Tulare Lake Subbasin Groundwater Sustainability Plan

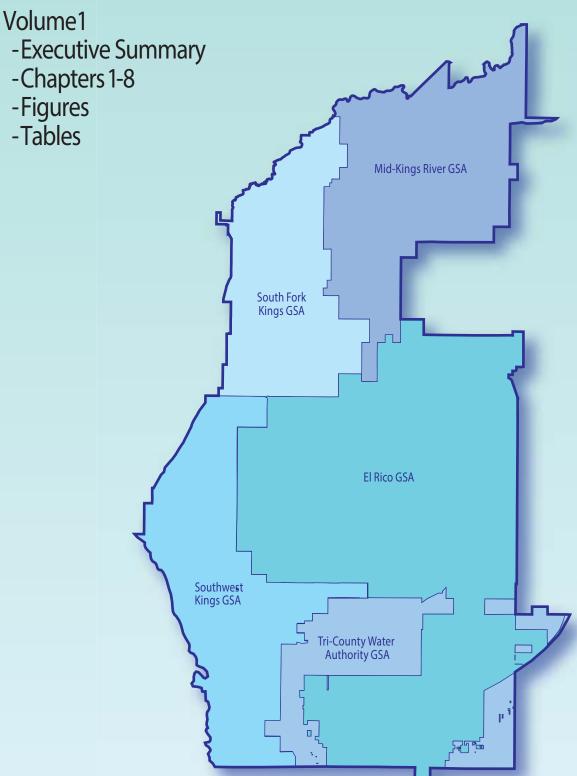












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ACRONYMS AND ABBREVIATIONS

%	Percent
§	Section
μm/sec	micrometers per second
μS/cm	microsiemens per centimeter
A-Clay	A perched unconfined aquifer exists above a locally extensive clay
/ 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
ВМР	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
МО	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"
РВО	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.

Southwest Kings Groundwater Sustainability Agency

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.

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 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

Monitoring and Management Programs

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.

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.

<u>Impact of GSP on Water Supply Assumptions within Land Use Plans</u>

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.

<u>City of Lemoore General Plan</u>

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 sulfurrich 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.

<u>Inflows</u>

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 aguifer 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.

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 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.

<u>Others</u>

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.

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

Date: 1/10/2020 Project No.: FR18161220

ES-1

Tri-County Water Authority GSA

ES-2

Southwest Poor Quality Groundwater

1.0 INTRODUCTION

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 groundwater basins through local agency coordination. SGMA expands the role of the California

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

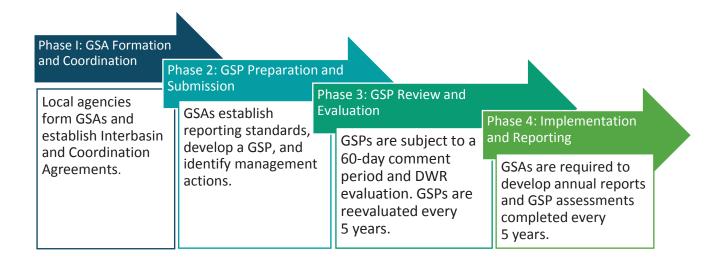
Department of Water Resources (DWR) to enforce local implementation of sustainable groundwater management practices through the review and approval of GSPs and allows for State Water Resources Control Board (SWRCB) intervention if groundwater basins do not meet sustainability requirements.

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

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)

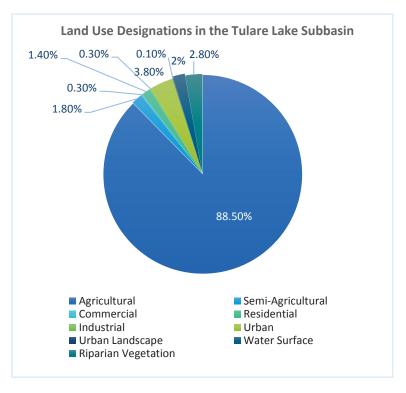
Source: DWR 2019b.

and there are no adjudicated areas in the groundwater basin.

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 Kings County Water District

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 <u>City of Hanford</u>

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 <u>Peoples Ditch Company</u>

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 <u>Last Chance Water Ditch Company</u>

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 <u>Armona Community Services District</u>

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 <u>Settlers Ditch Company</u>

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 <u>City of Lemoore</u>

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 <u>Empire Westside Irrigation District</u>

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 <u>Jacob Rancho Water Company</u>

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 <u>Tulare Lake Reclamation District #761</u>

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 <u>City of Corcoran</u>

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 <u>Alpaugh Irrigation District</u>

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 <u>Kings County</u>

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 ($\pm 7,100$ 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 <u>Irrigated Lands Regulatory Program</u>

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 <u>GSP Monitoring and Management Plans</u>

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 <u>Regulatory Decisions and Agreements</u>

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 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

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

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 <u>County of Kern General Plan</u>

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 <u>County of Kern</u>

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 <u>County of Tulare</u>

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 overpumping 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 <u>California Department of Pesticide Regulation</u>

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

Primary groundwater replenishment sources in the Plan area:

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

various smaller local streams. For more information, refer to Section 2.2.3, *Conjunctive Use Programs*, of the GSP.

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:

1. GSA Formation and Coordination

2. GSP
Development
and Submission

3. GSP Review and Evaluation

4. Implementation and Reporting

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.

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

Stakeholder Key Interests related to groundwater include:

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

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.

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

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

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 (μ m/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 μ m/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 <u>Water Supply Delivery System</u>

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 <u>Miocene and Pre-Miocene Sedimentary Deposits</u>

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 coarsergrained 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 <u>Los Gatos Creek and Arroyo Pasaj</u>ero 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 (μ S/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 μ S/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 μ S/cm (RWQCB 2017). The report further proposed the preferred alternative for AGR beneficial use de-designation be based on a 5,000 μ S/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 μ S/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 Aguitards

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 $1x10^{-4}$ (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 1×10^{-5} /ft and 4.5×10^{-2} /ft for semi-confined intervals above the E-Clay (Wood 2018). The specific storage of confined sediments below the Corcoran Clay ranges between 2.5×10^{-7} /ft and 1.25×10^{-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 acrefeet 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 <u>Climate Change</u>

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 wetperiods 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 <u>Clay Pluq</u>

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:

- 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:

- 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 aguifer 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 aguifer 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 aguifer 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 semiannual 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 reevaluate 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 <u>Identification of Data Gaps</u>

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, semiannual 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 aguifers. More frequent data may also be needed from the aguifer 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 aguifer 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 aguifer 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 multidepth 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 <u>Identification of Data Gaps</u>

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 aguifer 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 <u>Continuous Global Positioning System Stations</u>

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 <u>Kaweah Delta Water Conservation District</u>

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 <u>Project Benefits and Water Reliability</u>

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 <u>Project Ownership</u>

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 <u>Circumstances of Implementation</u>

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 <u>Project Benefits and Water Reliability</u>

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 <u>Circumstances of Implementation</u>

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 <u>Circumstances of Implementation</u>

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 <u>Project Status and Schedule</u>

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 <u>Circumstances of Implementation</u>

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 <u>Legal Authority</u>

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 <u>Project Cost Estimate/Acre-Foot of Yield</u>

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:

- Regular/Ongoing Sustainable Groundwater Management Act (SGMA) Compliance Activities;
- 2. GSP Five-Year Update;
- Plans to Fill Data Gaps;
- 4. Projects; and
- 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 Projects

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 acrefoot 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 aguifers 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 aguifer 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 aguifer is therefore related to the amount of associated subsidence.

7.2.2.2 <u>Local Water Balance, Overdraft and Sustainable Yield</u>

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 <u>Measurement of Groundwater Pumping</u>

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 <u>Groundwater Pumping Fees</u>

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:

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 <u>Timeline</u>

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 <u>Background</u>

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.

8.0 REFERENCES

- Armona CSD (Armona Community Services District). 2009. *Armona Community Plan.* Accessed on: 17 July 2019. http://www.countyofkings.com/home/showdocument?id=3126
- BLM (Bureau of Land Management). 2019. *BLM National Data*. Accessed on: 24 July 2019. https://blmegis.maps.arcgis.com/apps/webappviewer/index.html?id=6f0da4c7931440a8a80bfe20eddd7550%20&extent=-125,%2031.0,%20-114,%2043.0
- California State Waterboard. 2019. *Irrigated Lands Regulatory Program (ILRP)*. Accessed on 12 December 2019. https://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/
- California Open Data Portal. 2019. *NASA JPL InSAR Subsidence Data*. Accessed August 20, 2019 at: https://data.ca.gov/dataset/nasa-jpl-insar-subsidence-data
- Caltrans (California Department of Transportation). 2019. *Central Valley Spatial Reference Network –CVSRN*. Accessed on August 20, 2019 at: https://dot.ca.gov/-/media/dot-media/district-6/documents/d6-land-surveys/ct-realtime-gps-networks/cvsrn current map ada.pdf
- CCME (Canadian Council of Ministers of the Environment). 2007. Canadian Water Quality
 Guidelines for the Protection of Agricultural Water Uses, Chapter 5. Prepared for:
 Canadian Environmental Water Quality Guidelines. Accessed on: 13 July 2019.
 http://www.ccme.ca/en/resources/canadian environmental quality guidelines/index.h
 tml
- CV-Salts (Central Valley Salinity Alternatives for Long-Term Sustainability). 2013. Salt and Nutrients: Literature Review for Stock Drinking Water Final Report.
- City of Corcoran. 2014. 2005-2025 General Plan. Accessed on: 17 July 2019. http://www.cityofcorcoran.com/civica/filebank/blobdload.asp?BlobID=3796
- City of Corcoran. 2017. *Urban Water Management Plan*. Accessed on: 17 July 2019. http://www.cityofcorcoran.com/civica/filebank/blobdload.asp?BlobID=4281
- City of Hanford. 2011. 2010 Urban Water Management Plan. Accessed on: 17 July 2019. https://water.ca.gov/LegacyFiles/urbanwatermanagement/2010uwmps/Hanford,%20City%20of/Hanford%20UWMP%20Contents.pdf
- City of Hanford. 2017. 2035 General Plan Update. Accessed on: 31 July 2019.

 http://cms6.revize.com/revize/hanfordca/document_center/General%20Plan/2035%20

 General%20Plan%20Policy%20Document.pdf

- City of Lemoore. 2015. 2015 Urban Water Management Plan. Accessed on: 17 July 2019. https://lemoore.com/wp-content/uploads/2018/02/lemoore 2015 uwmp final.pdf
- Croft, M.G. 1972. Subsurface Geology of the Later Tertiary and Quaternary Water-Bearing Deposits of the Southern Part of the San Joaquin Valley, California.
- Croft, M.G., and G.V. Gordon, 1968. *Geology, Hydrology, and Quality of Water in the Hanford-Visalia Area, San Joaquin Valley, California*.
- Databasin. 2019. W.H. Wilbur Reclamation District #825. Accessed on: 12 December 2019. https://databasin.org/maps/new#datasets=8aee127380164046b32c2c85dee44d55.
- Davis, G.H., J.H. Green, F.H. Olmsted, and D.W. Brown. 1959. *Ground-Water Conditions and Storage Capacity in the San Joaquin Valley*. Prepared for: U.S. Geological Survey Water-Supply Paper 1469.
- Davis, G.H., B.E. Lofgren, and S. Mack. 1964. *Use of Ground-Water Reservoirs for Storage of Surface Water in the San Joaquin Valley, California*. Prepared for: U.S. Geological Survey Water-Supply Paper 1618, 125 p.
- Davis, G.H. and T.B. Coplen. 1989. Late Cenozoic Paleohydrogeology of the Western San Joaquin Valley, California, as Related to Structural Movements in the Central Coast Ranges.

 Prepared for: Geological Society of America Special Paper 234, 40 p.
- DGS (Department of General Services). 2019. *SPI GIS Map Viewer*. Accessed on: 24 July 1019. https://spigis.apps.dgs.ca.gov/
- DOF (Department of Finance). 2019. *Projections Organization Title*. Accessed: 17 July 2019. http://www.dof.ca.gov/Forecasting/Demographics/Projections/.
- DPR (Department of Pesticide Regulation). 2019. Surface Water Database (SURF) Access to the Data. Accessed on: 17 July 2019. https://www.cdpr.ca.gov/docs/emon/surfwtr/surfcont.htm
- Dudley Ridge WD (Dudley Ridge Water District). 2012. 2012 Agricultural Water Management Plan. Accessed on: 17 July 2019. https://water.ca.gov/LegacyFiles/wateruseefficiency/sb7/docs/2014/plans/Dudley%20Ridge%20WD%202012%20AWMP.pdf
- DTSC (Department of Toxic Substances Control). 2019. *EnviroStor*. Accessed July 17, 2019. https://www.envirostor.dtsc.ca.gov/public/
- DWR (Department of Water Resources). 1981. Water Well Standards: State of California

 Bulletin 74-81. Accessed on: 17 July 2019.

 https://water.ca.gov/LegacyFiles/pubs/groundwater/water-well-standards-bulletin-7

 4-81 /ca well standards bulletin-74-81 1981.pdf

- DWR (Department of Water Resources). 1991. *California Well Standards Bulletin 74-90.*Accessed on: 17 July 2019.

 https://water.ca.gov/LegacyFiles/pubs/groundwater/water well standards bulletin 7/4-90 /ca well standards bulletin 1991.pdf
- DWR (Department of Water Resources). 2006. San Joaquin Valley Groundwater Basin Tulare
 Lake Subbasin. Accessed on: 11 July 2019.
 https://water.ca.gov/LegacyFiles/pubs/groundwater/bulletin_118/basindescriptions/5-22.12.pdf
- DWR (Department of Water Resources). 2010. *Groundwater Elevation Monitoring Guidelines*. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/CASGEM/Files/CASGEM-DWR-GW-Guidelines-Final-121510.pdf
- DWR (Department of Water Resources). 2012. *Tulare Lake Bed Coordinated Groundwater Management Plan* Accessed on: 23 June 2019.

 https://water.ca.gov/LegacyFiles/groundwater/docs/GWMP/TL-23 TulareLakeBedCoordinated GWMP 2012.pdf
- DWR (Department of Water Resources). 2016 a. SGMA Draft Emergency Regulations for Groundwater Sustainability Plans and Alternatives. Accessed on: 1 May 2019

 https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/DRAFT_GSP_Emergency_Regulations_021816.pdf
- DWR (Department of Water Resources). 2016b. *California's Groundwater Bulletin 118 Interim Update*. Accessed 12 July 2019.

 https://water.ca.gov/LegacyFiles/groundwater/bulletin118/docs/Bulletin 118 Interim

 <u>Update 2016.pdf</u>
- DWR (Department of Water Resources). 2016c. Best Management Practices for the Sustainable Management of Groundwater, Hydrogeologic Conceptual Model.
- DWR (Department of Water Resources). 2016d. Land and Water Use Section, Land Use Surveys, Fresno County 1994 and 2000, Kern County 1990, 1998, and 2006, Kings County 1991, 1996, and 2003, Tulare County 1993 and 1999.
- DWR (Department of Water Resources). 2016e. Best Management Practices for the Sustainable Management of Groundwater, Monitoring Networks and Identification of Data Gaps. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-2-Monitoring-Networks-and-Identification-of-Data-Gaps.pdf
- DWR (Department of Water Resources). 2016f. Best Management Practices for the Sustainable Management of Groundwater, Monitoring Protocols, Standards, and Sites.

- https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-1-Monitoring-Protocols-Standards-and-Sites.pdf
- DWR (Department of Water Resources). 2017a. *CADWR Land Use Viewer*. Accessed on: 10 July 2019. https://gis.water.ca.gov/app/CADWRLandUseViewer/
- DWR (Department of Water Resources). 2017b. Draft Best Management Practices for the Sustainable Management of Groundwater: Sustainable Management Criteria.
- DWR (Department of Water Resources). 2018. Climate Action Plan, Phase 2: Climate Change Analysis Guidance.
- DWR (Department of Water Resources). 2019a. Sustainable Groundwater Management Act 2019 Basin Prioritization. Accessed on: 20 May 2019. https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization
- DWR (Department of Water Resources). 2019b. SGMA Basin Prioritization Mapper. Accessed on: 14 August 2019. https://gis.water.ca.gov/app/bp-dashboard/p2/#
- DWR (Department of Water Resources). 2019c. *Critically Overdrafted Basins*. Accessed on: 6 May 2019. https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118/Critically-Overdrafted-Basins
- DWR (Department of Water Resources). 2019d. *SMGA Portal: GSAs*. Accessed on: 2 July 2019. https://sgma.water.ca.gov/portal/gsa/print/226
- EPA (Environmental Protection Agency). 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process.*
- EPA. 2019. Wellhead Protection Program. Accessed on 12 December 2019. https://www3.epa.gov/region1/eco/drinkwater/pc_wellhead_protection.html
- Farr, T.G., Jones, C.E., Liu, Z. 2015. *Progress Report: Subsidence in the Central Valley, California*. Prepared for: Jet Propulsion Laboratory, California Institute of Technology.
- Farr, T.G., Jones, C.E., Liu, Z., 2017. Progress Report: Subsidence in California, March 2015 September 2016.
- Faunt, C.C., ed. 2009. *Groundwater Availability of the Central Valley Aquifer, California: U.S. Geological Survey Professional Paper 1766, 225 p.*
- Fresno County. 2010. Fresno County General Plan. Accessed on: 17 July 2019. https://www.co.fresno.ca.us/home/showdocument?id=1811

- Gray, Brian. 2018. *The Public Trust and SGMA*. Posted October 7, 2018, to the California Water Blog by US Davis Center for Watershed Sciences. Accessed August 20, 2019. https://californiawaterblog.com/2018/10/07/the-public-trust-and-sgma/
- Hansen, J.A., B.C. Jurgens, and M.S. Fram. 2018. *Quantifying Anthropogenic Contributions to Century-Scale Groundwater Salinity Changes, San Joaquin Valley, California, USA.*
- Harder, T., and J. Van de Water. 2017. *Hydrogeological Conceptual Model and Water Budget of the Tule Subbasin, Tule Subbasin MOU Group, 49 p.*
- Hilton, G.S., R.L. Klausing, and F. Kunkel. 1963. *Geology of the Terra Bella-Lost Hills Area, San Joaquin Valley, California*, Prepared for: U.S. Geological Survey Open-File Report 63-47, 158 p.
- High-Speed Rail Authority. 2019. *California High-Speed Rail Authority*. Accessed on: 18 July 2019. https://www.hsr.ca.gov/communication/info center/maps.aspx.
- Home Garden CSD (Home Garden Community Service District). 2015. *Home Garden Community Plan*. Accessed on: 19 July 2019. https://www.countyofkings.com/home/showdocument?id=13507
- Hopkins, J. A. 2016. A Field Manual for Groundwater-level Monitoring at the Texas Water Development Board.
- IWP and DC (International Water Power and Dam Construction). 2004. They might be giants Terminus dam's new Fusegates. Prepared for: International Water Power & Dam Construction. Accessed on: 23 June 2019.

 http://www.waterpowermagazine.com/features/featurethey-might-be-giants-terminus-dam-s-new-fusegates
- Ireland R.L., J.F. Poland, and F.S. Riley. 1984. *Land subsidence in the San Joaquin Valley, California, as of 1980.* Prepared for: United States Geological Survey Professional Paper 437-I, 93 p. Accessed on: 2 July 2019. http://pubs.er.usgs.gov/usgspubs/pp/pp4371.
- ITRC (Irrigation Training and Research Center). 2003. *California Crop and Soil Evapotranspiration for Water Balances and Irrigation Scheduling/Design*. Prepared for: California Polytechnic State University.
- Irrigation Training and Research Center (Cal Poly Irrigation Training & Research Center). 2008.

