water budgets, and projects and management actions in the five surrounding basins will also affect SFK GSA's final decision on its accounting system.

7.2.2.6 Groundwater Pumping Fees

After adopting an approach to the groundwater accounting system (see Section 7.7.5), SFK GSA will begin developing a fee structure for groundwater users. Fee structures that will be evaluated will include: no fees, a per-well or per parcel charge for administrative purposes, a flat rate structure based on reported pumping, and a tiered rate structure based on volume and timing of pumping. Other approaches will be considered based on public outreach. The approach to groundwater accounting will affect the decision on a pumping fee structure. For example, if a pumping allotment based on acreage is adopted, a no fee or nominal fee structure may be feasible, since reduction in groundwater pumping would be enforced through the allotment system. A volume-based fee structure would be more applicable if fees are used to discourage groundwater pumping. A hybrid between these two approaches is also possible.

7.2.2.7 Demand Reduction Program

Based on the currently estimated overdraft, SFK GSA intends to initiate a program to reduce demand for groundwater. For initial planning purposes, SFK GSA intends to achieve 50 percent (%) of its overdraft correction through demand reduction measures. The other 50% of overdraft reduction is expected to come from supply enhancement measures (see Section 7.7.8). The elements of SFK GSA's demand reduction program are as follows:

1. Enhancement of surface water delivery and on-farm efficiency improvement: The overall intent of this element is to improve delivery of surface water with the expectation that this will reduce groundwater demand. Enhancements may include canal efficiency improvements or extensions within the canal service areas. As part of the initial groundwater measurement survey, information on current irrigation practices and access to surface water will be collected. Technical assistance will be provided to growers for

areas where on-farm irrigation practices could be improved. Discussions with surface water providers will be initiated to make clear to that the intent of these improvements would be to reduce demand for groundwater. A linkage between the groundwater accounting system and delivery or on-farm efficiencies could be established and incentivized.

2. Seasonal cropping and dryland farming program: The overall intent of this element is to reduce the amount of irrigated land supplied by groundwater during dry or drought years. The seasonal cropping and dryland farming programs would establish incentives for landowners who have non-orchard lands that could be fallowed or planted with less water-intensive crops during dry or drought years. Through public outreach, landowner surveys, and an analysis of land use, candidate areas will be identified for both programs. The magnitude of seasonal cropping or dryland farming necessary to reduce overdraft and achieve sustainability is linked to other projects and management actions. It is also linked to the projected severity of any given dry or drought year. Therefore, this type of program is more complicated to manage and fund. In general, SFK GSA considers seasonal cropping or dryland farming a viable strategy to achieve sustainable groundwater pumping, but a strategy that will require sufficient financial and management resources to implement.

3. Land retirement or long-term fallowing contracts: The overall intent of this element is to reduce the amount of irrigated land supplied by groundwater on a permanent or long-term basis. Through public outreach, landowner surveys, and an analysis of land use, candidate areas will be identified for land retirement or long-term fallowing. These areas could be based on number of factors ranging from poor soils, incompatible or urbanizing adjacent land uses, or areas that are not easily serviced by surface water. The magnitude of land retirement or long-term fallowing necessary to reduce overdraft and achieve sustainability is linked to other projects and management actions. In general, SFK GSA considers land retirement or long-term fallowing a "last resort" to achieve sustainable groundwater pumping.

7.2.2.8 Supply Enhancement Program

Supply enhancement options in the SFK GSA are limited because of the hydrogeologic setting within the SFK GSA. Surface recharge of flood flows within the SFK GSA is not expected to significantly enhance groundwater levels. However, SFK GSA will consider investment in surface recharge projects being proposed in MKR GSA and other GSA's north and east of the Tulare Lake Subbasin that are tributary to the Kings River. The decision to invest in upgradient recharge basins will depend on whether there are sufficient expected benefits to groundwater levels and accessible pumping within the SFK GSA service area. The primary supply enhancement method within the SFK GSA service area will focus on Aquifer Storage and Recovery (ASR).

ASR is an established method to recharge aquifers through direct injection of water into wells. SFK GSA has initiated a pilot study to determine the efficacy of ASR and has applied for a CEQA exemption to pilot test an ASR well in 2020. Subject to a successful pilot test and approvals from the Regional Water Quality Control Board and Division of Drinking Water, SFK GSA would then develop a program that would enable individual landowners to develop and initiate ASR operations when they have access to surface water suitable for underground injection. The constraints and design requirements for implementing ASR would be prepared in a comprehensive ASR Plan that would be subject to CEQA review. The costs for individual ASR projects would be borne by landowners, with potential matching support by SFK GSA. The benefits to landowners and the linkage to the GSA groundwater accounting system would also be described in the ASR Plan.

7.2.2.9 Financing

The SFK GSA is currently financed through a maximum assessment of $9.80 per acre that was approved through a Proposition 218 election in 2017 and the assessment will sunset in 2023. SFK GSA will establish a financing program that actively seeks out grants and funding partnerships that can implement the projects and management actions outlined in the GSP. The objective will be to establish a long-term financing plan that minimizes the per-acre charge needed to fully implement the GSP before a new Proposition 218 election in 2023. The SFK GSA considers financing of the projects and management actions outlined here as a major potential obstacle to implementation. Every effort will be made to establish sufficient financial support, but the economic viability of the area will be given full consideration in the selection and timing of projects and management actions.

7.2.2.10 Timeline

The expected timeline for implementation of the various elements described above is shown in Table 7-1.

7.2.3 Southwest Kings Groundwater Sustainability Agency

The average annual storage change for the Southwest Kings (SWK) GSA is estimated to be in surplus, thus projects to mitigate overdraft are not currently needed in this GSA. No projects have been determined at this time. Management actions may be determined at a later time and will be based upon annual monitoring results. A management area is also identified in this region.

Should development of groundwater be accomplished in the management area, a set of criteria would be employed to identify the quantity of groundwater pumping and monitoring of groundwater levels. The SWK GSA has indicated to the other GSAs in the Subbasin that it would be interested in financially participating in projects elsewhere in the Subbasin if doing so would affordably increase the water supply to the SWK GSA.

The SWK GSA is applying for Proposition 1 Technical Support Services grant funding to offset some of the capital improvement costs associated with the development of new monitoring wells to fill existing data gaps in the monitoring network.

7.2.4 Tri-County Water Authority Groundwater Sustainability Agency

7.2.4.1 Background

Tri-County Water Authority (TCWA) is a Joint Powers Authority created between local agencies cooperatively working towards groundwater sustainability by establishing a GSA between Angiola WD, Deer Creek Storm Water District, W. H. Wilbur Reclamation District, and Kings County. TCWA intends to manage groundwater within its boundaries in the Tulare Lake Hydrologic Region to accomplish the goals set forth in the GSP.

Angiola WD was formed in 1957 for the purpose of delivering agricultural water. Angiola WD is located in both the Tule and Tulare Lake subbasins. Angiola WD has a comprehensive conveyance system that delivers water for beneficial use. Angiola WD’s surface water is supplied by the Kings River, Tule River, Kaweah River, Deer Creek, and the State Water Project (SWP). Angiola WD is a stockholder in New Deal Ditch Company, Tulare Lake Water Company, Tulare Lake Canal Company, Lone Oak Canal Company, Last Chance Water Ditch Company, Settlers Ditch Company, and Bayou Vista Ditch Company.

TCWA has approximately 48,000 acres located in the Tulare Lake Subbasin, of which about 4,100 acres are currently farmed. Pistachios occupy approximately 3,400 acres of the farmed acreage, with field and hay crops occupying the remaining 700 acres. There are approximately 11,200 acres that are pasture. The remaining lands are fallow. The current cropped acres rely mostly on groundwater.

7.2.4.2 Projects

The Liberty Project is a water storage project on about 20 sections of private lands within Angiola WD and Kings County. This project will enable the capture and temporary storage of winter/spring flows from the Fresno Slough – Fresno Irrigation District, Mercy Springs, the Kings, Tule and Kaweah rivers, SWP Article 21 and Central Valley Project 215 waters. The project will be built in phases and will ultimately be capable of 94,000 acre-feet of surface storage. The stored water will be used in-lieu of groundwater pumping and for aquifer recharge.

7.2.4.3 Management Actions

TCWA has acted to implement certain management strategies immediately and has recognized the ability to develop additional actions and strategies over the 20-year implementation period. Management actions will be reviewed and revised by the TCWA Board of Directors at the five-year milestones to ensure sustainability is reached.

TCWA will implement its agriculture supply well metering program in 2020. The Board of Directors has required property owners within its service area to install flow meters on all agricultural supply wells by July of 2020 and to begin reporting pumping data to TCWA starting in January of 2021.

To address overdraft conditions, a demand reduction of groundwater pumping may be implemented by TCWA. Although the implementation of projects that reduce the use of groundwater is the goal of the GSA, it is acknowledged that a demand reduction in groundwater pumping may be necessary when projects alone cannot meet sustainability goals. TCWA's Board of Directors and Technical Advisory Committee will be collecting data and developing additional management actions to meet the sustainability goals set forth in the GSP.

7.2.5 El Rico Groundwater Sustainability Agency

The El Rico GSA and technical advisors have developed the projects and management actions described in Chapter 6. Once the GSP is approved, the projects and management actions previously selected are proposed to be advanced and implemented. Each GSA proposes their method to achieve sustainability, utilizing a combination of projects and management actions. Section 6.5, *GSA Sustainable Methods*, describes the mix of projects and management actions chosen by the GSA to meet the goals.

7.3 Identify Funding Alternatives

> **23 CCR §354.6.** *Agency Information. 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:*
> *(e) An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.*

The Subbasin GSAs successfully pursued grant funding to help develop the GSP. A number of the GSAs have already passed Proposition 218 elections, which secured funds to generate sufficient revenue for the initial preparation of the GSP and initial GSA administrative functions. The annual operational costs have begun and are used to fund agency operations and activities required by SGMA, including retaining consulting firms and legal counsel to provide oversight and lead the various agencies through the steps for SGMA compliance. Expenses consist of administrative support, GSP development, and GSP implementation. GSP development and GSA administrative costs are ongoing. Some other GSA specific information is also included in Section 7.2.

7.4 Data Management System

23 CCR §352.6. *Data Management System. Each Agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the Plan and monitoring of the basin.*

In development of this GSP, the five GSAs have developed a model that has been calibrated to estimate future scenarios. The data management system plans to build on existing data inputs in the groundwater model and develop a more formalized approach to collecting and capturing the data. As stated in Chapter 5, *Monitoring Network*, future data will be gathered to develop annual reports, as well as provide necessary information for future and ongoing update to the groundwater models at five-year intervals upon GSP implementation. The Data Management System (DMS) that will be used is a geographical relational database that will include information on water levels, surface water diversions, land elevation measurements, and water quality testing. The DMS will allow the GSAs to share data and store the necessary information for annual reporting.

The DMS will be on local servers and data will be transmitted annually to form a single repository for data analysis for the Subbasin's groundwater, as well as to allow for preparation of annual reports. GSA representatives have access to data and will be able to ask for a copy of the regional DMS. The DMS currently includes the necessary elements required by the regulations, including:

- Well location and construction information for the representative monitoring points (where available)
- Water level readings and hydrographs including water year type
- Land based measurements
- Water quality testing results
- Estimate of groundwater storage change, including map and tables of estimation
- Graph with Water Year type, Groundwater Use, Annual Cumulative Storage Change

Reporting generated from data from the GSA’s will include but is not limited to:

- Seasonal groundwater elevation contours
- Estimated groundwater extraction by category
- Total water use by source

Additional items may be added to the DMS in the future as required. Data will be entered into the DMS by each GSA. The majority of the data will then be aggregated to the entity that will be responsible for the regional DMS and summarized for reporting to DWR. Groundwater contours are prepared outside of the DMS because of the need to evaluate the integrity of the data collected and generate a static contour set that has been reviewed and will not change once approved. Groundwater storage calculations are performed in accordance with the method described in Section 3.2.3, outside of the DMS. Results are uploaded to the DMS for annual reporting and trend monitoring. Since most of the pumping in the GSAs (and the Subbasin) are not currently measured, the groundwater pumping estimates are also calculated outside of the DMS using the methods developed by GSAs and uploaded to the DMS for annual reporting and trend analysis. Surface water deliveries are maintained by the surface water agencies in existing separate systems, so the data are collected by each GSA and provided to the DMS as an aggregate total by GSA. Table 7-2 provides how the DMS addresses each required element of the DMS and annual reporting requirements. The GSAs may choose to have their own separate system for additional analysis.

7.5 Annual Reporting

23 CCR § 356.2 *Annual Reports. Each Agency shall submit an annual report to the Department by April 1 of each year following the adoption of the Plan. The annual report shall include the following components for the preceding water year:*

(a) General information, including an executive summary and a location map depicting the basin covered by the report.

(b) A detailed description and graphical representation of the following conditions of the basin managed in the Plan:

(1) Groundwater elevation data from monitoring wells identified in the monitoring network shall be analyzed and displayed as follows:

(A) Groundwater elevation contour maps for each principal aquifer in the basin illustrating, at a minimum, the seasonal high and seasonal low groundwater conditions.

(B) Hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year.

(2) Groundwater extraction for the preceding water year. Data shall be collected using the best available measurement methods and shall be presented in a table that summarizes groundwater extractions by water use sector, and identifies the method of measurement (direct or estimate) and accuracy of measurements, and a map that illustrates the general location and volume of groundwater extractions.

(3) Surface water supply used or available for use, for groundwater recharge or in-lieu use shall be reported based on quantitative data that describes the annual volume and sources for the preceding water year.

(4) Total water use shall be collected using the best available measurement methods and shall be reported in a table that summarizes total water use by water use sector, water source type, and identifies the method of measurement (direct or estimate) and accuracy of measurements. Existing water use data from the most recent Urban Water Management Plans or Agricultural Water Management Plans within the basin may be used, as long as the data are reported by water year.

(5) Change in groundwater in storage shall include the following:

> *(A) Change in groundwater in storage maps for each principal aquifer in the basin. (B) A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.*
>
> *I A description of progress towards implementing the Plan, including achieving interim milestones, and implementation of projects or management actions since the previous annual report.*

The GSAs will provide the Plan Manager or Subbasin Coordinator the required information of groundwater levels, extraction volume, surface water use, total water use, groundwater storage changes, and progress of GSP implementation for the annual report in accordance with the timelines required to meet the April 1st deadline each year.

The annual report is anticipated to have an outline similar to the following:

- Chapter 1– Introduction
- Chapter 2– Land use and Surface Water Supplies
- Chapter 3– Groundwater Pumping
- Chapter 4– Sustainable Management Criteria
- Chapter 5– Monitoring Network Changes
- Chapter 6– Groundwater Projects and Management Actions Status

In addition to the required Subbasin-wide reporting to DWR, the annual report needs to include the following:

- Member and Participating agency project/program specific progress and status updates
- Newly identify projects and programs added to the project list
- Updates on changes in membership or organizational changes
- Policy changes or modifications
- New information collected in data gaps
- Area specific investigations or improvements
- Stakeholder engagement and outreach efforts
- GSA funding status

7.6 Periodic Evaluations

> **23 CCR §356.4** *Periodic Evaluation by Agency. Each Agency shall evaluate its Plan at least every five years and whenever the Plan is amended and provide a written assessment to the Department. The assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the basin, and shall include the following:*
>
> *(a) A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives, interim milestones and minimum thresholds.*

> *(b) A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions.*
> *(c) Elements of the Plan, including the basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives, shall be reconsidered and revisions proposed, if necessary.*
> *(d) An evaluation of the basin setting in light of significant new information or changes in water use, and an explanation of any significant changes. If the Agency's evaluation shows that the basin is experiencing overdraft conditions, the Agency shall include an assessment of measures to mitigate that overdraft.*
> *(e) A description of the monitoring network within the basin, including whether data gaps exist, or any areas within the basin are represented by data that does not satisfy the requirements of Sections 352.4 and 354.34(c). The description shall include the following:*
> > *(1) An assessment of monitoring network function with an analysis of data collected to date, identification of data gaps, and the actions necessary to improve the monitoring network, consistent with the requirements of Section 354.38.*
> > *(2) If the Agency identifies data gaps, the Plan shall describe a program for the acquisition of additional data sources, including an estimate of the timing of that acquisition, and for incorporation of newly obtained information into the Plan.*
> > *(3) The Plan shall prioritize the installation of new data collection facilities and analysis of new data based on the needs of the basin.*
>
> *(f) A description of significant new information that has been made available since Plan adoption or amendment, or the last five-year assessment. The description shall also include whether new information warrants changes to any aspect of the Plan, including the evaluation of the basin setting, measurable objectives, minimum thresholds, or the criteria defining undesirable results.*
> *(g) A description of relevant actions taken by the Agency, including a summary of regulations or ordinances related to the Plan.*
> *(h) Information describing any enforcement or legal actions taken by the Agency in furtherance of the sustainability goal for the basin.*
> *(i) A description of completed or proposed Plan amendments.*
> *(j) Where appropriate, a summary of coordination that occurred between multiple Agencies in a single basin, Agencies in hydrologically connected basins, and land use agencies.*
> *(k) Other information the Agency deems appropriate, along with any information required by the Department to conduct a periodic review as required by Water Code Section 10733.*

The annual report will include updates or changes to the GSP or policy changes by the GSA's. Certain components of the GSP may be re-evaluated more frequently than every five years, if deemed necessary. This may occur, for example, if sustainability goals are not adequately met, additional data are acquired, or priorities are altered. Those results will be incorporated into the GSP when it is resubmitted to DWR every five years.

In addition, the annual report will provide an assessment to DWR in accordance with the regulatory requirements, at least every five years. The assessment will include and provide an update on progress in achieving sustainability including current groundwater conditions, status of projects or management actions, evaluation of undesirable results relating to MOs and minimum thresholds, changes in monitoring network, summary of enforcement or legal actions, and agency coordination efforts in accordance with 23 CCR §356.4.

As projects and management actions are being considered to mitigate for overdraft many of the projects and management actions will have implications to the farming economy within the Subbasin. Overdraft mitigation measures consist of the following project and management actions:

- Infiltration basins
- Storage ponds
- New water delivery systems
- Maintenance to existing water delivery systems
- Crop rotation
- Fallowing of lands
- Pumping restrictions

These project and management actions will reduce the farmable acres, and initiate restriction of groundwater pumping. A reduction in farmable acres may result in adverse effects (e.g., reduction in jobs). On the other hand, groundwater pumping restrictions will result in positive effects (e.g., reduction in pumping costs and drilling of new wells).

Reduction in Farmable Acreage: Kings County anticipates a lack of water sources for agricultural production has the potential to impact employment statistics in the area (Nidever 2014). In 2014, Kings County residents experienced and average of 15% unemployment in February, according to a report released by the state Employment Development Department, compared to an unadjusted rate of 8.5% for California and 7% for the nation as a whole.

Reduction in Pumping: Transitioning the Subbasin area to sustainable groundwater management is expected to impact the agricultural sector in three ways. First, institutional restrictions on groundwater extraction are likely to alter the mix of crops grown in the region and the amount produced. Second, stabilized groundwater elevations are predicted to reduce groundwater pumping costs over time, thereby lowering costs of production. Third, stabilized groundwater elevations are expected to reduce the need for capital investment to refurbish wells and develop additional wells (RMC Water and Environment 2015).

However, the reduction in groundwater pumping section states there will be an equalization of cost associated with higher groundwater levels due to pumping restrictions. This does not address the increase in the unemployment rate associated with the reduction in pumping (e.g., demand reduction). At this time there is not sufficient information to develop a financial impact due to demand reduction.

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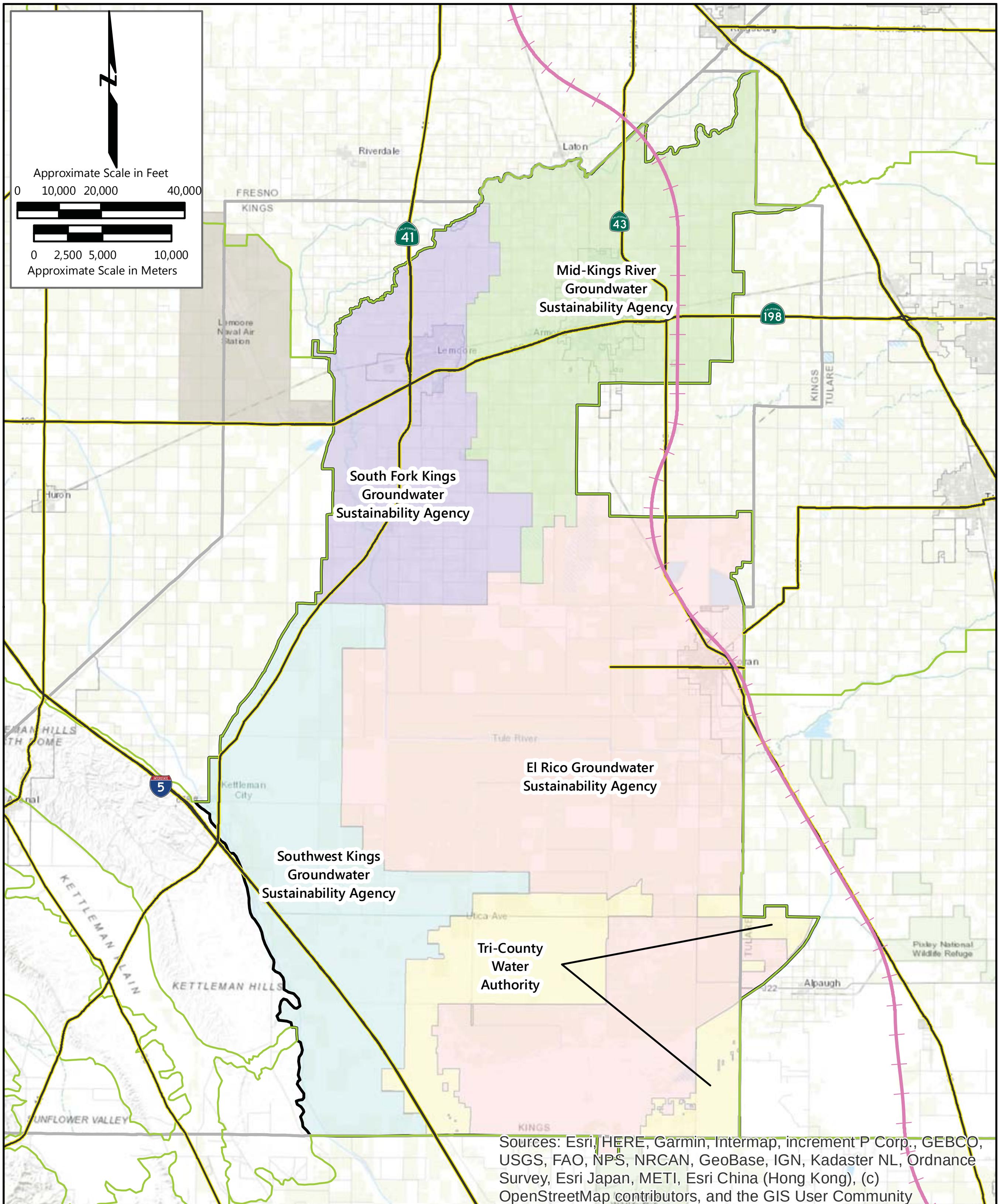

Explanation

- CHSR proposed route
- Other groundwater subbasins (DWR 2017)
- Subbasin boundary
- County

Tulare Lake Subbasin

Tulare LakeSubbasin Groundwater Sustainability Plan
Kings County, Calfiornia

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-1**

Date: 1/8/2020 Printed by: scott.mitchell2
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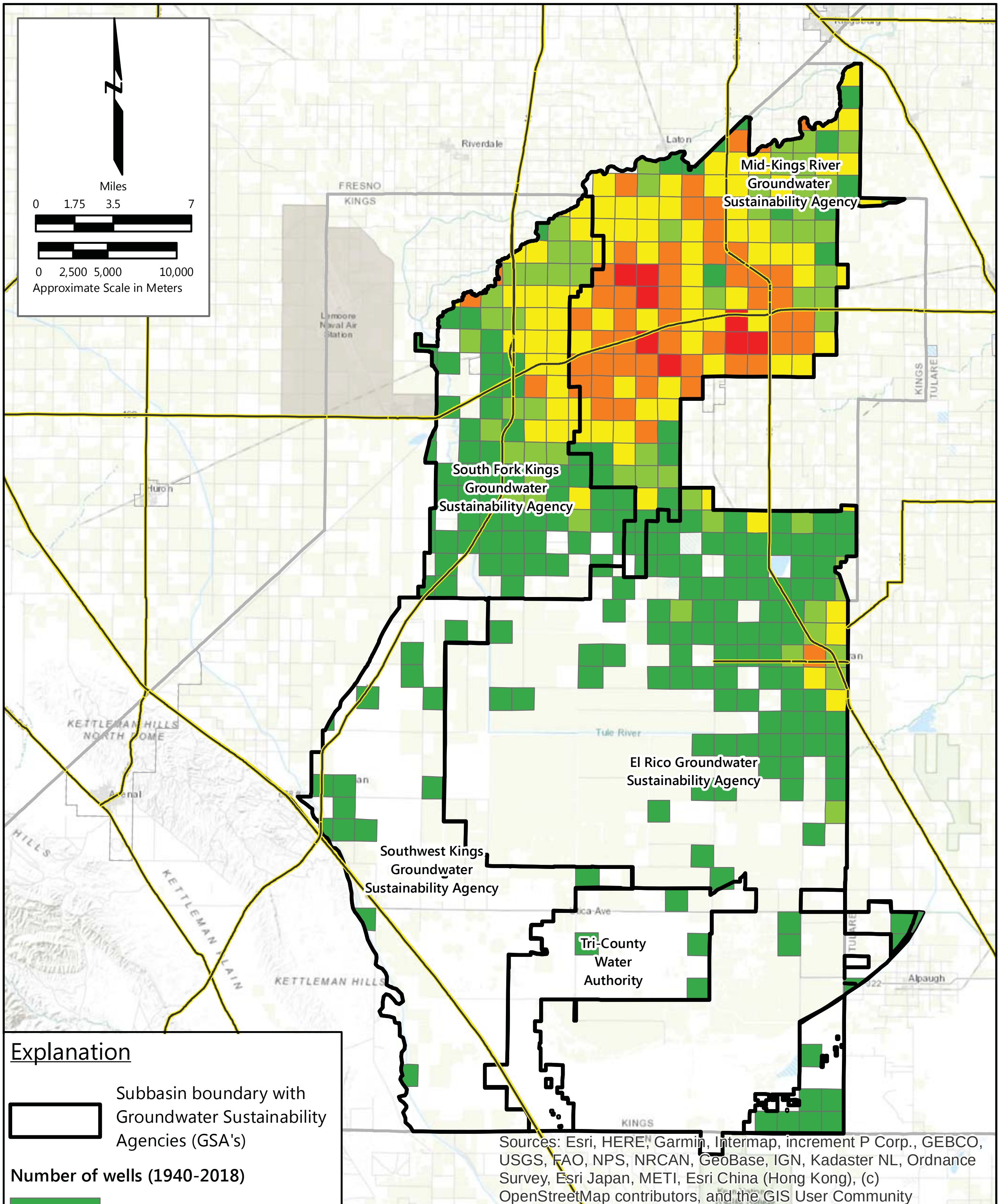

Explanation

Subbasin boundary with Groundwater Sustainability Agencies (GSA's)

Number of wells (1940-2018)

- 1-5
- 6-10
- 11-20
- 21-40
- 41-67

Notes:
1. Data accessed from the Department of Water Resources https://water.ca.gov/Programs/Groundwater-Management/Wells/Well-Completion-Reports November 2019

Well Density Map

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-2**

Date: 1/8/2020 Printed by: scott.mitchell2
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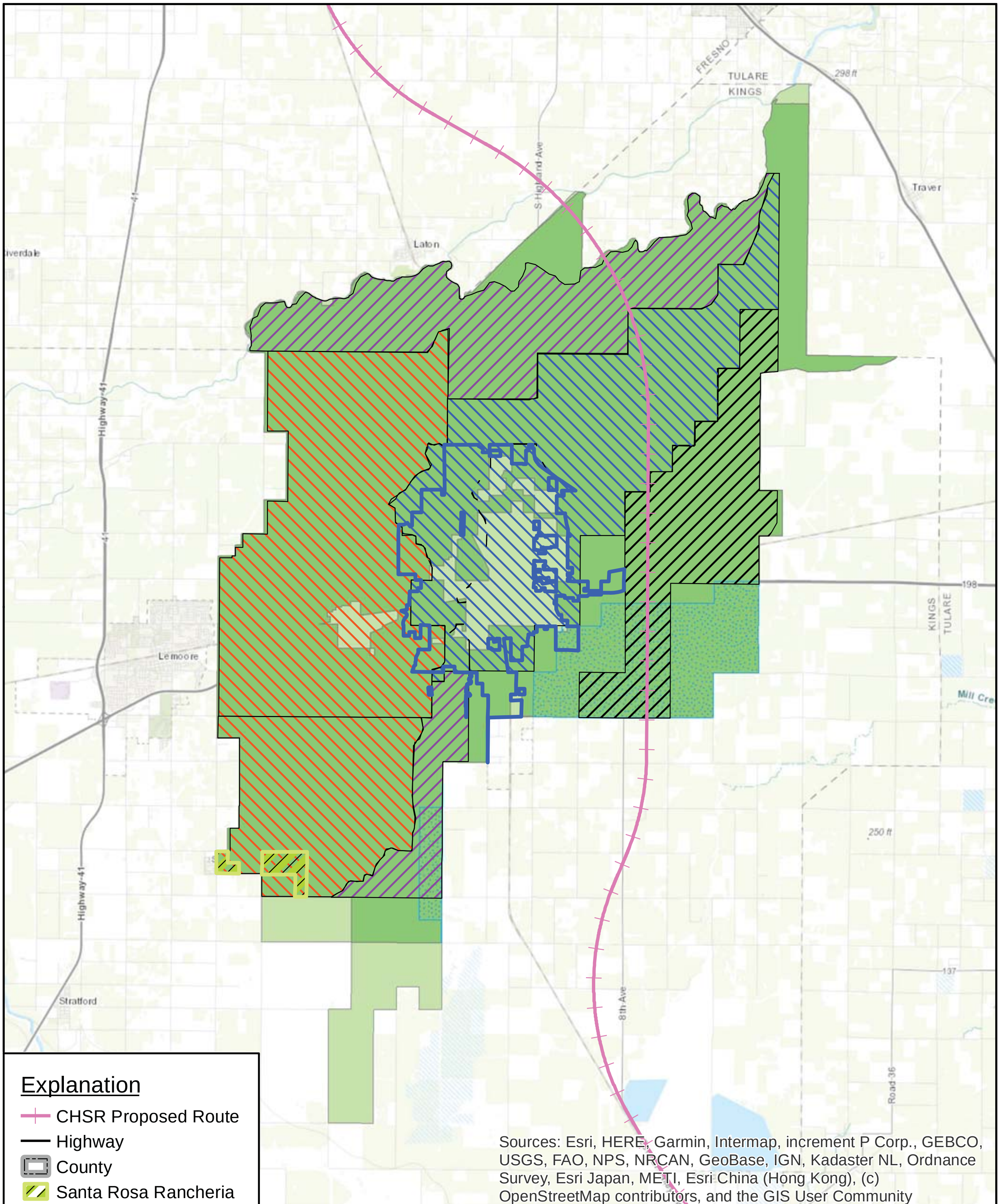

Jurisdictional Areas Within The Mid-Kings River GSA

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-3**

Date: 1/8/2020 Printed by: scott.mitchell2
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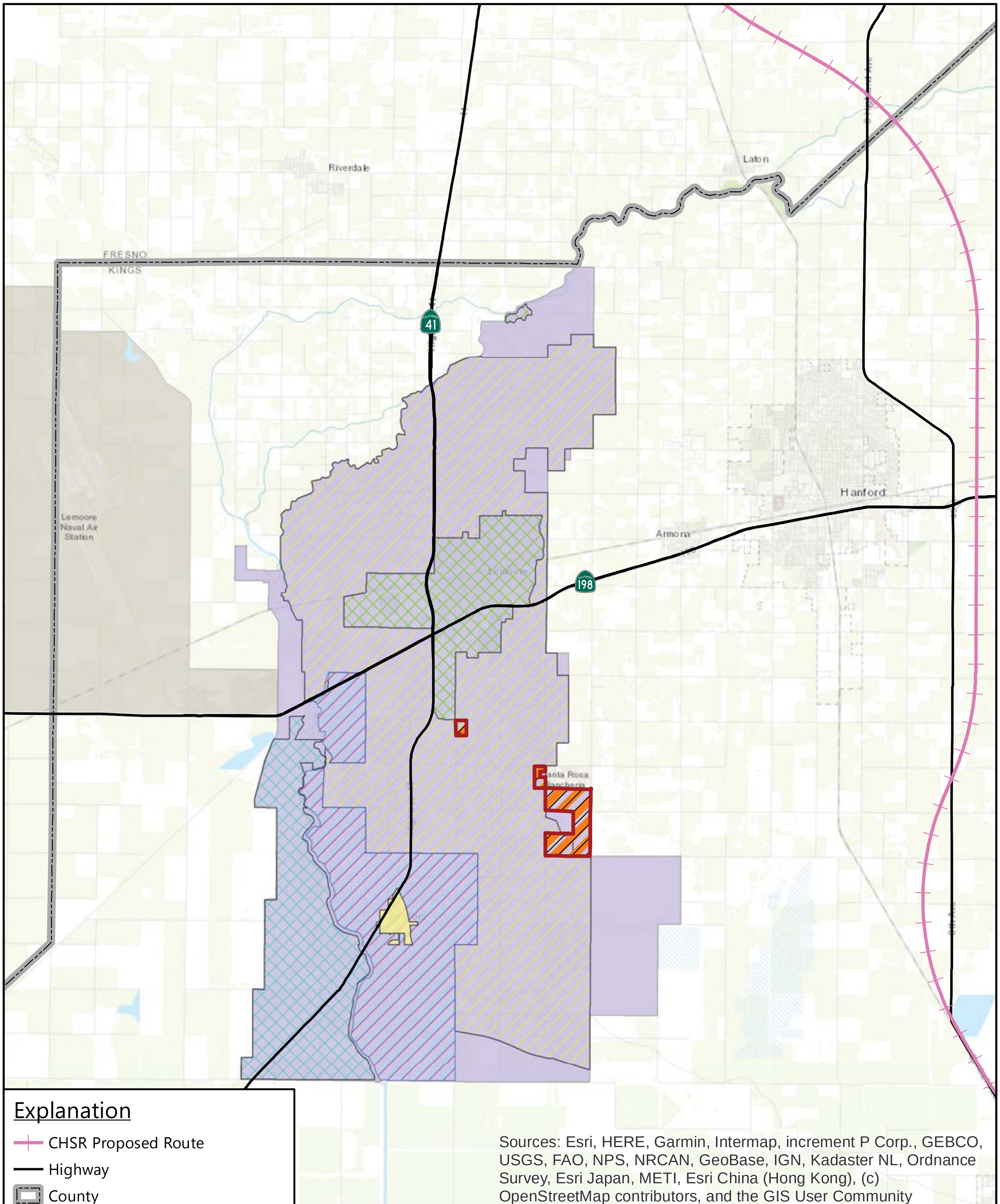

Explanation

- CHSR Proposed Route
- Highway
- County
- Santa Rosa Rancheria
- City of Lemoore
- Stratford PUD
- Empire Westside Irrigation District
- Stratford Irrigation District
- Lemoore Canal & Irrigation Co
- South Fork Kings GSA

Miles: 0, 1.25, 2.5, 5
Kilometers: 0, 1.25, 2.5, 5

N

Jurisdictional Areas Within The South Fork Kings GSA

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-4**

Date: 1/8/2020 Printed by: scott.mitchell2
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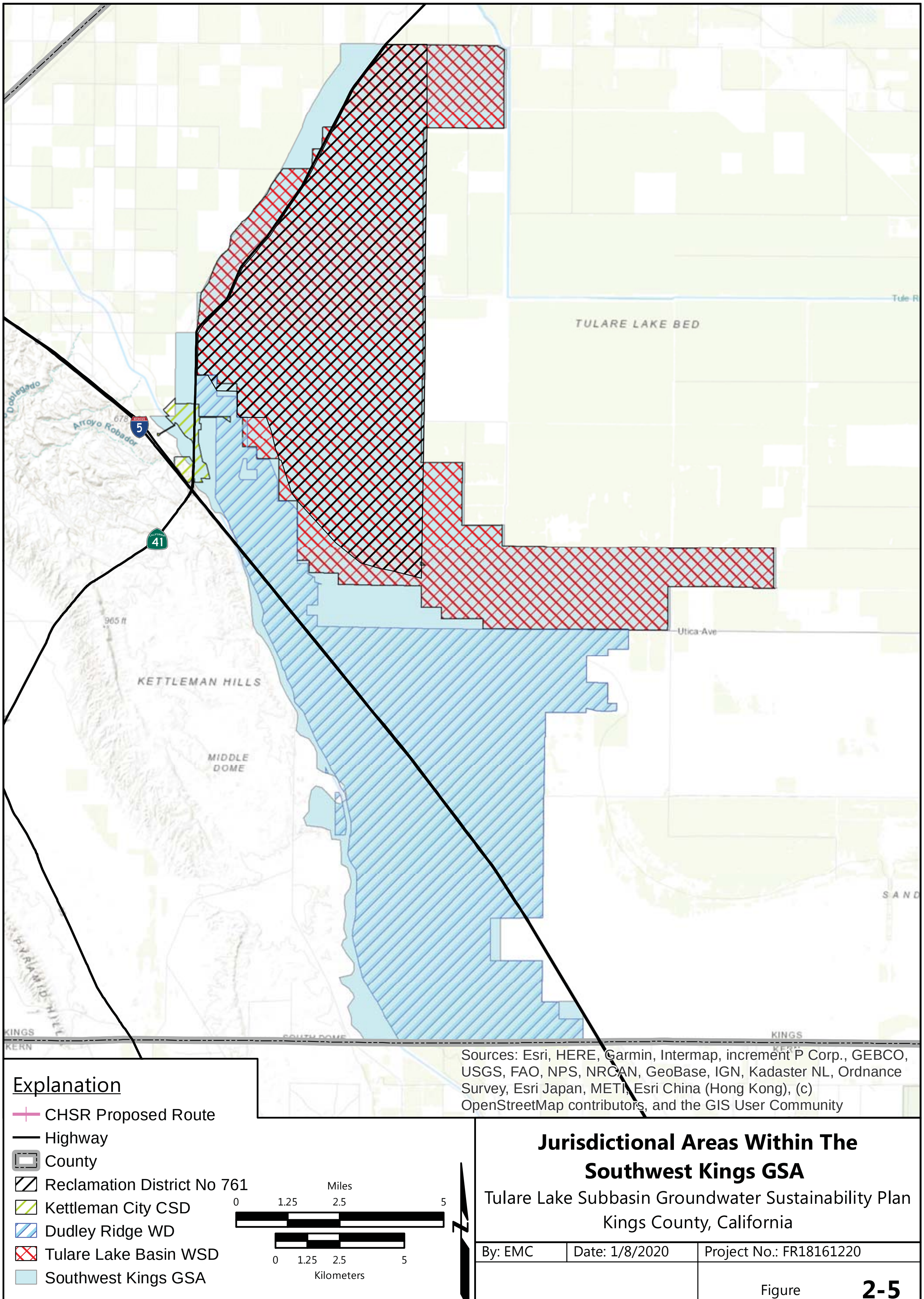

Jurisdictional Areas Within The Southwest Kings GSA

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-5**

Date: 1/8/2020 Printed by: scott.mitchell2
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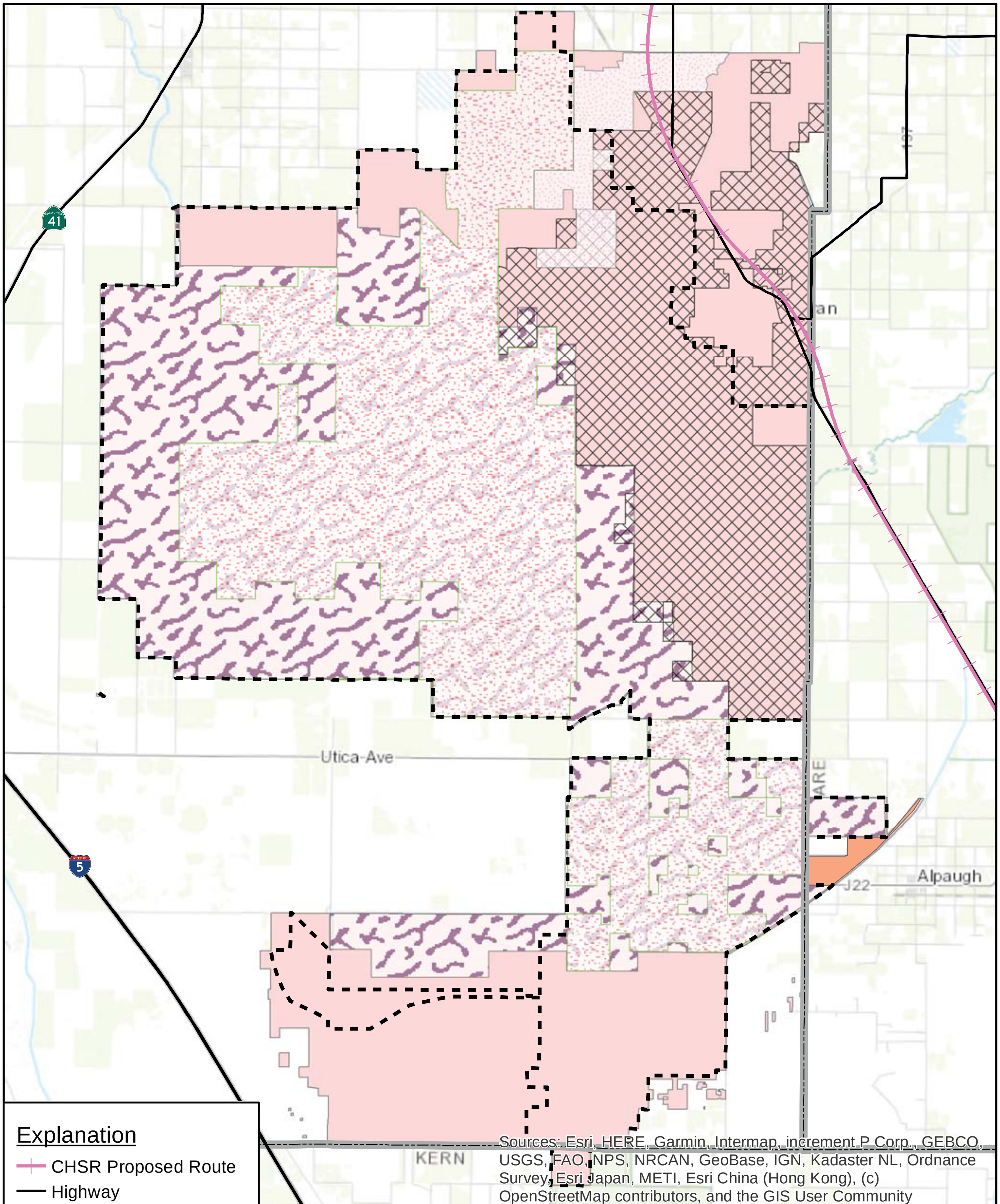

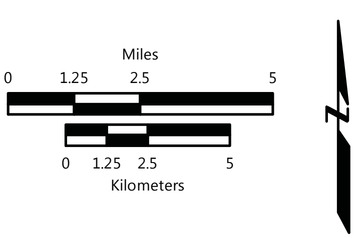

Jurisdictional Areas Within The El Rico GSA

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-6**

Date: 1/8/2020 Printed by: scott.mitchell2
Path: N:_FR_projects\FR18\FR18161220\gis\maps\2019\Plan_Area\Nov2019_fig2-6_ElRicoParticipants_8x11.mxd

Date: 1/8/2020 Printed by: scott.mitchell2
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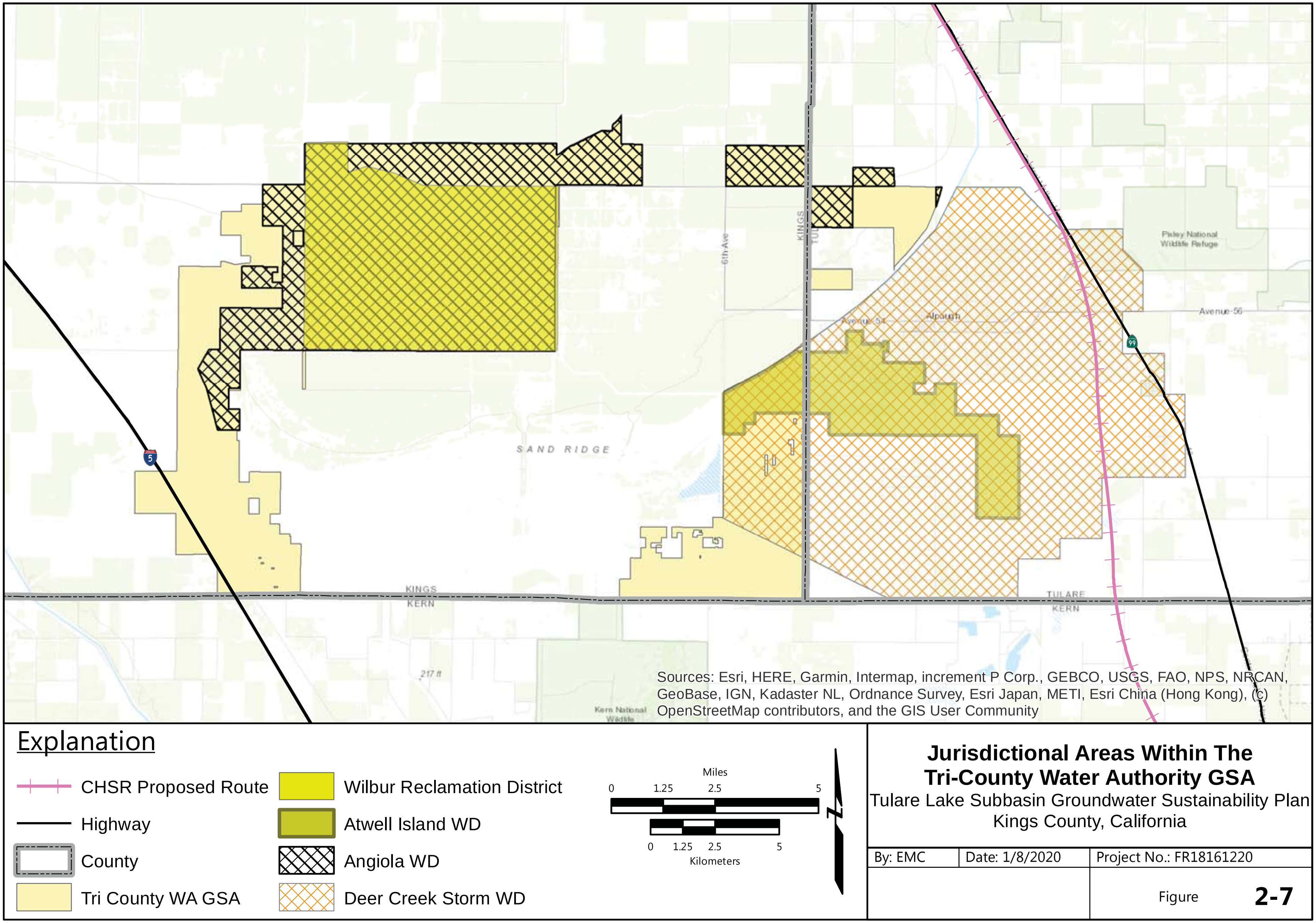


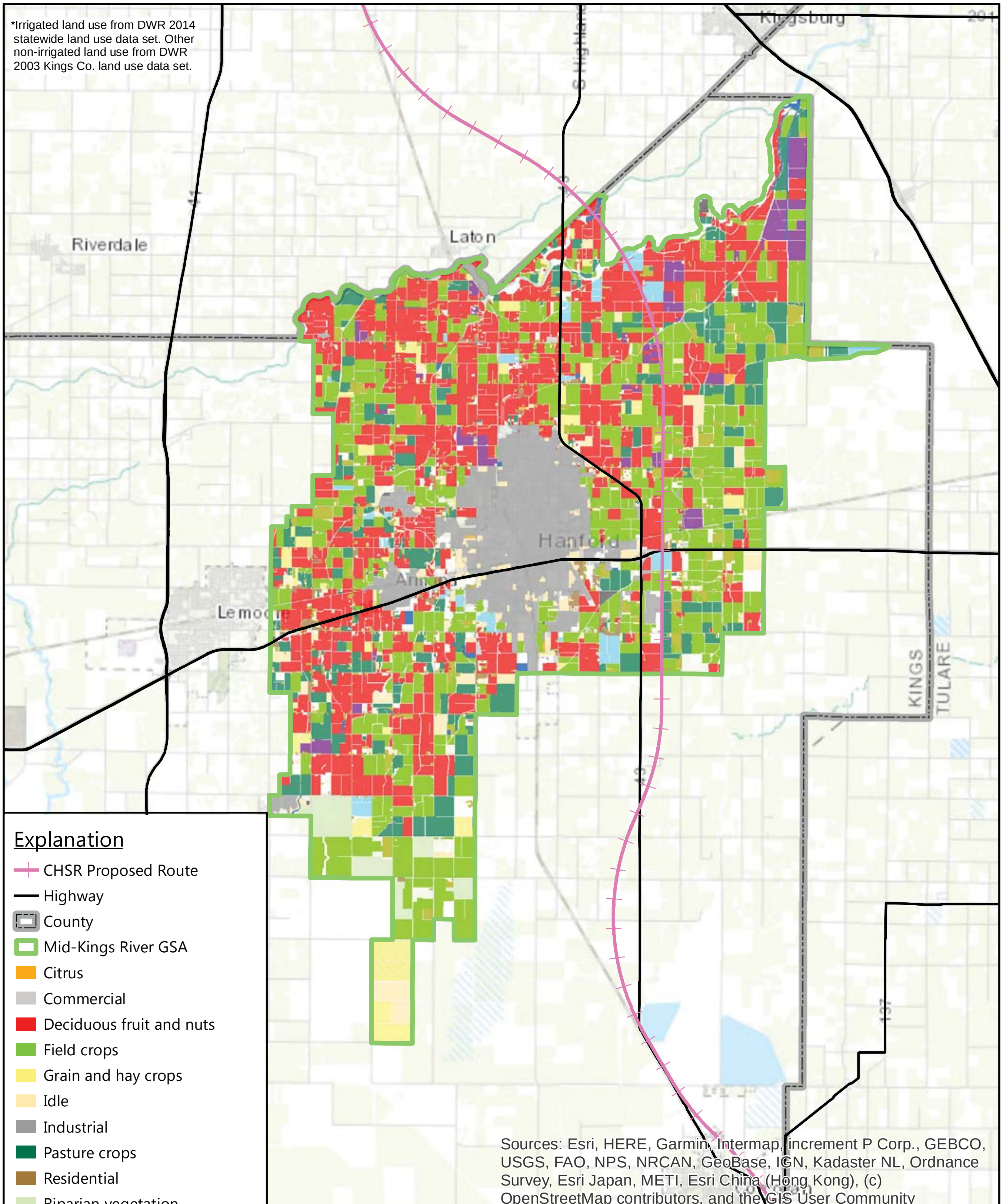
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Jurisdictional Areas Within The Tri-County Water Authority GSA

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 1/8/2020 | Project No.: FR18161220

Figure **2-7**



Explanation

- CHSR Proposed Route
- Highway
- County
- Mid-Kings River GSA
- Citrus
- Commercial
- Deciduous fruit and nuts
- Field crops
- Grain and hay crops
- Idle
- Industrial
- Pasture crops
- Residential
- Riparian vegetation
- Semiagricultural
- Truck, nursery and berry crops
- Urban
- Urban landscape
- Vineyards
- Water surfaces
- Young perennial

Miles
0 1.25 2.5 5

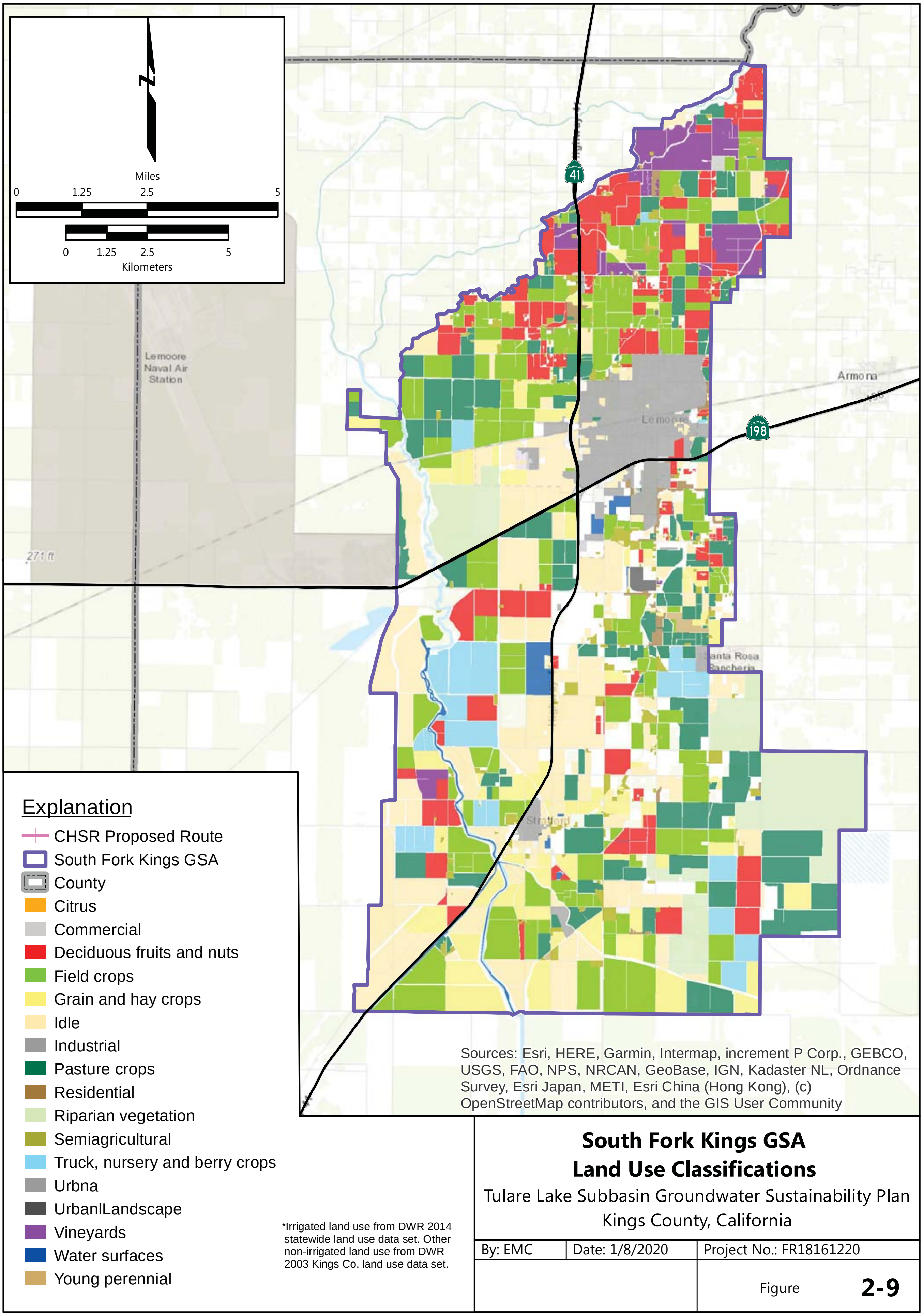
0 1.25 2.5 5
Kilometers

Mid-Kings River GSA
Land Use Classification

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-8**

Date: 1/8/2020 Printed by: scott.mitchell2
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Plan_Area\Nov2019_fig2-8_MidKings_Landuse_8x11.mxd



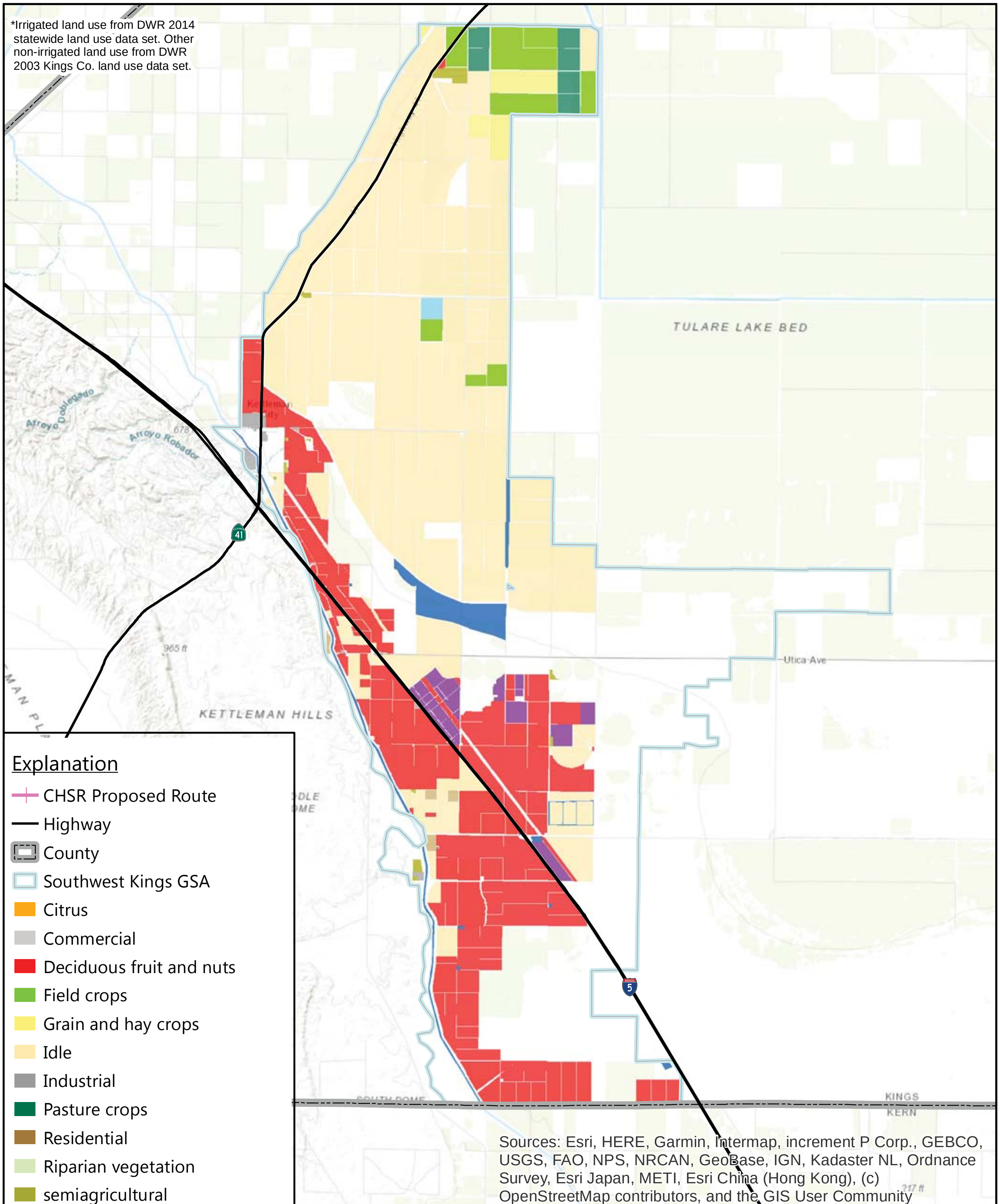
*Irrigated land use from DWR 2014 statewide land use data set. Other non-irrigated land use from DWR 2003 Kings Co. land use data set.

South Fork Kings GSA
Land Use Classifications

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-9**

Date: 1/8/2020 Printed by: scott.mitchell2
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Plan_Area\Nov2019_fig2-9_SouthFork_Landuse_8x11.mxd



Southwest Kings GSA

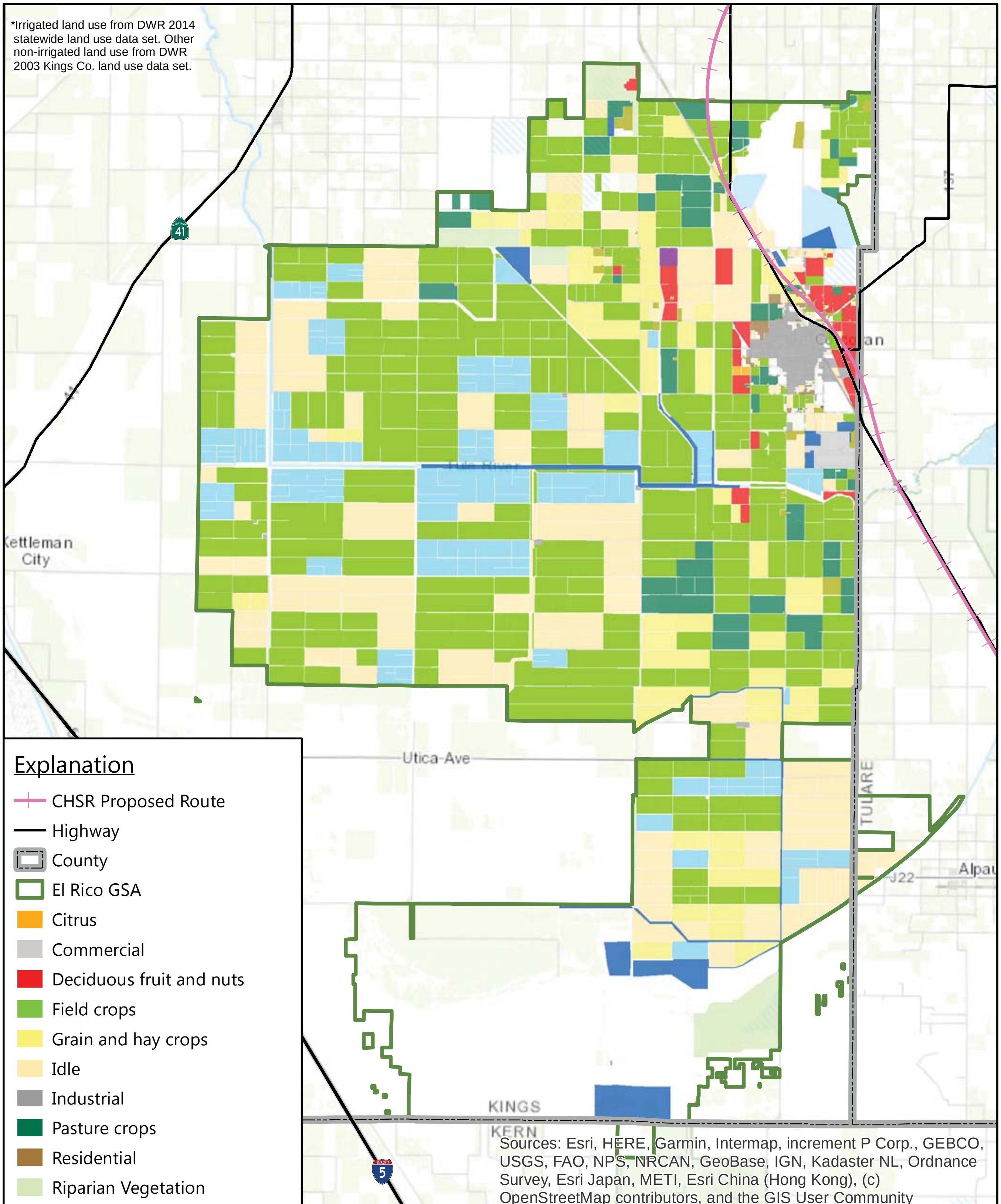
Land Use Classifications

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-10**

Date: 1/8/2020 Printed by: scott.mitchell2
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Plan_Area\Nov2019_fig2-10_SWKings_LandUse_8x11.mxd



Explanation

- CHSR Proposed Route
- Highway
- County
- El Rico GSA
- Citrus
- Commercial
- Deciduous fruit and nuts
- Field crops
- Grain and hay crops
- Idle
- Industrial
- Pasture crops
- Residential
- Riparian Vegetation
- Semiagricultural
- Truck, nursery, and berry crops
- Urban
- Urban landscape
- Vineyards
- Water surfaces
- Yound perennial

Miles: 0 1.25 2.5 5

Kilometers: 0 1.25 2.5 5

El Rico GSA Land Use Classification

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-11**

Date: 1/8/2020 Printed by: scott.mitchell2
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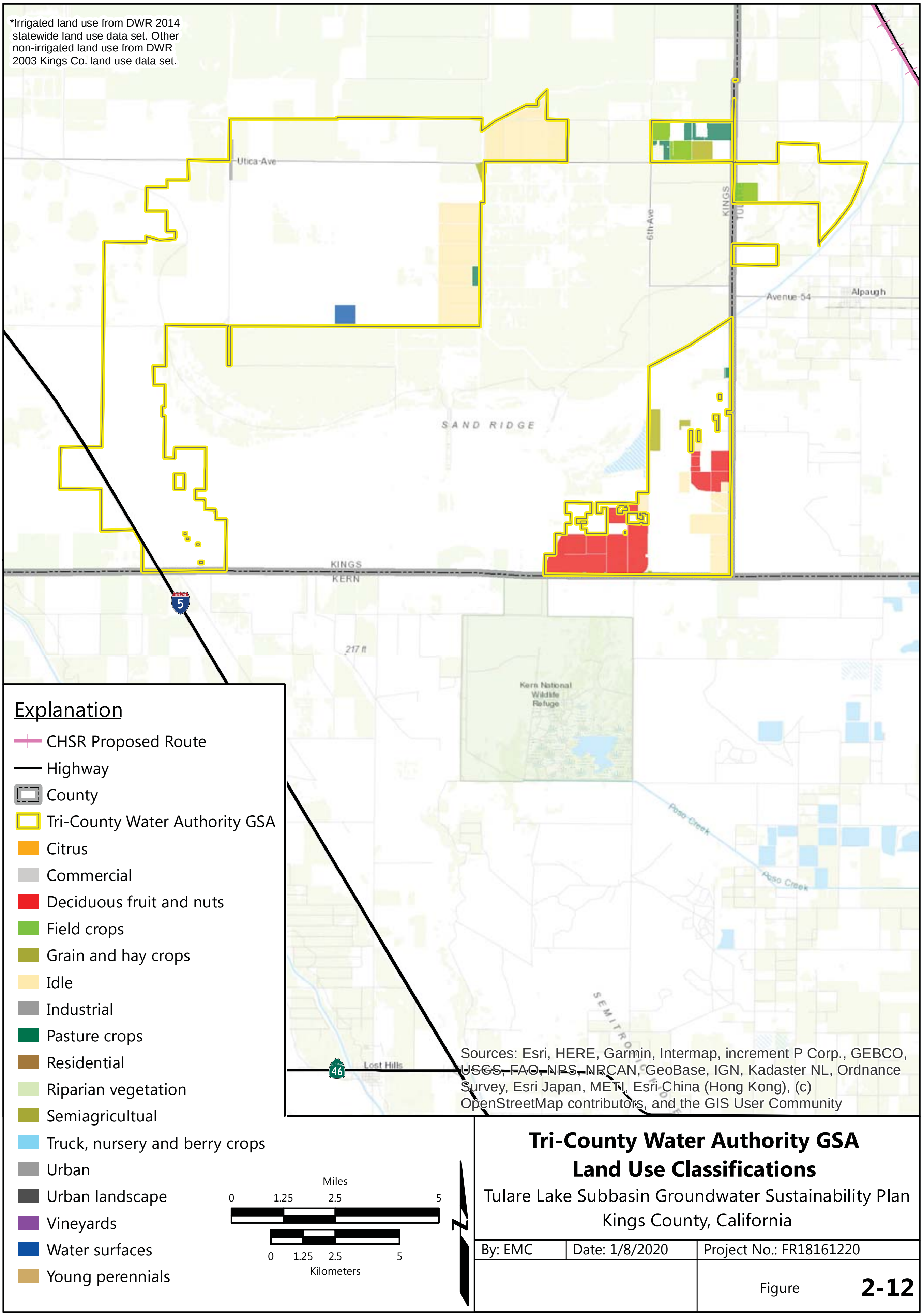
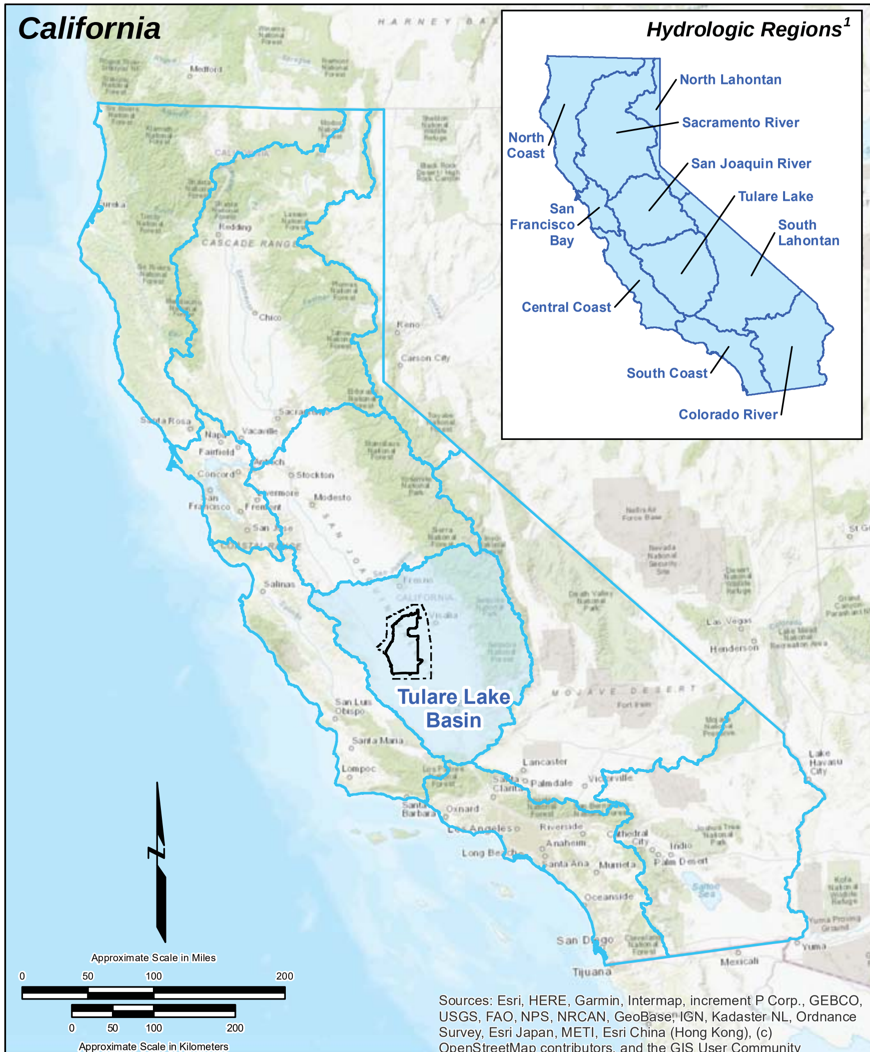


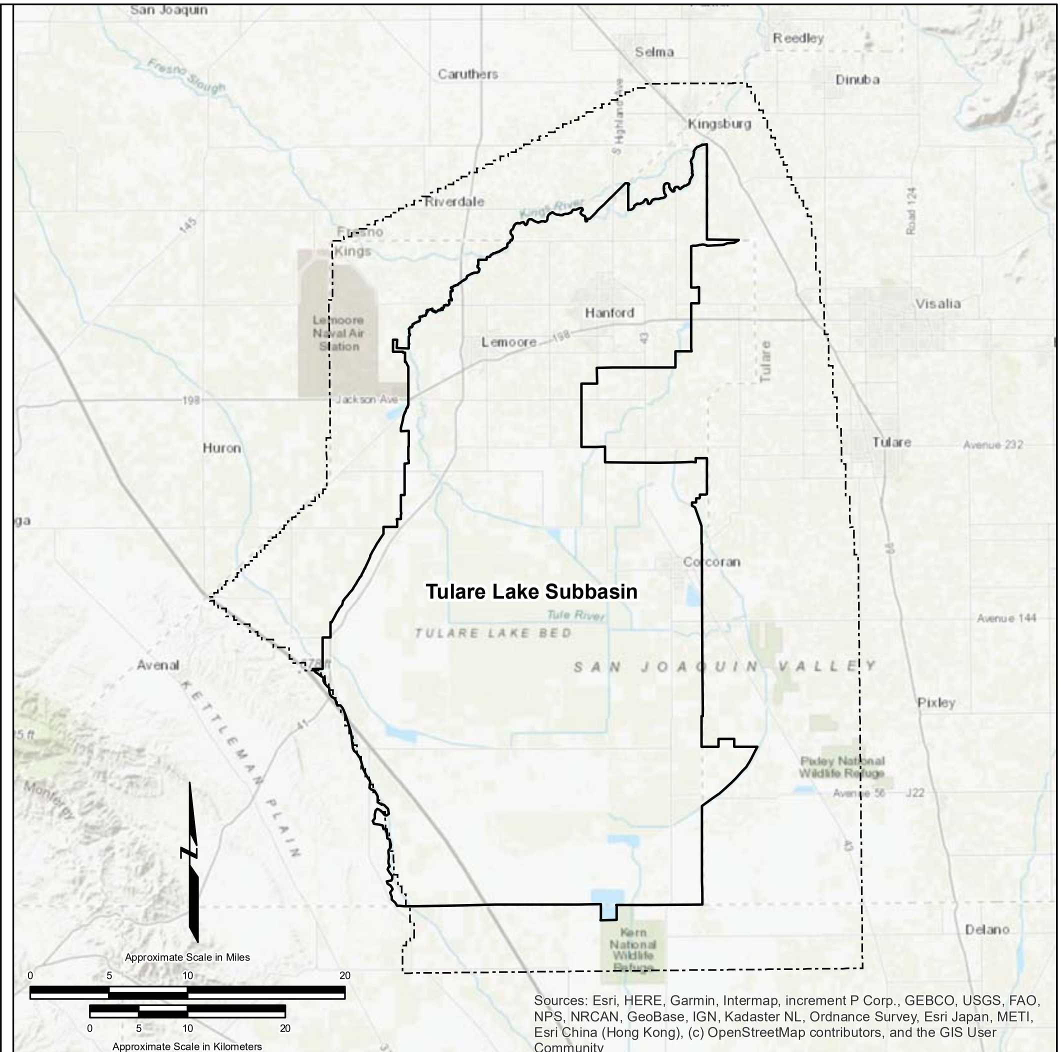
Tri-County Water Authority GSA
Land Use Classifications

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **2-12**

Date: 1/8/2020 Printed by: scott.mitchell2
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Plan_Area\Nov2019_fig2-12_TriCountyWA_LandUse_8.5x11.mxd





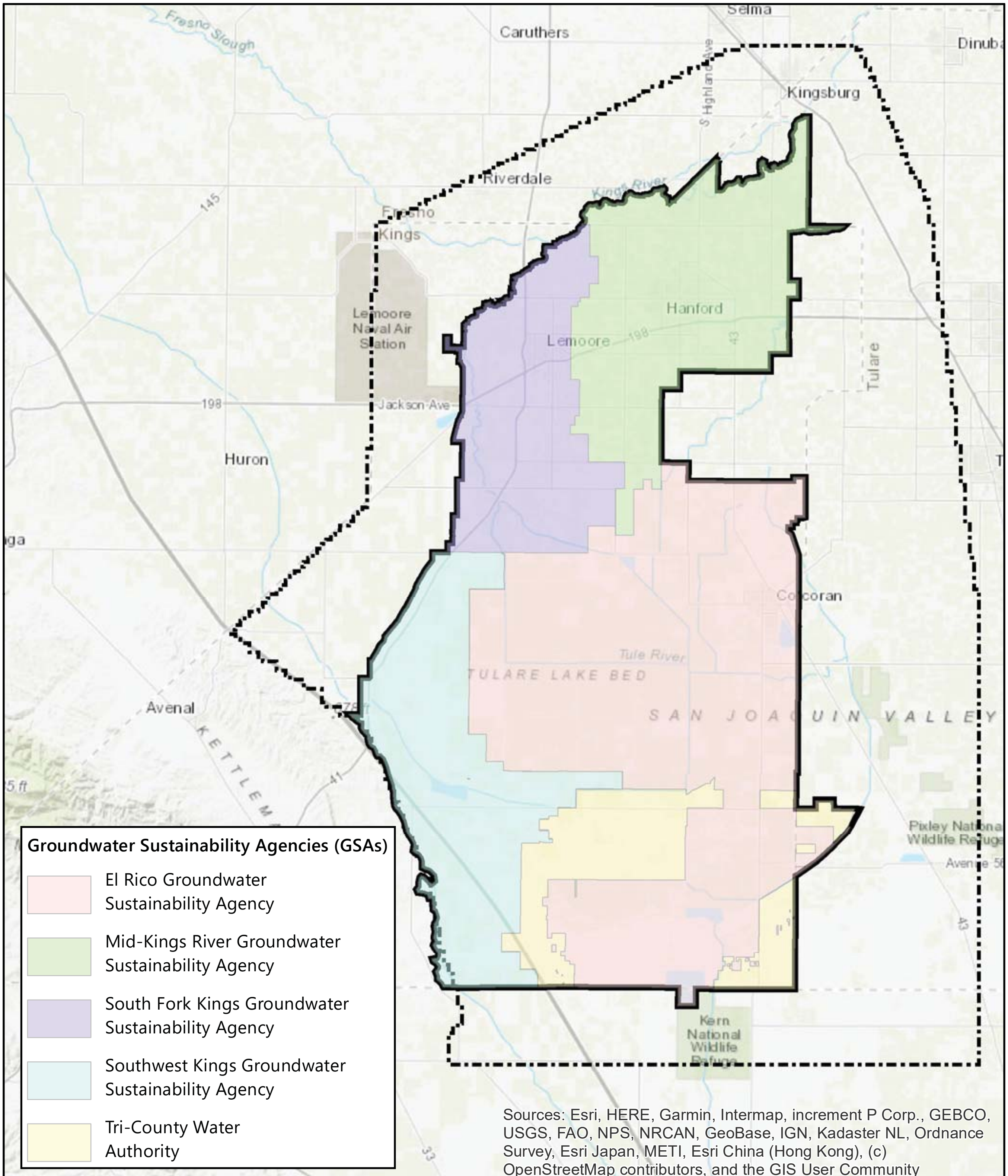
Explanation

- Hydrologic region
- Subbasin boundary
- Study Area

Note:
1) Hydrologic region dataset obtained from California Department of Water Resources (CA DWR), September 12, 2018.
https://data.ca.gov/dataset/hydrologic-regions

Site Location Map
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/9/2020	Project No.: FR18161220
		Figure **3-1**



Explanation

Study area

Subbasin boundary

Miles: 0 2 4 8

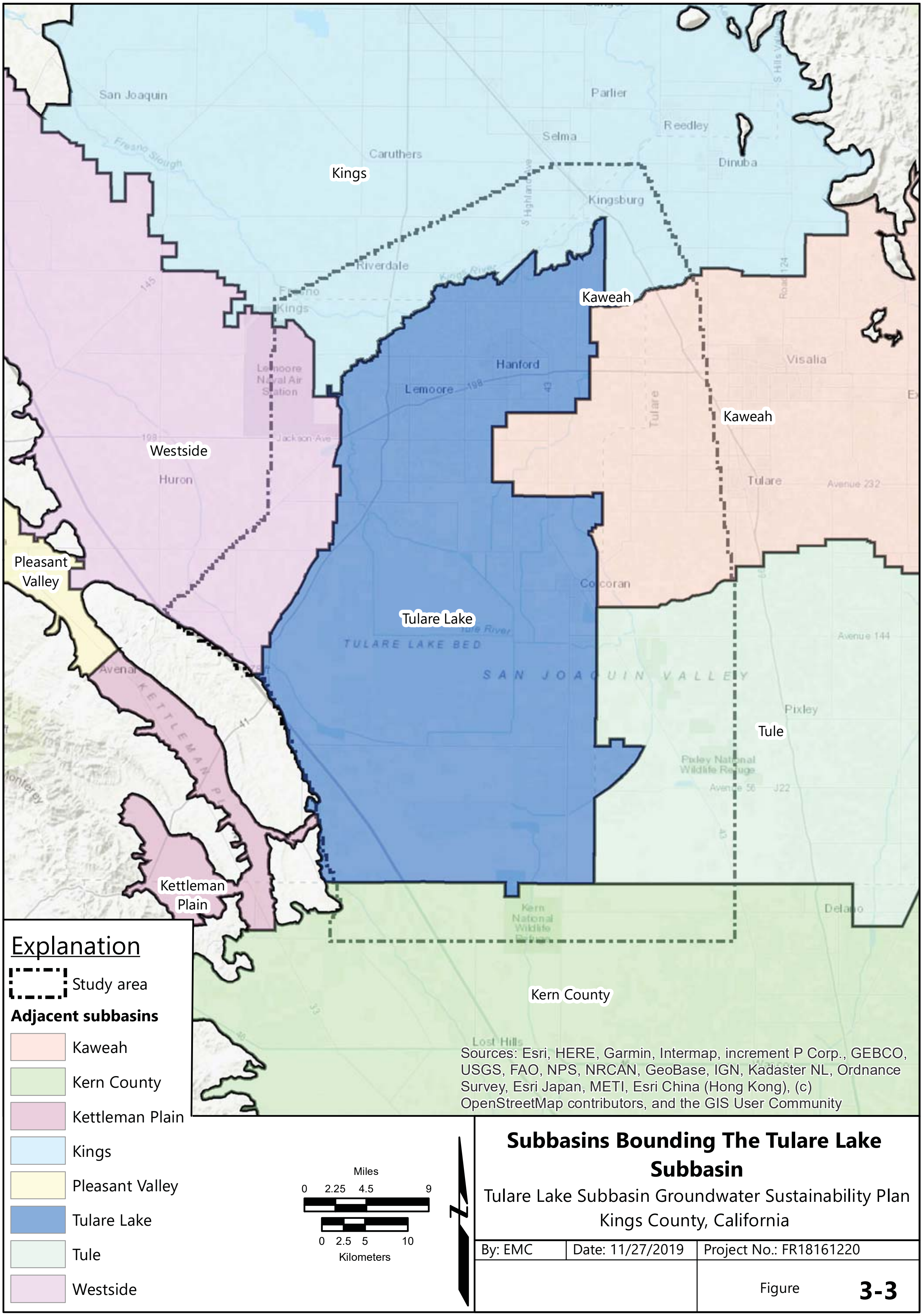
Kilometers: 0 2.5 5 10

Groundwater Sustainability Agencies in Tulare Lake Subbasin

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/27/2019	Project No.: FR18161220
		Figure **3-2**

Date: 11/27/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-2_GSAs.mxd



Subbasins Bounding The Tulare Lake Subbasin

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/27/2019	Project No.: FR18161220
		Figure **3-3**

Date: 11/27/2019 Printed by: elizabeth.chapman
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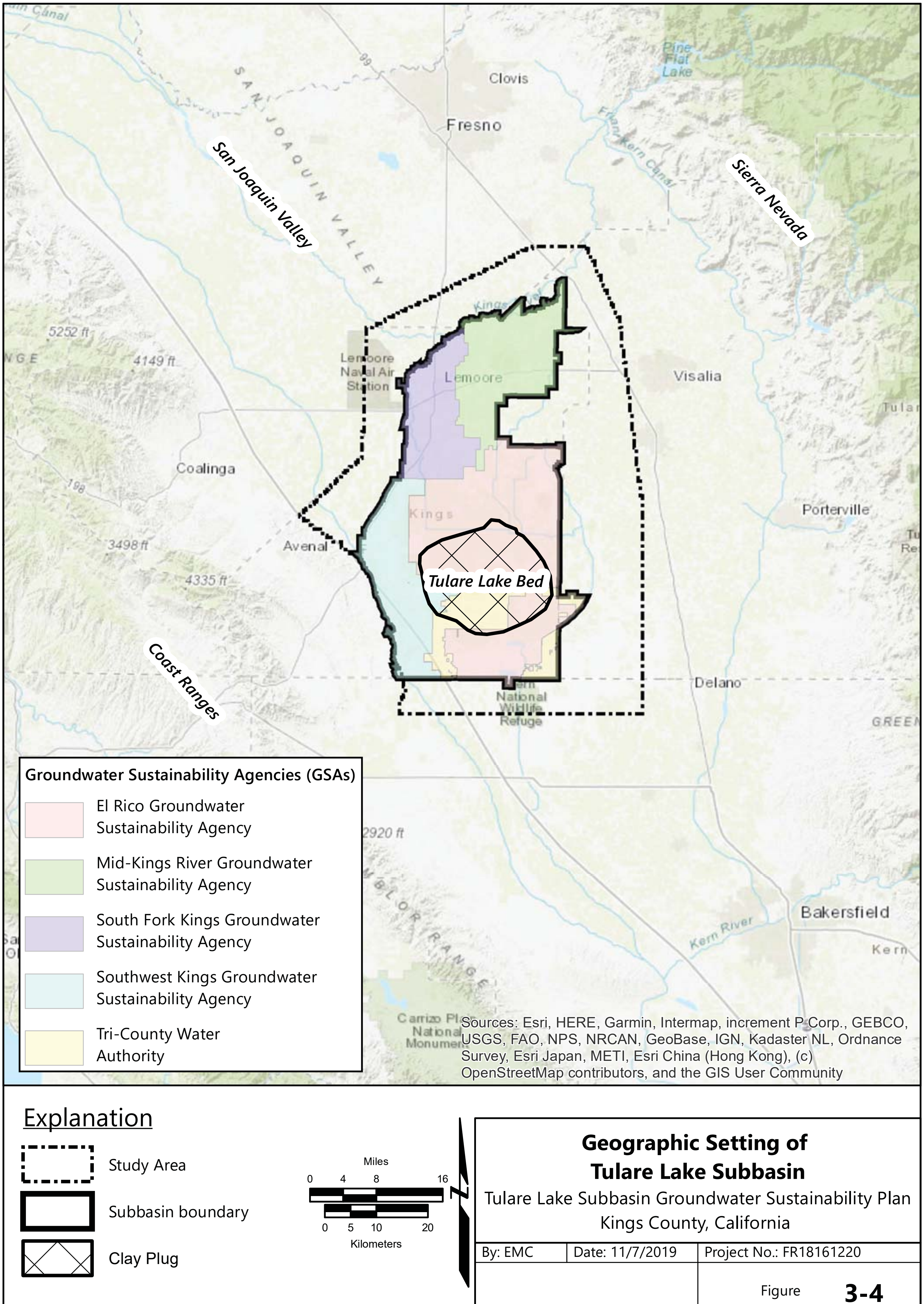


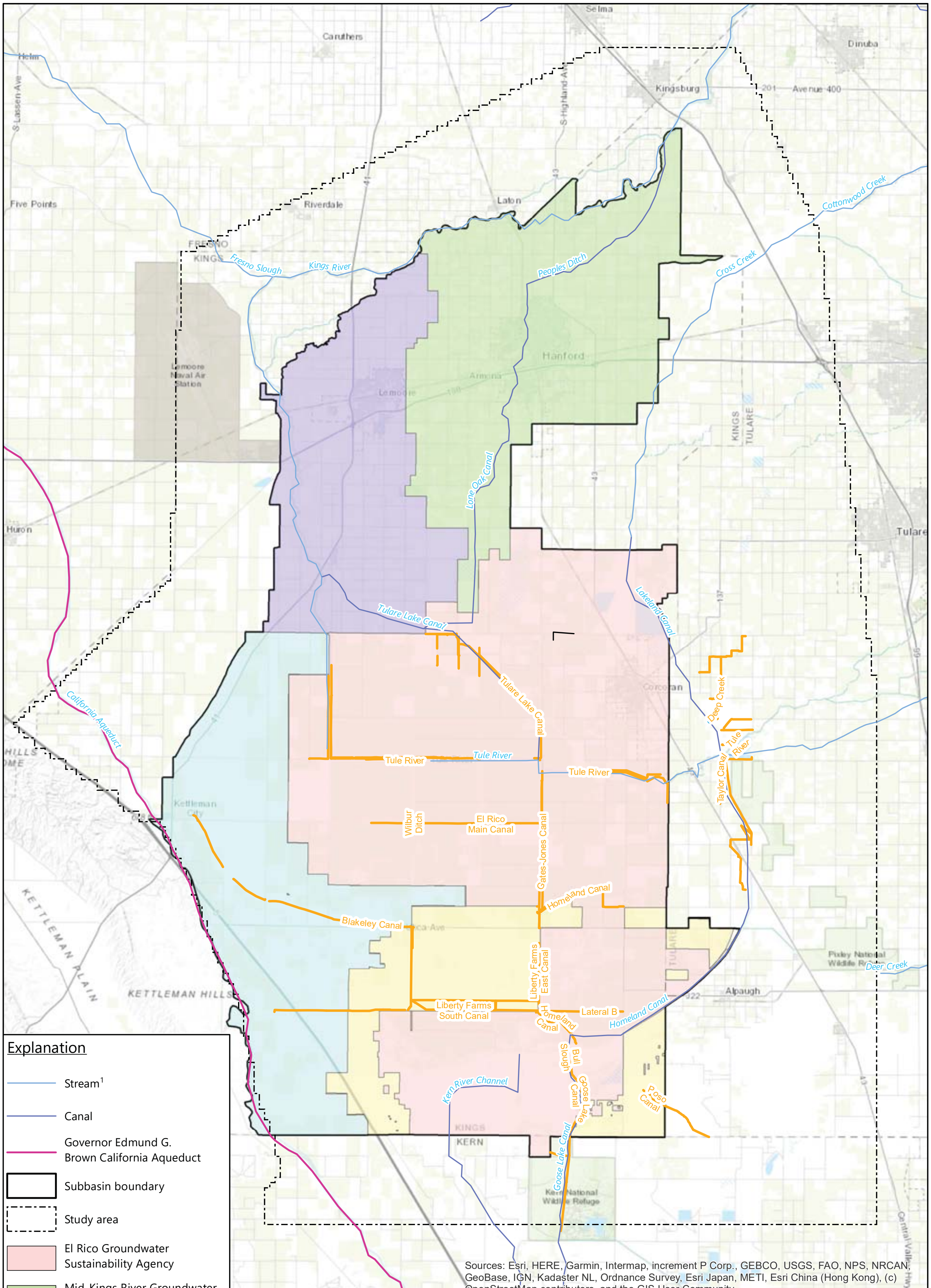
Geographic Setting of Tulare Lake Subbasin

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/7/2019	Project No.: FR18161220
		Figure **3-4**

Date: 11/7/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-4_GeographicMap.mxd

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-5_SurfaceWaterSystem.mxd



Approximate Scale in Miles: 0, 2, 4, 8

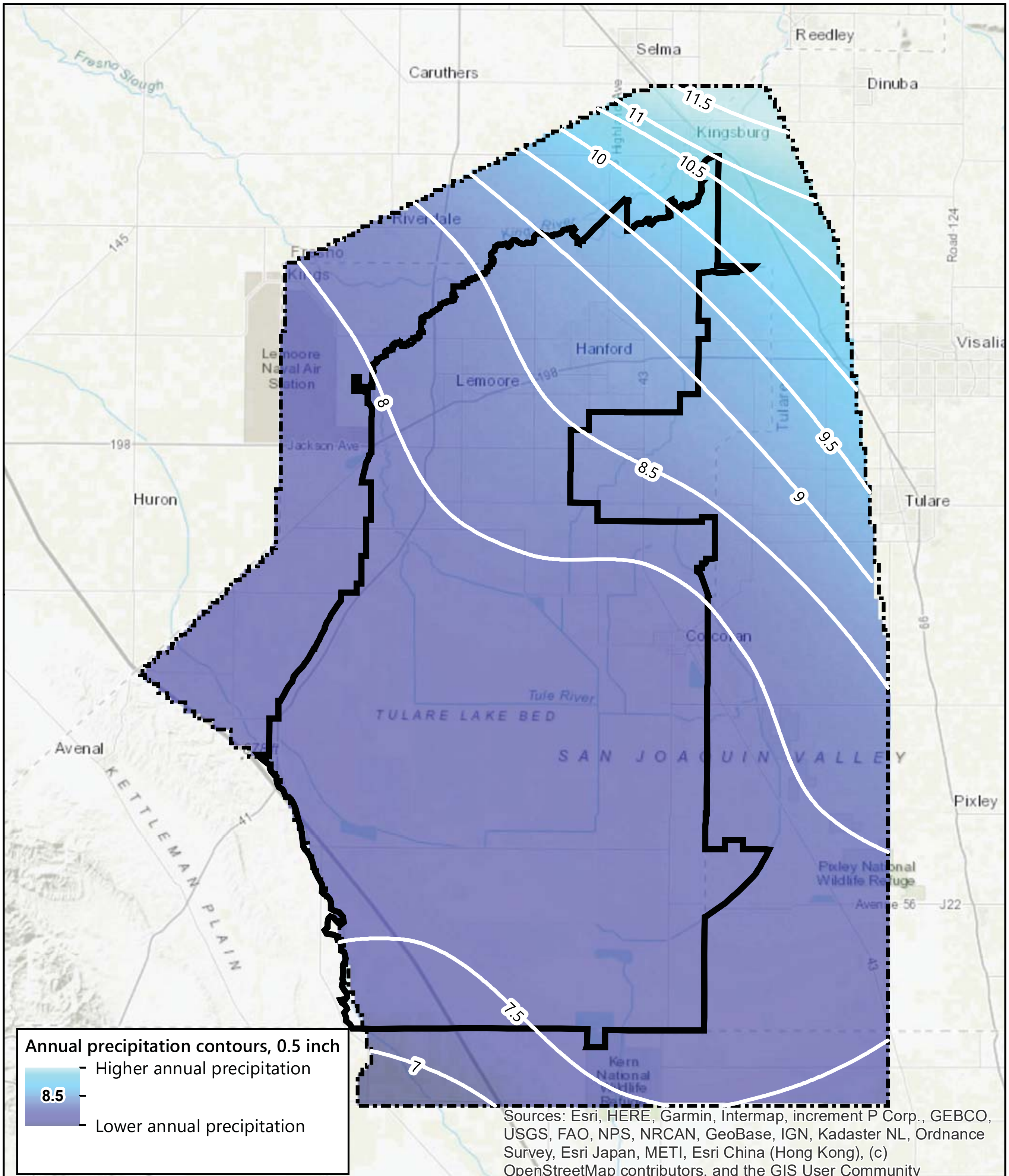
Approximate Scale in Kilometers: 0, 2, 4, 8

Notes:
1. Surface water data taken from ESRI World Hydro Basemap

Surface Water System

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/9/2020	Project No.: FR18161220
		Figure **3-5**



Explanation

Study area

Subbasin boundary

Miles: 0, 2, 4, 8

Kilometers: 0, 2.5, 5, 10

Notes:

1) PRISM climate group, Oregon State University, http://prism.oregonstate.edu, October 2018, (Prism, 2018)

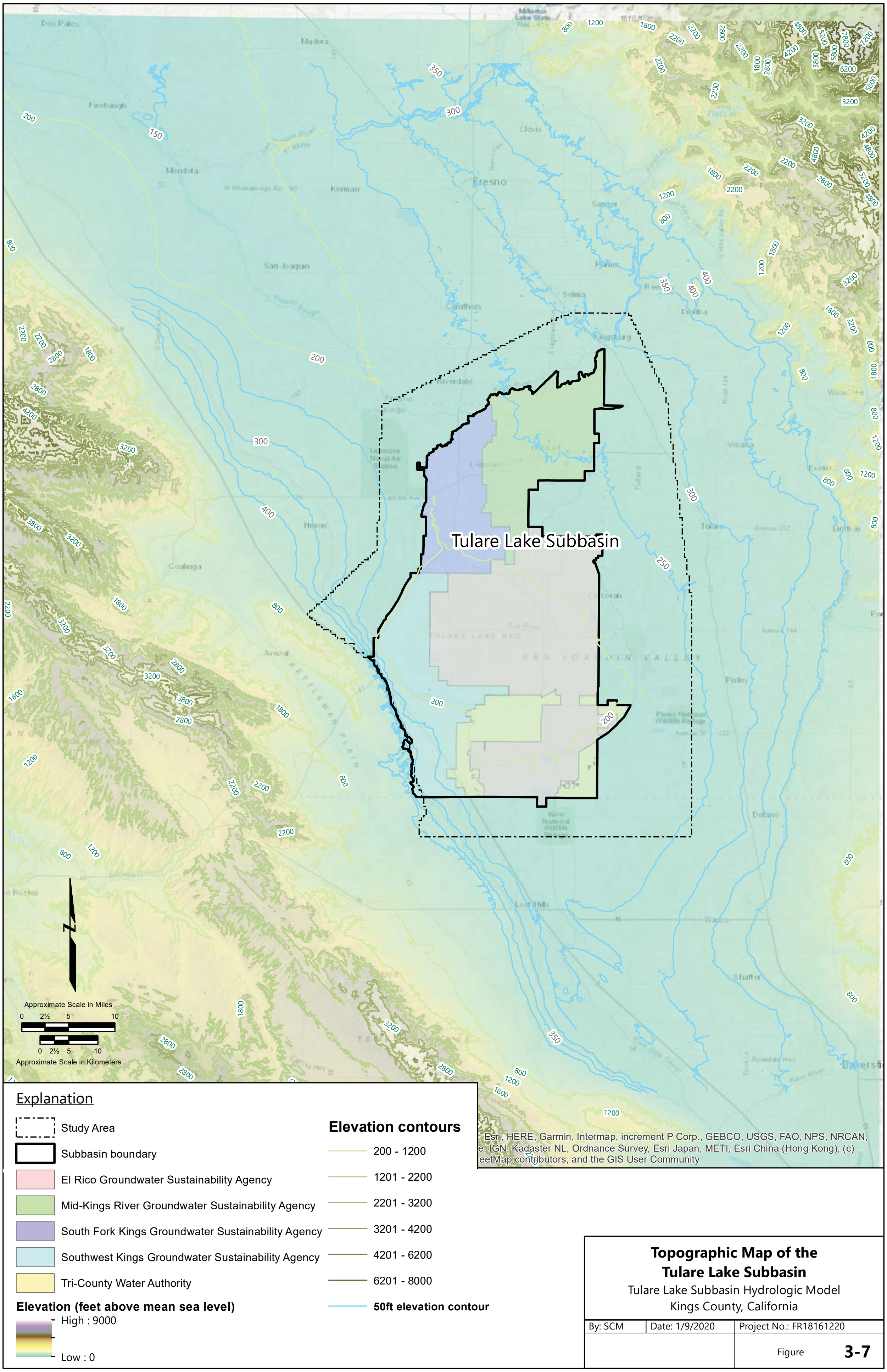
Annual Precipitation Distribution Isohyetal Contour Map 1981-2010 30-year Normal

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/27/2019	Project No.: FR18161220
		Figure **3-6**

Date: 11/27/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-6_AnnualPrecipDistribution.mxd

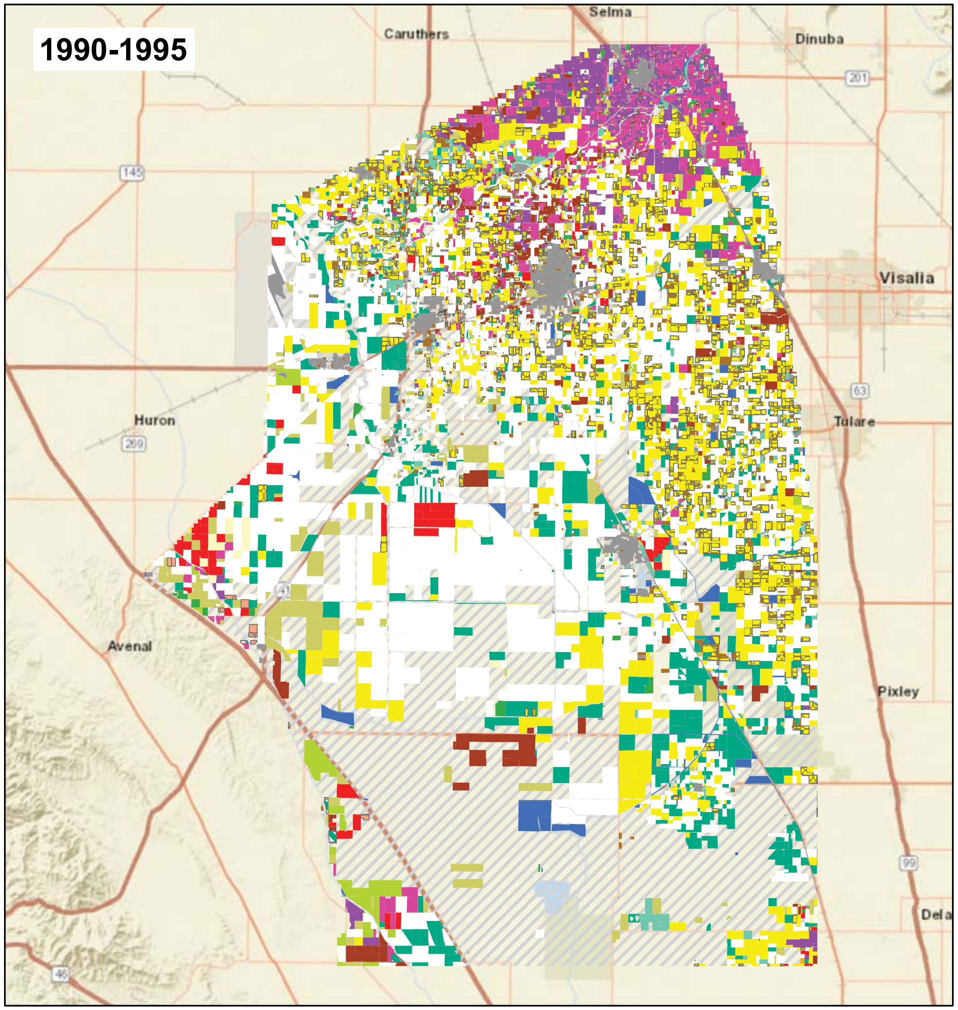
Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-7_TopographicMap.mxd

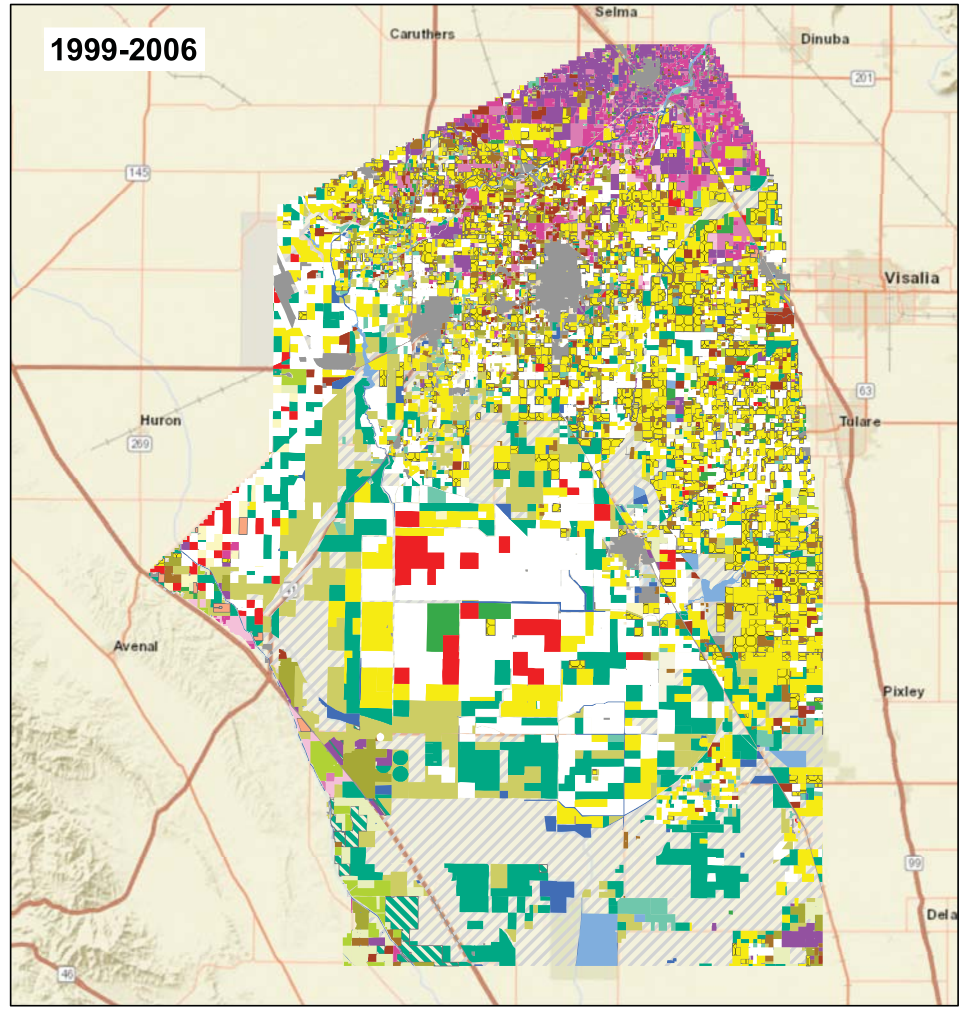


Topographic Map of the Tulare Lake Subbasin

Tulare Lake Subbasin Hydrologic Model
Kings County, California

By: SCM	Date: 1/9/2020	Project No.: FR18161220
		Figure **3-7**





Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Explanation

- Alfalfa Hay and Clover
- Almonds (Young)
- Almonds (Adolescent)
- Almonds (Mature)
- Berries
- Carrot Single Crop
- Citrus (no ground cover)
- Corn and Grain Sorghum
- Cotton
- Dairy Single Crop
- Fallow Land
- Forest
- Grain and Grain Hay
- Melons
- Misc. field crops
- Onions and Garlic
- Open Water
- Pasture and Misc. Grasses
- Pistachio (Young)
- Pistachio (Adolescent)
- Pistachio (Mature)
- Pomegranates (Young)
- Pomegranates (Adolescent)
- Potatoes, Sugar beets, Turnip etc..
- Riparian
- Small Vegetables
- Stone Fruit (Young)
- Stone Fruit (Adolescent)
- Stone Fruit (Mature)
- Tomatoes and Peppers
- Urban, Commercial
- Urban, Industrial
- Wine Grapes with 80% canopy
- Winter Wheat

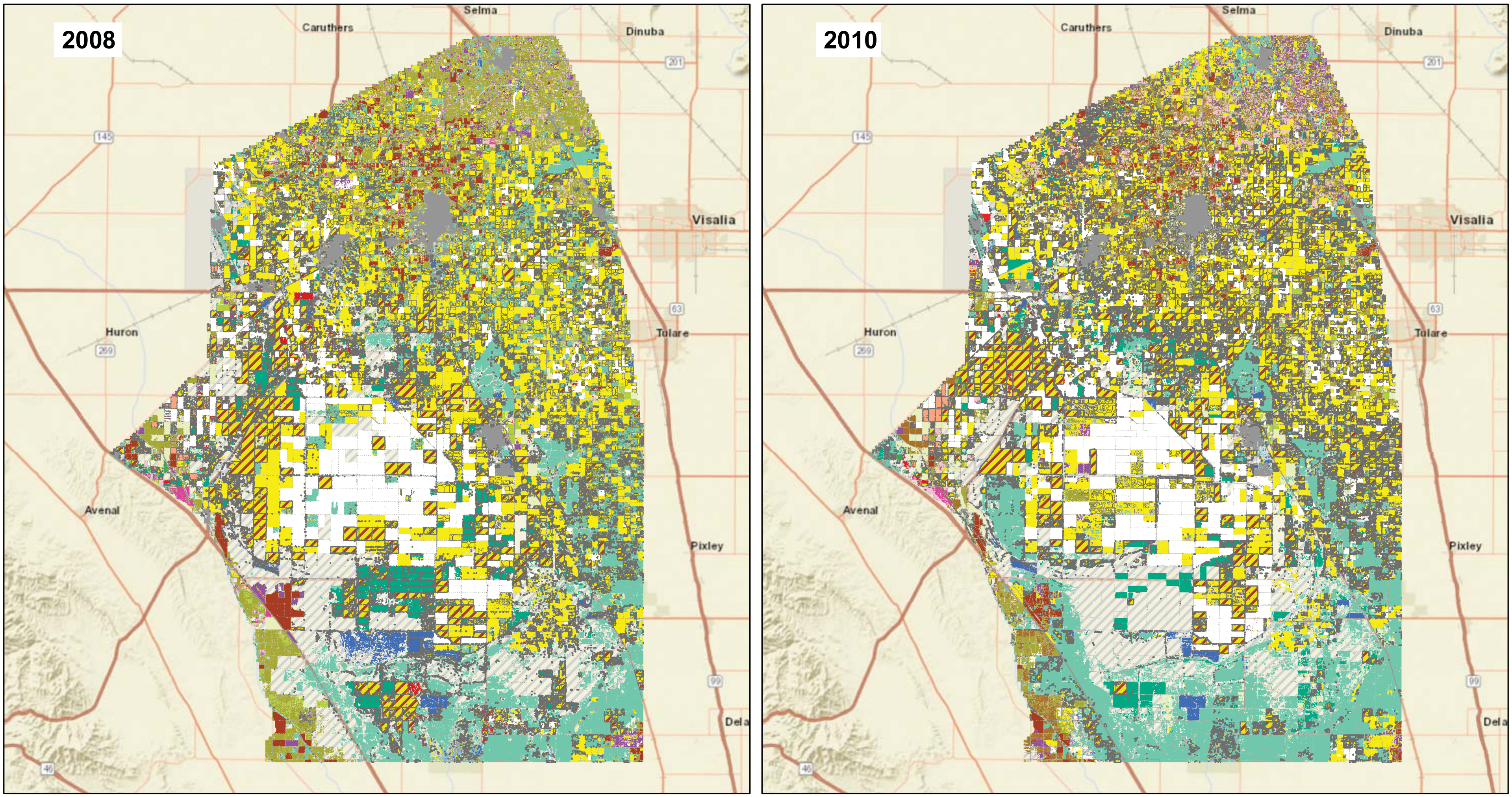
N

0 20,000 40,000
APPROXIMATE SCALE IN FEET

Crop Distributions
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: jmp	Date: 3/26/2019	Project No.: FR18161220
	Figure	**3-8a**

\\fsn-fs1\Graphics_FR_projects\FR18s\FR18161220\gis\maps\2018\Hydrogeologic_Conceptual_Model\Arcmap 10.4_fig3-8a_CropDistributions_rev.mxd



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Explanation

- Alfalfa Hay and Clover
- Almonds (Young)
- Almonds (Adolescent)
- Almonds (Mature)
- Berries
- Carrot Single Crop
- Citrus (no ground cover)
- Corn and Grain Sorghum
- Cotton
- Dairy Single Crop
- Fallow Land
- Forest
- Grain and Grain Hay
- Melons
- Misc. field crops
- Onions and Garlic
- Open Water
- Pasture and Misc. Grasses
- Pistachio (Young)
- Pistachio (Adolescent)
- Pistachio (Mature)
- Pomegranates (Young)
- Pomegranates (Adolescent)
- Potatoes, Sugar beets, Turnip etc..
- Riparian
- Small Vegetables
- Stone Fruit (Young)
- Stone Fruit (Adolescent)
- Stone Fruit (Mature)
- Tomatoes and Peppers
- Urban, Commercial
- Urban, Industrial
- Wine Grapes with 80% canopy
- Winter Wheat

N

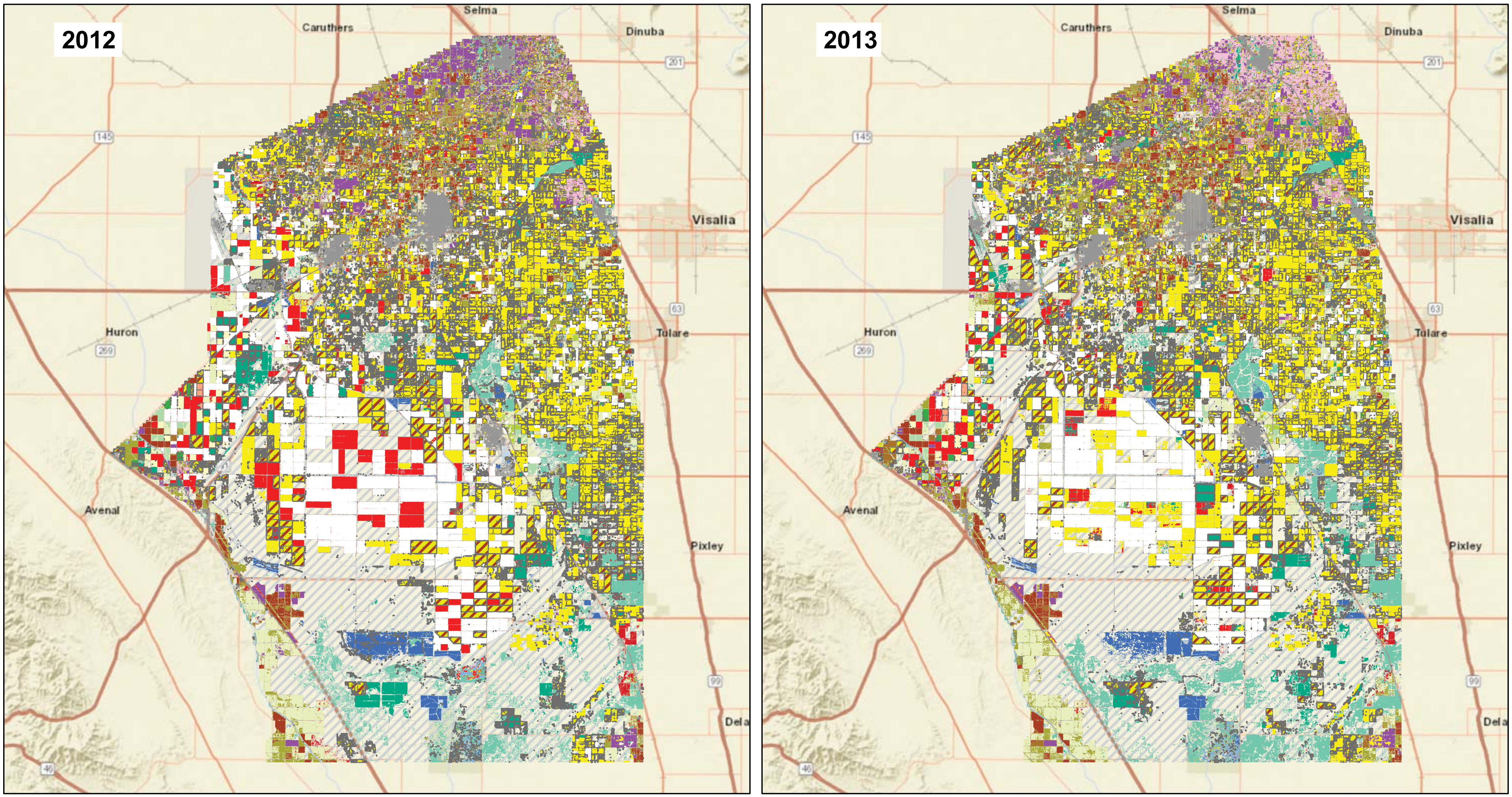
0 20,000 40,000
APPROXIMATE SCALE IN FEET

Crop Distributions
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: jmp | Date: 3/26/2019 | Project No.: FR18161220

Figure **3-8b**

\\fsn-fs1\Graphics_FR_projects\FR18s\FR18161220\gis\maps\2018\Hydrogeologic_Conceptual_Model\Arcmap 10.4_fig3-8b_CropDistributions_rev.mxd



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Explanation

- Alfalfa Hay and Clover
- Almonds (Young)
- Almonds (Adolescent)
- Almonds (Mature)
- Berries
- Carrot Single Crop
- Citrus (no ground cover)
- Corn and Grain Sorghum
- Cotton
- Dairy Single Crop
- Fallow Land
- Forest
- Grain and Grain Hay
- Melons
- Misc. field crops
- Onions and Garlic
- Open Water
- Pasture and Misc. Grasses
- Pistachio (Young)
- Pistachio (Adolescent)
- Pistachio (Mature)
- Pomegranates (Young)
- Pomegranates (Adolescent)
- Potatoes, Sugar beets, Turnip etc..
- Riparian
- Small Vegetables
- Stone Fruit (Young)
- Stone Fruit (Adolescent)
- Stone Fruit (Mature)
- Tomatoes and Peppers
- Urban, Commercial
- Urban, Industrial
- Wine Grapes with 80% canopy
- Winter Wheat

N

0 20,000 40,000
APPROXIMATE SCALE IN FEET

Crop Distributions
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: jmp | Date: 3/26/2019 | Project No.: FR18161220

Figure **3-8c**

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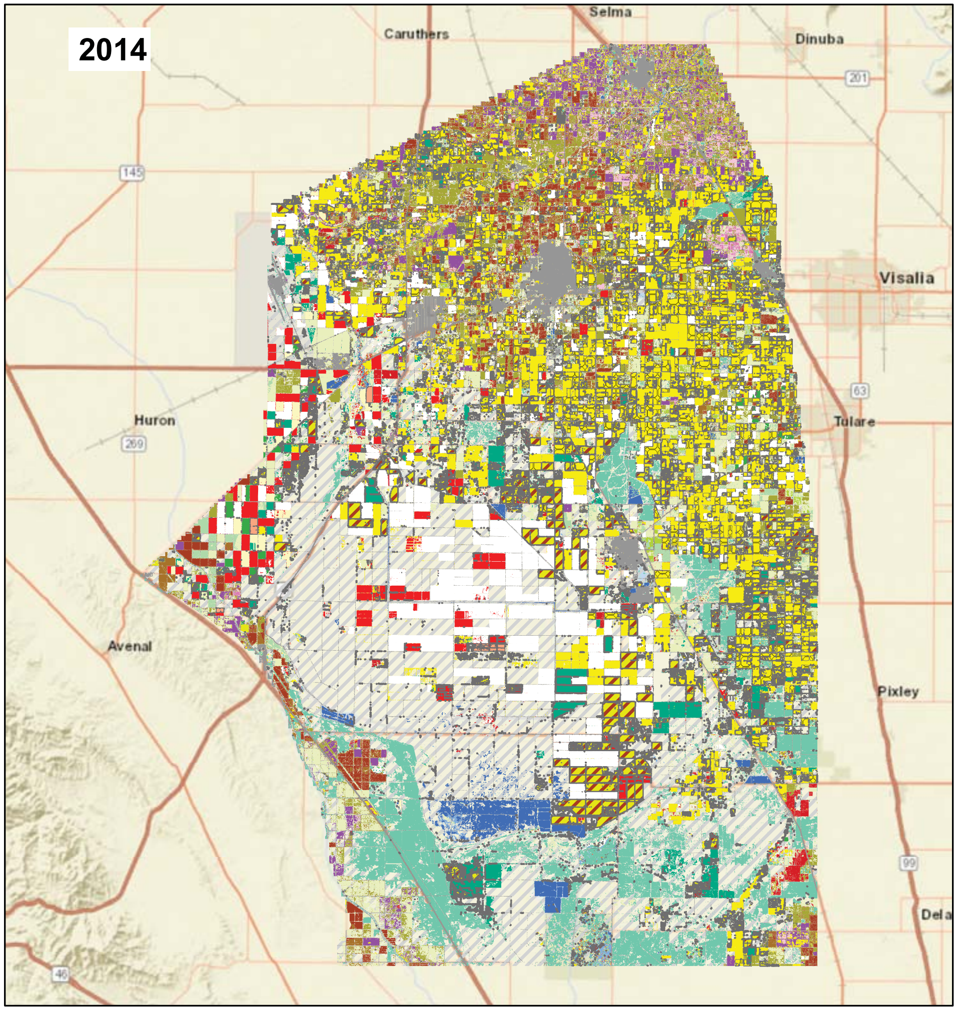
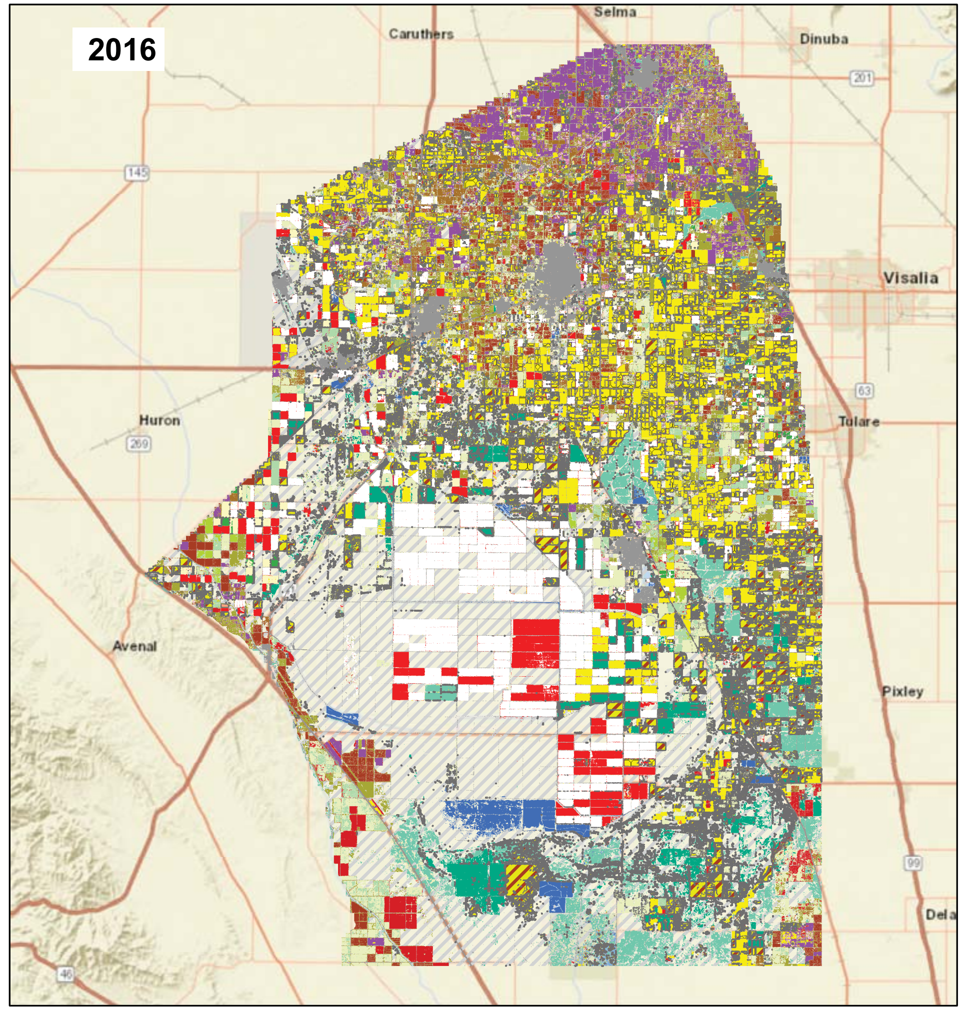




Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Explanation

- Alfalfa Hay and Clover
- Almonds (Young)
- Almonds (Adolescent)
- Almonds (Mature)
- Berries
- Carrot Single Crop
- Citrus (no ground cover)
- Corn and Grain Sorghum
- Cotton
- Dairy Single Crop
- Fallow Land
- Forest
- Grain and Grain Hay
- Melons
- Misc. field crops
- Onions and Garlic
- Open Water
- Pasture and Misc. Grasses
- Pistachio (Young)
- Pistachio (Adolescent)
- Pistachio (Mature)
- Pomegranates (Young)
- Pomegranates (Adolescent)
- Potatoes, Sugar beets, Turnip etc..
- Riparian
- Small Vegetables
- Stone Fruit (Young)
- Stone Fruit (Adolescent)
- Stone Fruit (Mature)
- Tomatoes and Peppers
- Urban, Commercial
- Urban, Industrial
- Wine Grapes with 80% canopy
- Winter Wheat

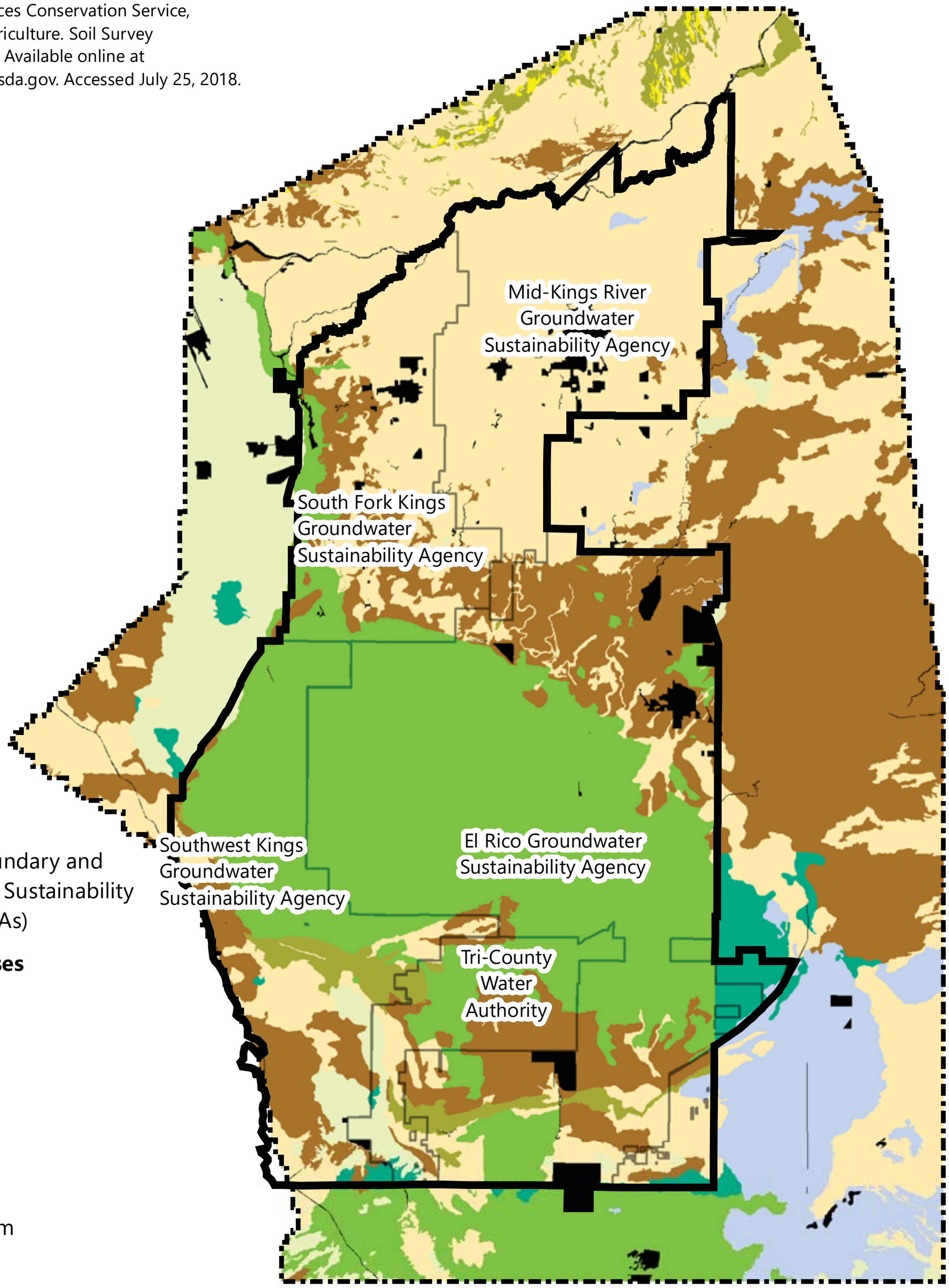
0 20,000 40,000
APPROXIMATE SCALE IN FEET

Crop Distributions
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: jmp	Date: 3/26/2019	Project No.: FR18161220
		Figure **3-8d**

\\fsn-fs1\Graphics_FR_projects\FR18s\FR18161220\gis\maps\2018\Hydrogeologic_Conceptual_Model\Arcmap 10.4_fig3-8d_CropDistributions_rev.mxd

Soil texture data adapted from:
Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Soil Survey Geographic (SSURGO) database. Available online at https://sdmdataaccess.sc.egov.usda.gov. Accessed July 25, 2018.



Explanation

Study area

Subbasin boundary and Groundwater Sustainability Agencies (GSAs)

USDA soil textural classes

- Clay
- Silty clay
- Clay loam
- Silty clay loam
- Silt loam
- Loam
- Sandy loam
- Loamy sand
- Sand
- Unweathered bedrock
- Soil data unavailable

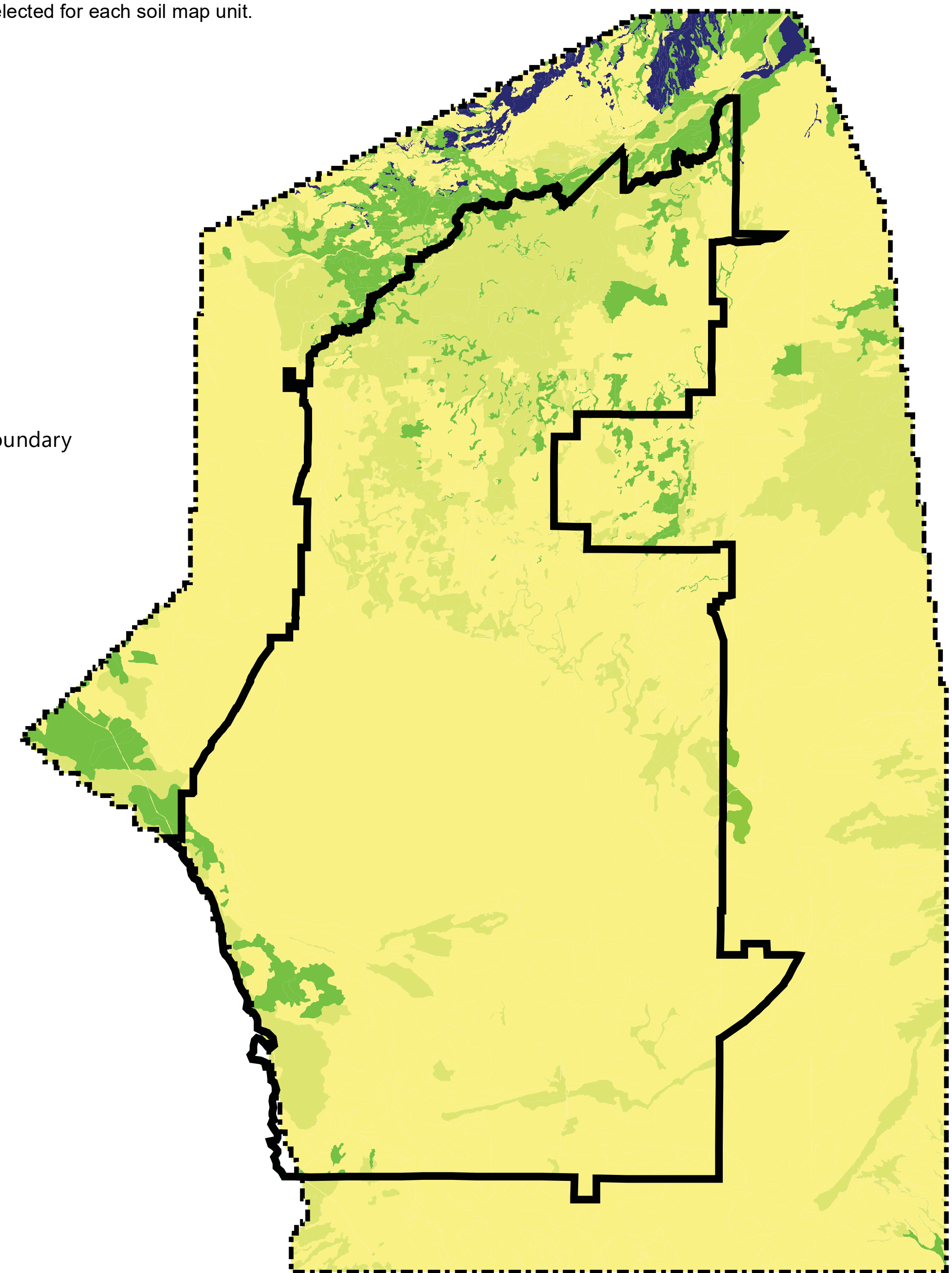
Miles: 0 2 4 8
Kilometers: 0 2.5 5 10

Soil Texture Map
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/15/2019	Project No.: FR18161220
		Figure **3-9**

Date: 11/15/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-9_SoilTexture.mxd

NOTES:
1) Minimum horizon Ksat selected for each soil map unit.



Explanation

Study area

Subbasin boundary

Ksat (µm/sec)

- 0.0 - 5.0
- 5.0 - 10.0
- 10.0 - 15.0
- 15.0 - 20.0
- 20.0 - 25.0
- 25.0 - 30.0
- 30.0 - 35.0
- 35.0 - 40.0
- 40.0 - 45.0
- 45.0 - 50.0
- 50.0 - 55.0
- 55.0 - 60.0
- 60.0 - 65.0
- 65.0 - 70.0
- 70.0 - 75.0
- 75.0 - 80.0
- 80.0 - 85.0
- 85.0 - 90.0
- 90.0 - 95.0

Miles
0 2 4 8
0 2.5 5 10
Kilometers

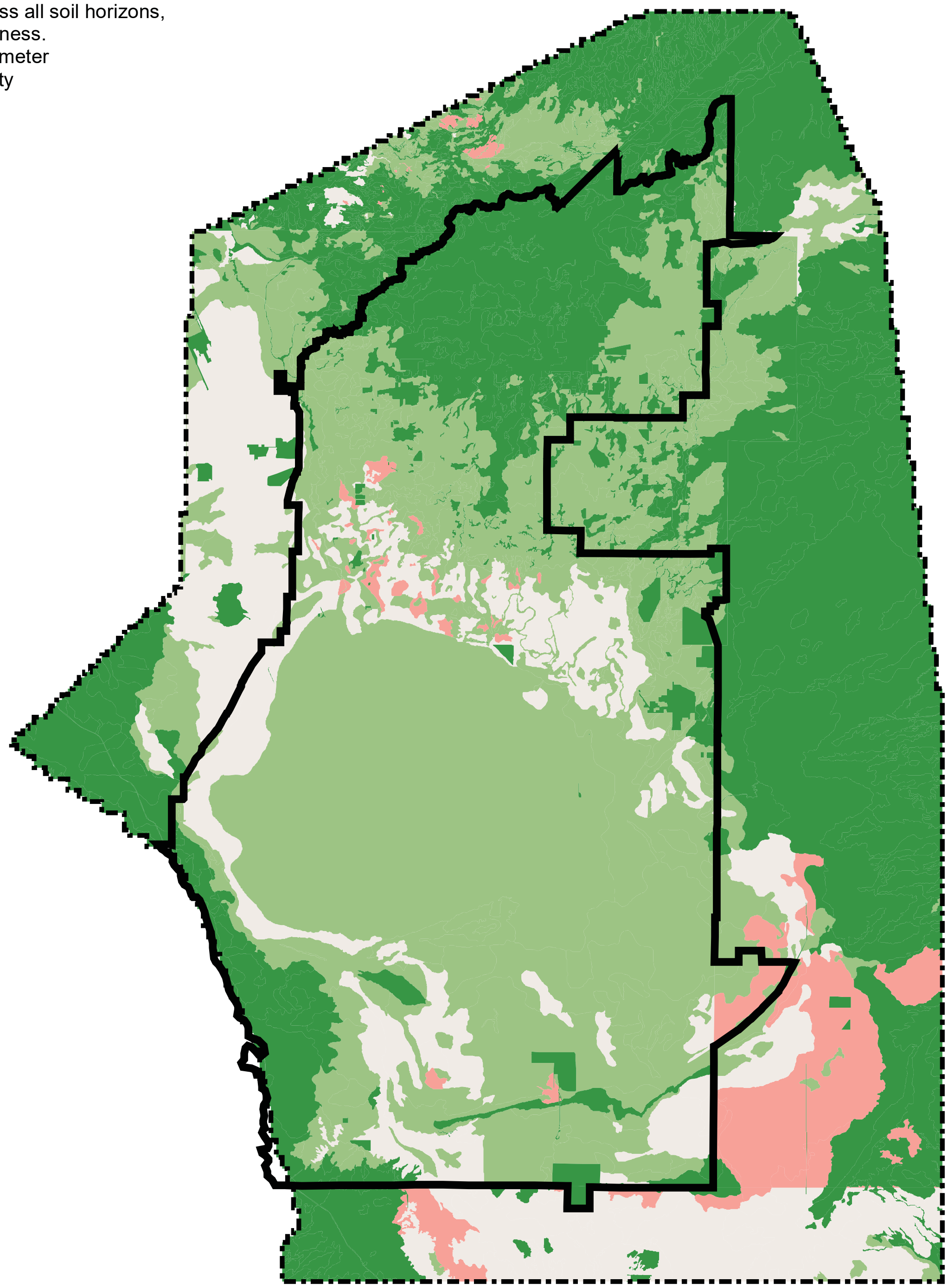
N

Soil Permeability Map
Minimum Ksat
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/15/2019	Project No.: FR18161220
		Figure **3-10**

Date: 11/15/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-10_SoilPermeability.mxd

Notes:
1. EC values averaged across all soil horizons, weighted by horizon thickness.
2. dS/m = deciSiemens per meter
3. EC = electrical conductivity



Explanation

- Study area
- Subbasin boundary

EC (dS/m)

- 0.0 - 4.5
- 4.5 - 9.0
- 9.0 - 15.0
- 15.0 - 18.0
- 18.0 - 25.0

Miles: 0, 2, 4, 8
Kilometers: 0, 2.5, 5, 10

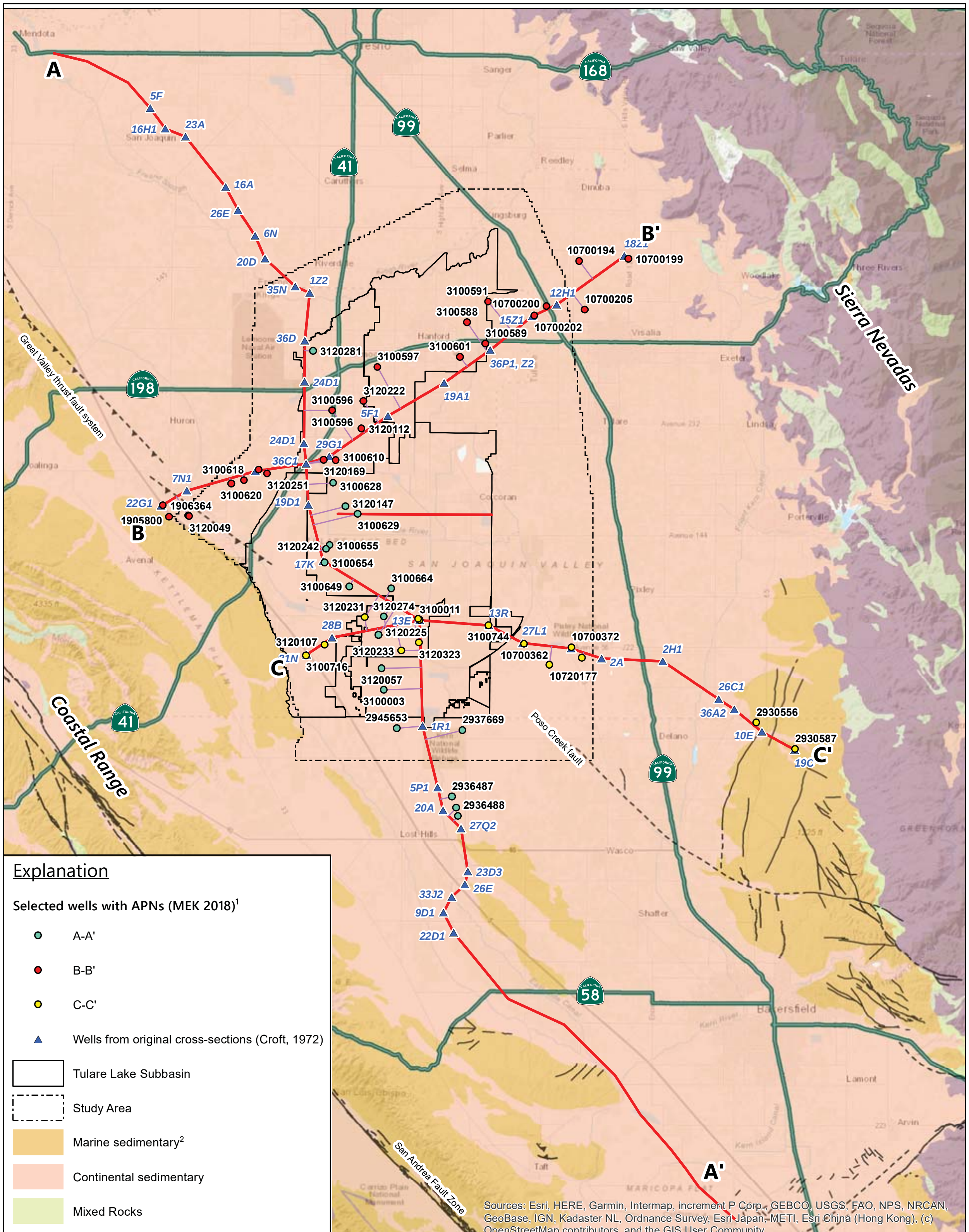
N

Soil Characteristics
Weighted Average on Salinity/ EC
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/15/2019	Project No.: FR18161220
		Figure **3-11**

Date: 11/15/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-11_SoilSalinity.mxd

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-12_SurficialGeology_20181106.mxd



Explanation

Selected wells with APNs (MEK 2018)[1]

- A-A'
- B-B'
- C-C'
- Wells from original cross-sections (Croft, 1972)
- Tulare Lake Subbasin
- Study Area
- Marine sedimentary[2]
- Continental sedimentary
- Mixed Rocks
- Igneous
- Metamorphic
- Wells projected onto cross-section lines
- Cross-section lines (Croft, 1972)
- Highways (TIGER/Line 2016)
- Constrained fault line[3]
- Inferred fault
- Inferred thrust fault

Approximate Scale in Miles: 0, 5, 10, 20

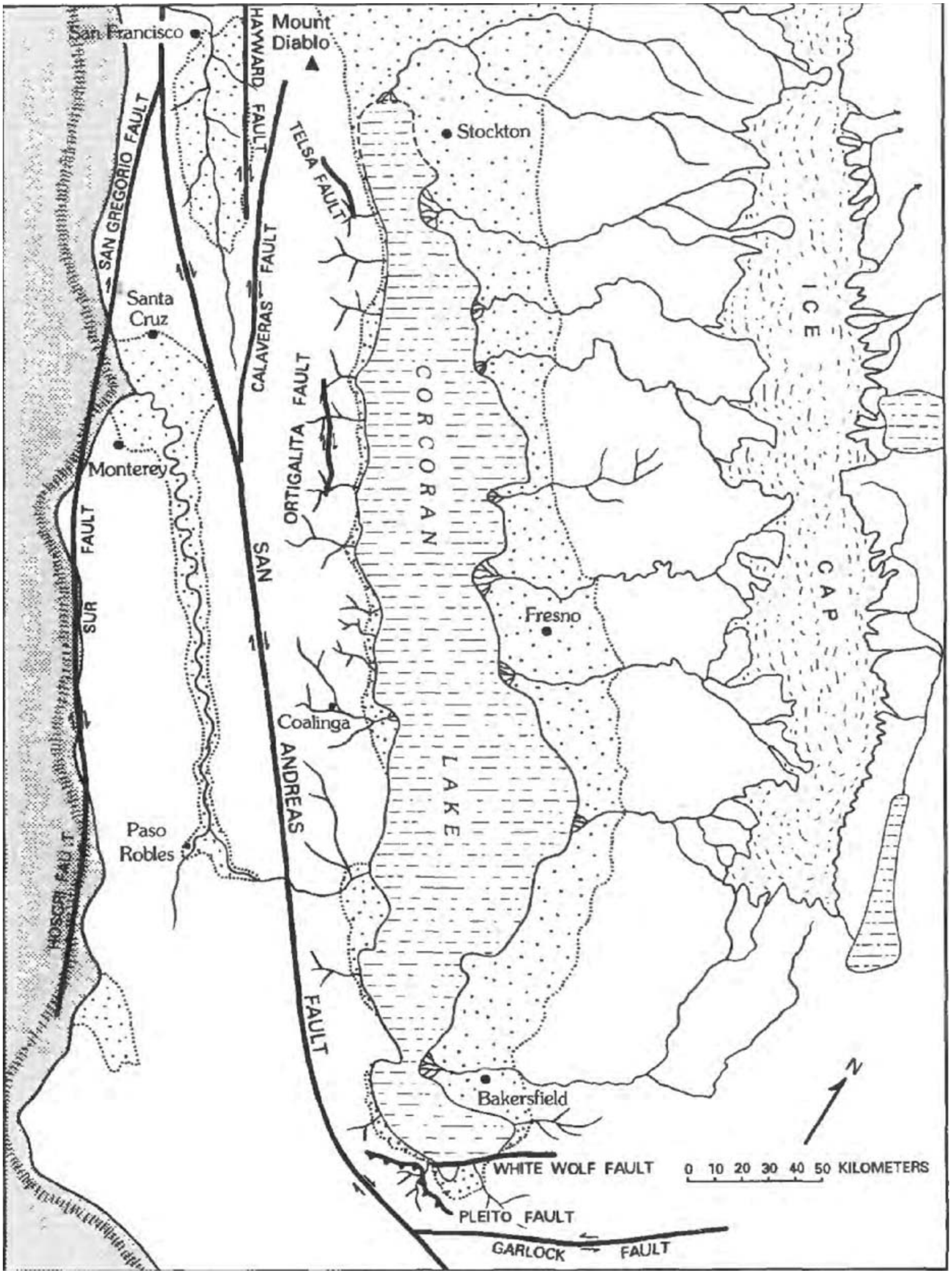
Approximate Scale in Kilometers: 0, 5, 10, 20

Notes:
1) Well records obtained from DOGGR well search. 2018. https://secure.conservation.ca.gov/WellSearch
2) Geologic Units derived from Geologic Map of California, 1977. USGS. https://mrdata.usgs.gov/geology/state
3) Fault data adapted from Quaternary Fault and Fold Database of the US. 2018 https://earthquake.usgs.gov/hazards/qfaults/

Geologic Map of the Southern San Joaquin Valley and Cross Section Locations

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/9/2020	Project No.: FR18161220
		Figure **3-12**



Pleistocene Extent of Corcoran Lake

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: SCM	Date: 1/9/2020	Project No.: FR18161220
		Figure **3-13**

Note:
1) Adapted from Figure 13 of Bartow (1991).

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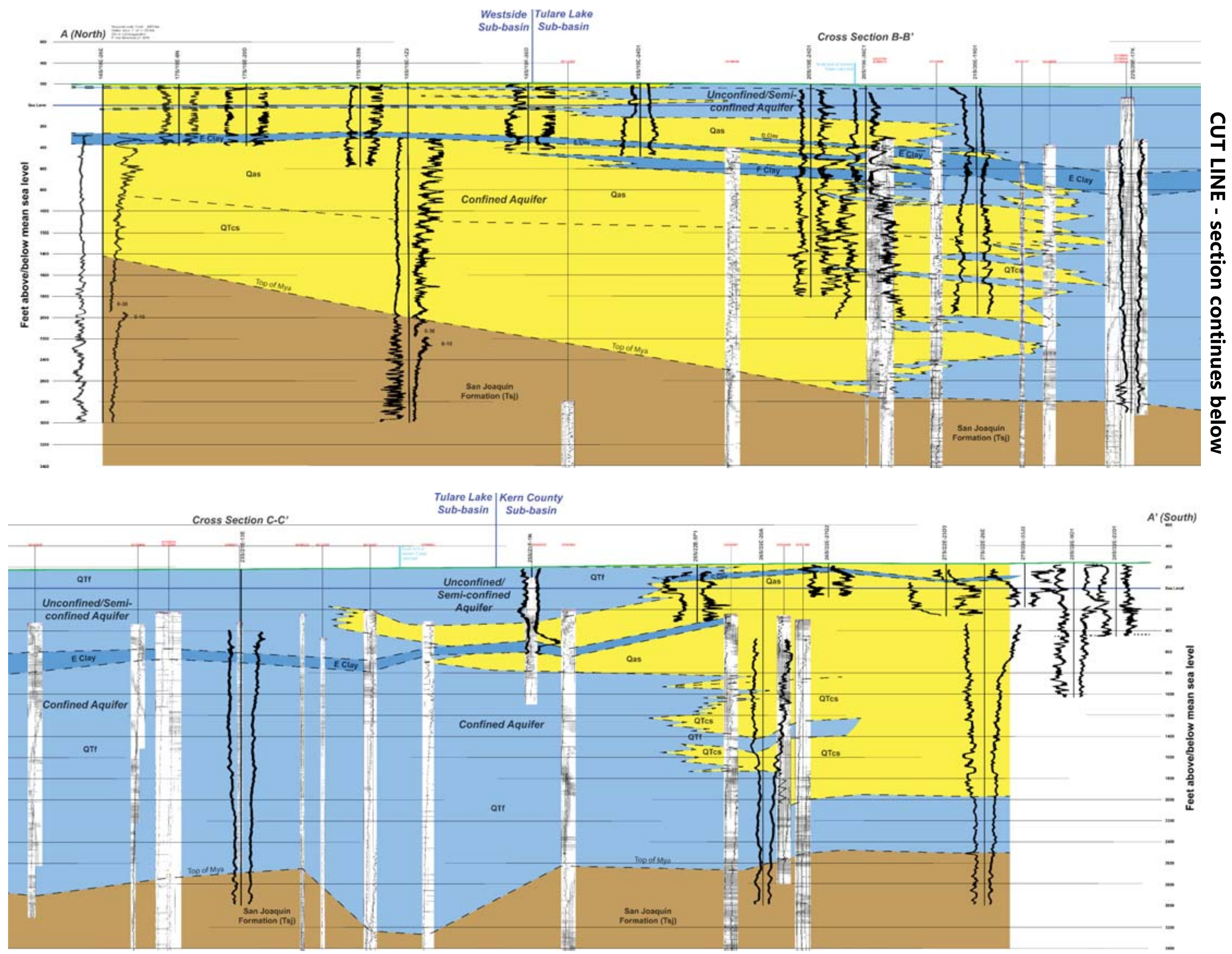
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-13_CorcoranLake.mxd



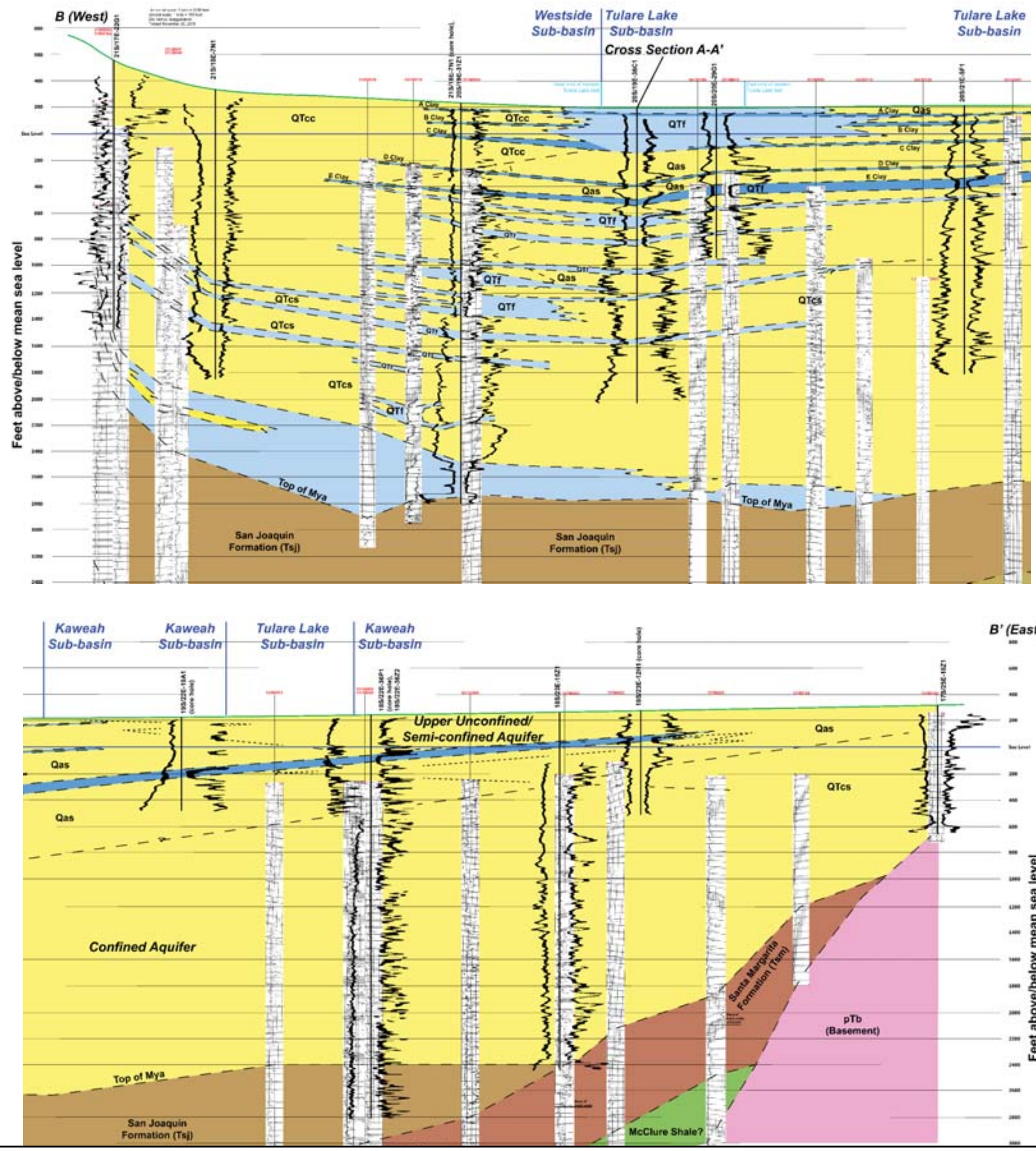
Explanation

- Coarse-grained alluvium / Tulare Formation
- San Joaquin Formation
- Alluvium / Tulare Formation lacustrine sediments
- Regional clay marker beds as defined by Croft (1972)
- **25S/21E-1N** CA DWR well name
- 03120281 CA DOGGR well APN
- 0 30 Electric log resistivity scale (ohmmeters)

Notes:
1) Contacts dashed where inferred.
2) CA DWR = California Department of Water Resources.
2) CA DOGGR = Division of Oil, Gas, and Geothermal Resources, California Department of Conservation.

Cross Section A-A'
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings county, California

By: EMC	Date: 1/9/2020	Project No.: FR18161220
		Figure **3-14a**



Explanation

- Coarse-grained alluvium / Tulare Formation
- San Joaquin Formation
- Etchegoin Formation
- Santa Margarita Formation
- Alluvium / Tulare Formation lacustrine sediments
- Regional clay marker beds as defined by Croft (1972)
- Crystalline basement
- **25S/21E-1N** CA DWR well name
- 03120281 CA DOGGR well APN
- 0 30 Electric log resistivity scale (ohmmeters)

Notes:
1) Contacts dashed where inferred.
2) CA DWR = California Department of Water Resources.
2) CA DOGGR = Division of Oil, Gas, and Geothermal Resources, California Department of Conservation.

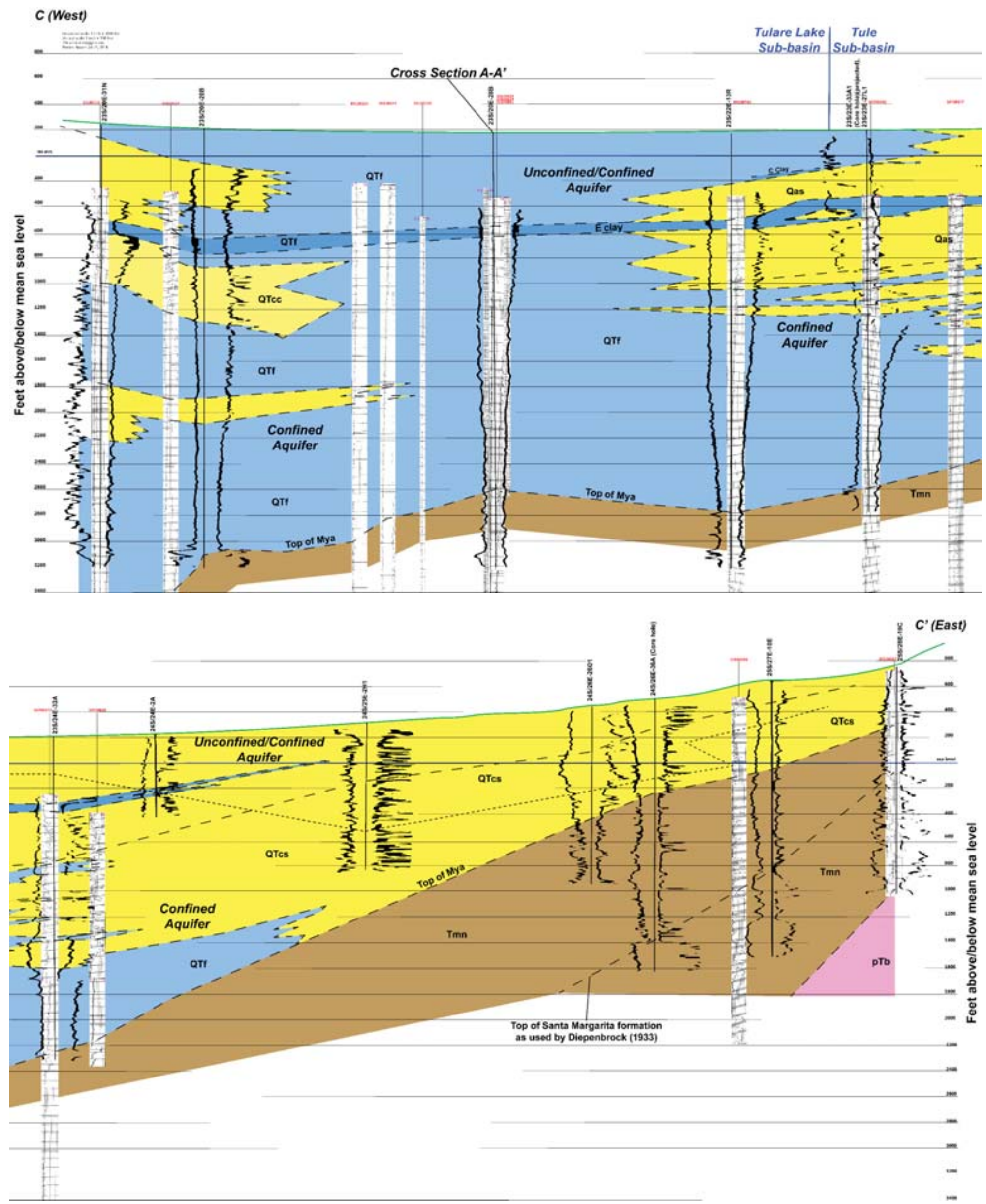
Cross Section B-B'

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/9/2020	Project No.: FR18161220

Figure **3-14b**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-14b_xsecB-B'.mxd



Explanation

- Coarse-grained alluvium / Tulare Formation
- San Joaquin Formation
- Alluvium / Tulare Formation lacustrine sediments
- Regional clay marker beds as defined by Croft (1972)
- Crystalline basement
- **25S/21E-1N** CA DWR well name
- 03120281 CA DOGGR well APN
- 0 30 Electric log resistivity scale (ohmmeters)

Notes:
1) Contacts dashed where inferred.
2) CA DWR = California Department of Water Resources.
3) CA DOGGR = Division of Oil, Gas, and Geothermal Resources, California Department of Conservation.

Cross Section C-C'

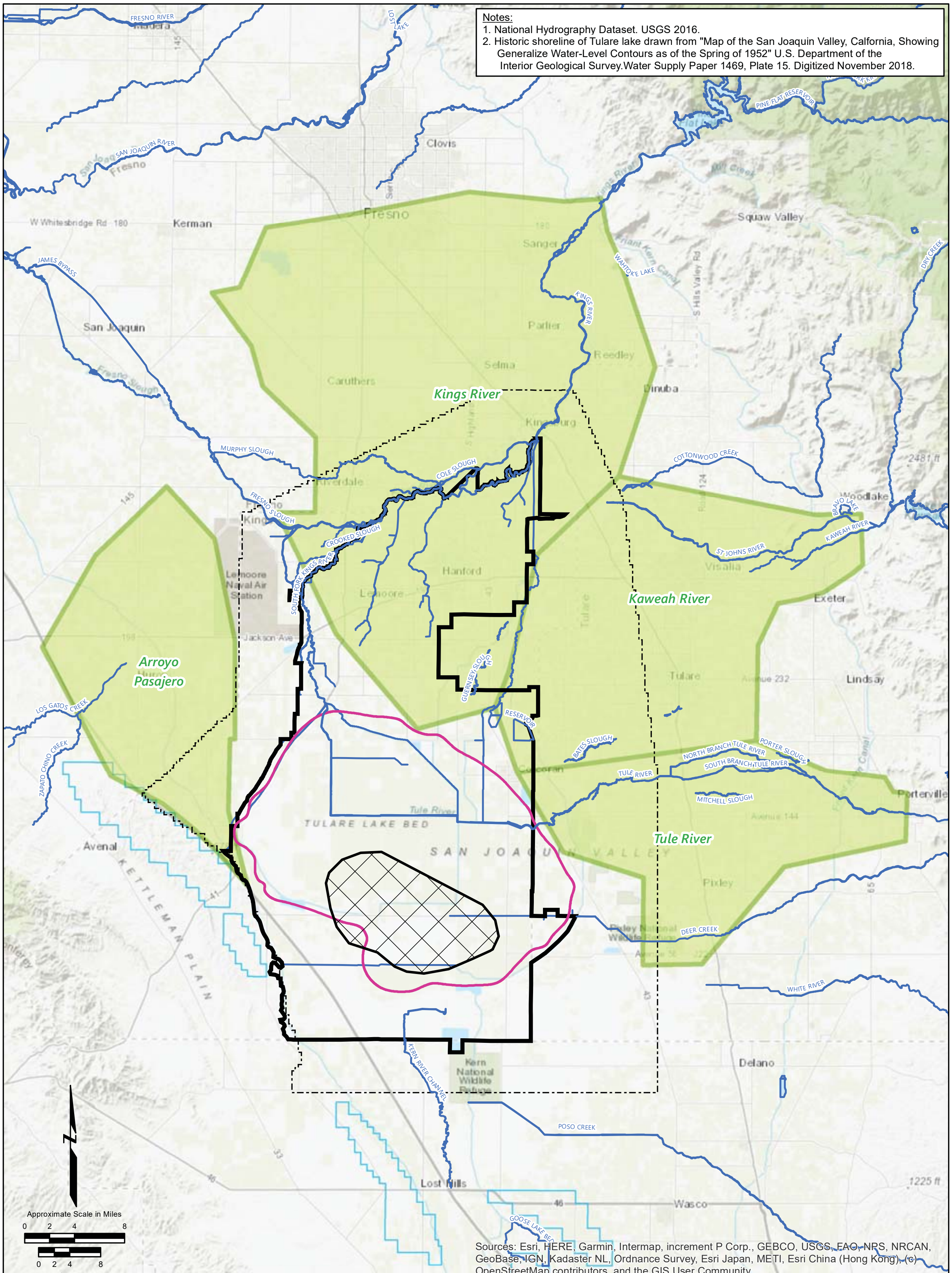
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 1/9/2020 | Project No.: FR18161220

Figure **3-14c**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-15_DepositionalEnvironments_GSAREV.mxd

Notes:
1. National Hydrography Dataset. USGS 2016.
2. Historic shoreline of Tulare lake drawn from "Map of the San Joaquin Valley, California, Showing Generalize Water-Level Contours as of the Spring of 1952" U.S. Department of the Interior Geological Survey.Water Supply Paper 1469, Plate 15. Digitized November 2018.



Explanation

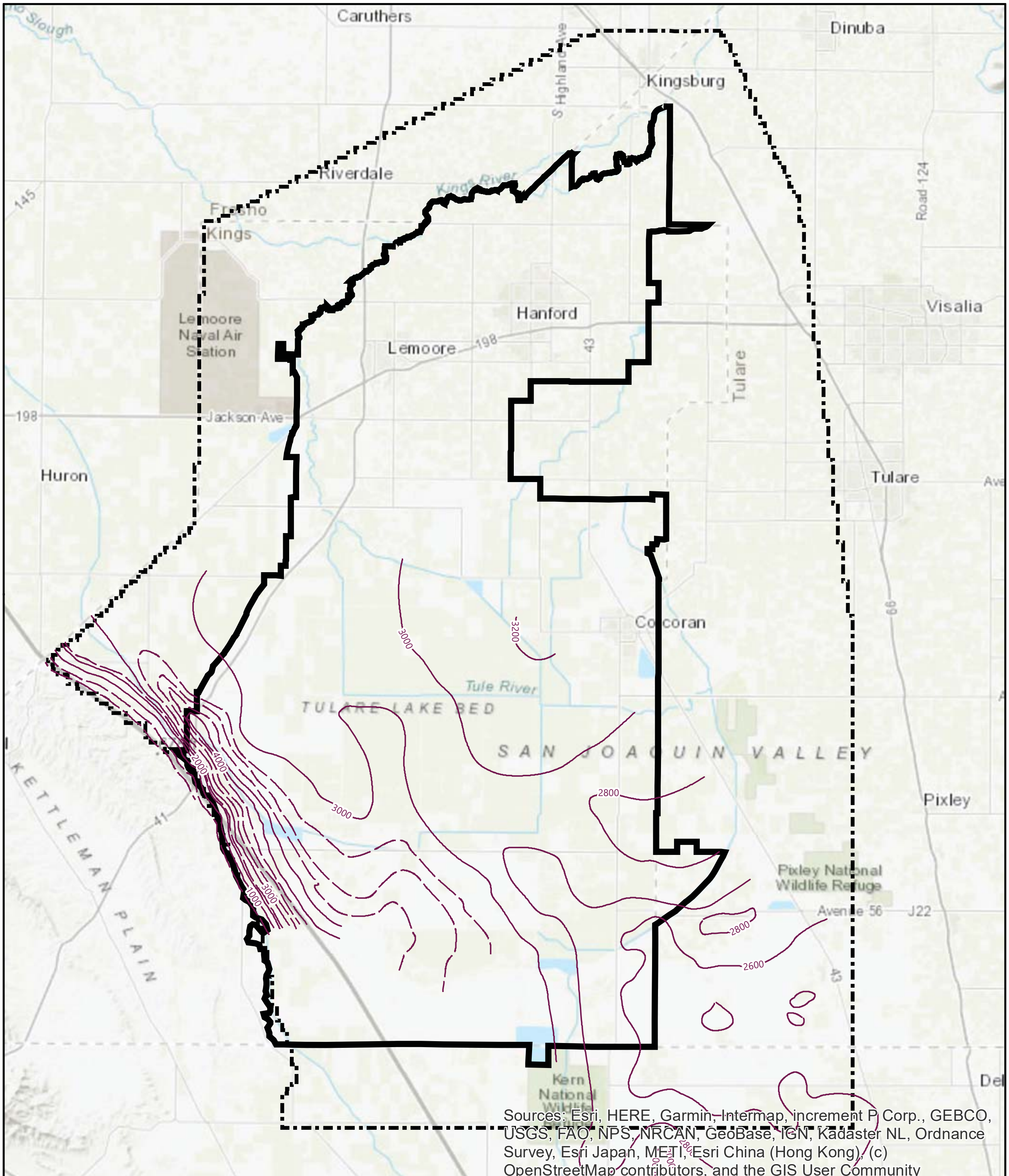
- NHD natural water bodies[1]
- Estimated extent of clay plug below E-clay
- Study Area
- Subbasin boundary
- Historic shoreline of Tulare Lake (modified from Summers, 1969)
- Alluvial fans (modified from Davis, 1959)
- DOGGR[2] Oil and Gas Fields

Notes:
1. NHD= National Hydrography Dataset. USGS 2016.
2. California Department of Conservation, 2017, Division of Oil, Gas, and geothermal Resources (DOGGR), http://www.conservation.ca.gov/dog/.

Depositional Environments in the Tulare Lake Subbasin

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/9/2020	Project No.: FR18161220
		Figure **3-15**



Explanation

Study area

Subbasin boundary

2000 Line of equal depth and thickness of Tulare Formation in 200 foot intervals

Miles 0 2 4 8

Kilometers 0 2.5 5 10

Map of Equal Depth to Base of Tulare Formation

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/8/2019	Project No.: FR18161220
		Figure **3-16**

Notes: 1. Contours adapted from *Geology beyond Kettleman Hills* R.W. Page, 1980.

Date: 11/8/2019 Printed by: elizabeth.chapman
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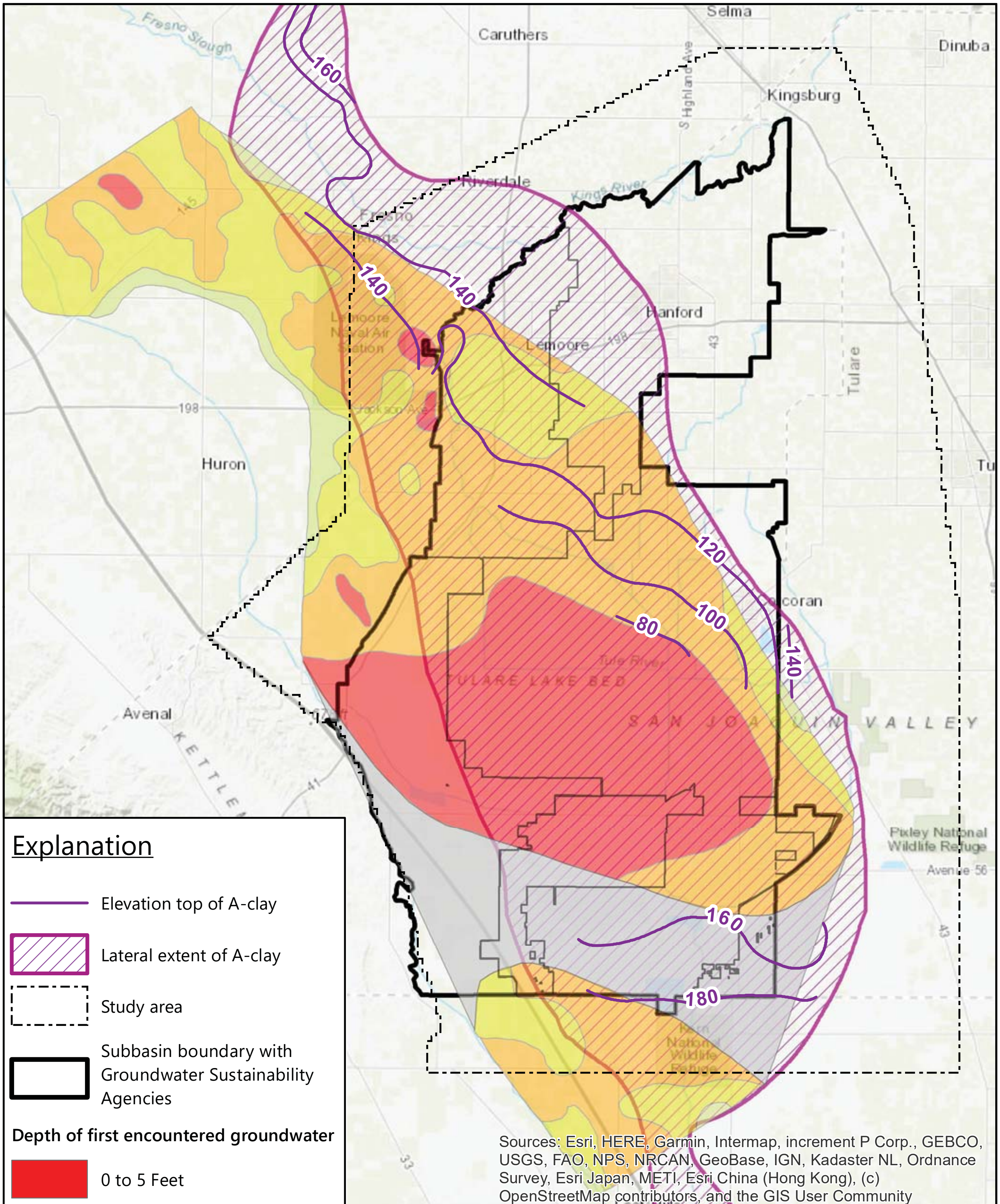

Notes:
Depth of first encountered groundwater data adapted from DWR "Present and Potential Drainage Problem Areas, San Joaquin Valley" Map, 2008

Lateral Extent and Elevation of the A-Clay and First Encountered Groundwater 2010

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: EMC	Date: 12/5/2019	Project No.: FR18161220
		Figure **3-17**

Date: 12/5/2019 Printed by: elizabeth.chapman
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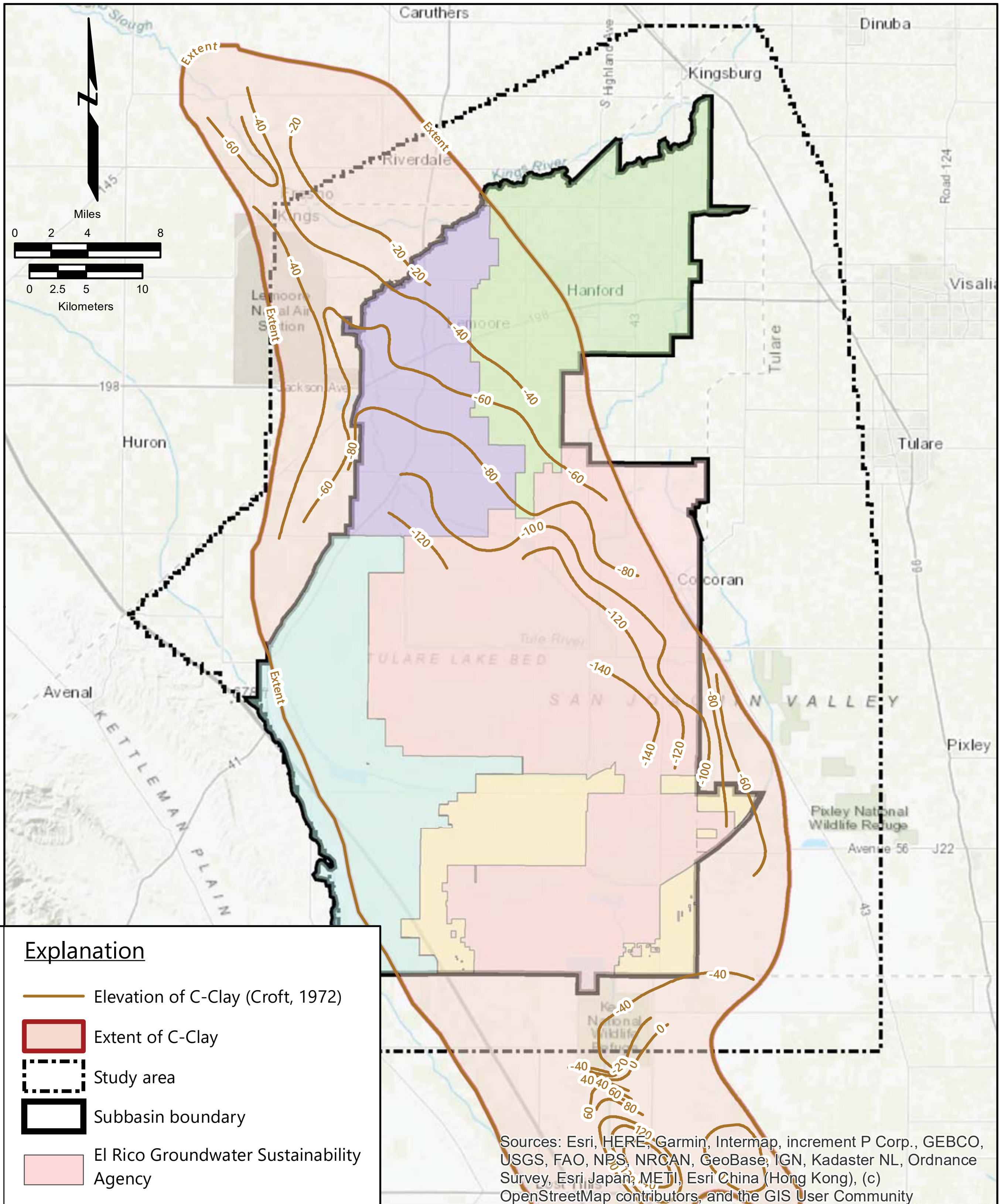


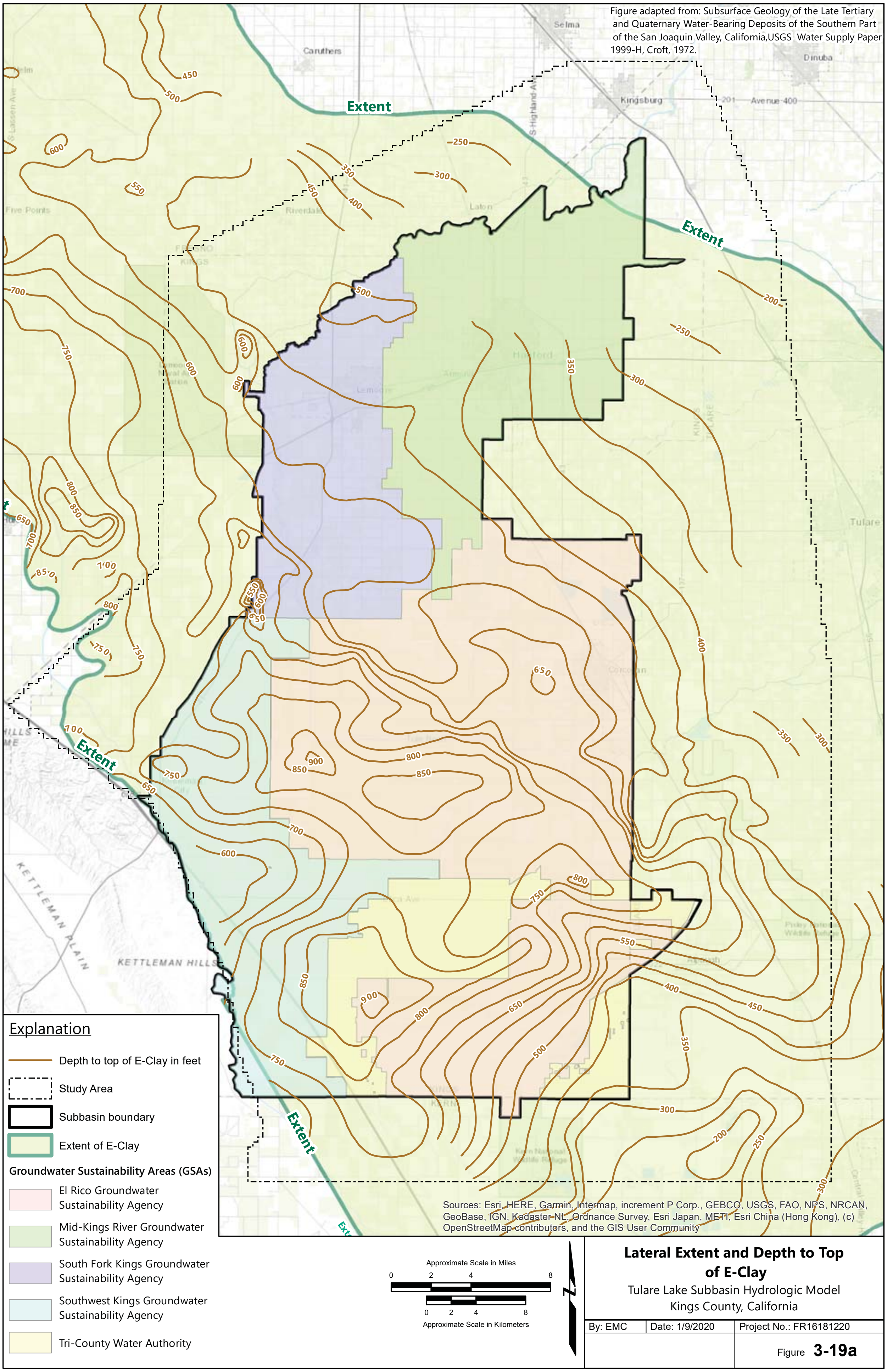
Lateral Extent and Elevation of the Top of C-Clay

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/12/2019	Project No.: FR18161220
		Figure **3-18**

Date: 11/12/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-18_LateralExtentElev_C_Clay.mxd

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-19a_Extent and Depth of E-Clay_Corcoran Clay Equivalent.mxd

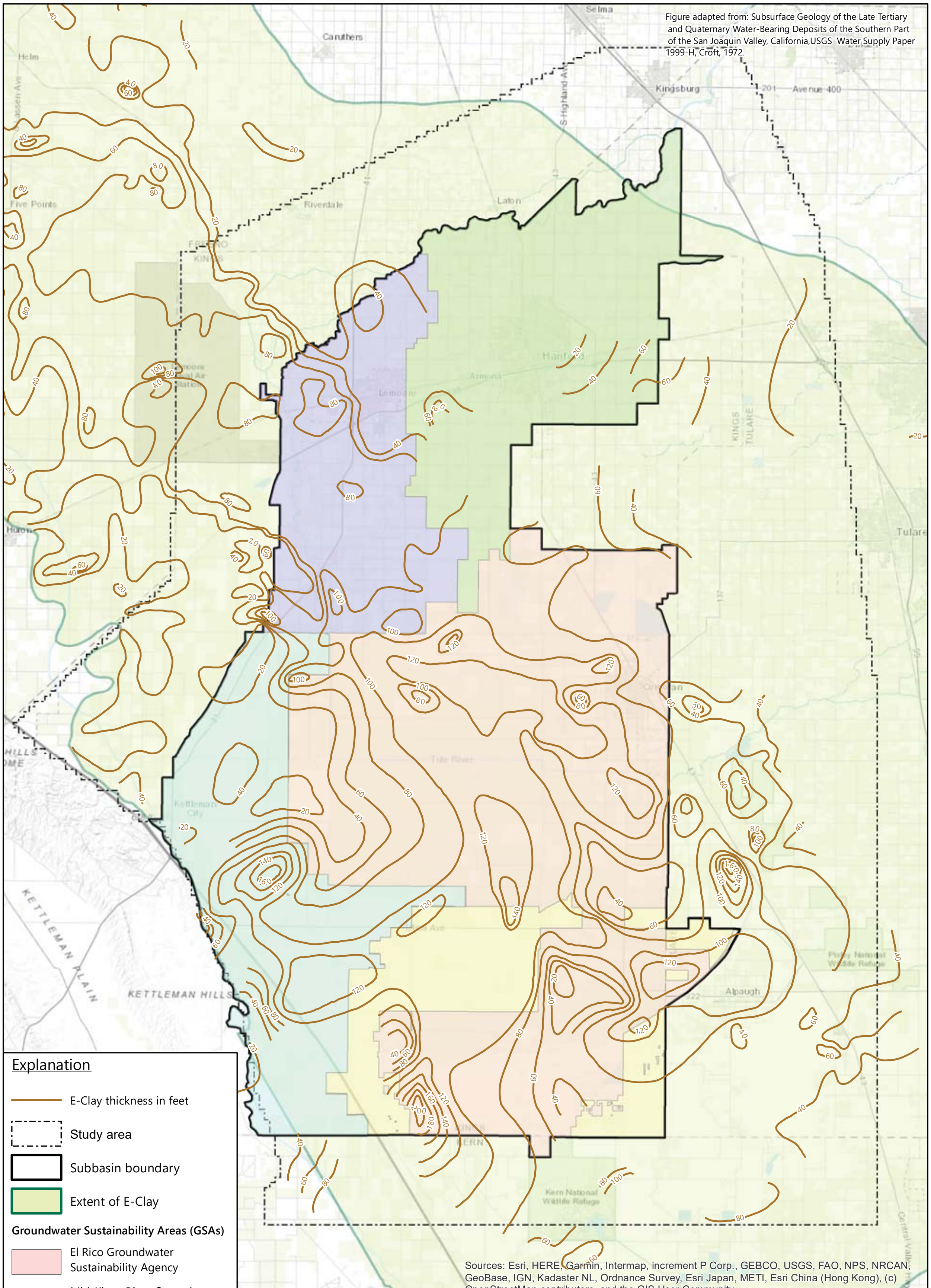


Lateral Extent and Depth to Top of E-Clay

Tulare Lake Subbasin Hydrologic Model
Kings County, California

By: EMC	Date: 1/9/2020	Project No.: FR16181220
		Figure **3-19a**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-19b_Extent and Thickness of E-Clay.mxd



Explanation

- E-Clay thickness in feet
- Study area
- Subbasin boundary
- Extent of E-Clay

Groundwater Sustainability Areas (GSAs)

- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

Approximate Scale in Miles: 0, 2.25, 4.5, 9

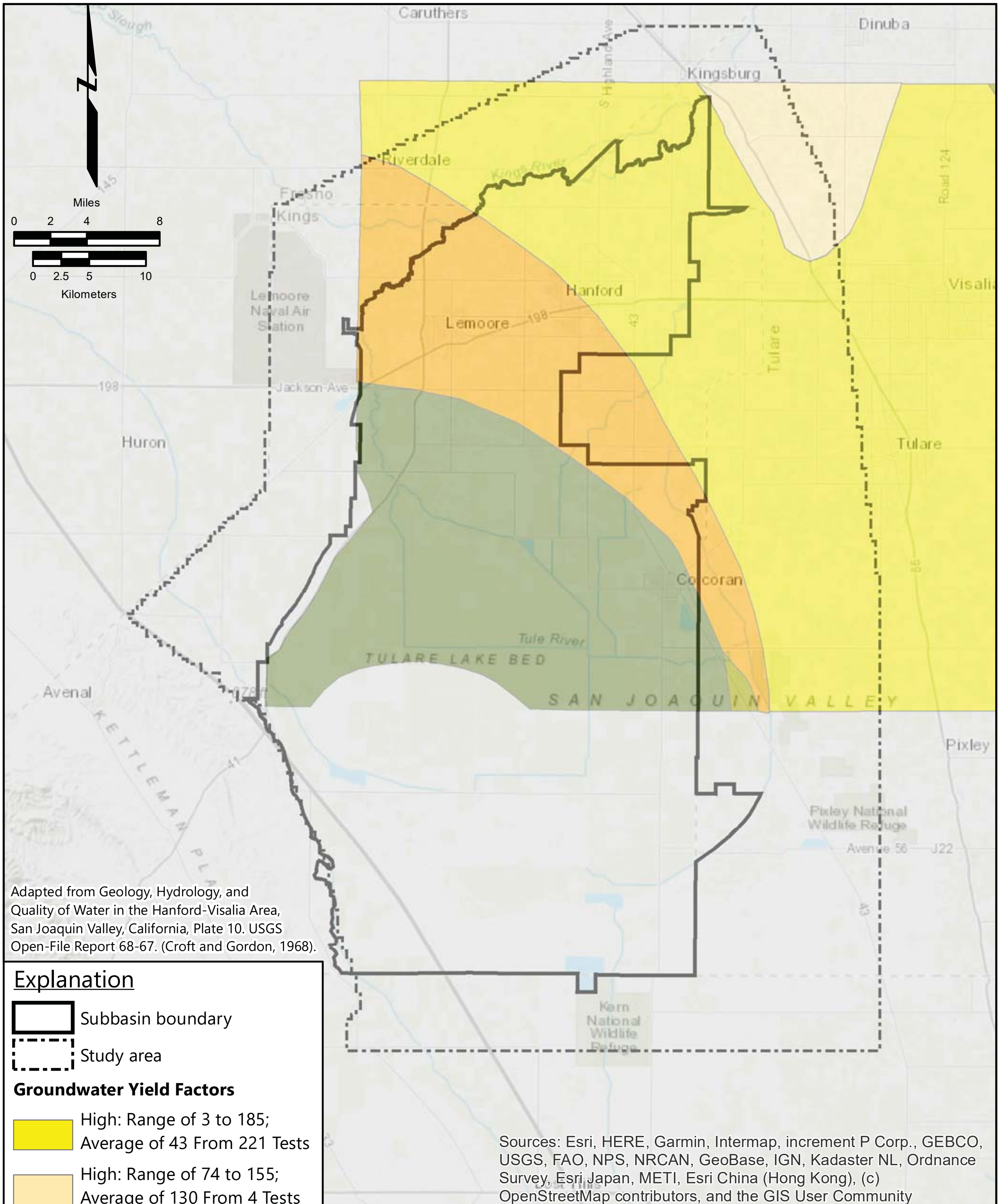
Approximate Scale in Kilometers: 0, 2.25, 4.5, 9

N

Lateral Extent and Thickness of E-Clay

Tulare Lake Subbasin Hydrologic Model
Kings County, California

By: EMC	Date: 1/9/2020	Project No.: FR16181220
		Figure **3-19b**



Explanation

- Subbasin boundary
- Study area

Groundwater Yield Factors

- High: Range of 3 to 185; Average of 43 From 221 Tests
- High: Range of 74 to 155; Average of 130 From 4 Tests
- Moderate: Range of 2 to 34; Average of 14 From 30 Tests
- Moderate: Range of 8 to 19; Average not calculated
- Low: Range of 1 to 10; Average of 4.3 From 46 Tests
- Undefined

Yield Factor (YF) = 100 x specific capacity / thickness of saturated well interval

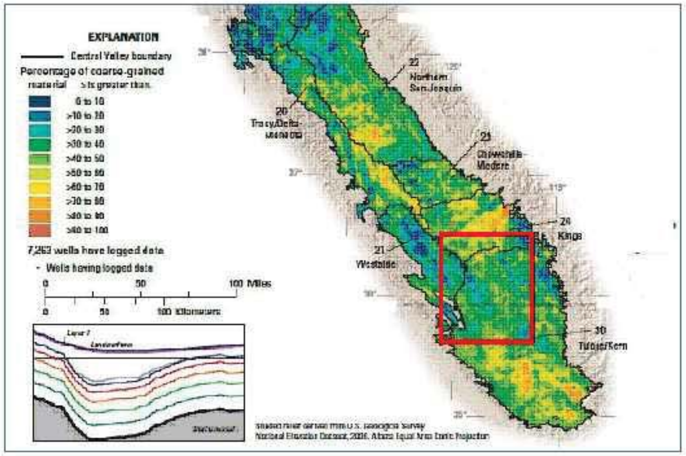
Map of Relative Permeability of Geologic Units as Interpreted from Yield Factors

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

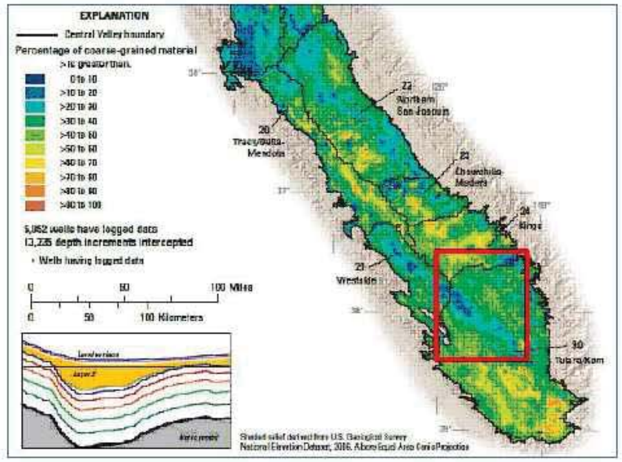
By: EMC	Date: 11/13/2019	Project No.: FR18161220
		Figure **3-20**

Date: 11/13/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-20_RelativePermeabilityFromYieldFactors.mxd

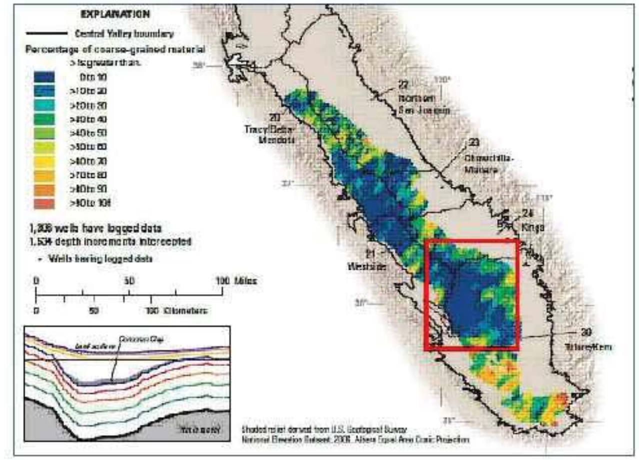
a. 0 - 50 foot depth interval



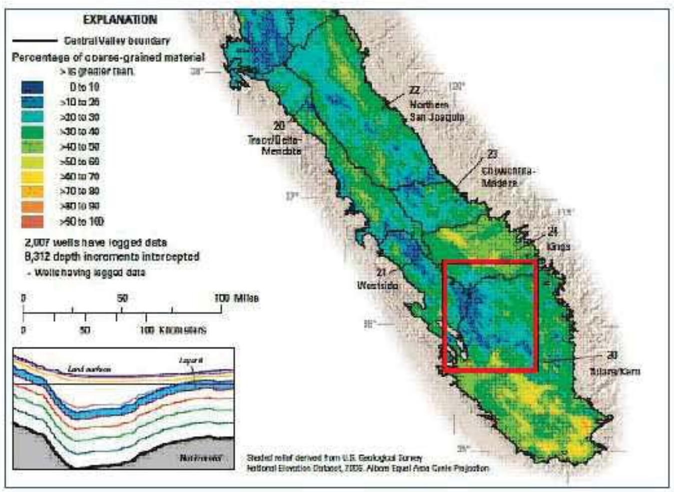
b. 50 - 200 foot depth interval



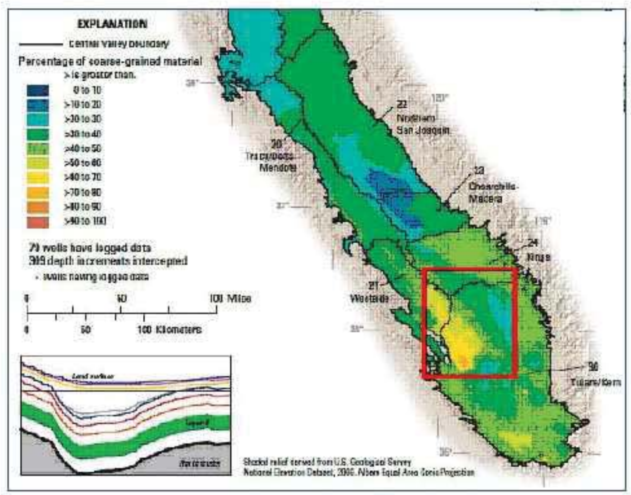
c. Corcoran Clay Depth interval



d. 100 foot depth interval immediately below Corcoran Clay



e. 200 foot depth interval from 400 to 700 feet bgs



Tulare Lake Subbasin Hydrologic Model study area

Kriged Distribution of Coarse Fraction for San Joaquin Valley Basin-Fill Sediments

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/9/2020	Project No.: FR16181220
		Figure **3-21**

Date: 1/9/2020 Printed by: elizabeth.chapman
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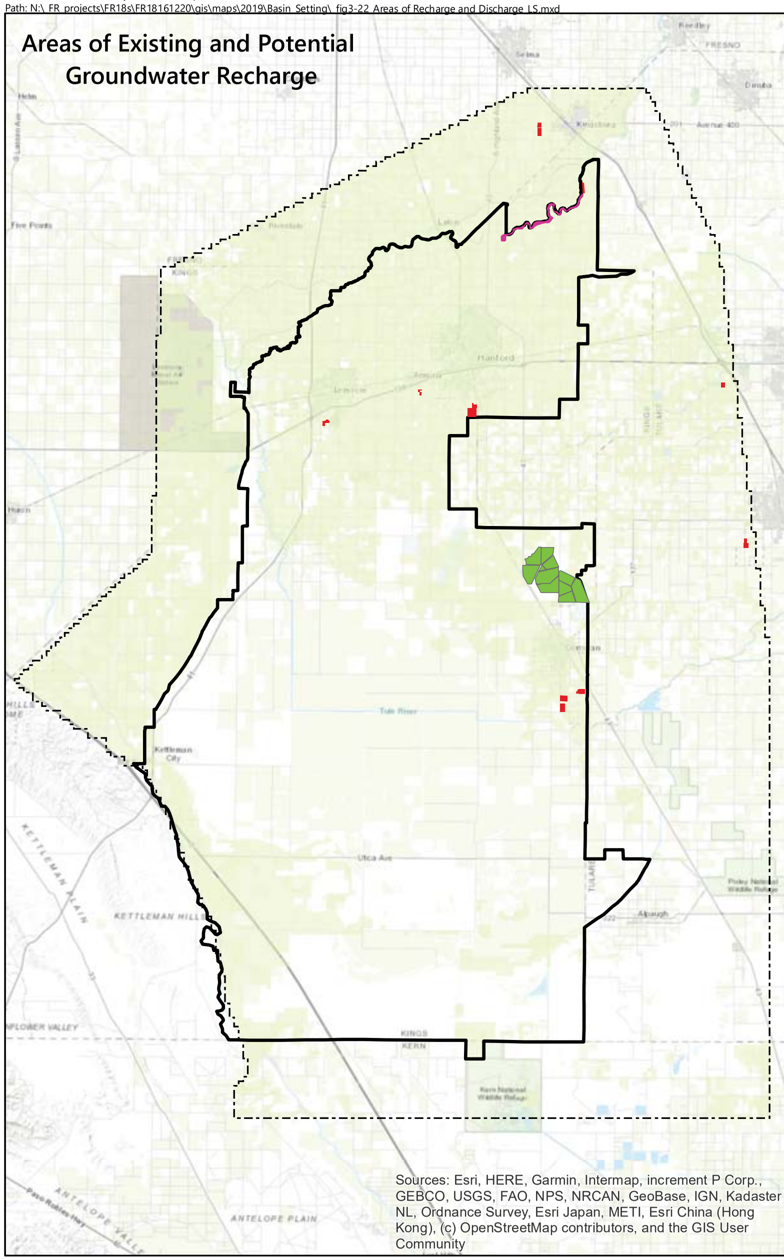
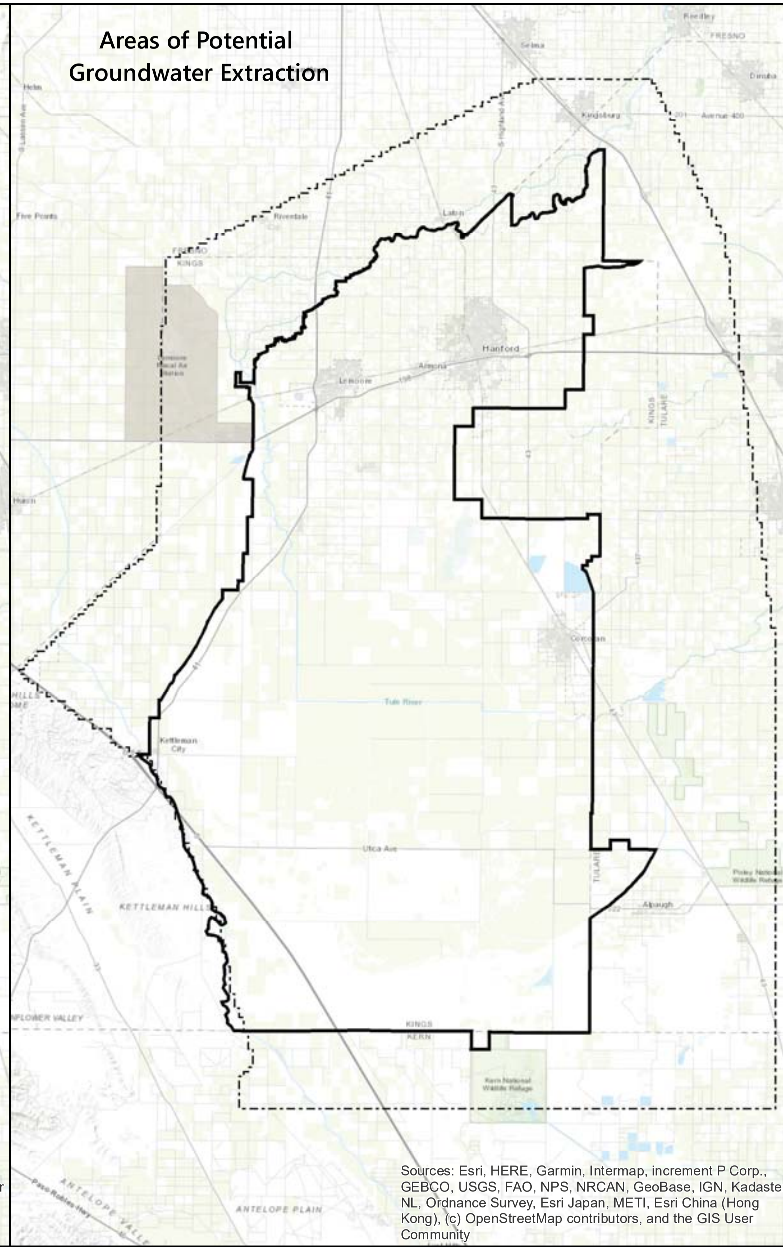




Explanation

- Study area
- Subbasin boundary
- Subsurface (tile) drained areas
- Area of potential groundwater extraction
- Stream and canal recharge
- Potential recharge area

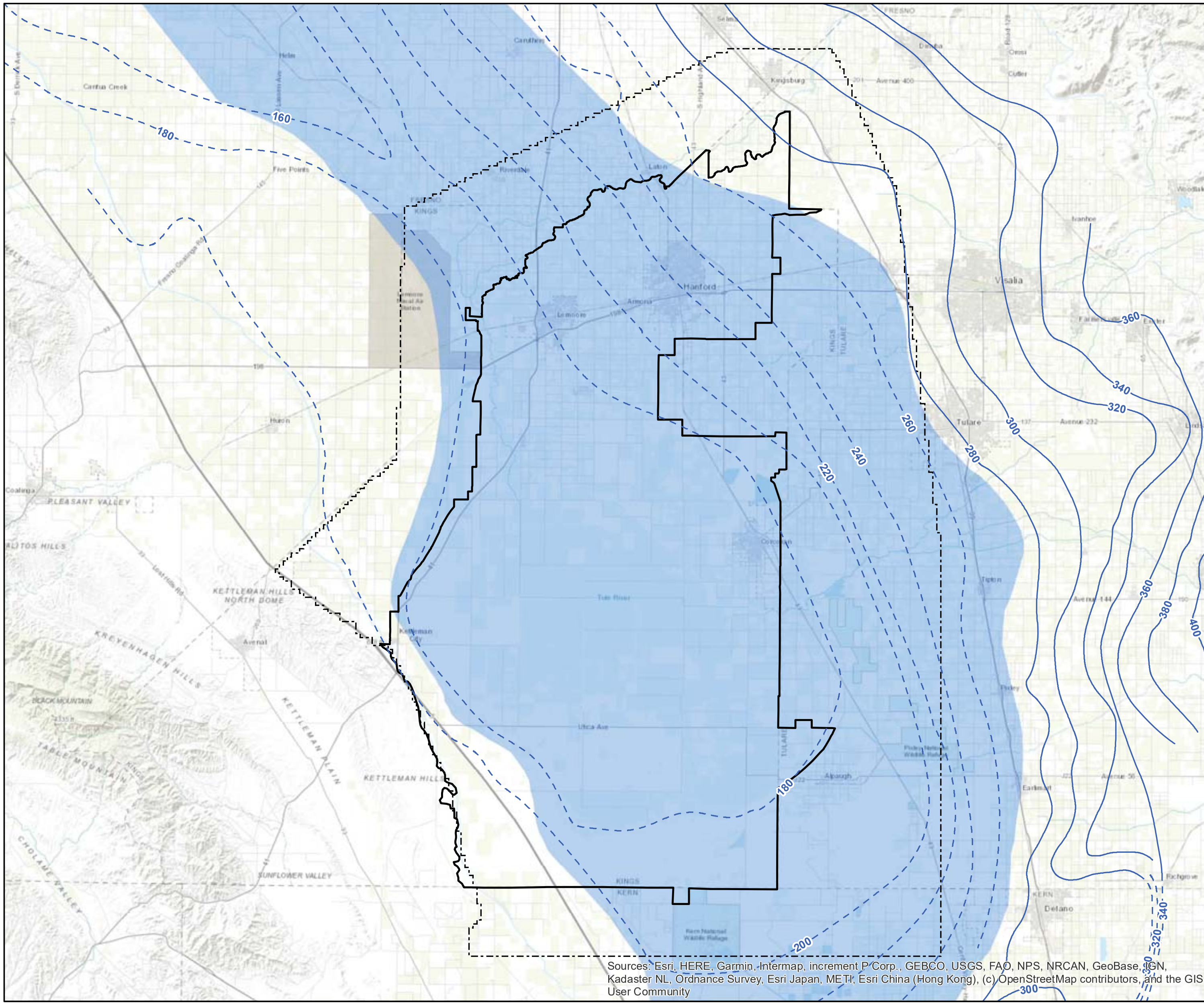
Existing areas of intentional recharge

- Waste Water Treatment Ponds
- Corcoran Irrigation District ponds
- Old river/ APEX Ranch

Approximate Scale in Feet: 0, 17,500, 35,000, 70,000
Approximate Scale in Meters: 0, 4,000, 8,000, 16,000

Areas of Existing and Potential Recharge and Extraction
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/9/2020	Project No.: FR18161220
		Figure **3-22**



Explanation

- Areas of flowing wells
- Study area
- Subbasin boundary

20-ft groundwater elevation contours (fmsl)

- Certain
- Uncertain

Notes:
1) Map adapted from Mendenhall et al (1916), Plate 1.
2) Elevations in feet above mean sea level.

Area of Flowing Wells 1905-1907

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 1/9/2020 | Project No.: FR18161220

Figure **3-23**

Date: 1/9/2020 Printed by: elizabeth.chapman
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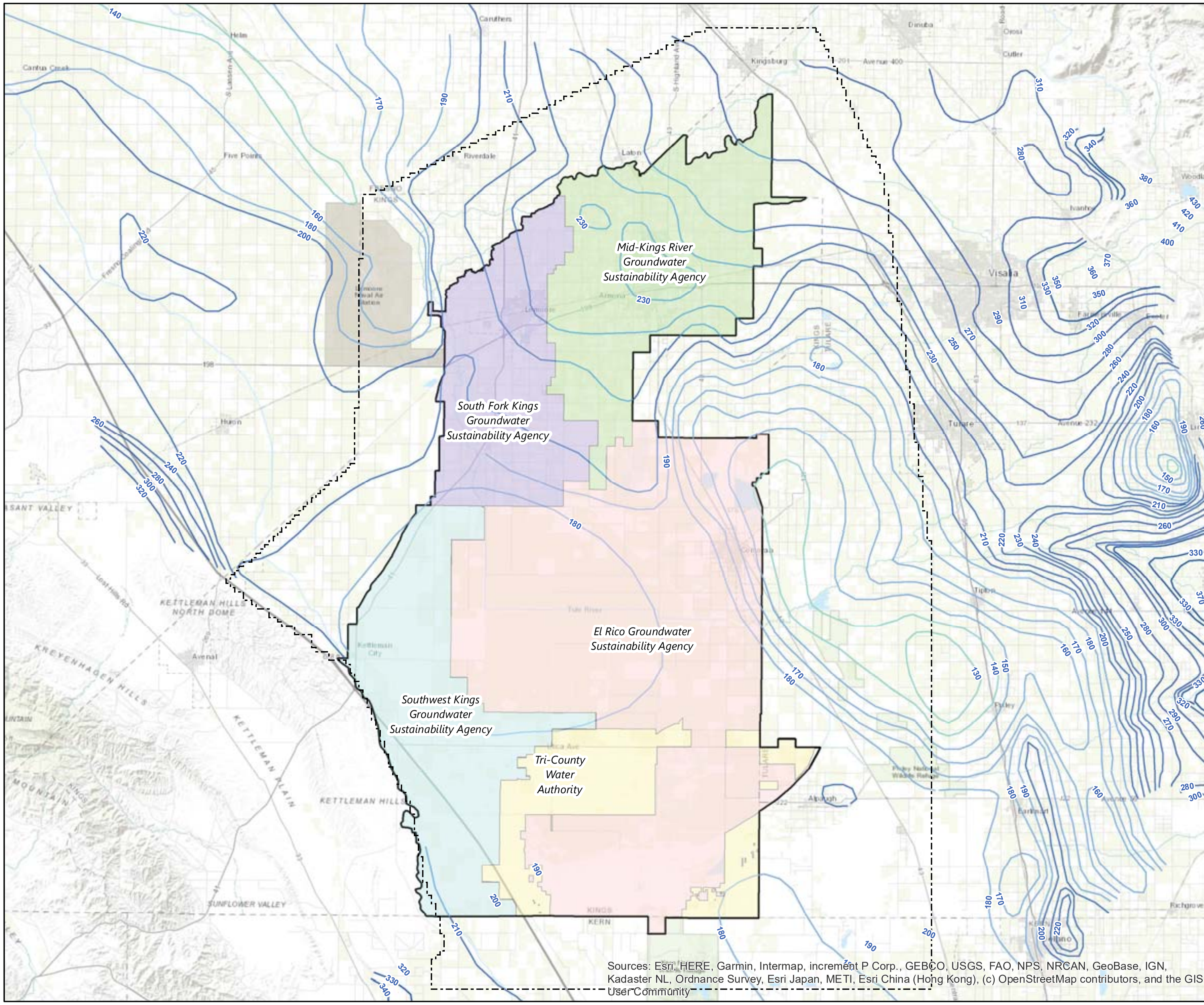

Explanation

- Study Area
- Subbasin boundary

10-ft groundwater elevation contours

- 100 - 150ft
- 150 - 200ft
- 210 - 250ft
- 260 - 300ft
- 310-450ft
- 460 - 500ft
- 510-580ft

Groundwater Sustainability Agencies (GSAs)

- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

N

Approximate Scale in Miles: 0, 2½, 5, 10

Approximate Scale in Kilometers: 0, 2½, 5, 10

Notes:
1) Map adapted from Davis (1959), Plate 15.
2) Elevations in feet above mean sea level.

Map of Unconfined Groundwater Conditions1952

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 1/9/2020 | Project No.: FR18161220

Figure **3-24**

Date: 1/9/2020 Printed by: elizabeth.chapman
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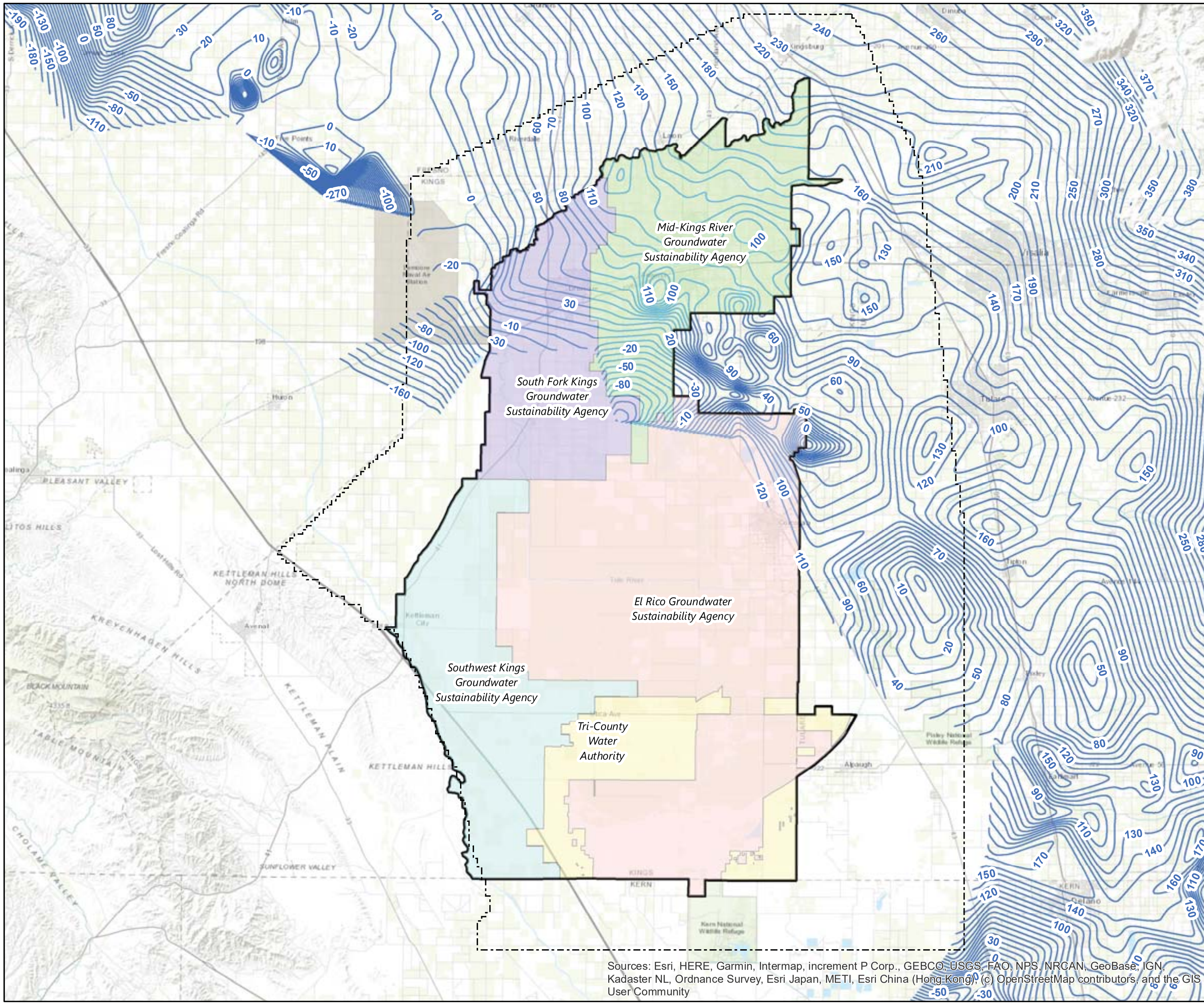


Explanation

- 10-ft lines of equal groundwater elevation
- Study area
- Subbasin boundary

Groundwater Sustainability Areas (GSAs)

- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

Approximate Scale in Miles: 0, 2½, 5, 10

Approximate Scale in Kilometers: 0, 2½, 5, 10

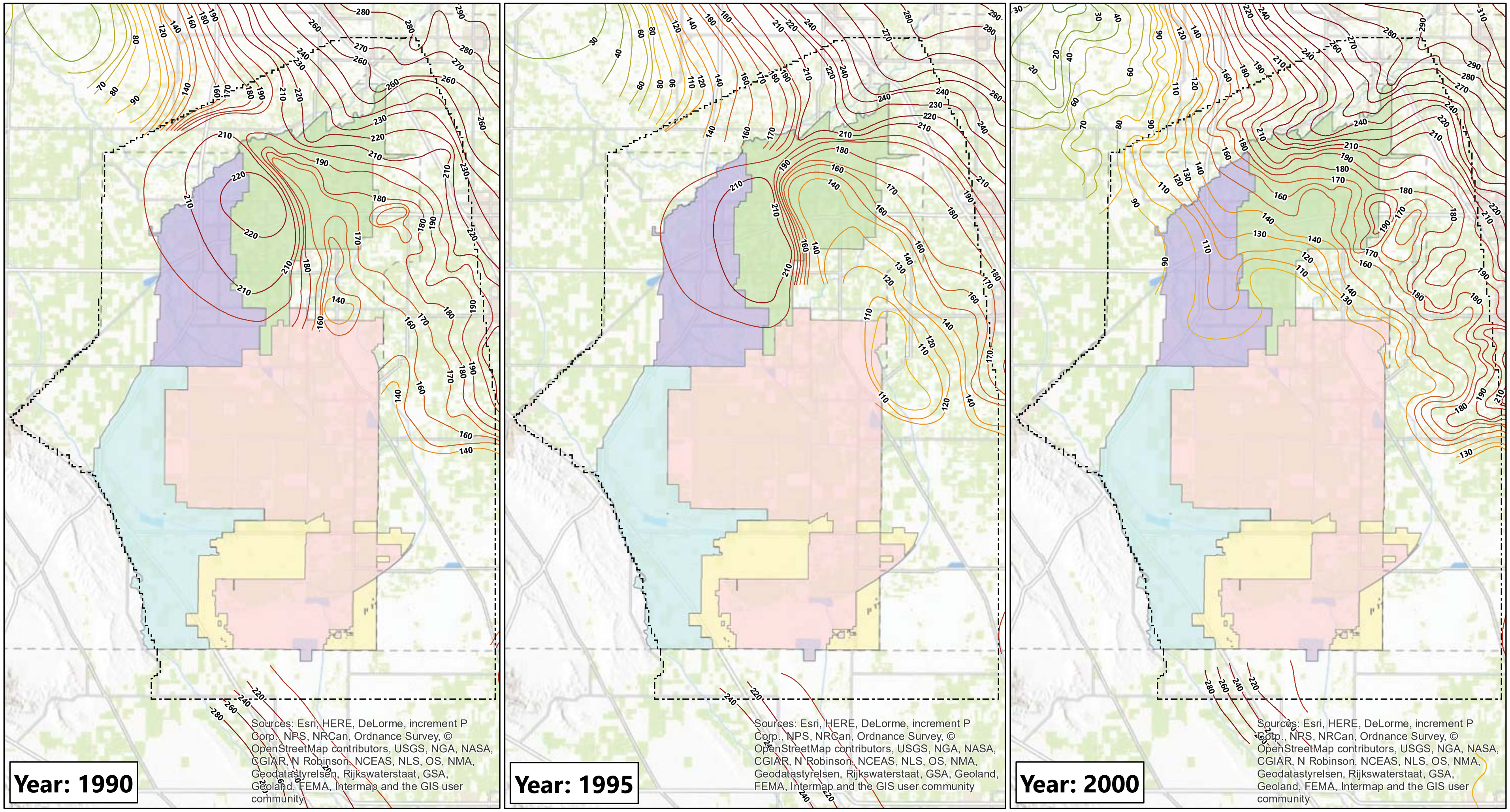
Notes:
1) Map adapted from DWR, June 2018.
2) Elevations in feet above mean sea level.

Map of Unconfined Groundwater Elevations 2016

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/15/2019	Project No.: FR18161220
		Figure **3-25**

Date: 11/15/2019 Printed by: shaina.price
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-25_GroundwaterConditions_2016.mxd



Explanation

- Study area
- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

Groundwater elevation (FMSL)
-700
-350

APPROXIMATE SCALE IN MILES
0 5 10 20

0 5 10 20
APPROXIMATE SCALE IN KILOMETERS

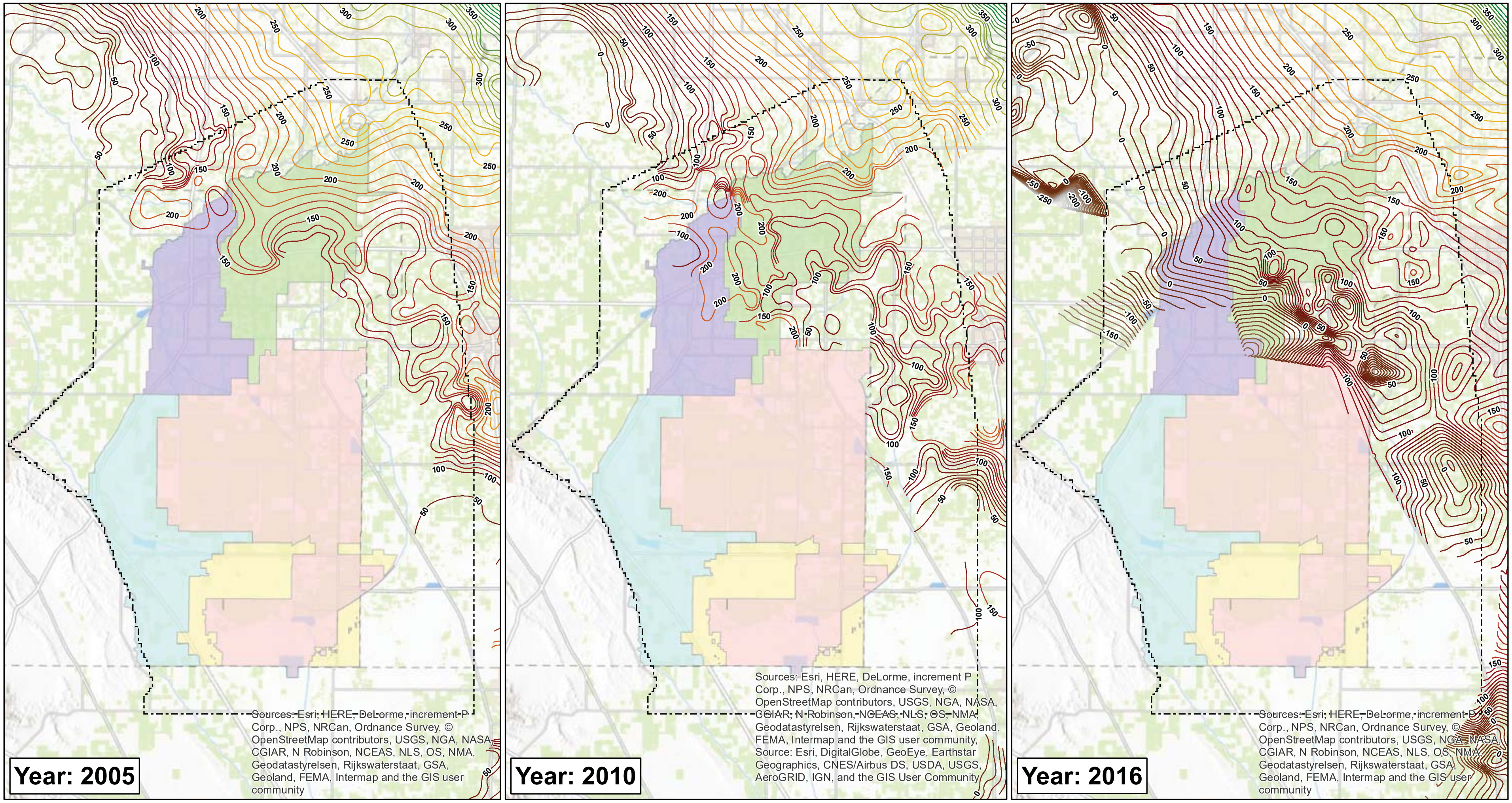
N

Historical DWR Groundwater Elevation Maps Unconfined Aquifer

Tulare Lake Subbasin Hydrologic Model
Kings County, California

By: EMC	Date: 11/15/2019	Project No.: FR18161220
	Figure	**3-26**

Date: 11/15/2019 Printed by: shaina.price
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-26_RecentGroundwaterConditions_1990_1995_2000.mxd



Explanation

- Study area
- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

Groundwater elevation (FMSL)
-700
-350

APPROXIMATE SCALE IN MILES
0 5 10 20

0 5 10 20
APPROXIMATE SCALE IN KILOMETERS

NOTE:
1) Groundwater elevation data obtained from California Department of Water Resources (CA DWR), June 2018: https://databasin.org/datasets/b05820cda86b4921a515065fa1deffcc
2) FMSL = Feet above mean sea level.

Historical DWR Groundwater Elevation Maps, Unconfined Aquifer
Tulare Lake Subbasin Hydrologic Model
Kings County, California

By: EMC	Date: 11/15/2019	Project No.: FR18161220
		Figure **3-27**

Date: 11/15/2019 Printed by: shaina.price
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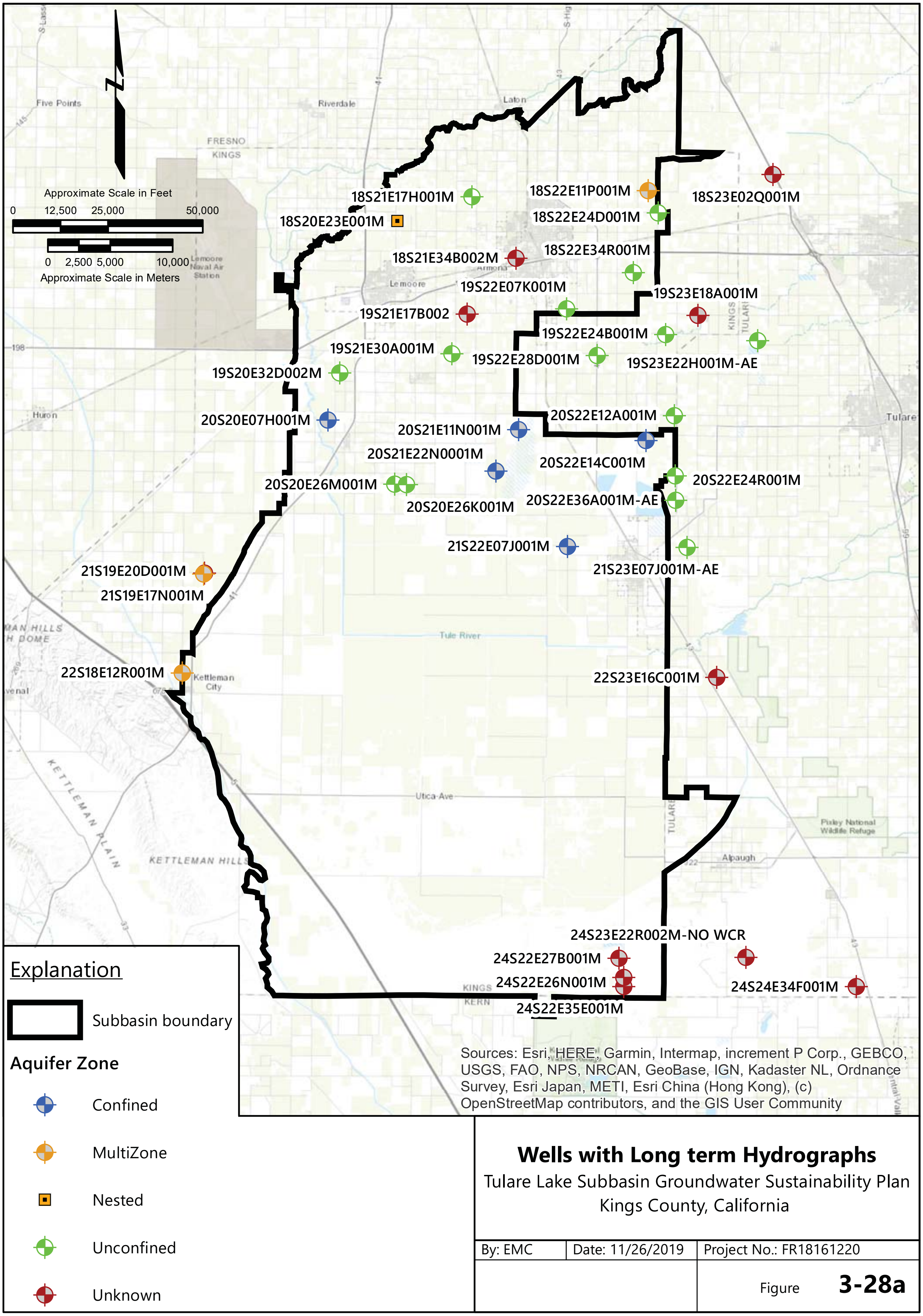

Wells with Long term Hydrographs

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/26/2019	Project No.: FR18161220
		Figure **3-28a**

Date: 11/26/2019 Printed by: elizabeth.chapman
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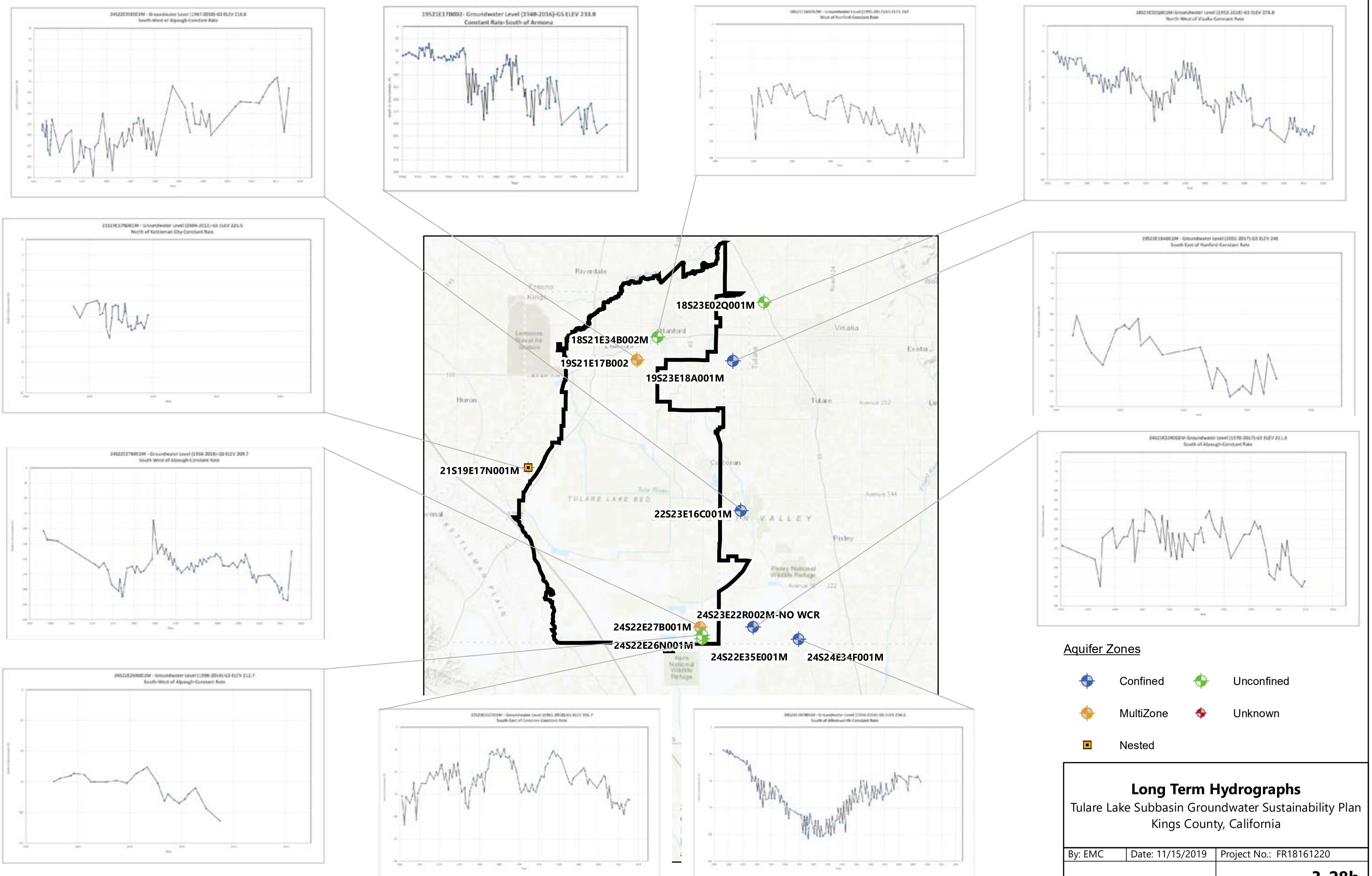

Long Term Hydrographs

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: EMC | Date: 11/15/2019 | Project No.: FR18161220

Figure **3-28b**

Date: 11/15/2019 Printed by: shaina.price

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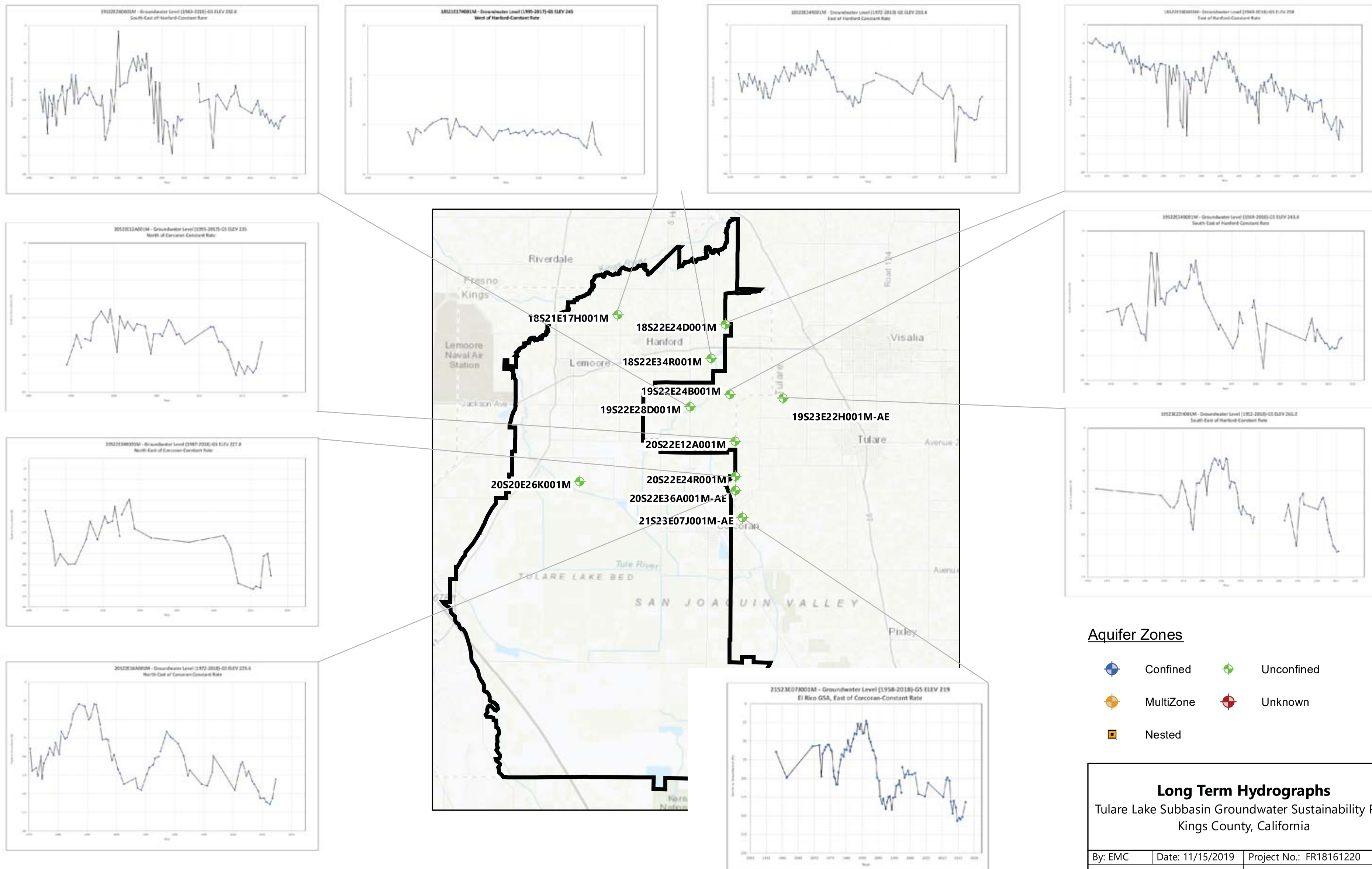

Long Term Hydrographs

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/15/2019	Project No.: FR18161220
		Figure **3-28c**

Date: 11/15/2019 Printed by: shaina.price
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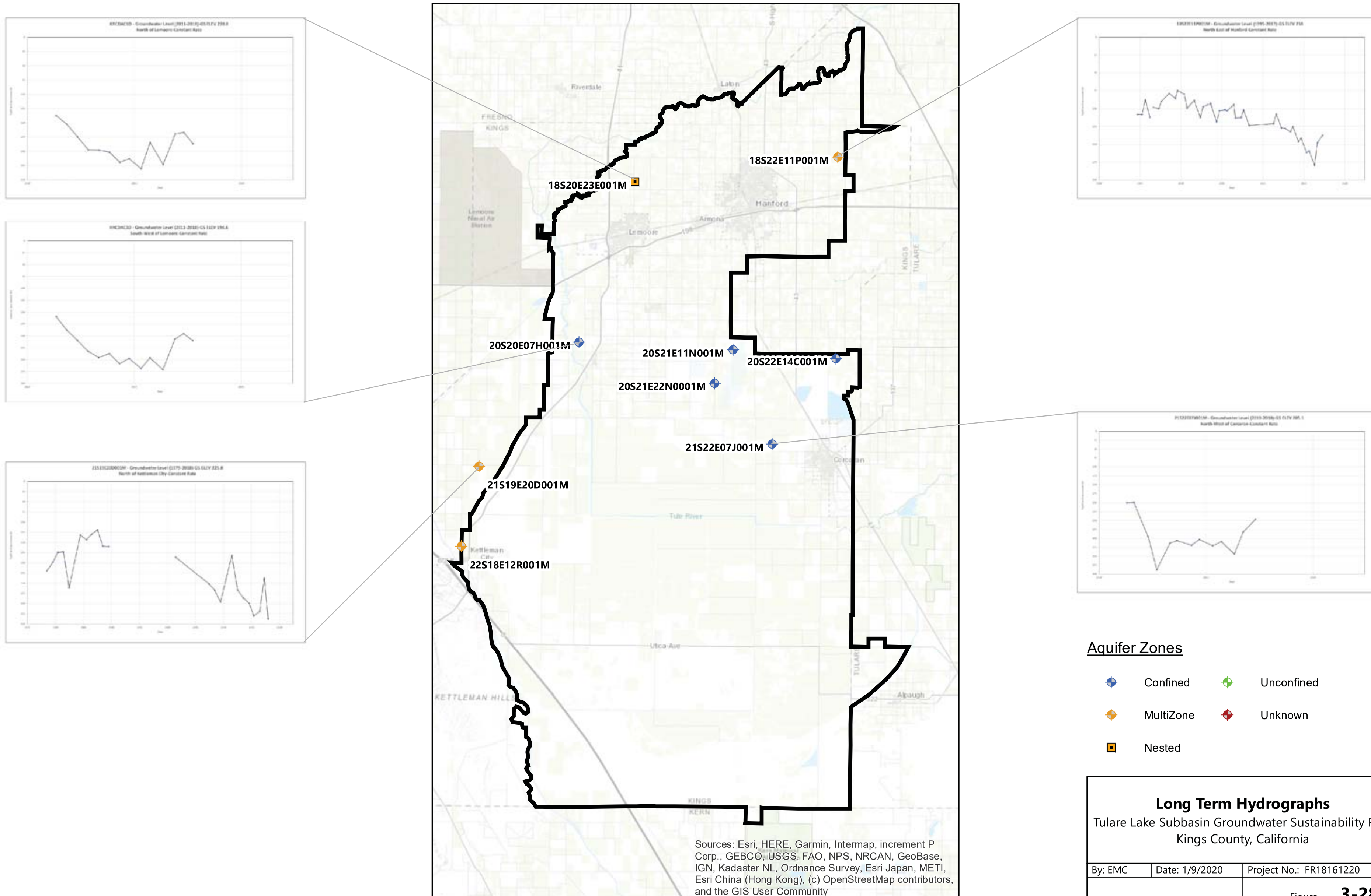


Aquifer Zones

- Confined
- Unconfined
- MultiZone
- Unknown
- Nested

Long Term Hydrographs

Tulare Lake Subbasin Groundwater Sustainability Plan

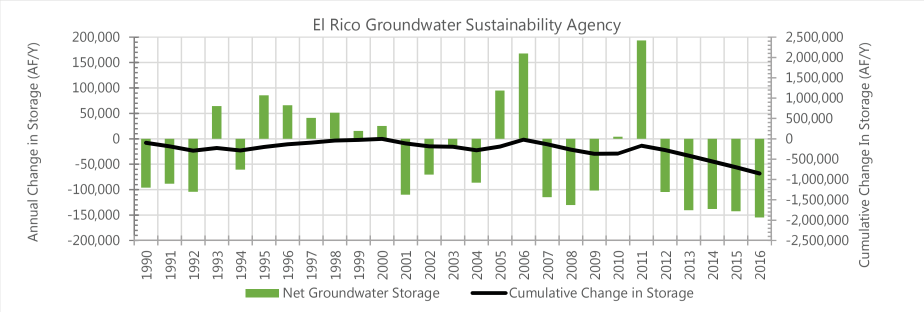
Kings County, California

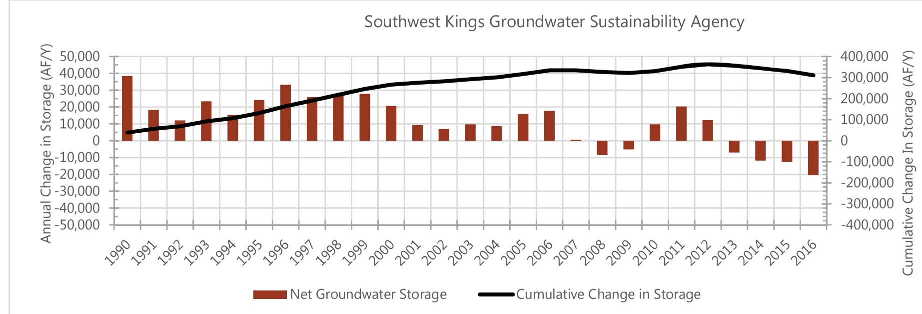
By: EMC	Date: 1/9/2020	Project No.: FR18161220
		Figure **3-28d**

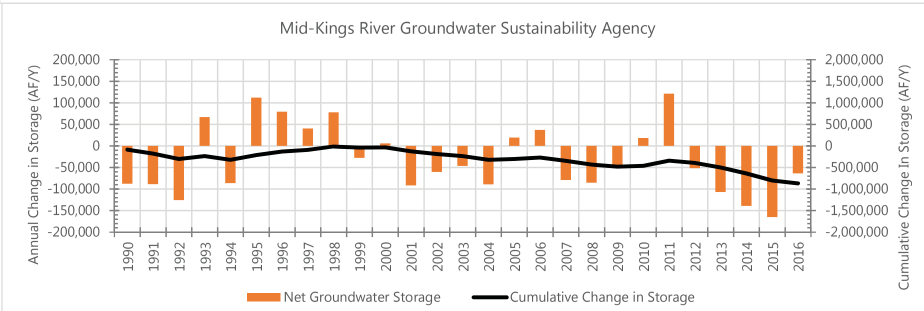
Date: 1/9/2020 Printed by: elizabeth.chapman

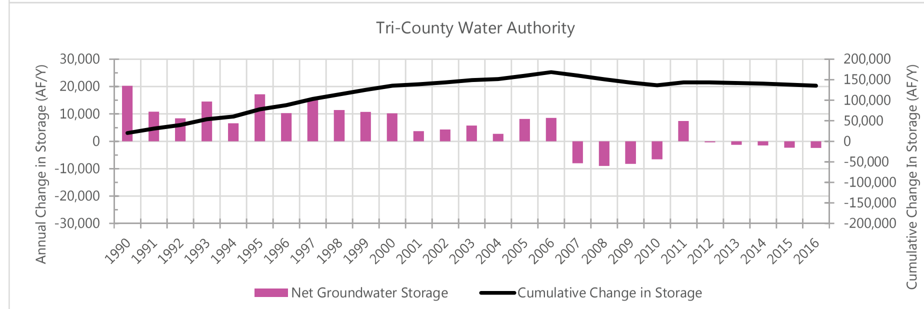
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-28D_ConfinedAquiferZoneHydrograph.mxd

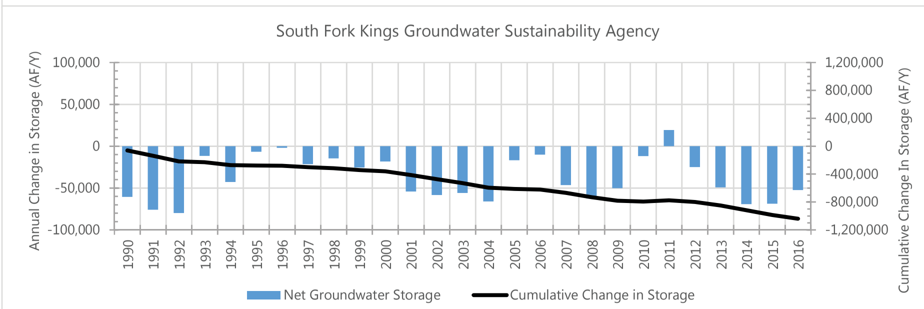
I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-29_3-53_120619.xlsmFigure 3-29a 1/8/2020

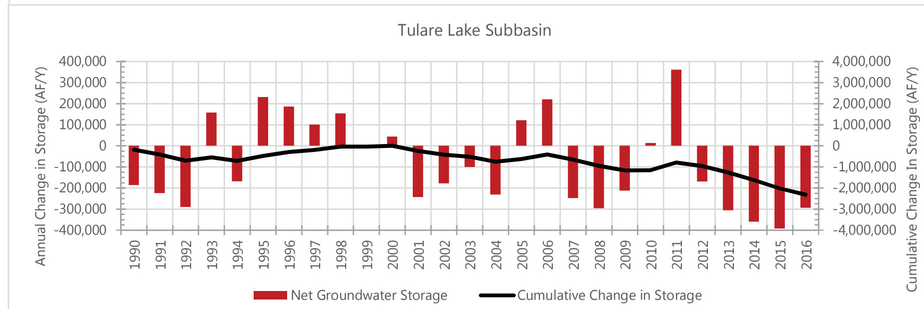










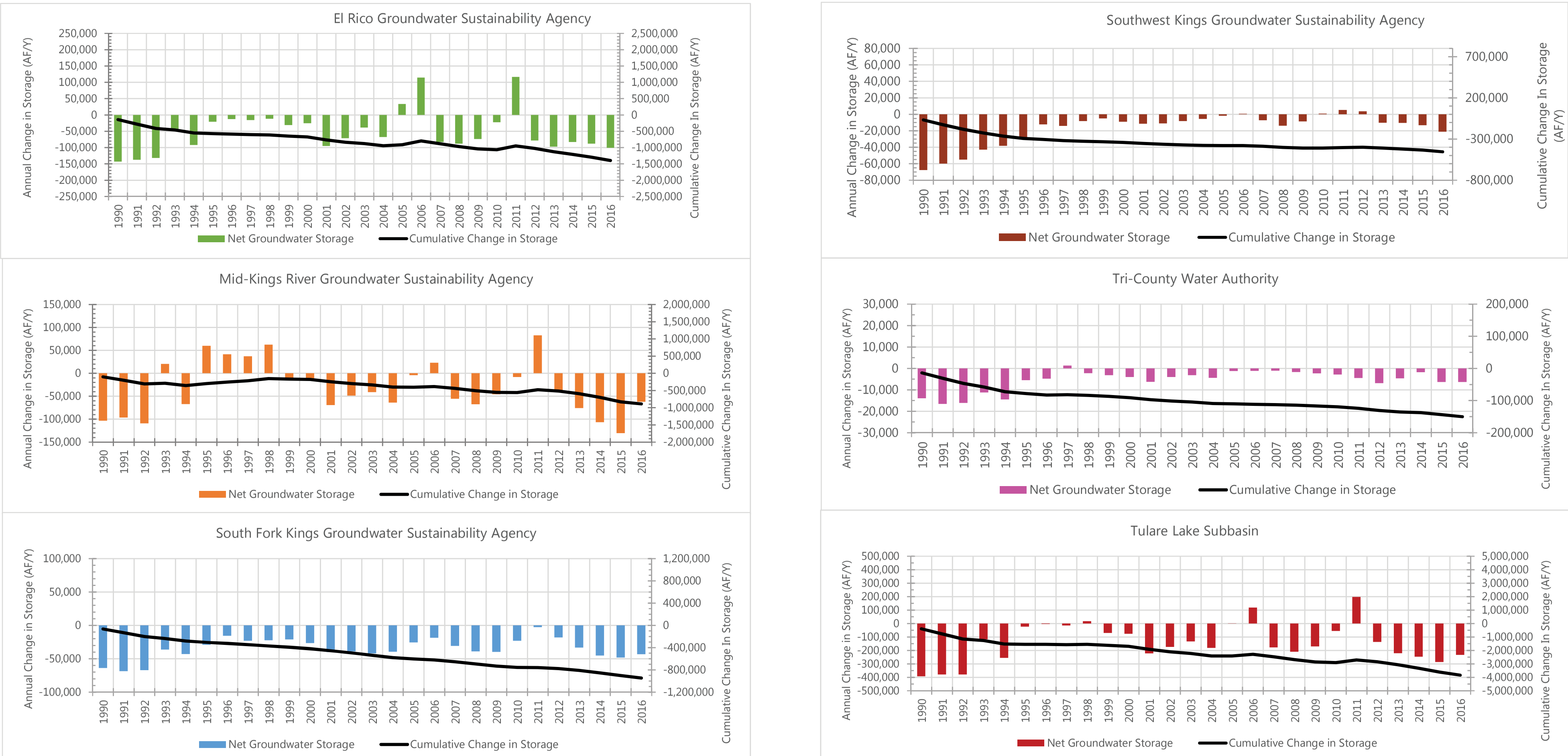


Notes:
1. AF/Y = acre-feet per year

Change in Groundwater Storage
All Aquifer Zones 1990 to 2016
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure: 3-29a

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-29_3-53_120619.xlsmFigure 3-29b 1/8/2020

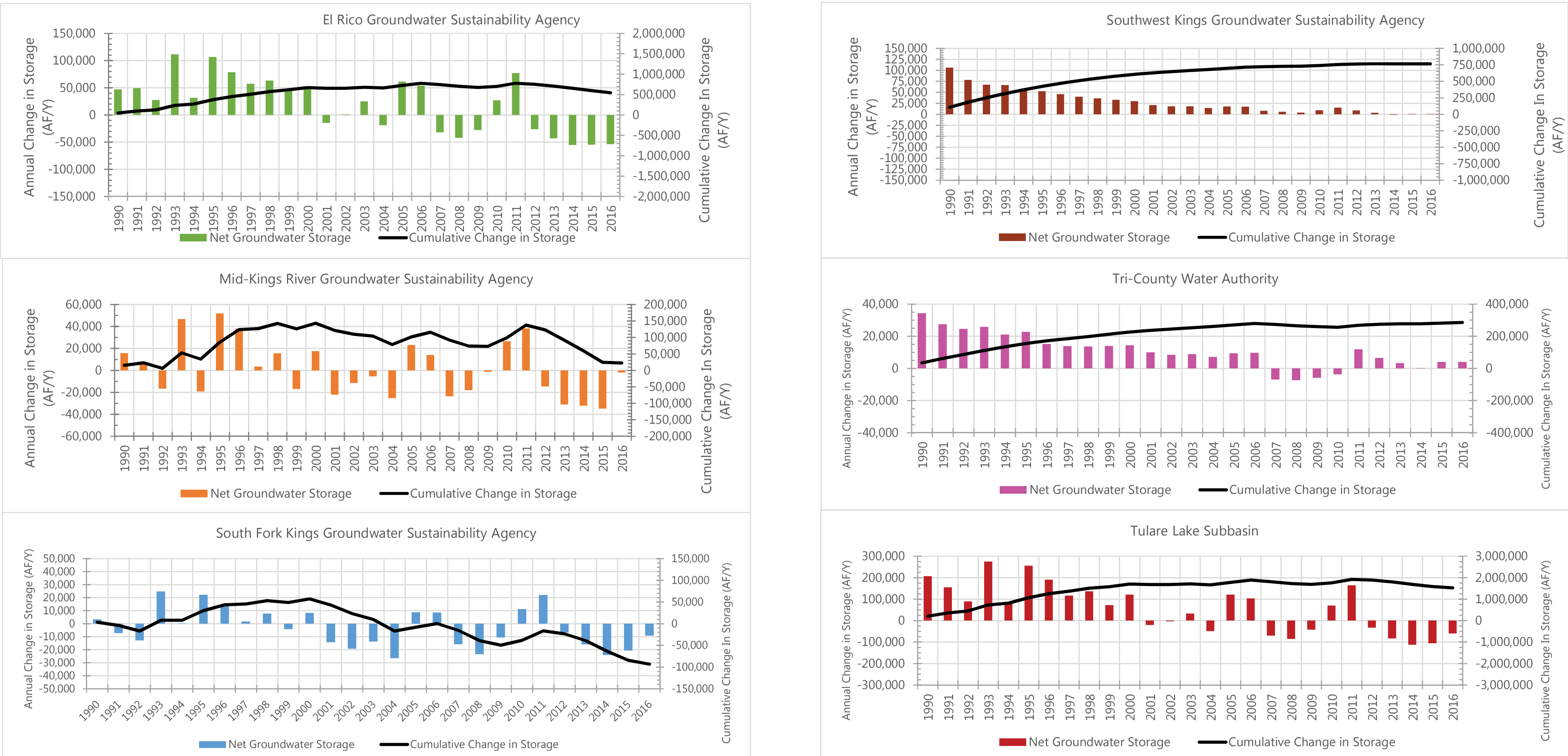


Notes:
1. AF/Y = acre-feet per year

Change in Groundwater Storage
Upper Aquifer Zone 1990 to 2016
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure: 3-29b

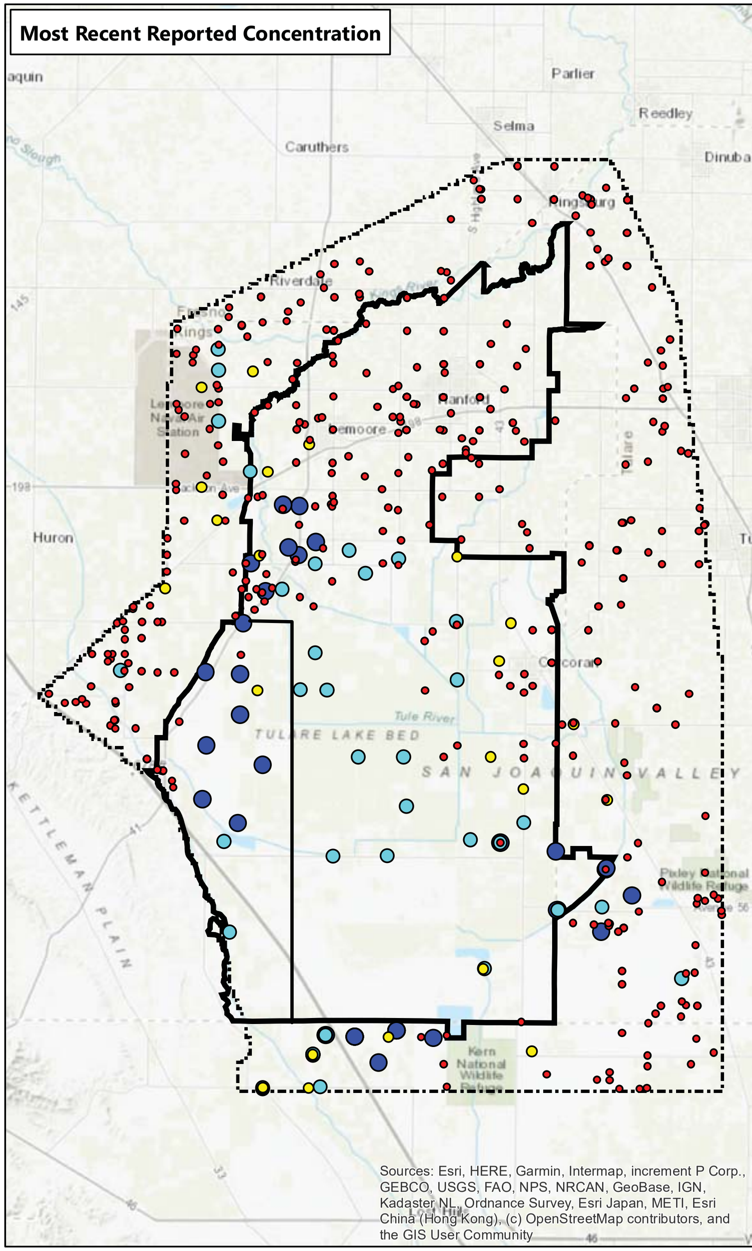
I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-29_3-53_120619.xlsmFigure 3-29c 1/8/2020

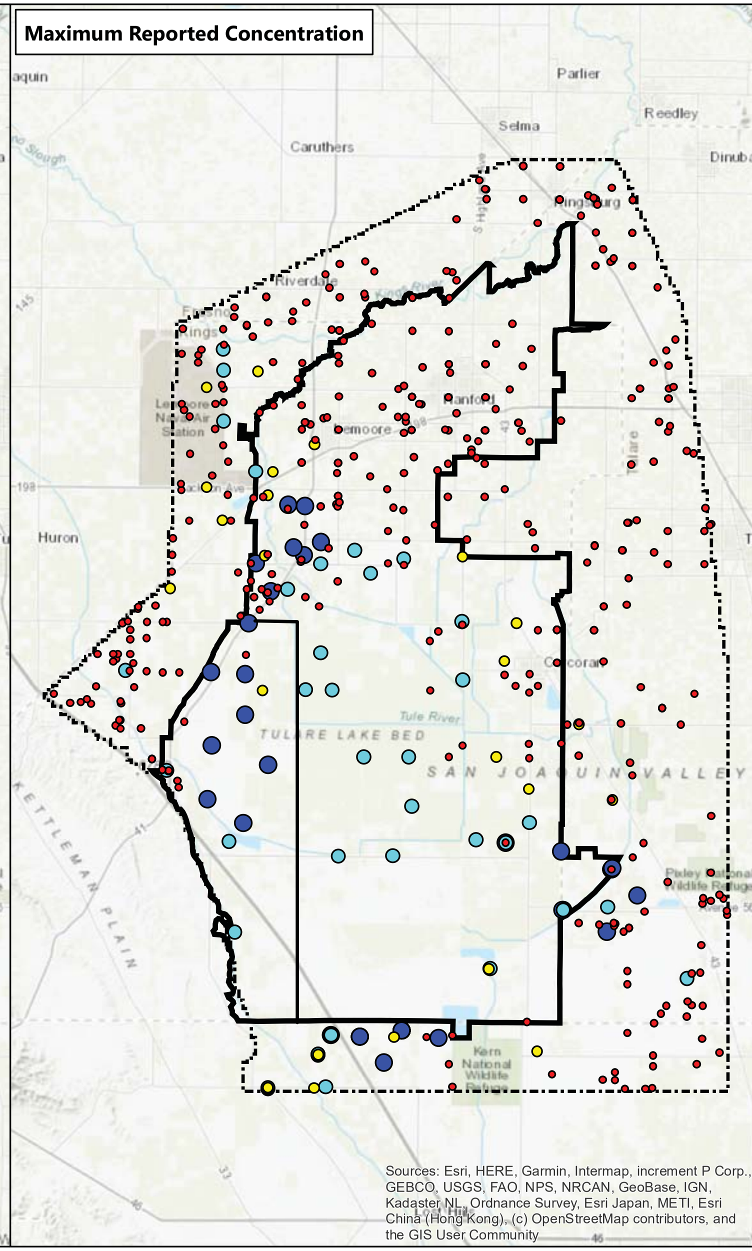


Notes:
1. AF/Y = acre-feet per year

Change in Groundwater Storage
Lower Aquifer Zone 1990 to 2016
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure: 3-29c





Explanation

- <1,500 mg/L
- 1,500 - 3,000 mg/L
- 3,000 - 10,000 mg/L
- >10,000 mg/L
- Study Area
- Subbasin boundary

Notes:
1) Data compiled from California Water Boards Geotracker. November 2018: https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp

Approximate Scale in Miles: 0, 5, 10, 20

Approximate Scale in Kilometers: 0, 5, 10, 20

Total Dissolved Solids in Groundwater

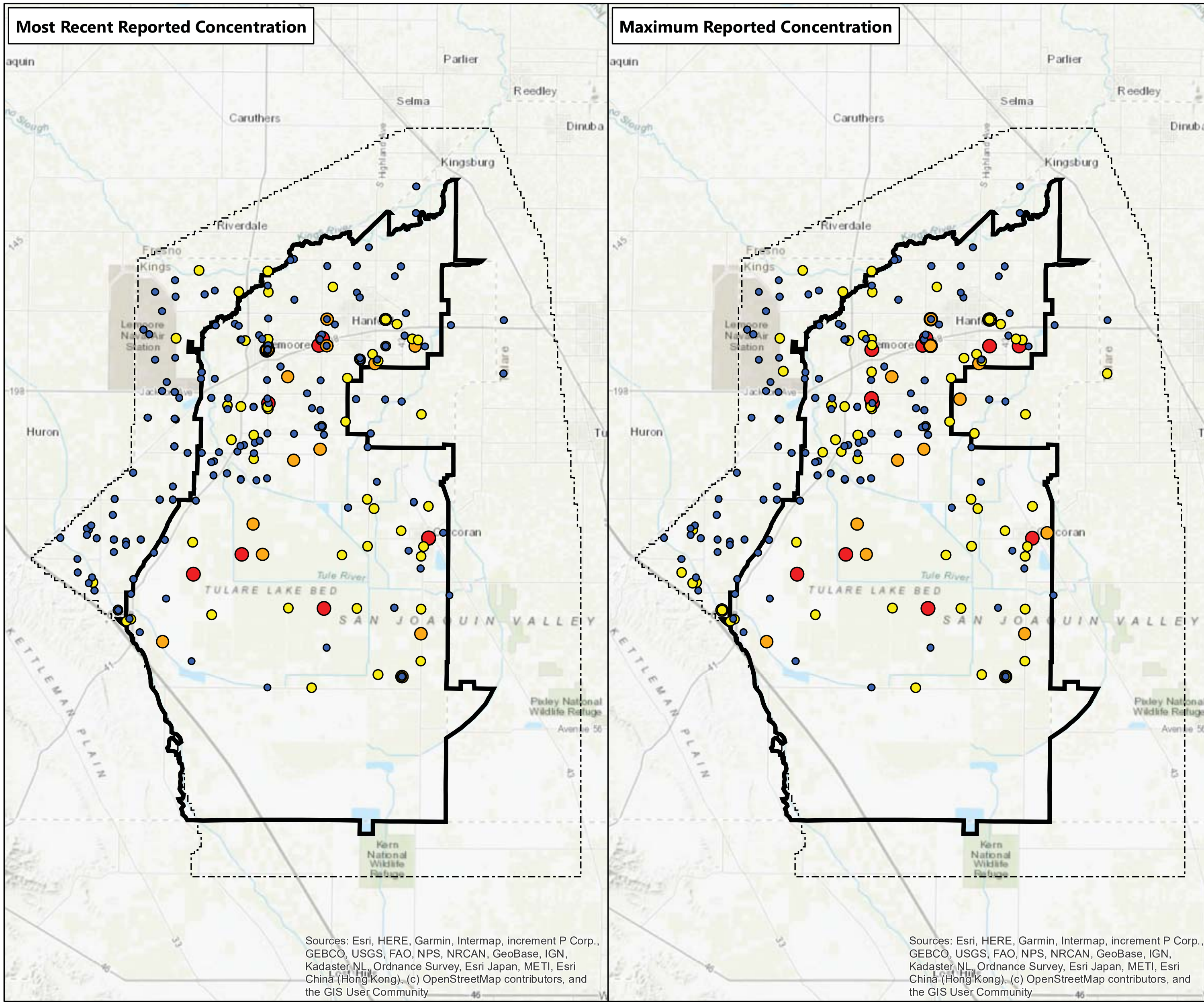
Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: SCM | Date: 1/9/2020 | Project No.: FR16181220

Figure **3-30**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-30_Total_Dissolved_Solids_NEW.mxd



Explanation

- <10 µg/L
- 10.01 - 50.0 µg/L
- 50.1 - 100.0 µg/L
- >100 µg/L
- Study Area
- Subbasin boundary

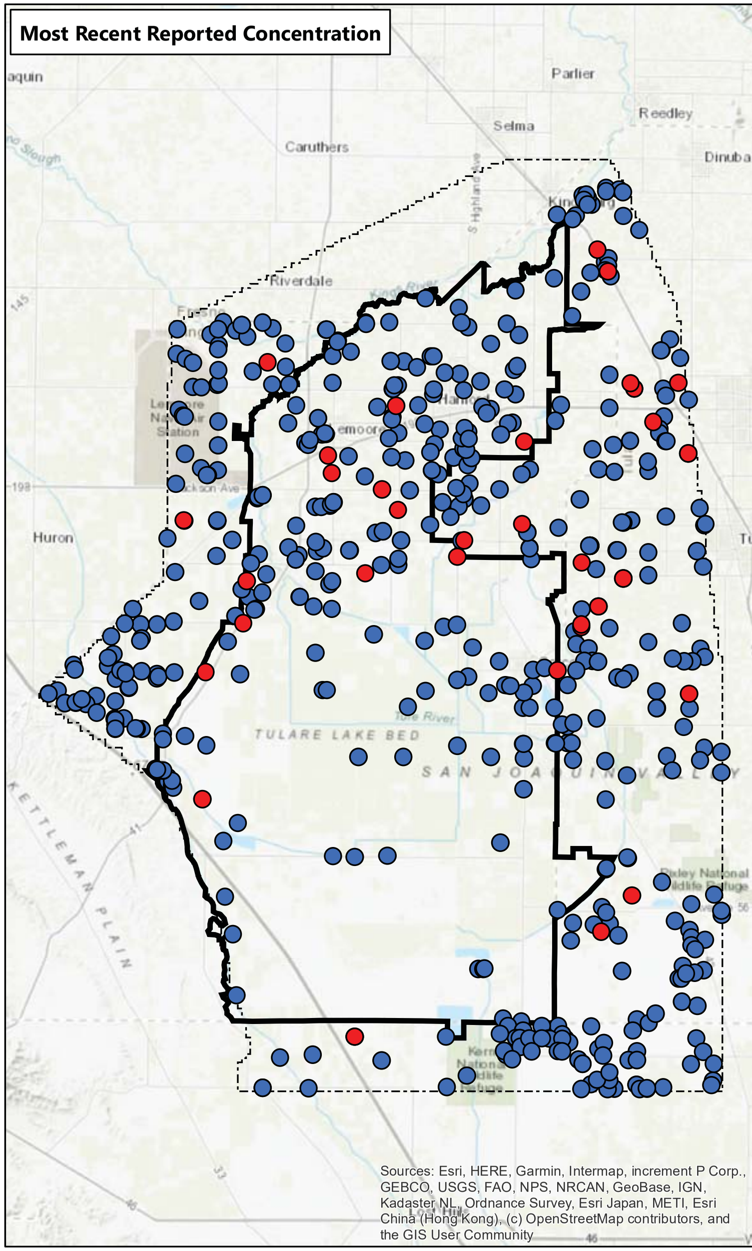
Notes:
1) Data compiled from California Water Boards. November 2018: https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp

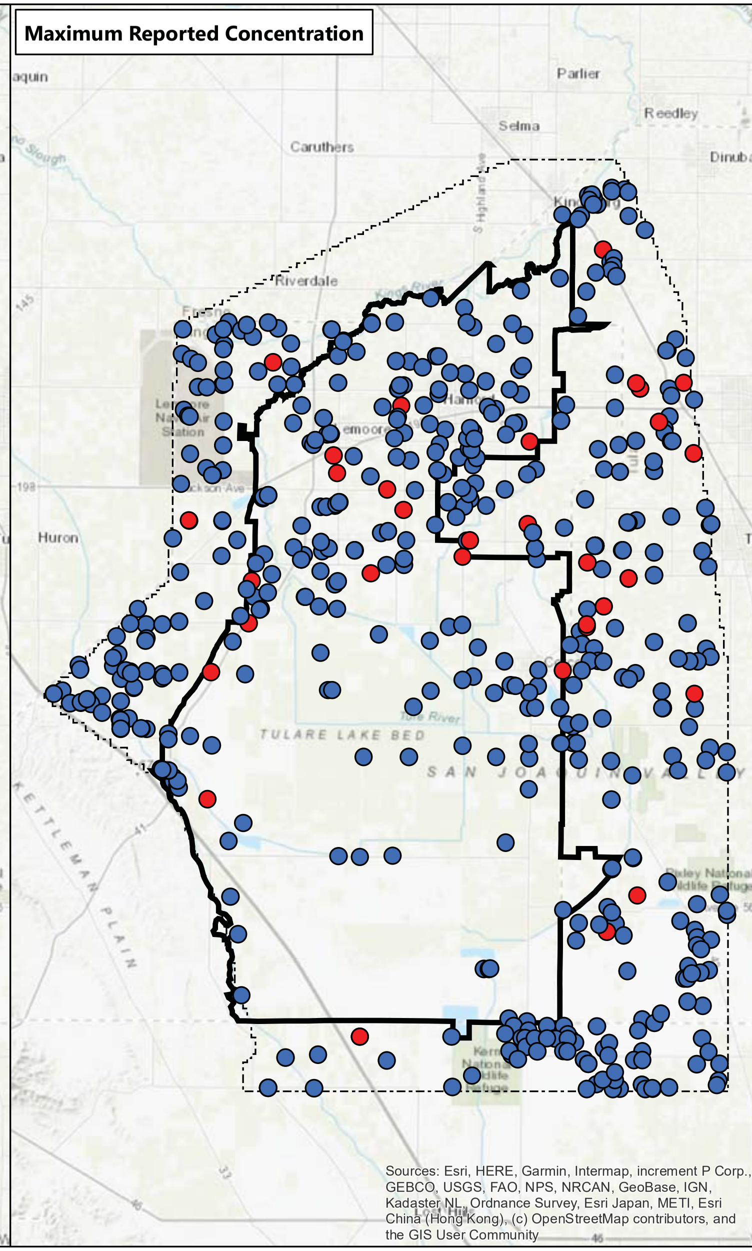
Approximate Scale in Miles: 0, 5, 10, 20
Approximate Scale in Kilometers: 0, 5, 10, 20

Arsenic in Groundwater
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: SCM	Date: 1/9/2020	Project No.: FR16181220
		Figure **3-31**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-31_Arsenic_in_Groundwater_NEW.mxd





Explanation

- <10 mg/L
- >10 mg/L
- Study Area
- Subbasin boundary

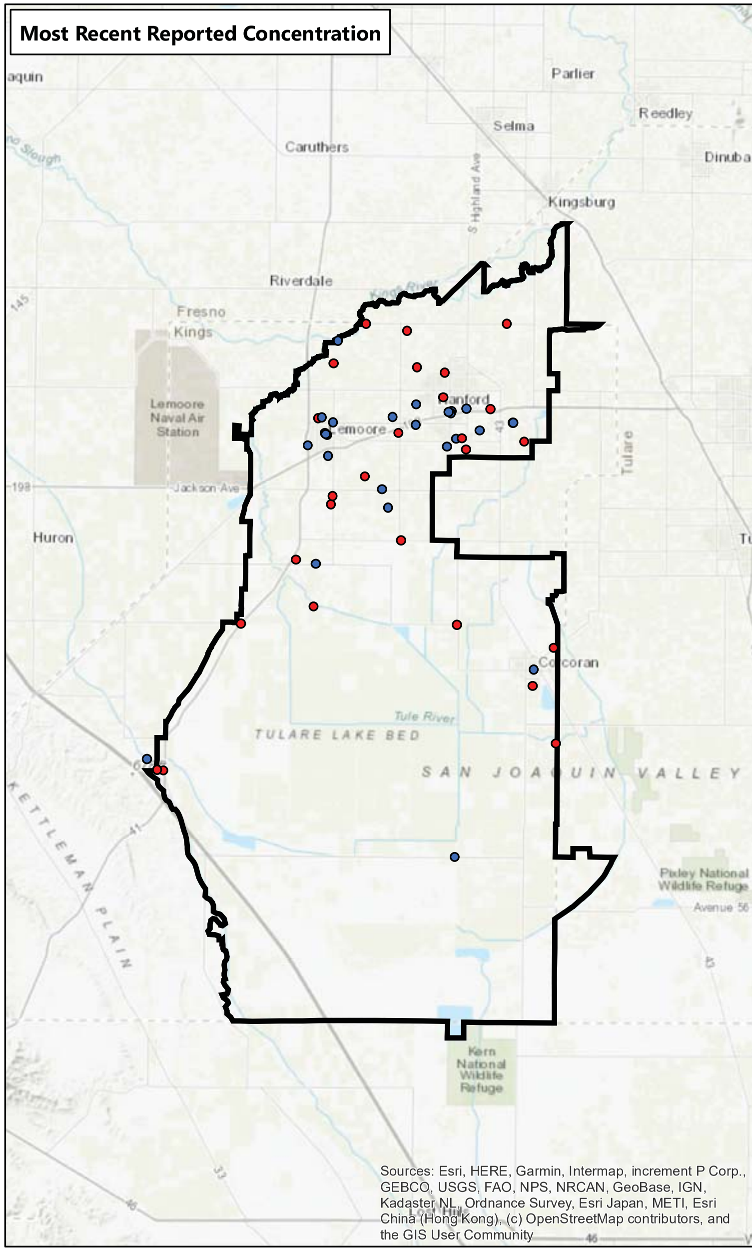
Notes:
1) Data compiled from California Water Boards. November 2018: https://gamagroundwater. waterboards.ca.gov/gama/gamamap/public/Default.asp

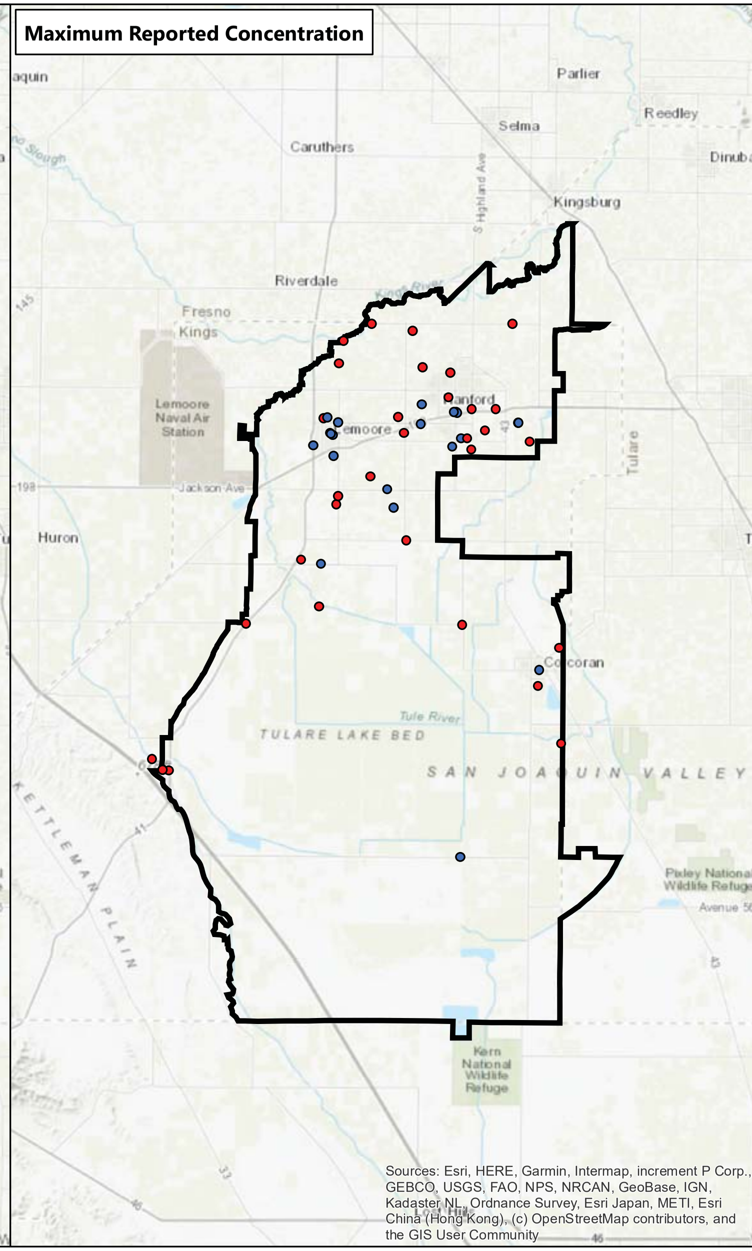
Approximate Scale in Miles: 0 5 10 20
Approximate Scale in Kilometers: 0 5 10 20

Nitrate in Groundwater
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: SCM	Date: 1/9/2020	Project No.: FR16181220
		Figure **3-32**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-32_Nitrate_in_Groundwater_NEW.mxd





Explanation

1,2,3-TCP

- <0.005
- >0.005
- Subbasin boundary

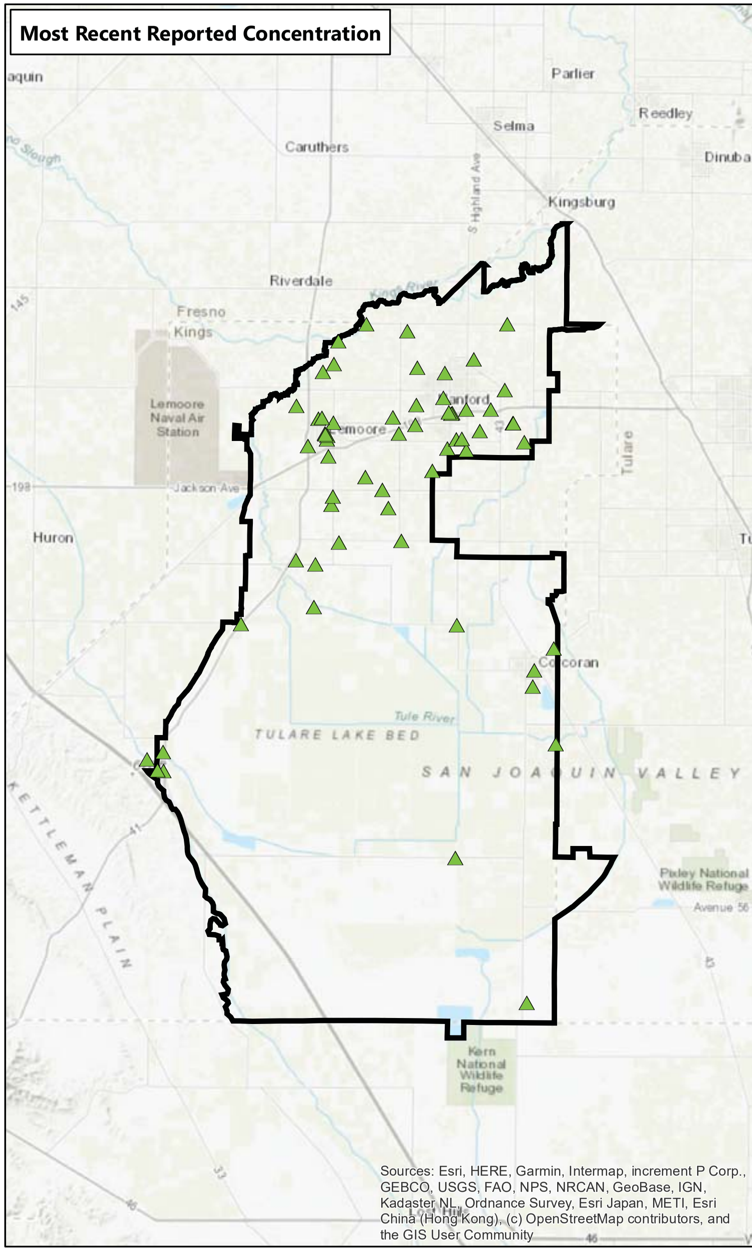
Notes:
1) Data compiled from California Water Boards. November 2018: https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp

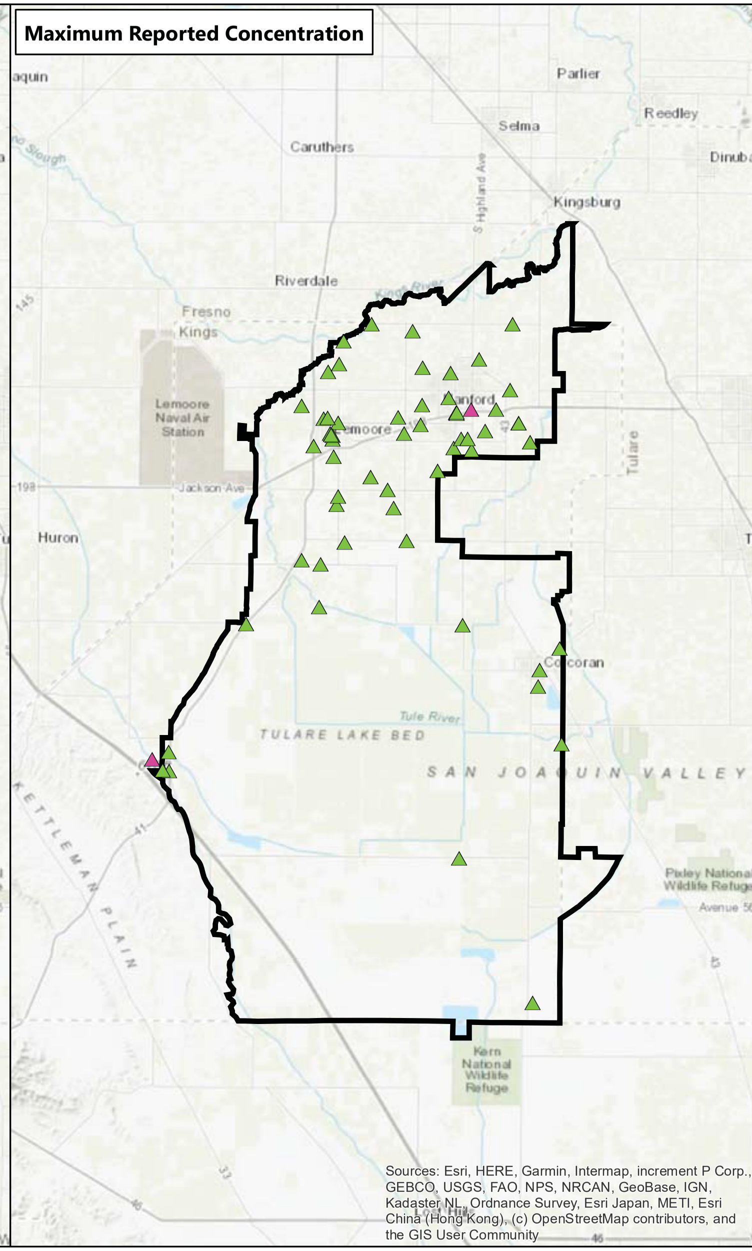
Approximate Scale in Miles: 0, 5, 10, 20
Approximate Scale in Kilometers: 0, 5, 10, 20

Volatile Organic Compounds in Groundwater
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: SCM	Date: 1/9/2020	Project No.: FR16181220
		Figure **3-33a**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-33_VOCs_in_Groundwater_NEW.mxd





Explanation

DBCP

<0.20 µg/L

>0.21 µg/L

Subbasin boundary

Notes:
1) Data compiled from California Water Boards. November 2018: https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp

Approximate Scale in Miles: 0, 5, 10, 20

Approximate Scale in Kilometers: 0, 5, 10, 20

Volatile Organic Compounds in Groundwater

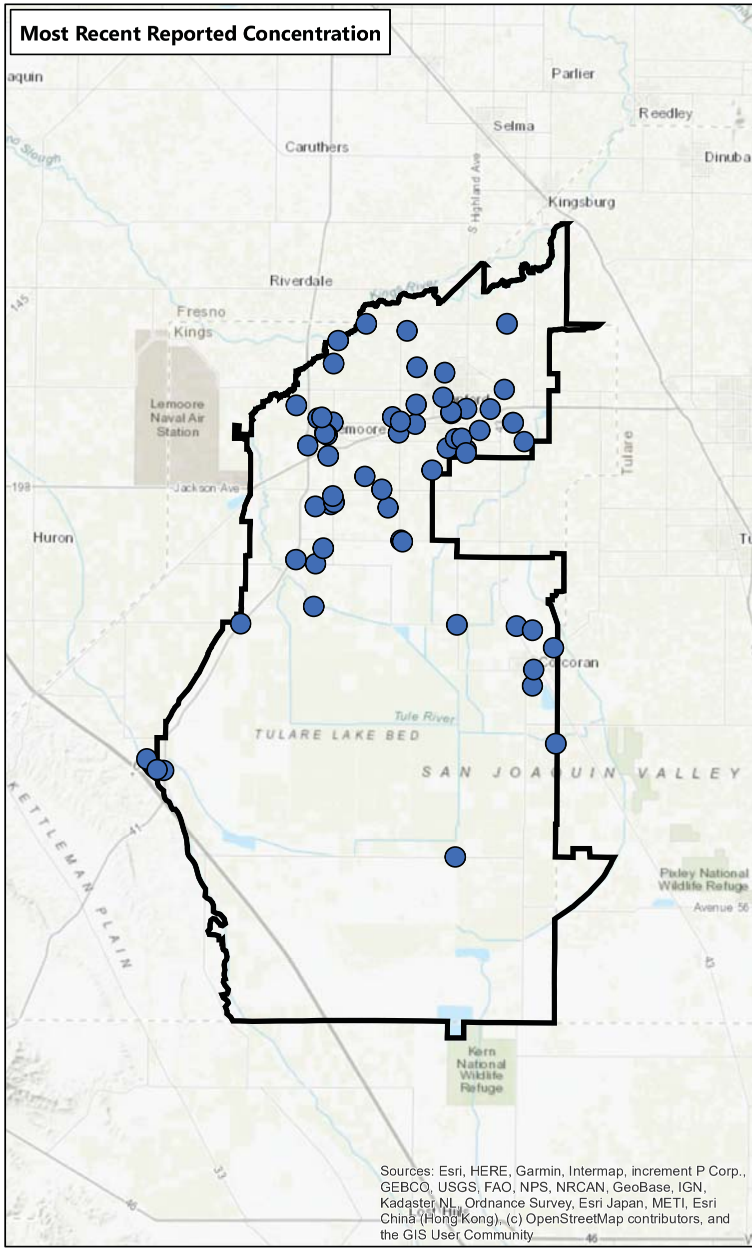
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

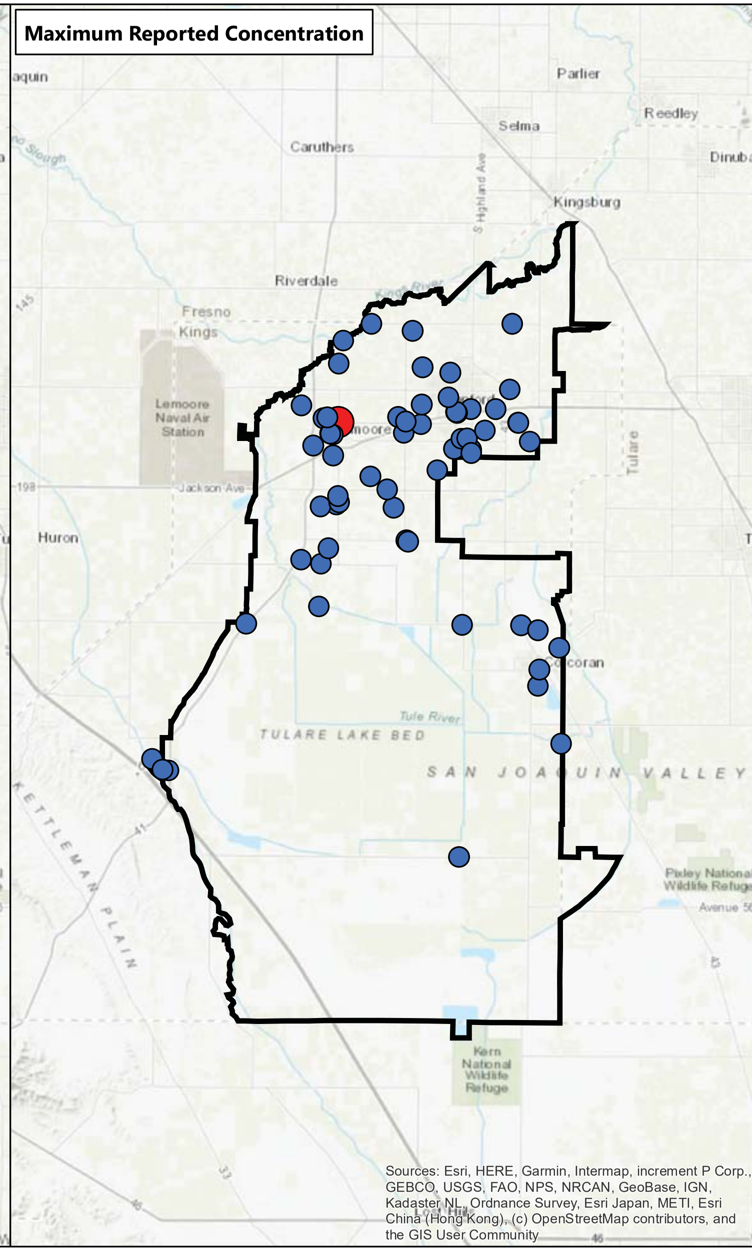
By: SCM | Date: 1/9/2020 | Project No.: FR16181220

wood.

Figure **3-33b**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-33b_VOCs_in_Groundwater_DBCP.mxd





Explanation

TCE

- <5.00 µg/L
- >5.01 µg/L
- Subbasin boundary

Notes:
1) Data compiled from California Water Boards. November 2018: https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp

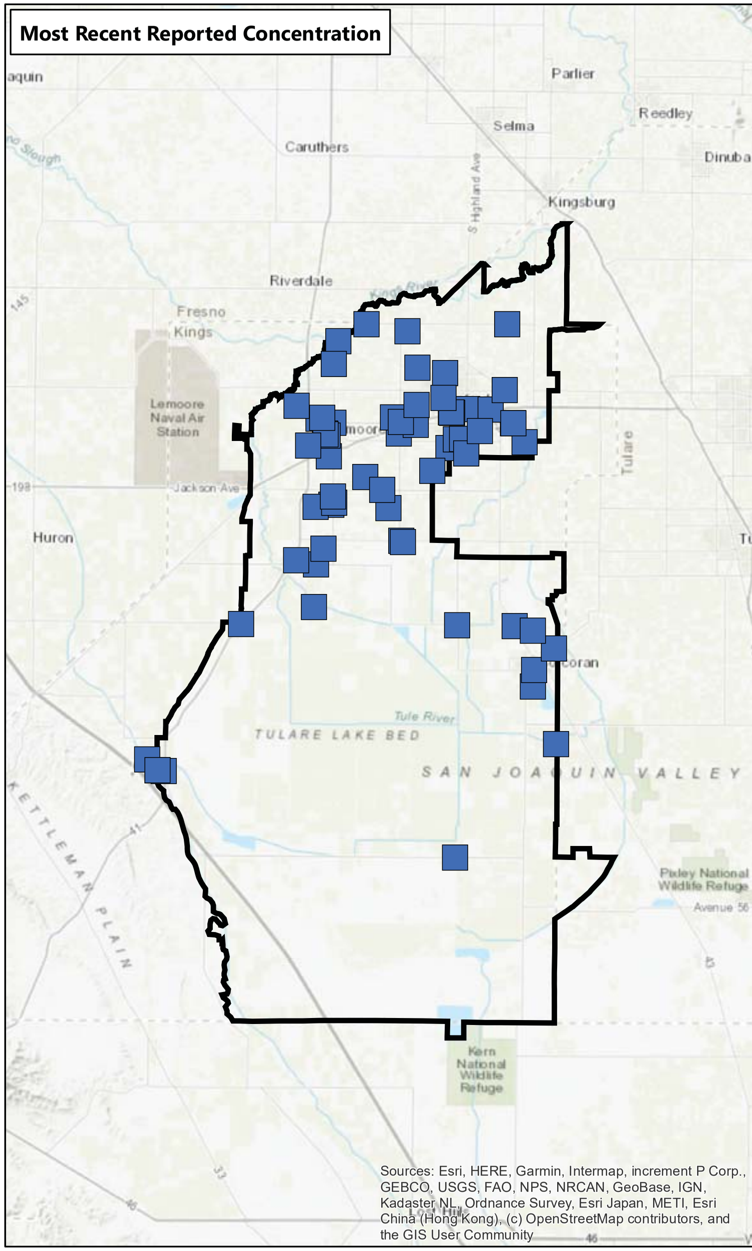
Approximate Scale in Miles: 0, 5, 10, 20
Approximate Scale in Kilometers: 0, 5, 10, 20

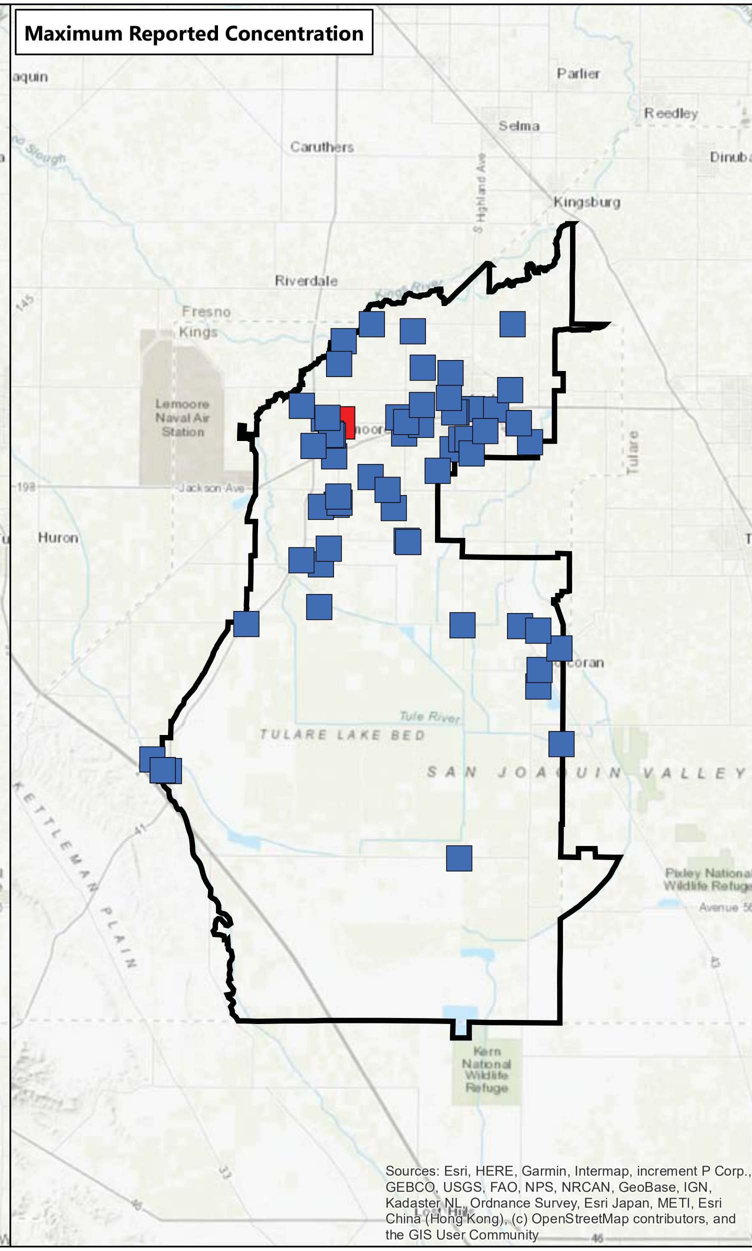
Volatile Organic Compounds in Groundwater

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: SCM	Date: 1/9/2020	Project No.: FR16181220
wood.		Figure **3-33c**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-33c_VOCs_in_Groundwater_TCE.mxd





Explanation

PCE

<5.00 µg/L

>5.01 µg/L

Subbasin boundary

Notes:
1) Data compiled from California Water Boards. November 2018: https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp

Approximate Scale in Miles: 0, 5, 10, 20

Approximate Scale in Kilometers: 0, 5, 10, 20

Volatile Organic Compounds in Groundwater

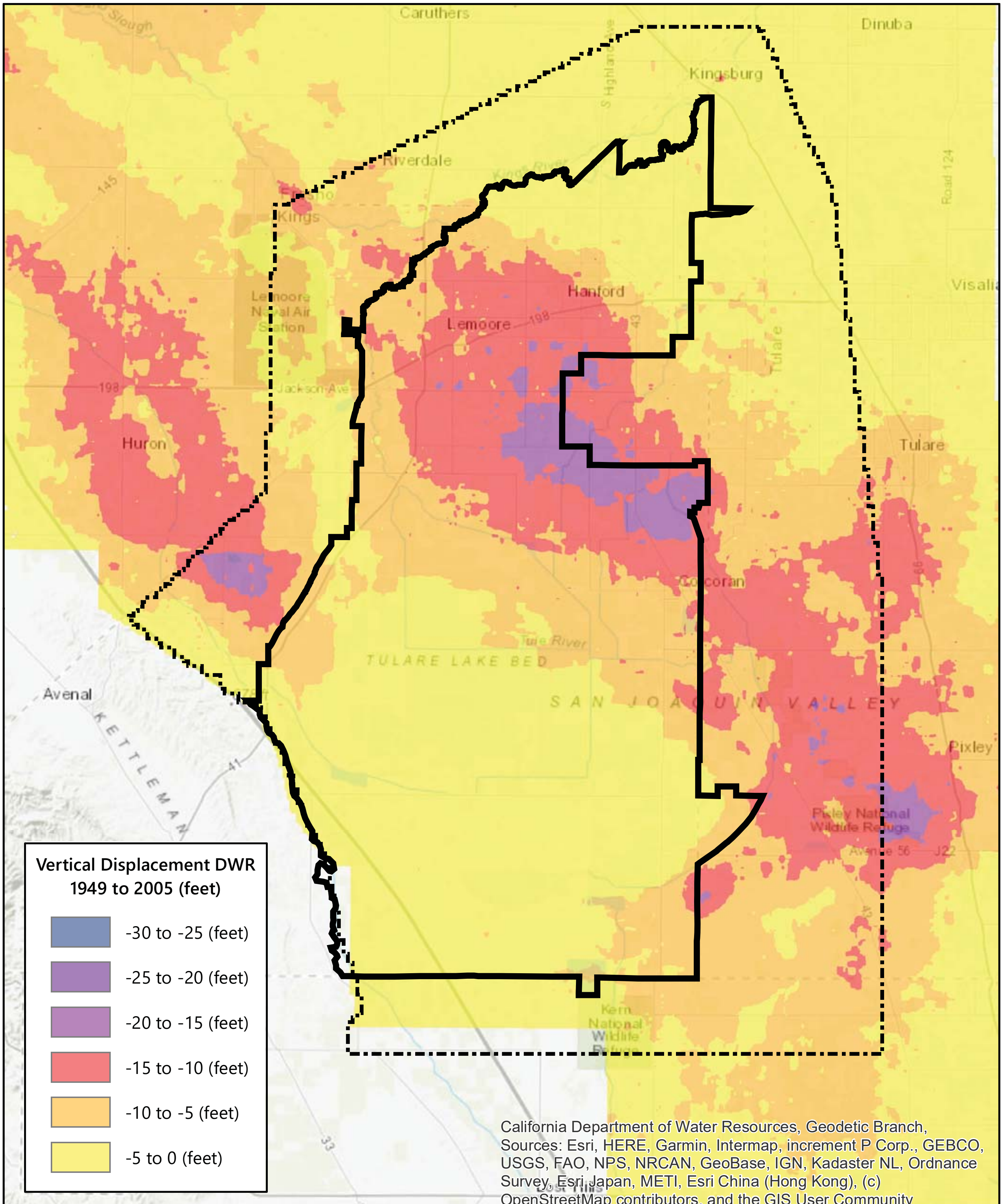
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: SCM | Date: 1/9/2020 | Project No.: FR16181220

wood.

Figure **3-33d**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR16181220\gis\maps\2019\Basin_Setting_fig3-33d_VOCs_in_Groundwater_PCE.mxd



Explanation

Study Area

Subbasin boundary

Miles: 0 2 4 8

Kilometers: 0 2.5 5 10

Notes:

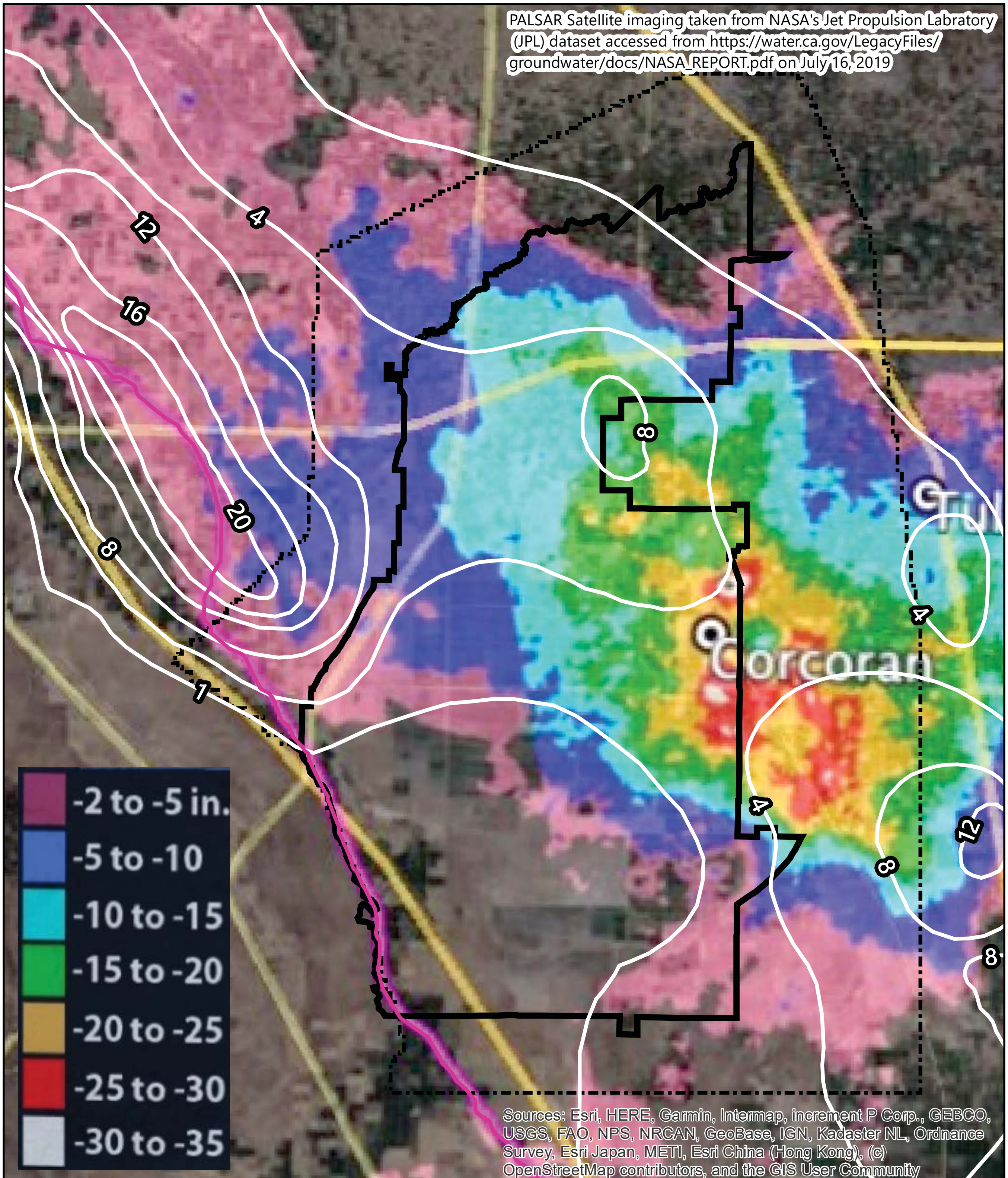
1. Vertical Displacement dataset taken from California Department of Water Resources (DWR) https://sgma.water.ca.gov/webgis. Accessed July 9, 2019.

Historical Subsidence of the Tulare Lake Subbasin

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/15/2019	Project No.: FR18161220
		Figure **3-34**

Date: 11/15/2019 Printed by: shaina.price
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-34_HistoricalSubsidenceTLSB.mxd



Explanation

Study Area

Subbasin boundary

Edmund G. Brown California Aqueduct

White line shows historical subsidence data from 1926-1970 (ft.)

Miles: 0 2 4 8

Kilometers: 0 2.5 5 10

N

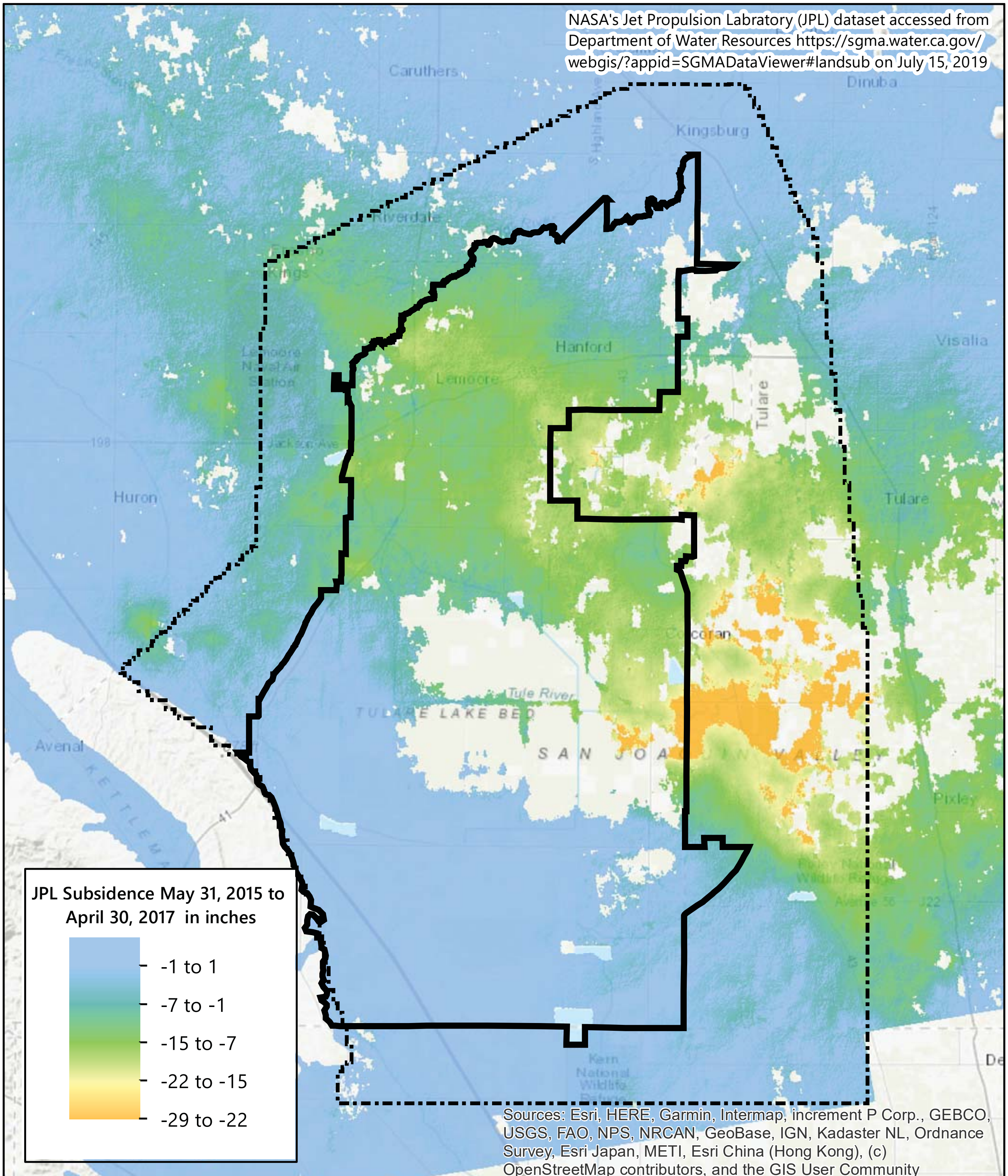
Subsidence in the Tulare Lake Subbasin 2007 to 2010

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: EMC	Date: 11/7/2019	Project No.: FR18161220
		Figure **3-35a**

Date: 11/7/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-35a_Subsidence2007-2010_8x11.mxd



Explanation

- Study Area
- Subbasin boundary

Miles: 0 2 4 8
Kilometers: 0 2.5 5 10

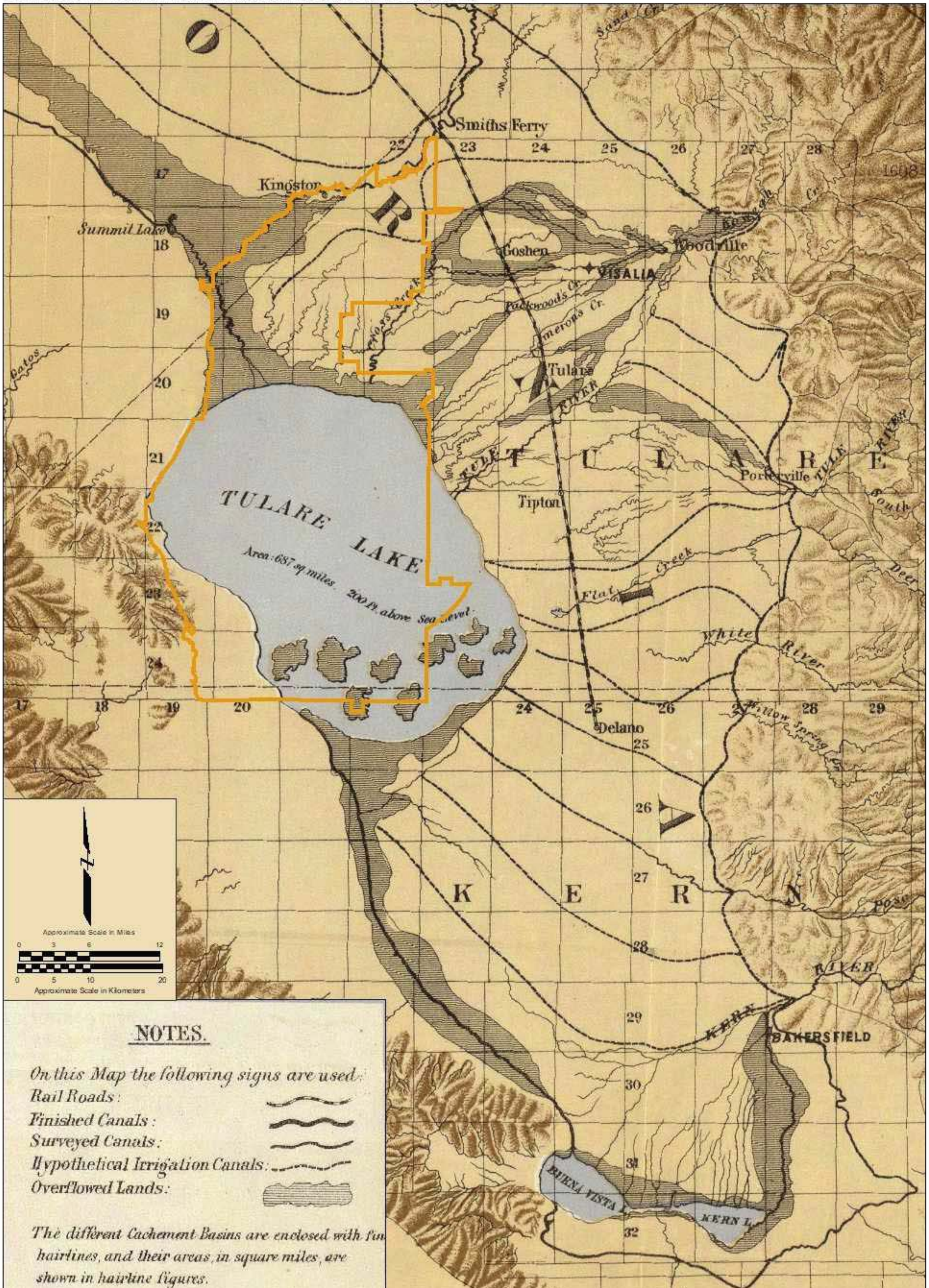
Subsidence in the Tulare Lake Subbasin 2015 to 2017

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/7/2019	Project No.: FR18161220
		Figure **3-35b**

Date: 11/7/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting\8.5x11_fig3-35b_Subsidence2015-2017_8x11.mxd

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-36_Historic Surface Water Systems San Joaquin Valley.mxd



Explanation

Boundary of Tulare Lake Subbasin

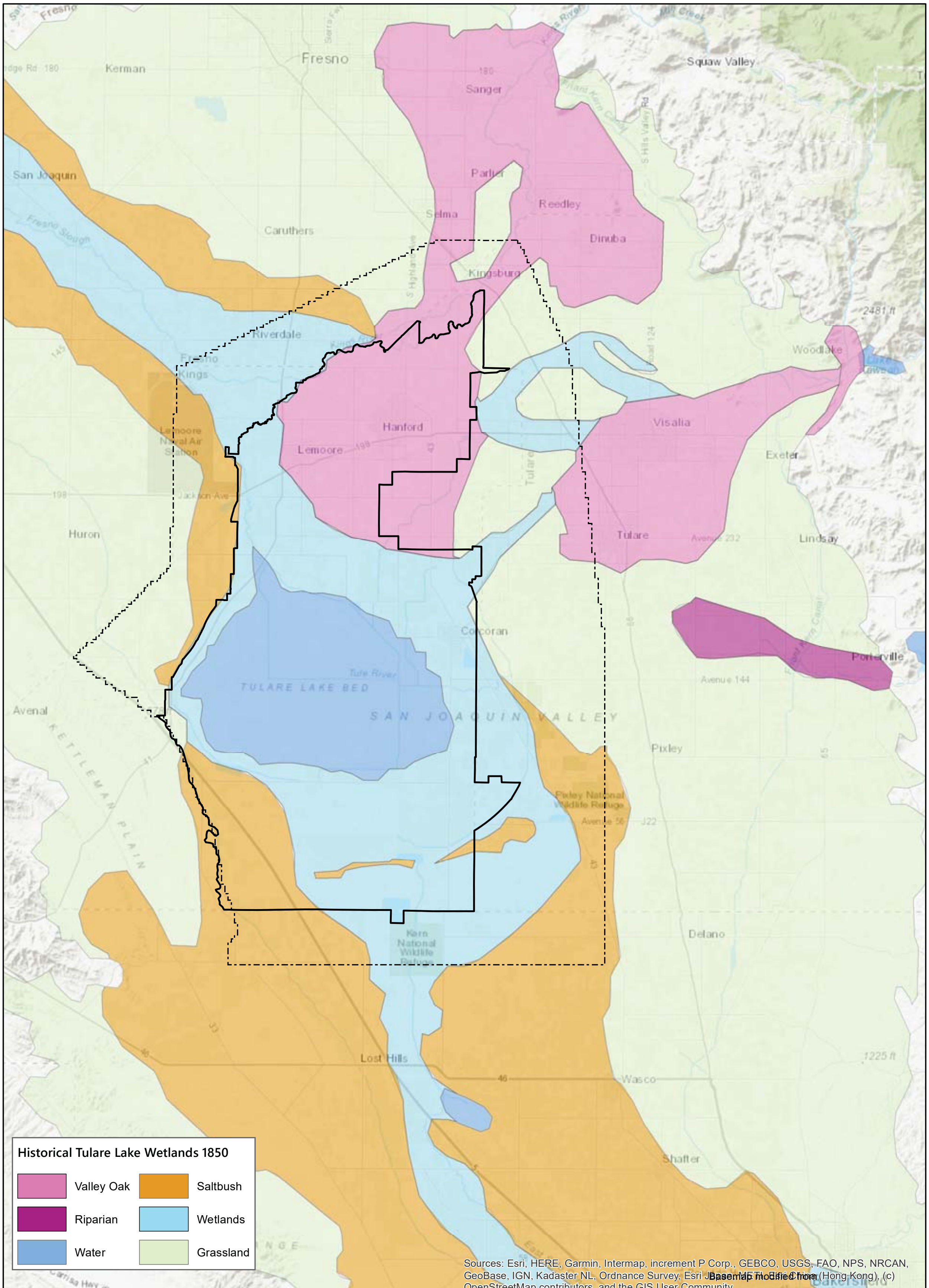
Note:

Adapted from "Map of the San Joaquin, Sacramento and Tulare Valleys, State of California, Prepared Under The Direction of the Board of Commissioners on Irrigation, 1873"

Historic Drainage System
Tulare Lake Basin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: GLK	Date: 1/9/2020	Project No.: FR16181220
		Figure **3-36**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-37_HistoricalTulareLakeWetlands.mxd



Explanation

Study area

Subbasin boundary

Miles: 0, 3.5, 7, 14

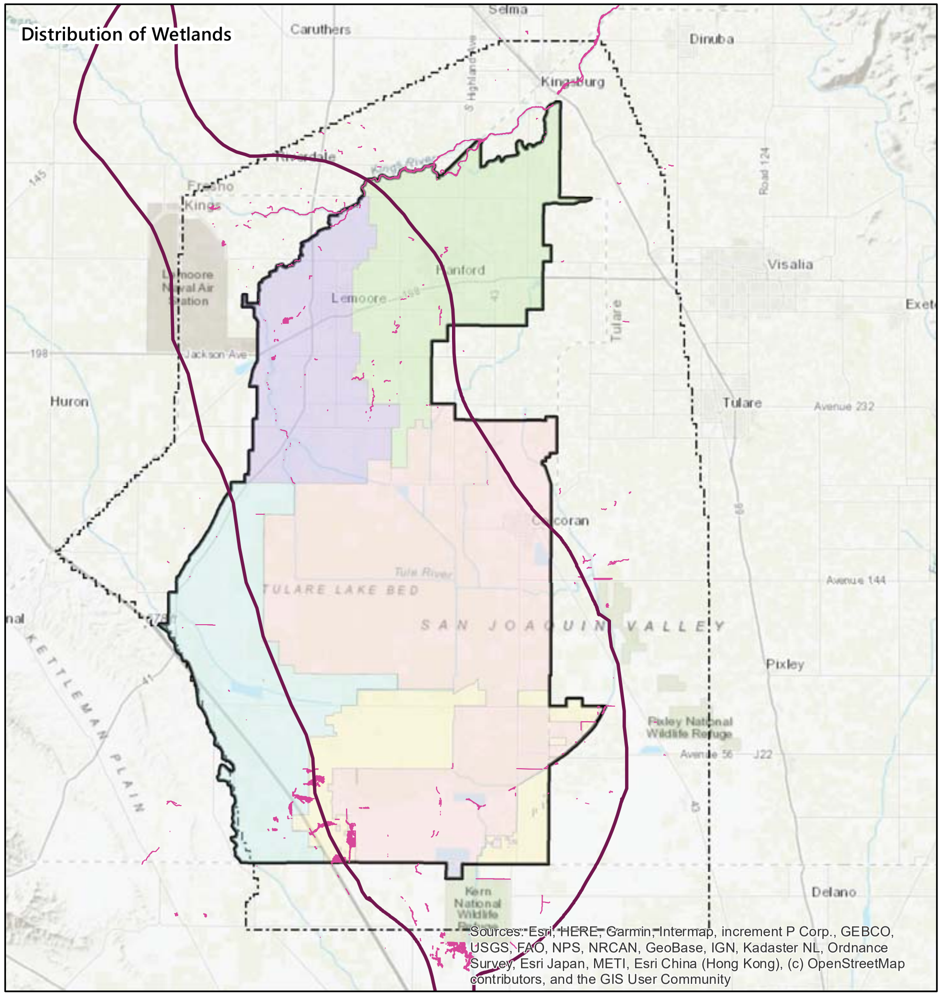
Kilometers: 0, 5, 10, 20

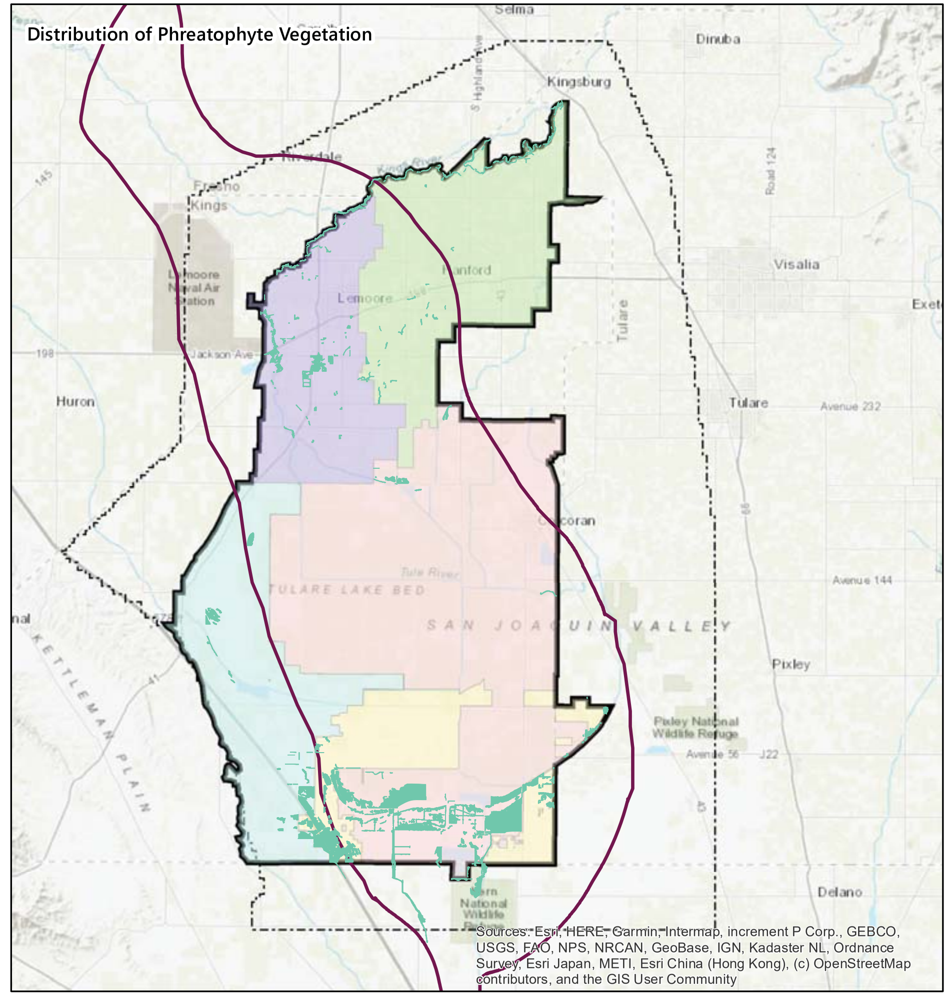
Notes:
figure adapted from http://www.tularebasinwildlifepartners.org/history.html. July 16, 2019

Historical Wetlands Distribution
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 1/9/2020 | Project No.: FR18161220

Figure **3-37**





Explanation

- Extent of A-Clay
- Subbasin boundary
- Study area
- California Natural Resources Agency wetlands
- California Natural Resources Agency phreatophyte vegetation

Groundwater Sustainability Agencies (GSAs)

- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

Miles: 0 4 8 16
Kilometers: 0 5 10 20

Notes:
1) California Natural Resources Agency data taken from http://resources.ca.gov/wetlands/inventories/inventories.html, accessed November 2018.

Distribution of Wetlands and Phreatophyte Vegetation

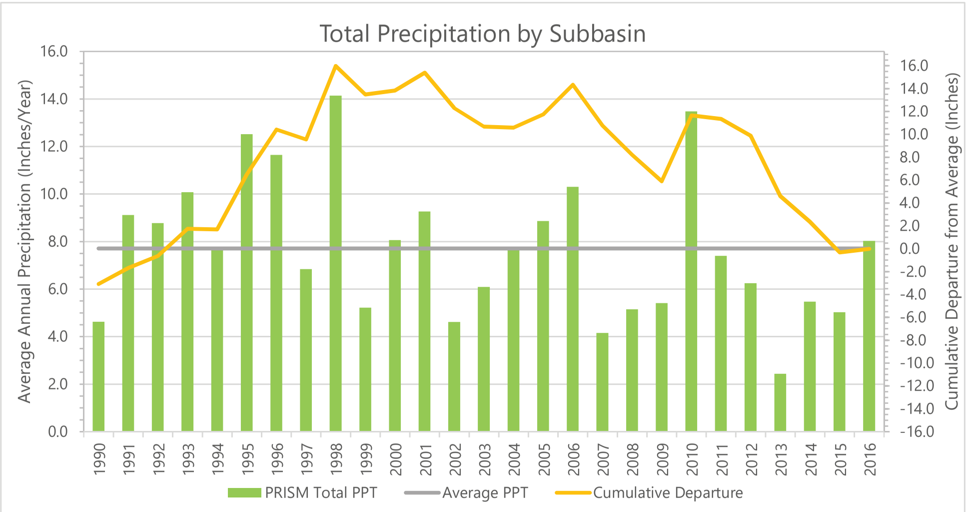
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

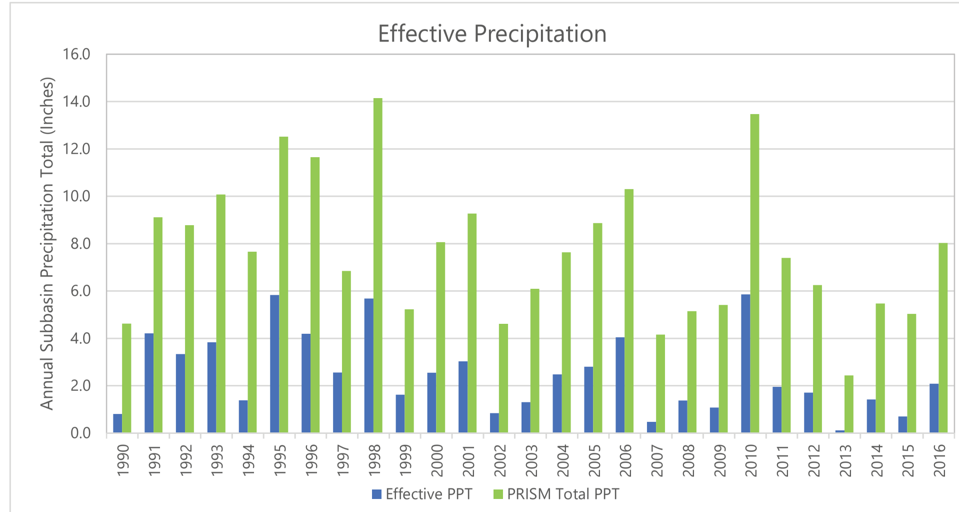
By: EMC | Date: 1/9/2020 | Project No.: FR18161220

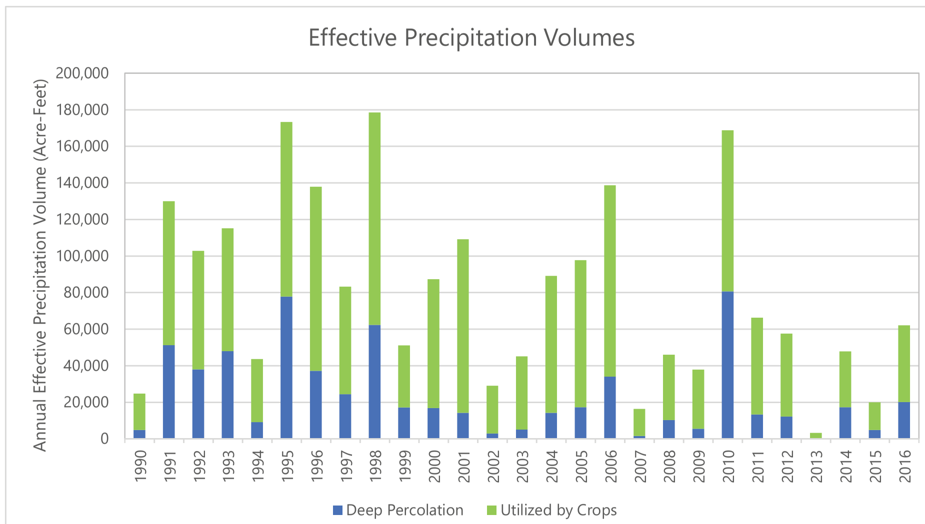
Figure **3-38**

Date: 1/9/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\Basin_Setting_fig3-38_DistributionofWetlandsPhreatophyteVeg.mxd

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-39_3-40_120619.xlsmFigure 3-39 12/9/2019







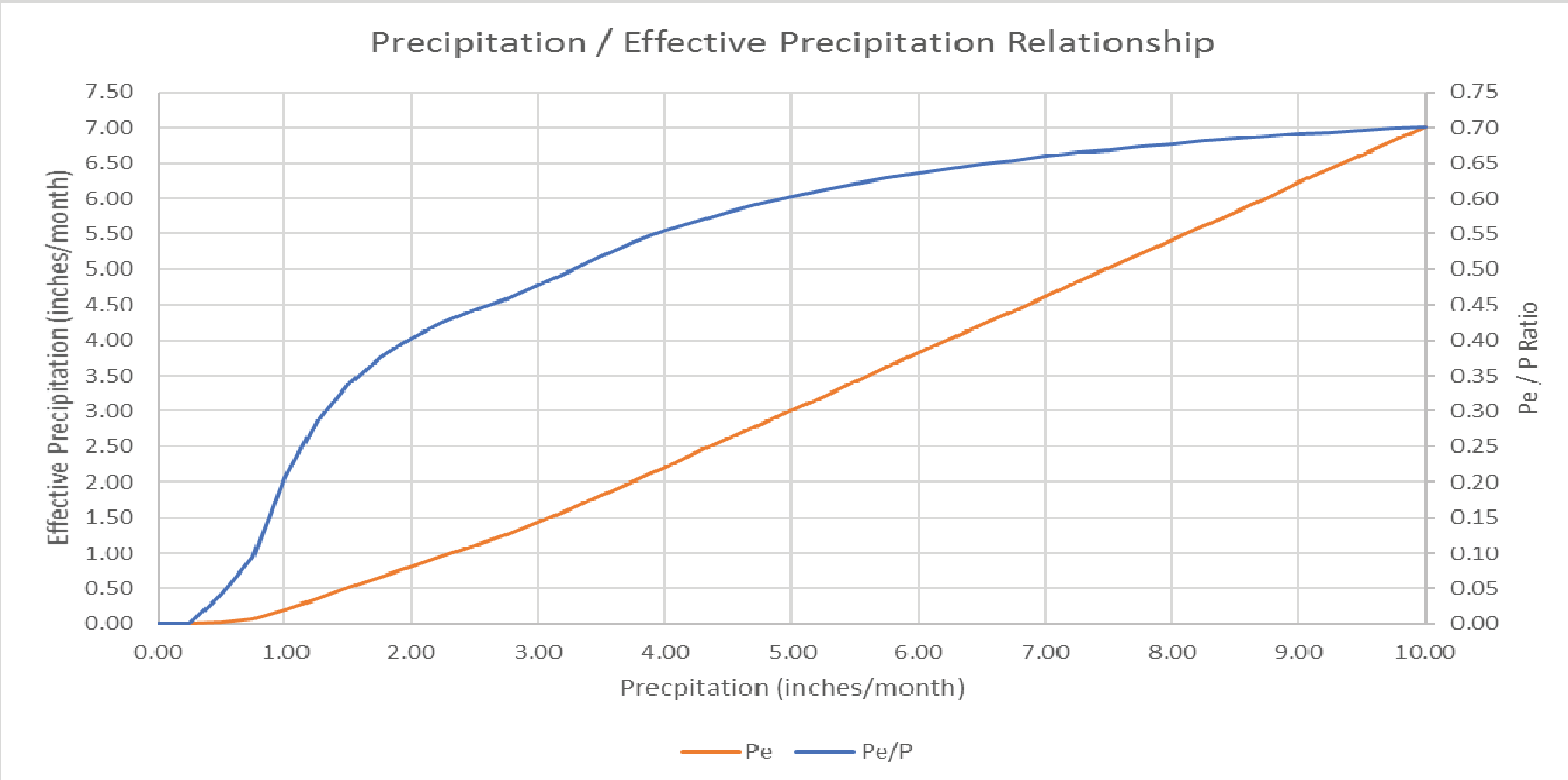
Notes:
1. PPT = precipitation
2. Climate data accessed from Parameter-elevation Regressions on Independent Slopes Model (PRISM) Climate group.. http://www.prism.oregonstate.edu/ Accessed November 2018

Annual Precipitation, Effective Precipitation, and Effective Precipitation Volumes

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb | Date: 11/20/2019 | Project No.: FR18161220

Figure: 3-39



Notes:

Modified from:
United Nations Food and Agriculture Organization (FAO)
FAO 56,Chapter 3 Table 6
Precipitation (P) and Effective Precipitation (Pe) in inches/month

Precipitation Versus
Effective Precipitation
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

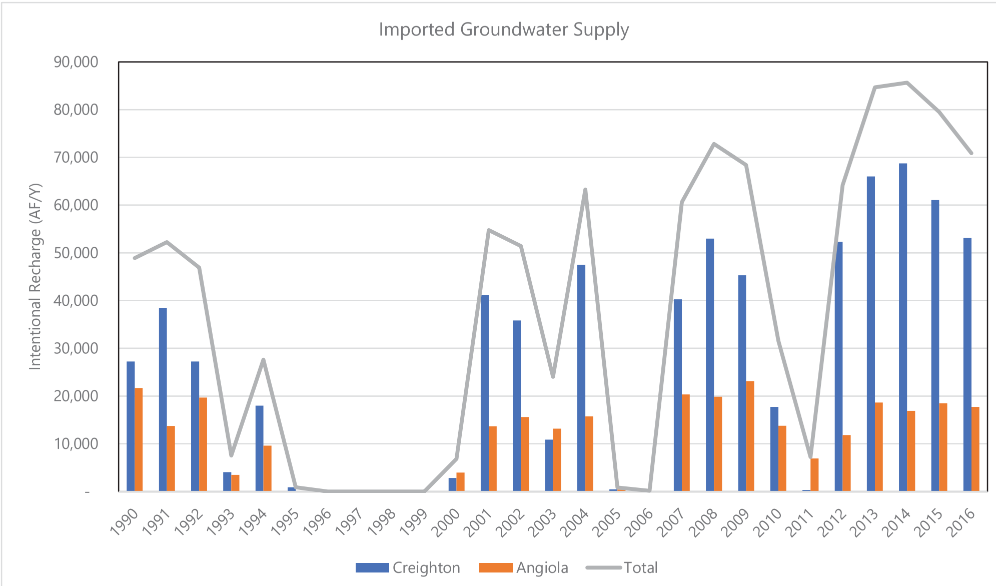
By: GLK	Date: 11/20/2018	Project No.: FR18161220
		Figure 3-40

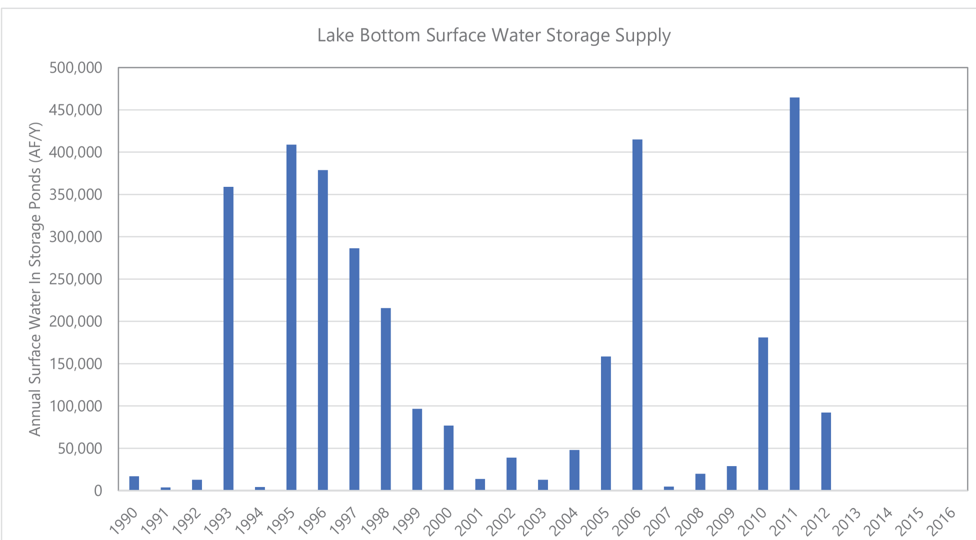
I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-29_3-53_120619.xlsmFigure 3-41 1/8/2020

Notes:
1. AF/Y = acre-feet per year

Surface Water Diversions
1990 to 2016
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2018	Project No.: FR18161220
		Figure: 3-41



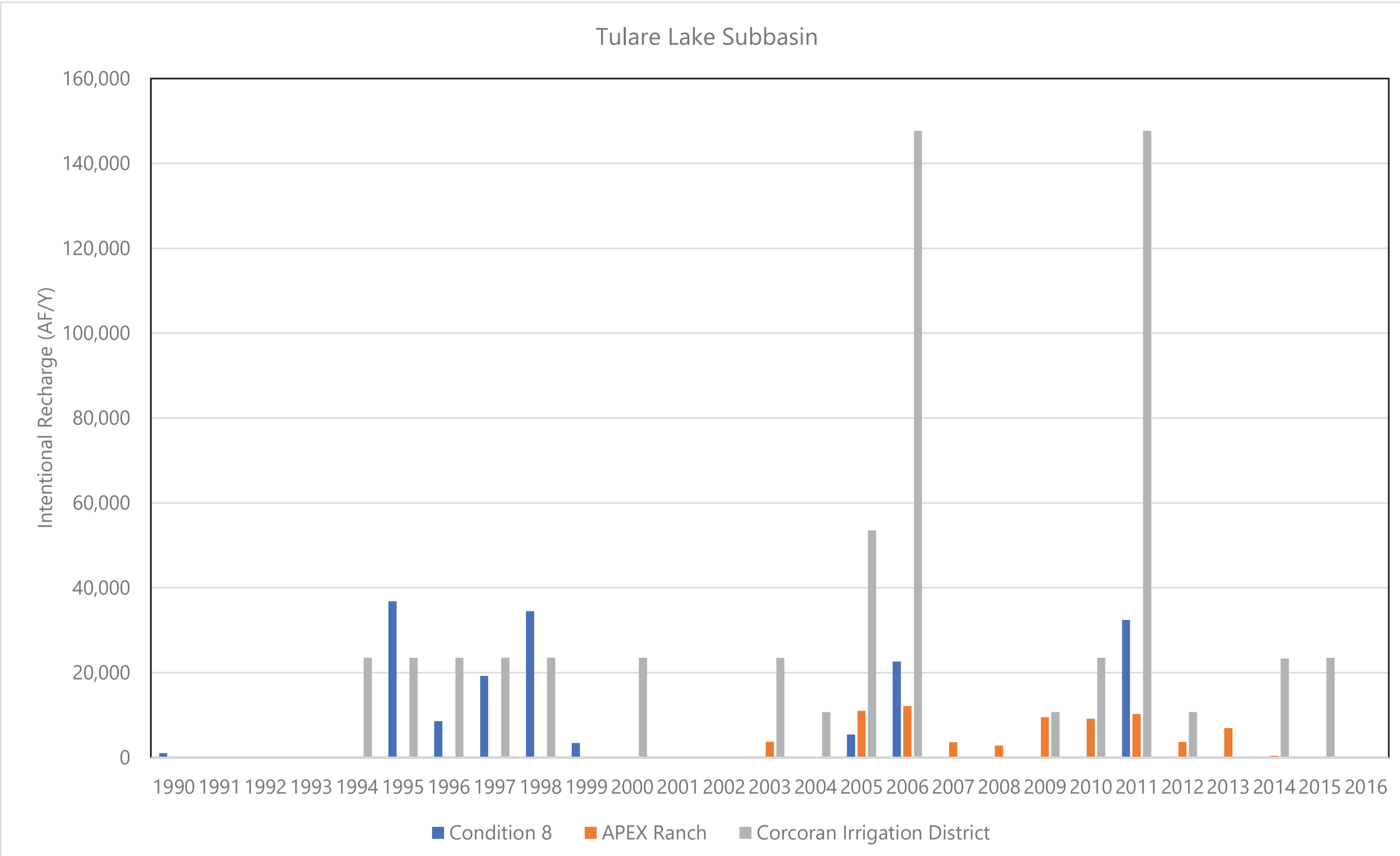


Notes:
1. Only EL Rico and TCWA GSAs import groundwater into the Tulare Lake Subbasin.
2. Only EL Rico and TCWA GSAs have significant surface water storage facilities.
3. Mid-Kings River GSA, South Fork Kings GSA, and Southwest Kings GSA do not have significant surface water storage facilities.
4. AF/Y = acre-feet per year

Lake Bottom Surface Water Storage and Imported Groundwater Supplies 1990-2016

Tulare Lake Subbasin Groundwater sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **3-42**



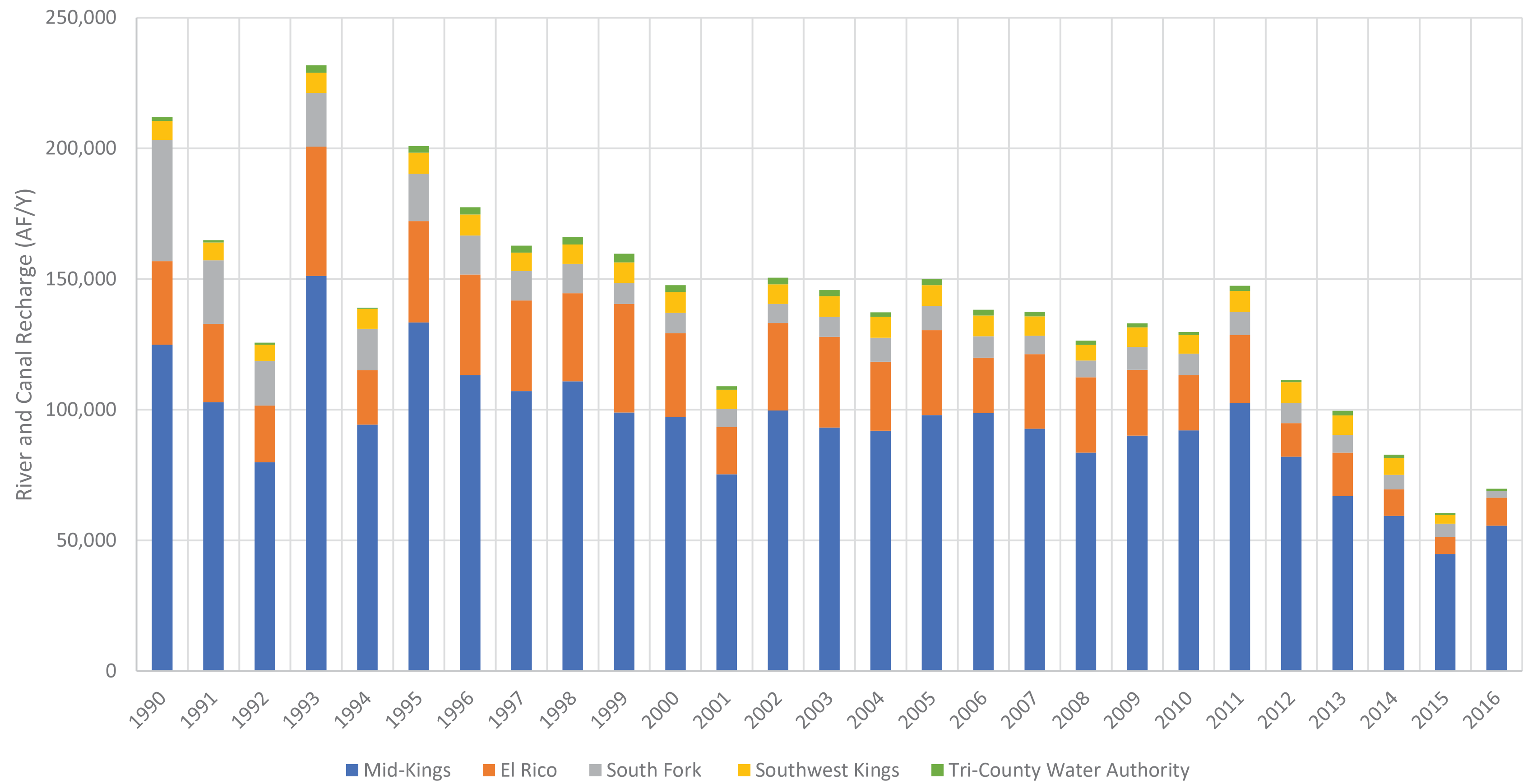
Notes:
1. The APEX Ranch recharge facility did not begin operation until 2002
Condition 8 water is only available in flood years
Corcoran Irrigation District (CID) recharge occurs in most years using only 1 or 2 ponds total 440 acres.
In flood years CID may recharge using 2,760 acres of ponds
2. AF/Y = acre-feet per year

Tulare Lake Subbasin
Intentional Recharge
1990 to 2016

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: GLK	Date: 11/20/2018	Project No.: FR18161220
		Figure 3-43

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-29_3-53_120619Figure 3-44 12/11/2019

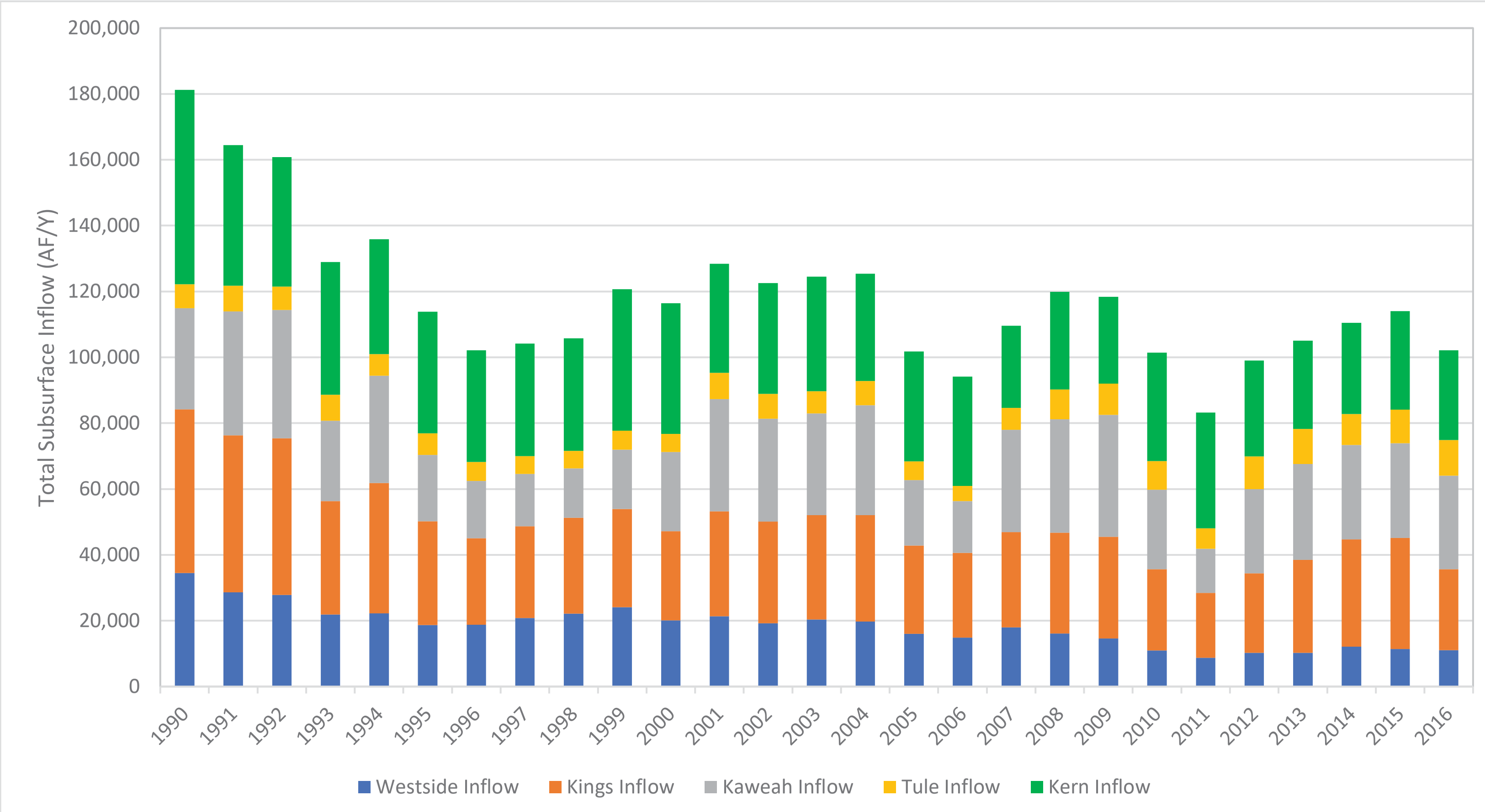


Notes:
1. AF/Y = acre-feet per year

Tulare Lake Subbasin
River and Canal Recharge
1990 to 2016
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure 3-44

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-29_3-53_120619Figure 3-45 12/11/2019

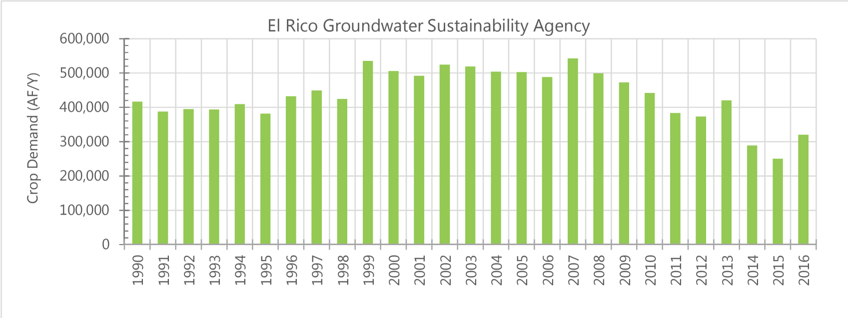


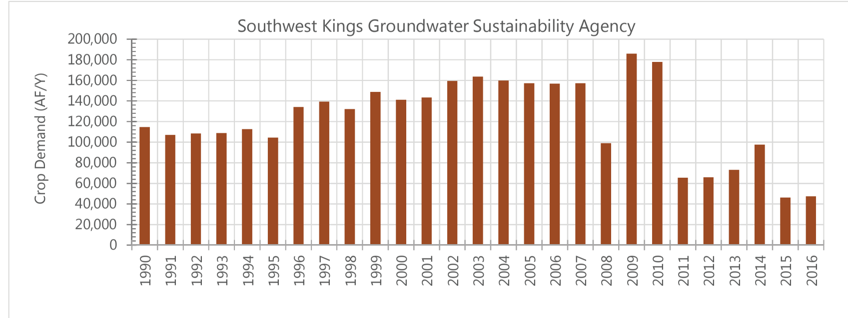
Notes:
1. AF/Y = acre-feet per year

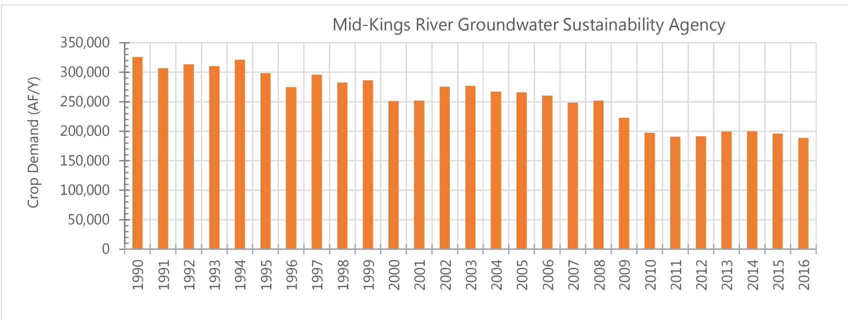
Tulare Lake Subbasin
Total Subsurface Inflows
1990 to 2016
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

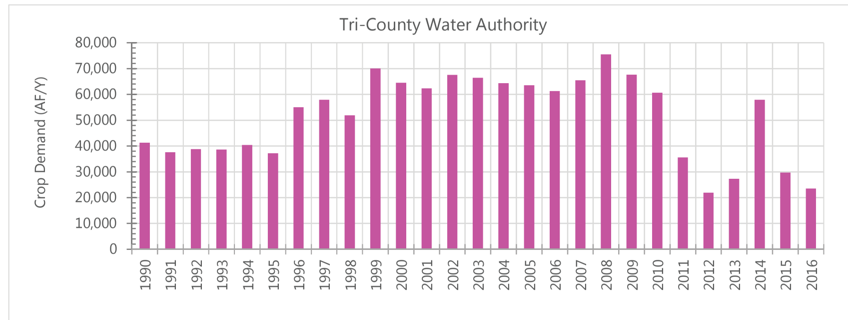
By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure 3-45

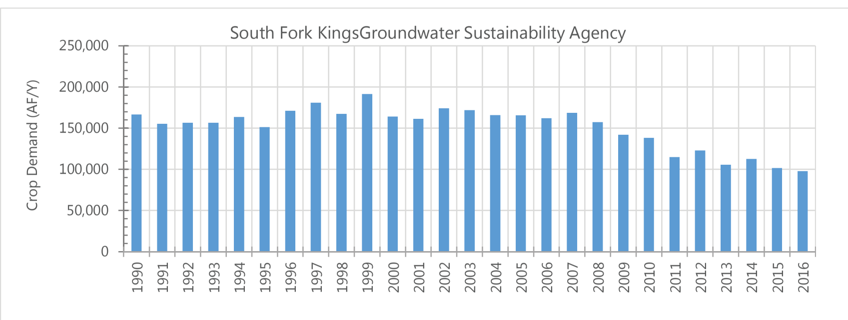
I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-29_3-53_120619.xlsmFigure 3-46 1/8/2020

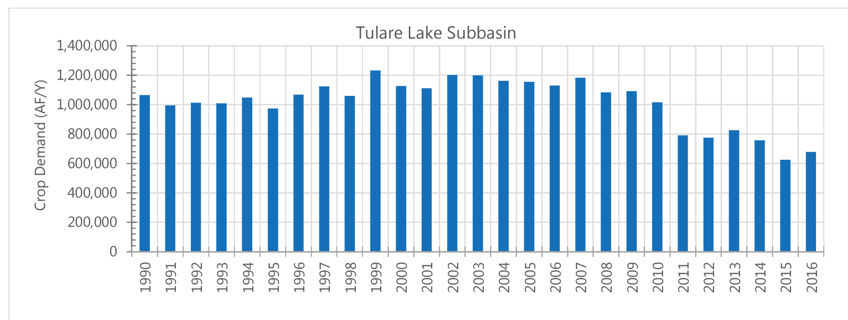










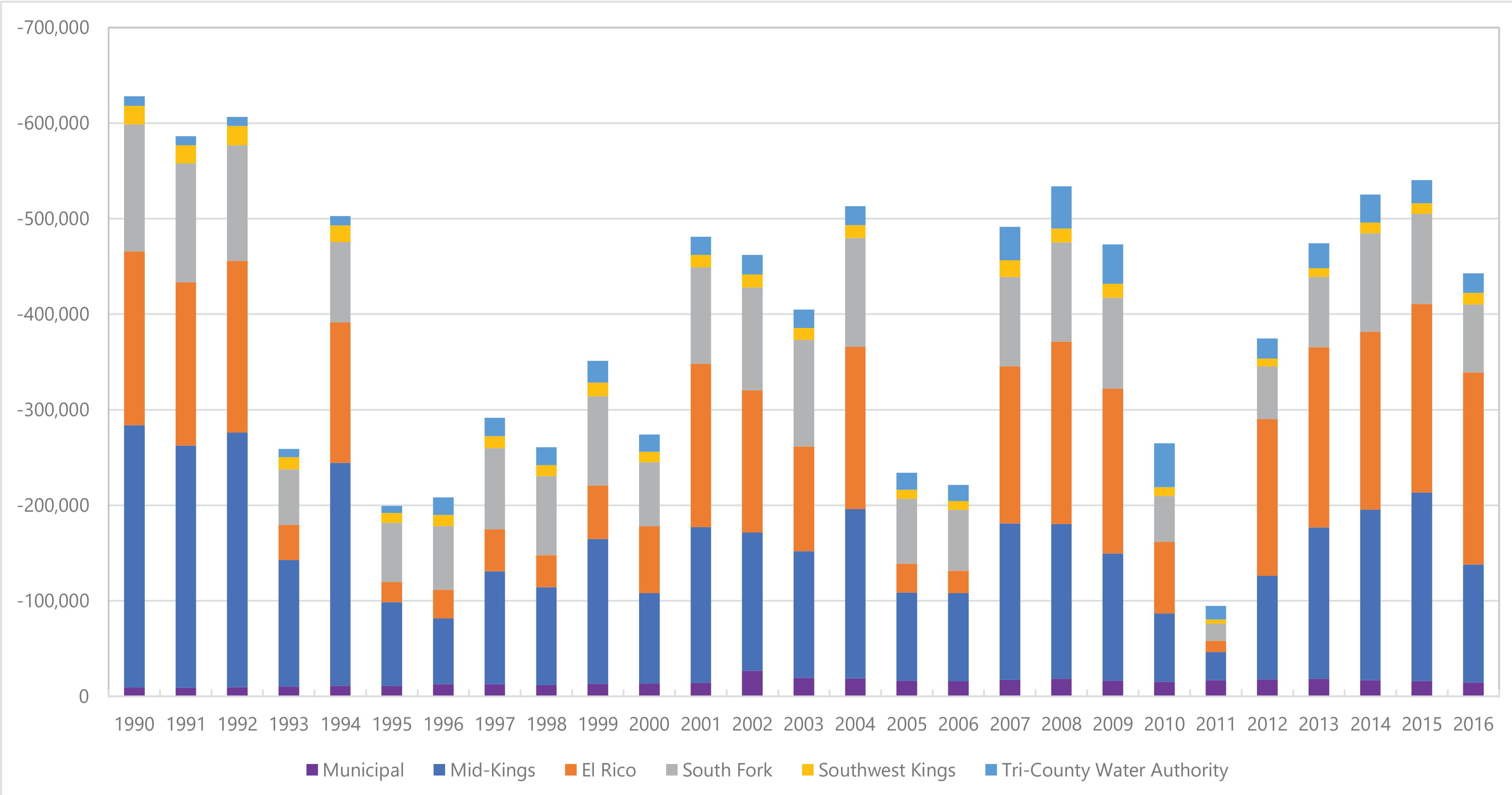


Notes:
1. AF/Y = acre-feet per year

Irrigated Crop Demand
1990 to 2016
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220

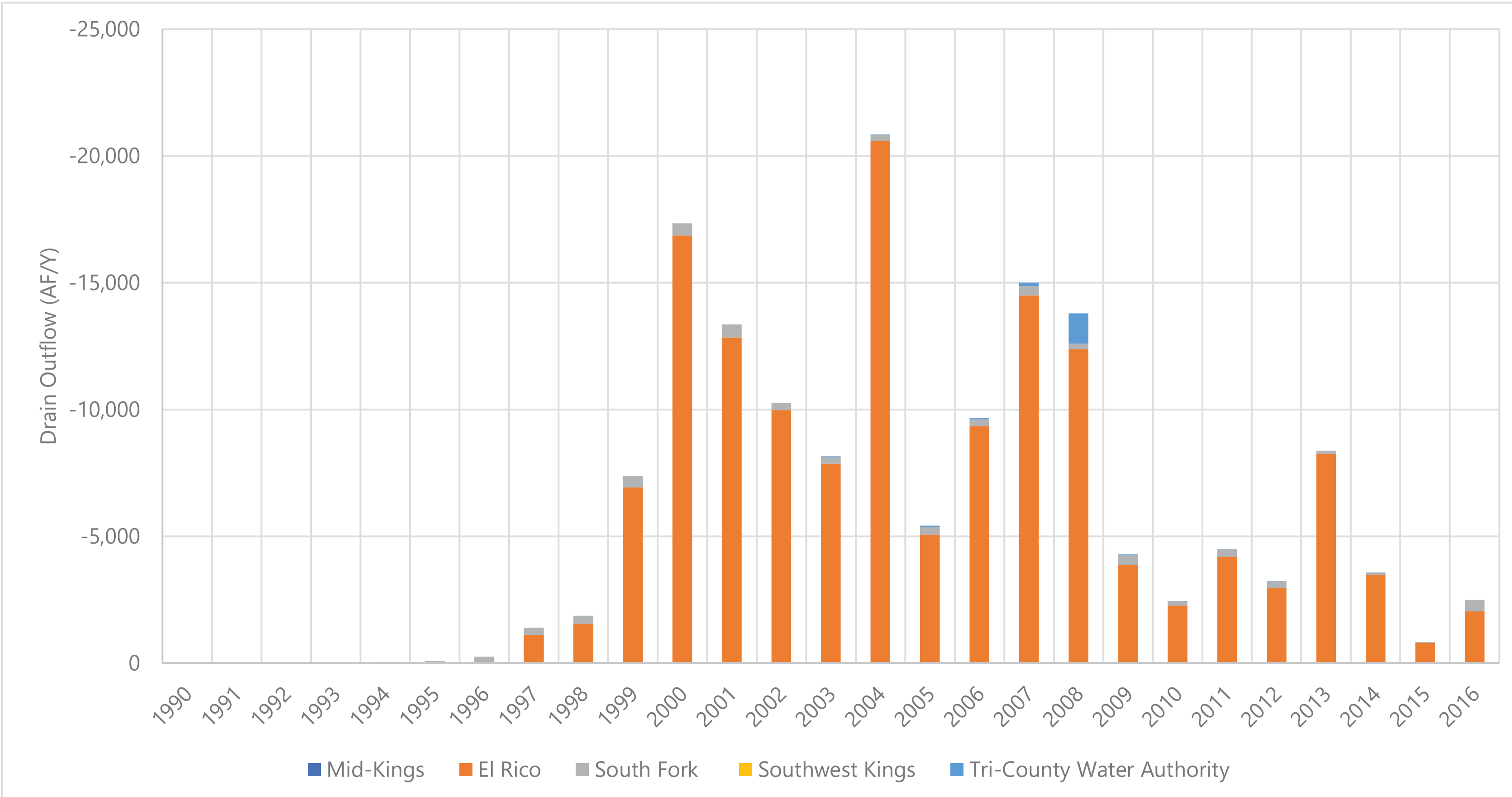
Figure: 3-46



Notes:
1. AF/Y = acre-feet per year
2. TCWA = Tri-County Water Authority

Agricultural and Municipal Pumping
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure 3-47

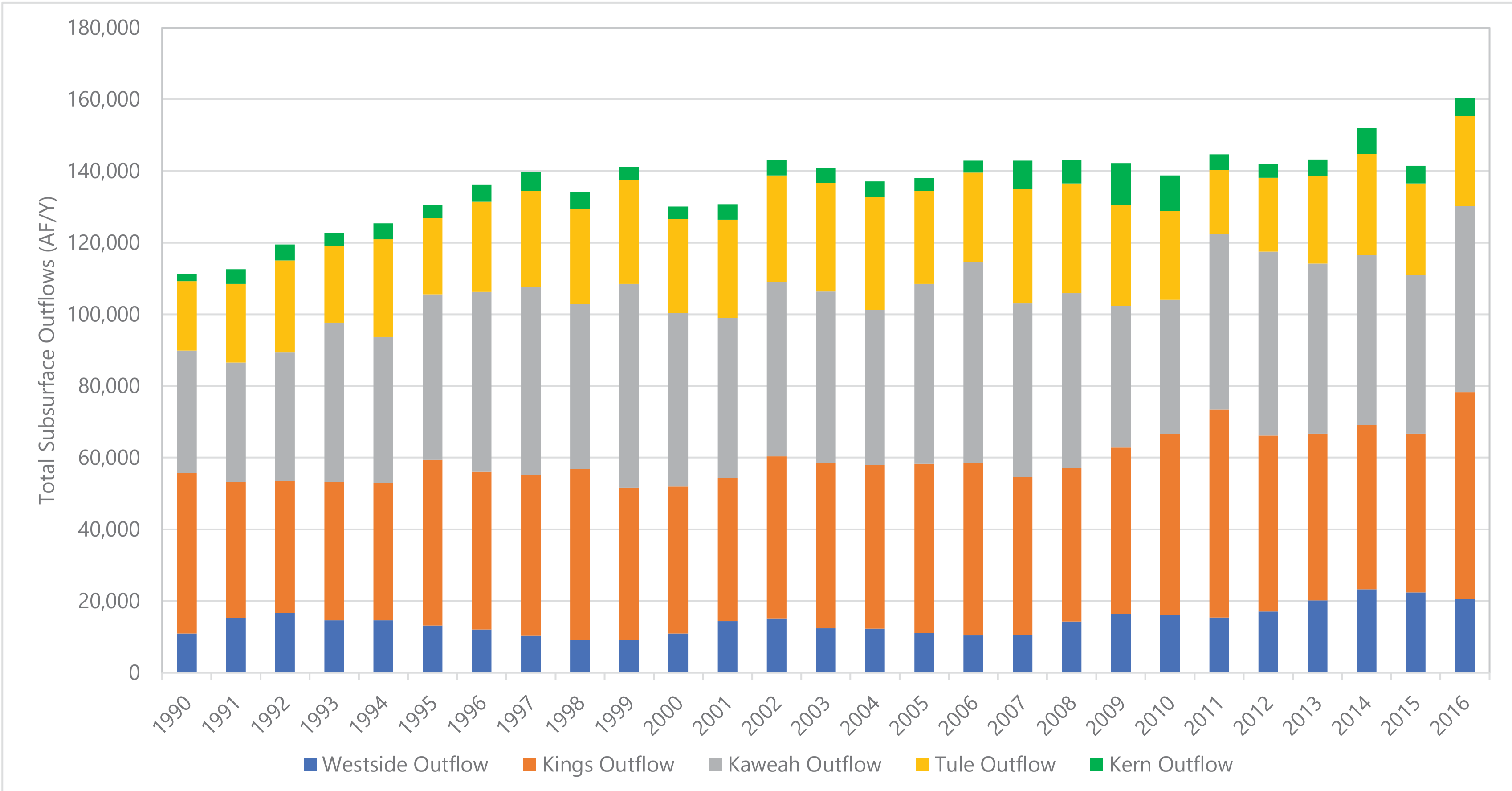


Notes:
1. Mid-Kings River GSA, South Fork Kings GSA, and Southwest Kings GSA do not have agricultural drain outflows.
2. AF/Y = acre-feet per year

Tulare Lake Subbasin Agricultural Drainage Outflows 1990 to 2016

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure 3-48

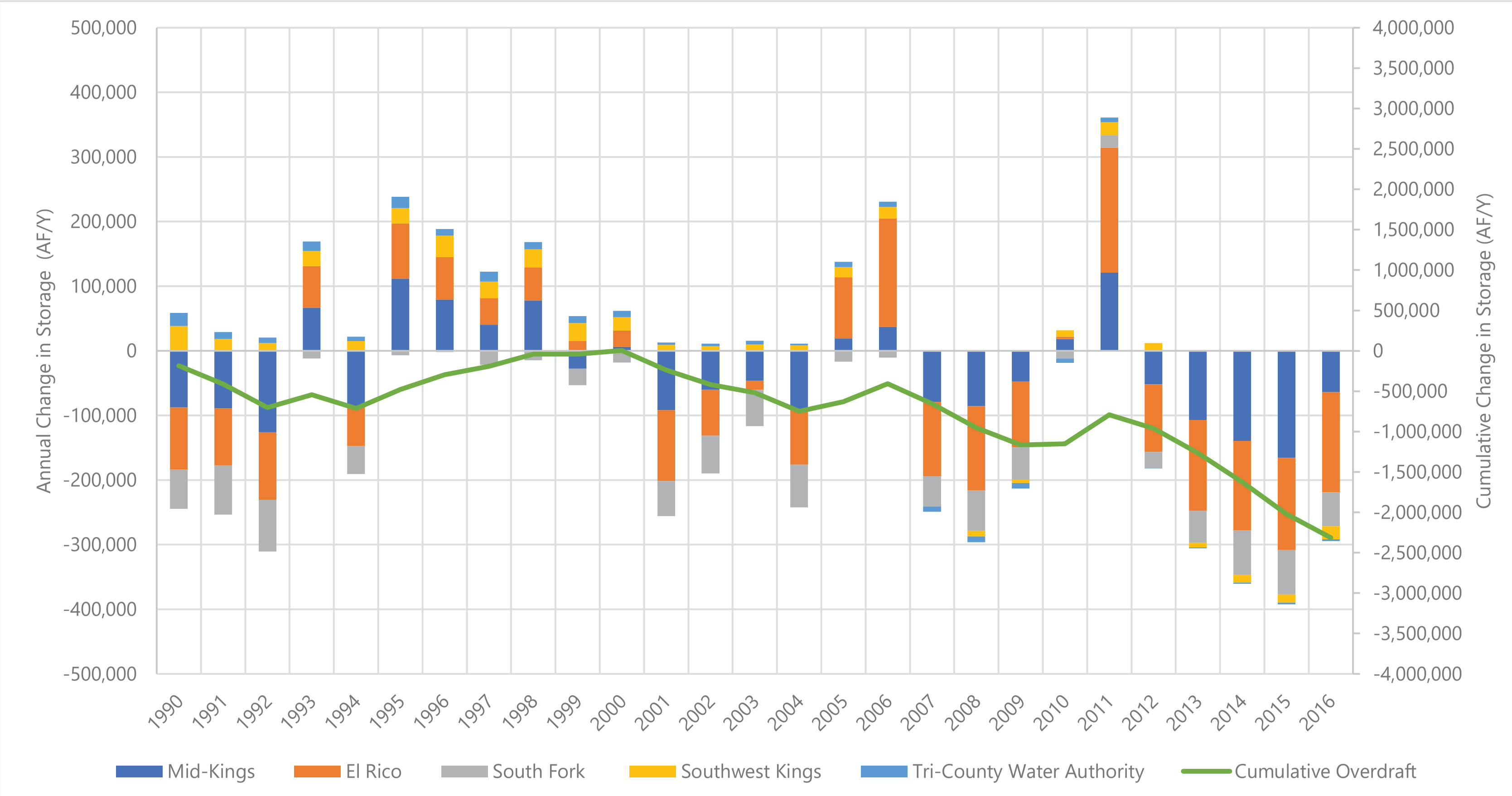


Notes:
1. AF/Y = acre-feet per year

Tulare Lake Subbasin
Total Subsurface Outflows
1990 to 2016
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure 3-49

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-29_3-53_120619Figure 3-50a 12/11/2019

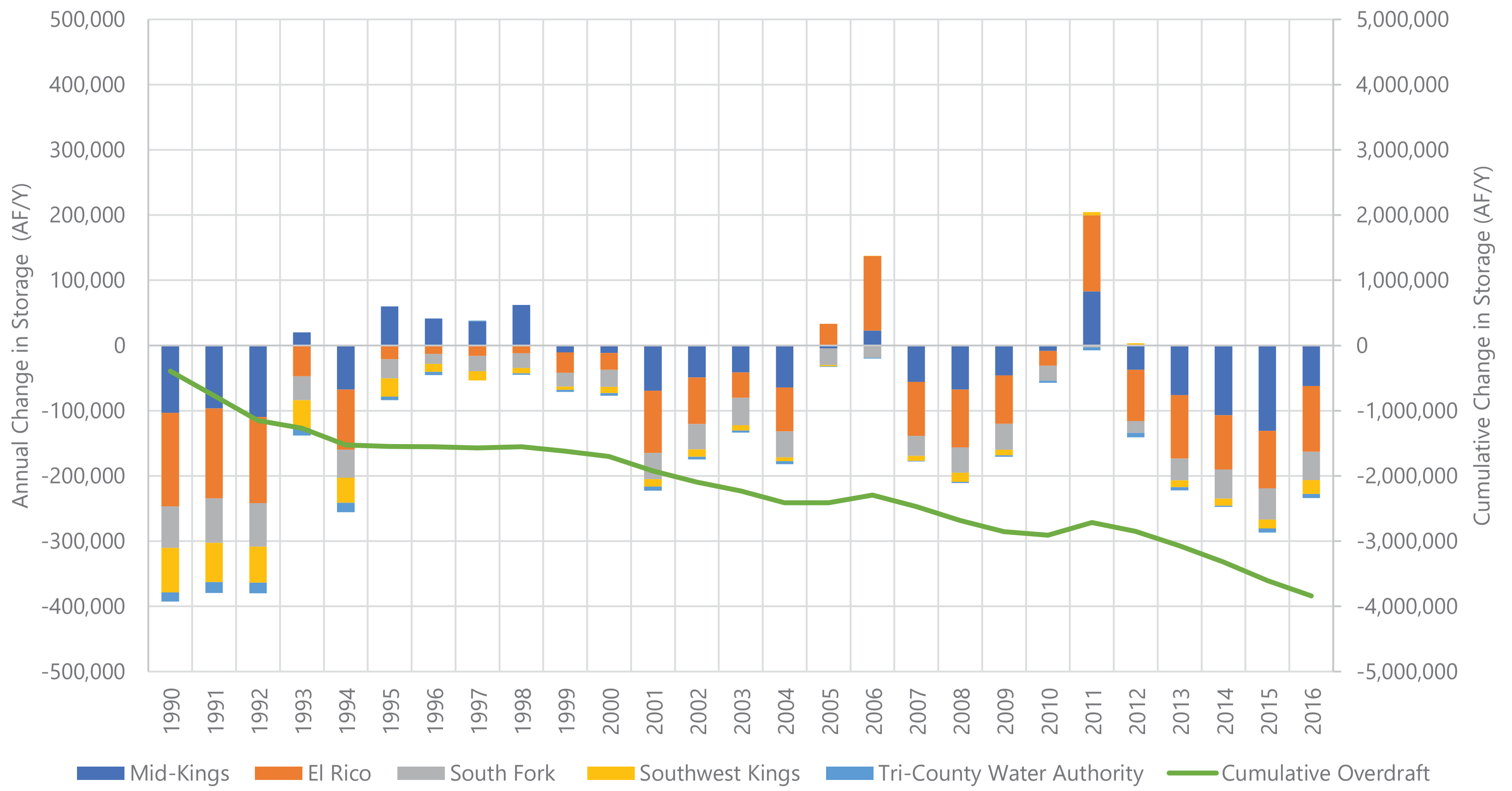


Notes:
1. AF/Y = acre-feet per year

Tulare Lake Subbasin
Total Overdraft
1990 to 2016
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure 3-50a

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-29_3-53_120619Figure 3-50b 12/11/2019

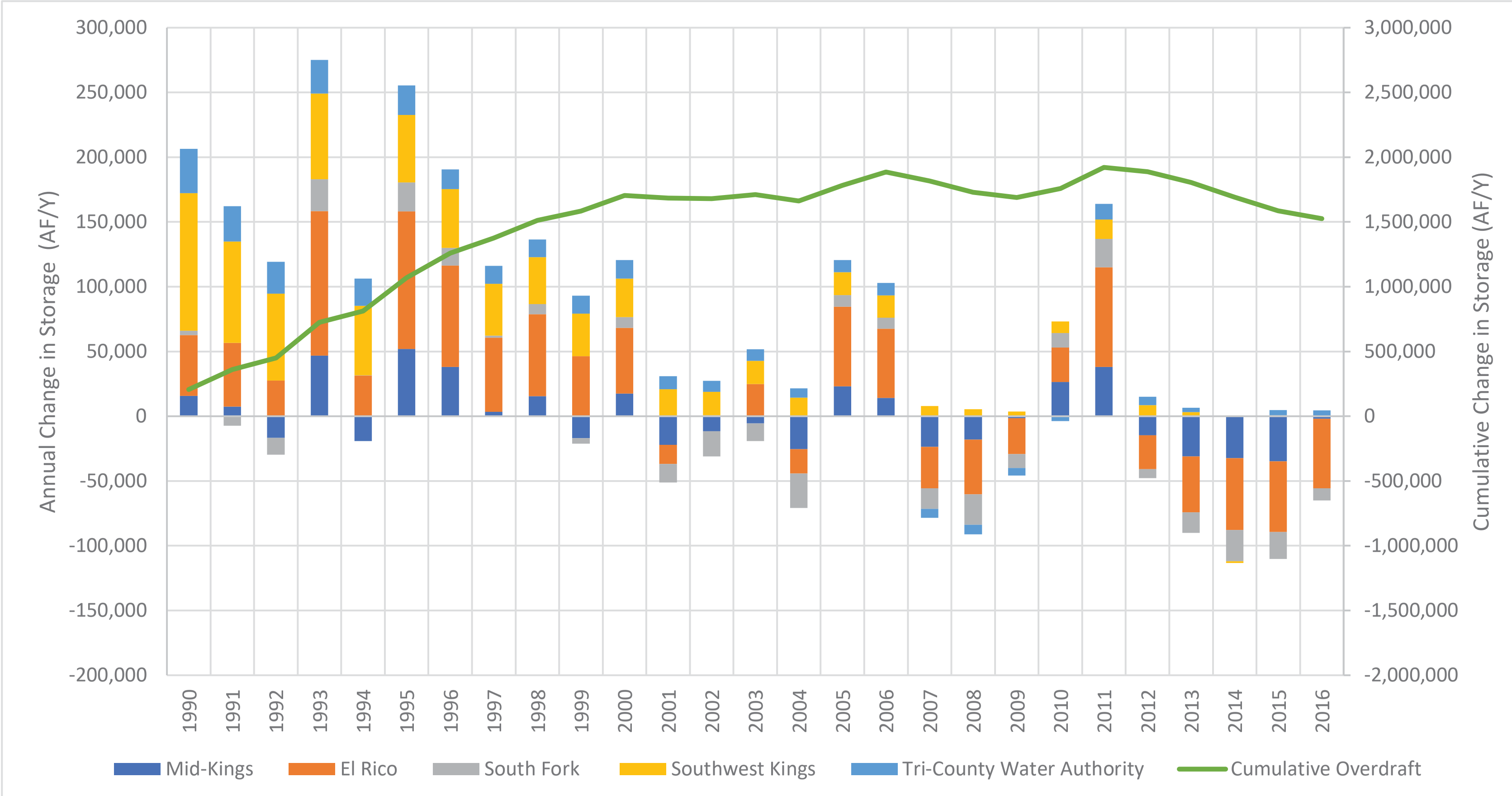


Notes:
1. AF/Y = acre-feet per year

Tulare Lake Subbasin
Upper Aquifer Overdraft
1990 to 2016

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure 3-50b



Notes:
1. AF/Y = acre-feet per year

Tulare Lake Subbasin
Lower Aquifer Overdraft
1990 to 2016

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure 3-50c

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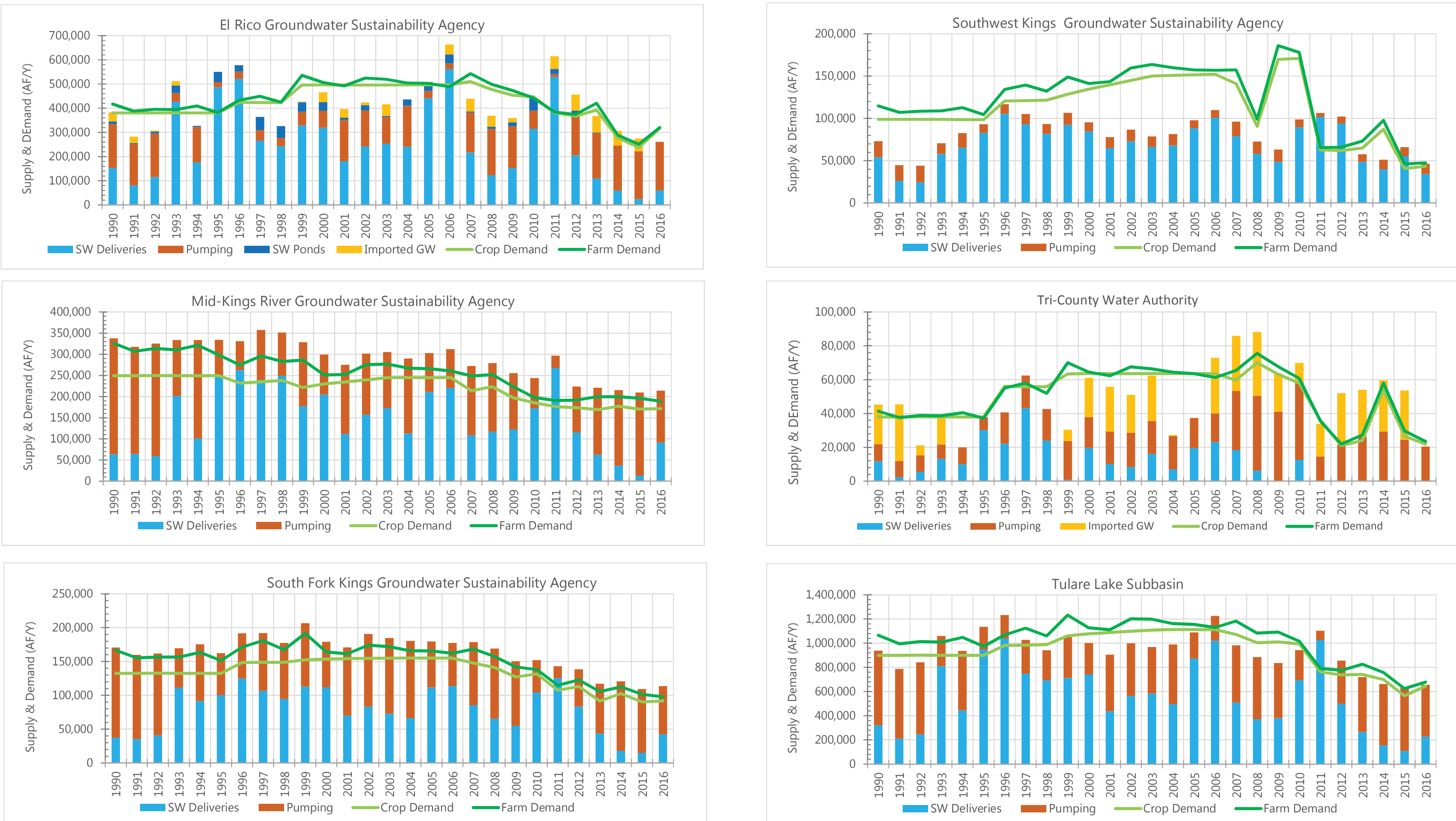


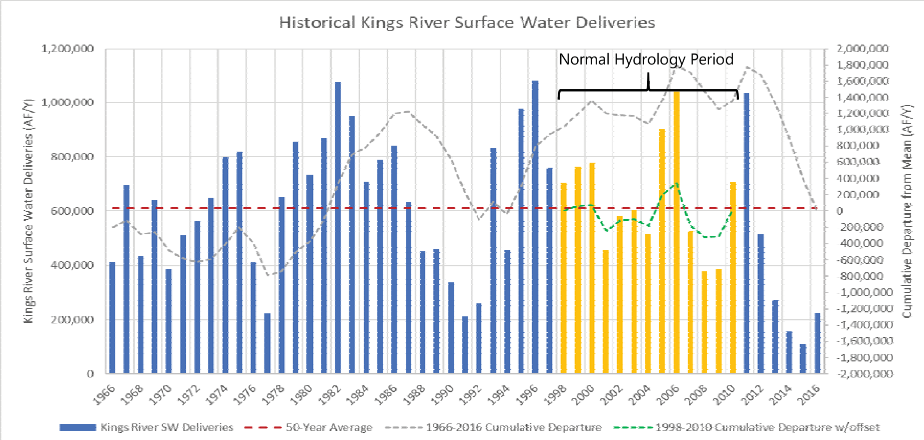
Notes:
1. AF/Y = acre-feet per year

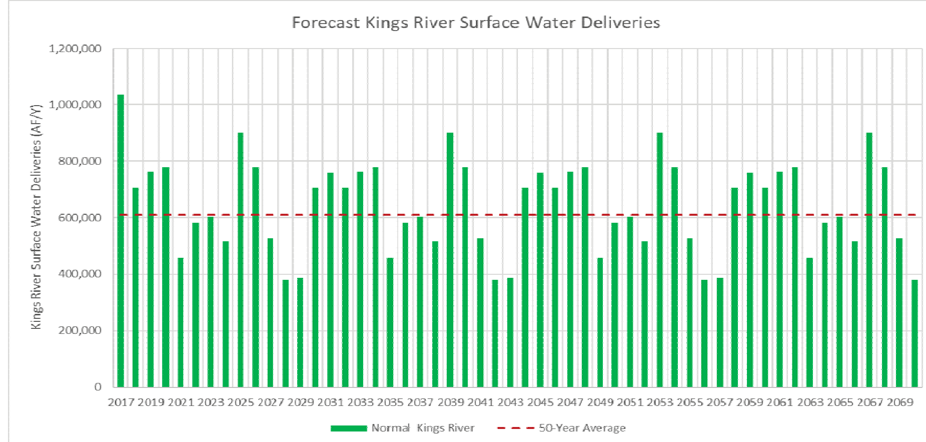
Water Supply and Demand
1990 to 2016
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

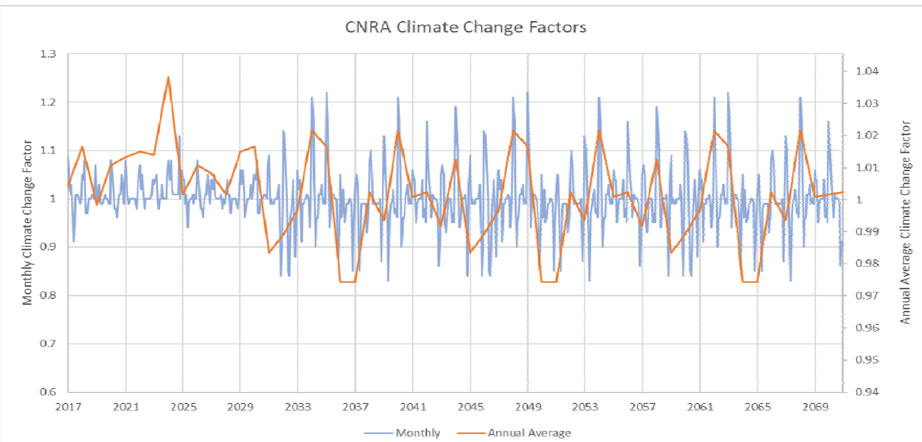
By: dmb	Date: 11/20/2019	Project No.: FR18161220

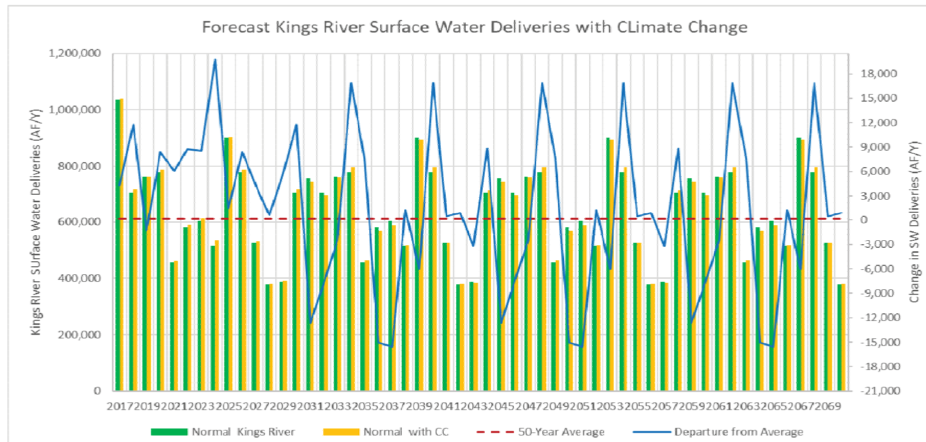
Figure: 3-51

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\GSPFigures 3-29_3-53_120619.xlsmFigure 3-52 1/8/2020







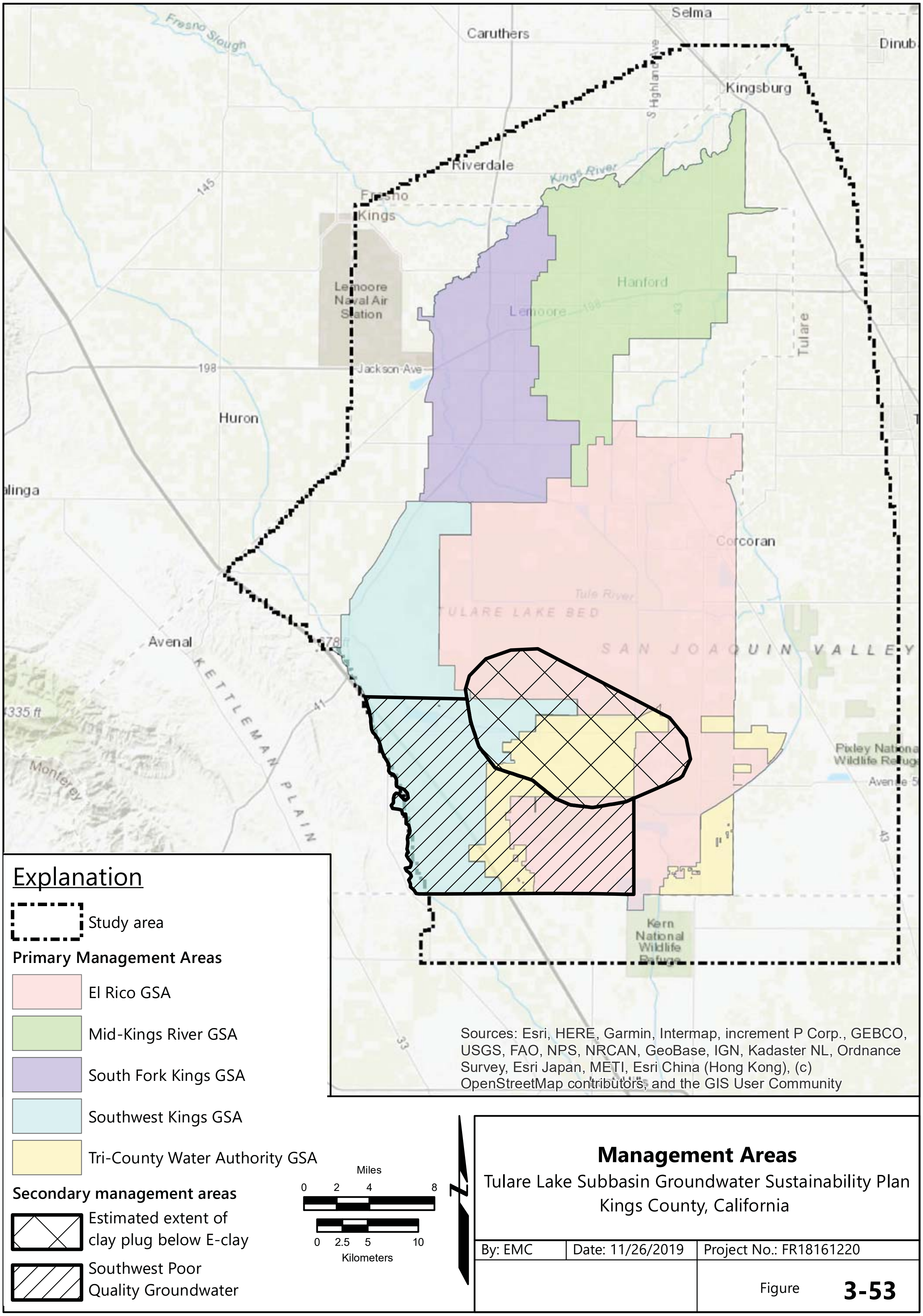


Notes:
1. AF/Y = acre-feet per year

Surface Water Delivery Foreacst with Climate Change

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 11/20/2019	Project No.: FR18161220
		Figure: 3-52



Management Areas

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/26/2019	Project No.: FR18161220
		Figure **3-53**

Date: 11/26/2019 Printed by: elizabeth.chapman
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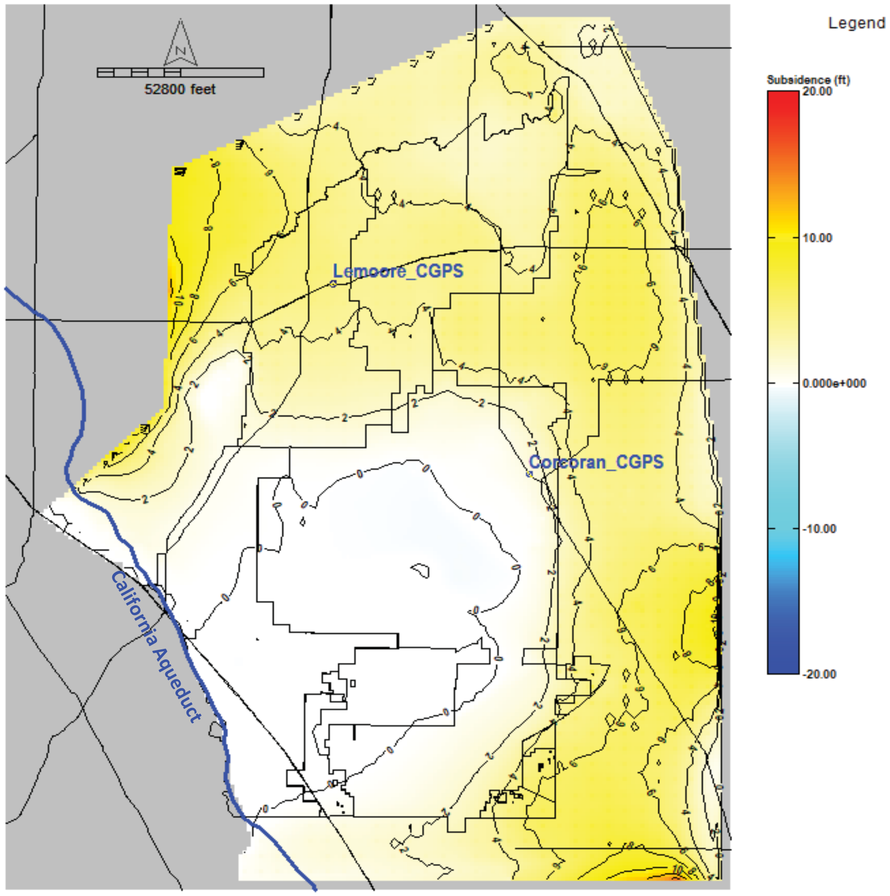
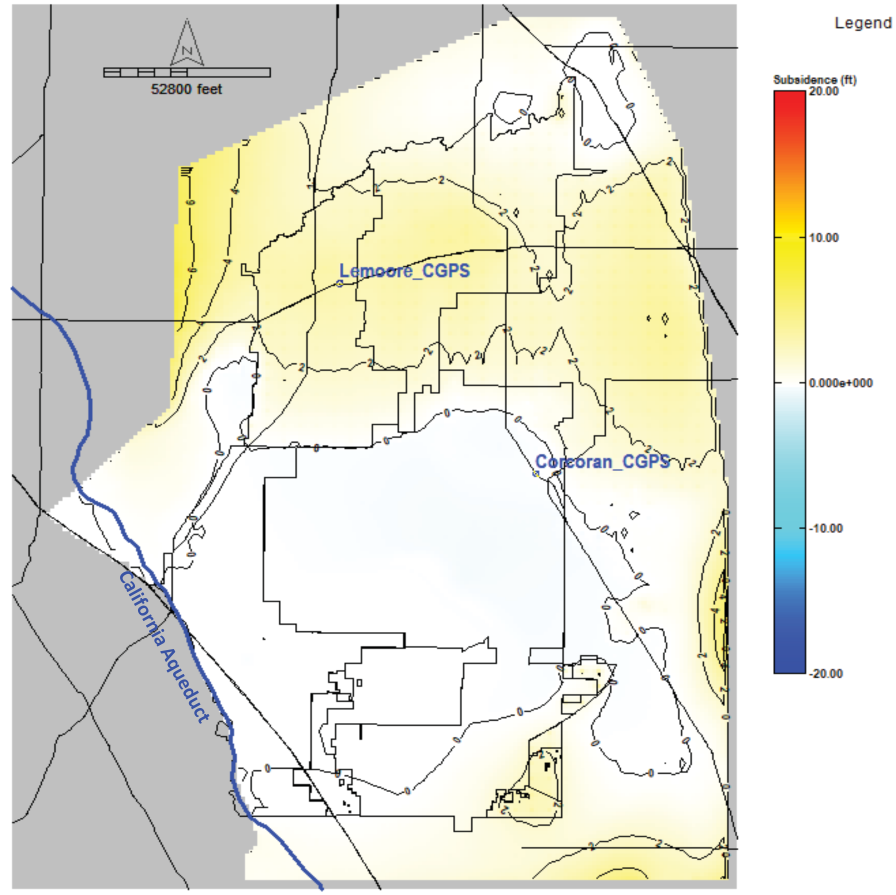


Kings SGMA 2017-2070 Layer: 1 SP: 284 Date: 2040.6

Baseline



Kings SGMA 2017-2070 Layer: 1 SP: 284 Date: 2040.6

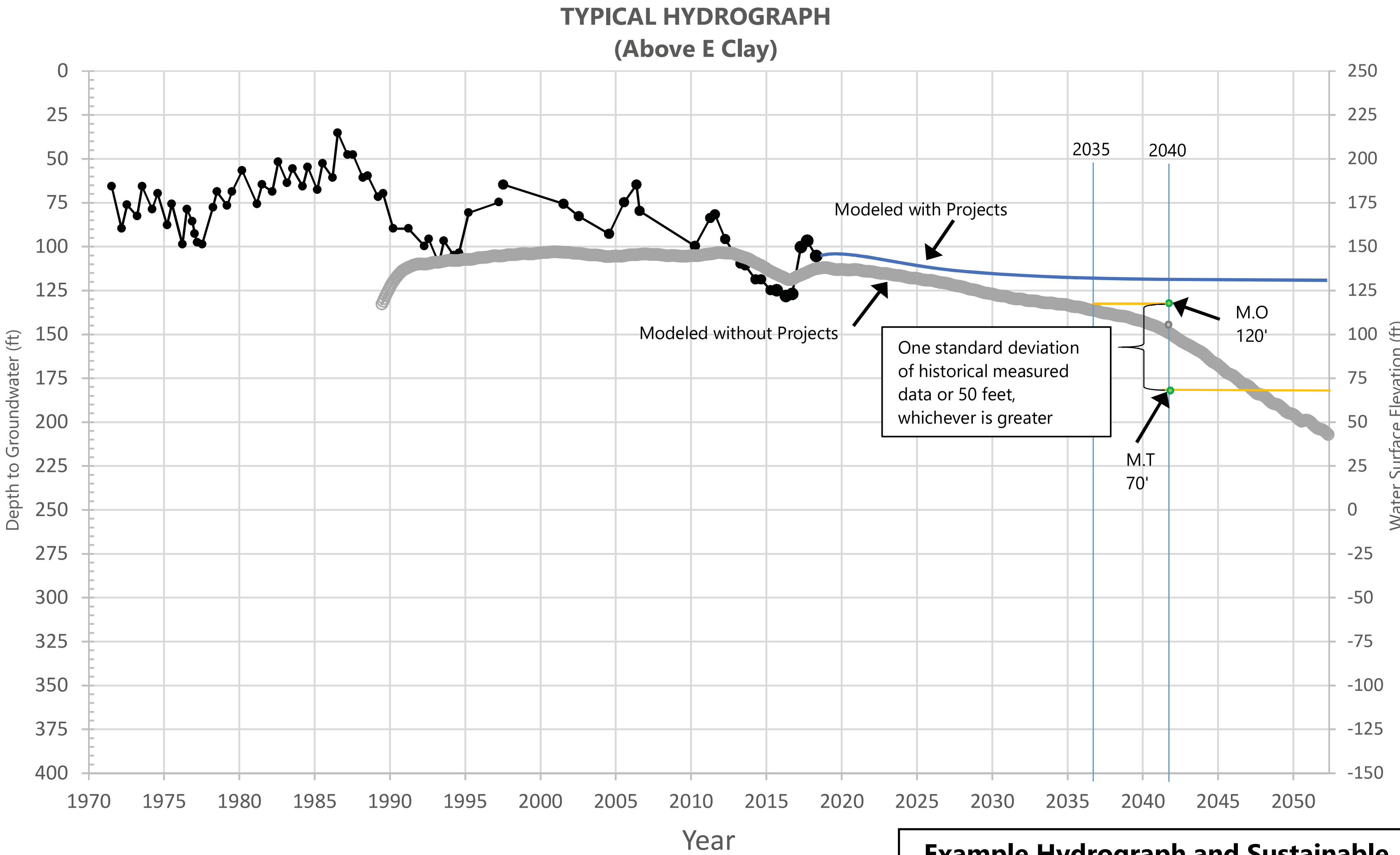
Projects

Note:
Cumulative Subsidence from January 2017 to July 2040

Forecast 2040 Subsidence
Baseline and Projects Forecast
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 01/06/2020	Project No.: FR18161220
		Figure **4-1**

N:_FR_projects\FR18s\FR18161220\gis\Tables\MonitoringNetwork\Copy of 2019 1126 _ComplianceWellsWithDataHydrographs.xlsm



M.O - Measurable Objective
M.T - Minimal Threshold

Example Hydrograph and Sustainable Management Criteria

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/27/19	Project No.: FR18161220
		Figure **4-2**

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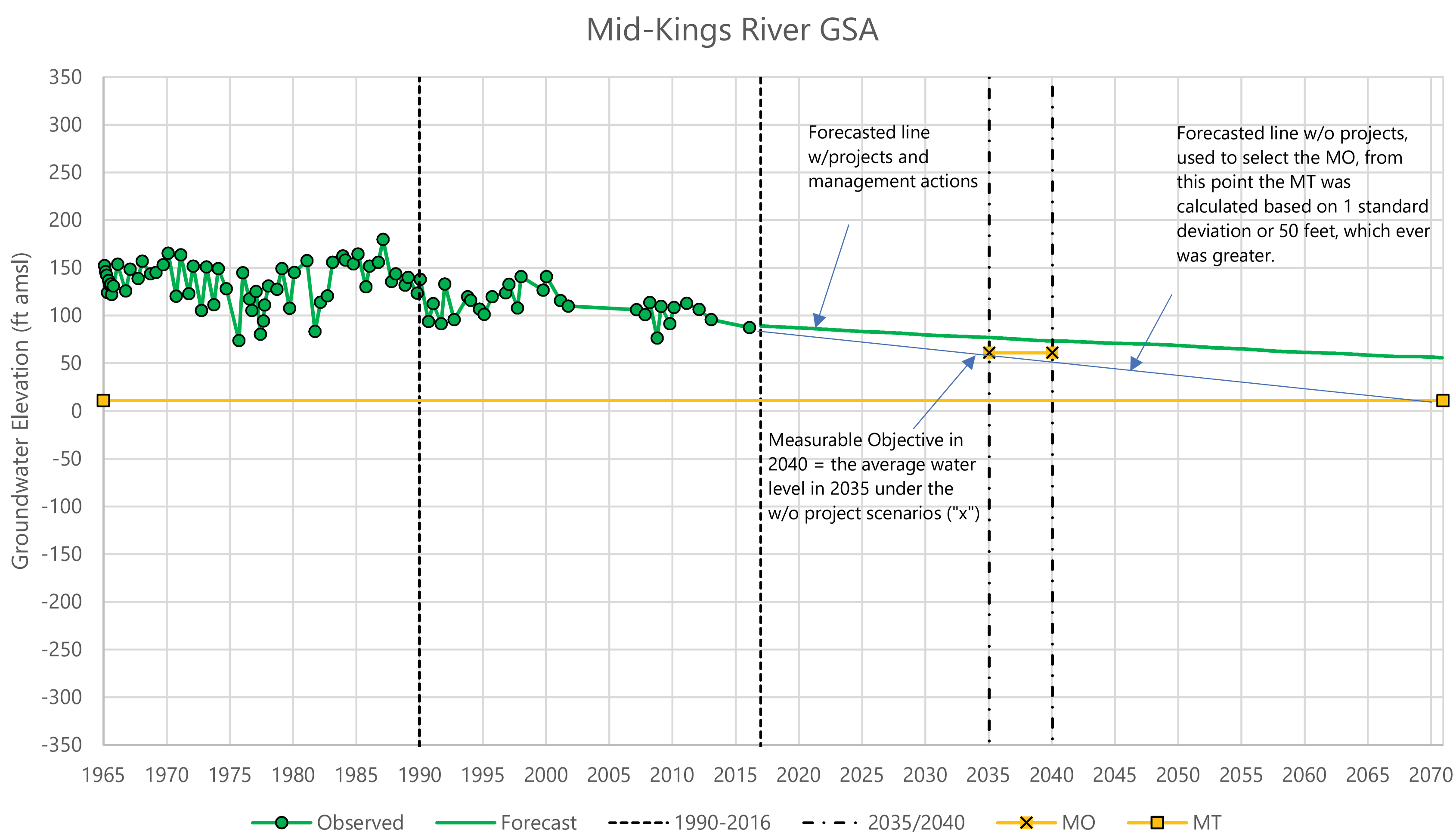

M.O Measurable Objective

M.T Measurable Threshhold

Example Hydrograph and Sustainable Management Criteria
Mid-Kings River GSA
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 08/28/2019	Project No.: FR18161220
		Figure **4-3**

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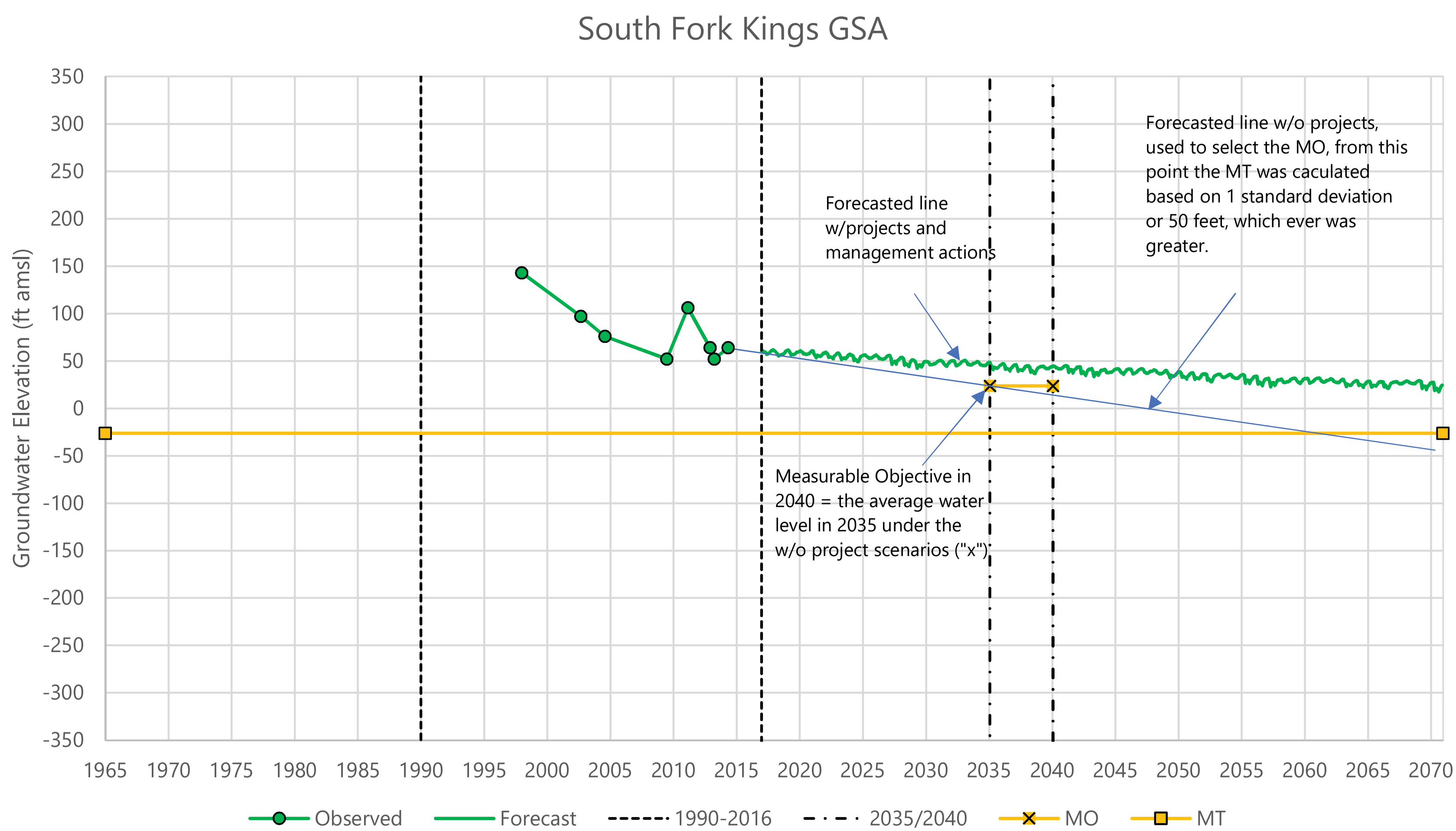
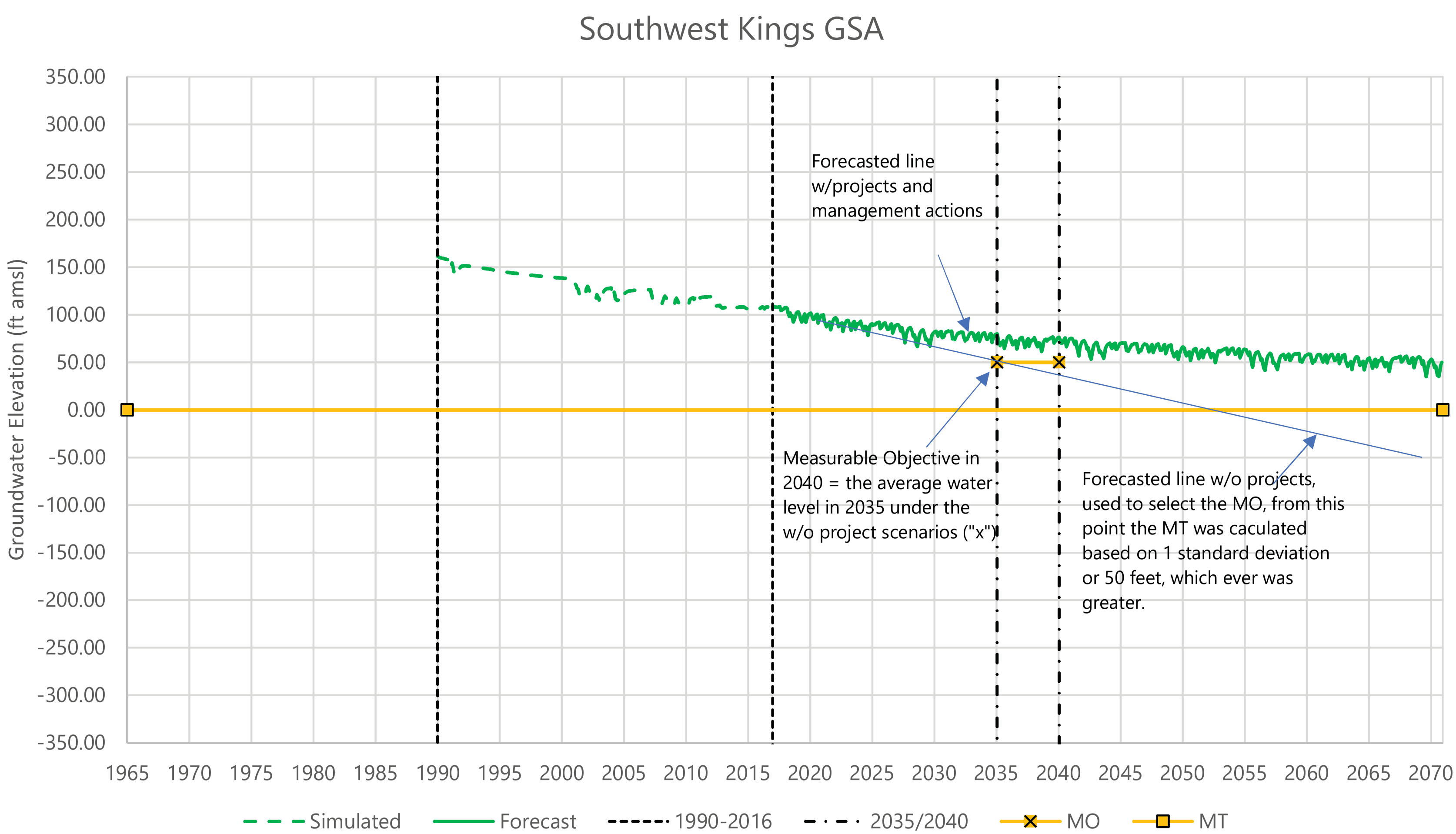


M.O Measurable Objective

M.T Measurable Threshhold

Example Hydrograph
and Sustainable Management Criteria
South Fork Kings GSA
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 08/28/2019	Project No.: FR18161220
		Figure **4-4**

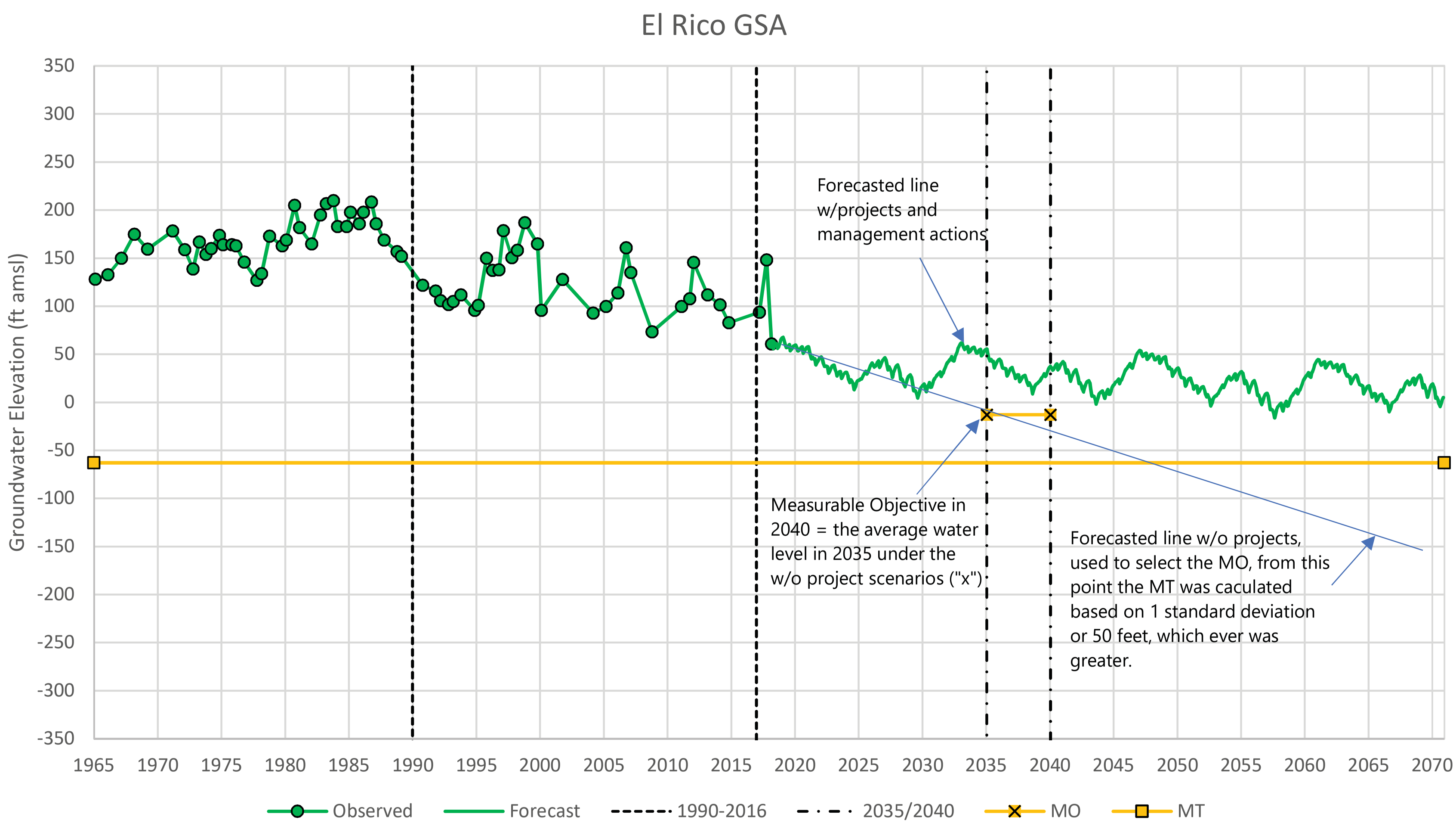


M.O Measurable Objective

M.T Measurable Threshhold

Example Hydrograph and Sustainable Management Criteria Southwest Kings GSA Tulare Lake Subbasin Groundwater Sustainability Plan Kings County, California		
By: EMC	Date: 08/28/2019	Project No.: FR18161220
		Figure **4-5**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\4-SMC\Tables\2019 0826_ComplianceWellsWithDataHydrographs.xlsm



M.O Measurable Objective

M.T Measurable Threshhold

Example Hydrograph
And Sustainable Management Criteria
El Rico GSA
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 08/28/2019	Project No.: FR18161220
		Figure **4-6**

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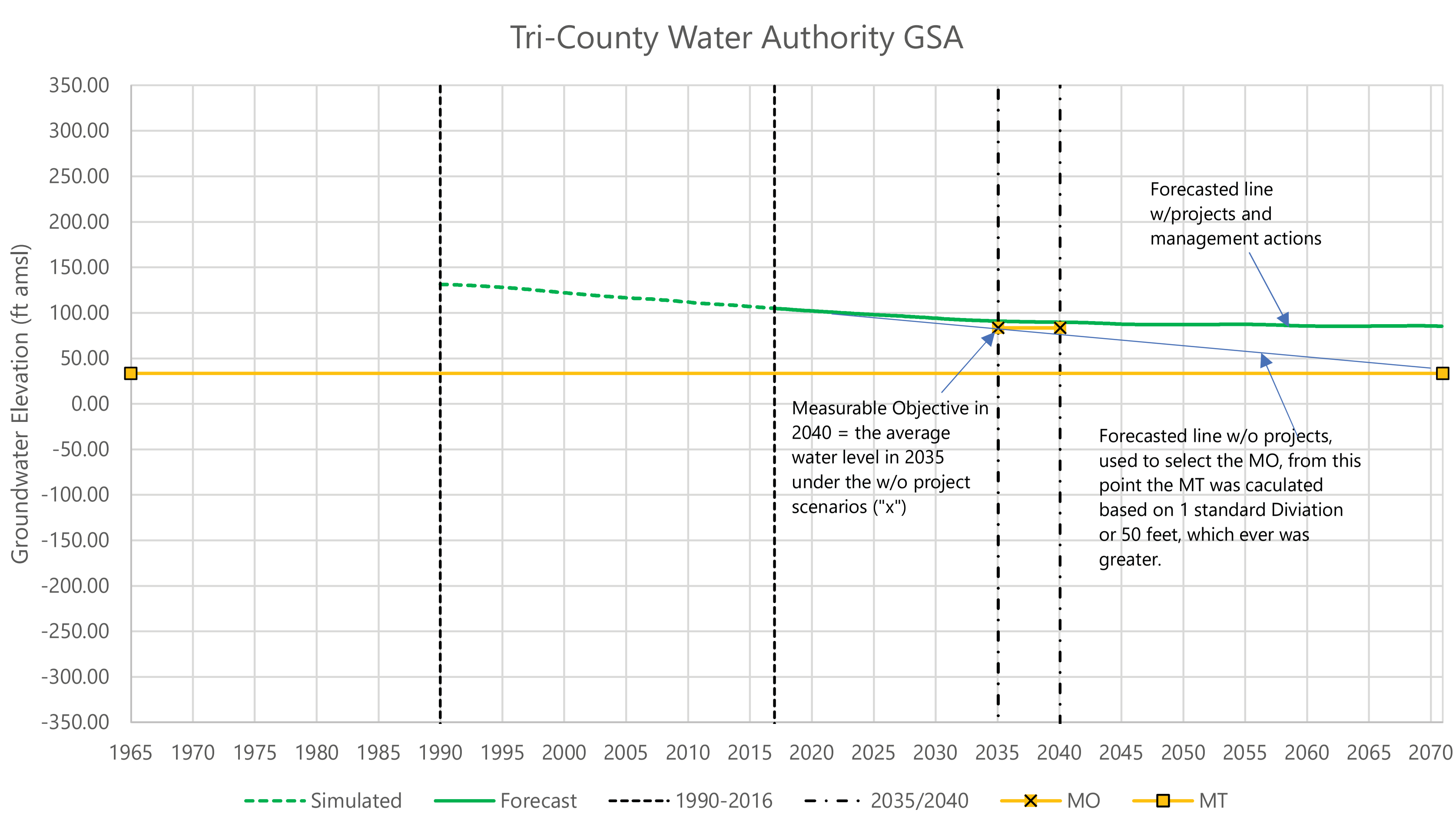
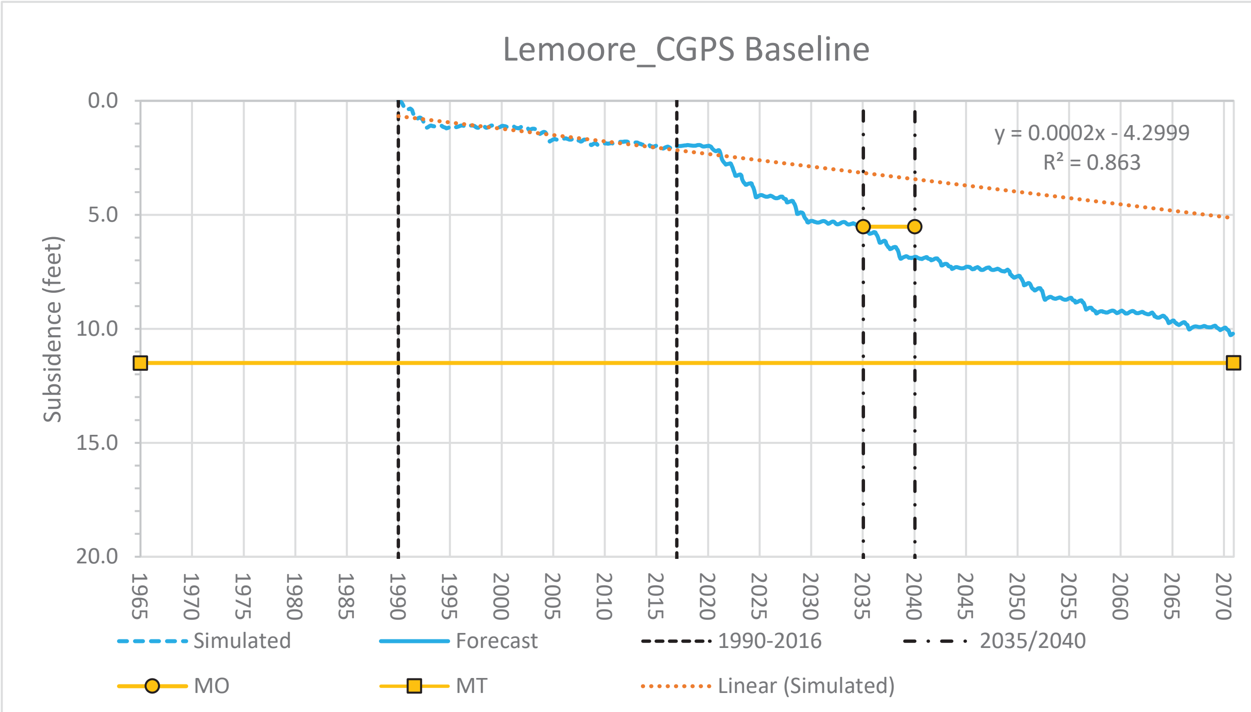


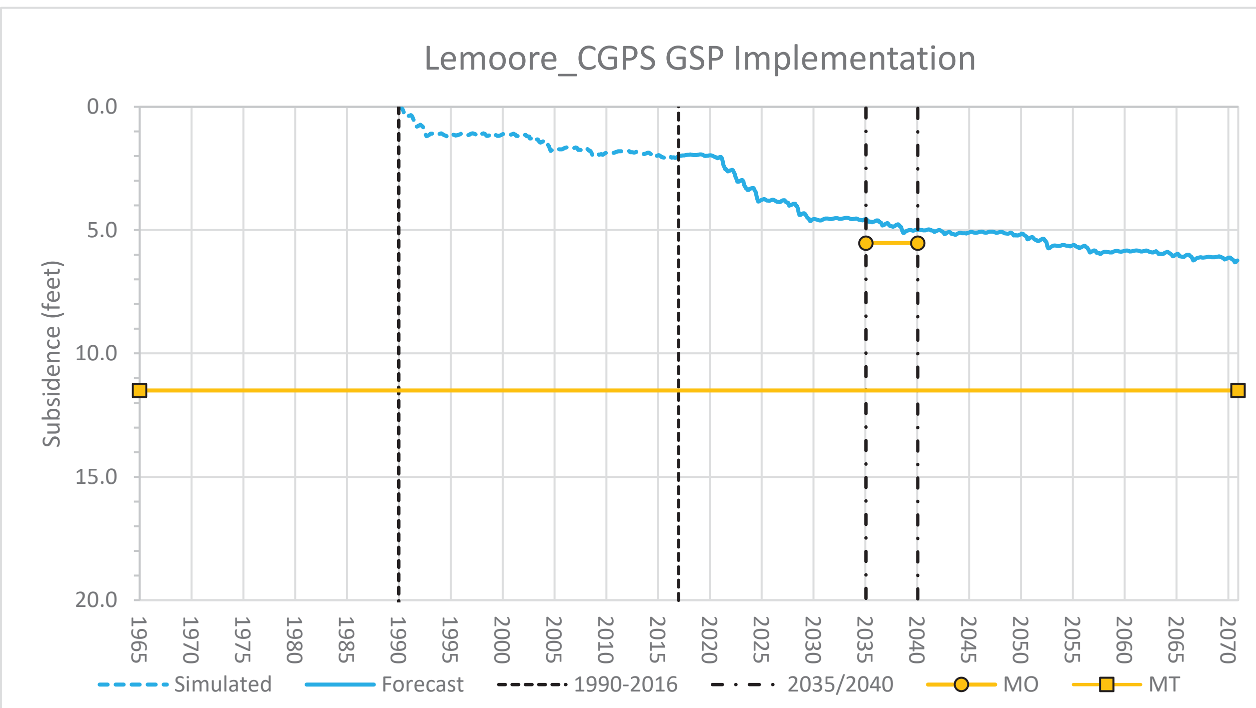
M.O Measurable Objective

M.T Measurable Threshhold

Example Hydrograph
and Sustainable Management Criteria
Tri-County Water Authority GSA
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 08/28/2019	Project No.: FR18161220
		Figure **4-7**

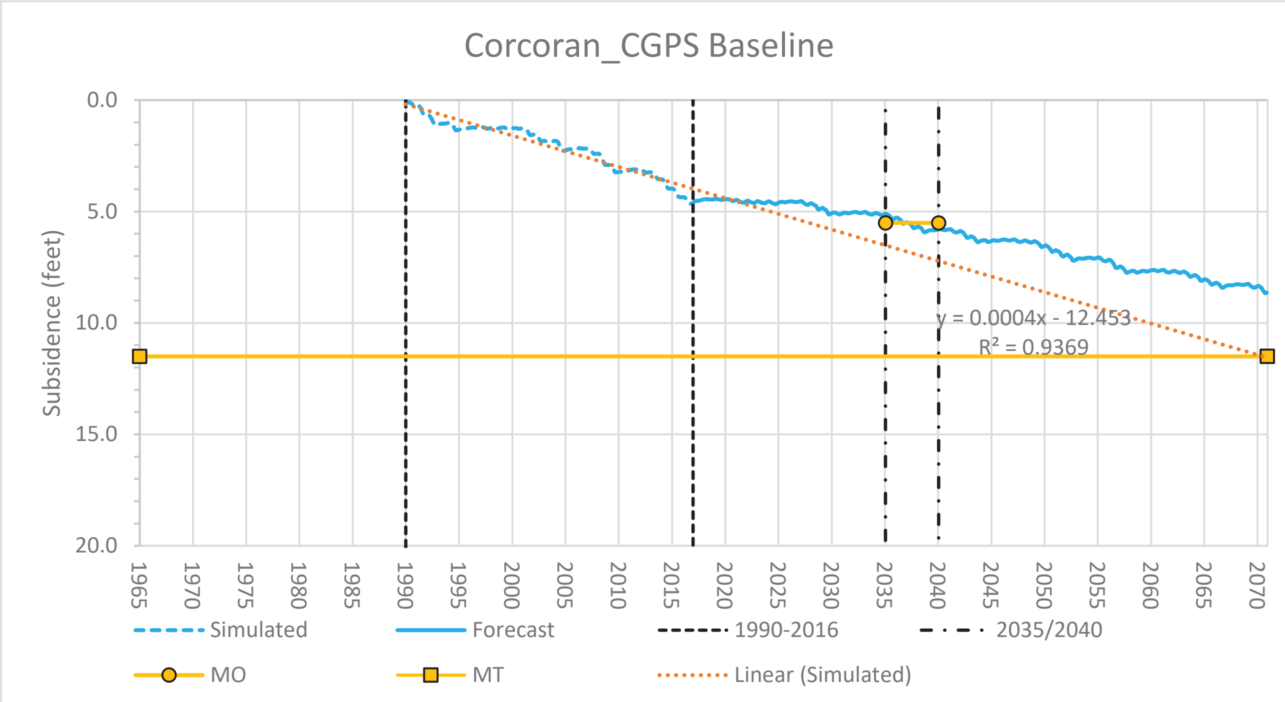


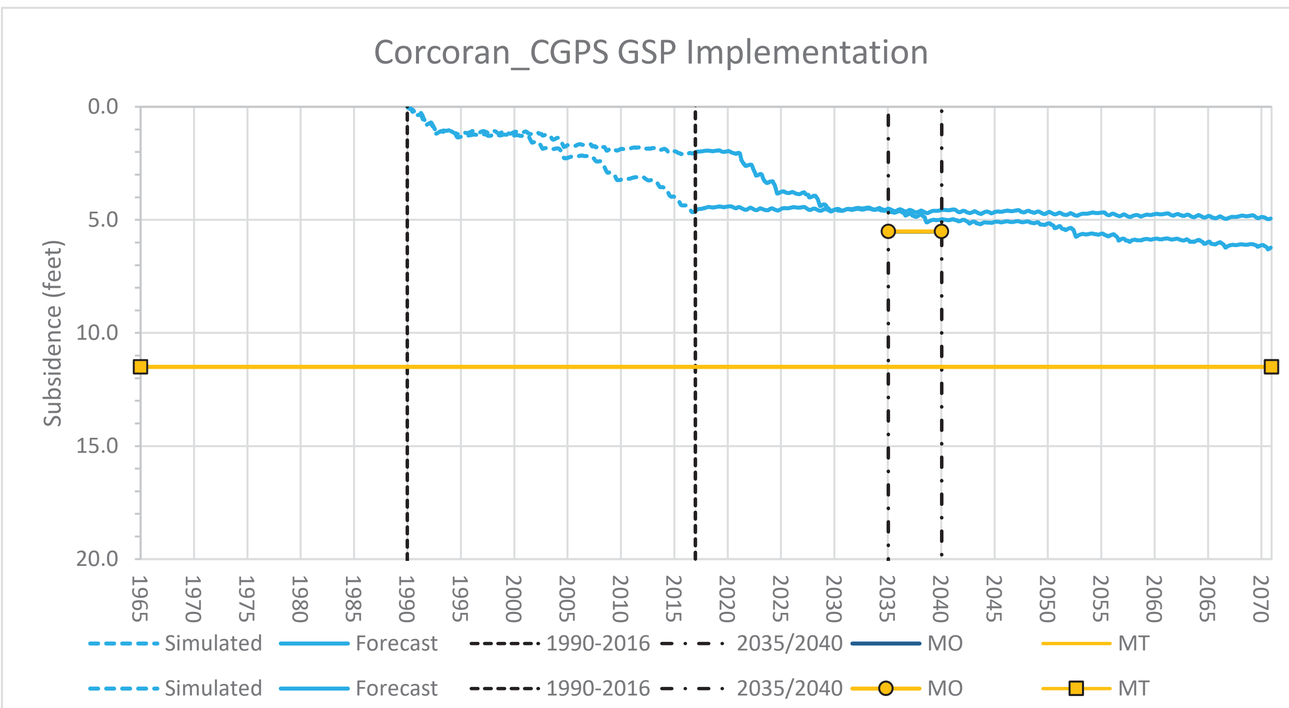


Forecast Land Subsidence under Baseline Conditions and with GSP Implementation
Lemoore RMS

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 01/07/2020	Project No.: FR18161220
		Figure **4-8**





Forecast Land Subsidence under Baseline Conditions and with GSP Implementation Corcoran RMS

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 01/07/2020	Project No.: FR18161220
		Figure **4-9**

Date: 12/17/2019 Printed by: elizabeth.chapman
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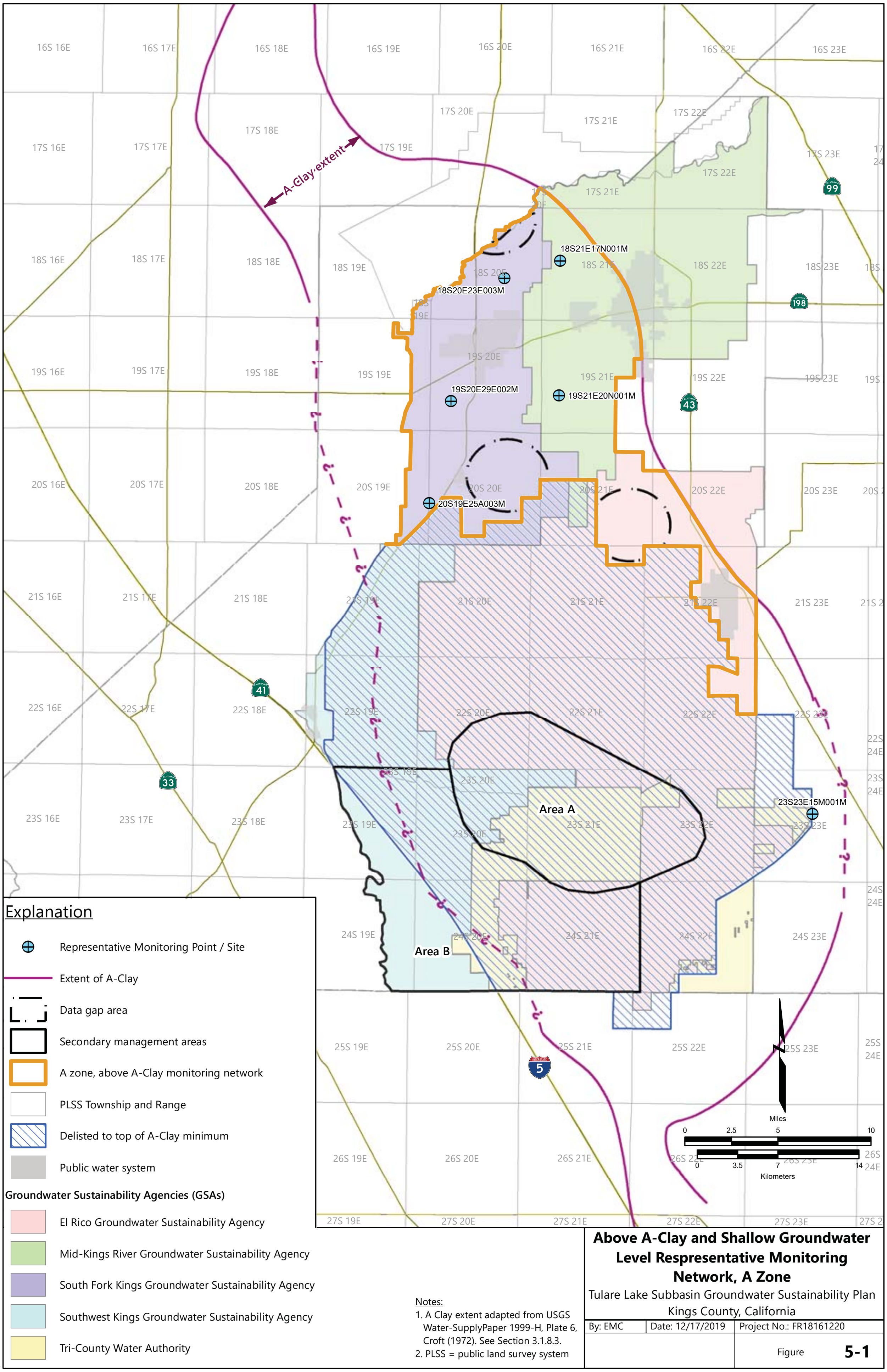

Notes:
1. A Clay extent adapted from USGS Water-SupplyPaper 1999-H, Plate 6, Croft (1972). See Section 3.1.8.3.
2. PLSS = public land survey system

Above A-Clay and Shallow Groundwater Level Respresentative Monitoring Network, A Zone

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 12/17/2019	Project No.: FR18161220
		Figure **5-1**

Date: 12/16/2019 Printed by: elizabeth.chapman
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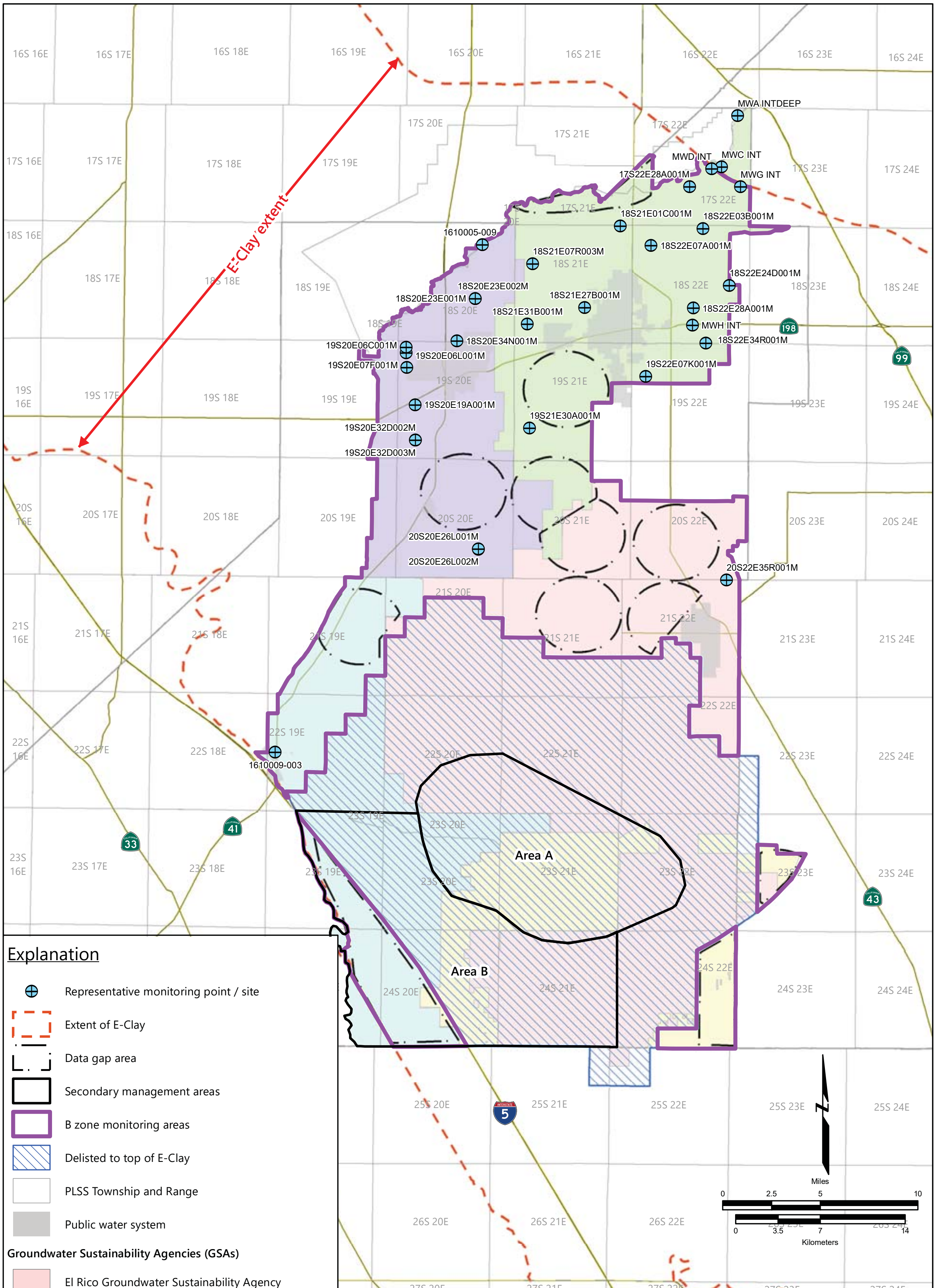

Explanation

- Representative monitoring point / site
- Extent of E-Clay
- Data gap area
- Secondary management areas
- B zone monitoring areas
- Delisted to top of E-Clay
- PLSS Township and Range
- Public water system

Groundwater Sustainability Agencies (GSAs)

- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

Notes:
1. E-Clay extent from USGS CVSD (2012). Based on Page (1986). See Section 3.1.8.3.
2. B Zone is above E-clay and below A-clay where the A-clay is present, and elsewhere above E-clay

Groundwater Level Representative Monitoring Network, B Zone

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 12/16/2019	Project No.: FR18161220
		Figure **5-2**

Date: 12/16/2019 Printed by: elizabeth.chapman
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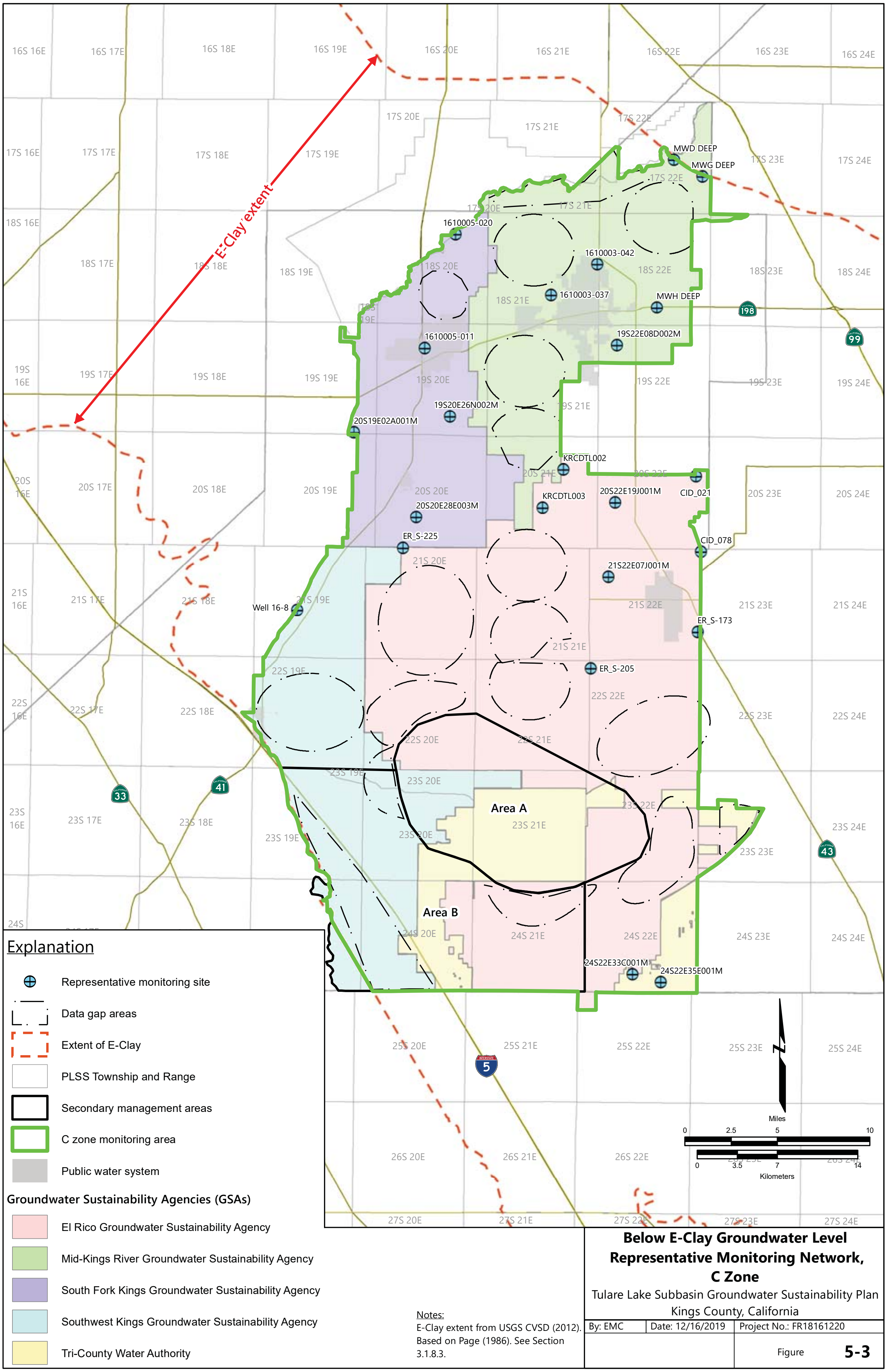


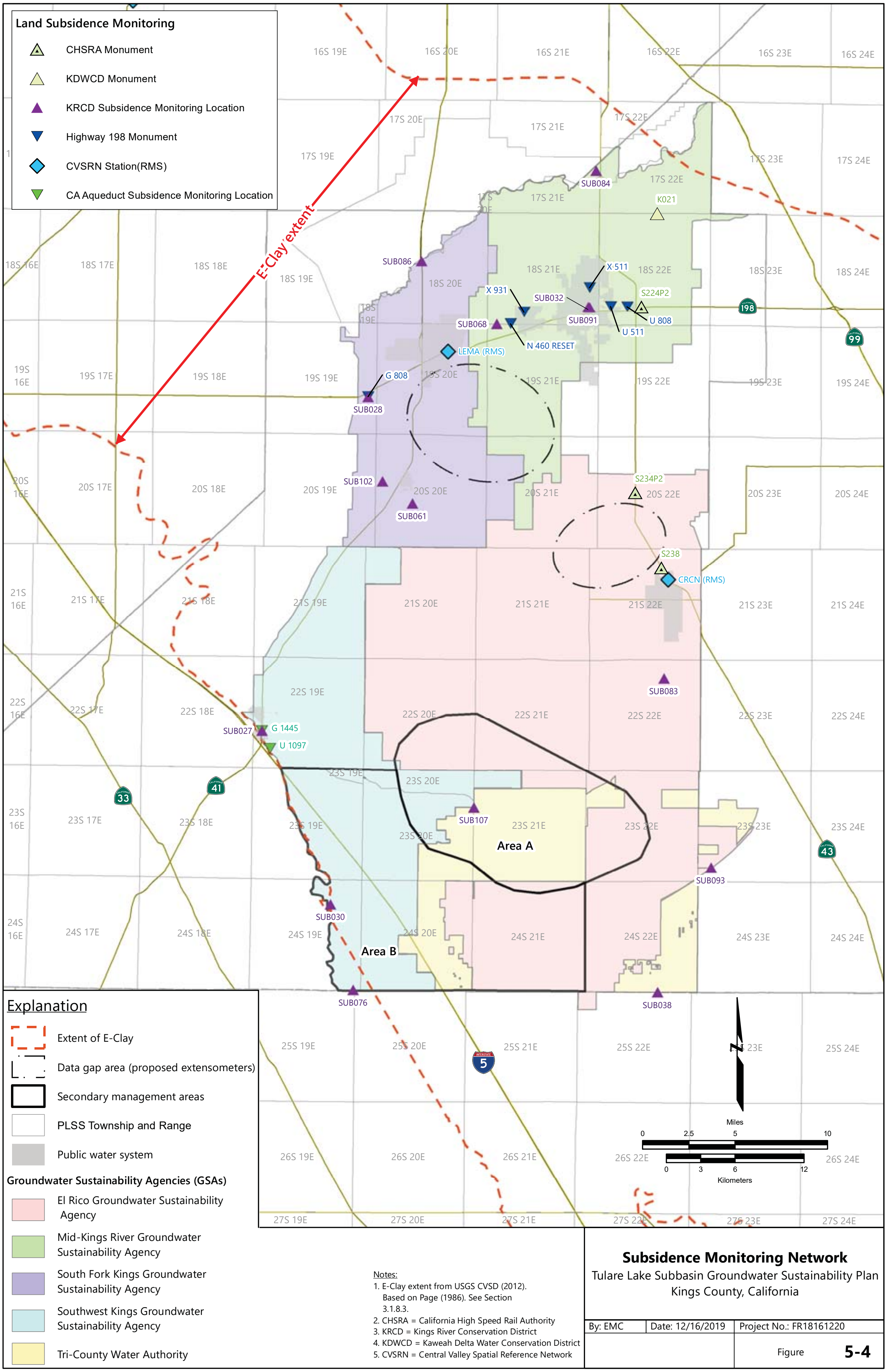
Notes:
E-Clay extent from USGS CVSD (2012). Based on Page (1986). See Section 3.1.8.3.