 Irrigation District Energy Survey. Accessed on: 10 July 2019.

 http://www.itrc.org/reports/pdf/districtenergy.pdf
- KCWD (Kings County Water District). 2011. Groundwater Management Plan.
- KDWCD (Kaweah Delta Water Conservation District). 2018. *District Projects*. Accessed on: 2 August 2018. http://www.kdwcd.com/kdwcdweb_002.html

- KDSA. Kenneth D. Schmidt and Associates, CDM Smith, and Summers Engineering. 2015.

 Technical and Regulatory Evaluation of MUN and AGR Beneficial Uses in the Tulare Lake

 Bed Area. Prepared for: Tulare Lake Drainage District and Tulare Lake Basin Water

 Storage District, 70 p.
- KDWCD (Kaweah Delta Water Conservation District). 2017. Groundwater Management Plan.
- Kern County. 2009. *General Plan*. Accessed on: 17 July 2019. https://kernplanning.com/planning/planning-documents/general-plans-elements/*Lemoore Urban Water Management Plan*
- Kern County. 2018. *Agricultural Well Permit Information*. Accessed on: 10 June 2019. https://kernpublichealth.com/wp-content/uploads/2018/01/Agricultural-Well-Permit-Information 011618.pdf
- Kern County. 2019. A Codification of the General Ordinances of Kern County, California.

 Accessed on: 10 July 2019.

 https://library.municode.com/ca/kern county/codes/code of ordinances?nodeId=TIT1

 4UT CH14.08WASUSY
- Kettleman City CSD (Kettleman City Community Service District). 2009. Kettleman City Community Plan. Accessed on: 17 July 2019. http://www.countyofkings.com/home/showdocument?id=3130
- Kings County. 2000. Ordinance No. 587: An Ordinance of the County of Kings Establishing Water Well Standards In Accordance with California Water Code Section 13801. Accessed on: 1 July 2019. https://www.countyofkings.com/home/showdocument?id=3100
- Kings County. 2001. Code of Ordinances of the County of Kings State of California, Chapter 14A.

 Article 2; Adopted 1969, Republished 2001. Accessed on: 4 June 2019.

 https://library.municode.com/ca/kings county/codes/code of ordinances?nodeId=CO

 OR CH14AWAWE ARTIIPE
- Kings County. 2010. 2035 Kings County General Plan: Introduction, Table I-4. Accessed on: 1
 June 2019. https://www.countyofkings.com/home/showdocument?id=3108
- Kings County. 2015. *Stratford Community Plan*. Accessed on: 10 July 2019. https://www.countyofkings.com/home/showdocument?id=13511
- Kings County. 2019. *Kings County About Us*. Accessed on: 13 July 2019. https://www.countyofkings.com/about-us
- Kings County Agricultural Commissioner. 2017. 2017 Kings County Agricultural Report. Accessed on: 8 June 2019. https://www.countyofkings.com/home/showdocument?id=19239

- Kings County Public Health Department. 2009. Requirements for New Wells: Community and Nontransient Noncommunity Water Systems. Division of Environmental Health Services. Accessed on: 13 June 2019. https://www.countyofkings.com/home/showdocument?id=17230
- Kings County. 2002. *Revised Dairy Element of Kings General Plan.* Accessed on: 12 December 2019. https://www.countyofkings.com/departments/community-development-agency/information/dairy-element
- Kings County WD (Kings County Water District). 2011. *Groundwater Management Plan*.

 Accessed on: 17 July 2019.

 https://water.ca.gov/LegacyFiles/groundwater/docs/GWMP/TL-13 KingsCountyWD GWMP 2011.pdf
- KRCD and KRWA (Kings River Conservation District and Kings River Water Association). 2009. The Kings River Handbook, Fifth Printing, 48 p.
- KRCD (Kings River Conservation District). 2009. *Kings River Handbook*. Accessed on: 17 July 2019. http://krcd.org/pdf/Kings River Handbook 2009.pdf
- Kings River Fisheries Management Program. 1999. Kings River Fisheries Management Program Framework Agreement. Accessed on: 17 July 2019.

 http://krfmp.org/ pdf fmp/FMP FrameworkAgreement1999.pdf
- Kings River Water Association. 2004. 2003-2004 Water Master Report.
- Kings River Water Association. 2019. Accessed on: 12 December 2019. http://www.kingsriverwater.org/.
- KRWQC (Kings River Water Quality Coalition). 2016. *Kings River Water Quality Coalition*. Accessed on: 20 July 2019. http://www.kingsriverwqc.org/
- Kings River Water Quality Coalition (KRWQC). 2016b. *Comprehensive Groundwater Quality Management Plan.*
- Lafco (Local Agency Formation Commission). 2019. Deer Creek Stormwater District. Accessed on: 12 December 2019. https://lafco.co.tulare.ca.us/lafco/index.cfm/maps/districts/districts-storm-water/
- Leake, S.A. 2016. *Land Subsidence from Ground-Water Pumping*. Accessed on: 29 July 2019 https://geochange.er.usgs.gov/sw/changes/anthropogenic/subside/?
- Lettis, W.R. and J.R. Unruh. 1991. *Quaternary Geology of the Great Valley, California, in Quaternary Nonglacial Geology: Conterminous U.S., Decade of North American Geology.*Prepared for: Geological Society of America, pp 164 176.

- Lohman, S.W. 1972. *Ground-Water Hydraulics, U.S. Geological Survey Professional Paper 708, reprinted 1979*, 70 p.
- Loomis, K.B. 1990. Late Neogene Depositional History and Paleoenvironments of the West-Central San Joaquin Basin, California. Prepared for: Stanford University, PhD Dissertation. 343 p.
- LSCE (Luhdorff & Scalmanini Consulting Engineers, Borchers, J, Carpenter, M). 2014. *Land Subsidence from Groundwater Use in California*. Prepared for: California Water Foundation 193p
- Meade, R.H. 1967. Petrology of Sediments Underlying Areas of Land Subsidence in Central California. Prepared for: U.S. Geological Survey Professional Paper 497-C, 83 p.
- Mendenhall, W.C., R.B. Dole, and H. Stabler. 1916. Ground Water in San Joaquin Valley, California, U.S. Geological Survey Water-Supply Paper 398, 310 p, (Mendenhall et al., 1916).
- Miller, R.E., J.H. Green, and G.H. Davis. 1971. *Geology of Compacting Deposits in the Los Banos-Kettleman City Subsidence Area, California*. Prepared for: U.S. Geological Survey Professional Paper 497-E, 46 p.
- NASA (National Aeronautics and Space Administration). n.d. *NASA JPL InSAR Subsidence Data*. Retrieved August 22, 2019, https://data.ca.gov/dataset/nasa-jpl-insar-subsidence-data
- NASA (National Aeronautics and Space Administration). 2017. NASA Data Show California's San Joaquin Valley Still Sinking. Accessed on: 17 July 2019. https://www.nasa.gov/feature/jpl/nasa-data-show-californias-san-joaquin-valley-still-sinking
- Nidever, Seth. 2014. *Drought shadow stretches across Kings unemployment rate*. Prepared for: Hanford Sentinel.
- NOAA (National Oceanographic Atmospheric Administration). 2019. *National Weather Service Forecast Office, Hanford California: Historic Average Annual Precipitation.* Accessed on: 15 March 2019. https://w2.weather.gov/climate/xmacis.php?wfo=hnx
- NRCS (National Resource Conservation Service). 2018. *Web Soil Survey*. Accessed on: 2 July 2019. https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx?aoissa=CA031
- Page, R.W. 1973. Base of Fresh Ground Water (Approximately 3,000 Micromhos) in the San Joaquin Valley, California. Prepared for: U.S. Geological Survey Hydrologic Investigations Atlas HA-489, 1 p.

- Page, R.W. 1981. Data on Depths to the Upper Mya Zone of the San Joaquin Formation in the Kettleman City Area, San Joaquin Valley, California. Prepared for: U.S. Geological Survey Open-File Report 81-699, 12 p.
- Page, R.W. 1983. Geology of the Tulare Formation and Other Continental Deposits, Kettleman City Area, San Joaquin Valley, California, with a Section on Ground-Water Management Considerations and Use of Texture Maps. Prepared for: U.S. Geological Survey Water-Resources Investigations Report 83-4000, 24 p.
- PRISM Climate Group. 2018. Prepared for: Oregon State University. Accessed on: 23 July 2019 http://prism.oregonstate.edu
- Provost & Pritchard Consulting Group. 2009, Apex Ranch Conjunctive Use Project Groundwater Monitoring Program October 2008 through September 2009, Kings County Water District. Prepared for Kings County Water District.
- Provost & Pritchard Consulting Group. 2011. *Groundwater Management Plan, Kings County Water District.* Prepared for Kings County Water District.
- RMC Water and Environment. 2015. *Transitioning to Sustainability: Modeling Groundwater Sustainability in the Kings- Tulare Lake Region.* Accessed on: 3 August 2019. http://californiawaterfoundation.org/wp-content/uploads/CWF-Transitioning-to-Sustainability-Final-Report 11 09 2015.pdf
- RWQCB (Regional Water Quality Control Board). 2015. Central Valley Region, 2015, Water Quality Control Plan for the Tulare Lake Basin, Second Edition, Revised January 2015 (with Approved Amendments). Accessed 16 July 2019.

 https://www.waterboards.ca.gov/rwqcb5/water issues/basin plans/tlbp.pdf
- RWQCB (Regional Water Quality Control Board). 2017. *Central Valley Region, Amendment to the Water Quality Control Plan for the Tulare Lake Basin to Remove the Municipal and Domestic Supply (MUN) and Agricultural Supply (AGR) Beneficial Uses within a Designated Horizontal and Vertical Portion of the Tulare Lake Bed, Final Staff Report.*Accessed on: 12 July 2019.
- RWQCB (Regional Water Quality Control Board). 2017b. Resolution R5-2017-0032. Amendment to the Water Quality Control Plan for the Tulare Lake Basin to Remove the Municipal and Domestic Supply (MUN) and Agricultural Supply (AGR) Beneficial Uses Within a Designated Horizontal and Vertical Portion of the Tulare Lake Bed.
- Scheirer, A.H., Ed. 2007. Petroleum Systems and Geologic Assessment of Oil and Gas in the San Joaquin Basin Province, California, 31 Chapters. Prepared for: U.S. Geological Survey Professional Paper 1713. Accessed on: 9 August 2018. https://pubs.usgs.gov/pp/pp1713/

- Soil Survey Staff. 2018. *Natural Resources Conservation Service, United States Department of Agriculture*. Prepared for: Soil Survey Geographic (SSURGO) Database. Accessed on: 25 July 2018. https://sdmdataaccess.sc.egov.usda.gov
- SCE (Southern California Edison). 2016. Kaweah Project Relicensing, SCE Pre-Application

 Document, Section 3.2 River Basin. Accessed on: 12 July 2018.

 https://www.sce.com/ko/regulatory/hydro-licensing/kaweah-project-relicensing/sce-pre-application-document
- Stewart, Ralph. 1946. *Geology of Reef Ridge-Coalinga District, California*. Prepared for: U.S. Geological Survey Professional Paper 205-C, 34 p.
- Summers Engineering, Inc. 2012. *Tulare Lake Bed Coordinated Groundwater Management Plan* (SB 1938 Compliant).
- SWRCB (State Water Resources Control Board). 2006. Resolution No. 88-63 (as revised by Resolution no. 2006-0008) Adoption of Policy Entitled "Sources of Drinking Water.
- SWRCB (State Water Resources Control Board). 2019a. *GeoTracker*. Accessed on: 17 July 2019. http://geotracker.waterboards.ca.gov./
- SWRCB (State Water Resources Control Board). 2019b. GAMA Groundwater Information System.
 https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp
- SWRCB. 2019c. Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS).

 Accessed on: 22 August 2019.

 https://www.waterboards.ca.gov/centralvalley/water issues/salinity/
- Tieman, Mary. 2017. "Safe Drinking Water Act (SDWA): A summary of the Act and Its Major Requirements. Page 1.
- Tulare County. 2012. 2030 Update Tulare County General Plan.

 http://generalplan.co.tulare.ca.us/documents/GP/001Adopted%20Tulare%20County%2

 OGeneral%20Plan%20Dlan%20Materials/000General%20Plan%202030%20Part%20I%20and%20

 https://generalplan.co.tulare.ca.us/documents/GP/001Adopted%20Tulare%20County%2

 OGeneral%20Plan%20Materials/000General%20Plan%202030%20Part%20I%20and%20

 Part%20II/GENERAL%20PLAN%202012.pdf
- Tulare County. 2017. Tulare County Ordinance Code Part IV. Health, Safety and Sanitation
 Chapter 13. Construction of Wells. Accessed on: 13 June 2019.
 https://tularecountyeh.org/eh/index.cfm/guidance-library/water-wells/tulare-county-water-well-ordinance-2017
- Tulare County. 2019. *Tulare County About*. Accessed on: 1 July 2019. https://tularecounty.ca.gov/county/index.cfm/about/
- Tulare Lake Basin Water Storage District. 2013. Agricultural Water Management Plan.

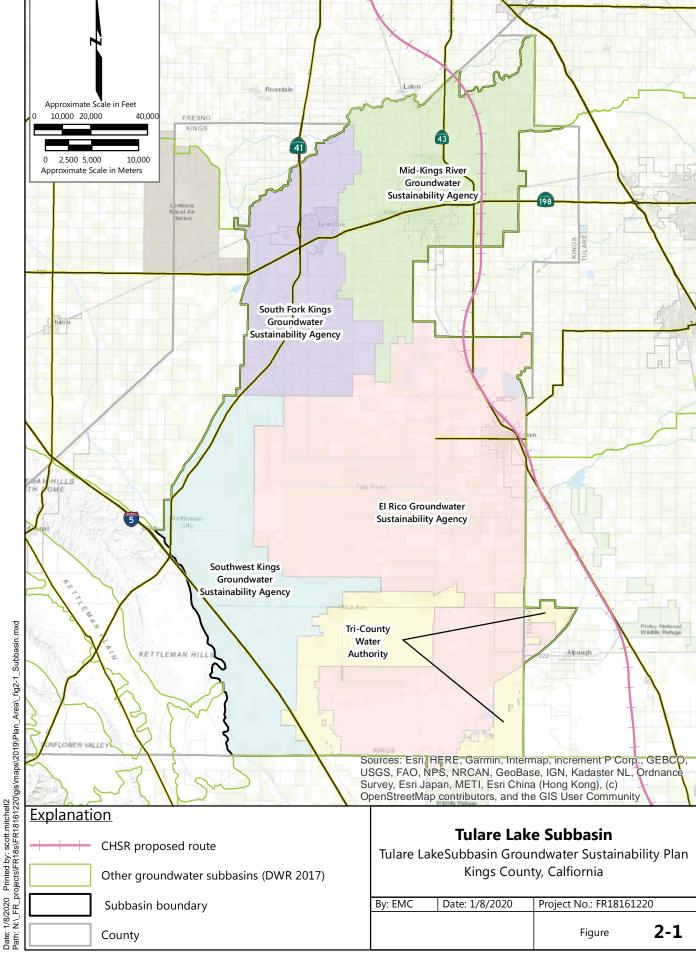
- Tulare Lake Basin Water Storage District. 2015. 2015 Agricultural Water Management Plan. Accessed on: 17 July 2019.
 - https://water.ca.gov/LegacyFiles/wateruseefficiency/sb7/docs/2015/plans/2015%20A WMP%20-%20Tulare%20Lake%20Basin%20WSD.pdf
- Tule River Basin. 2015. Integrated Regional Water Management Plan.
- UNAVCO. 2019. *PBO GPS Stations Network Monitoring*. Accessed August 20, 2019 at: https://www.unavco.org/instrumentation/networks/status/pbo/gps
- USACE (U.S. Army Corps of Engineers). 2017. Success Lake, Water Control Manual Deviation, Final Environmental Assessment. Accessed on: 12 June 2018.

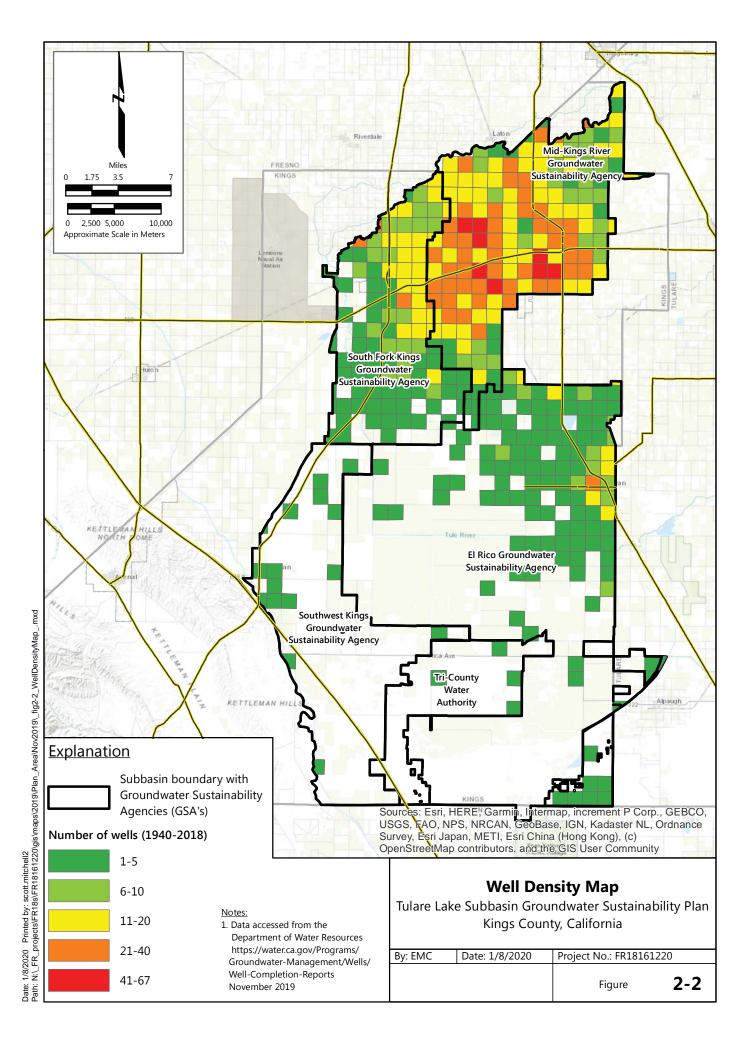
 http://www.spk.usace.army.mil/Portals/12/documents/civil-works/Success/FINAL%20S uccess%20Lake%20Deviation%20EA.pdf?ver=2017-06-06-182303-820,
- USBR (U.S. Bureau of Reclamation). 2003. *Raise Pine Flat Dam, Upper San Joaquin River Basin Storage Investigation, Surface Water Storage Option Technical Memorandum, Joint Study*. Prepared for: U.S. Bureau of Reclamation and California Department of Water Resources.
- USBR. 2017. Summary of Available Water Supplies.
- USBR. 2018. Central Valley Project Interim Renewal Contracts for Cross Valley Contractors 2016-2018. Accessed on: 17 July 2019. https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=31723
- USBR. 2019. About the Central Valley Project. Accessed on: 12 December 2019. https://www.usbr.gov/mp/cvp/about-cvp.html
- U.S. Census Bureau (United States Census Bureau). 2018. *U.S. Census Bureau QuickFacts: United States*. Accessed on: 17 July 2019. https://www.census.gov/quickfacts/fact/table/US/PST045218.
- USDA (U.S. Department of Agriculture). *National Agricultural Statistics Service Cropland Data Layer: 2006-2016*. Accessed on: 2 July 2019. http://nassgeodata.gmu.edu/CropScape/USDA-NASS
- USGS (United States Geological Survey). 2017. *USGS Land Subsidence Resources*. Retrieved from California Water Science Center: https://ca.water.usgs.gov/land-subsidence/california-subsidence-resources.php
- USGS (United States Geological Survey). 2019. *Areas of Land Subsidence in California*. Accessed on: 17 July 2019. https://ca.water.usgs.gov/land-subsidence/california-subsidence-areas.html

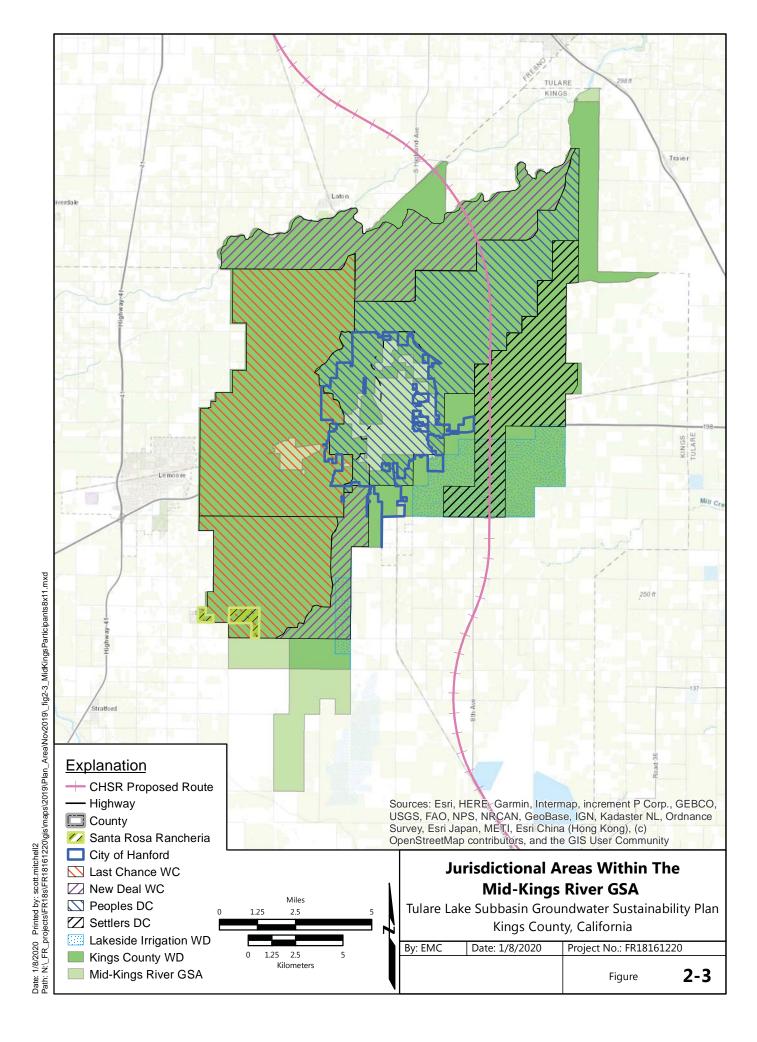
- WRIME (Water Resources & Information Management Engineering, Inc.). 2005. Kings River Conservation District, Lower Kings Basin Groundwater Management Plan Update.
- Wood (Wood Environment & Infrastructure Solutions, Inc.). 2018. First Quarter 2018

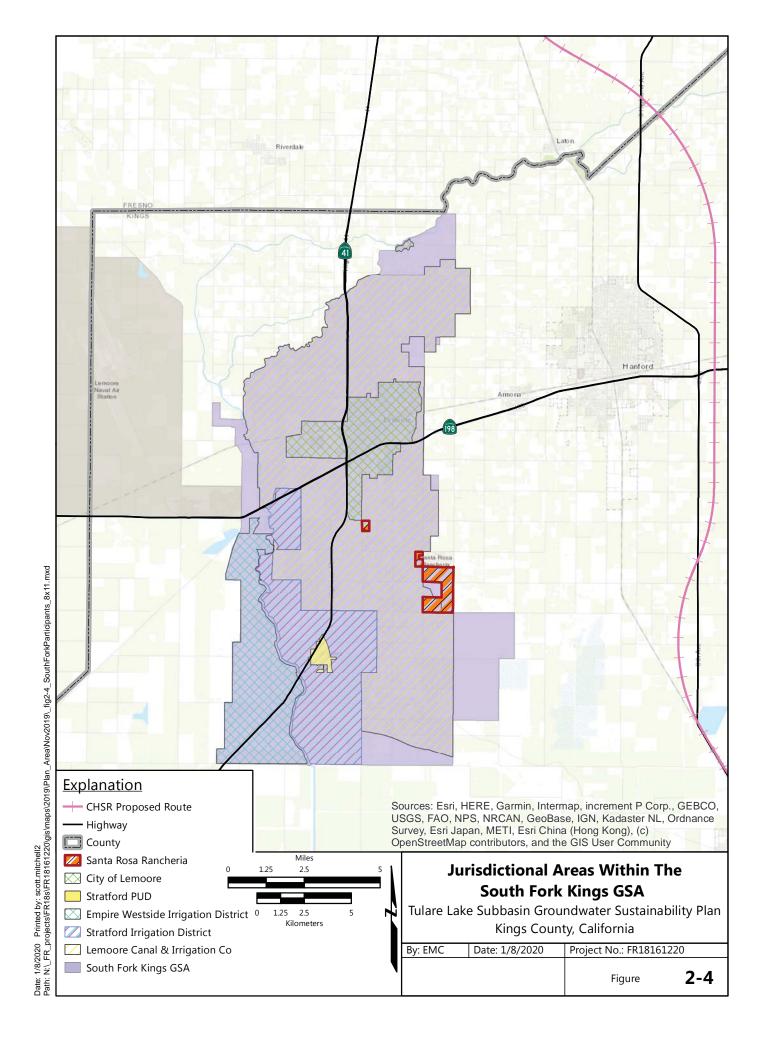
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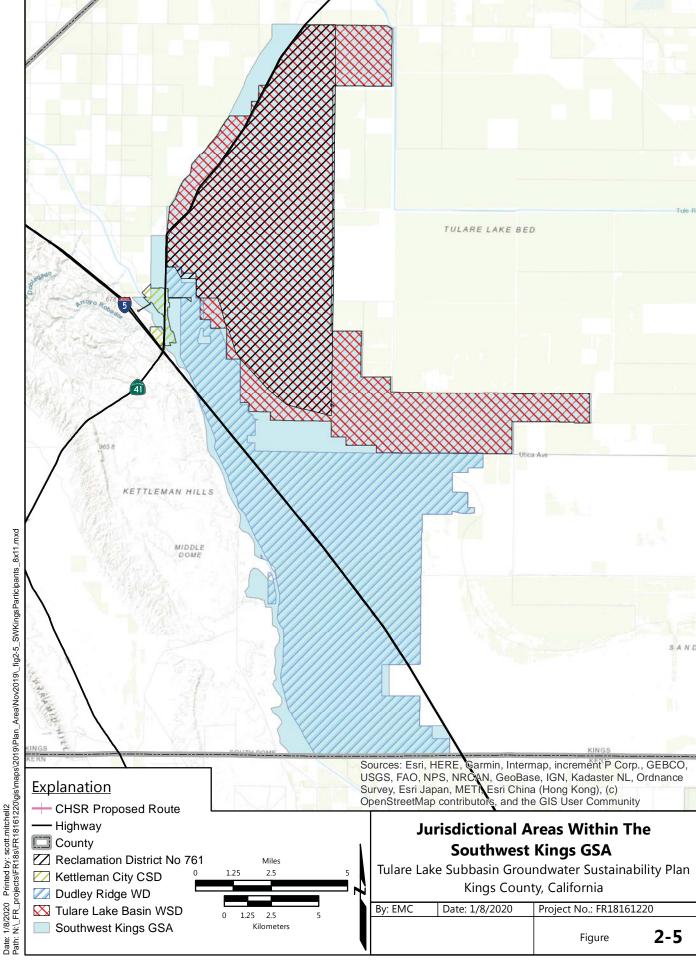
 Hills Facility. Prepared for Chemical Waste Management, Inc., 18 p, June 21.
- Woodring, W.P., R. Stewart, and R.W. Richards. 1940. *Geology of the Kettleman Hills Oil Field, California, Stratigraphy, Paleontology, and Structure*. Prepared for: U.S. Geological Survey Professional Paper 195, 170 p.
- WWQC (Westside Water Quality Coalition). 2019. Westside Water Quality Coalition. Accessed on: 24 July 2019. https://www.wwqc.org/