Below E-Clay Groundwater Level Representative Monitoring Network, C Zone

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 12/16/2019	Project No.: FR18161220

Figure **5-3**



Notes:
1. E-Clay extent from USGS CVSD (2012). Based on Page (1986). See Section 3.1.8.3.
2. CHSRA = California High Speed Rail Authority
3. KRCD = Kings River Conservation District
4. KDWCD = Kaweah Delta Water Conservation District
5. CVSRN = Central Valley Spatial Reference Network

Subsidence Monitoring Network
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 12/16/2019	Project No.: FR18161220
		Figure **5-4**

Date: 12/16/2019 Printed by: elizabeth.chapman
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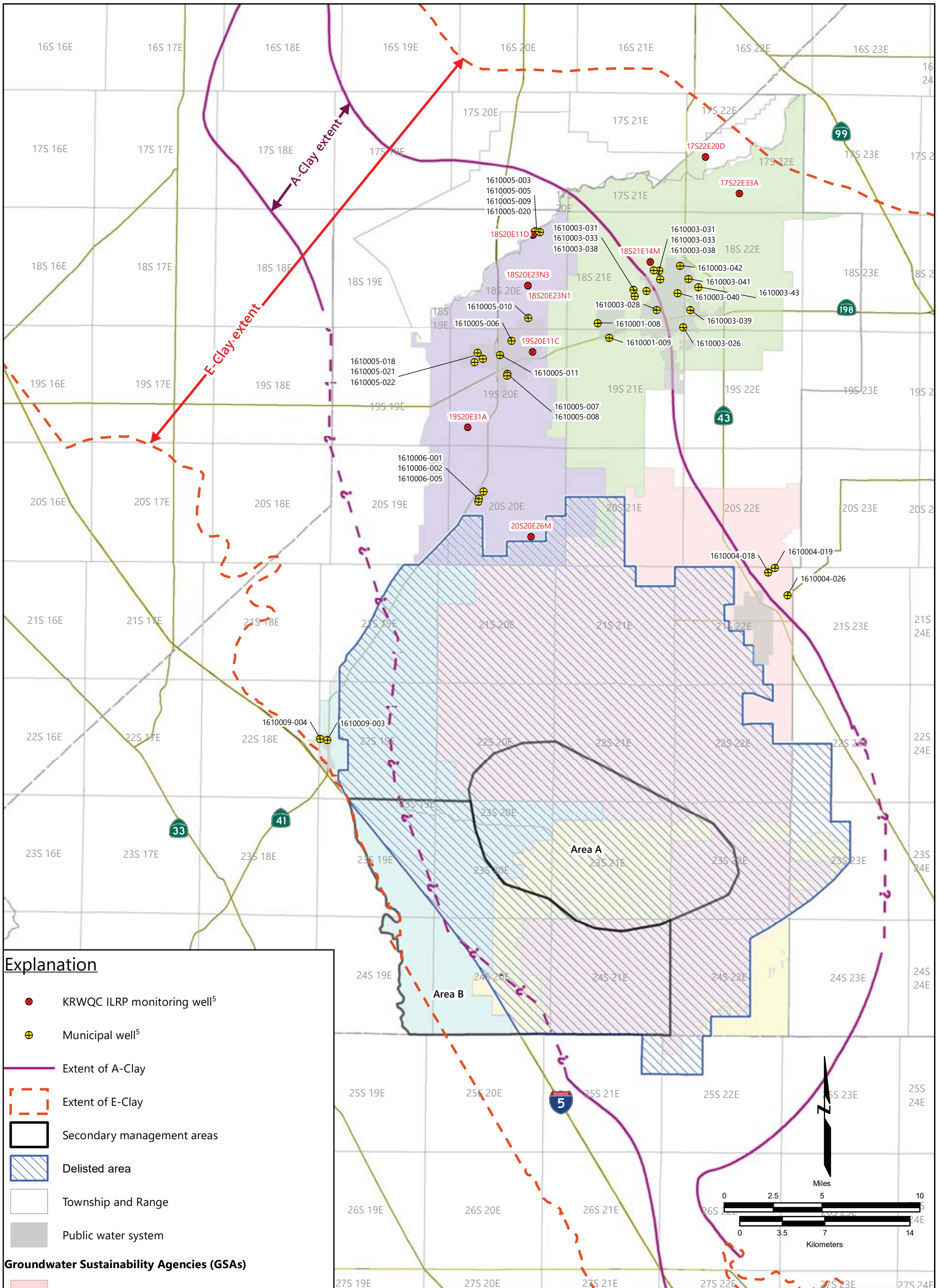


Explanation

- KRWQC ILRP monitoring well[5]
- Municipal well[5]
- Extent of A-Clay
- Extent of E-Clay
- Secondary management areas
- Delisted area
- Township and Range
- Public water system

Groundwater Sustainability Agencies (GSAs)

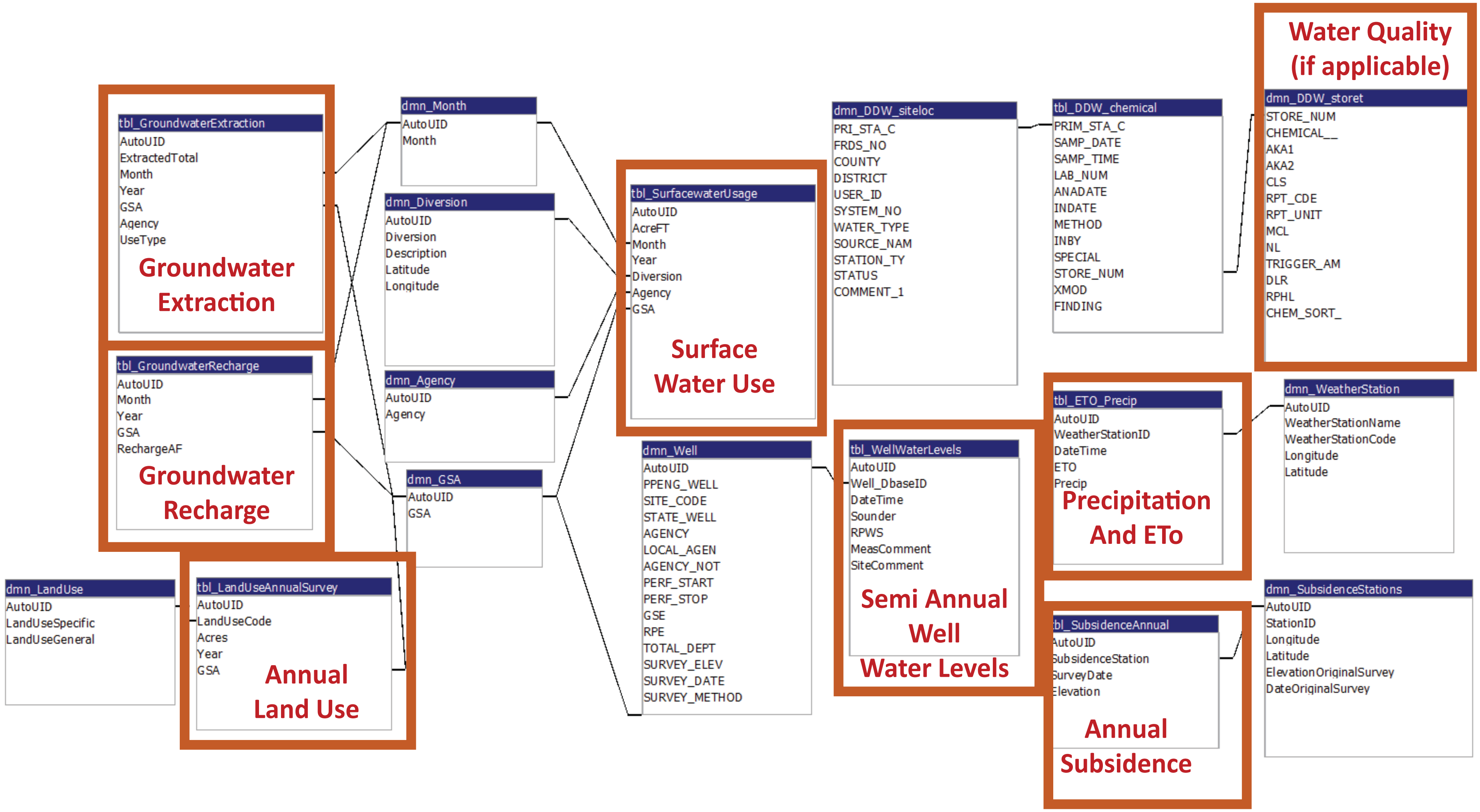
- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

Notes:
1. A-Clay extent adapted from USGS Water-SupplyPaper 1999-H, Plate 6, Croft (1972). See Section 3.1.8.3.
2. E-Clay extent from USGS CVSD (2012). Based on Page (1986). See Section 3.1.8.3.
3. KRWQA = Kings River Water Quality Coalition
4. ILRP = Irrigated Lands Regulatory Program
5. Wells are labeled with either water system ID or township, range, section designation

Groundwater Quality Monitoring Network

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 12/16/2019	Project No.: FR18161220
		Figure **5-5**



DMS Table Relationships

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 11/25/2019	Project No.: 006741
		Figure **5-6**

Date: 08/20/2019 Printed by Elizabeth.Chapman
Path: I:\FR18s\FR18161220 Tulare Lake GSP\Figures\5-MonitoringNetwork\Figures\November2019_fig5-6_TLSB_Draft.pdf

tbl_GroundwaterExtraction

AutoUID	ExtractedTotal	Month	Year	GSA	Agency	UseType	Click to Add
1	0	1	2016	1	1	1	
2	0	1	2016	1	2	2	
3	0	2	2016	2	4	3	

tbl_GroundwaterRecharge

AutoUID	Month	Year	GSA	RechargeAF	Click to Add
(New)		0		0	

tbl_LandUseAnnualSurvey

AutoUID	LandUseCode	Acres	Year	GSA	LUGeneral	Click to Add
5313		581.7	2014	El Rico Groundwater Sustainability Agency	FIELD CROPS	
5306		44.2	2014	El Rico Groundwater Sustainability Agency	TRUCK, NURSERY AND BERRY CROPS	
5320		451.6	2014	El Rico Groundwater Sustainability Agency	IDLE	

tbl_SubsidenceAnnual

AutoUID	SubsidenceID	Year	Elevation	SurveyDate	Click to Add
1	SUB001	2010			
2	SUB002	2010			
3	SUB003	2010			

tbl_SurfacewaterUsage

AutoUID	Month	Year	Diversion	Agency	AcreFT	GSA	Click to Add
1225	1	2016	1	1	0	1	
1226	2	2016	1	1	207	1	
1227	3	2016	1	1	0	1	

tbl_WellWaterLevels

AutoUID	PPENG_ID	SITE_CODE	COOP_ORG_NAME	COOP_AGENCY_ORG_ID	MSMT_CMT	WLM_ORG_NAME	WLM_ORG_ID	WLM_ACC_DESC	WLM_DESC
360	357320N1196997W001	357320N1196997W001	Department of Water Re	1		Department of Water Resources	1	Water level accuracy is unknown	Unknown
361	357320N1196997W001	357320N1196997W001	Department of Water Re	1		Department of Water Resources	1	Water level accuracy is unknown	Unknown
362	357320N1196997W001	357320N1196997W001	Department of Water Re	1		Department of Water Resources	1	Water level accuracy is unknown	Unknown

tbl_WellWaterLevels

WLM_DESC	WLM_QA_DESC	GSE_WSE	RPE_WSE	WSE	RDNG_RP	RDNG_WS	WLM_GSE	WLM_RPE	MSMT_DATE	WLM_ID	STN_ID_1	Click to Add
Unknown		6.3	8.3	216.08	8.3	0	222.38	224.38	7/9/2010	852041	24614	
Unknown		5.7	7.7	216.68	7.7	0	222.38	224.38	4/26/2010	852040	24614	
Unknown		6.1	8.1	216.28	8.1	0	222.38	224.38	1/28/2010	852039	24614	

Sample DMS Tables with Associated Fields

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 11/20/2019 | Project No.: FR18161220

Figure 5-7

Date: 08/20/2019 Printed by Elizabeth.Chapman
Path: I:\FR18s\FR18161220 Tulare Lake GSP\Figures\5-MonitoringNetwork\Figures\November2019_fig5-7_DMSTemplate.pdf

Table 1-1. GSP Requirements

Requirements
Groundwater conditions must be adequately defined and monitored to demonstrate the GSPs are achieving the sustainability goals for the basin
GSAs must be sufficiently defined and compatible to evaluate the effect of GSPs on adjacent basins
GSPs must meet substantial compliance standards
A GSA shall provide a description of basin setting and establish criteria that will maintain or achieve sustainable groundwater management
DWR will consider state policy regarding to the human right to water when implementing these regulations
The GSP sustainable groundwater management criteria, projects, and management actions should be based on the level of understanding of the basin setting including an understanding of uncertainty and data gaps
A GSP must achieve the sustainability goals for the basin in 20 years

Table 1-2. Participating GSA Contact Information

GSA	Plan Manager	Address	Telephone	Email
Mid-Kings River	Dennis Mills, Secretary	200 North Campus Dr. Hanford, CA 93230	(559) 584.6412	kcwdh2o@sbcglobal.net
El Rico	Jeof Wyrick, Chairman	101 W. Walnut St. Pasadena, CA 91103	(626) 583.3000	jwyrick@jgboswell.com
South Fork Kings	Charlotte Gallock, Program Administrator	4886 E. Jensen Ave. Fresno, CA 93725	(559) 242.6128	cgallock@krcd.org
Southwest Kings	Dale Melville, Executive Director	286 Cromwell Ave. Fresno, CA 93711	(559) 449.2700	dmelville@ppeng.com
Tri-County Water Authority	Deanna Jackson, Executive Director	944 Whitley Ave. Suite E. Corcoran, CA 93212	(559) 762.7240	djackson@tcwater.org

See Acronyms and Abbreviations list for definitions.

Table 1-3. GSA Member Agencies

GSA	GSA Member Agencies	
Mid-Kings River	▪ Kings County Water District ▪ City of Hanford	▪ Kings County
El Rico	▪ Alpaugh Irrigation District ▪ City of Corcoran ▪ Corcoran Irrigation District ▪ Kings County ▪ Lovelace Reclamation District No. 739	▪ Melga Water District ▪ Salyer Water District ▪ Tulare Lake Basin Water Storage District ▪ Tulare Lake Drainage District
South Fork Kings	▪ City of Lemoore ▪ Empire West Side Irrigation District ▪ Stratford Irrigation District	▪ Stratford Public Utility District ▪ Kings County
Southwest Kings	▪ Dudley Ridge Water District ▪ Tulare Lake Reclamation District No. 761	▪ Kettleman City Community Services District ▪ Tulare Lake Basin Water Storage District ▪ Kings County
Tri-County Water Authority	▪ Angiola Water District ▪ Kings County	▪ Deer Creek Storm Water District ▪ Wilbur Reclamation District #825

Table 1-4. Proportionate Costs Breakdown of Each GSA

GSA	Acres	Acreage Portion	Participant Portion	Total Cost Allocation
Mid-Kings River GSA	97,384.6	0.09084	0.1	0.19084
El Rico GSA/Alpaugh ID	228,653.4	0.21328	0.1	0.31328
South Fork Kings GSA	71,310.9	0.06652	0.1	0.16652
Southwest Kings GSA	90,037.1	0.08398	0.1	0.18398
Tri-County WA	48,656.5	0.04538	0.1	0.14538
Totals	536,042.5	0.50000	0.5	1.00000

Table 1-5. Estimate of Costs GSP Planning

Description	Mid-Kings River	South Fork Kings	El Rico	Southwest Kings	Tri-County Water Authority	Total
Model Development	$95,470.00	$83,260.00	$156,640.00	$91,990.00	$76,690.00	$500,000.00
GSP Development	$348,283.00	$303,899.00	$571,736.00	$335,764.00	$265,318.00	$1,825,000.00
Totals	$443,753.00	$387,159.00	$728,376.00	$427,754.00	$342,008.00	$2,325,000.00

See Acronyms and Abbreviations list for definitions.

Table 1-6. Estimate of Costs GSP Implementation

	Mid-Kings River		South Fork Kings		El Rico		Southwest Kings		Tri-County Water Authority		Total
	Cost (Dollars)	Annual Yield (AF/yr)	Cost (Dollars)	Annual Yield (AF/yr)	Cost (Dollars)	Annual Yield (AF/yr)	Cost (Dollars)	Annual Yield (AF/yr)	Cost (Dollars)	Annual Yield (AF/yr)	
Description											
Administration	$50,000		$50,000		$20,000		$5,000		$5,000		$130,000
Monitoring	$50,000		$50,000		$10,000		$5,000		$5,000		$120,000
Fill Data Gaps	$50,000		$50,000		$50,000		$50,000				$150,000
Annual Costs											$400,000
Projects											
Existing System Improvements	$8,800,000	6,000.00									$8,800,000
Recharge	$93,000,000	27,700.00	$28,000,000	7,000.00							$121,000,000
Aquifer Storage and Recovery			$15,000,000	13,000.00							$15,000,000
Surface Storage and Reregulation			$6,000,000	2,000.00	$100,000,000	26,000.00			$45,000,000	15,000.00	$151,000,000
On Farm Flooding											$0
Surface Water System Improvements			$5,000,000	5,000.00							$5,000,000

See Acronyms and Abbreviations list for definitions.

Table 1-6. Estimate of Costs GSP Implementation (Continued)

	Mid-Kings River		South Fork Kings		El Rico		Southwest Kings		Tri-County Water Authority		Total
	Cost (Dollars)	Annual Yield (AF/yr)	Cost (Dollars)	Annual Yield (AF/yr)	Cost (Dollars)	Annual Yield (AF/yr)	Cost (Dollars)	Annual Yield (AF/yr)	Cost (Dollars)	Annual Yield (AF/yr)	
Demand Management											
Crop Rotation/Fallowing	$1,380,000	6,250.00	$5,000,000	13,000.00		15,000.00					$6,380,000
Groundwater Measurement			$500,000	1,500.00							$500,000
On Farm Improvement			$1,000,000	2,500.00							$1,000,000
Conservation/Reuse			$1,000,000	1,000.00							$1,000,000
	$103,330,000	39,950	$61,650,000	45,000	$100,080,000	41,000	$60,000		$45,010,000	15,000	$309,680,000

See Acronyms and Abbreviations list for definitions.

Table 2-1. Land Use in Tulare Lake Subbasin (2014)

Land Use Classification	Percent of Total Area
Commercial	0.3%
Deciduous Fruit and Nuts	14.6%
Field Crops	30.1%
Grain and Hay Crops	6.2%
Idle	22.9%
Industrial	0.3%
Pasture Crops	7.1%
Residential	0.4%
Riparian Vegetation	2.8%
Semi agricultural	1.8%
Truck, Nursery, and Berry Crops	6.0%
Urban	3.8%
Urban Landscape	0.1%
Vineyards	1.5%
Water Surface	2.0%
Young Perennials	0.1%
TOTAL	**100.0%**

Source: DWR 2014.

See Acronyms and Abbreviations list for definitions.

Table 2-2. Primary Water Uses and Water Sources

Groundwater Sustainability Agency	Water Use Sector (Agency / Water Company)	Water Use	Water Source Type
El Rico GSA	Alpaugh Irrigation District	Irrigation	Groundwater
	City of Corcoran	Residential Commercial Residential	Groundwater
	Corcoran Irrigation District	Irrigation Recharge	Kings River Kaweah River St. John's River
	Corcoran Irrigation Company	Irrigation Recharge	Kings River Kaweah River St. John's River
	Peoples Ditch Company	Irrigation Recharge	Kings River
	Last Chance Water Ditch Company	Irrigation Recharge	Kings River
	Lakeside Canal Company	Irrigation Recharge	Kaweah River St. John's River CVP
	Tulare Lake Basin Water Storage District	Irrigation	Kings River Kaweah River St. John's River Tule River SWP
Tri-County Water Authority GSA	Angiola Water District	Irrigation Recharge	SWP CVP Kings River Tule River Deer Creek Groundwater Poso Creek
	Atwell Island Water District	Irrigation	Groundwater
	Deer Creek Storm Water District	Flood Control	Deer Creek Poso Creek
	W. H. Wilbur Reclamation District #825	Irrigation	Poso Creek
Mid-Kings River GSA	City of Hanford	Residential Commercial Industrial	Groundwater
	Armona Community Services District	Residential Commercial	Groundwater

See Acronyms and Abbreviations list for definitions.

Table 2-2. Primary Water Uses and Water Sources (Continued)

Groundwater Sustainability Agency	Water Use Sector (Agency / Water Company)	Water Use	Water Source Type
Mid-Kings River GSA (Continued)	Home Garden Community Services District	Residential	Groundwater
	Kings County Water District	Irrigation Recharge Banking	Kings River Kaweah River St. John's River CVP
	Lakeside Irrigation Water District & Canal Company	Irrigation Recharge	Kaweah River St. John's River CVP
	Peoples Ditch Company	Irrigation Recharge	Kings River
	Last Chance Water Ditch Company	Irrigation Recharge	Kings River
	Santa Rosa Rancheria	Residential Commercial	Groundwater
Southwest Kings GSA	Dudley Ridge Water District	Irrigation	SWP
	Tulare Lake Reclamation District #761	Irrigation	Kings River SWP Groundwater
	Tulare Lake Basin Water Storage District	Irrigation	Kings River Kaweah River St. John's River Tule River SWP
	Kettleman City Community Services District	Residential Commercial Industrial	SWP Groundwater (emergency supply)
South Fork Kings GSA	Lemoore Canal and Irrigation Company	Irrigation	Kings River
	Stratford Irrigation District	Irrigation	Kings River
	Stratford Public Utility District	Residential Commercial	Groundwater
	Santa Rosa Rancheria	Residential Commercial	Groundwater
	City of Lemoore	Municipal	Groundwater

See Acronyms and Abbreviations list for definitions.

Table 2-3. Summary of Applicable Plans

County	Plan	Online Source
Kings County	Kings County 2035 General Plan (adopted January 2010, includes Land Use, Circulation, Noise, Open Space, Resource Conservation, Health and Safety, and Air Quality Elements; Housing Element updated January 2016; Dairy Element adopted July 2002)	https://www.countyofkings.com/departments/community-development-agency/information/2035-general-plan
	Armona Community Plan (2009)	https://www.countyofkings.com/home/showdocument?id=13505
	Home Garden Community Plan (2015)	https://www.countyofkings.com/home/showdocument?id=13507
	Kettleman City Community Plan (2009)	https://www.countyofkings.com/home/showdocument?id=13509
	Stratford Community Plan (2009)	https://www.countyofkings.com/home/showdocument?id=3106
	City of Hanford – 2035 General Plan (April 2017)	http://www.cityofhanfordca.com/document_center/Planning/Plans/Hanford%20General%20Plan/2035%20General%20Plan%20%20Policy%20Document.pdf
	City of Lemoore – 2030 General Plan (May 2008)	http://lemoore.com/communitydevelopment/general-plan/
	City of Corcoran – 2025 General Plan (March 2007), 2005-2025 General Plan Enhancement (November 2014)	http://www.cityofcorcoran.com/civica/filebank/blobdload.asp?BlobID=3796
County of Tulare	County of Tulare – 2030 General Plan (August 2012)	http://generalplan.co.tulare.ca.us/documents/GP/001Adopted%20Tulare%20County%20General%20Plan%20Materials/000General%20Plan%202030%20Part%20I%20and%20Part%20II/GENERAL%20PLAN%202012.pdf
Kern County	Kern County – General Plan (September 2009)	https://kernplanning.com/planning/planning-documents/general-plans-elements/

See Acronyms and Abbreviations list for definitions.

Table 2-4. Beneficial Uses and Users by GSA

Stakeholder Group	Description
Mid-Kings River GSA	
Agricultural Users	Service area is composed of mostly agricultural lands and agricultural users.
Domestic Well Owners	There are domestic wells within the Mid-Kings River GSA, and it is understood that many rural domestic users will fall into the "de minimis extractor" category, so further work is being conducted to understand to what extent domestic users will be affected by GSP requirements.
Public Water Systems	Armona CSD, Home Garden CSD and Hardwick Water Company, as well as several transient public water systems for school districts are included in this category (Kings River-Hardwick, Pioneer, Hanford Christian).
Municipal Water Systems	City of Hanford
Local Land Use Planning Agencies	City of Hanford and Kings County
California Native American Tribes	See Appendix B, Section C.2
Disadvantaged Communities	Armona, Home Garde, Hardwick
Entities monitoring and reporting Subbasin groundwater elevations	Kings CWD monitors groundwater levels within its service area and is providing a subset of that information to the KRCD for submission to the CASGEM system.
South Fork Kings GSA	
Agricultural Users	Service area is composed of mostly agricultural lands and agricultural users.
Domestic Well Owners	There are domestic wells within the South Fork Kings GSA, and it is understood that many domestic users will fall into the "de minimis extractor" category, so further work is being conducted to understand to what extent domestic users will be affected by GSP requirements.
Municipal Well Operators	City of Lemoore, Stratford PUD
Local Land Use Planning Agencies	City of Lemoore, Kings County
California Native American Tribes	See Appendix B, Section C.2
Disadvantaged Communities	Community of Stratford
Entities monitoring and reporting Subbasin groundwater elevations	KRCD is the designated monitoring entity for the Kings and Tulare Lake Subbasins under CASGEM program. South Fork Kings GSA will coordinate its SGMA monitoring efforts with the CASGEM monitoring effort led by KRCD.
Southwest Kings GSA	
Agricultural Users	Approximately 99% of the GSA is composed of agricultural lands. Representatives of the agricultural community are currently involved on the GSA Board of Directors.
Domestic Well Owners	Only one or two landowners utilize a domestic well and are represented on the Board of Directors through member agencies.

See Acronyms and Abbreviations list for definitions.

Table 2-4. Beneficial Uses and Users by GSA (Continued)

Stakeholder Group	Description
Municipal Well Operators	Kettleman City CSD relies solely on surface water supply (effective October 2019). Their municipal wells are a back-up source to provide well water to residential and commercial customers within the GSA boundary in emergency situations when surface water is not accessible.
Local Land Use Planning Agencies	Kings County
California Native American Tribes	See Appendix D, Section C.2
Disadvantaged Communities	Kettleman City
Entities monitoring and reporting Subbasin groundwater elevations	KRCD is the designated monitoring entity for the Kings and Tulare Lake Subbasins under CASGEM program. Southwest Kings GSA will coordinate its SGMA monitoring efforts with the CASGEM monitoring effort led by KRCD.
El Rico GSA	
Agricultural Users	Represented through many of the GSA member agencies and/or by Kings County.
Domestic Well Owners	Represented through member agencies including Kings County or via exemption for small amounts of groundwater extraction.
Municipal Well Operators	City of Corcoran
Public Water Systems	City of Corcoran
Local Land Use Planning Agencies	City of Corcoran, Kings County
Surface Water Users	Represented through GSA member agencies
Disadvantaged Communities	City of Corcoran
Entities monitoring and reporting Subbasin groundwater elevations	Represented by GSA member agencies including TLBWSD that collects and reports data for multiple members of the agency via the Tulare Lake Coordinated Groundwater Management Plan.
Tri-County Water Authority GSA	
Agricultural Users	Composed almost entirely of agricultural users, including nut grower commodity groups and other agricultural use growers.
Domestic Well Owners	There are domestic wells within the GSA area, but because SGMA excludes “de minimis extractors,” it is anticipated that the GSP will exclude domestic wells from such requirements.
Local Land Use Planning Agencies	Kings County
Federal Government	Bureau of Land Management
Entities monitoring and reporting Subbasin groundwater elevations	Angiola WD, TLBWSD

Source: Appendix B.

See Acronyms and Abbreviations list for definitions.

Table 3-1. Historical Hanford Precipitation (Inches), Tulare Lake Subbasin SGMA Model, Kings County, California

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1899	M	M	M	M	M	M	M	M	0	0.67	M	0.87	M
1900	1.38	0	1.18	1.04	M	M	M	M	M	M	M	M	M
1901	M	M	M	M	M	M	M	T	1.04	T	M	0.15	M
1902	0.4	2	1.78	0.47	0.09	M	0	M	0	0.36	1.67	0.56	M
1903	1.31	0.38	1.71	0.5	0	0	0	0	0	0.05	0.47	0.15	4.57
1904	0.52	2.03	2.05	0.72	0	0	0	0	2.48	0.84	0.31	1.16	10.11
1905	1.28	1.09	2.1	0.56	0.65	0	0	0	0.07	0	1.16	0.23	7.14
1906	1.59	1.92	4.05	0.62	2.06	0.02	0	0	0	0	M	M	M
1907	M	M	M	M	M	M	M	M	M	M	M	M	M
1908	M	M	M	M	M	M	M	M	M	M	M	0.31	M
1909	M	M	M	M	M	M	M	M	M	M	M	M	M
1910	M	M	M	M	M	M	M	M	M	M	M	M	M
1911	M	M	M	M	M	M	M	M	M	M	M	M	M
1912	M	0.02	3.24	1.52	0.27	0	0	0	0	0	0.61	0.21	M
1913	1.26	1.55	0.34	0.78	0.76	0.06	0.08	0	M	M	M	1.35	M
1914	4.36	1.25	0.37	0.11	M	1.06	0	0	0	0	0.02	M	M
1915	M	M	0.3	1.37	M	M	M	M	M	M	M	M	M
1916	4.68	M	M	M	0.16	M	M	0.28	0.47	1.09	M	1.35	M
1917	M	M	M	M	0.31	M	M	M	M	M	M	M	M
1918	M	4.5	3.43	M	M	M	M	M	0.88	0.12	M	M	M
1919	M	M	1.01	0.15	0.1	M	M	M	M	M	M	M	M
1920	M	2.72	3.05	0.24	M	M	M	M	M	M	M	M	M
1921	M	0.89	M	M	0.87	M	M	M	M	M	M	M	M
1922	M	M	M	M	M	M	M	T	M	M	M	M	M
1923	M	M	M	2.43	M	M	M	M	M	M	M	0.22	M
1924	M	M	1.86	M	0	M	M	T	0	0.65	M	2.12	M
1925	M	M	1.58	M	M	M	0	M	0	M	M	M	M

See Acronyms and Abbreviations list for definitions.

Table 3-1. Historical Hanford Precipitation (Inches), Tulare Lake Subbasin SGMA Model, Kings County, California (Continued)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1926	0.82	1.44	0.2	2.67	T	0	0	0	0	0.76	3.67	0.65	10.21
1927	1.33	2.52	2.04	0.18	0.06	T	0	0.04	T	1.67	1.63	0.78	10.25
1928	0.09	0.96	1.55	0.08	0.1	0	0	0	0	T	1.47	1.69	5.94
1929	0.81	0.61	1.4	0.81	0	0.24	T	0	0.03	0	0	0.42	4.32
1930	1.66	1	1.66	0.15	0.37	0	0	0.02	0.38	0.07	0.67	0.3	6.28
1931	2.32	0.72	0.07	0.91	0.2	1.12	0	0.08	0.08	0	1.36	2.54	9.4
1932	1.85	1.52	0.47	0.71	0.13	0	0	0	0	0	0.28	0.93	5.89
1933	3.12	0.16	0.72	0.28	0.41	0.07	0	0	0	0.15	0	1.01	5.92
1934	0.17	1.53	0.05	0	0.22	0.14	0	0	0	1.06	2.15	1.84	7.16
1935	2.5	1.77	2	2.05	0	0	0.03	0	0.06	0.51	0.4	0.89	10.21
1936	0.66	4.7	0.97	0.55	T	T	0	0	0	1.84	0	2.87	11.59
1937	1.95	2.46	2.23	0.22	0	0	0	0	0	0.11	0.21	2.16	9.34
1938	1.76	3.51	4.59	1.15	0.11	0.17	0.07	0	0.13	0.19	0.19	1.42	13.29
1939	1.54	0.77	1.44	0.82	T	0.12	0	0	0.04	0.57	0.06	0.22	5.58
1940	3.53	3.61	0.99	0.18	T	T	0	0	0	0.85	T	3.61	12.77
1941	1.51	3.9	2.05	2.41	T	T	0	T	0	0.9	0.57	3.11	14.45
1942	1.21	0.88	0.94	1.19	0.16	0	0	M	0	0	0.43	1.1	M
1943	2.73	1.14	3.35	0.87	0	0	0	0	0	0.03	0.22	1.03	9.37
1944	1.28	2.97	0.22	0.86	0.28	0.23	0	0	0.02	0.23	2.25	0.97	9.31
1945	0.26	2.71	1.81	0.16	0.1	0.17	0	0	T	0.71	1.15	1.51	8.58
1946	0.34	1.53	2.56	0.07	0.41	0	0.11	0	0	1.33	1.1	2.06	9.51
1947	0.41	0.49	0.56	0.11	0.41	0	0	0	T	0.59	0.29	0.51	3.37
1948	0	0.44	1.46	1.55	0.54	0	0	0	0	0.03	0.01	0.99	5.02
1949	0.51	0.85	1.94	0.07	0.53	0	0	T	0	0	0.6	0.68	5.18
1950	1.93	1.13	1.1	0.4	0	0	0.08	0	0	0.34	0.63	1.06	6.67
1951	1.24	0.76	0.22	1.17	0.07	0	0	0	0	0.08	1.11	2.39	7.04
1952	3.08	0.27	2.18	0.79	0.01	0.02	T	0	0.17	0.05	0.65	2.96	10.18
1953	1.1	0.27	0.34	0.83	0.29	0.02	T	0	0	0.02	1.01	0.09	3.97
1954	1.89	0.78	2.21	0.52	0.34	0.08	0	0	0	0	0.66	1.61	8.09

See Acronyms and Abbreviations list for definitions.

Table 3-1. Historical Hanford Precipitation (Inches), Tulare Lake Subbasin SGMA Model, Kings County, California (Continued)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1955	3.25	1.31	M	M	0.9	0	0	M	0	0.02	0.92	4.67	M
1956	1.2	0.38	0.1	0.73	0.83	0	0	0	0	0.72	0	0.15	4.11
1957	1.39	1.17	0.56	0.67	0.63	0	0	0	0	0.2	1.39	1.41	7.42
1958	1.85	2.3	3.92	2.04	0.24	0	0	T	0.88	0	0.23	0.16	11.62
1959	0.86	1.9	0.11	0.52	T	0	0	T	0.11	0	0	0.17	3.67
1960	0.8	1.71	0.61	0.57	0	0	0.02	0	0	0.53	2.61	0.03	6.88
1961	1.34	0.22	0.67	0.22	0.37	0	0	0	0	0	1.11	1.28	5.21
1962	0.71	4.88	1.06	0	0.11	0	0	0	0.01	0.1	0	0.19	7.06
1963	1.19	1.68	1.37	2.88	0.56	0.17	0	0	0.33	0.75	1.23	0.29	10.45
1964	0.61	0.02	0.94	0.64	0.2	0	0	0.34	0	0.95	1.31	1.44	6.45
1965	1.18	0.33	0.33	1.6	0	0	0	0.05	0.07	0.05	2.15	1.97	7.73
1966	0.63	0.71	0.1	0	0.07	0.06	0.04	0	0.29	0	1.28	2.57	5.75
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1967	1.41	0.05	2.42	2.95	0.07	0.23	0	0	0.31	0	1.99	0.5	9.93
1968	0.57	0.64	1	0.5	0.08	0	0	0	0	1.33	0.98	1.64	6.74
1969	6.69	4.54	0.79	0.85	0.32	0.21	0.07	0	0.15	0.05	0.51	0.7	14.88
1970	1.6	1.33	1.42	0.16	0	T	T	0	0	T	2.4	1.23	8.14
1971	0.35	0.19	0.23	0.4	1.44	0	0	T	0.04	0.06	0.41	1.87	4.99
1972	0.04	0.35	0	0.23	0	0	0	0	0.24	0.21	2.9	0.65	4.62
1973	M	2.29	2.2	0.12	M	M	0	0	0	M	M	M	M
1974	2.97	0.11	1.75	0.03	0	0	0	0	0	0.65	0.24	1.4	7.15
1975	0.09	2.26	M	0.49	0	0	0	0	0.96	M	0.05	0.22	M
1976	T	2.94	0.19	1.47	0.03	0.51	0	0.22	1.47	0	1.15	0.96	8.94
1977	0.59	0.03	0.43	0	0.91	0.07	0	0	0	0.05	0.66	2.85	5.59
1978	2.22	5.05	4.12	1.71	0	0	0	0	1.1	0	0.79	0.5	15.49
1979	2.19	1.61	1.16	0.03	0	0	0.04	0	0.08	0.41	0.62	0.41	6.55
1980	2.9	2.71	1.28	0.05	0.04	0	0	0	0	0.09	0	0.2	7.27
1981	1.77	0.86	2.1	0.68	0.17	0	0	0	0	0.76	1.08	0.29	7.71
1982	0.84	0.38	3.52	1.75	0	0.45	0.18	0	0.64	1.03	2.15	0.71	11.65

See Acronyms and Abbreviations list for definitions.

Table 3-1. Historical Hanford Precipitation (Inches), Tulare Lake Subbasin SGMA Model, Kings County, California (Continued)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1983	3.74	2.59	3.39	1.63	0.04	0	0	0.05	0.82	0.43	1.66	1.22	15.57
1984	0.01	0.42	0.27	0.18	0	0	0	0	0	M	M	M	M
1985	0.59	M	0.7	0.12	0	0	M	0	T	M	2.11	0.66	M
1986	1.46	2.6	3.43	0.5	0	0	T	T	0.15	0	0.21	0.77	9.12
1987	1.77	2.07	2.02	0.06	0.13	0.05	0	0	0	0.58	0.47	1.7	8.85
1988	1.37	0.4	0.93	1.99	0.07	0	0	0	0	0	1.31	2.29	8.36
1989	0.17	1.04	0.85	0.02	0.39	0	0	T	0.67	0.32	0.2	0	3.66
1990	1.66	1.1	0.3	0.97	0.87	0	T	T	T	0.01	0.22	0.15	5.28
1991	0.31	0.12	6.62	0.19	T	0.12	0	0	0.11	0.41	0.14	M	M
1992	1.4	2.82	0.85	0.1	T	0	0.01	0.01	T	0.58	T	2.62	8.39
1993	3.88	2.48	2.16	0.07	0.08	0.3	0	0	0	0.24	0.64	0.66	10.51
1994	0.94	1.45	1.02	0.72	0.66	0	T	0	1.06	0.35	1.54	0.33	8.07
1995	4.7	0.51	4.77	0.65	0.87	0.04	T	0	T	0	T	1.59	13.13
1996	1.68	2.89	2.27	0.85	0.1	T	0	0	0	2.43	0.69	3.27	14.18
1997	3.02	0.12	0.21	0	0	T	T	0	0.06	0.09	1.96	1.8	7.26
1998	2	4.05	2.63	1.68	1.31	0.44	0	0	T	0.68	0.63	0.65	14.07
1999	3.01	0.56	0.43	1.37	0	0	0	T	0.01	0	0.15	T	5.53
2000	1.8	3.28	1.59	0.97	0.48	0.35	0	0	0.03	1.31	T	0.05	9.86
2001	1.98	1.48	1.24	1.12	0	0	0.09	0	T	0.18	1.84	1.99	9.92
2002	0.87	0.31	1.04	0.03	0.01	0.82	0	0	0	0	1.42	1.14	5.64
2003	0.24	1.08	1.01	1.5	0.62	0	T	0.07	0	0	0.49	2	7.01
2004	2	2.18	0.29	0.02	0.01	0	0	0	0	2.06	0.52	2.23	9.31
2005	2.63	1.58	2.24	0.71	0.83	0	0	T	0.01	0.01	0.19	2.07	10.27
2006	3.54	0.55	2.72	3.39	0.53	0	0	0	0	0.06	0.22	1.01	12.02
2007	0.65	0.89	0.26	0.33	0.01	0	0	0.12	0.37	0.35	0.12	1.32	4.42
2008	2.18	1.18	T	0	0.11	0	0	0	0	0.15	1.04	1.49	6.15
2009	0.8	1.86	0.2	0.02	0.41	0.22	0	0	0.18	1.32	0.28	1.42	6.71
2010	2.64	1.91	0.34	1.65	0.17	0	0	0	0	0.64	1.32	6.46	15.13
2011	1.52	1.53	2.87	0.3	0.4	1.04	0	0.08	0.01	0.55	0.8	0.06	9.16

See Acronyms and Abbreviations list for definitions.

Table 3-1. Historical Hanford Precipitation (Inches), Tulare Lake Subbasin SGMA Model, Kings County, California (Continued)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2012	M	M	M	1.39	0.03	M	T	0	0	0.28	0.49	1.9	M
2013	0.22	0.48	0.79	0.08	0.17	0	0	0	0.01	T	0.33	0.16	M
2014	0.3	1.38	0.27	0.35	T	0	0	0	0.03	0	0.94	2.52	5.79
2015	0.08	0.72	0.02	0.77	0.1	0	0.45	0	0	0.38	0.91	1.4	4.83
2016	2.56	0.58	1.99	0.57	0.02	0.09	0	0	0	0.76	0.4	1.6	8.57
2017	3.7	2.8	0.31	1.02	0.36	0.01	0	0.01	0.17	0.06	0.21	0.08	8.73
Mean	1.59	1.5	1.47	0.75	0.25	0.09	0.01	0.01	0.15	0.38	0.82	1.24	8.28
Min	6.69	5.05	6.62	3.39	2.06	1.12	0.45	0.34	2.48	2.43	3.67	6.46	15.57
	1969	1978	1991	2006	1906	1931	2015	1964	1904	1996	1926	2010	1983
Max	0	0	0	0	0	0	0	0	0	0	0	0	3.37
	1948	1900	1972	2008	2018	2015	2017	2016	2016	2014	1980	1989	1947

Source: https://w2.weather.gov/climate/xmacis.php?wfo=hnx.

Notes:
M – Data missing
T – Trace precipitation

See Acronyms and Abbreviations list for definitions.

Table 3-2. Historical Land Use, Tulare Lake Subbasin SGMA Model, Kings County, California

Tulare Lake Subbasin	1990-1995 (Acres)	1996-1998 (Acres)	1999-2006 (Acres)	2007 (Acres)	2008 (Acres)	2009 (Acres)	2010 (Acres)	2011 (Acres)	2012 (Acres)	2013 (Acres)	2014 (Acres)	2015 (Acres)	2016 (Acres)	Average (Acres)
Tulare Lake Subbasin														
Alfalfa Hay and Clover	41,604	32,564	54,301	72,459	80,600	71,504	69,685	38,789	42,131	49,318	35,820	29,665	24,245	45,987
Almonds (Adolescent)			2,908			5,127	7,927	3,222	4,464	7,476	6,526	6,222	5,365	2,470
Almonds (Mature)	7,682	5,241	4,550	12,897	11,825	9,826	8,374	10,140	10,818	11,441	12,876	15,046	15,105	7,852
Almonds (Young)		3,278	9,290	16,538	25,966	14,678	20,887	13,968	14,564	20,341	17,678	16,983	21,576	9,557
Berries	20								1	2		0		5
Carrot Single Crop								11	5	12	2	2	16	2
Citrus (no ground cover)			25		13	14	4	120	29	100	89	22	9	21
Corn and Grain Sorghum	14,280	38,896	29,349	39,271	31,762	34,643	23,031	33,780	29,175	27,566	22,638	18,826	17,400	25,404
Cotton	159,534	180,960	124,764	109,605	88,304	72,441	98,167	105,541	88,993	89,317	63,385	44,532	73,720	118,794
Dairy Single Crop*	3,816	4,077	4,385											2,438
Fallow Land*	193,695	138,392	89,606	65,169	85,144	99,688	90,192	152,391	172,697	172,486	195,172	237,790	200,972	136,159
Forest*	420	809	2,955	6	5	46	5			1		4	0	952
Grain and Grain Hay	28,708	48,533	62,962	19,266	27,870	27,406	25,980	7,758	9,968	11,194	12,213	21,196	19,069	34,833
Melons	250	56	284				14	2	11	7	797	18	86	170
Misc. field crops	17,116	12,819	51,311		2			0			2			18,531
Onions and Garlic	457	479	770			7	1,358	411	302	94	502	149	644	483
Open Water*	5,568	9,092	8,968	5,576	4,296	4,049	5,434	7,703	5,443	5,045	6,824	5,919	5,435	6,637
Pasture and Misc. Grasses	2,500	5,029	5,615	50,688	44,232	66,944	53,080	14,680	13,368	15,355	33,551	15,744	13,743	14,473
Pistachio (Adolescent)								170	218	370	882	3,575	3,836	335
Pistachio (Mature)	4,694	3,808	3,804	6,096	1,907	934	404	394	380	348	330	485	469	2,888
Pistachio (Young)		1,580	4,390	4,351	4,259	8,527	8,083	12,985	14,676	15,878	19,195	22,678	22,570	6,247
Pomegranates (Adolescent)											3	16	27	2
Pomegranates (Young)				61	1,705	545	256	5,012	804	1,395	2,207	1,312	3,111	608
Potatoes, Sugar beets, Turnip etc..	5,736	1	209	6		3		9		41		2	2	1,331
Riparian*		668	1,120	517	134	398	615	226	138	313	239	248	194	477
Small Vegetables	1,599	647	4,518	20	2	13	212	142	133	244	165	78	198	1,643
Stone Fruit (Adolescent)			1,478			14	66	100	125	69	47	191	170	412
Stone Fruit (Mature)	7,070	4,985	3,854	1,314	544	168	18	3	23	41	23	27	39	3,206
Stone Fruit (Young)		1,827	4,185	672	1,609	1,573	2,502	1,077	712	1,641	1,340	1,183	713	1,770
Tomatoes and Peppers	5,634	1,627	14,676	117	2	110	12	21,482	23,670	7,114	11,922	19,211	23,420	9,203
Urban, Industrial*	12,654	17,391	19,875	33,427	34,711	44,471	32,218	32,091	28,576	29,366	33,901	30,530	30,930	22,128
Wine Grapes with 80% canopy	2,948	3,226	5,779	5,588	3,499	2,240	2,746	5,361	9,228	4,655	6,472	4,672	10,985	4,565
Winter Wheat*				72,238	67,458	50,451	64,526	48,212	45,118	44,530	30,950	19,420	21,690	17,207
Tulare Lake Subbasin Irrigated Crop Acreage	**299,832**	**345,557**	**389,021**	**338,951**	**324,102**	**316,717**	**322,806**	**275,156**	**263,796**	**264,018**	**248,665**	**221,837**	**256,519**	**310,792**
Tulare Lake Subbasin Total Crop Acreage	**515,986**	**515,986**	**515,931**	**515,883**	**515,849**	**515,821**	**515,796**	**515,779**	**515,768**	**515,759**	**515,751**	**515,747**	**515,741**	**496,788**

Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year

See Acronyms and Abbreviations list for definitions.

Table 3-3. Generalized Stratigraphic Column for Tulare Lake Subbasin

System	Series	Geologic Unit		Lithologic Character	Maximum Thickness (feet)	Water-Bearing Character	Areas Where Important
QUATERNARY	Holocene	Tulare Formation	Flood Basin Deposits	Interbedded silt, clay, and fine sand. Interfingers with and age equivalent to Younger Alluvium.	<50	Poorly permeable, poor quality water, unconfined.	Not important source of water.
			Younger Alluvium	Interstratified and discontinuous beds of clay, silt, sand, and gravel, primarily located on recent alluvial fans and along stream channels. Interfingers with flood-basin and lake bed deposits.	0 - 100	Highly permeable, but largely unsaturated or seasonally saturated. Serves as conduit for recharge to underlying units.	May provide sufficient supplies for domestic and stock use where saturated.
	Pleistocene		Older Alluvium	Poorly to well sorted fine to coarse sand, gravel, silt and clay. Represents older alluvial fan material and contains well-developed soil profiles and hardpan horizons. Interfingers with lacustrine clays.	300 - 500	Moderately to highly permeable, unconfined and semiconfined. Yields large quantities of water to wells, major aquifer.	Important source of groundwater on eastern and northern portions of TLSB.
			Lacustrine Deposits	Corcoran Clay is extensive reduced clay formed in large fresh-water lake in late Pleistocene that extended throughout most of the San Joaquin Valley. Has been deformed across valley axis and has been dated at about 600,000 Ma.	50 - 200	Poorly permeable, forms major aquitard within San Joaquin Valley.	Occurs beneath nearly the entire TLSB, including Tulare Lake. Important aquitard on eastern and northern portions of TLSB.
				Tulare Lake bed clays are thick deposits that extend vertically from the surface beneath the former lake. These beds interfinger with alluvial and continental deposits to the east and west. Croft (1972) identified several of these interfingering lacustrine clay beds as the A-D and F clays. His E-clay is equivalent to the Corcoran Clay (above).	0 - 3,000	Poorly permeable, forms significant barrier to lateral groundwater flow in the TLSB and lateral tongues can form local confining conditions in alluvial and continental deposits.	Tulare Lake bed forms clay plug on western portion of TLSB. A and C clays are thin (10 - 60 feet) beds that may be important aquitards on the northern and eastern portions of TLSB.
TERTIARY	Pliocene		Continental Deposits, undifferentiated	Poorly to moderately sorted fine to medium sand, silt, gravel, and clay. Deposits may be reduced or oxidized. Provenance may be from Sierra Nevada or Coast Ranges. Sierran deposits typically arkosic and coarser grained than Coast Ranges deposits. Deposits from each provenance interfingering in an east-west line, depending upon major transgressive deposition from each mountain range.	2,000+	Poorly to moderately permeable, semi-confined to confined conditions. Yields significant quantities of groundwater, especially below Corcoran Clay.	Important source of groundwater on eastern and northern portions of TLSB and northwest and southeast of TLSB.
		San Joaquin Formation	Marine Deposits	Poorly sorted fine-grained sandstone, siltstone, and mudstone.	1,500+	Exposed in Kettleman Hills, dips steeply to east beneath Tulare formation. Semi-consolidated to consolidated, containing connate water of poor quality. Formation is poorly permeable and forms substantial aquitard at base of Tulare Formation.	No known beneficial uses of water, typical TDS of 3,000 to 20,000 mg/L.
		Etchegoin Formation	Marine Deposits	Silty and clayey sands, sandy silt, silty clay, blue sandstone, and conglomeratic sandstone.	3,000+	Exposed in Kettleman Hills, dips steeply to east beneath San Joaquin formation. Fine grained, interbedded nature, contains saline water.	No known wells into formation, not expected to be an aquifer.
	Miocene	Santa Margarita Formation	Marine Deposits	Fairly well-sorted to well-sorted gray sandstone.	0 - 600	Contains good quality water and yields significant water to wells for irrigation in places. However, sodium chloride front exists about 7 to 10 miles east of Highway 99.	Extensively used as aquifer in area from Terra Bella to Richgrove, east of Highway 99. Not an important aquifer in the TLSB.
	Eocene/Oligocene	Other Tertiary Sediments (undifferentiated)	Marine and Non-Marine Deposits		----	Few formations that contain usable water quality.	Too deep to be of concern in or near TLSB.
PRE-TERTIARY	Paleozoic/Mesozoic	Metamorphic and Igneous Rocks	Basement Complex	Crystalline rocks of metamorphosed sedimentary and igneous rocks invaded by largely granitic plutonic rocks.	----	Largely impermeable, contain fractures, faults, and joints that may yield small quantities of water to domestic and stock wells.	Used as water source only in foothills and mountain areas of Sierra Nevada.

Notes: Generalized stratigraphic column after Hilton et al., 1963; Croft and Gordon, 1968; Davis et al., 1959; Loomis, 1990; and Wood, 2018.

See Acronyms and Abbreviations list for definitions.

Table 3-4. Annual Specified Well Field Pumping, Tulare Lake Subbasin SGMA Model, Kings County, California

Date	El Rico GSA Well Field (AF/Y)	Creighton Ranch Well Field (AF/Y)	Corcoran ID Well Field (AF/Y)	Angiola Well Field (AF/Y)	Westlands Well Field (AF/Y)	Municipal Well Fields (AF/Y)	Apex Ranch Well Field (AF/Y)
1990	70,716	27,222	87,977	34,500	67,131	9,370	--
1991	57,509	38,484	84,438	23,396	98,656	9,109	--
1992	80,012	27,255	72,348	33,494	98,344	9,666	--
1993	11,395	4,035	14,248	5,956	44,056	10,208	--
1994	48,043	17,986	78,297	16,389	72,674	10,928	--
1995	2,897	905	7,145	-	27,589	10,775	--
1996	-	-	20,261	-	28,516	12,719	--
1997	-	-	15,586	-	27,000	12,775	--
1998	-	-	2,484	-	20,988	11,555	--
1999	-	-	33,406	-	37,185	13,087	--
2000	14,910	2,849	40,672	6,784	43,392	13,421	--
2001	89,799	41,120	64,353	23,244	65,947	13,895	--
2002	68,933	35,843	64,736	26,537	66,530	26,701	-
2003	32,420	10,856	62,246	22,429	40,841	19,349	526
2004	82,875	47,511	74,007	26,805	42,115	18,777	912
2005	-	468	20,138	662	14,744	16,536	-
2006	-	72	14,034	141	16,526	15,822	6,939
2007	69,863	40,266	85,434	32,894	40,373	17,221	6,319
2008	92,269	52,980	79,362	32,502	63,519	18,432	5,435
2009	78,097	45,292	81,493	37,798	69,904	16,354	7,677
2010	36,129	17,740	29,669	22,568	34,895	15,271	6,345
2011	606	314	7,328	11,336	15,509	17,042	-
2012	95,154	52,325	70,008	19,388	55,298	17,467	9,044
2013	100,275	66,005	78,175	30,528	70,940	18,411	4,970
2014	108,976	68,726	69,880	27,695	94,077	16,930	298
2015	116,254	61,050	67,982	30,220	90,723	16,146	-
2016	126,886	53,113	67,982	29,047	93,853	14,555	-
1990-2016 Average	51,260	26,386	51,618	18,308	53,382	14,908	4,847
1998-2010 Average	43,484	22,692	50,156	17,874	42,843	16,648	4,879
Well Count	99	52	98	51	150	30	5

See Acronyms and Abbreviations list for definitions.

Table 3-5. Historical Kings River Diversions, Tulare Lake Subbasin SGMA Model, Kings County, California

	GSA	Mid Kings River					South Fork Kings							Southwest Kings									
	Agency	Peoples Ditch Company	Last Chance Water Ditch Co.				Stratford Irrigation District	Empire West Side Irrigation District		Lemoore Canal & Irrigation Company						Dudley Ridge Water District-Monthly Diversions Assumed							
Kings River Water Years	Diversion	*Peoples Canal- MKRGSA Total*	*Last Chance Canal- MKRGSA Total*	*Lakeside IWD*	Imported Water	Mid Kings	Stratford Canal	Empire West Side ID total from SWP	Empire West Side Canal	Westlake Canal	Lemoore Canal	Imported Water	South Fork Kings River	*Blakeley Canal-Kings River & Lateral A*	TLBWSD Lateral C, T203	Dudley Ridge State Turnout (DR-1), T201	Dudley Ridge State Turnout (DR-1B), T202	Dudley Ridge State Turnout (DR-1A), T204	Dudley Ridge State Turnout (DR-2), T205	Dudley Ridge State Turnout (Paramount), T207	Dudley Ridge State Turnout (DR-3), T208	Imported Water, Angiola/Green Valley Well Fields, City of Lemoore and Westlands RD 761	Southwest Kings
		(acre-feet per year)																					
71%	1966	107,763	50,356	-	-	158,119	2,158	-	4,770	3,604	96,079	-	106,612	20,559	-	-	-	-	-	-	-	-	20,559
197%	1967	136,889	78,468	-	-	215,358	3,947	-	9,622	5,861	109,323	-	128,753	29,187	-	-	-	-	-	-	-	-	29,187
49%	1968	75,809	31,878	-	-	107,688	3,540	1,780	13,636	12,718	91,478	-	123,153	19,692	0	3,312	949	2,372	11,388	9	5,694	-	43,416
256%	1969	107,636	61,339	-	-	168,975	1,139	50	2,878	6,056	87,537	-	97,659	534	0	3,942	1,130	2,824	13,554	11	6,777	-	28,771
78%	1970	76,723	38,772	-	-	115,495	1,884	3,548	5,359	7,305	93,441	-	111,538	0	0	5,077	1,455	3,637	17,456	15	8,728	-	36,366
69%	1971	86,815	35,321	-	-	122,137	4,376	5,391	4,665	10,280	96,498	-	121,210	10,521	0	5,158	1,478	3,695	17,735	15	8,867	-	47,469
50%	1972	51,631	38,190	-	-	89,820	4,062	5,216	6,188	5,133	80,465	-	101,065	20,920	0	5,333	1,528	3,820	18,335	15	9,168	-	59,119
125%	1973	139,667	62,672	-	-	202,339	4,411	5,233	5,964	6,543	86,382	-	108,534	22,249	0	4,429	1,269	3,172	15,228	13	7,614	-	53,973
122%	1974	137,406	68,454	-	-	205,860	4,082	4,085	9,291	10,508	102,115	-	130,081	37,966	0	8,390	2,404	6,010	28,849	24	14,425	-	98,069
92%	1975	109,458	43,937	-	-	153,395	4,570	5,803	8,763	10,939	104,388	-	134,463	36,603	0	10,191	2,920	7,300	35,040	29	17,520	-	109,602
32%	1976	37,828	2,255	-	-	40,083	4,284	5,811	5,915	5,004	70,925	-	91,940	22,247	0	7,770	2,226	5,566	26,716	22	13,358	-	77,906
23%	1977	43,393	9,542	-	-	52,935	2,203	2,120	1,598	557	42,067	-	48,545	8,903	0	3,633	1,041	2,603	12,493	10	6,246	-	34,930
201%	1978	125,769	71,577	-	-	197,346	2,859	409	10,627	9,312	80,567	-	103,774	26,094	0	7,455	2,136	5,340	25,632	21	12,816	-	79,494
101%	1979	125,680	64,463	-	-	190,143	6,434	1,565	15,449	9,523	107,578	-	140,549	52,496	0	9,685	2,775	6,938	33,302	28	16,651	-	121,876
178%	1980	101,388	64,365	-	-	165,753	3,981	805	16,100	11,566	103,714	-	136,165	53,639	0	10,061	2,883	7,207	34,594	29	17,297	-	125,710
61%	1981	89,091	47,482	-	-	136,572	4,435	7,966	7,841	9,437	89,111	-	118,790	42,806	0	9,213	2,640	6,599	31,677	26	15,839	-	108,800
181%	1982	127,200	65,413	-	-	192,613	4,479	4,379	9,396	20,983	100,153	-	139,389	41,213	0	6,968	1,997	4,992	23,960	20	11,980	-	91,130
261%	1983	60,994	48,013	-	-	109,007	3,808	0	6,097	10,389	58,631	-	78,926	22,250	0	7,026	2,013	5,033	24,157	20	12,078	-	72,577
115%	1984	97,831	53,649	-	-	151,480	2,533	0	2,801	3,800	99,362	-	108,496	10,003	0	8,116	2,326	5,814	27,907	23	13,954	-	68,144

	GSA	El Rico													Tri-County Water Authority										
Kings River Water Years	Diversion	*Empire Weir No. 2 (over #2 weir to river extension, River Water) Modified Total-(Empire Weir No. 2 minus Tri-County Kings River*	*TLBWSD Lateral A, T200 (State Water)-Modified Total-(SWP Total for Lateral A minus Tri-County Entitlement, Then 20% taken*	*TLBWSD Lateral B, T206 (State Water)-Modified Total-(SWP Total for Lateral B minus Tri-County Entitlement)*	Lakelands Canal-Total	Tulare Lake Canal	*Melga Canal-Diversion of Peoples Canal, El Rico GSA Total*	Kern River	*Deer Creek-30% of Deer Creek Total*	Tule River-El Rico	Kaweah River	*Loan Oak/New Deal- Diversion of Last Chance, El Rico GSA Total*	Imported Water	El Rico	Poso Creek	*TLBWSD Lateral A, T200 (State Water)-Assumed Full Entitlement-25% to Lateral A*	*TLBWSD Lateral B, T206 (State Water)-Assumed Full Entitlement-75% to Lateral B*	Tule River-Tri-County	*Deer Creek-70% of Deer Creek Total*	White River	Kings River-Tri-County	Other Water	Imported Water	Tri-County	Annual Totals
		(acre-feet per year)																							
71%	1966	2,404	-	-	14,225	17,831	71,842	-	-	-	-	21,581	-	127,884	-	-	-	-	-	-	-	-	-	0	413,173
197%	1967	82,883	-	-	71,671	42,476	91,260	-	-	-	-	33,629	-	321,919	-	-	-	-	-	-	-	-	-	0	695,217
49%	1968	4,673	6,208	10,256	17,218	49,218	50,540	-	-	-	-	13,662	-	151,775	-	923	2,768	-	-	-	-	-	-	3,690	429,722
256%	1969	196,219	1,751	2,893	40,568	0	71,757	-	-	-	-	26,288	-	339,477	-	260	781	-	-	-	-	-	-	1,041	635,924
78%	1970	0	0	0	52,483	0	51,149	-	-	-	-	16,617	-	120,248	-	0	0	-	-	-	-	-	-	0	383,648
69%	1971	0	28,648	47,329	28,610	490	57,877	-	-	-	-	15,138	-	178,091	-	4,257	12,771	-	-	-	-	-	-	17,028	485,935
50%	1972	1,099	62,463	103,195	0	7,305	34,420	-	-	-	-	16,367	-	224,849	-	9,282	27,846	-	-	-	-	-	-	37,128	511,981
125%	1973	530	27,591	45,583	19,101	31,948	93,111	-	-	-	-	26,860	-	244,723	-	4,100	12,300	-	-	-	-	-	-	16,400	625,968
122%	1974	14,906	34,058	56,123	55,482	28,336	91,604	-	0	-	-	29,337	-	309,845	0	5,157	15,472	1,402	0	0	0	0	-	22,032	765,886
92%	1975	11,905	53,639	89,737	41,833	53,125	72,972	-	0	-	-	18,830	-	342,042	0	7,224	21,671	224	0	0	2,642	0	-	31,760	771,261
32%	1976	0	28,360	47,863	3,493	45,170	25,219	-	0	-	-	967	-	151,071	0	3,541	10,624	0	0	0	9,154	0	-	23,320	384,320
23%	1977	1,732	11,813	21,197	0	4,003	28,929	-	0	-	-	4,090	-	71,762	0	635	1,905	0	0	0	950	0	-	3,490	211,662
201%	1978	33,029	2,139	3,073	31,904	49,511	83,846	-	3,000	-	-	30,676	-	237,179	1,500	624	1,873	2,476	7,000	1,000	11,956	0	-	26,430	644,222
101%	1979	2,523	55,518	97,690	34,336	32,856	83,787	-	0	-	-	27,627	-	334,337	0	4,271	12,814	185	0	0	6,575	0	-	23,846	810,750
178%	1980	41,353	20,733	34,131	37,277	29,258	67,592	-	1,800	-	-	27,585	-	259,729	900	3,163	9,488	2,611	4,200	600	2,819	0	-	23,780	711,136
61%	1981	8,761	78,820	140,237	9,180	19,710	59,394	-	0	742	78,485	20,349	-	415,677	0	5,033	15,099	223	0	0	8,983	0	-	29,338	809,178
181%	1982	45,602	21,698	36,788	54,659	77,268	84,800	-	5,660	63,476	171,808	28,034	-	589,793	2,830	2,598	7,793	3,090	13,207	1,887	12,547	0	-	43,951	1,056,876
261%	1983	238,616	278	522	21,919	1,333	40,663	-	12,150	193,800	114,301	20,577	-	644,159	6,075	0	0	340	28,350	4,050	0	0	-	38,815	943,484
115%	1984	17,704	1,265	1,917	42,516	0	65,220	-	19,804	17,566	120,846	22,992	-	309,830	9,902	303	909	0	46,210	6,601	0	0	-	63,925	701,875

See Acronyms and Abbreviations list for definitions.

	GSA	Mid Kings River					South Fork Kings							Southwest Kings										El Rico													Tri-County Water Authority										
	Agency	Peoples Ditch Company	Last Chance Water Ditch Co.				Stratford Irrigation District	Empire West Side Irrigation District			Lemoore Canal & Irrigation Company					Dudley Ridge Water District-Monthly Diversions Assumed																															
Kings River Water Years	Diversion	*Peoples Canal- MKRGSA Total*	*Last Chance Canal- MKRGSA Total*	*Lakeside IWD*	Imported Water	Mid Kings	Stratford Canal	Empire West Side ID total from SWP	Empire West Side Canal	Westlake Canal	Lemoore Canal	Imported Water	South Fork Kings River	*Blakeley Canal-Kings River & Lateral A*	TLBWSD Lateral C, T203	Dudley Ridge State Turnout (DR-1), T201	Dudley Ridge State Turnout (DR-1B), T202	Dudley Ridge State Turnout (DR-1A), T204	Dudley Ridge State Turnout (DR-2), T205	Dudley Ridge State Turnout (Paramount), T207	Dudley Ridge State Turnout (DR-3), T208	Imported Water, Angiola/Green Valley Well Fields, City of Lemoore and Westlands RD 761	Southwest Kings	*Empire Weir No. 2 (over #2 weir to river extension, River Water) Modified Total-(Empire Weir No. 2 minus Tri-County Kings River*	*TLBWSD Lateral A, T200 (State Water)-Modified Total-(SWP Total for Lateral A minus Tri-County Entitlement, Then 20% taken*	*TLBWSD Lateral B, T206 (State Water)-Modified Total-(SWP Total for Lateral B minus Tri-County Entitlement)*	Lakelands Canal-Total	Tulare Lake Canal	*Melga Canal-Diversion of Peoples Canal, El Rico GSA Total*	Kern River	*Deer Creek-30% of Deer Creek Total*	Tule River-El Rico	Kaweah River	*Loan Oak/New Deal- Diversion of Last Chance, El Rico GSA Total*	Imported Water	El Rico	Poso Creek	*TLBWSD Lateral A, T200 (State Water)-Assumed Full Entitlement-25% to Lateral A*	*TLBWSD Lateral B, T206 (State Water)-Assumed Full Entitlement-75% to Lateral B*	Tule River-Tri-County	*Deer Creek-70% of Deer Creek Total*	White River	Kings River-Tri-County	Other Water	Imported Water	Tri-County	Annual Totals
		(acre-feet per year)																																													
73%	1985	105,362	39,583	-	-	144,944	4,869	4,677	5,209	6,827	103,148	-	124,731	34,288	0	7,791	2,232	5,581	26,788	22	13,394	-	90,096	16,118	49,527	84,042	20,108	29,821	70,241	-	0	367	73,859	16,964	-	361,048	0	5,881	17,644	826	0	0	1,586	0	-	25,937	746,756
190%	1986	111,962	62,457	-	-	174,419	7,329	2,070	7,345	16,723	87,761	-	121,227	27,361	0	6,427	1,841	4,604	22,098	18	11,049	-	73,398	28,395	23,163	41,528	50,896	51,205	74,641	-	5,144	43,384	71,918	26,767	-	417,043	2,572	1,269	3,806	1,701	12,004	1,715	11,054	0	-	34,121	820,207
45%	1987	70,406	24,792	-	-	95,198	5,177	3,961	4,959	10,982	90,541	-	115,620	28,582	0	5,816	1,666	4,166	19,996	17	9,998	-	70,242	18,250	35,048	60,441	27,104	57,023	46,938	-	0	0	44,445	10,625	-	299,874	0	3,517	10,550	0	0	0	9,366	0	-	23,432	604,366
48%	1988	60,312	21,844	-	-	82,156	3,953	3,128	4,457	2,949	76,554	-	91,041	21,261	0	6,030	1,728	4,319	20,733	17	10,367	-	64,456	8,209	23,389	40,544	18,863	17,816	40,208	-	0	0	25,873	9,362	-	184,264	0	2,207	6,622	0	0	0	984	0	-	9,814	431,730
53%	1989	60,579	19,935	-	-	80,514	0	2,700	0	-	56,519	-	59,219	13,458	0	7,168	2,054	5,134	24,645	21	12,323	-	64,802	0	44,142	75,859	7,458	0	40,386	-	0	0	24,550	8,544	-	200,939	0	4,605	13,814	150	0	0	0	1,580	-	20,149	425,623
40%	1990	53,292	9,909	-	-	63,201	0	2,979	0	-	34,465	-	37,444	6,485	0	4,606	1,320	3,299	15,836	13	7,918	14,540	54,016	0	21,271	37,168	15,114	0	35,528	-	0	0	39,853	4,247	-	153,181	0	1,810	5,430	0	0	0	0	4,556	-	11,796	319,638
63%	1991	45,654	18,622	-	-	64,276	1,760	199	1,006	964	31,492	-	35,420	5,941	0	1,670	479	1,196	5,743	5	2,871	8,181	26,085	344	1,536	2,855	6,143	2,870	30,436	-	0	0	28,897	7,981	-	81,060	0	16	49	604	0	0	1,604	0	-	2,274	209,115
41%	1992	49,394	9,361	-	-	58,755	1,759	1,219	0	0	37,968	-	40,945	6,003	0	1,696	486	1,215	5,831	5	2,915	6,095	24,245	0	19,688	35,181	0	0	32,930	-	279	0	23,442	4,012	-	115,532	140	1,156	3,469	0	652	93	0	0	-	5,510	244,987
149%	1993	147,363	53,498	-	-	200,860	5,070	2,467	4,314	8,612	91,166	-	111,629	30,546	0	2,917	836	2,090	10,031	8	5,016	6,480	57,925	25,174	31,782	58,745	66,990	44,555	68,050	-	101	0	108,379	22,928	-	426,703	50	565	1,694	1,155	235	34	6,919	2,575	-	13,226	810,344
50%	1994	69,510	30,738	-	-	100,248	2,997	1,499	3,808	6,811	76,550	-	91,666	26,295	0	3,834	1,099	2,747	13,184	11	6,592	11,642	65,404	15,625	15,834	28,204	0	49,718	38,072	-	0	0	28,376	-	-	175,829	0	990	2,970	0	0	0	6,098	0	-	10,058	443,205
202%	1995	143,785	102,300	-	-	246,085	6,123	1,468	6,419	1,410	85,049	-	100,469	34,039	0	5,715	1,637	4,094	19,650	16	9,825	8,131	83,107	51,722	34,276	59,720	52,969	48,240	75,670	-	2,285	13,777	149,232	-	-	487,891	1,142	3,032	9,095	6,040	5,331	762	4,902	0	-	30,303	947,854
122%	1996	166,765	95,338	-	-	262,103	6,774	1,681	5,576	5,778	105,398	-	125,206	41,813	0	6,886	1,973	4,933	23,677	20	11,839	14,505	105,645	33,027	60,026	107,966	61,767	36,006	81,522	-	1,847	236	139,238	-	-	521,635	924	3,055	9,165	1,913	4,311	616	2,219	0	-	22,202	1,036,790
155%	1997	133,158	85,505	20,657	-	239,321	7,460	0	8,239	2,079	89,117	-	106,896	25,259	0	7,895	2,262	5,655	27,146	23	13,573	11,319	93,132	19,089	5,679	2,107	32,557	25,047	65,232	-	9,220	40,122	66,638	-	-	265,690	4,610	1,895	5,684	1,701	21,513	3,073	4,729	0	-	43,206	748,244
181%	1998	141,107	77,863	29,871	-	248,841	5,578	488	4,596	8,447	75,590	-	94,698	17,157	3,528	6,955	1,993	4,982	23,916	20	11,958	11,348	81,857	4,514	5,745	17,487	32,918	16,707	75,570	-	5,590	26,731	58,340	-	-	243,601	2,795	1,057	3,171	2,083	13,042	1,863	50	0	-	24,061	693,058
74%	1999	101,773	62,938	12,119	-	176,830	4,971	2,858	6,135	3,624	95,504	-	113,092	25,132	0	7,958	2,280	5,701	27,363	23	13,681	10,280	92,418	4,359	59,502	140,451	8,184	13,492	49,810	-	0	2,235	51,184	-	-	329,217	0	95	286	274	0	0	167	0	-	822	712,379
90%	2000	108,835	82,526	13,181	-	204,541	4,598	1,619	2,184	4,566	99,074	-	112,041	21,426	0	7,397	2,119	5,299	25,433	21	12,717	10,299	84,711	16,796	39,928	86,346	35,062	33,304	56,416	-	871	2,900	48,050	-	-	319,674	435	3,935	11,804	1,166	2,032	290	0	0	-	19,663	740,630
59%	2001	73,419	31,031	7,017	-	111,467	4,959	1,674	1,993	2,680	58,979	-	70,285	11,377	0	6,030	1,728	4,319	20,732	17	10,366	10,306	64,875	21,146	21,658	39,067	2,122	38,045	38,433	-	0	8	20,131	-	-	180,610	0	1,027	3,082	0	0	0	3,044	3,000	-	10,154	437,390
67%	2002	99,376	52,020	5,354	-	156,751	4,104	1,265	1,364	2,202	74,196	-	83,131	13,083	0	6,930	1,986	4,964	23,828	20	11,914	10,291	73,016	14,150	20,707	33,324	46,842	7,942	45,043	-	0	490	73,770	-	-	242,267	0	2,004	6,011	124	0	0	0	190	-	8,329	563,493
83%	2003	104,545	54,735	13,325	-	172,605	4,356	1,292	752	3,362	63,511	-	73,273	8,256	0	6,657	1,907	4,768	22,888	19	11,444	10,359	66,299	13,153	14,887	44,894	36,750	45,168	48,228	-	0	1,748	49,413	-	-	254,241	0	2,152	6,455	790	0	0	6,652	160	-	16,209	582,626
61%	2004	79,743	27,306	5,667	-	112,717	2,019	3,206	1,650	1,480	58,257	-	66,611	12,382	0	6,383	1,829	4,572	21,946	18	10,973	10,072	68,176	17,145	22,857	42,460	40,917	16,768	40,719	-	0	1,106	59,030	-	-	241,003	0	265	795	559	0	0	0	5,293	-	6,912	495,419

See Acronyms and Abbreviations list for definitions.

(acre-feet per year)

Kings River Water Years	Diversion	Mid Kings River: Peoples Ditch Company – *Peoples Canal- MKRGSA Total*	Mid Kings River: Last Chance Water Ditch Co. – *Last Chance Canal- MKRGSA Total*	Mid Kings River: *Lakeside IWD*	Mid Kings River: Imported Water	Mid Kings River: Mid Kings	South Fork Kings: Stratford Irrigation District – Stratford Canal	South Fork Kings: Empire West Side Irrigation District – Empire West Side ID total from SWP	South Fork Kings: Empire West Side Irrigation District – Empire West Side Canal	South Fork Kings: Westlake Canal	South Fork Kings: Lemoore Canal & Irrigation Company – Lemoore Canal	South Fork Kings: Imported Water	South Fork Kings: South Fork Kings River
148%	2005	131,193	54,799	24,547	-	210,539	5,619	3,451	2,664	1,946	98,279	-	111,958
172%	2006	129,571	65,459	24,718	-	219,748	6,065	2,954	5,417	2,368	96,857	-	113,661
40%	2007	84,144	20,918	3,312	-	108,374	4,836	1,876	3,810	4,727	70,288	-	85,536
72%	2008	81,364	29,000	6,764	-	117,128	2,037	852	1,470	1,081	59,988	-	65,428
79%	2009	85,743	30,617	5,829	-	122,189	2,047	148	1,811	1,771	49,297	-	55,074
121%	2010	113,146	42,817	16,103	-	172,066	4,318	2,545	3,644	2,900	90,694	-	104,101
180%	2011	163,801	79,589	23,764	-	267,154	4,979	1,364	4,625	4,947	109,605	-	125,519
49%	2012	80,025	30,309	4,595	-	114,929	4,203	1,151	4,594	2,289	71,207	-	83,443
41%	2013	49,246	12,881	110	-	62,236	0	536	0	0	43,206	-	43,741
32%	2014	27,801	8,824	0	-	36,626	0	158	0	0	17,905	-	18,062
21%	2015	12,430	-	0	-	12,430	0	326	0	0	14,759	-	15,085
75%	2016	67,310	20,567	2,986	-	90,863	0	-	0	0	42,532	-	42,532
204%	2017	-	-		-	-	-	-	-	-	-	-	-
	Annual Averages	93,943	44,985	4,312		143,240	3,669	2,156	4,804	5,315	77,554		93,499

Kings River Water Years	Diversion	Southwest Kings: *Blakeley Canal-Kings River & Lateral A*	Southwest Kings: TLBWSD Lateral C, T203	Southwest Kings: Dudley Ridge Water District-Monthly Diversions Assumed – Dudley Ridge State Turnout (DR-1), T201	Dudley Ridge State Turnout (DR-1B), T202	Dudley Ridge State Turnout (DR-1A), T204	Dudley Ridge State Turnout (DR-2), T205	Dudley Ridge State Turnout (Paramount), T207	Dudley Ridge State Turnout (DR-3), T208	Southwest Kings: Imported Water, Angiola/Green Valley Well Fields, City of Lemoore and Westlands RD 761	Southwest Kings: Southwest Kings	El Rico: *Empire Weir No. 2 (over #2 weir to river extension, River Water) Modified Total-(Empire Weir No. 2 minus Tri-County Kings River*	El Rico: *TLBWSD Lateral A, T200 (State Water)-Modified Total-(SWP Total for Lateral A minus Tri-County Entitlement, Then 20% taken*	El Rico: *TLBWSD Lateral B, T206 (State Water)-Modified Total-(SWP Total for Lateral B minus Tri-County Entitlement)*	El Rico: Lakelands Canal-Total
148%	2005	24,480	0	7,366	2,111	5,276	25,327	21	12,663	11,115	88,360	73,872	27,755	75,546	42,290
172%	2006	34,147	0	7,766	2,225	5,563	26,702	22	13,351	11,115	100,891	70,800	22,444	52,463	80,614
40%	2007	25,308	0	6,090	1,745	4,363	20,940	17	10,470	9,975	78,909	21,586	20,496	39,927	17,889
72%	2008	10,209	0	5,292	1,516	3,791	18,195	15	9,097	10,016	58,131	9,553	9,155	11,833	8,051
79%	2009	7,997	0	3,982	1,141	2,852	13,691	11	6,846	12,178	48,699	855	8,865	13,750	22,036
121%	2010	17,655	0	4,144	1,187	2,969	14,249	12	7,125	42,300	89,641	34,789	9,185	32,026	38,210
180%	2011	43,781	0	3,373	966	2,416	11,597	10	5,799	34,012	101,953	89,121	13,902	25,964	88,052
49%	2012	22,689	0	2,775	795	1,988	9,543	8	4,771	51,435	94,006	24,964	16,910	43,921	3,483
41%	2013	3,284	0	3,591	1,029	2,572	12,346	10	6,173	19,602	48,606	0	10,771	13,062	58,140
32%	2014	567	0	2,136	612	1,530	7,345	6	3,672	23,852	39,720	0	1,858	3,681	41,472
21%	2015	184	0	3,271	937	2,343	11,247	9	5,623	31,718	55,333	0	605	0	21,076
75%	2016	-	-	-	-	-	-	-	-	34,248	34,248	0	-	-	32,114
204%	2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Annual Averages	20,737	68	5,535	1,586	3,965	19,033	16	9,516	8,734	69,598	26,210	21,684	40,175	31,229

Kings River Water Years	Diversion	El Rico: Tulare Lake Canal	El Rico: *Melga Canal-Diversion of Peoples Canal, El Rico GSA Total*	El Rico: Kern River	El Rico: *Deer Creek-30% of Deer Creek Total*	El Rico: Tule River-El Rico	El Rico: Kaweah River	El Rico: *Loan Oak/New Deal- Diversion of Last Chance, El Rico GSA Total*	El Rico: Imported Water	El Rico: El Rico	Tri-County Water Authority: Poso Creek	Tri-County Water Authority: *TLBWSD Lateral A, T200 (State Water)-Assumed Full Entitlement-25% to Lateral A*	Tri-County Water Authority: *TLBWSD Lateral B, T206 (State Water)-Assumed Full Entitlement-75% to Lateral B*	Tri-County Water Authority: Tule River-Tri-County	Tri-County Water Authority: *Deer Creek-70% of Deer Creek Total*	Tri-County Water Authority: White River	Tri-County Water Authority: Kings River-Tri-County	Tri-County Water Authority: Other Water	Tri-County Water Authority: Imported Water	Tri-County Water Authority: Tri-County	Annual Totals
148%	2005	64,243	67,430	-	1,767	2,372	86,750	-	-	442,024	884	116	347	1,680	4,123	589	10,632	1,235	-	19,605	872,486
172%	2006	74,920	69,623	-	2,392	17,135	171,601	-	-	561,992	1,196	126	378	795	5,581	797	14,253	0	-	23,126	1,019,418
40%	2007	31,676	46,218	-	0	153	39,474	-	-	217,420	0	50	149	0	0	0	18,083	63	-	18,345	508,584
72%	2008	5,282	41,851	-	0	158	37,662	-	-	123,545	0	156	468	828	0	0	4,756	0	-	6,208	370,440
79%	2009	99	43,482	-	0	1,383	62,389	-	-	152,859	0	7	21	0	0	0	0	0	-	28	378,849
121%	2010	37,297	55,771	-	0	5,059	102,754	-	-	315,091	0	2	7	1,676	0	0	10,587	282	-	12,555	693,453
180%	2011	78,409	83,250	-	0	11,316	140,553	-	-	530,567	0	68	205	-	0	0	0	-	-	273	1,025,466
49%	2012	15,977	39,616	-	0	200	60,683	-	-	205,755	0	57	170	-	0	0	0	-	-	227	498,360
41%	2013	0	27,281	-	-	-	-	-	-	109,253	0	58	174	-	0	0	0	-	-	232	264,069
32%	2014	0	12,461	-	-	-	-	-	-	59,473	0	38	115	-	0	0	0	-	-	154	154,035
21%	2015	0	2,493	-	-	-	-	-	-	24,175	0	45	0	-	0	0	0	-	-	45	107,068
75%	2016	0	27,677	-	-	-	-	-	-	59,791	0			-	0	0	0	-	-	0	227,433
204%	2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Annual Averages	26,107	54,847	0	1,383	8,586	45,614	10,052		268,189	705	1,816	5,446	666	3,227	470	3,333	364		16,175	590,701

Notes provided on next page.

See Acronyms and Abbreviations list for definitions.

1.) Values highlighted have been modified.
2.) Values with "0" indicate no surface water delivery to the best of our knowledge.
3.) Values with "-" have no verified data.
4.) Total flow from Peoples Canal is split 60% to Mid Kings, 40% to Melga.
5.) Last Chance Diversion is split 50% between Mid Kings and El Rico.
6.) Blakeley has added State Water from Lateral A for Southwest.
7.) Total flow from Deer Creek split 30% to El Rico, 70% to Tri-County.
8.) Tule River for El Rico includes the total of Elk Bayou and TID Spill.
8.) SWP from TLBWSD Split Throughout Tri-County & Southwest Kings.
9.) Kings River water in Tri-County was subtracted from the total in Empire Weir No. 2. 1976 and 2010 are 0 for Empire Weir No. 2 because of negative values.
10.) Lakeside is a portion of Kaweah River, Reduced Total Kaweah River between Mid Kings and El Rico
11.) Additional Tule River flow data added for Tri-County
12.) Empire West Side ID total from SWP reduce annual totals by 10%
13.) Dudley Ridge Water District reduce annual totals by 10%
14.) Lateral A (T200) & Lateral B (T206) reduce annual totals by 18% for El Rico & Tri-County
15.) Modifications to Peoples Canal and Last Chance as a result of discussions with Mid Kings River GSA 02/14/2019

Key	Average Annual
Wet Year	816,660
Dry Year	423,464
Average Precipitation	686,577
GSA Annual Totals	
Kings River Watershed Total	

Reduction in Entitlement	
Empire West Side ID Total from SWP	10%
Dudley Ridge State Turnouts	10%
Lateral A & B for El Rico & Tri-County	18%

See Acronyms and Abbreviations list for definitions.

Table 3-6A. 1990 - 2016 Historical Water Balance Total Subbasin, Tulare Lake Subbasin SGMA Model, Kings County, California

Date	Tulare Lake Drain Net (AF/Y)	Tulare Lake GHB Net (AF/Y)	Tulare Lake Well Net (AF/Y)	Tulare Lake River Net (AF/Y)	Tulare Lake Lake Net (AF/Y)	Tulare Lake Recharge Net (AF/Y)	Tulare Lake Farm Demand (AF/Y)	Tulare Lake Storage Net (AF/Y)	Tulare Lake Net Subsurface Inflow (AF/Y)	Tulare Lake Net Subsurface Outflow (AF/Y)	Tulare Lake Westside Net (AF/Y)	Tulare Lake Kings Net (AF/Y)	Tulare Lake Kaweah Net (AF/Y)	Tulare Lake Tule Net (AF/Y)	Tulare Lake Kern Net (AF/Y)	Tulare Lake Mid-Kings Net (AF/Y)	Tulare Lake El Rico Net (AF/Y)	Tulare Lake South Fork Net (AF/Y)	Tulare Lake Southwest Net (AF/Y)	Tulare Lake TCWA Net (AF/Y)	Tulare Lake Total Net (AF/Y)	Cumulative Delta Storage (AF)
1990	0	0	-618,843	212,023	0	150,920	-1,065,856	-185,926	181,209	-111,280	23,632	4,815	-3,467	-12,024	56,971	298	-6,672	5,316	22,658	-21,601	298	-185,926
1991	0	0	-577,240	164,892	0	135,941	-994,832	-224,464	164,488	-112,589	13,271	9,747	4,376	-14,187	38,693	-1,273	-6,163	2,959	24,852	-20,376	-1,273	-410,391
1992	0	0	-596,994	125,681	0	139,491	-1,012,909	-290,389	160,839	-119,495	11,225	10,812	2,987	-18,583	34,904	-245	-10,703	4,143	26,835	-20,030	-245	-700,780
1993	0	0	-248,824	231,839	0	167,981	-1,008,709	157,279	128,914	-122,683	7,344	-4,219	-20,133	-13,496	36,736	1,631	-6,528	-857	24,396	-18,642	1,631	-543,501
1994	-26	0	-491,956	139,080	0	173,457	-1,047,937	-168,707	135,909	-125,412	7,647	1,210	-8,114	-20,670	30,426	-2,370	-4,557	2,695	23,956	-19,723	-2,370	-712,208
1995	-82	0	-188,622	200,925	0	235,917	-973,503	231,421	113,880	-130,598	5,564	-14,723	-26,071	-14,705	33,217	8,131	-6,163	-10,023	24,809	-16,753	8,131	-480,786
1996	-251	0	-195,586	177,508	0	238,753	-1,067,962	186,481	102,129	-136,119	6,788	-17,826	-32,867	-19,334	29,250	12,774	1,109	-16,866	23,951	-20,968	12,774	-294,305
1997	-1,392	0	-278,726	162,833	0	252,651	-1,123,726	100,786	104,214	-139,610	10,524	-17,146	-36,466	-21,396	29,090	11,582	1,267	-17,016	25,376	-21,209	11,582	-193,519
1998	-1,870	0	-249,086	165,955	0	266,380	-1,059,009	153,536	105,817	-134,203	13,146	-18,649	-31,067	-21,177	29,362	13,428	145	-19,305	26,305	-20,573	13,428	-39,983
1999	-7,376	0	-338,241	159,660	0	201,878	-1,232,448	522	120,686	-141,114	15,099	-12,823	-38,853	-23,234	39,384	8,567	5,298	-17,001	26,326	-23,190	8,567	-39,461
2000	-17,343	0	-260,726	147,624	0	172,534	-1,127,412	43,638	116,391	-130,053	9,202	-14,008	-24,256	-20,878	36,279	12,669	-1,467	-16,122	26,034	-21,114	12,669	4,177
2001	-13,351	0	-467,326	108,934	0	119,202	-1,111,506	-243,059	128,384	-130,759	7,046	-8,208	-10,602	-19,402	28,791	13,602	-4,429	-14,996	27,329	-21,506	13,602	-238,882
2002	-10,253	0	-435,270	150,502	0	128,082	-1,201,455	-178,393	122,597	-142,986	4,116	-14,310	-17,484	-22,160	29,448	17,210	-4,785	-18,209	28,055	-22,272	17,210	-417,275
2003	-8,170	0	-385,602	145,737	0	157,010	-1,198,411	-101,083	124,533	-140,750	7,968	-14,505	-16,849	-23,580	30,749	18,229	-2,895	-22,651	29,364	-22,046	18,229	-518,358
2004	-20,849	0	-494,263	137,236	0	138,732	-1,162,011	-231,122	125,398	-137,076	7,475	-13,320	-9,952	-24,296	28,416	13,215	-6,077	-14,260	29,378	-22,256	13,215	-749,480
2005	-5,413	0	-217,488	150,074	0	227,638	-1,155,548	121,017	101,739	-138,073	4,993	-20,418	-30,344	-20,294	29,728	13,527	-585	-19,200	27,026	-20,768	13,527	-628,463
2006	-9,651	0	-205,429	138,230	0	339,860	-1,129,741	220,649	94,159	-142,864	4,446	-22,451	-40,403	-20,192	29,895	14,152	1,839	-20,925	24,221	-19,288	14,152	-407,814
2007	-14,999	0	-474,153	137,542	0	123,827	-1,183,096	-248,490	109,552	-142,905	7,330	-14,948	-17,451	-25,274	16,990	13,841	2,341	-15,691	26,046	-26,536	13,841	-656,305
2008	-13,795	0	-515,546	126,421	0	117,419	-1,083,093	-296,277	119,872	-143,019	1,856	-12,181	-14,428	-21,584	23,191	15,124	1,866	-14,493	28,346	-30,843	15,124	-952,581
2009	-4,295	0	-456,641	133,032	0	135,636	-1,091,697	-213,010	118,378	-142,215	-1,793	-15,575	-2,407	-18,590	14,527	18,226	6,659	-21,735	28,060	-31,210	18,226	-1,165,591
2010	-2,440	0	-249,776	129,805	0	171,969	-1,016,725	13,129	101,421	-138,727	-5,091	-25,818	-13,379	-16,097	23,078	17,294	7,760	-18,014	26,354	-33,394	17,294	-1,152,462
2011	-4,486	0	-77,680	147,432	0	355,590	-791,090	361,228	83,220	-144,621	-6,641	-38,331	-35,573	-11,696	30,840	15,170	-5,654	-15,516	22,355	-16,355	15,170	-791,234
2012	-3,226	0	-357,301	111,314	0	120,601	-776,133	-169,947	99,000	-141,994	-6,733	-25,065	-25,720	-10,775	25,299	16,520	-4,782	-14,082	22,062	-19,718	16,520	-961,181
2013	-8,381	0	-455,726	99,564	0	90,038	-826,405	-305,607	105,083	-143,219	-9,909	-18,283	-18,315	-13,933	22,304	14,998	-4,112	-12,022	24,044	-22,907	14,998	-1,266,788
2014	-3,579	0	-508,253	82,742	0	107,427	-757,265	-360,352	110,508	-151,969	-11,151	-13,313	-18,684	-18,842	20,529	15,626	2,274	-17,973	26,111	-26,037	15,626	-1,627,140
2015	-829	0	-524,338	60,439	0	99,444	-624,647	-392,279	114,003	-141,493	-10,951	-10,641	-15,502	-15,383	24,986	13,276	-5,612	-12,806	26,751	-21,609	13,276	-2,019,419
2016	-2,497	0	-428,423	69,718	0	123,037	-677,936	-294,325	102,102	-160,350	-9,455	-33,115	-23,497	-14,438	22,257	16,359	-11,753	-11,101	26,620	-20,125	-2,088	-2,313,744
1990-2016 Average	-5,724	0	-381,410	141,361	0	173,756	-1,018,558	-85,694	83,220	-111,280	3,961	-13,826	-19,427	-18,379	29,457	11,539	-2,310	-12,806	25,838	-22,261	10,856	-720,867
1998-2010 Average	-9,985	0	-365,350	140,827	0	176,936	-1,134,781	-73,765	181,209	-160,350	5,830	-15,939	-20,575	-21,289	27,680	14,545	436	-17,893	27,142	-24,230	14,545	-535,575

See Acronyms and Abbreviations list for definitions.

Table 3-6B. 1990 - 2016 Historical Water Balance Upper Aquifer, Tulare Lake Subbasin SGMA Model, Kings County, California

Date	Tulare Lake Drain Net (AF/Y)	Tulare Lake GHB Net (AF/Y)	Tulare Lake Well Net (AF/Y)	Tulare Lake River Net (AF/Y)	Tulare Lake Lake Net (AF/Y)	Tulare Lake Recharge Net (AF/Y)	Tulare Lake ET Net (AF/Y)	Tulare Lake Storage Net (AF/Y)	Tulare Lake Net Subsurface Inflow (AF/Y)	Tulare Lake Net Subsurface Outflow (AF/Y)	Tulare Lake Westside Net (AF/Y)	Tulare Lake Kings Net (AF/Y)	Tulare Lake Kaweah Net (AF/Y)	Tulare Lake Tule Net (AF/Y)	Tulare Lake Kern Net (AF/Y)	Tulare Lake Mid-Kings Net (AF/Y)	Tulare Lake El Rico Net (AF/Y)	Tulare Lake South Fork Net (AF/Y)	Tulare Lake Southwest Net (AF/Y)	Tulare Lake TCWA Net (AF/Y)	Tulare Lake Total Net (AF/Y)	Cumulative Delta Storage (AF)
1990	0	0	-363,970	212,023	0	150,920	0	-392,438	60,944	-52,493	10,293	-6,068	2,356	-2,438	4,309	-8,770	7,916	7,068	3,123	-9,337	-8,770	-392,438
1991	0	0	-351,785	164,892	0	135,941	0	-379,415	59,832	-44,466	9,849	-337	6,851	-3,950	2,953	-8,028	6,401	5,211	3,601	-7,185	-8,028	-771,853
1992	0	0	-345,307	125,681	0	139,491	0	-379,874	58,304	-43,733	9,211	1,619	7,092	-5,396	2,045	-6,955	5,529	3,812	3,711	-6,097	-6,955	-1,151,727
1993	0	0	-239,755	231,839	0	167,981	0	-117,785	51,892	-42,526	7,943	-136	4,801	-4,918	1,676	-4,786	5,130	2,368	3,440	-6,153	-4,786	-1,269,512
1994	-26	0	-310,055	139,080	0	173,457	0	-255,820	52,755	-44,438	7,097	625	5,581	-6,383	1,398	-4,950	4,717	2,121	3,471	-5,360	-4,950	-1,525,332
1995	-82	0	-205,637	200,925	0	235,917	0	-23,977	45,868	-50,708	5,953	-9,550	3,591	-6,120	1,286	-2,716	3,395	746	3,431	-4,856	-2,716	-1,549,309
1996	-251	0	-184,321	177,508	0	238,753	0	-4,023	42,064	-47,154	5,561	-7,356	979	-5,613	1,340	-1,526	3,881	-427	3,567	-5,495	-1,526	-1,553,331
1997	-1,392	0	-204,969	162,833	0	252,651	0	-15,247	40,618	-50,417	5,470	-9,442	-1,210	-5,876	1,259	-791	3,397	-1,403	3,400	-4,603	-791	-1,568,578
1998	-1,870	0	-191,289	165,955	0	266,380	0	17,175	38,754	-55,626	5,112	-14,784	-2,171	-6,255	1,226	-228	3,124	-2,136	3,467	-4,226	-228	-1,551,403
1999	-7,376	0	-227,049	159,660	0	201,878	0	-71,374	41,389	-47,970	5,311	-6,241	-1,422	-5,855	1,627	44	3,916	-2,399	3,599	-5,159	44	-1,622,778
2000	-17,343	0	-201,799	147,624	0	172,534	0	-76,900	41,391	-44,741	5,135	-5,270	889	-6,253	2,149	713	3,385	-2,978	3,773	-4,892	713	-1,699,678
2001	-13,351	0	-264,888	108,934	0	119,202	0	-222,719	44,167	-45,556	5,150	-3,924	1,956	-6,748	2,177	215	3,431	-2,996	3,872	-4,521	215	-1,922,397
2002	-10,253	0	-272,312	150,502	0	128,082	0	-174,685	46,006	-45,147	4,999	-2,792	3,355	-6,755	2,052	-373	3,874	-2,666	3,785	-4,620	-373	-2,097,082
2003	-8,170	0	-255,270	145,737	0	157,010	0	-133,547	45,798	-46,552	4,757	-3,317	2,678	-6,922	2,049	-308	4,005	-2,944	3,826	-4,578	-308	-2,230,628
2004	-20,849	0	-279,593	137,236	0	138,732	0	-181,729	46,099	-46,854	4,686	-2,691	2,602	-7,402	2,050	-688	3,857	-2,647	3,846	-4,368	-688	-2,412,358
2005	-5,413	0	-194,492	150,074	0	227,638	0	516	41,121	-48,908	4,301	-5,838	-1,307	-7,087	2,145	212	3,616	-3,177	3,796	-4,447	212	-2,411,841
2006	-9,651	0	-174,179	138,230	0	339,860	0	117,742	37,534	-56,025	3,971	-11,267	-6,576	-6,948	2,329	1,405	2,956	-3,767	3,678	-4,271	1,405	-2,294,099
2007	-14,999	0	-264,654	137,542	0	123,827	0	-177,972	42,192	-52,530	4,404	-5,195	-3,761	-7,669	1,883	385	3,549	-3,225	3,501	-4,210	385	-2,472,071
2008	-13,795	0	-283,431	126,421	0	117,419	0	-210,701	43,266	-49,766	4,321	-3,743	-38	-8,161	1,122	-622	4,068	-2,880	3,259	-3,825	-622	-2,682,773
2009	-4,295	0	-268,843	133,032	0	135,636	0	-170,773	43,877	-49,818	4,722	-3,492	961	-8,469	338	-626	4,176	-3,145	3,179	-3,584	-626	-2,853,545
2010	-2,440	0	-187,770	129,805	0	171,969	0	-56,332	37,974	-47,711	3,677	-4,768	-334	-8,179	-134	400	3,717	-3,559	3,094	-3,653	400	-2,909,877
2011	-4,486	0	-126,313	147,432	0	355,590	0	197,345	32,182	-58,840	2,822	-16,373	-6,573	-6,907	374	2,222	2,629	-4,345	3,147	-3,652	2,222	-2,712,533
2012	-3,226	0	-205,013	111,314	0	120,601	0	-137,135	34,819	-52,627	2,733	-7,480	-6,645	-7,386	969	1,491	2,935	-4,085	3,111	-3,452	1,491	-2,849,668
2013	-8,381	0	-252,639	99,564	0	90,038	0	-222,003	38,673	-50,934	3,106	-4,297	-4,573	-7,569	1,071	520	3,719	-3,772	3,013	-3,481	520	-3,071,671
2014	-3,579	0	-276,394	82,742	0	107,427	0	-247,305	41,277	-51,497	3,633	-2,586	-3,508	-8,263	503	-96	3,951	-3,688	2,996	-3,163	-96	-3,318,976
2015	-829	0	-283,699	60,439	0	99,444	0	-286,779	41,875	-50,653	3,580	-1,050	-3,164	-8,423	279	-674	3,899	-3,598	3,107	-2,734	-674	-3,605,754
2016	-2,497	0	-248,557	69,718	0	123,037	0	-234,011	36,829	-60,070	3,401	-14,540	-4,136	-8,370	403	-321	3,744	-3,738	3,005	-2,691	-2,088	-3,839,765
1990-2016 Average	-5,724	0	-246,814	141,361	0	173,756	0	-142,214	32,182	-42,526	5,230	-5,566	-64	-6,678	1,514	-1,291	4,034	-1,565	3,437	-4,615	-1,356	-2,160,777
1998-2010 Average	-9,985	0	-235,813	140,827	0	176,936	0	-103,177	60,944	-60,070	4,658	-5,640	-244	-7,131	1,616	41	3,667	-2,963	3,590	-4,335	41	-2,243,118

See Acronyms and Abbreviations list for definitions.

Table 3-6C. 1990 - 2016 Historical Water Balance Lower Aquifer, Tulare Lake Subbasin SGMA Model, Kings County, California

Date	Tulare Lake Drain Net (AF/Y)	Tulare Lake GHB Net (AF/Y)	Tulare Lake Well Net (AF/Y)	Tulare Lake River Net (AF/Y)	Tulare Lake Lake Net (AF/Y)	Tulare Lake Recharge Net (AF/Y)	Tulare Lake ET Net (AF/Y)	Tulare Lake Storage Net (AF/Y)	Tulare Lake Net Subsurface Inflow (AF/Y)	Tulare Lake Net Subsurface Outflow (AF/Y)	Tulare Lake Westside Net (AF/Y)	Tulare Lake Kings Net (AF/Y)	Tulare Lake Kaweah Net (AF/Y)	Tulare Lake Tule Net (AF/Y)	Tulare Lake Kern Net (AF/Y)	Tulare Lake Mid-Kings Net (AF/Y)	Tulare Lake El Rico Net (AF/Y)	Tulare Lake South Fork Net (AF/Y)	Tulare Lake Southwest Net (AF/Y)	Tulare Lake TCWA Net (AF/Y)	Tulare Lake Total Net (AF/Y)	Cumulative Delta Storage (AF)
1990	0	0	-254,873	0	0	0	0	206,511	120,265	-58,787	13,339	10,884	-5,823	-9,586	52,663	9,068	-14,587	-1,752	19,535	-12,264	9,068	206,511
1991	0	0	-225,455	0	0	0	0	154,951	104,657	-68,123	3,422	10,084	-2,475	-10,237	35,740	6,755	-12,564	-2,252	21,251	-13,191	6,755	361,463
1992	0	0	-251,686	0	0	0	0	89,485	102,535	-75,762	2,013	9,193	-4,106	-13,187	32,859	6,710	-16,232	331	23,124	-13,932	6,710	450,947
1993	0	0	-9,069	0	0	0	0	275,064	77,023	-80,157	-600	-4,082	-24,934	-8,578	35,060	6,416	-11,659	-3,226	20,957	-12,489	6,416	726,011
1994	0	0	-181,901	0	0	0	0	87,113	83,154	-80,974	550	585	-13,695	-14,288	29,028	2,579	-9,275	573	20,484	-14,362	2,579	813,124
1995	0	0	17,015	0	0	0	0	255,398	68,012	-79,891	-388	-5,174	-29,662	-8,585	31,931	10,847	-9,559	-10,769	21,378	-11,896	10,847	1,068,522
1996	0	0	-11,265	0	0	0	0	190,504	60,065	-88,966	1,227	-10,470	-33,846	-13,721	27,910	14,300	-2,772	-16,439	20,385	-15,474	14,300	1,259,026
1997	0	0	-73,758	0	0	0	0	116,032	63,597	-89,192	5,054	-7,705	-35,256	-15,520	27,831	12,373	-2,130	-15,613	21,976	-16,606	12,373	1,375,059
1998	0	0	-57,797	0	0	0	0	136,362	67,063	-78,577	8,034	-3,865	-28,896	-14,922	28,136	13,656	-2,978	-17,169	22,838	-16,347	13,656	1,511,420
1999	0	0	-111,192	0	0	0	0	71,897	79,296	-93,144	9,788	-6,582	-37,432	-17,379	37,757	8,524	1,382	-14,601	22,726	-18,031	8,524	1,583,317
2000	0	0	-58,927	0	0	0	0	120,539	75,001	-85,312	4,067	-8,738	-25,145	-14,625	34,130	11,957	-4,852	-13,144	22,261	-16,221	11,957	1,703,855
2001	0	0	-202,438	0	0	0	0	-20,340	84,217	-85,202	1,896	-4,283	-12,559	-12,654	26,614	13,388	-7,861	-12,000	23,458	-16,985	13,388	1,683,515
2002	0	0	-162,957	0	0	0	0	-3,708	76,591	-97,839	-883	-11,518	-20,839	-15,405	27,396	17,582	-8,658	-15,543	24,270	-17,652	17,582	1,679,807
2003	0	0	-130,332	0	0	0	0	32,464	78,735	-94,198	3,210	-11,188	-19,527	-16,659	28,700	18,537	-6,900	-19,706	25,538	-17,468	18,537	1,712,271
2004	0	0	-214,670	0	0	0	0	-49,393	79,299	-90,221	2,789	-10,629	-12,554	-16,894	26,366	13,904	-9,935	-11,614	25,533	-17,888	13,904	1,662,878
2005	0	0	-22,996	0	0	0	0	120,500	60,617	-89,165	692	-14,580	-29,037	-13,207	27,583	13,315	-4,201	-16,023	23,231	-16,321	13,315	1,783,378
2006	0	0	-31,250	0	0	0	0	102,907	56,625	-86,840	475	-11,184	-33,827	-13,243	27,566	12,747	-1,116	-17,157	20,543	-15,017	12,747	1,886,285
2007	0	0	-209,499	0	0	0	0	-70,518	67,360	-90,375	2,925	-9,752	-13,691	-17,605	15,108	13,455	-1,207	-12,467	22,545	-22,326	13,455	1,815,767
2008	0	0	-232,114	0	0	0	0	-85,575	76,606	-93,253	-2,465	-8,438	-14,390	-13,423	22,069	15,746	-2,202	-11,613	25,088	-27,018	15,746	1,730,191
2009	0	0	-187,798	0	0	0	0	-42,237	74,501	-92,397	-6,514	-12,082	-3,368	-10,120	14,189	18,852	2,483	-18,590	24,881	-27,626	18,852	1,687,954
2010	0	0	-62,006	0	0	0	0	69,461	63,446	-91,016	-8,768	-21,050	-13,046	-7,919	23,212	16,894	4,043	-14,456	23,260	-29,741	16,894	1,757,415
2011	0	0	48,633	0	0	0	0	163,884	51,038	-85,781	-9,463	-21,958	-28,999	-4,789	30,466	12,948	-8,283	-11,171	19,208	-12,702	12,948	1,921,299
2012	0	0	-152,288	0	0	0	0	-32,812	64,180	-89,367	-9,466	-17,585	-19,076	-3,389	24,330	15,029	-7,718	-9,997	18,951	-16,266	15,029	1,888,486
2013	0	0	-203,087	0	0	0	0	-83,604	66,410	-92,285	-13,015	-13,986	-13,742	-6,364	21,233	14,477	-7,831	-8,251	21,031	-19,426	14,477	1,804,883
2014	0	0	-231,859	0	0	0	0	-113,047	69,232	-100,472	-14,784	-10,727	-15,176	-10,580	20,026	15,722	-1,678	-14,285	23,115	-22,875	15,722	1,691,836
2015	0	0	-240,639	0	0	0	0	-105,501	72,128	-90,840	-14,531	-9,591	-12,338	-6,960	24,707	13,951	-9,511	-9,208	23,645	-18,876	13,951	1,586,335
2016	0	0	-179,866	0	0	0	0	-60,314	65,273	-100,280	-12,856	-18,575	-19,362	-6,068	21,854	16,680	-15,498	-7,363	23,614	-17,433	0	1,526,021
1990-2016 Average	0	0	-134,595	0	0	0	0	56,519	51,038	-58,787	-1,269	-8,259	-19,363	-11,700	27,943	12,830	-6,344	-11,241	22,401	-17,646	12,212	1,439,910
1998-2010 Average	0	0	-129,537	0	0	0	0	29,412	120,265	-100,472	1,173	-10,299	-20,331	-14,158	26,063	14,504	-3,231	-14,929	23,552	-19,895	14,504	1,707,542

See Acronyms and Abbreviations list for definitions.

Table 3-7. Historical and Current Water Balance, Tulare Lake Subbasin SGMA Model, Kings County, California

Land Surface Water Budget													
			Inflows						Outflows				
Year	Kings River Flows	Year Type	Effective Precipitation (AF)	Applied Surface Water (AF)	Applied Pond Water (AF)	Imported Groundwater (AF)	Applied Groundwater (AF)	Total Inflows (AF)	Drain Outflow (AF)	Farm Demand Evapotranspiration (AF)	Deep Percolation (AF)	Total Outflows (AF)	Net Inflow-Outflow (AF)
1990	40%	D	19,958	319,870	10,310	48,885	609,474	1,008,496	0	1,065,856	132,933	1,198,789	-190,293
1991	63%	D	78,722	209,568	3,793	52,225	568,130	912,439	0	994,832	125,674	1,120,507	-208,068
1992	41%	D	64,818	245,345	8,619	46,926	587,328	953,036	0	1,012,909	126,365	1,139,274	-186,238
1993	149%	W	67,191	811,312	31,153	7,533	238,616	1,155,805	0	1,008,709	124,472	1,133,181	22,624
1994	50%	D	34,514	443,731	4,237	27,612	481,028	991,122	26	1,047,937	129,432	1,177,394	-186,272
1995	202%	W	95,479	948,773	42,079	905	177,847	1,265,083	82	973,503	116,897	1,090,481	174,601
1996	122%	N	100,745	1,038,046	26,566	0	182,868	1,348,225	251	1,067,962	127,604	1,195,817	152,408
1997	155%	W	58,885	749,117	54,380	0	265,952	1,128,333	1,392	1,123,726	143,342	1,268,459	-140,126
1998	181%	W	116,167	693,908	49,104	0	237,530	1,096,709	1,870	1,059,009	128,533	1,189,412	-92,703
1999	74%	D	34,039	713,206	39,371	0	325,154	1,111,771	7,376	1,232,448	151,647	1,391,471	-279,701
2000	90%	N	70,413	741,494	35,618	6,833	247,306	1,101,664	17,343	1,127,412	95,624	1,240,379	-138,714
2001	59%	D	94,963	437,871	8,911	54,771	453,432	1,049,949	13,351	1,111,506	90,933	1,215,791	-165,841
2002	67%	D	26,034	564,134	21,817	51,428	408,568	1,071,981	10,253	1,201,455	85,417	1,297,125	-225,143
2003	83%	N	40,108	583,124	4,687	24,029	366,253	1,018,201	8,170	1,198,411	95,332	1,301,914	-283,713
2004	61%	D	74,858	495,764	25,863	63,254	475,486	1,135,226	20,849	1,162,011	86,876	1,269,736	-134,510
2005	148%	W	80,390	873,425	36,085	857	200,953	1,191,709	5,413	1,155,548	101,553	1,262,513	-70,804
2006	172%	W	104,703	1,020,922	37,530	154	189,607	1,352,916	9,651	1,129,741	108,496	1,247,887	105,029
2007	40%	D	14,800	508,886	4,613	60,608	456,931	1,045,839	14,999	1,183,096	97,935	1,296,030	-250,191
2008	72%	D	35,836	371,231	9,331	72,842	497,113	986,354	13,795	1,083,093	89,622	1,186,511	-200,157
2009	79%	N	32,367	379,590	16,632	68,391	440,286	937,266	4,295	1,091,697	94,173	1,190,165	-252,899
2010	121%	N	88,203	694,592	51,406	31,531	234,505	1,100,238	2,440	1,016,725	78,915	1,098,080	2,158
2011	180%	W	52,937	1,026,568	21,035	7,241	60,638	1,168,420	4,486	791,090	83,959	879,535	288,885
2012	49%	D	45,317	498,937	20,785	64,173	339,834	969,046	3,226	776,133	62,058	841,417	127,629
2013	41%	D	2,800	264,515	1,725	84,661	437,315	791,017	8,381	826,405	65,687	900,473	-109,456
2014	32%	D	30,586	154,346	0	85,650	491,323	761,906	3,579	757,265	62,755	823,599	-61,693
2015	21%	D	15,085	107,212	0	79,517	508,193	710,008	829	624,647	49,756	675,231	34,777
2016	75%	D	41,890	227,755	0	70,864	413,868	754,377	2,497	677,936	53,544	733,977	20,400
1990-2016 Avg	91%		56,363	560,120	20,950	37,440	366,501	1,041,375	5,724	1,018,558	100,353	1,124,635	-83,260
1998-2010 Avg	96%		62,529	621,396	26,228	33,438	348,702	1,092,294	9,985	1,134,781	100,389	1,245,155	-152,861

See Acronyms and Abbreviations list for definitions.

Table 3-7. Historical and Current Water Balance, Tulare Lake Subbasin SGMA Model, Kings County, California (Continued)

Subsurface Water Budget																	
			Inflows							Outflows							
			Deep Percolation				Interbasin Inflow			Groundwater Pumping		Interbasin Outflow			Annual Change in Storage		
Year	Kings River Flows	Year Type	Precipitation Infiltration (AF)	Applied Water Infiltration (AF)	Stream Leakage (AF)	Intentional Recharge (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Total Inflows (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Total Outflows (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Total Aquifer (AF)
1990	40%	D	17,012	132,933	222,466	1,021	60,944	120,265	554,640	363,970	254,873	52,493	58,787	730,124	-392,438	206,512	-185,926
1991	63%	D	10,310	125,674	149,106	0	59,832	104,657	449,578	351,785	225,455	44,466	68,123	689,829	-379,415	154,951	-224,464
1992	41%	D	13,215	126,365	122,515	0	58,304	102,535	422,934	345,307	251,686	43,733	75,762	716,488	-379,874	89,485	-290,389
1993	149%	W	43,499	124,472	178,243	61	51,892	77,023	475,190	239,755	9,069	42,526	80,157	371,507	-117,785	275,064	157,279
1994	50%	D	20,701	129,432	121,447	23,540	52,755	83,154	431,028	310,055	181,901	44,438	80,974	617,368	-255,820	87,113	-168,707
1995	202%	W	58,569	116,897	160,315	60,372	45,868	68,012	510,032	205,637	17,015	50,708	79,891	353,250	-23,977	255,398	231,421
1996	122%	N	78,864	127,604	161,750	32,081	42,064	60,065	502,429	184,321	11,265	47,154	88,966	331,705	-4,023	190,504	186,481
1997	155%	W	65,946	143,342	153,373	42,787	40,618	63,597	509,662	204,969	73,758	50,417	89,192	418,336	-15,247	116,032	100,786
1998	181%	W	75,095	128,533	152,395	61,425	38,754	67,063	523,264	191,289	57,797	55,626	78,577	383,288	17,175	136,362	153,536
1999	74%	D	47,885	151,647	180,710	0	41,389	79,296	500,928	227,049	111,192	47,970	93,144	479,355	-71,374	71,897	522
2000	90%	N	51,238	95,624	159,781	23,540	41,391	75,001	446,574	201,799	58,927	44,741	85,312	390,779	-76,900	120,539	43,638
2001	59%	D	26,775	90,933	124,376	0	44,167	84,217	370,468	264,888	202,438	45,556	85,202	598,085	-222,719	-20,340	-243,059
2002	67%	D	41,347	85,417	164,069	0	46,006	76,591	413,429	272,312	162,957	45,147	97,839	578,256	-174,685	-3,708	-178,393
2003	83%	N	36,128	95,332	174,955	23,540	45,798	78,735	454,487	255,270	130,332	46,552	94,198	526,352	-133,547	32,464	-101,083
2004	61%	D	40,008	86,876	148,458	10,700	46,099	79,299	411,440	279,593	214,670	46,854	90,221	631,339	-181,729	-49,393	-231,122
2005	148%	W	64,268	101,553	185,872	58,945	41,121	60,617	512,376	194,492	22,996	48,908	89,165	355,562	516	120,500	121,017
2006	172%	W	57,791	108,496	169,501	170,266	37,534	56,625	600,213	174,179	31,250	56,025	86,840	348,293	117,742	102,907	220,649
2007	40%	D	23,538	97,935	174,019	0	42,192	67,360	405,044	264,654	209,499	52,530	90,375	617,057	-177,972	-70,518	-248,490
2008	72%	D	26,373	89,622	137,369	0	43,266	76,606	373,236	283,431	232,114	49,766	93,253	658,564	-210,701	-85,575	-296,277
2009	79%	N	29,563	94,173	167,126	10,700	43,877	74,501	419,939	268,843	187,798	49,818	92,397	598,856	-170,773	-42,237	-213,010
2010	121%	N	67,953	78,915	145,364	23,540	37,974	63,446	417,193	187,770	62,006	47,711	91,016	388,504	-56,332	69,461	13,129
2011	180%	W	88,853	83,959	180,036	180,066	32,182	51,038	616,133	126,313	48,633	58,840	85,781	319,567	197,345	163,884	361,228
2012	49%	D	46,276	62,058	126,057	10,700	34,819	64,180	344,090	205,013	152,288	52,627	89,367	499,295	-137,135	-32,812	-169,947
2013	41%	D	23,005	65,687	123,434	0	38,673	66,410	317,209	252,639	203,087	50,934	92,285	598,945	-222,003	-83,604	-305,607
2014	32%	D	20,546	62,755	92,469	23,320	41,277	69,232	309,598	276,394	231,859	51,497	100,472	660,223	-247,305	-113,047	-360,352
2015	21%	D	25,814	49,756	74,156	23,540	41,875	72,128	287,269	283,699	240,639	50,653	90,840	665,831	-286,779	-105,501	-392,279
2016	75%	D	26,426	53,544	32,070	42,659	36,829	65,273	256,801	248,557	179,866	60,070	100,280	588,773	-234,011	-60,314	-294,325
1990-2016 Avg	91%		41,740	100,353	147,460	30,474	43,981	74,331	438,340	246,814	139,458	49,547	86,978	522,797	-142,214	56,519	-85,694
1998-2010 Avg	96%		45,228	100,389	160,307	29,435	42,274	72,258	449,892	235,813	129,537	49,016	89,811	504,176	-103,177	29,412	-73,765

See Acronyms and Abbreviations list for definitions.

Table 3-8. Historical Evapotranspiration Demand, Tulare Lake Subbasin SGMA Model, Kings County, California

Tulare Lake Subbasin	1990-1995 (AF/Y)	1996-1998 (AF/Y)	1999-2006 (AF/Y)	2007 (AF/Y)	2008 (AF/Y)	2009 (AF/Y)	2010 (AF/Y)	2011 (AF/Y)	2012 (AF/Y)	2013 (AF/Y)	2014 (AF/Y)	2015 (AF/Y)	2016 (AF/Y)	Average (AF/Y)
Tulare Lake Subbasin														
Alfalfa Hay and Clover	172,519	135,032	225,167	300,041	333,752	296,086	288,555	160,621	174,457	204,219	148,325	122,839	100,395	190,580
Almonds (Adolescent)			8,113			11,218	19,864	8,127	10,631	18,529	16,937	15,155	13,714	6,332
Almonds (Mature)	26,791	18,278	15,869	47,030	43,122	35,832	30,537	36,976	39,450	41,720	46,956	54,869	55,084	28,083
Almonds (Young)		2,287	6,480	12,062	26,125	15,445	17,964	13,431	14,580	18,458	17,621	15,779	20,206	8,292
Berries	47								2	6		1		11
Carrot Single Crop								37	16	41	7	6	56	6
Citrus (no ground cover)			91		42	46	14	405	99	335	300	74	32	74
Corn and Grain Sorghum	36,877	100,450	75,793	101,418	82,027	89,467	59,478	87,236	75,344	71,190	58,462	48,619	44,935	65,605
Cotton	463,179	525,386	362,232	320,870	258,511	212,071	287,383	308,970	260,527	261,476	185,559	130,368	215,815	345,645
Dairy Single Crop*	14,290	15,268	16,421											9,129
Fallow Land*														-
Forest*														-
Grain and Grain Hay	50,167	84,811	110,025	33,572	48,563	47,755	45,271	13,518	17,369	19,505	21,282	36,934	33,228	60,837
Melons	413	92	468				21	3	16	10	1,182	27	128	275
Misc. field crops	40,450	30,296	121,265		5			1			4			43,795
Onions and Garlic	807	846	1,359			12	2,417	731	538	167	893	266	1,146	854
Open Water*														-
Pasture and Misc. Grasses	10,799	21,726	24,256	218,974	191,082	289,198	229,306	63,417	57,751	66,333	144,942	68,014	59,370	62,524
Pistachio (Adolescent)								213	315	559	1,290	4,713	5,704	474
Pistachio (Mature)	15,229	12,354	12,341	17,831	5,680	2,825	1,236	1,283	1,237	1,135	1,075	1,412	1,374	9,256
Pistachio (Young)		394	2,265	1,091	1,370	2,454	2,395	3,729	5,770	7,498	8,281	8,231	9,024	2,477
Pomegranates (Adolescent)											5	23	41	3
Pomegranates (Young)				11	303	99	52	901	210	376	537	567	746	141
Potatoes, Sugar beets, Turnip etc..	18,604	4	676	19		10		29		127		7	7	4,317
Riparian*														-
Small Vegetables	2,835	1,147	8,009	33	3	20	340	227	212	390	264	126	317	2,905
Stone Fruit (Adolescent)			4,238			28	138	232	291	171	106	414	425	1,166
Stone Fruit (Mature)	25,350	17,875	13,818	4,560	1,886	584	64	11	80	141	79	95	136	11,485
Stone Fruit (Young)		1,310	3,001	466	1,234	1,217	1,879	1,010	547	1,250	1,186	913	667	1,308
Tomatoes and Peppers	12,971	3,747	33,791	261	5	246	26	47,851	52,725	15,847	26,555	42,793	52,168	20,892
Urban, Industrial*														-
Wine Grapes with 80% canopy	7,586	8,301	14,872	14,203	8,893	5,692	6,980	13,625	23,455	11,832	16,450	11,874	27,920	11,683
Winter Wheat*														-
Tulare Lake Subbasin Irrigated ET Demand	884,626	964,336	1,044,130	1,072,442	1,002,603	1,010,305	993,918	762,584	735,624	741,315	698,299	564,117	642,636	879,019
Tulare Lake Subbasin GSA Total ET Demand	898,916	979,604	1,060,551	1,072,442	1,002,603	1,010,305	993,918	762,584	735,624	741,315	698,299	564,117	642,636	888,148

Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year.

See Acronyms and Abbreviations list for definitions.

Table 4-1. Groundwater Levels - Measurable Objectives, Minimum Thresholds, and Interim Milestones (elevation in feet above mean sea level)

Index	Well ID	MO	MT	2017	2025	2030	2035	2040
1	ER_CID-021	-179.60	-229.60	-140.19	-152.59	-166.62	-210.38	-176.63
2	ER_Proposed_B2	105.64	55.64	118.05	107.92	97.52	117.63	96.87
3	ER_Proposed_B3	110.23	60.23	117.43	113.73	111.99	110.27	108.47
4	ER_Proposed_B4	106.13	56.13	121.59	114.46	109.19	105.60	102.02
5	ER_20S21E11N001M	-43.02	-93.02	-4.27	-12.39	-31.58	-77.55	-35.77
6	ER_20S21E24F001M	-126.33	-176.33	-68.10	-97.87	-112.62	-147.51	-113.27
7	ER_20S22E14C001M	-104.85	-154.85	-64.80	-75.71	-89.20	-136.63	-96.80
8	ER_21S22E07J001M	-146.77	-196.77	-40.70	-123.09	-135.64	-159.98	-131.32
9	ER_CID_078	-98.89	-148.89	-60.24	-73.92	-86.39	-130.18	-91.25
10	ER_KRCDTL002	7.43	-42.57	55.10	39.51	20.23	-24.08	15.70
11	ER_KRCDTL003	-153.55	-203.55	-106.50	-126.62	-143.64	-174.74	-144.25
12	ER_M-140	-146.62	-196.62	-110.87	-113.63	-128.31	-153.98	-114.08
13	ER_S-173	-192.36	-242.36	-60.83	-146.83	-153.70	-170.02	-142.00
14	ER_S-205	-280.27	-330.27	-239.05	-226.83	-233.70	-250.02	-222.00
15	ER_S-225	-208.49	-258.49	-150.47	-184.98	-191.70	-201.67	-167.46
16	ER_Proposed_C1	33.84	-16.16	40.29	46.93	35.43	25.72	38.25
17	ER_Proposed_C2	45.62	-4.38	43.42	51.73	43.94	44.67	47.34
18	ER_Proposed_C3	32.02	-17.98	36.64	44.70	33.79	24.40	37.87
19	ER_Proposed_C4	16.94	-33.06	22.23	32.42	21.43	8.12	28.22
20	ER_Proposed_C5	27.02	-22.98	14.22	28.46	24.35	28.82	30.11
21	ER_Proposed_C6	-46.08	-96.08	-28.52	-26.26	-50.49	-48.83	-39.29
22	ER_Proposed_C7	-0.37	-50.37	22.56	19.13	-14.82	4.87	-0.89
23	ER_Proposed_C8	86.76	36.76	96.11	91.72	76.91	90.46	90.44
24	MKR_18S21E17N001M	213.38	163.38	217.33	215.97	214.35	213.67	213.96
25	MKR_19S21E20N001M	210.10	160.10	212.72	212.37	211.51	210.59	210.07
26	MKR_17S22E28A001M	156.77	106.77	170.05	158.71	151.21	158.75	152.68
27	MKR_18S21E01C001M	169.09	119.09	178.38	176.59	170.04	167.95	166.34
28	MKR_18S21E07R003M	195.06	145.06	216.92	209.68	200.89	194.34	187.38
29	MKR_18S21E27B001M	70.00	20.00	100.88	87.71	73.98	66.05	59.51
30	MKR_18S21E31B001M	67.13	17.13	89.10	81.91	74.48	67.74	59.76
31	MKR_18S22E03B001M	134.48	84.48	138.88	139.13	134.60	135.56	135.80
32	MKR_18S22E07A001M	124.04	74.04	131.48	130.38	125.06	123.94	122.17
33	MKR_18S22E24D001M	110.23	60.23	119.30	115.80	112.82	111.53	110.07
34	MKR_18S22E28A001M	95.97	45.97	107.86	103.33	98.74	97.17	96.82
35	MKR_18S22E34R001M	144.38	94.38	123.50	151.00	147.01	145.74	145.10

See Acronyms and Abbreviations list for definitions.

Table 4-1. Groundwater Levels - Measurable Objectives, Minimum Thresholds, and Interim Milestones (elevation in feet above mean sea level) (Continued)

Index	Well ID	MO	MT	2017	2025	2030	2035	2040
36	MKR_19S21E30A001M	185.18	135.18	202.24	196.33	190.78	185.96	179.82
37	MKR_19S22E07K001M	48.48	-1.52	65.08	61.48	54.93	49.32	43.13
38	MKR_MWA_INTDEEP	253.50	203.50	242.06	256.37	252.08	254.02	253.67
39	MKR_MWC_INT	186.02	136.02	188.76	187.13	182.27	188.52	185.29
40	MKR_MWD_INT	191.22	141.22	185.58	191.51	186.29	194.26	188.87
41	MKR_MWG_INT	181.23	131.23	184.21	183.50	182.38	184.26	182.74
42	MKR_MWH_INT	110.17	60.17	115.63	117.87	113.63	110.76	109.24
43	MKR_Proposed_B1	215.15	165.15	220.91	218.68	212.12	215.81	212.50
44	MKR_Proposed_B2	178.95	128.95	183.87	186.04	179.11	177.75	176.67
45	MKR_Proposed_B3	84.90	34.90	102.29	96.83	91.02	85.88	79.45
46	MKR_Proposed_B4	84.84	34.84	99.81	94.01	89.49	85.43	80.26
47	MKR_19S22E08D002M	-39.50	-89.50	62.10	-12.10	-42.77	-63.99	-55.37
48	MKR_1610003-037	39.87	-10.13	83.60	60.44	33.03	20.67	19.35
49	MKR_1610003-042	67.63	17.63	105.80	84.32	57.53	45.99	46.68
50	MKR_MWD_DEEP	158.78	108.78	171.80	175.25	141.09	133.72	146.97
51	MKR_MWG_DEEP	132.82	82.82	151.18	150.45	117.77	108.79	121.59
52	MKR_MWH_DEEP	38.47	-11.53	26.80	67.29	33.50	10.96	22.80
53	MKR_Proposed_C1	104.91	54.91	133.56	116.58	92.65	85.24	91.79
54	MKR_Proposed_C2	79.29	29.29	122.48	100.96	66.57	50.59	63.84
55	MKR_Proposed_C3	69.22	19.22	105.75	86.11	61.35	51.89	54.08
56	MKR_Proposed_C4	0.39	-49.61	53.45	27.05	-6.17	-24.14	-18.10
57	MKR_Proposed_C5	-5.36	-55.36	42.75	20.47	-9.76	-31.74	-18.59
58	SFK_18S20E23E003M	198.40	148.40	199.90	199.81	199.49	199.12	198.78
59	SFK_19S20E29E002M	183.63	133.63	182.08	183.95	184.32	184.86	185.13
60	SFK_20S19E25A003M	199.21	149.21	197.05	200.17	198.83	199.87	200.39
61	SFK_Proposed_A1	182.42	132.42	182.77	183.43	183.10	182.92	183.64
62	SFK_Proposed_A2	236.77	186.77	235.98	237.33	237.02	237.07	237.14
63	SFK_1610005-009	31.30	-18.70	56.38	45.60	33.46	25.94	19.00
64	SFK_18S20E23E001M	26.39	-23.61	51.36	42.78	33.85	25.91	17.82
65	SFK_18S20E23E002M	28.42	-21.58	53.89	44.81	35.89	27.95	19.86
66	SFK_18S20E34N001M	68.17	18.17	110.82	82.17	75.93	69.21	61.60
67	SFK_19S20E19A001M	-77.73	-127.73	-38.99	-59.36	-76.06	-89.90	-91.31
68	SFK_19S20E06C001M	9.03	-40.97	42.14	25.85	18.50	10.47	1.42
69	SFK_19S20E06L001M	-46.58	-96.58	23.00	-26.06	-47.07	-57.97	-63.48

See Acronyms and Abbreviations list for definitions.

Table 4-1. Groundwater Levels - Measurable Objectives, Minimum Thresholds, and Interim Milestones (elevation in feet above mean sea level) (Continued)

Index	Well ID	MO	MT	2017	2025	2030	2035	2040
70	SFK_19S20E07F001M	-17.82	-67.82	24.00	-1.96	-8.90	-16.39	-24.89
71	SFK_19S20E32D002M	-26.91	-76.91	2.94	-15.48	-21.41	-26.36	-32.50
72	SFK_19S20E32D003M	-26.91	-76.91	-7.68	-15.48	-21.41	-26.36	-32.50
73	SFK_20S20E26L001M	45.75	-4.25	52.71	51.59	48.64	46.38	42.63
74	SFK_20S20E26L002M	-19.25	-69.25	-12.95	-13.40	-16.35	-18.61	-22.36
75	SFK_Proposed_B1	83.63	33.63	97.09	92.14	88.27	84.36	79.72
76	SFK_19S20E26N002M	-3.81	-53.81	41.56	18.16	-2.91	-26.38	-14.88
77	SFK_20S19E02A001M	-67.47	-117.47	-30.60	-48.13	-72.04	-91.94	-89.90
78	SFK_20S20E07H001M	-102.74	-152.74	-4.83	-82.67	-100.16	-126.98	-112.22
79	SFK_20S20E28E003M	-41.13	-91.13	-56.13	-23.02	-37.11	-61.17	-43.32
80	SFK_1610005-020	7.21	-42.79	43.24	22.11	0.63	-6.76	-9.05
81	SFK_1610005-011	-91.02	-141.02	-42.55	-71.85	-97.00	-114.74	-112.99
82	SFK_Proposed_C1	-5.54	-55.54	44.21	15.76	-9.25	-24.57	-24.06
83	SWK_1610009-003	70.58	20.58	78.00	72.98	72.02	71.04	69.90
84	SWK_Proposed_B1	107.75	57.75	120.01	114.77	111.38	107.77	103.95
85	SWK_Proposed_B2	177.02	127.02	176.13	176.37	176.36	176.90	177.87
86	SWK_Well_16-8	50.96	0.96	63.83	62.42	48.13	47.85	41.71
87	SWK_Proposed_C1	80.24	30.24	86.80	87.11	77.77	78.55	76.59
88	SWK_Proposed_C2	105.94	55.94	105.10	109.01	102.83	107.41	105.94
89	SWK_Proposed_C3	152.29	102.29	151.88	153.49	145.92	154.77	155.34
90	TCWA_23S23E15M001M	199.21	149.21	197.05	200.17	198.83	199.87	200.39
91	TCWA_Proposed_B1	89.18	39.18	115.99	105.46	97.53	89.33	81.42
92	TCWA_24S22E33C001M	-41.39	-91.39	-23.25	-21.72	-87.56	-36.65	-39.74
93	TCWA_24S22E35E001M	16.76	-33.24	22.94	41.02	-40.93	18.72	16.69
94	TCWA_Proposed_C1	-60.88	-110.88	-21.93	-29.46	-99.02	-62.31	-71.16
95	TCWA_Proposed_B2	105.57	55.57	115.39	111.71	108.88	105.98	102.97

See Acronyms and Abbreviations list for definitions.

Table 4-2a. Land Subsidence @ Baseline - Measurable Objectives, Minimum Thresholds, and Interim Milestones – Lemoore RMS (feet of cumulative subsidence since 1990)

MO	MT	Interim Milestones				
		2017	2025	2030	2035	2040
5.52	11.5	1.98	4.19	5.33	5.76	6.92

Table 4-2b. Land Subsidence w/GSP Implementation - Measurable Objectives, Minimum Thresholds, and Interim Milestones – Lemoore RMS (feet of cumulative subsidence since 1990)

MO	MT	Interim Milestones				
		2017	2025	2030	2035	2040
5.52	11.5	1.97	3.80	4.59	4.67	5.00

Table 4-3a. Land Subsidence @ Baseline - Measurable Objectives, Minimum Thresholds, and Interim Milestones – Corcoran RMS (feet of cumulative subsidence since 1990)

MO	MT	Interim Milestones				
		2017	2025	2030	2035	2040
8.90	11.5	4.52	4.58	5.07	5.21	5.82

Table 4-3b. Land Subsidence w/GSP Implementation - Measurable Objectives, Minimum Thresholds, and Interim Milestones – Corcoran RMS (feet of cumulative subsidence since 1990)

MO	MT	Interim Milestones				
		2017	2025	2030	2035	2040
8.90	11.5	4.51	4.49	4.54	4.59	4.57

See Acronyms and Abbreviations list for definitions.

Table 5-1. Summary of Existing & Proposed Monitoring Network Sites

Existing RMS Network	Water Level	Water Quality	Land Subsidence
Mid-King River GSA	25	18	11
South Fork King GSA	21	21	6
Southwest Kings GSA	2	2	4
El Rico GSA	10	3	5
Tri-County GSA	3	0	2
Total	61	44	28
Proposed Additions to RMS Network	**Water Level**	**Water Quality**	**Land Subsidence**
Mid-King River GSA	9	TBD	0
South Fork King GSA	4	TBD	1
Southwest Kings GSA	5	TBD	0
El-Rico GSA	13	TBD	1
Tri-County GSA	3	TBD	0
Total	34	0	2

Notes:

1) Summary of network includes nested (multiple casings installed in a single borehole) or clustered monitoring wells (multiple wells located close together) for water levels and water quality.

See Acronyms and Abbreviations list for definitions.

Table 5-2. Mid-Kings River GSA: Existing & Proposed Representative Monitoring Network

	Mid Kings River GSA						Facility				
	State Well ID / System Well Number *(if applicable)*	Local Agency Well ID *(if applicable)*	Aquifer Zone	Township	Range	Section	Type	Existing Program	Sustainability Indicator(s)[6]	SGMA Monitoring Frequency	Aquifer Monitored
Representative Monitoring Sites	18S21E17N001M	18S21E17N001M	A Zone	18S	21E	17	Unknown Use	KCWD	WL	Semiannual	Above A-Clay
	19S21E20N001M	19S21E20N001M	A Zone	19S	21E	20	Unknown Use	KCWD	WL	Semiannual	Above A-Clay
		MW-A	B Zone	17S	22E	1	Monitoring Well	KCWD	WL	Semiannual	Local
	17S22E28A001M	KRCDKCWD01	B Zone	17S	22E	28	Irrigation Well	DWR	WL	Semiannual	Above E-Clay
	18S22E03B001M	18S22E03B001M	B Zone	18S	22E	3	Unknown Use	KCWD	WL	Semiannual	Above E-Clay
	18S21E01C001M	18S21E01C001M	B Zone	18S	21E	1	Unknown Use	KCWD	WL	Semiannual	Above E-Clay
	18S22E07A001M	18S22E07A001M	B Zone	18S	22E	24	Unknown Use	USBR	WL	Semiannual	Above E-Clay
	18S22E24D001M	18S22E24D001M	B Zone	18S	22E	24	Irrigation Well	Lakeside Irrigation WD	WL	Semiannual	Above E-Clay
	18S22E28A001M	KRCDKCWD08	B Zone	18S	22E	28	Irrigation Well	KCWD	WL	Semiannual	Above E-Clay
	18S22E34R001M	18S22E34R001M	B Zone	18S	22E	34	Residential	KDWCD	WL	Semiannual	Above E-Clay
	19S22E07K001M	KRCDKCWD11	B Zone	19S	22E	7	Unknown Use	Lakeside Irrigation WD	WL	Semiannual	Above E-Clay
	18S21E27B001M	KRCDKCWD05	B Zone	18S	21E	27	Irrigation Well	KCWD	WL	Semiannual	Above E-Clay
	18S21E07R003M	18S21E07R003M	B Zone	18S	21E	7	Unknown Use	DWR	WL	Semiannual	Above E-Clay
	18S21E31B001M	18S21E31B001M	B Zone	18S	21E	31	Unknown Use	KCWD	WL	Semiannual	Above E-Clay
	19S21E30A001M	KRCDKCWD06	B Zone	19S	21E	30	Irrigation Well	KCWD	WL	Semiannual	Above E-Clay
		MW-C	B Zone	17S	22E	14	Monitoring Well	KCWD	WL	Semiannual	Above E-Clay
		MW-D	B & C Zone	17S	22E	23	Monitoring Well	KCWD	WL	Semiannual	Above/Below E-Clay
		MW-G	B & C Zone	17S	22E	25	Monitoring Well	KCWD	WL	Semiannual	Above/Below E-Clay
		MW-H	B & C Zone	18S	22E	34	Monitoring Well	KCWD	WL	Semiannual	Above/Below E-Clay
	1610003-042/[1]	Well_48	C Zone	18S	21E	13	Municipal Well	Hanford	WL/WQ/[3]	Semiannual	Below E-Clay
	1610003-037/[1]	Well 43	C Zone	18S	21E	27	Municipal Well	Hanford	WL/WQ/[3]	Semiannual	Below E-Clay
	19S22E08D002M	19S22E08D002M	C Zone	19S	22E	8	Observation	KDWCD	WL	Semiannual	Below E-Clay
Water Quality Sites	17S22E20D		B Zone	17S	22E	20	Domestic Well	ILRP	WQ/[4]	Annual	Above E-Clay/[5]
	17S22E33A		B Zone	17S	22E	33	Domestic Well	ILRP	WQ/[4]	Annual	Above E-Clay/[5]
	18S21E14M		B Zone	18S	21E	14	Irrigation Well	ILRP	WQ/[4]	Annual	Above E-Clay/[5]
	1610001-008			18S	21E	32	Municipal Well	Armona CSD	WQ/[3]	Annual	
	1610001-009			19S	21E	4	Municipal Well	Armona CSD	WQ/[3]	Annual	
	1610003-031		C Zone	18S	21E	23	Municipal Well	Hanford	WQ/[3]	Annual	Below E-Clay
	1610003-039		C Zone	18S	22E	30	Municipal Well	Hanford	WQ/[3]	Annual	Below E-Clay
	1610003-036		C Zone	18S	21E	22	Municipal Well	Hanford	WQ/[3]	Annual	Below E-Clay
	1610003-041			18S	22E	19	Municipal Well	Hanford	WQ/[3]	Annual	
	1610003-033		C Zone	18S	21E	14	Municipal Well	Hanford	WQ/[3]	Annual	Below E-Clay
	1610003-040			18S	21E	25	Municipal Well	Hanford	WQ/[3]	Annual	
	1610003-026			18S	21E	36	Municipal Well	Hanford	WQ/[3]	Annual	
	1610003-038		C Zone	18S	21E	14	Municipal Well	Hanford	WQ/[3]	Annual	Below E-Clay
	1610003-028		C Zone	18S	21E	26	Municipal Well	Hanford	WQ/[3]	Annual	Below E-Clay
	1610003-043			18S	22E	19	Municipal Well	Hanford	WQ/[3]	Annual	
	1610003-034			18S	21E	23	Municipal Well	Hanford	WQ/[3]	Annual	

See Acronyms and Abbreviations list for definitions.

Table 5-2. Mid-Kings River GSA: Existing & Proposed Representative Monitoring Network (Continued)

	Mid Kings River GSA						Facility				
	State Well ID / System Well Number *(if applicable)*	Local Agency Well ID *(if applicable)*	Aquifer Zone	Township	Range	Section	Type	Existing Program	Sustainability Indicator(s)[6]	SGMA Monitoring Frequency	Aquifer Monitored
Land Subsidence	SUB084			NA	NA	NA	Subsidence Monument	KRCD	LS	Semiannual	All
	K021			17S	22E	34	Subsidence Monument	KDWCD	LS	Semiannual	All
	S224P2			18S	22E	28	Subsidence Monument	CHSRA	LS	Semiannual	All
	U 808			18S	22E	29	Subsidence Monument	CalTrans	LS	Semiannual	All
	U 511			18S	22E	30	Subsidence Monument	CalTrans	LS	Semiannual	All
	X 511			18S	21E	24	Subsidence Monument	CalTrans	LS	Semiannual	All
	U 157, SUB091			18S	21E	36	Subsidence Monument	KRCD	LS	Semiannual	All
	Hanford RM1, SUB032			18S	21E	36	Subsidence Monument	KRCD	LS	Semiannual	All
	X 931			18S	21E	32	Subsidence Monument	CalTrans	LS	Semiannual	All
	N 460 RESET			18S	21E	32	Subsidence Monument	CalTrans	LS	Semiannual	All
	SUB068			18S	21E	31	Subsidence Monument	KRCD	LS	Semiannual	All
Proposed Facilities			B Zone	17S	22E	19	Monitoring Well		WL	Semiannual	Above E-Clay
			B Zone	17S	22E	27	Monitoring Well		WL	Semiannual	Above E-Clay
			B Zone	19S	21E	16	Monitoring Well		WL	Semiannual	Above E-Clay
			B Zone	20S	21E	8	Monitoring Well		WL	Semiannual	Above E-Clay
			C Zone	17S	21E	26	Monitoring Well		WL	Semiannual	Below E-Clay
			C Zone	18S	22E	3	Monitoring Well		WL	Semiannual	Below E-Clay
			C Zone	18S	21E	3	Monitoring Well		WL	Semiannual	Below E-Clay
			C Zone	19S	21E	8	Monitoring Well		WL	Semiannual	Below E-Clay
			C Zone	19S	21E	32	Monitoring Well		WL	Semiannual	Below E-Clay

Notes:
/1 Representative Monitoring Sites that are also included for Water Quality
/2 Proposed monitoring areas pending funding or collaboration with DWR or USGS
/3 State Water Resources Control Board Division (SWRCB) Division of Drinking Water (DDV)
/4 Kings River Water Quality Coalition (KRWQC), Irrigation Lands Regulatory Program (ILRP), samples annually, data will be retrieved annually
/5 Tentatively identified as B Zone Well
/6 WL -= water level, WQ = water quality, LS = land subsidence

Table 5-3. South Fork Kings GSA: Existing & Proposed Representative Monitoring Network

	South Fork Kings River GSA						Facility	Existing Program	Sustainability Indicator(s)[5]	SGMA Monitoring Frequency	Aquifer Monitored
	State Well ID / System Well Number *(if applicable)*	**Local Agency Well ID** *(if applicable)*	**Aquifer Zone**	**Township**	**Range**	**Section**	**Type**				
Representative Monitoring Sites	18S20E23E003M[/1]	KRCDAC1S	A Zone	18S	20E	23	Monitoring Well	CASGEM	WL/WQ[/3]	Semiannual	Above A-Clay
	19S20E29E002M	19S20E29E002M	A Zone	19S	20E	29	Unknown Use	DWR	WL	Semiannual	Above A-Clay
	20S19E25A003M	20S19E25A003M	A Zone	20S	19E	25	Monitoring Well	DWR	WL	Semiannual	Above A-Clay
	1610005-009[/1]	LEM_N-5	B Zone	18S	20E	11	Municipal Well	Lemoore	WL/WQ[/3]	Semiannual	Above E-Clay
	18S20E23E002M[/1]	KRCDAC1M	B Zone	18S	20E	23	Monitoring Well	CASGEM	WL/WQ[/4]	Semiannual	Above E-Clay
	18S20E23E001M	KRCDAC1D	B Zone	18S	20E	23	Monitoring Well	CASGEM	WL	Semiannual	Above E-Clay
	18S20E34N001M	18S20E34N001M	B Zone	18S	20E	34	Residential Well	DWR	WL	Semiannual	Above E-Clay
	19S20E06C001M	19S20E06C001M	B Zone	19S	20E	6	Irrigation Well	DWR	WL	Semiannual	Above E-Clay
	19S20E07F001M		B Zone	19S	20E	7	Unknown Use	DWR	WL	Semiannual	Above E-Clay
	19S20E32D002M[/1]	KRCDAC3M	B Zone	19S	20E	32	Monitoring Well	CASGEM	WL/ WQ[/4]	Semiannual	Above E-Clay
	19S20E32D003M	KRCDAC3D	B Zone	19S	20E	32	Monitoring Well	CASGEM	WL	Semiannual	Above E-Clay
	20S20E26L001M[/1]	KRCDAC5M	B Zone	20S	20E	26	Monitoring Well	CASGEM	WL/ WQ[/4]	Semiannual	Above E-Clay
	20S20E26L002M	KRCDAC5D	B Zone	20S	20E	26	Monitoring Well	CASGEM	WL	Semiannual	Above E-Clay
	19S20E06L001M	19S20E06L001M	Composite	19S	20E	6	Irrigation Well	DWR	WL	Semiannual	Above/Below E-Clay
	19S20E19A001M	19S20E19A001M	Composite	19S	20E	19	Irrigation Well	DWR	WL	Semiannual	Above/Below E-Clay
	1610005-020[/1]	LEM_N-6	C Zone	18S	20E	11	Municipal Well	Lemoore	WL/WQ[/3]	Semiannual	Below E-Clay
	1610005-011[/1]	LEM_12	C Zone	19S	20E	9	Municipal Well	Lemoore	WL/ WQ[/4]	Semiannual	Below E-Clay
	19S20E26N002M	CU-ELEM SCHOOL	C Zone	19S	20E	26	Municipal Well	Public Water Systems	WL	Semiannual	Below E-Clay
	20S19E02A001M	20S/19E-02A01	C Zone	20S	19E	2	Irrigation Well	Westlands Water District	WL	Semiannual	Below E-Clay
	20S20E07H001M	20S20E07H001M	C Zone	20S	20E	7	Irrigation Well	DWR	WL	Semiannual	Below E-Clay
	20S20E28E003M		C Zone	20S	20E	28	Unknown Use	DWR	WL	Semiannual	Below E-Clay
Water Quality Sites	1610006-001		Composite	20S	20E	17	Municipal Well	Stratford PUD	WQ[/3]	Annual	Above/Below E-Clay
	1610006-002			20S	20E	17	Municipal Well	Stratford PUD	WQ[/3]	Annual	
	1610006-005			20S	20E	17	Municipal Well	Stratford PUD	WQ[/3]	Annual	
	1610005-021			19S	20E	8	Municipal Well	Lemoore	WQ[/3]	Annual	
	1610005-007			19S	20E	15	Municipal Well	Lemoore	WQ[/3]	Annual	
	1610005-010			18S	20E	35	Municipal Well	Lemoore	WQ[/3]	Annual	
	1610005-003			18S	20E	11	Municipal Well	Lemoore	WQ[/3]	Annual	
	1610005-022			19S	20E	8	Municipal Well	Lemoore	WQ[/3]	Annual	
	1610005-005			18S	20E	11	Municipal Well	Lemoore	WQ[/3]	Annual	
	1610005-018			19S	20E	8	Municipal Well	Lemoore	WQ[/3]	Annual	
	1610005-008			19S	20E	15	Municipal Well	Lemoore	WQ[/3]	Annual	
	1610005-006			19S	20E	3	Municipal Well	Lemoore	WQ[/3]	Annual	
	19S20E11C			19S	20E	11	Unknown Use		WQ	Annual	
	18S20E11D			18S	20E	11	Public Well		WQ	Annual	

See Acronyms and Abbreviations list for definitions.

Table 5-3. South Fork Kings GSA: Existing & Proposed Representative Monitoring Network (Continued)

	South Fork Kings River GSA						Facility				
	State Well ID/System Well Number *(if applicable)*	Local Agency Well ID *(if applicable)*	Aquifer Zone	Township	Range	Section	Type	Existing Program	Sustainability Indicator(s)[5]	SGMA Monitoring Frequency	Aquifer Monitored
Land Subsidence	SOUTHFORK, SUB086			18S	20E	16	Subsidence Monument	KRCD	LS	Semiannual	All
	LEMA (RMS)			19S	20E	10	Subsidence Monument	CVSRN	LS	Semiannual	All
	G808	SUB028		19S	19E	24	Subsidence Monument	CalTrans/KCRD	LS	Semiannual	All
	SUB102			20S	20E	18	Subsidence Monument	KRCD	LS	Semiannual	All
	SUB061			20S	20E	21	Subsidence Monument	KRCD	LS	Semiannual	All
Proposed Facilities	Proposed Well		A Zone	19S	20E	32	Monitoring Well		WL	Semiannual	Above A-Clay
	Proposed Well		A Zone	20S	20E	26	Monitoring Well		WL	Semiannual	Above A-Clay
	Proposed Well		B Zone	19S	20E	26	Municipal Well		WL	Semiannual	Above E-Clay
	Proposed Well		C Zone	18S	20E	27	Monitoring Well		WL	Semiannual	Below E-Clay
	/2		All	19S	20E	35	Extensometer		LS	Semiannual	All

Notes:
/1 Representative Monitoring Sites that are also included for Water Quality
/2 Proposed monitoring areas pending funding or collaboration with DWR or USGS
/3 State Water Resources Control Board Division (SWRCB) Division of Drinking Water (DDW)
/4 Kings River Water Quality Coalition (KRWQC), Irrigated Lands Regulatory Program (ILRP) samples annually, data will be retrieved annually
/5 WL -= water level, WQ = water quality, LS = land subsidence

Table 5-4. Southwest Kings GSA: Existing & Proposed Representative Monitoring Network

	Southwest Kings GSA						Facility				
	State Well ID / System Well Number *(if applicable)*	Local Agency Well ID *(if applicable)*	Aquifer Zone	Township	Range	Section	Type	Existing Program	Sustainability Indicator(s)[5]	SGMA Monitoring Frequency	Aquifer Monitored
Representative Monitoring Sites	1610009-003[/1]	Becky Pease Well	B Zone	22S	19E	19	Municipal Well	Kettleman City CSD	WL/WQ[/3]	Semiannual	Above E-Clay
		Well 16-8	C Zone	21S	19E	21	Irrigation Well		WL	Semiannual	Below E-Clay
Water Quality Sites	1610009-004	Maud St. Well	B Zone	22S	19E	8	Municipal Well	Kettleman City CSD	WQ[/3]	Annual	Above E-Clay
Land Subsidence	G 1445, SUB027			22S	19E	30	Subsidence Monument	KRCD, California Aqueduct	LS	Semiannual	All
	U 1097			22S	19E	30	Subsidence Monument	California Aqueduct	LS	Semiannual	All
	SUB030			24S	19E	11	Subsidence Monument	KRCD	LS	Semiannual	All
	SUB076			24S	19E	36	Subsidence Monument	KRCD	LS	Semiannual	All
Proposed Facilities			B Zone	21S	19E	21	Monitoring Well		WL	Semiannual	Above E-Clay
	/2		B Zone	24S	20E	19	Monitoring Well		WL	Semiannual	Above E-Clay
			C Zone	22S	19E	18	Monitoring Well		WL	Semiannual	Below E-Clay
	/2		C Zone	23S	20E	8	Monitoring Well		WL	Semiannual	Below E-Clay
	/2		C Zone	24S	20E	18	Monitoring Well		WL	Semiannual	Below E-Clay

Notes:
/1 Representative Monitoring Sites that are also included for Water Quality
/2 Proposed monitoring areas pending funding or collaboration with DWR or USGS
/3 State Water Resources Control Board Division (SWRCB) Division of Drinking Water (DDW)
/4 Kings River Water Quality Coalition (KRWQC), Irrigated Lands Regulatory Program (ILRP) samples annually, data will be retrieved annually
/5 WL -= water level, WQ = water quality, LS = land subsidence

Table 5-5. El Rico GSA: Existing & Proposed Representative Monitoring Network

	El Rico GSA						Facility	Existing Program	Sustainability Indicator(s)[5]	SGMA Monitoring Frequency	Aquifer Monitored
	State Well ID / System Well Number *(if applicable)*	Local Agency Well ID *(if applicable)*	Aquifer Zone	Township	Range	Section	Type				
Representative Monitoring Sites	20S22E35R001M	20S22E35R001M	B Zone	20S	22E	35	Irrigation Well	DWR	WL	Semiannual	Above E-Clay
		ER_S-225	C Zone	20S	20E	32	Unknown Use		WL	Semiannual	Below E-Clay
		ER_S-173	C Zone	21S	22E	25	Unknown Use		WL	Semiannual	Below E-Clay
		ER_S-205	C Zone	22S	22E	6	Unknown Use		WL	Semiannual	Below E-Clay
		CID_078	C Zone	21S	22	1	Unknown Use		WL	Semiannual	Below E-Clay
	21S22E07J001M	21S22E07J001M	C Zone	21S	22E	7	Observation	KDWCD	WL	Semiannual	Below E-Clay
		CID 021	C Zone	20S	22E	13	Irrigation Well	CID	WL	Semiannual	Below E-Clay
	20S22E19J001M	20S22E19J001M	C Zone	20S	22E	19	Irrigation Well	DWR	WL	Semiannual	Below E-Clay
		KRCDTL002	C Zone	20S	21E	11	Irrigation Well		WL	Semiannual	Below E-Clay
		KRCDTL003	C Zone	20S	22E	22	Irrigation Well		WL	Semiannual	Below E-Clay
Water-Quality Sites	1610004-026			21S	22E	12	Municipal Well	Corcoran	WQ[/3]	Annual	
	1610004-018			21S	22E	2	Municipal Well	Corcoran	WQ[/3]	Annual	
	1610004-019			21S	22E	1	Municipal Well	Corcoran	WQ[/3]	Annual	
Land Subsidence	S234P2			20S	22E	16	Subsidence Monument	CHSRA	LS	Semiannual	All
	S238			21S	22E	10	Subsidence Monument	CHSRA	LS	Semiannual	All
	CRCN (RMS)			21S	22E	11	Subsidence Monument	CVSRN	LS	Semiannual	All
	SUB083			22S	22E	11	Subsidence Monument	KRCD	LS	Semiannual	All
	SUB093			23S	23E	31	Subsidence Monument	KRCD	LS	Semiannual	All
Proposed Facilities			A Zone	20S	21E	26	Monitoring Well		WL	Semiannual	Above A-Clay
			B Zone	20S	21E	23	Monitoring Well		WL	Semiannual	Above E-Clay
			B Zone	20S	22E	21	Monitoring Well		WL	Semiannual	Above E-Clay
			B Zone	21S	21E	21	Monitoring Well		WL	Semiannual	Above E-Clay
			B Zone	21S	22E	9	Monitoring Well		WL	Semiannual	Above E-Clay
			C Zone	21S	20E	10	Monitoring Well		WL	Semiannual	Below E-Clay
			C Zone	21S	21E	9	Monitoring Well		WL	Semiannual	Below E-Clay
			C Zone	21S	21E	27	Monitoring Well		WL	Semiannual	Below E-Clay
			C Zone	21S	21E	21	Monitoring Well		WL	Semiannual	Below E-Clay
	/2		C Zone	22S	21E	9	Monitoring Well		WL	Semiannual	Below E-Clay
	/2		C Zone	24S	21E	9	Monitoring Well		WL	Semiannual	Below E-Clay
	/2		All	20S	22E	31	Extensometer		LS	Semiannual	All

Notes:
/1 Representative Monitoring Sites that are also included for Water Quality
/2 Proposed monitoring areas pending funding or collaboration with DWR or USGS
/3 State Water Resources Control Board Division (SWRCB) Division of Drinking Water (DDW)
/4 Kings River Water Quality Coalition(KRWQC), Irrigated Lands Regulatory Program (ILRP) samples annually, data will be retrieved annually

See Acronyms and Abbreviations list for definitions.

Table 5-6. Tri-County Water Authority GSA Existing & Proposed Representative Monitoring Network

	Tri County Water Authority GSA						Facility	Existing Program	Sustainability Indicator(s)[5]	SGMA Monitoring Frequency	Aquifer Monitored
	State Well ID / System Well Number (*if applicable*)	Local Agency Well ID (*if applicable*)	Aquifer Zone	Township	Range	Section	Type				
Representative Monitoring Sites	23S23E15M001M		A Zone	23S	23E	15	Unknown Use	DWR	WL	Semiannual	Above A-Clay
	24S22E35E001M		C Zone	24S	22E	35	Unknown Use	DWR	WL	Semiannual	Below E-Clay
	24S22E33C001M		C Zone	24S	22E	33	Unknown Use	DWR	WL	Semiannual	Below E-Clay
Land Subsidence	SUB107			23S	21E	18	Subsidence Monument	KRCD	LS	Semiannual	All
	SUB038			24S	22E	34	Subsidence Monument	KRCD	LS	Semiannual	All
Proposed Facilities			B Zone	24S	22E	24	Monitoring Well		WL	Semiannual	Above E-Clay
			B Zone	23S	23E	16	Monitoring Well		WL	Semiannual	Below E-Clay
			C Zone	23S	23E	16	Monitoring Well		WL	Semiannual	Above E-Clay

Notes:
/1 Representative Monitoring Sites that are also included for Water Quality
/2 Proposed monitoring areas pending funding or collaboration with DWR or USGS
/3 State Water Resources Control Board Division (SWRCB) Division of Drinking Water (DDW)
/4 Kings River Water Quality Coalition (KWRQC), Irrigated Lands Regulatory Program (ILRP) samples annually, data will be retrieved annually
/5 WL -= water level, WQ = water quality, LS = land subsidence

See Acronyms and Abbreviations list for definitions.

Table 5-7. Annual Reporting Requirements

SGMA Section	Annual Reporting Requirement	Input to DMS (or link)
356.2(b)(1)(B)	Hydrographs including water year type from Jan 2015(?) to current	Generated in DMS from water level data input by GSAs
356.2(b)(1)(A)	GW Elevation Contours (spring & fall)	Generated outside DMS using data from DMS then contour maps created and a linked PDF maps from the DMS
356.2(b)(2)	GW extraction by water use sector including method of determination and map	Determined outside DMS. Total use by sector input by each GSA then summarized for subbasin in DMS as a summary table
356.2(b)(3)	Surface Water use by source	Total by GSA for input to DMS and summarized for subbasin in DMS as a summary table
356.2(b)(4)	Total Water use by sector	DMS summary table of water supplies by sector per GSA
356.2(b)(5)(A)	Change in GW Storage maps	Calculated outside DMS from contour data using basin-wide method then total per GSA input into DMS as a summary table
356.2(b)(5)(B)	Graph with Water Year type, est. GW use, annual & cumulative GW Storage change	DMS generated basin total graph using data in DMS.

Table 5-8. Reporting Standards

Category of Information	Reporting Units
Water Volumes	AF
Surface Water Flows Groundwater Flows	AF/Y or CFS AF/Y
Field Measurements of Elevations Groundwater Surface Water Land Surface	to nearest 0.1 ft relative to NAVD 88
Reference Point Elevations	To within 0.5 feet, or best available information relative to NAVD 88
Geographic Locations	GPS coordinates by latitude and longitude in decimal degrees to five decimal places, to a minimum accurate of 30 feet, relative to NAD 83

See Acronyms and Abbreviations list for definitions.

Table 6-1. Summary of Projects and Management Actions Chosen for Mid-Kings River GSA

Project	Implementing Agency	Cost	Annual Yield (AF/Y)
Rehabilitation of Existing Recharge Basins	Kings County Water District	$ 800,000	1,500
Conveyance Improvements and Construction on Riverside Canal	Kings County Water District	$ 320,000	1,500
Fallowing Program	Mid-Kings River GSA	$ 1,380,000	6,250
Cartright Basin Improvements	Kings County Water District, Lakeside Irrigation Water District	$ 884,000	650
Last Chance Side Ditch Improvements	Kings County Water District, Landowners	$ 6,798,000	1,000
Recharge Basin Construction	Kings County Water District, Mid-Kings River GSA	$ 90,000,000	44,444

Table 6-2. Summary of Projects and Management Actions Chosen for South Fork Kings GSA

Project	Implemented by	Annualized Benefit (AF/Y)	Priority	Estimated CAPEX ($)
Groundwater Measurement and Reporting	South Fork Kings GSA/Landowners	1,500	High	$ 500,000
Surface Water Delivery Improvement	South Fork Kings GSA/Landowners	5,000	High	$ 5,000,000
On-Farm Improvements	South Fork Kings GSA/Landowners	2,500	Med	$ 1,000,000
Conservation Reuse	South Fork Kings GSA/Lemoore	1,000	Med	$ 1,000,000
Cropping/Fallowing Program	South Fork Kings GSA	13,000	High	$ 5,000,000
Demand Reduction Sub-Total		**23,000**		**$ 12,500,000**
Aquifer Storage and Recovery	South Fork Kings GSA/Landowners	13,000	High	$ 15,000,000
Surface Storage	South Fork Kings GSA/Landowners	2,000	Low	$ 6,000,000
Mid-Kings Recharge Basin	South Fork Kings GSA	7,000	Med	$ 28,000,000
Supply Enhancement Sub-Total		**22,000**		**$ 49,000,000**
TOTAL		**45,000**		**$ 61,500,000**

See Acronyms and Abbreviations list for definitions.

Table 6-3. Summary of Projects and Management Actions Chosen for El Rico GSA

Project	Annual Project Use (Days)	Acres	Cost/Acre	Average Annual Yield (AF/Y)	Total Cost	Project Life (Years)
Storage Ponds	60	5,000	$20,000	26,000	$100,000,000	60
Canal Lining/Piping	150		3M/mile	25,000	$100,000,000	60
Demand Reduction	360	5,000		15,000		
Total				**76,000**		

Table 6-4. Summary of Projects and Management Actions Chosen for Tri-County Water Authority GSA

Project	Annual Project Use (Days)	Acres	Cost/Acre	Average Annual Yield (AF/Y)	Total Cost	Project Life (Years)
Storage Ponds	60	1,500	30,000	15,000	$45,000,000	
Demand Reduction						
Total				**15,000**		

See Acronyms and Abbreviations list for definitions.

Table 6-5. Project 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 may achieve the sustainability goal for the Subbasin, including projects and management actions to respond to changing conditions in the Subbasin.
(b) Each Plan shall include a description of the projects and management actions that include the following 1-9:
(c) Projects and management actions shall be supported by best available information and best available science.
(d) An Agency shall take into account the level of uncertainty associated with the Subbasin setting when developing projects or management actions.

#	Management Action (b)(1) *	Description (b)(1)	Measurable Objective (b)(1)	Circumstances of Implementation (b)(1)(A)	Quantification of Demand Reduction (b)(2)	Permitting & Regulatory Process (b)(3)	Status, Start, End, and Accrual of Benefits (b)(4)	Explanation of Benefits and Method of Evaluation (b)(5)	Explanation of Water Source and Reliability (b)(6)	Cost and Funding Options (b)(8)	Management of Groundwater Extraction and Recharge (b)(9)	Level of Uncertainty Associated with the Basin Setting, 1=uncertain 5=certain (d)
Projects												
1	Infiltration Basin Project	The Subbasin may adopt a policy to incentivize groundwater extractors through subsidies to utilize designated lands for banking only and or designated lands for scheduled banking under contract during certain periods of the season.	The goal is to encourage landowners to fallow land and replenish the groundwater, as well as encourage water trading between GSAs in the Tulare Lake Subbasin.	The policy will begin shortly after GSP approval and will solicit volunteers first. Project lands area needed will designed by GSA.	Demand reduction will be based on acreage removed from farming practices.	No permits or regulatory processes are required for the Subbasin to adopt the policy. The Subbasin has the power as outlined in the SGMA and related provisions to adopt ordinances.	Policy to be written by 2023 and implemented by 2025 and to remain indefinitely, but can be revised as needed.	A direct benefit to the groundwater levels will be accomplished through this policy. Groundwater elevation data will be utilized, and the amount (volume) of water recharged will be used as the evaluation method.	The management action may be accomplished through policy adoption by the Subbasin. Current water sources will be used in most cases and some external water sources may be needed.	Estimated cost to draft and adopt policy is $50,000. Costs associated with tracking resources have not been evaluated.	Chronic lowering of groundwater levels or depletion of supply during periods of drought may be partially offset by storing water in wetter years.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.
2	Storage Project	The Subbasin may adopt a policy to incentivize groundwater extractors through subsidies to utilize designated lands for storage only and or designated lands for scheduled storage under contract during certain periods of the season.	The goal is to encourage landowners to fallow land and replenish the groundwater, as well as encourage GSA water trading between GSAs in the Tulare subbasin.	The policy will begin shortly after GSP approval and will solicit volunteers first. Project lands area needed will designed by GSA.	Demand reduction will be based on acreage removed from farming practices.	No permits or regulatory processes are required for the Subbasin to adopt the policy. The Subbasin has the power as outlined in the SGMA and related provisions to adopt ordinances.	Policy to be written by 2023 and implemented by 2025 and to remain indefinitely, but can be revised as needed.	A direct benefit to the groundwater levels will be accomplished through this policy, for in-lieu groundwater supplies. Groundwater elevations will be utilized as the evaluation method.	The management action may be accomplished through policy adoption by the Subbasin. Existing surface water sources will be used.	Estimated cost to draft and adopt policy is $50,000. Costs associated with tracking resources have not been evaluated.	Chronic lowering of groundwater levels or depletion of supply during periods of drought may be partially offset by storing water in wetter years.	Level of uncertainty of the project is 4; in wet years there is water available for this area as well as the infrastructure to deliver it.

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#	Management Action (b)(1) *	Description (b)(1)	Measurable Objective (b)(1)	Circumstances of Implementation (b)(1)(A)	Quantification of Demand Reduction (b)(2)	Permitting & Regulatory Process (b)(3)	Status, Start, End, and Accrual of Benefits (b)(4)	Explanation of Benefits and Method of Evaluation (b)(5)	Explanation of Water Source and Reliability (b)(6)	Cost and Funding Options (b)(8)	Management of Groundwater Extraction and Recharge (b)(9)	Level of Uncertainty Associated with the Basin Setting, 1=uncertain 5=certain (d)
3	Existing Infrastructure and/or Rehabilitation of New Construction	The Subbasin may adopt efforts to fund projects to rehabilitate existing facilities and construct new facilities to divert, or bank water in areas conducive of these activities. Including diversion systems, check structures, banking facilities, and storage facilities. Also, would allow groundwater trading within the Subbasin. Not intended to restrict water right holders.	The goal is to modify or develop new facilities that can deliver a larger amount of water when needed, as well as service an area that does not have a delivery system.	Development of the projects will begin shortly after GSP approval.	These projects will work in conjunction with a banking project or other projects as needed.	No permits or regulatory processes are required for the Subbasin to adopt the project. The Subbasin has the power as outlined in the SGMA and related provisions to adopt ordinances or approve projects related to SGMA.	Projects to be included in the GSP. Soon after adoption of GSP projects to begin development.	A direct benefit to the groundwater levels will be accomplished through these projects, for in-lieu groundwater supplies. Groundwater elevations will be utilized as the evaluation method.	The management action may be accomplished through policy adoption by the Subbasin. Existing water sources will be used in most cases and some external water sources may be needed.	Estimated cost to draft and adopt policy is $50,000. Project costs will vary.	Chronic lowering of groundwater levels or depletion of supply during periods of drought may be partially offset by storing water in wetter years, trading of groundwater to minimize the concentration of pumping in one area.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.
4	Lining and/or piping of canals	Larger canals may be piped or lined to increase capacity and/or efficiency of water deliveries.	Increased water supply or efficiency to reduce fallowed land.	The project will begin after assessment is made and funding is secured.	Demand reduction will be minimized to capturing more water via efficient delivery.	No permits or regulatory process is required for the Subbasin to adopt the policy. The Subbasin has the power as outlined in the SGMA, and related provisions to adopt ordinances.	Project included in GSP, but funding not yet secured. Benefits would start upon completion of piping/lining. Benefits would accrue for duration of project.	A direct benefit to groundwater levels will be accomplished due to decreased pumping via increased deliveries.	Reliability is high, as many canals are used each year.	Estimated cost to line and pipe major canals is $100,000,000. Willing partners and participants are being approached.	Less extraction would occur. No extra monitoring required.	Level of uncertainty of the project is 3, because the project would save water year in and year out. However, the funding for the project is not yet certain.

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5	Agricultural land fallowing subsidies	The Subbasin may adopt a policy to incentivize farmers to annually fallow land through leases.	The goal is to reduce irrigated acreage. The MO is the acreage of fallowed land and offset groundwater pumping.	The policy development will begin shortly after GSP approval.	Demand reduction will be based on acreage removed from farming practices and offset groundwater pumping.	No permits or regulatory processes are required for the Subbasin to adopt the policy. The Subbasin has the power as outlined in the SGMA and related provisions to adopt ordinances.	Policy to be written by 2023 and implemented by 2025 and to remain indefinitely, but can be revised as needed.	A direct benefit to the groundwater levels will be accomplished through this policy, based on demand reduction. Groundwater elevations will be utilized as the evaluation method.	The management action may be accomplished through policy adoption by the Subbasin. No external water source is used.	Estimated cost to draft and adopt policy is $50,000.	Chronic lowering of groundwater levels or depletion of supply during periods of drought may be partially offset by permanent fallowing.	Level of uncertainty of the project is 2; in wet years there is water available for this area as well as the infrastructure to deliver it.
6	Aquifer Storage and Recovery (ASR)	ARS is a way to recharge an aquifer directly, using an existing well. ASR utilizes the aquifer as a means of local storage for use a later period..	Increased water levels and supply and reduce groundwater demand	Implementation will occur after GSP approval and landowner agreements are in place. The projects are likely to be implemented by individual landowners .	Demand reduction will occur, as the stormwater water will be used for recharge and will offset groundwater pumping.	It is expected that permits from the State Water Resources Control Board will be needed as well as Local compliance	Project can begin after adoption and approval of GSP upon GSA's development of the program.	A direct benefit to the groundwater levels will be accomplished through this policy. Groundwater elevation data will be utilized, and the amount (volume) of water injected will be used as the evaluation method.	Reliability is high, as there are many wells. Water source will be dependent on individual participants access to water.	Estimated total program cost is $15,000,000. Individual participants will fund projects.	Chronic lowering of groundwater levels or depletion of supply during periods of drought may be partially offset by storing water in wetter years.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.
Outreach												
1	Education of groundwater use per acre	The Subbasin may adopt a policy which provides groundwater extractors their approximate groundwater extraction on a per acre basis, and how SGMA will be enforced, as well as other policies developed by the Subbasin.	The goal is to provide education and promote awareness of the Subbasin overdraft condition particularly for those groundwater extractors who do not have meters. The MO is annual statements of groundwater extraction in acre-feet.	Implementation to occur at year one and thereafter, if extractor exceeds their extraction amount.	If individual extractors are over drafting, demand reduction will occur with compliance of this policy.	No permits or regulatory process is required for the Subbasin to adopt the policy.	The policy has not been drafted. It is expected to commence shortly after the adoption of the GSP and be completed within the first three years.	The expected benefit is to educate extractors of overdraft; this is the first step in policing SGMA. Extractors will be monitored.	The management action may be accomplished by Subbasin policy adoption. No external water source is used.	Estimated $50,000 cost to draft and adopt policy.	Within the education course, a description of how recharge and groundwater extraction will be credited to each extractor during drought and other periods.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.

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Assessment												
1	Pumping fees for groundwater allocation exceedances	Policy for exceedance of pumping beyond the current groundwater allocation. Can increase with each occurrence.	The goal is to incentivize groundwater extractors to pump only their groundwater allocation per year. The MO is the volume of groundwater extraction in acre-feet.	First phase of the policy will be written by 2023 and implemented by Jan 2025. Fees will increase every year after 2025 and with each occurrence.	This policy reduces demand and/or charges each extractor based on the budgeted amount of groundwater.	No permits or regulatory processes are required for the Subbasin to adopt the policy. The Subbasin has the power as outlined in SGMA and related provisions to adopt ordinances, levy financial penalties, and enforce policies.	Policy is expected to be drafted and commence after the adoption of the GSP. Benefits will be added revenue to mitigate other projects in the area.	The expected benefit is to deter groundwater extractors from exceeding their allocation. Other benefits will be revenue for projects to mitigate local overdraft. The method of evaluation will be a summary of over-extractors and the reduction of those over-extractors over time.	The management action may be accomplished by Subbasin policy adoption and enforcement. No external water source is used.	Estimated $50,000 cost to draft and adopt policy. Initial GSA assessments will be needed to fund the development of this policy.	Chronic lowering of groundwater levels or depletion of supply during periods of drought may be offset by temporary increases in fee structure or groundwater pumping restrictions.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.
2	Pumping fees for groundwater extractions	The Subbasin may adopt a policy to impose fees on groundwater extractors on a per acre-foot basis. Fees are intended to support GSA activities and are not intended to be overbearing.	The goal is to incentivize groundwater extractors to reduce pumping and look for other sources of water. The MO is the revenue generated to support GSA operations.	Policy to be written and implemented by 2025 and to remain indefinitely.	No direct reduction in demand.	No permits or regulatory processes are required for the Subbasin to adopt the policy. The Subbasin has the power as outlined in the SGMA and related provisions to adopt ordinances, levy financial penalties, and enforce policies.	Policy is expected to be drafted and commence after the adoption of the GSP. Benefits will be added revenue to support GSA operations.	The expected benefits will provide funding for GSAs to operate under the SGMA.	The management action may be accomplished through policy adoption by the Subbasin and enforcement. No external water source is used.	Estimated $50,000 cost to draft and adopt policy. Initial GSA assessments will be needed to fund the development of this policy.	This policy in intended to be a part of the entire GSA operational Bylaws; there is no direct offset of chronic lowering of groundwater.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.
Groundwater Allocation												
1	Flood Flows (spills into the Subbasin) include Tule River, Deer Creek, Cross-Creeks and Kings River	The Subbasin may adopt a policy for actions to divert flows during flood releases to needed areas and a credit system for those who divert.	Validate Water Rights and existing agreements. MO is to allocate water to the rightful owner.	Policy to be drafted by 2023 and implemented by 2025.	This management action alone may not generate a quantifiable demand reduction. However, it allocates water to be used in the proper service area.	No permits or regulatory processes are required for the Subbasin to adopt the policy. SWRCB is paying close attention to policies within a GSA that pertain to water rights and flood water diversion.	Policy to be written by 2023 and implemented by 2025 and to remain indefinitely, but can be revised as needed.	The expected benefit is to encourage diversion of flood flows to areas to make the most groundwater level impact.	Contract holder; reliability varies based on allocation.	Estimated $25,000 cost to draft and adopt policy.	Banked water will offset a depletion of supply during periods of drought.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.

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2	Development of groundwater allocation	The Subbasin may adopt a policy which provides a finite groundwater allocation, either based on the modeling efforts or the sustainable yield. Ultimate groundwater allocation may take into consideration the existing water rights holders, disadvantaged communities (DACs) and CA Native American tribes. The Subbasin may allocate to agencies or individual landowners.	The goal is to ensure a fair groundwater allocation which clearly defines the acceptable groundwater extraction volume per year at a certain rate, based on crop growing season(s). The MO is the volume of groundwater extraction in acre-feet.	Policy to be written by 2023 and implemented by 2025.	This policy will be a direct reduction in demand as extractors will need to operate within the means of the allocation. Groundwater levels and pumped volumes will be used to evaluate demand reduction.	No permits or regulatory processes are required for the Subbasin to adopt the policy. The Subbasin has the power as outlined in SGMA and related provisions to adopt ordinances.	Policy to be written by 2023 and implemented by 2025 and can be revised as needed.	The expected benefits may mitigate overdraft by ensuring groundwater supplies are withdrawn in a sustainable manner. Extractions will be monitored.	The management action may be accomplished by Subbasin policy adoption. No external water source is used.	Estimated $100,000 cost to draft and adopt policy.	Chronic lowering of groundwater levels or depletion of supply during periods of drought may be eliminated by implementation of sustainable change in groundwater allocation.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.
3	Groundwater Marketing	This policy will include groundwater marketing. Marketing will include groundwater from within the Subbasin with options to market within the GSAs, between GSAs.	The goal is to set policy that encourages water marketing within the Subbasin while not causing undesirable results.	Policy to be written by 2023 and implemented by 2025.	This policy will be a direct reduction in demand as small volume extractors will be encouraged to fallow land and market groundwater within their allocated amount. Groundwater levels and market volumes will be used as the quantification of demand reduction.	No permits or regulatory processes are required for the Subbasin to conduct the study. Through the study, multiple jurisdictions and agencies may be contacted for the potential permits and regulatory requirements for new surface water supplies.	The water marketing strategy grant has been approved by the USBR; Funding opportunity to close in May of 2019. Other grant solicitations are expected.	The expected benefits include utilizing groundwater supplies within the Subbasin. Encourage demand reduction through fallowing. Groundwater levels and marketed volumes will be evaluated.	The management action may be accomplished by Subbasin policy adoption. No external water source is used.	Estimated cost is $100,000 to draft and adopt policy.	This policy will include the requirement that landowners who are a purchaser or seller of groundwater shall install a water meter on their wells and report all activities to their GSAs.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.

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Development												
1	Require new developments (non-de minimis extractors) to prove sustainable water supplies	This policy requires all permitted developments (non-de minimis extractors) to prove sustainable water supplies based upon the current Subbasin groundwater allocation and constant with current State Law. The Subbasin may review and comment on all new development environmental documents to ensure water balance and corresponding mitigation measures are implemented. Requires County support.	The goal is to ensure all new developments (non-de minimis extractors) do not exceed the current Subbasin groundwater allocation and groundwater supplies are consumed or retained within the Subbasin boundary. The MO is to monitor and hold developers accountable as well as promote connection to city services where applicable.	To be implemented as a revision to the local ordinances.	Policy is to minimize undesirable effects by requiring construction of wells to be designed for MTs. To be implemented after approval of GSP.	The regulatory process may require cooperation from the county/city to ensure the Subbasin has had the opportunity to review and comment on the environmental documents prior to county/city approval. The Subbasin GSAs have the power as outlined in the SGMA and related provisions to adopt ordinances. Potential incorporation into a peer review process.	Policy to be written and implemented by 2023.	The expected benefits may mitigate overdraft by ensuring new developments utilize groundwater supplies in accordance with current Subbasin groundwater allocations, and groundwater supplies are consumed or retained within the Subbasin boundary. The method of evaluation may be quantifying the number of new developments that are approved with and without Subbasin comment/approval.	The management action may be accomplished through Subbasin policy adoption and coordination with the county/city. The Subbasin may request county/city development procedures to include the circulation of environmental documents and approval from Subbasin GSAs prior to county/city approval. No external water source is used.	Estimated cost to draft and adopt policy is $25,000.	Policy will help in data collection and extraction reporting as part of the permitting process.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.
Monitoring Reporting												
1	Flood Flows (spills into the Subbasin) include Tule River, Deer Creek, Cross-Creeks and Kings River	The Subbasin may adopt a policy for actions to divert flows during flood releases to needed areas and a credit system for those who divert.	Validate the water right; MO is to allocate water to the rightful owner.	Policy will begin soon after GSP is approved and will help fill data gaps.	This management action alone may not generate a quantifiable demand reduction. However, it allocates water to be used in the proper service area.	No permits or regulatory processes are required for the Subbasin to adopt the policy. SWRCB is paying close attention to policies within a GSA that pertain to water rights and flood water diversion.	Policy to be written and implemented in 2023.	The expected benefit is the guarantee that purchased water is credited to correct area. Data gathered will fill data gaps. Groundwater elevations will be the method of evaluation.	Contract holder; reliability varies based on allocation.	Estimated cost to draft and adopt policy is $25,000.	Utilized contract volumes to be included in the calculation of the groundwater extraction proportionate share.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.

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2	Registration of extraction facilities	The Subbasin may adopt a policy to require registration of a groundwater extraction facility within the Subbasin. Requires county support. Includes existing and future facilities.	The goal is to improve the Subbasin's database of groundwater extraction locations. The MO is the number of new registered facilities and fill data gaps.	The policy may be implemented shortly after the adoption of the GSP and remain until the Subbasin's overdraft has ended or indefinitely. The county must also support the policy.	This policy will help fill data gaps and give a better understanding of the groundwater within the Subbasin.	The regulatory process may require cooperation from the county to ensure new well permits issued within the Subbasin adhere to the Subbasin's policy. The Subbasin has the power as outlined in SGMA and related provisions to adopt ordinances.	Policy to be written and implemented in 2023.	The expected benefits may mitigate overdraft by improving the Subbasin's knowledge of groundwater extraction locations. The method of evaluation may be comparing the number of registered wells vs. the county/state databases known wells.	The management action may be accomplished by policy adoption by the Subbasin and coordination with the county. The Subbasin may request county well permit procedures to include the Subbasin's requirements prior to issuance. No external water source is used.	Estimated cost to draft and adopt policy is $25,000. There will be a cost to administer the policy, which is not known at this time.	Fill data gaps and include this information in the calculation of the groundwater extraction proportionate share.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.
3	Require self-reporting of groundwater extraction, water level, and water quality data	The Subbasin may adopt a policy to require groundwater users (excluding de minimis extractors) to self-report groundwater extractions, static water levels, and water quality data twice per year.	The goal is to improve the Subbasin's database of groundwater extractions, water level and quality monitoring network, and serve other management actions.	This policy will fill data gaps. To be incorporated into a well testing policy for wells with meters. The policy may be implemented shortly after the adoption of the GSP and remain indefinitely or until Subbasin's overdraft has ended.	This policy will help fill data gaps and give a better understanding of the groundwater within the Subbasin.	No permits or regulatory processes are required for the Subbasin to adopt the policy. The Subbasin has the power as outlined in SGMA and related provisions to adopt ordinances, levy financial penalties, and charge administrative fees.	Policy to be written and implemented in 2023.	The expected benefits may mitigate overdraft by improving the Subbasin's knowledge of groundwater extractions, water levels, water quality and provide extractors with useful information. The method of evaluation may be reviewing the number of responses from groundwater users (excluding de minimis extractors), analyzing data validity/accuracy, and filling data gaps.	The management action may be accomplished by policy adoption by the Subbasin. The Subbasin may develop an online reporting tool. No external water source is used.	Estimated cost to draft and adopt policy is $25,000. There will be a cost to administer the policy, which is not known at this time, but is expected to be high.	Fill data gaps and include this information in the calculation of the groundwater extraction proportionate share.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.

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4	Require well meters, sounding tubes, and water quality sample ports	The Subbasin may adopt a policy to require meters, sounding tubes, and sample ports be installed on wells, pump and motor replacements, and well repairs (excluding de minimis extractors). Requires county support. Calibration of meters shall conform to Senate Bill 88.	The goal is to improve the Subbasin's data collection of groundwater extractions, water level and quality monitoring network. The MO is the number of well permits and filling the data gaps.	The policy may be implemented shortly after the adoption of the GSP and remain until Subbasin's overdraft has ended or indefinitely. The county must also support the policy.	This policy will help fill data gaps and give a better understanding of the groundwater within the Subbasin.	The regulatory process may require cooperation from the county to ensure new well permits issued within the Subbasin adhere to the Subbasin's policy. The Subbasin has the power as outlined in SGMA and related provisions to adopt ordinances.	Policy to be written and implemented in 2023.	The expected benefits may mitigate overdraft by improving the Subbasin's knowledge of groundwater extractions, water levels, water quality, and fill data gaps. The method of evaluation may be reviewing the number of well permits and confirming whether meters, sounding tubes, and sample ports were installed.	The management action may be accomplished by policy adoption by the Subbasin and coordination with the county. The Subbasin may request county well permit procedures to include the Subbasin's requirements prior to issuance. No external water source is used.	Estimated cost to draft and adopt policy is $25,000. There will be a cost to implement the policy, it is not known at this time, but is expected to be high.	Fill data gaps and include this information in the calculation of the groundwater extraction proportionate share.	Level of uncertainty of the project is 3; in wet years there is water available for this area as well as the infrastructure to deliver it.
Existing Contracts												
1	Flood Flows (spills into the Subbasin) include Tule River, Deer Creek, Cross-Creeks and Kings River	The Subbasin may adopt a policy for actions to divert flows during flood releases to needed areas and a credit system for those who divert.	Validate water rights and existing agreements. MO is to allocate water to the rightful owner.	Policy to be drafted by 2023 and implemented by 2025.	This management action alone may not generate a quantifiable demand reduction. However, it allocates water to be used in the proper service area.	No permits or regulatory processes are required for the Subbasin to adopt the policy. SWRCB is paying close attention to policies within a GSA that pertain to water rights and flood water diversion.	Policy to be written by 2023 and implemented by 2025 and to remain indefinitely, but can be revised as needed.	The expected benefit is to encourage diversion of flood flows to areas to make the most groundwater level impact.	Contract Holder; reliability varies based on allocation.	Estimated $25,000 cost to draft and adopt policy.	Diverted water will offset a depletion of supply during periods of drought.	Level of uncertainty of the project is 2; in wet years there is water available for this area as well as the infrastructure to deliver it.

* (b)1() refers to the subsection of §354.44 that the column addresses.
Note: The following sections were noted below because they apply to all management actions with very little variance.
Public Notice (b)(1)(B): The Subbasin may provide public notice in multiple formats and platforms, adopted policies may reside in Subbasin Board Meeting minutes and Subbasin Policy Manual available on the Subbasin website. Electronic notice may be provided to any person who requests email notifications. The Subbasin Board may hold regular monthly meetings and annual education workshops.
Legal Authority (b)(7): The Subbasin has the power as outlined in the SGMA, and related provisions to adopt ordinances, levy financial penalties, and enforce programs.
Cost & Funding Options (b)(8): Subbasin administrative and operating costs may be funded through various financial avenues discussed further in GSP Chapter 7.2.

See Acronyms and Abbreviations list for definitions.

Table 7-1. Proposed SFK GSA GSP Implementation Timeline

	Current Year (2020)	YEAR 1 (2021)		YEAR 2 (2022)		YEAR 3 (2023)		YEAR 4 (2024)	
	Q1/2	**Q3/4**	**Q1/2**	**Q3/4**	**Q1/2**	**Q3/4**	**Q1/2**	**Q3/4**	**Q1/2**
Administrative Actions									
Pumping Measurement Program	Landowner Well Survey		**Adopt measurement standards and reporting requirements**		Land Use/Metering Update		Land Use/Metering Update		Land Use/Metering Update
Land Use/Land Cover Program	Land Cover & Demand Study								
Groundwater Accounting Program			Accounting Program White Paper	Public Outreach	**Adopt GW Accounting System**	Public Outreac h			
Monitoring Program	**Annual Report**		**Annual Report**		**Annual Report**		**Annual Report**		**Annual Report**
Data Management Program									
Annual Reports									
KRCD Admin + Legal									
GSP 5-Year Update									
Funding Activities	State/Federal						Current Funding Sunsets	Adopt New Funding Method	
	Private/Foundation/ NGO								
	Other Mechanisms								

Table 7-1. Proposed SFK GSA GSP Implementation Timeline (Continued)

	Current Year (2020)	YEAR 1 (2021)		YEAR 2 (2022)		YEAR 3 (2023)		YEAR 4 (2024)	
	Q1/2	Q3/4	Q1/2	Q3/4	Q1/2	Q3/4	Q1/2	Q3/4	Q1/2
Demand Reduction Actions									
SW Delivery Improvements	SW Delivery Agreements	Surface Water Efficiency Study		**Adopt Canal Program**					
On-Farm Efficiency Improvements **Permanent/Long Term Fallowing** **Seasonal Fallowing Program**	Conjunctive Use White Paper	Targeted Outreach	Develop On-Farm Efficiency Targets and Dry-Farming/Fallowing Program	Public Outreach	**Develop On-Farm Efficiency Targets and Dry-Farming/Fallowing Program**	**Surface Water Improvement Implementation**		**Surface Water Improvement Implementation**	
Supply Enhancement Actions									
Aquifer Storage and Recovery	Work Plan			**ASR Pilot Test**		**ASR CEQA**		**ASR Implementation**	
Surface Recharge		Review & Coordinate Recharge Projects in Surrounding Basins			**Approve Surface Recharge Investments**				
Surface Storage									

Table 7-2. DMS Annual Reporting Requirements

Regulation	Requirement	Input to DMS
356.2(b)(1)(B)	Hydrographs incl water year type from Jan 2015	Generated in DMS from water level data input by GSAs
356.2(b)(1)(A)	GW Elevation Contours (spring & fall)	Generated outside DMS using data from DMS then contour lines uploaded into DMS
356.2(b)(2)	GW extraction by water use sector incl method of determination and map	Determined outside DMS. Total use by sector input by each GSA then summarized for basin in DMS
356.2(b)(3)	Surface Water use by source	Total by GSA input to DMS and summarized for basin in DMS
356.2(b)(4)	Total Water use by sector	DMS summary table of water supplies by sector per GSA
356.2(b)(5)(A)	Change in GW Storage map	Calculated outside DMS from contour data using basin-wide method then total per GSA input into DMS
356.2(b)(5)(B)	Graph with Water Year type, GW use, annual & cumulative GW Storage change	DMS generated basin total graph using data in DMS

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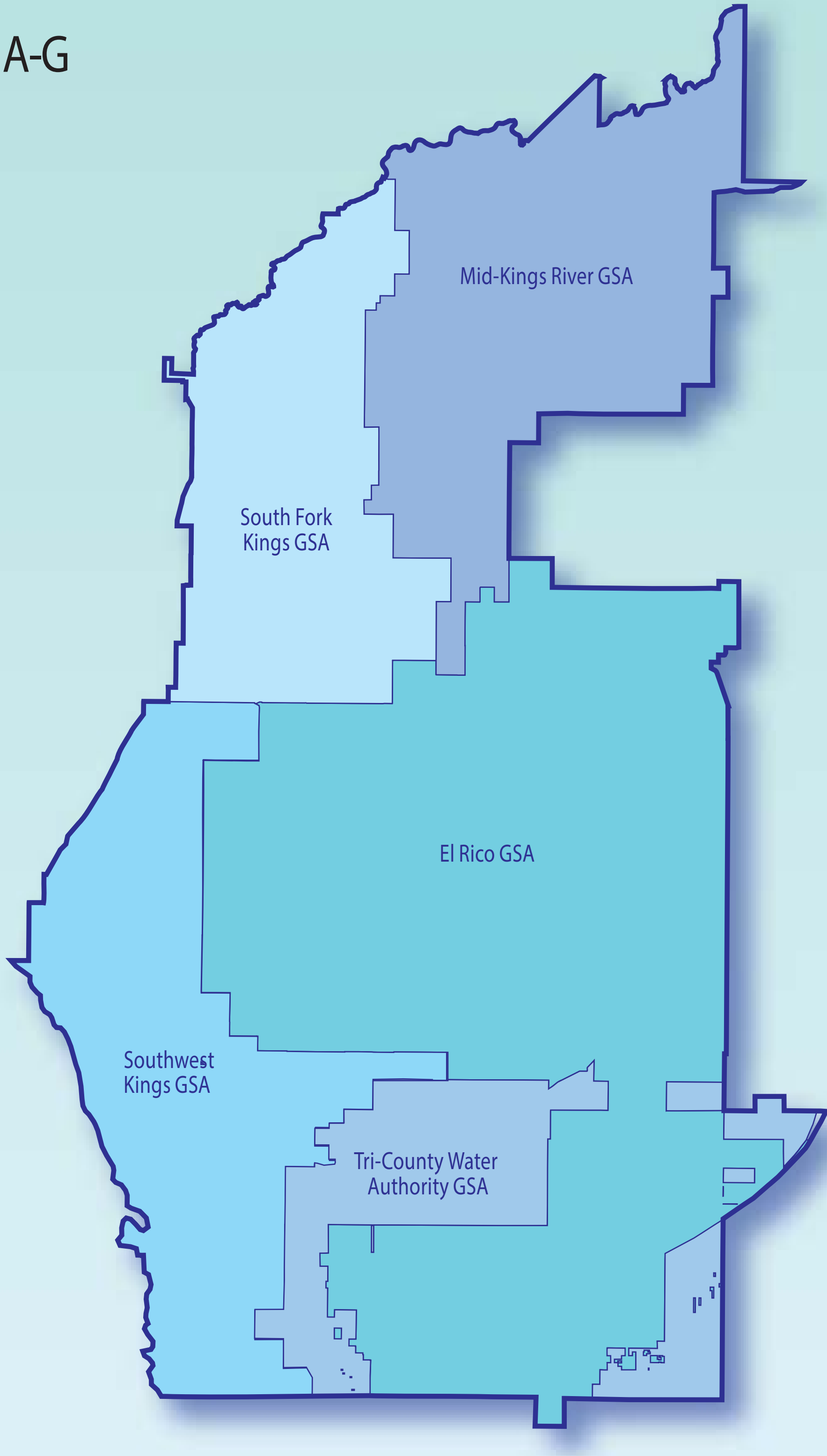


MID-KINGS RIVER GROUNDWATER SUSTAINABILITY AGENCY

South Fork Kings Groundwater Sustainability Agency

El Rico GSA

SWK Southwest Kings Groundwater Sustainability Agency

TRI-COUNTY WATER AUTHORITY

APPENDIX A

CONTACT INFORMATION FOR GSAs

APPENDIX A

Contact Information for the Tulare Lake Subbasin Groundwater Sustainability Agencies

Groundwater Sustainability Agency	Plan Manager	Address	Telephone	Email
Mid-Kings River	Dennis Mills, Secretary	200 North Campus Dr. Hanford, CA 93230	(559) 584.6412	kcwdh2o@sbcglobal.net
El Rico	Jeof Wyrick, Chairman	101 W. Walnut St. Pasadena, CA 91103	(626) 583.3000	jwyrick@jgboswell.com
South Fork Kings	Charlotte Gallock, Program Administrator	4886 E. Jensen Ave. Fresno, CA 93725	(559) 242.6128	cgallock@krcd.org
Southwest Kings	Dale Melville, Executive Director	286 Cromwell Ave. Fresno, CA 93711	(559) 449.2700	dmelville@ppeng.com
Tri-County Water Authority	Deanna Jackson, Executive Director	944 Whitley Ave. Suite E. Corcoran, CA 93212	(559) 762.7240	djackson@tcwater.org

APPENDIX B

STAKEHOLDER COMMUNICATION AND ENGAGEMENT PLAN

Appendix B: Stakeholder Communication & Engagement

A. Communication & Engagement Overview

As required by SGMA, GSAs must consider the interests of all beneficial uses and users of groundwater and include them in the GSP development process. The five GSAs within the Tulare Lake Subbasin developed a joint Communication & Engagement (**C&E**) Plan that addressed how stakeholders within the individual GSA boundaries (and when collaboration was plausible, at the subbasin-level) would be engaged through stakeholder education and opportunities for input and public review during the development and implementation of the GSP. This plan provides an overview of the Tulare Lake Subbasin GSAs, their stakeholders, and decision-making process; identifies opportunities for public engagement and discussion of how public input and responses would be used; describes how the Tulare Lake Subbasin GSAs encouraged the active involvement of diverse, social, cultural, and economic elements of the population within their individual boundaries and subbasin boundary; and the methods to be used to inform the public stakeholders about the progress of GSP development, public review and implementation. The Tulare Lake Subbasin GSAs' complete C&E Plan can be downloaded from the GSAs' individual websites.

As outlined by the DWR in the GSP Stakeholder Communication and Engagement Guidance Document, the Communication & Engagement Plan defines the Tulare Lake Subbasin GSAs' process for accomplishing the seven general steps in stakeholder communication and engagement:

- **Set Goals and Desired Outcomes –** Description of the situation at a high level with clear goals and objectives, identifying overriding concerns
- **Identify Stakeholders –** Development of a broad list of individuals, groups and organizations who need to be engaged in the process
- **Stakeholder Survey and Mapping –** Conducting a stakeholder survey to develop a "Lay of the Land" overview
- **Messages and Talking Points –** Definition of the key messages needed to effectively convey to the various subbasin stakeholders
- **Venues for Engaging –** Identification of opportunities (venues and methods) to engage stakeholders
- **Implementation Timeline –** Creation of a timeline to inform the process and highlight when to engage with stakeholders
- **Evaluation and Assessment –** Definition of a process to evaluate if communication and engagement goals are being met at the individual GSA level and through collaborative subbasin efforts

A.1 Communication Objectives to Support the GSP

The ultimate goal of communication objectives during the formation/coordination, GSP development, public review and implementation phases of the SGMA compliance, is to encourage active involvement of diverse, social, cultural, and economic elements of the population within the GSA boundary. The Tulare Lake Subbasin GSAs have given beneficial users and users of groundwater opportunities to engage in the GSP process, and provided educational outreach opportunities for stakeholders while reaching out through specific communication avenues. As active stakeholders, members of the Boards of Directors and Stakeholder/Advisory Committees are direct representatives of their districts, communities and industries, and they continually gather feedback/input, and the concerns/needs of their constituents and report back to their respective meetings. Any stakeholder input received was reviewed by the GSA and Subbasin technical teams and taken into consideration during GSP development.

A.1.1 Phase 1: GSA Formation and Coordination

Phase 1: GSA Formation and Coordination was the first phase completed. This phase stretched from 2015 through 2018, and consisted of forming the individual GSAs, development of a subbasin coordination agreement, establishing the List of Interested Parties, and creating the Communication & Engagement Plan to outline communication efforts for the GSP development, public review and implementation phases. Stakeholder input was utilized during the GSA formation phase, as beneficial users and stakeholders with interests in groundwater usage within the GSAs' boundaries were notified via public meeting notices as soon as the process began.

A.1.2 Phase 2: GSP Preparation and Submission

Phase 2: GSP Preparation and Submission spanned from 2018 through January 31, 2020. With the goal of having the draft GSP before the end of the third quarter in 2019, 2018 was primarily the technical development of the plan, while working with GSA Boards of Directors, technical teams/committees, and GSA management at the subbasin level, as well as stakeholders for feedback and input. During the last quarter of 2018, the first round of public outreach meetings and interaction with stakeholder groups and other community organizations and entities was held with the purpose of educating and informing stakeholders about SGMA and the GSP process, while also soliciting feedback and input from these groups to consider and possibly include feedback and input into the GSP. Public outreach for this phase was completed by the individual GSAs.

A.1.3 Phase 3: GSP Review and Evaluation

During 2019, Phase 3: GSP Review and Evaluation, the communication and engagement efforts continued. Once the draft of the GSP was completed in September 2019, the public review process began. A 90-day comment period was held, with the GSP draft posted on the Tulare Lake Subbasin GSAs' websites for all stakeholders to conveniently download and review and provide comments. Outreach meetings were held during this phase both on subbasin-wide level, as well as by individual GSAs. These meetings focused on an overview of the GSP content, while giving stakeholders a public forum to provide their feedback and comments. The public review period concluded with a public hearing regarding the GSP Draft on December 2, 2019.

Once the public review period was completed, public comments were taken into consideration and incorporated into the final version of the Tulare Lake Subbasin GSP before submitting to the DWR by January 31, 2020. Following submittal, stakeholders will be given a second 60-day comment period through the DWR's SGMA portal at http://sgma.water.ca.gov/portal/. Comments will be posted to the DWR's website prior to the state agency's evaluation, assessment and approval.

A.1.4 Phase 4: Implementation and Reporting

Phase 4: Implementation and Reporting will begin once the plan is submitted by January 31, 2020. Even while the DWR is reviewing the GSP, SGMA-implementation at the GSA-level must begin. During the implementation phase, communication and engagement efforts will be shifted to educational and informational awareness of the requirements and processes for reaching groundwater sustainability as set forth in the submitted GSP. Active involvement of all stakeholders will be encouraged during this phase, and public notices are required for any public meetings and prior to imposing, and later increasing, any fees. Public outreach for this phase will also be completed by the individual GSAs with collaborative subbasin-wide efforts when target audiences span more than one GSA boundary.

B. Tulare Lake Subbasin GSAs' Decision-Making Process

The Tulare Lake Subbasin GSAs' decision-making process is broken down by the roles of the subbasin management team, Board of Directors and Stakeholder/Advisory Committees. The roles of these subbasin and GSA entities and their responsibilities are outlined below.

- **Subbasin Management Team –** Comprised of a representative from each of the five GSAs working collaboratively to jointly manage groundwater within the Tulare Lake Subbasin and to develop a GSP. These individuals met on a monthly and then bi-weekly basis throughout the GSP development and public review phases.
- **Boards of Directors –** Adopts general policies regarding development and implementation of the individual GSAs and the GSP.
- **Stakeholder/Advisory Committees –** Representing all beneficial uses and users of groundwater within the individual GSA boundaries, makes recommendations to the Boards of Directors and technical consultants regarding feedback from stakeholders and adoption of a GSP that accounts for local interests. Not all GSAs have stakeholder/advisory committees, and while allowed within SGMA, these committees are not required.

B.1 Role of Boards of Directors

The Tulare Lake Subbasin GSAs' Boards of Directors all consistently function as the governing body of the specific GSA, formed to adopt general policies regarding development and implementation of the GSP. Governance of each GSA is described below, and meeting dates, times and locations for each board are noted. All meetings were open to the public during the formation, development and public review phases, and will continue to be open to the public during the implementation phase.

B.1.1 El Rico GSA

El Rico GSA's Board of Directors consists of seven directors: one representative appointed by the Tulare Lake Basin Water Storage District board, one representative appointed by the governing board of Salyer Water District, two representatives appointed by the Corcoran Irrigation District, two representatives appointed by Melga Water District, and one representative appointed by the Lovelace Reclamation District No. 739.

El Rico GSA's board meetings are held on the first Wednesday of each month at 1 p.m. at the Tulare Lake Basin Water Storage District's office, located at 1001 Chase Avenue in Corcoran, unless otherwise posted on the Kings River Region Groundwater Portal's calendar.

B.1.2 Mid-Kings River GSA

The Board of Directors of the Mid-Kings River GSA are appointed, three elected members of the KCWD, and one elected member of the City of Hanford. The Mid-Kings River GSA Board of Directors meet on the second Tuesday of every month at 1 p.m. at the Kings County Water District, located at 200 Campus Drive in Hanford.

B.1.3 South Fork Kings GSA

The governing board of the South Fork Kings GSA is composed of one appointee of each member agency as a "principal director." The principal director is an individual currently serving on the board or council of each of the members. Board of Directors meetings for the South Fork Kings GSA are held bi-monthly on the third Thursday of every February, April, June, August, October and December at 5:30 p.m. in the Lemoore City Council Chambers, located at 429 C Street in Lemoore.

B.1.4 Southwest Kings GSA

Southwest Kings GSA is governed by a five-person board of directors comprised of two members of the Dudley Ridge Water District, two members of the Tulare Reclamation District No. 761, and one director selected by a majority vote of the other four appointed members. The non-district member is a landowner, or his/her representative, who owns land in the white areas of the GSA boundary.

The Southwest Kings GSA's board meetings are held on the second Wednesday of every month at 3 p.m. at 286 W. Cromwell Avenue in Fresno. A monthly GSA status report is posted on the GSA's website.

B.1.5 Tri-County Water Authority GSA

The Tri-County Water Authority GSA JPA board of directors is comprised of four signatories and five board seats: Angiola Water District (general manager and a representative), Deer Creek Storm Water District (general manager and representative), Wilbur Reclamation District #825 (one representative), and County of Kings (non-voting representative). The Board of Directors meetings are held on the second Thursday of every other month at 1 p.m. at the Tri-County Water Authority Boardroom, located at 944 Whitley Avenue in Corcoran.

B.2 Role of Stakeholder/Advisory Committees

In Section 10727.8 "Public Notification and Participation; Advisory Committee" of the Sustainable Groundwater Management Act, GSAs may appoint and consult with an advisory committee for the purpose of developing and implementing a GSP. Through a stakeholder/advisory committee, a GSA is able to encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin prior to and during the development and implementation of the GSP.

B.2.1 Tri-County Water Authority GSA

The Tri-County Water Authority GSA's Technical Advisory Committee and Stakeholder Advisory Committee meet jointly on the fourth Wednesday of every month at 10 a.m. at the Tri-County Water Authority, located at the 944 Whitley Avenue in Corcoran.

C. Beneficial Uses and Users of Groundwater

Based on the applicable interests identified in SGMA, Section 10723.2 "Consideration of All Interests of All Beneficial Uses and Users of Groundwater", the five Tulare Lake Subbasin GSAs (El Rico, Mid-Kings River, South Fork Kings, Southwest Kings and Tri-County Water Authority) identified the stakeholder groups with interests within their GSA boundaries. These specific stakeholder groups have financial, political, business or personal stakes in the management of groundwater within the jurisdiction of the Tulare Lake Subbasin and were the focus of communication and engagement efforts during the GSP development and public review phases, and will continue to be engaged during the implementation phase. These stakeholders are listed by GSA in **Table 1**, **Table 2**, **Table 3**, **Table 4** and **Table 5**.

C.1 Environmental Users of Groundwater

It should be noted that environmental users of groundwater within the Tulare Lake Subbasin were investigated by the El Rico GSA, MKRGSA, SFKGSA, SWKGSA and TCWA, but there were not any identified that have specific groundwater interests within the subbasin.

C.2 Native American Tribes

The only Native American Tribe within the Tulare Lake Subbasin boundary is the Santa Rosa Rancheria Tachi-Yokut Tribe. The Tachi-Yokut Tribe was invited to participate in GSP development via a letter sent on June 28, 2016 by the then Upper Tulare Lake GSA MOU Group (now known as the South Fork Kings GSA). A copy of the letter is included in the Appendix A of the Tulare Lake Subbasin GSAs' Communication & Engagement Plan. The Tribe's EPA director attended one of the South Fork Kings GSA's board meetings, and has been on their Interested Parties List since April 2017, receiving regular updates about GSP development within the SFKGSA and the Tulare Lake Subbasin. In addition, a Sacred Lands File & Native American Contacts List Request was also sent to the Native American Heritage Commission.

C.3 Subbasin Industries and DACs

C.3.1 Industries

Collaboration meetings were held with the companies and organizations within the following industries to make sure their organizational visions and groundwater needs for facility operations were taken into consideration during GSP development and implementation phases. While an overview of the main industries within the Tulare Lake Subbasin are described below, the industries specific to each GSA are described in **Section C.4**.

Agriculture

Agriculture is one of the top three industries in Kings County. According to the 2017 Kings County Agricultural Crop Report published by the Kings County Ag Commissioner's office, the county is the tenth largest agriculture production county in California and grossed over $2 billion in 2017. With over 818,000 acres of farmland, the top commodities produced in Kings County are milk, cotton, cattle, nuts (almonds, pistachios and walnuts), tomatoes, silage corn, grapes, and stone fruit. As one of the primary industries, agriculture is the largest private employer in the county.

Because of the significant presence of agriculture production within the Tulare Lake Subbasin, agriculture industry stakeholders needed to be involved and informed during the development and public review phases of the GSP. Implementation will have a significant direct impact on the industry, and ultimately the local, state and national economies. The Tulare Lake Subbasin GSAs engaged with agriculture stakeholders routinely on an individual GSA-basis, and collaboratively at a subbasin level.

Food Processing

Kings County is a home to multiple food processors. Four of the top employers within the county are food processing facilities, accounting for over 4,000 jobs for the local workforce. Within the South Fork Kings GSA, Leprino Foods, alone, is responsible for 40 percent of water usage and provides just over 1,000 jobs. Because of their direct tie to the agricultural industry and reliance on groundwater supplies, to operate their facilities, food processors are included in the groundwater sustainability management within the subbasin boundary. The Tulare Lake Subbasin GSAs met with the food processing companies within their GSA boundaries on an individual basis for direct input and feedback during the GSP development and public review phases, and will continue to do so during the implementation phase.

Oil Production

Oil production is a main industry in certain areas of Kings County and the Tulare Lake Subbasin, primarily within in the Kettleman City area. Oil was discovered in the Kettleman Hills in 1928 at the Kettleman North Dome Oil Field. This oil field became one of the most productive oil fields in the United States in the early 1930s. Within this region, oil and agricultural production share the land surface, and will continue with joint usage of well drilling rigs and agricultural production activities such as grazing. The oil industry is considered a beneficial user of groundwater, and Tulare Lake Subbasin GSAs engaged with the oil companies within their GSA boundaries on an individual basis for direct input and feedback during the GSP development and public review phases, and will continue to do so during implementation phases.

C.3.2 DACs

Communication and educational outreach efforts with disadvantaged communities (**DAC**) and severely disadvantaged communities (**SDAC**) was needed for the development and implementation of the Tulare Lake Subbasin's GSP according to the Department of Water Resources' Best Management Practices. Information used to communicate to and engage the DACs in the GSP process, included an explanation of SGMA and soliciting feedback. GSA representatives regularly communicated with DACs and gave presentations on SGMA to community representatives, while gathering their feedback and input.

By including DACs and SDACs in communication efforts during the development, public review and implementation phases of the GSP, residents were more likely to participate and provide feedback that could be crucial to long-term solutions for groundwater sustainability within their communities. Any feedback received from DAC/SDAC residents was reviewed and evaluated by the Tulare Lake Subbasin GSAs during the GSP development and public review phases.

C.4 GSA-Specific Stakeholders

The GSAs worked cooperatively with their respective stakeholders throughout the development and public review of the GSP, and will continue to do so through the implementation phase.

C.4.1 El Rico GSA Stakeholders

The interests of the parties identified in **Table 1** were considered in the operation of the El Rico GSA and the development and implementation of the GSP. The primary industry within the El Rico GSA is agriculture. Other industries within the boundary include food processing, as well as warehousing and distribution, and standard commerce industry that is standard in a community of 10,000 people (automotive shops, supermarkets, etc.).

Table 1. Stakeholder Groups with Interests in the El Rico GSA

Stakeholder Group	Description
Agricultural Users	Represented through many of the GSA member agencies and/or by the County of Kings.
Domestic Well Owners	Represented through member agencies including the County of Kings or via exemption for small amounts of groundwater extraction.
Municipal Well Operators	City of Corcoran
Public Water Systems	City of Corcoran
Local Land Use Planning Agencies	City of Corcoran, County of Kings
Surface Water Users	Represented through GSA member agencies
Disadvantaged Communities	City of Corcoran
Entities monitoring and reporting groundwater elevations in all or part of a groundwater basin	Represented by GSA member agencies including Tulare Lake Basin Water Storage District that collects and reports data for multiple members of the agency via the Tulare Lake Coordinated Groundwater Management Plan.

C.4.2 Mid-Kings River GSA Stakeholders

The interests of all beneficial uses and users of groundwater within the MKRGSA are identified in **Table 2**. The primary industries within the Mid-Kings River GSA is agriculture and food processing.

Table 2. Stakeholder Groups with Interests in the Mid-Kings River GSA

Stakeholder Group	Description
Agricultural Users	Service area is composed of mostly agricultural lands and agricultural users
Domestic Well Owners	There are domestic wells within the MKRGSA area, and it is understood that many rural domestic users will fall into the "de minimis extractor" category, so further work is being conducted to understand to what extent domestic users will be affected by GSP requirements.
Public Water Systems	Armona CSD, Home Garden CSD and Hardwick Water Company, as well as several transient public water systems for school districts are included in this category (Kings River-Hardwick, Pioneer, Hanford Christian).
Municipal Water Systems	City of Hanford
Local Land Use Planning Agencies	City of Hanford and County of Kings
California Native American Tribes	See Section C.2.
Disadvantaged Communities	Armona, Home Garden, Hardwick
Entities monitoring and reporting groundwater elevations in all or part of a groundwater basin	Kings County Water District monitors groundwater levels within its service area and is providing a subset of that information to the Kings River Conservation District for submission to the CASGEM system.

C.4.3 South Fork Kings GSA Stakeholders

An initial list of stakeholders within the South Fork Kings GSA is described in **Table 3**. The primary industries within the South Fork Kings GSA is agriculture and food processing.

Table 3. Stakeholder Groups with Interests in the South Fork Kings GSA

Stakeholder Group	Description
Agricultural Users	Service area is composed of mostly agricultural lands and agricultural users
Domestic Well Owners	There are domestic wells within the SFKGSA, and it is understood that many domestic users will fall into the “de minimis extractor” category. Further work is being conducted to understand to what extent domestic users will be affected by GSP requirements.
Municipal Well Operators	City of Lemoore, Stratford Public Utility District
Local Land Use Planning Agencies	City of Lemoore, County of Kings
California Native American Tribes	See Section C.2.
Disadvantaged Communities	Community of Stratford
Entities monitoring and reporting groundwater elevations in all or part of a groundwater basin	KRCD is the designated monitoring entity for the Kings and Tulare Lake Subbasins under CASGEM program. SFKGSA will coordinate its SGMA monitoring efforts with the CASGEM monitoring effort led by KRCD.

C.4.4 Southwest Kings GSA Stakeholders

The interests of all beneficial uses and users of groundwater within the Southwest Kings GSA are described in **Table 4**. The primary industries within the Southwest Kings GSA are agriculture, oil production and commercial usage specific to Kettleman City.

Table 4. Stakeholder Groups with Interests in the Southwest Kings GSA

Stakeholder Group	Description
Agricultural Users	Approximately 99 percent of the GSA’s area is composed of agricultural lands. Representatives of the agricultural community are currently involved on the GSA Board of Directors.
Domestic Well Owners	Only one or two landowners utilize a domestic well, and are represented on the Board of Directors through member agencies.
Municipal Well Operators	Kettleman City CSD relies solely on surface water supply (effective October 2019). Their municipal wells are a back-up source to provide well water to residential and commercial customers within the GSA boundary in emergency situations when surface water is not accessible.
Local Land Use Planning Agencies	County of Kings
California Native American Tribes	See Section C.2.
Disadvantaged Communities	Kettleman City
Entities monitoring and reporting groundwater elevations in all or part of a groundwater basin	KRCD is the designated monitoring entity for the Kings and Tulare Lake Subbasins under CASGEM program. SWKGSA will coordinate its SGMA monitoring efforts with the CASGEM monitoring effort led by KRCD.

C.4.5 Tri-County Water Authority GSA Stakeholders

The Tri-County Water Authority provided stakeholder groups identified in **Table 5** with opportunities to provide input throughout the process of developing, operating and implementing the GSA and GSP. The primary industry within the Tri-County Water Authority GSA is almost entirely agriculture.

Table 5. Stakeholder Groups with Interests in the Tri-County Water Authority GSA

Stakeholder Group	Description
Agricultural Users	Composed almost entirely of agricultural users, including nut grower commodity groups and other agricultural use growers
Domestic Well Owners	There are domestic wells within the GSA area, but because SGMA excludes "de minimis extractors," it is anticipated that the GSP will exclude domestic wells from such requirements.
Local Land Use Planning Agencies	County of Kings
Federal Government	Bureau of Land Management
Entities monitoring and reporting groundwater elevations in all or part of a groundwater basin	Angiola Water District, Tulare Lake Basin Water Storage District

D. Public Outreach Meetings/Stakeholder Involvement Opportunities

D.1 Communication & Outreach Methods

There were a variety of opportunities, venues and methods for the Tulare Lake Subbasin GSAs to connect with and engage stakeholders throughout GSA formation, GSP development, GSP review, and will continue to be utilized through the GSP implementation phases. Stakeholder groups identified in **Section C** were engaged through communication methods outlined in this section.

D.1.1 Printed Communication

Printed materials incorporated the visual imagery established through individual GSA branding efforts and was tailored for specific means of communication throughout the phases of GSP development, public review and implementation. Printed materials were also translated into Spanish, when necessary for thorough, diverse stakeholder education.

- **Fliers –** Fliers designed and tailored for stakeholder audiences, encompassed infographics and text with key messages that were pertinent for that phase of GSP development. Distribution was via GSA-website posting, direct mail, email, and direct distribution as handouts throughout communities, GSA and subbasin outreach meetings. For outreach to DACs/SDACs, fliers were available in both English and Spanish languages.

- **Letter Correspondence –** When letter correspondence was necessary, particularly during the public review and implementation phases, letters were distributed via email and/or direct mail. Letters included pertinent facts and explanations that needed to be communicated to specific stakeholder groups.

- **Presentation Materials –** Power Point presentations were utilized at educational/outreach public meetings. For a consistent message subbasin-wide, a draft presentation was developed for the GSP development and public review phases, with placeholder slides for GSAs to update with GSA-specific information. Handouts of presentations and smaller versions of display boards were distributed to stakeholders in attendance, emailed to the Interested Parties list, and posted on individual GSAs' websites for stakeholders to access, particularly if they were unable to attend.

D.1.2 Digital Communication

Digital communication outlets were also designed to incorporate Tulare Lake Subbasin GSAs' branding and was a significant mode of communication through the GSP development and public review phases, and will continue to be crucial during the implementation phase.

- **Websites –** Public meeting notices, agendas and minutes of the Board of Directors and Stakeholder/Advisory Committee meetings were posted on the individual GSAs' websites. These websites serve as integral resources for stakeholders within the Tulare Lake Subbasin boundary. Electronic files of printed materials, presentations and other educational resources, and direct links to stakeholder surveys (English and Spanish versions) were also accessible via the websites.

  As printed materials were created, PDFs of the same information were added to the GSAs' websites. This served as a way for stakeholders to easily educate themselves on the GSP process and phases.

  Table 6. Tulare Lake Subbasin GSAs' Websites

GSA	Website
El Rico GSA	None – Meetings posted at kingsgroundwater.info
Mid-Kings River GSA	www.midkingsrivergsa.org
South Fork Kings GSA	southforkkings.org
Southwest Kings GSA	www.swkgsa.org
Tri-County Water Authority GSA	tcwater.org
Kings River Regional Groundwater Info Portal *(an additional online informational resource)*	kingsgroundwater.info

- **Interested Parties List –** As required by SGMA 10723.4 "Maintenance of Interested Persons List," the Tulare Lake Subbasin GSAs maintain contact lists and regularly distribute emails to those who have expressed interest in the GSAs' progress. These emails consist of meeting notices and other documents that are pertinent to the Tulare Lake Subbasin GSAs and their communication efforts. This process will continue through the GSP implementation phase.

- **Email Blasts –** Email blasts for meeting notices, stakeholder surveys, public review notices, and other crucial information were coordinated with community organizations and stakeholder groups by utilizing their distribution lists. Examples of these organizations are Kings County Farm Bureau, and water/irrigation districts within the individual GSAs' boundaries.

D.1.3 Media Coverage

Press releases were written and distributed to the media list of local newspaper publications. These press releases focused on notification of public engagement opportunities such as targeted stakeholder meetings, public review/comment processes and opportunities, and will be distributed for meetings and notifications during the GSP implementation.

D.1.4 Stakeholder Surveys

Stakeholder surveys were used for the deliberate polling of stakeholders to give them a direct voice in the GSP development phase. The South Fork Kings GSA and Southwest Kings GSA circulated physical surveys, while the remaining three GSAs conducted verbal surveys through one-on-one discussions with stakeholders within their GSA boundaries. For the GSAs who administered physical stakeholder surveys, they developed both online and printed versions of their surveys. Survey links were posted as Google Forms on the individual GSAs' websites and were utilized in email blasts to the Interested Parties Lists. Hard copies were also available for distribution throughout the respective GSA. An outline of the survey questions is provided in **Table 7**.

Table 7. GSAs Circulating Stakeholder Surveys

GSA	Survey Questions
El Rico GSA	Conducted verbal stakeholder survey discussions.
Mid-Kings River GSA	Conducted verbal stakeholder survey discussions.
South Fork Kings GSA	1. How important are the following uses of water to you personally? *Please rank the categories with 1 being the most important use of water and 6 being the least important. (Municipal, Agricultural, Recreational, Mining/Petroleum, Manufacturing, Wildlife/Fisheries)* 2. How important are the following uses of water to the region? *Please rank the categories with 1 being the most important use of water and 6 being the least important. (Municipal, Agricultural, Recreational, Mining/Petroleum, Manufacturing, Wildlife/Fisheries)* 3. Please rank the categories with 1 being the most important for reason for managing groundwater and 5 being the least important. *(Ensure drinking water supply for domestic uses; My ability to earn a living is directly linked; Future economic growth for region; Ensure water supply for future generations; Provide reliable water for industry/business; Other)* 4. How knowledgeable do you consider yourself of local water issues? *(Circle one – Extremely Knowledgeable to Not Very Knowledge)* 5. How knowledgeable do you consider yourself of the new groundwater regulation, the Sustainable Groundwater Management Act? *(Circle one – Extremely Knowledgeable to Not Very Knowledge)* 6. Are you currently engaged in activity or discussions regarding groundwater management in your area? 7. How important to you is information on anticipated impacts of new state regulations. *(Circle one – Extremely Important to Not Very Important)* 8. Which format or formats would you prefer for receiving information about groundwater management planning process? *(Check all that apply – Newsletters, phone number to call for information, regular public meetings, electronic media, news stories, information through interest groups, don't know)* 9. Which applies to you? I am a stakeholder representing pumping for… (*Check all that apply – business use, small community use, domestic use, school use, agricultural use, federal use, industrial use, municipal use, tribal use, environmental use, does not apply)* 10. Which best describes the community in which you or your industry/business resides? *(Circle all that apply – Rural Kings County, within the City of Lemoore, within the Community of Stratford, outside of the South Fork Kings GSA service area, don't know)* 11. Please indicate your age range? *(Circle one – 25 and under, 26-35 years, 36-45 years, 46-55 years, 56-65 years, over 65 years, no answer)*
Southwest Kings GSA	1. Are you familiar with Sustainable Groundwater Management Act (SGMA) regulations? 2. Are you currently engaged in activity of discussions regarding groundwater management in this region? 3. Do you own or manage/operate land in this region? 4. Do you manage water resources? If yes, what is your role? 5. What is your primary interest in land or water resources management? 6. Do you have concerns about groundwater management? If so, what are they? 7. Do you have recommendations regarding groundwater management? If so, what are they?
Tri-County Water Authority GSA	Conducted verbal stakeholder survey discussions.

D.2 Tulare Lake Subbasin-Wide Outreach Efforts

The Tulare Lake Subbasin GSAs maintained a timeline of communication and outreach efforts completed throughout the GSA development and GSP development and public review phases, both on a subbasin-wide level and on the individual GSA level. Subbasin-wide public outreach meetings and presentations are shown in **Table 8**. **Figure 1**, **Figure 2** and **Figure 3** demonstrate a visual guide for consolidated subbasin and individual GSA stakeholder involvement completed since the GSAs were formed.

Table 8. Tulare Lake Subbasin-Wide Public Meetings, Notifications, Presentations & One-on-One Meetings

Event	Date
Kings County Water Commission Meeting – SGMA Update Presentation	May 21, 2018
Kings County Farm Bureau Board Meeting – SGMA Update Presentation	June 19, 2018
Kings County Ag/Water Commissions Joint Meeting – SGMA Update Presentation	March 25, 2019
Kings County Farm Bureau Meeting – GSP Public Review Presentation	August 20, 2019
Subbasin-Wide Public Review Outreach Meeting – Lakeside Community Church, Hanford	5:30 p.m., October 9, 2019
Subbasin-Wide Public Review Outreach Meeting – Lemoore Civic Auditorium, Lemoore	5:30 p.m., October 15, 2019
Subbasin-Wide Meeting regarding GSP with five GSA managers and County of Kings representatives (County Counsel SGMA liaison, CAO, Board of Supervisor Verboon)	November 6, 2019 at the TLBWSD office in Corcoran
Tulare Lake Subbasin GSP Public Hearing – Kings County Board of Supervisors Chambers	10 a.m., December 2, 2019

D.2.1 Public Noticing

I.D.2.1.1 Phase 1: GSA Formation and Coordination

During Phase 1: GSA Formation and Coordination, the five individual GSAs published public notices to notify stakeholders within their boundaries of the public hearings held prior to the official formation of the agencies. These notices are documented in **Table 9**.

Table 9. Public Notices for GSA Formation Public Hearings

GSA	Publication	Date Published	Date Public Hearing Held
El Rico GSA	The Corcoran Journal Visalia Times Delta The Bakersfield Californian	January 19, 2017; January 26, 2017 January 19, 2017; January 26, 2017 January 20, 2017; January 26, 2017	February 7, 2017
Mid-Kings River GSA	Hanford Sentinel	December 20, 2016; December 27, 2016	January 5, 2017
South Fork Kings GSA	Hanford Sentinel	February 15, 2017; February 22, 2017	March 8, 2017
Southwest Kings GSA	The Corcoran Journal	February 16, 2017; February 23, 2017; March 2, 2017	March 8, 2017
Tri-County Water Authority GSA	The Hanford Sentinel	January 17, 2017; January 24, 2017	January 31, 2017

I.D.2.1.2 Phase 3: GSP Review and Evaluation

A 90-day comment period was held the last quarter of 2019, with the GSP draft posted on the Tulare Lake Subbasin GSAs' websites for all stakeholders to conveniently download and review and provide comments. Public notices were published in local newspapers to notify stakeholders of the start of the public review period 90 days prior to the public hearing, and published again within 45 days of the public hearing (**Table 10**).

Table 10. Public Notices for GSP Public Review & Public Hearing

Publication	Date Published	Purpose of Notice
The Bakersfield Californian	September 3, 2019; September 10, 2019	Notice of Public Review of Tulare Lake Subbasin Draft GSP
The Corcoran Journal	September 5, 2019; September 12, 2019	
Hanford Sentinel	September 3, 2019; September 10, 2019	
Visalia Times Delta	September 3, 2019; September 10, 2019	
The Bakersfield Californian	October 19, 2019; October 25, 2019	Notice of Public Hearing on Tulare Lake Subbasin Draft GSP, scheduled for December 2, 2019
The Corcoran Journal	October 24, 2019; October 31, 2019	
Hanford Sentinel	October 18, 2019; October 25, 2019	
Visalia Times Delta	October 31, 2019; November 7, 2019	

D.2.2 Interbasin Coordination Efforts

Tulare Lake Subbasin GSAs and technical consultants met with surrounding subbasins throughout the development of the GSP to discuss how to achieve sustainability on a regional level, develop interbasin agreements, address boundary issues, discuss groundwater monitoring and groundwater modeling, and share data when possible. Between the five GSAs, meetings were held periodically with other GSAs within the Kern, Tule, Kaweah, Kings and Westside subbasins. GSA managers were also involved with other GSA boards and technical committees in other subbasins due to some member agencies' boundaries crossing into other subbasins. This allowed the managers to communicate a regional perspective in sustainability discussions, as their stakeholders hold interests in more than one subbasin.

While inter-basin issues were communicated and discussed during these numerous meetings, due to time constraints and each subbasin progressing at a different pace in the development of their GSPs, resolutions to conflicts are acknowledged but impractical to fully analyze prior to the GSP submittal deadline of January 31, 2020. These discussions will continue, and resolutions will be addressed in annual reports and/or the 2025 Tulare Lake Subbasin GSP Update.

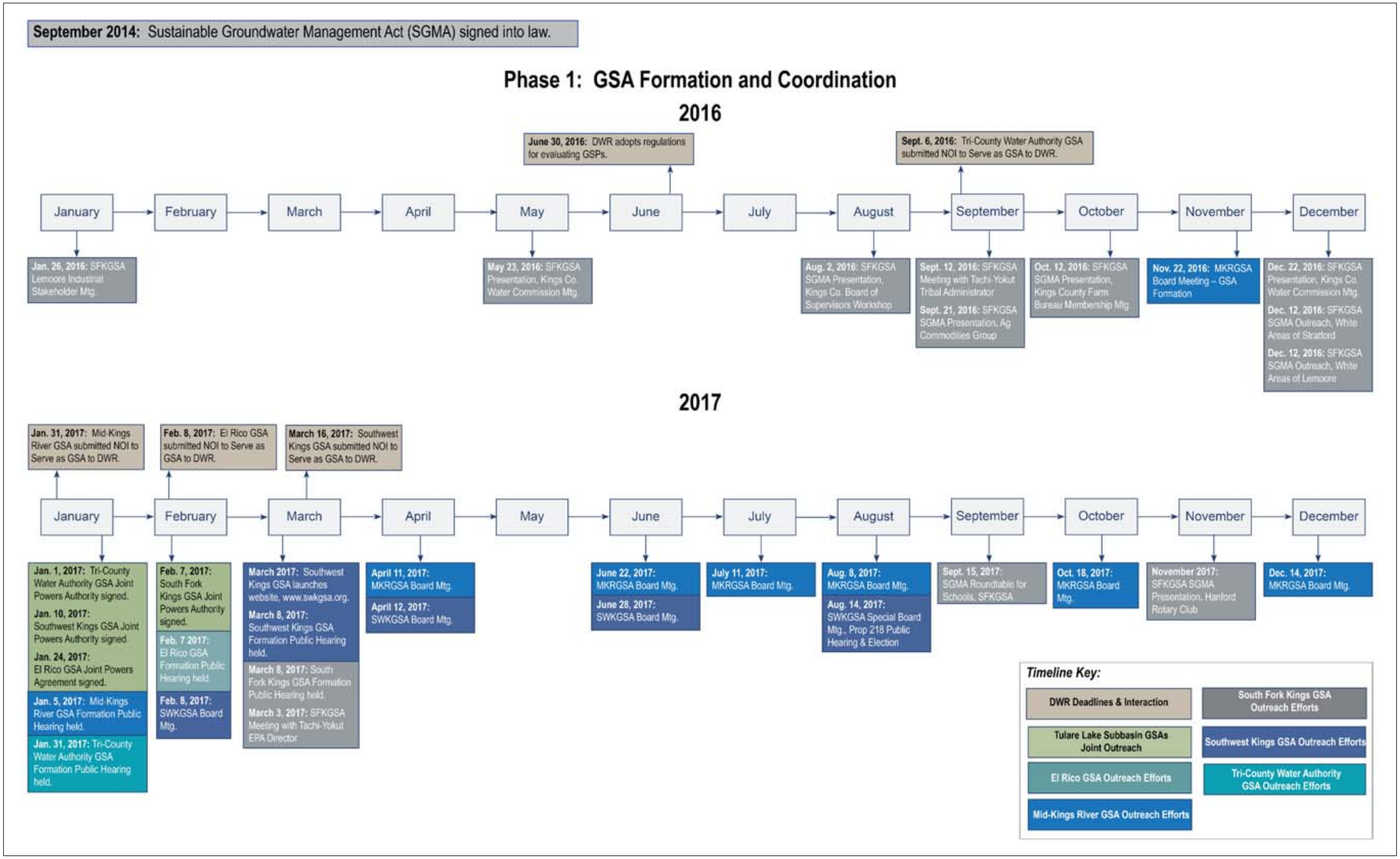


Figure 1. Tulare Lake Subbasin Communication & Engagement Timeline – Phase 1: GSA Formation and Coordination

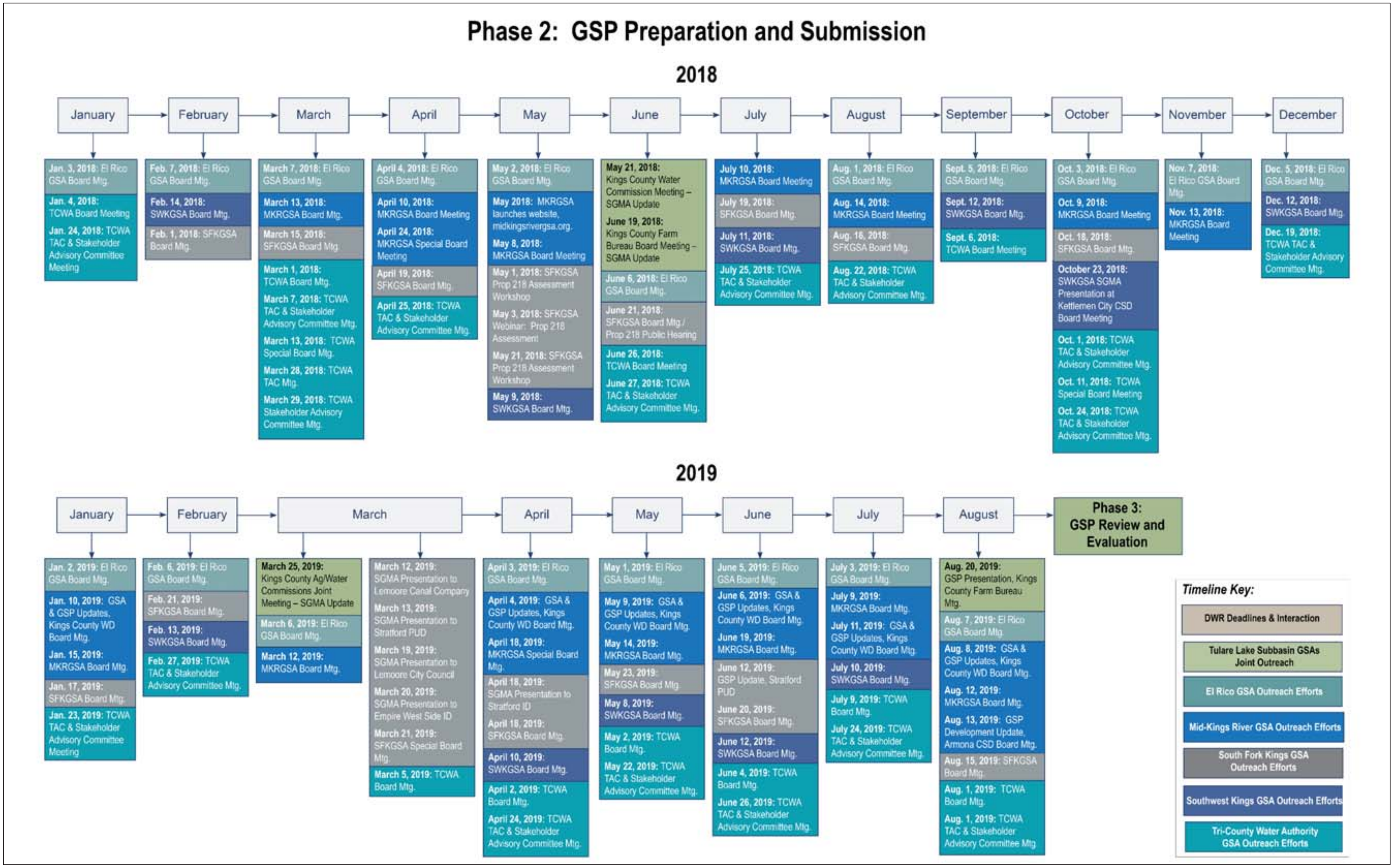


Figure 2. Tulare Lake Subbasin Communication & Engagement Timeline – Phase 2: GSP Preparation and Submission

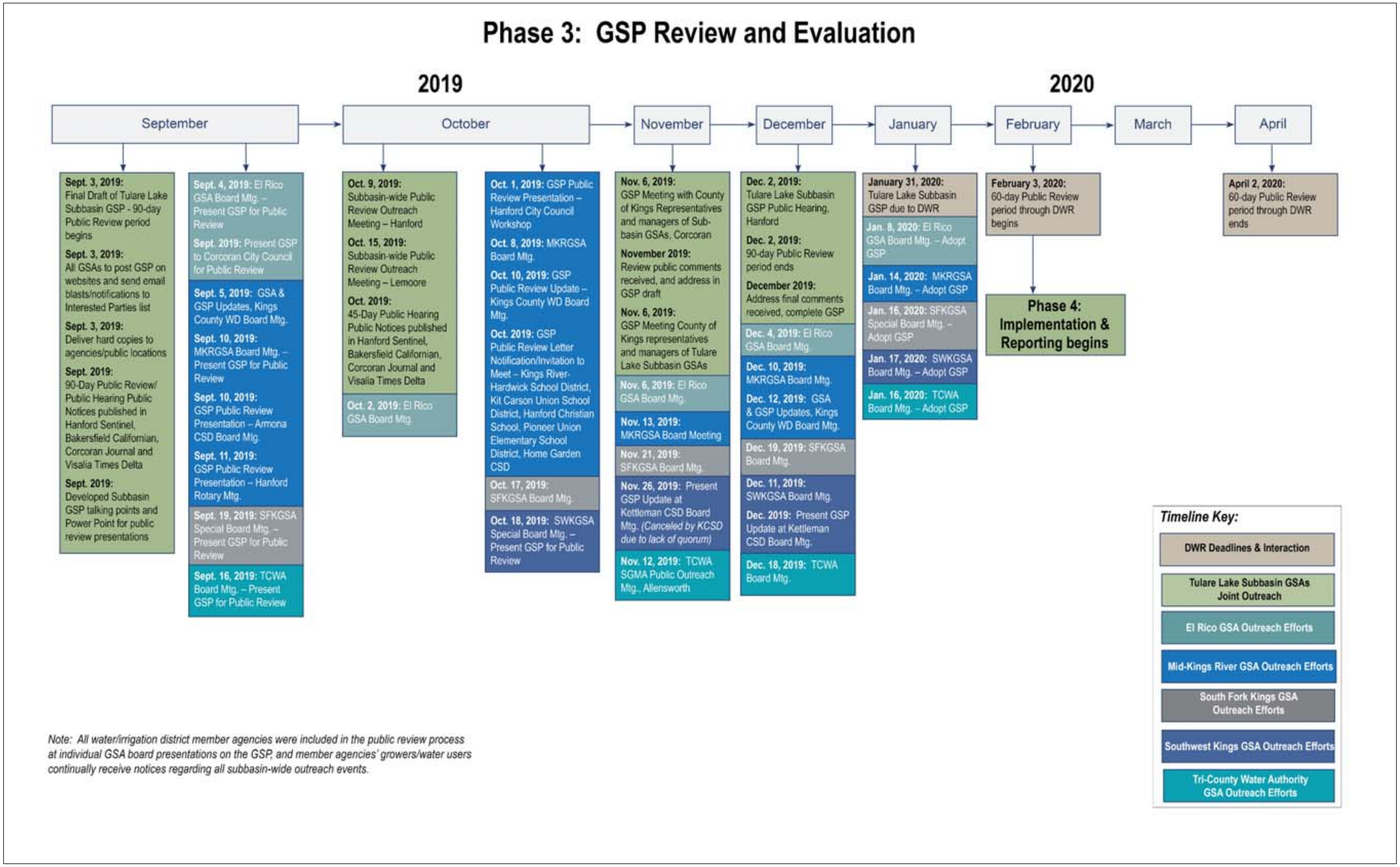


Figure 3. Tulare Lake Subbasin Communication & Engagement Timeline – Phase 3: GSP Review and Evaluation

D.3 El Rico GSA

Table 11. El Rico GSA Public Meetings, Presentations & One-on-One Meetings

Event	Date
One-on-one meetings with landowners of over 85 percent of the GSA area	Ongoing
SGMA & GSP Update meetings and negotiations with City of Corcoran personnel	Ongoing
GSA board meeting notices sent to all interested parties	Ongoing
Monthly meetings with “Un-districted Dairy Owners”	Ongoing
El Rico GSA Board Meeting	1 p.m., January 3, 2018
El Rico GSA Board Meeting	1 p.m., February 7, 2018
El Rico GSA Board Meeting	1 p.m., March 7, 2018
El Rico GSA Board Meeting	1 p.m., April 4, 2018
El Rico GSA Board Meeting	1 p.m., May 2, 2018
El Rico GSA Board Meeting	1 p.m., June 6, 2018
El Rico GSA Board Meeting	1 p.m., August 1, 2018
El Rico GSA Board Meeting	1 p.m., September 5, 2018
El Rico GSA Board Meeting	1 p.m., October 3, 2018
El Rico GSA Board Meeting	1 p.m., November 7, 2018
El Rico GSA Board Meeting	1 p.m., December 5, 2018
El Rico GSA Board Meeting	1 p.m., January 2, 2019
El Rico GSA Board Meeting	1 p.m., February 6, 2019
El Rico GSA Board Meeting	1 p.m., March 6, 2019
El Rico GSA Board Meeting	1 p.m., April 3, 2019
El Rico GSA Board Meeting	1 p.m., May 1, 2019
El Rico GSA Board Meeting	1 p.m., June 5, 2019
El Rico GSA Board Meeting	1 p.m., July 3, 2019
El Rico GSA Board Meeting	1 p.m., August 7, 2019
El Rico GSA Board Meeting	1 p.m., September 4, 2019
El Rico GSA Board Meeting	1 p.m., October 2, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Hanford	5:30 p.m., October 9, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Lemoore	5:30 p.m., October 15, 2019
El Rico GSA Board Meeting	1 p.m., November 6, 2019
GSP Meeting with County of Kings representatives and managers of Tulare Lake Subbasin GSAs	1:30 p.m., November 6, 2019
Tulare Lake Subbasin GSP Public Hearing – Hanford	10 a.m., December 2, 2019
El Rico GSA Board Meeting	1 p.m., December 4, 2019
El Rico GSA Board Meeting	1 p.m., January 8, 2020

D.4 Mid-Kings River GSA

D.4.1 Website – www.midkingsrivergsa.org

The Mid-Kings River GSA's website went live in May 2018 for the purpose of informing stakeholders about the GSA, public outreach opportunities, and as a resource with SGMA-related information. A site map is outlined below:

- **Homepage –** Introduction of Mid-Kings River GSA; GSA News
- **About Us –** Overview of SGMA; About the Mid-Kings River GSA; Member Agencies; Mid-Kings River GSA Information (links to Notice of Intent, JPA Members Agreement, GSA Boundary Map, Subbasin Boundary Map)
- **Board & Committees –** Board of Directors; (Agendas, Minutes, List of Board Members)
- **GSA Resources –** SGMA-Related Resources; Other Tulare Lake Subbasin GSAs (links); Partnering Agencies (links)
- **Contact Us –** Questions (telephone and email); Location/Mailing Address; Interested Parties List Sign-Up Form

Picture 1. Screenshot of www.midkingsrivergsa.org Homepage

D.4.2 Mid-Kings River GSA Outreach Tracking

Table 12. Mid-Kings River GSA Public Meetings, Notifications, Presentations & One-on-One Meetings

Event	Date
Landowner Meetings for requested updates on SGMA	Ongoing
Greater Kaweah GSA Collaboration – Updates to TAC and BOD on Tulare Lake Subbasin efforts	Ongoing
Participation in local DWR meetings	Ongoing
Coordination meetings with other subbasins and South Valley Practitioners Group	Ongoing
MKRGSA Board Meeting – GSA Formation	1 p.m., December 13, 2016
MKRGSA Board Meeting & Public Hearing to Become GSA	10 a.m., January 5, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., April 11, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., June 22, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., July 11, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., August 8, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., October 18, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., December 14, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	3 p.m., March 13, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	3 p.m., April 10, 2018
MKRGSA Special Board Meeting	9:30 a.m., April 24, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., May 8, 2018
Kings County Water Commission Meeting – SGMA Update	May 21, 2018
Kings County Farm Bureau Board Meeting – SGMA Update	June 19, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., July 10, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., August 14, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., October 9, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., November 13, 2018
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., January 10, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., January 15, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., March 12, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., April 4, 2019
MKRGSA Special Board Meeting – SGMA and GSP Development Updates	1 p.m., April 18, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., May 9, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., May 14, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., June 6, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., June 19, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., July 9, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., July 11, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., August 8, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., August 12, 2019
Armona CSD Board Meeting Presentation – SGMA and GSP Development Updates	6 p.m., August 13, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., September 5, 2019

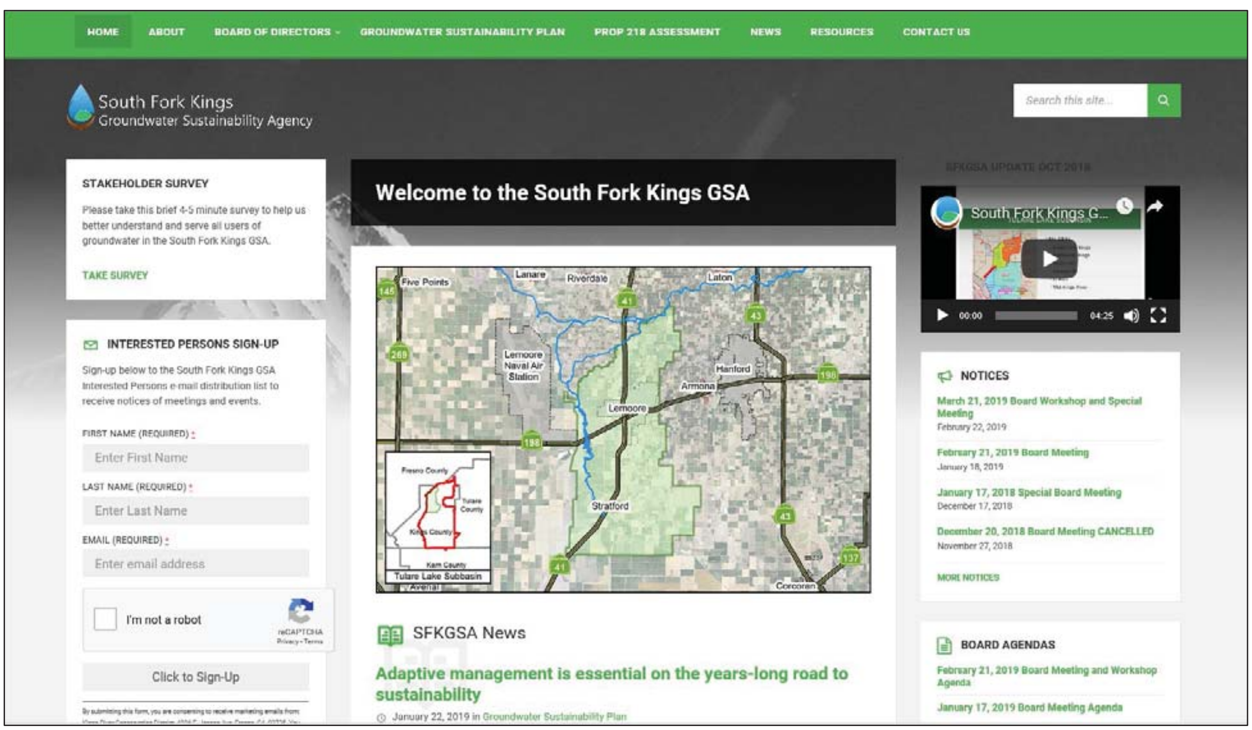
Event	Date
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., September 10, 2019
GSP Public Review Presentation at Armona CSD Board Meeting	6 p.m., September 10, 2019
GSP Public Review Presentation at Hanford Rotary Meeting	5:30 p.m., September 11, 2019
GSP Public Review Update – Kings County Water District Board Meeting	1:30 p.m., October 10, 2019
GSP Public Review Presentation at Hanford City Council Workshop	5:30 p.m., October 1, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., October 8, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Hanford	5:30 p.m., October 9, 2019
Home Garden CSD – Draft Tulare Lake Subbasin Groundwater Sustainability Plan Public Review Letter Notification & Invitation to Meet	Mailed via USPS and emailed October 11, 2019
Kings River-Hardwick School District – Draft Tulare Lake Subbasin Groundwater Sustainability Plan Public Review Letter Notification & Invitation to Meet	Mailed via USPS and emailed October 11, 2019
Kit Carson Union School District – Draft Tulare Lake Subbasin Groundwater Sustainability Plan Public Review Letter Notification & Invitation to Meet	Mailed via USPS and emailed October 11, 2019
Hanford Christian School – Draft Tulare Lake Subbasin Groundwater Sustainability Plan Public Review Letter Notification & Invitation to Meet	Mailed via USPS and emailed October 11, 2019
Pioneer Union Elementary School District – Draft Tulare Lake Subbasin Groundwater Sustainability Plan Public Review Letter Notification & Invitation to Meet	Mailed via USPS and emailed October 11, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Lemoore	5:30 p.m., October 15, 2019
GSP Meeting with County of Kings representatives and other GSA managers, Corcoran	1:30 p.m., November 6, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., November 13, 2019
Tulare Lake Subbasin GSP Public Hearing – Hanford	10 a.m., December 2, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., December 10, 2019
GSA & GSP GSP Public Review Update – Kings County Water District Board Meeting	1:30 p.m., December 12, 2019
MKRGSA Board Meeting – Adoption of GSP	1 p.m., January 14, 2020

D.5 South Fork Kings GSA

D.5.1 Website – https://southforkkings.org/

The South Fork Kings GSA's website is a solid source of information for SGMA and the impacts within the GSA boundary. A site map is outlined below:

- **Homepage –** Welcome page with quick links to Stakeholder Survey, Interested Persons Sign-Up, GSA News, Notices, Board Agendas/Minutes, Proposition 218 Groundwater Assessment Resources
- **About Us –** About the South Fork Kings GSA; Quick links to Stakeholder Survey, Interested Persons Sign-Up, Board Agendas/Minutes, Documents
- **Board of Directors –** Board of Directors; Quick links to Stakeholder Survey, Interested Persons Sign-Up, Board Agendas/Minutes, Documents; Upcoming Events
- **Groundwater Sustainability Plan Portal –** Calendar, Projects, Coordination, Resources; Groundwater Sustainability Plan Development; GSP Implementation Roles (GSA, Stakeholder, DWR, SWRCB); GSP Schedule
- **Proposition 218 Assessment –** Election Results; Prop 218 Frequently Asked Questions; Prop 218 Election Documents; Overview of Groundwater Assessment
- **News**
- **Resources**
- **Contact Us –** Contact Us Inquiry Form; SGMA Update E-News Sign-Up; Quick links to Stakeholder Survey and Interested Persons Sign-Up



Picture 2. Screenshot of https://southforkkings.org/ Homepage

Table 13. 2017 SFKGSA Website Views

Month	Views
January	N/A
February	N/A
March	N/A
April	N/A
May	N/A
June	355
July	203
August	126
September	231
October	134
November	98
December	84

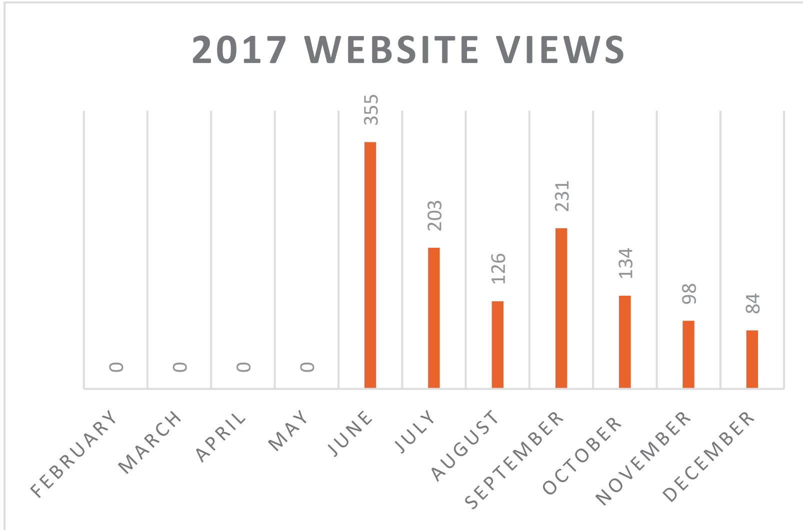


Table 14. 2018 SFKGSA Website Views

Month	Views
January	197
February	203
March	158
April	302
May	418
June	332
July	359
August	248
September	216
October	373
November	182
December	237

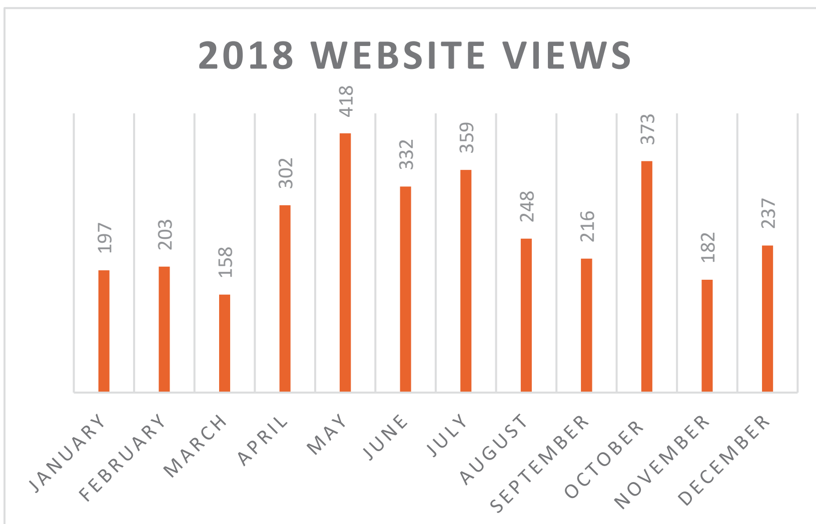
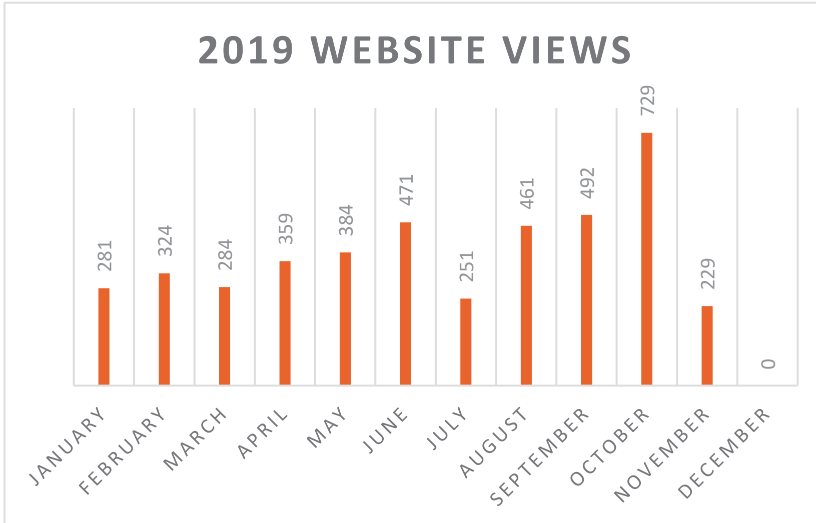


Table 15. 2019 SFKGSA Website Views

Month	Views
January	281
February	324
March	284
April	359
May	384
June	471
July	251
August	461
September	492
October	729
November	458
December	318



D.5.2 South Fork Kings GSA Outreach Tracking

Table 16. South Fork Kings GSA Public Meetings, Presentations & One-on-One Meetings

Event	Date	Attendance	Audience
Lemoore City Council Study Session	4/22/2015	15	Stakeholders
Empire Westside Water District Board Meeting	9/16/2015	7	Stakeholders
Stratford PUD Board Meeting	11/18/2015		Stakeholders (DAC)
Kings County Water Commission Meeting	11/23/2015	20	Stakeholders
Lemoore Industrial Stakeholder Meeting	1/26/2016	9	Stakeholders
Kings County Water Commission Meeting	5/23/2016	20	Stakeholders
Kings County Board of Supervisors Workshop	8/2/2016	30	Stakeholders
Janice Cuara, Tribal Administrator Tachi-Yokut	9/12/2016		Stakeholders – Native American
Ag Commodities Group Update	9/21/2016	8	
Kings County Farm Bureau Membership	10/12/2016	30	Stakeholders, Landowners
SFK White Areas – Stratford	12/12/2016		Stakeholders (DAC)
SFK White Areas – Lemoore	12/12/2016	35	Stakeholders
Kings County Water Commission Meeting	12/22/2016		Stakeholders
Noah Ignacio, EPA Director Tachi-Yokut	3/3/2017		Stakeholders – Native American
SGMA Roundtable for Schools SFK	9/15/2017	30	Stakeholders
SGMA Presentation, Hanford Rotary Club	11/2017	40	Stakeholders
Board Meeting, Lemoore City Council Chambers	02/1/2018	20	Stakeholders
Board Meeting, Lemoore City Council Chambers	3/15/2018	10	Stakeholders
Board Meeting, Lemoore City Council Chambers	4/19/2018	13	Stakeholders
Proposition 218 Assessment Workshop, Lemoore	5/1/2018	20	Landowners, City of Lemoore residents
Webinar: Proposition 218 Assessment	5/3/2018	1	Landowners

Event	Date	Attendance	Audience
Prop 218 Assessment Workshop, Lemoore	5/21/2018	21	Landowners, City of Lemoore residents
Board Meeting/Public Hearing for Proposition 218 Election	6/21/2018	25	Landowners, stakeholders
Board Meeting, Lemoore City Council Chambers	7/19/2018	19	Stakeholders
Board Meeting, Lemoore City Council Chambers	8/16/2018	16	Stakeholders
Board Meeting, Lemoore City Council Chambers	10/18/2018	19	Stakeholders
Board Meeting, Lemoore City Council Chambers	01/17/2019	24	Stakeholders
Board Meeting, Lemoore City Council Chambers	02/21/2019	14	Stakeholders
Presentation to Lemoore Canal Company	03/12/2019		Stakeholders
Presentation to Stratford Public Utility District	03/13/2019		Stakeholders
Presentation to Lemoore City Council	03/19/2019		Stakeholders
Presentation to Empire West Side Irrigation District	03/20/2019		Stakeholders
Special Board Meeting, Lemoore City Council Chambers	03/21/2019	19	Stakeholders
Presentation to Stratford Irrigation District	04/18/2019		Stakeholders
Board Meeting, Lemoore City Council Chambers	04/18/2019	13	Stakeholders
Board Meeting, Lemoore City Council Chambers	05/23/2019	14	Stakeholders
GSP Update, Stratford Public Utility District	06/12/2019		Stakeholders
Board Meeting, Lemoore City Council Chambers	06/20/2019	12	Stakeholders
Board Meeting, Lemoore City Council Chambers	08/15/2019	18	Stakeholders
Board Meeting – Lemoore City Council Chambers	09/19/2019	14	Stakeholders
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Hanford	10/9/2019	27	Stakeholders
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Lemoore	10/15/2019	35	Stakeholders
Board Meeting, Lemoore City Council Chambers	10/17/2019	12	Stakeholders
Board Meeting, Lemoore City Council Chambers	11/21/2019	13	Stakeholders
Tulare Lake Subbasin GSP Public Hearing – Hanford	12/2/2019		Stakeholders
Board Meeting, Lemoore City Council Chambers	12/19/2019		Stakeholders
Special Board Meeting – Adoption of GSP, Lemoore City Council Chambers	01/16/2020		Stakeholders

Table 17. South Fork Kings GSA Website Articles

Title/Topic	Date	Views
Kings County Farm Bureau newsletter article	Jul-15	N/A
SFK Board Approves Contract with Hydrogeological Consultant	6/20/2017	26
Board Supports Effort to Develop a Single GSP for the Tulare Lake Subbasin	7/20/2017	16
Contract Approved with Geosyntec Consultants	8/21/2017	28
Board Approves Preparation of Engineering Report for 218 Election	9/25/2017	23
Board Approves Data Sharing Agreements with North Fork Kings GSA, Westlands Water District	2/9/2018	17
The Model, the Data and Groundwater Sustainability	2/9/2018	225
Board Approves Engineer's Report, Moves Forward with Prop 218 Assessment	3/27/2018	84
Proposition 218 Election to Fund Local Groundwater Management Passes	6/22/2018	29
Consultants update Board on the groundwater model, a Groundwater Sustainability Plan foundation	7/24/2019	31
Groundwater Sustainability Plan schedule update	10/11/2018	28
Project and management action concepts discussed at Board workshop	10/22/2018	76
Adaptive management is essential on the years-long road to sustainability	1/22/2019	46
Preliminary Monitoring Network Identified	3/15/2019	49
Creativity and adaptive management will reduce 45,000 AF of estimated overdraft in the South Fork Kings	4/24/2019	70
Twelve Wells will Monitor Groundwater	6/7/2019	67
Board Approves $9.80 Assessment	6/25/2019	25

Table 18. Email Correspondence with Interested Persons List - Email Blasts

Message/Topic	Date Sent	Open Rate	Click Rate	Reach/Quantity
Board Agenda Packet	6/20/2017	43.5%	20.0%	24
Board Agenda Packet	7/21/2017	60.7%	5.9%	29
Board Agenda Packet	8/21/2017	46.4%	7.7%	30
Board Agenda Packet	9/25/2017	46.7%	7.1%	32
Board Agenda Packet	11/3/2017	53.3%	56.3%	32
Model, Data, Sustainability Tech Consultant; Data-Sharing Agreements Approved	2/9/18	49.2%	51.6%	67
Model, Data, Sustainability tech consultant; data sharing agreements approved	3/12/18	49%	51%	67
Board Agenda Packet	3/27/18	46%	50%	65
Engineer's Report Adopted; Prop 218 Election; Board meeting schedule update	4/16/18	44%	27%	68
Board Agenda Packet	5/2/18	48%	57%	76
Prop 218 Workshop Highlight, State Intervention, Groundwater Fee	5/7/18	N/A	N/A	0
Ballots mailed, local vs. state control, prop 218 resources, public hearing date	5/31/18	60%	33%	91
Submit your ballot by June 21 hearing date	7/27/18	47%	34%	106

Message/Topic	Date Sent	Open Rate	Click Rate	Reach/Quantity
Update to landowner on the overdraft number for the Tulare Lake Subbasin	7/16/18	N/A	N/A	1
Board Agenda Packet	7/24/18	57%	57%	113
Groundwater Model, Technical Services Continued with Geosyntec	8/13/18	52%	33%	117
Board Agenda Packet	10/15/18	54%	46%	119
Board Agenda Packet	10/23/18	46%	33%	120
Project and management actions discussed at workshop, DWR funding opportunity, Tulare Lake Subbasin Communication & Engagement Plan adopted, Stakeholder Survey, #SGMAMadeSimple	12/13/18	47%	42%	121
Meeting Cancellation Notice	12/17/18	44%	N/A	126
Board Agenda	1/17/2019	56%	44%	126
Adaptive management for sustainability, GSP Portal Updates, Stakeholder Survey, Water Budget video	1/23/2019	54%	35%	128
Board Agenda	2/15/2019	52%	33%	134
Meeting notice	2/22/2019	40%	8%	N/A
Timeline to GSP completion, Board appoints officers, monitoring network identified, water quality infographic	3/15/2019	50%	28%	141
Board Agenda	3/18/2019	44%	34%	141
Board Agenda	4/15/2019	43%	28%	142
Creativity and adaptive management will reduce overdraft, land subsidence infographic, board workshop slides	4/25/2019	51%	28%	142
Board Agenda, Budget Committee Agenda	5/20/2019	43%	24%	154
Twelve Wells will monitor groundwater, groundwater storage infographic	6/7/2019	41%	37%	153
Board Agenda	6/17/2019	39%	27%	152
Board approves &9.80 assessment, SGMA Made Simple video, June 20th workshop presentation	6/25/2019	35%	37%	153
Board Agenda	8/12/2019	51%	43%	209
Board Agenda	9/16/2019	45%	40%	218
GSP available for download, upcoming GSP workshops	10/2/2019	41%	18%	219
Board Agenda	10/14/2019	41%	24%	222
Upcoming GSP workshop promo	11/5/2019	42%	22%	222
Upcoming Irrigation Technology event at CSU Fresno	11/5/2019	36%	7%	224

Table 19. Direct Mailings to Stakeholders

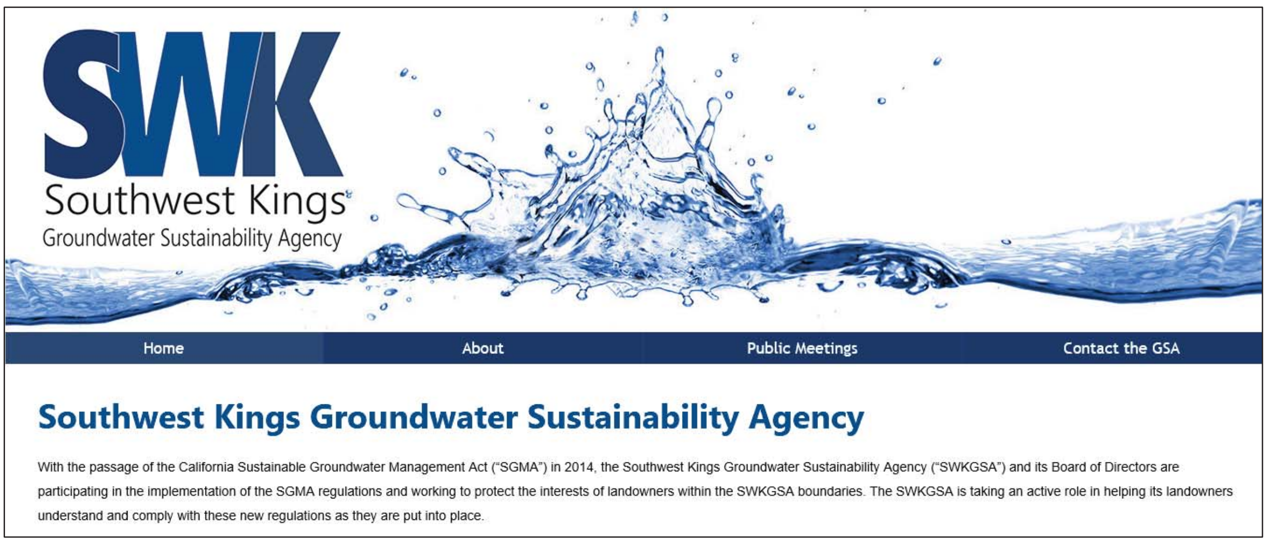
Date	Title	Audience	Quantity
April 2018	Prop 218 Informational Mailer	Landowners	897
April 2018	Prop 218 Informational Mailer (Spanish)	Residents	317
May 2018	Postcard: Final Workshop notice	Landowners	897
May 2018	Postcard: Final Workshop notice (Spanish)	Residents	317
June 2018	Postcard: final ballot reminder	Landowners	897
June 2018	Postcard: final ballot reminder (Spanish)	Residents	317
October 2018	Fall Mailer: Prop 28 results and GSP update	Landowners	897
October 2018	Fall Mailer: Prop 28 results and GSP update (Spanish)	Residents	317
July 2019	Contact Form and GSP education mailer	Landowners	1,089
July 2019	Contact Form and GSP education mailer (Spanish)	Residents	Online
October 2019	GSP Workshop promo mailer	Landowners	1,089
October 2019	GSP Workshop promo mailer (Spanish)	Residents	Online

D.6 Southwest Kings GSA

D.6.1 Website – www.swkgsa.org

The Southwest Kings GSA launched a website in March 2017 as a key avenue to inform stakeholders about the GSA, public outreach opportunities, and as a resource with SGMA-related information. A site map is outlined below:

- **Homepage –** Introduction of Southwest Kings GSA; Important Dates; News & Press Releases; and Quick Links to GSA Boundary Map and SGMA-Related Resources
- **About SGMA & SWKGSA –** What is SGMA?; SGMA and the Southwest Kings GSA; SWKGSA Information (links to boundary map, Bylaws & Policies, JPA Members Agreement, Cost-Sharing Agreement); Governance (Board of Directors, Alternate Directors, GSA Members, Management/Consultant Team)
- **Public Meetings –** Public Hearings; Board Meetings (agendas and minutes); Public Outreach Workshops
- **Contact the GSA –** Questions; Location; Interested Parties List Sign-Up Form



Picture 3. Screenshot of www.swkgsa.org Homepage

D.6.2 Outreach Tracking

Table 20. Southwest Kings GSA Public Meetings, Presentations & One-on-One Meetings

Meeting/Event	Date
Southwest Kings GSA Board Meeting – SGMA and GSA Formation	3 p.m., February 8, 2017
Southwest Kings GSA Board Meeting – SGMA and GSA Formation	3 p.m., March 8, 2017
Southwest Kings GSA Board Meeting – SGMA and GSP Development	3 p.m., April 12, 2017
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., June 28, 2017
Southwest Kings GSA Special Board Meeting – Proposition 218 Public Hearing & Election	10 a.m., August 14, 2017
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., February 14, 2018
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., May 9, 2018
Southwest Kings GSA Board Meeting with special presentation on Preliminary Water Budget	3 p.m., July 11, 2018
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., September 12, 2018
Kettleman City Community Services District Board Meeting – SGMA/GSA Presentation	6 p.m., October 23, 2018
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., December 12, 2018
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., February 13, 2019
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., May 8, 2019
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., July 10, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Hanford	5:30 p.m., October 9, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Lemoore	5:30 p.m., October 15, 2019
Southwest Kings GSA Special Board Meeting – GSP Public Review Update	3 p.m., October 18, 2019
GSP Meeting with County of Kings representatives and other GSA managers	1:30 p.m., November 6, 2019
GSP Public Review Presentation – Kettleman Community Services District Board Meeting *(Note: Presentation scheduled for Nov. 19, rescheduled for Nov. 26, but board meeting canceled by KCSD both dates due to lack of quorum)*	6 p.m., November 26, 2019
Tulare Lake Subbasin GSP Public Hearing – Hanford	10 a.m., December 2, 2019
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., December 11, 2019
Special Board Meeting – Adoption of GSP	9 a.m., January 17, 2020

D.7 Tri-County Water Authority

D.7.1 Website – http://tcwater.org

The Tri-County Water Authority launched a website to aid in achieving the Authority's goal of world class groundwater management in the Tulare Lake Hydrologic Region. A site map of the website is outlined below:

- **Homepage –** Primary goal of Tri-County Water Authority; Updates/Reports; Notifications; Quick Links to SGMA Overview; Tri-County Water Authority Map; News; Calendar; About the Water Authority
- **SGMA –** What is The SGMA?; SGMA Purpose; What Are Your Rights?; Overview of The Water Problem; Frequently Asked Questions; Tri-County Water Authority Territory
- **About Us –** About Us Overview; Board of Directors; Trusted News Sources Links – http://tcwater.org/news/ ; Calendar – http://tcwater.org/events/
- **Contact the GSA**

Picture 4. Screenshot of http://tcwater.org Homepage

D.7.2 Outreach Tracking

Table 21. Tri-County Water Authority Public Meetings, Presentations & One-on-One Meetings

Tri-County Water Authority Meetings/Presentations/One-on-One Discussions	
Meeting/Event	Date
TCWA Board Meeting	1 p.m., January 4, 2018
TCWA Technical Advisory Committee Meeting	10 a.m., January 24, 2018
TCWA Stakeholder Advisory Committee Meeting	1 p.m., January 24, 2018
TCWA Board Meeting	1 p.m., March 1, 2018
TCWA Technical Advisory Committee Meeting	10 a.m., March 7, 2018

Tri-County Water Authority Meetings/Presentations/One-on-One Discussions	
Meeting/Event	Date
TCWA Stakeholder Advisory Committee Meeting	1 p.m., March 7, 2018
TCWA Special Board Meeting	1 p.m., March 13, 2018
TCWA Technical Advisory Committee Meeting	10 a.m., March 28, 2018
TCWA Stakeholder Advisory Committee Meeting	1 p.m., March 29, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., April 25, 2018
TCWA Board Meeting	1 p.m., June 26, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., June 27, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., July 25, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., August 22, 2018
TCWA Board Meeting	1 p.m., September 6, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., October 1, 2018
TCWA Special Board Meeting	1 p.m., October 11, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., October 24, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	9 a.m., December 19, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., January 23, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., February 27, 2019
TCWA Board Meeting	1 p.m., March 5, 2019
TCWA Board Meeting	1 p.m., April 2, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., April 24, 2019
TCWA Board Meeting	1 p.m., May 2, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., May 22, 2019
TCWA Board Meeting	1 p.m., June 4, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., June 26, 2019
TCWA Board Meeting	1 p.m., July 9, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., July 24, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., August 1, 2019
TCWA Board Meeting	1 p.m., August 1, 2019
TCWA Board Meeting – Public Review of GSP Presentation	1 p.m., September 16, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Hanford	5:30 p.m., October 9, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Lemoore	5:30 p.m., October 15, 2019
GSP Meeting with County of Kings representatives and other GSA managers	1:30 p.m., November 6, 2019
TCWA & SGMA – Public Outreach Meeting, Allensworth	2 p.m., November 12, 2019
Tulare Lake Subbasin GSP Public Hearing – Hanford	10 a.m., December 2, 2019
TCWA Board Meeting	1 p.m., December 18, 2019
TCWA Board Meeting – Adoption of GSP	1 p.m., January 16, 2020

APPENDIX C

STAKEHOLDER COMMENTS AND RESPONSES

APPENDIX C – PUBLIC COMMENTS ON THE DRAFT GSP

The Groundwater Sustainability Agencies (GSAs) solicited public and stakeholder comments on the draft Tulare Lake Subbasin (Subbasin) Groundwater Sustainability Plan (GSP) from September 6, 2019, to December 2, 2019. During this period, the GSAs received comments transmitted to them in six letters and in one email. During the Public Hearing on December 2, 2019, one verbal comment was received. This section provides summaries of the comments contained in the letters and email and as presented verbally on the draft GSP and the responses to each comment.

Each letter, email, and verbal comment received is listed in Table C-1 and identified by comment author and date received by the GSAs.

Table C-1. List of Commenters

Comment ID	Comment Author	Comment Date
Organizations		
0-1	The Nature Conservancy	November 26, 2019
0-2	California Poultry Federation	November 27, 2019
0-3	Clean Water Action/Clean Water Fund; Local Government Commission; Audubon/California; The Nature Conservancy	December 2, 2019
0-4	Westlands Water District	December 2, 2019
0-5	Westlands Water District	December 2, 2019
Individuals		
I-1	Colleen Courtney	October 11,2019
I-2	Bill Miguel	October 15,2019
I-3	Bill Toss	December 2, 2019
I-4	Doug Verboon	December 2, 2019

Each of the comments is summarized below followed by responses from the GSAs. Hard copies of the comment correspondence received by the GSAs and a written summary of the verbal comment are compiled and presented following the comments and responses section.

Comment O-1

In The Nature Conservancy's letter to the South Fork Kings (SFK) GSA, they address the GSP's consideration of the beneficial uses and users of groundwater including environmental uses and users. The comment letter states:

> *Although there is a robust description of the confined (lower) and unconfined/semiconfined (upper) aquifers there is no explicit description with supporting data and information of how groundwater above the A- and C- clays in the upper aquifer interacts with the unconfined aquifer or is influenced by pumping in the unconfined portion of the aquifer. DWR's definition of a principal aquifer, is defined as an "aquifer of aquifer system that stores, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems."*
>
> *These shallow and perched areas within the upper aquifer range from near surface to 30 feet below ground surface and likely provide water supply to GDEs and ISWs. As such, they yield significant quantities of groundwater to surface water systems and beneficial users, and should not be dismissed because they do not yield groundwater for human use.*

These statements are the basis for the other resulting comments in their letter that request additional data and information, suggest that the GSA's and GSP recognize groundwater dependent ecosystems (GDEs) and interconnected surface water (ISW), and suggest a need for monitoring of these potential areas.

Response: Thank you for your letter and comments. Related to the Hydrologic Conceptual Model as presented in Section 3.1.8 of the draft GSP, there are geologic deposits in the Subbasin that are lacustrine clays named the A- through F-Clays. The A- through D-Clays may be more important locally in restricting the downward movement of groundwater. Figure 3-17 shows the areal extent of the A-Clay and the depth to groundwater above the A-Clay. Comparing this figure with your web-based GDE Pulse indicates an area along the South Fork Kings River where there would be the most interest in evaluating whether GDEs and ISWs occur.

From Section 4.0 of the draft GSP "Indicators for the sustainable management of groundwater were established under Sustainable Groundwater Management Act of 2014 (SGMA) based on factors that have the potential to impact the health and general well-being of the public. The following indicators were evaluated within the Subbasin: groundwater levels, groundwater storage volume, land subsidence, water quality, interconnected surface water, and seawater intrusion." ISW and seawater intrusion are not present within the Subbasin and were omitted from further consideration in the draft GSP. GDEs are not one of the sustainability indicators but rather dependent on ISW systems. Section 3.2.8 describes more fully the conditions found within the plan area.

It is also recognized that the GSP is adaptive in nature and will be updated as more information becomes available. It is noted in Section 5.4.1.2 that the ability to add and/or alter the existing monitor programs is envisioned. The individual GSAs will determine if or when additional attempts will be made to collect that data. Temporal adjustments may be made for the different aquifer zones or in certain areas. For example, semi-annual water level readings in above the A-Clay wells is probably sufficient to capture seasonal and long-term trends in most of that aquifer zone because water levels in the aquifer are relatively stable in most of the area. Near the Kings River it may be desirable to collect more frequent data from above the A-Clay to better understand the relationship between the river and shallow groundwater.

Comment O-2

The California Poultry Federation (CPF) is the trade association for California's poultry industry. In their letter to the Southwest Kings (SWK) GSA, they expressed their support for effective measures to assure reliable water supplies. CPF's comments largely focused on 2 main issues:

1. Supply augmentation should be a top priority of the GSP.
2. Regarding demand management, the GSP does not explain precisely how it will be done and the public will need to have opportunities to participate in the development of demand management measures. Also, the GSAs should do their best to ameliorate economic impacts by adopting demand management measures that are cost-effective.

Response: Thank you for your letter and comments. The GSAs agree that supply augmentation should be a top priority for this Subbasin. Several supply augmentation projects and their implementation are described in Chapters 6 and 7.

The draft GSP has been revised to remove demand management or demand reduction as a definitive programmatic action. The potential for demand management is described in Section 6.4 only as an option for the GSAs should it be needed to meet the Sustainability Goal. If implementation is necessary, the GSAs are committed to executing such programs in a cost effective manner and with the input of the local communities.

Comment O-3

This letter was submitted to the Tri-County Water Authority GSA on behalf of the Clean Water Action/Clean Water Fund, Local Government Commission, Audubon/California, and The Nature Conservancy in the interests of disadvantaged communities (DACs), drinking water, and the environment. The letter presented a checklist of GSP review criteria and summary comments addressing 9 elements as indicated in the response.

Response: Thank you for your letter and comments. Responses to the summary comments in the letter are provided below.

1. **How the DACs were determined and engaged in the GSP development process.**
   DACs were identified using the California Department of Water Resources (DWR) DAC online mapping tool and associated Geographic Information System data (2018) and the Tulare Lake Basin DAC Water Study (published 2013). The GSAs conducted a substantial amount of stakeholder engagement, including outreach to DACs, during the development of the GSP. These efforts are described in detail in Appendix B.

2. **Financial assistance for DACs.**
   SGMA did not intend for the GSAs to provide financial assistance to entities in the Subbasin. Representatives of the GSAs will reasonably assist entities in identifying potential sources of financial assistance, if requested and necessary, and will provide other non-financial assistance to the extent that it is required in the SGMA regulations and the GSAs have the resources to do so.

3. **The development of Measurable Objectives and Minimum Thresholds Sustainable Management Criteria needs to be explained.**
   The development of Measurable Objectives and Minimum Thresholds are described in Chapter 4 of the draft GSP. The methods used and the rational for selecting these criteria are described in this chapter.

4. **There should be stakeholder engagement during GSP implementation.**
   The GSAs conducted a substantial amount of stakeholder engagement during the development of the GSP. These efforts are described in detail in Appendix B. The GSAs intend to continue stakeholder engagement efforts through GSP implementation.

5. **The potential for impacts to domestic water supply wells from GSP implementation.**
   Domestic water supply wells in the Subbasin typically are the shallowest wells in the Subbasin and have historically been subject to a dynamic groundwater system whereby water levels change frequently due to seasonal fluctuations and climatic changes (such as drought). Prior to SGMA, these wells also experienced gradual long-term decline of water levels due to the curtailment of federal and state surface water deliveries to the Subbasin. In this environment, owners of these wells have successfully adjusted by modifying the wells or drilling new wells. Under SGMA, water levels will continue to change frequently due to seasonal fluctuations and climatic changes and until the GSP is fully implemented, the wells may also experience gradual decline of water levels. However, as the GSP is

implemented, shallow water levels are expected to stabilize, thereby providing a positive benefit to domestic well owners.

6. **Groundwater Dependent Ecosystems should be addressed.**
   From Section 4.0 of the draft GSP "Indicators for the sustainable management of groundwater were established under SGMA based on factors that have the potential to impact the health and general well-being of the public. The following indicators were evaluated within the Subbasin: groundwater levels, groundwater storage volume, land subsidence, water quality, interconnected surface water, and seawater intrusion." Interconnected surface water and seawater intrusion are not present within the Subbasin and were omitted from further consideration in the draft GSP. GDEs are not one of the sustainability indicators but rather dependent on interconnected surface water systems. Section 3.2.8 describes more fully the conditions found within the plan area.

   It is also recognized that the GSP is adaptive in nature and will be updated as more information becomes available. It is noted in Section 5.4.1.2 that the ability to add and/or alter the existing monitor programs is envisioned. The following is offered; "The individual GSAs will determine if or when additional attempts will be made to collect that data. Temporal adjustments may be made for the different aquifer zones or in certain areas. For example, semi-annual water level readings in above the A-Clay wells is probably sufficient to capture seasonal and long-term trends in most of that aquifer zone because water levels in the aquifer are relatively stable in most of the area. Near the Kings River it may be desirable to collect more frequent data from above the A-Clay to better understand the relationship between the river and shallow groundwater."

7. **Climate change must be considered in development of the GSP.**
   As required by DWR, climate change is accounted for in the groundwater model (Appendix D) using assumptions and parameters provided by DWR.

8. **Drinking water should be considered in the water budget.**
   Municipal water use throughout the Subbasin is accounted for in the water budget. Water use from private domestic wells is not known nor is well construction known. The amount of water from domestic wells is estimated to be a *de minimis* amount in the overall water budget.

9. **Continued groundwater level decline during GSP implementation.**
   Per SGMA requirements, the GSAs have developed a GSP the implementation of which will result in groundwater sustainability for the Subbasin by 2040. At that point, average groundwater levels will become stable.

Comments O-4 and 0-5

Westlands Water District (Westlands) occupies the Westside Subbasin located to the southwest and adjacent to the Subbasin and is the GSA for this subbasin. In Westland's letters to the SWK GSA and SFK GSA (which are identical), they commented on 7 findings presented in the GSP, identified 3 discrepancies within the text, and offered 1 general comment.

Thank you for your letter and comments. Responses are provided below.

Finding 1 Comment
Finding 1 is in regard to groundwater flows into and out of the Subbasin and adjoining subbasins as described in Section 3.2.2 of the draft GSP. The letter states "*there is no substantial evidence to support the statements regarding groundwater flow directions out of the Subbasin to the Westside Subbasin."*

Response: Potentiometric surface maps prepared by DWR from 1990 through 2016 clearly show that heads in the unconfined aquifer in the SFK GSA area are decreasing towards the southwest from the Subbasin into the Westside Subbasin. The winter 2014/2015 potentiometric surface map for the lower (confined) aquifer provided by Westlands in the comment letter also shows that groundwater from the SWK GSA is flowing towards the northwest towards a pumping depression southeast of Huron and to the southeast towards what appears to be a pumping center at the border between SFK GSA and SWK GSA with a contour of -160 feet. A review of the available water level elevation data for lower aquifer monitoring wells (some of it provided by Westlands) in this area of the Subbasin show between 1990 and 2016 the heads typically ranged from -100 feet to +100 feet. During this same period, wells in the Westside Subbasin typically ranged from -130 to +100 feet, generally lower than the wells in the Subbasin. A few new deep El Rico GSA wells started pumping in the 2014/2015 time range and had water level elevation in the -230 feet range, and may possibly be the source for the -160 foot contour shown on the map. However, these wells only operated in the last couple of years and are not representative of the long-term groundwater levels along the boundary between Subbasin and Westside Subbasin. In summary, there is evidence that between 1990 and 2016, the general direction of groundwater flow was from the Subbasin towards the Westside Subbasin both in the unconfined and confined aquifers.

Finding 2 Comment

The letter states *Figures 3-28b to 3-28d shows long term hydrographs for wells within the Tulare Lake Subbasin. Unfortunately, the data displayed by the hydrographs is pixelated, therefore unreviewable. Westlands GSA recommends revising the mentioned figures to display hydrographs using a higher resolution to allow the public to review.*

Response: These figures have been revised to show the hydrographs at a higher resolution.

Finding 3 Comment

Finding 3 is in regard to groundwater quality, as described in Section 3.2.5 in the draft GSP and shown on Figures 3-30 through 32. The letter states *We recommend that the draft GSP be revised to accurately convey groundwater quality data by aquifer and by the timeframe the data represents. In addition, we recommend that the groundwater quality data be reviewed for accuracy.*

Response: The groundwater quality data have been reviewed for accuracy and have been corrected where needed. Figures 3-30, 3-31, 3-32, and 3-33 have been revised to show the highest concentration of the constituents reported and the most recent concentrations. The source for the groundwater quality data used in these figures does not indicate the aquifer from which the data were collected.

Finding 4 Comment

The letter states *Figures 3-34 contains a legend that is incomplete and is unable to be reviewed. Westlands GSA recommends applying the corresponding color scheme to the vertical displacement legend to allow readers to be able to review the presented information.*

Response: The figure has been revised as recommended.

Finding 5 Comment

Finding 5 is in regard to the Sustainable Management Criteria presented in the draft GSP, specifically with respect to future water level decline. The letter states *The potential for curtailing historic underflow into the Westside Subbasin may be a substantial factor in contributing to significant and unreasonable subsidence and frustrate the Westlands' GSA ability to achieve the sustainability goal.*

Response: Thank you for your comment.

To evaluate your concern, the data developed within the draft GSP's was placed on a map showing the location of representative wells, aquifer representation, measurable objective, and minimum thresholds. It should be noted that within the Tulare Lake GSP, there is a shallow zone above the A-Clay that is an additional aquifer that was not identified in the Westside Subbasin GSP. Thus the above E-Clay and Below E-Clay values were identified. Upon comparison for the above E-Clay designation, there are few wells in this zone in the westside basin. From the information, the data suggest that flow is from the Subbasin to the Westside Subbasin. For the below E-Clay aquifer, the data also suggest that the flow is from the Subbasin to the Westside Subbasin. So your initial suggestion that continued lowering of groundwater levels in the Tulare Lake GSP allows groundwater levels to become lower than levels established at 2015 is not supported. With the gradients that would result from these levels, it is recognized that groundwater outflow would continue to the Westside Subbasin. Per your point in your comment letter "The department shall evaluate whether a groundwater sustainability plan adversely affects the ability of an adjacent basin to implement their groundwater sustainability plan or impedes achievement of sustainability goals in an adjacent basin".

As to historical underflow that you mention in your comments, we would refer you to Figures 3-23 and 3-24. Historical groundwater flows have historically flown from the Westside Subbasin into the Subbasin. It is believed that groundwater pumping from within the Westside Subbasin has altered these flow paths and it appears that the Westlands GSP is proposing to continue this practice. As you stated, overlying and appropriative uses of groundwater within the Subbasin are entitled to legal and equitable protection against infringement by an action that deprives them of their historical inflows. More coordination is warranted between our subbasins to reach a resolution. We look forward to discussing with you more thoroughly these boundary conditions and how we might develop a solution.

Finding 6 Comment

Finding 6 is in regard to the Sustainable Management Criteria presented in the draft GSP, specifically with respect to future subsidence. The letter states *Westlands GSA is concerned that allowing subsidence rates as proposed may impact critical infrastructure such as roads, railroads, and may increase flood risks to existing land uses, especially near Corcoran where subsidence rates are critical, in the Westside Subbasin and other neighboring subbasins.*

Response: Thank you for your comment. The GSA's within the Subbasin are concerned about lowering of groundwater levels as well as land subsidence. To this end, it is recognized that land subsidence is a regional concern and based upon historical information, is thought to be a result of groundwater pumping beneath the Corcoran Clay. The historical data and model developed for the basin suggests that regionally the largest change in land subsidence is located Southeast of the Subbasin and within the Tule Subbasin. The rate of subsidence continues into the Subbasin with rates experienced in Lemoore being approximately half of the rate at the Corcoran site.

Section 4.4.1.3 has been revised to reflect this historic information and set a minimum threshold of 8 feet of subsidence at the Lemoore site. To quote from the revised GSP, "These values have been selected using historical subsidence data. There has been no information suggesting that there has been local significant damage to infrastructure in both these areas. At each five-year milestone, information from the groundwater model suggests subsidence will continue for the first five years until project and management actions are fully implemented."

Finding 7 Comment

Finding 7 is in regard to analysis in the groundwater model report presented in Appendix D of the draft GSP indicate the General Head Boundary (GHB) is driving groundwater flow out of the Westside Subbasin and into the Subbasin. The letter states *Westlands recommends reanalyzing the water level contour data from the numerical model and GSP.*

<u>Response:</u> The GHBs in the Westside Subbasin basically follows the boundary between Fresno and Kings Counties. The GHB heads were interpolated from water level elevation data provided by DWR and Westlands for wells near the edge of the model on both side of the county line. The resulting GHB heads have historically tended to decrease from north and southwest to a low area near the bend in the county line. The winter 2014/2015 potentiometric surface map for the lower (confined) aquifer provided by Westlands in the comment letter also shows that the water level elevation contours along the county (GHB) line are also converging towards a low area near the bend in the county line. We believe the GHBs heads utilized in the Westside Subbasin are a reasonable interpretation of historical water level elevation in the area.

Reporting Discrepancy #1

The letter states *Total lateral subsurface inflow into the Westside Subbasin shown in Figure D5-5 averages 72,296 AFY (67,347 from the Tulare Lake Subbasin and 4,948 AFY from the Kings Subbasin). Table 3-6 of the GSP shows average annual subsurface flow from the Tulare Lake Subbasin to the Westside Subbasin of 41,390. What is the source of this discrepancy?*

<u>Response:</u> The figure was referencing an incorrect cell and has been corrected.

Reporting Discrepancy #2

The letter states *In the graphic depicting aquifer specific fluxes in Figure D5-5, the sum of the "Net GW Flux" (which presumably is lateral subsurface flow between adjacent subbasins) totals 4,936 AFY while the total in the table shown in Figure D5-5 is 72,296 AFY. What is the source of this discrepancy?*

<u>Response:</u> The figure was referencing an incorrect cell and has been corrected.

Reporting Discrepancy #3

The letter states *Figure numbers in the Appendix D text do not correspond to the correct figures. Figure DS-10 is titled "Simulated Subsidence 1990-2016". Figure D5-8 shows "Groundwater Mass Balance Tule Subbasin".*

Response: The figure numbers have been corrected.

General Comment

Westlands recommended that GSA representatives from the two subbasins meet and confer at the earliest opportunity to determine whether an interbasin agreement can be reached. The agreement would be used to reach a cooperative resolution of important issues that will enable coordinated sustainable management in our GSAs.

Response: The GSAs in the Subbasin agree that efforts should be made to develop and interbasin agreement and look forward to the opportunity following submittal of the respective GSPs.

Comment I-1

In her email of October 11, 2019, Ms. Courtney made clear her opposition to the GSP and using groundwater for agriculture.

Response: Thank you for your email and comments. The comments do not pertain to the GSP's analysis. Opposition to the GSP has been noted and the email is included in full herein and will be forwarded to the DWR for consideration.

Comment I-2

The comment letter from Mr. Miguel has a number of points related to surface water supplies and the Kings River Water Association. While the letter recognizes that the GSP and GSA's have no authority, he goes on to assert that the GSP could be used to be a proponent of change and public awareness. The letter suggests that there has been an opportunity missed in the capture and use of surface water flows from the Kings River and that storage contemplated and permitted has not been fully utilized.

Response: Thank you for your letter and comments. As is recognized in the letter, the GSA's and GSP have no authority of surface water rights, diversion and beneficial uses of these rights. These surface water rights have historic origins, were initially exercised in the 1800s, predate statehood and more recently have been permitted by the State Water Resources Control Board. A watermaster has been charged with oversight of the river and assuring that the surface water diversions are in accordance with the licenses for diversion. As to your suggestion that additional surface supplies could be utilized to offset overdraft, that is the plan. Please review Section 6.0 that identifies the projects envisioned to increased surface diversion and use. You will note that all the GSA's are planning on projects to divert and either recharge (where possible and the geologic conditions allow) or storage and reregulation of supply. These are most notable in the SFK, and El Rico, and Tri-County Water Agency GSA's. We look forward to the planning and implementation of these projects to allow for the continued farming and prosperity for the area.

Comment I-3

Mr. Toss provided a verbal comment at the Public Hearing on December 2, 2019, in which he stated that the demand reduction presented in Chapter 6 of the GSP as a management action to help achieve groundwater sustainability in the subbasin would be very damaging to Kings County and its growers. He requested that this management action be changed.

Response: Thank you for your comment. The draft GSP has been revised to remove demand management or demand reduction has a definitive programmatic action. The potential for demand management is described in Section 6.4 only as an option for the GSAs should it be needed to meet the Sustainability Goal. If implementation is necessary, the GSAs are committed to executing such programs in a cost effective manner and with the input of the local communities.

Comment I-4

Mr. Verboon is a Kings County Supervisor, but clarified that his comments were from him individually and "not on behalf of the Board of Supervisors". In his letter to the five GSAs, Mr. Verboon, on behalf of other signatories to the letter, made 3 main comments:

Comment 1: There were procedural defects that limited Kings County and its water uses in their opportunity to review and comment on the draft GSP.

Response: Thank you for your letter and comments. The GSAs understand that they have met their notice and other obligations to Kings County under Section 10728.4. The GSAs view that there were no procedural defects in the notice provided to the County. Consultation with Kings County took place at a meeting on November 6, 2019, roughly a month prior to the comment period close. Kings County chose to not submit any written or verbal comments on the draft GSP.

Comment 2: The projects presented in the draft GSP are too vague and non-committal.

Response: The draft GSP indicates that there exist a number of legal and practical uncertainties regarding project identification and adoption. Projects referenced in the draft GSP, and possibly others, will be identified and adopted by the GSAs, but only after sufficient data are collected, adequate analysis conducted, and funds are appropriated for the projects. Refer to Chapter 7 for further details on project implementation.

Comment 3: Land fallowing should be used as a demand reduction management action only as a last resort and after other demand reduction strategies and water recharge projects have been implemented.

Response: It appears that Mr. Verboon has interpreted the details of some groundwater model evaluations as planned GSA management strategies, and that is incorrect. Also, upon review, there were descriptions of land fallowing that were misleading and likely added to the confusion. These portion of the GSP have been revised. Also, the GSAs agree that supply augmentation should be a top priority for this Subbasin. Several supply augmentation projects and their implementation are described in Chapters 6 and 7.

Public Comment Letters

From: Colleen Courtney <colleencourtney66@gmail.com>

Sent: Saturday, October 12, 2019 1:01 AM

To: Colleen Courtney <colleencourtney66@gmail.com>; comments@southforkkings.org; jwyrick@jgboswell.com; kcwdh20@sbcglobal.net

Subject: GSAS-Kings County Resident STATES NO ON GROUND WATER FOR AGRICULTURAL PURPOSES!

Colleen Courtney
14234 16th Avenue
Lemoore, CA 93245-9517
Email: colleencourtney66@gmail.com

October 11,2019

To: GSAS Commissioners Board;

HELL NO! These sod Busters DO NOT DRAIN the Valleys Ground Water for their crops that ships out of State or over seas for your personal Padding Their wallets!

NOT AT this Valleys populations expense for their personal gains!

We need that water for drinking for people, animales we eat and other business endeavors other than these Sod Busters causing our lungs to fill with their crop dirt, pesticides from those dam planes or choppers that keep sprayers on to do a turns. Bull shit!

You sod Busters use your homes water well resource to water your acreages! Or drill more water wells on your own property or truck in tankers of water from the Rockies or Serras!

Or tap into your local City water line. Their water line is petty much secured source for your crop of your own choice of Occupational decision of becoming a FATCAT Farmer! At the other people's thirst expense!

We are already breathing your property's dirt and pesticides! Your surface soil covers our house and vechicals in one month! And pushing your sludge mixed with our water down that dam drive away!

I am about to phone the Sheriffs Department on that sod buster's property that constantly trespasses and squats on our property and buries everything!
We accumulated more of his farm land than he actually possesses!

These sodbusters are like city slumlords just purchased cheap property sell high, cut costs, don't maintain, rape the earth, suck it out of every earthly nutrients, minerals possible drain others water for your sole purposes to pad your wallets. And in the end abandon the worthless property your raped the hell out of. To go to another place to fu ck up for the next generation to overhaul that damage you caused in the first place!

NO GROUND WATER To SOD BUSTERS!
And SOD BUSTERS are NOT in the
AGRICULTURAL COMMUNITIES!

The Real Farmers know how to take care of the earth and would not ever think of asking people to give up their drinking water for themselves and their animals. For his crops. This Farmer would sacrifice his crops for those people when it came to water rights. And not directed by padding his wallet!

VOTE NO ON GROUND WATER! Let these sod busters truck in their water from Rockies or Serras! Just a cheap expense compared to Shipping crops to New York or Over Seas!

Cheap son of a bitches! Go dry up!

Colleen Courtney

RECEIVED K.R.C.D.

OCT 15 2019

File No. ____________

South Fork Kings Groundwater Sustainability Agency
4886 E Jensen Avenue
Fresno, CA 93725

TO: SFKGSA Board Members and members of the Public.

RE: Response to SFKGSA Sustainability Plan.

I use this opportunity to respond to the South Fork Kings Groundwater Sustainability Plan. I understand that the SFKGSA is limited in its scope of responsibility and governance, however I feel the SFKGSA can become a useful proponent and informational resource for public awareness.

The primary source of groundwater recharge is the sandy bottom of the Kings River. Domestic wells, agriculture wells, groundwater dependent ecosystems, and other beneficial users are dependent upon the river's natural surface water flows to recharge underground aquifers. These surface water flows are managed by the Kings River Water Association (KRWA) whose 28 member districts receive water from a designated "point of diversion" on the Kings River. It has become common practice to divert surface water from lower stream points of diversion to upper stream diversion points to reduce what is commonly termed "channel loss". However, channel loss is also groundwater recharge. These diversions have a direct and negative impact on holders of overlying groundwater rights by diminishing groundwater recharge and adding to groundwater overdraft.

PART 1.
GROUNDWATER RIGHT HOLDERS:
SUSTAINABLE GROUNDWATER MANAGEMENT ACT: 10723.2.

"The groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans. These interests include, but are not limited to, all of the following:"

(a) Holders of overlying groundwater rights, including:
(1) Agricultural users.
(2) Domestic well owners.
(b) Municipal well operators.
(c) Public water systems.
(d) Local land use planning agencies.
(e) Environmental users of groundwater.

Excerpts from CALIFORNIA WATER CODE:

§ 1706. The person entitled to the use of water by virtue of an appropriation other than under the Water Commission Act or this code may change the point of diversion, place of use, or purpose of use if others are not injured by such change...

§ 1707. (a) (1) Any person entitled to the use of water, whether based upon an appropriative, riparian, or other right, may petition the board pursuant to this chapter, Chapter 6.6 (commencing with Section 1435) or Chapter 10.5 (commencing with Section 1725) for a change for purposes of preserving or enhancing wetlands habitat, fish and wildlife resources, or recreation in, or on, the water.

Being a public entity, it is incumbent on the SFKGSA monitor and quantify the amount of groundwater recharge lost due to points of diversion changes. Further, it is an inherent responsibility of the SFKGSA to challenge any such diversions per California Water Code Sections 1706 and 1707, and by other codes sections not mentioned, and to advocate on behalf of those harmed by such diversions.

PART 2.

DECISION 1290

In 1967 the State of California State Water Rights Board issued its Decision 1290, a pivotal benchmark for Kings River water management. The following are excerpts from the Decision:

Page 16: "The primary source of all ground water in the Kings River service area is the river and its distributaries...".

Page 21: "The contracts with members of the KRWA result in the controlled release of water from these reservoirs* (Courtright, Wishon, Pine Flat) *to satisfy downstream requirements for irrigation and ground-water recharge."

Page 35-36: "...the association* (KRWA) *members have planned their overall project to take maximum advantage of all storage facilities available to them. This includes recharge of ground water and underground storage as well as the storage of flood waters in Tulare Lake Basin and maximum retention in Pine Flat Reservoir. Consulting Engineer Henry Karrer testified to the effect that under certain ideal conditions, about 2,000,000 acre-feet could be stored and regulated in Pine Flat Reservoir in any one year (RT192). He also said that up to 1,000,000 acre-feet of water could be stored in the cellular dyke system in Tulare Lake Basin (RT 192)."

This position was reaffirmed in a July 30, 2019 letter to Mitchell Moody of the State Water Resource Control Board when stating; "Decision 1290 expressly recognized the KRWA member units planned their overall project to take maximum advantage of all available storage facilities...".

Present estimate of King River Basin groundwater overdraft is 120,000 acre-feet per year, while average annual floodwater diverted to the San Joaquin River is 100,000 acre-feet. Opportunities of using Tulare Lake as a storage facility have been repeatedly missed as it has become common practice to redirect flood release water away from the ***cellular dyke system in Tulare Lake Basin*** to the San Joaquin. The beneficial use of this un-stored water is then lost to all.

It is understandable that stakeholders who would be harmed by the flooding of the Tulare Lake Basin would wish that flood release waters be diverted. The flooding of the Tulare Lake Basin would cause economic hardship to business interests. However, as noted in Decision 1290 and empirically known, the Kings River waters do naturally flow to the Tulare Lake Basin, into what is known as Tulare Lake.

It is likewise understandable that this diversion of flood release water comes at an equal price to stakeholders outside the Tulare Lake Basin. Water diverted away from the dyke system storage facility is water waisted and unused for negating groundwater overdraft and recharge. If full usage of the cellular dyke system were utilized as stated in Decision 1290, groundwater overdraft could be diminished by as much as 100,000 per year.

With SGMA deadlines approaching, stakeholders up-stream of the Tulare Lake Basin find themselves mired in a groundwater overdraft problem. They face the economic consequence of fallowed land and tax surcharges for groundwater pumping, while 100,000 acre-feet of Kings River surface water is re-routed to the San Joaquin River. Simply put; until the cellular dyke system in Tulare Lake Basin is fully utilized as intended, upstream right-holders and stakeholders a will pay the price for the problem Tulare Lake Basin interests pass on.

As stated, SFKGSA is a public entity and has an inherent responsibility to monitor, quantify and make publicly known the amount of groundwater recharge lost and the groundwater overdraft resulting from the non-use of the cellular dyke storage system as stated in Decision 1290. Additionally, it is requested that the SFKGSA study and make known the impact changes in points of diversion (Part 1) and non-use of the cellular dyke storage system in Tulare Lake Basin (Part 2) have upon groundwater recharge and overdraft prior to implementation of overdraft enforcement procedures.

Thank you for your consideration.

Bill Miguel
21425 Grangeville Blvd
Lemoore, California
October 11, 2019

The Nature Conservancy
Protecting nature. Preserving life.

CALIFORNIA WATER | **GROUNDWATER**

555 Capitol Mall, Suite 1290
Sacramento, California 95814
[916] 449-2850

nature.org
GroundwaterResourceHub.org

November 26, 2019

South Fork Kings Groundwater Sustainability Agency
4886 E. Jensen Avenue
Fresno, CA 93725
comments@southforkkings.org

Submitted online via: https://southforkkings.org/wp-content/uploads/2019/09/2019-0906-tulare-lake-subbasin-gsp-prelim-draft_for-upload.pdf

Re: Tulare Lake Subbasin Groundwater Sustainability Plan, Preliminary Draft

Dear Agency Staff,

The Nature Conservancy (TNC) appreciates the opportunity to comment on the Groundwater Sustainability Plan (GSP) for the Tulare Lake Subbasin that is being prepared under the Sustainable Groundwater Management Act (SGMA).

TNC as a Stakeholder Representative for the Environment

TNC is a global, nonprofit organization dedicated to conserving the lands and waters on which all life depends. We seek to achieve our mission through science-based planning and implementation of conservation strategies. For decades, we have dedicated resources to establishing diverse partnerships and developing foundational science products for achieving positive outcomes for people and nature in California. TNC was part of a stakeholder group formed by the Water Foundation in early 2014 to develop recommendations for groundwater reform and actively worked to shape and pass SGMA.

Our reason for engaging is simple: California's freshwater biodiversity is highly imperiled. We have lost more than 90 percent of our native wetland and river habitats, leading to precipitous declines in native plants and the populations of animals that call these places home. These natural resources are intricately connected to California's economy providing direct benefits through industries such as fisheries, timber and hunting, as well as indirect benefits such as clean water supplies. SGMA must be successful for us to achieve a sustainable future, in which people and nature can thrive within the Tulare Lake Groundwater Subbasin and California.

We believe that the success of SGMA depends on bringing the best available science to the table, engaging all stakeholders in robust dialog, providing strong incentives for beneficial outcomes and rigorous enforcement by the State of California.

Given our mission, we are particularly concerned about the inclusion of nature, as required, in GSPs. TNC has developed a suite of tools based on best available science to help Groundwater Sustainability Agencies (GSAs), consultants, and stakeholders efficiently incorporate nature into GSPs. These tools and resources are available online at

GroundwaterResourceHub.org. TNC's tools and resources are intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

Addressing Nature's Water Needs in GSPs

SGMA requires that all beneficial uses and users, including environmental users of groundwater, be considered in the development and implementation of GSPs (Water Code § 10723.2).

The GSP Regulations include specific requirements to identify and consider groundwater-dependent ecosystems (GDEs) [23 CCR §354.16(g)] when determining whether groundwater conditions are having potential effects on beneficial uses and users. GSAs must also assess whether sustainable management criteria may cause adverse impacts to beneficial uses and users, which include environmental uses, such as plants and animals. TNC has identified each part of GSPs where consideration of beneficial uses and users are required. That list is available here: https://groundwaterresourcehub.org/importance-of-gdes/provisions-related-to-groundwater-dependent-ecosystems-in-the-groundwater-s. Please ensure that environmental beneficial users are addressed accordingly throughout the GSP. Adaptive management is embedded within SGMA and provides a process to work toward sustainability over time by beginning with the best available information to make initial decisions, monitoring the results of those decision, and using data collected through monitoring to revise decisions in the future. Over time, GSPs should improve as data gaps are reduced and uncertainties addressed.

To help ensure that GSPs adequately address nature as required under SGMA, TNC has prepared a checklist (**Attachment A**) for GSAs and their consultants to use. TNC believes the following elements are foundational for 2020 GSP submittals. For detailed guidance on how to address the checklist items, please also see our publication, *GDEs under SGMA: Guidance for Preparing GSPs*[1].

1. Environmental Representation

SGMA requires that GSAs consider the interests of all beneficial uses and users of groundwater. To meet this requirement, we recommend actively engaging environmental stakeholders by including environmental representation on the GSA board, technical advisory group, and/or working groups. This could include local staff from state and federal resource agencies, nonprofit organizations and other environmental interests. By engaging these stakeholders, GSAs will benefit from access to additional data and resources, as well as a more robust and inclusive GSP.

2. Basin GDE and ISW Maps

SGMA requires that GDEs and interconnected surface waters (ISWs) be identified in the GSP. We recommend using the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) provided online[2] by the Department of Water Resources (DWR) as a starting point for the GDE map. The NC Dataset was developed through a collaboration between DWR, the California Department of Fish and Wildlife (CDFW) and TNC. We also recommend using GDE Pulse, which is also available on the internet at https://gde.codefornature.org/#/home. We also recommend using the California Natural

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[1] GDEs under SGMA: Guidance for Preparing GSPs is available at: https://groundwaterresourcehub.org/public/uploads/pdfs/GWR_Hub_GDE_Guidance_Doc_2-1-18.pdf

[2] The Department of Water Resources' Natural Communities Commonly Associated with Groundwater dataset is available at: https://gis.water.ca.gov/app/NCDatasetViewer/

Diversity Database (CNDDB) provided by CDFW to look up species occurrences within your area.

3. Potential Effects on Environmental Beneficial Users

SGMA requires that potential effects on GDEs and environmental surface water users be described when defining undesirable results. In addition to identifying GDEs in the basin, TNC recommends identifying beneficial users of surface water, which include environmental users. This is a critical step, as it is impossible to define "significant and unreasonable adverse impacts" without knowing *what* is being impacted. For your convenience, we've provided a list of freshwater species within the boundary of the Tulare Lake Groundwater Subbasin (Subbasin) in **Attachment C**. Our hope is that this information will help your GSA better evaluate the impacts of groundwater management on environmental beneficial users of surface water. We recommend that after identifying which freshwater species exist in your basin, especially federal- and state-listed species, that you contact staff at CDFW, United States Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Services (NMFS) to obtain their input on the groundwater and surface water needs of the organisms on the GSA's freshwater species list. We also refer you to the Critical Species Lookbook[3] prepared by TNC and partner organizations for additional background information on the water needs and groundwater reliance of critical species. Since effects to plants and animals are difficult and sometimes impossible to reverse, we recommend erring on the side of caution to preserve sufficient groundwater conditions to sustain GDEs and ISWs.

4. Biological and Hydrological Monitoring

If sufficient hydrological and biological data in and around GDEs is not available in time for the 2020/2022 plan, data gaps should be identified along with actions to reconcile the gaps in the monitoring network.

TNC has reviewed the Tulare Lake Preliminary Draft GSP and appreciates the use of some our relevant resources in addressing GDE-related topics. However, we consider it to be **inadequate** under SGMA since key environmental beneficial uses and users are not adequately identified and considered. In particular, 1) ISWs and GDEs are not adequately identified and evaluated for ecological importance or adequately considered in the basin's sustainable management criteria, and 2) connectivity and extent of the of ISWs and GDEs with the shallow / perched zones of the unconfined / semiconfined aquifer were not characterized. **Please present a more thorough analysis of the 1) connectivity of the shallow and perched portions of the unconfined aquifer, 2) extent of the perched and shallow areas within the aquifer, and 3) identification and evaluation of ISWs and GDEs in subsequent drafts of the GSP. Once potential GDEs and ISWs are identified, they must be considered when defining undesirable results and evaluated for further monitoring needs until data gaps are filled in the future. If they are not adequately defined, then they need to be identified as a data gap in the interim.**

Our specific comments related to the Tulare Lake GSP are provided in detail in **Attachment B** and are in reference to the numbered items in **Attachment A. Attachment C** provides a list of the freshwater species located in the Subbasin. **Attachment D** describes six best practices that GSAs and their consultants can apply when using local groundwater data to confirm a connection to groundwater for DWR's NC Dataset. **Attachment E** provides an overview of a new, free online tool (i.e., GDE Pulse) that allows GSAs to assess changes in GDE health using satellite, rainfall, and groundwater data.

[3] Available online at: https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/

Thank you for fully considering our comments as you develop your GSP.

Best Regards,

Sandi Matsumoto
Associate Director, California Water Program
The Nature Conservancy

The Nature Conservancy

Attachment A

Environmental User Checklist

The Nature Conservancy is neither dispensing legal advice nor warranting any outcome that could result from the use of this checklist. Following this checklist does not guarantee approval of a GSP or compliance with SGMA, both of which will be determined by DWR and the State Water Resources Control Board.

GSP Plan Element*		GDE Inclusion in GSPs: Identification and Consideration Elements	Check Box
Admin Info	**2.1.5 Notice & Communication** *23 CCR §354.10*	**Description of the types of environmental beneficial uses of groundwater that exist within GDEs and a description of how environmental stakeholders were engaged throughout the development of the GSP.**	1
Planning Framework	**2.1.2 to 2.1.4 Description of Plan Area** *23 CCR §354.8*	**Description of jurisdictional boundaries, existing land use designations, water use management and monitoring programs; general plans and other land use plans relevant to GDEs and their relationship to the GSP.**	2
		Description of instream flow requirements, threatened and endangered species habitat, critical habitat, and protected areas.	3
		Summary of process for permitting new or replacement wells for the basin, and how the process incorporates any protection of GDEs	4
Basin Setting	**2.2.1 Hydrogeologic Conceptual Model** *23 CCR §354.14*	**Basin Bottom Boundary:** Is the bottom of the basin defined as at least as deep as the deepest groundwater extractions?	5
		Principal aquifers and aquitards: Are shallow aquifers adequately described, so that interconnections with surface water and vertical groundwater gradients with other aquifers can be characterized?	6
		Basin cross sections: Do cross-sections illustrate the relationships between GDEs, surface waters and principal aquifers?	7
	2.2.2 Current & Historical Groundwater Conditions *23 CCR §354.16*	**Interconnected surface waters:**	8
		Interconnected surface water maps for the basin with gaining and losing reaches defined (included as a figure in GSP & submitted as a shapefile on SGMA portal).	9
		Estimates of current and historical surface water depletions for interconnected surface waters quantified and described by reach, season, and water year type.	10
		Basin GDE map included (as figure in text & submitted as a shapefile on SGMA Portal).	11

		If NC Dataset *was* used:	Basin GDE map denotes which polygons were kept, removed, and added from NC Dataset (Worksheet 1, can be attached in GSP section 6.0).	12
			The basin's GDE shapefile, which is submitted via the SGMA Portal, includes two new fields in its attribute table denoting: 1) which polygons were kept/removed/added, and 2) the change reason (e.g., why polygons were removed).	13
			GDEs polygons are consolidated into larger units and named for easier identification throughout GSP.	14
		If NC Dataset *was not* used:	Description of why NC dataset was not used, and how an alternative dataset and/or mapping approach used is best available information.	15
		Description of GDEs included:		16
		Historical and current groundwater conditions and variability are described in each GDE unit.		17
		Historical and current ecological conditions and variability are described in each GDE unit.		18
		Each GDE unit has been characterized as having high, moderate, or low ecological value.		19
		Inventory of species, habitats, and protected lands for each GDE unit with ecological importance (Worksheet 2, can be attached in GSP section 6.0).		20
	2.2.3 Water Budget *23 CCR §354.18*	Groundwater inputs and outputs (e.g., evapotranspiration) of native vegetation and managed wetlands are included in the basin's historical and current water budget.		21
		Potential impacts to groundwater conditions due to land use changes, climate change, and population growth to GDEs and aquatic ecosystems are considered in the projected water budget.		22
Sustainable Management Criteria	**3.1 Sustainability Goal** *23 CCR §354.24*	**Environmental stakeholders/representatives were consulted.**		23
		Sustainability goal mentions GDEs or species and habitats that are of particular concern or interest.		24
		Sustainability goal mentions whether the intention is to address pre-SGMA impacts, maintain or improve conditions within GDEs or species and habitats that are of particular concern or interest.		25
	3.2 Measurable Objectives *23 CCR §354.30*	**Description of how GDEs were considered and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.**		26
	3.3 Minimum Thresholds *23 CCR §354.28*	**Description of how GDEs and environmental uses of surface water were considered when setting minimum thresholds for relevant sustainability indicators:**		27
		Will adverse impacts to GDEs and/or aquatic ecosystems dependent on interconnected surface waters (beneficial user of surface water) be avoided with the selected minimum thresholds?		28
		Are there any differences between the selected minimum threshold and state, federal, or local standards relevant to the species or habitats residing in GDEs or aquatic ecosystems dependent on interconnected surface waters?		29
	3.4 Undesirable Results *23 CCR §354.26*	**For GDEs, hydrological data are compiled and synthesized for each GDE unit:**		30
		If hydrological data *are available* within/nearby the GDE	Hydrological datasets are plotted and provided for each GDE unit (Worksheet 3, can be attached in GSP Section 6.0).	31
			Baseline period in the hydrologic data is defined.	32

			GDE unit is classified as having high, moderate, or low susceptibility to changes in groundwater.	33
			Cause-and-effect relationships between groundwater changes and GDEs are explored.	34
		If hydrological data *are not available* within/nearby the GDE	Data gaps/insufficiencies are described.	35
			Plans to reconcile data gaps in the monitoring network are stated.	36
		For GDEs, biological data are compiled and synthesized for each GDE unit:		37
		Biological datasets are plotted and provided for each GDE unit, and when possible provide baseline conditions for assessment of trends and variability.		38
		Data gaps/insufficiencies are described.		39
		Plans to reconcile data gaps in the monitoring network are stated.		40
		Description of potential effects on GDEs, land uses and property interests:		41
		Cause-and-effect relationships between GDE and groundwater conditions are described.		42
		Impacts to GDEs that are considered to be "significant and unreasonable" are described.		43
		Known hydrological thresholds or triggers (e.g., instream flow criteria, groundwater depths, water quality parameters) for significant impacts to relevant species or ecological communities are reported.		44
		Land uses include and consider recreational uses (e.g., fishing/hunting, hiking, boating).		45
		Property interests include and consider privately and publicly protected conservation lands and opens spaces, including wildlife refuges, parks, and natural preserves.		46
Sustainable Management Criteria	**3.5 Monitoring Network** *23 CCR §354.34*	Description of whether hydrological data are spatially and temporally sufficient to monitor groundwater conditions for each GDE unit.		47
		Description of how hydrological data gaps and insufficiencies will be reconciled in the monitoring network.		48
		Description of how impacts to GDEs and environmental surface water users, as detected by biological responses, will be monitored and which GDE monitoring methods will be used in conjunction with hydrologic data to evaluate cause-and-effect relationships with groundwater conditions.		49
Projects & Mgmt Actions	**4.0. Projects & Mgmt Actions to Achieve Sustainability Goal** *23 CCR §354.44*	Description of how GDEs will benefit from relevant project or management actions.		50
		Description of how projects and management actions will be evaluated to assess whether adverse impacts to the GDE will be mitigated or prevented.		51

* In reference to DWR's GSP annotated outline guidance document, available at: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GD_GSP_Outline_Final_2016-12-23.pdf

Attachment B

TNC Evaluation of the
Tulare Lake Subbasin Groundwater Sustainability Plan, Preliminary Draft

A complete draft of the Tulare Lake Subbasin GSP is available at https://southforkkings.org/wp-content/uploads/2019/09/2019-0906-tulare-lake-subbasin-gsp-prelim-draft_for-upload.pdf for public review and comment and is dated August 2019. This attachment summarizes our comments on the complete public draft GSP. Comments are provided in the order of the checklist items included as Attachment A.

Checklist Item 1 - Notice & Communication (23 CCR §354.10)

[Section 2.5.3 Beneficial Uses and Users (p. 2-28)]

- The flow chart on p. 2-28 shows the engagement process with groundwater users during the development and implementation of the GSP. Table 2-4 (pp. 2-47 to 2-49) identifies all the beneficial uses and users of groundwater within the Subbasin by GSA in greater detail, but does not include environmental uses and users. Users identified include agricultural, public water systems, domestic well owners, municipal water systems, planning agencies, Native American Tribes, Disadvantaged Communities, monitoring entities, and surface water users (as represented by GSA members). California Water Code §1305(f) defines that beneficial uses of waters of the State include "preservation and enhancement of fish, wildlife, and other aquatic resources and preserves". **Please expand Table 2-4 to include environmental uses and users that are present in the Subbasin, such as:**
    - **ecological areas; preserves; potential ISWs and GDEs; managed wetlands;**
    - **Protected Lands, including conservation areas; and**
    - **Public Trust Uses including wildlife, aquatic habitat, fisheries, and recreation.**

Checklist Items 2 to 4 - Description of the Plan Area (23 CCR §354.8)

[Section 2.0 Plan Area (pp. 2-1 to 2-2)]

- The types and locations of environmental uses, species and habitats supported, and the designated beneficial environmental uses and users of surface waters that may be affected by groundwater extraction in the Subbasin should be specified in the section and in Table 2-4. **Please elaborate on the "surface water uses and users" by identifying the environmental uses and users of surface water for all GSAs in Table 2-4. Please explicitly identify the environmental users and take particular note of the species with protected status and any critical habitat that exists within the Subbasin.** The following are resources that can be used:
    - Natural Communities Commonly Associated with Groundwater dataset (NC Dataset) - https://gis.water.ca.gov/app/NCDatasetViewer/

- The list of freshwater species located in the Tulare Lake Subbasin in Attachment C of this letter.
- The California Department of Fish and Wildlife's California Natural Diversity Database (CNDDB) for species occurrences.
- The USFWS's Environmental Conservation Online System (ECOS) for mapping critical habitat, wildlife and contaminants - https://ecos.fws.gov/ecp/

- The GSP addresses state and federal land ownership to some degree, but there is no mention of uses related to open space areas, managed wetlands, natural preserve areas, or other protected lands that contain natural resources. Per the USFWS ECOS website the Kern National Wildlife Refuge Complex, Tulare Basin Wildlife Management Area (on southern boundary), and Pixley National Wildlife Refuge (to the east of Highway 43) abut the GSP area. Within these areas there is critical habitat mapped for the Buena Vista Lake ornate shrew (*Sorex ornatus relictus*) near the Lemoore Naval Air Station and in the Kern National Wildlife Refuge, and the vernal pool fairy shrimp (*Branchinecta lynchyi*) in the Pixley National Wildlife Refuge. These habitat areas or species are not addressed in the description of the plan area, nor are sensitive habitats within the plan area acknowledged.
  - **Please identify the natural resources within the plan area and elaborate on any and all state, federal or other land ownership that exists within the plan area that provide protection of natural resources.**
  - **Please address how the GSP will address natural resource management on a regional scale since management within the GSP could affect neighboring sensitive resources.**
- The GSP goes on to state on p. 2-2 that the primary land use designations are for agricultural, urban, residential, commercial and industrial lands; however, the figure on that page shows riparian vegetation and water surface land use classifications that amount to more than residential and semi-agricultural. **Please revise the statement concerning primary land use designations to accurately reflect the percentages on the chart (i.e., agricultural, urban, riparian vegetation, water surface, etc.). Please identify the natural resources within the plan area and elaborate on any and all state, federal or other land ownership that exists within the plan area that provide protection of natural resources.**
- On page 2-2, it is stated that it was not possible to differentiate types of well uses between irrigation and domestic extractors because DWR does not have that data. However, these data are available on well completion reports which may be accessed on line through the GeoTracker GAMA website (https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp). This is the approach taken in almost every other GSP we have reviewed and is an important distinction of use as it relates to prioritization of project needs and management decisions. _**Please either address this issue or identify this as a data gap to reconcile in the 5-year GSP update.**

[Section 2.1 Summary of Jurisdictional Areas and Other Features (pp. 2-3 to 2-10)]

- The Plan summarizes the GSP Area and describes the jurisdictional areas and entities of the GSAs, but does not say anything about the jurisdictional areas of the resource agencies. **Please elaborate on the jurisdictional areas of the resource agencies and what resources they are in place to protect.**
- With exception of a short description of the Kings River Fisheries Management Program in Section 2.2.2.4, the GSP does not provide a description of other instream flow requirements, if any, or how the water infrastructure is in compliance with regulatory requirements set to protect species of concern. **Please provide a description of any current and planned instream flow requirements for Tulare Subbasin streams / rivers including Kings, Tule, White, Kaweah, and St. John's Rivers; and undammed streams including Deer, Dry, Mill, Cottonwood, and Poso Creeks. If there are no other instream flow requirements in place or planned, then please state that in the document.**

[Section 2.2.1 Monitoring and Management Programs (pp. 2-11 to 2-12)]

- This section addresses the water resources management actions that are being undertaken to monitor groundwater level, extraction and quality; subsidence; irrigated lands; and surface water. Management of natural resources is not considered in this section but should be described in order to provide a context for how groundwater management actions will be coordinated with environmental requirements to prevent undesirable results. **Please include a description of the natural resource management and monitoring programs occurring within the GSP area that affects instream, wetland and riparian ecosystems that have the potential to be groundwater dependent (i.e., interconnected surface water [ISWs] and groundwater dependent ecosystems [GDEs]).**

[Section 2.3 Relation to General Plans (pp. 2-14 to 2-17)]

- The GSP includes a very short description of the general plans within the GSP area but fails to specifically elaborate on the goals and policies outlined in the plans, and how the GSP will fit in with or affect the general plans' goals and policies related to the protection and management of GDEs, ISWs and aquatic resources that could be affected by groundwater withdrawals. **Please include a discussion of how implementation of the GSP may affect and be coordinated with General Plan policies and procedures regarding the protection of wetlands, aquatic resources, other GDEs and ISWs, and related threatened or endangered species.**
- This section should identify other land use plans, including Habitat Conservation Plans (HCPs) or Natural Community Conservation Plans (NCCPs) within the Subbasin and if they are associated with areas with instream flow requirements; or critical, GDE or ISW habitats. **Please identify all relevant HCPs and NCCPs within the Subbasin, and any reaches with instream flow and critical habitat requirements. Please elaborate on the natural resources within the Subbasin and address how GSP implementation will coordinate with the**

goals of these plans and requirements. If there are no HCPs, NCCPs, or preservation areas that could be affected, then that should be stated. The Critical Species Lookbook[4] includes the potential groundwater reliance of critical species in the basin. **Please include a discussion regarding the management of critical species and their habitats for these aquatic ecosystems and its relationship to the GSP.**

- **Please describe how the GSP will coordinate with the General Plan elements within the GSP area. Specifically, please elaborate on conservation, recreation and open space elements.**
- This section states (p. 2-15) that "It is considered unlikely that any Kern County General Plan Policies have any practical relevance to the plan area". The Kern National Wildlife Refuge Complex abuts the GSP area and it is difficult to understand that the General Plan for Kern County does not address habitat concerns and conservation that could be directly or indirectly affected by potential groundwater management actions within and adjacent to the Kern Subbasin. **Please 1) elaborate on the Kern County General Plan's conservation elements, 2) how the Tulare Lake Subbasin's GSP will comply with or not impact conservation elements being employed within protected habitat areas adjacent to the Tulare Subbasin, and 3) expand this conversation to include other neighboring habitat areas, such as Pixley National Wildlife Refuge.**

[Section 2.3.4 Permitting Process for New or Replacement Wells (pp. 2-17 to 2-19)]

- This section summarizes well permitting requirements and county ordinances for the counties of Kings, Kern and Tulare. **Please include a discussion of the following in this section:**
  - Future well permitting must be coordinated with the GSP to assure achievement of the Plan's sustainability goals.
  - How the well permitting process incorporates protection of GDEs within the Subbasin.
  - The State Third Appellate District recently found that Counties have a responsibility to consider the potential impacts of groundwater withdrawals on public trust resources when permitting new wells near streams with public trust uses (ELF v. SWRCB and Siskiyou County, No. C083239). **The need for well permitting programs to comply with this requirement should be stated in the text.**

<u>Checklist Items 5 to 7 – Hydrogeologic Conceptual Model (23 CCR §354.14)</u>

[Section 3.1.7 Definable Bottom of the Basin (pp. 3-16 to 3-19)]

- The GSP uses two methods (Water Quality and Geologic) to define the bottom of the basin but which method, or combination of the methods, that is being relied on for this GSP is not clearly stated. **Please explicitly state the final decision on how the bottom of the basin was determined, and what it was determined to be.**

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[4] Available online at: https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/

- Defining the bottom of the Subbasin based on geochemical properties is a suitable approach for defining the base of freshwater, however, as noted on page 9 of DWR's Hydrogeologic Conceptual Model BMP (https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_HCM_Final_2016-12-23.pdf) "the definable bottom of the basin should be at least as deep as the deepest groundwater extractions". **Thus, groundwater extraction well depth data should also be included in the determination of the basin bottom.** This will prevent the possibility of extractors with wells deeper than the basin boundary (defined by the base of freshwater) from claiming exemption of SGMA due to their well residing outside the vertical extent of the basin boundary. **Please characterize groundwater well extractions from the deepest wells in relation to defining the basin bottom.**

[Section 3.1.8 Hydrogeologic Setting: Principal Groundwater Aquifers and Aquitards (pp. 3-19 to 3-23)]

- Although there is robust description of the confined (lower) and unconfined / semi-confined (upper) aquifers there is no explicit description with supporting data and information of how groundwater above the A- and C-clays in the upper aquifer interacts with the unconfined aquifer, or is influenced by pumping in the unconfined portion of the upper aquifer. DWR's definition of a principal aquifer, is defined as an "aquifer or aquifer system that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems" [*23 CCR §351(aa)*]. These shallow and perched areas within the upper aquifer range from near surface to 30 feet below ground surface (bgs) (Figure 3-17, p. 3-74) and likely provide water supply to GDEs and ISWs. As such, they yield significant quantities of groundwater to surface water systems and beneficial users, and should not be dismissed because they do not yield groundwater for human use. **Please expand the description of the upper aquifer to include the interaction of the unconfined and shallow areas of the upper aquifer. Include cross-sections to show their connectivity and relationship to potential ISWs and GDEs.**
- Regional geologic cross sections are provided in Figures 3-14a, 3-14b and 3-14c (pp. 3-69 to 3-71). These cross-sections do not include a graphical representation of the shallow groundwater-bearing zones that may be connected to GDEs and ISWs in the GSP area, and how they are connected to the upper aquifer system. **Please include example near-surface cross section details that depict the conceptual understanding of shallow groundwater and stream interactions at different locations, including the shallow zones, any perched aquifers, and the unconfined / semi-confined upper aquifer.**
- Based on the information provided in the GSP, it appears that the confined lower aquifer is being considered a principal aquifer because of the large amount of consumption for agriculture and municipal water supply, but this is not explicitly stated. The unconfined / semi-confined aquifer is stated to have limited use because of water quality. On pages 3-18 and 3-19, there is a discussion of water quality and although water with TDS higher than 3,000 is not considered suitable for water supply or most agriculture, it is potentially suitable for livestock and production of crops with higher tolerance to salinity. Conversely, in Section 3.1.11 (pages 3-25

and 3-26), the GSP states that the upper aquifer is primarily used for domestic and municipal supplies, and agricultural pumping does occur in the deeper portion of the upper aquifer. Also, if water in the unconfined aquifer is significantly supporting GDEs and ISWs, production of salt tolerant crops, or livestock operations, then it should also be identified as a principal aquifer. Even if ultimately the GSA doesn't define shallow groundwater as a principal aquifer, the text indicates current or future use that could impact ISWs and GDEs. **Thus, disregarding this shallow groundwater as a principal aquifer due to its water quality is not supported by the data and is inadequate.** SGMA requires GSAs to sustainably manage groundwater resources in all aquifers, especially if groundwater use and management can result in impacts to beneficial uses and users. Please refer to Best Practice #1 in Attachment D for further explanation and accompanying graphics. **Please explicitly enumerate the principal aquifer(s) and intervening aquitards, their relationship to each other, and their role in supplying groundwater to all beneficial uses and users of groundwater (including environmental).**

[Section 3.2 Groundwater Conditions (pp. 3-26 to 3-28)]

- Groundwater elevation contours are shown for 1905-1907, 1952, 1990, 1995, 2000, 2005, 2010 and 2016 on Figures 3-24 through 3-27 with respect to mean sea level. However, the wells used to contour groundwater levels in the upper aquifer do not necessarily monitor shallow or perched groundwater that may be in communication with GDEs and ISWs. In addition, depth to groundwater cannot be readily assessed from the maps because they are presented with respect to sea level. **Please provide the following:**
    1) **Groundwater level contour maps representative of the uppermost aquifer where GDEs and ISWs may be reliant. If this data does not exist, then identify it as a data gap that will be addressed in the GSP when the GSP is updated.**
    2) **Depth to water contour maps that allow interpretation of beneficial groundwater uses by environmental users.**
    3) **If these data are not available, please identify this as a data gap and outline measures to address the data gap in subsequent sections of the GSP.**

[Section 3.2.5 Groundwater Quality (pp. 3-30 to 3-31)]

- There is water quality information for the upper aquifer and a statement that increases in TDS concentrations, arsenic, nitrate and volatile organic chemicals (VOCs) are largely due to agricultural practices and pumping, but there is no information regarding water quality of the perched water or other areas of the upper aquifer to understand how water quality may affect GDEs, ISWs and associated aquatic species. **Please modify this section of the GSP to include data about water quality in the zones where GDEs are present. If there are no data available, then please recognize this as a data gap and specify that additional data will be collected and analyzed for the GSP update.**

Checklist Items 8 to 10 – Interconnected Surface Waters (ISWs) (23 CCR §354.16)

[Figure 3.1.10 Groundwater Recharge and Discharge Areas (p. 3-25)]

- The text states that "Some discharge is impacted by direct soil evaporation and evapotranspiration, particularly in areas where groundwater is less than 10 feet bgs." Elsewhere the text states that agricultural drainage must be provided in some areas, indicating very shallow groundwater, or makes reference to deeper groundwater levels of about 30 feet for groundwater above the A-Clay. Earlier in this comment letter we pointed out the discrepancy between the various shallow groundwater levels that are presented (see Section 3.2 Groundwater Conditions [pp. 3-26 to 3-28]). This GSP also states that riparian and emergent marsh ecosystems are prevalent in certain areas where they have not already been degraded by land development. **Please 1) rectify the discrepancies in groundwater levels, particularly as they pertain to ISWs and GDEs; and 2) include the locations of phreatophytes and other GDEs to provide a complete representation of evapotranspiration within all groundwater discharge areas. If the regional groundwater connection of phreatophytes and other GDEs is not known, 1) please identify this data gap, 2) provide an approach to address it, and 3) include the ISWs and GDEs as potential features on a figure until they can be more conclusively evaluated.**

[Section 3.2.8 Interconnected Surface Water and Groundwater Systems (pp. 3-33 to 3-34)]

- The regulations [23 CCR §351(o)] define ISWs 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". "At any point" has both a spatial and temporal component. Even short durations of interconnections of groundwater and surface water can be crucial for surface water flow and supporting environmental users of groundwater and surface water. ISWs can be either gaining or losing. The GSP disregards IWSs by stating that hydrologic conditions have been so altered that the ISWs that were historically connected are not any longer. There are inconsistencies throughout this GSP in regard to ISWs. The GSP states:
    - Section 3.1.10 (p. 3-25, also see the comment directly above): "Groundwater recharge in the Subbasin occurs primarily by two methods: 1) infiltration of surface water from the Kings River and unlined conveyances; and 2) infiltration of applied water for irrigation of crops." **ISWs can be either gaining or losing (see the definition above). If recharge primarily occurs through infiltration from rivers and streams, then these features must be included as an ISW with gaining and losing reaches defined on a map.**
    - Section 3.2.8 (p. 34): "A persistent, shallow perched water table at a depth of about 30 feet bgs is often present above the A-clay in the vicinity of surface water conveyances and below recharge facilities; however, this shallow perched zone is disconnected from the regional unconfined aquifer. Other localized shallow perched zones may exist elsewhere in the Subbasin, but these are not considered a significant source of groundwater." Section 3.1.8

states (p. 3-21) that the perched water is as shallow as 15 feet in some areas, and the groundwater elevation contour maps show it ranging from 0-20 feet AMSL. Data to support the claims about the nature of the perched aquifers is conflicting and the claims that perched units are disconnected or insignificant are not supported by data. **Please clarify the discrepancy between groundwater depths reported for the shallow perched water table that are provided in the text and on figures. If the location and size of other shallow perched zones is unknown, this information needs to be identified as a data gap, rather than a reason to completely disregard the features.** It is inadequate to assume that shallow perched zones are not a significant source of groundwater if they have not been fully characterized, and could be a significant source for GDEs and ISWs. **Please reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells) along surface water features in the Monitoring Network section of the GSP to improve identification of ISWs prior to disregarding them in the GSP.**

<u>Checklist Items 11 to 15 – Identifying and Mapping GDEs (23 CCR §354.16)</u>

[Section 3.2.8.1 Groundwater Dependent Ecosystems (GDEs) (p. 3-34 to 3-35)]

- The text states (p. 3-35): "Groundwater pumping from the principal aquifer system is not likely to impact the occurrence of perched groundwater because the two systems are separated by the A-Clay aquitard. Perched groundwater above the A-Clay is not directly interconnected with the underlying unconfined / semiconfined aquifer in that pumping from the unconfined / semiconfined aquifer does not induce increased leakage through the A-Clay aquitard." This statement is not supported by the data provided in the GSP (see comments above) and is not a valid reason to disregard potential GSPs without further evidence. The A-Clay is reported to vary significantly in thickness and to contain permeable sands in some locations. **Please:**
    1) **Explicitly identify the principal aquifers;**
    2) **Provide data regarding the competence of the A-Clay as an aquitard**
    3) **Evaluate the potential degree of connection between the perched and unconfined aquifer based on objective data;**
    4) **Acknowledge the extent of the perched aquifers throughout the Subbasin as a data gap;**
    5) **Address data gaps associated with the interconnectivity with the unconfined / semiconfined aquifer to be reconciled in the GSP update; and**
    6) **Acknowledge the potential for GDEs and ISWs to be dependent on these groundwater resources.**
- Although this GSP did use the NCCAG database to preliminarily identify GDEs (p. 3-34), all were disregarded without acknowledgment of data gaps and further characterization of the natural communities in association with potential perched aquifers, and disparities in groundwater levels that have not yet been characterized. This evaluation potentially misses GDEs due to the potential for GDEs to utilize the

shallow and perched areas of the unconfined / semi-confined aquifer. The following comments apply:

- o While depth to groundwater levels within 30 feet are generally accepted as being a proxy for deciding if polygons in the NC dataset are connected to groundwater, it is highly advised that seasonal and interannual groundwater fluctuations in the groundwater regime are taken into consideration. Utilizing groundwater data from one point in time or during a discrete season can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Based on a study we recently submitted to *Frontiers in Environmental Science*, we've observed riparian forests along the Cosumnes River to experience a range in groundwater levels between 1.5 and 75 feet over seasonal and interannual timescales. Seasonal fluctuations in the regional water table can support perched groundwater near an intermittent river that seasonally runs dry due to such fluctuations. While perched groundwater itself cannot directly be managed due to its position in the vadose zone, the water table position within the regional aquifer (via pumping rate restrictions, restricted pumping at certain depths, restricted pumping around GDEs, well density rules, etc.) and its interactions with surface water (e.g., timing and duration) can be managed to prevent adverse impacts to ecosystems due to changes in groundwater quality and quantity under SGMA. **We highly recommend using depth to groundwater data from multiple seasons and water year types (e.g., wet, dry, average, drought) to determine the range of depth to groundwater around NC dataset polygons. Please refer to Attachment D of this letter for best practices for using local groundwater data to verify whether polygons in the NC Dataset are supported by groundwater in an aquifer. If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset seasonally and interannually, or to determine conclusively whether shallow groundwater is hydraulically connected (directly or indirectly) to underlying aquifers, include those polygons in the GSP until data gaps are reconciled in the monitoring network, and include specific measures and time tables to address the data gaps.**
- o If there are insufficient groundwater level data in the shallow and perched zones, then the NCCAGs in these areas should be included as GDEs in the GSP until data gaps are reconciled in the monitoring network. **Confirmation of GDEs should be based on depth to groundwater in the shallow and perched areas. Please revise the GDE analysis in the GSP to include a complete analysis and identification of data gaps.**
- o **Please provide depth to groundwater contour maps and note the following best practices for doing so:**
  - ▪ Are the wells used for interpolating depth to groundwater sufficiently close (<5km) to NC Dataset polygons to reflect local conditions relevant to ecosystems?

- Are the wells used for interpolating depth to groundwater screened within the surficial unconfined aquifer and capable of measuring the true water table?
- Is depth to groundwater contoured using groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape? This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM) to estimate depth-to-groundwater contours across the landscape. This will provide much more accurate contours of depth to groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make. It is better to assume that water surface elevations are constant in between wells, and then calculate depth to groundwater using a DEM of the land surface to contour depth to groundwater.

o Groundwater requirements of GDEs vary with vegetation types and rooting depths. In identifying GDEs, care should be taken to consider rooting depths of vegetation. **Please indicate what vegetation is present in the potential GDEs, and whether the GDE was eliminated or retained based solely on a specified depth limit.** While Valley Oak (*Quercus lobata*) have been observed to have a maximum rooting depth of ~24 feet (https://groundwaterresourcehub.org/gde-tools/gde-rooting-depths-database-for-gdes/), rooting depths vary spatially and temporally based on local hydrologic conditions. Also, maximum rooting depths do not take capillary action into consideration, which will vary with soil type and is an important consideration since woody phreatophytes generally do not prefer to have their roots submerged in groundwater for extended periods of time, and hence effectively redistribute their root systems to straddle the water table as it fluctuates. Hence, many riparian, floodplain and desert ecosystem species are highly capable of accessing groundwater at much deeper depths when needed.

o Rohde, Froend and Howard (2017) acknowledged GDEs as ecosystems that can rely on groundwater for <u>some or all</u> their requirements. This publication can be found at: https://ngwa.onlinelibrary.wiley.com/doi/pdf/10.1111/gwat.12511. GDEs can rely on multiple water sources simultaneously and at different temporal and / or spatial scales (e.g., precipitation, river water, reservoir water, soil moisture in the vadose zone, groundwater, applied water, treated wastewater effluent, urban stormwater, irrigated return flow). SGMA (Section 351.0) defines GDEs as "ecological communities and species that depend on groundwater <u>emerging from aquifers</u> or on groundwater <u>occurring near</u> the ground surface". **Hence, we recommend using depth to groundwater contour maps derived from subtracting groundwater levels from a DEM, as described above, to identify whether a connection to groundwater exists for the wetlands mapped in Figure 3-38 in the Subbasin.**

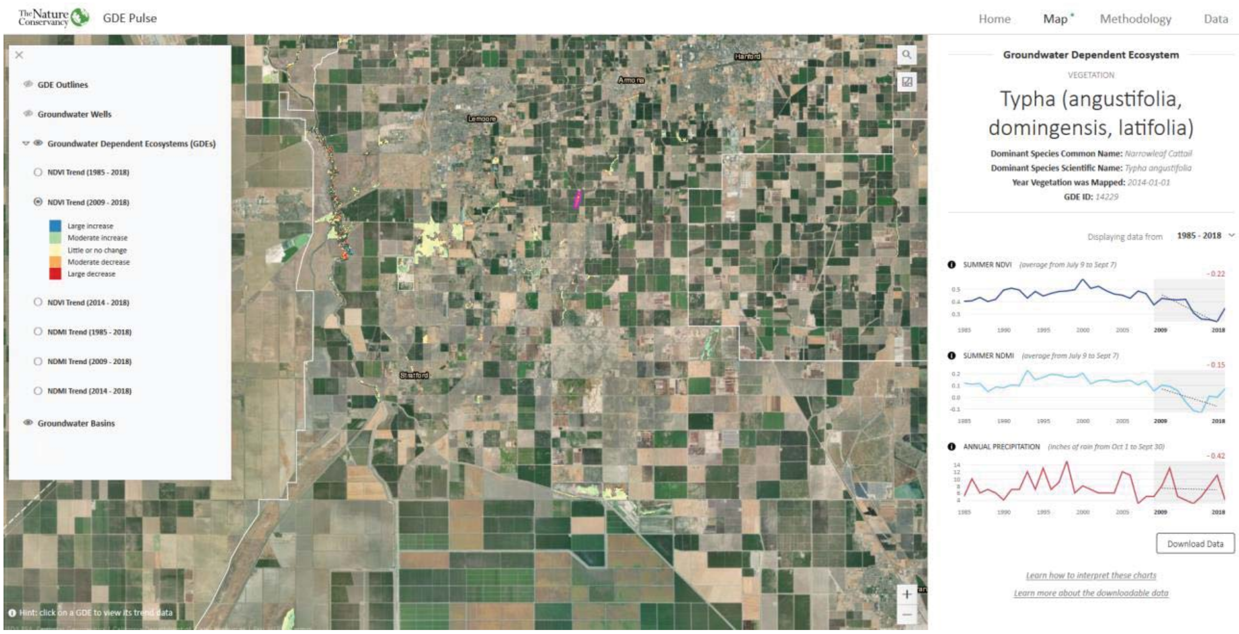
Please refer to Attachments D and E of this letter for best practices for using local groundwater data to 1) verify whether polygons in the NC Dataset are supported by groundwater in an aquifer, and 2) verify ecosystem decline or recovery is correlated with groundwater levels.

- The GSP states (p. 3-35), "Most of these vegetation types/plant species [identified in the NCCGA] are associated with riparian habitat that rely on surface water", and goes on to disregard them because they are primarily located on the perched areas above the A-Clay layer and the " A-Clay is not directly interconnected with the underlying unconfined / semi-confined aquifer". Section 354.16 of the California Code of Regulations states that "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 that includes…GDEs". Just because GDEs are <u>thought</u> to rely on surface water and the perched areas are <u>thought</u> to not be <u>directly</u> connected to the unconfined aquifer, does not make them insignificant to the environment. Many data gaps exist that could clarify these statements, for example: 1) indirect and direct connection of perched aquifers have not been fully characterized, 2) the location and extent of perched areas have not been fully characterized, and 3) species composition and potential max rooting depths have not be tabulated. Many rare and protected species reside in GDEs since they are very unique ecosystems. **Please provide further information on the analysis of GDEs and potential ISWs, including citing field studies or modeling studies that show the hydrologic nature of these systems. Specifically indicate 1) which streams and GDE polygons were excluded, 2) identify any data gaps, and 3) ensure that GDE polygons are <u>retained until data gaps are reconciled</u>.**

<u>Checklist Items 16 to 20 - Describing GDEs (23 CCR §354.16)</u>

[Section 3.2.8.1 Groundwater Dependent Ecosystems (GDEs) (p. 3-34 to 3-35)]

- **Please provide information on the historical or current groundwater conditions specifically near the GDEs or the ecological conditions present. If data gaps exist, please acknowledge them and state how they may be reconciled in the future.** Refer to GDE Pulse (https://gde.codefornature.org; See Attachment E of this letter for more details) or any other locally available data (e.g., leaf area index, evapotranspiration or other data) to describe depth to groundwater trends in and around GDE areas, as well as trends in plant growth (e.g., NDVI) and plant moisture (e.g., NDMI). Below is a screenshot example of data available in GDE Pulse for NC dataset polygons found in the Tulare Lake GSP Area.



- **Please provide an ecological inventory (see Appendix III, Worksheet 2 of the GDE Guidance) for all potential GDEs that includes vegetation or habitat types and rank the GDEs as having a high, moderate or low value. Explain how each rank was characterized.**
- **Please identify whether any endangered or threatened freshwater species of animals and plants, or areas with critical habitat were found in or near any of the GDEs since some organisms rely on uplands and wetlands during different stages of their lifecycle**. Resources for this include the list of freshwater species located in the Subbasin that can be found in Attachment C of this letter, the Critical Species Lookbook, and the USFWS's ECOS and CDFW's CNDDB databases / mapping tools.

<u>Checklist Items 21 and 22 – Water Budget (23 CCR §354.18)</u>

[Section 3.3.1.2 Outflows (pp. 3-39 to 3-40)]

- Evapotranspiration (ET) is included as an outflow category in the water budget; however, it is only included as it pertains to crop water requirements. Groundwater outflow to the ET of natural ecosystems (i.e., GDEs, riparian areas, etc.) should be identified as a groundwater budget component. If the outflow is not known, it should be identified as a data gap and provisional information should be provided until an analysis can be performed to address the data gap. **Since natural ecosystems may be beneficial users of groundwater: 1) please provide a breakdown of ET for all land-cover types, including native and riparian vegetation (such as wetlands, riparian vegetation, phreatophytes and other communities); 2) identify any data gaps; 3) outline the actions needed to address them; 4) and the schedule for their implementation.**

Checklist Item 23-26 Sustainability Goal (23 CCR §354.24)

[Section 4.0 Sustainable Management Criteria (p. 4-1)]

- The GSP states that there is no ISW connectivity within the entire Subbasin, but data to support this broad assertion are insufficient to dismiss this sustainability indicator. It is acknowledged earlier in the GSP that recharge primarily occurs through surface streams / rivers and unlined canals; however, there isn't any quantitative analysis, monitoring data, or other information provided to support that ISWs are not present, and statements within the GSP are contradictory. **Please address ISWs in the Sustainable Management Criteria and the Sustainability Goal until sufficient data is available to conclude the status of ISWs.**
- The GSP states "Indicators for the sustainable management of groundwater were determined by SGMA based on factors that have the potential to impact the health and general well-being of the public." This chapter starts off by disregarding the environmental use and users of groundwater. Sweeping statements like this should be modified throughout the chapter to acknowledge <u>all</u> beneficial users. **Since GDEs and ISWs may be present in and near the GSP area due to the prevalence of shallow groundwater (please see comments under Checklist Items 16-20) they should be explicitly recognized in the establishment of sustainable management criteria for the groundwater level decline and ISW sustainability indicators. Please also update this section to recognize environmental beneficial groundwater uses as a component of the sustainable management goals.**

[Section 4.1 Sustainability Goal (pp. 4-1 to 4-3)]

- The Sustainability Goal states that "…the sustainability goal works as a tool for managing groundwater, basin-wide, on a long-term basis to protect quality of life through the continuation of existing economic industries in the area, including but not limited to agriculture". The overall theme is to protect groundwater resources for developed water users, particularly agriculture. **The narrative discussion of the sustainability goal should be expanded to include other beneficial uses and users of groundwater including environmental uses and users of groundwater.**
- The Discussion of Measures states that "management actions will be implemented to help mitigate overdraft based on the demand from beneficial uses and users", but developed users are the only parties identified in this chapter. Criteria used to evaluate the priority given to beneficial users during overdraft periods is not described. **Please update this section to provide a discussion of how human and environmental beneficial uses will be balanced in the implementation of management actions during periods of drought and overdraft.**
- **Since GDEs and ISWs may be present in the Subbasin (please see comments under Checklist Items 16-20) they should be recognized as beneficial users of groundwater and should be included in the Sustainability Goal and Discussion of Measures. In addition, a statement about any intention to address pre-SGMA impacts should be included.**

- GDEs are dependent, in part, on suitable water quality; however, the GSP focuses on subsidence, groundwater levels and changes in groundwater storage; and only considers water quality for irrigation and domestic use. **Given that there are potential GDEs and ISWs in the Subbasin, and they may be affected by water quality they should be included in the Sustainability Goal and addressed in the Sustainable Management Criteria established for the Water Quality Sustainability Indicator.**

[Section 4.2.4 Groundwater Quality Indicator (pp. 4-5 to 4-6)]

- The GSP states that the GSAs will rely on the existing programs in place for monitoring groundwater quality, and the "local GSAs will focus on water quality issues that are related to groundwater pumping rather than on issues related to contamination". However, since much of the groundwater is being used for irrigation, which then leaches back into the soil or drains elsewhere and carries nutrients and other solutes with it, the GSA should monitor constituents related to agriculture in addition to those related to pumping, such as arsenic. This includes nitrates, phosphates, salts, sodium, boron, chloride and acidification from carbonic acid which affects soil biota, structure, geochemistry, GDEs and ISWs. **Please consider revising this section to include monitoring for agricultural constituents.**

<u>Checklist Item 26 – Measurable Objectives (23 CCR §354.30</u>)

[Section 4.5 Measurable Objectives (pp. 4-18 to 4-20)]

- This Measurable Objectives do not consider the water quality needs of GDEs and ISWs. **Please modify this section to include impacts from degraded water quality on the plant and wildlife communities, and species they support within these habitats.**
- This GSP states that "ISWs do not exist within the Subbasin". However, this conclusion was based on well groundwater levels that are not reasonably close to the drainages, shallow or nested monitoring wells to assess potential interaction with surface water and GDEs and connectivity to underlying aquifers, or hydrogeologic data that does not fully characterize the location and extent of perched and shallow zones within the upper aquifer. In addition, there are no supporting data and information that demonstrates shallow groundwater near the streams and rivers is not supporting ISWs or GDEs. As such, the data are insufficient to dismiss this sustainability indicator under the GSP regulations. **Please modify this section of the GSP to retain ISWs as a sustainability indicator, pending the characterization of the shallow / perched zones and analysis of monitoring data or monitoring from additional wells to be installed in the future.**
- Since there are wildlife refuges and protected wildlife area that contain critical habitat directly adjacent to the GSP area, the GSP needs to address these areas, whether there are potential GDEs or ISWs, and how management actions within the Subbasin would affect these sensitive habitats. **Please explain how the measurable objectives will benefit adjacent subbasins and not hinder the**

ability of adjacent subbasins to be sustainable; and how the measurable objectives would benefit adjacent critical habitat areas. What are the mechanisms for this benefit?

- Sweeping statements, such as (p. 4-20) "interconnected surface waters do not exist within the Subbasin, so this indicator will not be further discussed in terms of Measurable Objectives" are completely dismissive with disregard for data gaps. There is not enough evidence to make statements like these. Many of the wells are screened too deep, not in the proper location to make comparisons, and / or nested wells have not been installed to inform how shallow groundwater interacts with potential ISWs, GDEs or the unconfined aquifer. **Please include all potential ISWs in the analysis and develop measurable objectives and minimum thresholds for these, to be managed until data gaps prove they are not interconnected.**

<u>Checklist Item 27-29 – Minimum Thresholds (23 CCR §354.28</u>)

[Section 4.4.1.2 Description of Minimum Thresholds and Processes to Establish [for Groundwater Level Indicator (p. 4-13), Section 4.4.1.4 Description of Minimum Thresholds and Processes to Establish [for Groundwater Quality Indicator (p. 4-14), and Section 4.4.1.5 Description of Minimum Thresholds and Processes to Establish [for Interconnected Surface Water Intrusion (p. 4-14)]

- These Minimum Thresholds do not consider GDEs and ISWs. **Please include GDEs (see comments under checklist items 8-20) in this section and whether the minimum thresholds and interim milestones will help achieve the potential sustainability goal as it pertains to the environment.**
- Section 4.4.1.5 (p. 4-14) states that "Interconnected surfaces waters are not considered present in the Subbasin are; therefore, no further discussion will occur on this indictor in terms of MTs". However, the GSP fails to provide any monitoring data, analysis or other information to substantiate this position. Based on the inconsistencies in groundwater levels presented previously in the GSP and this letter, and the unknowns associated with the extent and location of shallow and/or perched zones in the upper aquifer, it is possible that rivers, streams and GDEs may be hydraulically connected to the regional aquifer system. Minimum thresholds must be established for ISWs and GDEs unless and until sufficient data are provided to eliminate them from consideration. **Please modify this section of the GSP to 1) develop minimum thresholds for possible ISWs, including GDEs, and 2) include a statement that a data gap exists related to the interconnectedness of the of the Tulare Lakebed, rivers / streams, and shallow groundwater zones.**

[Section 4.4.4 Potential Effects to Beneficial Uses and Users (p. 4-17 to 4-18)]

- The evaluation of minimum thresholds completely disregards consideration of environmental beneficial users, such as ISWs, GDEs or the species they support. Effects to beneficial uses and users is focused on well capacity, pumping costs, extraction, and impacts from subsidence on infrastructure. There is no mention about potential impacts to GDEs or ISWs that could be affected by lowering of the shallow portions of the unconfined or semi-confined portions of the upper aquifer since a continuity / discontinuity between the two is a data gap. Although there are many data gaps associated with ISWs and GDEs, it must be assumed that potential significant and unreasonable impacts to these beneficial users could occur. As such, they should be addressed in the evaluation of minimum thresholds. Section 4.4.4 should be modified to address how potential ISWs and GDEs would be affected by further lowering of groundwater levels. **Please address how 1) potential ISWs and GDEs would be affected by further lowering of groundwater levels, 2) these beneficial users will be protected / managed in the interim until data gaps are filled, and 3) what measures will be employed to protect GDEs and ISWs that are confirmed after data gaps are filled.**

- This Section does not include the required analysis of how the selected minimum thresholds for decline in groundwater levels could affect potential ISWs and GDEs within and near the GSP area. **Please include an analysis of the potential effect of the established minimum thresholds on ISWs and GDES within and near the GSP area, particularly in adjacent wildlife preserves / refuges.**
- Although agricultural and domestic water quality concerns have been articulated, similar concerns were not identified for environmental users. Degradation of water quality can impact terrestrial and aquatic wildlife that live in or near these ecosystems during at least part of the year even if the water is not a concern from an agricultural or municipal standpoint. **Please include a discussion about GDEs and water quality and whether the minimum thresholds and interim milestones will help achieve sustainability for environmental users.**

<u>Checklist Item 30-46 – Undesirable Results (23 CCR §354.26</u>)

[Section 4.3 Undesirable Results (pp. 4-6 to 4-12), and Subsection 4.3.3 Potential Effects to Beneficial Uses and Users (pp. 4-11 to 4-12)]

- The GSP states that there are no ISWs; however, this is largely based on assumptions and there are no monitoring data, analyses or other information to support this statement. In addition, the GSP indicates that 1) streams and rivers are the primary source of recharge; 2) a connection may exist between shallow and perched groundwater, but the extent and location of perched groundwater is unknown; and 3) surface and groundwater may be periodically connected in Tulare Lake. Furthermore, GDEs may exist within and near the GSP area. This is a data gap that needs to be identified and rectified by employing a monitoring network to verify the status of ISWs prior to complete dismissal of ISWs from the GSP. **Please modify this section of the GSP to include:**
    1) **A statement that there are potential ISWs and GDEs, unless adequate data can be provided to dismiss them.**
    2) **An assessment of the nature of potential undesirable results to ISWs and GDEs.**
    3) **A statement that the aquifers will be managed such there will be no depletion of ISWs that results in a significant and unreasonable impacts to ISWs or GDEs.**

4) **Data gaps and specific steps to verify the presence or absence of ISWs and GDEs with monitoring wells screened at the appropriate depths.**

- This section only describes undesirable results relating to human beneficial uses of groundwater and neglects environmental beneficial uses / users that could be adversely affected by chronic groundwater level decline or depletion of ISWs. **Please add "possible adverse impacts to potential GDEs and ISWs" to the list of potential undesirable results.**
- The GDE Pulse web application developed by TNC provides easy access to 35 years of satellite data to view trends of vegetation metrics, groundwater depth (where available), and precipitation data. This satellite imagery can be used to observe trends for NC dataset polygons within and near the GSA. Over the past 10 years (2009-2018), some NC dataset vegetation polygons have experienced adverse impacts to vegetation growth and moisture. An example screen shot of GDEs near Lemoore, California from the GDE Pulse tool is presented under Checklist items 16 to 20 above.
  - **For each potential GDE unit with supporting hydrological datasets please include the following:**
    - Plot and provide hydrological datasets for each GDE.
    - Define the baseline period in the hydrologic data.
    - Classify GDE units as having high, moderate, or low susceptibility to changes in groundwater.
    - Explore cause-and-effect relationships between groundwater changes and GDEs.
  - **For each identifiable GDE unit without supporting hydrological datasets please describe data gaps and / or insufficiencies.**
  - **Compile and synthesize biological data from CDFW's CNDDB, USFWS' ECOS Mapper, NC dataset, and / or the GDE Pulse tool (as applicable) for each GDE unit by:**
    - Characterizing biological resources for each GDE unit, and when possible provide baseline conditions for assessment of trends and variability.
    - Describing data gaps / insufficiencies.
  - **Describe possible effects on potential ISWs, GDEs, land uses, and property interests, including:**
    - Cause-and-effect relationships between potential ISWs and GDEs with groundwater conditions.
    - Impacts to potential ISWs and GDEs that are considered to be "significant and unreasonable".
    - Report known hydrological thresholds or triggers (e.g., instream flow criteria, groundwater depths, water quality parameters) for significant impacts to relevant species or ecological communities.
    - Land uses should include recreational uses (e.g., fishing/hunting, hiking, boating).
    - Property interests should include and consider privately and publicly protected conservation lands and opens spaces, including wildlife refuges, parks, and natural preserves.

- This section discusses water quality with respect to agricultural and municipal use but does not include a discussion of potential undesirable results for GDEs and ISWs. **Please modify this section to address how degraded water quality could affect vegetation and wildlife species that rely on GDEs and ISWs. Although arsenic is mentioned in this GSP, please consider adding a statement that over-pumping and dewatering of aquitards has been identified as a potential source of elevated arsenic concentrations above drinking water standards in San Joaquin Valley aquifers.** The following is a link to a paper by Smith, Knight and Fendorf (2018) titled "Overpumping leads to California groundwater arsenic threat": https://www.nature.com/articles/s41467-018-04475-3

Checklist Items 47-49 – Monitoring Network (23 CCR §354.34)

[Chapter 5 Monitoring Network (pp. 5-1 to 5-3), and Section 5.1 Description of Monitoring Network (pp. 5-3 to 5-15)]

- The GSP describes groundwater monitoring locations and states that groundwater monitoring in areas de-designated by the Tulare Lake Basin Plan amendment and associated aquifer zones is not proposed as decided by the GSAs. Although these areas (designated Management Area A and B) are not designated for municipal and agricultural uses in the Basin Plan, the groundwater could still potentially be used or is being used for livestock, crops with a higher tolerance to salt, domestic supply, public supply, and potentially other uses in the future. Since it is currently unclear how withdrawals within the unconfined aquifer will affect the perched and shallow areas of the aquifer (as associated with the A-Clay and C-Clay layers), Management Areas A and B still need to be monitored to assess effects to the unconfined aquifer as a whole. As stated above in the comments for other Checklist Items, **please reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells, GDE and ISW responses to groundwater levels) along rivers, creek and the Tulare Lakebed in this section of the GSP to improve ISW and GDE mapping in future GSPs**.
- It is not acceptable to completely disregard these Management Areas based purely on a de-designation from municipal and agricultural uses only when there are still current and potential environmental uses of this groundwater. In addition, there is much uncertainty how the shallow aquifers are interacting with GDEs and ISWs. **Please add Representative Monitoring Sites (RMS) for these areas in order to better understand the interaction of the A-Clay and C-Clay layers with the unconfined aquifer, and potential GDEs and ISWs.**
- This section lists the proposed facilities for monitoring groundwater levels, storage and quality, and subsidence on pp. 5-9 through 5-15. This section proposes to use groundwater level monitoring to assess potential groundwater level and storage declines, existing programs to monitor water quality, and monitored surface conditions to evaluate land subsidence. It may acceptable to use groundwater level [in combination with assessment of vegetation response, for example by remote sensing] as a proxy for assessing potential effects on ISWs and GDEs, but the data gaps associated with the A-Clay, C-Clay, and shallow water tables need to be addressed. A set of representative wells have been selected to monitor the upper

and lower aquifer (Figures 5-1 to 5-3). There are only five wells that represent the "Above A-Clay and Shallow Groundwater Levels (i.e., Zone A)", and there are three data gaps areas identified (Figure 5-1). **Please describe 1) how these five wells are considered representative of the entire GSP Area, 2) how those data gap areas were selected, and 3) what methodologies would be used to extrapolate results to other areas where there are no wells or identified data gaps.**

- Many of the monitoring wells are not screened in the upper portion of the unconfined aquifer, where environmental beneficial users would obtain the groundwater on which they rely. Finally, there are currently no plans to monitor groundwater level declines to assess the potential for significant and unreasonable impacts to ISWs or GDEs in response to groundwater level declines. **Please modify the description of the new well network in the Proposed Facilities Section (Sections 5.1.4, p. 5-9) and Groundwater Levels Section (Section 5.1.4, p.5-9 to 5-11) to provide methodologies, data and other information to support the monitoring of GDEs and ISWs so as to assess and prevent potential significant and unreasonable impacts. This modification should include 1) locating new wells that are appropriately screened to detect connectivity of GDEs and ISWs with the unconfined aquifer and 2) identifying or installing additional stream gages in areas where there is potential for ISWs and GDEs. In addition, monitoring GDE responses to groundwater level declines should be included. GDE Pulse represents an example of how remote sensing can be used to achieve this objective. Please expand on the discussion of how the new well, stream and other data will be used to improve ISW mapping and inform an adequate analysis, and how the data will be used to verify possible GDEs and their sensitivity to groundwater level declines.**

[Section 5.1.1 Monitoring Network Objectives (p. 5-6)]

- The monitoring objectives listed include developing data to evaluate impacts to beneficial uses and users of groundwater but does not include filling data gaps as they specifically pertain to environmental users of groundwater. **Please expand this list to include monitoring to inform data gaps associated with groundwater use by potential GDEs, ISWs and the species that they support.**

[Section 5.4.1.4 Site Selection (p. 5-23)]

- This section includes the scientific rationale for the groundwater level monitoring network and the rationale used to add new wells to the monitoring system. However, evaluation and monitoring of potential GDEs and ISWs were not considered in new well site selection. **Please modify the site selection criteria to include the potential to install new wells that will provide information to support the investigation of GDEs and ISWs. This modification should include locating new / existing wells that are appropriately screened to detect connectivity of GDEs and ISWs with the shallow zones of the unconfined**

aquifer, and 2) expanding information on the extent and location of shallow / perched areas within the unconfined aquifer.

[Section 5.5 Data Storage and Reporting (pp. 5-31 to 5-32)]

- The data management system (DMS) described in this section allows for upload and storage of information related to the development and implementation of the GSP. The types of information that will be stored in the DMS are listed. Other than groundwater elevations, quality, and site information, there is no information being stored specific to the monitoring and evaluation of GDEs or ISWs. **We recommend adding remote sensing information to this list to evaluate possible correlations of ecosystem response to potential declines in groundwater level or quality due to pumping. This can be accomplished by incorporating the GDE pulse tool, Sentinel data, evapotranspiration, or leaf area index.**

<u>Checklist Items 50 and 51 – Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)</u>

[Chapter 6 Projects and Management Actions to Achieve Sustainability (pp. 6-1 to 6-21)]

- **This chapter should identify the specific actions and schedules proposed to address data gaps in the hydrogeologic conceptual model, water budget and monitoring network.**

[Section 6.3 Projects (pp. 6-4 to 6-17)]

- This section identifies many important types of projects, including conveyance facilities modifications and construction of new facilities, above-ground surface water storage, intentional recharge basins, on-farm recharge, and aquifer storage and recovery through injection. However, the descriptions of Measurable Objectives for these projects only identifies benefits to water level and storage through changes in allocation, imports, surface water diversions, pumping allowances; and adding recharge projects or water banking. Since maintenance or recovery of groundwater levels, or construction of recharge facilities, may have potential environmental benefits it would be advantageous to demonstrate multiple benefits from a funding and prioritization perspective.
  - **For the projects already identified, please consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue.**
  - If ISWs will not be adequately protected by those listed, **please include and describe additional management actions and projects targeted for protecting potential ISWs.**
  - Storage and recharge projects can be designed as multiple-benefit projects to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. In some cases, such facilities have been incorporated into local HCPs and NCCPs, more fully recognizing the value of the habitat that they provide and the species they support. On-farm recharge may benefit waterfowl during migration, and recreational hunting and birdwatching depending on the time of year that fields are flooded. For

recharge projects, **please consider identifying if there is habitat value incorporated into the design and how the recharge ponds can be managed as multiple-benefit projects to benefit environmental users. Grant and funding opportunities for SGMA-related work may be available for multi-benefit projects that can address water quantity as well as provide environmental benefits. Please include environmental benefits and multiple benefits as criteria for assessing project priorities.**

- The GSP states that recharged water typically remains in the unconfined aquifer, above the A-Clay, C-Clay and E-Clay; and that existing wells in the area will be used for extraction of stored water. There appear to be many unknowns as to the extent and location of perched and shallow areas in the unconfined aquifer, and the connectivity of those areas with the aquifer. In addition, there are currently only five wells that will be used to monitor shallow zones throughout the entire GSP area. There remains a fair amount of uncertainty as to how this would operate or affect potential GDEs and ISWs. **Please acknowledge these uncertainties and address 1) how these recharge operations could affect environmental beneficial users, 2) how ecosystems that could be affected by recharge in the unconfined aquifer, particularly above the A- and C-Clay layers will be monitored if there are only five wells.**
- For examples of case studies on how to incorporate environmental benefits into groundwater projects, please visit our website: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/

[Section 6.5 GSA Sustainable Methods (pp. 6-18 to 6-21)]

- The Subbasin potentially includes GDEs and ISWs (see our comments under Checklist Items 8-10 and 16-20 above) that are beneficial uses and users of groundwater and may include sensitive and protected resources. Protection of these environmental users and uses should be considered in establishing project priorities. In addition, and consistent with existing grant and funding guidelines for SGMA-related work, **priority should be given to multi-benefit projects that can address water quantity and quality as well as providing environmental benefits or benefits to disadvantaged communities.**

Attachment C

Freshwater Species Located in the Tulare Lake Subbasin

To assist in identifying the beneficial users of surface water necessary to assess the undesirable result "depletion of interconnected surface waters", Attachment C provides a list of freshwater species located within the Tulare Lake Subbasin. To produce the freshwater species list, we used ArcGIS to select features within the California Freshwater Species Database version 2.0.9 within the GSA's boundary. This database contains information on ~4,000 vertebrates, macroinvertebrates and vascular plants that depend on fresh water for at least one stage of their life cycle. The methods used to compile the California Freshwater Species Database can be found in Howard et al. 2015[5]. The spatial database contains locality observations and/or distribution information from ~400 data sources. The database is housed in the California Department of Fish and Wildlife's BIOS[6] as well as on TNC's science website[7].

		Legally Protected Status		
Scientific Name	**Common Name**	**Federal**	**State**	**Other**
BIRDS				
Actitis macularius	Spotted Sandpiper			
Aechmophorus clarkii	Clark's Grebe			
Aechmophorus occidentalis	Western Grebe			
Agelaius tricolor	Tricolored Blackbird	BCC	SSC	BSSC - First priority, BLM
Aix sponsa	Wood Duck			
Anas acuta	Northern Pintail			
Anas americana	American Wigeon			
Anas clypeata	Northern Shoveler			
Anas crecca	Green-winged Teal			
Anas cyanoptera	Cinnamon Teal			
Anas discors	Blue-winged Teal			
Anas platyrhynchos	Mallard			
Anas strepera	Gadwall			
Anser albifrons	Greater White-fronted Goose			
Ardea alba	Great Egret			
Ardea herodias	Great Blue Heron			
Aythya affinis	Lesser Scaup			
Aythya americana	Redhead		SSC	BSSC - Third priority
Aythya collaris	Ring-necked Duck			

[5] Howard, J.K. et al. 2015. Patterns of Freshwater Species Richness, Endemism, and Vulnerability in California. PLoSONE, 11(7). Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0130710
[6] California Department of Fish and Wildlife BIOS: https://www.wildlife.ca.gov/data/BIOS
[7] Science for Conservation: https://www.scienceforconservation.org/products/california-freshwater-species-database

Aythya marila	Greater Scaup			
Aythya valisineria	Canvasback		SSC	
Botaurus lentiginosus	American Bittern			
Bucephala albeola	Bufflehead			
Bucephala clangula	Common Goldeneye			
Butorides virescens	Green Heron			
Calidris alpina	Dunlin			
Calidris mauri	Western Sandpiper			
Calidris minutilla	Least Sandpiper			
Chen caerulescens	Snow Goose			
Chen rossii	Ross's Goose			
Chlidonias niger	Black Tern		SSC	BSSC - Second priority
Chroicocephalus philadelphia	Bonaparte's Gull			
Cistothorus palustris palustris	Marsh Wren			
Cygnus columbianus	Tundra Swan			
Dendrocygna bicolor	Fulvous Whistling-Duck		SSC	BSSC - First priority
Egretta thula	Snowy Egret			
Empidonax traillii	Willow Flycatcher	BCC	Endangered	USFS
Fulica americana	American Coot			
Gallinago delicata	Wilson's Snipe			
Gallinula chloropus	Common Moorhen			
Grus canadensis	Sandhill Crane			
Himantopus mexicanus	Black-necked Stilt			
Icteria virens	Yellow-breasted Chat		SSC	BSSC - Third priority
Limnodromus scolopaceus	Long-billed Dowitcher			
Lophodytes cucullatus	Hooded Merganser			
Megaceryle alcyon	Belted Kingfisher			
Mergus merganser	Common Merganser			
Mergus serrator	Red-breasted Merganser			
Numenius americanus	Long-billed Curlew			
Numenius phaeopus	Whimbrel			
Nycticorax nycticorax	Black-crowned Night-Heron			
Oxyura jamaicensis	Ruddy Duck			

Pelecanus erythrorhynchos	American White Pelican		SSC	BSSC - First priority
Phalacrocorax auritus	Double-crested Cormorant			
Phalaropus tricolor	Wilson's Phalarope			
Plegadis chihi	White-faced Ibis		Watch list	
Pluvialis squatarola	Black-bellied Plover			
Podiceps nigricollis	Eared Grebe			
Podilymbus podiceps	Pied-billed Grebe			
Porzana carolina	Sora			
Rallus limicola	Virginia Rail			
Recurvirostra americana	American Avocet			
Riparia riparia	Bank Swallow		Threatened	
Setophaga petechia	Yellow Warbler			BSSC - Second priority
Tachycineta bicolor	Tree Swallow			
Tringa melanoleuca	Greater Yellowlegs			
Tringa semipalmata	Willet			
Tringa solitaria	Solitary Sandpiper			
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		SSC	BSSC - Third priority
CRUSTACEANS				
Branchinecta lindahli	Versatile Fairy Shrimp			
HERPS				
Actinemys marmorata marmorata	Western Pond Turtle		SSC	ARSSC, BLM, USFS
Ambystoma californiense californiense	California Tiger Salamander	Threatened	Threatened	ARSSC
Anaxyrus boreas boreas	Boreal Toad			
Spea hammondii	Western Spadefoot	Under Review in the Candidate or Petition Process	SSC	ARSSC, BLM
Thamnophis sirtalis sirtalis	Common Gartersnake			
INSECTS AND OTHER INVERTEBRATES				
Ameletus amador	A Mayfly			
Ameletus spp.	Ameletus spp.			

Anax walsinghami	Giant Green Darner			
Archilestes californica	California Spreadwing			
Argia emma	Emma's Dancer			
Baetis adonis	A Mayfly			
Baetis spp.	Baetis spp.			
Caudatella columbiella				Not on any status lists
Caudatella spp.	Caudatella spp.			
Cinygmula gartrelli	A Mayfly			
Cinygmula spp.	Cinygmula spp.			
Doroneuria baumanni	Cascades Stone			
Drunella coloradensis	A Mayfly			
Drunella doddsii	A Mayfly			
Drunella spinifera	A Mayfly			
Drunella spp.	Drunella spp.			
Enallagma carunculatum	Tule Bluet			
Enallagma civile	Familiar Bluet			
Epeorus albertae	A Mayfly			
Epeorus spp.	Epeorus spp.			
Ephemerella tibialis	A Mayfly			
Erythemis collocata	Western Pondhawk			
Hetaerina americana	American Rubyspot			
Heterlimnius corpulentus				Not on any status lists
Ischnura barberi	Desert Forktail			
Ischnura cervula	Pacific Forktail			
Ischnura denticollis	Black-fronted Forktail			
Libellula saturata	Flame Skimmer			
Malenka bifurcata				Not on any status lists
Malenka spp.	Malenka spp.			
Optioservus canus	Pinnacles Optioservus Riffle Beetle		SSC	
Optioservus spp.	Optioservus spp.			
Oroperla barbara	Gilltail Springfly			
Pachydiplax longipennis	Blue Dasher			
Pantala flavescens	Wandering Glider			
Pantala hymenaea	Spot-winged Glider			
Parapsyche almota	A Caddisfly			
Parapsyche elsis	A Caddisfly			

Parapsyche spp.	Parapsyche spp.			
Rhionaeschna multicolor	Blue-eyed Darner			
Rhithrogena decora	A Mayfly			
Rhithrogena spp.	Rhithrogena spp.			
Rhyacophila acuminata	A Caddisfly			Not on any status lists
Rhyacophila spp.	Rhyacophila spp.			
Simulium anduzei				Not on any status lists
Simulium spp.	Simulium spp.			
Skwala americana	American Springfly			
Skwala spp.	Skwala spp.			
Sperchon spp.	Sperchon spp.			
Sperchon stellata				Not on any status lists
Sweltsa adamantea				Not on any status lists
Sweltsa spp.	Sweltsa spp.			
Telebasis salva	Desert Firetail			
Tramea lacerata	Black Saddlebags			
Zapada columbiana	Columbian Forestfly			
MAMMALS				
Castor canadensis	American Beaver			Not on any status lists
Ondatra zibethicus	Common Muskrat			Not on any status lists
MOLLUSKS				
Anodonta californiensis	California Floater		SSC	USFS
PLANTS				
Cephalanthus occidentalis	Common Buttonbush			
Cirsium crassicaule	Slough Thistle		SSC	CRPR - 1B.1, BLM
Cyperus erythrorhizos	Red-root Flatsedge			
Cyperus squarrosus	Awned Cyperus			
Eragrostis hypnoides	Teal Lovegrass			
Euthamia occidentalis	Western Fragrant Goldenrod			
Galium trifidum	Small Bedstraw			
Juncus effusus effusus	NA			
Lasthenia ferrisiae	Ferris' Goldfields		SSC	CRPR - 4.2

Ludwigia peploides peploides	NA			Not on any status lists
Myosurus minimus	NA			
Persicaria lapathifolia				Not on any status lists
Rorippa palustris palustris	Bog Yellowcress			
Salix gooddingii	Goodding's Willow			
FISHES				
Catostomus occidentalis occidentalis	Sacramento sucker			Least Concern - Moyle 2013
Cottus asper ssp. 1	Prickly sculpin			Least Concern - Moyle 2013
Lavinia exilicauda exilicauda	Sacramento hitch		SSC	Near-Threatened - Moyle 2013
Oncorhynchus mykiss irideus	Coastal rainbow trout			Least Concern - Moyle 2013
Oncorhynchus tshawytscha - CV fall	Central Valley fall Chinook salmon	SSC	SSC	Vulnerable - Moyle 2013
Oncorhynchus tshawytscha - CV late fall	Central Valley late fall Chinook salmon	SSC		Endangered - Moyle 2013
Orthodon microlepidotus	Sacramento blackfish			Least Concern - Moyle 2013
Ptychocheilus grandis	Sacramento pikeminnow			Least Concern - Moyle 2013

Notes:
ARSSC = At-Risk Species of Special Concern
BCC = Bird of Conservation Concern
BSSC = Bird Species of Special Concern
CRPR = California Rare Plant Rank
CS = Currently Stable
IUCN = International Union for Conservation of Nature
SSC = Species of Special Concern

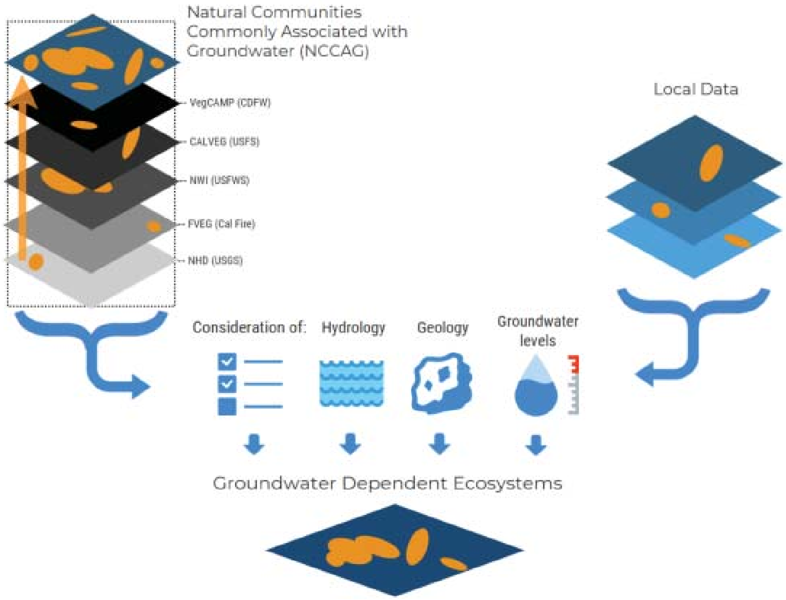
Attachment D

The Nature Conservancy

July 2019

IDENTIFYING GDEs UNDER SGMA
Best Practices for using the NC Dataset

The Sustainable Groundwater Management Act (SGMA) requires that groundwater dependent ecosystems (GDEs) be identified in Groundwater Sustainability Plans (GSPs). As a starting point, the Department of Water Resources (DWR) is providing the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) online[8] to help Groundwater Sustainability Agencies (GSAs), consultants, and stakeholders identify GDEs within individual groundwater basins. To apply information from the NC Dataset to local areas, GSAs should combine it with the best available science on local hydrology, geology, and groundwater levels to verify whether polygons in the NC dataset are likely supported by groundwater in an aquifer (Figure 1)[9]. This document highlights six best practices for using local groundwater data to confirm whether mapped features in the NC dataset are supported by groundwater.



[8] *NC Dataset Online Viewer: https://gis.water.ca.gov/app/NCDatasetViewer/*

[9] California Department of Water Resources (DWR). 2018. Summary of the "Natural Communities Commonly Associated with Groundwater" Dataset and Online Web Viewer. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Statewide-Reports/Natural-Communities-Dataset-Summary-Document.pdf

The NC Dataset identifies vegetation and wetland features that are good indicators of a GDE. The dataset is comprised of 48 publicly available state and federal datasets that map vegetation, wetlands, springs, and seeps commonly associated with groundwater in California[10]. It was developed through a collaboration between DWR, the Department of Fish and Wildlife, and The Nature Conservancy (TNC). TNC has also provided detailed guidance on identifying GDEs from the NC dataset[11] on the Groundwater Resource Hub[12], a website dedicated to GDEs.

BEST PRACTICE #1. Establishing a Connection to Groundwater

Groundwater basins can be comprised of one continuous aquifer (Figure 2a) or multiple aquifers stacked on top of each other (Figure 2b). In unconfined aquifers (Figure 2a), using the depth-to-groundwater and the rooting depth of the vegetation is a reasonable method to infer groundwater dependence for GDEs. If groundwater is well below the rooting (and capillary) zone of the plants and any wetland features, the ecosystem is considered disconnected and groundwater management is not likely to affect the ecosystem (Figure 2d). However, it is important to consider local conditions (e.g., soil type, groundwater flow gradients, and aquifer parameters) and to review groundwater depth data from multiple seasons and water year types (wet and dry) because intermittent periods of high groundwater levels can replenish perched clay lenses that serve as the water source for GDEs (Figure 2c). Maintaining these natural groundwater fluctuations are important to sustaining GDE health.

Basins with a stacked series of aquifers (Figure 2b) may have varying levels of pumping across aquifers in the basin, depending on the production capacity or water quality associated with each aquifer. If pumping is concentrated in deeper aquifers, SGMA still requires GSAs to sustainably manage groundwater resources in shallow aquifers, such as perched aquifers, that support springs, surface water, domestic wells, and GDEs (Figure 2). This is because vertical groundwater gradients across aquifers may result in pumping from deeper aquifers to cause adverse impacts onto beneficial users reliant on shallow aquifers or interconnected surface water. The goal of SGMA is to sustainably manage groundwater resources for current and future social, economic, and environmental benefits. While groundwater pumping may not be currently occurring in a shallower aquifer, use of this water may become more appealing and economically viable in future years as pumping restrictions are placed on the deeper production aquifers in the basin to meet the sustainable yield and criteria. Thus, identifying GDEs in the basin should done irrespective to the amount of current pumping occurring in a particular aquifer, so that future impacts on GDEs due to new production can be avoided. A good rule of thumb to follow is: *if groundwater can be pumped from a well - it's an aquifer*.

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[10] *For more details on the mapping methods, refer to: Klausmeyer, K., J. Howard, T. Keeler-Wolf, K. Davis-Fadtke, R. Hull, A. Lyons. 2018. Mapping Indicators of Groundwater Dependent Ecosystems in California: Methods Report. San Francisco, California. Available at: https://groundwaterresourcehub.org/public/uploads/pdfs/iGDE_data_paper_20180423.pdf*

[11] "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans" is available at: https://groundwaterresourcehub.org/gde-tools/gsp-guidance-document/

[12] *The Groundwater Resource Hub: www.GroundwaterResourceHub.org*

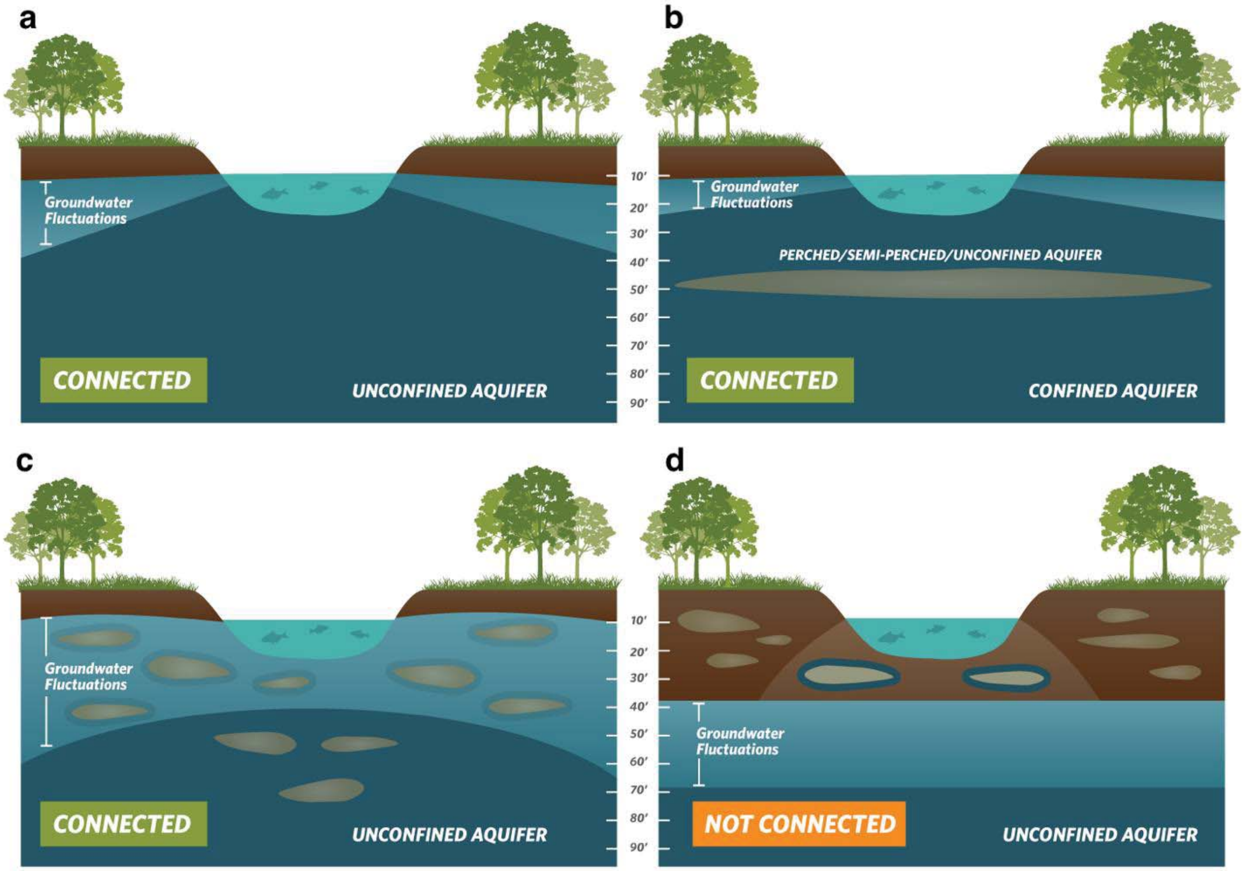

Figure 2. Confirming whether an ecosystem is connected to groundwater. Top: (a) Under the ecosystem is an unconfined aquifer with depth-to-groundwater fluctuating seasonally and interannually within 30 feet from land surface. **(b)** Depth-to-groundwater in the shallow aquifer is connected to overlying ecosystem. Pumping predominately occurs in the confined aquifer, but pumping is possible in the shallow aquifer. **Bottom: (c)** Depth-to-groundwater fluctuations are seasonally and interannually large, however, clay layers in the near surface prolong the ecosystem's connection to groundwater. **(d)** Groundwater is disconnected from surface water, and any water in the vadose (unsaturated) zone is due to direct recharge from precipitation and indirect recharge under the surface water feature. These areas are not connected to groundwater and typically support species that do not require access to groundwater to survive.

BEST PRACTICE #2. Characterize Seasonal and Interannual Groundwater Conditions

SGMA requires GSAs to describe current and historical groundwater conditions when identifying GDEs [23 CCR §354.16(g)]. Relying solely on the SGMA benchmark date (January 1, 2015) or any other single point in time to characterize groundwater conditions (e.g., depth-to-groundwater) is inadequate because managing groundwater conditions with data from one time point fails to capture the seasonal and interannual variability typical of California's climate. DWR's Best Management Practices document on water budgets[13] recommends using 10 years of water supply and water budget information to describe how historical conditions have impacted the operation of the basin within sustainable yield, implying that a baseline[14] could be determined based on data between 2005 and 2015. Using this or a similar time period, depending on data availability, is recommended for determining the depth-to-groundwater.

GDEs depend on groundwater levels being close enough to the land surface to interconnect with surface water systems or plant rooting networks. The most practical approach[15] for a GSA to assess whether polygons in the NC dataset are connected to groundwater is to rely on groundwater elevation data. As detailed in TNC's GDE guidance document[4], one of the key factors to consider when mapping GDEs is to contour depth-to-groundwater in the aquifer that is supporting the ecosystem (see Best Practice #5).

Groundwater levels fluctuate over time and space due to California's Mediterranean climate (dry summers and wet winters), climate change (flood and drought years), and subsurface heterogeneity in the subsurface (Figure 3). Many of California's GDEs have adapted to dealing with intermittent periods of water stress, however if these groundwater conditions are prolonged, adverse impacts to GDEs can result. While depth-to-groundwater levels within 30 feet[4] of the land surface are generally accepted as being a proxy for confirming that polygons in the NC dataset are supported by groundwater, it is highly advised that fluctuations in the groundwater regime be characterized to understand the seasonal and interannual groundwater variability in GDEs. Utilizing groundwater data from one point in time can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Time series data on groundwater elevations and depths are available on the SGMA Data Viewer[16]. However, if insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP <u>until</u> data gaps are reconciled in the monitoring network (see Best Practice #6).

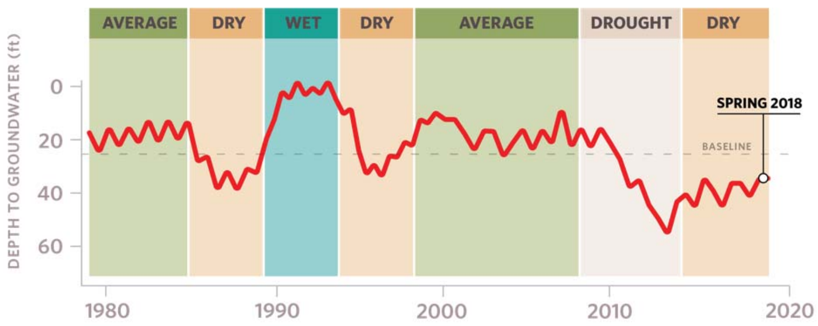

Figure 3. Example seasonality and interannual variability in depth-to-groundwater over time. Selecting one point in time, such as Spring 2018, to characterize groundwater conditions in GDEs fails to capture what groundwater conditions are necessary to maintain the ecosystem status into the future so adverse impacts are avoided.

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[13] DWR. 2016. Water Budget Best Management Practice. Available at: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Water_Budget_Final_2016-12-23.pdf

[14] *Baseline is defined under the GSP regulations as "historic information used to project future conditions for hydrology, water demand, and availability of surface water and to evaluate potential sustainable management practices of a basin." [23 CCR §351(e)]*

[15] Groundwater reliance can also be confirmed via stable isotope analysis and geophysical surveys. For more information see The GDE Assessment Toolbox (Appendix IV, GDE Guidance Document for GSPs[4]).

[16] *SGMA Data Viewer: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer*

BEST PRACTICE #3. Ecosystems Often Rely on Both Groundwater and Surface Water

GDEs are plants and animals that rely on groundwater for all or some of its water needs, and thus can be supported by multiple water sources. The presence of non-groundwater sources (e.g., surface water, soil moisture in the vadose zone, applied water, treated wastewater effluent, urban stormwater, irrigated return flow) within and around a GDE does not preclude the possibility that it is supported by groundwater, too. SGMA defines GDEs as "ecological communities and species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" [23 CCR §351(m)]. Hence, depth-to-groundwater data should be used to identify whether NC polygons are supported by groundwater and should be considered GDEs. In addition, SGMA requires that significant and undesirable adverse impacts to beneficial users of surface water be avoided. Beneficial users of surface water include environmental users such as plants or animals[17], which therefore must be considered when developing minimum thresholds for depletions of interconnected surface water.

GSAs are only responsible for impacts to GDEs resulting from groundwater conditions in the basin, so if adverse impacts to GDEs result from the diversion of applied water, treated wastewater, or irrigation return flow away from the GDE, then those impacts will be evaluated by other permitting requirements (e.g., CEQA) and may not be the responsibility of the GSA. However, if adverse impacts occur to the GDE due to changing groundwater conditions resulting from pumping or groundwater management activities, then the GSA would be responsible (Figure 4).

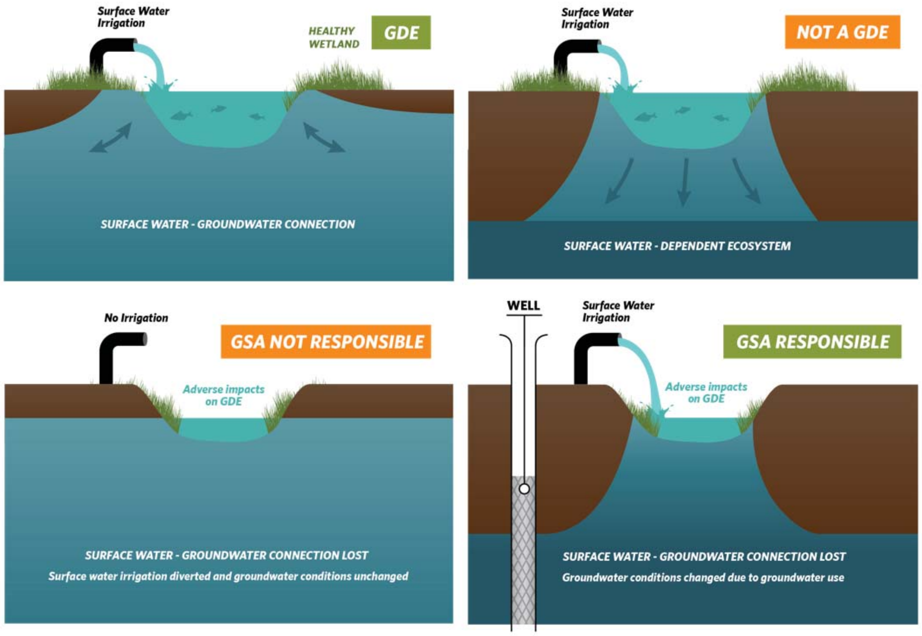


Figure 4. Ecosystems often depend on multiple sources of water. Top: (Left) Surface water and groundwater are interconnected, meaning that the GDE is supported by both groundwater and surface water. **(Right)** Ecosystems that are only reliant on non-groundwater sources are not groundwater-dependent. **Bottom: (Left)** An ecosystem that was once dependent on an interconnected surface water, but loses access to groundwater solely due to surface water diversions may not be the GSA's responsibility. **(Right)** Groundwater dependent ecosystems once dependent on an interconnected surface water system, but loses that access due to groundwater pumping is the GSA's responsibility.

[17] *For a list of environmental beneficial users of surface water by basin, visit: https://groundwaterresourcehub.org/gde-tools/environmental-surface-water-beneficiaries/*

BEST PRACTICE #4. Select Representative Groundwater Wells

Identifying GDEs in a basin requires that groundwater conditions are characterized to confirm whether polygons in the NC dataset are supported by the underlying aquifer. To do this, proximate groundwater wells should be identified to characterize groundwater conditions (Figure 5). When selecting representative wells, it is particularly important to consider the subsurface heterogeneity around NC polygons, especially near surface water features where groundwater and surface water interactions occur around heterogeneous stratigraphic units or aquitards formed by fluvial deposits. The following selection criteria can help ensure groundwater levels are representative of conditions within the GDE area:

- Choose wells that are within 5 kilometers (3.1 miles) of each NC Dataset polygons because they are more likely to reflect the local conditions relevant to the ecosystem. If there are no wells within 5km of the center of a NC dataset polygon, then there is insufficient information to remove the polygon based on groundwater depth. Instead, it should be retained as a potential GDE until there are sufficient data to determine whether or not the NC Dataset polygon is supported by groundwater.

- Choose wells that are screened within the surficial unconfined aquifer and capable of measuring the true water table.

- Avoid relying on wells that have insufficient information on the screened well depth interval for excluding GDEs because they could be providing data on the wrong aquifer. This type of well data should not be used to remove any NC polygons.

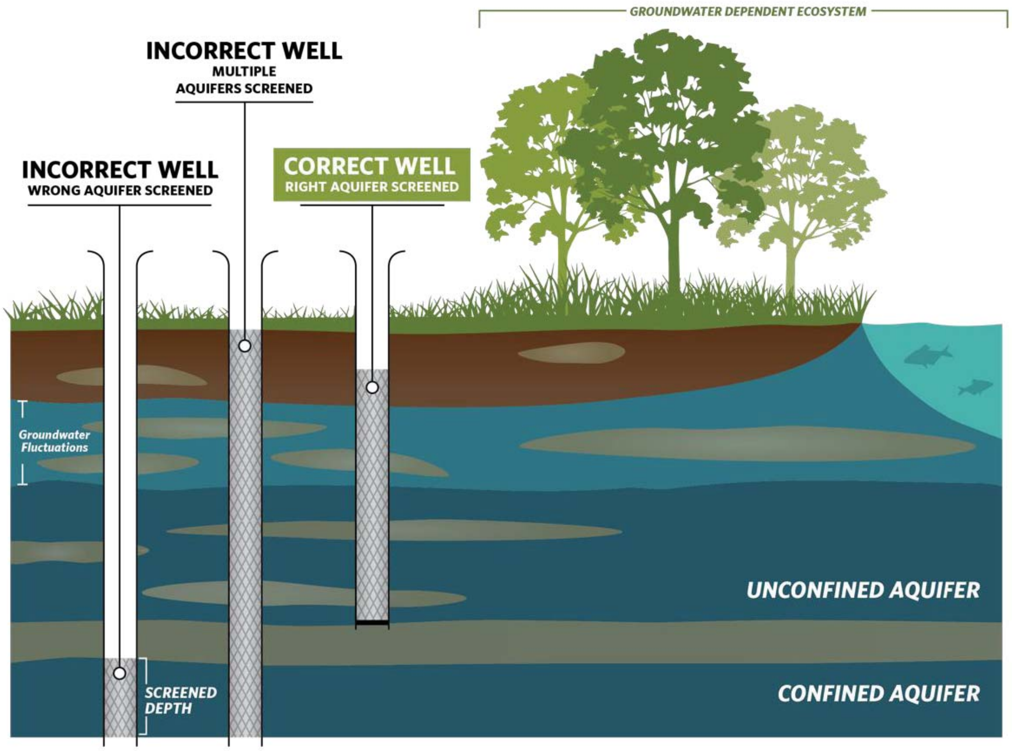


Figure 5. Selecting representative wells to characterize groundwater conditions near GDEs.

BEST PRACTICE #5. Contouring Groundwater Elevations

The common practice to contour depth-to-groundwater over a large area by interpolating measurements at monitoring wells is unsuitable for assessing whether an ecosystem is supported by groundwater. This practice causes errors when the land surface contains features like stream and wetland depressions because it assumes the land surface is constant across the landscape and depth-to-groundwater is constant below these low-lying areas (Figure 6a). A more accurate approach is to interpolate **groundwater elevations** at monitoring wells to get groundwater elevation contours across the landscape. This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM)[18] to estimate depth-to-groundwater contours across the landscape (Figure b; Figure 7). This will provide a much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found.

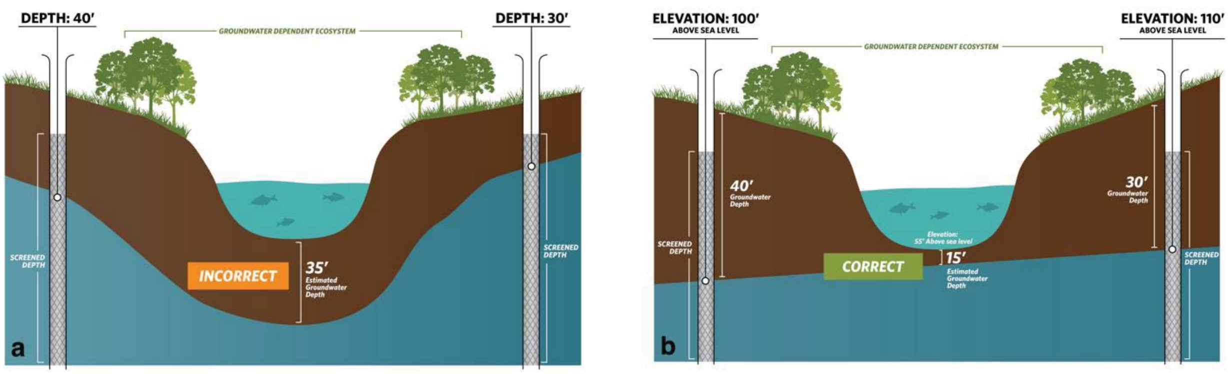


Figure 6. Contouring depth-to-groundwater around surface water features and GDEs. (a) Groundwater level interpolation using depth-to-groundwater data from monitoring wells. **(b)** Groundwater level interpolation using groundwater elevation data from monitoring wells and DEM data.

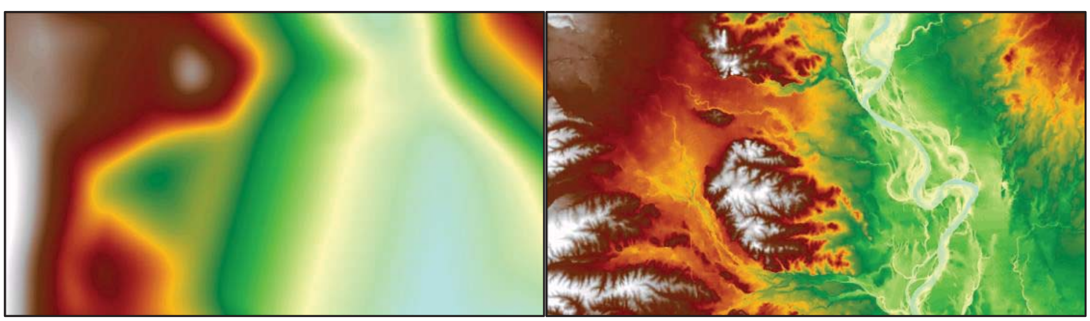


Figure 7. Depth-to-groundwater contours in Northern California. (Left) Contours were interpolated using depth-to-groundwater measurements determined at each well. **(Right)** Contours were determined by interpolating groundwater elevation measurements at each well and superimposing ground surface elevation from DEM spatial data to generate depth-to-groundwater contours. The image on the right shows a more accurate depth-to-groundwater estimate because it takes the local topography and elevation changes into account.

[18] USGS Digital Elevation Model data products are described at: https://www.usgs.gov/core-science-systems/ngp/3dep/about-3dep-products-services and can be downloaded at: https://iewer.nationalmap.gov/basic/

BEST PRACTICE #6. Best Available Science

Adaptive management is embedded within SGMA and provides a process to work toward sustainability over time by beginning with the best available information to make initial decisions, monitoring the results of those decisions, and using the data collected through monitoring programs to revise decisions in the future. In many situations, the hydrologic connection of NC dataset polygons will not initially be clearly understood if site-specific groundwater monitoring data are not available. If sufficient data are not available in time for the 2020/2022 plan, **The Nature Conservancy strongly advises that questionable polygons from the NC dataset be included in the GSP until data gaps are reconciled in the monitoring network.** Erring on the side of caution will help minimize inadvertent impacts to GDEs as a result of groundwater use and management actions during SGMA implementation.

KEY DEFINITIONS

Groundwater basin is an aquifer or stacked series of aquifers with reasonably well-defined boundaries in a lateral direction, based on features that significantly impede groundwater flow, and a definable bottom. *23 CCR §341(g)(1)*

Groundwater dependent ecosystem (GDE) are ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface. *23 CCR §351(m)*

Interconnected surface water (ISW) 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. *23 CCR §351(o)*

Principal aquifers are aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems. *23 CCR §351(aa)*

ABOUT US

The Nature Conservancy is a science-based nonprofit organization whose mission is *to conserve the lands and waters on which all life depends*. To support successful SGMA implementation that meets the future needs of people, the economy, and the environment, TNC has developed tools and resources (www.groundwaterresourcehub.org) intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

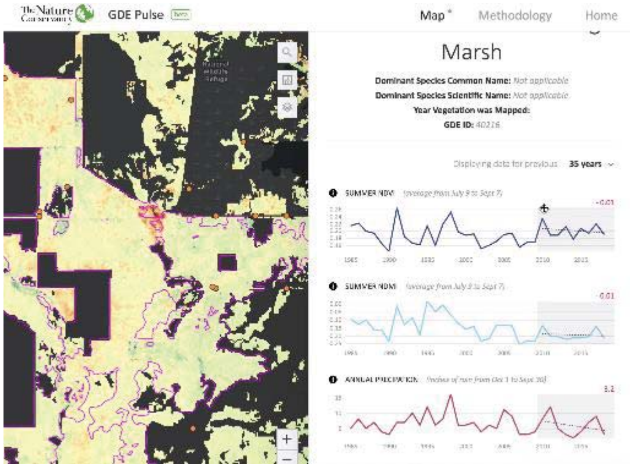
Attachment E

GDE Pulse

A new, free online tool that allows Groundwater Sustainability Agencies to assess changes in groundwater dependent ecosystem (GDE) health using satellite, rainfall, and groundwater data.

The Nature Conservancy
Protecting nature. Preserving life.

Visit
https://gde.codefornature.org/



Remote sensing data from satellites has been used to monitor the health of vegetation all over the planet. GDE pulse has compiled 35 years of satellite imagery from NASA's Landsat mission for every polygon in the Natural Communities Commonly Associated with Groundwater Dataset[19]. The following datasets are included:

Normalized Difference Vegetation Index (NDVI) is a satellite-derived index that represents the greenness of vegetation. Healthy green vegetation tends to have a higher NDVI, while dead leaves have a lower NDVI. We calculated the average NDVI during the driest part of the year (July - Sept) to estimate vegetation health when the plants are most likely dependent on groundwater.

Normalized Difference Moisture Index (NDMI) is a satellite-derived index that represents water content in vegetation. NDMI is derived from the Near-Infrared (NIR) and Short-Wave Infrared (SWIR) channels. Vegetation with adequate access to water tends to have higher NDMI, while vegetation that is water stressed tends to have lower NDMI. We calculated the average NDVI during the driest part of the year (July–September) to estimate vegetation health when the plants are most likely dependent on groundwater.

Annual Precipitation is the total precipitation for the water year (October 1st – September 30th) from the PRISM dataset[20]. The amount of local precipitation can affect vegetation with more precipitation generally leading to higher NDVI and NDMI.

Depth to Groundwater measurements provide an indication of the groundwater levels and changes over time for the surrounding area. We used groundwater well measurements from nearby (<1km) wells to estimate the depth to groundwater below the GDE based on the average elevation of the GDE (using a digital elevation model) minus the measured groundwater surface elevation.

[19] The Natural Communities Commonly Associated with Groundwater Dataset is hosted on the California Department of Water Resources' website: https://gis.water.ca.gov/app/NCDatasetViewer/#

[20] The PRISM dataset is hosted on Oregon State University's website: http://www.prism.oregonstate.edu/

California Poultry FEDERATION
4640 SPYRES WAY, SUITE 4 | MODESTO, CA 95356 | PHONE: (209) 576-6355 | FAX: (209) 576-6119 | WWW.CPIF.ORG

VIA E-MAIL (lsales@ppeng.com)

November 27, 2019

Members of the Tulare Lake Subbasin Board
of Directors
c/o Laurie Sales, Project Administrator
Southwest Kings GSA
286 West Cromwell Avenue
Fresno, California 93711

Re: Tulare Lake Subbasin GSP

Dear Board Members:

The California Poultry Federation ("CPF") appreciates the opportunity to comment on the draft Tulare Lake Subbasin Groundwater Sustainability Plan (the "Draft GSP"). CPF is the trade association for California's diverse and dynamic poultry industry. Our members include growers, hatchers, breeders, and processors that work with chickens, turkeys, ducks, game birds, and squab. Water is essential for all of them—both for nutrition and for maintaining sanitary conditions. CPF therefore supports effective measures to assure reliable water supplies.

In this regard, CPF recommends that each Tulare Lake Subbasin Groundwater Sustainability Agency ("GSA") make supply augmentation its top priority. We were encouraged to see that the Draft GSP incorporated storage, recharge, and conveyance projects and that Table 7-1 listed consideration of incentives as a means of encouraging participation in augmentation. Additional extraction rights in particular would be an excellent method of increasing landowner support for supply projects.

But we are concerned that the Draft GSP also emphasized substantial demand management without explaining precisely how that would be done. The listed management actions are "conceptual" (Draft GSP page 6-2) and Appendix E, which is to contain GSA appendices, is blank. Nor does the Draft GSP appear to set out any principles—which should include minimizing economic impact, maintaining established water rights, and incentivizing investment in water supply infrastructure—for developing demand management measures. The public will need to have meaningful opportunities to participate in the development of any specific demand management measures, which means that there must be sufficient time to evaluate supporting information and submit written comments. That is especially important in light of the finding (at Draft GSP page 7-7) that "[a]t this time there is not sufficient information to develop a financial impact due to demand reduction." CPF expects all the Subbasin GSAs to do their best to ameliorate economic impacts by adopting implementation measures that are cost-effective.

One other point about public comment deserves mention. It was difficult to ascertain when written comments on the Draft GSP were due and where they should be sent. The Subbasin GSAs should establish, utilize, and publicize one central clearinghouse available through the Internet for disseminating information about further proposed actions in the Subbasin and receiving written comments.

Please contact me if you need any further information about these comments.

Very truly yours,

Bill Mattos

Bill Mattos
President

December 1, 2019

Sent via email to djackson@tcwater.org and dmelville@ppeng.com

Re: Comments on Draft Groundwater Sustainability Plan for Tri County Water Authority Tulare Lake Groundwater Basin

To Whom It May Concern,

On behalf of the above-listed organizations, we would like to offer the attached comments on the draft Groundwater Sustainability Plan for the Tri County Water Authority Tulare Lake Groundwater Basin. Our organizations are deeply engaged in and committed to the successful implementation of the Sustainable Groundwater Management Act (SGMA) because we understand that groundwater is a critical piece of a resilient California water portfolio, particularly in light of our changing climate. Because California's water and economy are interconnected, the sustainable management of each basin is of interest to both local communities and the state as a whole. This letter adopts by reference the comments and recommendations submitted by The Nature Conservancy on this draft plan.

Our organizations have significant expertise in the environmental needs of groundwater and the needs of disadvantaged communities.

- The Nature Conservancy, in collaboration with state agencies, has developed several tools[1] for identifying groundwater dependent ecosystems in every SGMA groundwater basin and has made that tool available to each Groundwater Sustainability Agency.
- Local Government Commission supports leadership development, performs community engagement, and provides technical assistance dealing with groundwater management and other resilience-related topics at the local and regional scales; we provide guidance and resources for statewide applicability to the communities and GSAs we are working with directly in multiple groundwater basins.
- Audubon California is an expert in understanding wetlands and their role in groundwater recharge and applying conservation science to develop multiple-benefit solutions for sustainable groundwater management.
- Clean Water Action and Clean Water Fund are sister organizations that have deep expertise in the provision of safe drinking water, particularly in California's small disadvantaged communities, and co-authored a report on public and stakeholder engagement in SGMA[2].

[1] https://groundwaterresourcehub.org/

[2] https://www.cleanwater.org/publications/collaborating-success-stakeholder-engagement-sustainable-groundwater-management-act

Because of the number of draft plans being released and our interest in reviewing every plan, we have identified key plan elements that are necessary to ensure that each plan adequately addresses essential requirements of SGMA. A summary review of your plan using our evaluation framework is attached to this letter as Appendix A. Our hope is that you can use our feedback to improve your plan before it is submitted in January 2020.

This review does not look at data quality but instead looks at how data was presented and used to identify and address the needs of disadvantaged communities (DACs), drinking water and the environment. In addition to informing individual groundwater sustainability agencies of our analysis, we plan to aggregate the results of our reviews to identify trends in GSP development, compare plans and determine which basins may require greater attention from our organizations.

Key Indicators

Appendix A provides a list of the questions we posed, how the draft plan responds to those questions and an evaluation by element of major issues with the plan. Below is a summary by element of the questions used to evaluate the plan.

1. Identification of Beneficial Users. This element is meant to ascertain whether and how DACs and groundwater-dependent ecosystems (GDEs) were identified, what standards and guidance were used to determine groundwater quality conditions and establish minimum thresholds for groundwater quality, and how environmental beneficial users and stakeholders were engaged through the development of the draft plan.
2. Communications plan. This element looks at the sufficiency of the communications plan in identifying ongoing stakeholder engagement during plan implementation, explicit information about how DACs were engaged in the planning process and how stakeholder input was incorporated into the GSP process and decision-making.
3. Maps related to Key Beneficial Uses. This element looks for maps related to drinking water users, including the density, location and depths of public supply and domestic wells; maps of GDE and interconnected surface waters with gaining and losing reaches; and monitoring networks.
4. Water Budgets. This element looks at how climate change is explicitly incorporated into current and future water budgets; how demands from urban and domestic water users were incorporated; and whether the historic, current and future water demands of native vegetation and wetlands are included in the budget.
5. Management areas and Monitoring Network. This element looks at where, why and how management areas are established, as well what data gaps have been identified and how the plan addresses those gaps.
6. Measurable Objectives and Undesirable Results. This element evaluates whether the plan explicitly considers the impacts on DACs, GDEs and environmental beneficial users in the development of Undesirable Results and Measurable Objectives. In addition, it examines whether stakeholder input was solicited from these beneficial users during the development of those metrics.
7. Management Actions and Costs. This element looks at how identified management actions impact DACs, GDEs and interconnected surface water bodies; whether mitigation for impacts to DACs is discussed or funded; and what efforts will be made to fill identified data gaps in the first five years of the plan. Additionally, this element asks whether any changes to local ordinances or land use plans are included as management actions.

Conclusion

We know that SGMA plan development and implementation is a major undertaking, and we want every basin to be successful. We would be happy to meet with you to discuss our evaluation as you finalize your Plan for submittal to DWR. Feel free to contact Suzannah Sosman at suzannah@aginnovations.org for more information or to schedule a conversation.

Sincerely,

Jennifer Clary
Water Program Manager
Clean Water Action/Clean Water Fund

Danielle V. Dolan
Water Program Director
Local Government Commission

Samantha Arthur
Working Lands Program Director
Audubon California

Sandi Matsumoto
Associate Director, California Water Program
The Nature Conservancy

Appendix A
Review of Public Draft GSP

Groundwater Basin/Subbasin: Tulare Lake Subbasin (DWR 5-22-12)
GSA: Five GSAs (Mid-Kings River, South Fork Kings, Southwest Kings, El Rico, and the Tri-County Water Authority GSAs)
GSP Date: August 2019 Public Review Draft

1. Identification of Beneficial Users

Were key beneficial users identified and engaged?

Selected relevant requirements and guidance:
GSP Element 2.1.5, "Notice & Communication" (§354.10):
(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.
GSP Element 2.2.2, "Groundwater Conditions" (§354.16):
(d) 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.
(f) 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.
(g) 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.
GSP Element 3.3, "Minimum Thresholds" (§354.28):
(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

Review Criteria		Yes	No	N/A	Relevant Info per GSP	Location (Section, Page[1])
1. Do beneficial users (BUs) identified within the GSP area include:	a. Disadvantaged Communities (DACs)	X			From Table 2-4, DACs include Armona, Home Garde, Hardwick, Community of Stratford, Kettleman City, and City of Corcoran.	Table 2-4, Page 94
	b. Tribes	X			"The only Native American Tribe within the Tulare Lake Subbasin boundary is the Santa Rosa Rancheria Tachi-Yokut Tribe. The Tachi-Yokut Tribe was invited to participate in GSP development via a letter sent on June 28, 2016 by the then Upper Tulare Lake GSA MOU Group (now known as the South Fork Kings GSA). A copy of the letter is included in the Appendix A of the Tulare Lake Subbasin GSAs' Communication & Engagement Plan. The Tribe's EPA director attended one of the South Fork Kings GSA's board meetings, and has been on their Interested Parties List since April 2017, receiving regular updates about GSP development within the SFKGSA and the Tulare Lake Subbasin. In addition, a Sacred Lands File & Native American Contacts List Request was also sent to the Native American Heritage Commission."	Appendix B, Page 373
	c. Small community public water systems (<3,300 connections)	X			Public water systems such as Armona CSD and Home Garden CSD are included in Table 2-4. It is not clear from the GSP which systems have fewer than 3,300 connections.	Table 2-4, Page 94
2. What data were used to identify presence or absence	d. DWR DAC Mapping Tool[2]		X		Data source is not clear from the GSP.	
	i. Census Places		X			

[1] Page numbers refer to the page of the PDF.
[2] DWR DAC Mapping Tool: https://gis.water.ca.gov/app/dacs/

of DACs?	ii. Census Block Groups		X			
	iii. Census Tracts		X			
	e. Other data source		X			
3. Groundwater Conditions section includes discussion of:	f. Drinking Water Quality	X			"Currently, as described in Section 5.4.3, groundwater quality in the northern portion of the Subbasin encompassing the Mid-Kings River GSA and South Fork Kings GSA is generally excellent for irrigation and satisfactory for municipal and industrial use (KCWD 2011). South of Stratford and Corcoran, groundwater quality diminishes, and portions of the Tulare Lakebed have been undesignated from being suitable for municipal, domestic, agricultural irrigation, and stock watering supply. Shallow groundwater contamination from fuel hydrocarbons, agricultural chemicals, or solvents are localized in the urbanized areas of Lemoore and Hanford and some smaller communities. Limited regional data is available for determining current nutrient concentrations based on groundwater depth and location. As discussed in Section 3.2.5, shallow groundwater can have elevated concentrations of nitrates and TDS, but the majority of the region is generally below Maximum Contaminant Levels (MCLs)."	4.4.1.4, Page 248
	g. California Maximum Contaminant Levels (CA MCLs)[3] (or Public Health Goals where MCL does not exist, e.g. Chromium VI)		X		See above. MCLs are only briefly discussed.	4.4.1.4, Page 248
4. What local, state, and federal standards or plans were used to assess drinking water BUs in the development of Minimum Thresholds (MTs)?	h. Office of Environmental Health Hazard Assessment Public Health Goal (OEHHA PHGs)[4]		X			
	i. CA MCLs[3]	X			"The basic authority of the GSAs is to locally determine the sustainable amount of groundwater that can be pumped and to manage the transition from the current groundwater usage to a groundwater usage that is sustainable. Also, GSAs do not have the authority to modify surface water rights. Federal and state agencies provide direct oversight of quality and set their own appropriate thresholds such as Maximum Contaminant Levels for drinking water. These will be utilized by the Subbasin for MOs and MTs. For these reasons, the local GSAs will focus on water quality issues that are related to groundwater pumping rather than on issues related to contamination." "MTs will follow the state, federal, and local standards related to the relevant sustainability indicators set by the coalitions."	4.2.4, Page 239 4.4.2.4, Page 249
	j. Water Quality Objectives (WQOs) in Regional Water Quality Control Plans		X			
	k. Sustainable Communities Strategies/ Regional Transportation Plans[5]		X			

[3] CA MCLs: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.html
[4] OEHHA PHGs: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.html
[5] CARB: https://ww2.arb.ca.gov/resources/documents/scs-evaluation-resources

	I. County and/or City General Plans, Zoning Codes and Ordinances[6]		X			

Summary/ Comments
It is recommended that the GSP clearly identify the data sources that were used to identify the presence of DACs, and include as maps showing the locations of DACs. The representative monitoring networks should be shown on maps that include the location of DACs so that one can assess the networks' ability to monitor potential impacts to these sensitive beneficial users.

The GSP should provide much more thorough information on what the water quality MTs/MOs are and what standards were used in the development of MTs/MOs. Such information is crucial to the drinking water beneficial users in the subbasin.

[6] OPR General Plan Guidelines: http://www.opr.ca.gov/planning/general-plan/

2. Communications Plan

How were key beneficial users engaged and how was their input incorporated into the GSP process and decisions?

Selected relevant requirements and guidance:
GSP Element 2.1.5, "Notice & 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:
(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.

DWR Guidance Document for GSP Stakeholder Communication and Engagement[7]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Is a Stakeholder Communication and Engagement Plan (SCEP) included?	X			Appendix B: Stakeholder Communication and Engagement Plan (no date)	Appendix B, Page 368
2. Does the SCEP or GSP identify that ongoing engagement will be conducted during GSP implementation?	X			"During the implementation phase, communication and engagement efforts focus on educational and informational awareness of the requirements and processes for reaching groundwater sustainability as set forth in the submitted GSP. Active involvement of all stakeholders is encouraged during implementation, and public notices are required for any public meetings, as well as prior to imposing or increasing any fees. Public outreach is also completed by the individual GSAs with collaborative efforts when target audiences span more than one GSA boundary."	2.5.1, Page 73
3. Does the SCEP or GSP specifically identify how DAC beneficial users were engaged in the planning process?	X			"Communication and educational outreach efforts with disadvantaged communities (DAC) and severely disadvantaged communities (SDAC) was needed for the development and implementation of the Tulare Lake Subbasin's GSP according to the Department of Water Resources' Best Management Practices. Information used to communicate to and engage the DACs in the GSP process, included an explanation of SGMA and soliciting feedback. GSA representatives regularly communicated with DACs and gave presentations on SGMA to community representatives, while gathering their feedback and input. By including DACs and SDACs in communication efforts during the development, public review and implementation phases of the GSP, residents were more likely to participate and provide feedback that could be crucial to long-term solutions for groundwater sustainability within their communities.	Appendix B, Page 374, 377

[7] DWR Guidance Document for GSP Stakeholder Communication and Engagement
https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Guidance-Document-for-Groundwater-Sustainability-Plan---Stakeholder-Communication-and-Engagement.pdf

				Any feedback received from DAC/SDAC residents was reviewed and evaluated by the Tulare Lake Subbasin GSAs during the GSP development and public review phases." "For outreach to DACs/SDACs, fliers were available in both English and Spanish languages."	
4. Does the SCEP or GSP explicitly describe how stakeholder input was incorporated into the GSP process and decisions?	X			"As active stakeholders, members of the Boards of Directors and Stakeholder/Advisory Committees are direct representatives of their districts, communities and industries, and they continually gather feedback/input, and the concerns/needs of their constituents and report back to their respective meetings. Any stakeholder input received was reviewed by the GSA and Subbasin technical teams and taken into consideration during GSP development." "Stakeholder input was utilized during the GSA formation phase, as beneficial users and stakeholders with interests in groundwater usage within the GSAs' boundaries were notified via public meeting notices as soon as the process began." "With the goal of having the draft GSP before the end of the third quarter in 2019, 2018 was primarily the technical development of the plan, while working with GSA Boards of Directors, technical teams/committees, and GSA management at the subbasin level, as well as stakeholders for feedback and input. During the last quarter of 2018, the first round of public outreach meetings and interaction with stakeholder groups and other community organizations and entities was held with the purpose of educating and informing stakeholders about SGMA and the GSP process, while also soliciting feedback and input from these groups to consider and possibly include feedback and input into the GSP. Public outreach for this phase was completed by the individual GSAs." "Once the draft of the GSP was completed in September 2019, the public review process began. A 90-day comment period was held, with the GSP draft posted on the Tulare Lake Subbasin GSAs' websites for all stakeholders to conveniently download and review and provide comments. Outreach meetings were held during this phase both on subbasin-wide level, as well as by individual GSAs. These meetings focused on an overview of the GSP content, while giving stakeholders a public forum to provide their feedback and comments." Outreach tracking is also presented in tables by each GSA in Appendix D.	Appendix B, Page 370

Summary/ Comment
It is important that stakeholder engagement be maintained through the development of future projects and management actions and other SGMA compliance and implementation steps.

3. Maps Related to Key Beneficial Uses

Were best available data sources used for information related to key beneficial users?

Selected relevant requirements and guidance:
GSP Element 2.1.4 "Additional GSP Elements" (§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:
(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.

GSP Element 3.5 Monitoring Network (§354.34)
(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:
(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.
(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.
(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.
(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:
(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.

Review Criteria		Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP Include Maps Related to Drinking Water Users?	a. Well Density		X		No maps are provided. Page 47 indicates that there are 75 public supply wells in the Subbasin and the total number of wells is about 3,871.	Section 2, Page 47
	b. Domestic and Public Supply Well Locations & Depths		X		The GSP does not appear to include information on domestic and public supply well locations and depths.	
	i. Based on DWR Well Completion Report Map Application[8]?			X		

[8] DWR Well Completion Report Map Application: https://www.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37

	ii. Based on Other Source(s)?				X		
2. Does the GSP include maps of monitoring networks?	a. Existing Monitoring Wells		X			Existing monitoring wells for subsidence and water quality can be found in Figure 5-4 and 5-5.	Figure 5-4, Page 301 Figure 5-4, Page 302
	b. Existing Monitoring Well Data sources:	i. California Statewide Groundwater Elevation Monitoring (CASGEM)	X			"Groundwater levels are measured in the various networks and types of wells including: […] CASGEM Wells: DWR collects groundwater levels reported by local agencies and reports them through the CASGEM program. There are currently 17 CASGEM wells in the Subbasin."	5.1.5, Page 276
		ii. Water Board Regulated monitoring sites	X			"Water quality data will be obtained from the below-mentioned coalitions: […] RWQCB - Regional Water Quality Control Board" "Though water quality has been periodically analyzed within the Subbasin for irrigation suitability, monitoring programs are generally not in place with defined temporal and spatial distribution, except for municipal water suppliers, RWQCB sites with WDRs, and monitoring at evaporation ponds."	4.4.2.4, Page 250 5.4.3, Page 291
		iii. Department of Pesticide Regulation (DPR) monitoring wells	X			"The California Department of Pesticide Regulation (DPR) maintains a Surface Water Database (SURF) containing data from a wide variety of environmental monitoring studies designed to test for the presence or absence of pesticides in California surface waters. As part of DPR's effort to provide public access to pesticide information, this database provides access to data from DPR's SURF (DPR 2019)."	2.4.3.3, Page 68
	c. SGMA-Compliance Monitoring Network		X			Figure 5-1 to Figure 5-5	Figure 5-1 to Figure 5-5, Page298-302
	i. SGMA Monitoring Network map includes identified DACs?			X		DACs are not included. However, public water systems are shown on the maps.	
	ii. SGMA Monitoring Network map includes identified GDEs?			X		GDEs are not included.	

Summary/ Comments

The draft GSP does not provide maps showing "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" as required by 23 CCR § 354.8.(a)(5). The GSP should include the density, location and depths of all domestic and public supply wells in the GSA area using the best available information, and present this information on maps along with the proposed SGMA-compliance monitoring network so that the public can evaluate how well the monitoring network addresses these key beneficial users.

Providing maps of the monitoring network overlaid with location of DACs, GDEs, and any other sensitive beneficial users will also allow the reader to evaluate adequacy of the network to monitor conditions near these beneficial users.

4. Water Budgets

How were climate change projections incorporated into projected/future water budget and how were key beneficial users addressed?

Selected relevant requirements and guidance:
GSP Element 2.2.3 "Water Budget Information" (Reg. § 354.18)
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.

*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:*
(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.
(6) The water year type associated with the annual supply, demand, and change in groundwater stored.
(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.*

DWR Water Budget BMP[9]
DWR Guidance for Climate Change Data Use During GSP Development and Resource Guide[10]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Are climate change projections explicitly incorporated in future/ projected water budget scenario(s)?	X			"The projected water budget for the Subbasin represents a hypothetical forecast for the 54-year period from 2017 through 2070 based on an assumed "normal hydrology" period and estimated future climate change impacts."	3.3.7, Page 141
2. Is there a description of the methodology used to include climate change?	X			"In a climate period analysis, climate change is modeled as a shift from a baseline condition, usually historically observed climate where every year or month of the simulation it is shifted in a way that represents the climate change signal at a future 30-year climate period. Climate period analysis provides advantages in this situation because it isolates the climate change signal independent of the monthly variability signal. In a climate period analysis, monthly variability is based on the reference period from which change is being measured, meaning that all differences between the future	3.3.7.3, Page 142-143

[9] DWR BMP for the Sustainable <management of Groundwater Water Budget: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-4-Water-Budget.pdf
[10] DWR Guidance Document for the Sustainable Management of Groundwater Guidance for Climate Change Data Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Climate-Change-Guidance_Final.pdf

						simulation and the reference period are the result of the climate change signal alone. Climate period analysis was utilized to modify the 54-year forecast of "normal hydrology" to account for future climate change. The 2017-2070 forecast incorporates climate period analysis using the 2030 and 2070 monthly change factors (CNRA 2018) for each forecast analog month (Figure 3-52). The 2030 monthly change factors were applied to the forecast months January 2017 through December 2030. The 2070 monthly change factors were applied to the forecast months January 2031 through December 2070. There is a notable increase in magnitude of the 2070 change factors compared to the 2030 change factors."	
3. What is used as the basis for climate change assumptions?	a. DWR-Provided Climate Change Data and Guidance[11]		X			"The DWR provides guidance on how to incorporate climate change into hydrology forecasts. There are two basic approaches that have been used to simulate climate change in water resource modeling: 1) transient analysis; and 2) climate period analysis (DWR 2018)."	3.3.7.3, Page 142
	b. Other			X			
4. Does the GSP use multiple climate scenarios?				X			
5. Does the GSP quantitatively incorporate climate change projections?			X			Based on the information presented in Figure 3-53, the GSP appears to have quantitatively incorporated climate change projections. However, no descriptions or tables are provided regarding the quantitative results of the climate change projections.	Figure 3-53, Page 219
6. Does the GSP explicitly account for climate change in the following elements of the future/projected water budget?	a. Inflows:	i. Precipitation	X			"The climate change factors were also applied to 54-year forecasts of monthly inflows (effective precipitation, surface water deliveries, lake bottom storage, and canal and river seepage) and outflows (agricultural demand) for the "normal hydrology" forecast."	3.3.7.4, Page 143
		ii. Surface Water	X				
		iii. Imported Water	X				
		iv. Subsurface Inflow	X				
	b. Outflows:	i. Evapotranspiration	X				
		ii. Surface Water Outflows (incl. Exports)			X		
		iii. Groundwater Outflows (incl. Exports)	X				
7. Are demands by these sectors (drinking water users) explicitly included in the future/projected	a. Domestic Well users (<5 connections)		X			"Municipal and domestic groundwater pumping are estimated upward based on projected population growth at an annual rate of 0.03%." It is not clear from the GSP if demands by some or all of these community and non-community water systems were considered. The GSP also does not identify the number of connections of the various	3.3.7.4, Page 143
	b. State Small Water systems (5-14 connections)			X			
	c. Small community water systems (<3,300 connections)			X			

[11] DWR Guidance Document for the Sustainable Management of Groundwater Guidance for Climate Change Data Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Climate-Change-Guidance_Final.pdf
DWR Resource Guide DWR-Provided Climate Change Data and Guidance for Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Resource-Guide-Climate-Change-Guidance_v8.pdf

water budget?	d. Medium and Large community water systems (> 3,300 connections)		X		public water systems present in the basin.	
	e. Non-community water systems		X			

Summary/ Comments

Given the uncertainties of climate change, the GSP should include and analyze the effects of multiple climate change scenarios.

The GSP should present the results of the projected water budget in a tabulated, transparent format. The GSP should also clearly identify and quantify water demands of all drinking water users in the projected water budget, including the small and large public water systems. Such information is necessary for the public to assess whether drinking water demands were fully and appropriately considered in the GSP.

5. Management Areas and Monitoring Network

How were key beneficial users considered in the selection and monitoring of Management Areas and was the monitoring network designed appropriately to identify impacts on DACs and GDEs?

Selected relevant requirements and guidance:
GSP Element 3.3, "Management Areas" (§354.20):

(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.
(3) The level of monitoring and analysis appropriate for each management area.
(4) An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.
(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.

CWC Guide to Protecting Drinking Water Quality under the SGMA[12]
TNC's Groundwater Dependent Ecosystems under the SGMA, Guidance for Preparing GSPs[13]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP define one or more Management Area?	X			"In order to facilitate implementation of the GSP, management areas have been created for the Subbasin. There are five Primary Management Areas and two Secondary Management Areas."	3.4, Page 144 Figure 3-54, Page 220
2. Were the management areas defined specifically to manage GDEs?		X		"Primary Management Areas have been formed from each of the five GSAs." "Two Secondary Management Areas have been formed for the Subbasin. These two Secondary Management Areas are different from the Primary Management Areas and each other due to distinctly different groundwater conditions in each area."	3.4, Page 144
3. Were the management areas defined specifically to manage DACs?		X			
a. If yes, are the Measurable Objectives (MOs) and MTs for GDE/DAC management areas more restrictive than for the basin as a whole?			X		
b. If yes, are the proposed management actions for GDE/DAC management areas more restrictive/ aggressive than for the basin as a whole?			X		
4. Does the GSP include maps or descriptions indicating what DACs are located in each Management Area(s)?	X			Table 2-4 describes DACs in each GSA area.	Table 2-4, Page 94
5. Does the GSP include maps or descriptions indicating what GDEs are located in each Management Area(s)?	X			Figure 3-38. Distribution of Wetlands and Phreatophyte Vegetation	Figure 3-38, Page 198

[12] CWC Guide to Protecting Drinking Water Quality under the SGMA: https://d3n8a8pro7vhmx.cloudfront.net/communitywatercenter/pages/293/attachments/original/1559328858/Guide_to_Protecting_Drinking_Water_Quality_Under_the_Sustainable_Groundwater_Management_Act.pdf?1559328858
[13] TNC's Groundwater Dependent Ecosystems under the SGMA, Guidance for Preparing GSPs: https://www.scienceforconservation.org/assets/downloads/GDEsUnderSGMA.pdf

Summary/ Comments

It is recommended that the GSP includes maps of the identified DACs located within each Management Area.

Care should be taken so that the management areas and the associated monitoring network are designed to adequately assess and protect against impacts to all beneficial users, including GDEs and DACs.

6. Measurable Objectives, Minimum Thresholds, and Undesirable Results

How were DAC and GDE beneficial uses and users considered in the establishment of Sustainable Management Criteria?

Selected relevant requirements and guidance:
GSP Element 3.4 "Undesirable Results" (§ 354.26):
(b) The description of undesirable results shall include the following:
(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

GSP Element 3.2 "Measurable Objectives" (§ 354.30)
(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.

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Are DAC impacts considered in the development of Undesirable Results (URs), MOs, and MTs for groundwater levels and groundwater quality?		X		The impacts to DACs are not explicitly considered. Water Level URs: "Exceedance of MTs leading to undesirable results related to groundwater level in the Subbasin would cause a diminished level of groundwater supplies for agricultural and municipal needs. Groundwater levels are anticipated to continue to decrease at current rates in the next several years before implemented programs have a positive effect on the stabilization of groundwater levels based on the variability of hydrology and availability of flood water. As stated above, agriculture is the main economic enterprise of the Subbasin, so effective management of groundwater for sustainable future use is critical to the continuation of current economic interests, which add value to the Subbasin's communities. Decreases in groundwater levels will continue to increase the cost of energy for pumping. If MT levels are reached or exceeded, wells have the potential to go dry and require deepening to reach the lowered water table. Alternatively, pumps may be lowered if the existing well casing is sufficiently deeper. However, once the Subbasin reaches sustainability in the future, the depth of the wells will be known and can be designed to meet those depths to prevent future wells from becoming dry." Water Level MTs: "Due to the timely process of infrastructure development and program implementation, and variability in hydrology and the availability of flood water, groundwater levels are expected to continue to decrease in the next several years before programs have a positive effect on the stabilization of groundwater levels. Decreases in groundwater levels will continue to increase the cost of energy for pumping. If MT levels are reached, there may be some wells that go dry and require deepening to reach the water table. Alternatively, pumps may be lowered if the existing well casing is sufficiently deeper. However, once the Subbasin reaches sustainability in the future, the design depth for wells will be known and will be used in planning of future	4.3.3, Page 245 4.4.4, Page 251

				well construction to minimize future wells from becoming dry." Water Quality MTs: "If water quality is allowed to deteriorate to levels set by MTs, agricultural producers may experience a decrease in crop yield and/or crop quality. Poor water quality would cause a buildup of salts and nitrates in the surface layers of soil. The best way to treat nutrient build up is by leaching or over-irrigating enough to push soluble contaminants through the soil column."	
2. Does the GSP explicitly discuss how stakeholder input from DAC community members was considered in the development of URs, MOs, and MTs?		X		The GSP does not explicitly discuss how stakeholder input from DACs was considered.	
3. Does the GSP clearly identify and detail the anticipated degree of water level decline from current elevations to the water level MOs and MTs?		X		The GSP does not clearly identify the anticipated degree of water level decline. However, current water levels and MOs/MTs are presented in Table 4-1. Based on this if water levels reach MTs, this will represent an average decline of approx. 100 feet below 2017 conditions, and over 200 feet below current conditions in some parts of the subbasin (i.e., wells SFK_B_1920E19A001M, SFK_C_20S20E07H001M, and SFK_C_LEM_12). Even MOs represent over 100 feet of decline below 2017 water levels in many areas of the Subbasin.	Table 4-1, Page 262
4. If yes, does it include: a. Is this information presented in table(s)?		X			
b. Is this information presented on map(s)?		X			
c. Is this information presented relative to the locations of DACs and domestic well users?		X			
d. Is this information presented relative to the locations of ISW and GDEs?		X			
5. Does the GSP include an analysis of the anticipated impacts of water level MOs and MTs on drinking water users?		X		"Due to the timely process of infrastructure development and program implementation, and variability in hydrology and the availability of flood water, groundwater levels are expected to continue to decrease in the next several years before programs have a positive effect on the stabilization of groundwater levels. Decreases in groundwater levels will continue to increase the cost of energy for pumping. If MT levels are reached, there may be some wells that go dry and require deepening to reach the water table. Alternatively, pumps may be lowered if the existing well casing is sufficiently deeper. However, once the Subbasin reaches sustainability in the future, the design depth for wells will be known and will be used in planning of future well construction to minimize future wells from becoming dry." Impacts on drinking water users are not explicitly considered. Based on the water level declines identified above, it would be expected that such impacts could be significant.	4.4.4, Page 251
6. If yes: a. On domestic well users?		X			
b. On small water system production wells?		X			
c. Was an analysis conducted and clearly illustrated (with maps) to identify what wells would be expected to be partially and fully dewatered at the MOs?		X			
d. Was an analysis conducted and clearly illustrated (with maps) to identify what wells would be expected to be partially and fully dewatered at the MTs?		X			
e. Was an economic analysis performed to assess the increased operation costs associated with increased lift as a result of water level decline?		X			
9. Does the sustainability goal explicitly include drinking water and nature?		X		"This GSP aims to manage groundwater resources to continue to provide an adequate water supply for existing beneficial uses and users in accordance with counties and cities general plans while meeting established measurable objectives (MO) to maintain a sustainable yield. This goal aims to continue to provide adequate water supply for existing beneficial uses and users while ensuring the future, sustainable use of groundwater. Additionally, the sustainability goal works as a tool for managing groundwater, basin-wide, on a long-term basis to protect quality of life through the continuation of existing economic industries in the area including but not limited to agriculture."	1.3.1, Page 40 Table 2-4, Page 94

				Table 2-4. Beneficial Uses and Users by GSA The sustainability goal does not include nature.	

Summary/ Comments
Based on the presented information, impacts to DACs are not explicitly considered in the discussion of URs, MOs, and MTs. More detail and specifics regarding DACs, including those that rely on smaller community drinking water systems and domestic wells, is necessary to demonstrate that these beneficial users were adequately considered. It is recommended that the GSP present a thorough and robust analysis, supported by maps, that identifies: (1) what domestic wells are likely to be impacted (including partially dewatered) at the MTs and at the MOs and (2) the location of the likely impacted wells with respect to DACs and other communities and systems dependent on groundwater.

Based on the information presented in Table 4-1 of the draft GSP, if water levels reach MTs, this will represent an average decline of approx. 100 feet below 2017 water levels, and over 200 feet below current conditions in some parts of the subbasin (i.e., wells SFK_B_1920E19A001M, SFK_C_20S20E07H001M, and SFK_C_LEM_12). Even MOs represent an average decline of over 50 feet below current conditions and over 100 feet of decline in many areas of the Subbasin. The GSP needs to explain how such water level declines represent sustainable conditions and are protective of beneficial uses and users in the Subbasin.

A proactive assistance program should be developed for potentially impacted beneficial users, including DACs, small water systems, and domestic wells, to mitigate potential future adverse impacts.

The GSP should also explicitly demonstrate whether and how the stakeholder input from DACs was considered in the development of URs, MOs, and MTs.

We recommend that the sustainability goal explicitly includes environmental beneficial uses of groundwater.

7. Management Actions and Costs

What does the GSP identify as specific actions to achieve the MOs, particularly those that affect the key BUs, including actions triggered by failure to meet MOs? What funding mechanisms and processes are identified that will ensure that the proposed projects and management actions are achievable and implementable?

Selected relevant requirements and guidance
GSP Element 4.0 Projects and Management Actions to Achieve Sustainability Goal (§ 354.44)
(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.

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP identify benefits or impacts to DACs as a result of identified management actions?		X		The impacts to DACs are not explicitly discussed in the GSP. Recharge projects are noted in the GSP as expected to improve water quality.	6.3.3, Page 323
2. If yes: a. Is a plan to mitigate impacts on DAC drinking water users included in the proposed Projects and		X			

		Management Actions?					
	b.	Does the GSP identify costs to fund a mitigation program?		X			
	c.	Does the GSP include a funding mechanism to support the mitigation program?		X			
3.	Does the GSP identify any demand management measures in its projects and management actions?		X			Section 6.3 and 6.4 provide potential P/MAs options that may be utilized by the GSAs. Table 6-1 to 6-4 in Section 6.5 list the P/MAs chosen for each GSA.	6.3, Page 317-330 6.4, Page 330-331 6.5, Page 331-334
4. If yes, does it include:	a.	Irrigation efficiency program		X			
	b.	Ag land fallowing (voluntary or mandatory)	X			Fallowing programs are identified by Mid-Kings River GSA, El Rico GSA, and South Fork Kings GSA. "The Subbasin may adopt a policy to incentive farmers to permanently fallow land. Policy will solicit volunteers first then look towards mandatory fallowing based on percentage reductions possibly on a rotation basis."	
	c.	Pumping allocation/restriction	X			Groundwater allocation is listed as a potential management action in Section 6.4.	
	d.	Pumping fees/fines	X			Pumping fees for groundwater allocation exceedances and groundwater extractions are listed as potential management actions in Section 6.4.	
	e.	Development of a water market/credit system	X			Groundwater marketing and trade is listed as a potential management action in Section 6.4.	
	f.	Prohibition on new well construction		X			
	g.	Limits on municipal pumping		X		It is not clear if there would be limits on municipal pumping.	
	h.	Limits on domestic well pumping		X		It is not clear if there would be limits on domestic well pumping.	
	i.	Other	X			"Require new developments (non-de minimis extractors) to prove sustainable water supplies if land use conversion is not a conservation measure"	
5.	Does the GSP identify water supply augmentation projects in its projects and management actions?		X			Section 6.3 and 6.4 provide potential P/MAs options that may be utilized by the GSAs. Table 6-1 to 6-4 in Section 6.5 list the P/MAs chosen for each GSA.	6.3, Page 317-330 6.4, Page 330-331 6.5, Page 331-334
6. If yes, does it include:	a.	Increasing existing water supplies	X			"Each GSA is proposing to use their existing contract and rights for surface water as access to import more surface water into the Subbasin."	
	b.	Obtaining new water supplies		X			
	c.	Increasing surface water storage	X			Storage projects are identified by South Fork Kings GSA, El Rico GSA, and Tri-County Water GSA.	
	d.	Groundwater recharge projects – District or Regional level	X			Recharge projects are identified by Mid-Kings River GSA and South Fork Kings GSA.	
	e.	On-farm recharge	X			On-Farm Improvements project is identified by South Fork Kings GSA.	
	f.	Conjunctive use of surface water	X			The recharge projects also involve conjunctive use of surface water.	
	g.	Developing/utilizing recycled water		X			

	h. Stormwater capture and reuse		X			
	i. Increasing operational flexibility (e.g., new interties and conveyance)	X			The Mid-Kings River GSA plans to pursue improvement to conveyance systems and expanded surface water delivery system.	
	j. Other		X			
7. Does the GSP include plans to fill identified data gaps by the first five-year report?		X			Section 5.4.1.3 discusses plans to fill data gaps in groundwater level monitoring network, including plans to collect well completion reports, perform a video inspection of wells to obtain construction information, construct a dedicated monitoring well, and replace monitor point with another alternate private well. Some P/MAs in Table 7-1 are also noted in the GSP as expected to help fill data gaps, including (1) Flood Flows (Spills into the Subbasin), include, Tule River, Deer Creek, Cross-Creeks and Kings River; (2) Registration of extraction facilities; (3) Require self-reporting of groundwater extraction, water level, and water quality data; and (4) Require well meters, sounding tubes, and water quality sample ports.	5.4.1.3, Page 286 Table 7-1, Page 343
8. Do proposed management actions include any changes to local ordinances or land use planning?		X			"Require new developments (non-de minimis extractors) to prove sustainable water supplies if land use conversion is not a conservation measure"	6.4, Page 330
9. Does the GSP identify additional/contingent actions and funding mechanisms in the event that MOs are not met by the identified actions?			X		"This section identifies the proposed project and management action targets envisioned to achieve sustainability. These preliminary amounts will be reevaluated, and conditions monitored while efforts are implemented. This will allow the GSA to compare the anticipated versus resulting change in groundwater levels as well as other sustainability criteria to determine if additional measures need to be employed to achieve sustainability." However, the GSP does not provide details on what projects and management actions will be implemented as additional measures.	6.5, Section 331
10. Does the GSP provide a plan to study the interconnectedness of surface water bodies?			X		"As discussed in Section 3.2.8, Interconnected Surface Water and Groundwater Systems, the Subbasin does not contain interconnected surface and groundwater systems based on review of groundwater potentiometric surface maps. Groundwater contours indicate the Kings River, Cross Creek, and Mill Creek are losing streams that directly recharge groundwater. Groundwater is not in contact with these streams and cannot contribute any base flow to them. Due to the lack of connected water systems, interconnected surface water will not be monitored or considered when making management decisions."	4.2.5, Page 240
11. If yes:	a. Does the GSP identify costs to study the interconnectedness of surface water bodies?			X		
	b. Does the GSP include a funding mechanism to support the study of interconnectedness surface water bodies?			X		

Summary/ Comments

The GSP should identify the potential impacts of the proposed projects or management actions on DACs. If impacts are expected, the GSP should include plans to monitor for, prevent, and/or mitigate against such impacts, provide the estimated costs, and identify the funding sources.

The GSP does not appear to include any plans to address impacts to domestic well users if water quality in these wells is degraded in the future. The GSP should include plan to

monitor for and mitigate impacts to DAC drinking water users.

Westlands Water District
3130 N. Fresno Street, P.O. Box 6056, Fresno, California 93703-6056, (559) 224-1523, FAX (559) 241-6277

December 2, 2019

Southwest Kings Groundwater Sustainability Agency
Kings Subbasin
Basin Number 5-22.08
Transmitted via online submission at: info@swkgsa.org

Subject: Tulare Lake Subbasin Draft Groundwater Sustainability Plan

Dear Southwest Kings GSA Group:

Westlands Water District ("Westlands GSA") appreciates the opportunity to provide comments on the Tulare Lake Subbasin Draft Groundwater Sustainability Plan ("Draft GSP"). The Westlands Groundwater Sustainability Agency ("GSA") respectfully submits the following comments.

Finding 1 (Page 3-27): Figures 3-26 and 3-27, Table 3-6, and Section 3.2.2 of the GSP states with respect to groundwater flow in the unconfined aquifer that, "[i]n general, groundwater flowed into the Subbasin from the Kings, Kaweah, and Tule Subbasins and out of the Subbasin to the Westside Subbasin." This statement is supplemented by contours of unconfined potentiometric head developed by DWR from 1990 through 2016.

Westlands' Comment: The unconfined water level data are used to make inferences about general groundwater flow directions. As stated in Section 3.2.3 of the GSP, vertical gradients can exceed 50 feet per 100 feet suggesting that flow directions can be heavily dependent on the depth horizons that are selected and therefore, change considerably with depth. Model results provided in Appendix D also highlight how groundwater flow directions vary with depth.

DWR does not provide groundwater contours for the majority of the boundary shared between the Westside and Tulare Lake Subbasin. In fact, contours from 2005, 2010 and 2016 provide almost no overlap with the shared Subbasin boundary. As a result, there is no substantial evidence to support the statements regarding groundwater flows "out of the Subbasin to the Westside Subbasin."

The spatial information for wells used to develop the DWR water level contours are readily available for 2016 (DWR, 2019). Review of these data reveals that the majority of wells used by DWR to develop contours of unconfined potentiometric head within the Westside Subbasin are screened in the Lower Aquifer (**WWD Attachment: Figure 1**). Given that groundwater level readings can vary considerably between the Upper Aquifer and Lower Aquifer, water levels from the Lower Aquifer are unlikely to be representative of unconfined water levels (even in the Spring) and should not be used to support the GSP conclusions of subsurface flow in the unconfined aquifer between the Westside and Tulare Lake Subbasins.

Therefore, the analysis is not supported by substantial evidence and we respectfully disagree with the conclusion set forth in the GSP relating to groundwater conditions in the unconfined aquifer.

Finding 2 (Page 3-87): Figures 3-28b, 3-28c and 3-28d display wells within the Tulare Lake Subbasin with long term hydrographs.

Westlands' Comment: Figures 3-28b to 3-28d shows long term hydrographs for wells within the Tulare Lake Subbasin. Unfortunately, the data displayed by the hydrographs is pixelated, therefore unreviewable. Westlands GSA recommends revising the mentioned figures to display hydrographs using a higher resolution to allow the public to review.

Finding 3 (Page 3-93): Figures 3-30 through 3-32, and Section 3.2.5 describes groundwater quality data in the Tulare Lake and Westside Subbasins. With respect to TDS, the GSP cites reports from Davis et al., 1956 and Hansen et al., 2018.

Westlands Comments: Both reports highlight how depth significantly influences TDS concentrations. However, Figure 3-30 does not report the depth of the wells or the aquifer the TDS sample represents which can substantially influence how data is interpreted. Furthermore, none of the maps shows the time period being represented. With respect to the concentration of arsenic in groundwater, neither the most recent nor the maximum arsenic concentration in the data available from GeoTracker is as high as those shown in Figure 3-31 (**WWD Attachment: Figure 2 and 3**). Furthermore, the density of wells with available arsenic data in the Geotracker GAMA database is substantially less than that shown in Figure 3-31.

The concentration of nitrate in groundwater is shown in Figure 3-32. This map shows nitrate concentration exceeding the MCL in four locations adjacent to the Westside Subbasin boundary. A review of data available from Geotracker GAMA show that samples exceeding the MCL were measured in the mid to late-1980's and likely do not reflect the current ambient nitrate concentration at these locations.

We recommend that the draft GSP be revised to accurately convey groundwater quality data by aquifer and by the timeframe the data represents. In addition, we recommend that the groundwater quality data be reviewed for accuracy.

Finding 4 (Page 3-87): Figures 3-34 displaying historical subsidence in the San Joaquin Valley from 1949 – 2005.

Westlands' Comment: Figures 3-34 contains a legend that is incomplete and is unable to be reviewed. Westlands GSA recommends applying the corresponding color scheme to the vertical displacement legend to allow readers to be able to review the presented information.

Finding 5 (Page 4-18): Section 4.5.1.1 introduces the following sustainable management criteria for Groundwater Levels paraphrased as follows: The Sustainable Management Criteria for Groundwater Level (Section 4.5.1.1) proposes the Measurable Objective to be set at a groundwater level using Method 4, which forecasts water levels to 2035 and sets the 2035 water level as the Measurable Objective. Minimum Thresholds were based on assumed stability of groundwater levels between 2035 and 2040 and are designed to be a last-resort warning before more severe measures must be taken to protect groundwater resources. Section 4.4.3 (Selection Process of Minimum Thresholds to Avoid

Undesirable Results) establishes the Minimum Thresholds as "one standard deviation of all observed head data in compliance wells or modeled forecasted data." Figure 4-2 through 4-6 describe establishment of the Minimum Thresholds as "one standard deviation or 50 feet, whichever is greater."

Westlands' Comment: Sustainable Management Criteria, which includes the measurable objectives and the minimum thresholds, allows groundwater levels in the aquifer to decline past the Westside Subbasin's Measurable Objectives and Minimum Thresholds, set at 2015 groundwater levels, and may negatively impact the Westside Subbasin's ability to achieve sustainability by reducing net inflow into the Westside Subbasin and/or reversing the groundwater flow direction. More specifically, the proposed decline of groundwater levels in the Southwest Kings GSA may alter the groundwater conditions near the boundary between the Westside Subbasin and the Kings Subbasin and result in a lowering of groundwater levels in the Westside Subbasin. This action would have the effect of shifting the burden of SGMA compliance from the Southwest Kings GSA to Westlands GSA. This is not permissible. The GSP is devoid of substantial evidence and any explanation as to how the Minimum Thresholds will avoid a significant and unreasonable reduction in groundwater storage and significant and unreasonable land subsidence contributing to the impairment of surface uses within the Westside Subbasin.

Water Code section 10733, subdivision (c) provides in relevant part:

> "The department shall evaluate whether a groundwater sustainability plan adversely affects the ability of an adjacent basin to implement their groundwater sustainability plan or impedes achievement of sustainability goals in an adjacent basin"

Further, we respectfully call your attention to Code of Regulations, title 23, section 355.4, subdivision (b)(7):

> "When evaluating whether a Plan is likely to achieve the sustainability goal for the basin, the Department shall consider . . . whether the Plan *will adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of its sustainability goal.*" (emphasis added)

and Code of Regulations, title 23, section 354.28, subdivision (b)(3):

> "The description of minimum thresholds shall include . . . 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*." (emphasis added)

Moreover, the implementation of SGMA and a GSP cannot be used to override the protections afforded common law water rights. Overlying and appropriative uses of groundwater within the Westside Subbasin are entitled to legal and equitable protection against infringement by an action that deprives them of their historical subsurface inflows. (*City of Lodi v. East Bay Municipal Utility District* (1936) 7 Cal.2d 316, 344 [protecting groundwater levels against lowering from another party's pumping]; *Trussell v. City of San Diego* (1959) 172 Cal.App.2d 593, 611 [enjoining a party for lowering water table by interrupting surface flow].)

Practically speaking, proposing a continued decline of groundwater levels in the Lower Aquifer is not supported by substantial evidence because the GSP acknowledges that it does not have enough data to support its finding that there will be no impact to historical boundary flow conditions between the

Subbasins. The potential for curtailing historic underflow into the Westside Subbasin may be a substantial factor in contributing to significant and unreasonable subsidence and frustrate the Westlands' GSA ability to achieve the sustainability goal.

Finding 6 (Page 4-21): Section 4.5.33 Land Subsidence references Table 4-2: *Lemoore-Average Land Subsidence Interim Milestones based on Measurable Objectives for the Subbasin,* which displays modeled subsidence rates and interim milestones for those subsidence rates. The Tulare Lake Subbasin also proposes a minimum threshold of 16 ft by 2040 in Section 4.4.1.3.

Westlands' Comment: Westlands GSA is concerned that allowing subsidence rates as proposed may impact critical infrastructure such as roads, railroads, and may increase flood risks to existing land uses, especially near Corcoran where subsidence rates are critical, in the Westside Subbasin and other neighboring subbasins. Westlands GSA strongly recommend selecting Measurable Objectives and Minimum Thresholds to subsidence rates that will not negatively impact infrastructure in neighboring subbasins. The GSP fails to reference any substantial evidence that the minimum threshold will avoid significant and unreasonable land subsidence that impairs surface uses in the Westside Subbasin.

Finding 7 (Appendix D): The information provided in the GSP suggests a conceptual error leading to flows between the Westside Subbasin and Tulare Lake Subbasin to be misrepresented in the numerical model and GSP. Figure D5-5 in Appendix D shows the average model simulated net lateral subsurface flow of 158,405 AFY from the Lower Aquifer to the general head boundary (GHB) in the Westside Subbasin. Contours of simulated Lower Aquifer groundwater levels from 2015 in Figure D5-3 show a cone of depression along the GHB in the Westside Subbasin. Figure D5-5 shows pumping from the Lower Aquifer is a net positive suggesting that intraborehole flow from the Upper Aquifer to the Lower Aquifer is greater than the amount extracted from wells, suggesting the GHB is driving the flow across the boundary between the Westside and Tulare Lake Subbasins and out of the Westside Subbasin.

Westlands' Comment:
Lower Aquifer contours developed from water level data at the end of the 2014 irrigation year (one year before the simulated contour data provided) do not show a cone of depression in the location of the GHB (**WWD Attachment: Figure 4**). These contours also cannot be interpreted to suggest that groundwater flow is from the Tulare Lake Subbasin to the Westside Subbasin. Furthermore, it is unclear what physical process would cause a localized cone of depression to form in this location, especially considering that the groundwater model simulates positive net pumping from the Lower Aquifer in the Westside Subbasin.

The analysis is not supported by substantial evidence and for the reasons set forth above, Westlands recommends reanalyzing the water level contour data from the numerical model and GSP.

Lastly, the Westlands GSA identified the following reporting discrepancies within the text of the GSP and Appendix D that should be reviewed:

1. Total lateral subsurface inflow into the Westside Subbasin shown in Figure D5-5 averages 72,296 AFY (67,347 from the Tulare Lake Subbasin and 4,948 AFY from the Kings Subbasin). Table 3-6 of the GSP shows average annual subsurface flow from the Tulare Lake Subbasin to the Westside Subbasin of 41,390. What is the source of this discrepancy?

2. In the graphic depicting aquifer specific fluxes in Figure D5-5, the sum of the "Net GW Flux" (which presumably is lateral subsurface flow between adjacent subbasins) totals 4,936 AFY while the total in the table shown in Figure D5-5 is 72,296 AFY. What is the source of this discrepancy?

3. Figure numbers in the Appendix D text do not correspond to the correct figures. Figure D5-10 is titled "Simulated Subsidence 1990-2016". Figure D5-8 shows "Groundwater Mass Balance Tule Subbasin".

Westlands' General Comment: The GSP Regulations include a provision authorizing GSAs in adjacent basins to enter into interbasin agreements. The interbasin agreements can "establish compatible sustainability goals" and be included in GSPs to "support a finding that implementation of the Plan will not adversely affect an adjacent basin's ability to implement its Plan or impede the ability to achieve its sustainability goal." (Code Regs., tit. 23, § 357.2.)[1] The interbasin agreements may also address: (1) "an estimate of groundwater flow across basin boundaries;" (2) how the GSAs will reconcile differing minimum thresholds and measurable objectives in the basins to avoid undesirable results; and (3) a process for resolving conflicts between the GSAs. (*Id.*) Given the potential reduction of historical cross-boundary flow attributable to the planned operation with the Tulare Lake Subbasin Draft GSP, Westlands strongly recommends that we meet and confer at the earliest opportunity to determine whether an interbasin agreement can be reached. Our intention is to reach a cooperative resolution of these important issues that will enable coordinated sustainable management in our GSAs.

If you have any questions or concerns, regarding these comments, please contact Kiti Campbell by email at kcampbell@wwd.ca.gov or by phone at (559) 241-6226. Thank you for the opportunity to provide comments on the Tulare Lake Subbasin Draft GSP.

Sincerely,

Russ Freeman

Russ Freeman, P.E.
Deputy General Manager – Resources
Westlands Water District

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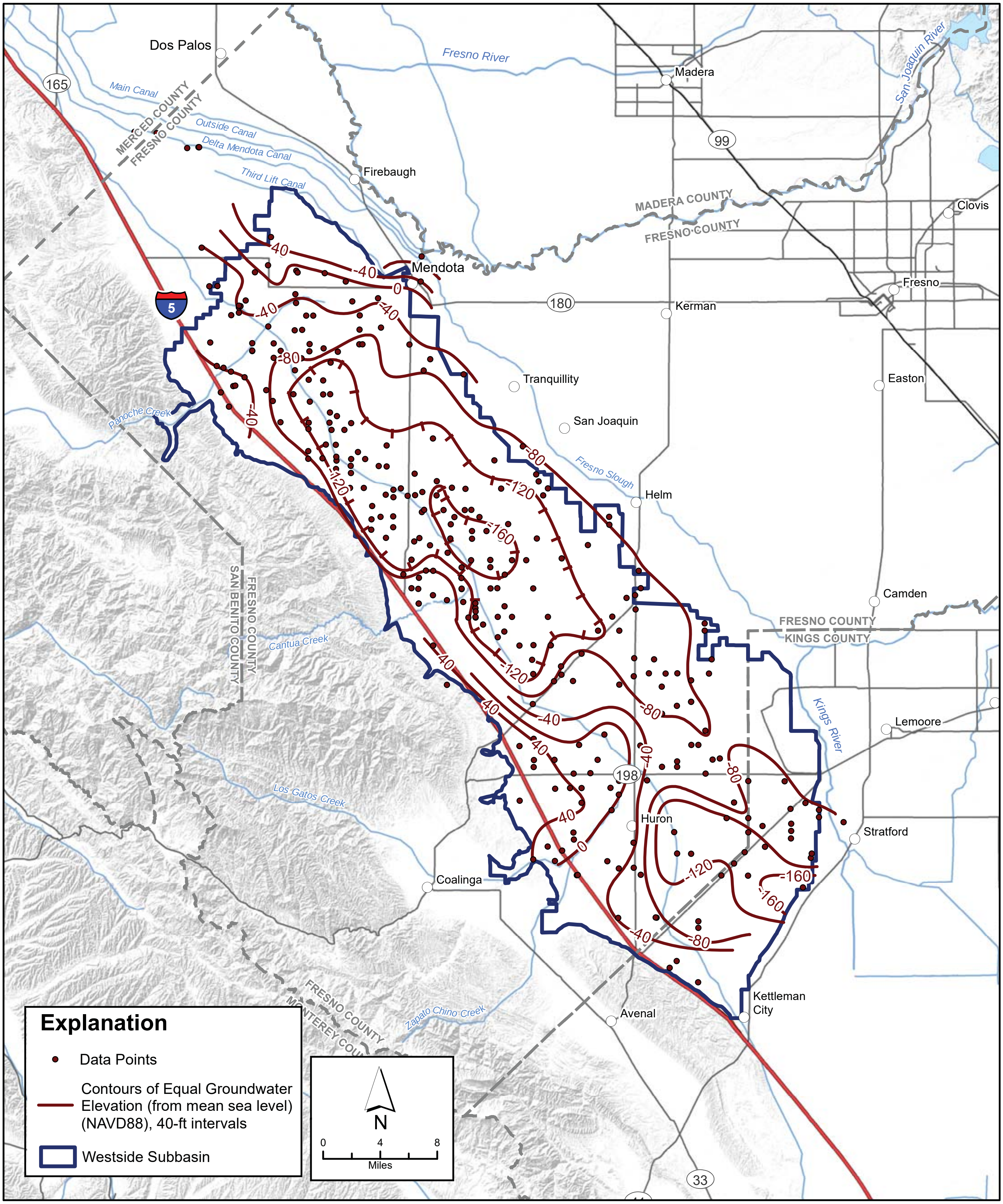
[1] See Appendix A for the complete text of the provisions of SGMA and the GSP Regulations (Code Regs., tit. 23, § 350, *et seq.*) cited herein.

Figure 4

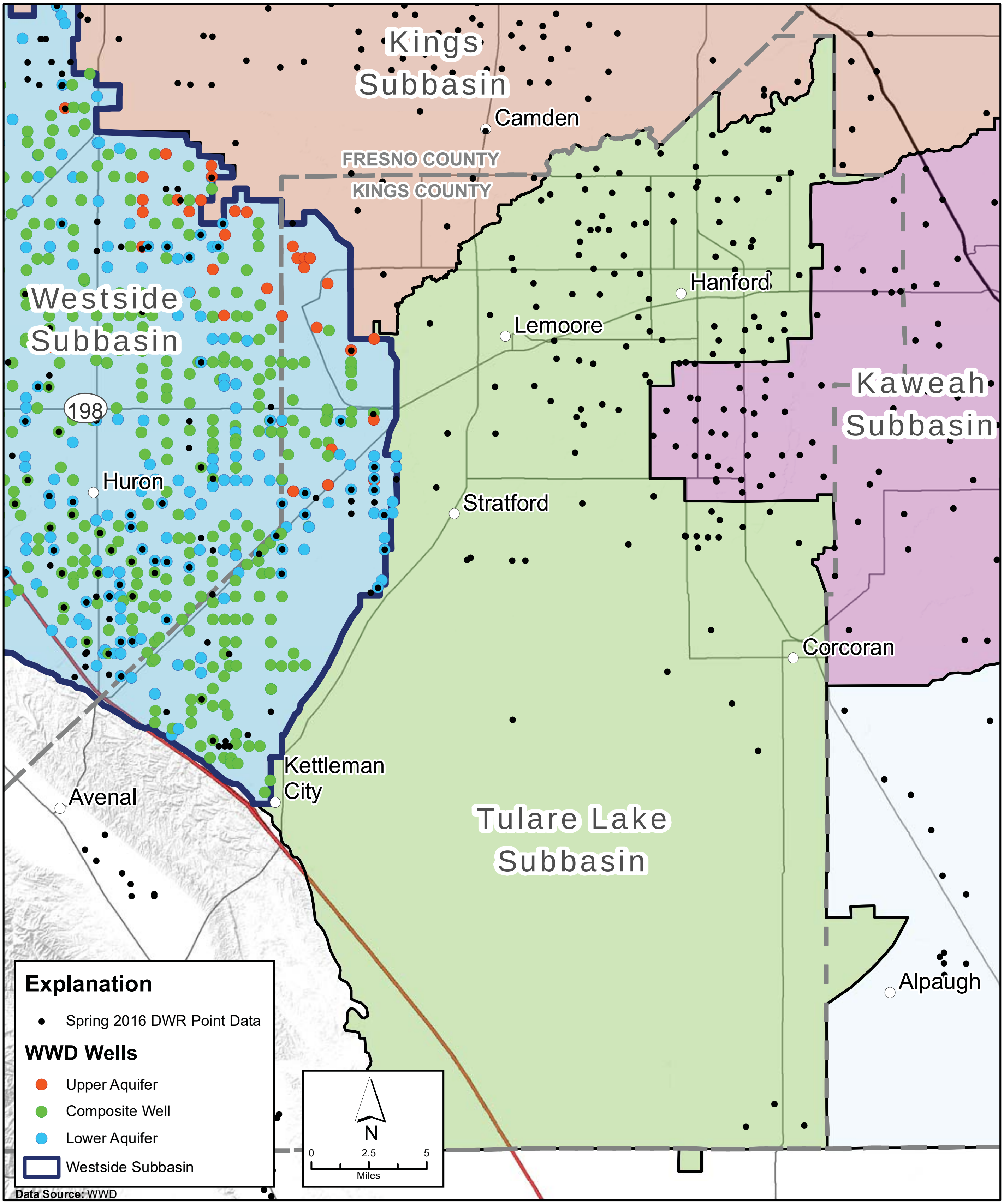


X:\2017\17-082 Westlands WD - GSP Support Services\GIS\MapFiles\Chapter_2\Figure 2-40.mxd

Luhdorff & Scalmanini
Consulting Engineers

FIGURE 2-40
Contours of Equal Groundwater Elevation
Lower Aquifer, Winter 2014/2015

Groundwater Sustainability Plan
Westside Subbasin



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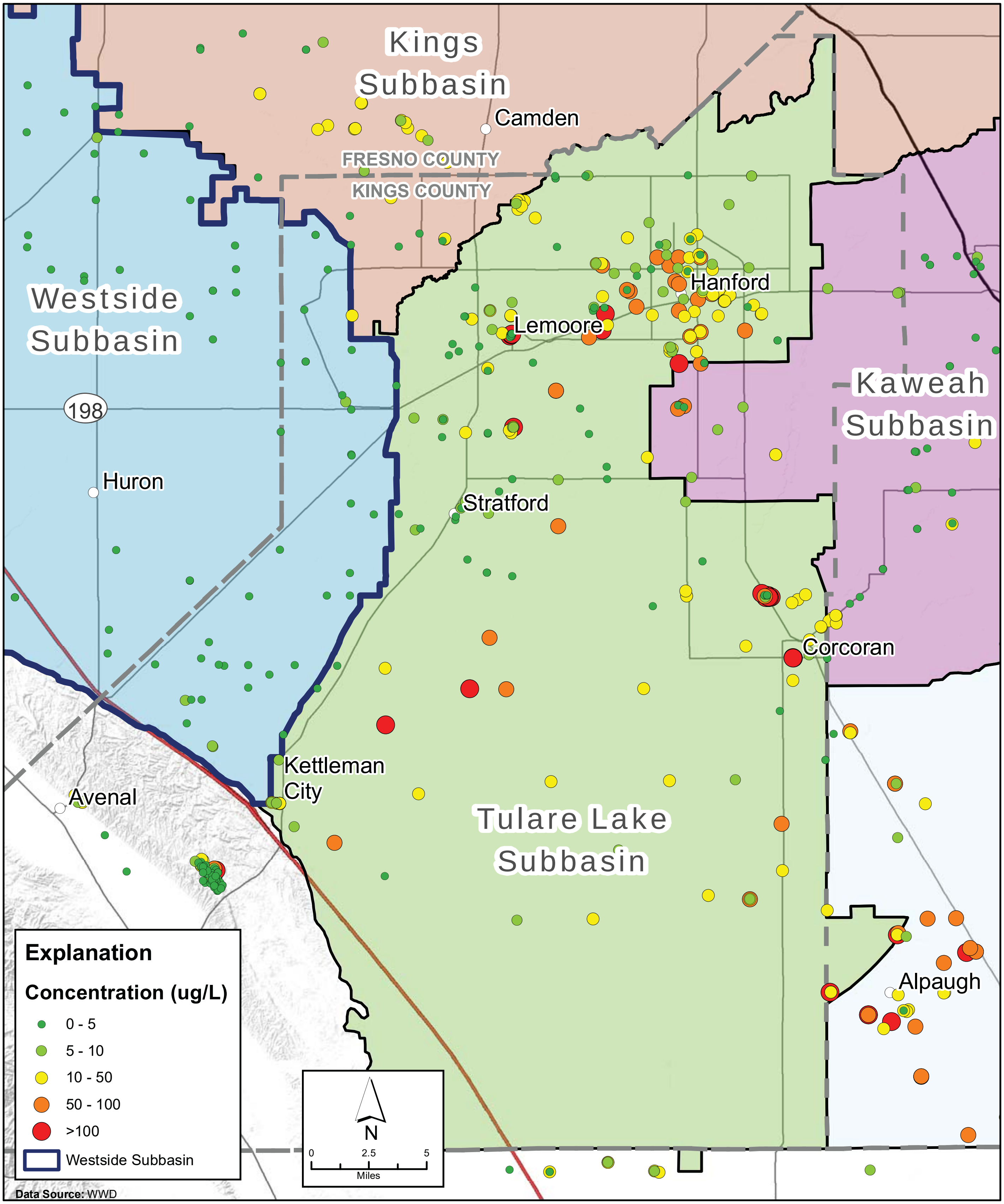
Luhdorff & Scalmanini Consulting Engineers

FIGURE 1

DWR Point Data Used to Develop Contours of the Unconfined Aquifer vs Westlands Well Construction

Groundwater Sustainability Plan
Westside Subbasin



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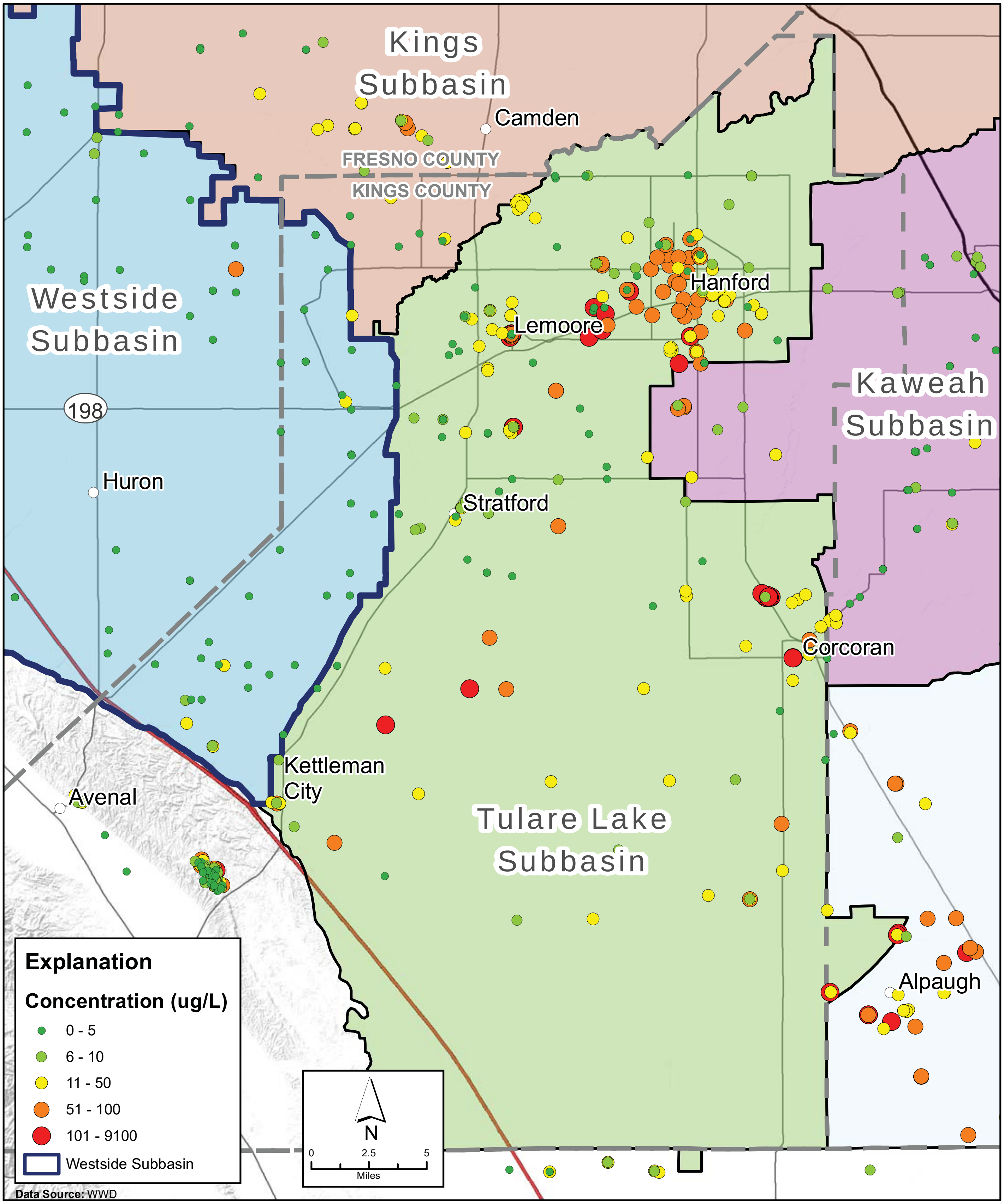
Luhdorff & Scalmanini
Consulting Engineers

FIGURE 2
Arsenic Concentration in Groundwater Wells
Most Recent Reported Value

Groundwater Sustainability Plan
Westside Subbasin



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Luhdorff & Scalmanini
Consulting Engineers

FIGURE 3
Arsenic Concentration in Groundwater Wells
Maximum Reported Value

Groundwater Sustainability Plan
Westside Subbasin

Westlands Water District
3130 N. Fresno Street, P.O. Box 6056, Fresno, California 93703-6056, (559) 224-1523, FAX (559) 241-6277

December 2, 2019

South Fork Kings Groundwater Sustainability Agency
Kings Subbasin
Basin Number 5-22.08
Transmitted via online submission at: comments@southforkkings.org

Subject: Tulare Lake Subbasin Draft Groundwater Sustainability Plan

Dear South Fork Kings GSA Group:

Westlands Water District ("Westlands GSA") appreciates the opportunity to provide comments on the Tulare Lake Subbasin Draft Groundwater Sustainability Plan ("Draft GSP"). The Westlands Groundwater Sustainability Agency ("GSA") respectfully submits the following comments.

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Subbasins. The potential for curtailing historic underflow into the Westside Subbasin may be a substantial factor in contributing to significant and unreasonable subsidence and frustrate the Westlands' GSA ability to achieve the sustainability goal.

Finding 6 (Page 4-21): Section 4.5.33 Land Subsidence references Table 4-2: *Lemoore-Average Land Subsidence Interim Milestones based on Measurable Objectives for the Subbasin,* which displays modeled subsidence rates and interim milestones for those subsidence rates. The Tulare Lake Subbasin also proposes a minimum threshold of 16 ft by 2040 in Section 4.4.1.3.

Westlands' Comment: Westlands GSA is concerned that allowing subsidence rates as proposed may impact critical infrastructure such as roads, railroads, and may increase flood risks to existing land uses, especially near Corcoran where subsidence rates are critical, in the Westside Subbasin and other neighboring subbasins. Westlands GSA strongly recommend selecting Measurable Objectives and Minimum Thresholds to subsidence rates that will not negatively impact infrastructure in neighboring subbasins. The GSP fails to reference any substantial evidence that the minimum threshold will avoid significant and unreasonable land subsidence that impairs surface uses in the Westside Subbasin.

Finding 7 (Appendix D): The information provided in the GSP suggests a conceptual error leading to flows between the Westside Subbasin and Tulare Lake Subbasin to be misrepresented in the numerical model and GSP. Figure D5-5 in Appendix D shows the average model simulated net lateral subsurface flow of 158,405 AFY from the Lower Aquifer to the general head boundary (GHB) in the Westside Subbasin. Contours of simulated Lower Aquifer groundwater levels from 2015 in Figure D5-3 show a cone of depression along the GHB in the Westside Subbasin. Figure D5-5 shows pumping from the Lower Aquifer is a net positive suggesting that intraborehole flow from the Upper Aquifer to the Lower Aquifer is greater than the amount extracted from wells, suggesting the GHB is driving the flow across the boundary between the Westside and Tulare Lake Subbasins and out of the Westside Subbasin.

Westlands' Comment:
Lower Aquifer contours developed from water level data at the end of the 2014 irrigation year (one year before the simulated contour data provided) do not show a cone of depression in the location of the GHB (**WWD Attachment: Figure 4**). These contours also cannot be interpreted to suggest that groundwater flow is from the Tulare Lake Subbasin to the Westside Subbasin. Furthermore, it is unclear what physical process would cause a localized cone of depression to form in this location, especially considering that the groundwater model simulates positive net pumping from the Lower Aquifer in the Westside Subbasin.

The analysis is not supported by substantial evidence and for the reasons set forth above, Westlands recommends reanalyzing the water level contour data from the numerical model and GSP.

Lastly, the Westlands GSA identified the following reporting discrepancies within the text of the GSP and Appendix D that should be reviewed:

1. Total lateral subsurface inflow into the Westside Subbasin shown in Figure D5-5 averages 72,296 AFY (67,347 from the Tulare Lake Subbasin and 4,948 AFY from the Kings Subbasin). Table 3-6 of the GSP shows average annual subsurface flow from the Tulare Lake Subbasin to the Westside Subbasin of 41,390. What is the source of this discrepancy?

2. In the graphic depicting aquifer specific fluxes in Figure D5-5, the sum of the "Net GW Flux" (which presumably is lateral subsurface flow between adjacent subbasins) totals 4,936 AFY while the total in the table shown in Figure D5-5 is 72,296 AFY. What is the source of this discrepancy?

3. Figure numbers in the Appendix D text do not correspond to the correct figures. Figure D5-10 is titled "Simulated Subsidence 1990-2016". Figure D5-8 shows "Groundwater Mass Balance Tule Subbasin".

Westlands' General Comment: The GSP Regulations include a provision authorizing GSAs in adjacent basins to enter into interbasin agreements. The interbasin agreements can "establish compatible sustainability goals" and be included in GSPs to "support a finding that implementation of the Plan will not adversely affect an adjacent basin's ability to implement its Plan or impede the ability to achieve its sustainability goal." (Code Regs., tit. 23, § 357.2.)[1] The interbasin agreements may also address: (1) "an estimate of groundwater flow across basin boundaries;" (2) how the GSAs will reconcile differing minimum thresholds and measurable objectives in the basins to avoid undesirable results; and (3) a process for resolving conflicts between the GSAs. (*Id.*) Given the potential reduction of historical cross-boundary flow attributable to the planned operation with the Tulare Lake Subbasin Draft GSP, Westlands strongly recommends that we meet and confer at the earliest opportunity to determine whether an interbasin agreement can be reached. Our intention is to reach a cooperative resolution of these important issues that will enable coordinated sustainable management in our GSAs.

If you have any questions or concerns, regarding these comments, please contact Kiti Campbell by email at kcampbell@wwd.ca.gov or by phone at (559) 241-6226. Thank you for the opportunity to provide comments on the Tulare Lake Subbasin Draft GSP.

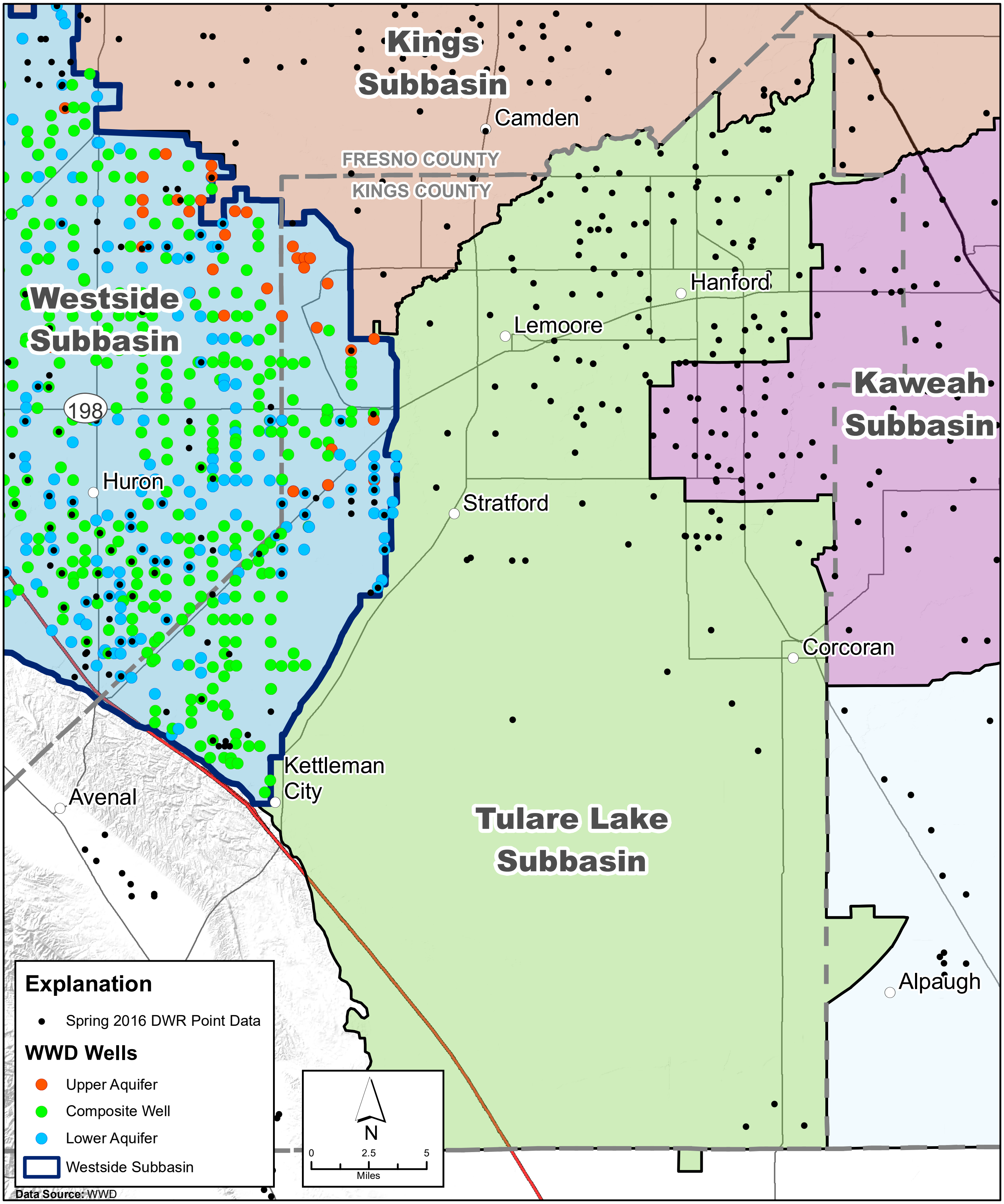
Sincerely,

Russ Freeman

Russ Freeman, P.E.
Deputy General Manager – Resources
Westlands Water District

---

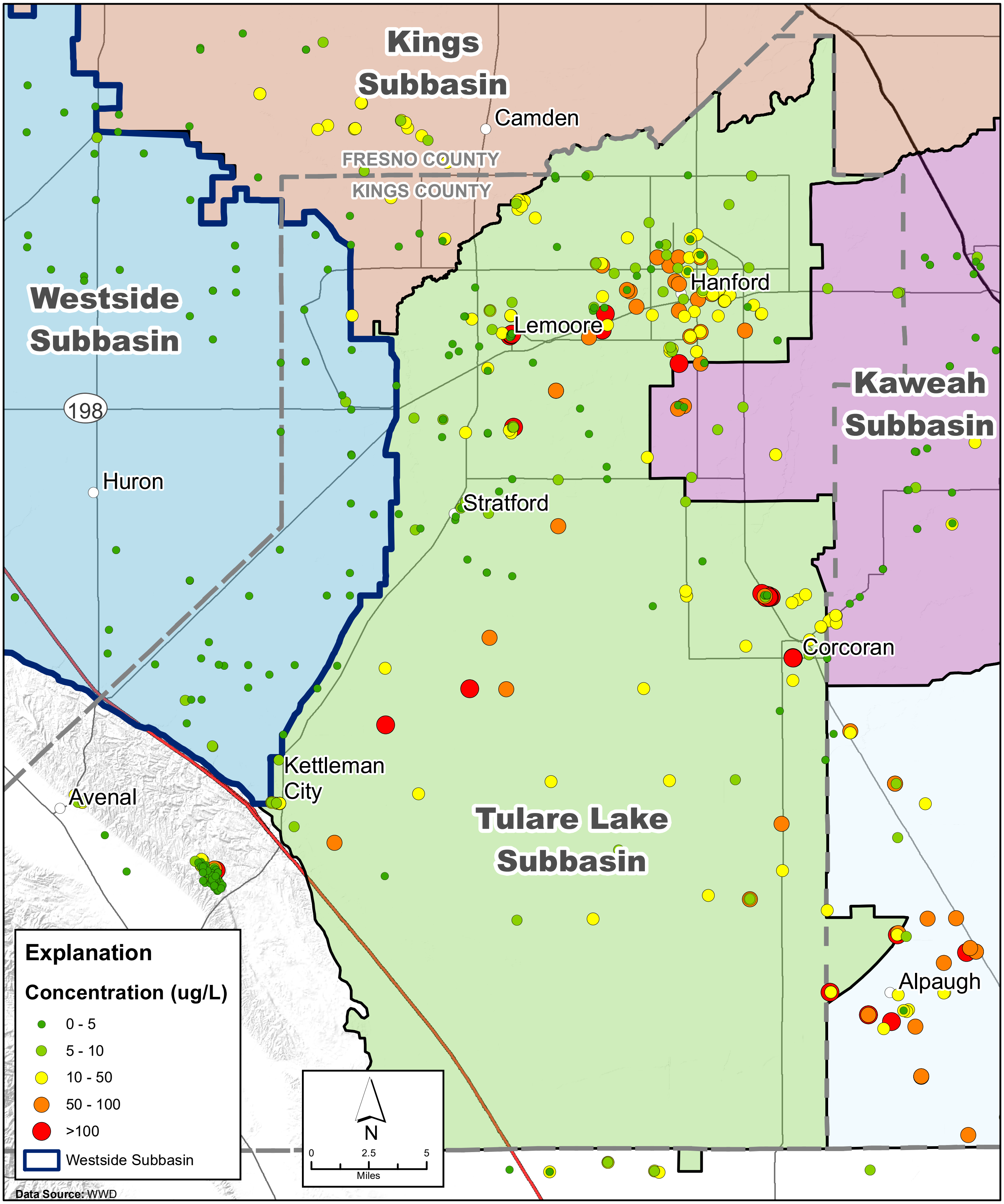
[1] See Appendix A for the complete text of the provisions of SGMA and the GSP Regulations (Code Regs., tit. 23, § 350, *et seq.*) cited herein.



X:\2017\17-082 Westlands WD - GSP Support Services\GIS\MapFiles\CommentLetters\TulareLake_WaterLevels.mxd

Luhdorff & Scalmanini
Consulting Engineers

FIGURE 1
DWR Point Data Used to Develop Contours of the Unconfined Aquifer vs Westlands Well Construction
Groundwater Sustainability Plan
Westside Subbasin



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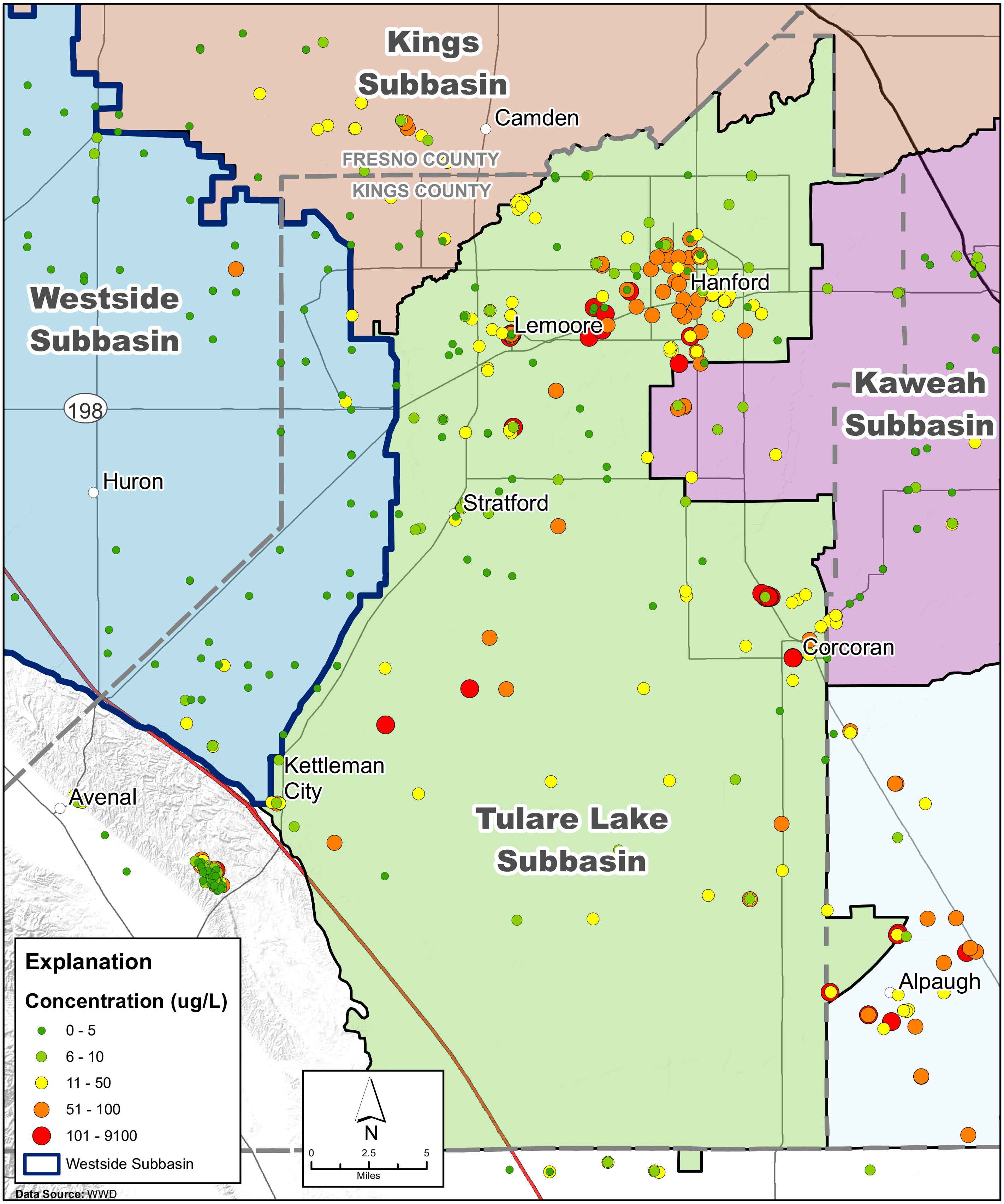
Luhdorff & Scalmanini Consulting Engineers

FIGURE 2
Arsenic Concentration in Groundwater Wells
Most Recent Reported Value

Groundwater Sustainability Plan
Westside Subbasin



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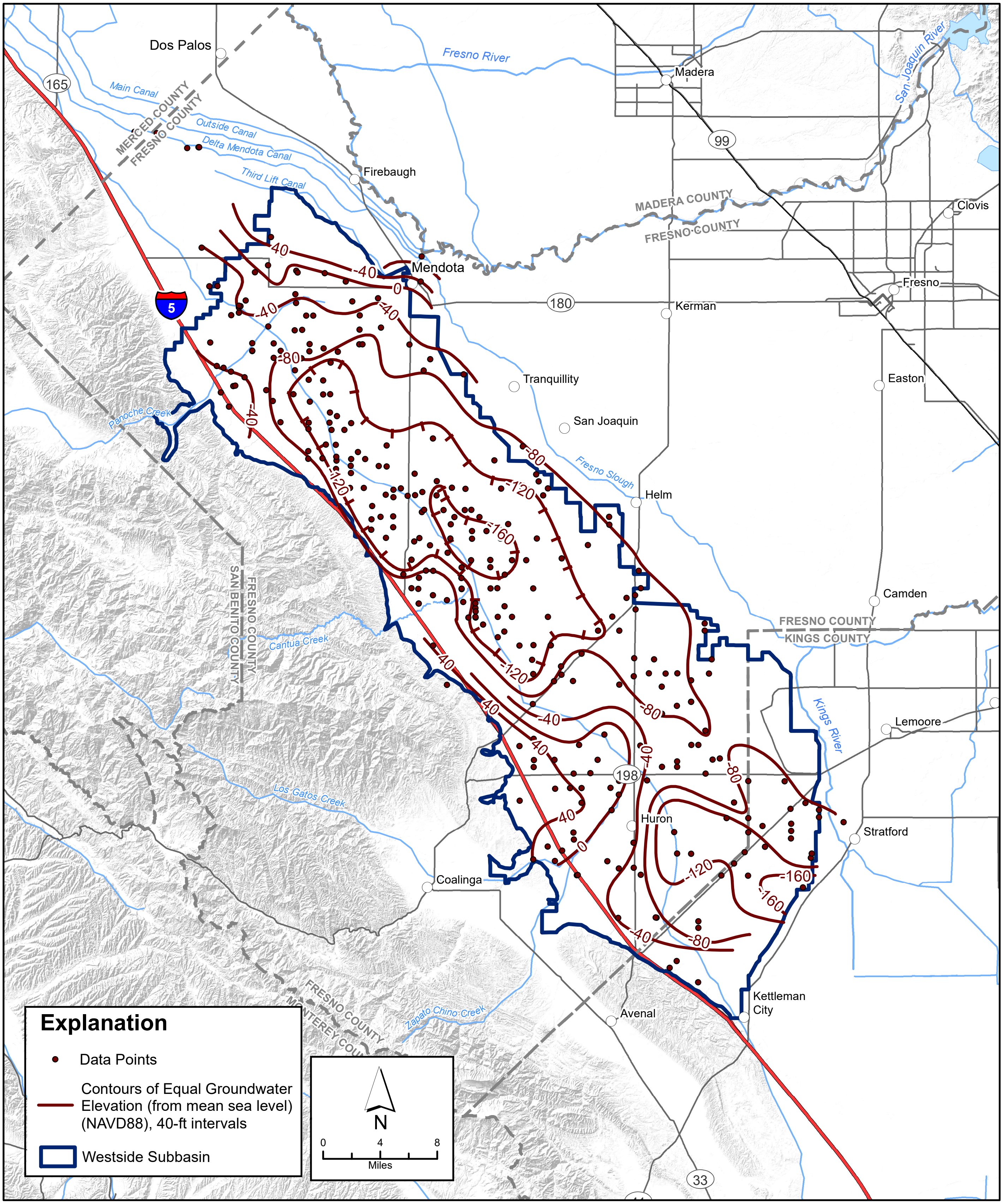
Luhdorff & Scalmanini
Consulting Engineers

FIGURE 3
Arsenic Concentration in Groundwater Wells
Maximum Reported Value
Groundwater Sustainability Plan
Westside Subbasin

Figure 4



X:\2017\17-082 Westlands WD - GSP Support Services\GIS\MapFiles\Chapter_2\Figure 2-40.mxd

Luhdorff & Scalmanini
Consulting Engineers

FIGURE 2-40
Contours of Equal Groundwater Elevation
Lower Aquifer, Winter 2014/2015

Groundwater Sustainability Plan
Westside Subbasin

DOUG VERBOON
Supervisor
District 3

BOARD OF SUPERVISORS
Kings County Government Center
Hanford, CA 93230
Phone (559) 852-2366
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December 2, 2019

Via Hand Delivery

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Re: Comments on the Tulare Lakes Subbasin Groundwater Sustainability Plan

Dear Messrs. and Madams:

I am writing as a duly elected Supervisor for the County of Kings (the "County") and not on behalf of the Board of Supervisors. I am also writing on behalf of the other signatories to this letter, who care as deeply as I do about the issues raised in the Tulare Lakes Subbasin Groundwater Sustainability Plan (the "GSP") that has been proposed and is subject to this public hearing. I am submitting my comments and proposed changes in writing so that they may be incorporated into the GSP prior to its submission to the State Department of Water Resources ("DWR") by January 31, 2020.

Procedural Defects

The Groundwater Sustainability Agencies addressed above ("GSAs") issued a notice on September 3, 2019 for the December 2, 2019 public hearing to comment on the GSP. The narrative part of the GSP – approximately 500 pages – was not issued until three days later, on September 6, 2019. The Appendix D to the GSP – the Water Modeling Report – and the Water Model itself were not released to the public for review until October 17th, 2019, a month and half later. Even though the County requested to, and did, coordinate with the GSAs on Wednesday, November 6th, the GSAs' delay in getting the complete GSP out for the full 90-day review period set out in Section 10728.4 of the Water Code impeded any serious review and feedback on the GSP.

Under Section 10728.4, you were required to provide the County – and, consequently, the public – with at least 90-days written notice of the public hearing at which you planned to adopt the GSP. When the GSAs were told their "notice" was inadequate because of the lengthy delay in issuing the entire GSP, the responses have typically been two-fold: First, they claim the statute is ambiguous as to what it meant by "notice" of the public hearing. In other words, the statute does not say with specificity that the GSP had to be released at the same time as the notice. The second response has been, "Well, you'll get to comment at the State level once the GSP is lodged with the State in January, so it shouldn't matter whether you had adequate opportunity to comment now." Neither of these responses excuses the GSAs from giving the County and its water users a full opportunity to review and comment on the draft GSP.

For public notice to be effective, it must satisfy the requirements of administrative due process. Federal and California courts have ruled over the last half-century that adequate notice must be "reasonably calculated, under all the circumstances, to apprise the interested parties of the pendency of the action and afford them an opportunity to present their objections . . . ." (*Mullane v. Cent. Hanover Bank & Trust Co.* (1950) 339 U.S. 306, 314.) Furthermore, the notice must "convey the required information" within "a reasonable time for those interested" to be heard "at a meaningful time and in a meaningful manner." (See *id;* see also *Mathews v. Eldridge* (1976) 424 U.S. 319, 333.) From these cases and others, it is clear that the September 3rd notice needed to include at least 90-days written notice of the date, time, and location of the public hearing, as well as service of the entire GSP.

Second, regardless of whether the County or anyone else has an opportunity to comment to the State on the final GSP submission, it was the legislature's intent that all interested parties have a meaningful opportunity to comment *before* it was submitted to the State. At least the legislature believed that the GSAs should be given the benefit of substantive input on the GSP before they submitted it. Unfortunately, the GSAs' delay in getting the draft GSP prepared in time for any substantive review, feedback and opportunity to revise the draft GSP in response to the public's comments has compromised the successful adoption and implementation of the GSP.

Project Vagueness

One of the most important parts, in my view, of a successful GSP is convincing the State that the GSAs are committed to creating a sustainable source of groundwater for the region and that they can be trusted to implement an approved GSP. I am concerned that the purported "projects" set out in the GSP are too vague and non-committal and, consequently, won't convince the State to defer to the GSAs when it comes to groundwater sustainability. If the State rejects the GSP as being too vague – or for any other reason – the Sustainable Groundwater Management Act ("SGMA") makes clear that the State will take over our groundwater management and local control of that essential water resource will be history.

I attended the October 22nd, 2019, Board of Supervisors meeting when Dennis Mills addressed the Board and stated openly that the GSAs had made a judgment decision to keep the description of the GSP's proposed projects vague; he said the GSAs didn't want to commit to any specific projects in case, on further review, it was determined a project was not viable. I was also part of the delegation from the County that met with the GSAs on November 6th to consult on the draft GSP. As we discussed whether the GSAs had considered certain elements of certain projects, such as CEQA requirements, Dennis stated that none of the GSA Boards had committed to any of the projects in the GSP. The fact that the GSA Boards haven't committed to doing anything (other than perhaps a groundwater monitoring program) as part of the GSP process is not going to instill confidence in the State and I'm concerned it could lead to the State's rejection of the GSP. The "projects" that have been proposed in the GSP should be firmed up as much as possible before the plan is submitted in January.

Land Fallowing Project

Finally, and most importantly, I am very concerned about the GSP proposal to fallow significant amounts of land within the County so as to cut agricultural demand for groundwater by at least 25 percent in 12 years. When we spoke with the GSAs during the November 6th consultation meeting, Jeof Wyrick confirmed that the GSP model incorporated an assumption that two percent (2%) of the land in the subbasin – not even spread out over the entire County – would be fallowed each year until we met the 2040 compliance deadline. If that is pursued, it would result in approximately 220,000 acres of agricultural land being fallowed. A good portion of that fallowed land would have to be permanent tree crops, which would result in the destruction of a significant amount of the value of the land (as they have to be irrigated every year) as well as the County's tax base.

During our consultation meeting, Jeof said that the water model consultants had erroneously incorporated the two percent (2%) assumption into the model, thus, overstating the amount of land to be fallowed as a result of GSP implementation. He said the GSP was going to be revised to incorporate an assumption of one percent (1%) per year fallowing that would result in "only approximately 100,000 acres" in the GSAs' boundaries being fallowed. I have no idea whether that has been done already or if it actually will be done before the GSP is submitted to the State. That amount of fallowed land is certainly less by half than what was previously projected, but when there are only approximately 420,000 acres of agricultural land within the GSAs' boundaries, that is an unacceptable level of fallowing both to the farmers whose land would be fallowed and, I believe, to the residents of the County. This 25 percent of total agricultural land fallowing is consistent with representations that the GSAs made publicly at the public outreach meeting in Lemoore, California, on October 15, 2019.

I was also surprised when Jeof said at our consultation meeting that implementation of the GSP was really "farmer versus farmer warfare" and that what was going to happen is "private adjudication of water rights in a public forum" (*i.e.*, before the GSAs). We all know what's going to happen when the few large farm and agricultural interests in the County go after the small, family-owned farms: The small farms are going to lose. I'm going to do everything in my power as a member of the Board of Supervisors to make sure that doesn't happen.

For this reason alone, the GSP should be revised to clarify that land fallowing in Kings County will be deployed only as a last resort after every other possible means of demand reduction and water recharge have been fully implemented and only at the minimal levels absolutely necessary to achieve sustainability. It is important to have survivability for the small farmer so that he can be competitive with the large corporate famers when it comes to ground water pumping. The Tulare Lake Subbasin will never achieve sustainability if the exported ground water from the subbasin to surrounding areas in the region is left unaddressed.

I am available to answer questions and discuss these concerns.

Sincerely,

Doug Verboon

DOUG VERBOON
Supervisor

Name: Jerome Warmerdam
Business: Warmerdam Walnut Co.

Name:
Business: Casaca Vineyards

Name: Stanley Neves
Business: Golden Valley Farms

Name: Eddie Warmerdam
Business: Warmerdam Farms

Name:
Business: Trinity Ranches LLC

Name: Cornelius Warmer
Business:

Name: Rocky Silveira
Business: 4-B Farms

Name:
Business: Simba Farms

Name: Eddie N. Warmerdam
Business: ENW Farms Inc

Name:
Business: Millers Rentaland Inc

Name: Tim Parolini
Business: Parolini Farms

Name: Doug Wisecarver
Business: Wiscarver Farms

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Memorandum

To:	Tulare Lake Subbasin GSAs' Managers and Technical Team
From:	Trilby Barton, Public Outreach Coordinator, Provost & Pritchard
Subject:	Tulare Lake Subbasin GSAs' Groundwater Sustainability Plan Public Hearing Comments
Date:	December 2, 2019

December 2, 2019 Draft GSP Public Hearing Recap

The Tulare Lake Subbasin Groundwater Sustainability Agencies (GSAs) held a public hearing on the Draft Groundwater Sustainability Plan (GSP) on December 2, 2019. The hearing was held in the County of Kings Board of Supervisors' Chambers, and was called to order at 10:01 a.m. by Mid-Kings River GSA Manager, Dennis Mills.

Mr. Mills introduced himself and the other four GSA managers: Deanna Jackson with Tri-County Water Authority, Dale Melville with Southwest Kings GSA, Jeof Wyrick with El Rico GSA, and Charlotte Gallock with South Fork Kings GSA. Mr. Mills also introduced Trilby Barton, public outreach consultant with Provost & Pritchard Consultant Group. Mr. Mills and Ms. Barton explained the process for the public hearing, and Mr. Mills opened the floor for public comments.

Twenty stakeholders were in attendance, and one public comment was provided:

- **Bill Toss, Grower in Mid-Kings River GSA**
  "Reading through the plan that is available, the only thing that really struck out to me was the 25 percent set aside for reduction. That of course is most likely very damaging, and would not be sustainable economically here for Kings County or for us as growers. I hope that there is a change to that, and to make sure that is not the status quo."

Upon seeing that no other stakeholders wanted to provide oral comments, Mr. Mills thanked everyone for attending and closed the public hearing at 10:06 a.m.

APPENDIX D

GROUNDWATER MODEL REPORT

Tulare Lake Subbasin Hydrologic Model for Groundwater Sustainability Plan Development: Calibration and Predictive Simulations

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Prepared for:
Mid-Kings River Groundwater Sustainability Agency
Hanford, California

January 8, 2020
Project FR18161220

wood.

Tulare Lake Subbasin Hydrologic Model for Groundwater Sustainability Plan Development: Calibration and Predictive Simulations

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Prepared for:

Mid-Kings River Groundwater Sustainability Agency
200 North Campus Drive
Hanford, California 93230

Prepared by:

Wood Environment & Infrastructure Solutions, Inc.
1281 East Alluvial Avenue, Suite 101
Fresno, California 93720
T: 559-264-2535

January 8, 2020
Project FR18161220

Professional declaration

This document was prepared by Wood staff under the supervision of Geologist whose seal and signature appear hereon. The findings, recommendations, specifications, or professional opinions presented in this document were prepared in accordance with generally accepted professional geologic practice and within the scope of the project. No other warranty, express or implied, is provided.

David M. Bean, PG, CHg
Principal Hydrogeologist

PROFESSIONAL GEOLOGIST
David M. Bean
No. HG-606
CERTIFIED HYDROGEOLOGIST
STATE OF CALIFORNIA

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Abbreviations and Acronyms

%	percent
AF	acre-feet
AF/D	acre-feet per day
AF/M	acre-feet per month
AF/Y	acre-feet per year
bgs	below ground surface
CID	Corcoran Irrigation District
CT	Critical Thresholds
CVHM	United States Geological Survey Central Valley Hydrologic Model
CVP	Central Valley Project
DWR	California Department of Water Resources
ER GSA	El Rico Groundwater Sustainability Agency
ETc	Crop Evapotranspiration
ft/d	feet per day
ft^2/d	square feet per day
ft/m	feet per month
GHB	General Head Boundary
GSAs	groundwater sustainability agencies
GSP	Groundwater Sustainability Plan
GUI	Graphic User Interface
GWV	Environmental Simulations Inc.'s Groundwater Vistas™ Version 7 simulation code GUI
HCM	hydrogeologic conceptual model
K	hydraulic conductivity
f_c	coarse fraction
KCWD	Kings County Water District
K_h	horizontal hydraulic conductivity
K_v	vertical hydraulic conductivity
MKR GSA	Mid-Kings River Groundwater Sustainability Agency
MO	Monitoring Objective
MODFLOW	USGS Modular finite-difference family of numerical simulation codes
NRMS	Normalized root mean square error
MNW2	Version 2 of the MODFLOW multi-node well package
msl	mean sea level
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RMS	root mean square
SFK GSA	South Fork Kings Groundwater Sustainability Agency
SSR	sum of the square of the residuals
S_s	specific storage
S_y	specific yield
Subbasin	Tulare Lake Subbasin
SGMA	Sustainable Groundwater Management Act of 2014
SWK GSA	Southwest Kings Groundwater Sustainability Agency
SWP	State Water Project
TCWA GSA	Tri-County Water Authority Groundwater Sustainability Agency
TLSBHM	Tulare Lake Subbasin Hydrologic Model
USGS	United States Geological Survey
WD	Water District
Wood	Wood Environment & Infrastructure Solutions, Inc.

1.0 Introduction

Wood Environment & Infrastructure Solutions, Inc. (Wood), has been retained by the Mid-Kings River Groundwater Sustainability Agency to prepare and document a hydrologic flow model of the Tulare Lake Subbasin (Subbasin) to aid local agencies in compliance with the Sustainable Groundwater Management Act of 2014 (SGMA). The Subbasin is located primarily in Kings County, within the Tulare Lake Hydrologic Region of the San Joaquin Valley, California (Figure D1-1). This project is a cooperative effort among five Groundwater Sustainability Agencies (GSAs) within the Subbasin including: Mid-Kings River GSA (MKR GSA), El Rico GSA (ER GSA), South Fork Kings GSA (SFK GSA), Southwest Kings GSA (SWK GSA), and Tri-County Water Authority GSA (TCWA GSA). Although the Subbasin is the primary focus of this modeling study, the modeling effort encompasses portion of adjacent California Department of Water Resources (DWR)-defined groundwater subbasins including the Kings, Kaweah, Tule, Kern, and Westside subbasins.

1.1 Background

Included as part of SGMA was a requirement that the DWR identify groundwater basins and subbasins in conditions of critical overdraft. As defined by DWR, overdraft occurs where the average annual amount of groundwater extraction exceeds the long-term average annual supply of water to the basin. Effects of overdraft can include land subsidence, groundwater depletion, and/or chronic lowering of groundwater levels. DWR Bulletin 118 defines critical overdraft as "when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts."

Based on this criterion and a formal evaluation of groundwater basins across the state, the DWR found much of the Tulare Lake Hydrologic Region to be one of the most critically over-drafted regions of the state. The Subbasin sits at the lowest point of the Tulare Lake Hydrologic Region and receives both surface water inflows from several rivers and streams (including Kings River, Kaweah River, Tule River, and Deer Creek) and the State Water Project (SWP), but also irrigation return flows (tailwater) draining from irrigated lands. Nonetheless, in most years, especially during frequent drought cycles, agricultural water demand exceeds the surface water inflows, leading to the drilling of wells to develop the groundwater resources to fulfill that unmet demand. In fact, under recent historical conditions, the average annual demand on groundwater resources significantly exceeds the average existing recharge to the groundwater system, leading the DWR to declare the Subbasin critically over drafted, triggering the need to develop a Groundwater Sustainability Plan (GSP) by January 31, 2020, per SGMA requirements.

The Tulare Lake Subbasin Hydrologic Model (TLSBHM) developed for this project provides a quantitative tool for development and evaluation of alternative water management scenarios considered for the GSP. Additional model development and calibration will occur throughout the implementation of the GSP as additional data are collected.

1.2 Modeling Objectives

The objectives of the current modeling efforts were to:

1. Prepare a three-dimensional numerical surface water/groundwater flow model of the Subbasin and portions of adjoining subbasins.

2. Calibrate the surface water/groundwater flow model for the period 1990-2016, with a focus on the "normal hydrology" period 1998 through 2010, for initial calibration using available groundwater elevation observations and stream flow observations.
3. Provide a Baseline Forecast from 2017-2070 assuming continued recent land use and continued 1998 through 2010 "normal hydrology" conditions modified to account for climate change. This forecast was utilized to establish Critical Thresholds (CT) and Monitoring Objectives (MO) throughout the Subbasin.
4. Provide a Projects Forecast from 2017-2070 assuming continued recent land use, continued 1998 through 2010 "normal hydrology" conditions as modified to account for climate change, and additional Surface Water Supply and Aquifer Recharge resulting from several projects assumed to be implemented throughout the Subbasin and adjoining subbasins.
5. Compare the Baseline and Projects forecasts and estimate what additional projects and management actions (such as land fallowing) may be required to obtain sustainability by 2040 and thereafter.

2.0 Hydrogeologic Conceptual Model

A hydrogeologic conceptual model (HCM) is a simplified description of the groundwater flow system, frequently in the form of a block diagram or cross-section with an accompanying narrative description of the function and interaction of the various components that comprise the hydrogeologic system (Anderson et al., 2015). The nature of the HCM determines the dimensions of the numerical model and the design of the grid, the distribution of the hydrogeologic properties, and the definition and distribution (over space and time) of external and internal stresses and boundary conditions. The purpose of the HCM is to establish an initial understanding of the groundwater system and organize the associated data and information so that the system can be analyzed more effectively.

Figure D2-1 presents block diagrams that schematically represents key aspects of the HCM for the TLSBHM under both pre-development and current conditions. Details related to this HCM for the project include: (1) description of the model domain, (2) delineation of the hydrostratigraphic units within the model domain, (3) definition of sources and sinks and estimation of the water budget, and (4) narrative description of the flow system. Each of these items are discussed in the following subsections.

2.1 Basin Location and Study Area

The Subbasin is located primarily in Kings County in the Tulare Lake Hydrologic Region of the San Joaquin Valley, California (Figure D2-2). The Subbasin covers an area of approximately 535,869 acres or about 837 square miles (DWR, 2016b). The Subbasin in bounded by the Kings Subbasin to the north, the Kaweah Subbasin to the northeast, the Tule Subbasin to the southeast, the Kern Subbasin to the south, the Kettleman Plain Subbasin to the southwest, and the Westside Subbasin to the northwest.

As shown on the figure, the study area extends beyond the official Subbasin boundaries (as delineated by the DWR) from 3 to 6 miles into adjacent subbasins to better evaluate interactions with groundwater in those adjacent areas. The study area includes approximately 151,880 acres (~237.3 square miles) of the Kaweah Subbasin, approximately 119,360 acres (~186.5 square miles) of the Kings Subbasin, approximately 126,600 acres (~197.8 square miles) of the Tule Subbasin, approximately 81,760 acres (~127.8 square miles) of the Westside Subbasin, and approximately 78,000 acres (~121.8 square miles) of the Kern Subbasin.

The vertical extent of the study area is the freshwater hydrogeologic system, based on the United States Geological Survey (USGS) Central Valley Hydrologic Model (CVHM; Faunt et al., 2009), and modified to be consistent with the findings of Tulare Lake Bed de-designation studies (RWQCB, 2017). The depth zones that comprise the freshwater hydrogeologic system extend to a depth of about 3,000 feet below ground surface (bgs), but not reaching down into the deeper confined saline groundwater below.

2.2 Topography

The Subbasin and surrounding area is generally located in the lowest portion of the San Joaquin Valley (Figure D2-3). Ground surface gently rises to the northeast from about 180 feet above mean sea level (msl) at the Tulare Lake bottom to about 300 feet above msl near Kingsburg. To the southwest, ground surface rises rapidly from the Tulare Lake bottom to about 500 feet near the Kettleman Hills. To the south, ground surface gently rises from the lake bottom to about 220 above msl at the Kern County line.

2.3 Geology

The Subbasin is located in the south-central portion of the greater San Joaquin Valley. The valley was formed generally as a structural trough subsiding between two uplifts: the tectonically driven tilted block of the Sierra Nevada and the thrust belts of the Coast Ranges created by crustal shortening east of the San Andreas fault.

Episodic intrusion of the Pacific Ocean through land gaps along the northern and southern boundaries of the San Joaquin Valley occurred during Miocene and Pliocene times, allowing deposition of marine sediments to accumulate in the subsiding shallow sea environment of the San Joaquin basin. These deposits were subjected to deformation as the Sierra Nevada rose on the east and Coastal Range rose to the west and the valley trough subsided. The marine deposits are exposed in the west-side thrust belts, which typically reach elevations of 2,000 feet or less. Beneath the San Joaquin Valley, the top of the marine deposits are typically 3,000 feet or more below the valley floor, rising on the southeastern portion of the valley to cap the igneous rocks of the uplifted Sierra foothills.

As the land gaps closed in the mid-Pliocene, the continued uplift of the Sierra Nevada and Coast Ranges shed continental deposits to the San Joaquin Valley. These continental deposits, typically assigned to the Plio-Pleistocene Tulare Formation, have filled the valley trough in places with more than 3,000 feet of sediments. Where Pleistocene geologic features periodically cut off the route of major rivers and tributaries to the sea, wide spread and sometimes extreme thicknesses of lacustrine sediments were deposited. Significant examples of these lacustrine deposits are the Tulare Lake Bed clays, the Buena Vista clays, and the Corcoran Clay (sometimes referred to as the E-Clay or modified E-Clay).

2.3.1 Tulare Formation – Continental Deposits

Various investigators in the San Joaquin Valley have assigned ages and names to what they have identified as formations in their respective study areas. The Plio-Pleistocene Tulare Formation, which has its type section on the eastern slope of the North Dome of the Kettleman Hills (Woodring et al., 1940), has been correlated stratigraphically with other valley formations such as the Laguna Formation in the northeast portion of the valley (Woodring et al., 1940) and Kern River formations in the southeast portion of the valley (Bartow, 1991).
In the Subbasin, the primary stratigraphic units containing usable groundwater include the Tulare Formation, older alluvium, and younger alluvium. The Tulare Formation is by far the thickest of these three. The bottom of the Tulare Formation has been defined by Woodring et al. (1940) as occurring just above the Mya interval of the primarily marine San Joaquin Formation, over which it conformably lies on

the North Dome, just northwest of the Tulare Lake bed. The Tulare Formation/San Joaquin Formation contact dips steeply eastward from the Kettleman Hills, lying more than 3,000 feet beneath the trough in the Tulare Lake area (Croft and Gordon, 1968). Woodring et al. (1940) have defined the Tulare as the uppermost continental deposits deformed by the folding associated with the Kettleman Hills. However, as noted by Davis et al. (1959), the upper contact of the Tulare Formation with younger continental deposits (older and younger alluvium) is not easily discerned because "at many places along the valley border the dips increase westward so gradually that only a rough separation can be effected between the valley alluvium and the Tulare Formation. Separation of the alluvium from the Tulare Formation beneath the valley is virtually impossible because of their lithologic similarity."

2.3.2 Lacustrine, Marsh, and Flood Deposits

In the Subbasin, Croft & Gordon (1968) identified a number of lacustrine clays in the subsurface that they correlated to lacustrine clays identified by Woodring et al. (1940) in the Tulare Formation in Kettleman Hills. Croft & Gordon (1968) identified these in geophysical logs and named them the A- through F-Clays, with the E-Clay being equivalent to the diatomaceous Corcoran Clay. Though the A- through D-Clays may be important locally in restricting downward movement of groundwater, by far the most important is the EC-Clay, which has been identified as a spatially extensive (about 3,500 square miles, Croft, 1972) and thick clay that separates regionally confined and unconfined groundwater zones in the southern San Joaquin Valley (Figure D2-4). The E-Clay has been age-dated as mid-Pleistocene and is considered part of the Tulare Formation (Croft & Gordon, 1968). Beneath the Tulare Lake bed, there is a thick, nearly homogeneous deposit of lacustrine clays from ground surface to the San Joaquin Formation, including the E-Clay. However, the E-Clay extends far beyond the shoreline of Tulare Lake (Croft, 1972).

2.3.3 Older and Younger Alluvium

The other continental deposits that have been identified in published reports as containing groundwater are the older and younger alluvium (Croft & Gordon, 1968). In the Tulare Lake area, these deposits are primarily Sierran in origin, being deposited by the major stream channels emanating from the Sierra Nevada. Some sediments may have Coast Range origin, but the axis of Tulare Lake bed is close to the Kettleman Hills, which leaves little room for Coast Range sediment deposition on the west side. The older alluvium is widespread throughout the San Joaquin Valley and in other areas represents deposition from both the Coast Ranges on the west side of the valley and the Sierra on the east. It typically overlies the Tulare Formation, though as mentioned earlier, there is no way to differentiate between the two in the subsurface. It is considered Pleistocene to Recent in age. Most of the groundwater withdrawn from the Subbasin comes from the older alluvium/Tulare Formation complex.

The younger alluvium is generally thinner than the older alluvium and is present in current stream channels and as a veneer over the older alluvium as the deposits stretch to the west. The younger alluvium is primarily arkosic and contains groundwater only ephemerally or where underlying clays tend to restrict downward movement of recharging water. It is considered of Recent age.

2.3.4 Tulare Lake Bed

The Tulare Lake bed is the prominent sedimentary feature in the Subbasin. It was a natural lake bed fed by streams from the east and south. Its elongate shape to the northwest reflects the subsidence of the valley trough east of the Kettleman Hills. Geologic cross sections through the Tulare Lake bed (Croft, 1972; Croft & Gordon, 1968; Davis et al., 1959) illustrate the thick and continuous nature of the clay deposits beneath the lake bed (Figure D2-5).

Cross-section A-A′ (Plate 4, Croft & Gordon, 1968) indicates uninterrupted lacustrine deposits from the surface to at least 2,200 feet bgs beneath the central portion of the lake. Cross-sections B-B′ and C-C′ (Plates 5 and 6, Croft & Gordon, 1968) illustrate the interfingering of the coarser sediments and the thinner clay zones along the periphery of the lake with the thick clay deposits beneath the lake. Though Croft & Gordon (1968) did not carry the E-Clay through the lake deposits, Davis et al. (1959, Plate 10, Section G-G′, Diatomaceous Clay) and Croft (1972, Plate 3, Section G-G′, E-Clay) felt they had enough evidence to map it beneath the lake. Davis et al. (1959) show it as being warped downward along the axis of the lake with a maximum thickness of 150 to 175 feet. These cross sections indicate the Tulare Lake deposits form a clay "plug" across the center of the San Joaquin Valley that may be 15 miles wide, 8 miles long, and over ½ mile deep at its maximum dimensions.

2.4 Hydrogeology

The hydrogeology of the Subbasin is complex in that the only physical boundaries are the Kings River and the Kettleman Hills on the southwest edge of the Subbasin. The remaining edges of the Subbasin are based on political and water management areas. The Corcoran Clay under lies most of the Subbasin, and essentially subdivides the Subbasin into two aquifer systems: an unconfined to semi-confined aquifer system above the Corcoran Clay and a confined aquifer system below the Corcoran Clay.

The Kings River appears to be a natural groundwater divide separating the Subbasin and Kings Subbasin. The Kings River is also the primary source of surface water diversion into the Subbasin. As such, the Kings River hydrologic year has a significant influence on groundwater levels in the Subbasin. In the unconfined aquifer, groundwater outflow from the Kings Subbasin into the Subbasin is primarily due to leakage from the Kings River. However, this groundwater predominantly flows along the course of the Kings River and therefore does not remain exclusive to the Subbasin. In the confined aquifer, groundwater outflow from the Kings Subbasin into the Subbasin is also due to leakage from the Kings River in the northeast portion of the Subbasin where the Corcoran Clay is not present. This groundwater has a strong downward vertical component which creates steep southward hydraulic gradients beneath the Corcoran Clay. This groundwater tends to remain resident in the Subbasin confined aquifer.

The groundwater flow system for these two aquifer systems is summarized in the following subsections.

2.4.1 Unconfined Aquifer

The unconfined and semi-confined upper portion of the regional fresh-water aquifer are found above the Corcoran Clay. This upper portion of the regional freshwater aquifer is generally comprised of coarse- to medium-grained sediments (i.e., sand and gravel) with silt and clay interbeds.

Groundwater beneath the Subbasin and surrounding areas is typically found between depths from 30 to 250 feet bgs, depending on location and time. A review was conducted of available DWR groundwater elevation contour maps of the unconfined aquifer from 1960 to 2010 and briefly described below (DWR, 2018). The maps show a persistent, large data gap beneath the Tulare Lake bed where there are few observations of groundwater levels due to a lack of wells.

- In 1990, a dry hydrologic year on the Kings River, groundwater was at an elevation of about 260 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom (Figure D2-6a). Groundwater elevations beneath Hanford were about 170 feet msl, and about 140 feet msl near Corcoran. There were several cones of depression in the water table near Hanford, north and south of Corcoran, and around Alpaugh. The Kings River appears to be a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kern, Kings, Kaweah, and Tule subbasins and out of the Subbasin to the Westside Subbasin.

- In 1995, a wet hydrologic year on the Kings River, groundwater was at an elevation of about 260 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom (Figure D2-6a). Groundwater elevations beneath Hanford were about 150 feet msl and about 110 feet msl near Corcoran. The cone of depression in the water table between Hanford and Corcoran has merged into a single large depression. The Kings River continues to be a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kern, Kings, Kaweah, and Tule subbasins and out of the Subbasin to the Westside Subbasin.

- In 2000, an average hydrologic year on the Kings River, groundwater was at an elevation of about 250 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom (Figure D2-6a). Groundwater elevations beneath Hanford were about 150 feet msl and less than 100 feet msl near Corcoran. The Kings River continues to be a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kings, Kaweah, and presumably the Kern subbasins and out of the Subbasin to the Tule and Westside subbasins.

- In 2005, a wet hydrologic year on the Kings River, groundwater was at an elevation of about 260 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom. Groundwater elevations beneath Hanford were about 140 feet msl, about 10 feet lower than in 2000 (Figure D2-6b). Throughout the Subbasin, groundwater levels were about 10 or more feet lower than in 2000. The Kings River continues to be a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kings, Kaweah, and Tule subbasins and out of the Subbasin to the Westside Subbasin.

- In 2010, an average hydrologic year on the Kings River, groundwater was at an elevation of about 250 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom. Groundwater elevations beneath Hanford were about 130 feet msl and less than 10 feet msl near Corcoran (Figure D2-6b). Throughout the Subbasin, groundwater levels were about 10 or more feet lower than in 2005. The Kings River continues to be a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kings, Kaweah, Tule, and presumably the Kern subbasins and out of the Subbasin to the Westside Subbasin.

- In 2016, a dry hydrologic year on the Kings River, groundwater was at an elevation of about 230 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom. In the Hanford area, groundwater levels were about 110 feet msl, about 20 feet lower than in 2010. Cones of depression in the water table west, north, and southeast of Corcoran are still present and becoming deeper (-40 feet msl). The Kings River no longer is a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kings and Kaweah subbasins and out of the Subbasin to the Kern, Tule, and Westside subbasins.

2.4.2 Confined Aquifer

The sediments below the Corcoran Clay comprise the lower confined portion of the regional fresh-water aquifer. This lower portion of the regional freshwater aquifer is generally comprised of clay, silt, sandy silt and clay, sand, silty/clayey sand, gravel, and sandy, silty and clayey gravel (Page, 1983).

There are few available maps showing groundwater elevations in the confined aquifer beneath the Subbasin and surrounding areas (Harder, 2017). In fall 1998 and spring 1999, a wet hydrologic year on the Kings River, groundwater was at an elevation of about 100 feet msl near Corcoran, decreasing to the south towards an apparent pumping center near Alpaugh. In general, the potentiometric surface map (Harder, 2017) indicates that groundwater was flowing into the Subbasin from the Kaweah Subbasin and out of the Subbasin to the Tule Subbasin.

In fall 2010, an average hydrologic year on the Kings River, groundwater was at an elevation of about -50 feet msl near Corcoran, decreasing towards an apparent pumping center southwest of Corcoran. In general, groundwater was flowing into the Subbasin from the Kaweah and Tule subbasins.

2.4.3 Subsidence

Land subsidence due to groundwater drawdown associated with heavy groundwater pumping has affected large areas of the San Joaquin Valley since the 1920s, including the Subbasin (AFW, 2018). Between 1926 and 1970, there was approximately 4 feet of cumulative subsidence near Corcoran, 4 to 6 feet of subsidence near Hanford, and as much as 12 feet of subsidence near Pixley (Figure D2-7). Following the completion of the SWP and Central Valley Project (CVP), surface water became readily available and groundwater extraction was reduced and subsidence due to groundwater drawdown was temporarily slowed or stopped.

In the past 10 to 25 years, groundwater pumping has once again been increasing, with associated resumption and acceleration of groundwater drawdown and associated subsidence. The subsidence was exacerbated during a moderate to severe drought from 2007 through 2009, and a severe to exceptional drought from 2012 through 2016. A Jet Propulsion Laboratory study of subsidence between June 2007 and December 2010 (JPL, 2012) indicated subsidence rates were as high as 8.5 inches per year in the vicinity of Corcoran (Figure D2-7). A more recent study by Jet Propulsion Laboratory (JPL, 2017) indicted that subsidence rates accelerated in some areas during the recent drought, with annual subsidence rates of 1 to 1.5 feet near Corcoran in 2015-2016 (Figure D2-8). Groundwater pumping and drawdown, and consequent subsidence, are anticipated to continue into the future at least until sustainable groundwater pumping is achieved. Due to inelastic soil behavior, subsidence is mostly irreversible even if groundwater pumping decreases and groundwater level recovers.

2.5 Surface Water Occurrence

Historically, river runoff from the Sierra Nevada collected in terminal lakes on the basin floor in the San Joaquin Basin creating vast regions of Tule marshes and woodland wetlands (Figure D2-9a). Tulare Lake, the largest terminal lake, received runoff from four major rivers, the South Fork Kings, Kaweah, Tule, and Kern Rivers (ECORP, 2007). These rivers formed broad deltaic and alluvial fans as they emerged from the Sierra foothills forming multiple channels and sloughs that shifted periodically especially during flooding events (ECORP, 2007). The natural hydrology of the Tulare Lake Basin has been extensively altered over the last 130 years for flood control, irrigation, land reclamation, and water conservation. Concerns about water supplies led to the construction of large dams and reservoirs on each of the four major rivers and channelization of the rivers for flood control and water banking have further modified the Tulare Basins hydrography (ECORP, 2007). The surface water sources that supply the Subbasin are primarily from man-made canals and diverted rivers.

2.5.1 Tulare Lake

Tulare Lake was the largest freshwater lake west of the Mississippi River estimated to encompass 790 square miles at its highest overflow lever of 216 feet in 1862 and 1868 (Figure D2-9a) (ECORP, 2007). The lake was very shallow and had no natural outlet when the water levels was below 207 feet (ECORP, 2007). However, at 207 feet, the water could flow north into the San Joaquin River Basin. Increased diversion of water from the rivers and tributaries that previously flowed into Tulare Lake resulted in the lake drying up in the late 1800s except when occasionally flooded.

2.5.2 Kings River

The Kings River is a 133-mile-long river, the largest river draining the southern Sierra Nevada. The Kings River has three main tributaries, the North Fork, Middle Fork and South Fork, with the North and Middle forks flowing north to the San Joaquin River and the South Fork flowing south to the old Tulare Lake bed. Significant water development structures including the Pine Flat Dam were constructed in the last century to control and modified the rivers flow. The Kings River lies along the boundary between the Subbasin and Kings Subbasin, a portion of the boundary between the Subbasin and Westside Subbasin, and a portion of the boundary between the Subbasin and Kaweah Subbasin (Figure D2-9b). Leakage of water from the Kings River and distributary canals provides significant groundwater recharge in the Kings, Kaweah, Westside, and Tulare Lake subbasins, resulting in complex groundwater flow patterns between the subbasins.

2.5.3 Kaweah River

The Kaweah River is a 100-mile-long river in Tulare County and drains the southern Sierra Nevada (Figure D2-9a). The Kaweah River begins as four forks in Sequoia National Park, then flows in a southwest direction to Lake Kaweah – the only major reservoir on the river – and into the San Joaquin Valley, where it diverges into multiple channels across an alluvial plain around Visalia. The lower course of the river and its many distributaries – including the St. John's River and Mill Creek – form the Kaweah Delta, a productive agricultural region in the Kaweah Subbasin. Before the diversion of its waters for irrigation, the river flowed into Tulare Lake.

2.5.4 Tule River

The Tule River is a 71-mile-long river in Tulare County and drains the southern Sierra Nevada (Figure D2-8c). The Tule River has three main tributaries, the North Fork, Middle Fork and South Fork, that in the past flowed into Tulare Lake. Currently, water in the Tule River now flows into Lake Success, a reservoir constructed in 1961 near Porterville, California, and only in times of above normal precipitation or snow melt is water released onto the dry Tulare Lake bed.

2.5.5 Canals and Pipelines

There are 34 rivers, streams, canals, and diversions entering and within the Subbasin that deliver surface water to the Subbasin (Figures D2-9b-d).

Water is imported into the Subbasin using facilities of the SWP located west of the Subbasin and the CVP. Water can also be exported out of the Subbasin using the SWP and CVP facilities in combination with facilities developed by local water districts (ECORP, 2007). The CVP imports San Joaquin River water into the Subbasin through the Friant-Kern Canal and Delta water through the Delta-Mendota and San Luis Canals.

The Friant-Kern Canal is operated and maintained by the Friant Water Authority and is used to convey water from the San Joaquin River to Kern County. The canal originates at the Friant Dam, which is operated by the United States Bureau of Reclamation. The Friant-Kern Canal flows southeasterly along the western flank of the Sierra Nevada foothills through Fresno, Tulare, and Kern counties. The Friant-Kern Canal has a capacity of approximately 5,300 cubic feet per second or about 10,510 acre-feet per day (AF/D), which decreases to about 2,500 cubic feet per second or about 4,960 AF/D as demand decreases toward its end in the Kern River, near Bakersfield, California (AFW, 2018).

2.6 Climate

The climate in the Subbasin is semi-arid characterized by hot, dry summers and cool moist winters and is classified as Mediterranean steppe climate (Köppen climate classification). The wet season occurs from November through March with 80 percent (%) of precipitation falling during this time frame (ECORP, 2007). The valley floor often receives little to no rainfall in the summer months. Precipitation typically occurs from storms that move in from the northwest off the Pacific Ocean and occasionally storms from the southwest that contain warm sub-tropical moisture can produce heavy rains especially during El Nino episodes.

Historical annual precipitation at the Hanford weather Station from 1899 to 2017 (Hanford, 2017) has ranged from a low of 3.37 inches in 1947 to a maximum of 15.57 inches in 1983 (Table D2-1). Monthly precipitation in the area ranges between 0 and 6.69 inches per month and averages about 8.28 inches per year. This results in an estimated 2 inches per year of infiltration into the unconfined aquifer. Figure D2-10 provides a chart of the annual precipitation at the Hanford station from 1940 to 2017.

2.7 Land Use

Land use in the Subbasin and surrounding areas is predominately agricultural with smaller urban areas. Land use was evaluated using DWR land use maps for 1990 through 2006 (DWR, 2016a) and annual CropScape maps from 2006 through 2016 (USDA, 2016). These maps were provided in Geographic Information System formats, allowing for aggregation of similar land uses (i.e., crop types) to simplify analysis (Figure D2-11a-d). A total of 33 land uses were identified and evaluated (Table D2-2). Of these land uses, 27 were assumed to be irrigated, while 6 land uses (open water, forests, etc.) were assumed to only receive precipitation.

The Subbasin covers an area of approximately 535,869 acres or about 837 square miles (DWR 2016b). Between 1990 and 2016, the Subbasin had an average of approximately 310,800 acres of crops, 7,110 acres of riparian or open water, 137,110 acres of fallow or non-developed land, and 22,130 acres of urban and industrial development (Table D2-2, Appendix D1). The mix of crops grown and fallow lands has changed over time as agricultural practices changed in response to agricultural markets and drought conditions. A chart of area by land use shows that fallow acreage increased significantly during the 2010-2016 drought, while riparian, cotton, and pasture acreage all decreased during the drought (Figure D2-12). Cotton showed the most change with a decrease of over 85,000 acres between 1995 and 2016. The data also show that the was an overall increase in permanent crops over time, with increases in young and mature almonds from approximately 7,680 acres in 1995 to 42,300 acres in 2016. The total acreage of pistachios also increased from 4,700 to 26,900 acres between 1995 and 2016; however, there was a loss of 4,220 acres of mature pistachios with a concurrent increase of 26,400 acres of young pistachios.

Annualized tables and charts of land use for the Subbasin GSAs and the portions of the Westside, Kings, Kaweah, Tule, and Kern subbasins within the model domain are presented in Appendix D1.

2.8 Basin Water Budget

The basin water budget describes the inflows to and outflows from the Subbasin hydrogeologic system. Inflow and outflow can occur from the hydraulic boundaries of the system, from various sources within the model domain such as rainfall, lakes, and leakage from rivers and canals, and from the exit points or sinks such as wells or drainage systems. The boundaries, sources, and sinks identified within the model domain are discussed below.

2.8.1 Inflows

Inflows consist of precipitation, surface water diversions for irrigation, imported groundwater for irrigation, intentional recharge, and leakage from streams and conveyances.

2.8.1.1 Precipitation

Precipitation can be a significant source of water to the Subbasin and surrounding area. Given the large areal extent of the Subbasin and surrounding area, it was determined that using a single weather station to estimate precipitation would be inadequate to represent the entire Subbasin. Instead, the Parameter-elevation Regression on Independent Slopes Model (PRISM) database maintained by the Oregon State University was used to estimate monthly precipitation from January 1990 through December 2016 across the model domain (PRISM, 2017). The PRISM database contains monthly total precipitation for the entire United States using a 4-kilometer grid. The monthly precipitation values are statistically derived values based on local weather stations and corrections for topographic variations. A total of 304 PRISM data sets were downloaded for the model domain. The monthly precipitation data were summed by Subbasin area to estimate the potential annual precipitation volume for each subbasin (Figure D2-13a). Maps of average monthly rainfall across the model domain for the months of January, March, May, July, September, and November shows that precipitation also varies spatially across the model domain (Figure D2-13b).

Not all rainfall is available for use by crops – some fall on impervious surface, some is taken up by dry soils, some is intercepted by foliage and on evaporates before it can infiltrate, and some deep percolates and recharges groundwater. Monthly effective precipitation was estimated by multiplying the monthly PRISM data sets by the Precipitation / Effective Precipitation ratios presented in FAO 56 (Chapter 3, Table 6; Allen et al., 1998) and shown on Figure D2-14. A table and chart summarizing annual effective precipitation by subbasin within the model domain is presented on Figure D2-15. This shows that between 1990 and 2016, effective precipitation provided as little as 9,320 acre-feet (AF) in a dry year (2013) to 501,030 AF in a wet year (2010) and averaged approximately 214,720 acre-feet per year (AF/Y) of water across the model domain.

2.8.1.2 Surface Water Diversions

Surface water diversion from external sources are the most significant source of water to the Subbasin and surrounding area. There are 34 rivers, streams, canals, and diversions entering and within the Subbasin that have recorded diversions (Figure D2-9a-c). Two primary data sources were employed for the surface water inflows and deliveries to the farms within the model domain:

- For lands within the Subbasin itself, surface water delivery and diversion records were obtained by via direct contacts with the various GSAs (and member water management agencies within the

GSAs) within the Subbasin proper (Table D2-3). Those records were relatively complete from 1990 through 2016 for diversions off the Kings system and SWP. As shown on Table D2-3, during the period 1998 through 2010, the Kings River had six below normal water years, four average water years, and three above average water years. Over the 1998-2010 period is Kings River water years average 96% of normal, making this a "normal hydrology" period.

- For deliveries to lands located within the model buffer area (between the boundaries of the Subbasin as defined by the DWR and the TLSBHM model domain boundaries), a combination of data gathered for GSAs whose footprint extended into the Subbasin proper, and data mined from the C2VSIM (Brush et al., 2016) model for those GSAs and water management districts that lay completely outside the official Subbasin boundary were utilized. The C2VSIM model surface water data covered from the beginning of the TLSBHM model period through the end of 2011 and was extended through the end of 2016 by correlation of those inflows with Kings River deliveries at Peoples weir. In general, inflows into this area from Kaweah and Tule Rivers, and Deer Creek were reconstructed from a variety of disparate data.

A table and chart summarizing annual surface water diversions by subbasin within the model domain is presented on Figure D2-16. Monthly surface water diversions by subbasin by GSA and subbasin are provide in Appendix D2. This shows that between 1990 and 2016, surface water diversions provided an average of 948,370 AF/Y of water across the model domain and as much as 1,696,540 AF of water in wet years.

The surface water diversions are not delivered uniformly across the model domain spatially or temporally (Figure D2-17). During the 1990-2016 period, there are several areas that historically have not received any surface water diversions or have received intermittent deliveries of surface water (Figure D2-17).

2.8.1.3 Imported Groundwater Supply

One unique feature of the Subbasin is the importation of groundwater supplies from adjacent subbasins. The ER GSA and TCWA GSA operated well fields in the adjacent Tule Subbasin and import the pumped groundwater into the Subbasin as an additional water supply. Between 1990 and 2016, ER GSA operated up to 52 wells in the Creighton Ranch well field, which delivered up to 68,730 AF in a dry year (2014) and as little as 0 AF in wet years (1996-1999) and averaged approximately 39,320 AF/Y in non-wet years (Table D2-4). The TCWA GSA operated up to 51 wells in the Angiola Water District (WD) well field, which delivered groundwater to TCWA GSA lands in both the Subbasin (about 60%) and Tule Subbasin (about 40%). Between 1990 and 2016, the Angiola WD well field delivered up to 23,100 AF in a dry year (2009) and as little as 0 AF in wet years (1996-1999) and averaged approximately 15,950 AF/Y in non-wet years (Table D2-4).

2.8.1.4 Lake Bottom Water Storage

Another unique feature of the Subbasin is the utilization of certain portions of the historical lake bottom for storage of the excess surface water inflows that were not diverted by others. This stored surface water is later used as an irrigation supply. In some years, sufficient water can be stored in the lake bottom to eliminate the need for supplemental groundwater pumping to meet the irrigation demand.

As observed in historical aerial imagery, the area occupied and the locations of water storage changes from year to year, although certain areas to the south appear to be more regularly utilized by storage (Figure D2-18). This can result in significant volumes of stored water in some years. Permanent lakebed storage facilities have the capacity to store approximately 70,000 AF at any given time. During flood events, as an example of conjunctive use, some fields can be flooded allowing for the storage of significant volumes of water, in some years up to 450,000 AF in the ER GSA management area (Figure D2-18). When available, the storage water is typically utilized to supplement surface water deliveries in lieu of groundwater pumping. The importance of this conjunctive management capability is illustrated by the fact that the cumulative excess inflow stored in the lake bottom allowed lake bottom farmers to completely turn off their groundwater well fields between January 1995 and June 1999 (Table D2-4).

2.8.1.5 Intentional Recharge

Groundwater recharge in the Subbasin also occurs from intentional percolation of surface water in infiltration ponds and water banks. The Corcoran Irrigation District (CID) has operated nine intentional recharge basins covering approximately 2,760 acres since the 1980s (Figure D2-19). Aerial photograph analysis shows that only one or two basins are typically utilized each year between March and September when surface water is available, percolating an estimated average of 23,500 AF/Y of surface water. The other ponds are typically dry except in extremely wet years such as 2005-2006, 2010-2011, and 2017 when as much as 147,700 AF of water has been estimated to be percolated. During the 1990-2016 simulation period, the CID Ponds percolated an estimated 616,100 AF of excess surface water.

Kings County Water District (KCWD) has been infiltrating Kings River flood waters along the Old Kings River channel since the 1940s (referred to as Condition 8). Condition 8 water is surface water that naturally would have infiltrated along the Old Kings River channel during high river flow years had the river not been diverted for irrigation. Between 1990 and 2016, Condition 8 recharge has ranged from as little as 0 AF in most years and as much as 36,800 AF in flood years (1995) and averaged approximately 30,370 AF/Y in wet years (Figure D2-20).

In addition, KCWD operates 25 recharge basins totaling about 720 acres within the MKR GSA and also began operating a water bank on the Old Kings River Channel in 2002. Since 2002, approximately 73,600 AF of water has been recharged via percolation through approximately 50 acres of ponds through the water bank, and approximately 48,500 AF has been recovered utilizing five recovery wells. This leaves a positive balance of approximately 25,100 AF in the unconfined aquifer system as of 2016.

In the Chamberlain Ranch area of the ER GSA, 640 acres has been utilized for percolation basins. In 2017, approximately 5,000 AF was recharged. Immediately adjacent to the eastern boundary of the ER GSA in the Tule Subbasin, there are recharge basins that are operated by ER GSA landowners.

2.8.1.6 River and Canal Seepage

Seepage losses from river and canals provide another source of water to the Subbasin and surrounding areas. There are over 290 miles of major streams and canals within the Subbasin, in addition to many more miles of small distribution ditches on individual farms (Figures D2-9b-d). Most to the stream and canals are unlined and can have significant seepage losses. Ownership of canal and river seepage is to be determined. There was little available information on seepage losses in the Subbasin, although anecdotal reports indicate the Old River Channel, Peoples Ditch, and Lakeland Canal all have substantial losses near the head gates at Peoples Weir (personal communication, Dennis Mills).

2.8.2 Outflows

Outflows consist of evapotranspiration, agricultural pumping, municipal pumping, and agricultural drains.

2.8.2.1 Evapotranspiration

Crop evapotranspiration (ETc) or crop demand use is the largest outflow of water from the Subbasin. ETc data are based on spatial distributions of different types of crops, as well as estimated rates of evapotranspiration for the Subbasin area. Crop data comes from DWR data sets for the counties of Fresno, Kern, Kings, and Tulare (surveyed intermittently between 1990-2006) and from CropScape datasets (surveyed annually from 2007-2016). Monthly ETc varies by crop type and by season, typically peaking during the summer months. ETc rates were estimated from published ITRC rates (ITRC, 2003) under normal year conditions for the region (Table D2-5).

Annual crop demand was calculated for each crop type on a 40-acre basis as follows:

Annual Crop Acres (Acres) * *Annual Crop ETc* (Feet/Acre) = *Irrigated Crop Demand* (AF/Y)
(Table D2-2) (Table D2-5) (Table D2-6)

Note: some crop types do not receive irrigation water and thus have zero irrigated crop demand.

Between 1990 and 2016, the total irrigated crop demand in the Subbasin ranged from 564,120 AF in 2015 to 1,072,440 AF in 2007 and had an average irrigated crop demand of approximately 879,020 AF/Y (Table D2-6).

The mix of crops grown and fallow lands has changed over time as agricultural practices changed in response to agricultural markets and drought conditions. A chart of annual crop acreage shows that total crop acreage has generally decreased since 2010 (Figure D2-12). Crop demand shows a similar pattern, generally decreasing from 2009 through 2015 (Table D2-6). Cotton showed the most change with a decrease of crop demand over 50% between 1995 and 2016. The data also show that during the 2011-2016 drought, there was an overall increase in row crop demand including tomatoes, peppers, small vegetables, onion, garlic, grain, and hay. In addition, the data show a large increase in ETc demand from almonds, pistachios, and stone fruits. Annualized tables and charts of crop demand for the Subbasin GSAs and the portions of the Westside, Kings, Kaweah, Tule, and Kern subbasins within the model domain are presented in Appendix D3.

2.8.2.2 Specified Agricultural Well Field Pumping

Agricultural pumping is typically not recorded over much of California, including the Subbasin. However, there are 455 wells with reported production in 6 agricultural well fields within the model domain. A wellfield consists of a group of wells generally located in the same area and operated a single entity to provide a reliable groundwater supply. The agricultural wellfields include: ER GSA (99 wells), Creighton Ranch (52 wells), CID (98 wells), Angiola Water District (51 wells), Westlands Water District (150 wells), and Apex Ranch (5 wells) (Figure D2-21). The ER GSA and CID well fields service local areas in the Subbasin. The Creighton Ranch and Angola Water District well fields, located in the Tule Subbasin, service the Tule Subbasin and also export significant amounts of groundwater to the Subbasin. The Westlands Water District well field only services the Westside Subbasin. The specified pumping from the agricultural well fields has varied significantly over time, ranging from 23,470 AF (1998) to 370,880 AF (2016) and averaging about 202,750 AF/Y (Figure D2-22). The reduction in annual pumping coincides with the availability of surface flood waters (Figure D2-18). Appendix D4 presents an annualized summary of reported pumping by agricultural well fields within the model domain.

2.8.2.3 Specified Municipal Well Field Pumping

Municipal pumping of groundwater occurs in the Subbasin by the cities of Hanford, Lemoore, Stratford, and Corcoran (Figure D2-21). Specified pumping from the 30 identified municipal well fields has been slowly increasing over time but has remained relatively consistent (Figure D2-22). Between 1990 and 2016, reported municipal pumping has ranged from 9,110 AF (1991) to 26,700 AF (2002) and averaged 14,910 AF/Y over this 26-year period. The municipal pumping demand varies seasonally, peaking in the summer months. As noted in Section 2.4, municipal pump has created persistent cones of depression in the potentiometric surface near the cities of Hanford and Corcoran. Appendix D4 presents an annualized summary of pumping by municipal wells within the model domain as reported by the cities.

2.8.2.4 Estimated Agricultural Pumping

As noted above, agricultural pumping is typically not recorded over much of California, including the Subbasin. However, agricultural pumping by subbasin can be estimated using a simple water balance approach where:

Irrigated Crop Demand (AF/Y)- *Effective Precipitation* (AF/Y) */ Irrigation Efficiency* (%) = *Farm Demand* (AF/Y)

and

Farm Demand (AF/Y) – *Surface Water Supplies* (AF/Y) = *Estimated Agricultural Pumping Demand* (AF/Y) (Figure D2-23)

Note: Surface Water Supplies include Surface Water Deliveries, imported groundwater, and lake bottom water storage

Although this simple water balance approach does not account for subtleties in the areal distribution of effective precipitation, irrigation efficiency, and surface water deliveries, it does provide a reasonable gross estimate of agricultural pumping on the subbasin scale. Based on this analysis, gross agricultural pumping demand in the Subbasin from 1990 through 2016 has ranged from 24,730 AF (1995) to 785,260 AF (1991) and averaged approximately 469,560 AF/Y (Figure D2-23).

2.8.2.5 Agricultural Drains

Agricultural drains are used in several areas across the model domain to keep soil from becoming waterlogged in the root zone. Typically, a tile or French drain system is used, with tiles buried approximately 4 to 6 feet bgs draining to sumps. Subsurface drainage collected in the sumps is pumped via pipeline to evaporation basins. Figure D2-24 shows the approximate location of known subsurface drains within the Subbasin.

3.0 Simulation Code

In order to meet the model objectives discussed in Section 1.3, the groundwater flow model code must meet the following criteria:

- be able to simulate three-dimensional groundwater flow within the model domain,
- be well documented and verified against analytical solutions for specific flow scenarios,
- be accepted by regulatory agencies,
- be readily understandable and usable by others for simulation of future groundwater conditions, and
- have a readily available technical support structure.

The groundwater flow model codes MODFLOW2005-NWT (Niswonger et al., 2011) and MODFLOW-OWHM (Hanson et al., 2014) are two distinct versions from the well-known MODFLOW family of groundwater simulation codes. These codes were used to develop the Subbasin model.

MODFLOW is a modular, finite-difference computer code developed by the USGS to simulate three-dimensional groundwater flow (McDonald and Harbaugh, 1988, Harbaugh, A. W., 2005). The use of the MODFLOW family of codes is well documented in technical literature and is a de facto standard for groundwater flow modeling worldwide.

MODFLOW2005-NWT is a particular version of MODFLOW that implements the Newton method for handling non-linearities in flow equations, which allows for very efficient solution of the flow equation including complexities such as unsaturated zone flow, eliminated the cell draining and re-wetting problems of earlier versions of MODFLOW (Niswonger et al., 2011). MODFLOW-OWHM is a relatively new version of MODFLOW (still under development) specifically developed to provide a flexible and robust approach to simulate conjunctive management of surface water and groundwater resources in an agricultural crop production setting (Boyce et al., 2016).

3.1 Model Code Selection

Once the decision was made to develop a model using the MODFLOW family of codes, the initial plan was to develop both a MODFLOW2005-NWT model and a MODFLOW-OWHM model to provide independent, yet complementary, methods for model development. This was planned due to the fact that both codes will share many of the same input files, only differing in how the farm irrigation pumping is specified. For the NWT model, the farm irrigation pumping requirement would be calculated externally in a de-coupled modeling approach, whereas with OWHM, the farm irrigation pumping is calculated internally as a dynamic component.

The MODFLOW-NWT ("MF-NWT") code would be employed to develop a "de-coupled" model of conjunctive surface water – groundwater management in the Subbasin. In the de-coupled approach, the following four-step procedure is used to build surface boundary processes (irrigation, crop water use, return flows, etc.), build the irrigation well pumping file, and run the model to simulate system response:

- the crop ETc demand calculated externally on a model cell-by-cell basis based on cropping patterns, crop coefficients, and reference ETc;
- effective precipitation and specified surface water deliveries are also calculated on a model cell-by-cell basis, irrigation pumping demand is calculated as the ETc demand – effective precipitation - surface water supplies;
- the resulting cell-by-cell irrigation pumping demand is subsequently summed by area, and assigned to a hypothetical pumping well in the center of the area in the de-coupled model; and
- the model is run to simulate groundwater-system response (drawdown, loss of storage, subsidence) to the stresses (including municipal and irrigation pumping, natural recharge, intentional artificial recharge, recharge from stream and canal leakage, recharge from irrigation return flows.

The MODFLOW-OWHM ("MF-OWHM") code was investigated as a tool to dynamically simulate conjunctive management of surface water and groundwater resources in the Subbasin. The MF-OWHM model employs basically the same input data sets used to calculate the ETc and irrigation pumping demands externally for the de-coupled MF-NWT model, but the MF-OWHM simulations are dynamic in the sense that the ETc and irrigation pumping are calculated internally within the model allowing for “feedback loops” between these two key stressors on the groundwater system. The MF-NWT de-coupled model does not address these types of feedback loops that actually can be occurring in the field.

The MF-OWHM, the code is currently undergoing enhancements (from to its capabilities and numerical methods. In January 2019, the USGS indicated that updated version of the model code (OWHM v2) would be available in March 2019. The most recent communication with the USGS indicated that the updated model code might not be ready until the end of October 2019, too late for the GSP schedule. Thus, further development of the OWHM was suspended at the end of March and efforts were directed at completing the de-coupled MF-NWT model for the Subbasin within the project schedule. The remainder of this report focusses on the de-coupled model development, application, and results.

3.2 Code Assumptions and Limitations

There are certain model code assumptions and limitations that must be considered when developing, applying, and interpreting a numerical model. Some key assumptions and limitations that may affect the site models are briefly discussed below.

Porous Media: The MODFLOW family of codes is limited simulation of saturated and unsaturated flow in porous media. It does not simulate flow through fractures or relatively impermeable bedrock.

Layer Continuity: MODFLOW requires that all layer extend from edge-to-edge of the model domain. This limits the ability to explicitly simulate formation pinch-outs or unconformities. Instead these features may be simulated using a hydraulic conductivity contrast.

Unsaturated Flow: The MODFLOW Unsaturated Zone Flow (UZF1) package can simulate flow in the unsaturated zone using an approximation to Richards’ equation to simulate vertical unsaturated flow. The approach is limited in that unsaturated flow occurs in response to gravity, and there must be uniform hydraulic properties in the unsaturated zone for each vertical column of model cells. This limits the ability of the MODFLOW to simulate different properties of the thick unsaturated zone. The Brooks-Corey function is used to define the relation between unsaturated hydraulic conductivity and water content. Variables used by the UZF1 Package include initial and saturated water contents, saturated vertical hydraulic conductivity (Kv), and an exponent in the Brooks-Corey function. Residual water content is calculated internally by the UZF1 Package on the basis of the difference between saturated water content and specific yield (Sy).

The UZF1 Package is also substitution for the Recharge (RCH) and Evapotranspiration (ET) Packages of MODFLOW-2005. The UZF1 Package differs from the RCH Package in that an infiltration rate is applied at land surface instead of a specified recharge rate directly to ground water. The applied infiltration rate is further limited by the saturated Kv. The UZF1 Package differs from the ET Package in that evapotranspiration losses are first removed from the unsaturated zone above the evapotranspiration extinction depth, and if the demand is not met, water can be removed directly from ground water whenever the depth to ground water is less than the extinction depth. The UZF1 Package also differs from the ET Package in that water is discharged directly to land surface whenever the altitude of the water table exceeds land surface. Water that is discharged to land surface, as well as applied infiltration in excess of the saturated Kv, may be routed directly as inflow to specified streams or lakes if these packages are active; otherwise, this water is removed from the model similar to the Drain (DRN) Package.

Stress Periods: MODFLOW requires that temporally variable data be consistent within each stress period. This results in some temporally averaging of data. For example, stream flow or municipal pumping may vary hourly or daily in response to demand, while agricultural well field may pump nearly continuously for several months in a row. The averaging of transient stress into consistent monthly stress period tends to smooth out the hydraulic impacts of the transient stresses.

3.3 Graphic Pre/Post-Processor

To facilitate the preparation and evaluation of each model simulation, Wood utilized the graphics pre/post processor GWVistas® Version 7 (GWV) by Environmental Simulations, Inc. (ESI, 2017). GWV is a Windows® program that utilizes a graphic user interface (GUI) to build and modify a database of model parameters. The model grid, hydraulic properties, and boundary conditions are input using the GUI, and then GWV creates the necessary MODFLOW and MT3DMS data input files. The input files generated by GWV are generic (standard) files compatible with USGS MODFLOW-NWT and MT3DMS. Wood also utilized some in-house utilities and Microsoft EXCEL spreadsheets to generate standard MODFLOW data input files for selected simulations and for post-processing simulation results. For example, PYTHON scripts were utilized to add and subtract the large matrices containing 27 years of monthly data worth of effective precipitation, surface water deliveries, and crop demand to estimate agricultural pumping. Similarly, an Excel spreadsheet was created to allocate the estimated agricultural pumping demand to hypothetical wells, and export file formatted for importation into GWV.

GWV was also utilized to post-process the model simulations. GWV can display the simulated head results as plan views and cross-sections. In plan view, the contour intervals and labels specified by the user and dry cells are denoted by a different color. In cross-section view, the water table surface is also plotted. Most outputs to the screen can be saved in a number of formats (DXF, WMF, PCX, SURFER, etc.) for utilization in other graphics programs.

4.0 Model Design

The following sections describe the numerical groundwater flow model for the TLSBHM. The model construction was based on the HCM presented in Section 2.0, with each of the key features described in that Section represented numerically in the TLSBHM. This modeling effort is a revision to the preliminary groundwater model of the Subbasin (Kings Model) developed in 2016-2018 on behalf of the Kings County Community Development Agency (AFW, 2018).

4.1 Model Domain/Grid

As described in Section 2.1, the TLSBHM model domain is centered on the Subbasin and extends beyond the Subbasin several miles, overlapping adjacent subbasins within the Tulare Lake Hydrologic Region (Figure D2-2). The model domain was extended beyond the Subbasin so that model boundary conditions are sufficiently far away the area of interest in the Subbasin; these areas beyond the extent of the Subbasin henceforth are referred to as the “buffer areas” (Figure D2-2). The buffer areas extend approximately 3 miles beyond the DWR-defined Subbasin boundaries on the north, south, and east sides; on the west and southwest sides, however, a large buffer area is not included because the alluvial groundwater basin is truncated by low-permeability geologic units on those side. The active model grid covers an area of approximately 1,091,320 acres (about 1,705 square miles) and is orientated due north to align the model grid with the predominant direction State Plane coordinate system of Township/Range/Sections.

The preliminary Kings Model (AFW, 2018) exhibited some boundary condition interference along the eastern edge of the model. Hence the TLSBHM model grid was extended further east approximately

2.5 miles. In addition, some of the active model grid edges were modified to yield straighter lines to simplify specified boundary conditions. The resulting TLSBHM model grid consists of 281,750 active cells with uniform dimensions of 1,320 x 1,320 feet (¼ mile x ¼ mile, or 40-acres) (Figure D4-1). The complete model grid consists of 230 rows, 175 columns, and 7 layers.

4.2 Model Layers

The purpose of model layers is to represent the hydraulic influence of stratigraphy at a scale appropriate to the model objectives. One way to think of "hydraulic influence" is how finer-grained deposits present resistance to flow, both laterally and vertically, and it is only through multiple model layers that one can simulated the vertical resistance to flow. It is understood that stratigraphic variations occur at scales that are both smaller and larger than that characterized for this model.

- Those hydrostratigraphic variations that are of the same scale or larger than the numerical grid cell size, for example the Corcoran Clay, are captured explicitly in model property variations.
- Those hydrostratigraphic variations that are much smaller than the model cell size are not treated explicitly in the model, but rather their effect is incorporated into the model via appropriate assignment of large scale "effective" properties for the model cell as described above in Section 2.1.1. For example, say three 1- to 2- foot thick clay layer or lenses extend across a large portion of the 1,320-foot x 1,320-foot plan view area of a 50-foot thick model cell. To capture the hydraulic effect of those layers in the 50-foot thick model cell requires significantly reducing the Kv as guided by this conceptual model and application of the harmonic average as a lower bracket for significantly reducing Kv compared to what is in the CVHM model data that was provided to the TLSBHM modeling team by the USGS.

In addition to direct import of the CVHM hydraulic conductivity fields (based on the USGS sediment texture study) as the starting point for the model, refinements to the conceptual and numerical models of the site were based on consideration of several types of information. Supplement information considered included both recent and older USGS literature (Croft, 1972; Page, 1986), monitoring well perforation intervals in sub-areas of the site, and qualitative and quantitative information obtained directly from the GSAs.

The initial basis for the TLSBHM model layering scheme was based on a modified version of the CVHM (AFW, 2018). The modified CVHM model had 13 layers including 5 layers above the Corcoran Clay, 3 layers representing the Corcoran Clay, and 5 layers below the Corcoran Clay. The TLSBHM layering scheme was reduced from 13 layers to 7 layers to simplify the model and make it more consistent with the 3- to 4-layer models being developed for the Tule and Kaweah subbasins. The TLSBHM layer count was reduced by combining several thin layers into a single, thicker layer. For example, the 3 layers representing the Corcoran Clay in the CVHM model were combined into a single layer in the TLSBHM. Layer elevations and thicknesses were also modified in some areas based on local information. The resulting Cross-sections showing the model layering scheme and initial hydraulic conductivity distribution are shown on Figures D4-2 and D4-3.

4.3 Model Duration and Stress Periods

The TLSBHM simulates the period from 1990 through 2016 using 324 monthly stress periods (Table D4-1). The model simulates the period from 1990 to 1995 as a "run-up" period to stabilize the model hydraulics prior to the 1998-2010 focused calibration period. The model continues from 2010 through 2016 to bring the model up to date with current hydraulic conditions as required under SGMA.

4.4 Model Hydraulic Parameters

The initial hydraulic properties assigned to the TLSBHM were extracted from CVHM. The hydraulic parameters were only modified as necessary during the model calibration process to improve the fit between simulated and observed heads. As such, the model contains no more complexity than is justified by the available data, the model objectives, and the model results to date. Section 4.4.1 briefly describes how the USGS used textural information from thousands of boring logs to develop three-dimensional maps of the hydraulic properties.

The range of final hydraulic properties, hydraulic conductivity, Kv, storage, Sy, and porosity used as a result of the calibration process are briefly summarized in the following subsections.

4.4.1 Hydraulic Conductivity

Geologically speaking, the Central Valley is a large structural trough filled with sediments of Jurassic to Holocene age. These sediments reach thicknesses on the order of 15,000 feet in the San Joaquin Valley, and as much as 30,000 feet in the Sacramento Valley. In general, the Sacramento Valley is predominantly fine-grained and reflects more fine-grained volcanic-derived sediments, and in the San Joaquin Valley the areas of coarse-grained texture are more widespread than the areas of fine-grained texture and occur along the major rivers, especially on the eastern side.

The texture (particle size) of these sediments and how that texture varies spatially strongly impacts how groundwater flows in response to recharge and discharge stresses on the system. Therefore, the textural distribution of the basin-fill sediments was used to define the initial vertical and lateral hydraulic conductivity and storage property distributions for the TLSBHM domain.

To characterize the Central Valley basin-fill deposits, scientists from the USGS developed a geologic texture model to describe the coarseness or fineness of basin-fill materials that make up the hydrogeologic system, and then used it to estimate hydraulic properties (hydraulic conductivity and storage properties) for every cell in the model grid. To create a sediment texture model for the Central Valley, the USGS compiled and analyzed data and information from approximately 8,500 drillers' logs of boreholes ranging in depth from 12 to 3,000 feet below land surface (Faunt el al., 2009). The textural characterization focused on the variability and spatial distribution of the fraction of coarse sediments (f_c) over 50-foot depth intervals. Figure D4-4 presents the f_c for several of the model layers, and Figure D4-5 presents an oblique view of f_c for the San Joaquin Valley, with the TLSBHM study area outlined in red. In general, there are two key aquifer systems, the upper unconfined and semi-confined aquifer and the deeper confined aquifer system, separated by the Corcoran Clay aquitard. On Figures D4-4 and D4-5, the Corcoran Clay horizon is found in model layers 6 through 8, with the unconfined and semi-confined shallow aquifer system in model layers 1 through 5 and the deeper confined aquifers in model layers 9 through 13.

The USGS generated estimates of hydraulic properties from their texture model developed for the CVHM. These values were imported directly into the TLSBHM to use as initial values prior to beginning model calibration. The initial hydraulic conductivity distribution utilized in the TLSBHM is shown on Figure D4-6.

Beneath the Subbasin study area, previous studies have identified extensive deposits of fine-grained materials consisting of lacustrine and marsh sediments (Croft and Gordon, 1968; Croft, 1972; Page, 1986, Williamson et.al., 1989). A cumulative thickness of as much as 3,000 feet of these fine- grained deposits have been identified and include laterally extensive clay layers (A – F Clays). The A-, C-, and E-Clays (i.e., Corcoran Clay) cover much of the TLSBHM domain. During the calibration process, these studies and input from the GSAs were utilized to adjust hydraulic properties derived from the USGS texture model to be more representative of the Tulare Lake bed and surrounding area (Figure D4-7). The following subsections provide a summary of the hydraulic properties for each of these depth intervals.

4.4.1.1 Unconfined and Semi-Confined Aquifer Zones above the Corcoran Clay

Above the Corcoran Clay is the unconfined to semi-confined upper portion of the regional fresh-water aquifer. This upper portion of the regional freshwater aquifer is generally comprised of coarse- to medium-grained sediments (i.e., sand and gravel) with silt and clay interbeds.

According to the USGS CVHM, the grid-block-scale horizontal hydraulic conductivity (K_h), ranges from 8 to 75 feet per day (ft/d). These values span the lower range of a “good aquifer” as defined by Bear (1972). Figure D4-4 presents the K_h distribution derived from the USGS texture study for selected model layers. On Figure D4-4 (as well as Figure D4-6), a broad swath of lower permeability (low sand fraction) deposits is evident that run from the northwest side of the model domain trending to the southeast toward the southeast corner of the model domain. In this zone, the hydraulic conductivities derived from the CVHM are in the 5 to 25 ft/d range, which is closer to the range of a “poor aquifer” (Bear, 1972), and which appear to be lower than values obtained from pumping tests in these areas (P&P, 2009). In fact, the averaging of sediment texture (f_c) over 50-foot depth intervals leads to “smoothing out” of permeability contrasts.

As described previously, it is important to recognize that even in the zones with a higher fraction of coarse textured sediments, clayey layers and lenses are found throughout the profile. This is especially important for estimating effective horizontal-to-vertical anisotropy of hydraulic conductivity for a numerical model layer thickness of 50 feet, which is the scale of vertical averaging that the USGS employed in their sediment texture study. For example, say the fraction of coarse-materials over a 50-foot depth interval is 90%; if the remaining 10% consists of a fine fraction that is concentrated in a few clay layers on the order of a foot thickness, then the effective K_v should tend toward the harmonic average of a clay and a sand (Freeze and Cherry, 1979). If the sand has a K_h of 90 ft/d and the clay layers have a K_h of 0.01 ft/d, then the effective K_v for that grid cell could be estimated using a layer-thickness weighted harmonic average as:

$$K_v \approx [50 / ((5/0.01) + (45/90))] = [\ 50/500.5] \approx 0.1 \text{ ft/d}$$

The effective K_h can be estimated as the layer-thickness weighted arithmetic average:

$$K_h \approx [\ (45x90) + (5x0.01)] / 50 \approx 90^* (45/50) = 81 \text{ ft/d}$$

These simple calculations indicate that it would be reasonable to expect very high anisotropy ratios (very low effective K_v), and indeed that is what was found during the model calibration process (see Section 5.0).

The storage properties above the Corcoran Clay do not vary nearly as much as the hydraulic conductivity in this portion of the aquifer. The S_y of the sediments above the Corcoran Clay (Layers 1 through 3) range from 0.08 to 0.3, while the specific storage (S_s) ranges between 1.5x10-5/feet and 7.3x10-3/feet.

4.4.1.2 Corcoran Clay Aquitard

The lateral extent and thickness of the Corcoran Clay are shown on Figure D2-4. While it is sometimes considered a continuous layer of low permeability sediments spanning across the San Joaquin Valley, in fact comparing these figures to the CVHM hydraulic conductivity maps for model layers 4 through 10 (Figures D4-4 through D4-6) clearly shows that the Corcoran Clay grades into coarse materials laterally, as well as above and below. They also show that some clay lenses exist above and throughout areas characterized as relatively "coarser" in the USGS texture study. Recognizing that the texture maps were developed from averaging f_c over 50-foot depth intervals, this impacts the effective Kv used in the TLSBHM as described in the previous section.

This is consistent with recent investigations by the USGS in the San Joaquin Valley, which indicate that the groundwater conditions grade from unconfined, or water-table, at the shallowest depths to semi-confined with increasing depth, eventually grading into fully confined conditions beneath the Corcoran Clay. Geophysical well logs indicate that the Corcoran Clay, although probably the largest single confining bed, constitutes only a small percentage of the total cumulative thickness of clay layers in the fresh-water bearing unconsolidated sediments in the Subbasin. Thus, it is more accurate to consider the confinement as the result of numerous overlapping clay lenses and beds. Further, the difference in hydraulic head directly above and below the Corcoran Clay is relatively small when compared to head differences between larger intervals of the deeper parts of the aquifer system. Again, rather than to explicitly simulate each of these thin clay layers and lenses discretely in the model, their impact on the flow system is simulated through the high anisotropy in hydraulic conductivity (very low Kv).

Hydraulic conductivity (K_h) values of the Corcoran Clay cells in the model domain from the USGS CVHM range from 0.5 to 10 ft/d, which is rather high for an aquitard material, and especially high considering that the harmonic average should be the guide for effective K_v. As mentioned in Section 4.4.1, hydraulic conductivity values at the depth horizon of the Corcoran Clay were adjusted during model calibration to improve the fit between the simulated and observed hydraulic heads over time.

In addition, as discussed in Section 2.3.4, Croft & Gordon (1968) identified uninterrupted lacustrine (clay) deposits from the surface to at least 2,200 feet bgs beneath the central portion of the Tulare Lake bed (Figure D2-5). These lacustrine deposits interfinger with coarser sediments and the thinner clay zones along the periphery of the lake with the thick clay deposits beneath the lake bed itself. The Corcoran Clay (E-Clay) has been identified as extending beneath the lake bed (Davis et al., 1959). show it as being warped downward along the axis of the lake with a maximum thickness of 150 to 175 feet. These cross sections indicate the Tulare Lake deposits form a clay "plug" across the center of the San Joaquin Valley that may be 15 miles wide, 8 miles long, and ½ mile deep at its maximum dimensions. This was incorporated into the TLSBHM (Figure D4-7).

Again, the storage properties do not vary as much as the hydraulic conductivity, with S_s of the Corcoran Clay and other sediments in this depth horizon ranging between 4.5x10-4/feet and 1.2x10-3/feet, with the S_y ranging from 0.10 to 0.15 where unconfined. Storage values were adjusted during model calibration to improve the fit between the simulated and observed hydraulic heads over time.

4.4.1.3 Confined Aquifer Beneath the Corcoran Clay

Hydraulic conductivities initially assigned to the model layers beneath the Corcoran Clay horizon were derived from the USGS CVHM. Conductivity values generally ranged from 20 to 40 ft/d, except for two broad regions of lower permeability. One of the areas with a predominance of low-K_h materials at depth is in the Westside Subbasin to the west, and the other is beneath the southeast buffer areas near where Deer Creek enters the model domain. Again, the storage properties do not vary as much as the hydraulic conductivity, with Ss of the sediments below the Corcoran Clay ranging between $6.8x10^{-4}$/feet and $1.5x10^{-3}$/feet. Storage values were adjusted during model calibration to improve the fit between the simulated and observed hydraulic heads over time.

The TLSBHM groundwater model was initially assigned variable K_h values that ranged between $4.0x10^{-4}$ ft/d for aquitard clay units to 91 ft/d for aquifers, with the spatial distribution of the properties derived from the CVHM. These values were modified as necessary during the calibration process to improve the model fit to observed groundwater elevations (Figure D4-7).

4.4.2 Storage

The TLSBHM groundwater model was initially assigned S_s values from the USGS CVHM. Initial S_s values ranged between $1.5x10^{-5}$ to $7.3x10^{-3}$ feet-1. These values are within the published range of values for the silty to sandy sediment types (Spitz and Moreno, 1996). S_s values were modified over a limited range during the model calibration process.

4.4.3 Specific Yield

The TLSBHM groundwater model was initially assigned S_y values from the USGS CVHM. Initial S_y values ranged between $7.9x10^{-2}$ to $3.0x10^{-1}$. These values are within the published range of values for the silty to sandy sediment types (Spitz and Moreno, 1996). S_y values were modified over a limited range during the model calibration process.

4.4.4 Porosity

The TLSBHM groundwater model was initially assigned porosity values from the USGS CVHM. Initial porosity values ranged between $9.1x10^{-2}$ to $2.9x10^{-1}$. These values are within the published range of values for the silty to sandy sediment types (Spitz and Moreno, 1996). Porosity values were modified over a limited range during the model calibration process.

4.5 Model Boundary Conditions

Significant hydraulic boundaries (sources and sinks) within the model domain that must be considered in the site numerical model include the inflows and outflows from surrounding subbasins, inflows and outflows of surface water, return flows and intentional recharge, and groundwater pumping. These boundaries are discussed in the following subsections.

4.5.1 General Head Boundaries

The MODFLOW General Head Boundary (GHB) package was utilized to simulate the north, south, and east edges of the model domain and represent the aquifer system beyond the model domain (Figure D4-8). For the TLSBHM, the GHBs were developed based on historical water level observations in well located within 2 miles of the model domain boundary. Figure D4-8 shows the locations of wells evaluated to develop the GHB boundary conditions. The GHBs were developed as a series of 20 GHB reaches. The GHB heads at the ends of each reach were interpolated on a monthly basis from the available hydrograph data. The GHB heads for each cell within a reach were then linearly interpolated between the end points. This resulted in a relative smooth variation in GHB heads along the length of each reach.

The GHB conductance term, which governs how much water can flow through the GHB, was calculated as:

Conductance = KLW/M in square feet per day (ft^2/d), where:

K is the hydraulic conductivity of the sediments (assumed to be 25 ft/d),
L is the GHB length or distance to the head value (assumed to be 1,320 feet),
W is the GHB width (assumed to be 1,320 feet), and
M is the saturated thickness of GHB layer (assumed to be 100 feet).

4.5.2 River and Canal Boundaries

As noted above, several rivers and streams deliver surface water to irrigated lands within the model domain. The most important of these is the Kings River, which enters the model domain on the northeast side, and it flows westward near the top of the model domain before turning southwest then southward in the western portion of the model domain. Other major surface water inflows are provided by the Kaweah River, the Tule River, Deer Creek, and Poso Creek. Figure D4-9 shows the locations of each of these surface water features; also shown are the major distributary canals that take the deliveries from the streams and rivers and distribute that water to the irrigation farmlands.

The MODFLOW River (RIV) package was utilized to simulate all the stream and canals that deliver water to irrigated lands. The streams were developed as a series of 23 RIV reaches, where each RIV reach is composed on many model cells. The RIV package is a head dependent boundary and will allow water to enter groundwater via seepage (losing stream) or exit groundwater (gaining stream) based on river stage (Head) and a steam bed conductance term:

Conductance = KLW/M in ft^2/d, where:

K is the hydraulic conductivity of the sediments (assumed to be 1 to 10 ft/d),
L is the length of the river reach (variable in feet),
W is the river width (assumed to be 10 to 40 feet), and
M is the thickness of the river bed (assumed to be 10 feet).

The rivers were assumed to leak anytime there were surface water diversions down a particular river reach. Throughout the Subbasin, almost all river are disconnected from groundwater and are losing rivers. Appendix D2 presents an annualized summary of river flow by reach within the model domain.

4.5.3 Agricultural Drains

The MODFLOW Drain (DRN) package was utilized to simulate the agricultural drains within the model domain (Figure D2-24). The DRN package is a head dependent boundary condition that only collects groundwater above a specified elevation. Similar to GHBs, the rate of removal is governed by a conductance term:

Conductance = KLW/M in ft^2/d, where:

K is the hydraulic conductivity of the sediments (assumed to be 100 ft/d),
L is the length of the drain (assumed to be 1,320 feet),
W is the width of the drain (assumed to be 1,320 feet), and
M is the thickness of the drain bed (assumed to be 1 foot).

In areas where drains were simulated, if simulated groundwater rose to within 4 feet of ground surface, then groundwater was collected by the drains and assumed to be discharged to evaporation basins where it evaporated and was removed from the model domain.

4.5.4 Groundwater Extraction

Groundwater extraction for municipal, industrial, and agricultural demand was simulated using the MODFLOW Multi-Node Well (MNW2) package. The MNW2 package is a powerful enhancement to the original MODFLOW well package in that it allows for simulation of wells screened across multiple model layers (aquifers). Thus, the MNW2 package will calculate inflows from each model layer within the screened interval as well as the calculating flow within the well casing, including flows from one layer to another when the well is not being pumped. In addition, the MNW2 package will automatically increase pumping from deeper intervals as shallower aquifers become dewatered until the pumping level in the well approaches a specified elevation (such as a pump setting).

4.5.4.1 Specified Pumping Wells

As discussed in Sections 2.8.2.2 and 2.8.2.3, there are 485 known municipal, industrial, recovery, and agricultural wells that have data on well construction as well as reported pumping rates over time (Figure D2-21). The pumping rates were specified for the municipal wells based on monthly historical pumping data obtained from the cities of Corcoran, Hanford, Lemoore, and Stratford (Table D2-3), or reported monthly pumping data from irrigation districts such as CID, ER GSA, Westlands Water District, and reported pumping from well fields like Creighton Ranch and Angiola well fields (Table D2-6).

4.5.4.2 Hypothetical Agricultural Irrigation Wells

As discussed in Section 2.8.2.4, agricultural pumping is not typically recorded throughout most of the Subbasin. As such agricultural pumping had to be estimated based on available cropping data using a water balance method. Recognizing that many more wells exist in the Subbasin than those 485 known wells, an additional 1,091 hypothetical irrigation wells were uniformly distributed across the model domain on approximately 1-mile centers for those areas with unknown well completion intervals, resulting in the final well distribution as shown on Figure D4-10. The hypothetical wells were specified to be screened in the upper (above Corcoran) or lower (below Corcoran) aquifer zones based on statistics of well completions for 238 known irrigation wells in the Subbasin. In addition, approximately 25% of the hypothetical irrigation wells were specified to be completed across the Corcoran, producing groundwater from permeable intervals both above and below the aquitard, consistent with the completion statistics for the 238 known irrigation wells in the Subbasin.

Crop Evapotranspiration Rates

Field crops (alfalfa, row crops, corn, cotton, etc.) are assigned on an annual basis in the model. For example, if the annual DWR crop survey/CropScape data (DWR, 2016a) indicate that corn was present in a particular model cell, then it was assumed that corn was the only crop within that cell for the full calendar year (12 stress periods). The applied evapotranspiration rates for that cell were assigned based on the monthly ETc rates for corn.

Permanent crops including vineyards, almonds, pistachios, pomegranates, and stone fruit (tree crops) are assumed to be fully mature at the beginning of the simulation in 1990 (based on 1994-1996 DWR crop data). As the model progresses forward in time, the available crop data changed, and the spatial distribution of crops also changed, with a recent trend to more permanent tree crops being planted.
As the permanent crop grows from seedling to full maturity, the evapotranspiration rate was assumed to

increase as well. The presence of a crop within a specific space in a cell was tracked over time by assigning crop IDs that reflect the number of years of maturity for each tree crop and using the intersect tool in ArcMap to see specific areas of overlap between year n tree crops and year n+1 tree crops. If an intersected area of the domain has almonds in year n and in year n+1, it is assumed that the almonds have matured in that particular portion of the cell.

The crop data for the Subbasin indicates that there was a substantial increase in the number of acres planted in tree crops during the 2010-2016 period (Section 2.8.2.1, Table D2-2). Rather than assuming full maturity and peak evapotranspiration rates for these new areas of tree crops, the ET rates for these areas are assumed to be a fraction of the mature ET rates.

For example, almonds are assumed to mature over a 5-year period, so the first year that almonds are present in a portion of a model cell they are assigned ET rates that are 1/5th of the mature rate. If those almonds are still in the same area the next year, then they are assigned an ET rate of 2/5^{ths} of the mature rate, and so on. If almonds are in the same spot for 5 years, they are assumed to have the full ET rates of a mature almond tree. Anything beyond 5 years, up to 25 years, uses the full maturity ET rates. For instances where almonds have been in a portion of a cell more than 25 years, the almond trees are assumed to have been replanted, and start over at the 1-year, 1/5th mature ET rates.

Almonds were assumed to mature over a 5-year period and were assumed to be replanted after 25 years. Pistachios were assumed to mature over a 13-year period and are assumed to remain in place for 100 years once they are planted. Pomegranates were assumed to mature over a 19-year period and were assumed to be replanted after 44 years. Stone fruits were assumed to mature over a 5-year period and were assumed to be replanted after 25 years.

Irrigated Areas/Irrigated Fractions

Area fractions within cells were used to compute an area-weighted average for crop ET values within each cell and to determine the irrigated areas of each cell for use with surface water delivery matrix processing. The crop distributions for each stress period were intersected with the active domain grid in ArcMap. Each cell containing crops was subdivided into multiple pieces, one for each crop type within the cell. The areas of each crop type within the cells were calculated for each stress period. The ET demand for a single cell is computed as the area of the crop type times the rate of ET for that crop, divided by the total area of the cell.

Irrigated areas also play a part in the surface water delivery preprocessing. Surface water deliveries were assumed to be spread evenly across the entire irrigated area of each GSA Area (or farm). Not all cells within a GSA may be fully irrigated; there may be a portion of a cell which is fallow, or contains non-irrigated land uses (winter wheat, native vegetation, urban areas). Therefore, the irrigated area of a cell can be used as a weighting factor against the full area of the cell to adjust the effective rates of surface water delivered within a specific cell in a GSA.

For example, if a GSA has a surface water delivery of 30,000 AF in the month of September and the total irrigated area of the GSA is 10,000 acres, then the nominal rate of surface water delivery is 30,000 AF / 30 days = 1,000 AF/D over an irrigated area of 10,000 acres. Going a step further, this becomes (1,000 AF/D) / (10,000 acres) = 0.1 ft/d rate of surface water delivery. For a cell where only half of the area is irrigated, the weighted surface water delivery rate for that cell would be 0.05 ft/d.

Agricultural Irrigation Pumping Demand

Monthly pumping rates for the hypothetical irrigation wells were computed based on crop ETc demand (Section 2.8.2.1) minus the sum of effective precipitation (Section 2.8.1.1), surface water deliveries (Section 2.8.1.2) and Lake Bottom Water Storage (Section 2.8.1.3). The logic behind the calculation of the hypothetical irrigation well pumping rates is summarized below.

For each monthly stress period and each 40-acre model cell:

- Area Weighted Crop Acreage (acres) x Crop ETc (feet per month [ft/m]) = ET Demand (acre-feet per month [AF/M])
- [-ET Demand (AF/M) + Effective Precipitation (ft/m)] / Irrigation Efficiency = -Farm Demand (AF/M)

  (*Note: over most of the model domain, Irrigation Efficiency was assumed to be 75% from 1990 to 2000 and then increase to 85% from 2000 through 2016. Irrigation Efficiency from the lake bottom area was assumed to be 95% from 1990 through 2016. Approximately 50% of excess Effective Precipitation was assumed to infiltrate and 50% was assumed lost to evaporation. Farm Demand is the volume of water needed to irrigate a field and meet crop demand due to inefficiencies in irrigation methods*)

- -Farm Demand (AF/M) + Surface Water Deliveries (AF/M) + Lake Bottom Storage Water (AF/M) = -Unmet Demand (AF/M) and +Tailwater Flow (AF/M)

  (Note: monthly Surface Water Deliveries were summed by GSA and applied to irrigated areas within each GSA. Lake Bottom Water Storage typically occurred only during and following very wet years and was an additional water supply for the ER GSA and TCWA GSA)

- -Unmet Demand (AF/M) + Avg Tailwater Flow/GSA (AF/M) = -Ag Pumping Demand (AF/M) and +Excess Applied Water (AF/M)

  (Note: Tailwater Flows were assumed to stay within each GSA. The monthly Average Tailwater Flow/GSA (AF/M) = Sum of Tailwater flow per GSA (AF/M) divided by GSA irrigated area. Approximately 75% of excess Applied Water was assumed to infiltrate and 25% was assumed lost to evaporation.)

Typically, each hypothetical agricultural irrigation well was assigned a service area (or farm) consisting of 16 model cells totaling 1-square mile (Figure D4-11). The sum of the monthly Ag Pumping Demand (AF/M) for the 16 model cells was assigned to each hypothetical agricultural irrigation well. For some hypothetical agricultural irrigation well the cell count was more or less than 16 model cells due to boundaries no-flow boundaries or to eliminate hypothetical wells servicing only 1 or 2 cells.

In addition, there are several large areas (ER GSA, CID, SWK GSA, TCWA GSA, and Westlands Water District) that were assumed to be operated as single service areas (or farms) with equal access to surface water and pumped groundwater within the service area. Several of the service areas supplied groundwater by wells located within the service area and/or by external well fields outside of the service area. For example, ER GSA is supplied groundwater from wells within the GSA and by the Creighton Ranch well field in the Tule Subbasin. Likewise, both SWK GSA and TCWA GSA are supplied groundwater from a few wells inside the GSAs and by the Angiola well field in the Tule Subbasin. CID and Westlands Water District are assumed to be supplied groundwater from the wells within each service area.

4.5.5 Deep Percolation and Intentional Recharge

Groundwater recharge occurs within the Subbasin from deep percolation of applied water and intentional recharge. Intentional recharge occurs at specific locations including Apex Ranch, CID ponds, and the Old Kings River (Section 2.8.1.4). Deep percolation of applied water occurs almost everywhere in the TLSBHM where there is active irrigation due to inefficient irrigation practices. There are three components to deep percolation including Farm Demand, Excess Applied Water, and Intentional Recharge. Deep percolation is estimated for each monthly stress period and each 40-acre model cell or farm as follows:

- [+Farm Demand (AF/M) / (1-1/Irrigation Efficiency)] + Excess Applied Water (AF/M) + APEX/CID/Condition 8 Intentional Recharge (AF/M) = Deep Percolation (AF/M)

  (*Note: over most of the model domain 75% of Excess Applied Water was assumed to percolate and 25% was assumed to evaporate*)

Deep percolation is applied to the TLSBHM for each stress period and each model cell using the RCH Package.

4.5.6 Subsidence

Land subsidence due to extraction of groundwater was simulated using the MODFLOW Subsidence (SUB) package. The SUB Package simulates elastic (recoverable) compaction and expansion, and inelastic (permanent) compaction of compressible fine-grained beds (interbeds) within the aquifers. The compaction of the interbeds is caused by head or pore-pressure changes (changes in effective stress) within the interbeds. If the stress is less than the pre-consolidation stress of the sediments, the deformation is elastic; if the stress is greater than the pre-consolidation stress, the deformation is inelastic.

The SUB package parameters of:

Sk_e skeletal storage elastic,

Sk_i skeletal storage in elastic,

b_{equiv} combine thickness of delay interbeds within a model layer, and

n_{equiv} combine thickness of non-delay interbeds within a model layer

were derived from CVHM and modified during calibration to approximate observed subsidence during the simulation period.

5.0 Model Calibration

Calibration of a groundwater flow model is a process through which the model is demonstrated to be capable of simulating the field-measured heads and flows that comprise the calibration targets. Calibration is accomplished by selecting a set of model parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field measurements within a pre-established range of error. Because of the multiplicity of parameters involved in the calibration process, a unique solution (e.g., one set of parameters) cannot be achieved. A brief discussion of the calibration of the groundwater flow model for the site is presented in the following subsections.

5.1 Model Calibration Criteria

The quantitative fit of the model to observed water level measurements is conducted through statistical analysis of the residuals, (the difference between observed and simulated water levels or heads) at specified observation locations, and in the case of transient calibration, with time. The residual is calculated as the observed value minus the simulated value; thus, a positive residual indicates that the simulated head value is less than the observed value, and vice-versa. The principal statistical measures of the residuals of all data points combined include the following:

- the mean of the residuals,
- the mean of the absolute value of the residuals,
- the standard deviation of the residuals,
- the sum of the square of the residuals (SSR),
- the root mean square (RMS) error of the residuals,
- the min and max of the residuals,
- the range of the observed values, and
- normalized root mean square error (NRMS) (e.g., the root mean square error divided by the range of observed values or the standard deviation divided by the range in observed values).

There is no industry standard for determining when a numerical model is adequately calibrated. However, a commonly used rule of thumb criterion for acceptable calibration is a normalized RMS error of less than 10% (Anderson et al., 2015). The RMS is the square root of the SSR divided by the number of observations throughout the model divided by the range of observed water level measurements. In addition, a plot of observed versus computed head values should track close to a 45-degree line and generally fall within one standard deviation of the mean error.

A common qualitative (visual) measure of goodness of fit in numerical modeling is a comparison of observe and simulated values using hydrographs for individual wells. In addition, a map view plot of the average residuals may be used to help identify targets or areas where the residuals in the model domain are largest. Clusters or patterns of gradation of positive or negative residuals may suggest areas where model parameters need to be adjusted further.

5.2 1990-2016 Transient Model Calibration

The transient TLSBHM simulated the period January 1990 through December 2016 using 324 monthly stress periods (Table D4-1). The TLSBHM was calibrated to two data sets, one data set covering the 1990-2016 period and a second data set limited to the 1998-2010 "normal hydrology" period.

The 1990-2016 calibration period included 16,468 groundwater level observations collected from 593 observation wells across the model domain. The 1998-2010 "normal hydrology" calibration period included 7,028 groundwater level observations collected from 544 observation wells across the model domain. Most of the observation wells had little or no completion interval information, making it difficult to assign the observations to a particular model layer. Wells with known completion intervals includes 81 wells above the Corcoran Clay and 69 wells below the Corcoran Clay. The other observation wells were assigned to model layers based on the similarity of observations with nearby known wells. Although additional observation wells with groundwater elevation measurements are available, many were determined to have too short a record, too many spurious observations, or uncertain completion intervals and hence were not utilized.

Numerous model iterations were needed to calibrate the TLSBHM model. Various hydraulic parameters (K_h, K_v, S_s, S_y) and boundary conditions (RCH, GHB heads, RIV conductance) were incrementally modified using the manual trial and error method.

The calibration statistics for the entire 1990-2016 historical simulation period include a residual mean of -4.98 feet, a RMS error of 50.85 feet, a range of 575.33 feet, and a NRMS of 8.84 %, meeting the calibration criteria of a NRMS of <10% (Figure D5-1a). A scattergram of observed and simulated values shows that many values fall within one standard deviation of the perfect 45-degree fit. A residual distribution chart shows that the residual error approximates a gaussian distribution with a slight bias to over predicting heads.

The calibration statistics for 1998-2010 "normal hydrology" calibration period include a residual mean of 2.26 feet, a RMS error of 46.26 feet, a range of 545.16 feet, and a NRMS of 8.50 %, slightly better than for the 1990-2016 period, and meeting the calibration criteria of a NRMS of <10% (Figure D5-1b). A scattergram of observed and simulated values shows that most values are closer to the perfect 45-degree fit compared to the 1990-2016 period. A residual distribution chart shows that the residual error approximates a gaussian distribution with a slight bias to over predicting heads.

A qualitative comparison of observed and simulated heads in selected monitoring wells using hydrographs shows a reasonable fit for several wells, and poor fits for others (Figures D5-2a through D5-2g). In general, the hydrographs show that simulated heads are slightly under predicted above the Corcoran Clay (Figures D5-2a to D5-2c). Within the Corcoran Clay, the hydrographs show that simulated heads tend to start out lower than observed during the ramp-up period but end up with a relatively good fit after 1998 (Figure D5-2d). Below the Corcoran Clay, the hydrographs show that simulated heads are generally on trend with the observed, although seasonal variations are not simulated very well (Figures D5-2e to D5-2g). Observed and simulated heads in selected all monitoring wells used for model calibration are provided in Appendix D5.

Simulated potentiometric surface maps with groundwater flow vectors from above and below the Corcoran Clay show how the general direction of groundwater flow between the subbasins for December 2015 (Figure D5-3). In general, above the Corcoran Clay, simulated groundwater flow is entering the Subbasin from the north, east, and south, and leaving the Subbasin to the west. Below the Corcoran Clay, simulated groundwater flow is also entering the Subbasin from the north. The simulation results also show consistent cones of depression above the Corcoran Clay around pumping centers beneath the cities of Hanford, Lemoore, and Corcoran. There is also a large, persistent cones of depression beneath CID and lake bottom well fields southeast of the City of Corcoran and along the border between the Tulare Lake and Tule subbasins.

The maps also show that there is a large area in the lake bottom area where groundwater appears to be mounding slightly and the groundwater flow vectors show little movement of groundwater above and below the Corcoran Clay (Figure D5-3). This area has been described as being under lain by an extensive sequence of lacustrine and marsh deposits (i.e., Tulare Lake bed "clay plug") which are relatively impervious. Thus, the apparent mounding may result from a zone of residual high heads that are draining more slowly than surrounding areas as groundwater levels are being drawn down due to pumping, recharge to the lake bottom, or it could result as a combination of both.

5.3 1990-2016 Water Balance Calculations

The calibrated transient TLSBHM was used to estimate the groundwater flows that occur between the Subbasin and the adjoining subbasins (Figure D2-2). The following subsection present water balances 1990-2016 simulation period and the 1998-2010 “normal hydrology” period for the Subbasin itself, as well as for each adjoining subbasin, and net flows between the Subbasin can be extracted from these results. Note that the protrusion of the Kaweah Subbasin boundary into the Subbasin and the presence of large wellfields near subbasin boundaries complicate the assessment of inter-basin flows.

5.3.1 Tulare Lake Subbasin

The 1990-2016 annualized net water balance for the Subbasin shows that overall there is a long-term net outflow of groundwater from the Subbasin to the Kings, Kaweah and Tule subbasins (Table D5-1, Figure D5-4), while there is a long-term net inflow of groundwater from the Westside and Kern subbasins. These overall results can be disaggregated to subbasin interactions above and below the Corcoran Clay. Above the Corcoran Clay, there is a net outflow of groundwater from the Subbasin to the Kings, Kaweah, and Tule subbasins, and a net inflow of groundwater from the Westside and Kern subbasins. Below the Corcoran Clay, there is a net outflow of groundwater from the Subbasin to the Westside, Kings, Kaweah and Tule subbasins and a net inflow of groundwater from the Kern Subbasin. The inflows and outflows of groundwater from below the Corcoran Clay are greater than those from above the Corcoran Clay.

The change in storage in the Subbasin has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -392,280 AF (2015) to 361,230 AF (2011) and averaged -85,690 AF/Y. During 1990-2016, the estimated cumulative change in storage was about -2,313,740 AF. During the 1998-2010 “normal hydrology” period, the estimated change in storage has ranged from about -220,650 AF (2006) to -296,280 AF (2008) and averaged -73,770 AF/Y. During the 1998-2010 period, the estimated cumulative change in storage was about -958,940 AF.

5.3.2 Westside Subbasin

Annualized net water balance for the portions of the Westside Subbasin within the model domain shows that there is a long-term net outflow from the Westside Subbasin to the Tulare Lake and Kings subbasins (Figure D5-5). In general, the long-term outflow from the Westside Subbasin to the Subbasin is greater than that from the Kings Subbasin above the Corcoran Clay, while the long-term inflow to the Westside Subbasin from the Subbasin is less than that from the Kings Subbasin below the Corcoran Clay. The potentiometric surface maps (Figure D5-3) show that the outflow of groundwater from the Subbasin is due to both pumping in the Westside Subbasin and leakage from the South Fork of the Kings River.

The change in storage for the portions of the Westside Subbasin within the model domain has varied from year to year depending on the water year type. Between 1990 and 2016 the estimated change in storage has ranged from -425,290 AF (1990) to 103,573 AF (1998) and averaged -84,070 AF/Y. During 1990-2016 the estimated cumulative change in storage was about -2,269,800 AF. During the 1998-2010 “normal hydrology” period the estimated change in storage has ranged from -177,600 AF (2008) to 103,573 AF (1998) and averaged about -47,080 AF/Y. During the 1998-2010 period the estimated cumulative change in storage was about -612,040 AF.

5.3.3 Kings Subbasin

Annualized net water balance for the portions of the Kings Subbasin within the model domain shows that there is a long-term net groundwater inflow to the Kings Subbasin from the Tulare Lake, Westside, and

Kaweah subbasins (Figure D5-6). In general, the groundwater inflow to the Kings Subbasin from the Tulare Lake and Kaweah subbasins is from both above and below the Corcoran Clay, while there is a net outflow from the Kings Subbasin to the Westside Subbasin below the Corcoran Clay. The potentiometric surface maps (Figure D5-3) show that above the Corcoran Clay, the outflow of groundwater from the Subbasin is primarily due to leakage from the Kings River. Below the Corcoran Clay, the outflow of groundwater from the Subbasin to the Kings Subbasin is due to leakage from the Kings River (where the Corcoran Clay is not present).

The change in storage for the portions of the Kings Subbasin within the model domain has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -229,310 AF (2015) to 74,030 AF (1998) and averaged -68,220 AF/Y. During 1990-2016, the estimated cumulative change in storage was about -1,841,980 AF. During the 1998-2010 "normal hydrology" period, the estimated change in storage has ranged from -162,950 AF (2004) to 74,030 AF (1998) and averaged about -66,520 AF/Y. During the 1998-2010 period, the estimated cumulative change in storage was about -864,720 AF.

5.3.4 Kaweah Subbasin

Annualized net water balance for the portions of the Kaweah Subbasin within the model domain shows that there is a long-term net groundwater inflow to the Kaweah Subbasin from the Tulare Lake and Tule subbasins and a long-term net groundwater outflow to the Kings Subbasin (Figure D5-6). In general, the groundwater outflow from the Tule Subbasin is greater than that from the Subbasin above the Corcoran Clay, while the outflow from the Subbasin is greater than that from the Tule Subbasin below the Corcoran Clay. The potentiometric surface maps (Figure D5-3) show that a portion of the Kaweah Subbasin protrudes into the Subbasin. This complicates the calculation of inter-basin groundwater flow because there is both inflow and outflow between the Tulare Lake and Kaweah subbasins through this area. In addition, there is outflow of groundwater from the Kaweah Subbasin to the Subbasin due to well field pumping in the area near the City of Corcoran.

The change in storage for the portions of the Kaweah Subbasin within the model domain has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -317,310 AF (2014) to 31,300 AF (2011) and averaged -156,640 AF/Y. During 1990-2016, the estimated cumulative change in storage was about -4,229,350 AF. During the 1998-2010 "normal hydrology" period, the estimated change in storage has ranged from -239,860 AF (2004) to -2,110 AF (1998) and averaged about -128,390 AF/Y. During the 1998-2010 period, the estimated cumulative change in storage was about -1,669,020 AF.

5.3.5 Tule Subbasin

Annualized net water balance for the portions of the Tule Subbasin within the model domain shows that there is a log-term net groundwater inflow to the Tule Subbasin from the Tulare Lake and Kern subbasins and a log-term net groundwater outflow from the Tule Subbasin to the Kaweah Subbasin (Figure D5-8). In general, the flow from the Subbasin is greater than that from the Kaweah Subbasin both above and below the Corcoran Clay, with greater groundwater flow below the Corcoran Clay. The potentiometric surface maps (Figure D5-8) show that the outflow of groundwater from the Subbasin is primarily due to pumping wellfields southeast of the City of Corcoran and a pumping center east of the model domain in the vicinity of the City of Pixley.

The change in storage for the portions of the Tule Subbasin within the model domain has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -247,850 AF (1990) to -1,820 AF (2011) and averaged -143,770 AF/Y. During 1990-2016, the estimated cumulative change in storage was about -3,881,750 AF. During the 1998-2010 "normal hydrology" period, the estimated change in storage has ranged from -224,920 AF (2008) to -46,570 AF (2006) and averaged about -140,900 AF/Y. During the 1998-2010 period, the estimated cumulative change in storage was about -1,831,680 AF.

5.3.6 Kern Subbasin

Annualized net water balance for the portions of the Kern Subbasin within the model domain shows that there is a long-term net groundwater outflow from the Kern Subbasin to the Tulare Lake and Tule subbasins (Figure D5-9). In general, the outflow from the Kern Subbasin to the Subbasin is greater than that to the Tule Subbasin both above and below the Corcoran Clay, with greater groundwater flow below the Corcoran Clay. The potentiometric surface maps (Figure D5-3) show that the outflow of groundwater above the Corcoran Clay from the Subbasin to the Kern Subbasin. Starting in the mid-2000s, the groundwater flow filed above the Corcoran Clay reversed and there was a net inflow from the Kern Subbasin to the Subbasin. Below the Corcoran Clay, the water balance charts and potentiometric surface maps show a general decline in the outflow of groundwater from the Subbasin to the Kern Subbasin.

The change in storage for the portions of the Kern Subbasin within the model domain has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -97,940 AF (2013) to 64,860 AF (2011) and averaged -17,490 AF/Y. During 1990-2016, the estimated cumulative change in storage was about -472,140 AF. During the 1998-2010 "normal hydrology" period, the estimated change in storage has ranged from -84,350 AF (2008) to 64,860 AF (1999) and averaged about -10,950 AF/Y. During the 1998-2010 period, the estimated cumulative change in storage was about -141,330 AF.

5.3.7 Groundwater Storage

The change in storage in the Subbasin has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -392,280 AF (2015) to 361,230 AF (2011) and averaged -85,690 AF/Y. During the 26-year 1990-2016 simulation period, the estimated cumulative change in storage was about -2,313,740 AF (Table D5-1, Figure D5-4). During the 1998-2010 "normal hydrology" period, the estimated change in storage has ranged from about -220,650 AF (2006) to -296,280 AF (2008) and averaged -73,770 AF/Y. During the 13-year 1998-2010 "normal hydrology" period, the estimated cumulative change in storage was about -958,940 AF.

The simulated groundwater mass balance data were used to estimate the change in groundwater storage in the Subbasin on an annual basis for the simulation period. The simulation results indicate that between 1990 and 2016, the estimated annual change in storage averaged -85,690 AF/Y while during the 1998-2010 "normal hydrology" period, the estimated annual change in storage averaged -73,770 AF/Y or about 14 % less than the 1990-2016 period. Likewise, the estimated net cumulative change in storage for the 26-year 1990-2016 period was about -2,313,740 AF while the estimated net cumulative change in storage for the 13-year 1998-2010 period was about –958,940 AF or almost 60% less than during the 1990-2016 period. Note that following the wet years of 1995-1998, 2005-2006, and 2010-2011, there was a small net increase in groundwater storage in the Subbasin (Table D5-1, Figure D5-4). This indicates that the Subbasin is relatively sensitive to water year type, and that during wet years, there can be a significant increase in the amount of groundwater in storage. Likewise, as shown on Figure D5-4, extended drought periods (like 2011-2016) can results in a significant loss of groundwater in storage.

5.3.8 Subsidence

Simulated cumulative land subsidence due to extraction of groundwater was simulated for the period 1990-2015 (Figure D5-10). Throughout most of the Subbasin, simulated cumulative subsidence was less than 2 feet. However, in the vicinity of the wellfields southeast of Corcoran in the Tule Subbasin, simulated subsidence was over 9 feet. The simulation results also indicate up to 4 feet of subsidence in the Westside, Kaweah, and Kern subbasins. Charts of simulated subsidence over time was also calculated for the major municipal and agricultural wellfields in the TLSBHM (Figure D5-11). These charts show that there was 1 to 2 feet of cumulative subsidence in the vicinity of Hanford, Lemoore, and Stratford, while there was about 5 feet of subsidence at Corcoran, and up to 9 feet of subsidence at the Angiola and Creighton Ranch well fields in Tule Subbasin. The charts also show a small seasonal pattern of elastic subsidence rebound. During the early simulation period (1990-1992), the simulated subsidence occurred at all locations and then stabilized from 1993 through 2001. Simulated subsidence at that time started to increase again after 2002 in a series of steps. Additional calibration of the model to subsidence is needed as more data are collected.

6.0 Sensitivity Analysis

A sensitivity analysis was conducted to evaluate the sensitivity of the model to a change in the estimated hydraulic conductivity and storage parameters. These values in the model were systematically modified over the plausible range of values for the sediment types present beneath the site, and the model was re-run. The sensitivity model run results were compared to the calibration model result to estimate the change in model calibration due to the change in the model parameter.

The sensitivity analysis results indicate that the aquifers above and below the Corcoran Clay are relatively sensitive to changes in K_h, while the Corcoran Clay is not sensitive, as shown by the change (delta) in the sum of square residual (Figure D6-1). The results indicate that little improvement in calibration could be expected by modifying the K_h parameters.

The model sensitivity is reversed with respect to K_v, with the Corcoran Clay heads relatively sensitive to changes in K_v, while the aquifers above and below the Corcoran Clay are relatively insensitive (Figure D6-1). The results indicate that a small improvement in calibration could be obtained by decreasing the K_v above the Corcoran Clay.

The sensitivity analysis results indicate that the model is also relatively sensitive to changes in aquifer S_s, with the change in sum of squares error increasing with lower values of storage (Figure D6-1). A small improvement in calibration could be obtained by decreasing the S_s above the Corcoran Clay.

The sensitivity analysis results indicate that the model is also relatively in sensitive to changes in the Sy of the unconfined aquifer above the Corcoran Clay, with the change in sum of squares error decreasing with lower values of S_y (Figure D6-1).

7.0 Predictive Simulations

The calibrated groundwater flow model was modified to develop two 54-year transient predictive simulations from 2017 through 2070: (1) a Baseline Forecast to evaluate potential undesirable impacts from maintaining the recent land use under “normal hydrology” conditions (i.e., the status quo); and

(2) a Projects Forecast to evaluate potential impacts of implementing alternative land uses and projects to obtain groundwater sustainability. Both forecast models consist of 649 monthly stress periods starting with December 2016 and ending with December 2070. The SGMA requires that any forecast model start with current conditions. The models were started in December 2016 to permit the importation of the calibration simulations results as the start for the forecast models. The forecast models assume multiple repeating 14-year cycles of "normal hydrology" (e.g., precipitation, stream flow, surface water deliveries, and boundary conditions) from 1998 to 2010 (Figure D7-1), starting with using 2011 hydrology as an analog for 2017, which was a wet year. A summary of the forecast year and associated "normal hydrology" analog year is presented on Table D7-1. The forecast models were developed as described in the following subsections.

7.1 Baseline Forecast Scenario

The TLSBHM Baseline Forecast model represents conditions that assume land use recovering from the 2010-2015 drought conditions to "normal hydrology" conditions in the first few years of the simulation and maintaining these "normal hydrology conditions for the duration of the simulations. The Baseline Forecast model were developed as described below.

7.1.1 Baseline Forecast Land Use

A review of historical land use shows that major cropping acreage patterns have changed significantly over the past decades (Table D2-6, Figure D2-12). Acreage of cotton, pasture, and dairy fodder decreased, especially during the 2011-2016 drought. During this same period, acreage of almonds, pistachios, pomegranates, and fallow land increased. Note that the more recent plantings of almonds, pistachios, pomegranates have not yet reached maturity and associated increased water demand (Section 4.5.4.2).

During this early Baseline Forecast stress period, the acreage of corn and cotton that had been fallowed during the drought was assumed to be replanted, except for the acreage that had been converted to permanent crops. In addition, the water demand of more recently planted acreage of almonds, pistachios, and pomegranates was assumed to increase as the trees matured as discussed in Section 4.5.4.2.

For crop maturation, tree crops are assumed to continue to mature on a 25-year cycle (except for pistachios which can produce for over 100 years) and continuously mature forward in time. All other crops/land use is assumed to revert to whatever the land use was in the seed year for that particular forecast year. For example, assume there is a new patch of almonds planted in 2016 (crop zone 201). In 2021, it will be in its sixth year of existence, so it's assigned the ET rate of 6-year old almonds (crop zone 206). The other crops around this patch of almonds will revert to whatever was planted there in 2001, since 2001 is the seed year for the forecast year 2021. Three years from then, the patch of almonds is now mature and assigned an ET rate for mature almonds (crop zone 209), while the nearby crops are represented by seed year 2004 (corresponding to 2024). Further into the forecast, the almonds will be in their 25th year of existence in 2041 (crop zone 225), while the surrounding crops will be represented by seed year 2007. That same patch of almonds will be replaced, cycle back to being represented by 1st year almond ET rates (crop zone 201), and since it is 2042, the other crops are represented by whatever was planted in 2008. A chart of Baseline Forecast crop acreage is presented on Figure D7-2. Note that the crop acreage chart shows a repeating cycle of replanting of permanent tree crops.

7.1.2 Baseline Forecast Municipal Pumping

Baseline Forecast municipal water demand for the cities of Hanford, Lemoore, and Corcoran were assumed to vary seasonally at the average of 2011-2015 pumping rates. Municipal pumping was assumed to increase slowly with populations growth at a rate of 0.35% per year from about 25,060 AF (2017) to about 30,160 AF (2070).

7.1.3 Baseline Forecast Hypothetical Irrigation Pumping

As discussed in Section 4.5.4.2, the calibration model utilized the available groundwater pumping data for the individual wells and well fields servicing the ER GSA, CID, SWK GSA, TCWA GSA, and Westlands Water District, which allowed these areas to be treated as individual service area or "farms" (Figure D4-11). In the rest of the model domain, the agricultural pumping demand was calculated on approximately 40-acre spacing and assigned to hypothetical agricultural wells on approximately a 1-miles spacing. A similar process was utilized for the forecast models with a few modifications as described below.

For the forecast models, the service area or "farm" concept was extended throughout model domain by dividing the model by subbasin and GSAs into 10 services areas or "farms" (Figure D7-3). For each service area, the monthly agricultural pumping demand was calculated as follows:

- Service Area Weighted Crop Acreage (acres) x Crop ETc (ft/m) = Service Area ET Demand (AF/M)
- [-Service Area ET Demand (AF/M) + Effective Precipitation (ft/m)] / Irrigation Efficiency = -Service Area Farm Demand (AF/M)

  (*Note: over most of the model domain, Irrigation Efficiency was assumed to be 85% from 2017 to 2070. In the lake bottom area Irrigation Efficiency from was assumed to be 95% from 2017 through 2070. Approximately 50% of excess Effective Precipitation was assumed to infiltrate and 50% was assumed lost to evaporation).*
- -Service Area Farm Demand (AF/M) + Service Area Surface Water Deliveries (AF/M) + Service Area Lake Bottom Storage Water (AF/M) +Service Area Project Water (AF/M) = -Service Area Ag Pumping Demand (AF/M)

  (Note: when monthly Service Area water supplies exceeded monthly Service Area Farm Demand the excess water supply was assumed to carry over as available water supply in the following month).

The resulting service area agricultural pumping demand was then divided equally amongst the wells and well fields suppling groundwater to each servicing area. However, pumping from the Westlands Water District, CID, ER GSA, Creighton Ranch, and Angiola wells fields was limited to the maximum historical pumping from each well field (although not necessarily for each well). While this approach many not replicate the individual historical pumping from each well in a service area, it does provide a reasonable approach to allocate forecast groundwater agricultural pumping in each service area and thus a reasonable estimate of groundwater system demand.

7.1.4 Baseline Forecast GHBs

As shown on Table D7-1, the Baseline Forecast uses historical years as analogs for the hydrology conditions in the forecast. For example, 2019 is assumed to have hydrology similar to 1999. However, the GHB heads in 1999 are many feet higher than those in 2016 when the Baseline Forecast model starts. To correct for this head discrepancy, the general head boundaries for the Baseline Forecast model were developed by calculating the difference in monthly heads for each stress period of the calibration simulation, and then adding that difference to the forecast GHB head from the previous month. This allows the Baseline Forecast GHBs to have a similar change in heads between stress periods as the calibration model, but from a different initial (2016) elevation. For example, the Baseline Forecast GHB heads for simulation year 2019 are based on the heads difference for the analog year 1999. If the head difference for GHB cell 1001 between December 1998-January 1999 was 0.55 feet in the calibration model, then 0.55 feet was added to the GHB cell 1001 head for the December 2018 to yield the January 2019 GHB head. Thus the resulting Baseline Forecast GHBs exhibit a change in heads similar to that for the calibration model analog year, but from a different initial condition.

7.1.5 Baseline Forecast of Climate Change

The SGMA guidelines require that climate change be considered in any forecasts of future land uses. The California Natural Resources Association (CNRA) has developed a set of tools that can apply change factors to historical precipitation, ET demand, and surface water delivery data to make historical data consistent with forecasted conditions under climate change. The CNRA has developed two climate change factor data sets, one for 2030 and one for 2070.

7.1.5.1 Effective Precipitation

The Baseline Forecast monthly effective precipitation data set was processed through the CNRA python script/ArcGIS tool. The tool takes monthly data and processes it using change factors, which vary temporally and spatially. For model cells that cross multiple change factor grid cells, an area-weighted average change factor is applied. The change factors for a 2030 forecast were used for the forecast period January 2017-Dececember 2030 (stress periods 2 – 169) while the change factors for a 2070 forecast were used for the forecast period January 2031-December 2070 (stress periods 170 – 649).

7.1.5.2 Crop Evapotranspiration

The Baseline Forecast monthly ETc data set was processed through the CNRA python script/ArcGIS tool. The tool takes monthly data and processes it using change factors, which vary temporally and spatially. Since the “normal hydrology” Baseline Forecast scheme rotates through a series of years from 1997 to 2010 (with a 2011-based year for 2017), each ET distribution for the Baseline Forecast is unique when accounting for tree crop maturation. For model cells that cross multiple change factor grid cells, an area-weighted average change factor is applied. The change factors for a 2030 forecast were used for the forecast period January 2017-December 2030 (stress periods 2 – 169) while the change factors for a 2070 forecast were used for the forecast period January 2031-December 2070 (stress periods 170 – 649).

7.1.5.3 Surface Water Deliveries

The Baseline Forecast surface water delivery data set incorporates a reduction in historical surface water allocations to SWK GSA and TCWA GSA due the sale of water rights. The Baseline Forecast surface water delivery data set all GSAs outside of the Subbasin were not modified. CNRA change factors for surface water deliveries do not vary spatially, and are simply a multiplier applied to the historical surface water delivery volume. Different change factors are available for 2030 and 2070 climate change forecasted conditions. Like the effective precipitation and ETc data sets, the 2030 change factors were used for the forecast period January 2017-December 2030 (stress periods 2 – 169) while the change factors for a 2070 forecast were used for the forecast period January 2031-December 2070 (stress periods 170 – 649). The Baseline Forecast of surface water deliveries is shown on Figure D7-4.

7.1.6 Baseline Forecast Simulation Results

A comparison of simulated potentiometric surface maps from above and below the Corcoran Clay for December 2015 (Figure D5-3) with simulated Baseline Forecast potentiometric surface maps from above and below the Corcoran Clay for June 2040 (Figure D7-5) show that the groundwater elevations beneath the Subbasin above and below the Corcoran clay are projected to decline about 25 feet and 50 feet, respectively during the 25-year simulation period. Dewatered areas in the upper aquifer on the east side of the model domain (mostly in the Kaweah and Tule subbasins) are projected to expanded and migrate into deeper intervals. The cones of depression above and below the Corcoran Clay in the Lemoore, Creighton Ranch, and Angiola Water District well field areas are projected to become more pronounced.

Simulated Baseline Forecast potentiometric surface maps from above and below the Corcoran Clay for December 2070 (Figure D7-6) show that the groundwater elevations beneath the Subbasin above and below the Corcoran clay are projected to decline about 50 feet and 150 feet, respectively, during the 54-year simulation period. Dewatered areas in the upper aquifer in the Kaweah and Tule subbasins are projected to expanded significantly and migrate into deeper intervals. The cones of depression above and below the Corcoran Clay in the Westside Subbasin, Creighton Ranch, and Angiola well field areas are projected to become much more pronounced.

Simulated Baseline Forecast hydrographs for selected compliance wells in the vicinity of the cities of Corcoran, Hanford, and Lemoore show a continued gradual decline in groundwater elevations in the unconfined aquifer above and below the Corcoran Clay, with seasonal variations much greater below the Corcoran Clay (Figure D7-7). Over the 54-year simulation period, the hydrographs above the Corcoran Clay show approximately 100 feet of decline in the Corcoran area, about 90 feet of decline in the Hanford area, and about 100 feet of decline in the Lemoore area. Over the same period, the hydrographs below the Corcoran Clay show about 100 feet of decline in the Corcoran area, about 100 feet of decline in the Hanford area, and about 100 feet of decline in the Lemoore area.

The Baseline Forecast simulation results indicate that subsidence will continue over the next 54 years under continued existing conditions. A map of cumulative subsidence from 2017-2040 shows that the is about 0 to 4 feet of additional subsidence over most of the Subbasin, with up to 6 feet of additional subsidence in the Lemoore area and Angiola and Creighton Ranch wells fields in the Tule Subbasin (Figure D7-8). Baseline Forecast subsidence in the lake bottom area are minimal. A map of cumulative subsidence from 2017-2070 shows that the is about 0 to 8 feet of additional subsidence over most of the Subbasin, with up to 10 feet of additional subsidence in the Lemoore area and over 10 feet of subsidence in the Angiola and Creighton Ranch wells fields in the Tule Subbasin (Figure D7-8).

Simulated Baseline Forecast subsidence hydrographs for continuous GPS compliance point near the cities of Corcoran and Lemoore wells show that under continued existing conditions, subsidence rate remain consistent during the forecast period (Figure D7-8). The minimum threshold for subsidence was specified as 11.5 feet, which was the maximum simulated subsidence within the TLSBHM domain in 2070.

The Baseline Forecast simulation groundwater mass balance data were used to estimate the change in groundwater storage in the Subbasin on an annual basis for the 54-year forecast simulation period (Figure D7-9). Similar to the 1998-2010 "normal hydrology" period in the calibration model, the period 2040-2048 represents a "normal" or "hydrologically balanced" period in the forecast model. Under the Baseline Forecast assumptions described above, the 2040-2408 "hydrologically balanced period" annual change in groundwater storage averaged about -149,430 AF/Y. During the 2017-2070 period, the annual change in groundwater storage averaged about -142,990 AF/Y, and as much as -7.72 million AF of cumulative storage depletion from the Subbasin.

In summary, the Baseline Forecast simulation results indicate continued overdraft conditions in the Subbasin, with chronic lowering of groundwater levels, continued reduction of groundwater in storage, continued land subsidence, and possibly degraded groundwater quality. Thus, the Baseline Forecast indicates that sustainable groundwater conditions in the Subbasin cannot be achieved without changes in groundwater usage and management.

7.2 Forecast Project Simulations

Multiple Projects Forecast simulations were created iteratively by modifying the Baseline Forecast and incorporating various potential projects and management actions developed by the GSAs for the Subbasin and surrounding subbasins (see Section 7.6) (Figure D7-10). The objectives of the projects and management actions are to obtain groundwater sustainability (defined as stable groundwater elevations with minimal changes in storage, land subsidence, and water quality degradation over time) by 2040 through a combination of increase water supplies and demand reduction.

Potential projects and management actions considered include:

- Above ground surface water storage projects,
- Intentional recharge basins,
- On-Farm Recharge,
- Aquifer Storage and Recovery (ASR), and
- Agricultural pumping limits in surrounding subbasins.

The combined projects were assumed to provide an annual average of 40,500 AF/Y of increases water supply and 38,000 AF/Y of groundwater recharge for a total of about 78,500 AF/Y of new water supply (Table D7-2, Figure D7-11). This is slightly more than the average overdraft (-73,760 AF/Y) observed during the 1998-2010 “normal hydrology” period and about 92% of the 1990-2016 average overdraft (-85,690 AF/Y). In addition, land use changes resulting from construction of the projects are anticipated to reduce agricultural demand by approximately 26,900 AF/Y. In total, the proposed project may yield an average of up to 104,400 AF/Y of additional water supply to the Subbasin. The proposed projects are described below by Subbasin GSAs.

Mid-Kings River Groundwater Sustainability Agency

The Mid-Kinks River GSA has proposed constructing several 40-80 acre groundwater recharge facilities in the GSA. For modeling purposes, the proposed recharge facility was assumed to be constructed on about 1,500 acres of land in the northeast portion of the GSA (Figure D7-10). The simulated facility was implemented in four 5-year phases starting in 2020. Full build out would be completed in 2035. Due to conversion of irrigated crop land to recharge basins, the recharge facility construction is estimated to result in a permanent annual agricultural demand reduction of about 4,500 AF once completed. The facility was assumed to recharge Kings River flood waters with an assumed percolation rate of approximately 1-foot per day for a 150-day period from March through July when flood waters are typically available based on the historical hydrology cycles used to construct the forecast (Figure D7-11). Flood water were assumed to be available about every 6 to 7 years. Total recharge capacity would increase in 5-year phases from an initial 50,000 AF to an estimated 200,000 AF during flood years when fully built out. Annual average project yield is estimated to be about 38,000 AF/Y over the simulation period, and about 44,440 AF/Y over the hydrologically balanced 2040-2048 period (Table D7-2). Intentional recharge was simulated in the Projects Forecast using the RCH package.

El Rico Groundwater Sustainability Agency

The ER GSA has proposed constructing an intermittent surface water storage facility to store Kings River flood water when available (Figure D7-10). The proposed surface water storage facility was assumed to be constructed by 2030 using raised 6-foot berms to enclose approximately 6,400 acres of land. The land would continue to be farmed during non-flood years, so the net average agricultural demand reduction is estimated to be about 8,400 AF/Y. The surface water storage facility was assumed to store approximately 40,000 AF of Kings River flood waters at a rate of about 8,000 AF/M during a 150-day period from March through July when flood water are typically available based on the historical hydrology cycles used to construct the forecast (Figure D7-11). Because of the clayey nature of the Lake Bottom sediments, infiltration of storage water was assumed to be de minimis. Annual average project yield is estimated to be about 8,780 AF/Y over the simulation period, and 8,890 AF/Y over the hydrologically balanced 2040-2048 period (Table D7-2). This additional surface water supply was added to the Baseline Forecast surface water deliveries for the ER GSA.

South Fork Kings Groundwater Sustainability Agency

The SFK GSA has proposed a number of small projects including aquifer storage and recovery (ASR) wells, new surface water storage facilities, and land fallowing. The potential projects for SFK GSA were very conceptual in nature. The location of the potential ASR well field(s) and potential recharge and recovery rates has not been identified. The locations of potential surface water storage facilities and land fallowing areas were also undefined. Hence, for forecast modeling purposes, a single large surface water storage facility was assumed to be constructed in the southeast portion of the GSA (Figure D7-11). The simulated surface water storage facility was assumed to be constructed by 2030 using raised 6-foot berms to enclose approximately 10,000 acres of land. Approximately half of this land was assumed to already be fallow, so the net agricultural demand reduction is estimated to be about 15,000 AF/Y after 2030. Because of the clayey nature of the sediments in this area, infiltration of storage water was assumed to be de minimis. The surface water storage facility was assumed to store approximately 60,000 AF of Kings River flood waters at a rate of about 12,000 AF/M from March through July when flood water are typically available based on the historical hydrology cycles used to construct the forecast (Figure D7-11). Annual average project yield is estimated to be about 13,170 AF/Y over the simulation period, and 13,330 AF/Y over the hydrologically balanced 2040-2048 period (Table D7-2). This additional surface water supply was added to the Baseline Forecast surface water deliveries for the SFK GSA.

Tri-County Water Authority Groundwater Sustainability Agency

The TCWA GSA has proposed constructing a new surface water storage facility over the middle portion of the GSA (Figure D7-11). The simulated surface water storage facility was assumed to be constructed by 2030 using raised 6-foot berms to enclose approximately 13,340 acres of fallow land, so there was no net agricultural demand reduction. Because of the clayey nature of the sediments in this area, infiltration of storage water was assumed to be de minimis. The surface water storage facility was assumed to store approximately 80,000 AF of Kings River flood waters at a rate of about 16,000 AF/M from March through July when flood water are typically available based on the historical hydrology cycles used to construct the forecast (Figure D7-11). Annual average project yield is estimated to be about 17,561 AF/Y over the simulation period, and 17,780 AF/Y over the hydrologically balanced 2040-2048 period (Table 7-2). This additional surface water supply was added to the Baseline surface water deliveries for the TCWA GSA and SWK GSA.

Surrounding Subbasins Projects

As shown on Figure D2-2, the Subbasin is surround by the Westside, Kings, Kaweah, Tule, and Kern subbasins. It was assumed that these surrounding subbasins would also implement projects similar in scope and yield as those proposed for the Subbasin in order to obtain groundwater sustainability. Since all the surrounding subbasins were developing potential projects as part of their GSPs, there was insufficient time to coordinate with the surrounding subbasins and implement their proposed projects into the TLSBHM Projects Forecast model. Therefore, for simplicity, it was assumed that each surrounding subbasins would implement projects that would yield additional surface water supplies similar to what is proposed for the Subbasin, or approximately 75% of the 1990-2016 annual average change in storage estimated for that portion of each subbasin within the TLSBHM (Figures D5-4 through D5-9). It was further assumed, for simplicity, that the surrounding subbasin projects would be implement outside of the TLSBHM model domain and that the additional water supply would be imported into the TLSBHM domain as addition surface water deliveries. The assumed surrounding subbasin additional water supplies include:

- Westside Subbasin 60,330 AF/Y
- Kings Subbasin 50,960 AF/Y
- Kaweah Subbasin 114,400 AF/Y
- Tule Subbasin 104,220 AF/Y
- Kern Subbasin 35,720 AF/Y

This additional surface water supply was added to the Baseline surface water deliveries for each of the surrounding subbasins.

Surrounding Subbasins Pumping Limits

Another management option under consideration by the surrounding subbasins is a limitation of groundwater pumping to a prescribed number of acre-feet per acre of irrigated land. Based on review of draft GSPs and discussions with other GSA the pumping limits under consideration include:

Subbasin	GSA	Irrigated Acres in Model	Pumping Limit (af/ac)	Agricultural Pumping (AF/Y)
Kaweah	All	127,870	2.00	255,740
Kings	Central Kings	16,170	1.13	18,275
Kings	Kings River East	15,800	0.73	11,530
Kings	North Fork Kings	41,864	1.10	46,050
Kern	--	36,190	1.00	36,190
Tule	--	79,920	0.54	43,160
Westside	--	62,920	0.60	37,750

The prescribed pumping limit volumes were assumed to be uniformly distributed between all agricultural wells in each subbasin within the model domain.

7.2.1 Projects Forecast Land Use

Land use under the Projects Forecast is identical to that used in the Baseline Forecast with the exception that lands utilized for most of the Subbasin projects was assumed to go out of production as the projects are built out over time, resulting in a step-wise decrease in agricultural demand (Figure D7-10).

Land fallowing in the surrounding subbasins resulting from implementation of pumping limits was not explicitly simulated in the model. Only the reduction in agricultural pumping was specified in the forecast model.

7.2.2 Projects Forecast Municipal Pumping

The Project Forecast municipal water demand for the cities of Hanford, Lemoore, and Corcoran is identical to that used in the Baseline Forecast. Municipal pumping was assumed to increase slowly with populations growth at a rate of 0.35% per year from about 25,060 AF (2017) to about 30,160 AF (2070).

7.2.3 Projects Forecast Hypothetical Irrigation Pumping

The Projects Forecast of agricultural irrigation pumping was calculated in an identical manner as for the Baseline Forecast, assuming increased surface water deliveries from the projects and pumping limits in the surrounding subbasins. The available surface water supplies were increased by the proposed project yields as described in Section 7.2.1. During flood events, additional stored surface water was assumed to be available to supplement surface water deliveries the month following storage, less evaporative losses. For example, the volume of water stored in the proposed SFK GSA surface water pond during March 2031 (about 1.2 feet over 10,000 acres) would be available to be redistributed as additional surface water supply to SFK GSA in April 2013 minus open water evaporation for March (about 0.38 feet). This assumption allows the proposed project surface water storage to be depleted in a timely manner by both evaporation and re-use.

7.2.4 Projects Forecast GHBs

The Projects Forecast GHBs were calculated in an identical manner as for the Baseline Forecast with one modification. As described in Section 7.1.4, the general head boundaries for the Baseline Forecast model were developed by calculating the difference in monthly heads for each stress period of the calibration simulation, and then adding that difference to the forecast GHB head from the previous month. This allows the forecast GHBs to have a similar change in heads between stress periods as the calibration model, but from a different initial (2016) elevation. This same process was used for the Projects Forecast GHBs with the addition of a head change factor that assumes projects were implemented in the subbasins surrounding the Subbasin resulting in a gradual stabilization (or "soft landing") of heads around 2040. The head change factor had a value of 100% from 2017 through 2026, and then decreased by 5% per year until 2040 where the head change factor was fixed at 25% for the duration of the simulation. The resulting Projects Forecast GHBs show a more gradual decrease in the rate of decline compared to the Baseline GHBs (Figure D7-12).

7.2.5 Projects Forecast of Climate Change

The SGMA guidelines require that climate change be considered in any forecasts of future land uses. The same CNRA climate change factor data sets for 2030 and 2070 used in the Baseline Forecast were applied to the Projects Forecast ET demand, and surface water delivery data. The CNRA corrected effective precipitation results remained identical to the Baseline Forecast.

7.2.6 Projects Forecast Simulation Results

As discussed in Section 7.2, multiple Projects Forecast simulations were created iteratively by modifying the Baseline Forecast and incorporating various potential projects and management actions developed by the Subbasin GSAs and surrounding subbasins. The Projects Forecast scenarios evolved as follows:

1. Projects Forecast Scenario 1: The Baseline Forecast was modified by added projects and associated land fallowing in the Subbasin only (discussed below). The simulation results showed a continued lowering of groundwater levels, reduction of groundwater in storage, continued land subsidence, and increased outflow to surrounding subbasins.
2. Projects Forecast Scenario 2: The Projects Forecast was further modified with GHBs that caused an asymptotic flatting (i.e., soft landing) of the GHB heads in 2040, representing the effects of assumed projects in other subbasins. The modification of the GHBs simulation results showed only a slight reduction of groundwater level declines compared to Projects Forecast Scenario 1, with continued reduction of groundwater in storage, continued land subsidence, and continued outflow to surrounding subbasins.
3. Projects Forecast Scenario 3: The Projects Forecast was further modified by assuming each surrounding subbasin implemented projects that would yield additional surface water supplies similar to what is proposed for the Subbasin, or approximately 75% of the 1990-2016 annual average change in storage estimated for that portion of each subbasin within the TLSBHM. The simulation results showed a substantial reduction of groundwater level declines over time compared to Projects Forecast Scenarios 1 and 2, but with continued declining groundwater levels, reduction of groundwater in storage, continued land subsidence, and continued outflow to surrounding subbasins, after 2040.
4. Projects Forecast Scenario 4: The Projects Forecast was further modified by implementing agricultural pumping limits in the surrounding subbasins. The simulation results showed a substantial reduction of groundwater level declines over time compared to Projects Forecast Scenarios 1 through 3, resulting in stable groundwater elevations throughout most of the Subbasin and surrounding subbasins, with significantly reduced reduction of groundwater in storage, and significantly reduced land subsidence. These results are presented below.

A comparison of simulated potentiometric surface maps from above and below the Corcoran Clay for the Baseline Forecast for June 2040 (Figure D7-5) with simulated Projects Forecast Scenario 4 (hereafter referred to simply as the Projects Forecast) potentiometric surface maps from above the Corcoran Clay for June 2040 (Figure D7-13) show that the simulated groundwater elevations beneath the Subbasin above the Corcoran Clay are about 10 feet higher under the Projects Forecast compared to the Baseline Forecast. Simulated groundwater elevations in the surrounding subbasins are substantially higher with groundwater elevation increases ranging from 20 to 30 feet in Kaweah, Kings, and Tule subbasins. The Westside Subbasin showed groundwater elevations increases in the 10 to 20 foot range, while there was little increase in the Kern Subbasin.

Simulated groundwater elevations for June 2040 beneath the Subbasin below the Corcoran Clay are about 20 to 30 feet higher under the Projects Forecast compared to the Baseline Forecast. In the Kaweah and Kings subbasins, simulated heads are 20 to 40 feet higher compared to the Baseline Forecast. In the Tule Subbasin in Creighton Ranch and Angiola well field areas, simulated heads are as much as 130 feet higher compared to the Baseline Forecast. The Westside Subbasin showed groundwater elevations increases in the 40- to 100-foot range, while the heads in the Kern Subbasin increased as much as 50 feet.

A comparison of simulated potentiometric surface maps from above and below the Corcoran Clay for the Baseline Forecast for December 2070 (Figure D7-5) with simulated Projects Forecast potentiometric surface maps from above the Corcoran Clay for December 2070 (Figure D7-14) show that the simulated groundwater elevations beneath the Subbasin above the Corcoran Clay are about 10 to 30 feet higher under the Projects Forecast compared to the Baseline Forecast. Simulated groundwater elevations in the surrounding subbasins are substantially higher with groundwater elevation increases ranging from 20 to 40 feet in Kaweah and Kings subbasins, and as much as 80 feet in the Tule Subbasin. The Westside Subbasin showed groundwater elevations increases in the 10 to 20 to 60 foot range, while the heads in the Kern Subbasin increased as much as 40 feet.

Simulated groundwater elevations for December 2070 beneath the Subbasin below the Corcoran Clay are about 30 to 40 feet higher under the Projects Forecast compared to the Baseline Forecast. In the Kaweah and Kings subbasins, simulated heads are 30 to 60 feet higher compared to the Baseline Forecast. In the Tule Subbasin in Creighton Ranch and Angiola well field areas, simulated heads are as much as 160 feet higher compared to the Baseline Forecast. The Westside Subbasin showed groundwater elevations increases in the 50-to 130-foot range, while the heads in the Kern Subbasin increased as much as 90 feet.

Simulated Projects Forecast hydrographs for selected compliance wells in the vicinity of the cities of Corcoran, Hanford, and Lemoore show a gradual stabilization of groundwater elevations in the unconfined aquifer above and confined below the Corcoran Clay, with seasonal variations much greater below the Corcoran Clay (Figure D7-15). Over the 54-year simulation period, the hydrographs above the Corcoran Clay show approximately 15 feet of decline in the Corcoran area, about 25 feet of decline in the Hanford area, and about 60 feet of decline in the Lemoore area. Over the same period, the hydrographs below the Corcoran Clay show about 30 feet of decline in the Corcoran area, about 25 feet of decline in the Hanford area, and about 20 feet of decline in the Lemoore area.

The Projects Forecast simulation results indicate that subsidence will continue over the next 54 years under the assumed forecast conditions. A map of cumulative subsidence from 2017-2040 shows that the is about 0 to 2 feet of additional subsidence over most of the Subbasin, with up to 2 feet of additional subsidence in the Lemoore area (Figure D7-16). Subsidence in the Angiola and Creighton Ranch wells fields in the Tule Subbasin is significantly less compared to the Baseline Forecast (Figure D7-7). Projects Forecast subsidence in the lake bottom area in minimal. A map of cumulative subsidence from 2017-2070 shows that the is about 2 to 4 feet of additional subsidence over the northern portion of the Subbasin, with up to 2 feet of additional subsidence in the Angiola and Creighton Ranch wells fields in the Tule Subbasin (Figure D7-16).

Simulated Projects Forecast subsidence hydrographs for continuous GPS compliance point near the cities of Corcoran and Lemoore wells show that under project conditions, the subsidence continues to occur (Figure D7-17), but at significant reduced rates compared to the Baseline Forecast (Figure D7-8).

The Projects Forecast simulation groundwater mass balance data were used to estimate the change in groundwater storage in the Subbasin on an annual basis for the 54-year forecast simulation period (Figure D7-18). Under the Projects Forecast assumptions described above, between 2017 and 2070, there would continue to be an annual average of about -36,200 AF/Y of groundwater storage depletion (a reduction of 75% compared to the Baseline Forecast), and as much as -7.72 million AF of cumulative storage depletion from the Subbasin. Most of the remaining overdraft in the Subbasin appears to result from the continued outflow of groundwater to the surrounding subbasins, which average approximately -58,610 AF/Y over the 2017-2070 simulation periods (Figure D7-18).

As discussed in Section 7.2, for simulation purposes it was assumed that the surrounding subbasins would implement projects and management actions that would increase surface water supply and decrease agricultural demand. However, until the magnitude and timing of actual projects and management actions to be implemented in the surrounding subbasins can be incorporated into the TLSBHM, the model forecasts will have a degree of uncertainty regarding future water balance and overdraft estimates.

In summary, the Projects Forecast simulation results indicate that overdraft conditions in the Subbasin will be mostly eliminated, with stable groundwater levels by 2040. While there continues to be some reduction of groundwater in storage, the forecast that groundwater levels remain relatively stable through 2070 indicates that the continued reduction in groundwater in storage is also sustainable. Likewise, although some land subsidence will continue over time, the forecast that groundwater levels remain relatively stable through 2070 indicates that the continued subsidence is also sustainable. Thus, the Projects Forecast indicates that sustainable groundwater conditions in the Subbasin can be achieved by 2040 with implementation of the proposed projects and management actions in the Subbasin and assumed projects and management actions in the surrounding subbasins.

7.2.7 Historical vs. Projects Forecast Simulation Comparison

A comparison of the 1990-2016 historical model, 2017-2070 Baseline Forecast, and 2017-2070 Projects Forecast was made using the annual average groundwater balance data for each simulation (Table D7-3). The Baseline and Projects forecast models both assume that land fallowed during the 2011-2016 drought would be put back into production, and that overall crop demand would increase due to the maturation of permanent crop as described in Section 7.1.1. The increase in ET demand was also exacerbated by climate change. Furthermore, the forecasts also assume that groundwater levels would continue to decline at historical rates for 10 or more years prior to project implementation. As a result, for the even though the Baseline Forecast 2017-2070 average annual pumping, recharge, and river leakage are similar to the Calibration 1990-2016 average values, the net change in storage increased from -85,690 AF/Y to -142,990 AF/Y because there was more interbasin outflow from the Subbasin into the surrounding subbasins. The annual average values for 1998-2010 and 2040-2048 “normal hydrology” periods have similar results, where the net change in storage increased from -73,760 AF/Y to -149,430 AF/Y.

The Projects Forecast shows a different trend. With implementation of the projects, the 2017-2070 average annual pumping decreases, groundwater recharge increases, and interbasin flow decreases. As a result, the net change in storage decreased from -85,690 AF/Y to -36,200 AF/Y (nearly a 60% decrease). The results are similar for the 1998-2010 and 2040-2048 “normal hydrology” periods, where the net change in storage decreased from -73,760 AF/Y to -19,390 AF/Y.

The results of the Projects forecast simulation indicate that under the assumed forecast conditions, implementation of the proposed projects to increase surface water supply and recharge coupled with agricultural demand reductions in the surrounding subbasins can significantly reduce overdraft to sustainable levels in the Subbasin as evidenced by the stabilization of groundwater levels throughout most of the subbasins (Figure D7-15, GSP Appendix G) and the reduction of subsidence (Figure 7-17).

8.0 Data Limitations

Groundwater models are designed to estimate changes over time in groundwater levels, flow directions, and storage given a set of inflows (precipitation, surface water, under flow in, etc.) and outflows (evapotranspiration, pumping, underflow out, etc.). Prior to the SGMA there were no requirements to manage or report groundwater usage. As a result, most GSAs do know the location, construction, and pumping history of many pumping wells within their GSAs. Furthermore, most GSAs often do not have a good historical accounting of which parcels have received surface waters and at what rates. Hence, these inputs and outputs need to be approximated by other means than direct measurement.

The data utilized for construction and calibration of the TLSBHM were provided by various private parties, public agencies, and data extracted from existing numerical models of the area including DWR's 2014 release of C2VSim in the Coarse Grid version, USGS CVHM, the Kaweah Delta Water Conservation District model (Fugro West, 2005), and the preliminary Tule Subbasin and Westside Subbasin models. Other numerical models adjacent to and/or covering portions of the TLSBHM are known to exist, but were unavailable for this effort. The data gathering effort also occurred before many GSAs were organized, so it is likely that some data were unavailable at the time the model was developed. It is anticipated that as the TLSBHM is reviewed and utilized that some corrections of input data will be necessary and that additional data, unavailable at the time, will need to be incorporated into the model.

Much of the hydrologic data used to construct and calibrate the TLSBHM are based on estimates or inferred from multiple data sources. As noted above, most GSAs do not know the historical delivery of surface water to various parcels within the GSAs. Hence it was necessary to assume that all irrigated parcels received some surface water allotment. Likewise, the location, construction, and pumping history of most of the irrigation wells in the TLSBHM domain are not known. Hence hypothetical irrigation well locations were assumed to be distributed with relatively uniform spacing across the model domain. The hypothetical irrigation wells were also assumed to have completion intervals and frequency similar to that of a small subset of wells with known constructions. Hypothetical irrigation wells pumping was estimated based on a water balance method using estimated agricultural demand based on reported crop type minus the assumed distribution of surface water supplies. While these simplifying assumptions and estimates are reasonable given the sparseness of measurements, they add uncertainty to the model.

Overtime, under the SGMA, more accurate spatial and temporal groundwater pumping, and surface water delivery data should be collected and utilized to construct and update groundwater models of the Subbasin. As the models are populated with actual measurement instead of estimate, the models will become more useful tool for managing groundwater in the Subbasin.

9.0 Summary of Model Reliability and Peer Review

The TLSBHM is an approximation of existing conditions beneath and in the vicinity of the Subbasin. It covers a large area with very dynamic hydrologic conditions that have significant changes over the simulation period. Due to a lack of historical data, much of the data utilized to construct the model had to be inferred from alternative data sets. Given the uncertainty of these estimates, the model can approximate on average, but not completely reproduce, all observations across the entire site area under all conditions. Overall, the TLSBHM can reliably predict groundwater elevations in response to various hydrologic conditions within the calibration period based on the available data and estimates. However, forecast simulations with extreme ranges in hydrologic conditions (i.e., severe drought conditions or extreme flooding) may produce less reliable results.

The TLSBHM was submitted for peer review to Dr James T McCord of GeoSystems Analysis, Inc. Dr. McCord has over 30 years of experience in hydrology, hydrogeology, and water resource investigations, with emphasis on characterization of groundwater and surface water systems, numerical modeling of hydrologic systems. He has authored numerous consulting reports and technical peer-reviewed papers, and co-authored the textbook, Vadose Zone Processes (CRC Press, 1999). He has served as an Adjunct Professor of Earth Science at New Mexico Technical University since 1991, as well as Adjunct

Professor of Civil Engineering at the University of New Mexico and of Civil and Environmental Engineering at New Mexico Tech since 2007. Dr. McCord's per review in include in Appendix D6.

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Table D2-1
Historical Precipitation - Hanford, California[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1899	M	M	M	M	M	M	M	M	0	0.67	M	0.87	M
1900	1.38	0	1.18	1.04	M	M	M	M	M	M	M	M	M
1901	M	M	M	M	M	M	M	T	1.04	T	M	0.15	M
1902	0.4	2	1.78	0.47	0.09	M	0	M	0	0.36	1.67	0.56	M
1903	1.31	0.38	1.71	0.5	0	0	0	0	0	0.05	0.47	0.15	4.57
1904	0.52	2.03	2.05	0.72	0	0	0	0	2.48	0.84	0.31	1.16	10.11
1905	1.28	1.09	2.1	0.56	0.65	0	0	0	0.07	0	1.16	0.23	7.14
1906	1.59	1.92	4.05	0.62	2.06	0.02	0	0	0	0	M	M	M
1907	M	M	M	M	M	M	M	M	M	M	M	M	M
1908	M	M	M	M	M	M	M	M	M	M	M	0.31	M
1909	M	M	M	M	M	M	M	M	M	M	M	M	M
1910	M	M	M	M	M	M	M	M	M	M	M	M	M
1911	M	M	M	M	M	M	M	M	M	M	M	M	M
1912	M	0.02	3.24	1.52	0.27	0	0	0	0	0	0.61	0.21	M
1913	1.26	1.55	0.34	0.78	0.76	0.06	0.08	0	M	M	M	1.35	M
1914	4.36	1.25	0.37	0.11	M	1.06	0	0	0	0	0.02	M	M
1915	M	M	0.3	1.37	M	M	M	M	M	M	M	M	M
1916	4.68	M	M	M	0.16	M	M	0.28	0.47	1.09	M	1.35	M
1917	M	M	M	M	0.31	M	M	M	M	M	M	M	M
1918	M	4.5	3.43	M	M	M	M	M	0.88	0.12	M	M	M
1919	M	M	1.01	0.15	0.1	M	M	M	M	M	M	M	M
1920	M	2.72	3.05	0.24	M	M	M	M	M	M	M	M	M
1921	M	0.89	M	M	0.87	M	M	M	M	M	M	M	M
1922	M	M	M	M	M	M	M	T	M	M	M	M	M
1923	M	M	M	2.43	M	M	M	M	M	M	M	0.22	M
1924	M	M	1.86	M	0	M	M	T	0	0.65	M	2.12	M
1925	M	M	1.58	M	M	M	0	M	0	M	M	M	M
1926	0.82	1.44	0.2	2.67	T	0	0	0	0	0.76	3.67	0.65	10.21
1927	1.33	2.52	2.04	0.18	0.06	T	0	0.04	T	1.67	1.63	0.78	10.25
1928	0.09	0.96	1.55	0.08	0.1	0	0	0	0	T	1.47	1.69	5.94
1929	0.81	0.61	1.4	0.81	0	0.24	T	0	0.03	0	0	0.42	4.32
1930	1.66	1	1.66	0.15	0.37	0	0	0.02	0.38	0.07	0.67	0.3	6.28
1931	2.32	0.72	0.07	0.91	0.2	1.12	0	0.08	0.08	0	1.36	2.54	9.4
1932	1.85	1.52	0.47	0.71	0.13	0	0	0	0	0	0.28	0.93	5.89
1933	3.12	0.16	0.72	0.28	0.41	0.07	0	0	0	0.15	0	1.01	5.92
1934	0.17	1.53	0.05	0	0.22	0.14	0	0	0	1.06	2.15	1.84	7.16
1935	2.5	1.77	2	2.05	0	0	0.03	0	0.06	0.51	0.4	0.89	10.21
1936	0.66	4.7	0.97	0.55	T	T	0	0	0	1.84	0	2.87	11.59
1937	1.95	2.46	2.23	0.22	0	0	0	0	0	0.11	0.21	2.16	9.34
1938	1.76	3.51	4.59	1.15	0.11	0.17	0.07	0	0.13	0.19	0.19	1.42	13.29
1939	1.54	0.77	1.44	0.82	T	0.12	0	0	0.04	0.57	0.06	0.22	5.58
1940	3.53	3.61	0.99	0.18	T	T	0	0	0	0.85	T	3.61	12.77

Table D2-1

Historical Precipitation - Hanford, California[1]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	1.51	3.9	2.05	2.41	T	T	0	T	0	0.9	0.57	3.11	14.45
1942	1.21	0.88	0.94	1.19	0.16	0	0	M	0	0	0.43	1.1	M
1943	2.73	1.14	3.35	0.87	0	0	0	0	0	0.03	0.22	1.03	9.37
1944	1.28	2.97	0.22	0.86	0.28	0.23	0	0	0.02	0.23	2.25	0.97	9.31
1945	0.26	2.71	1.81	0.16	0.1	0.17	0	0	T	0.71	1.15	1.51	8.58
1946	0.34	1.53	2.56	0.07	0.41	0	0.11	0	0	1.33	1.1	2.06	9.51
1947	0.41	0.49	0.56	0.11	0.41	0	0	0	T	0.59	0.29	0.51	3.37
1948	0	0.44	1.46	1.55	0.54	0	0	0	0	0.03	0.01	0.99	5.02
1949	0.51	0.85	1.94	0.07	0.53	0	0	T	0	0	0.6	0.68	5.18
1950	1.93	1.13	1.1	0.4	0	0	0.08	0	0	0.34	0.63	1.06	6.67
1951	1.24	0.76	0.22	1.17	0.07	0	0	0	0	0.08	1.11	2.39	7.04
1952	3.08	0.27	2.18	0.79	0.01	0.02	T	0	0.17	0.05	0.65	2.96	10.18
1953	1.1	0.27	0.34	0.83	0.29	0.02	T	0	0	0.02	1.01	0.09	3.97
1954	1.89	0.78	2.21	0.52	0.34	0.08	0	0	0	0	0.66	1.61	8.09
1955	3.25	1.31	M	M	0.9	0	0	M	0	0.02	0.92	4.67	M
1956	1.2	0.38	0.1	0.73	0.83	0	0	0	0	0.72	0	0.15	4.11
1957	1.39	1.17	0.56	0.67	0.63	0	0	0	0	0.2	1.39	1.41	7.42
1958	1.85	2.3	3.92	2.04	0.24	0	0	T	0.88	0	0.23	0.16	11.62
1959	0.86	1.9	0.11	0.52	T	0	0	T	0.11	0	0	0.17	3.67
1960	0.8	1.71	0.61	0.57	0	0	0.02	0	0	0.53	2.61	0.03	6.88
1961	1.34	0.22	0.67	0.22	0.37	0	0	0	0	0	1.11	1.28	5.21
1962	0.71	4.88	1.06	0	0.11	0	0	0	0.01	0.1	0	0.19	7.06
1963	1.19	1.68	1.37	2.88	0.56	0.17	0	0	0.33	0.75	1.23	0.29	10.45
1964	0.61	0.02	0.94	0.64	0.2	0	0	0.34	0	0.95	1.31	1.44	6.45
1965	1.18	0.33	0.33	1.6	0	0	0	0.05	0.07	0.05	2.15	1.97	7.73
1966	0.63	0.71	0.1	0	0.07	0.06	0.04	0	0.29	0	1.28	2.57	5.75
1967	1.41	0.05	2.42	2.95	0.07	0.23	0	0	0.31	0	1.99	0.5	9.93
1968	0.57	0.64	1	0.5	0.08	0	0	0	0	1.33	0.98	1.64	6.74
1969	6.69	4.54	0.79	0.85	0.32	0.21	0.07	0	0.15	0.05	0.51	0.7	14.88
1970	1.6	1.33	1.42	0.16	0	T	T	0	0	T	2.4	1.23	8.14
1971	0.35	0.19	0.23	0.4	1.44	0	0	T	0.04	0.06	0.41	1.87	4.99
1972	0.04	0.35	0	0.23	0	0	0	0	0.24	0.21	2.9	0.65	4.62
1973	M	2.29	2.2	0.12	M	M	0	0	0	M	M	M	M
1974	2.97	0.11	1.75	0.03	0	0	0	0	0	0.65	0.24	1.4	7.15
1975	0.09	2.26	M	0.49	0	0	0	0	0.96	M	0.05	0.22	M
1976	T	2.94	0.19	1.47	0.03	0.51	0	0.22	1.47	0	1.15	0.96	8.94
1977	0.59	0.03	0.43	0	0.91	0.07	0	0	0	0.05	0.66	2.85	5.59
1978	2.22	5.05	4.12	1.71	0	0	0	0	1.1	0	0.79	0.5	15.49
1979	2.19	1.61	1.16	0.03	0	0	0.04	0	0.08	0.41	0.62	0.41	6.55
1980	2.9	2.71	1.28	0.05	0.04	0	0	0	0	0.09	0	0.2	7.27
1981	1.77	0.86	2.1	0.68	0.17	0	0	0	0	0.76	1.08	0.29	7.71
1982	0.84	0.38	3.52	1.75	0	0.45	0.18	0	0.64	1.03	2.15	0.71	11.65
1983	3.74	2.59	3.39	1.63	0.04	0	0	0.05	0.82	0.43	1.66	1.22	15.57
1984	0.01	0.42	0.27	0.18	0	0	0	0	0	M	M	M	M
1985	0.59	M	0.7	0.12	0	0	M	0	T	M	2.11	0.66	M

Table D2-1

Historical Precipitation - Hanford, California[1]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1986	1.46	2.6	3.43	0.5	0	0	T	T	0.15	0	0.21	0.77	9.12
1987	1.77	2.07	2.02	0.06	0.13	0.05	0	0	0	0.58	0.47	1.7	8.85
1988	1.37	0.4	0.93	1.99	0.07	0	0	0	0	0	1.31	2.29	8.36
1989	0.17	1.04	0.85	0.02	0.39	0	0	T	0.67	0.32	0.2	0	3.66
1990	1.66	1.1	0.3	0.97	0.87	0	T	T	T	0.01	0.22	0.15	5.28
1991	0.31	0.12	6.62	0.19	T	0.12	0	0	0.11	0.41	0.14	M	M
1992	1.4	2.82	0.85	0.1	T	0	0.01	0.01	T	0.58	T	2.62	8.39
1993	3.88	2.48	2.16	0.07	0.08	0.3	0	0	0	0.24	0.64	0.66	10.51
1994	0.94	1.45	1.02	0.72	0.66	0	T	0	1.06	0.35	1.54	0.33	8.07
1995	4.7	0.51	4.77	0.65	0.87	0.04	T	0	T	0	T	1.59	13.13
1996	1.68	2.89	2.27	0.85	0.1	T	0	0	0	2.43	0.69	3.27	14.18
1997	3.02	0.12	0.21	0	0	T	T	0	0.06	0.09	1.96	1.8	7.26
1998	2	4.05	2.63	1.68	1.31	0.44	0	0	T	0.68	0.63	0.65	14.07
1999	3.01	0.56	0.43	1.37	0	0	0	T	0.01	0	0.15	T	5.53
2000	1.8	3.28	1.59	0.97	0.48	0.35	0	0	0.03	1.31	T	0.05	9.86
2001	1.98	1.48	1.24	1.12	0	0	0.09	0	T	0.18	1.84	1.99	9.92
2002	0.87	0.31	1.04	0.03	0.01	0.82	0	0	0	0	1.42	1.14	5.64
2003	0.24	1.08	1.01	1.5	0.62	0	T	0.07	0	0	0.49	2	7.01
2004	2	2.18	0.29	0.02	0.01	0	0	0	0	2.06	0.52	2.23	9.31
2005	2.63	1.58	2.24	0.71	0.83	0	0	T	0.01	0.01	0.19	2.07	10.27
2006	3.54	0.55	2.72	3.39	0.53	0	0	0	0	0.06	0.22	1.01	12.02
2007	0.65	0.89	0.26	0.33	0.01	0	0	0.12	0.37	0.35	0.12	1.32	4.42
2008	2.18	1.18	T	0	0.11	0	0	0	0	0.15	1.04	1.49	6.15
2009	0.8	1.86	0.2	0.02	0.41	0.22	0	0	0.18	1.32	0.28	1.42	6.71
2010	2.64	1.91	0.34	1.65	0.17	0	0	0	0	0.64	1.32	6.46	15.13
2011	1.52	1.53	2.87	0.3	0.4	1.04	0	0.08	0.01	0.55	0.8	0.06	9.16
2012	M	M	M	1.39	0.03	M	T	0	0	0.28	0.49	1.9	M
2013	0.22	0.48	0.79	0.08	0.17	0	0	0	0.01	T	0.33	0.16	M
2014	0.3	1.38	0.27	0.35	T	0	0	0	0.03	0	0.94	2.52	5.79
2015	0.08	0.72	0.02	0.77	0.1	0	0.45	0	0	0.38	0.91	1.4	4.83
2016	2.56	0.58	1.99	0.57	0.02	0.09	0	0	0	0.76	0.4	1.6	8.57
2017	3.7	2.8	0.31	1.02	0.36	0.01	0	0.01	0.17	0.06	0.21	0.08	8.73
Mean	1.59	1.5	1.47	0.75	0.25	0.09	0.01	0.01	0.15	0.38	0.82	1.24	8.28
Min	6.69 1969	5.05 1978	6.62 1991	3.39 2006	2.06 1906	1.12 1931	0.45 2015	0.34 1964	2.48 1904	2.43 1996	3.67 1926	6.46 2010	15.57 1983
Max	0 1948	0 1900	0 1972	0 2008	0 2018	0 2015	0 2017	0 2016	0 2016	0 2014	0 1980	0 1989	3.37 1947

1. From: https://w2.weather.gov/climate/xmacis.php?wfo=hnx
   M = missing data and T = trace amount of precipitation.

Table D2-2

Historical Land Use

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Tulare Lake Subbasin[1]	1990-1995 (acres)	1996-1998 (acres)	1999-2006 (acres)	2007 (acres)	2008 (acres)	2009 (acres)	2010 (acres)	2011 (acres)	2012 (acres)	2013 (acres)	2014 (acres)	2015 (acres)	2016 (acres)	Average (acres)
Alfalfa Hay and Clover	41,604	32,564	54,301	72,459	80,600	71,504	69,685	38,789	42,131	49,318	35,820	29,665	24,245	**45,987**
Almonds (Adolescent)			2,908			5,127	7,927	3,222	4,464	7,476	6,526	6,222	5,365	**2,470**
Almonds (Mature)	7,682	5,241	4,550	12,897	11,825	9,826	8,374	10,140	10,818	11,441	12,876	15,046	15,105	**7,852**
Almonds (Young)		3,278	9,290	16,538	25,966	14,678	20,887	13,968	14,564	20,341	17,678	16,983	21,576	**9,557**
Berries	20								1	2		0		**5**
Carrot Single Crop								11	5	12	2	2	16	**2**
Citrus (no ground cover)			25		13	14	4	120	29	100	89	22	9	**21**
Corn and Grain Sorghum	14,280	38,896	29,349	39,271	31,762	34,643	23,031	33,780	29,175	27,566	22,638	18,826	17,400	**25,404**
Cotton	159,534	180,960	124,764	109,605	88,304	72,441	98,167	105,541	88,993	89,317	63,385	44,532	73,720	**118,794**
Dairy Single Crop*	3,816	4,077	4,385											**2,438**
Fallow Land*	193,695	138,392	89,606	65,169	85,144	99,688	90,192	152,391	172,697	172,486	195,172	237,790	200,972	**136,159**
Forest*	420	809	2,955	6	5	46	5			1		4	0	**952**
Grain and Grain Hay	28,708	48,533	62,962	19,266	27,870	27,406	25,980	7,758	9,968	11,194	12,213	21,196	19,069	**34,833**
Melons	250	56	284				14	2	11	7	797	18	86	**170**
Misc. field crops	17,116	12,819	51,311		2			0			2			**18,531**
Onions and Garlic	457	479	770			7	1,358	411	302	94	502	149	644	**483**
Open Water*	5,568	9,092	8,968	5,576	4,296	4,049	5,434	7,703	5,443	5,045	6,824	5,919	5,435	**6,637**
Pasture and Misc. Grasses	2,500	5,029	5,615	50,688	44,232	66,944	53,080	14,680	13,368	15,355	33,551	15,744	13,743	**14,473**
Pistachio (Adolescent)								170	218	370	882	3,575	3,836	**335**
Pistachio (Mature)	4,694	3,808	3,804	6,096	1,907	934	404	394	380	348	330	485	469	**2,888**
Pistachio (Young)		1,580	4,390	4,351	4,259	8,527	8,083	12,985	14,676	15,878	19,195	22,678	22,570	**6,247**
Pomegranates (Adolescent)											3	16	27	**2**
Pomegranates (Young)				61	1,705	545	256	5,012	804	1,395	2,207	1,312	3,111	**608**
Potatoes, Sugar beets, Turnip etc..	5,736	1	209	6		3		9		41		2	2	**1,331**
Riparian*		668	1,120	517	134	398	615	226	138	313	239	248	194	**477**
Small Vegetables	1,599	647	4,518	20	2	13	212	142	133	244	165	78	198	**1,643**
Stone Fruit (Adolescent)			1,478			14	66	100	125	69	47	191	170	**412**
Stone Fruit (Mature)	7,070	4,985	3,854	1,314	544	168	18	3	23	41	23	27	39	**3,206**
Stone Fruit (Young)		1,827	4,185	672	1,609	1,573	2,502	1,077	712	1,641	1,340	1,183	713	**1,770**
Tomatoes and Peppers	5,634	1,627	14,676	117	2	110	12	21,482	23,670	7,114	11,922	19,211	23,420	**9,203**
Urban, Industrial*	12,654	17,391	19,875	33,427	34,711	44,471	32,218	32,091	28,576	29,366	33,901	30,530	30,930	**22,128**
Wine Grapes with 80% canopy	2,948	3,226	5,779	5,588	3,499	2,240	2,746	5,361	9,228	4,655	6,472	4,672	10,985	**4,565**
Winter Wheat*				72,238	67,458	50,451	64,526	48,212	45,118	44,530	30,950	19,420	21,690	**17,207**
Tulare Lake Subbasin Irrigated Crop Acreage	**299,832**	**345,557**	**389,021**	**338,951**	**324,102**	**316,717**	**322,806**	**275,156**	**263,796**	**264,018**	**248,665**	**221,837**	**256,519**	**310,792**
Tulare Lake Subbasin Total Crop Acreage	**515,986**	**515,986**	**515,931**	**515,883**	**515,849**	**515,821**	**515,796**	**515,779**	**515,768**	**515,759**	**515,751**	**515,747**	**515,741**	**496,788**

1. Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year

Table D2-3
Historical Kings River Diversions

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Kings River Water Years	GSA / Agency / Diversion	Mid-Kings River: Peoples Ditch Company — *Peoples Canal- MKRGSA Total*	Mid-Kings River: Last Chance Water Ditch Company — *Last Chance Canal- MKRGSA Total*	Mid-Kings River: *Lakeside IWD*	Mid-Kings River: Imported Water	Mid-Kings River: Mid Kings	South Fork Kings: Stratford Irrigation District — Stratford Canal	South Fork Kings: Empire West Side Irrigation District — Empire West Side ID total from SWP	South Fork Kings: Empire West Side Irrigation District — Empire West Side Canal	South Fork Kings: Westlake Canal	South Fork Kings: Lemoore Canal & Irrigation Company — Lemoore Canal	South Fork Kings: Imported Water	South Fork Kings: South Fork Kings River
		(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)
71%	1966	107,763	50,356	-	-	158,119	2,158	-	4,770	3,604	96,079	-	106,612
197%	1967	136,889	78,468	-	-	215,358	3,947	-	9,622	5,861	109,323	-	128,753
49%	1968	75,809	31,878	-	-	107,688	3,540	1,780	13,636	12,718	91,478	-	123,153
256%	1969	107,636	61,339	-	-	168,975	1,139	50	2,878	6,056	87,537	-	97,659
78%	1970	76,723	38,772	-	-	115,495	1,884	3,548	5,359	7,305	93,441	-	111,538
69%	1971	86,815	35,321	-	-	122,137	4,376	5,391	4,665	10,280	96,498	-	121,210
50%	1972	51,631	38,190	-	-	89,820	4,062	5,216	6,188	5,133	80,465	-	101,065
125%	1973	139,667	62,672	-	-	202,339	4,411	5,233	5,964	6,543	86,382	-	108,534
122%	1974	137,406	68,454	-	-	205,860	4,082	4,085	9,291	10,508	102,115	-	130,081
92%	1975	109,458	43,937	-	-	153,395	4,570	5,803	8,763	10,939	104,388	-	134,463
32%	1976	37,828	2,255	-	-	40,083	4,284	5,811	5,915	5,004	70,925	-	91,940
23%	1977	43,393	9,542	-	-	52,935	2,203	2,120	1,598	557	42,067	-	48,545
201%	1978	125,769	71,577	-	-	197,346	2,859	409	10,627	9,312	80,567	-	103,774
101%	1979	125,680	64,463	-	-	190,143	6,434	1,565	15,449	9,523	107,578	-	140,549
178%	1980	101,388	64,365	-	-	165,753	3,981	805	16,100	11,566	103,714	-	136,165
61%	1981	89,091	47,482	-	-	136,572	4,435	7,966	7,841	9,437	89,111	-	118,790
181%	1982	127,200	65,413	-	-	192,613	4,479	4,379	9,396	20,983	100,153	-	139,389
261%	1983	60,994	48,013	-	-	109,007	3,808	0	6,097	10,389	58,631	-	78,926
115%	1984	97,831	53,649	-	-	151,480	2,533	0	2,801	3,800	99,362	-	108,496
73%	1985	105,362	39,583	-	-	144,944	4,869	4,677	5,209	6,827	103,148	-	124,731
190%	1986	111,962	62,457	-	-	174,419	7,329	2,070	7,345	16,723	87,761	-	121,227
45%	1987	70,406	24,792	-	-	95,198	5,177	3,961	4,959	10,982	90,541	-	115,620
48%	1988	60,312	21,844	-	-	82,156	3,953	3,128	4,457	2,949	76,554	-	91,041
53%	1989	60,579	19,935	-	-	80,514	0	2,700	0	-	56,519	-	59,219
40%	1990	53,292	9,909	-	-	63,201	0	2,979	0	-	34,465	-	37,444
63%	1991	45,654	18,622	-	-	64,276	1,760	199	1,006	964	31,492	-	35,420
41%	1992	49,394	9,361	-	-	58,755	1,759	1,219	0	0	37,968	-	40,945
149%	1993	147,363	53,498	-	-	200,860	5,070	2,467	4,314	8,612	91,166	-	111,629
50%	1994	69,510	30,738	-	-	100,248	2,997	1,499	3,808	6,811	76,550	-	91,666
202%	1995	143,785	102,300	-	-	246,085	6,123	1,468	6,419	1,410	85,049	-	100,469
122%	1996	166,765	95,338	-	-	262,103	6,774	1,681	5,576	5,778	105,398	-	125,206
155%	1997	133,158	85,505	20,657	-	239,321	7,460	0	8,239	2,079	89,117	-	106,896
181%	1998	141,107	77,863	29,871	-	248,841	5,578	488	4,596	8,447	75,590	-	94,698
74%	1999	101,773	62,938	12,119	-	176,830	4,971	2,858	6,135	3,624	95,504	-	113,092
90%	2000	108,835	82,526	13,181	-	204,541	4,598	1,619	2,184	4,566	99,074	-	112,041
59%	2001	73,419	31,031	7,017	-	111,467	4,959	1,674	1,993	2,680	58,979	-	70,285
67%	2002	99,376	52,020	5,354	-	156,751	4,104	1,265	1,364	2,202	74,196	-	83,131
83%	2003	104,545	54,735	13,325	-	172,605	4,356	1,292	752	3,362	63,511	-	73,273
61%	2004	79,743	27,306	5,667	-	112,717	2,019	3,206	1,650	1,480	58,257	-	66,611
148%	2005	131,193	54,799	24,547	-	210,539	5,619	3,451	2,664	1,946	98,279	-	111,958
172%	2006	129,571	65,459	24,718	-	219,748	6,065	2,954	5,417	2,368	96,857	-	113,661
40%	2007	84,144	20,918	3,312	-	108,374	4,836	1,876	3,810	4,727	70,288	-	85,536
72%	2008	81,364	29,000	6,764	-	117,128	2,037	852	1,470	1,081	59,988	-	65,428
79%	2009	85,743	30,617	5,829	-	122,189	2,047	148	1,811	1,771	49,297	-	55,074
121%	2010	113,146	42,817	16,103	-	172,066	4,318	2,545	3,644	2,900	90,694	-	104,101
180%	2011	163,801	79,589	23,764	-	267,154	4,979	1,364	4,625	4,947	109,605	-	125,519
49%	2012	80,025	30,309	4,595	-	114,929	4,203	1,151	4,594	2,289	71,207	-	83,443
41%	2013	49,246	12,881	110	-	62,236	0	536	0	0	43,206	-	43,741
32%	2014	27,801	8,824	0	-	36,626	0	158	0	0	17,905	-	18,062
21%	2015	12,430	-	0	-	12,430	0	326	0	0	14,759	-	15,085
75%	2016	67,310	20,567	2,986	-	90,863	0	-	0	0	42,532	-	42,532
204%	2017	-	-		-	-	-	-	-	-	-	-	-
	Annual Averages	93,943	44,985	4,312		143,240	3,669	2,156	4,804	5,315	77,554		93,499

Kings River Water Years	GSA / Agency / Diversion	Southwest Kings: *Blakeley Canal-Kings River & Lateral A*	Southwest Kings: TLBWSD Lateral C, T203	Dudley Ridge Water District-Monthly Diversions Assumed: Dudley Ridge State Turnout (DR-1), T201	Dudley Ridge State Turnout (DR-1B), T202	Dudley Ridge State Turnout (DR-1A), T204	Dudley Ridge State Turnout (DR-2), T205	Dudley Ridge State Turnout (Paramount), T207	Dudley Ridge State Turnout (DR-3), T208	Imported Water, Angiola/Green Valley Well Fields, City of Lemoore and Westlands RD 761	Southwest Kings
		(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)
71%	1966	20,559	-	-	-	-	-	-	-	-	20,559
197%	1967	29,187	-	-	-	-	-	-	-	-	29,187
49%	1968	19,692	0	3,312	949	2,372	11,388	9	5,694	-	43,416
256%	1969	534	0	3,942	1,130	2,824	13,554	11	6,777	-	28,771
78%	1970	0	0	5,077	1,455	3,637	17,456	15	8,728	-	36,366
69%	1971	10,521	0	5,158	1,478	3,695	17,735	15	8,867	-	47,469
50%	1972	20,920	0	5,333	1,528	3,820	18,335	15	9,168	-	59,119
125%	1973	22,249	0	4,429	1,269	3,172	15,228	13	7,614	-	53,973
122%	1974	37,966	0	8,390	2,404	6,010	28,849	24	14,425	-	98,069
92%	1975	36,603	0	10,191	2,920	7,300	35,040	29	17,520	-	109,602
32%	1976	22,247	0	7,770	2,226	5,566	26,716	22	13,358	-	77,906
23%	1977	8,903	0	3,633	1,041	2,603	12,493	10	6,246	-	34,930
201%	1978	26,094	0	7,455	2,136	5,340	25,632	21	12,816	-	79,494
101%	1979	52,496	0	9,685	2,775	6,938	33,302	28	16,651	-	121,876
178%	1980	53,639	0	10,061	2,883	7,207	34,594	29	17,297	-	125,710
61%	1981	42,806	0	9,213	2,640	6,599	31,677	26	15,839	-	108,800
181%	1982	41,213	0	6,968	1,997	4,992	23,960	20	11,980	-	91,130
261%	1983	22,250	0	7,026	2,013	5,033	24,157	20	12,078	-	72,577
115%	1984	10,003	0	8,116	2,326	5,814	27,907	23	13,954	-	68,144
73%	1985	34,288	0	7,791	2,232	5,581	26,788	22	13,394	-	90,096
190%	1986	27,361	0	6,427	1,841	4,604	22,098	18	11,049	-	73,398
45%	1987	28,582	0	5,816	1,666	4,166	19,996	17	9,998	-	70,242
48%	1988	21,261	0	6,030	1,728	4,319	20,733	17	10,367	-	64,456
53%	1989	13,458	0	7,168	2,054	5,134	24,645	21	12,323	-	64,802
40%	1990	6,485	0	4,606	1,320	3,299	15,836	13	7,918	14,540	54,016
63%	1991	5,941	0	1,670	479	1,196	5,743	5	2,871	8,181	26,085
41%	1992	6,003	0	1,696	486	1,215	5,831	5	2,915	6,095	24,245
149%	1993	30,546	0	2,917	836	2,090	10,031	8	5,016	6,480	57,925
50%	1994	26,295	0	3,834	1,099	2,747	13,184	11	6,592	11,642	65,404
202%	1995	34,039	0	5,715	1,637	4,094	19,650	16	9,825	8,131	83,107
122%	1996	41,813	0	6,886	1,973	4,933	23,677	20	11,839	14,505	105,645
155%	1997	25,259	0	7,895	2,262	5,655	27,146	23	13,573	11,319	93,132
181%	1998	17,157	3,528	6,955	1,993	4,982	23,916	20	11,958	11,348	81,857
74%	1999	25,132	0	7,958	2,280	5,701	27,363	23	13,681	10,280	92,418
90%	2000	21,426	0	7,397	2,119	5,299	25,433	21	12,717	10,299	84,711
59%	2001	11,377	0	6,030	1,728	4,319	20,732	17	10,366	10,306	64,875
67%	2002	13,083	0	6,930	1,986	4,964	23,828	20	11,914	10,291	73,016
83%	2003	8,256	0	6,657	1,907	4,768	22,888	19	11,444	10,359	66,299
61%	2004	12,382	0	6,383	1,829	4,572	21,946	18	10,973	10,072	68,176
148%	2005	24,480	0	7,366	2,111	5,276	25,327	21	12,663	11,115	88,360
172%	2006	34,147	0	7,766	2,225	5,563	26,702	22	13,351	11,115	100,891
40%	2007	25,308	0	6,090	1,745	4,363	20,940	17	10,470	9,975	78,909
72%	2008	10,209	0	5,292	1,516	3,791	18,195	15	9,097	10,016	58,131
79%	2009	7,997	0	3,982	1,141	2,852	13,691	11	6,846	12,178	48,699
121%	2010	17,655	0	4,144	1,187	2,969	14,249	12	7,125	42,300	89,641
180%	2011	43,781	0	3,373	966	2,416	11,597	10	5,799	34,012	101,953
49%	2012	22,689	0	2,775	795	1,988	9,543	8	4,771	51,435	94,006
41%	2013	3,284	0	3,591	1,029	2,572	12,346	10	6,173	19,602	48,606
32%	2014	567	0	2,136	612	1,530	7,345	6	3,672	23,852	39,720
21%	2015	184	0	3,271	937	2,343	11,247	9	5,623	31,718	55,333
75%	2016	-	-	-	-	-	-	-	-	34,248	34,248
204%	2017	-	-	-	-	-	-	-	-	-	-
	Annual Averages	20,737	68	5,535	1,586	3,965	19,033	16	9,516	8,734	69,598

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Table D2-3
Historical Kings River Diversions

Tulare Lake Subbasin Hydrologic Model
Kings County, California

GSA		El Rico												Tri-County											
Kings River Water Years	Agency / Diversion	***Empire Weir No. 2 (over #2 weir to river extension, River Water) Modified Total-(Empire Weir No. 2 minus Tri County Kings River Water)***	***TLBWSD Lateral B, T206 (State Water)-Modified Total-(SWP Total for Lateral B minus Tri County Entitlement)***	Lakelands Canal-Total	Tulare Lake Canal	***Melga Canal-Diversion of Peoples Canal, El Rico GSA Total***	Kern River	***Deer Creek-30% of Deer Creek Total***	Tule River-El Rico	Kaweah River	***Loan Oak/New Deal- Diversion of Last Chance, El RicoGSA Total***	Imported Water	El Rico	Poso Creek	***TLBWSD Lateral A, T200 (State Water)-Assumed Full Entitlement-25% to Lateral A***	***TLBWSD Lateral B, T206 (State Water)-Assumed Full Entitlement-75% to Lateral B***	Tule River-Tri County	***Deer Creek-70% of Deer Creek Total***	White River	Kings River-Tri County	Other Water	Imported Water	Tr-County	**Annual Totals**
		(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)
71%	1966	2,404	-	14,225	17,831	71,842	-	-	-	-	21,581	-	127,884	-	-	-	-	-	-	-	-	-	0	413,173
197%	1967	82,883	-	71,671	42,476	91,260	-	-	-	-	33,629	-	321,919	-	-	-	-	-	-	-	-	-	0	695,217
49%	1968	4,673	10,256	17,218	49,218	50,540	-	-	-	-	13,662	-	151,775	-	923	2,768	-	-	-	-	-	-	3,690	429,722
256%	1969	196,219	2,893	40,568	0	71,757	-	-	-	-	26,288	-	339,477	-	260	781	-	-	-	-	-	-	1,041	635,924
78%	1970	0	0	52,483	0	51,149	-	-	-	-	16,617	-	120,248	-	0	0	-	-	-	-	-	-	0	383,648
69%	1971	0	47,329	28,610	490	57,877	-	-	-	-	15,138	-	178,091	-	4,257	12,771	-	-	-	-	-	-	17,028	485,935
50%	1972	1,099	103,195	0	7,305	34,420	-	-	-	-	16,367	-	224,849	-	9,282	27,846	-	-	-	-	-	-	37,128	511,981
125%	1973	530	45,583	19,101	31,948	93,111	-	-	-	-	26,860	-	244,723	-	4,100	12,300	-	-	-	-	-	-	16,400	625,968
122%	1974	14,906	56,123	55,482	28,336	91,604	-	0	-	-	29,337	-	309,845	0	5,157	15,472	1,402	0	0	0	0	-	22,032	765,886
92%	1975	11,905	89,737	41,833	53,125	72,972	-	0	-	-	18,830	-	342,042	0	7,224	21,671	224	0	0	2,642	0	-	31,760	771,261
32%	1976	0	47,863	3,493	45,170	25,219	-	0	-	-	967	-	151,071	0	3,541	10,624	0	0	0	9,154	0	-	23,320	384,320
23%	1977	1,732	21,197	0	4,003	28,929	-	0	-	-	4,090	-	71,762	0	635	1,905	0	0	0	950	0	-	3,490	211,662
201%	1978	33,029	3,073	31,904	49,511	83,846	-	3,000	-	-	30,676	-	237,179	1,500	624	1,873	2,476	7,000	1,000	11,956	0	-	26,430	644,222
101%	1979	2,523	97,690	34,336	32,856	83,787	-	0	-	-	27,627	-	334,337	0	4,271	12,814	185	0	0	6,575	0	-	23,846	810,750
178%	1980	41,353	34,131	37,277	29,258	67,592	-	1,800	-	-	27,585	-	259,729	900	3,163	9,488	2,611	4,200	600	2,819	0	-	23,780	711,136
61%	1981	8,761	140,237	9,180	19,710	59,394	-	0	742	78,485	20,349	-	415,677	0	5,033	15,099	223	0	0	8,983	0	-	29,338	809,178
181%	1982	45,602	36,788	54,659	77,268	84,800	-	5,660	63,476	171,808	28,034	-	589,793	2,830	2,598	7,793	3,090	13,207	1,887	12,547	0	-	43,951	1,056,876
261%	1983	238,616	522	21,919	1,333	40,663	-	12,150	193,800	114,301	20,577	-	644,159	6,075	0	0	340	28,350	4,050	0	0	-	38,815	943,484
115%	1984	17,704	1,917	42,516	0	65,220	-	19,804	17,566	120,846	22,992	-	309,830	9,902	303	909	0	46,210	6,601	0	0	-	63,925	701,875
73%	1985	16,118	84,042	20,108	29,821	70,241	-	0	367	73,859	16,964	-	361,048	0	5,881	17,644	826	0	0	1,586	0	-	25,937	746,756
190%	1986	28,395	41,528	50,896	51,205	74,641	-	5,144	43,384	71,918	26,767	-	417,043	2,572	1,269	3,806	1,701	12,004	1,715	11,054	0	-	34,121	820,207
45%	1987	18,250	60,441	27,104	57,023	46,938	-	0	0	44,445	10,625	-	299,874	0	3,517	10,550	0	0	0	9,366	0	-	23,432	604,366
48%	1988	8,209	40,544	18,863	17,816	40,208	-	0	0	25,873	9,362	-	184,264	0	2,207	6,622	0	0	0	984	0	-	9,814	431,730
53%	1989	0	75,859	7,458	0	40,386	-	0	0	24,550	8,544	-	200,939	0	4,605	13,814	150	0	0	0	1,580	-	20,149	425,623
40%	1990	0	37,168	15,114	0	35,528	-	0	0	39,853	4,247	-	153,181	0	1,810	5,430	0	0	0	0	4,556	-	11,796	319,638
63%	1991	344	2,855	6,143	2,870	30,436	-	0	0	28,897	7,981	-	81,060	0	16	49	604	0	0	1,604	0	-	2,274	209,115
41%	1992	0	35,181	0	0	32,930	-	279	0	23,442	4,012	-	115,532	140	1,156	3,469	0	652	93	0	0	-	5,510	244,987
149%	1993	25,174	58,745	66,990	44,555	68,050	-	101	0	108,379	22,928	-	426,703	50	565	1,694	1,155	235	34	6,919	2,575	-	13,226	810,344
50%	1994	15,625	28,204	0	49,718	38,072	-	0	0	28,376	-	-	175,829	0	990	2,970	0	0	0	6,098	0	-	10,058	443,205
202%	1995	51,722	59,720	52,969	48,240	75,670	-	2,285	13,777	149,232	-	-	487,891	1,142	3,032	9,095	6,040	5,331	762	4,902	0	-	30,303	947,854
122%	1996	33,027	107,966	61,767	36,006	81,522	-	1,847	236	139,238	-	-	521,635	924	3,055	9,165	1,913	4,311	616	2,219	0	-	22,202	1,036,790
155%	1997	19,089	2,107	32,557	25,047	65,232	-	9,220	40,122	66,638	-	-	265,690	4,610	1,895	5,684	1,701	21,513	3,073	4,729	0	-	43,206	748,244
181%	1998	4,514	17,487	32,918	16,707	75,570	-	5,590	26,731	58,340	-	-	243,601	2,795	1,057	3,171	2,083	13,042	1,863	50	0	-	24,061	693,058
74%	1999	4,359	140,451	8,184	13,492	49,810	-	0	2,235	51,184	-	-	329,217	0	95	286	274	0	0	167	0	-	822	712,379
90%	2000	16,796	86,346	35,062	33,304	56,416	-	871	2,900	48,050	-	-	319,674	435	3,935	11,804	1,166	2,032	290	0	0	-	19,663	740,630
59%	2001	21,146	39,067	2,122	38,045	38,433	-	0	8	20,131	-	-	180,610	0	1,027	3,082	0	0	0	3,044	3,000	-	10,154	437,390
67%	2002	14,150	33,324	46,842	7,942	45,043	-	0	490	73,770	-	-	242,267	0	2,004	6,011	124	0	0	0	190	-	8,329	563,493
83%	2003	13,153	44,894	36,750	45,168	48,228	-	0	1,748	49,413	-	-	254,241	0	2,152	6,455	790	0	0	6,652	160	-	16,209	582,626
61%	2004	17,145	42,460	40,917	16,768	40,719	-	0	1,106	59,030	-	-	241,003	0	265	795	559	0	0	0	5,293	-	6,912	495,419
148%	2005	73,872	75,546	42,290	64,243	67,430	-	1,767	2,372	86,750	-	-	442,024	884	116	347	1,680	4,123	589	10,632	1,235	-	19,605	872,486
172%	2006	70,800	52,463	80,614	74,920	69,623	-	2,392	17,135	171,601	-	-	561,992	1,196	126	378	795	5,581	797	14,253	0	-	23,126	1,019,418
40%	2007	21,586	39,927	17,889	31,676	46,218	-	0	153	39,474	-	-	217,420	0	50	149	0	0	0	18,083	63	-	18,345	508,584
72%	2008	9,553	11,833	8,051	5,282	41,851	-	0	158	37,662	-	-	123,545	0	156	468	828	0	0	4,756	0	-	6,208	370,440
79%	2009	855	13,750	22,036	99	43,482	-	0	1,383	62,389	-	-	152,859	0	7	21	0	0	0	0	0	-	28	378,849
121%	2010	34,789	32,026	38,210	37,297	55,771	-	0	5,059	102,754	-	-	315,091	0	2	7	1,676	0	0	10,587	282	-	12,555	693,453
180%	2011	89,121	25,964	88,052	78,409	83,250	-	0	11,316	140,553	-	-	530,567	0	68	205	-	0	0	0	-	-	273	1,025,466
49%	2012	24,964	43,921	3,483	15,977	39,616	-	0	200	60,683	-	-	205,755	0	57	170	-	0	0	0	-	-	227	498,360
41%	2013	0	13,062	58,140	0	27,281	-	-	-	-	-	-	109,253	0	58	174	-	0	0	0	-	-	232	264,069
32%	2014	0	3,681	41,472	0	12,461	-	-	-	-	-	-	59,473	0	38	115	-	0	0	0	-	-	154	154,035
21%	2015	0	0	21,076	0	2,493	-	-	-	-	-	-	24,175	0	45	0	-	0	0	0	-	-	45	107,068
75%	2016	0	-	32,114	0	27,677	-	-	-	-	-	-	59,791	0			-	0	0	0	-	-	0	227,433
204%	2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Annual Averages	26,210	40,175	31,229	26,107	54,847	0	1,383	8,586	45,614	10,052		268,189	705	1,816	5,446	666	3,227	470	3,333	364		16,175	590,701

Table D2-3
Historical Kings River Diversions

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Notes:
1. Values highlighted have been modified.
2. Values with "0" indicate no surface water delivery to the best of our knowledge.
3. Values with "-" have no verified data.
4. Total flow from Peoples Canal is split 60% to Mid-Kings, 40% to Melga.
5. Last Chance Diversion is split 50% between Mid-Kings and El Rico.
6. Blakeley has added State Water from Lateral A for Southwest.
7. Total flow from Deer Creek split 30% to El Rico, 70% to Tri-County.
8. Tule River for El Rico includes the total of Elk Bayou and TID Spill.
9. SWP from TLBWSD Split Through out Tri-County and Southwest Kings.
10. Kings River water in Tri-County was subtracted from the total in Empire Weir No. 2. 1976 and 2010 are 0 for Empire Weir No. 2 because of negative values.
11. Lakeside is a portion of Kaweah River, Reduced Total Kaweah River between Mid-Kings and El Rico.
12. Additional Tule River flow data added for Tri-County.
13. Empire Westside Irrigation District total from SWP reduce annual totals by 10%.
14. Dudley Ridge Water District reduce annual totals by 10%.
15. Lateral A (T200) & Lateral B (T206) reduce annual totals by 18% for El Rico & Tri-County.
16. Modifications to Peoples Canal and Last Chance as a result of discussions with Mid-Kings River GSA on 2/14/19.

Key
Wet Year
Dry Year
Average Precipitation
GSA Annual Totals
Kings River Watershed Total

Average Annual
690,714
494,326
649,938

Reduction in Entitlement	
Empire West Side ID Total from SWP	10%
Dudley Ridge State Turnouts	10%
Lateral A & B for El Rico & Tri County	18%

Table D2-4
Annual Specified Well Field Pumping[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Date	El Rico GSA Well Field (AF/Y)	Creighton Ranch Well Field (AF/Y)	Corcoran ID Well Field (AF/Y)	Angiola Well Field (AF/Y)	Westlands Well Field (AF/Y)	Municipal Well Fields (AF/Y)	Apex Ranch Well Field (AF/Y)
1990	70,716	27,222	87,977	34,500	67,131	9,370	--
1991	57,509	38,484	84,438	23,396	98,656	9,109	--
1992	80,012	27,255	72,348	33,494	98,344	9,666	--
1993	11,395	4,035	14,248	5,956	44,056	10,208	--
1994	48,043	17,986	78,297	16,389	72,674	10,928	--
1995	2,897	905	7,145	-	27,589	10,775	--
1996	-	-	20,261	-	28,516	12,719	--
1997	-	-	15,586	-	27,000	12,775	--
1998	-	-	2,484	-	20,988	11,555	--
1999	-	-	33,406	-	37,185	13,087	--
2000	14,910	2,849	40,672	6,784	43,392	13,421	--
2001	89,799	41,120	64,353	23,244	65,947	13,895	--
2002	68,933	35,843	64,736	26,537	66,530	26,701	--
2003	32,420	10,856	62,246	22,429	40,841	19,349	526
2004	82,875	47,511	74,007	26,805	42,115	18,777	912
2005	-	468	20,138	662	14,744	16,536	--
2006	-	72	14,034	141	16,526	15,822	6,939
2007	69,863	40,266	85,434	32,894	40,373	17,221	6,319
2008	92,269	52,980	79,362	32,502	63,519	18,432	5,435
2009	78,097	45,292	81,493	37,798	69,904	16,354	7,677
2010	36,129	17,740	29,669	22,568	34,895	15,271	6,345
2011	606	314	7,328	11,336	15,509	17,042	--
2012	95,154	52,325	70,008	19,388	55,298	17,467	9,044
2013	100,275	66,005	78,175	30,528	70,940	18,411	4,970
2014	108,976	68,726	69,880	27,695	94,077	16,930	298
2015	116,254	61,050	67,982	30,220	90,723	16,146	--
2016	126,886	53,113	67,982	29,047	93,853	14,555	--
1990-2016 Average	**51,260**	**26,386**	**51,618**	**18,308**	**53,382**	**14,908**	**4,847**
1998-2010 Average	**43,484**	**22,692**	**50,156**	**17,874**	**42,843**	**16,648**	**4,879**
Well Count	**99**	**52**	**98**	**51**	**150**	**30**	**5**

1. GSA = Groundwater Sustainability Agency, ID = Irrigation District, and AF/Y = acre-feet per year.

Table D2-5
Reference Crop Evapotranspiration Values[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Crop Evapotranspiration	January (inches)	February (inches)	March (inches)	April (inches)	May (inches)	June (inches)	July (inches)	August (inches)	September (inches)	October (inches)	November (inches)	December (inches)
Reference ETo	0.82	2.22	4.5	6.73	8.52	8.23	8.34	7.62	5.8	4.2	1.28	0.84
Fallow Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Almonds	0.83	0.85	2.71	3.91	6.75	6.39	6.58	6.08	3.92	2.25	0.75	0.83
Pistachio	0.83	0.66	1.92	1.13	2.77	5.91	8.17	7.65	5.26	2.99	0.81	0.83
Grain and Grain Hay	0.89	2.09	4.67	6.86	3.84	0.14	0.20	0.09	0.08	0.38	0.84	0.89
Cotton	0.88	0.64	1.88	0.75	1.62	4.68	8.17	7.70	5.35	1.52	0.78	0.87
Corn and Grain Sorghum	0.88	0.64	2.89	1.16	2.83	7.00	8.06	5.12	0.38	0.38	0.78	0.87
Misc. field crops	0.88	0.64	2.89	1.16	2.77	7.32	7.56	3.03	0.08	0.38	0.78	0.87
Alfalfa Hay and Clover	0.88	2.12	4.31	5.78	7.25	7.02	7.01	6.34	4.80	2.01	1.33	0.91
Pasture and Misc. Grasses	0.89	1.64	3.37	5.17	7.83	7.64	7.74	7.00	5.32	3.25	1.18	0.87
Small Vegetables	0.88	1.29	4.07	1.25	0.02	0.11	0.18	1.08	1.54	1.84	1.61	0.90
Potatoes, Sugar beets, Turnip etc.	0.88	0.92	3.13	6.72	8.84	8.58	7.58	0.18	0.08	0.37	0.77	0.86
Onions and Garlic	0.88	1.88	4.10	5.48	4.80	0.56	0.18	0.08	0.08	0.37	1.34	0.88
Citrus (no ground cover)	0.83	1.98	3.96	4.69	5.54	5.76	5.72	5.24	3.91	3.14	1.47	0.86
Tomatoes and Peppers	0.88	0.63	2.57	0.70	4.39	8.12	7.42	0.78	0.08	0.37	0.77	0.86
Wine Grapes with 80% canopy	0.84	0.66	2.17	1.42	4.18	6.06	6.00	4.82	2.74	0.40	0.75	0.84
Dairy Single Crop	1.03	1.94	3.48	4.67	4.50	6.71	7.72	6.32	3.91	2.27	1.24	1.14
Carrot Single Crop	1.02	1.60	3.14	5.95	4.79	5.75	6.16	4.36	3.70	2.85	1.77	1.19
Carrot Double Cropping	0.54	1.40	2.93	4.41	5.84	3.59	2.71	3.53	3.12	2.60	1.41	1.12
Dairy Double Cropping	0.59	1.59	3.26	4.65	3.57	5.27	7.87	6.81	3.71	0.77	0.59	0.67
Urban, Commercial	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urban, Industrial	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Riparian	0.00	0.01	3.49	6.13	8.33	8.23	8.34	7.62	5.74	3.91	1.02	0.10
Open Water	0.82	2.22	4.50	6.73	8.52	8.23	8.34	7.62	5.80	4.20	1.58	0.84
Average All Crops	0.85	1.29	3.19	3.66	4.56	5.37	5.84	4.23	2.67	1.56	1.05	0.90

Table D2-5

Reference Crop Evapotranspiration Values[1]

Crop Evapotranspiration	January (ft/d)	February (ft/d)	March (ft/d)	April (ft/d)	May (ft/d)	June (ft/d)	July (ft/d)	August (ft/d)	September (ft/d)	October (ft/d)	November (ft/d)	December (ft/d)
Reference ETo	0.00220	0.00661	0.01210	0.01869	0.02290	0.02286	0.02242	0.02048	0.01611	0.01129	0.00356	0.00226
Fallow Land	0	0	0	0	0	0	0	0	0	0	0	0
Almonds	0.00223	0.00253	0.00728	0.01086	0.01815	0.01775	0.01769	0.01634	0.01089	0.00605	0.00208	0.00223
Pistachio	0.00223	0.00196	0.00516	0.00314	0.00745	0.01642	0.02196	0.02056	0.01461	0.00804	0.00225	0.00223
Grain and Grain Hay	0.00239	0.00622	0.01255	0.01906	0.01032	0.00039	0.00054	0.00024	0.00022	0.00102	0.00233	0.00239
Cotton	0.00237	0.00190	0.00505	0.00208	0.00435	0.01300	0.02196	0.02070	0.01486	0.00409	0.00217	0.00234
Corn and Grain Sorghum	0.00237	0.00190	0.00777	0.00322	0.00761	0.01944	0.02167	0.01376	0.00106	0.00102	0.00217	0.00234
Misc. field crops	0.00237	0.00190	0.00777	0.00322	0.00745	0.02033	0.02032	0.00815	0.00022	0.00102	0.00217	0.00234
Alfalfa Hay and Clover	0.00237	0.00631	0.01159	0.01606	0.01949	0.01950	0.01884	0.01704	0.01333	0.00540	0.00369	0.00245
Pasture and Misc. Grasses	0.00239	0.00488	0.00906	0.01436	0.02105	0.02122	0.02081	0.01882	0.01478	0.00874	0.00328	0.00234
Small Vegetables	0.00237	0.00384	0.01094	0.00347	0.00005	0.00031	0.00048	0.00290	0.00428	0.00495	0.00447	0.00242
Potatoes, Sugar beets, Turnip etc.	0.00237	0.00274	0.00841	0.01867	0.02376	0.02383	0.02038	0.00048	0.00022	0.00099	0.00214	0.00231
Onions and Garlic	0.00237	0.00560	0.01102	0.01522	0.01290	0.00156	0.00048	0.00022	0.00022	0.00099	0.00372	0.00237
Citrus (no ground cover)	0.00223	0.00589	0.01065	0.01303	0.01489	0.01600	0.01538	0.01409	0.01086	0.00844	0.00408	0.00231
Tomatoes and Peppers	0.00237	0.00188	0.00691	0.00194	0.01180	0.02256	0.01995	0.00210	0.00022	0.00099	0.00214	0.00231
Wine Grapes with 80% canopy	0.00226	0.00196	0.00583	0.00394	0.01124	0.01683	0.01613	0.01296	0.00761	0.00108	0.00208	0.00226
Dairy Single Crop	0.00276	0.00578	0.00936	0.01296	0.01211	0.01863	0.02076	0.01698	0.01085	0.00611	0.00344	0.00305
Carrot Single Crop	0.00274	0.00476	0.00844	0.01652	0.01288	0.01598	0.01657	0.01173	0.01027	0.00765	0.00490	0.00320
Carrot Double Cropping	0.00144	0.00416	0.00788	0.01226	0.01570	0.00998	0.00729	0.00950	0.00867	0.00700	0.00393	0.00301
Dairy Double Cropping	0.00158	0.00474	0.00877	0.01291	0.00958	0.01463	0.02115	0.01831	0.01029	0.00207	0.00165	0.00180
Urban, Commercial	0	0	0	0	0	0	0	0	0	0	0	0
Urban, Industrial	0	0	0	0	0	0	0	0	0	0	0	0
Riparian	0.00000	0.00004	0.00938	0.01703	0.02240	0.02286	0.02242	0.02048	0.01595	0.01052	0.00284	0.00026
Open Water	0.00220	0.00661	0.01210	0.01869	0.02290	0.02286	0.02242	0.02048	0.01611	0.01129	0.00439	0.00226
Average All Crops	0.00229	0.00383	0.00858	0.01016	0.01227	0.01491	0.01569	0.01138	0.00742	0.00420	0.00293	0.00243

1. Grass reference ETo based on typical year, CIMIS Zone 16 monthly evapotranspiration. Irrigation Training and Research Center, California Polytechnic State University, San Luis Obispo.
   ft/d = feet per day.

Table D2-6
Historical Evapotranspiration Demand

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Tulare Lake Subbasin[1]	1990-1995 (AF/Y)	1996-1998 (AF/Y)	1999-2006 (AF/Y)	2007 (AF/Y)	2008 (AF/Y)	2009 (AF/Y)	2010 (AF/Y)	2011 (AF/Y)	2012 (AF/Y)	2013 (AF/Y)	2014 (AF/Y)	2015 (AF/Y)	2016 (AF/Y)	Average (AF/Y)
Alfalfa Hay and Clover	172,519	135,032	225,167	300,041	333,752	296,086	288,555	160,621	174,457	204,219	148,325	122,839	100,395	**190,580**
Almonds (Adolescent)			8,113			11,218	19,864	8,127	10,631	18,529	16,937	15,155	13,714	**6,332**
Almonds (Mature)	26,791	18,278	15,869	47,030	43,122	35,832	30,537	36,976	39,450	41,720	46,956	54,869	55,084	**28,083**
Almonds (Young)		2,287	6,480	12,062	26,125	15,445	17,964	13,431	14,580	18,458	17,621	15,779	20,206	**8,292**
Berries	47								2	6		1		**11**
Carrot Single Crop								37	16	41	7	6	56	**6**
Citrus (no ground cover)			91		42	46	14	405	99	335	300	74	32	**74**
Corn and Grain Sorghum	36,877	100,450	75,793	101,418	82,027	89,467	59,478	87,236	75,344	71,190	58,462	48,619	44,935	**65,605**
Cotton	463,179	525,386	362,232	320,870	258,511	212,071	287,383	308,970	260,527	261,476	185,559	130,368	215,815	**345,645**
Dairy Single Crop*	14,290	15,268	16,421											**9,129**
Fallow Land*														**-**
Forest*														**-**
Grain and Grain Hay	50,167	84,811	110,025	33,572	48,563	47,755	45,271	13,518	17,369	19,505	21,282	36,934	33,228	**60,837**
Melons	413	92	468				21	3	16	10	1,182	27	128	**275**
Misc. field crops	40,450	30,296	121,265		5			1			4			**43,795**
Onions and Garlic	807	846	1,359			12	2,417	731	538	167	893	266	1,146	**854**
Open Water*														**-**
Pasture and Misc. Grasses	10,799	21,726	24,256	218,974	191,082	289,198	229,306	63,417	57,751	66,333	144,942	68,014	59,370	**62,524**
Pistachio (Adolescent)								213	315	559	1,290	4,713	5,704	**474**
Pistachio (Mature)	15,229	12,354	12,341	17,831	5,680	2,825	1,236	1,283	1,237	1,135	1,075	1,412	1,374	**9,256**
Pistachio (Young)		394	2,265	1,091	1,370	2,454	2,395	3,729	5,770	7,498	8,281	8,231	9,024	**2,477**
Pomegranates (Adolescent)											5	23	41	**3**
Pomegranates (Young)				11	303	99	52	901	210	376	537	567	746	**141**
Potatoes, Sugar beets, Turnip etc.	18,604	4	676	19		10		29		127		7	7	**4,317**
Riparian*														**-**
Small Vegetables	2,835	1,147	8,009	33	3	20	340	227	212	390	264	126	317	**2,905**
Stone Fruit (Adolescent)			4,238			28	138	232	291	171	106	414	425	**1,166**
Stone Fruit (Mature)	25,350	17,875	13,818	4,560	1,886	584	64	11	80	141	79	95	136	**11,485**
Stone Fruit (Young)		1,310	3,001	466	1,234	1,217	1,879	1,010	547	1,250	1,186	913	667	**1,308**
Tomatoes and Peppers	12,971	3,747	33,791	261	5	246	26	47,851	52,725	15,847	26,555	42,793	52,168	**20,892**
Urban, Industrial*														**-**
Wine Grapes with 80% canopy	7,586	8,301	14,872	14,203	8,893	5,692	6,980	13,625	23,455	11,832	16,450	11,874	27,920	**11,683**
Winter Wheat*														**-**
Tulare Lake Subbasin Irrigated ET Demand	**884,626**	**964,336**	**1,044,130**	**1,072,442**	**1,002,603**	**1,010,305**	**993,918**	**762,584**	**735,624**	**741,315**	**698,299**	**564,117**	**642,636**	**879,019**
Tulare Lake Subbasin GSA Total ET Demand	**898,916**	**979,604**	**1,060,551**	**1,072,442**	**1,002,603**	**1,010,305**	**993,918**	**762,584**	**735,624**	**741,315**	**698,299**	**564,117**	**642,636**	**888,148**

1. Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year. AF/Y = acre-feet per year, GSA = Groundwater Sustainability Agency, and ET = evapotranspiration.

wood.

Table D2-7
Historical Farm Demand[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Date	Other SB (AF/Y)	TLSB (AF/Y)	Westside (AF/Y)	Kings (AF/Y)	Kaweah (AF/Y)	Tule (AF/Y)	Kern (AF/Y)	Mid-Kings (AF/Y)	El Rico (AF/Y)	South Fork (AF/Y)	Southwest (AF/Y)	TCWA (AF/Y)
Jan-90	1,728,732	1,065,856	379,829	425,121	552,538	256,615	114,629	325,993	417,055	166,690	114,789	41,329
Jan-91	1,614,099	994,832	358,828	401,725	514,334	233,176	106,035	306,828	388,094	155,314	107,036	37,561
Jan-92	1,628,359	1,012,909	343,450	406,535	528,115	241,481	108,779	313,628	395,489	156,526	108,443	38,824
Jan-93	1,625,686	1,008,709	347,335	404,875	524,762	240,425	108,288	310,417	394,078	156,684	108,853	38,677
Jan-94	1,667,754	1,047,937	339,746	419,143	544,830	251,521	112,514	321,367	409,642	163,677	112,809	40,442
Jan-95	1,518,505	973,503	292,869	389,226	502,007	229,979	104,424	298,503	382,014	151,236	104,578	37,172
Jan-96	1,576,024	1,067,962	313,585	344,546	482,623	304,804	130,465	274,763	432,798	171,197	134,163	55,041
Jan-97	1,680,694	1,123,726	337,872	377,306	511,503	317,630	136,383	296,047	449,362	180,958	139,428	57,931
Jan-98	1,549,840	1,059,009	286,711	361,492	480,381	294,124	127,132	282,666	424,886	167,423	132,138	51,896
Jan-99	1,691,385	1,232,448	339,665	407,814	535,160	327,150	81,596	286,433	535,576	191,560	148,842	70,039
Jan-00	1,445,415	1,127,412	284,814	349,602	457,426	279,949	73,623	251,153	506,236	164,195	141,354	64,475
Jan-01	1,448,592	1,111,506	309,426	344,390	447,420	273,032	74,325	252,107	492,321	161,311	143,460	62,308
Jan-02	1,541,594	1,201,455	318,210	370,000	480,162	290,750	82,471	275,691	524,619	174,107	159,485	67,554
Jan-03	1,555,120	1,198,411	341,139	366,586	474,349	288,517	84,529	276,879	519,352	171,951	163,815	66,414
Jan-04	1,505,353	1,162,011	319,587	357,269	463,075	281,525	83,897	267,176	504,557	165,885	160,028	64,366
Jan-05	1,470,433	1,155,548	293,659	353,639	461,355	278,436	83,344	266,036	503,020	165,545	157,409	63,538
Jan-06	1,423,773	1,129,741	281,543	345,256	445,626	268,596	82,751	260,555	488,753	162,180	156,955	61,299
Jan-07	1,645,495	1,183,096	324,200	294,958	447,694	338,016	240,627	248,586	542,967	168,715	157,357	65,471
Jan-08	1,618,955	1,083,093	307,929	286,930	474,164	335,571	214,361	252,038	499,213	157,222	99,089	75,531
Jan-09	1,579,778	1,091,697	349,701	288,327	381,416	286,941	273,394	222,909	473,147	141,969	186,010	67,662
Jan-10	1,563,995	1,016,725	297,419	297,831	370,133	326,713	271,898	197,569	442,224	138,271	178,015	60,646
Jan-11	1,145,135	791,090	287,744	234,224	382,183	166,368	74,617	190,992	384,027	114,892	65,595	35,584
Jan-12	1,254,900	776,133	330,525	245,767	397,981	200,454	80,173	191,423	373,845	122,949	65,986	21,930
Jan-13	1,322,113	826,405	371,025	237,221	406,748	194,551	112,569	199,812	420,487	105,696	73,137	27,273
Jan-14	1,422,271	757,265	413,917	266,385	385,588	218,818	137,564	199,827	289,182	112,733	97,591	57,932
Jan-15	1,335,608	624,647	428,797	253,146	362,160	194,523	96,982	196,099	250,843	101,691	46,314	29,700
Jan-16	1,285,028	677,936	417,581	260,622	348,283	168,493	90,048	188,850	320,298	97,905	47,386	23,497
1990-2016 Average	**1,512,764**	**1,018,558**	**333,967**	**336,664**	**457,853**	**262,524**	**121,756**	**257,568**	**435,707**	**151,425**	**122,595**	**51,263**
1998-2010 Average	**1,541,517**	**1,134,781**	**311,846**	**340,315**	**455,259**	**297,640**	**136,457**	**256,907**	**496,682**	**163,872**	**152,612**	**64,707**

1. SB = subbasin, TLSB = Tulare Lake Subbasin, TCWA = Tri-County Water Agency, AF/Y = acre-feet per year.

Table D4-1
Tulare Lake Subbasin Hydrologic Model Stress Periods

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Date	Stress Period	Days	Date	Stress Period	Days
Jan-90	1	31	Mar-93	39	31
Feb-90	2	28	Apr-93	40	30
Mar-90	3	31	May-93	41	31
Apr-90	4	30	Jun-93	42	30
May-90	5	31	Jul-93	43	31
Jun-90	6	30	Aug-93	44	31
Jul-90	7	31	Sep-93	45	30
Aug-90	8	31	Oct-93	46	31
Sep-90	9	30	Nov-93	47	30
Oct-90	10	31	Dec-93	48	31
Nov-90	11	30	Jan-94	49	31
Dec-90	12	31	Feb-94	50	28
Jan-91	13	31	Mar-94	51	31
Feb-91	14	28	Apr-94	52	30
Mar-91	15	31	May-94	53	31
Apr-91	16	30	Jun-94	54	30
May-91	17	31	Jul-94	55	31
Jun-91	18	30	Aug-94	56	31
Jul-91	19	31	Sep-94	57	30
Aug-91	20	31	Oct-94	58	31
Sep-91	21	30	Nov-94	59	30
Oct-91	22	31	Dec-94	60	31
Nov-91	23	30	Jan-95	61	31
Dec-91	24	31	Feb-95	62	28
Jan-92	25	31	Mar-95	63	31
Feb-92	26	29	Apr-95	64	30
Mar-92	27	31	May-95	65	31
Apr-92	28	30	Jun-95	66	30
May-92	29	31	Jul-95	67	31
Jun-92	30	30	Aug-95	68	31
Jul-92	31	31	Sep-95	69	30
Aug-92	32	31	Oct-95	70	31
Sep-92	33	30	Nov-95	71	30
Oct-92	34	31	Dec-95	72	31
Nov-92	35	30	Jan-96	73	31
Dec-92	36	31	Feb-96	74	29
Jan-93	37	31	Mar-96	75	31
Feb-93	38	28	Apr-96	76	30

Table D4-1
Tulare Lake Subbasin Hydrologic Model Stress Periods

Date	Stress Period	Days	Date	Stress Period	Days
May-96	77	31	Oct-99	118	31
Jun-96	78	30	Nov-99	119	30
Jul-96	79	31	Dec-99	120	31
Aug-96	80	31	Jan-00	121	31
Sep-96	81	30	Feb-00	122	29
Oct-96	82	31	Mar-00	123	31
Nov-96	83	30	Apr-00	124	30
Dec-96	84	31	May-00	125	31
Jan-97	85	31	Jun-00	126	30
Feb-97	86	28	Jul-00	127	31
Mar-97	87	31	Aug-00	128	31
Apr-97	88	30	Sep-00	129	30
May-97	89	31	Oct-00	130	31
Jun-97	90	30	Nov-00	131	30
Jul-97	91	31	Dec-00	132	31
Aug-97	92	31	Jan-01	133	31
Sep-97	93	30	Feb-01	134	28
Oct-97	94	31	Mar-01	135	31
Nov-97	95	30	Apr-01	136	30
Dec-97	96	31	May-01	137	31
Jan-98	97	31	Jun-01	138	30
Feb-98	98	28	Jul-01	139	31
Mar-98	99	31	Aug-01	140	31
Apr-98	100	30	Sep-01	141	30
May-98	101	31	Oct-01	142	31
Jun-98	102	30	Nov-01	143	30
Jul-98	103	31	Dec-01	144	31
Aug-98	104	31	Jan-02	145	31
Sep-98	105	30	Feb-02	146	28
Oct-98	106	31	Mar-02	147	31
Nov-98	107	30	Apr-02	148	30
Dec-98	108	31	May-02	149	31
Jan-99	109	31	Jun-02	150	30
Feb-99	110	28	Jul-02	151	31
Mar-99	111	31	Aug-02	152	31
Apr-99	112	30	Sep-02	153	30
May-99	113	31	Oct-02	154	31
Jun-99	114	30	Nov-02	155	30
Jul-99	115	31	Dec-02	156	31
Aug-99	116	31	Jan-03	157	31
Sep-99	117	30	Feb-03	158	28

Table D4-1

Tulare Lake Subbasin Hydrologic Model Stress Periods

Date	Stress Period	Days	Date	Stress Period	Days
Mar-03	159	31	Aug-06	200	31
Apr-03	160	30	Sep-06	201	30
May-03	161	31	Oct-06	202	31
Jun-03	162	30	Nov-06	203	30
Jul-03	163	31	Dec-06	204	31
Aug-03	164	31	Jan-07	205	31
Sep-03	165	30	Feb-07	206	28
Oct-03	166	31	Mar-07	207	31
Nov-03	167	30	Apr-07	208	30
Dec-03	168	31	May-07	209	31
Jan-04	169	31	Jun-07	210	30
Feb-04	170	29	Jul-07	211	31
Mar-04	171	31	Aug-07	212	31
Apr-04	172	30	Sep-07	213	30
May-04	173	31	Oct-07	214	31
Jun-04	174	30	Nov-07	215	30
Jul-04	175	31	Dec-07	216	31
Aug-04	176	31	Jan-08	217	31
Sep-04	177	30	Feb-08	218	29
Oct-04	178	31	Mar-08	219	31
Nov-04	179	30	Apr-08	220	30
Dec-04	180	31	May-08	221	31
Jan-05	181	31	Jun-08	222	30
Feb-05	182	28	Jul-08	223	31
Mar-05	183	31	Aug-08	224	31
Apr-05	184	30	Sep-08	225	30
May-05	185	31	Oct-08	226	31
Jun-05	186	30	Nov-08	227	30
Jul-05	187	31	Dec-08	228	31
Aug-05	188	31	Jan-09	229	31
Sep-05	189	30	Feb-09	230	28
Oct-05	190	31	Mar-09	231	31
Nov-05	191	30	Apr-09	232	30
Dec-05	192	31	May-09	233	31
Jan-06	193	31	Jun-09	234	30
Feb-06	194	28	Jul-09	235	31
Mar-06	195	31	Aug-09	236	31
Apr-06	196	30	Sep-09	237	30
May-06	197	31	Oct-09	238	31
Jun-06	198	30	Nov-09	239	30
Jul-06	199	31	Dec-09	240	31

Table D4-1
Tulare Lake Subbasin Hydrologic Model Stress Periods

Date	Stress Period	Days	Date	Stress Period	Days
Jan-10	241	31	Jul-13	283	31
Feb-10	242	28	Aug-13	284	31
Mar-10	243	31	Sep-13	285	30
Apr-10	244	30	Oct-13	286	31
May-10	245	31	Nov-13	287	30
Jun-10	246	30	Dec-13	288	31
Jul-10	247	31	Jan-14	289	31
Aug-10	248	31	Feb-14	290	28
Sep-10	249	30	Mar-14	291	31
Oct-10	250	31	Apr-14	292	30
Nov-10	251	30	May-14	293	31
Dec-10	252	31	Jun-14	294	30
Jan-11	253	31	Jul-14	295	31
Feb-11	254	28	Aug-14	296	31
Mar-11	255	31	Sep-14	297	30
Apr-11	256	30	Oct-14	298	31
May-11	257	31	Nov-14	299	30
Jun-11	258	30	Dec-14	300	31
Jul-11	259	31	Jan-15	301	31
Aug-11	260	31	Feb-15	302	28
Sep-11	261	30	Mar-15	303	31
Oct-11	262	31	Apr-15	304	30
Nov-11	263	30	May-15	305	31
Dec-11	264	31	Jun-15	306	30
Jan-12	265	31	Jul-15	307	31
Feb-12	266	29	Aug-15	308	31
Mar-12	267	31	Sep-15	309	30
Apr-12	268	30	Oct-15	310	31
May-12	269	31	Nov-15	311	30
Jun-12	270	30	Dec-15	312	31
Jul-12	271	31	Jan-16	313	31
Aug-12	272	31	Feb-16	314	29
Sep-12	273	30	Mar-16	315	31
Oct-12	274	31	Apr-16	316	30
Nov-12	275	30	May-16	317	31
Dec-12	276	31	Jun-16	318	30
Jan-13	277	31	Jul-16	319	31
Feb-13	278	28	Aug-16	320	31
Mar-13	279	31	Sep-16	321	30
Apr-13	280	30	Oct-16	322	61
May-13	281	31	Nov-16	323	30
Jun-13	282	30	Dec-16	324	31

wood.

Table D5-1

Tulare Lake Subbasin Historical and Current Water Balance[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Land Surface Water Budget

			Inflows						Outflows				Net
Year	Kings River Flows	Year Type	Effective Precipitation (AF)	Applied Surface Water (AF)	Applied Pond Water (AF)	Imported Groundwater (AF)	Applied Groundwater (AF)	Total Inflows (AF)	Drain Outflow (AF)	Farm Demand Evapotranspiration (AF)	Deep Percolation (AF)	Total Outflows (AF)	Inflow-Outflow (AF)
1990	40%	D	19,958	319,870	10,310	48,885	609,474	1,008,496	0	1,065,856	132,933	1,198,789	-190,293
1991	63%	D	78,722	209,568	3,793	52,225	568,130	912,439	0	994,832	125,674	1,120,507	-208,068
1992	41%	D	64,818	245,345	8,619	46,926	587,328	953,036	0	1,012,909	126,365	1,139,274	-186,238
1993	149%	W	67,191	811,312	31,153	7,533	238,616	1,155,805	0	1,008,709	124,472	1,133,181	22,624
1994	50%	D	34,514	443,731	4,237	27,612	481,028	991,122	26	1,047,937	129,432	1,177,394	-186,272
1995	202%	W	95,479	948,773	42,079	905	177,847	1,265,083	82	973,503	116,897	1,090,481	174,601
1996	122%	N	100,745	1,038,046	26,566	0	182,868	1,348,225	251	1,067,962	127,604	1,195,817	152,408
1997	155%	W	58,885	749,117	54,380	0	265,952	1,128,333	1,392	1,123,726	143,342	1,268,459	-140,126
1998	181%	W	116,167	693,908	49,104	0	237,530	1,096,709	1,870	1,059,009	128,533	1,189,412	-92,703
1999	74%	D	34,039	713,206	39,371	0	325,154	1,111,771	7,376	1,232,448	151,647	1,391,471	-279,701
2000	90%	N	70,413	741,494	35,618	6,833	247,306	1,101,664	17,343	1,127,412	95,624	1,240,379	-138,714
2001	59%	D	94,963	437,871	8,911	54,771	453,432	1,049,949	13,351	1,111,506	90,933	1,215,791	-165,841
2002	67%	D	26,034	564,134	21,817	51,428	408,568	1,071,981	10,253	1,201,455	85,417	1,297,125	-225,143
2003	83%	N	40,108	583,124	4,687	24,029	366,253	1,018,201	8,170	1,198,411	95,332	1,301,914	-283,713
2004	61%	D	74,858	495,764	25,863	63,254	475,486	1,135,226	20,849	1,162,011	86,876	1,269,736	-134,510
2005	148%	W	80,390	873,425	36,085	857	200,953	1,191,709	5,413	1,155,548	101,553	1,262,513	-70,804
2006	172%	W	104,703	1,020,922	37,530	154	189,607	1,352,916	9,651	1,129,741	108,496	1,247,887	105,029
2007	40%	D	14,800	508,886	4,613	60,608	456,931	1,045,839	14,999	1,183,096	97,935	1,296,030	-250,191
2008	72%	D	35,836	371,231	9,331	72,842	497,113	986,354	13,795	1,083,093	89,622	1,186,511	-200,157
2009	79%	N	32,367	379,590	16,632	68,391	440,286	937,266	4,295	1,091,697	94,173	1,190,165	-252,899
2010	121%	N	88,203	694,592	51,406	31,531	234,505	1,100,238	2,440	1,016,725	78,915	1,098,080	2,158
2011	180%	W	52,937	1,026,568	21,035	7,241	60,638	1,168,420	4,486	791,090	83,959	879,535	288,885
2012	49%	D	45,317	498,937	20,785	64,173	339,834	969,046	3,226	776,133	62,058	841,417	127,629
2013	41%	D	2,800	264,515	1,725	84,661	437,315	791,017	8,381	826,405	65,687	900,473	-109,456
2014	32%	D	30,586	154,346	0	85,650	491,323	761,906	3,579	757,265	62,755	823,599	-61,693
2015	21%	D	15,085	107,212	0	79,517	508,193	710,008	829	624,647	49,756	675,231	34,777
2016	75%	D	41,890	227,755	0	70,864	413,868	754,377	2,497	677,936	53,544	733,977	20,400
1990-2016 Avg	**91%**	**--**	**56,363**	**560,120**	**20,950**	**37,440**	**366,501**	**1,041,375**	**5,724**	**1,018,558**	**100,353**	**1,124,635**	**-83,260**
1998-2010 Avg	**96%**	**--**	**62,529**	**621,396**	**26,228**	**33,438**	**348,702**	**1,092,294**	**9,985**	**1,134,781**	**100,389**	**1,245,155**	**-152,861**

Subsurface Water Budget

			Inflows							Outflows					Annual Change in Storage		
			Deep Percolation				Interbasin Inflow			Groundwater Pumping		Interbasin Outflow					
Year	Kings River Flows	Year Type	Precipitation Infiltration (AF)	Applied Water Infiltration (AF)	Stream Leakage (AF)	Intentional Recharge (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Total Inflows (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Total Outflows (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Total Aquifer (AF)
1990	40%	D	17,012	132,933	222,466	1,021	60,944	120,265	554,640	363,970	254,873	52,493	58,787	730,124	-392,438	206,512	-185,926
1991	63%	D	10,310	125,674	149,106	0	59,832	104,657	449,578	351,785	225,455	44,466	68,123	689,829	-379,415	154,951	-224,464
1992	41%	D	13,215	126,365	122,515	0	58,304	102,535	422,934	345,307	251,686	43,733	75,762	716,488	-379,874	89,485	-290,389
1993	149%	W	43,499	124,472	178,243	61	51,892	77,023	475,190	239,755	9,069	42,526	80,157	371,507	-117,785	275,064	157,279
1994	50%	D	20,701	129,432	121,447	23,540	52,755	83,154	431,028	310,055	181,901	44,438	80,974	617,368	-255,820	87,113	-168,707
1995	202%	W	58,569	116,897	160,315	60,372	45,868	68,012	510,032	205,637	17,015	50,708	79,891	353,250	-23,977	255,398	231,421
1996	122%	N	78,864	127,604	161,750	32,081	42,064	60,065	502,429	184,321	11,265	47,154	88,966	331,705	-4,023	190,504	186,481
1997	155%	W	65,946	143,342	153,373	42,787	40,618	63,597	509,662	204,969	73,758	50,417	89,192	418,336	-15,247	116,032	100,786
1998	181%	W	75,095	128,533	152,395	61,425	38,754	67,063	523,264	191,289	57,797	55,626	78,577	383,288	17,175	136,362	153,536
1999	74%	D	47,885	151,647	180,710	0	41,389	79,296	500,928	227,049	111,192	47,970	93,144	479,355	-71,374	71,897	522
2000	90%	N	51,238	95,624	159,781	23,540	41,391	75,001	446,574	201,799	58,927	44,741	85,312	390,779	-76,900	120,539	43,638
2001	59%	D	26,775	90,933	124,376	0	44,167	84,217	370,468	264,888	202,438	45,556	85,202	598,085	-222,719	-20,340	-243,059
2002	67%	D	41,347	85,417	164,069	0	46,006	76,591	413,429	272,312	162,957	45,147	97,839	578,256	-174,685	-3,708	-178,393
2003	83%	N	36,128	95,332	174,955	23,540	45,798	78,735	454,487	255,270	130,332	46,552	94,198	526,352	-133,547	32,464	-101,083
2004	61%	D	40,008	86,876	148,458	10,700	46,099	79,299	411,440	279,593	214,670	46,854	90,221	631,339	-181,729	-49,393	-231,122
2005	148%	W	64,268	101,553	185,872	58,945	41,121	60,617	512,376	194,492	22,996	48,908	89,165	355,562	516	120,500	121,017
2006	172%	W	57,791	108,496	169,501	170,266	37,534	56,625	600,213	174,179	31,250	56,025	86,840	348,293	117,742	102,907	220,649
2007	40%	D	23,538	97,935	174,019	0	42,192	67,360	405,044	264,654	209,499	52,530	90,375	617,057	-177,972	-70,518	-248,490
2008	72%	D	26,373	89,622	137,369	0	43,266	76,606	373,236	283,431	232,114	49,766	93,253	658,564	-210,701	-85,575	-296,277
2009	79%	N	29,563	94,173	167,126	10,700	43,877	74,501	419,939	268,843	187,798	49,818	92,397	598,856	-170,773	-42,237	-213,010
2010	121%	N	67,953	78,915	145,364	23,540	37,974	63,446	417,193	187,770	62,006	47,711	91,016	388,504	-56,332	69,461	13,129
2011	180%	W	88,853	83,959	180,036	180,066	32,182	51,038	616,133	126,313	48,633	58,840	85,781	319,567	197,345	163,884	361,228
2012	49%	D	46,276	62,058	126,057	10,700	34,819	64,180	344,090	205,013	152,288	52,627	89,367	499,295	-137,135	-32,812	-169,947
2013	41%	D	23,005	65,687	123,434	0	38,673	66,410	317,209	252,639	203,087	50,934	92,285	598,945	-222,003	-83,604	-305,607
2014	32%	D	20,546	62,755	92,469	23,320	41,277	69,232	309,598	276,394	231,859	51,497	100,472	660,223	-247,305	-113,047	-360,352
2015	21%	D	25,814	49,756	74,156	23,540	41,875	72,128	287,269	283,699	240,639	50,653	90,840	665,831	-286,779	-105,501	-392,279
2016	75%	D	26,426	53,544	32,070	42,659	36,829	65,273	256,801	248,557	179,866	60,070	100,280	588,773	-234,011	-60,314	-294,325
1990-2016 Avg	**91%**	**--**	**41,740**	**100,353**	**147,460**	**30,474**	**43,981**	**74,331**	**438,340**	**246,814**	**139,458**	**49,547**	**86,978**	**522,797**	**-142,214**	**56,519**	**-85,694**
1998-2010 Avg	**96%**	**--**	**45,228**	**100,389**	**160,307**	**29,435**	**42,274**	**72,258**	**449,892**	**235,813**	**129,537**	**49,016**	**89,811**	**504,176**	**-103,177**	**29,412**	**-73,765**

1. AF = acre-feet, D = dry, W = wet, and N = normal.

Table D7-1

2017 – 2070 Forecast Model Hydrology Sequence[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Stress Period	Forecast Year	Hydrology Conditions	Normal Kings River Flow (AF)	CNRA Change Factor	Kings River Flow CNRA (AF)
1	2017	2011	1,037,113	1.004167	1,041,434
2	2018	2010	706,083	1.016667	717,851
3	2019	1999	763,007	0.998333	761,735
4	2020	2000	777,871	1.010833	786,298
5	2021	2001	456,607	1.013333	462,695
6	2022	2002	582,769	1.015000	591,510
7	2023	2003	603,080	1.014167	611,624
8	2024	2004	515,426	1.038333	535,184
9	2025	2005	901,509	1.001667	903,011
10	2026	2000	777,871	1.010833	786,298
11	2027	2007	526,947	1.008333	531,338
12	2028	2008	379,491	1.001667	380,123
13	2029	2009	387,005	1.015000	392,810
14	2030	2010	706,083	1.016667	717,851
15	2031	1997	757,901	0.983333	745,269
16	2032	1998	704,676	0.989167	697,042
17	2033	1999	763,007	0.996667	760,463
18	2034	2000	777,871	1.021667	794,725
19	2035	2001	456,607	1.016667	464,217
20	2036	2002	582,769	0.974167	567,714
21	2037	2003	603,080	0.974167	587,500
22	2038	2004	515,426	1.002500	516,714
23	2039	2005	901,509	0.993333	895,499
24	2040	2000	777,871	1.021667	794,725
25	2041	2007	526,947	1.000833	527,386
26	2042	2008	379,491	1.002500	380,440
27	2043	2009	387,005	0.991667	383,780
28	2044	2010	706,083	1.012500	714,909
29	2045	1997	757,901	0.983333	745,269
30	2046	1998	704,676	0.989167	697,042
31	2047	1999	763,007	0.996667	760,463
32	2048	2000	777,871	1.021667	794,725
33	2049	2001	456,607	1.016667	464,217
34	2050	2002	582,769	0.974167	567,714
35	2051	2003	603,080	0.974167	587,500
36	2052	2004	515,426	1.002500	516,714

Table D7-1

2017 – 2070 Forecast Model Hydrology Sequence[1]

Stress Period	Forecast Year	Hydrology Conditions	Normal Kings River Flow (AF)	CNRA Change Factor	Kings River Flow CNRA (AF)
37	2053	2005	901,509	0.993333	895,499
38	2054	2000	777,871	1.021667	794,725
39	2055	2007	526,947	1.000833	527,386
40	2056	2008	379,491	1.002500	380,440
41	2057	2009	387,005	0.991667	383,780
42	2058	2010	706,083	1.012500	714,909
43	2059	1997	757,901	0.983333	745,269
44	2060	1998	704,676	0.989167	697,042
45	2061	1999	763,007	0.996667	760,463
46	2062	2000	777,871	1.021667	794,725
47	2063	2001	456,607	1.016667	464,217
48	2064	2002	582,769	0.974167	567,714
49	2065	2003	603,080	0.974167	587,500
50	2066	2004	515,426	1.002500	516,714
51	2067	2005	901,509	0.993333	895,499
52	2068	2000	777,871	1.021667	794,725
53	2069	2007	526,947	1.000833	527,386
54	2070	2008	379,491	1.002500	380,440

1. AF = acre-feet and CNRA = California Natural Resources Agency.

Table D7-2

2017 – 2070 Projects Forecast Model Project Development and Yields[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

				Mid-Kings GSA	El Rico GSA		South Fork Kings GSA	TCWA GSA	New Project
	Kings River Hydrology			Proposed Recharge	Existing Ponds	Proposed 6,400 AC SW Pond	Proposed 10,000 AC SW Pond	Proposed 13,340 AC SW Pond	Total SW Supply
Year	% Normal Flows	Flood Years	Project Descriptions	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)
2017	180%			0	0	0	0	0	0
2018	121%			0	0	0	0	0	0
2019	74%			0	0	0	0	0	0
2020	90%		Construct 340 acres of Perc Basins	0	0	0	0	0	0
2021	59%			0	0	0	0	0	0
2022	67%			0	0	0	0	0	0
2023	83%			0	0	0	0	0	0
2024	61%			0	0	0	0	0	0
2025	148%	Flood		50,000	71,000	0	0	0	0
2026	90%		Construct 340 acres of Perc Basins	0	0	0	0	0	0
2027	40%			0	0	0	0	0	0
2028	72%		Construct 6,400, 10,000, and 13,400	0	0	0	0	0	0
2029	79%		acres of SW Ponds	0	0	0	0	0	0
2030	121%		Construct 340 acres of Perc Basins	0	0	0	0	0	0
2031	155%	Flood		150,000	71,000	40,000	60,000	80,000	180,000
2032	181%	Flood		150,000	71,000	40,000	60,000	80,000	180,000
2033	74%			0	0	0	0	0	0
2034	90%			0	0	0	0	0	0
2035	59%		Construct 340 acres of Perc Basins	0	0	0	0	0	0
2036	67%			0	0	0	0	0	0
2037	83%			0	0	0	0	0	0
2038	61%			0	0	0	0	0	0
2039	148%	Flood		200,000	71,000	40,000	60,000	80,000	180,000
2040	90%			0	0	0	0	0	0
2041	40%			0	0	0	0	0	0
2042	72%			0	0	0	0	0	0
2043	79%			0	0	0	0	0	0
2044	121%			0	0	0	0	0	0
2045	155%	Flood		200,000	71,000	40,000	60,000	80,000	180,000
2046	181%	Flood		200,000	71,000	40,000	60,000	80,000	180,000
2047	74%			0	0	0	0	0	0
2048	90%			0	0	0	0	0	0
2049	59%			0	0	0	0	0	0
2050	67%			0	0	0	0	0	0
2051	83%			0	0	0	0	0	0
2052	61%			0	0	0	0	0	0
2053	148%	Flood		200,000	71,000	40,000	60,000	80,000	180,000
2054	90%			0	0	0	0	0	0
2055	40%			0	0	0	0	0	0
2056	72%			0	0	0	0	0	0
2057	79%			0	0	0	0	0	0
2058	121%			0	0	0	0	0	0
2059	155%	Flood		200,000	71,000	40,000	60,000	80,000	180,000
2060	181%	Flood		200,000	71,000	40,000	60,000	80,000	180,000
2061	74%			0	0	0	0	0	0
2062	90%			0	0	0	0	0	0
2063	59%			0	0	0	0	0	0
2064	67%			0	0	0	0	0	0
2065	83%			0	0	0	0	0	0
2066	61%			0	0	0	0	0	0
2067	148%	Flood		200,000	71,000	40,000	60,000	80,000	180,000
2068	90%			0	0	0	0	0	0
2069	40%			0	0	0	0	0	0
2070	72%			0	0	0	0	0	0
			Project Annual Average	**38,043**	**15,435**	**8,780**	**13,171**	**17,561**	**40,500**
			2040-2048 Average	**44,444**	**15,778**	**8,889**	**13,333**	**17,778**	**40,000**

1. GSA = Groundwater Sustainability Agency, TCWA = Tri-County Water Authority, AC = acre, SW = southwest, SF = surface water, and AF = acre-feet.

wood.