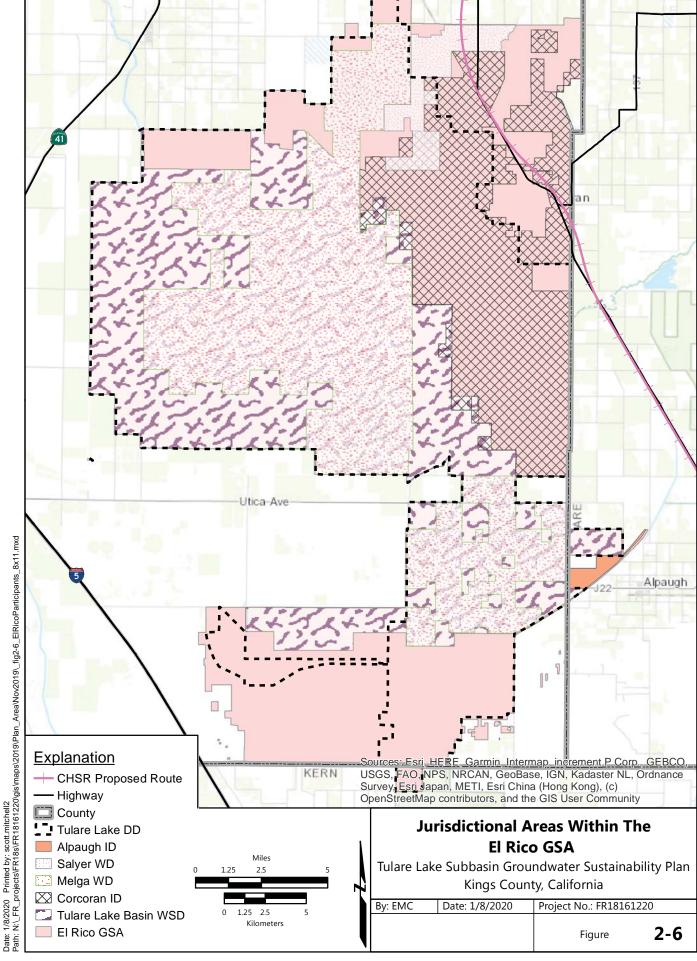


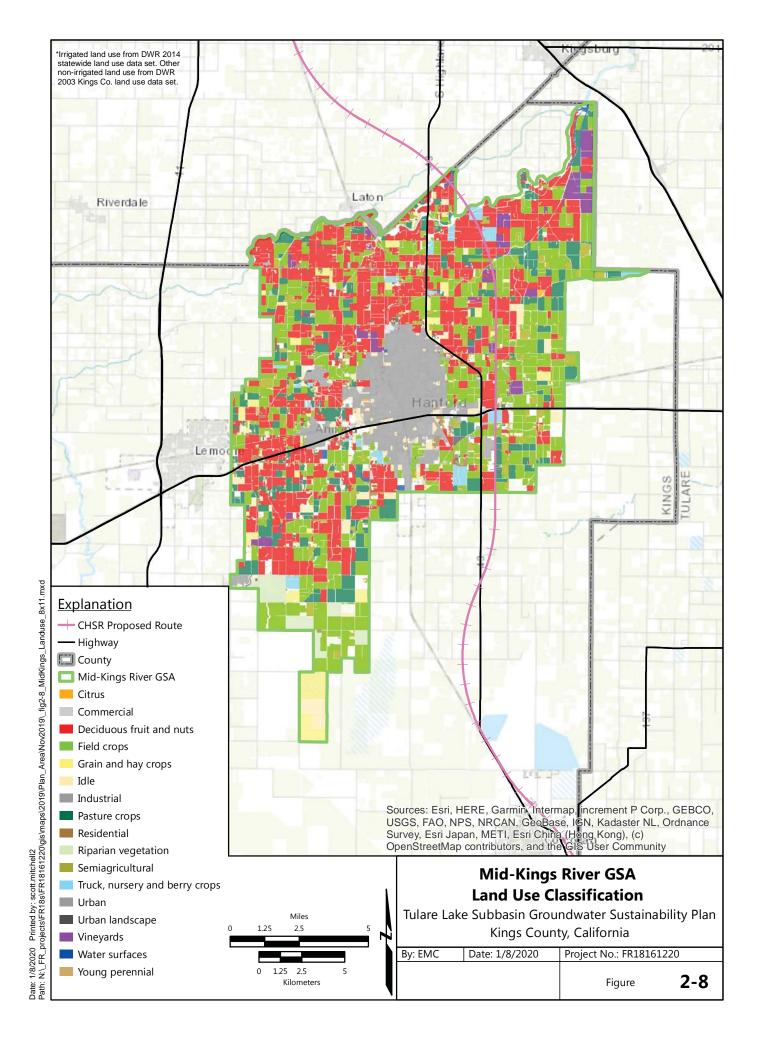


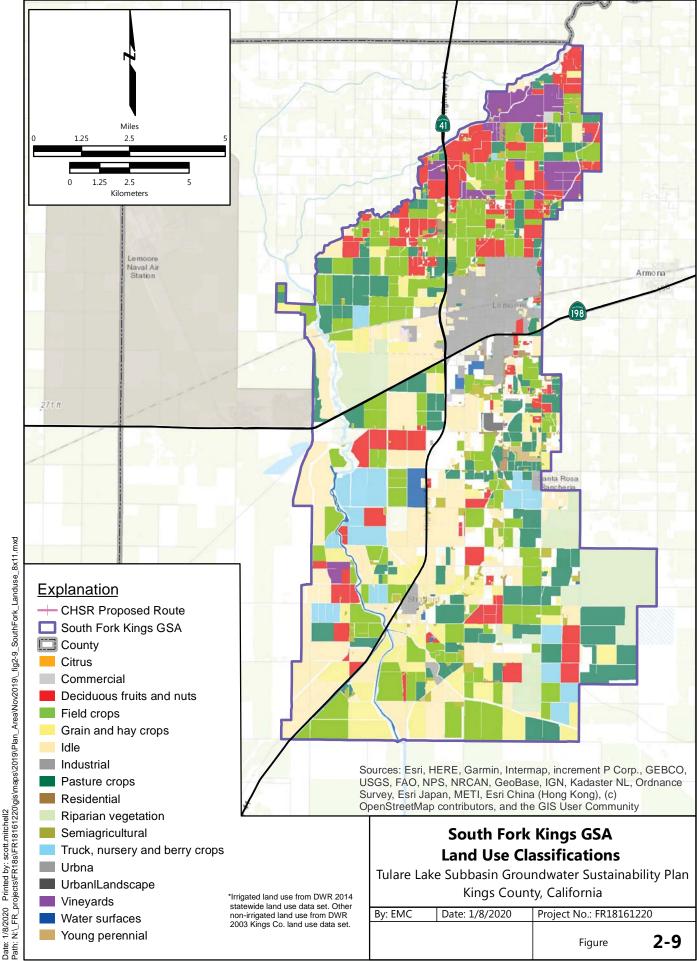


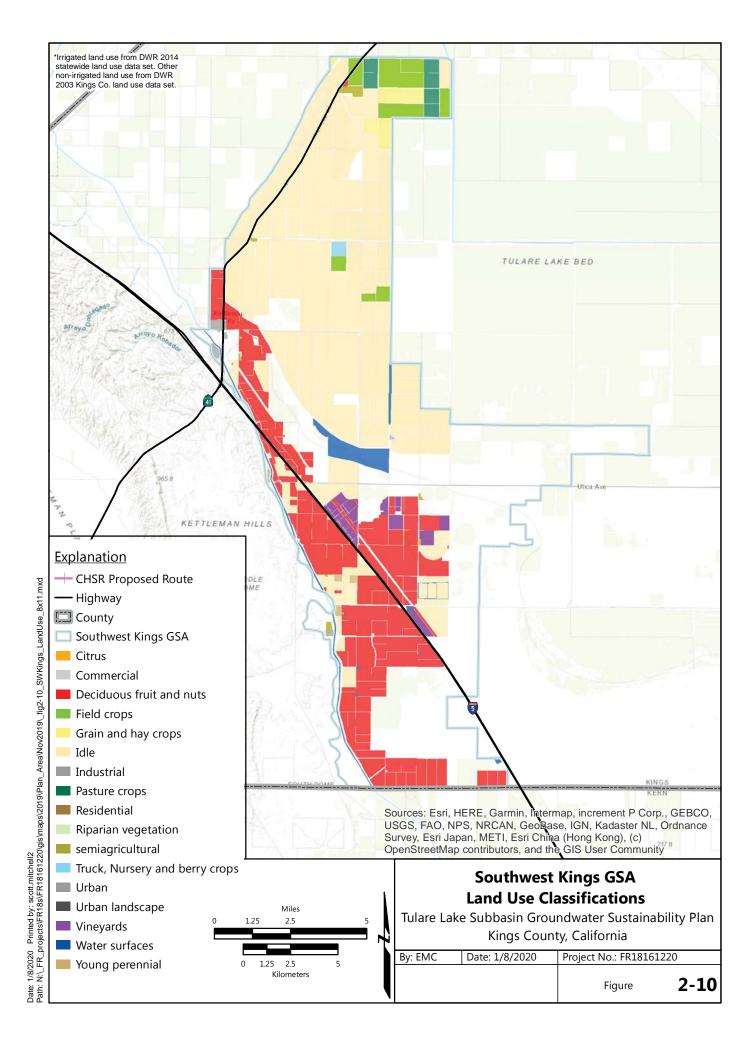


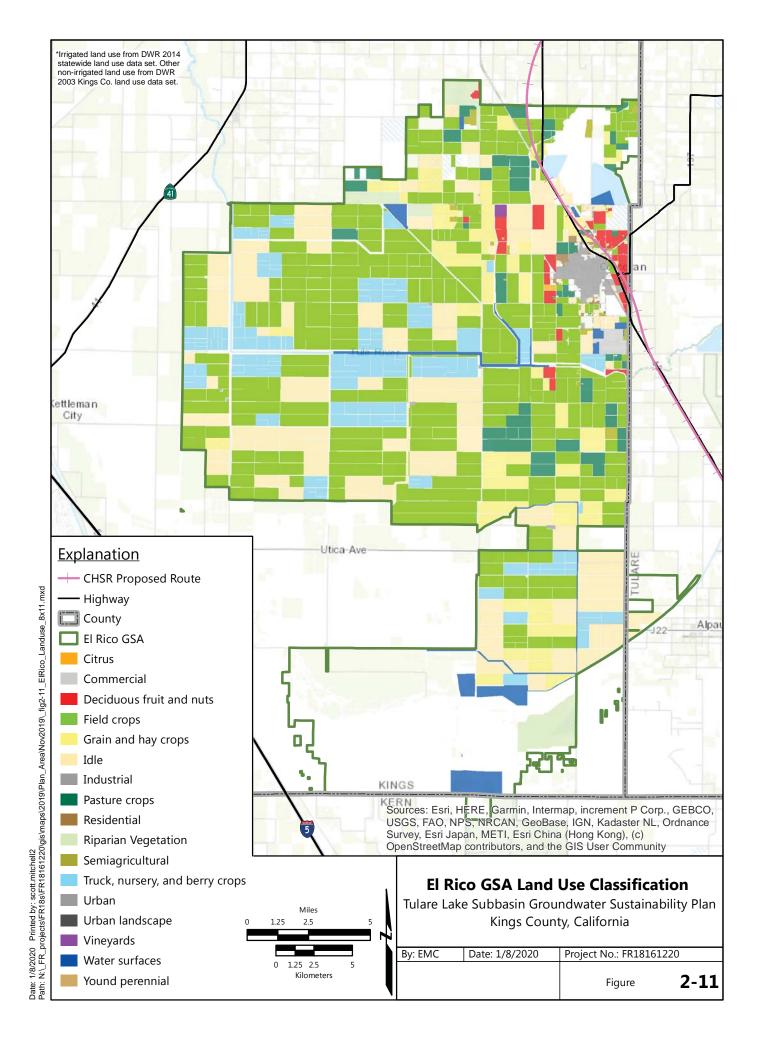


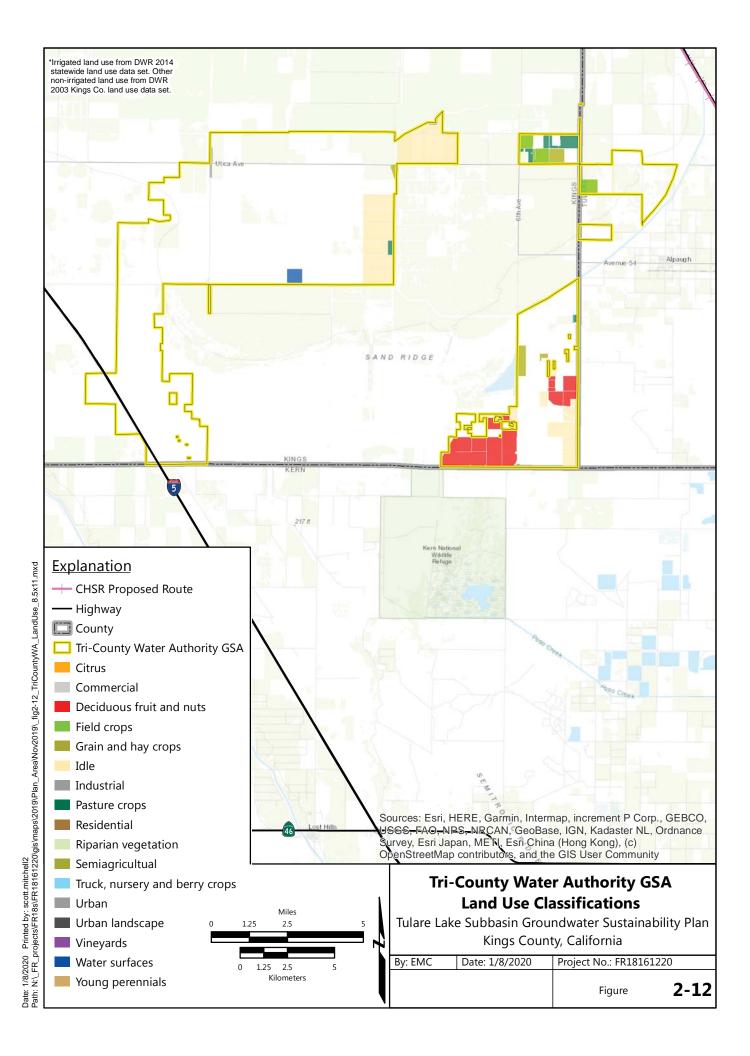


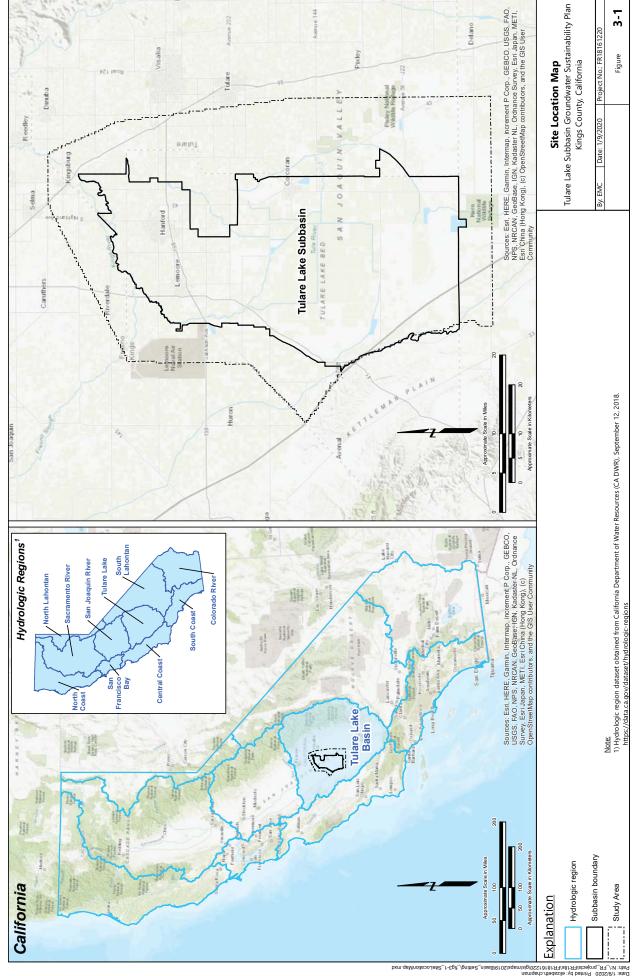


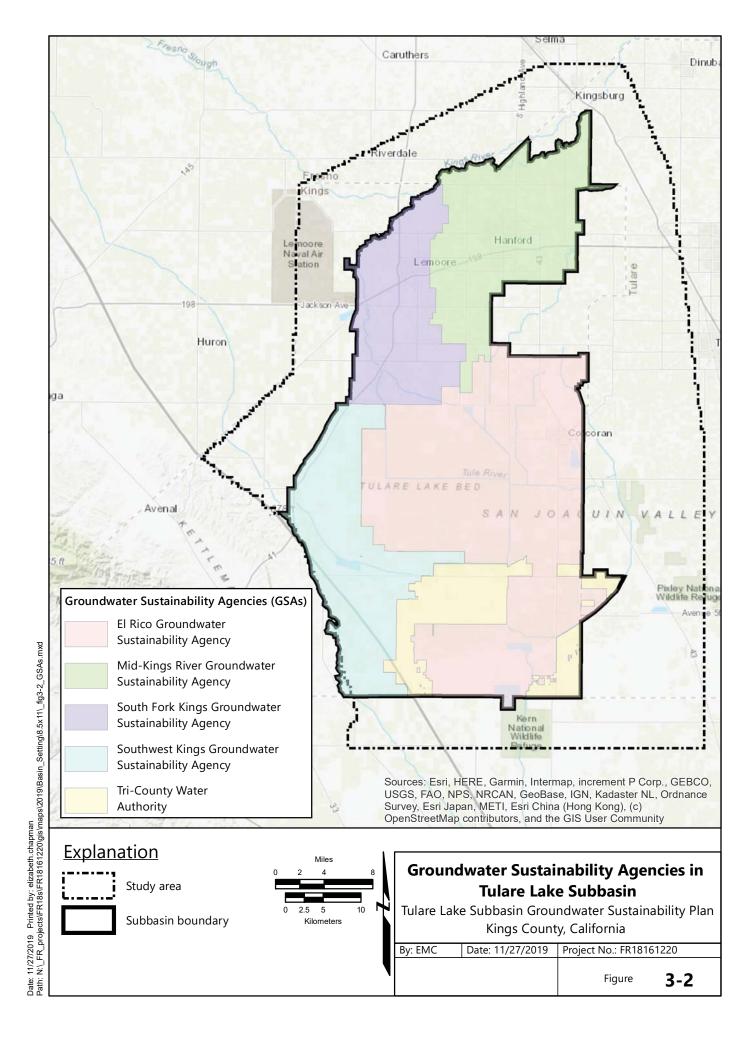


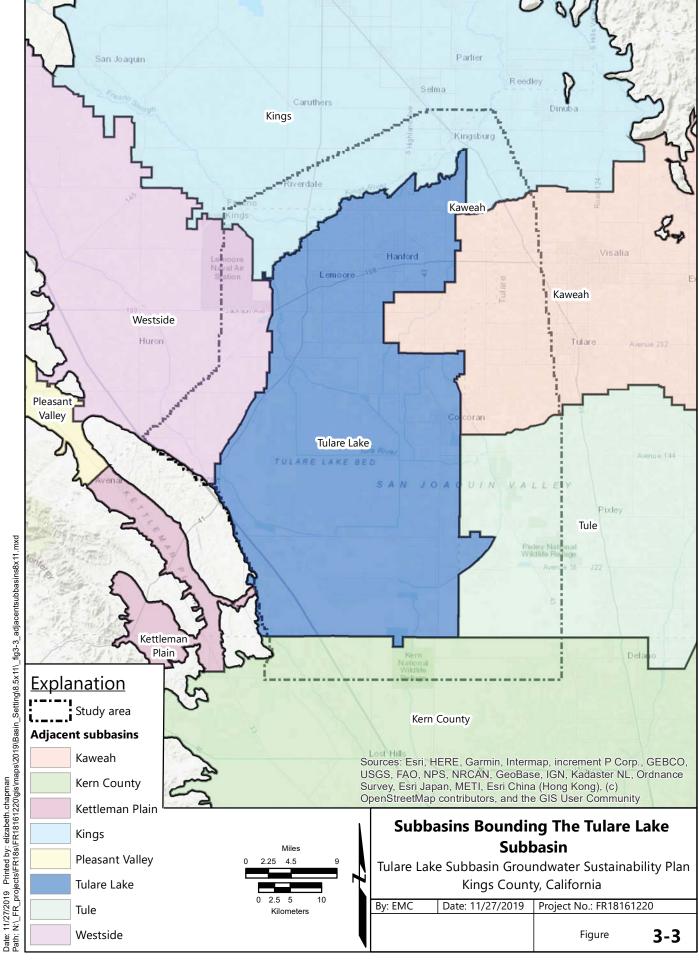


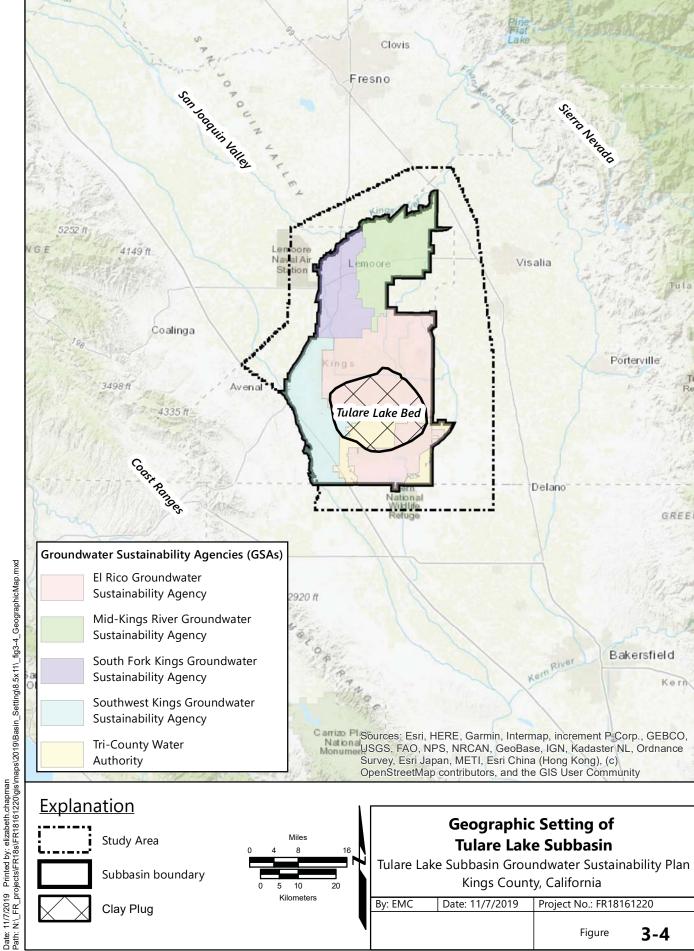


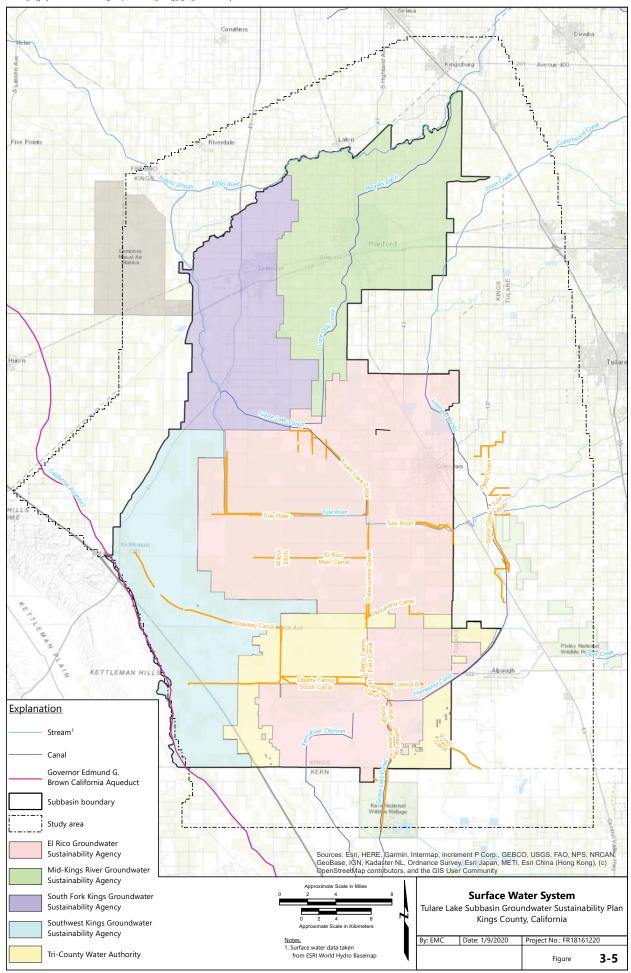