Table D7-3

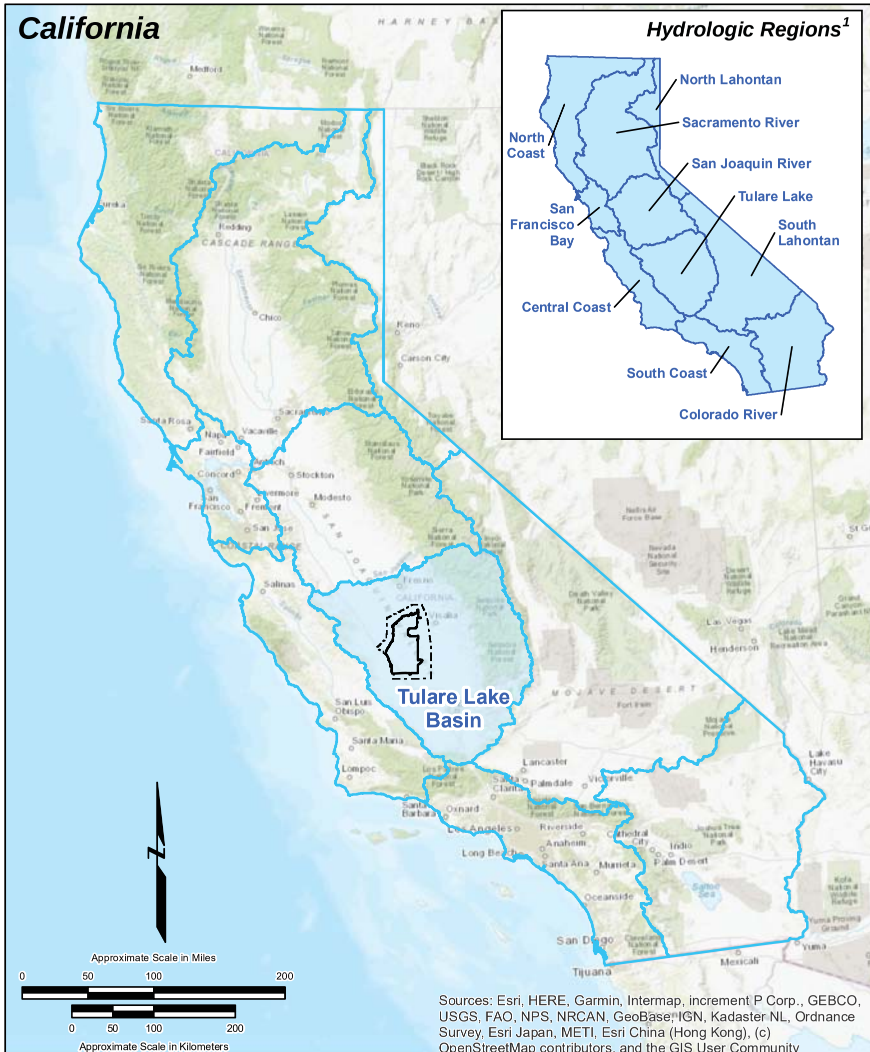
Historical and Forecasts Groundwater Balance Comparison[1]

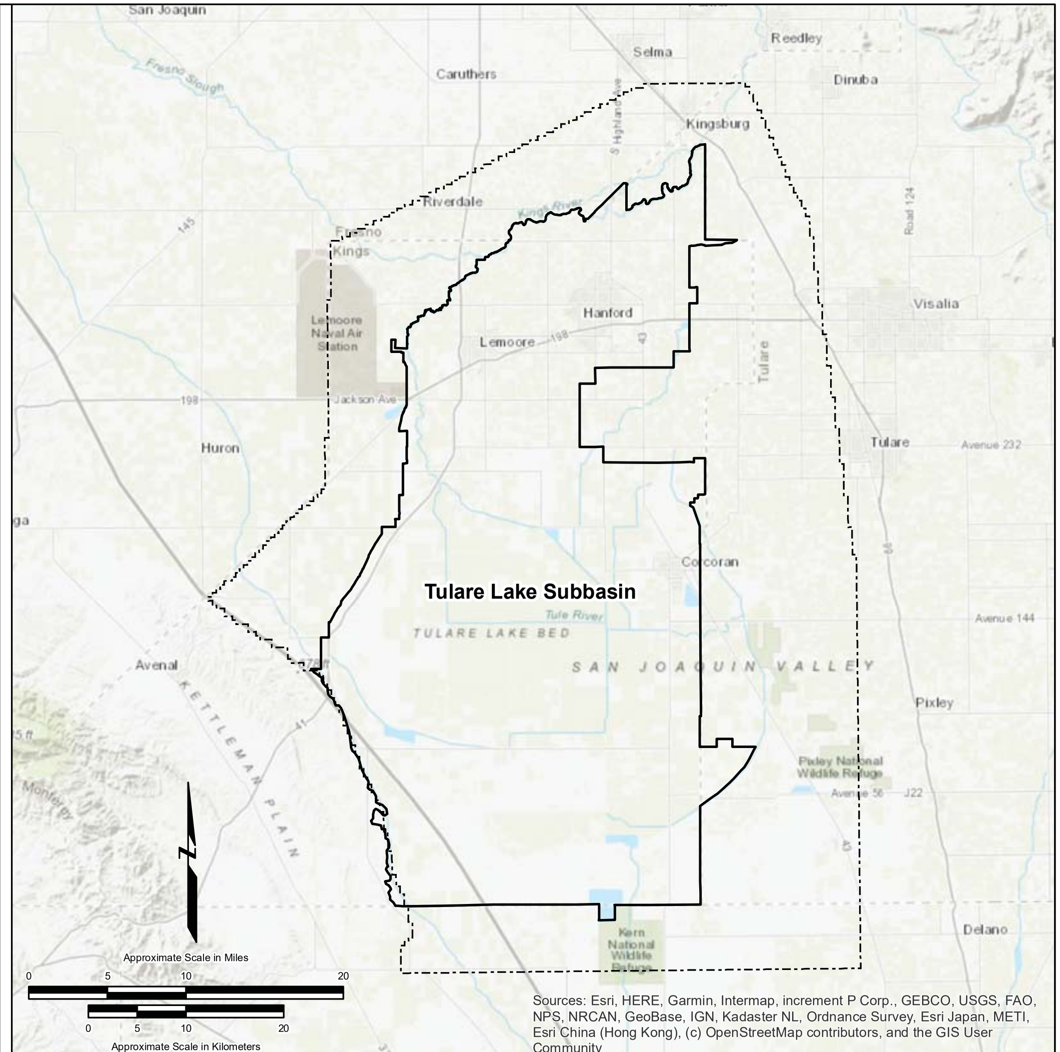
Tulare Lake Subbasin Hydrologic Model
Kings County, California

Simulation	Total Simulation Period	Tulare Lake Drain Net (AF/Y)	Tulare Lake Well Net (AF/Y)	Tulare Lake River Net (AF/Y)	Tulare Lake Recharge Net (AF/Y)	Tulare Lake Storage Net (AF/Y)	Tulare Lake Net Interbasin Flow (AF/Y)	Tulare Lake - Westside Net (AF/Y)	Tulare Lake - Kings Net (AF/Y)	Tulare Lake - Kaweah Net (AF/Y)	Tulare Lake - Tule Net (AF/Y)	Tulare Lake - Kern Net (AF/Y)
Above Corcoran Clay												
Calibration	1990-2016 Average	-5,724	-246,814	141,361	173,756	-142,214	-5,565	5,230	-5,566	-64	-6,678	1,514
Baseline Forecast	2017-2070 Average	-2,915	-233,018	148,209	172,329	-91,547	-30,438	1,288	-8,263	-8,955	-13,336	-1,172
Projects Forecast	2017-2070 Average	-3,919	-196,130	109,294	200,120	-29,931	-16,363	1,707	-4,390	-6,625	-6,988	-67
Below Corcoran Clay												
Calibration	1990-2016 Average	0	-134,595	0	0	56,519	-12,648	-1,269	-8,259	-19,363	-11,700	27,943
Baseline Forecast	2017-2070 Average	0	-90,714	0	0	-51,440	-108,636	-24,350	-25,894	-44,226	-35,198	21,032
Projects Forecast	2017-2070 Average	0	-89,353	0	0	-6,269	-42,250	-11,794	-4,500	-27,202	-6,599	7,845
Total Aquifer												
Calibration	1990-2016 Average	-5,724	-381,410	141,361	173,756	-85,694	-18,213	3,961	-13,826	-19,427	-18,379	29,457
Baseline Forecast	2017-2070 Average	-2,915	-323,732	148,209	172,329	-142,987	-139,074	-23,062	-34,157	-53,181	-48,534	19,860
Projects Forecast	2017-2070 Average	-3,919	-285,483	109,294	200,120	-36,200	-58,613	-10,086	-8,890	-33,827	-13,587	7,778

Simulation	Normal Hydrology Period	Tulare Lake Drain Net (AF/Y)	Tulare Lake Well Net (AF/Y)	Tulare Lake River Net (AF/Y)	Tulare Lake Recharge Net (AF/Y)	Tulare Lake Storage Net (AF/Y)	Tulare Lake Net Interbasin Flow (AF/Y)	Tulare Lake - Westside Net (AF/Y)	Tulare Lake - Kings Net (AF/Y)	Tulare Lake - Kaweah Net (AF/Y)	Tulare Lake - Tule Net (AF/Y)	Tulare Lake - Kern Net (AF/Y)
Above Corcoran Clay												
Calibration	1998-2010 Average	-9,985	-235,813	140,827	176,936	-103,177	-6,741	4,658	-5,640	-244	-7,131	1,616
Baseline Forecast	2040-2048 Average	-1,986	-231,248	141,765	170,054	-104,055	-34,749	965	-10,192	-9,468	-13,930	-2,124
Projects Forecast	2040-2048 Average	-3,288	-182,304	89,564	210,859	-25,079	-19,005	1,572	-6,346	-7,148	-6,743	-341
Below Corcoran Clay												
Calibration	1998-2010 Average	0	-129,537	0	0	29,412	-17,552	1,173	-10,299	-20,331	-14,158	26,063
Baseline Forecast	2040-2048 Average	0	-72,702	0	0	-45,379	-121,729	-29,706	-29,475	-46,470	-36,501	20,423
Projects Forecast	2040-2048 Average	0	-62,943	0	0	5,687	-53,972	-15,058	-8,292	-31,963	-6,195	7,536
Total Aquifer												
Calibration	1998-2010 Average	-9,985	-365,350	140,827	176,936	-73,765	-24,294	5,830	-15,939	-20,575	-21,289	27,680
Baseline Forecast	2040-2048 Average	-1,986	-303,950	141,765	170,054	-149,434	-156,477	-28,740	-39,667	-55,938	-50,431	18,299
Projects Forecast	2040-2048 Average	-3,288	-245,247	89,564	210,859	-19,392	-72,977	-13,485	-14,638	-39,111	-12,938	7,195

1. AF/Y = acre-feet per year.





Explanation

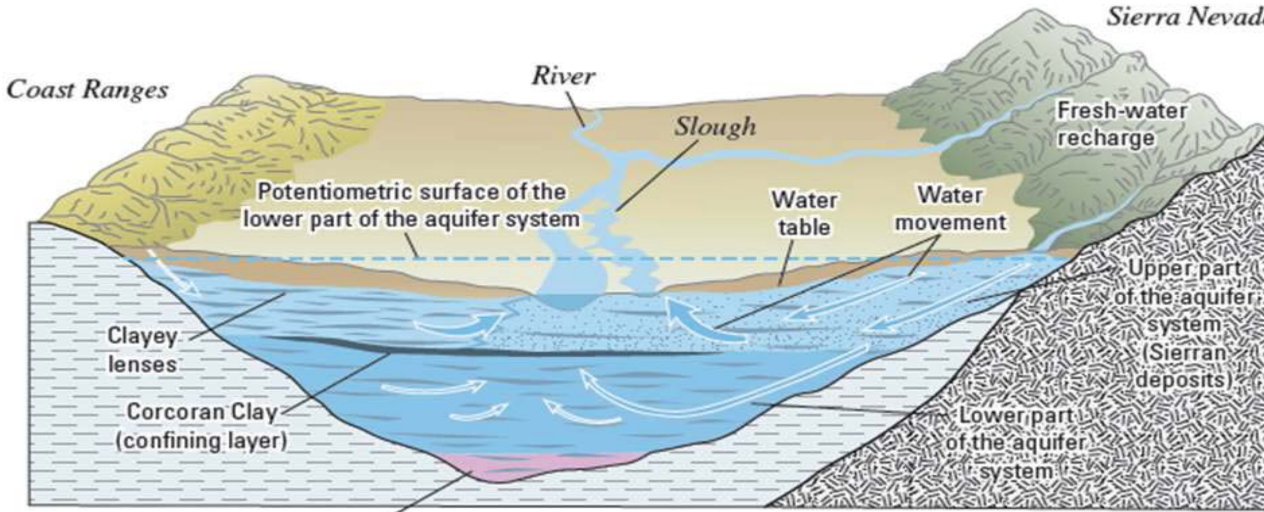
- Hydrologic region
- Subbasin boundary
- Model Domain

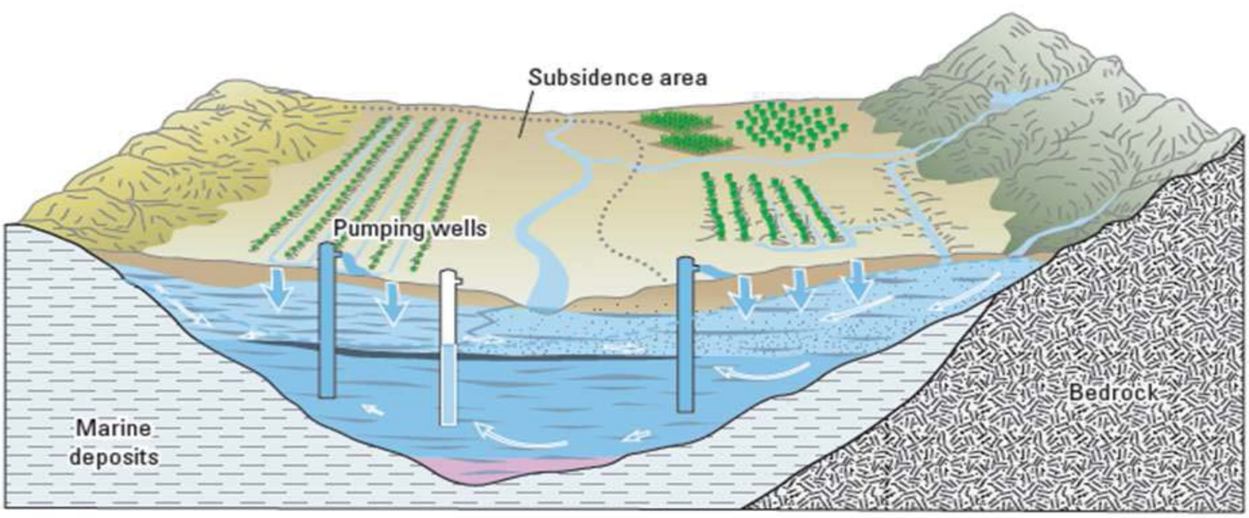
Note:
1) Hydrologic region dataset obtained from California Department of Water Resources (CA DWR), September 12, 2018. https://data.ca.gov/dataset/hydrologic-regions

Site Location Map
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 12/12/2019	Project No.: FR18161220
		Figure **D1-1**

Pre-Development





Post-Development

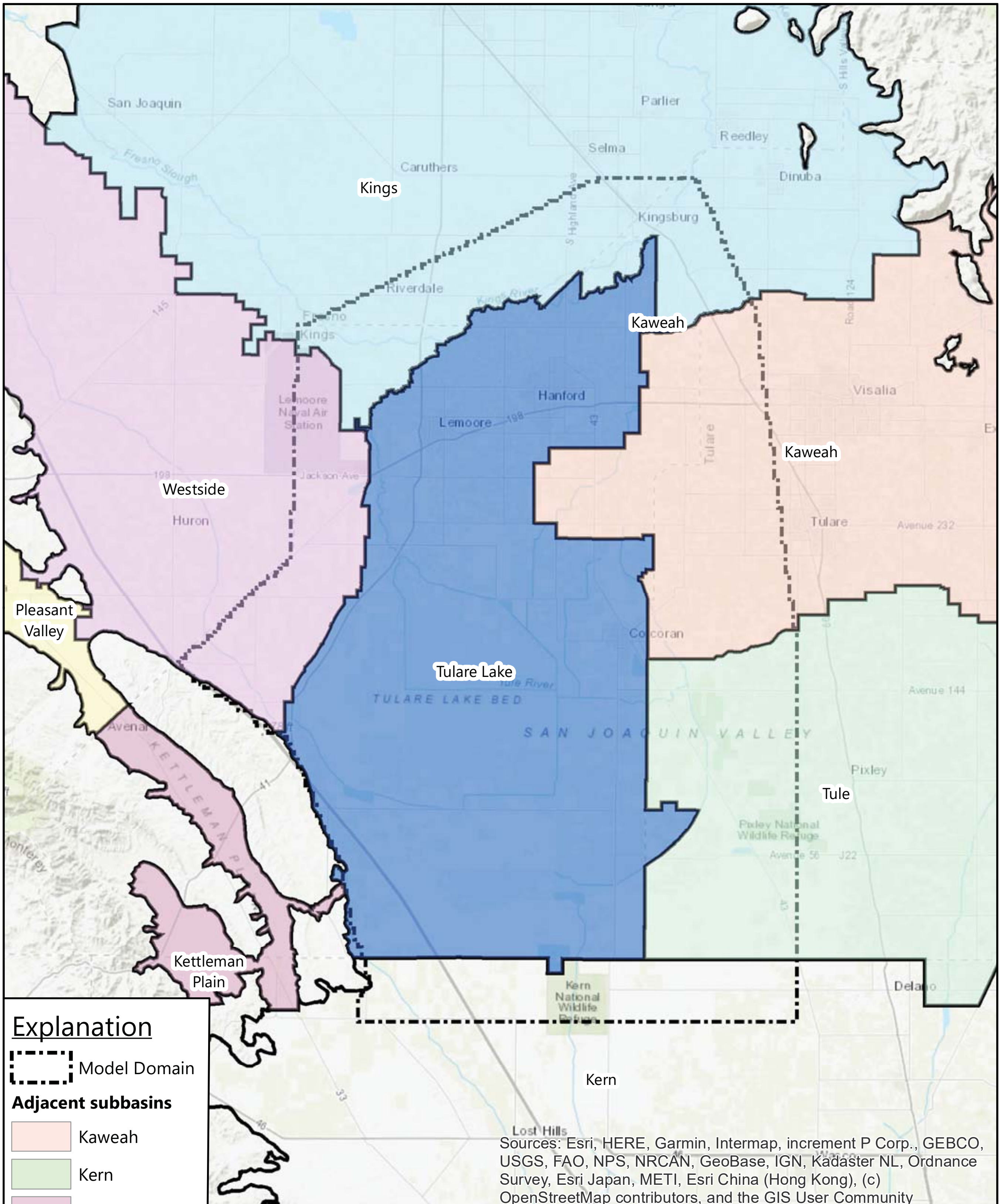
Pre-Development and Post-Development Hydrogeologic Conceptual Model for the San Joaquin Valley

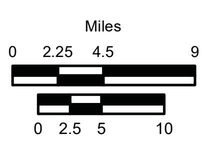
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 08/26/2019	Project No.: FR18161220
		Figure **D2-1**

adapted from Fig. A9, USGS Prof. Paper 1766

Date: 1/7/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\AppendixD_figD2-2_ModelDomain.mxd

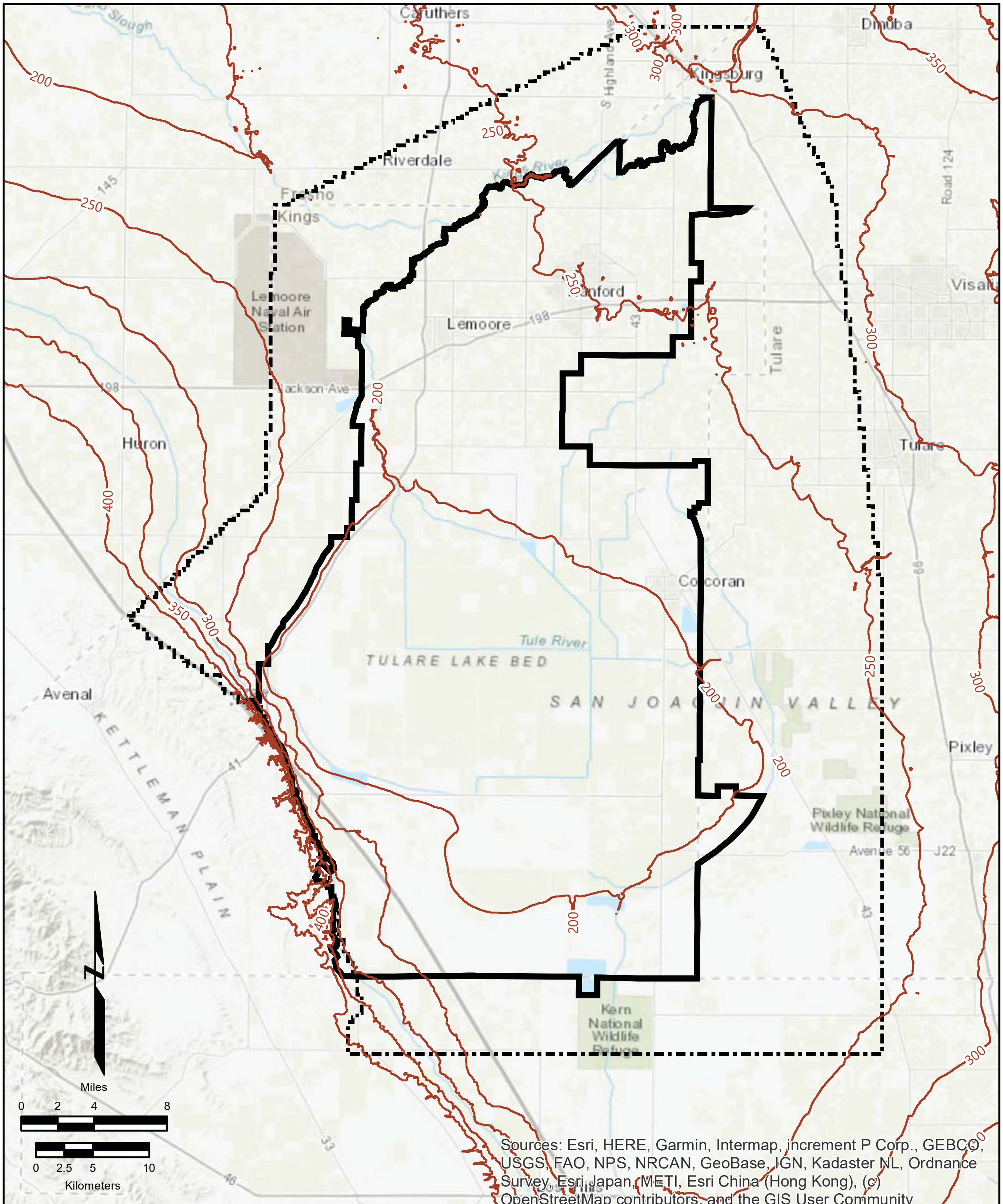




Subbasins Bounding The Tulare Lake Subbasin

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/7/2020	Project No.: FR18161220
		Figure **D2-2**



Explanation

50ft elevation contour

Subbasin boundary

Model domain

Surface Topography

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: EMC	Date: 12/12/2019	Project No.: FR18161220
		Figure **D2-3**

Date: 12/12/2019 Printed by: shaina.price
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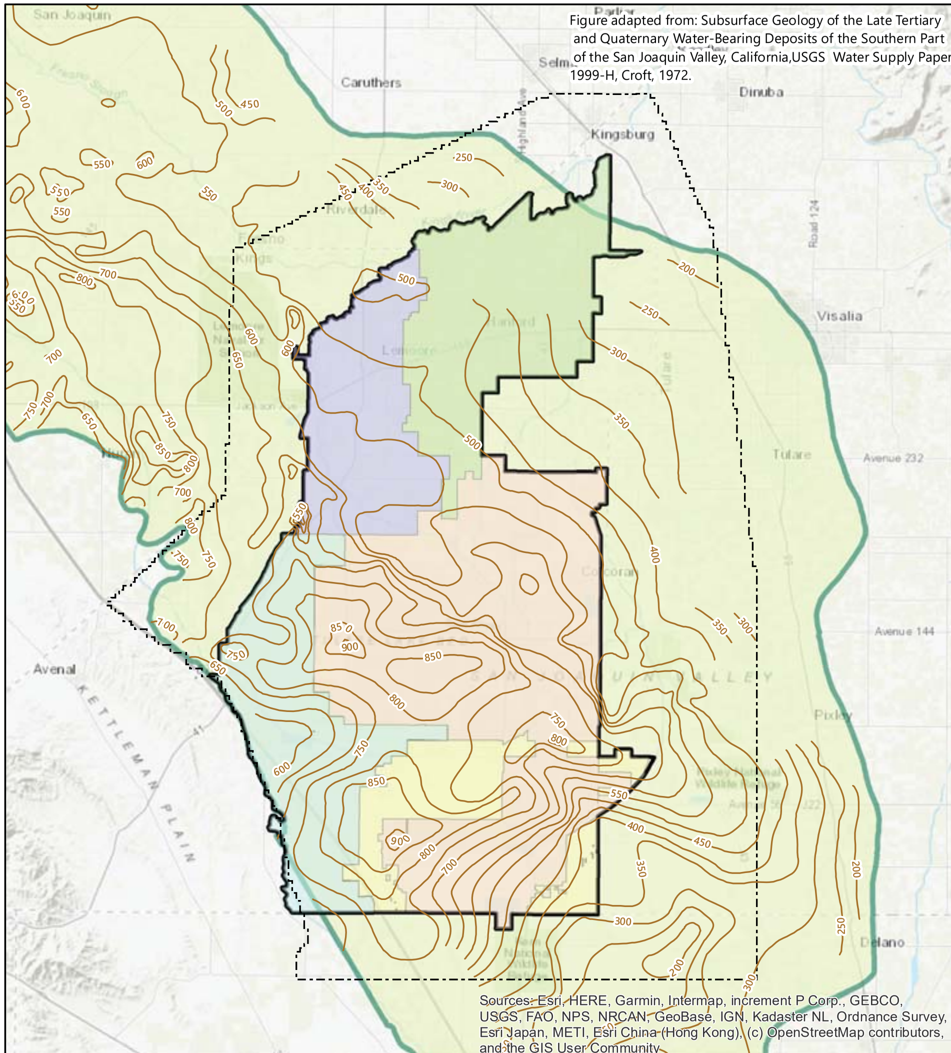
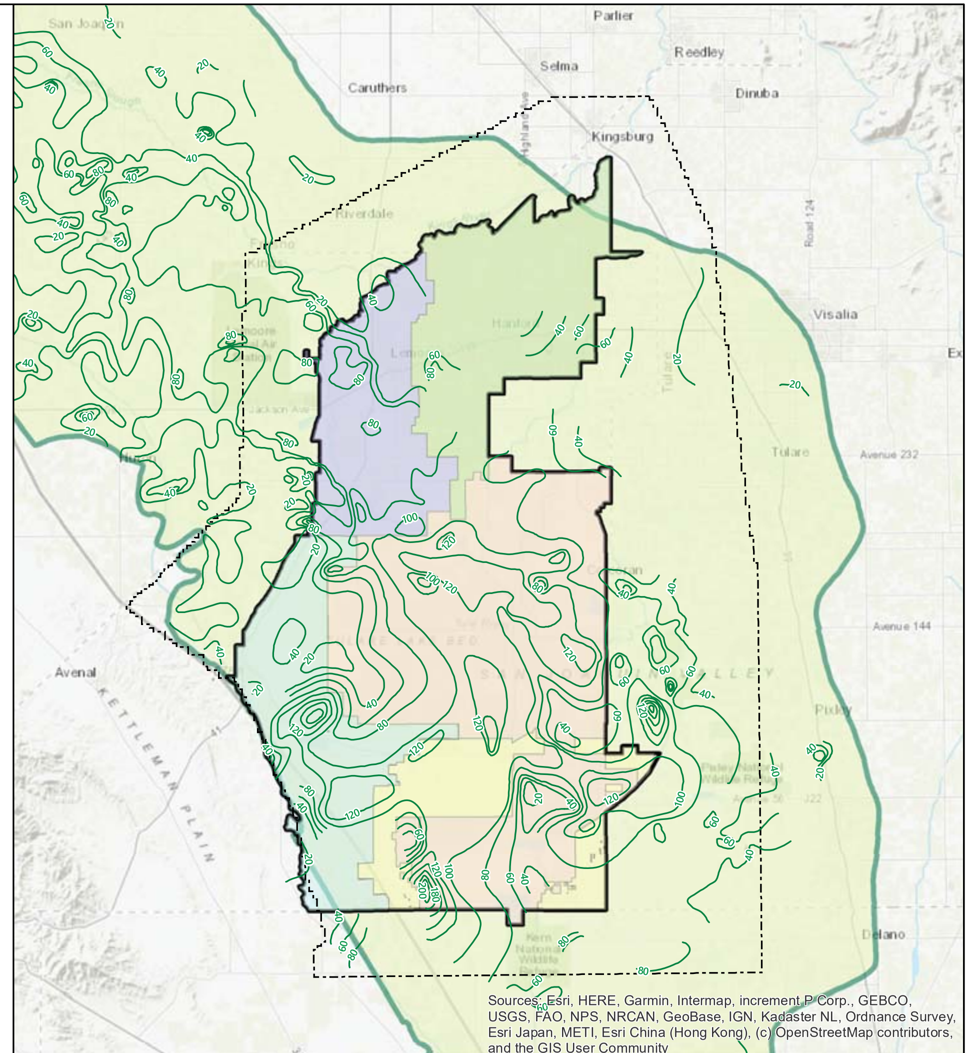




Explanation

- Depth to top of E-Clay in feet
- Thickness of E-Clay in feet
- Model domain
- Subbasin boundary
- Extent of E-Clay

Groundwater Sustainability Areas (GSAs)

- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

Approximate Scale in Miles: 0 4 8 16

Approximate Scale in Kilometers: 0 4 8 16

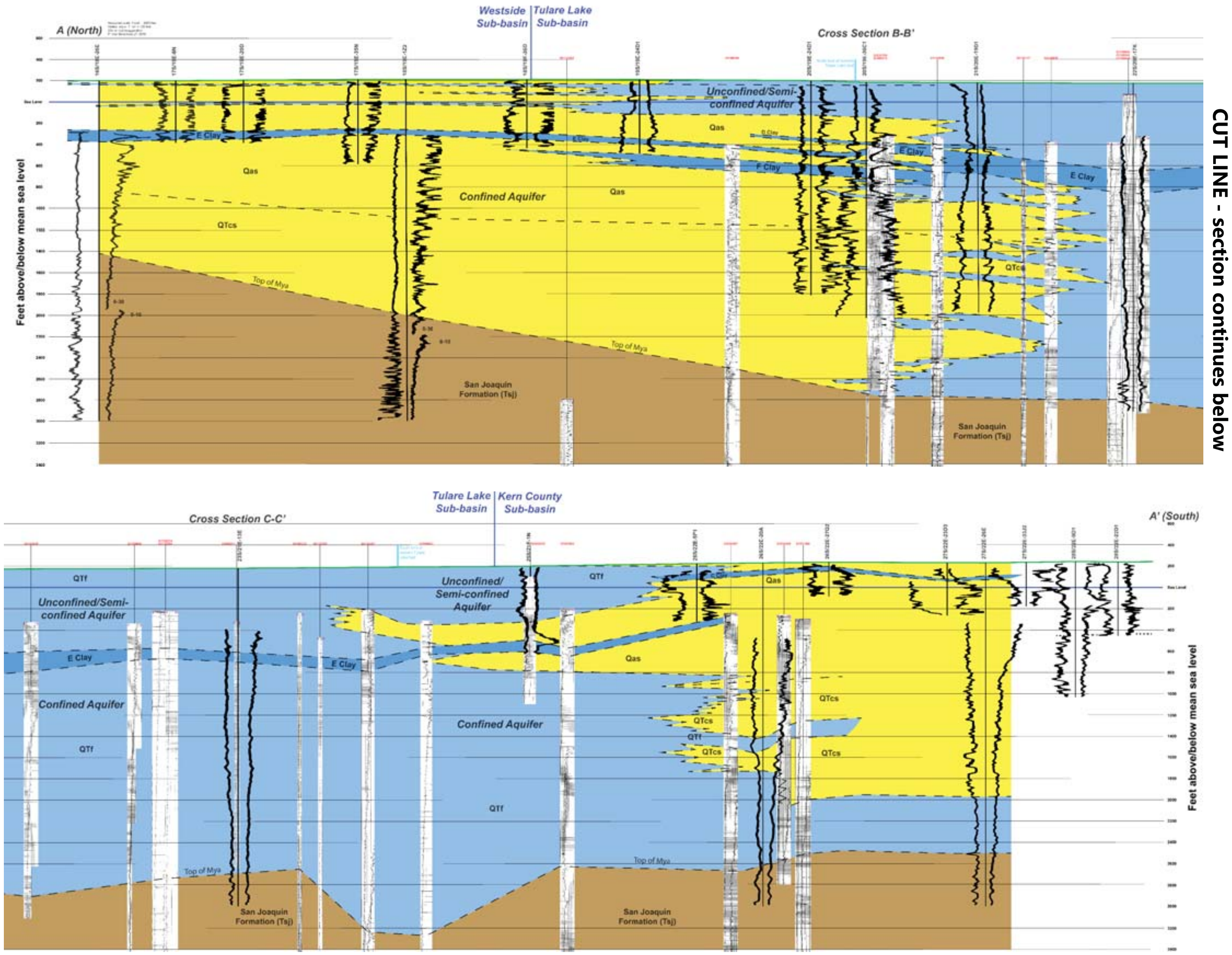
N

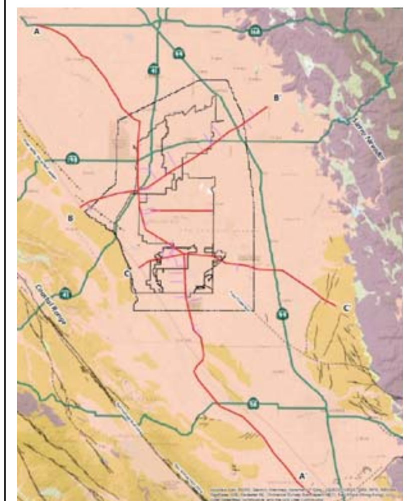
Lateral Extent Elevation and Thickness of E-Clay

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/7/2020	Project No.: FR16181220
		Figure **D2-4**

Date: 1/7/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR16181220\gis\maps\2019\AppendixD_figD2-4_Corcoran Clay.mxd





Explanation

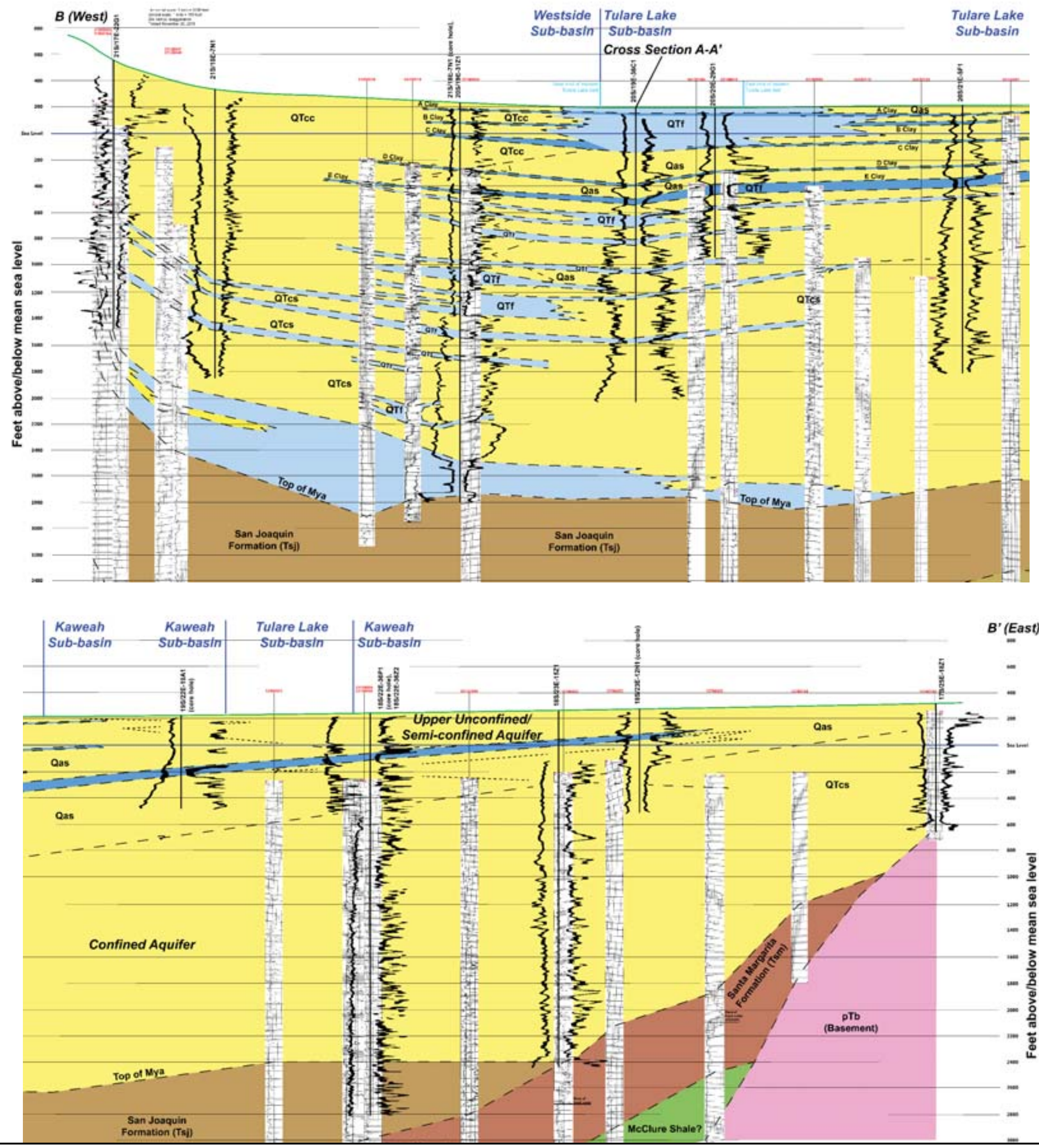
- Coarse-grained alluvium / Tulare Formation
- San Joaquin Formation
- Alluvium / Tulare Formation lacustrine sediments
- Regional clay marker beds as defined by Croft (1972)
- **25S/21E-1N** CA DWR well name
- 03120281 CA DOGGR well APN
- 0 30 Electric log resistivity scale (ohmmeters)

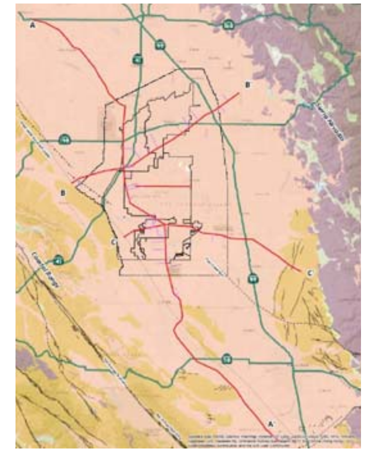
Notes:
1) Contacts dashed where inferred.
2) CA DWR = California Department of Water Resources.
2) CA DOGGR = Division of Oil, Gas, and Geothermal Resources, California Department of Conservation.

North-South Geologic Cross-Section A-A'
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings county, California

By: EMC | Date: 12/13/2019 | Project No.: FR18161220

Figure **D2-5a**





Explanation

- Coarse-grained alluvium / Tulare Formation
- San Joaquin Formation
- Etchegoin Formation
- Santa Margarita Formation
- Alluvium / Tulare Formation lacustrine sediments
- Regional clay marker beds as defined by Croft (1972)
- Crystalline basement
- **25S/21E-1N** CA DWR well name
- 03120281 CA DOGGR well APN
- 0 30 Electric log resistivity scale (ohmmeters)

Notes:
1) Contacts dashed where inferred.
2) CA DWR = California Department of Water Resources.
2) CA DOGGR = Division of Oil, Gas, and Geothermal Resources, California Department of Conservation.

West-East Geologic Cross-Section B-B'

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 12/13/2019	Project No.: FR18161220

Figure **D2-5b**

Date: 12/13/2019 Printed by: shaina.price
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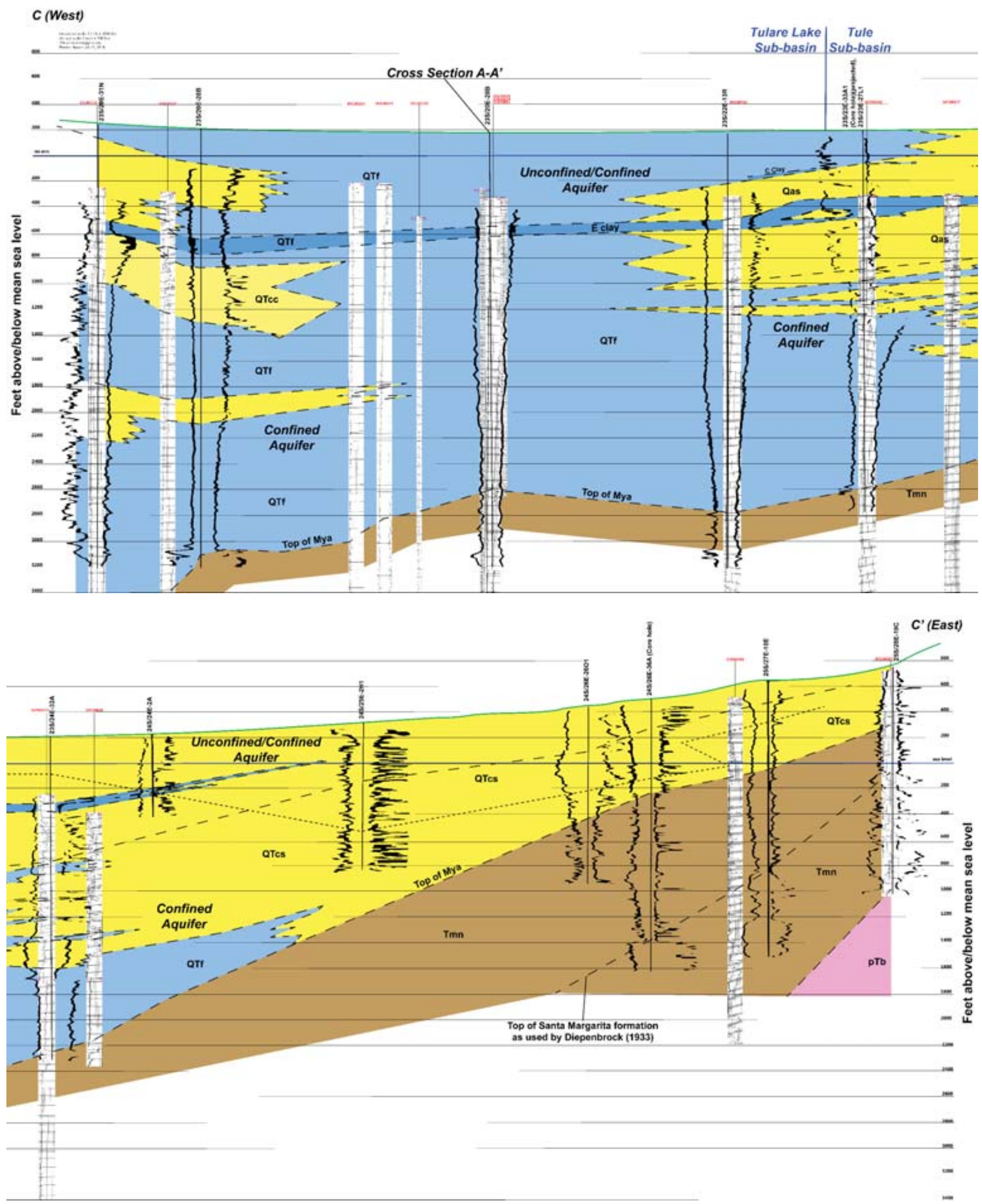
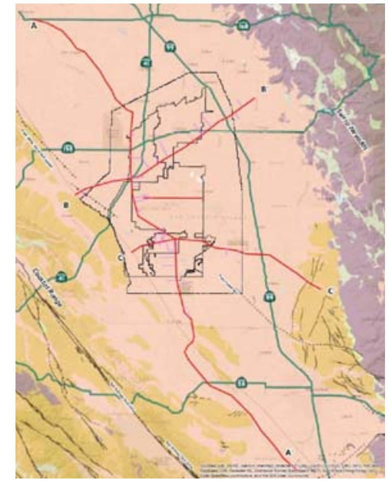




Explanation

(yellow)	Coarse-grained alluvium / Tulare Formation
(brown)	San Joaquin Formation
(light blue)	Alluvium / Tulare Formation lacustrine sediments
(blue)	Regional clay marker beds as defined by Croft (1972)
(pink)	Crystalline basement
25S/21E-1N	CA DWR well name
03120281	CA DOGGR well APN
0 30	Electric log resistivity scale (ohmmeters)

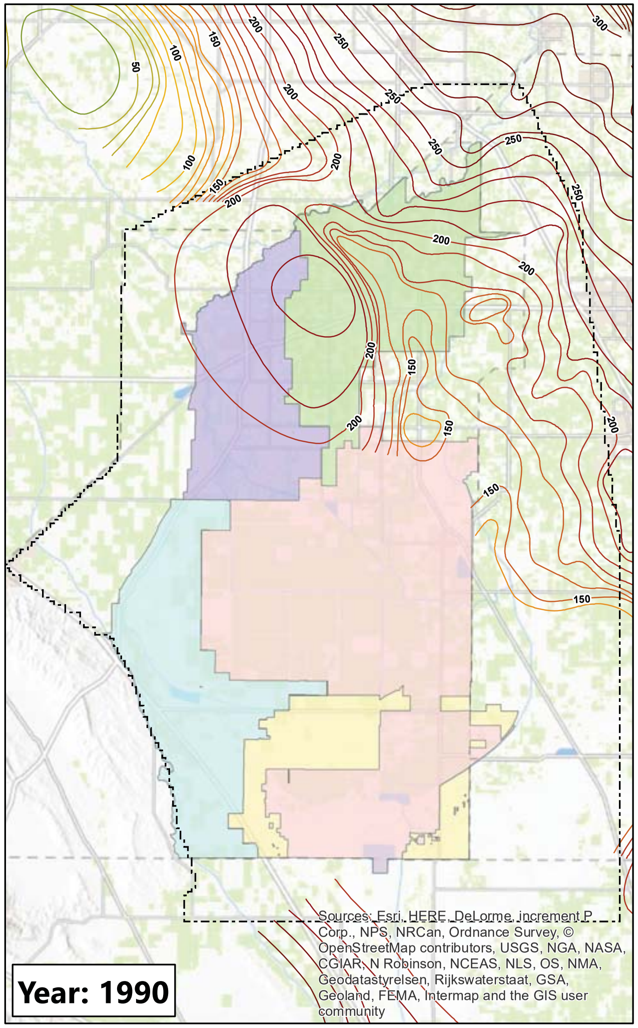
Notes:
1) Contacts dashed where inferred.
2) CA DWR = California Department of Water Resources.
2) CA DOGGR = Division of Oil, Gas, and Geothermal Resources, California Department of Conservation.

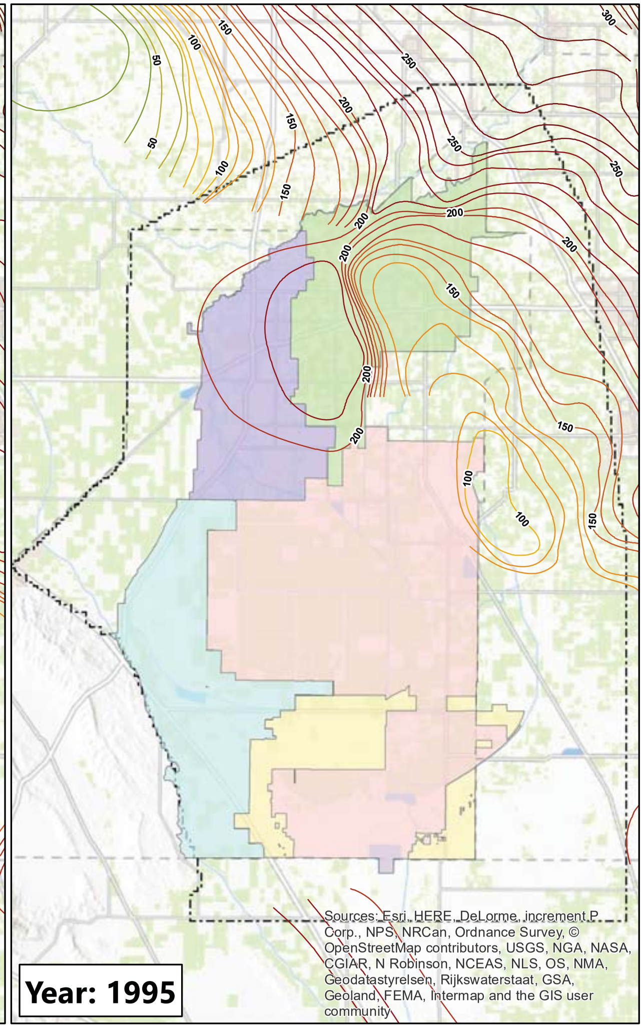
North - South Geologic Cross-Section Through the Tulare Lake Bed

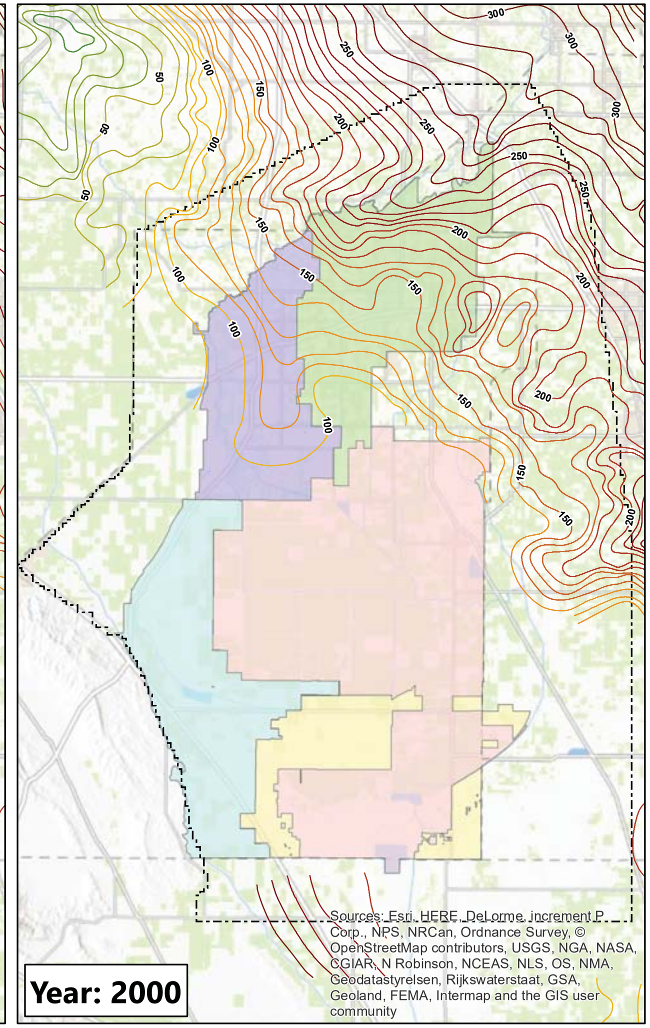
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 12/13/2019 | Project No.: FR18161220

Figure **D2-5c**







Explanation

- Model domain
- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

Groundwater elevation (FMSL)
700
-350

APPROXIMATE SCALE IN MILES
0 5 10 20

0 5 10 20
APPROXIMATE SCALE IN KILOMETERS

N

Historical DWR Groundwater Elevation Maps Unconfined Aquifer

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 1/8/2020 | Project No.: FR18161220

Figure **D2-6a**

Date: 1/8/2020 Printed by: elizabeth.chapman
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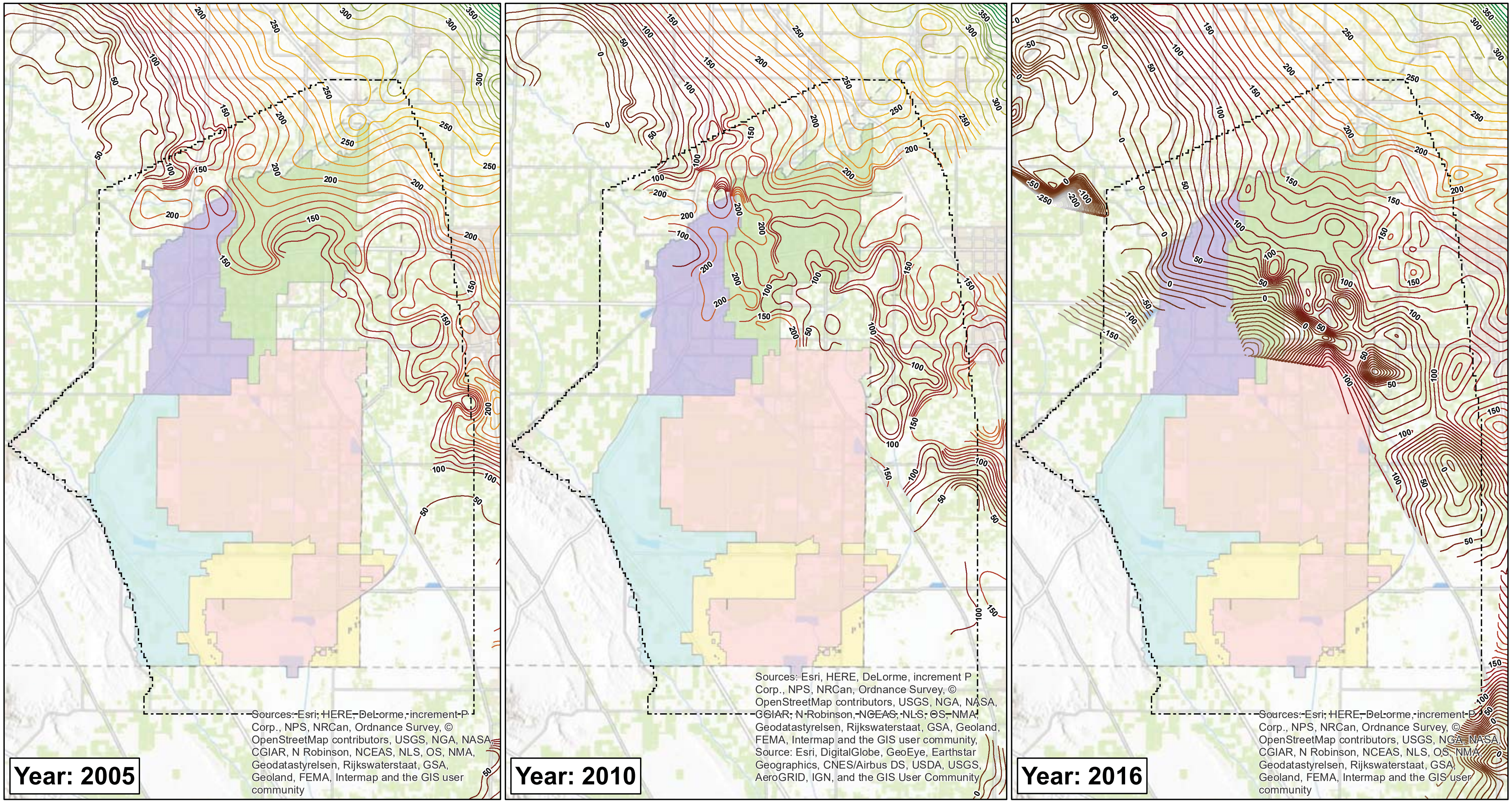


Explanation

- Model domain
- El Rico Groundwater Sustainability Agency
- Mid-Kings River Groundwater Sustainability Agency
- South Fork Kings Groundwater Sustainability Agency
- Southwest Kings Groundwater Sustainability Agency
- Tri-County Water Authority

Groundwater elevation (FMSL)
-700
-350

APPROXIMATE SCALE IN MILES
0 5 10 20

0 5 10 20
APPROXIMATE SCALE IN KILOMETERS

NOTE:
1) Groundwater elevation data obtained from California Department of Water Resources (CA DWR), June 2018: https://databasin.org/datasets/b05820cda86b4921a515065fa1deffcc
2) FMSL = Feet above mean sea level.

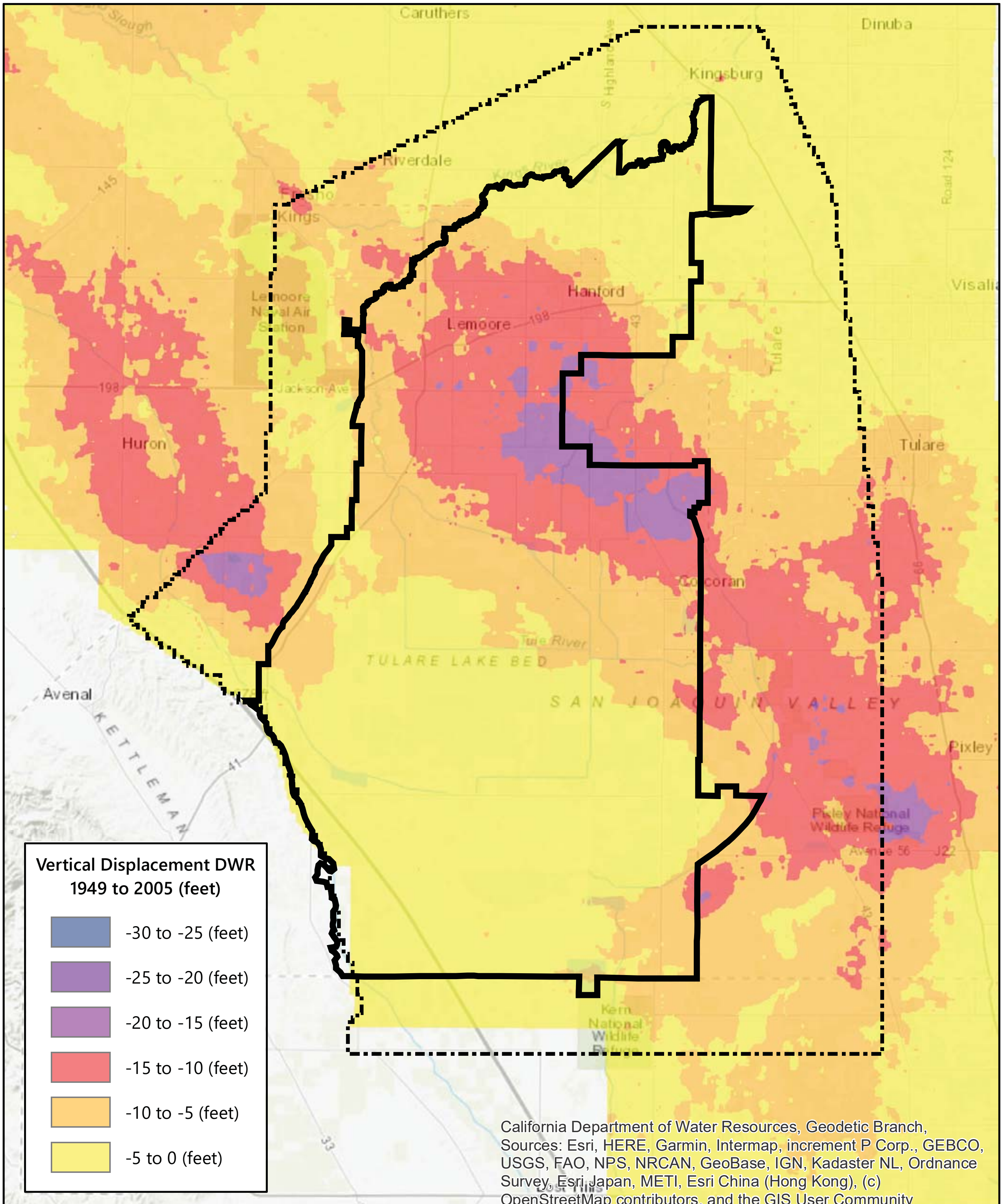
Historical DWR Groundwater Elevation Maps, Unconfined Aquifer

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 12/13/2019 | Project No.: FR18161220

Figure **D2-6b**

Date: 12/13/2019 Printed by: shaina.price
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\AppendixD_figD2-6b_RecentGroundwaterConditions_2005_2010_2016.mxd



Explanation

- Model domain
- Subbasin boundary

Miles: 0 2 4 8

Kilometers: 0 2.5 5 10

Notes:

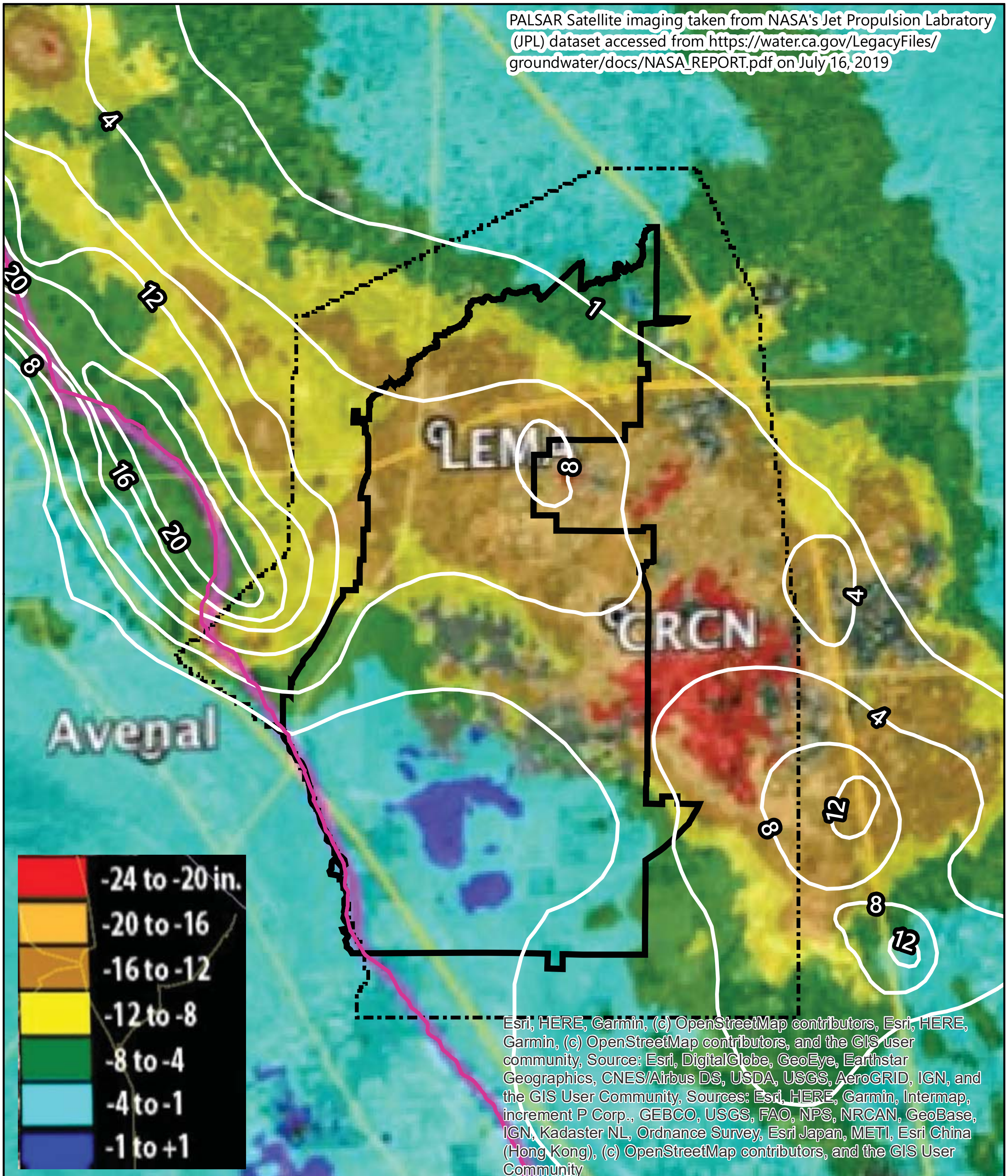
1. Vertical Displacement dataset taken from California Department of Water Resources (DWR) https://sgma.water.ca.gov/webgis. Accessed July 9, 2019.

Historical Subsidence of the Tulare Lake Subbasin

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 12/13/2019	Project No.: FR18161220
		Figure **D2-7**

Date: 12/13/2019 Printed by: shaina.price
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\AppendixD_figD2-7_Historical Subsidence TLSB8x11.mxd



Explanation

Subbasin boundary

Model domain

Edmund G. Brown California Aqueduct

White line shows historical subsidence data from 1926-1970 (ft.)

Miles 0 2 4 8

0 2.5 5 10 Kilometers

N

Subsidence in the Tulare Lake Subbasin 2007 to 2010

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 12/13/2019	Project No.: FR18161220
		Figure **D2-8**

Date: 12/13/2019 Printed by: shaina.price
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\AppendixD_figD2-8_Historical Subsidence TLSB8x11.mxd

Date: 12/12/2019 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\gis\maps\2019\AppendixD_figD2-9a_Historic Surface Water Systems San Joaquin Valley.mxd

Explanation

Model domain

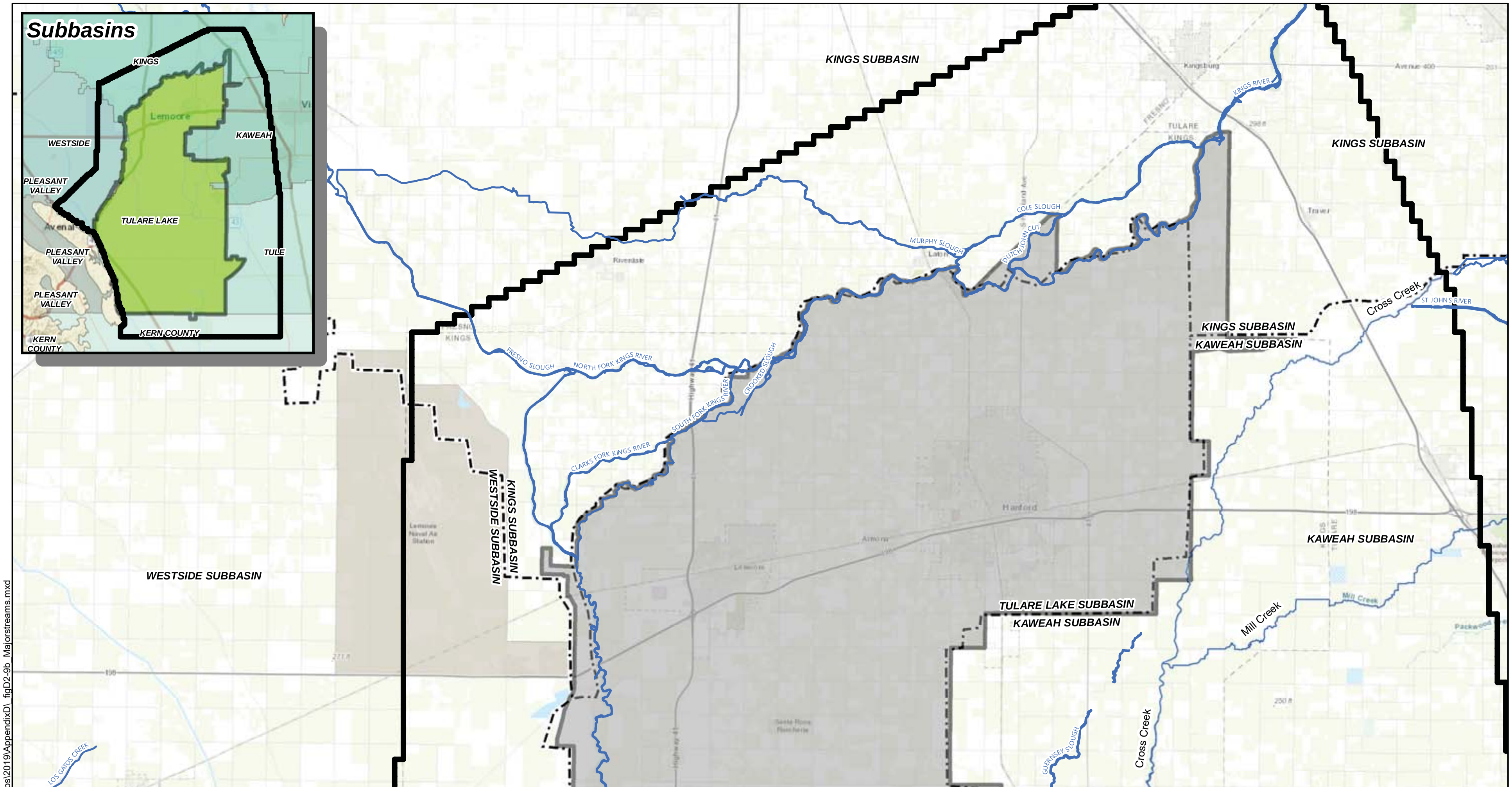
Subbasin boundary

Note:
Adapted from "Map of the San Joaquin, Sacramento and Tulare Valleys, State of California, Prepared Under The Direction of the Board of Commissioners on Irrigation, 1873"

Historic Drainage System
Tulare Lake Basin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: GLK	Date: 12/12/2019	Project No.: FR16181220

Figure **D2-9a**



Explanation

- River/Lake [1]
- Model Domain
- Tulare Lake subbasin boundary
- Boundaries of adjacent subbasins

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

APPROXIMATE SCALE IN MILES
0 1 2 4

0 1 2 4
APPROXIMATE SCALE IN KILOMETERS

N

Notes:
1. Data accessed from the National Hydrography Dataset (2018)

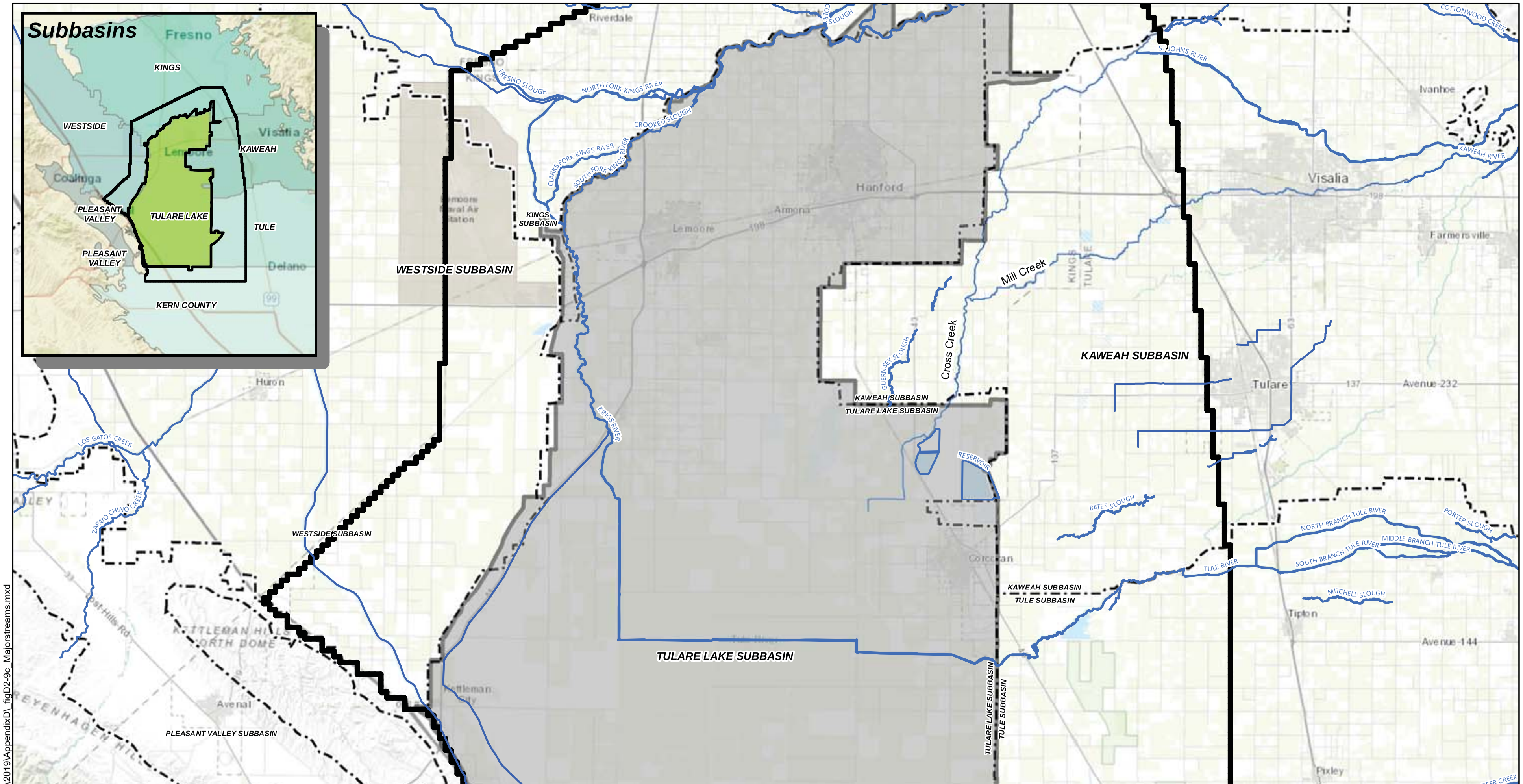
Simulated Major Streams and Distribution Channels

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 12/13/2019	Project No.: FR18161220

Figure **D2-9b**

N:_FR_projects\FR18s\FR18161220\gis\maps\2019\AppendixD_figD2-9b_Majorstreams.mxd



Explanation

- River/Lake [1]
- Model Domain
- Tulare Lake subbasin boundary
- Boundaries of adjacent subbasins

Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

APPROXIMATE SCALE IN MILES
0 1 2 4

0 1 2 4
APPROXIMATE SCALE IN KILOMETERS

N

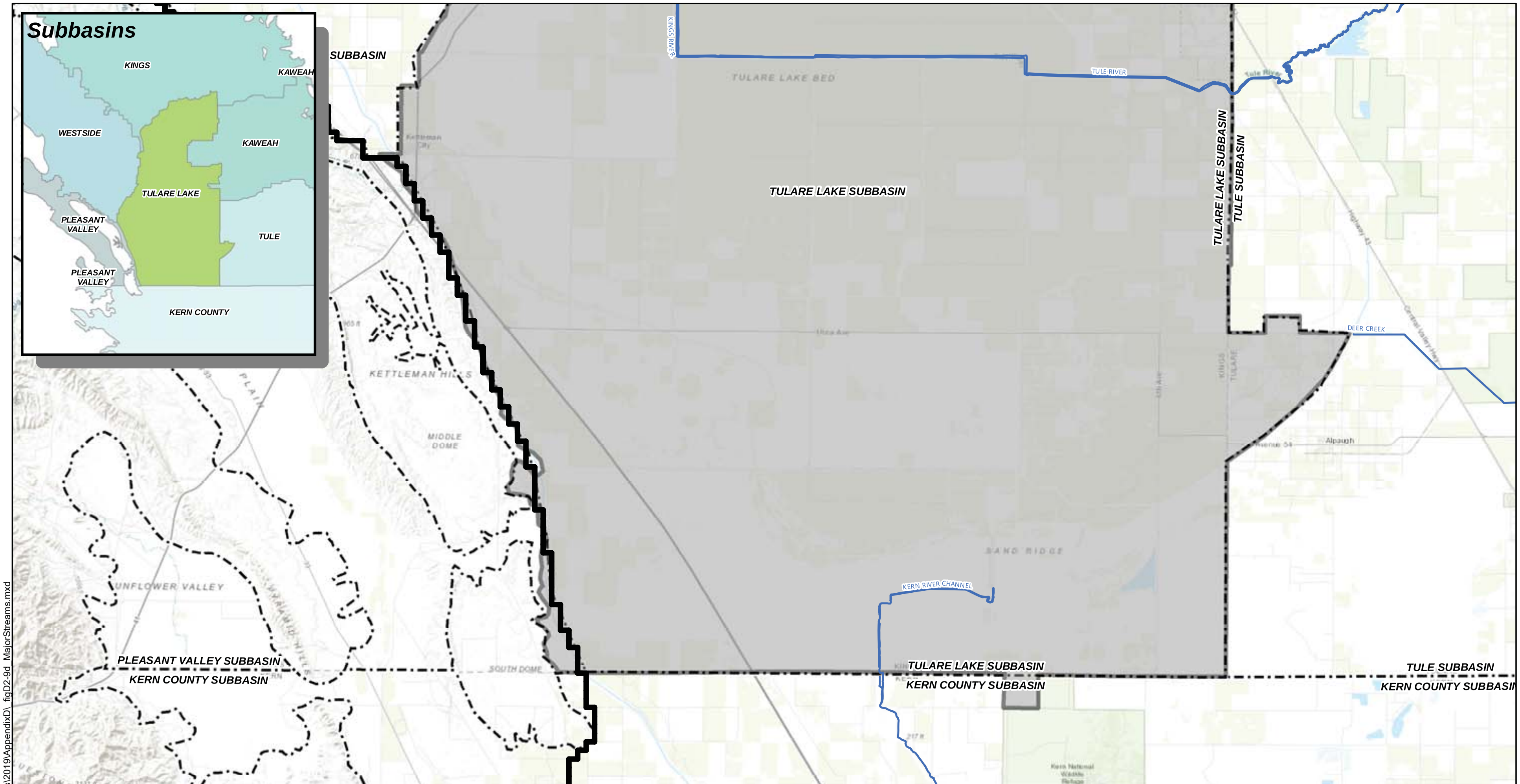
Notes:
1. Data accessed from the National Hydrography Dataset (2018)

Major Streams and Distribution Channels

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/2/2020	Project No.: FR18161220
		Figure **D2-9c**

N:_FR_projects\FR18s\FR18161220\gis\maps\2019\AppendixD_figD2-9c_Majorstreams.mxd



Explanation

- River/Lake [1]
- Model domain
- Subbasin boundary
- Boundaries of adjacent subbasins

Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

APPROXIMATE SCALE IN MILES
0 1 2 4

0 1 2 4
APPROXIMATE SCALE IN KILOMETERS

N

Notes:
1. Data accessed from the National Hydrography Dataset (2018)

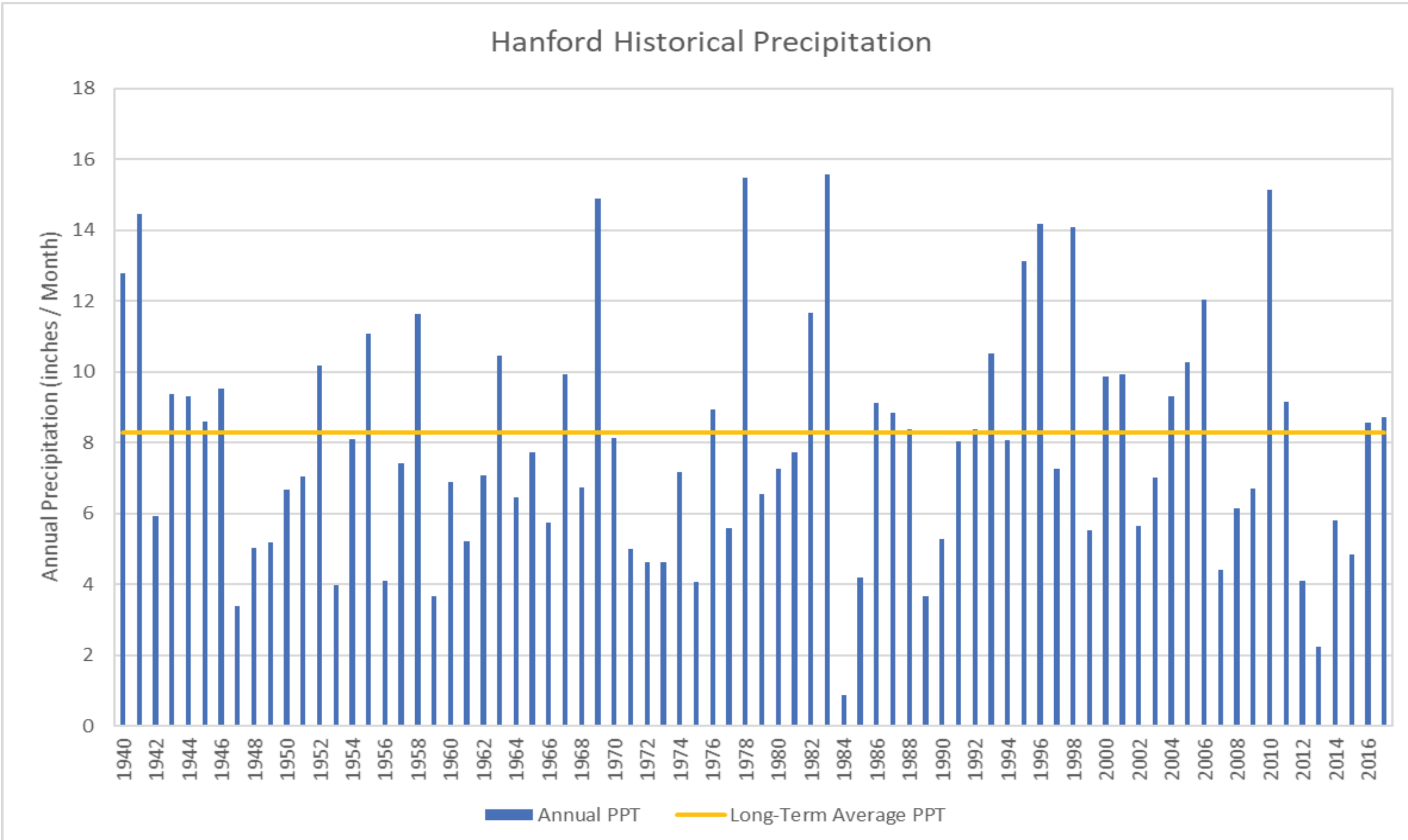
Major Streams and Distribution Channels
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC | Date: 12/13/2019 | Project No.: FR18161220

Figure **D2-9d**

N:_FR_projects\FR18s\FR18161220\gis\maps\2019\AppendixD_figD2-9d_MajorStreams.mxd

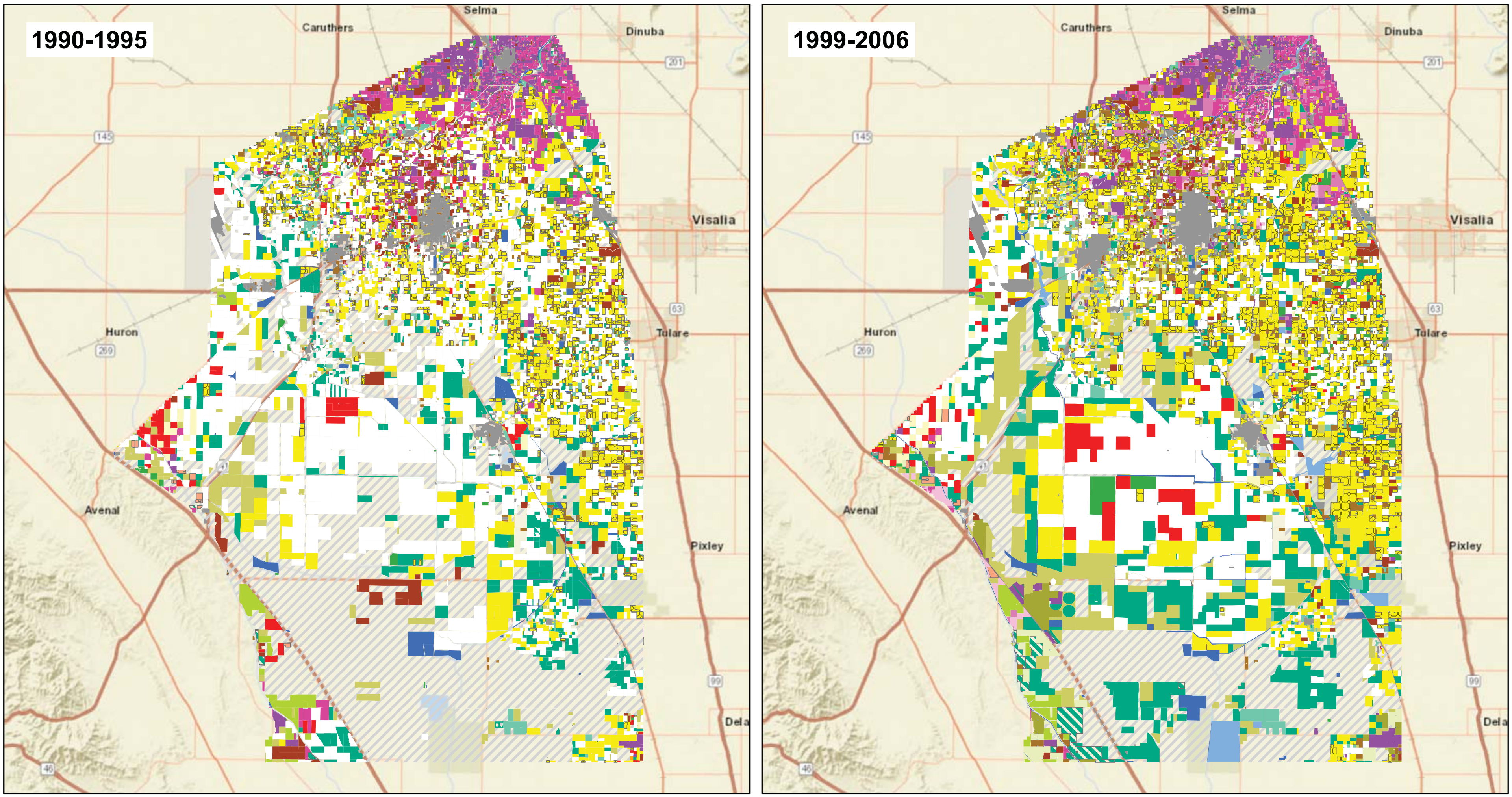
I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSe□ing\Figures\DAV□S FOLD□R\DRAFT_TLSB_SGMA_GWModel_Figures_v3Fig D2-10 □an□ord PPT 12□13□2019



Historical Annual Precipitation
Hanford, California

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure D□□□□



Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, © OpenStreetMap contributors, and the GIS User Community

Explanation

- Alfalfa Hay and Clover
- Almonds (Young)
- Almonds (Adolescent)
- Almonds (Mature)
- Berries
- Carrot Single Crop
- Citrus (no ground cover)
- Corn and Grain Sorghum
- Cotton
- Dairy Single Crop
- Fallow Land
- Forest
- Grain and Grain Hay
- Melons
- Misc. field crops
- Onions and Garlic
- Open Water
- Pasture and Misc. Grasses
- Pistachio (Young)
- Pistachio (Adolescent)
- Pistachio (Mature)
- Pomegranates (Young)
- Pomegranates (Adolescent)
- Potatoes, Sugar beets, Turnip etc..
- Riparian
- Small Vegetables
- Stone Fruit (Young)
- Stone Fruit (Adolescent)
- Stone Fruit (Mature)
- Tomatoes and Peppers
- Urban, Commercial
- Urban, Industrial
- Wine Grapes with 80% canopy
- Winter Wheat

N

0 20,000 40,000
APPROXIMATE SCALE IN FEET

Crop Distributions
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: jmp | Date: 3/26/2019 | Project No.: FR18161220

Figure D2-11a

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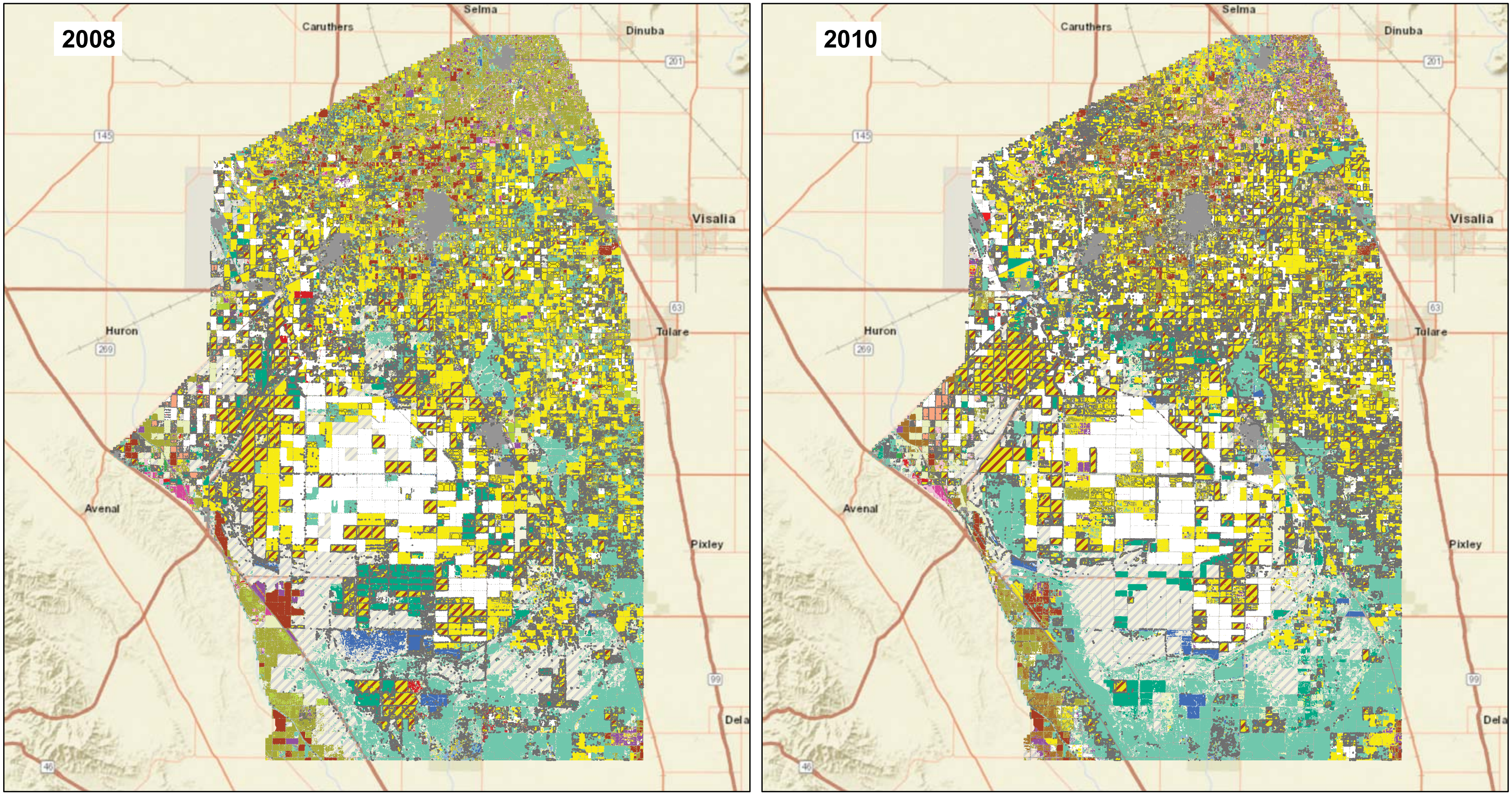

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- Winter Wheat

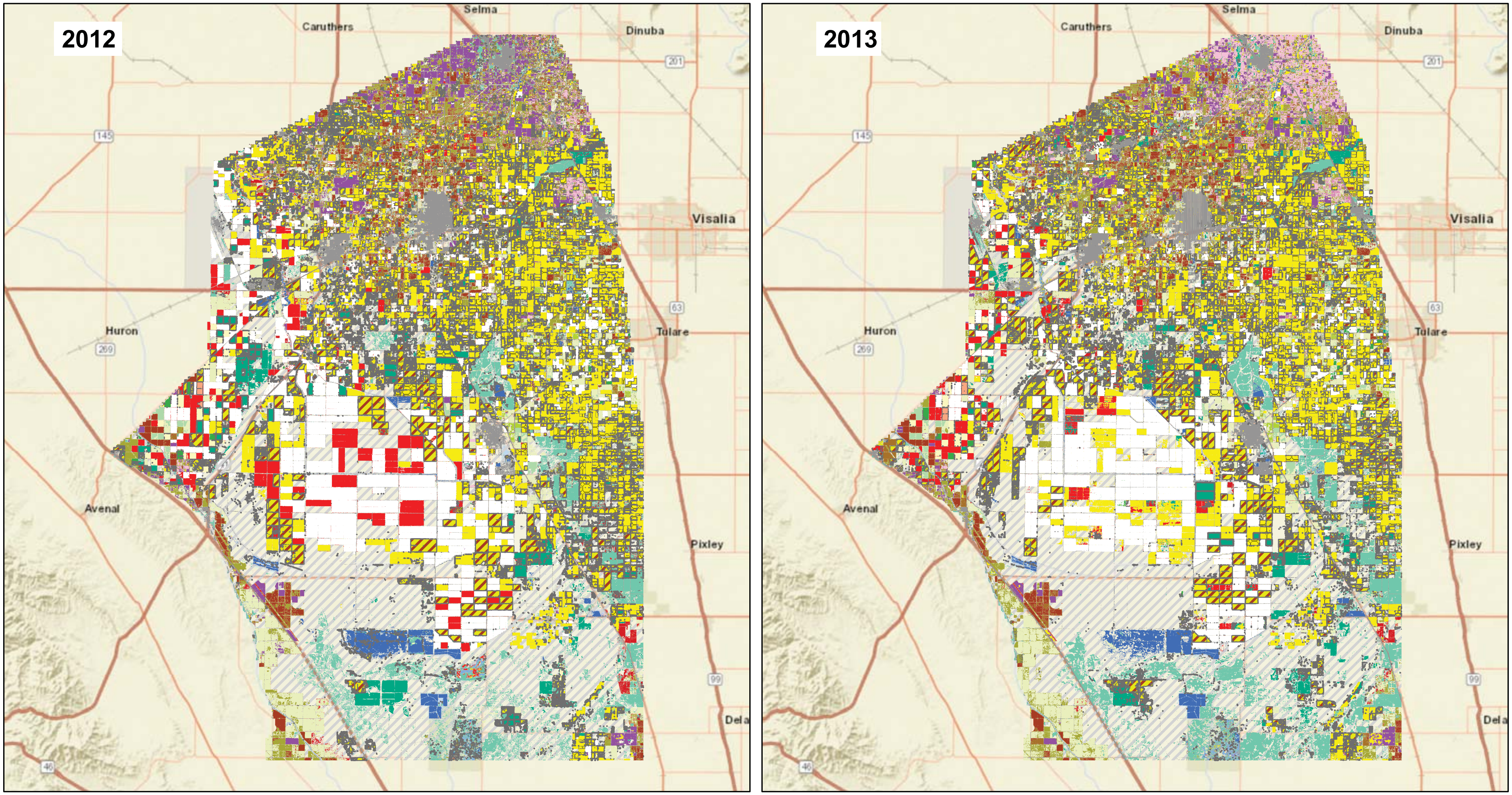
N

0 20,000 40,000
APPROXIMATE SCALE IN FEET

Crop Distributions
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: jmp	Date: 3/26/2019	Project No.: FR18161220
	Figure **D2-11b**	

\\fsn-fs1\Graphics_FR_projects\FR18s\FR18161220\gis\maps\2018\Hydrogeologic_Conceptual_Model\Arcmap 10.4_fig3-8b_CropDistributions_rev.mxd



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Explanation

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- Winter Wheat

N

0 20,000 40,000
APPROXIMATE SCALE IN FEET

Crop Distributions
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: jmp | Date: 3/26/2019 | Project No.: FR18161220

Figure **D2-11c**

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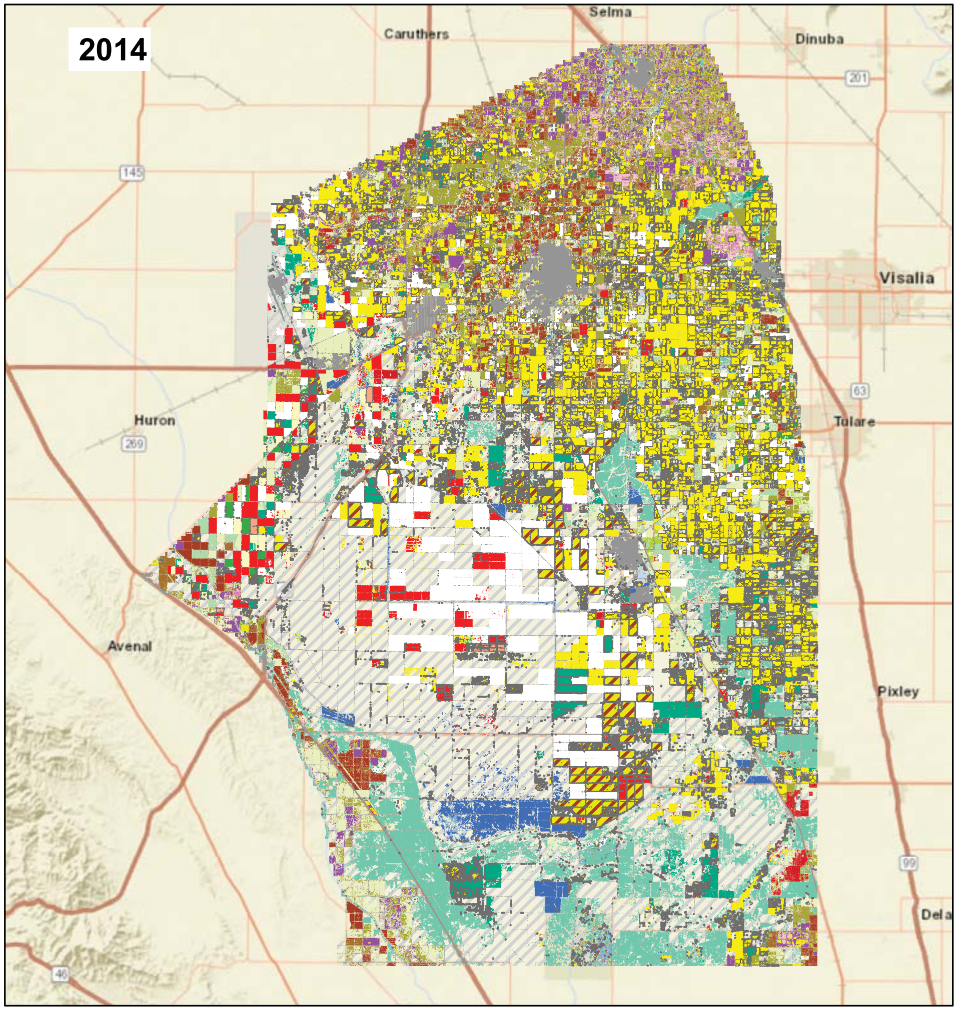

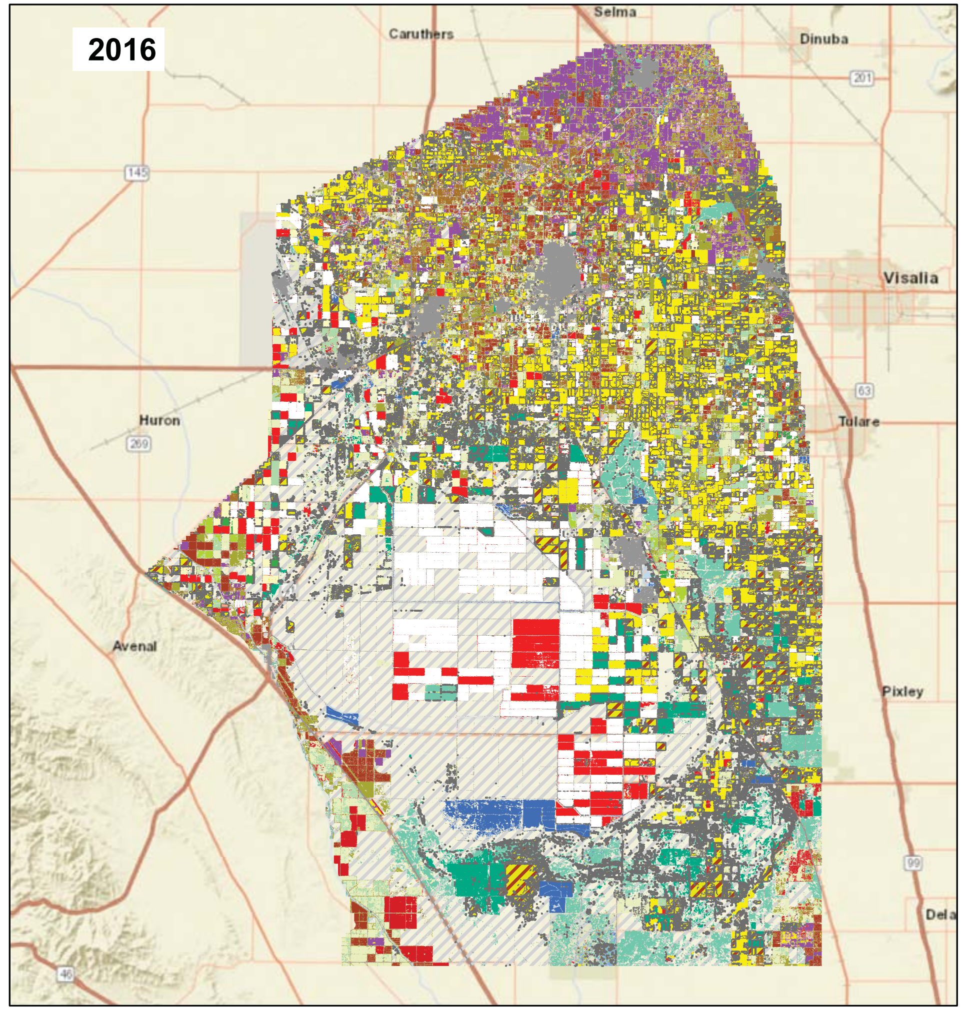

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- Tomatoes and Peppers
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- Wine Grapes with 80% canopy
- Winter Wheat

N

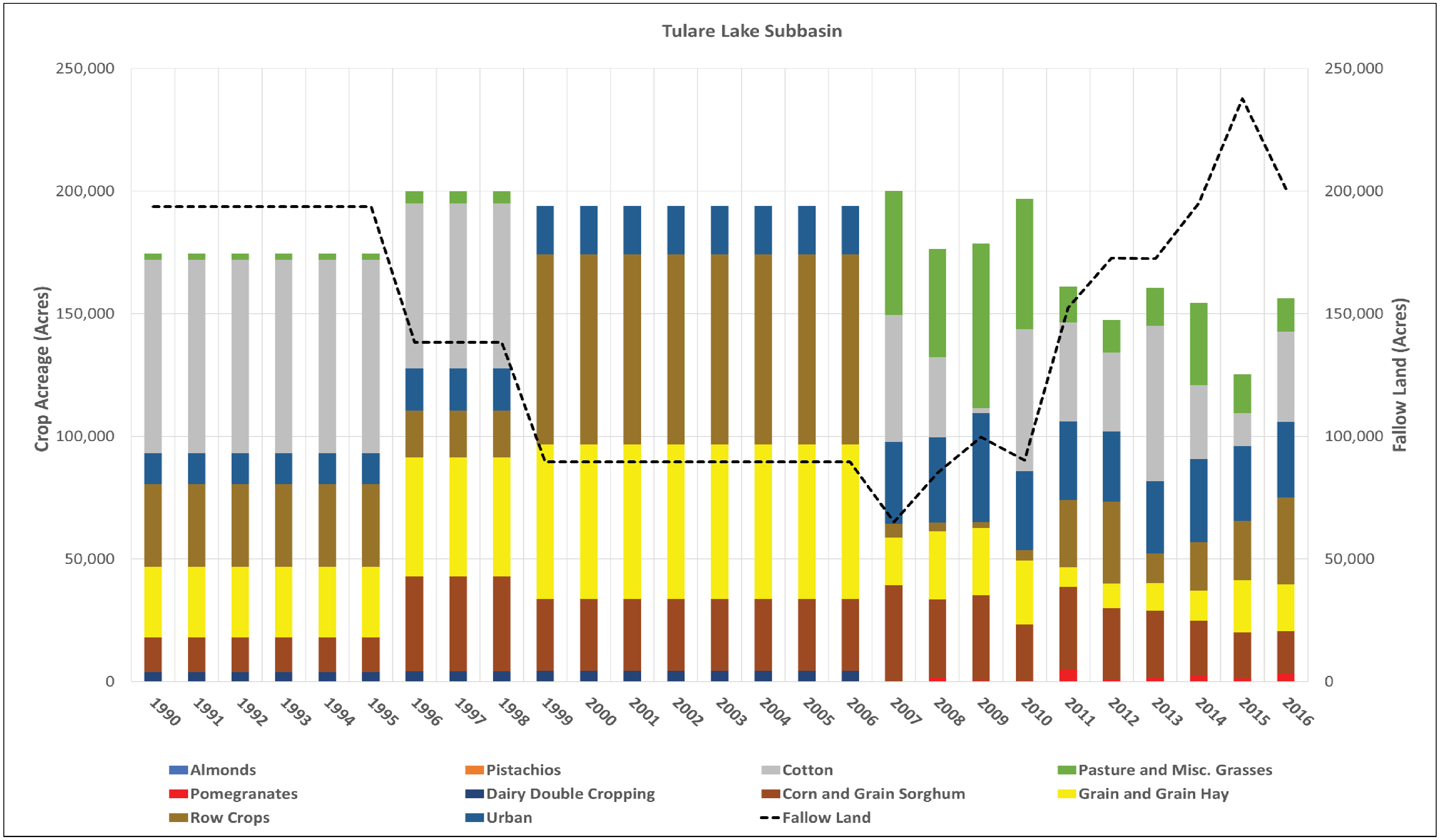
0 20,000 40,000
APPROXIMATE SCALE IN FEET

Crop Distributions
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: jmp	Date: 3/26/2019	Project No.: FR18161220
		Figure **D2-11d**

\\fsn-fs1\Graphics_FR_projects\FR18s\FR18161220\gis\maps\2018\Hydrogeologic_Conceptual_Model\Arcmap 10.4_fig3-8d_CropDistributions_rev.mxd

N:_FR_projects\FR18s\FR18161220\temp\DBean_Hydro_\Wood Figure TemplatesFig 2-12 HstoricalCrop Acreage 9/7/2019



Historical Crop Acreage in Model Domain

Tulare Lake Subbasin Groundwater Sustainabilty Plan

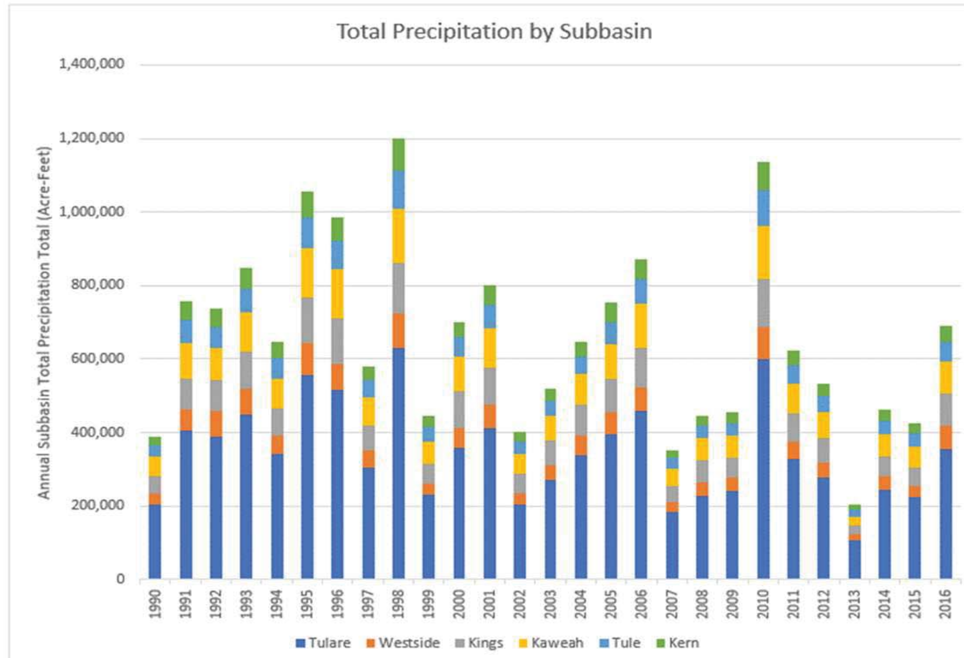
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D2-12**

N:_FR_projects\FR18s\FR18161220\temp\DBean_Hydro_\Wood Figure Templates.xlsxFig d2-13a Annual SB PPT 1/6/2020

ANNUAL TOTAL PRECIPITATION (ACRE-FEET)

SP	Tulare	Westside	Kings	Kaweah	Tule	Kern	Total
1990	205,446	28,212	48,930	51,309	30,947	24,023	388,867
1991	405,080	57,267	83,913	96,137	63,627	50,916	756,939
1992	390,074	67,498	84,716	87,700	57,619	48,389	735,997
1993	447,720	71,443	101,727	105,426	65,907	54,792	847,015
1994	340,437	50,626	75,966	80,699	54,192	45,398	647,318
1995	556,440	85,801	126,208	134,572	83,809	68,943	1,055,774
1996	517,621	70,468	123,183	132,981	78,164	62,576	984,993
1997	304,204	46,045	70,190	75,198	46,704	38,101	580,442
1998	628,620	94,415	137,547	149,223	102,104	88,545	1,200,453
1999	231,988	30,280	53,202	60,123	39,033	32,569	447,196
2000	358,410	53,273	99,777	96,159	51,600	40,115	699,334
2001	411,922	63,322	101,366	106,449	63,662	52,859	799,578
2002	205,011	30,798	53,013	53,586	32,171	26,641	401,219
2003	270,548	40,570	66,233	68,593	40,425	33,269	519,638
2004	339,269	53,188	82,590	83,239	49,381	40,603	648,271
2005	394,033	61,121	90,935	93,355	60,700	53,816	753,960
2006	457,938	64,091	108,085	119,504	69,821	52,995	872,434
2007	184,578	26,460	44,432	46,579	29,322	21,777	353,148
2008	228,631	37,419	58,349	59,869	35,246	27,247	446,762
2009	240,260	36,916	55,236	59,739	34,814	29,497	456,461
2010	598,897	88,582	130,029	144,182	96,270	80,046	1,138,006
2011	328,748	46,550	76,276	80,288	51,437	40,143	623,442
2012	277,729	39,653	66,630	72,324	43,489	33,195	533,019
2013	108,142	15,048	22,376	25,747	19,794	14,606	205,713
2014	243,088	37,368	54,143	61,105	38,200	29,654	463,558
2015	223,458	29,592	51,681	58,217	35,773	25,262	423,982
2016	356,639	60,978	87,691	88,184	53,105	44,307	690,904
min	108,142	15,048	22,376	25,747	19,794	14,606	205,713
max	628,620	94,415	137,547	149,223	102,104	88,545	1,200,453
mean	342,775	51,370	79,793	84,833	52,864	42,973	654,608



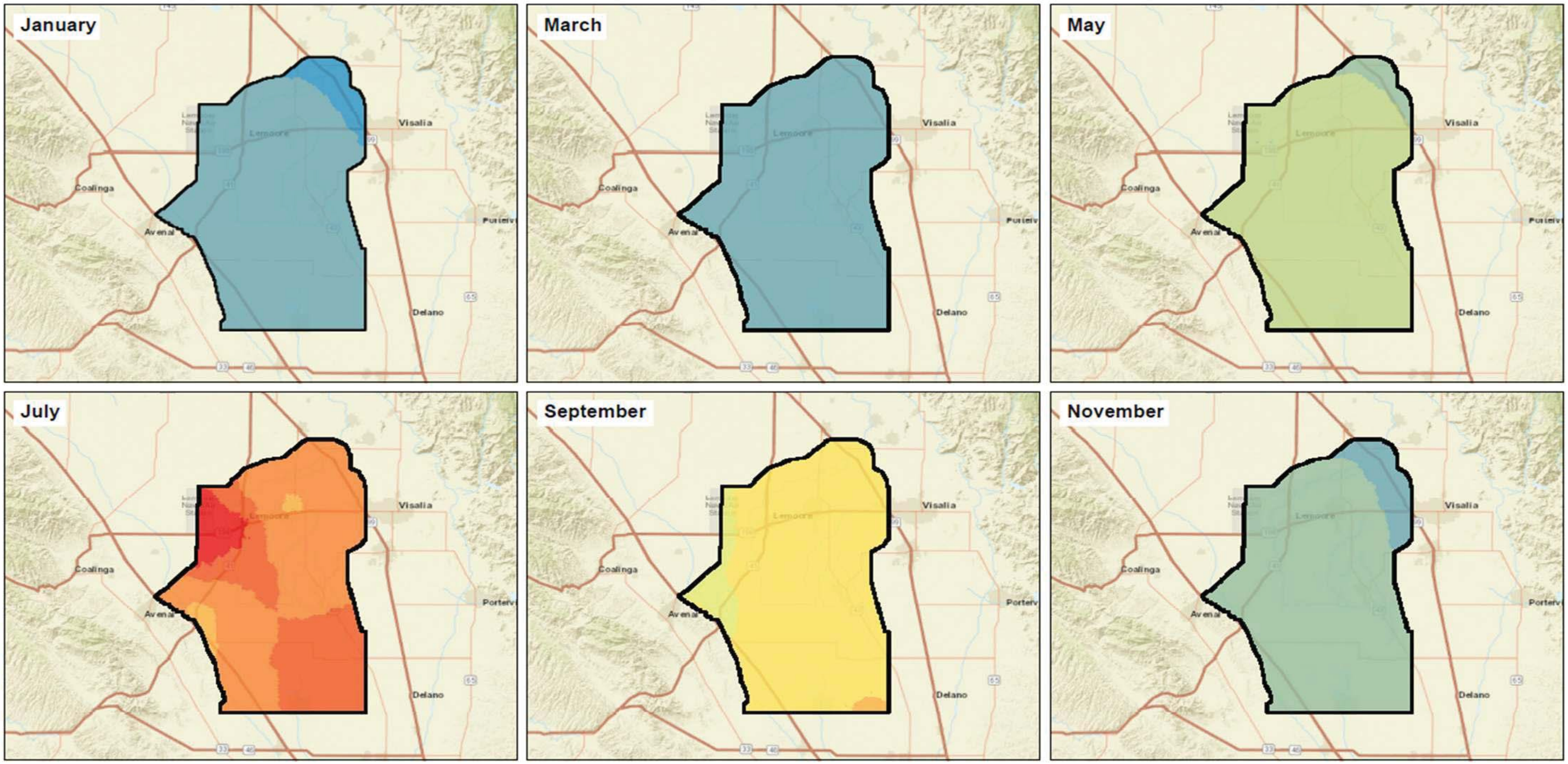
Note:
Annual precipitation totals are based on 4-kilometer grids of precipitation from the Oregon State University PRISM database. Monthly totals taken from January 1990 to December 2016

Estimated Annual Total Precipitation by Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb | Date: 07/30/19 | Project No.: FR18161220

Figure **D2-13a**

N:_FR_projects\FR18s\FR18161220\temp\DBean_Hydro_\Wood Figure TemplatesFig 2-13b Month Avg PPT 9/7/2019



Explanation

Model Domain

Precipitation (feet per day)

- 5.1e-003 - 1.0e-002
- 2.1e-003 - 5.0e-003
- 1.1e-003 - 2.0e-003
- 5.1e-004 - 1.0e-003
- 2.1e-004 - 5.0e-004
- 1.1e-004 - 2.0e-004
- 5.1e-005 - 1.0e-004
- 2.1e-005 - 5.0e-005
- 1.1e-005 - 2.0e-005
- 7.0e-006 - 1.0e-005

Service Layer Credits: Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

0 50,000 100,000

APPROXIMATE SCALE IN FEET

Average Monthly Precipitation Across Model Domain 1990-2016

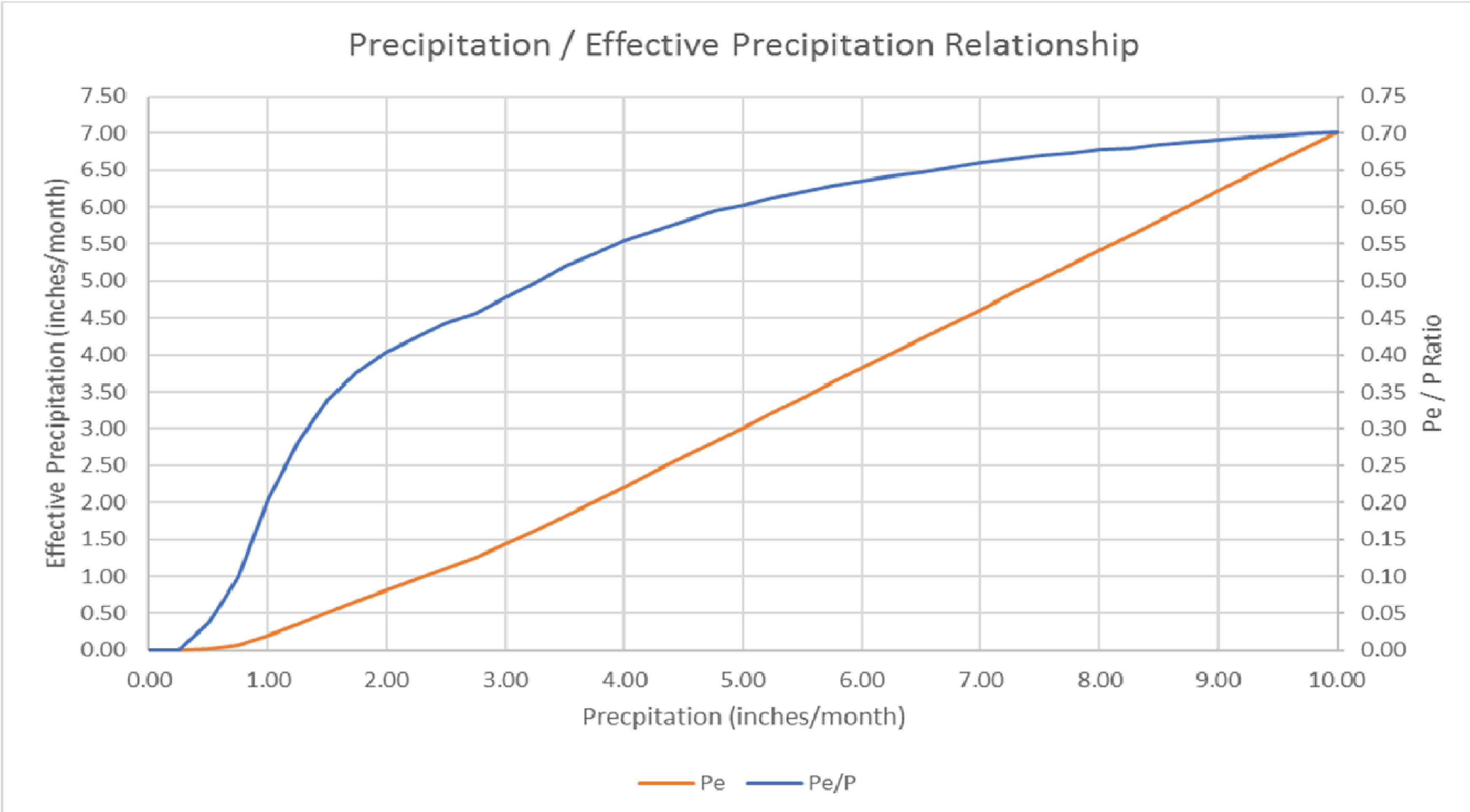
Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: EMC	Date: 09/07/19	Project No.: FR18161220
		Figure **D2-13b**

C:\Model\Kings\Report\Figures_fig_2_8_PrecipitationAcrossDomain.mxd

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D2-14 PPT-Pe
12/19/2019



Modified from:
United Nations Food and Agricultre Organization (FAO)
FAO 56, Chapter 3 Table 6
Precipitation (P) and Effective Precipitation (Pe) in mm/month

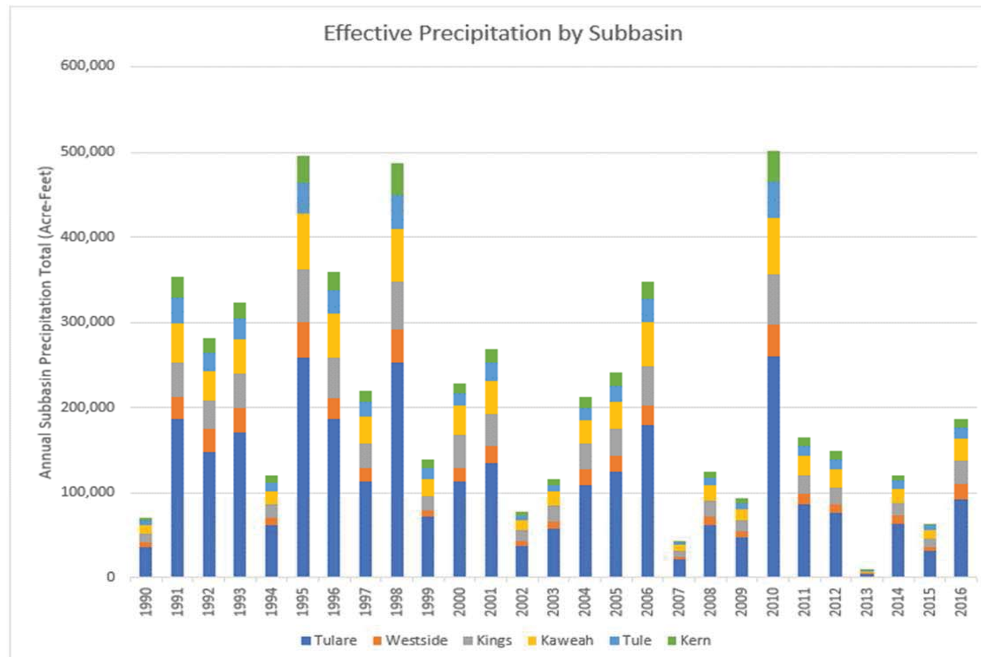
Precipitation Versus Effective Precipitation

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D2-14**

ANNUAL EFFECTIVE PRECIPITATION (ACRE-FEET)

Date	Tulare	Westside	Kings	Kaweah	Tule	Kern	Total
1990	35,788	5,208	10,921	10,176	4,812	3,714	70,619
1991	187,134	25,313	40,273	46,723	29,809	23,715	352,967
1992	148,073	27,645	33,148	33,386	21,388	17,350	280,990
1993	170,267	29,369	40,873	40,049	23,350	19,250	323,158
1994	61,232	8,593	15,645	16,141	10,127	8,240	119,978
1995	259,175	41,208	62,347	64,874	37,212	30,391	495,207
1996	186,149	24,278	48,754	51,487	27,483	21,442	359,593
1997	113,642	15,748	28,680	30,918	17,369	13,352	219,710
1998	252,323	38,854	56,898	60,724	41,542	36,341	486,681
1999	71,917	7,632	16,648	20,114	13,016	10,619	139,945
2000	113,113	16,314	38,555	34,058	15,532	11,155	228,726
2001	134,333	20,616	37,779	38,654	20,766	17,000	269,148
2002	37,068	5,535	12,943	11,666	5,956	4,445	77,613
2003	57,809	8,545	17,995	17,097	8,207	6,806	116,460
2004	109,787	18,411	29,462	28,012	14,496	12,064	212,232
2005	124,268	19,089	31,607	31,363	18,469	16,100	240,896
2006	179,592	23,246	45,635	51,807	27,290	19,450	347,021
2007	20,953	2,745	7,604	7,072	3,259	1,764	43,397
2008	61,111	11,105	18,873	18,211	9,119	6,389	124,809
2009	47,768	7,417	12,492	13,028	6,456	5,711	92,872
2010	260,214	37,095	58,830	65,701	43,440	35,754	501,035
2011	86,495	12,603	22,107	21,802	12,693	9,244	164,943
2012	75,839	10,048	19,758	21,768	12,555	8,764	148,732
2013	4,721	561	939	1,214	1,153	735	9,322
2014	63,051	9,701	14,375	17,224	9,896	6,761	121,008
2015	30,969	4,190	10,169	11,275	5,114	1,900	63,617
2016	92,375	18,143	27,302	25,956	12,925	10,086	186,788
min	4,721	561	939	1,214	1,153	735	9,322
max	260,214	41,208	62,347	65,701	43,440	36,341	501,035
mean	110,562	16,638	28,171	29,278	16,794	13,279	214,721



Note:
Annual effective precipitation totals are based on 4 kilometer grids of precipitation from the Oregon State University PRISM database and Effective Precipitation Chart

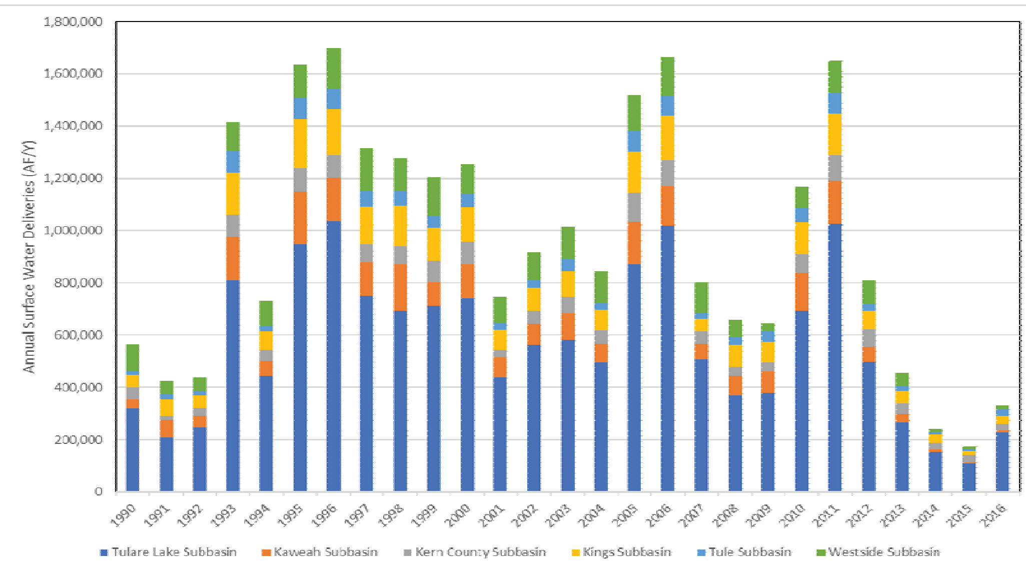
Estimated Annual Effective Precipitation by Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb | Date: 07/30/19 | Project No.: FR18161220

Figure **D2-15**

Annual Surface Water Deliveries (Acre-Feet / Year)

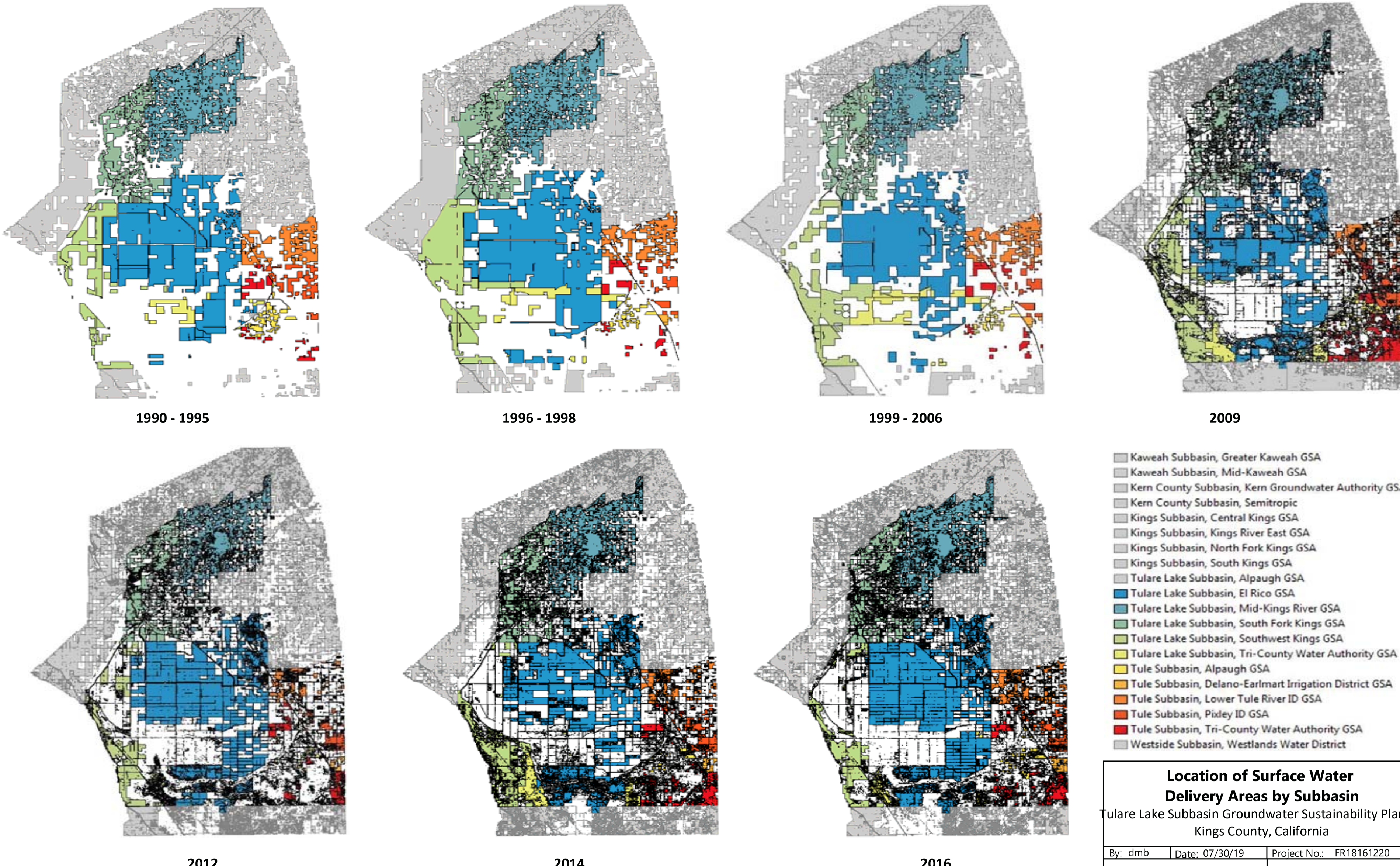
Date	Tulare Lake Subbasin	Kaweah Subbasin	Kern County Subbasin	Kings Subbasin	Tule Subbasin	Westside Subbasin	Total Model Domain
1990	319,638	34,691	46,977	47,706	14,494	101,753	565,259
1991	209,115	66,976	16,670	60,707	20,365	50,314	424,147
1992	244,988	48,175	29,248	47,266	18,257	51,537	439,472
1993	810,344	165,910	83,835	160,515	85,065	109,771	1,415,439
1994	443,205	56,606	44,535	69,284	22,852	94,931	731,414
1995	947,855	199,690	91,209	186,720	82,330	127,670	1,635,474
1996	1,036,790	163,574	87,848	177,280	75,768	155,283	1,696,544
1997	748,244	131,645	68,613	142,094	63,303	162,313	1,316,212
1998	693,058	179,630	69,486	153,596	54,029	127,191	1,276,990
1999	712,379	90,346	82,217	123,948	49,408	147,138	1,205,436
2000	740,630	131,085	85,279	129,655	53,811	114,126	1,254,586
2001	437,390	75,793	31,430	73,740	27,230	100,268	745,851
2002	563,492	79,353	51,035	87,765	28,672	107,362	917,680
2003	582,626	100,822	63,030	96,972	46,562	125,166	1,015,176
2004	495,419	71,381	49,475	80,158	28,180	120,407	845,020
2005	872,486	161,327	109,892	158,076	78,061	139,083	1,518,926
2006	1,019,418	150,216	100,573	170,799	74,941	147,368	1,663,316
2007	508,584	60,204	44,265	51,185	21,408	118,138	803,785
2008	370,440	74,103	34,343	83,836	29,913	64,483	657,118
2009	378,849	81,144	34,414	79,124	39,295	33,190	646,016
2010	693,453	145,197	71,837	120,646	54,005	81,772	1,166,909
2011	1,025,466	165,643	97,315	159,548	78,345	125,949	1,652,265
2012	498,360	56,953	65,646	72,022	26,220	90,518	809,719
2013	264,069	33,712	41,542	46,333	17,950	51,684	455,291
2014	154,035	8,482	24,232	31,689	7,799	15,092	241,330
2015	107,068	7,140	24,818	18,233	7,799	9,836	174,894
2016	227,433	8,482	24,232	31,689	24,908	15,092	331,837
1990-2016 Average	**559,438**	**94,381**	**58,296**	**98,540**	**41,888**	**95,831**	**948,374**
1998-2010 Average	**620,633**	**107,739**	**63,637**	**108,423**	**45,039**	**109,669**	**1,055,139**



Estimated Annual Surface Water Diversions by Subbasin

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

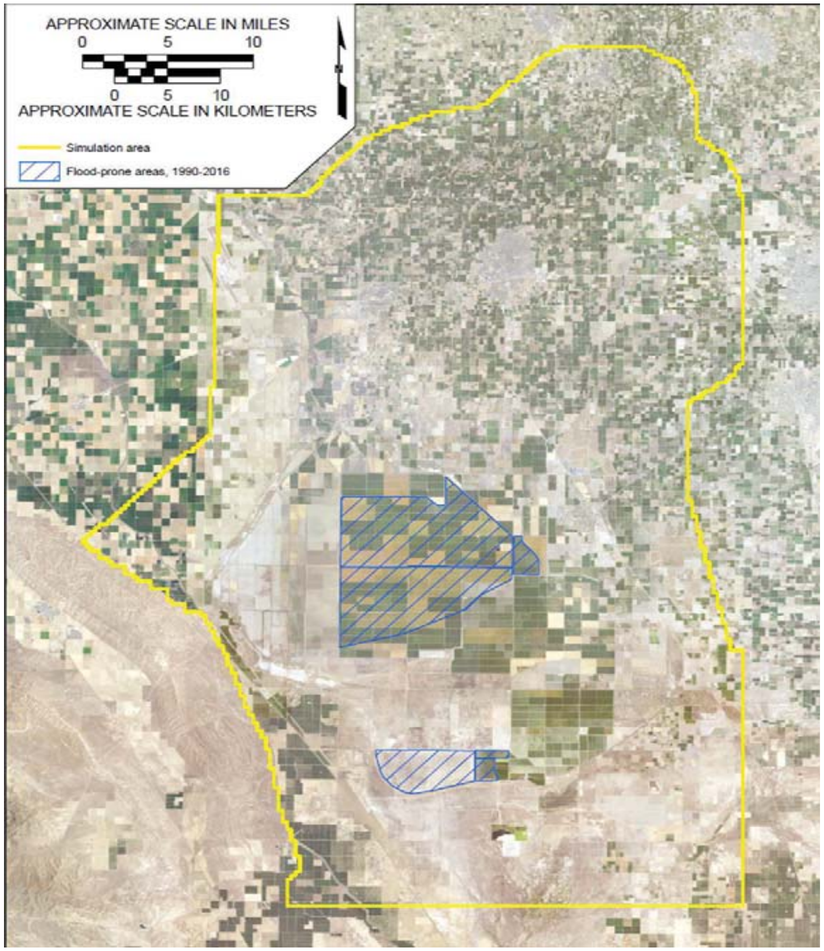
By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D2-16**

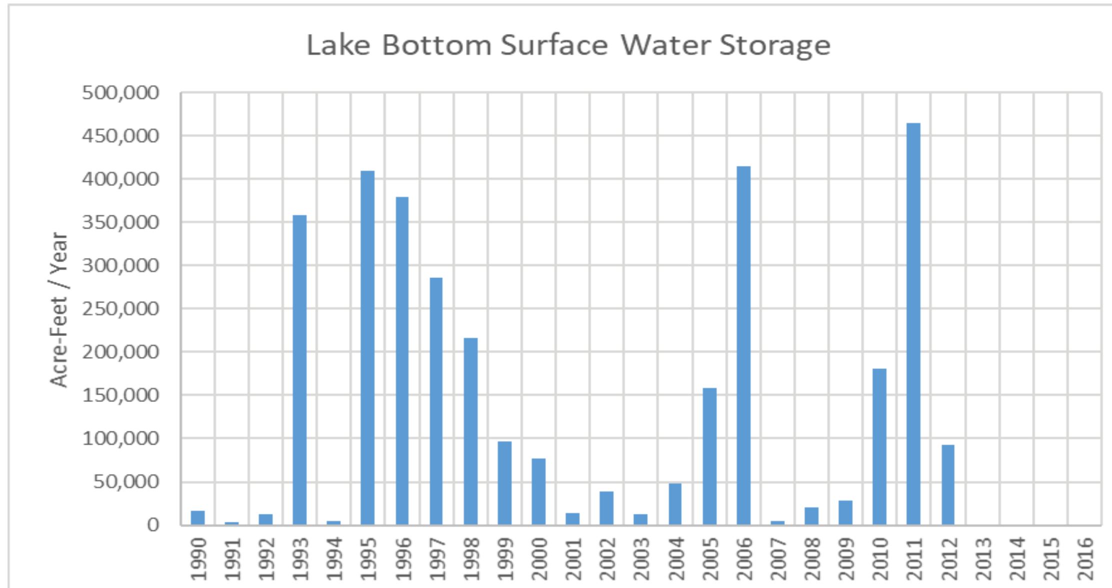


Location of Surface Water Delivery Areas by Subbasin

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D2-17**





Explanation

Model Area

Surface Water Ponds

Location of Surface Water Storage Areas and Estimated Annual Lake Bottom Storage

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D2-18**

Date	Pond 1 (AF/Y)	Pond 2 (AF/Y)	Pond 3 (AF/Y)	Pond 4 (AF/Y)	Pond 5 (AF/Y)	Pond 6 (AF/Y)	Pond 7 (AF/Y)	Pond 8 (AF/Y)	Pond 9 (AF/Y)	Total (AF/Y)
1990	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	0	0	0	0
1994	10,700	12,840	0	0	0	0	0	0	0	23,540
1995	10,700	12,840	0	0	0	0	0	0	0	23,540
1996	10,700	12,840	0	0	0	0	0	0	0	23,540
1997	10,700	12,840	0	0	0	0	0	0	0	23,540
1998	10,700	12,840	0	0	0	0	0	0	0	23,540
1999	0	0	0	0	0	0	0	0	0	0
2000	10,700	12,840	0	0	0	0	0	0	0	23,540
2001	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0
2003	10,700	12,840	0	0	0	0	0	0	0	23,540
2004	10,700	0	0	0	0	0	0	0	0	10,700
2005	10,700	12,840	14,980	14,980	0	0	0	0	0	53,500
2006	10,700	12,840	14,980	14,980	21,400	25,680	12,840	23,540	10,700	147,660
2007	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0
2009	10,700	0	0	0	0	0	0	0	0	10,700
2010	10,700	12,840	0	0	0	0	0	0	0	23,540
2011	10,700	12,840	14,980	14,980	21,400	25,680	12,840	23,540	10,700	147,660
2012	10,700	0	0	0	0	0	0	0	0	10,700
2013	0	0	0	0	0	0	0	0	0	0
2014	10,600	12,720	0	0	0	0	0	0	0	23,320
2015	10,700	12,840	0	0	0	0	0	0	0	23,540
2016	0	0	0	0	0	0	0	0	0	0
Total	171,100	166,800	44,940	44,940	42,800	51,360	25,680	47,080	21,400	616,100

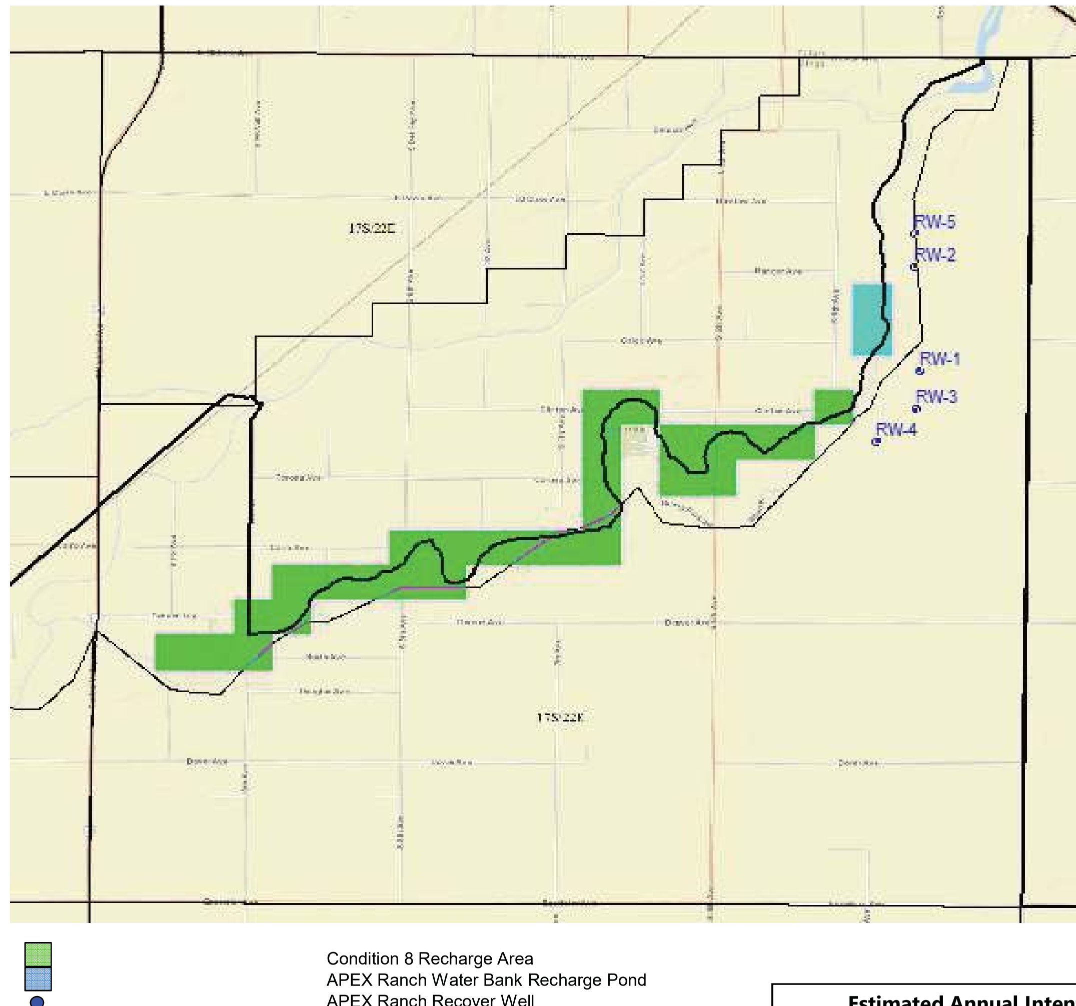
Estimated Annual Intentional Recharge - Corcorian Irrigation District

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb | Date: 07/30/19 | Project No.: FR18161220

Figure **D2-19**

Date	Cond 8 Recharge (AF/Y)	APEX Recharge (AF/Y)	APEX Recovery (AF/Y)	APEX Storage (AF/Y)
1990	1,021	--	--	--
1991	0	--	--	--
1992	0	--	--	--
1993	61	--	--	--
1994	0	--	--	--
1995	36,806	--	--	--
1996	8,541	--	--	--
1997	19,259	--	--	--
1998	37,879	--	--	--
1999	0	--	--	--
2000	0	--	--	--
2001	0	--	--	--
2002	0	225	0	225
2003	0	3,742	526	3,216
2004	0	0	912	-912
2005	5,442	10,994	0	10,994
2006	22,611	12,152	6,939	5,213
2007	0	3,630	6,319	-2,689
2008	0	2,792	5,435	-2,643
2009	0	9,514	7,677	1,837
2010	0	9,154	6,345	2,809
2011	32,441	10,292	0	10,292
2012	0	3,692	9,044	-5,352
2013	0	6,962	4,970	1,992
2014	0	441	298	143
2015	0	0	0	0
2016	42,672	0	0	0
Total	206,732	73,590	48,465	25,125

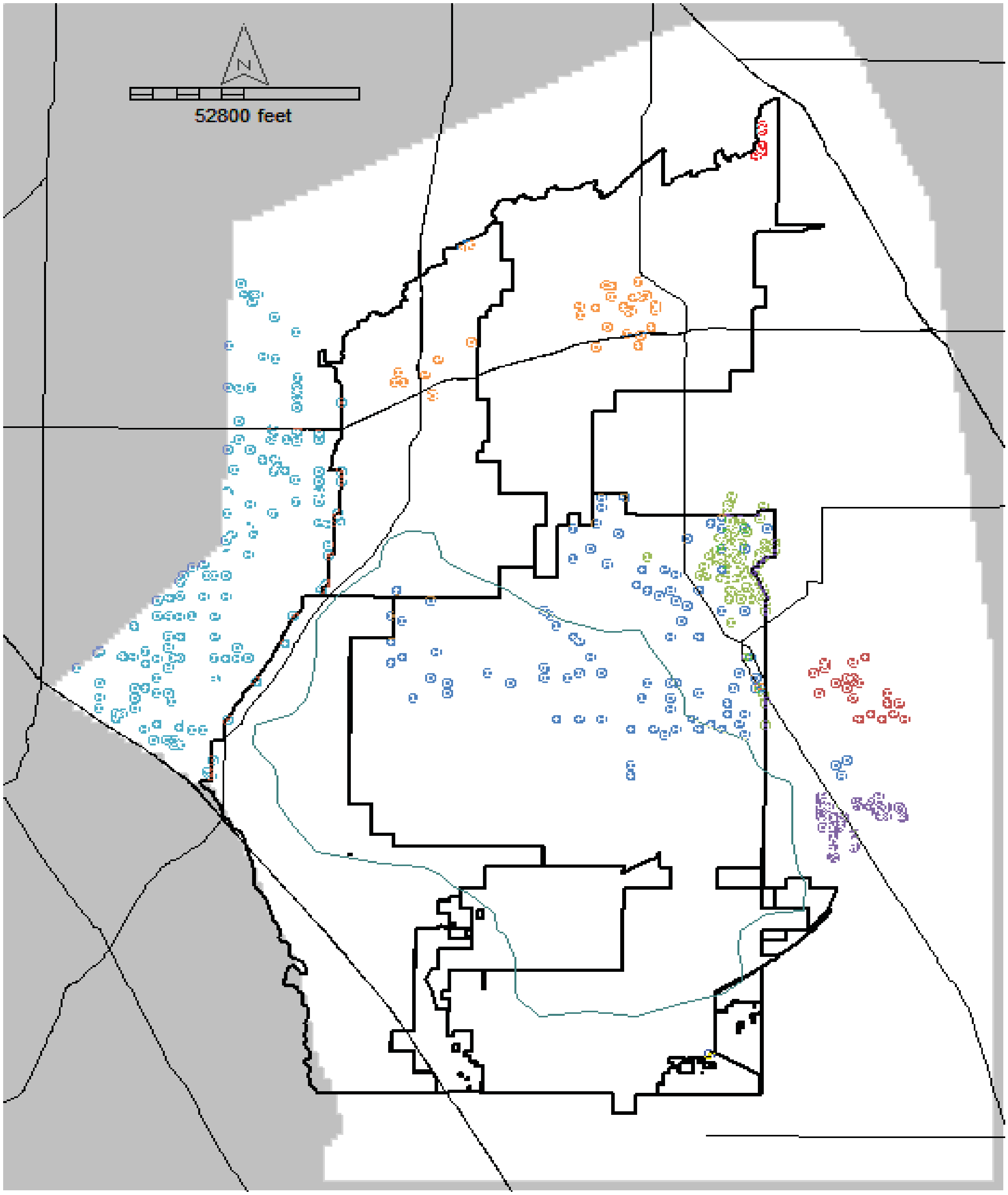


Estimated Annual Intentional Recharge - Condition 8 and APEX Ranch

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb | Date: 07/30/19 | Project No.: FR18161220

Figure **D2-20**



Municipal
Westlands Water District
Corcoran Irrigation District
El Rico GSA
Creighton Ranch
Angiola Well Field
Apex Ranch

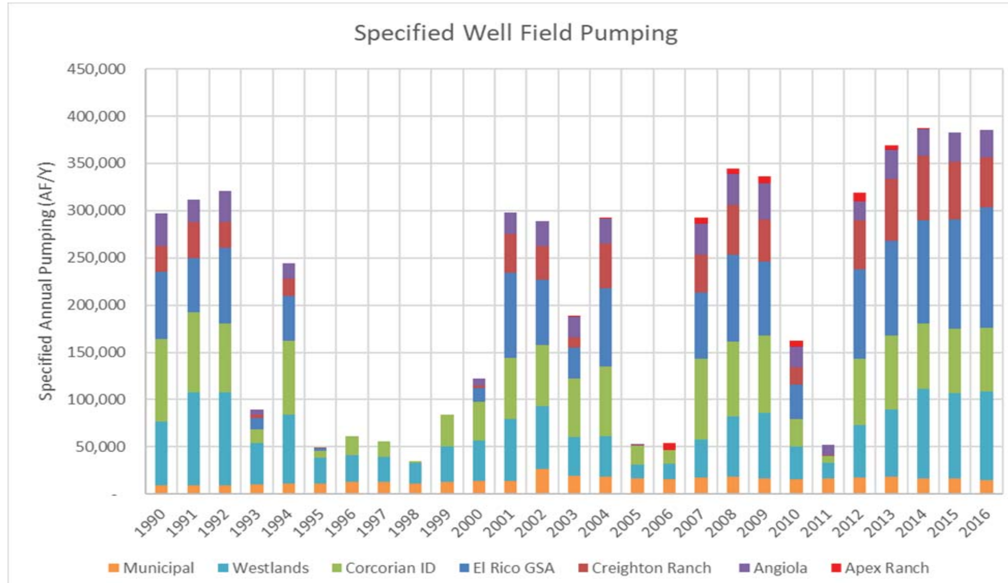
Location of Wells with Specified Pumping and Known Construction

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D2-21**

Date	El Rico GSA Well Field (AF/Y)	Creighton Ranch Well Field (AF/Y)	Corcorian ID Well Field (AF/Y)	Angiola Well Field (AF/Y)	Westlands Well Field (AF/Y)	Municipal Well Fields (AF/Y)	Apex Ranch Well Field (AF/Y)
1990	70,716	27,222	87,977	34,500	67,131	9,370	--
1991	57,509	38,484	84,438	23,396	98,656	9,109	--
1992	80,012	27,255	72,348	33,494	98,344	9,666	--
1993	11,395	4,035	14,248	5,956	44,056	10,208	--
1994	48,043	17,986	78,297	16,389	72,674	10,928	--
1995	2,897	905	7,145	-	27,589	10,775	--
1996	-	-	20,261	-	28,516	12,719	--
1997	-	-	15,586	-	27,000	12,775	--
1998	-	-	2,484	-	20,988	11,555	--
1999	-	-	33,406	-	37,185	13,087	--
2000	14,910	2,849	40,672	6,784	43,392	13,421	--
2001	89,799	41,120	64,353	23,244	65,947	13,895	--
2002	68,933	35,843	64,736	26,537	66,530	26,701	-
2003	32,420	10,856	62,246	22,429	40,841	19,349	526
2004	82,875	47,511	74,007	26,805	42,115	18,777	912
2005	-	468	20,138	662	14,744	16,536	-
2006	-	72	14,034	141	16,526	15,822	6,939
2007	69,863	40,266	85,434	32,894	40,373	17,221	6,319
2008	92,269	52,980	79,362	32,502	63,519	18,432	5,435
2009	78,097	45,292	81,493	37,798	69,904	16,354	7,677
2010	36,129	17,740	29,669	22,568	34,895	15,271	6,345
2011	606	314	7,328	11,336	15,509	17,042	-
2012	95,154	52,325	70,008	19,388	55,298	17,467	9,044
2013	100,275	66,005	78,175	30,528	70,940	18,411	4,970
2014	108,976	68,726	69,880	27,695	94,077	16,930	298
2015	116,254	61,050	67,982	30,220	90,723	16,146	-
2016	126,886	53,113	67,982	29,047	93,853	14,555	-



Notes:
1. El Rico Groundwater Sustainability Agency (GSA), Corcoran Irrigation District, and Creighton Ranch pumping provided by the El Rico GSA
2. Angiola Well Field pumping data provided by Angiola Water District
3. Westlands pumping provided by Westlands Water District
4. Municipal pumping and Apex pumping provided by various municipalities and Kings River Water District

Annual Specified Pumping by Well Field
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb | Date: 07/30/19 | Project No.: FR18161220

Figure D2-22

Annual Crop Demand (AF/Y)

Date	TLSB	Westside	Kings	Kaweah	Tule	Kern	Total
1990	901,131	291,990	328,863	424,556	197,637	87,217	2,231,393
1991	901,119	288,262	328,849	424,556	197,637	87,217	2,227,639
1992	902,016	284,489	329,148	424,998	197,921	87,318	2,225,890
1993	901,095	283,147	328,833	424,556	197,637	87,217	2,222,484
1994	900,719	263,495	328,833	424,556	197,637	87,217	2,202,456
1995	900,633	243,070	328,775	424,556	197,637	87,217	2,181,887
1996	982,820	257,687	292,187	406,852	254,257	107,481	2,301,283
1997	985,893	268,823	300,664	408,439	253,933	108,406	2,326,158
1998	989,781	243,239	309,316	410,462	254,000	109,483	2,316,281
1999	1,062,749	263,950	316,538	415,430	253,992	63,054	2,375,713
2000	1,079,872	258,530	324,230	418,470	254,108	66,574	2,401,785
2001	1,089,515	283,910	325,407	419,045	253,769	69,132	2,440,778
2002	1,100,326	277,743	326,810	420,081	253,820	71,790	2,450,569
2003	1,111,248	299,919	328,199	421,117	253,870	74,447	2,488,801
2004	1,113,509	289,665	328,509	422,104	254,310	75,582	2,483,679
2005	1,113,269	268,262	328,310	422,163	253,971	76,507	2,462,481
2006	1,114,369	261,146	328,236	422,685	254,021	77,537	2,457,995
2007	1,074,260	280,336	257,665	387,633	290,933	205,928	2,496,756
2008	1,004,624	273,945	256,884	421,390	296,194	186,808	2,439,846
2009	1,012,322	305,821	256,214	336,797	250,674	237,356	2,399,183
2010	995,249	278,025	281,457	346,870	301,120	247,643	2,450,365
2011	764,558	257,795	219,117	346,680	152,303	67,393	1,807,847
2012	738,639	292,444	227,094	361,650	182,653	73,426	1,875,904
2013	743,729	318,593	202,452	346,907	166,566	96,210	1,874,457
2014	701,059	365,392	239,018	343,552	193,931	120,344	1,963,297
2015	566,898	370,658	223,336	318,118	170,463	83,566	1,733,039
2016	646,034	371,623	241,082	317,784	152,776	80,645	1,809,944
Min	566,898	243,070	202,452	317,784	152,303	63,054	1,733,039
Max	1,114,369	371,623	329,148	424,998	301,120	247,643	2,496,756
1990-2016 Average	940,646	286,739	292,075	394,889	227,325	104,545	2,246,219
1998-2010 Average	1,066,238	275,730	305,213	404,942	263,445	120,142	2,435,710

Annual Effective Precipitation Utilized by Crops (AF/Y)

Date	TLSB	Westside	Kings	Kaweah	Tule	Kern	Total
1990	19,958	4,318	9,898	10,134	4,021	1,244	49,574
1991	78,722	16,428	27,444	38,793	21,719	7,694	190,800
1992	64,818	24,269	24,144	28,899	15,747	5,740	163,617
1993	67,191	20,008	25,068	30,973	16,254	6,004	165,498
1994	34,514	6,123	14,367	15,929	7,877	2,828	81,637
1995	95,479	21,157	36,745	48,040	24,113	8,897	234,430
1996	100,745	20,047	33,683	44,875	24,361	9,632	233,344
1997	58,885	12,805	17,579	24,815	14,337	6,118	134,539
1998	116,167	25,963	38,123	50,183	32,155	14,137	276,727
1999	34,039	6,590	10,459	14,066	7,218	1,858	74,231
2000	70,413	13,814	26,881	29,672	15,472	3,995	160,246
2001	94,963	18,024	32,490	38,749	21,039	5,954	211,219
2002	26,034	4,299	12,099	11,948	5,990	1,685	62,054
2003	40,108	7,125	16,388	17,922	7,930	2,591	92,063
2004	74,858	15,360	24,636	28,506	14,362	4,272	161,995
2005	80,390	16,208	27,519	30,024	16,637	5,669	176,448
2006	104,703	19,345	34,578	43,910	25,059	7,201	234,795
2007	14,800	1,940	6,669	7,093	3,456	1,379	35,337
2008	35,836	9,454	12,655	18,355	10,733	4,599	91,630
2009	32,367	5,698	10,965	12,592	6,666	4,957	73,244
2010	88,203	22,750	27,939	32,256	23,244	16,507	210,899
2011	52,937	10,835	19,879	21,821	10,643	3,971	120,086
2012	45,317	8,817	17,930	23,369	12,074	5,282	112,788
2013	2,800	326	525	1,175	893	527	6,246
2014	30,586	10,563	12,275	15,813	7,632	3,413	80,282
2015	15,085	3,280	7,920	10,283	4,837	1,131	42,536
2016	41,890	13,881	19,341	21,746	9,312	4,102	110,272
Min	2,800	326	525	1,175	893	527	6,246
Max	116,167	25,963	38,123	50,183	32,155	16,507	276,727
1990-2016 Average	56,363	12,571	20,304	24,887	13,473	5,237	132,835
1998-2010 Average	62,529	12,813	21,646	25,790	14,612	5,754	143,145

Annual Farm Demand (AF/Y)

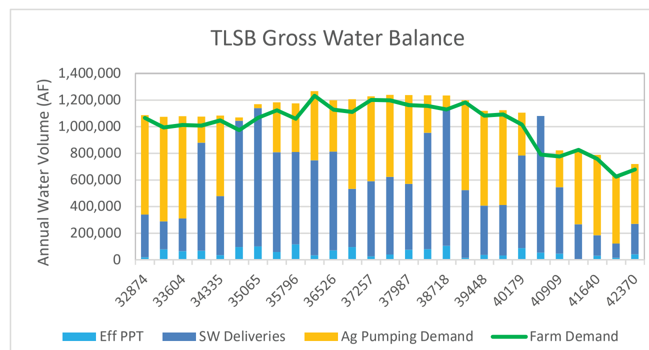
Date	TLSB	Westside	Kings	Kaweah	Tule	Kern	Total
1990	1,065,856	379,829	425,121	552,538	256,615	114,629	2,794,588
1991	994,832	358,828	401,725	514,334	233,176	106,035	2,608,931
1992	1,012,909	343,450	406,535	528,115	241,481	108,779	2,641,268
1993	1,008,709	347,335	404,875	524,762	240,425	108,288	2,634,395
1994	1,047,937	339,746	419,143	544,830	251,521	112,514	2,715,691
1995	973,503	292,869	389,226	502,007	229,979	104,424	2,492,007
1996	1,067,962	313,585	344,546	482,623	304,804	130,465	2,643,985
1997	1,123,726	337,872	377,306	511,503	317,630	136,383	2,804,420
1998	1,059,009	286,711	361,492	480,381	294,124	127,132	2,608,849
1999	1,232,448	339,665	407,814	535,160	327,150	81,596	2,923,833
2000	1,127,412	284,814	349,602	457,426	279,949	73,623	2,572,827
2001	1,111,506	309,426	344,390	447,420	273,032	74,325	2,560,098
2002	1,201,455	318,210	370,000	480,162	290,750	82,471	2,743,049
2003	1,198,411	341,139	366,586	474,349	288,517	84,529	2,753,532
2004	1,162,011	319,587	357,269	463,075	281,525	83,897	2,667,364
2005	1,155,548	293,659	353,639	461,355	278,436	83,344	2,625,980
2006	1,129,741	281,543	345,256	445,626	268,596	82,751	2,553,513
2007	1,183,096	324,200	294,958	447,694	338,016	240,627	2,828,591
2008	1,083,093	307,929	286,930	474,164	335,571	214,361	2,702,048
2009	1,091,697	349,701	288,327	381,416	286,941	273,394	2,671,475
2010	1,016,725	297,419	297,831	370,133	326,713	271,898	2,580,720
2011	791,090	287,744	234,224	382,183	166,368	74,617	1,936,226
2012	776,133	330,525	245,767	397,981	200,454	80,173	2,031,033
2013	826,405	371,025	237,221	406,748	194,551	112,569	2,148,518
2014	757,265	413,917	266,385	385,588	218,818	137,564	2,179,536
2015	624,647	428,797	253,146	362,160	194,523	96,982	1,960,255
2016	677,936	417,581	260,622	348,283	168,493	90,048	1,962,964
Min	624,647	281,543	234,224	348,283	166,368	73,623	1,936,226
Max	1,232,448	428,797	425,121	552,538	338,016	273,394	2,923,833
1990-2016 Average	1,018,558	333,967	336,664	457,853	262,524	121,756	2,531,322
1998-2010 Average	1,134,781	311,846	340,315	455,259	297,640	136,457	2,676,298

Annual SW Deliveries (AF/Y)

Date	TLSB	Westside	Kings	Kaweah	Tule	Kern	Total
1990	319,870	101,619	47,539	34,733	14,511	46,975	565,248
1991	209,568	50,258	60,256	67,030	20,368	16,662	424,142
1992	245,345	51,466	46,973	48,204	18,265	29,256	439,510
1993	811,312	109,501	159,335	166,035	85,071	83,829	1,415,083
1994	443,731	94,821	68,919	56,681	22,866	44,530	731,548
1995	948,773	127,445	185,554	199,827	82,318	91,195	1,635,112
1996	1,038,046	155,077	176,089	163,768	75,817	87,846	1,696,643
1997	749,117	162,214	141,157	131,813	63,410	68,603	1,316,314
1998	693,908	127,058	152,543	179,774	54,049	69,486	1,276,818
1999	713,206	147,012	123,314	90,454	49,410	82,217	1,205,613
2000	741,494	114,048	128,808	131,211	53,836	85,257	1,254,654
2001	437,871	100,121	73,383	75,856	27,236	31,432	745,899
2002	564,134	107,249	87,249	79,437	28,684	51,013	917,765
2003	583,124	124,958	96,413	100,930	46,590	63,012	1,015,028
2004	495,764	120,232	79,759	71,463	28,189	49,469	844,876
2005	873,425	138,809	157,030	161,487	78,104	109,872	1,518,728
2006	1,020,922	147,160	169,818	150,345	74,983	100,583	1,663,811
2007	508,886	117,825	51,225	60,221	21,430	44,262	803,848
2008	371,231	64,289	83,113	74,197	29,911	34,341	657,082
2009	379,590	33,075	78,392	81,233	39,292	34,417	645,999
2010	694,592	81,618	119,468	145,326	54,007	71,839	1,166,851
2011	1,026,568	125,783	158,177	165,812	78,345	97,317	1,652,002
2012	498,937	90,342	71,505	57,021	26,222	65,649	809,676
2013	264,515	51,613	45,947	33,756	17,953	41,540	455,323
2014	154,346	15,048	31,361	8,517	7,799	24,232	241,303
2015	107,212	9,806	18,103	7,154	7,800	24,819	174,894
2016	227,755	15,061	31,385	8,505	24,909	24,233	331,849
Min	107,212	9,806	18,103	7,154	7,799	16,662	174,894
Max	1,038,046	162,214	185,554	199,827	85,071	109,872	1,696,643
1990-2016 Average	560,120	95,685	97,882	94,474	41,903	58,292	948,356
1998-2010 Average	621,396	109,497	107,732	107,841	45,055	63,631	1,055,152

Annual Agricultural Pumping Demand (AF/Y)

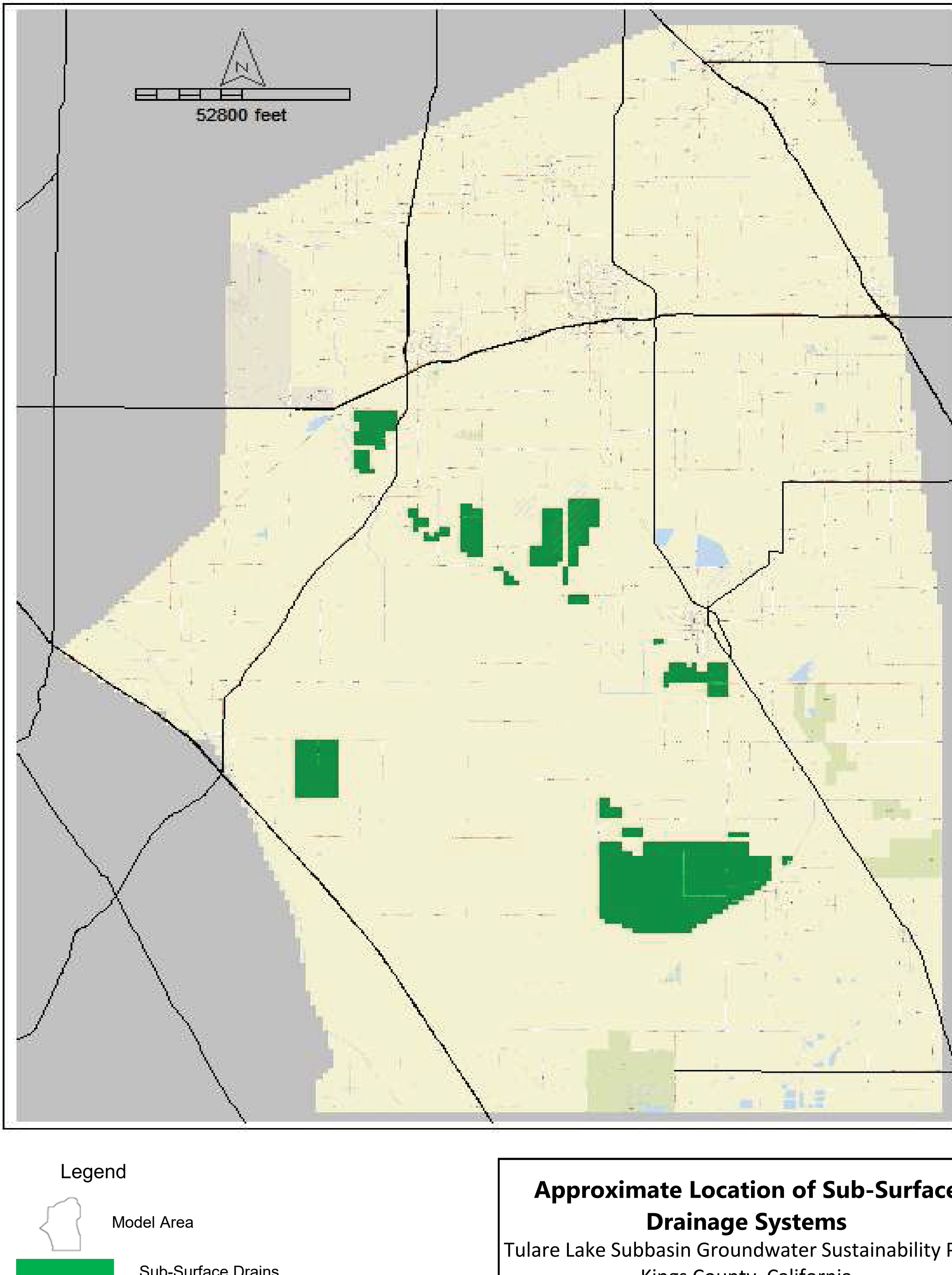
Date	TLSB	Westside	Kings	Kaweah	Tule	Kern	Total
1990	-745,986	-278,210	-377,582	-517,805	-242,104	-67,654	-2,229,341
1991	-785,264	-308,570	-341,469	-447,304	-212,809	-89,372	-2,184,789
1992	-767,564	-291,984	-359,561	-479,910	-223,216	-79,523	-2,201,759
1993	-197,397	-237,834	-245,540	-358,728	-155,354	-24,459	-1,219,312
1994	-604,206	-244,926	-350,224	-488,149	-228,655	-67,983	-1,984,143
1995	-24,730	-165,424	-203,672	-302,179	-147,661	-13,229	-856,896
1996	-29,915	-158,508	-168,457	-318,855	-228,987	-42,619	-947,342
1997	-374,608	-175,659	-236,149	-379,690	-254,220	-67,780	-1,488,105
1998	-365,102	-159,653	-208,949	-300,607	-240,074	-57,645	-1,332,031
1999	-519,242	-192,653	-284,500	-444,706	-277,739	621	-1,718,220
2000	-385,918	-170,767	-220,794	-326,215	-226,113	11,634	-1,318,173
2001	-673,635	-209,305	-271,007	-371,563	-245,796	-42,893	-1,814,199
2002	-637,322	-210,961	-282,751	-400,725	-262,067	-31,459	-1,825,285
2003	-615,287	-216,181	-270,173	-373,419	-241,927	-21,516	-1,738,504
2004	-666,247	-199,354	-277,510	-391,613	-253,336	-34,428	-1,822,488
2005	-282,123	-154,850	-196,609	-299,869	-200,331	26,529	-1,107,252
2006	-108,819	-134,383	-175,438	-295,282	-193,614	17,832	-889,703
2007	-674,210	-206,375	-243,733	-387,473	-316,586	-196,365	-2,024,743
2008	-711,862	-243,641	-203,818	-399,968	-305,659	-180,020	-2,044,967
2009	-712,107	-316,626	-209,935	-300,183	-247,649	-238,977	-2,025,477
2010	-322,133	-215,801	-178,363	-224,807	-272,706	-200,059	-1,413,869
2011	0	-161,961	-76,046	-216,371	-88,024	22,700	-519,702
2012	-277,196	-240,183	-174,262	-340,959	-174,232	-14,524	-1,221,356
2013	-561,890	-319,412	-191,274	-372,992	-176,598	-71,029	-1,693,195
2014	-602,919	-398,869	-235,024	-377,071	-211,018	-113,332	-1,938,233
2015	-517,434	-418,991	-235,043	-355,006	-186,723	-72,163	-1,785,361
2016	-450,181	-402,520	-229,237	-339,778	-143,584	-65,815	-1,631,116
Min	-785,264	-418,991	-377,582	-517,805	-316,586	-238,977	-2,229,341
Max	0	-134,383	-76,046	-216,371	-88,024	26,529	-519,702
1990-2016 Average	-467,159	-238,282	-238,782	-363,379	-220,622	-63,464	-1,591,687
1998-2010 Average	-513,385	-202,350	-232,583	-347,418	-252,584	-72,827	-1,621,147



Gross Annual Water Balance

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

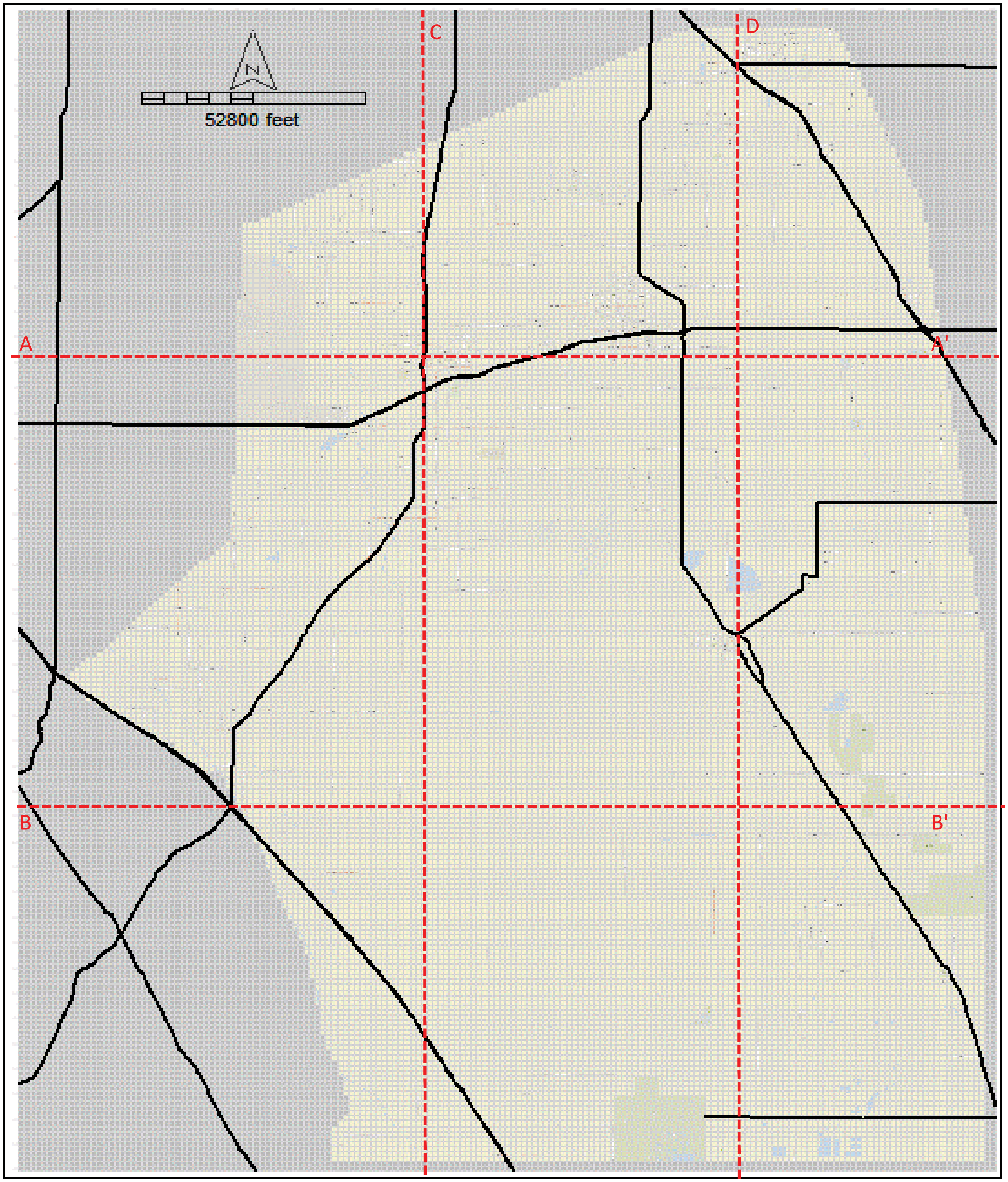
By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D2-23**



Approximate Location of Sub-Surface Drainage Systems

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D2-24**



Explanation

- Cross Section
- Major Roads
- No Flow

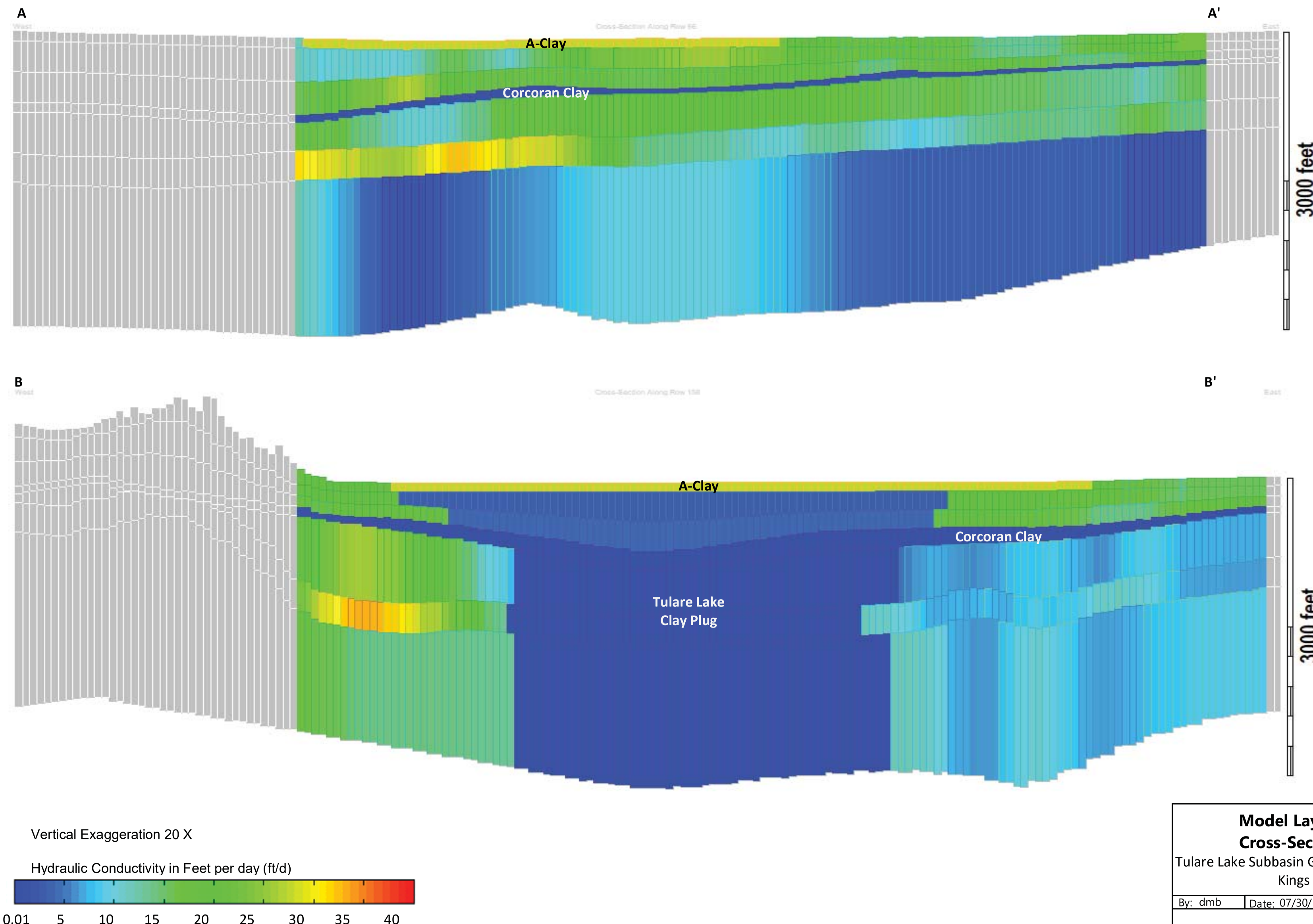
Tulare Lake Subbasin Hydrologic Model Domain and Grid

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D4-1**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D4-2 E-W X-Sections 12/19/2019



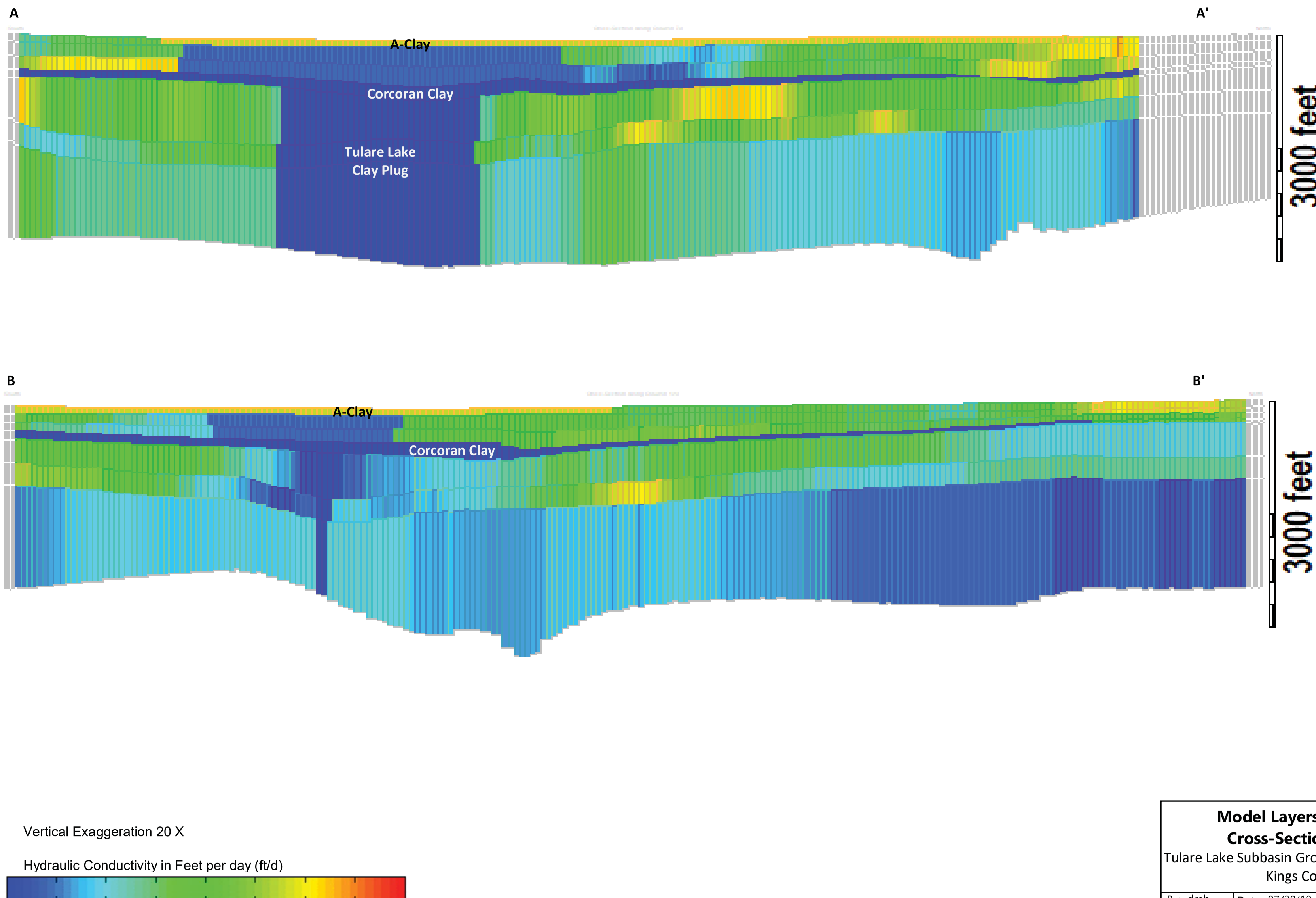
Model Layers and East-West Cross-Sections A-A' and B-B'

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb | Date: 07/30/19 | Project No.: FR18161220

Figure **D4-2**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D4-3 N-S X-Sections 12/19/2019

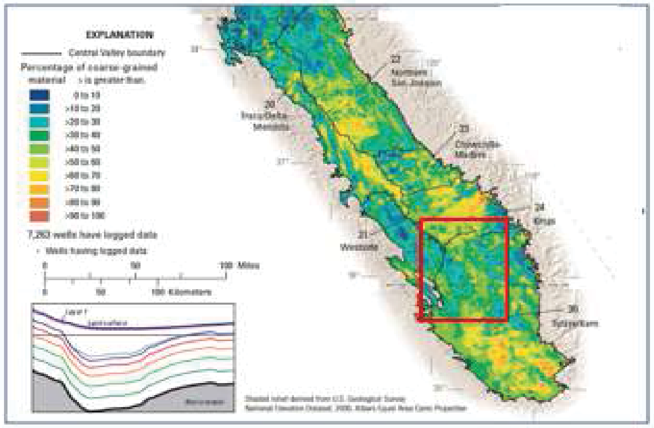


Model Layers and North-South Cross-Sections C-C' and D-D'

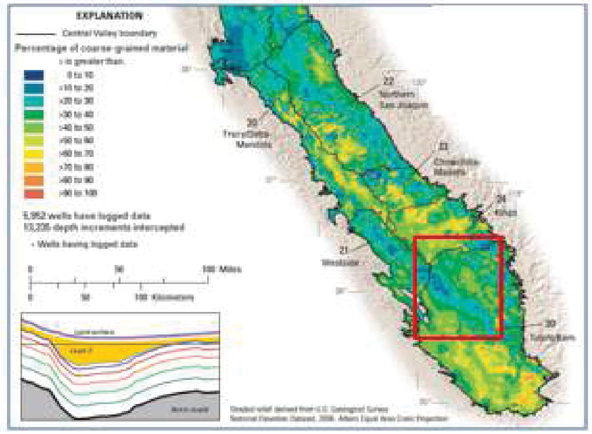
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D4-3**

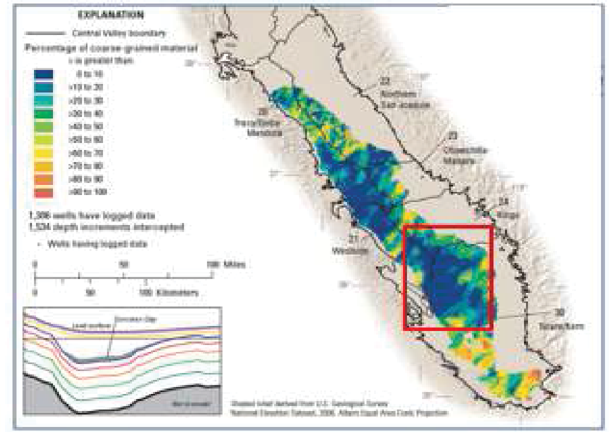
a. 0 - 50 foot depth interval



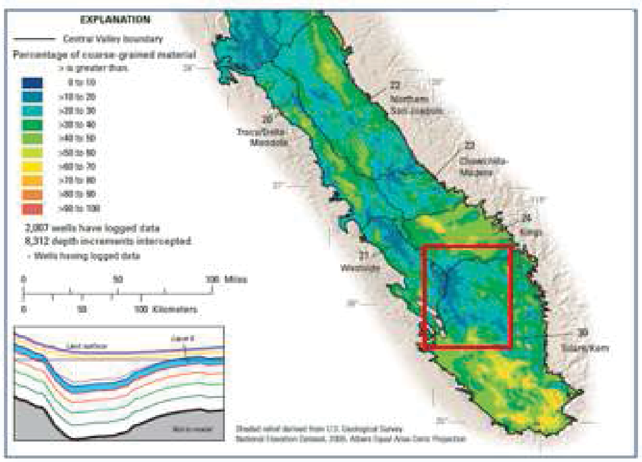
b. 50 - 200 foot depth interval



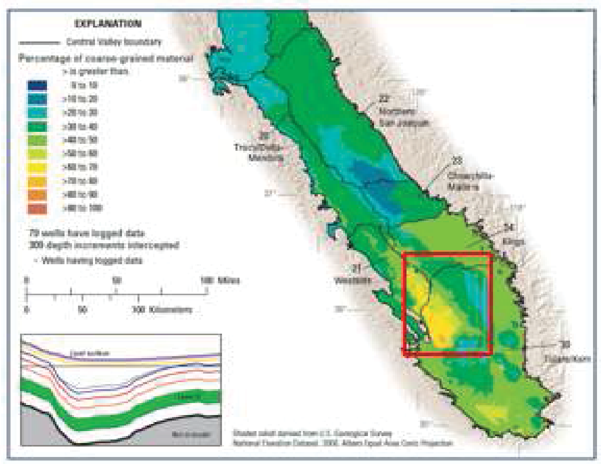
c. Corcoran Clay Depth interval



d. 100 foot depth interval immediately below Corcoran Clay



e. 200 foot depth interval from 400 to 700 feet bgs



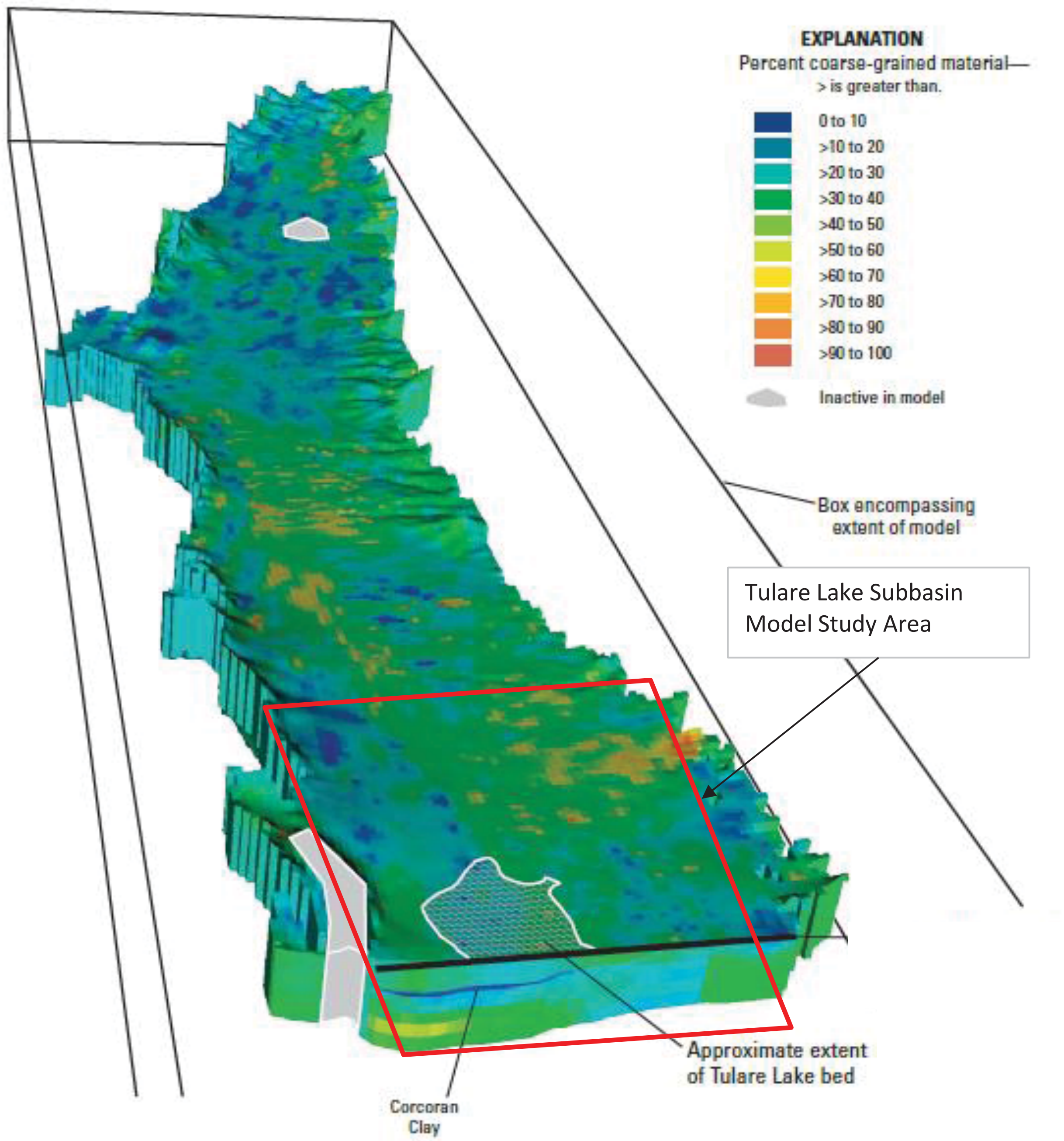
Tulare Lake Subbasin Hydrologic Model study area

*adapted from Fig. A12, USGS Prof. Paper 1766

Kriged Distribution of Coarse Fraction For San Joaquin Valley Basin-Fill Sediments at Five Depth Intervals

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure D4-4



Modified from USGS Prof. Paper 1766

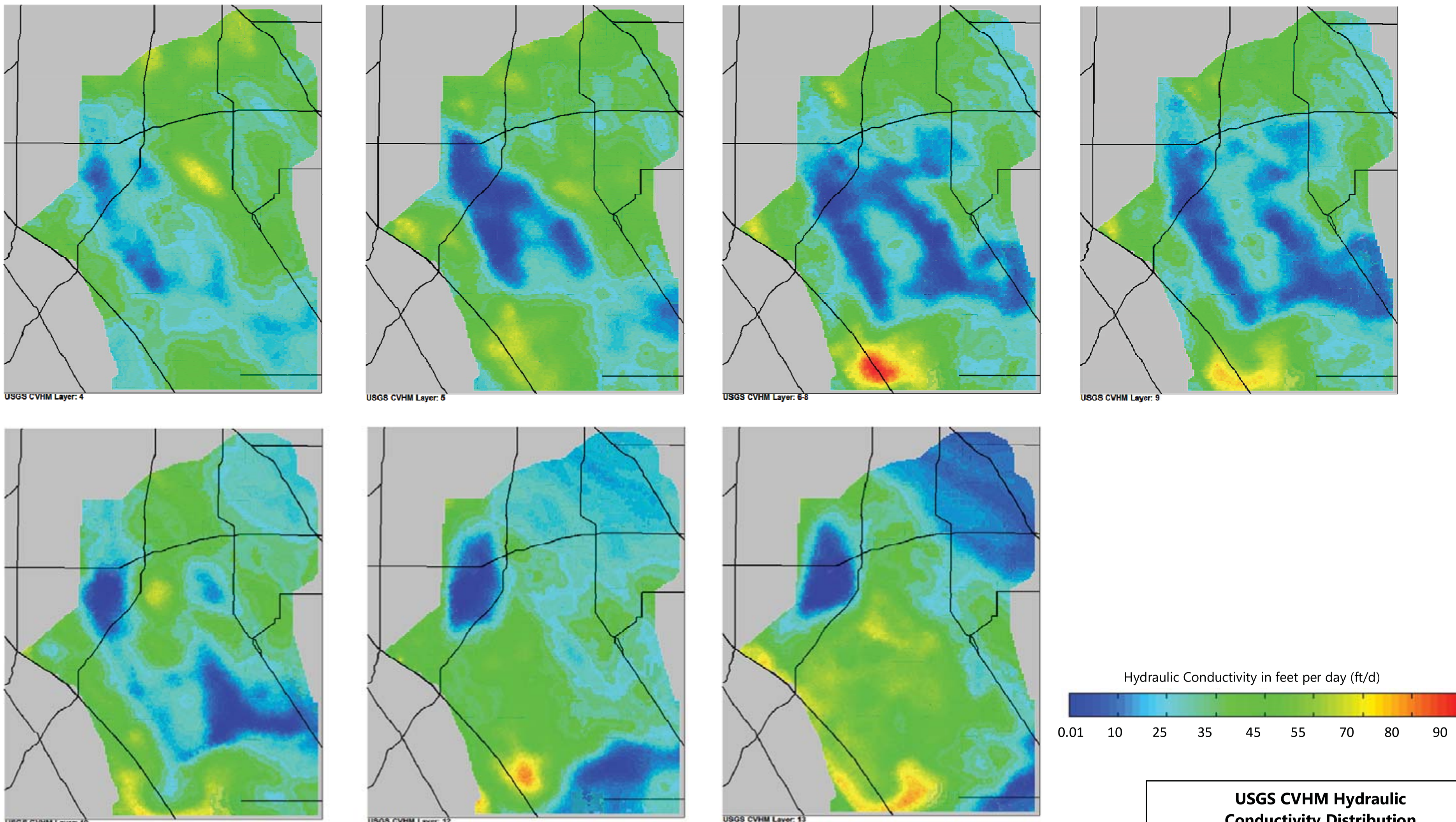
3D Oblique Image of San Joaquin Valley Coarse Fraction Percentage Estimated by USGS Sediment Texture Study

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D4-[illegible]**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVIS FOLDER\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig [illegible]-[illegible] Oblique Texture Model 1[illegible]2020

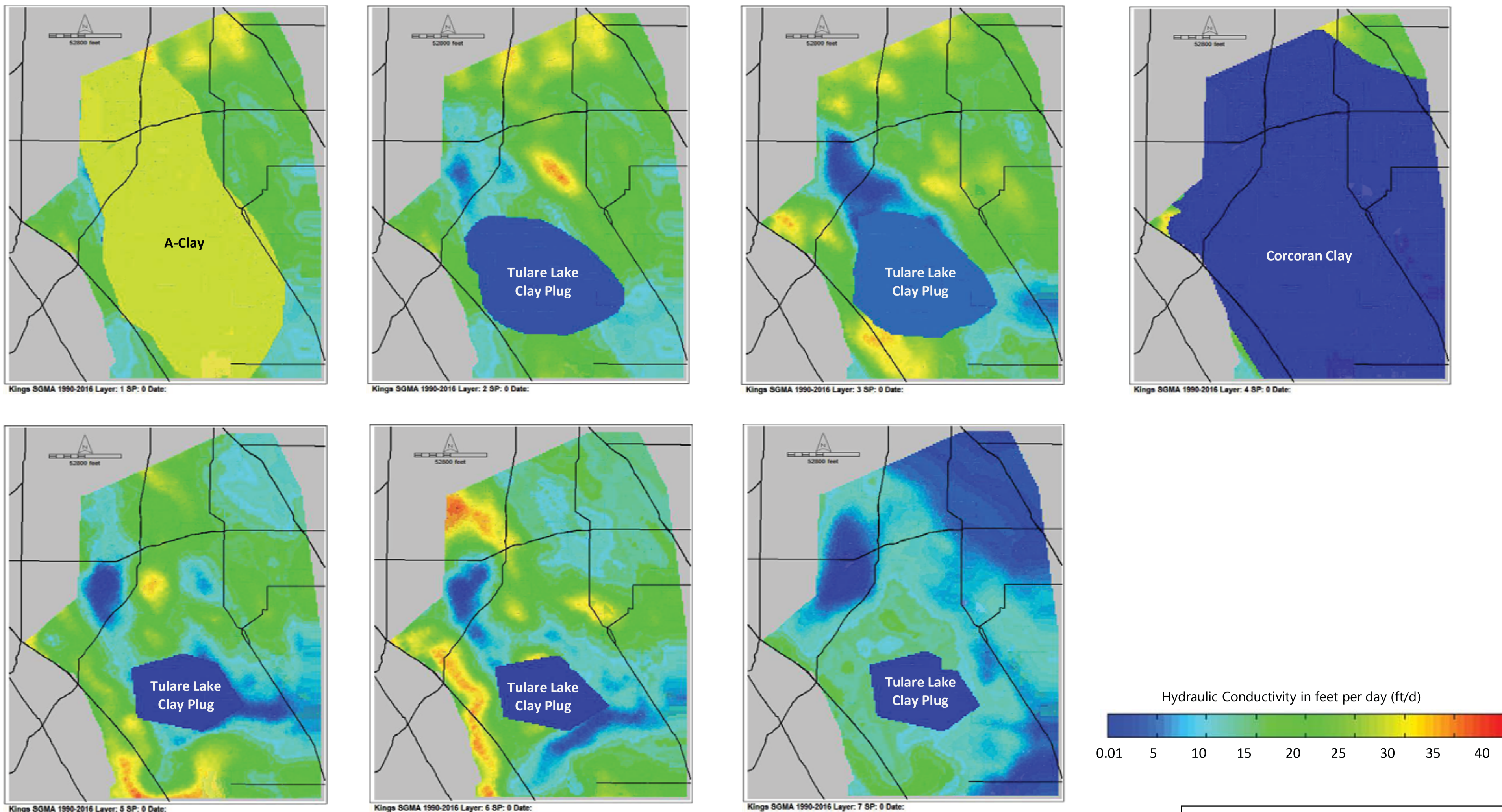


USGS CVHM Hydraulic Conductivity Distribution

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D4-6**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig 4-7 Calibrated Model Kh 1/6/2020

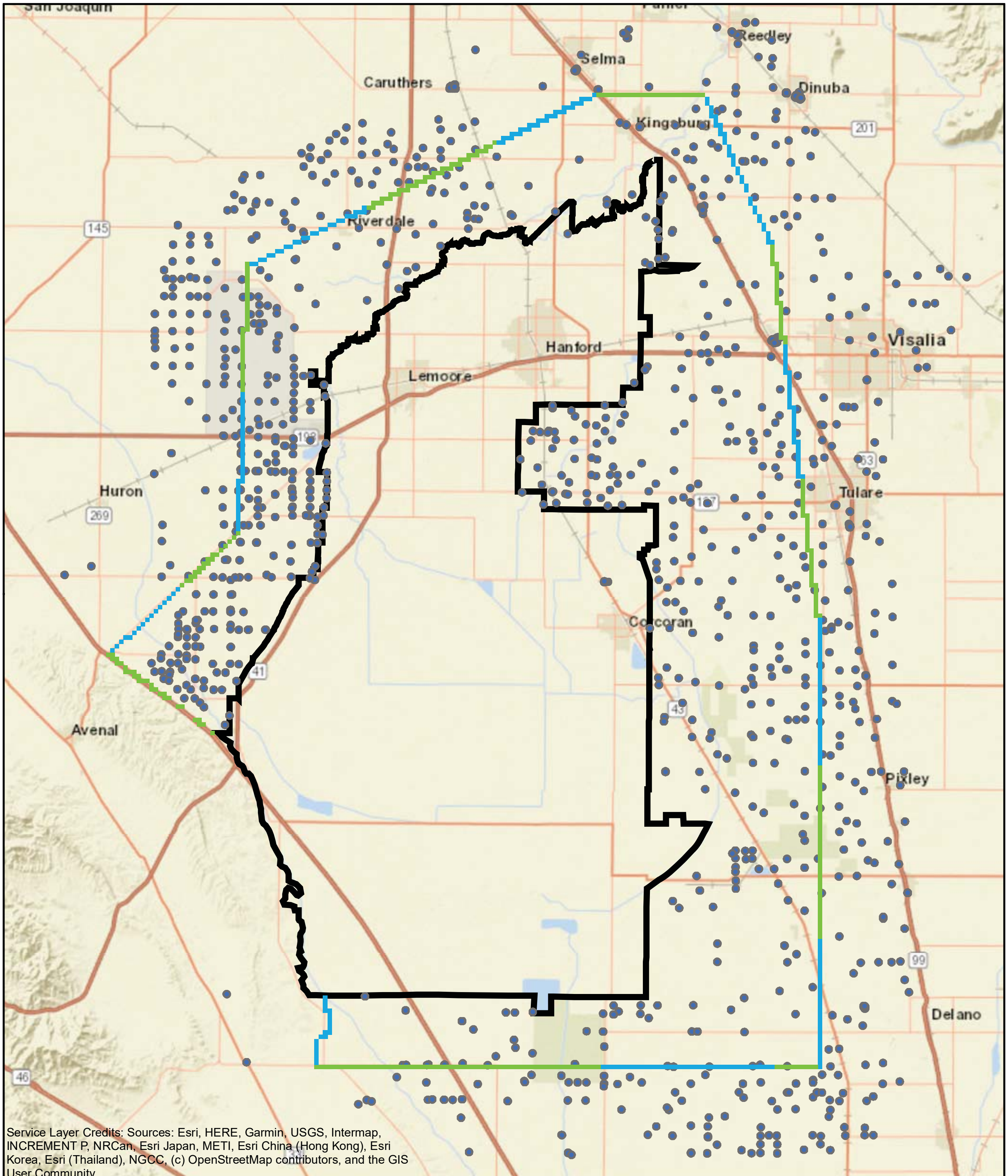


Calibrated Model Layer Hydraulic Conductivity Distribution

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb | Date: 07/30/19 | Project No.: FR18161220

Figure **D4-7**



Explanation

- Evaluated wells
- General head boundaries

Miles: 0 2 4 8

Kilometers: 0 2.5 5 10

N

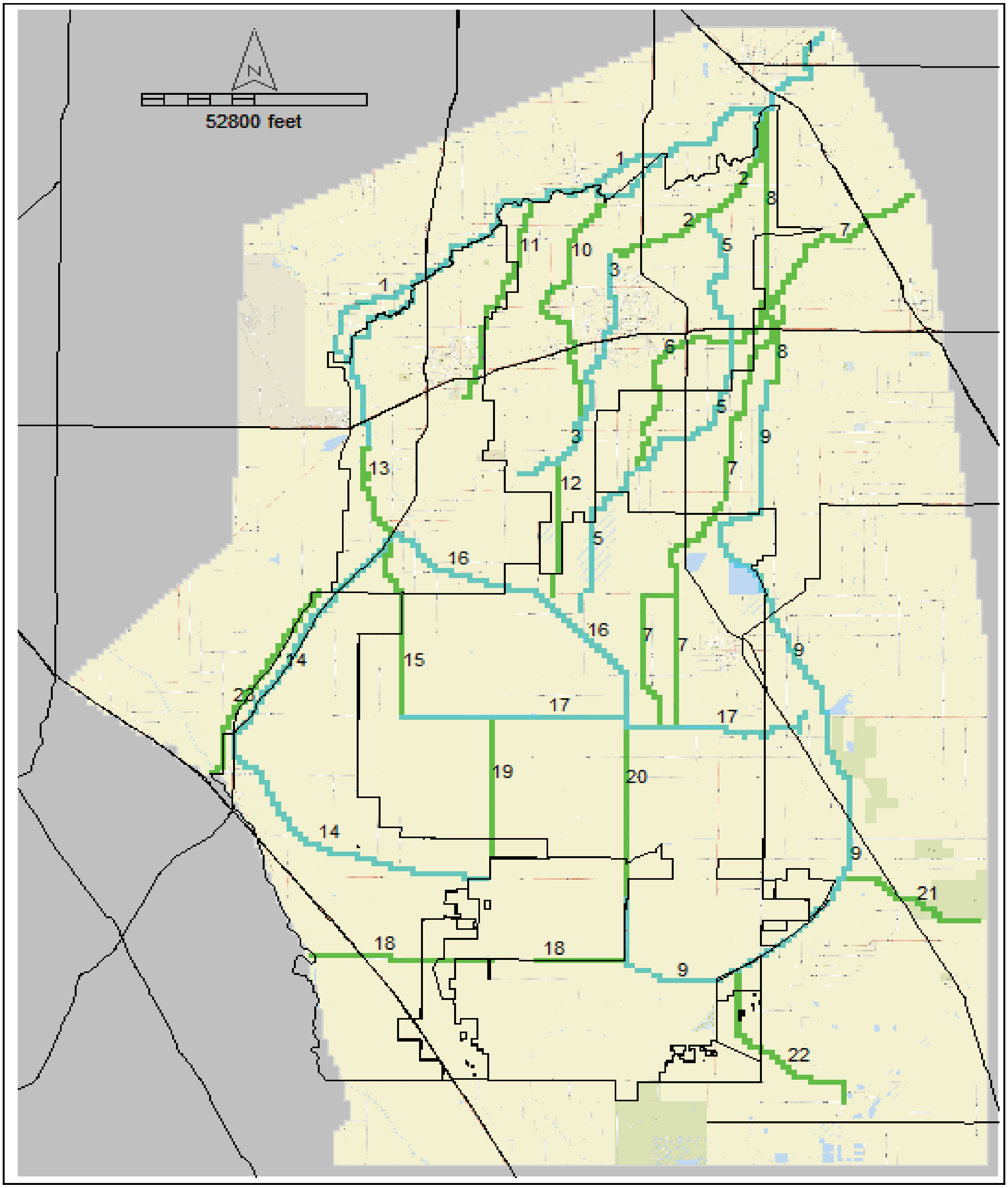
Location of Wells Evaluated for General Head Boundaries

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/7/2020	Project No.: FR18161220
		Figure **D4-8**

Date: 1/7/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18\FR18161220\gis\maps\2019\AppendixD_figD4-8_wellsandGHBs.mxd

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\3-BasinSetting\Figures\DAVES FOLDER\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsx

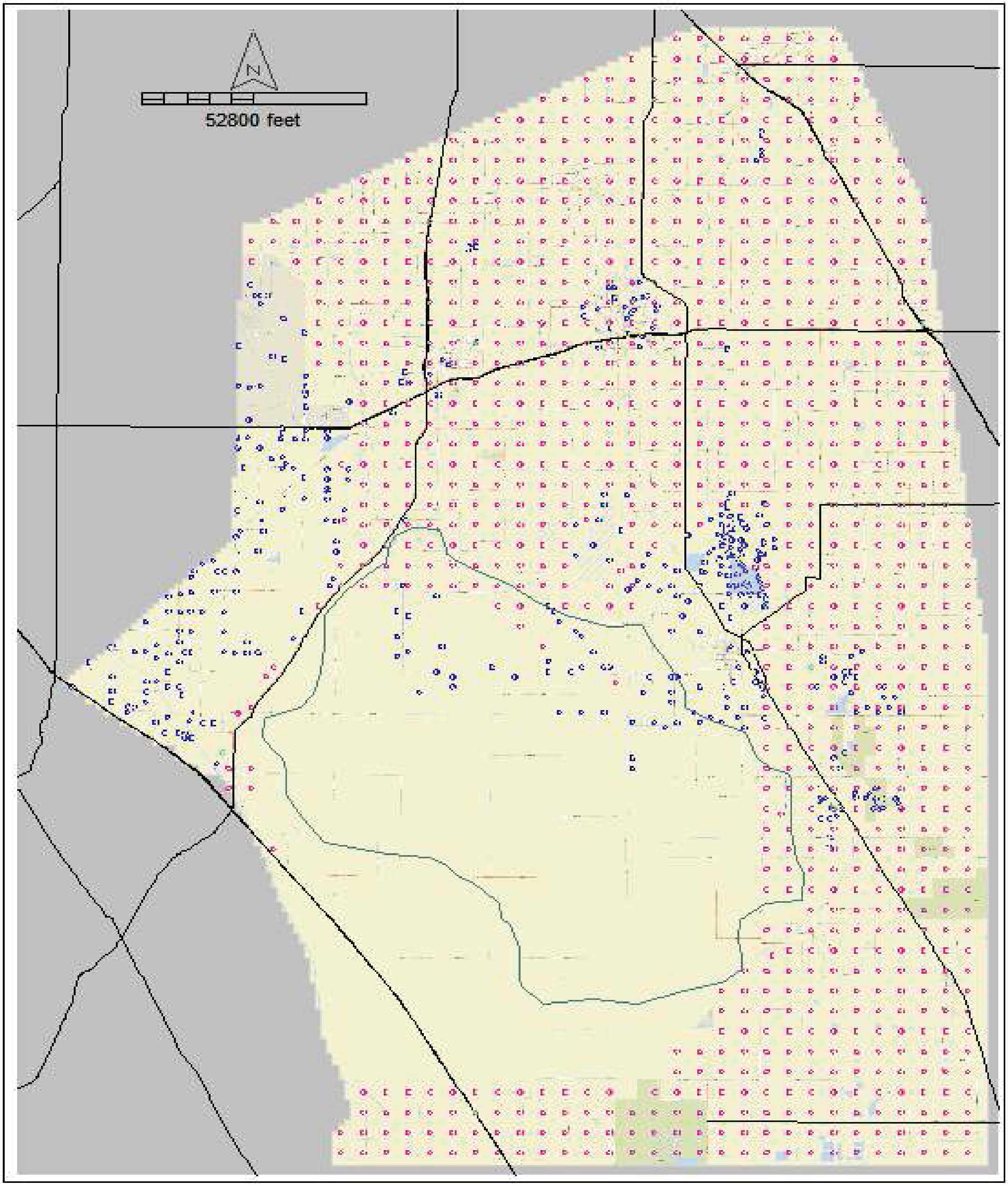


Notes:
1) Numbers shown are River Reaches
2) Colors delinate different reaches

Location of Rivers, Streams, and Canals for River Boundaries

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

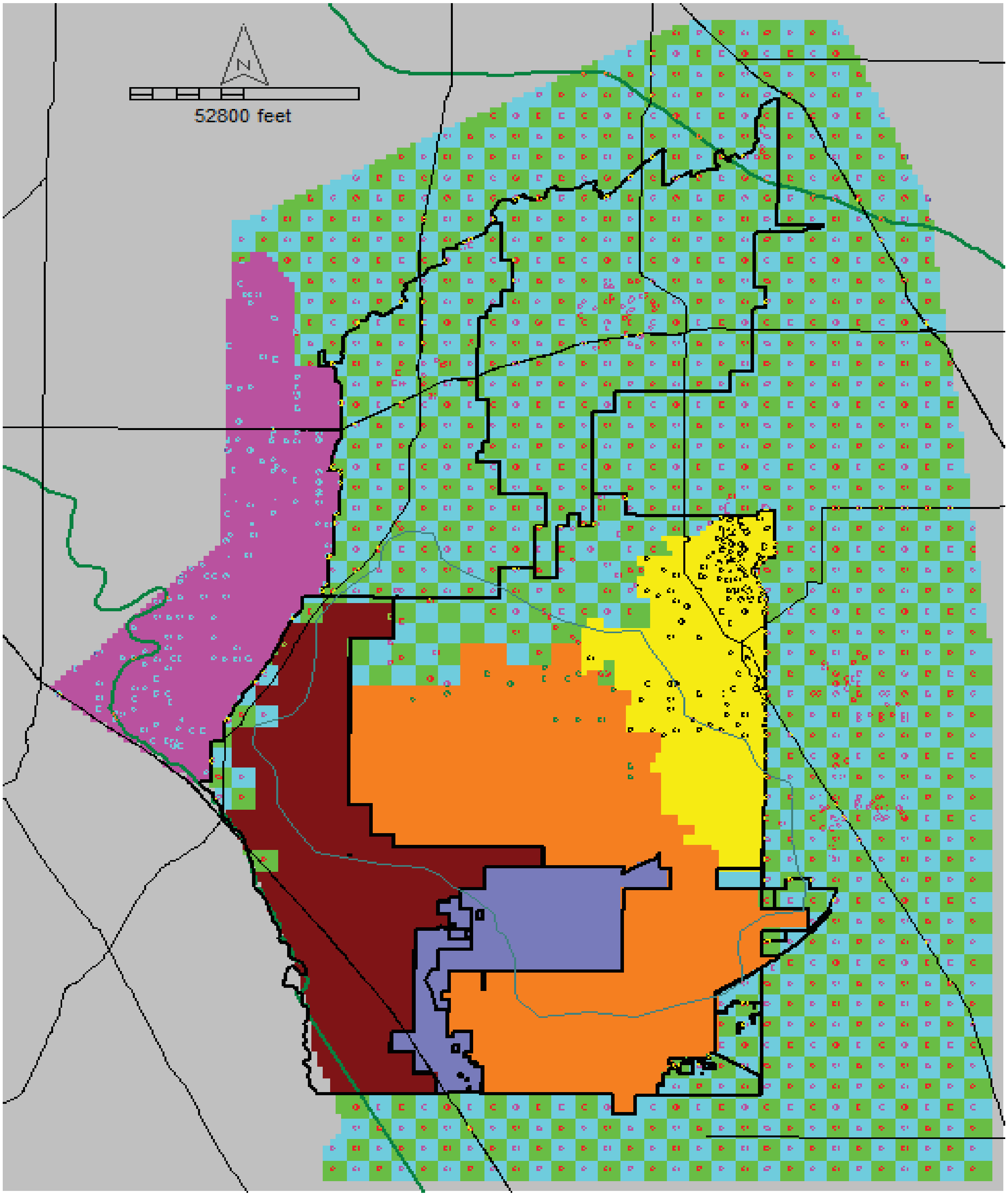
By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D4-9**



Location of Existing and Hypothetical Pumping Well within Model Domain

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D4-10**



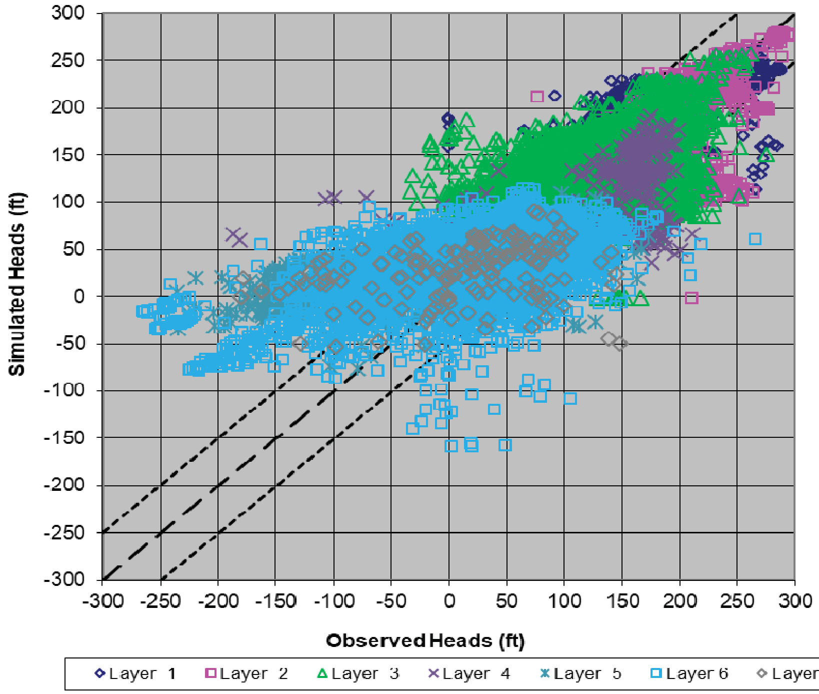
- Hypothetical Agricultural Well Service Area
- Hypothetical Agricultural Well Service Area
- Corcorain ID Service Area
- El Rico GSA Service Area
- Westlands Water District Service Area
- SouthWest Kings GSA Service Area
- Tri County Water Authority Service Area

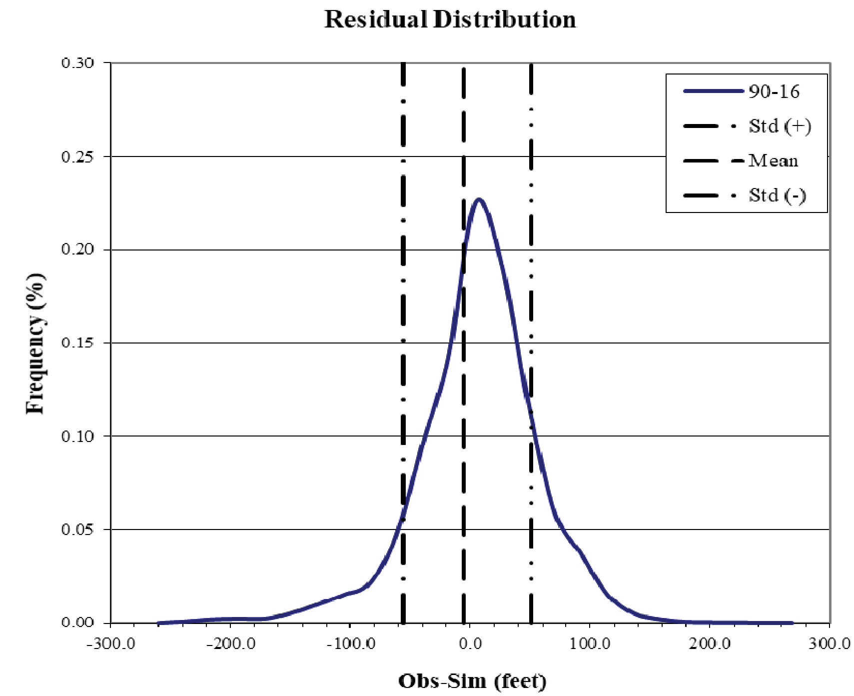
Location of Hypothetical Irrigation Well Service Areas within Model Domain

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D4-11**



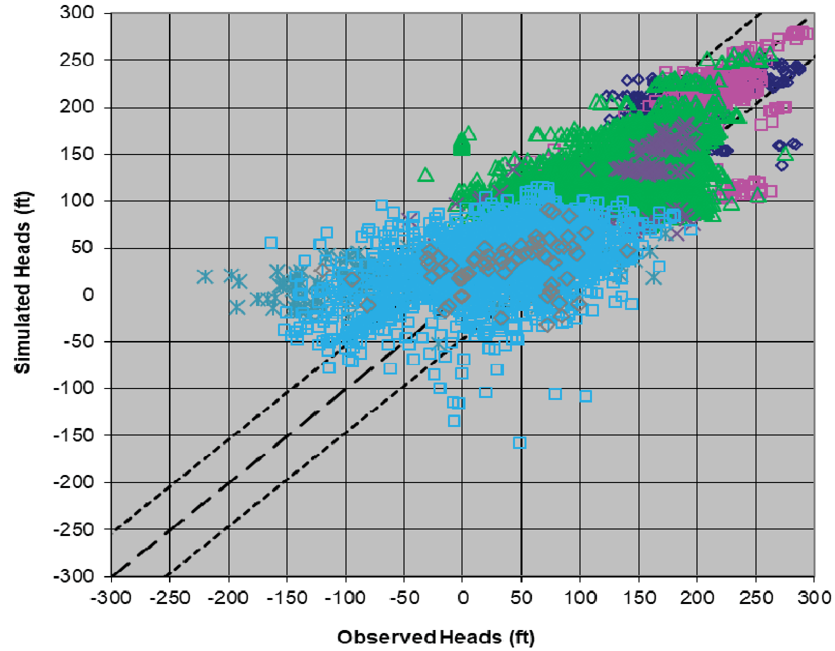


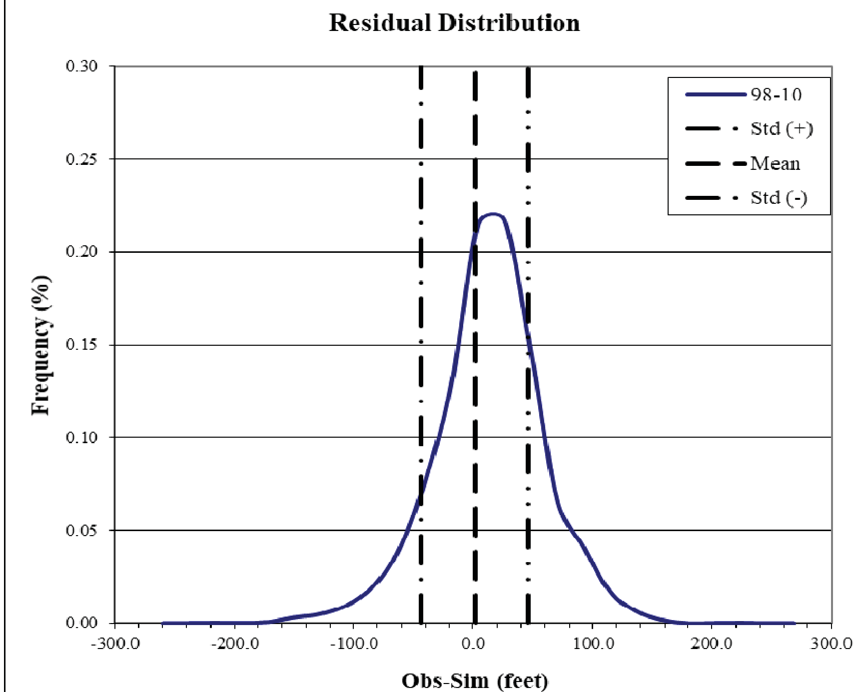
Statistics	Layer 1 - 7		Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7
Residual Mean	-4.98	ft	-9.30	185.26	-1.18	25.67	-35.43	-11.66	-11.45
Absolute Residual Mean	37.03	ft	26.33	38.80	30.55	36.38	64.09	49.81	45.61
Residual Std. Deviation	50.61	ft	34.84	44.84	39.78	53.49	75.82	63.58	63.42
Sum of Squares	42586112	ft^2	1733398	45812399	12887543	1291708	5743049	18228849	780823
RMS Error	50.85	ft	34.84	44.84	39.78	53.49	75.82	63.58	63.42
Min. Residual	-255.01	ft	-179.50	-1.00	-180.93	-252.97	-240.51	-255.01	-197.45
Max. Residual	213.28	ft	152.58	280.01	143.90	151.42	154.06	213.28	197.53
Number of Observations	16468		1333	1261	8136	367	820	4363	188
Range in Observations	575.33	ft	332.09	281.01	324.83	404.39	394.58	468.29	394.98
Scaled Residual Std. Deviation	8.80%		10.49%	15.96%	12.25%	13.23%	19.22%	13.58%	16.06%
Scaled Absolute Residual Mean	6.44%		7.93%	13.81%	9.40%	9.00%	16.24%	10.64%	11.55%
Scaled RMS Error	8.84%		10.49%	15.96%	12.25%	13.23%	19.22%	13.58%	16.06%
Scaled Residual Mean	-0.87%		-2.80%	65.92%	-0.36%	6.35%	-8.98%	-2.49%	-2.90%
Correlation Coefficient	82%		66%	64%	74%	76%	92%	82%	82%

1990 - 2016 Calibration Statistics and Scattergram
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb | Date: 11/20/19 | Project No.: FR18161220

Figure **D5-1a**



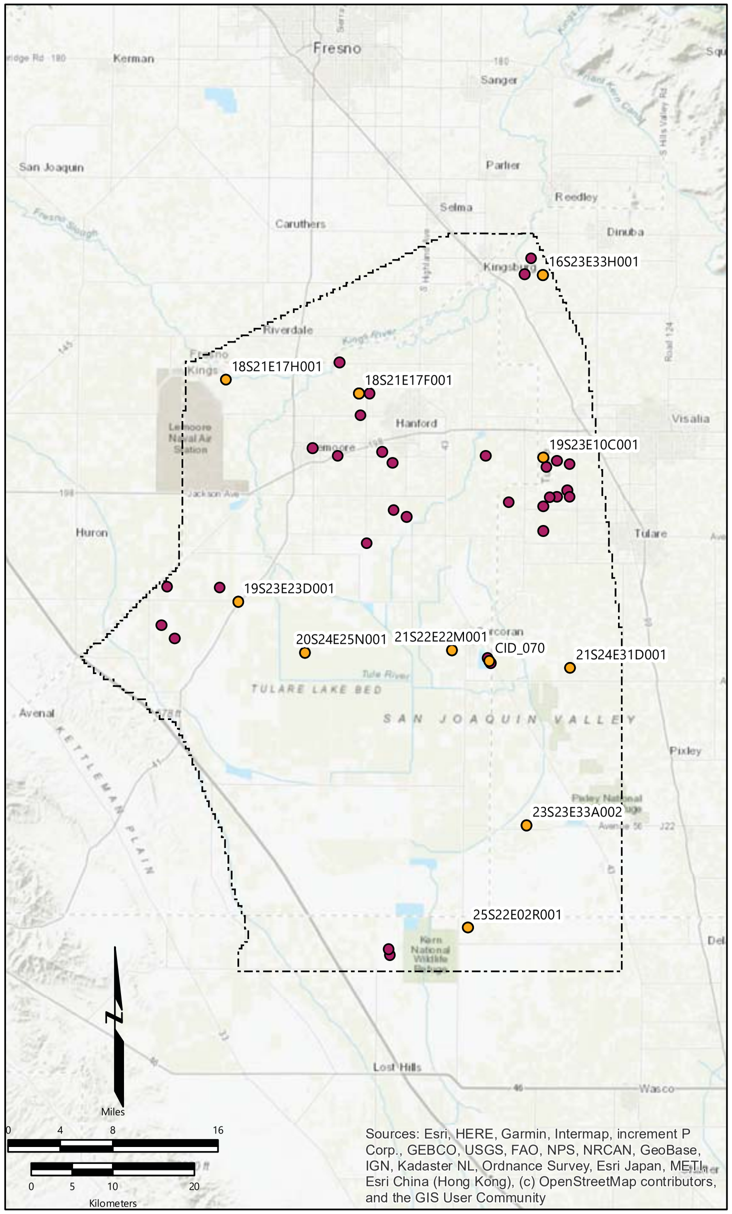


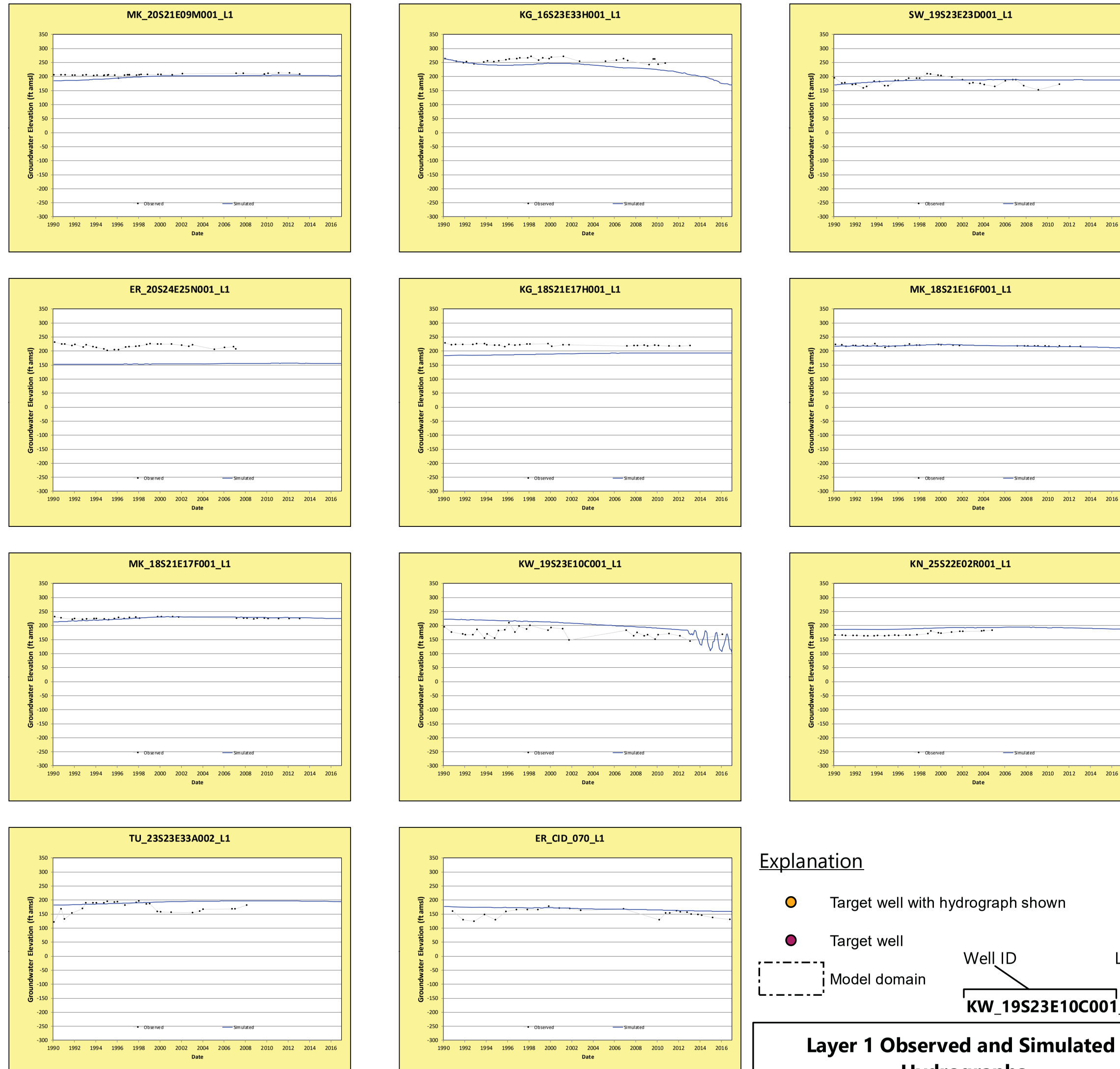
Statistics	Layer 1 - 7		Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7
Residual Mean	2.26	ft	-3.24	185.61	5.32	20.05	-26.55	-1.71	4.83
Absolute Residual Mean	34.78	ft	23.78	40.69	29.78	28.23	61.79	44.63	35.33
Residual Std. Deviation	46.26	ft	32.01	47.25	38.69	40.99	73.64	55.32	48.41
Sum of Squares	15075869	ft^2	561933	19148686	5416707	316496	2009708	5707709	160941
RMS Error	46.32	ft	32.01	47.25	38.69	40.99	73.64	55.32	48.41
Min. Residual	-240.16	ft	-89.83	-1.00	-167.94	-125.53	-240.16	-219.41	-145.72
Max. Residual	213.28	ft	133.86	280.01	143.40	121.24	144.32	213.28	108.57
Number of Observations	7028		543.00	522.00	3552.00	152.00	328.00	1863.00	68.00
Range in Observations	545.16	ft	223.69	281.01	311.34	246.77	384.47	432.70	254.29
Scaled Residual Std. Deviation	8.49%		14.31%	16.81%	12.43%	16.61%	19.15%	12.79%	19.04%
Scaled Absolute Residual Mean	6.38%		10.63%	14.48%	9.57%	11.44%	16.07%	10.31%	13.89%
Scaled RMS Error	8.50%		14.31%	16.81%	12.43%	16.61%	19.15%	12.79%	19.04%
Scaled Residual Mean	0.41%		-1.45%	66.05%	1.71%	8.12%	-6.91%	-0.39%	1.90%
Correlation Coefficient	82%		58%	62%	77%	66%	91%	79%	78%

1998 - 2010 Calibration Statistics and Scattergram
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb | Date: 07/30/19 | Project No.: FR18161220

Figure **D5-1b**





Explanation

- Target well with hydrograph shown
- Target well
- Model domain

Well ID — Layer

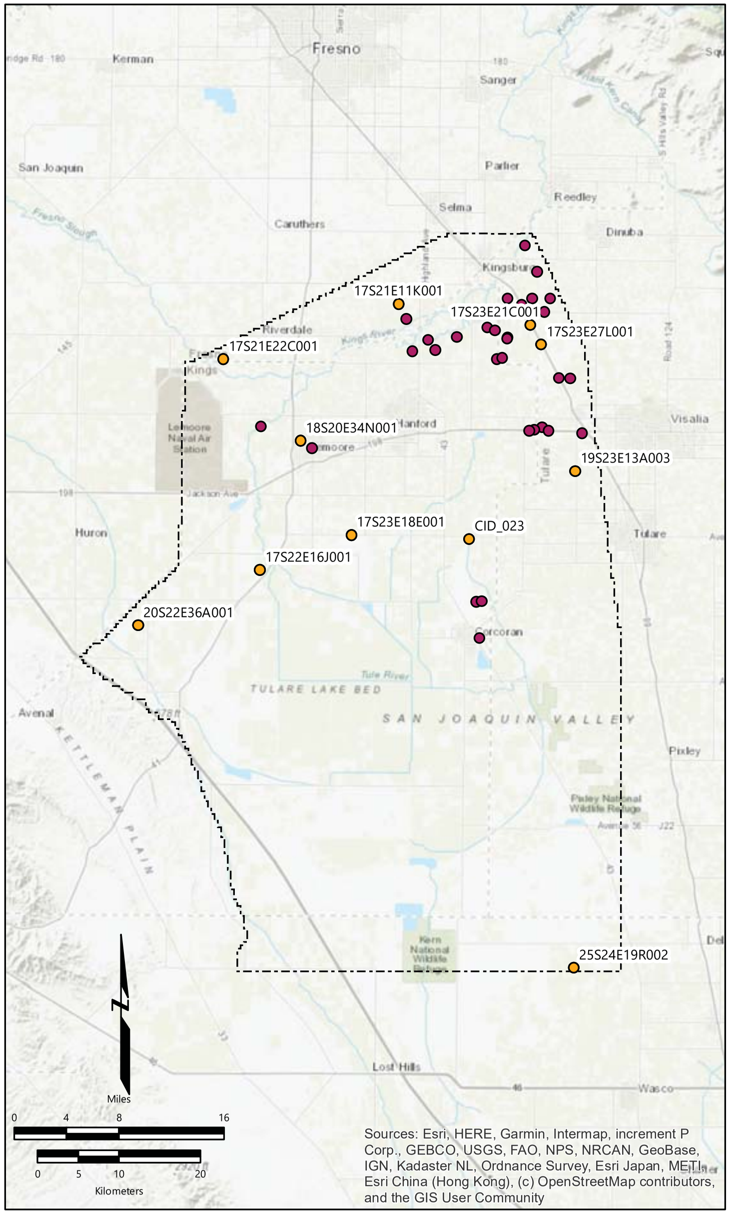
KW_19S23E10C001_L1

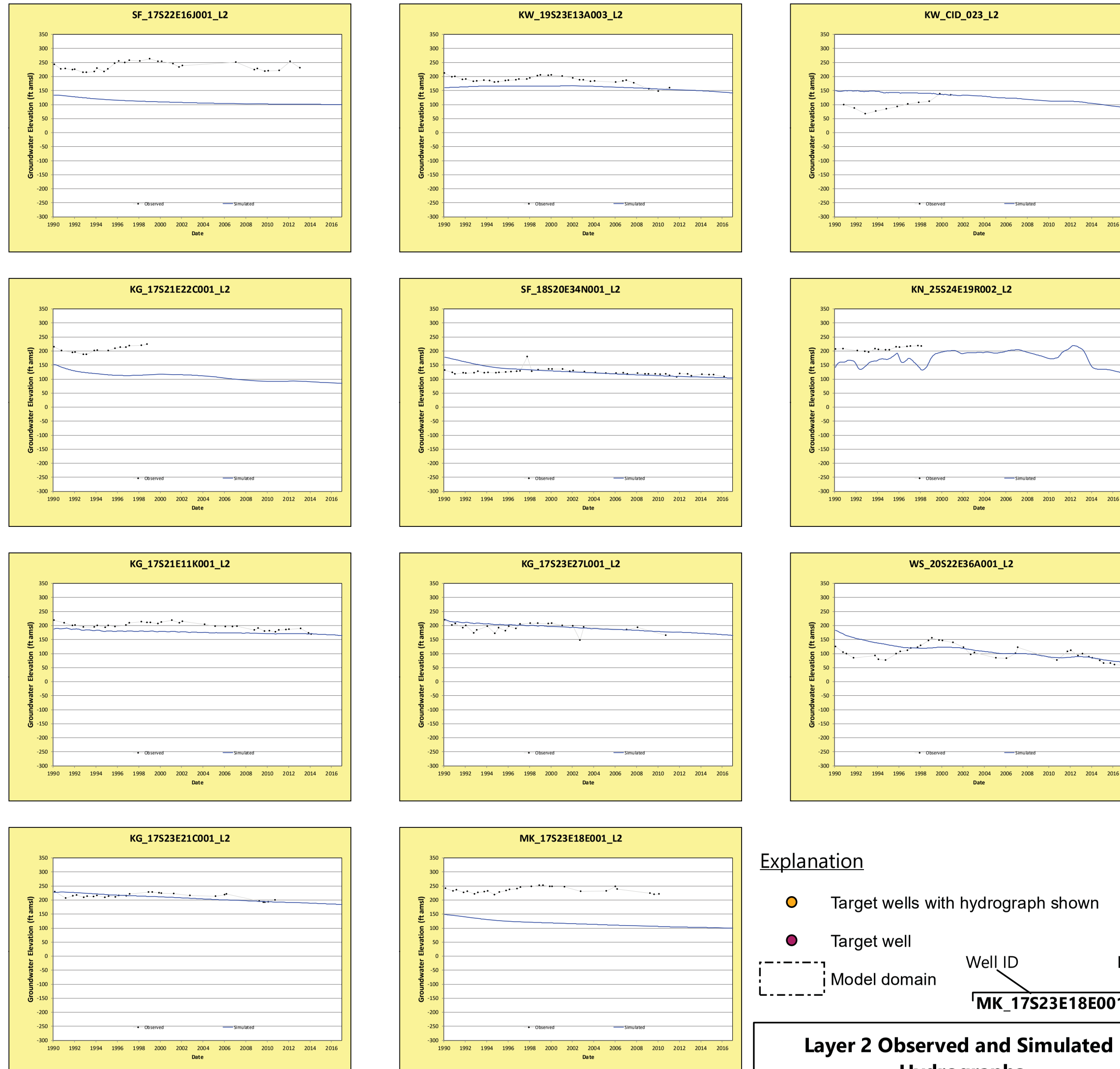
Layer 1 Observed and Simulated Hydrographs

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **D5-2a**

Date: 1/8/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\temp\DBean_Hydro__fig01_layeredHydrographs_20191218.mxd





Explanation

- Target wells with hydrograph shown
- Target well
- Model domain

Well ID — Layer: MK_17S23E18E001_L2

Layer 2 Observed and Simulated Hydrographs

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **D5-2b**

Date: 1/8/2020 Printed by: elizabeth.chapman
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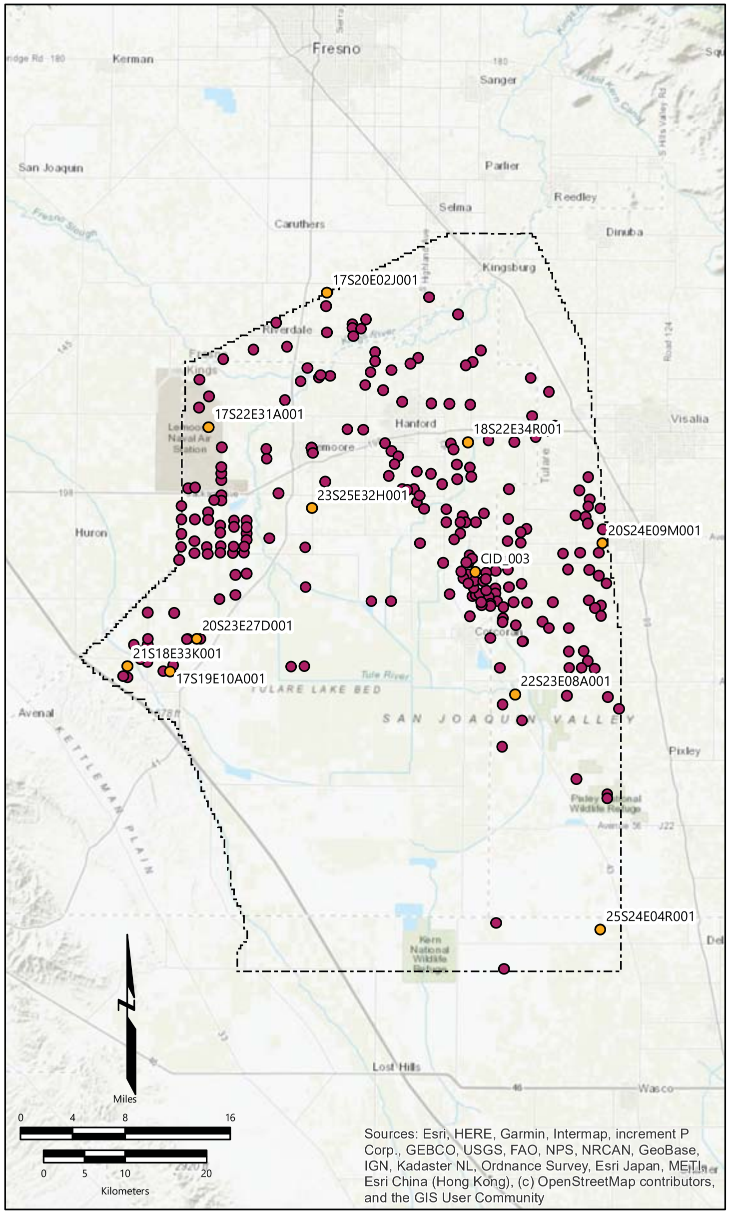

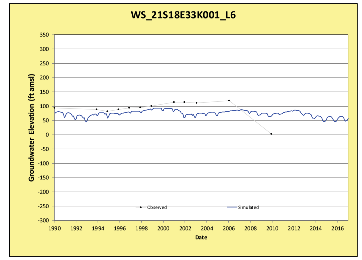

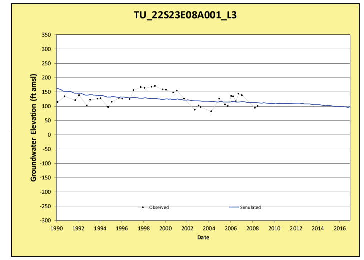

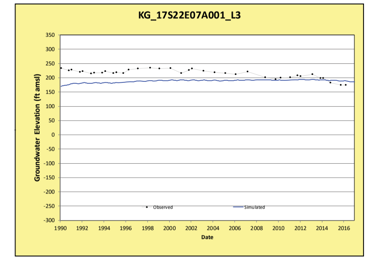

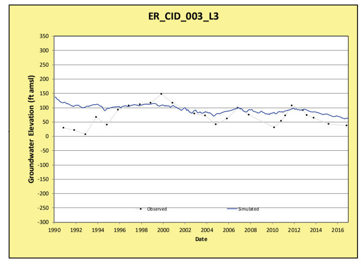

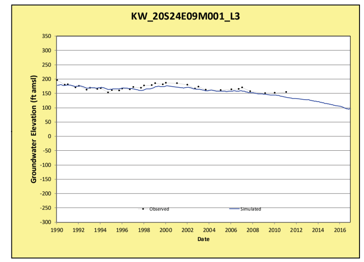

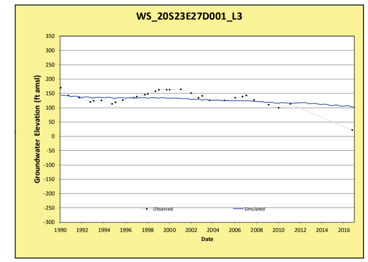

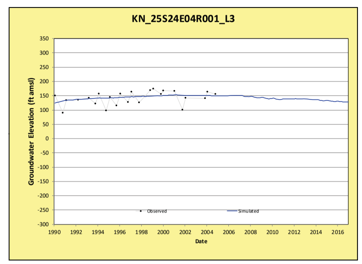

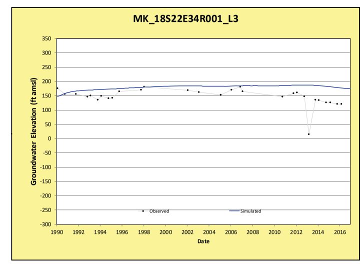

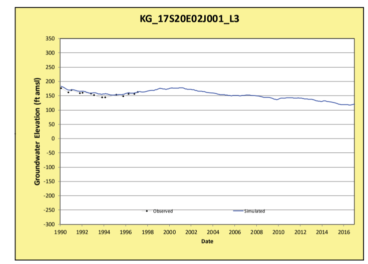

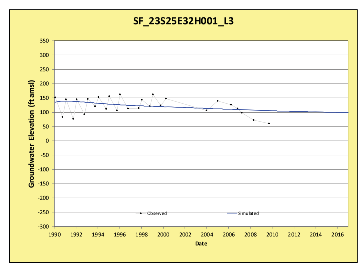

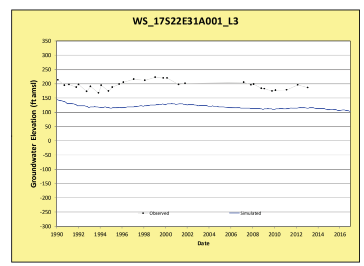

Explanation

- Target wells with hydrograph shown
- Target well
- Model domain

Well_ID — Layer: SF_23S25E32H001_L3

Layer 3 Observed and Simulated Hydrographs

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **D5-2c**

Date: 1/8/2020 Printed by: elizabeth.chapman
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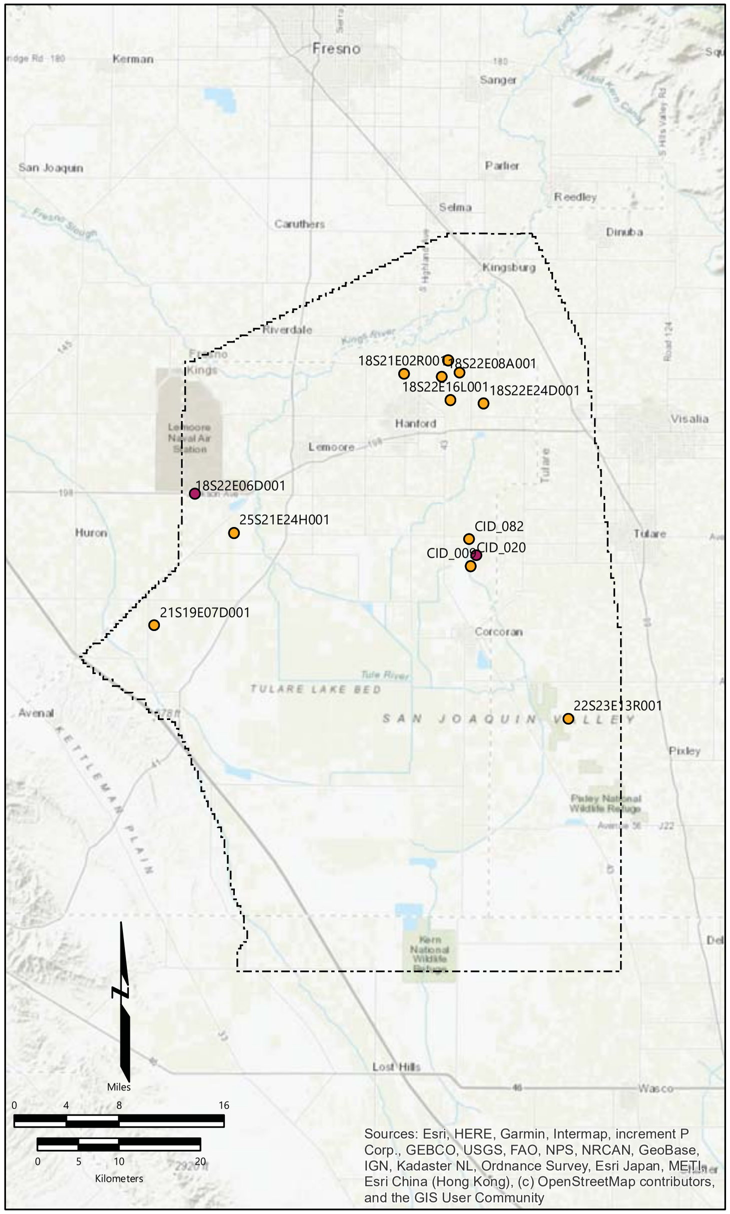

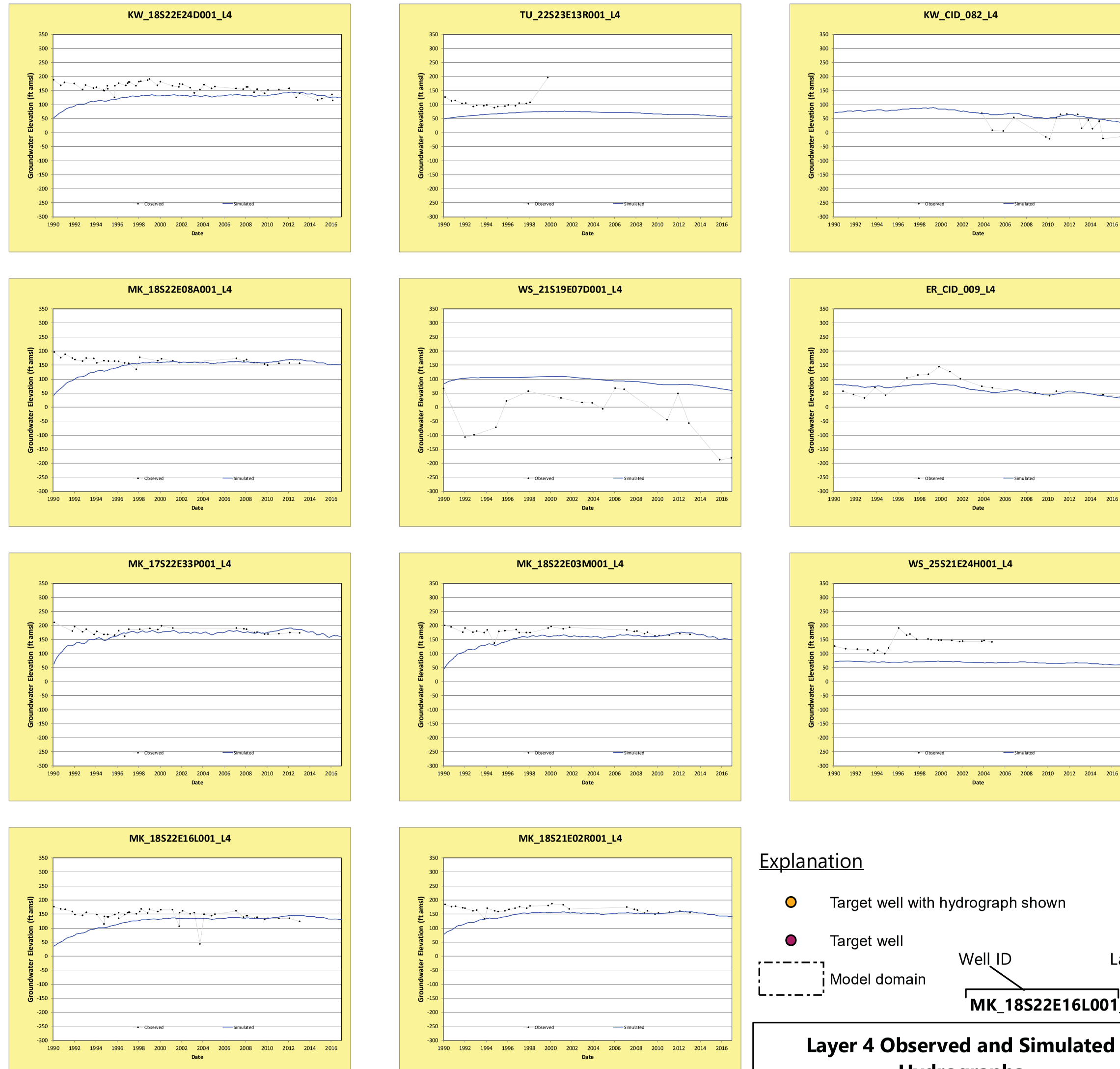

Explanation

- Target well with hydrograph shown
- Target well
- Model domain

Well ID — Layer
MK_18S22E16L001_L4

Layer 4 Observed and Simulated Hydrographs

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **D5-2d**

Date: 1/8/2020 Printed by: elizabeth.chapman
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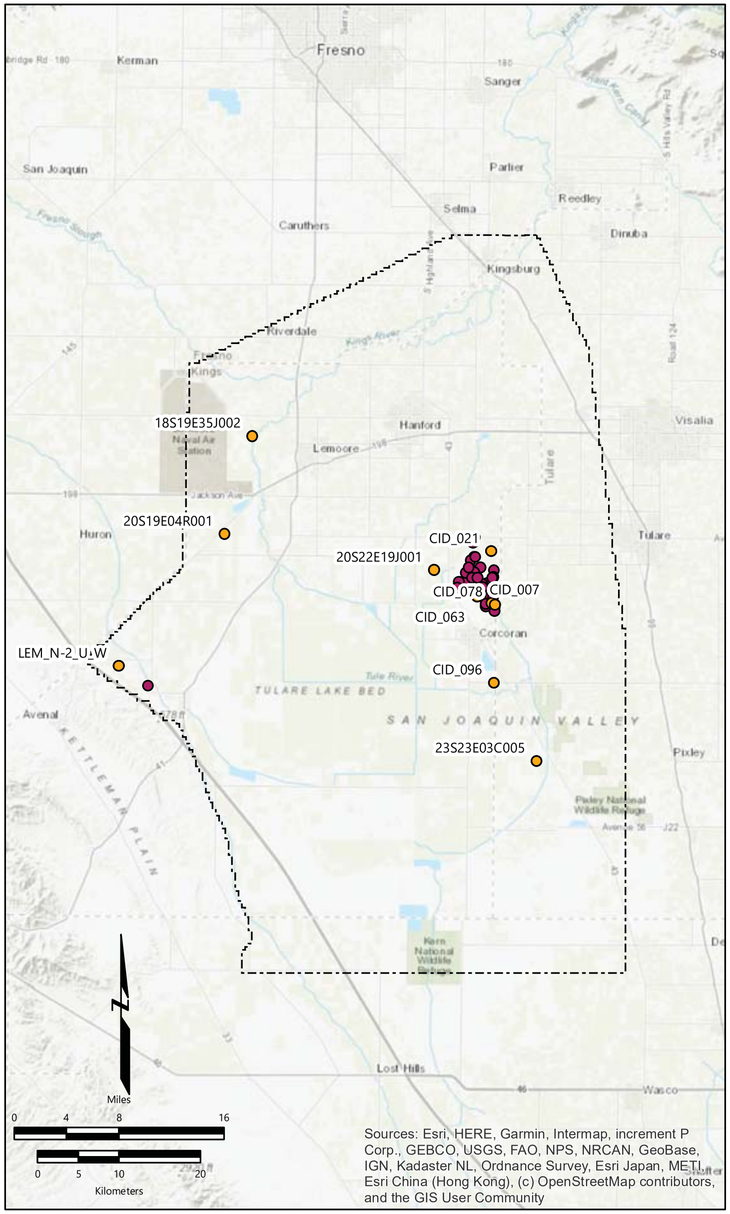

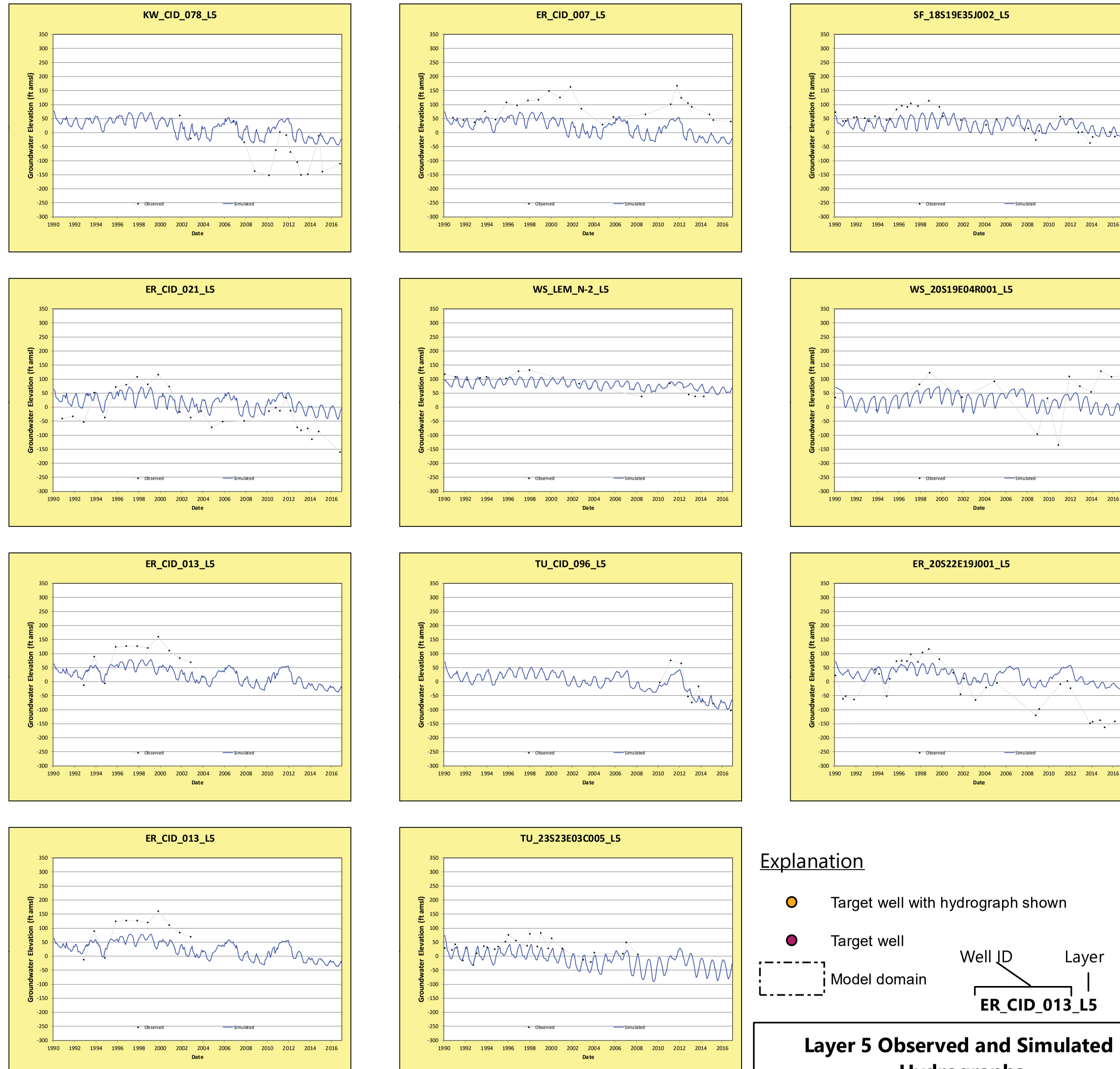

Explanation

- Target well with hydrograph shown
- Target well
- Model domain

Well ID — Layer
ER_CID_013_L5

Layer 5 Observed and Simulated Hydrographs

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **D5-2e**

Date: 1/8/2020 Printed by: elizabeth.chapman
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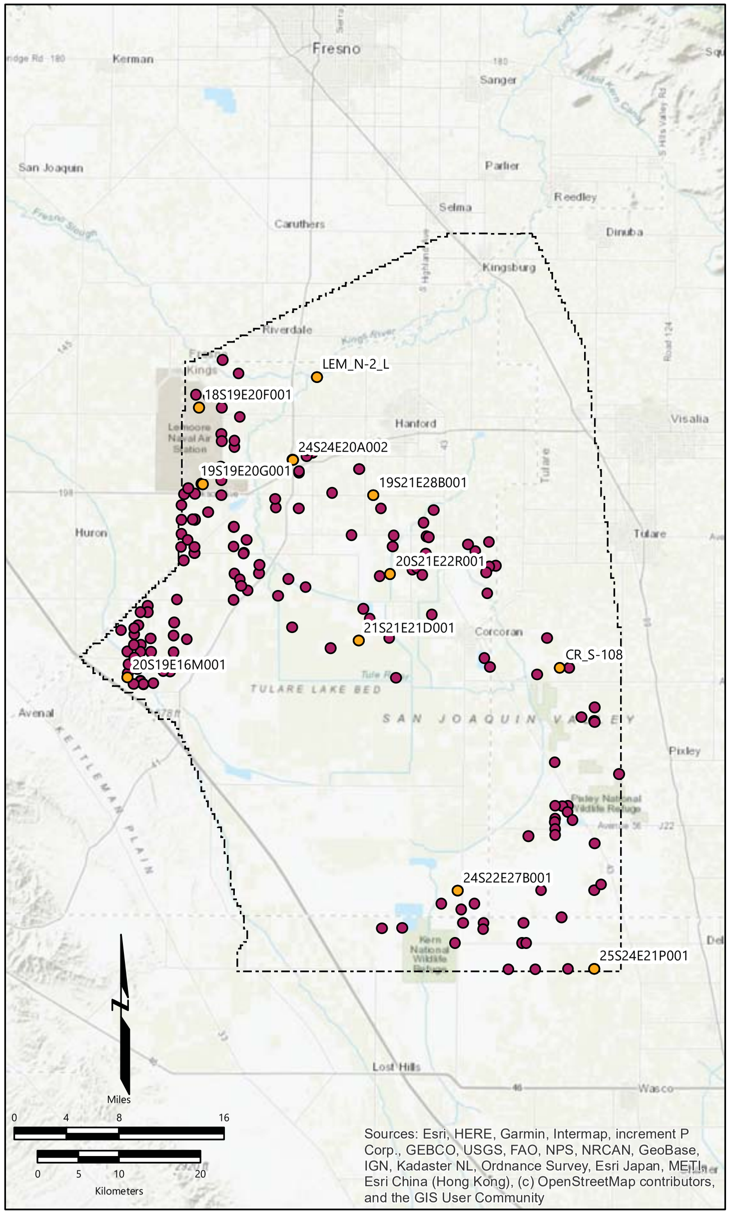

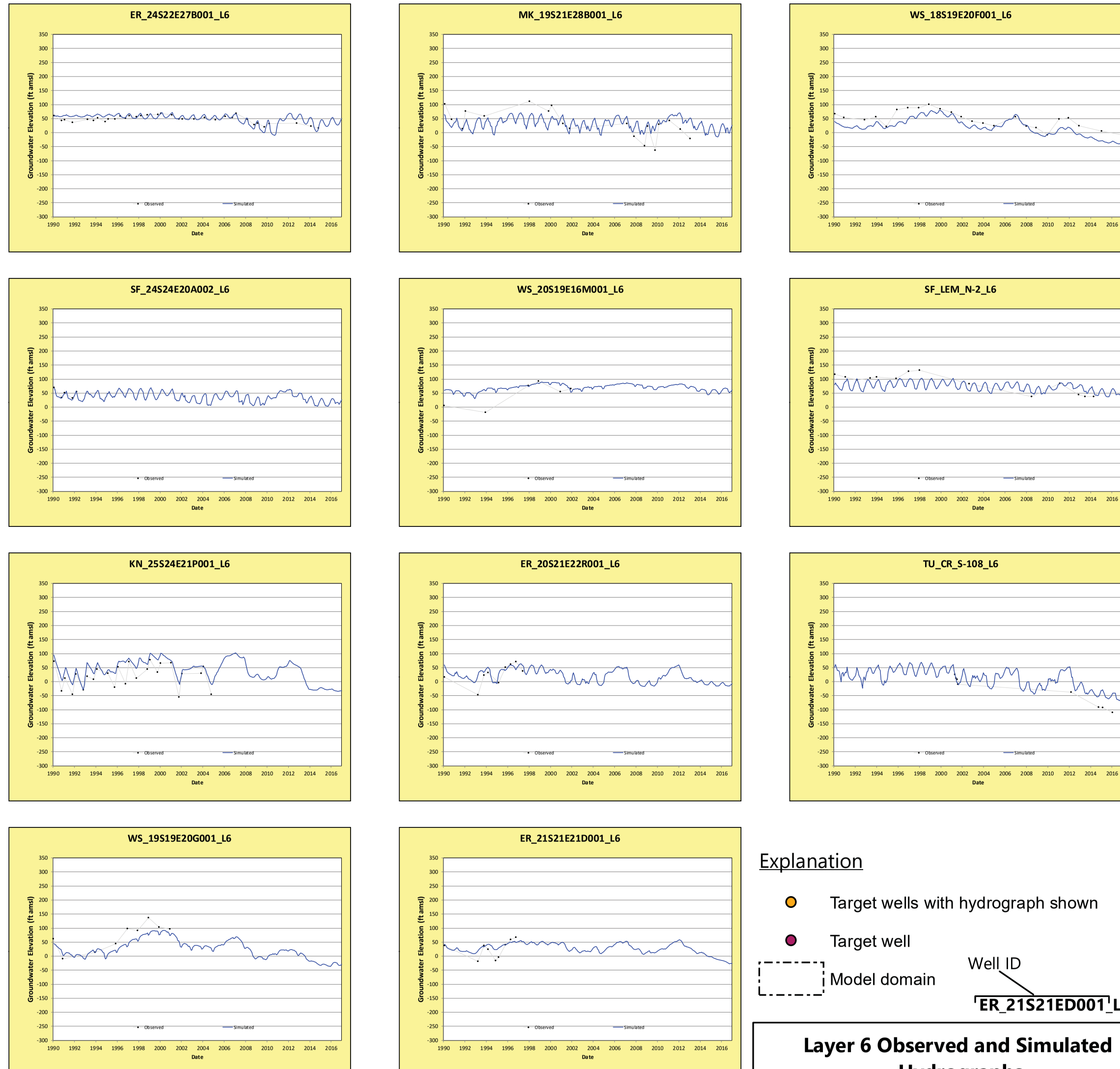

Explanation

- Target wells with hydrograph shown
- Target well
- Model domain

Well ID — Layer
ER_21S21ED001_L6

Layer 6 Observed and Simulated Hydrographs

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220
		Figure **D5-2f**

Date: 1/8/2020 Printed by: elizabeth.chapman
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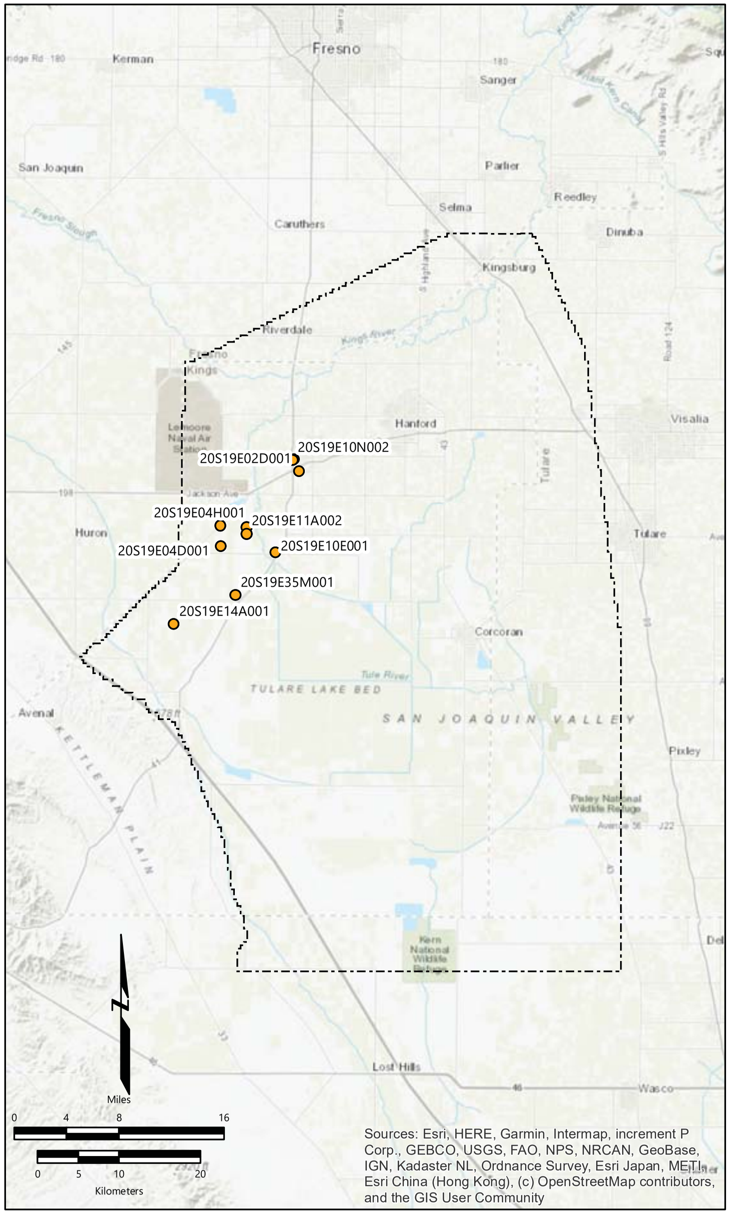
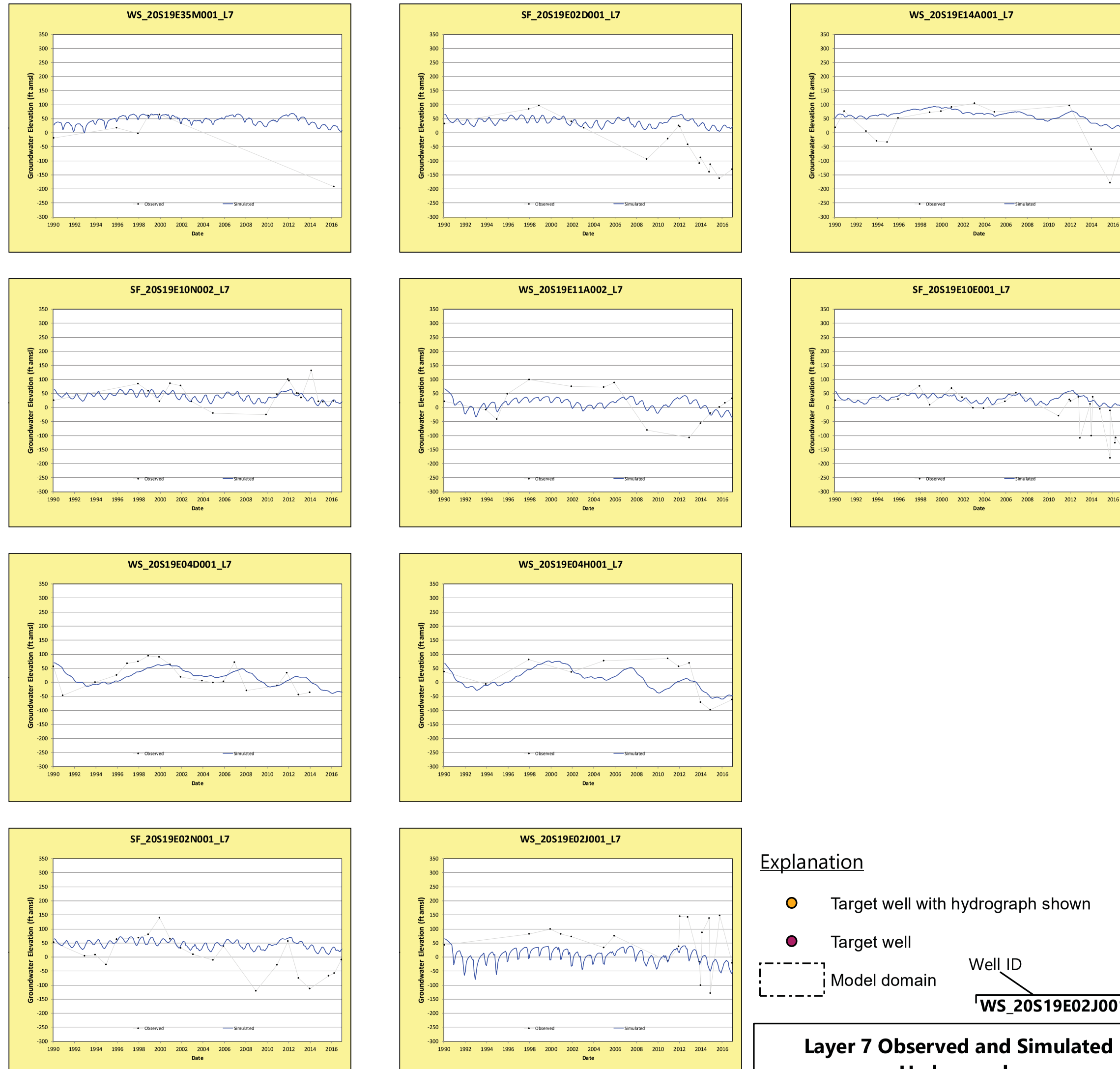




Explanation

- Target well with hydrograph shown
- Target well
- Model domain

Well ID — Layer: WS_20S19E02J001_L7

Layer 7 Observed and Simulated Hydrographs

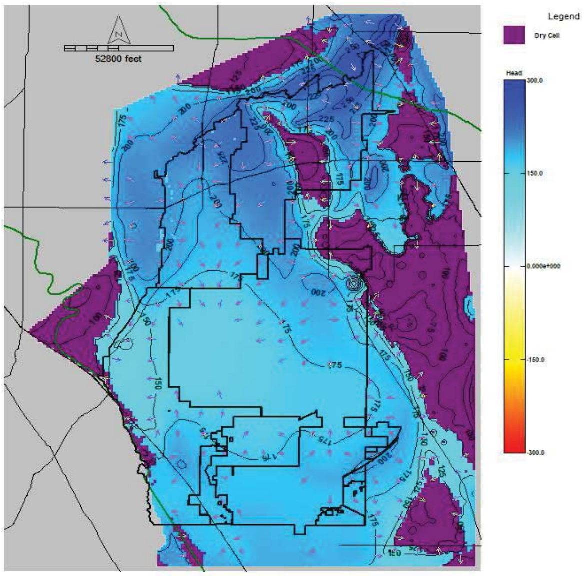
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: EMC	Date: 1/8/2020	Project No.: FR18161220

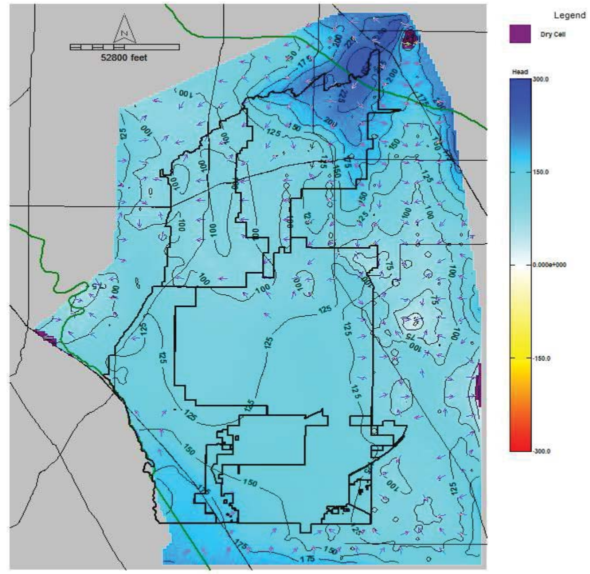
Figure **D5-2g**

Date: 1/8/2020 Printed by: elizabeth.chapman
Path: N:_FR_projects\FR18s\FR18161220\temp\DBean_Hydro__fig07_layeredHydrographs_20191218.mxd

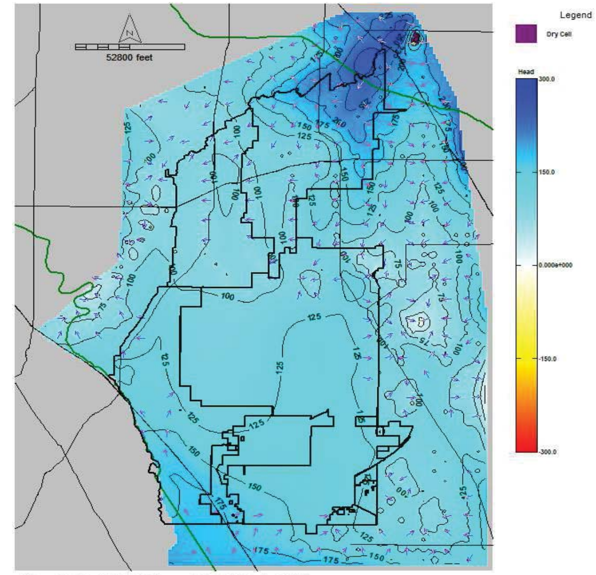
I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D5-3 Calib Potentiometrics 12/19/2019



Kings SGMA 1990-2016 Layer: 1 SP: 312 Date: 2016.0



Kings SGMA 1990-2016 Layer: 2 SP: 312 Date: 2016.0



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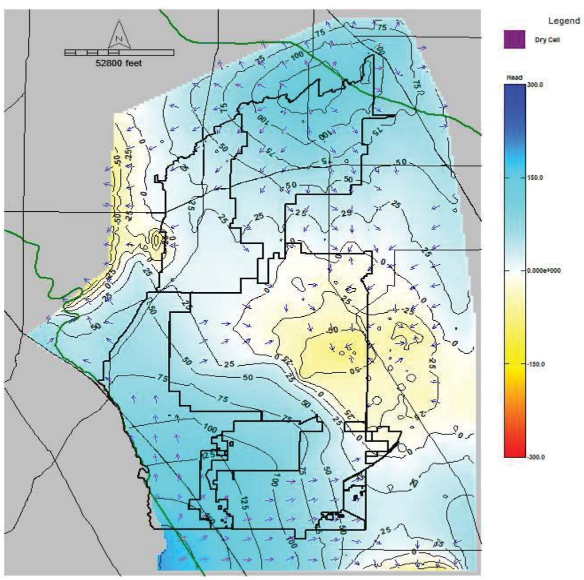

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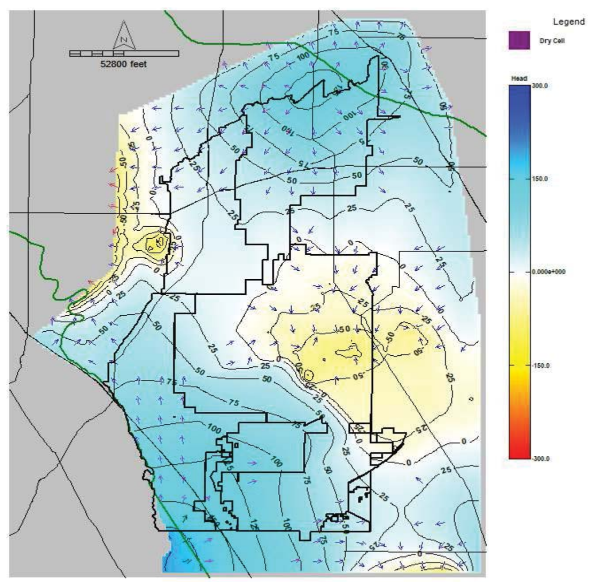


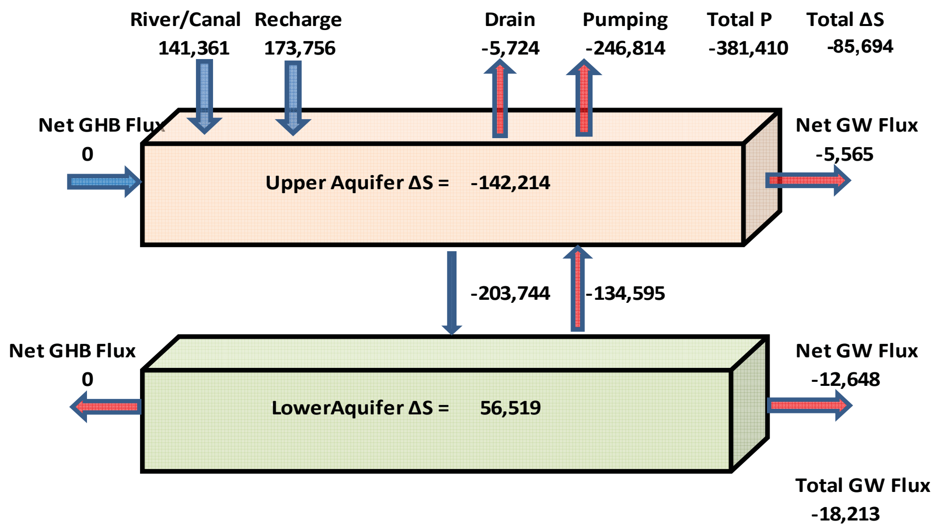
Kings SGMA 1990-2016 Layer: 6 SP: 312 Date: 2016.0

Simulated December 2015 Groundwater Elevations and Groundwater Flow Vectors

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

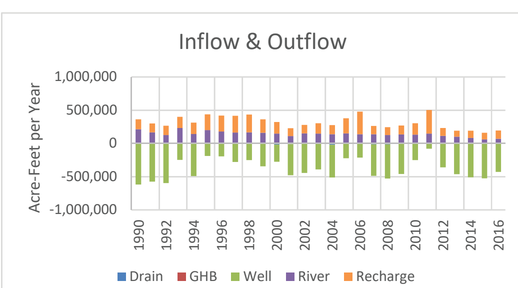
By: dmb	Date: 07/30/19	Project No.: FR18161220
	Figure	**D5-3**

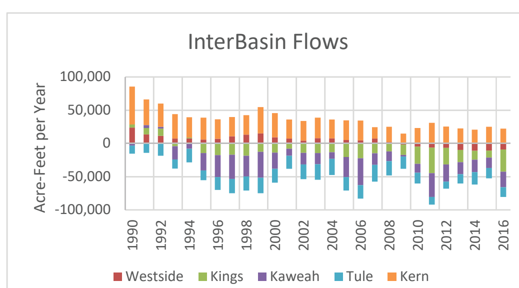
1990-2016
Average Groundwater Balance
Tulare Lake SB

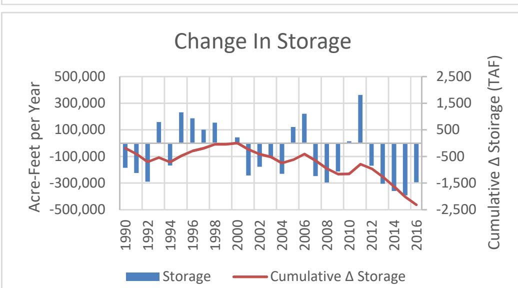


1990 - 2016
Tulare Lake Subbasin

TulareLake Date	Net Drain	Net GHB	Net Well	Net River	Net Recharge	Net Storage	TulareLake Interbasin	Westside Interbasin	Kings Interbasin	Kaweah Interbasin	Tule Interbasin	Kern Interbasin
1990	0	0	-618,843	212,023	150,920	-185,926	69,929	23,632	4,815	-3,467	-12,024	56,971
1991	0	0	-577,240	164,892	135,941	-224,464	51,899	13,271	9,747	4,376	-14,187	38,693
1992	0	0	-596,994	125,681	139,491	-290,389	41,344	11,225	10,812	2,987	-18,583	34,904
1993	0	0	-248,824	231,839	167,981	157,279	6,232	7,344	-4,219	-20,133	-13,496	36,736
1994	-26	0	-491,956	139,080	173,457	-168,707	10,497	7,647	1,210	-8,114	-20,670	30,426
1995	-82	0	-188,622	200,925	235,917	231,421	-16,719	5,564	-14,724	-26,071	-14,705	33,217
1996	-251	0	-195,586	177,508	238,753	186,481	-33,990	6,788	-17,826	-32,867	-19,334	29,250
1997	-1,392	0	-278,726	162,833	252,651	100,786	-35,395	10,524	-17,146	-36,466	-21,396	29,090
1998	-1,870	0	-249,086	165,955	266,380	153,536	-28,386	13,146	-18,649	-31,067	-21,177	29,362
1999	-7,376	0	-338,241	159,660	201,878	522	-20,428	15,099	-12,823	-38,853	-23,234	39,384
2000	-17,343	0	-260,727	147,624	172,534	43,638	-13,661	9,202	-14,008	-24,256	-20,878	36,279
2001	-13,351	0	-467,326	108,934	119,202	-243,059	-2,375	7,046	-8,208	-10,602	-19,402	28,791
2002	-10,253	0	-435,270	150,502	128,082	-178,393	-20,389	4,116	-14,310	-17,484	-22,160	29,448
2003	-8,170	0	-385,602	145,737	157,010	-101,083	-16,217	7,968	-14,505	-16,849	-23,580	30,749
2004	-20,849	0	-494,263	137,236	138,732	-231,122	-11,678	7,475	-13,320	-9,952	-24,296	28,416
2005	-5,413	0	-217,488	150,074	227,638	121,017	-36,335	4,993	-20,418	-30,344	-20,294	29,728
2006	-9,651	0	-205,429	138,230	339,860	220,649	-48,705	4,446	-22,451	-40,403	-20,192	29,895
2007	-14,999	0	-474,153	137,542	123,827	-248,490	-33,353	7,330	-14,948	-17,451	-25,274	16,990
2008	-13,795	0	-515,546	126,421	117,419	-296,277	-23,147	1,856	-12,181	-14,428	-21,584	23,191
2009	-4,295	0	-456,641	133,032	135,636	-213,010	-23,837	-1,793	-15,575	-2,407	-18,590	14,527
2010	-2,440	0	-249,776	129,805	171,969	13,129	-37,307	-5,091	-25,818	-13,379	-16,097	23,078
2011	-4,486	0	-77,680	147,432	355,590	361,228	-61,401	-6,641	-38,331	-35,573	-11,696	30,840
2012	-3,226	0	-357,301	111,314	120,601	-169,947	-42,994	-6,733	-25,065	-25,720	-10,775	25,299
2013	-8,381	0	-455,726	99,564	90,038	-305,607	-38,136	-9,909	-18,283	-18,315	-13,933	22,304
2014	-3,579	0	-508,253	82,742	107,427	-360,352	-41,461	-11,151	-13,313	-18,684	-18,842	20,529
2015	-829	0	-524,338	60,439	99,444	-392,279	-27,490	-10,951	-10,641	-15,502	-15,383	24,986
2016	-2,497	0	-428,423	69,718	123,037	-294,325	-58,248	-9,455	-33,115	-23,497	-14,438	22,257
1990-2016 Average	**-5,724**	**0**	**-381,410**	**141,361**	**173,756**	**-85,694**	**-18,213**	**3,961**	**-13,826**	**-19,427**	**-18,379**	**29,457**
1998-2010 Average	**-9,985**	**0**	**-365,350**	**140,827**	**176,936**	**-73,765**	**-24,294**	**5,830**	**-15,939**	**-20,575**	**-21,289**	**27,680**



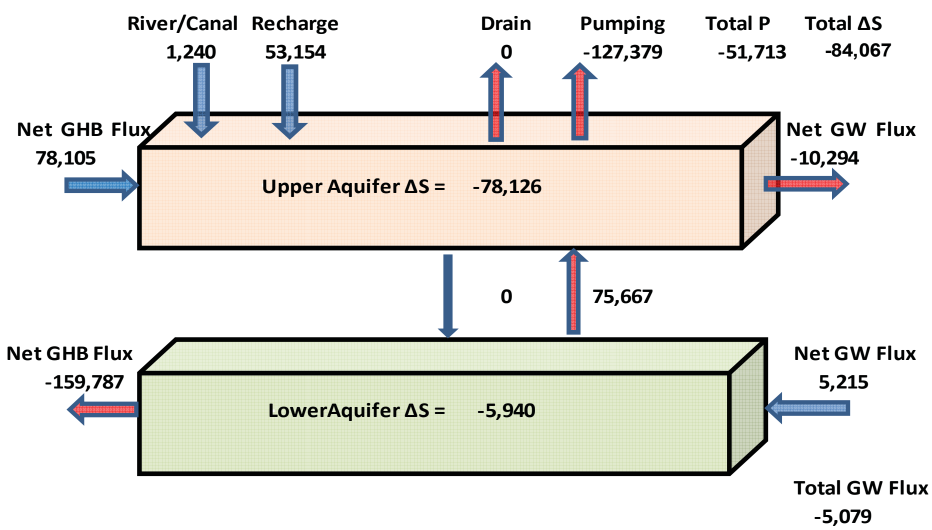




Groundwater Mass Balance
Tulare Lake Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

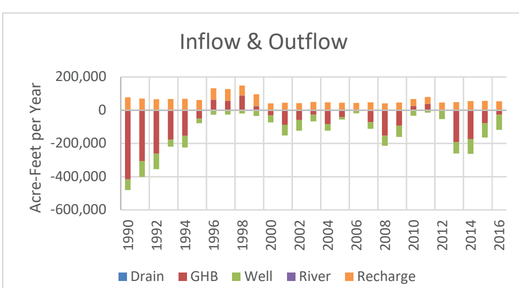
By: dmb	Date: 12/15/19	Project No.: FR18161220
		Figure **D5-4**

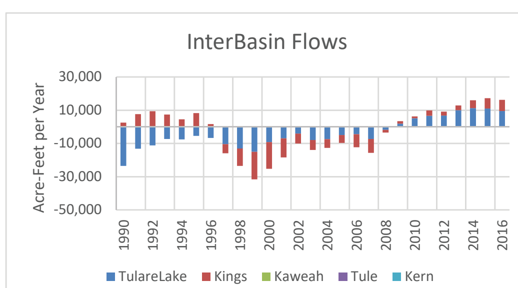
1990-2016
Average Groundwater Balance
Westside SB

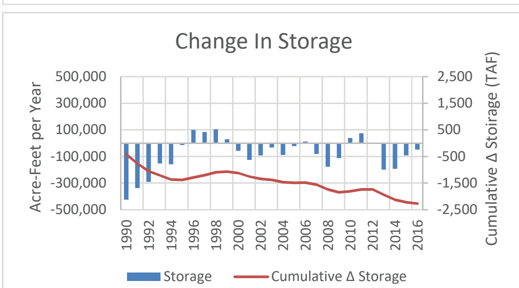


1990 - 2016
Westside Subbasin

TulareLake Date	Net Drain	Net GHB	Net Well	Net River	Net Recharge	Net Storage	Interbasin TulareLake	Interbasin Westside	Interbasin Kings	Interbasin Kaweah	Interbasin Tule	Interbasin Kern
1990	0	-416,613	-64,299	1,305	75,411	-425,294	-23,632	0	2,518	0	0	0
1991	0	-306,833	-94,899	1,315	67,929	-338,123	-13,271	0	7,580	0	0	0
1992	0	-260,820	-94,233	1,297	64,558	-291,005	-11,225	0	9,334	0	0	0
1993	0	-177,022	-42,742	1,275	65,909	-152,615	-7,344	0	7,293	0	0	0
1994	0	-154,444	-69,800	1,262	67,284	-158,845	-7,647	0	4,416	0	0	0
1995	0	-51,451	-26,944	1,258	59,364	-15,122	-5,564	0	8,215	0	0	0
1996	0	61,385	-27,841	1,253	69,011	98,671	-6,788	0	1,651	0	0	0
1997	0	55,068	-26,074	1,249	69,862	84,080	-10,524	0	-5,501	0	0	0
1998	0	86,377	-20,708	1,252	60,275	103,573	-13,146	0	-10,476	0	0	0
1999	0	22,760	-35,621	1,250	71,595	28,355	-15,099	0	-16,531	0	0	0
2000	0	-31,098	-42,612	1,262	38,891	-58,827	-9,202	0	-16,069	0	0	0
2001	0	-88,368	-64,117	1,269	42,859	-126,795	-7,046	0	-11,392	0	0	0
2002	0	-59,530	-64,657	1,278	40,823	-92,170	-4,116	0	-5,977	0	0	0
2003	0	-28,132	-39,554	1,283	47,458	-32,937	-7,968	0	-6,025	0	0	0
2004	0	-83,841	-40,547	1,290	46,023	-89,837	-7,475	0	-5,288	0	0	0
2005	0	-42,330	-14,695	1,291	43,362	-22,114	-4,993	0	-4,750	0	0	0
2006	0	-2,135	-16,480	1,294	41,476	11,768	-4,446	0	-7,942	0	0	0
2007	0	-73,077	-39,686	1,296	45,543	-81,676	-7,330	0	-8,423	0	0	0
2008	0	-153,303	-61,382	1,307	39,326	-177,598	-1,856	0	-1,697	0	0	0
2009	0	-92,631	-68,431	1,308	44,595	-111,863	1,793	0	1,497	0	0	0
2010	0	24,802	-34,671	1,310	40,459	38,085	5,091	0	1,094	0	0	0
2011	0	37,267	-15,329	1,312	40,675	73,785	6,641	0	3,219	0	0	0
2012	0	-449	-54,215	1,318	44,354	99	6,733	0	2,358	0	0	0
2013	0	-191,800	-68,720	1,316	47,308	-199,093	9,909	0	2,894	0	0	0
2014	0	-173,365	-90,404	1,313	52,774	-193,733	11,151	0	4,762	0	0	0
2015	0	-77,549	-87,385	1,313	54,676	-91,693	10,951	0	6,279	0	0	0
2016	0	-28,273	-90,193	0	53,365	-48,877	9,455	0	6,768	0	0	0
1990-2016 Average	**0**	**-81,682**	**-51,713**	**1,240**	**53,154**	**-84,067**	**-3,961**	**0**	**-1,118**	**0**	**0**	**0**
1998-2010 Average	**0**	**-40,039**	**-41,782**	**1,284**	**46,360**	**-47,080**	**-5,830**	**0**	**-7,075**	**0**	**0**	**0**



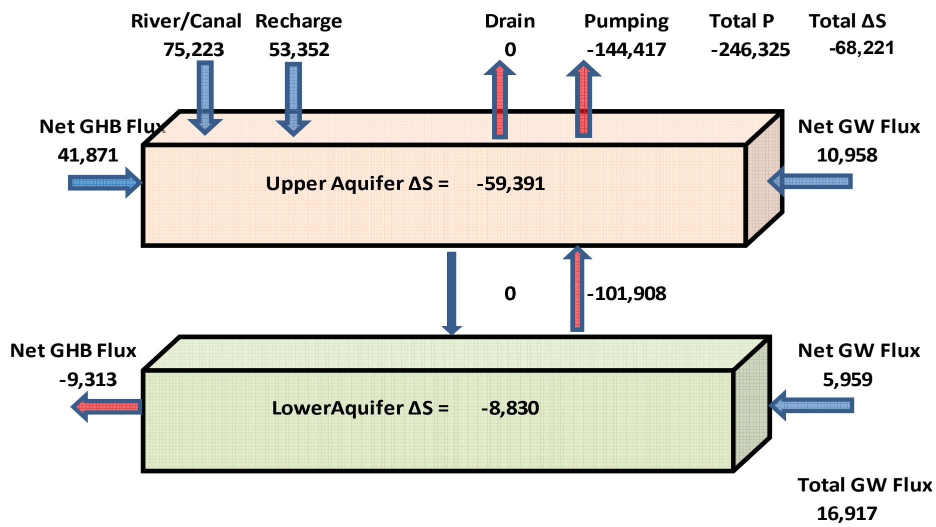




Groundwater Mass Balance
Westside Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

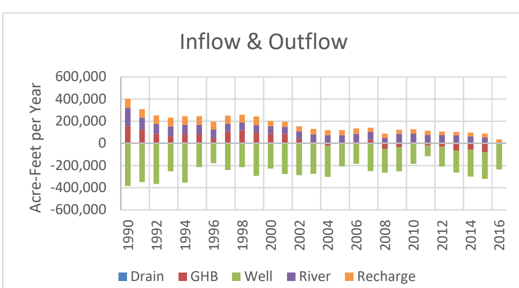
By: dmb	Date: 12/15/19	Project No.: FR18161220
		Figure **D5-5**

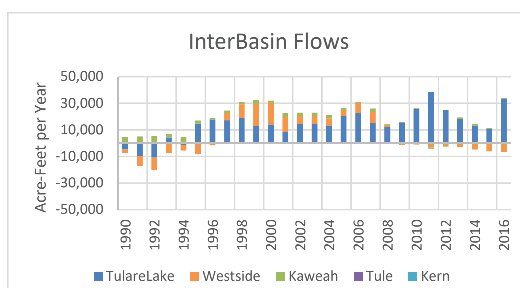
1990-2016
Average Groundwater Balance
Kings SB

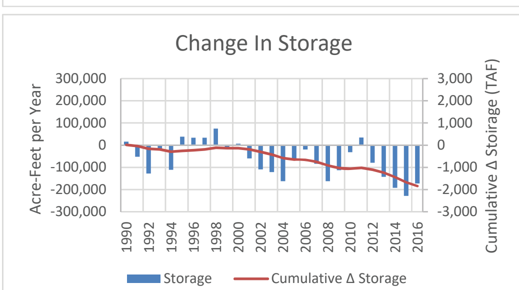


1990 - 2016
Kings Subbasin

TulareLake Date	Net Drain	Net GHB	Net Well	Net River	Net Recharge	Net Storage	Interbasin TulareLake	Interbasin Westside	Interbasin Kings	Interbasin Kaweah	Interbasin Tule	Interbasin Kern
1990	0	153,507	-384,337	169,046	79,741	15,208	-4,815	-2,518	0	4,504	0	0
1991	0	124,539	-348,796	107,577	75,776	-53,100	-9,747	-7,580	0	5,048	0	0
1992	0	85,636	-366,658	91,057	76,643	-128,172	-10,812	-9,334	0	5,220	0	0
1993	0	63,444	-251,847	90,672	77,740	-20,149	4,219	-7,293	0	2,874	0	0
1994	0	82,944	-355,512	83,133	78,922	-111,410	-1,210	-4,416	0	4,642	0	0
1995	0	84,637	-215,315	82,151	77,734	38,072	14,724	-8,215	0	2,339	0	0
1996	0	48,223	-178,362	77,072	68,853	32,844	17,826	-1,651	0	873	0	0
1997	0	107,723	-241,638	70,229	72,279	33,073	17,146	5,501	0	1,803	0	0
1998	0	118,175	-214,567	69,924	69,494	74,029	18,649	10,476	0	1,860	0	0
1999	0	96,736	-292,444	67,565	78,859	-16,762	12,823	16,531	0	3,100	0	0
2000	0	85,919	-227,760	68,455	47,204	5,842	14,008	16,069	0	1,936	0	0
2001	0	82,301	-277,276	67,448	45,197	-59,687	8,208	11,392	0	2,987	0	0
2002	0	38,507	-286,933	68,043	47,651	-109,739	14,310	5,977	0	2,634	0	0
2003	0	10,551	-275,240	72,558	47,606	-121,577	14,505	6,025	0	2,345	0	0
2004	0	-19,464	-283,587	72,500	46,386	-162,951	13,320	5,288	0	2,545	0	0
2005	0	-4,898	-203,108	72,979	47,504	-61,361	20,418	4,750	0	976	0	0
2006	0	13,674	-184,500	72,546	47,592	-19,644	22,451	7,942	0	614	0	0
2007	0	32,310	-250,493	70,241	37,723	-84,139	14,948	8,423	0	2,632	0	0
2008	0	-50,566	-214,765	49,586	38,416	-162,941	12,181	1,697	0	463	0	0
2009	0	-33,972	-217,422	85,755	37,471	-113,549	15,575	-1,497	0	479	0	0
2010	0	9,787	-185,133	78,260	39,636	-32,243	25,818	-1,094	0	459	0	0
2011	0	-17,920	-97,073	75,380	39,597	34,158	38,331	-3,219	0	-966	0	0
2012	0	-29,573	-179,351	74,885	31,796	-79,785	25,065	-2,358	0	-281	0	0
2013	0	-64,621	-198,165	72,788	30,437	-143,078	18,283	-2,894	0	1,051	0	0
2014	0	-57,537	-243,399	63,777	34,247	-193,050	13,313	-4,762	0	1,243	0	0
2015	0	-79,762	-242,398	55,138	32,307	-229,309	10,641	-6,279	0	958	0	0
2016	0	-1,216	-234,685	2,254	33,689	-172,561	33,115	-6,768	0	944	0	0
1990-2016 Average	**0**	**32,559**	**-246,325**	**75,223**	**53,352**	**-68,221**	**13,826**	**1,118**	**0**	**1,973**	**0**	**0**
1998-2010 Average	**0**	**29,159**	**-239,479**	**70,451**	**48,518**	**-66,517**	**15,939**	**7,075**	**0**	**1,771**	**0**	**0**



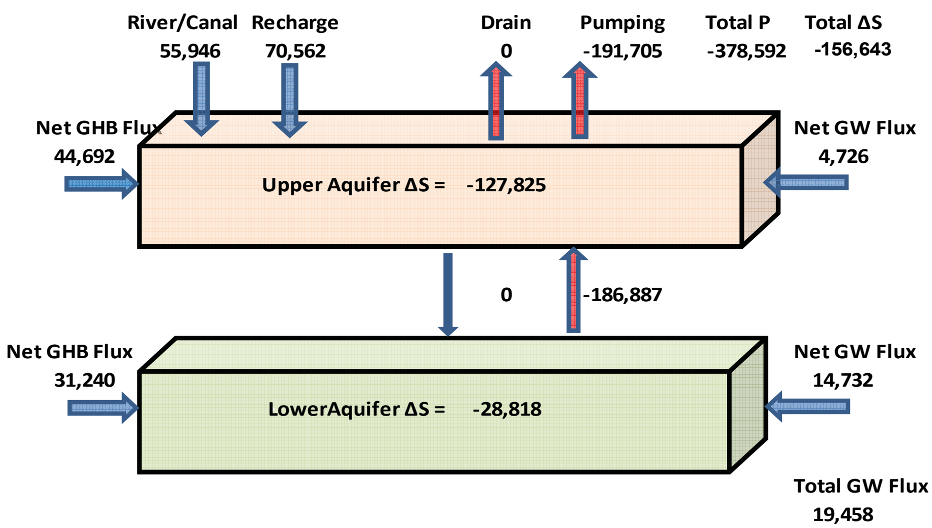




Groundwater Mass Balance
Kings Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

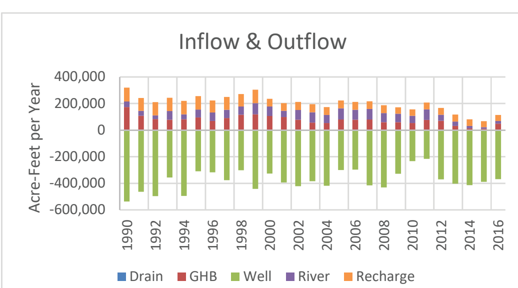
By: dmb	Date: 12/15/19	Project No.: FR18161220
		Figure **D5-6**

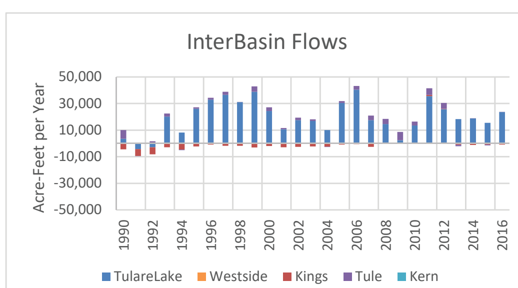
1990-2016
Average Groundwater Balance
Kaweah SB

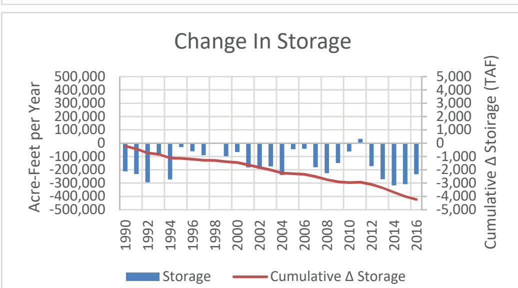


1990 - 2016
Kaweah Subbasin

TulareLake Date	Net Drain	Net GHB	Net Well	Net River	Net Recharge	Net Storage	Interbasin TulareLake	Interbasin Westside	Interbasin Kings	Interbasin Kaweah	Interbasin Tule	Interbasin Kern
1990	0	172,831	-537,159	42,496	103,609	-212,649	3,467	0	-4,504	0	6,568	0
1991	0	107,583	-463,728	36,764	96,709	-232,084	-4,376	0	-5,048	0	-11	0
1992	0	81,651	-497,528	29,290	99,060	-294,105	-2,987	0	-5,220	0	1,542	0
1993	0	77,286	-356,606	66,092	99,049	-94,514	20,133	0	-2,874	0	2,383	0
1994	0	80,902	-495,185	37,053	102,172	-272,016	8,114	0	-4,642	0	-549	0
1995	0	94,932	-309,662	59,838	100,083	-30,023	26,071	0	-2,339	0	1,054	0
1996	0	68,503	-317,375	63,686	91,031	-60,703	32,867	0	-873	0	1,443	0
1997	0	89,438	-377,453	63,327	96,295	-91,317	36,466	0	-1,803	0	2,354	0
1998	0	114,652	-301,969	63,291	92,691	-2,106	31,067	0	-1,860	0	22	0
1999	0	118,216	-442,308	84,491	100,527	-99,162	38,853	0	-3,100	0	4,070	0
2000	0	106,502	-327,865	70,296	58,536	-67,290	24,256	0	-1,936	0	2,897	0
2001	0	97,263	-394,189	48,197	57,101	-182,971	10,602	0	-2,987	0	972	0
2002	0	78,197	-422,360	72,804	61,265	-193,353	17,484	0	-2,634	0	1,815	0
2003	0	56,243	-384,827	77,120	60,606	-175,029	16,849	0	-2,345	0	1,236	0
2004	0	53,353	-419,713	60,149	59,185	-239,862	9,952	0	-2,545	0	-308	0
2005	0	78,649	-300,204	85,039	59,441	-46,176	30,344	0	-976	0	1,502	0
2006	0	77,866	-298,321	74,806	59,613	-43,395	40,403	0	-614	0	2,795	0
2007	0	79,789	-415,842	79,484	57,284	-180,937	17,451	0	-2,632	0	3,492	0
2008	0	58,458	-431,763	68,344	60,460	-226,521	14,428	0	-463	0	4,003	0
2009	0	58,932	-329,201	63,510	48,642	-150,022	2,407	0	-479	0	6,147	0
2010	0	52,112	-234,294	55,673	48,421	-62,200	13,379	0	-459	0	2,962	0
2011	0	76,346	-216,915	79,408	50,989	31,298	35,573	0	966	0	4,929	0
2012	0	70,075	-370,148	45,029	50,752	-173,616	25,720	0	281	0	4,380	0
2013	0	31,050	-403,265	33,241	51,860	-270,970	18,315	0	-1,051	0	-1,157	0
2014	0	12,193	-415,074	18,863	49,171	-317,311	18,684	0	-1,243	0	26	0
2015	0	9,525	-390,330	11,544	46,175	-309,136	15,502	0	-958	0	-619	0
2016	0	47,596	-368,704	20,716	44,451	-233,187	23,497	0	-944	0	174	0
1990-2016 Average	**0**	**75,931**	**-378,592**	**55,946**	**70,562**	**-156,643**	**19,427**	**0**	**-1,973**	**0**	**2,005**	**0**
1998-2010 Average	**0**	**79,249**	**-361,758**	**69,477**	**63,367**	**-128,386**	**20,575**	**0**	**-1,771**	**0**	**2,431**	**0**



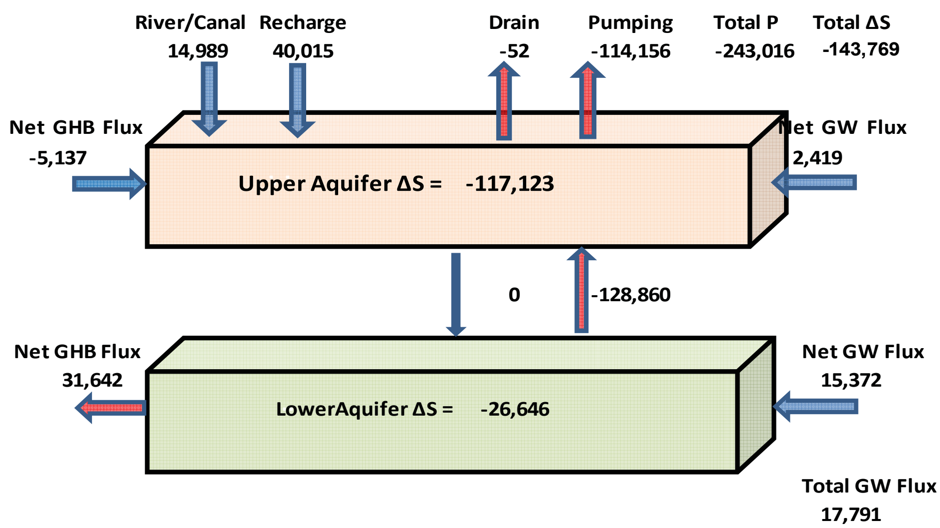




Groundwater Mass Balance
Kaweah Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

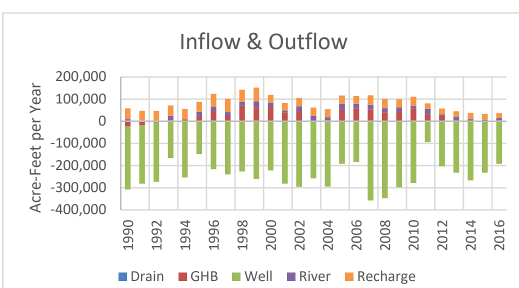
By: dmb	Date: 12/15/19	Project No.: FR18161220
		Figure **D5-7**

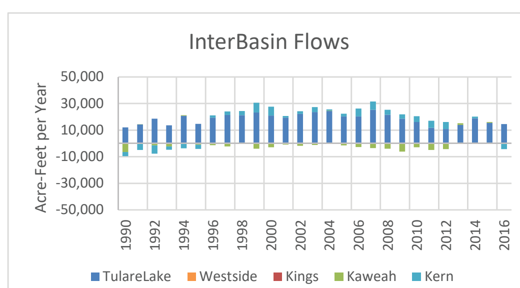
1990-2016
Average Groundwater Balance
Tule SB

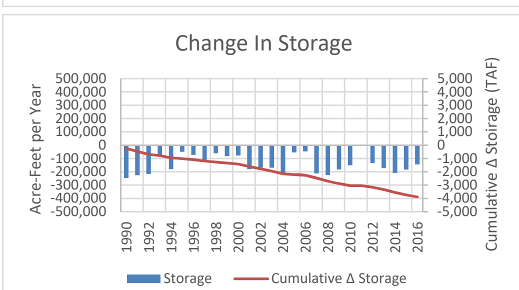


1990 - 2016
Tule Subbasin

TulareLake Date	Net Drain	Net GHB	Net Well	Net River	Net Recharge	Net Storage	Interbasin TulareLake	Interbasin Westside	Interbasin Kings	Interbasin Kaweah	Interbasin Tule	Interbasin Kern
1990	0	-23,566	-284,555	9,618	48,228	-247,845	12,024	0	0	-6,568	0	-3,025
1991	0	-18,667	-263,398	3,449	43,409	-225,953	14,187	0	0	11	0	-4,946
1992	0	-5,300	-268,690	684	45,275	-217,174	18,583	0	0	-1,542	0	-6,183
1993	0	4,326	-165,862	20,019	46,394	-86,494	13,496	0	0	-2,383	0	-2,484
1994	0	7,958	-253,837	0	46,982	-181,434	20,670	0	0	549	0	-3,757
1995	0	25,307	-148,402	16,882	44,943	-50,717	14,705	0	0	-1,054	0	-3,098
1996	0	45,820	-216,603	19,552	57,888	-73,711	19,334	0	0	-1,443	0	1,739
1997	0	23,106	-239,747	18,382	59,597	-116,961	21,396	0	0	-2,354	0	2,659
1998	0	68,956	-227,472	17,741	54,979	-61,553	21,177	0	0	-22	0	3,087
1999	-94	62,510	-260,854	27,404	61,127	-83,406	23,234	0	0	-4,070	0	7,338
2000	-82	63,667	-221,821	19,580	35,921	-78,068	20,878	0	0	-2,897	0	6,685
2001	-43	40,136	-282,286	7,462	34,734	-180,420	19,402	0	0	-972	0	1,148
2002	-77	45,471	-295,718	21,943	36,975	-169,024	22,160	0	0	-1,815	0	2,037
2003	-143	785	-257,704	23,994	36,852	-170,227	23,580	0	0	-1,236	0	3,644
2004	-88	3,599	-294,831	14,519	35,955	-215,230	24,296	0	0	308	0	1,012
2005	-174	52,654	-191,897	26,378	36,973	-55,320	20,294	0	0	-1,502	0	1,954
2006	-151	57,771	-184,092	20,669	35,792	-46,574	20,192	0	0	-2,795	0	6,040
2007	-209	51,182	-357,542	22,998	43,001	-212,594	25,274	0	0	-3,492	0	6,196
2008	-143	40,599	-347,405	18,133	42,686	-224,920	21,584	0	0	-4,003	0	3,628
2009	-103	46,193	-297,514	16,553	36,625	-182,508	18,590	0	0	-6,147	0	3,296
2010	-36	58,280	-279,500	10,122	41,904	-151,840	16,097	0	0	-2,962	0	4,255
2011	-58	32,131	-94,078	23,936	24,249	-1,823	11,696	0	0	-4,929	0	5,231
2012	-13	25,701	-203,630	4,825	26,348	-135,064	10,775	0	0	-4,380	0	5,310
2013	0	3,110	-232,680	16,090	25,641	-173,089	13,933	0	0	1,157	0	-340
2014	0	505	-266,921	8,515	28,447	-209,336	18,842	0	0	-26	0	1,301
2015	0	-1,136	-231,535	6,160	26,210	-184,562	15,383	0	0	619	0	-262
2016	0	4,541	-192,869	9,100	23,267	-145,904	14,438	0	0	-174	0	-4,209
1990-2016 Average	**-52**	**26,505**	**-243,016**	**14,989**	**40,015**	**-143,769**	**18,379**	**0**	**0**	**-2,005**	**0**	**1,417**
1998-2010 Average	**-103**	**45,523**	**-269,126**	**19,038**	**41,040**	**-140,899**	**21,289**	**0**	**0**	**-2,431**	**0**	**3,871**



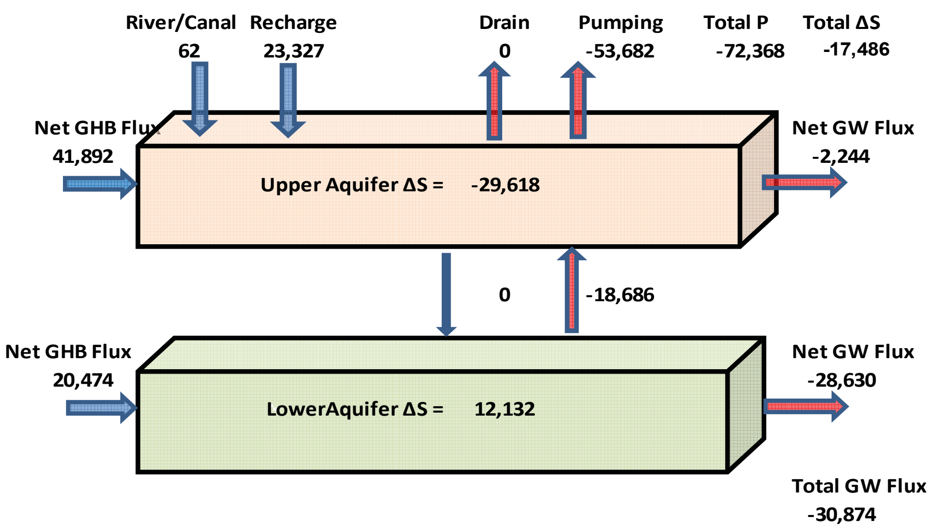




Groundwater Mass Balance
Tule Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

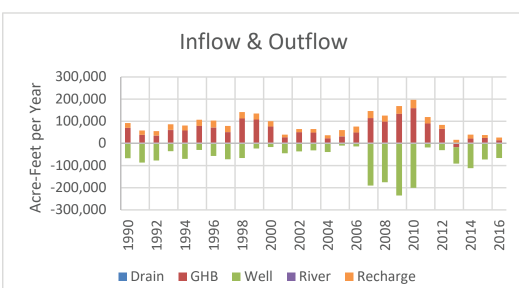
By: dmb	Date: 12/15/19	Project No.: FR18161220
		Figure **D5-8**

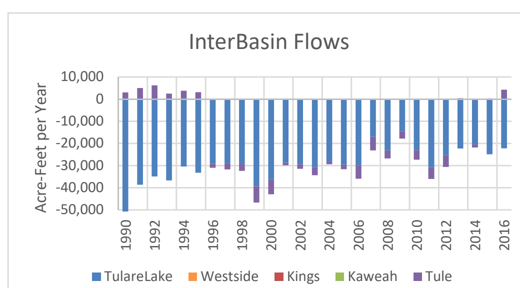
1990-2016
Average Groundwater Balance
Kern SB

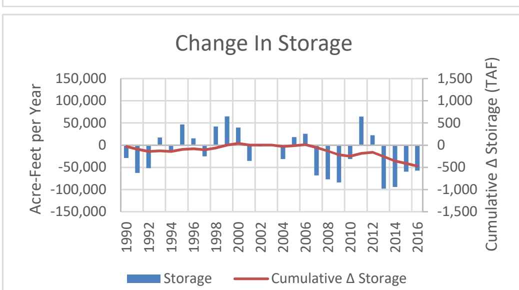


1990 - 2016
Kern Subbasin

TulareLake Date	Net Drain	Net GHB	Net Well	Net River	Net Recharge	Net Storage	Interbasin TulareLake	Interbasin Westside	Interbasin Kings	Interbasin Kaweah	Interbasin Tule	Interbasin Kern
1990	0	69,796	-67,231	0	22,116	-29,265	-56,971	0	0	0	3,025	0
1991	0	38,262	-87,211	0	20,006	-62,690	-38,693	0	0	0	4,946	0
1992	0	34,064	-77,917	187	20,626	-51,761	-34,904	0	0	0	6,183	0
1993	0	60,245	-35,270	185	26,026	16,935	-36,736	0	0	0	2,484	0
1994	0	57,842	-69,714	0	22,828	-15,712	-30,426	0	0	0	3,757	0
1995	0	78,149	-30,062	185	28,292	46,446	-33,217	0	0	0	3,098	0
1996	0	70,592	-56,706	187	31,895	14,979	-29,250	0	0	0	-1,739	0
1997	0	50,141	-72,084	185	28,287	-25,219	-29,090	0	0	0	-2,659	0
1998	0	111,858	-66,609	185	28,908	41,894	-29,362	0	0	0	-3,087	0
1999	0	107,107	-23,290	0	27,767	64,863	-39,384	0	0	0	-7,338	0
2000	0	75,337	-17,088	187	24,123	39,596	-36,279	0	0	0	-6,685	0
2001	0	27,538	-44,901	0	11,757	-35,545	-28,791	0	0	0	-1,148	0
2002	0	50,642	-36,158	0	13,888	-3,114	-29,448	0	0	0	-2,037	0
2003	0	48,468	-31,250	0	16,522	-652	-30,749	0	0	0	-3,644	0
2004	0	22,793	-39,107	0	14,192	-31,550	-28,416	0	0	0	-1,012	0
2005	0	30,314	-10,054	185	29,176	17,940	-29,728	0	0	0	-1,954	0
2006	0	48,548	-13,906	185	26,744	25,637	-29,895	0	0	0	-6,040	0
2007	0	114,520	-190,698	0	31,175	-68,188	-16,990	0	0	0	-6,196	0
2008	0	97,862	-175,605	0	27,362	-77,200	-23,191	0	0	0	-3,628	0
2009	0	133,803	-235,193	0	34,866	-84,347	-14,527	0	0	0	-3,296	0
2010	0	159,358	-200,492	0	36,801	-31,667	-23,078	0	0	0	-4,255	0
2011	0	89,684	-18,947	0	29,513	64,180	-30,840	0	0	0	-5,231	0
2012	0	65,311	-30,394	0	17,679	21,988	-25,299	0	0	0	-5,310	0
2013	0	-18,128	-73,820	0	15,969	-97,943	-22,304	0	0	0	340	0
2014	0	21,647	-111,701	0	17,652	-94,232	-20,529	0	0	0	-1,301	0
2015	0	24,001	-72,531	0	13,114	-60,141	-24,986	0	0	0	262	0
2016	0	14,125	-65,994	0	12,550	-57,368	-22,257	0	0	0	4,209	0
1990-2016 Average	**0**	**62,366**	**-72,368**	**62**	**23,327**	**-17,486**	**-29,457**	**0**	**0**	**0**	**-1,417**	**0**
1998-2010 Average	**0**	**79,088**	**-83,412**	**57**	**24,868**	**-10,949**	**-27,680**	**0**	**0**	**0**	**-3,871**	**0**

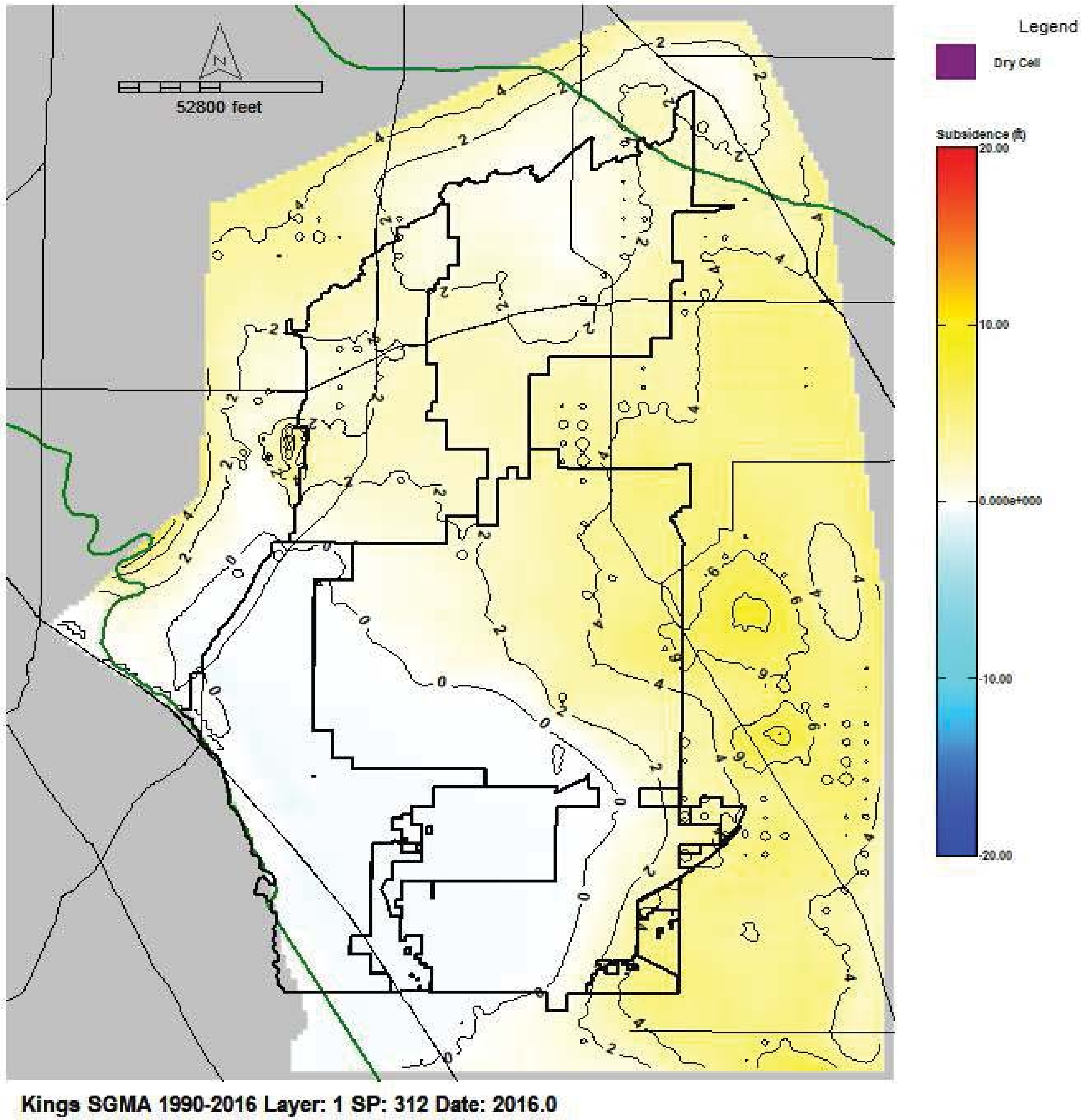






Groundwater Mass Balance
Kern Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/15/19	Project No.: FR18161220
		Figure **D5-9**



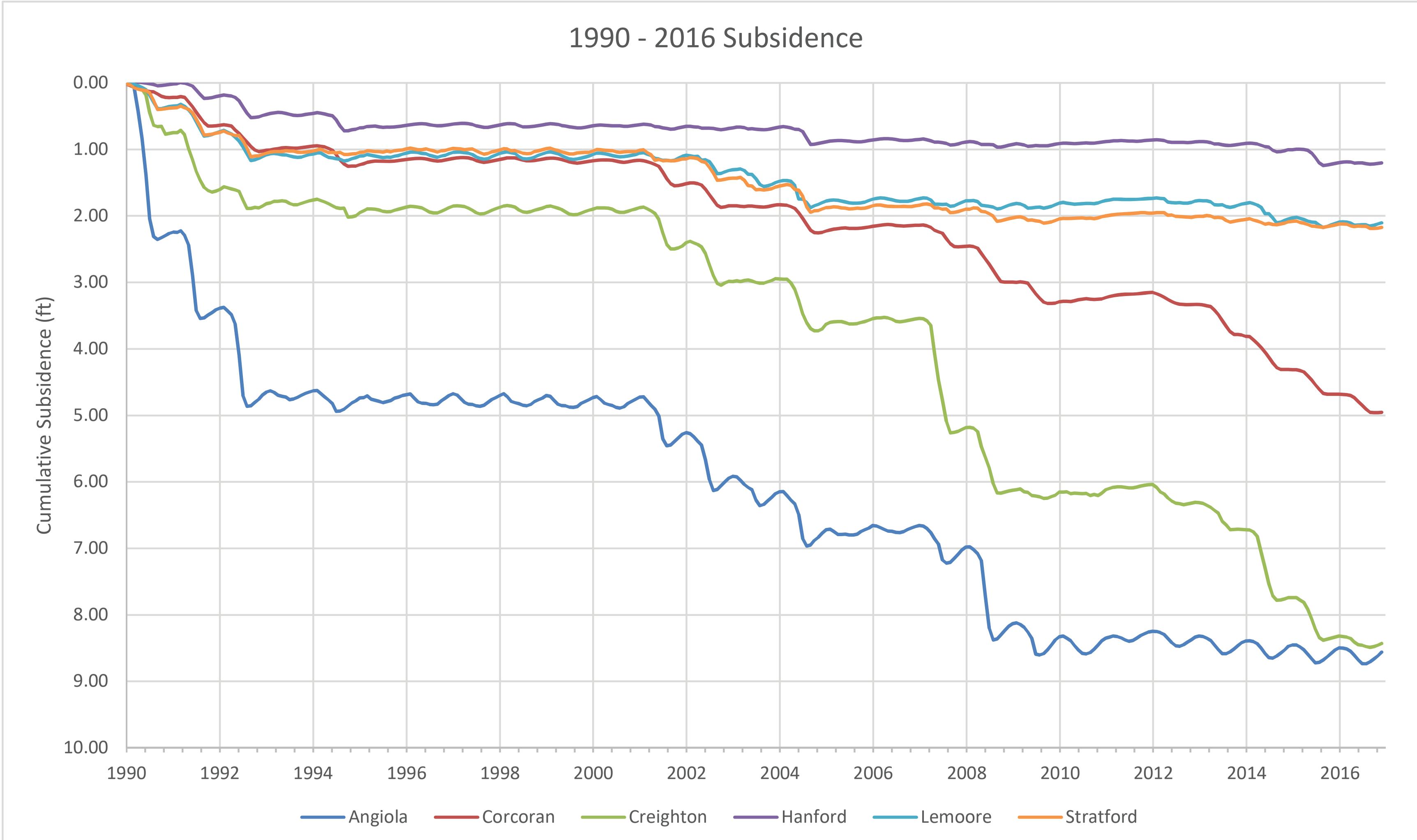
Simulated Subsidence 1990-2015

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

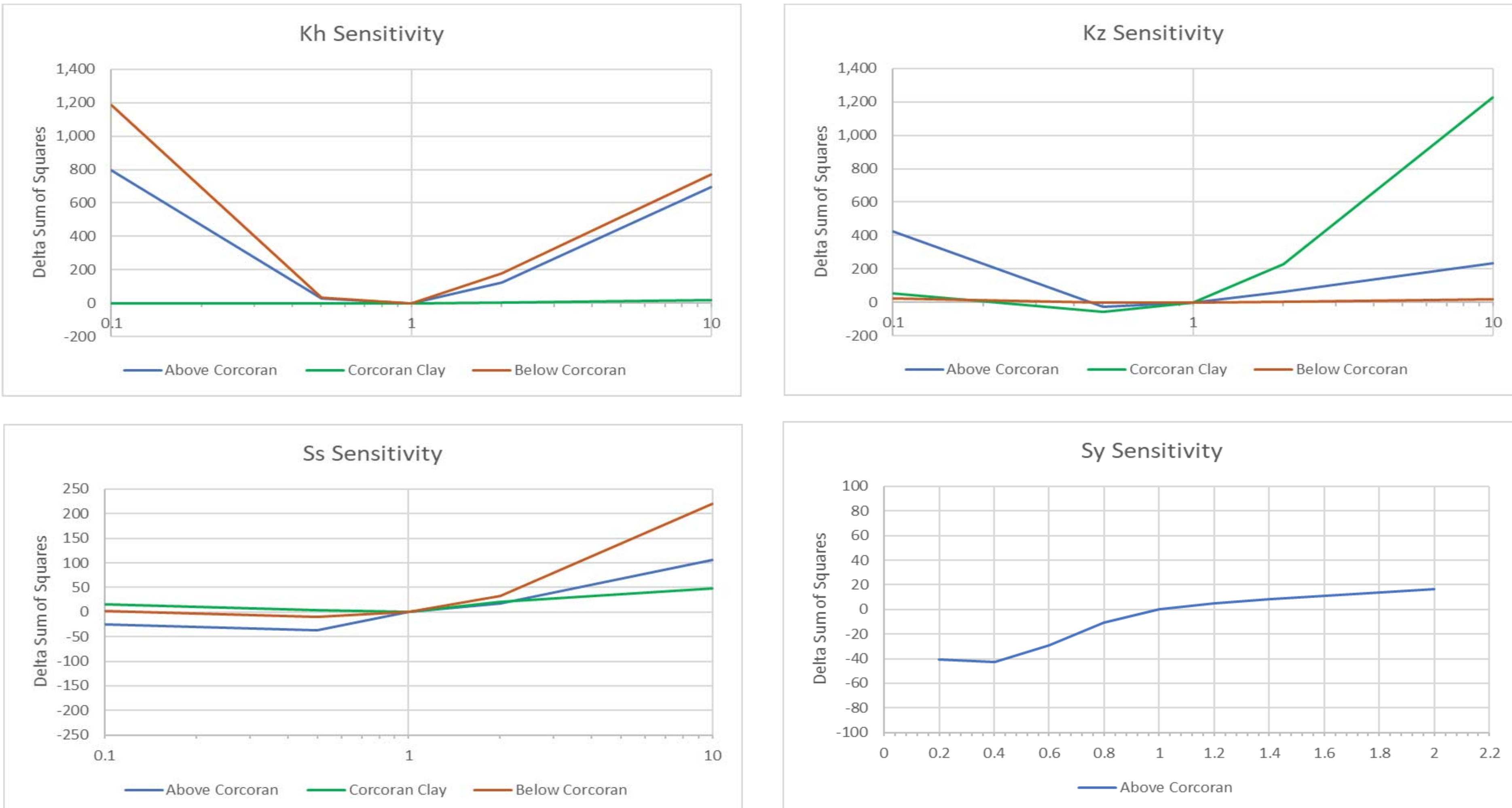
By: dmb	Date: 12/12/19	Project No.: FR18161220
		Figure **D5-10**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D5-11 Sub Hydrographs



Simulated Cumulative Subsidence
Municipal and Agricultural Well Field
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/12/19	Project No.: FR18161220
		Figure **D5-11**

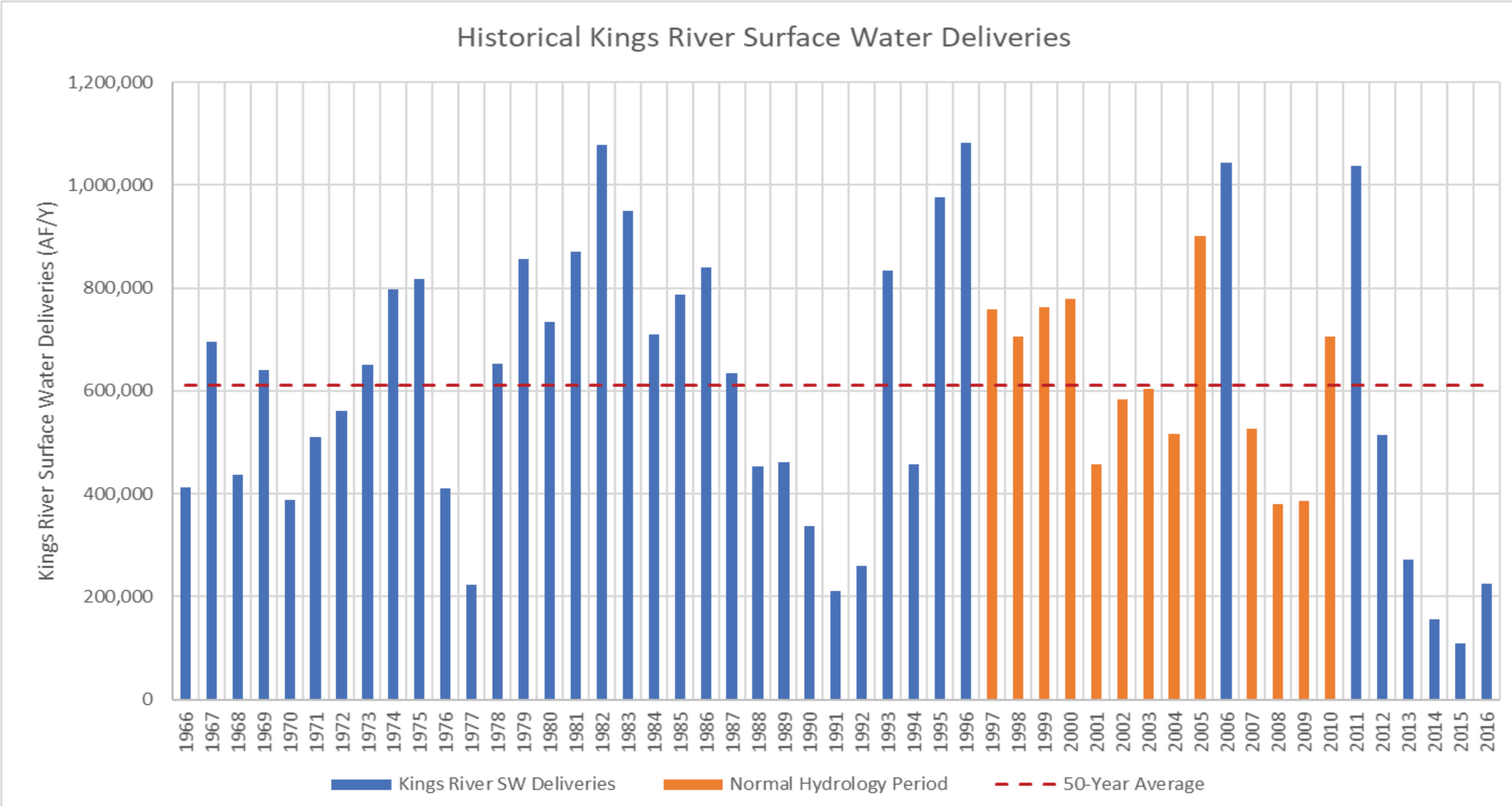


Model Hydraulic Parameter Sensitivity Anlysis

Tulare Lake Subbasin SGMA Model
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D6-1**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D7-1 Normal Kings Hydrology

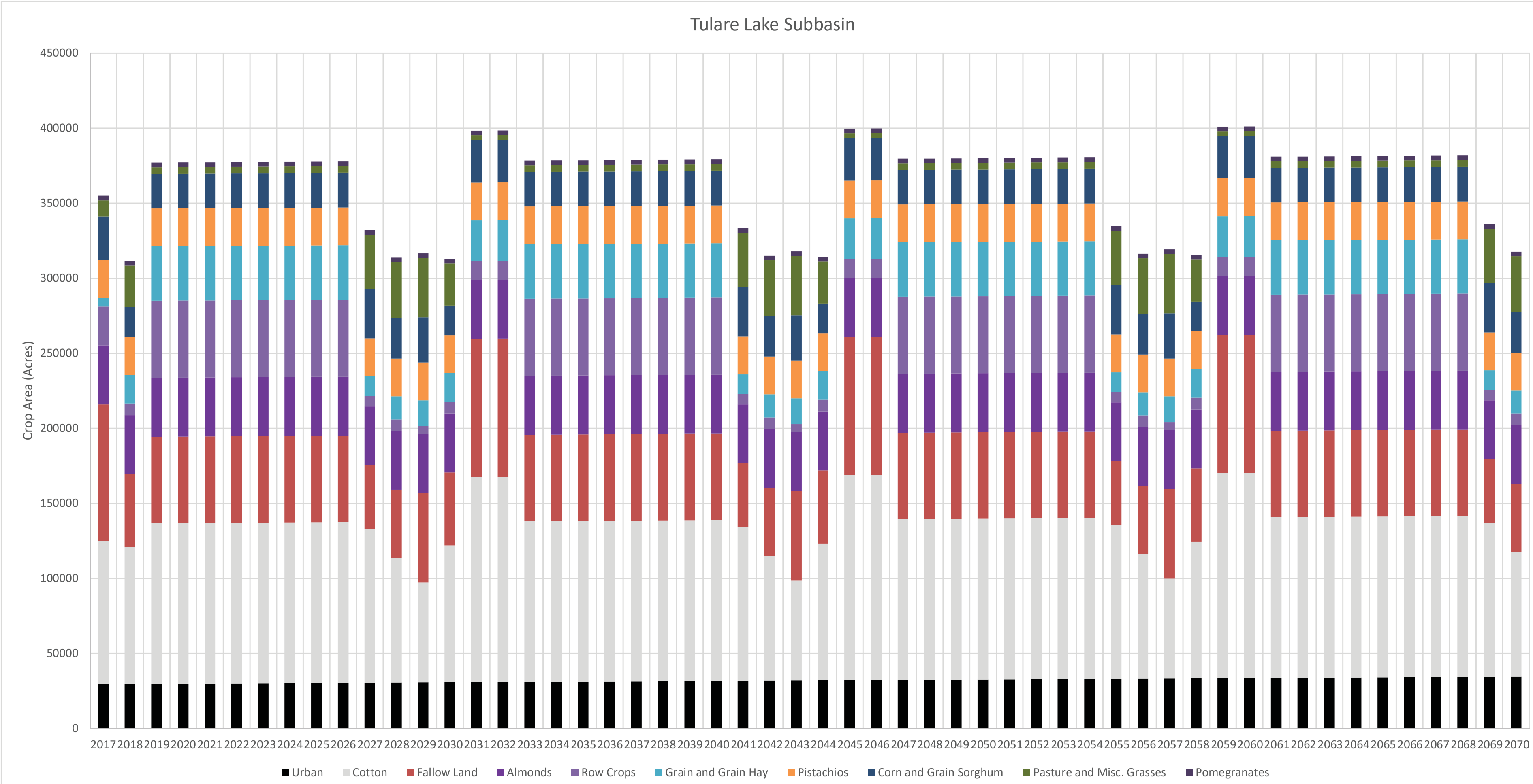


Note: Normal hydrologic cycle included 199[illegible] instead of 2006 to match the 50-year average

Historical Kings River Surface Water Deliveries with Normal Hydrology

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

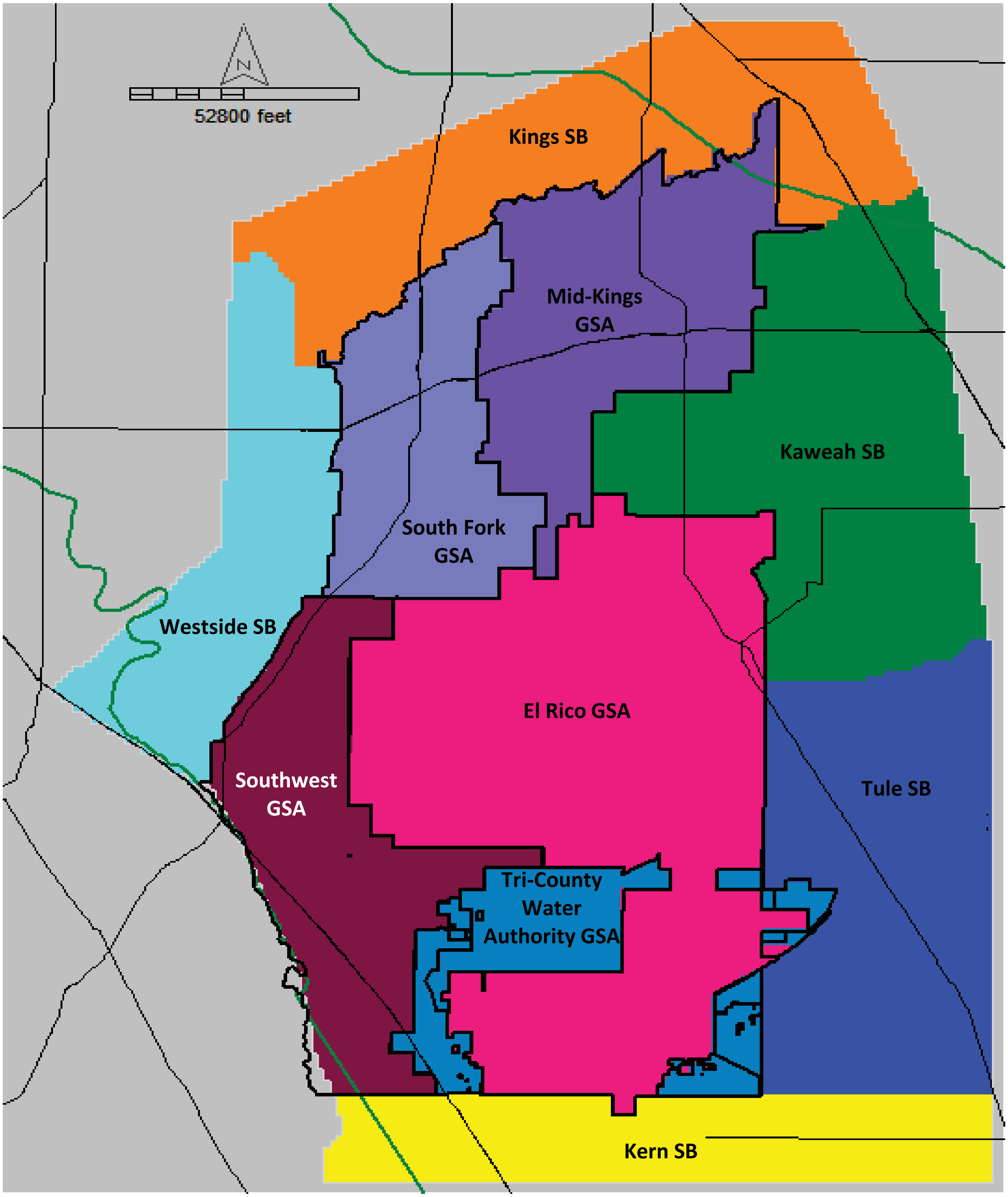
By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure D[illegible]



2017-2070 Baseline Forecast
Crop Acerage

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/12/2019	Project No.: FR18161220
	Figure	**D7-2**



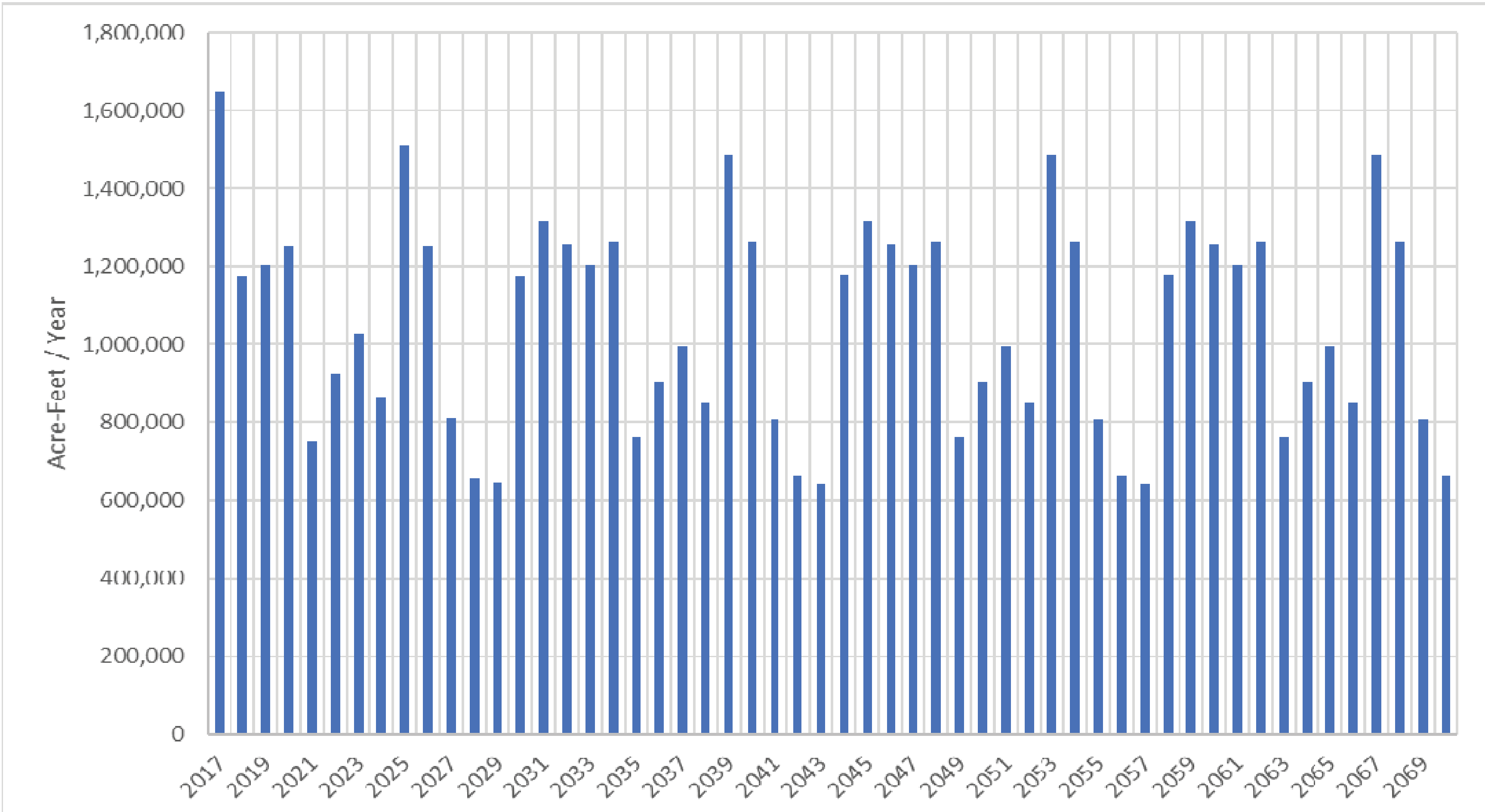
Forecast Model Service Areas

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: dmb	Date: 12/12/19	Project No.: FR18161220
		Figure **D7-3**

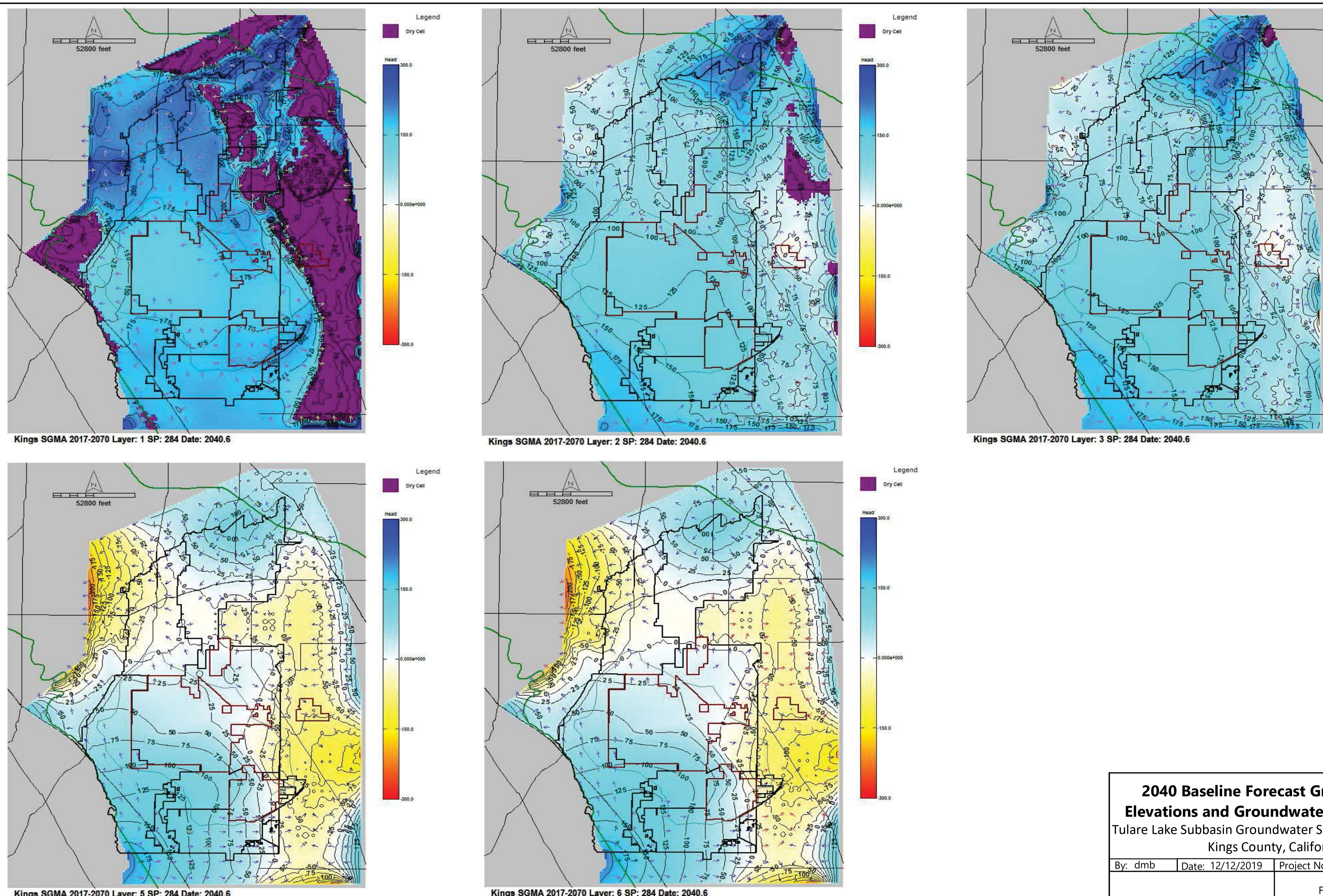
I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D7-4 Baseline SWD CNRA



2017-2070 Baseline Forecast of Surface Water Deliveries with CNRA

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-4**



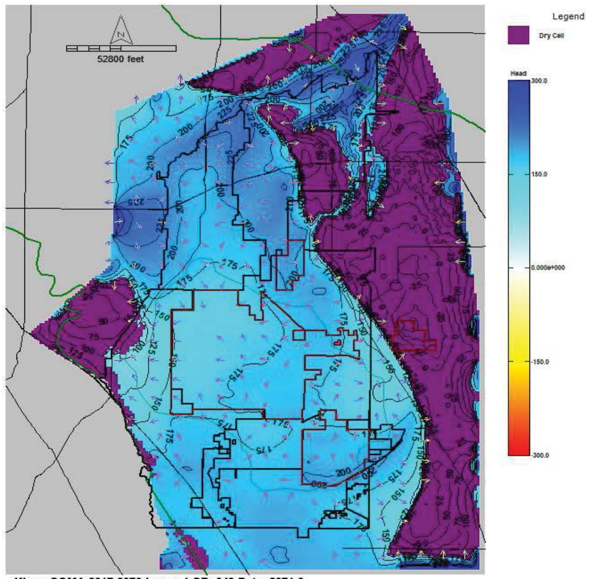
2040 Baseline Forecast Groundwater Elevations and Groundwater Flow Vectors

Tulare Lake Subbasin Groundwater Sustainability Plan

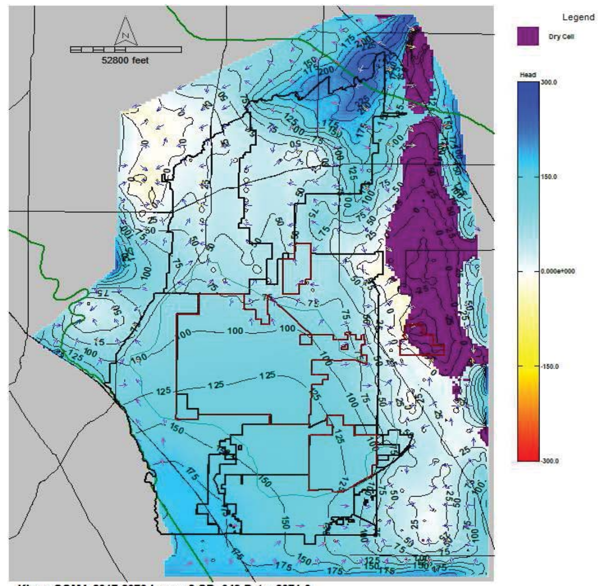
Kings County, California

By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-5a**

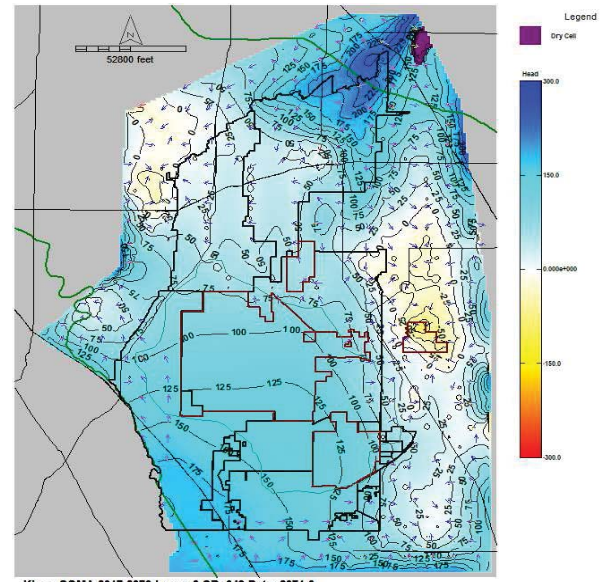
I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFigD7-5b 2070 Baseline Potentio 12/19/2019



Kings SGMA 2017-2070 Layer: 1 SP: 649 Date: 2071.0



Kings SGMA 2017-2070 Layer: 2 SP: 649 Date: 2071.0



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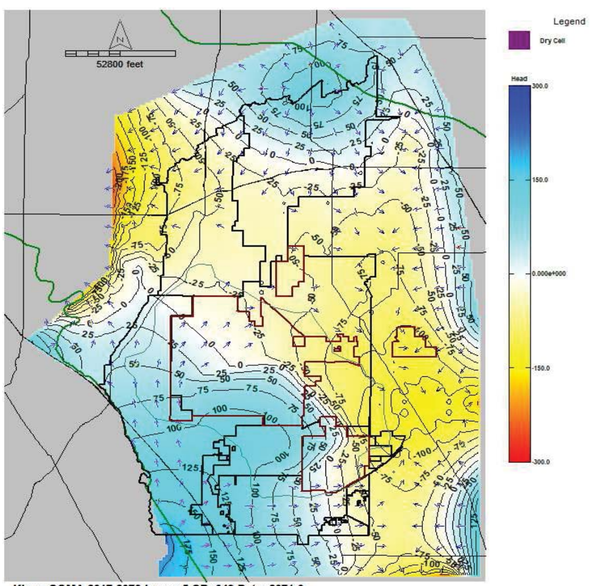
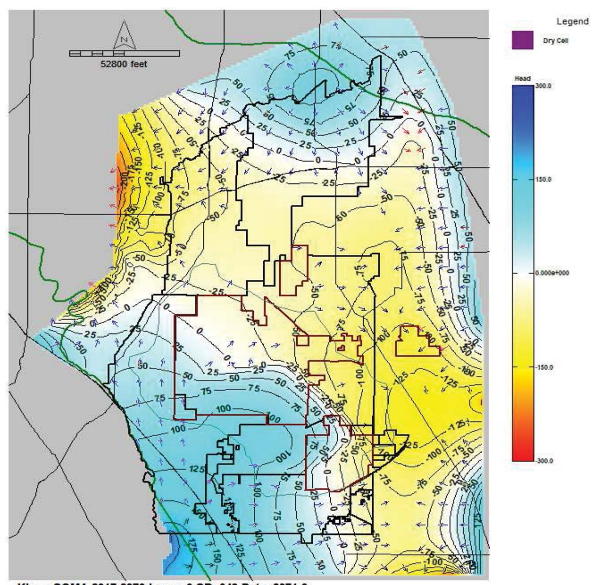


Kings SGMA 2017-2070 Layer: 5 SP: 649 Date: 2071.0



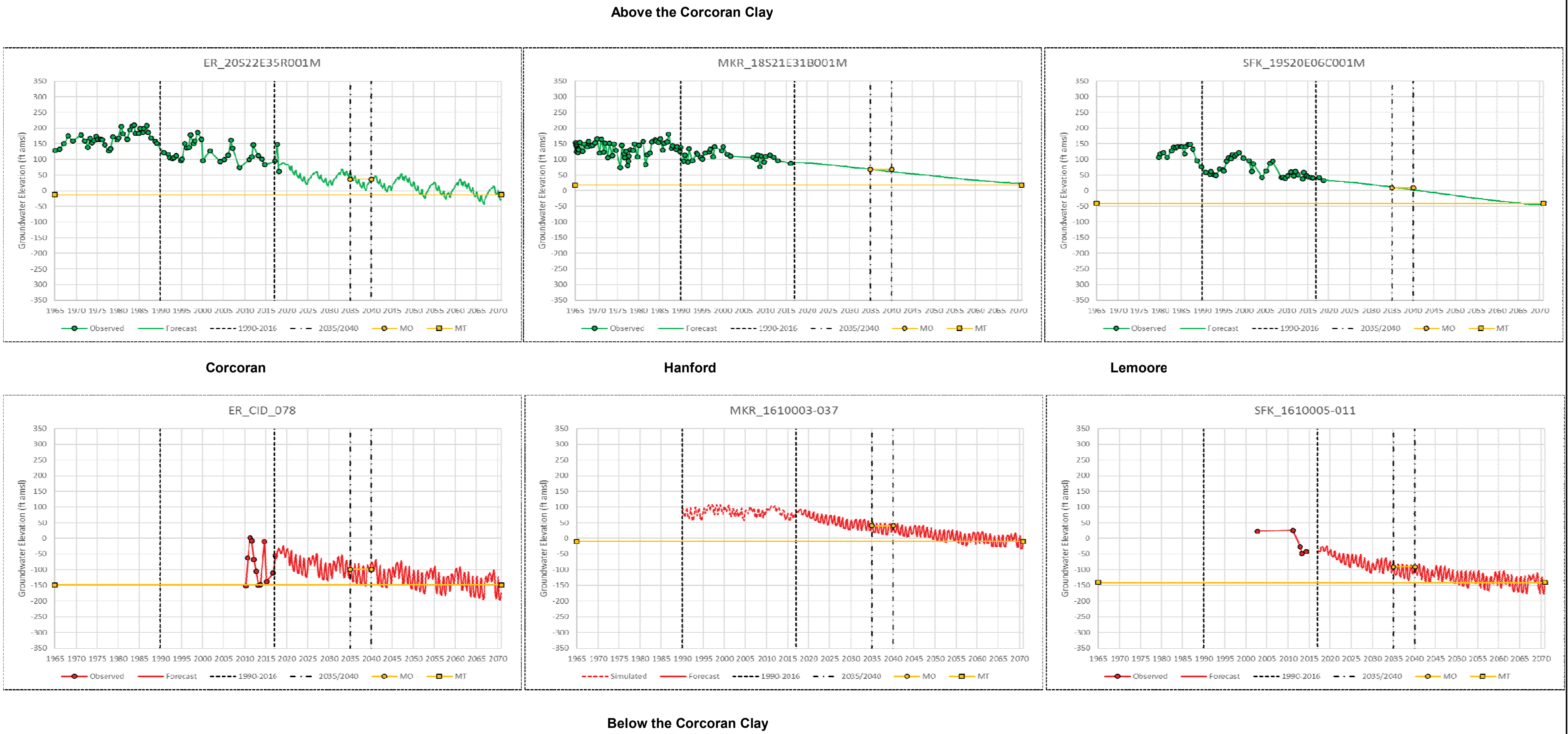
Kings SGMA 2017-2070 Layer: 6 SP: 649 Date: 2071.0

2070 Baseline Forecast Groundwater Elevations and Groundwater Flow Vectors

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-5b**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D7-6 Baseline Hydros 12/19/2019

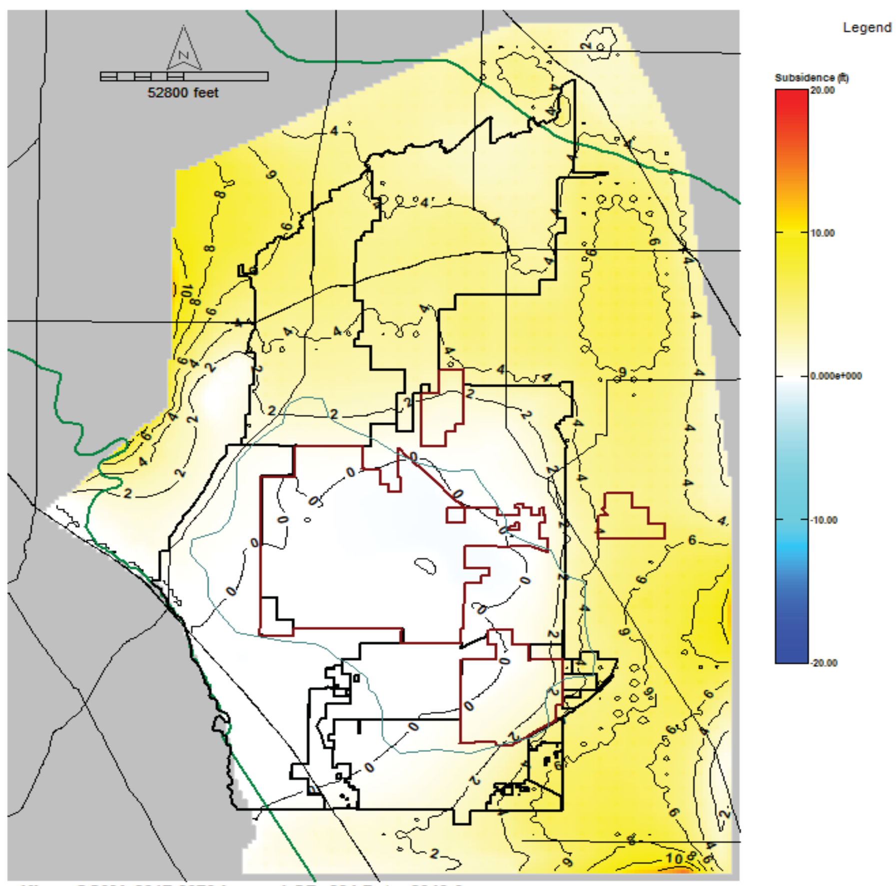


Baseline Forecast Hydrographs for Selected Compliance Wells

Tulare Lake Subbasin Groundwater Sustainability Plan

Kings County, California

By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-6**



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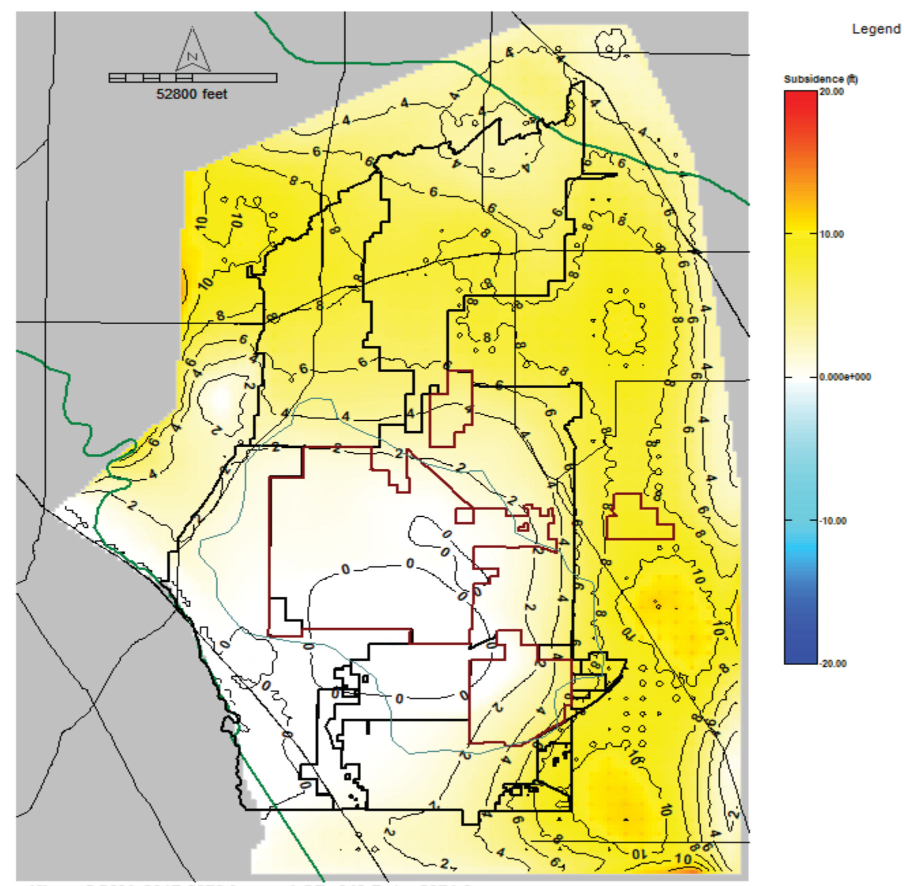
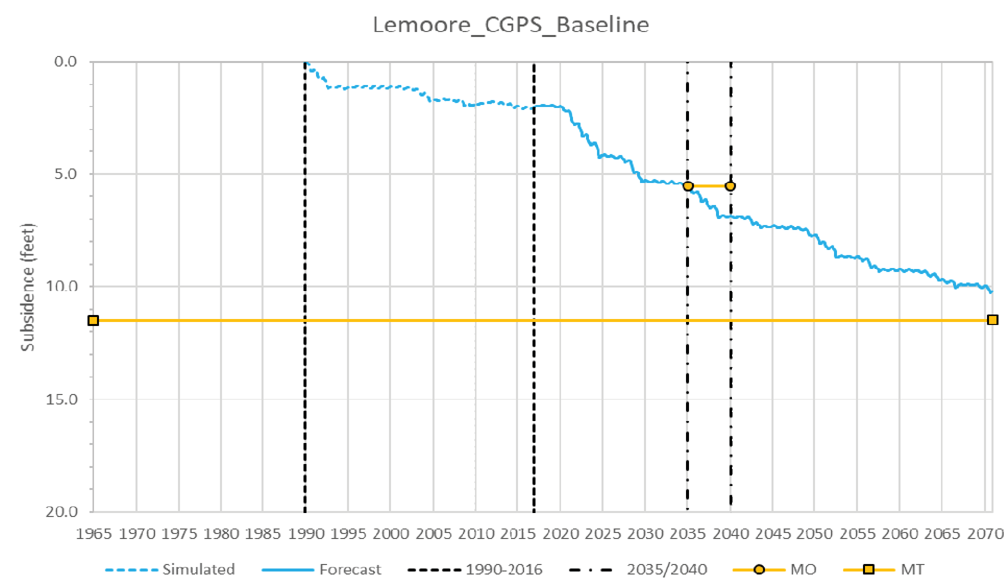


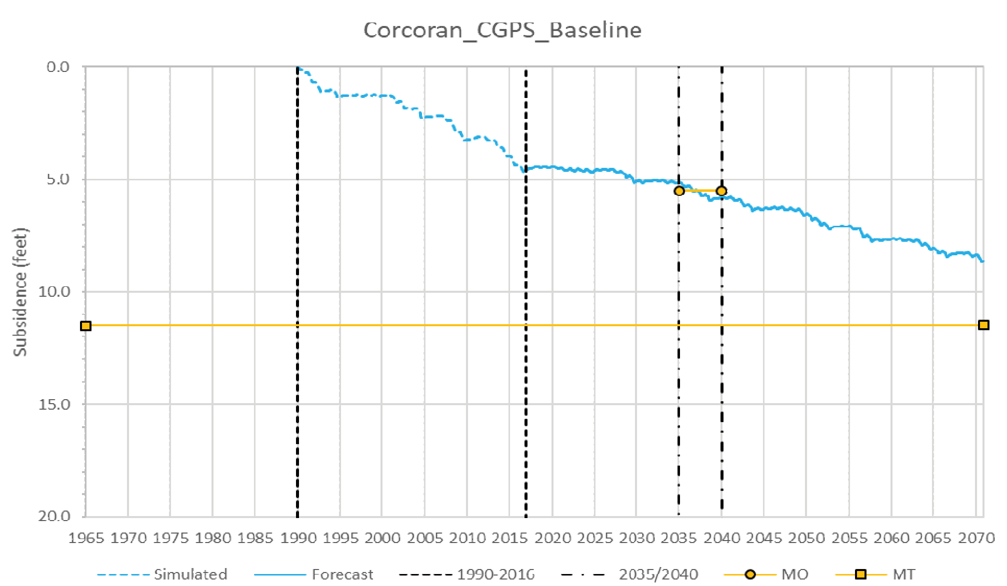
Kings SGMA 2017-2070 Layer: 1 SP: 649 Date: 2071.0

Cumulative Subsidence Since 2017
Baseline Forecast 2040 and 2070
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-7**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D7-8 BaselineSub Hydrograph

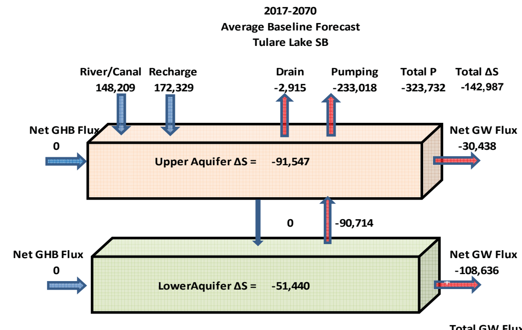




Baseline Forecast Cumulative Subsidence Compliance Monitoring Points

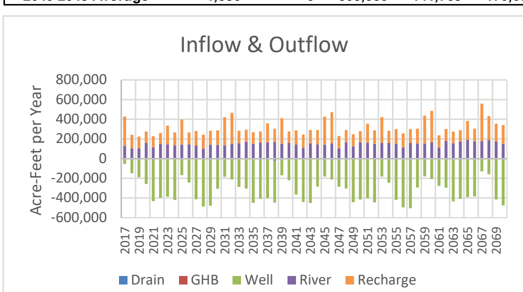
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

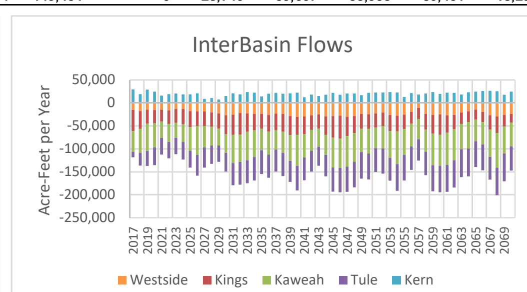
By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-8**

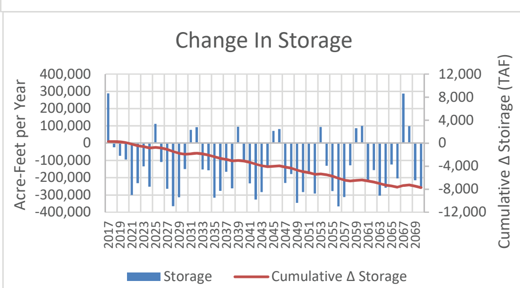


2017 - 2070
Tulare Lake Subbasin

TulareLake Date	Net Drain	Net GHB	Net Well	Net River	Net Recharge	Net Storage	Interbasin TulareLake	Interbasin Westside	Interbasin Kings	Interbasin Kaweah	Interbasin Tule	Interbasin Kern
2017	-3,292	0	-50,431	129,387	298,093	287,496	0	-15,464	-46,141	-45,027	-11,808	29,206
2018	-750	0	-148,570	103,459	138,862	-24,232	0	-17,988	-38,795	-51,760	-28,153	18,718
2019	-396	0	-188,615	104,781	118,404	-74,022	0	-15,131	-29,903	-59,520	-32,928	28,989
2020	-1,210	0	-257,766	157,370	117,021	-95,284	0	-15,775	-29,008	-52,335	-38,614	24,297
2021	-2,134	0	-431,121	113,552	113,998	-301,058	0	-14,764	-25,890	-35,441	-36,496	15,557
2022	-9,578	0	-389,656	148,571	110,833	-232,720	0	-16,726	-29,434	-38,896	-35,732	18,943
2023	-9,797	0	-377,216	144,092	191,118	-135,035	0	-13,681	-29,968	-32,679	-35,692	20,379
2024	-9,276	0	-411,385	134,798	130,845	-252,348	0	-13,684	-33,320	-37,721	-38,735	18,554
2025	-9,008	0	-159,588	141,173	253,920	111,310	0	-17,983	-35,252	-50,832	-36,944	18,440
2026	-9,295	0	-234,658	143,339	121,516	-109,828	0	-18,531	-31,998	-62,773	-45,480	20,936
2027	-3,084	0	-411,439	132,425	148,658	-264,518	0	-18,810	-31,605	-46,647	-44,056	8,731
2028	-4,347	0	-482,752	101,674	139,826	-365,116	0	-20,740	-31,663	-40,554	-40,011	10,437
2029	-6,207	0	-473,450	141,914	140,738	-313,258	0	-22,944	-33,514	-36,563	-35,540	7,245
2030	-5,243	0	-300,946	136,633	150,653	-150,025	0	-27,132	-41,551	-40,361	-40,522	14,791
2031	-1,757	0	-183,915	134,735	285,585	76,477	0	-25,861	-44,113	-61,335	-48,021	20,901
2032	-2,659	0	-210,461	147,907	316,900	92,627	0	-22,307	-46,545	-59,821	-49,298	18,382
2033	-6,860	0	-282,130	156,810	126,029	-152,839	0	-23,116	-40,010	-61,887	-49,937	23,404
2034	-3,818	0	-300,116	169,446	122,795	-157,549	0	-23,758	-36,466	-58,144	-50,904	22,083
2035	-8,633	0	-441,194	147,758	120,698	-315,937	0	-23,778	-32,290	-47,258	-51,696	13,843
2036	-2,844	0	-407,576	162,808	113,725	-277,090	0	-26,818	-35,974	-49,950	-50,780	19,653
2037	-6,973	0	-393,826	164,766	193,473	-165,962	0	-23,577	-36,481	-41,818	-47,739	21,758
2038	-23,724	0	-423,714	170,466	133,975	-261,844	0	-23,777	-39,306	-46,292	-50,188	20,025
2039	-8,671	0	-162,253	150,468	261,073	94,885	0	-28,683	-41,620	-56,396	-45,765	20,788
2040	-8,057	0	-212,170	157,556	119,233	-106,996	0	-30,546	-39,238	-67,365	-53,540	21,850
2041	-5,104	0	-361,502	144,072	142,798	-233,348	0	-29,977	-38,432	-50,504	-49,720	12,021
2042	-2,748	0	-438,341	110,385	133,689	-327,522	0	-27,427	-31,574	-45,003	-45,971	18,233
2043	-1,965	0	-450,808	154,853	135,856	-283,322	0	-25,454	-30,918	-39,388	-41,293	15,057
2044	0	0	-285,516	142,901	148,782	-136,357	0	-29,141	-40,661	-43,988	-46,473	17,555
2045	0	0	-183,727	141,152	284,955	70,430	0	-29,079	-46,558	-65,167	-52,607	21,462
2046	0	0	-211,949	154,734	316,279	81,644	0	-27,918	-50,088	-63,422	-53,666	17,673
2047	0	0	-285,777	102,969	125,867	-230,338	0	-30,204	-42,632	-66,180	-54,785	20,405
2048	0	0	-305,758	167,267	123,023	-179,098	0	-28,919	-36,899	-62,428	-55,825	20,440
2049	0	0	-444,243	125,538	120,150	-346,793	0	-24,332	-31,416	-51,824	-57,332	16,661
2050	0	0	-415,786	163,797	114,030	-283,289	0	-25,029	-31,754	-53,927	-56,321	21,685
2051	0	0	-404,556	159,642	194,042	-178,887	0	-23,093	-30,523	-44,967	-51,903	22,394
2052	0	0	-446,277	150,374	135,694	-291,833	0	-21,035	-29,966	-48,316	-54,946	22,494
2053	0	0	-183,305	159,180	263,059	93,063	0	-26,612	-35,116	-58,392	-49,382	23,630
2054	0	0	-244,986	159,110	123,386	-131,840	0	-28,062	-34,361	-71,317	-58,079	22,469
2055	0	0	-420,853	148,192	151,360	-277,705	0	-25,895	-31,453	-55,998	-55,894	12,657
2056	0	0	-496,998	114,335	140,360	-366,983	0	-19,449	-25,676	-50,048	-50,927	21,022
2057	0	0	-504,789	159,039	140,232	-312,851	0	-10,938	-24,080	-44,316	-46,355	17,853
2058	0	0	-294,759	152,165	150,384	-129,034	0	-24,334	-34,112	-48,062	-51,043	20,463
2059	0	0	-180,750	151,281	284,994	86,505	0	-26,011	-40,937	-68,809	-56,756	23,490
2060	0	0	-208,497	167,175	316,329	99,201	0	-25,369	-44,674	-67,186	-57,771	19,186
2061	0	0	-278,224	111,075	125,072	-214,084	0	-27,627	-37,207	-70,470	-58,722	21,985
2062	0	0	-295,518	179,447	121,650	-156,830	0	-26,398	-31,219	-67,227	-59,432	21,834
2063	0	0	-435,625	155,188	119,632	-304,744	0	-21,333	-24,539	-55,367	-60,737	17,855
2064	0	0	-410,660	176,101	112,798	-258,488	0	-18,537	-23,571	-57,476	-60,516	23,108
2065	0	0	-390,901	190,501	191,607	-124,017	0	-14,810	-21,614	-47,222	-56,154	24,170
2066	0	0	-385,749	175,809	126,968	-204,212	0	-19,675	-22,308	-48,698	-56,466	25,517
2067	0	0	-130,038	177,997	380,464	286,962	0	-27,089	-31,484	-59,206	-49,777	26,094
2068	0	0	-159,015	188,104	244,419	97,660	0	-29,769	-36,271	-75,275	-59,838	25,307
2069	0	0	-416,014	176,019	178,001	-215,012	0	-26,190	-25,091	-58,935	-60,557	17,413
2070	0	0	-475,674	149,023	191,903	-257,301	0	-24,047	-19,259	-51,309	-53,012	24,403
2017-2070 Average	**-2,915**	**0**	**-323,732**	**148,209**	**172,329**	**-142,987**	**0**	**-23,062**	**-34,157**	**-53,181**	**-48,534**	**19,860**
2040-2048 Average	**-1,986**	**0**	**-303,950**	**141,765**	**170,054**	**-149,434**	**0**	**-28,740**	**-39,667**	**-55,938**	**-50,431**	**18,299**

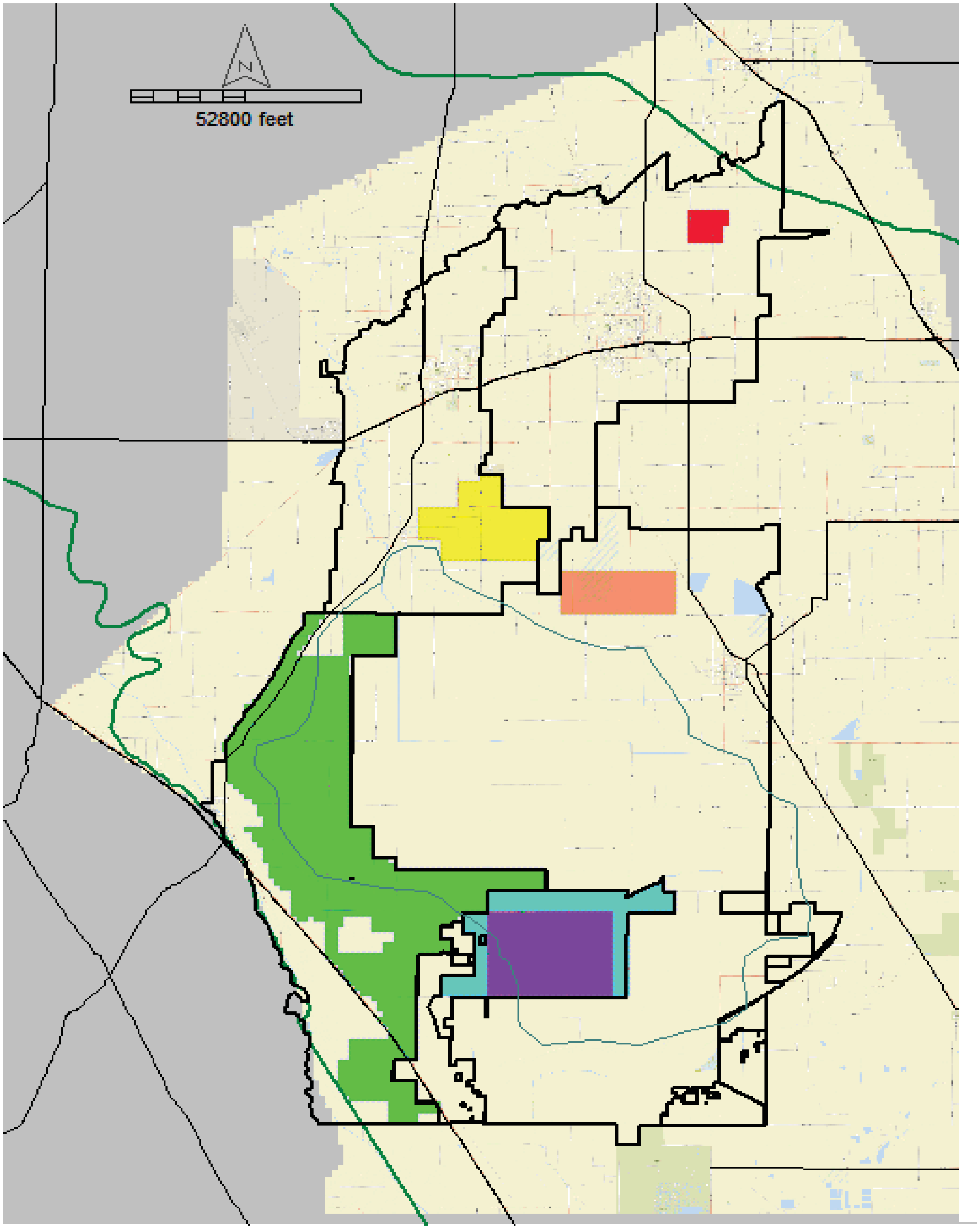






Baseline Forecast Groundwater
Mass Balance Tulare Lake Subbasin
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/15/19	Project No.: FR18161220
		Figure **D7-9**



Explanation

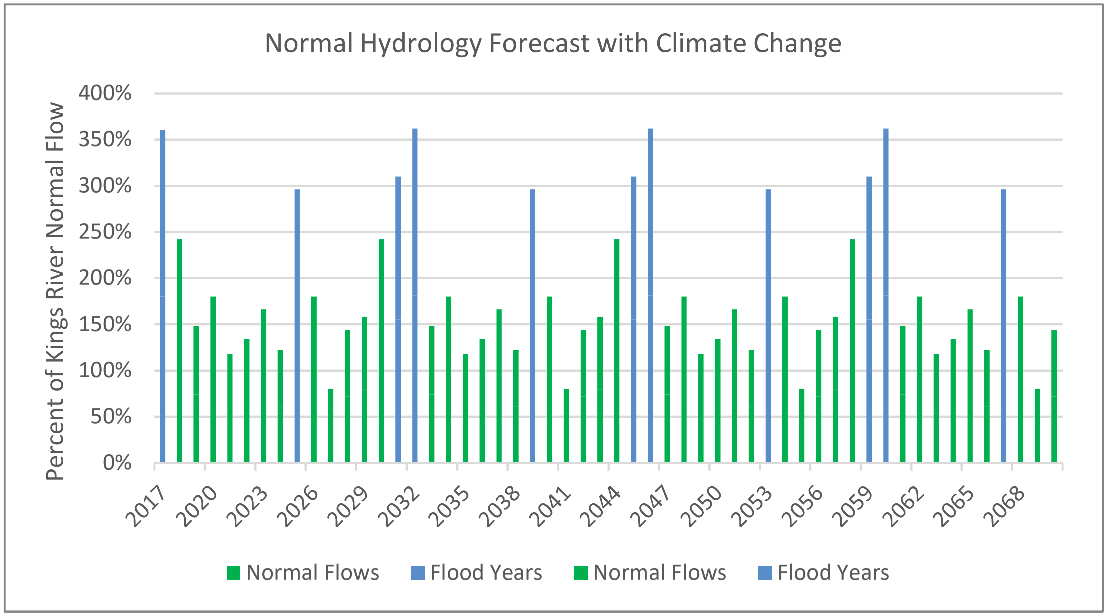
- Mid-Kings River GSA Intentional Recharge Basins
- El Rico GSA Intermittal Surface Water Storage Ponds
- South Fork Kings GSA Surface Water Storage Ponds
- TCWA GSA Surface Water Storage Ponds
- Southwest Kings GSA Land Fallowing
- TCWA GSA Land Fallowing