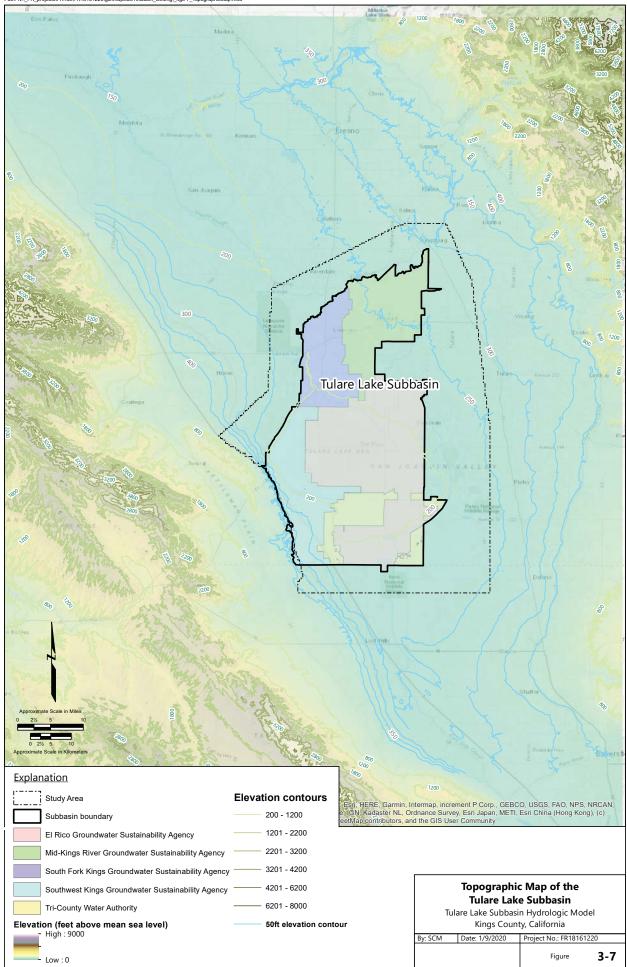


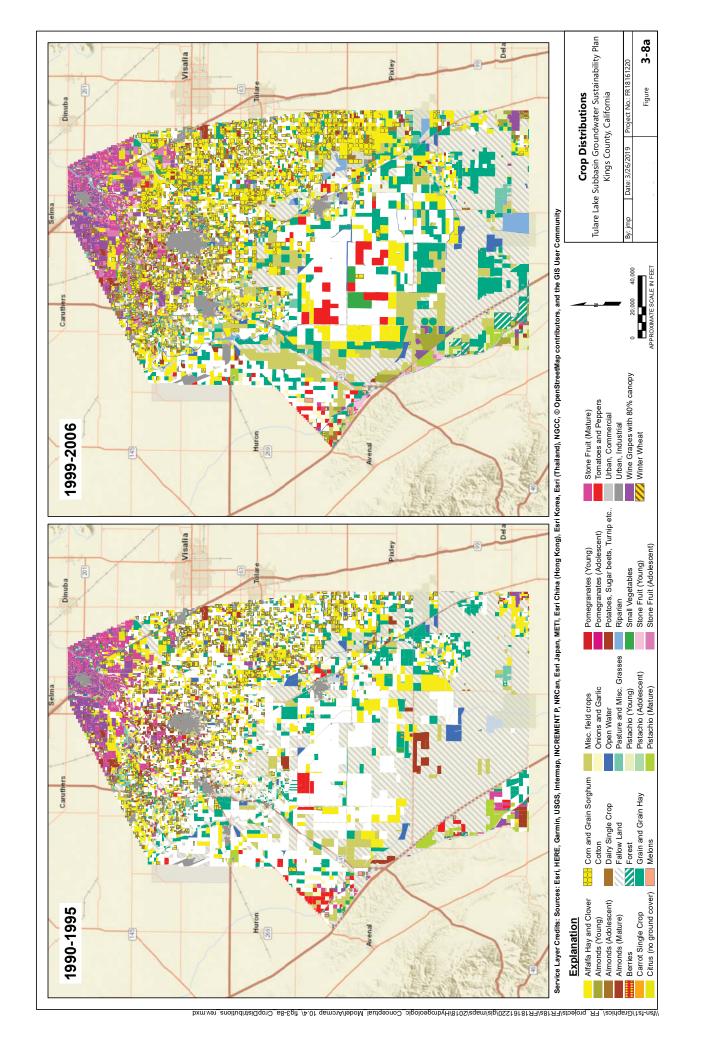


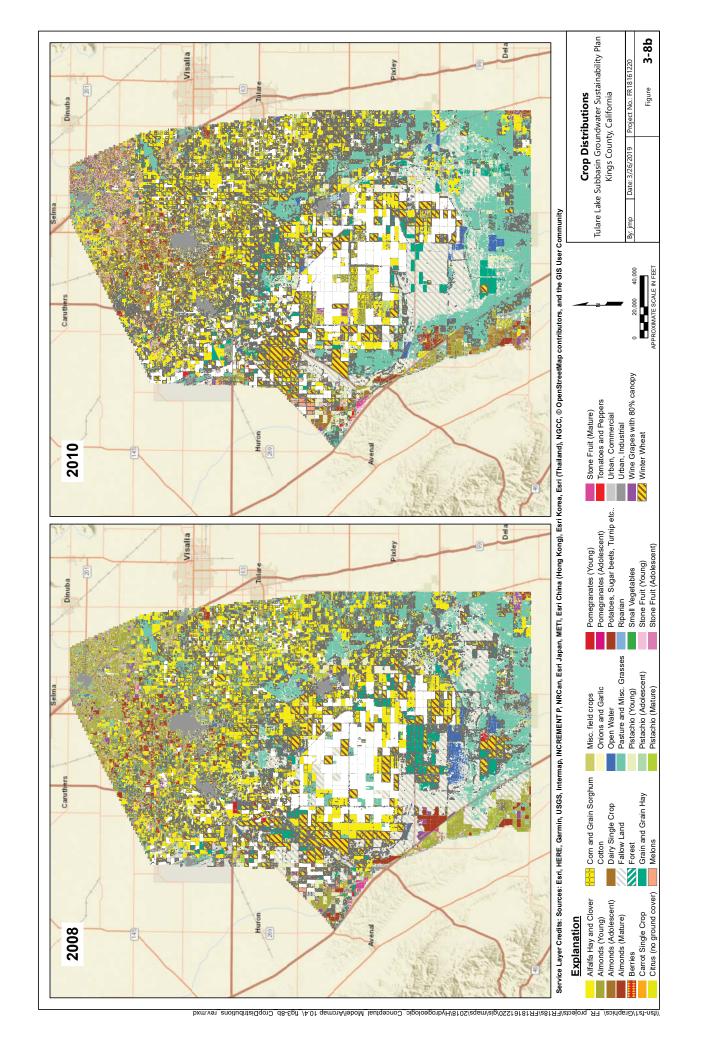


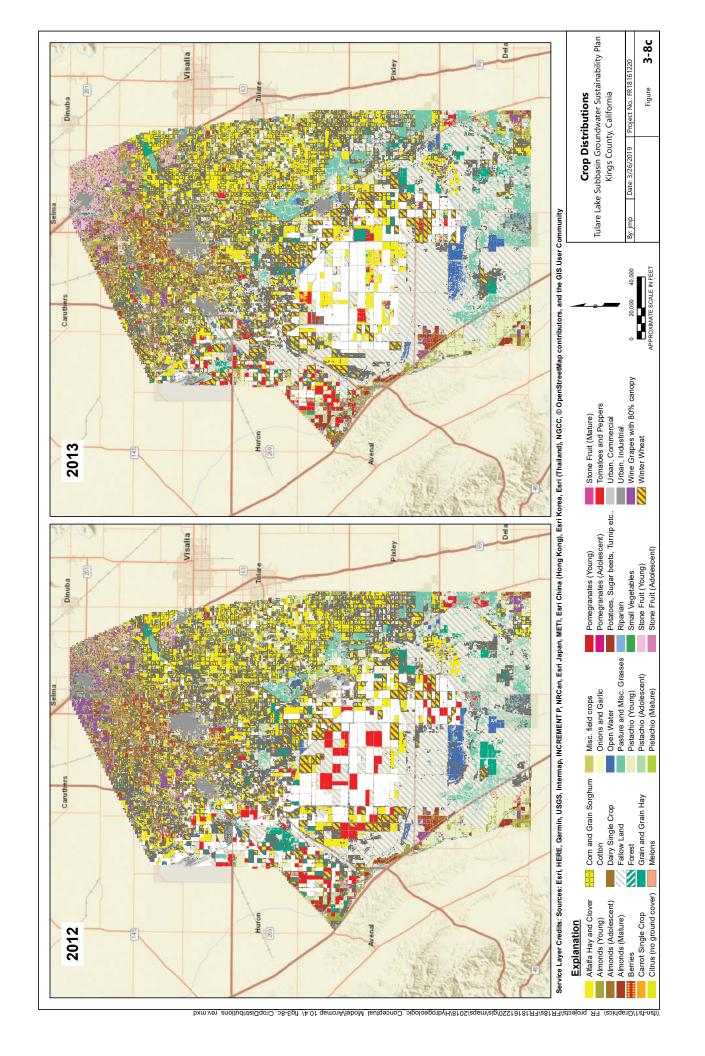


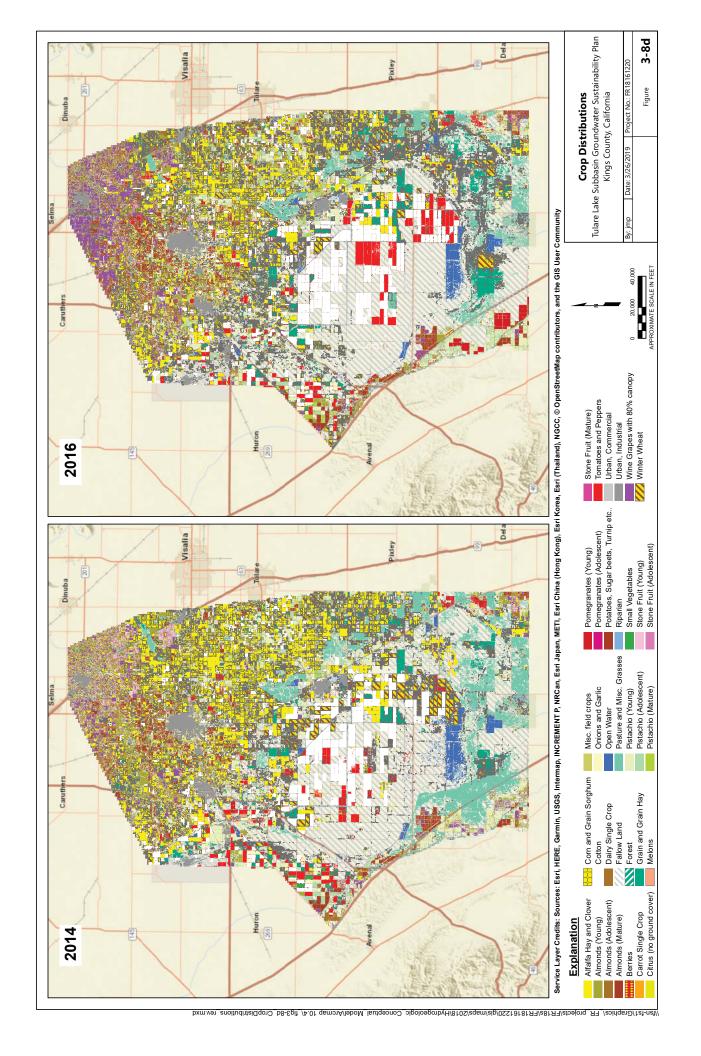


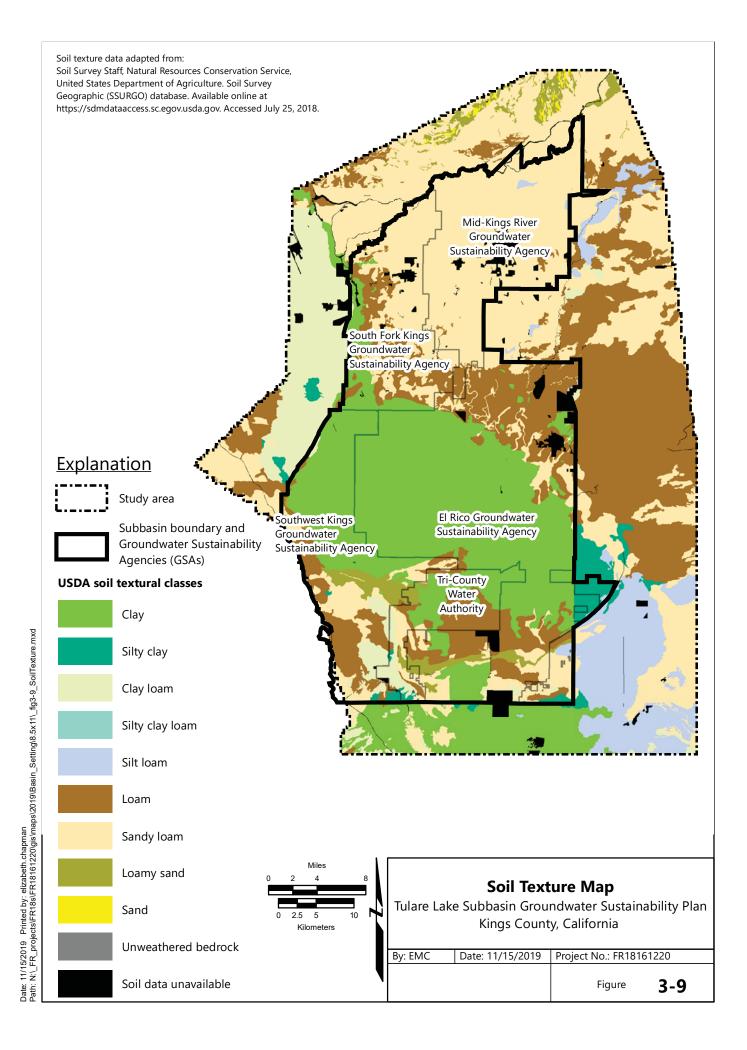


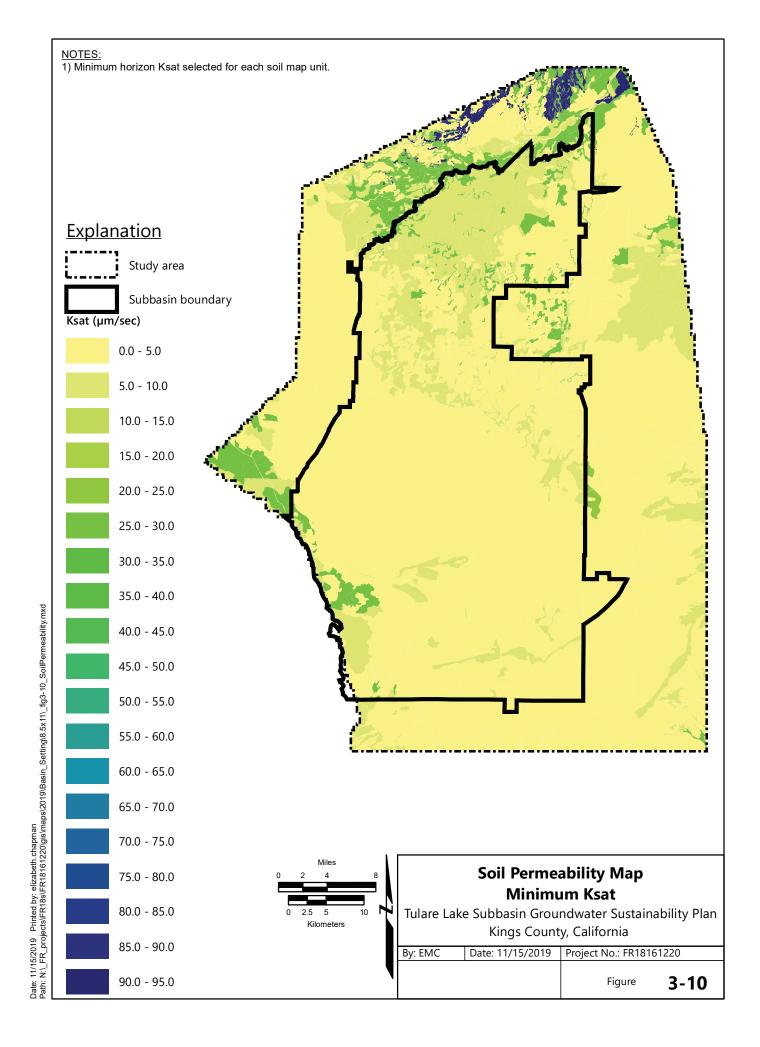


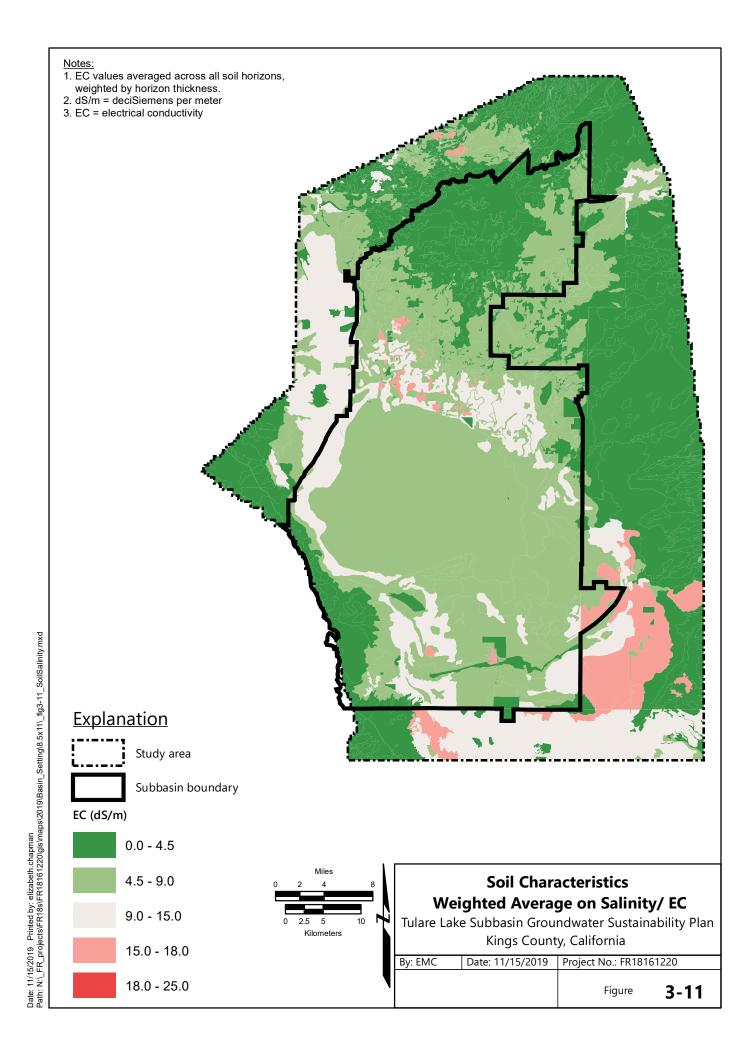


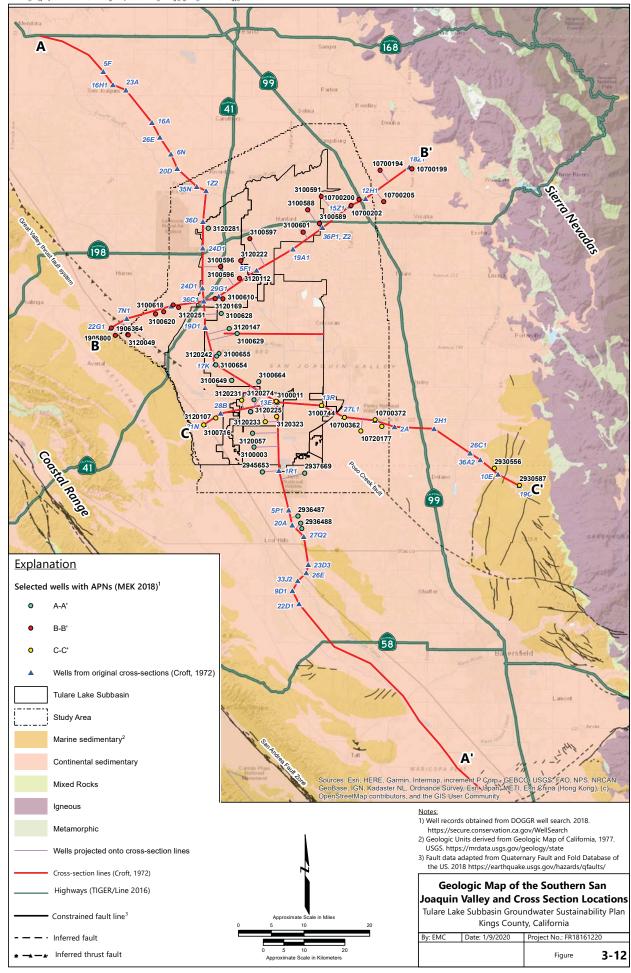












Mount Diablo

Stockton

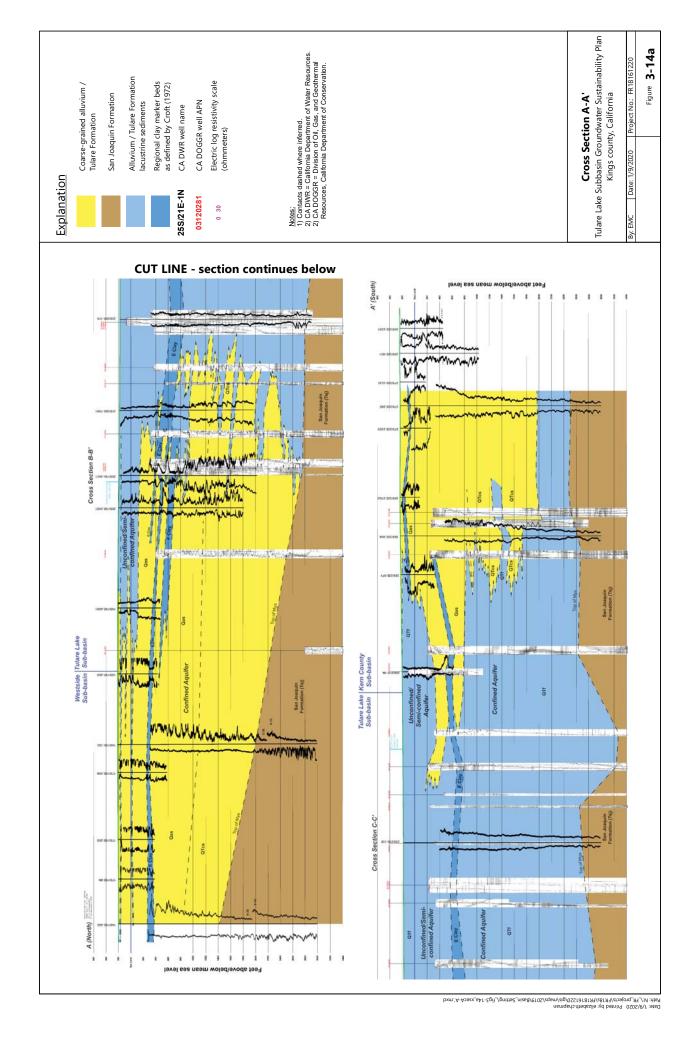
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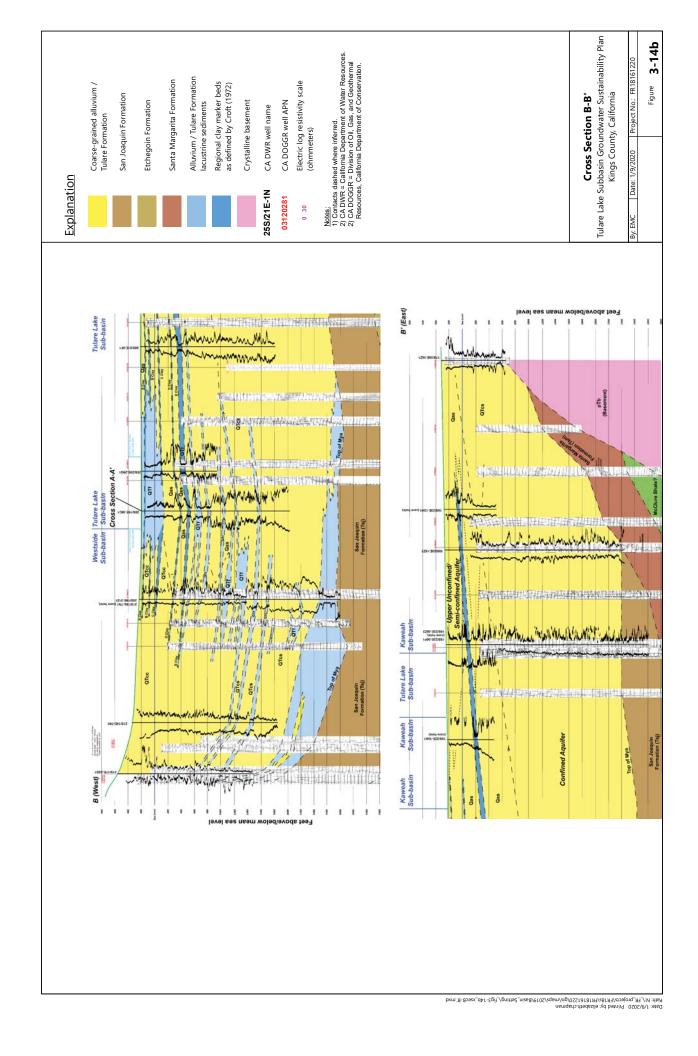
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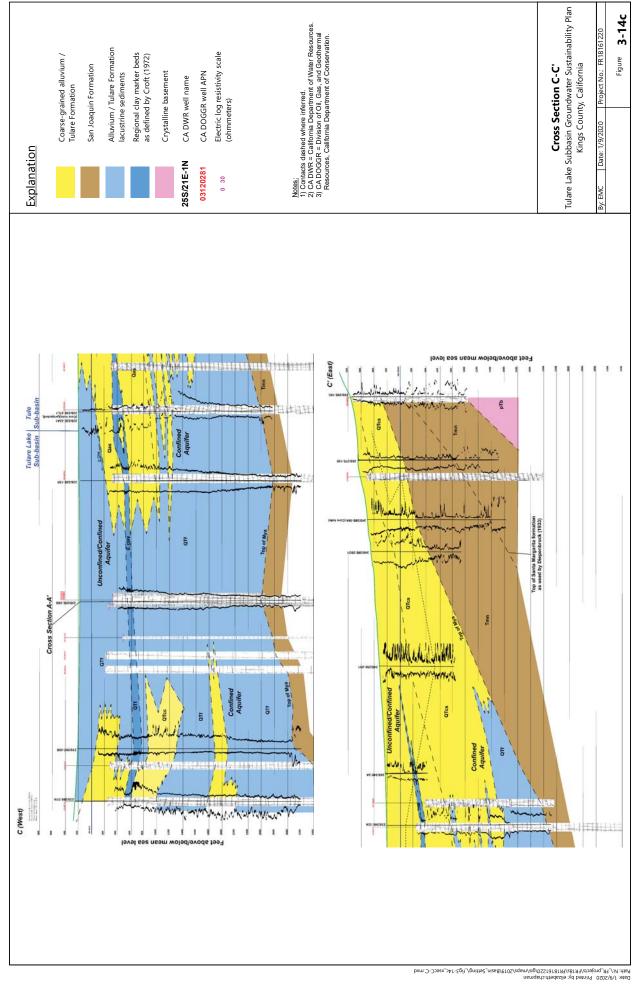
Pleistocene Extent of Corcoran Lake

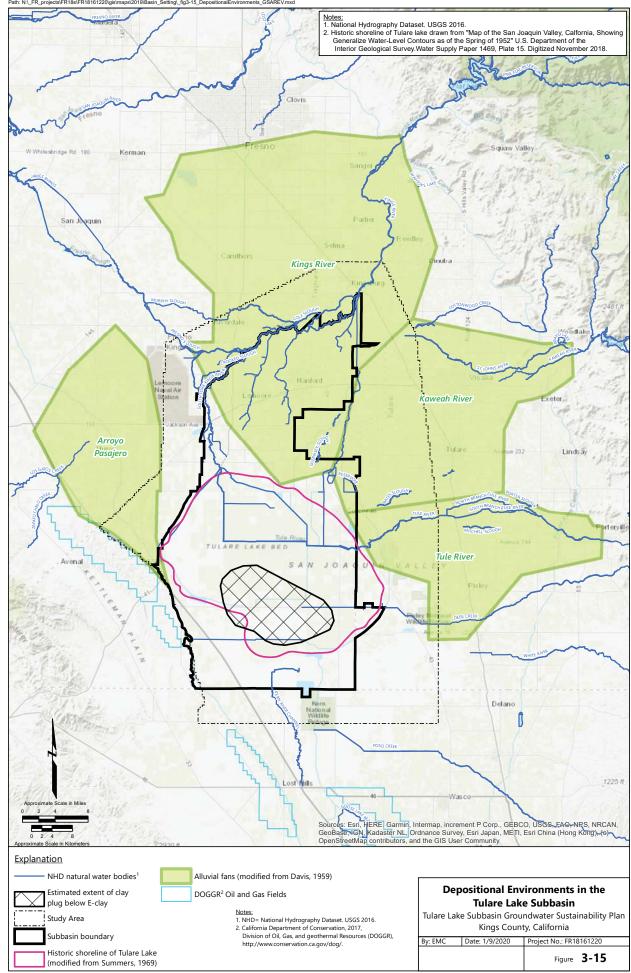
Tulare Lake Subbasin Groundwater Sustainability Plan Kings County, California

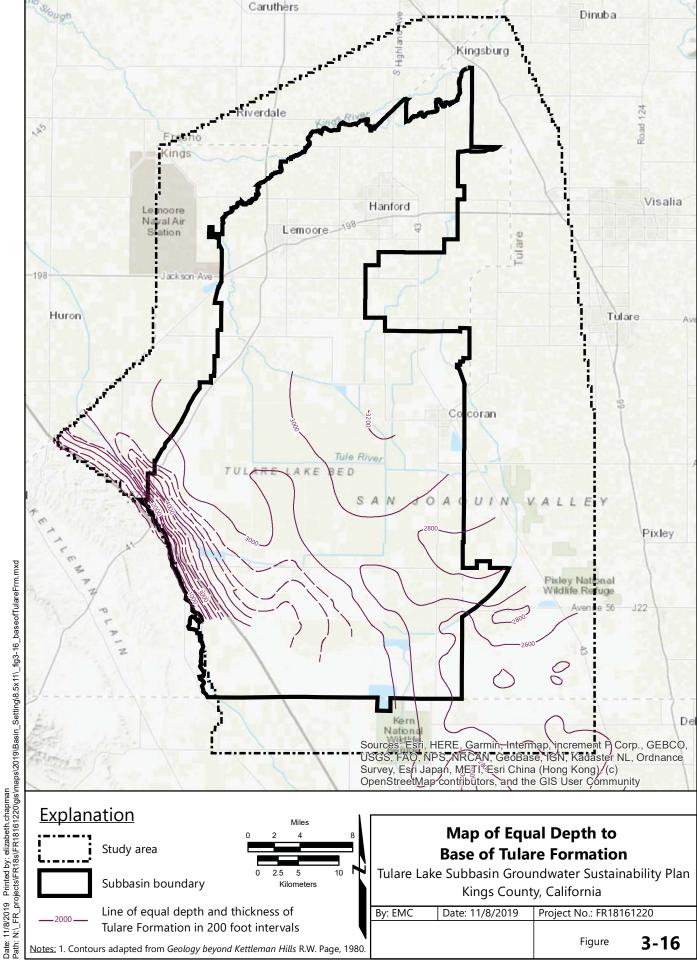
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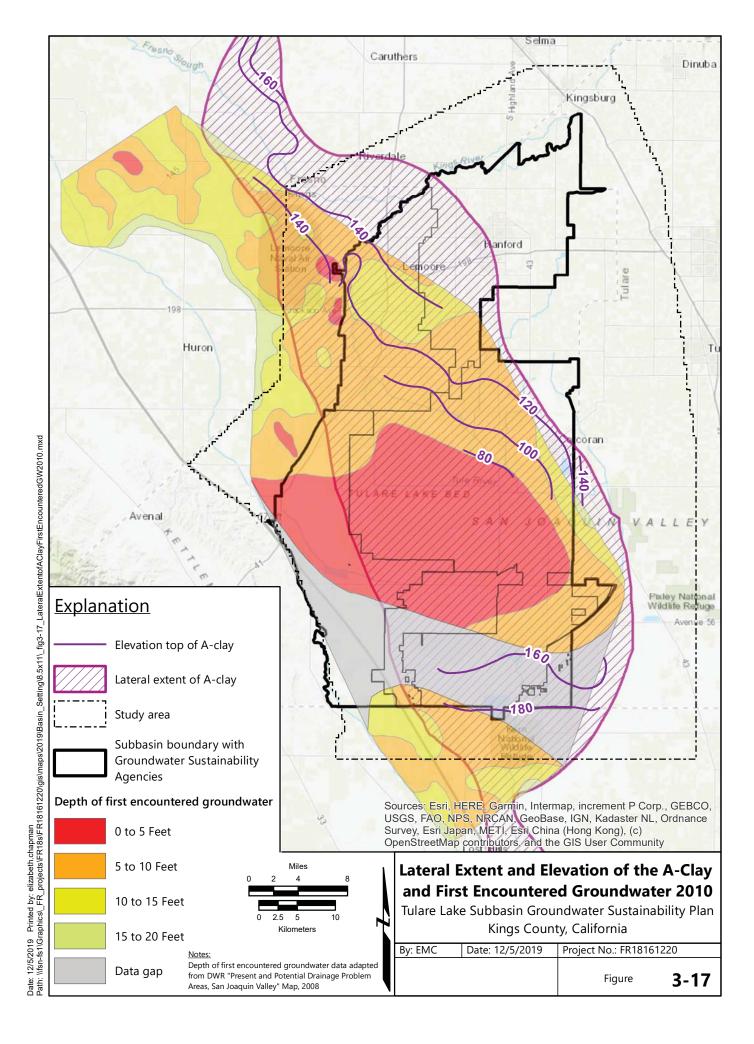