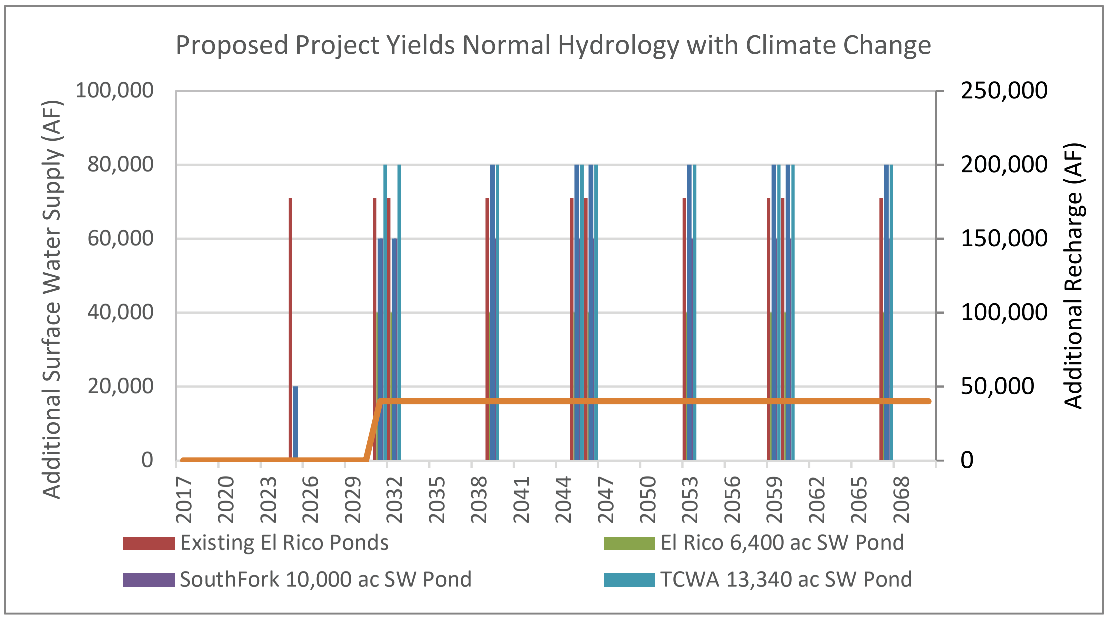
Forecast Project Areas

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D7-10**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D7-11 Project Yields



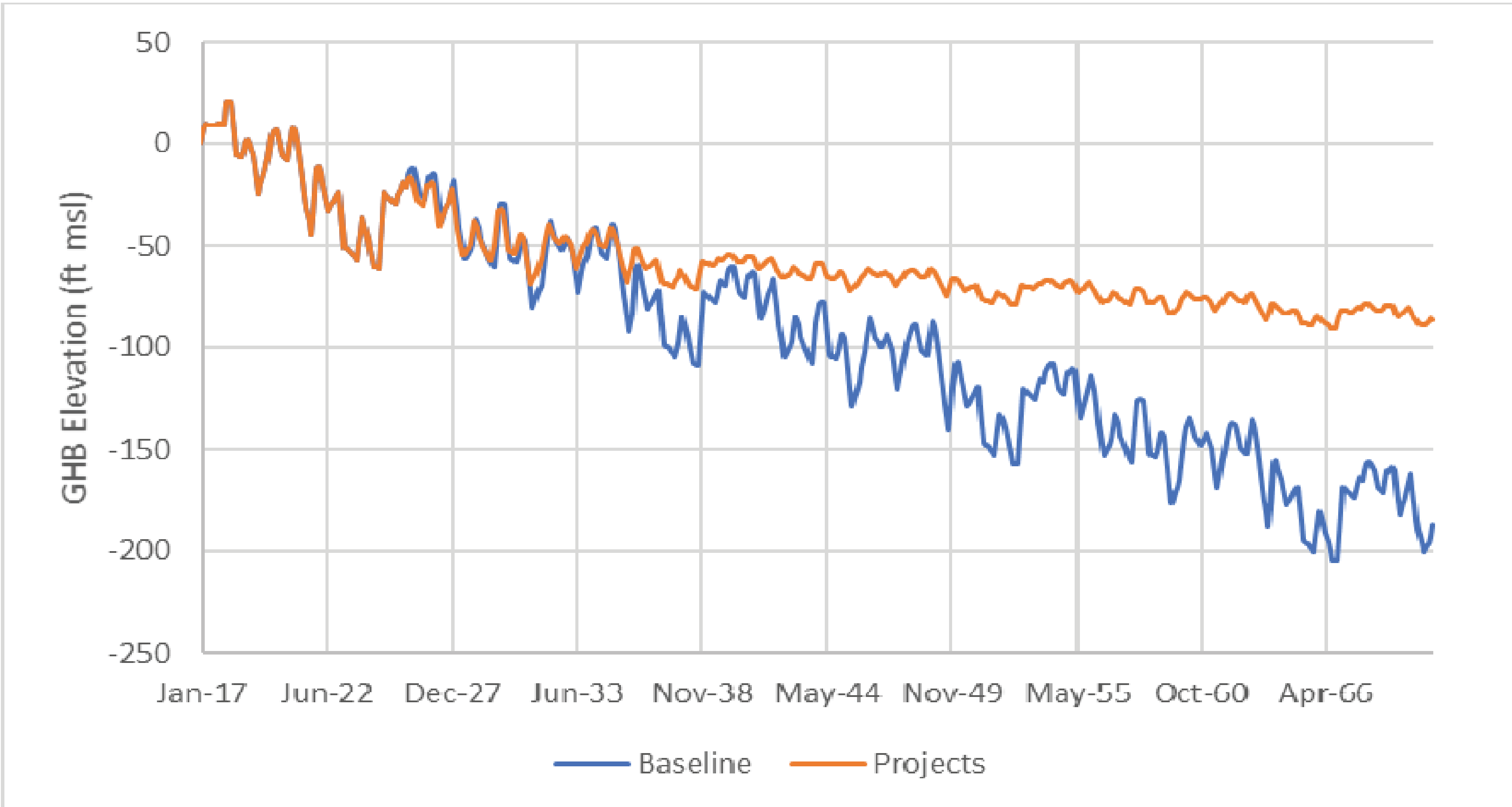


Project Forecast Flood Years and Project Performance

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D7-11**

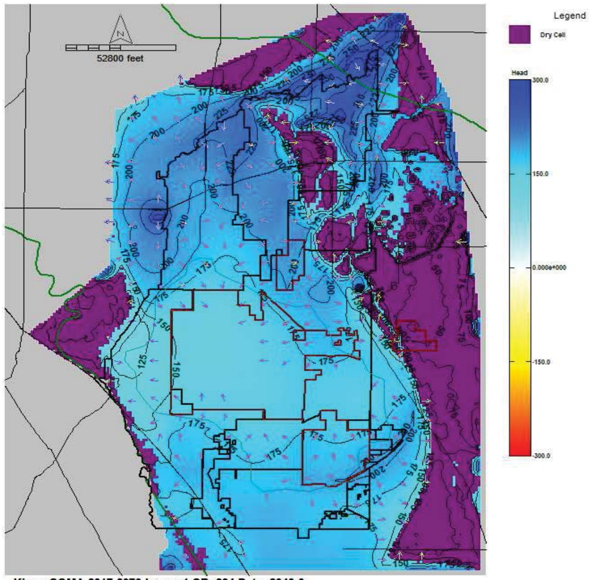
I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D7-12 Project GHBs



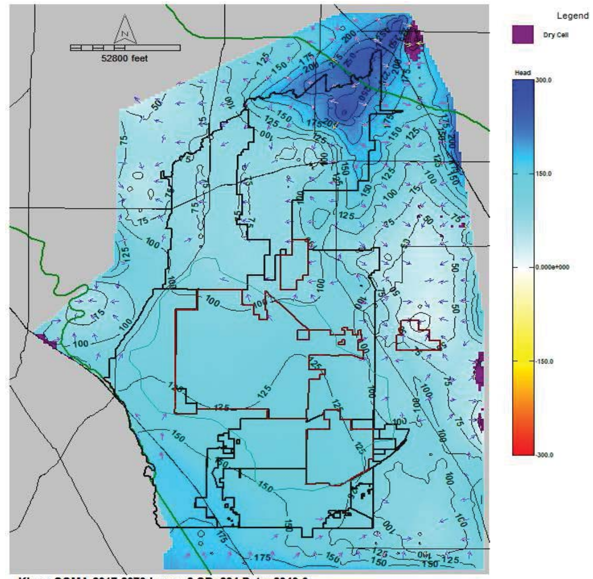
Project vs Baseline GHB Example
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 07/30/19	Project No.: FR18161220
		Figure **D7-12**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D7-13 2040 Projects Potento 12/19/2019



Kings SGMA 2017-2070 Layer: 1 SP: 284 Date: 2040.6



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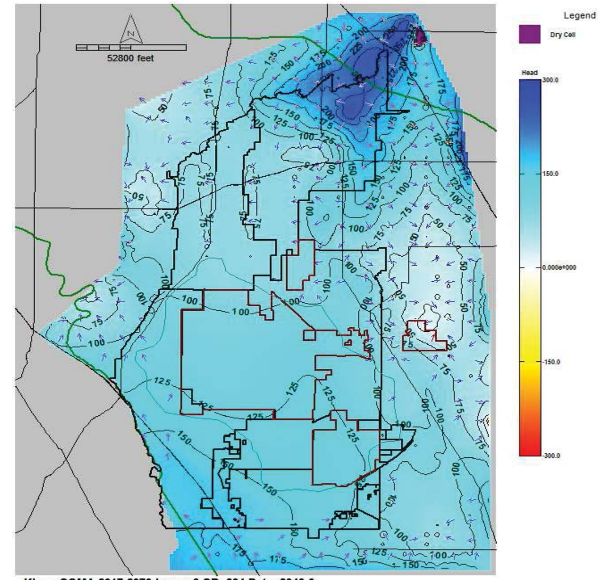

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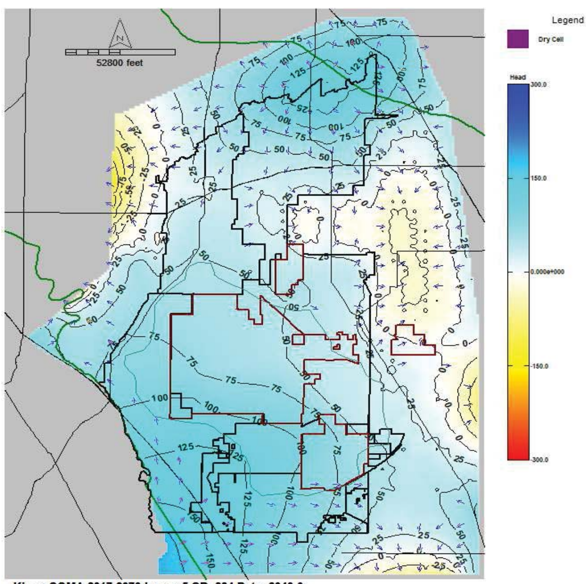

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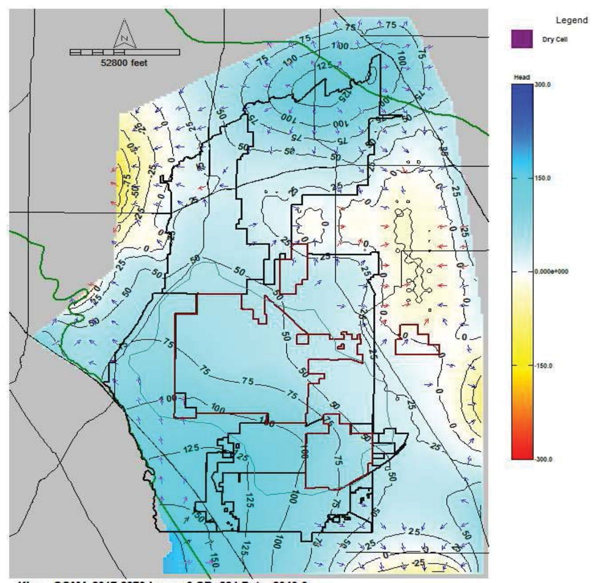
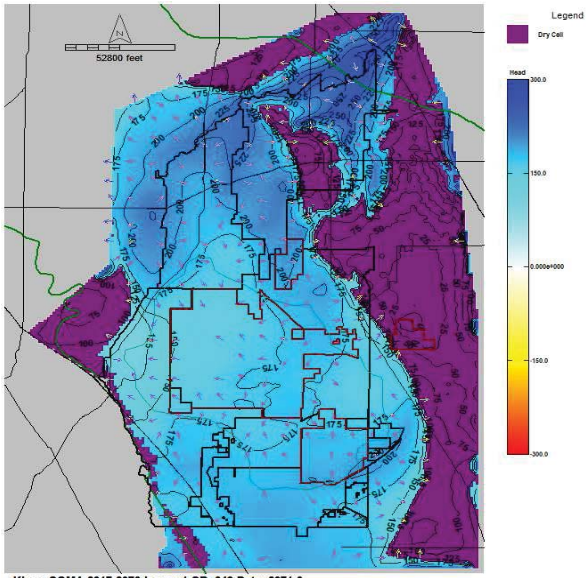


Kings SGMA 2017-2070 Layer: 6 SP: 284 Date: 2040.6

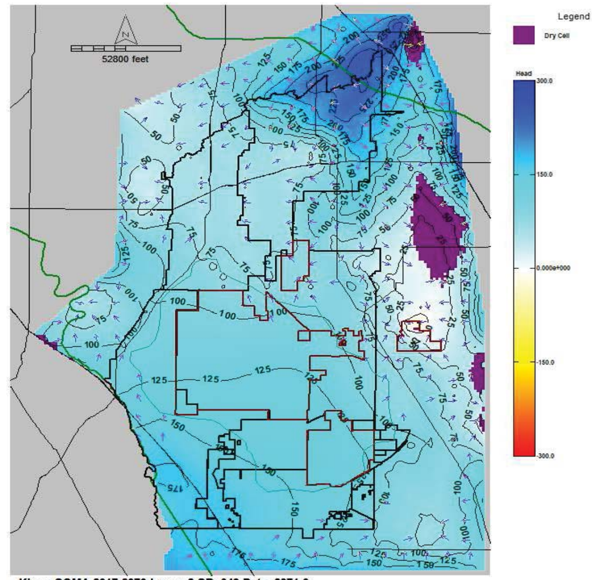
2040 Project Forecast Groundwater Elevations and Groundwater Flow Vectors

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

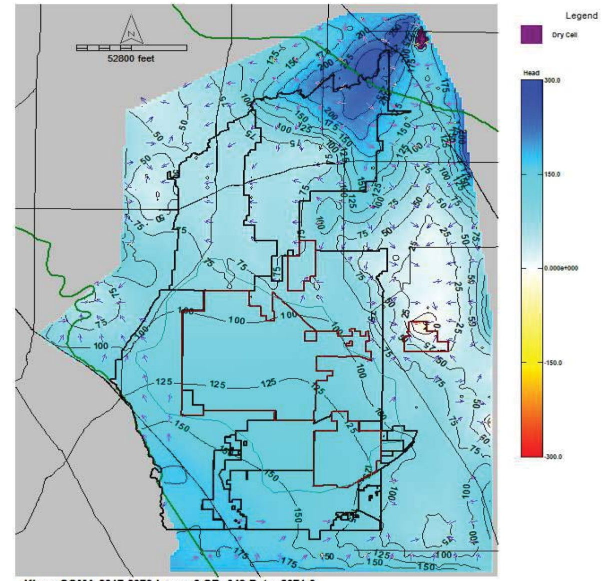
By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-13**



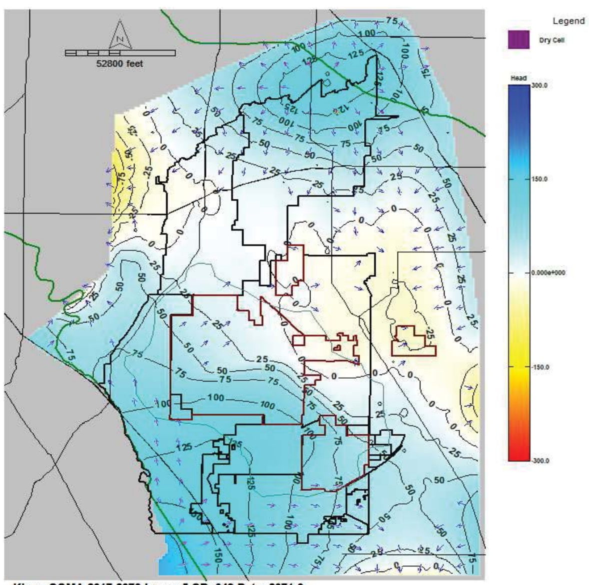
Kings SGMA 2017-2070 Layer: 1 SP: 649 Date: 2071.0



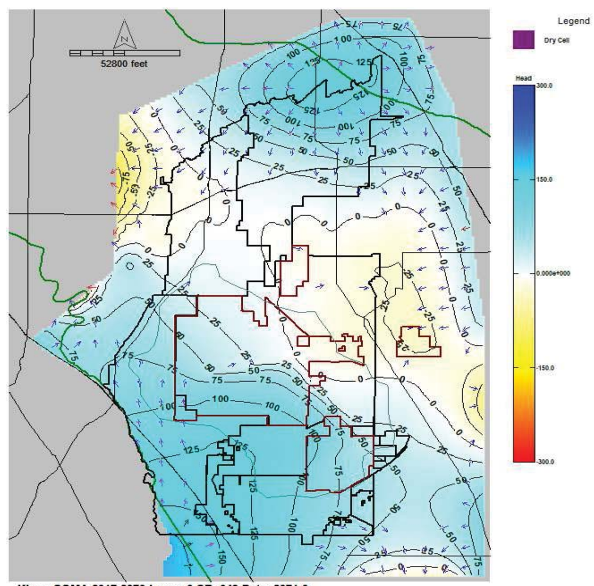
Kings SGMA 2017-2070 Layer: 2 SP: 649 Date: 2071.0



Kings SGMA 2017-2070 Layer: 3 SP: 649 Date: 2071.0



Kings SGMA 2017-2070 Layer: 5 SP: 649 Date: 2071.0



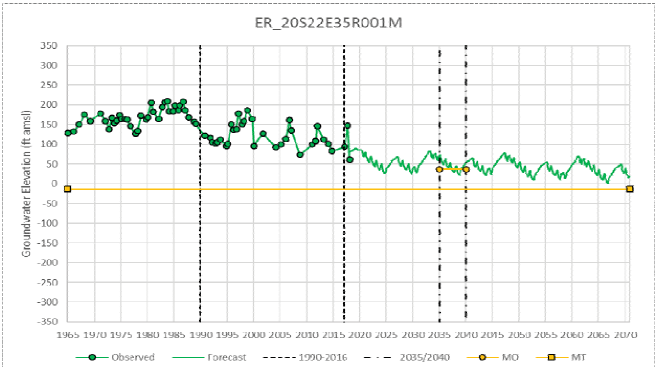
Kings SGMA 2017-2070 Layer: 6 SP: 649 Date: 2071.0

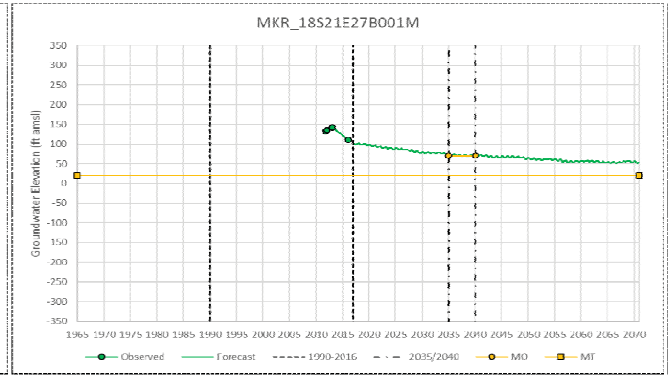
2070 Project Forecast Groundwater Elevations and Groundwater Flow Vectors

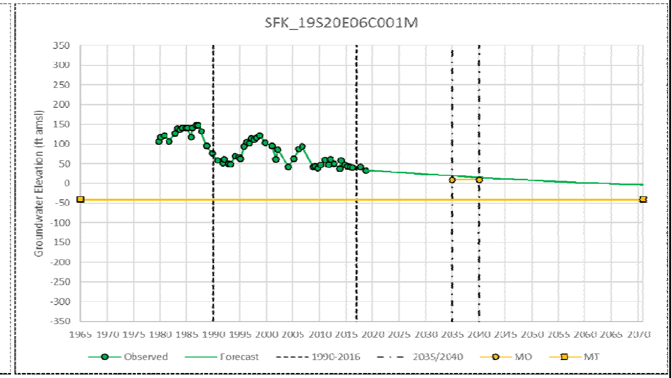
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-14**

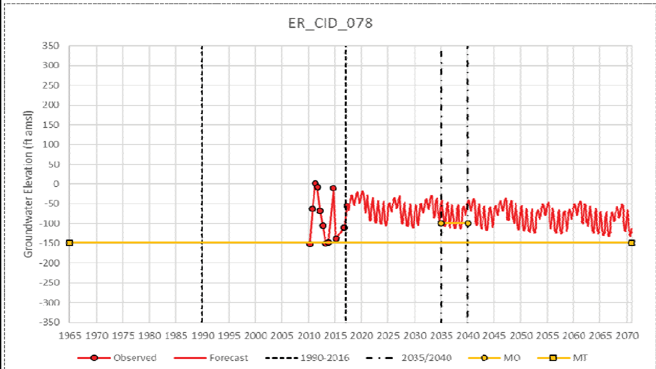
Above the Corcoran Clay

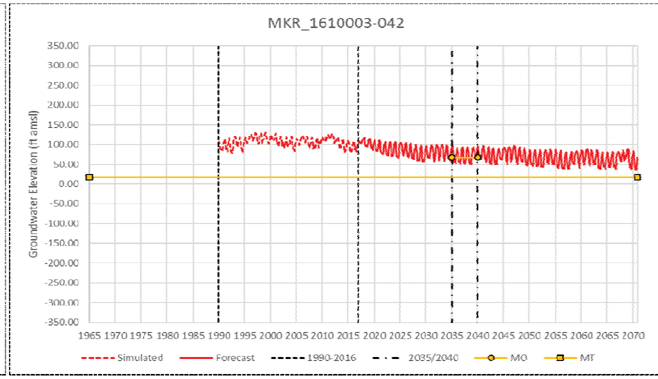


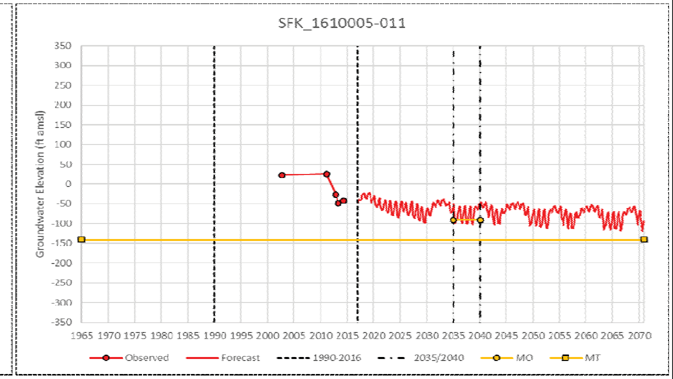




Corcoran **Hanford** **Lemoore**





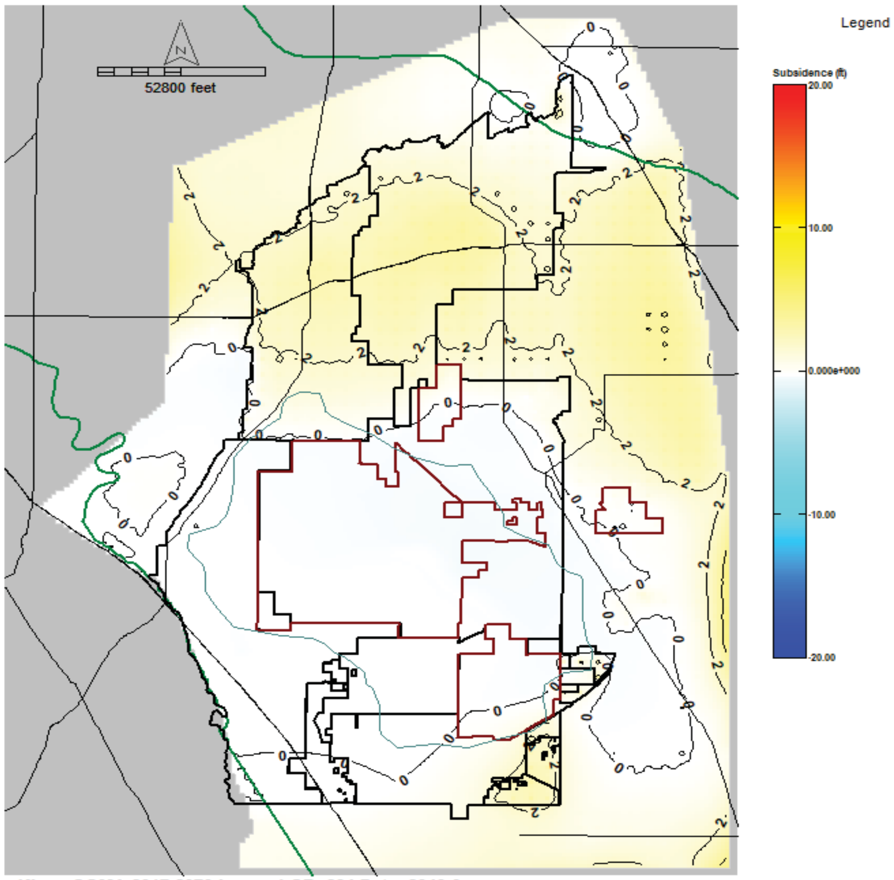


Below the Corcoran Clay

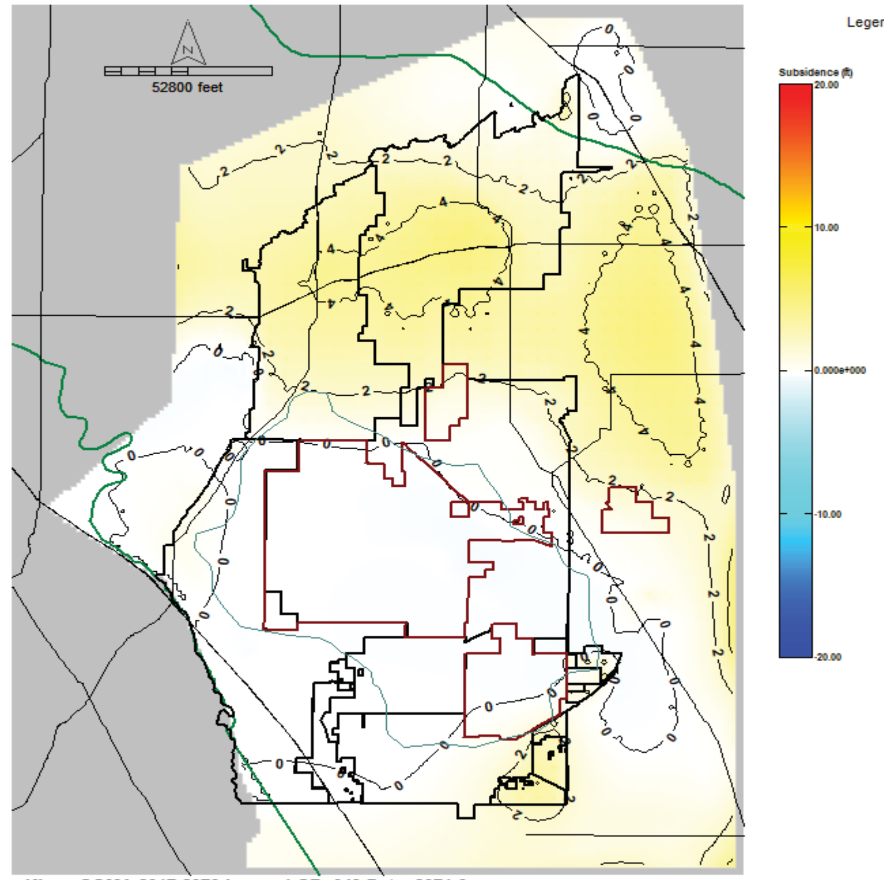
Project Forecast Hydrographs for Selected Compliance Wells
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-15**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D7-16 Project Subsidence



Kings SGMA 2017-2070 Layer: 1 SP: 284 Date: 2040.6



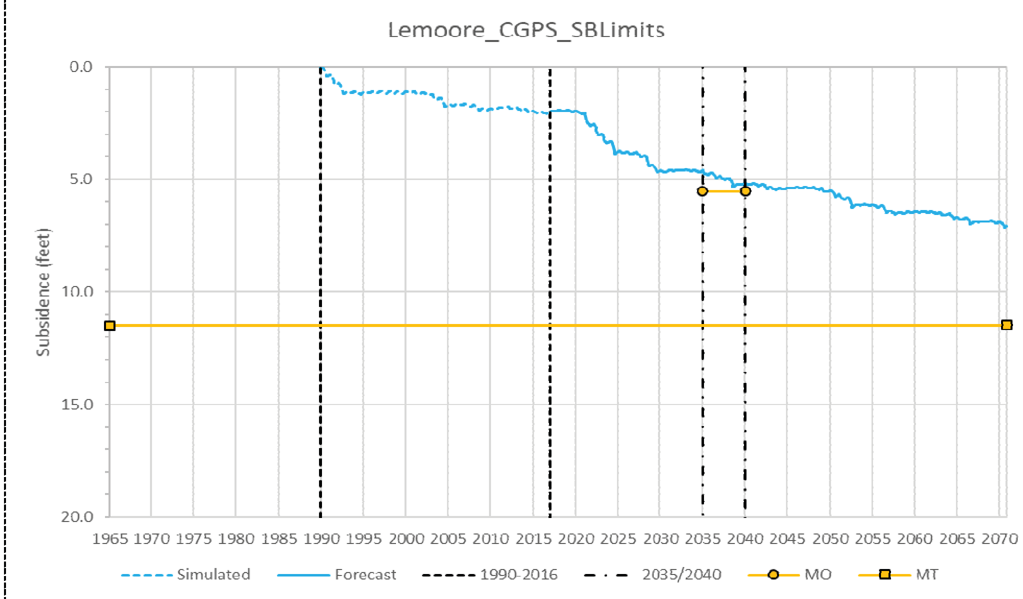
Kings SGMA 2017-2070 Layer: 1 SP: 649 Date: 2071.0

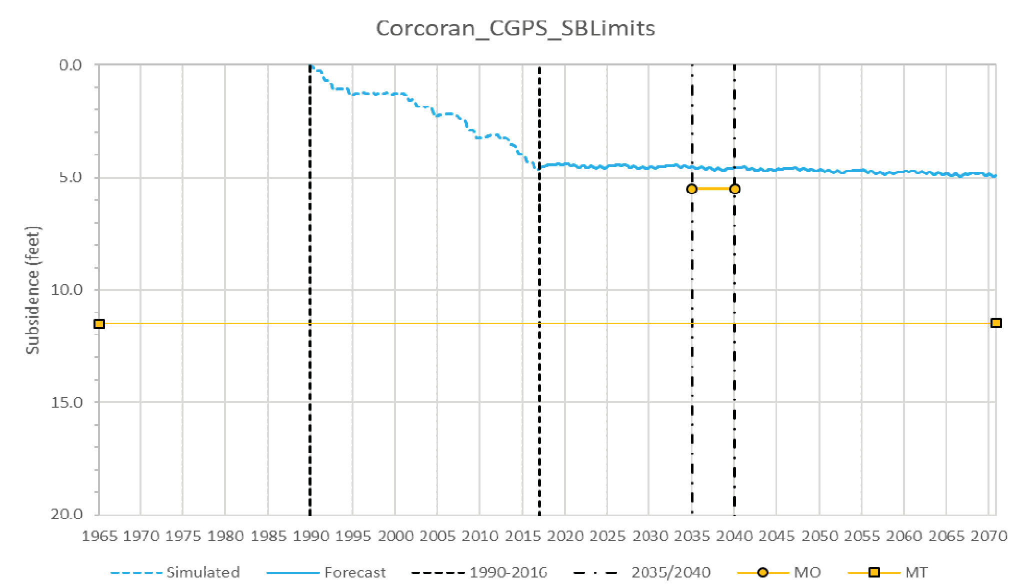
Cumulative Subsidence Since 2017
Project Forecast 2040 and 2070

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-16**

I:\FR18s\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D7-17 Project Sub Hydros

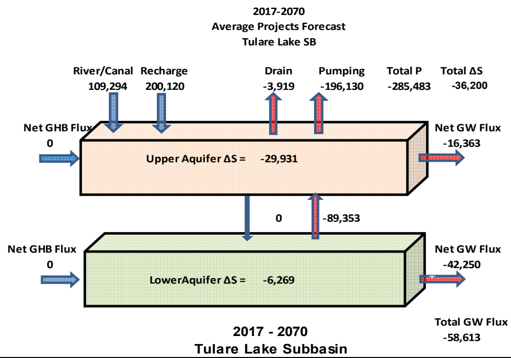




Project Forecast with Subbasin Pumping Limits Cumulative Subsidence Compliance Monitoring Points

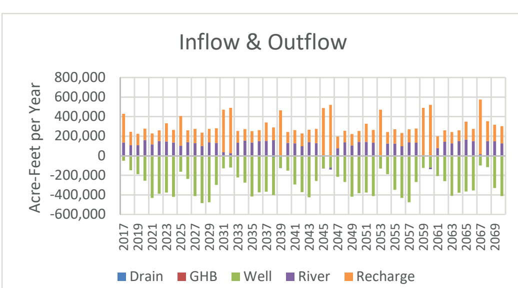
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

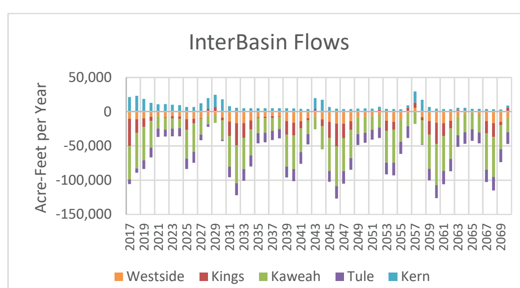
By: dmb	Date: 12/12/2019	Project No.: FR18161220
		Figure **D7-17**

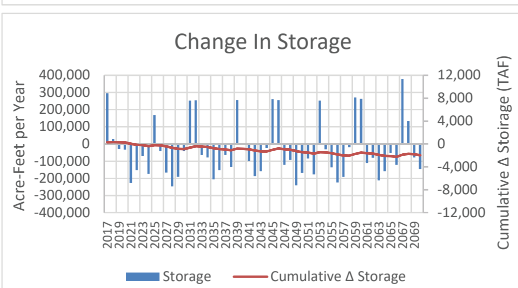


2017 - 2070
Tulare Lake Subbasin

TulareLake Date	Net Drain	Net GHB	Net Well	Net River	Net Recharge	Net Storage	Interbasin TulareLake	Interbasin Westside	Interbasin Kings	Interbasin Kaweah	Interbasin Tule	Interbasin Kern
2017	-768	0	-49,996	134,061	294,631	293,851	0	-9,992	-40,297	-48,598	-6,953	21,200
2018	-51	0	-147,931	106,461	137,333	29,785	0	-10,916	-20,328	-51,541	-6,322	23,003
2019	-69	0	-188,204	107,068	117,120	-29,333	0	-9,689	-12,439	-49,028	-12,606	18,498
2020	-751	0	-255,895	160,022	116,429	-33,567	0	-7,499	-6,200	-38,702	-14,321	12,890
2021	-2,567	0	-429,344	114,591	113,000	-228,163	0	-6,324	1,150	-18,147	-12,345	9,568
2022	-742	0	-387,832	149,597	110,391	-153,344	0	-8,036	-1,192	-16,819	-10,142	11,115
2023	-2,081	0	-375,607	144,279	186,092	-72,254	0	-6,559	-3,333	-14,772	-11,461	10,147
2024	-12,152	0	-409,790	134,618	129,097	-173,684	0	-6,923	-3,333	-14,122	-11,585	9,682
2025	-5,901	0	-158,066	103,591	300,300	167,712	0	-11,065	-15,504	-41,827	-15,388	6,934
2026	-6,425	0	-231,683	138,003	120,755	-42,544	0	-10,328	-7,050	-41,311	-15,866	6,838
2027	-4,097	0	-408,650	128,404	144,489	-166,792	0	-9,442	-924	-23,018	-8,481	12,393
2028	-3,806	0	-479,787	98,269	137,572	-247,432	0	-6,650	4,048	-12,008	-3,496	15,713
2029	-4,776	0	-470,493	136,664	136,267	-190,413	0	-4,525	6,786	-11,984	87	17,840
2030	-2,184	0	-296,843	131,230	148,799	-43,406	0	-8,521	-4,397	-27,797	-2,292	17,851
2031	-1,342	0	-128,244	34,194	435,214	252,338	0	-14,173	-21,527	-44,586	-15,432	8,110
2032	-2,135	0	-118,244	25,043	464,633	253,462	0	-16,860	-32,389	-55,308	-17,407	5,767
2033	-2,751	0	-219,926	132,336	120,754	-64,405	0	-16,851	-21,233	-45,466	-17,455	5,077
2034	-2,351	0	-273,863	153,223	119,220	-78,745	0	-12,647	-13,009	-38,118	-16,298	4,879
2035	-1,785	0	-414,804	134,016	116,897	-206,981	0	-7,842	-1,636	-21,888	-14,849	4,870
2036	-1,969	0	-372,544	149,859	110,501	-153,893	0	-7,391	-2,192	-21,086	-14,068	4,967
2037	-4,264	0	-363,305	152,162	186,307	-63,641	0	-6,467	-2,997	-18,447	-13,642	4,983
2038	-15,878	0	-386,782	158,310	129,519	-135,618	0	-6,736	-1,043	-17,305	-13,856	4,989
2039	-12,937	0	-112,427	-1,549	463,139	255,562	0	-13,698	-19,924	-46,314	-16,200	4,904
2040	-4,822	0	-147,191	129,532	113,179	-3,861	0	-15,971	-18,585	-49,122	-17,955	4,620
2041	-6,403	0	-288,654	125,667	136,255	-100,523	0	-13,749	-10,872	-34,353	-17,111	4,246
2042	-2,511	0	-369,213	97,116	129,325	-188,355	0	-9,518	-2,914	-20,346	-15,076	3,738
2043	-5,152	0	-419,146	138,244	128,118	-160,121	0	-7,192	1,016	-18,647	3,140	15,790
2044	-1,928	0	-256,990	128,874	144,339	-23,229	0	-11,233	-9,893	-34,027	233	17,141
2045	-1,615	0	-127,421	-2,607	487,733	260,886	0	-14,968	-23,284	-48,182	-15,906	6,928
2046	-2,192	0	-118,440	-22,036	518,991	254,254	0	-17,181	-33,280	-58,225	-18,145	4,513
2047	-1,846	0	-213,881	74,677	120,491	-120,887	0	-17,529	-21,199	-48,012	-18,486	3,949
2048	-3,121	0	-266,286	136,608	119,296	-92,692	0	-14,027	-12,735	-41,083	-17,137	3,833
2049	-955	0	-417,584	104,902	116,316	-241,563	0	-8,059	420	-24,754	-15,986	3,853
2050	-2,104	0	-380,556	141,874	110,770	-169,379	0	-7,332	852	-23,106	-14,955	3,988
2051	-2,151	0	-373,868	139,939	186,903	-85,094	0	-6,328	191	-20,161	-14,365	4,080
2052	-2,945	0	-409,066	132,768	131,240	-178,002	0	-4,743	2,951	-18,330	-15,302	4,171
2053	-1,757	0	-130,174	5,547	465,172	251,586	0	-13,057	-14,939	-46,488	-17,189	4,219
2054	-5,694	0	-182,931	124,170	117,298	-32,521	0	-14,787	-11,432	-48,072	-18,716	3,894
2055	-2,953	0	-346,167	123,932	144,789	-137,299	0	-11,714	-597	-31,503	-17,950	3,589
2056	-5,089	0	-426,442	96,606	136,007	-224,340	0	-3,053	5,860	-18,230	-17,157	3,278
2057	-2,832	0	-472,419	136,967	132,395	-192,493	0	5,515	7,767	-17,808	129	16,150
2058	-1,986	0	-265,982	132,665	145,904	-19,975	0	-8,004	-4,928	-34,531	-1,020	17,529
2059	-1,441	0	-124,741	1,848	487,775	270,056	0	-13,579	-19,998	-49,951	-16,865	6,926
2060	-5,248	0	-115,440	-16,351	519,068	263,398	0	-16,253	-30,525	-60,325	-19,196	4,327
2061	-878	0	-207,328	77,986	119,694	-112,695	0	-16,694	-19,066	-50,528	-19,593	3,699
2062	-6,177	0	-255,034	141,942	117,940	-79,683	0	-13,385	-11,283	-44,118	-18,210	3,559
2063	-2,104	0	-409,125	127,082	115,805	-213,067	0	-7,479	2,086	-27,132	-16,779	3,593
2064	-2,912	0	-375,558	149,053	109,563	-159,420	0	-3,670	1,802	-26,339	-16,899	3,789
2065	-4,655	0	-360,424	163,296	184,366	-52,779	0	-1,038	-312	-24,380	-16,820	4,124
2066	-4,273	0	-350,525	150,290	122,618	-121,655	0	-5,683	-471	-24,161	-15,961	4,244
2067	-5,939	0	-94,695	15,041	558,534	377,959	0	-13,561	-18,174	-52,954	-18,116	3,915
2068	-13,107	0	-102,855	148,782	203,000	133,847	0	-16,690	-20,384	-58,120	-19,784	3,545
2069	-7,533	0	-321,613	147,416	168,607	-78,689	0	-14,878	-4,800	-35,079	-19,070	3,256
2070	-7,539	0	-406,054	125,600	176,541	-146,985	0	-9,685	5,622	-20,423	-17,074	3,291
2017-2070 Average	**-3,919**	**0**	**-285,483**	**109,294**	**200,120**	**-36,200**	**0**	**-10,086**	**-8,890**	**-33,827**	**-13,587**	**7,778**
2040-2048 Average	**-3,288**	**0**	**-245,247**	**89,564**	**210,859**	**-19,392**	**0**	**-13,485**	**-14,638**	**-39,111**	**-12,938**	**7,195**







Projects Forecast Groundwater Mass Balance Tulare Lake Subbasin

Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

By: dmb	Date: 12/16/19	Project No.: FR18161220
		Figure **D7-18**

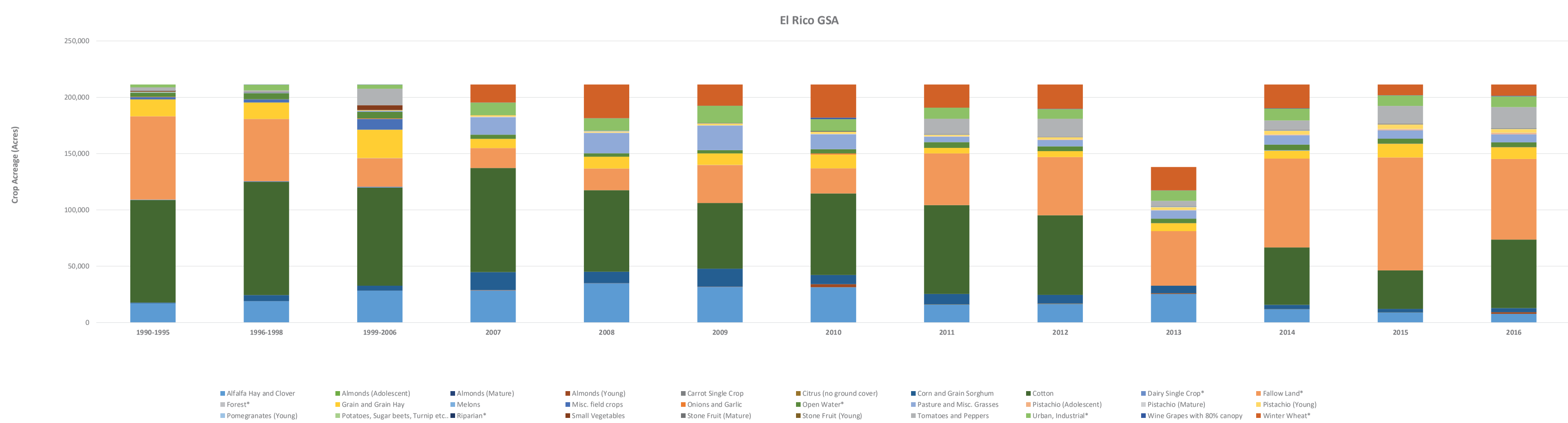
Appendix D1

Land Use and Crop Acreage

APPENDIX D1-1

Sum of Crop Acreage (Acres) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
El Rico GSA													
Alfalfa Hay and Clover	17062	18882	28224	28550	34759	31625	31388	16035	16646	25428	11801	8919	7682
Almonds (Adolescent)	0	0	0	0	0	0	0	2	1	1	8	2	4
Almonds (Mature)	0	0	0	0	0	0	0	0	0	0	0	0	0
Almonds (Young)	0	0	0	258	180	197	2669	238	259	636	208	246	1546
Carrot Single Crop	0	0	0	0	0	0	0	6	2	0	0	0	4
Citrus (no ground cover)	0	0	0	0	0	0	0	5	0	2	0	1	1
Corn and Grain Sorghum	782	5521	4532	16009	10213	16088	8204	9059	7686	6589	3771	2958	3518
Cotton	91026	100576	87075	92487	72329	58241	72345	78989	70591	0	50987	34147	60879
Dairy Single Crop*	386	493	718	0	0	0	0	0	0	0	0	0	0
Fallow Land*	73850	55208	25343	17545	19197	33697	22362	45881	51731	48511	78767	100327	71667
Forest*	0	12	156	0	3	36	1	0	0	0	0	0	0
Grain and Grain Hay	15048	14737	25257	8152	10582	10260	12219	4876	5254	7028	7005	12142	10308
Melons	0	0	0	0	0	0	0	1	6	1	491	3	63
Misc. field crops	2012	2737	9414	0	2	0	0	0	0	0	0	0	0
Onions and Garlic	253	165	606	0	0	0	1031	26	59	28	43	82	62
Open Water*	3550	5363	5676	3742	3038	2939	3748	5020	4152	4064	4826	4456	4232
Pasture and Misc. Grasses	444	682	902	15534	17925	21653	13233	4887	5745	7242	8473	7506	7212
Pistachio (Adolescent)	0	0	0	0	0	0	0	168	188	225	433	732	931
Pistachio (Mature)	0	0	0	519	494	348	294	286	281	260	259	414	386
Pistachio (Young)	0	92	612	1286	1030	1613	2066	1148	1837	2468	3146	3862	3324
Pomegranates (Young)	0	0	0	3	518	237	24	460	92	425	541	324	292
Potatoes, Sugar beets, Turnip etc..	465	0	0	5	0	0	0	1	0	1	0	1	1
Riparian*	0	0	260	11	59	93	386	20	14	54	83	92	101
Small Vegetables	807	298	4282	0	0	2	58	14	18	67	64	5	73
Stone Fruit (Mature)	0	0	0	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Young)	0	0	0	2	13	64	3	4	123	1	2	57	60
Tomatoes and Peppers	3069	1361	14625	5	1	67	0	13774	16185	4920	8549	16040	18943
Urban, Industrial*	2645	5070	3531	11025	10872	15246	10536	9841	8535	9304	10539	9274	9570
Wine Grapes with 80% canopy	0	196	130	160	142	18	1400	89	407	36	215	186	377
Winter Wheat*	0	0	0	16033	29951	18879	29323	20451	21465	20757	21059	9497	10032
El Rico GSA Irrigated Crop Acreage	**130966**	**145246**	**175658**	**162969**	**148189**	**140412**	**144935**	**130069**	**125380**	**128584**	**95998**	**87624**	**115666**
El Rico GSA Total Crop Acreage	**211398**	**211393**	**211342**	**211325**	**211311**	**211301**	**211291**	**211282**	**211278**	**211273**	**211272**	**211270**	**211268**

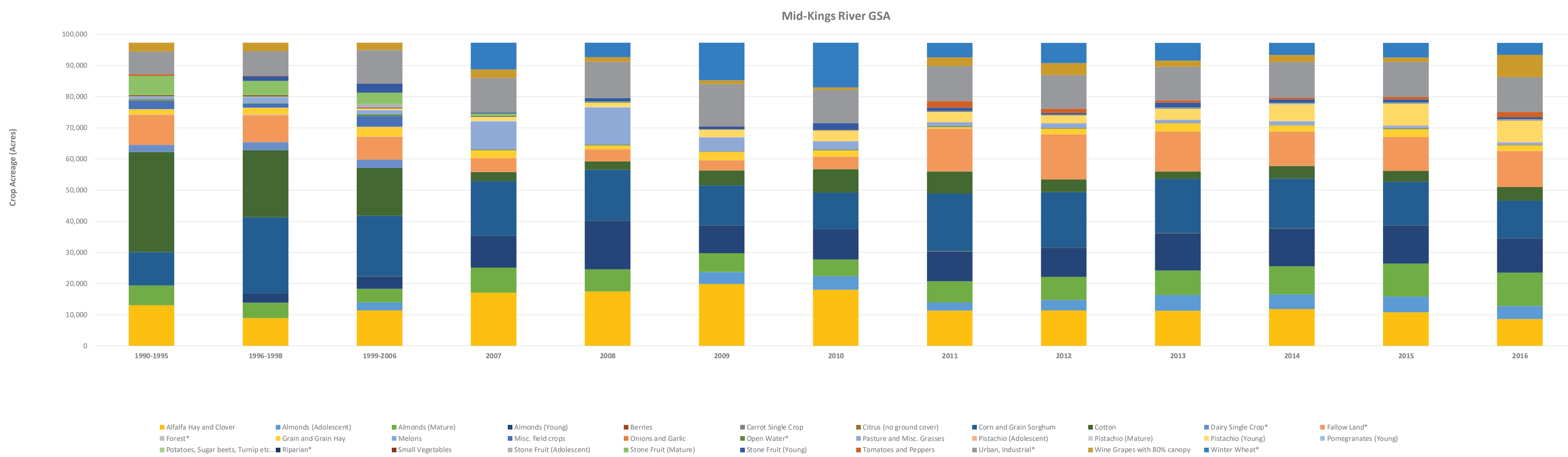
Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



APPENDIX D1-2

Sum of Crop Acreage (Acres) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mid-Kings River GSA													
Alfalfa Hay and Clover	13077	8955	11390	17127	17455	19907	17997	11349	11422	11310	11841	10814	8641
Almonds (Adolescent)	0	0	2646	0	0	3787	4400	2615	3312	5048	4677	5026	4221
Almonds (Mature)	6279	4955	4272	8040	7115	6086	5356	6765	7410	7851	9051	10582	10643
Almonds (Young)	0	3000	4011	10240	15571	8903	9640	9566	9308	11916	12070	12231	10961
Berries	0	0	0	0	0	0	0	0	1	2	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	1	2	0	2	0	4
Citrus (no ground cover)	0	0	21	0	10	9	4	110	27	89	30	17	4
Corn and Grain Sorghum	10777	24410	19454	17506	16434	12857	11789	18456	17872	17415	16054	13966	12211
Cotton	32138	21479	15330	2895	2617	4746	7523	7128	4136	2391	4027	3536	4295
Dairy Single Crop*	2278	2624	2666	0	0	0	0	0	0	0	0	0	0
Fallow Land*	9607	8651	7329	4456	3877	3288	3992	13754	14408	12757	11022	10897	11563
Forest*	93	163	71	2	0	7	1	0	0	1	0	0	0
Grain and Grain Hay	1658	2181	3123	2539	1275	2690	2058	498	1815	2657	1915	2558	1776
Melons	151	56	27	0	0	0	0	1	3	4	0	0	13
Misc. field crops	2574	1297	3410	0	0	0	0	0	0	0	0	0	0
Onions and Garlic	58	0	0	0	0	1	20	36	71	4	61	7	118
Open Water*	457	209	560	246	228	121	274	280	177	103	122	203	212
Pasture and Misc. Grasses	860	1881	1360	8942	12009	4550	2646	1272	1468	1001	1177	750	595
Pistachio (Adolescent)	0	0	0	0	0	0	0	2	14	41	112	244	227
Pistachio (Mature)	99	78	74	244	95	46	27	25	17	16	14	14	19
Pistachio (Young)	0	137	452	1302	1386	2477	3444	3198	2521	3410	5367	6919	6844
Pomegranates (Young)	0	0	0	1	21	5	5	114	50	254	220	26	74
Potatoes, Sugar beets, Turnip etc..	0	1	0	2	0	2	0	0	0	0	0	0	1
Riparian*	0	20	20	178	18	20	4	66	9	29	69	10	38
Small Vegetables	336	348	236	15	1	2	98	99	64	102	87	29	92
Stone Fruit (Adolescent)	0	0	1183	0	0	3	60	100	124	69	46	191	166
Stone Fruit (Mature)	6217	4597	3662	793	345	29	7	3	23	41	23	27	39
Stone Fruit (Young)	0	1504	2816	342	1126	953	2187	1008	485	1549	1150	1093	612
Tomatoes and Peppers	589	132	48	1	0	35	0	2108	1412	788	603	763	1651
Urban, Industrial*	7209	7934	10796	11097	11599	13542	10655	11296	10679	10709	11395	11219	11192
Wine Grapes with 80% canopy	2868	2713	2368	2768	1506	1180	778	2768	3935	2023	2241	1448	7218
Winter Wheat*	0	0	0	8574	4606	12043	14313	4658	6509	5691	3894	4696	3835
Mid-Kings River GSA Irrigated Crop A	**77681**	**77725**	**75883**	**72754**	**76968**	**68269**	**68042**	**67222**	**65492**	**67981**	**70768**	**70242**	**70424**
Mid-Kings River GSA Total Crop Acre	**97326**	**97326**	**97325**	**97307**	**97296**	**97289**	**97282**	**97276**	**97273**	**97272**	**97269**	**97267**	**97265**

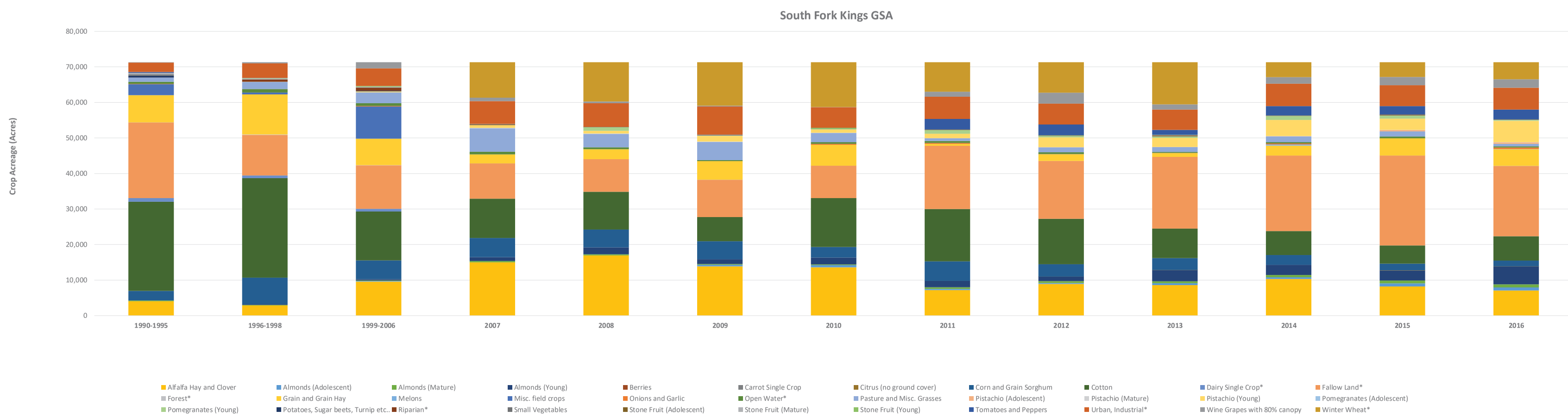
Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



APPENDIX D1-3

Sum of Crop Acreage (Acres) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
South Fork Kings GSA													
Alfalfa Hay and Clover	4030	2892	9546	14989	16927	13848	13603	7183	8911	8561	10328	8208	7048
Almonds (Adolescent)	0	0	172	0	0	431	605	301	272	538	469	857	905
Almonds (Mature)	213	143	135	383	332	259	221	507	522	584	651	818	829
Almonds (Young)	0	188	322	1113	1972	1328	1916	1794	1231	3147	2833	2825	5066
Berries	0	0	0	0	0	0	0	0	0	0	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	1	0	2	0	2	7
Citrus (no ground cover)	0	0	5	0	0	0	0	4	1	5	0	1	1
Corn and Grain Sorghum	2721	7461	5363	5344	4974	5058	2951	5499	3523	3375	2758	1893	1639
Cotton	25101	27984	13748	11091	10661	6816	13753	14685	12783	8294	6759	5136	6829
Dairy Single Crop*	998	761	781	0	0	0	0	0	0	0	0	0	0
Fallow Land*	21306	11422	12200	9929	9182	10491	9125	17821	16304	20156	21235	25318	19818
Forest*	6	106	97	4	1	4	3	0	0	0	0	1	0
Grain and Grain Hay	7688	11325	7401	2545	2791	5254	5903	570	1868	1073	2824	4829	4710
Melons	0	0	0	0	0	0	5	0	2	1	302	0	10
Misc. field crops	3029	537	9083	0	0	0	0	0	0	0	0	0	0
Onions and Garlic	146	0	164	0	0	4	278	262	63	61	316	40	446
Open Water*	568	944	770	707	508	239	479	505	493	289	363	435	314
Pasture and Misc. Grasses	1196	1992	3076	6612	3776	5167	2585	764	1385	1335	1598	1466	736
Pistachio (Adolescent)	0	0	0	0	0	0	0	0	15	20	45	388	391
Pistachio (Mature)	0	0	0	138	122	64	61	61	61	56	51	50	58
Pistachio (Young)	0	34	231	784	778	1662	903	1265	2756	2520	4547	3177	6029
Pomegranates (Adolescent)	0	0	0	0	0	0	0	0	0	0	3	16	27
Pomegranates (Young)	0	0	0	10	1005	102	188	996	411	467	1142	933	292
Potatoes, Sugar beets, Turnip etc..	468	0	209	0	0	2	0	0	0	38	0	1	0
Riparian*	0	648	841	190	14	66	27	101	22	212	32	124	43
Small Vegetables	430	2	0	5	0	8	11	14	30	43	4	38	28
Stone Fruit (Adolescent)	0	0	65	0	0	0	0	1	0	0	1	0	4
Stone Fruit (Mature)	408	316	192	3	0	0	0	0	0	0	0	0	0
Stone Fruit (Young)	0	94	245	38	53	95	229	61	94	86	85	32	40
Tomatoes and Peppers	287	51	0	93	2	8	12	2982	3060	1400	2605	2355	2749
Urban, Industrial*	2631	4086	4952	6415	6654	7933	5793	6213	5863	5729	6304	5928	6151
Wine Grapes with 80% canopy	80	317	1706	974	503	254	60	1408	3084	1481	1877	2279	2329
Winter Wheat*	0	0	0	9941	11051	12214	12590	8305	8551	11832	4173	4154	4807
South Fork Kings GSA Irrigated Crop	**45796**	**53338**	**51663**	**44120**	**43896**	**40359**	**43287**	**38359**	**40073**	**33087**	**39198**	**35344**	**40172**
South Fork Kings GSA Total Crop Ac	**71305**	**71305**	**71305**	**71305**	**71305**	**71305**	**71305**	**71305**	**71305**	**71305**	**71305**	**71305**	**71305**

Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



APPENDIX D1-4

Sum of Crop Acreage (Acres) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Southwest Kings GSA													
Alfalfa Hay and Clover	4524	1347	4850	10391	9787	5943	6228	3472	4626	3475	1381	960	715
Almonds (Adolescent)	0	0	90	0	0	908	2921	304	879	1889	1372	337	235
Almonds (Mature)	1190	143	143	4474	4377	3481	2797	2867	2887	3005	3175	3646	3633
Almonds (Young)	0	90	4957	4922	8214	4248	6657	2329	3744	4631	2555	1577	3997
Berries	20	0	0	0	0	0	0	0	0	0	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	0	0	0	0	0	0
Citrus (no ground cover)	0	0	0	0	3	4	0	0	2	3	59	4	4
Corn and Grain Sorghum	0	17	0	66	18	640	85	492	32	73	34	4	31
Cotton	10438	26255	2279	2960	1746	2428	3832	4690	1444	5300	1466	1388	1671
Dairy Single Crop*	39	0	15	0	0	0	0	0	0	0	0	0	0
Fallow Land*	53229	41443	25225	17464	35584	26521	24733	48292	49251	49716	51859	61821	58286
Forest*	321	527	2617	0	0	0	0	0	0	0	0	3	0
Grain and Grain Hay	1595	4379	14293	1981	1010	2189	1583	188	597	306	132	796	1251
Melons	100	0	257	0	0	0	9	0	0	0	4	0	1
Misc. field crops	8580	5377	20902	0	0	0	0	0	0	0	2	0	0
Onions and Garlic	0	314	0	0	0	2	25	64	104	2	80	20	15
Open Water*	902	1805	1657	606	473	737	891	1233	536	543	749	774	619
Pasture and Misc. Grasses	0	472	276	9716	1984	24511	23979	1343	898	1176	10802	1403	998
Pistachio (Adolescent)	0	0	0	0	0	0	0	0	1	84	293	2212	2288
Pistachio (Mature)	4595	3730	3730	5195	1195	476	21	21	20	17	6	6	6
Pistachio (Young)	0	1316	3094	829	1002	2610	1360	7358	7551	7459	5794	8509	5688
Pomegranates (Young)	0	0	0	49	147	166	16	3397	249	241	161	23	2448
Potatoes, Sugar beets, Turnip etc..	0	0	0	0	0	0	0	2	0	0	0	0	0
Riparian*	0	0	0	76	1	219	186	35	27	13	25	13	12
Small Vegetables	27	0	0	1	1	0	38	14	19	2	9	5	5
Stone Fruit (Adolescent)	0	0	229	0	0	11	6	0	0	0	0	0	0
Stone Fruit (Mature)	445	72	0	518	198	139	11	0	0	0	0	0	0
Stone Fruit (Young)	0	229	1124	289	416	462	83	4	10	4	102	0	2
Tomatoes and Peppers	1689	83	3	19	0	1	0	2601	3012	3	144	7	54
Urban, Industrial*	169	262	546	3643	4212	6157	4050	3619	2776	2885	4250	3199	3148
Wine Grapes with 80% canopy	0	0	1576	1684	1312	788	505	1093	1796	1113	2137	757	1060
Winter Wheat*	0	0	0	22975	16175	5212	7839	4436	7394	5913	1262	388	1688
Southwest Kings GSA Irrigated Crop	**33202**	**43824**	**57801**	**43094**	**31411**	**49008**	**50156**	**30239**	**27869**	**28783**	**29707**	**21654**	**24100**
Southwest Kings GSA Total Crop Acr	**87862**	**87862**	**87860**	**87858**	**87856**	**87855**	**87854**	**87854**	**87853**	**87853**	**87852**	**87852**	**87852**

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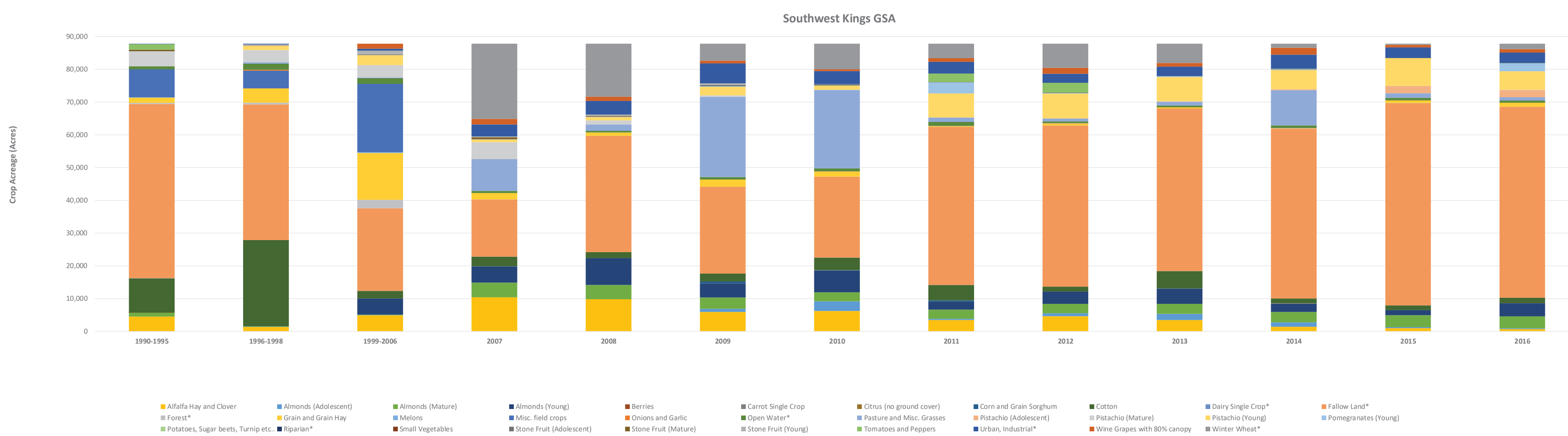

APPENDIX D1-5

Sum of Crop Acreage (Acres) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tri-County Water Authority GSA													
Alfalfa Hay and Clover	2917	488	290	1402	1672	181	469	750	526	544	469	765	159
Almonds (Adolescent)	0	0	0	0	0	0	0	0	0	0	0	0	0
Almonds (Young)	0	0	0	5	28	2	6	42	21	11	12	104	7
Carrot Single Crop	0	0	0	0	0	0	0	2	0	9	0	0	0
Citrus (no ground cover)	0	0	0	0	0	0	0	1	0	0	0	0	0
Corn and Grain Sorghum	0	1486	0	347	123	0	2	274	62	114	20	5	1
Cotton	830	4665	6333	172	952	210	714	49	39	104	147	325	47
Dairy Single Crop*	116	199	205	0	0	0	0	0	0	0	0	0	0
Fallow Land*	35703	21667	19509	15775	17303	25691	29979	26643	41003	41346	32290	39427	39639
Forest*	0	0	14	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	2719	15911	12888	4050	12212	7013	4217	1625	433	130	336	872	1024
Melons	0	0	0	0	0	0	0	0	0	0	0	15	0
Misc. field crops	921	2871	8503	0	0	0	0	0	0	0	0	0	0
Onions and Garlic	0	0	0	0	0	0	3	22	5	0	1	0	2
Open Water*	90	771	305	274	49	13	42	665	86	45	764	51	58
Pasture and Misc. Grasses	0	1	1	9885	8538	11063	10637	6414	3873	4601	11501	4618	4202
Pistachio (Adolescent)	0	0	0	0	0	0	0	0	0	0	0	0	0
Pistachio (Mature)	0	0	0	0	0	0	0	0	0	0	0	0	0
Pistachio (Young)	0	1	1	151	63	164	309	16	11	22	342	212	685
Pomegranates (Young)	0	0	0	0	14	35	22	46	2	8	143	7	5
Potatoes, Sugar beets, Turnip etc..	4803	0	0	0	0	0	0	6	0	1	0	0	0
Riparian*	0	0	0	63	42	0	11	3	67	5	30	9	1
Small Vegetables	0	0	0	0	0	0	6	0	1	30	0	1	1
Stone Fruit (Mature)	0	0	0	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Young)	0	0	0	1	0	0	0	0	0	0	1	0	0
Tomatoes and Peppers	0	0	0	0	0	0	0	17	1	4	20	46	24
Urban, Industrial*	0	39	50	1247	1374	1594	1184	1122	722	740	1413	910	868
Wine Grapes with 80% canopy	0	0	0	2	36	0	3	2	6	2	3	2	0
Winter Wheat*	0	0	0	14715	5675	2104	462	10361	1199	337	563	685	1327
Irrigated Crop Acreage	**12191**	**25423**	**28017**	**16014**	**23638**	**18668**	**16387**	**9267**	**4981**	**5582**	**12994**	**6971**	**6157**
Total Crop Acreage	**48099**	**48099**	**48099**	**48088**	**48081**	**48070**	**48064**	**48061**	**48059**	**48056**	**48053**	**48053**	**48051**

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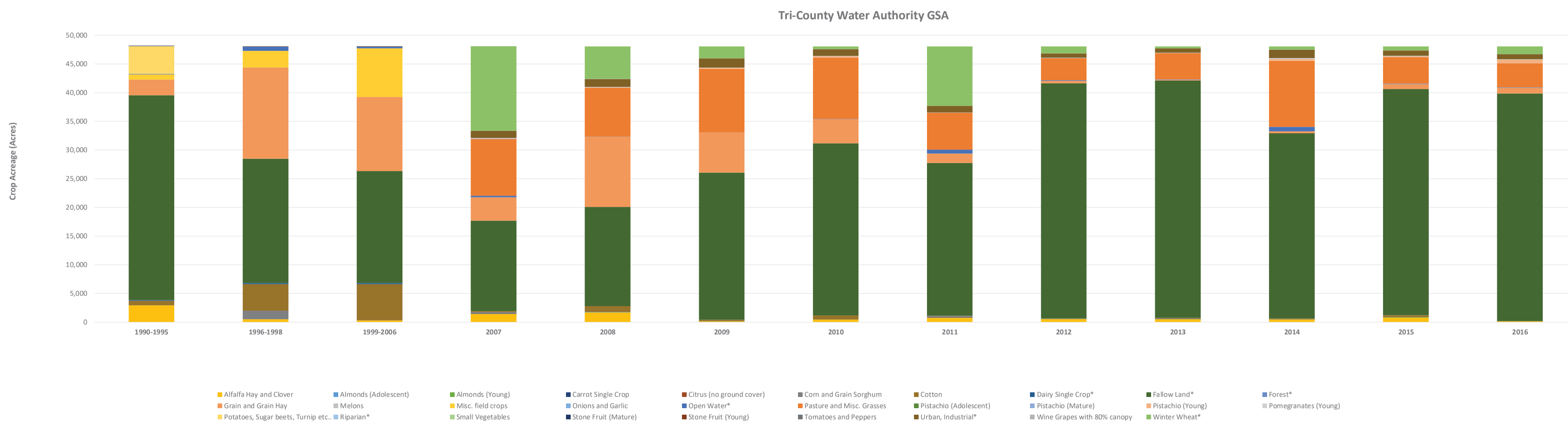

Sum of Crop Acreage (Acres) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tulare Lake Subbasin													
Alfalfa Hay and Clover	41604	32564	54301	72459	80600	71504	69685	38789	42131	49318	35820	29665	24245
Almonds (Adolescent)	0	0	2908	0	0	5127	7927	3222	4464	7476	6526	6222	5365
Almonds (Mature)	7682	5241	4550	12897	11825	9826	8374	10140	10818	11441	12876	15046	15105
Almonds (Young)	0	3278	9290	16538	25966	14678	20887	13968	14564	20341	17678	16983	21576
Berries	20	0	0	0	0	0	0	0	1	2	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	11	5	12	2	2	16
Citrus (no ground cover)	0	0	25	0	13	14	4	120	29	100	89	22	9
Corn and Grain Sorghum	14280	38896	29349	39271	31762	34643	23031	33780	29175	27566	22638	18826	17400
Cotton	159534	180960	124764	109605	88304	72441	98167	105541	88993	89317	63385	44532	73720
Dairy Single Crop*	3816	4077	4385	0	0	0	0	0	0	0	0	0	0
Fallow Land*	193695	138392	89606	65169	85144	99688	90192	152391	172697	172486	195172	237790	200972
Forest*	420	809	2955	6	5	46	5	0	0	1	0	4	0
Grain and Grain Hay	28708	48533	62962	19266	27870	27406	25980	7758	9968	11194	12213	21196	19069
Melons	250	56	284	0	0	0	14	2	11	7	797	18	86
Misc. field crops	17116	12819	51311	0	2	0	0	0	0	0	2	0	0
Onions and Garlic	457	479	770	0	0	7	1358	411	302	94	502	149	644
Open Water*	5568	9092	8968	5576	4296	4049	5434	7703	5443	5045	6824	5919	5435
Pasture and Misc. Grasses	2500	5029	5615	50688	44232	66944	53080	14680	13368	15355	33551	15744	13743
Pistachio (Adolescent)	0	0	0	0	0	0	0	170	218	370	882	3575	3836
Pistachio (Mature)	4694	3808	3804	6096	1907	934	404	394	380	348	330	485	469
Pistachio (Young)	0	1580	4390	4351	4259	8527	8083	12985	14676	15878	19195	22678	22570
Pomegranates (Adolescent)	0	0	0	0	0	0	0	0	0	0	3	16	27
Pomegranates (Young)	0	0	0	61	1705	545	256	5012	804	1395	2207	1312	3111
Potatoes, Sugar beets, Turnip etc..	5736	1	209	6	0	3	0	9	0	41	0	2	2
Riparian*	0	668	1120	517	134	398	615	226	138	313	239	248	194
Small Vegetables	1599	647	4518	20	2	13	212	142	133	244	165	78	198
Stone Fruit (Adolescent)	0	0	1478	0	0	14	66	100	125	69	47	191	170
Stone Fruit (Mature)	7070	4985	3854	1314	544	168	18	3	23	41	23	27	39
Stone Fruit (Young)	0	1827	4185	672	1609	1573	2502	1077	712	1641	1340	1183	713
Tomatoes and Peppers	5634	1627	14676	117	2	110	12	21482	23670	7114	11922	19211	23420
Urban, Industrial*	12654	17391	19875	33427	34711	44471	32218	32091	28576	29366	33901	30530	30930
Wine Grapes with 80% canopy	2948	3226	5779	5588	3499	2240	2746	5361	9228	4655	6472	4672	10985
Winter Wheat*	0	0	0	72238	67458	50451	64526	48212	45118	44530	30950	19420	21690
Tulare Lake Subbasin Irrigated Crop	**299832**	**345557**	**389021**	**338951**	**324102**	**316717**	**322806**	**275156**	**263796**	**264018**	**248665**	**221837**	**256519**
Tulare Lake Subbasin Total Crop Acr	**515986**	**515986**	**515931**	**515883**	**515849**	**515821**	**515796**	**515779**	**515768**	**515759**	**515751**	**515747**	**515741**

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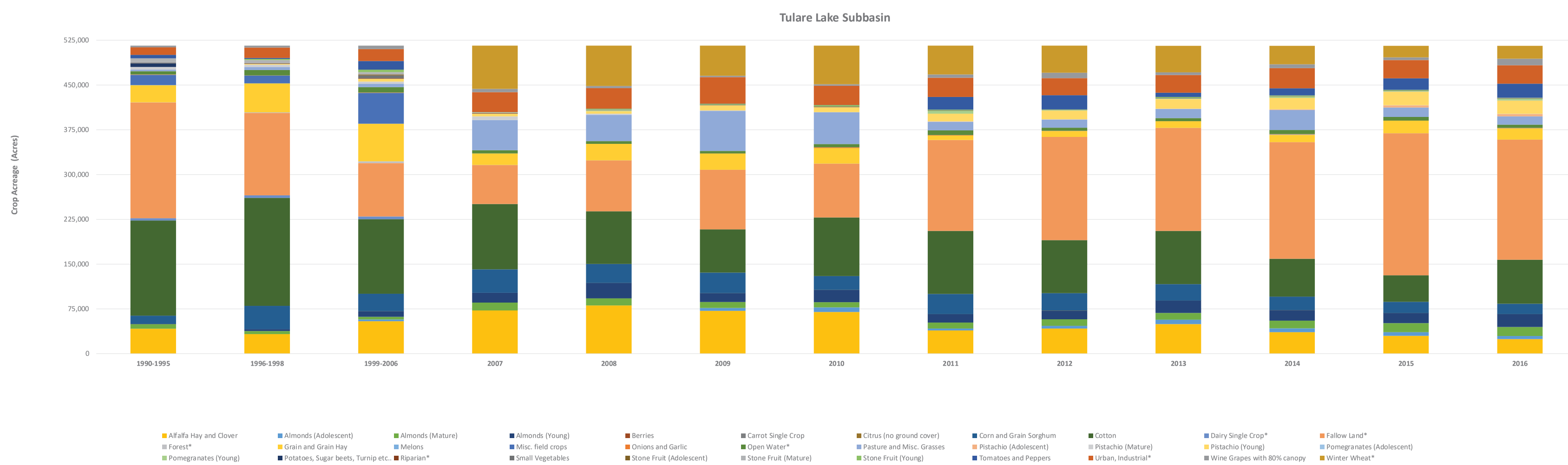

Sum of Crop Acreage (Acres) Kaweah Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Kaweah Subbasin													
Alfalfa Hay and Clover	27850	25488	29418	43095	41094	43668	40716	32231	33810	31880	30293	28662	26949
Almonds (Adolescent)	0	0	771	0	0	1532	2066	872	1229	1617	1456	1803	3445
Almonds (Mature)	3153	2535	2191	1736	1410	1077	921	1634	1819	1926	2456	2749	2995
Almonds (Young)	0	790	398	6870	11485	6194	8294	5130	4634	6064	9091	13550	14488
Berries	0	9	9	0	0	0	0	0	0	0	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	26	2	0	3	0	4
Citrus (no ground cover)	0	0	0	4	10	15	4	12	10	53	73	5	8
Corn and Grain Sorghum	26638	43219	43776	27456	32303	22468	21812	45387	47930	48395	48640	42286	34456
Cotton	59129	39071	33139	13910	9429	11494	18937	17481	13112	10144	9699	6535	10619
Dairy Single Crop*	4739	5962	6386	0	0	0	0	0	0	0	0	0	0
Fallow Land*	9002	7460	7147	2975	2992	3242	3633	15205	9874	13007	11274	12526	11575
Forest*	176	46	35	0	1	20	0	0	0	1	3	0	0
Grain and Grain Hay	7117	7703	8178	6799	501	2199	1849	745	1957	2730	1408	2541	1462
Melons	153	101	101	0	0	1	0	3	1	14	0	2	102
Misc. field crops	1745	1167	1439	0	1	1	0	0	0	0	0	0	0
Onions and Garlic	429	229	229	0	0	0	33	167	24	1	9	4	277
Open Water*	1210	726	866	246	233	247	516	579	378	199	277	492	424
Pasture and Misc. Grasses	1206	1112	1494	14364	26396	9090	9378	3711	6078	5345	5242	4515	4501
Pistachio (Adolescent)	0	0	0	0	0	0	0	336	493	880	1833	4513	4211
Pistachio (Mature)	1020	955	955	2307	1657	1343	1083	1034	886	794	771	1046	900
Pistachio (Young)	0	1985	2037	2026	2702	4762	4110	8081	9263	8907	9834	8573	8411
Pomegranates (Young)	0	0	0	4	155	10	3	89	52	430	128	102	395
Potatoes, Sugar beets, Turnip etc..	419	684	611	6	0	1	0	107	58	3	205	155	188
Riparian*	0	934	934	16	14	32	3	13	15	59	34	9	58
Small Vegetables	1749	3208	3163	89	1	5	2	175	490	782	766	780	725
Stone Fruit (Adolescent)	0	0	1320	0	0	22	26	20	128	382	403	82	30
Stone Fruit (Mature)	1645	883	762	125	24	5	0	19	3	7	70	94	17
Stone Fruit (Young)	0	1360	310	120	828	489	824	923	1191	818	1005	558	258
Tomatoes and Peppers	752	2013	1691	14	1	16	0	1188	384	697	546	1415	1750
Urban, Industrial*	3123	3412	3648	7583	7565	10932	7414	7056	6340	6453	6684	6941	6921
Wine Grapes with 80% canopy	801	1007	1036	1909	1183	630	547	1589	1944	1146	1170	862	4520
Winter Wheat*	0	0	0	20373	12023	32495	29802	8152	9855	9222	8580	11152	12262
Kaweah Subbasin Irrigated Crop Acr	**133807**	**133516**	**133027**	**120832**	**129180**	**105020**	**110604**	**120961**	**125498**	**123017**	**125103**	**120831**	**120710**
Kaweah Subbasin Total Crop Acreag	**152057**	**152057**	**152044**	**152025**	**152007**	**151987**	**151972**	**151966**	**151959**	**151957**	**151955**	**151951**	**151949**

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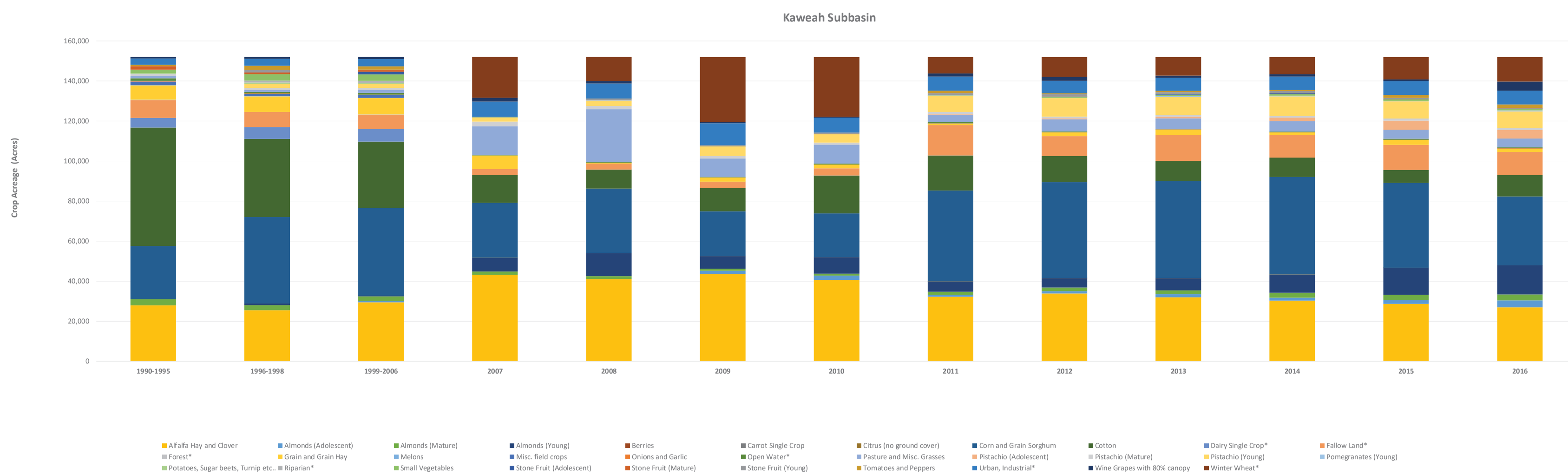

APPENDIX D1-8

Sum of Crop Acreage (Acres) Kern County Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Kern County Subbasin													
Alfalfa Hay and Clover	4901	4407	1624	4680	3816	4559	6610	2076	2224	3033	3011	2533	2915
Almonds (Adolescent)	0	0	812	0	0	1015	2696	295	249	1001	1166	529	567
Almonds (Mature)	1966	1035	402	2459	2384	2079	1689	1674	1889	1875	1878	2559	2635
Almonds (Young)	0	835	2229	5818	7283	2776	1820	1994	3570	4715	3756	3421	2367
Berries	0	0	0	0	0	0	0	0	0	8	0	0	0
Carrot Single Crop	53	0	0	0	0	0	0	0	0	3	1	1	2
Citrus (no ground cover)	0	0	0	0	131	278	0	2	19	2	152	1	1
Corn and Grain Sorghum	234	184	439	635	878	504	218	964	1186	852	491	614	144
Cotton	7102	10686	800	474	798	283	1970	614	385	66	120	30	62
Dairy Single Crop*	1	0	331	0	0	0	0	0	0	0	0	0	0
Fallow Land*	48223	31069	38616	13275	16082	6615	6146	40232	43273	36573	35547	40594	38237
Forest*	168	3	4832	0	1	1	0	0	2	0	0	0	0
Grain and Grain Hay	4362	11541	8261	506	1043	838	1682	1944	1374	1267	1078	1121	2860
Melons	0	0	0	0	0	1	0	0	21	8	1	0	4
Misc. field crops	2316	1463	1842	0	0	0	0	0	0	0	0	0	0
Onions and Garlic	130	56	0	0	0	0	9	52	71	10	16	34	102
Open Water*	2	308	376	513	376	796	241	553	408	202	331	137	126
Pasture and Misc. Grasses	1641	3129	2856	35869	32488	45504	44155	8180	8962	13185	18668	10827	9311
Pistachio (Adolescent)	0	0	0	0	0	0	0	0	0	2	61	758	807
Pistachio (Mature)	1847	1786	1775	2033	207	1	0	0	0	0	0	0	0
Pistachio (Young)	0	1906	4110	1063	631	663	1182	5304	7047	7601	4011	8202	6088
Pomegranates (Young)	0	0	0	0	361	0	0	5246	486	199	188	59	3850
Potatoes, Sugar beets, Turnip etc..	84	0	0	0	0	1	0	0	1	0	2	5	1
Riparian*	0	4723	4997	1015	956	1662	470	406	748	1307	571	1029	788
Small Vegetables	22	0	50	0	2	0	12	4	12	9	6	11	12
Stone Fruit (Adolescent)	0	0	20	0	0	0	0	0	0	0	0	0	3
Stone Fruit (Mature)	1600	245	202	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Young)	0	27	3	5	124	60	14	42	14	25	246	24	119
Tomatoes and Peppers	724	766	0	0	0	1	0	83	80	17	24	28	127
Urban, Industrial*	16	237	266	2445	2462	4764	3065	2002	1443	1807	2236	1848	1751
Wine Grapes with 80% canopy	1779	2764	2324	2284	1647	852	1439	1520	1657	1530	2223	1418	1343
Winter Wheat*	0	0	0	4077	5456	3860	3684	3907	1963	1781	1292	1290	2849
Kern County Subbasin Irrigated Crop	**28760**	**40830**	**27749**	**55826**	**51792**	**59414**	**63495**	**29994**	**29247**	**35407**	**37098**	**32174**	**33318**
Kern County Subbasin Total Crop Ac	**77170**	**77170**	**77168**	**77150**	**77125**	**77111**	**77102**	**77094**	**77084**	**77078**	**77074**	**77073**	**77070**

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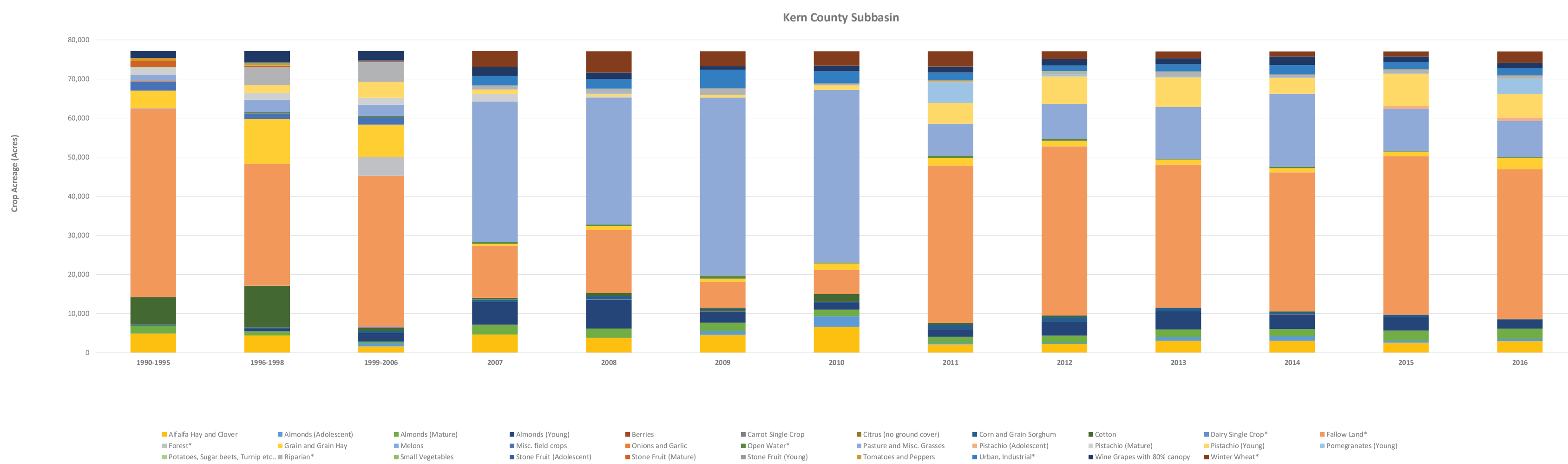

Sum of Crop Acreage (Acres) Kings Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Kings Subbasin													
Alfalfa Hay and Clover	16306	11835	14019	24478	21394	30890	33571	14356	14247	13523	17393	14242	12182
Almonds (Adolescent)	0	0	3414	0	0	10231	8066	3031	3819	5446	5193	4806	8502
Almonds (Mature)	4542	3495	3350	5386	4752	3247	2623	5737	5882	3838	4426	6262	5965
Almonds (Young)	0	3529	1164	26493	40739	14505	10844	19230	18486	16474	23168	29556	14910
Berries	0	3	3	0	0	0	0	0	2	16	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	14	1	2	36	0	8
Citrus (no ground cover)	532	557	557	74	93	851	57	206	148	1165	2395	975	570
Corn and Grain Sorghum	9363	14915	13000	5986	10644	6420	7212	13547	12495	9374	12586	9486	8811
Cotton	17806	11022	8861	3151	3700	3875	7667	6017	4335	2911	4225	2613	3156
Dairy Single Crop*	2549	2553	2615	0	0	0	0	0	0	0	0	0	0
Fallow Land*	9327	7519	6268	4149	1922	4614	3512	10692	11063	6697	5755	7343	8050
Forest*	413	229	266	17	9	22	9	2	11	2	2	4	16
Grain and Grain Hay	3299	2801	3445	1384	1109	2770	3757	987	1365	3407	1774	2054	677
Melons	407	180	130	0	3	18	4	1	10	33	7	9	29
Misc. field crops	3315	3204	3954	0	0	1	0	0	0	0	0	0	0
Onions and Garlic	0	0	106	27	58	91	38	175	73	65	389	107	236
Open Water*	671	893	1398	536	483	241	350	473	459	471	418	539	374
Pasture and Misc. Grasses	3833	2326	1914	9370	10809	5861	6552	1431	2665	2291	1789	1361	1172
Pistachio (Adolescent)	0	0	0	0	0	0	0	3	10	3	21	38	34
Pistachio (Mature)	172	109	109	96	73	66	59	59	58	58	56	56	34
Pistachio (Young)	0	9	121	1806	1466	3603	1931	5141	3223	3251	4585	2899	4214
Pomegranates (Young)	0	0	0	142	194	337	312	966	661	581	601	414	315
Potatoes, Sugar beets, Turnip etc..	0	31	233	1	0	2	0	9	0	0	0	2	0
Riparian*	0	584	821	417	54	454	44	280	110	147	219	75	67
Small Vegetables	1465	961	728	9	38	3	15	80	133	591	63	20	52
Stone Fruit (Adolescent)	0	0	8693	0	0	9	87	120	241	326	234	311	141
Stone Fruit (Mature)	20143	16740	16500	1663	324	64	42	12	15	12	32	24	14
Stone Fruit (Young)	0	8804	865	632	3153	3757	6595	4583	2872	14281	4299	3588	1501
Tomatoes and Peppers	51	450	309	15	4	147	23	632	484	1101	554	489	1483
Urban, Commercial*	234	0	0	0	0	0	0	0	0	0	0	0	0
Urban, Industrial*	4096	4846	4942	9013	8793	12129	8555	8395	7942	10273	7943	8218	8190
Wine Grapes with 80% canopy	20602	21532	21331	16829	6248	5113	8126	17826	21517	14294	17966	19448	34154
Winter Wheat*	0	0	0	7416	3009	9737	8988	5024	6696	8390	2883	4070	4153
Kings Subbasin Irrigated Crop Acrea	**101836**	**102501**	**102807**	**97542**	**104801**	**91860**	**97580**	**94163**	**92742**	**93040**	**101794**	**98762**	**98160**
Kings Subbasin Total Crop Acreage	**119125**	**119125**	**119116**	**119090**	**119071**	**119056**	**119038**	**119030**	**119023**	**119019**	**119014**	**119012**	**119009**

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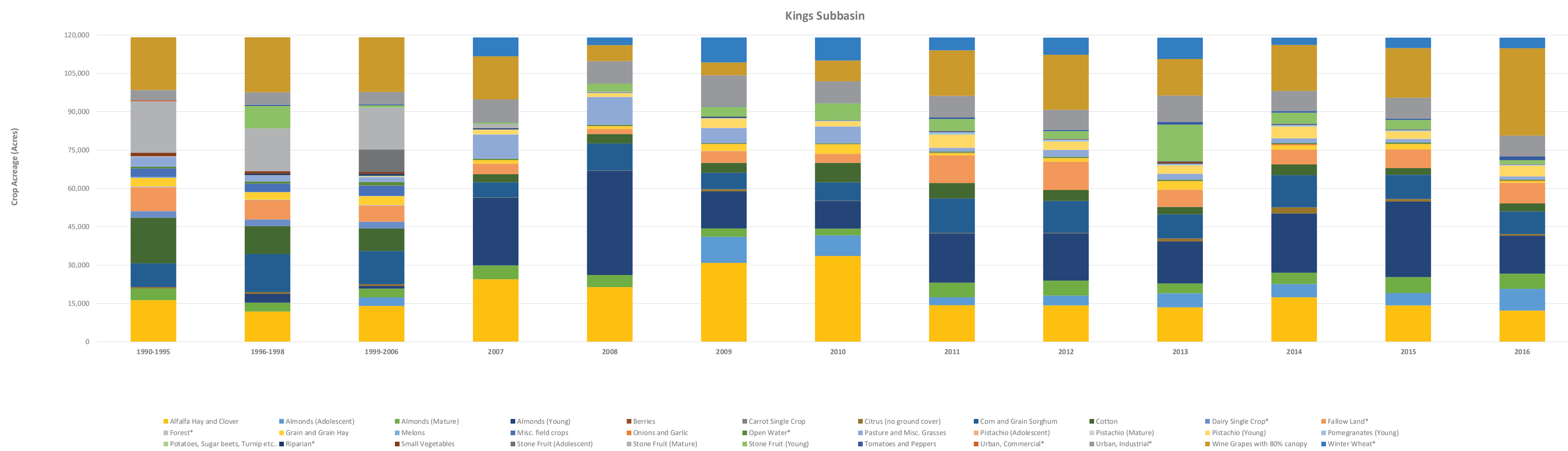

Sum of Crop Acreage (Acres) Tule Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tule Subbasin													
Alfalfa Hay and Clover	11815	24766	24766	24935	23335	18778	21039	12659	13696	12191	12634	10375	10831
Almonds (Adolescent)	0	0	2	0	0	48	32	5	3	20	48	98	413
Almonds (Mature)	43	13	13	0	0	0	0	3	0	0	0	6	6
Almonds (Young)	0	2	0	656	1520	1020	306	1111	740	1320	2101	2193	1892
Berries	0	0	0	0	0	0	0	0	0	0	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	1	0	0	0	1	17
Citrus (no ground cover)	0	0	0	0	0	0	0	5	0	3	4	2	1
Corn and Grain Sorghum	7656	13330	13330	8428	8660	5049	3069	18412	17304	11863	13687	10594	6087
Cotton	26378	13577	13577	1320	1507	2684	5541	2100	1527	1080	1498	1346	1809
Dairy Single Crop*	1668	3213	3213	0	0	0	0	0	0	0	0	0	0
Fallow Land*	50291	34370	34370	19350	25634	23018	24491	57622	52185	58262	47946	49332	40907
Forest*	59	9	9	0	0	13	0	0	0	0	0	0	0
Grain and Grain Hay	20747	22935	22934	3486	3875	4813	8244	6775	6675	7204	8679	11225	13366
Melons	12	0	0	0	0	5	0	1	2	1	65	4	27
Misc. field crops	1909	2492	2494	0	0	0	0	0	0	0	0	0	0
Onions and Garlic	2	0	0	1	0	0	83	41	103	1	5	20	59
Open Water*	2437	1373	1373	686	547	653	788	935	437	716	654	700	650
Pasture and Misc. Grasses	238	2419	2419	36249	38175	33240	40465	7292	14196	15170	18730	15904	11931
Pistachio (Adolescent)	0	0	0	0	0	0	0	459	371	429	624	995	1192
Pistachio (Mature)	0	0	0	100	67	41	33	33	33	32	32	398	398
Pistachio (Young)	0	201	201	1954	1313	3170	3336	2747	3086	4184	4677	4328	6906
Pomegranates (Young)	0	0	0	2	98	67	17	1076	2311	1363	2648	2709	2393
Potatoes, Sugar beets, Turnip etc..	929	2278	2278	0	0	1	0	1	1	1	4	7	1
Riparian*	0	2509	2509	199	121	57	183	186	58	158	68	63	47
Small Vegetables	0	517	517	1	1	5	204	10	33	31	55	43	236
Stone Fruit (Adolescent)	0	0	20	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Mature)	9	0	0	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Young)	0	20	0	7	72	9	2	35	31	1	43	41	6
Tomatoes and Peppers	2	18	18	1	0	2	0	105	108	72	268	233	658
Urban, Industrial*	950	1116	1116	4262	4258	6251	4117	3636	3116	3057	3771	3517	3402
Wine Grapes with 80% canopy	71	61	61	35	93	33	99	124	187	32	106	119	136
Winter Wheat*	0	0	0	23544	15937	26255	13161	9833	9005	8017	6859	10955	21832
Tule Subbasin Irrigated Crop Acreag	**69813**	**82629**	**82629**	**77175**	**78716**	**68963**	**82470**	**52997**	**60406**	**54997**	**65908**	**60640**	**58368**
Tule Subbasin Total Crop Acreage	**125218**	**125218**	**125218**	**125215**	**125214**	**125210**	**125209**	**125208**	**125207**	**125206**	**125206**	**125206**	**125205**

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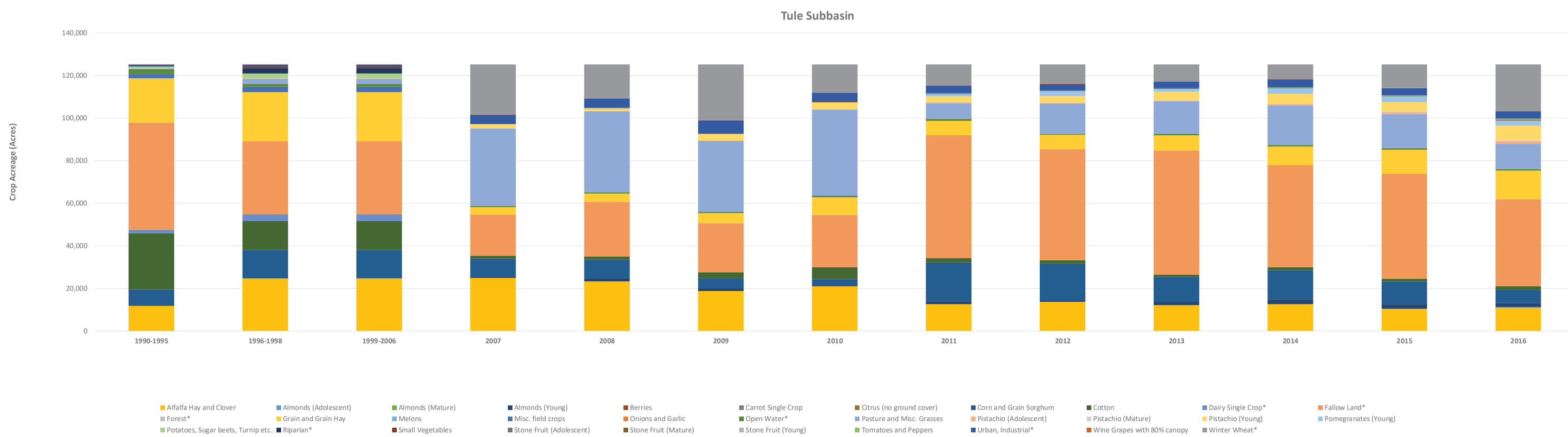

Sum of Crop Acreage (Acres) Westside Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Westside Subbasin													
Alfalfa Hay and Clover	3565	1318	4209	5516	7401	9897	6821	2099	2614	2755	1895	1262	1284
Almonds (Adolescent)	0	0	485	0	0	1873	2016	183	381	1622	1309	802	736
Almonds (Mature)	152	0	0	1044	968	729	240	1962	2029	2068	2348	3129	2866
Almonds (Young)	0	492	680	3525	4619	1617	3064	2645	2375	2820	2693	2702	3720
Berries	12	9	11	0	0	0	0	0	194	0	0	0	30
Carrot Single Crop	0	0	0	0	0	0	0	52	0	1	3	28	2
Citrus (no ground cover)	8	7	18	0	37	16	0	72	0	128	276	27	146
Corn and Grain Sorghum	484	805	423	3151	3625	4814	1747	312	302	9	29	8	45
Cotton	39262	43751	28342	19395	8364	4552	11801	22437	17678	8400	5293	4097	5286
Dairy Single Crop*	95	0	0	0	0	0	0	0	0	0	0	0	0
Fallow Land*	12574	9781	4611	12872	16866	19744	11787	11910	13995	19578	26359	36778	32844
Forest*	47	0	0	11	3	112	206	0	0	11	0	0	0
Grain and Grain Hay	5433	4637	8954	2865	5720	1326	3954	952	7891	2061	3743	1900	2345
Melons	777	2323	1020	3	3702	556	2743	368	414	741	394	158	85
Misc. field crops	5520	3801	14307	0	0	0	14	0	0	0	0	0	0
Onions and Garlic	1997	2306	3392	767	381	1373	385	3942	4252	4107	3712	3762	4236
Open Water*	517	986	678	490	351	385	275	348	379	233	369	479	364
Pasture and Misc. Grasses	0	2	74	2414	2521	2822	4201	429	894	988	881	254	280
Pistachio (Adolescent)	0	0	0	0	0	0	0	900	1016	1184	1676	1740	1956
Pistachio (Mature)	1089	1048	1046	748	387	3	2	2	2	1	0	874	876
Pistachio (Young)	0	382	481	3177	3380	2036	3957	4225	4973	5282	7563	3854	4571
Pomegranates (Adolescent)	0	0	0	0	0	0	0	0	0	24	0	0	0
Pomegranates (Young)	0	0	0	259	395	136	645	251	168	210	13	168	239
Potatoes, Sugar beets, Turnip etc..	0	0	1051	106	0	0	0	30	0	0	0	0	2
Riparian*	0	0	0	19	8	348	39	11	2	17	10	6	8
Small Vegetables	651	537	281	2210	421	286	305	834	878	1259	2529	385	814
Stone Fruit (Adolescent)	0	0	67	0	0	87	42	50	40	13	53	0	0
Stone Fruit (Mature)	865	712	508	1081	867	605	494	435	1	0	6	0	0
Stone Fruit (Young)	0	101	1173	250	485	452	1600	520	127	114	86	2	60
Tomatoes and Peppers	4765	4606	4502	2001	77	1284	497	7045	8011	10820	9286	6558	6171
Urban, Commercial*	21	0	0	0	0	0	0	0	0	0	0	0	0
Urban, Industrial*	2219	2465	3683	6617	6463	8360	6217	5623	4131	4533	4628	4411	4697
Wine Grapes with 80% canopy	353	341	408	1780	1265	714	686	725	1333	1503	1881	1261	1756
Winter Wheat*	0	0	0	10100	12089	16257	16641	12017	6298	9893	3340	5724	4952
Westside Subbasin Irrigated Crop Ac	**64932**	**67173**	**71432**	**50291**	**44615**	**35179**	**45215**		**55572**	**46111**	**45668**	**32972**	**37506**
Westside Subbasin Total Crop Acrea	**80405**	**80405**	**80404**	**80400**	**80394**	**80386**	**80381**	**80378**	**80376**	**80375**	**80373**	**80371**	**80371**

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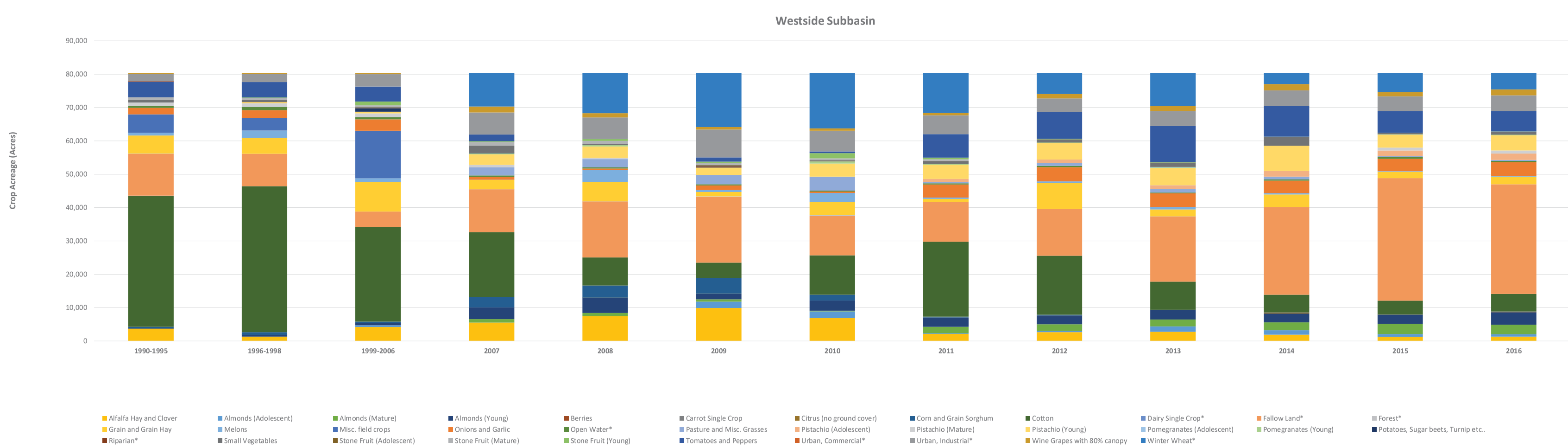
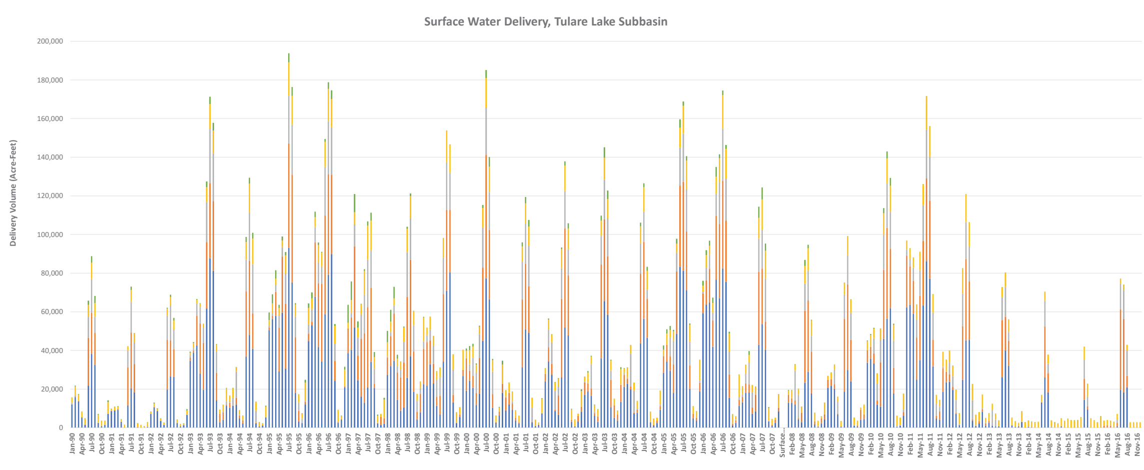


Appendix D2
Monthly Surface Water Deliveries by GSA and Subbasin

APPENDIX D2-1

Surface Water Delivery (Acre-Feet)	El Rico GSA	Mid-Kings River GSA	South Fork Kings GSA	Southwest Kings GSA	Tri-County Water Authority GSA	Tulare Lake Subbasin Total
Jan-90	12096	0	799	2753	12	15660
Feb-90	15780	532	389	4646	439	21787
Mar-90	13668	183	0	3383	136	17370
Apr-90	5311	0	0	3008	136	8454
May-90	1550	0	0	3191	159	4900
Jun-90	21777	24810	10647	6343	2198	65774
Jul-90	38337	21228	17294	8527	3431	88817
Aug-90	32604	16448	8315	7059	3826	68253
Sep-90	2580	0	0	4198	328	7106
Oct-90	788	0	0	2760	78	3626
Nov-90	1498	0	0	2048	164	3709
Dec-90	7192	0	0	6100	889	14181
Jan-91	8679	0	0	1104	181	9965
Feb-91	8930	0	0	1727	185	10843
Mar-91	9149	547	0	1291	182	11170
Apr-91	3017	45	0	1251	62	4375
May-91	114	0	0	1304	1	1420
Jun-91	11492	19825	8674	2059	6	42056
Jul-91	20315	29037	15627	6390	1621	72990
Aug-91	18326	14618	11119	4857	21	48941
Sep-91	329	202	0	1793	3	2328
Oct-91	58	0	0	1244	1	1303
Nov-91	111	0	0	725	1	837
Dec-91	540	0	0	2339	8	2888
Jan-92	7246	0	0	920	273	8440
Feb-92	10577	299	0	1569	546	12991
Mar-92	8589	0	0	1126	352	10067
Apr-92	3607	0	0	1104	175	4886
May-92	1444	0	0	1157	101	2702
Jun-92	19886	25477	12628	3649	434	62074
Jul-92	26610	18544	18112	4383	1222	68870
Aug-92	26266	14436	10146	4586	1475	56908
Sep-92	2425	0	17	1607	210	4260
Oct-92	733	0	0	1107	50	1890
Nov-92	1399	0	42	788	105	2334
Dec-92	6752	0	0	2247	568	9567
Jan-93	34635	1882	1061	1250	518	39346
Feb-93	38849	1049	1263	2577	606	44344
Mar-93	42588	15260	6536	1765	484	66632
Apr-93	27978	25934	8549	1783	190	64434
May-93	19683	24280	7672	2096	49	53781
Jun-93	61633	34418	20707	7760	2909	127427
Jul-93	87698	38923	27999	12806	3881	171307
Aug-93	81214	36099	24734	11805	3983	157835
Sep-93	14088	14353	10776	3878	252	43346
Oct-93	2877	4303	0	2120	24	9326
Nov-93	3993	3868	580	3408	51	11900
Dec-93	11465	490	1753	6678	277	20663
Jan-94	10334	2575	689	2961	7	16565
Feb-94	11346	324	3923	4813	240	20646
Mar-94	12003	3460	13518	2370	74	31425
Apr-94	4798	1453	468	2327	74	9121
May-94	2215	1617	63	2408	87	6390
Jun-94	36961	33759	16145	9249	2660	98774
Jul-94	48009	38368	25061	14823	3141	129403
Aug-94	40822	18407	25402	13274	2948	100854
Sep-94	2209	284	6397	4309	208	13407
Oct-94	589	0	0	2259	43	2891
Nov-94	1124	0	0	1123	90	2336
Dec-94	5419	0	0	5487	486	11392
Jan-95	50543	1489	872	2742	4002	59648
Feb-95	56193	1601	1274	5234	4718	69020
Mar-95	57904	12501	3713	3136	4209	81464
Apr-95	29106	22707	6177	3981	1644	63614
May-95	59386	29180	4786	3452	2211	99016
Jun-95	30642	33398	15773	9446	1637	90896
Jul-95	93097	54051	24738	17192	4769	193847
Aug-95	75149	55594	25997	14978	4617	176335
Sep-95	18055	28881	10439	6469	600	64444
Oct-95	3250	5460	4122	4404	130	17366
Nov-95	2410	0	1993	2751	275	7430
Dec-95	12155	1222	586	9321	1489	24773
Jan-96	44804	3917	4812	8505	2349	64387
Feb-96	53068	1691	6610	5587	3070	70027
Mar-96	67724	28082	7981	5191	2808	111787
Apr-96	41794	32997	10433	9367	1218	95808
May-96	34362	40058	8963	7192	410	90985
Jun-96	58752	51099	24996	13079	1533	149459
Jul-96	79092	52174	27425	16679	3469	178839
Aug-96	89843	40906	24649	14773	4495	174666
Sep-96	24394	10256	8963	9114	940	53668
Oct-96	2515	415	373	5858	131	9293
Nov-96	4276	0	0	1720	277	6274
Dec-96	21009	507	0	8581	1500	31597
Jan-97	38642	12784	0	2864	9282	63572
Feb-97	40362	16730	2192	6744	9729	75757
Mar-97	51972	41932	11303	6310	9411	120928
Apr-97	24596	12751	9437	5063	3232	55079
May-97	16136	29820	12593	5395	166	64110
Jun-97	12763	36157	19809	12465	842	82036
Jul-97	20865	41549	24488	17688	2223	106812
Aug-97	34090	38432	18975	15742	4045	111285
Sep-97	20520	2208	7805	6062	2594	39189
Oct-97	2187	0	294	3743	581	6804
Nov-97	1598	4010	0	1392	172	7173
Dec-97	1959	2947	0	9663	931	15499
Jan-98	27236	9019	488	7448	5942	50133
Feb-98	31844	15587	1993	5453	6191	61069
Mar-98	34696	24491	4235	3483	6014	72919
Apr-98	14460	14200	3219	3832	2058	37768
May-98	8776	17329	3981	4124	109	34318
Jun-98	10527	23256	10677	7449	401	52311
Jul-98	25767	42068	22992	12083	1124	104033
Aug-98	37026	49842	21467	11524	1358	121217
Sep-98	18449	21166	13410	7283	192	60500
Oct-98	4362	4005	5516	3488	45	17417
Nov-98	7941	9537	2820	3536	99	23932
Dec-98	22517	18341	3900	12154	528	57440
Jan-99	21858	22424	3602	3790	92	51766
Feb-99	32889	12418	5423	6632	105	57468
Mar-99	22875	10239	9343	4919	89	47466
Apr-99	11286	4682	8966	4310	35	29278
May-99	6892	9519	9693	5002	8	31114
Jun-99	34267	34956	18737	10197	60	98216
Jul-99	70847	41958	24375	16565	114	153859
Aug-99	80450	32271	19217	14414	173	146525
Sep-99	13128	3880	13204	7652	87	37951
Oct-99	2379	0	306	5179	4	7868
Nov-99	5597	1225	223	3566	9	10619
Dec-99	26748	3260	3	10193	47	40249
Jan-00	19168	16688	0	3981	1203	41040
Feb-00	24248	5154	3492	7221	2132	42247
Mar-00	20602	6407	9117	5813	1472	43410
Apr-00	11770	6319	10455	4060	687	33292
May-00	17655	18463	12305	3963	345	52732
Jun-00	44925	37946	20771	10132	1476	115251
Jul-00	77296	63999	24480	15187	4158	185120
Aug-00	66535	35841	19517	13197	5017	140108
Sep-00	10350	7067	11589	5866	714	35586
Oct-00	2705	0	0	3524	169	6399
Nov-00	6375	1920	167	1939	357	10757
Dec-00	18044	4739	148	9827	1933	34689
Jan-01	8961	6643	306	3439	7	19357
Feb-01	12104	5840	413	4738	249	23344
Mar-01	9359	3393	955	5022	77	18805
Apr-01	3836	1392	0	3725	77	9030
May-01	2267	621	0	3302	90	6280
Jun-01	31309	35031	19672	7838	2141	95991
Jul-01	50997	33980	20650	10499	3334	119460
Aug-01	49055	24248	20927	9909	3350	107488
Sep-01	2898	319	7363	4769	186	15535
Oct-01	808	0	0	3235	44	4088
Nov-01	1545	0	0	1047	93	2685
Dec-01	7472	0	0	7351	505	15328
Jan-02	23954	3915	0	2950	50	30869
Feb-02	34366	7194	9184	5270	523	56538
Mar-02	27523	5518	11211	3970	187	48409
Apr-02	8687	535	9845	4403	163	23633
May-02	6720	10074	4546	4164	176	25680
Jun-02	25952	40777	15782	9963	815	93288
Jul-02	51918	51345	19135	13258	2180	137837
Aug-02	47781	31068	13428	10907	2618	105802
Sep-02	3024	974	0	5499	364	9861
Oct-02	753	0	0	3507	86	4346
Nov-02	3255	2826	0	1030	182	7292
Dec-02	8335	2524	0	8095	984	19937
Jan-03	17035	6380	178	2599	251	26443
Feb-03	18975	3997	356	5205	759	29292
Mar-03	16464	3997	12382	4018	398	37259
Apr-03	6235	1332	536	3573	240	11916
May-03	3104	2694	180	3447	189	9614
Jun-03	35955	48545	14724	7872	2655	109751
Jul-03	65530	42356	20487	11279	5552	145204
Aug-03	58315	30398	19584	10022	4429	122748
Sep-03	10724	14051	4602	5418	390	35185
Oct-03	5060	6628	0	3235	93	15015
Nov-03	3534	3270	0	1849	195	8849
Dec-03	13310	8954	246	7783	1057	31349
Jan-04	21193	6202	887	2469	169	30920
Feb-04	22630	2751	421	5211	232	31245
Mar-04	19750	1700	16892	4331	188	42861
Apr-04	7463	567	11364	3817	76	23287
May-04	7649	1847	202	4028	23	13750
Jun-04	43669	36111	15703	8761	1864	106108
Jul-04	56276	39905	15616	12716	2044	126557
Aug-04	46550	20059	4869	9753	2102	83334
Sep-04	2893	0	0	5344	48	8285
Oct-04	1143	426	0	3106	11	4686
Nov-04	2473	1234	27	1335	24	5093
Dec-04	9313	1915	630	7305	130	19292
Jan-05	28328	8681	318	3073	2183	42584
Feb-05	34297	8543	211	5698	2211	50959
Mar-05	29485	7573	9716	3712	2191	52678
Apr-05	17953	14774	12322	4882	736	50667
May-05	48534	32390	9719	4539	2573	97756
Jun-05	83212	42082	19626	10292	4362	159573
Jul-05	81301	45958	24885	14477	2262	168883
Aug-05	71251	30263	21741	15052	2244	140551
Sep-05	20198	12158	12151	8680	770	53957
Oct-05	4823	2388	126	3795	5	11137
Nov-05	3751	1321	193	3261	10	8536
Dec-05	18891	4407	951	10899	57	35205
Jan-06	59292	10338	592	3257	2512	75991
Feb-06	63754	12505	6626	6422	2541	91849
Mar-06	64764	17538	6973	4837	2663	96774
Apr-06	41883	13691	3840	5137	2833	67383
May-06	76704	32999	11252	8857	5127	134938
Jun-06	67064	38328	21556	12485	2077	141510
Jul-06	82441	45232	27164	17302	2425	174563
Aug-06	75475	31743	21761	15341	2036	146355
Sep-06	15527	12043	11907	9365	807	49649
Oct-06	1262	853	149	4680	33	6977
Nov-06	2510	1310	156	1921	11	5908
Dec-06	11319	3168	1686	11288	62	27522
Jan-07	13171	2716	1406	4102	0	21395
Feb-07	18115	4927	4753	4776	12	32582
Mar-07	18252	4158	11450	3792	2061	39713
Apr-07	7207	3220	7950	3630	4	22010
May-07	8494	8585	313	3894	4	21291
Jun-07	42957	37657	17154	10846	5784	114397
Jul-07	53608	28757	20138	15667	6199	124370
Aug-07	40221	14702	22073	14551	3777	95325
Sep-07	3237	0	300	6629	473	10638
Oct-07	1095	474	0	2879	2	4449
Nov-07	2519	1514	0	1013	5	5050
Dec-07	8543	1666	0	7129	24	17363

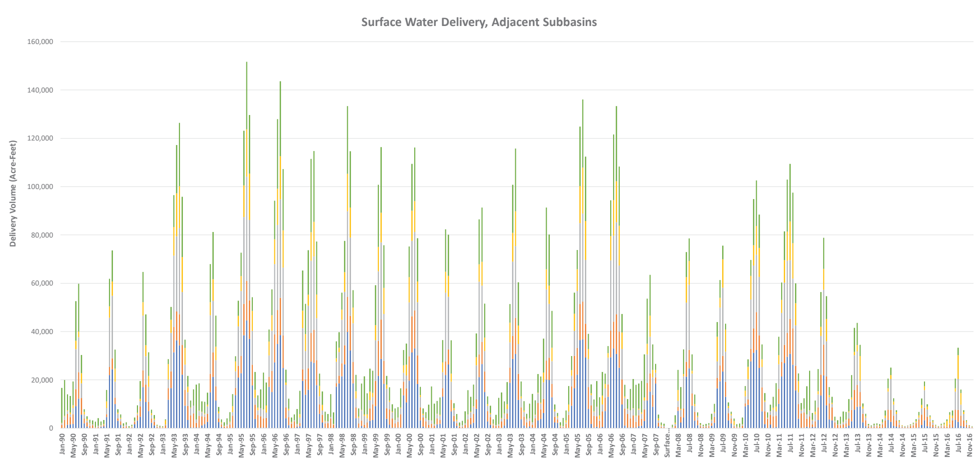
Surface Water Delivery (Acre-Feet)	El Rico GSA	Mid-Kings River GSA	South Fork Kings GSA	Southwest Kings GSA	Tri-County Water Authority GSA	Tulare Lake Subbasin Total
			APPENDIX D2-1 (Cont)			
Jan-08	12877	4236	0	2158	249	19521
Feb-08	12794	2358	0	4154	286	19592
Mar-08	12030	2029	15452	3035	260	32806
Apr-08	4310	676	12129	2975	94	20185
May-08	2848	4804	280	2918	14	10863
Jun-08	23201	37252	14023	9327	3063	86866
Jul-08	28911	36960	15430	11570	1795	94666
Aug-08	17737	21618	8115	8066	321	55857
Sep-08	1686	1694	0	4266	28	7674
Oct-08	535	324	0	2614	7	3479
Nov-08	2311	2600	0	966	14	5891
Dec-08	4305	2578	0	6083	77	13042
Jan-09	20714	4035	0	1996	0	26745
Feb-09	21578	3528	0	3511	2	28619
Mar-09	20219	2386	7422	2559	1	32585
Apr-09	6912	583	5834	2571	1	15900
May-09	626	0	0	2805	1	3432
Jun-09	18684	37791	12420	6179	3	75077
Jul-09	29891	44375	14955	9897	7	99125
Aug-09	24119	21353	13859	7115	9	66454
Sep-09	992	0	583	3621	1	5197
Oct-09	662	513	0	2362	0	3537
Nov-09	4030	5151	0	1119	1	10300
Dec-09	4435	2475	0	4964	3	11878
Jan-10	33578	6591	0	4533	503	45205
Feb-10	35716	6121	0	6119	503	48460
Mar-10	33280	5202	7720	5041	503	51746
Apr-10	11965	2285	8767	4939	168	28125
May-10	10826	23142	11452	5874	0	51294
Jun-10	45995	35698	18042	11282	2611	113628
Jul-10	56367	47091	23080	12815	3684	143036
Aug-10	61845	30709	19039	13661	4026	129280
Sep-10	17793	13208	13979	8270	556	53806
Oct-10	417	0	736	5071	0	6224
Nov-10	1053	221	221	3629	0	5126
Dec-10	6255	1797	1065	8405	1	17524
Jan-11	62292	26805	3271	4336	0	96704
Feb-11	63568	19954	3729	5631	17	92899
Mar-11	58959	17047	6734	5266	5	88011
Apr-11	24884	21763	9084	8007	5	63744
May-11	34998	33281	13176	9466	6	90927
Jun-11	63404	33286	18476	10767	26	125958
Jul-11	86173	42788	25299	17245	72	171578
Aug-11	77137	40417	22548	15888	87	156077
Sep-11	31800	13857	13793	9652	12	69114
Oct-11	4824	1194	6244	4587	3	16851
Nov-11	4056	4435	2415	3445	6	14358
Dec-11	18473	12326	750	7661	34	39243
Jan-12	23492	5381	289	6088	0	35250
Feb-12	23705	4034	5923	6199	14	39875
Mar-12	19686	1379	5543	5520	4	32131
Apr-12	7287	460	6581	5292	4	19625
May-12	1402	0	454	5644	5	7504
Jun-12	24802	27755	16731	13201	21	82510
Jul-12	45234	42066	19057	14465	60	120883
Aug-12	45391	30434	18014	12409	72	106320
Sep-12	3441	840	9880	8366	10	22537
Oct-12	777	123	405	5250	2	6556
Nov-12	2219	1192	59	4525	5	8001
Dec-12	8318	1267	508	7047	28	17168
Jan-13	893	1266	330	2519	0	5009
Feb-13	2596	939	7	3906	14	7463
Mar-13	1013	33	8164	3040	4	12254
Apr-13	613	11	3540	3028	4	7196
May-13	717	0	0	3016	5	3738
Jun-13	26176	29510	11863	5136	22	72707
Jul-13	39994	17398	15372	7502	61	80327
Aug-13	31989	12980	4464	6522	74	56030
Sep-13	1222	0	0	4031	11	5264
Oct-13	371	0	0	2910	2	3284
Nov-13	665	0	0	1723	5	2393
Dec-13	3004	99	0	5274	29	8405
Jan-14	31	27	0	2773	0	2831
Feb-14	331	0	7	3338	9	3686
Mar-14	231	138	0	2791	3	3163
Apr-14	120	0	0	2745	3	2869
May-14	141	0	0	2816	3	2959
Jun-14	13183	0	0	3744	14	16941
Jul-14	25975	26500	13175	4647	41	70337
Aug-14	18326	9961	4790	4555	49	37681
Sep-14	246	0	90	3414	7	3757
Oct-14	71	0	0	2751	2	2824
Nov-14	138	0	0	2041	3	2182
Dec-14	681	0	0	4106	19	4806
Jan-15	4	0	0	3439	0	3443
Feb-15	32	0	0	4691	2	4725
Mar-15	45	0	31	3836	3	3915
Apr-15	27	0	11	3764	2	3804
May-15	32	0	0	3840	2	3874
Jun-15	55	0	65	5326	4	5451
Jul-15	14382	10880	9816	6779	10	41868
Aug-15	9458	1549	5162	6539	9	22718
Sep-15	23	0	0	4764	2	4788
Oct-15	17	0	0	3743	1	3761
Nov-15	25	0	0	2725	2	2752
Dec-15	75	0	0	5887	6	5968
Jan-16	0	896	0	2854	0	3750
Feb-16	116	1103	0	2854	0	4073
Mar-16	0	896	0	2854	0	3750
Apr-16	0	299	0	2854	0	3153
May-16	672	2004	1559	2854	0	7089
Jun-16	19693	41699	12988	2854	0	77234
Jul-16	18328	38082	14830	2854	0	74094
Aug-16	20982	5884	13154	2854	0	42874
Sep-16	0	0	0	2854	0	2854
Oct-16	0	0	0	2854	0	2854
Nov-16	0	0	0	2854	0	2854
Dec-16	0	0	0	2854	0	2854



APPENDIX D2-2

Surface Water Delivery (Acre-Feet)	Kaweah Subbasin	Kern County Subbasin	Kings Subbasin	Tule Subbasin	Westside Subbasin
Jan-90	47	1371	641	98	14547
Feb-90	130	3377	1373	244	14780
Mar-90	1444	4469	1141	386	6613
Apr-90	1596	2992	1217	636	6917
May-90	1731	4044	2573	1121	9906
Jun-90	9129	7032	16562	3468	16410
Jul-90	12238	10939	14508	2300	19830
Aug-90	5593	6916	6048	4178	7587
Sep-90	2007	1975	1688	1038	1151
Oct-90	652	1725	781	670	1147
Nov-90	85	936	851	296	1291
Dec-90	41	1201	324	59	1575
Jan-91	8	307	94	53	2212
Feb-91	42	378	461	131	3188
Mar-91	605	178	324	159	1529
Apr-91	760	466	259	269	1647
May-91	4621	1175	2598	2722	4730
Jun-91	22007	3359	20363	4708	11412
Jul-91	24361	4596	25900	5856	12927
Aug-91	9982	2702	6574	5370	7908
Sep-91	3052	1040	1852	547	1387
Oct-91	1344	1418	1184	359	1441
Nov-91	53	485	336	159	972
Dec-91	143	566	763	32	960
Jan-92	7	103	99	82	508
Feb-92	55	251	386	204	558
Mar-92	1716	798	320	249	1368
Apr-92	3133	2152	715	429	3036
May-92	4802	4154	2222	941	7373
Jun-92	17030	6905	22629	5580	12539
Jul-92	10891	7189	11734	4545	12735
Aug-92	7065	3767	6252	4529	9834
Sep-92	2278	1713	1418	842	1429
Oct-92	1139	1486	843	560	1418
Nov-92	35	460	326	248	374
Dec-92	24	270	322	49	366
Jan-93	3	233	45	223	283
Feb-93	24	1115	327	1878	329
Mar-93	11765	4796	3525	6456	2058
Apr-93	16628	6952	15864	5452	5331
May-93	31394	10498	29534	11882	13180
Jun-93	36360	11963	31144	17772	19969
Jul-93	34332	12848	35642	17361	26255
Aug-93	22197	12206	21941	14504	24952
Sep-93	9298	6569	10424	6972	3412
Oct-93	3372	5814	5706	2284	4458
Nov-93	284	4976	3108	248	2854
Dec-93	253	5866	3255	31	6689
Jan-94	293	1859	1457	62	14391
Feb-94	235	4902	2052	154	11245
Mar-94	1174	3746	1735	187	4253
Apr-94	1700	3097	1026	352	4789
May-94	2645	3262	3119	733	4923
Jun-94	14876	7646	24290	5384	15762
Jul-94	21182	10130	21360	9021	19556
Aug-94	11467	5895	10842	5542	12822
Sep-94	2504	1525	2089	759	1917
Oct-94	455	1049	516	434	1230
Nov-94	27	623	151	187	1490
Dec-94	50	801	649	37	2553
Jan-95	62	1517	822	294	3945
Feb-95	107	5076	1466	2446	4999
Mar-95	13717	2946	6844	4178	2134
Apr-95	21008	4724	16379	4430	6216
May-95	22750	7162	26917	6118	9726
Jun-95	38495	12984	35898	13129	22645
Jul-95	44604	16411	43101	19611	27976
Aug-95	36972	16002	33223	19211	24260
Sep-95	17742	8571	13976	8283	5616
Oct-95	3822	5892	2839	3356	7384
Nov-95	171	5241	1991	1162	5016
Dec-95	241	4683	3265	112	7753
Jan-96	257	3830	3497	171	15241
Feb-96	227	4045	2233	2850	9564
Mar-96	17084	4212	8807	5755	4982
Apr-96	14994	8713	16632	6401	10742
May-96	27215	11626	29126	10291	15910
Jun-96	34883	14051	35248	14968	28780
Jul-96	38539	15436	40793	17823	31016
Aug-96	24891	13542	28073	15431	25341
Sep-96	4141	4517	9234	1028	5287
Oct-96	1268	3364	2693	684	4243
Nov-96	43	1779	492	306	1763
Dec-96	33	2734	452	60	2416
Jan-97	465	318	888	96	6174
Feb-97	780	1350	2277	1360	9686
Mar-97	19616	4778	17019	7234	16640
Apr-97	13855	6395	11696	7037	12485
May-97	15904	8934	25906	4524	18409
Jun-97	27570	11860	29858	11890	30312
Jul-97	27017	13740	30387	14320	29306
Aug-97	17755	10410	17428	9734	21987
Sep-97	5995	3886	3381	4308	5058
Oct-97	2392	3114	1834	2352	5550
Nov-97	209	1807	686	391	3755
Dec-97	86	2021	735	57	2950
Jan-98	40	4058	557	53	9421
Feb-98	16	1413	136	180	4800
Mar-98	17198	1462	8816	1500	6959
Apr-98	18553	3193	9764	1807	6464
May-98	21517	5380	17966	4202	7069
Jun-98	26476	7845	22139	8145	12919
Jul-98	39784	14518	35487	15503	28073
Aug-98	32219	14327	32359	12476	23258
Sep-98	18559	8841	16058	6449	7230
Oct-98	4207	4416	3715	2929	6783
Nov-98	184	1743	2377	583	3331
Dec-98	877	2290	4223	202	10884
Jan-99	270	1175	3687	554	15754
Feb-99	128	2220	1732	1655	8688
Mar-99	3039	5126	3462	3523	9463
Apr-99	3354	6552	3010	1742	9135
May-99	9147	10436	16776	6266	16579
Jun-99	21666	14488	28786	10130	25709
Jul-99	28645	16359	31931	12287	27148
Aug-99	18298	9651	19378	10795	17599
Sep-99	3892	4405	8003	1635	3740
Oct-99	1489	6242	3144	537	5503
Nov-99	233	3775	2670	237	2996
Dec-99	186	1789	1369	47	4824
Jan-00	183	2447	1682	75	4298
Feb-00	195	5584	2515	351	7826
Mar-00	13554	5723	3625	3107	6384
Apr-00	10637	5906	5303	4436	8766
May-00	19686	10031	22335	10465	12749
Jun-00	31336	15006	31244	12509	19346
Jul-00	33065	15694	32482	12724	22269
Aug-00	18279	11856	22034	8593	17887
Sep-00	3187	5443	4314	769	3424
Oct-00	618	3815	1001	512	2275
Nov-00	165	2624	1086	226	2571
Dec-00	181	1151	2033	45	6332
Jan-01	96	1721	1304	73	14080
Feb-01	79	836	681	182	8421
Mar-01	1619	2440	1699	222	5282
Apr-01	1845	1588	1697	375	7266
May-01	13061	3564	6552	4061	9234
Jun-01	22013	5679	28434	8687	17537
Jul-01	26342	6281	21764	8711	16982
Aug-01	6921	4870	7429	3397	13782
Sep-01	2808	2297	2379	753	2108
Oct-01	904	1182	867	501	2447
Nov-01	47	561	206	222	1305
Dec-01	58	412	728	44	1826
Jan-02	111	1242	555	77	5044
Feb-02	263	3354	1887	191	10078
Mar-02	1567	2679	2407	232	6151
Apr-02	2279	3694	2782	392	8934
May-02	8056	3793	14135	3426	9804
Jun-02	21134	9403	30090	7238	18587
Jul-02	26501	9237	23318	9796	22521
Aug-02	14993	8456	8492	5606	14048
Sep-02	2807	4270	2133	787	3193
Oct-02	1460	3142	1181	524	2963
Nov-02	54	1076	411	348	1778
Dec-02	127	689	375	57	4261
Jan-03	125	882	459	181	10900
Feb-03	103	2700	1212	218	10555
Mar-03	1043	2788	2060	266	4915
Apr-03	3767	2265	1936	1959	9139
May-03	18843	6246	10425	8209	7639
Jun-03	28702	9500	30798	11859	19955
Jul-03	30699	14946	29784	14417	25924
Aug-03	11713	10773	12405	7635	17902
Sep-03	3771	4893	3616	901	6180
Oct-03	1102	3625	2000	600	3883
Nov-03	224	2201	1216	265	2084
Dec-03	729	2211	1061	53	6090
Jan-04	205	1248	884	83	11775
Feb-04	127	4067	1213	207	5917
Mar-04	3259	7192	4015	252	7697
Apr-04	3828	3913	2446	426	10818
May-04	6348	5772	6833	4041	14128
Jun-04	20114	7846	29563	8286	25508
Jul-04	19954	9223	22297	7586	21170
Aug-04	12796	5486	9468	5573	15280
Sep-04	2383	2398	2093	855	2084
Oct-04	2235	1451	661	569	1365
Nov-04	96	485	345	252	1231
Dec-04	36	392	340	50	3433
Jan-05	37	1723	515	973	4077
Feb-05	142	5371	1397	2875	7664
Mar-05	9329	7917	4535	2312	5803
Apr-05	16557	13449	10234	7101	8779
May-05	22141	11096	23578	9012	7929
Jun-05	36488	14923	33535	15303	24589
Jul-05	36866	15534	36452	19067	28207
Aug-05	29242	14034	26373	16129	26623
Sep-05	7968	9057	11583	4196	6209
Oct-05	1790	7564	4348	715	3728
Nov-05	191	4929	1583	316	4856
Dec-05	574	4297	3944	63	10618
Jan-06	44	3048	619	1536	7565
Feb-06	498	6448	2851	3751	9719
Mar-06	7048	5619	3734	1916	4257
Apr-06	13024	5112	11080	1843	2963
May-06	29347	11068	29089	9981	14873
Jun-06	33094	11030	35571	14724	27155
Jul-06	30714	16449	38124	16978	31089
Aug-06	24962	15057	27330	16460	24540
Sep-06	9862	10336	12634	6849	7608
Oct-06	1096	6974	4504	591	4830
Nov-06	216	5659	1983	261	3936
Dec-06	311	3774	3280	52	8834
Jan-07	261	5025	2830	143	12097
Feb-07	306	2356	2228	298	12803
Mar-07	863	4484	2370	363	10386
Apr-07	985	2811	2165	612	13021
May-07	2965	4835	3624	1350	17784
Jun-07	11494	7256	11801	4407	18668
Jul-07	15168	7529	15169	8696	16893
Aug-07	8858	4901	7301	3060	10555
Sep-07	18477	2571	1890	1228	2441
Oct-07	713	1595	948	818	1590
Nov-07	57	536	396	361	1003
Dec-07	58	366	463	72	896

Surface Water Delivery (Acre-Feet)	APPENDIX D2-2 (Cont) Kaweah Subbasin	Kern County Subbasin	Kings Subbasin	Tule Subbasin	Westside Subbasin
Jan-08	18	152	246	83	902
Feb-08	76	852	802	552	3112
Mar-08	7172	1651	2476	4489	8384
Apr-08	2395	2361	2802	424	9010
May-08	4395	3761	13361	934	10147
Jun-08	21269	6219	24490	10546	10365
Jul-08	24815	7612	26919	9910	9325
Aug-08	9279	5128	8168	1262	6755
Sep-08	3121	3576	2429	849	3966
Oct-08	1277	2028	1254	566	1414
Nov-08	205	549	529	250	602
Dec-08	80	454	359	50	502
Jan-09	228	401	302	81	756
Feb-09	94	767	377	200	680
Mar-09	988	1077	1194	244	2448
Apr-09	2213	2440	1660	416	3365
May-09	16510	4280	6848	10204	6105
Jun-09	19393	6669	23889	3994	7381
Jul-09	23418	6562	28183	11783	5651
Aug-09	13001	6142	12501	9198	2372
Sep-09	3185	3051	2110	827	1515
Oct-09	1964	2051	1283	551	1004
Nov-09	98	627	533	1747	945
Dec-09	52	348	244	48	967
Jan-10	9	193	118	75	1524
Feb-10	91	784	555	203	2815
Mar-10	9084	1151	2912	2390	1932
Apr-10	9661	2259	8354	5168	3111
May-10	27630	5169	20455	9836	6608
Jun-10	31224	10058	26047	8433	19120
Jul-10	32344	15684	23806	11894	18808
Aug-10	24931	13524	24152	12023	13783
Sep-10	7017	9882	8430	3200	6138
Oct-10	1650	5379	3908	511	3096
Nov-10	55	3811	363	226	2129
Dec-10	1501	3942	1547	46	2707
Jan-11	199	4763	2695	829	4520
Feb-11	452	4746	1734	2065	9670
Mar-11	10065	6270	10124	3745	7657
Apr-11	21424	6019	20262	5438	7172
May-11	26993	7494	25764	9322	11941
Jun-11	29531	9935	29828	12067	21540
Jul-11	30783	14434	24313	16092	23798
Aug-11	26314	14932	20716	14640	20960
Sep-11	15653	10223	16679	9216	8234
Oct-11	3935	6062	4893	4634	3188
Nov-11	193	5978	1164	247	2826
Dec-11	101	6460	1375	49	4443
Jan-12	583	3300	1743	82	11629
Feb-12	260	4623	2325	204	16398
Mar-12	442	1161	1600	248	2847
Apr-12	441	2454	2814	1126	4631
May-12	3353	5228	5466	1221	9250
Jun-12	13499	8711	16026	3763	14397
Jul-12	21816	12788	22698	8687	12811
Aug-12	9476	11893	14638	9194	9482
Sep-12	3692	6552	2578	840	3343
Oct-12	3264	5333	1361	559	2483
Nov-12	108	2295	520	247	1604
Dec-12	18	1308	252	49	1642
Jan-13	36	1248	396	82	2969
Feb-13	152	1411	828	204	4297
Mar-13	574	1361	1343	248	3226
Apr-13	1043	2932	2598	419	5102
May-13	2885	4727	4167	923	9255
Jun-13	7655	8186	14386	1376	9966
Jul-13	8922	8924	13925	2653	9178
Aug-13	9089	5862	4616	10351	4590
Sep-13	2433	3503	2168	840	1332
Oct-13	782	2414	1215	559	963
Nov-13	82	597	423	247	375
Dec-13	59	378	269	49	431
Jan-14	109	361	701	82	559
Feb-14	22	840	299	204	616
Mar-14	18	523	202	248	704
Apr-14	63	1566	438	419	1138
May-14	269	2973	990	923	2222
Jun-14	3386	4293	7480	1376	3990
Jul-14	2612	4990	12797	1604	3047
Aug-14	940	4270	4563	1248	1399
Sep-14	647	2565	2645	840	729
Oct-14	287	1166	906	559	381
Nov-14	108	413	376	247	122
Dec-14	22	272	291	49	184
Jan-15	59	336	607	82	70
Feb-15	27	805	325	204	225
Mar-15	114	1076	416	248	433
Apr-15	154	1989	413	419	793
May-15	266	3394	693	923	1440
Jun-15	1336	4267	2704	1376	2637
Jul-15	3306	5141	7295	1604	1975
Aug-15	852	3915	2958	1248	937
Sep-15	610	2046	1250	840	528
Oct-15	287	1166	906	559	381
Nov-15	108	413	376	247	263
Dec-15	22	272	291	49	155
Jan-16	109	361	701	142	559
Feb-16	22	840	299	477	616
Mar-16	18	523	202	2211	704
Apr-16	63	1566	438	3442	1138
May-16	269	2973	990	923	2222
Jun-16	3386	4293	7480	1376	3990
Jul-16	2612	4990	12797	9836	3047
Aug-16	940	4270	4563	4806	1399
Sep-16	647	2565	2645	840	729
Oct-16	287	1166	906	559	381
Nov-16	108	413	376	247	122
Dec-16	22	272	291	49	184

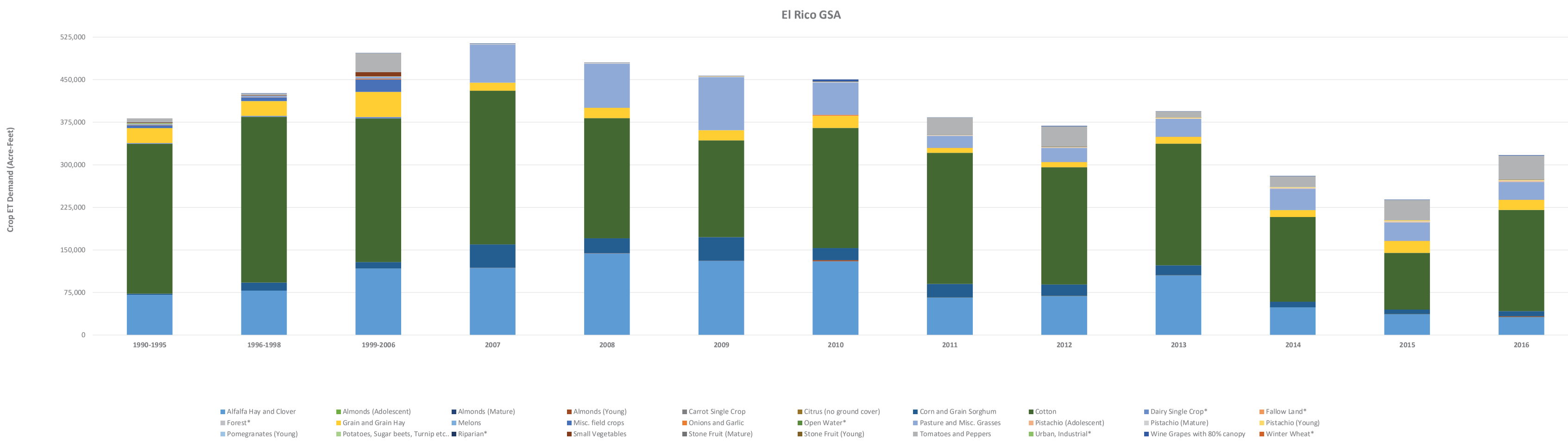


Appendix D3
Summary of Crop Demand

APPENDIX D3-1

Sum of Crop ET Demand (Acre-Feet/Year) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
El Rico GSA													
Alfalfa Hay and Clover	70729	78296	117038	118221	143932	130955	129971	66396	68927	105292	48866	36930	31810
Almonds (Adolescent)	0	0	0	0	0	0	0	3	2	2	18	5	10
Almonds (Mature)	0	0	0	0	0	0	0	0	0	0	0	0	0
Almonds (Young)	0	0	0	188	146	145	1951	180	194	477	170	185	1163
Carrot Single Crop	0	0	0	0	0	0	0	19	8	1	0	0	16
Citrus (no ground cover)	0	0	0	0	0	0	0	16	0	7	0	2	4
Corn and Grain Sorghum	2018	14258	11703	41343	26375	41546	21187	23395	19850	17015	9740	7639	9086
Cotton	264279	292007	252807	270755	211744	170500	211791	231241	206654	214373	149263	99964	178223
Dairy Single Crop*	1445	1847	2688	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	26296	25753	44136	14205	18440	17878	21292	8497	9155	12247	12207	21158	17961
Melons	0	0	0	0	0	0	0	1	8	2	728	4	93
Misc. field crops	4755	6468	22248	0	4	0	0	0	0	0	0	0	0
Onions and Garlic	446	291	1070	0	0	0	1834	47	105	49	77	146	111
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	1917	2947	3895	67107	77436	93539	57165	21110	24818	31286	36605	32424	31157
Pistachio (Adolescent)	0	0	0	0	0	0	0	211	277	370	687	1003	1370
Pistachio (Mature)	0	0	0	1232	1293	983	897	932	917	847	842	1184	1122
Pistachio (Young)	0	23	221	322	376	619	698	392	735	1140	1492	1535	1315
Pomegranates (Young)	0	0	0	0	91	42	4	81	24	93	148	164	162
Potatoes, Sugar beets, Turnip etc..	1508	0	0	14	0	0	0	4	0	4	0	3	3
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Vegetables	1430	528	7590	0	0	3	94	23	29	107	103	8	116
Stone Fruit (Mature)	0	0	0	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Young)	0	0	0	2	9	44	2	3	85	1	2	40	78
Tomatoes and Peppers	7067	3135	33674	11	2	150	0	30683	36052	10959	19043	35729	42194
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	0	503	334	407	362	47	3559	227	1035	92	546	472	958
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
El Rico GSA Irrigated ET Demand	**380445**	**424208**	**494716**	**513807**	**480209**	**456451**	**450445**	**383463**	**368875**	**394364**	**280539**	**238594**	**316952**
El Rico GSA Total ET Demand	**381890**	**426054**	**497404**	**513807**	**480209**	**456451**	**450445**	**383463**	**368875**	**394364**	**280539**	**238594**	**316952**

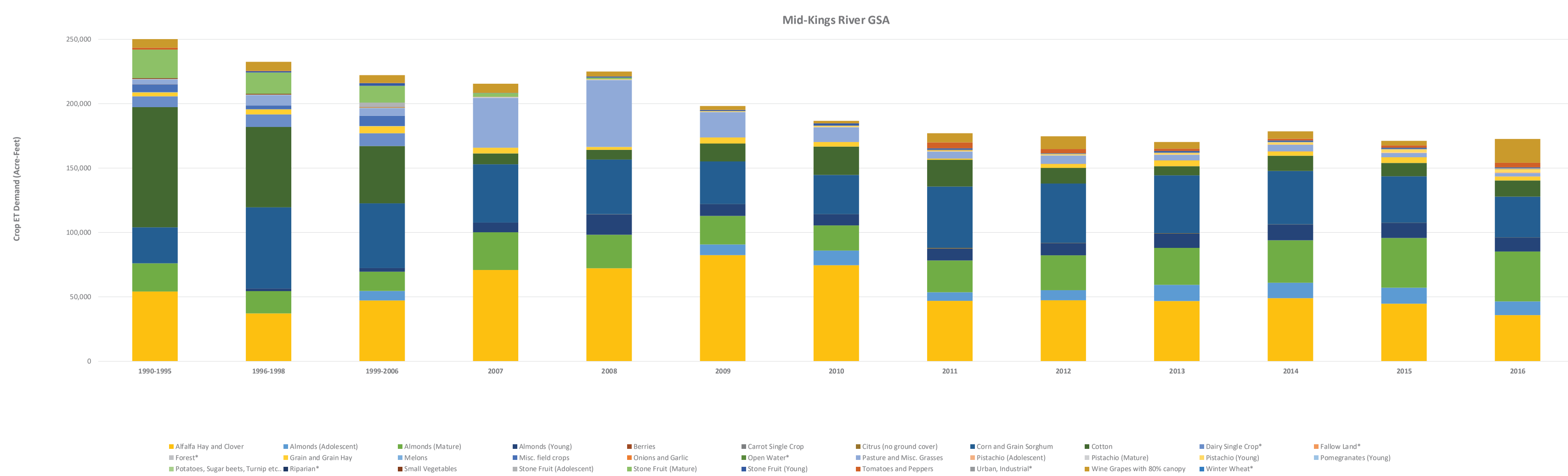
Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



APPENDIX D3-2

Sum of Crop ET Demand (Acre-Feet/Year) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Mid-Kings River GSA													
Alfalfa Hay and Clover	54225	37134	47231	70920	72279	82432	74524	46996	47297	46833	49033	44781	35779
Almonds (Adolescent)	0	0	7382	0	0	8287	11414	6655	7948	12571	11964	12357	10700
Almonds (Mature)	21899	17282	14900	29318	25948	22195	19532	24669	27021	28629	33006	38590	38813
Almonds (Young)	0	2093	2798	7469	15899	9090	8694	9270	9515	11128	12224	11764	10892
Berries	0	0	0	0	0	0	0	0	1	6	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	4	7	1	7	0	14
Citrus (no ground cover)	0	0	75	0	32	31	14	370	89	299	102	56	12
Corn and Grain Sorghum	27832	63039	50239	45210	42440	33204	30445	47662	46154	44975	41460	36068	31535
Cotton	93307	62361	44507	8474	7660	13894	22023	20867	12109	7001	11789	10353	12573
Dairy Single Crop*	8529	9826	9984	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	2897	3811	5457	4423	2221	4688	3586	868	3163	4629	3337	4457	3095
Melons	248	92	45	0	0	0	0	2	5	6	0	0	20
Misc. field crops	6082	3065	8059	0	0	0	0	0	0	0	0	0	0
Onions and Garlic	102	0	0	0	0	1	36	65	126	7	109	13	210
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	3717	8128	5877	38630	51880	19656	11431	5495	6343	4322	5084	3241	2570
Pistachio (Adolescent)	0	0	0	0	0	0	0	2	18	55	152	343	350
Pistachio (Mature)	321	254	241	675	270	135	86	83	57	52	45	46	55
Pistachio (Young)	0	34	215	326	374	674	983	947	885	1156	1706	2353	2641
Pomegranates (Young)	0	0	0	0	4	1	1	20	10	46	40	5	13
Potatoes, Sugar beets, Turnip etc..	0	4	0	5	0	5	0	1	0	1	0	1	2
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Vegetables	595	617	418	24	2	4	158	159	103	164	139	46	147
Stone Fruit (Adolescent)	0	0	3393	0	0	5	126	230	290	171	105	414	416
Stone Fruit (Mature)	22291	16483	13130	2753	1199	102	26	11	80	141	79	95	136
Stone Fruit (Young)	0	1079	2020	237	879	730	1645	958	386	1186	1054	845	560
Tomatoes and Peppers	1355	304	110	2	0	77	0	4695	3145	1754	1343	1699	3679
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	7381	6981	6093	7034	3829	2999	1976	7037	10002	5141	5696	3681	18346
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
Mid-Kings River GSA Irrigated ET De	**242254**	**222759**	**212189**	**215500**	**224914**	**198211**	**186699**	**177065**	**174754**	**170274**	**178474**	**171208**	**172557**
Mid-Kings River GSA Total ET Dema	**250784**	**232585**	**222173**	**215500**	**224914**	**198211**	**186699**	**177065**	**174754**	**170274**	**178474**	**171208**	**172557**

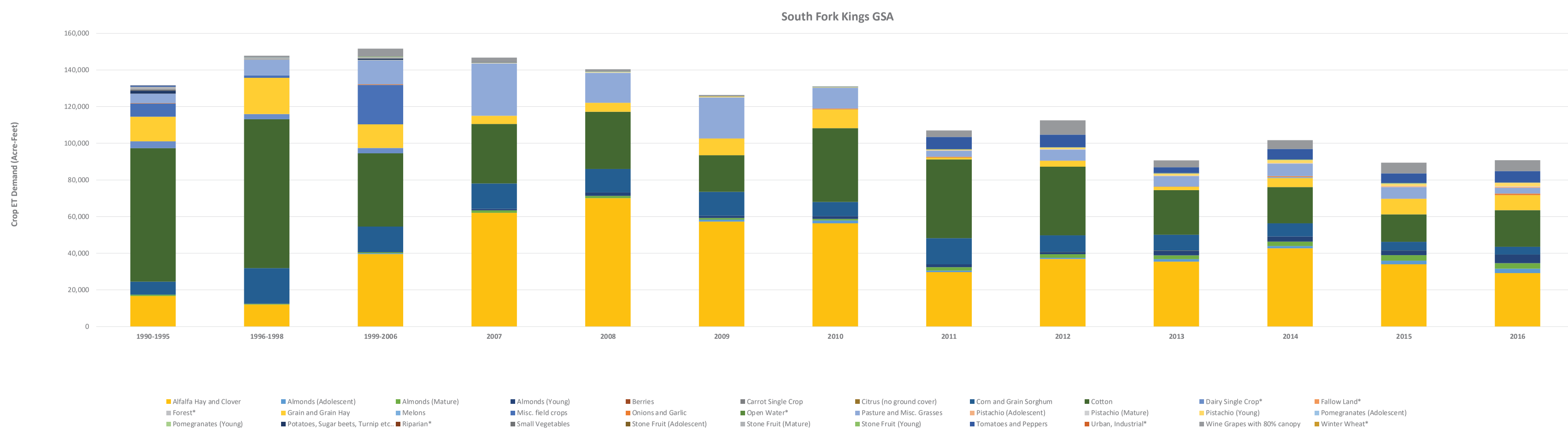
Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



APPENDIX D3-3

Sum of Crop ET Demand (Acre-Feet/Year) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
South Fork Kings GSA													
Alfalfa Hay and Clover	16709	11994	39584	62068	70090	57340	56328	29744	36900	35451	42768	33986	29185
Almonds (Adolescent)	0	0	480	0	0	944	1576	777	652	1305	1236	1974	2399
Almonds (Mature)	743	499	472	1396	1211	944	805	1850	1903	2131	2373	2984	3024
Almonds (Young)	0	131	225	812	1861	1270	1646	1631	1226	2518	2843	2414	4672
Berries	0	0	0	0	0	0	0	0	1	0	0	1	0
Carrot Single Crop	0	0	0	0	0	0	0	4	2	7	0	6	26
Citrus (no ground cover)	0	0	17	0	0	0	0	14	3	18	0	2	2
Corn and Grain Sorghum	7027	19269	13851	13800	12846	13062	7622	14201	9097	8717	7123	4889	4232
Cotton	72878	81246	39915	32470	31210	19953	40263	42989	37422	24280	19786	15035	19992
Dairy Single Crop*	3737	2849	2925	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	13435	19790	12933	4435	4864	9156	10285	993	3255	1869	4921	8414	8207
Melons	0	0	0	0	0	0	8	1	2	2	448	0	15
Misc. field crops	7159	1270	21466	0	0	0	0	1	0	0	0	0	0
Onions and Garlic	258	0	289	0	0	8	495	467	112	108	563	71	795
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	5165	8608	13288	28562	16311	22322	11169	3302	5982	5766	6903	6334	3180
Pistachio (Adolescent)	0	0	0	0	0	0	0	0	19	29	64	504	585
Pistachio (Mature)	1	0	0	311	306	176	184	200	199	181	168	162	177
Pistachio (Young)	0	9	83	196	206	442	246	360	878	1028	1600	1130	1957
Pomegranates (Adolescent)	0	0	0	0	0	0	0	0	0	0	5	23	41
Pomegranates (Young)	0	0	0	2	176	19	41	196	121	161	294	393	140
Potatoes, Sugar beets, Turnip etc..	1518	0	676	0	0	5	0	0	0	119	0	3	1
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Vegetables	762	3	0	8	0	13	18	23	49	69	7	62	44
Stone Fruit (Adolescent)	0	0	188	0	0	0	0	1	1	0	2	0	9
Stone Fruit (Mature)	1463	1135	688	9	0	0	0	0	0	0	0	0	0
Stone Fruit (Young)	0	67	175	26	38	67	167	47	69	61	60	28	28
Tomatoes and Peppers	660	117	0	207	3	17	26	6642	6816	3119	5802	5246	6122
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	205	816	4390	2477	1278	644	153	3578	7838	3765	4771	5792	5920
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
South Fork Kings GSA Irrigated ET D	**127983**	**144955**	**148720**	**146777**	**140400**	**126381**	**131035**	**107022**	**112547**	**90701**	**101735**	**89454**	**90754**
South Fork Kings GSA Total ET Dema	**131720**	**147804**	**151645**	**146777**	**140400**	**126381**	**131035**	**107022**	**112547**	**90701**	**101735**	**89454**	**90754**

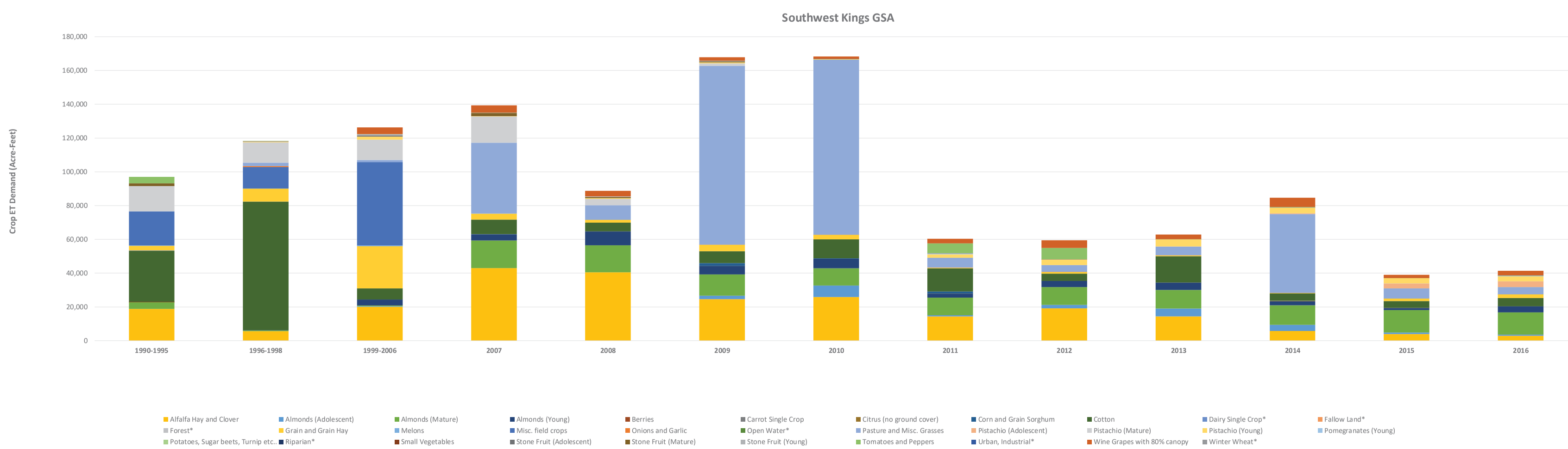
Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



APPENDIX D3-4

Sum of Crop ET Demand (Acre-Feet/Year) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Southwest Kings GSA													
Alfalfa Hay and Clover	18759	5587	20110	43026	40528	24609	25791	14378	19154	14389	5716	3975	2961
Almonds (Adolescent)	0	0	251	0	0	1987	6874	691	2030	4651	3718	819	604
Almonds (Mature)	4150	497	497	16316	15963	12694	10200	10456	10526	10960	11577	13295	13247
Almonds (Young)	0	63	3457	3590	8199	4939	5669	2319	3629	4328	2374	1340	3474
Berries	47	0	0	0	0	0	0	0	0	0	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	1	0	0	0	0	1
Citrus (no ground cover)	0	0	0	0	10	15	0	1	6	12	197	13	13
Corn and Grain Sorghum	0	45	0	170	47	1654	219	1271	82	188	89	10	80
Cotton	30305	76227	6616	8666	5111	7109	11217	13730	4226	15517	4291	4063	4891
Dairy Single Crop*	145	0	55	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	2788	7652	24977	3452	1759	3814	2758	328	1041	533	231	1387	2180
Melons	165	0	423	0	0	0	14	0	1	0	6	0	1
Misc. field crops	20277	12708	49397	0	1	0	0	0	0	0	4	0	0
Onions and Garlic	0	555	0	0	0	3	45	113	186	3	143	36	26
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	0	2040	1192	41974	8570	105889	103590	5801	3878	5081	46667	6062	4311
Pistachio (Adolescent)	0	0	0	0	0	0	0	0	1	105	387	2863	3399
Pistachio (Mature)	14907	12101	12101	15614	3811	1532	68	68	64	55	20	20	20
Pistachio (Young)	0	328	1744	208	396	675	390	2026	3269	4168	3397	3156	2931
Pomegranates (Young)	0	0	0	9	30	30	3	596	56	74	30	5	430
Potatoes, Sugar beets, Turnip etc..	0	0	0	0	0	0	0	7	0	0	0	0	1
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Vegetables	47	0	0	1	1	0	61	23	30	2	14	8	8
Stone Fruit (Adolescent)	0	0	658	0	0	23	12	0	0	0	0	0	0
Stone Fruit (Mature)	1596	257	0	1799	688	482	38	0	0	0	0	0	0
Stone Fruit (Young)	0	164	806	200	307	376	64	3	7	3	70	0	1
Tomatoes and Peppers	3889	191	6	42	0	2	0	5793	6709	6	321	16	120
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	0	0	4055	4280	3334	2002	1284	2777	4565	2829	5430	1925	2694
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
Southwest Kings GSA Irrigated ET De	**96929**	**118416**	**126291**	**139347**	**88756**	**167834**	**168296**	**60381**	**59459**	**62904**	**84684**	**38993**	**41393**
Southwest Kings GSA Total ET Dema	**97074**	**118416**	**126346**	**139347**	**88756**	**167834**	**168296**	**60381**	**59459**	**62904**	**84684**	**38993**	**41393**

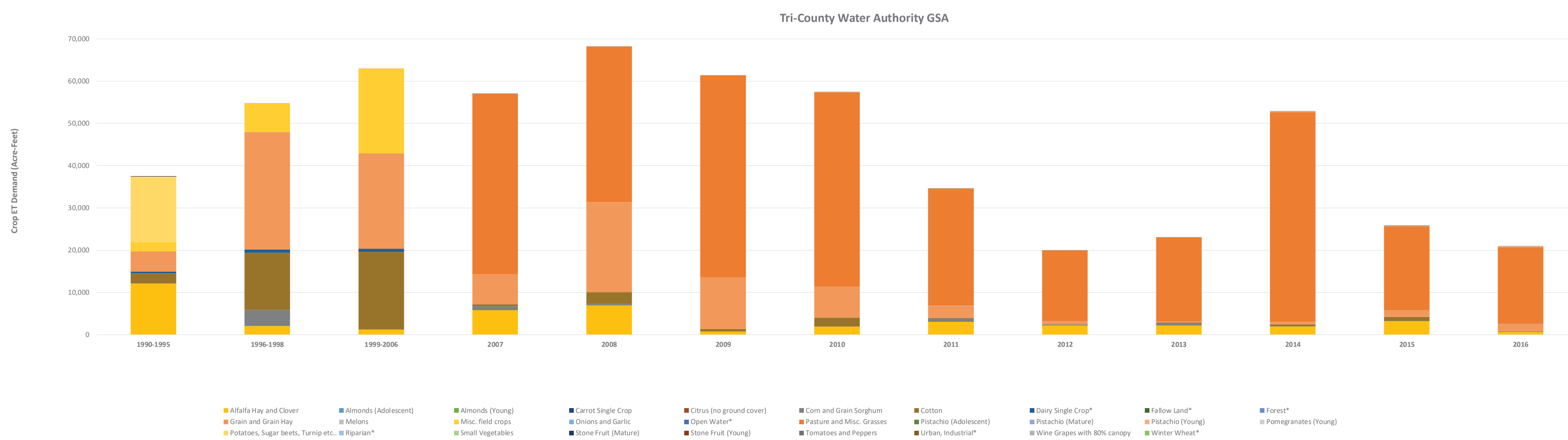
Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



APPENDIX D3-5

Sum of Crop ET Demand (Acre-Feet/Year) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tri-County Water Authority GSA													
Alfalfa Hay and Clover	12097	2022	1204	5806	6923	750	1941	3106	2180	2254	1941	3166	659
Almonds (Adolescent)	0	0	0	0	0	0	0	0	0	0	0	0	0
Almonds (Young)	0	0	0	4	21	1	4	30	16	8	9	76	5
Carrot Single Crop	0	0	0	0	0	0	0	9	0	32	0	0	0
Citrus (no ground cover)	0	0	0	0	0	0	0	4	0	0	0	0	0
Corn and Grain Sorghum	0	3839	0	895	319	1	5	706	160	294	51	13	2
Cotton	2410	13544	18387	505	2786	616	2089	143	115	306	431	952	136
Dairy Single Crop*	433	747	768	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	4751	27805	22522	7057	21279	12220	7349	2832	755	227	585	1519	1785
Melons	0	0	0	0	0	0	0	0	0	0	0	22	0
Misc. field crops	2177	6785	20095	0	0	0	0	0	0	0	0	0	0
Onions and Garlic	0	0	0	0	0	0	6	40	9	0	1	0	4
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	0	4	4	42701	36886	47791	45951	27710	16730	19878	49684	19952	18152
Pistachio (Adolescent)	0	0	0	0	0	0	0	0	0	0	0	0	0
Pistachio (Mature)	0	0	0	0	0	0	0	0	0	0	0	0	0
Pistachio (Young)	0	0	1	38	18	44	78	4	3	5	87	57	180
Pomegranates (Young)	0	0	0	0	2	6	4	8	0	1	25	1	1
Potatoes, Sugar beets, Turnip etc..	15578	0	0	0	0	0	0	17	0	3	0	0	0
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Vegetables	0	0	0	0	0	0	10	1	1	48	1	2	2
Stone Fruit (Mature)	1	0	0	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Young)	0	0	0	1	0	0	0	0	0	0	0	0	0
Tomatoes and Peppers	0	0	0	0	0	0	0	38	3	8	46	102	53
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	0	0	0	5	91	0	7	6	16	6	7	5	1
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigated ET Demand	**37015**	**53999**	**62214**	**57010**	**68324**	**61429**	**57443**	**34654**	**19988**	**23072**	**52867**	**25868**	**20980**
Total ET Demand	**37449**	**54746**	**62982**	**57010**	**68324**	**61429**	**57443**	**34654**	**19988**	**23072**	**52867**	**25868**	**20980**

Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



APPENDIX D3-6

Sum of Crop ET Demand (Acre-Feet/Year) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tulare Lake Subbasin													
Alfalfa Hay and Clover	172519	135032	225167	300041	333752	296086	288555	160621	174457	204219	148325	122839	100395
Almonds (Adolescent)	0	0	8113	0	0	11218	19864	8127	10631	18529	16937	15155	13714
Almonds (Mature)	26791	18278	15869	47030	43122	35832	30537	36976	39450	41720	46956	54869	55084
Almonds (Young)	0	2287	6480	12062	26125	15445	17964	13431	14580	18458	17621	15779	20206
Berries	47	0	0	0	0	0	0	0	2	6	0	1	0
Carrot Single Crop	0	0	0	0	0	0	0	37	16	41	7	6	56
Citrus (no ground cover)	0	0	91	0	42	46	14	405	99	335	300	74	32
Corn and Grain Sorghum	36877	100450	75793	101418	82027	89467	59478	87236	75344	71190	58462	48619	44935
Cotton	463179	525386	362232	320870	258511	212071	287383	308970	260527	261476	185559	130368	215815
Dairy Single Crop*	14290	15268	16421	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	50167	84811	110025	33572	48563	47755	45271	13518	17369	19505	21282	36934	33228
Melons	413	92	468	0	0	0	21	3	16	10	1182	27	128
Misc. field crops	40450	30296	121265	0	5	0	0	1	0	0	4	0	0
Onions and Garlic	807	846	1359	0	0	12	2417	731	538	167	893	266	1146
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	10799	21726	24256	218974	191082	289198	229306	63417	57751	66333	144942	68014	59370
Pistachio (Adolescent)	0	0	0	0	0	0	0	213	315	559	1290	4713	5704
Pistachio (Mature)	15229	12354	12341	17831	5680	2825	1236	1283	1237	1135	1075	1412	1374
Pistachio (Young)	0	394	2265	1091	1370	2454	2395	3729	5770	7498	8281	8231	9024
Pomegranates (Adolescent)	0	0	0	0	0	0	0	0	0	0	5	23	41
Pomegranates (Young)	0	0	0	11	303	99	52	901	210	376	537	567	746
Potatoes, Sugar beets, Turnip etc..	18604	4	676	19	0	10	0	29	0	127	0	7	7
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	
Small Vegetables	2835	1147	8009	33	3	20	340	227	212	390	264	126	317
Stone Fruit (Adolescent)	0	0	4238	0	0	28	138	232	291	171	106	414	425
Stone Fruit (Mature)	25350	17875	13818	4560	1886	584	64	11	80	141	79	95	136
Stone Fruit (Young)	0	1310	3001	466	1234	1217	1879	1010	547	1250	1186	913	667
Tomatoes and Peppers	12971	3747	33791	261	5	246	26	47851	52725	15847	26555	42793	52168
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	7586	8301	14872	14203	8893	5692	6980	13625	23455	11832	16450	11874	27920
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
Tulare Lake Subbasin Irrigated ET De	**884626**	**964336**	**1044130**	**1072442**	**1002603**	**1010305**	**993918**	**762584**	**735624**	**741315**	**698299**	**564117**	**642636**
Tulare Lake Subbasin GSA Total ET D	**898916**	**979604**	**1060551**	**1072442**	**1002603**	**1010305**	**993918**	**762584**	**735624**	**741315**	**698299**	**564117**	**642636**

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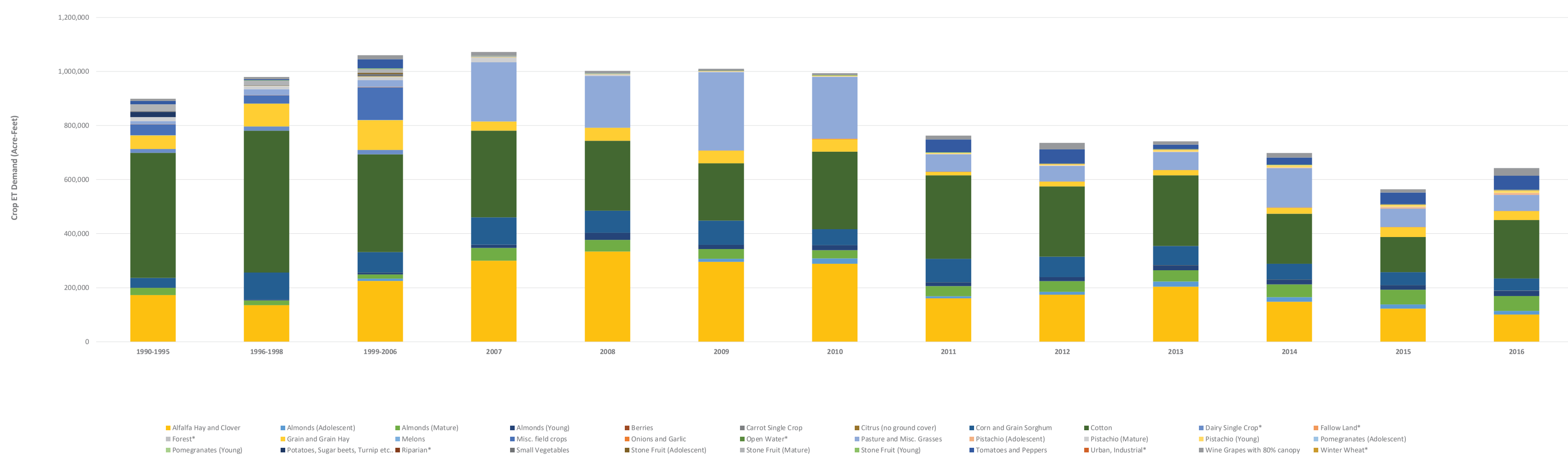
Tulare Lake Subbasin



APPENDIX D3-7

Sum of Crop Acreage (Acres) Kaweah Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Kaweah Subbasin													
Alfalfa Hay and Clover	115486	105689	121989	178448	170164	180822	168599	133463	140002	132011	125440	118685	111593
Almonds (Adolescent)	0	0	2151	0	0	3352	5331	2218	2912	4107	3639	4441	8087
Almonds (Mature)	10994	8841	7642	6331	5140	3927	3359	5959	6632	7023	8956	10024	10922
Almonds (Young)	0	551	277	5010	10534	5981	7005	4784	4303	5354	7935	12728	14258
Berries	0	20	20	0	0	0	0	0	1	1	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	91	6	0	10	1	14
Citrus (no ground cover)	0	0	0	14	32	52	14	41	35	178	247	18	26
Corn and Grain Sorghum	68793	111613	113052	70905	83423	58024	56330	117213	123778	124980	125613	109204	88983
Cotton	171670	113435	96213	40721	27603	33648	55438	51177	38387	29695	28395	19132	31086
Dairy Single Crop*	17748	22327	23914	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	12438	13462	14290	11846	873	3831	3221	1298	3410	4757	2453	4427	2548
Melons	253	167	167	0	0	1	0	4	2	21	0	3	151
Misc. field crops	4124	2758	3400	0	2	2	0	0	0	0	0	0	0
Onions and Garlic	758	404	404	0	0	0	59	297	43	2	16	7	492
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	5210	4802	6452	62054	114029	39268	40513	16032	26257	23092	22644	19504	19446
Pistachio (Adolescent)	0	0	0	0	0	0	0	421	701	1303	2697	6183	6637
Pistachio (Mature)	3309	3097	3097	7106	5394	4376	3529	3368	2888	2586	2512	3113	2640
Pistachio (Young)	0	495	1990	508	928	1646	1688	2718	4237	5070	5543	3449	3661
Pomegranates (Young)	0	0	0	1	28	2	0	16	9	76	24	22	81
Potatoes, Sugar beets, Turnip etc..	1361	2217	1983	18	0	2	0	332	180	9	634	478	580
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Vegetables	3100	5686	5606	142	2	7	3	281	783	1251	1226	1248	1160
Stone Fruit (Adolescent)	0	0	3787	0	0	45	68	44	272	852	1000	191	70
Stone Fruit (Mature)	5897	3165	2730	433	84	18	0	66	9	25	244	328	60
Stone Fruit (Young)	0	975	222	83	602	359	606	770	1131	749	864	472	255
Tomatoes and Peppers	1732	4634	3894	31	2	36	0	2646	855	1553	1216	3151	3897
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	2062	2591	2667	4852	3006	1600	1390	4039	4940	2914	2975	2190	11487
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
Kaweah Subbasin Irrigated ET Dema	**407187**	**384603**	**392034**	**388504**	**421846**	**336999**	**347154**	**347277**	**361772**	**347610**	**344283**	**318999**	**318135**
Kaweah Subbasin Total ET Demand	**424935**	**406930**	**415948**	**388504**	**421846**	**336999**	**347154**	**347277**	**361772**	**347610**	**344283**	**318999**	**318135**

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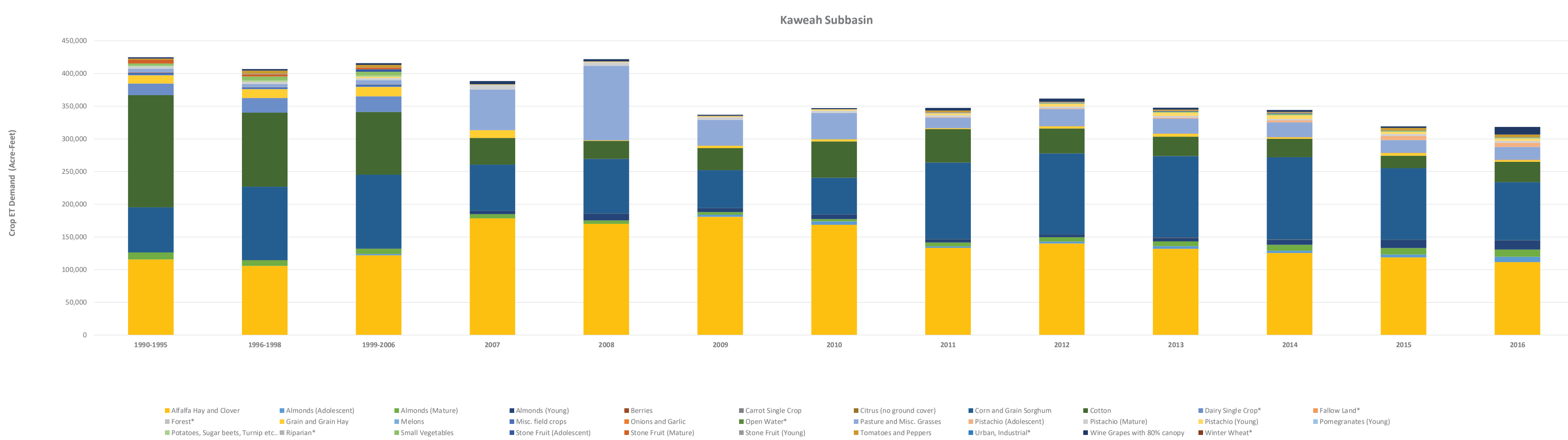
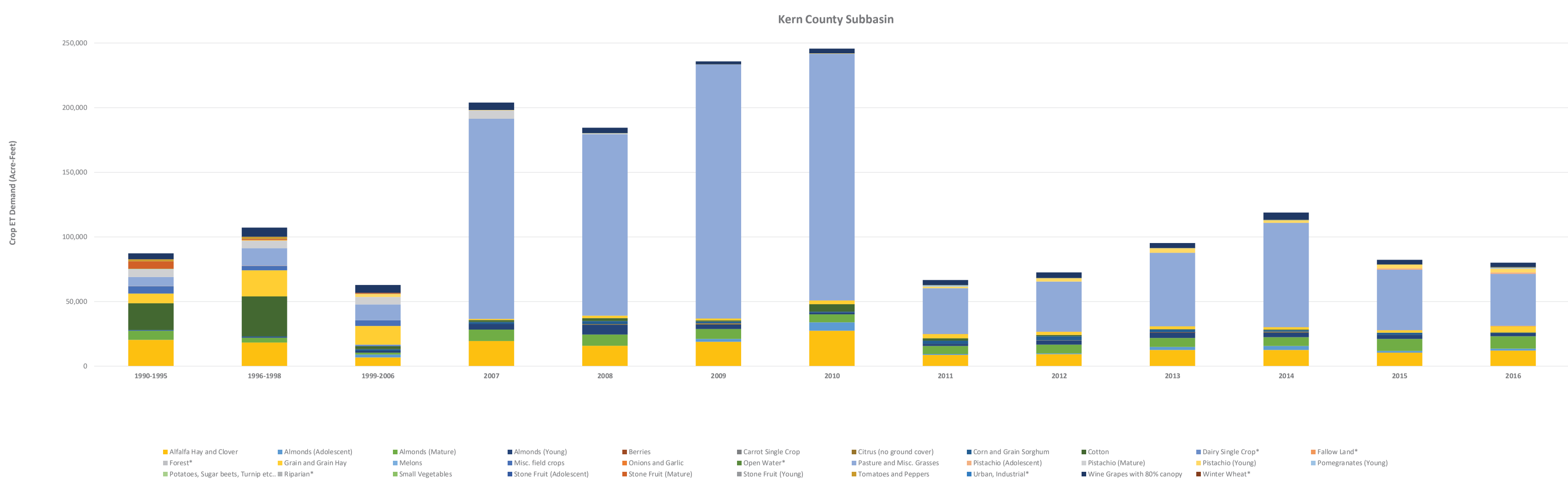


APPENDIX D3-8

Sum of Crop ET Demand (Acre-Feet/Year) Kern County Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Kern County Subbasin													
Alfalfa Hay and Clover	20321	18273	6736	19380	15803	18878	27373	8596	9207	12561	12467	10488	12071
Almonds (Adolescent)	0	0	2266	0	0	2222	6474	833	571	2331	3094	1258	1413
Almonds (Mature)	6857	3611	1401	8966	8694	7583	6160	6105	6889	6838	6847	9333	9610
Almonds (Young)	0	583	1555	4243	7634	3583	1592	1620	3251	4381	3710	3081	2335
Berries	0	0	0	0	0	0	0	0	0	18	0	0	0
Carrot Single Crop	188	0	0	0	0	0	0	1	0	10	5	3	5
Citrus (no ground cover)	0	0	0	0	440	935	0	6	64	7	510	4	3
Corn and Grain Sorghum	603	475	1135	1640	2267	1302	562	2488	3062	2200	1269	1586	371
Cotton	20621	31026	2324	1387	2337	829	5767	1798	1127	192	351	89	181
Dairy Single Crop*	3	0	1239	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	7623	20168	14436	881	1817	1460	2931	3387	2394	2208	1878	1953	4984
Melons	0	0	0	0	0	1	0	0	31	12	2	0	6
Misc. field crops	5473	3458	4354	0	0	0	0	0	0	0	0	0	0
Onions and Garlic	230	99	0	0	0	1	16	92	127	18	28	60	181
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	7088	13517	12338	154954	140349	196576	190751	35338	38717	56959	80646	46771	40224
Pistachio (Adolescent)	0	0	0	0	0	0	0	0	0	2	77	966	1205
Pistachio (Mature)	5993	5796	5758	6465	674	2	0	0	0	0	0	0	0
Pistachio (Young)	0	476	2322	266	174	174	300	1350	2464	3525	2055	2939	2940
Pomegranates (Young)	0	0	0	0	63	0	0	921	158	42	35	16	679
Potatoes, Sugar beets, Turnip etc..	272	0	0	0	0	2	0	1	2	0	6	17	2
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Vegetables	38	0	88	0	2	0	19	6	19	14	9	17	19
Stone Fruit (Adolescent)	0	0	58	0	0	0	0	0	0	0	0	0	7
Stone Fruit (Mature)	5735	877	723	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Young)	0	19	2	4	86	44	10	30	11	18	174	22	85
Tomatoes and Peppers	1667	1763	0	0	0	2	0	185	178	37	53	63	283
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	4578	7112	5979	5806	4185	2166	3657	3862	4212	3889	5651	3603	3413
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
Kern County Subbasin Irrigated ET D	**87287**	**107253**	**61474**	**203992**	**184526**	**235758**	**245611**	**66619**	**72486**	**95264**	**118867**	**82269**	**80017**
Kern County Subbasin Total ET Dem	**87290**	**107253**	**62713**	**203992**	**184526**	**235758**	**245611**	**66619**	**72486**	**95264**	**118867**	**82269**	**80017**

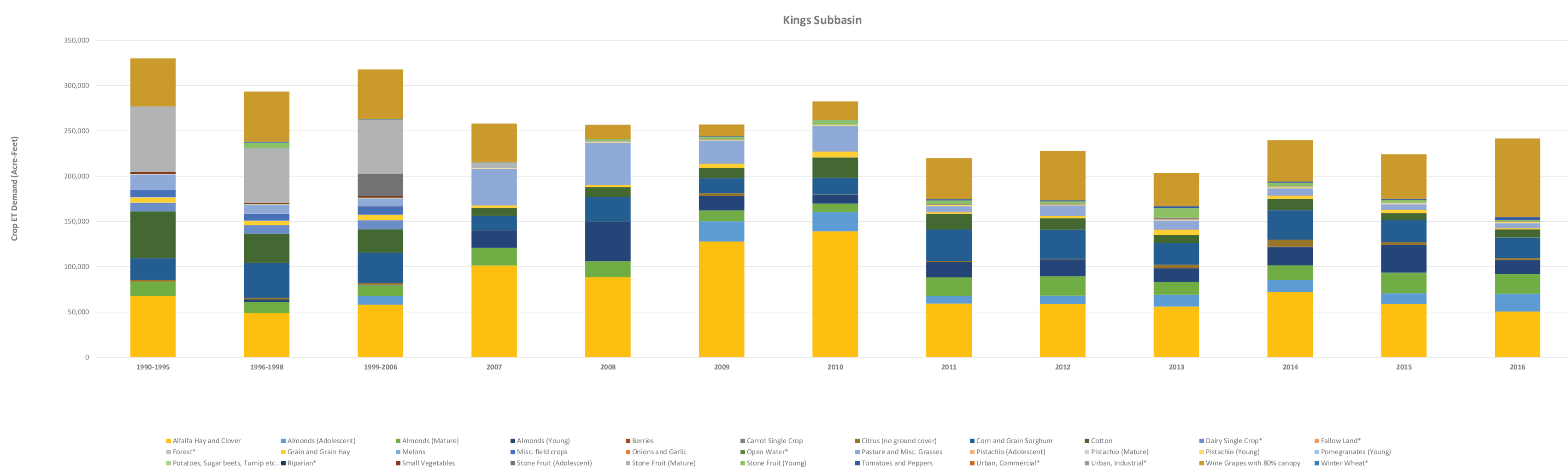
Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



APPENDIX D3-9

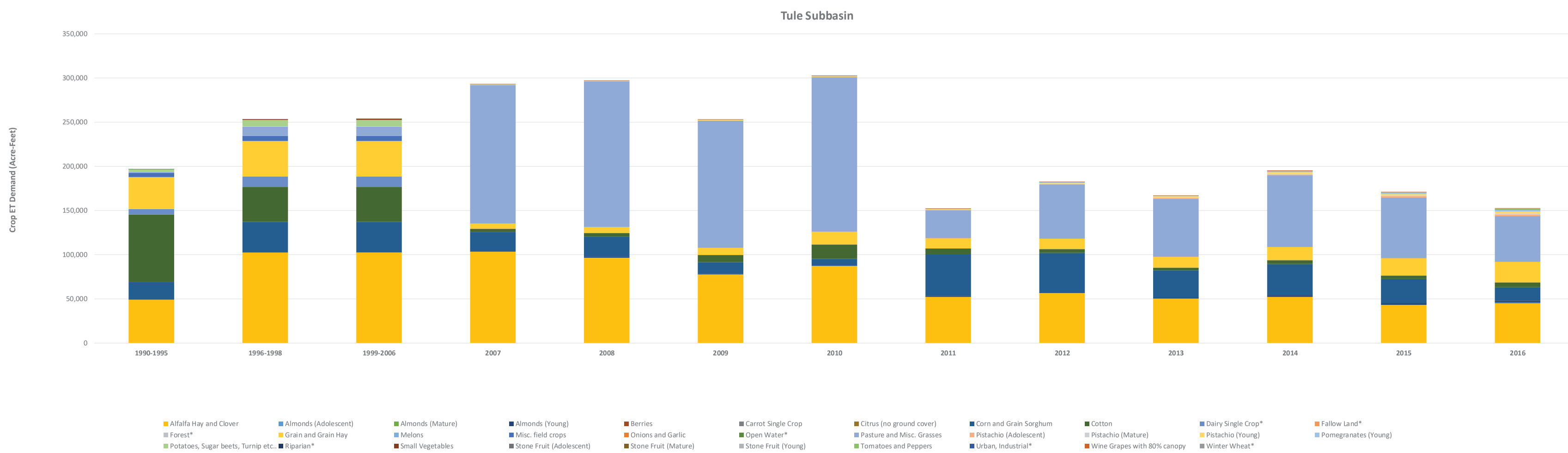
Sum of Crop ET Demand (Acre-Feet/Year) Kings Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Kings Subbasin													
Alfalfa Hay and Clover	67617	49074	58132	101357	88588	127908	139012	59444	58992	55996	72022	58974	50444
Almonds (Adolescent)	0	0	9525	0	0	22385	21317	7909	9004	13168	13348	11819	19720
Almonds (Mature)	15841	12188	11683	19642	17328	11842	9567	20922	21449	13995	16138	22835	21754
Almonds (Young)	0	2461	812	19323	43483	16082	9544	17088	18720	15125	20298	30152	15595
Berries	0	8	8	0	0	0	0	1	5	38	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	48	5	7	126	0	30
Citrus (no ground cover)	1912	2002	2002	249	313	2861	192	694	496	3915	8050	3278	1915
Corn and Grain Sorghum	24180	38518	33574	15458	27487	16580	18626	34985	32268	24209	32503	24496	22755
Cotton	51696	32000	25728	9225	10830	11344	22446	17615	12690	8521	12370	7650	9240
Dairy Single Crop*	9546	9561	9791	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	5766	4894	6019	2412	1933	4827	6546	1719	2379	5936	3092	3579	1179
Melons	671	297	215	0	5	27	6	1	15	48	11	14	42
Misc. field crops	7835	7572	9345	0	0	2	0	0	0	0	0	0	0
Onions and Garlic	0	0	188	47	103	162	67	312	130	116	692	190	420
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	16557	10047	8269	40480	46696	25318	28303	6182	11512	9898	7730	5879	5061
Pistachio (Adolescent)	0	0	0	0	0	0	0	4	13	4	27	50	50
Pistachio (Mature)	558	353	353	289	229	212	192	192	188	187	184	183	111
Pistachio (Young)	0	2	37	453	385	955	571	1349	1006	949	1302	943	1353
Pomegranates (Young)	0	0	0	25	38	67	71	189	187	119	107	97	60
Potatoes, Sugar beets, Turnip etc..	0	99	754	2	0	5	0	27	1	1	1	8	0
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Vegetables	2596	1703	1291	15	61	5	24	127	212	945	102	32	84
Stone Fruit (Adolescent)	0	0	24935	0	0	19	185	261	517	747	529	673	329
Stone Fruit (Mature)	72220	60018	59160	5770	1126	223	144	42	51	41	111	84	48
Stone Fruit (Young)	0	6313	620	439	2253	2798	4964	4060	2371	10498	4070	2798	1273
Tomatoes and Peppers	117	1037	711	33	9	327	51	1407	1078	2452	1235	1090	3304
Urban, Commercial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	53016	55408	54892	42775	15880	12995	20652	45308	54690	36332	45665	49431	86809
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
Kings Subbasin Irrigated ET Demand	**320581**	**283996**	**308252**	**257993**	**256747**	**256945**	**282481**	**219886**	**227981**	**203247**	**239711**	**224256**	**241575**
Kings Subbasin Total ET Demand	**330127**	**293556**	**318043**	**257993**	**256747**	**256945**	**282481**	**219886**	**227981**	**203247**	**239711**	**224256**	**241575**

Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



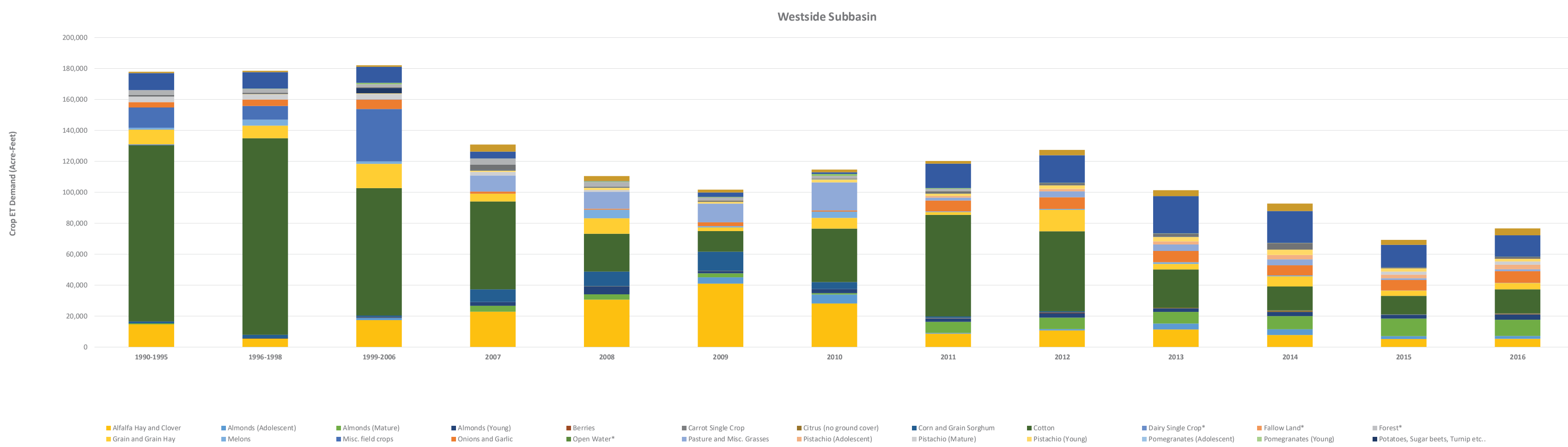
Sum of Crop ET Demand (Acre-Feet/Year) Tule Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Tule Subbasin													
Alfalfa Hay and Clover	48995	102696	102695	103253	96627	77757	87117	52421	56712	50482	52317	42961	44851
Almonds (Adolescent)	0	0	6	0	0	104	83	13	8	45	113	223	943
Almonds (Mature)	152	45	45	0	0	0	0	12	1	1	1	22	22
Almonds (Young)	0	2	0	479	1195	833	245	820	590	1052	1679	1995	1722
Berries	0	0	0	0	0	0	0	0	0	0	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	4	2	1	0	2	61
Citrus (no ground cover)	0	0	0	0	0	0	0	17	1	11	15	7	4
Corn and Grain Sorghum	19772	34425	34425	21765	22365	13040	7925	47549	44687	30636	35347	27359	15720
Cotton	76583	39418	39418	3865	4411	7859	16222	6149	4469	3160	4387	3940	5296
Dairy Single Crop*	6246	12030	12030	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	36255	40079	40077	6075	6753	8386	14365	11806	11631	12553	15122	19560	23291
Melons	20	0	0	0	0	7	0	2	4	2	96	5	40
Misc. field crops	4512	5890	5893	0	0	0	0	0	0	0	0	0	0
Onions and Garlic	4	0	0	1	0	0	147	73	183	1	9	36	105
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	1030	10450	10450	156596	164915	143596	174809	31502	61326	65535	80914	68705	51541
Pistachio (Adolescent)	0	0	0	0	0	0	0	575	558	722	1073	1324	1792
Pistachio (Mature)	0	0	0	301	218	135	108	107	106	106	105	929	1021
Pistachio (Young)	0	50	201	490	528	1184	1246	793	1182	1770	2221	1795	2525
Pomegranates (Young)	0	0	0	0	17	12	3	189	545	585	1024	1409	1596
Potatoes, Sugar beets, Turnip etc..	3015	7388	7388	0	0	2	0	4	3	2	11	21	3
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Vegetables	0	916	916	1	1	7	326	15	53	49	88	68	378
Stone Fruit (Adolescent)	0	0	58	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Mature)	33	0	0	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Young)	0	15	0	5	50	6	1	25	22	1	30	29	5
Tomatoes and Peppers	4	40	40	3	0	5	0	234	239	159	597	518	1466
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	183	157	157	88	237	83	252	314	476	81	269	304	346
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
Tule Subbasin Irrigated ET Demand	**190557**	**241571**	**241770**	**292921**	**297316**	**253017**	**302850**	**152624**	**182797**	**166953**	**195419**	**171213**	**152727**
Tule Subbasin Total ET Demand	**196803**	**253600**	**253800**	**292921**	**297316**	**253017**	**302850**	**152624**	**182797**	**166953**	**195419**	**171213**	**152727**

Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



Sum of Crop ET Demand (Acre-Feet/Year) Westside Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Westside Subbasin													
Alfalfa Hay and Clover	14783	5463	17452	22840	30645	40982	28245	8690	10822	11407	7847	5227	5318
Almonds (Adolescent)	0	0	1353	0	0	4098	5704	471	870	3772	3691	1847	1898
Almonds (Mature)	530	0	0	3808	3528	2660	877	7155	7400	7542	8563	11411	10450
Almonds (Young)	0	343	474	2571	5132	1461	2712	2247	2802	2334	2597	2396	3486
Berries	29	22	27	0	0	0	0	0	462	0	0	0	71
Carrot Single Crop	0	0	0	0	0	0	0	183	2	5	10	99	9
Citrus (no ground cover)	30	23	64	0	124	53	0	241	0	430	927	90	491
Corn and Grain Sorghum	1249	2078	1093	8137	9361	12433	4512	806	779	23	75	20	115
Cotton	113990	127022	82287	56779	24486	13325	34546	65685	51753	24591	15497	11995	15476
Dairy Single Crop*	354	0	0	0	0	0	0	0	0	0	0	0	0
Fallow Land*	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest*	0	0	0	0	0	0	0	0	0	0	0	0	0
Grain and Grain Hay	9494	8102	15647	4992	9968	2311	6890	1659	13750	3591	6523	3310	4086
Melons	1280	3829	1681	4	5492	824	4069	545	615	1099	584	235	126
Misc. field crops	13047	8983	33812	0	0	0	33	0	0	0	0	0	0
Onions and Garlic	3528	4074	5993	1365	678	2444	685	7017	7569	7310	6608	6697	7539
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	0	7	320	10430	10890	12191	18149	1854	3863	4268	3807	1098	1211
Pistachio (Adolescent)	0	0	0	0	0	0	0	1128	1498	1959	2858	2443	2926
Pistachio (Mature)	3533	3399	3392	2354	1261	11	6	6	6	3	0	1971	2172
Pistachio (Young)	0	95	399	796	1355	1077	1795	1444	2313	2857	3446	2046	1707
Pomegranates (Adolescent)	0	0	0	0	0	0	0	0	0	35	0	0	0
Pomegranates (Young)	0	0	0	45	90	43	139	91	65	49	2	30	42
Potatoes, Sugar beets, Turnip etc..	0	0	3407	326	0	0	0	92	0	0	0	0	7
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Vegetables	1154	951	498	3536	674	458	488	1335	1405	2014	4046	616	1302
Stone Fruit (Adolescent)	0	0	191	0		182	101	112	83	35	112	0	0
Stone Fruit (Mature)	3100	2553	1822	3750	3010	2099	1713	1511	3	1	20	0	0
Stone Fruit (Young)	0	72	841	174	419	391	1171	527	95	119	68	2	41
Tomatoes and Peppers	10971	10604	10367	4457	172	2860	1108	15693	17844	24101	20685	14607	13747
Urban, Commercial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	0
Wine Grapes with 80% canopy	907	877	1050	4524	3216	1815	1743	1842	3387	3819	4781	3205	4462
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	0
Westside Subbasin Irrigated ET Dem	**177626**	**178498**	**182172**	**130889**	**110499**	**101717**	**114687**	**120333**	**127387**	**101365**	**92746**	**69345**	**76682**
Westside Subbasin Total ET Demanc	**177980**	**178498**	**182172**	**130889**	**110499**	**101717**	**114687**	**120333**	**127387**	**101365**	**92746**	**69345**	**76682**

Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year



Appendix D4
Annualized Specified Pumping by Well Field

Annualized Specified Pumping

Well field	Well_ID	1990 (AF/Y)	1991 (AF/Y)	1992 (AF/Y)	1993 (AF/Y)	1994 (AF/Y)	1995 (AF/Y)	1996 (AF/Y)	1997 (AF/Y)	1998 (AF/Y)	1999 (AF/Y)	2000 (AF/Y)	2001 (AF/Y)	2002 (AF/Y)	2003 (AF/Y)	2004 (AF/Y)	2005 (AF/Y)	2006 (AF/Y)	2007 (AF/Y)	2008 (AF/Y)	2009 (AF/Y)	2010 (AF/Y)	2011 (AF/Y)	2012 (AF/Y)	2013 (AF/Y)	2014 (AF/Y)	2015 (AF/Y)	2016 (AF/Y)
Angiola	E1	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E10	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E11	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E13	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E14	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E15	0.00	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E16	0.00	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E17	0.00	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E18	0.00	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E19	0.00	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	E21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E4	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E5	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	E7	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G1	802.33	371.37	531.65	94.54	260.14	0.00	0.00	0.00	0.00	0.00	107.68	368.95	421.22	356.02	425.48	10.51	2.24	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	G11	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G13	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G14	802.33	371.37	531.65	94.54	260.14	0.00	0.00	0.00	0.00	0.00	107.68	368.95	421.22	356.02	425.48	10.51	2.24	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	G16	802.33	371.37	531.65	94.54	260.14	0.00	0.00	0.00	0.00	0.00	107.68	368.95	421.22	356.02	425.48	10.51	2.24	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	G17	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G18	0.00	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G19	0.00	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G2(NEW)	802.33	371.37	531.65	94.54	260.14	0.00	0.00	0.00	0.00	0.00	107.68	368.95	421.22	356.02	425.48	10.51	2.24	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	G20	0.00	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G21	0.00	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G22	0.00	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	G24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	G25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	G26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	G3	802.33	371.37	531.65	94.54	260.14	0.00	0.00	0.00	0.00	0.00	107.68	368.95	421.22	356.02	425.48	10.51	2.24	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	G5	802.33	371.37	531.65	94.54	260.14	0.00	0.00	0.00	0.00	0.00	107.68	368.95	421.22	356.02	425.48	10.51	2.24	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	G7	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	W11	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	W12	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	W13	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	W14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	W15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	W16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	W17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	W6	802.33	371.37	531.65	94.54	260.14	0.00	0.00	0.00	0.00	0.00	107.68	368.95	421.22	356.02	425.48	10.51	2.24	432.82	361.13	419.98	250.76	125.95	215.42	339.20	307.72	335.78	322.74
Angiola	W7	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	W8	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
Angiola	W9	1,604.65	742.73	1,063.30	189.08	520.29	0.00	0.00	0.00	0.00	0.00	215.37	737.90	842.44	712.03	850.95	21.02	4.48	865.63	722.27	839.96	501.51	251.90	430.85	678.40	615.44	671.56	645.49
El Rico	ER_C-16	1,800.27	2,870.99	1,808.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,571.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_C-33	2,310.31	1,917.00	2,319.99	0.00	723.00	81.00	0.00	0.00	0.00	0.00	0.00	0.00	635.00	567.00	1,894.00	0.00	0.00	1,774.02	451.00	177.17	0.00	0.00	676.60	692.36	721.93	0.00	0.00
El Rico	ER_G-9	0.00	557.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	611.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_Heck1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,155.63	976.07	2,999.27	2,409.04
El Rico	ER_HR-190	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,754.98	2,495.81	1,925.97	905.10	7.48	2,119.00	1,963.66	1,667.61	1,279.25	1,120.47
El Rico	ER_HR-28	0.00	835.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,611.30	972.50	449.34	1,175.75	0.00	0.00	1,045.76	1,002.92	914.27	503.12	0.00	1,240.01	868.40	865.22	653.07	211.39
El Rico	ER_HR-29	0.00	739.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,116.93	1,132.31	424.33	1,056.00	0.00	0.00	979.28	755.17	742.50	376.96	3.11	792.86	654.05	533.04	436.01	408.77
El Rico	ER_HR-30	0.00	872.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,018.00	1,042.20	431.86	1,236.00	0.00	0.00	1,031.59	1,209.69	788.33	400.12	3.22	881.46	704.78	668.79	562.82	501.81
El Rico	ER_M-137	2,847.89	2,264.10	2,855.99	247.00	1,829.00	42.98	0.00	0.00	0.00	0.00	204.00	2,001.81	1,470.62	1,297.66	2,097.00	0.00	0.00	2,047.10	2,261.11	2,271.83	896.08	6.20	2,050.50	1,369.69	1,879.81	1,526.53	1,849.82
El Rico	ER_M-140	2,150.06	1,811.41	2,157.00	261.00	1,459.00	35.01	0.00	0.00	0.00	0.00	1,102.84	2,286.25	1,710.31	1,045.01	1,756.00	0.00	0.00	1,875.32	2,064.27	1,891.50	1,143.24	52.52	1,846.08	1,408.40	570.87	411.26	0.00
El Rico	ER_M-141	1,176.07	885.72	1,180.00	146.00	573.00	21.00	0.00	0.00	0.00	0.00	860.64	1,162.00	798.00	543.00	805.00	0.00	0.00	727.97	69.14	655.19	342.10	2.60	0.00	0.00	0.00	0.00	0.00
El Rico	ER_M-143	1,017.51	883.69	1,022.00	131.00	1,690.00	24.00	0.00	0.00	0.00	0.00	580.31	1,240.48	843.00	493.00	590.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_M-144	1,837.75	1,248.17	1,844.00	241.00	1,186.00	35.01	0.00	0.00	0.00	0.00	1,117.95	1,782.20	1,041.81	502.87	1,101.00	0.00	0.00	1,086.25	928.44	833.34	242.64	5.58	865.23	791.49	658.50	185.54	683.66
El Rico	ER_M-145	1,268.00	1,065.48	1,268.00	172.00	878.00	24.00	0.00	0.00	0.00	0.00	820.56	1,334.00	999.00	606.00	783.00	0.00	0.00	898.42	967.08	820.42	476.67	3.57	1,210.60	1,085.95	1,041.87	912.18	636.02
El Rico	ER_M-146	1,125.00	980.69	1,125.00	145.00	875.00	30.00	0.00	0.00	0.00	0.00	865.15	1,713.00	1,076.00	692.00	555.00	0.00	0.00	1,074.51	1,038.96	517.93	332.79	0.00	1,041.64	781.67	494.71	404.75	351.36
El Rico	ER_M-147	2,298.75	1,695.17	2,304.99	205.00	1,411.00	40.00	0.00	0.00	0.00	0.00	944.77	2,163.00	1,509.00	995.00	1,501.00	0.00	0.00	1,368.64	1,389.19	1,215.32	429.98	13.42	1,015.01	938.89	1,700.98	1,777.19	1,779.69
El Rico	ER_M-148	3,241.85	2,353.72	3,250.99	362.00	2,009.00	55.00	0.00	0.00	0.00	0.00	1,553.20	2,601.99	2,049.00	1,251.00	2,180.99	0.00	0.00	2,229.32	2,555.65	2,400.02	1,366.79	41.82	2,535.94	2,111.49	2,253.66	2,289.41	2,275.77
El Rico	ER_M-149	2,739.24	2,182.51	2,746.99	264.00	1,663.00	47.00	0.00	0.00	0.00	0.00	1,592.32	2,389.99	1,937.00	1,032.00	2,080.00	0.00	0.00	1,755.84	1,804.78	495.83	1,394.04	49.18	2,045.42	2,154.85	1,995.12	657.24	0.00
El Rico	ER_M-150	2,509.06	2,156.20	2,515.99	283.00	1,045.00	14.00	0.00	0.00	0.00	0.00	1,097.00	2,673.99	1,866.00	1,149.00	2,161.00	0.00	0.00	2,094.07	2,558.80	2,194.59	1,186.13	50.26	2,225.49	2,046.19	1,761.41	1,642.53	1,503.20
El Rico	ER_M-151	2,081.75	792.00	2,088.00	234.00	1,300.00	0.00	0.00	0.00	0.00	0.00	103.98	431.00	0.00	0.00	419.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_M-153	2,282.17	1,905.10	2,288.99	300.00	1,270.00	27.00	0.00	0.00	0.00	0.00	0.00	1,375.00	1,417.00	419.00	1,811.00	0.00	0.00	1,536.96	1,878.58	1,621.68	629.88	6.61	1,835.05	2,307.41	2,093.23	1,684.08	1,388.40
El Rico	ER_M-154	2,199.44	1,761.58	2,205.99	275.00	1,222.00	25.98	0.00	0.00	0.00	0.00	0.00	0.00	0.00	240.05	1,615.00	0.00	0.00	1,509.29	1,523.09	1,568.91	618.14	6.45	448.82	0.00	0.00	789.05	1,514.80

Annualized Specified Pumping

Well field	Well_ID	1990 (AF/Y)	1991 (AF/Y)	1992 (AF/Y)	1993 (AF/Y)	1994 (AF/Y)	1995 (AF/Y)	1996 (AF/Y)	1997 (AF/Y)	1998 (AF/Y)	1999 (AF/Y)	2000 (AF/Y)	2001 (AF/Y)	2002 (AF/Y)	2003 (AF/Y)	2004 (AF/Y)	2005 (AF/Y)	2006 (AF/Y)	2007 (AF/Y)	2008 (AF/Y)	2009 (AF/Y)	2010 (AF/Y)	2011 (AF/Y)	2012 (AF/Y)	2013 (AF/Y)	2014 (AF/Y)	2015 (AF/Y)	2016 (AF/Y)
El Rico	ER_M-158	2,232.55	1,527.82	2,238.99	132.00	1,323.00	0.00	0.00	0.00	0.00	0.00	0.00	661.00	1,400.00	846.00	1,190.00	0.00	0.00	677.03	1,736.03	1,542.60	616.54	16.26	825.51	0.00	0.00	0.00	0.00
El Rico	ER_M-159	0.00	75.00	908.00	101.00	361.00	825.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_M-161	0.00	0.00	1,840.00	375.00	1,728.00	42.98	0.00	0.00	0.00	0.00	129.11	3,048.72	1,916.85	661.65	2,271.99	0.00	0.00	1,259.21	1,953.95	1,996.68	841.78	7.98	1,943.88	1,984.78	318.00	0.00	0.00
El Rico	ER_M-163	0.00	0.00	1,680.00	318.00	1,778.00	966.00	0.00	0.00	0.00	0.00	173.73	2,395.99	1,344.00	619.00	1,481.00	0.00	0.00	1,210.58	1,728.49	1,099.94	513.17	4.13	1,317.26	523.36	0.00	0.00	0.00
El Rico	ER_M-166	0.00	0.00	1,671.00	346.00	1,758.00	42.98	0.00	0.00	0.00	0.00	593.35	2,699.66	2,148.02	1,280.59	2,262.99	0.00	0.00	2,247.74	2,390.46	2,402.21	725.28	6.82	2,328.07	1,810.63	0.00	0.00	0.00
El Rico	ER_M-168	0.00	0.00	1,254.00	320.00	1,546.00	32.02	0.00	0.00	0.00	0.00	325.06	2,667.79	1,735.12	592.18	1,117.00	0.00	0.00	1,672.00	2,185.50	1,940.01	784.63	0.04	2,027.28	2,070.43	1,386.28	1,832.52	1,772.13
El Rico	ER_M-169	0.00	0.00	1,381.00	316.00	1,526.00	30.03	0.00	0.00	0.00	0.00	325.67	2,724.11	1,755.43	645.10	2,174.00	0.00	0.00	1,733.90	2,405.69	1,549.94	257.02	4.94	1,077.09	1,111.80	1,011.80	913.28	0.00
El Rico	ER_M-170	0.00	0.00	254.00	304.00	1,534.00	32.02	0.00	0.00	0.00	0.00	307.88	2,575.19	1,683.01	747.92	2,075.00	0.00	0.00	1,731.22	2,450.65	2,231.45	862.97	7.96	2,152.31	2,235.27	2,145.84	2,026.97	1,951.97
El Rico	ER_M-171	0.00	0.00	147.00	1,413.00	1,510.00	28.00	0.00	0.00	0.00	0.00	343.99	2,442.99	1,501.00	666.00	756.00	0.00	0.00	1,526.34	2,208.94	2,000.90	537.82	29.32	0.00	0.00	0.00	0.00	0.00
El Rico	ER_M-172	0.00	0.00	0.00	0.00	772.00	0.00	0.00	0.00	0.00	0.00	253.00	2,315.99	1,447.00	141.00	1,546.00	0.00	0.00	1,179.42	1,821.88	1,344.49	655.27	6.37	1,674.70	1,562.70	1,539.75	1,396.80	1,251.10
El Rico	ER_M-175	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	235.20	1,674.00	1,046.00	389.00	1,134.00	0.00	0.00	854.99	1,165.23	1,061.06	280.26	1.45	674.27	648.82	539.98	405.57	0.06
El Rico	ER_M-176	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	223.54	1,577.00	1,125.00	431.00	1,102.00	0.00	0.00	862.71	924.46	618.59	215.46	2.88	821.85	625.79	517.70	511.23	485.09
El Rico	ER_M-178	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,946.00	1,348.00	554.00	1,566.00	0.00	0.00	1,008.86	1,816.84	1,504.51	550.40	5.14	1,412.16	1,476.51	1,344.94	939.62	0.00
El Rico	ER_M-179	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	86.00	247.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_M-181	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	166.07	1,374.00	872.00	337.00	982.00	0.00	0.00	738.93	931.46	880.21	346.94	3.47	38.47	0.00	0.00	0.00	0.00
El Rico	ER_R-26	2,265.99	411.00	2,265.99	222.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.00	514.00	411.00	0.00	0.00	999.00	746.36	255.13	0.00	0.00	1,221.08	1,143.98	948.86	653.64	174.78
El Rico	ER_R-27	1,861.00	34.00	1,861.00	296.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	443.00	0.00	0.00	0.00	831.00	238.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_R-33	0.00	787.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	42.00	436.00	1,203.00	0.00	0.00	1,440.66	1,668.12	156.32	0.00	0.00	2.00	0.00	0.00	0.00	0.00
El Rico	ER_R-35	2,144.00	471.00	2,144.00	279.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	154.00	30.00	865.00	0.00	0.00	1,351.84	1,004.22	0.00	0.00	0.00	1,435.08	888.81	0.00	0.00	0.00
El Rico	ER_R-47	1,859.48	1,610.93	1,863.00	121.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,228.00	1,344.00	520.00	1,640.00	0.00	0.00	6.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_S-111	90.00	239.00	90.00	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_S-113	90.00	763.27	90.00	0.00	360.00	0.00	0.00	0.00	0.00	0.00	0.00	822.00	660.00	171.00	678.00	0.00	0.00	359.45	636.40	532.75	230.80	2.08	525.67	384.38	470.03	367.38	263.73
El Rico	ER_S-120	3,124.06	2,198.62	3,132.99	366.22	706.00	43.00	0.00	0.00	0.00	0.00	162.29	2,702.99	1,663.00	604.00	1,984.00	0.00	0.00	1,888.04	2,234.46	1,852.52	691.55	6.36	1,787.12	1,656.47	1,153.40	842.51	351.44
El Rico	ER_S-127	2,904.44	2,011.31	2,911.99	348.00	1,759.00	49.03	0.00	0.00	0.00	0.00	319.14	2,693.46	1,654.08	563.24	1,964.00	0.00	0.00	1,847.00	1,906.27	416.61	830.46	7.27	2,028.06	2,000.17	1,434.00	0.00	0.00
El Rico	ER_S-160	1,615.41	1,776.86	1,622.00	255.00	928.00	20.00	0.00	0.00	0.00	0.00	0.00	1,017.00	1,337.00	487.00	1,657.00	0.00	0.00	908.71	1,722.46	1,049.80	0.00	13.15	1,006.31	934.65	652.22	43.90	370.48
El Rico	ER_S-162	2,015.00	1,912.27	2,015.00	502.00	1,738.00	56.00	0.00	0.00	0.00	0.00	282.02	3,407.99	2,171.00	786.00	2,689.99	0.00	0.00	2,433.37	2,850.05	1,979.59	530.13	7.00	1,926.89	1,854.70	1,649.31	1,422.80	1,393.60
El Rico	ER_S-164	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,461.00	314.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_S-165	1,045.00	1,445.69	1,045.00	220.00	1,030.00	0.00	0.00	0.00	0.00	0.00	74.60	2,489.99	1,641.00	592.00	2,034.00	0.00	0.00	1,639.21	1,711.75	520.57	796.53	10.19	574.24	551.17	394.73	0.00	0.00
El Rico	ER_S-167	1,626.00	1,618.86	1,626.00	384.00	1,888.00	52.00	0.00	0.00	0.00	0.00	152.49	3,048.99	1,893.00	684.00	2,262.99	0.00	0.00	2,065.85	1,245.14	0.00	0.00	0.00	0.00	1,440.79	1,077.44	1,535.36	311.72
El Rico	ER_S-173	0.00	2,085.34	0.00	106.00	2,092.00	63.00	0.00	0.00	0.00	0.00	0.00	2,325.99	2,373.99	886.00	2,969.99	0.00	0.00	1,859.87	2,717.95	2,087.83	998.67	10.23	2,932.26	3,120.53	3,114.65	3,063.55	1,652.10
El Rico	ER_S-174	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,529.99	2,101.00	779.00	2,558.99	0.00	0.00	2,185.60	2,743.38	2,424.90	966.68	7.94	1,877.19	563.24	730.78	603.26	502.54
El Rico	ER_S-188	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	985.80	1,507.20	1,185.16	288.20	3.33	750.92	311.28	679.15	409.23	196.40
El Rico	ER_S-191	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	258.84	0.00	0.00	0.00	0.00	0.00	238.00	0.00	0.00
El Rico	ER_S-192	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,099.00	2,470.89	1,076.58	0.00	2,565.67	2,601.49	2,322.96	2,055.21	1,804.77
El Rico	ER_S-193	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,983.06	2,102.49	1,079.61	9.36	2,559.21	2,639.88	2,346.56	2,241.24	2,036.11
El Rico	ER_S-194	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,558.77	2,582.76	1,082.20	9.02	2,216.67	1,910.75	910.07	358.99	2.97
El Rico	ER_S-195	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,460.00	2,699.86	1,153.29	10.14	2,836.87	3,126.31	2,966.75	2,880.80	2,816.01
El Rico	ER_S-196	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,325.00	2,731.97	1,106.82	9.67	2,402.58	2,731.07	2,569.80	2,426.92	2,298.25
El Rico	ER_S-198	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,213.84	2,609.13	1,148.39	0.00	2,777.98	2,751.41	2,415.86	2,114.48	1,830.73
El Rico	ER_S-199	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	676.34	2,409.49	1,142.78	10.16	2,677.37	2,887.71	2,794.52	2,505.17	2,553.13
El Rico	ER_S-200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,168.99	1,105.84	0.00	2,759.92	2,870.49	2,742.45	2,169.81	1,614.97
El Rico	ER_S-201	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	748.95	1,142.04	10.57	1,918.94	2,450.16	2,382.50	1,667.81	2,142.77
El Rico	ER_S-202	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	544.42	15.16	3,460.57	3,338.14	2,617.87	1,693.30	1,718.73
El Rico	ER_S-203	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	230.77	15.70	3,884.90	4,107.45	4,368.74	4,445.74	4,282.34
El Rico	ER_S-205	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,781.11	5,081.66	4,185.44	3,486.88	5,161.08
El Rico	ER_S-206	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,533.13	4,681.16	4,513.79	3,703.62
El Rico	ER_S-209	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,196.76	3,963.35	3,437.13	3,401.15
El Rico	ER_S-211	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,256.46	4,387.34	4,068.25	3,619.99
El Rico	ER_S-213	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,064.55	3,900.73	3,966.16
El Rico	ER_S-214	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,635.46	4,518.85	4,306.07
El Rico	ER_S-215	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,909.40	3,886.35	3,975.84
El Rico	ER_S-216	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,425.40	4,537.42	4,416.25
El Rico	ER_S-217	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,757.98	4,318.93	4,497.61
El Rico	ER_S-218	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,118.39	4,278.81	4,292.27
El Rico	ER_S-219	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	498.85	4,477.82	4,406.65
El Rico	ER_S-220	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,283.65	4,397.68
El Rico	ER_S-221	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,924.61	3,970.97
El Rico	ER_S-222	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,122.29	3,786.41
El Rico	ER_S-223	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	766.91	3,935.35
El Rico	ER_S-224	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,925.50
El Rico	ER_S-225	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,580.64
El Rico	ER_S-226	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,928.44
El Rico	ER_S-227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,191.19
El Rico	ER_S-228	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,146.70
El Rico	ER_S-229	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	864.59
El Rico	ER_S-70	2,569.10	2,001.72	2,574.99	314.00	1,537.00	15.00	0.00	0.00	0.00	0.00	0.00	1,928.00	1,664.00	559.00	1,956.00	0.00	0.00	1,608.48	2,251.61	1,886.48	486.25	90.47	1,655.35	1,622.35	1,081.70	622.95	0.00
El Rico	ER_SR-13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	314.00	186.00	484.00	0.00	0.00	424.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_SR-14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	208.00	1,430.00	0.00	0.00	585.19	1,471.77	399.48	0.00	0.00	0.00	789.73	1,810.23	1,103.14	0.00
El Rico	ER_SR-15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	826.00	544.00	1,209.00	0.00	0.00	1,203.67	1,687.76	295.48	0.00	0.00	0.00	381.63	1,020.65	237.17	0.00
El Rico	ER_SR-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	181.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_SR-8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	429.00	453.00	270.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_T-155	3,088.17	2,219.82	3,096.99	362.00	1,759.00	45.00	0.00	0.00	0.00	0.00	0.00	1,761.00	2,039.00	774.00	2,166.00	0.00	0.00	2,213.87	2,242.79	1,778.14	947.64	7.04	1,646.97	2,306.66	1,547.05	1,031.41	0.00
El Rico	ER_T-156	2,771.68	668.00	2,775.99	42.00	498.00	53.00	0.00	0.00	0.00	0.00	0.00	2,541.99	1,238.00	53.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_T-157	3,306.20	2,238.96	3,312.99	384.00	777.00	0.00	0.00	0.00	0.00	0.00	0.00	2,203.99	1,890.00	719.00	1,344.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Annualized Specified Pumping

Well field	Well_ID	1990 (AF/Y)	1991 (AF/Y)	1992 (AF/Y)	1993 (AF/Y)	1994 (AF/Y)	1995 (AF/Y)	1996 (AF/Y)	1997 (AF/Y)	1998 (AF/Y)	1999 (AF/Y)	2000 (AF/Y)	2001 (AF/Y)	2002 (AF/Y)	2003 (AF/Y)	2004 (AF/Y)	2005 (AF/Y)	2006 (AF/Y)	2007 (AF/Y)	2008 (AF/Y)	2009 (AF/Y)	2010 (AF/Y)	2011 (AF/Y)	2012 (AF/Y)	2013 (AF/Y)	2014 (AF/Y)	2015 (AF/Y)	2016 (AF/Y)
El Rico	ER_T-177	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	928.17	975.13	389.17	707.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
El Rico	ER_T-182	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,705.00	1,842.00	664.00	1,235.00	0.00	0.00	2,364.40	523.65	0.00	118.30	2.38	518.39	756.61	221.34	0.00	0.00
El Rico	ER_T-61	3,222.89	1,635.00	3,227.99	303.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	424.18	523.48	874.00	0.00	0.00	0.00	1,318.20	305.96	0.00	0.00	1,302.55	0.00	0.00	0.00	0.00
Creighton Ranch	CR_CR-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,626.79	1,849.41	1,705.15	1,320.74
Creighton Ranch	CR_CR-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	433.41	538.08	437.91	289.92
Creighton Ranch	CR_CR-6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	170.04	523.12	512.68	511.33
Creighton Ranch	CR_CR-7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,022.41	1,342.09	1,098.35	830.86
Creighton Ranch	CR_EC-1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	964.80	1,521.00	436.50	2,028.60	0.00	0.00	1,361.81	1,442.77	1,011.40	468.42	3.94	825.11	735.16	834.01	767.03	681.29
Creighton Ranch	CR_EC-2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,816.20	1,339.20	437.40	1,433.70	0.00	0.00	752.12	811.61	953.34	353.70	2.89	849.40	897.20	817.27	540.13	517.71
Creighton Ranch	CR_EC-3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,686.60	1,033.20	262.80	1,071.90	0.00	0.00	775.64	980.13	486.81	192.35	3.54	1,528.18	999.18	897.40	790.45	691.30
Creighton Ranch	CR_EC-4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,782.90	1,187.10	88.20	715.50	0.00	0.00	757.83	1,016.12	887.14	327.42	2.73	925.07	886.85	819.55	780.30	706.68
Creighton Ranch	CR_EC-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	742.50	358.20	1,557.90	0.00	0.00	1,378.09	1,865.43	1,654.84	638.59	0.00	1,507.24	1,543.45	1,420.86	1,348.86	1,157.05
Creighton Ranch	CR_EC-6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	474.30	430.20	1,954.80	0.00	0.00	1,449.81	2,367.72	2,217.50	701.82	2.38	1,973.90	2,059.83	2,022.39	1,912.80	279.52
Creighton Ranch	CR_EC-7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,329.30	0.00	0.00	1,545.86	2,080.28	2,066.13	674.60	6.43	834.67	1,737.98	1,554.98	1,247.94	1,058.44
Creighton Ranch	CR_S-100	484.00	1,074.20	484.00	110.00	314.00	15.02	0.00	0.00	0.00	0.00	0.00	1,197.05	875.26	261.80	1,050.00	0.00	0.00	923.62	1,118.45	963.91	363.81	3.60	1,104.47	1,106.76	778.83	0.00	0.00
Creighton Ranch	CR_S-103	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	534.00	0.00	0.00	705.72	1,531.18	1,498.63	612.45	5.52	1,625.00	1,620.42	1,502.45	1,447.79	553.63
Creighton Ranch	CR_S-105	708.30	768.38	708.30	149.40	355.50	29.72	0.00	0.00	0.00	0.00	73.37	1,603.90	1,026.61	283.76	770.40	0.00	0.00	1,231.92	1,223.44	363.33	100.91	2.13	567.39	165.91	0.00	0.00	0.00
Creighton Ranch	CR_S-106	324.00	568.80	324.00	121.50	342.00	36.00	0.00	0.00	0.00	0.00	199.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Creighton Ranch	CR_S-108	1,727.10	1,190.05	1,727.10	231.30	1,715.40	2.70	0.00	0.00	0.00	0.00	0.00	1,631.12	1,249.14	314.31	1,623.60	0.00	1.83	1,204.17	1,722.36	1,942.71	804.47	28.36	1,572.01	980.71	669.79	615.39	1,481.35
Creighton Ranch	CR_S-109	1,227.32	1,847.11	1,227.60	244.80	1,749.60	51.30	0.00	0.00	0.00	0.00	204.62	1,324.71	772.55	316.10	1,602.90	0.00	62.02	1,180.48	1,599.53	1,427.47	615.08	27.28	1,294.39	1,561.03	873.80	859.07	1,343.12
Creighton Ranch	CR_S-110	698.12	2,335.62	698.40	0.00	0.00	48.61	0.00	0.00	0.00	0.00	343.99	1,954.25	1,495.75	487.94	2,233.79	0.00	0.00	1,657.27	2,046.15	1,234.31	700.55	16.33	1,647.26	1,635.60	1,468.44	1,304.75	1,317.23
Creighton Ranch	CR_S-114	928.80	1,416.78	928.80	165.60	1,148.40	33.31	0.00	0.00	0.00	0.00	261.45	1,418.76	966.67	384.07	1,386.90	107.10	2.05	989.20	1,273.28	1,170.74	462.43	16.27	434.15	454.04	361.08	274.32	176.55
Creighton Ranch	CR_S-115	666.90	1,254.50	666.90	114.30	817.20	23.38	0.00	0.00	0.00	0.00	185.45	1,221.72	704.39	311.38	1,257.30	89.10	0.00	891.02	1,171.90	894.20	453.19	49.00	1,020.84	946.69	819.85	543.40	507.17
Creighton Ranch	CR_S-116	544.50	1,058.24	544.50	93.60	673.20	19.80	0.00	0.00	0.00	0.00	205.84	1,075.84	803.80	305.65	1,145.70	88.20	1.61	747.45	530.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Creighton Ranch	CR_S-117	449.10	1,125.46	449.10	0.00	724.50	21.58	0.00	0.00	0.00	0.00	140.88	1,006.30	706.05	252.59	1,020.60	72.00	1.21	765.57	374.45	291.06	127.03	1.15	815.08	892.15	822.96	753.26	663.00
Creighton Ranch	CR_S-119	513.90	1,080.96	513.90	105.30	762.30	22.50	0.00	0.00	0.00	0.00	339.04	1,780.48	1,407.59	272.69	1,035.00	0.00	0.00	781.30	1,021.43	830.78	349.24	3.50	721.75	919.82	919.48	770.81	915.08
Creighton Ranch	CR_S-121	847.67	1,873.11	847.80	161.10	469.80	37.80	0.00	0.00	0.00	0.00	67.28	1,963.80	1,543.50	435.60	1,830.60	0.00	0.00	1,680.41	1,933.83	1,435.48	553.40	5.57	1,595.17	1,629.63	1,328.48	1,101.72	874.44
Creighton Ranch	CR_S-122	2,289.44	1,427.02	2,295.89	272.70	516.60	38.70	0.00	0.00	0.00	0.00	0.00	1,411.20	1,286.10	379.80	853.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Creighton Ranch	CR_S-123	508.37	1,211.83	508.50	95.40	1,029.60	127.80	0.00	0.00	0.00	0.00	227.00	1,639.80	1,062.00	295.20	1,207.80	0.00	0.00	1,125.99	1,361.89	1,066.67	395.97	4.23	1,169.63	1,288.35	1,285.32	978.43	1,006.36
Creighton Ranch	CR_S-124	757.80	511.20	757.80	117.90	1,155.60	35.10	0.00	0.00	0.00	0.00	264.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	719.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Creighton Ranch	CR_S-125	1,151.10	1,813.87	1,151.10	201.33	1,332.90	31.51	0.00	0.00	0.00	0.00	335.24	2,151.89	1,446.94	524.45	1,735.20	111.60	1.20	1,420.40	1,714.76	1,417.40	687.57	33.42	1,603.42	1,483.27	1,278.20	1,084.70	1,174.88
Creighton Ranch	CR_S-129	468.90	1,062.90	468.90	119.70	351.90	26.07	0.00	0.00	0.00	0.00	0.00	1,038.39	989.14	276.02	1,067.40	0.00	0.00	997.00	1,387.29	1,195.67	447.46	0.00	1,177.31	1,141.83	1,174.67	1,119.90	1,135.92
Creighton Ranch	CR_S-130	476.00	700.52	476.00	110.00	298.00	22.99	0.00	0.00	0.00	0.00	0.00	1,009.59	830.71	229.05	780.00	0.00	0.00	191.76	924.84	203.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Creighton Ranch	CR_S-131	311.40	1,239.39	311.40	123.30	335.70	24.27	0.00	0.00	0.00	0.00	0.00	1,011.77	978.22	283.66	1,216.80	0.00	0.00	1,014.61	1,284.51	1,152.84	449.99	4.01	1,256.76	1,404.28	1,256.95	1,118.88	990.26
Creighton Ranch	CR_S-132	1,333.24	836.22	1,337.40	141.30	358.20	29.72	0.00	0.00	0.00	0.00	0.00	1,127.70	930.20	240.93	709.20	0.00	0.00	1,361.83	1,332.57	1,340.85	513.02	4.58	1,373.03	1,394.13	1,306.25	1,205.36	1,196.98
Creighton Ranch	CR_S-134	345.60	1,211.96	345.60	66.60	511.20	15.31	0.00	0.00	0.00	0.00	0.00	333.32	901.23	287.95	1,387.80	0.00	1.70	995.66	1,358.11	1,217.67	496.88	4.70	980.34	958.35	1,108.44	1,043.79	648.49
Creighton Ranch	CR_S-135	549.00	1,267.62	549.00	138.00	394.00	30.03	0.00	0.00	0.00	0.00	0.00	1,372.00	1,061.00	305.07	1,111.00	0.00	0.00	773.37	701.81	454.06	347.44	3.81	1,070.52	730.93	863.08	835.17	890.83
Creighton Ranch	CR_S-138	1,602.46	1,463.52	1,607.40	196.20	342.00	26.10	0.00	0.00	0.00	0.00	0.00	1,140.30	1,193.40	328.45	1,539.90	0.00	0.00	1,248.92	1,700.89	1,542.83	510.08	10.12	1,457.37	1,035.02	1,300.24	1,288.59	1,304.07
Creighton Ranch	CR_S-183	0.00	1,593.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	801.00	1,554.30	370.80	2,181.59	0.00	0.00	1,765.58	1,797.71	1,785.59	710.78	18.40	1,503.65	1,560.04	1,370.94	691.79	342.08
Creighton Ranch	CR_S-187	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,312.39	1,696.80	1,498.09	538.34	4.52	1,216.82	898.60	748.61	435.77	0.00
Creighton Ranch	CR_S-189	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	676.47	1,397.26	507.94	4.93	1,251.80	864.87	1,089.38	1,090.70	1,085.31
Creighton Ranch	CR_S-197	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,375.06	3,016.17	1,130.32	9.76	2,937.88	2,980.16	3,049.06	3,425.72	3,342.29
Creighton Ranch	CR_S-204	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,989.78	5,174.18	4,814.78	4,644.04	4,492.56
Creighton Ranch	CR_S-207	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	460.40	5,700.81	4,838.66	4,195.61	2,838.11
Creighton Ranch	CR_S-208	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,429.56	5,504.19	5,132.88	4,673.93	4,034.77
Creighton Ranch	CR_S-210	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,853.51	4,542.36	3,990.52	3,818.24
Creighton Ranch	CR_S-212	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	341.65	4,909.10	4,612.65	4,075.88
Creighton Ranch	CR_S-79	1,079.66	1,386.12	1,080.00	142.20	273.60	19.80	0.00	0.00	0.00	0.00	0.00	421.20	1,057.50	237.74	1,513.80	0.00	0.00	1,255.70	1,616.90	1,390.51	499.91	6.25	1,480.50	1,529.03	1,431.37	1,366.64	1,175.41
Creighton Ranch	CR_S-80	738.00	830.23	738.00	121.50	118.80	0.00	0.00	0.00	0.00	0.00	0.00	400.50	636.30	240.30	900.90	0.00	0.00	753.18	798.32	343.46	313.21	2.57	744.00	736.72	721.53	582.38	141.32
Creighton Ranch	CR_S-81	1,371.38	1,280.23	1,375.20	159.30	339.30	25.20	0.00	0.00	0.00	0.00	0.00	1,034.10	1,034.10	310.50	1,264.50	0.00	0.00	1,093.82	1,233.06	916.40	301.90	3.08	1,304.50	1,210.52	934.69	789.60	676.48
Creighton Ranch	CR_S-82	906.86	1,271.32	909.90	63.90	346.50	23.40	0.00	0.00	0.00	0.00	0.00	819.00	801.00	274.13	1,414.80	0.00	0.00	884.21	985.61	971.44	204.58	8.16	320.34	358.49	355.36	300.10	302.90
Creighton Ranch	CR_S-83	1,645.63	442.80	1,650.60	165.60	168.30	12.60	0.00	0.00	0.00	0.00	0.00	6.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Creighton Ranch	CR_S-84	1,746.68	1,157.21	1,751.40	197.10	415.80	28.80	0.00	0.00	0.00	0.00	0.00	1,094.40	573.30	172.80	903.60	0.00	0.00	1,224.11	1,380.55	855.35	416.28	4.44	1,638.18	1,755.27	1,418.07	890.68	644.51
Creighton Ranch	CR_S-88	414.00	1,271.67	414.00	0.00	342.90	25.20	0.00	0.00	0.00	0.00	0.00	1,073.70	1,019.70	279.90	1,264.50	0.00	0.00	1,137.49	2,337.77	1,382.07	768.63	6.34	2,118.27	2,076.08	1,631.52	1,872.64	1,919.45
Creighton Ranch	CR_S-92	406.80	911.70	406.80	106.20	283.50	20.70	0.00	0.00	0.00	0.00	0.00	805.50	639.00	180.00	876.60	0.00	0.00	930.40	1,204.58	78.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_001	2,016.23	1,449.20	898.28	204.16	1,072.20	77.47	157.42	0.00	0.00	247.35	511.99	96.71	137.48	1,030.94	330.71	14.42	0.00	571.89	193.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_002	1,343.58	1,129.61	773.27	276.09	1,236.20	84.51	232.23	0.00	0.00	223.41	300.51	298.76	922.95	331.81	608.88	102.08	0.00	568.81	424.68	488.77	22.38	0.04	511.54	784.41	661.26	269.84	269.84
Corcorian ID	CID_003	2,295.40	2,455.53	1,798.95	272.49	737.44	2.14	61.66	0.00	0.00	255.57	468.39	957.97	1,569.26	871.26	554.29	0.00	0.00	1,334.59	925.45	845.58	281.71	41.63	208.52	0.00	0.00	0.00	0.00
Corcorian ID	CID_004	1,103.53	87.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_005	739.82	589.79	486.41	34.03	284.93	0.00	46.86	0.00	0.00	23.03	131.08	381.60	411.78	284.75	233.00	38.68	55.15	542.51	510.74	271.16	0.00	0.00	210.74	378.57	233.77	562.40	562.40
Corcorian ID	CID_006	554.73	449.73	364.07	26.09	243.38	0.00	45.95	0.00	0.00	102.98	216.29	421.32	598.01	79.91	346.99	99.29	83.11	928.85	590.30	271.35	0.00	0.00	80.23	297.22	683.04	580.99	580.99
Corcorian ID	CID_007	1,472.15	845.16	684.22	66.14	812.91	59.64	416.42	412.17	0.00	619.70	68.04	1,241.44	1,434.43	1,397.27	1,250.77	97.77	0.00	305.84	561.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_008	613.99	509.01	379.24	46.12	287.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_009	544.71	450.01	463.61	86.54	196.62	10.93	10.05	0.00	0.00	3.12	7.90	241.43	759.95	390.53	582.83	0.41	0.00	515.74	518.44	559.73	99.80	0.00	781.35	317.26	150.07	70.00	70.00
Corcorian ID	CID_010	627.86	634.04	535.86	20.58	386.64	0.00	50.68	0.00	0.00	166.19	91.94	560.84	611.82	401.46	637.43	49.50	27.84	563.95	514.06	426.49	144.73	0.05	629.21	743.55	626.48	843.38	843.38
Corcorian ID	CID_011	1,095.87	852.03	699.44	24.83	487.89	0.00	20.24	0.00	0.00	181.05	167.53	281.89	3.23	600.15	1,188.49	88.36	107.58	939.77	800.67	1,339.42	372.23	33.88	235.38	0.05	0.00	0.00	0.00
Corcorian ID	CID_012	2,646.53	2,904.86	2,402.93	731.41	2,376.85	172.13	961.47	832.87	159.92	1,247.80	0.00	0.00	0.00	1,249.09	1,340.48	495.63	552.67	2,241.76	1,920.72	1,547.25	482.90	218.98	929.05	1,794.97	1,578.69	1,413.54	1,413.54
Corcorian ID	CID_013	688.46	424.26	301.06	24.57	278.99	0.00	2.00	0.00	0.00	47.82	129.14	32.96	240.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_014	1,064.50	823.87	638.99	0.00	514.76	0.00	100.05	0.00	0.00	88.62	133.40	247.50	383.97	604.77	439.13	85.99	0.00	1,680.93	417.98	1,111.68	333.57	27.58	1,025.94	1,168.49	765.75	12.56	12.56
Corcorian ID	CID_015	983.35	681.20	471.33	35.58	420.81	0.00	84.55	0.00	0.00	102.53	108.71	631.10	613.15	336.36	580.81	58.85	12.85	465.51	172.01	151.65	0.01	660.30	307.92	122.48	0.00	0.00	0.00
Corcorian ID	CID_016	533.37	547.86	425.90	23.03	351.59	36.12	28.90	0.00	0.00	77.11	106.72	88.60	0.12	52.11	199.39	7.69	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_017	1,278.44	1,386.96	975.15	176.79	1,293.32	206.88	499.85	261.66	0.00	818.02	1,242.18	1,747.47	1,247.56	488.25	448.95	408.94	101.82	1,389.98	1,473.27	1,463.99	133.79	38.17	1,244.58	1,309.51	1,183.41	980.85	980.85

Annualized Specified Pumping

Well field	Well_ID	1990 (AF/Y)	1991 (AF/Y)	1992 (AF/Y)	1993 (AF/Y)	1994 (AF/Y)	1995 (AF/Y)	1996 (AF/Y)	1997 (AF/Y)	1998 (AF/Y)	1999 (AF/Y)	2000 (AF/Y)	2001 (AF/Y)	2002 (AF/Y)	2003 (AF/Y)	2004 (AF/Y)	2005 (AF/Y)	2006 (AF/Y)	2007 (AF/Y)	2008 (AF/Y)	2009 (AF/Y)	2010 (AF/Y)	2011 (AF/Y)	2012 (AF/Y)	2013 (AF/Y)	2014 (AF/Y)	2015 (AF/Y)	2016 (AF/Y)
Corcorian ID	CID_018	943.66	749.64	701.03	152.18	949.61	64.22	0.00	0.00	0.00	389.81	552.60	674.14	968.82	810.87	919.52	489.30	96.06	1,480.59	1,008.63	729.60	264.65	240.75	1,249.10	1,122.97	980.39	887.85	887.85
Corcorian ID	CID_019	1,141.43	1,055.25	797.10	130.18	733.06	0.00	116.50	0.00	0.00	258.48	146.36	940.79	750.55	896.51	1,415.36	306.71	199.99	1,279.65	1,343.86	929.27	154.62	81.15	1,217.95	1,479.14	1,039.33	1,226.58	1,226.58
Corcorian ID	CID_020	1,682.59	1,222.03	743.03	73.31	1,142.60	87.36	155.47	0.00	0.00	127.25	523.92	1,049.50	1,208.63	1,367.01	1,039.10	273.64	197.83	843.20	988.20	641.34	300.74	119.40	1,241.00	1,151.67	1,028.68	772.84	772.84
Corcorian ID	CID_021	973.70	1,019.30	717.27	161.22	1,259.62	42.20	283.41	765.16	116.83	574.45	1,003.18	1,414.21	600.80	1,031.67	1,343.40	264.05	220.09	1,377.89	1,046.65	649.39	393.76	12.50	974.52	792.87	797.92	128.61	128.61
Corcorian ID	CID_022	992.52	810.03	693.96	141.75	643.68	75.24	111.76	0.00	0.00	43.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_023	858.00	744.13	547.71	0.00	558.21	26.48	116.26	0.00	0.00	400.61	518.95	462.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_024	1,836.70	2,033.55	1,689.40	368.63	2,092.55	105.69	290.01	980.44	130.41	924.59	1,393.04	1,348.60	1,555.08	523.66	1,441.63	175.26	169.60	1,959.05	1,197.09	2,036.26	709.24	21.26	1,397.81	213.99	1,318.92	195.89	195.89
Corcorian ID	CID_025	2,200.45	1,742.98	1,395.37	237.66	1,347.50	141.01	330.06	599.95	134.92	599.76	1,311.78	1,680.88	1,414.68	951.18	1,395.77	369.19	311.44	2,117.80	1,833.45	1,897.24	401.36	506.80	1,865.98	1,963.80	1,541.33	1,589.06	1,589.06
Corcorian ID	CID_026	2,054.10	1,752.35	2,044.83	332.41	1,992.01	313.63	186.98	755.01	229.09	735.74	1,095.24	1,398.85	1,363.25	309.84	1,420.85	693.28	217.92	2,049.11	1,398.39	1,446.66	108.73	235.06	1,581.51	1,821.77	1,704.64	1,538.76	1,538.76
Corcorian ID	CID_027	1,346.31	1,366.56	837.69	112.16	1,086.54	79.80	538.93	671.98	0.00	369.42	704.45	1,400.45	1,106.74	693.76	388.57	366.41	76.24	332.03	645.93	1,061.16	153.59	125.36	949.56	768.78	500.00	514.07	514.07
Corcorian ID	CID_028	1,759.43	2,454.37	1,851.81	384.68	2,660.59	150.14	845.41	514.20	94.87	1,819.92	2,777.40	3,244.34	1,540.61	2,267.13	2,119.73	347.32	671.10	2,370.25	2,101.08	1,720.37	158.47	0.00	0.00	1,149.04	1,854.99	1,267.36	1,267.36
Corcorian ID	CID_029	1,869.41	2,096.46	1,683.73	321.28	2,311.90	282.17	567.92	372.23	83.58	1,331.91	2,515.63	2,623.93	1,646.22	1,753.96	1,496.24	790.66	0.20	618.44	340.29	0.00	68.66	0.00	0.00	677.62	1,008.13	194.65	194.65
Corcorian ID	CID_030	1,033.99	234.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_031	744.47	606.00	617.43	125.94	688.72	64.45	0.00	0.00	0.00	243.97	433.74	311.91	522.61	794.13	451.74	113.97	132.28	423.17	340.78	185.08	0.00	0.63	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_032	2,478.85	1,769.45	1,965.95	543.81	1,931.68	161.50	804.49	732.98	247.42	1,111.84	0.00	0.00	0.00	301.13	633.74	271.47	0.00	0.00	1,496.72	1,712.44	847.98	65.61	1,540.00	1,633.14	1,514.64	1,385.37	1,385.37
Corcorian ID	CID_033	1,379.94	899.71	1,359.42	306.02	1,413.69	150.67	288.74	0.00	0.00	734.29	1,294.95	1,373.09	1,628.69	1,515.12	1,217.83	337.36	125.60	1,773.95	1,764.90	694.03	630.17	133.66	1,365.41	812.42	22.00	453.53	453.53
Corcorian ID	CID_034	1,618.32	1,291.57	1,024.49	120.41	1,097.03	105.03	37.67	0.00	0.00	480.87	771.69	1,259.83	507.95	654.28	999.16	129.75	62.81	1,283.75	847.22	659.79	115.26	0.00	1,091.28	1,129.49	1,225.34	1,204.38	1,204.38
Corcorian ID	CID_035	1,295.37	1,693.60	1,493.93	333.89	1,721.01	111.08	512.54	273.14	215.25	1,426.21	1,590.00	499.62	0.00	985.65	2,204.94	509.33	437.62	2,442.24	2,187.69	2,419.10	871.86	58.45	1,869.01	496.05	0.00	0.00	0.00
Corcorian ID	CID_036	993.71	1,106.31	1,222.96	292.35	1,126.13	165.28	472.55	253.53	0.00	699.75	1,053.95	1,700.40	1,307.80	1,160.17	897.62	304.18	251.08	1,215.38	1,130.81	1,395.02	1,055.11	316.34	1,239.06	1,380.37	1,078.82	1,278.24	1,278.24
Corcorian ID	CID_037	1,344.64	1,981.76	1,250.45	260.64	1,723.95	150.68	600.69	341.34	65.27	128.13	419.34	741.83	1,268.20	1,484.38	1,878.90	582.54	351.38	1,532.13	1,230.39	1,151.86	538.73	23.36	612.84	0.00	-0.02	0.00	0.00
Corcorian ID	CID_038	2,139.10	2,553.65	2,343.27	360.78	2,614.25	224.79	776.11	378.39	0.00	1,367.84	1,564.95	2,101.25	2,025.91	1,740.78	1,318.42	645.71	484.89	2,221.00	2,099.24	2,049.18	810.60	27.00	1,906.51	1,063.32	2.80	369.57	369.57
Corcorian ID	CID_039	588.86	605.10	338.75	22.95	135.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_040	926.15	1,394.96	2,165.44	856.73	2,185.85	430.57	435.13	222.54	4.40	496.27	226.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_041	1,728.95	1,941.95	1,528.32	166.00	1,191.76	19.27	183.57	60.48	0.00	365.75	330.60	283.99	276.67	239.43	708.61	112.37	26.96	454.23	371.59	370.87	92.05	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_042	1,692.50	864.41	1,239.68	250.66	1,566.67	118.48	210.11	0.00	0.00	616.36	1,002.06	1,448.33	1,428.97	1,081.34	867.66	303.24	288.09	1,578.76	1,448.04	627.67	501.39	152.11	1,365.87	1,229.59	121.05	467.66	467.66
Corcorian ID	CID_043	284.50	1,025.86	788.77	0.00	945.45	0.00	188.63	0.00	0.00	450.51	352.45	735.51	786.59	229.17	743.31	634.30	278.22	1,412.90	1,390.02	1,292.64	351.27	61.51	1,094.73	1,052.46	1,104.45	1,163.51	1,163.51
Corcorian ID	CID_044	2,029.22	2,100.06	1,637.63	709.97	1,802.08	547.81	731.24	162.90	29.33	484.21	922.29	1,556.49	455.60	1,084.36	758.02	104.03	57.82	637.83	1,063.14	1,054.04	174.91	8.30	272.36	121.12	0.02	0.00	0.00
Corcorian ID	CID_045	1,224.74	1,179.34	928.36	211.27	1,088.56	110.45	292.71	464.68	0.00	936.86	1,366.65	1,420.29	1,187.86	1,415.47	757.22	403.80	260.08	1,157.39	555.50	0.03	52.14	21.44	376.24	8.26	0.00	233.10	233.10
Corcorian ID	CID_046	989.39	998.34	534.12	129.56	997.58	218.11	218.98	14.94	0.00	533.14	1,338.92	971.73	1,018.56	505.35	471.23	357.23	286.09	522.10	319.19	1,059.49	388.39	16.28	727.21	0.00	0.00	133.84	133.84
Corcorian ID	CID_047	734.05	533.05	64.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_048	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_049	1,536.11	1,242.17	1,007.51	476.14	1,683.34	172.65	513.42	502.13	102.50	962.82	61.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_050	836.66	847.12	348.50	457.36	1,775.01	319.22	759.79	617.50	114.57	166.79	0.00	772.26	1,706.63	938.81	1,506.57	365.02	464.85	1,370.48	2,063.72	1,776.53	859.53	351.17	1,995.65	1,794.20	1,651.95	1,581.65	1,581.65
Corcorian ID	CID_051	1,263.69	903.10	610.18	13.28	758.27	1.42	166.40	0.00	0.00	168.74	286.75	750.62	883.60	695.86	1,150.74	63.77	0.00	1,168.23	643.60	730.05	776.54	0.00	328.34	498.59	883.24	1,006.86	1,006.86
Corcorian ID	CID_052	1,991.91	995.68	1,036.49	0.00	749.17	80.23	149.37	87.23	0.00	0.69	414.45	750.07	1,464.56	704.16	1,556.32	127.65	0.00	1,189.35	1,446.50	831.86	576.55	72.77	1,394.98	0.36	769.40	1,783.85	1,783.85
Corcorian ID	CID_053	1,836.83	1,344.56	1,165.61	99.22	832.81	0.00	98.02	762.31	0.00	539.91	907.06	1,523.06	1,816.36	676.03	1,526.97	409.15	309.93	1,543.69	1,958.95	1,697.35	534.79	186.30	2,064.82	1,397.63	1,401.31	812.65	812.65
Corcorian ID	CID_054	1,451.67	1,174.62	1,135.27	279.69	1,492.00	217.17	413.17	229.71	121.84	743.08	1,167.10	873.06	544.35	920.54	963.95	257.76	122.34	1,244.66	1,464.17	727.87	526.74	12.28	714.45	1,678.15	1,507.17	1,201.17	1,201.17
Corcorian ID	CID_055	2,365.41	1,436.58	1,476.88	441.19	1,386.77	121.08	275.37	679.83	0.00	564.72	1,197.01	2,607.04	1,613.90	2,007.08	1,746.33	132.10	565.44	1,492.46	1,945.02	1,958.99	1,268.44	210.35	1,910.51	2,189.52	1,816.23	1,667.14	1,667.14
Corcorian ID	CID_056	738.47	899.22	907.33	30.66	525.20	0.00	90.85	0.00	0.00	137.20	146.30	240.95	112.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_057	608.80	531.36	439.66	31.84	571.42	0.00	112.63	0.00	0.00	206.13	124.98	141.95	937.95	465.40	896.06	269.11	382.14	992.97	817.96	677.84	93.08	45.76	655.66	806.32	455.50	190.09	190.09
Corcorian ID	CID_058	782.84	1,487.40	1,445.57	72.68	1,461.54	8.37	275.47	0.00	0.00	592.73	566.75	701.85	1,246.44	1,368.91	2,152.07	435.74	390.39	657.44	1,068.66	767.14	71.18	0.00	220.51	1,016.28	541.40	0.00	0.00
Corcorian ID	CID_059	1,064.65	789.51	878.63	29.92	859.07	0.00	126.21	0.00	0.00	183.55	89.17	444.63	631.08	483.03	1,203.38	83.63	156.67	1,246.42	794.91	608.13	329.65	238.86	887.67	434.38	581.54	1,126.40	1,126.40
Corcorian ID	CID_060	1,186.15	836.46	764.81	24.75	564.07	0.00	59.39	0.00	0.00	148.74	141.85	305.96	524.69	548.08	718.07	15.28	78.66	688.72	627.04	743.75	165.17	43.44	506.06	385.22	555.47	1,243.15	1,243.15
Corcorian ID	CID_061	1,839.79	1,763.78	1,343.82	96.53	1,166.08	0.00	42.90	0.00	0.00	225.47	161.15	749.72	1,345.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_062	1,510.19	1,402.87	851.17	74.78	567.56	0.00	48.19	0.00	0.00	300.69	85.41	49.06	444.21	304.33	526.07	64.98	2.41	164.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_063	2,116.83	2,169.74	1,729.88	664.94	1,792.09	275.77	981.68	887.72	167.38	1,181.73	0.00	0.00	0.00	1,438.93	1,750.63	550.79	538.72	1,868.28	1,484.65	1,675.69	1,293.54	203.43	965.59	280.73	0.03	0.00	0.00
Corcorian ID	CID_064	2,074.68	1,327.64	1,123.30	543.00	1,087.03	2.46	512.08	662.32	126.51	746.76	0.00	0.00	0.00	883.95	1,208.47	440.98	383.93	699.74	0.00	1,510.93	548.35	329.55	1,622.10	816.65	1,052.12	822.86	822.86
Corcorian ID	CID_065	1,942.43	1,804.73	2,012.33	8.49	1,601.31	235.59	660.05	338.52	68.98	7.07	56.60	809.67	361.00	912.87	570.92	294.10	290.66	1,146.88	112.93	27.01	0.87	14.62	706.91	728.36	433.30	489.35	489.35
Corcorian ID	CID_066	898.36	2,125.69	1,738.59	341.96	2,000.57	224.44	632.38	306.49	102.26	1,174.19	1,328.18	1,311.76	1,753.59	1,384.98	1,760.36	518.70	352.57	1,539.70	1,329.17	615.29	680.97	44.63	627.21	1,497.67	1,680.60	1,581.47	1,581.47
Corcorian ID	CID_067	501.07	1,786.21	1,343.64	0.90	1,171.53	362.37	630.97	259.32	60.60	1,063.45	1,475.18	2,016.68	1,693.56	1,248.29	738.11	541.95	256.87	1,379.68	708.03	1,415.60	600.85	44.10	1,440.96	1,606.41	1,662.27	1,577.51	1,577.51
Corcorian ID	CID_068	686.17	2,321.54	2,221.60	590.11	2,542.92	257.96	448.15	331.17	75.84	732.05	1,387.50	1,606.13	2,023.64	2,071.91	2,455.38	783.78	483.49	2,285.23	2,022.20	1,924.91	891.60	122.02	2,103.11	1,980.63	1,948.43	2,031.33	2,031.33
Corcorian ID	CID_069	660.62	1,174.00	1,257.34	83.78	910.55	0.00	118.40	0.00	0.00	322.60	254.88	834.92	1,318.93	1,334.52	1,335.06	142.86	151.90	1,038.21	966.18	1,481.98	581.05	59.73	1,369.45	1,773.00	1,234.69	1,662.08	1,662.08
Corcorian ID	CID_070	184.97	275.55	165.35	27.69	107.46	4.60	21.23	134.21	15.16	14.33	0.00	22.15	257.37	230.30	197.92	17.42	7.54	189.28	10.66	14.26	63.64	6.27	0.00	124.92	124.32	137.06	137.06
Corcorian ID	CID_071	0.00	118.15	142.04	0.00	103.91	9.51	56.51	153.38	17.39	32.98	93.47	255.58	240.42	184.43	216.73	27.04	10.50	59.65	0.00	21.80	106.99	12.30	320.79	344.77	231.63	240.45	240.45
Corcorian ID	CID_072	0.00	95.97	109.90	36.91	29.04	7.31	8.98	22.36	0.00	9.99	104.91	119.09	80.83	0.00	3.58	7.98	6.65	0.00	0.00	0.00	-0.90	0.89	0.01	0.00	0.00	0.04	0.04
Corcorian ID	CID_073	0.00	142.84	310.98	67.77	234.63	11.31	11.59	0.00	0.00	122.98	180.62	243.11	343.09	202.04	163.85	22.48	16.64	226.31	202.17	0.00	60.93	100.01	0.00	196.04	85.09	0.00	0.00
Corcorian ID	CID_074	0.00	0.00	364.26	397.13	1,245.96	125.65	293.08	0.00	0.00	622.39	620.98	1,253.41	1,834.78	1,616.65	2,471.79	1,059.92	512.47	2,121.78	2,147.19	1,894.95	865.95	105.57	330.88	0.57	0.00	0.00	0.00
Corcorian ID	CID_075	0.00	0.00	251.55	225.46	989.02	0.00	105.87	0.00	0.00	305.79	314.55	1,173.34	1,238.55	1,362.63	1,757.47	111.55	91.83	978.03	819.89	843.24	0.00	0.00	2.00	959.89	1,013.14	1,098.97	1,098.97
Corcorian ID	CID_076	0.00	0.00	0.00	0.00	234.89	111.78	634.61	541.05	0.00	272.51	610.40	1,860.09	1,638.49	1,356.17	1,835.78	425.89	380.38	2,196.13	2,152.32	1,863.13	790.24	97.44	1,954.80	2,143.33	219.61	0.36	0.36
Corcorian ID	CID_077	0.00	0.00	0.00	0.00	0.00	0.00	0.00	123.51	0.00	237.17	187.97	225.90	298.14	320.75	99.52	57.46	74.24	140.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_078	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,668.87	1,369.61	1,606.41	1,482.16	308.50	144.84	982.56	962.93	729.61	0.00	81.84	1,049.74	1,049.20	1,186.57	72.24	72.24
Corcorian ID	CID_079	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,735.25	1,734.52	1,824.40	1,342.88	325.61	197.09	1,309.95	1,359.77	1,443.55	340.79	170.81	1,080.45	550.07	746.57	907.46	907.46
Corcorian ID	CID_080	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,660.37	1,583.12	1,635.26	1,523.73	347.82	282.27	1,443.19	871.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_081	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	487.72	1,518.23	1,538.22	152.23	78.55	1,271.28	1,444.23	1,641.26	313.71	99.39	444.08	722.62	1,122.74	1,585.55	1,585.55
Corcorian ID	CID_082	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	315.07	1,287.24	245.95	186.05	1,239.63	492.18	922.72	497.22	18.21	1,269.58	1,409.00	1,376.68	1,127.54	1,127.54
Corcorian ID	CID_083	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	91.59	663.41	437.53	112.73	1,368.03	1,577.93	1,328.94	465.39	222.46	1,239.53	1,601.77	1,425.61	869.57	869.57
Corcorian ID	CID_084	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	125.95	183.58	93.35	834.67	947.18	988.60	223.77	37.16	540.41	0.01	49.57	987.79	987.79
Corcorian ID	CID_085	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	534.63	296.53	1,886.07	1,778.62	1,746.80	709.95	220.89	1,615.89	1,673.35	1,168.21	0.00	0.00
Corcorian ID	CID_086	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	160.70	1,036.72	330.95	1,000.21	397.67	5.91	816.21	398.68	0.04	0.00	0.00
Corcorian ID	CID_087	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	378.71	1,827.95	1,247.36	1,274.21	211.04	224.24	1,023.00	1,371.43	1,466.07	1,521.31	1,521.31
Corcorian ID	CID_088	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,263.58	1,261.12	1,461.71	246.31	0.00	1,146.15	1,440.28	1,179.16	1,313.66	1,313.66
Corcorian ID	CID_089	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	349.93	538.06	1,434.87	454.84	0.00	1,193.74	1,389.61	0.03	0.00	0.00
Corcorian ID	CID_090	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	607.56	1,291.87	467.41	0.00	342.47	1,557.85	1,126.84	1,427.48	1,427.48
Corcorian ID	CID_091	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	859.04	1,767.72	592.13	0.01	1,413.28	2,641.50	1,826.26	1,869.65	1,869.65

Annualized Specified Pumping

Well field	Well_ID	1990 (AF/Y)	1991 (AF/Y)	1992 (AF/Y)	1993 (AF/Y)	1994 (AF/Y)	1995 (AF/Y)	1996 (AF/Y)	1997 (AF/Y)	1998 (AF/Y)	1999 (AF/Y)	2000 (AF/Y)	2001 (AF/Y)	2002 (AF/Y)	2003 (AF/Y)	2004 (AF/Y)	2005 (AF/Y)	2006 (AF/Y)	2007 (AF/Y)	2008 (AF/Y)	2009 (AF/Y)	2010 (AF/Y)	2011 (AF/Y)	2012 (AF/Y)	2013 (AF/Y)	2014 (AF/Y)	2015 (AF/Y)	2016 (AF/Y)
Corcorian ID	CID_092	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	859.35	1,550.38	437.84	244.98	1,141.08	1,105.51	1,066.16	1,298.44	1,298.44
Corcorian ID	CID_093	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	741.70	1,487.20	372.01	165.25	750.50	1,032.04	999.00	1,253.67	1,253.67
Corcorian ID	CID_094	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	896.47	1,692.61	626.91	145.20	1,171.04	1,738.69	1,475.47	1,674.79	1,674.79
Corcorian ID	CID_095	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	627.84	1,662.93	573.14	87.26	1,072.90	1,293.26	1,510.39	1,427.72	1,427.72
Corcorian ID	CID_096	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.47	54.99	317.46	3,420.23	2,889.80	3,510.53	3,510.53
Corcorian ID	CID_097	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	155.44	3,085.52	2,159.80	2,290.52	2,290.52
Corcorian ID	CID_098	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,056.92	1,361.42	1,473.69	1,473.69
Corcorian ID	CID_099	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,209.37	517.23	517.23
Corcorian ID	CID_100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,885.47	1,884.87	1,884.87
Corcorian ID	CID_101	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.34	975.48	975.48
Corcorian ID	CID_102	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_103	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_104	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corcorian ID	CID_105	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Westlands WD	WWD_18S19E-18Q01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_18S19E-19K01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_18S19E-20E01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_18S19E-20F01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_18S19E-28M02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_18S19E-29D01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_18S19E-31N01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-04M01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-05K01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-07N02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-08N04	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-10E02	550.08	725.53	680.15	461.72	573.98	338.21	360.23	325.08	253.81	400.51	512.10	606.57	629.47	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.18	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-15D02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-15D03	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-15E02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-15N01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-18C01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-19K01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-26D03	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-26E03	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-27D01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-27M01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-28K02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-29A01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-29A02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-29A03	328.85	485.30	444.10	316.62	391.76	250.01	282.69	247.40	199.56	283.18	410.21	459.73	477.57	329.33	290.74	199.55	205.46	399.29	552.81	580.16	372.56	215.27	401.83	520.17	556.07	566.97	556.07
Westlands WD	WWD_19S19E-29J01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-30L01	655.02	887.19	827.97	461.72	671.23	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-30M01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-30M02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-31A01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-31D03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_19S19E-31N03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_19S19E-32K01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-33E01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_19S19E-33Q02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S18E-24H01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S18E-25E01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S18E-26K01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S18E-35D02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S18E-35E03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S18E-36C03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S18E-36D05	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-02A01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-02D01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-02E02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-02J01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-02N01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-04D02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-04D03	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-04H01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-06N04	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-07D01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-07G01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-07G02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-08M01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-09D02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-09D03	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-09N02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11

Annualized Specified Pumping

Well field	Well_ID	1990 (AF/Y)	1991 (AF/Y)	1992 (AF/Y)	1993 (AF/Y)	1994 (AF/Y)	1995 (AF/Y)	1996 (AF/Y)	1997 (AF/Y)	1998 (AF/Y)	1999 (AF/Y)	2000 (AF/Y)	2001 (AF/Y)	2002 (AF/Y)	2003 (AF/Y)	2004 (AF/Y)	2005 (AF/Y)	2006 (AF/Y)	2007 (AF/Y)	2008 (AF/Y)	2009 (AF/Y)	2010 (AF/Y)	2011 (AF/Y)	2012 (AF/Y)	2013 (AF/Y)	2014 (AF/Y)	2015 (AF/Y)	2016 (AF/Y)
Westlands WD	WWD_20S19E-10E01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-11D03	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-11E01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-14A01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-14E01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-14F01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-14H01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-17M01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-17M02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-18D02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-19D03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-19N01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-19N02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-19R01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-20D01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-20D02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-20D03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-23K01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-26C01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-31D01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_20S19E-35D02	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_20S19E-35M01	686.94	957.05	941.26	461.72	765.21	338.21	360.23	325.08	253.81	413.11	512.10	660.00	688.37	378.27	364.24	199.55	205.46	470.25	653.10	659.00	378.80	215.27	497.87	600.17	728.11	711.26	728.11
Westlands WD	WWD_21S17E-24J01	324.49	578.77	528.71	222.32	333.06	76.85	59.76	85.38	112.32	176.41	280.46	342.34	301.91	155.73	140.09	21.62	7.59	219.12	303.24	431.66	160.11	0.00	247.66	478.21	647.24	652.89	647.24
Westlands WD	WWD_21S18E-01B02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-01N01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-02C03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-02D03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-03G01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-09L01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-10B01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-11C01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-11D03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-11N01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-11Q01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-14M07	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-15M02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-16N01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-16P01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-17N03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-18R01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-22B05	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-22E01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-23B02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-23D07	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-23E01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-26N01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-27B01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-27E01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-27K02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-28G06	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-28Q02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-29E02	324.49	578.77	528.71	222.32	333.06	76.85	59.76	85.38	112.32	176.41	280.46	342.34	301.91	155.73	140.09	21.62	7.59	219.12	303.24	431.66	160.11	0.00	247.66	478.21	647.24	652.89	647.24
Westlands WD	WWD_21S18E-29N02	324.49	578.77	528.71	222.32	333.06	76.85	59.76	85.38	112.32	176.41	280.46	342.34	301.91	155.73	140.09	21.62	7.59	219.12	303.24	431.66	160.11	0.00	247.66	478.21	647.24	652.89	647.24
Westlands WD	WWD_21S18E-31H01	324.49	578.77	528.71	222.32	333.06	76.85	59.76	85.38	112.32	176.41	280.46	342.34	301.91	155.73	140.09	21.62	7.59	219.12	303.24	431.66	160.11	0.00	247.66	478.21	647.24	652.89	647.24
Westlands WD	WWD_21S18E-32R01	324.49	578.77	528.71	222.32	333.06	76.85	59.76	85.38	112.32	176.41	280.46	342.34	301.91	155.73	140.09	21.62	7.59	219.12	303.24	431.66	160.11	0.00	247.66	478.21	647.24	652.89	647.24
Westlands WD	WWD_21S18E-33G01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-33N02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-35D01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-35Q01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S18E-35Q02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S19E-06B01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S19E-07D01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S19E-07N02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S19E-17E01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S19E-17Q01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S19E-18N03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S19E-19C03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S19E-20D01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S19E-30D04	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_21S19E-30D05	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-01E02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-01K01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-02G05	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-03B01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00

Annualized Specified Pumping

Well field	Well_ID	1990 (AF/Y)	1991 (AF/Y)	1992 (AF/Y)	1993 (AF/Y)	1994 (AF/Y)	1995 (AF/Y)	1996 (AF/Y)	1997 (AF/Y)	1998 (AF/Y)	1999 (AF/Y)	2000 (AF/Y)	2001 (AF/Y)	2002 (AF/Y)	2003 (AF/Y)	2004 (AF/Y)	2005 (AF/Y)	2006 (AF/Y)	2007 (AF/Y)	2008 (AF/Y)	2009 (AF/Y)	2010 (AF/Y)	2011 (AF/Y)	2012 (AF/Y)	2013 (AF/Y)	2014 (AF/Y)	2015 (AF/Y)	2016 (AF/Y)
Westlands WD	WWD_22S18E-04H01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-05B01	324.49	578.77	528.71	222.32	333.06	76.85	59.76	85.38	112.32	176.41	280.46	342.34	301.91	155.73	140.09	21.62	7.59	219.12	303.24	431.66	160.11	0.00	247.66	478.21	647.24	652.89	647.24
Westlands WD	WWD_22S18E-10A01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-10C01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-11C02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-11C03	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-11G01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-12R01	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_22S18E-13K02	311.52	472.04	476.59	181.10	319.20	90.51	81.94	82.06	67.59	130.95	153.24	309.43	288.00	200.33	216.07	35.99	56.71	149.91	276.10	338.57	136.64	34.49	310.36	401.68	562.00	523.80	562.00
Westlands WD	WWD_FARM_24_141	951.61	864.42	802.36	423.25	712.63	212.87	419.18	510.96	243.94	496.07	558.07	770.78	779.45	759.89	763.70	239.73	166.23	639.83	707.60	747.47	496.10	212.44	632.85	857.61	918.01	900.73	918.01
Westlands WD	WWD_FARM_25_012	613.28	515.09	548.89	17.77	269.36	16.44	41.24	119.70	65.89	127.75	104.06	441.50	427.47	413.57	529.14	116.35	52.19	289.39	509.78	542.56	89.33	4.46	311.87	800.63	1,036.48	1,023.31	1,036.67
Westlands WD	WWD_FARM_25_044	613.28	515.09	548.89	17.77	269.36	16.44	41.24	119.70	65.89	127.75	104.06	441.50	427.47	413.57	529.14	116.35	52.19	289.39	509.78	542.56	89.33	4.46	311.87	800.63	1,036.48	1,023.31	1,036.67
Westlands WD	WWD_FARM_26_001	275.60	386.59	450.92	156.07	326.58	44.00	104.66	157.88	36.72	316.41	86.83	162.60	181.16	157.15	177.76	9.55	0.00	89.14	208.00	178.48	2.45	0.00	23.43	190.50	369.83	287.40	369.83
Westlands WD	WWD_FARM_26_003	275.60	386.59	450.92	156.07	326.58	44.00	104.66	157.88	36.72	316.41	86.83	162.60	181.16	157.15	177.76	9.55	0.00	89.14	208.00	178.48	2.45	0.00	23.43	190.50	369.83	287.40	369.83
Westlands WD	WWD_FARM_26_008	275.60	386.59	450.92	156.07	326.58	44.00	104.66	157.88	36.72	316.41	86.83	162.60	181.16	157.15	177.76	9.55	0.00	89.14	208.00	178.48	2.45	0.00	23.43	190.50	369.83	287.40	369.83
Westlands WD	WWD_FARM_26_015	275.60	386.59	450.92	156.07	326.58	44.00	104.66	157.88	36.72	316.41	86.83	162.60	181.16	157.15	177.76	9.55	0.00	89.14	208.00	178.48	2.45	0.00	23.43	190.50	369.83	287.40	369.83
Westlands WD	WWD_FARM_26_029	275.60	386.59	450.92	156.07	326.58	44.00	104.66	157.88	36.72	316.41	86.83	162.60	181.16	157.15	177.76	9.55	0.00	89.14	208.00	178.48	2.45	0.00	23.43	190.50	369.83	287.40	369.83
City of Hanford	Hanford_02	102.40	99.06	105.88	111.91	120.67	118.07	142.15	143.82	129.29	147.07	151.50	156.30	269.50	233.05	299.93	328.43	299.61	334.24	305.46	3.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Hanford	Hanford_11	113.39	112.69	122.58	128.31	140.26	137.11	168.62	167.88	159.18	179.28	184.81	192.29	234.03	230.14	275.32	184.07	266.40	311.91	324.67	291.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Hanford	Hanford_18	186.85	181.48	191.61	204.13	219.22	215.95	254.91	256.53	234.21	263.63	270.19	280.47	520.85	405.58	331.20	317.92	336.53	559.96	854.08	615.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Hanford	Hanford_31	261.74	251.86	263.87	280.59	299.14	294.73	340.76	344.91	307.34	348.05	356.58	368.32	822.26	681.10	697.40	548.66	670.78	707.48	349.60	91.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Hanford	Hanford_32	96.22	95.54	103.07	107.80	116.74	115.68	141.62	140.22	130.28	147.78	151.05	157.56	225.24	134.37	210.78	314.05	158.14	249.19	280.72	154.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Hanford	Hanford_33	206.19	193.86	204.59	218.47	235.94	226.56	269.86	276.06	243.13	274.60	286.68	291.22	587.13	73.84					13.89	426.27	487.42	935.72	285.66	312.93	48.94	31.23	11.56
City of Hanford	Hanford_34	614.68	597.66	631.99	667.18	710.53	705.48	816.25	819.50	741.51	838.28	855.84	887.24	1,846.51	1,293.61	1,238.78	1,121.06	1,770.59	1,731.57	1,188.37	888.77	233.03	0.00	0.00	0.00	0.00	0.00	0.00
City of Hanford	Hanford_35	285.27	272.85	287.83	305.56	327.44	319.54	372.41	377.61	337.77	381.36	393.84	404.11	842.03	1,097.87	1,122.26	1,277.45	854.27	464.84	832.93	403.41	347.71	315.84	288.32	278.63	25.49	58.73	68.08
City of Hanford	Hanford_36	211.55	201.39	212.34	226.34	242.33	236.11	276.88	283.06	249.97	282.84	292.62	299.34	629.07	626.07	628.28	901.04	795.99	178.64	995.84	451.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Hanford	Hanford_37																73.90	435.65	374.67	266.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Hanford	Hanford_38	100.71	97.15	105.18	110.65	120.04	116.39	143.06	145.01	129.90	149.22	154.17	159.32	241.52	179.08	116.58	163.01	200.08	223.35	322.31	174.12	283.19	262.46	377.34	430.89	146.21	139.46	5.52
City of Hanford	Hanford_40	404.29	393.17	416.59	438.20	466.63	461.04	535.33	535.83	485.52	548.53	562.80	581.17	1,192.58	1,109.49	1,047.04	862.25	123.37	1,717.66	1,523.56	525.05	601.79	446.13	456.49	814.28	1,077.77	361.24	536.60
City of Hanford	Hanford_41	700.43	682.01	725.15	766.28	818.86	810.69	968.71	974.11	871.39	993.08	1,014.91	1,053.27	1,998.41	357.39	1,593.93	1,953.86	1,871.00	1,941.46	1,909.83	1,060.98	0.00	0.00	0.00	0.00	0.00	0.00	126.92
City of Hanford	Hanford_42	676.84	646.25	684.73	728.22	782.32	760.35	899.56	916.40	815.26	924.48	956.39	981.47	1,916.88	1,433.44	1,197.86	0.00	0.00	0.00	707.22	1,259.53	994.28	1,246.09	1,592.03	1,671.66	1,921.12	1,343.45	1,222.72
City of Hanford	Hanford_43																			80.08	97.72	4.07	96.72	192.33	511.79	520.62	1,265.51	964.64
City of Hanford	Hanford_44																			0.00	67.06	1,326.56	2,300.01	2,306.05	497.23	1,769.99	1,601.15	1,432.46
City of Hanford	Hanford_45(16)	592.06	571.40	602.83	637.05	679.68	669.17	775.47	779.09	701.87	792.49	813.78	839.64	1,789.82	678.50	378.47	433.81	391.24	404.94	0.00	1,182.88	2,173.71	1,624.04	1,697.82	1,836.68	1,207.41	3,184.25	1,505.65
City of Hanford	Hanford_46(8)	387.84	394.83	424.30	442.70	477.72	480.41	581.43	567.39	543.16	611.14	619.96	653.80	908.09	0.55						962.51	1,337.10	643.47	602.00	997.27	1,119.86	926.88	620.64
City of Hanford	Hanford_47(22)	254.40	252.00	271.68	284.61	305.69	303.22	373.64	371.65	338.02	387.11	394.79	412.43	634.56	2.17	1.27	0.17	0.28	0.00	0.00	0.00	127.95	1,195.99	1,034.26	1,497.96	811.55	617.40	694.24
City of Hanford	Hanford_48(25)	296.46	296.08	315.90	330.28	351.96	354.39	423.87	416.57	382.60	436.75	440.52	464.36	834.77	564.41	547.16	711.74	229.77	503.55	344.90	0.00	307.79	951.61	782.60	1,647.20	639.09	246.90	957.11
City of Hanford	Hanford_49	389.12	379.55	405.57	427.31	457.80	453.78	543.29	545.98	490.71	557.99	571.50	591.86	1,064.12	48.56		440.11	356.84	522.45	637.00	361.32	0.00	0.00	0.00	0.00	0.00	0.00	47.23
City of Lemoore	LEM_02	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	215.75	178.77	233.66	284.18	574.32	590.44	594.39	634.47	620.90	594.92	593.46	0.00	75.87	0.00	360.17	0.00
City of Lemoore	LEM_04	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	215.75	178.77	233.66	284.18	574.32	590.44	594.39	634.47	620.90	594.92	593.46	446.96	836.73	1,068.20	360.96	4.38
City of Lemoore	LEM_05	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	215.75	178.77	233.66	284.18	574.32	590.44	594.39	634.47	620.90	594.92	593.46	0.00	86.80	268.55	382.28	60.44
City of Lemoore	LEM_06	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	215.75	178.77	233.66	284.18	574.32	590.44	594.39	634.47	620.90	594.92	593.46	1,811.88	1,454.78	886.18	599.81	947.31
City of Lemoore	LEM_07	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	215.75	178.77	233.66	284.18	574.32	590.44	594.39	634.47	620.90	594.92	593.46	185.36	589.68	101.76	461.95	427.91
City of Lemoore	LEM_08	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	292.25	357.47	315.26	423.81	600.92	616.80	601.25	611.47	501.97	548.90	560.06	132.40	75.87	0.00	360.17	0.00
City of Lemoore	LEM_09	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	211.56	191.52	228.92	394.94	559.85	540.33	450.23	538.57	625.12	548.15	528.96	136.28	75.87	0.00	360.17	0.00
City of Lemoore	LEM_10	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	526.94	1,420.70	2,072.97	2,416.84	2,570.42	2,298.46	2,205.27	574.32	590.44	594.39	634.47	620.90	594.92	593.46	1,809.74	1,482.52	1,784.18	862.75	1,541.31
City of Lemoore	LEM_11	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	215.75	3,175.77	4,259.05	1,243.12	574.32	590.44	594.39	634.47	620.90	594.92	593.46	661.39	622.93	713.77	506.67	599.20
City of Lemoore	LEM_12	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	473.76	2,597.27	1,461.96	2,834.40	574.32	590.44	594.39	634.47	620.90	594.92	593.46	972.56	873.70	126.17	543.30	535.47
City of Lemoore	LEM_13	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	215.75	178.77	233.66	284.18	574.32	590.44	594.39	634.47	620.90	594.92	593.46	853.49	1,279.86	1,636.77	862.22	1,445.57
City of Lemoore	LEM_14	290.78	282.54	299.17	316.07	337.92	333.04	390.89	392.77	339.74	309.35	261.46	215.75	178.77	233.66	284.18	574.32	590.44	594.39	634.47	620.90	594.92	593.46	841.73	460.35	1,056.74	709.06	799.97
Apex Ranch	APEX_RW-1	--	--	--	--	--	--	--	--	--	--	--	--	0	105.2	182.4	0	1387.8	1263.8	1087	1535.4	1269	0	1808.8	994	59.6	0	0
Apex Ranch	APEX_RW-2	--	--	--	--	--	--	--	--	--	--	--	--	0	105.2	182.4	0	1387.8	1263.8	1087	1535.4	1269	0	1808.8	994	59.6	0	0
Apex Ranch	APEX_RW-3	--	--	--	--	--	--	--	--	--	--	--	--	0	105.2	182.4	0	1387.8	1263.8	1087	1535.4	1269	0	1808.8	994	59.6	0	0
Apex Ranch	APEX_RW-4	--	--	--	--	--	--	--	--	--	--	--	--	0	105.2	182.4	0	1387.8	1263.8	1087	1535.4	1269	0	1808.8	994	59.6	0	0
Apex Ranch	APEX_RW-5	--	--	--	--	--	--	--	--	--	--	--	--	0	105.2	182.4	0	1387.8	1263.8	1087	1535.4	1269	0	1808.8	994	59.6	0	0

Appendix D5
Observed and Simulated Target Well Hydrographs

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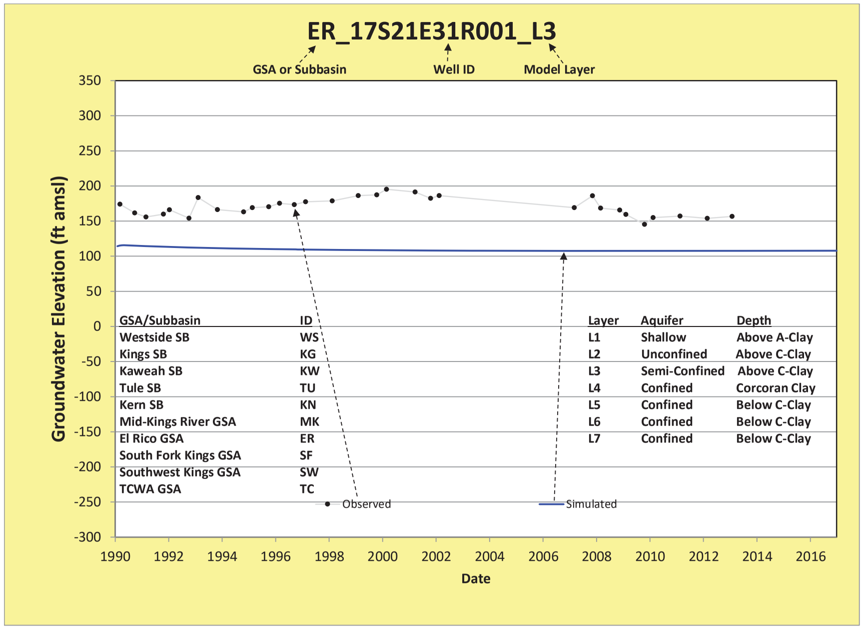
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Model Layer
Groundwater Elevation (ft amsl)
Date
GSA/Subbasin ID
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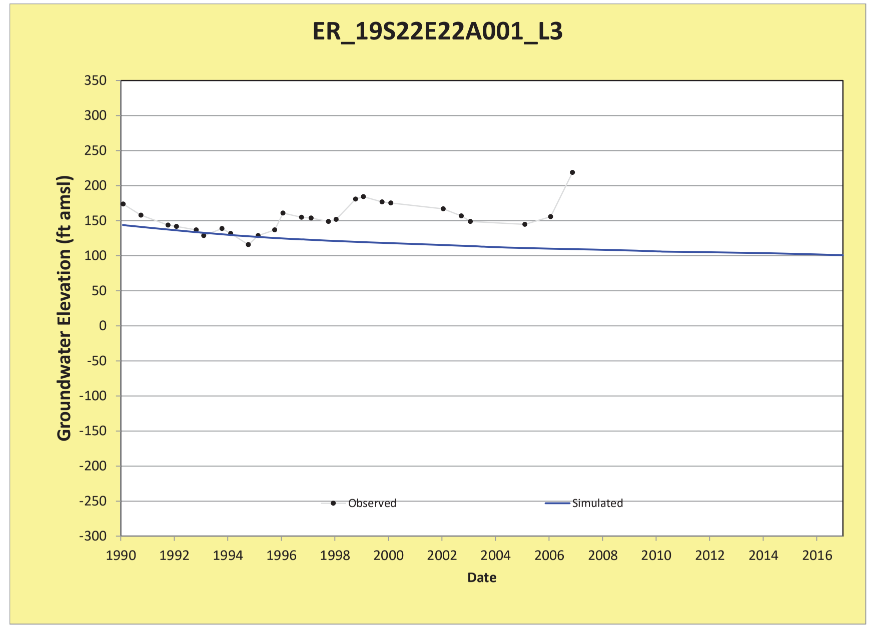
Kings SB KG
Kaweah SB KW
Tule SB TU
Kern SB KN
Mid-Kings River GSA MK
El Rico GSA ER
South Fork Kings GSA SF
Southwest Kings GSA SW
TCWA GSA TC
Layer Aquifer Depth
L1 Shallow Above A-Clay
L2 Unconfined Above C-Clay
L3 Semi-Confined Above C-Clay
L4 Confined Corcoran Clay
L5 Confined Below C-Clay
L6 Confined Below C-Clay
L7 Confined Below C-Clay
Observed
Simulated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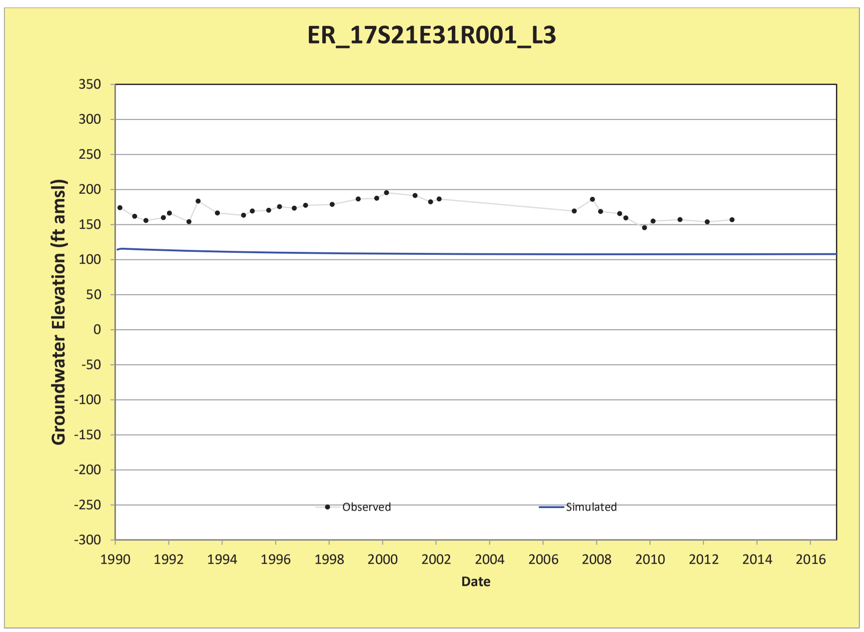
Observed
Simulated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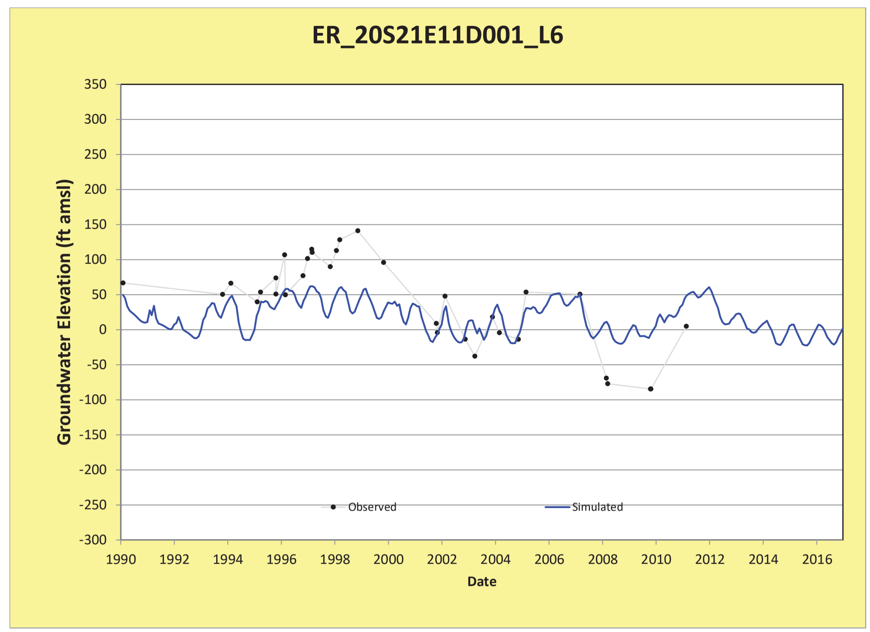
Observed
Simulated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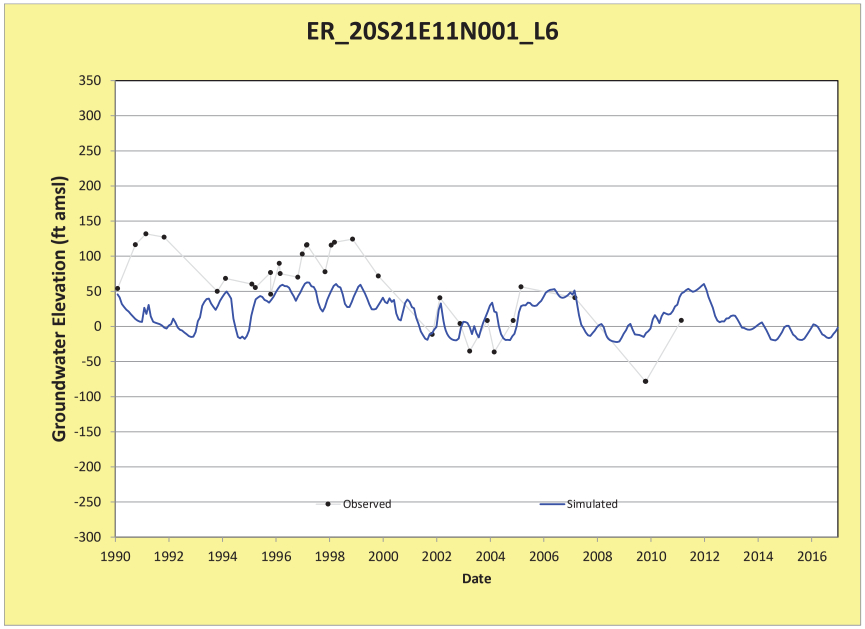
Date
Observed
Simulated



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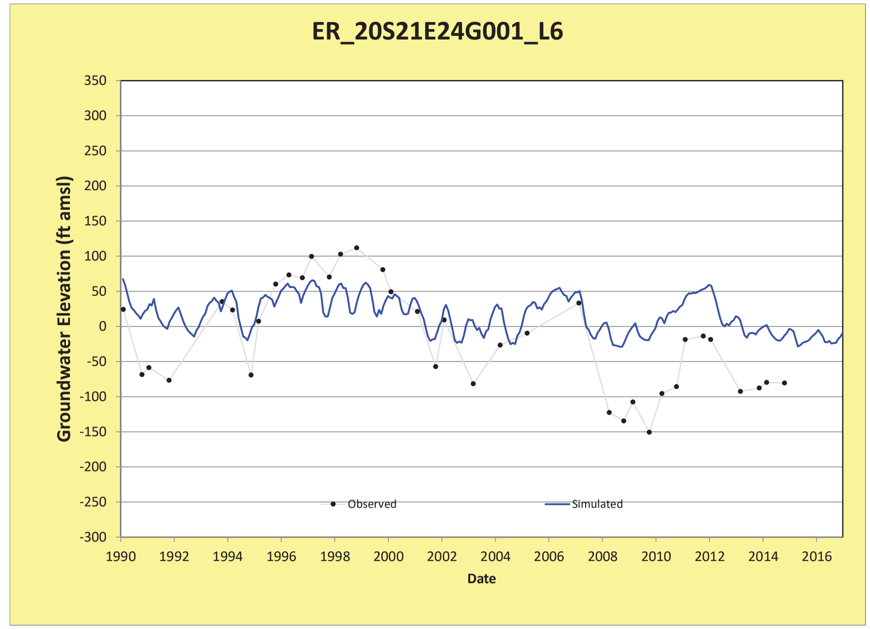
Observed
Simulated



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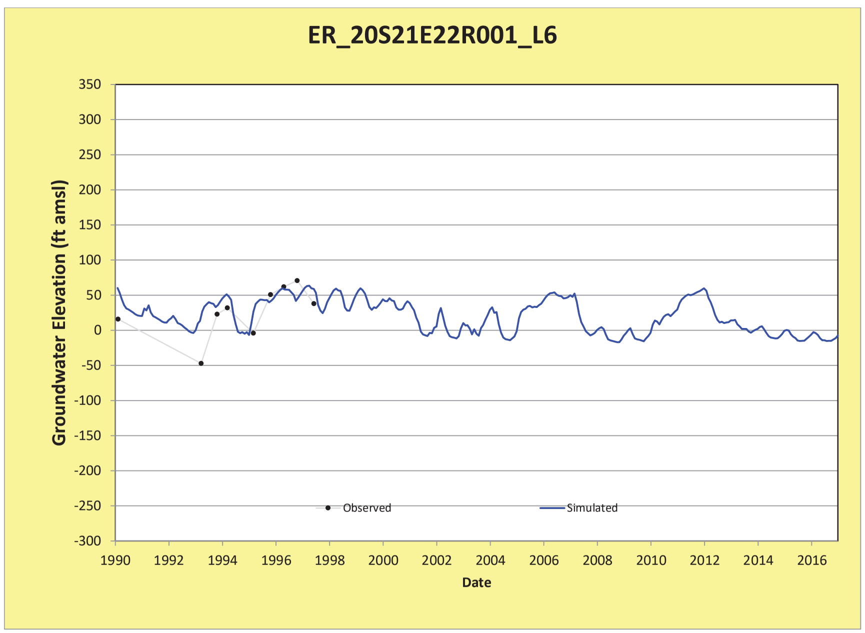
Simulated



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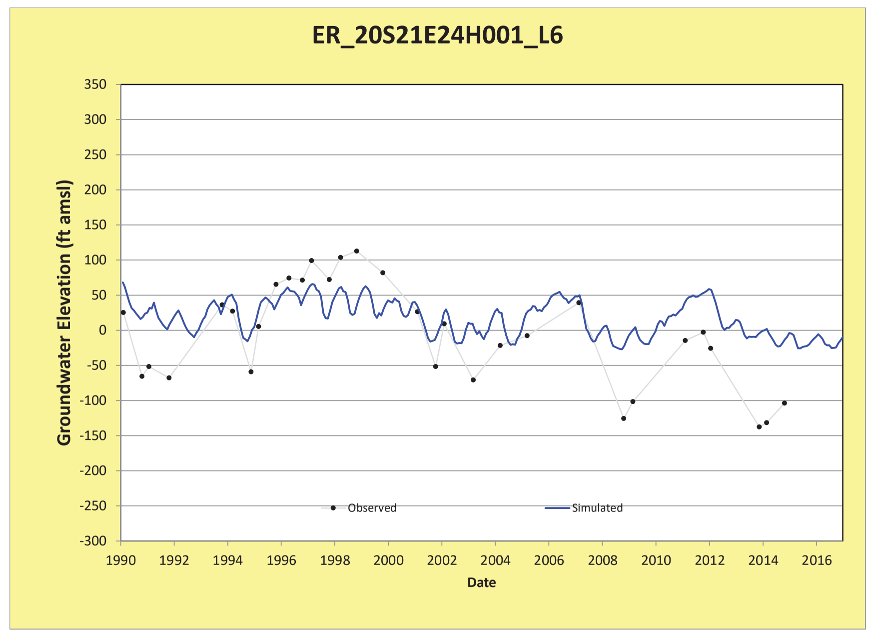
Observed
Simulated



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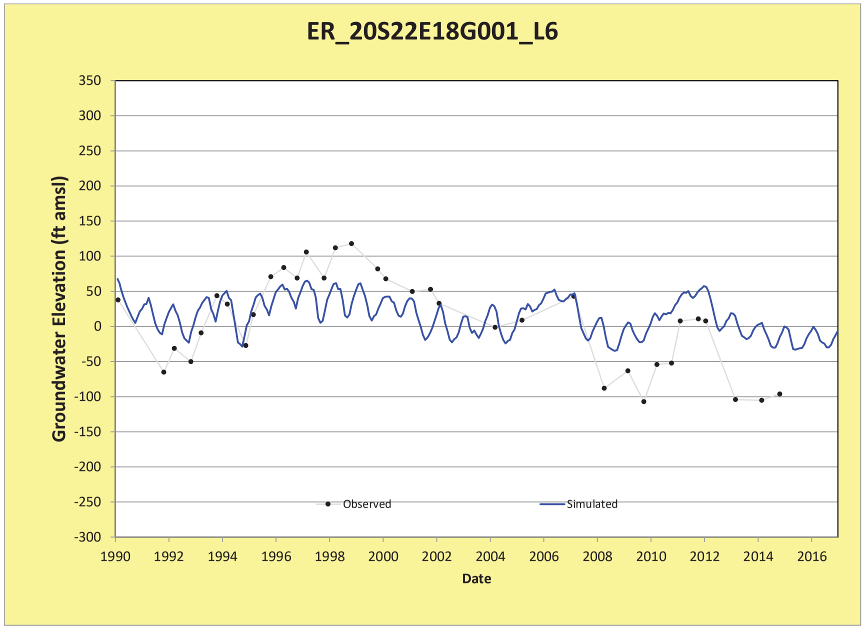
Observed
Simulated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-50
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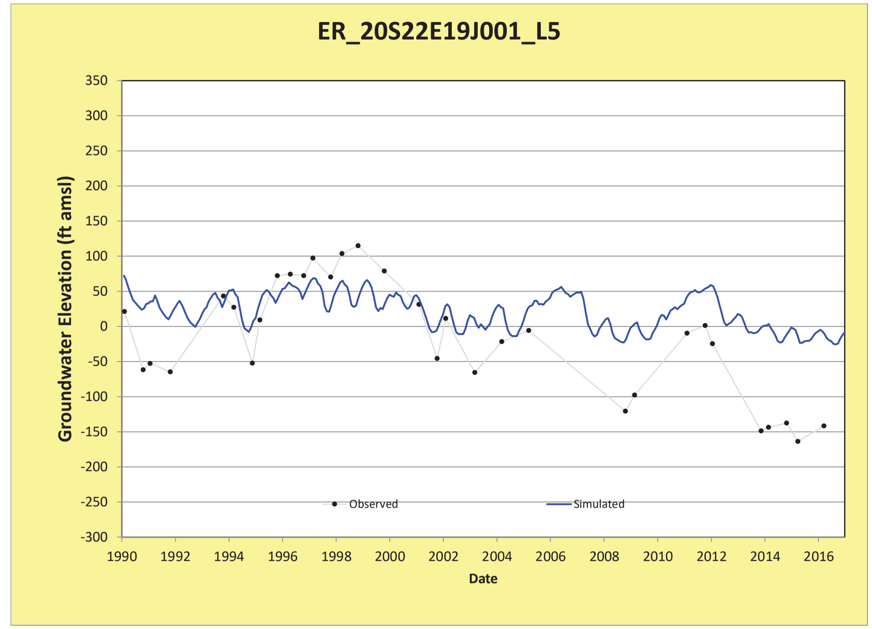
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated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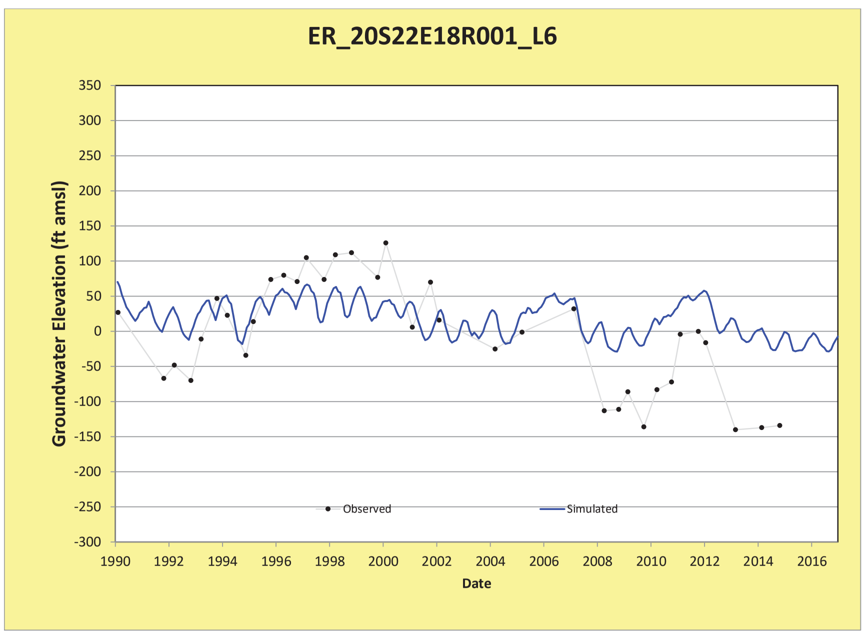
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated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Groundwater Elevation (ft amsl)
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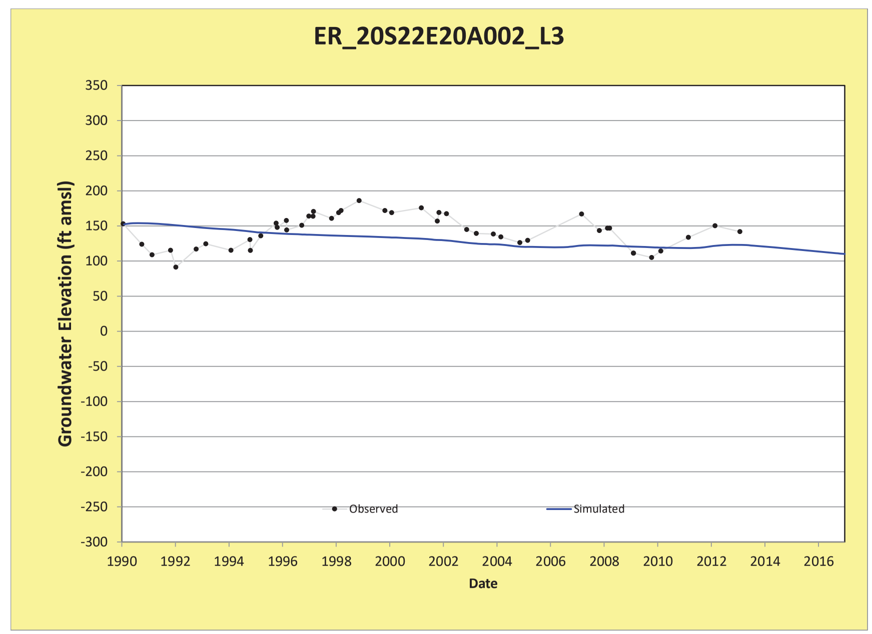
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


ER_20S22E20A002_L3
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
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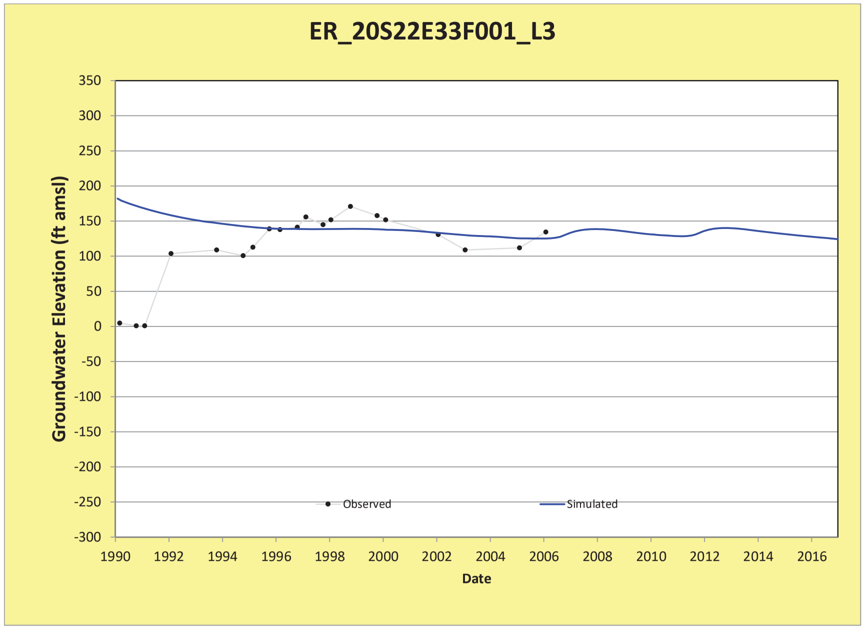
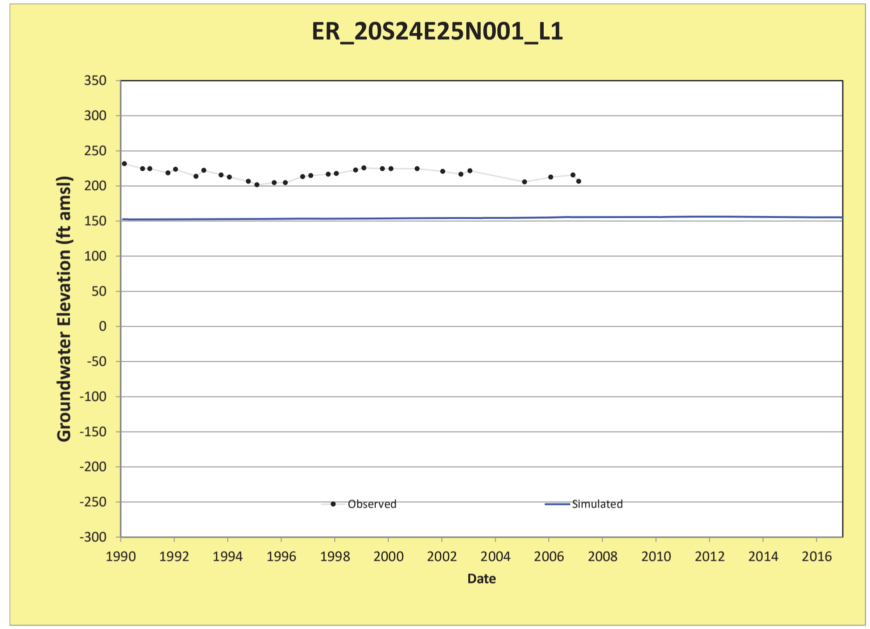
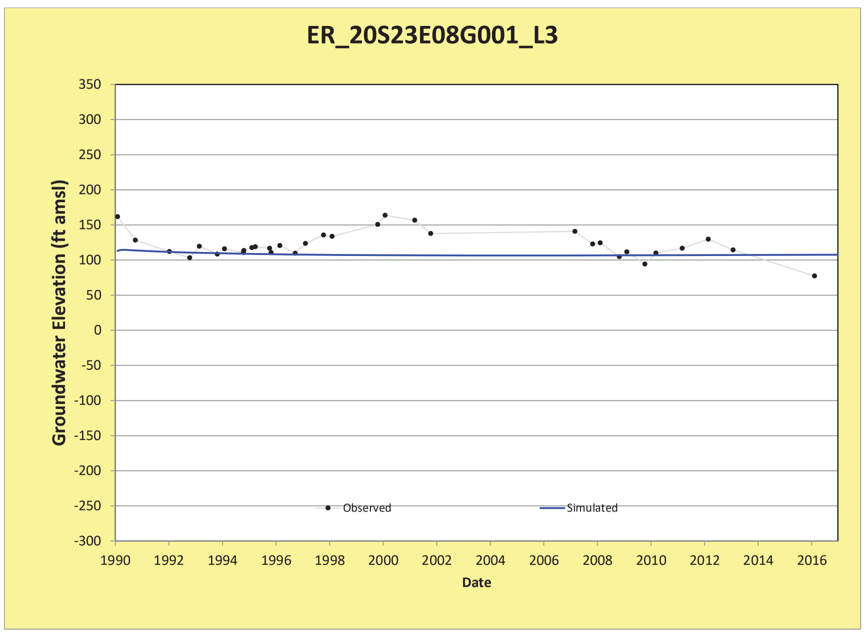
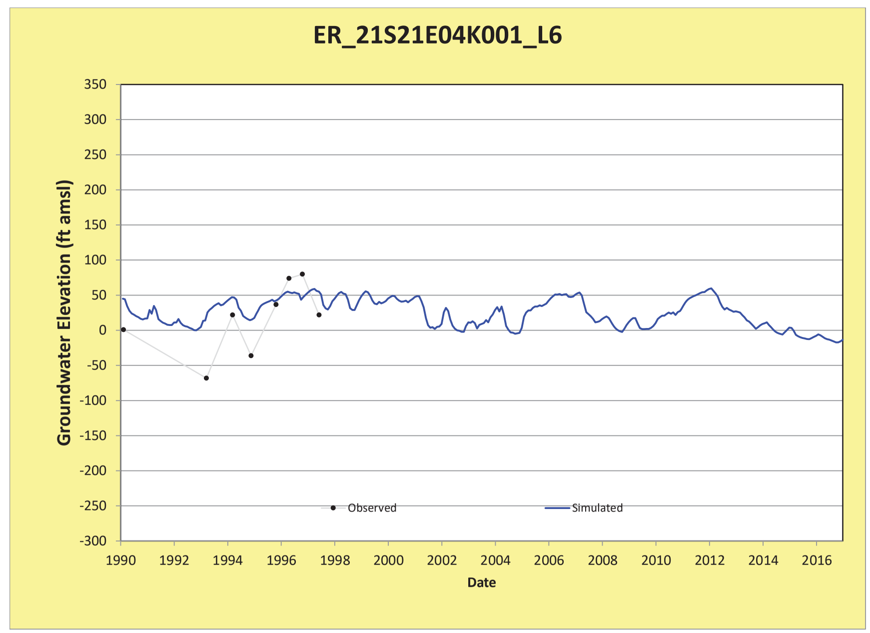
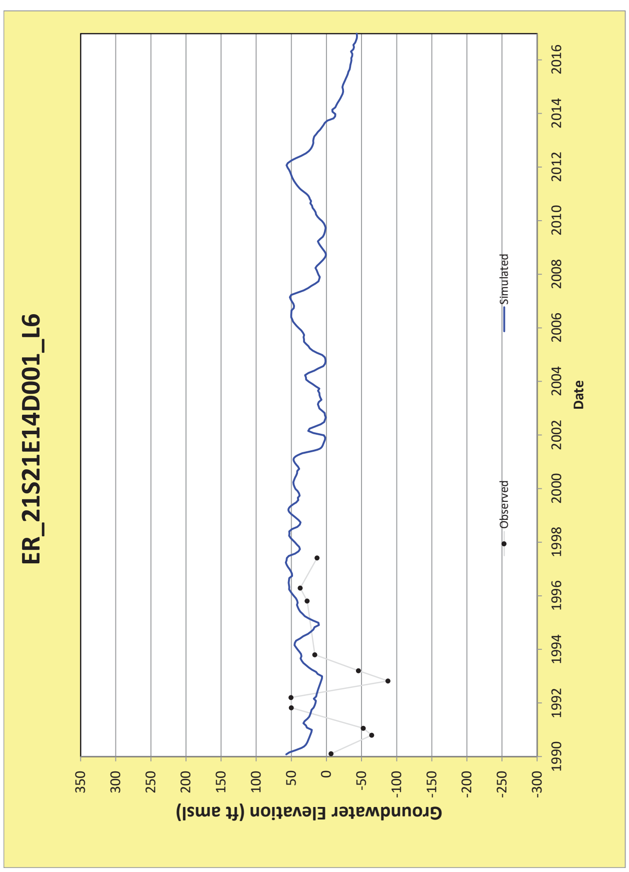
2010
2012
2014
2016
Date
Observed
Simulated


ER_20S22E33F001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_20S24E25N001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_20S23E08G001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_21S21E04K001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_21S21E14D001_L6
Groundwater Elevation (ft amsl)
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300
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200
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0
-50
-100
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-200
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-300
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1994
1996
1998
2000
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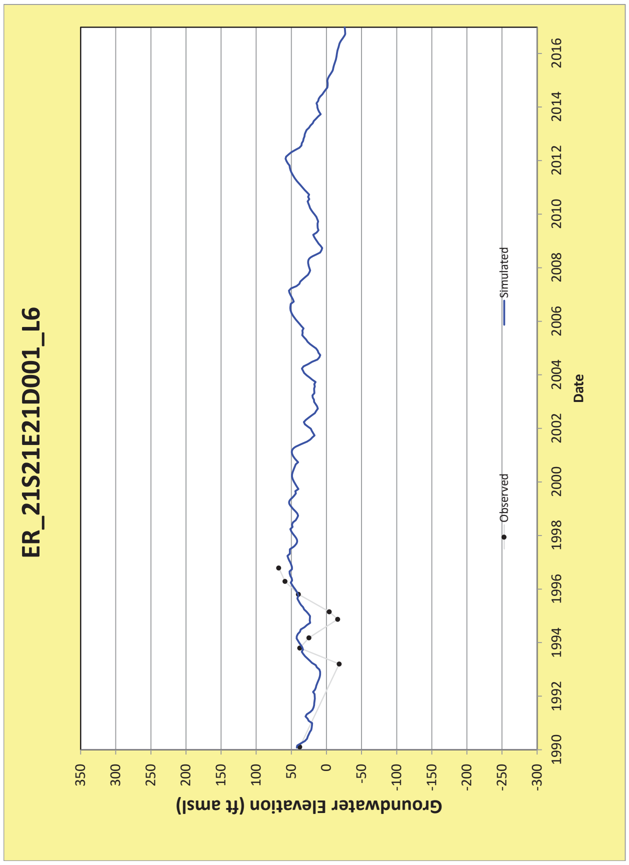
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


ER_21S21E21D001_L6
Groundwater Elevation (ft amsl)
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-50
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-200
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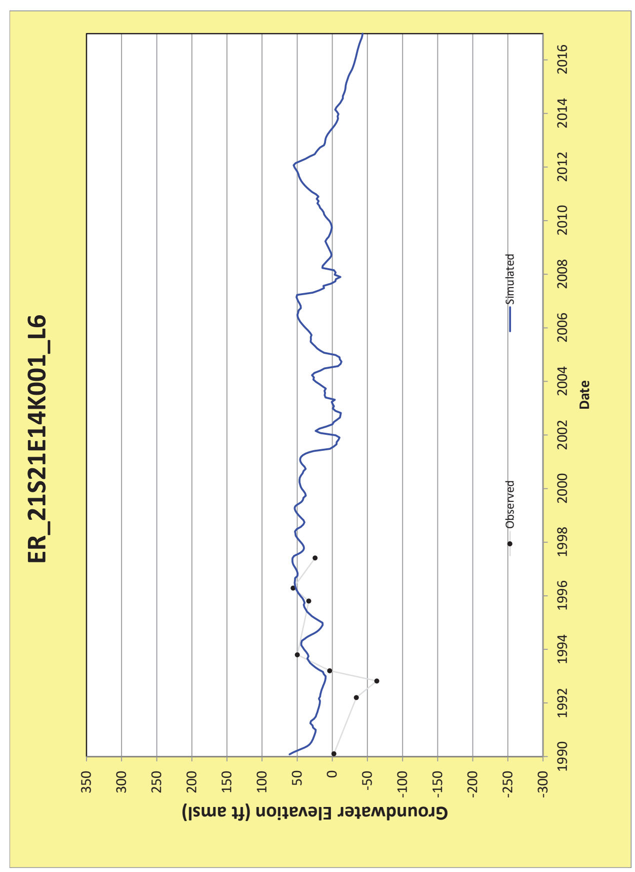
Date
Observed
Simulated


ER_21S21E14K001_L6
Groundwater Elevation (ft amsl)
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-200
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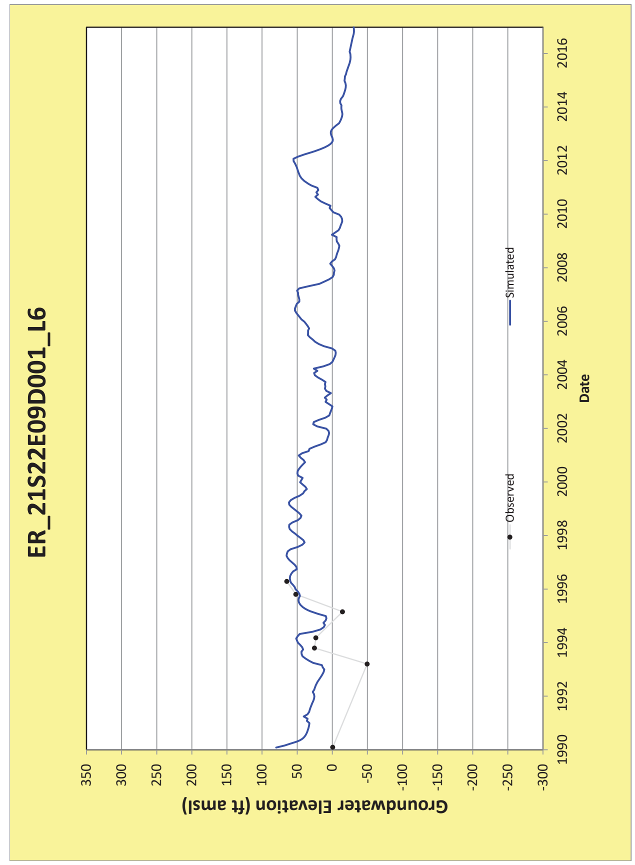
Date
Observed
Simulated


ER_21S22E09D001_L6
Groundwater Elevation (ft amsl)
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-200
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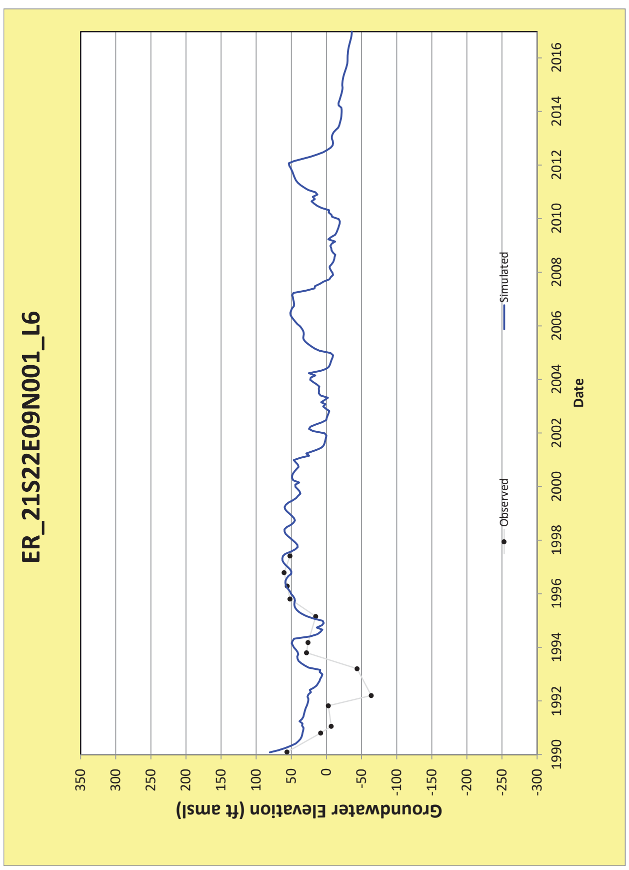
Date
Observed
Simulated


ER_21S22E09N001_L6
Groundwater Elevation (ft amsl)
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200
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0
-50
-100
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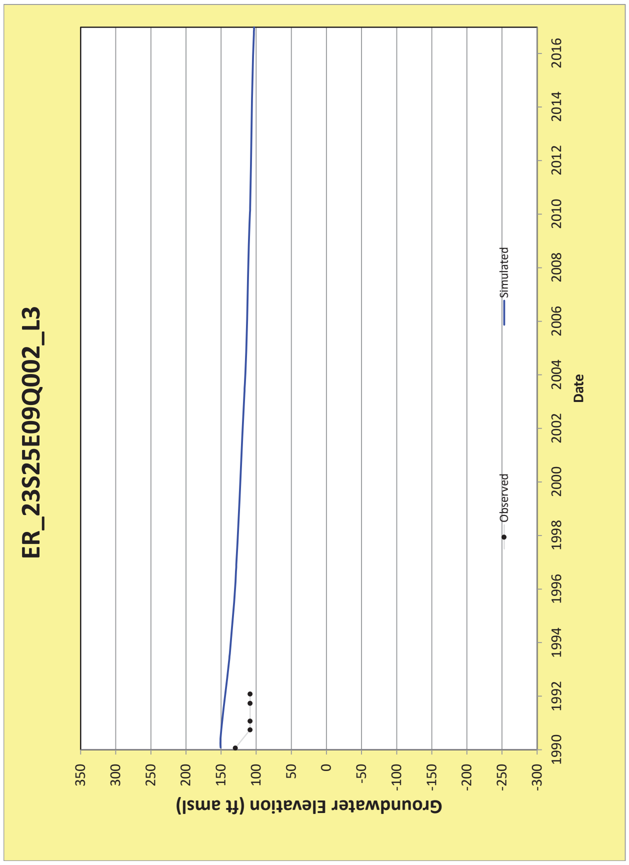
Date
Observed
Simulated


ER_23S25E09Q002_L3
Groundwater Elevation (ft amsl)
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0
-50
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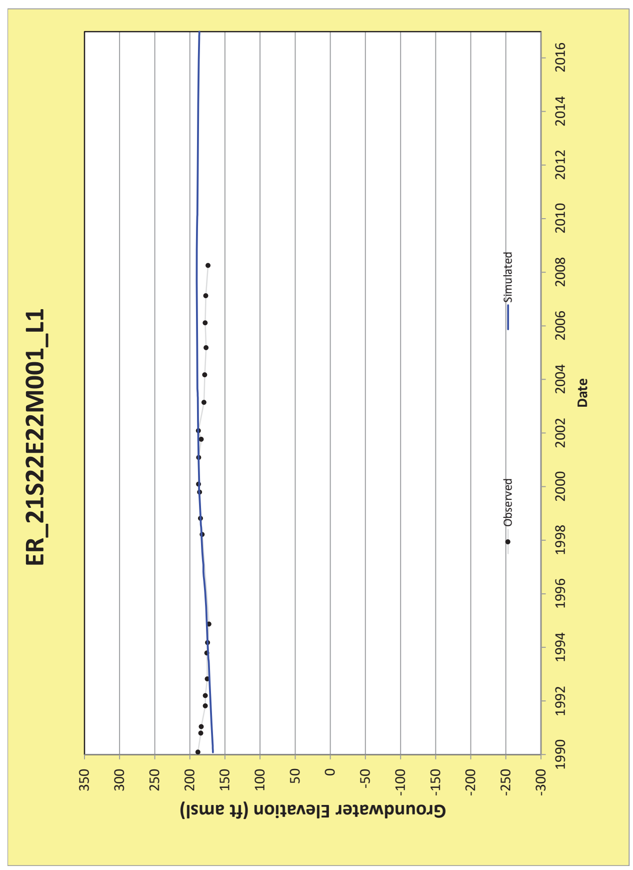
Date
Observed
Simulated


ER_21S22E22M001_L1
Groundwater Elevation (ft amsl)
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200
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100
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0
-50
-100
-150
-200
-250
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1994
1996
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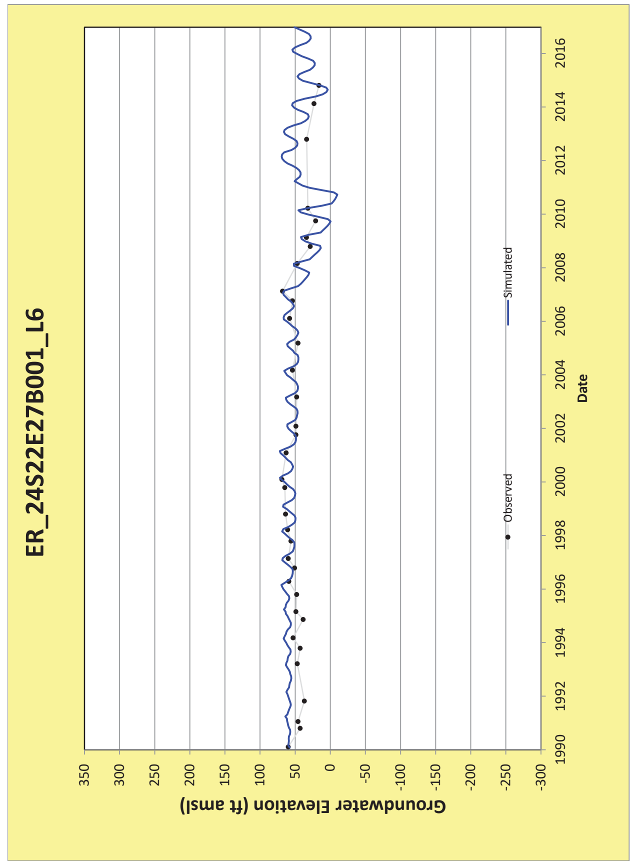
2012
2014
2016
Date
Observed
Simulated


ER_24S22E27B001_L6
Groundwater Elevation (ft amsl)
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-200
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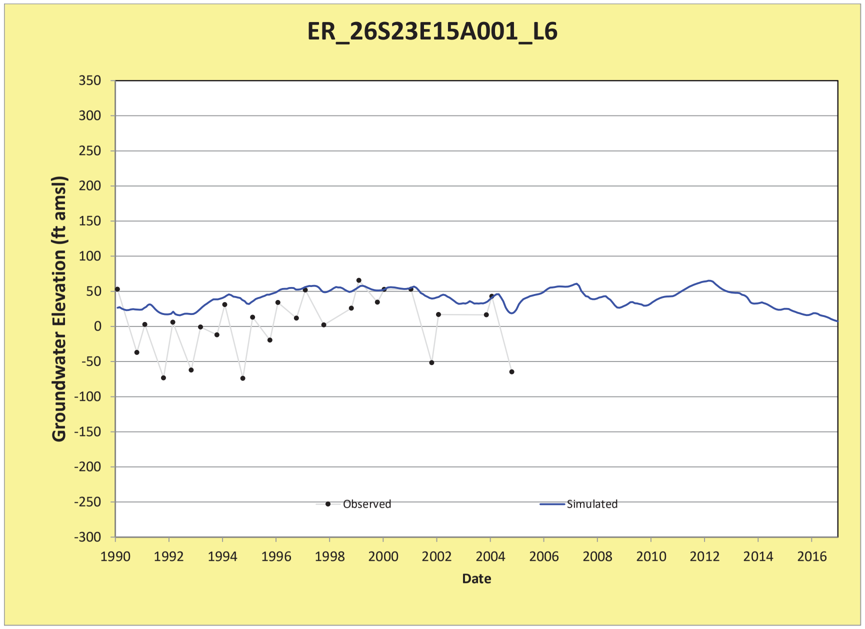
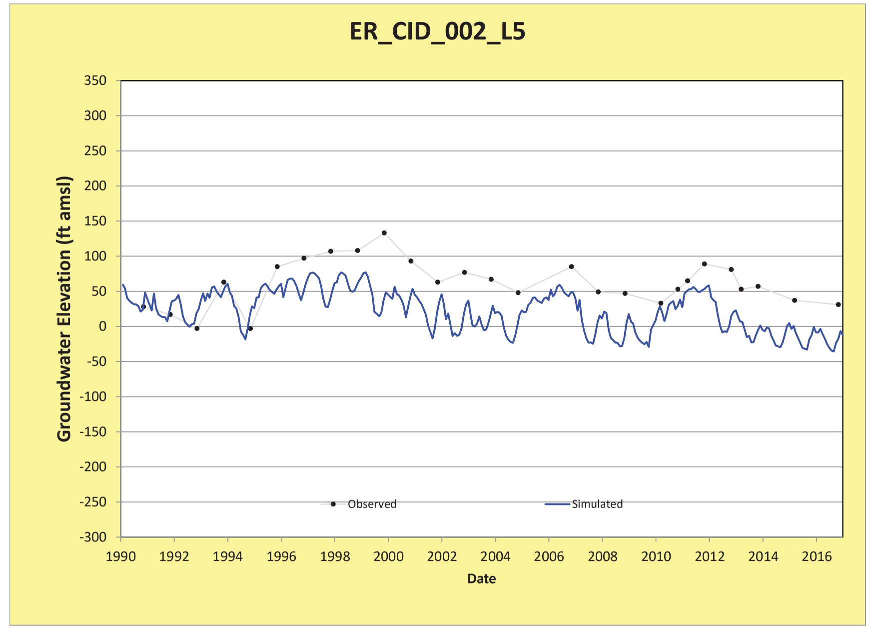
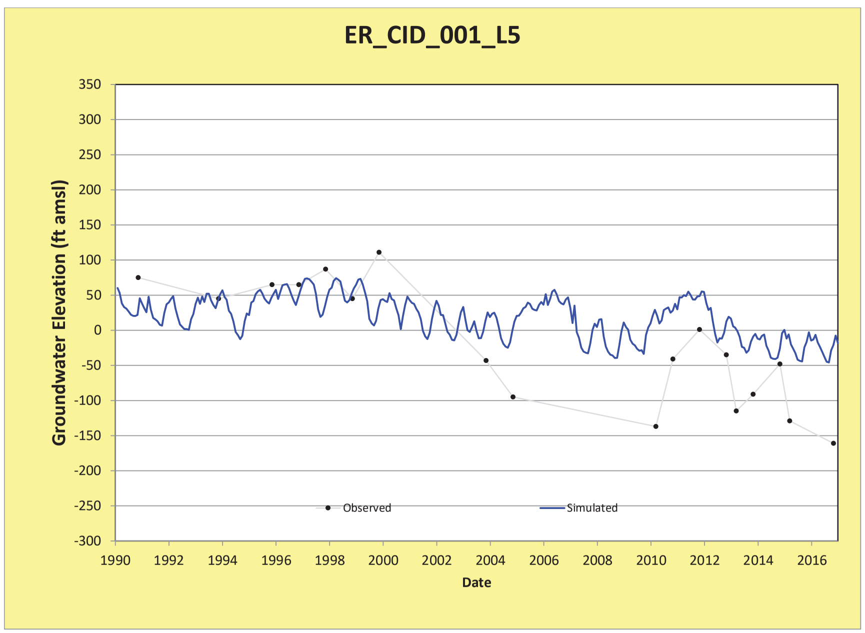
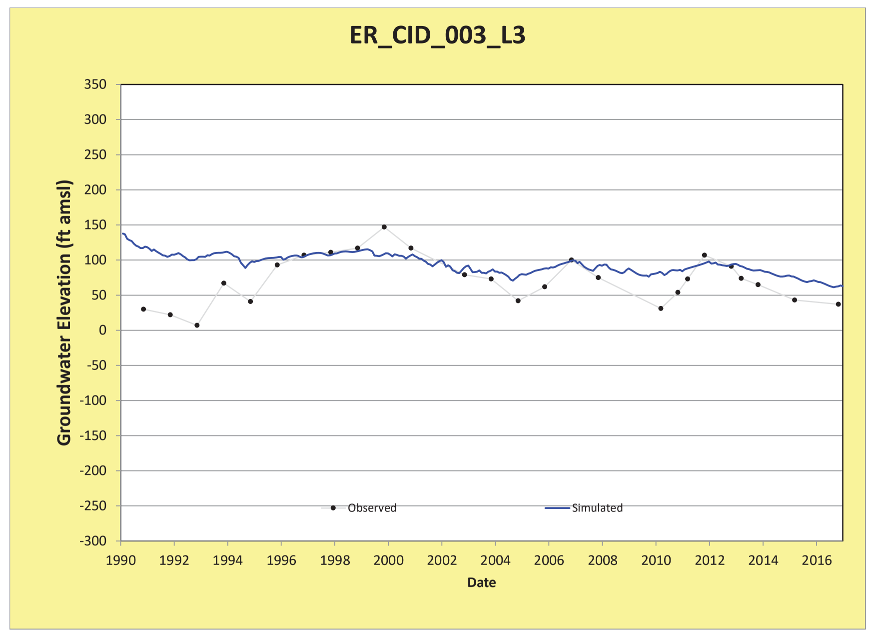
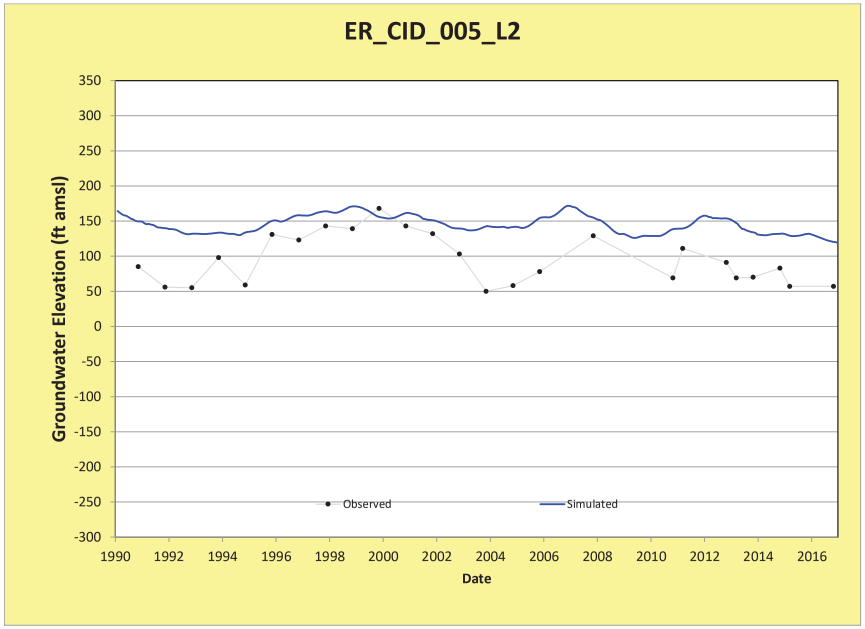
2012
2014
2016
Date
Observed
Simulated

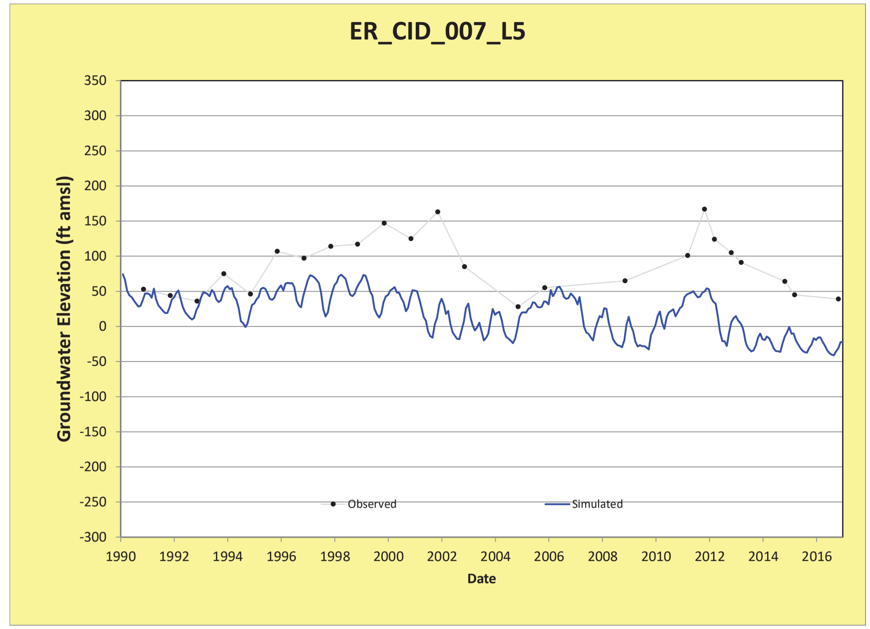

ER_26S23E15A001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

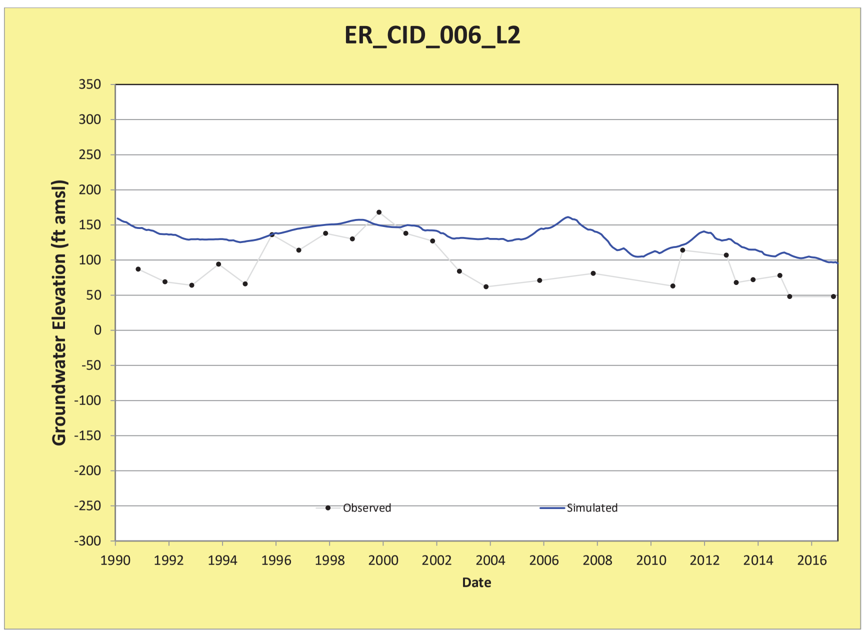

ER_CID_002_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

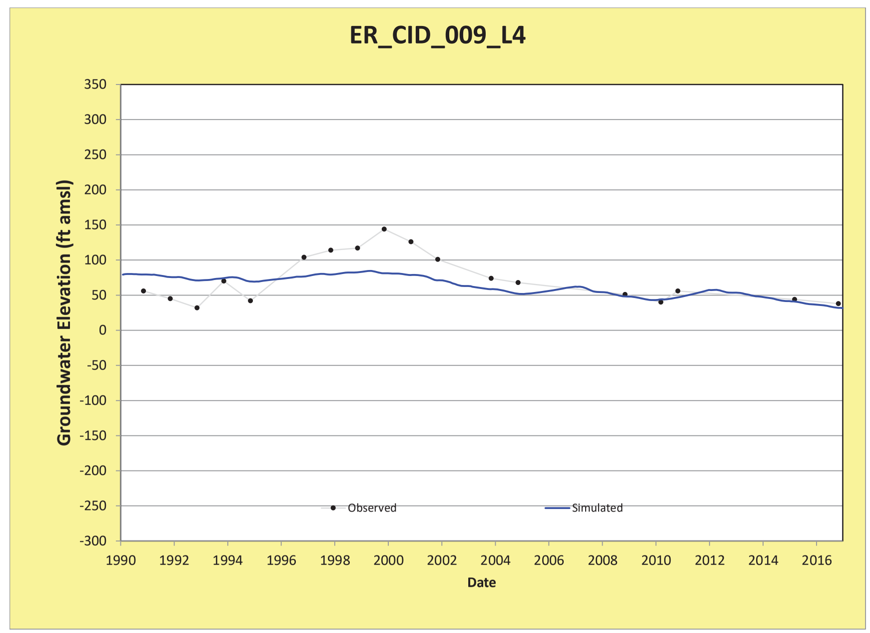

ER_CID_001_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

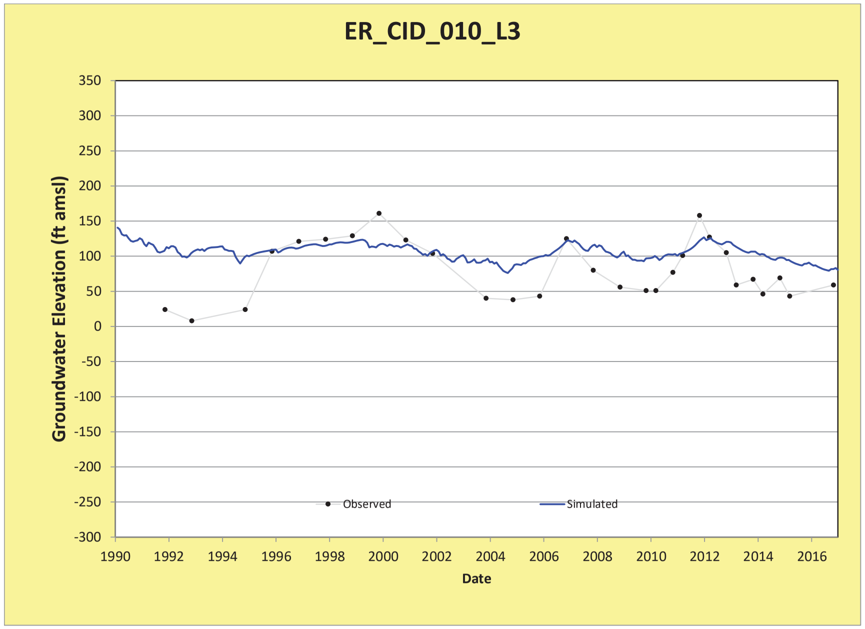

ER_CID_003_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

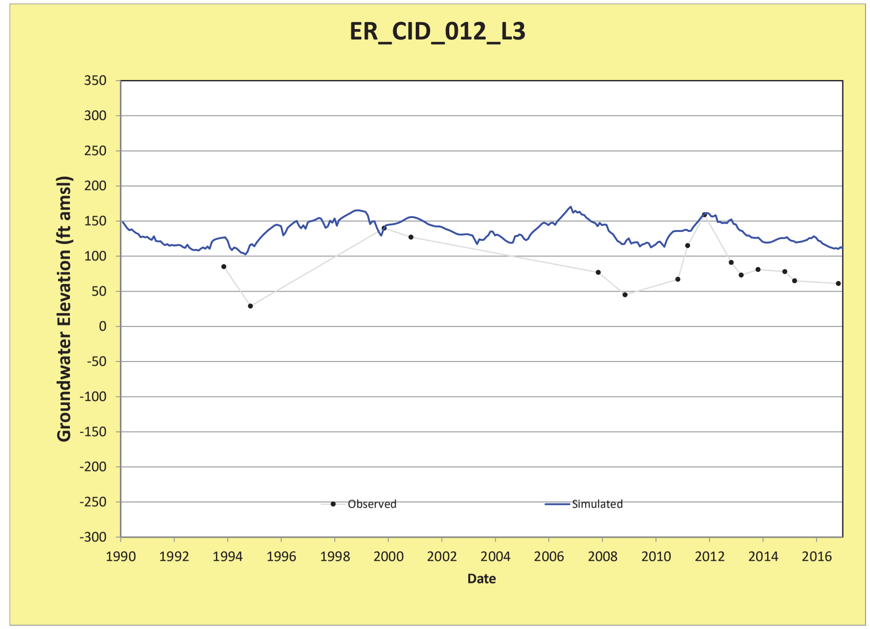

ER_CID_005_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

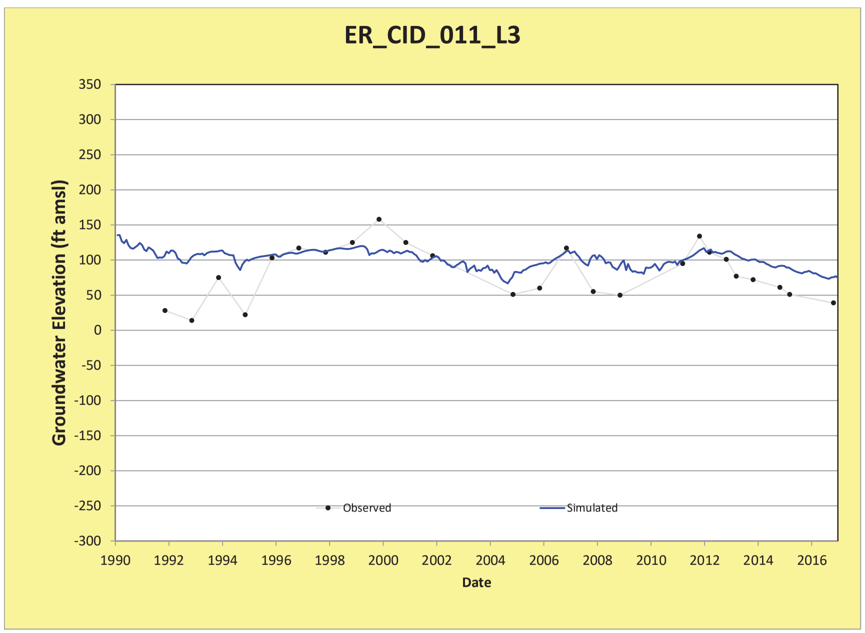

ER_CID_007_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

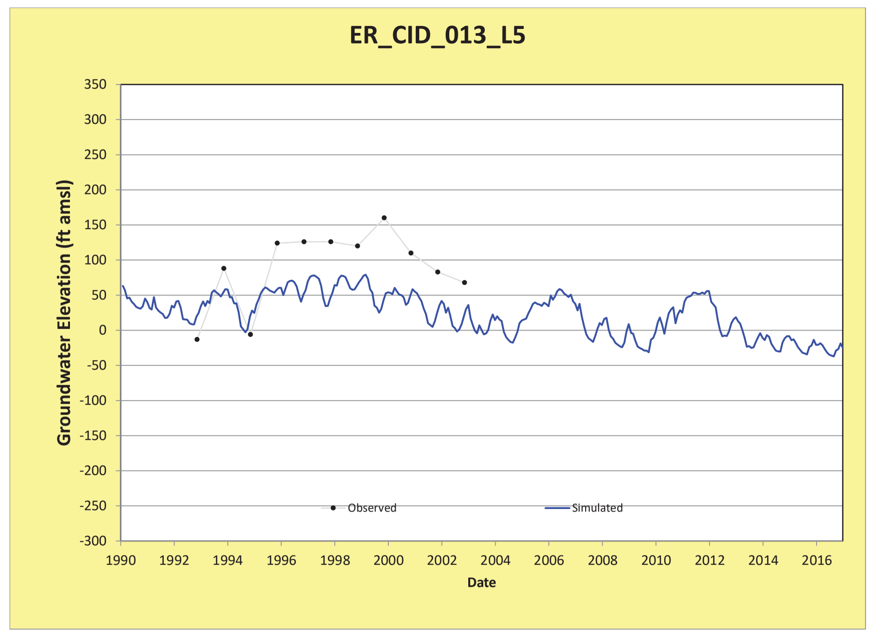

ER_CID_006_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_CID_009_L4
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

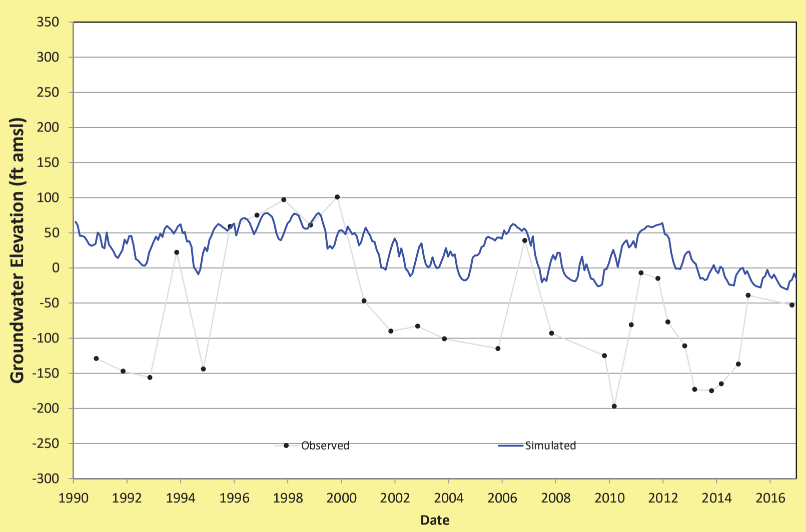

ER_CID_010_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_CID_012_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

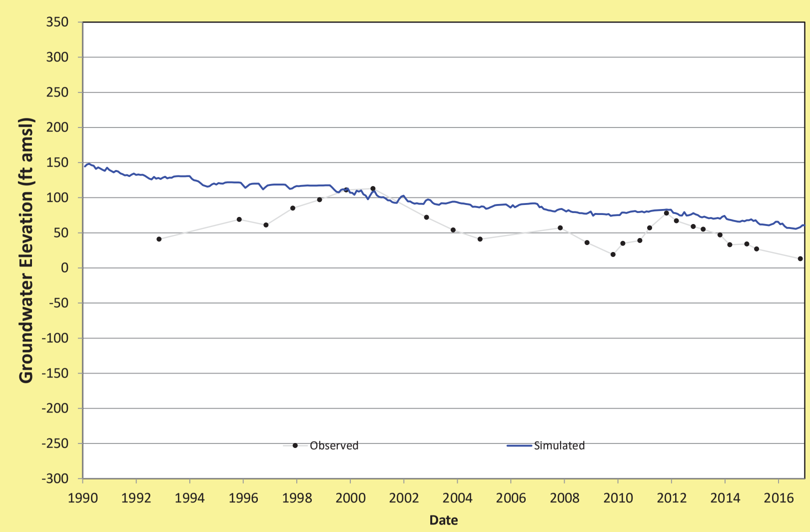

ER_CID_011_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_CID_013_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

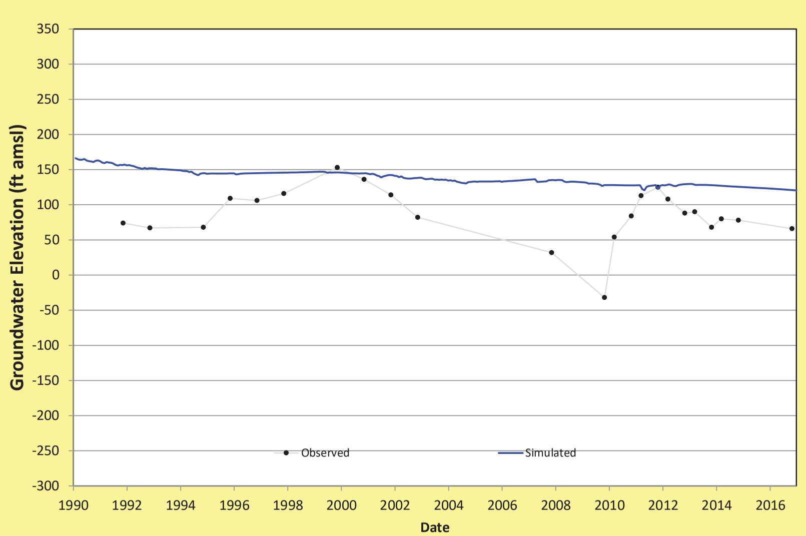
ER_CID_014_L5



ER_CID_017_L3



ER_CID_015_L3



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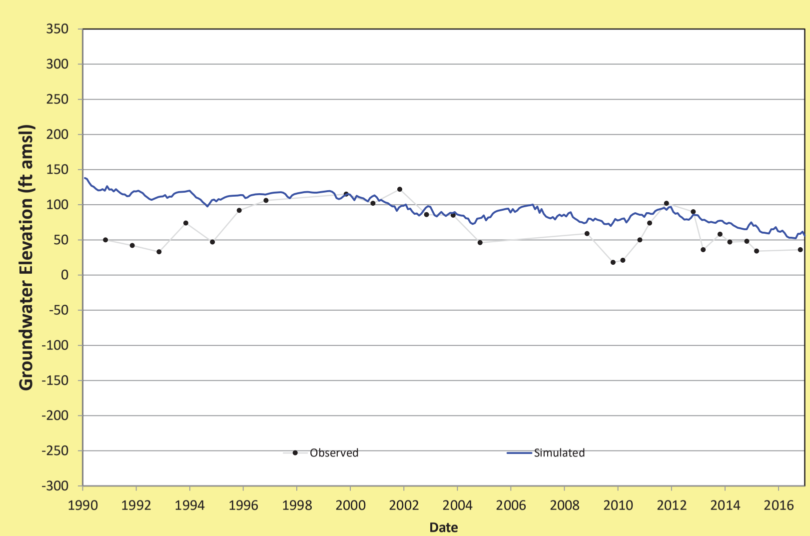
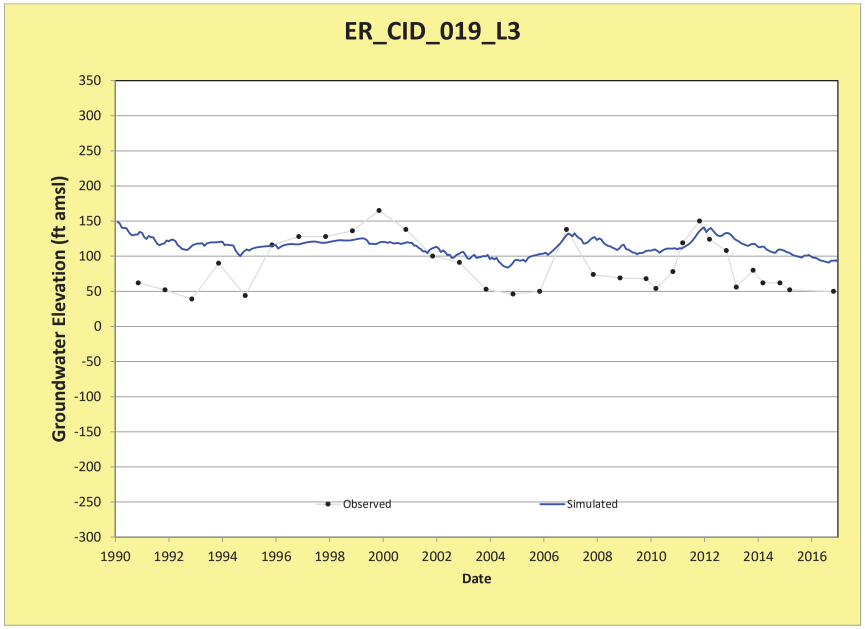
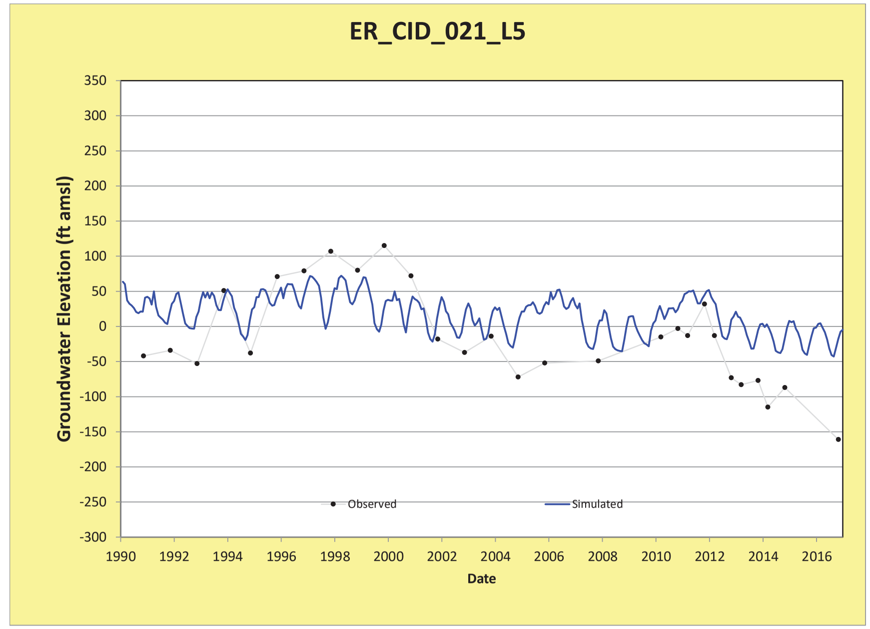
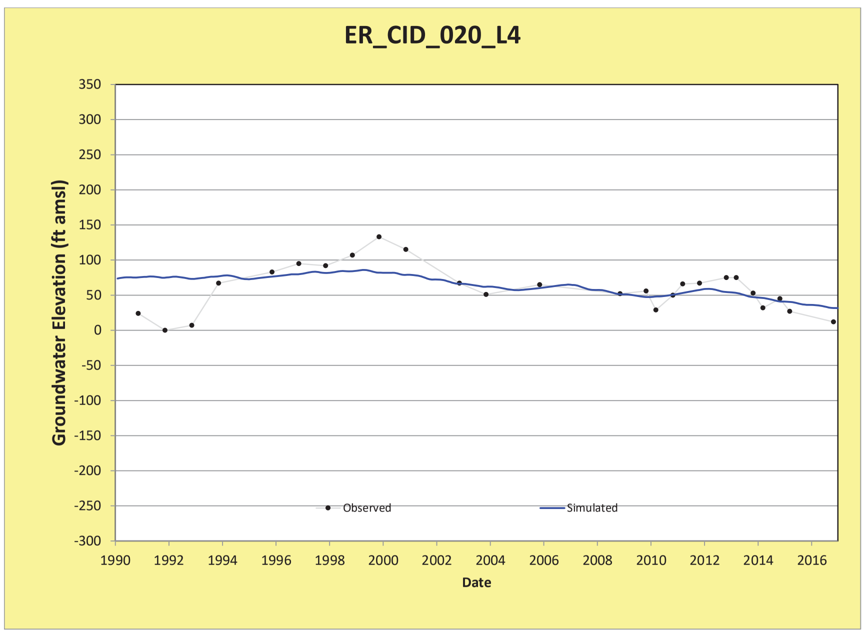
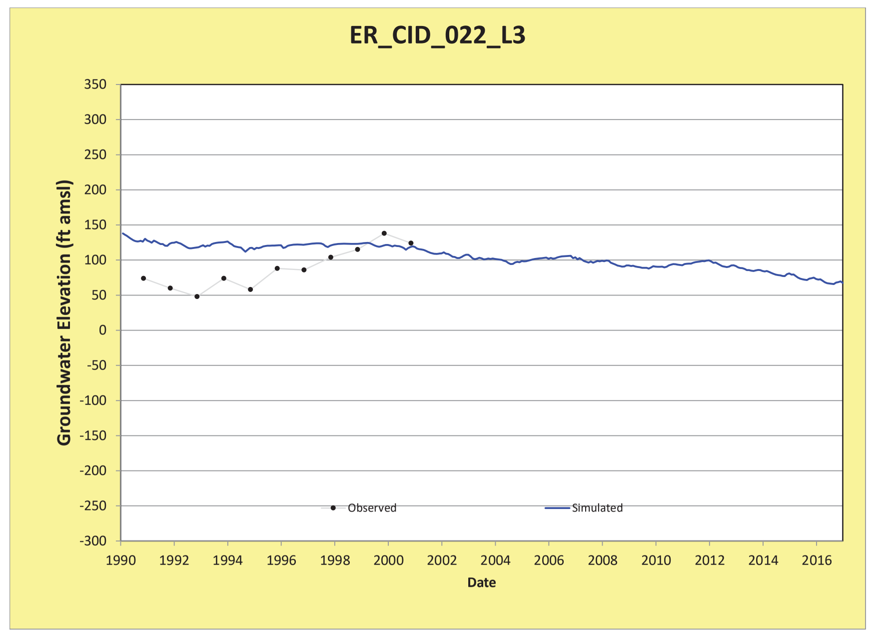
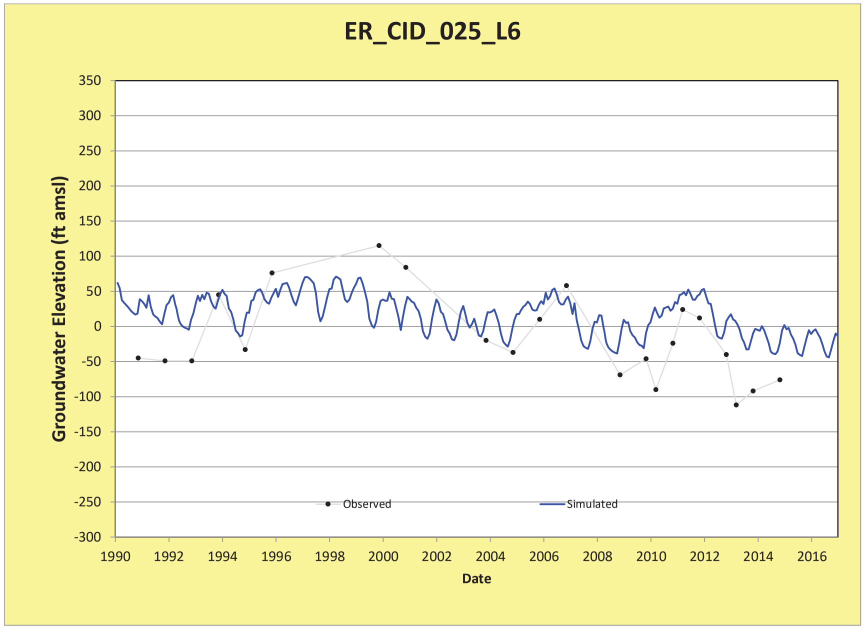



ER_CID_019_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

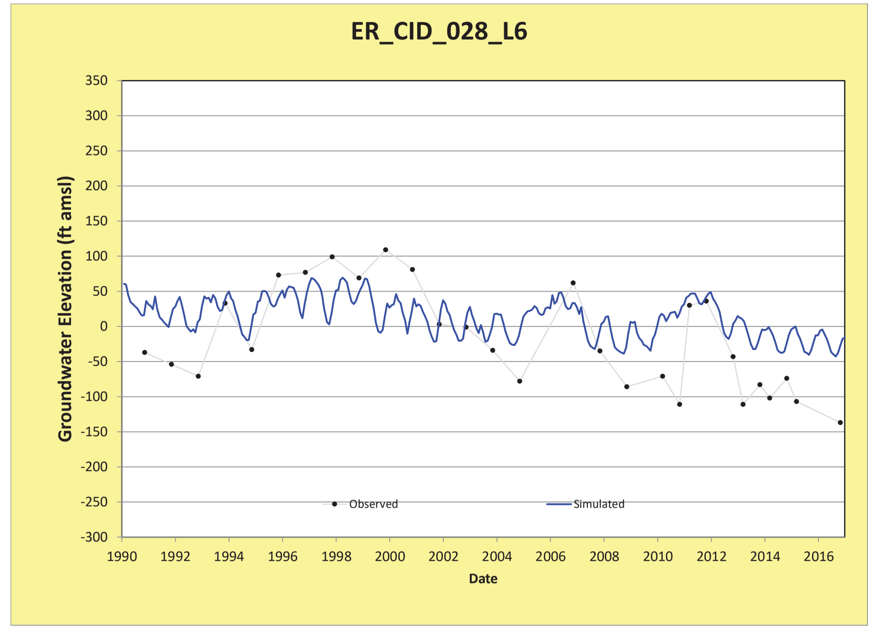

ER_CID_021_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_CID_020_L4
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

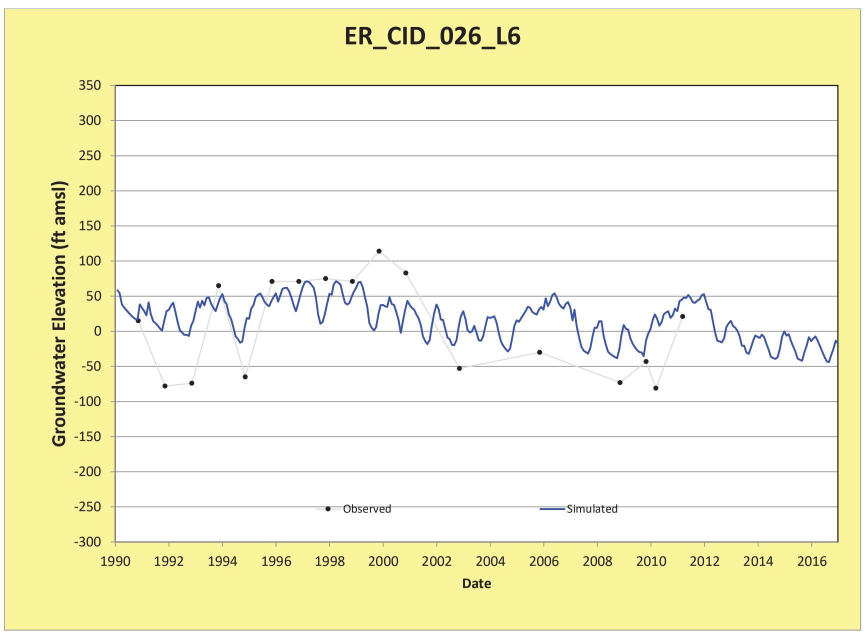

ER_CID_022_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



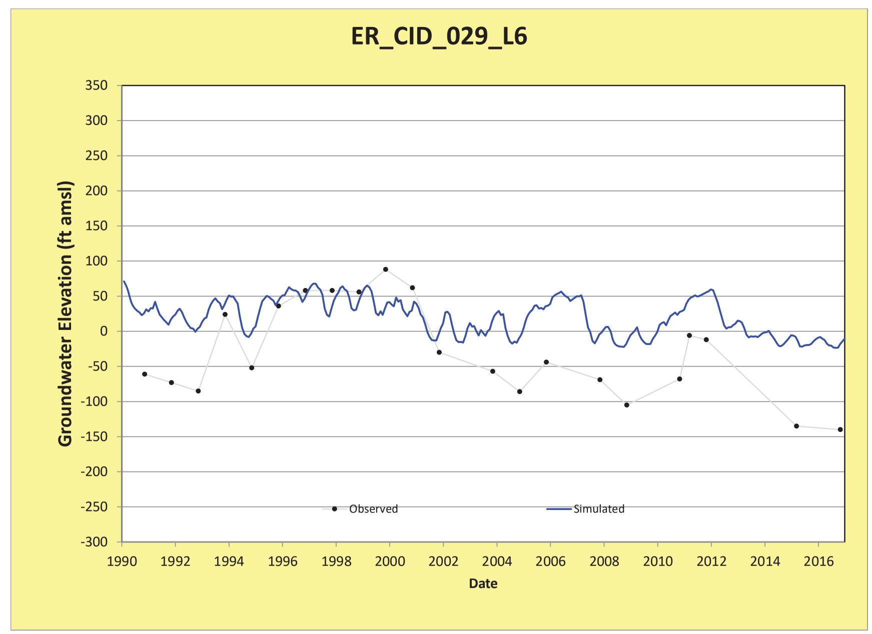
ER_CID_025_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



ER_CID_028_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

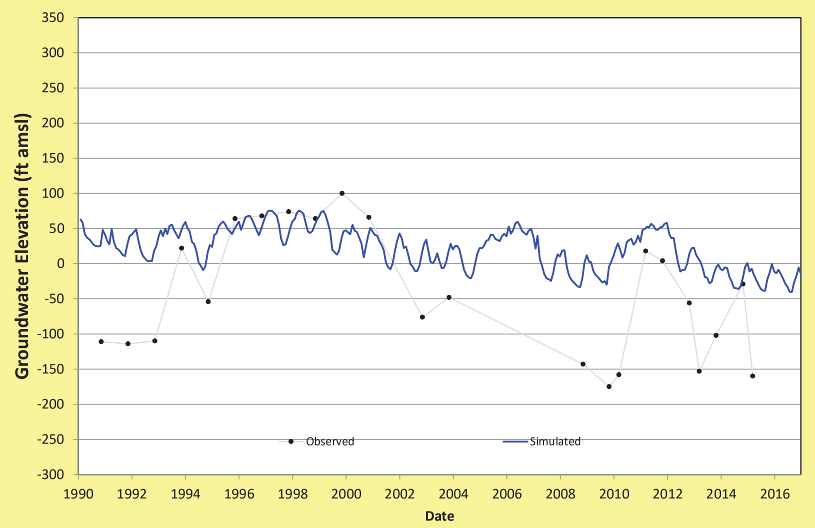


ER_CID_026_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



ER_CID_029_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

ER_CID_031_L5



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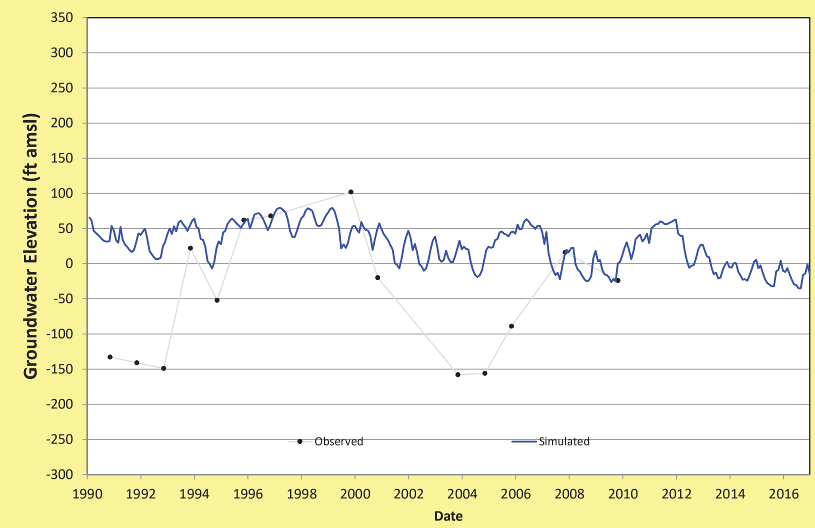

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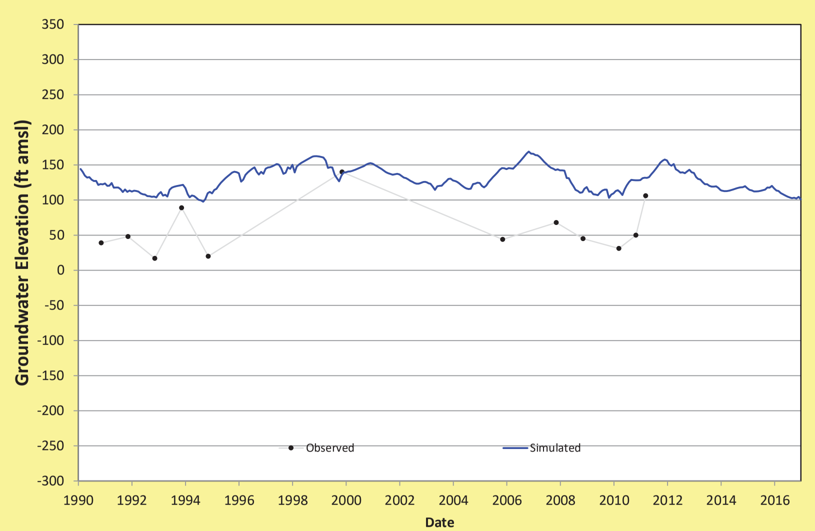

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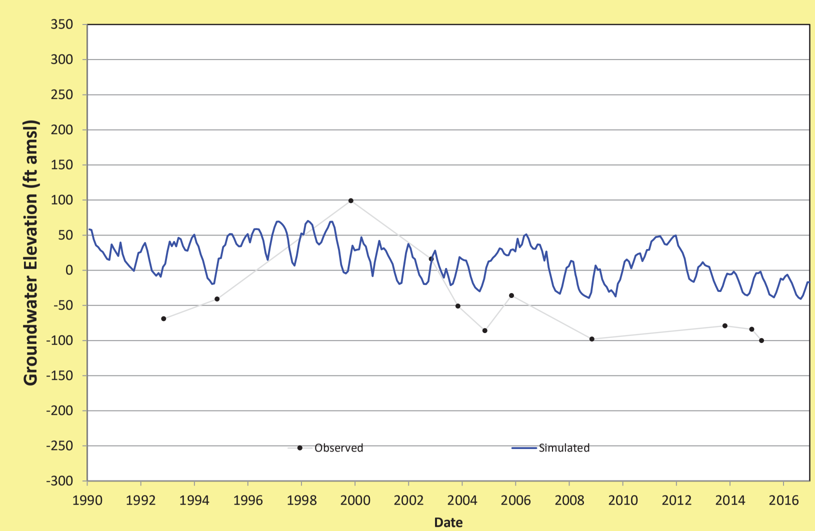
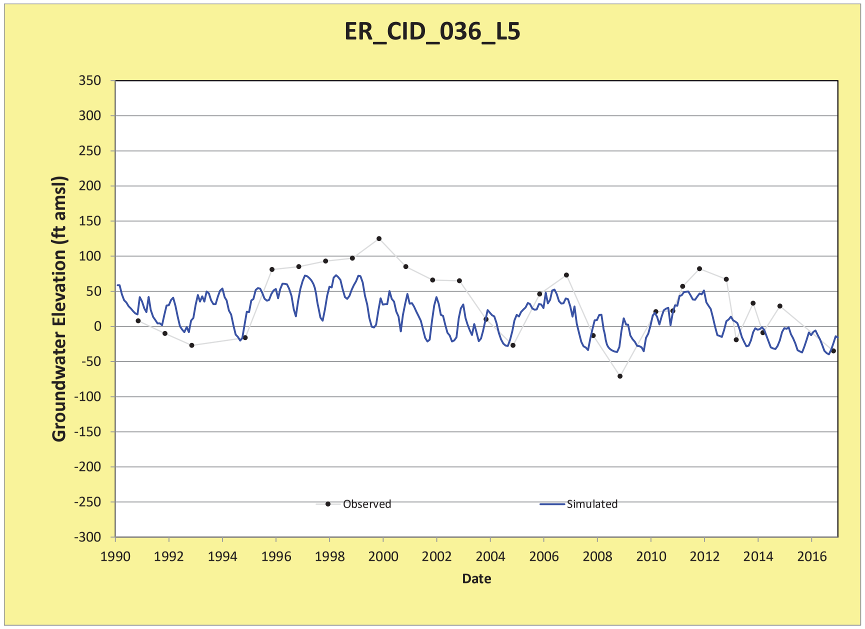
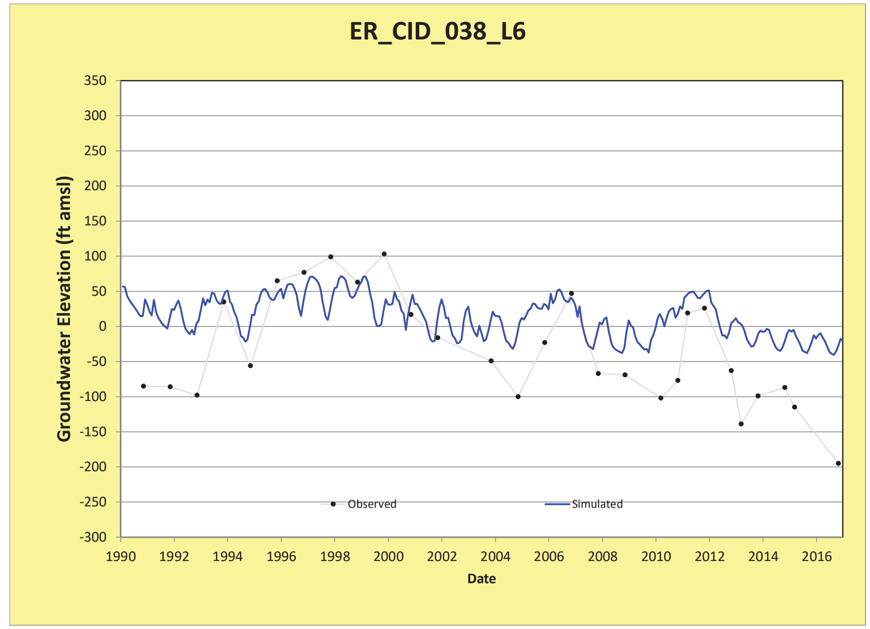
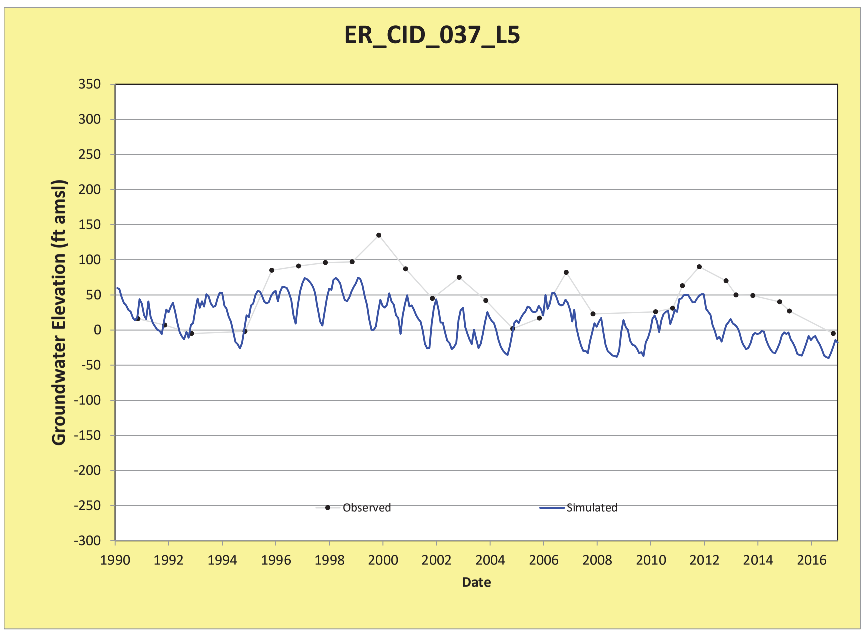
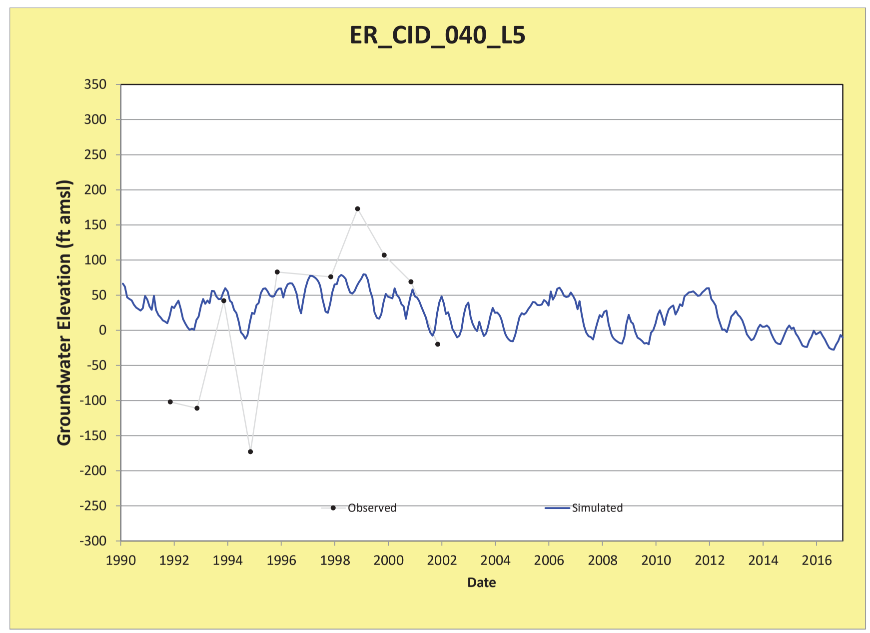
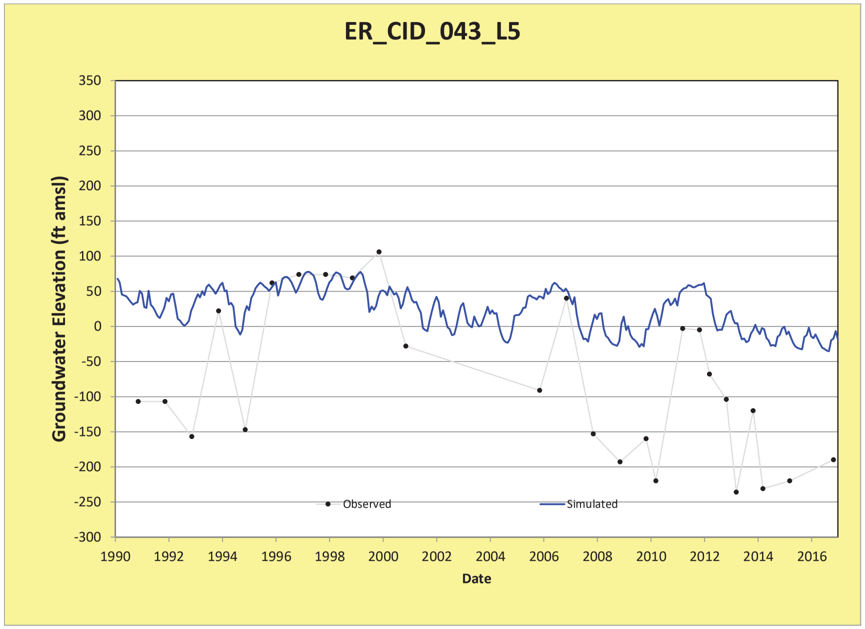