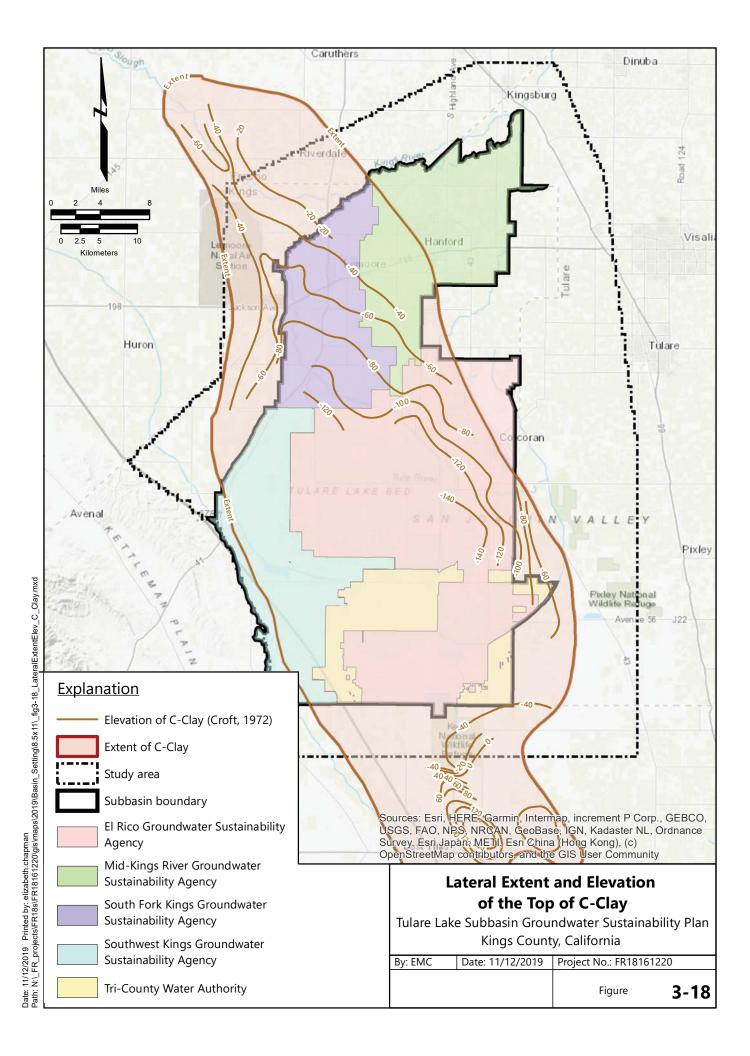












Tri-County Water Authority

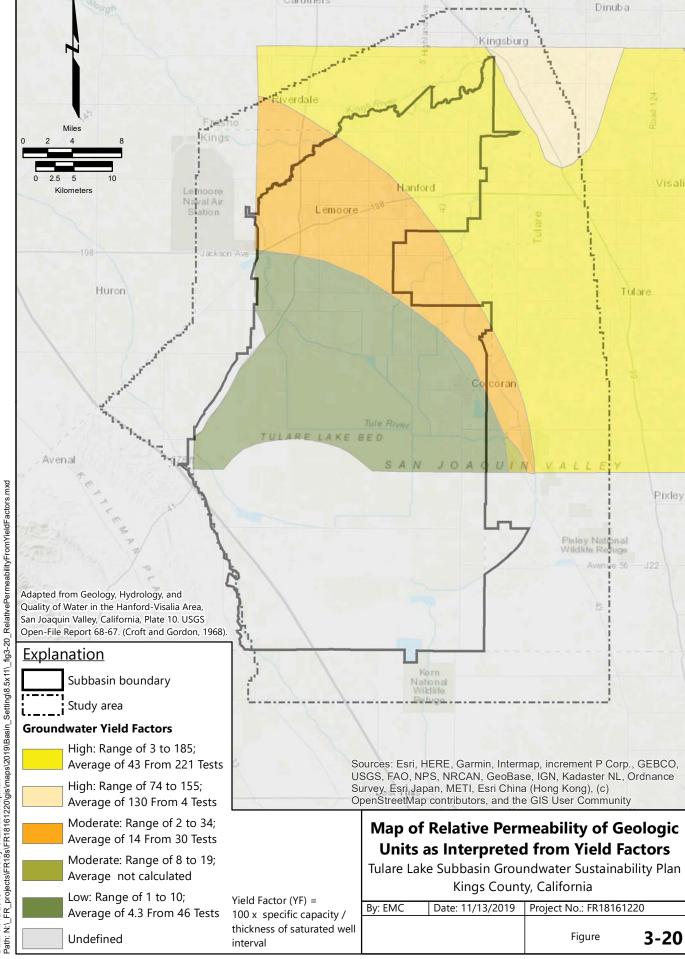
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Figure **3-19a**

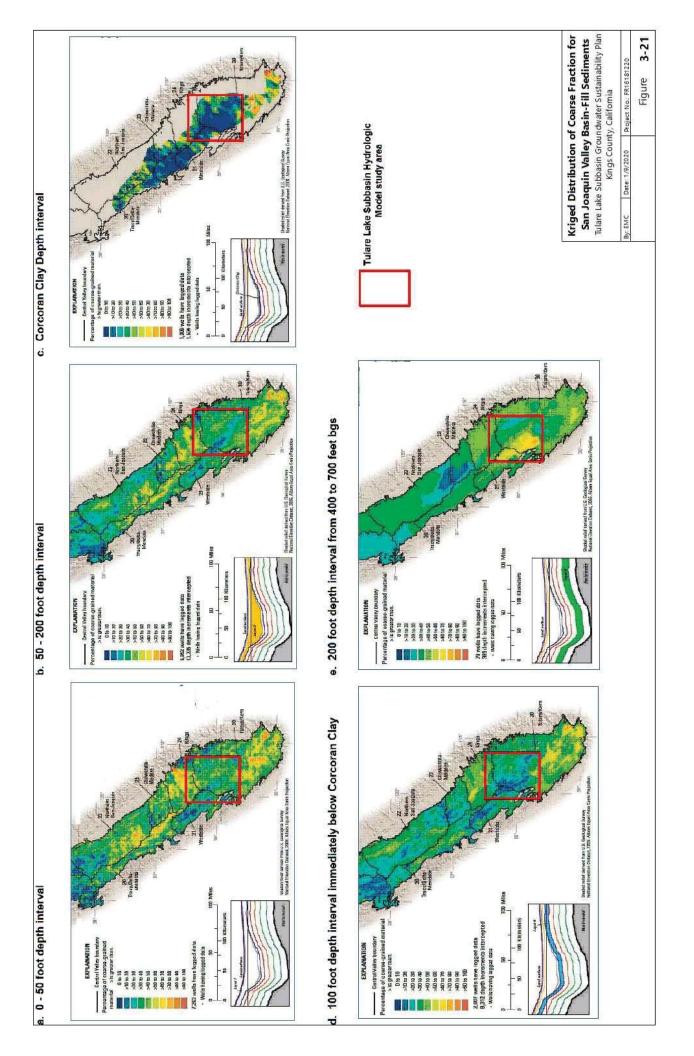
Figure 3-19b

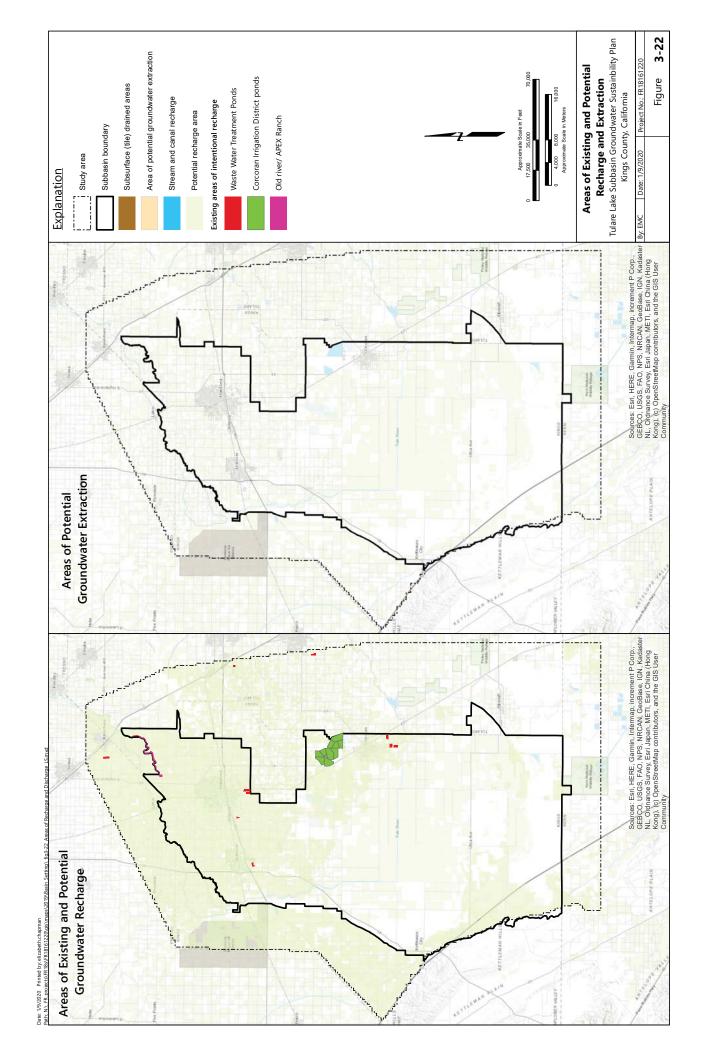
Tri-County Water Authority

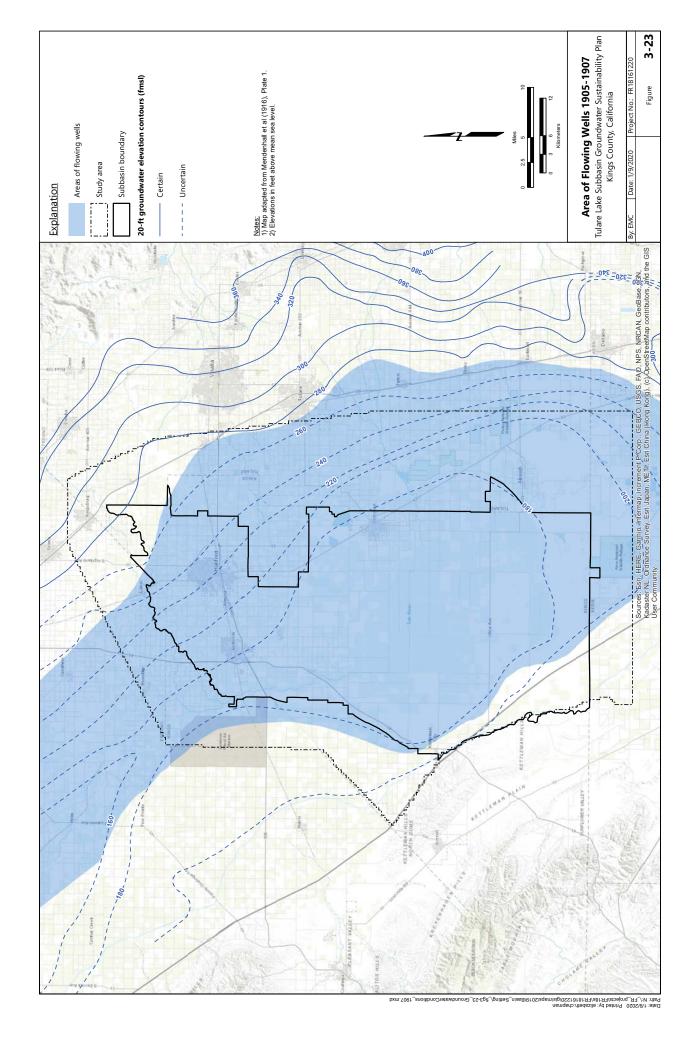


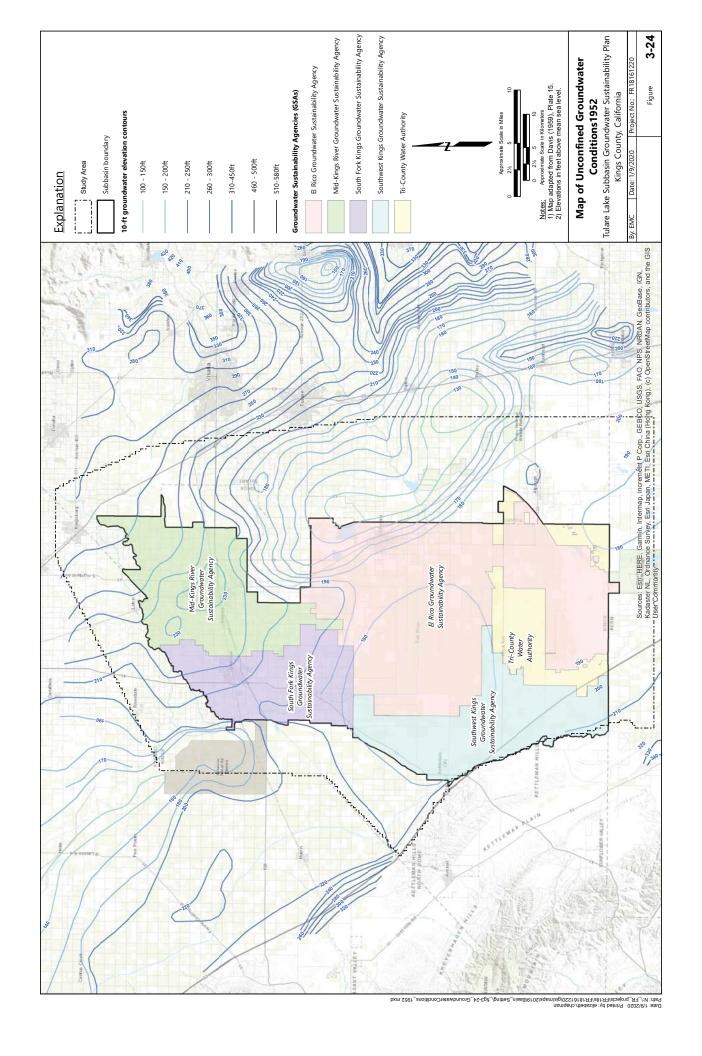
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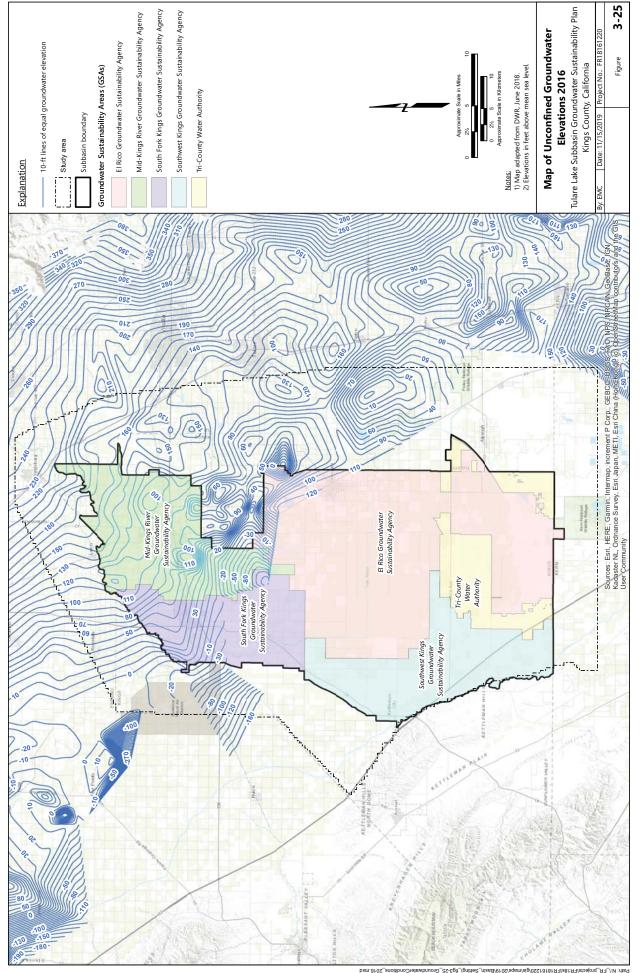
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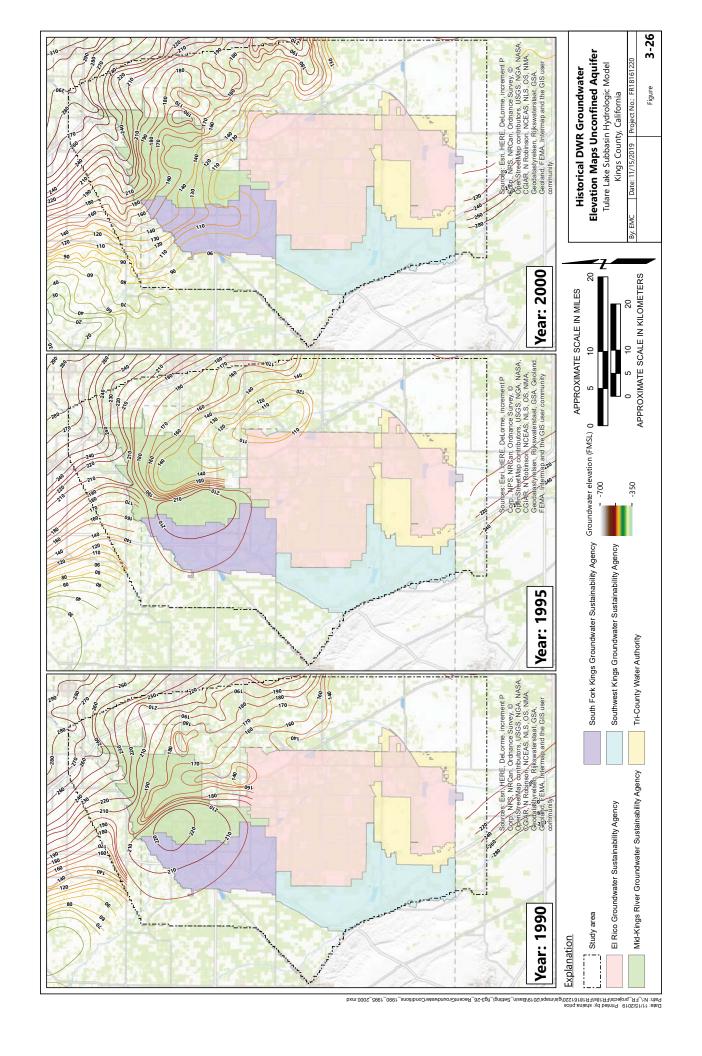