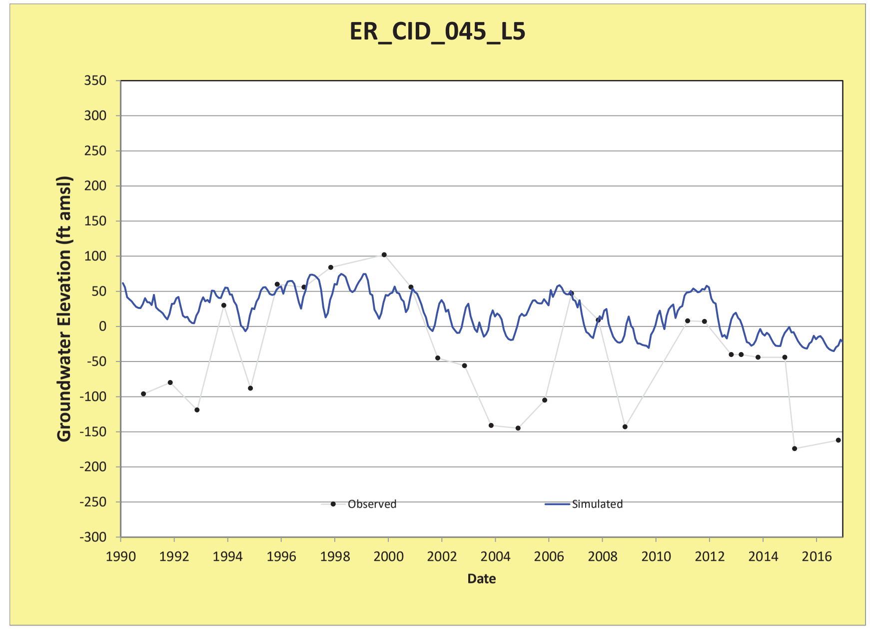

ER_CID_036_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

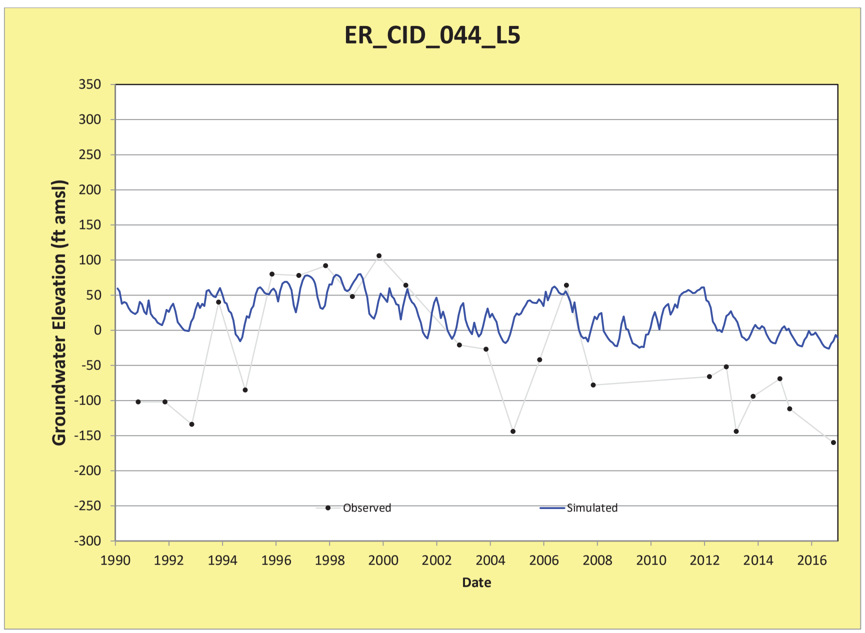

ER_CID_038_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

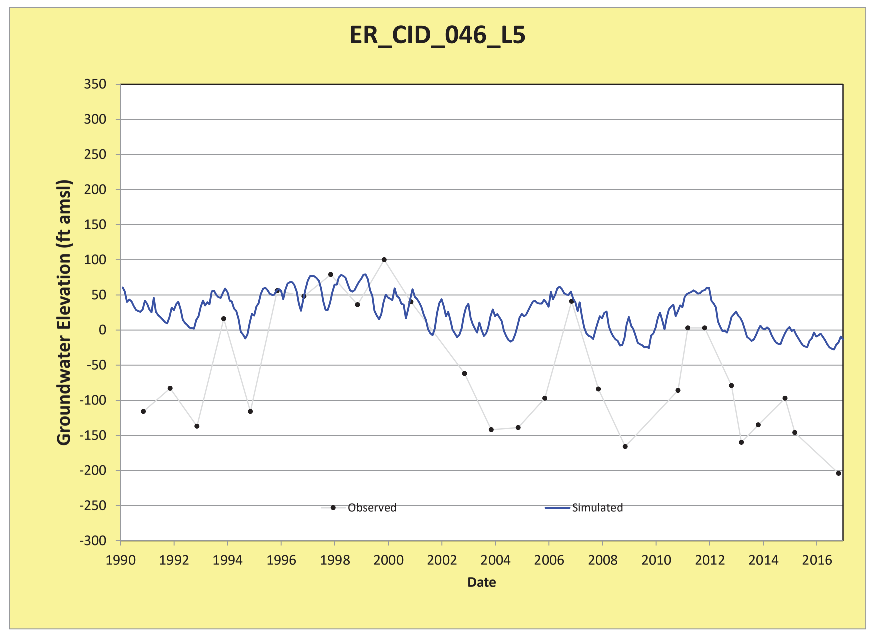

ER_CID_037_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

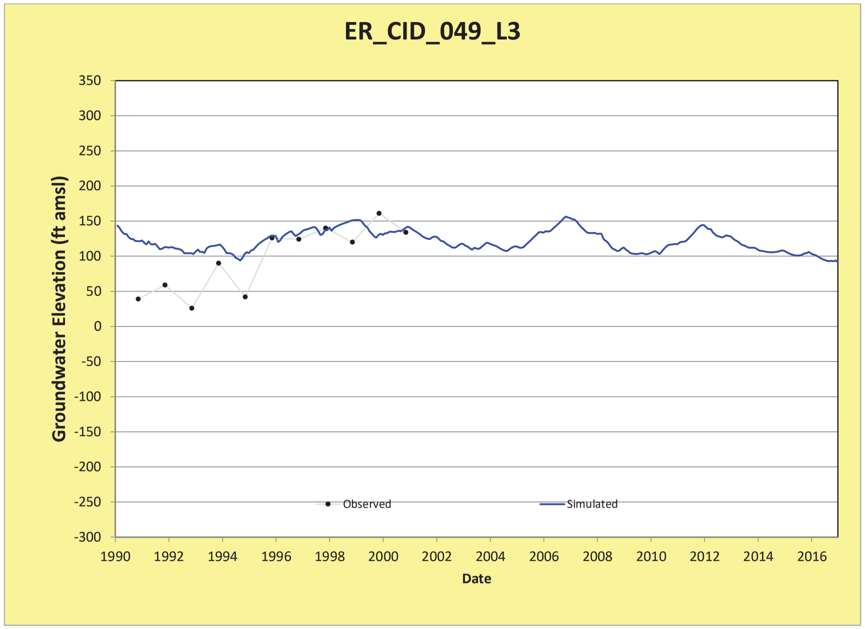

ER_CID_040_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

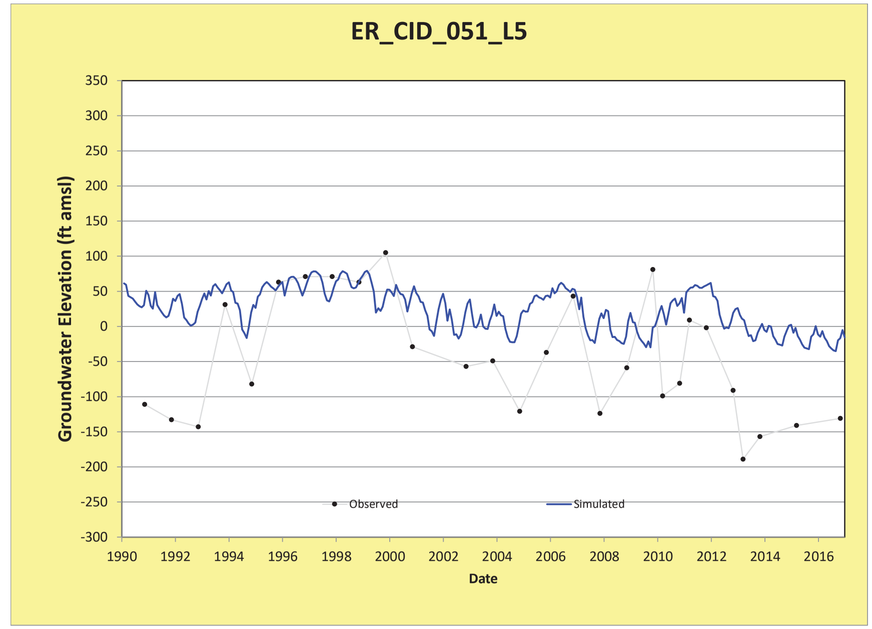

ER_CID_043_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

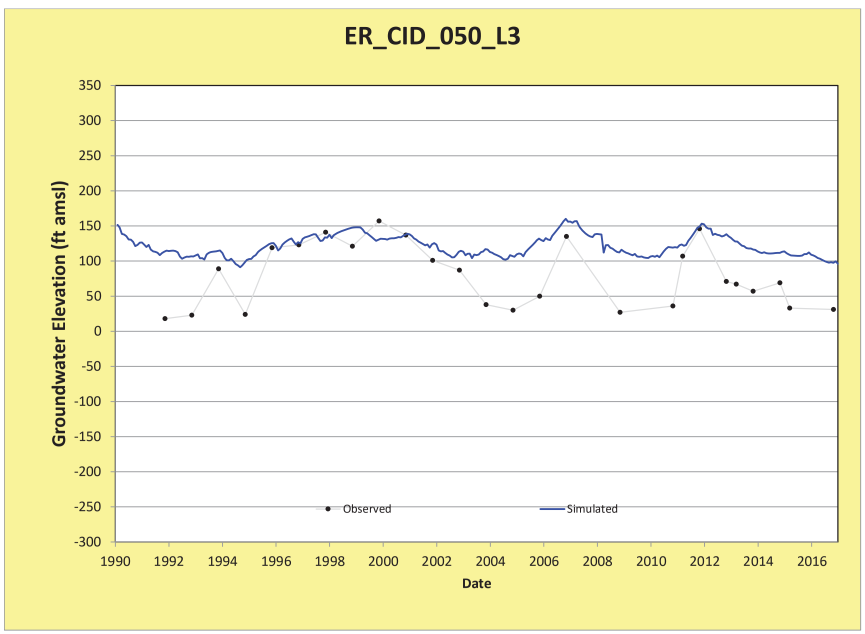

ER_CID_045_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

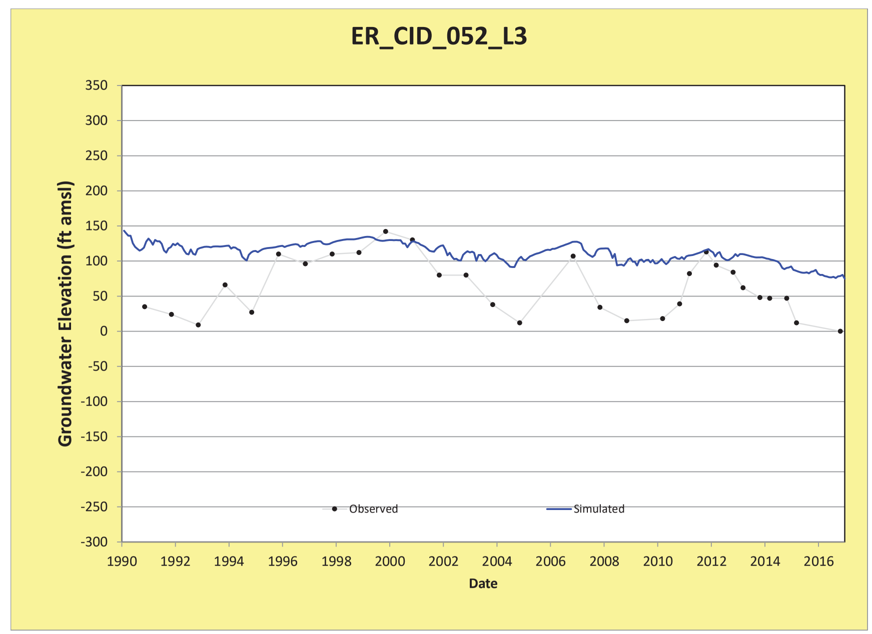

ER_CID_044_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

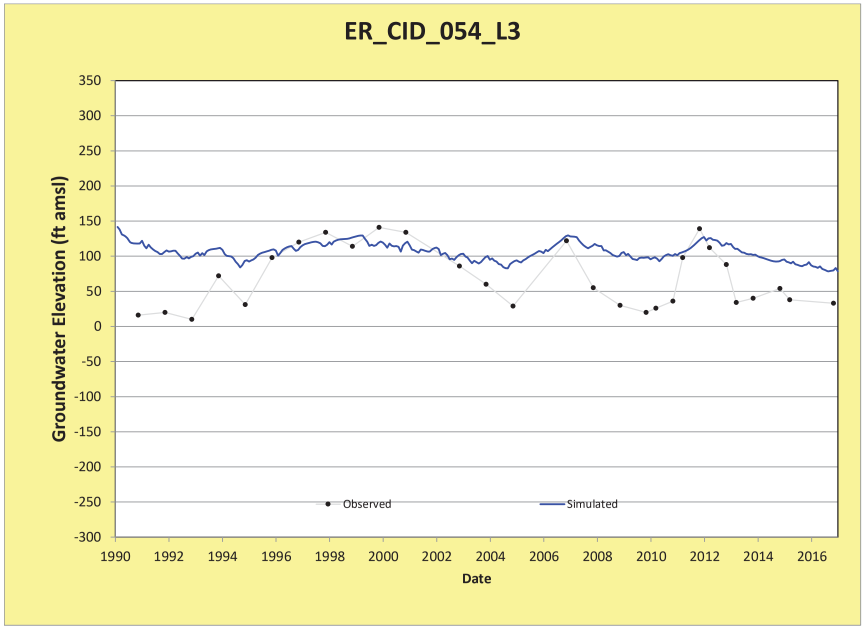

ER_CID_046_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

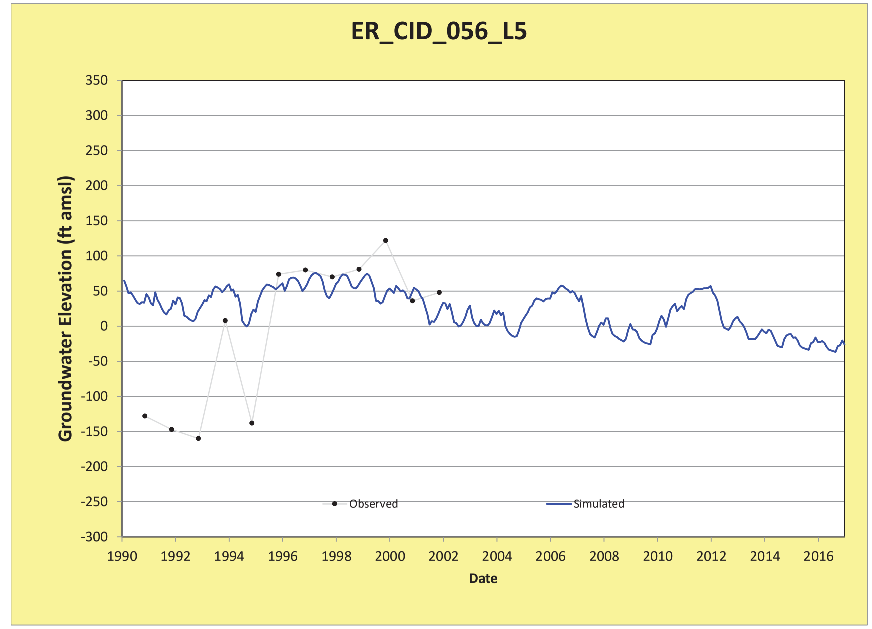

ER_CID_049_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

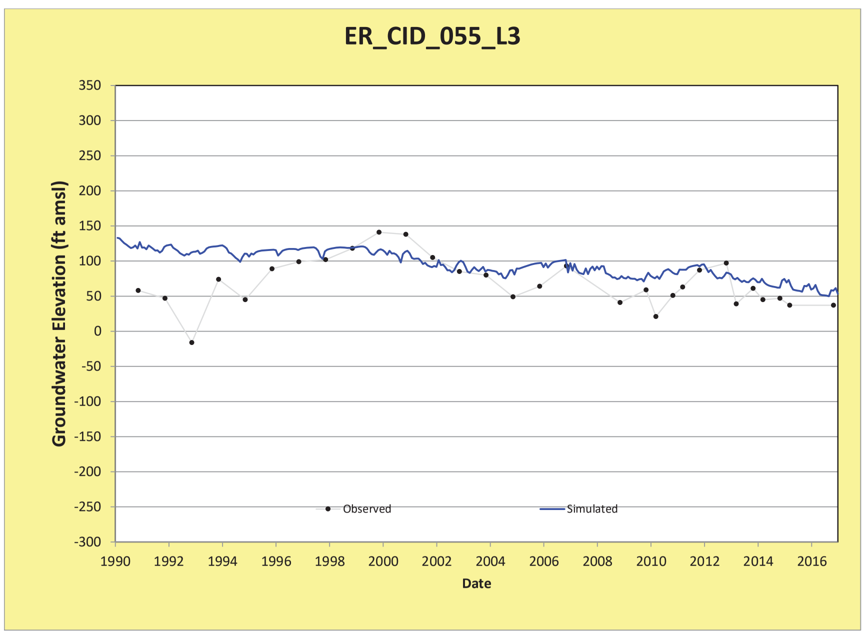

ER_CID_051_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

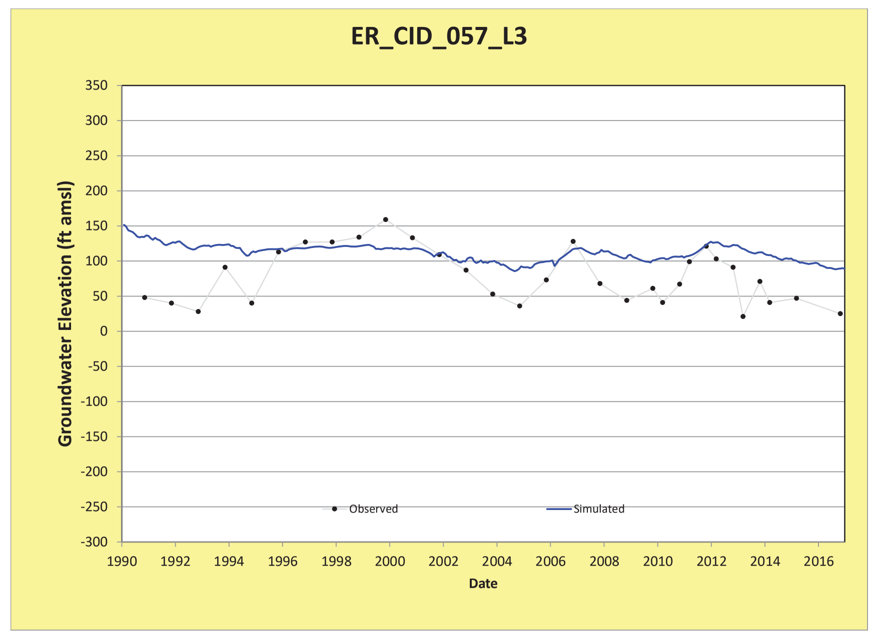

ER_CID_050_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

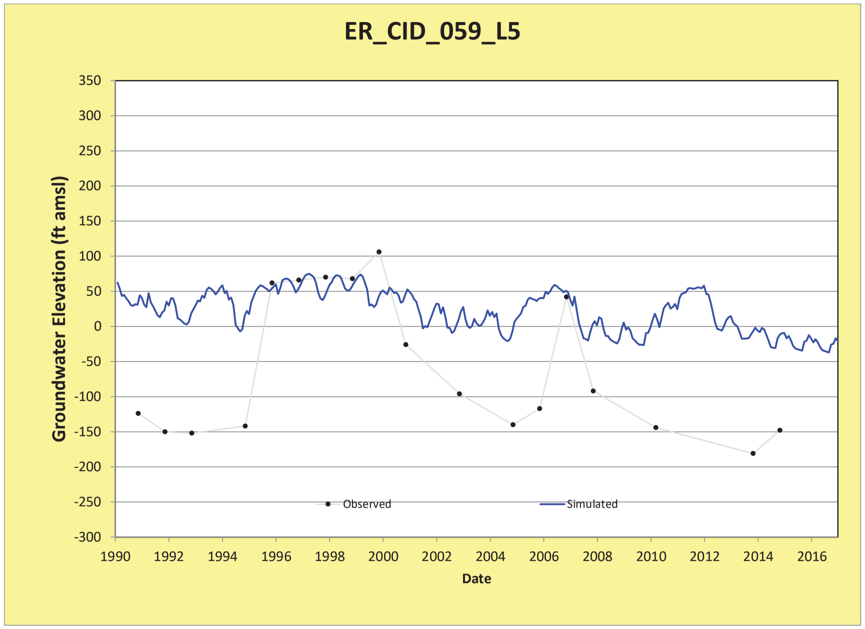

ER_CID_052_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

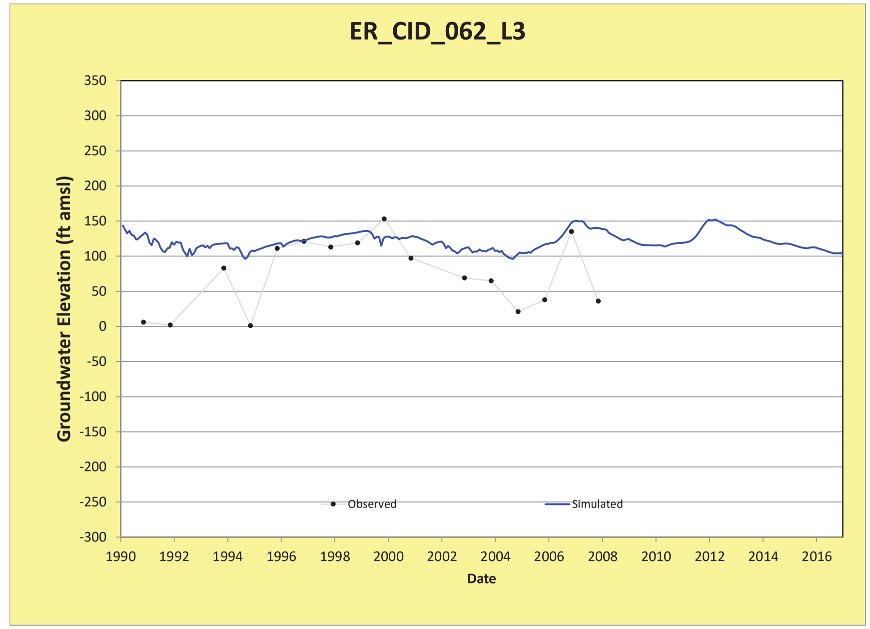

ER_CID_054_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

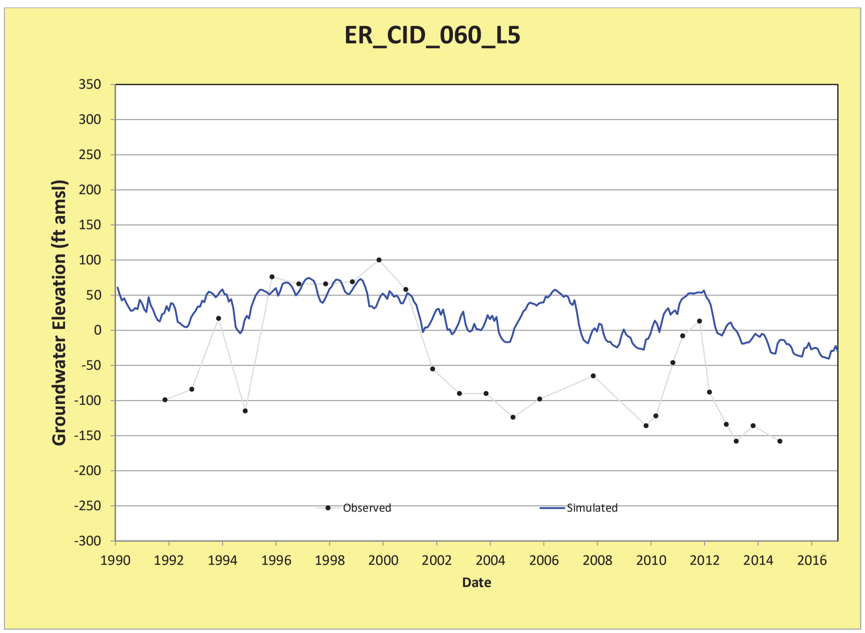

ER_CID_056_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

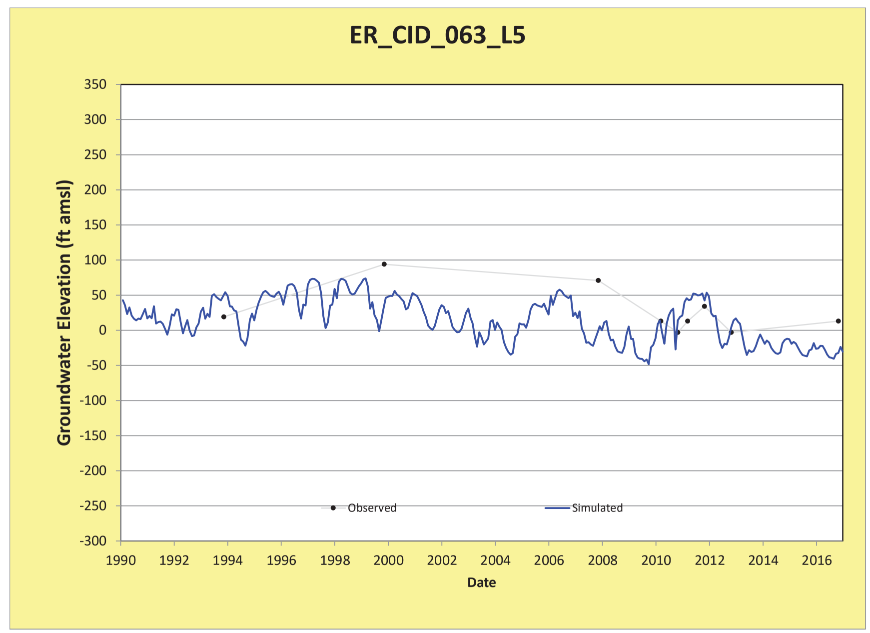

ER_CID_055_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_CID_057_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_CID_059_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_CID_062_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


ER_CID_060_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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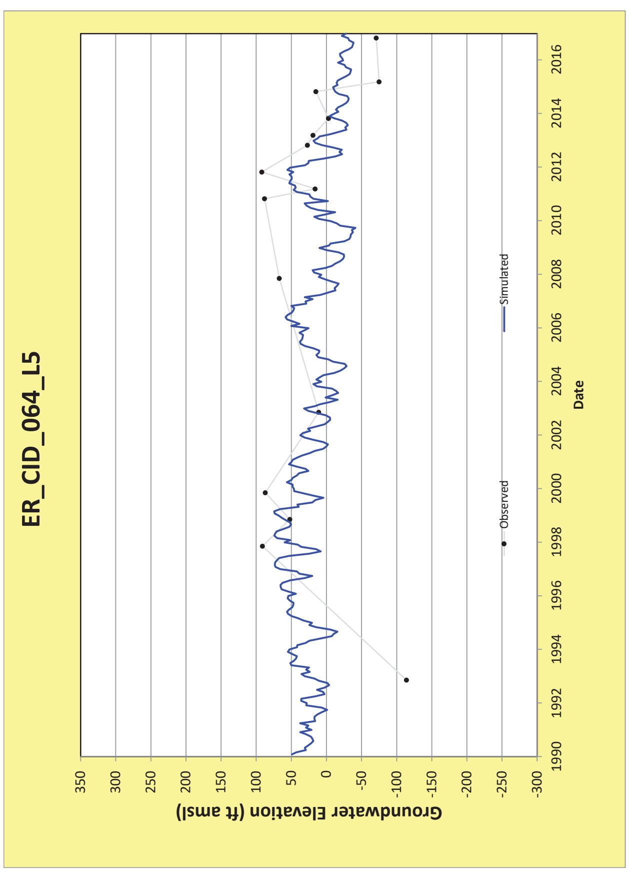
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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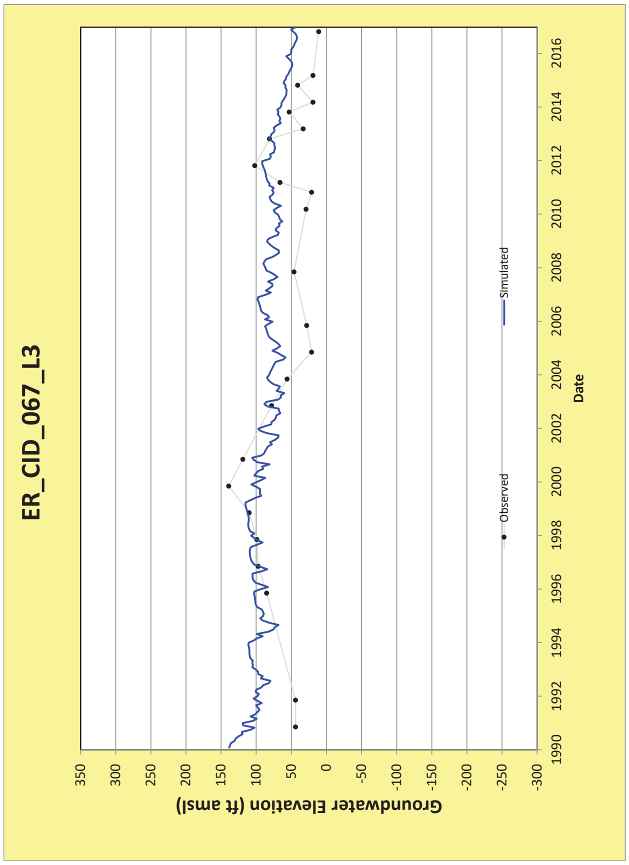
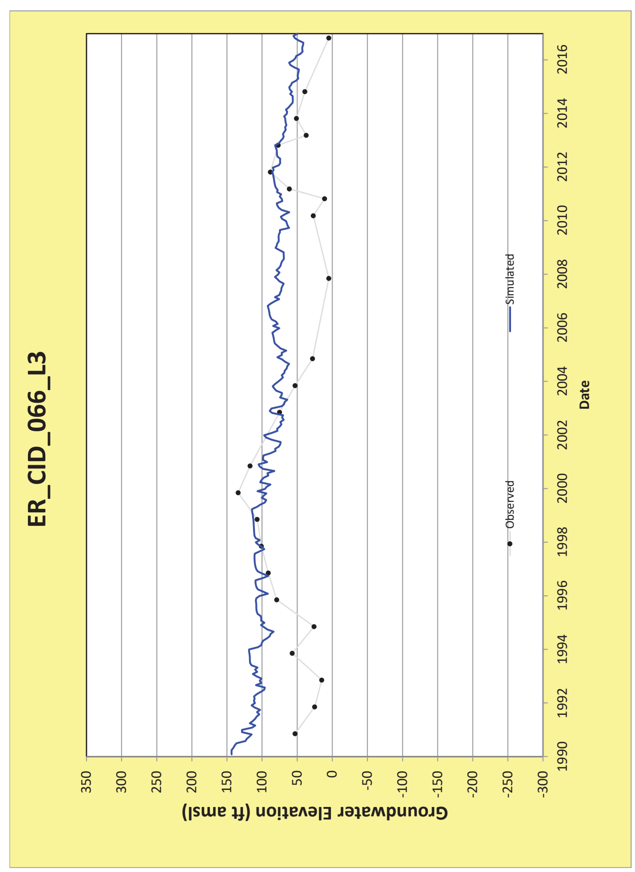
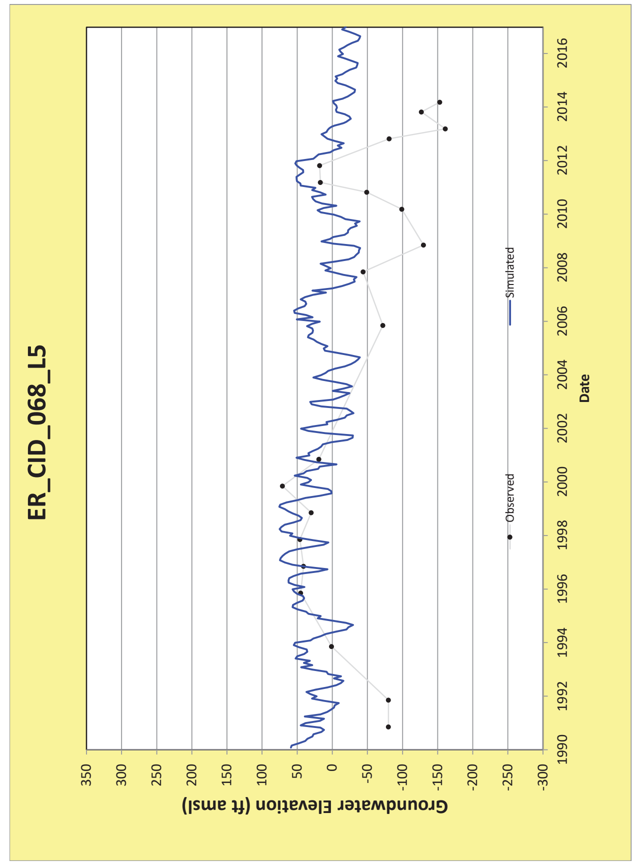
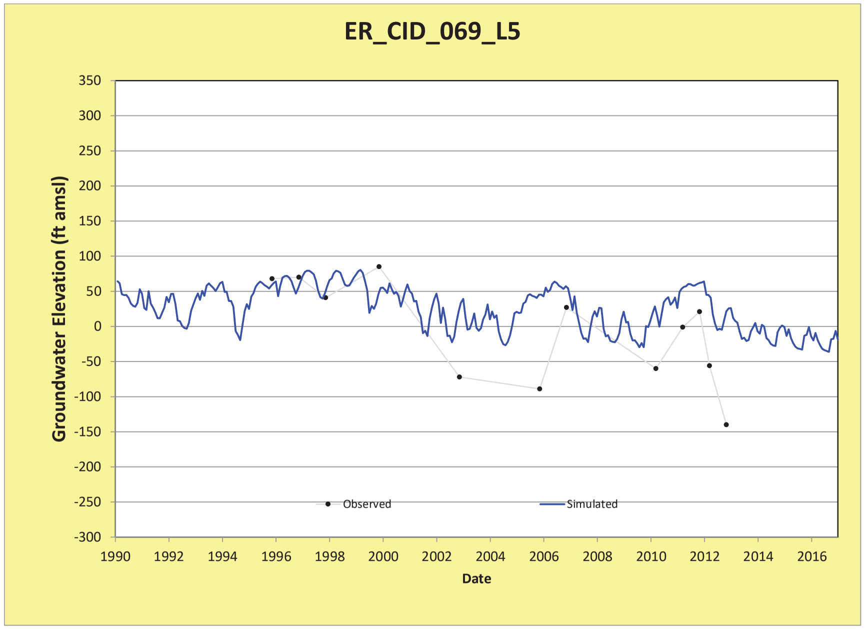
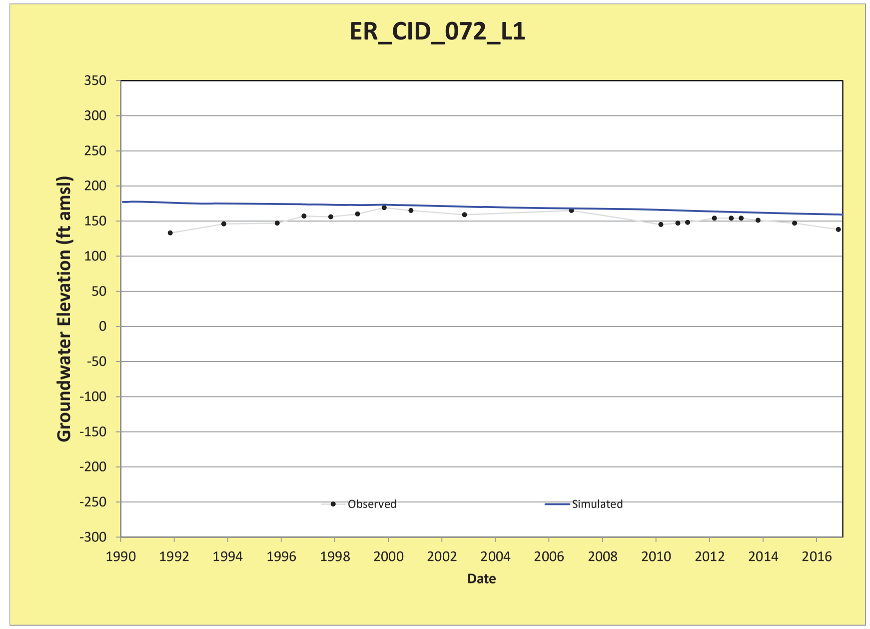
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

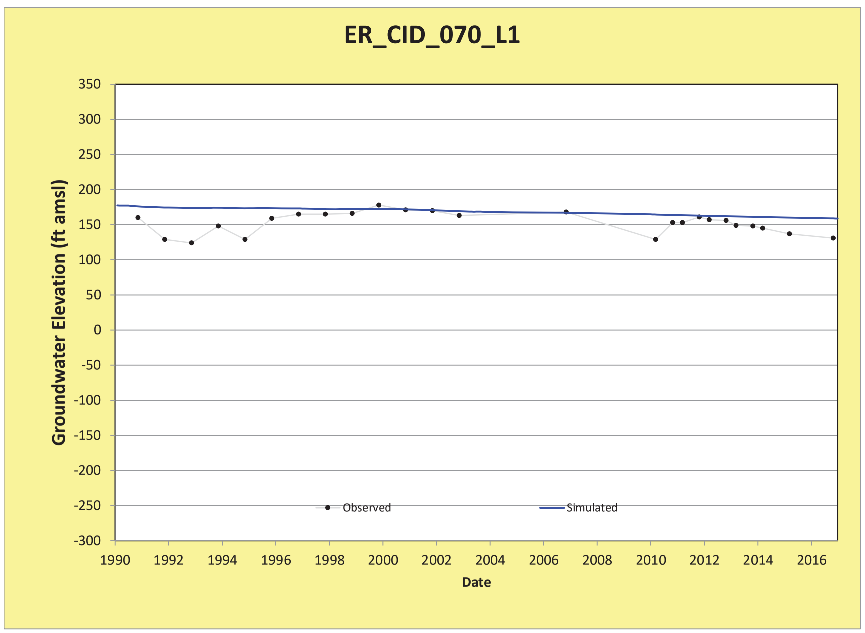

ER_CID_067_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

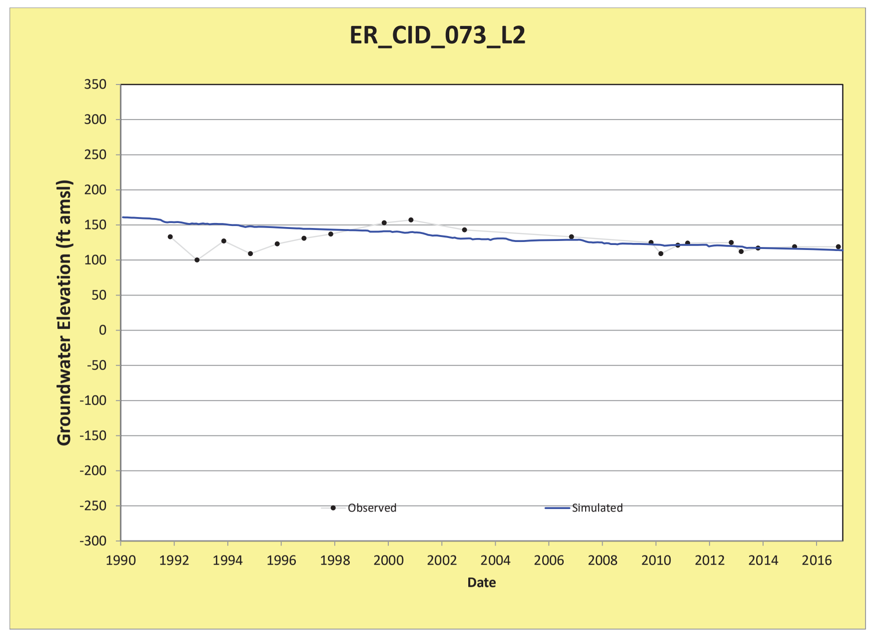

ER_CID_066_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

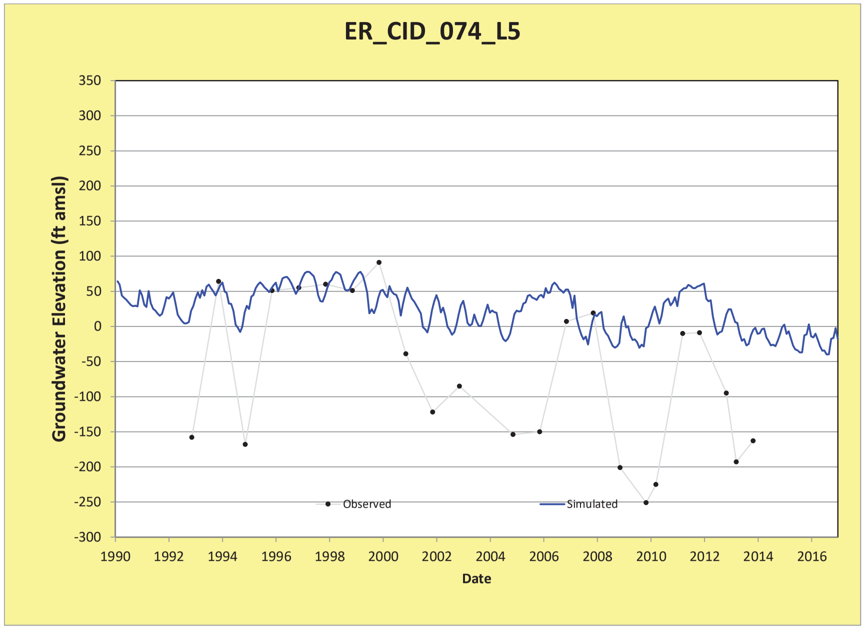

ER_CID_068_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

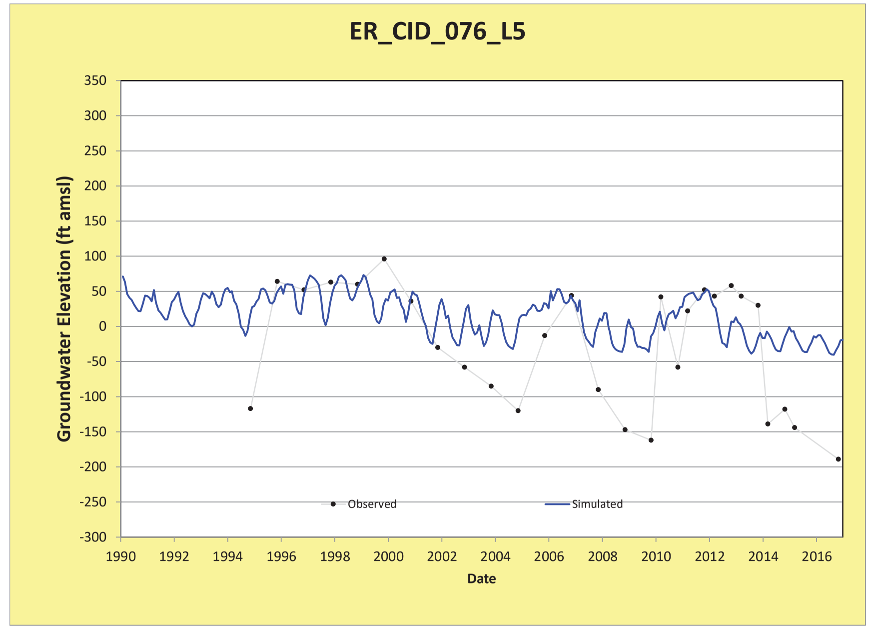

ER_CID_069_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

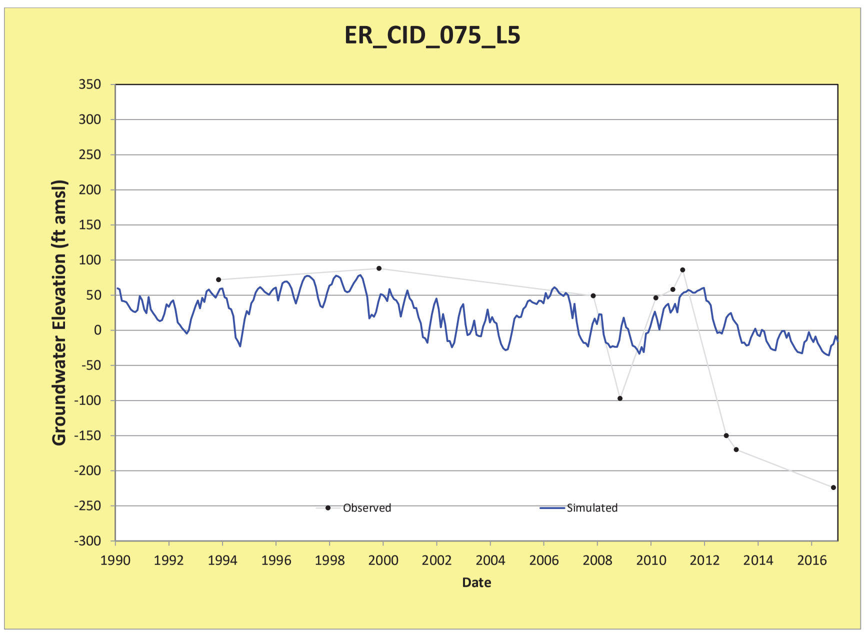

ER_CID_072_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

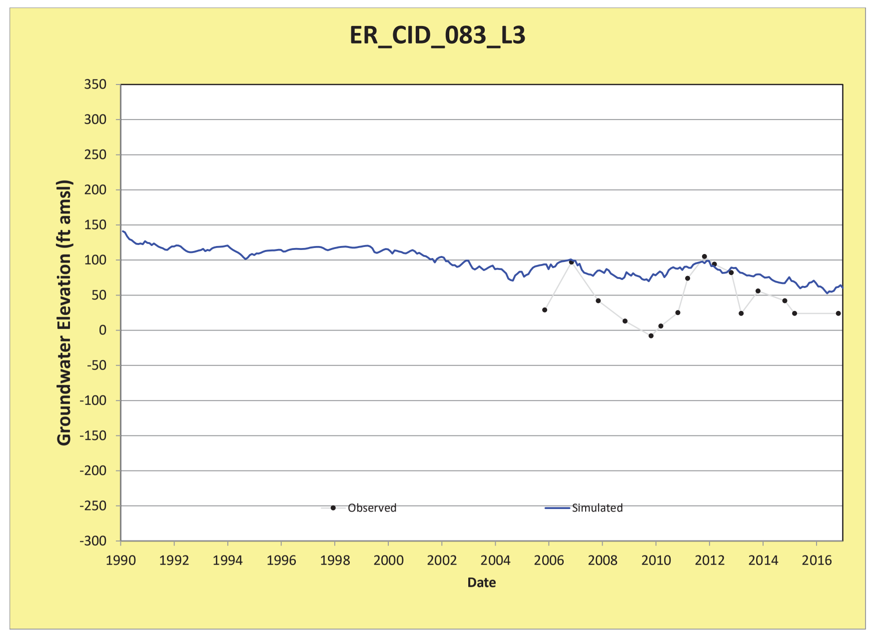

ER_CID_070_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

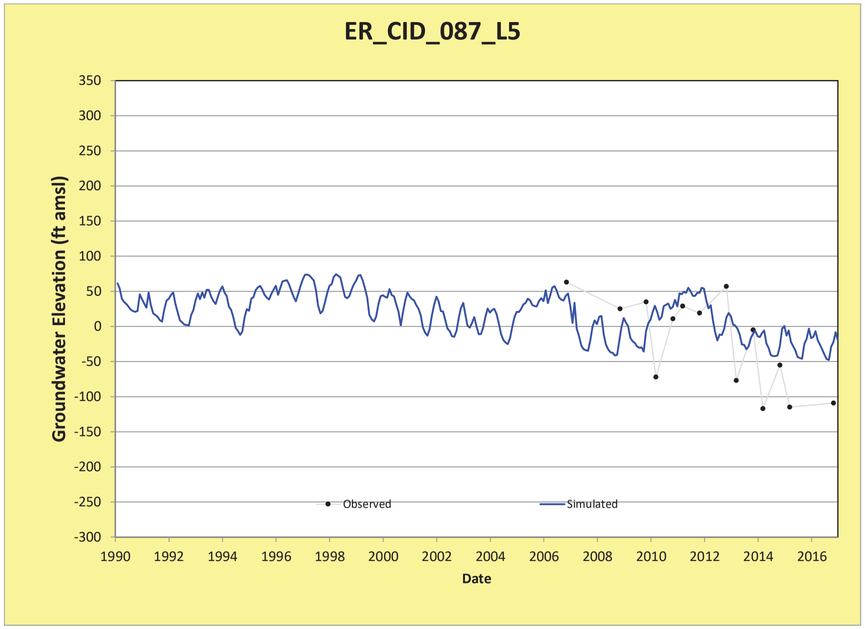

ER_CID_073_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

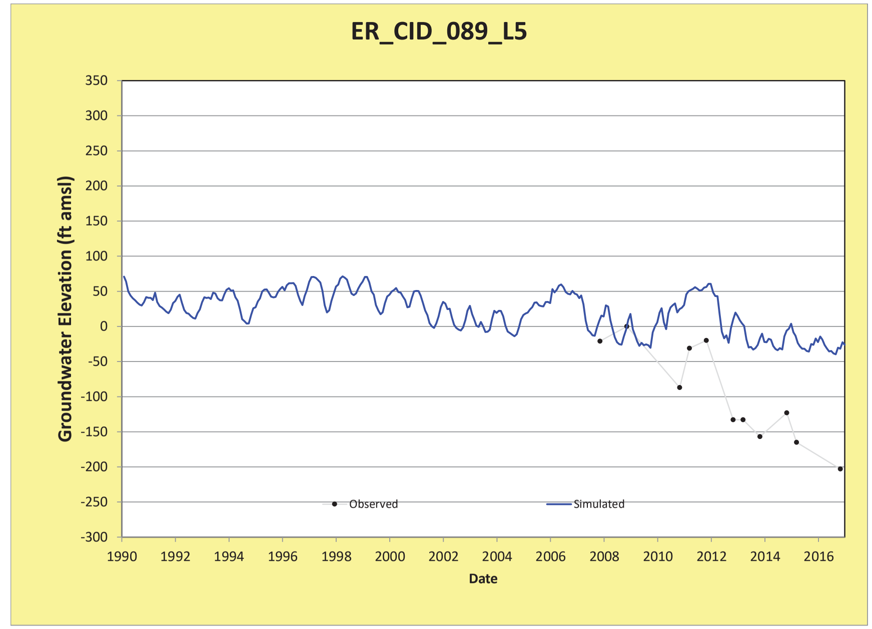

ER_CID_074_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

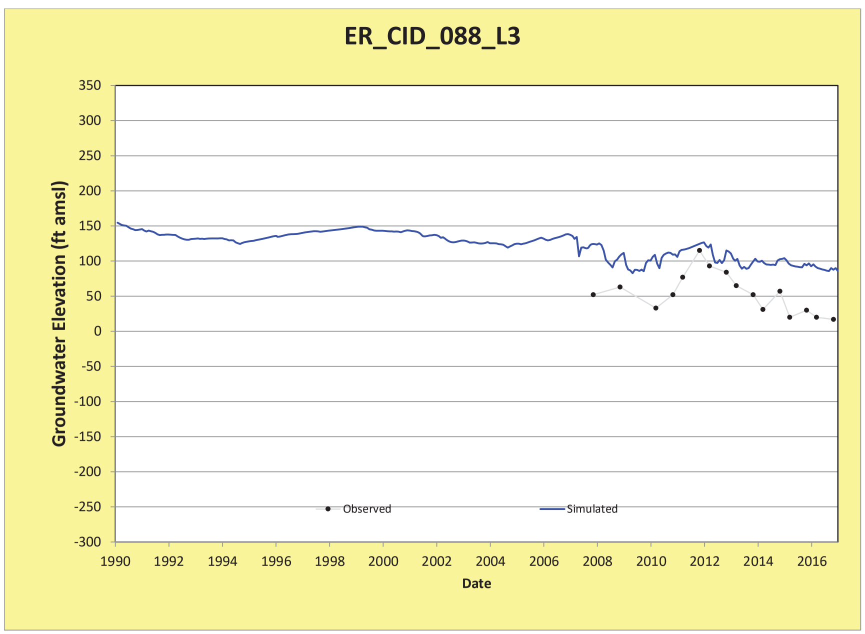

ER_CID_076_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

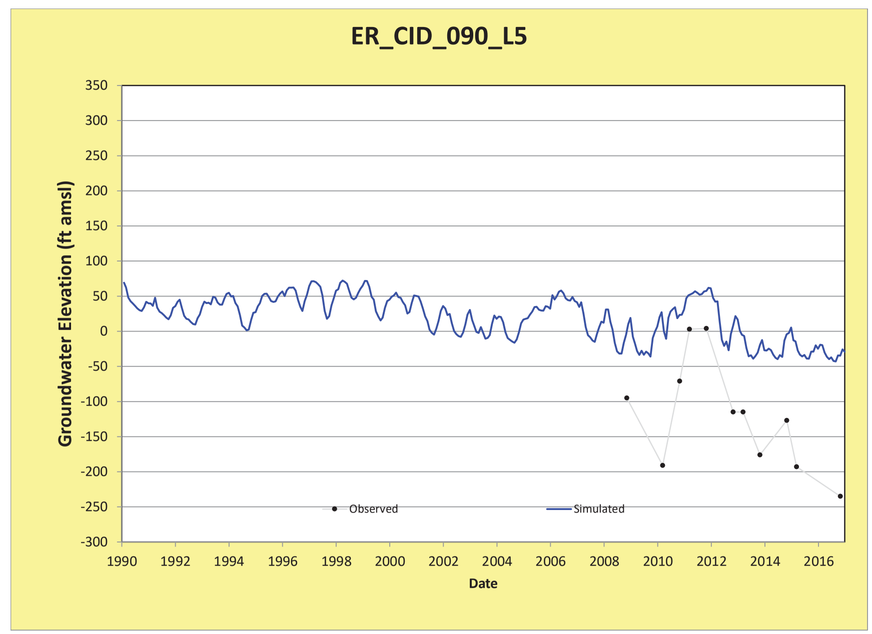

ER_CID_075_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

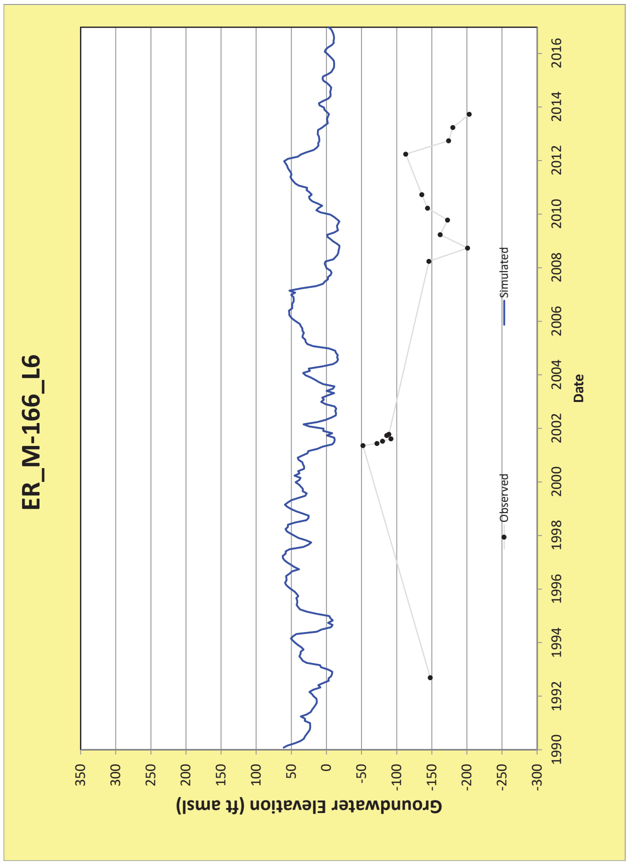

ER_CID_083_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

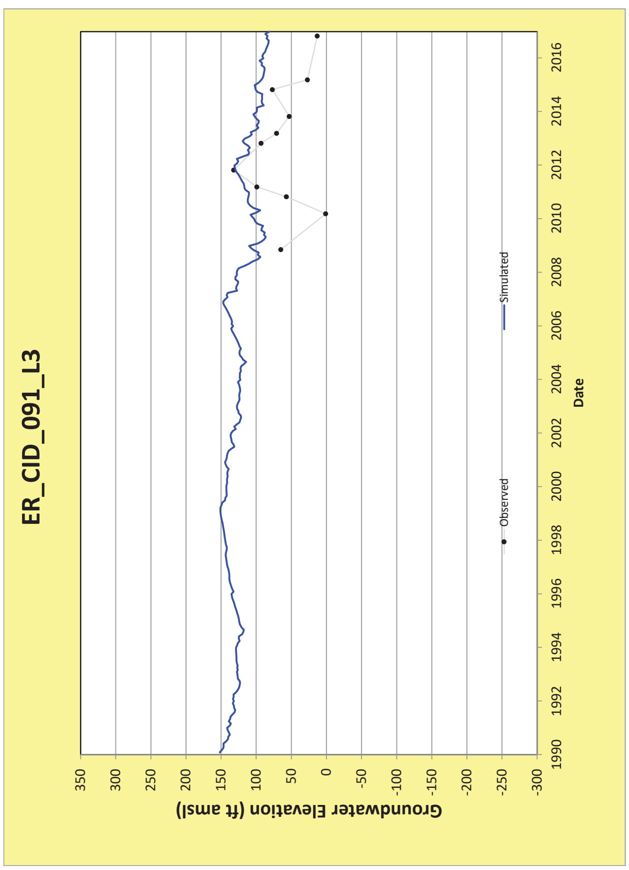

ER_CID_087_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

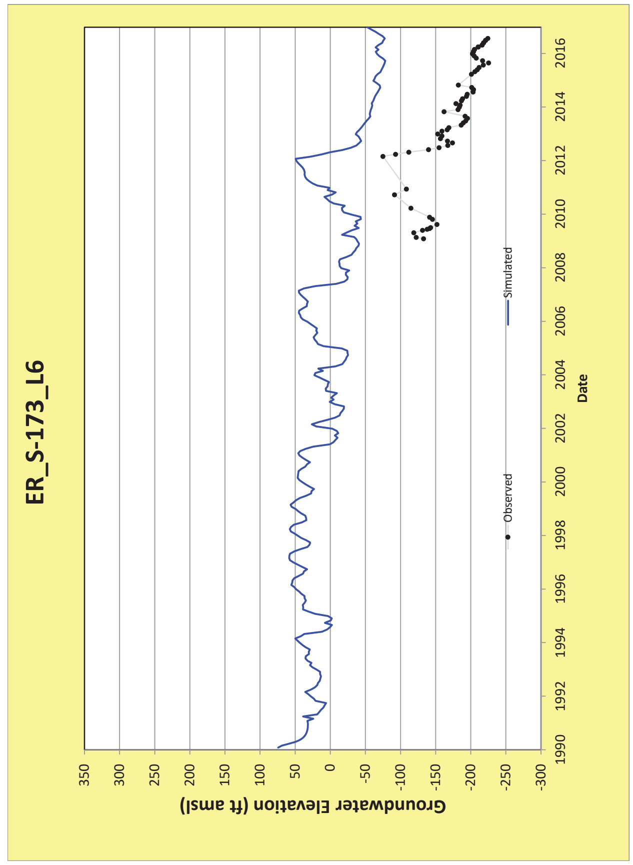

ER_CID_089_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

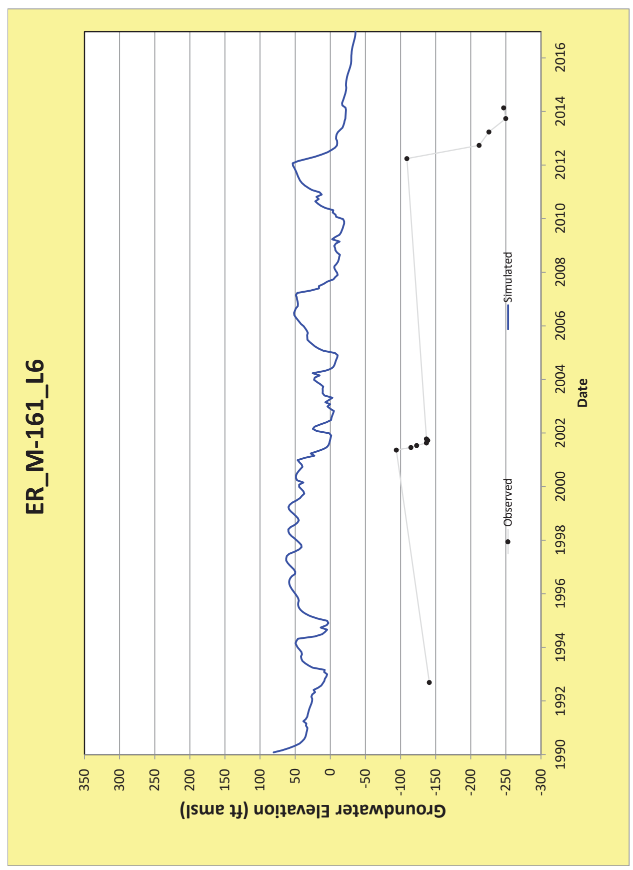

ER_CID_088_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

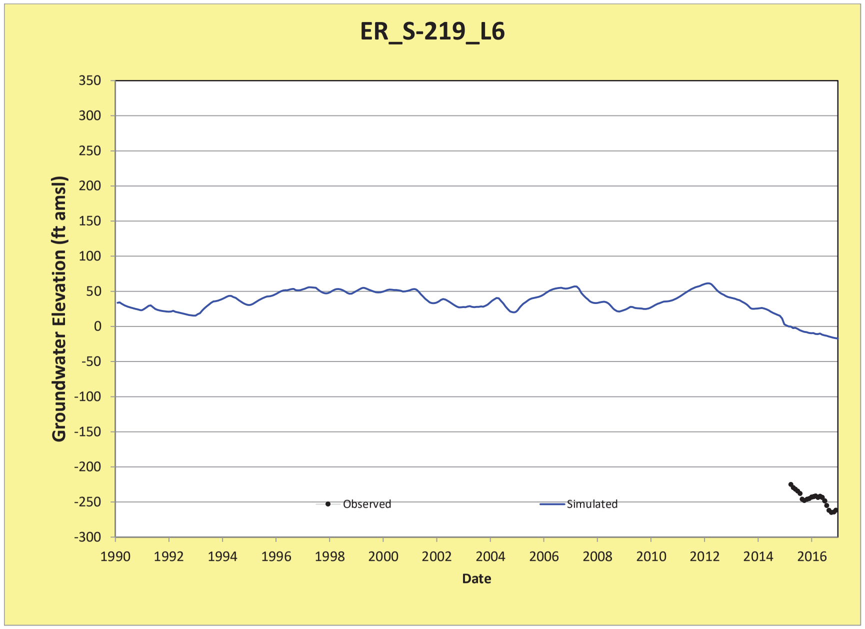

ER_CID_090_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

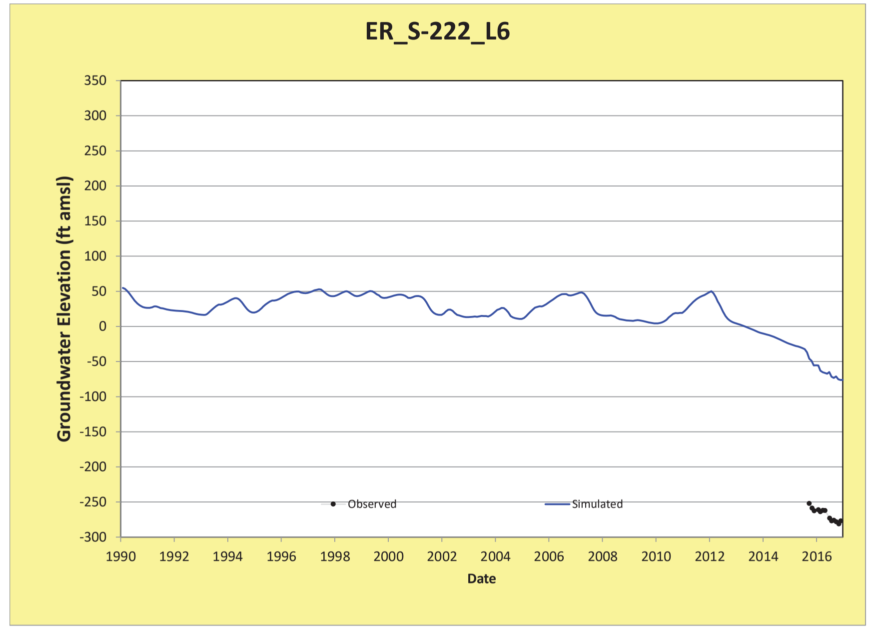

ER_M-166_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

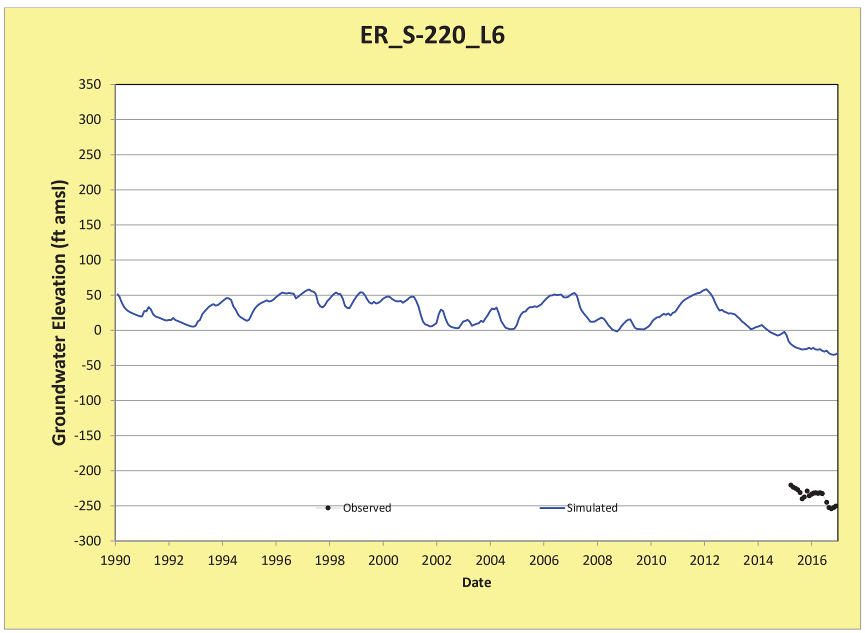

ER_CID_091_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

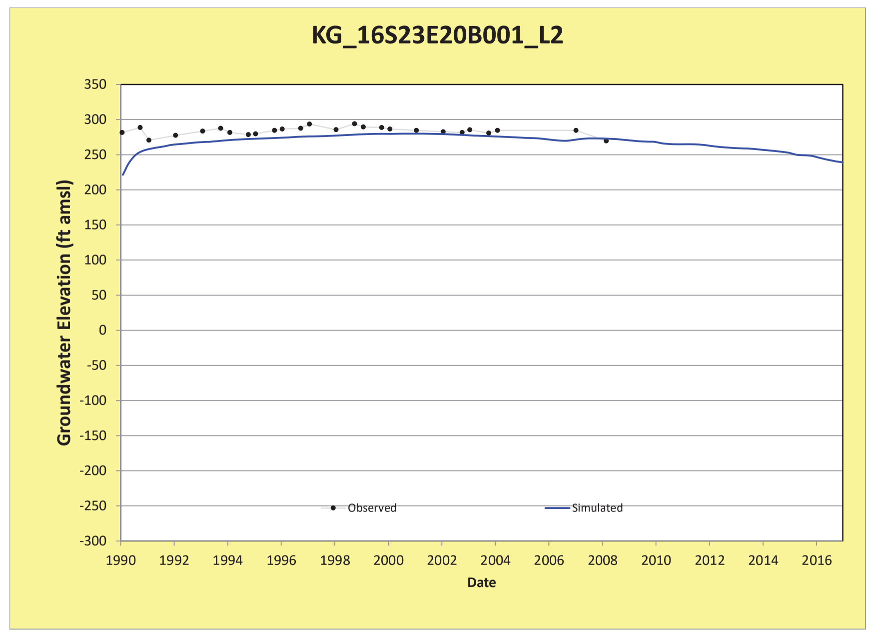

ER_S-173_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

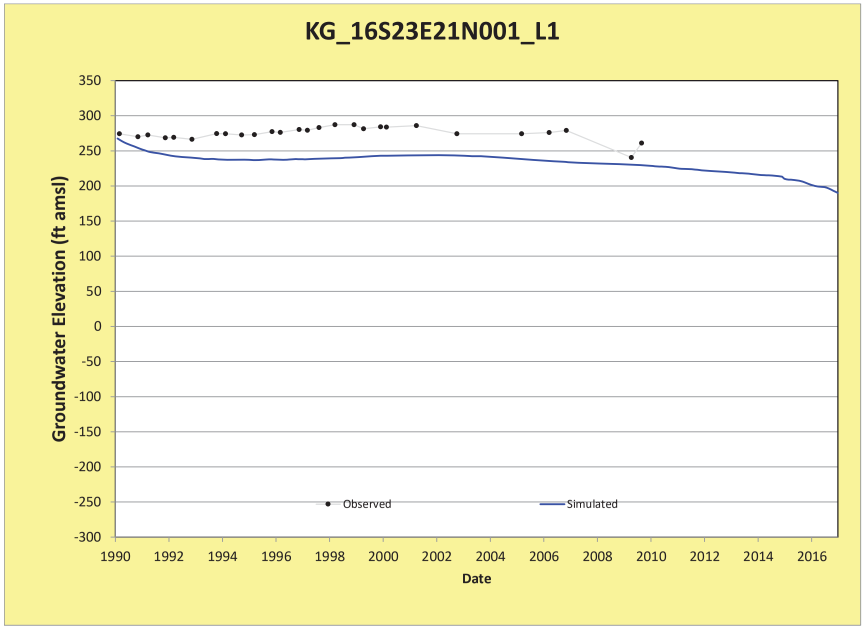

ER_M-161_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

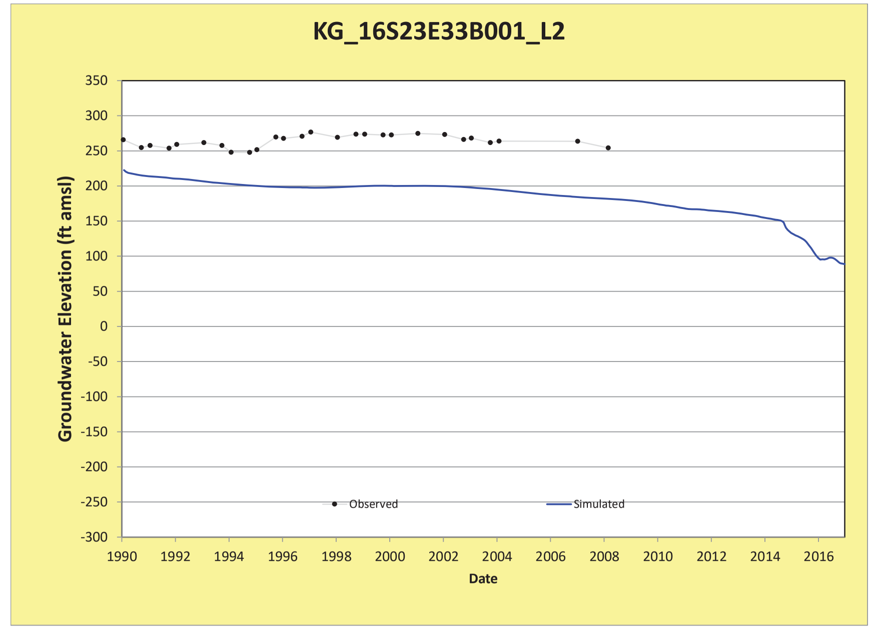

ER_S-219_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

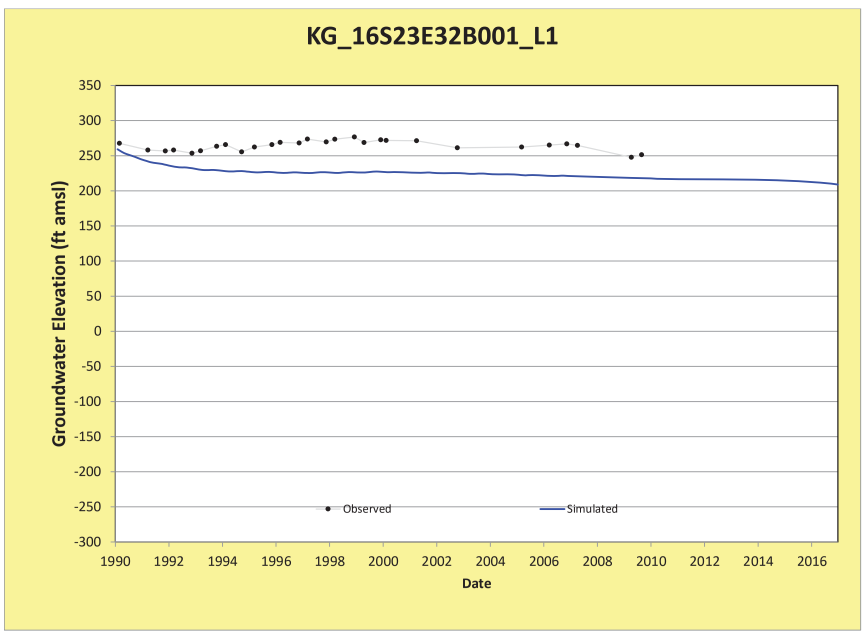

ER_S-222_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

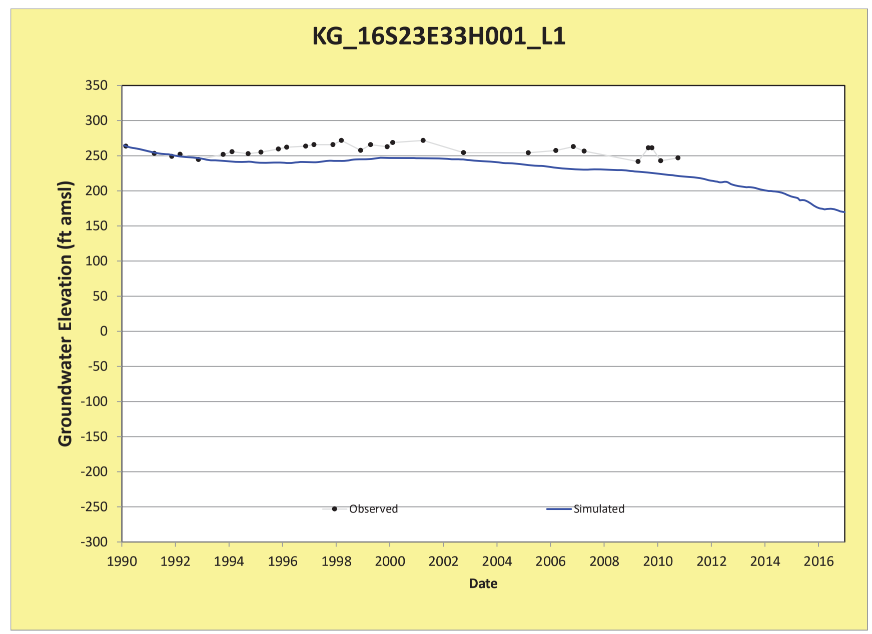

ER_S-220_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

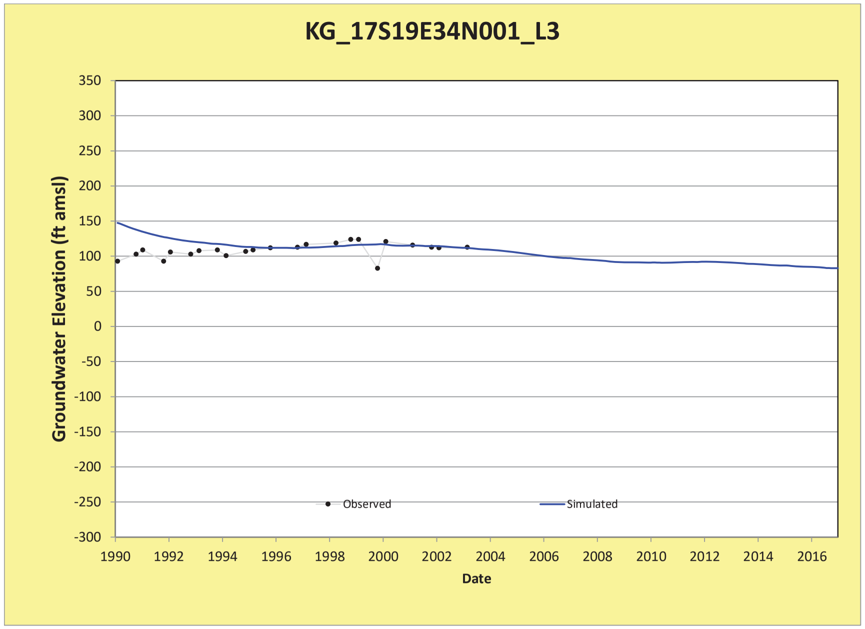

KG_16S23E20B001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

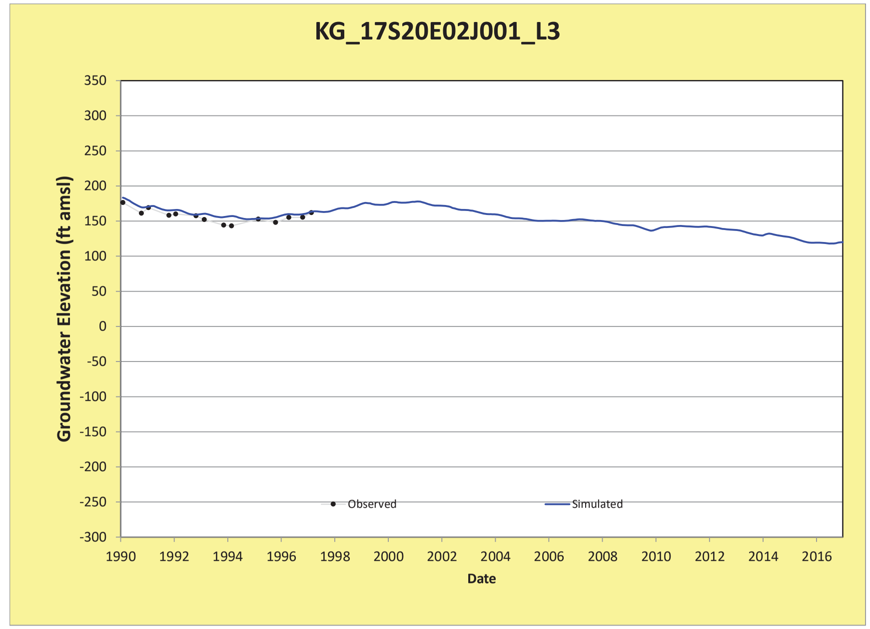

KG_16S23E21N001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

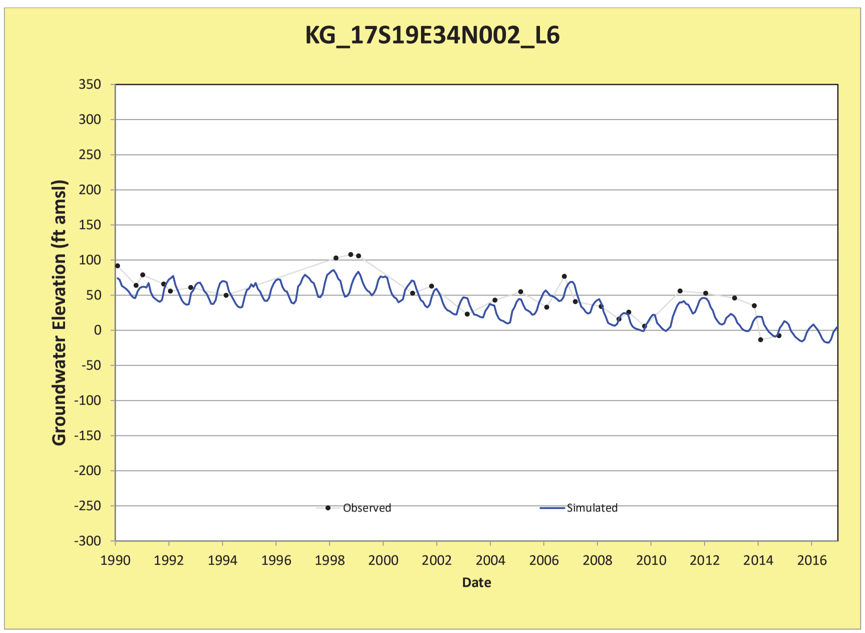

KG_16S23E33B001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

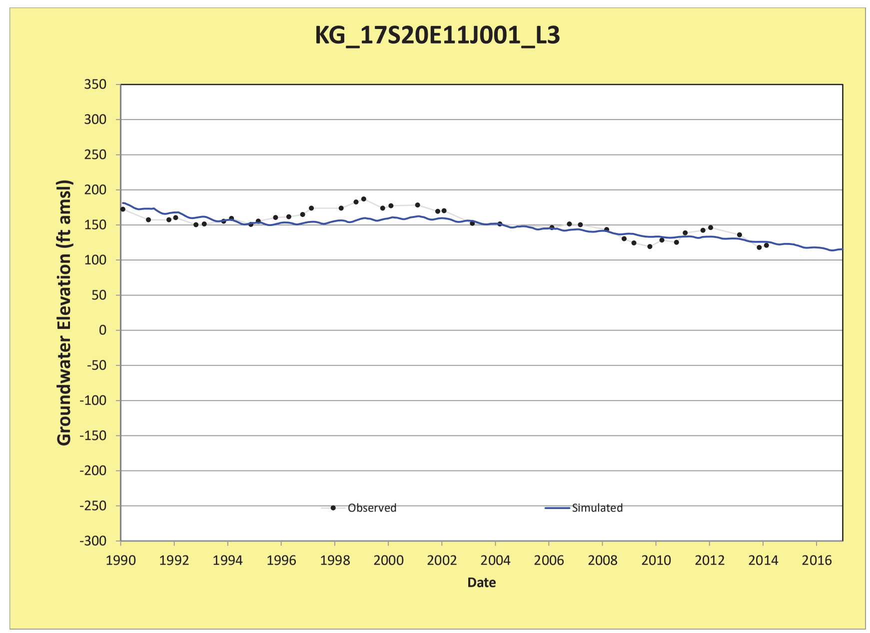

KG_16S23E32B001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

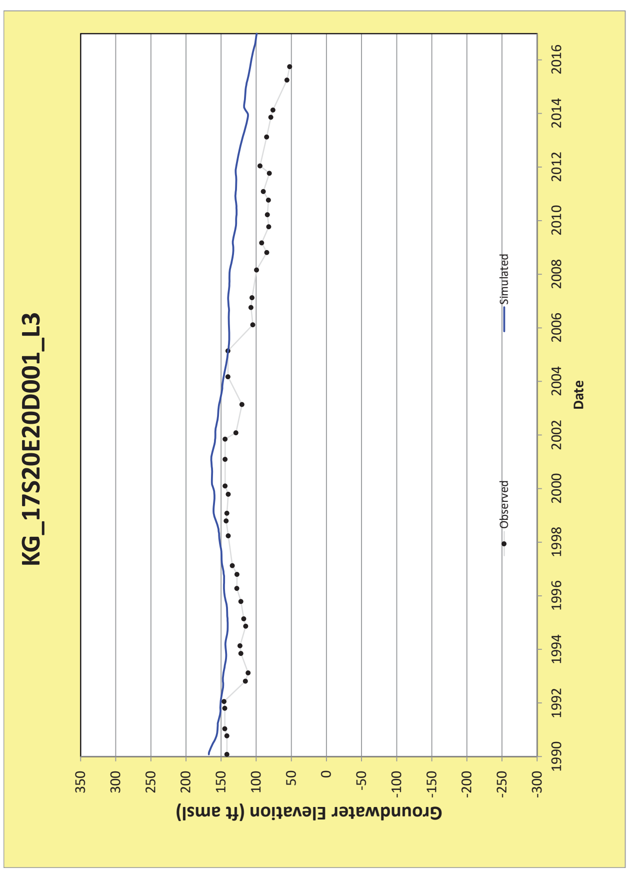

KG_16S23E33H001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

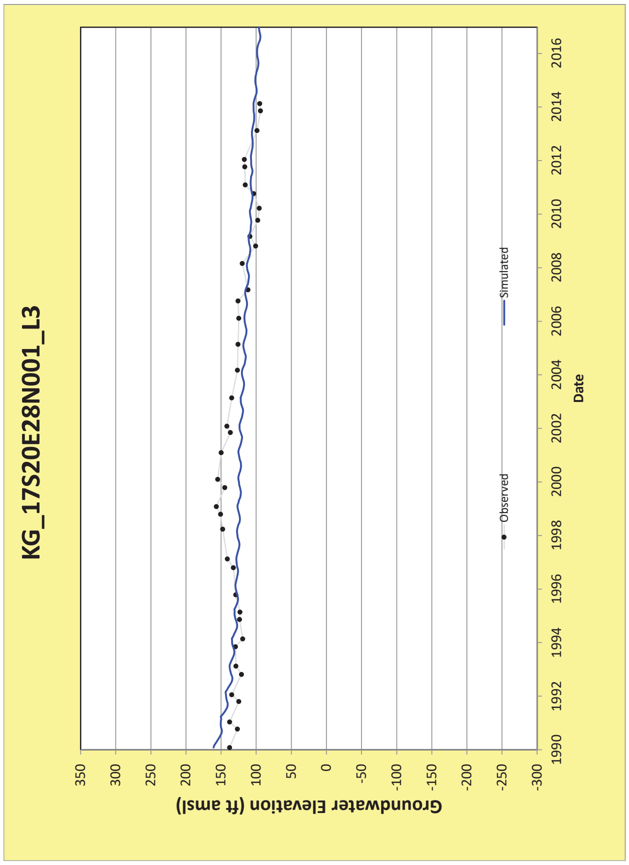

KG_17S19E34N001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

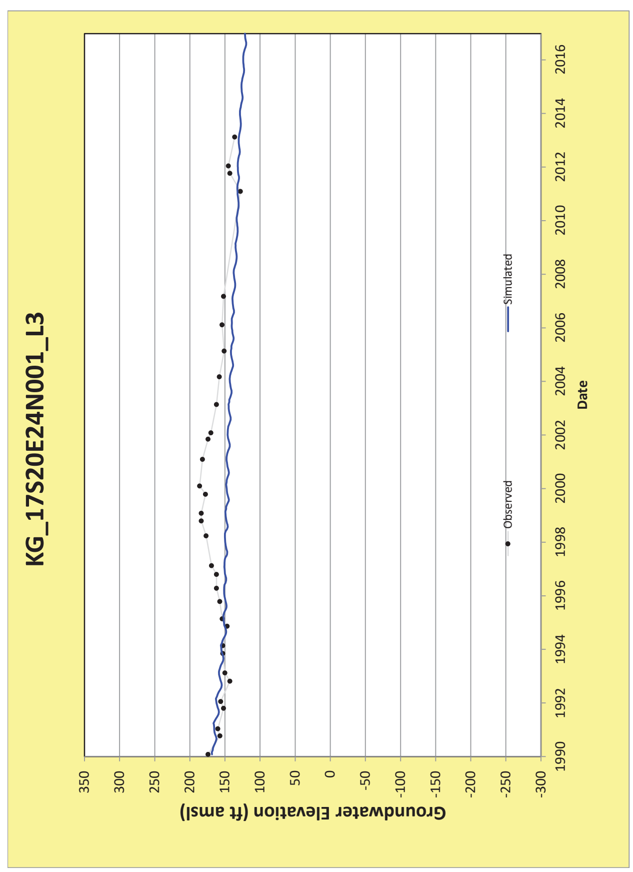

KG_17S20E02J001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

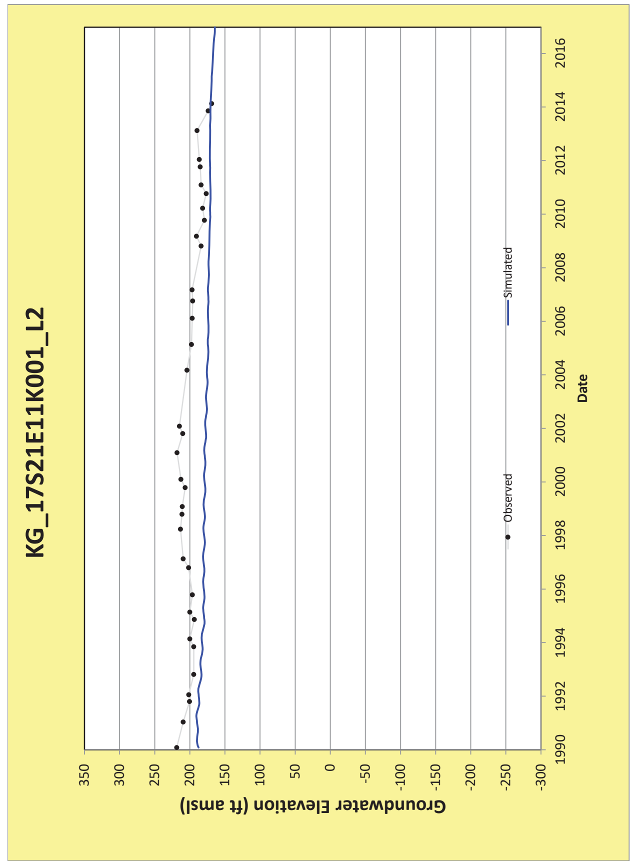

KG_17S19E34N002_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KG_17S20E11J001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

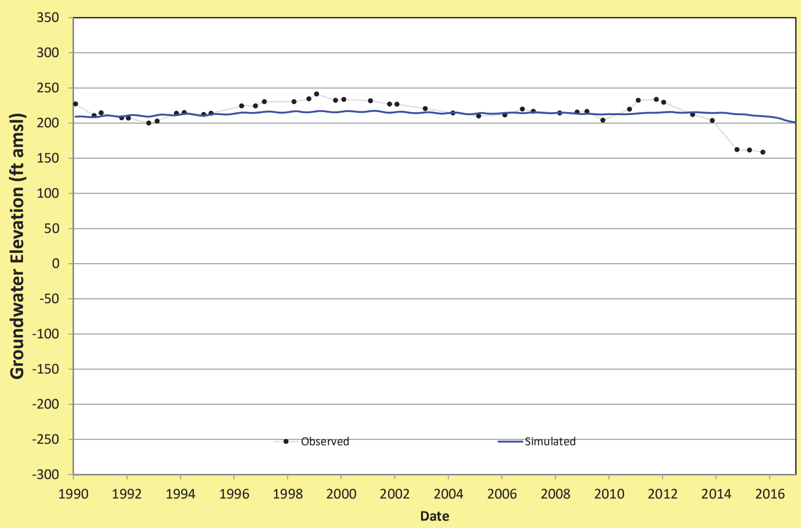

KG_17S20E20D001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KG_17S20E28N001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

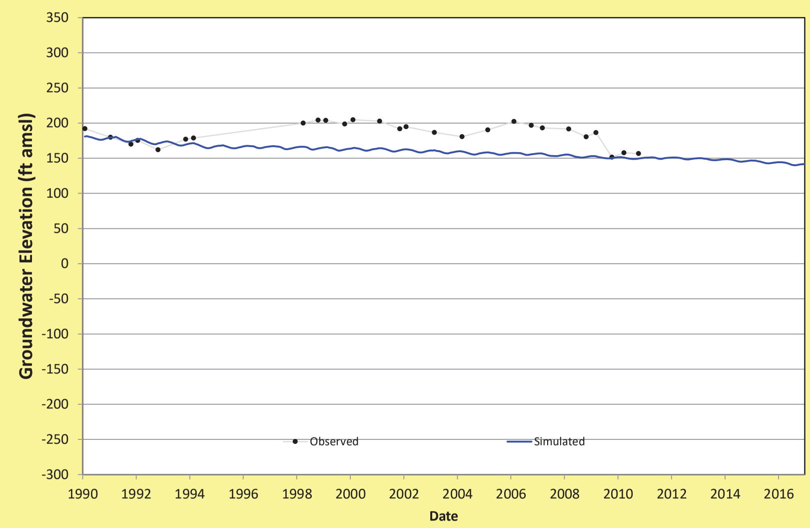

KG_17S20E24N001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KG_17S21E11K001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

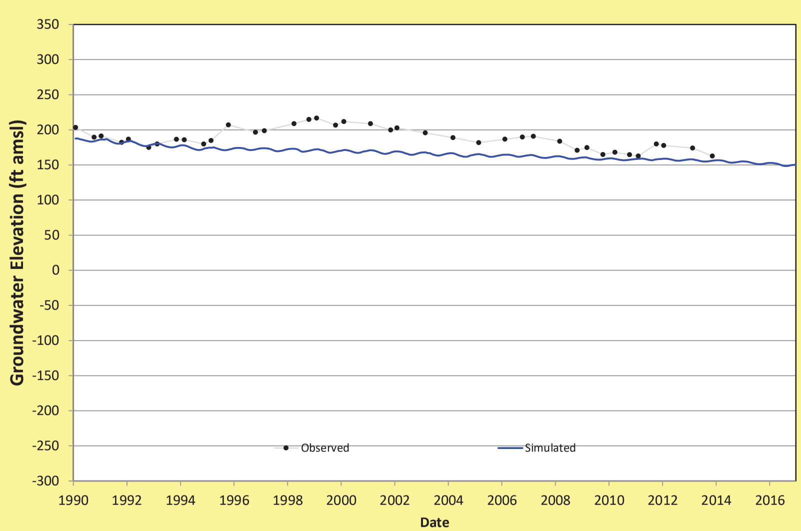
KG_17S21E13M001_L2



KG_17S21E19A002_L3



KG_17S21E17J001_L3



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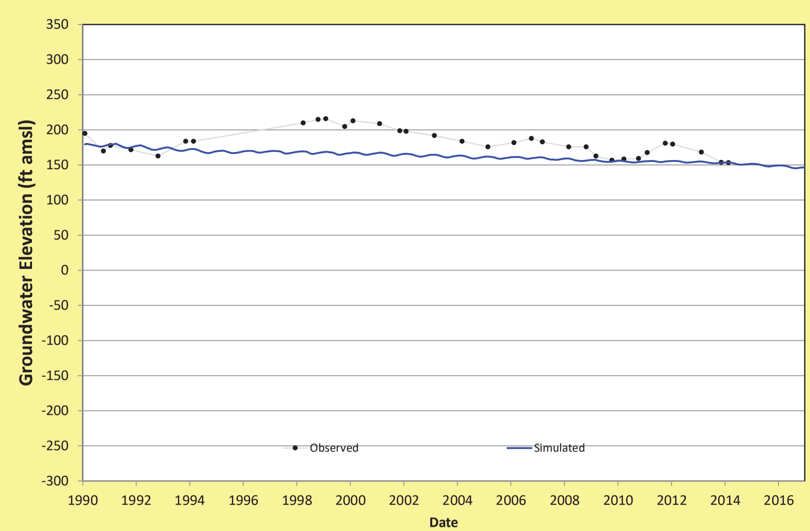
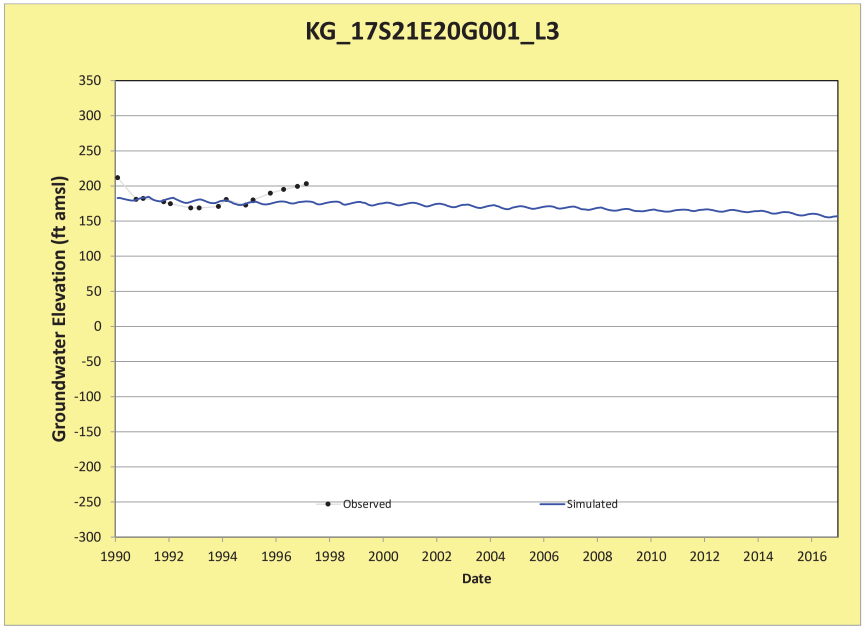
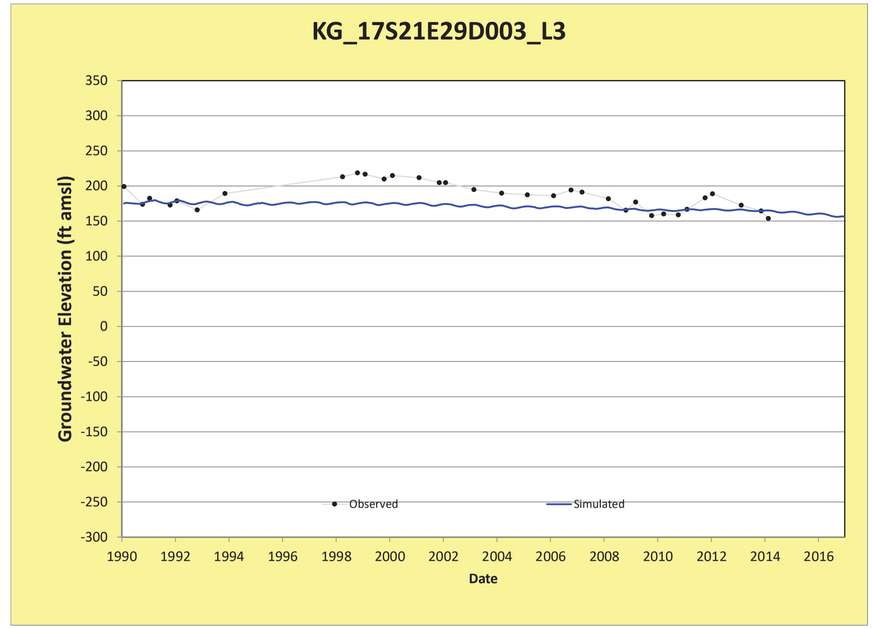
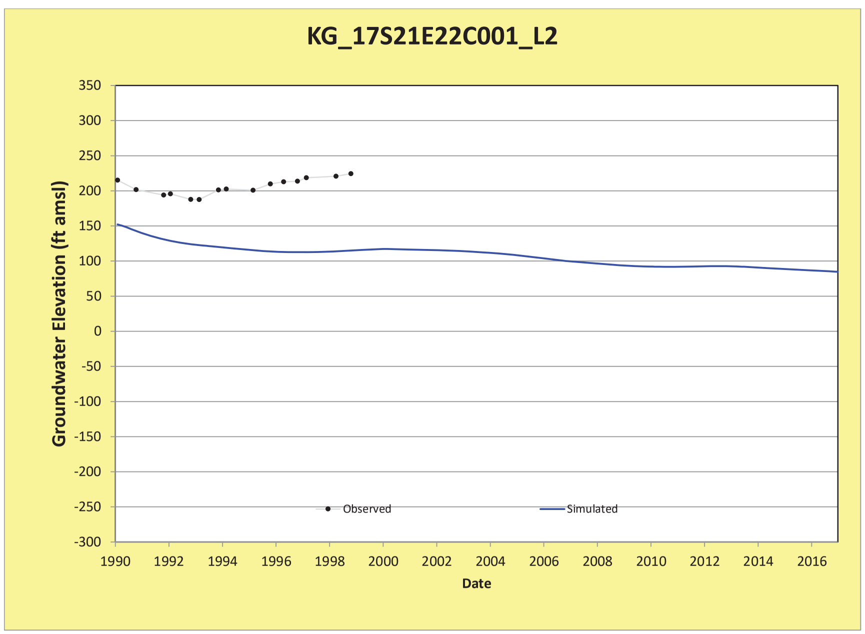
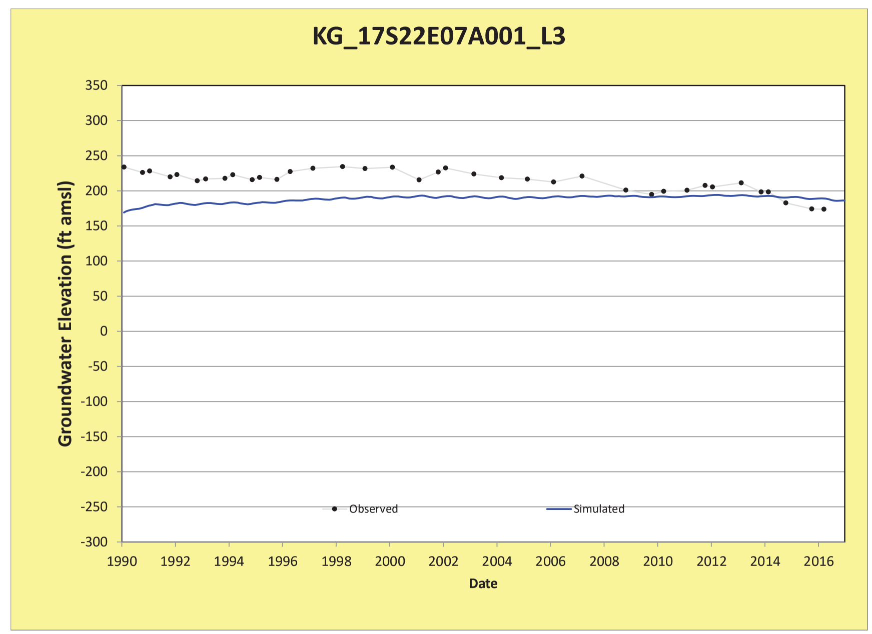
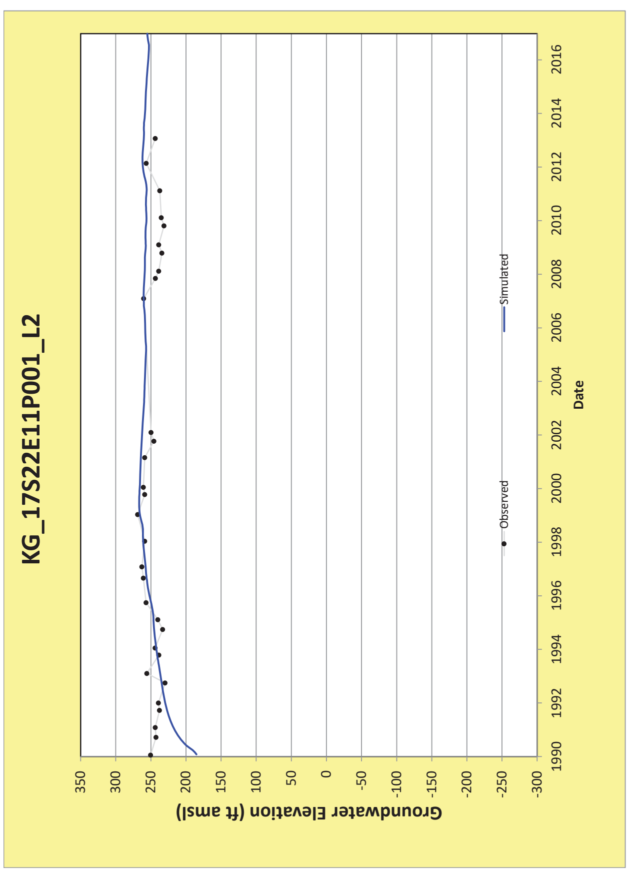


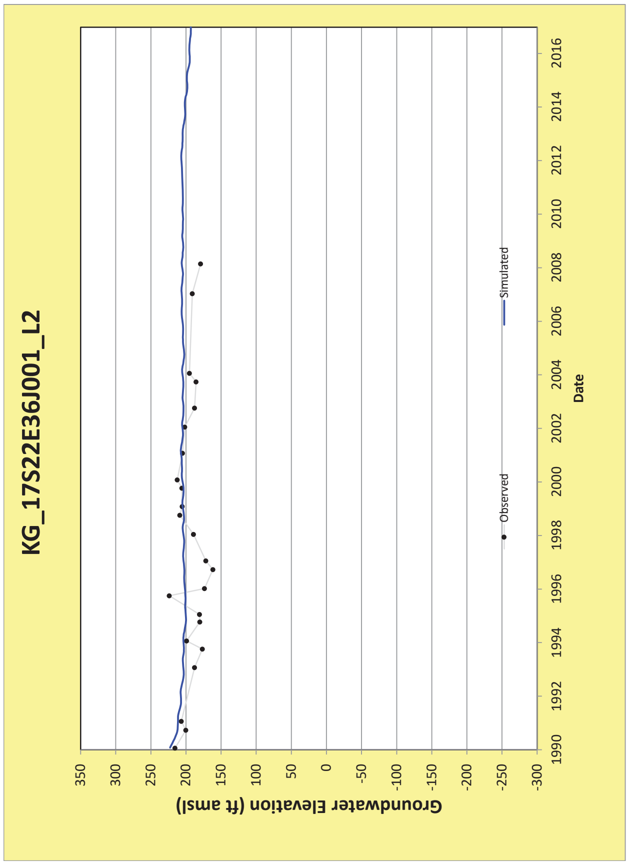

KG_17S21E20G001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

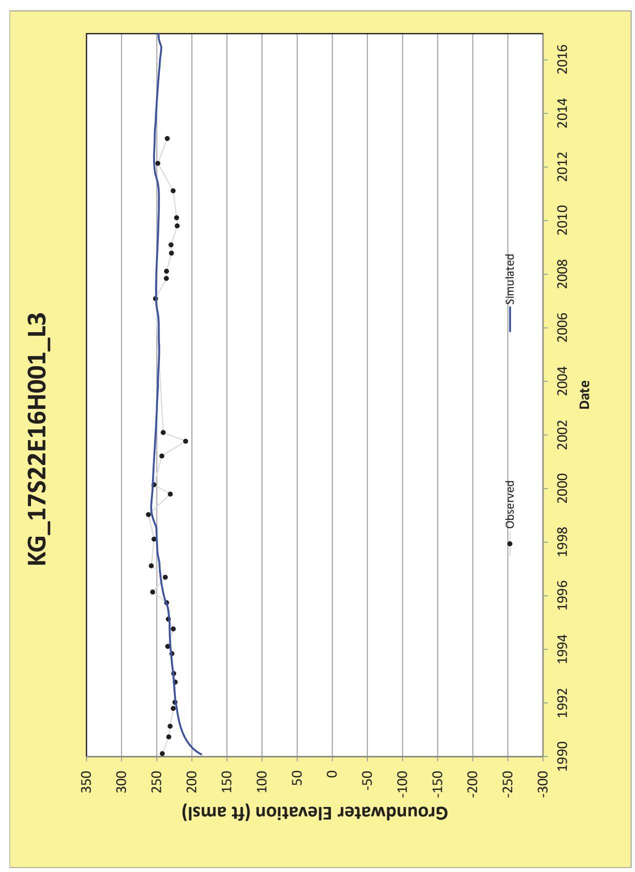

KG_17S21E29D003_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KG_17S21E22C001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KG_17S22E07A001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KG_17S22E11P001_L2
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


KG_17S22E36J001_L2
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


KG_17S22E16H001_L3
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
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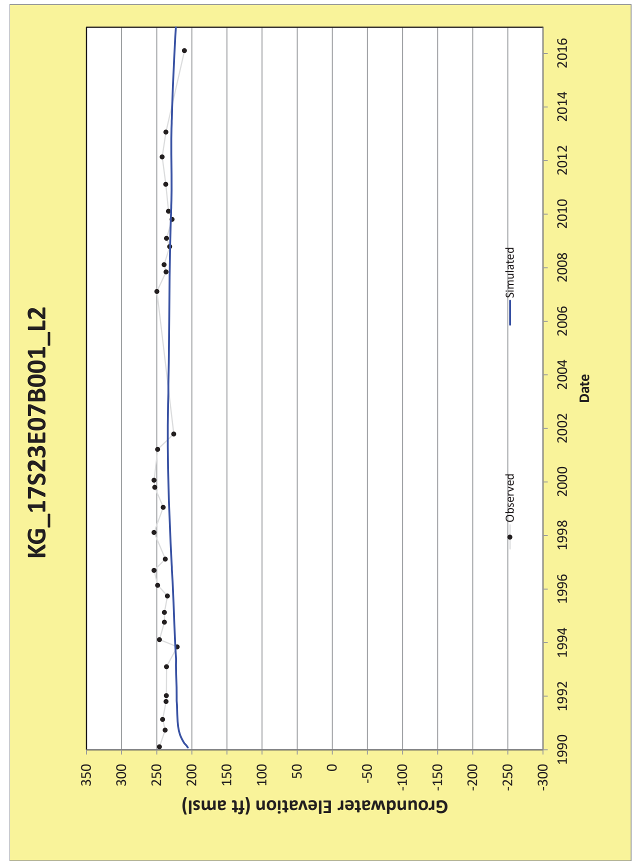
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


KG_17S23E07B001_L2
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
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-200
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-300
1990
1992
1994
1996
1998
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2002
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2010
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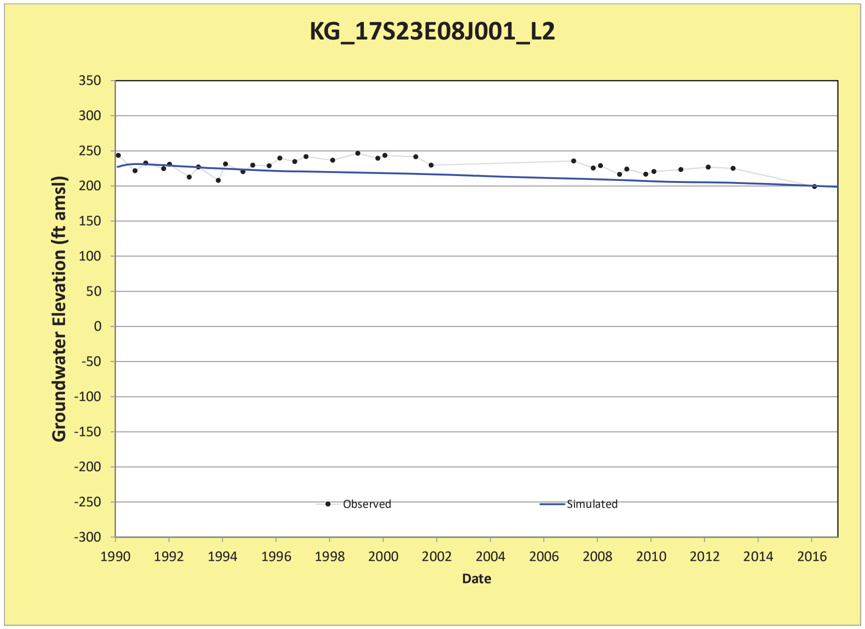
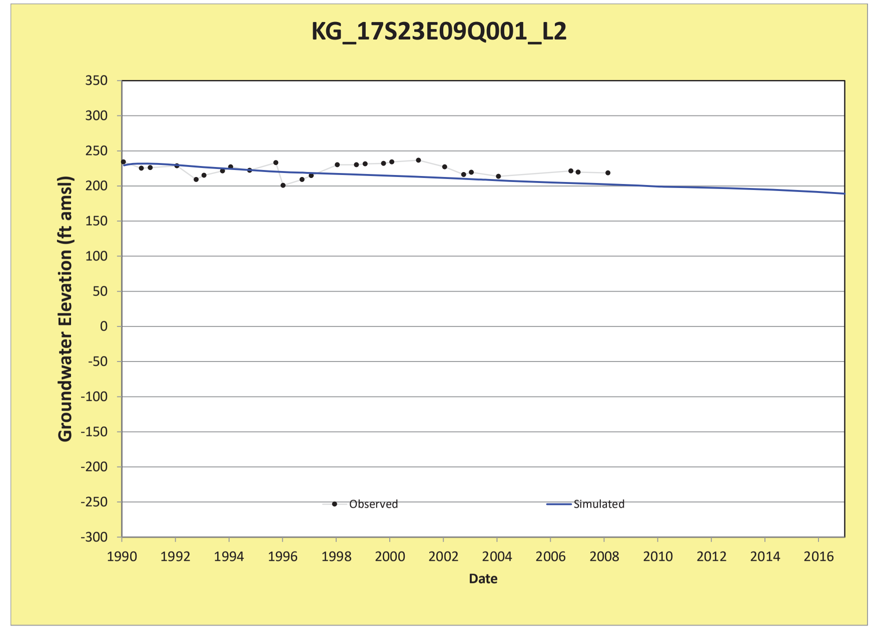
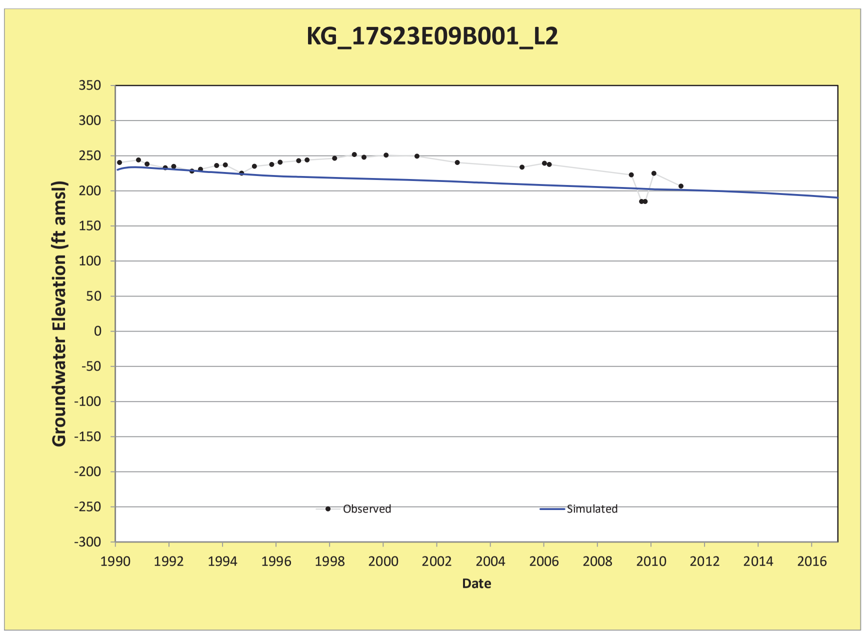
Date
Observed
Simulated


KG_17S23E08J001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KG_17S23E09Q001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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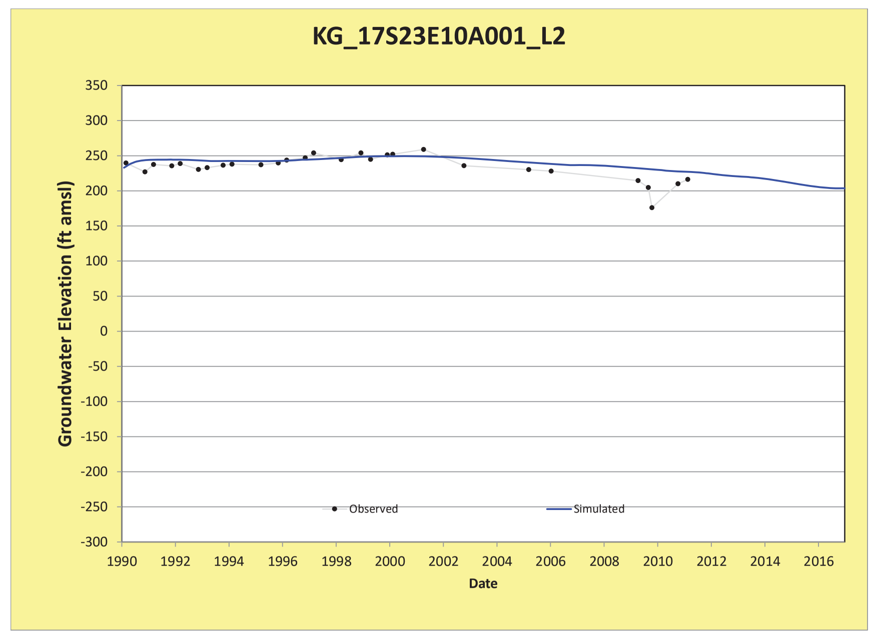
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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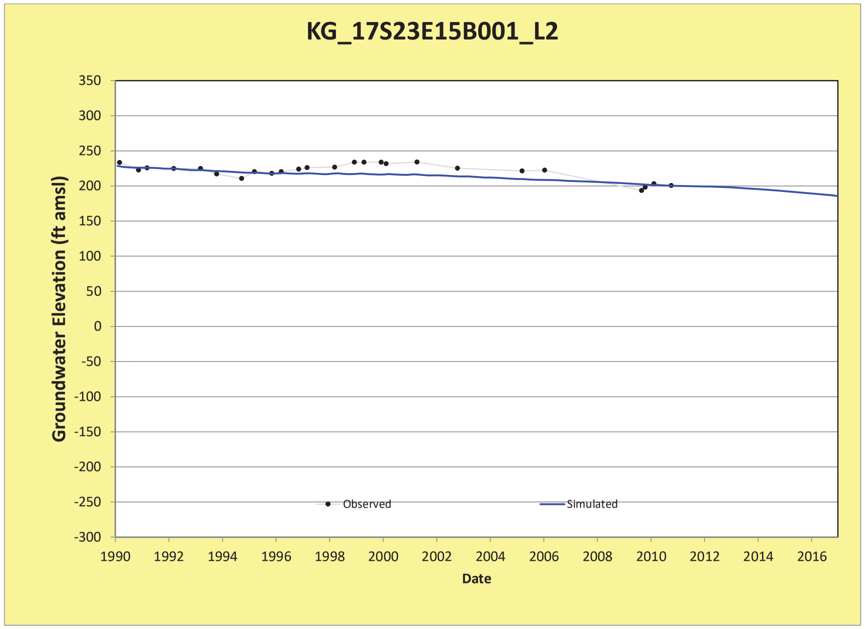
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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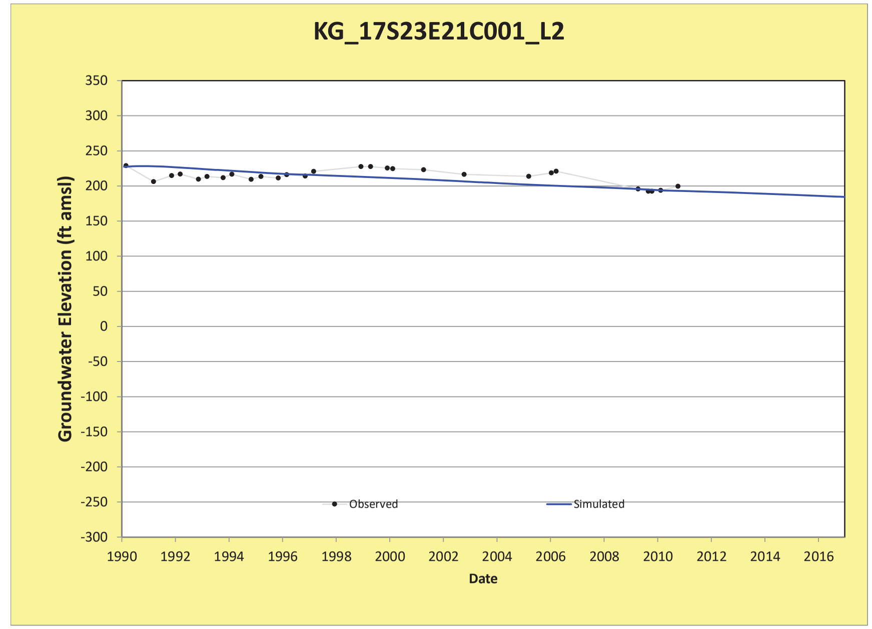
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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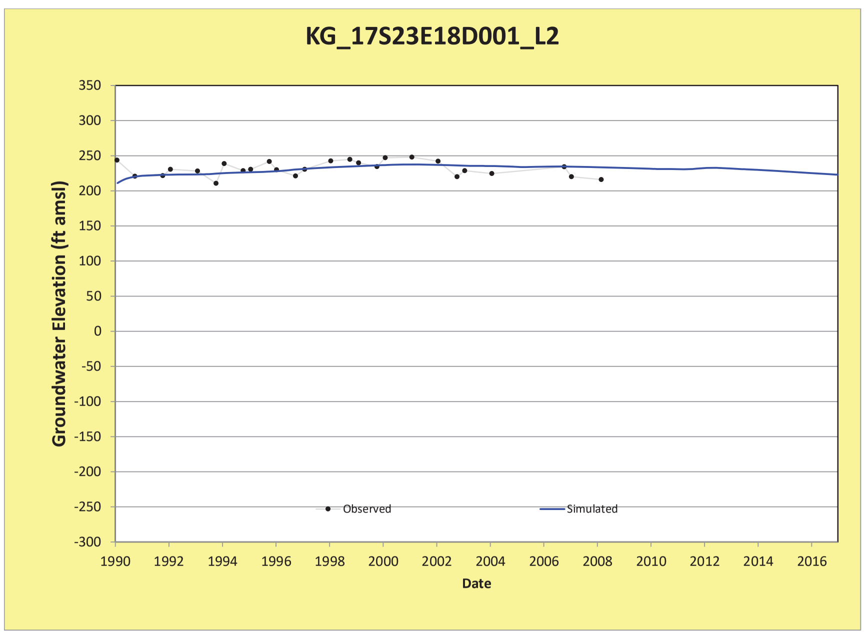
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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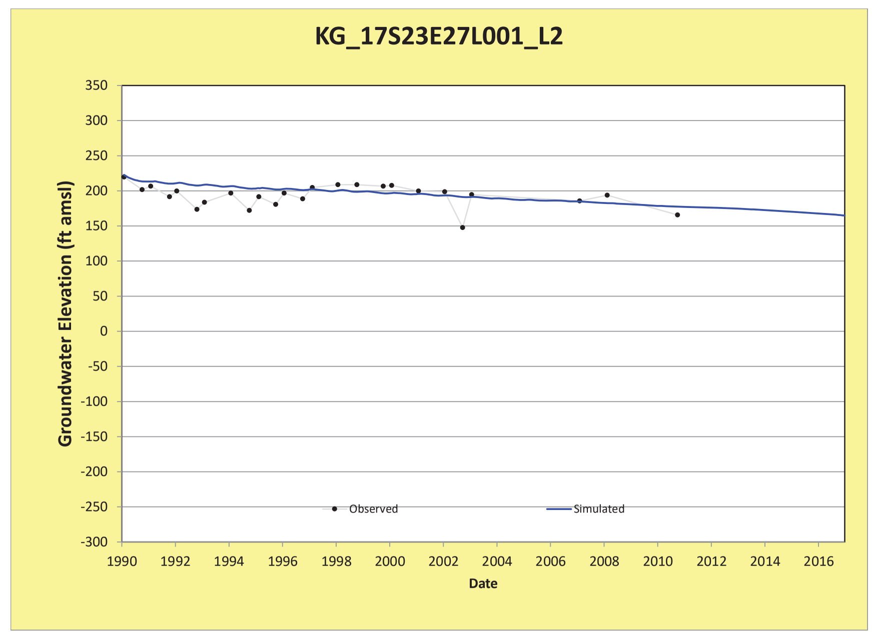
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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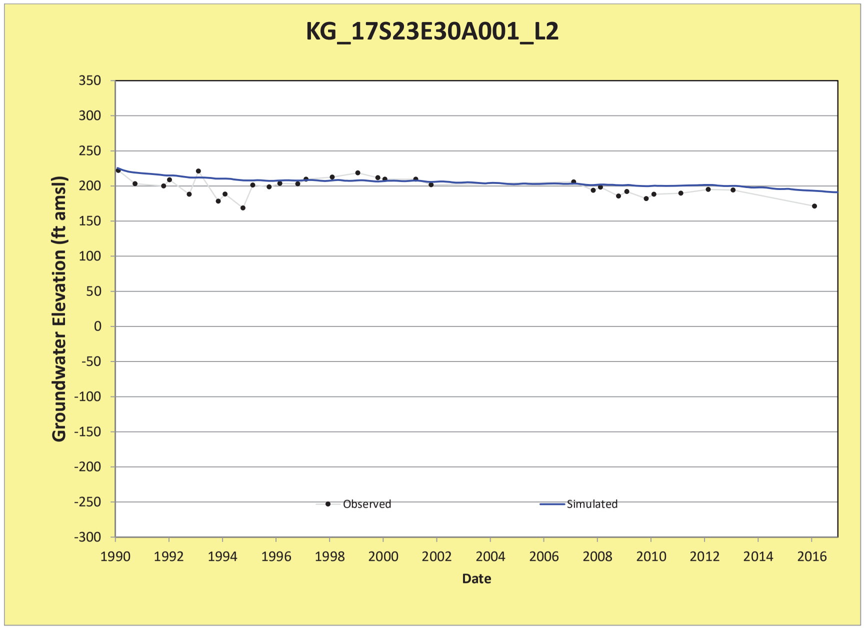
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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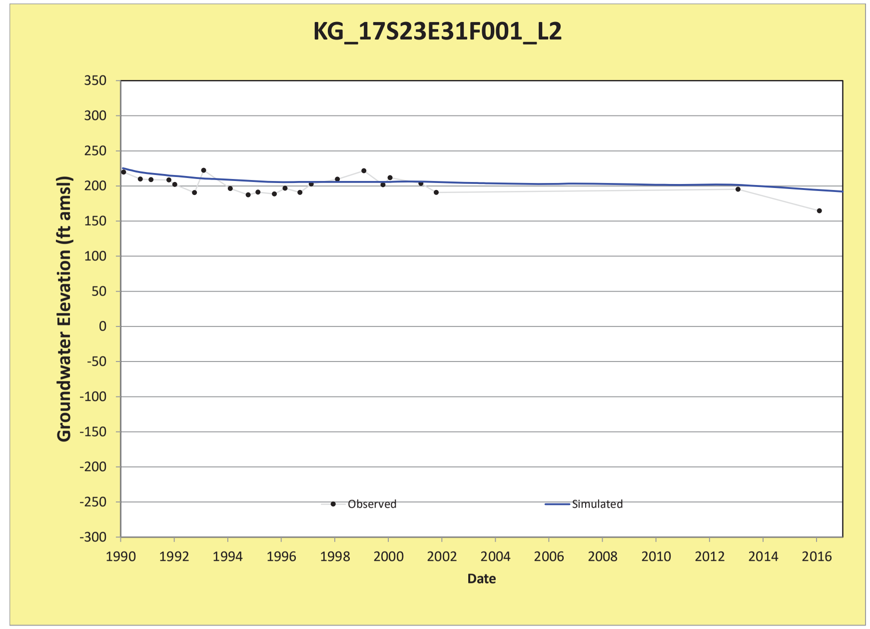
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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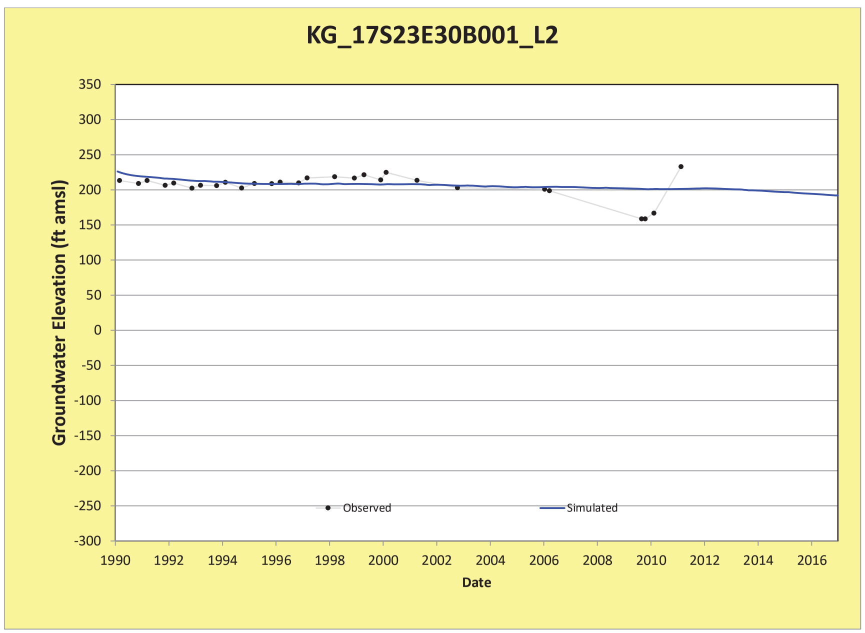
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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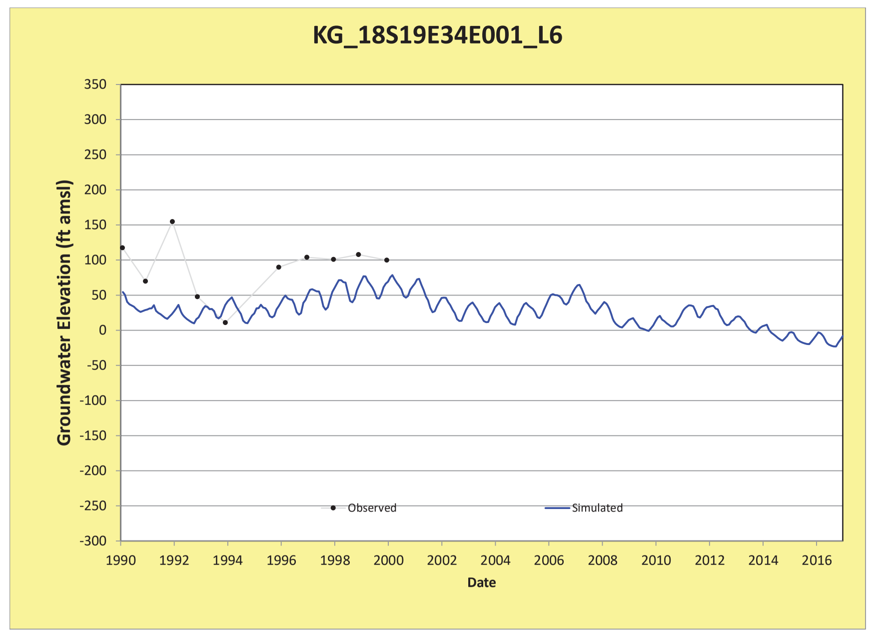
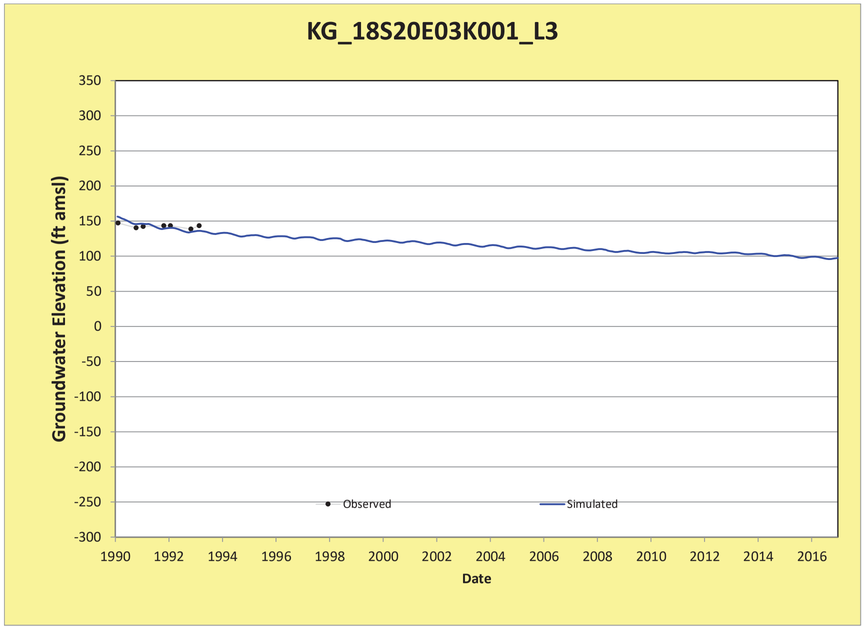
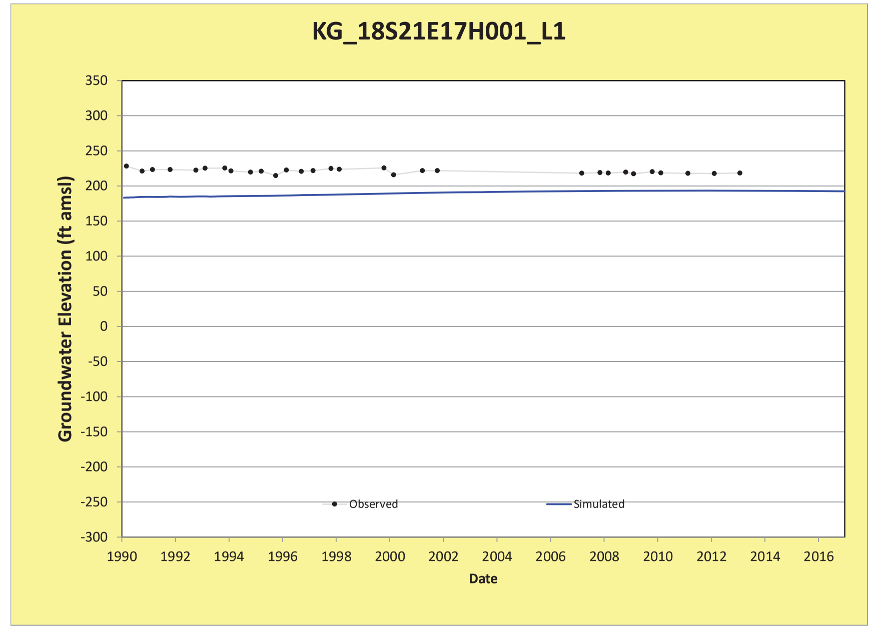
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

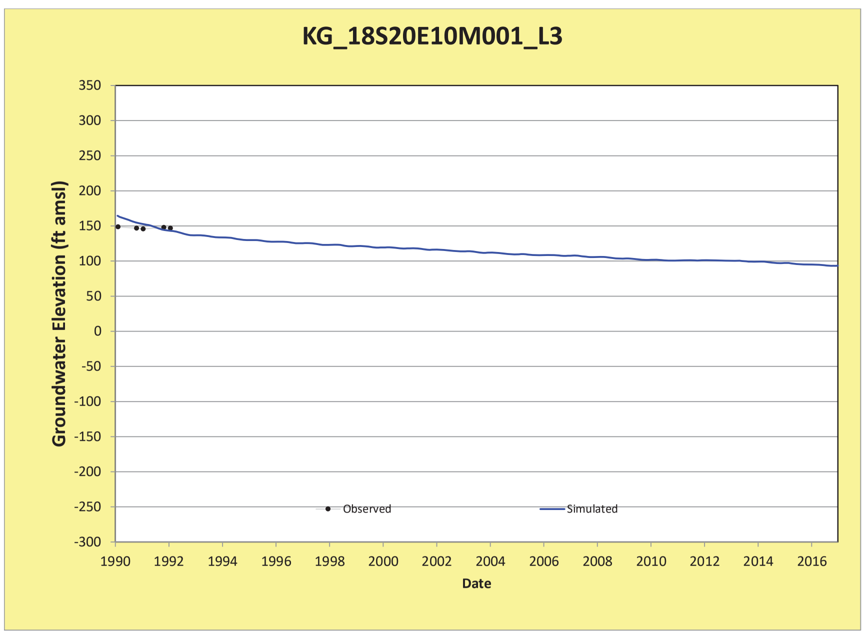

KG_18S19E34E001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



KG_18S20E03K001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



KG_18S21E17H001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



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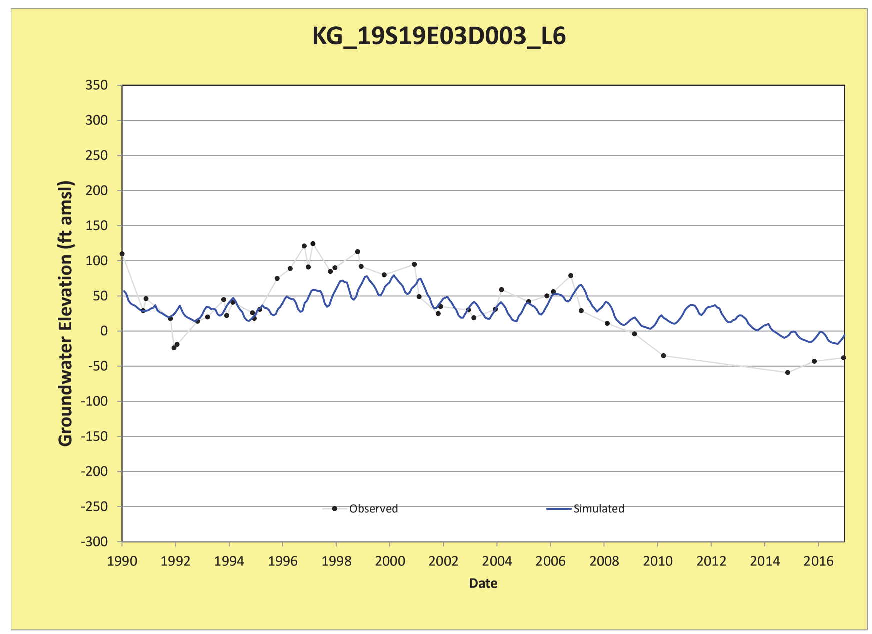
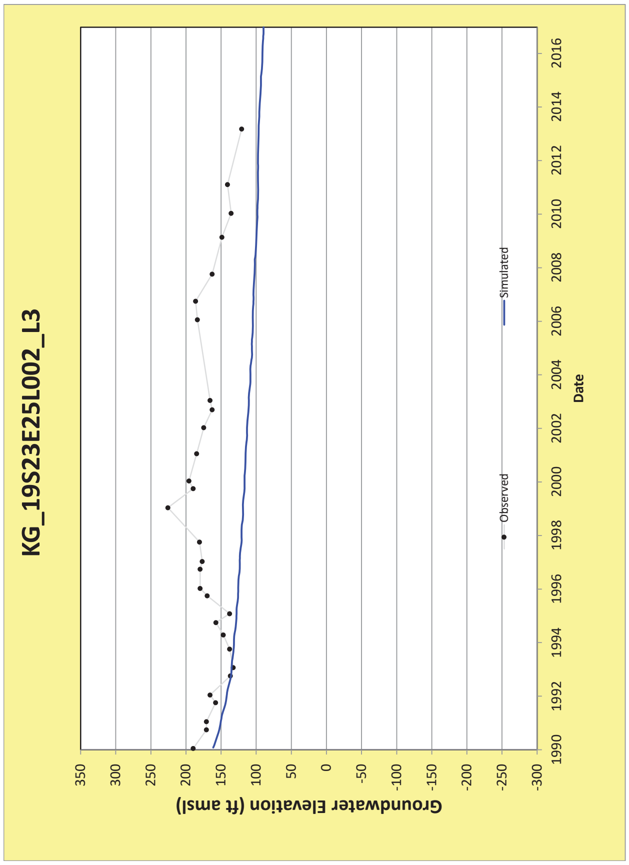
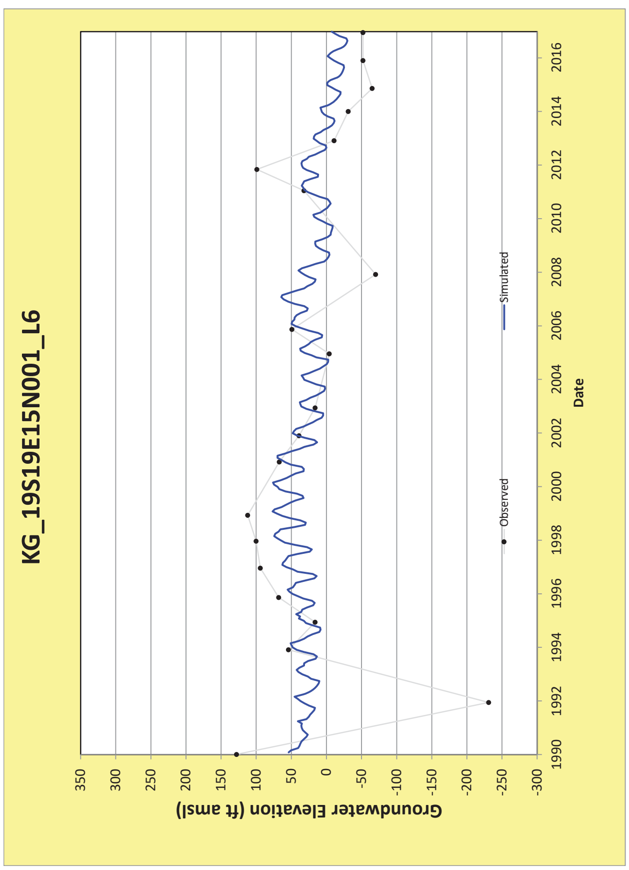
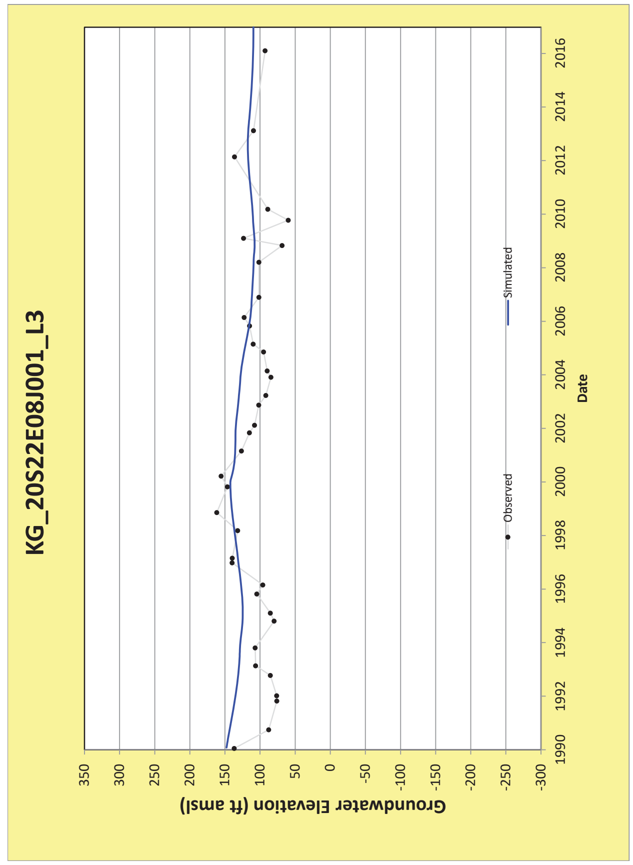
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



KG_19S19E03D003_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KG_19S23E25L002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KG_19S19E15N001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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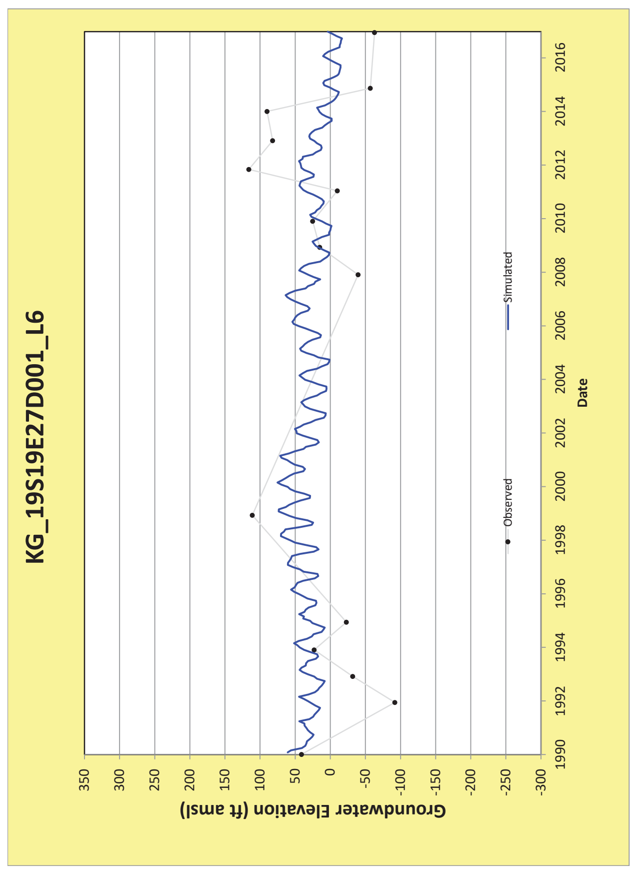
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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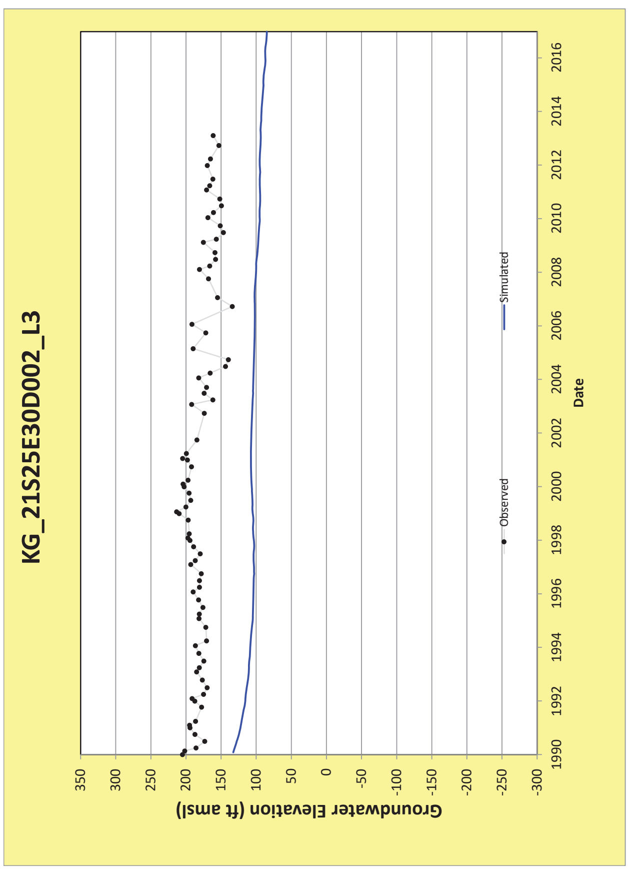
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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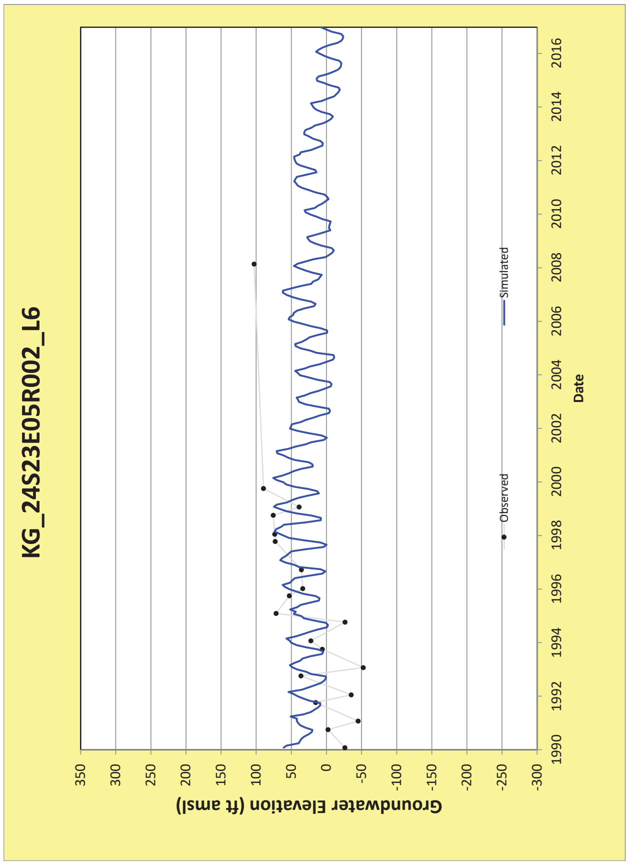
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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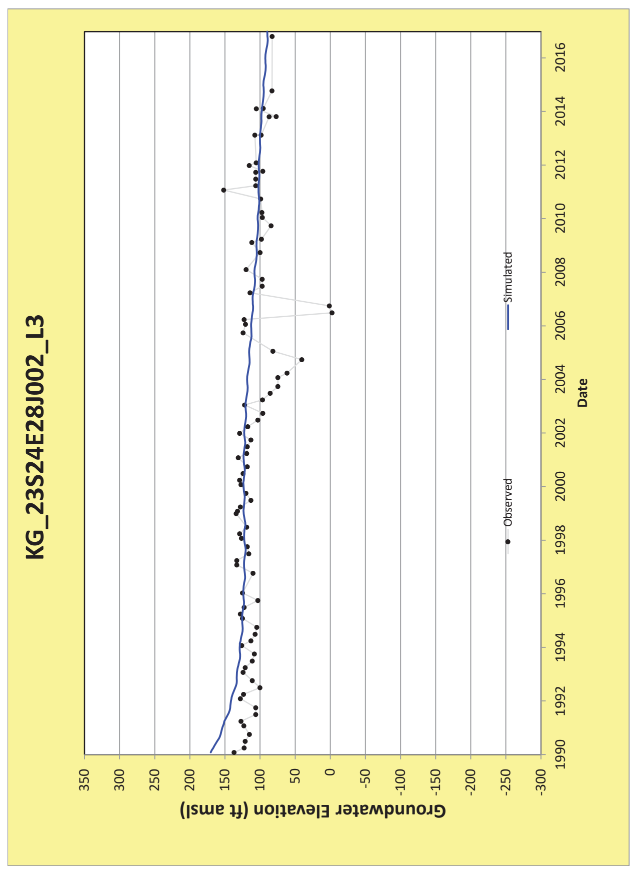
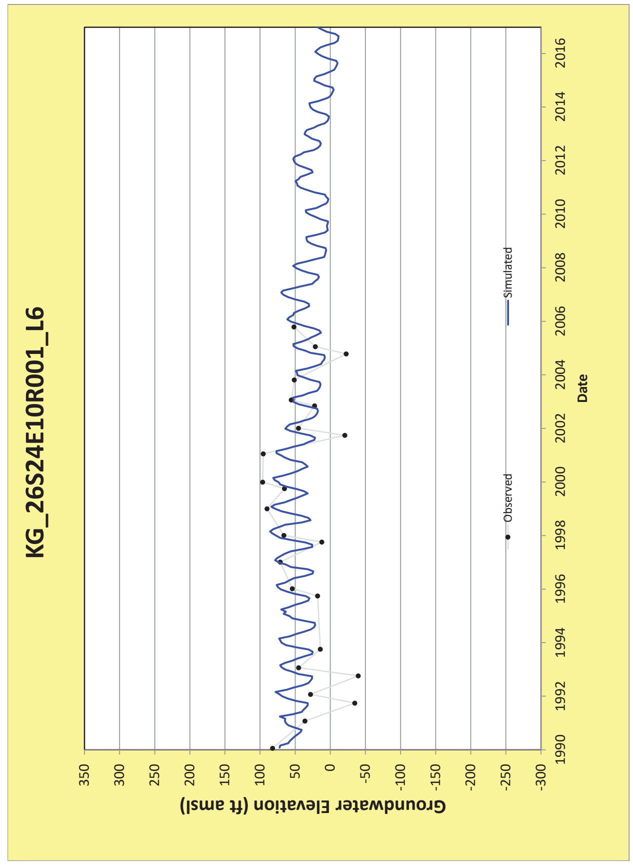
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KG_23S24E28J002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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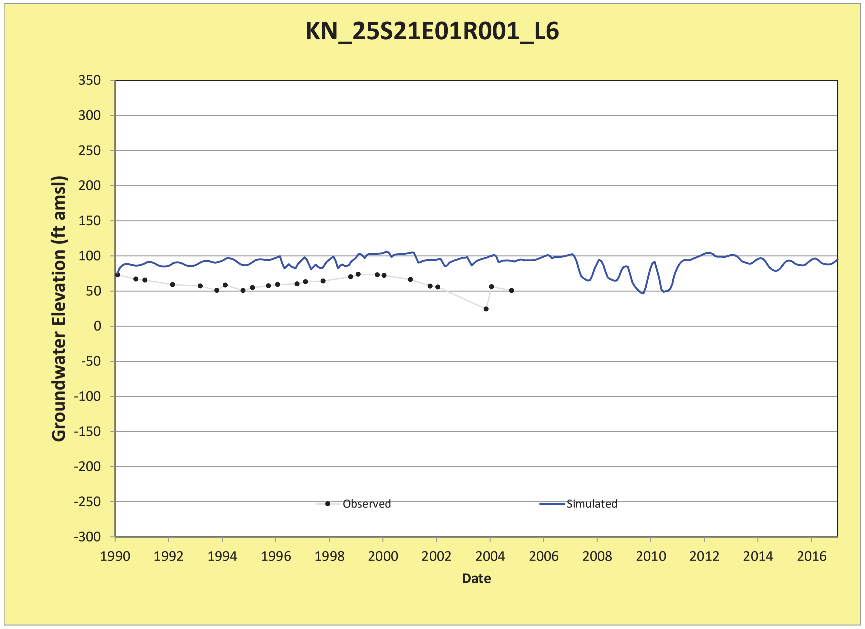
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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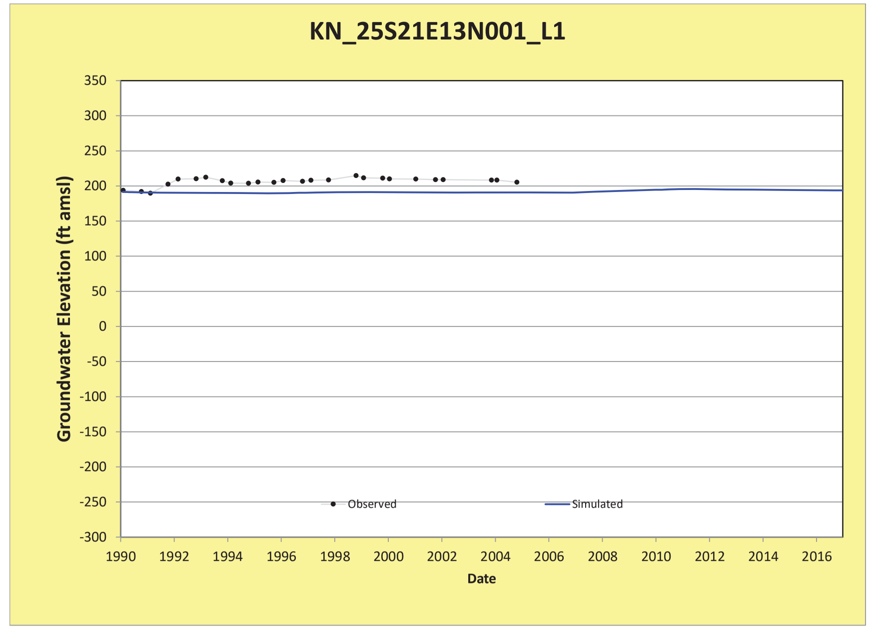
Date
Observed
Simulated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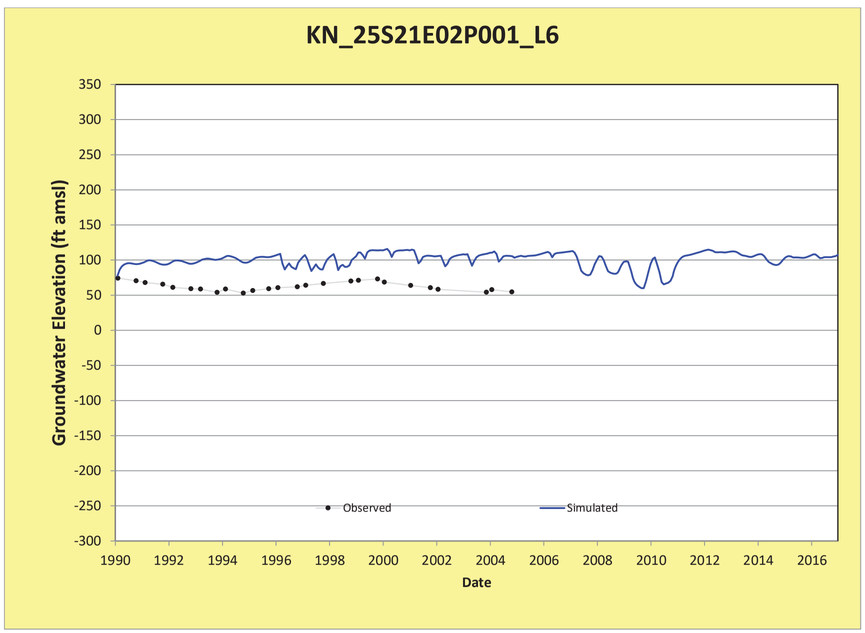
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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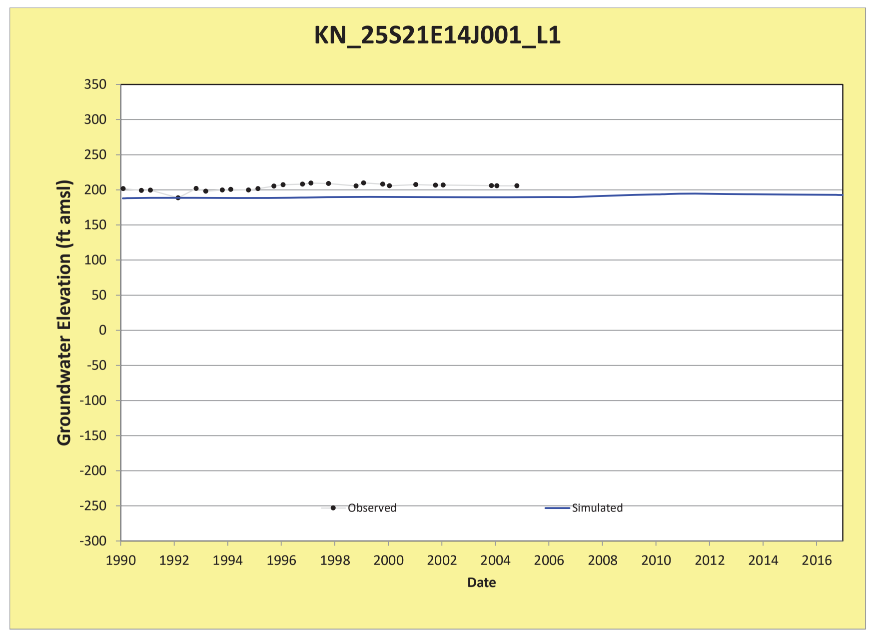
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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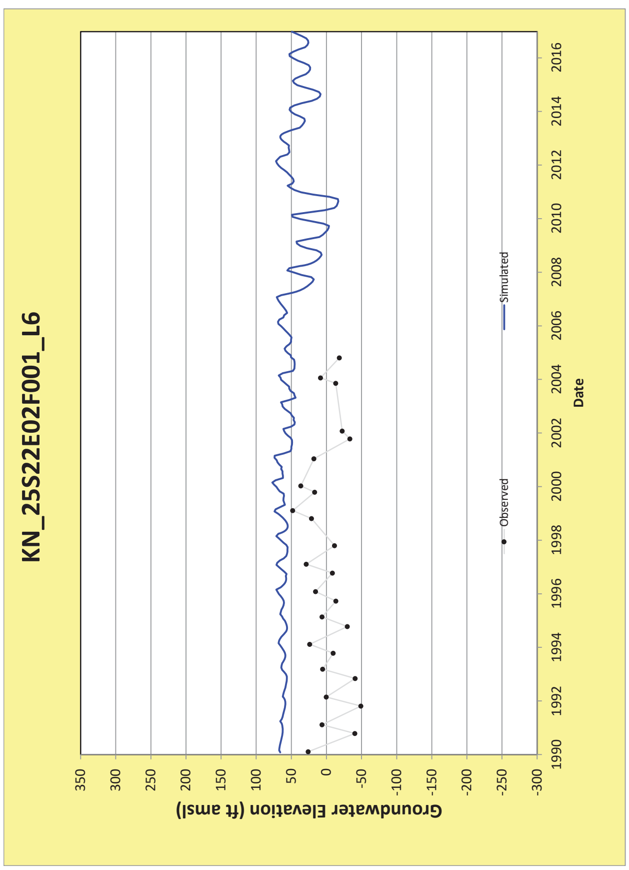
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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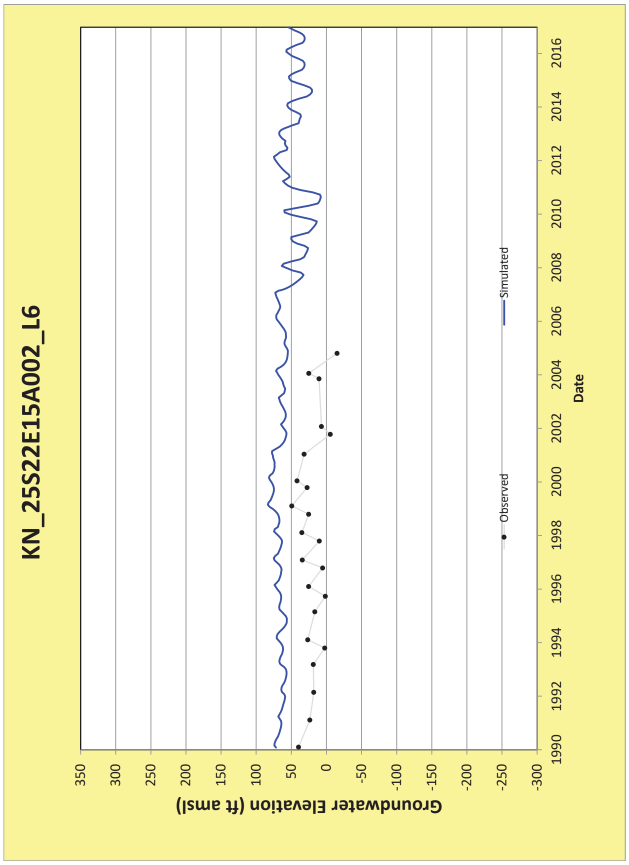
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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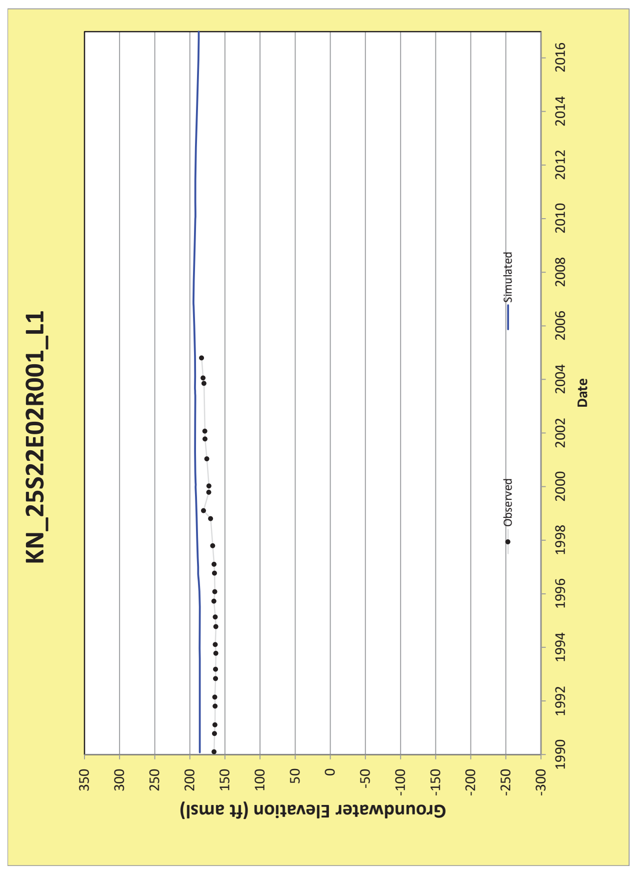
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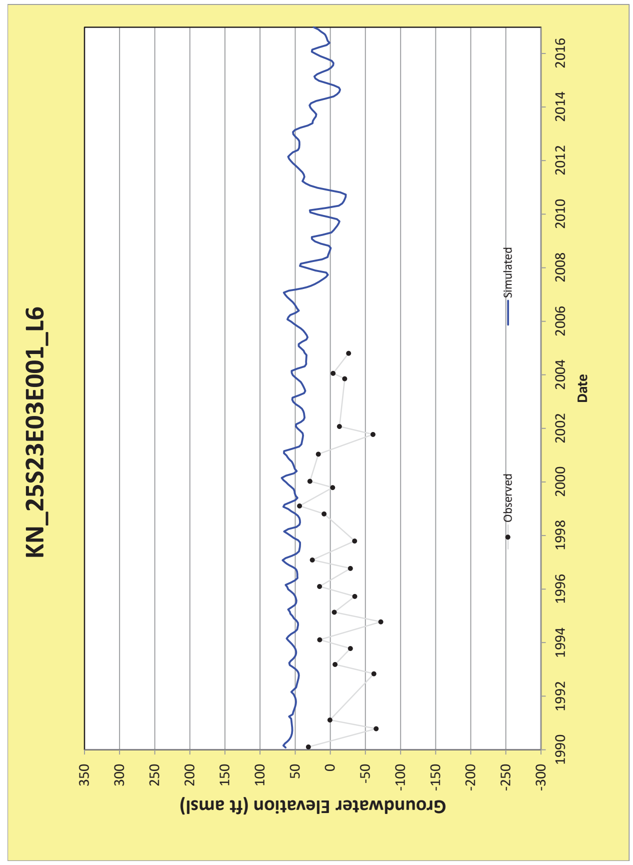
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Groundwater Elevation (ft amsl)
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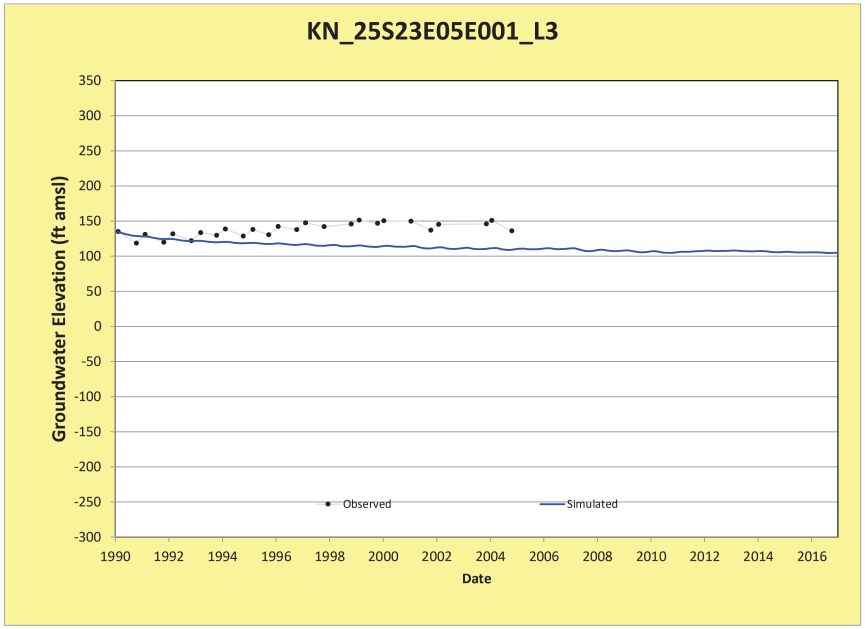
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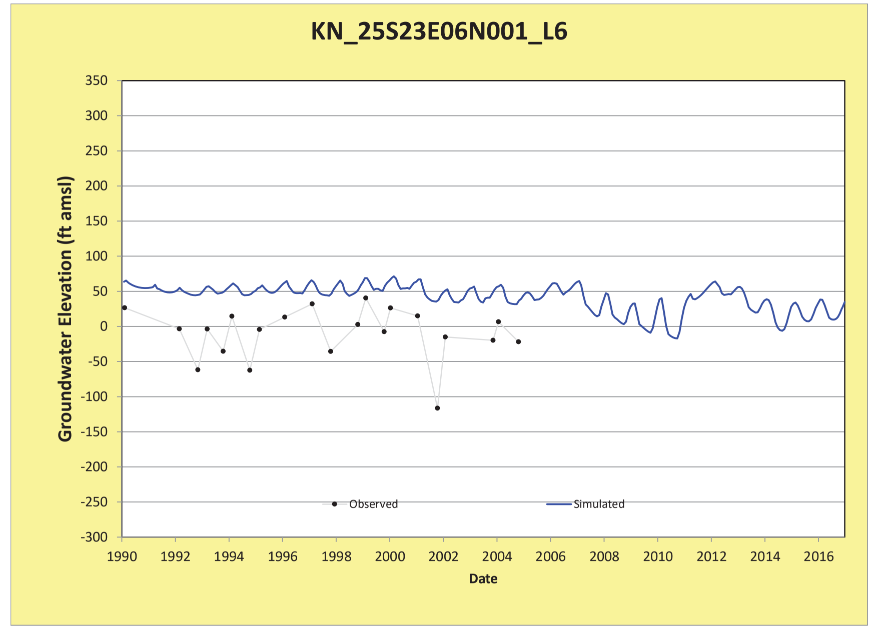
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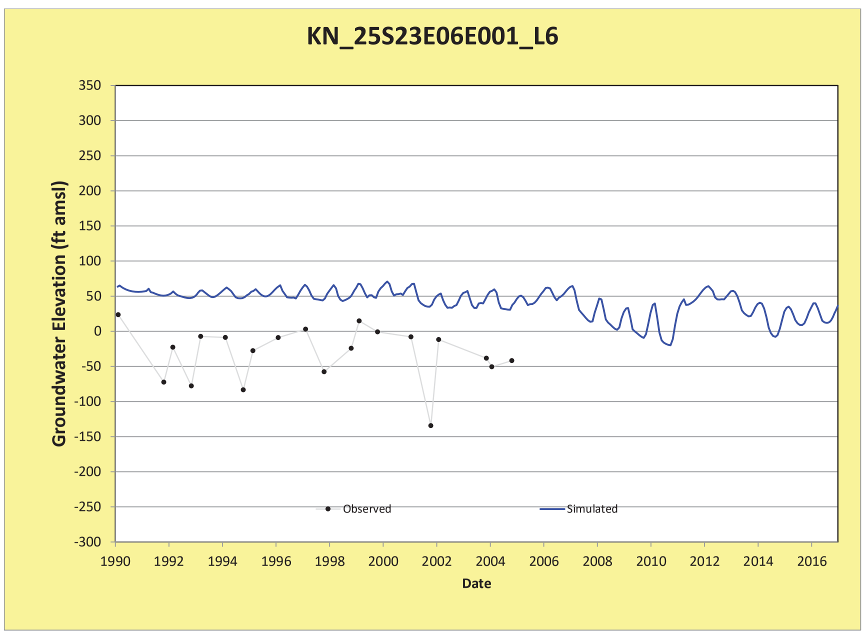
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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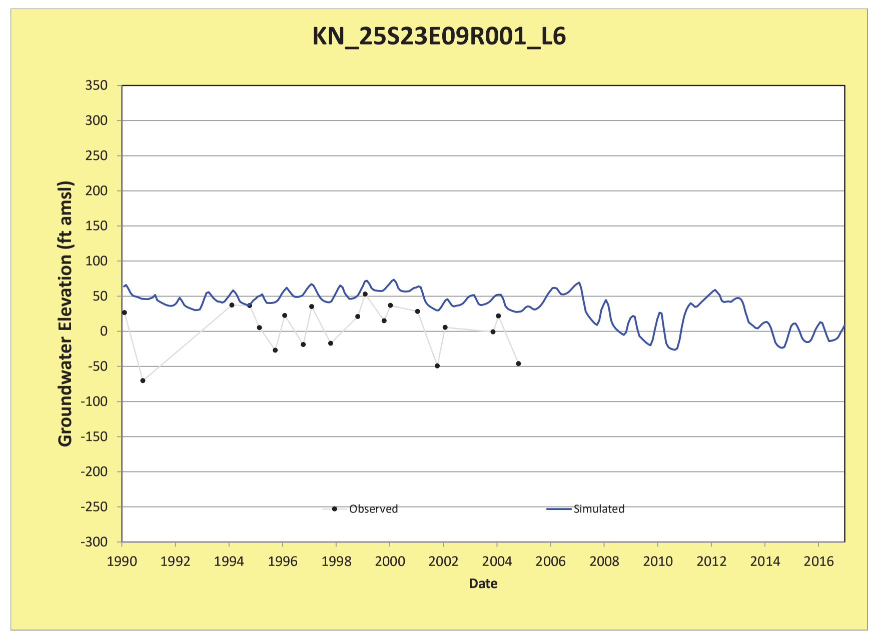
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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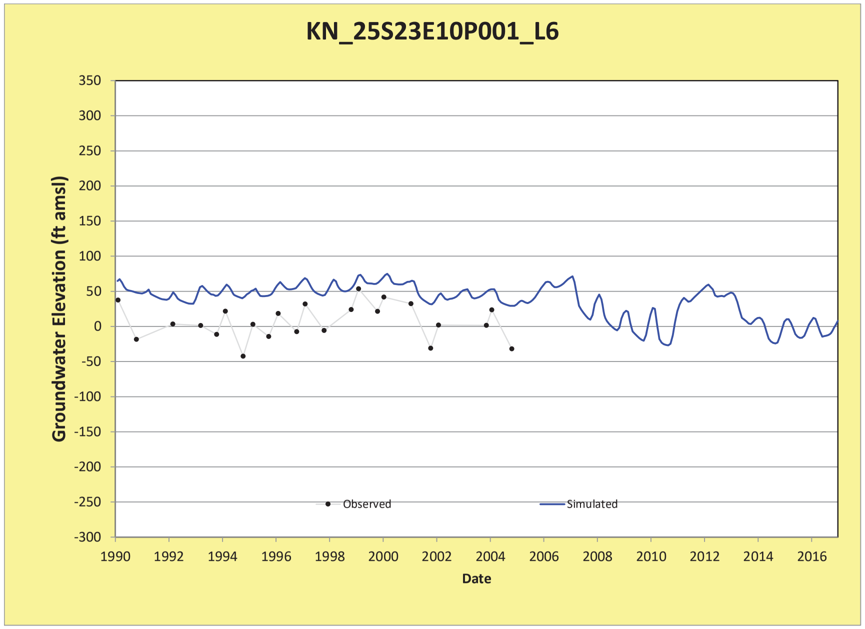
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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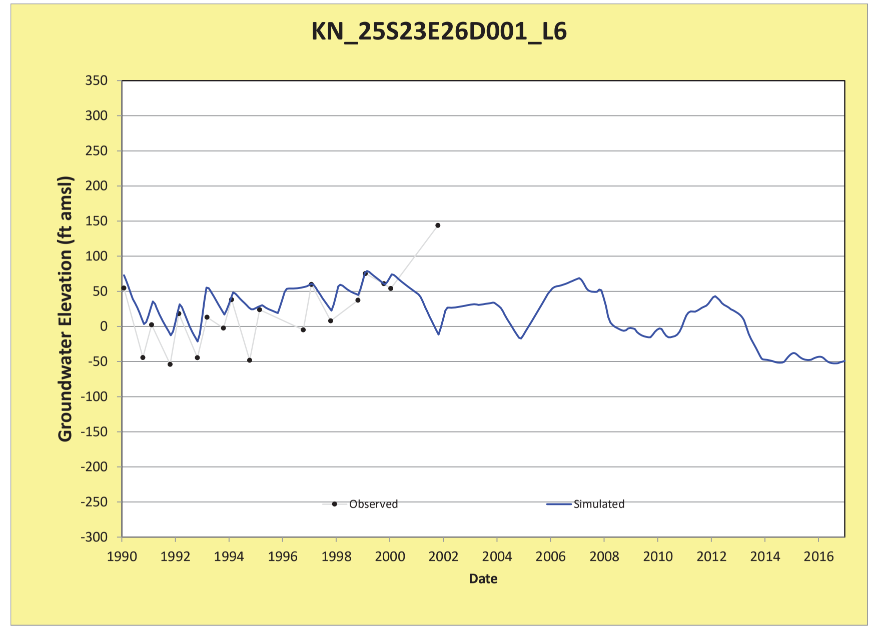
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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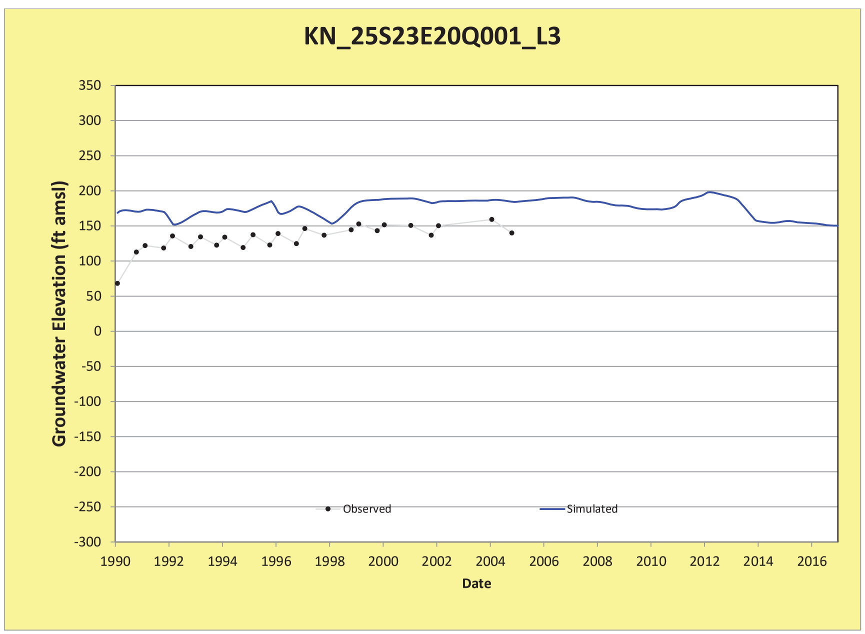
Simulated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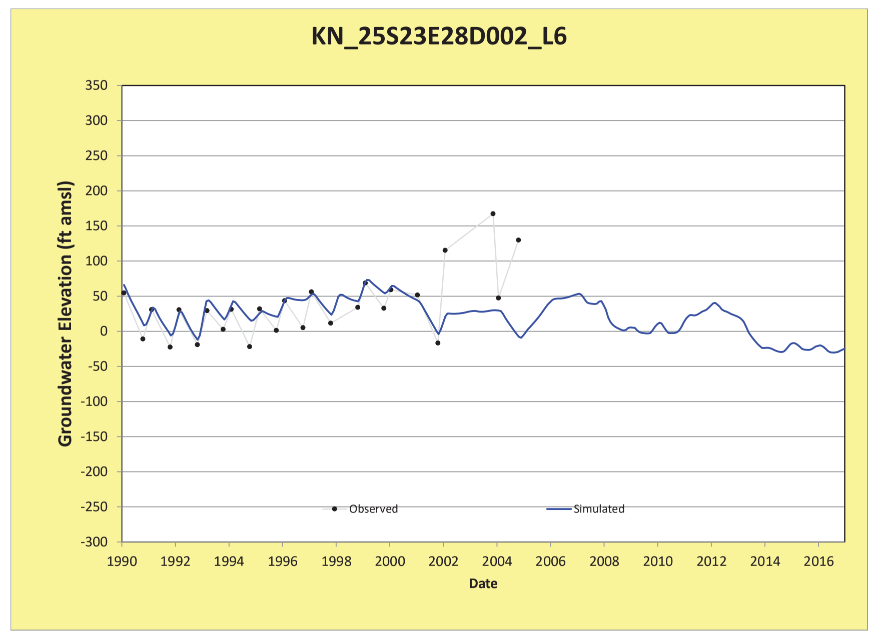
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Date
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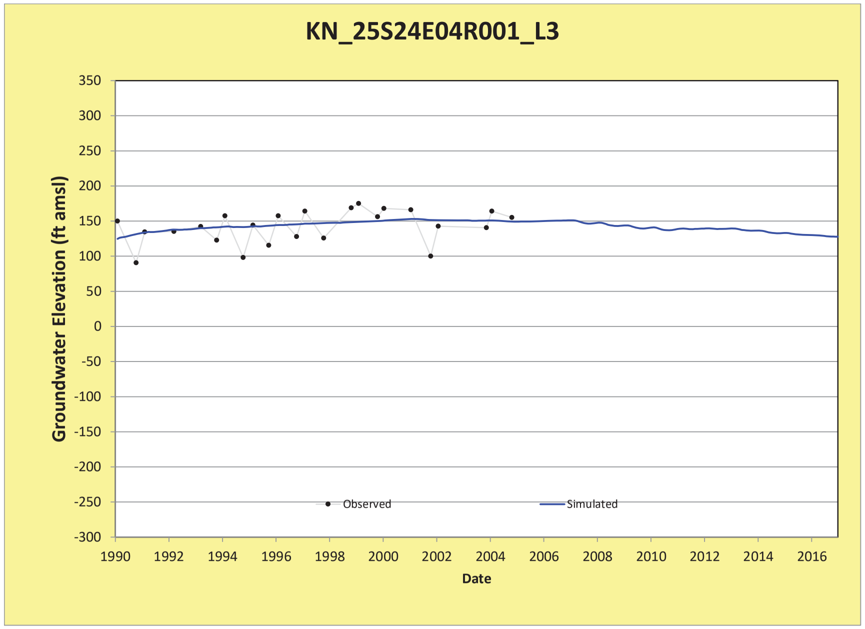
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Date
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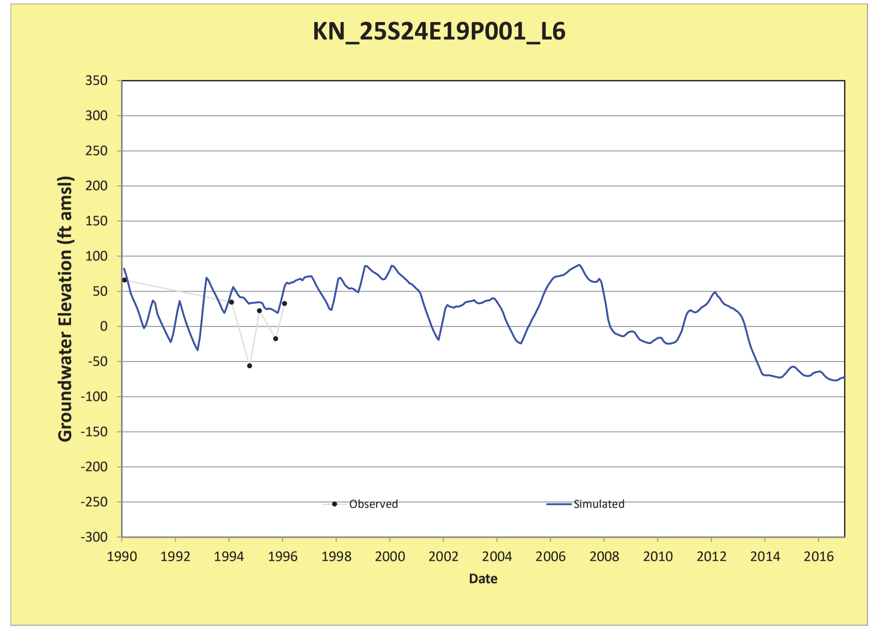
Simulated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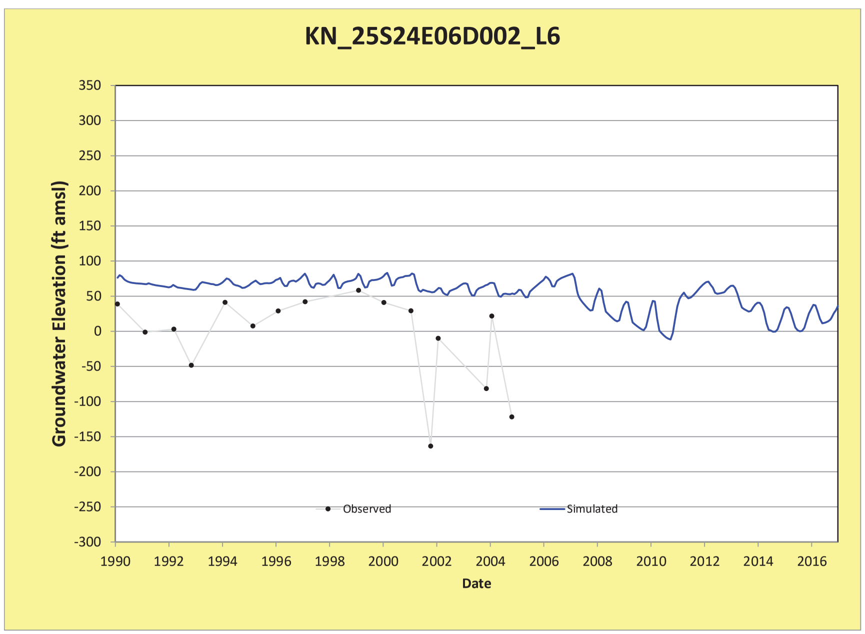
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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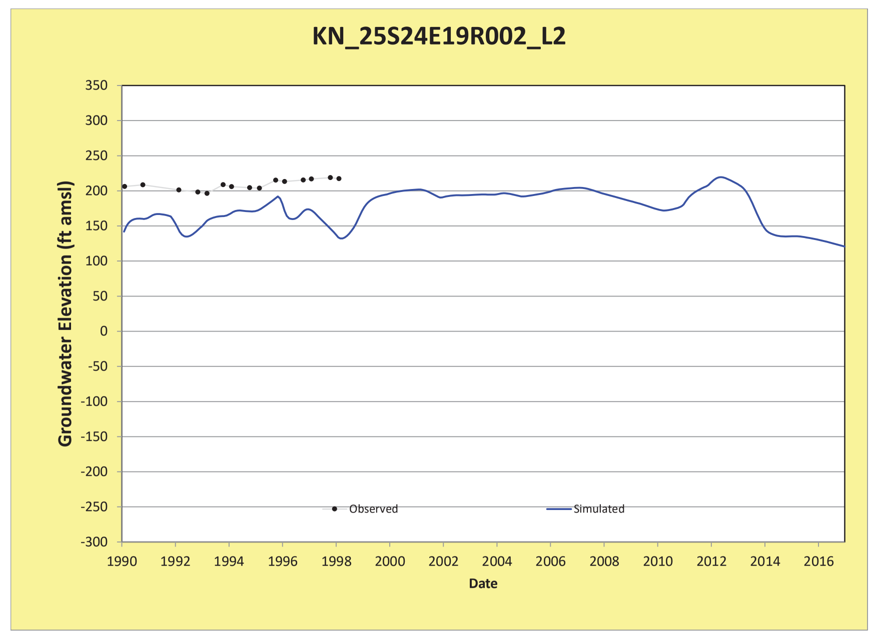
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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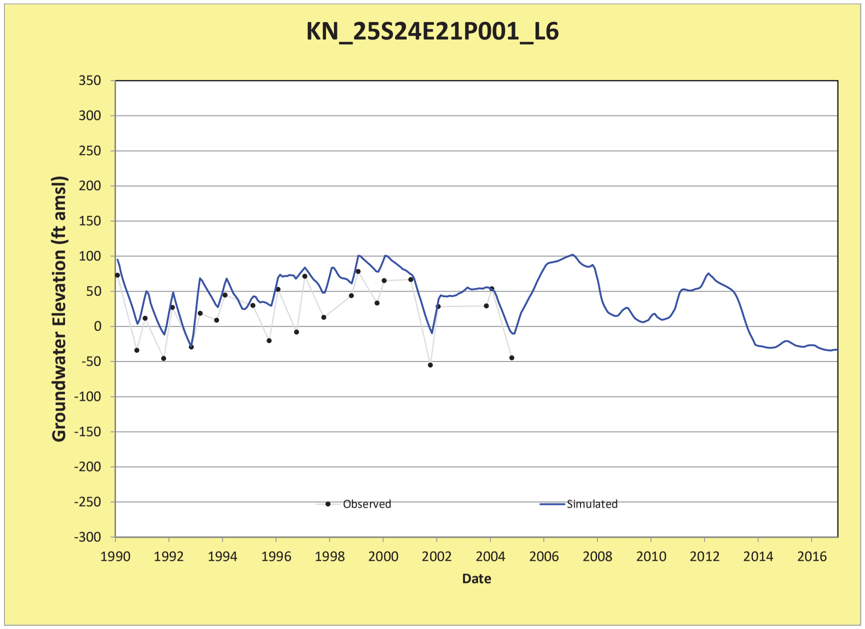
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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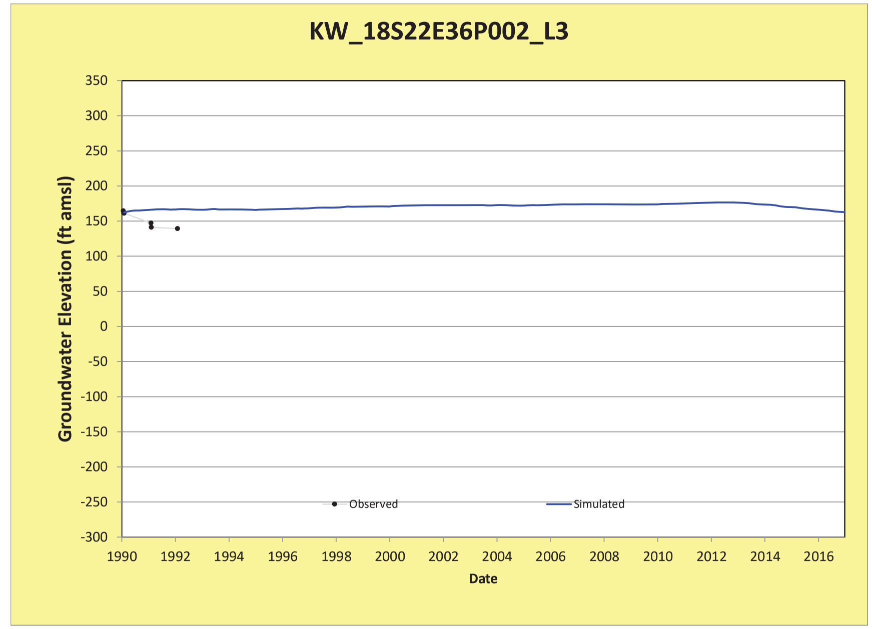
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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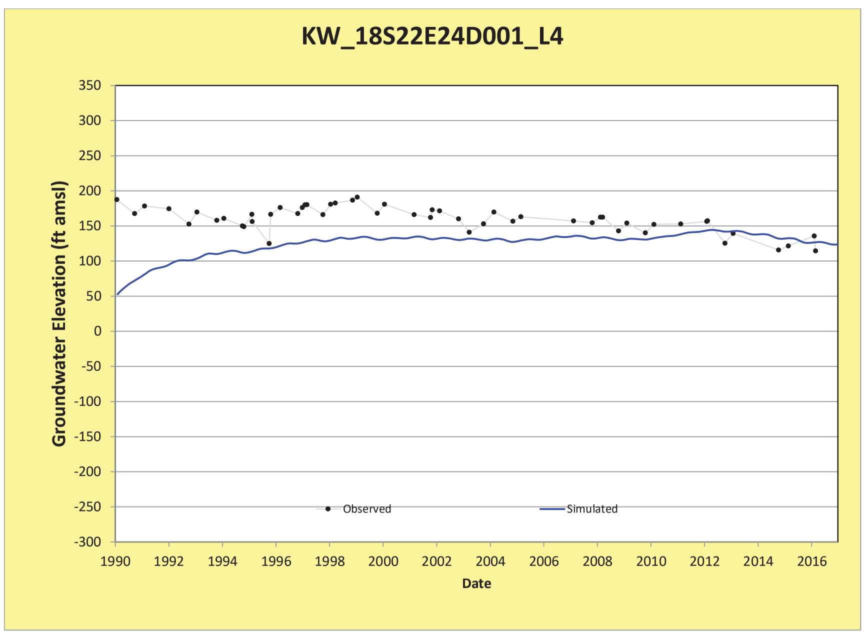
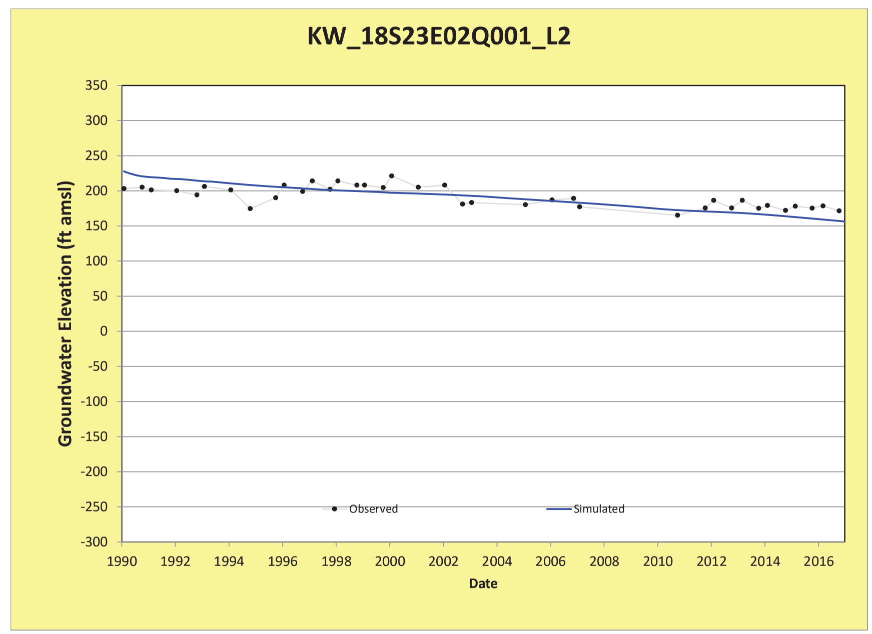
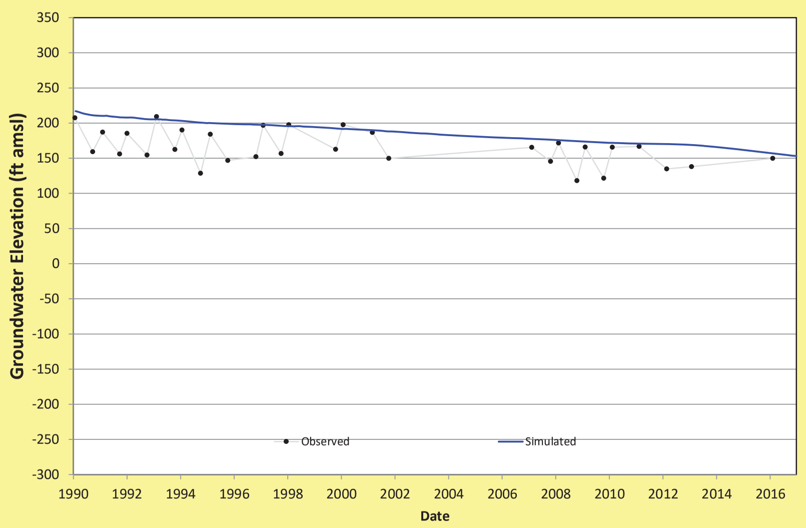
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_18S22E24D001_L4
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_18S23E02Q001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

KW_18S23E04Q001_L3



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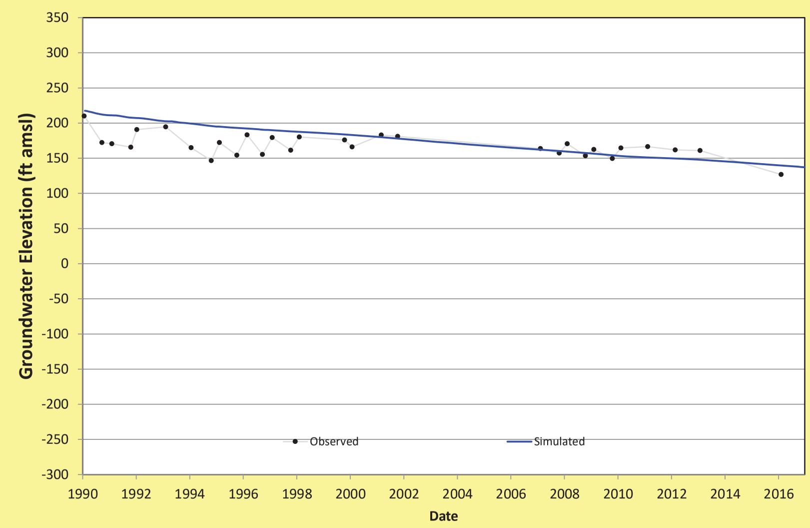

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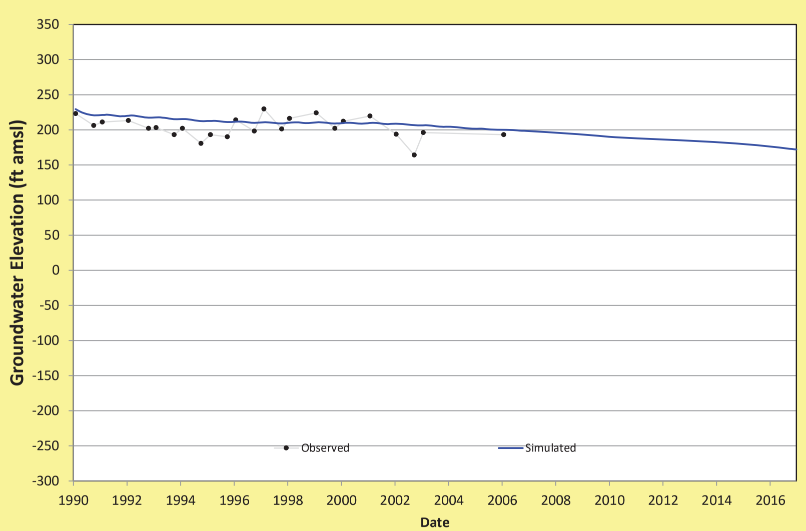

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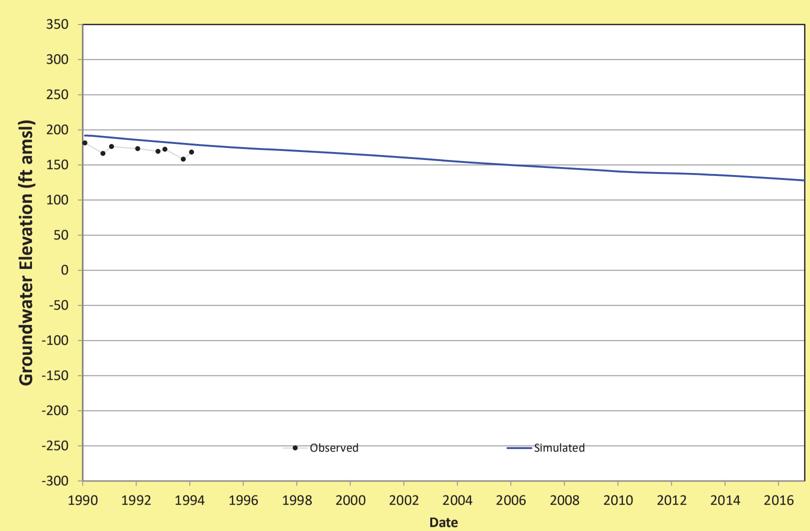

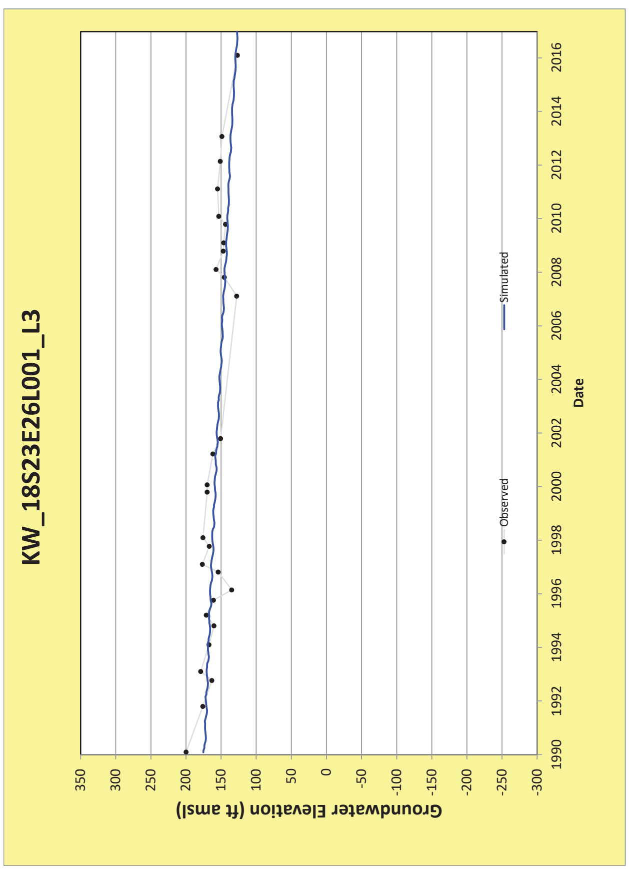
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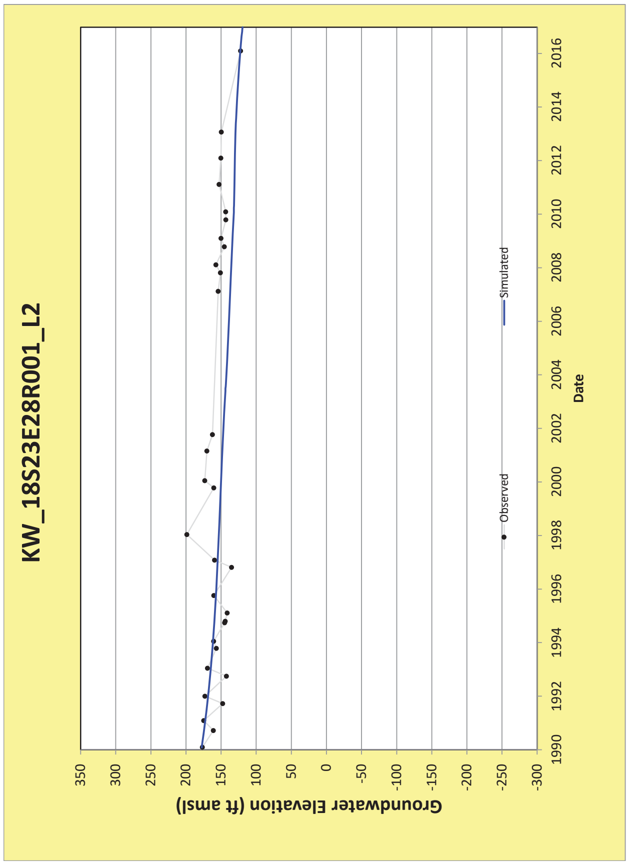
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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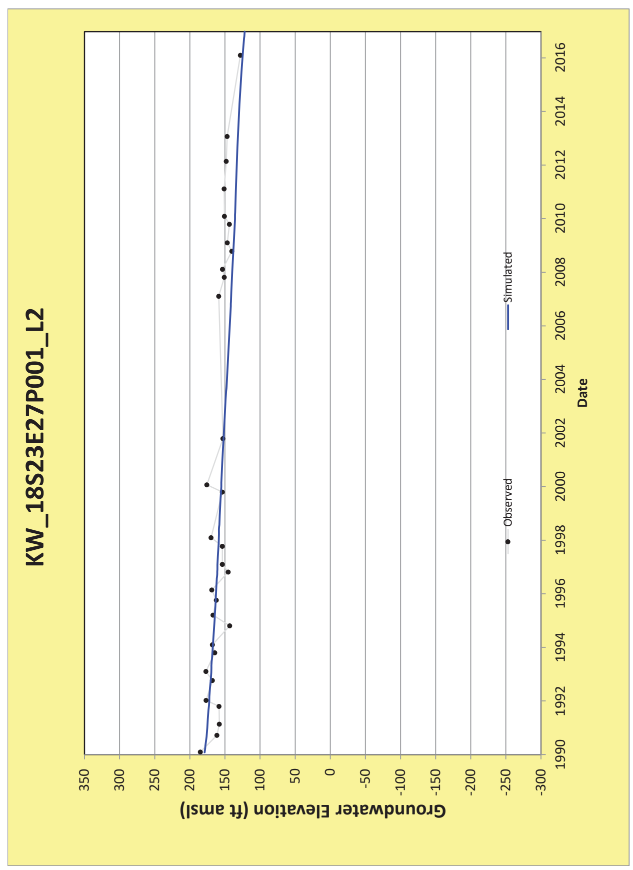
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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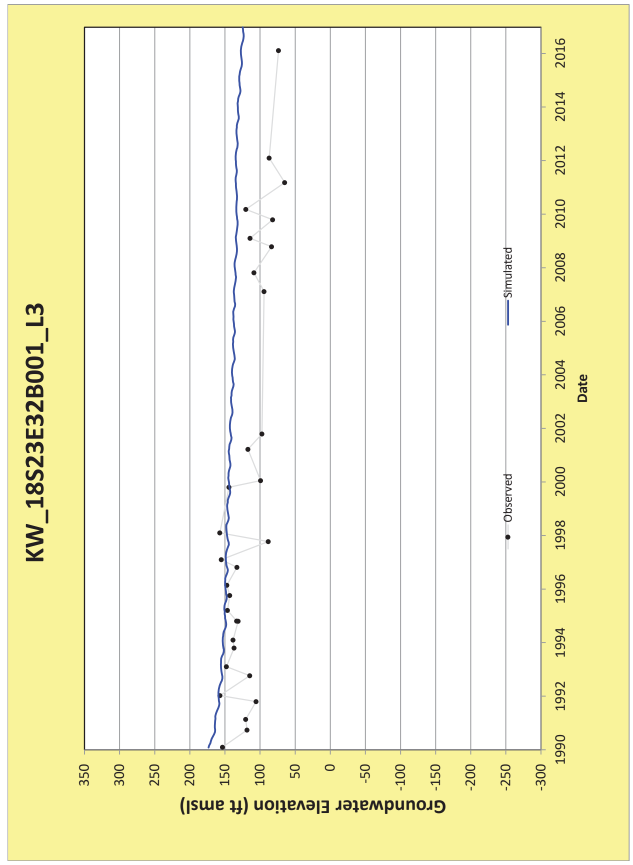
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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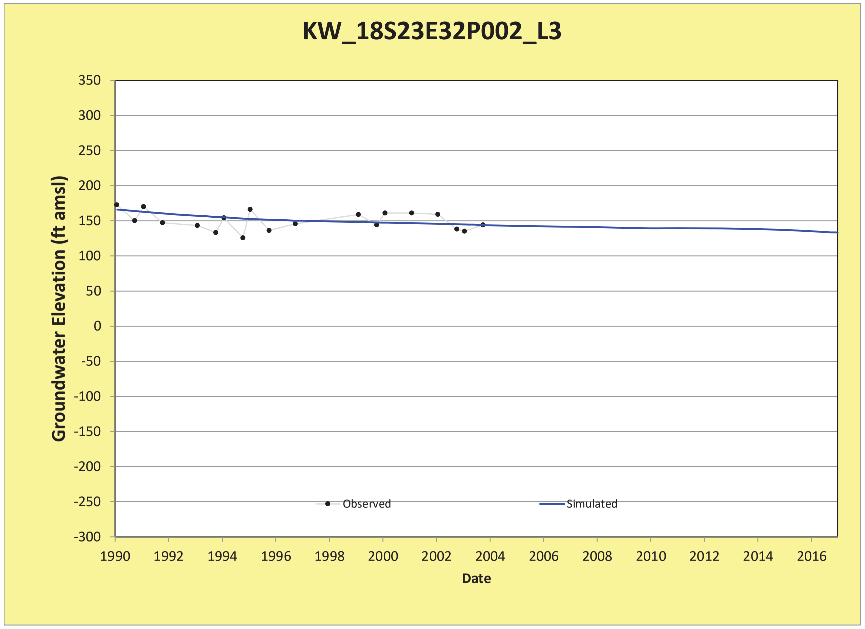
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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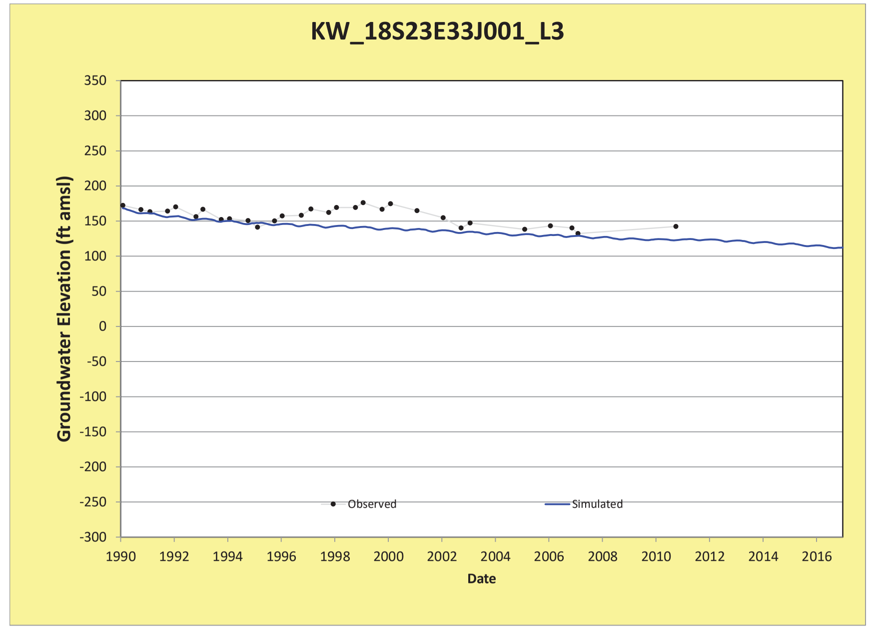
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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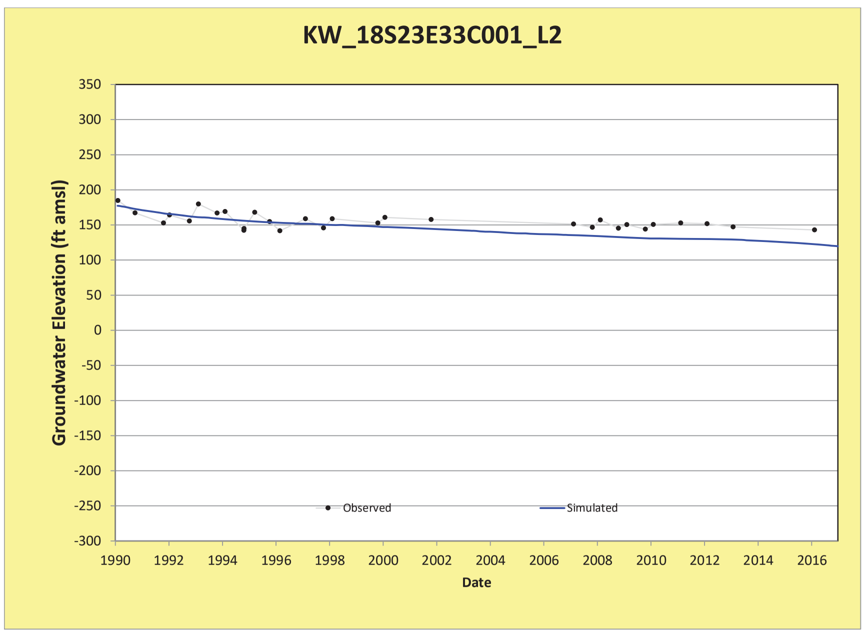
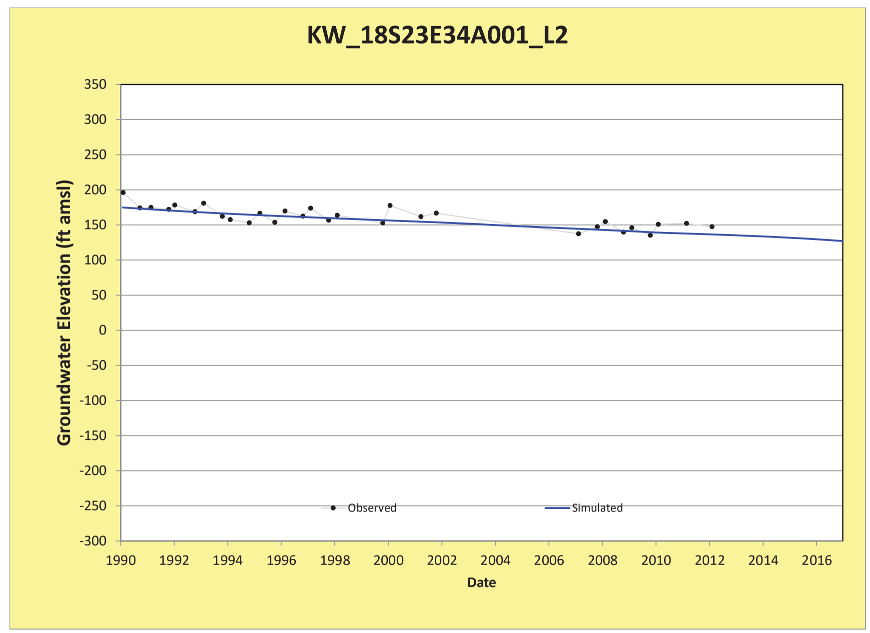
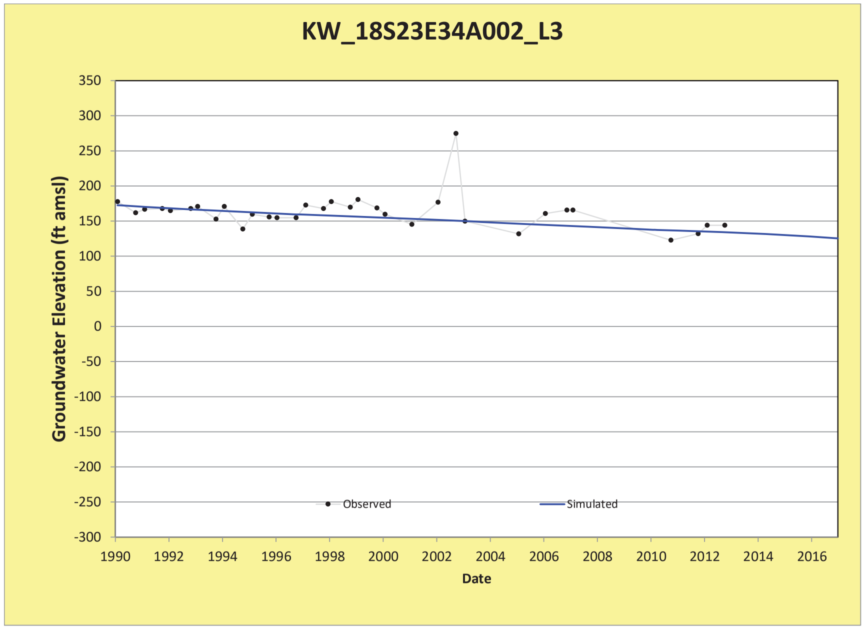
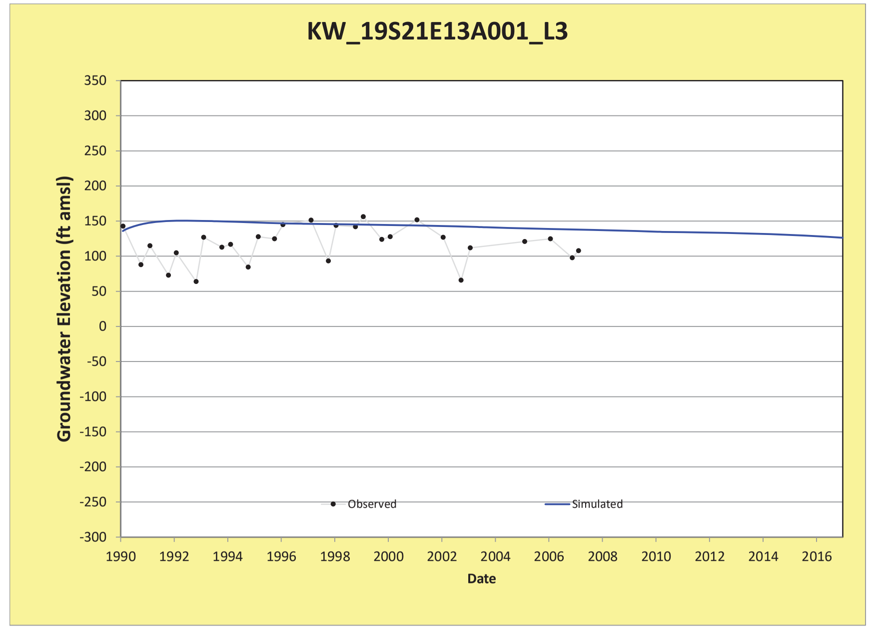
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_18S23E33C001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

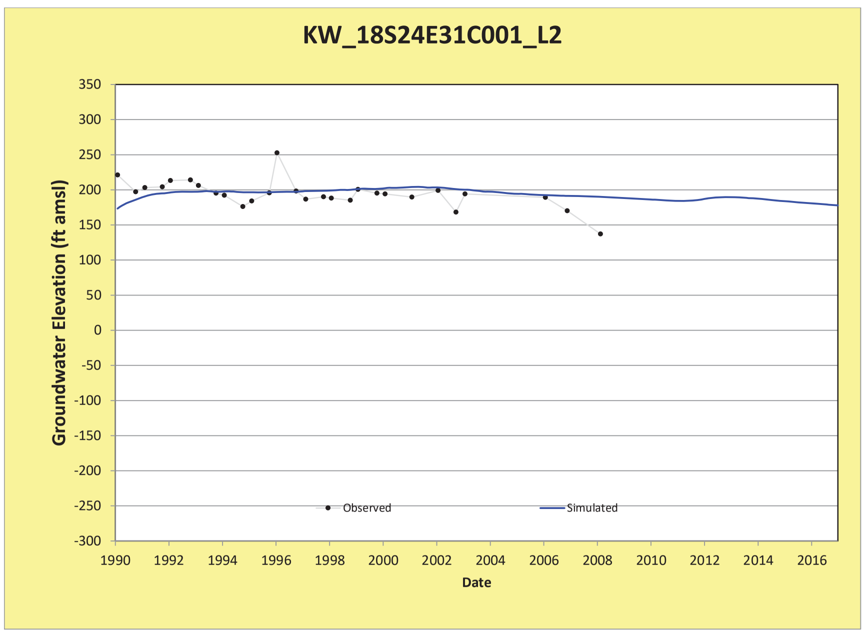

KW_18S23E34A001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



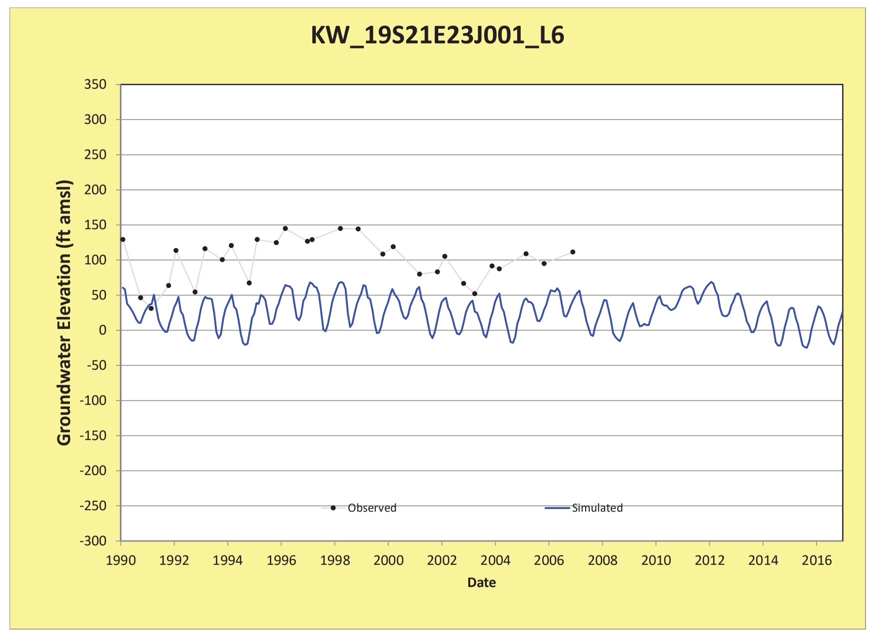
KW_18S23E34A002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



KW_19S21E13A001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

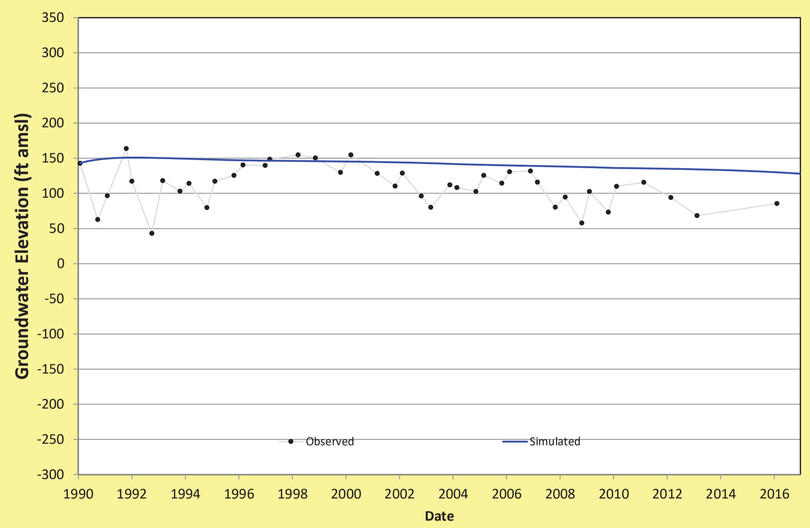


KW_18S24E31C001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

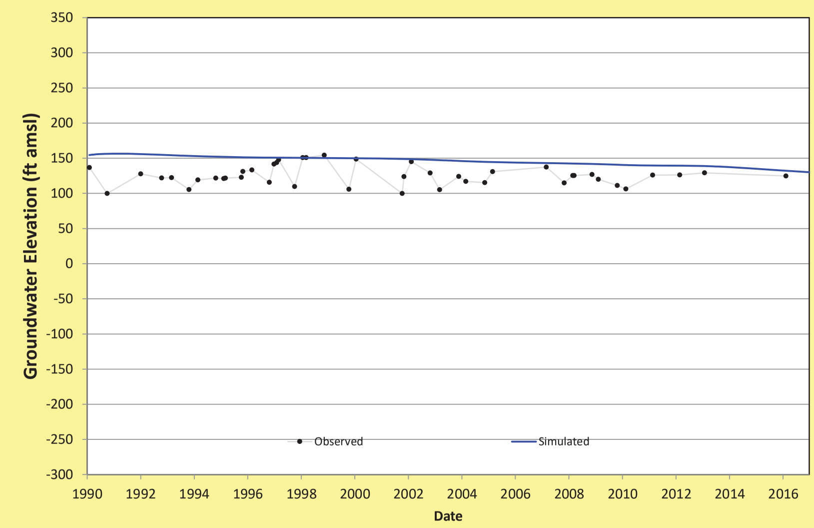


KW_19S21E23J001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

KW_19S21E24H001_L3

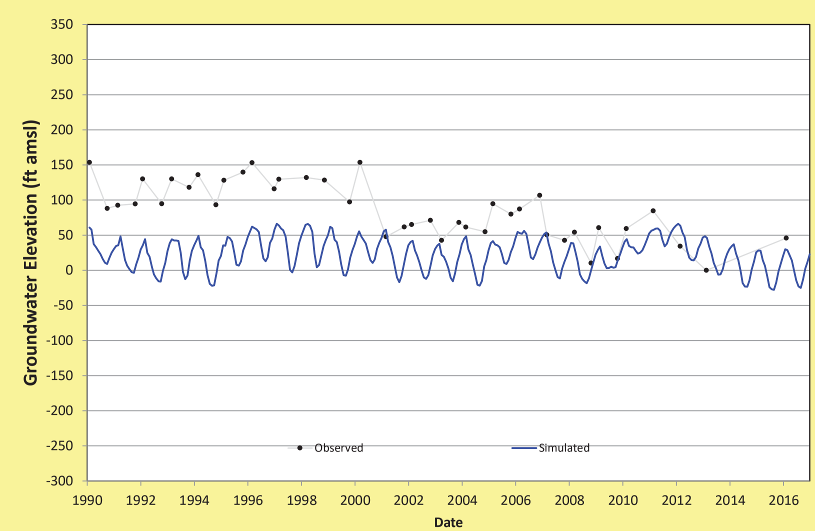


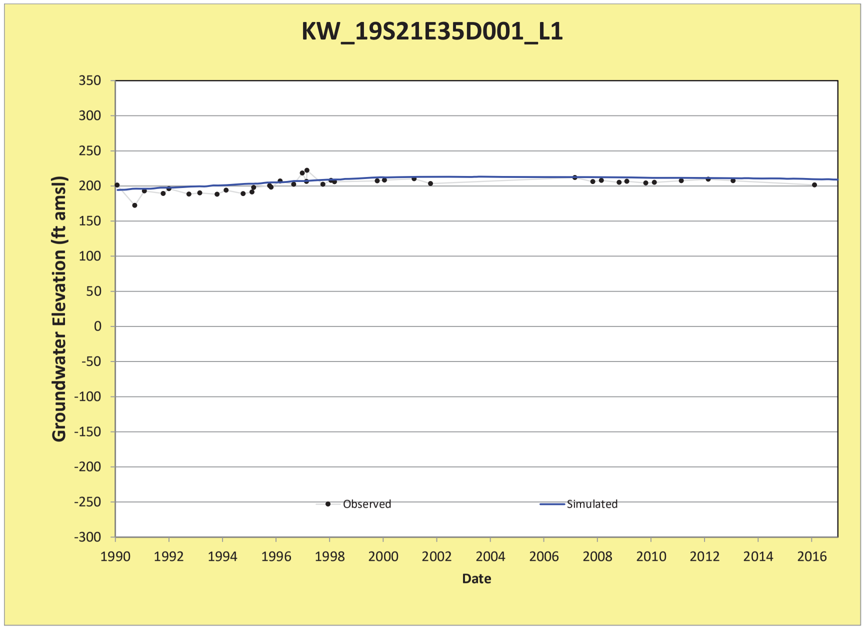
KW_19S21E25J001_L3



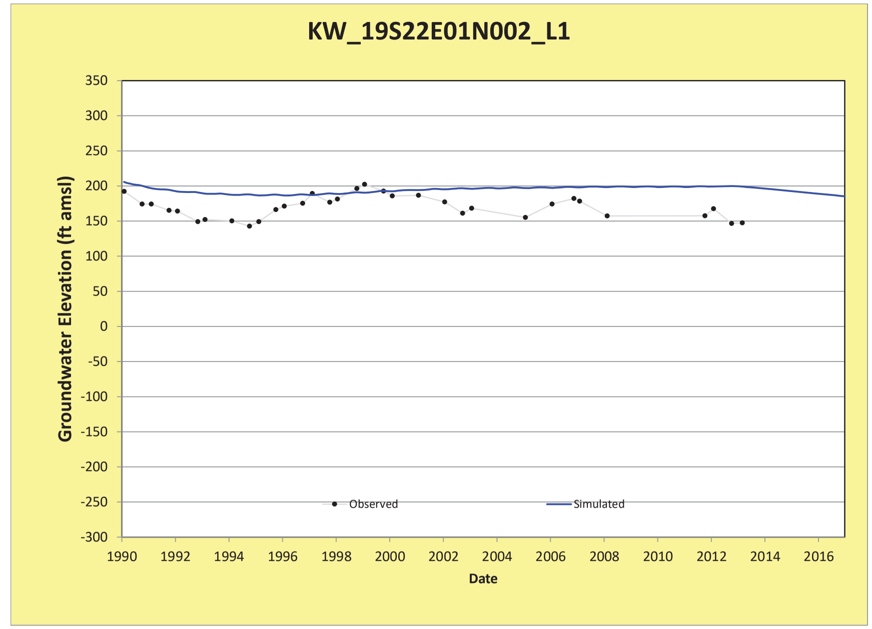
KW_19S21E24L001_L3

KW_19S21E26B001_L6

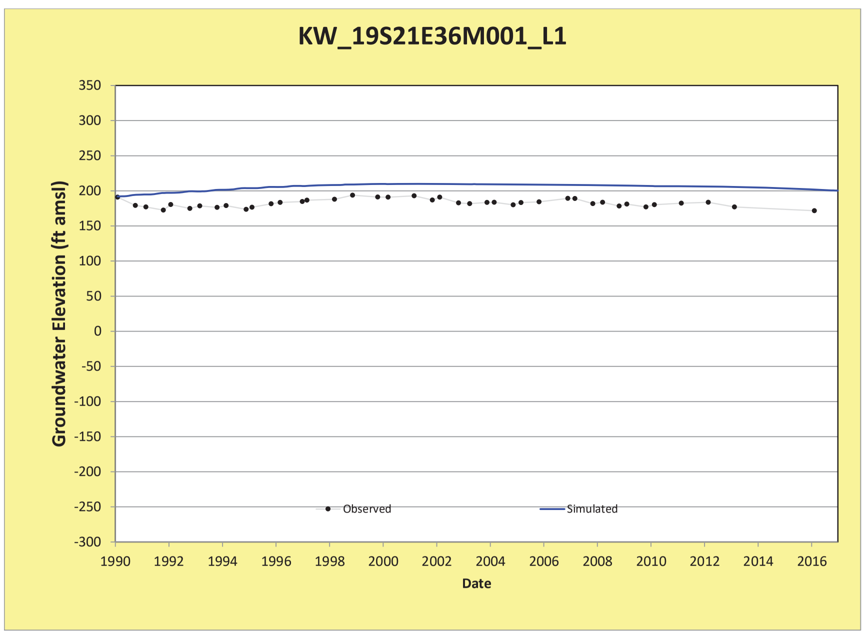




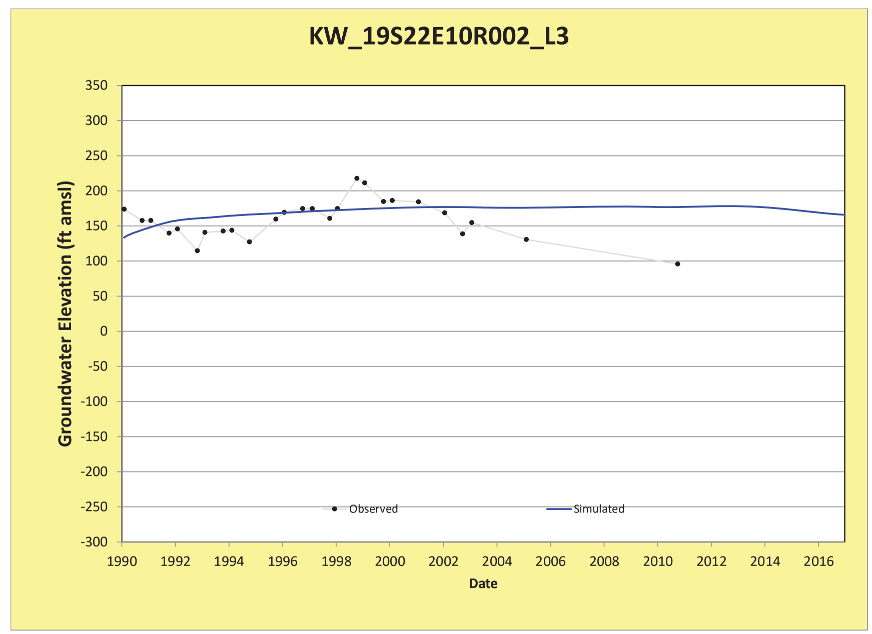
KW_19S21E35D001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



KW_19S22E01N002_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

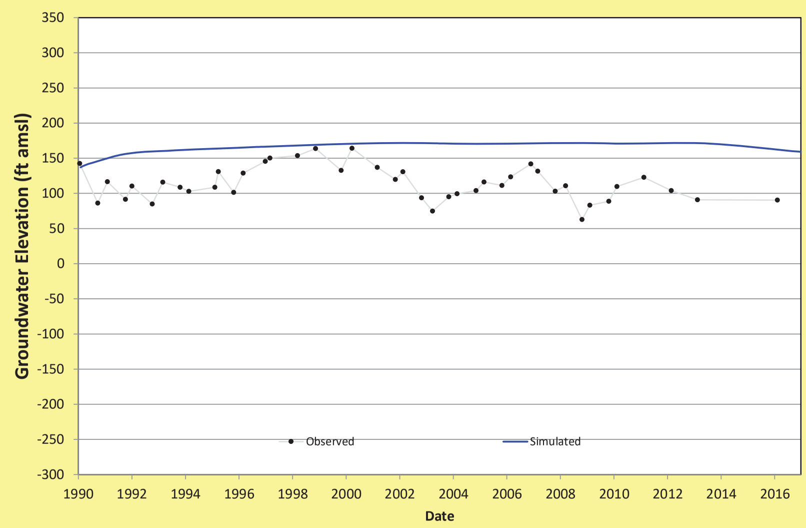


KW_19S21E36M001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

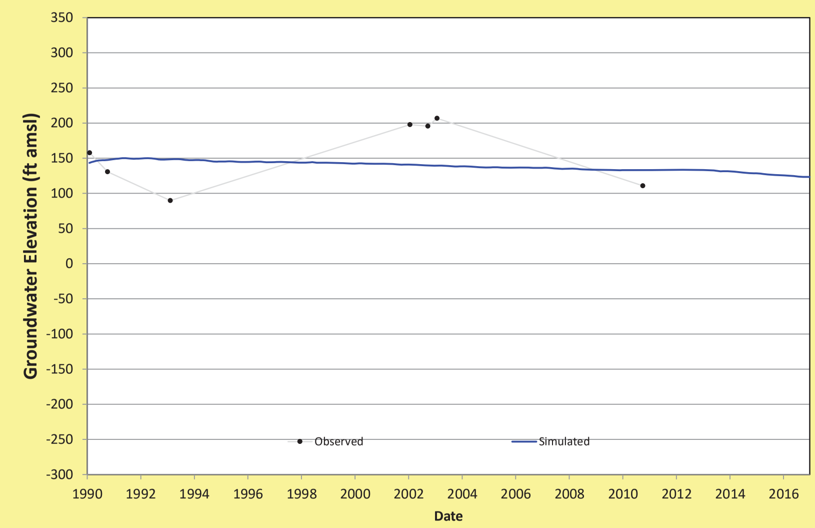


KW_19S22E10R002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

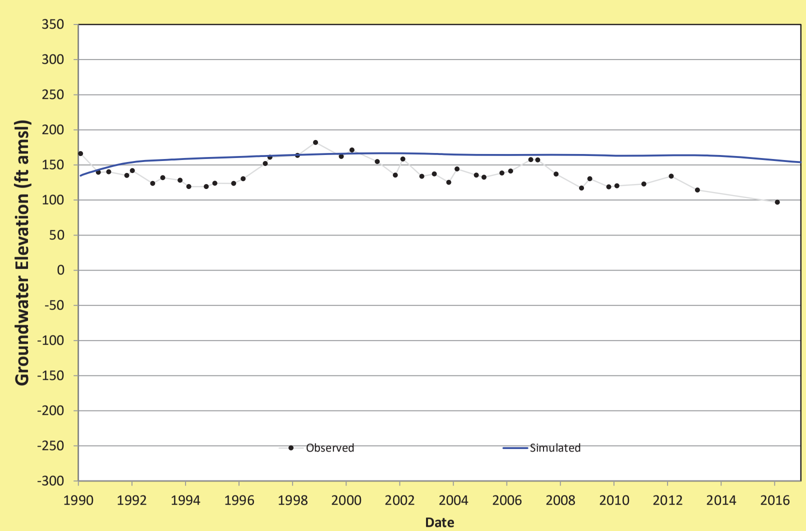
KW_19S22E14M001_L3



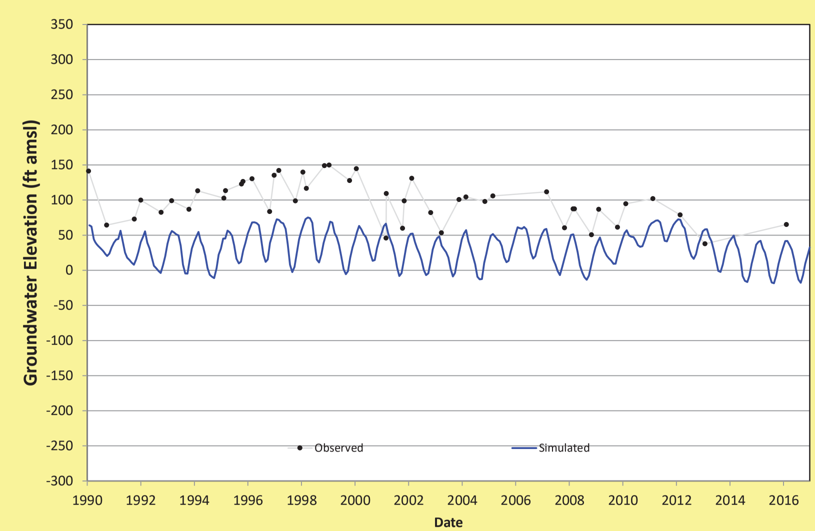
KW_19S22E17E001_L3

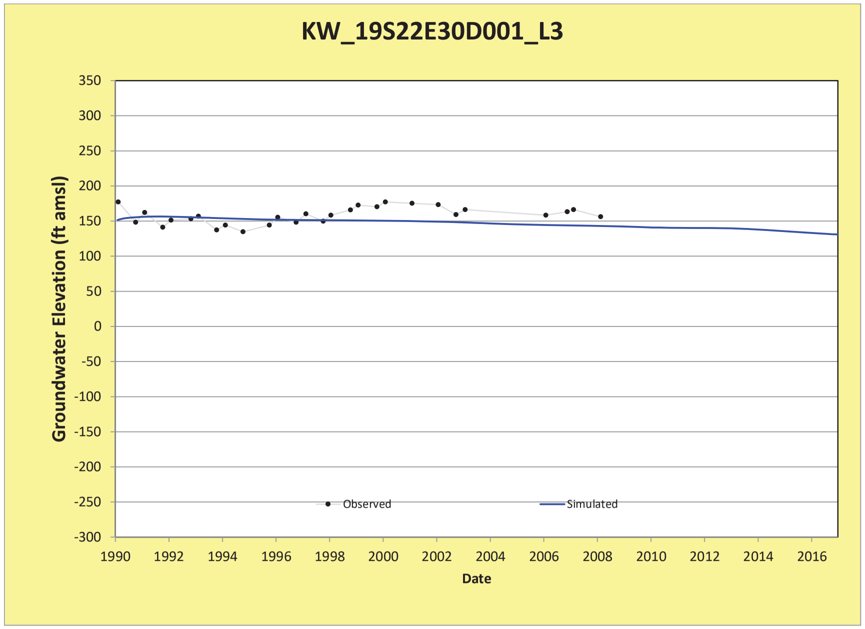


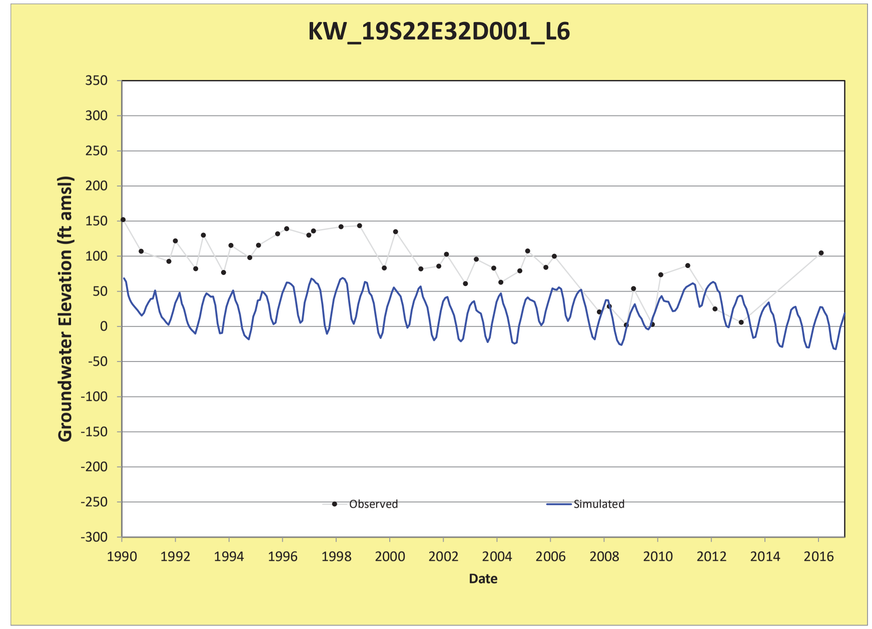
KW_19S22E15M001_L3

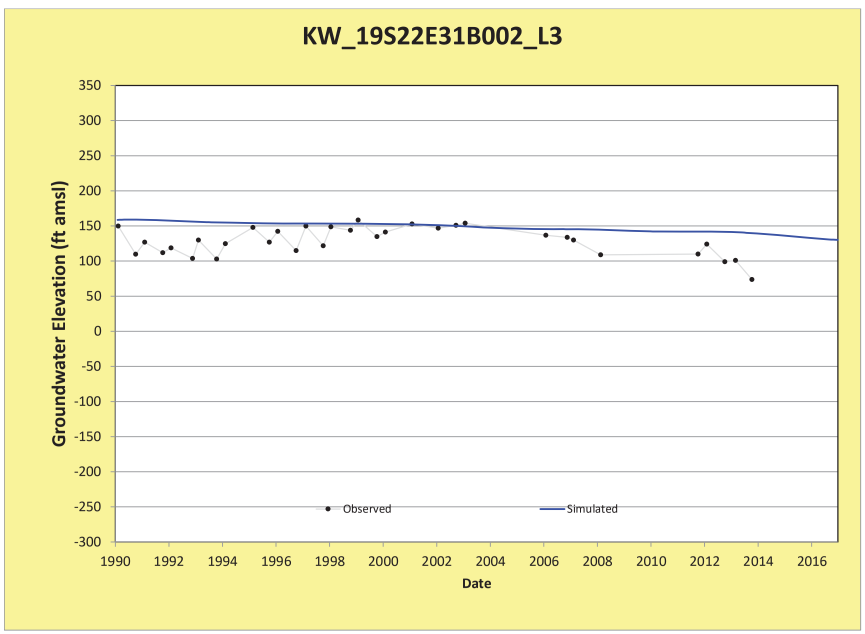


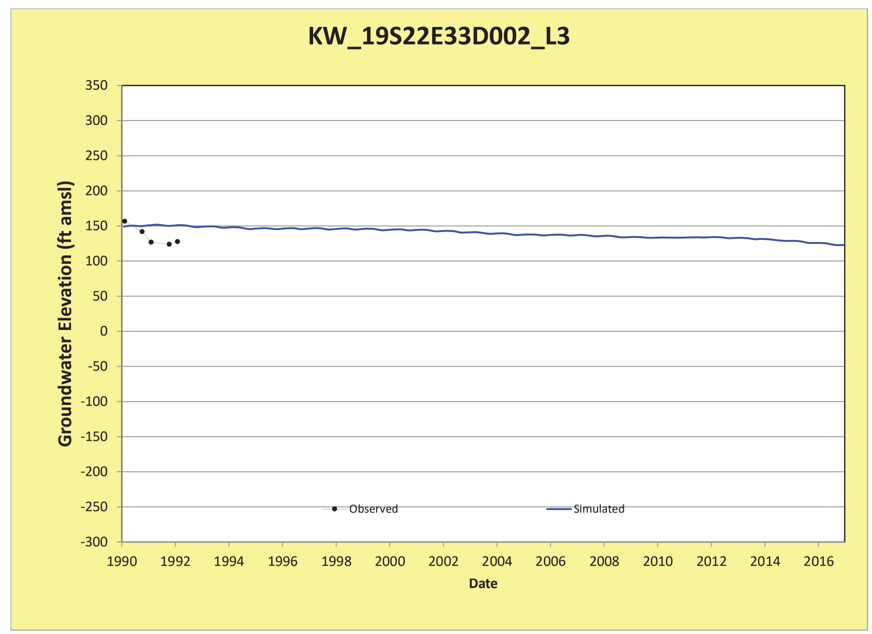
KW_19S22E20A001_L6

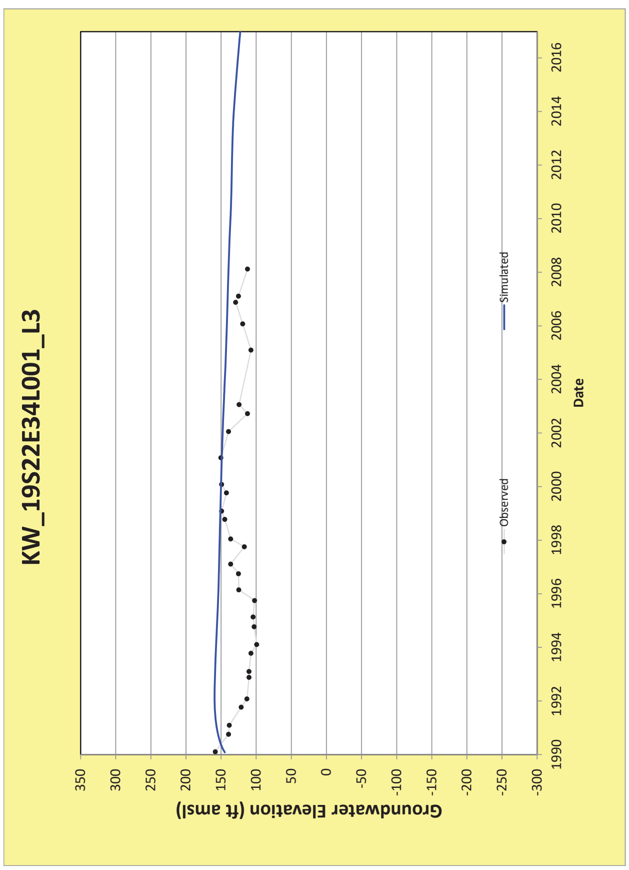



KW_19S22E30D001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_19S22E32D001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_19S22E31B002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_19S22E33D002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_19S22E34L001_L3
Groundwater Elevation (ft amsl)
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300
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-150
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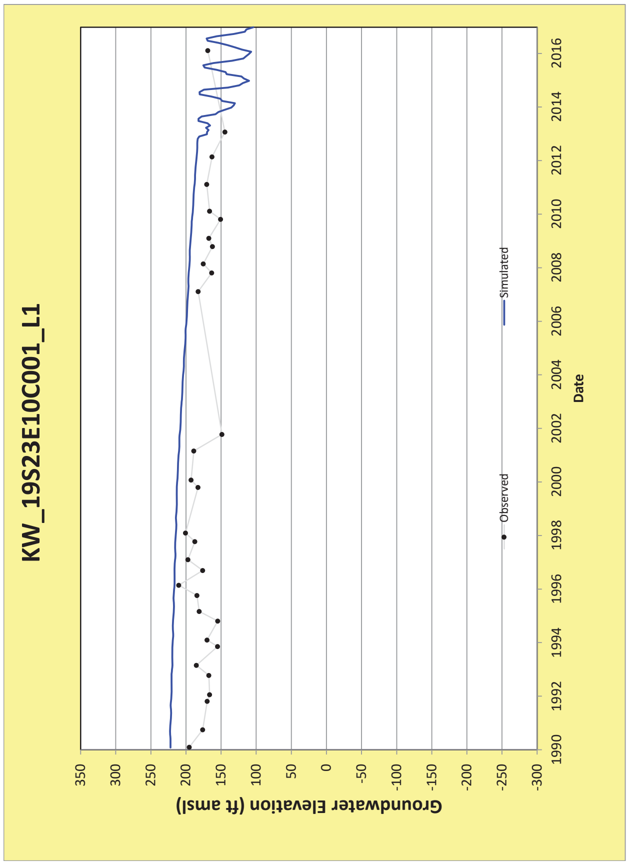
Date
Observed
Simulated


KW_19S23E10C001_L1
Groundwater Elevation (ft amsl)
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200
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0
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-100
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-200
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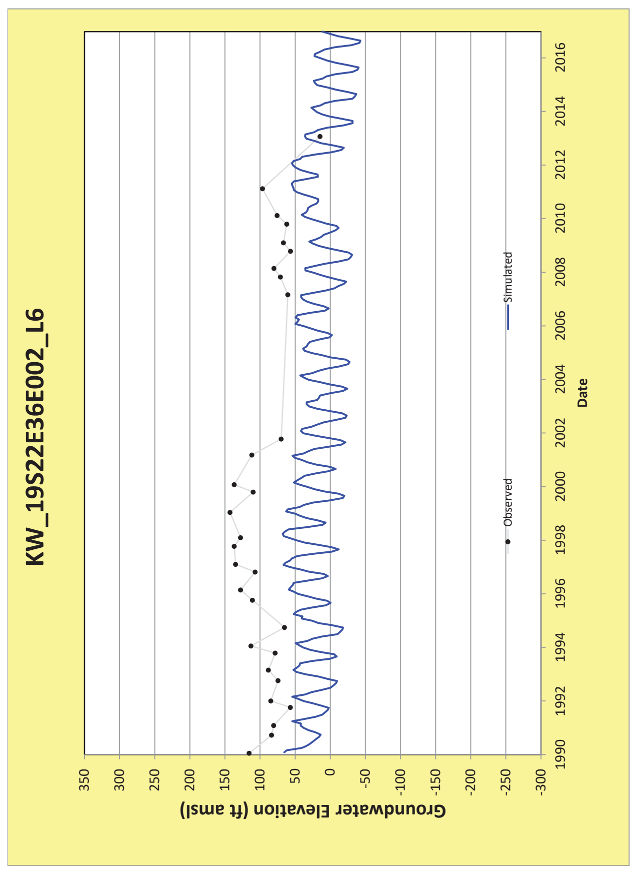
2016
Date
Observed
Simulated


KW_19S22E36E002_L6
Groundwater Elevation (ft amsl)
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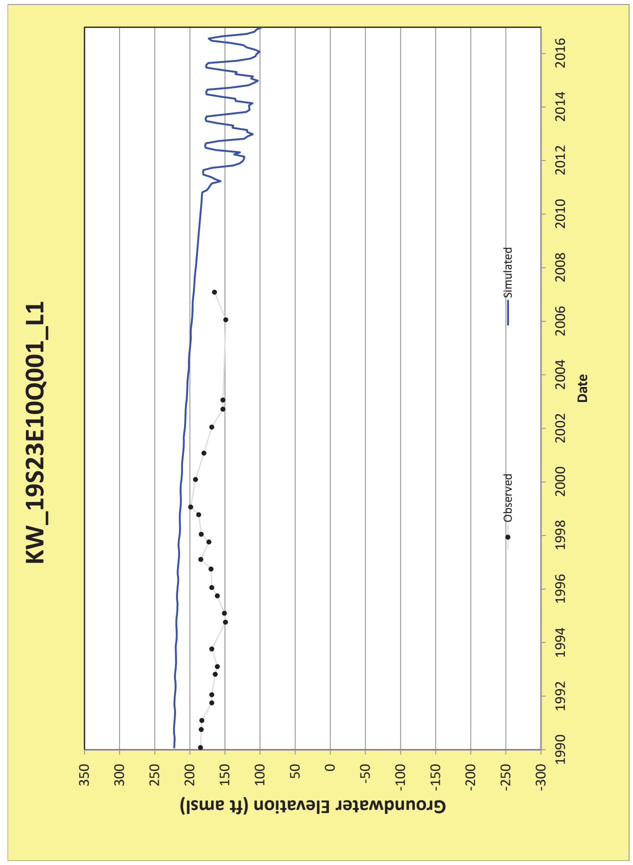
Date
Observed
Simulated


KW_19S23E10Q001_L1
Groundwater Elevation (ft amsl)
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-100
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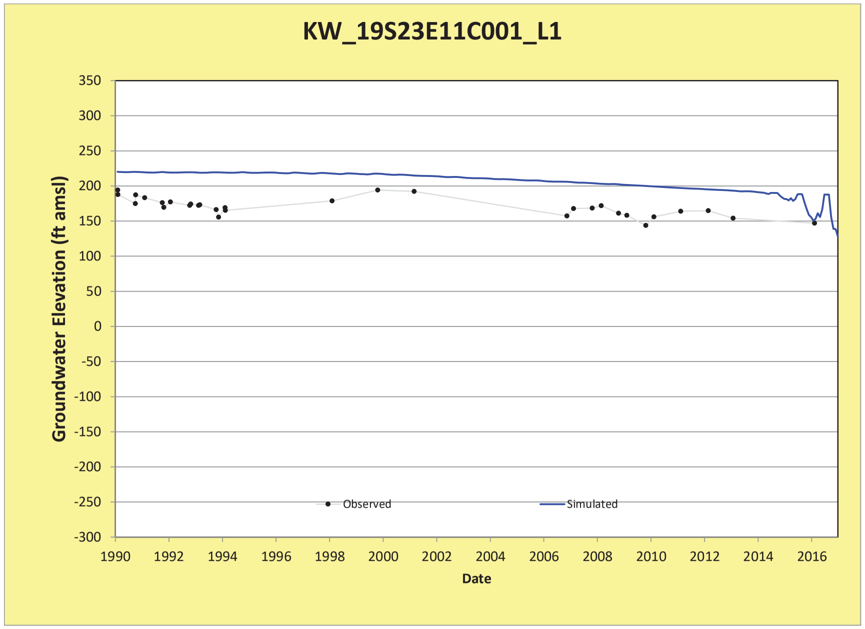
Date
Observed
Simulated


KW_19S23E11C001_L1
Groundwater Elevation (ft amsl)
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-200
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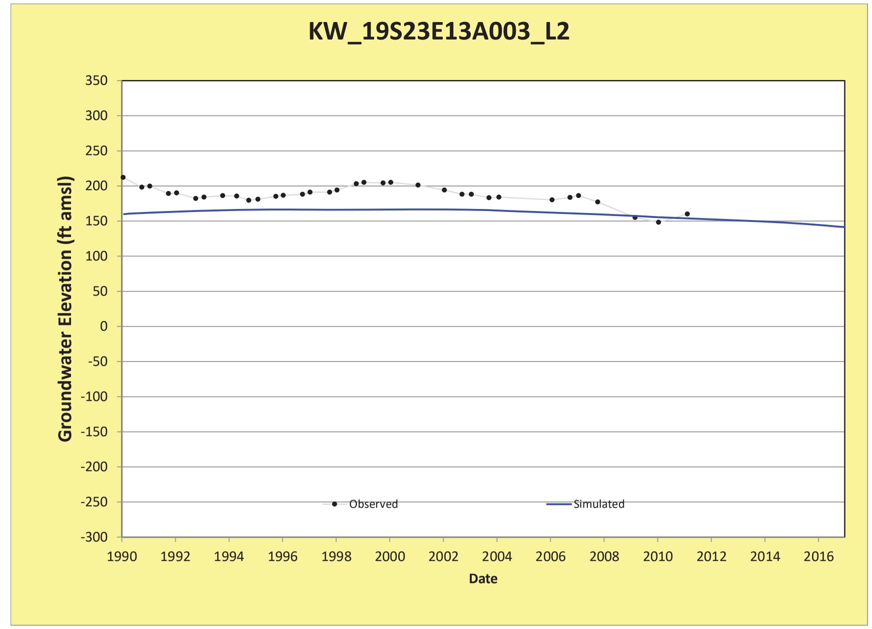
Date
Observed
Simulated


KW_19S23E13A003_L2
Groundwater Elevation (ft amsl)
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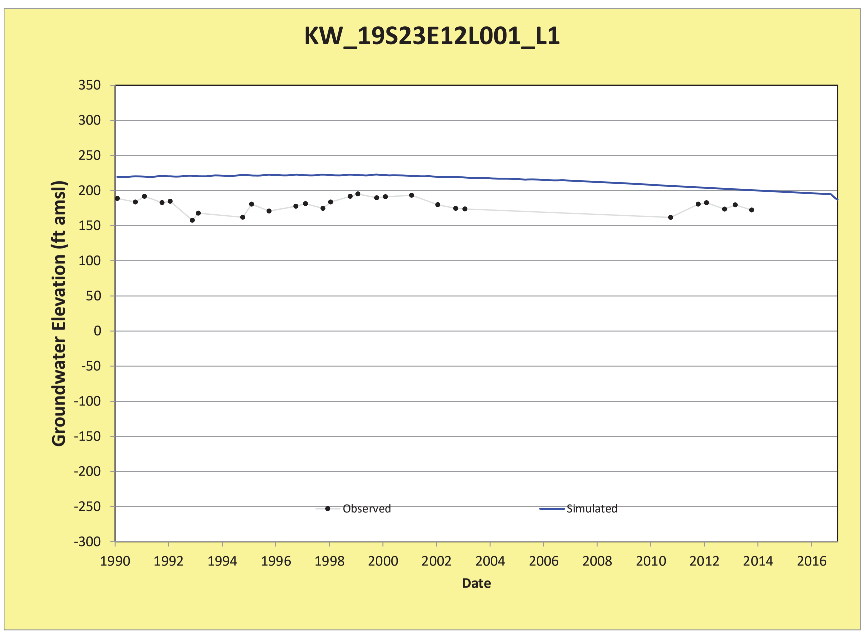
Date
Observed
Simulated


KW_19S23E12L001_L1
Groundwater Elevation (ft amsl)
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300
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-100
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-200
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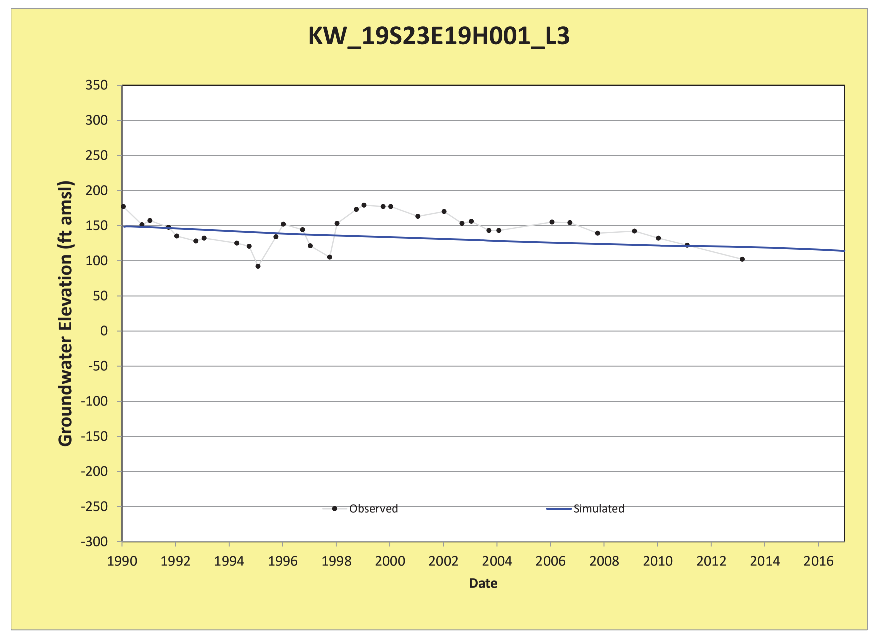
Date
Observed
Simulated


KW_19S23E19H001_L3
Groundwater Elevation (ft amsl)
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-50
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Date
Observed
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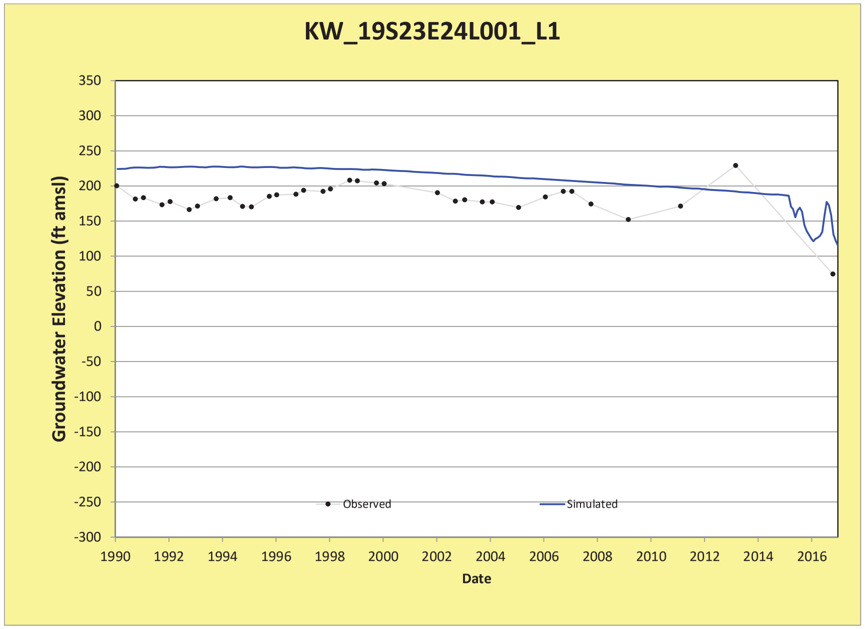
KW_19S23E24L001_L1
Groundwater Elevation (ft amsl)
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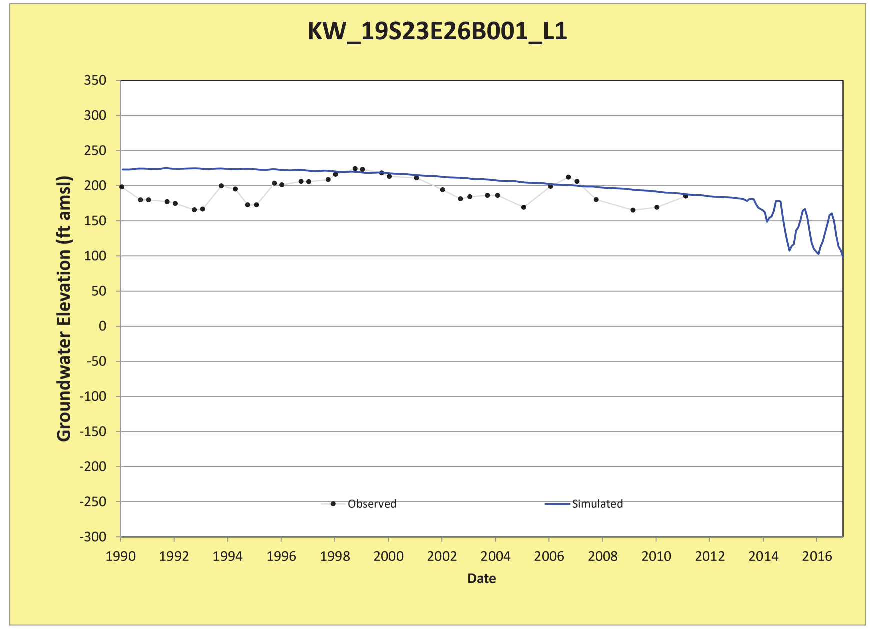
Date
Observed
Simulated


KW_19S23E26B001_L1
Groundwater Elevation (ft amsl)
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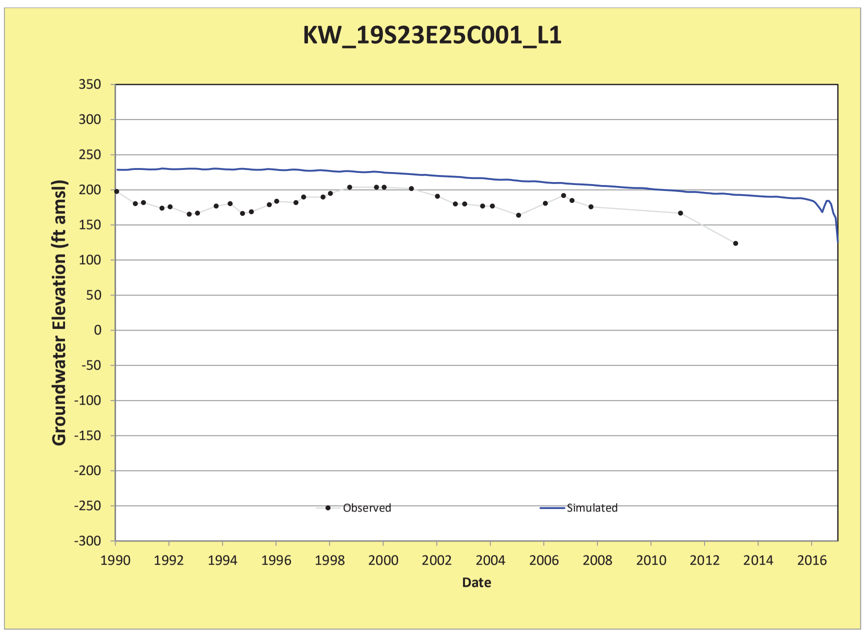
Date
Observed
Simulated


KW_19S23E25C001_L1
Groundwater Elevation (ft amsl)
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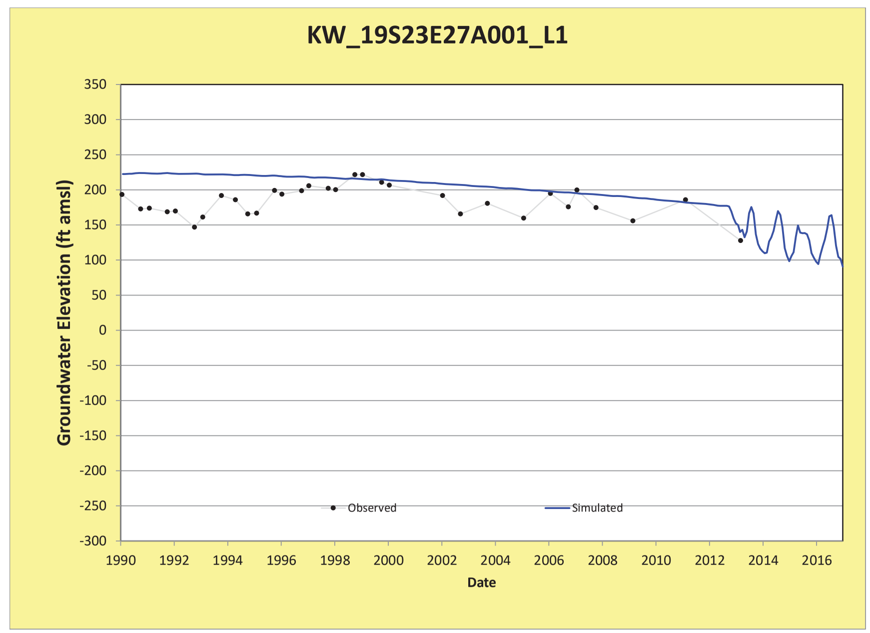
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Date
Observed
Simulated


KW_19S23E27A001_L1
Groundwater Elevation (ft amsl)
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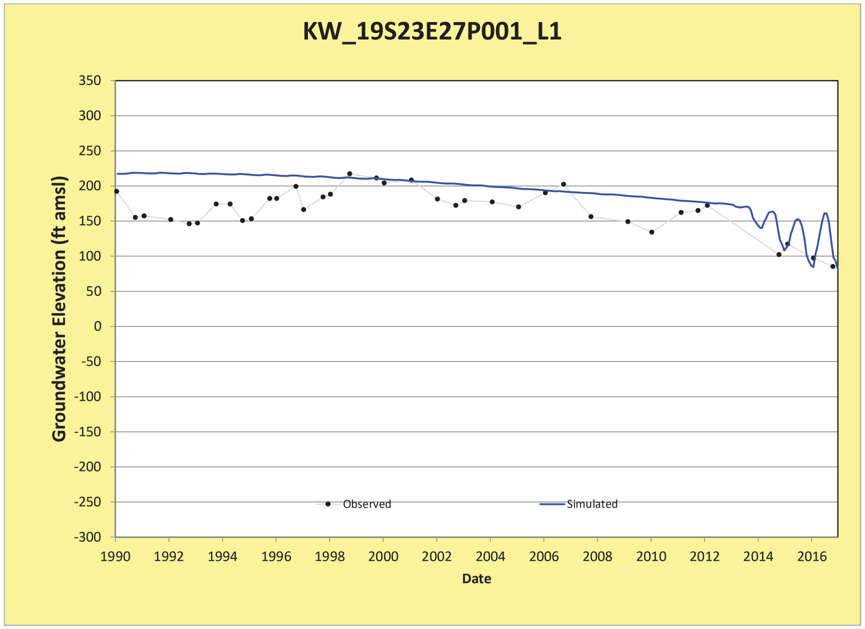
-300
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Date
Observed
Simulated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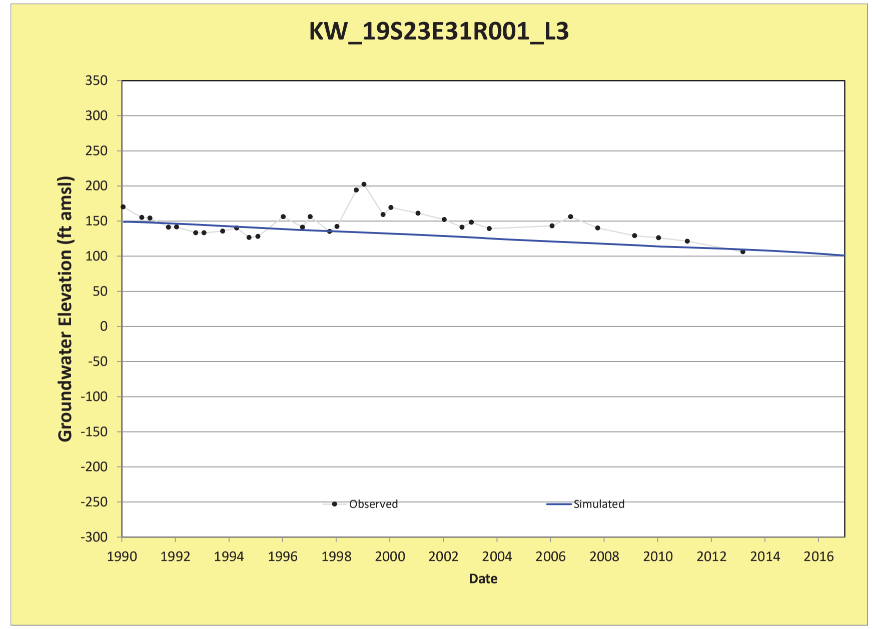
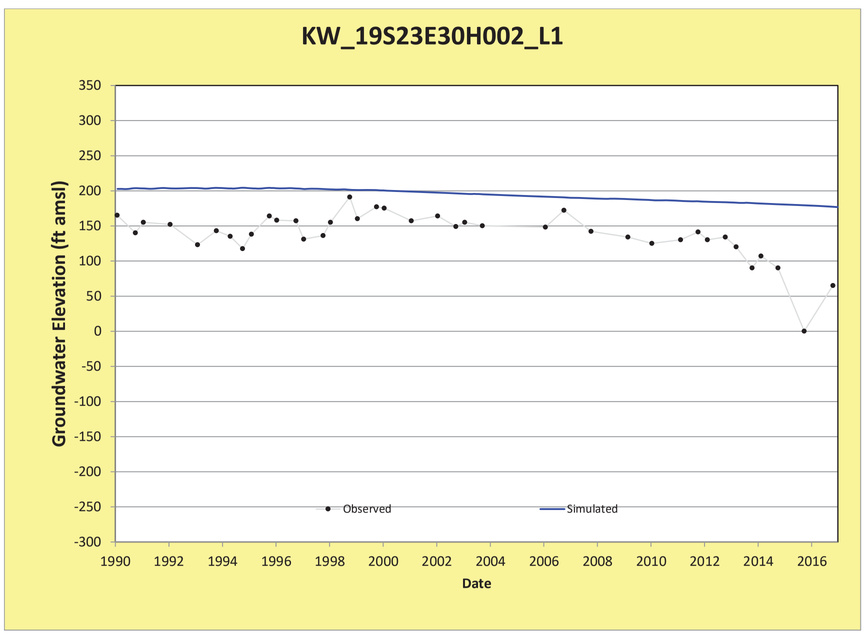
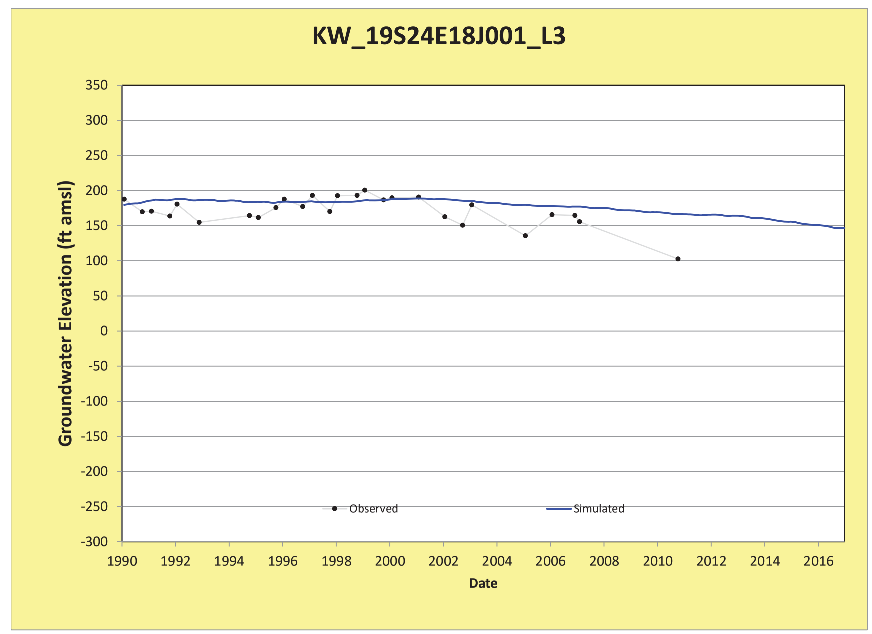
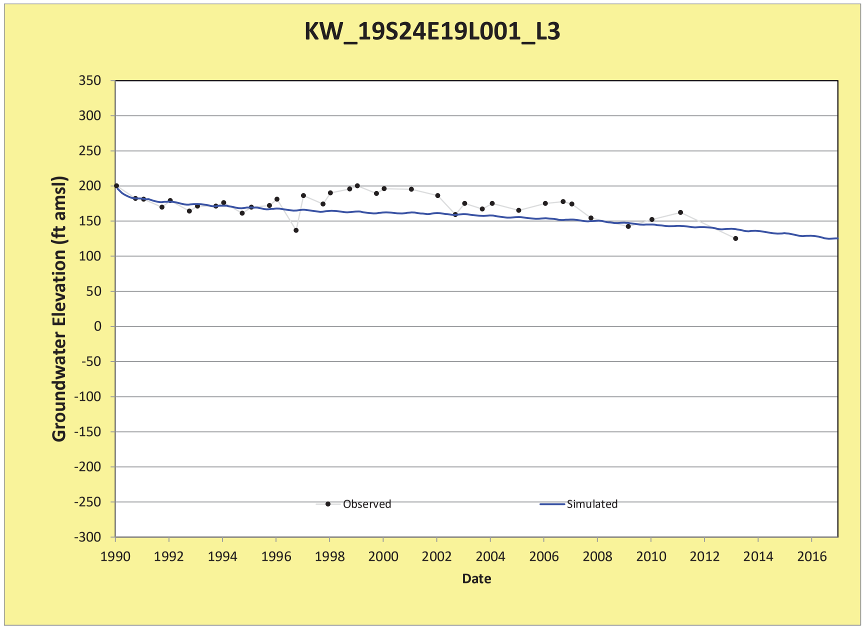
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_19S23E31R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_19S23E30H002_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_19S24E18J001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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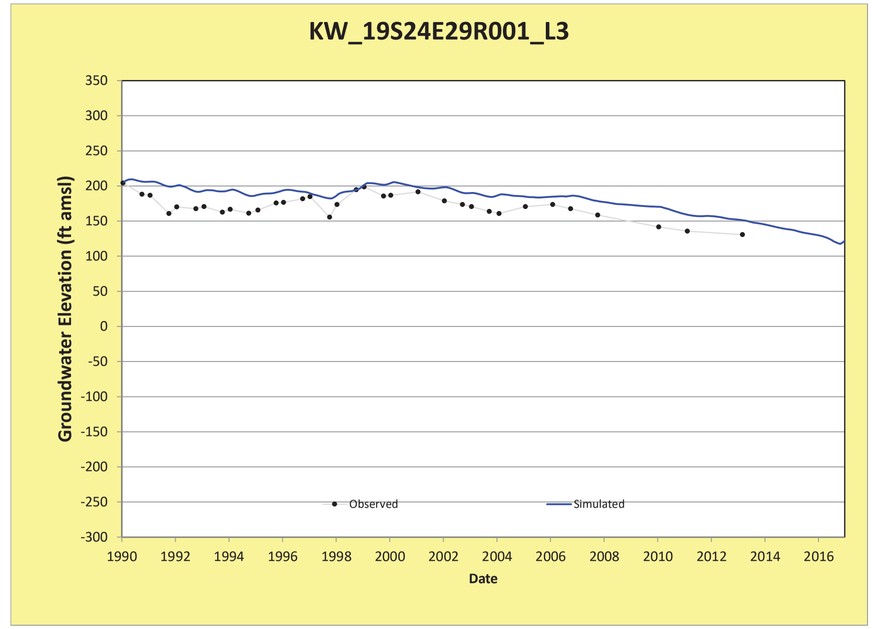
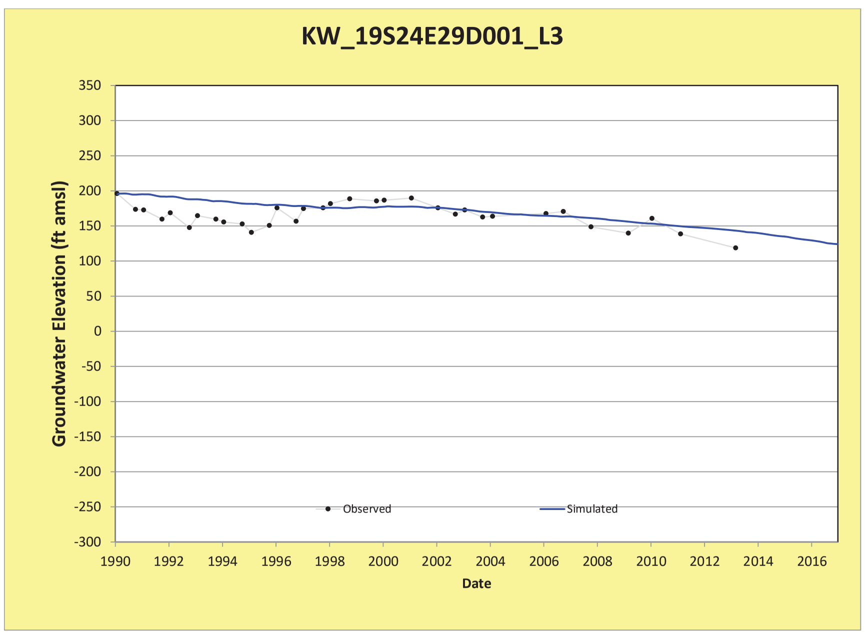
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_19S24E29R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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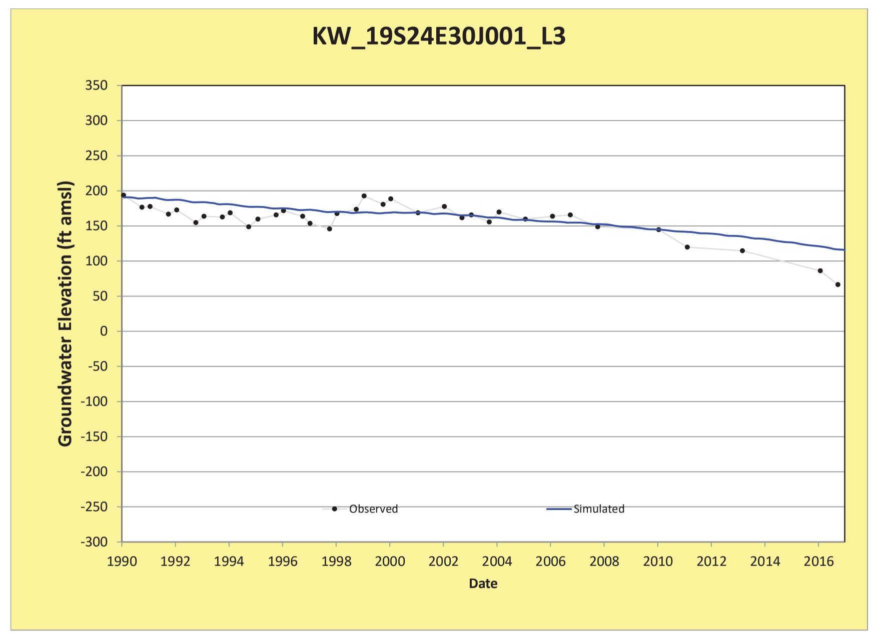
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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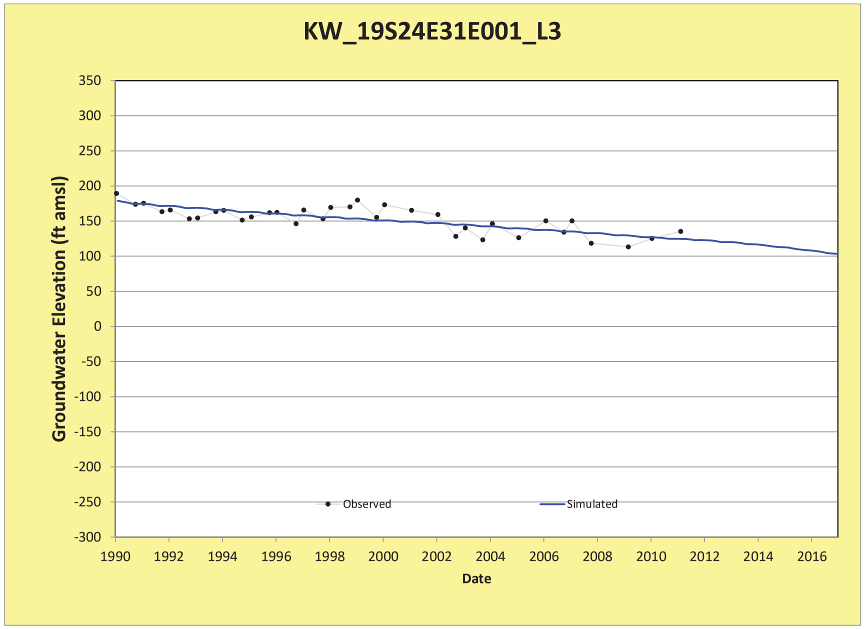
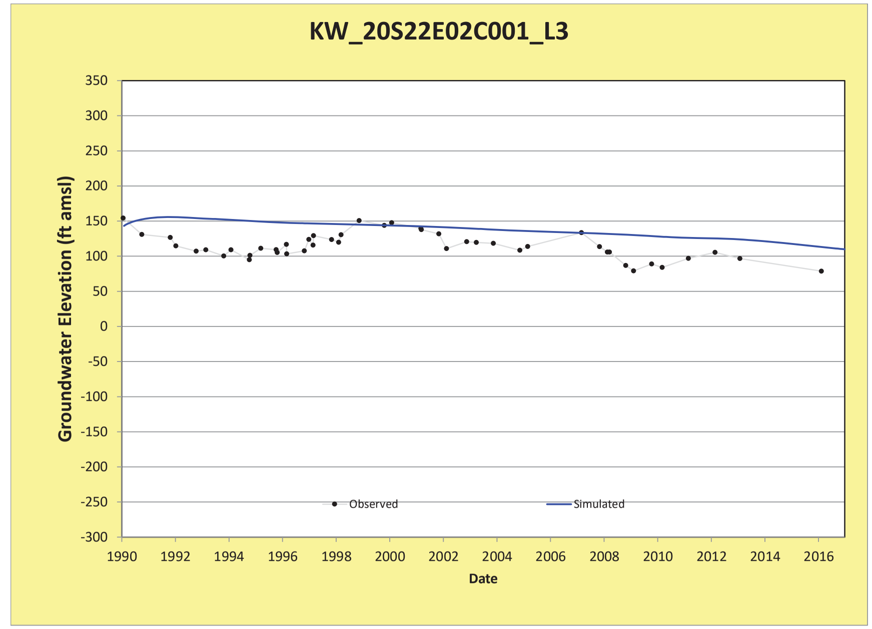
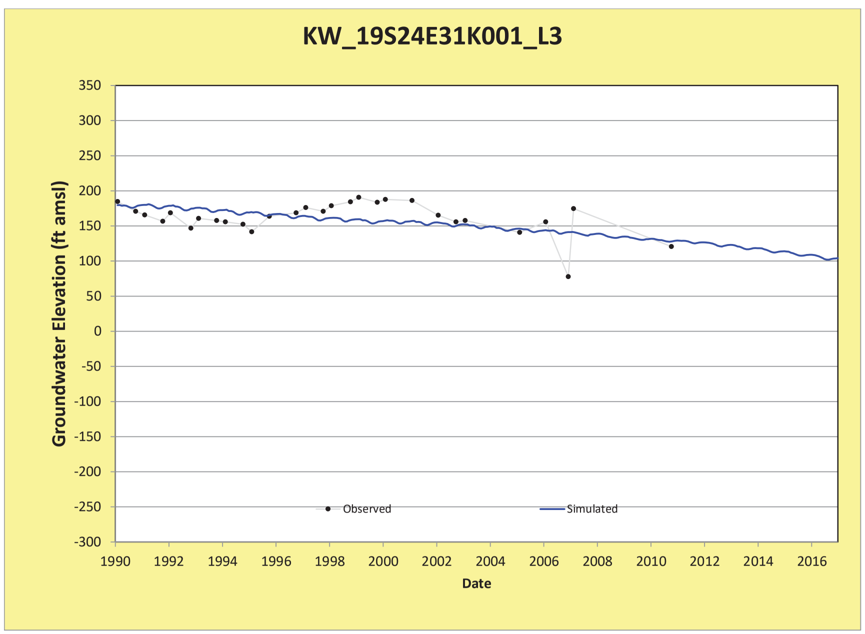
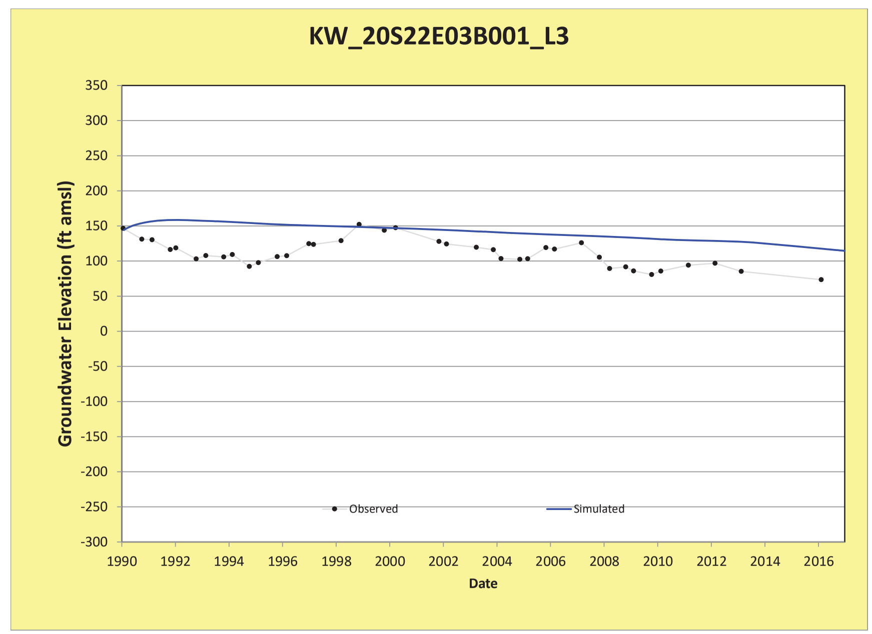
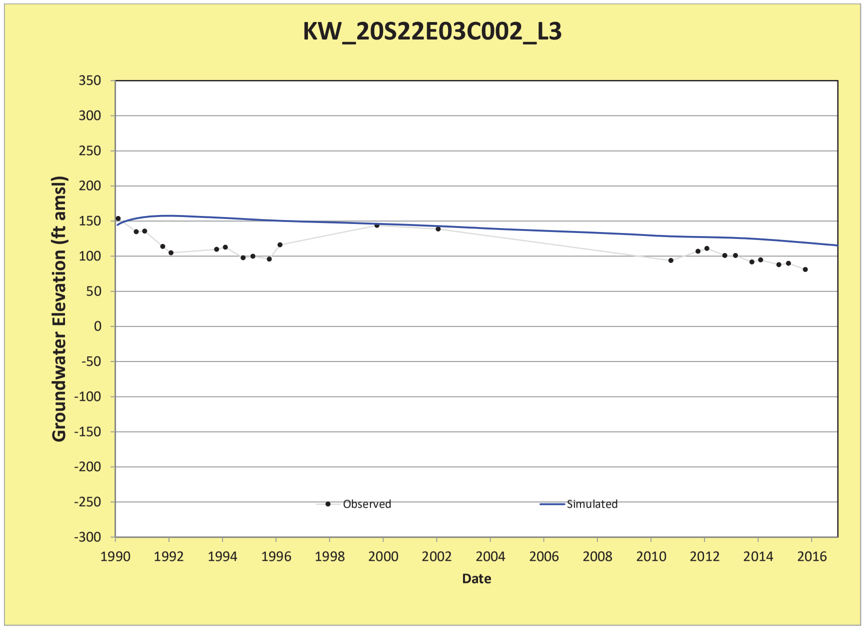
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

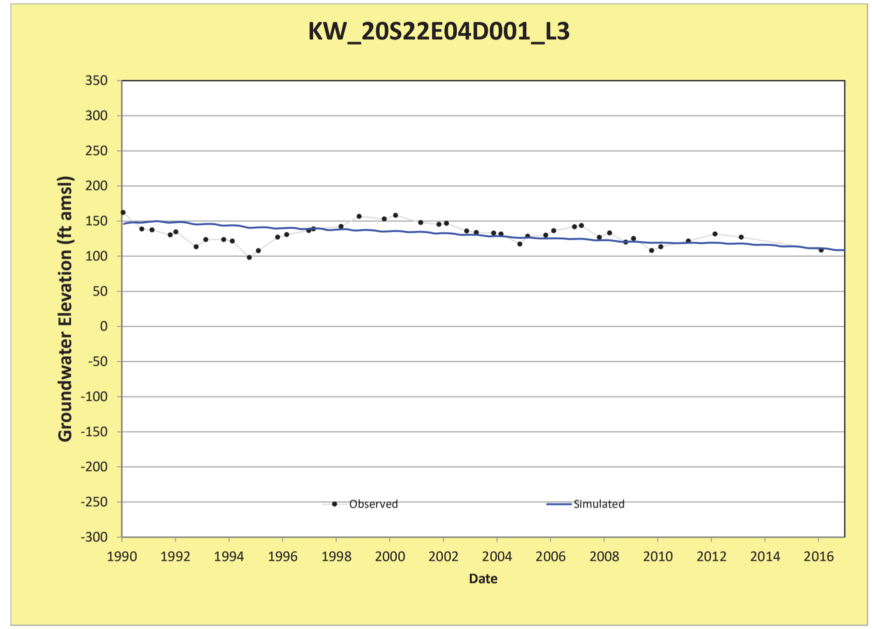

KW_19S24E31E001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

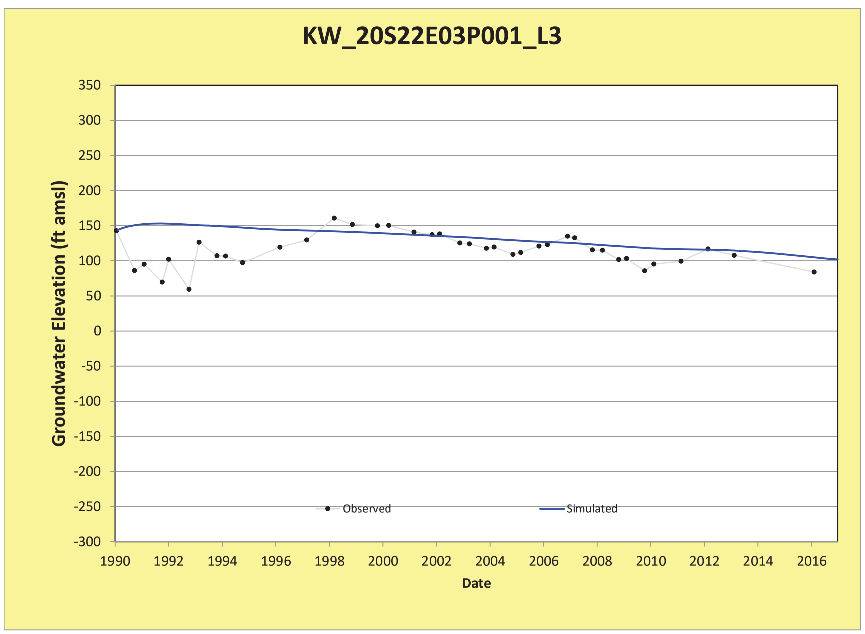

KW_20S22E02C001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

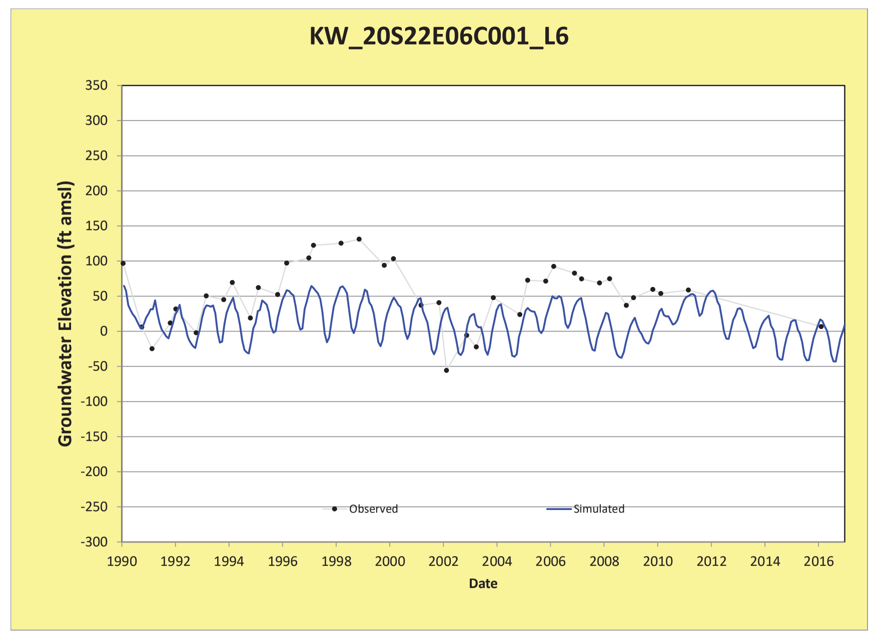

KW_19S24E31K001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

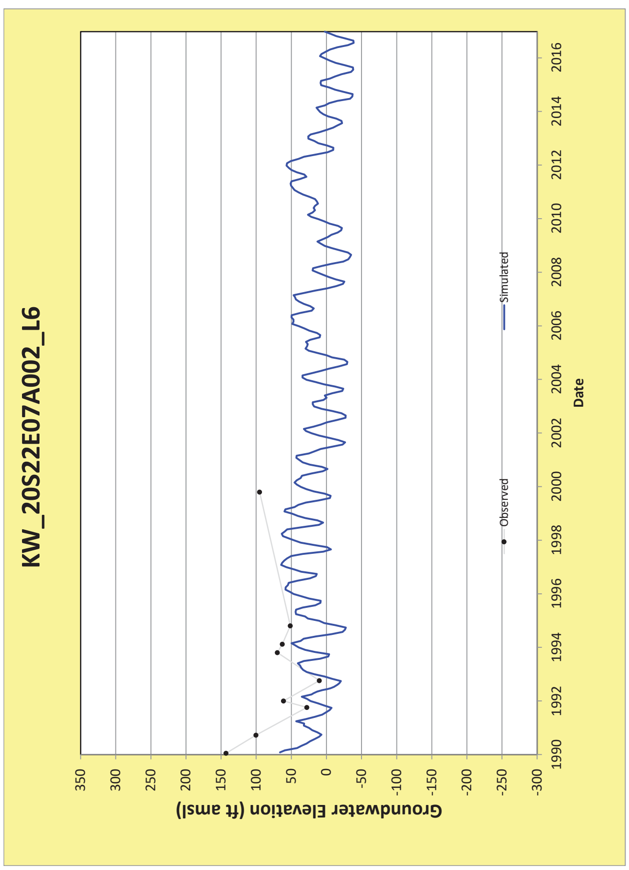

KW_20S22E03B001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S22E03C002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S22E04D001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S22E03P001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S22E06C001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S22E07A002_L6
Groundwater Elevation (ft amsl)
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150
100
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-50
-100
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-200
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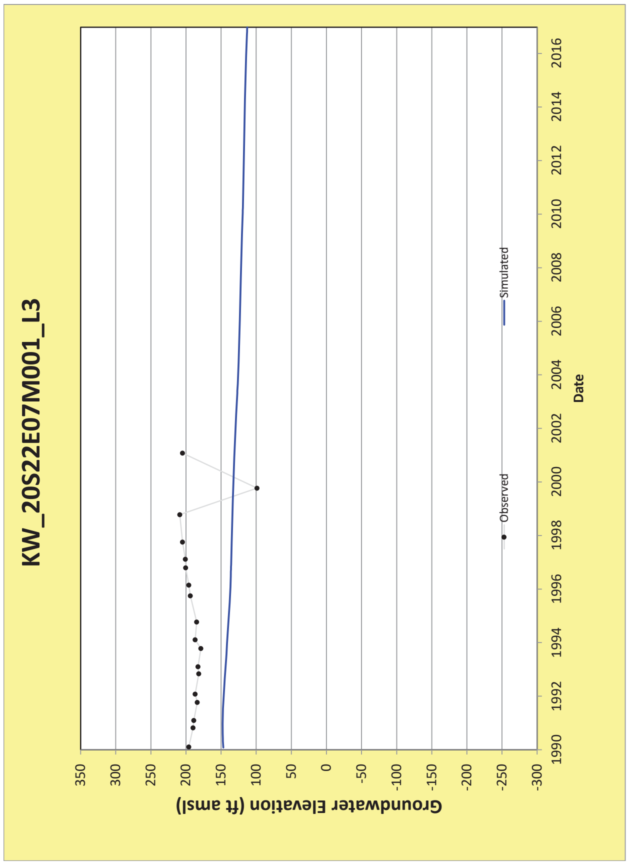
2016
Date
Observed
Simulated


KW_20S22E07M001_L3
Groundwater Elevation (ft amsl)
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300
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-250
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1990
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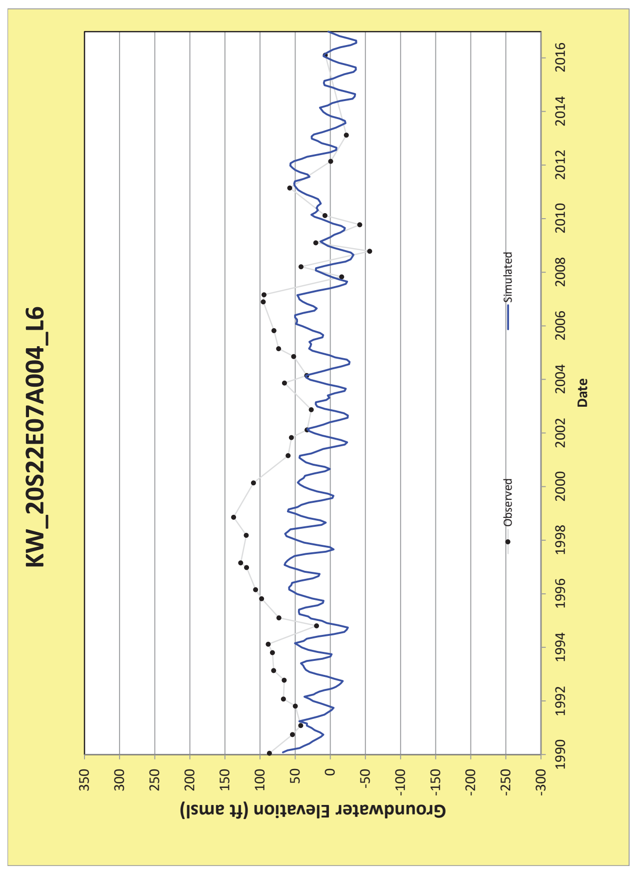
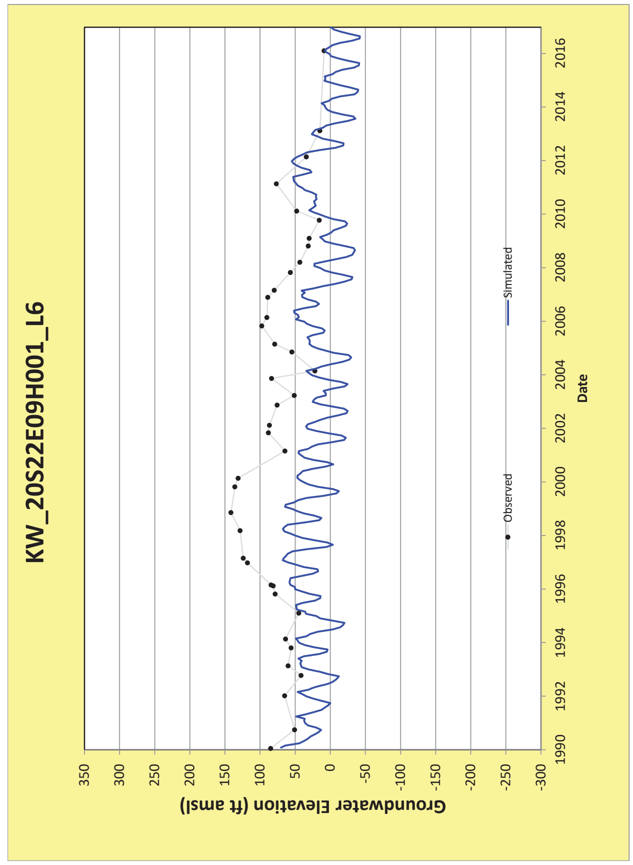
2016
Date
Observed
Simulated


KW_20S22E07A004_L6
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


KW_20S22E09H001_L6
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
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2008
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2012
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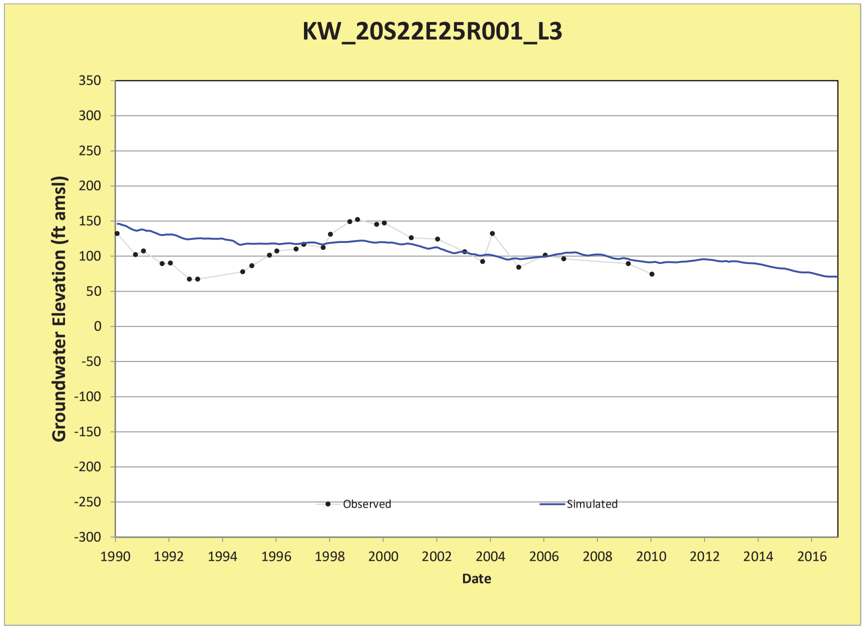
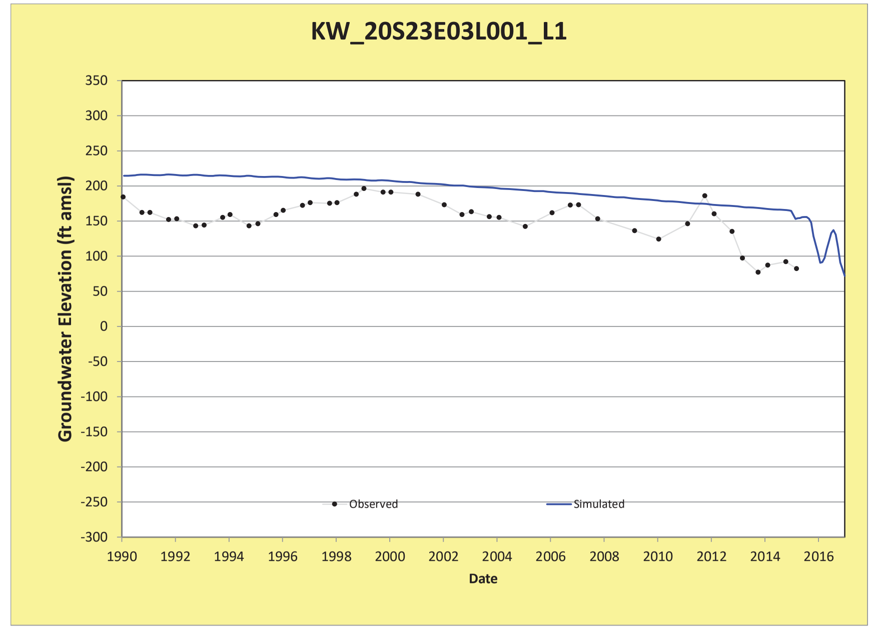
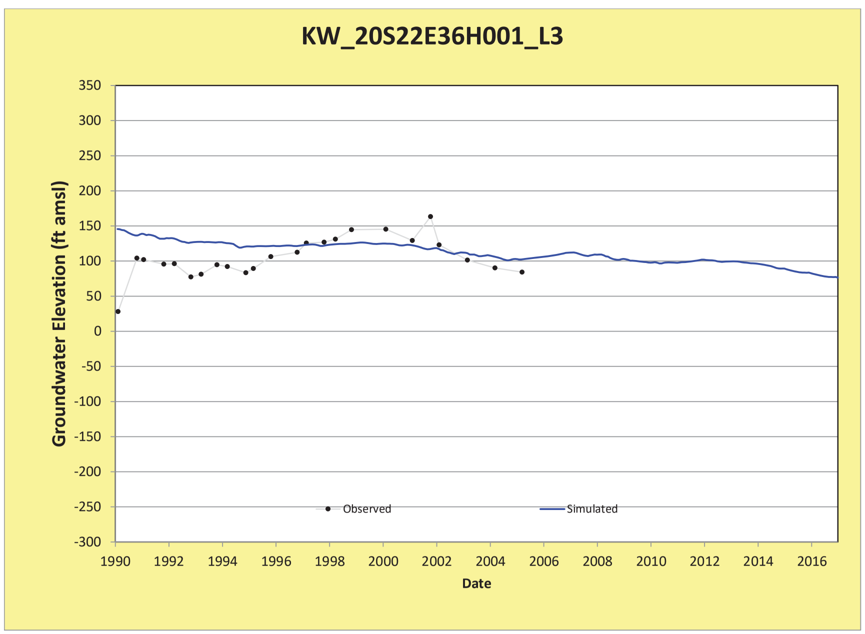
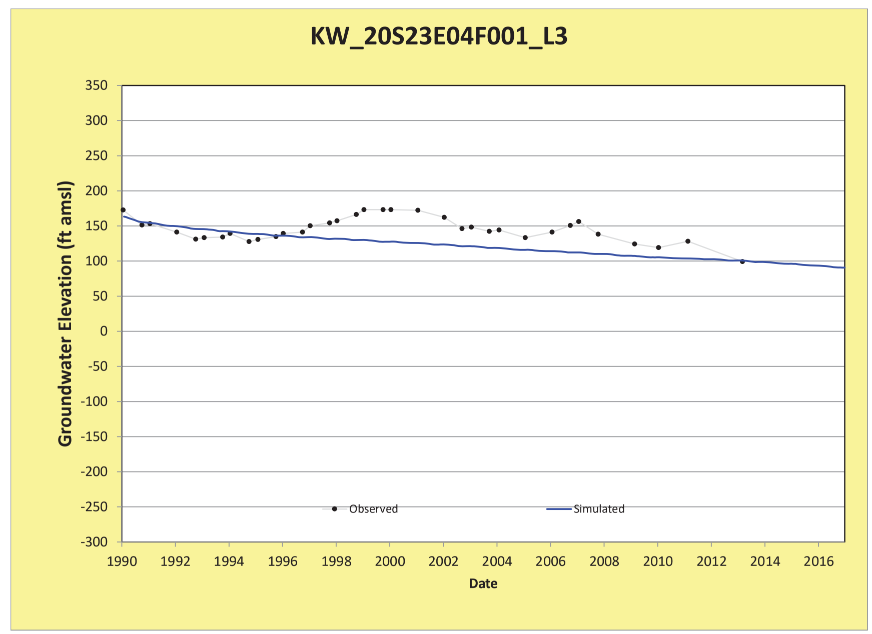
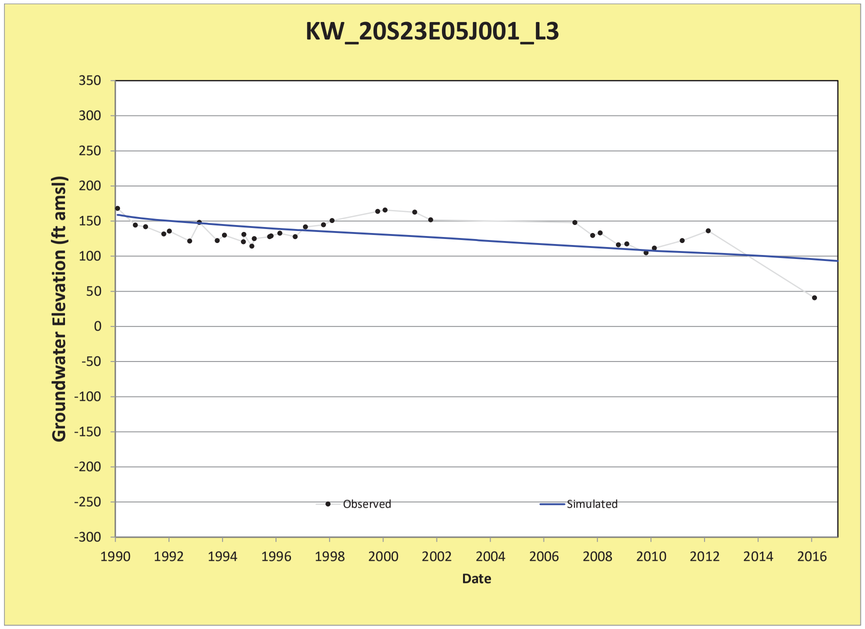
2016
Date
Observed
Simulated


KW_20S22E25R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S23E03L001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S22E36H001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S23E04F001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S23E05J001_L3
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
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2000
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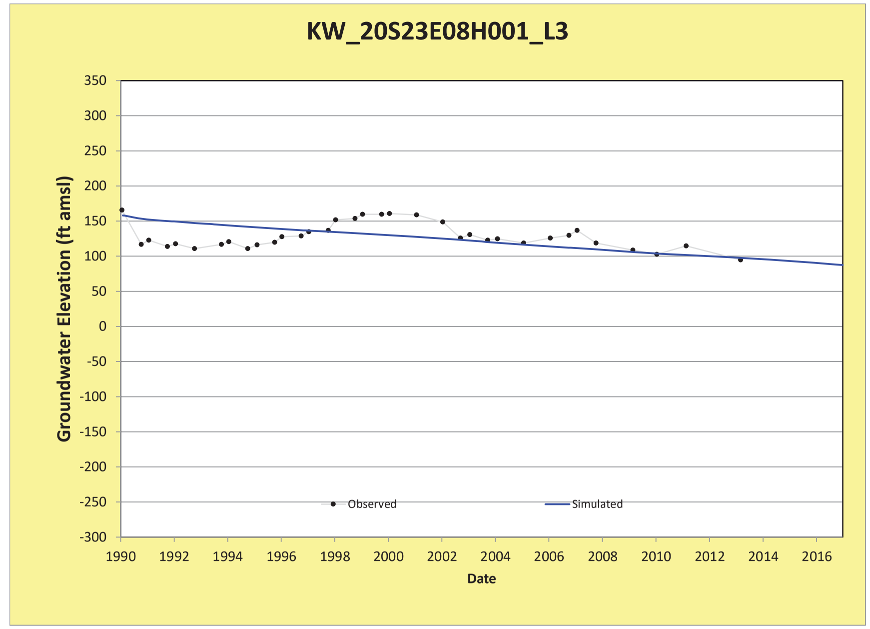
2010
2012
2014
2016
Date
Observed
Simulated


KW_20S23E08H001_L3
Groundwater Elevation (ft amsl)
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300
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200
150
100
50
0
-50
-100
-150
-200
-250
-300
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1996
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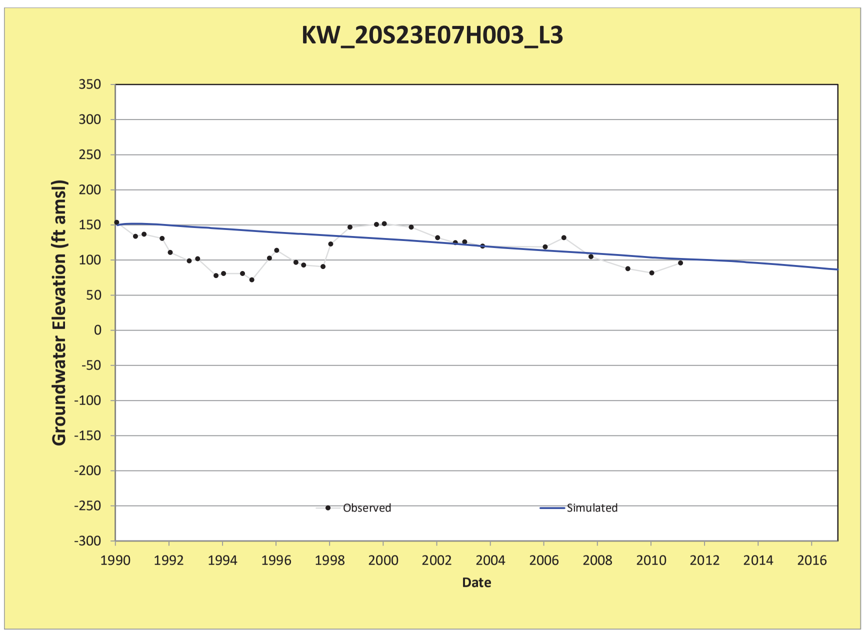
2014
2016
Date
Observed
Simulated


KW_20S23E07H003_L3
Groundwater Elevation (ft amsl)
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300
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-100
-150
-200
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1996
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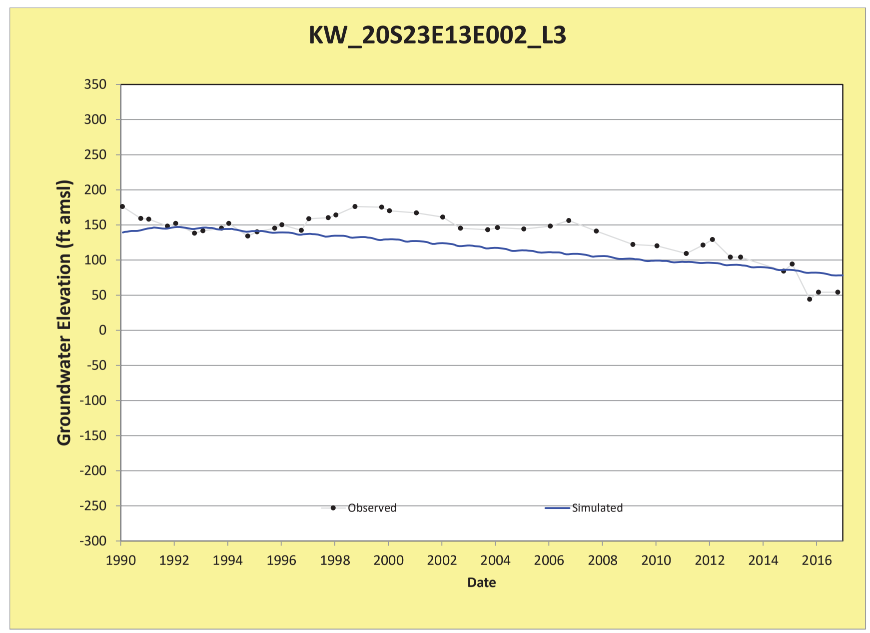
Date
Observed
Simulated


KW_20S23E13E002_L3
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
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1996
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2000
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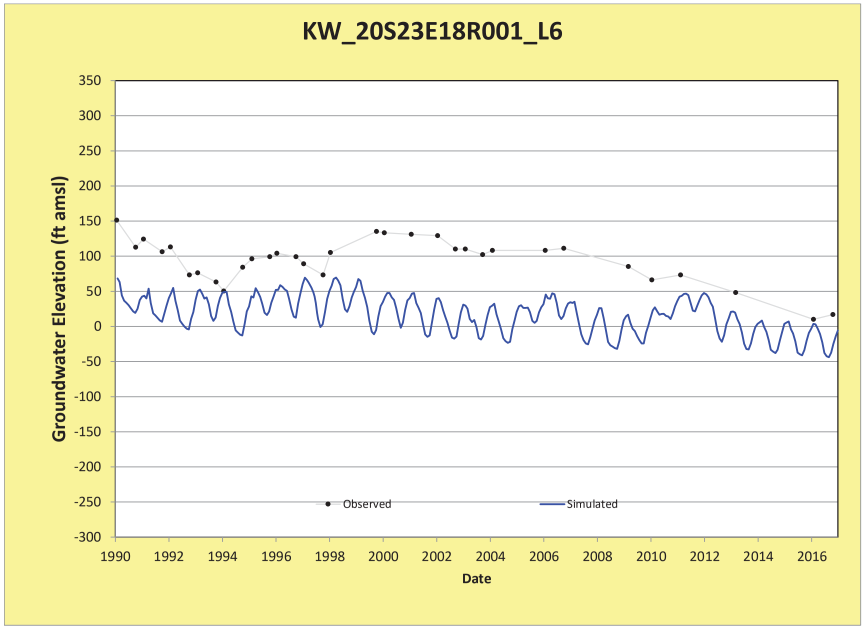
2014
2016
Date
Observed
Simulated


KW_20S23E18R001_L6
Groundwater Elevation (ft amsl)
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300
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200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
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2010
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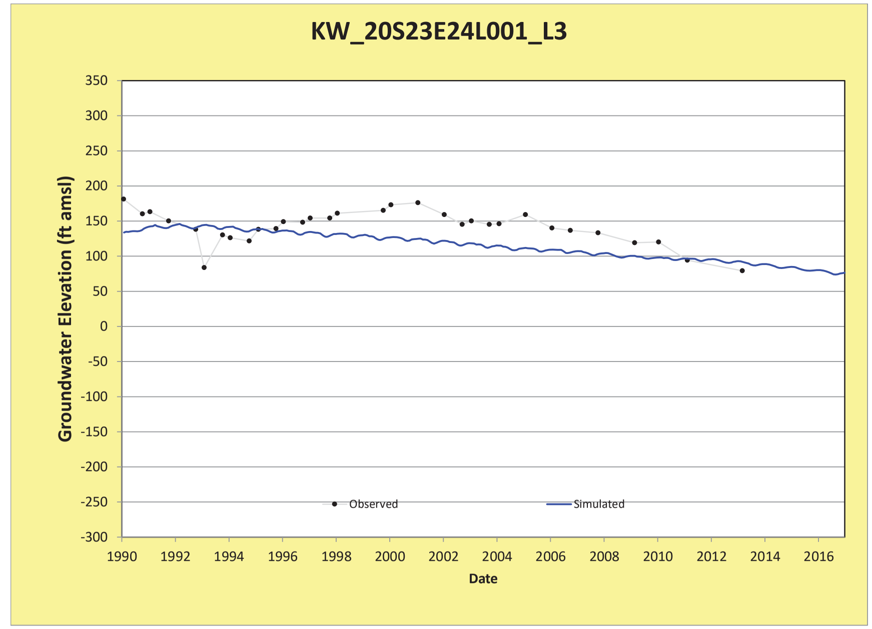
2014
2016
Date
Observed
Simulated


KW_20S23E24L001_L3
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
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1992
1994
1996
1998
2000
2002
2004
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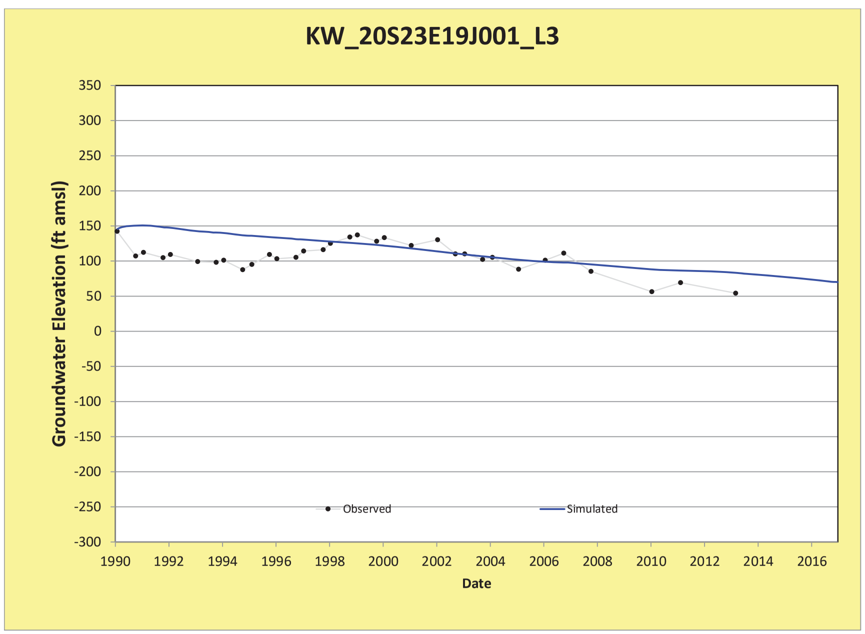
2008
2010
2012
2014
2016
Date
Observed
Simulated


KW_20S23E19J001_L3
Groundwater Elevation (ft amsl)
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300
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200
150
100
50
0
-50
-100
-150
-200
-250
-300
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1992
1994
1996
1998
2000
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2006
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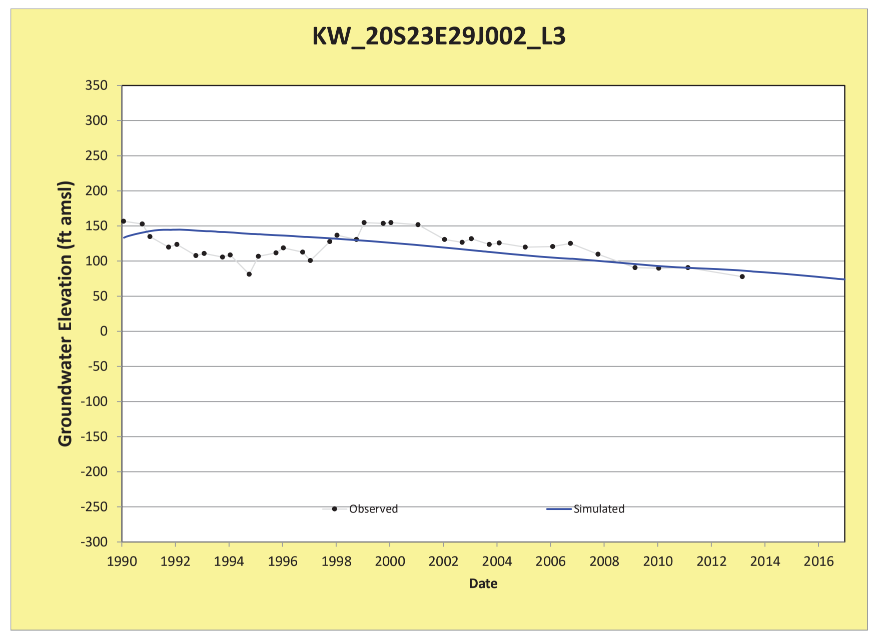
2010
2012
2014
2016
Date
Observed
Simulated


KW_20S23E29J002_L3
Groundwater Elevation (ft amsl)
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300
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200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
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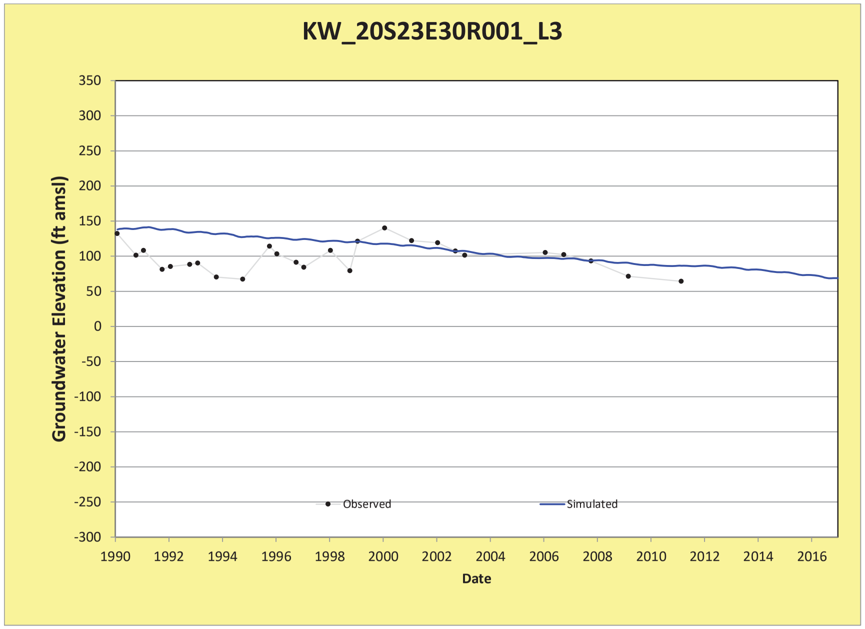
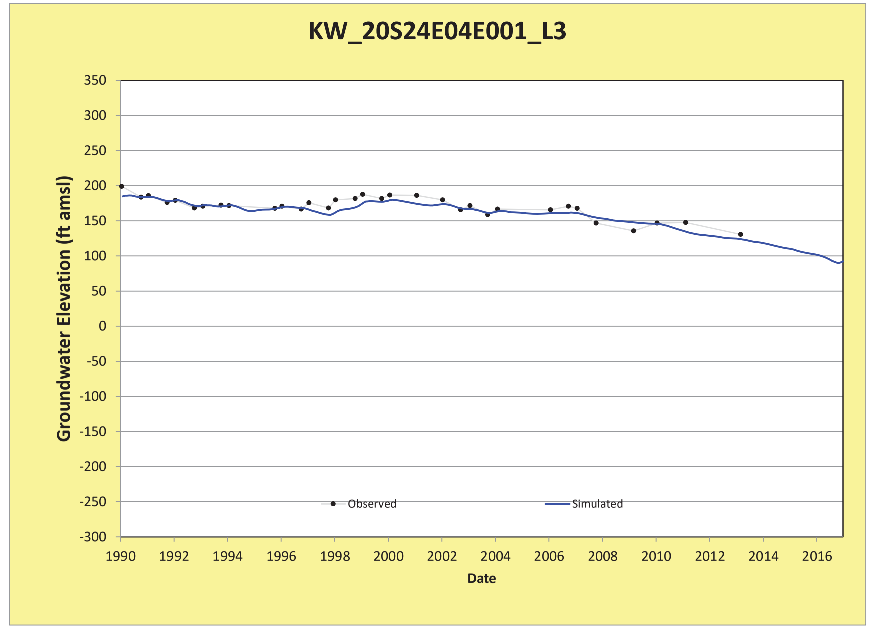
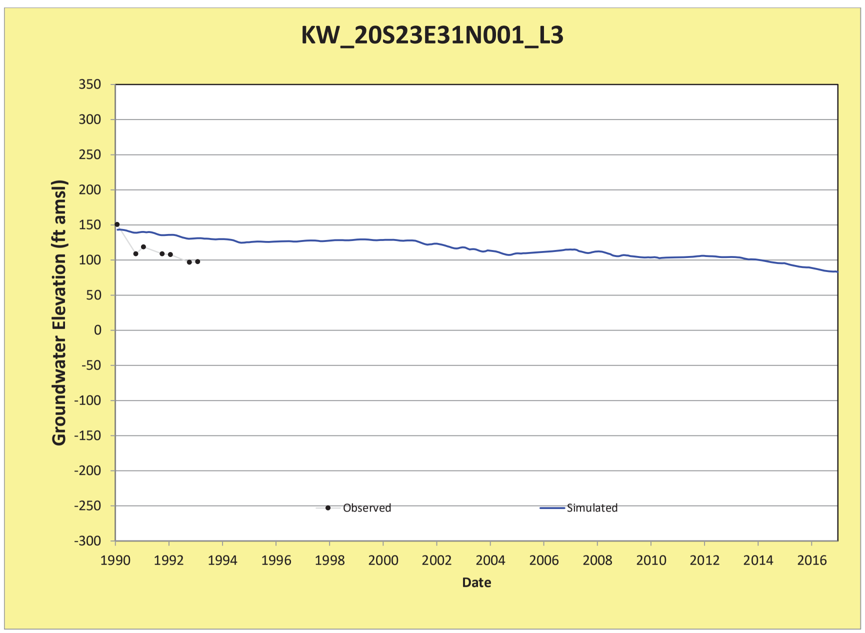
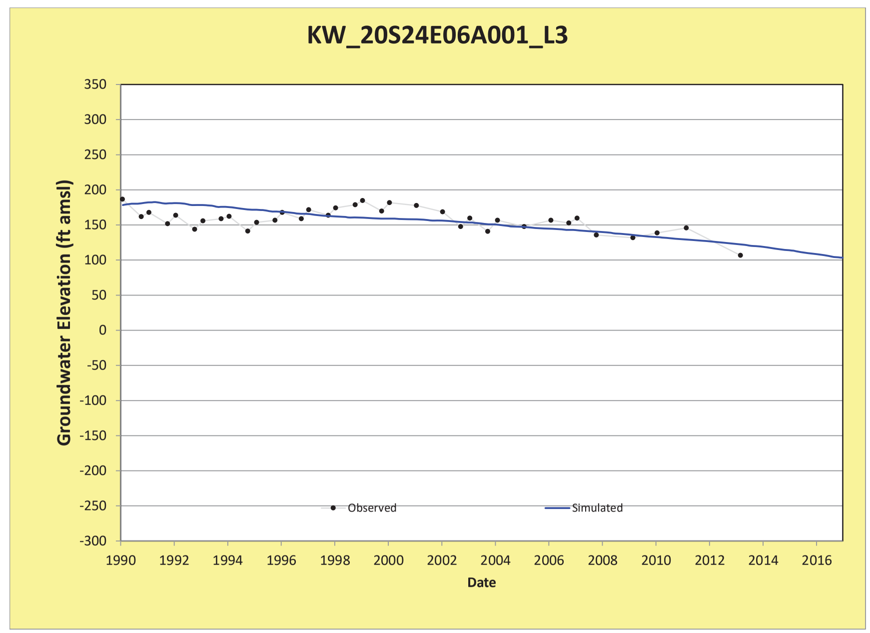
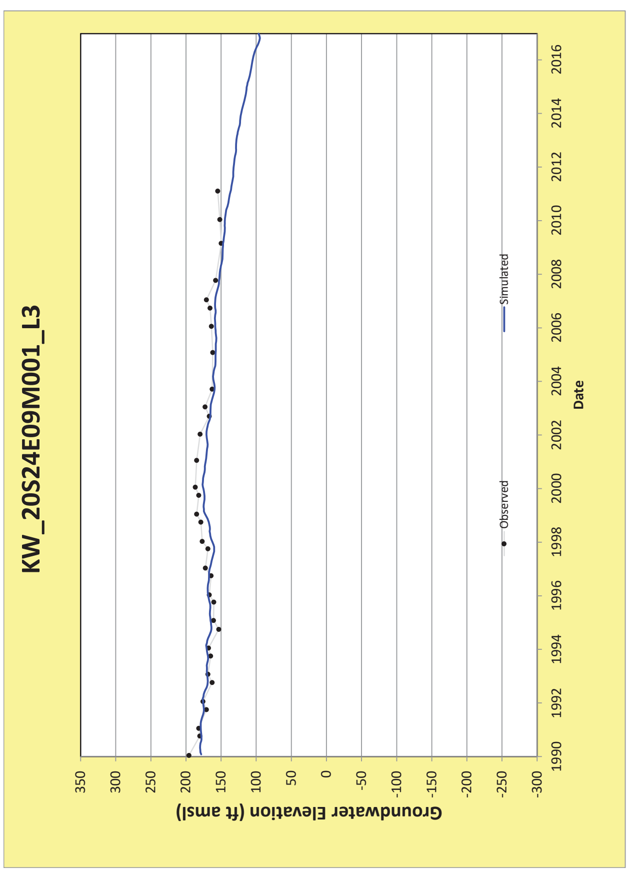
2008
2010
2012
2014
2016
Date
Observed
Simulated


KW_20S23E30R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

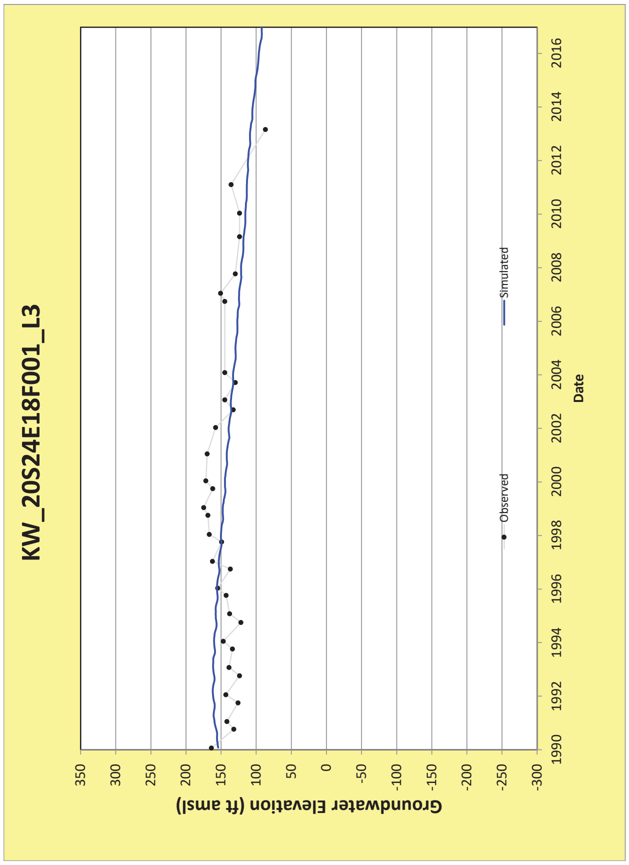

KW_20S24E04E001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S23E31N001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

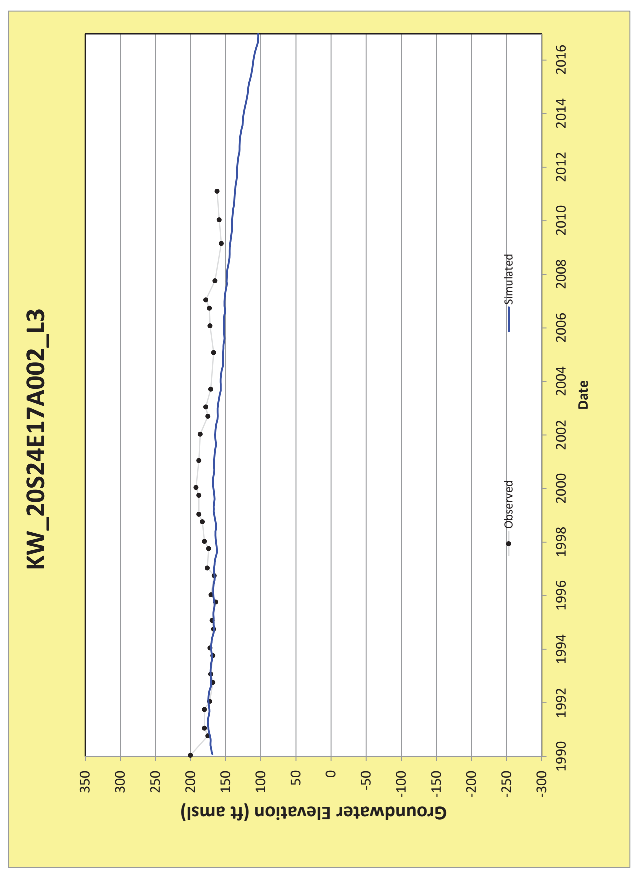

KW_20S24E06A001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



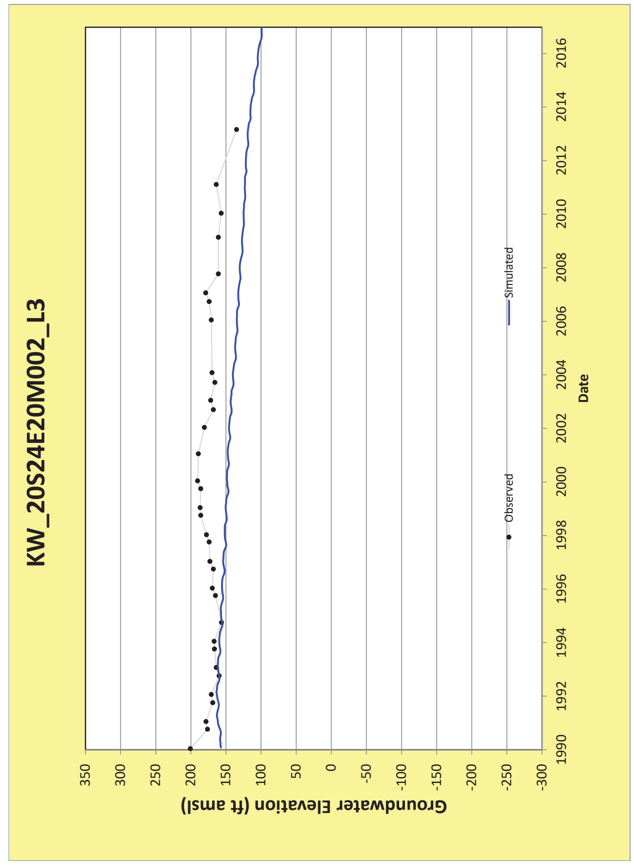
KW_20S24E09M001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



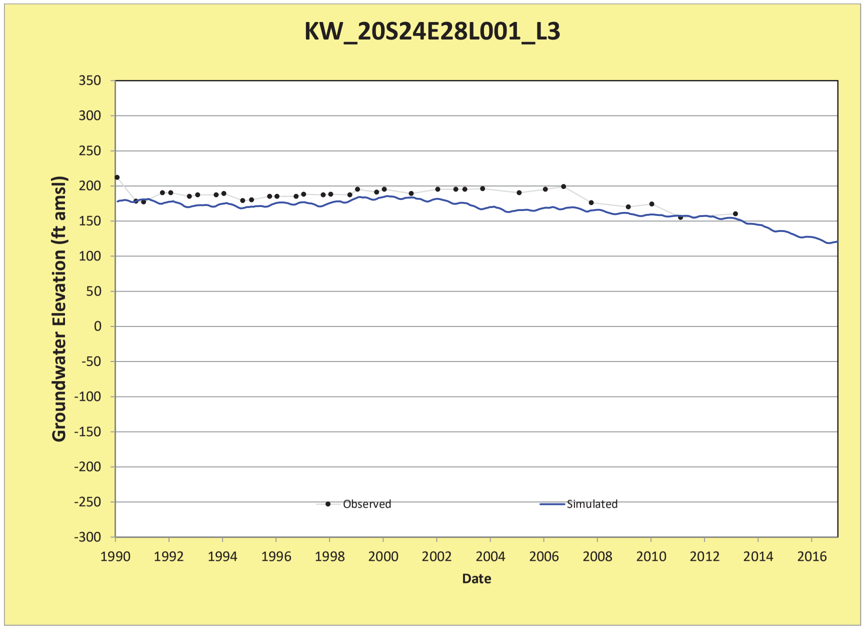
KW_20S24E18F001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



KW_20S24E17A002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



KW_20S24E20M002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_20S24E28L001_L3
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
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1992
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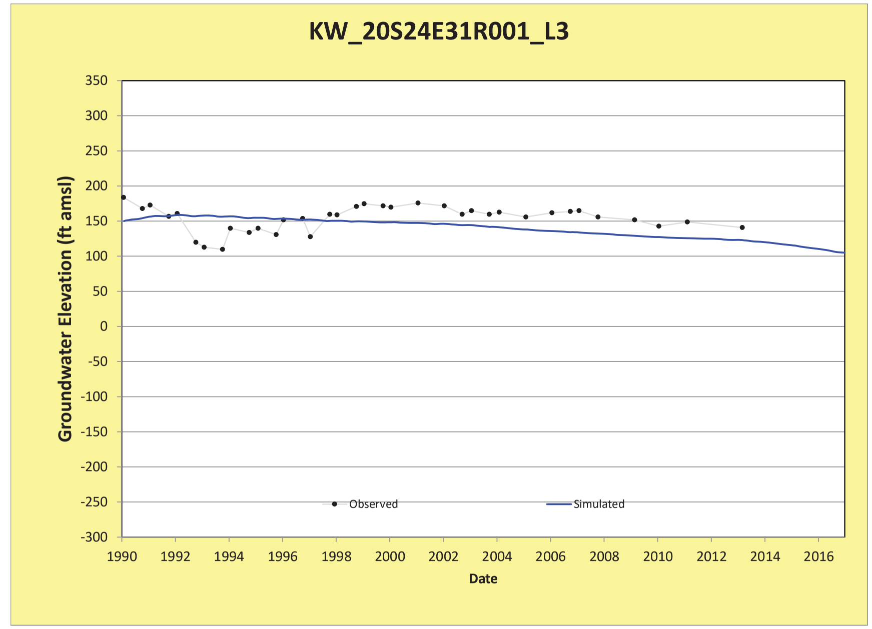
2012
2014
2016
Date
Observed
Simulated


KW_20S24E31R001_L3
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
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1992
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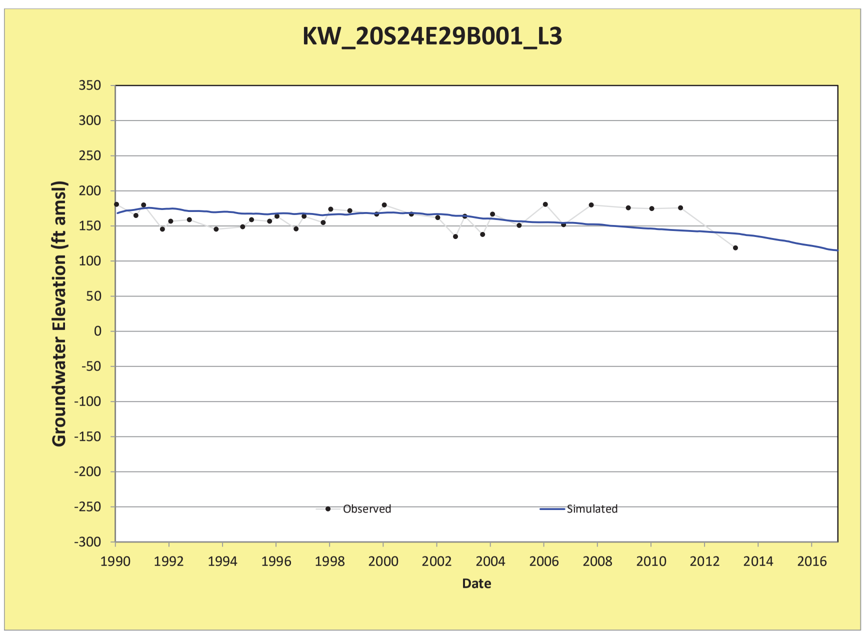
2016
Date
Observed
Simulated


KW_20S24E29B001_L3
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
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1992
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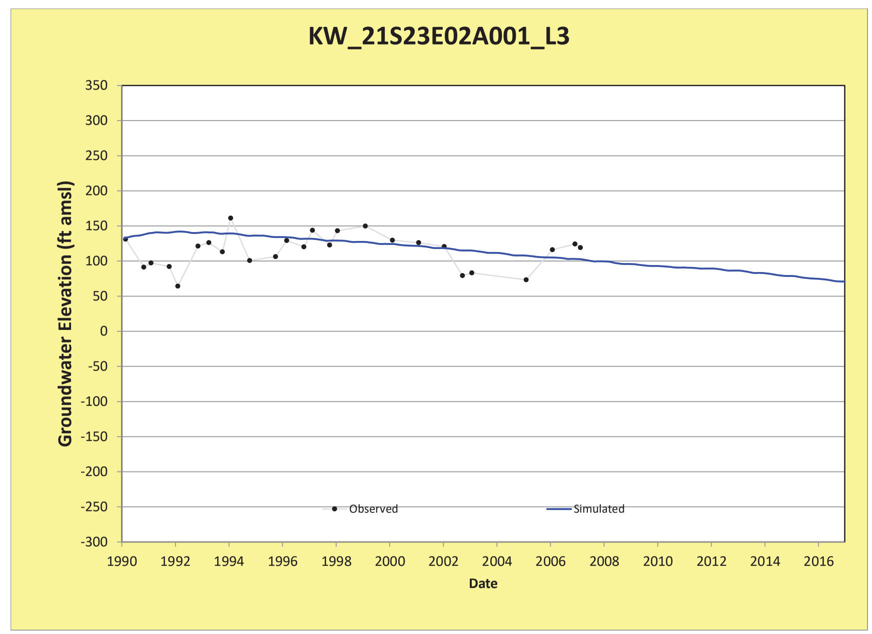
2016
Date
Observed
Simulated


KW_21S23E02A001_L3
Groundwater Elevation (ft amsl)
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200
150
100
50
0
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-100
-150
-200
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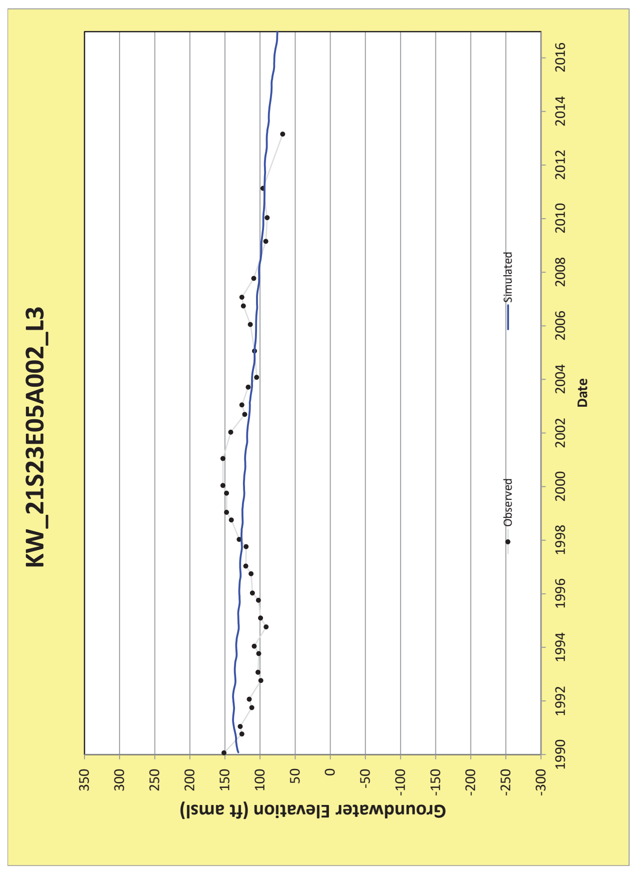
Date
Observed
Simulated


KW_21S23E05A002_L3
Groundwater Elevation (ft amsl)
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200
150
100
50
0
-50
-100
-150
-200
-250
-300
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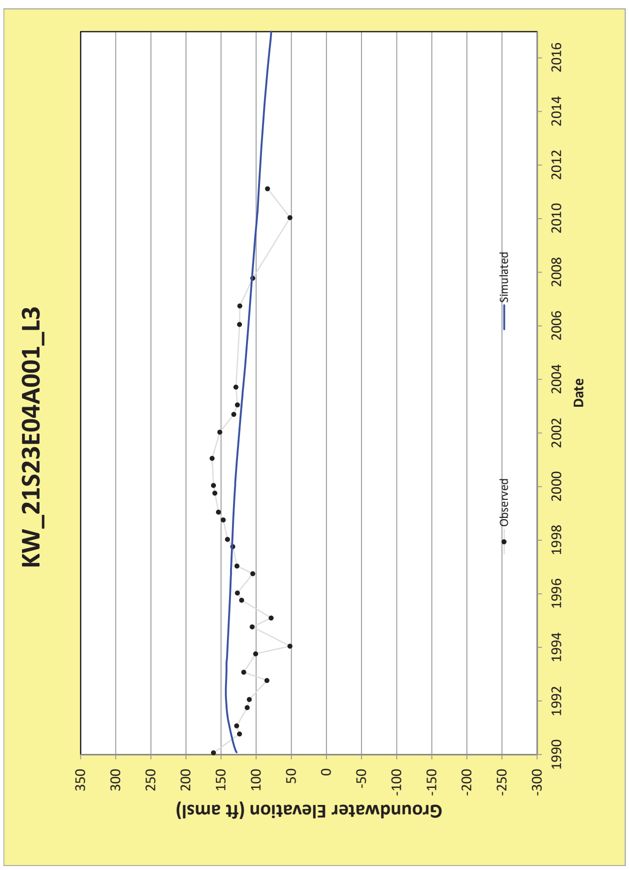
Date
Observed
Simulated


KW_21S23E04A001_L3
Groundwater Elevation (ft amsl)
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200
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0
-50
-100
-150
-200
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-300
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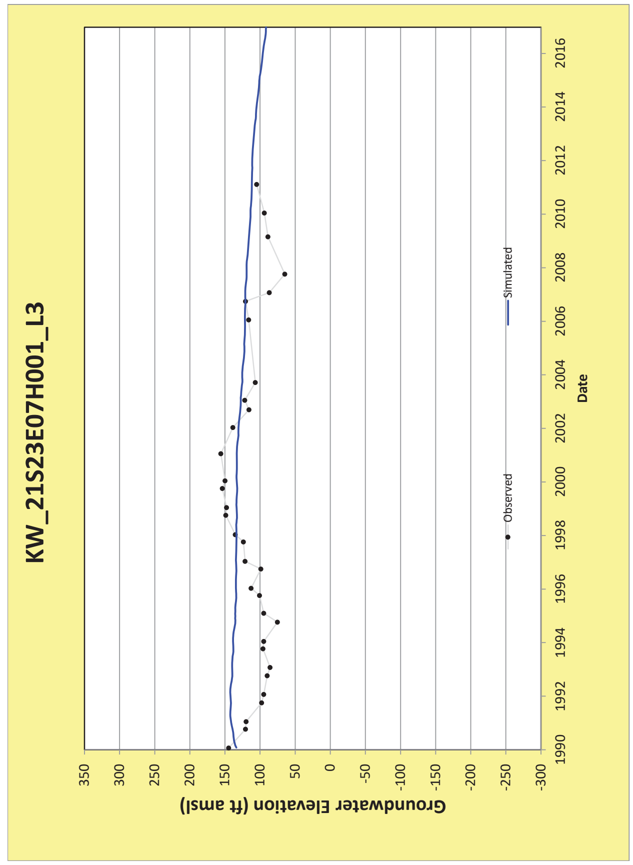
Date
Observed
Simulated


KW_21S23E07H001_L3
Groundwater Elevation (ft amsl)
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200
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0
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-100
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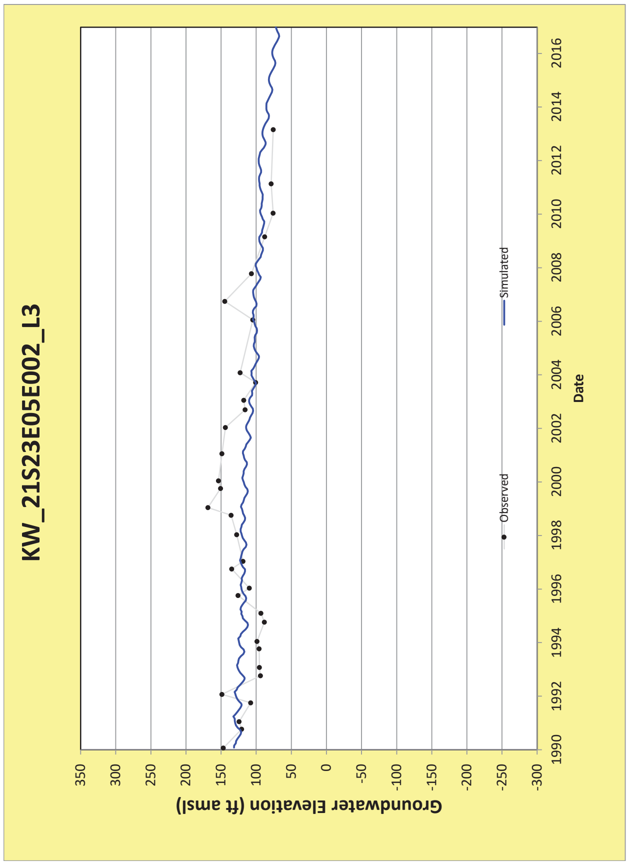
Date
Observed
Simulated


KW_21S23E05E002_L3
Groundwater Elevation (ft amsl)
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300
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200
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100
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0
-50
-100
-150
-200
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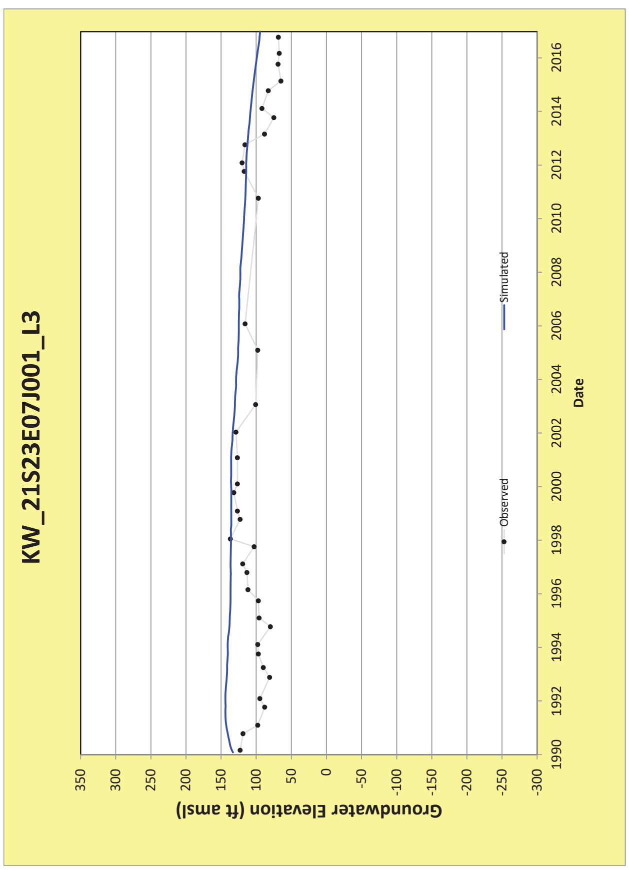
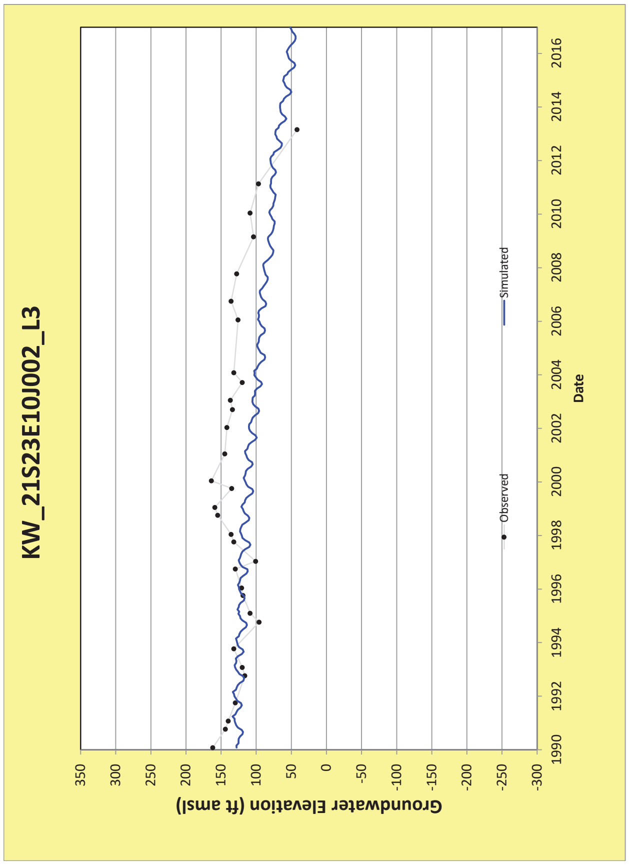
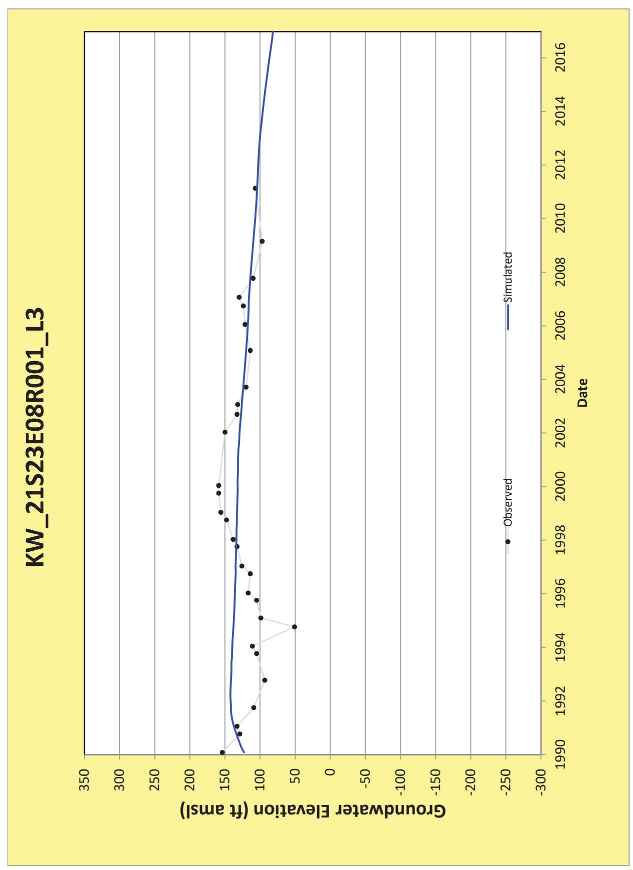
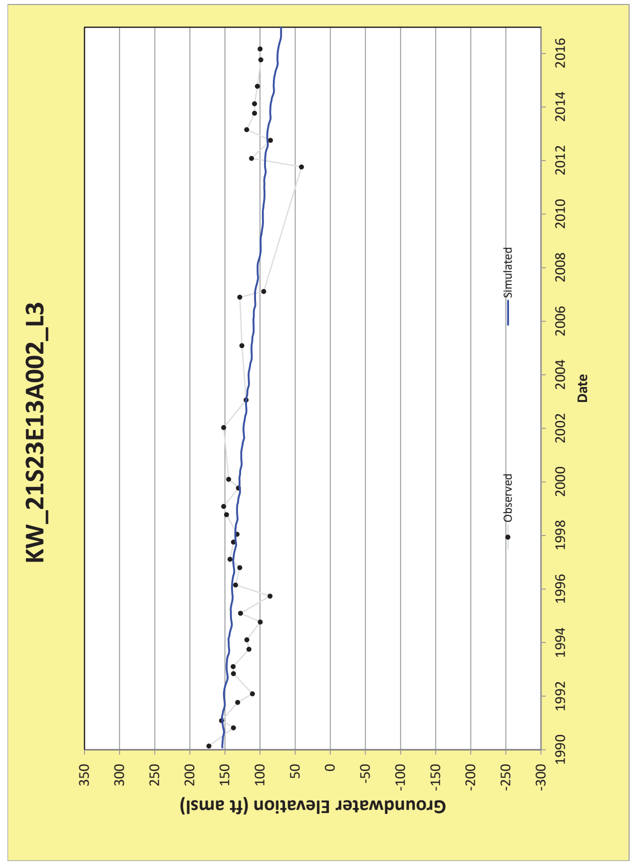
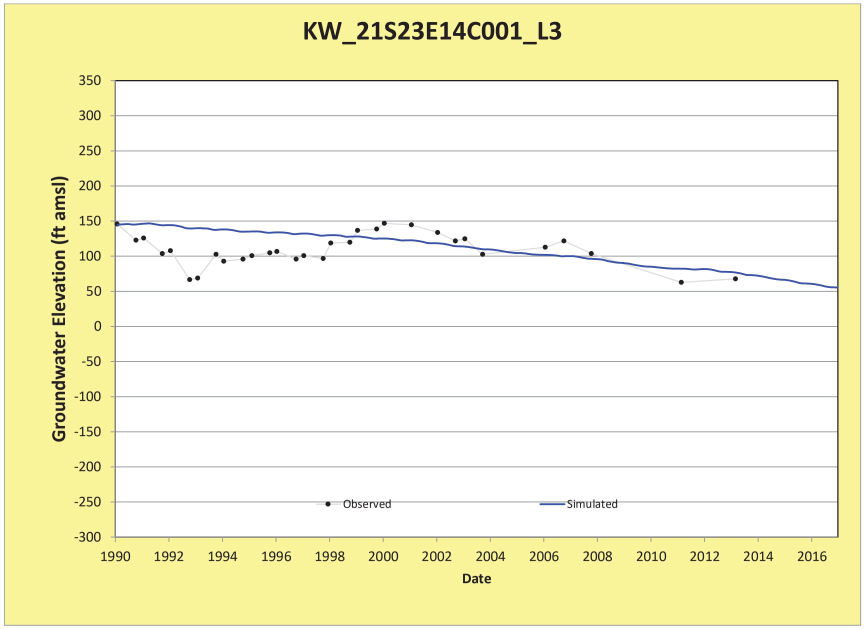
Date
Observed
Simulated

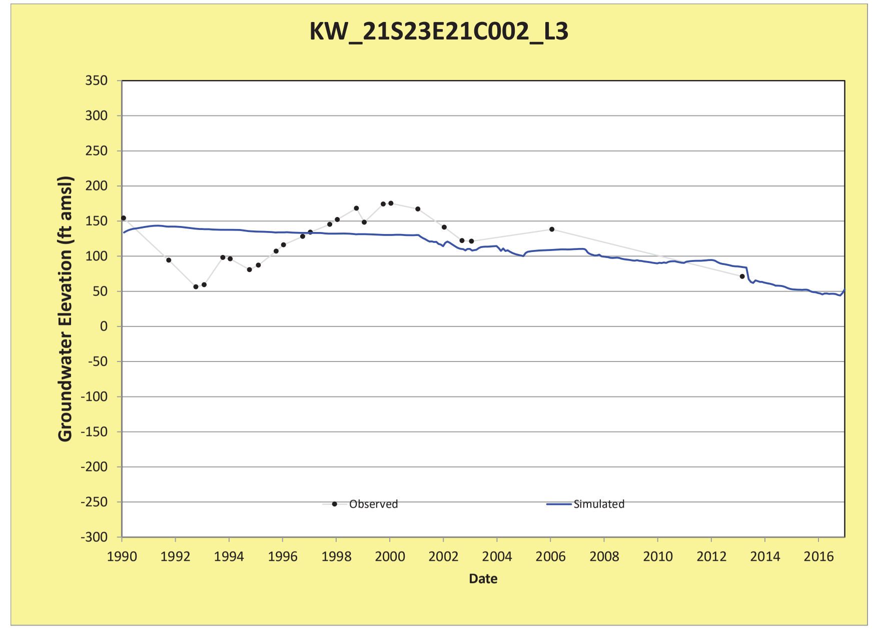

KW_21S23E07J001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

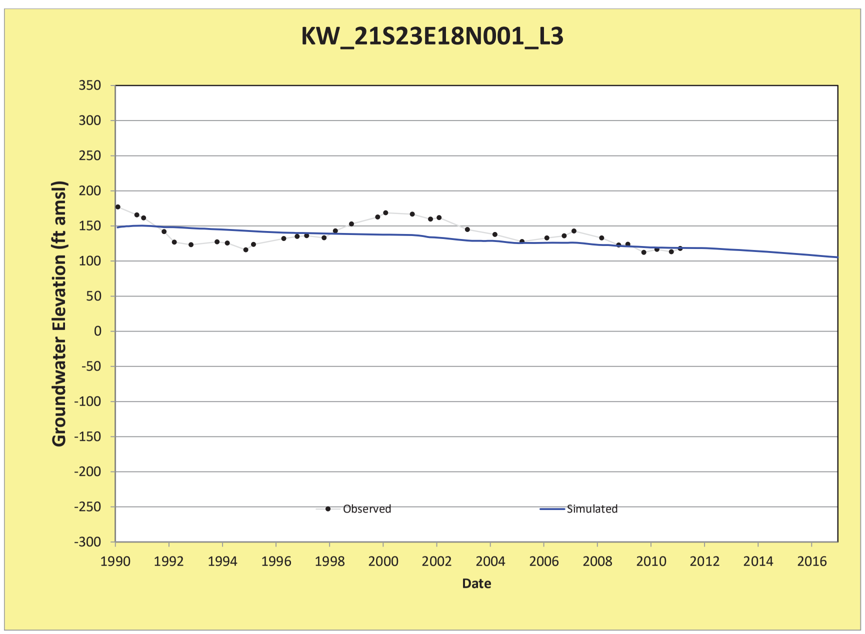

KW_21S23E10J002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

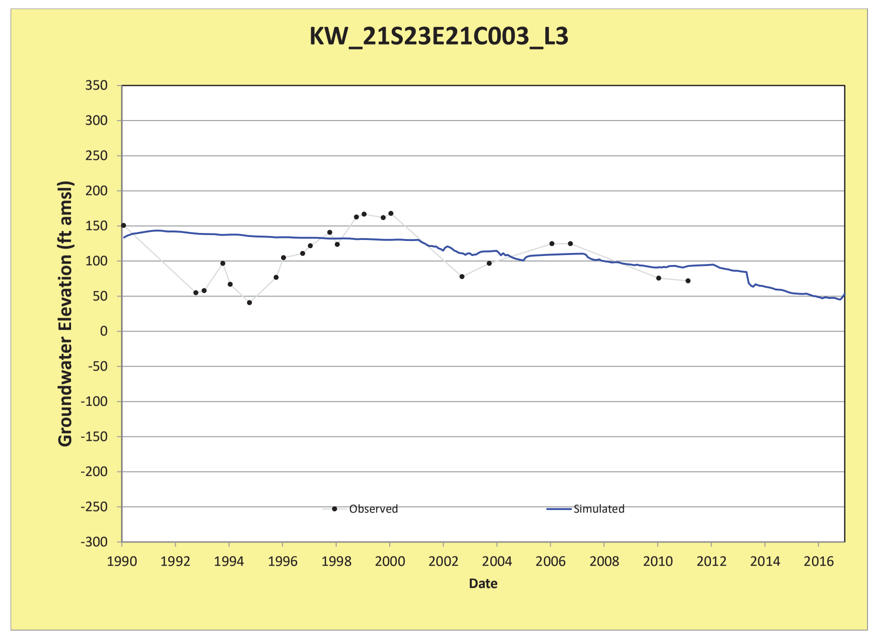

KW_21S23E08R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

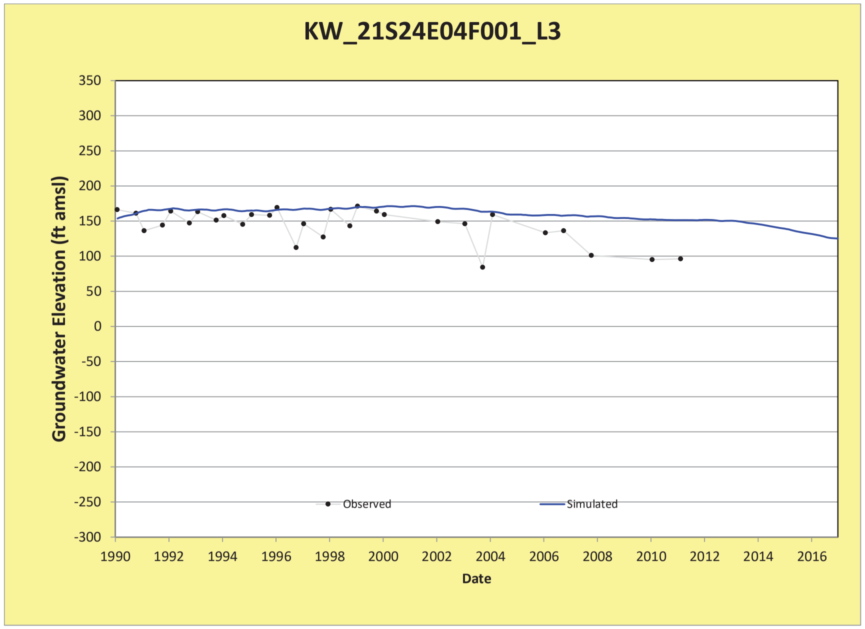

KW_21S23E13A002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

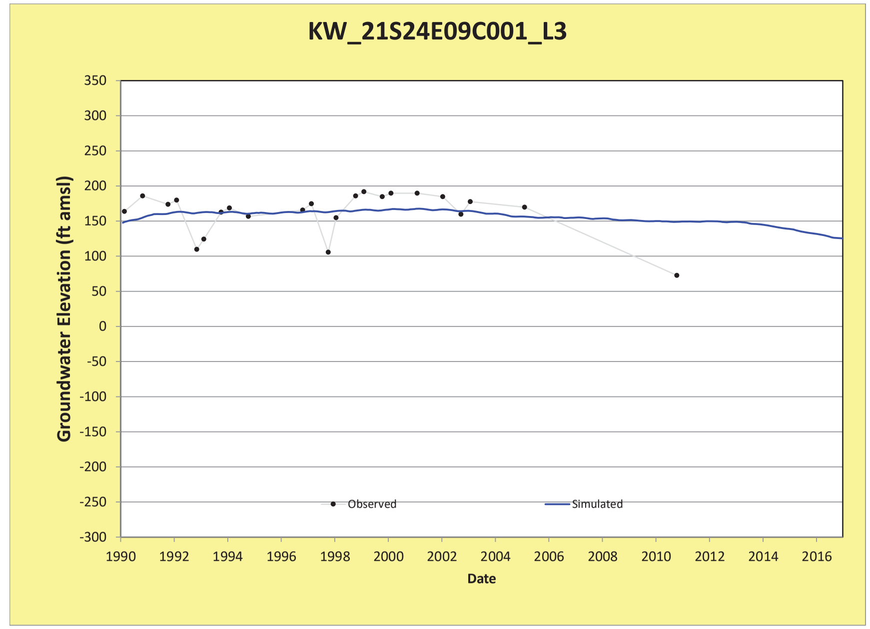

KW_21S23E14C001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

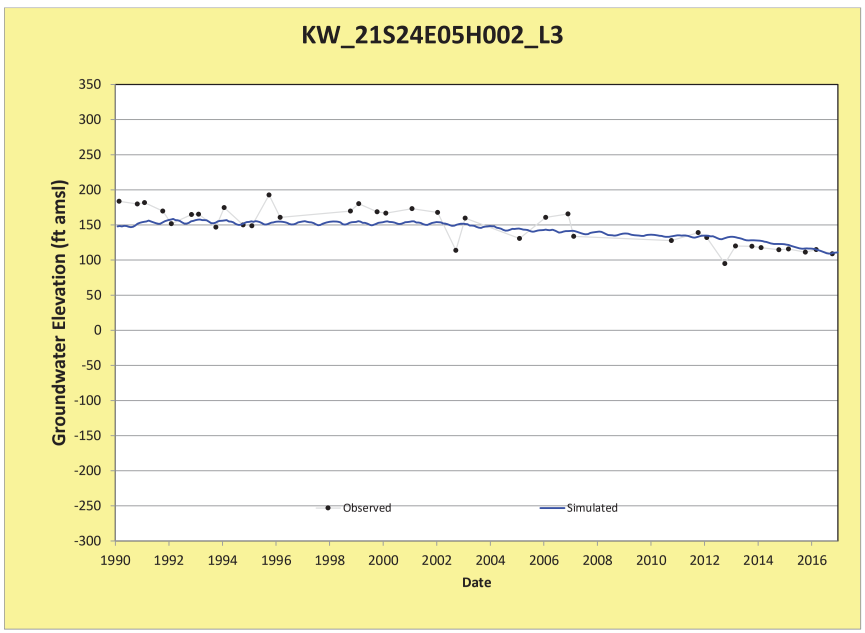

KW_21S23E21C002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

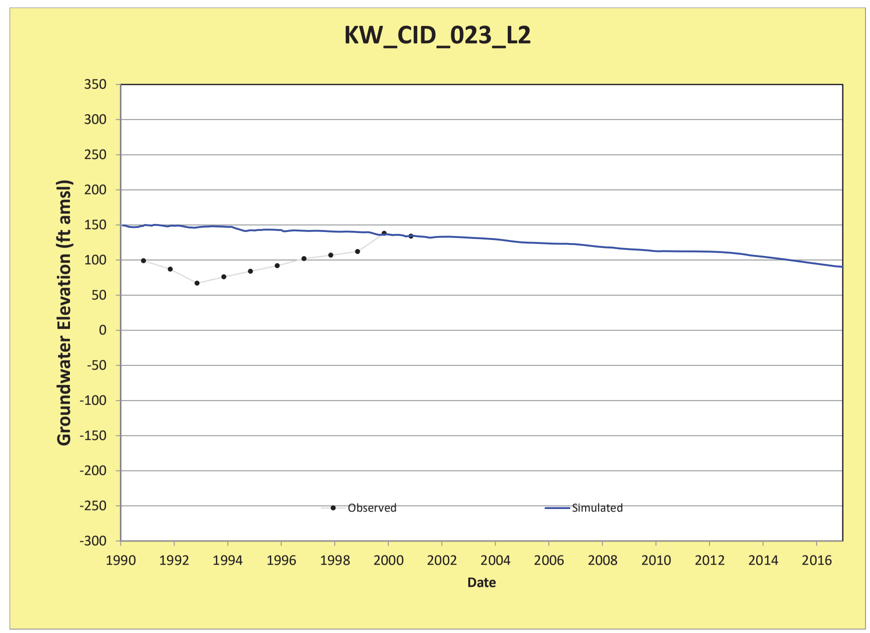

KW_21S23E18N001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

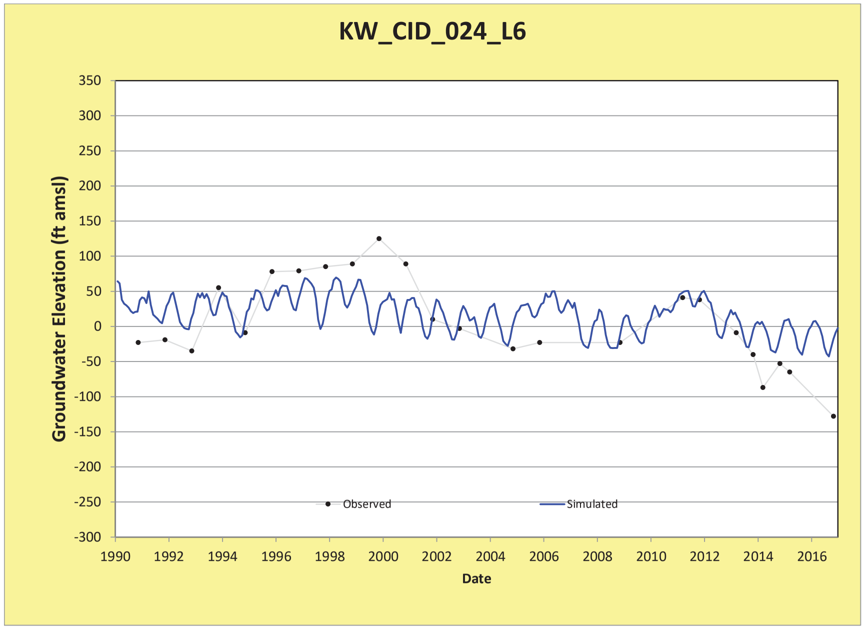

KW_21S23E21C003_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

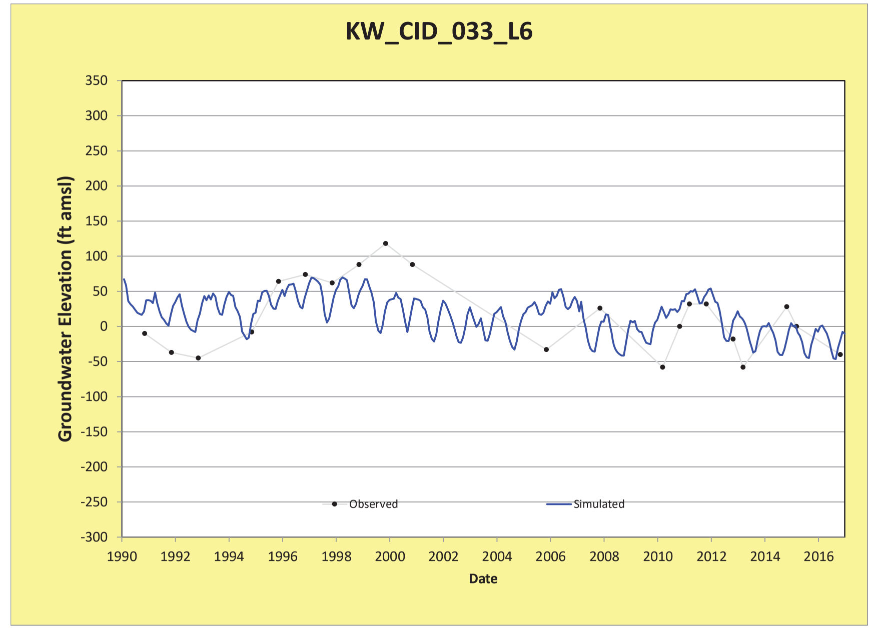

KW_21S24E04F001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

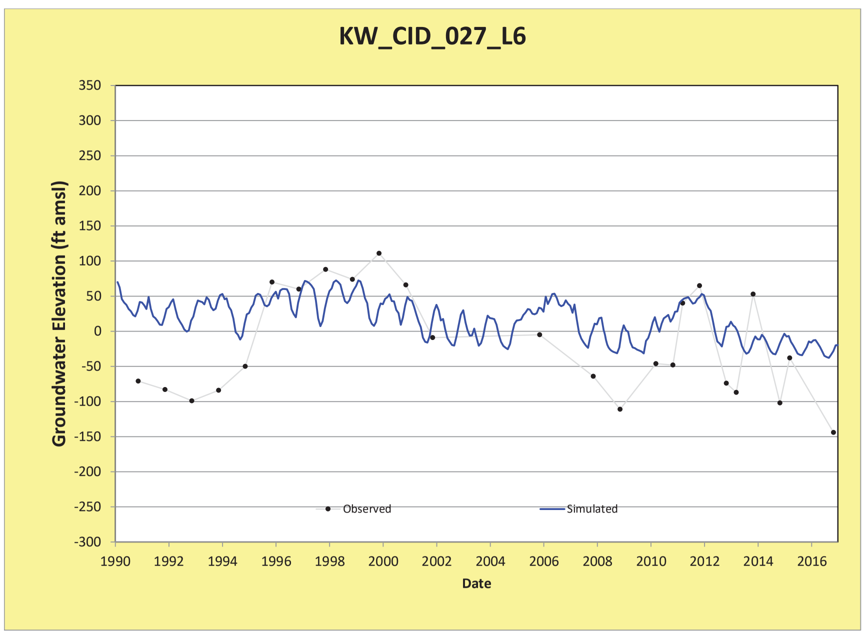

KW_21S24E09C001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

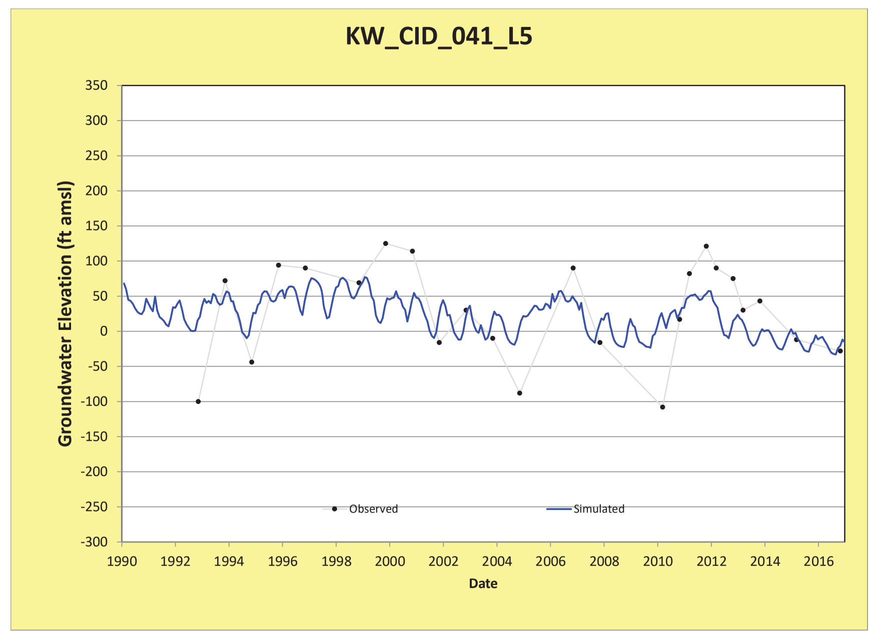

KW_21S24E05H002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

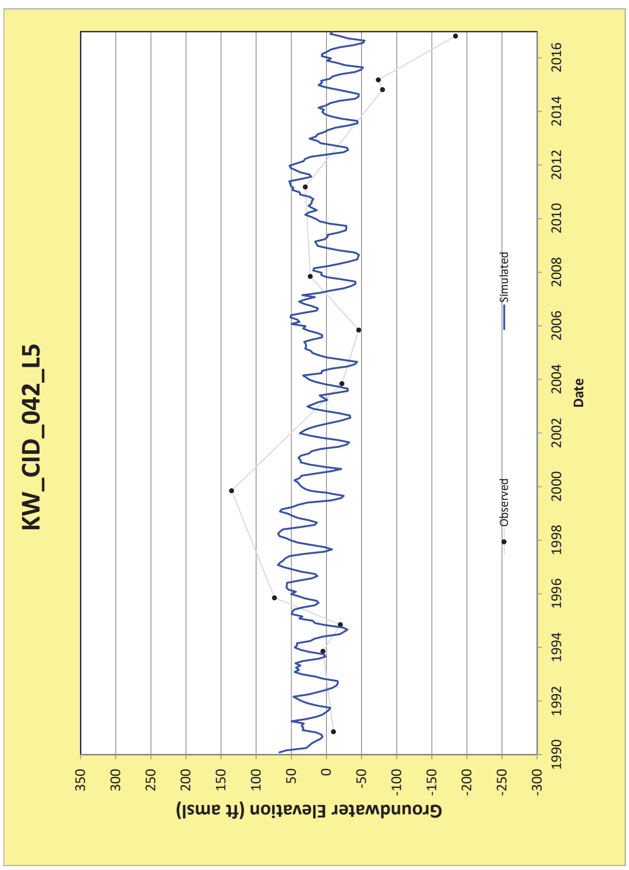

KW_CID_023_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

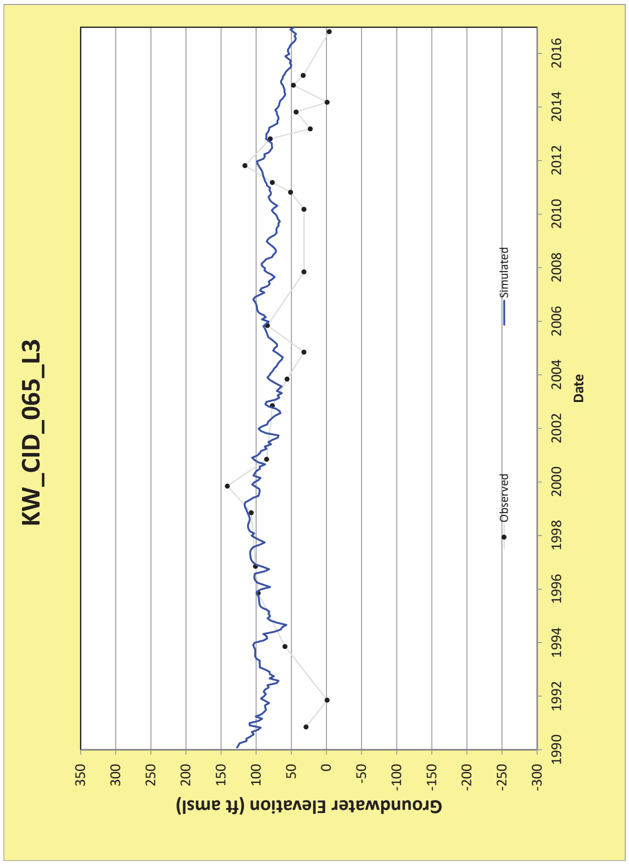

KW_CID_024_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_CID_033_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_CID_027_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_CID_041_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


KW_CID_042_L5
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


KW_CID_065_L3
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
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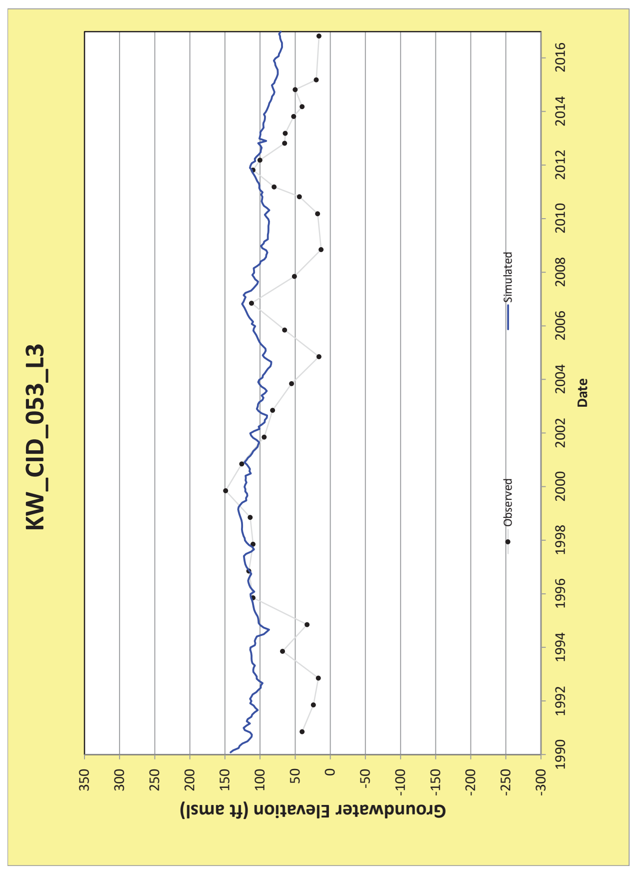
2008
2010
2012
2014
2016
Date
Observed
Simulated


KW_CID_053_L3
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
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2010
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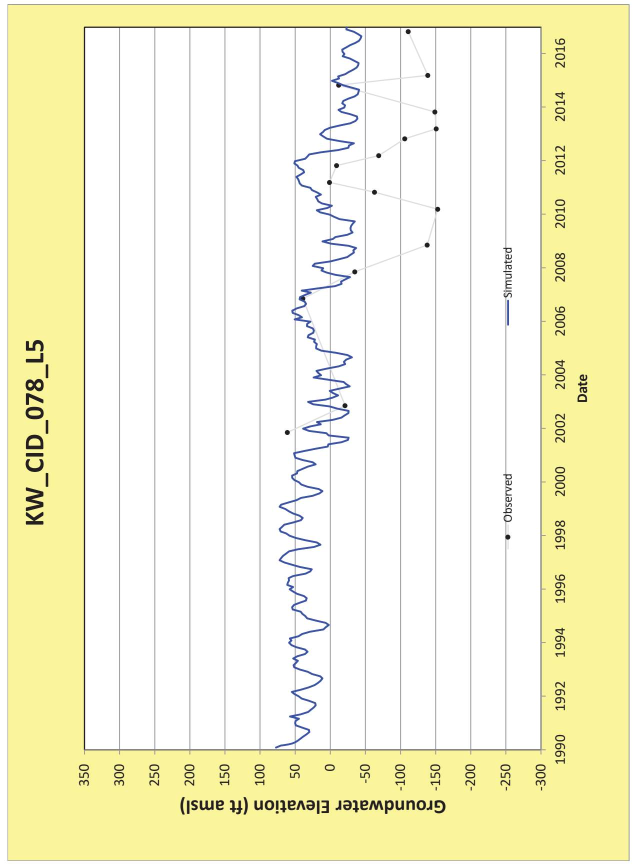
2016
Date
Observed
Simulated


KW_CID_078_L5
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
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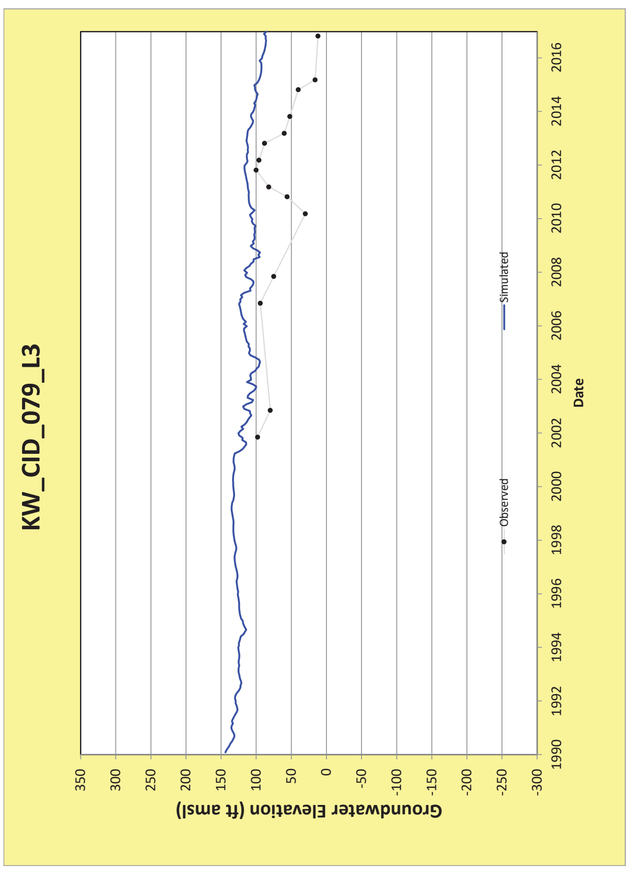
2008
2010
2012
2014
2016
Date
Observed
Simulated


KW_CID_079_L3
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
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2004
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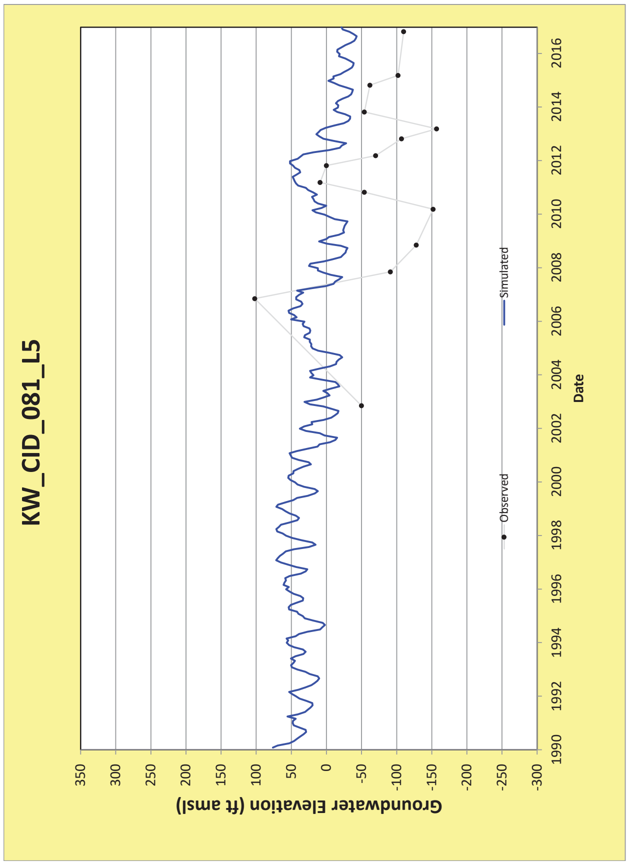
2010
2012
2014
2016
Date
Observed
Simulated


KW_CID_081_L5
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
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2000
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2004
2006
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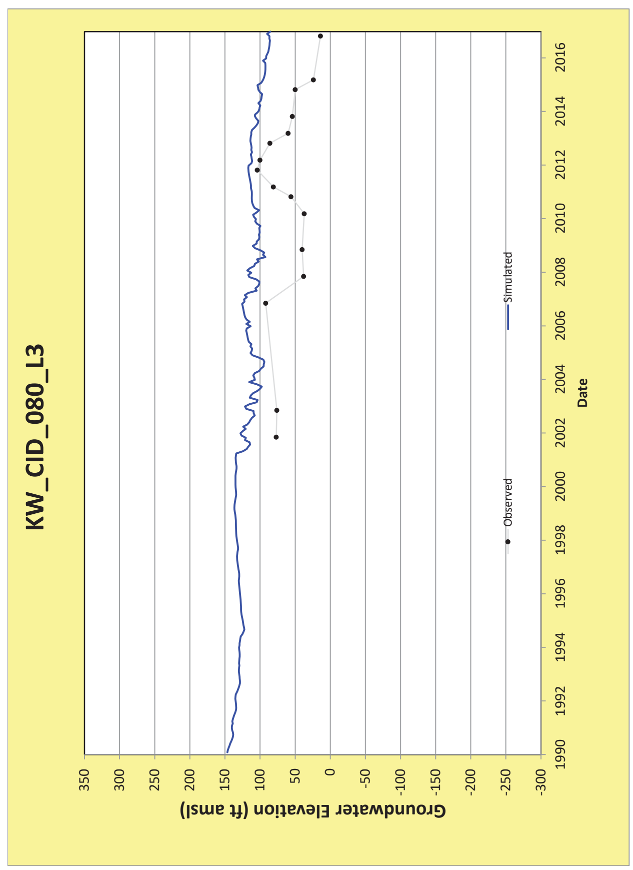
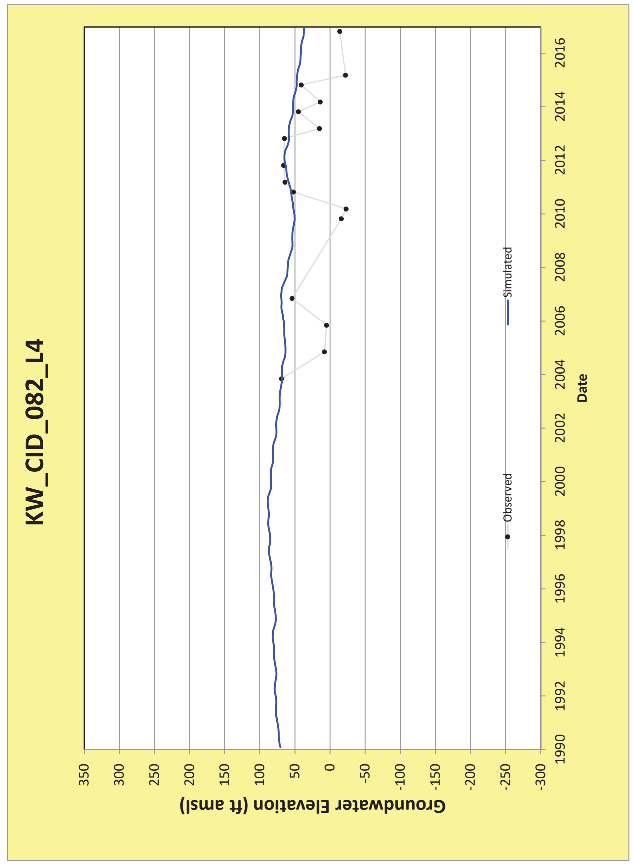
2014
2016
Date
Observed
Simulated


KW_CID_080_L3
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


KW_CID_082_L4
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
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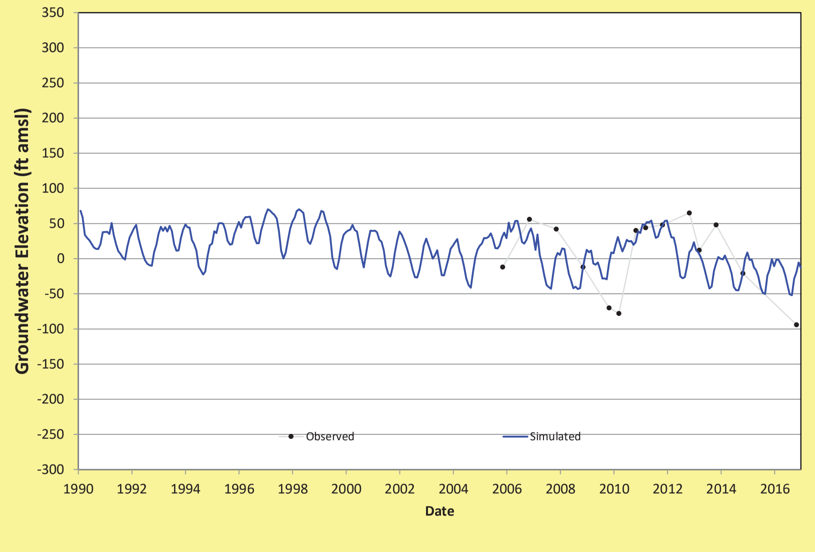
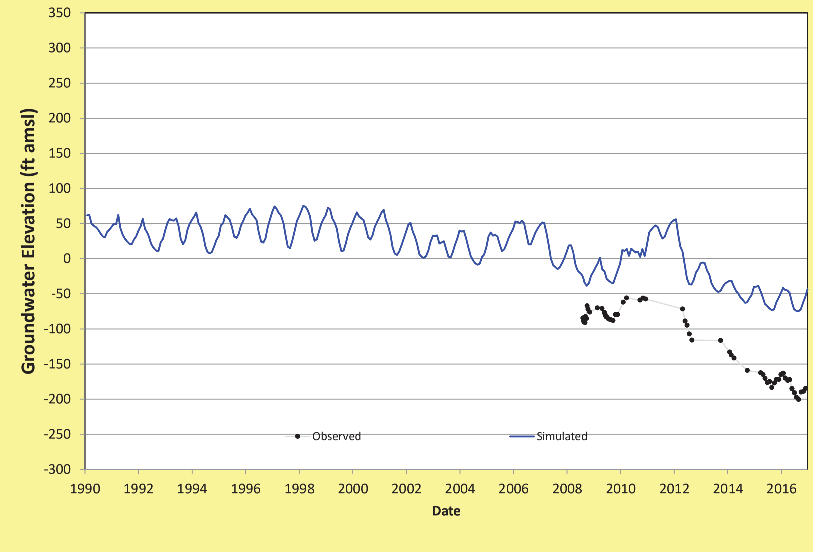
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated

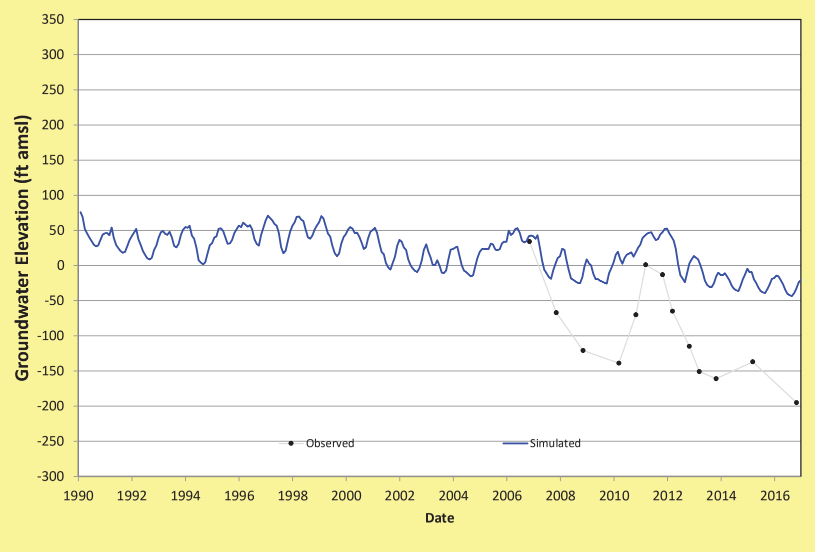
KW_CID_084_L5



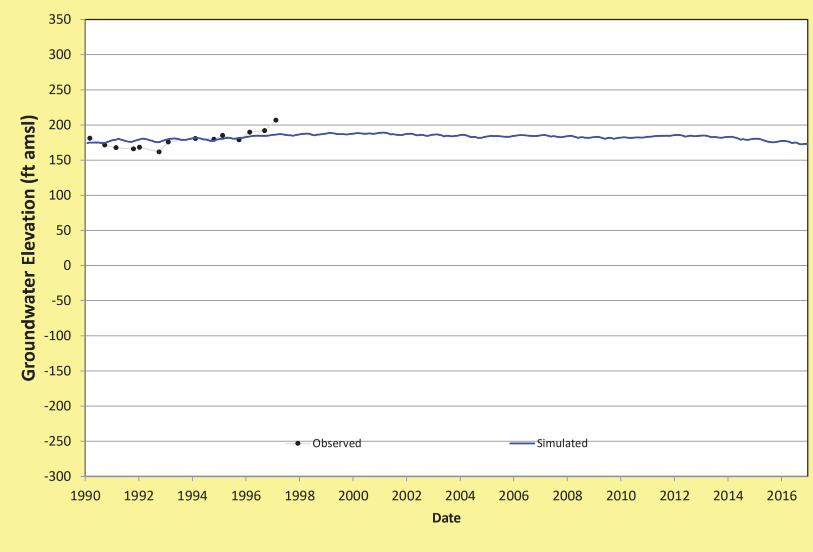
KW_CR_S-197_L6

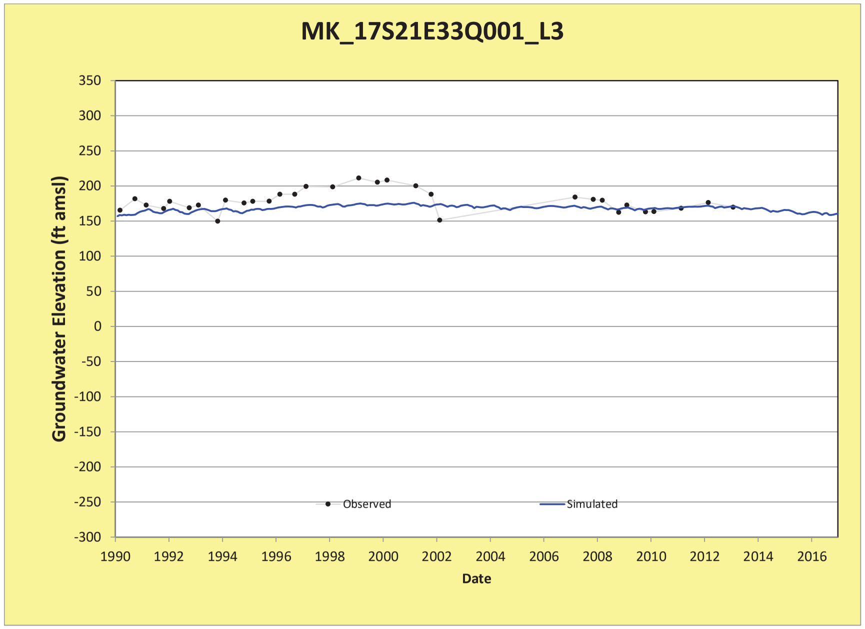


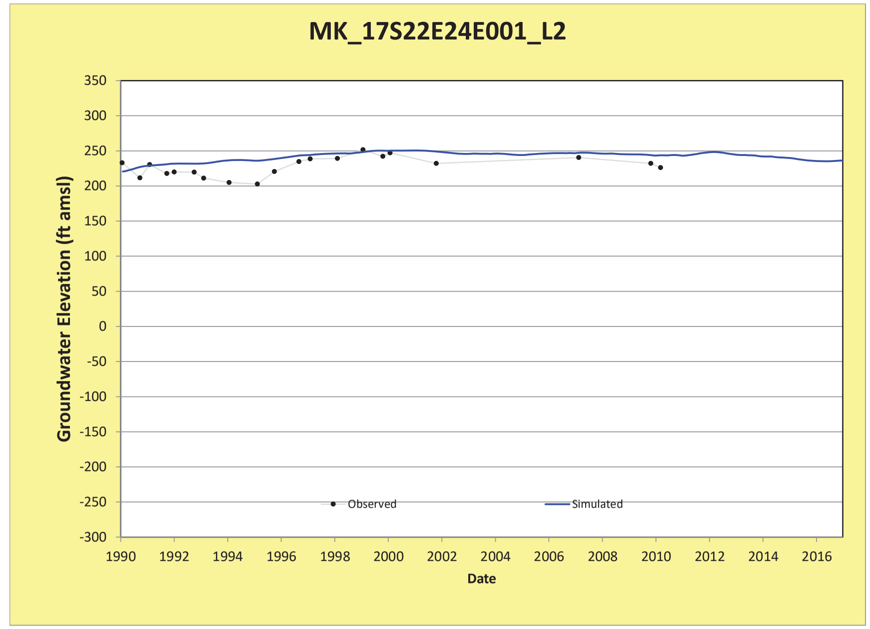
KW_CID_085_L5

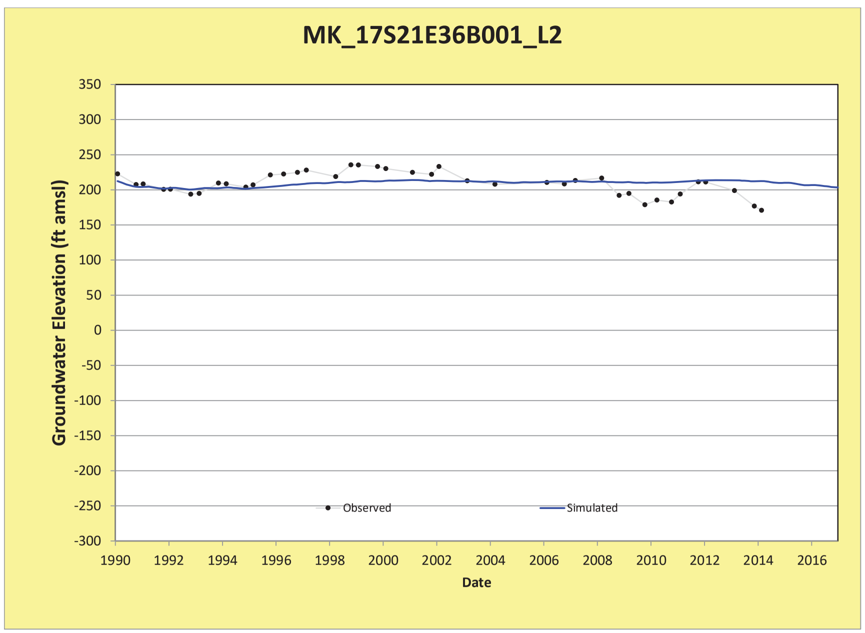


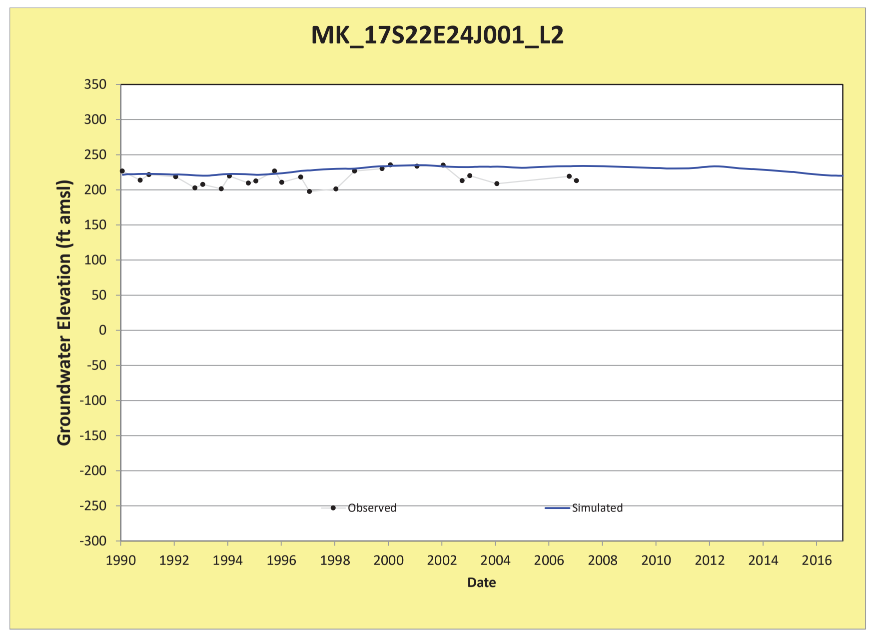
MK_17S21E33B001_L3

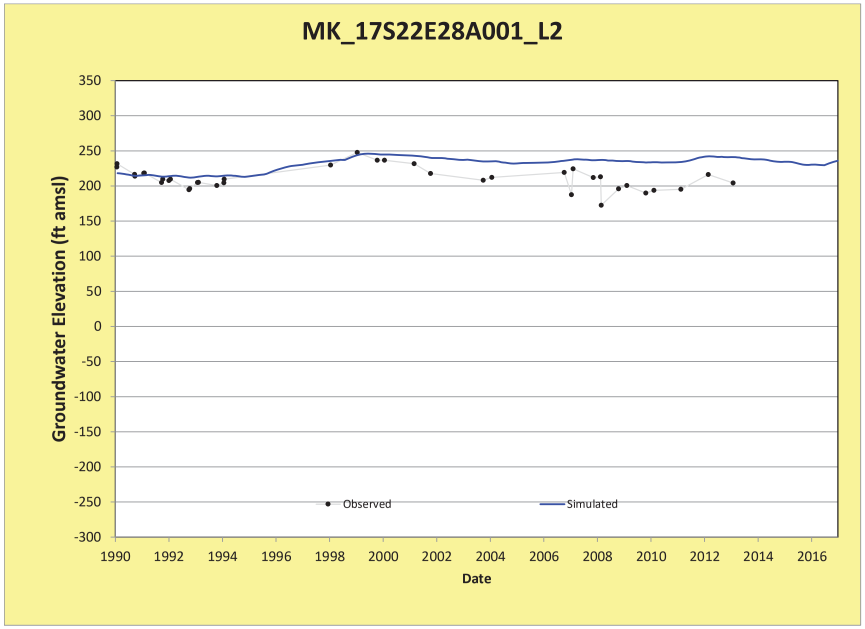



MK_17S21E33Q001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_17S22E24E001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_17S21E36B001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_17S22E24J001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_17S22E28A001_L2
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
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1992
1994
1996
1998
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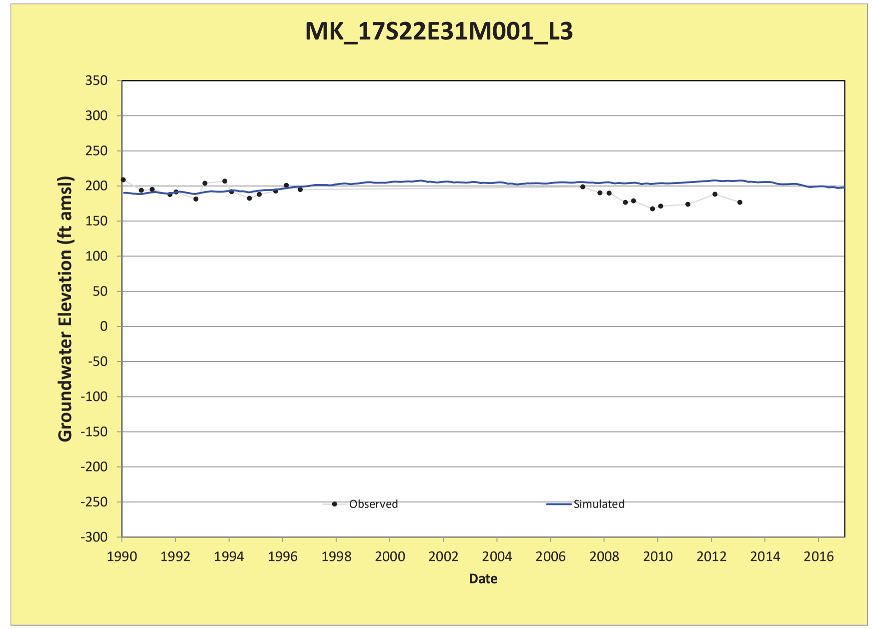
2010
2012
2014
2016
Date
Observed
Simulated


MK_17S22E31M001_L3
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
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2010
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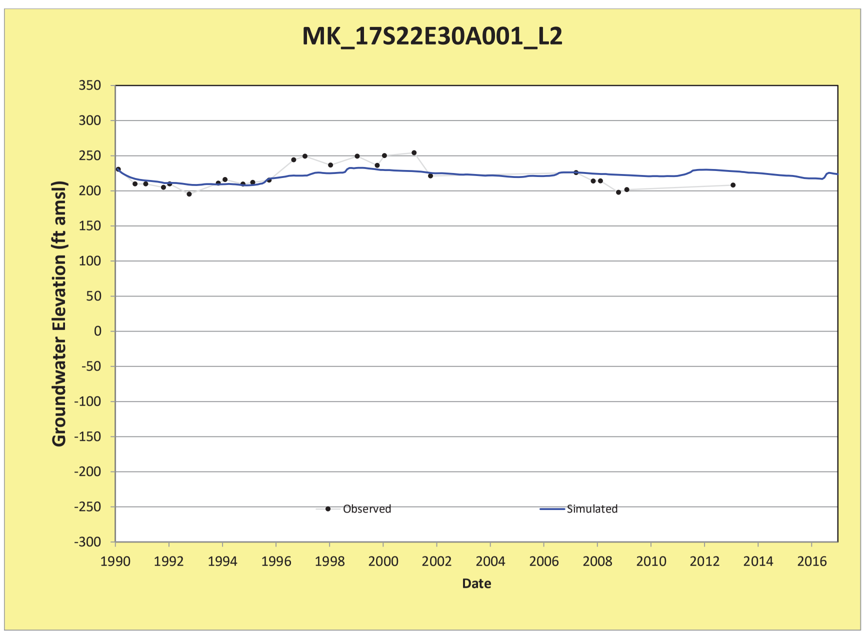
2014
2016
Date
Observed
Simulated


MK_17S22E30A001_L2
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
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1992
1994
1996
1998
2000
2002
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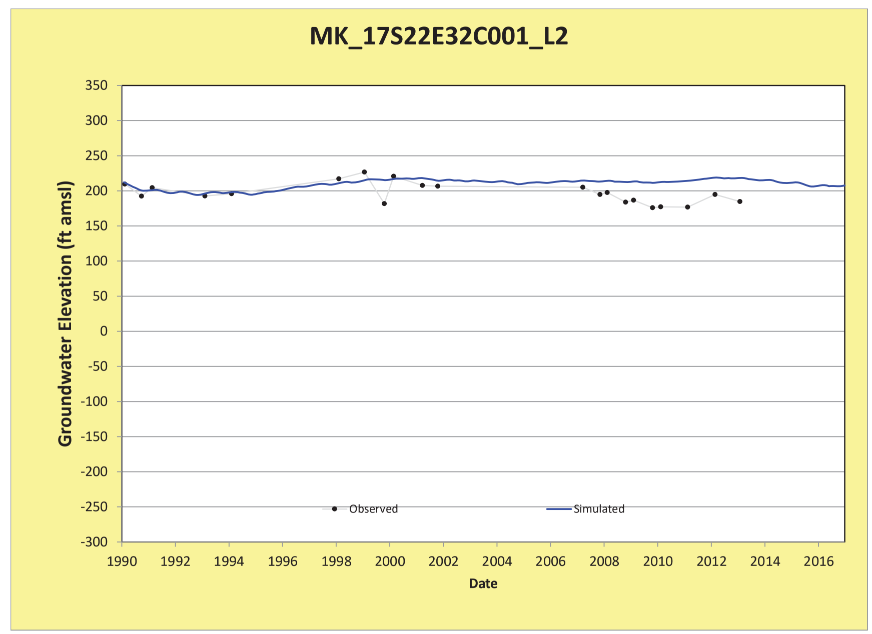
2010
2012
2014
2016
Date
Observed
Simulated


MK_17S22E32C001_L2
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
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1992
1994
1996
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2000
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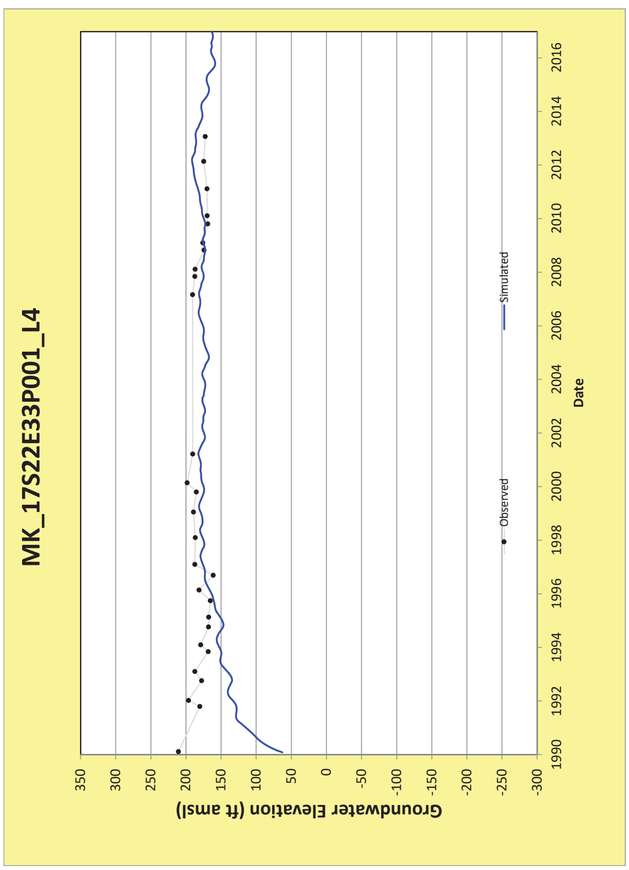
2010
2012
2014
2016
Date
Observed
Simulated


MK_17S22E33P001_L4
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
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1992
1994
1996
1998
2000
2002
2004
2006
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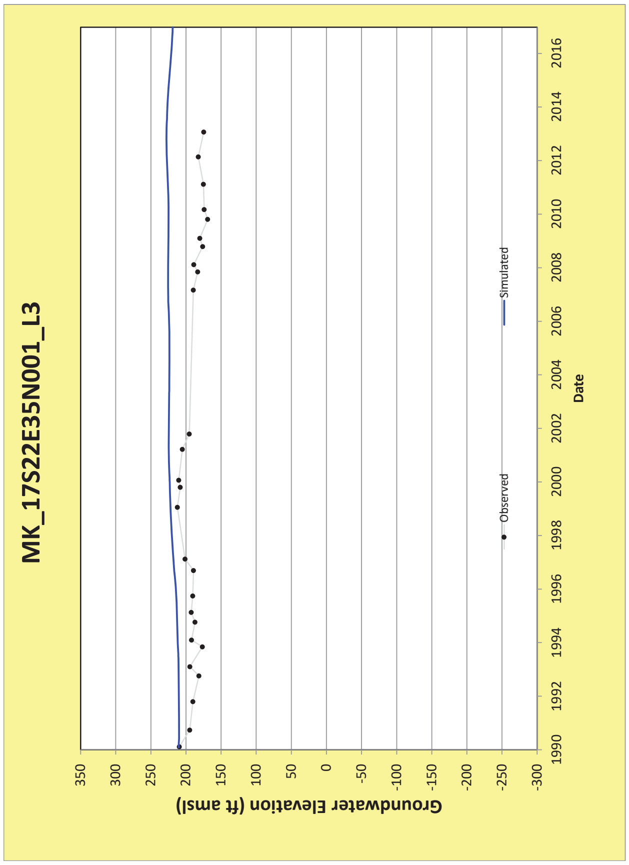
2010
2012
2014
2016
Date
Observed
Simulated


MK_17S22E35N001_L3
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
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1992
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2010
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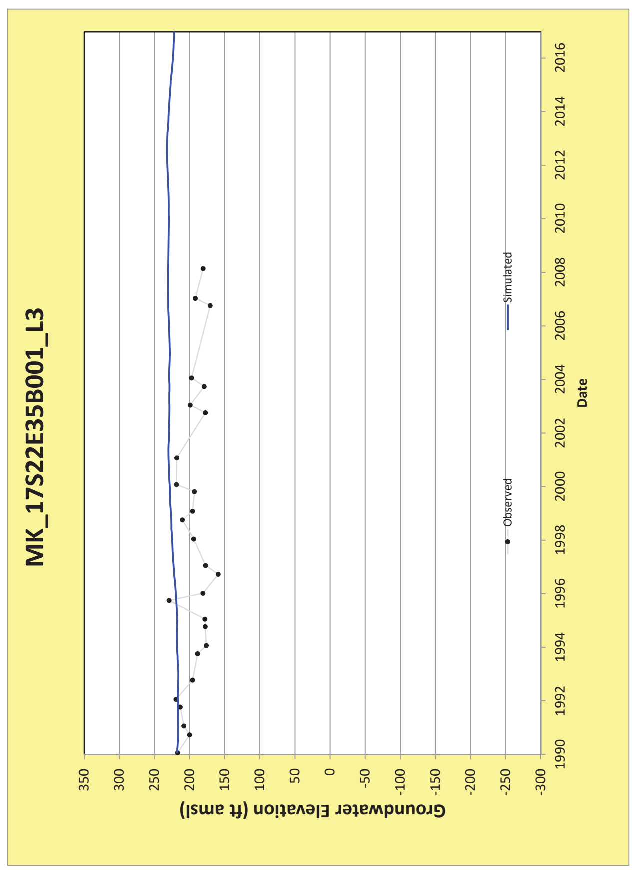
2016
Date
Observed
Simulated


MK_17S22E35B001_L3
Groundwater Elevation (ft amsl)
350
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250
200
150
100
50
0
-50
-100
-150
-200
-250
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1990
1992
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2000
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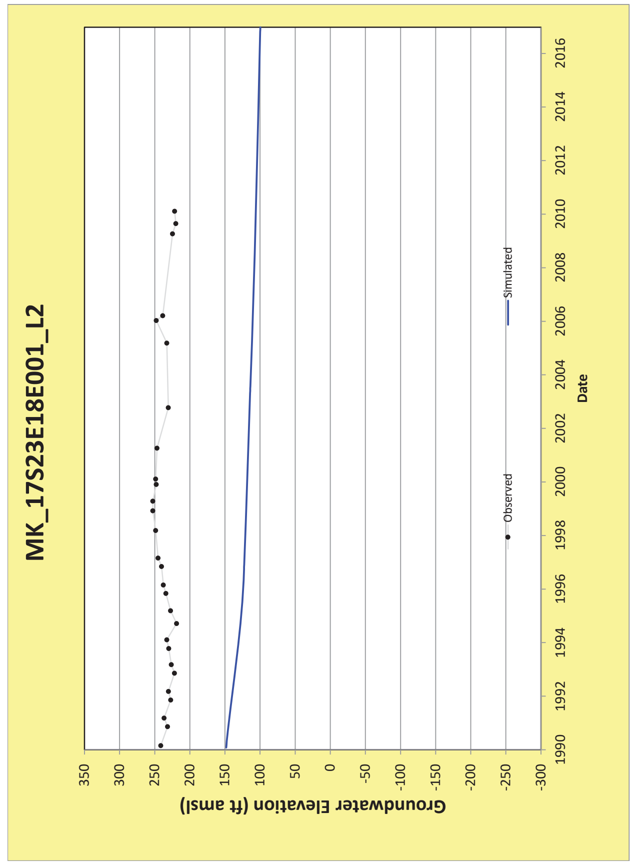
Date
Observed
Simulated


MK_17S23E18E001_L2
Groundwater Elevation (ft amsl)
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200
150
100
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0
-50
-100
-150
-200
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-300
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1992
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1996
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2000
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2010
2012
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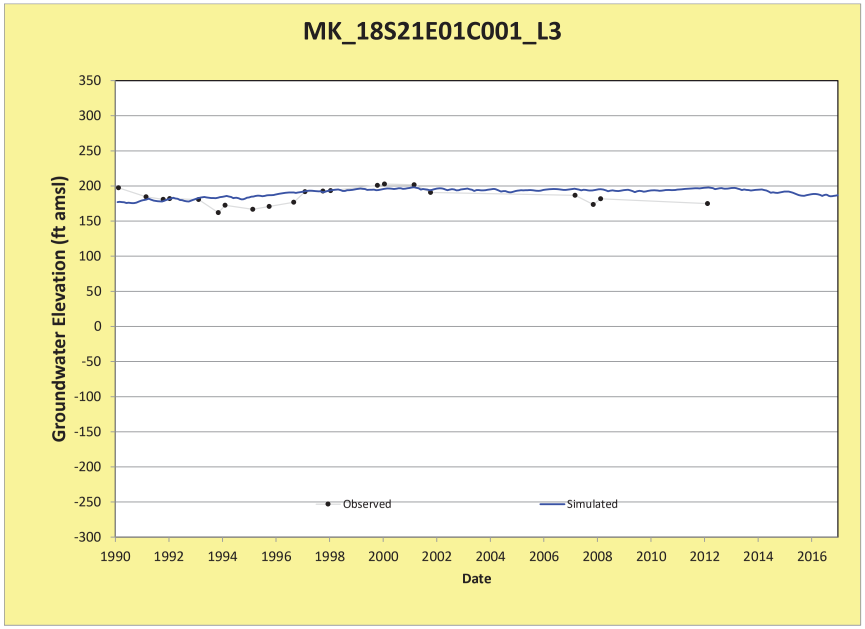
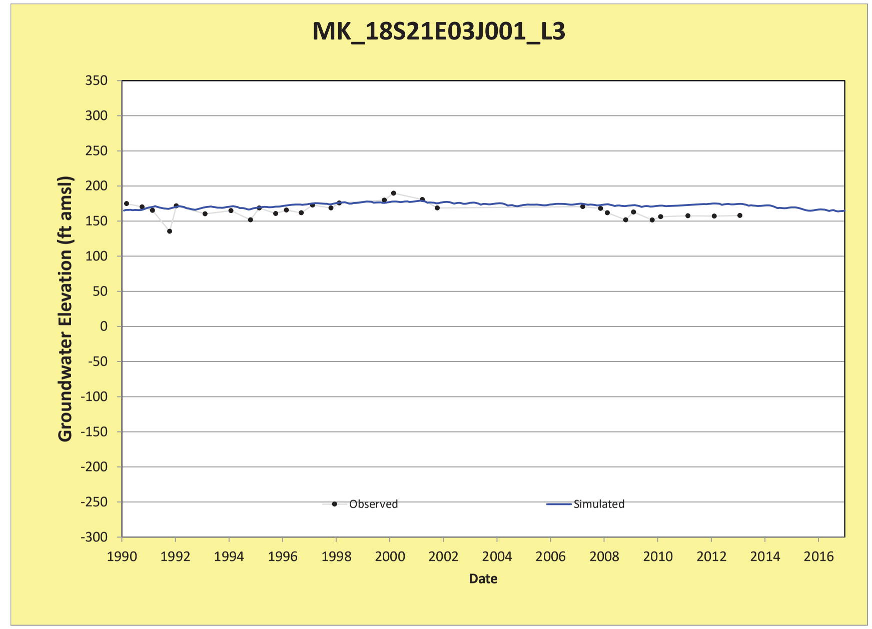
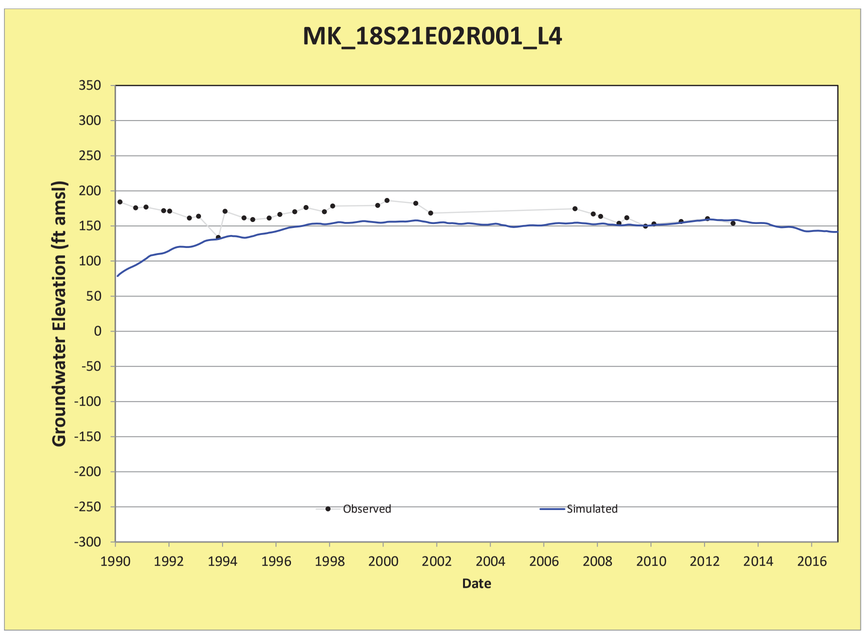
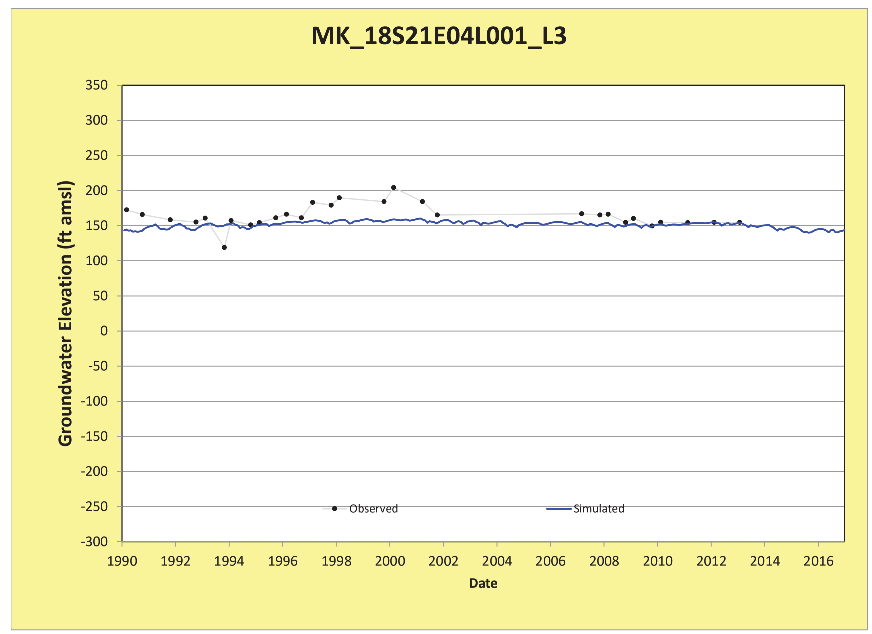
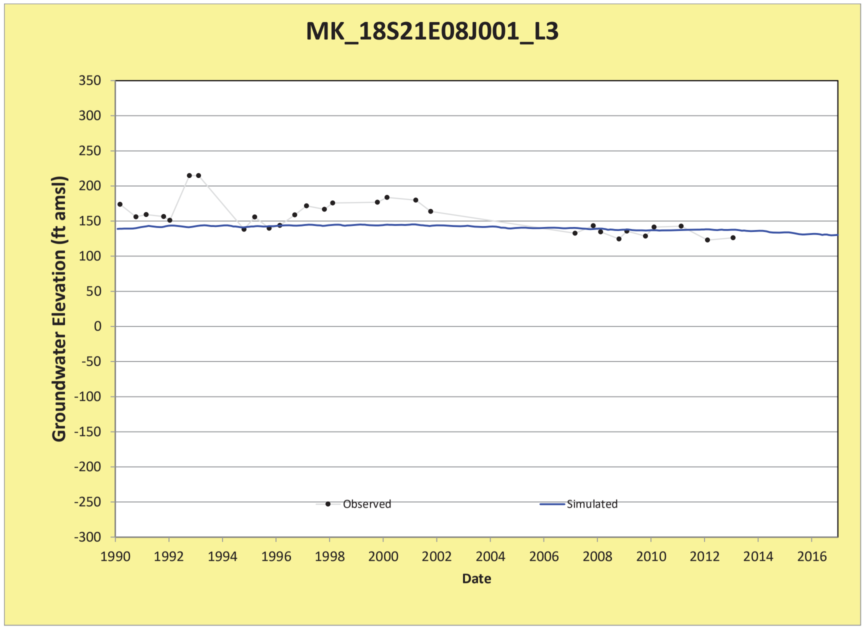
2016
Date
Observed
Simulated

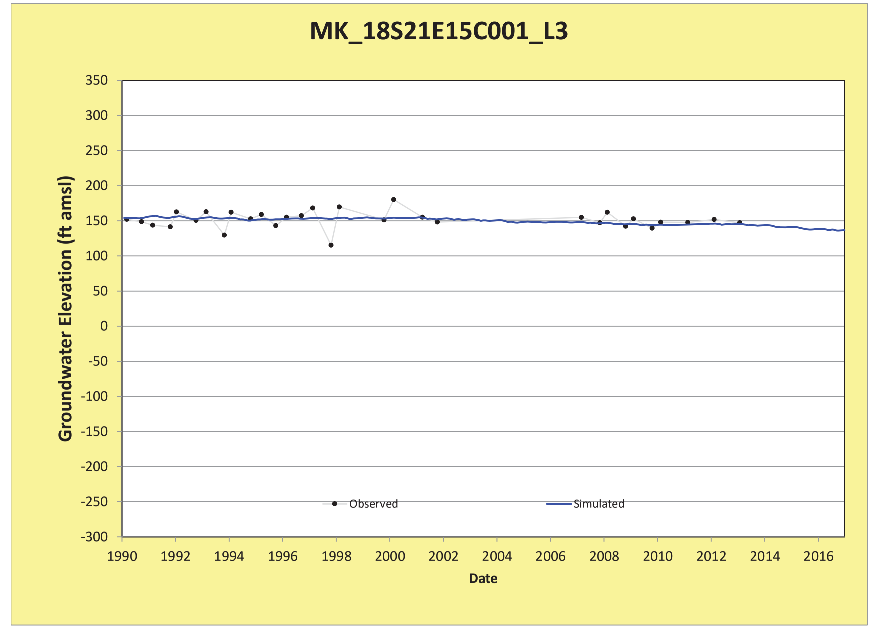

MK_18S21E01C001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

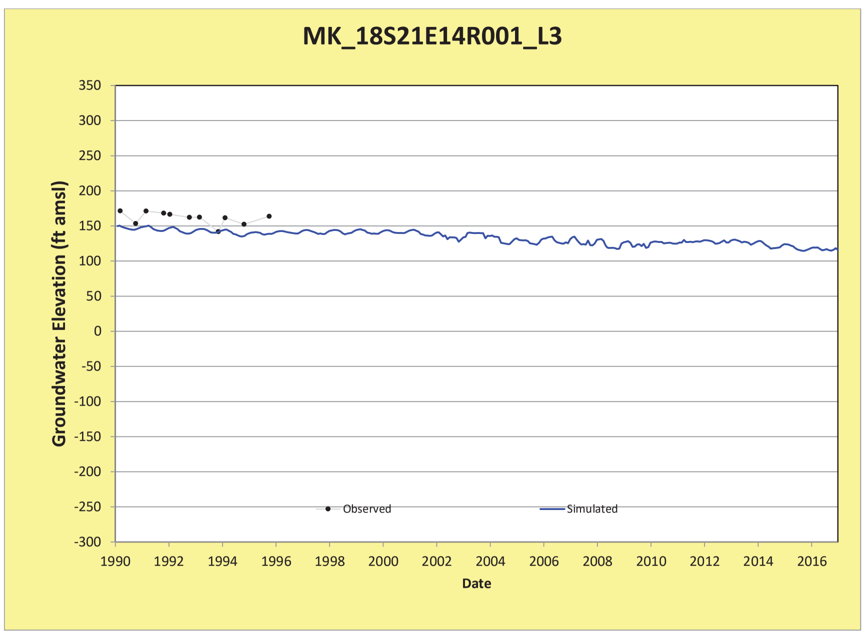

MK_18S21E03J001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

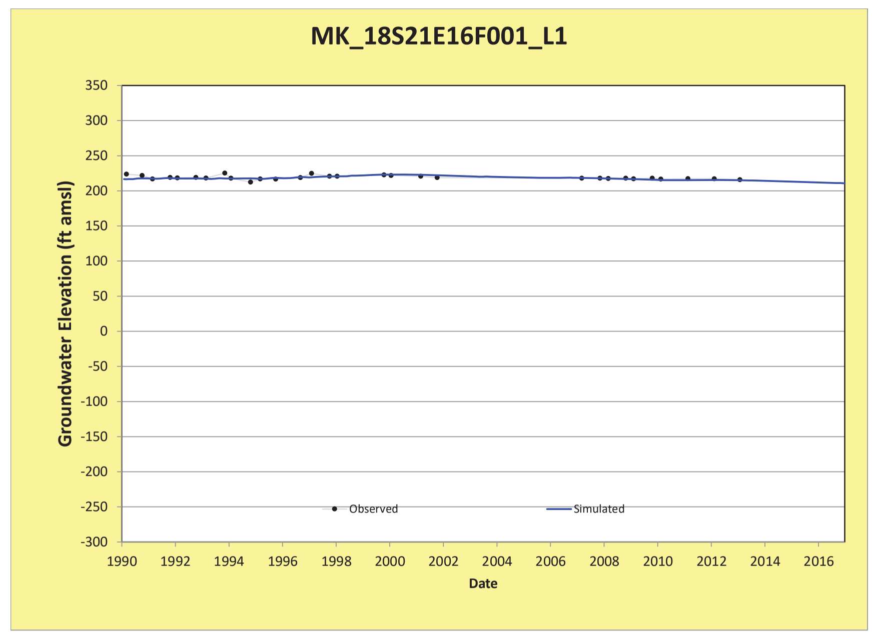

MK_18S21E02R001_L4
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

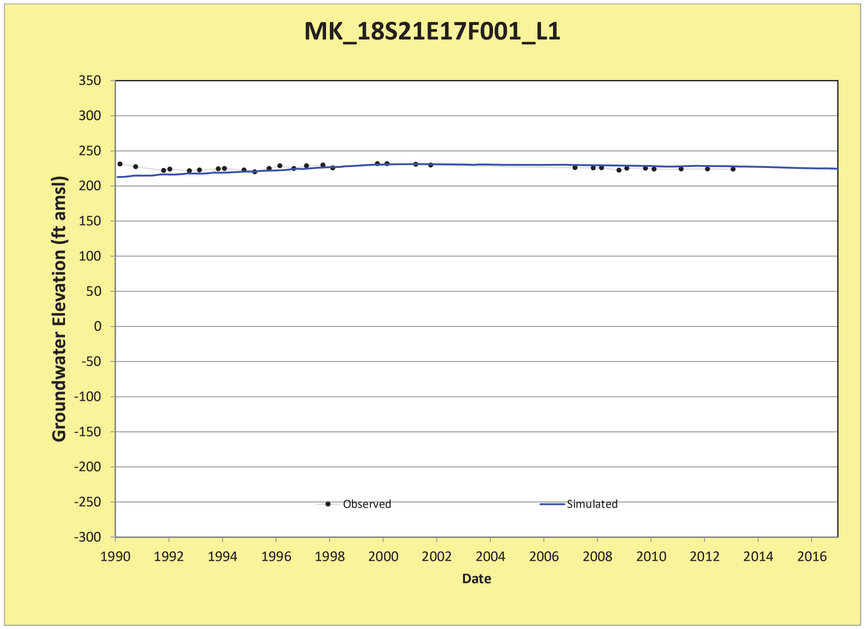

MK_18S21E04L001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_18S21E08J001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

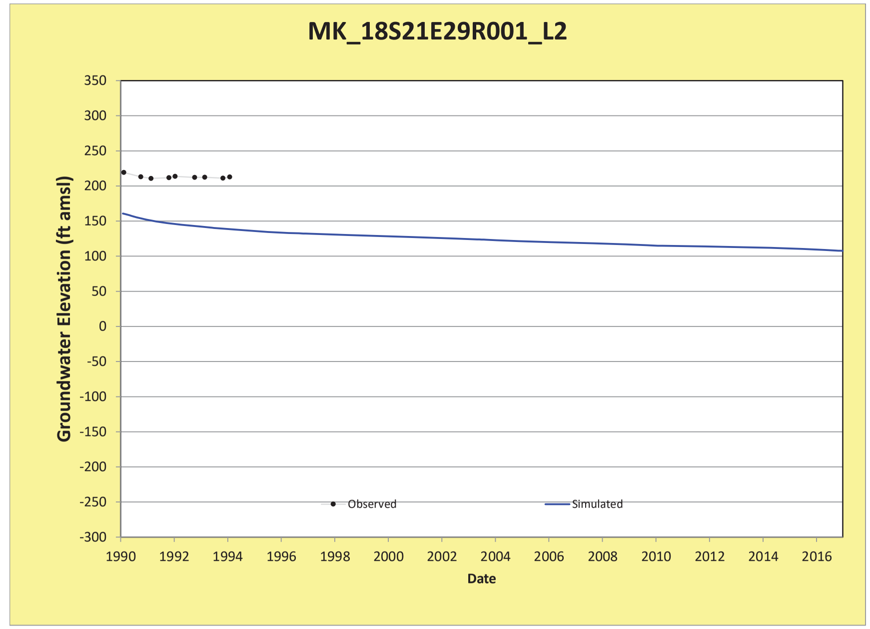

MK_18S21E15C001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_18S21E14R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

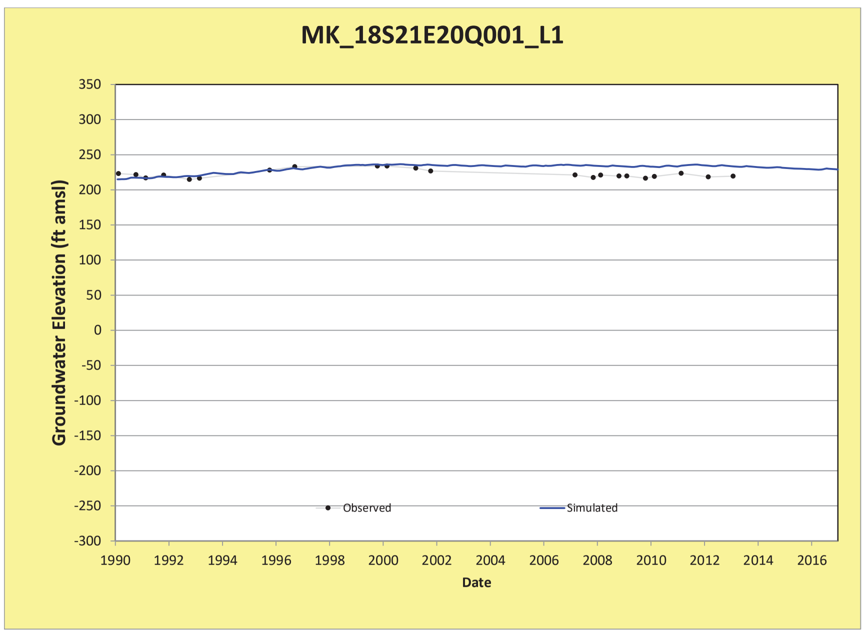

MK_18S21E16F001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



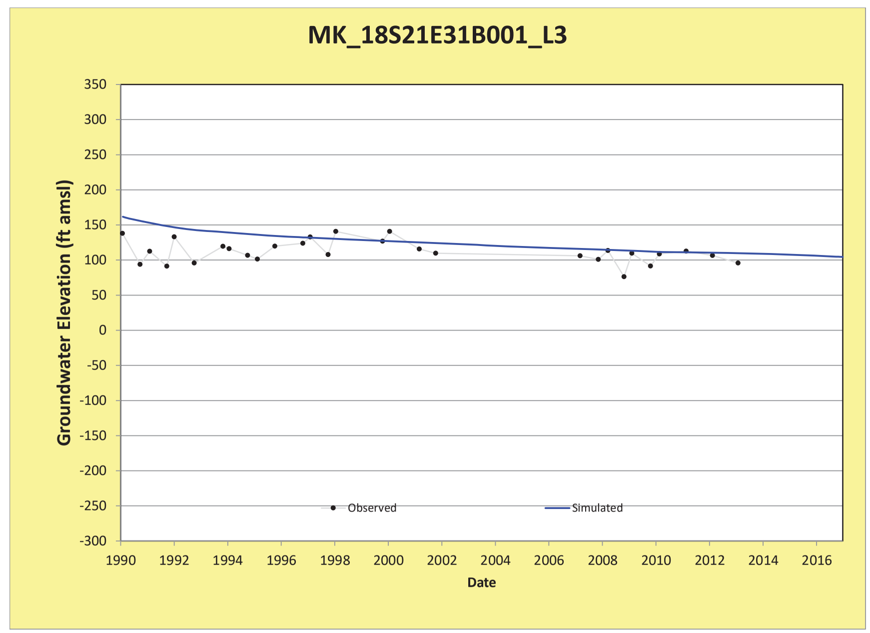
MK_18S21E17F001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



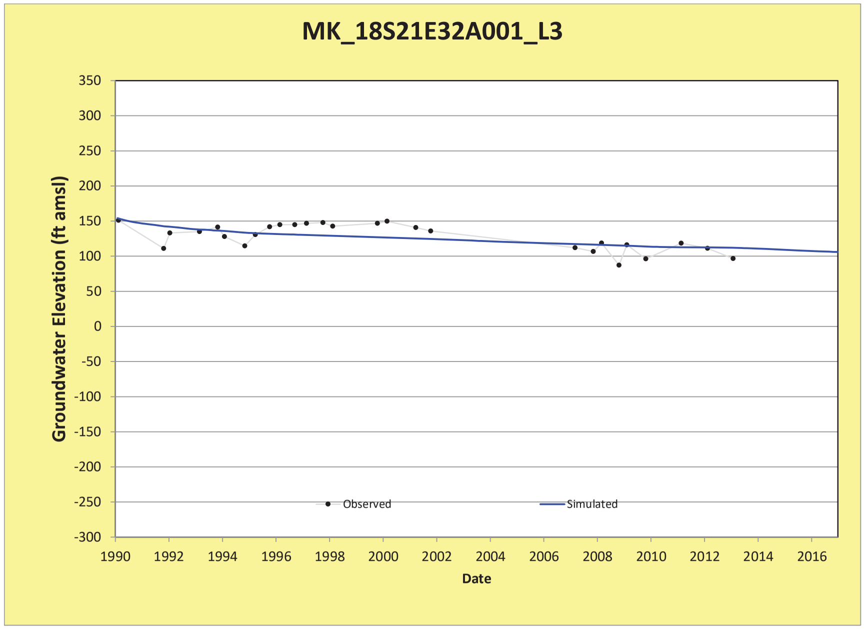
MK_18S21E29R001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

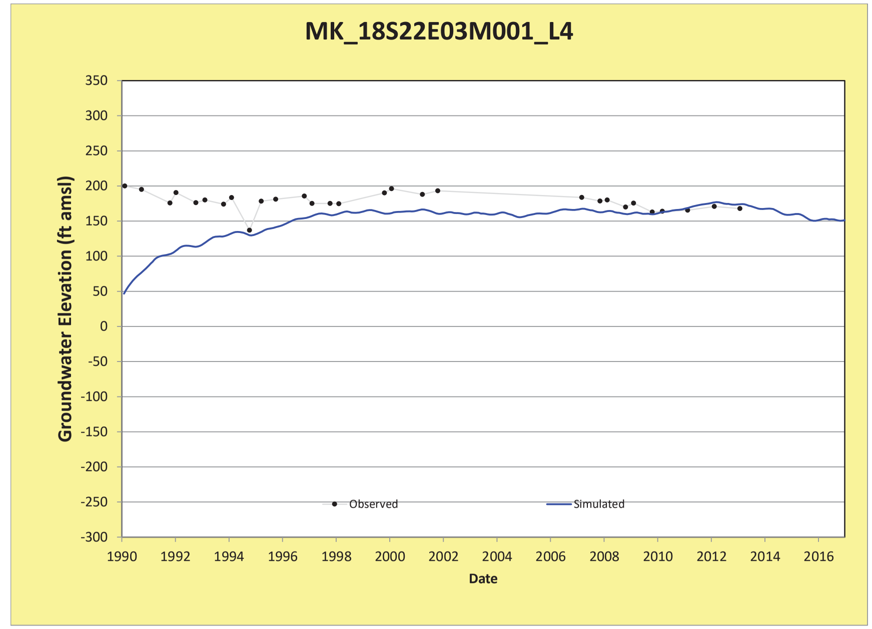


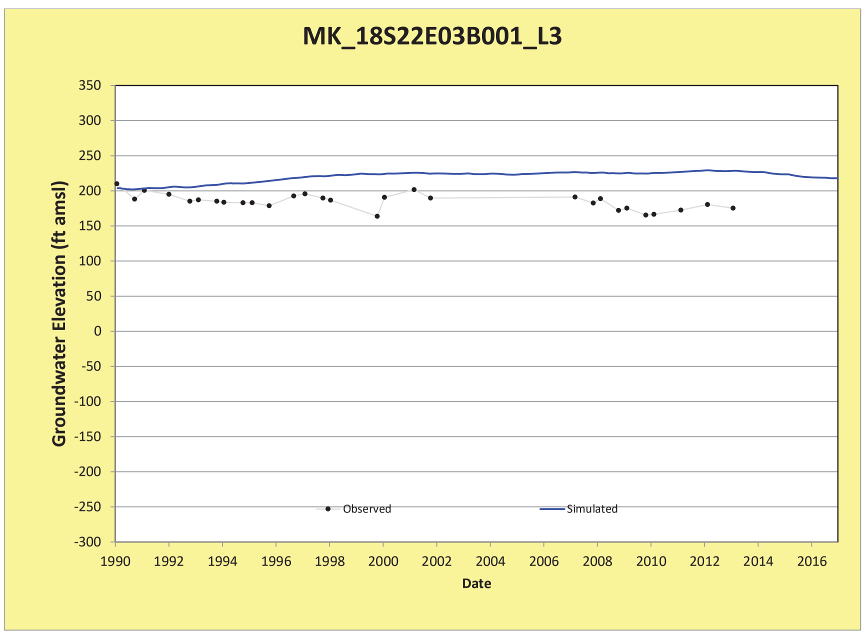
MK_18S21E20Q001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

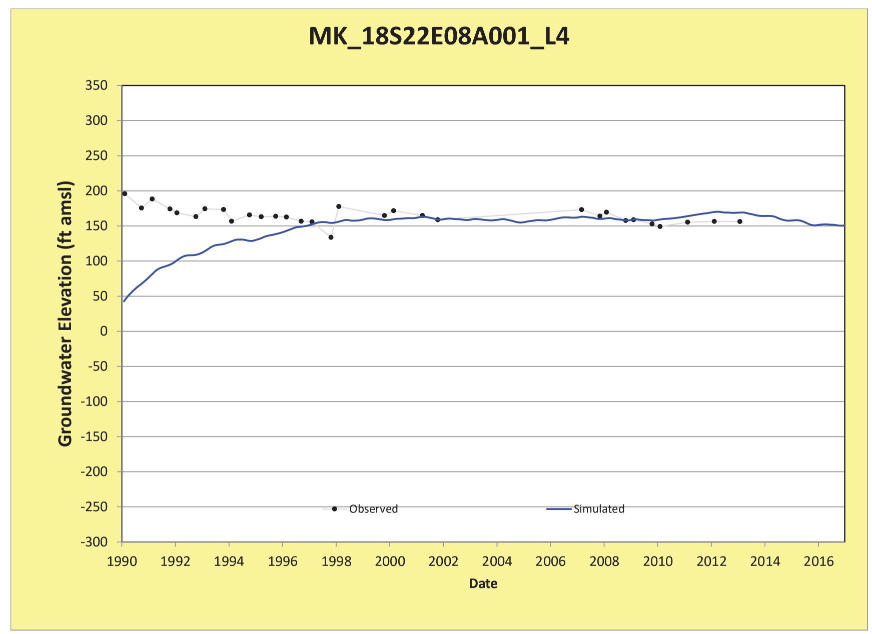


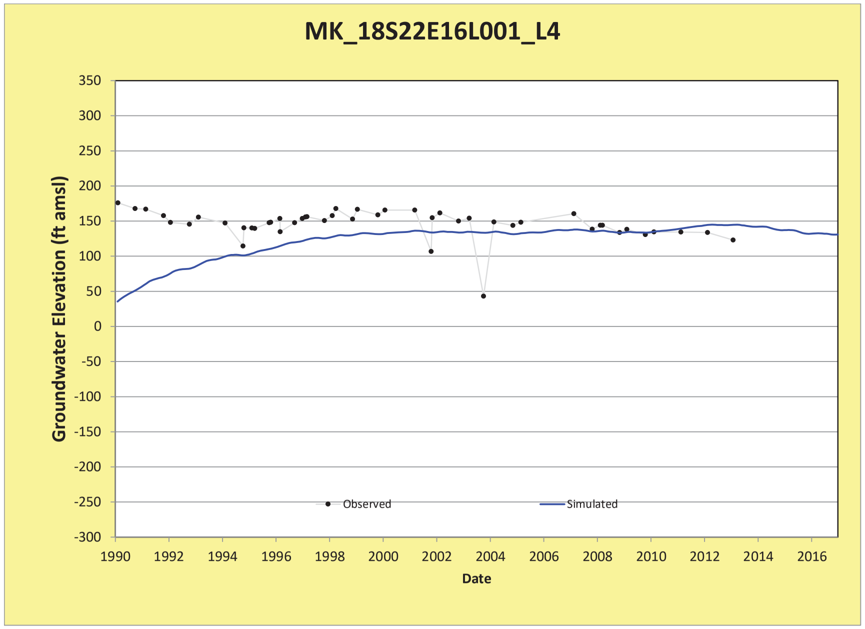
MK_18S21E31B001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

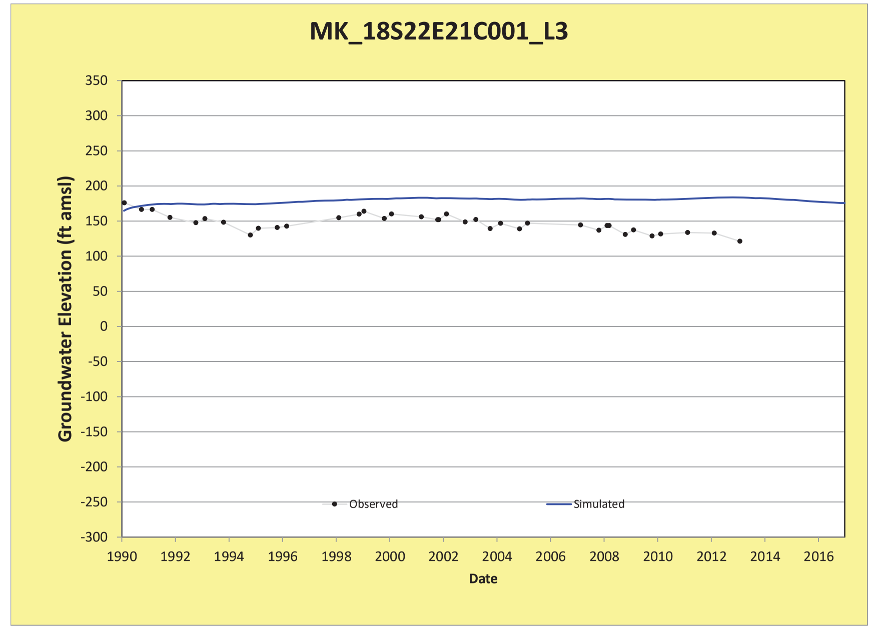

MK_18S21E32A001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

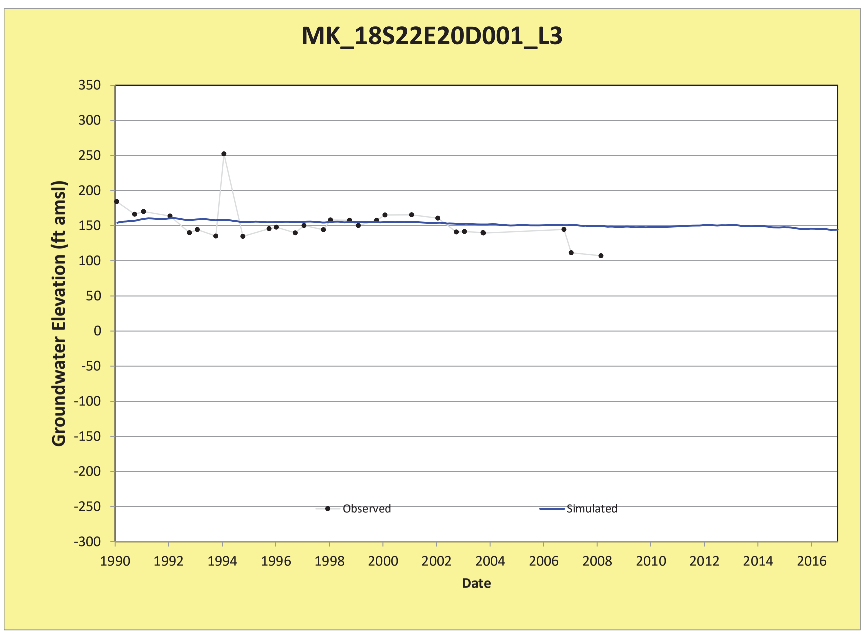

MK_18S22E03M001_L4
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

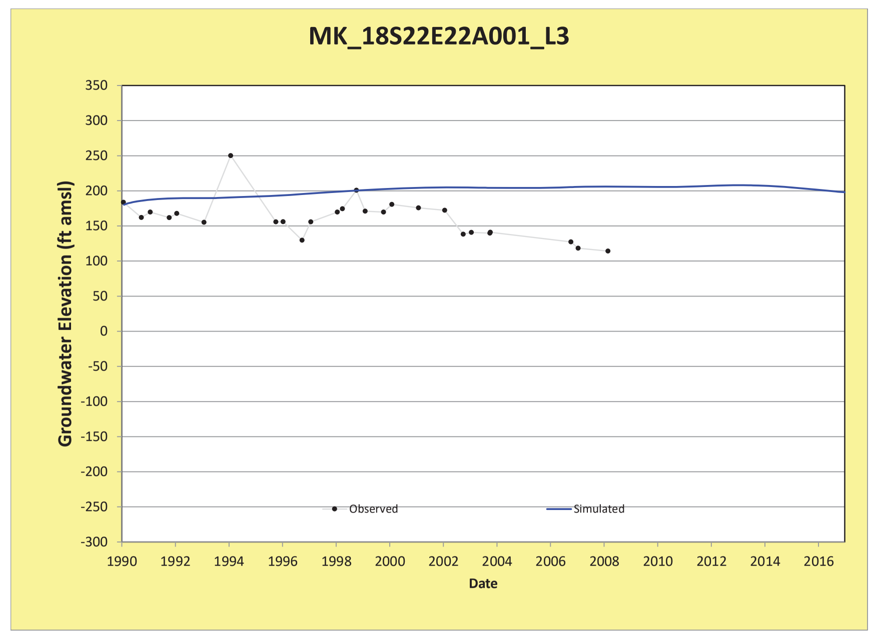

MK_18S22E03B001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

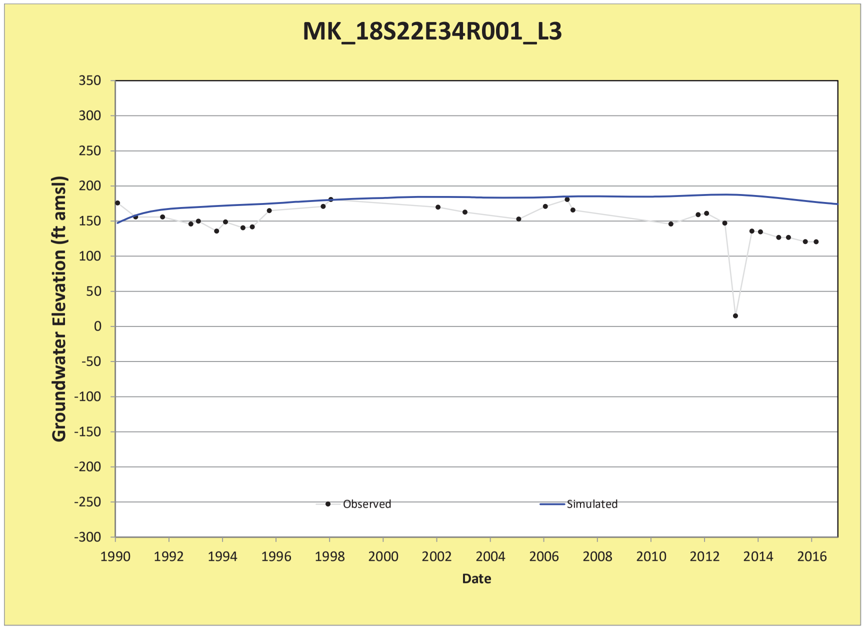

MK_18S22E08A001_L4
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_18S22E16L001_L4
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_18S22E21C001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_18S22E20D001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_18S22E22A001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_18S22E34R001_L3
Groundwater Elevation (ft amsl)
350
300
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200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
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1996
1998
2000
2002
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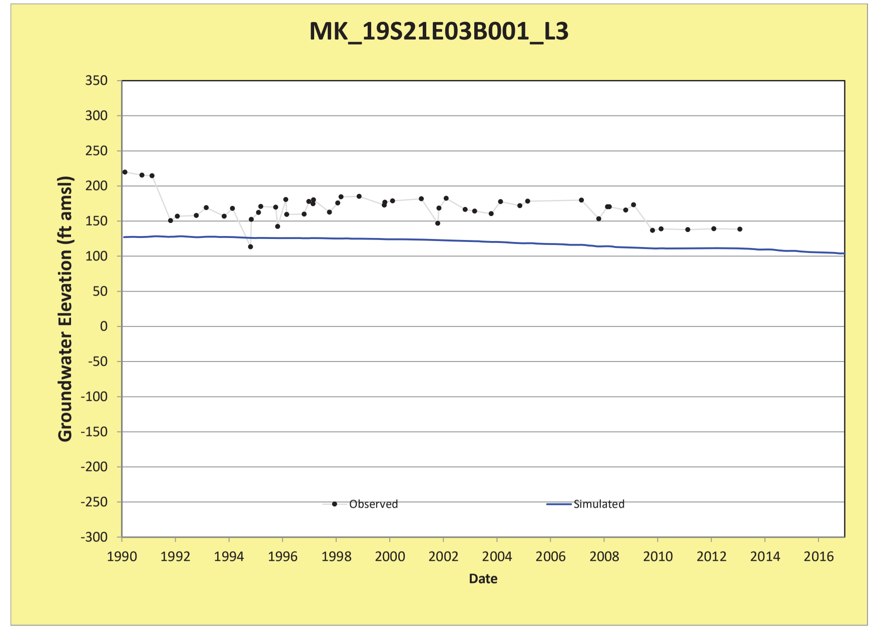
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


MK_19S21E03B001_L3
Groundwater Elevation (ft amsl)
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200
150
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0
-50
-100
-150
-200
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1992
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1996
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2000
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2008
2010
2012
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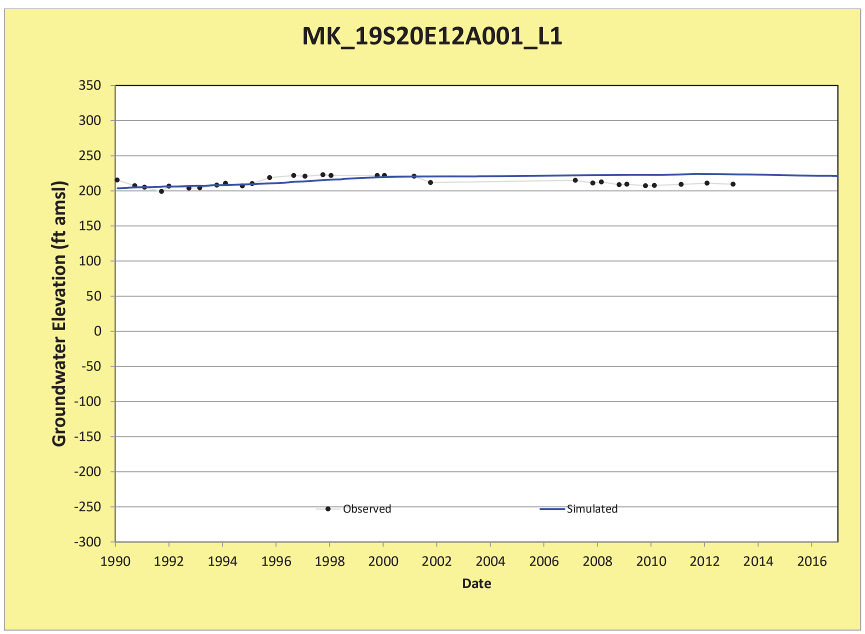
2016
Date
Observed
Simulated


MK_19S20E12A001_L1
Groundwater Elevation (ft amsl)
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300
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200
150
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50
0
-50
-100
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-200
-250
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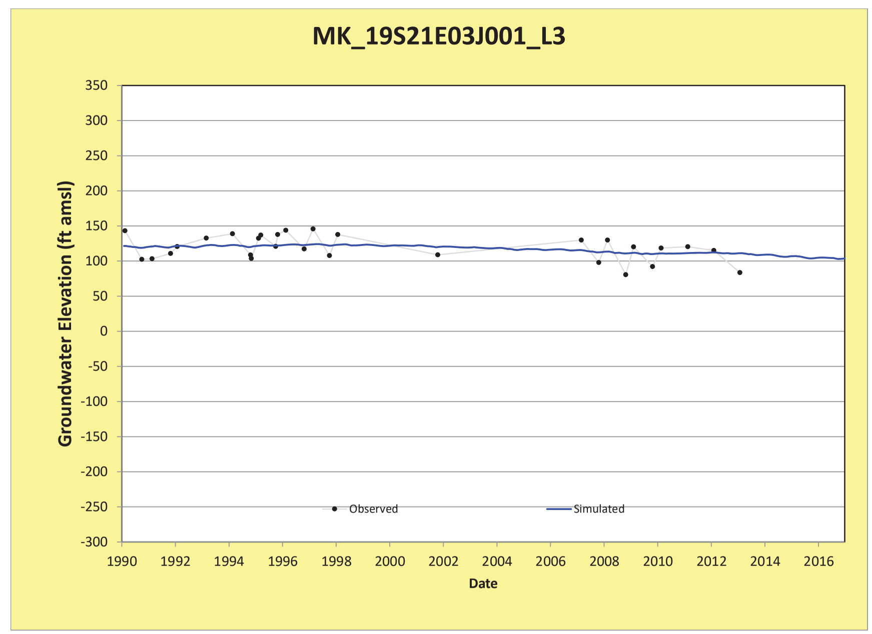
Date
Observed
Simulated


MK_19S21E03J001_L3
Groundwater Elevation (ft amsl)
350
300
250
200
150
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0
-50
-100
-150
-200
-250
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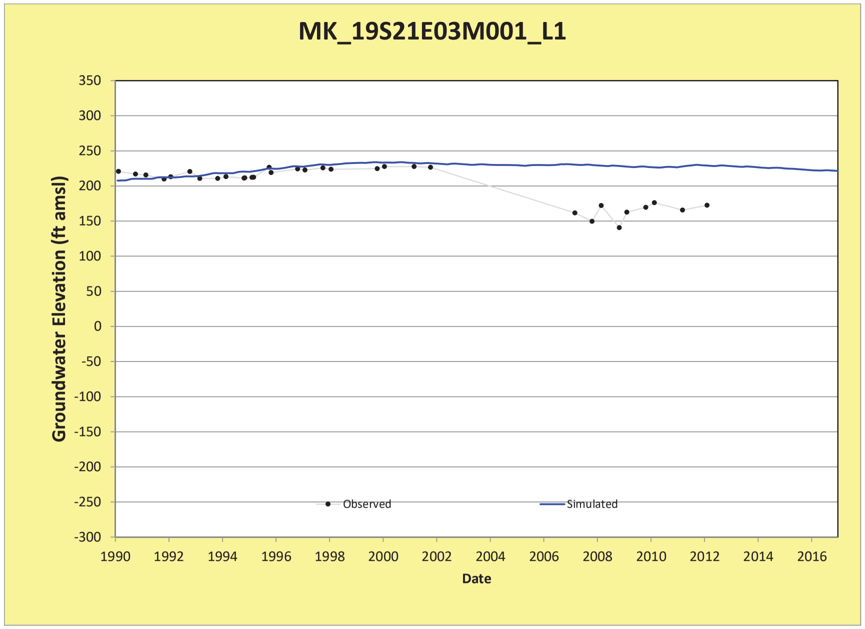
Date
Observed
Simulated


MK_19S21E03M001_L1
Groundwater Elevation (ft amsl)
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300
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200
150
100
50
0
-50
-100
-150
-200
-250
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Date
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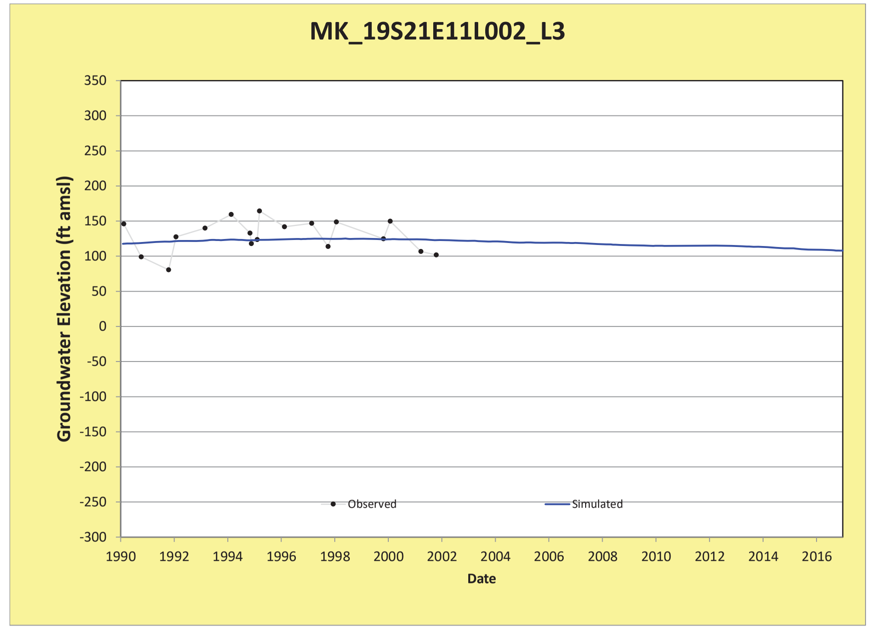
MK_19S21E11L002_L3
Groundwater Elevation (ft amsl)
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300
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200
150
100
50
0
-50
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-150
-200
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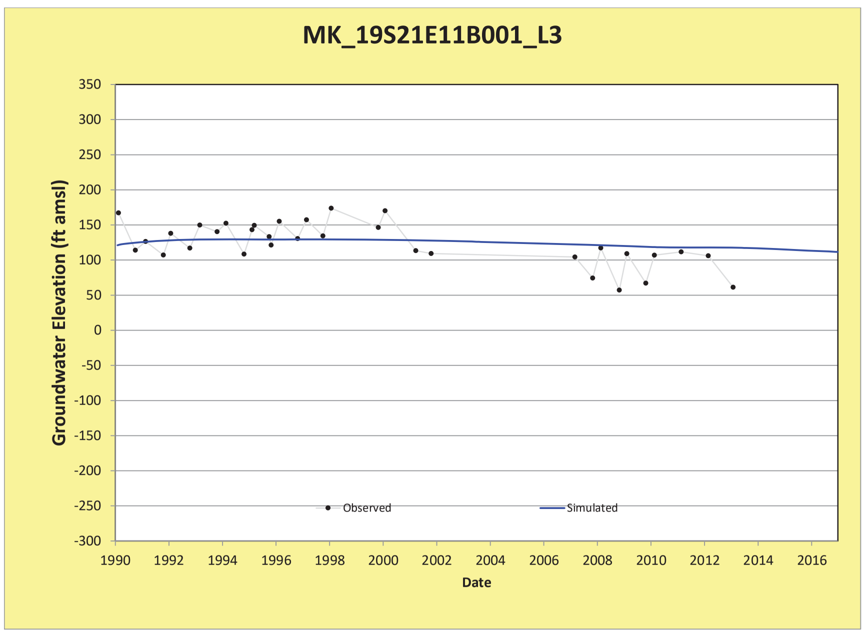
Date
Observed
Simulated


MK_19S21E11B001_L3
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-200
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Date
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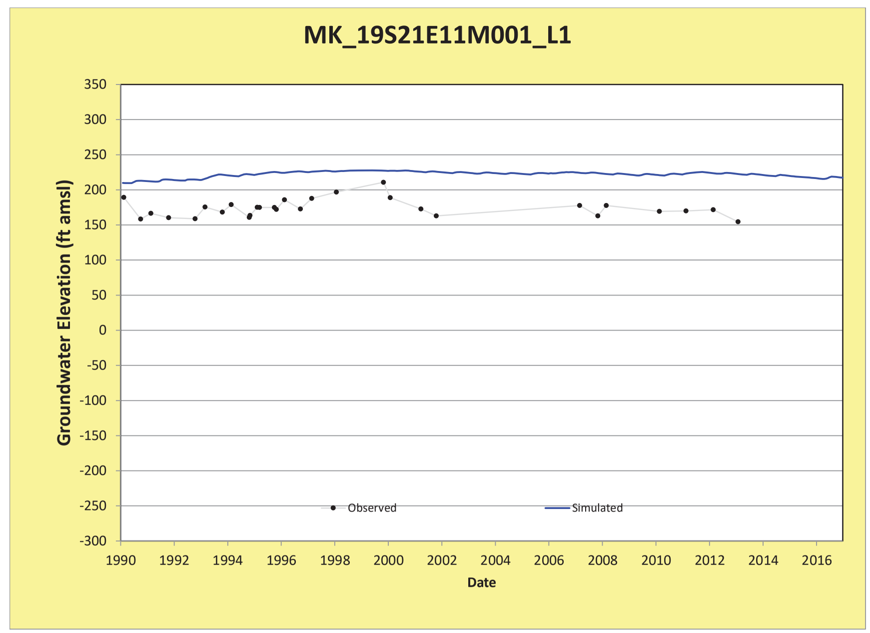
MK_19S21E11M001_L1
Groundwater Elevation (ft amsl)
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200
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50
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-50
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-200
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Date
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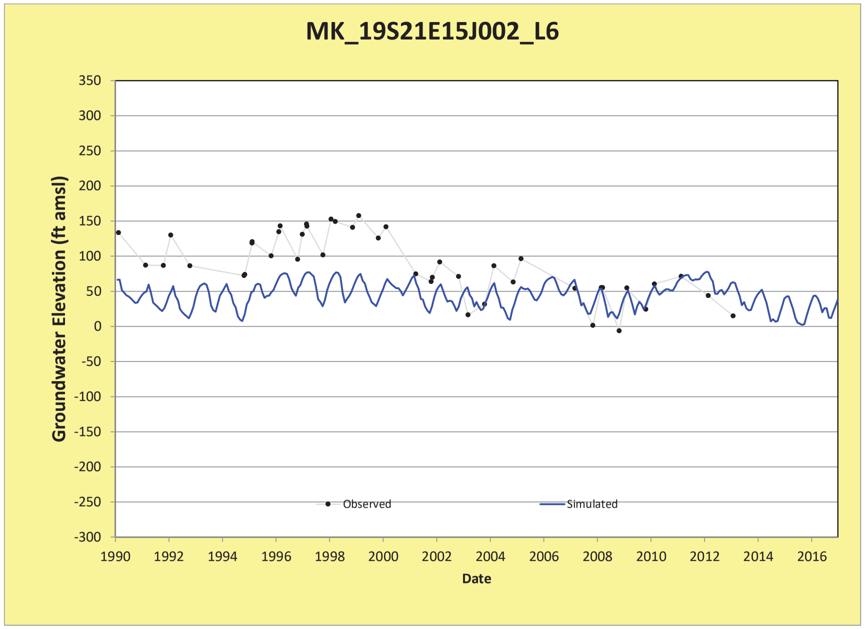
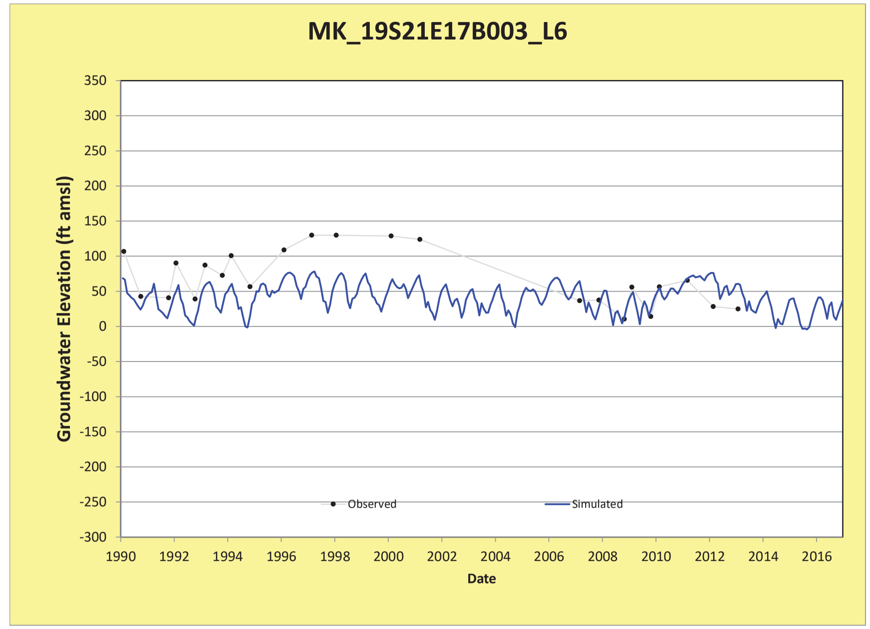
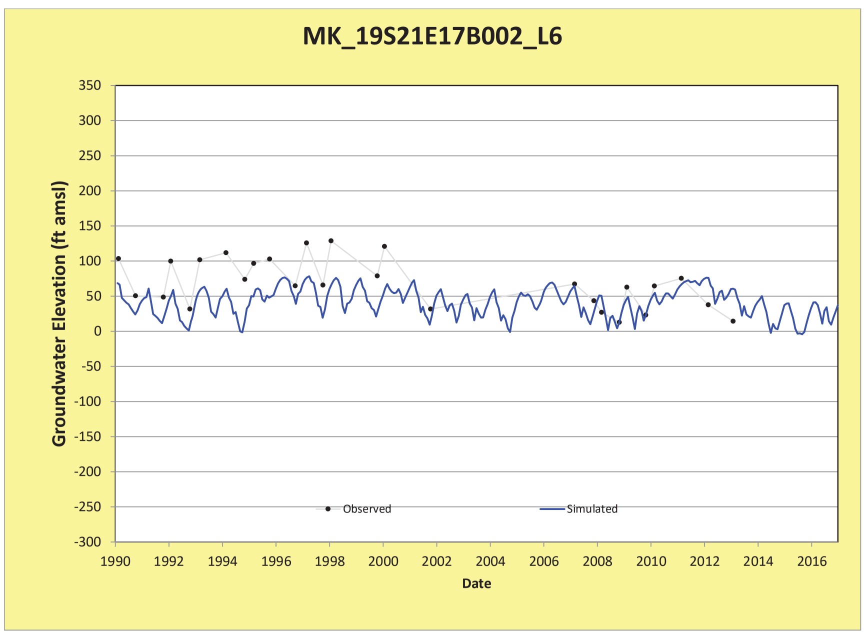
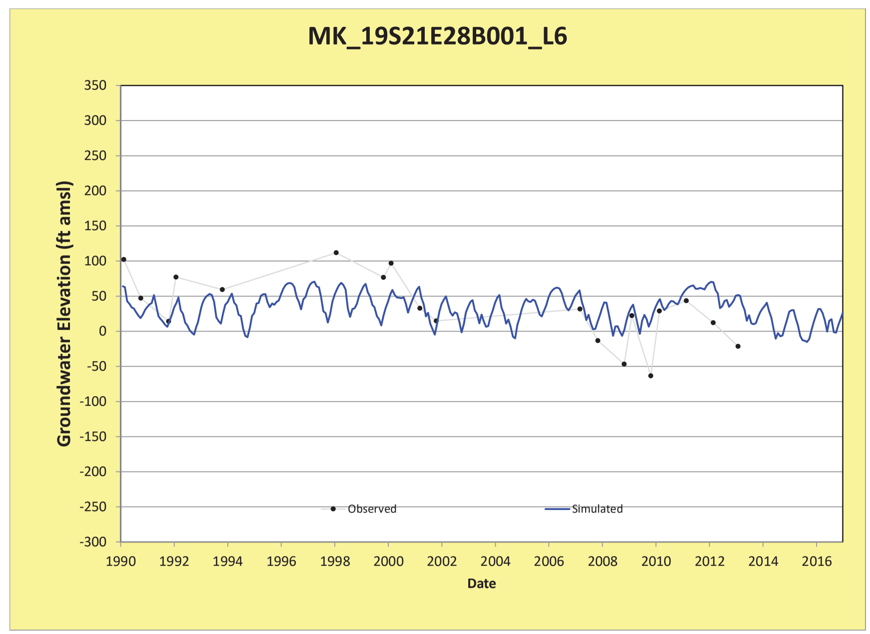

MK_19S21E15J002_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_19S21E17B003_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_19S21E17B002_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


MK_19S21E28B001_L6
Groundwater Elevation (ft amsl)
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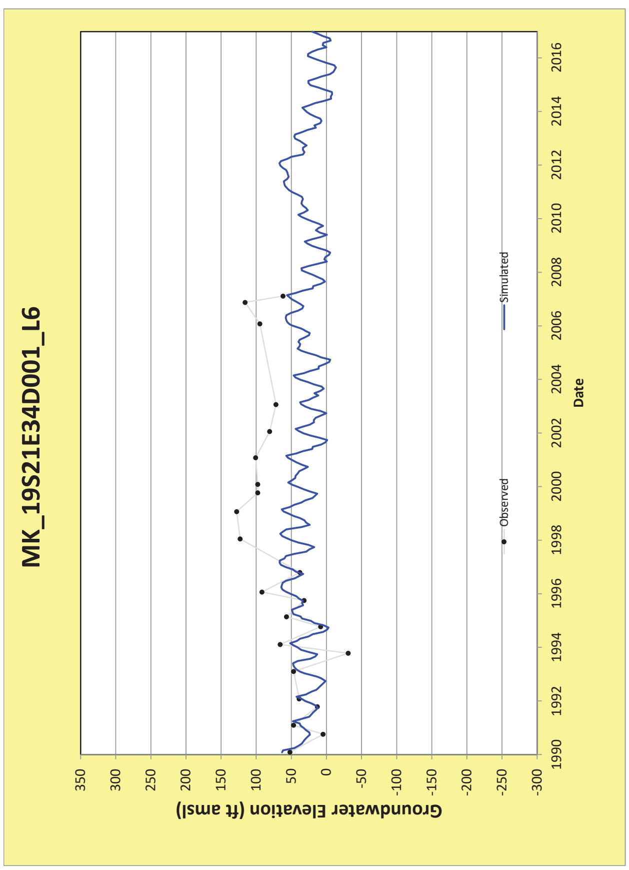
Simulated


MK_19S21E34D001_L6
Groundwater Elevation (ft amsl)
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300
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200
150
100
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0
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-100
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-200
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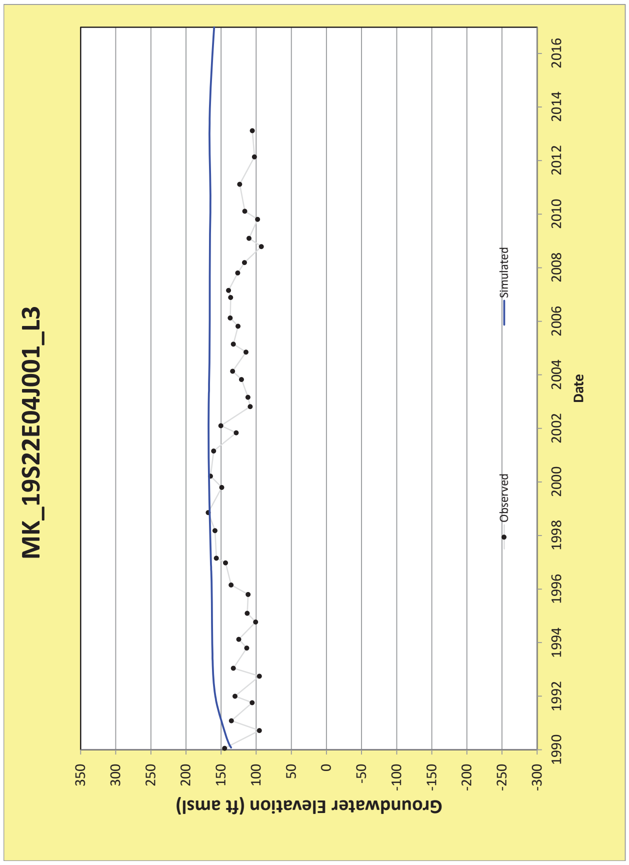
Date
Observed
Simulated


MK_19S22E04J001_L3
Groundwater Elevation (ft amsl)
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0
-50
-100
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-200
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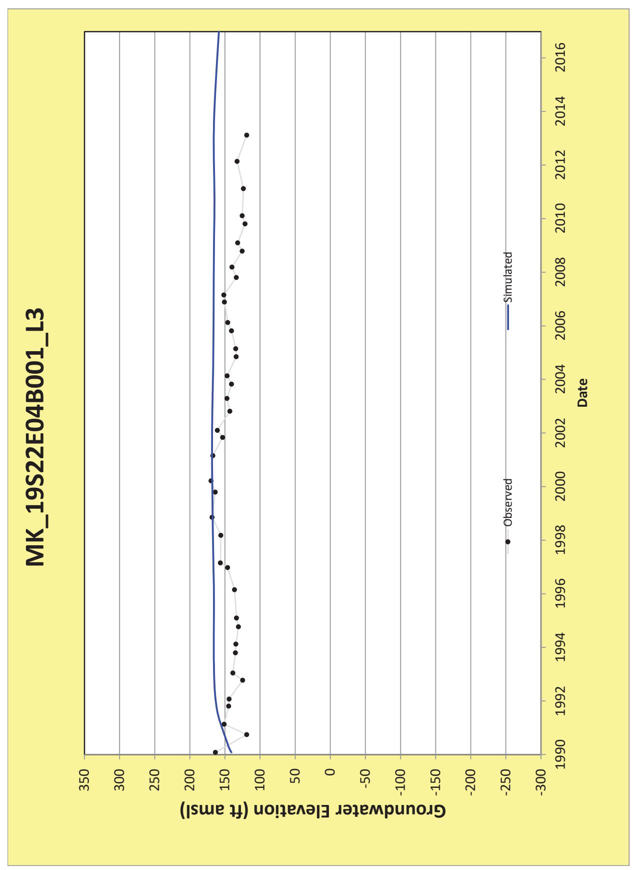
Date
Observed
Simulated


MK_19S22E04B001_L3
Groundwater Elevation (ft amsl)
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0
-50
-100
-150
-200
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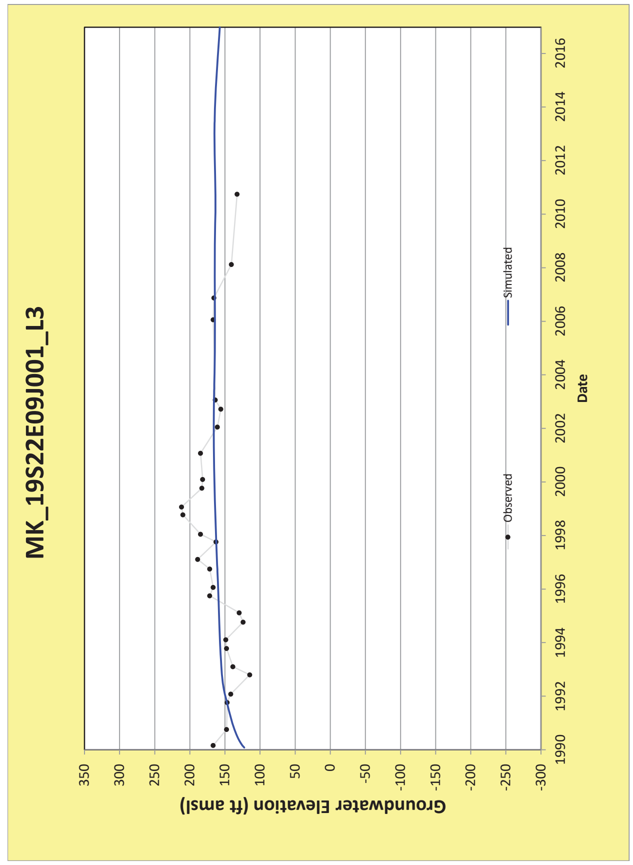
Date
Observed
Simulated


MK_19S22E09J001_L3
Groundwater Elevation (ft amsl)
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100
50
0
-50
-100
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-200
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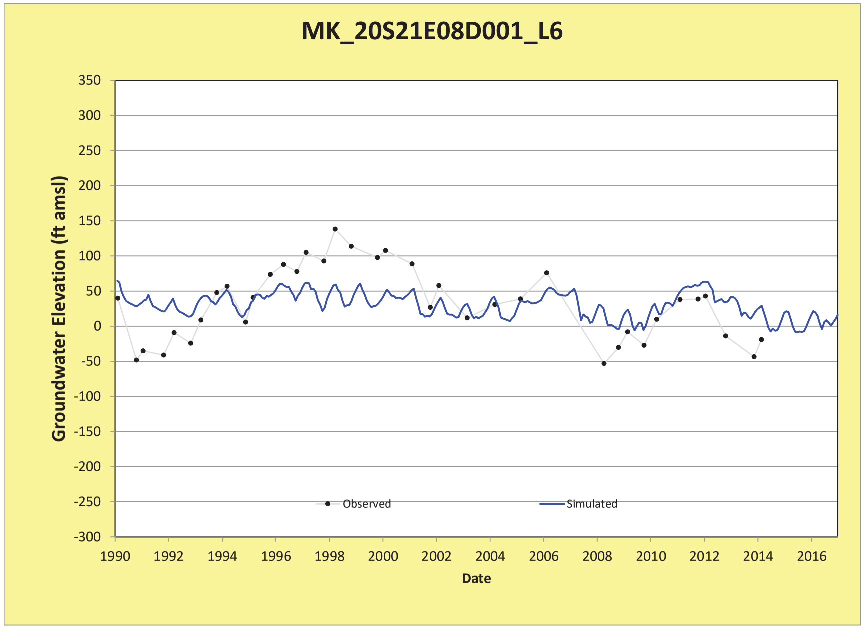
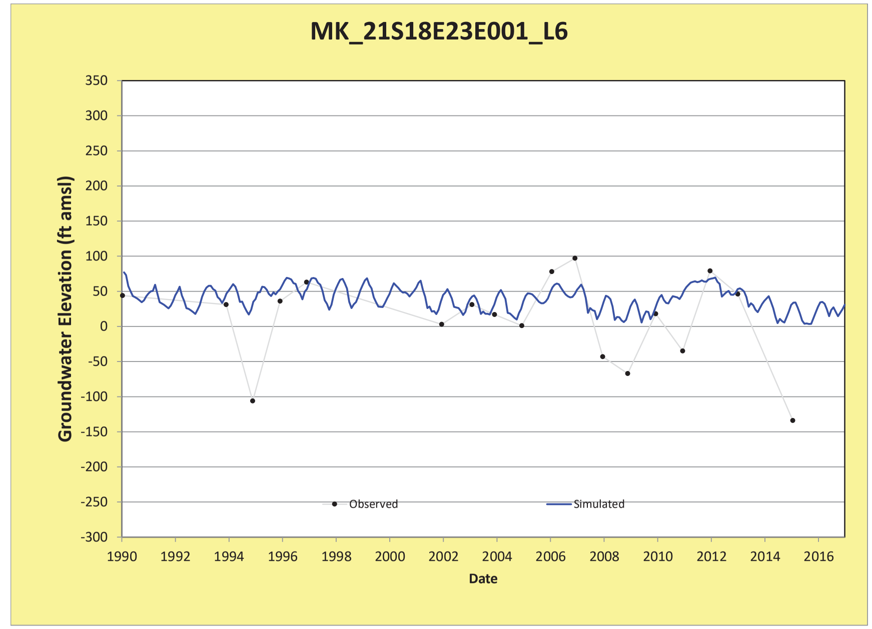
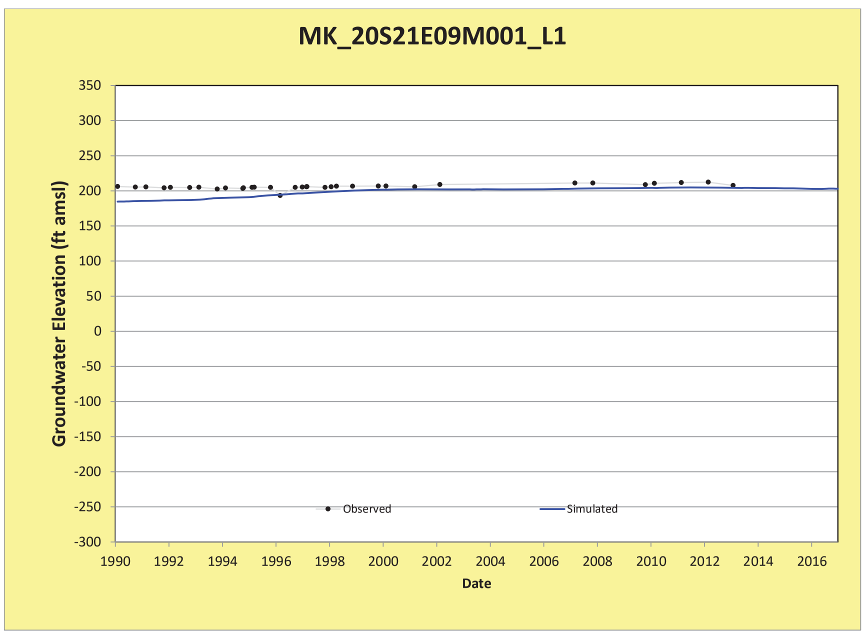
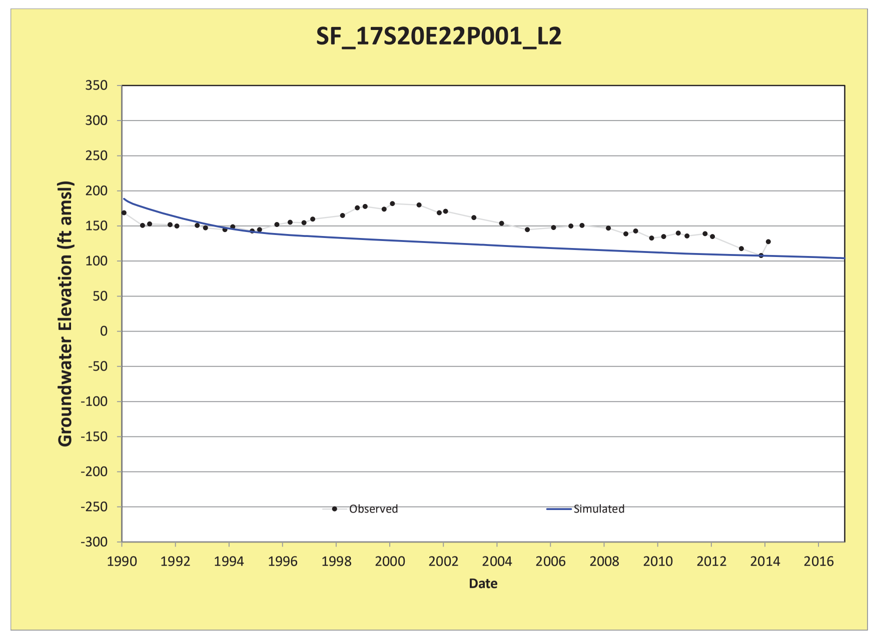
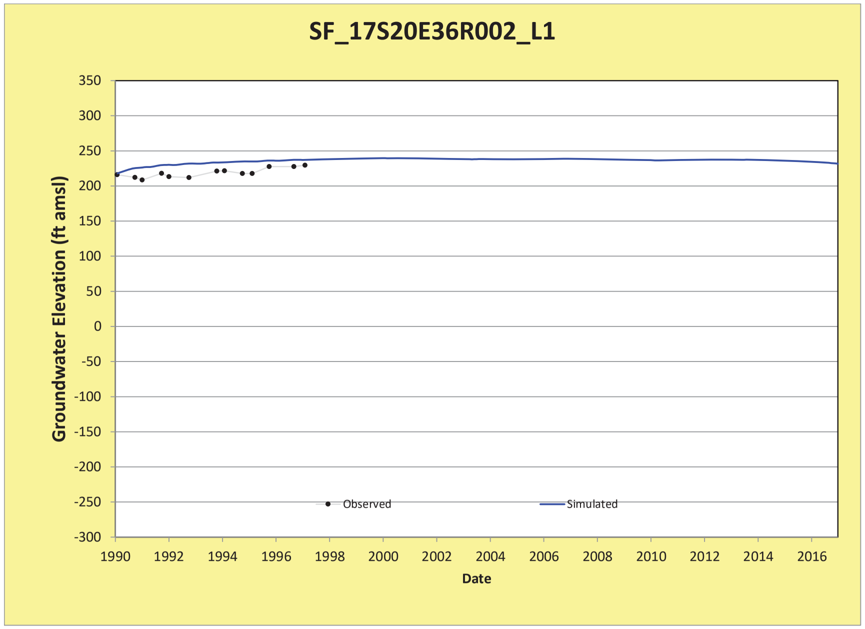
Date
Observed
Simulated

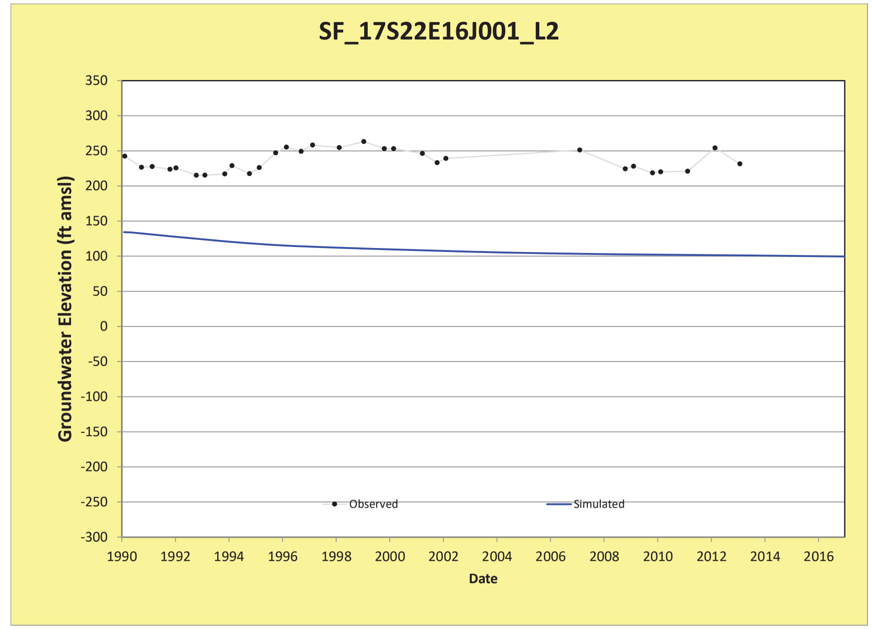

MK_20S21E08D001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

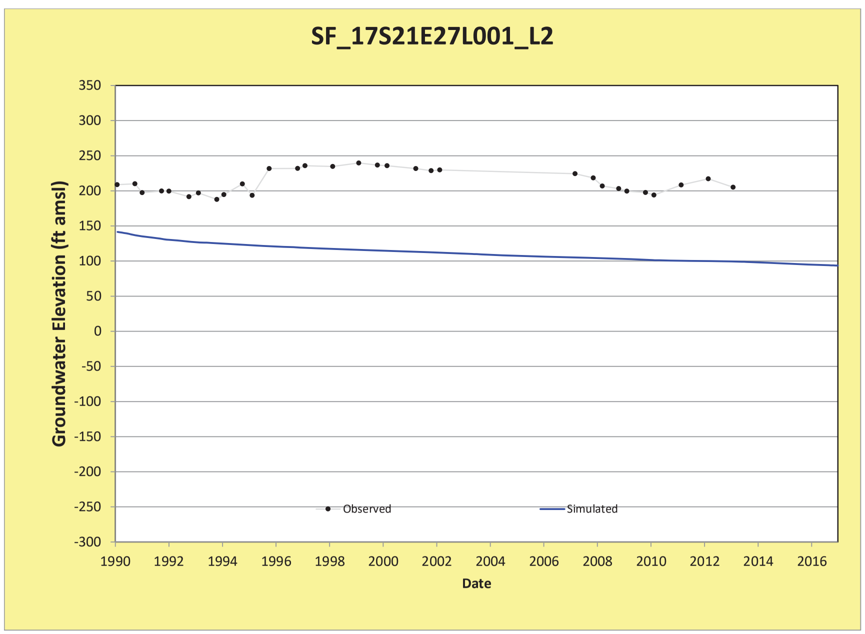

MK_21S18E23E001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

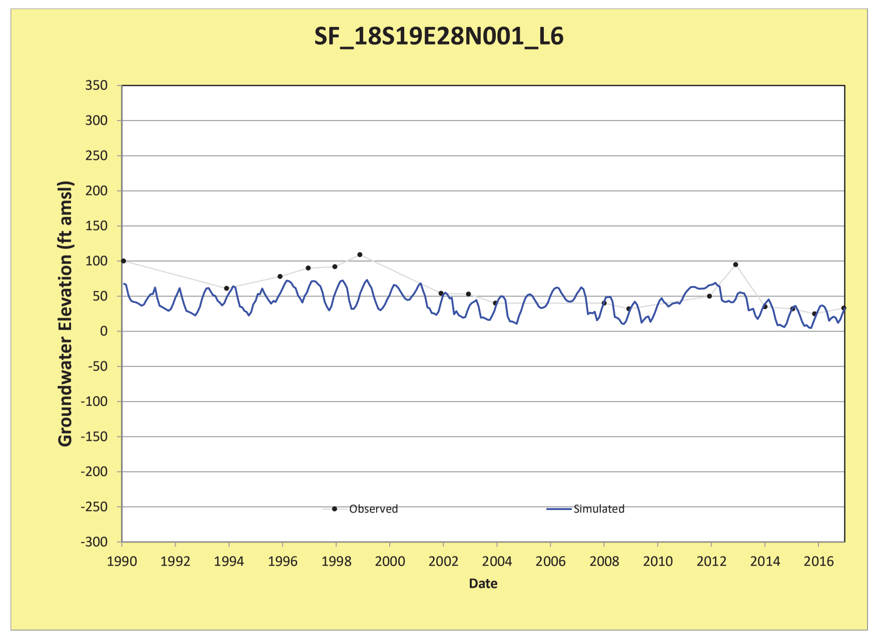

MK_20S21E09M001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

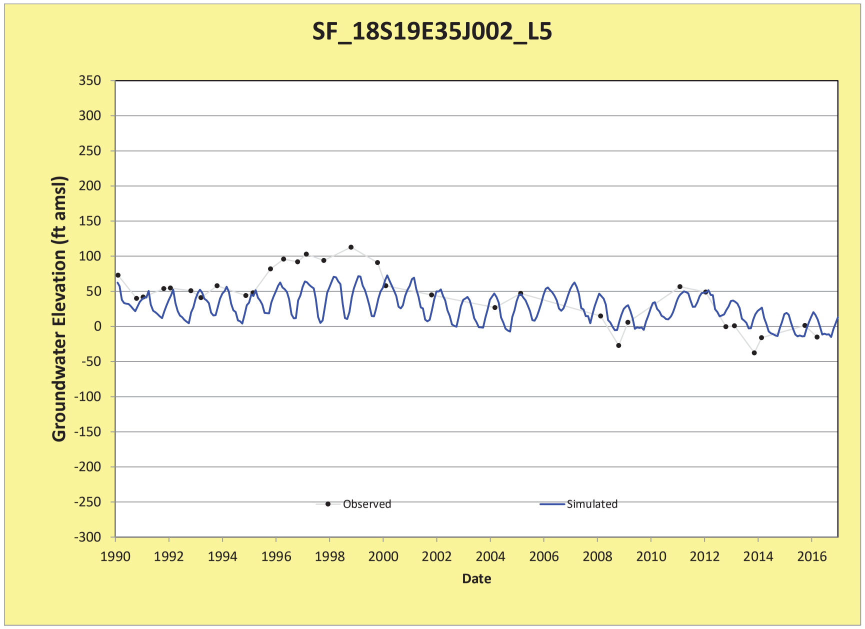

SF_17S20E22P001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

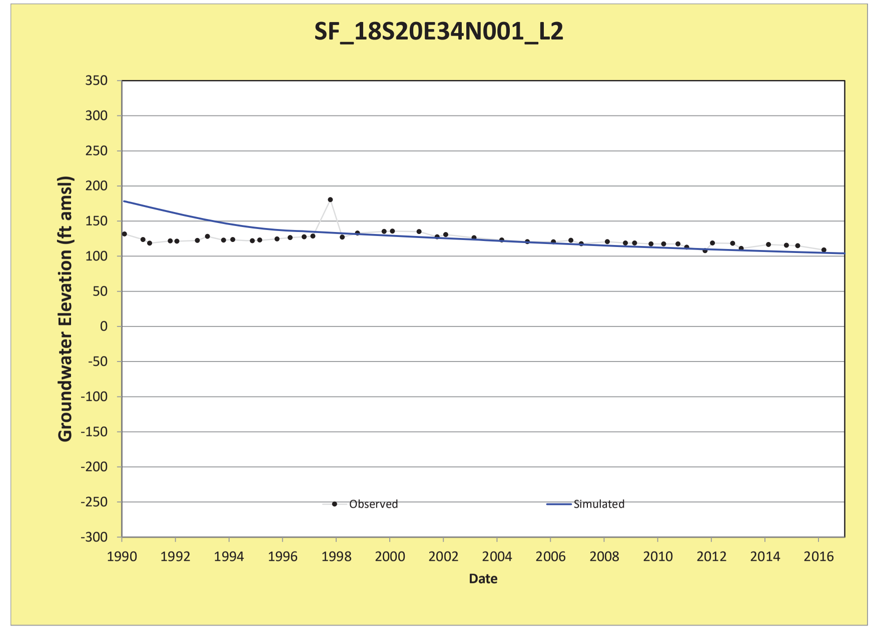

SF_17S20E36R002_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

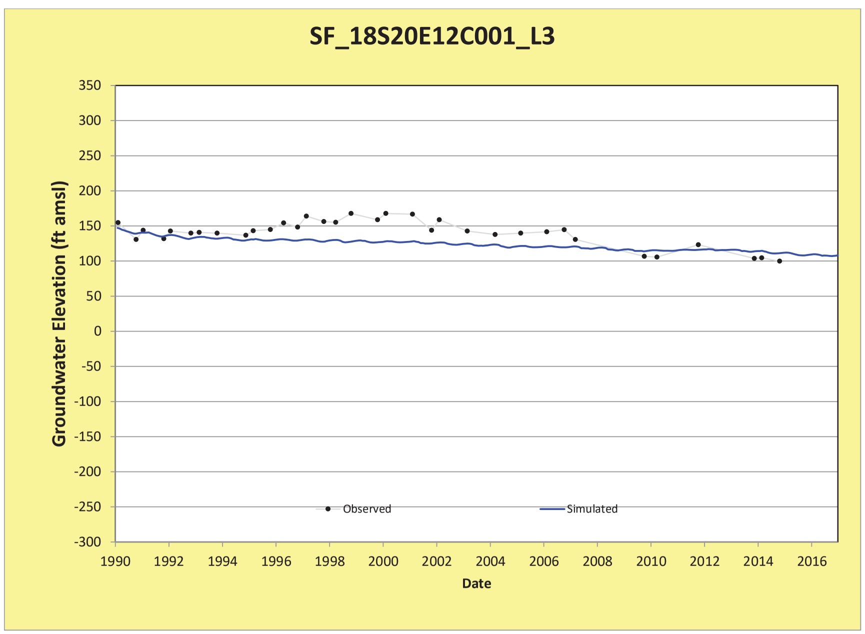

SF_17S22E16J001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

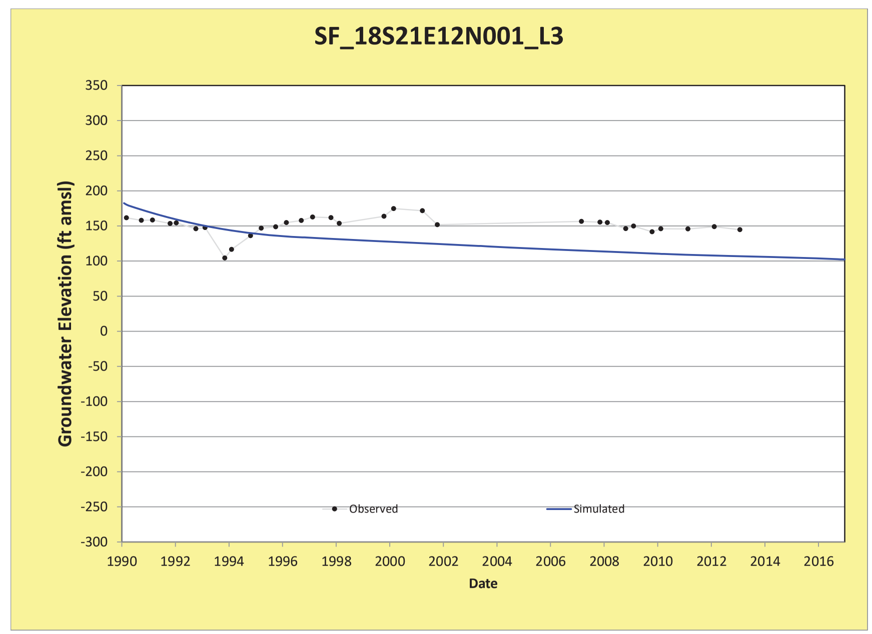

SF_17S21E27L001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

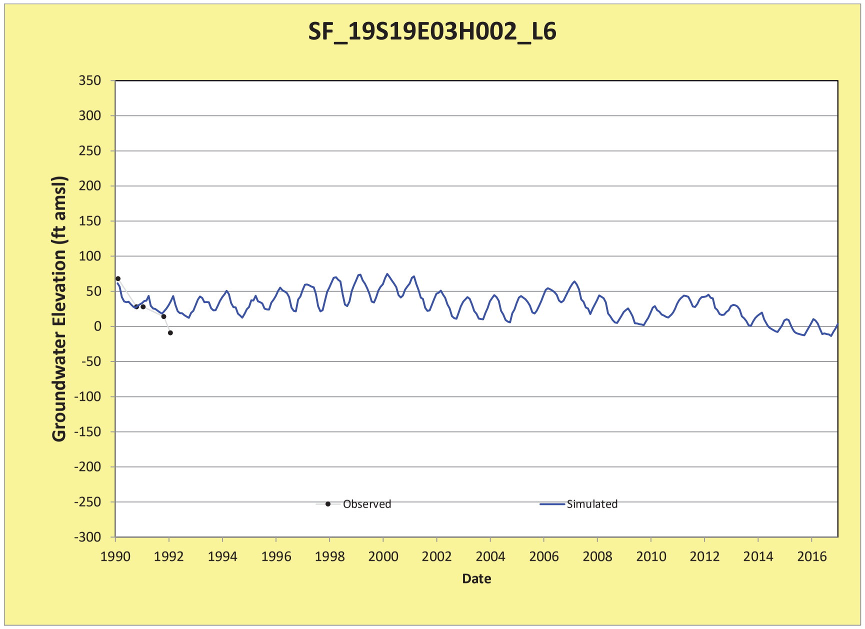

SF_18S19E28N001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_18S19E35J002_L5
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_18S20E34N001_L2
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_18S20E12C001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_18S21E12N001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_19S19E03H002_L6
Groundwater Elevation (ft amsl)
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300
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200
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-50
-100
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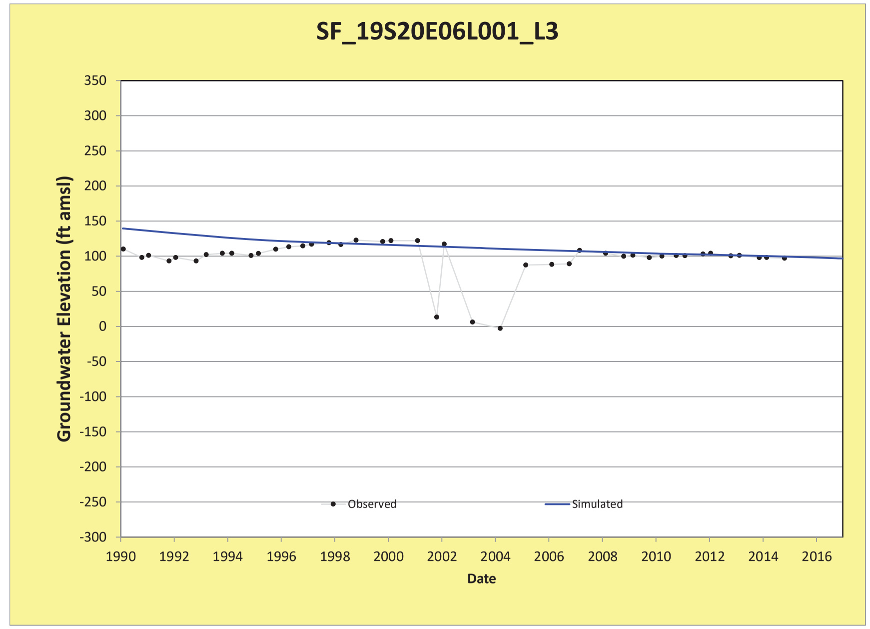
Date
Observed
Simulated


SF_19S20E06L001_L3
Groundwater Elevation (ft amsl)
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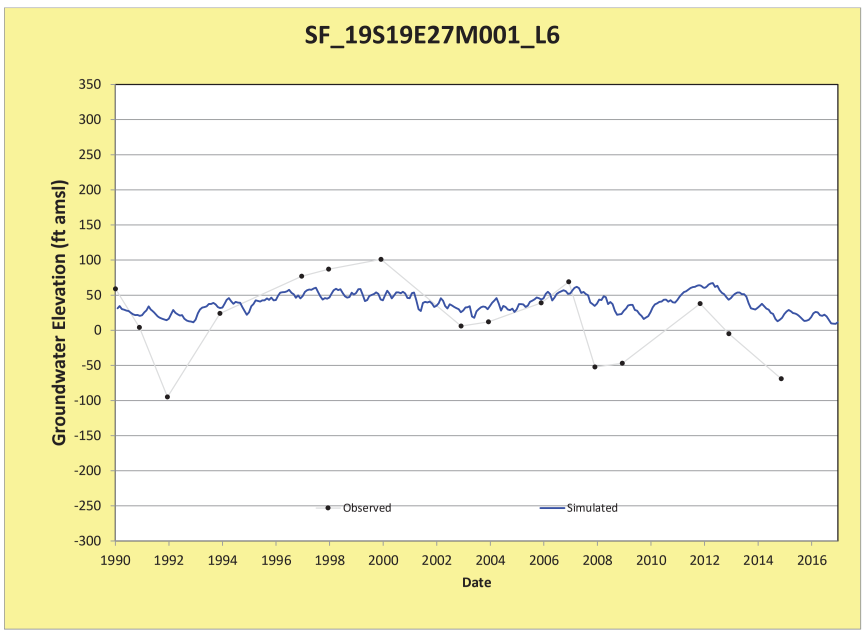
Date
Observed
Simulated


SF_19S19E27M001_L6
Groundwater Elevation (ft amsl)
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-200
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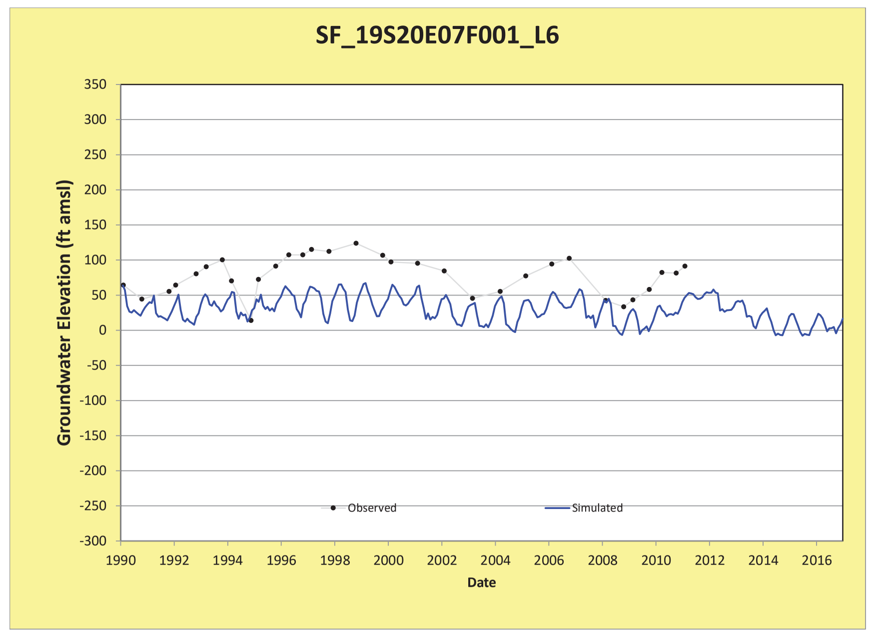
Date
Observed
Simulated


SF_19S20E07F001_L6
Groundwater Elevation (ft amsl)
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-200
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Date
Observed
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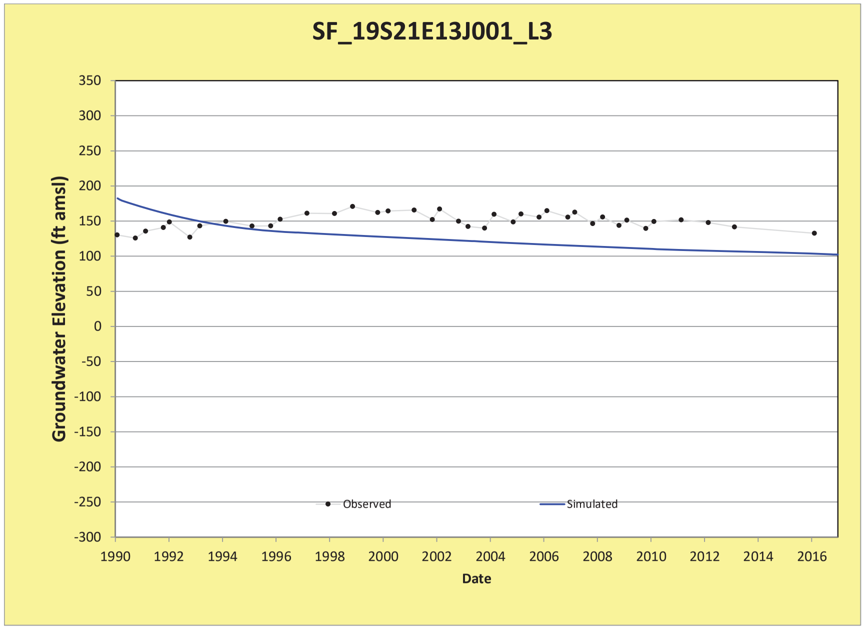
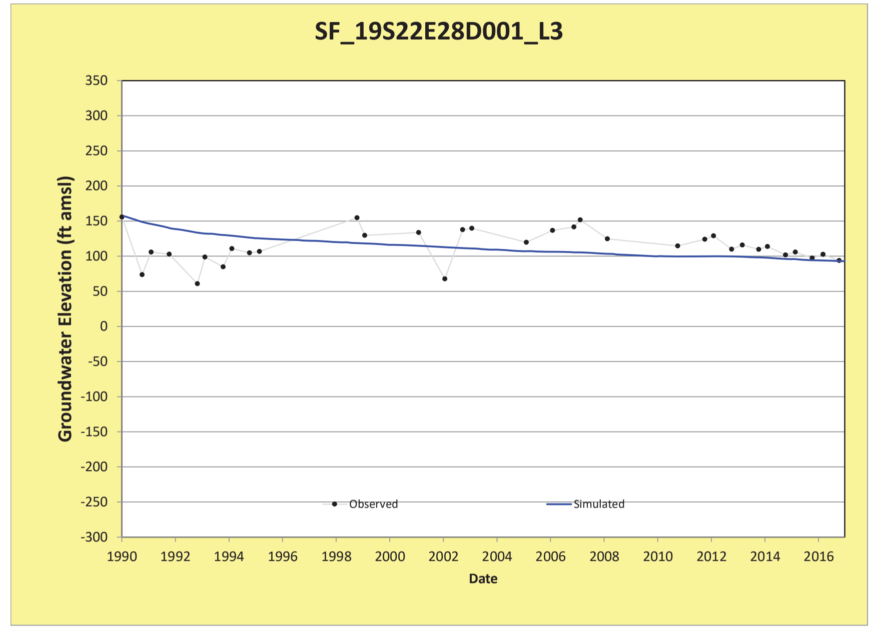
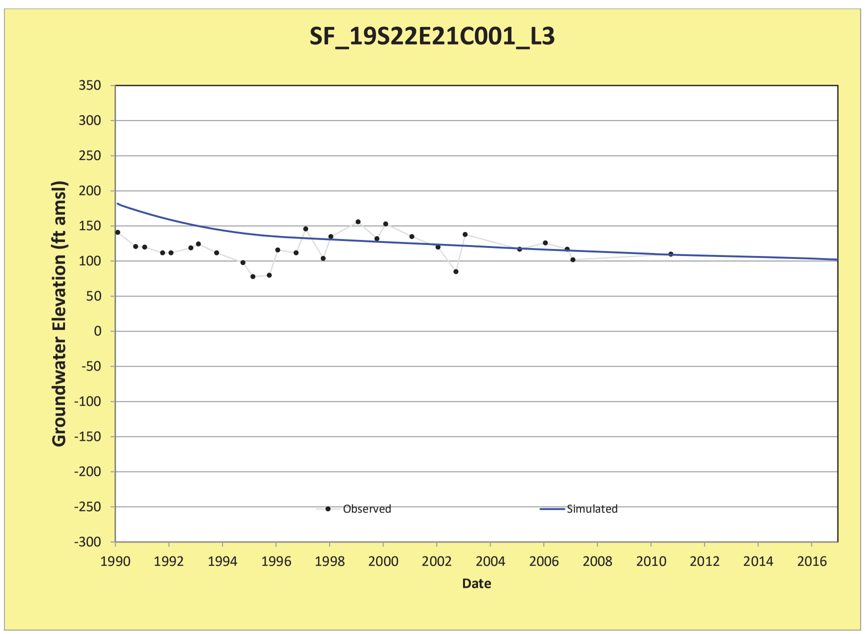

SF_19S21E13J001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_19S22E28D001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_19S22E21C001_L3
Groundwater Elevation (ft amsl)
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Observed
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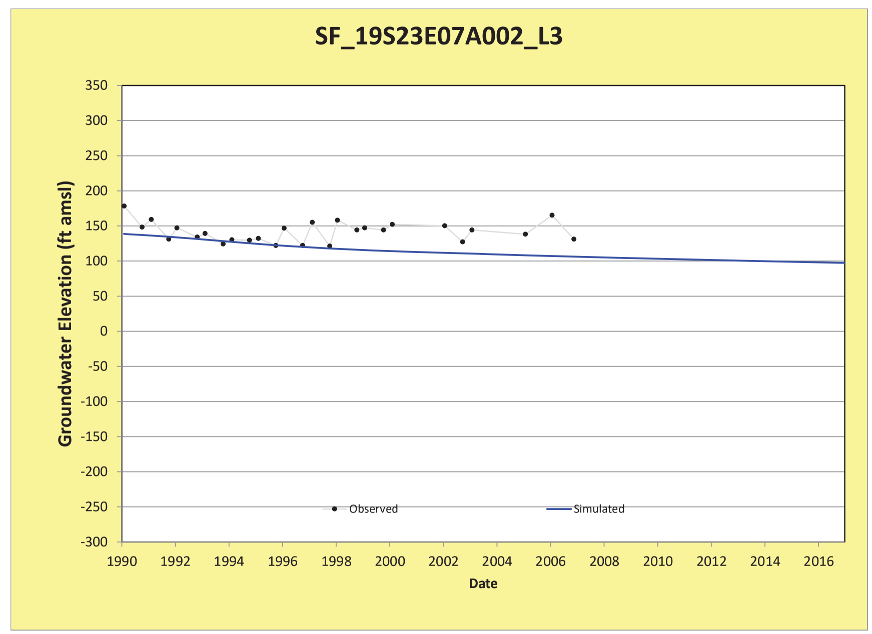
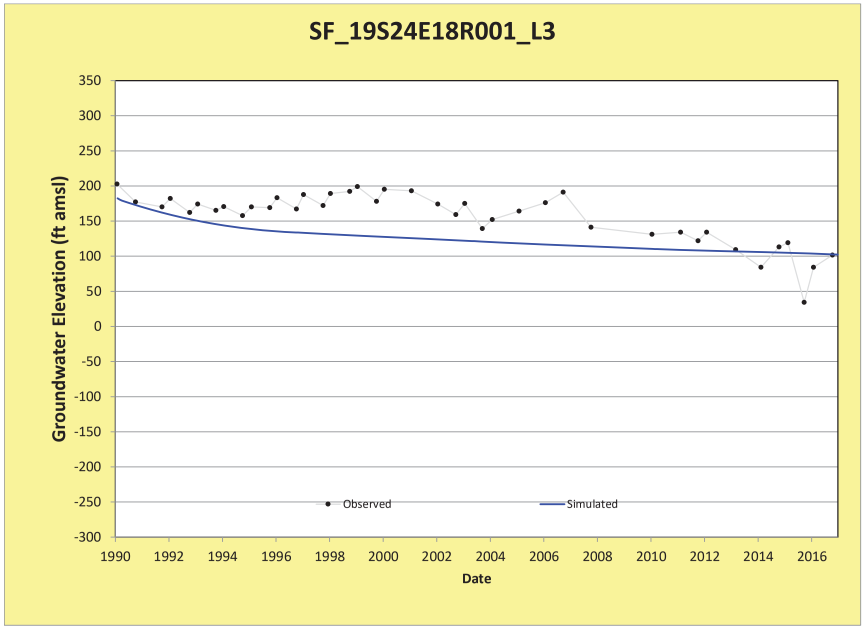

SF_19S23E07A002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_19S24E18R001_L3
Groundwater Elevation (ft amsl)
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0
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-200
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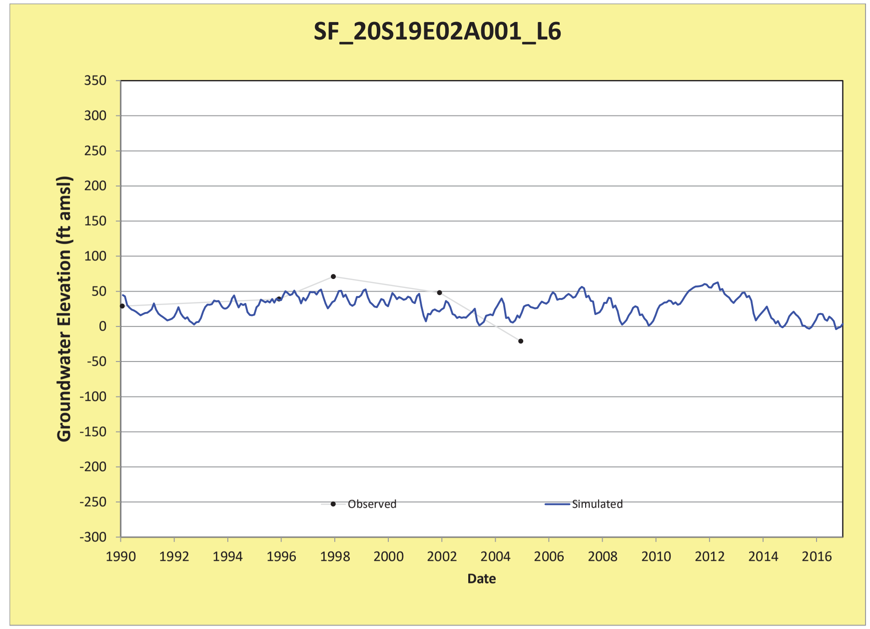
Date
Observed
Simulated


SF_20S19E02A001_L6
Groundwater Elevation (ft amsl)
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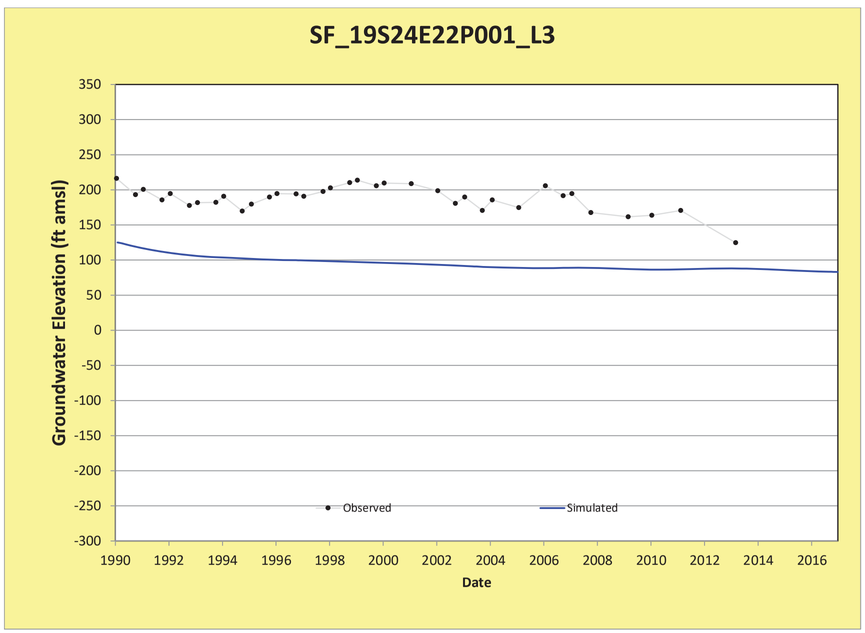
Date
Observed
Simulated


SF_19S24E22P001_L3
Groundwater Elevation (ft amsl)
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Observed
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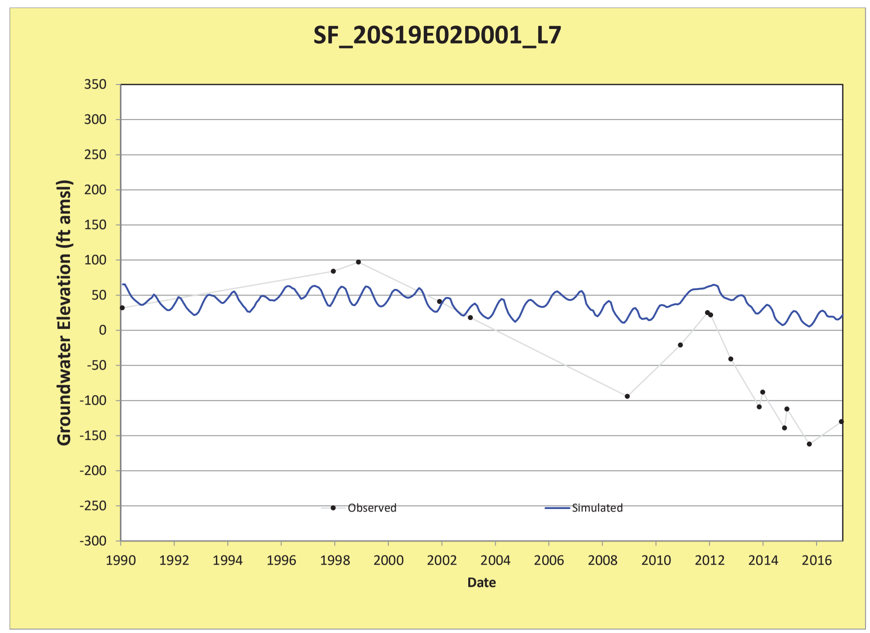
SF_20S19E02D001_L7
Groundwater Elevation (ft amsl)
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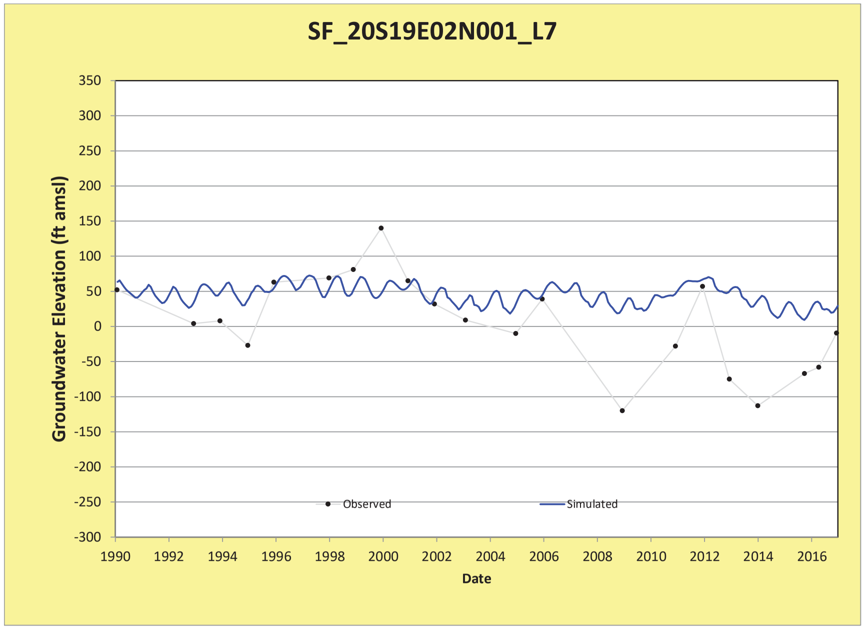
Date
Observed
Simulated


SF_20S19E02N001_L7
Groundwater Elevation (ft amsl)
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Observed
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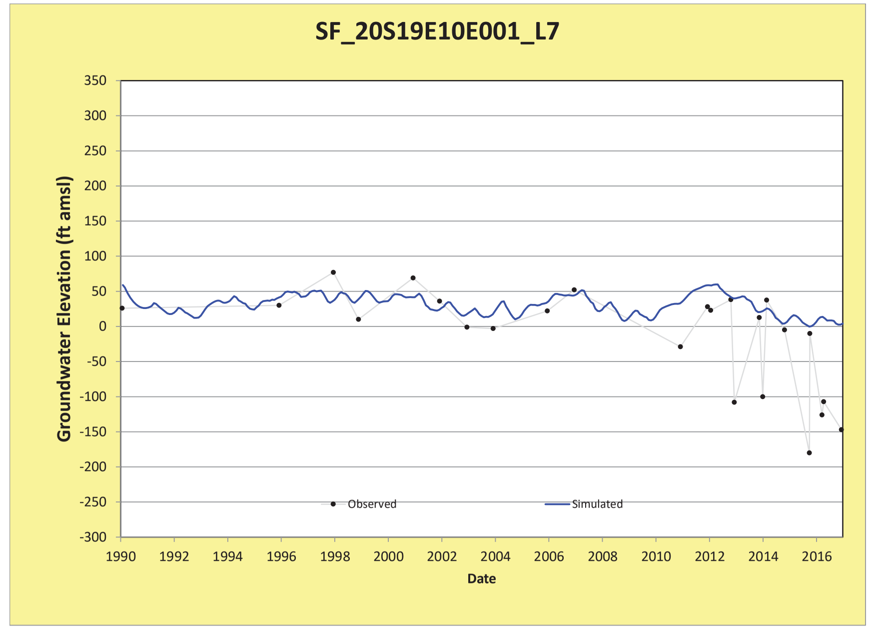
SF_20S19E10E001_L7
Groundwater Elevation (ft amsl)
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Observed
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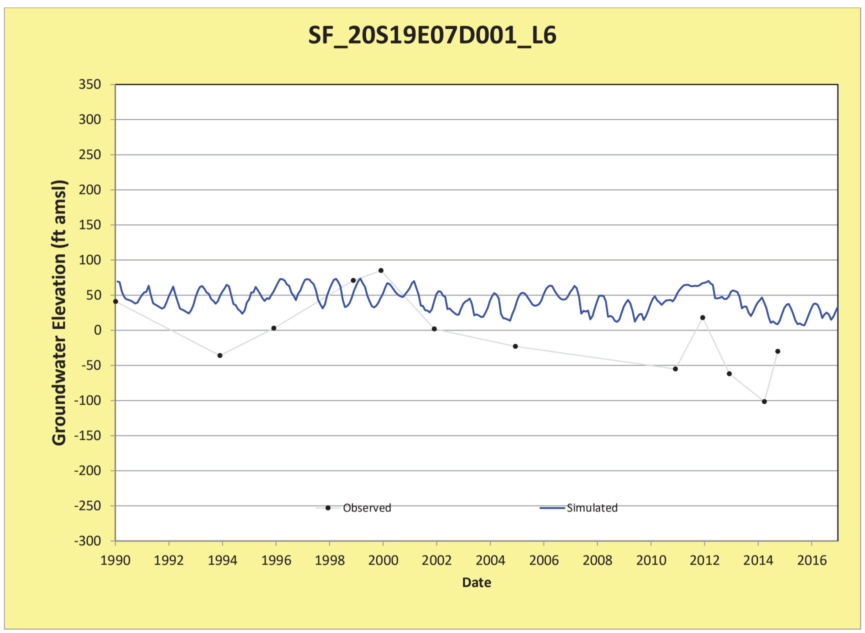
SF_20S19E07D001_L6
Groundwater Elevation (ft amsl)
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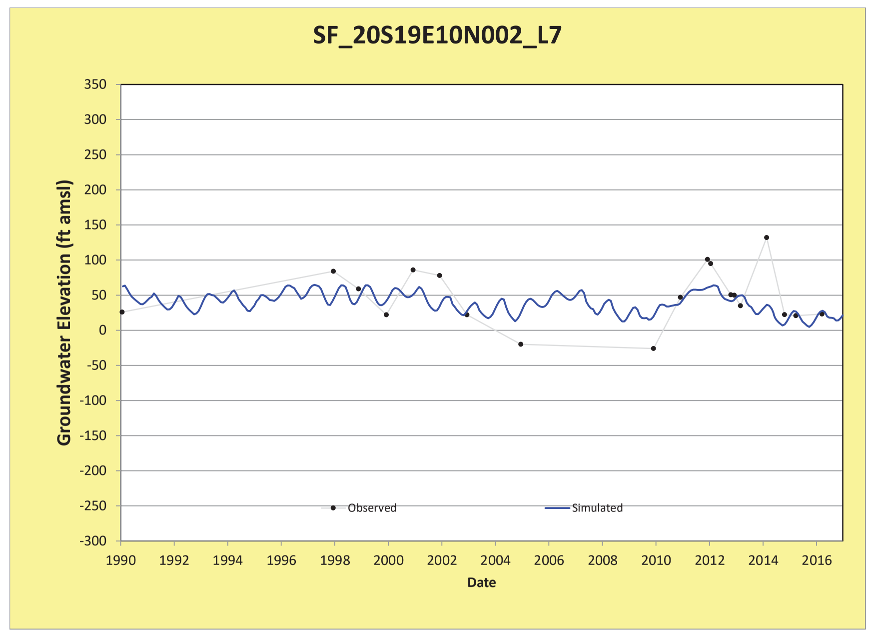
SF_20S19E10N002_L7
Groundwater Elevation (ft amsl)
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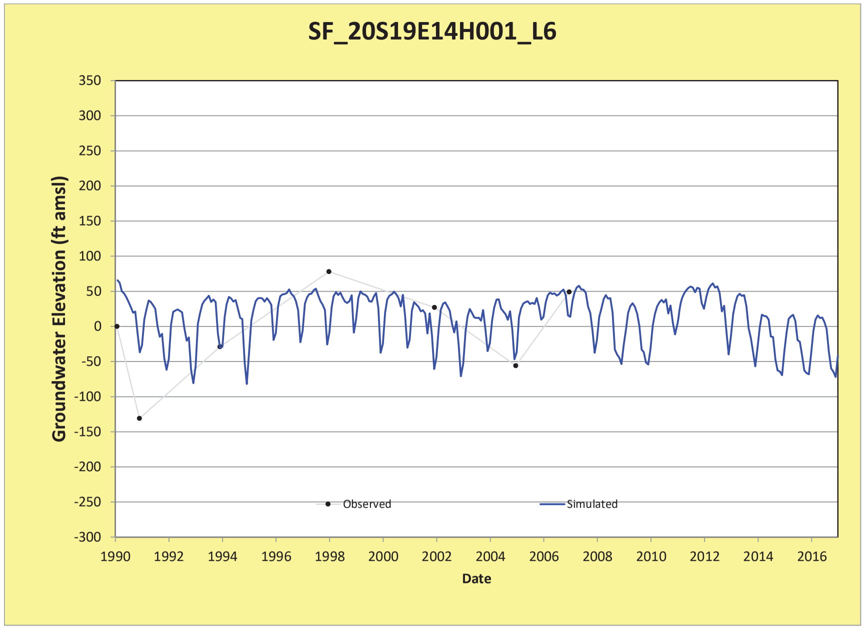
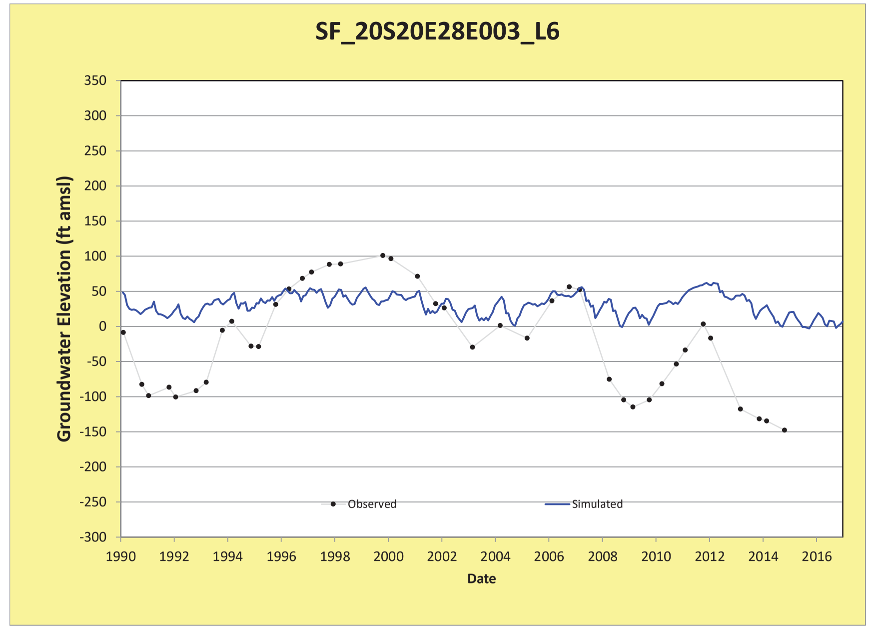
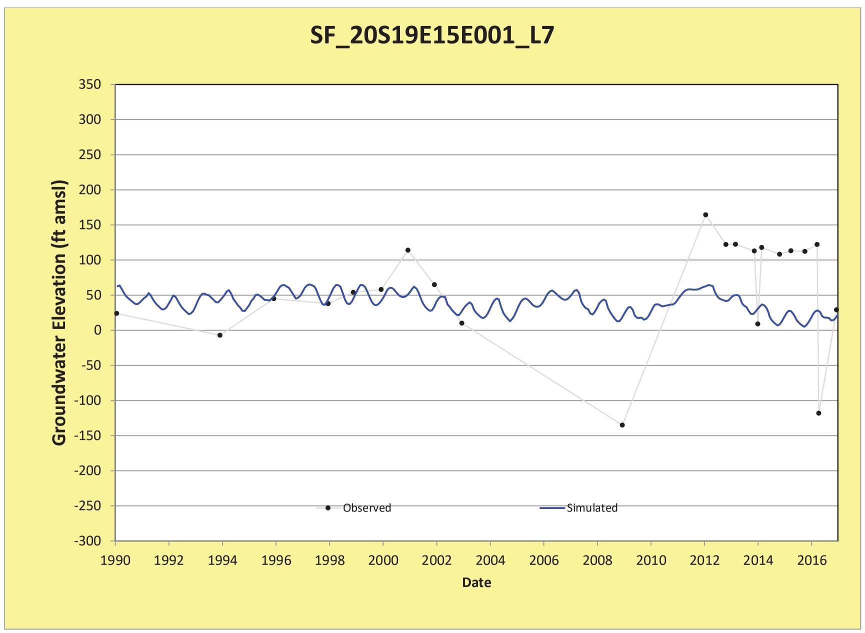
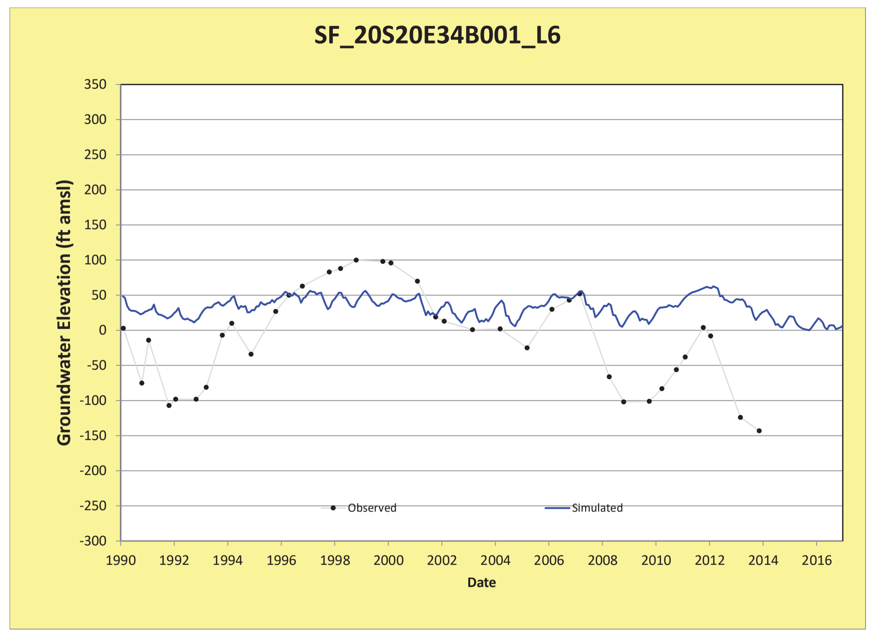
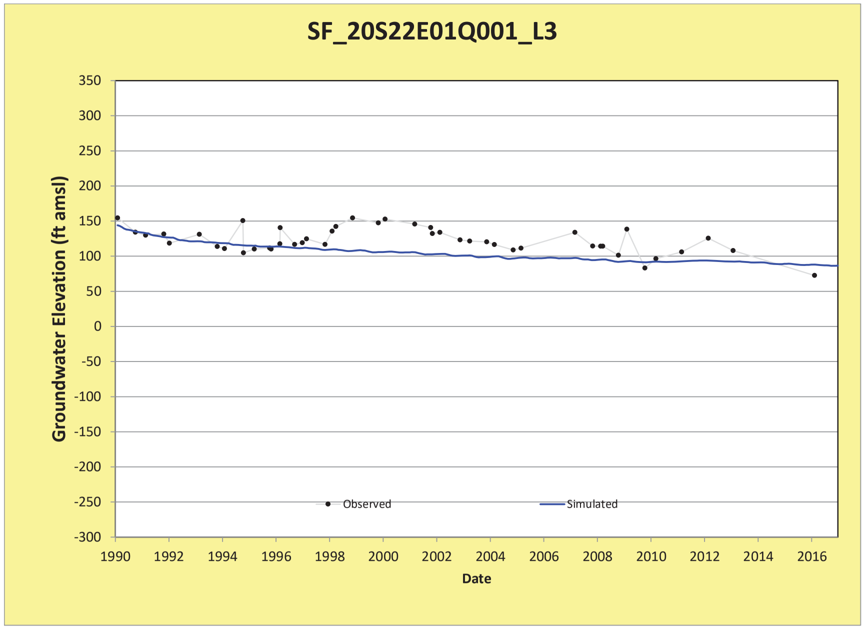
Date
Observed
Simulated

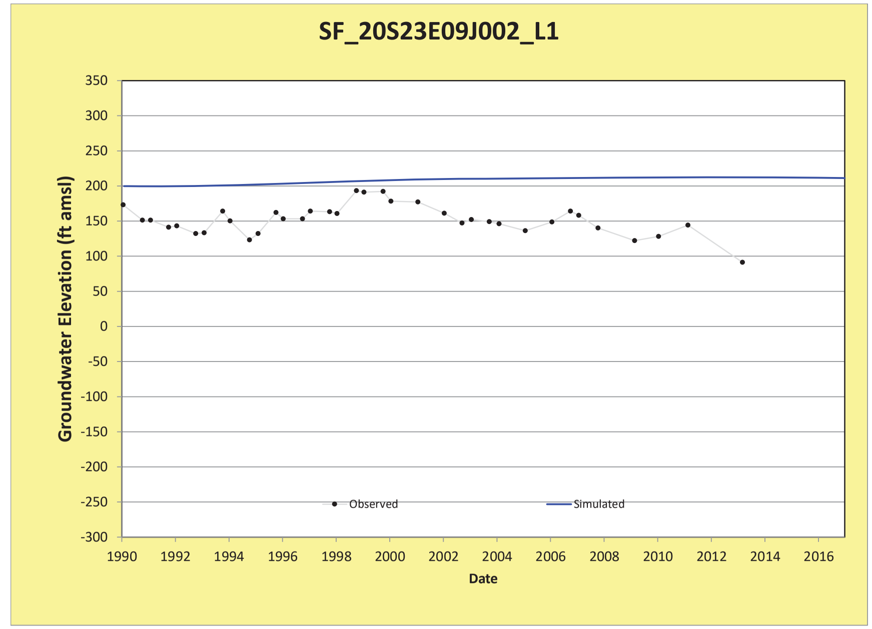

SF_20S19E14H001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

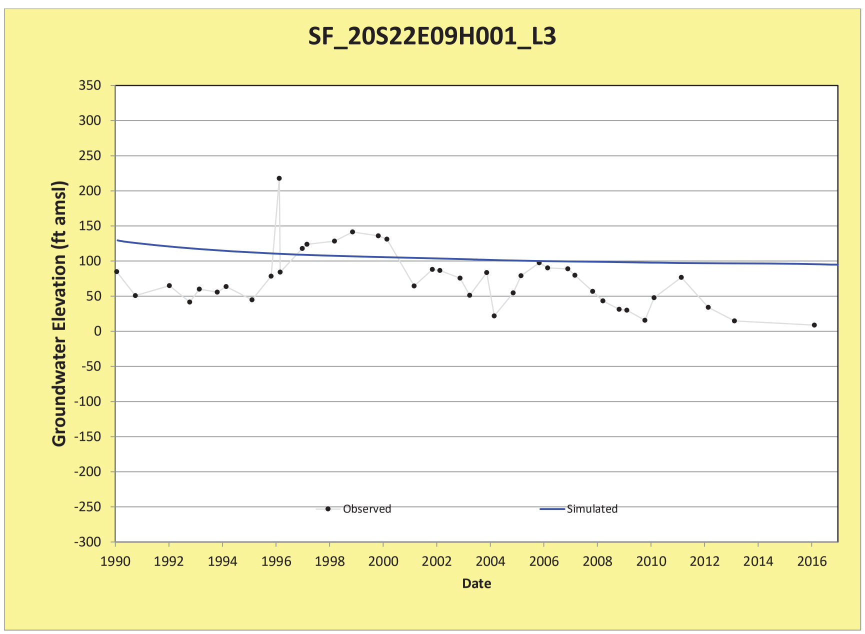

SF_20S20E28E003_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

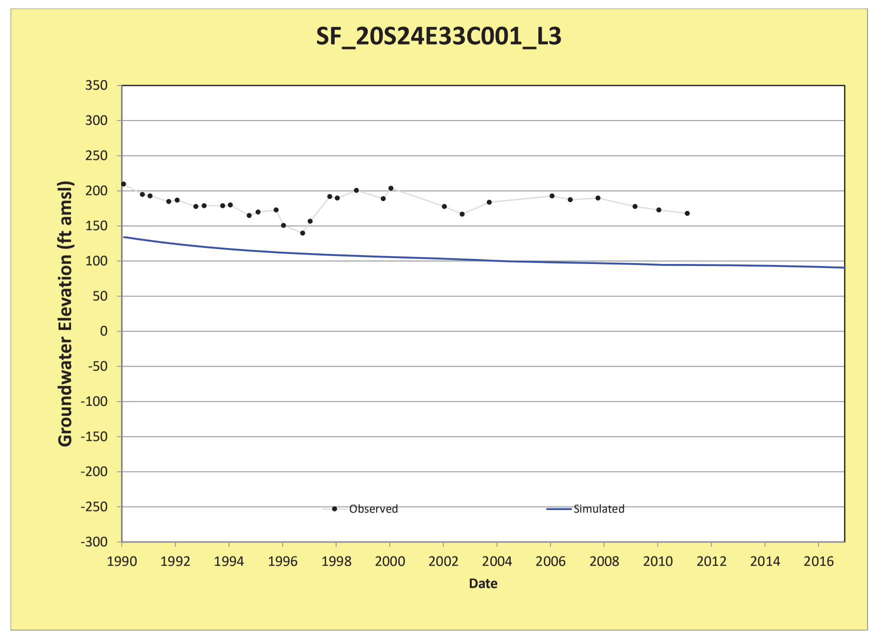

SF_20S19E15E001_L7
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

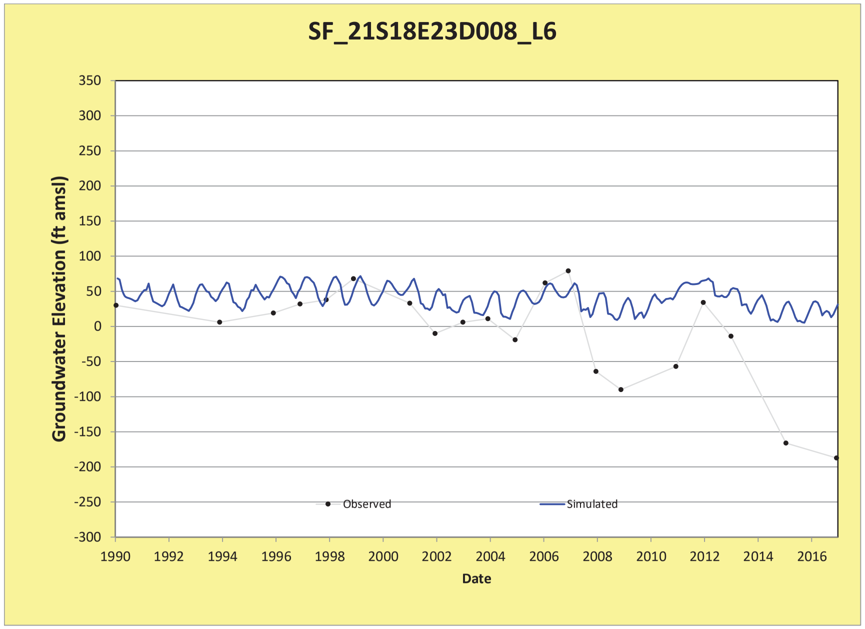

SF_20S20E34B001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_20S22E01Q001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_20S23E09J002_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_20S22E09H001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_20S24E33C001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_21S18E23D008_L6
Groundwater Elevation (ft amsl)
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300
250
200
150
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50
0
-50
-100
-150
-200
-250
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1994
1996
1998
2000
2002
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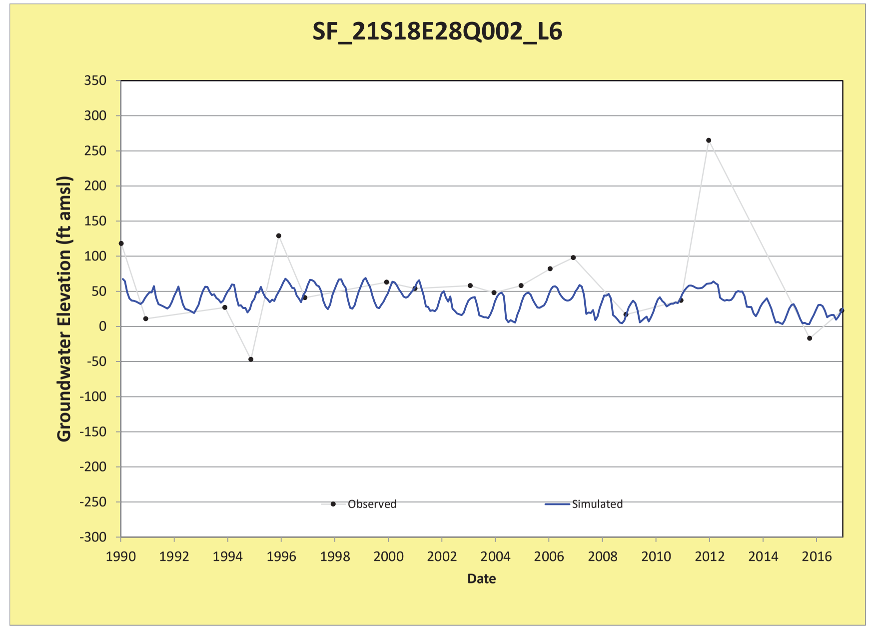
2010
2012
2014
2016
Date
Observed
Simulated


SF_21S18E28Q002_L6
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
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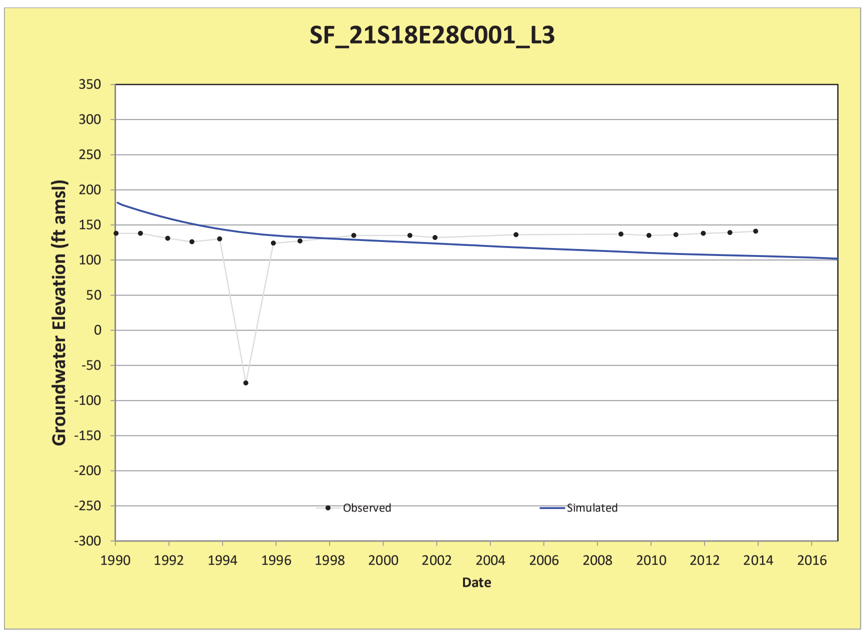
2010
2012
2014
2016
Date
Observed
Simulated


SF_21S18E28C001_L3
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
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2010
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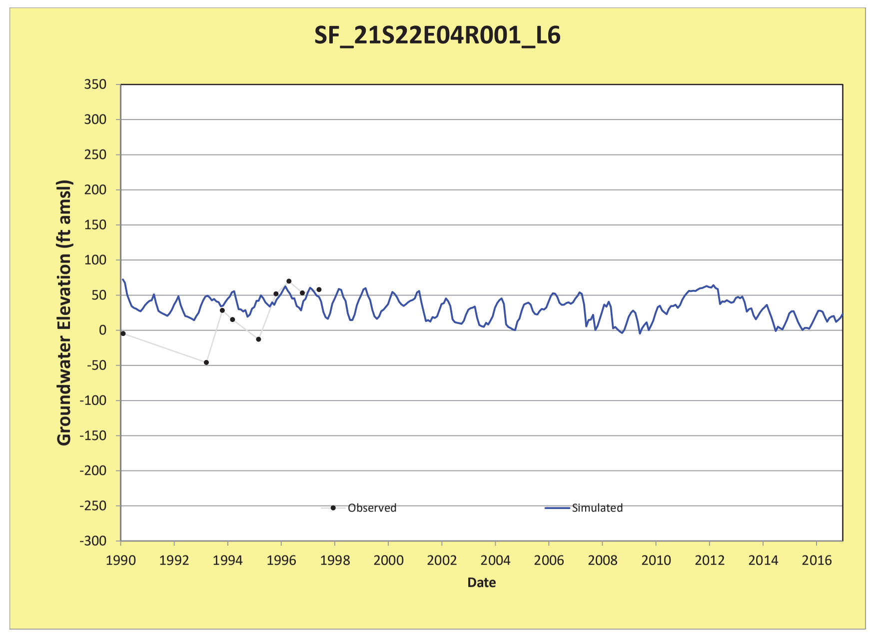
2016
Date
Observed
Simulated


SF_21S22E04R001_L6
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
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2004
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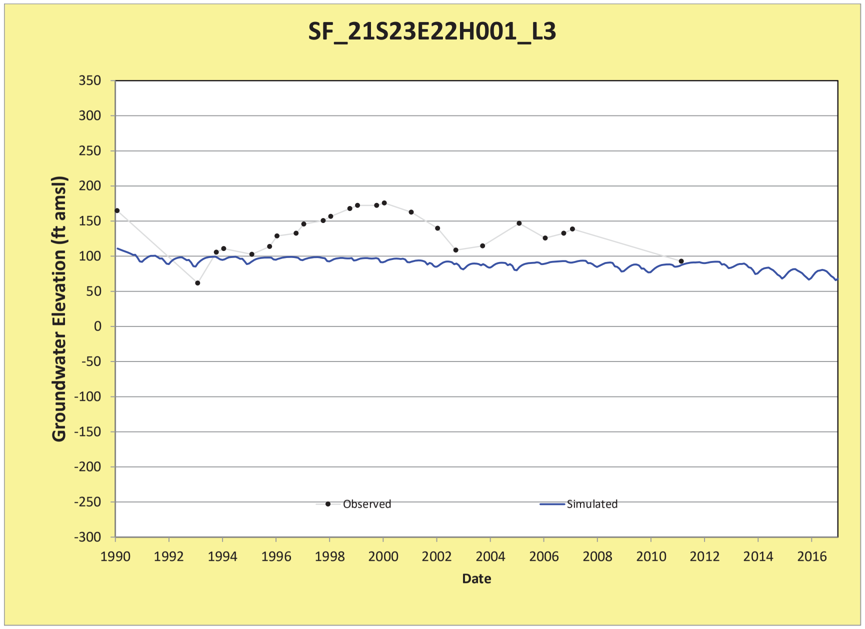
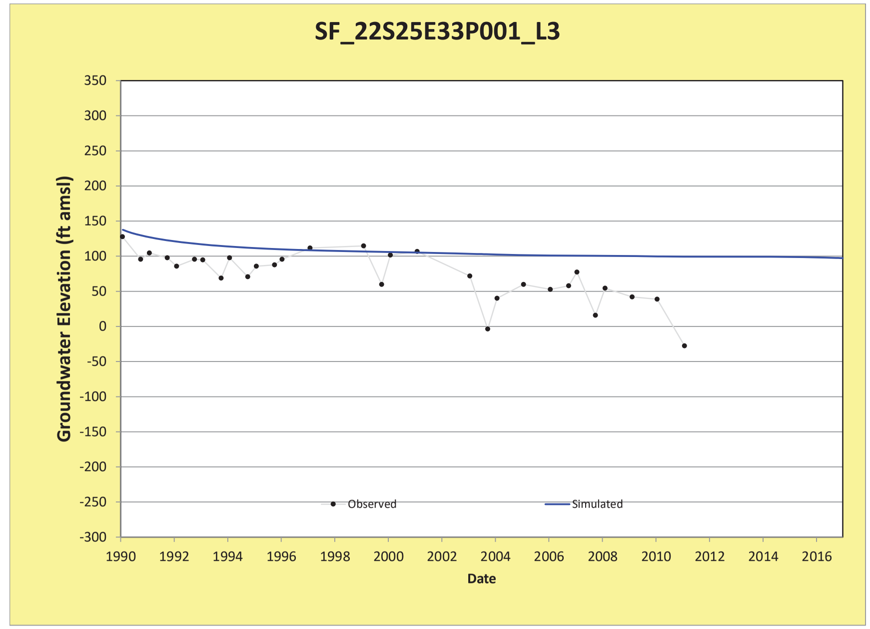
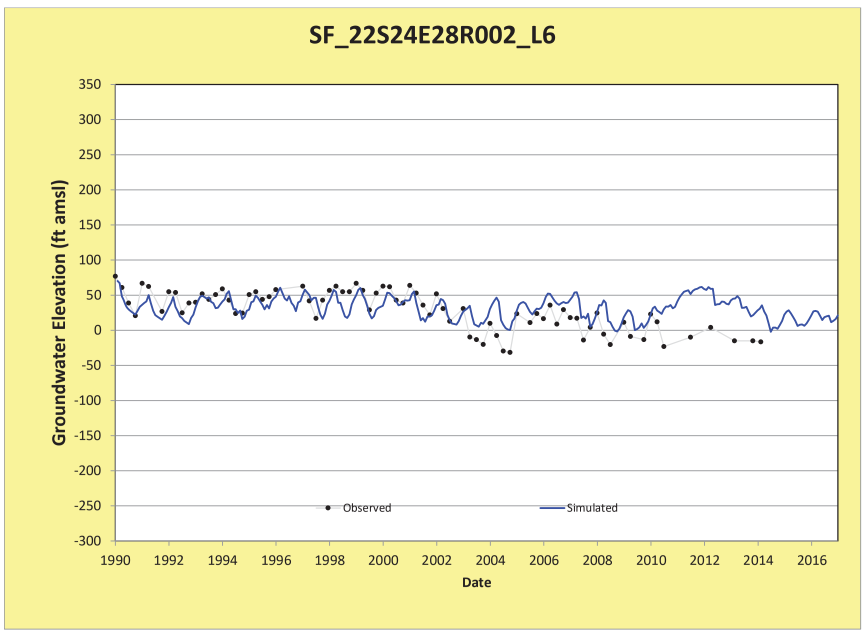
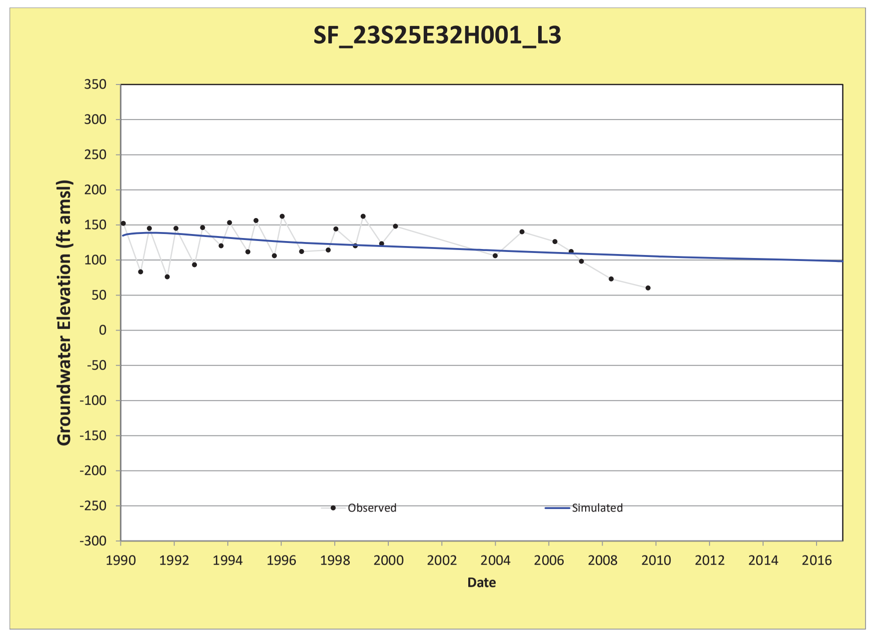
2008
2010
2012
2014
2016
Date
Observed
Simulated

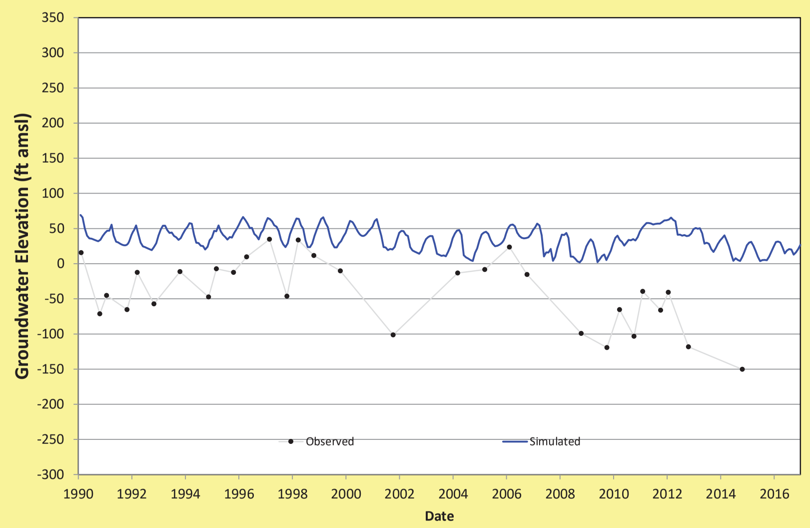

SF_21S23E22H001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_22S25E33P001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

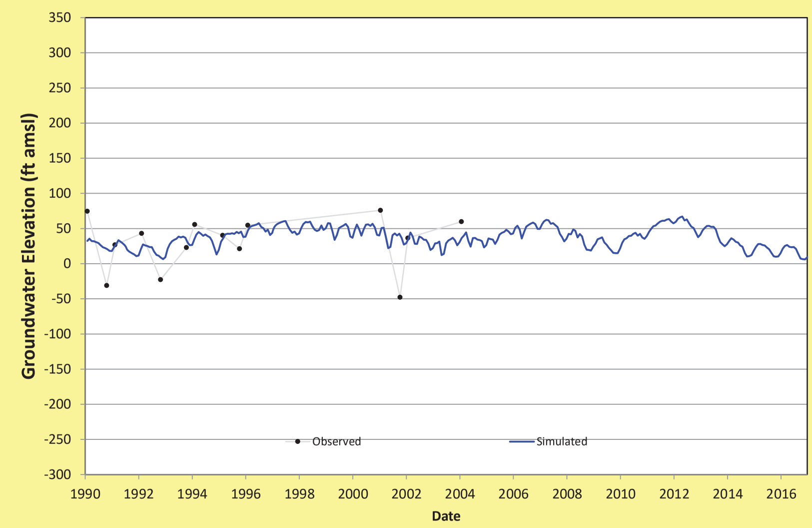

SF_22S24E28R002_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_23S25E32H001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

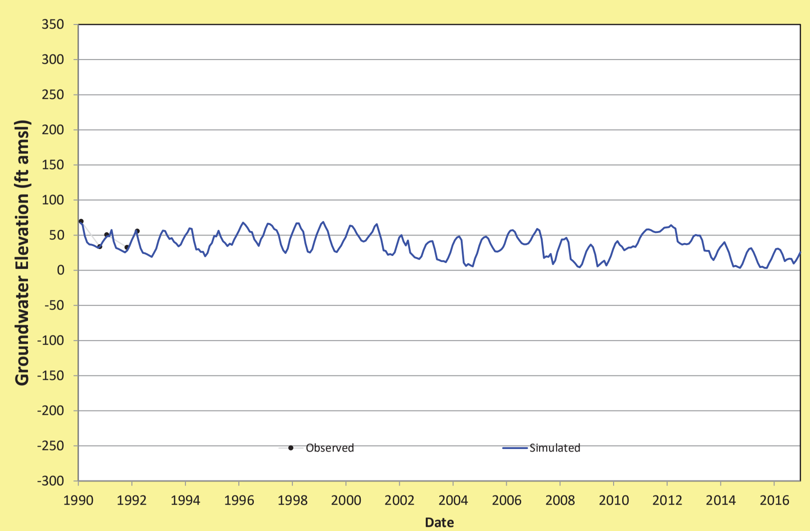
SF_24S23E15R001_L6



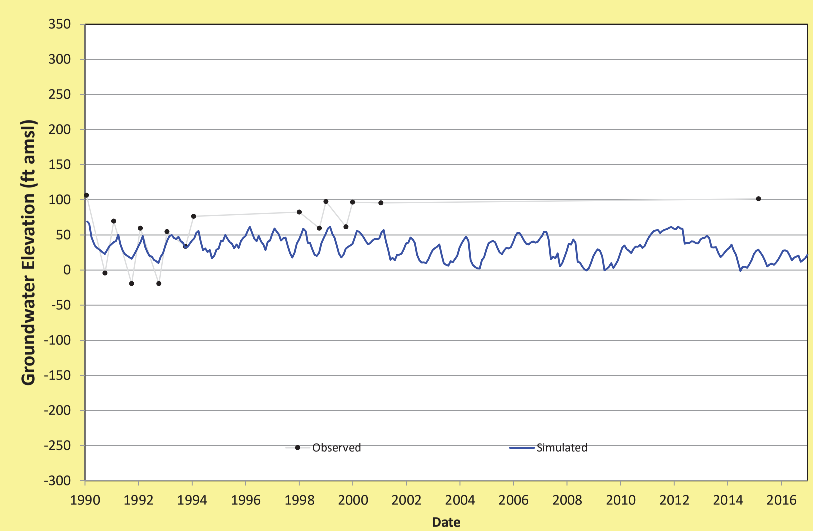
SF_25S24E27R004_L6

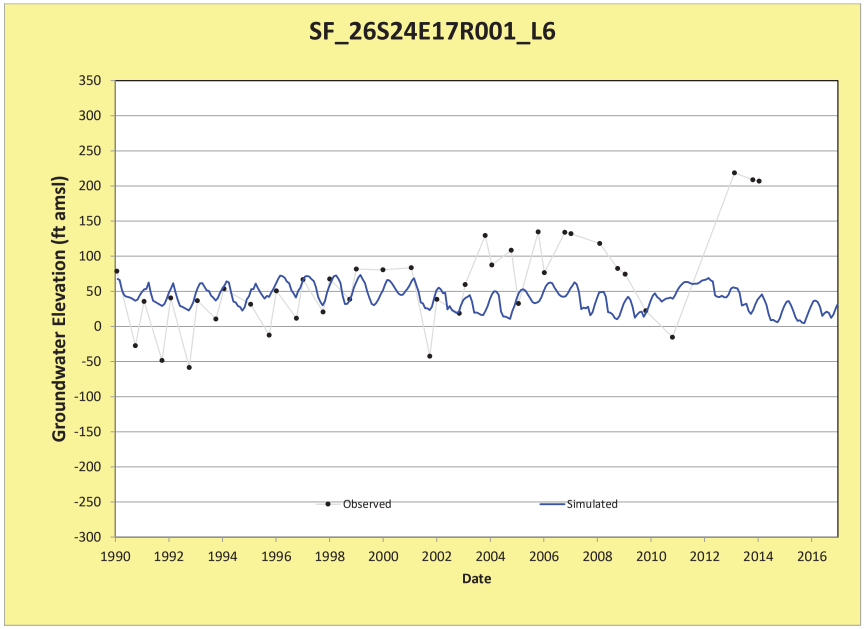


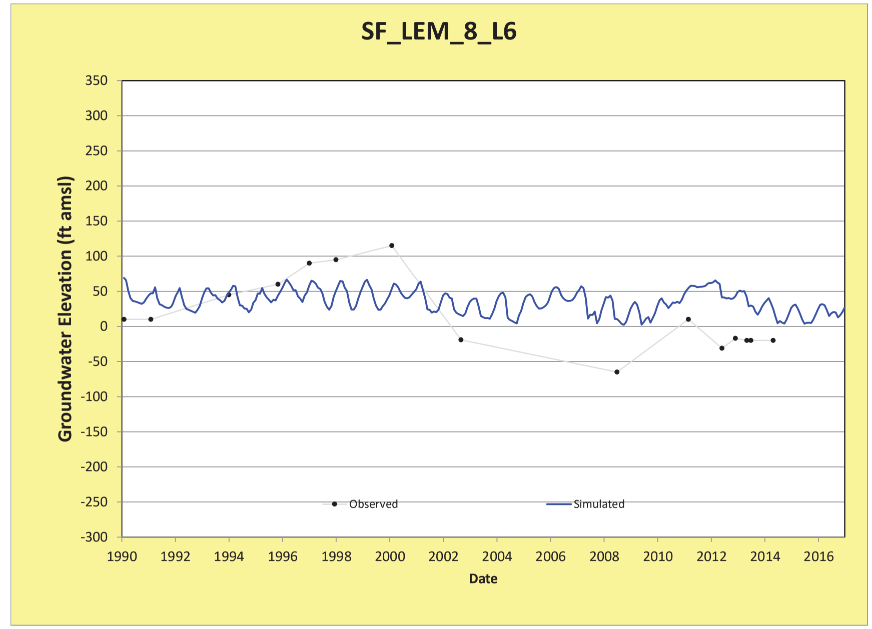
SF_24S24E20A002_L6

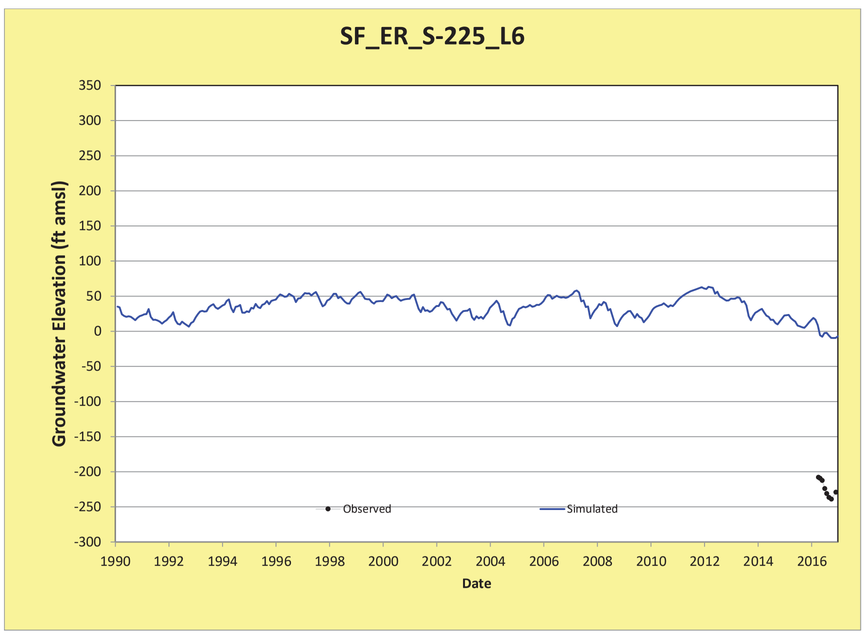


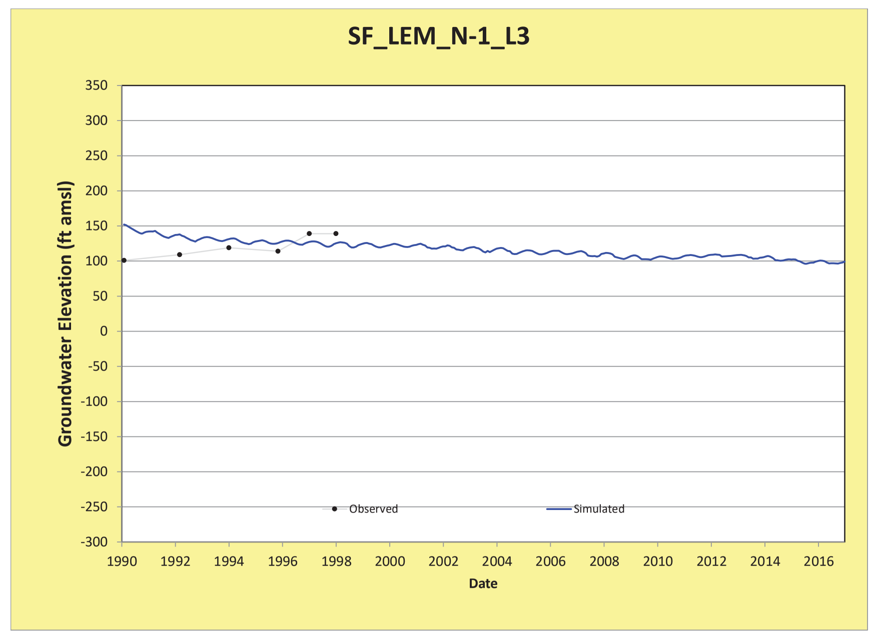
SF_25S24E35R001_L6

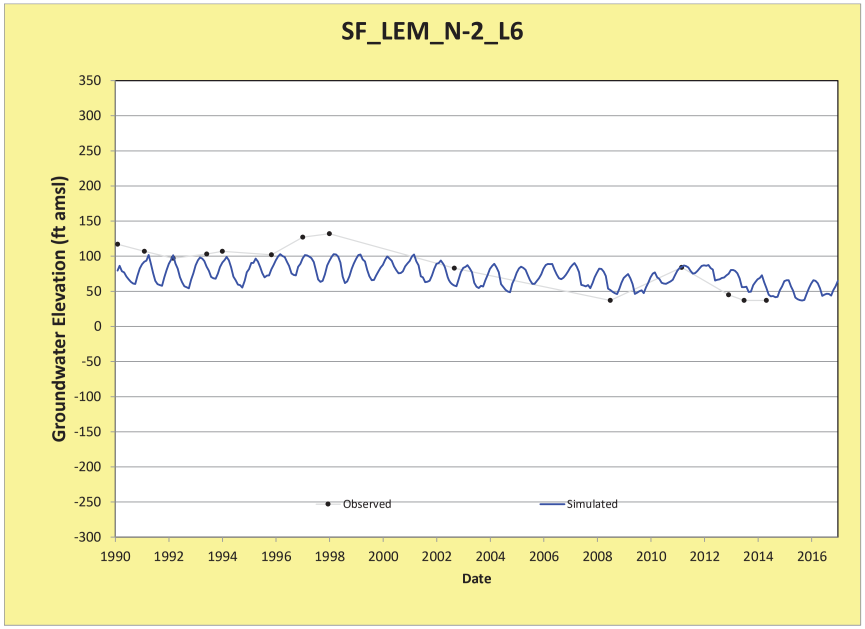



SF_26S24E17R001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_LEM_8_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_ER_S-225_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_LEM_N-1_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


SF_LEM_N-2_L6
Groundwater Elevation (ft amsl)
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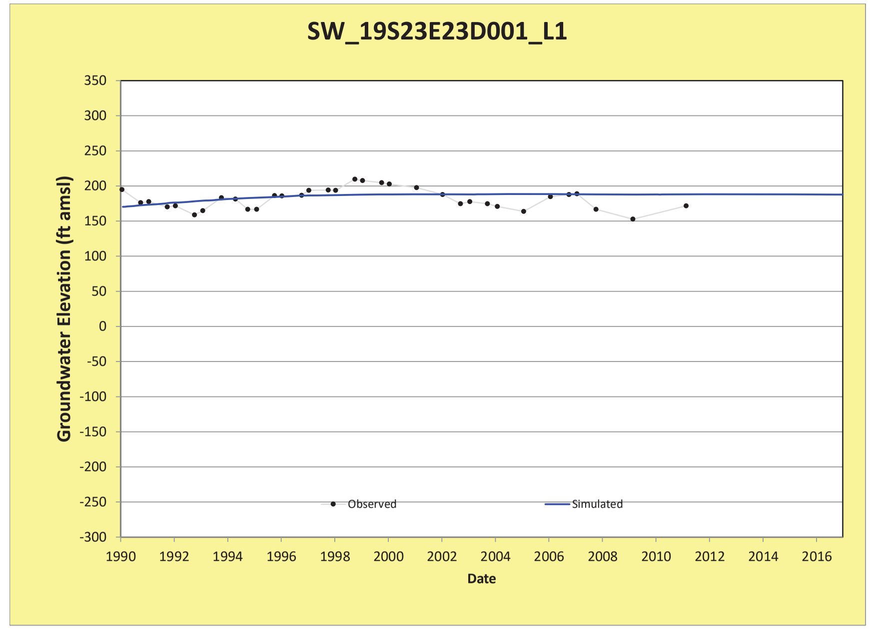
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Date
Observed
Simulated


SW_19S23E23D001_L1
Groundwater Elevation (ft amsl)
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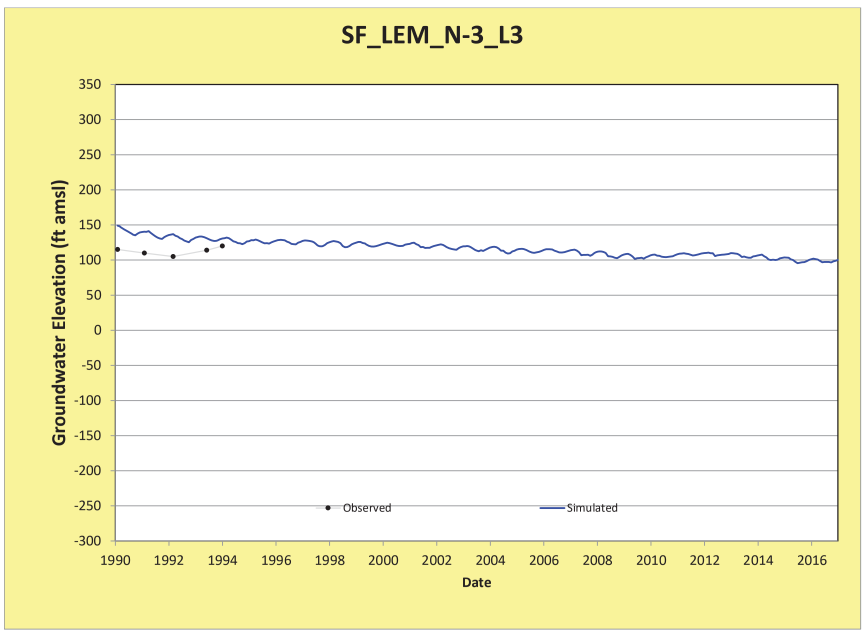
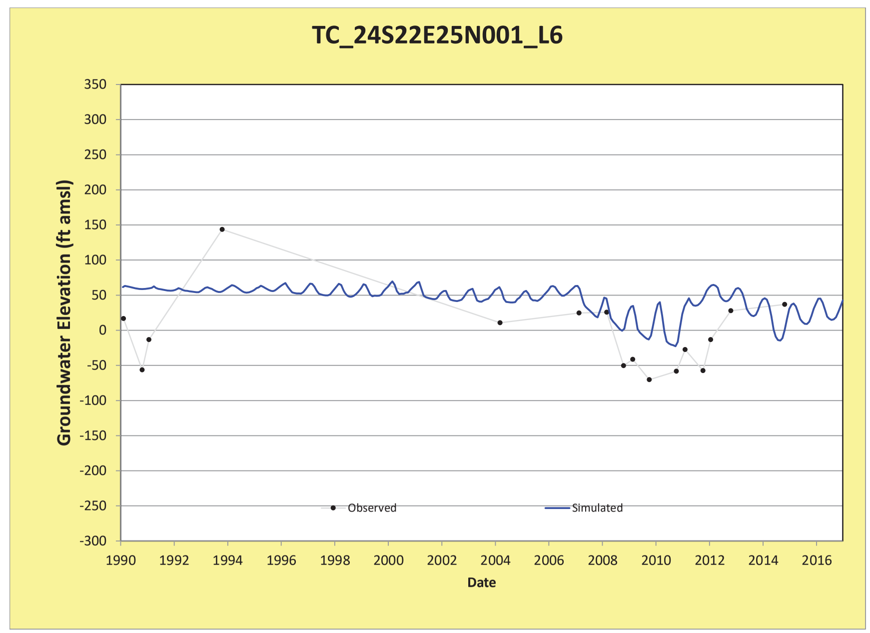
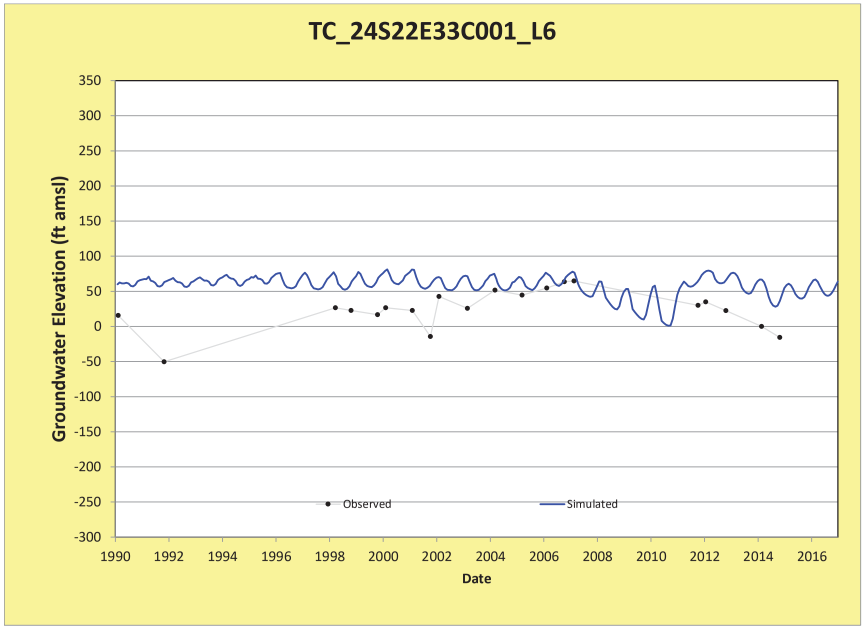
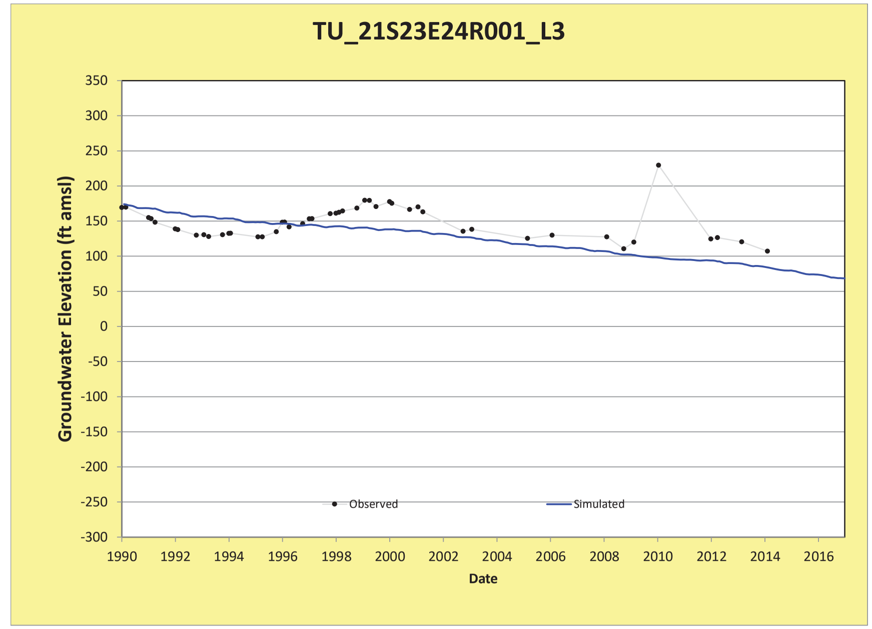
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Date
Observed
Simulated


SF_LEM_N-3_L3
Groundwater Elevation (ft amsl)
350 300 250 200 150 100 50 0 -50 -100 -150 -200 -250 -300
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Date
Observed
Simulated

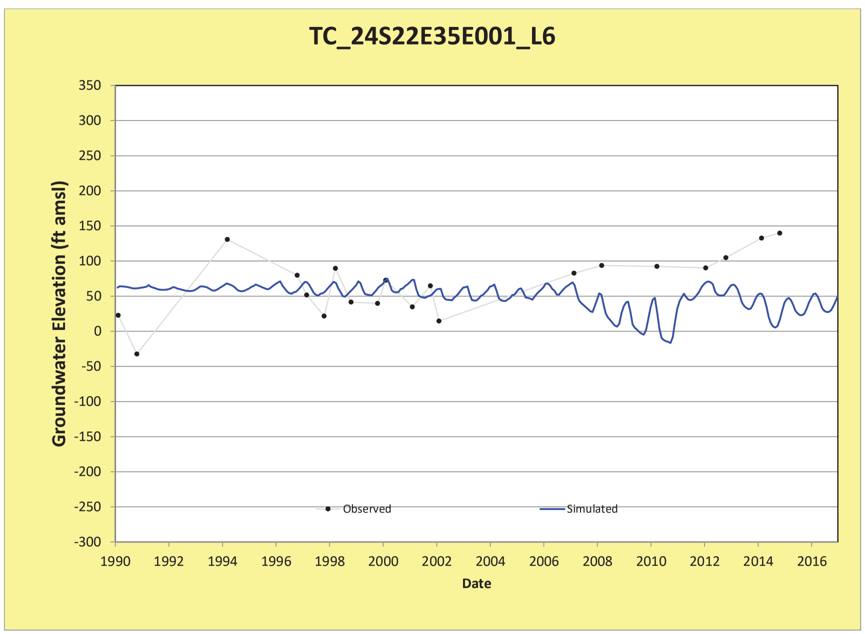

TC_24S22E25N001_L6
Groundwater Elevation (ft amsl)
350 300 250 200 150 100 50 0 -50 -100 -150 -200 -250 -300
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Date
Observed
Simulated



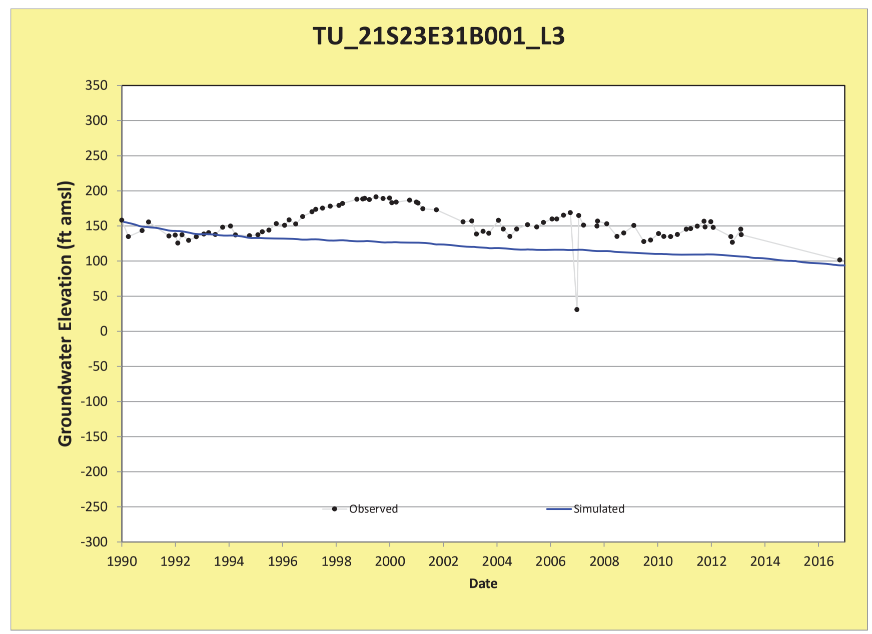
TC_24S22E33C001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated



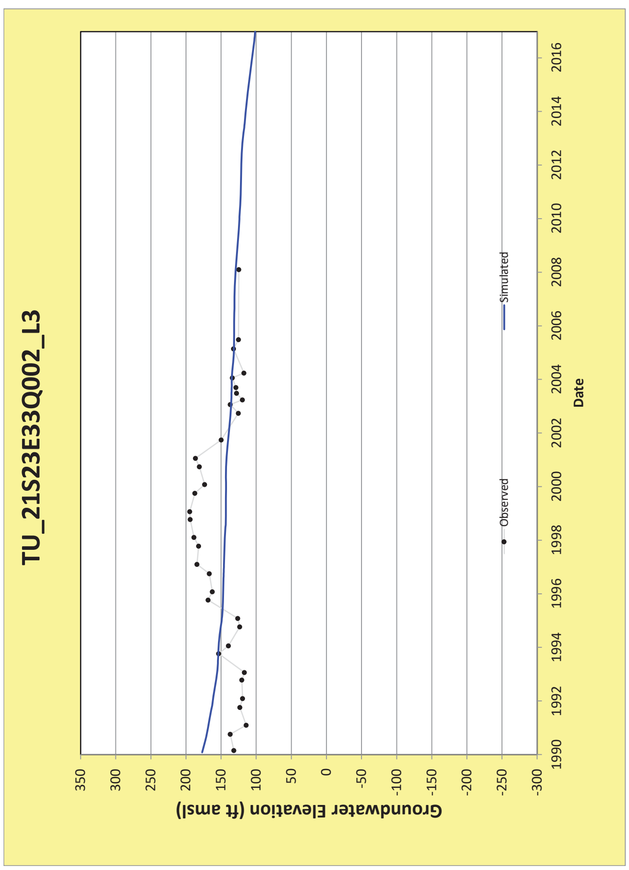
TU_21S23E24R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

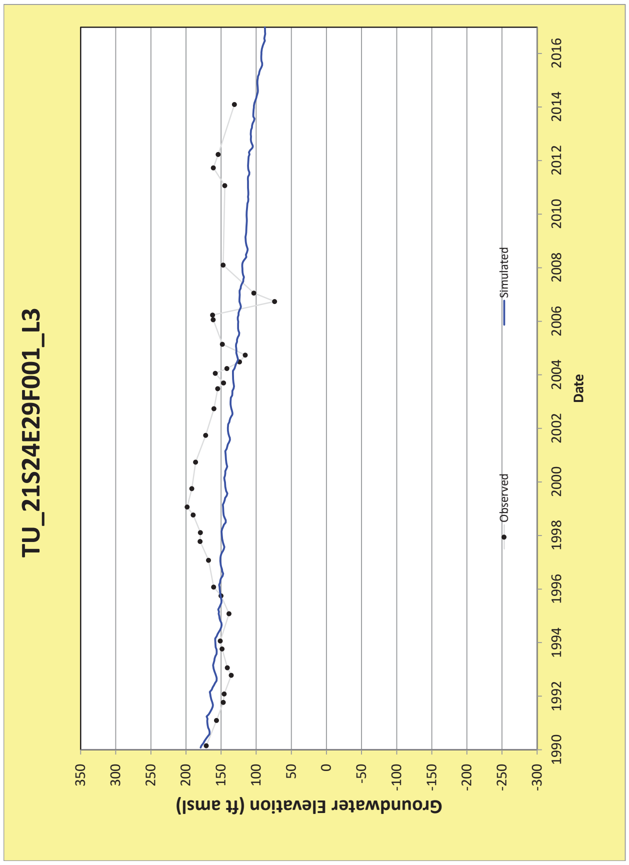


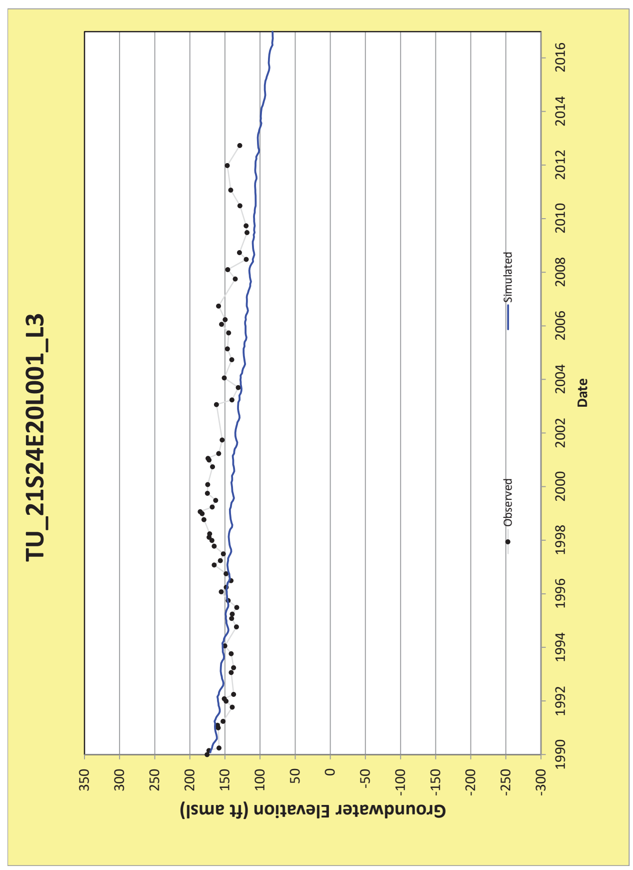
TC_24S22E35E001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

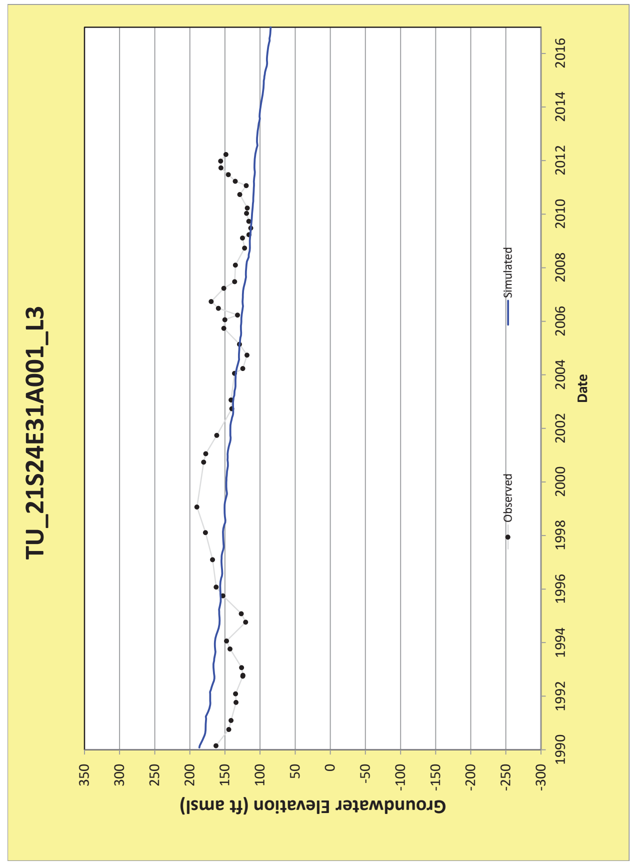


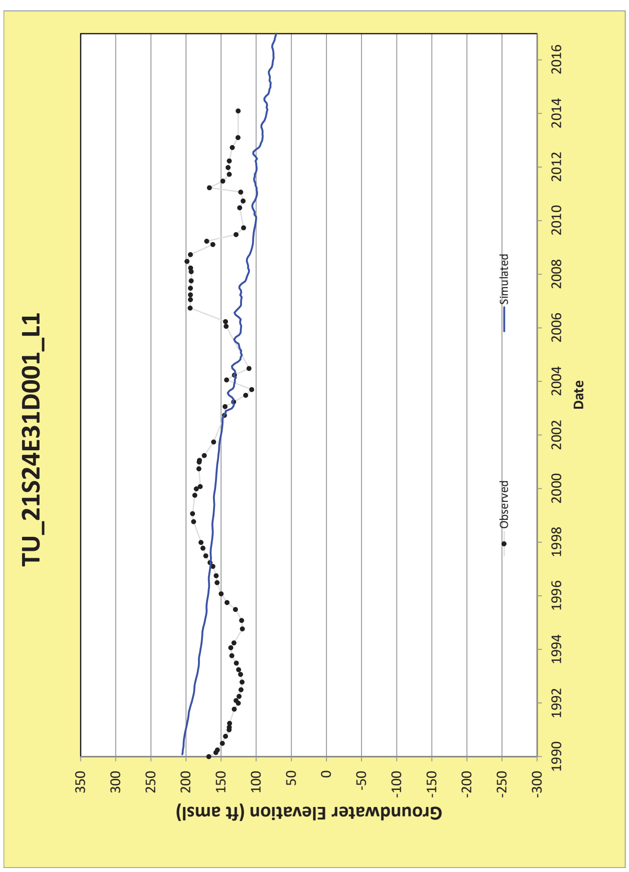
TU_21S23E31B001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

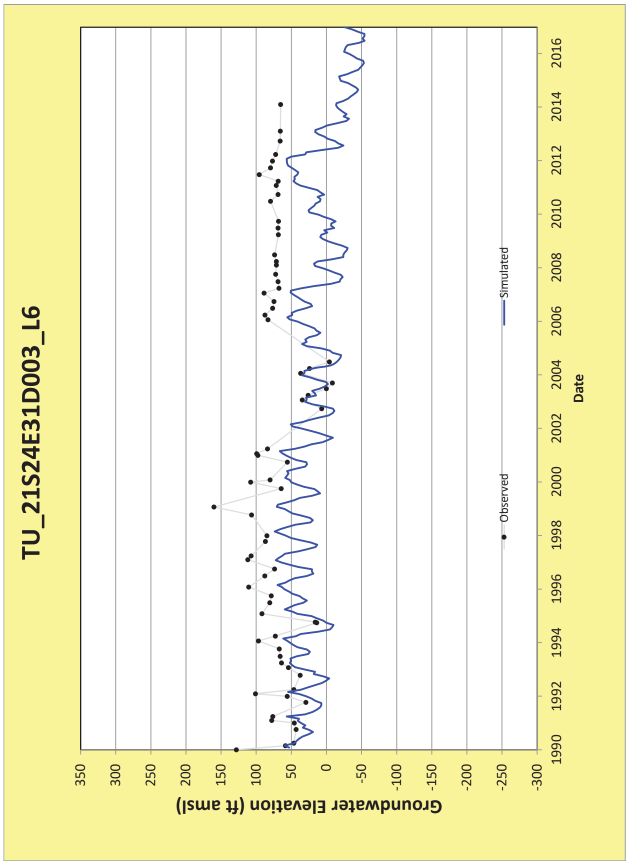

TU_21S23E33Q002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

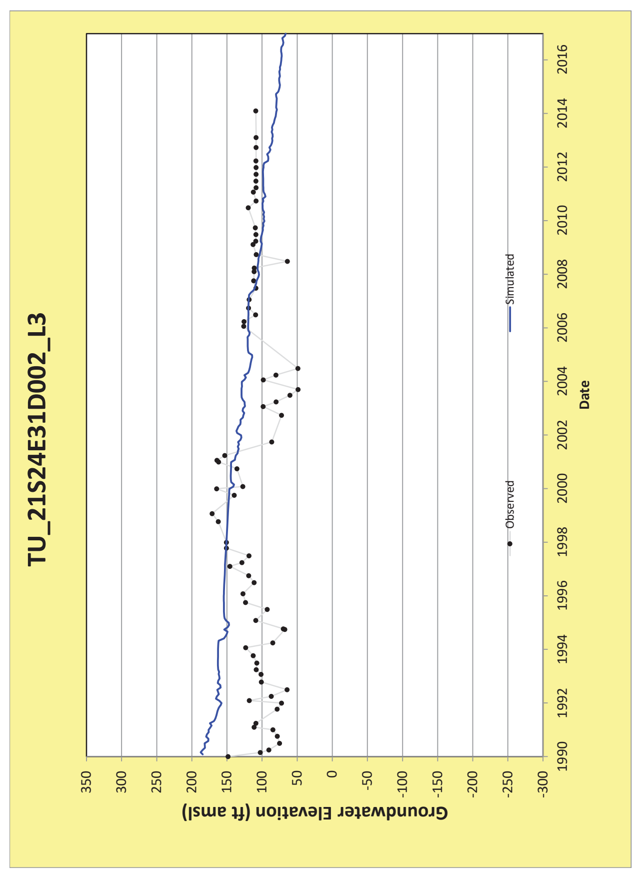

TU_21S24E29F001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

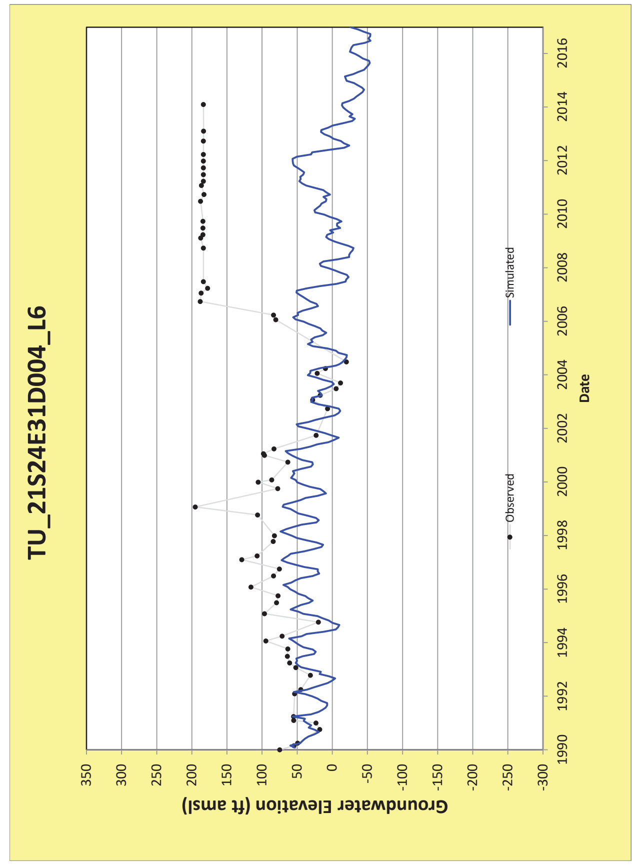

TU_21S24E20L001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

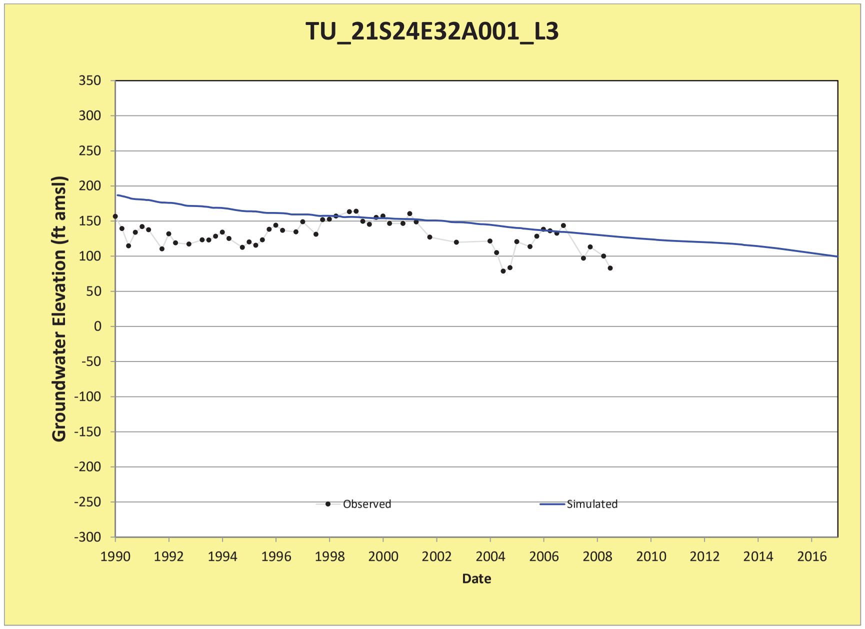

TU_21S24E31A001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


TU_21S24E31D001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


TU_21S24E31D003_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


TU_21S24E31D002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


TU_21S24E31D004_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


TU_21S24E32A001_L3
Groundwater Elevation (ft amsl)
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300
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200
150
100
50
0
-50
-100
-150
-200
-250
-300
Observed
Simulated
1990
1992
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2012
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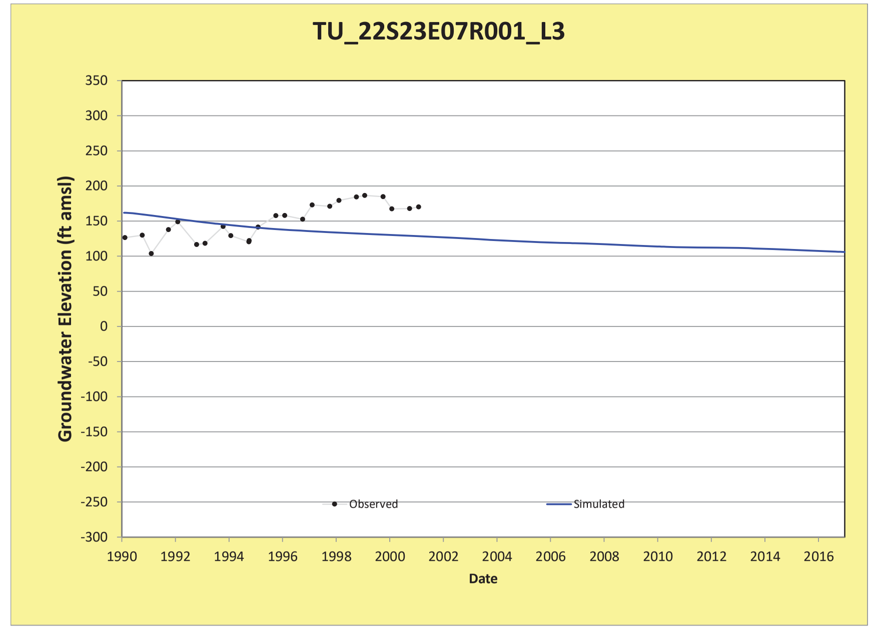
2016
Date


TU_22S23E07R001_L3
Groundwater Elevation (ft amsl)
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300
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200
150
100
50
0
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-100
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-200
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Observed
Simulated
1990
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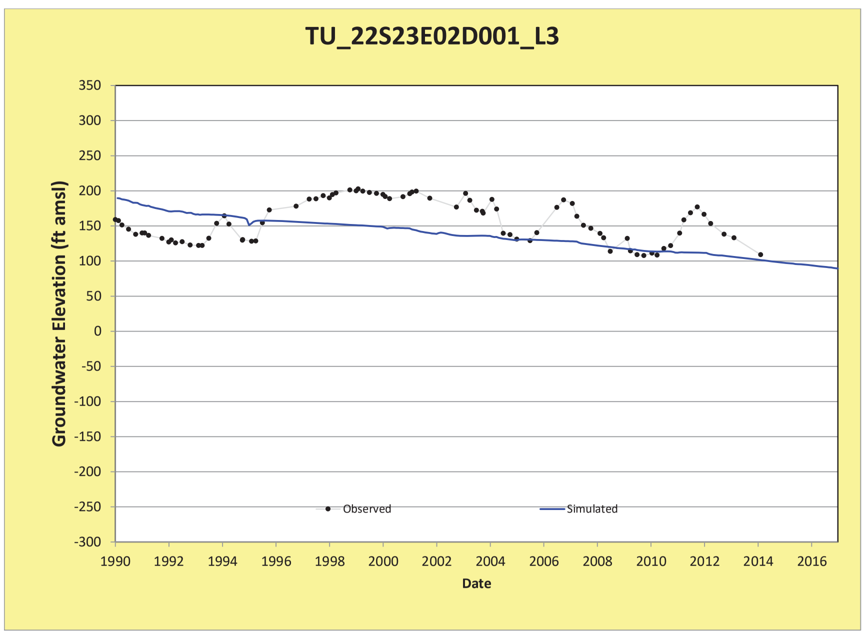
2016
Date


TU_22S23E02D001_L3
Groundwater Elevation (ft amsl)
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200
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0
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-200
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Observed
Simulated
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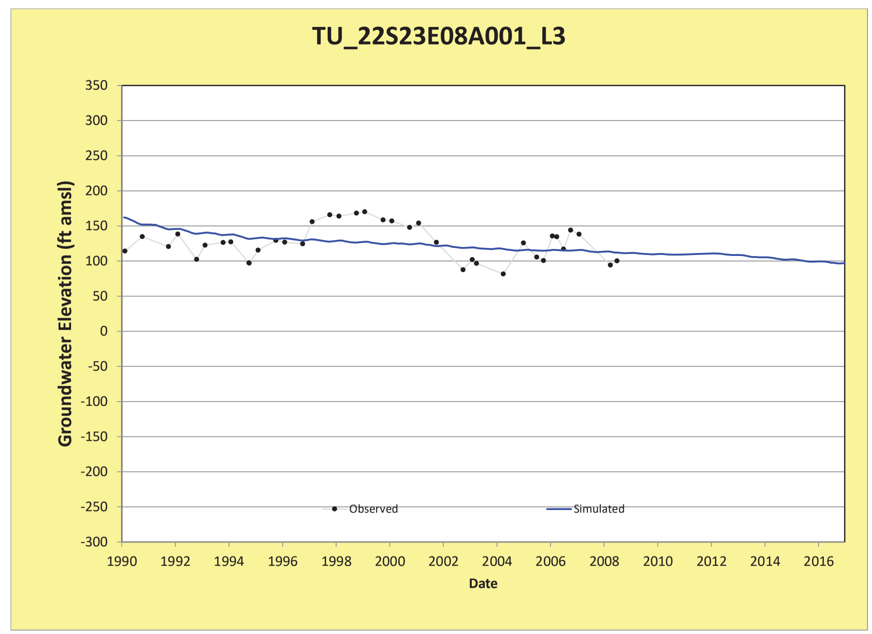
2016
Date


TU_22S23E08A001_L3
Groundwater Elevation (ft amsl)
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300
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200
150
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0
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-100
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Simulated
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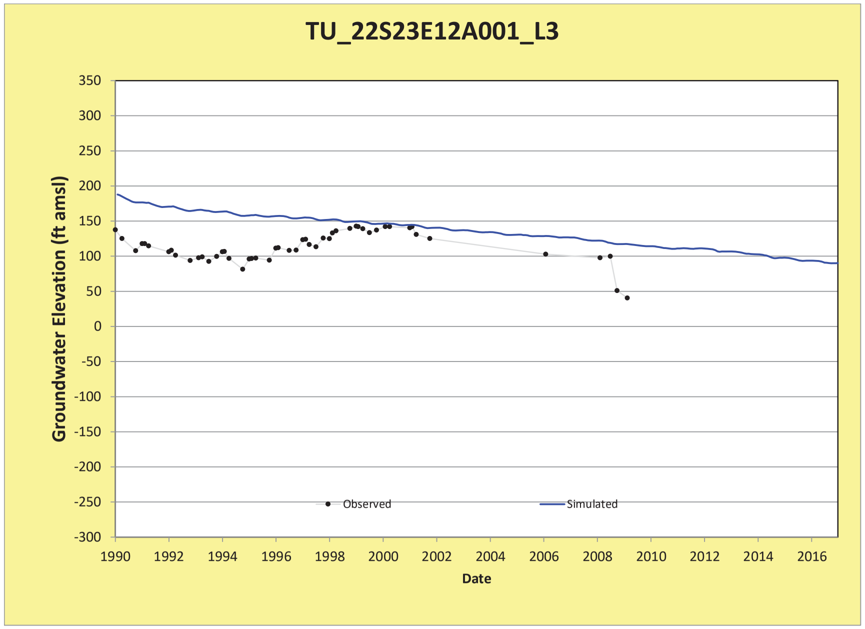
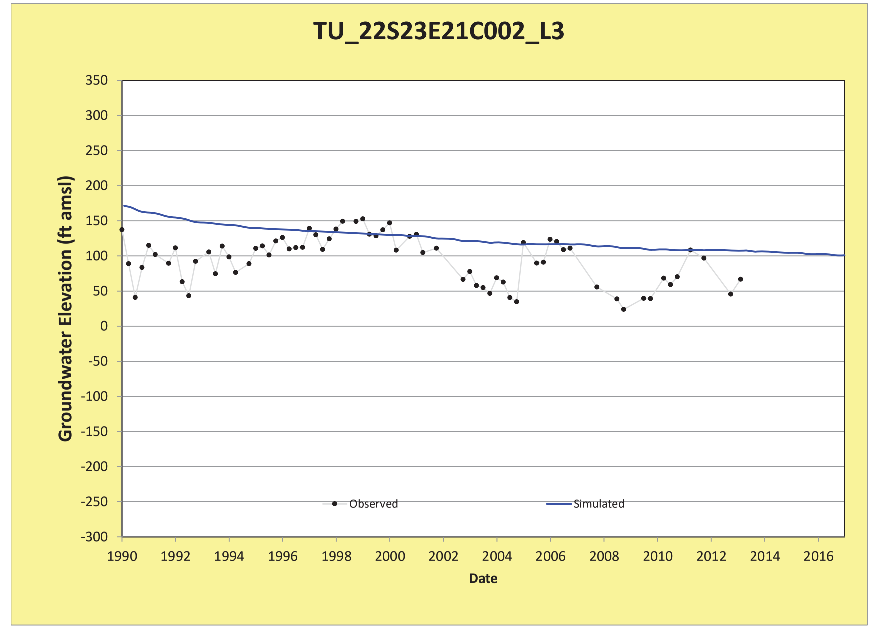
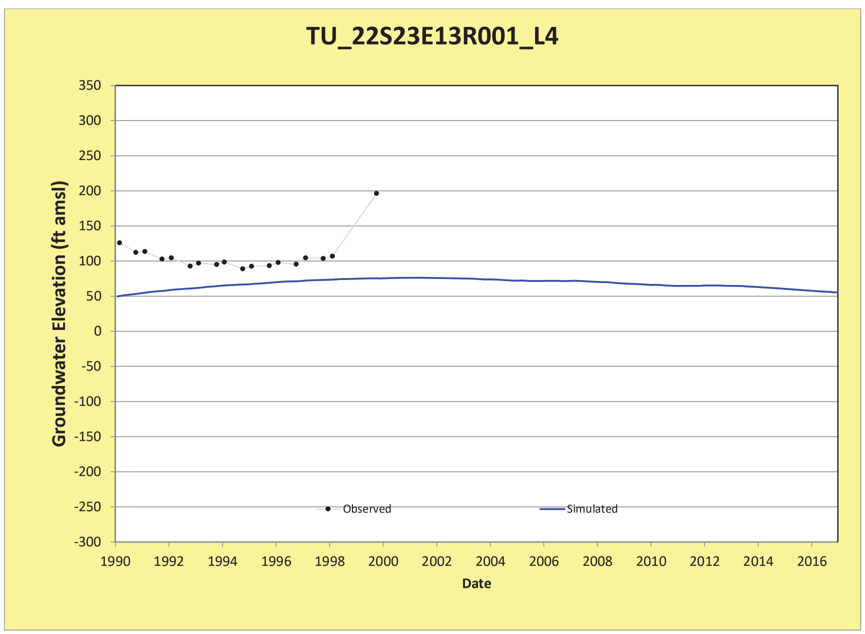
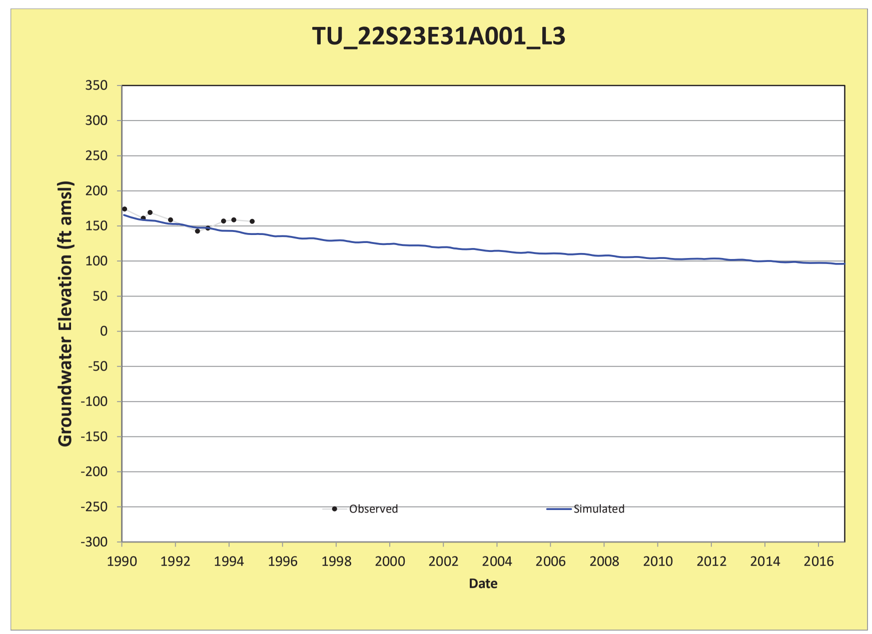
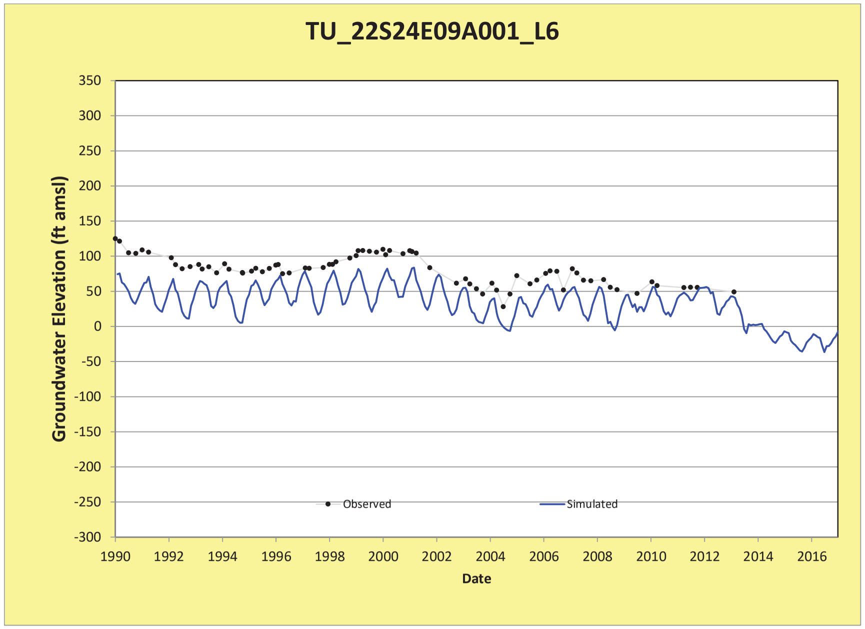
Date


TU_22S23E12A001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


TU_22S23E21C002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


TU_22S23E13R001_L4
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


TU_22S23E31A001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


TU_22S24E09A001_L6
Groundwater Elevation (ft amsl)
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300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
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2010
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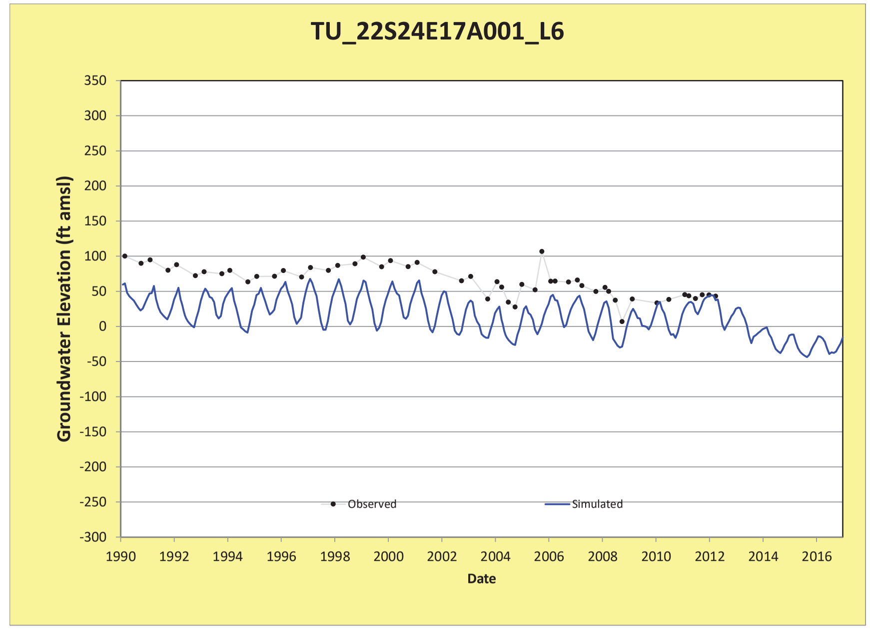
Date
Observed
Simulated


TU_22S24E17A001_L6
Groundwater Elevation (ft amsl)
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150
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50
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-50
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-200
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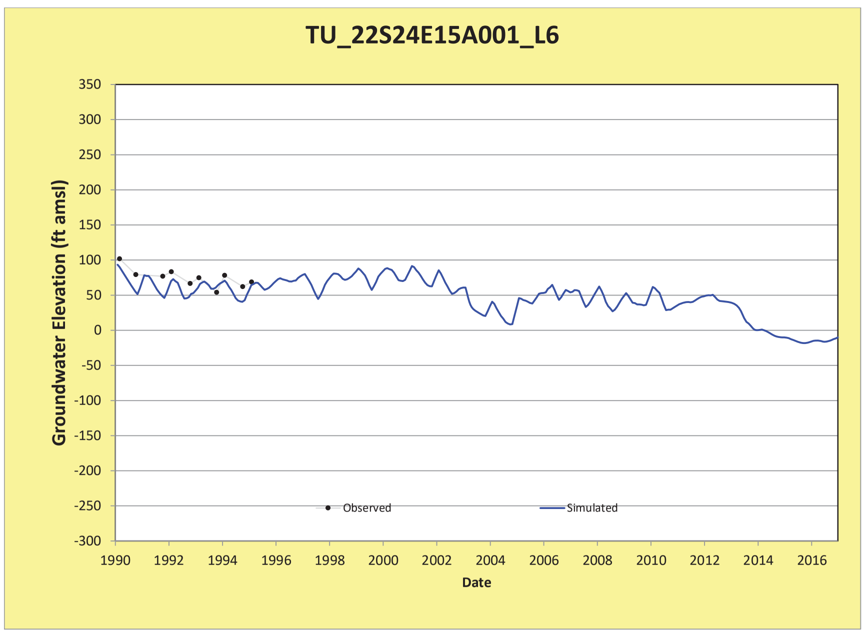
Date
Observed
Simulated


TU_22S24E15A001_L6
Groundwater Elevation (ft amsl)
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200
150
100
50
0
-50
-100
-150
-200
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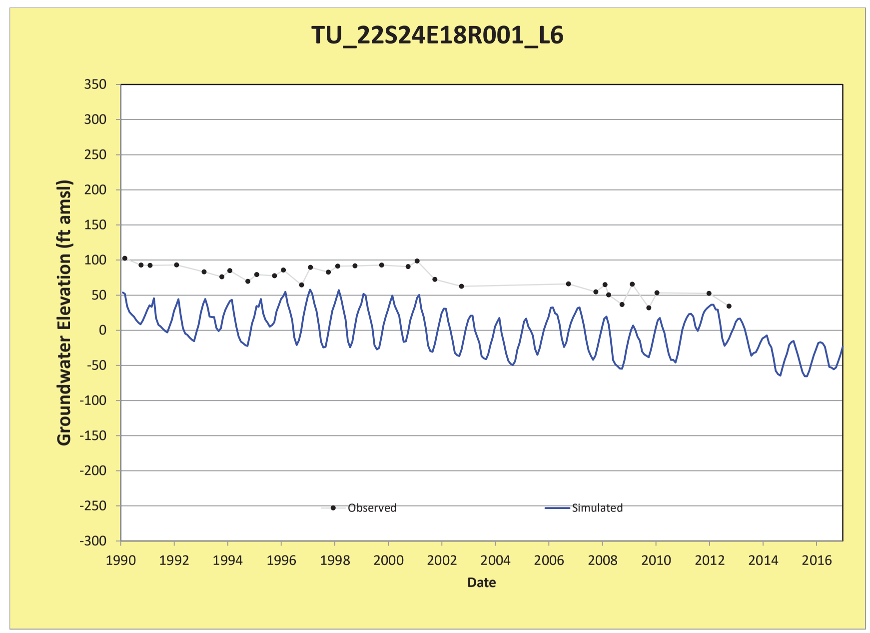
2016
Date
Observed
Simulated


TU_22S24E18R001_L6
Groundwater Elevation (ft amsl)
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200
150
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0
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-200
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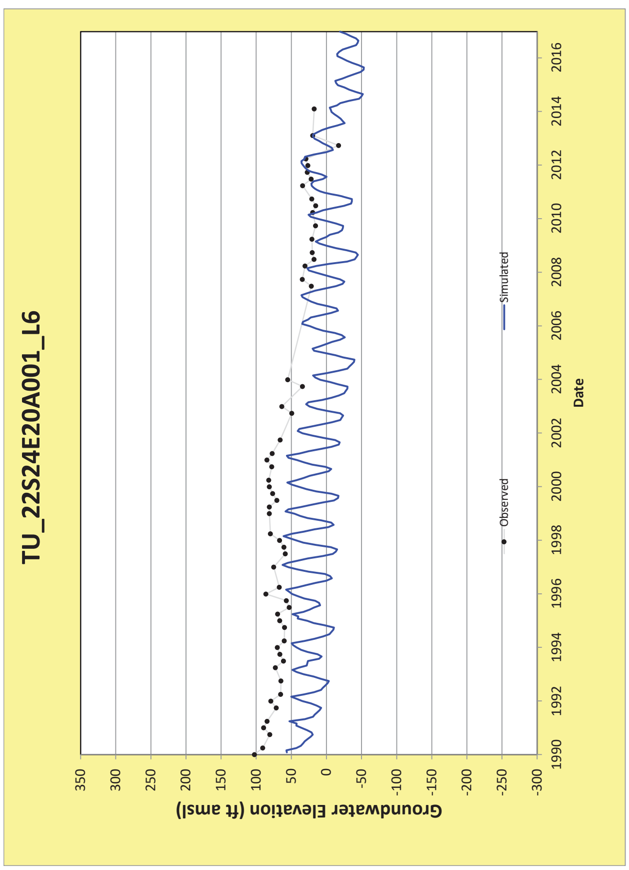
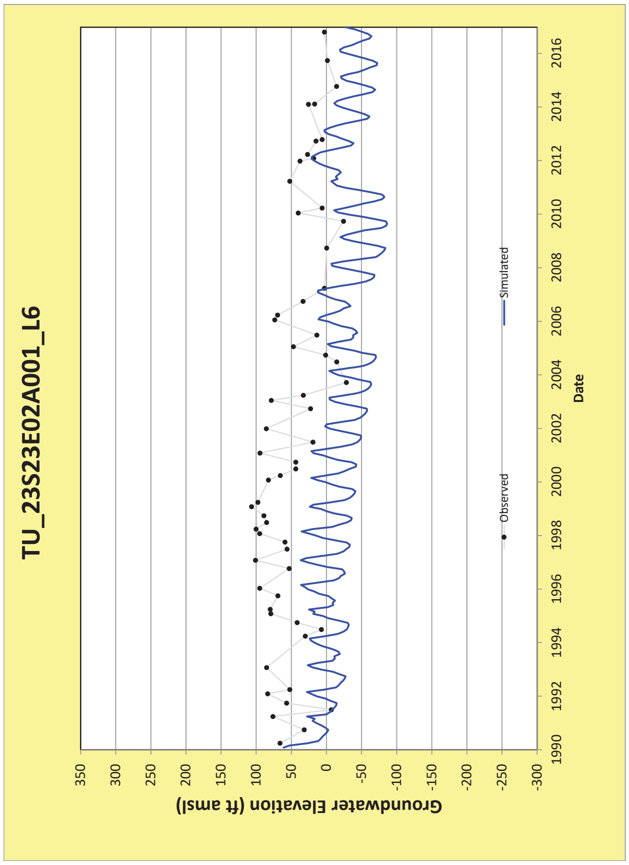
Date
Observed
Simulated


TU_22S24E20A001_L6
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


TU_23S23E02A001_L6
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
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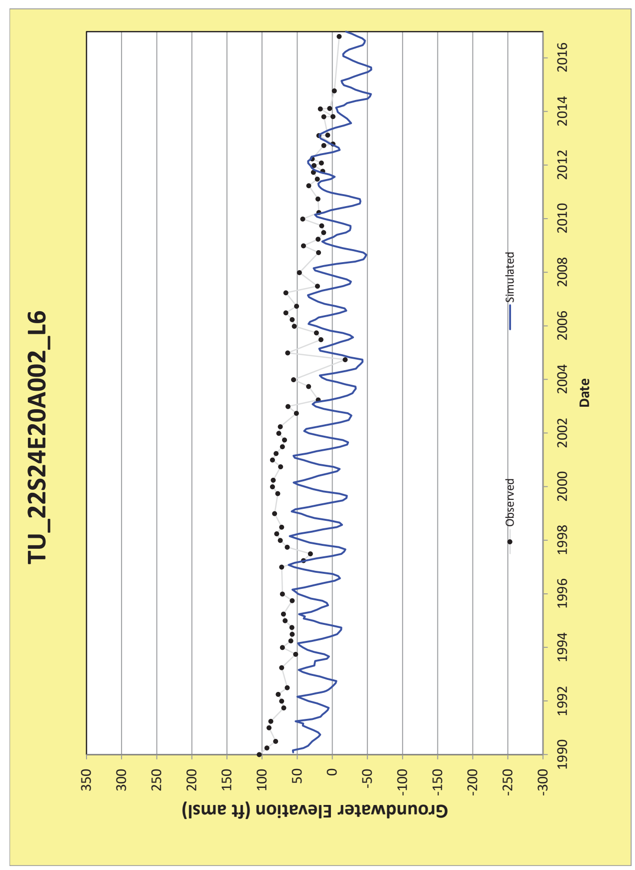
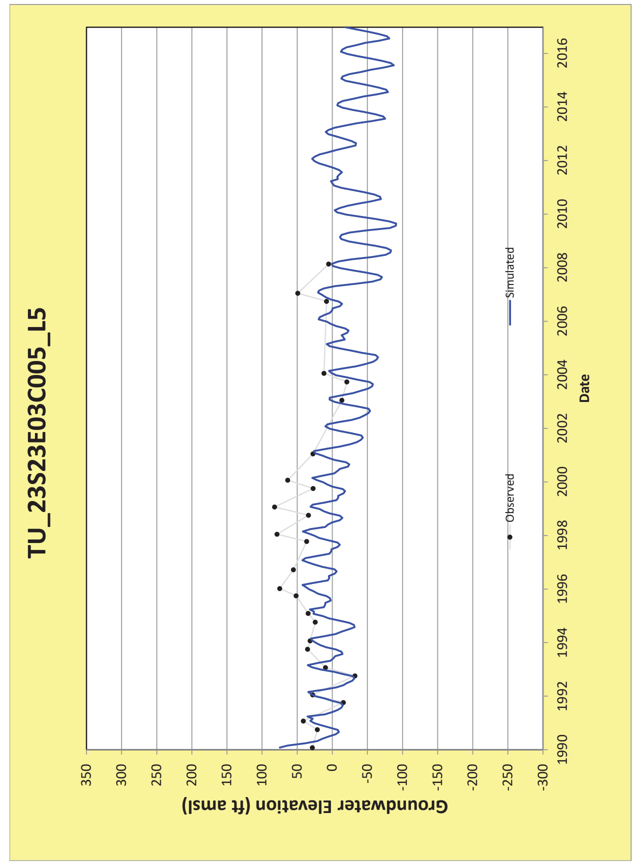
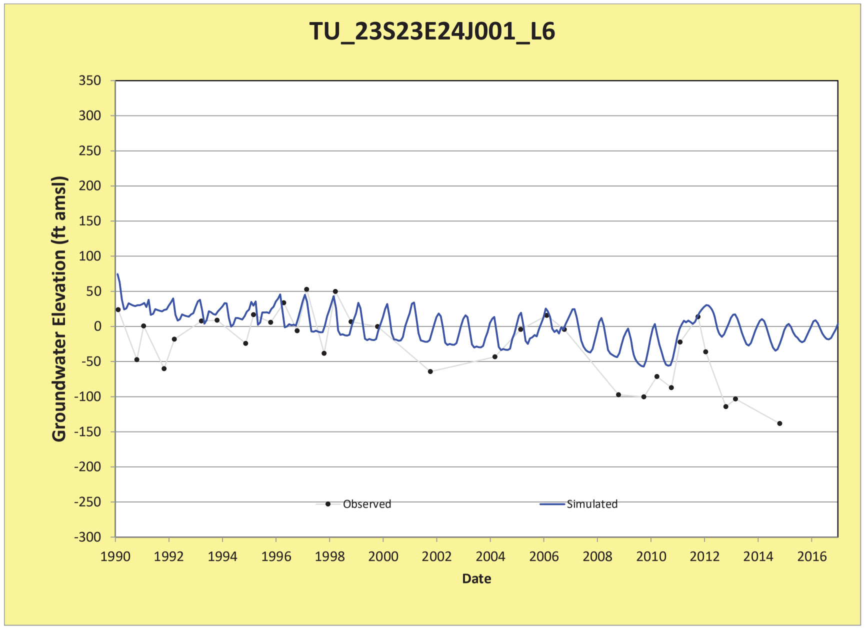
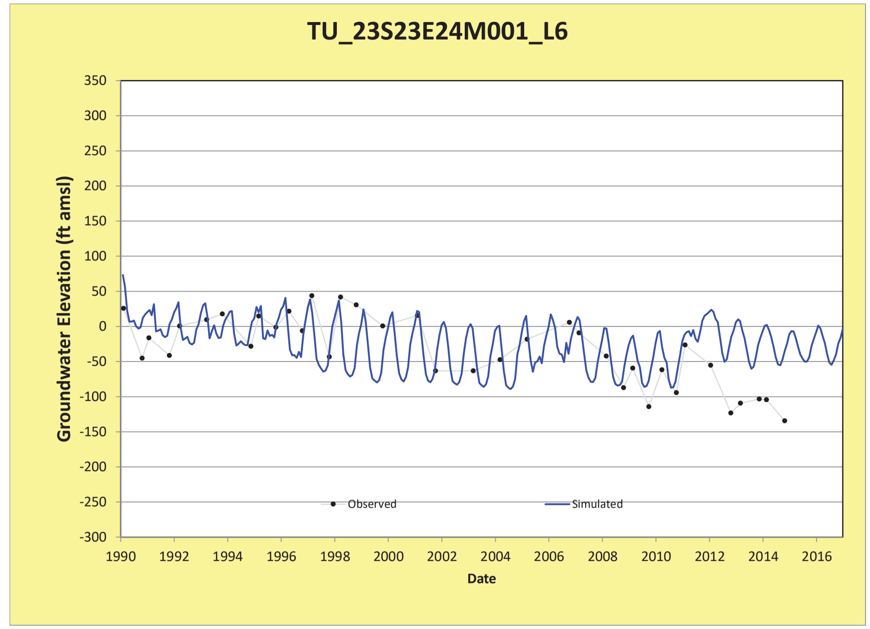
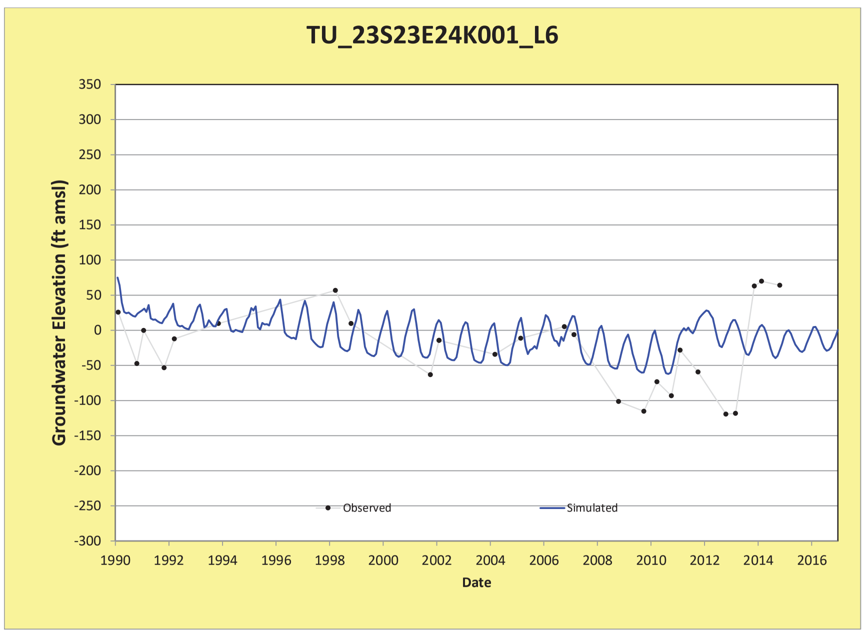
2010
2012
2014
2016
Date
Observed
Simulated

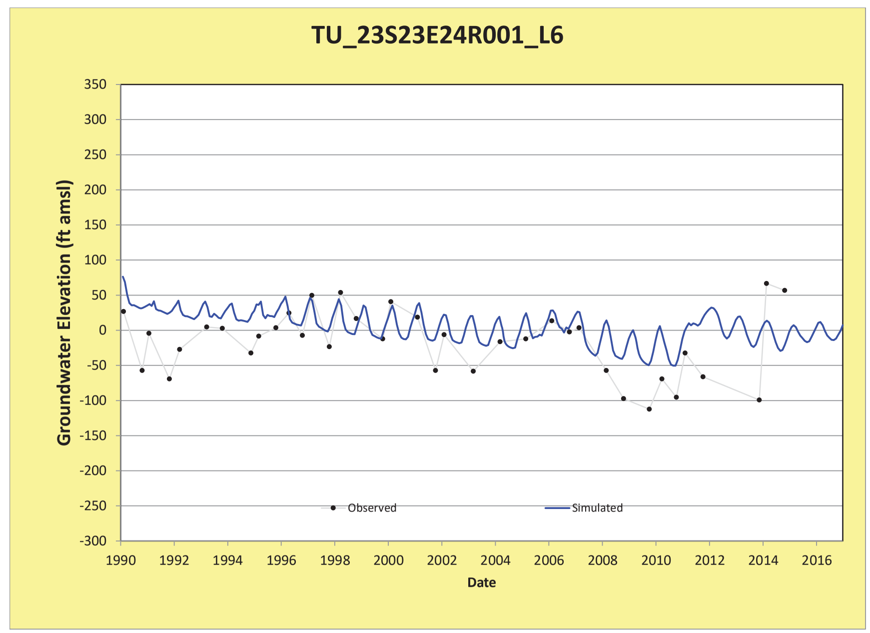

TU_22S24E20A002_L6
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated

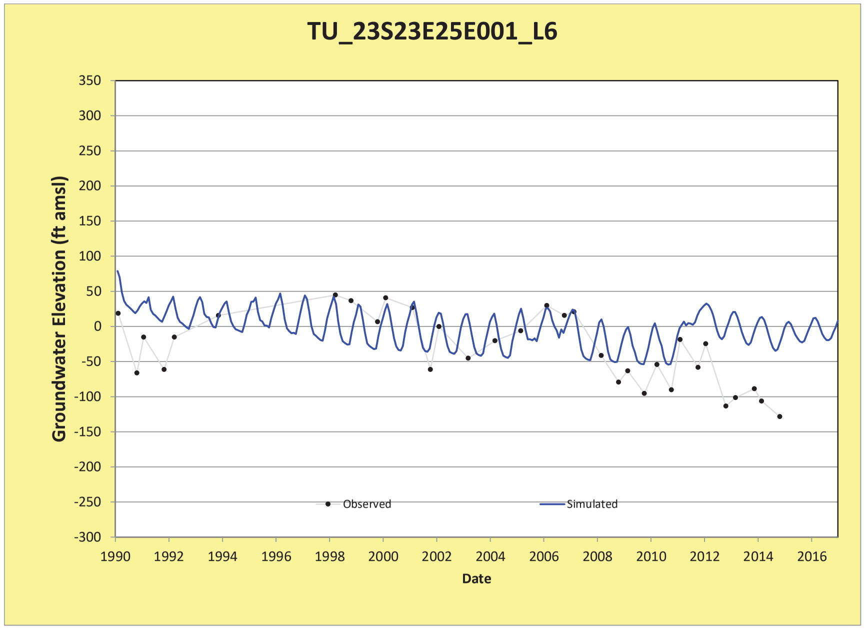

TU_23S23E03C005_L5
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated

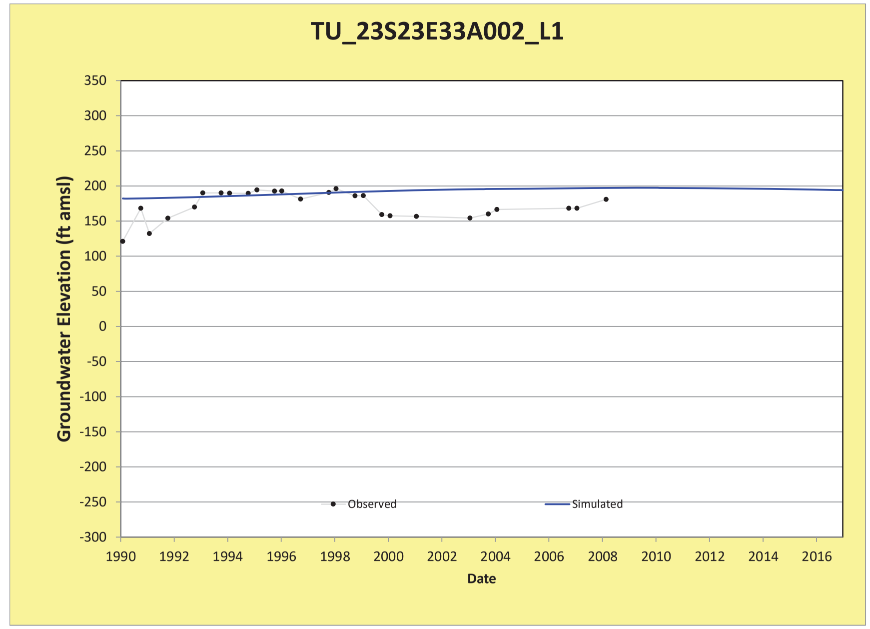

TU_23S23E24J001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

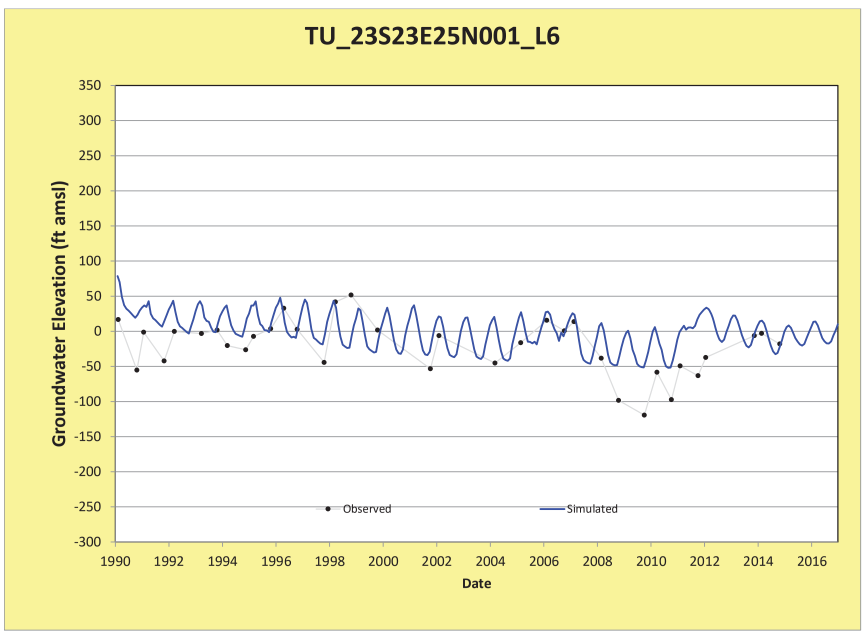

TU_23S23E24M001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

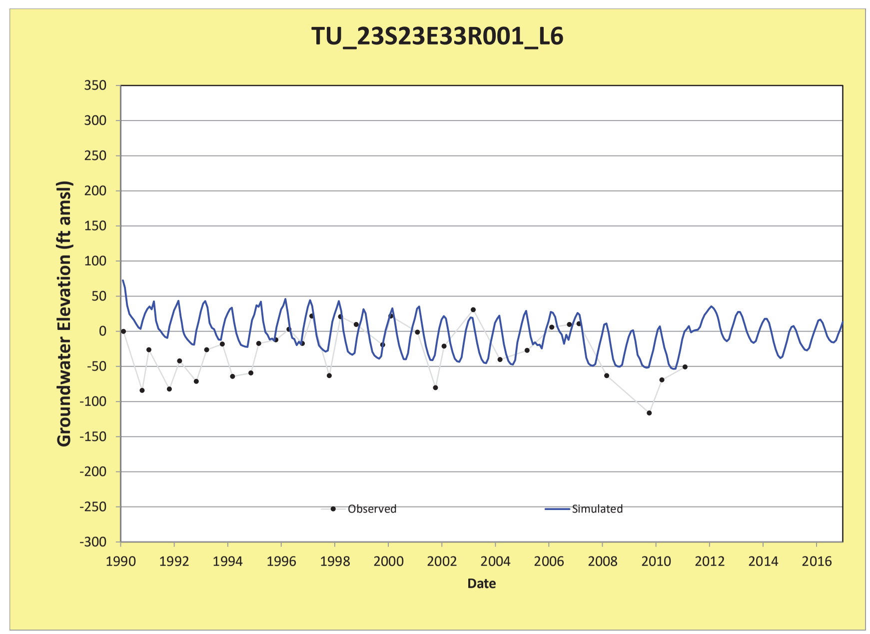

TU_23S23E24K001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

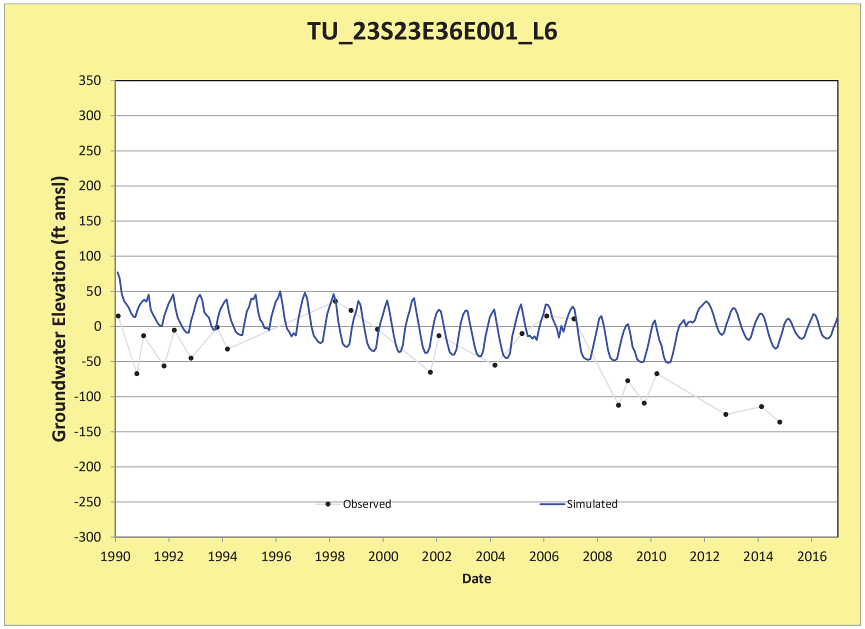

TU_23S23E24R001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

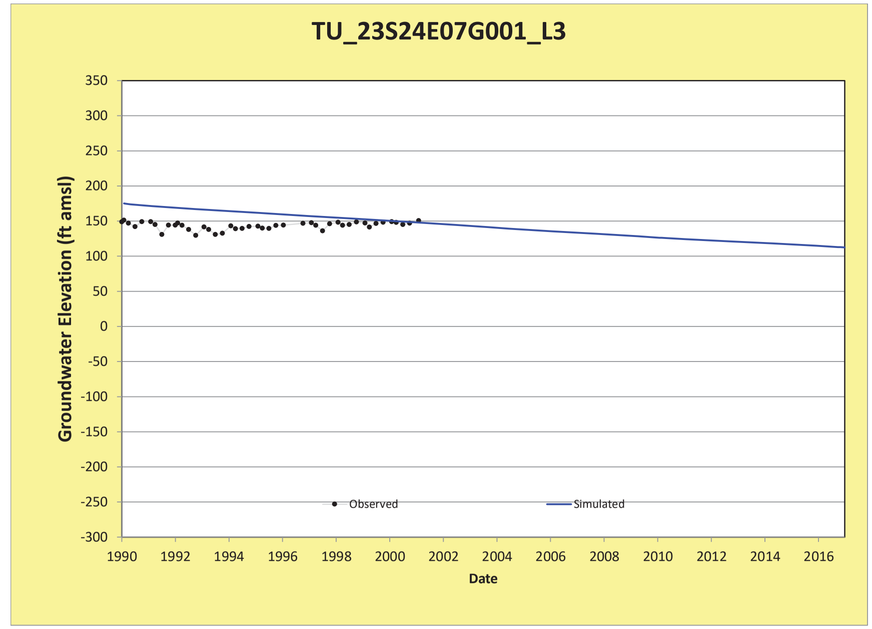

TU_23S23E25E001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

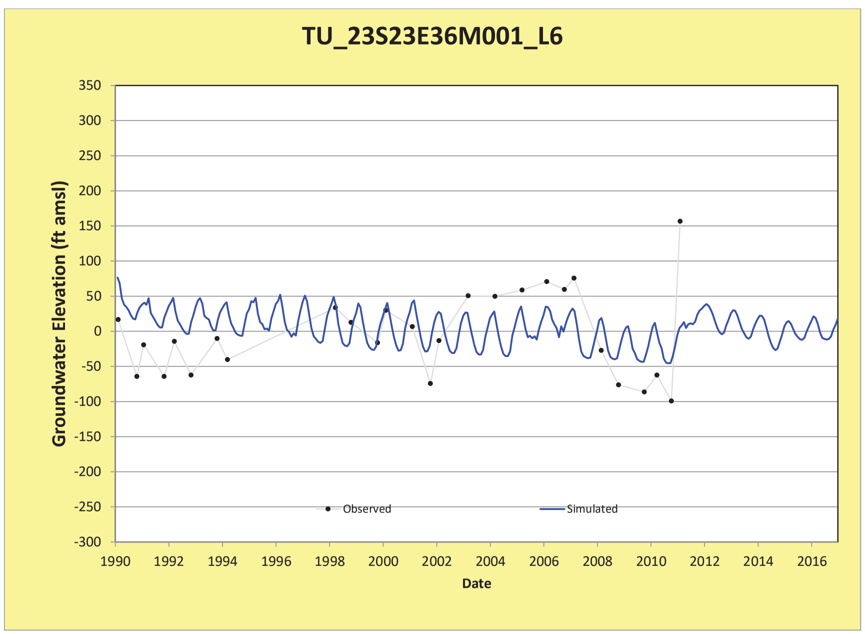

TU_23S23E33A002_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

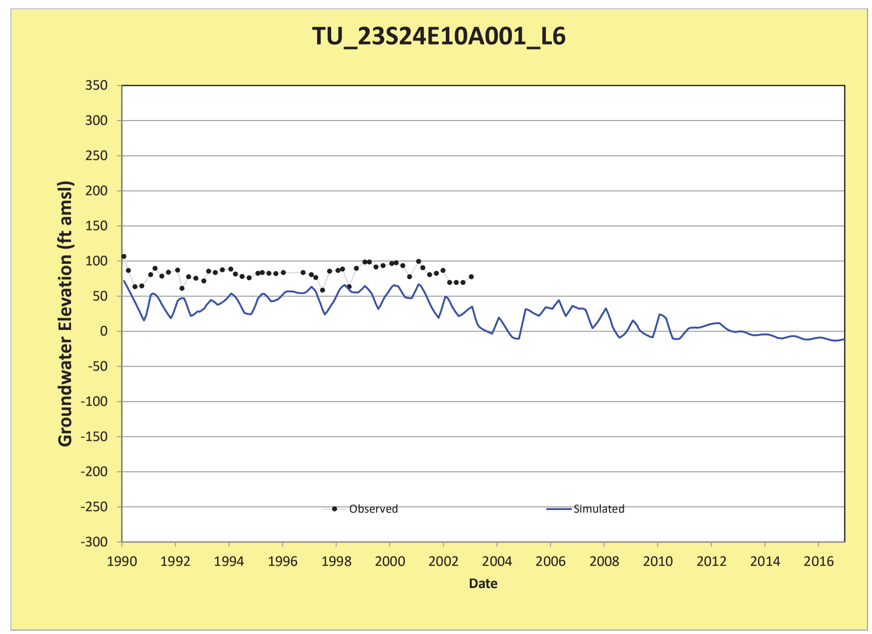

TU_23S23E25N001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

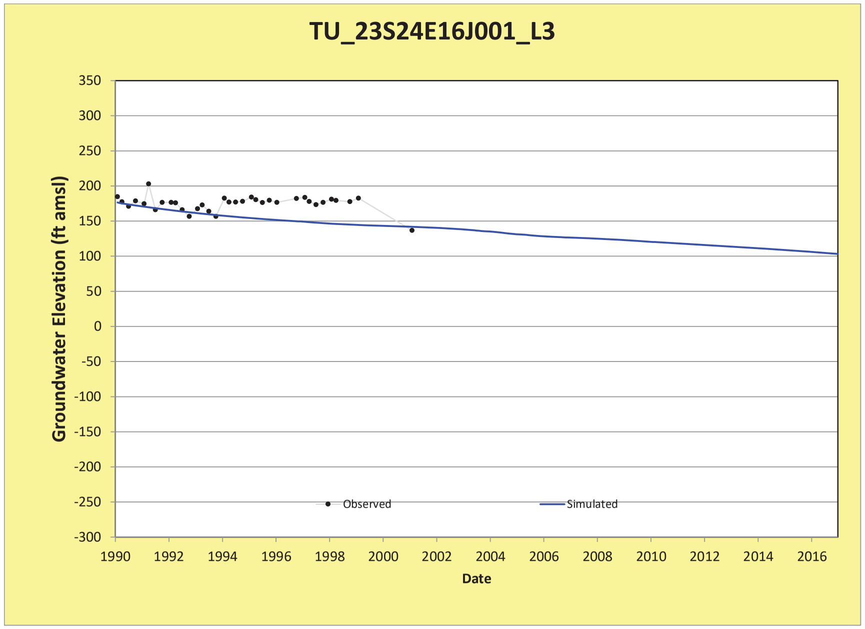

TU_23S23E33R001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

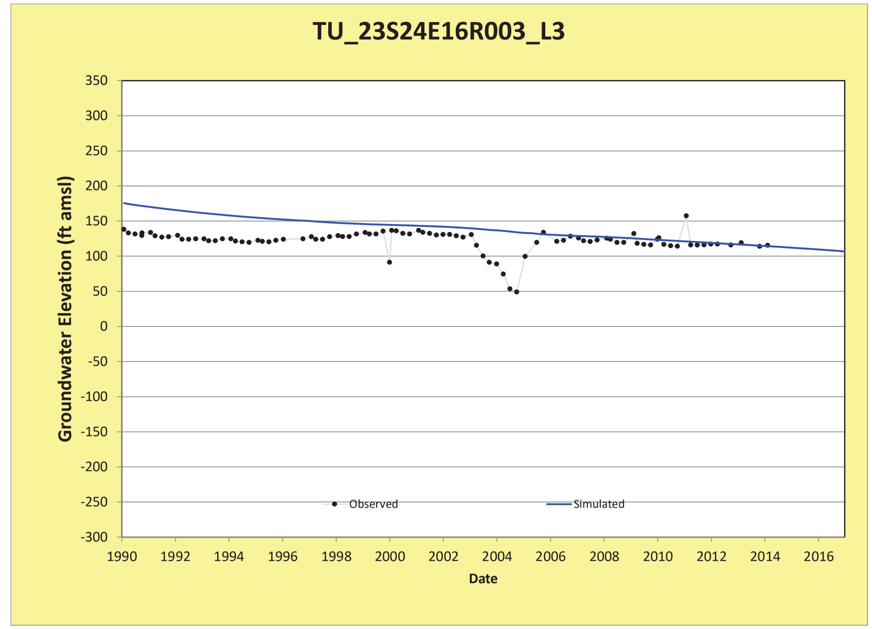

TU_23S23E36E001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

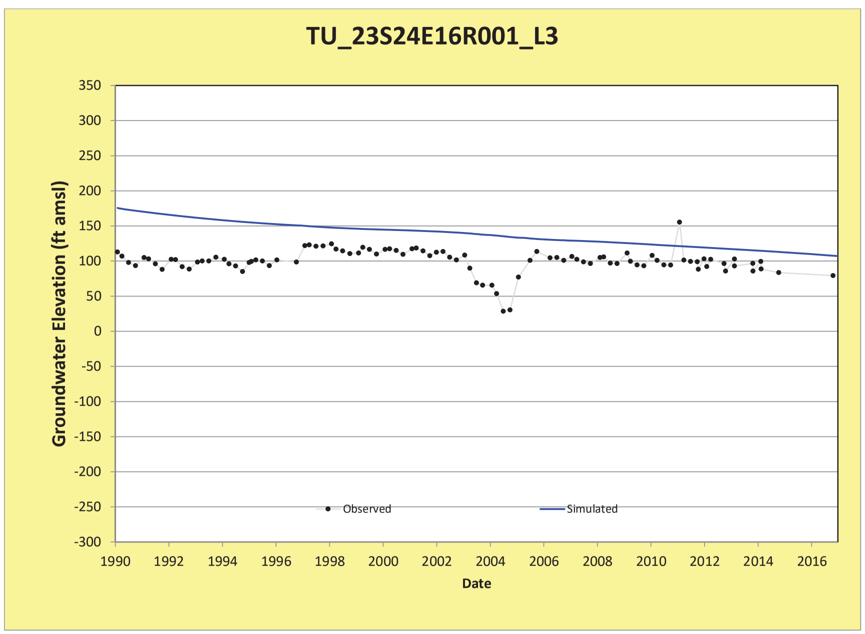

TU_23S24E07G001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

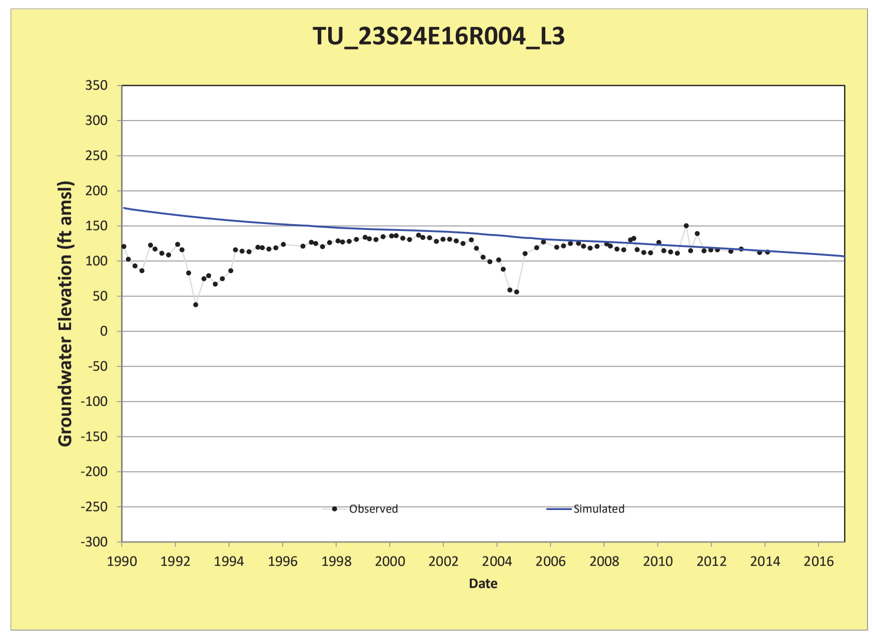

TU_23S23E36M001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

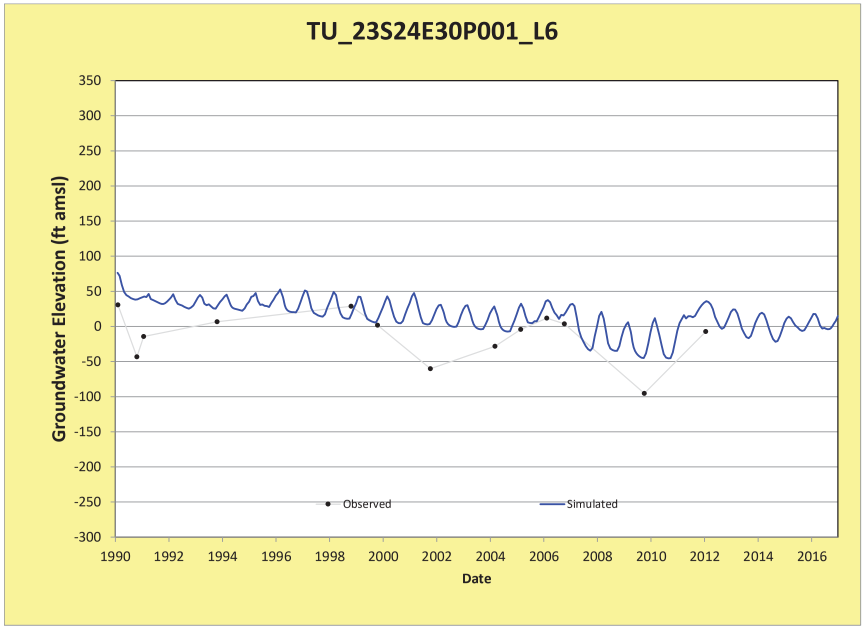

TU_23S24E10A001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

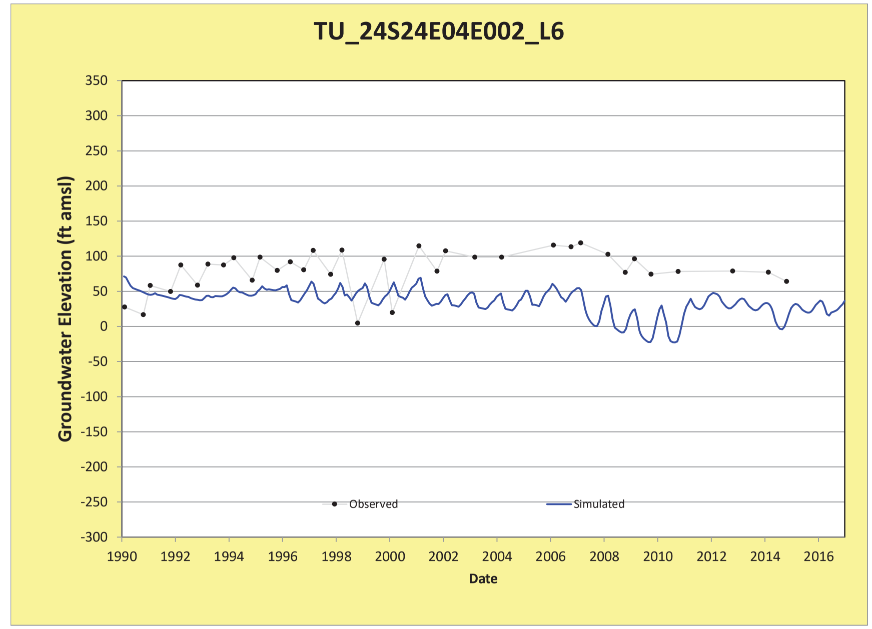

TU_23S24E16J001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

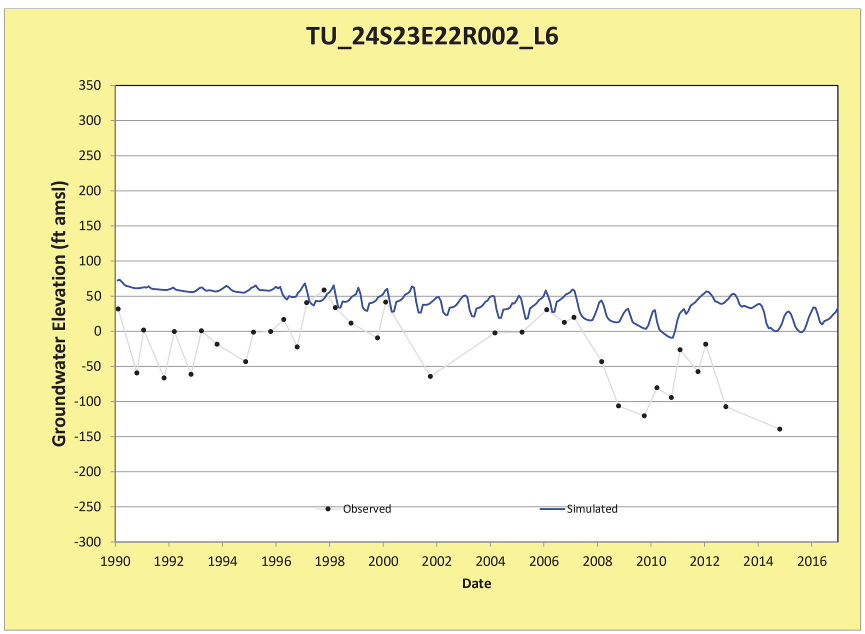

TU_23S24E16R003_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

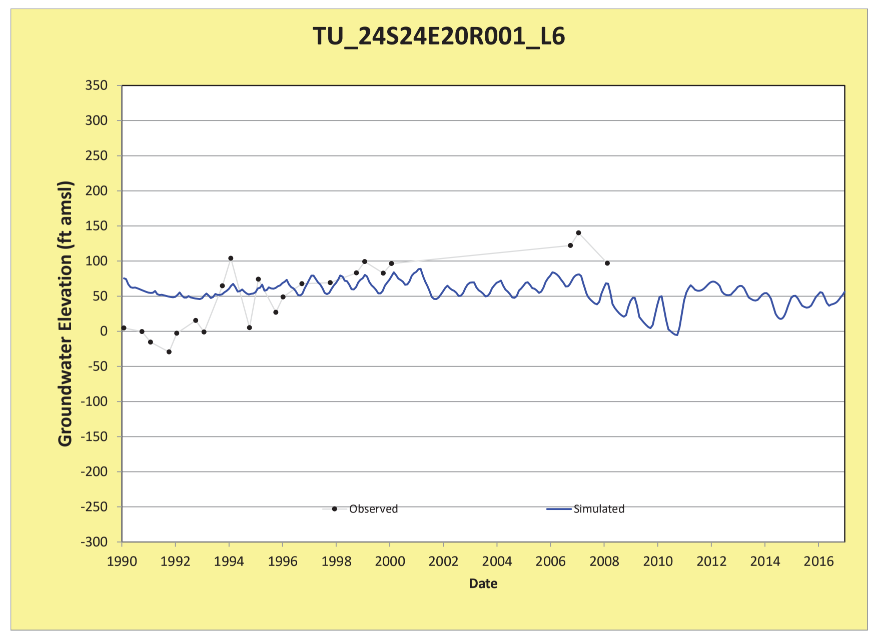

TU_23S24E16R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

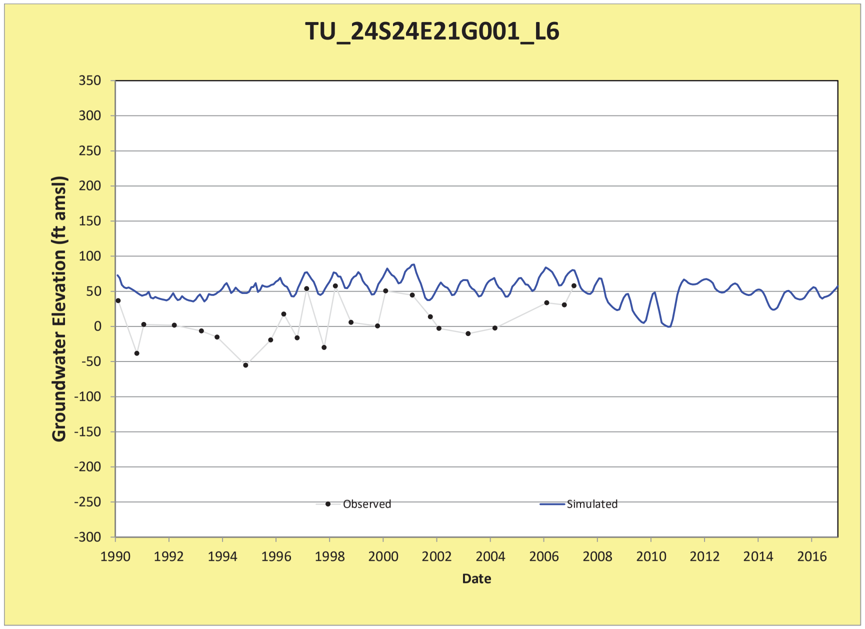

TU_23S24E16R004_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

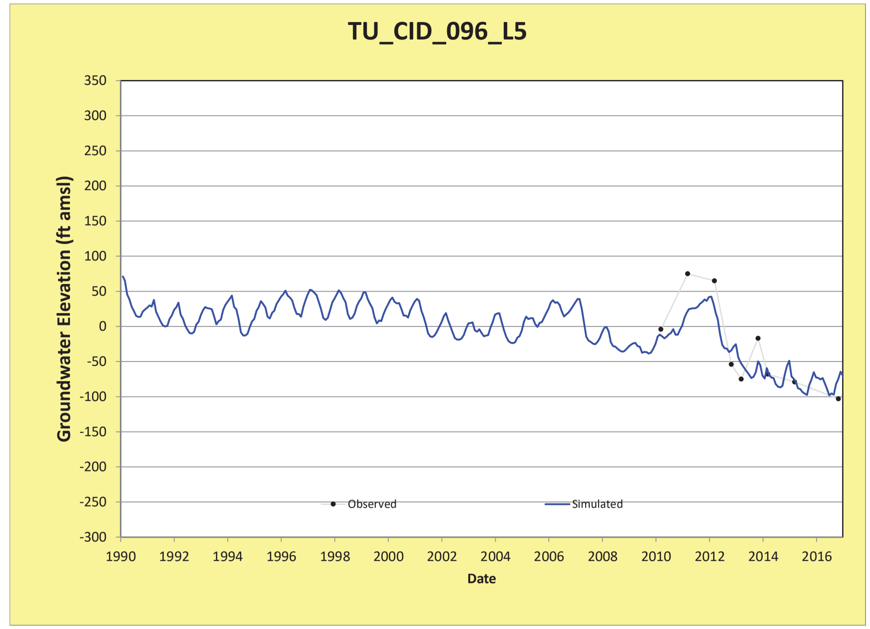

TU_23S24E30P001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

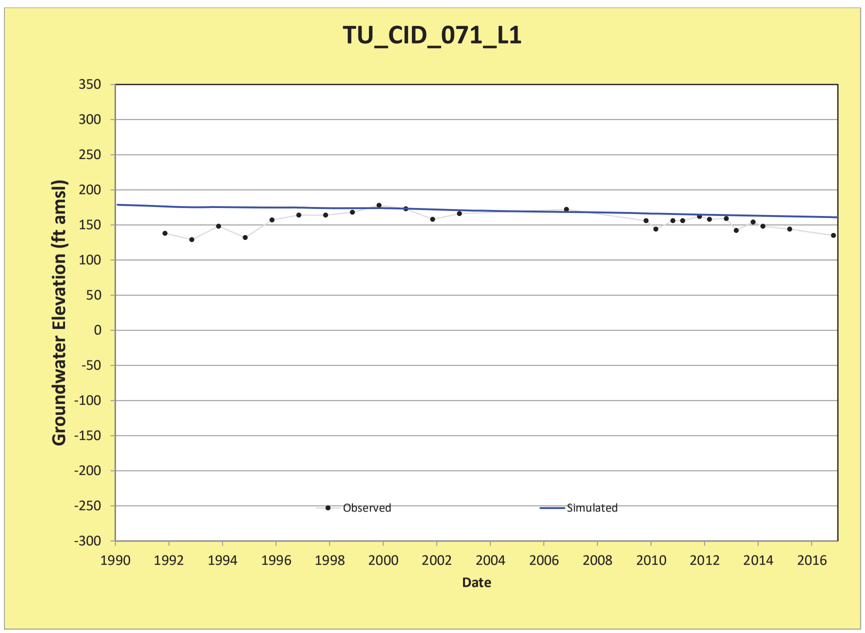

TU_24S24E04E002_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

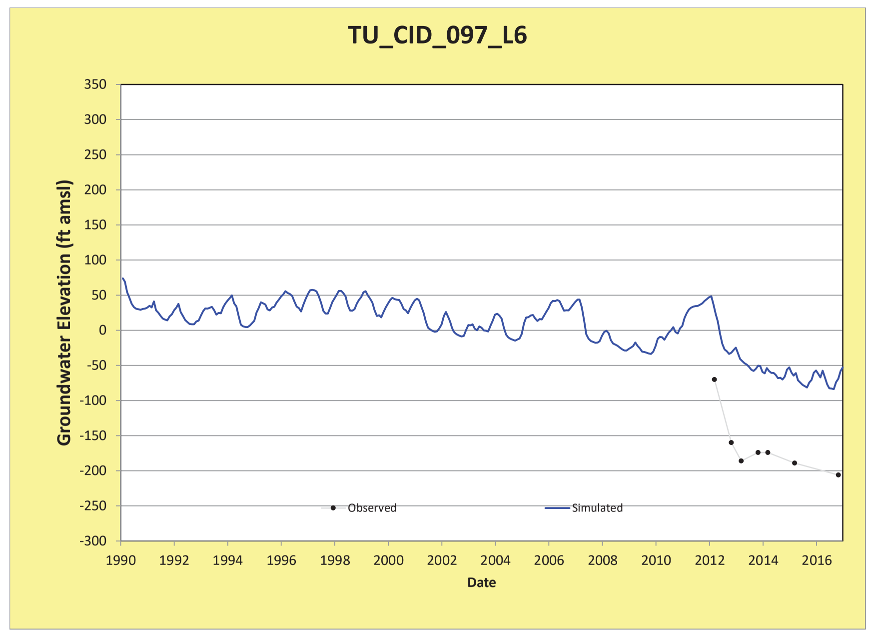

TU_24S23E22R002_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

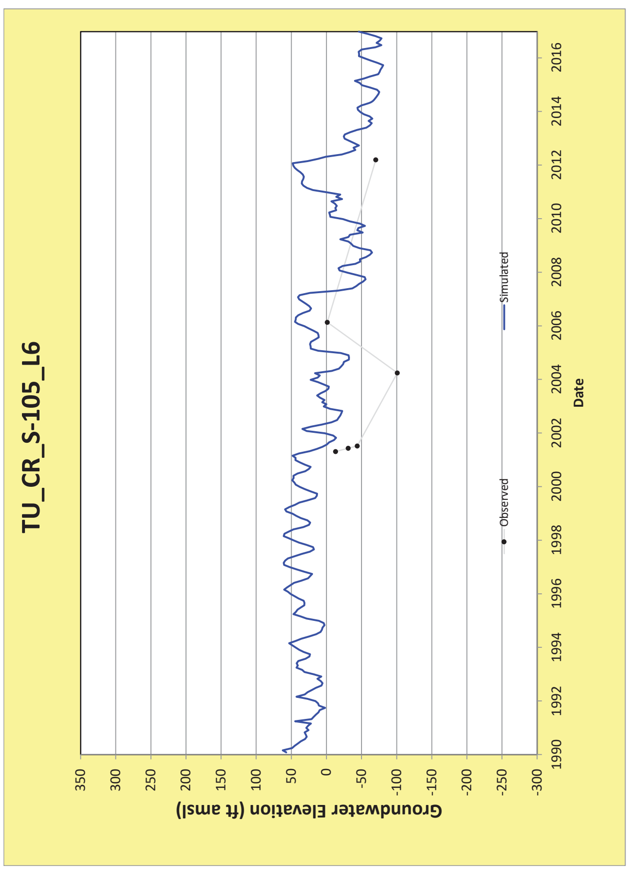

TU_24S24E20R001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

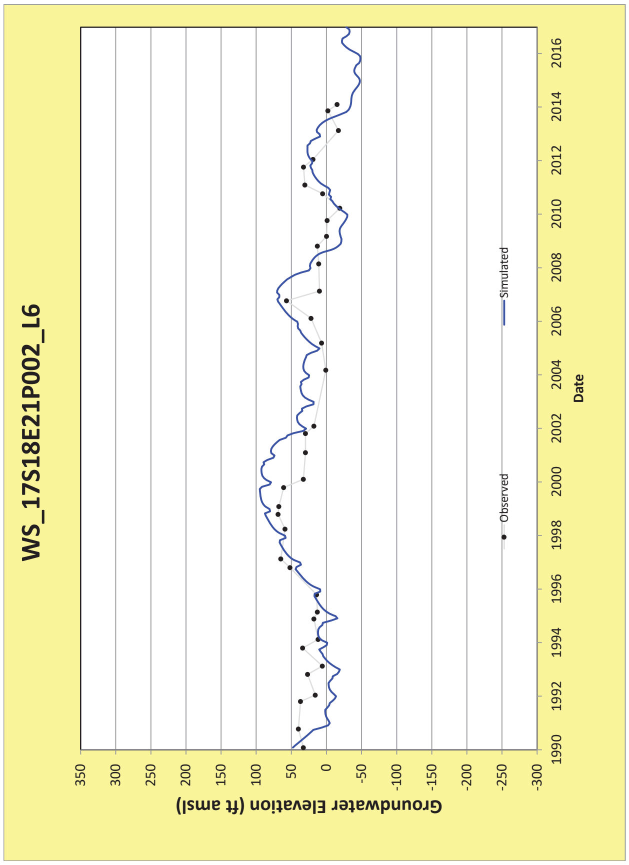

TU_24S24E21G001_L6
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated

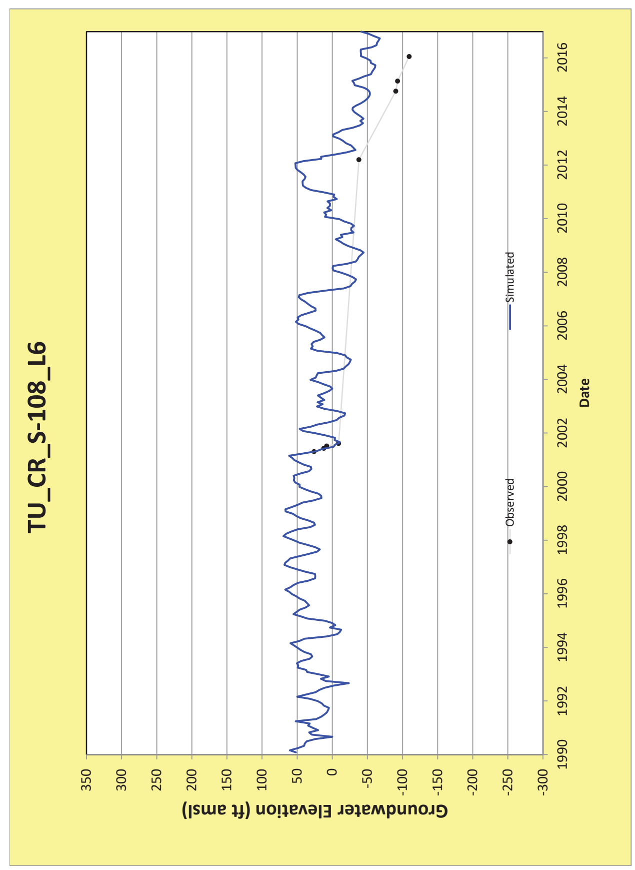

TU_CID_096_L5
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated

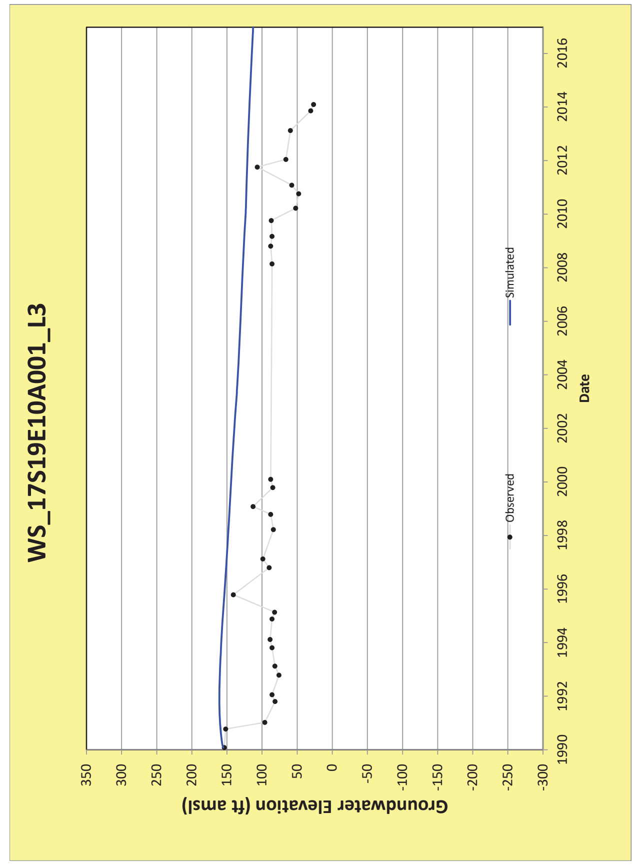

TU_CID_071_L1
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated

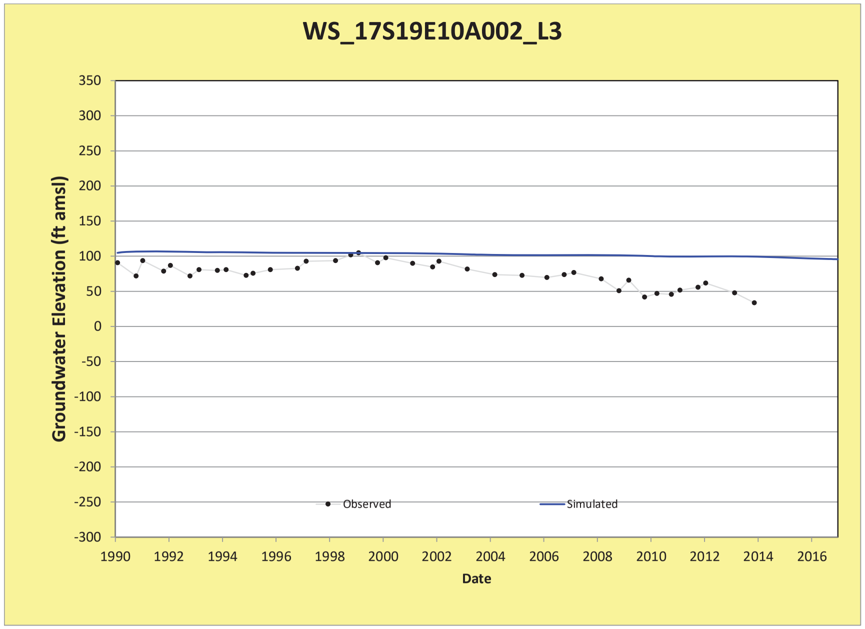

TU_CID_097_L6
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated

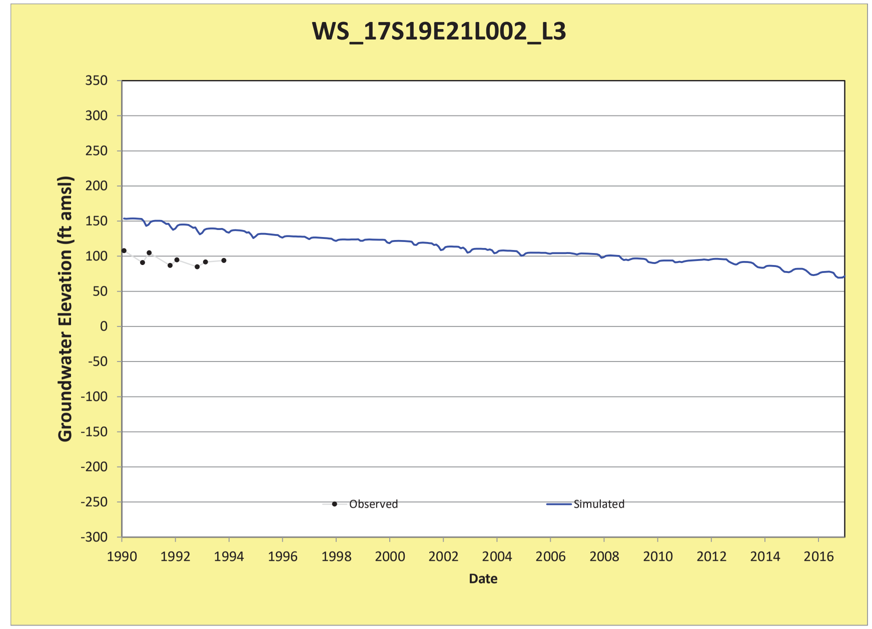

TU_CR_S-105_L6
Groundwater Elevation (ft amsl)
350 300 250 200 150 100 50 0 -50 -100 -150 -200 -250 -300
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Date
Observed
Simulated

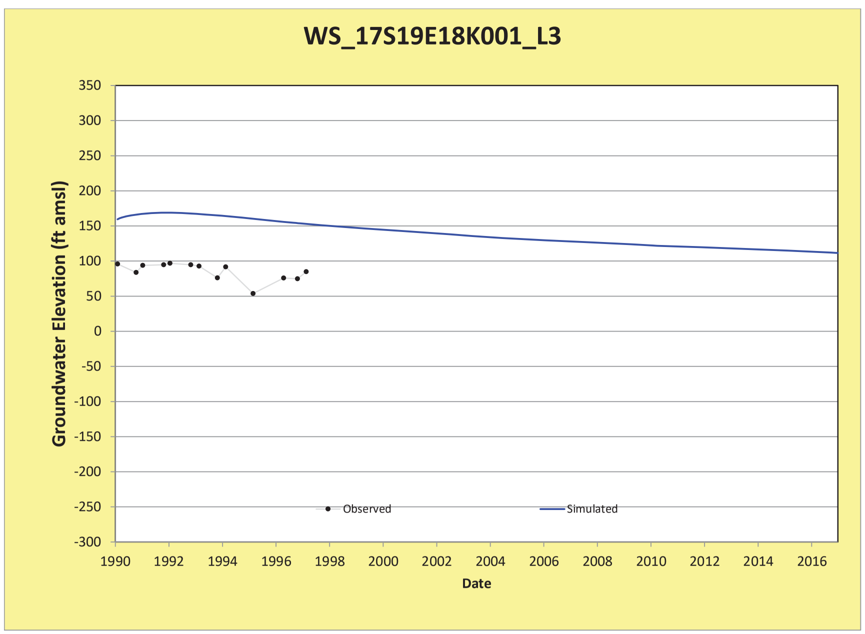

WS_17S18E21P002_L6
Groundwater Elevation (ft amsl)
350 300 250 200 150 100 50 0 -50 -100 -150 -200 -250 -300
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Date
Observed
Simulated

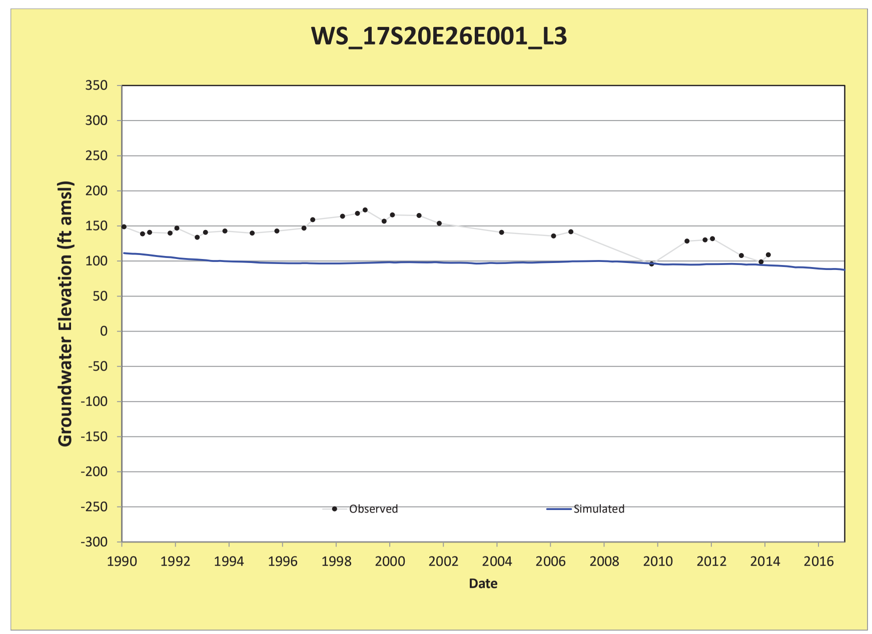

TU_CR_S-108_L6
Groundwater Elevation (ft amsl)
350 300 250 200 150 100 50 0 -50 -100 -150 -200 -250 -300
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Date
Observed
Simulated

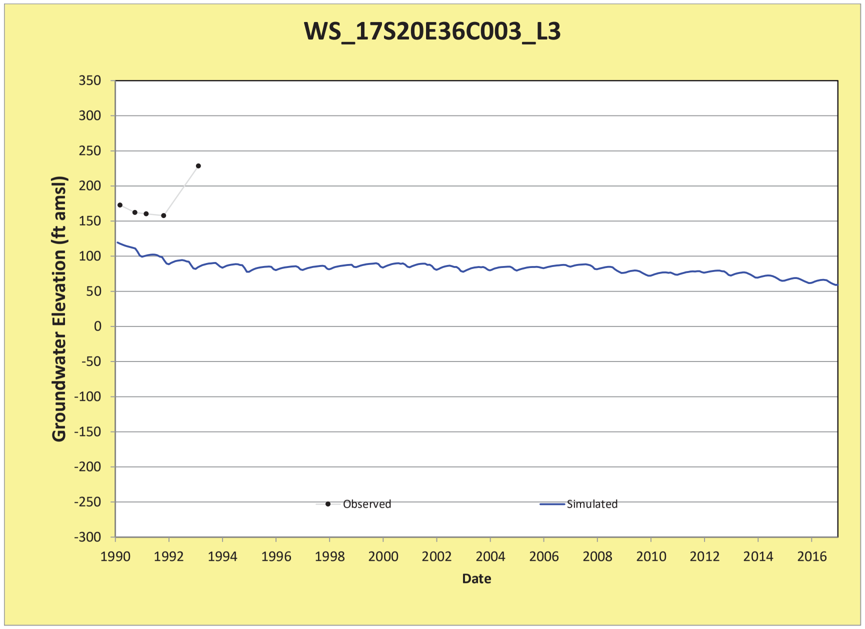

WS_17S19E10A001_L3
Groundwater Elevation (ft amsl)
350 300 250 200 150 100 50 0 -50 -100 -150 -200 -250 -300
1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012 2014 2016
Date
Observed
Simulated


WS_17S19E10A002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_17S19E21L002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_17S19E18K001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_17S20E26E001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_17S20E36C003_L3
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
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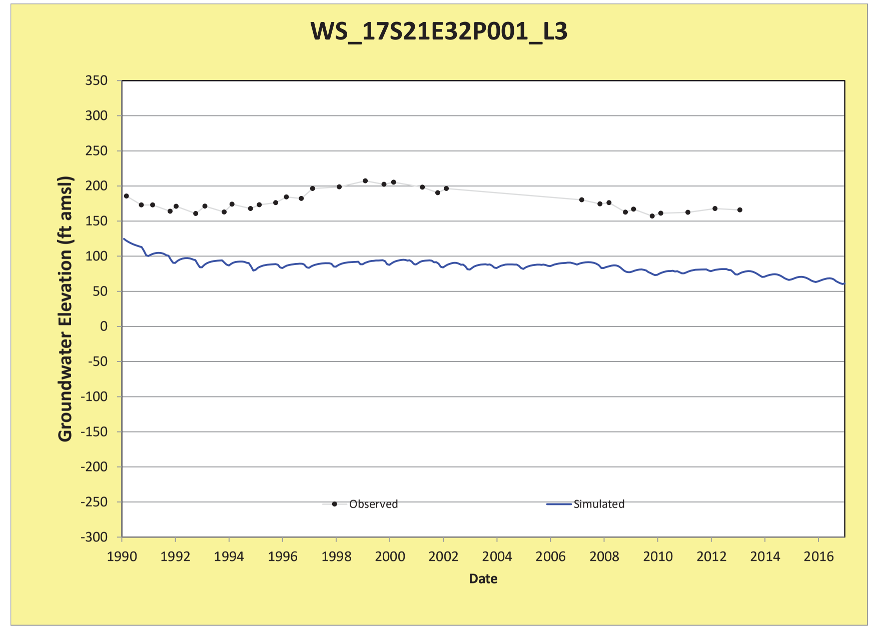
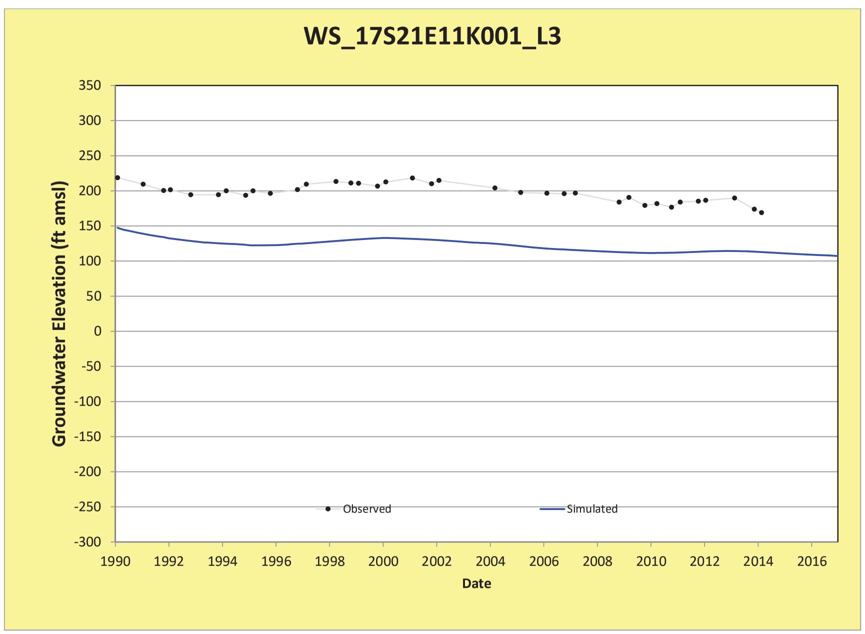
2010
2012
2014
2016
Date
Observed
Simulated


WS_17S21E32P001_L3
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated


WS_17S21E11K001_L3
Groundwater Elevation (ft amsl)
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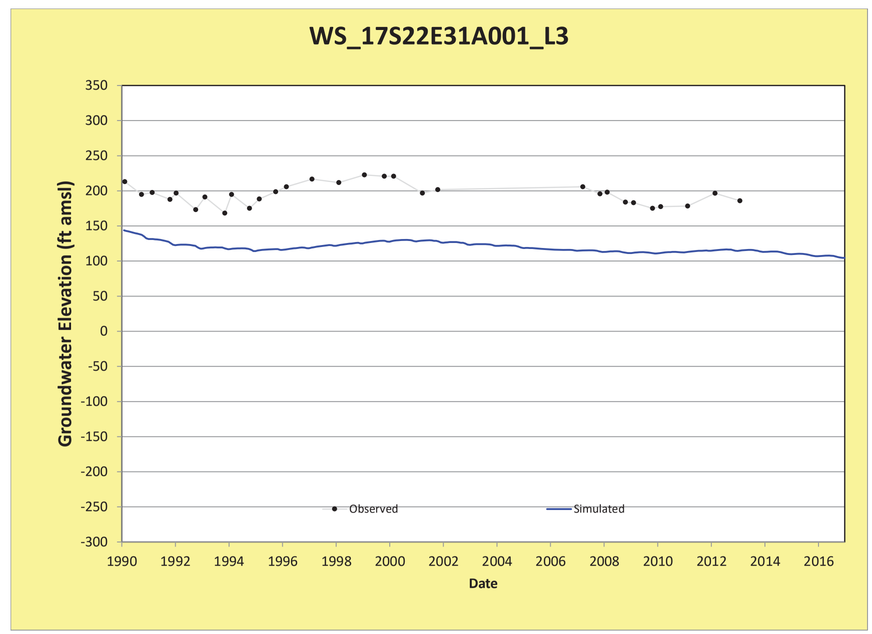
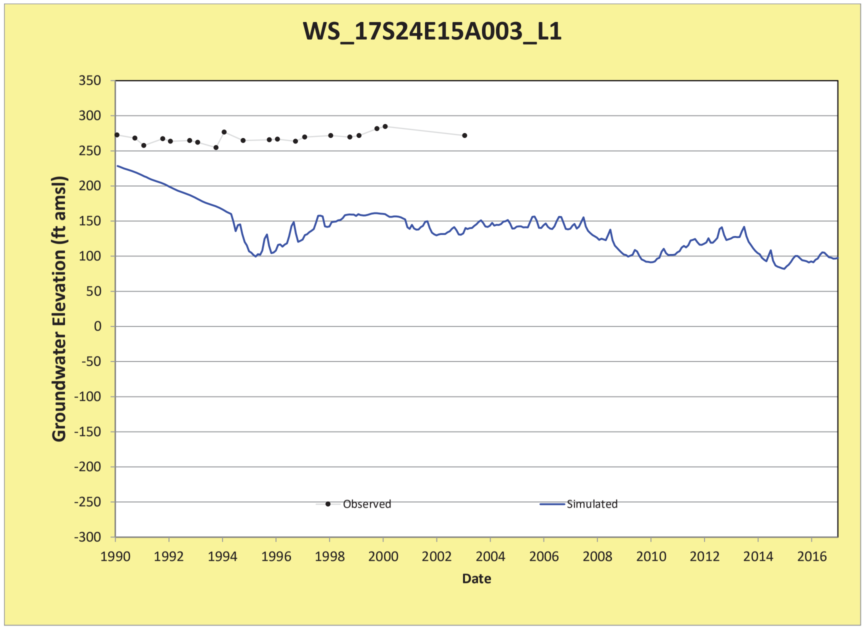
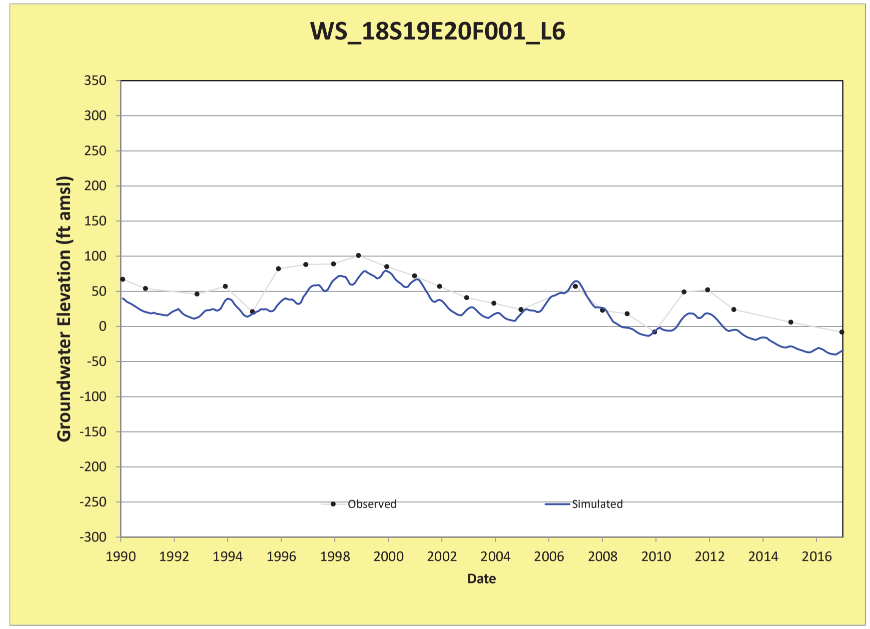
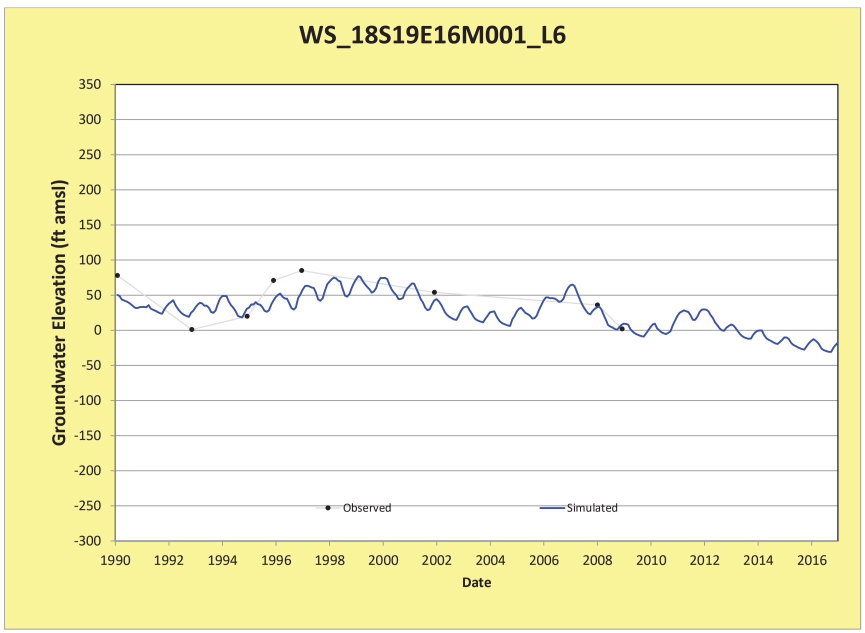
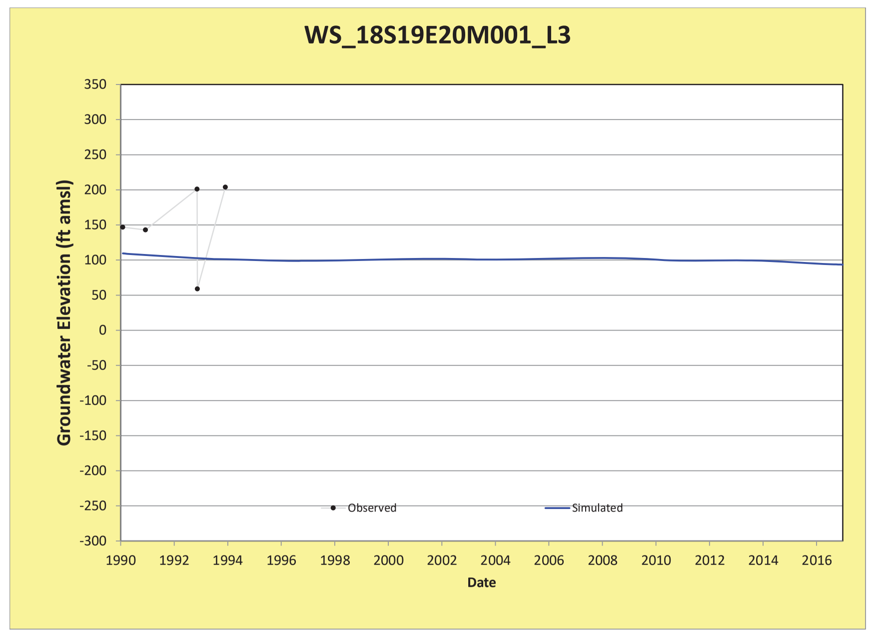
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated

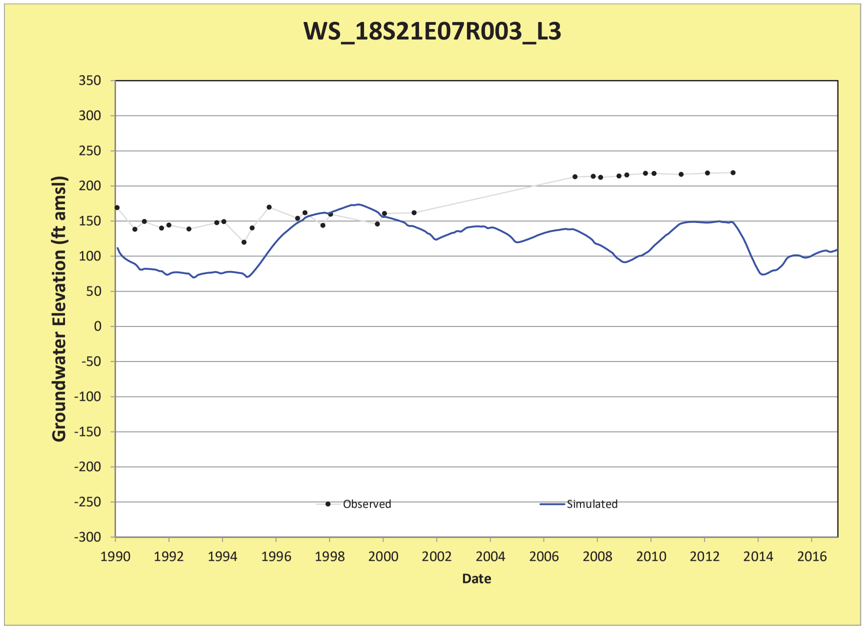

WS_17S22E31A001_L3
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Date
Observed
Simulated

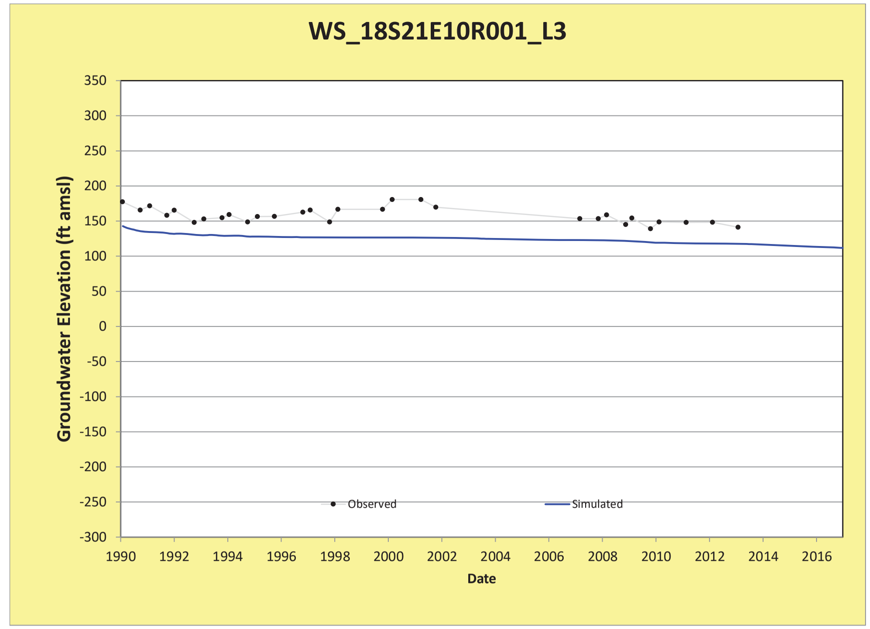

WS_17S24E15A003_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

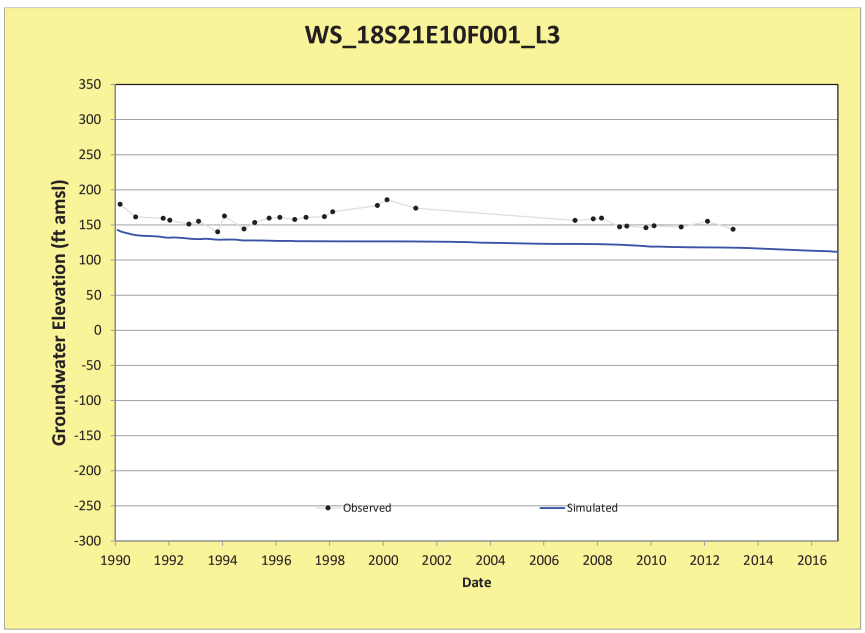

WS_18S19E20F001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

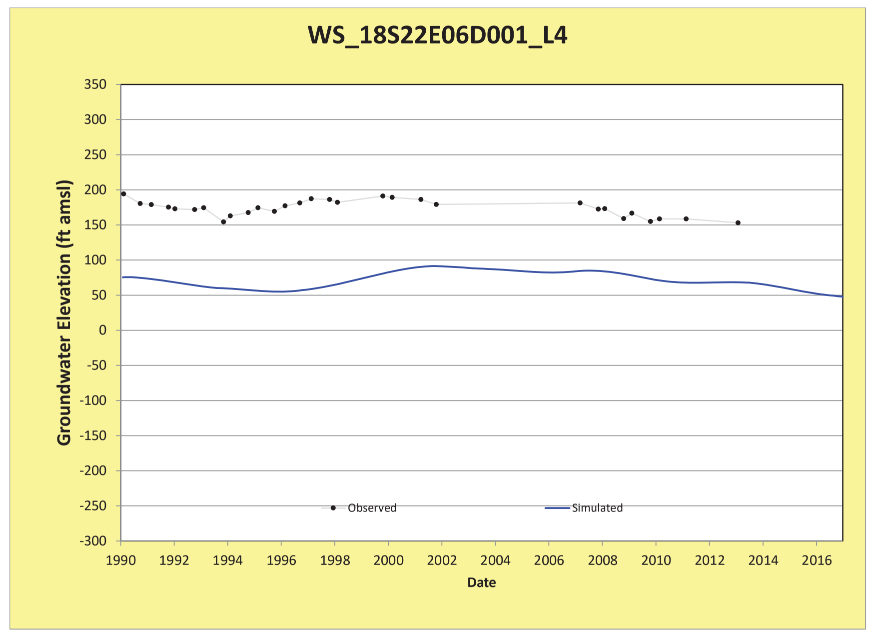

WS_18S19E16M001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

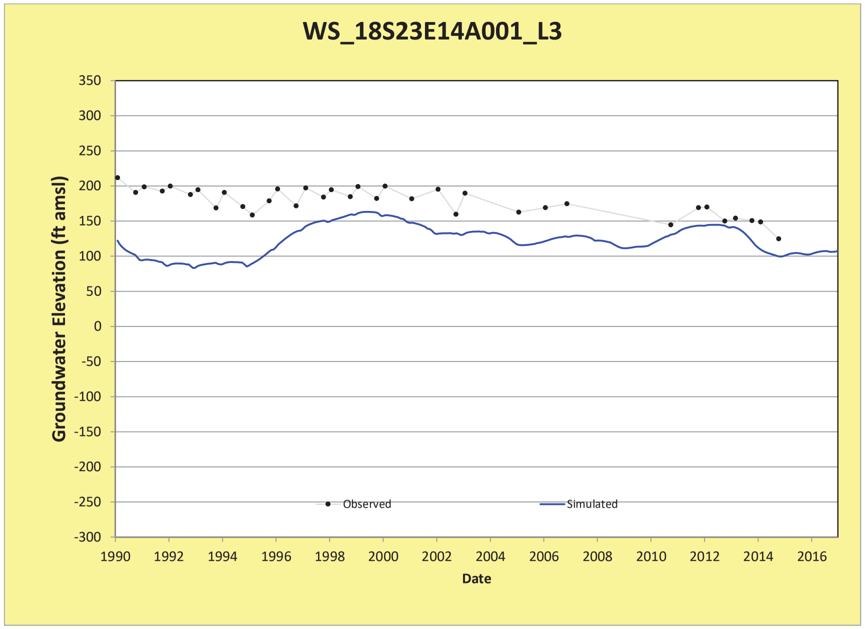

WS_18S19E20M001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

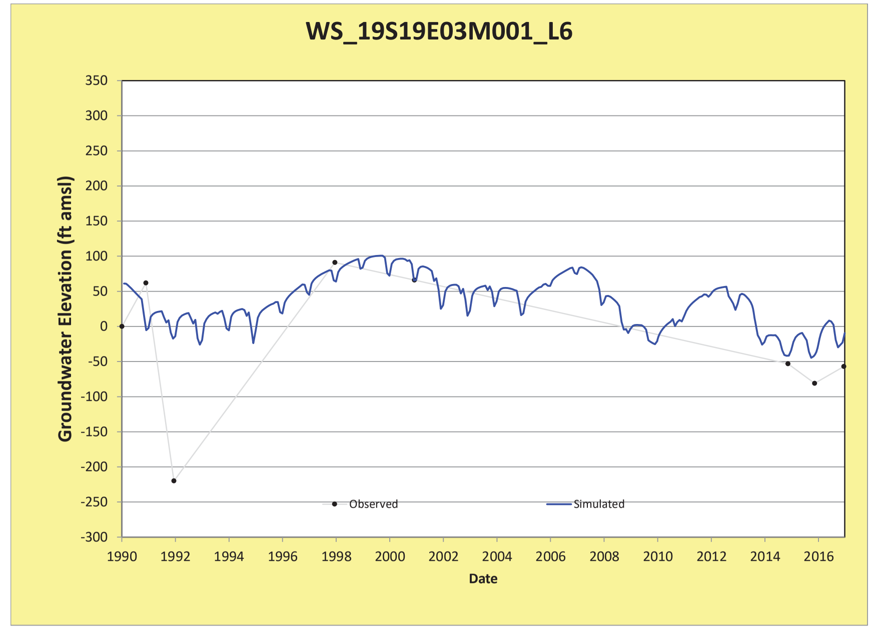

WS_18S21E07R003_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

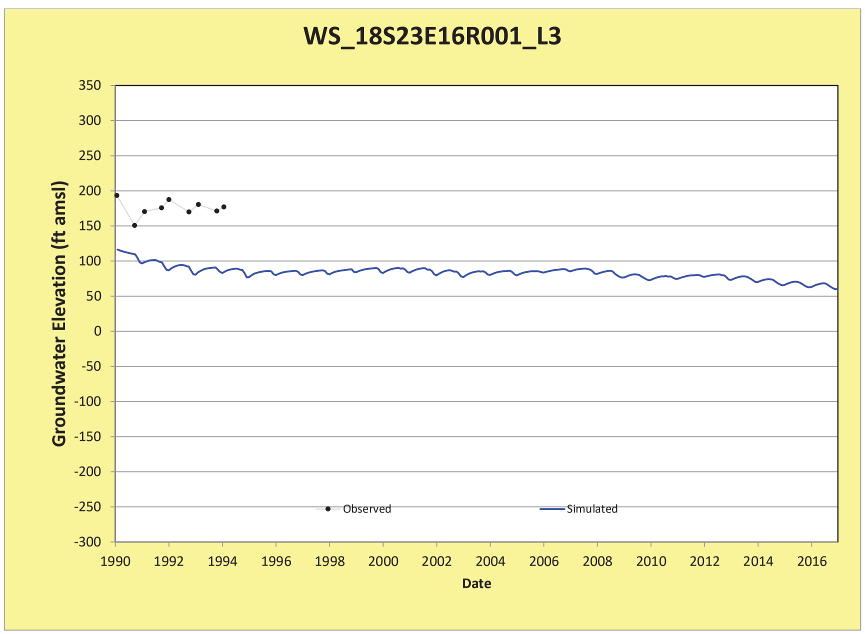

WS_18S21E10R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

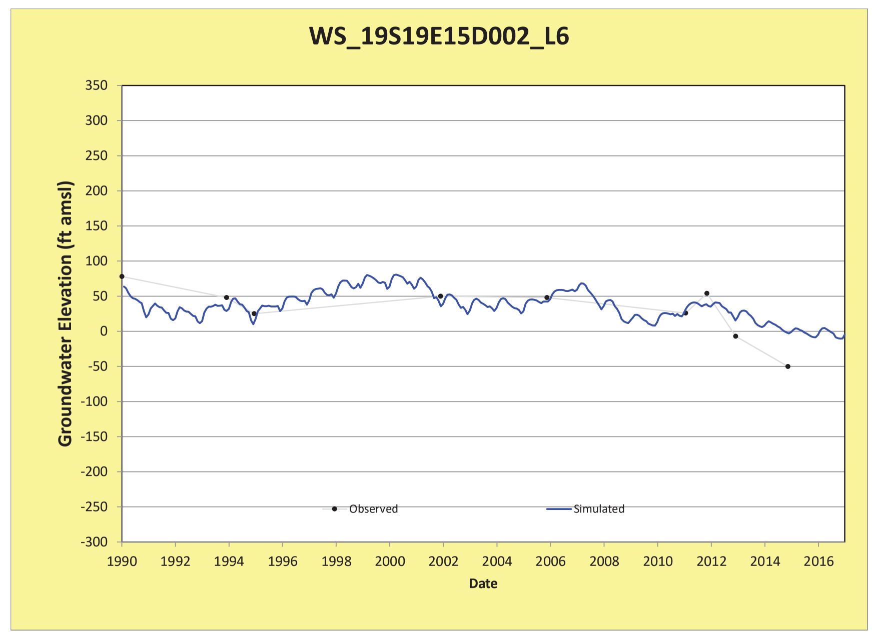

WS_18S21E10F001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated

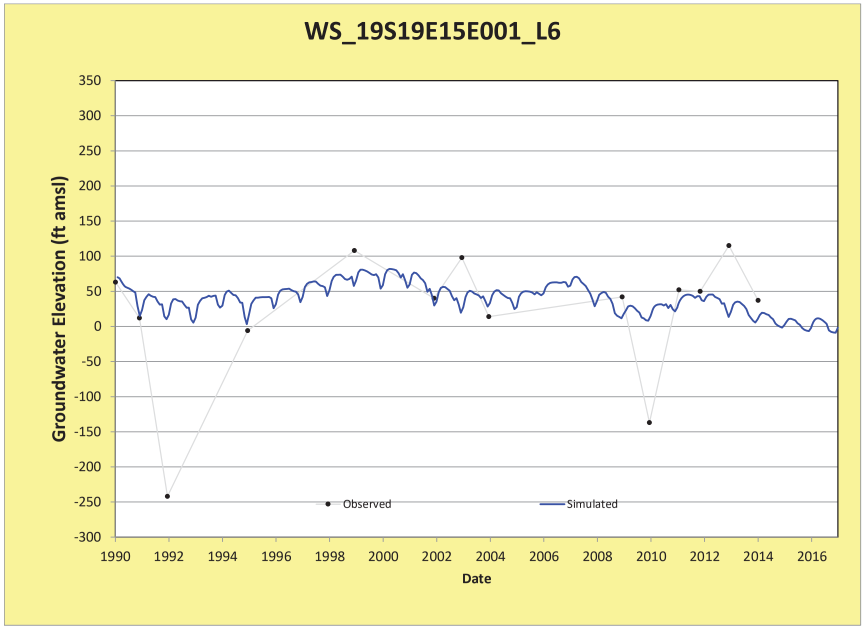

WS_18S22E06D001_L4
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_18S23E14A001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S19E03M001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_18S23E16R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S19E15D002_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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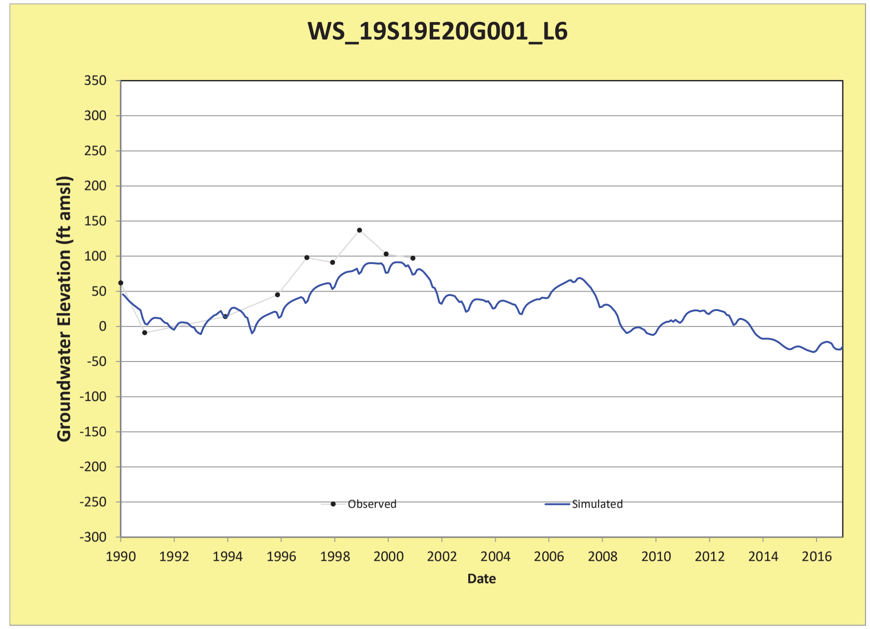
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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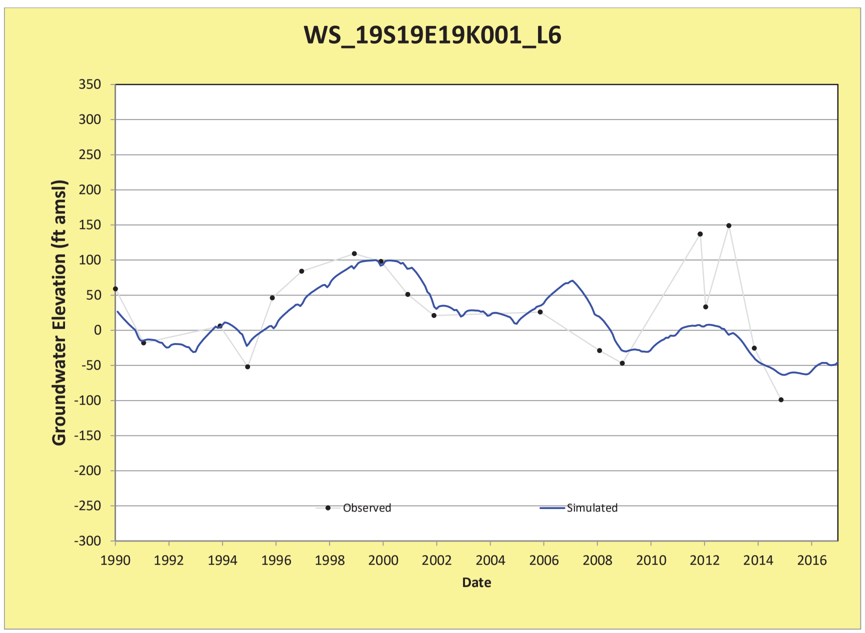
Observed
Simulated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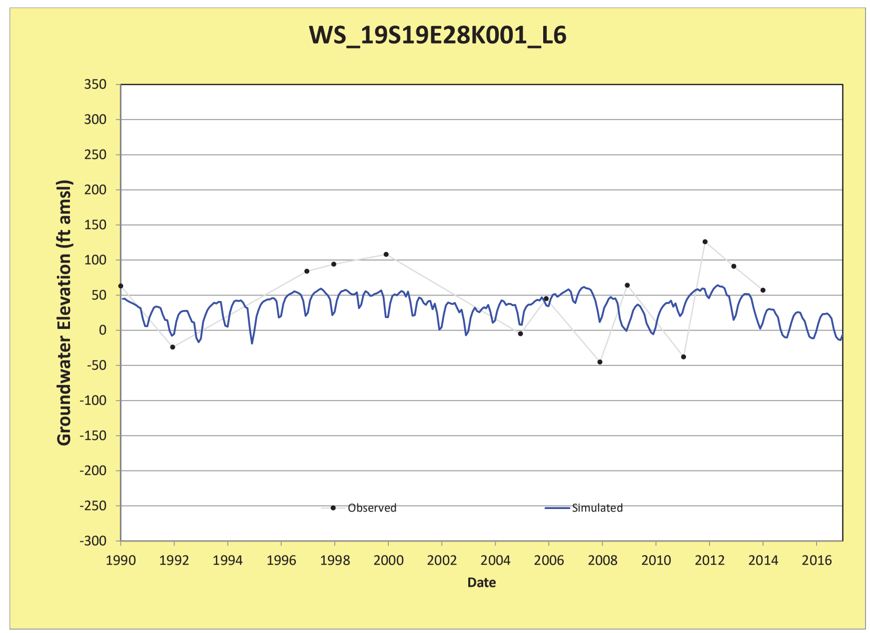
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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Groundwater Elevation (ft amsl)
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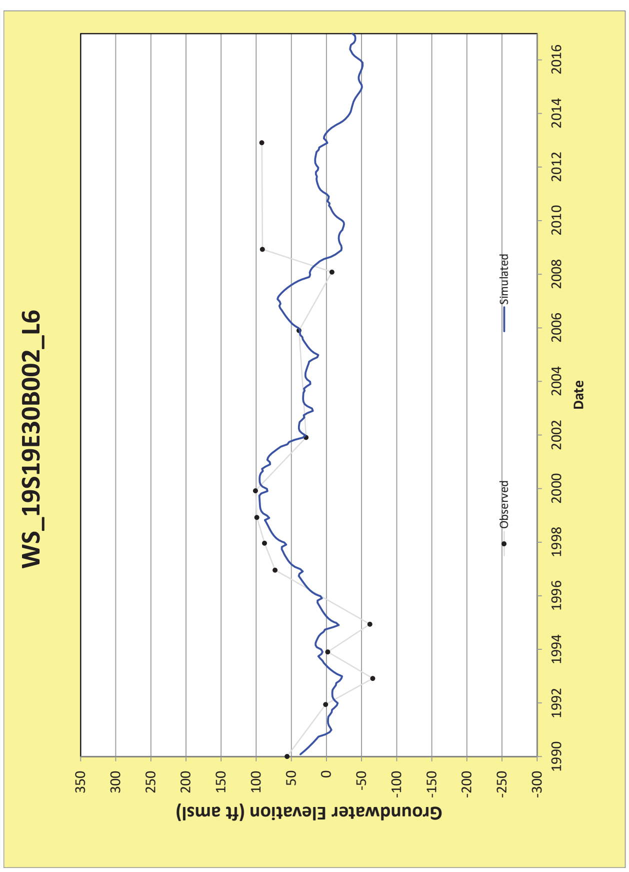
Observed
Simulated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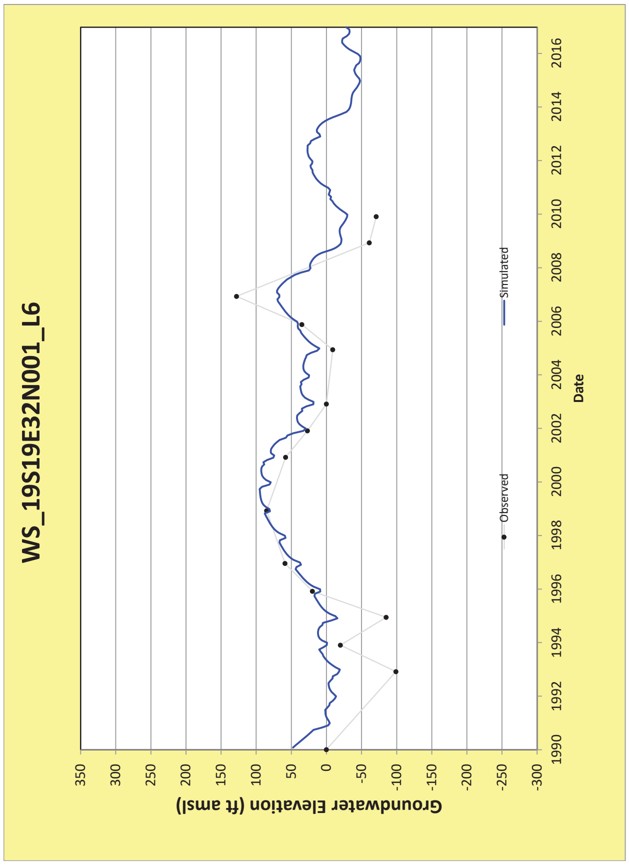
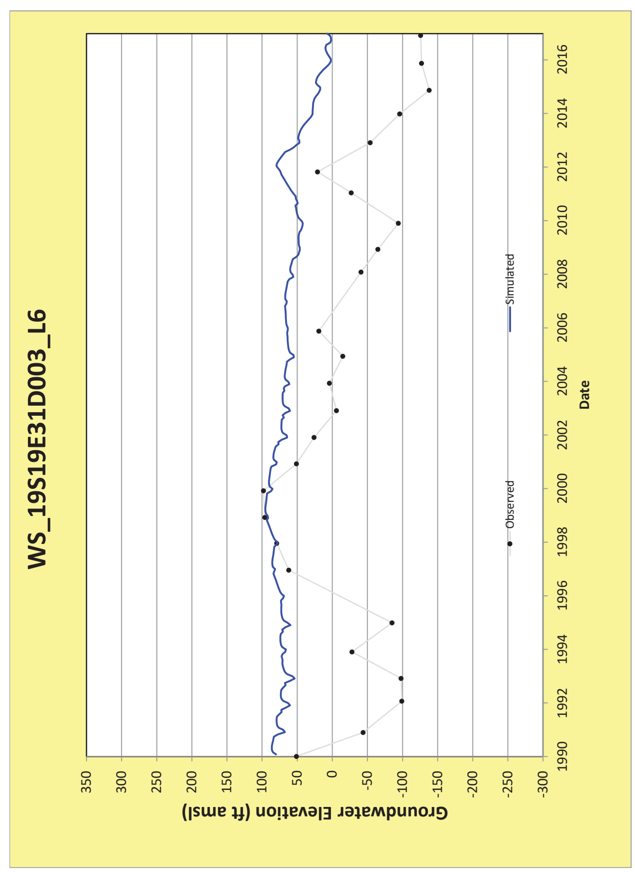
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S19E32N001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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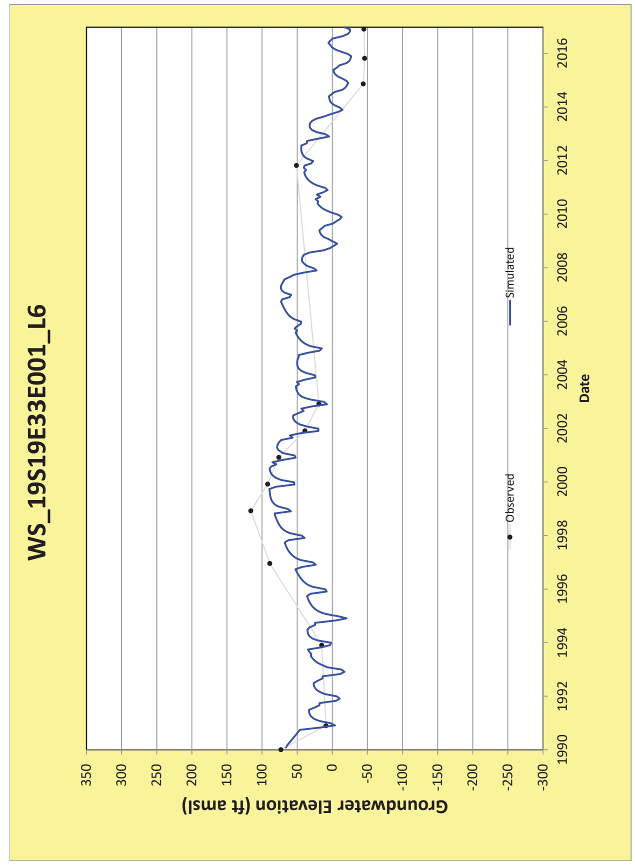
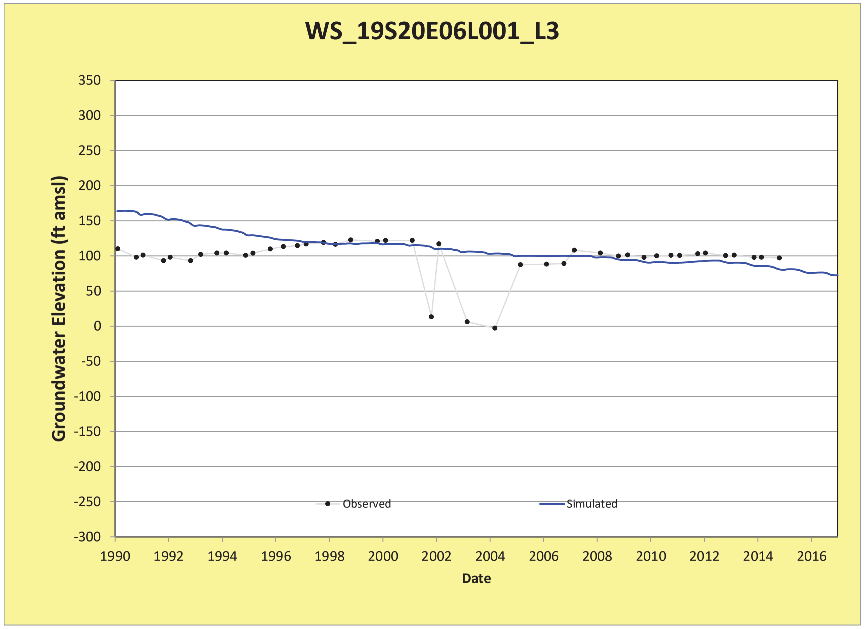
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S19E33E001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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Groundwater Elevation (ft amsl)
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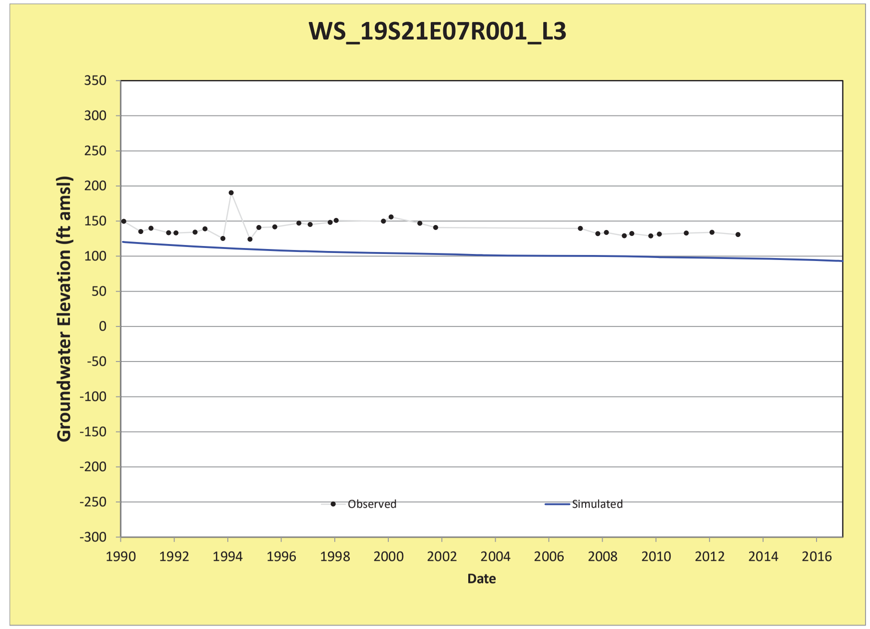
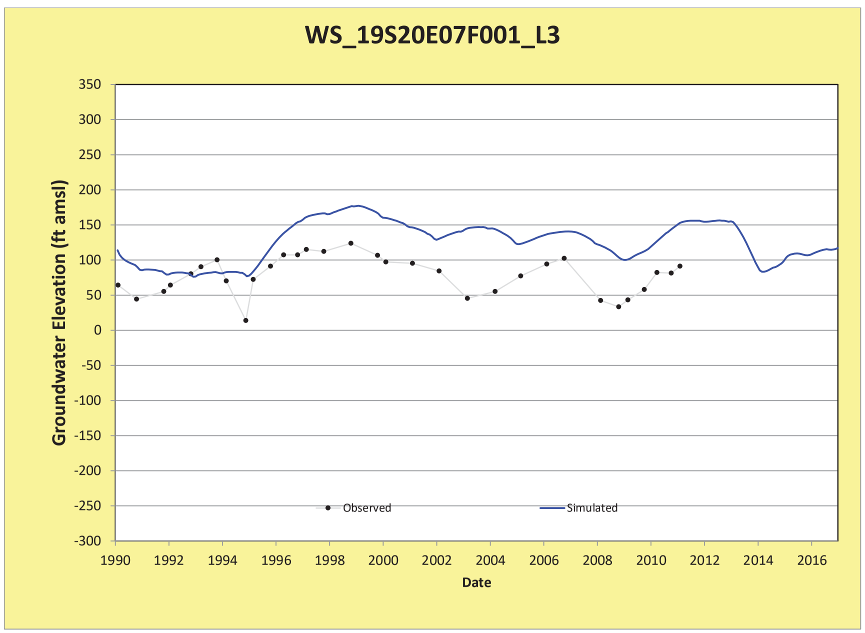
Observed
Simulated


WS_19S21E07R001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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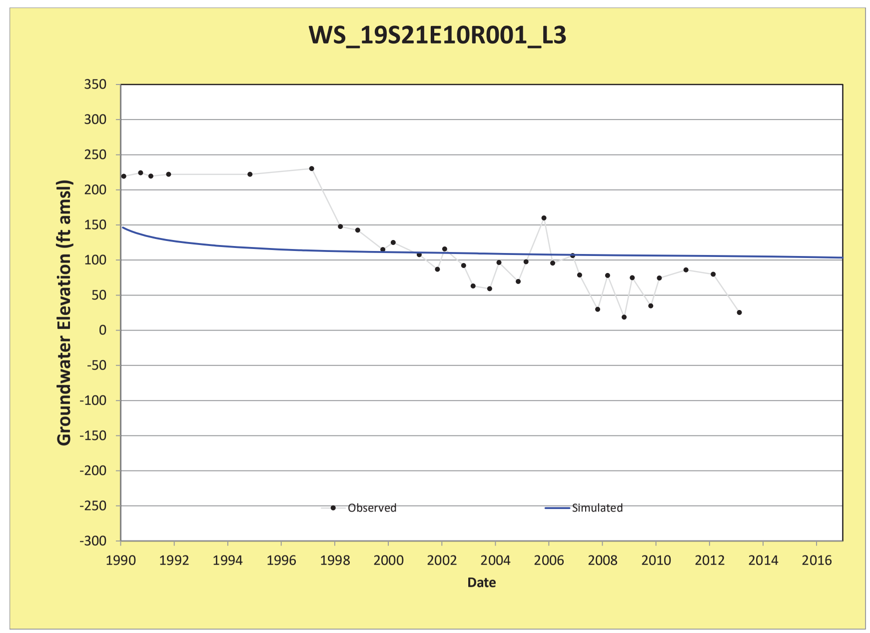
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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Observed
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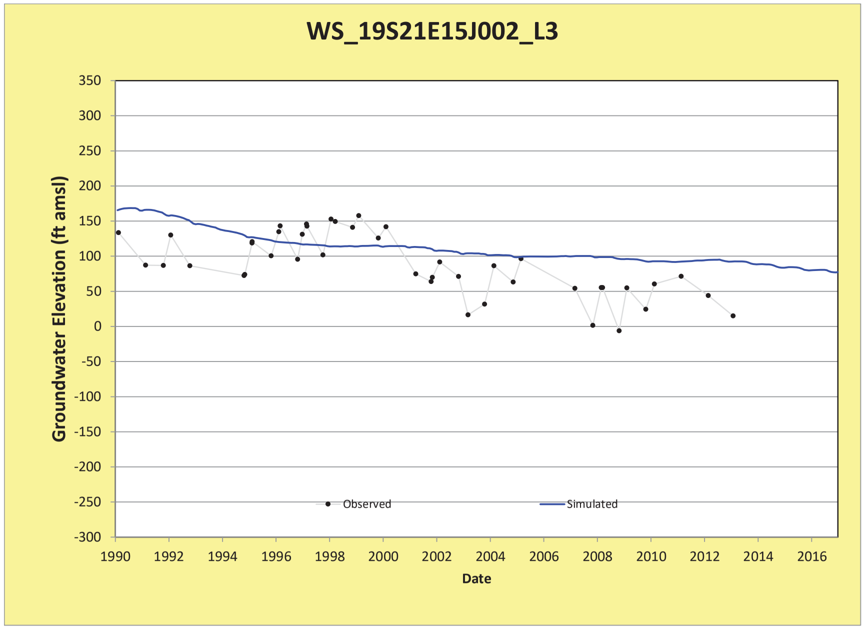
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Groundwater Elevation (ft amsl)
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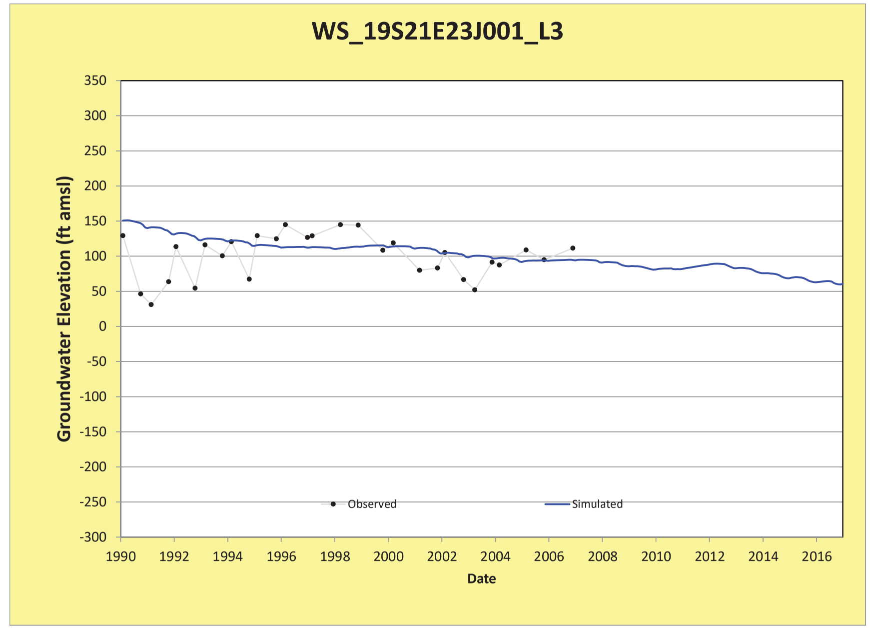
Date
Observed
Simulated


WS_19S21E23J001_L3
Groundwater Elevation (ft amsl)
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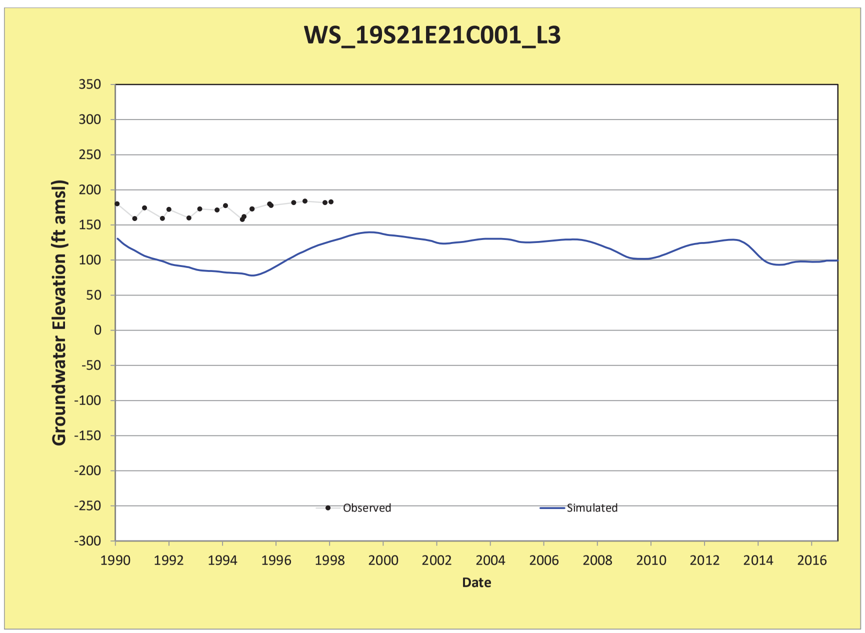
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Date
Observed
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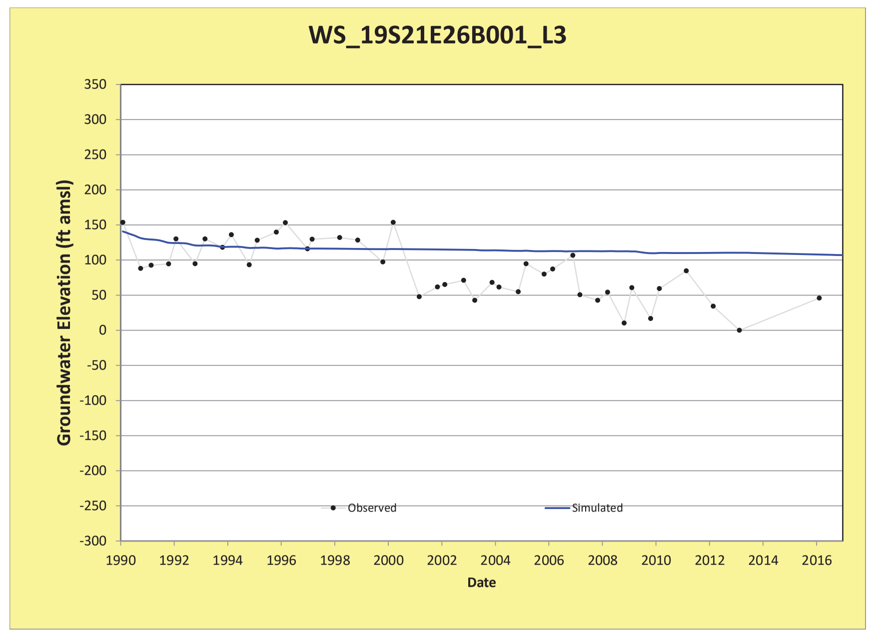
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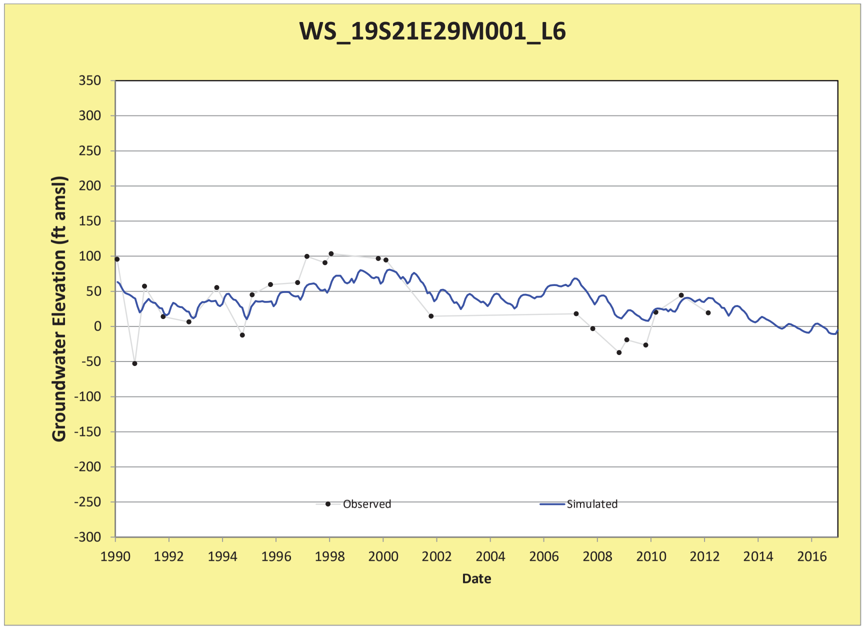
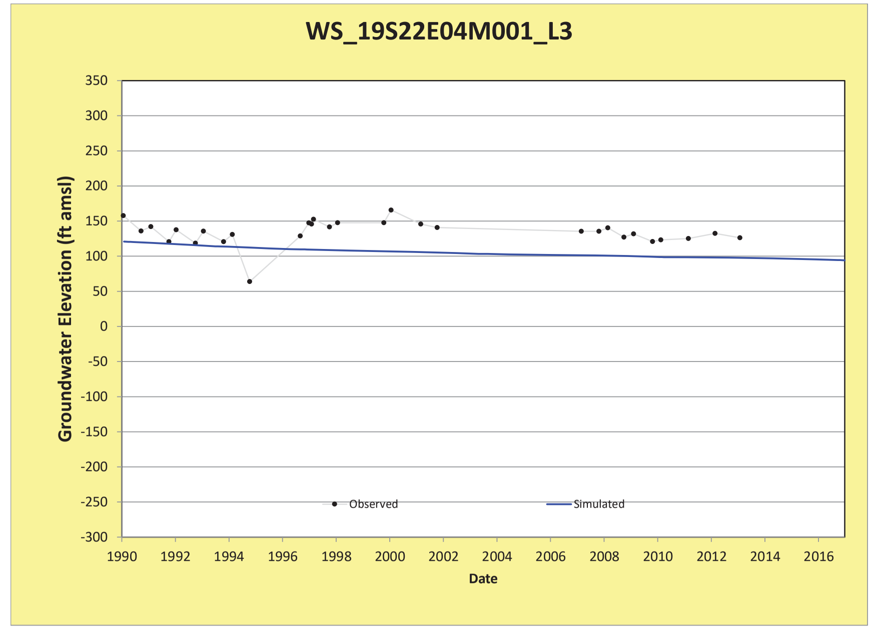
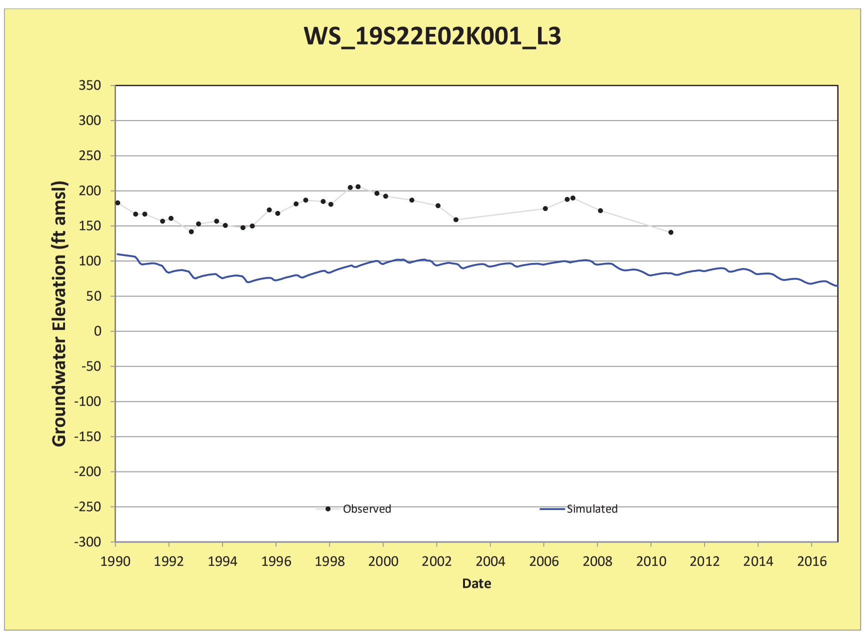
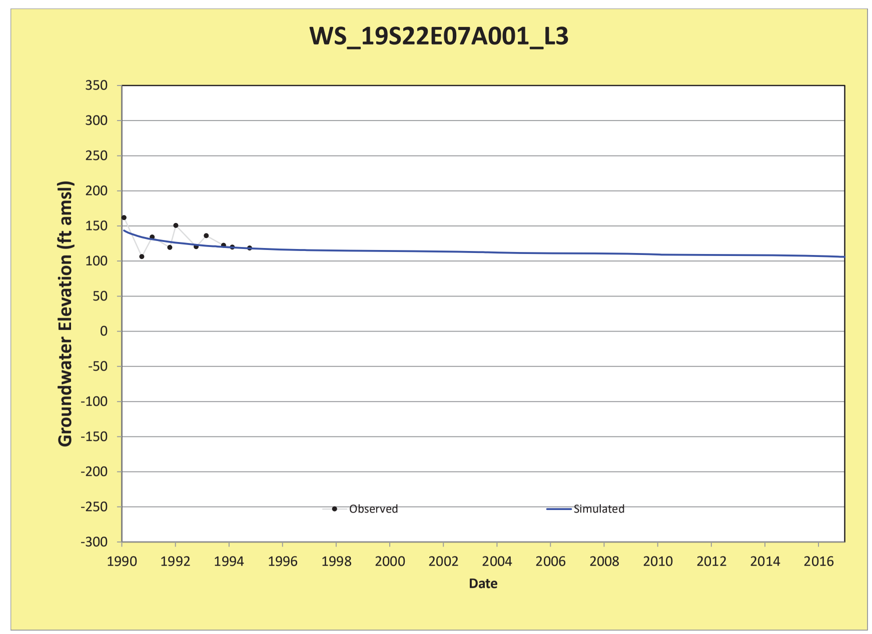
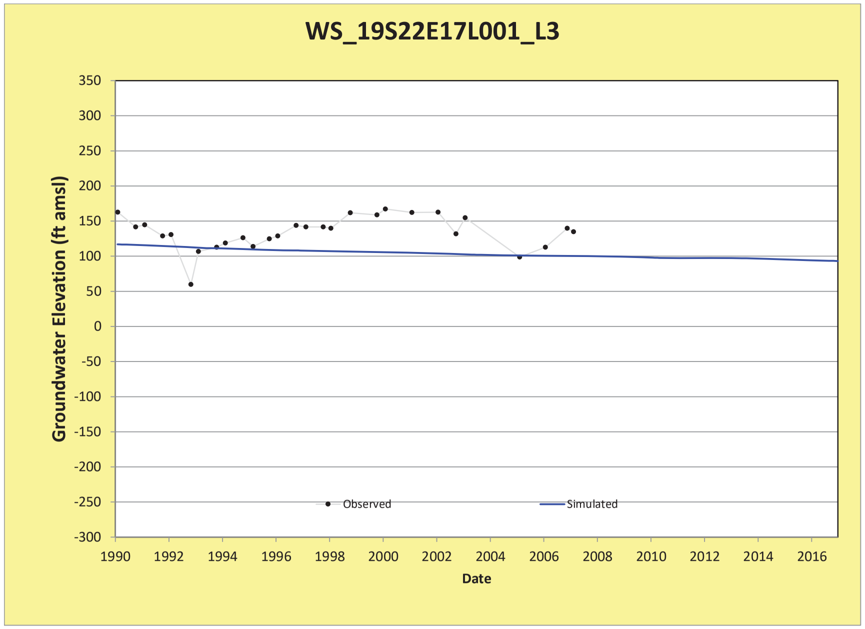
Date
Observed
Simulated

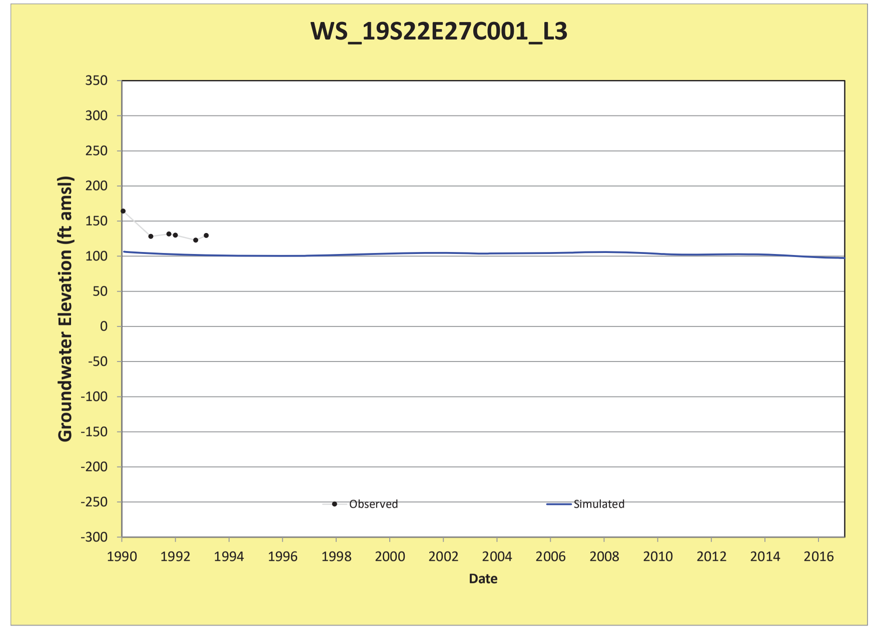

WS_19S21E29M001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S22E04M001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S22E02K001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S22E07A001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S22E17L001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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Groundwater Elevation (ft amsl)
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Observed
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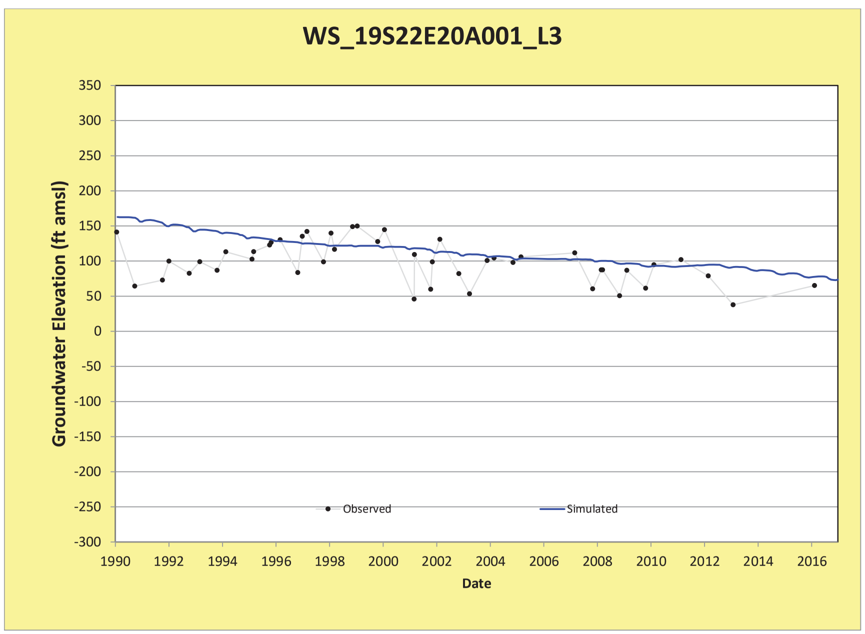
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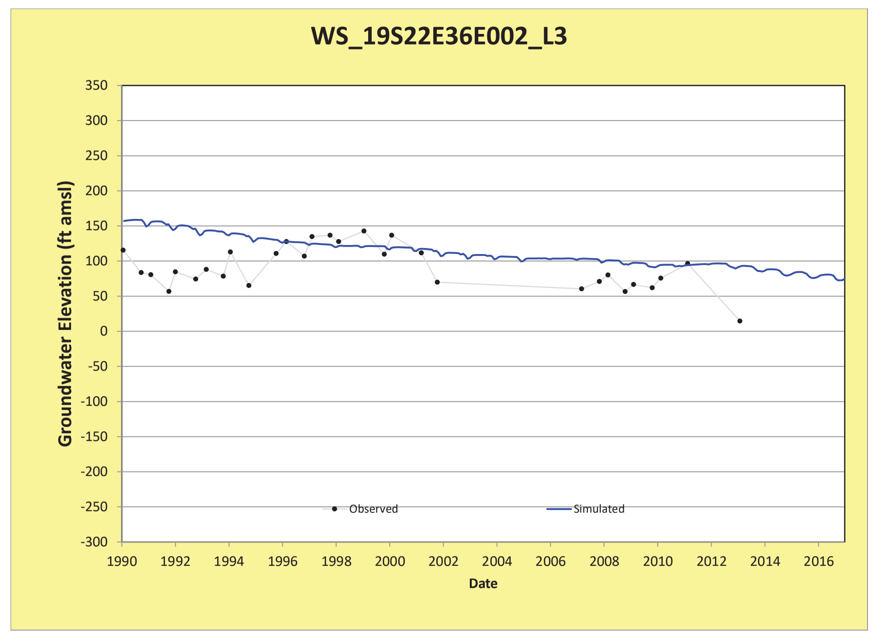
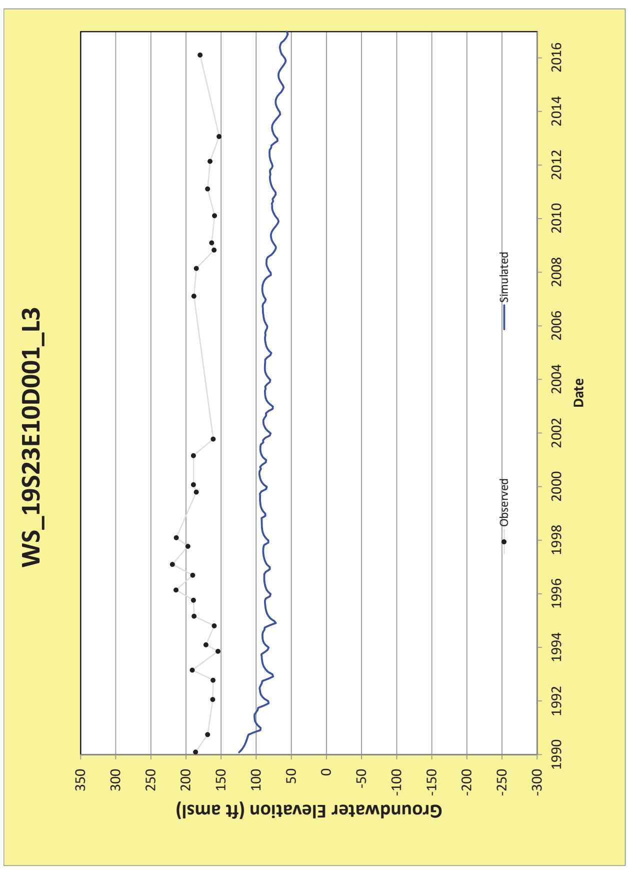
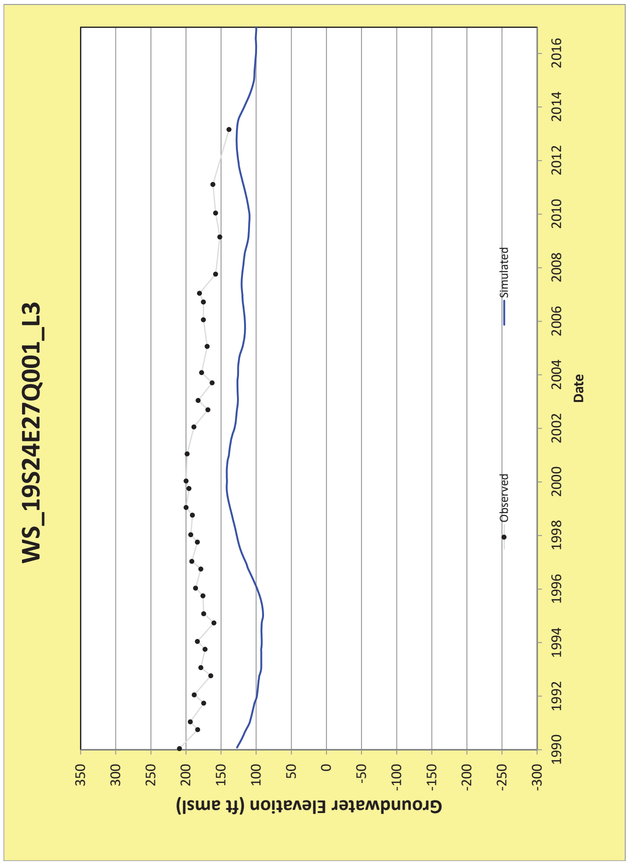
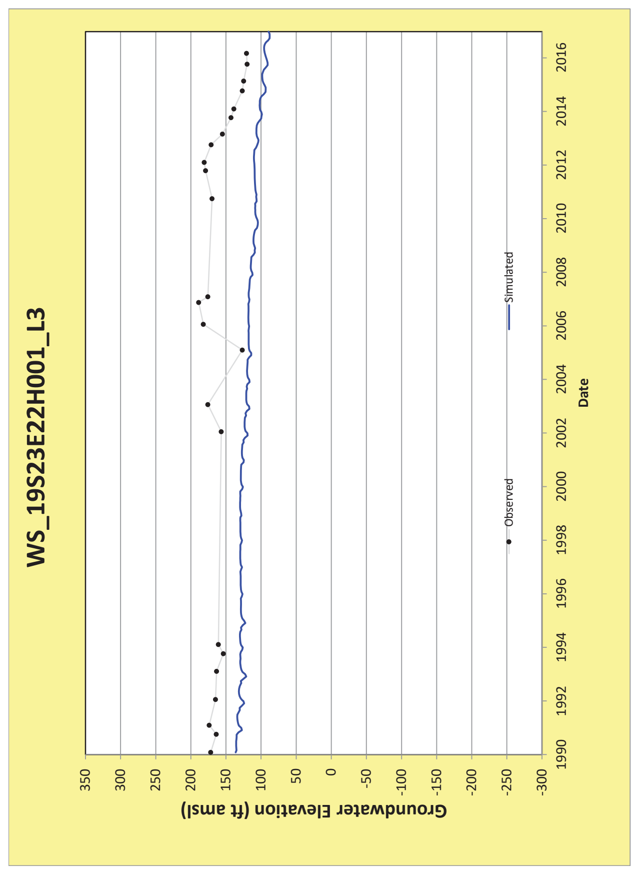
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S22E36E002_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S23E10D001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_19S24E27Q001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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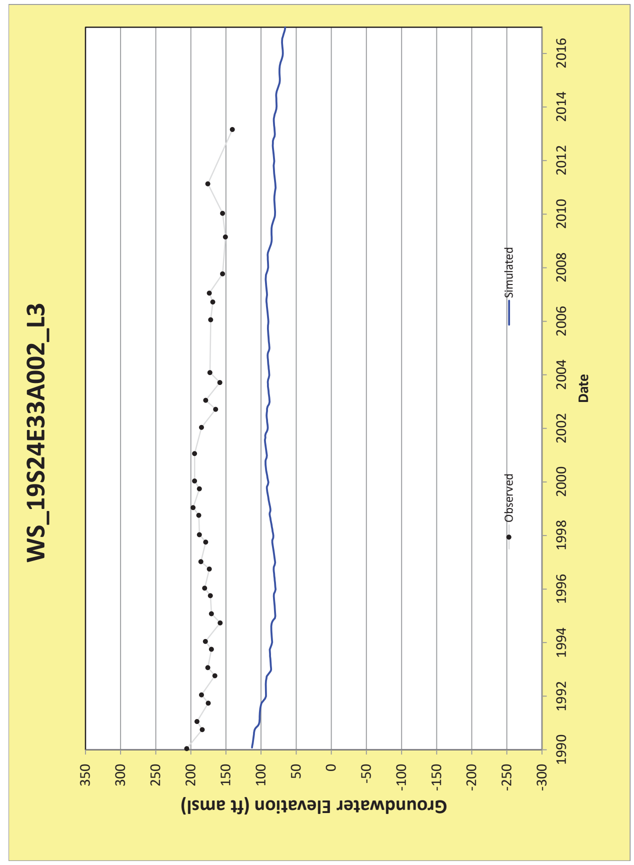
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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Groundwater Elevation (ft amsl)
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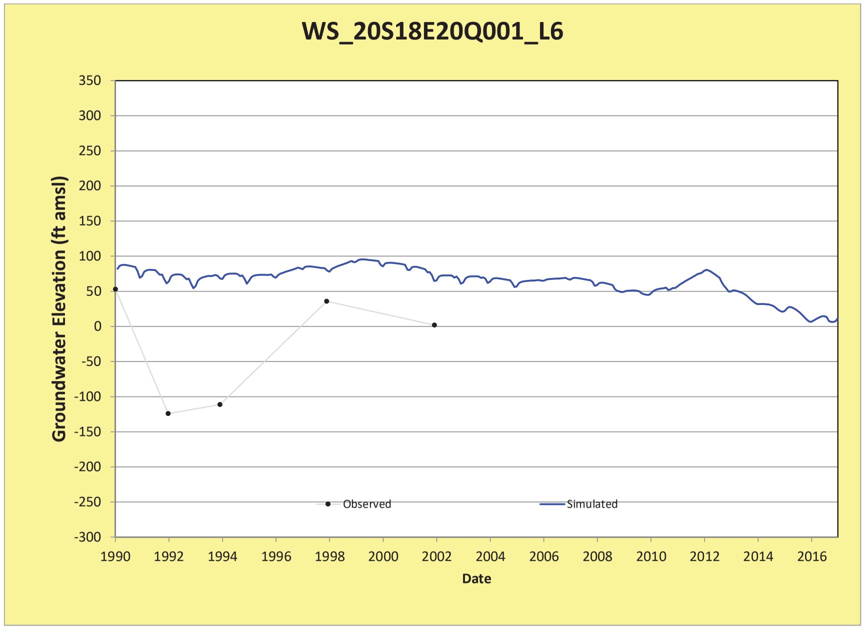
Observed
Simulated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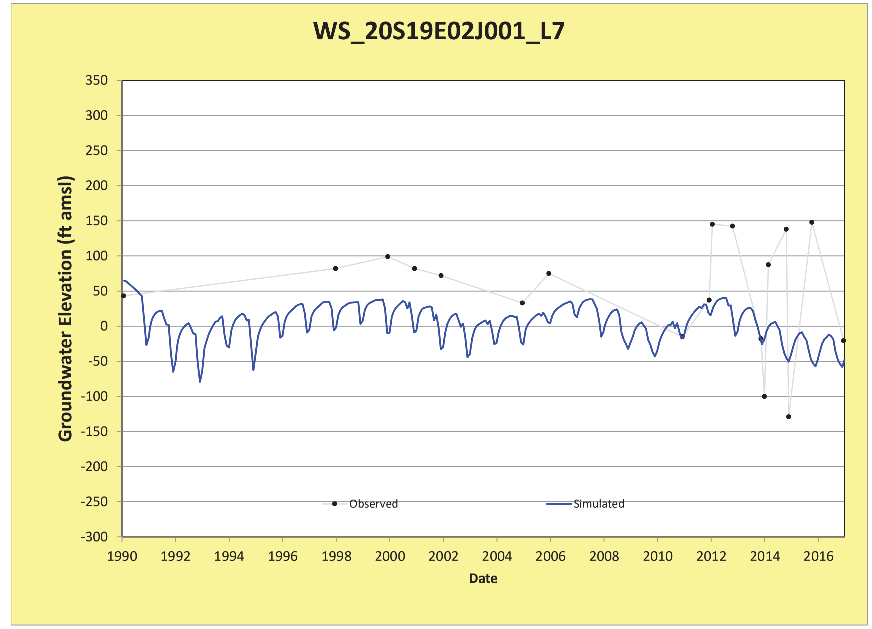
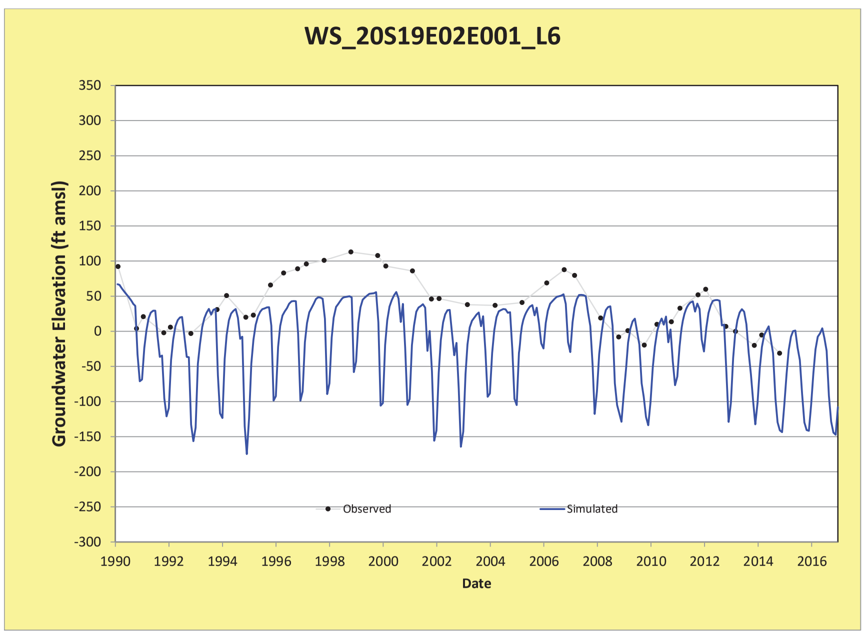
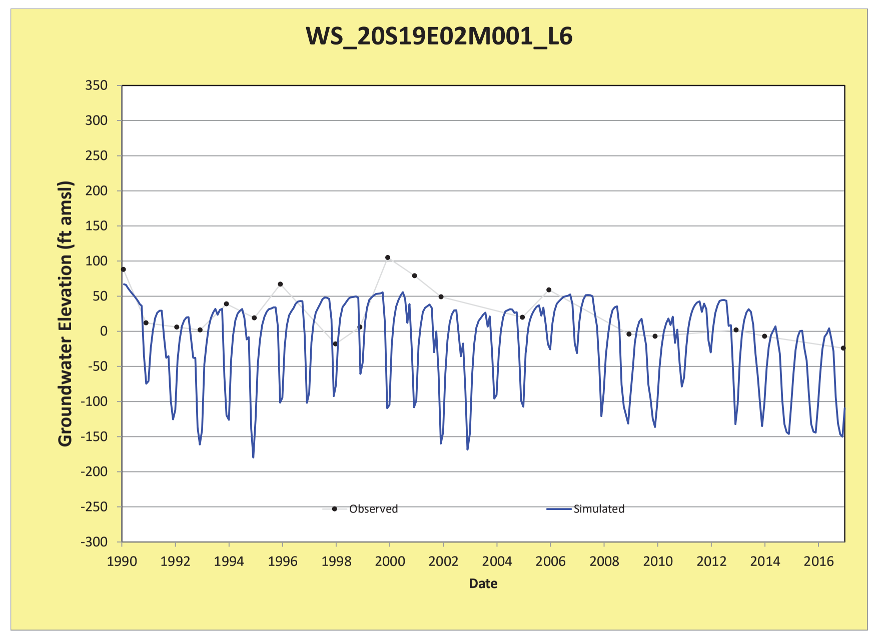
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_20S19E02J001_L7
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_20S19E02E001_L6
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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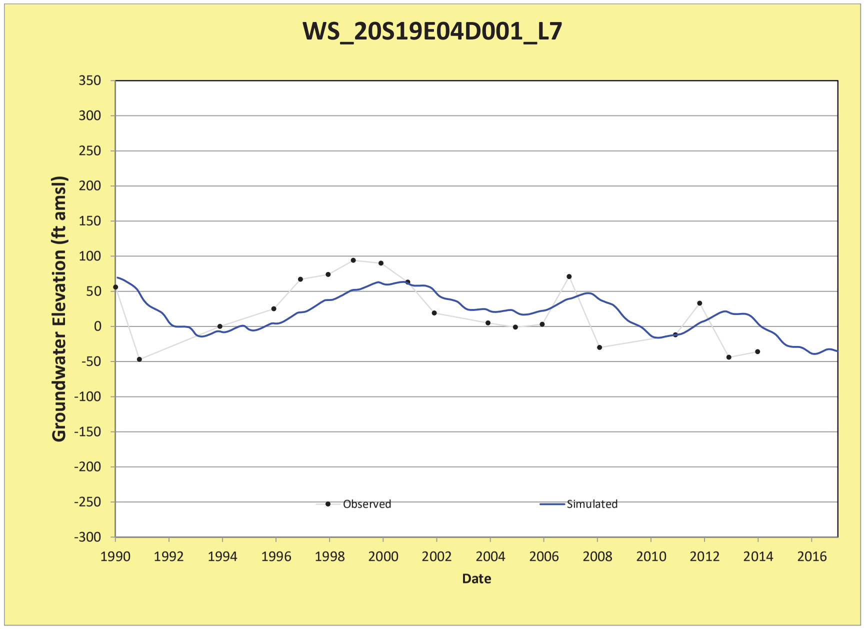
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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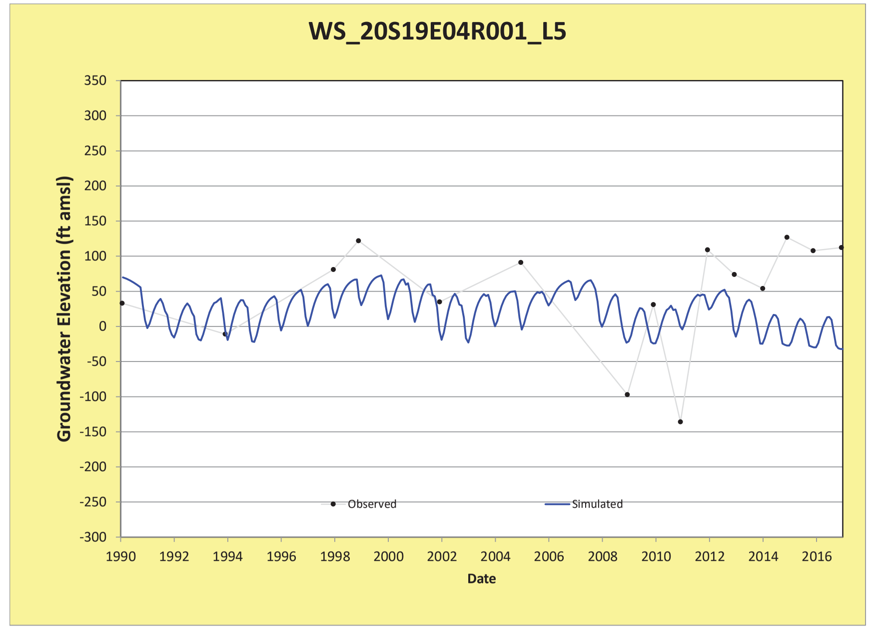
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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Groundwater Elevation (ft amsl)
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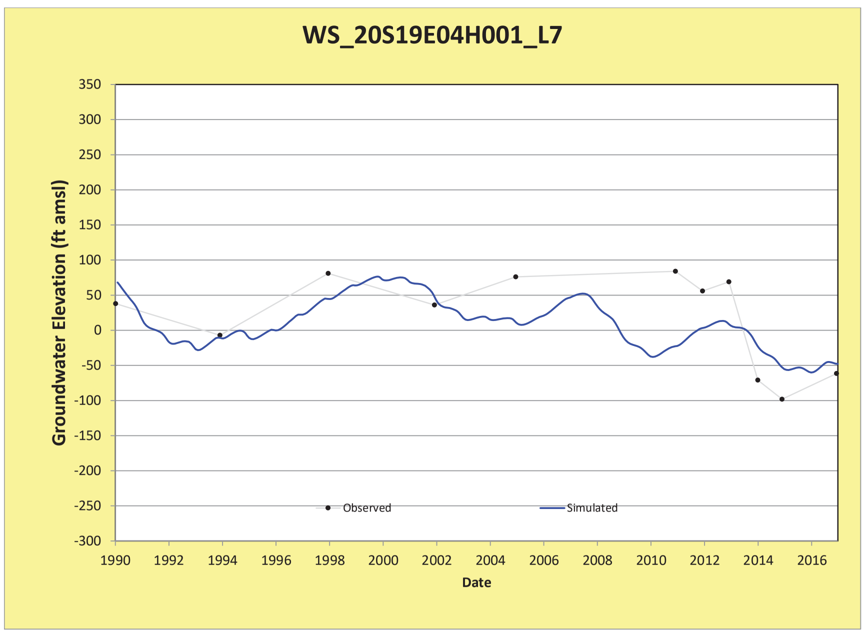
Observed
Simulated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Groundwater Elevation (ft amsl)
Date
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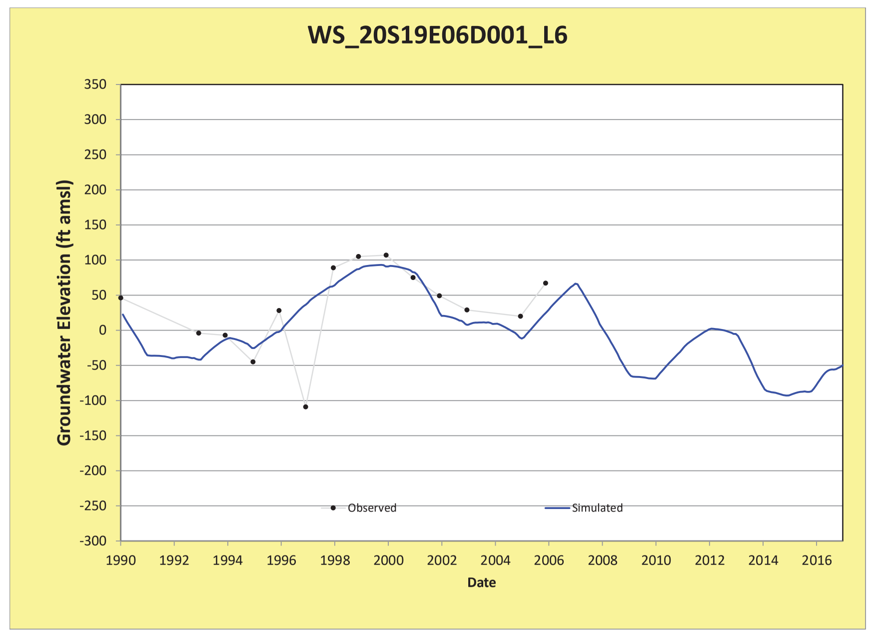
Simulated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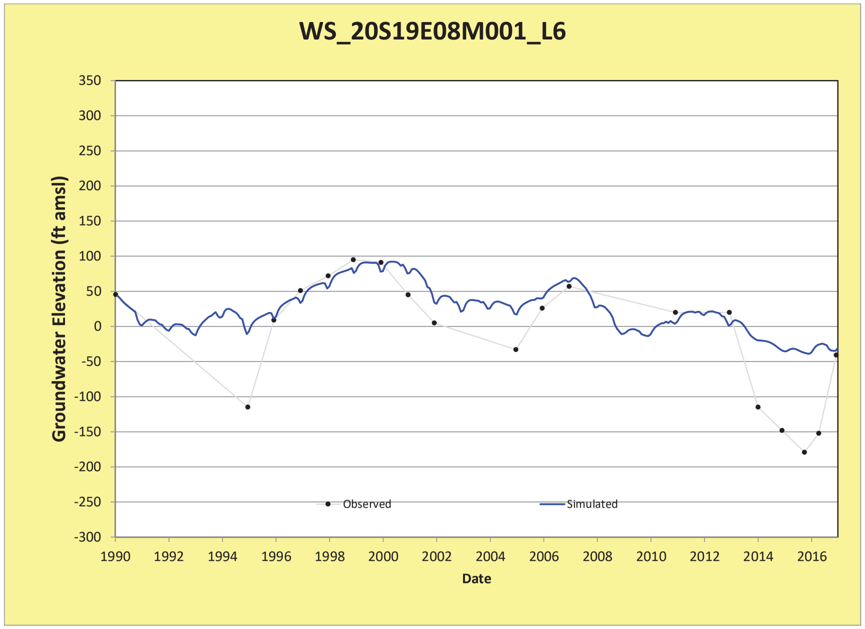
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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Groundwater Elevation (ft amsl)
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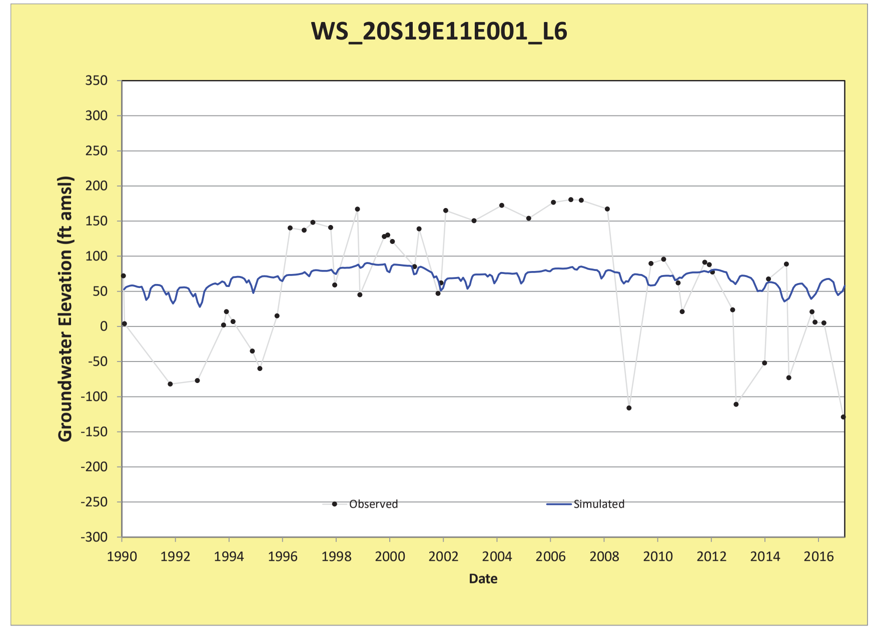
Simulated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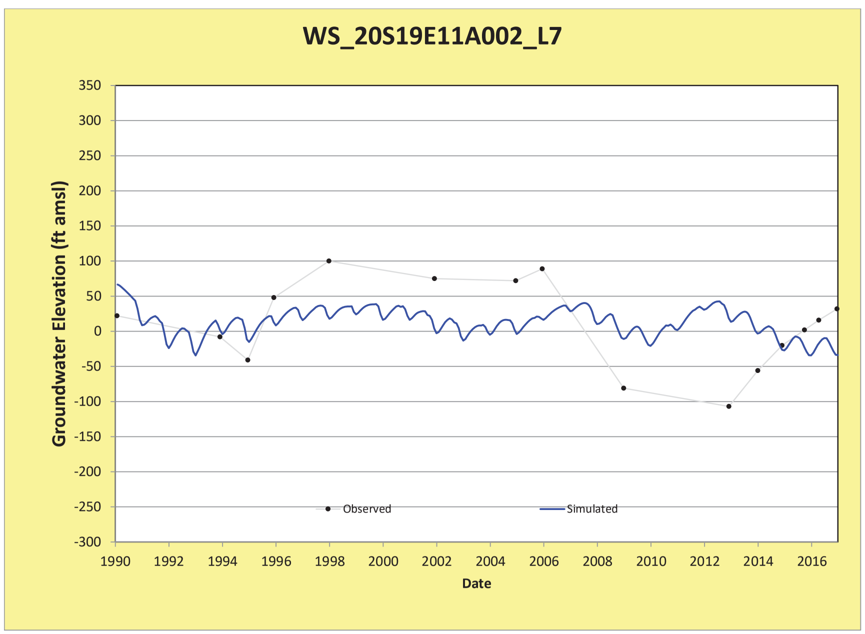
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_20S19E11A002_L7
Groundwater Elevation (ft amsl)
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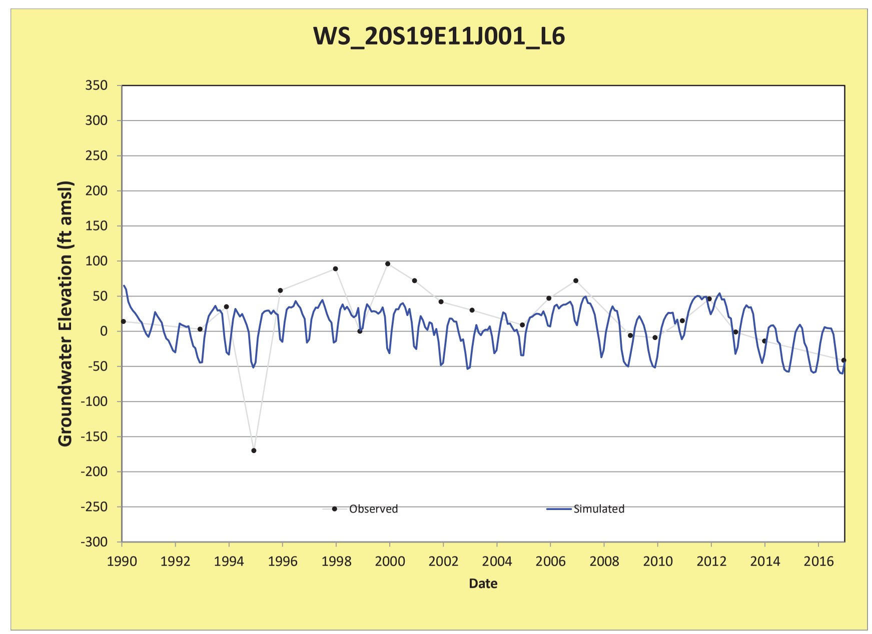
Observed
Simulated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Groundwater Elevation (ft amsl)
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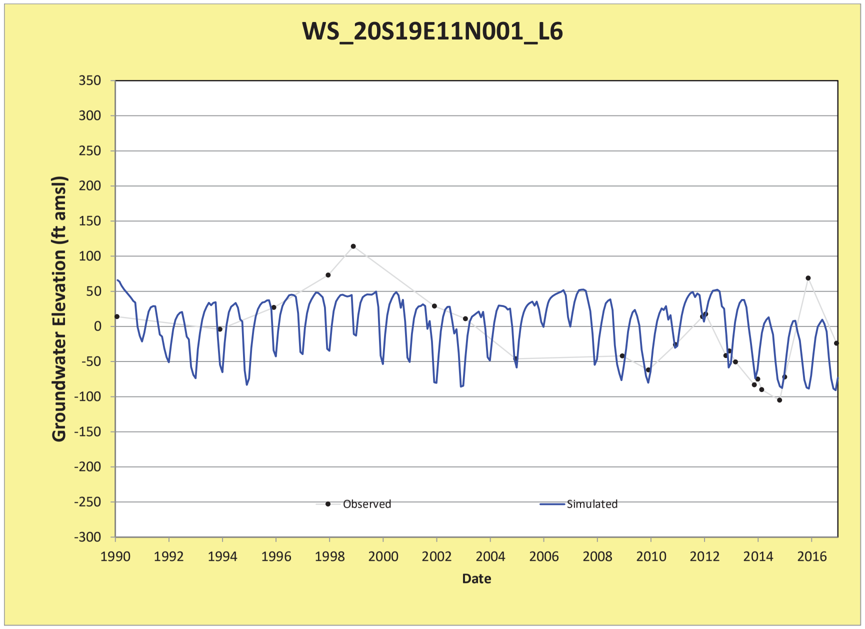
Observed
Simulated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Groundwater Elevation (ft amsl)
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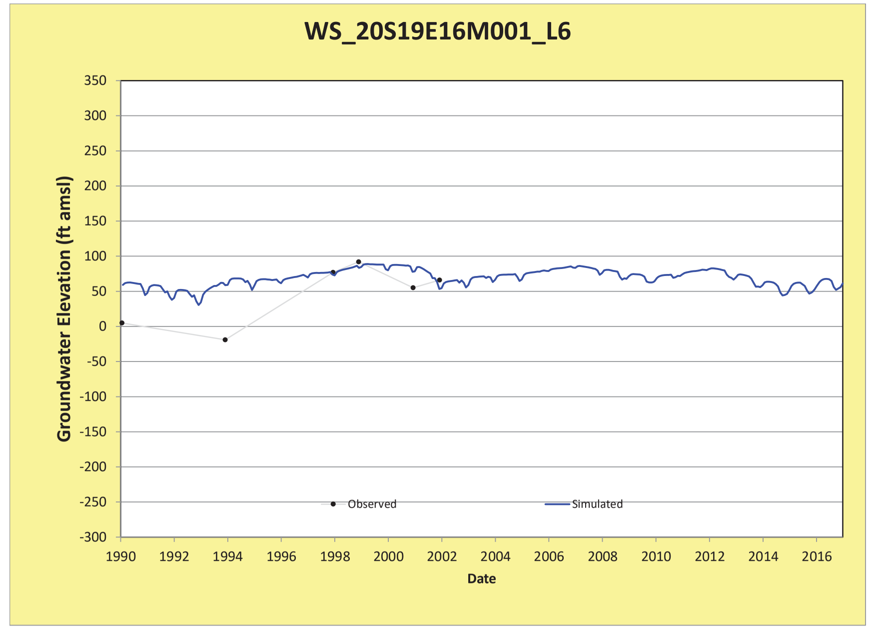
Date
Observed
Simulated


WS_20S19E16M001_L6
Groundwater Elevation (ft amsl)
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Date
Observed
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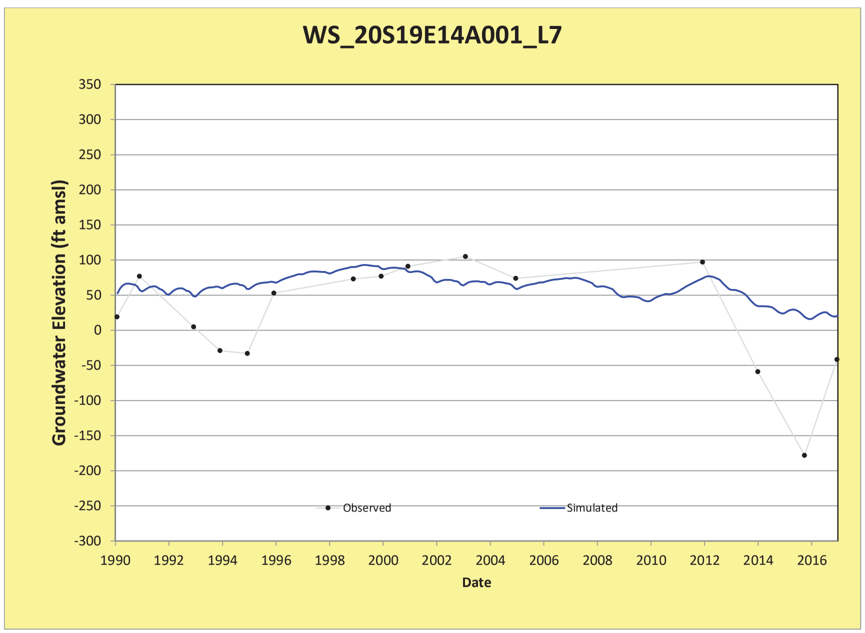
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Groundwater Elevation (ft amsl)
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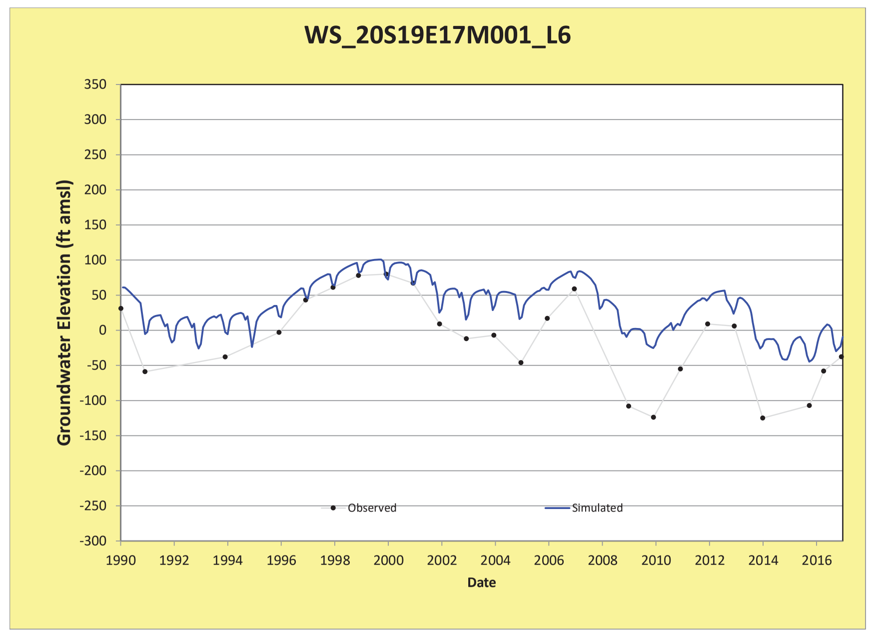
Observed
Simulated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Groundwater Elevation (ft amsl)
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Date
Observed
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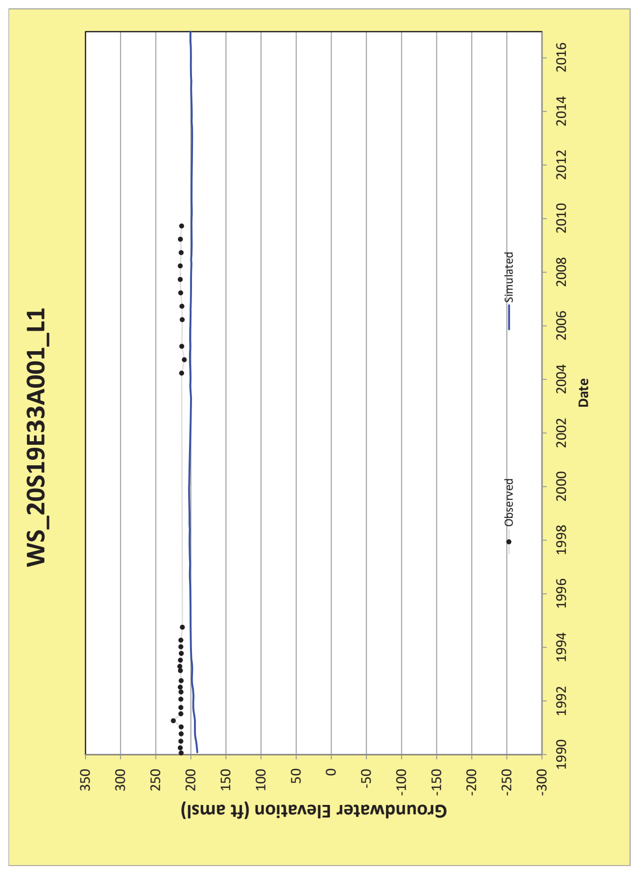
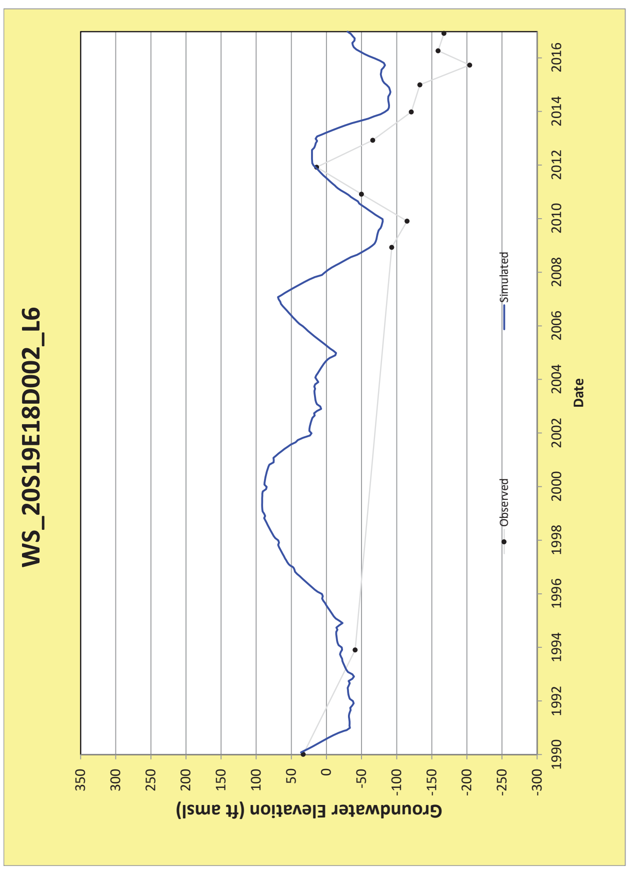

WS_20S19E33A001_L1
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_20S19E18D002_L6
Groundwater Elevation (ft amsl)
Date
Observed
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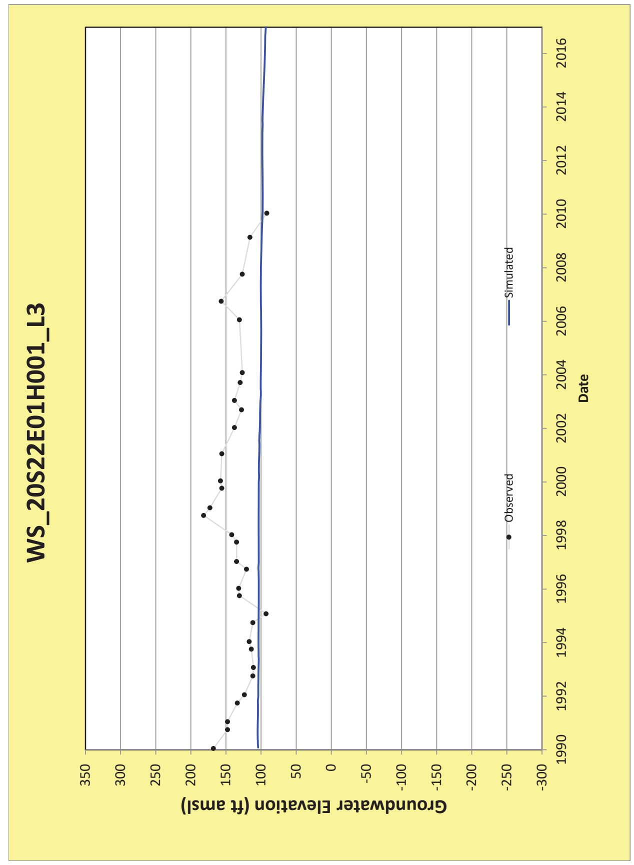
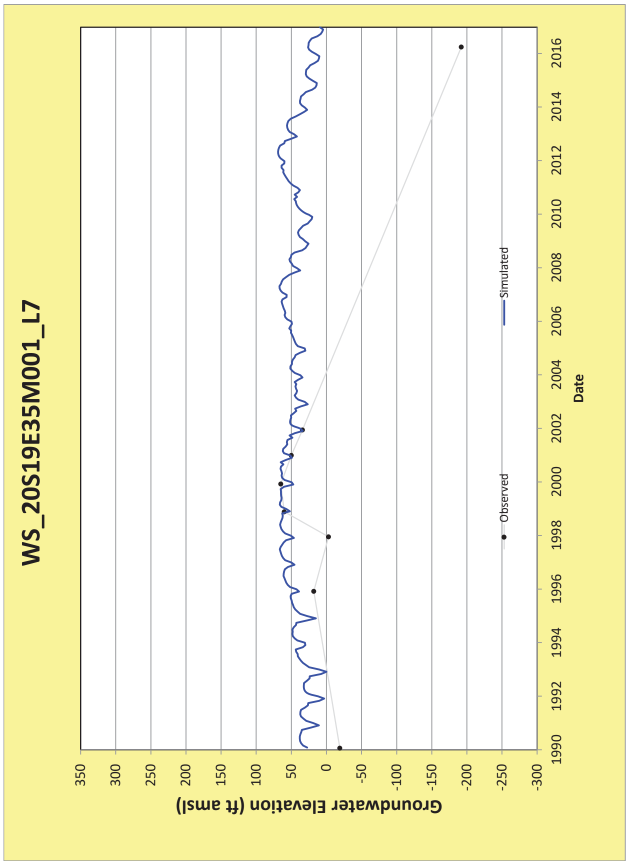
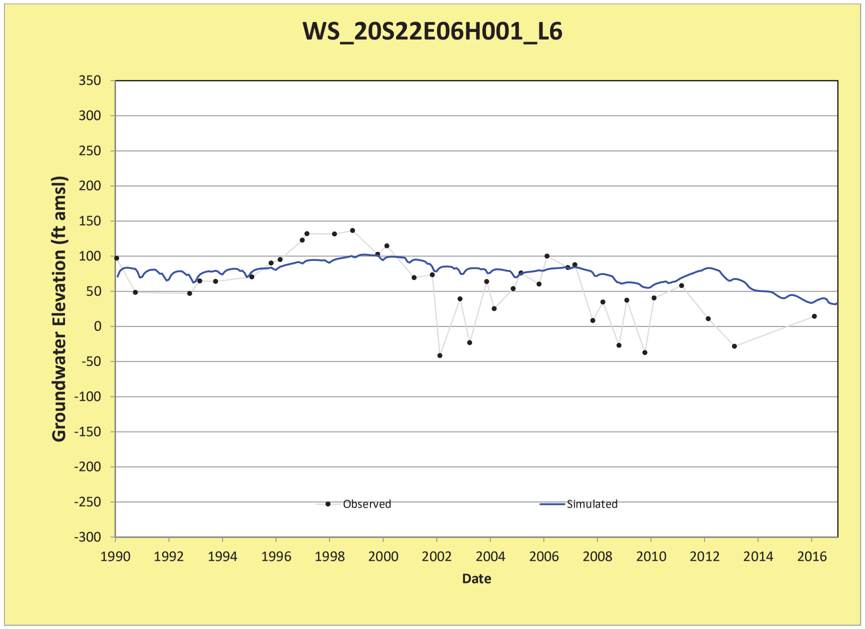

WS_20S22E01H001_L3
Groundwater Elevation (ft amsl)
Date
Observed
Simulated


WS_20S19E35M001_L7
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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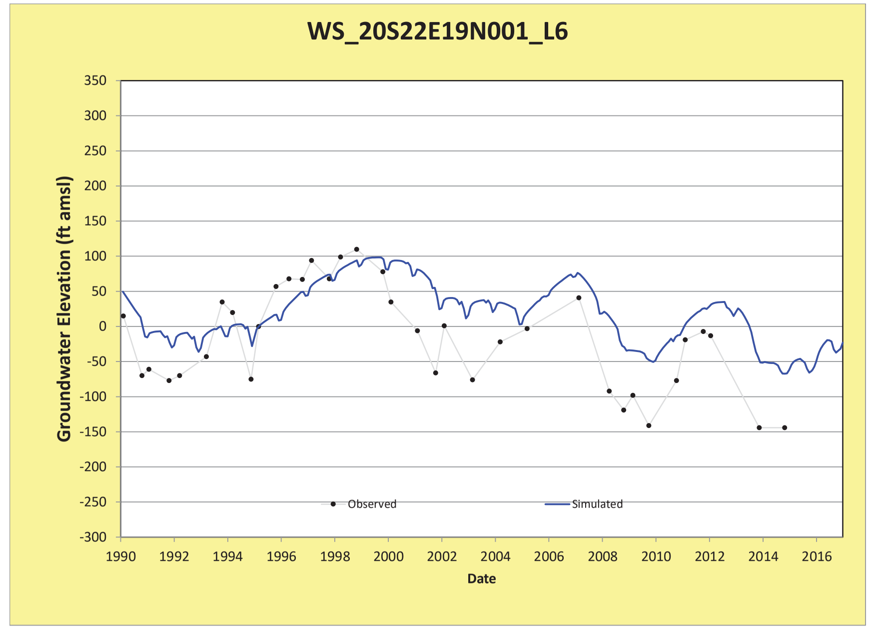
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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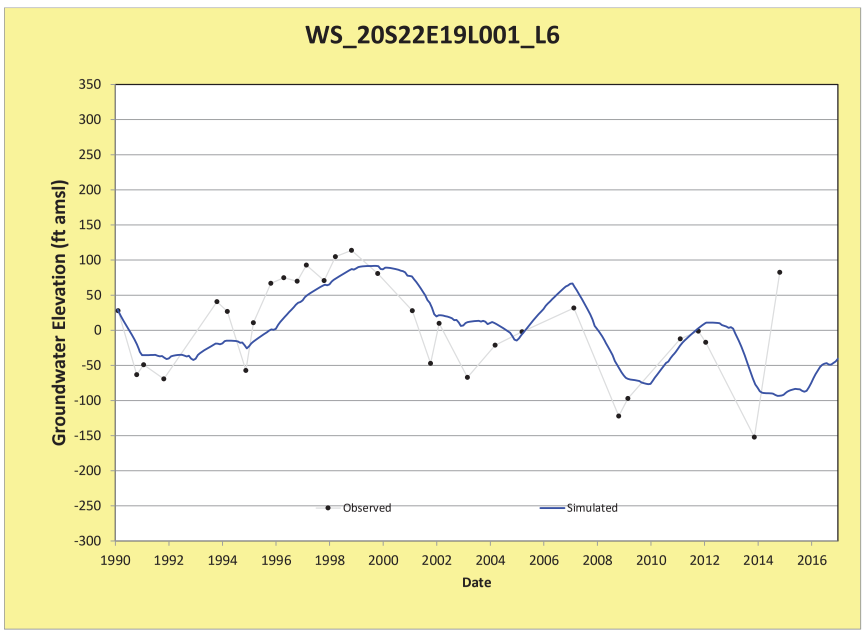
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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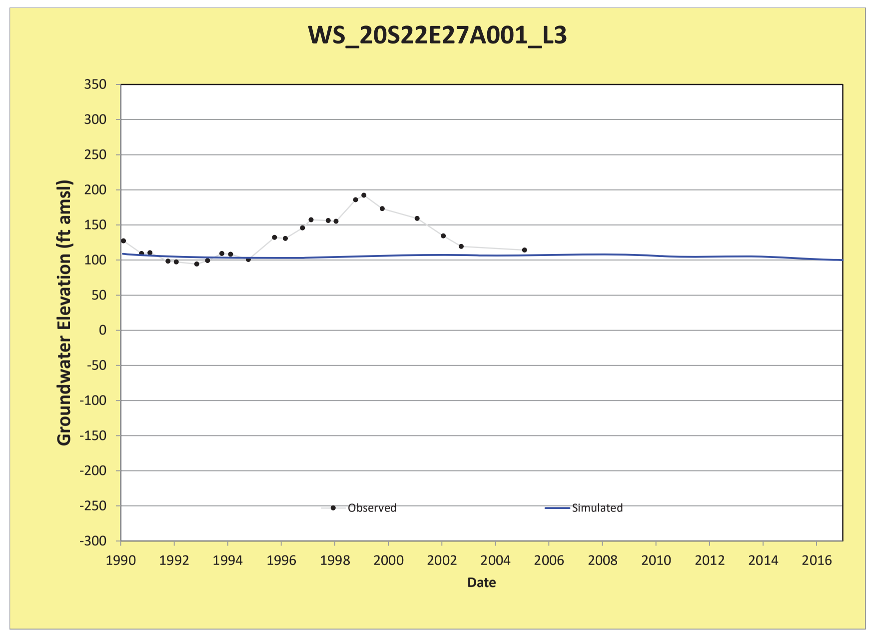
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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Groundwater Elevation (ft amsl)
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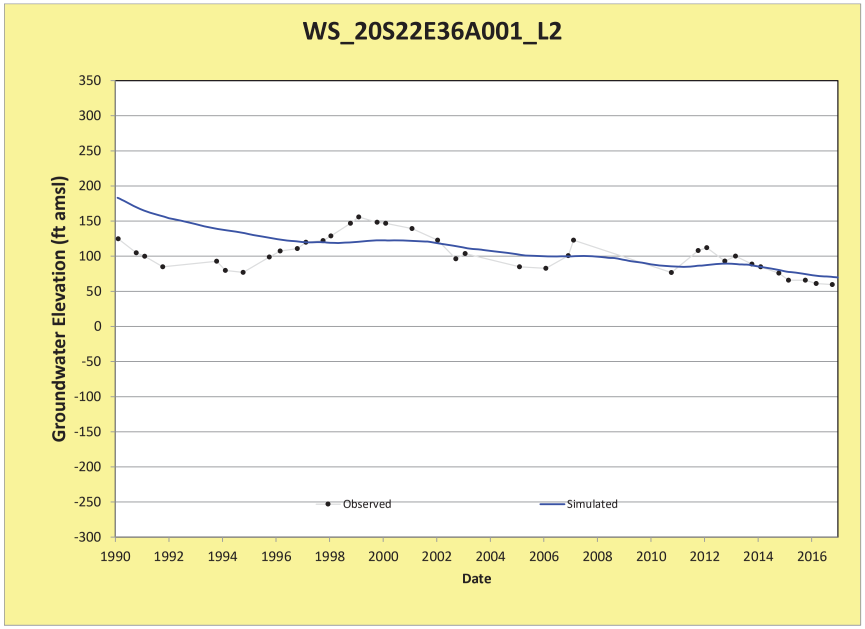
Observed
Simulated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Observed
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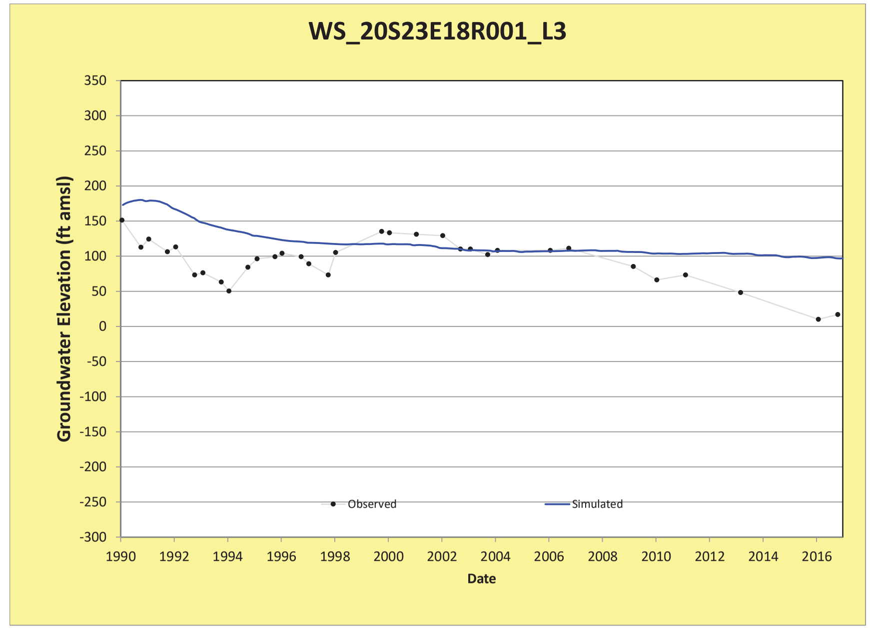
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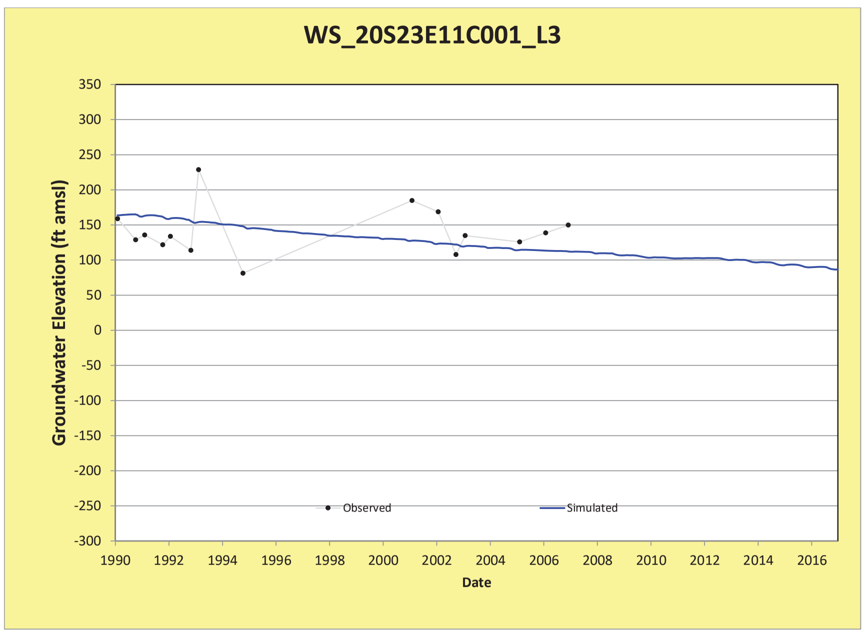
Observed
Simulated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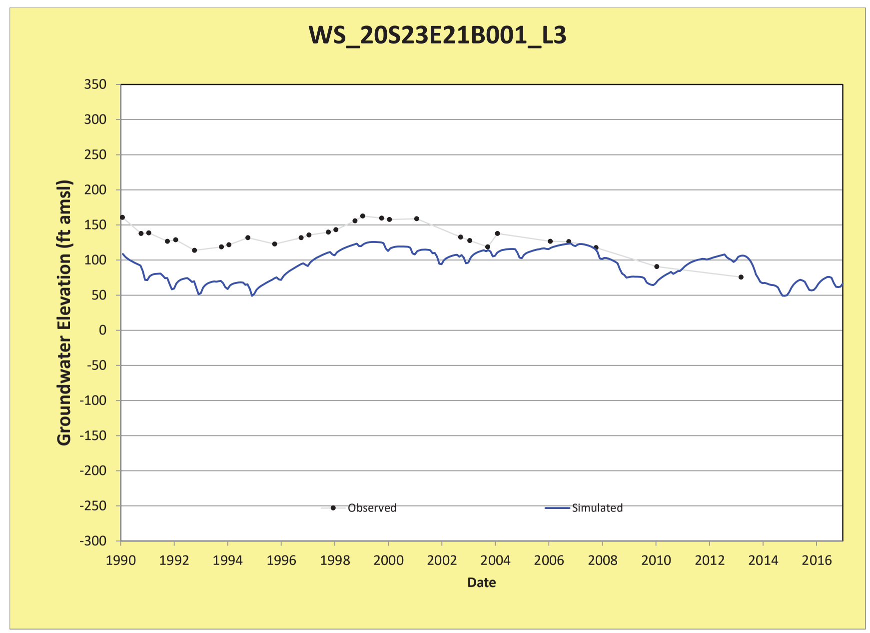
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Date
Observed
Simulated

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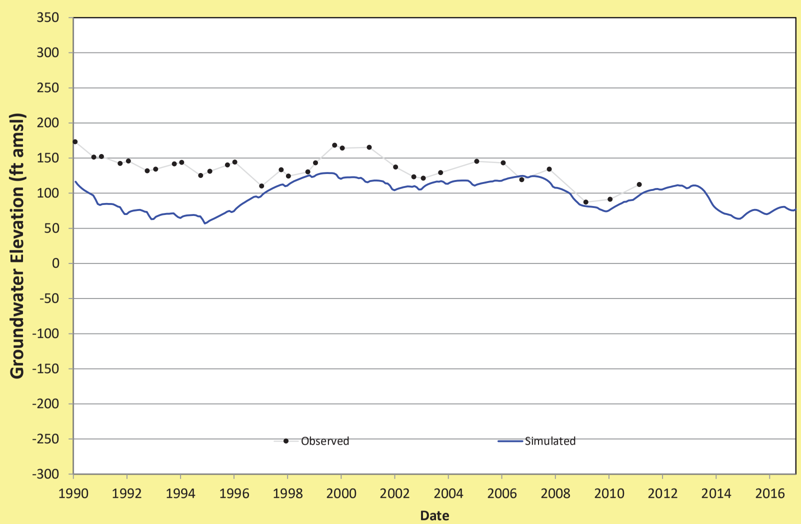

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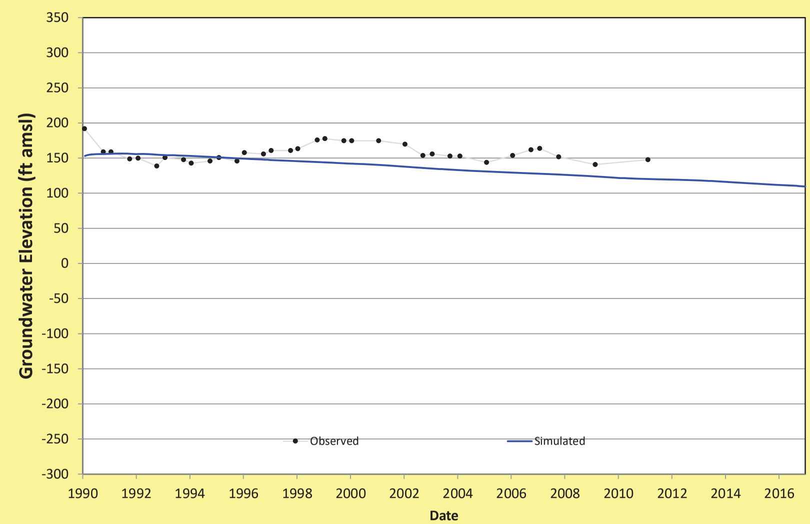

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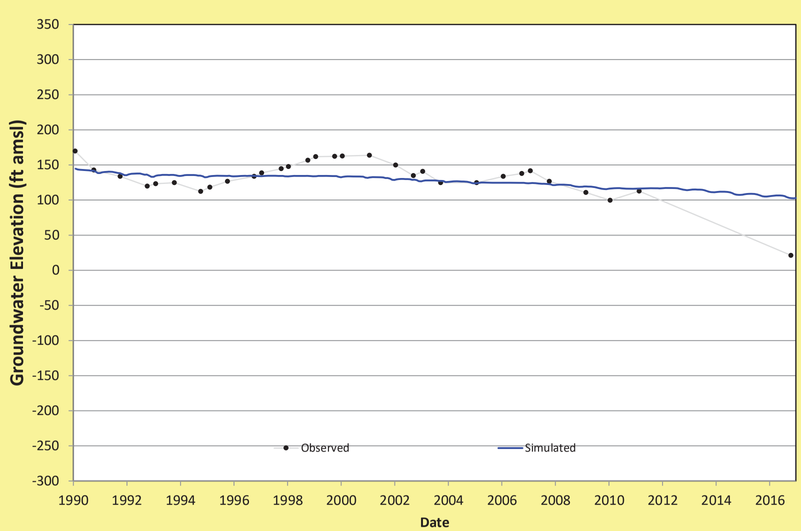

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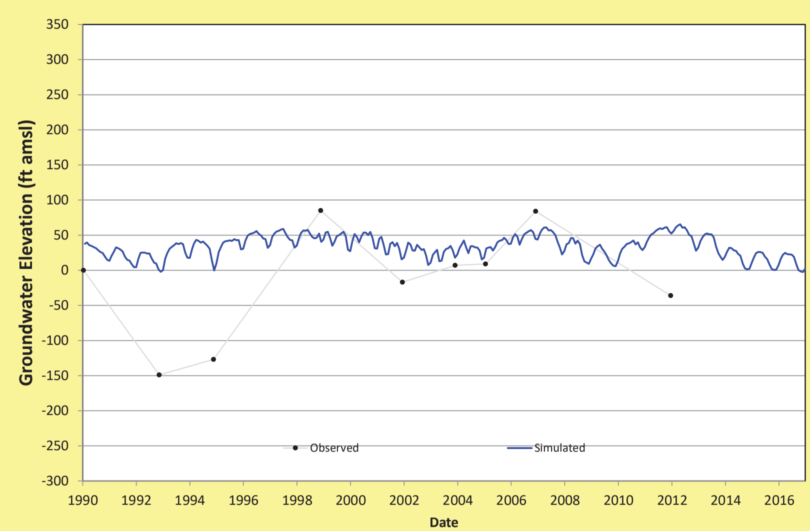

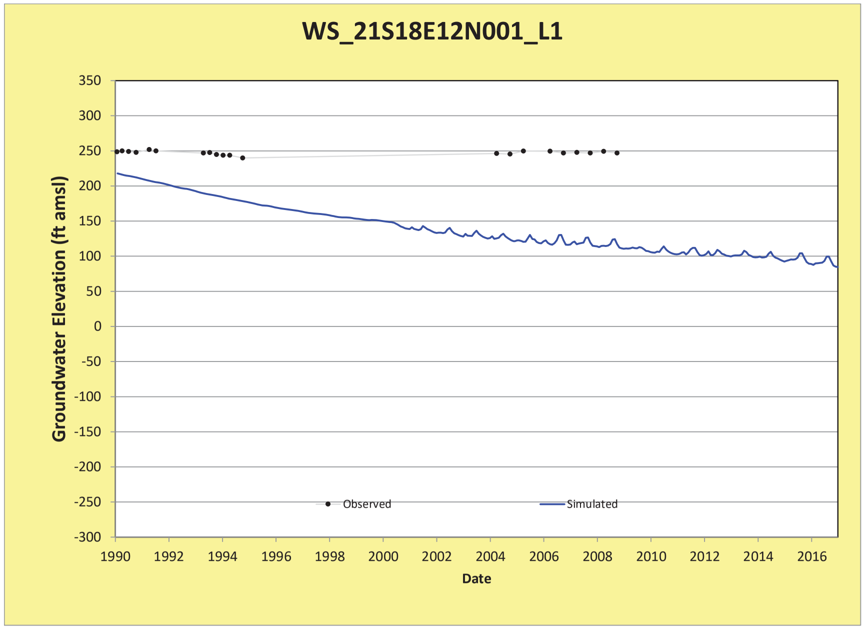
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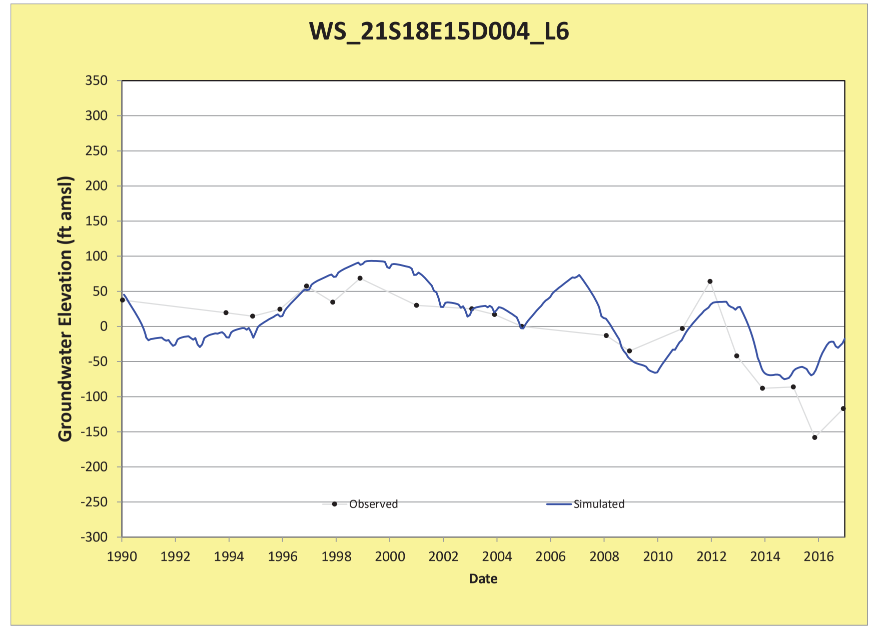
Groundwater Elevation (ft amsl)
Date
Observed
Simulated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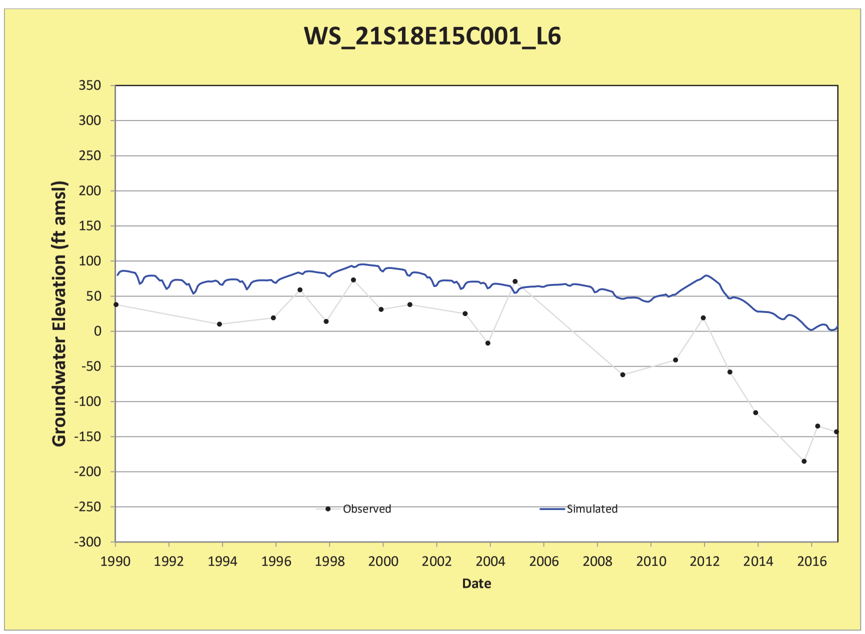
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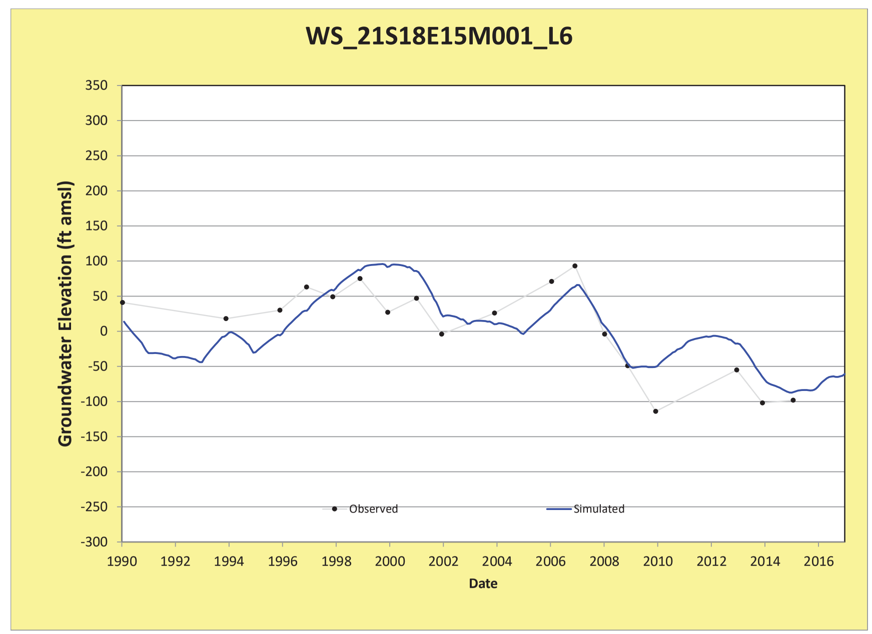
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Groundwater Elevation (ft amsl)
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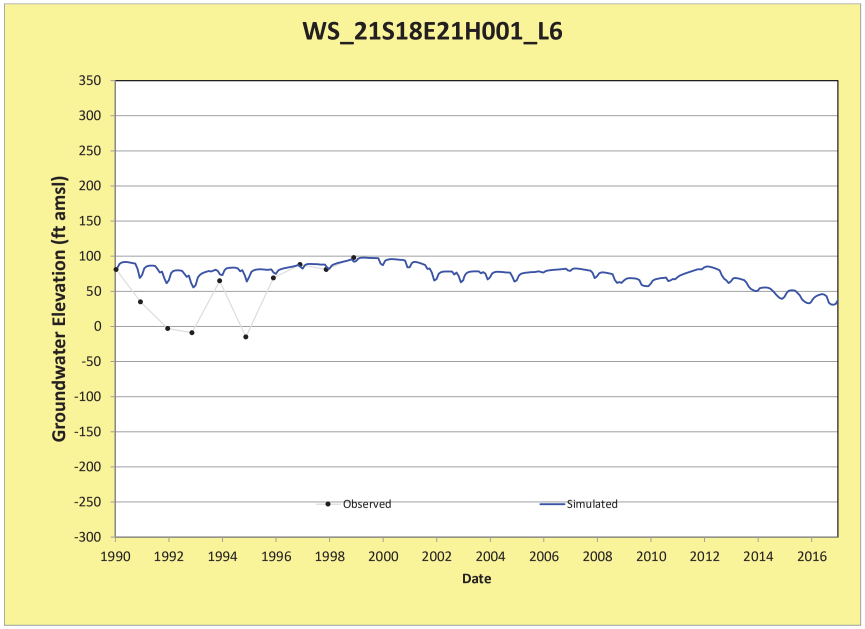
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Groundwater Elevation (ft amsl)
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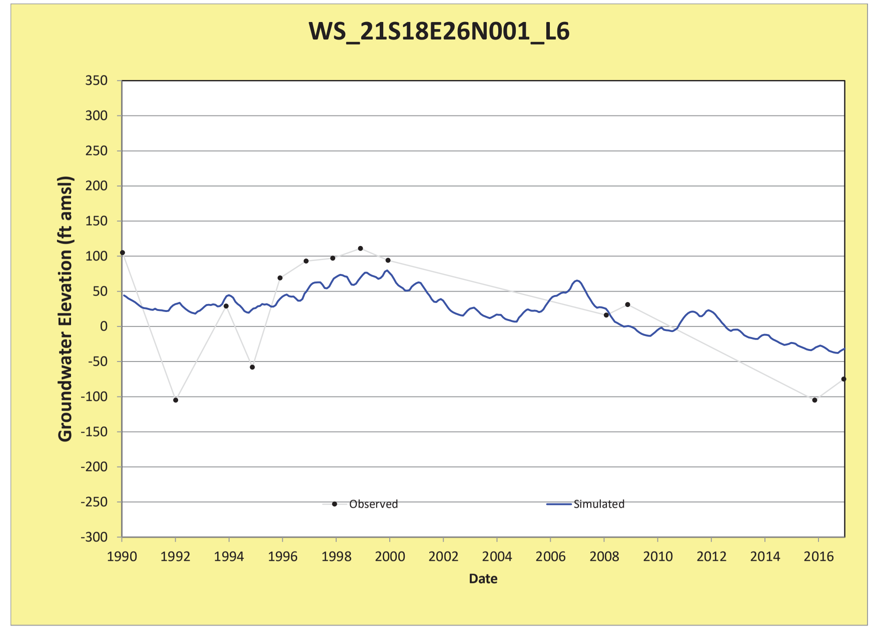
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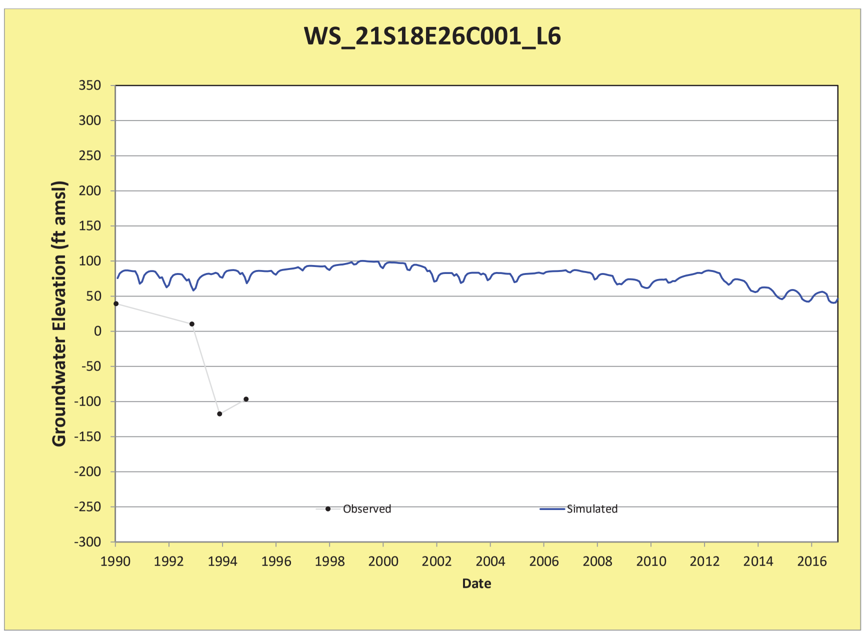
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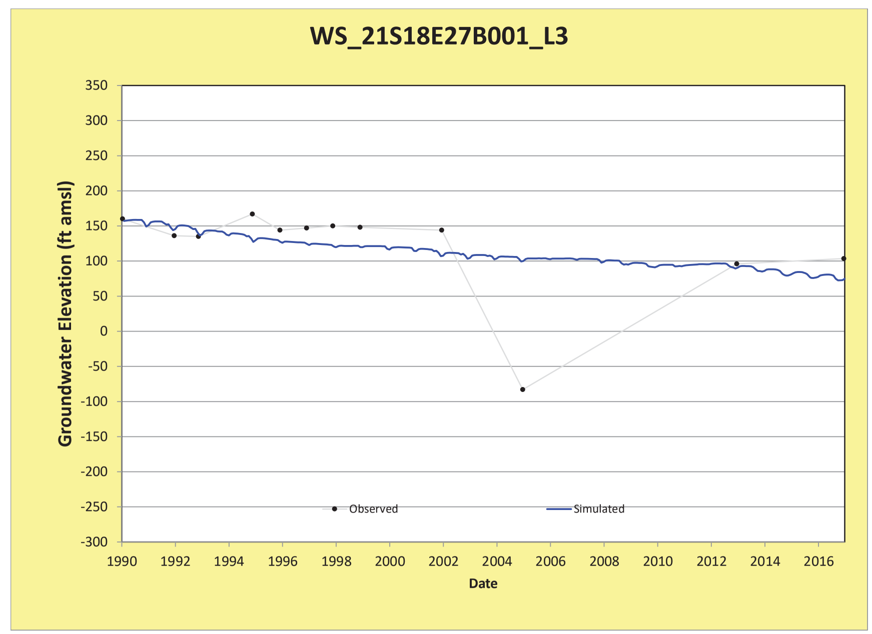
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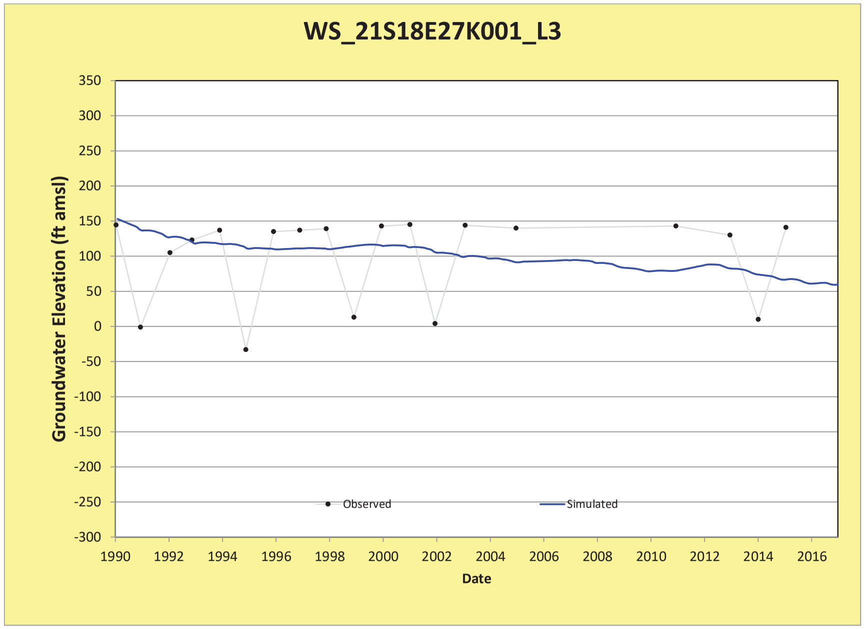
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Groundwater Elevation (ft amsl)
Date
Observed
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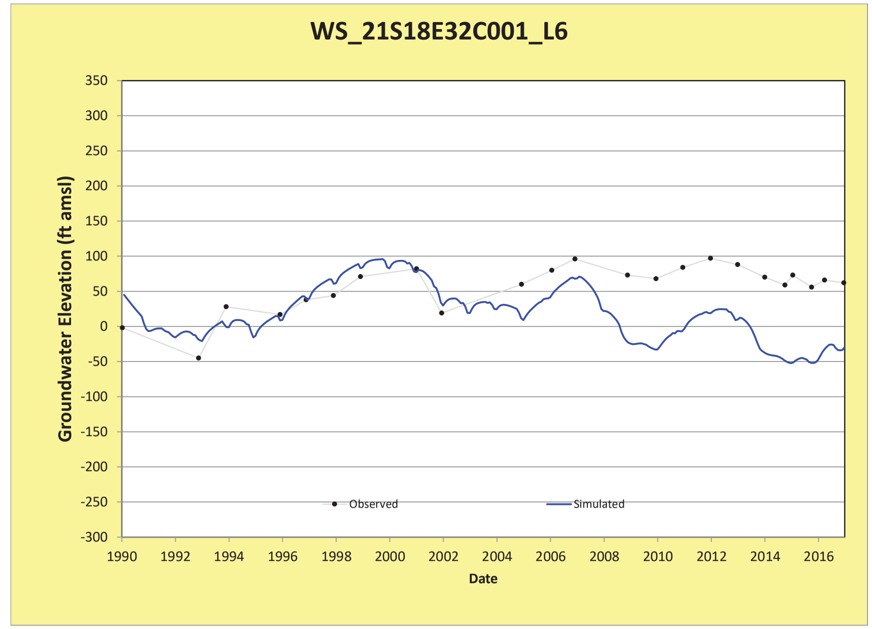
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Groundwater Elevation (ft amsl)
Date
Observed
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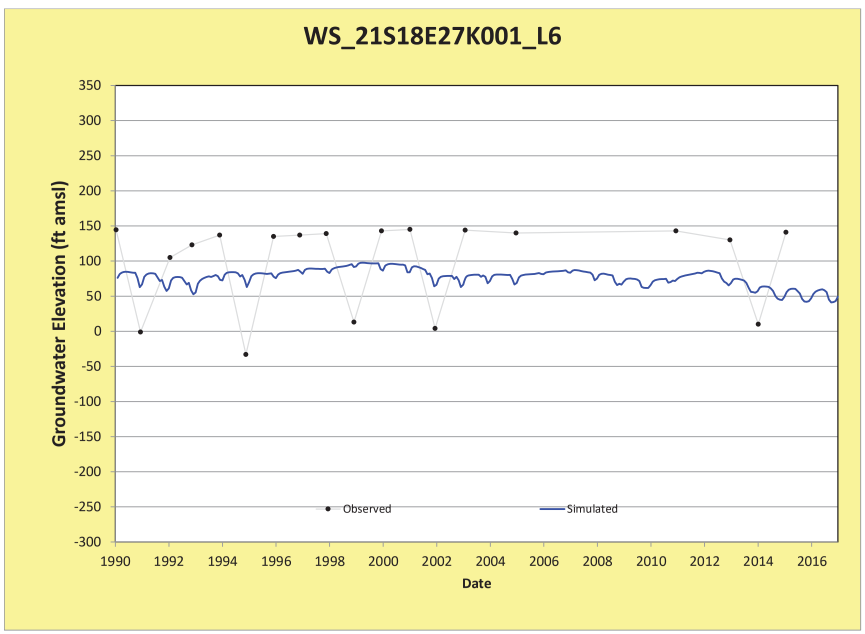
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Groundwater Elevation (ft amsl)
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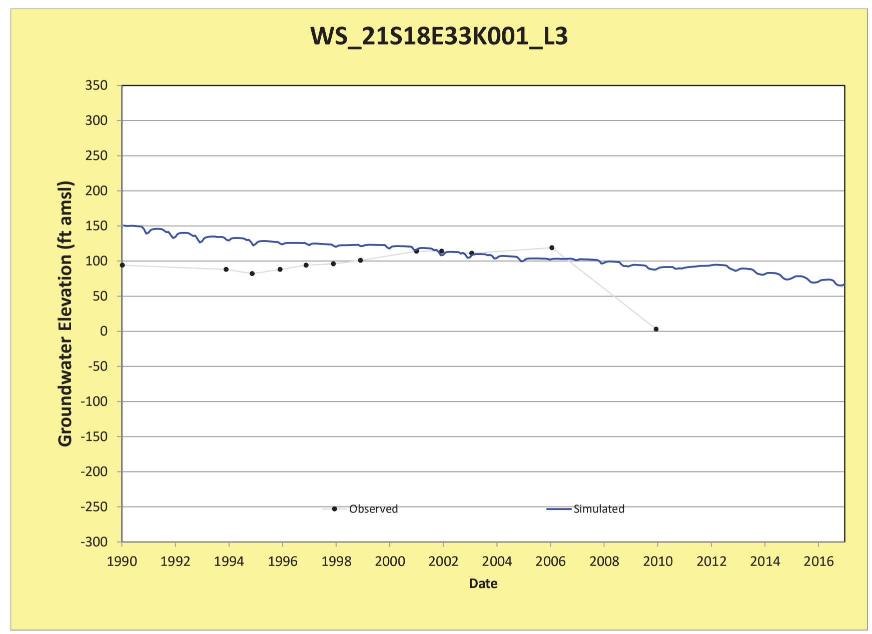
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Groundwater Elevation (ft amsl)
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Observed
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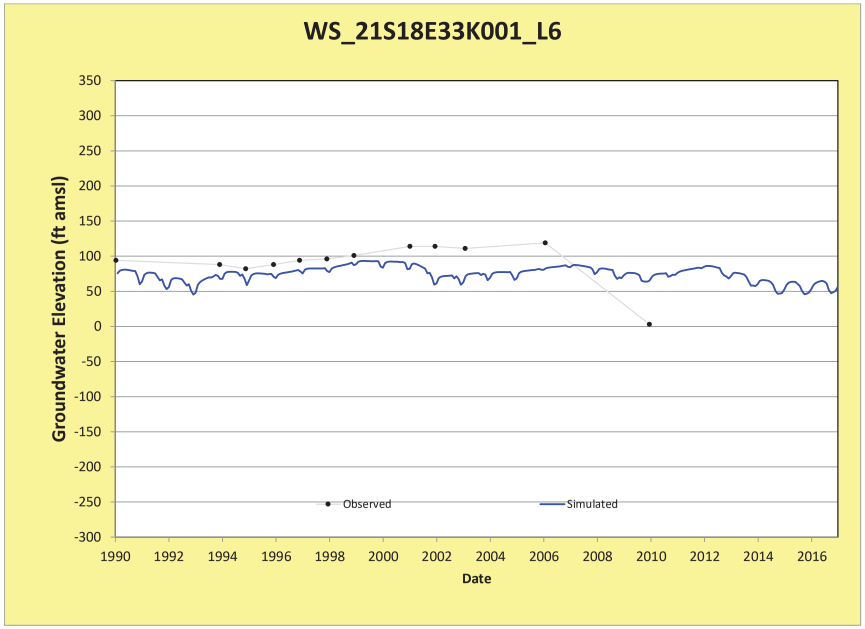
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Groundwater Elevation (ft amsl)
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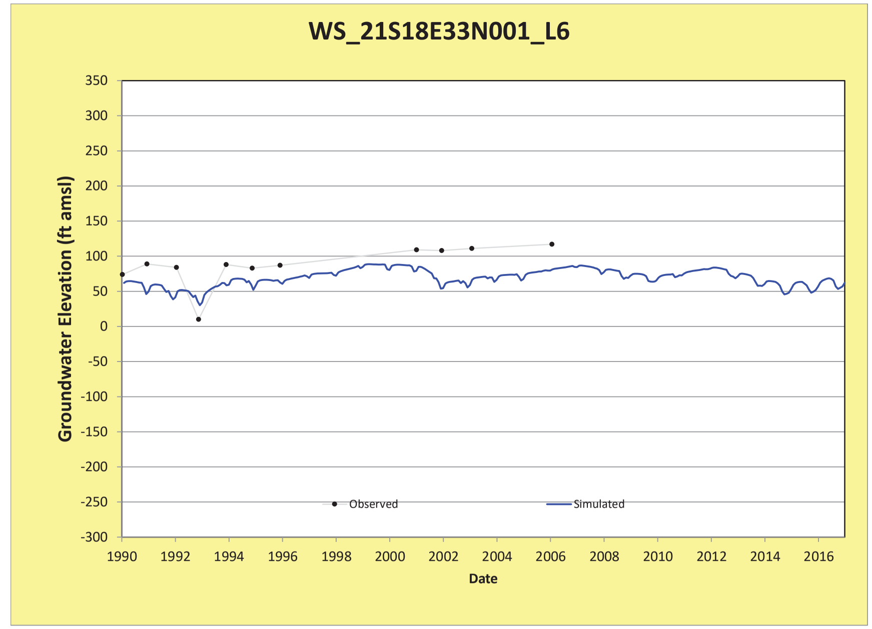
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Observed
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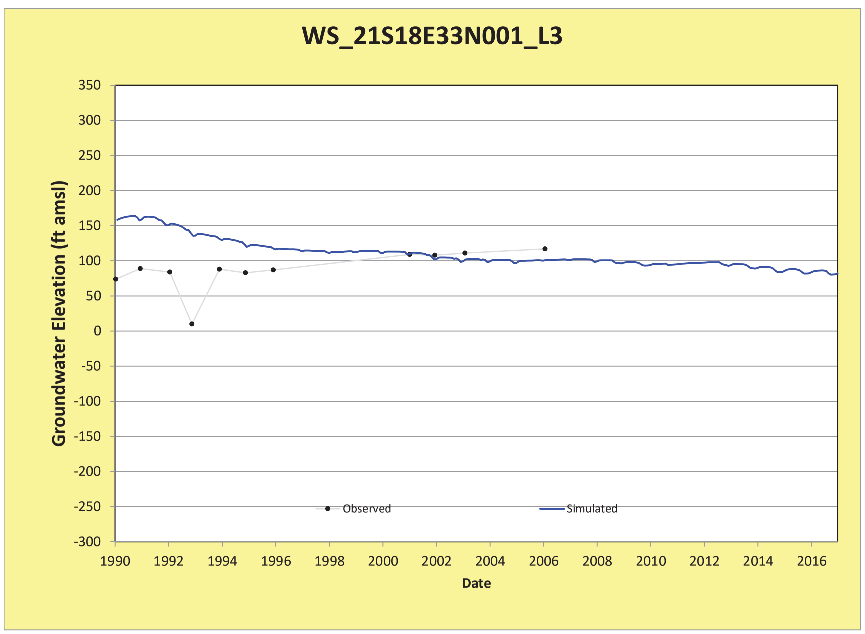
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Groundwater Elevation (ft amsl)
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Observed
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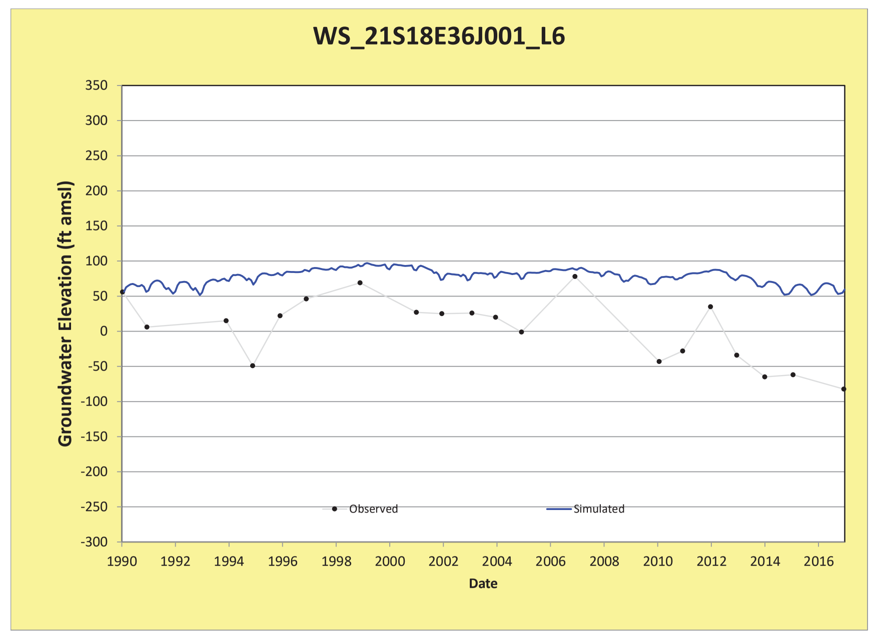
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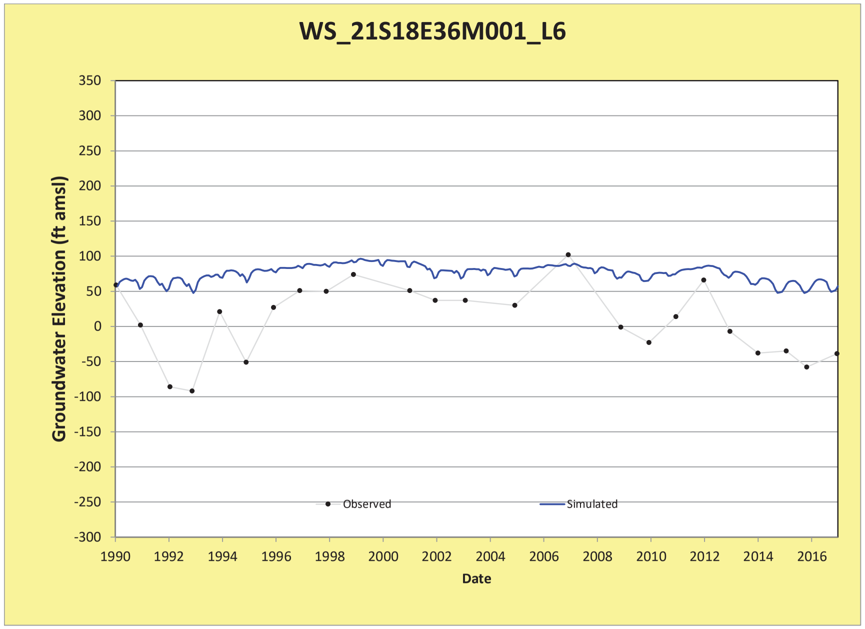
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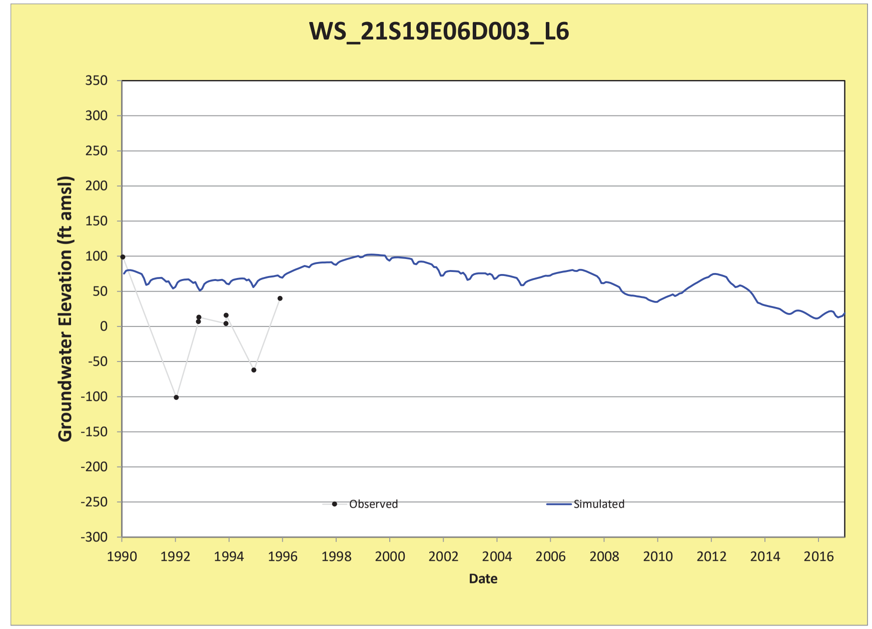
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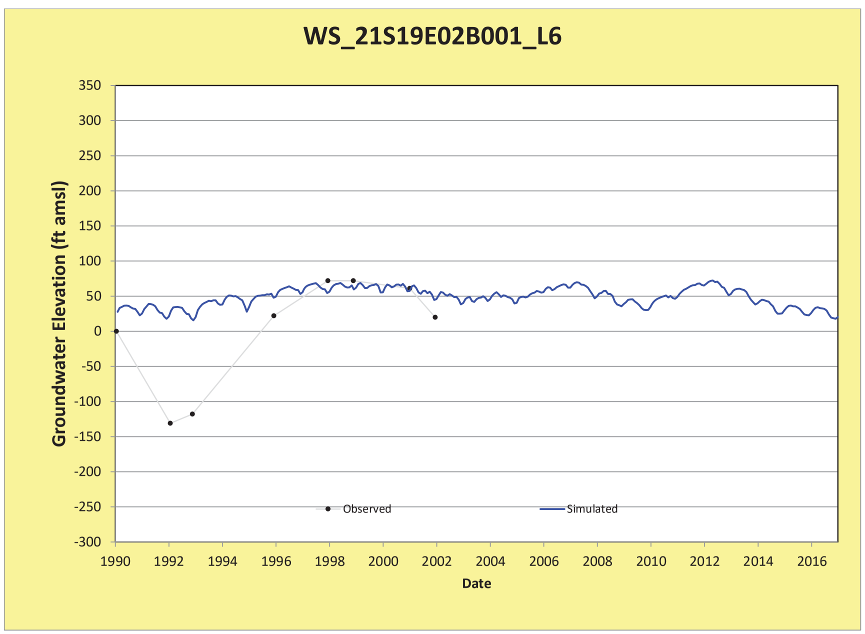
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Observed
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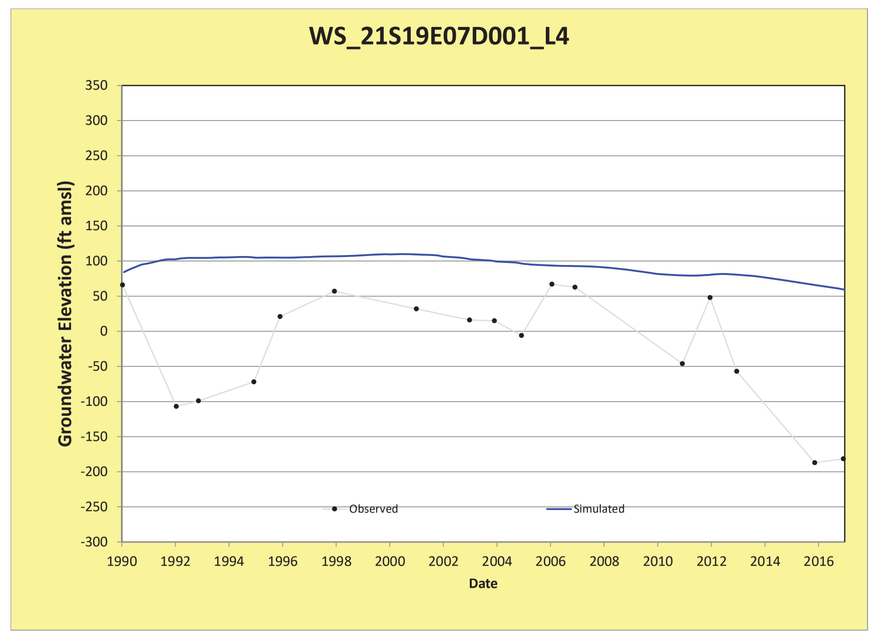
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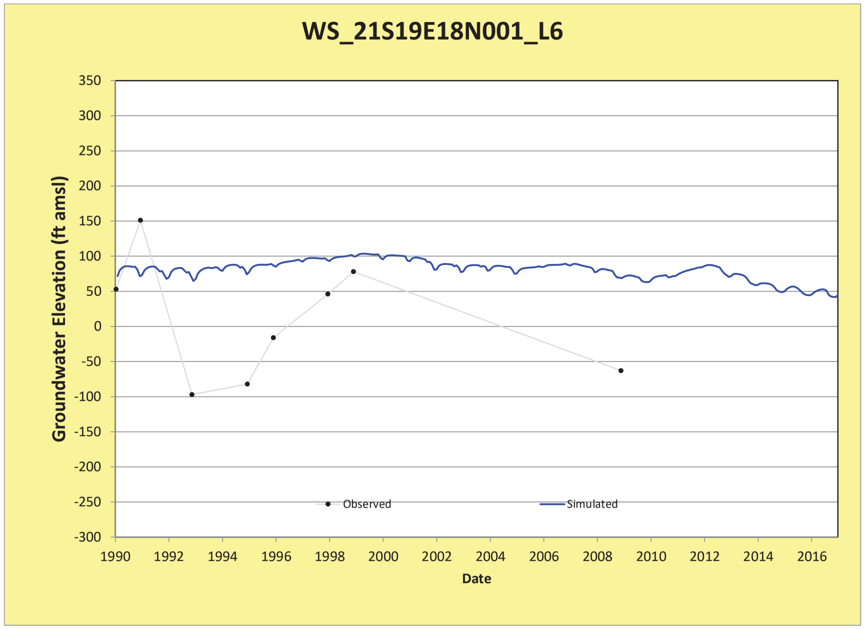
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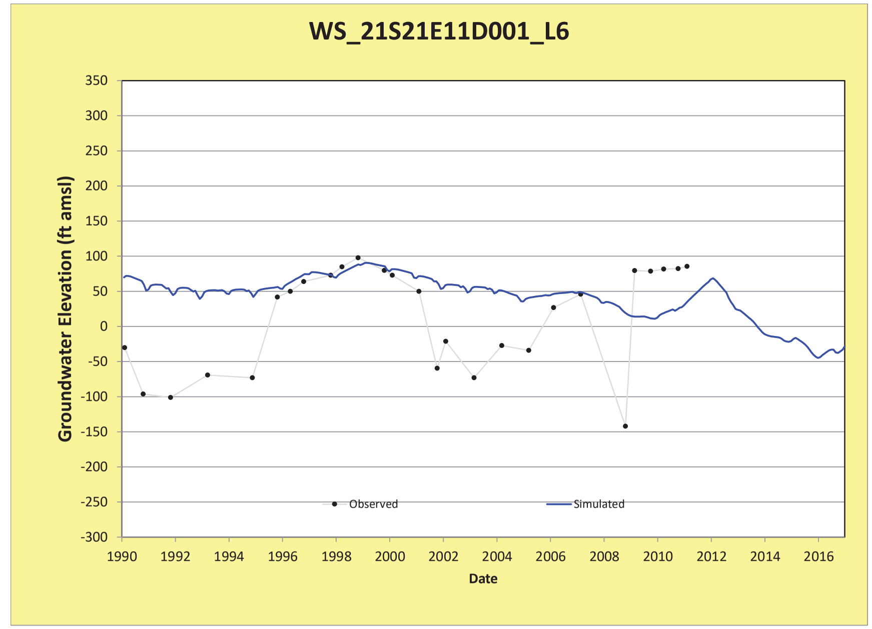
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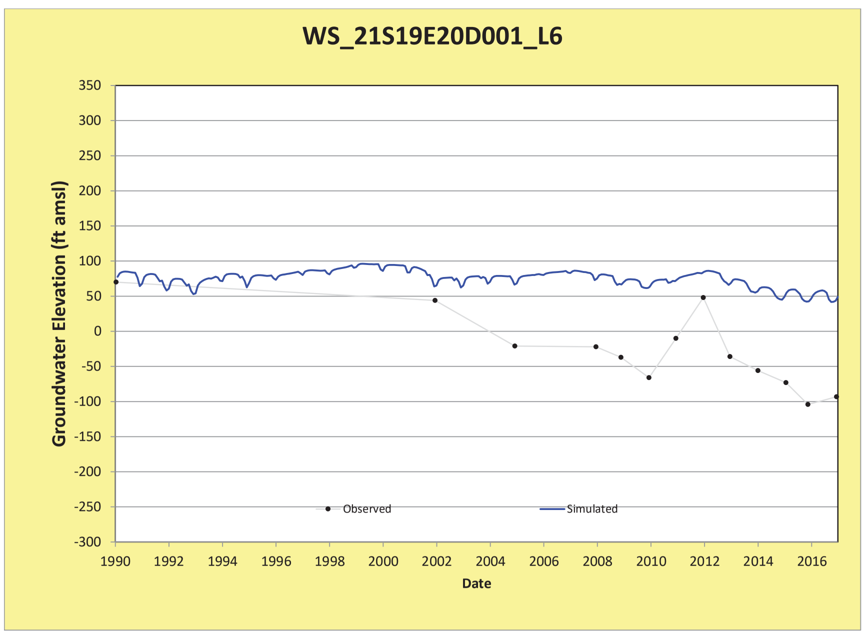
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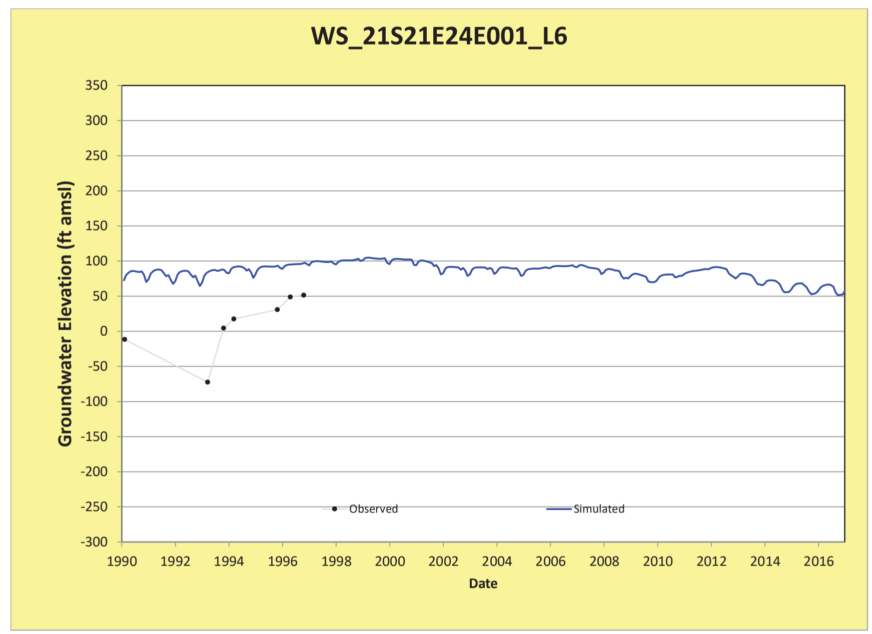
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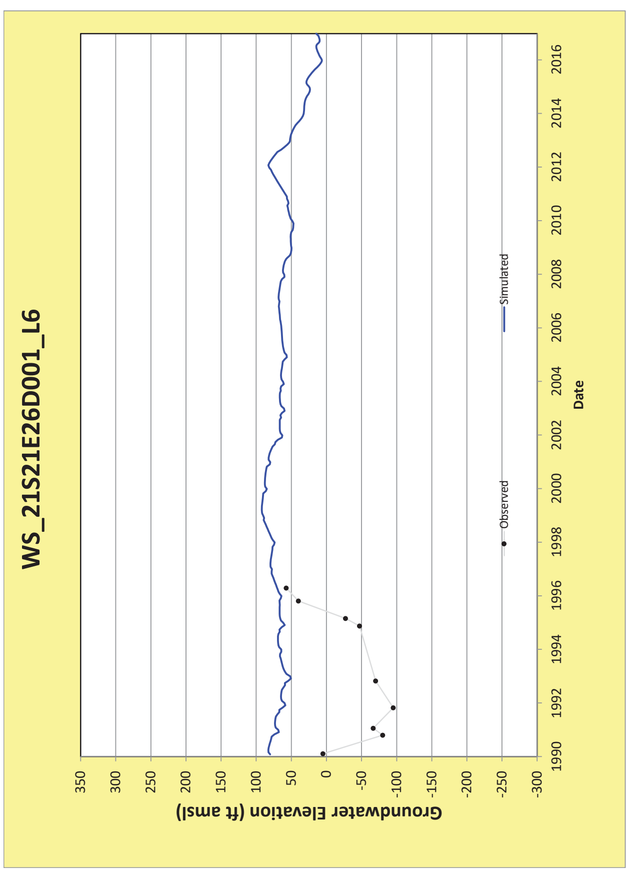
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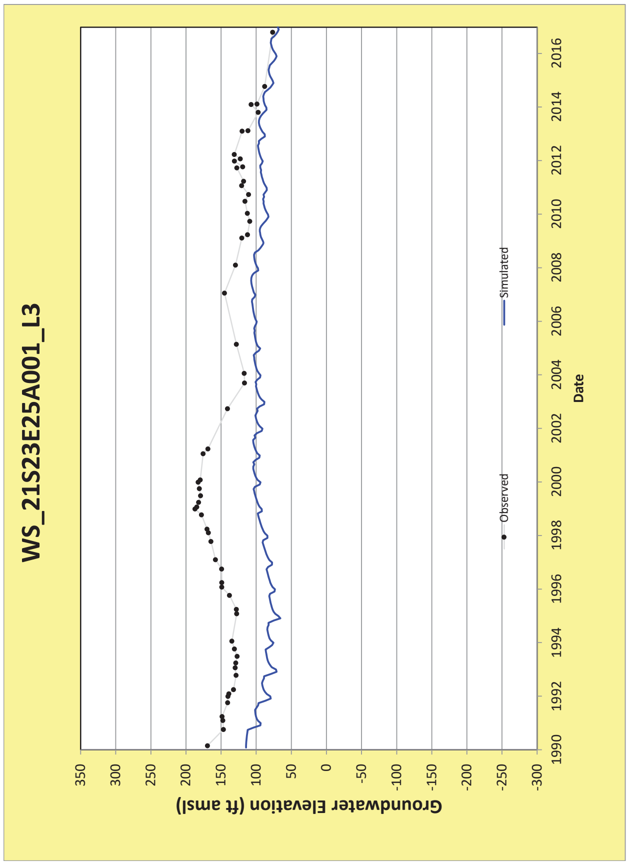
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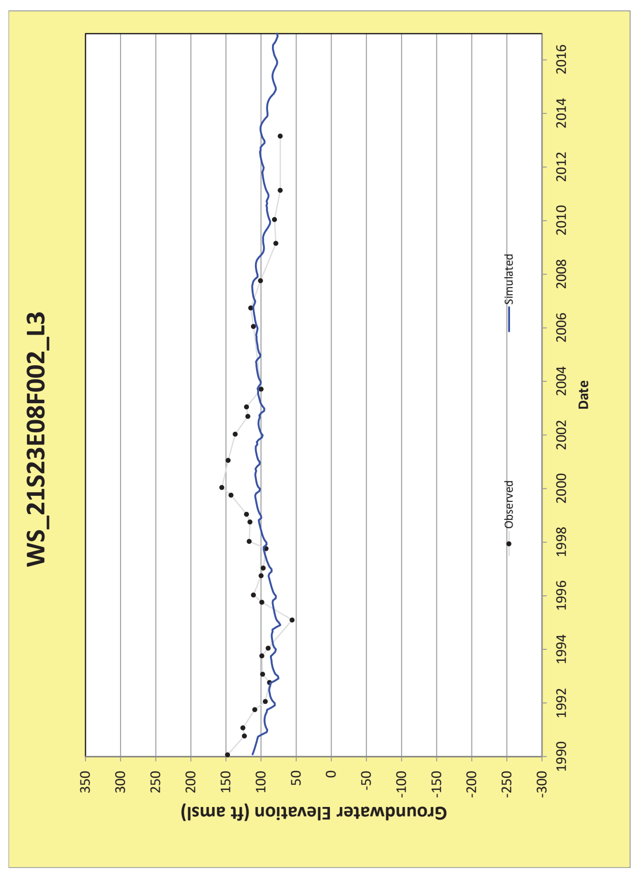
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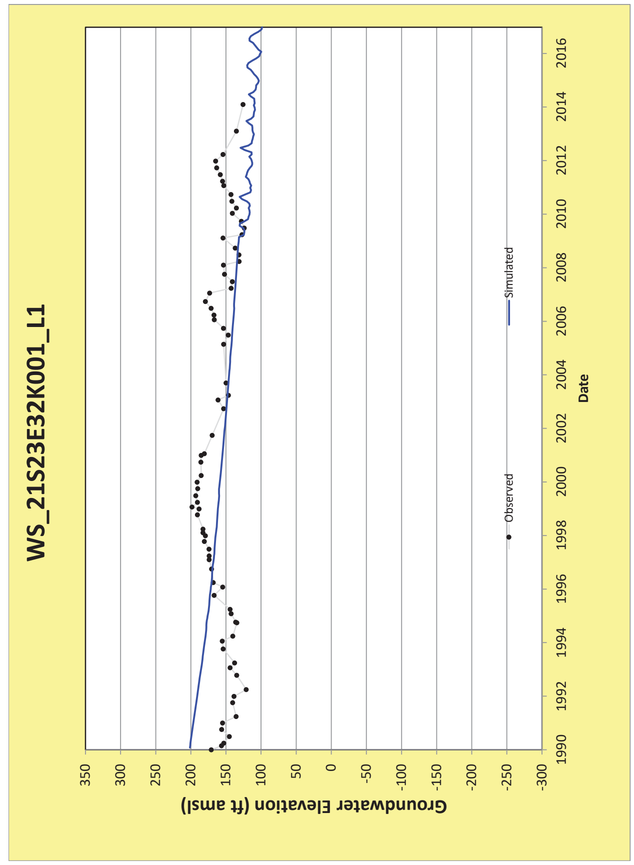
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Groundwater Elevation (ft amsl)
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Observed
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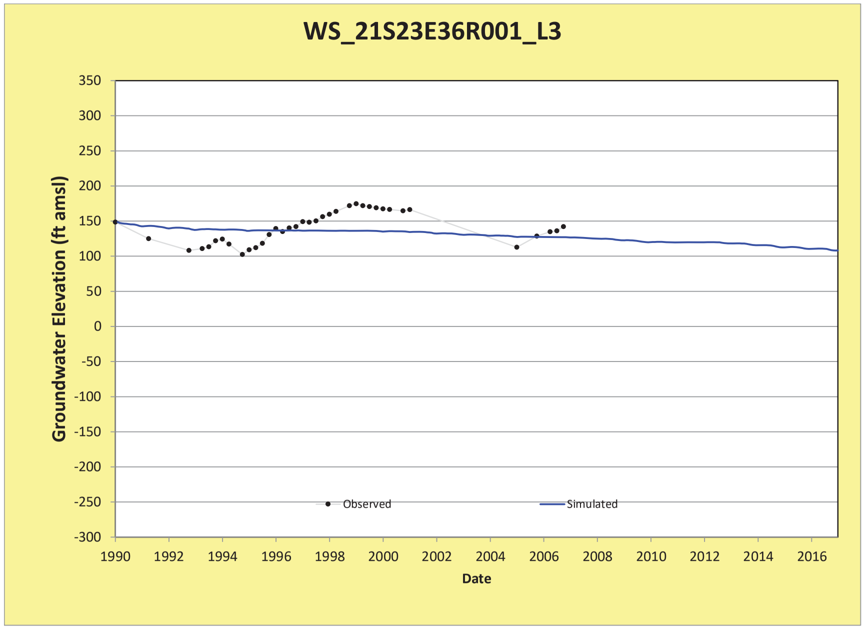
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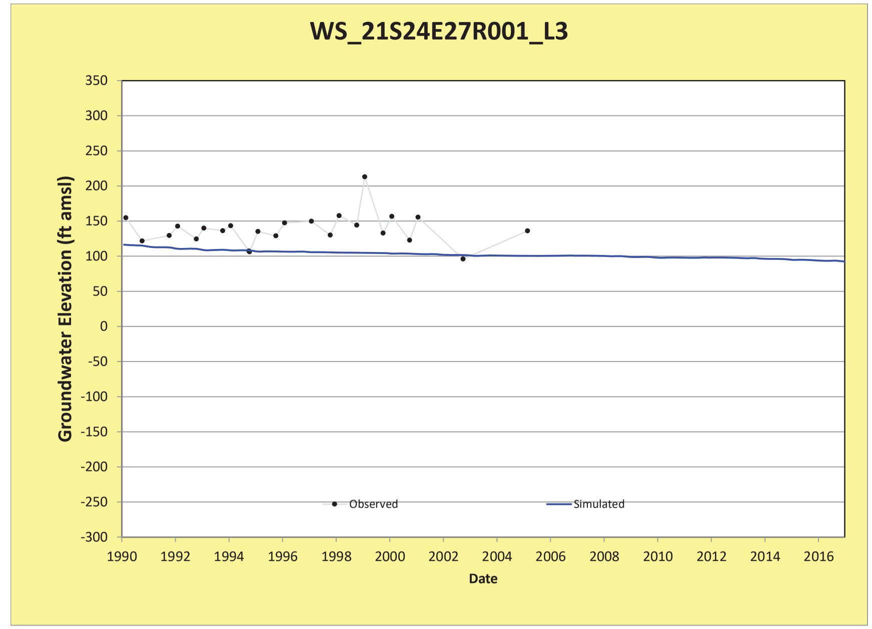
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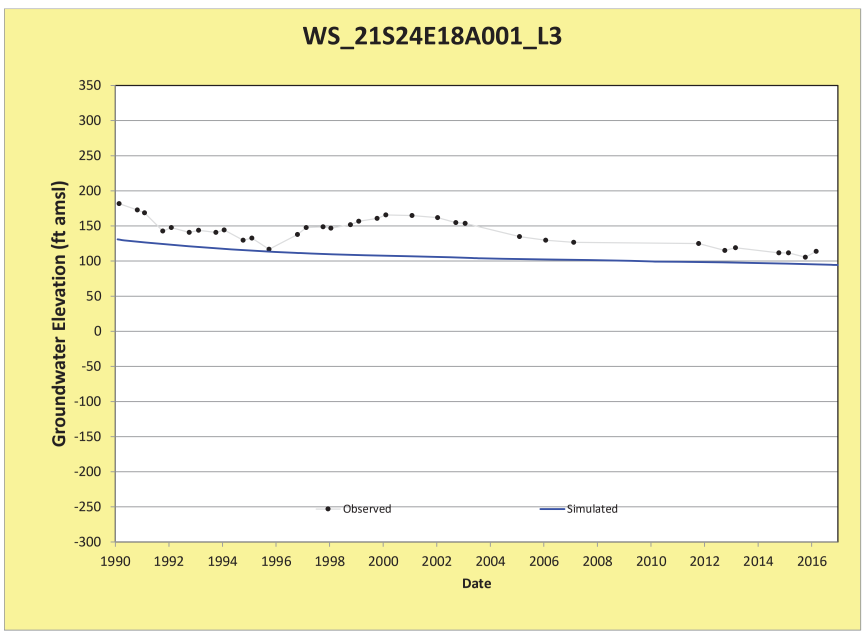
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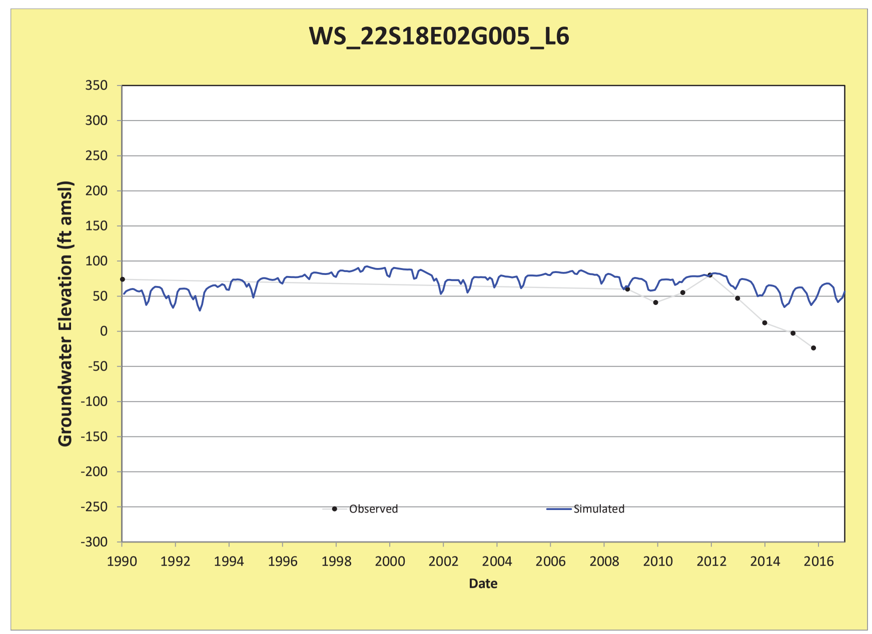
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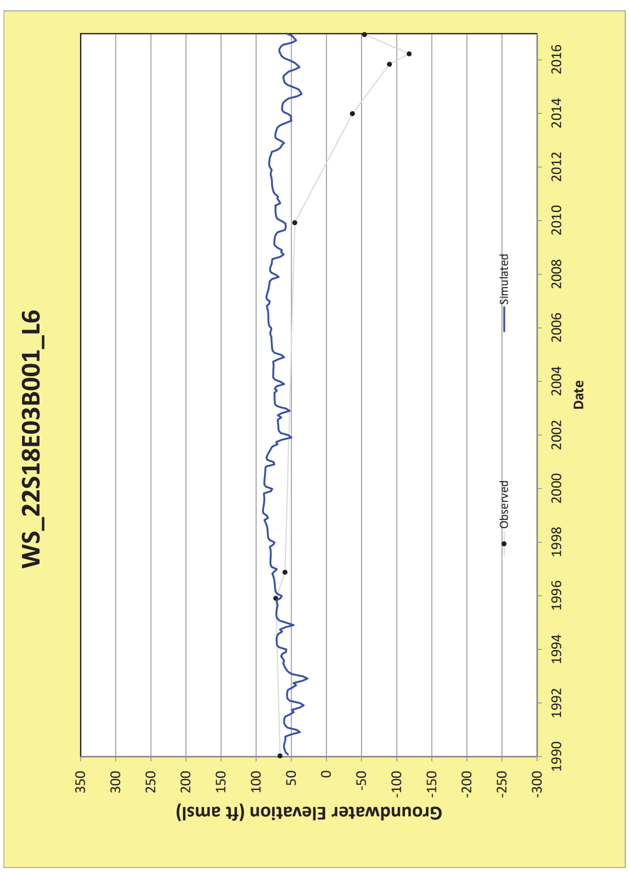
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Groundwater Elevation (ft amsl)
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Observed
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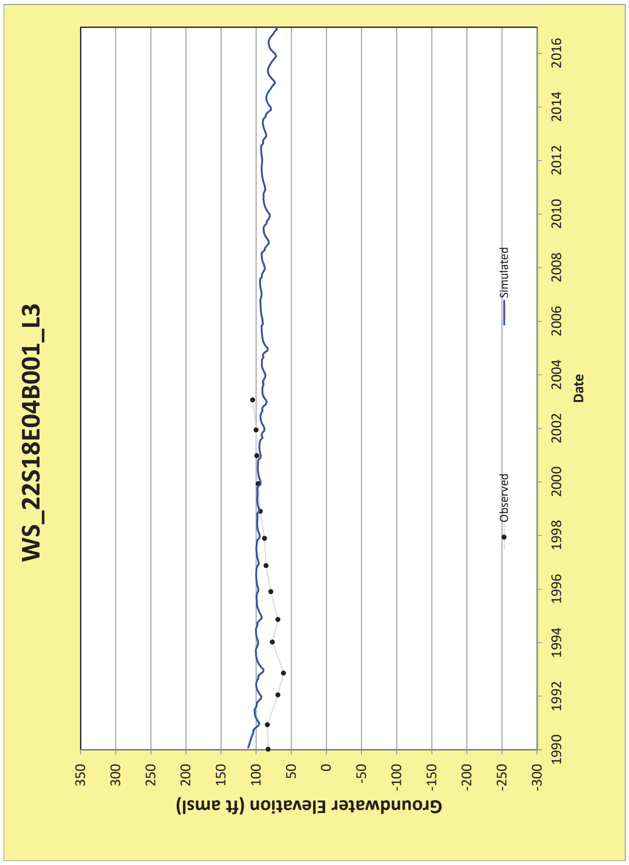
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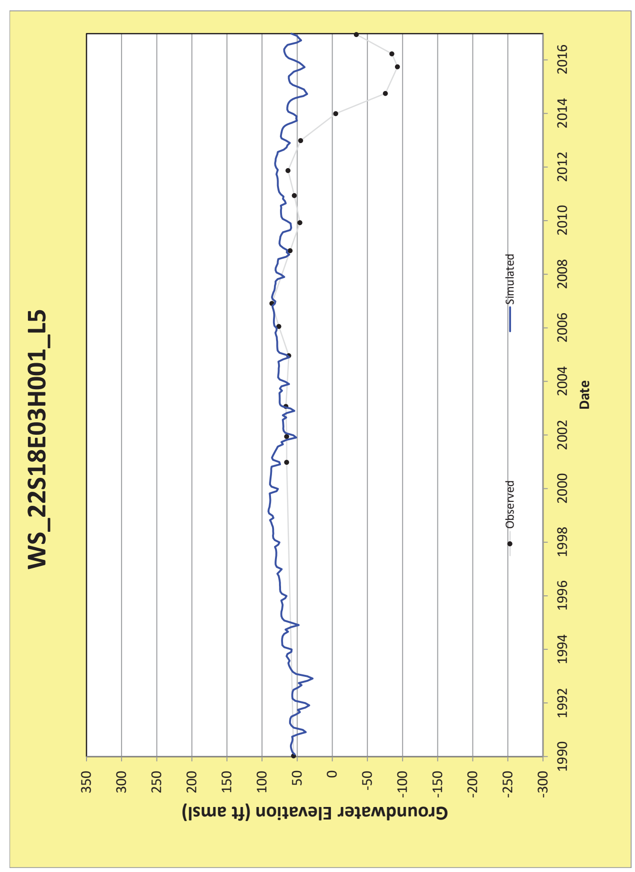
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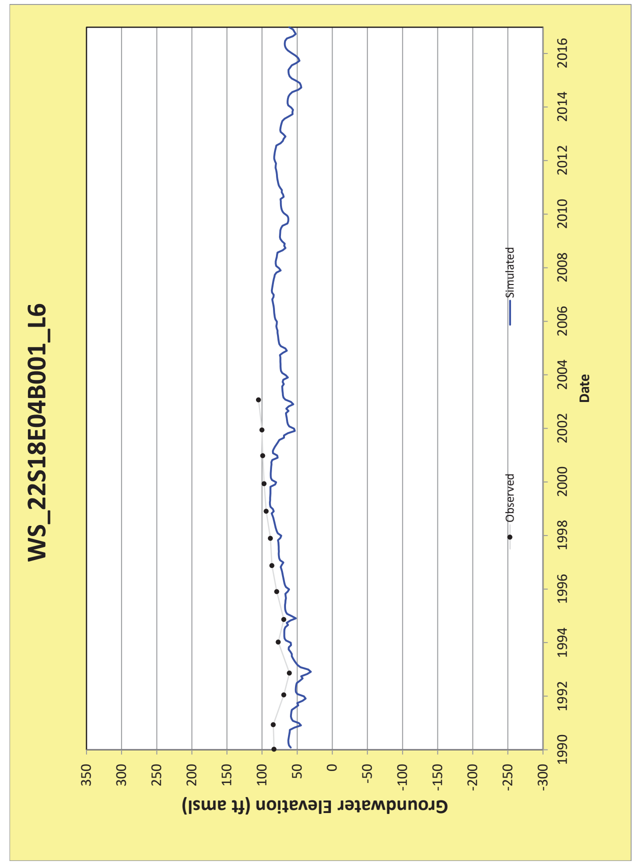
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Groundwater Elevation (ft amsl)
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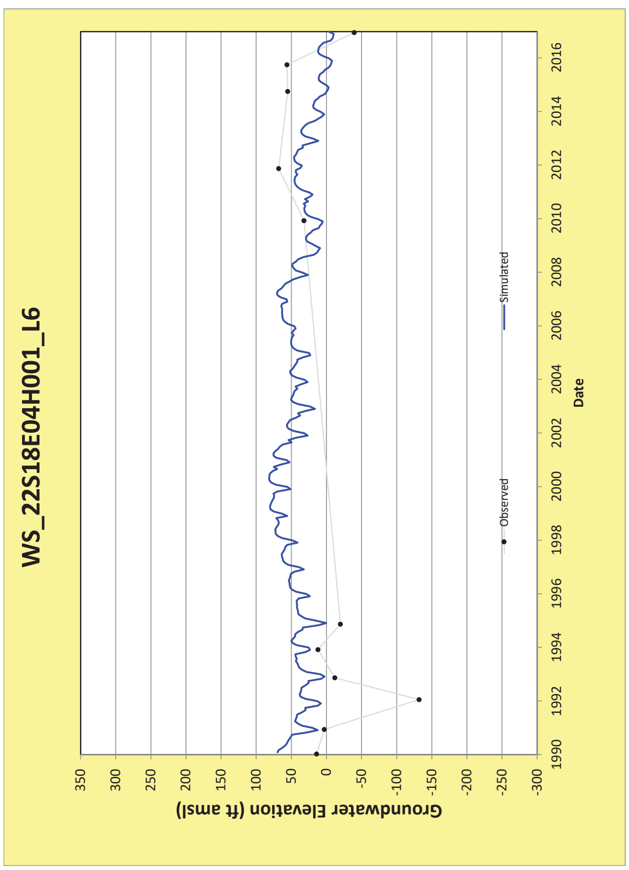
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Groundwater Elevation (ft amsl)
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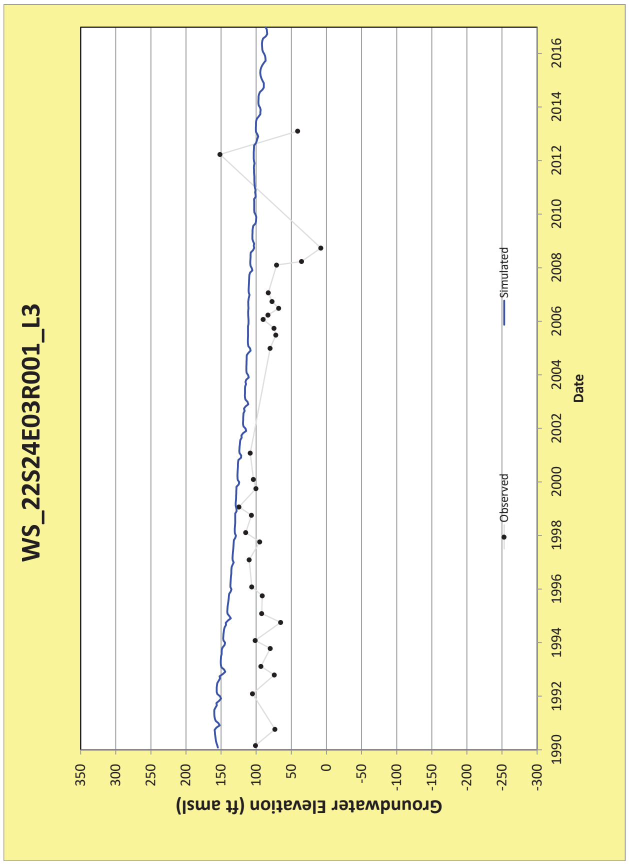
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Groundwater Elevation (ft amsl)
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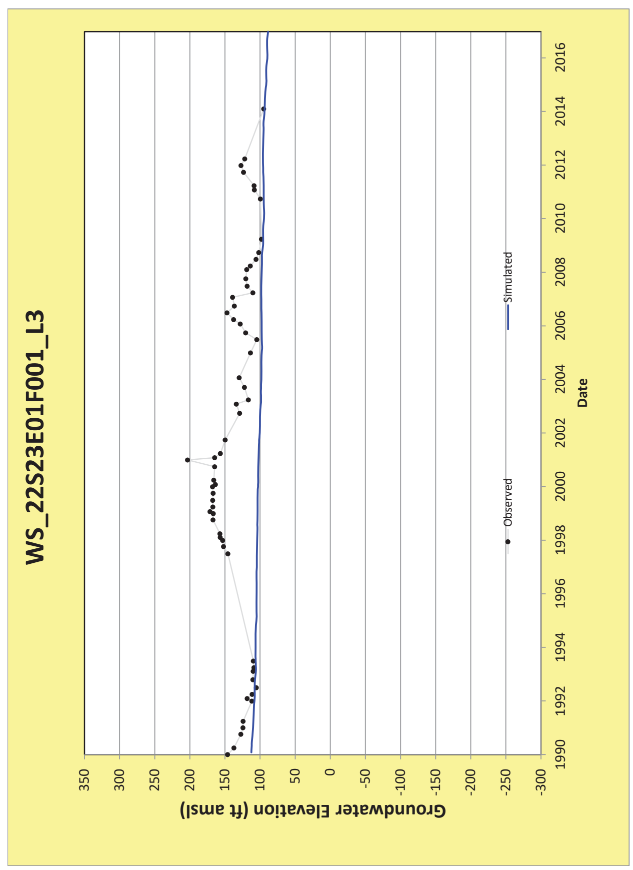
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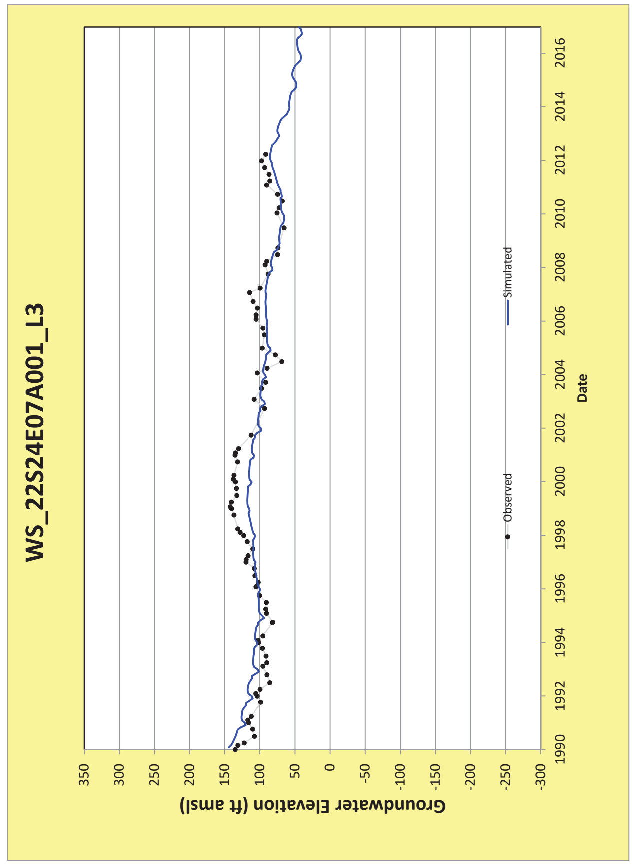
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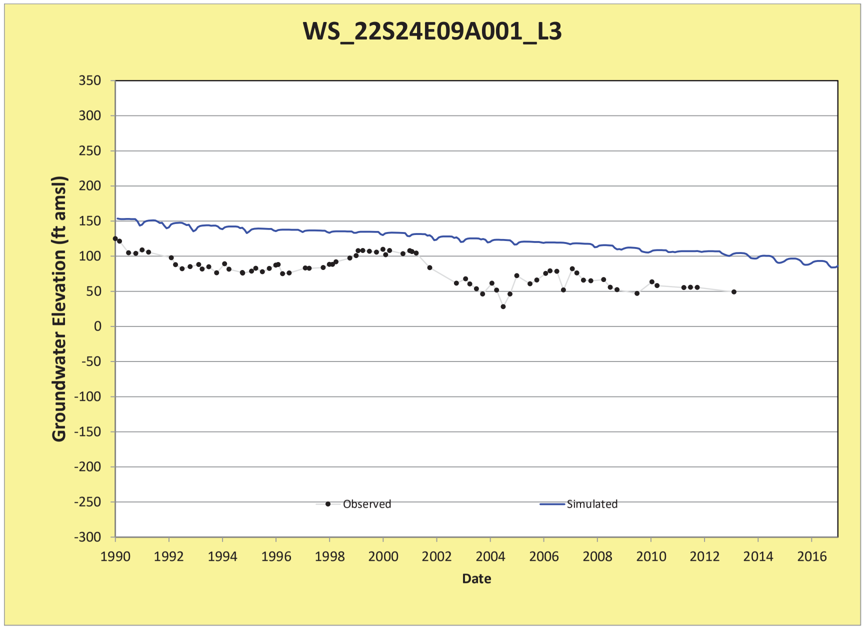
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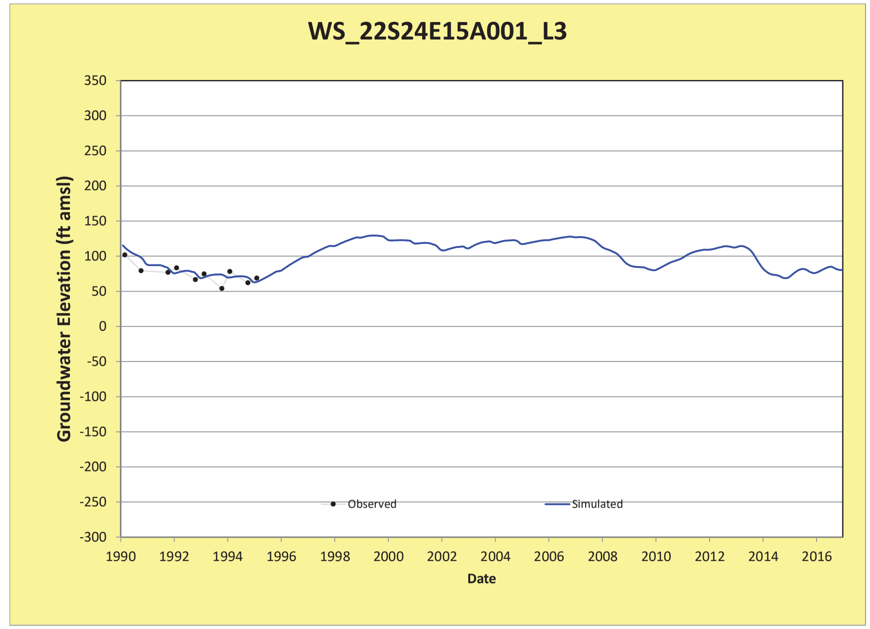
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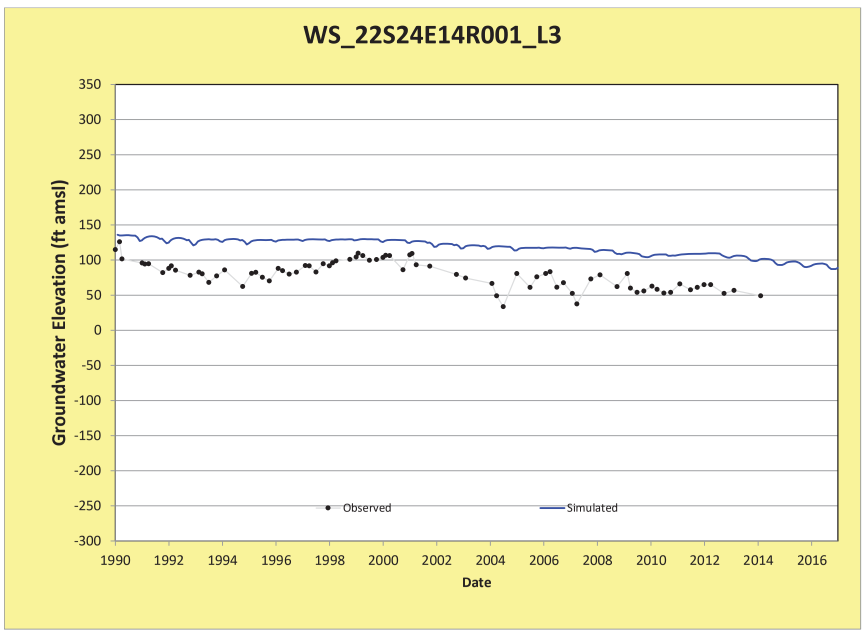
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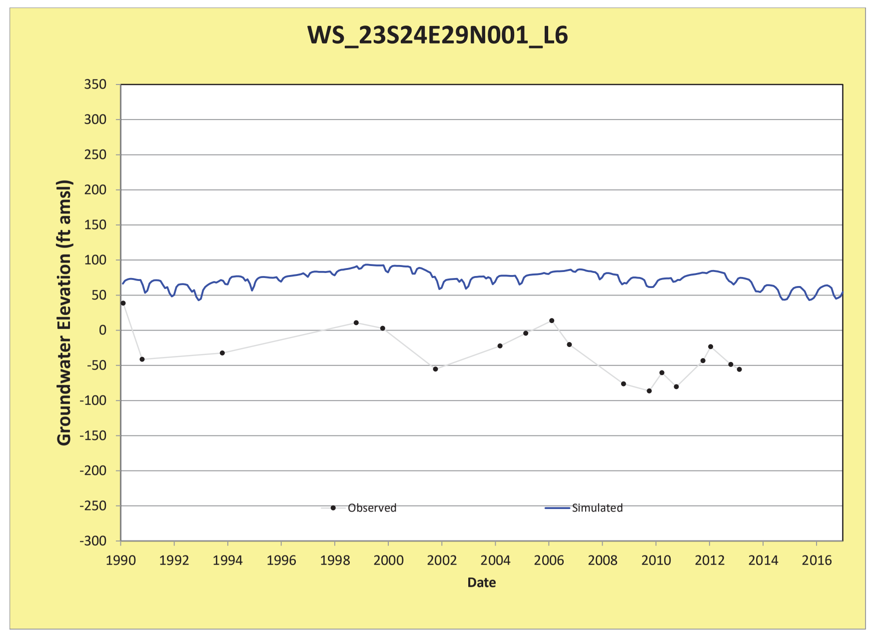
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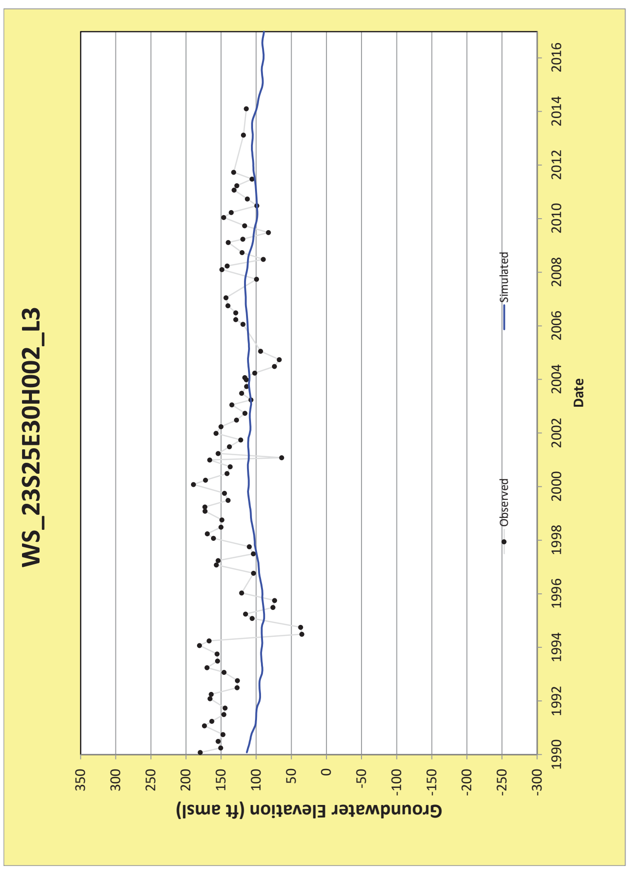
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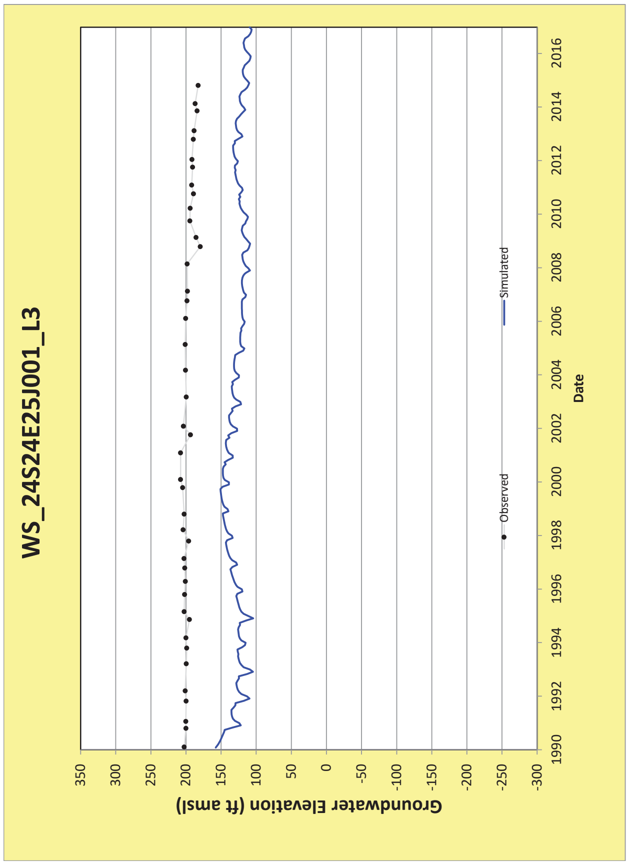
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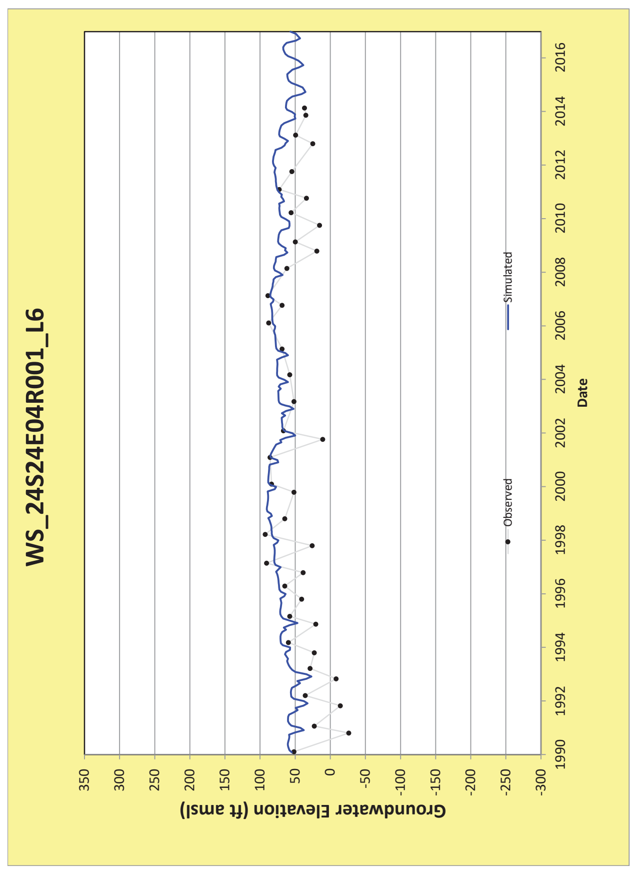
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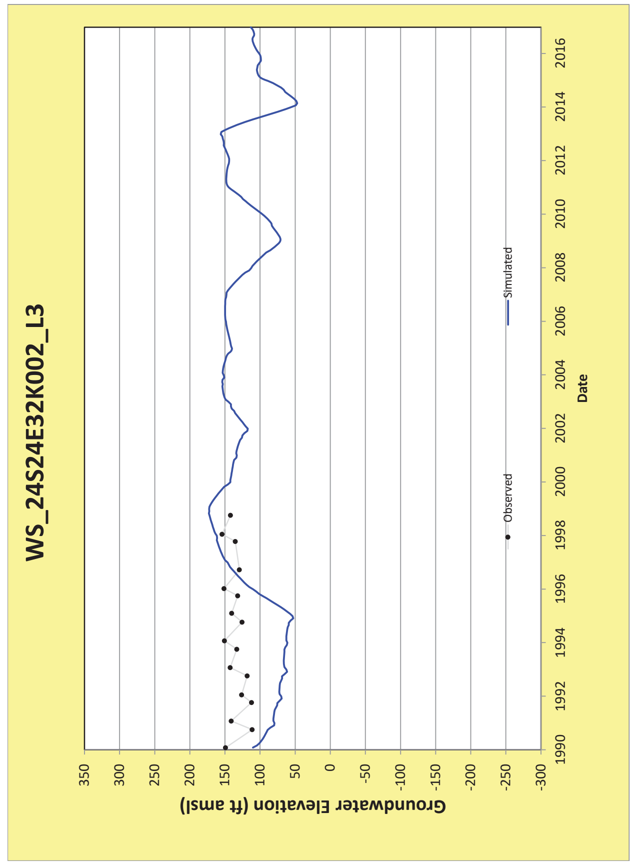
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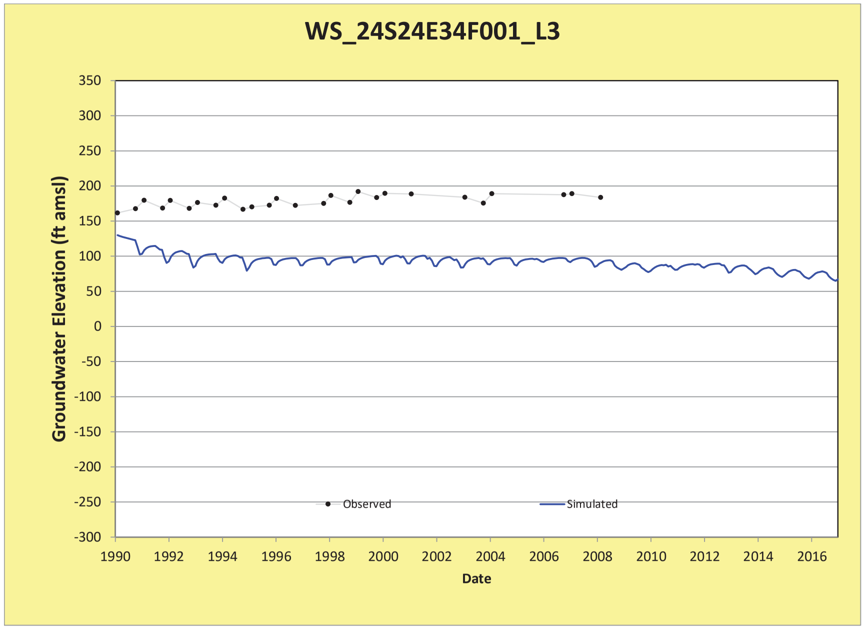
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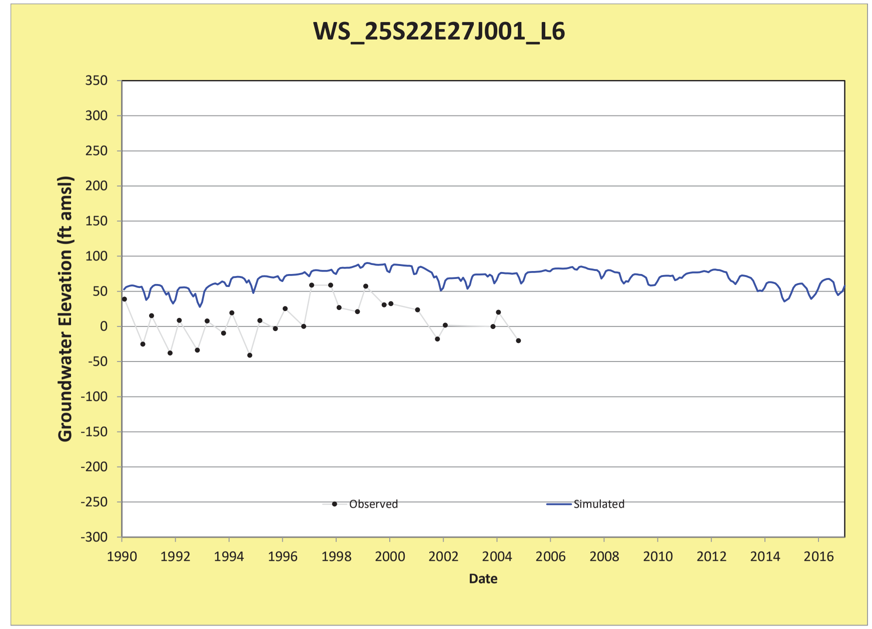
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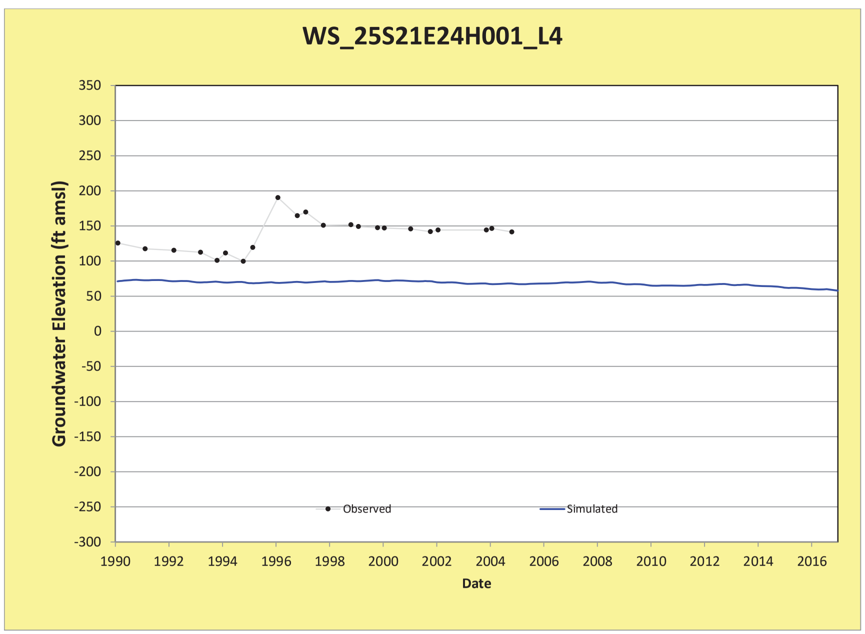
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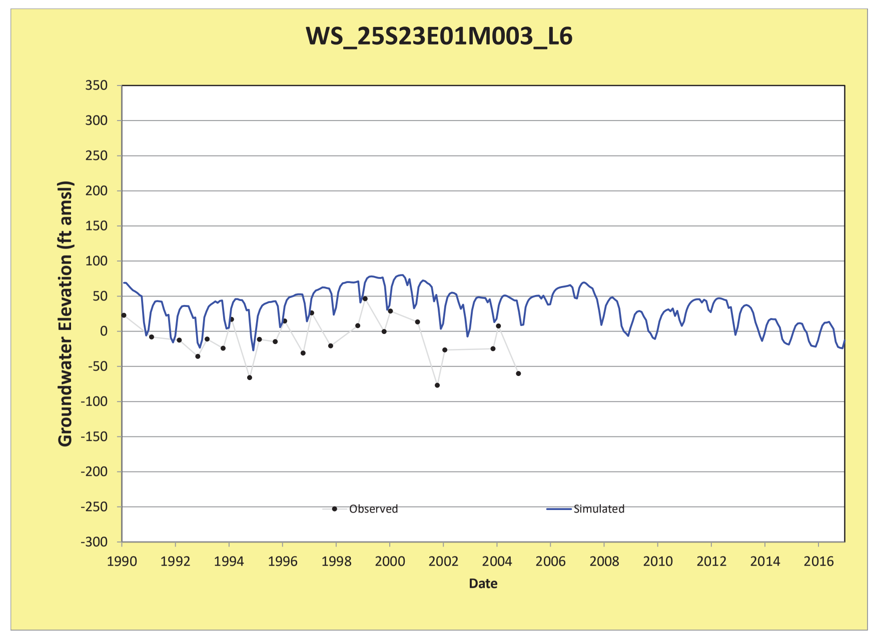
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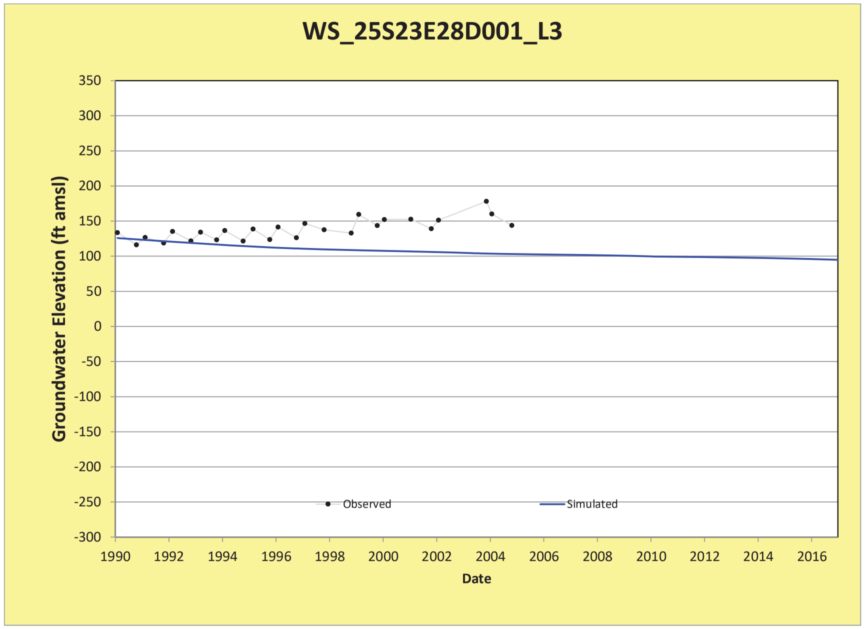

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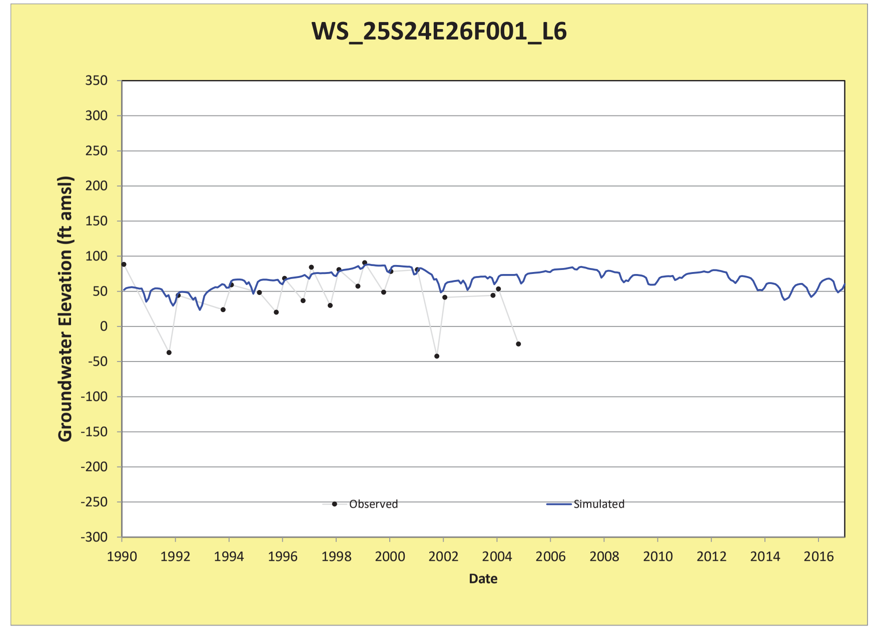

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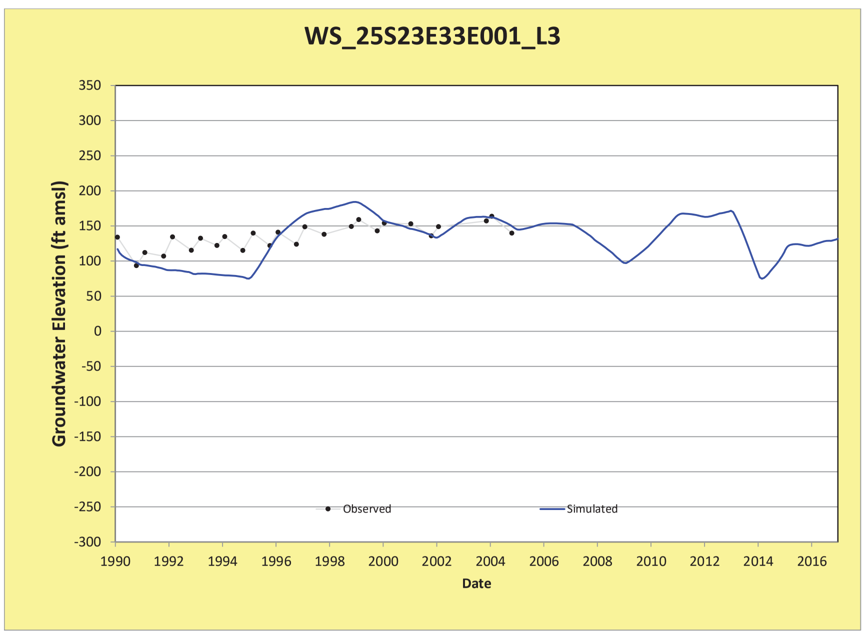

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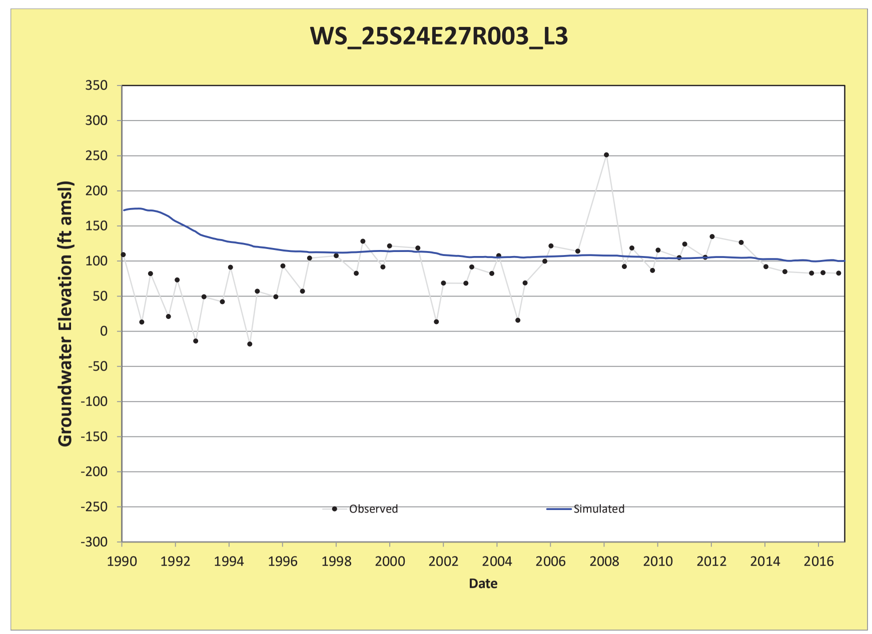

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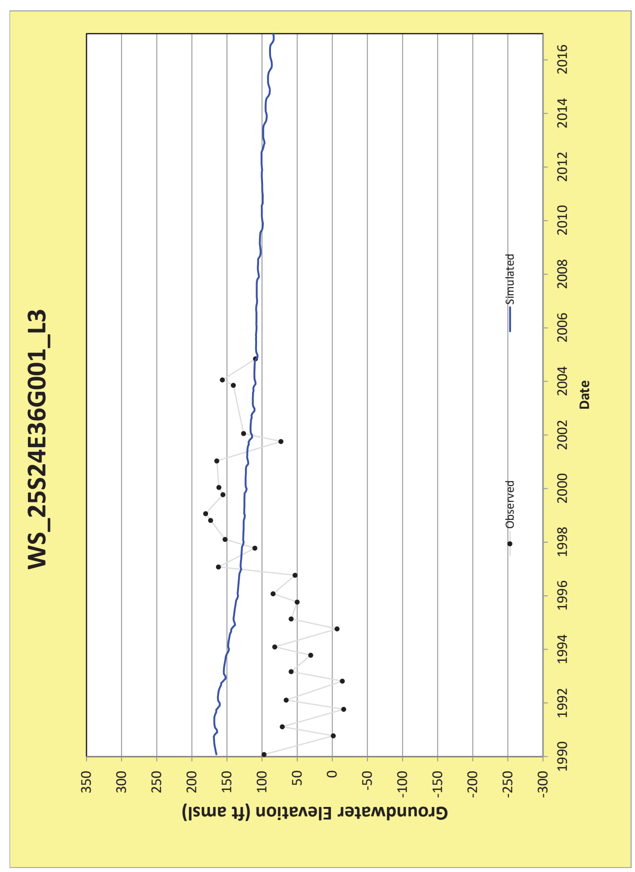

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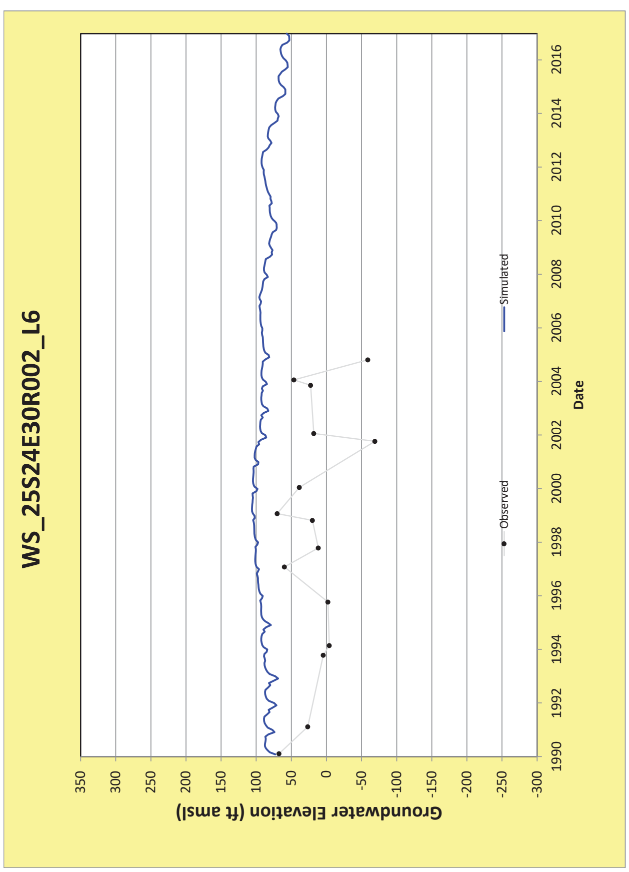

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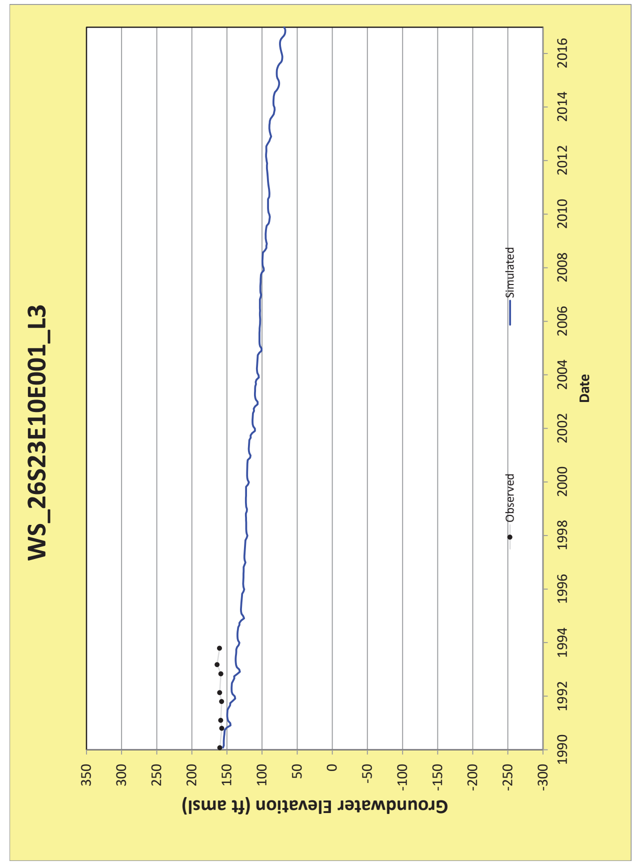

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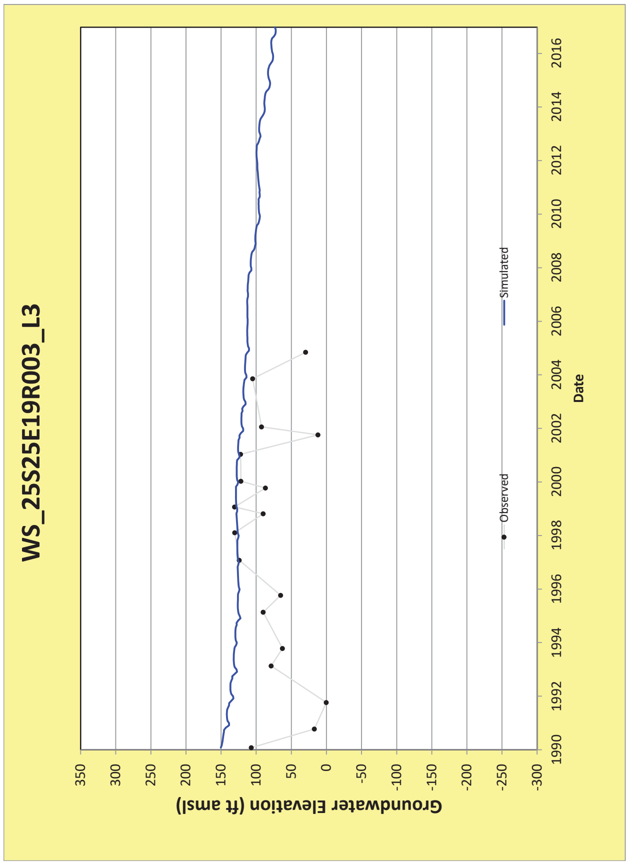

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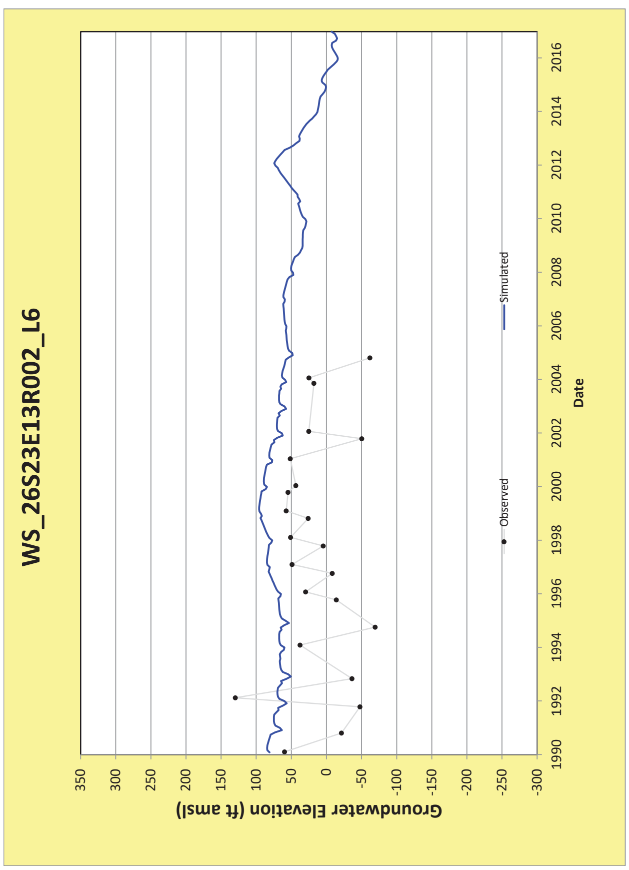

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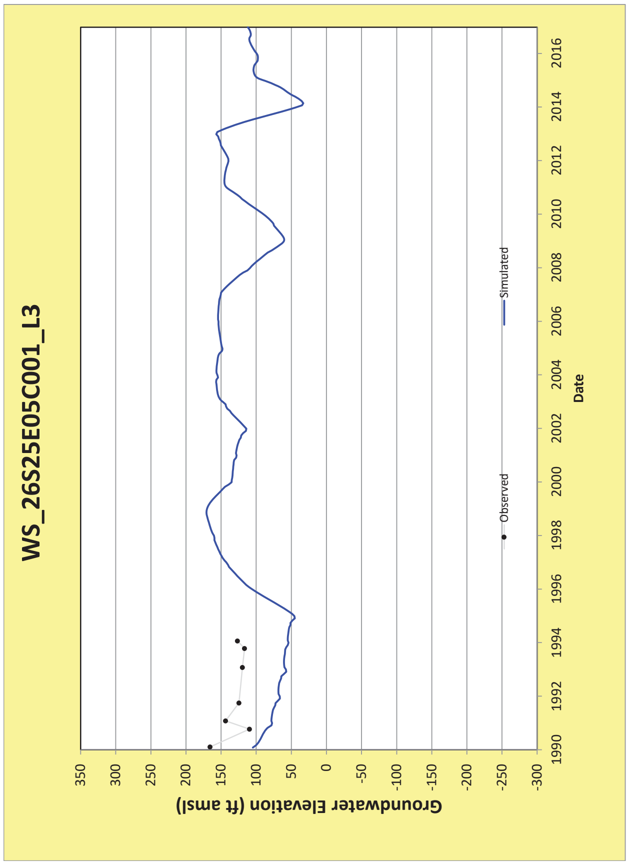

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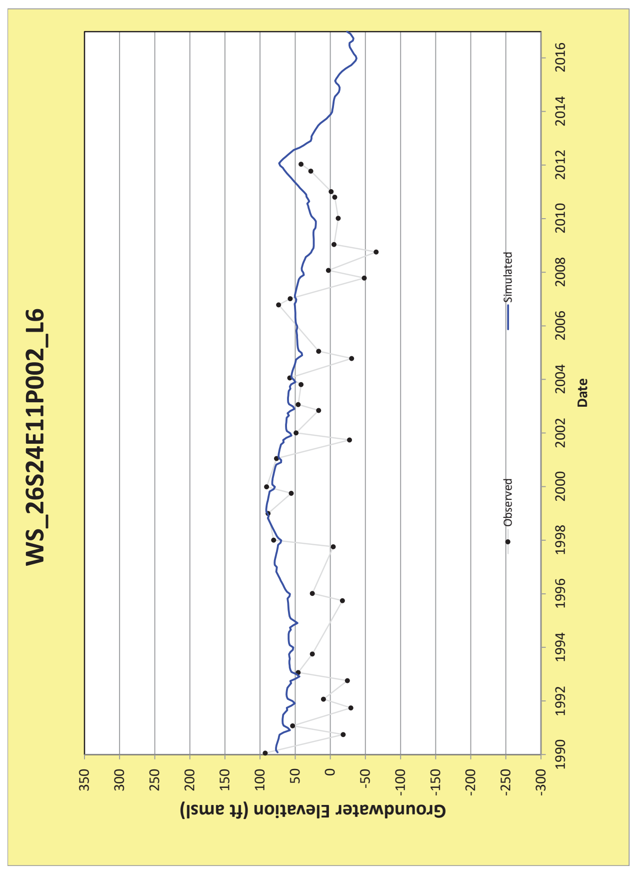

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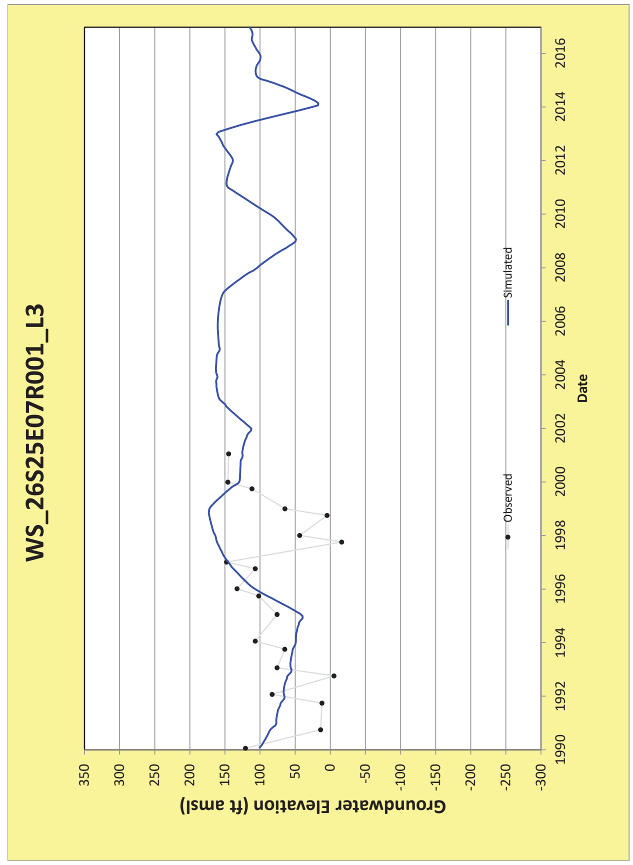

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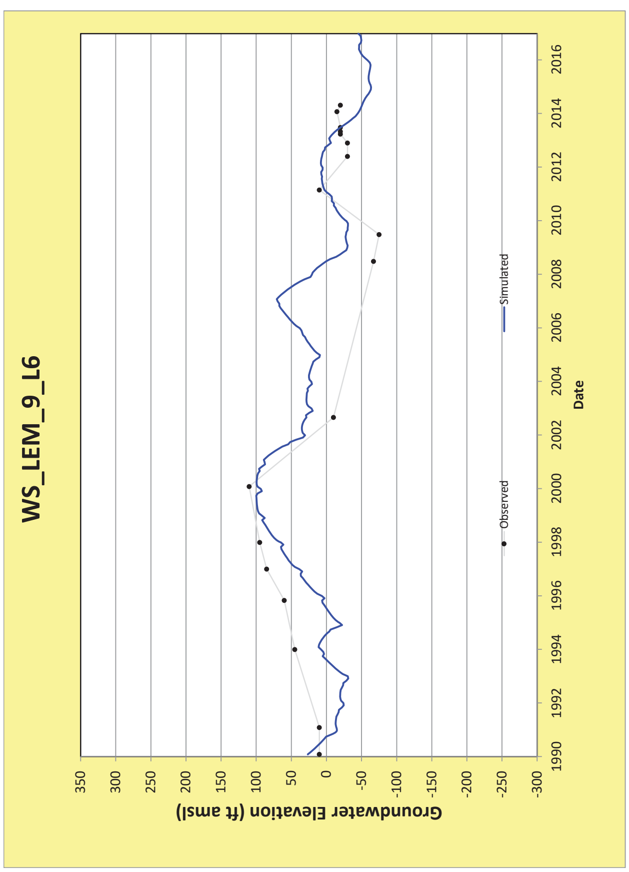
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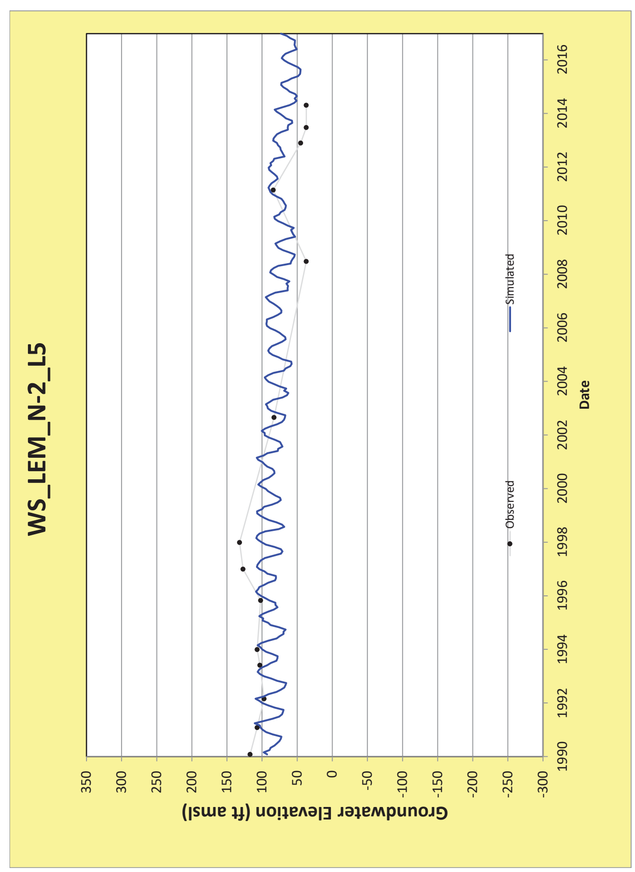
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Appendix D6

Peer Review of TLSBHM

GSA GeoSystems Analysis, Inc.
Innovations in Hydrology

08 November 2019

Bill Pipes
Principal Hydrogeologist
Wood Plc.
1281 East Alluvial Avenue, Suite 101
Fresno, CA 93720-2659

Re: Kings County – Tulare Lake Subbasin GSP Project: Groundwater Model Peer Review

As requested, I performed a technical peer review of the Tulare Lake Subbasin Hydrologic Model (TLSBHM) and associated report developed by Wood Environment & Infrastructure Solutions, Inc. ("Wood"). This model has been and is continuing to be utilized as a tool for evaluation of hydrologic impacts of future water management scenarios being considered as part of the Groundwater Sustainability Plan (GSP) for the Tulare Lake Subbasin (TLSB) as part of the required Sustainable Groundwater Management Act (SGMA) implementation for that planning region. My review focused of four aspects of the model, specifically:

- the model objectives,
- the Hydrogeologic Conceptual Model (HCM) of the TLSB,
- the development and documentation of numerical groundwater model as a predictive simulation tool based on the HCM, and
- documentation of model development and application in a report that is included as an appendix as part of the final GSP report.

Each of these topics is discussed in separate subsections below.

<u>Model Objectives</u>

Model objectives are clearly stated in Section 1.2, and importantly the stated objectives are consistent with model requirements define in the SGMA (Sustainable Groundwater Management Act of 2014) regulations. Specifically, as required by SGMA, the stated objectives include development of a model capable of forecasting groundwater management actions over a 50-year planning horizon (Cal. Water Code §10727.2(c)), establishment of measurable objectives and critical / minimum thresholds (Cal. Code of Regulations, "CCR," §354.29 and CCR §354.30), and development of a numerical model to quantify and evaluate projected water budget conditions (CCR §354.18).

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Tucson, Arizona 85716

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fax: 520-628-1122

Hydrogeologic Conceptual Model

A hydrogeologic conceptual model (HCM) is the fundamental basis upon which a numerical model of groundwater flow is based. The HCM is basically a narrative description of the physical system, including:

- the areal extent of the model (typically referred to as the model domain)
- the hydrostratigraphic units within the model domain, including a description of the spatial distribution (area covered, depth, continuity, and thickness)
- the water sources and sink, also referred to as the inflows and outflows, within the model domain
- a description of the flow system functioning, and a preliminary water budget.

Section 2 of the Wood report covers the HCM, utilizing block diagrams to illustrate key flow components under both pre-development and developed conditions. The report section on the HCM covers all items listed above, including a narrative description of the evolution and chronology of hydrogeologic conditions in the basin / study area since development began. The conceptual model describes all recharge sources and surface water sources available and applied to meet water demands in the study area. Land subsidence due to groundwater withdrawal is explicitly described in the HCM, setting the stage for explicit simulation of subsidence in the TLSB numerical model. The HCM section also includes a separate subsection on the basin water budget, citing ranges of values for each of the inflow and outflow components. It is recommended that a table be added that summaries the preliminary water budget documented in the HCM section.

Development and Documentation of Numerical Groundwater Model

As previously noted, CCR §354.18 requires the development of a model to quantify and evaluate projected water budget conditions for the GSP. While a simple spreadsheet model can be employed for development of historical water budgets based on available data, a more quantitative approach is need for predict basin sustainability into future conditions. A numerical model is the most common tool employed for quantitative predictions of basin response to future stresses. Per SGMA requirements, the numerical model must: include publicly available supporting documentation; be based on field or laboratory measurements and calibrated against site specific field data; and developed using public domain, open-source software (CCR §352.4(f)(1-3)) As part of the model documentation, the Wood (2019) groundwater model report notes that the model was developed using the MODFLOW-2005-NWT code, and cites publicly available background documents related to this code, its mathematical development, capabilities, and user guide. The Wood (2019) report also describes the preliminary application of the MODFLOW-OWHM code, and explains why that code ultimately was not utilized for this current phase of the TLSB GSP project. The "Model Design" section of the Wood (2019) report provides a detailed description of each of the key model inputs and data sources for assigning/developing input values, including all the boundary conditions used. The methodology employed to develop agricultural pumping estimates are well-described, as well as the methodology for accounting for in-basin storage and management of excess surface inflows in wet years (for subsequent irrigation when surface inflow supplies are insufficient to meet demands).

The model calibration section describes in detail calibration criteria employed, as well as a description of the calibration data. It appears that that significant effort was invested in gathering and compiling whatever calibration data could be obtained from public sources, as well as from stakeholders / participants in the GSP process. For example, the 1990 – 2016 calibration period included 16,621 groundwater level observations collected from 593 observation wells across the model domain. The 1998 – 2010 "normal hydrology" calibration period included 7,028 groundwater level observations collected from 544 observation wells across the model domain. Wood (2019) also note that additional data was available and reviewed as part of the calibration process, but ultimately was not used due to data uncertainty / data quality concerns. The trial & error calibration procedure is well described, and plots are presented showing "goodness-of-fit for wells employed in the calibration process. The final calibration statistics are presented, showing that the final calibrated model generally meets defined criteria for an adequately calibrated model (e.g., Normalized Root Mean Squared Error < 10%).

Detailed water balance results are presented for the calibrated model, including for interactions between the TLSB and adjacent subbasins in the southern San Joaquin Valley. The calibration model simulated subsidence is also presented, although Wood (2019) notes that additional calibration of the model to observed subsidence is needed.

Consistent with good model practice, a model parameter sensitivity analysis is presented to show that the sensitivity of the model results to changes in hydraulic conductivity and storage parameters. The sensitivity analysis showed the calibrated model to be quite robust to changes in model parameters, and the importance of the Kv parameter of the Corcoran Clay layer, and Kh for the shallow and deeper aquifers (above and below the Corcoran, respectively).

Finally, the Wood (2019) report summarizes forecast models to predictive TLSB hydrologic condition 50 years into the future under two future scenarios:

- a Baseline Forecast scenario projecting current cropping patterns into the future, a slow growth rate in municipal pumping(0.3% per year) with a 50-year hydrology driver that accounts for climate change following the guidelines of the California Natural Resources Association (CNRA) for applying "change factors" to historical precipitation, ET demand, and surface water delivery data to make historical data consistent with forecasted conditions under climate change.
- multiple Project Forecast simulations; that involved by modifying the Baseline Forecast and incorporating various potential projects and management actions developed by the GSAs for the TLSB and surrounding subbasins. Potential projects and management action considered include: (i) Above ground surface water storage projects, (ii) Intentional recharge basins, (iii) On-Farm Recharge, (iv) Aquifer Storage and Recovery (ASR), and (v) Agricultural demand reductions.

The results for the Forecast model results include projected water budgets into the future, as well as piezometric levels and changes to basin storage (both elastic and inelastic) for the Baseline and Sustainability Project scenarios. The forecast model results are also presented for water level hydrographs for selected Compliance Wells (which were identified in the main body of the GSP report) in Figures 7-6 and 7-15 and predicted subsidence for Subsidence Compliance

Monitoring points (Figures 7-8 and 7-17). Identification of and calculation of responses at designated Compliance Monitoring points meets the SGMA requirement that the model be able to quantify Sustainability Indicators (23 CCR §354.28(b)), which are clearly defined in Chapter 4 of the GSP report.

Summary

The TLSB groundwater model developed to support groundwater sustainability planning for the TLSB was reviewed and evaluated against explicit needs and requirements for basin sustainability planning under SGMA. Based on this Peer Review of the model, it was found that the model was developed following good groundwater modeling practice in terms of compilation and integration of historical available data and information, groundwater calibration criteria, sustainability analyses, forecasts of future conditions under Baseline and implementation of sustainability Projects, and clear documentation of model development and application. As required under SGMA, the model develops a rigorous groundwater budget under the historical calibration period as well as under the two future Forecast scenarios (Baseline and Project). In addition, it also quantifies groundwater response at key monitoring points in the basin in the context of sustainability criteria and thresholds identified in Chapter 4 of the GSP.

If you have any questions, please do not hesitate to contact me. As always, we appreciate this opportunity to work with the Wood – Provost & Pritchard team.

Best Regards,

James T. McCord

Jim McCord, PhD, PE
Principal Hydrogeologist

APPENDIX E

GSP CHECKLIST

Appendix E - GSP Checklist

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
Article 5. Plan Contents, Subarticle 1. Administrative Information				
354.4	10733.2	General Information	a. Executive Summary- written in plain language b. A list of references and technical studies. Groundwater Sustainability Agencies (GSAs) must provide the California Department of Water Resources (DWR) an electronic copy of documents that are not available to the public	a. Executive Summary p. ES-1 to ES-40 b.Ch. 8, References p. 8-1 to 8-12
354.6	10733.2	Agency Information	a. GSA Mailing Address b. Organization and Management Structure including persons with management authority for Groundwater Sustainability Plan (GSP) implementation c. Contact Information of Plan Manager d. Legal Authority of GSA e. Estimate of Implementation Costs	a. Appendix A b. Section 1.4.1 (p. 1-6) c. Appendix A d. Section 1.4.2 (p. 1-6) e. Section 1.4.3 (p. 1-7)
354.8.(a)	10733.2	Map(s)	1. Area covered by GSP 2. Adjudicated areas, other agencies within the basin, and areas covered by an Alternative 3. Jurisdictional boundaries of federal or state land 4. Existing Land Use Designations & identification of water use sector/water source type 5. Density of wells per square mile	1. Chapter 2 (p. 2-1) 2. Section 2-1, (p. 2-3) 3. Section 2-1, (p. 2-3) 4. Chapter 2 (p. 2-1) 5. Chapter 2 (p. 2-2)
354.8.(b)	10733.2	Description of the Plan Area	b. Written summary of jurisdictional areas and other features	Section 2-1, (p. 2-3)

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
354.8.(c, d, e)	10733.2	Water resource monitoring and management programs	c. Description of water resources monitoring and management programs d. Description of how water resource monitoring or management programs may limit operational flexibility e. Description of Subbasin's conjunctive use programs	c. Section 2.2.1 (p. 2-10) d. Section 2.2.2 (p. 2-13) e. Section 2.2.3 (p. 2-14)
354.8.(f)	10733.2	Land Use Elements or Topic Categories of Applicable General Plans	1. Summary of general plans and other land use plans 2. Description of how implementation of the GSP may change water demands or affect achievement of sustainability and how the GSP addresses those effects 3. Description of how implementation of the GSP may affect the water supply assumptions of relevant land use plans 4. Summary of the process for permitting new or replacement wells in the basin 5. Information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management	1. Section 2.3.1 (p. 2-15) 2. Section 2.3.2 (p. 2-15) 3. Section 2.3.3 (p. 2-16) 4. Section 2.3.4 (p. 2-18) 5. Section 2.3.5 (p. 2-20)
354.8.(g)	10727.4	Additional GSP Contents	Additional GSP elements	Section 2.4 (p. 2-21)
354.10	10733.2	Notice and Communication	a. Description of beneficial uses and users b. List of public meetings c. GSP comments and responses d. Communication section including the following:	a. Section 2.5.3 (p. 2-28) and Appendix B b. Appendix B c. Appendix C D. Appendix B

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
			1. Explanation of GSA's decision making process 2. Identification of opportunities for public engagement and how public input will be used 3. How agencies will encourage diverse active involvement from community 4. How the GSAs will inform the public about progress of the GSP	1. Section 2.5.2 (p. 2-27) 2. Section 2.5.4 (p. 2-29) 3. Section 2.5.5 (p. 2-31) 4. Section 2.5.4 (p. 2-29)
Article 5. Plan Contents, Subarticle 2. Basin Setting				
354.14.(a-b)	10727.2	Hydrogeologic Conceptual Model (HCM), descriptive text	a. Hydrogeologic Conceptual Model and maps of the physical components and interaction of the surface water and groundwater systems in the basin. b. The HCM will include: 1. Regional geologic and structural setting of the Subbasin, as well as surrounding areas 2. Lateral basin boundaries including major geologic features 3. Definable bottom of the basin 4. Principal aquifers and aquitards including: a. formation names b. physical properties of aquifers and aquitards c. structural properties of the Subbasin that restrict groundwater flow within the aquifers d. General water quality of principal aquifers e. identification of primary uses of each aquifer including domestic, irrigation, municipal water supplies f. Identification of data gaps and uncertainty in the HCM	a. Section 3.1 (p. 3-2) and Appendix D b. HCM summarized in written descriptions within: 1. Sects 3.1.1 to 3.1.3 (p. 3-2) 2. Section 3.1.6 (p. 3-14) 3. Section 3.1.7 (p. 3-17) 4a. Section 3.1.8 (p. 3-20) 4b. Section 3.1.8 (p. 3-20) 4c. Section 3.1.8 (p. 3-20) 4d. Section 3.2.5 (p. 3-33) 4e. Section 3.1.11 (p. 3-27) 4f. Section 3.1.12 (p. 3-28)

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
354.14.(c-d)	10733.2	HCM, Maps	c. Include at least 2 cross section maps of the HCM that depict major stratigraphic and structural features of the Subbasin d. Map(s)pf physical characteristics of the Subbasin 1. Topographic information 2. Surficial geology (by USGS or other applicable agency) 3. Soil characteristics (by NCRS or other applicable agency) 4. Delineation of existing recharge areas, potential recharge areas, and discharge areas 5. Surface water bodies 6. Source and point of delivery for imported water supplies	c. Figures 3-14a to 3-14c d1. Figure 3-7 d2. Figure 3-12 d3. Figures 3-9 to 3-11 d4. Figure 3-22 d5. Figure 3-5 d6. Section 3.1.1.6 (p. 3-8)
354.16	10733.2	Groundwater Conditions	a. Groundwater elevation data 1. Groundwater elevation contour maps (depict groundwater table or potentiometric surface) 2. Hydrographs for long term groundwater elevations, historic levels, and hydraulic gradients b. Estimate of groundwater storage (graph). Graph must include annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions including annual use and water year type c. Seawater intrusion conditions (including maps and cross sections for each principal aquifer) d. Groundwater quality issues including locations of known groundwater contamination sites and plumes e. Extent, cumulative total, and annual rate of land subsidence (including map of total subsidence based on data from DWR)	a1. Figures 3-24 to 3-27 a2. Figures 3-23 through 3-28d and Appendix D b. Figures 3-29a,b,c c. Section 3.2.4 (p. 3-32) d. Section 3.2.5 (p. 3-33) e. Section 3.2.6 (p. 3-35) f. Section 3.2.8 (p. 3-37) g. Section 3.2.8.1 (p. 3-38)

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
			f. Identification of interconnected surface water systems and estimate of quantity and timing of the depletions using DWR data g. Identification of groundwater-dependent ecosystems (using data from DWR)	
354.18.(a-b)	10733.2	Water Budget Information	a. Water budget that provides an assessment of total annual volume of groundwater and surface water entering and leaving the Subbasin (including historic, current, and projected) b. The water budget shall quantify the following through estimates or direct measurements: 1. Total surface water entering and leaving the Subbasin (by water source type) 2. Inflow to the groundwater system by water source type 3. Outflows from the groundwater system by water use sector 4. Change in annual volume of groundwater in storage 5. Quantification of overdraft over a period of years including water year and water supply conditions compared to average conditions 6. Water year type associated with annual supply, demand, and change in groundwater 7. Estimate of sustainable yield	a. Section 3.3 (p. 3-40) b1. Section 3.3.1 (p. 3-41) b2. Section 3.3.1 (p. 3-41) b3. Section (3.3.1 p. 3-41) b4. Section 3.3.2 (p. 3-49) b5. Section 3.3.3 (p. 3-50) b6. Section 3.3.4 (p. 3-51) b7. Section 3.3.4 (p. 3-51)
354.18.(c)	10733.2	Quantification of Water Budget	c. Each Plan shall quantify the current, historic, and projected water budget including: 1. Current water budget information including current inflows and outflows 2 Historical water budget must include the following:	1. Section 3.3.5 (p. 3-52) 2. Section 3.3.6 (p. 3-52) 3. Section 3.3.7 (p. 3-54)

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
			• Quantitative evaluation of availability/reliability of historical surface water supply (by water source type and water year type) *must be based on the most recent 10 years of data • Quantitative evaluation of historic water budget to project the future water budget information and future aquifer response to GSP implementation • Description of how historical conditions have impacted GSA ability to create sustainable yield 3. Projected water budget to estimate future baseline conditions for GSP implementation and identify uncertainties. This section should include the following: • Projected hydrology must include 50-year historical precipitation, evapotranspiration, and streamflow information as the baseline *climate change must also be incorporated • Projected water demand will utilize the most recent land use, evapotranspiration, and crop coefficient data. Projected changes in local land use planning, pop growth and climate must be included • Projected surface water supply will use most recent data and also consider historical surface water supply	
354.18 (d)	10733.2	Water Budget Data Source	d. The Agency shall utilize the following information provided by the DWR (or other comparable data) to develop the Water Budget 1 .Historical water budget information: use 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	d. Section 3.3 (p. 3-40) 1. Section 3.3.6 (p. 3-52) 2. Section 3.3.5 (p. 3-52) 3. Section 3.3.7 (p. 3-54)

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
			3. Projected water budget information for population, population growth, climate change.	
354.18 (e, f)	10733.2	Water Budget	e. Must use a numerical groundwater and surface water model or the Plan must identify and describe an alternate method f. DWR will provide the Ca Central Valley Groundwater-Surface Water Simulation Model and the Integrated Water Flow Model for GSA use. (GSA can also select an alternate method but must be called out by type)	e. Appendix D f. Noted
354.20	10733.2	Management Areas	a. Define management areas and if they will have different measurable objectives (MOs) and minimum thresholds (MTs) b. Describe the following on Management areas: 1. Reason for creation of each management area 2. MO/MTs for each management area and why those values were selected if vary from Subbasin 3. Level of monitoring and analysis in each management area 4. Why MO/MTs can differ without causing undesirable results c. GSP must include descriptions and maps of management areas.	a. Section 3.4 (p. 58) b1. Section 3.4 (p. 58) b2. Section 3.4 (p. 58) b3. Section 3.4 (p. 58) b4. Section 3.4 (p. 58) c. Section 3.4 (p. 58)
Article 5. Plan Contents, Subarticle 3. Sustainable Management Criteria				
354.24	10733.2	Sustainability Goal	Description of the Sustainability Goal	Section 4.1.1 (p. 4-2)
354.26	10733.2, 10721, 10723.2, 10727.2, 10733.2, 10733.8	Undesirable Results	a-b. Description of Undesirable Results, including: 1. Cause of Groundwater Conditions that would lead to Undesirable Results 2. Criteria used to define Undesirable Results for each sustainability indicator	a-b. Section 4.2 (p. 4-4) 1. Causes of undesirable results are discussed in Section 4.2.1 (p. 4-4)

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
			3. Potential effects of Undesirable Results on beneficial uses and users of groundwater c. Evaluation of multiple MTs and monitoring sites to determine undesirable results	2. Criteria to define undesirable results are discussed in Section 4.2.2 (p. 4-10) 3. Potential effects of undesirable results are discussed in Section 4.2.2 (p. 4-10) c. Section 4.3 (p. 4-11)
354.28 (a-b)	10723.2, 10727.2.(d).1, 10727.2.(d).2,	Minimum Thresholds	a-b. Description of each MT and how they were established for each sustainability indicator, including numeric values. 1. Information and criteria that establish and justify the MTs for each sustainability indicator 2. Relationship between MTs for each sustainability indicator 3. How MTs have been selected to avoid undesirable results for each sustainability indicator 4. How MTs may affect the interest of beneficial uses and users of groundwater 5. How state, federal, or local standards relate to the relevant sustainability indicator 6. How each MT will be quantitatively measured	a-b. Section 4.3 (p. 4-11) describes each MT 1. Section 4.3.1 (p. 4-12) 2. Section 4.3.1 (p. 4-12) 3. Section 4.4.1 (p. 4-12) 4. Section 4.3.1 (p. 4-12) 5. Section 4.3.1 (p. 4-12) 6. Section 4.3.2 (p. 4-16)
354.28 (c-d)	10733.2	Minimum Thresholds	c. Definition of MTs for each sustainability indicator: 1. Chronic lowering of groundwater levels a. Rate of groundwater elevation decline based on historical trends, water year type, and projected use b. Potential effects on other sustainability indicators 2. Reduction of groundwater storage	c. Section 4.3 (p. 4-11) 1. Section 4.3.1.1 (p. 4-12) a. Section 4.3.1.1 (p. 4-12) b. Section 4.3.1.1 (p. 4-12) 2. Section 4.3.1.2 (p. 4-14) 3. N/A

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
			3. Seawater intrusion 4. Degraded water quality 5. Land subsidence a. Identification of land uses and property interests affected by land subsidence and explanation of how the GSAs have determined and considered those uses and interests b. Maps and graphs showing the extent and rate of land subsidence 6. Depletions of interconnected surface water a. The location, quantity, and timing of depletions of interconnected surface water b. Description of the groundwater and surface water model used to quantify surface water depletion (or an equally effective method) d. Representative MT for groundwater elevation to serve as the value for multiple sustainability indicators e. Undesirable results related to sustainability indicators that are not present in the basin are not required to establish MTs	4. Section 4.3.1.4 (p. 4-15) 5. Section 4.2.1.3 (p. 4-7) a. Section 4.2.1.3 (p. 4-7) b. Figures 3-34, 3-34a, and 3-34b 6. N/A a. N/A b. N/A d. Section 4.3 (p. 4-11) e. N/A

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
354.30	10727.2.(b).1, 10727.2.(b).2, 10727.2.(d).1 10727.2.(d).2, 10727.4, 10733.2	Measureable Objectives	a-b. Establishment of the measureable objectives for each sustainability indicator c. Description of how a reasonable margin of operational flexibility was established for each measureable objective d-e. Description of a reasonable path to achieve and maintain the sustainability goal, including a description of interim milestones f-g. Optional inclusion of additional MOs, interim milestones where appropriate	a-b. Section 4.4.1 (p. 4-19) c. Section 4.4.2 (p. 4-21) d-e. Section 4.4.3 (p. 4-22) f-g. N/A
Article 5. Plan Contents, Subarticle 4. Monitoring Network				
354.34.(a-b)	10727.2.(d).1, 10727.2.(d).2, 10727.2.(e), 10727.2.(f)	Monitoring Network	a-b. Description of Monitoring Network objectives and how the network will be developed and implemented with sufficient spatial and temporal frequency to: 1. Demonstrate progress towards achieving MOs 2. Monitor impacts to beneficial uses or users of groundwater 3. Monitor changes in groundwater conditions relative to MOs and MTs 4. Quantify annual changes in water budget components	a-b. Section 5.1.1. (p. 5-5) 1. Sections 5.1.5 through 5.1.8 (p. 5-8 through 5-12)

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
354.34.(c)	10727.2.(d).1, 10727.2.(d).2, 10727.2.(e), 10727.2.(f)	Monitoring Network	c. Description of how the monitoring network provides adequate coverage of sustainability indicators: 1. Chronic lowering of groundwater levels a. Sufficient density of monitoring wells b. Static groundwater elevation measurements collected two times per year 2. Reduction of groundwater storage 3. Seawater intrusion 4. Degraded water quality 5. Land subsidence 6. Depletions of interconnected surface water d. Adequate coverage of sustainability indicators to evaluate conditions in the basin e. Site information and monitoring data from existing sources	c. Section 5.1 (p. 5-2) 1. a. Section 5.1.5 (p. 5-8) b. Section 5.1.5 (p. 5-8) 2. Section 5.1.6 (p. 5-11) 3. N/A 4. Section 5.1.7 (p. 5-11) 5. Section 5.1.8 (p.5-11) 6. N/A d. Section 5.1.3 (p. 5-7) e. Section 5.1.3 (p. 5-7)
354.34.(e-i)		Monitoring Network	f. Density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends determined by: 1. Amount of current and projected water use 2. Aquifer characteristics that affect groundwater flow 3. Impacts to beneficial uses and users 4. Whether the Agency has long-term existing monitoring results to demonstrate aquifer response g. Scientific rational (or reason) for site selection	f. Section 5.1 (p. 5-3) 1. Section 3.3.5 (p. 3-51); Section 3.3.7 (p. 3-54) 2. Section 3.1 (p. 3-2) 3. Section 3.1.11 (p. 3-27) 4. Section 5.1.3 (p. 5-7) g. 1. Section 5.2 (p. 5-13) 2. Section 5.2 (p. 5-13)

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
			1. Consistency with data and reporting standards 2. Corresponding sustainability indicator, MTs, MOs, and interim milestone h. 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 i. Description of technical standards, data collection methods, and other procedures or protocols to ensure comparable data and methodologies	h. Figures 5-1 through 5-5; Tables 5-1 through 5-6 i. Section 5.2 (p. 5-13)
354.36		Representative Monitoring	a. Description of representative sites with defined quantitative MTs, MOs, and interim milestones b. Demonstration of adequacy of using groundwater elevations as proxy for other sustainability indicators c. Adequate evidence demonstrating representative monitoring sites reflects general conditions in the area	a. Section 5.3 (p. 5-15) b. N/A c. Section 5.4 (p. 5-16)
354.38		Assessment and Improvement of Monitoring Network	a. Review and evaluation of the monitoring network b-c. Identification and description of data gaps 1. Location and reason for data gaps 2. Local issues and circumstances that limit or prevent monitoring d. Description of steps to fill data gaps before the next 5-year assessment e. Adjustment of monitoring frequency and site density to provide site-specific surface water and groundwater conditions	a. Section 5.4 (p. 5-16) b-c. Section 5.4.1.2 (p. 5-18) 1. Section 5.4.1.2 (p. 5-18) 2. Section 5.4.1.2 (p. 5-18) d. Section 5.4.1.3 (p. 5-20) e. Section 5.4.1.3 (p. 5-20)

GSP Regulation Section	Water Code Section	Requirement	Description	Section(s) and Page Number(s) in the GSP
354.40	10733.2	Reporting Monitoring Data to the Department	Monitoring data stored in the data management system developed pursuant to Section 352.6 and included in the Annual Report	Noted
Article 5. Plan Contents, Subarticle 5. Projects and Management Actions				
354.44 (a-b)		Projects and Management Actions	a-b. Description of projects and management actions, including the following: 1. List of projects and management actions with a description of the MO that it addresses a. The circumstances and criteria to trigger project implementation and the process by which the GSAs will determine the conditions requiring implementation b. How the GSAs will notice the public and other agencies that projects will be implemented	a-b. Sections 6.3 (p. 6-5) and 6.4 (p. 6-18) 1. Sections 6.3 (p. 6-5) and 6.4 (p. 6-18) a. Section 7.2 (p. 7-2) b. Appendix B
354.44 (c-d)			c. Projects and management actions shall be supported by the best available science d. Level of uncertainty associated with the basin should be taken into account when developing projects or management actions	c-d. Occurs throughout Chapter 6.

APPENDIX F

INTERIM OPERATING AGREEMENT

Interim Operating Agreement for the Tulare Lake Subbasin to Develop and Implement a Groundwater Sustainability Plan

THIS INTERIM OPERATING AGREEMENT FOR THE TULARE LAKE SUBBASIN TO DEVELOP AND IMPLEMENT A GROUNDWATER SUSTAINABILITY PLAN (this "Agreement") is effective September 1, 2017, among the MID-KINGS RIVER GROUNDWATER SUSTAINABILITY AGENCY, SOUTH FORK KINGS GROUNDWATER SUSTAINABILITY AGENCY, EL RICO GROUNDWATER SUSTAINABILITY AGENCY, SOUTHWEST KINGS GROUNDWATER SUSTAINABILITY AGENCY, TRI-COUNTY WATER AUTHORITY, and ALPAUGH IRRIGATION DISTRICT. The signatories to this Agreement are hereinafter referred to collectively as the "Parties" or individually as "Party".

RECITALS

WHEREAS, the Parties are all located within the Tulare Lake Hydrologic Region, San Joaquin Valley Groundwater Basin, Tulare Lake Subbasin, a groundwater subbasin recognized by the California Department of Water Resources ("DWR") Bulletin 118 (2016) as Groundwater Basin No. 5-22.12 (hereinafter "Subbasin") and a depiction of the Subbasin is attached hereto as Exhibit "A" and incorporated herein by this reference; and

WHEREAS, the State of California has classified the entire Subbasin as an Economically Distressed Area and each community within the Subbasin as a Disadvantaged Community; and

WHEREAS, all lands within the Subbasin are included within one of the six groundwater sustainability agencies ("GSAs") that are the Parties to this Agreement, and each Party has been or are in the process of being determined an "exclusive" GSA by DWR; and

WHEREAS, the Sustainable Groundwater Management Act ("SGMA") requires the development and establishment of groundwater sustainability plans ("GSPs"), which are designed to ensure the sustainability of groundwater basins and subbasins; and

WHEREAS, DWR has identified the Subbasin as a critically overdrafted subbasin; and

WHEREAS, SGMA allows local agencies or a combination of local agencies overlying a groundwater basin to serve as a GSA to develop and implement a GSP over an entire basin, subbasin, or a portion of a basin; and

WHEREAS, pursuant to Water Code §10727, SGMA allows for the preparation of a GSP by three methods: (a) a single GSP covering the entire basin/subbasin developed and implemented by one GSA, (b) a single GSP covering the entire basin/subbasin developed and implemented by multiple GSAs, or (c) multiple GSPs implemented by two or more GSAs that are subject to a single Coordination Agreement that covers the entire basin/subbasin; and

WHEREAS, Water Code §10727.6 requires that if multiple GSPs will be implemented within a subbasin, then a Coordination Agreement must be prepared to ensure that the GSPs utilize the same data and methodologies within that subbasin for the following items: (a) groundwater elevation data, (b) groundwater extraction data, (c) surface water supply, (d) total water use, (e) change in groundwater storage, (f) water budget, and (g) sustainable yield; and

WHEREAS, the Parties acknowledge that multiple GSAs have been formed within the Subbasin and those GSAs currently seek to explore the possibility of developing and implementing a single GSP. The Parties also acknowledge the desire to have a single GSP may not be achievable, but regardless of whether one or more GSPs are developed for the Subbasin, an interim agreement is beneficial to the Parties in proceeding to initially develop and coordinate the data and methodologies required by SGMA for the Subbasin; and

WHEREAS, the Parties acknowledge that the GSAs need to do further data collection prior to making decisions with regard to GSP preparation and implementation, but the Parties agree that in the future a Coordination Agreement or an amendment to or replacement of this Agreement will be necessary based on the additional information obtained and decisions made by the Parties under this Agreement; and

WHEREAS, the purpose of this Agreement is to provide a framework among the Parties for a cooperative means of gathering the initial data and information for a single GSP, applying for grant funding, selecting consultants, and coordinating on other SGMA-related issues for the Subbasin.

NOW, THEREFORE, in consideration of the mutual promises, covenants, and conditions hereinafter set forth and the above Recitals, which are hereby incorporated herein by this reference, it is agreed by and among the Parties hereto as follows.

SECTION 1. DEFINITIONS

1.1 "Tulare Lake Subbasin" or "Subbasin" refers to that subbasin identified and described in California Department of Water Resources Groundwater Bulletin 118 as part of the Tulare Lake Hydrologic Region, San Joaquin Valley Groundwater Basin, Tulare Lake Subbasin, also identified as Groundwater Basin No. 5-22.12, and is depicted in Exhibit "A" of this Agreement.

1.2 "Groundwater Sustainability Agency" or "GSA" means one or more local agencies that implement the provisions of SGMA as defined by Water Code §10721(j).

1.3. "Groundwater Sustainability Plan" or "GSP" means a plan of one or more GSAs proposed or adopted under SGMA as defined in Water Code §10721(k).

1.4 "Coordination Agreement" shall be the agreement (whether one or more GSPs are developed within the Subbasin) to ensure coordination of the data and methodologies used by each GSA in developing the GSP(s) within the Subbasin for the following assumptions: (a) groundwater elevation data, (b) groundwater extraction data, (c) surface water supply, (d) total water use, (e) change in groundwater storage, (f) water budget, and (g) sustainable yield (Water Code §10721(d); 10727.6).

SECTION 2. PURPOSES AND GOALS

2.1 The Parties are entering into this Agreement to perform the following:

(a) Set forth their mutual intent to work towards the development of a single GSP for the Subbasin.

(b) Authorize research and collection of the data required for the GSP according to a mutually agreeable timeline.

(c) The Parties agree to utilize their best efforts in selecting and fully cooperating with the consultants gathering the information, preparing grant applications, and preparing the GSP.

(d) The Parties agree that after they gather data and determine an appropriate governance structure, they will either (1) amend or replace this Agreement to reflect specifics required to finalize a GSP or (2) if a single GSP is not to occur, prepare and enter into a Coordination Agreement setting forth appropriate assumptions based on information gathered and developed as a result of this Agreement.

SECTION 3. COST SHARING AND GOVERNANCE

3.1 The Parties agree that if grant funds are available for grant applications, efforts necessary to develop a GSP(s), facilitation and/or consultant costs, and similar efforts to develop a GSP(s) for the Subbasin, then the Parties have the authority to and shall act jointly in applying for and seeking to obtain such grant funds. Any grant funds received on behalf of the Subbasin and/or all of the Parties, shall first be applied to eligible costs incurred after July 1, 2017; should any funds then remain, the Parties may develop a method for reimbursing relevant costs incurred by the Parties prior to the effective date of this Agreement.

3.2 The Parties agree to the following formula, identified in the table below, for sharing costs to develop and implement the actions taken within the confines of this Agreement. As shown below, after combining the El Rico GSA and Alpaugh Irrigation District, one-half the costs shall be allocated one-fifth to each of the participants and one-half of the costs shall be allocated in proportion to the relative acreage of each Party. The overall proportionate cost of each Party is shown as the Total Cost Allocation in the table below.

GSA	Acres	Acreage Portion	Participant Portion	Total Cost Allocation
Mid-Kings River GSA	97,384.6	0.09084	0.1	0.19084
South Fork Kings GSA	71,310.9	0.06652	0.1	0.16652
El Rico GSA/Alpaugh ID	228,653.4	0.21328	0.1	0.31328
Southwest Kings GSA	90,037.1	0.08398	0.1	0.18398
Tri-County WA	48,656.5	0.04538	0.1	0.14538
Totals	536,042.5	0.50000	0.5	1.00000

3.3 All decisions related to implementing or amending this Agreement shall require a unanimous vote of the authorized representatives of each of the five (5) entities[1] identified in the table shown in Section 3.2 of this Agreement; a quorum is represented by any four (4) authorized representatives of these five (5) entities. Decisions may include, but are not limited to hiring experts or consultants to prepare and draft documents associated with this Agreement that would exceed $100,000, developing the Coordination Agreement (if necessary), applying for grant funding, and/or developing all or portions of a GSP(s).

SECTION 4. GENERAL PROVISIONS

4.1. Term. This Agreement shall become effective on the date first above written and shall remain in effect until superseded by amendment to this Agreement or another agreement among the Parties which shall address more specifics that are not available at this time for the final development and implementation of the GSP(s).

4.2 Withdrawal. Any Party shall have the right to withdraw from this Agreement by giving each of the other Parties written notice at least 30 days prior to its date of withdrawal ("Withdrawal Date"). The withdrawing Party shall be responsible for its share of any costs incurred under this Agreement up to its Withdrawal Date. Except as set forth in the preceding sentence, and except for the withdrawing Party's obligations under Section 5 hereof relating to confidential information, effective as of the Withdrawal Date, the withdrawing Party shall be

[1] For purposes of cost sharing and voting, the El Rico GSA and Alpaugh ID are to be considered as one entity; it shall be up to those two GSAs to determine their internal cost-sharing and voting process.

relieved and released of all obligations under this Agreement.

4.3 Construction of Terms. This Agreement is for the sole benefit of the Parties and shall not be construed as granting rights to or imposing obligations on any person other than the Parties.

4.4 Good Faith. Each Party shall use its best efforts and work in good faith for the completion of the purposes and goals of this Agreement and the satisfactory performance of its terms.

4.5 Rights of the Parties and Constituencies. This Agreement does not contemplate the Parties taking any action that would (a) adversely affect the rights of any of the Parties or (b) adversely affect the constituencies of any of the Parties.

4.6 Counterparts. This Agreement may be executed in counterparts and the signed counterparts shall constitute a single instrument. The signatories to this Agreement represent that they have the authority to sign this Agreement and to bind the Party for whom they are signing.

4.7 Governing Law. This Agreement and all documents provided for herein and the rights and obligations of the Parties hereto shall be governed in all respects, including validity, interpretation and effect, by the laws of the State of California (without giving effect to any choice of law principles).

4.8 Waiver. The failure of any Party to insist on strict compliance with any provision of this Agreement shall not be considered a waiver of any right to do so, whether for that breach or any subsequent breach. The acceptance by any Party of either performance or payment shall not be considered to be a waiver of any preceding breach of the Agreement by any other Party.

4.9 Recitals and Exhibits. The Recitals and Exhibits are incorporated into the Agreement.

SECTION 5. CONFIDENTIALITY PROVISIONS

5.1 Confidential Information. The confidential information to be disclosed under this Agreement (“Confidential Information”) includes data, information, modeling, projections, estimates, plans, that are not public information and in which each Party has a reasonable expectation of confidentiality, regardless of whether such information is designated as Confidential Information at the time of its disclosure.

5.2 Duty to Protect. In addition to the above, Confidential Information shall also include, and the Parties shall have a duty to protect, other confidential and/or sensitive information which is (a) disclosed in writing and marked as confidential (or with other similar designation) at the time of disclosure; and/or (b) disclosed in any other manner and identified as confidential at the time of disclosure or is summarized and designated as confidential in a written memorandum delivered within thirty (30) days of the disclosure.

5.3 Limited Use. The Parties shall use the Confidential Information only for the purposes set forth in this Agreement.

5.4 Limited Disclosure. The Parties shall limit disclosure of Confidential Information within its own organization to its directors, officers, partners, members and/or employees having a need to know and shall not disclose Confidential Information to any third party (whether an individual, corporation, or other entity) without prior written consent of all the Parties. The Parties shall satisfy their obligations under this paragraph if they take affirmative measures to ensure compliance with these confidentiality obligations through their employees, agents, consultants and others who are permitted access to or use of the Confidential Information.

5.5 Allowable Disclosure. This Agreement imposes no obligation upon the Parties with respect to any Confidential Information (a) that was possessed before receipt; (b) is or becomes a matter of public knowledge through no fault of receiving Party; (c) is rightfully received from a third party not owing a duty of confidentiality; (d) is disclosed without a duty of confidentiality to a third party by, or with the authorization of the disclosing Party; or (e) is independently developed.

IN WITNESS WHEREOF, the Parties hereto have executed this Agreement to be effective as of the date first above written.

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Mid-Kings River Groundwater Sustainability Agency

By: Barry McCutcheon (signature) Title: Chairman

Name: Barry McCutcheon

South Fork Kings Groundwater Sustainability Agency

By:________________________ Title:__________________

Name: ________________________

El Rico Groundwater Sustainability Agency

By:________________________ Title:__________________

Name: ________________________

Southwest Kings Groundwater Sustainability Agency

By:________________________ Title:__________________

Name: ________________________

Tri-County Water Authority

By:________________________ Title:__________________

Name: ________________________

Alpaugh Irrigation District

By:________________________ Title: __________________

Name: ________________________

Mid-Kings River Groundwater Sustainability Agency

By:____________________ Title:____________

Name: ____________________

South Fork Kings Groundwater Sustainability Agency

By: Joe Neves Title: Chairman

Name: Joe Neves

El Rico Groundwater Sustainability Agency

By:____________________ Title:____________

Name: ____________________

Southwest Kings Groundwater Sustainability Agency

By:____________________ Title:____________

Name: ____________________

Tri-County Water Authority

By:____________________ Title:____________

Name: ____________________

Alpaugh Irrigation District

By:____________________ Title: ____________

Name: ____________________

Mid-Kings River Groundwater Sustainability Agency

By:______________________________ Title:________________

Name: ______________________________

South Fork Kings Groundwater Sustainability Agency

By:______________________________ Title:____________________

Name: ______________________________

El Rico Groundwater Sustainability Agency

By: [signature] Title: CHAIRMAN

Name: JEOF WYRICK

Southwest Kings Groundwater Sustainability Agency

By:______________________________ Title:________________

Name: ______________________________

Tri-County Water Authority

By:______________________________ Title:________________

Name: ______________________________

Alpaugh Irrigation District

By:______________________________ Title: ________________

Name: ______________________________

Mid Kings Groundwater Sustainability Agency

By:________________________ Title:________________

Name: ________________________

South Fork Kings Groundwater Sustainability Agency

By:________________________ Title:________________

Name: ________________________

El Rico Groundwater Sustainability Agency

By:________________________ Title:________________

Name: ________________________

Southwest Kings Groundwater Sustainability Agency

By: [signature] Title: President

Name: William D Phillimore

Tri-County Water Authority

By:________________________ Title:________________

Name: ________________________

Alpaugh Irrigation District

By:________________________ Title: ________________

Name: ________________________

Mid Kings Groundwater Sustainability Agency

By:__________________________ Title:________________

Name: __________________________

South Fork Kings Groundwater Sustainability Agency

By:__________________________ Title:________________

Name: __________________________

El Rico Groundwater Sustainability Agency

By:__________________________ Title:________________

Name: __________________________

Southwest Kings Groundwater Sustainability Agency

By:__________________________ Title:________________

Name:__________________________

Tri-County Water Authority

By: [signature] Title: Chairman

Name: MATTHEW H. HURLEY

Alpaugh Irrigation District

By:__________________________ Title: ________________

Name: __________________________

Mid-Kings River Groundwater Sustainability Agency

By:______________________________ Title:________________

Name: ____________________________

South Fork Kings Groundwater Sustainability Agency

By:______________________________ Title:____________________

Name: ____________________________

El Rico Groundwater Sustainability Agency

By:______________________________ Title:________________

Name: ____________________________

Southwest Kings Groundwater Sustainability Agency

By:______________________________ Title:________________

Name: ____________________________

Tri-County Water Authority

By:______________________________ Title:________________

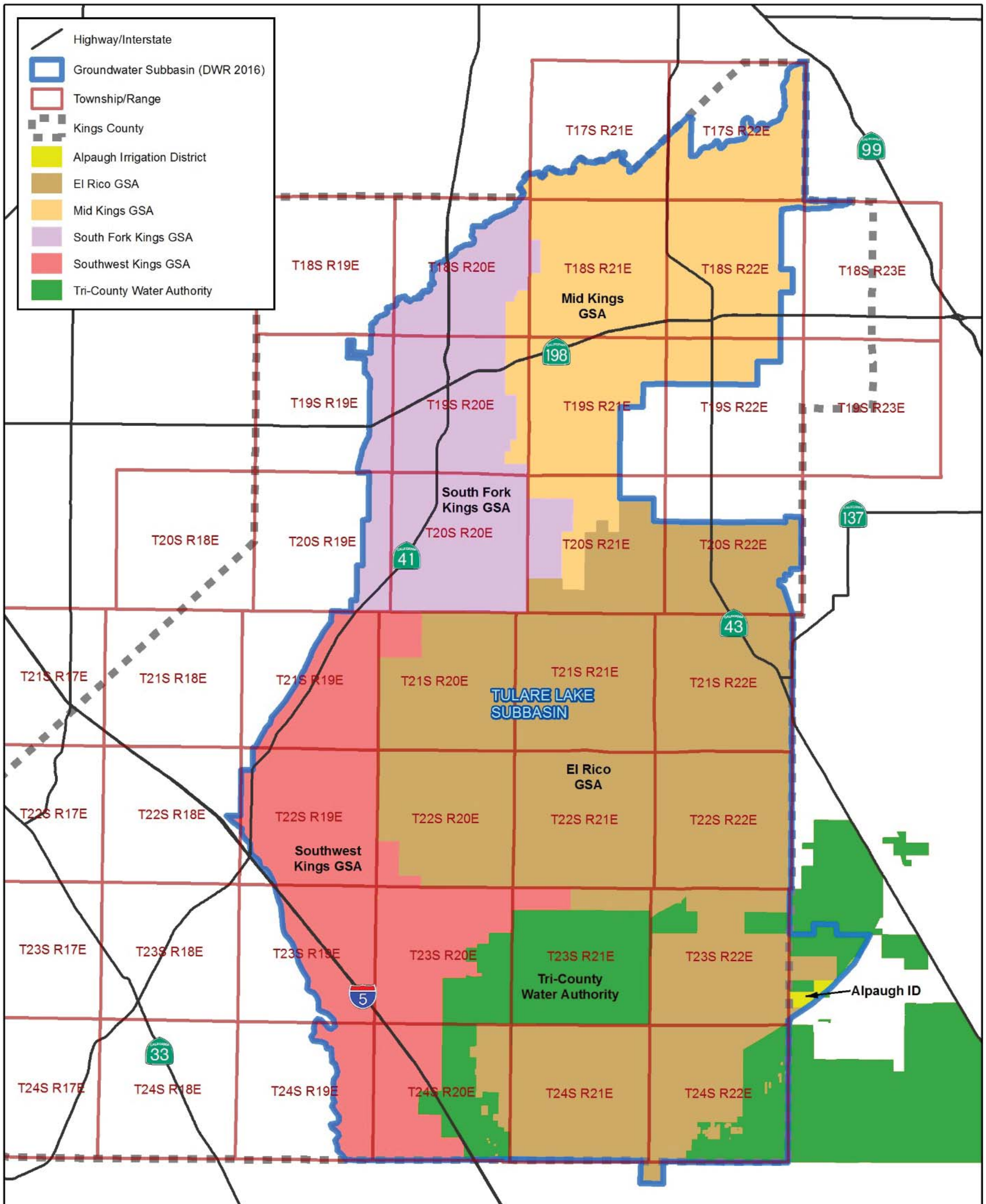
Name: ____________________________

Alpaugh Irrigation District

By: [signature] Title: G.M.

Name: BRUCE HOWARTH

Exhibit "A"
Map of Tulare Lake Subbasin as Described in
DWR Bulletin 118



EST. 1968
PROVOST& PRITCHARD
CONSULTING GROUP
An Employee Owned Company

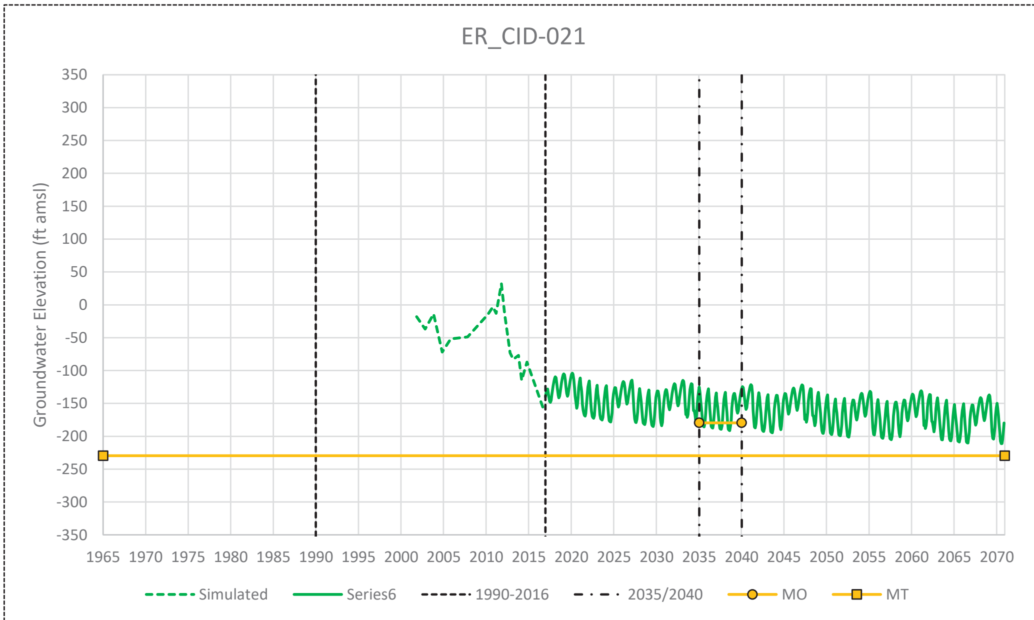
N
0 2 4
Miles

EXHIBIT A
Map of Tulare Lake Subbasin
as Described in DWR Bulletin 118

7/14/2017 : G:\Southwest Kings GSA-2612\GIS\Map\Subbasin\tularelake_sub_gsa.mxd

APPENDIX G

REPRESENTATIVE MONITORING SITES FORECAST HYDROGRAPHS WITH PROJECTS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200
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-200
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-300
-350
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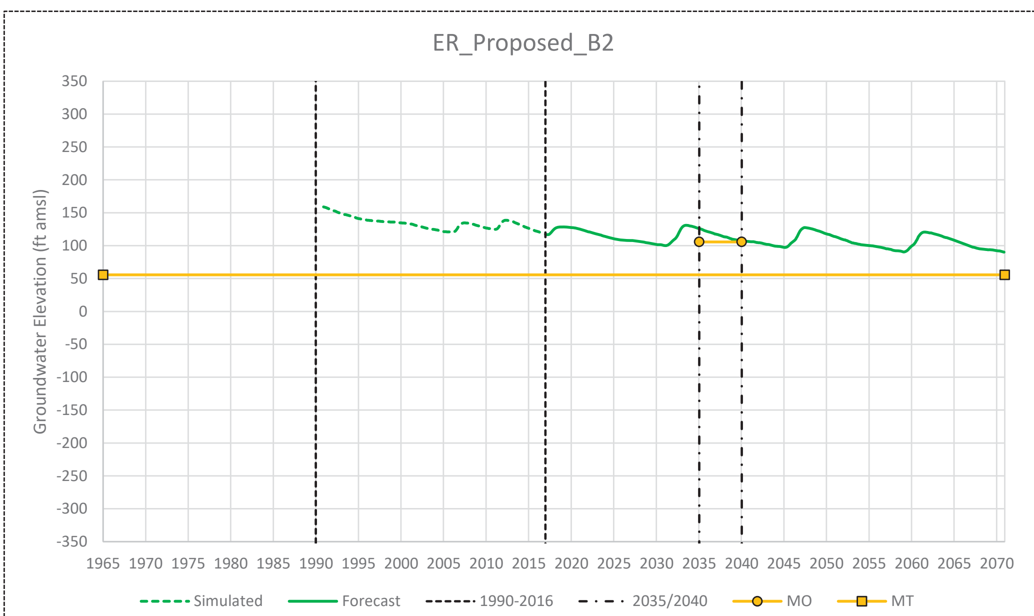
Simulated
Series6
1990-2016
2035/2040
MO
MT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300
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200
150
100
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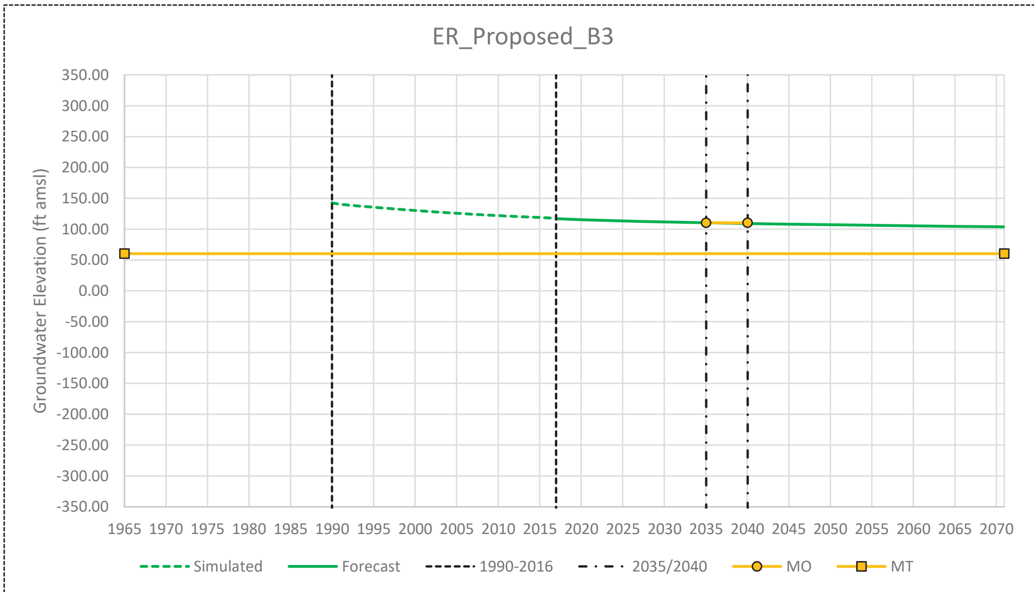
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT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250.00
200.00
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100.00
50.00
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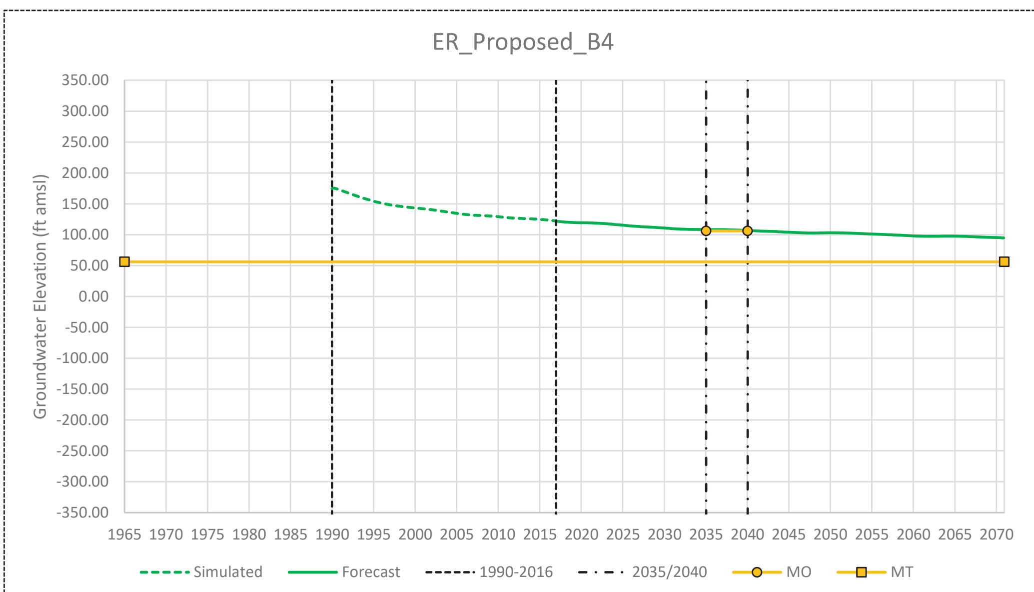
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT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200.00
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-150.00
-200.00
-250.00
-300.00
-350.00
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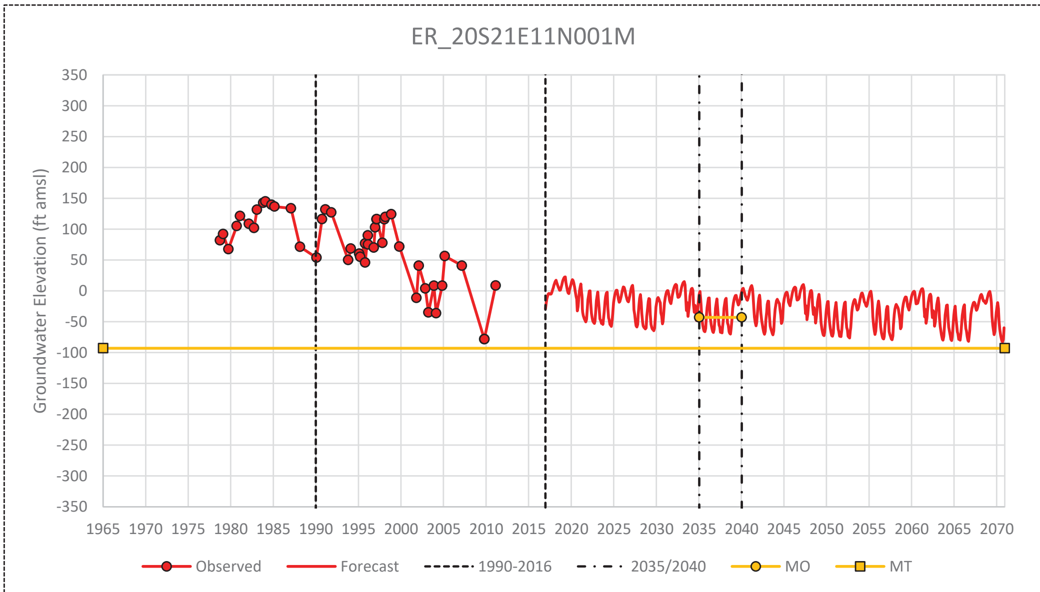
Simulated
Forecast
1990-2016
2035/2040
MO
MT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-50
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-150
-200
-250
-300
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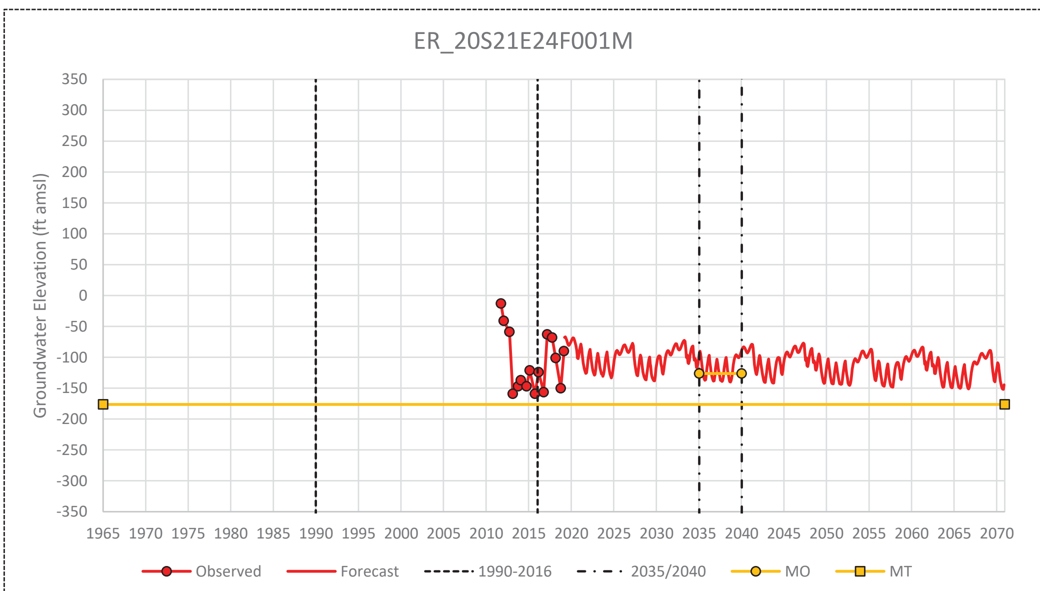
Forecast
1990-2016
2035/2040
MO
MT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-200
-250
-300
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MO
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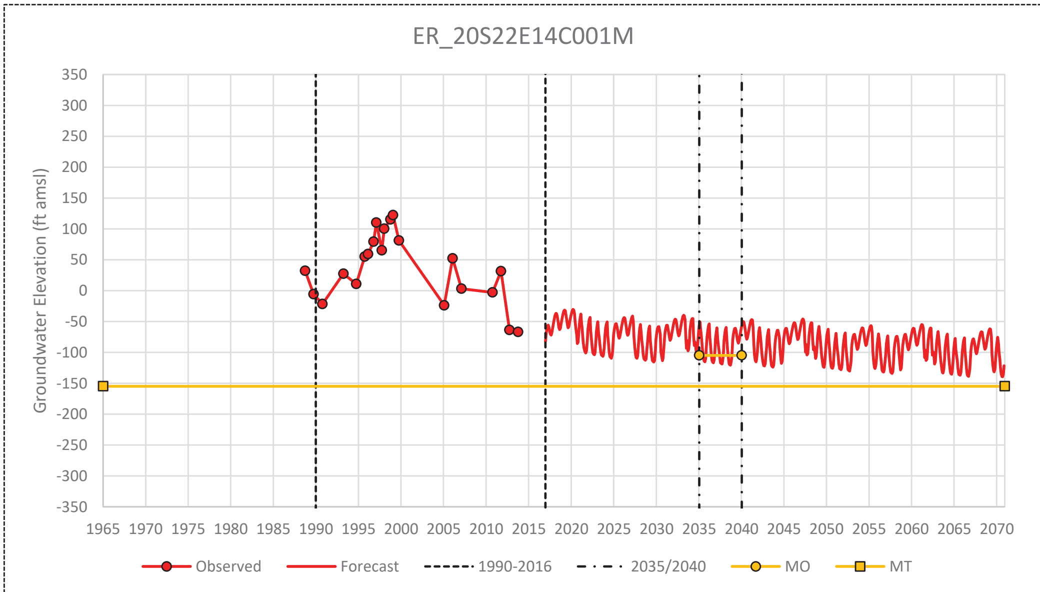
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-200
-250
-300
-350
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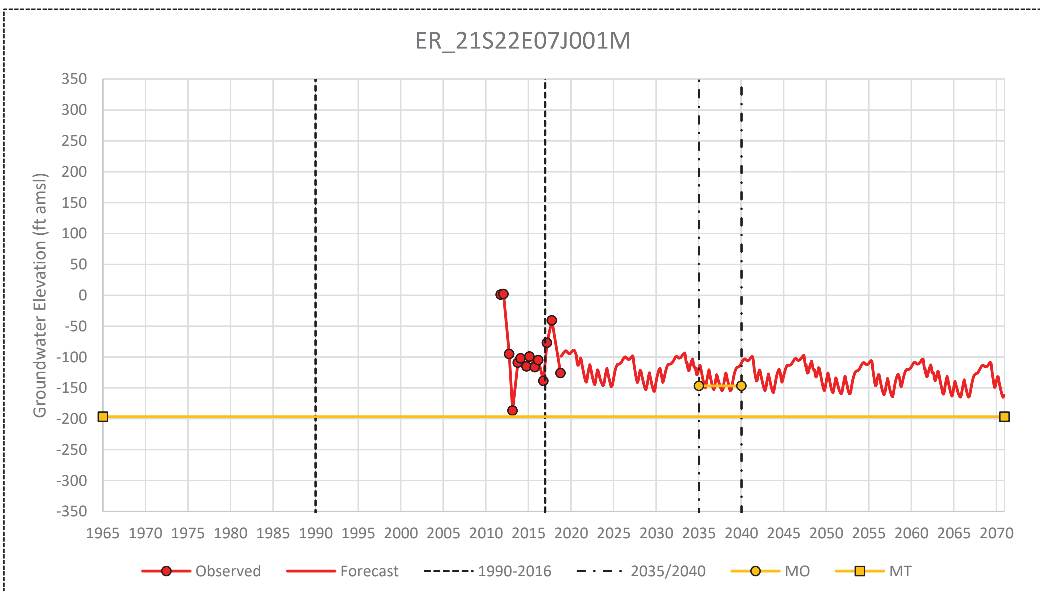
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300
250
200
150
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-200
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-300
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1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
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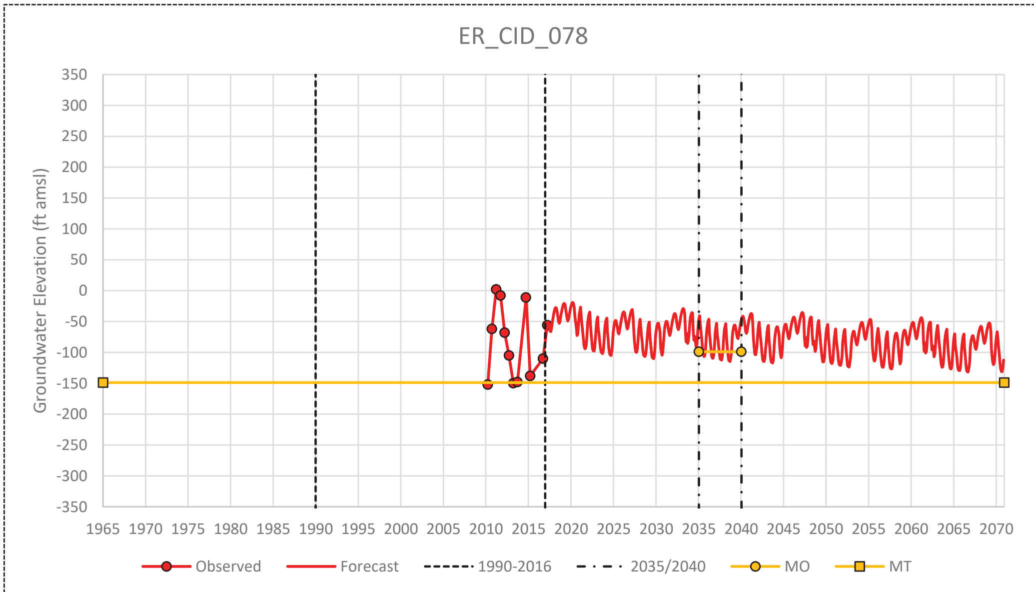
Forecast
1990-2016
2035/2040
MO
MT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50
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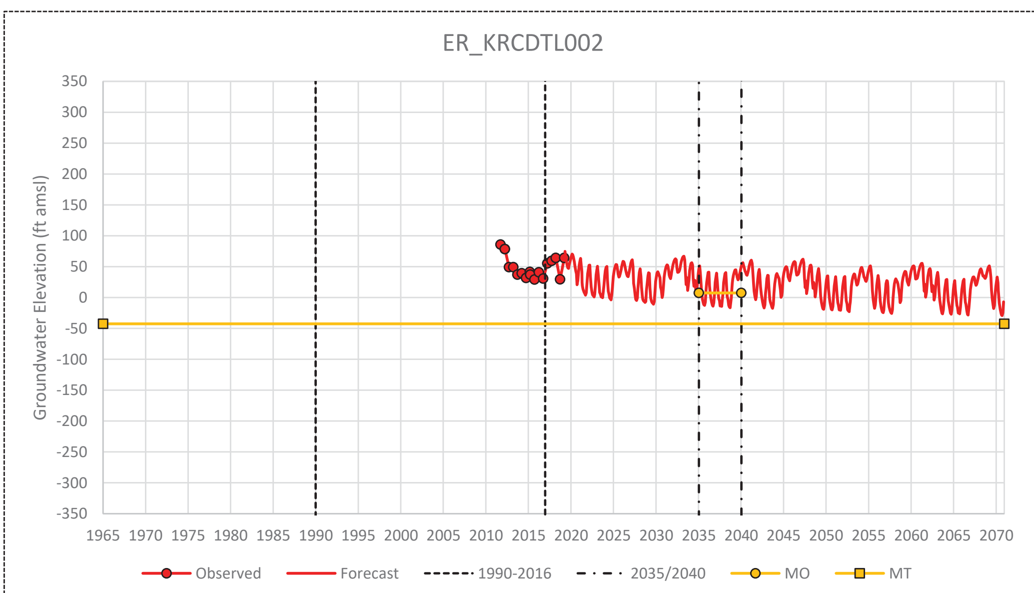
2035/2040
MO
MT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300
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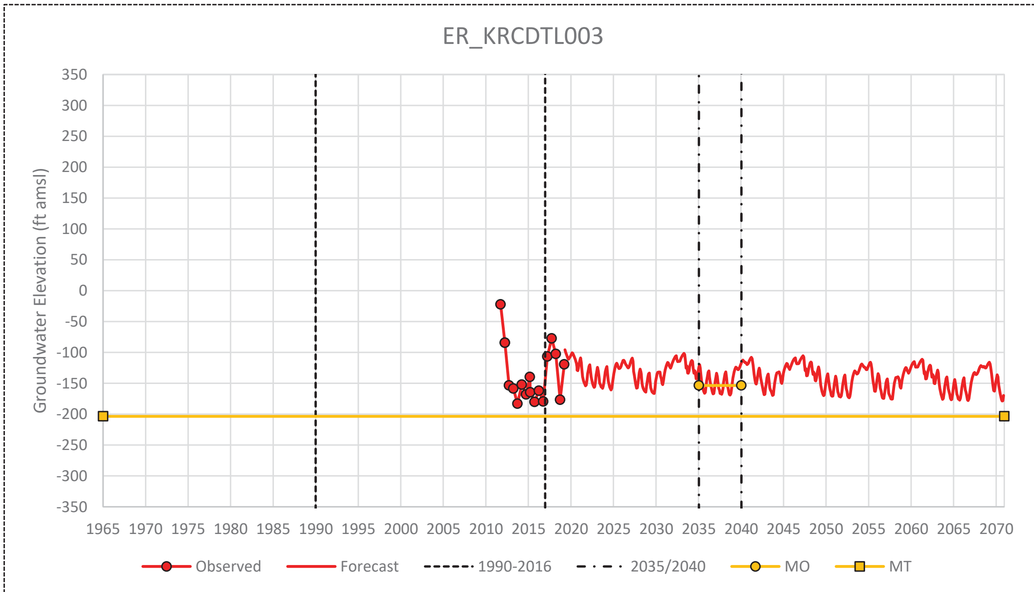
2035/2040
MO
MT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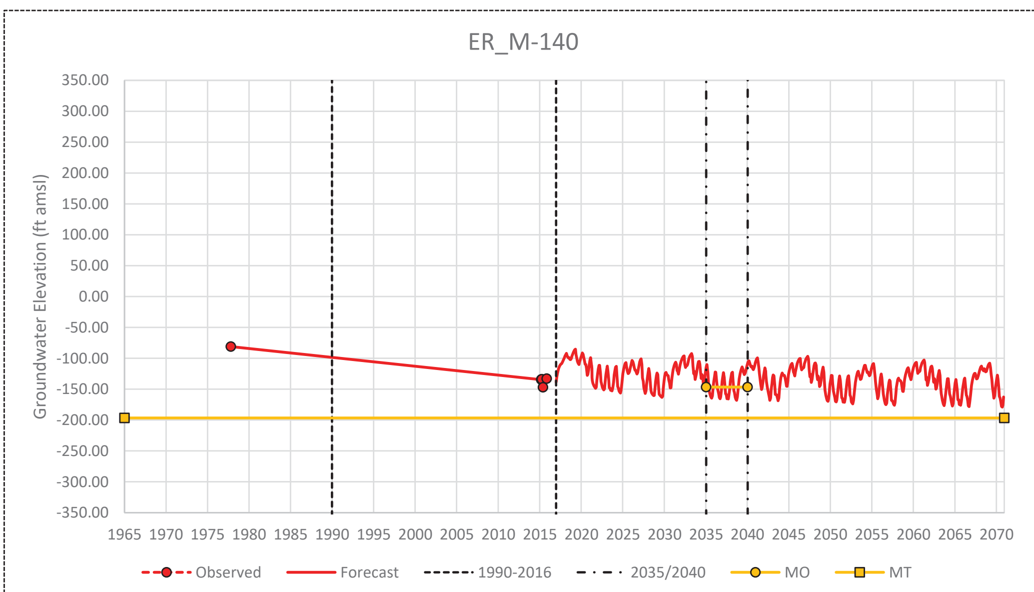
Observed
Forecast
1990-2016
2035/2040
MO
MT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-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
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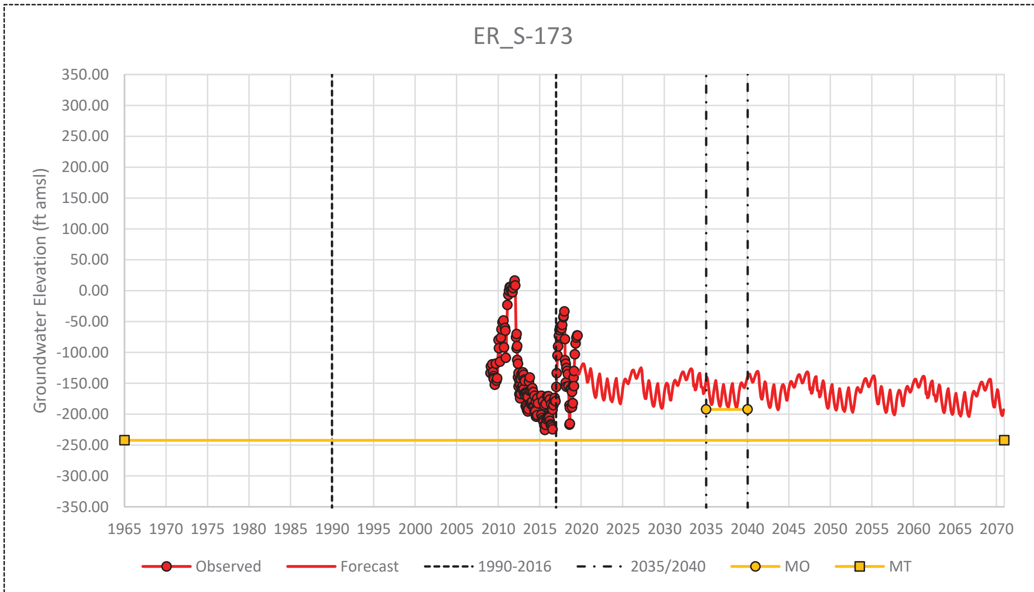
Observed
Forecast
1990-2016
2035/2040
MO
MT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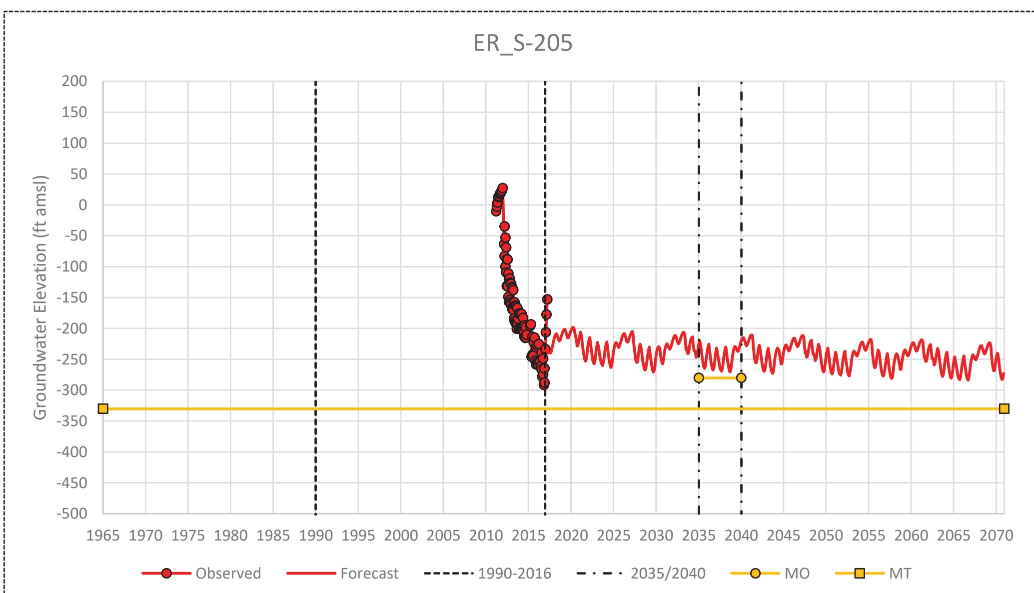
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT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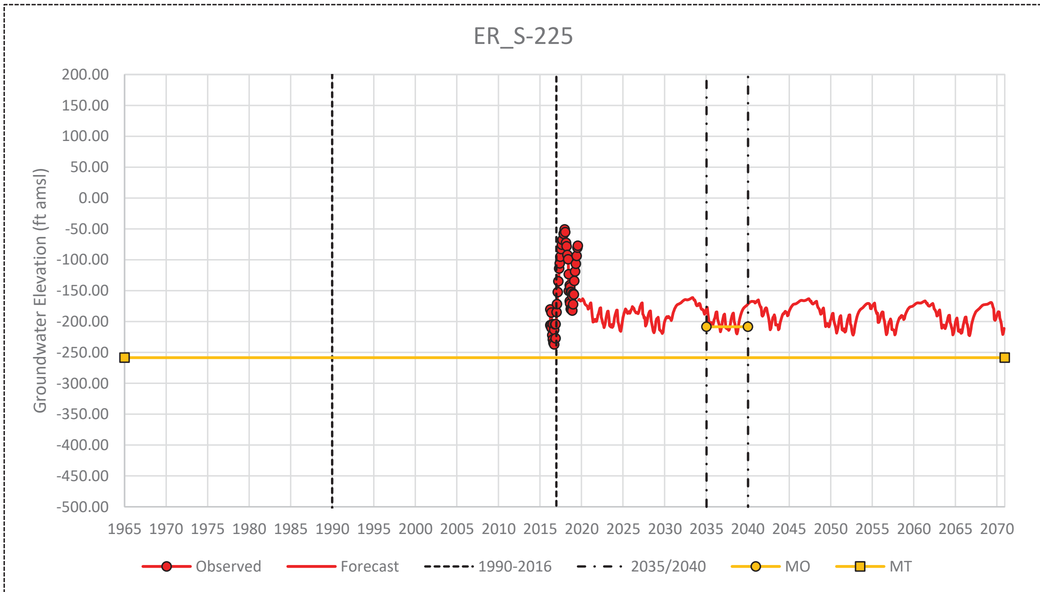
Groundwater Elevation (ft amsl)
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT



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-200.00
-250.00
-300.00
-350.00
-400.00
-450.00
-500.00
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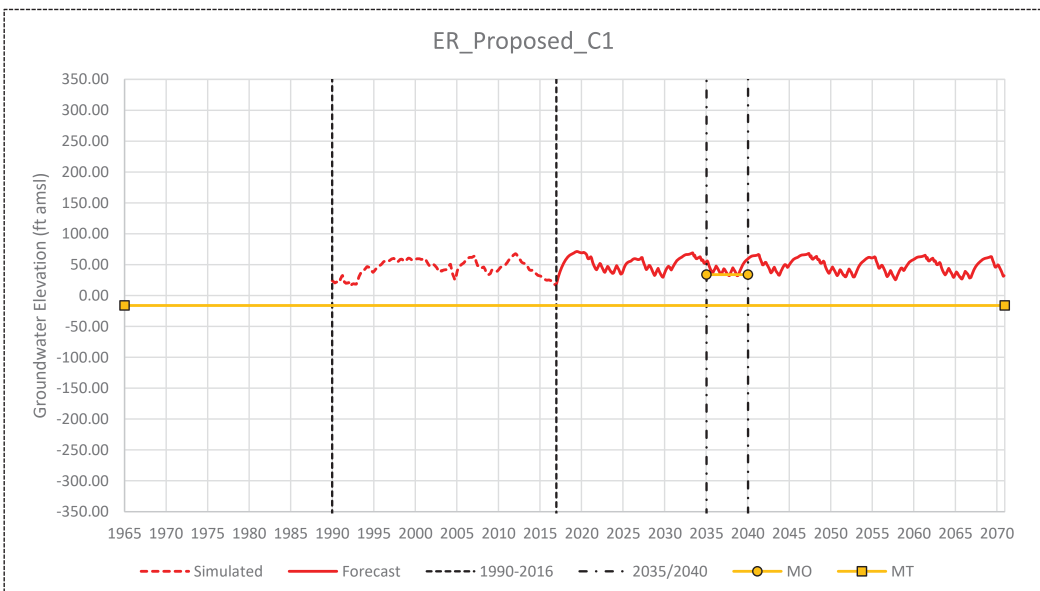
Observed
Forecast
1990-2016
2035/2040
MO
MT



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200.00
150.00
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-50.00
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-150.00
-200.00
-250.00
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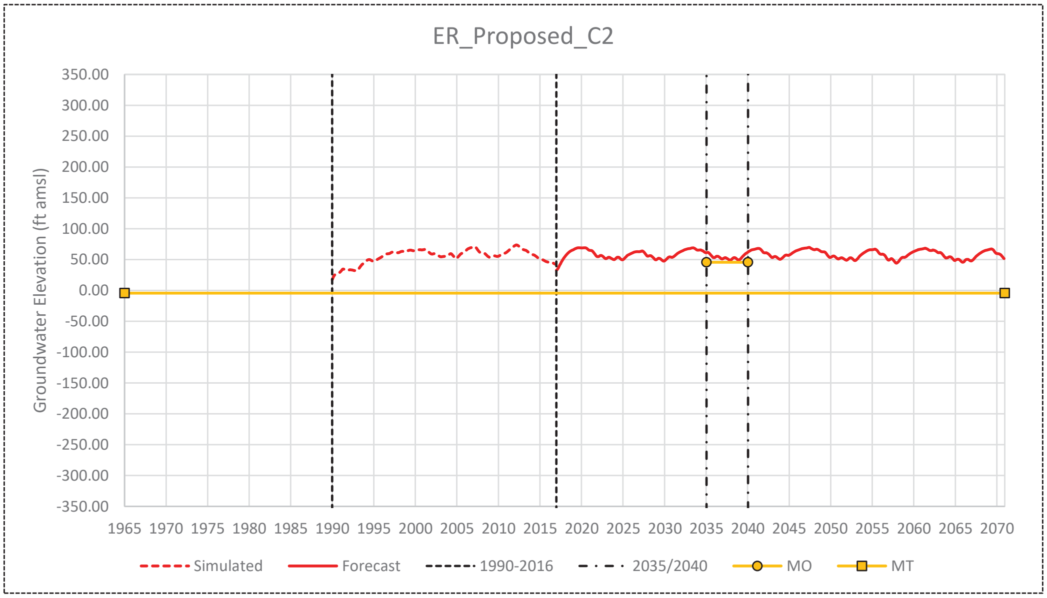
Simulated
Forecast
1990-2016
2035/2040
MO
MT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250.00
200.00
150.00
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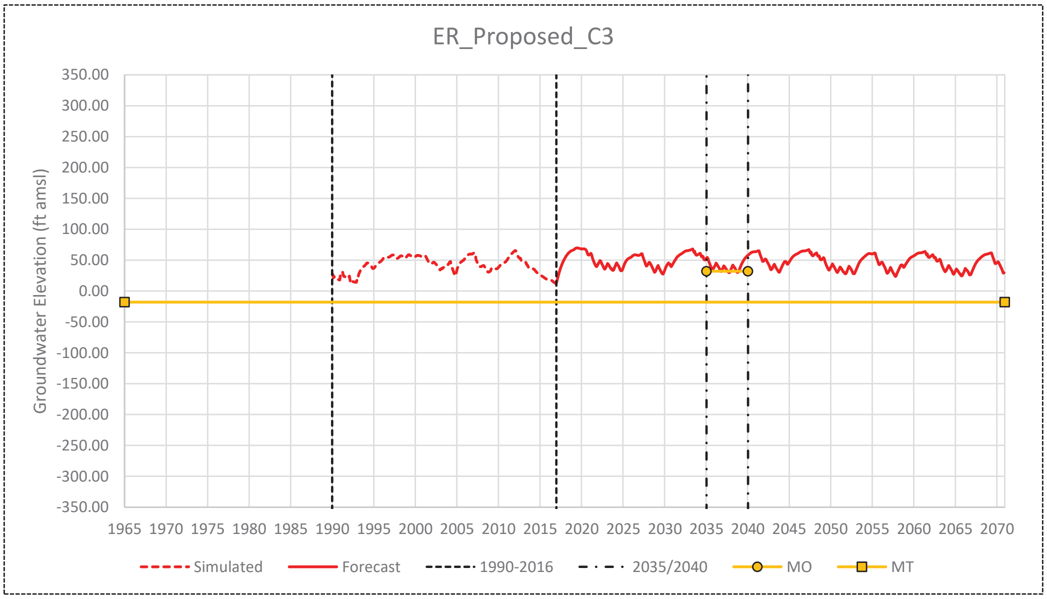
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT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200.00
150.00
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-150.00
-200.00
-250.00
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-350.00
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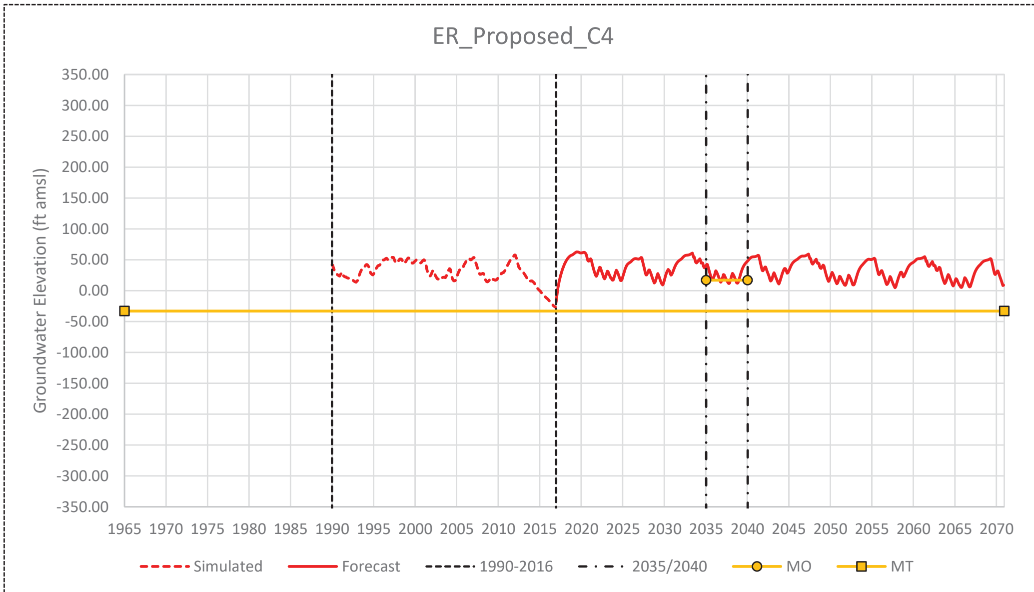
Simulated
Forecast
1990-2016
2035/2040
MO
MT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Groundwater Elevation (ft amsl)
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150.00
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-50.00
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Simulated
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1990-2016
2035/2040
MO
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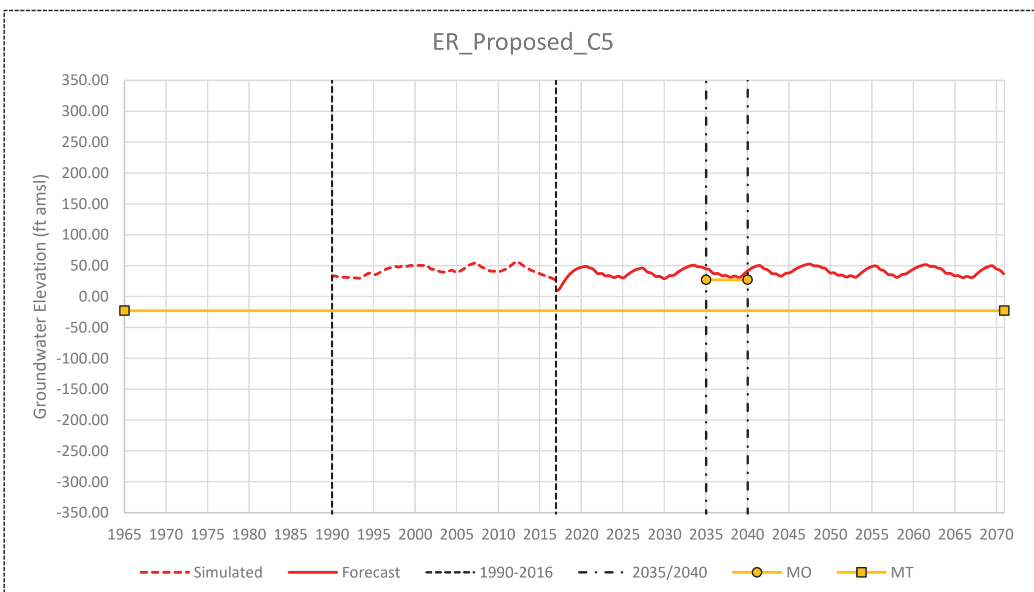
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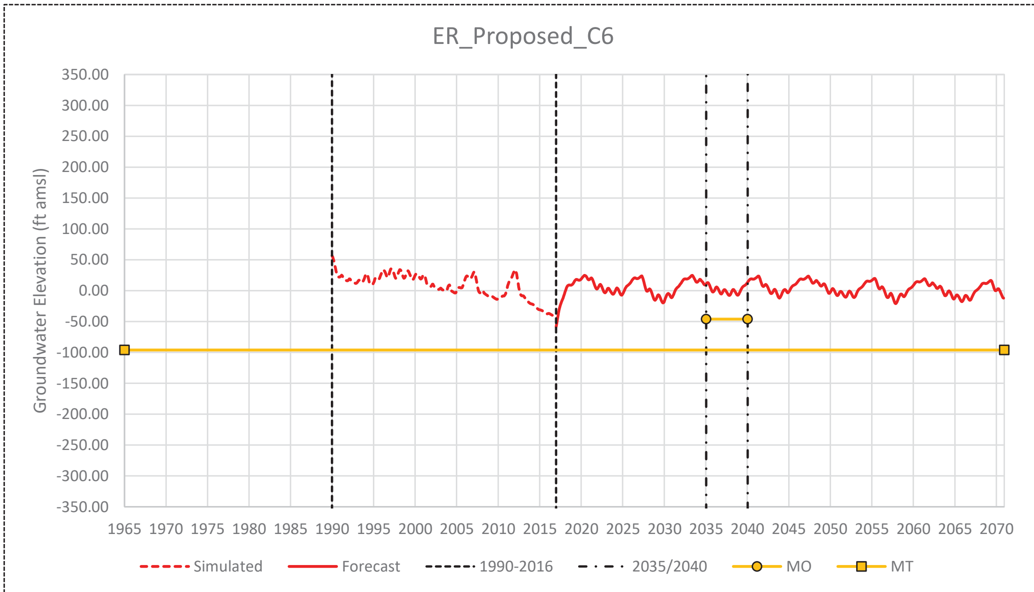
Forecast
1990-2016
2035/2040
MO
MT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-50.00
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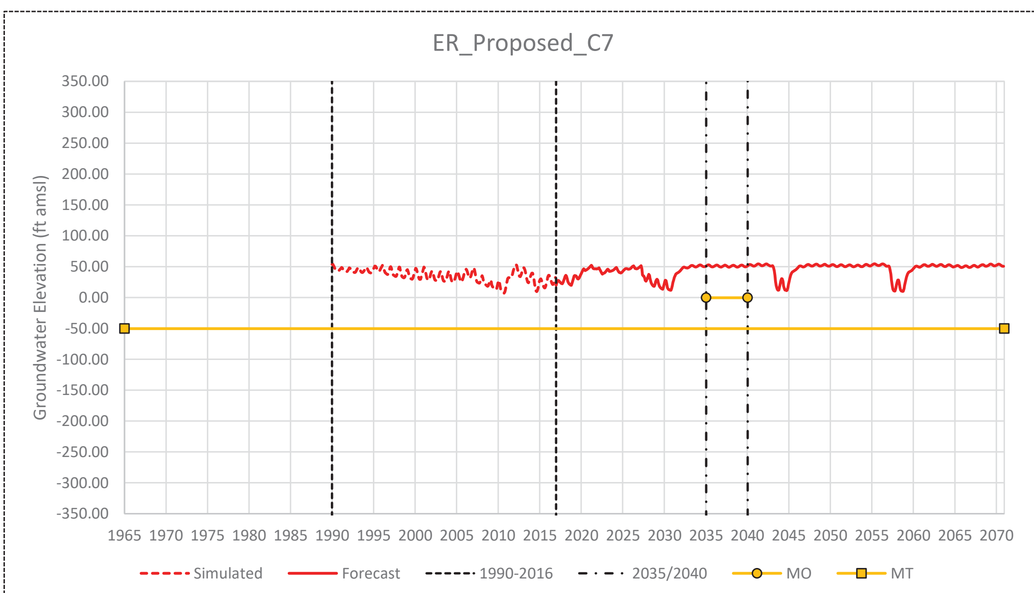
Simulated
Forecast
1990-2016
2035/2040
MO
MT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200.00
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-50.00
-100.00
-150.00
-200.00
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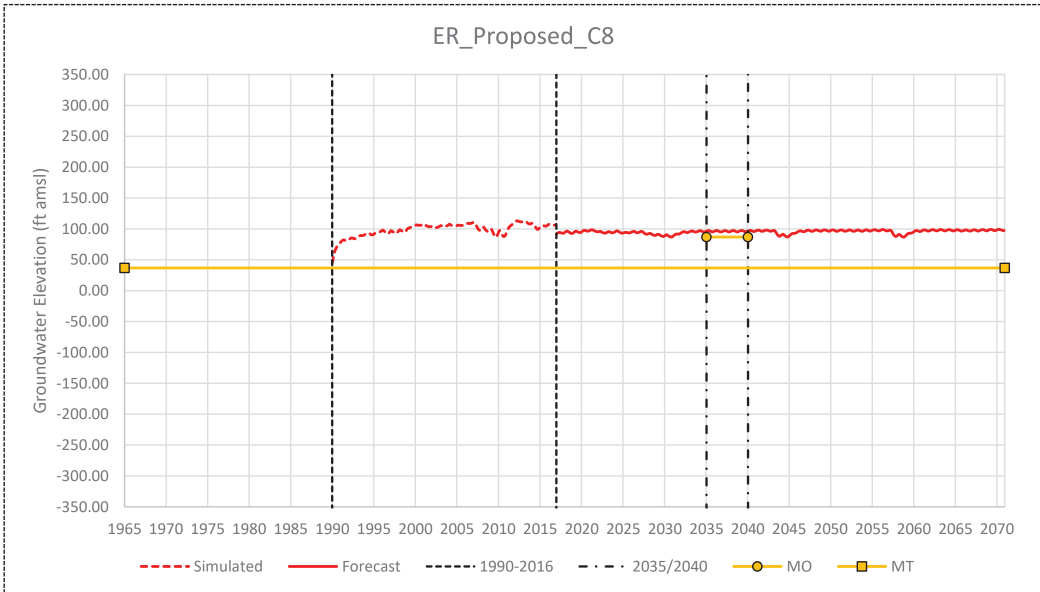
Simulated
Forecast
1990-2016
2035/2040
MO
MT



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200.00
150.00
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50.00
0.00
-50.00
-100.00
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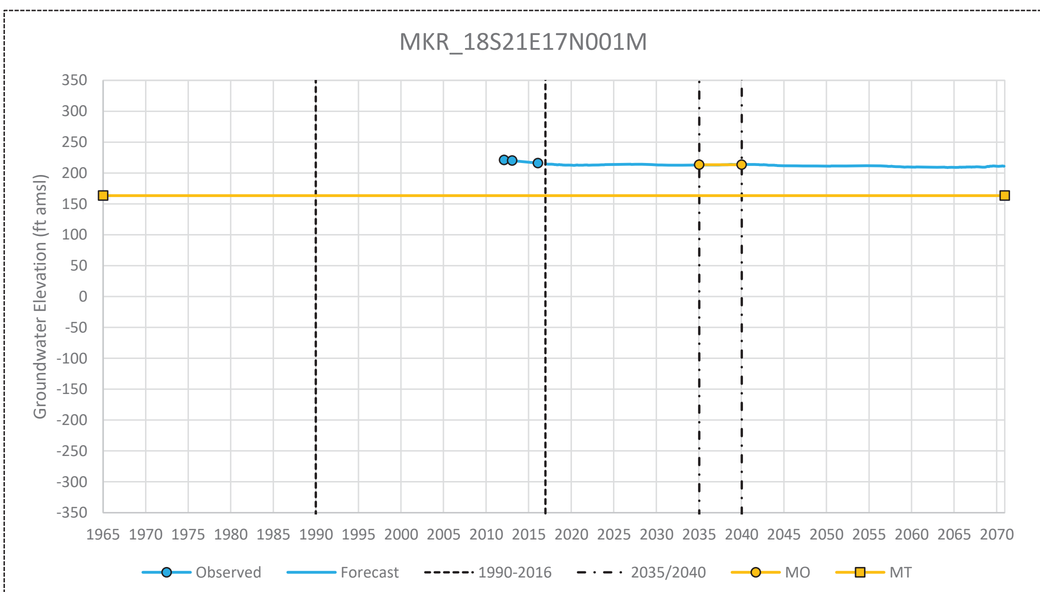
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT



MKR_18S21E17N001M
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150
100
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0
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-200
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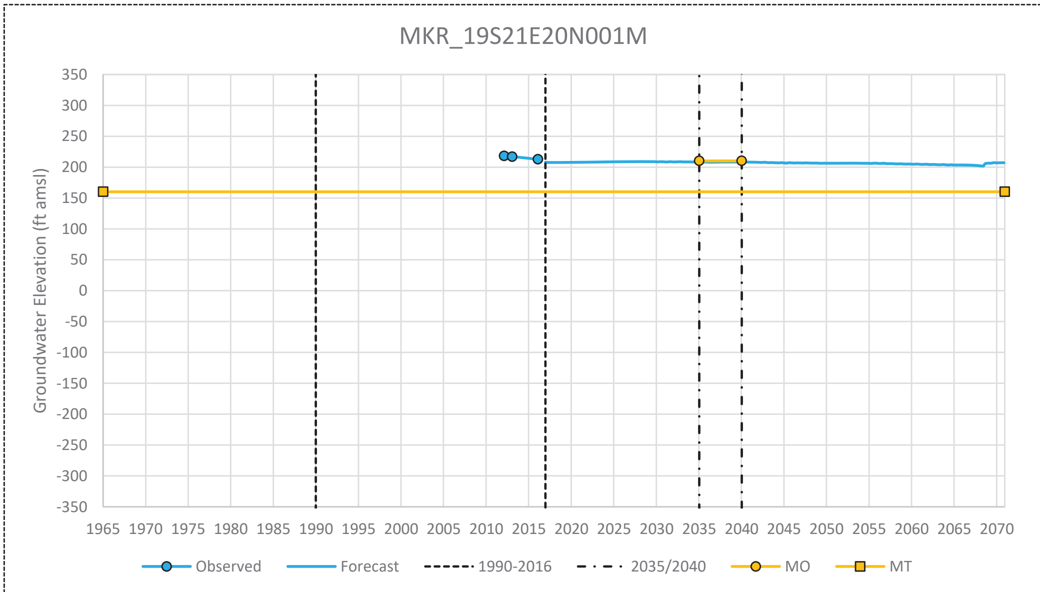
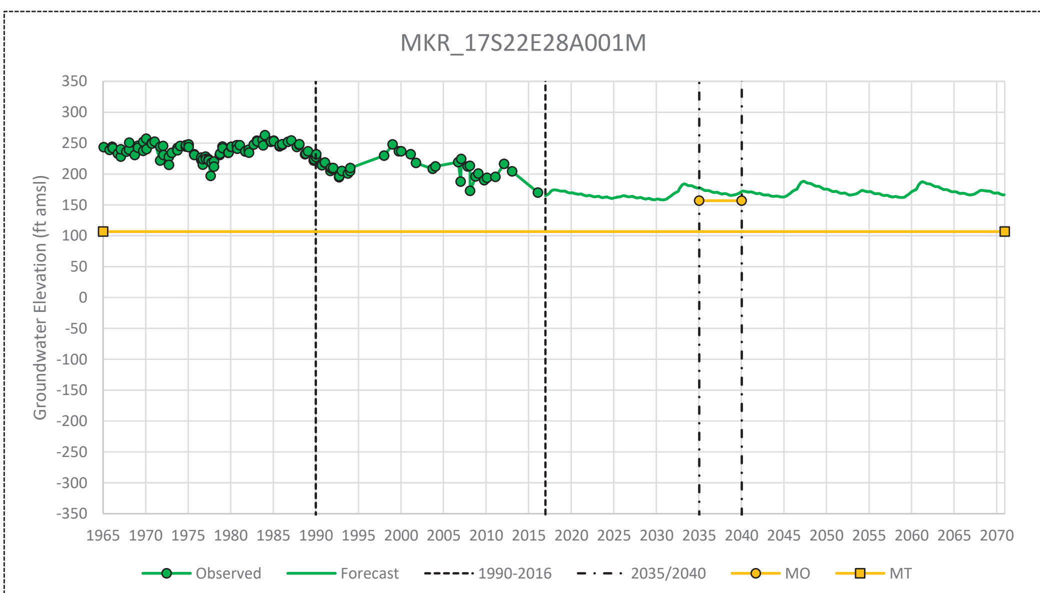
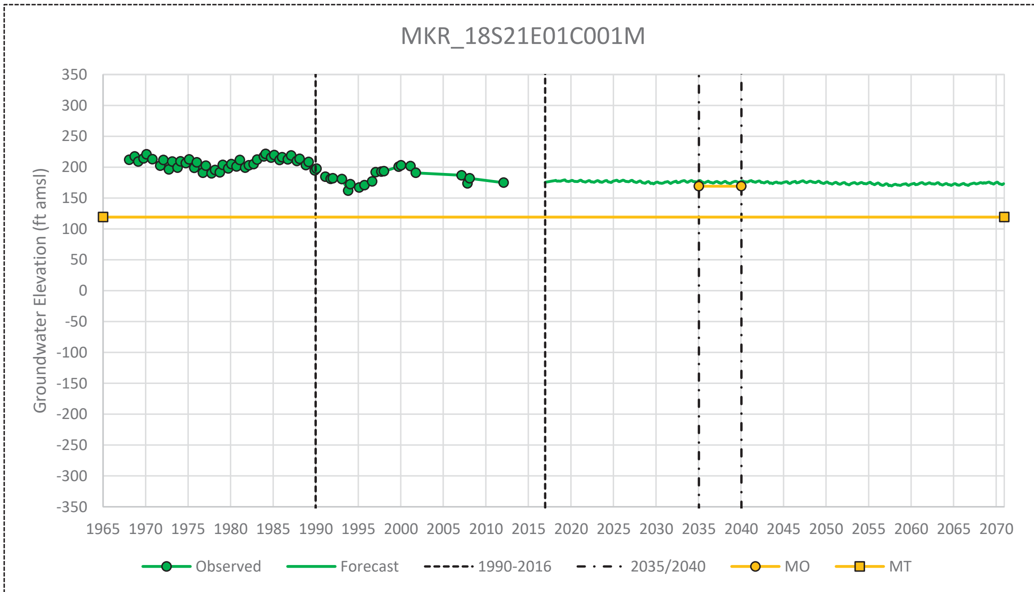
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_19S21E20N001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_17S22E28A001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_18S21E01C001M
Groundwater Elevation (ft amsl)
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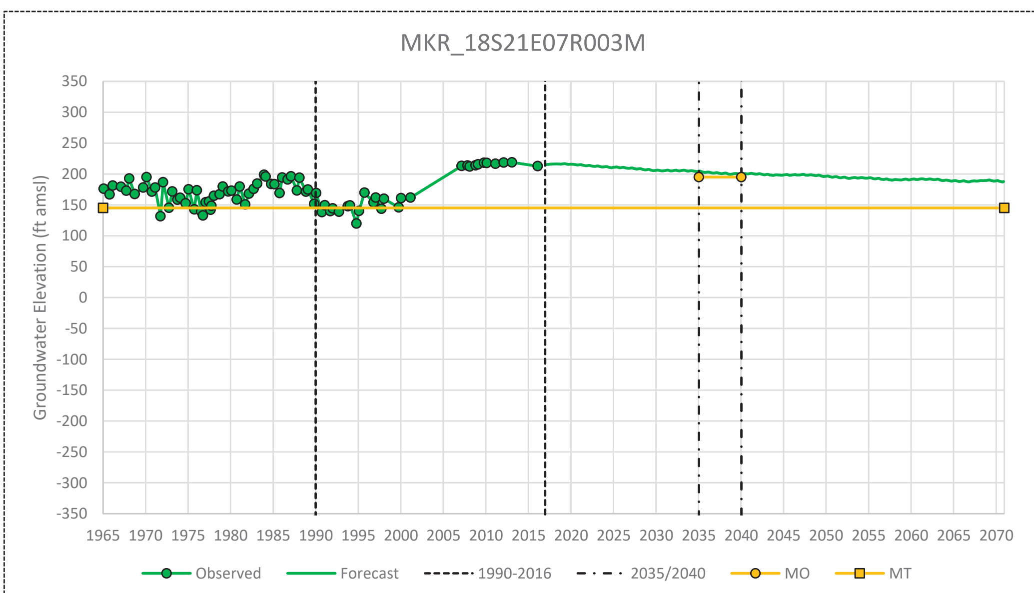
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_18S21E07R003M
Groundwater Elevation (ft amsl)
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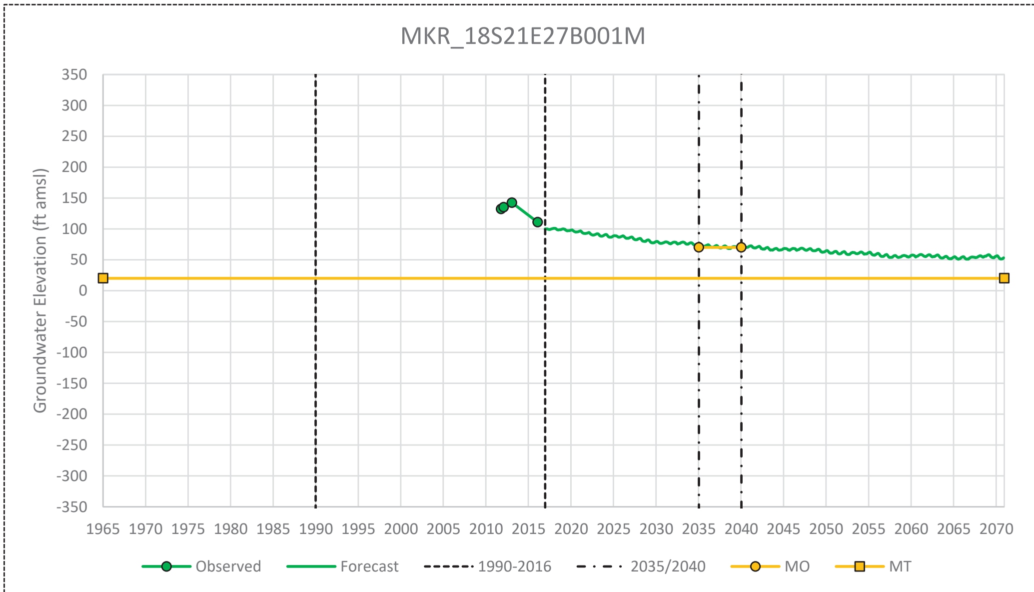
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_18S21E27B001M
Groundwater Elevation (ft amsl)
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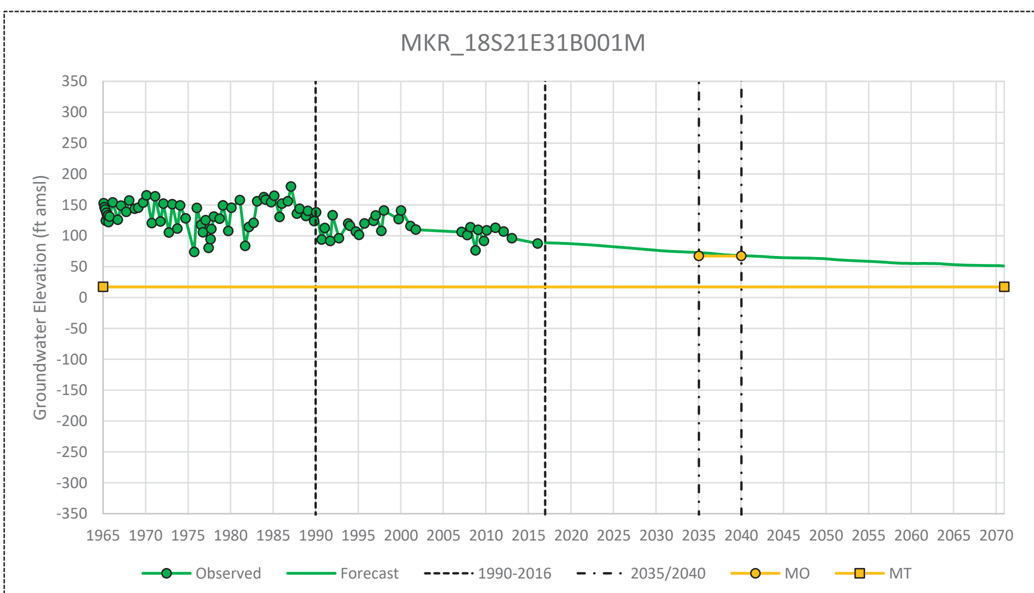
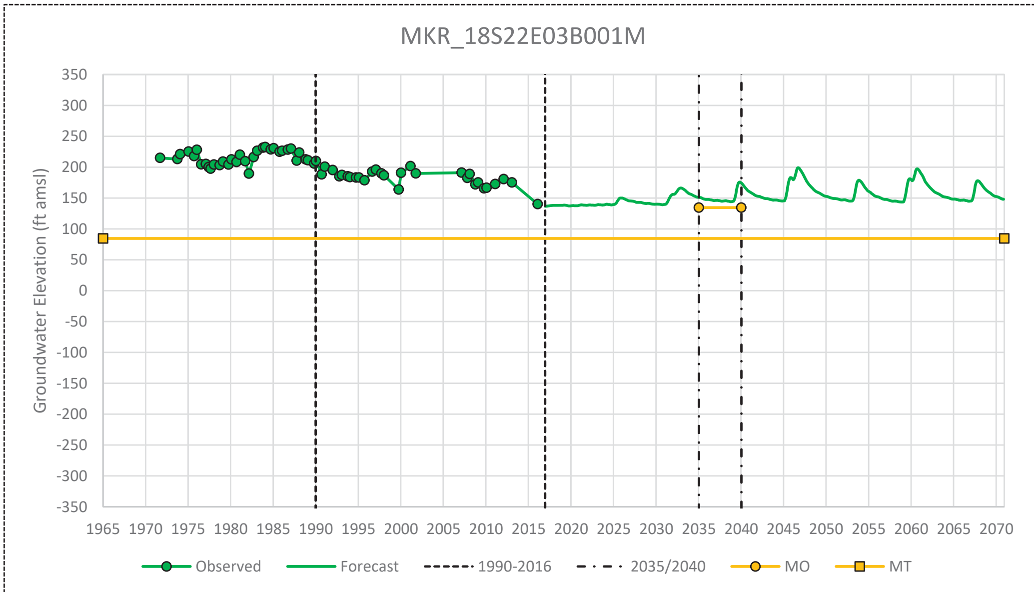
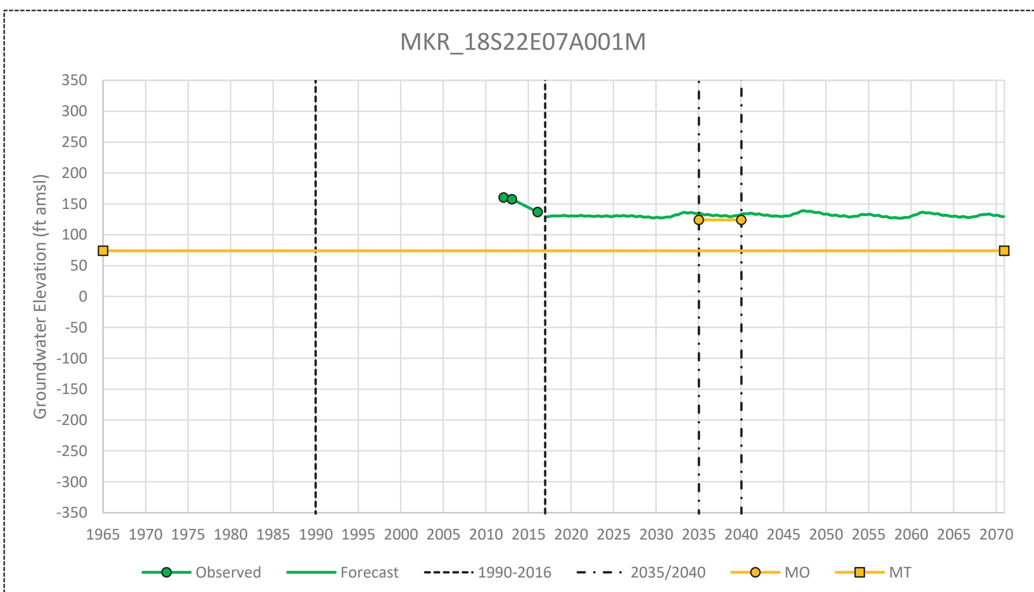
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

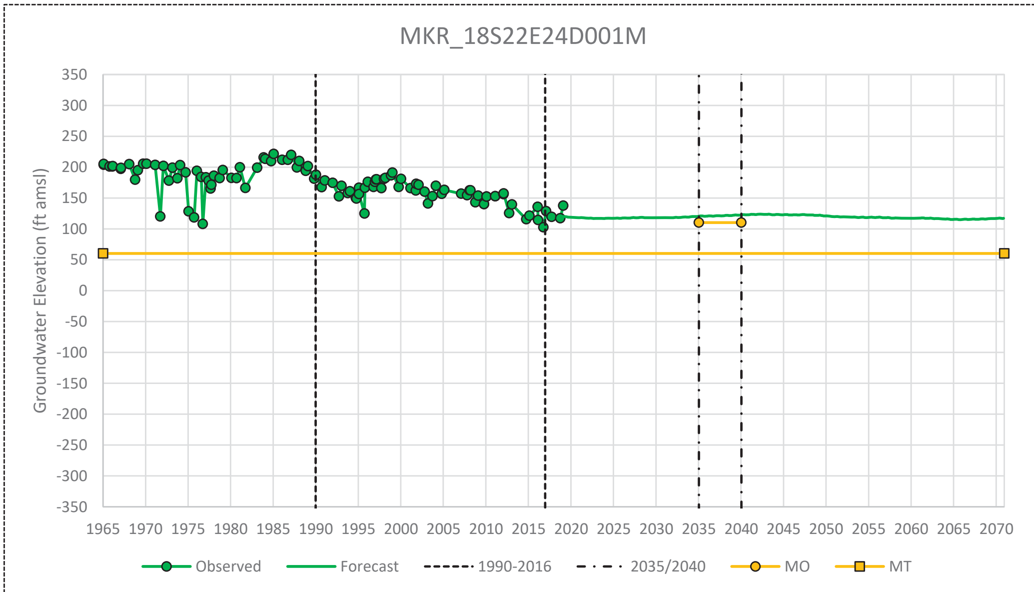

MKR_18S21E31B001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT



MKR_18S22E03B001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT



MKR_18S22E07A001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_18S22E24D001M
Groundwater Elevation (ft amsl)
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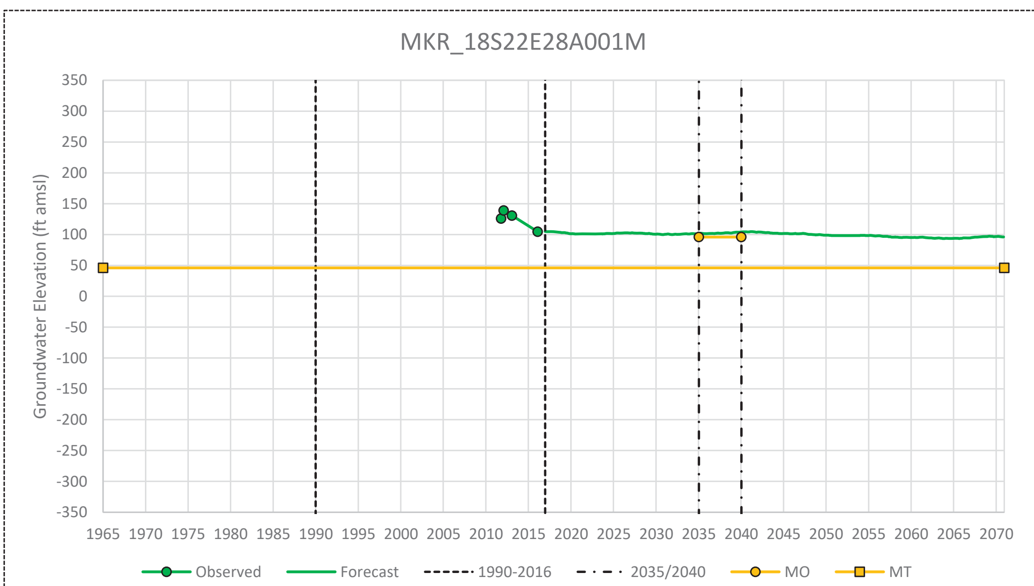
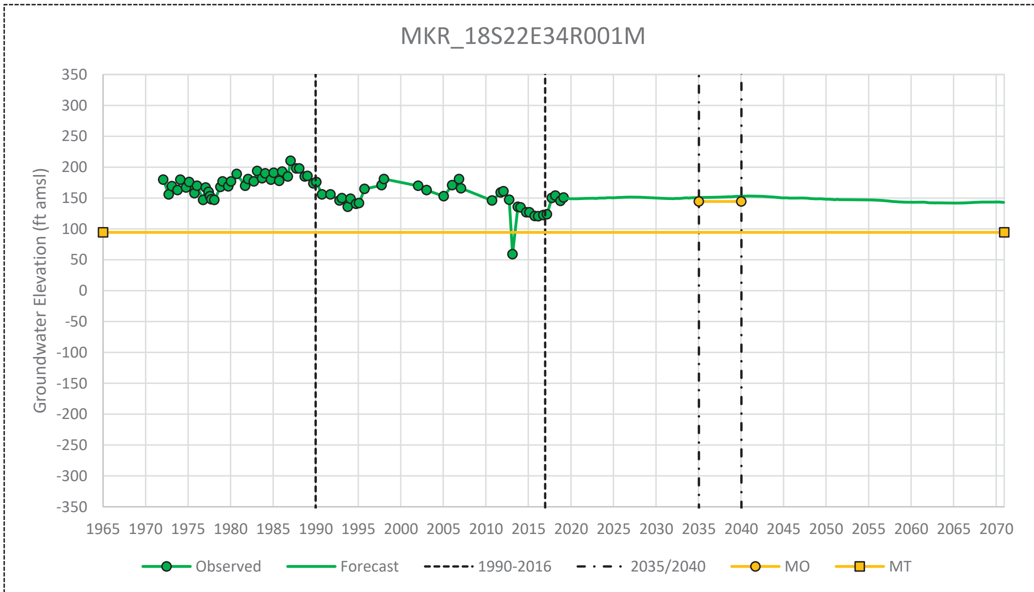
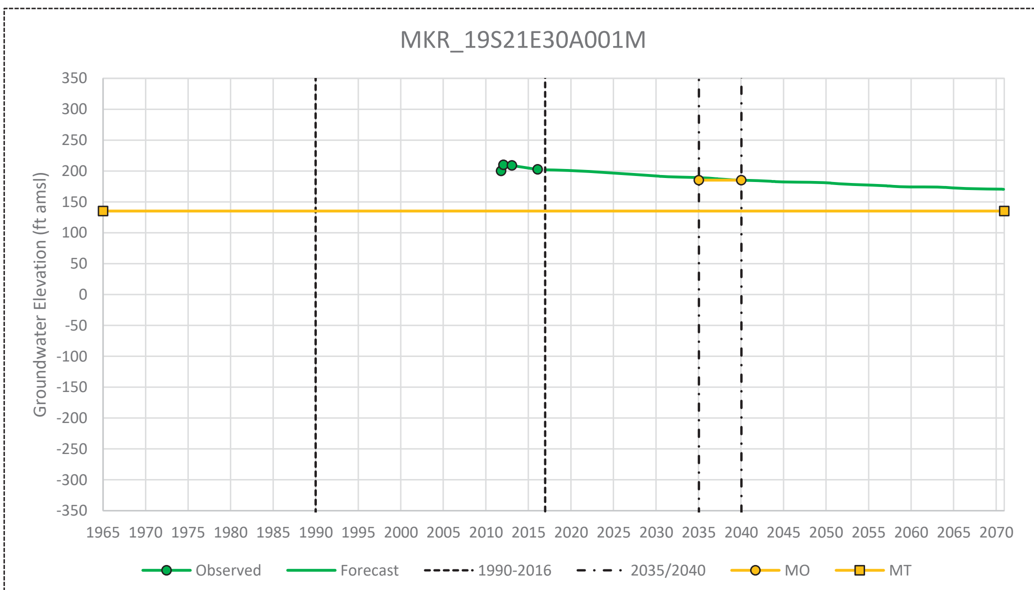
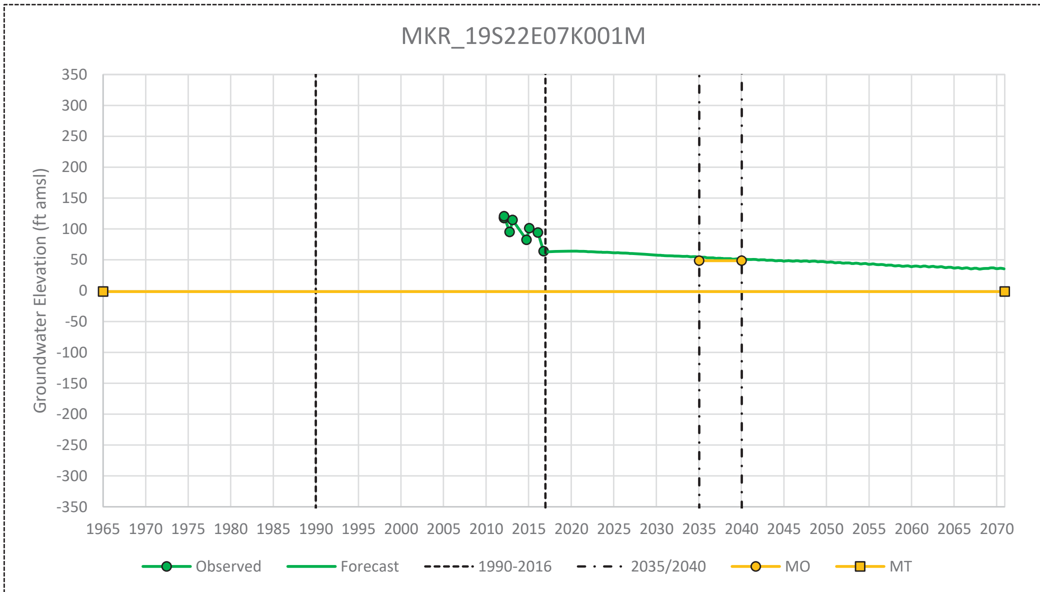
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_18S22E28A001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_18S22E34R001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_19S21E30A001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_19S22E07K001M
Groundwater Elevation (ft amsl)
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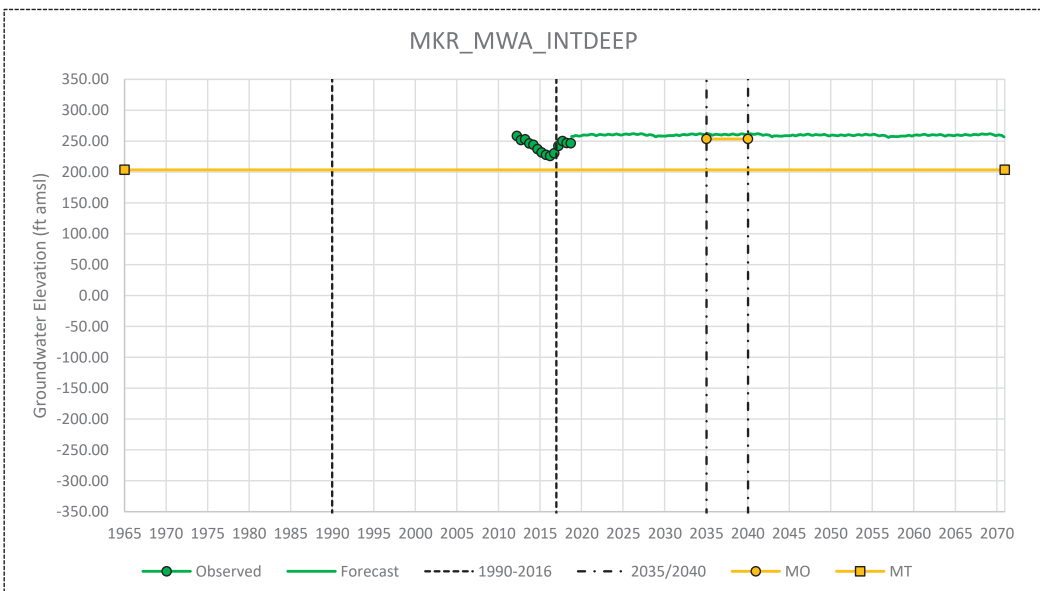
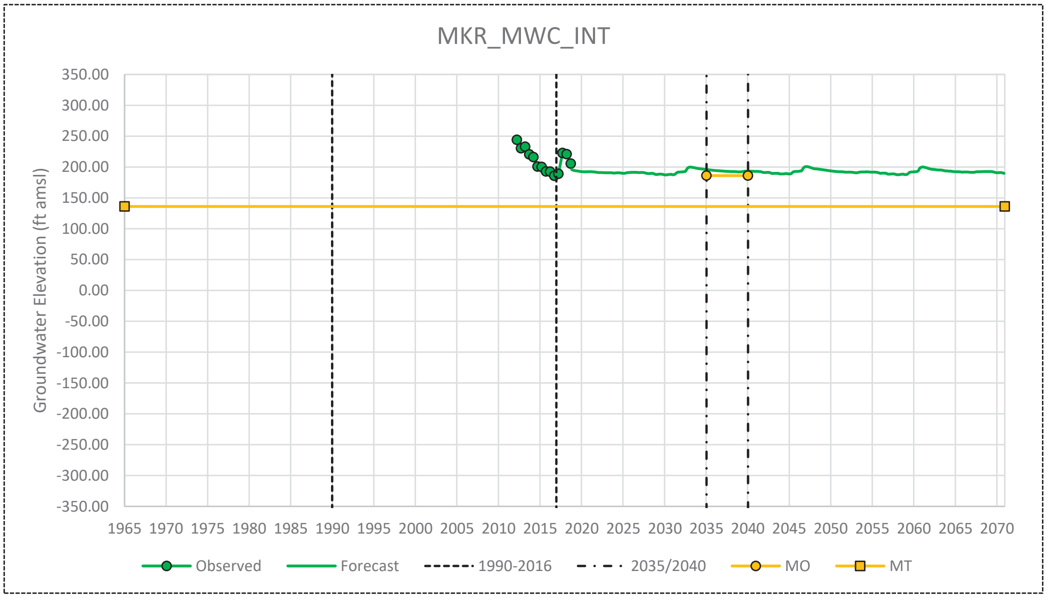
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_MWA_INTDEEP
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_MWC_INT
Groundwater Elevation (ft amsl)
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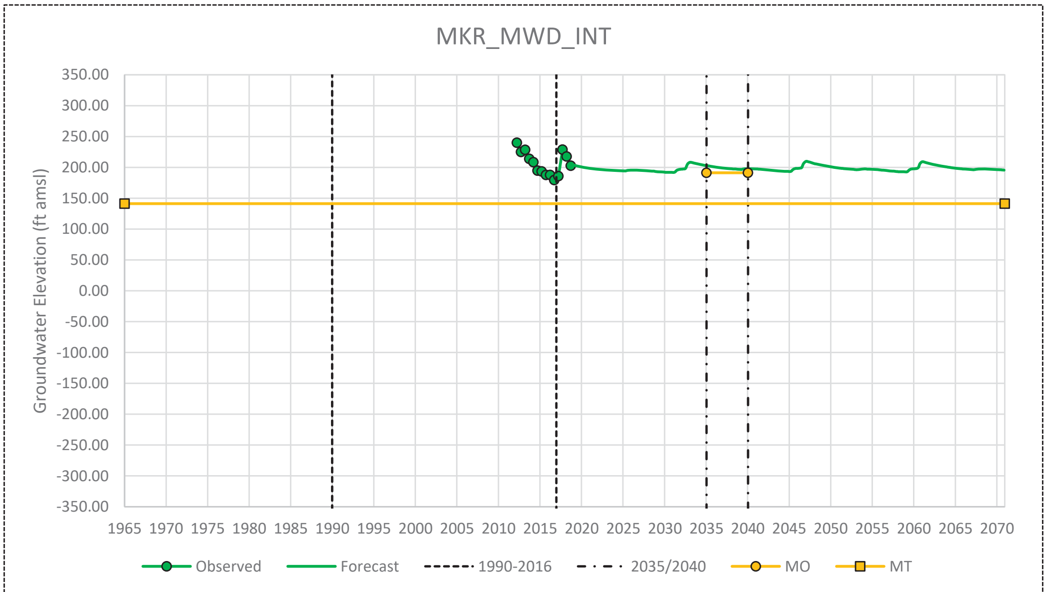
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_MWD_INT
Groundwater Elevation (ft amsl)
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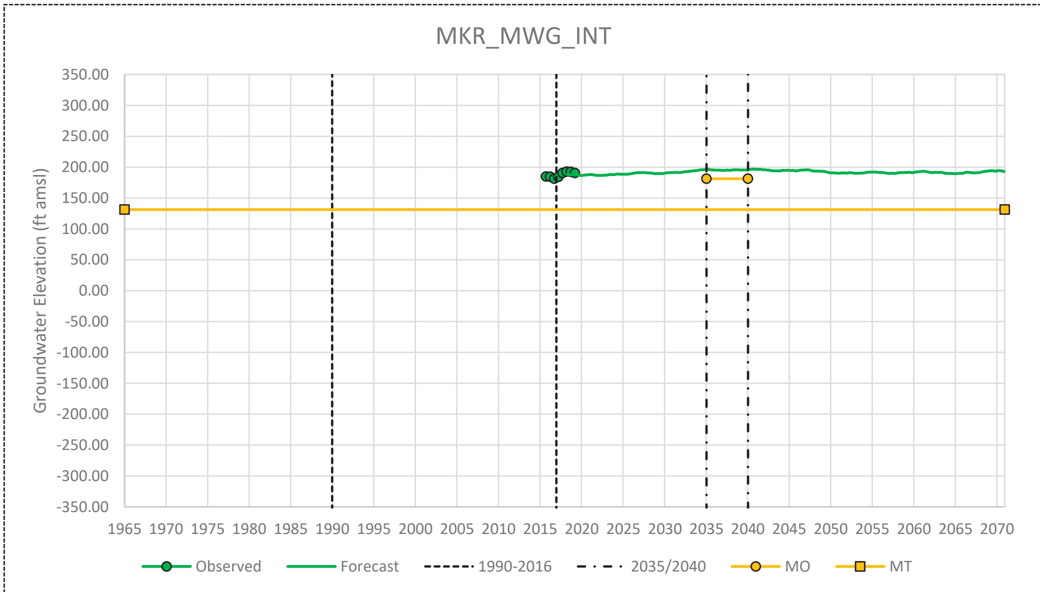
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_MWG_INT
Groundwater Elevation (ft amsl)
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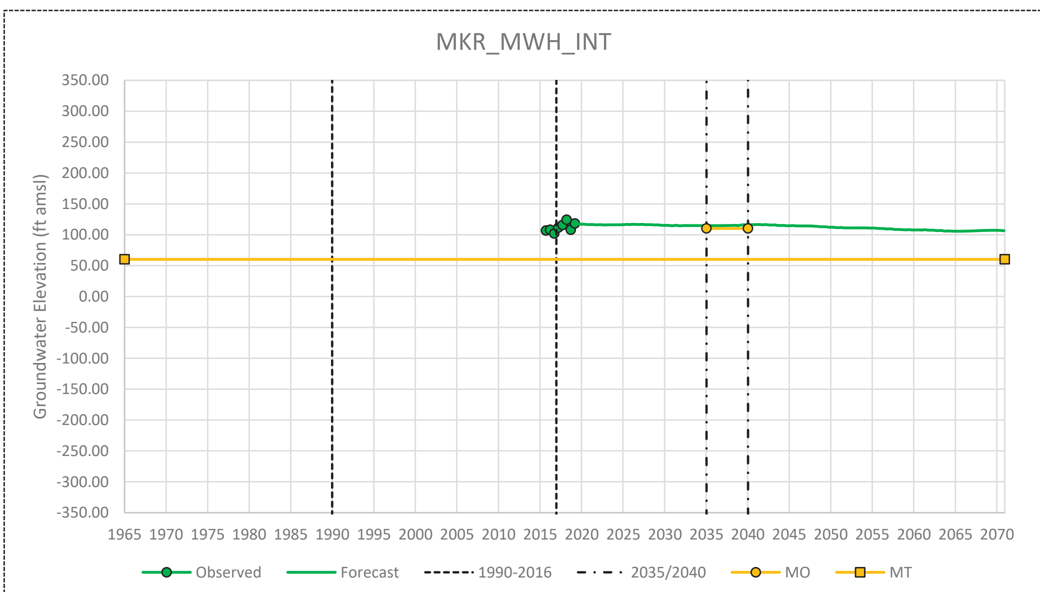
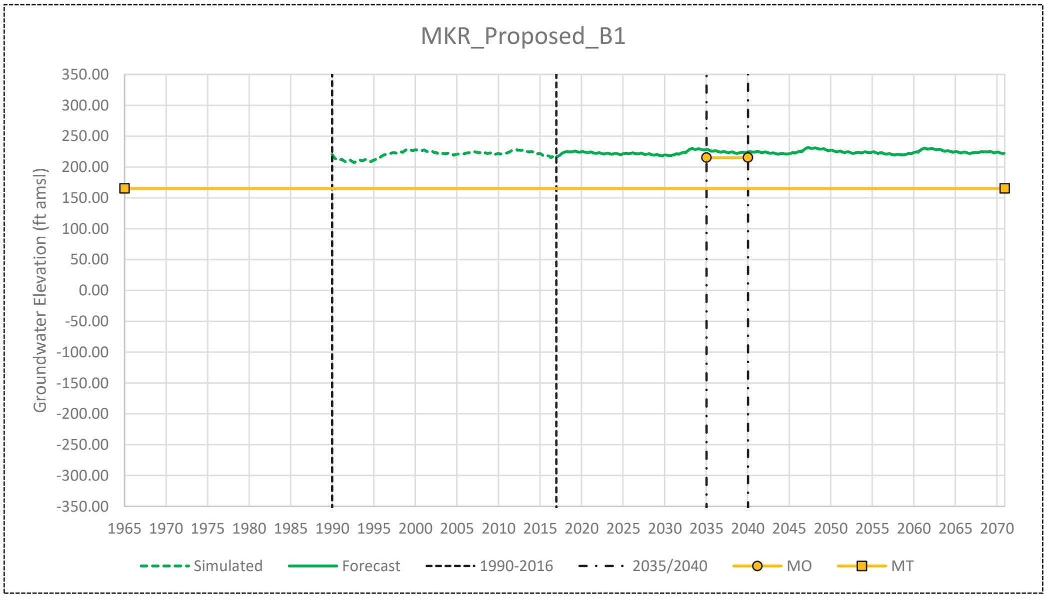
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_MWH_INT
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_Proposed_B1
Groundwater Elevation (ft amsl)
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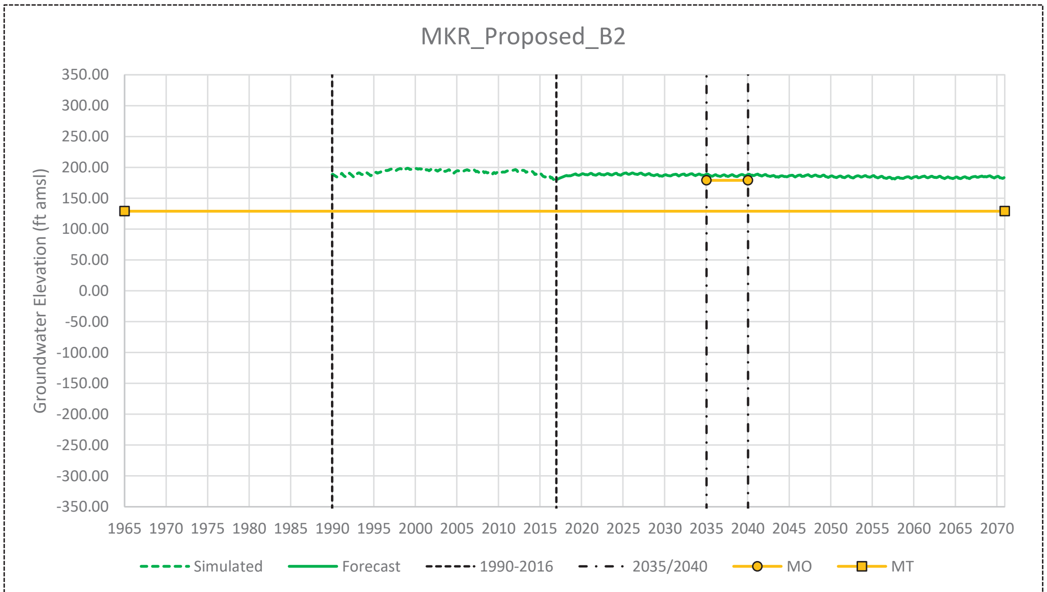
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


MKR_Proposed_B2
Groundwater Elevation (ft amsl)
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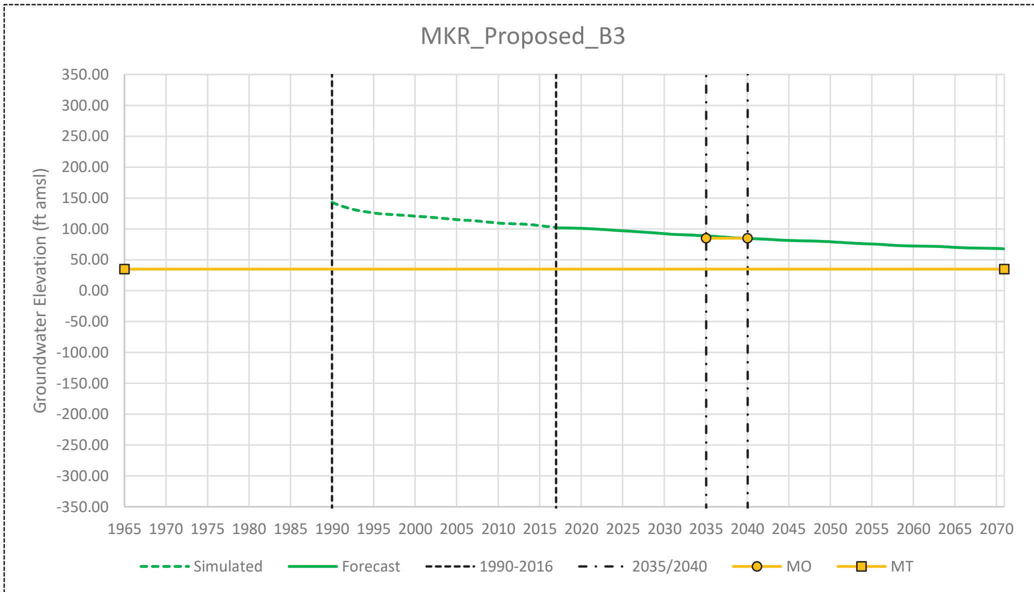
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT



MKR_Proposed_B3
Groundwater Elevation (ft amsl)
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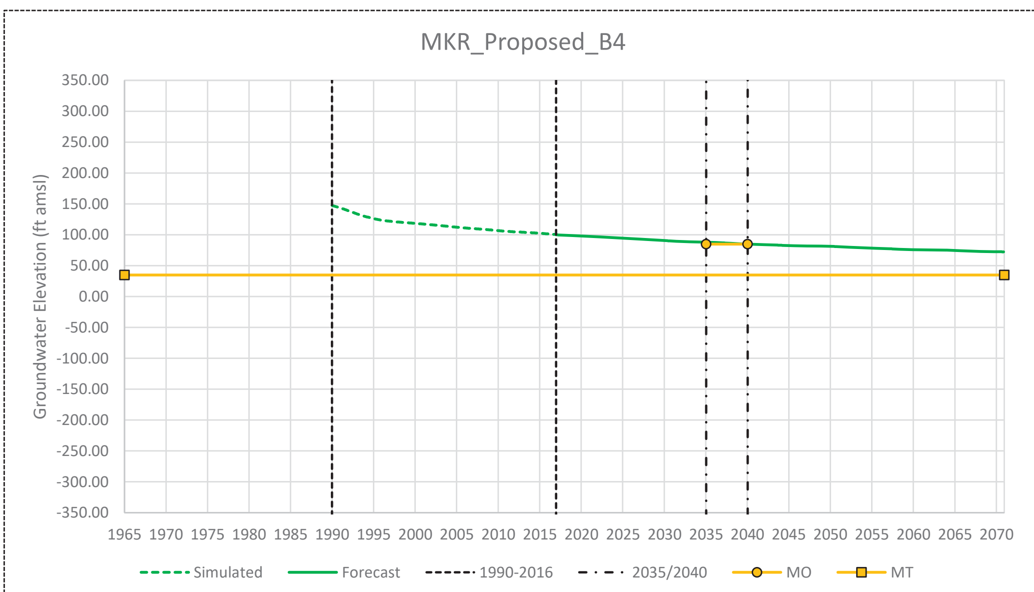
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT



MKR_Proposed_B4
Groundwater Elevation (ft amsl)
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250.00
200.00
150.00
100.00
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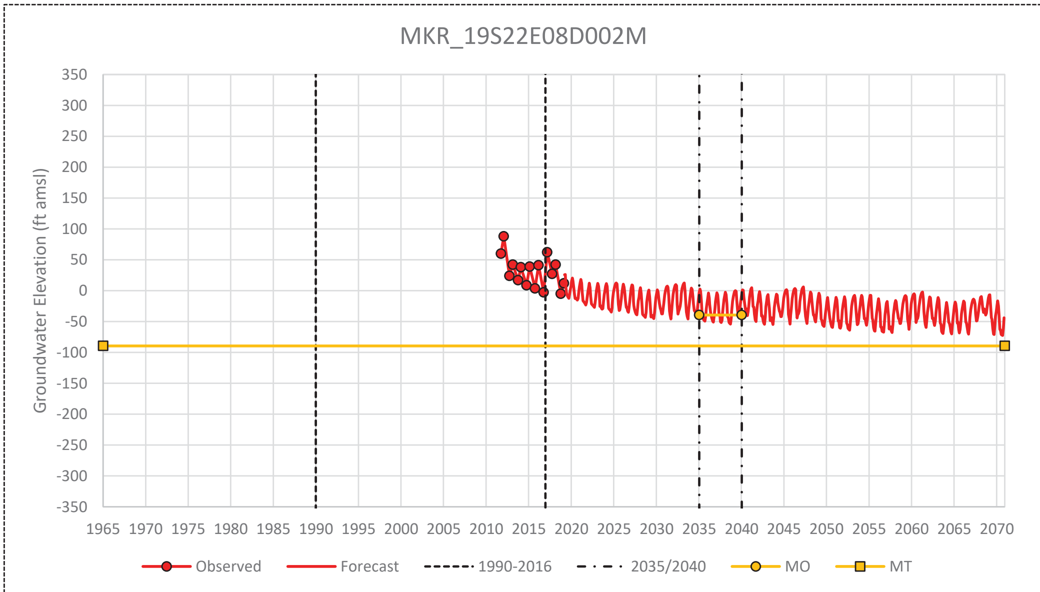
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


MKR_19S22E08D002M
Groundwater Elevation (ft amsl)
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300
250
200
150
100
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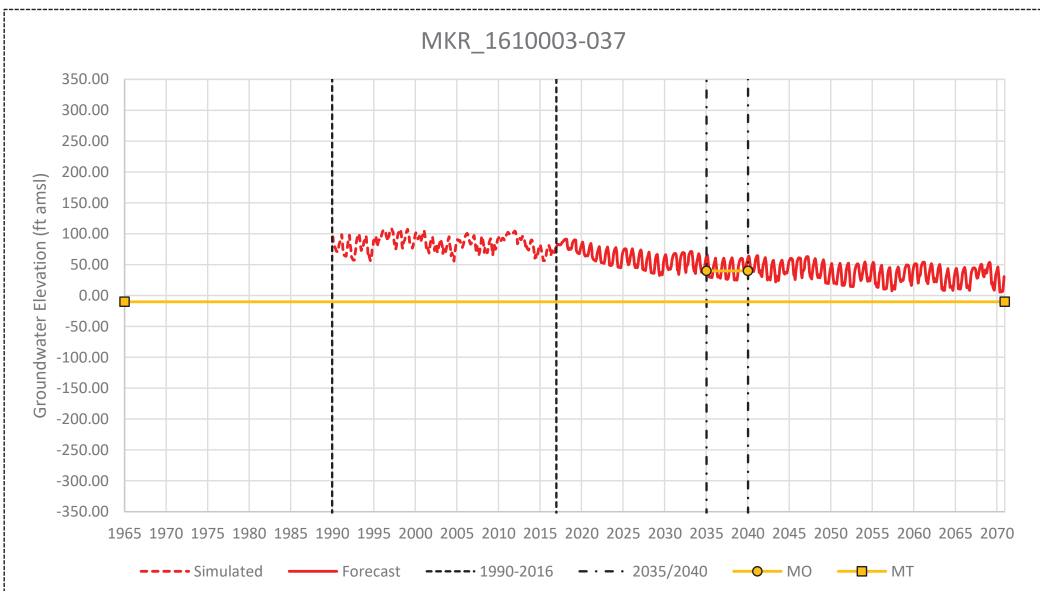
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_1610003-037
Groundwater Elevation (ft amsl)
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100.00
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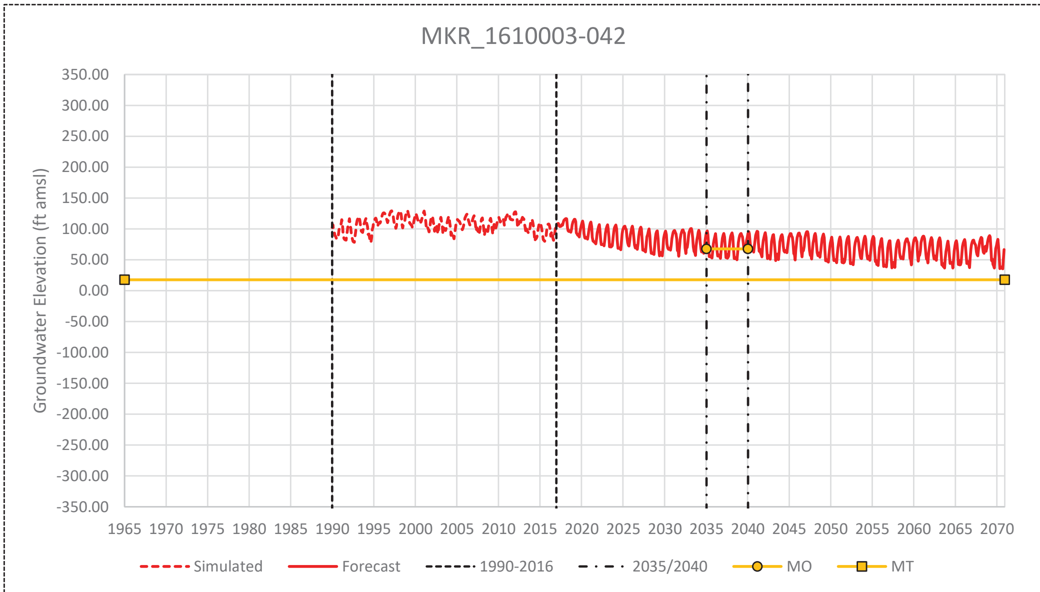
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


MKR_1610003-042
Groundwater Elevation (ft amsl)
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250.00
200.00
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100.00
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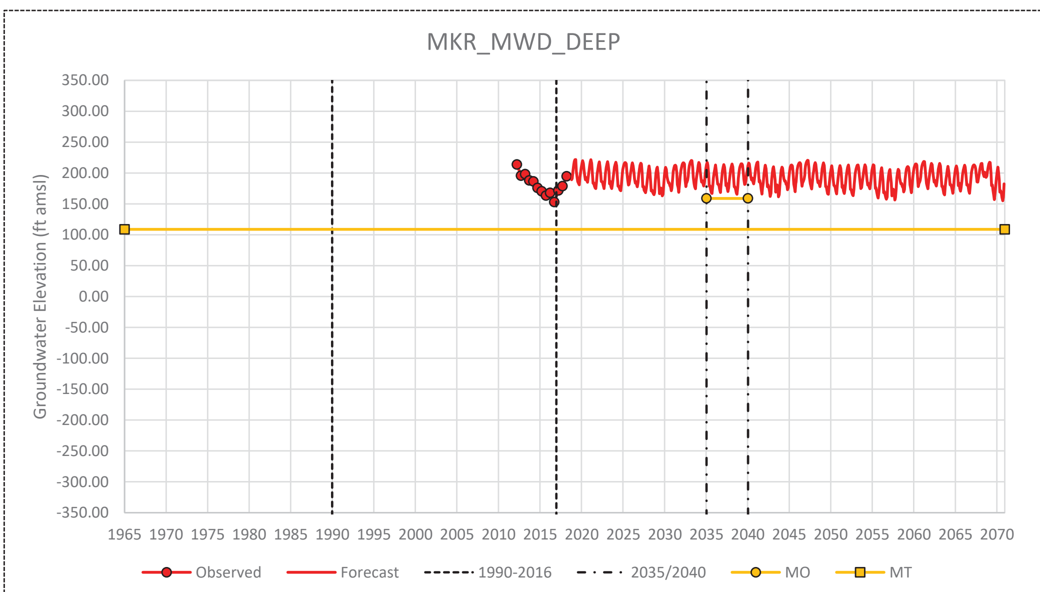
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


MKR_MWD_DEEP
Groundwater Elevation (ft amsl)
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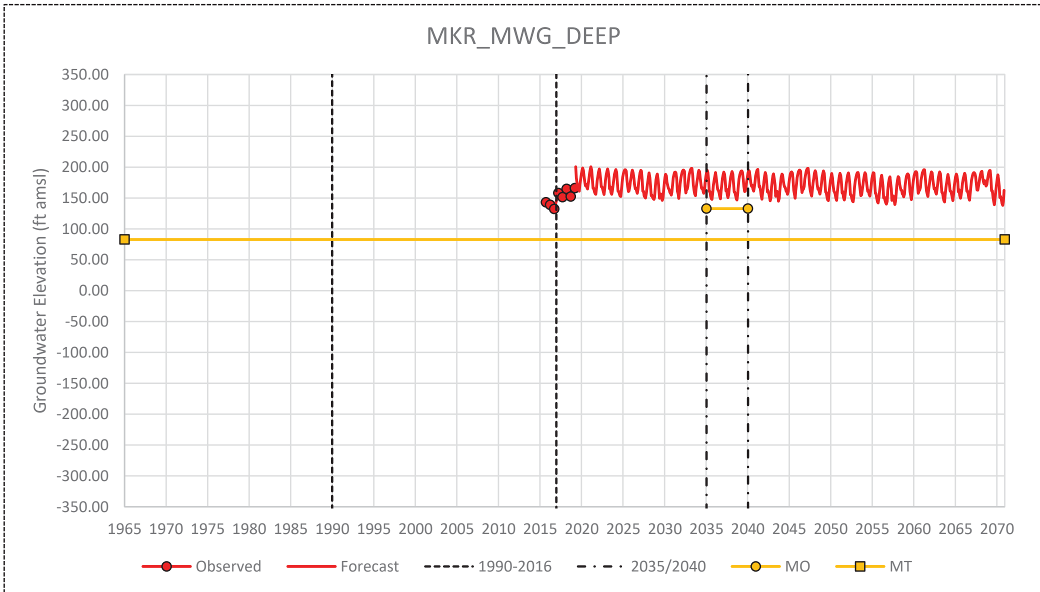
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_MWG_DEEP
Groundwater Elevation (ft amsl)
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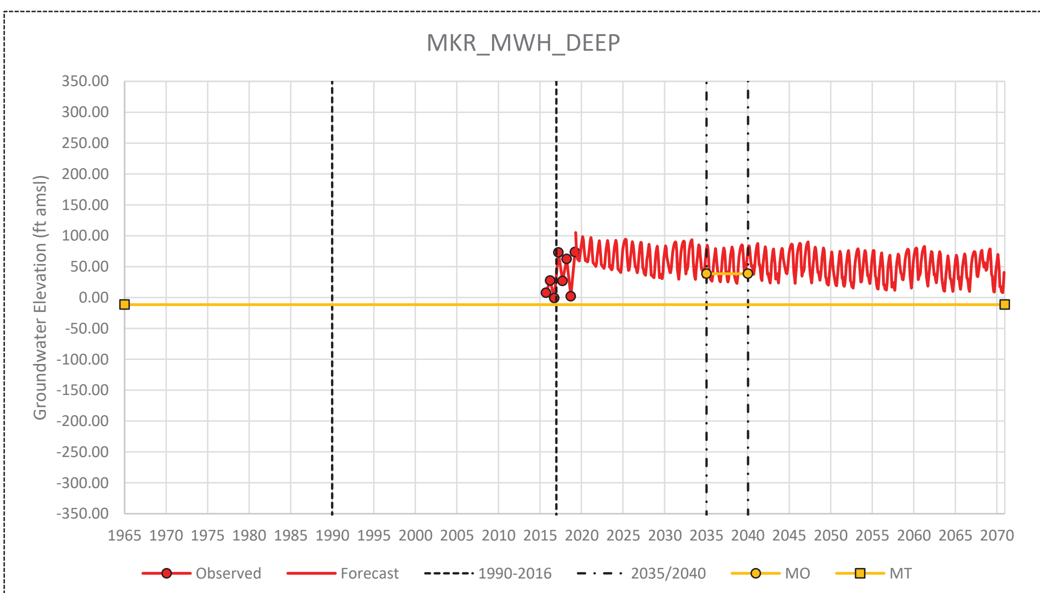
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_MWH_DEEP
Groundwater Elevation (ft amsl)
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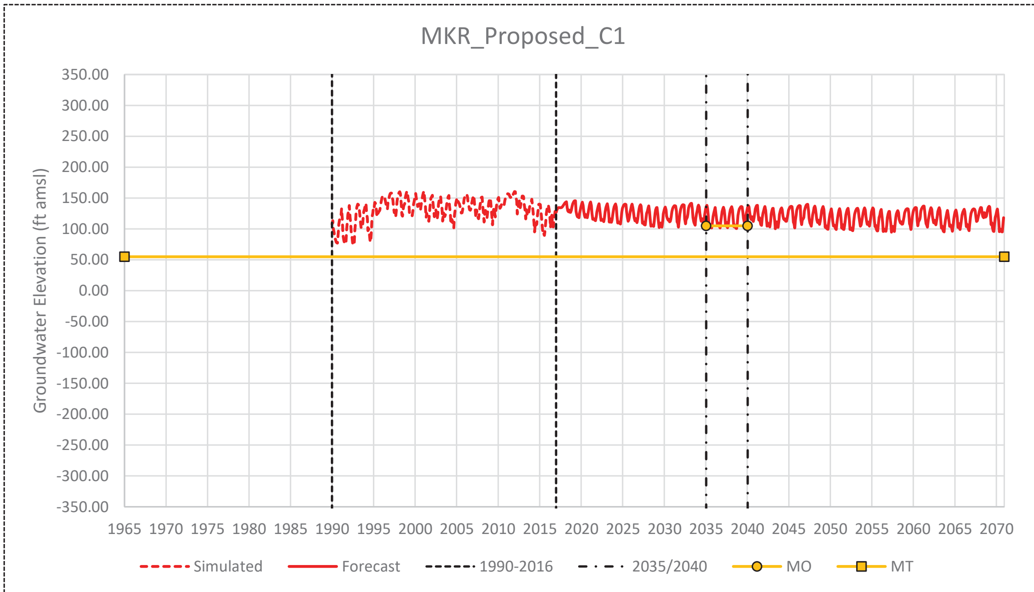
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


MKR_Proposed_C1
Groundwater Elevation (ft amsl)
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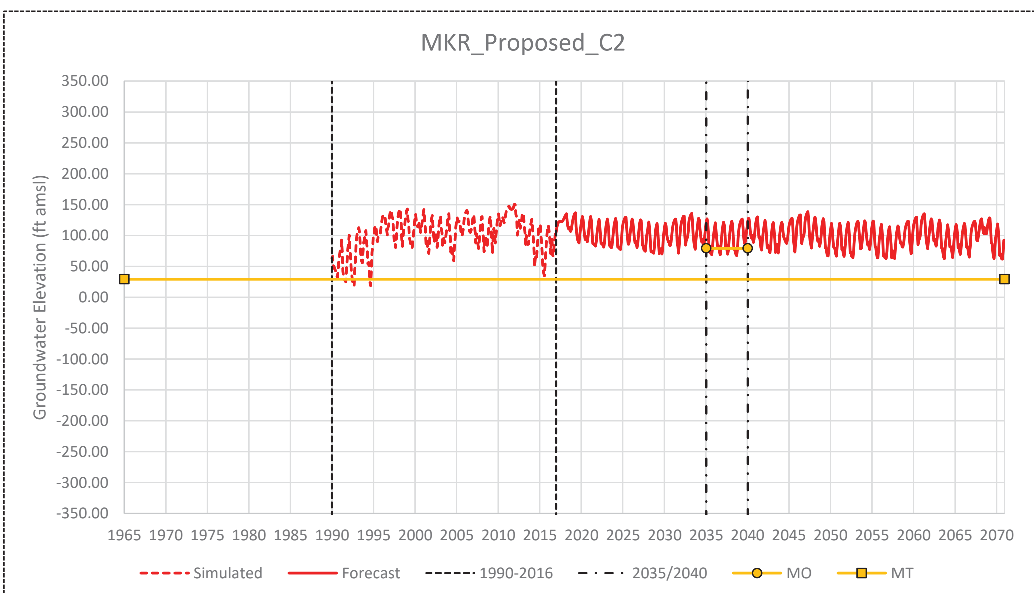
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


MKR_Proposed_C2
Groundwater Elevation (ft amsl)
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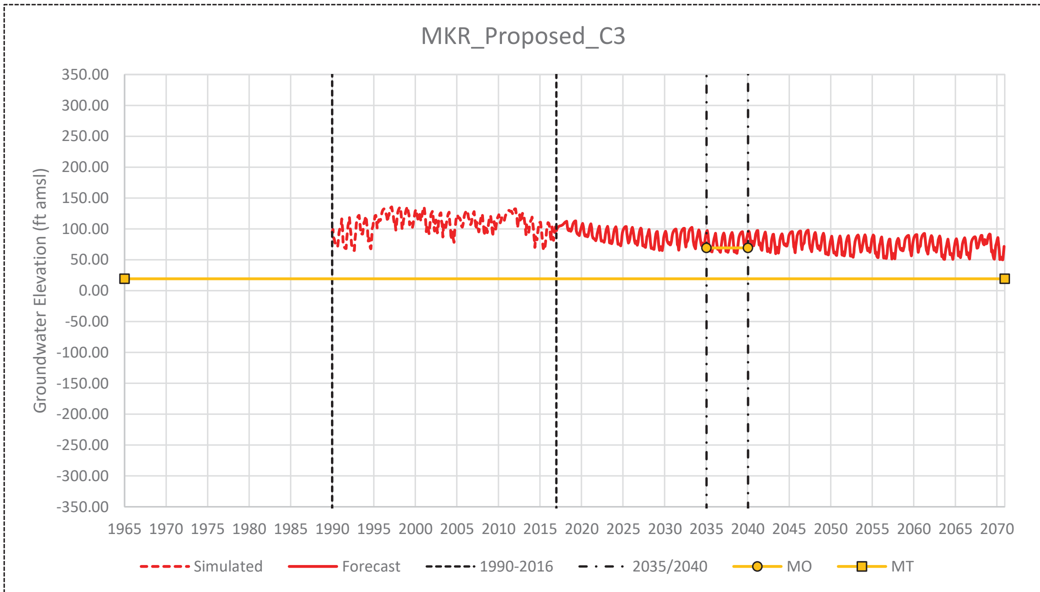
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


MKR_Proposed_C3
Groundwater Elevation (ft amsl)
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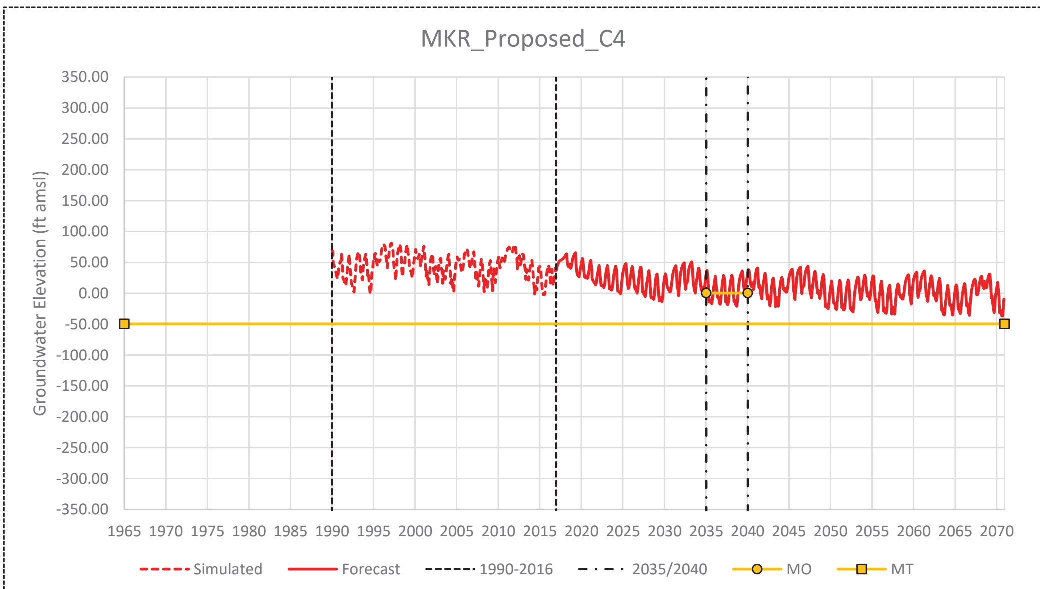
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


MKR_Proposed_C4
Groundwater Elevation (ft amsl)
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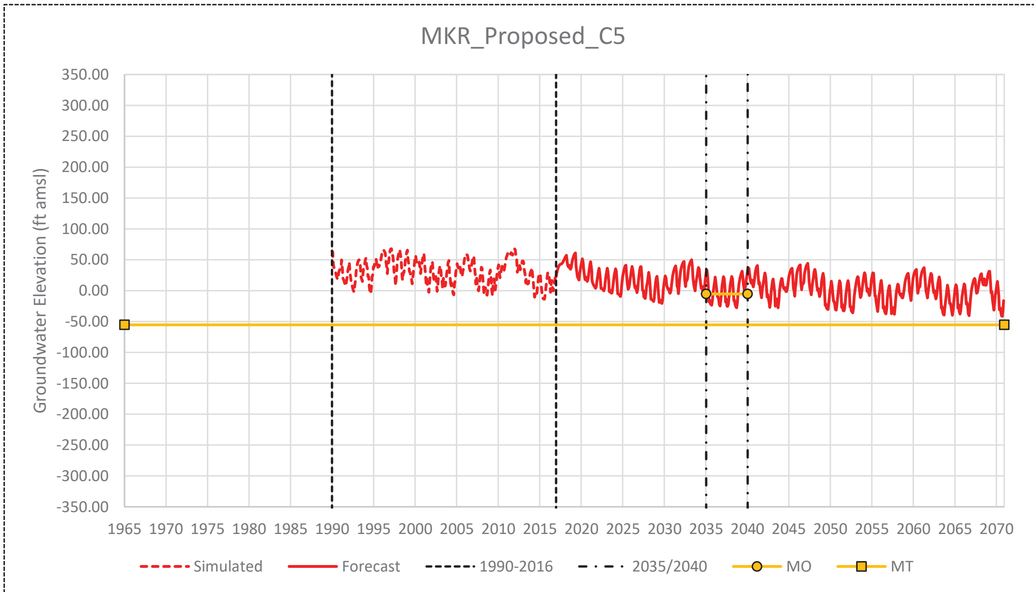
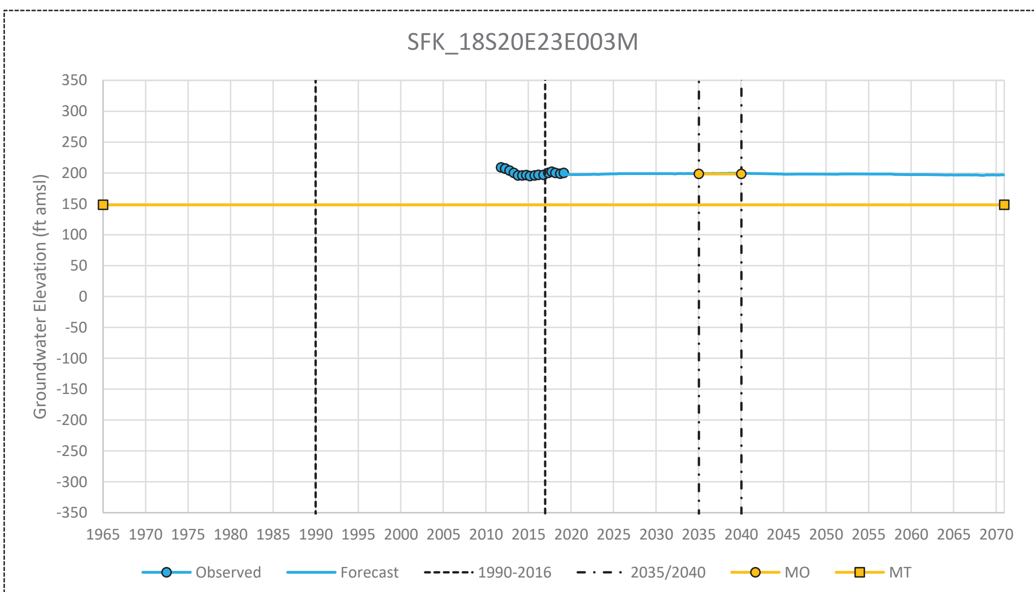
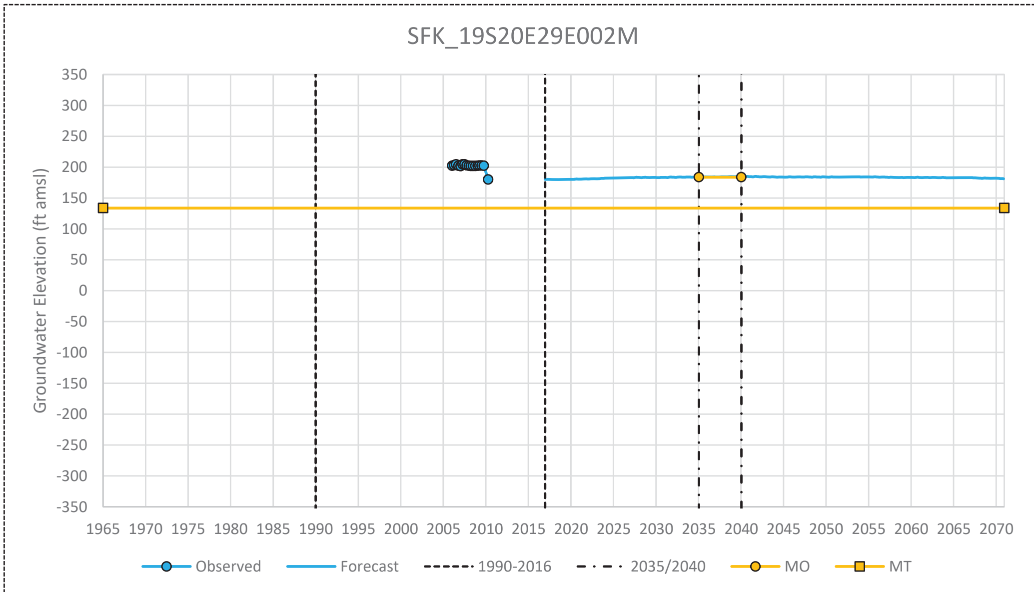
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT

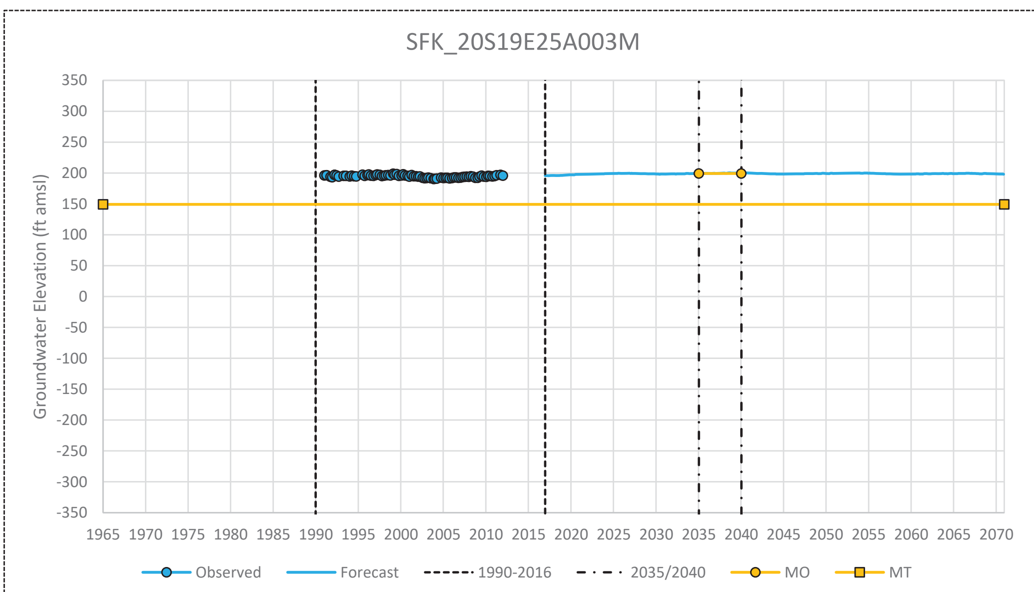


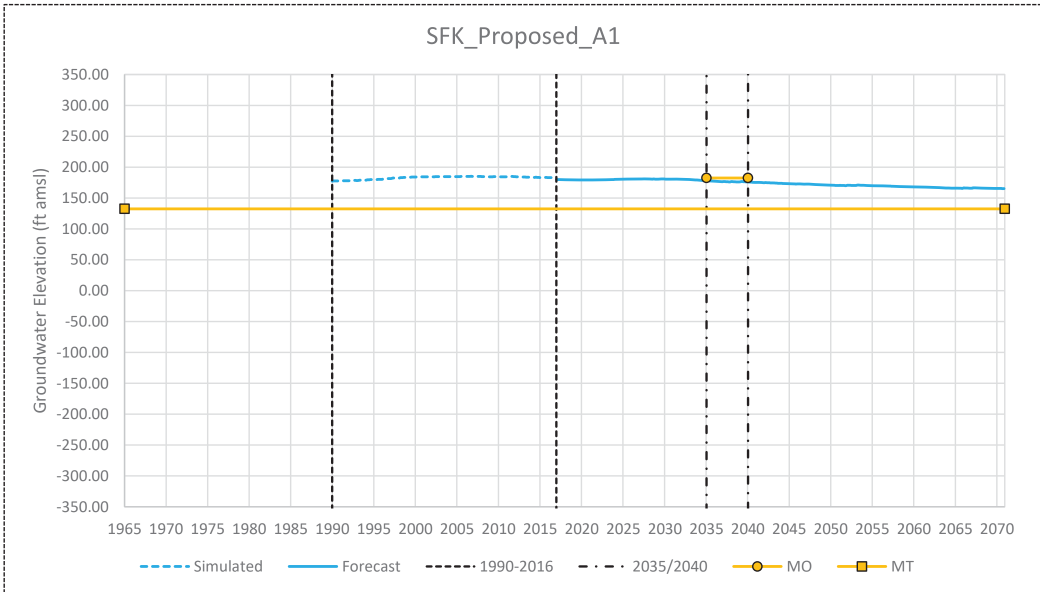
MKR_Proposed_C5
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT

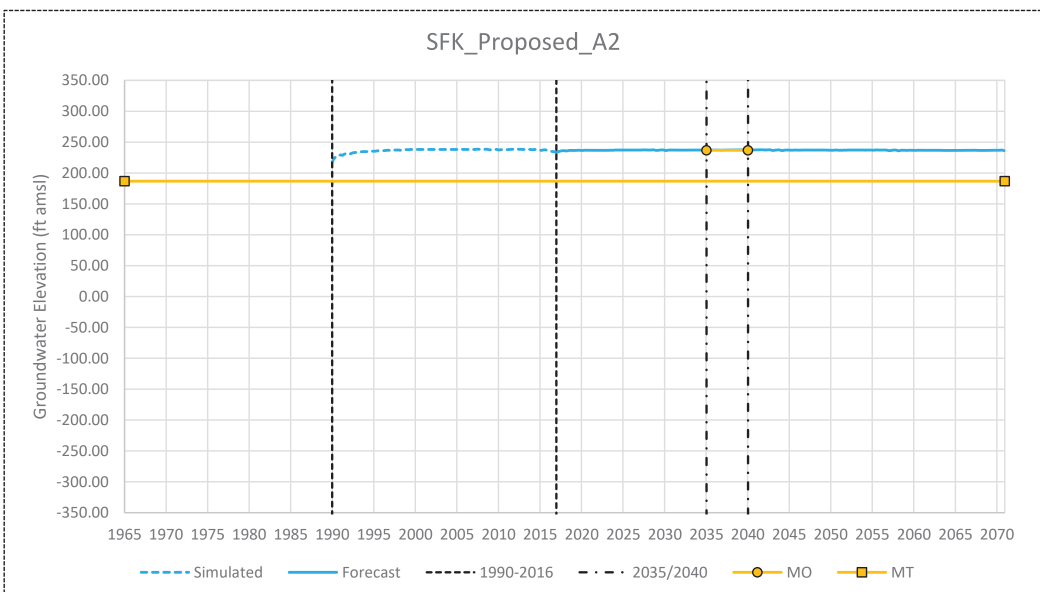


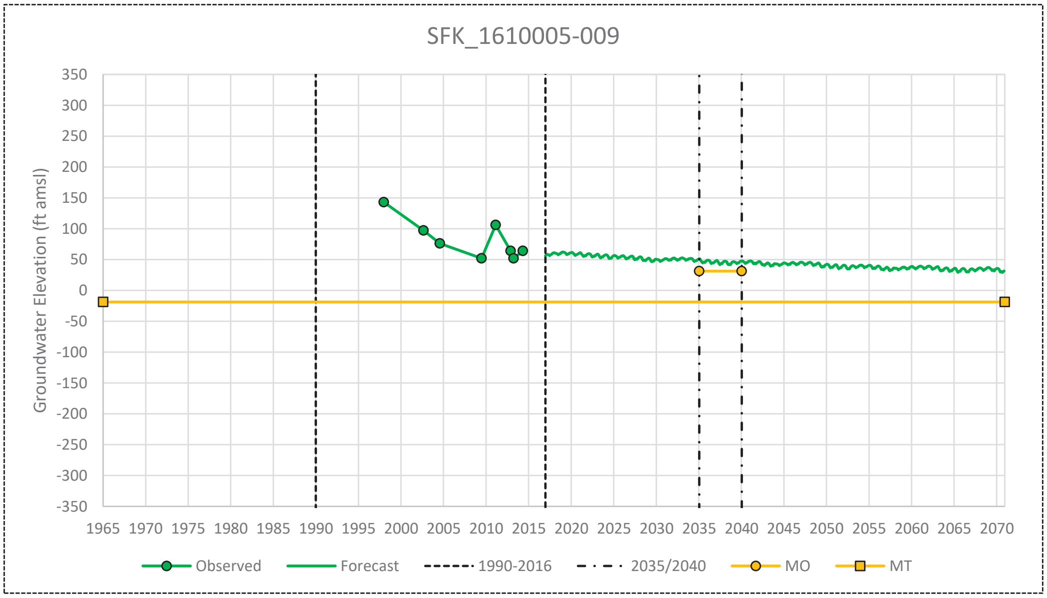
SFK_18S20E23E003M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

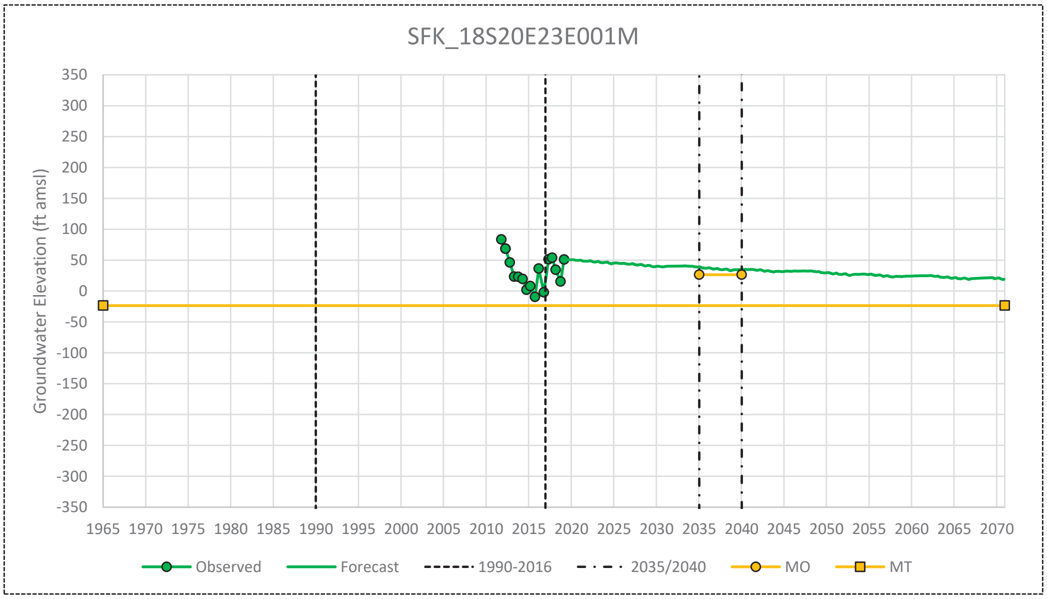

SFK_19S20E29E002M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

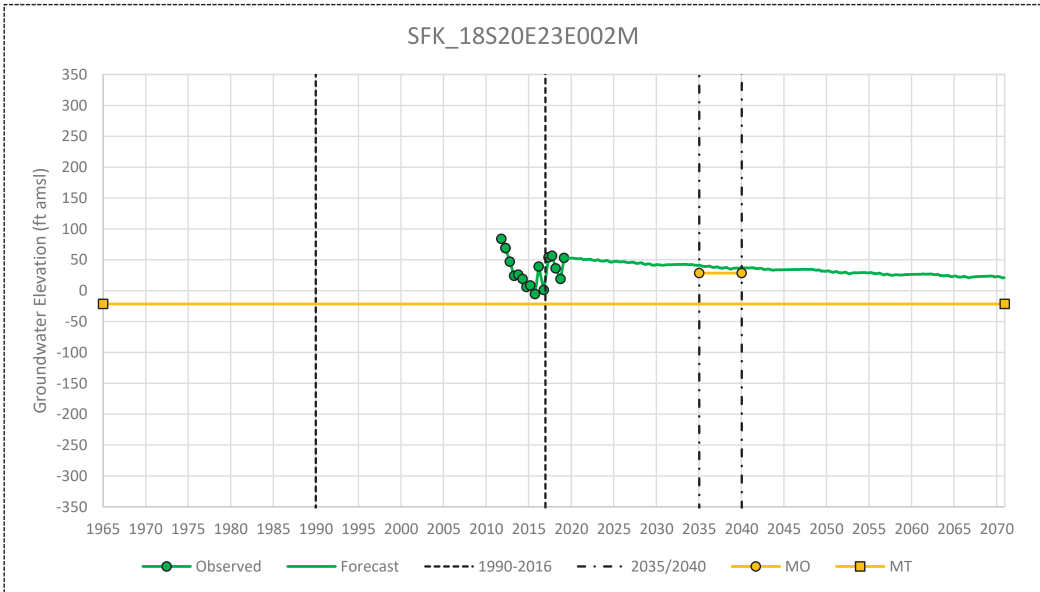

SFK_20S19E25A003M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

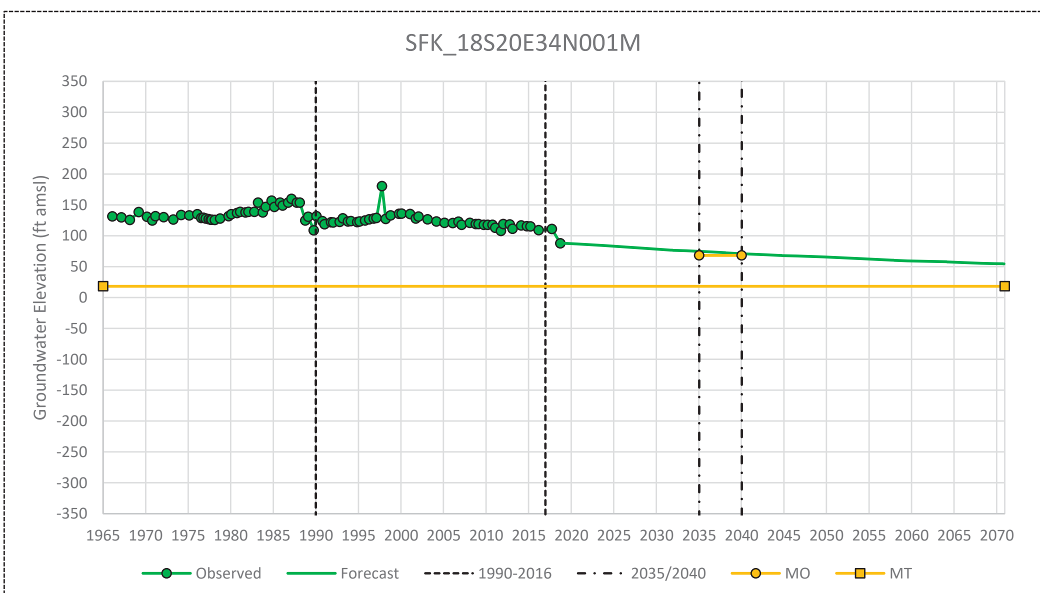

SFK_Proposed_A1
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT

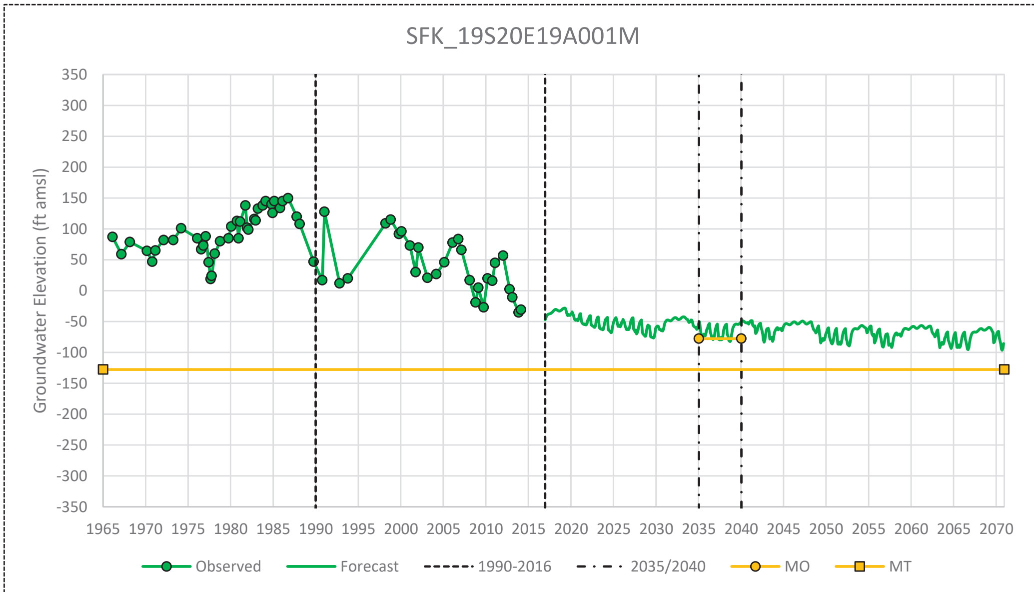

SFK_Proposed_A2
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT

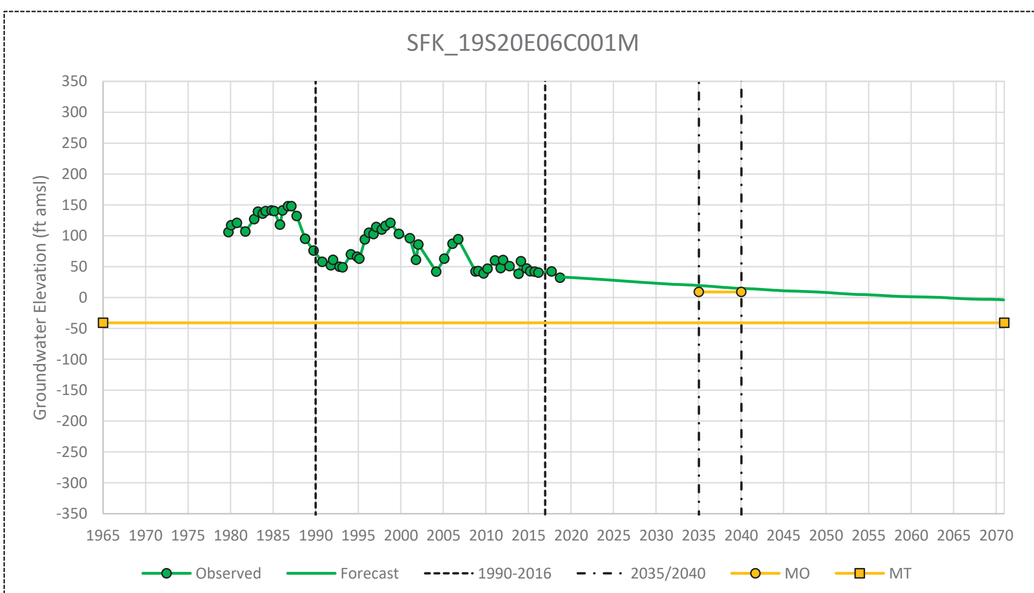

SFK_1610005-009
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

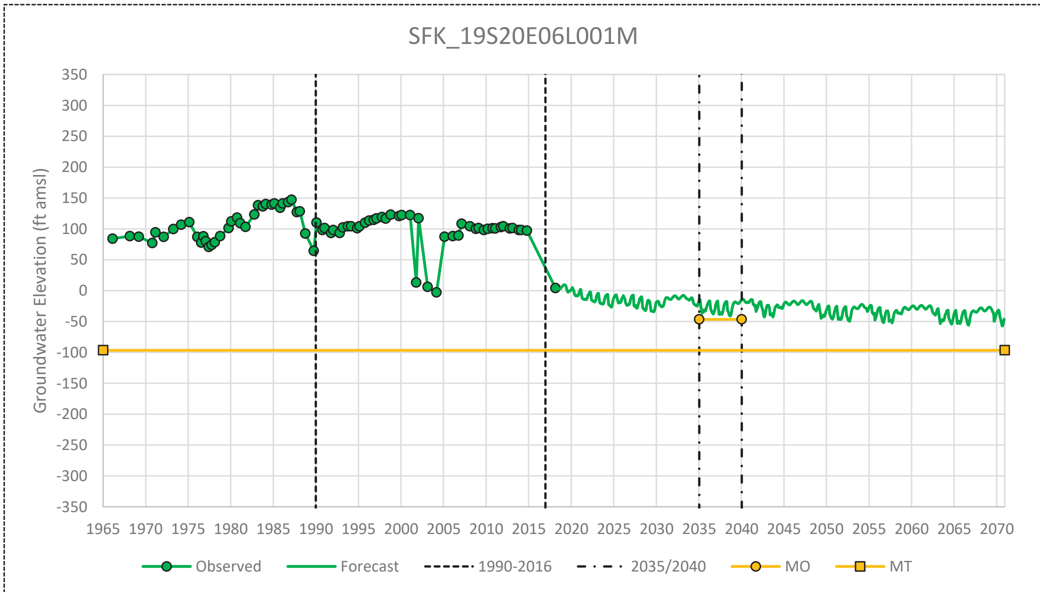

SFK_18S20E23E001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

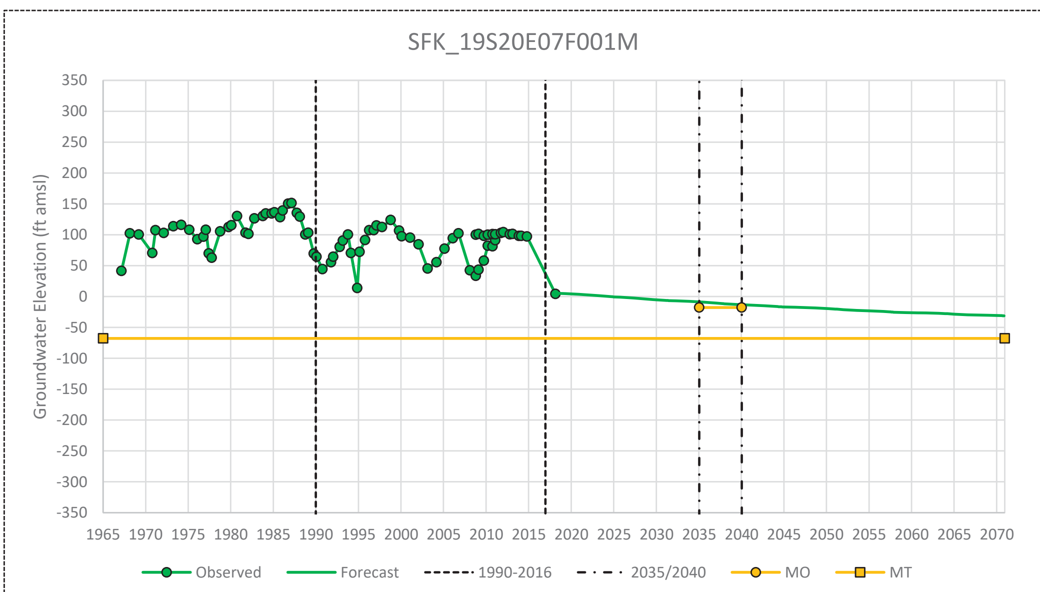

SFK_18S20E23E002M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

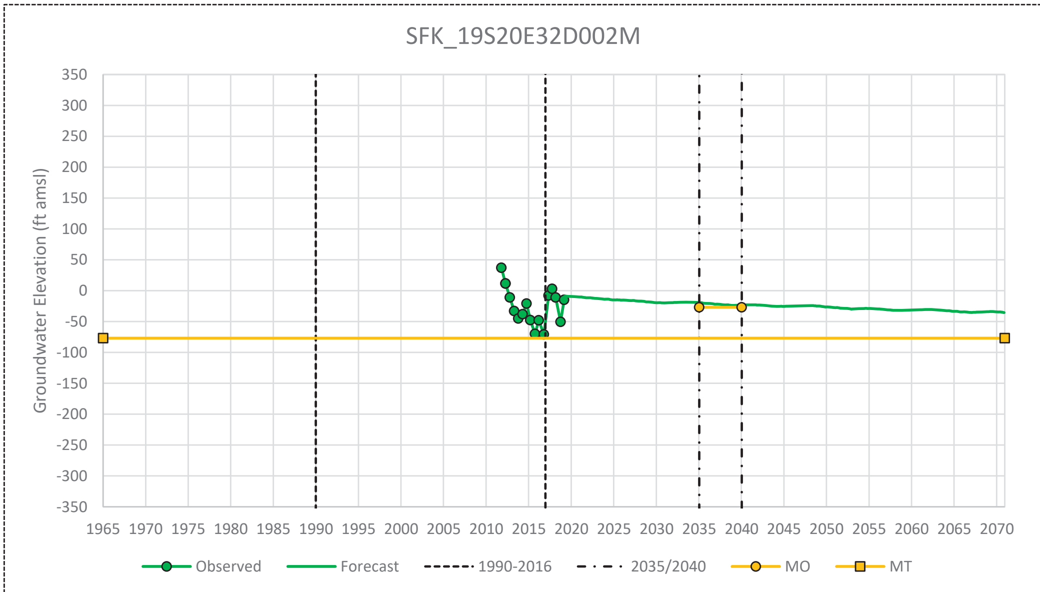

SFK_18S20E34N001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

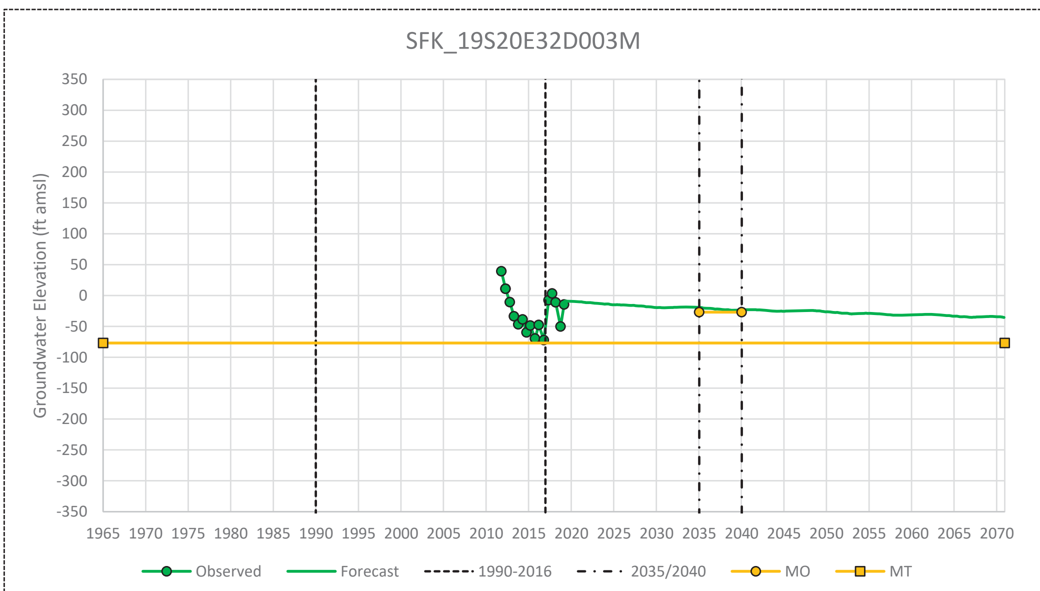

SFK_19S20E19A001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

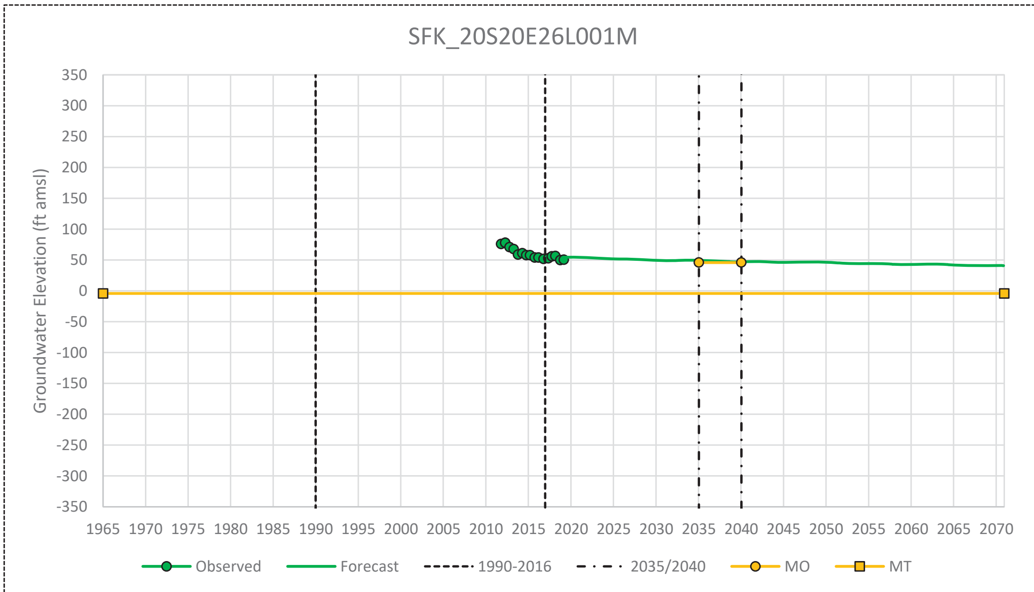

SFK_19S20E06C001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

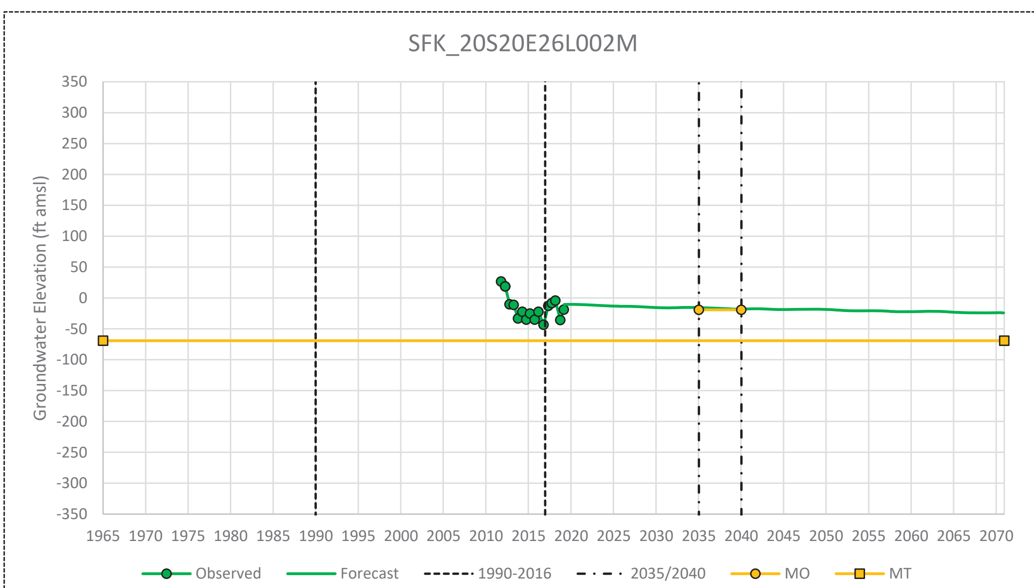

SFK_19S20E06L001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

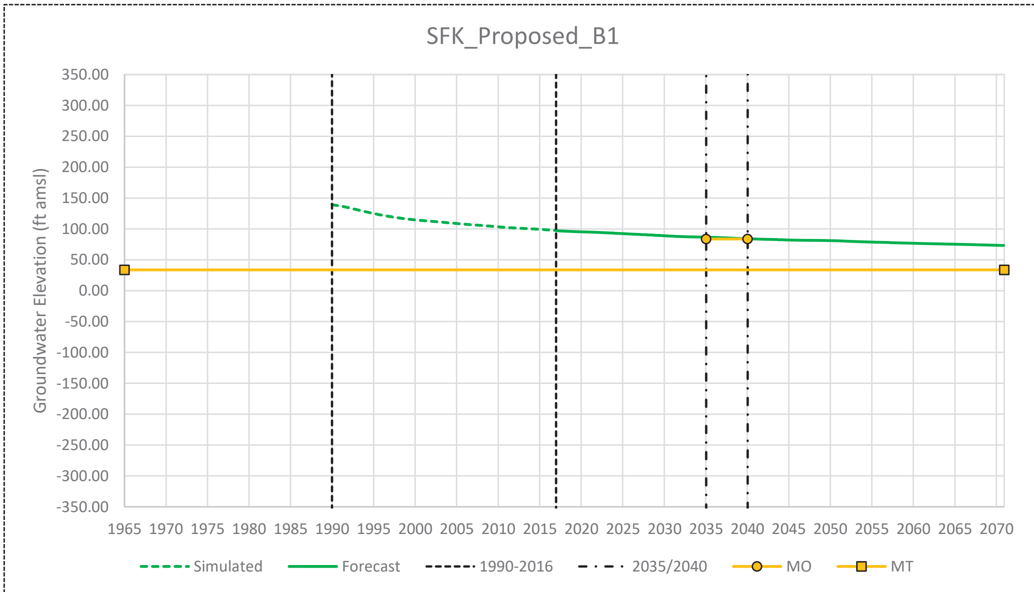

SFK_19S20E07F001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


SFK_19S20E32D002M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

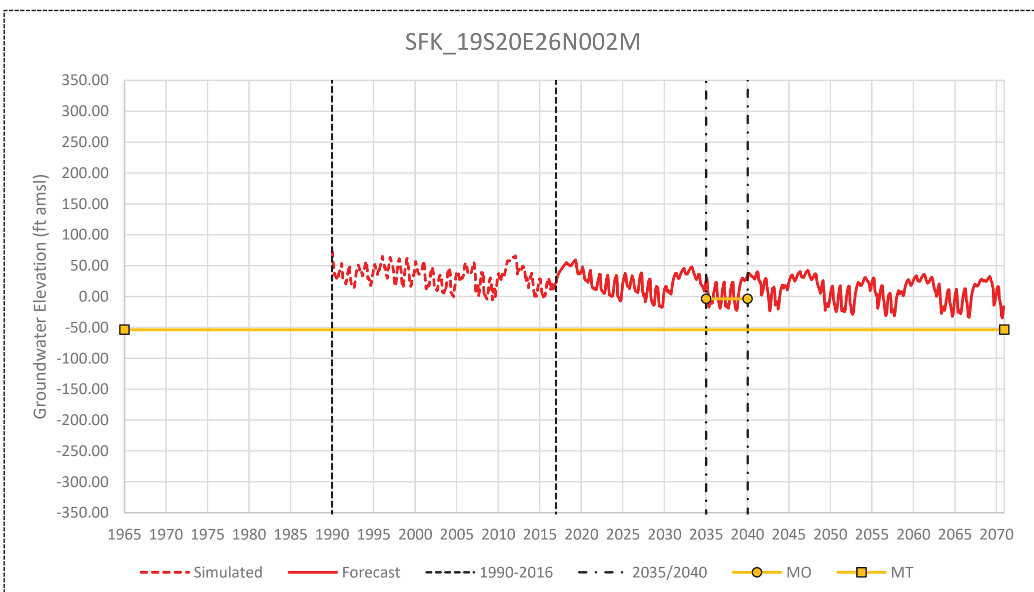

SFK_19S20E32D003M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


SFK_20S20E26L001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

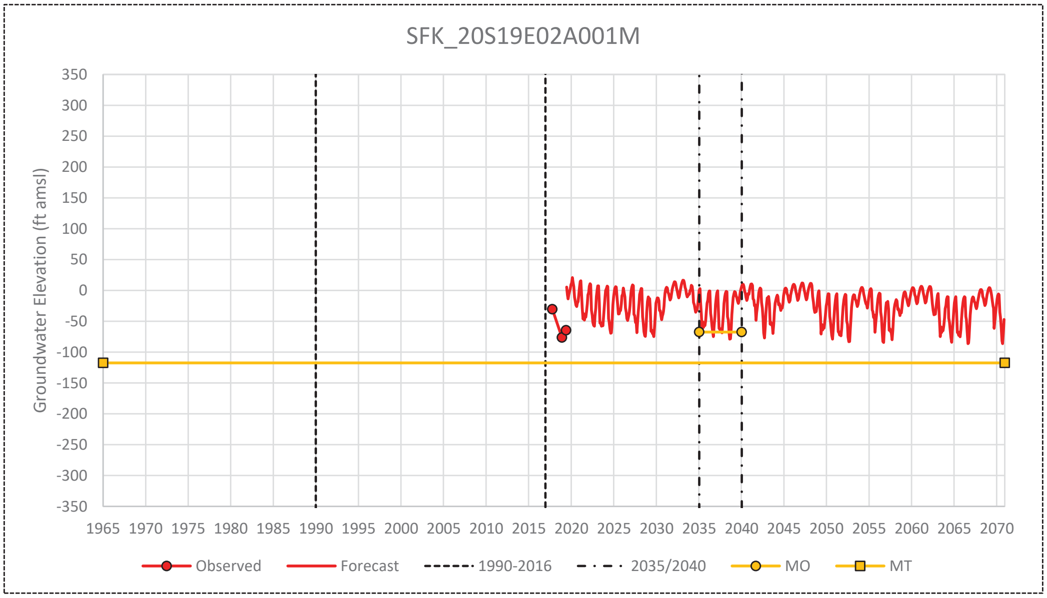

SFK_20S20E26L002M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

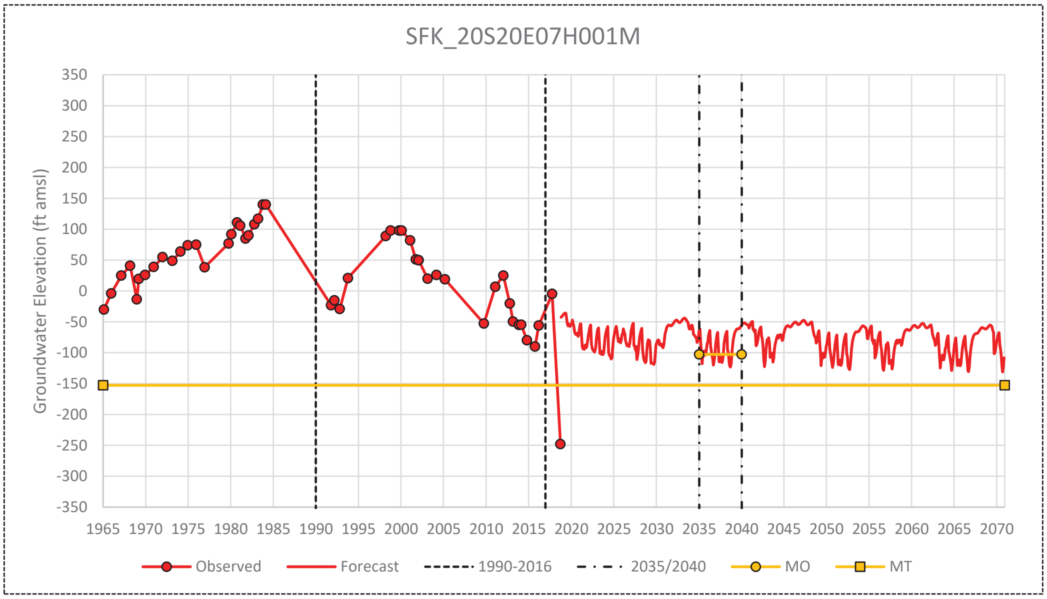


SFK_Proposed_B1
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT



SFK_19S20E26N002M
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


SFK_20S19E02A001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


SFK_20S20E07H001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
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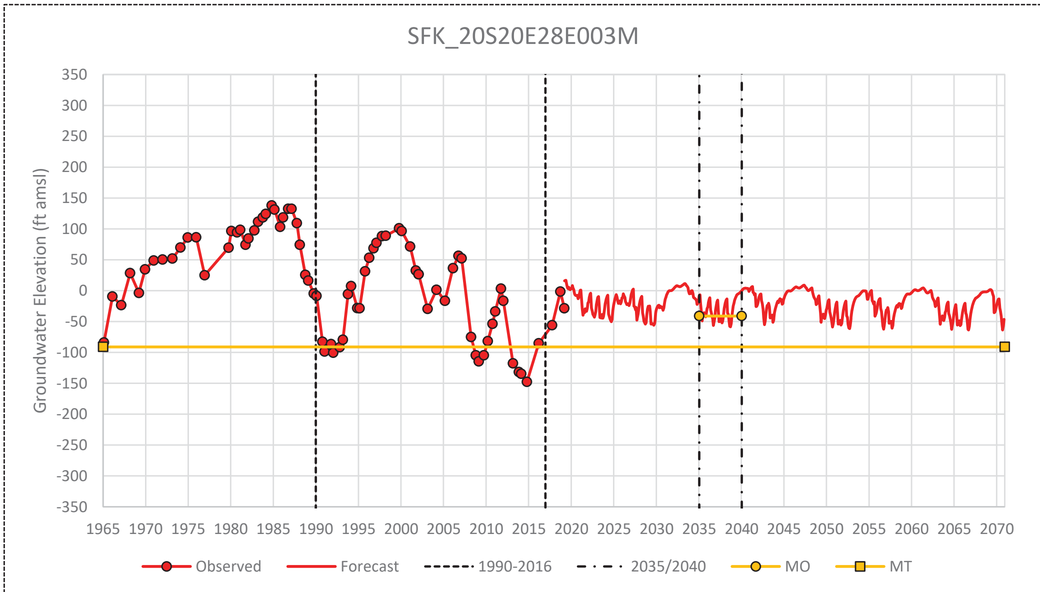
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


SFK_20S20E28E003M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
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-200
-250
-300
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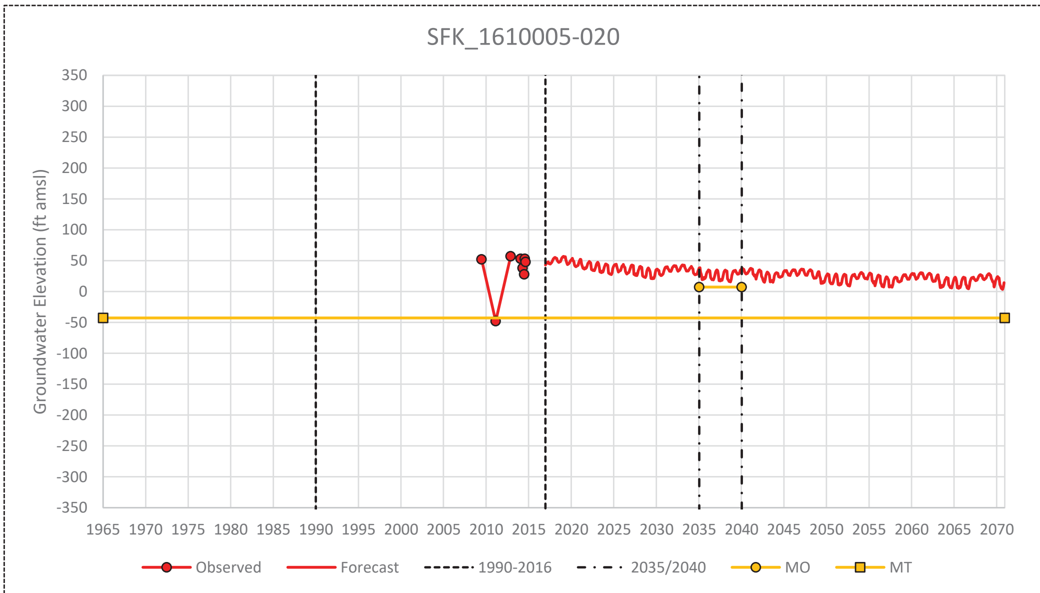
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


SFK_1610005-020
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
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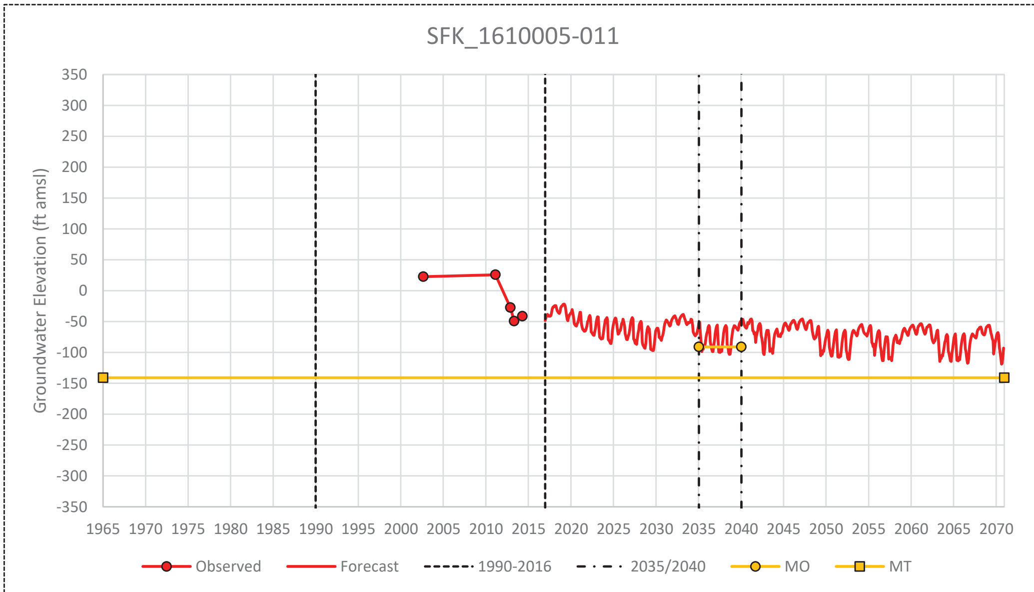
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT


SFK_1610005-011
Groundwater Elevation (ft amsl)
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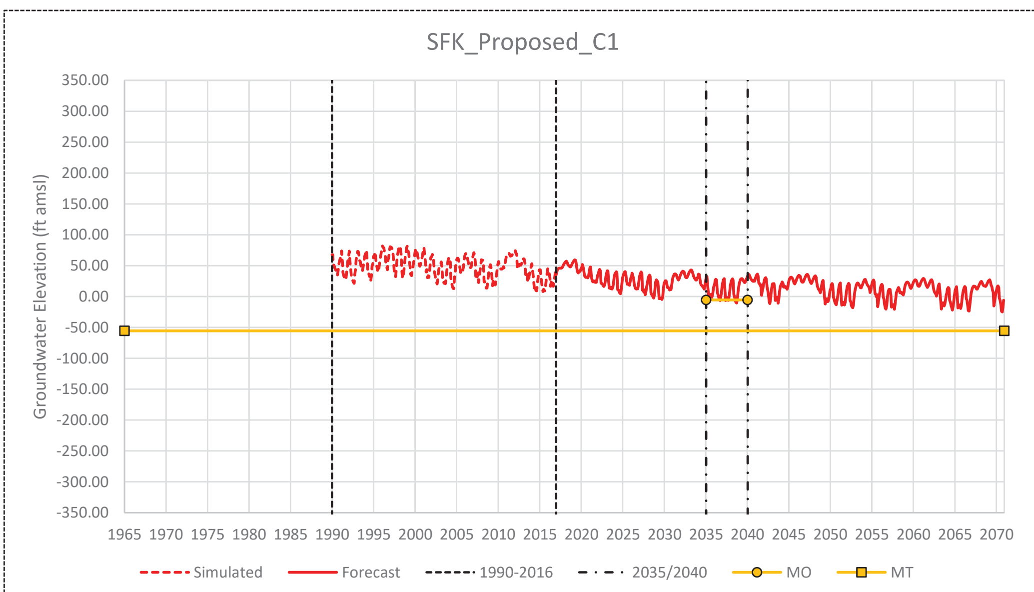
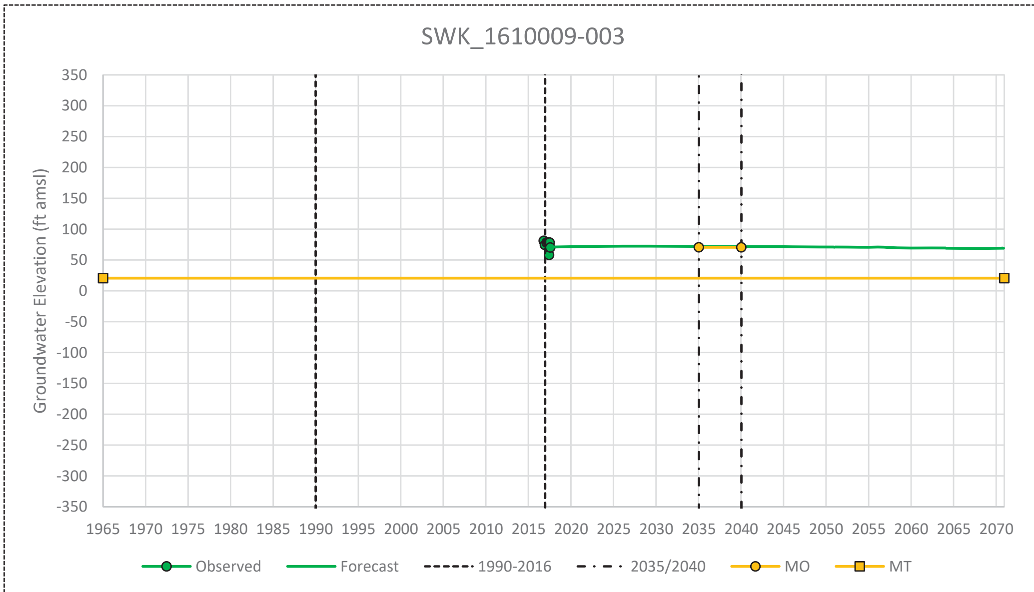
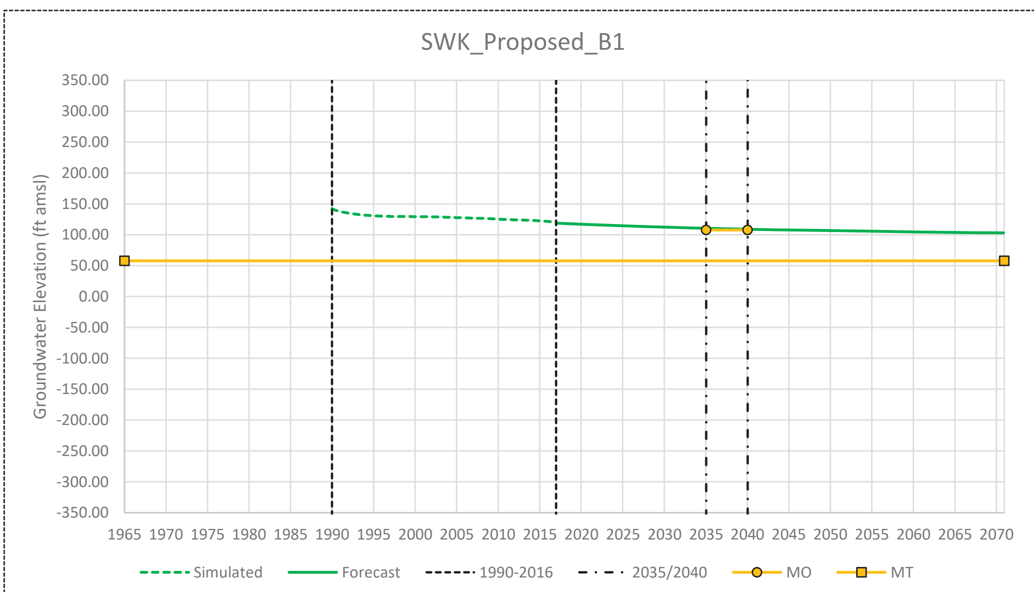
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT

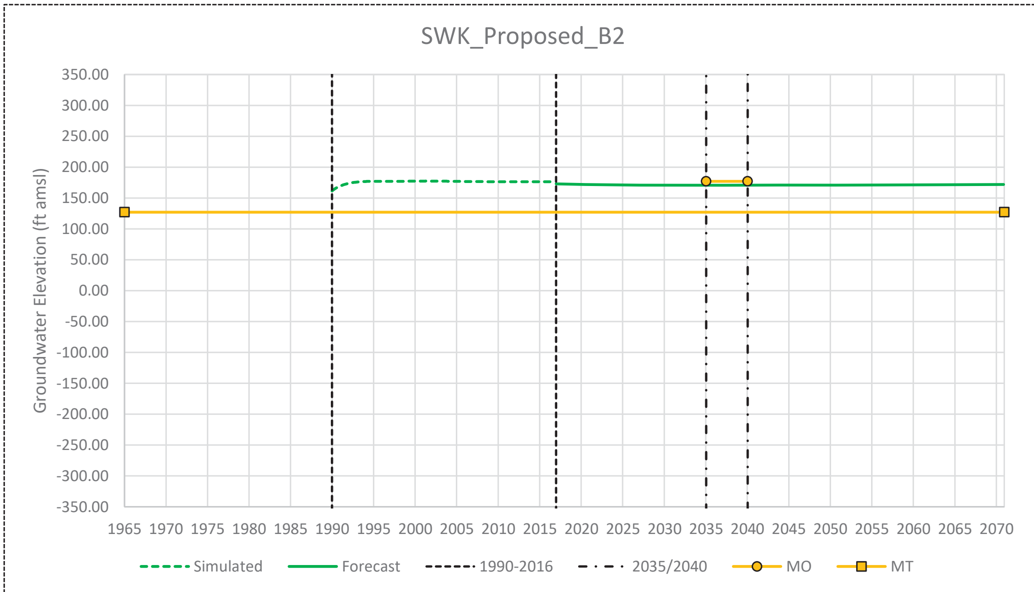

SFK_Proposed_C1
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT

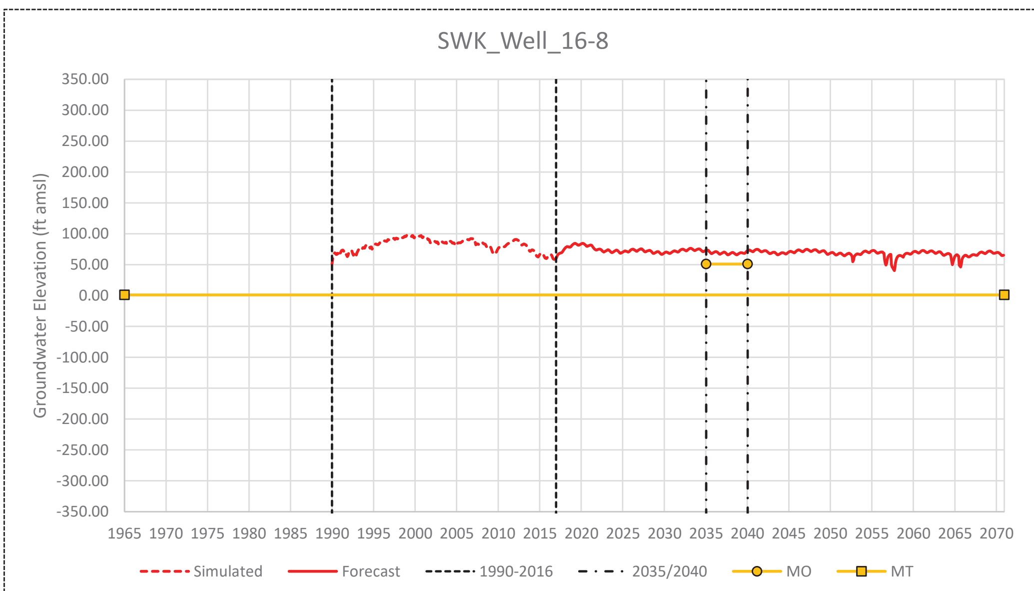


SWK_1610009-003
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT



SWK_Proposed_B1
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


SWK_Proposed_B2
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


SWK_Well_16-8
Groundwater Elevation (ft amsl)
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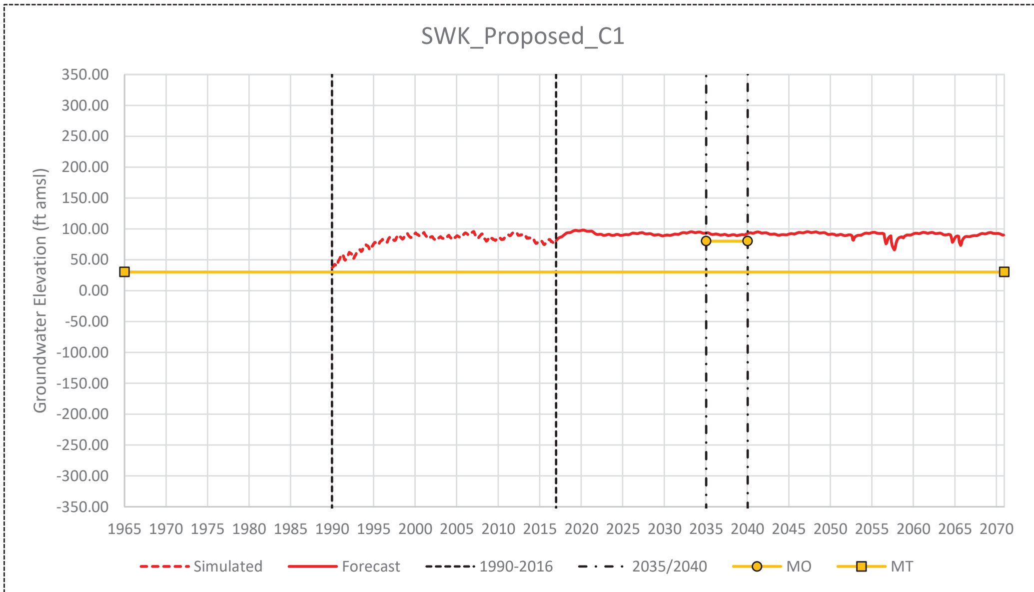
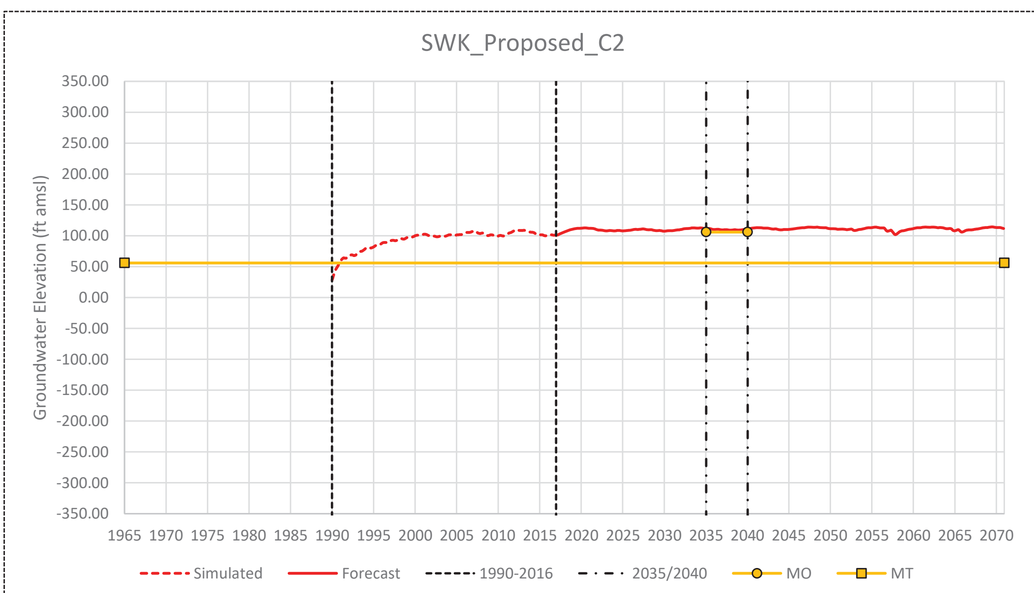
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


SWK_Proposed_C1
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


SWK_Proposed_C2
Groundwater Elevation (ft amsl)
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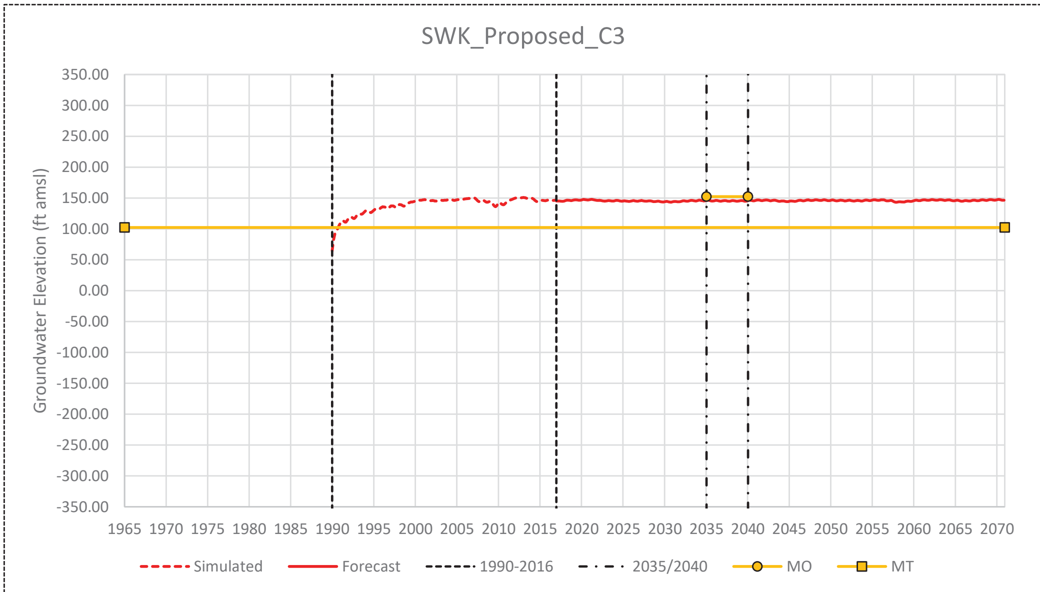
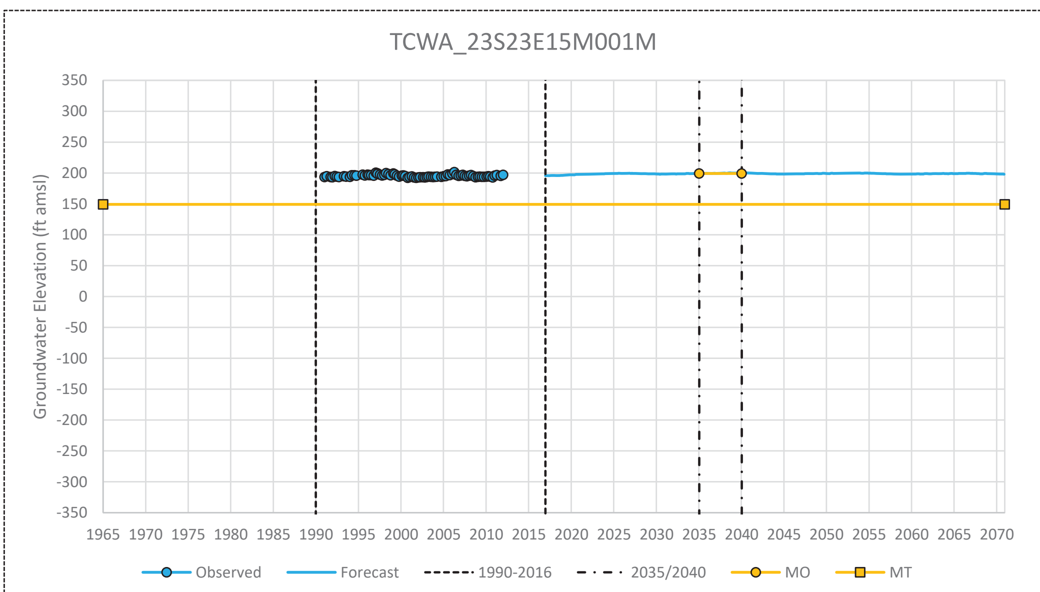
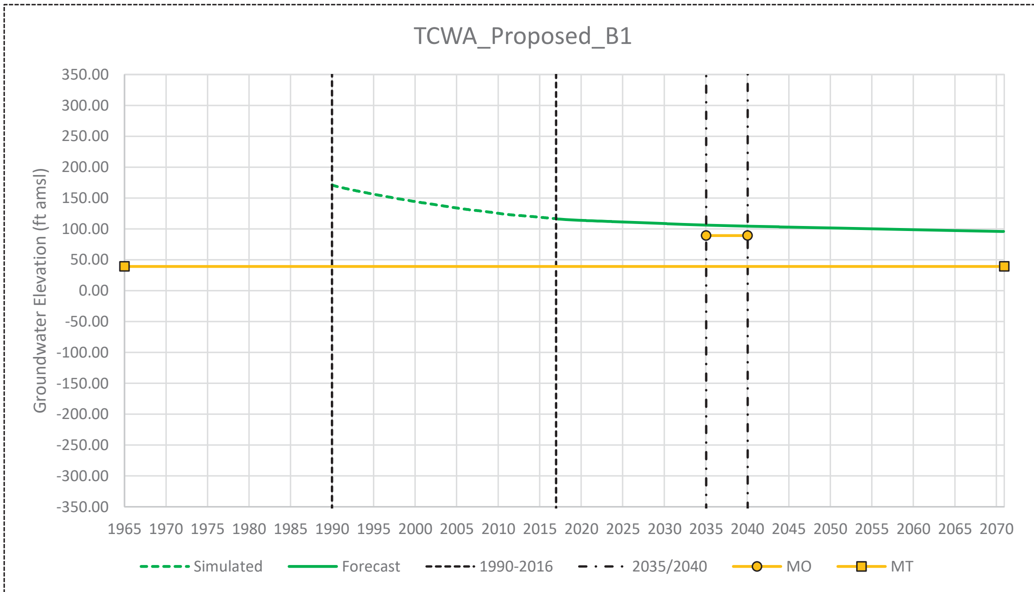
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT



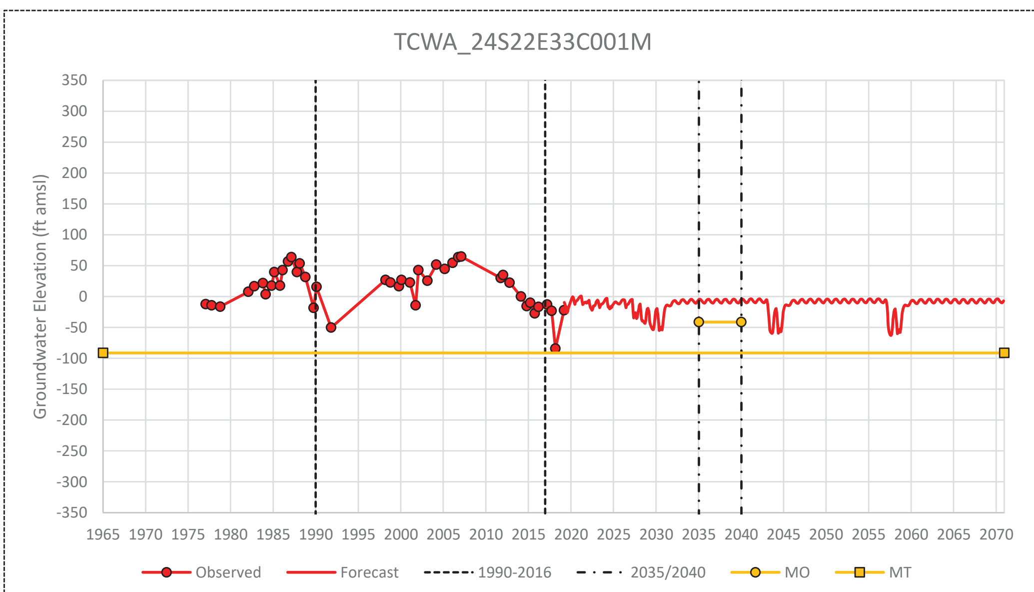
SWK_Proposed_C3
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT



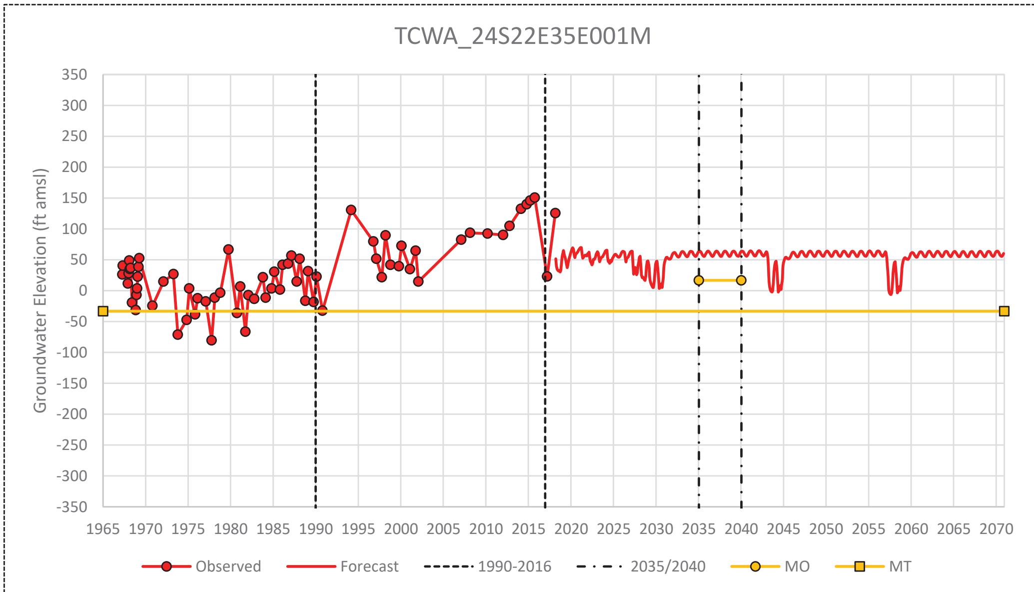
TCWA_23S23E15M001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT



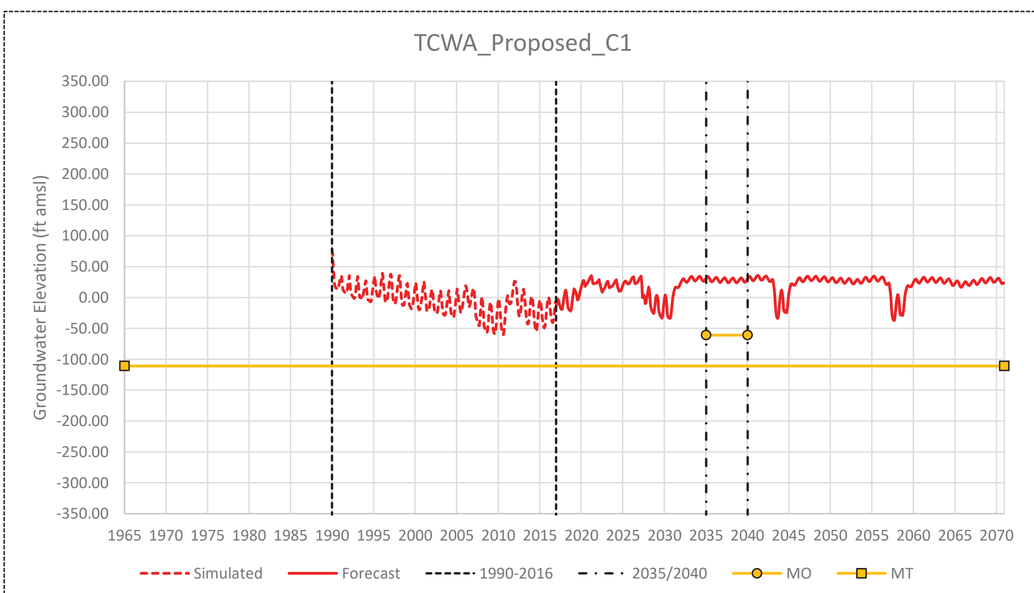
TCWA_Proposed_B1
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT



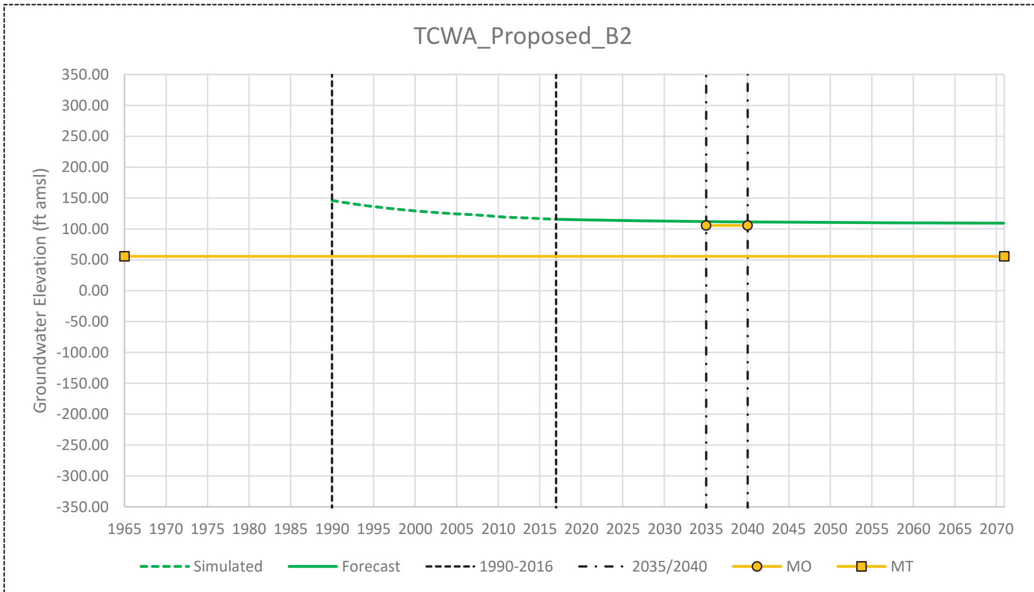
TCWA_24S22E33C001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT



TCWA_24S22E35E001M
Groundwater Elevation (ft amsl)
350
300
250
200
150
100
50
0
-50
-100
-150
-200
-250
-300
-350
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Observed
Forecast
1990-2016
2035/2040
MO
MT



TCWA_Proposed_C1
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT


TCWA_Proposed_B2
Groundwater Elevation (ft amsl)
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070
Simulated
Forecast
1990-2016
2035/2040
MO
MT