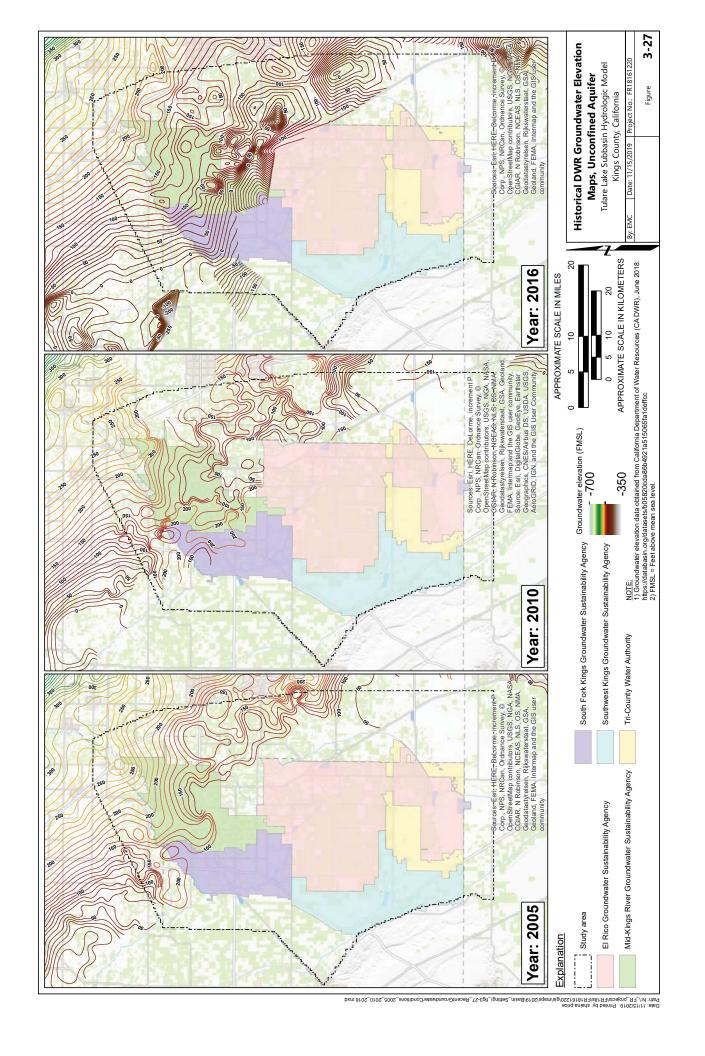


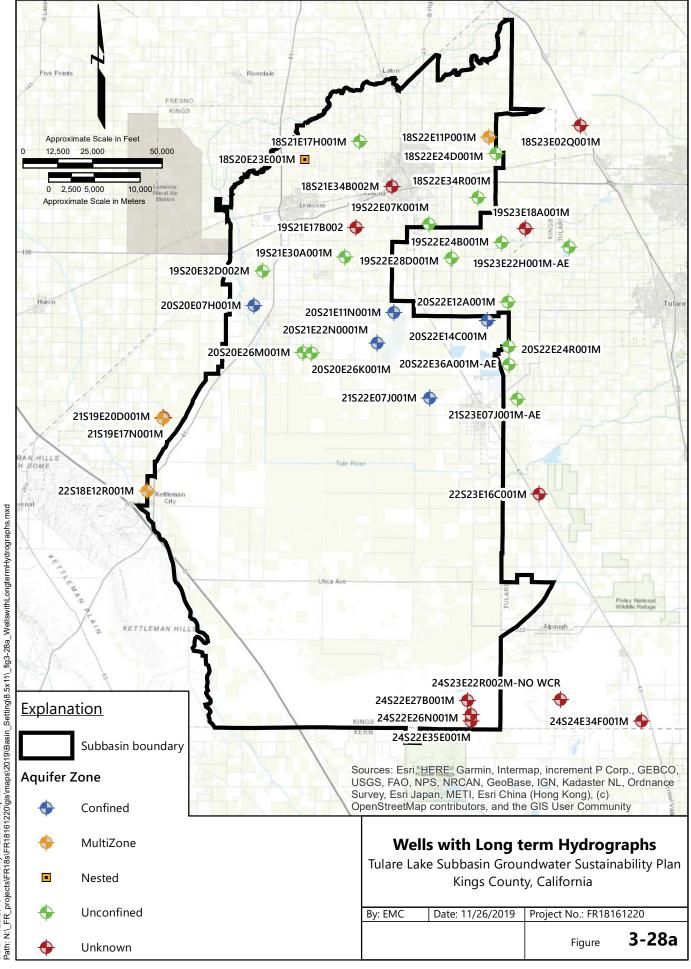






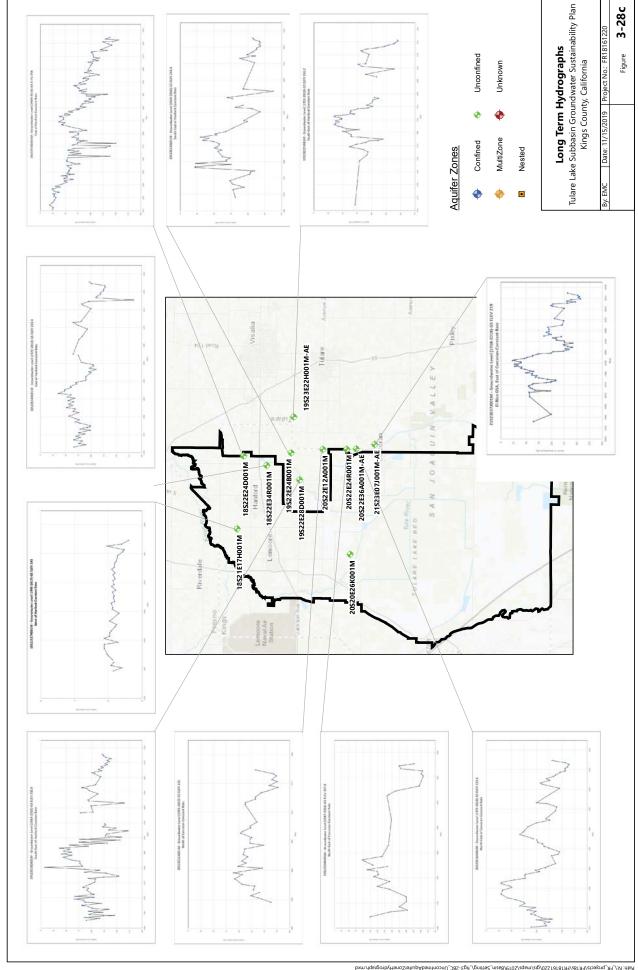


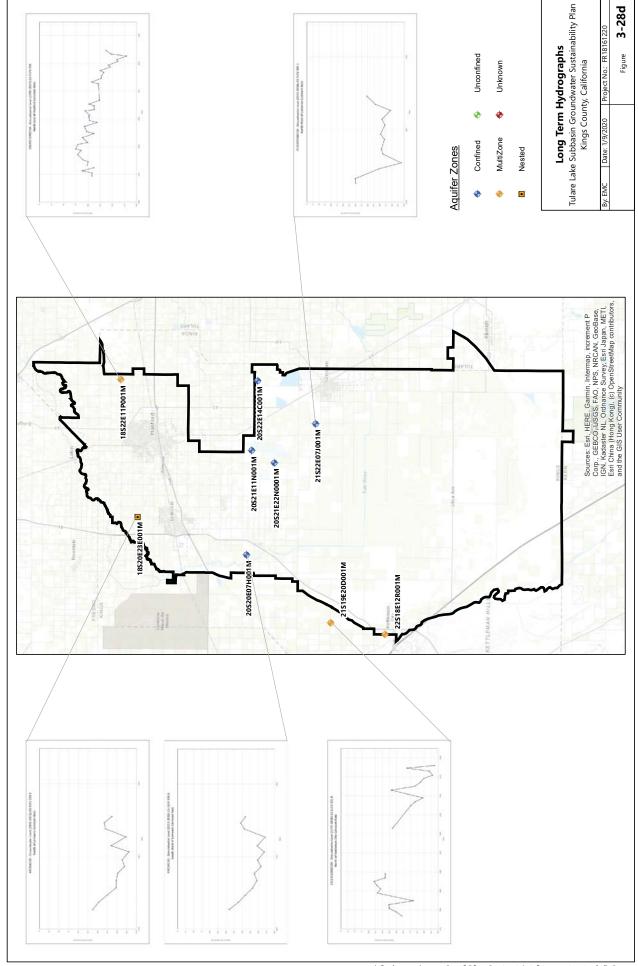


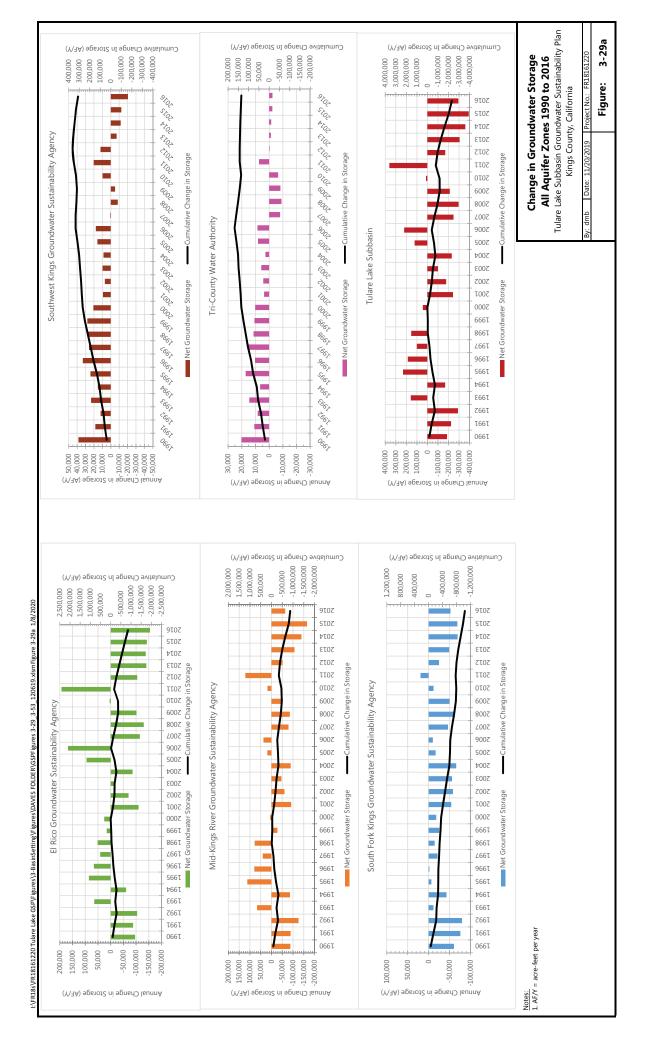


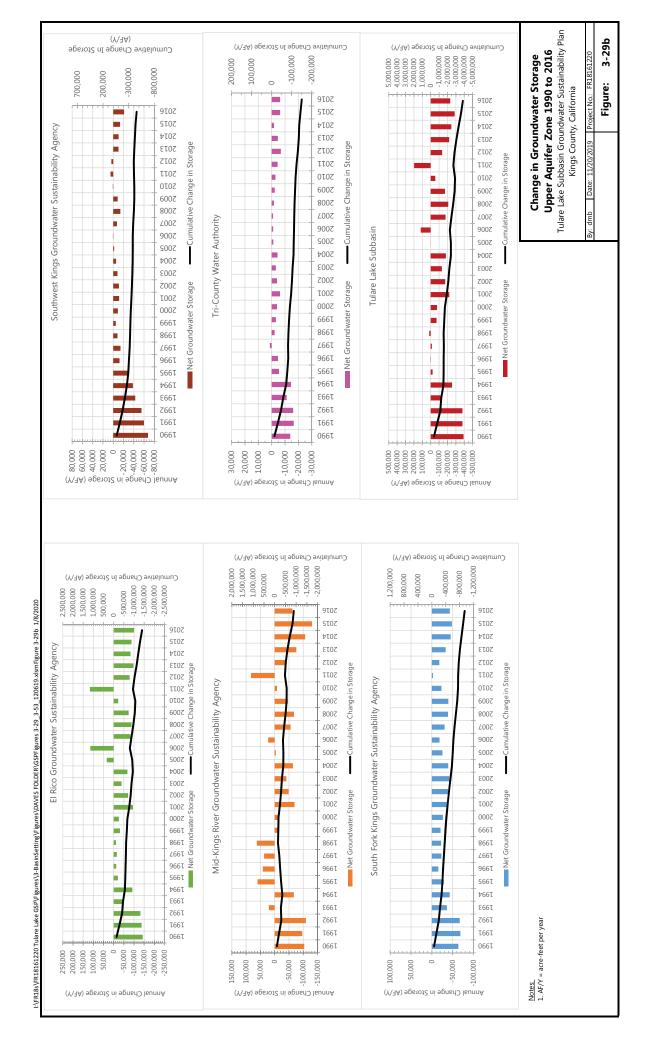
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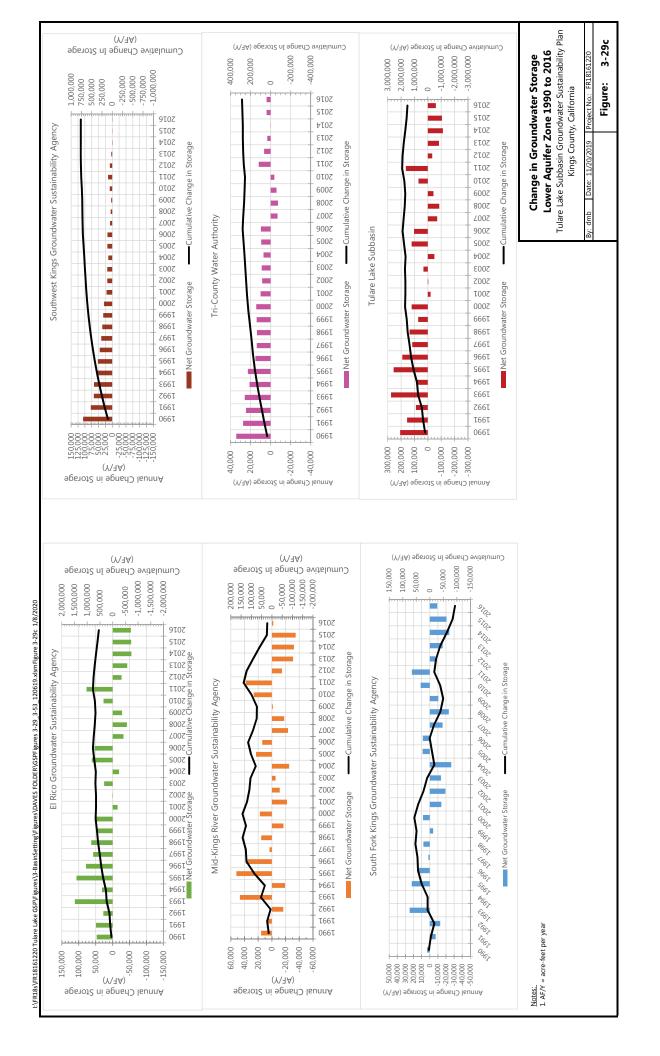


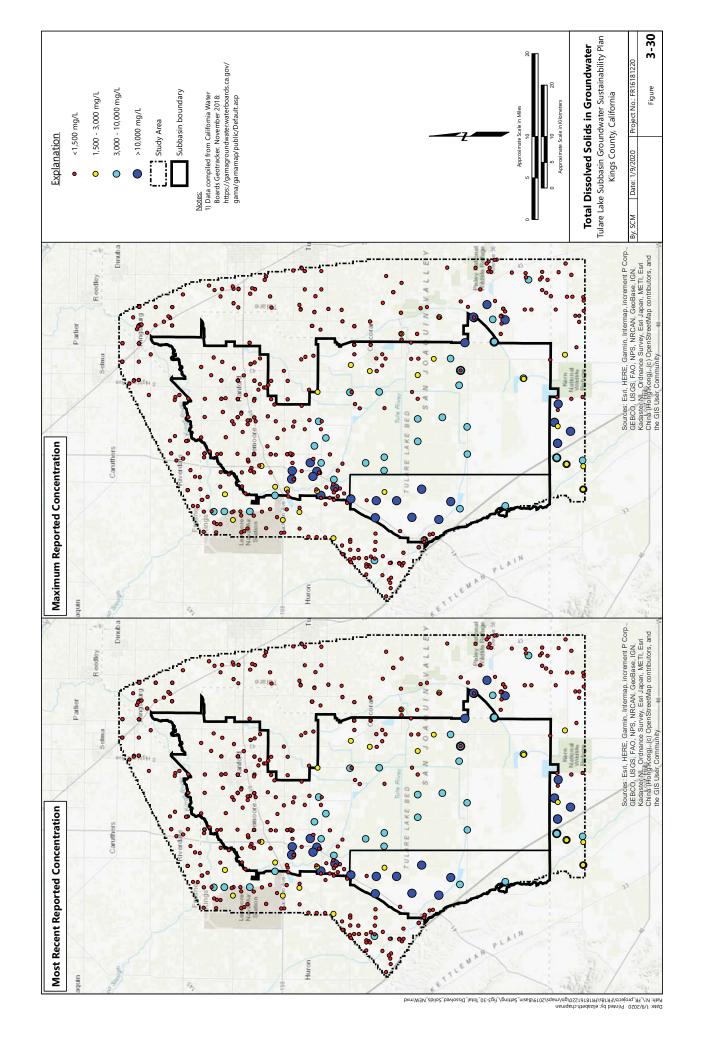


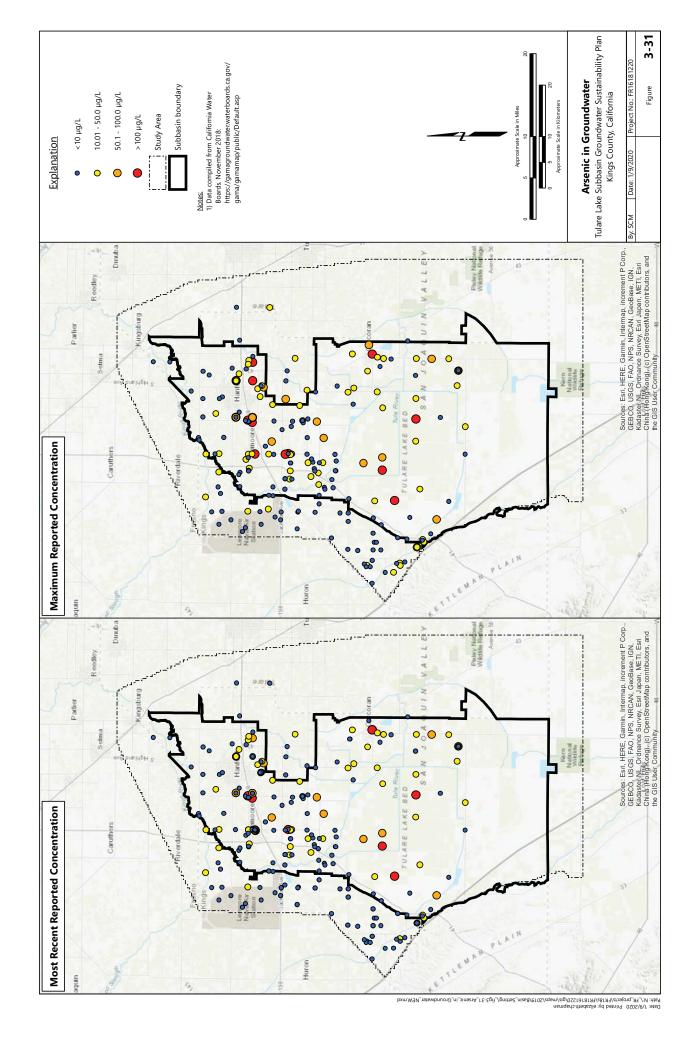


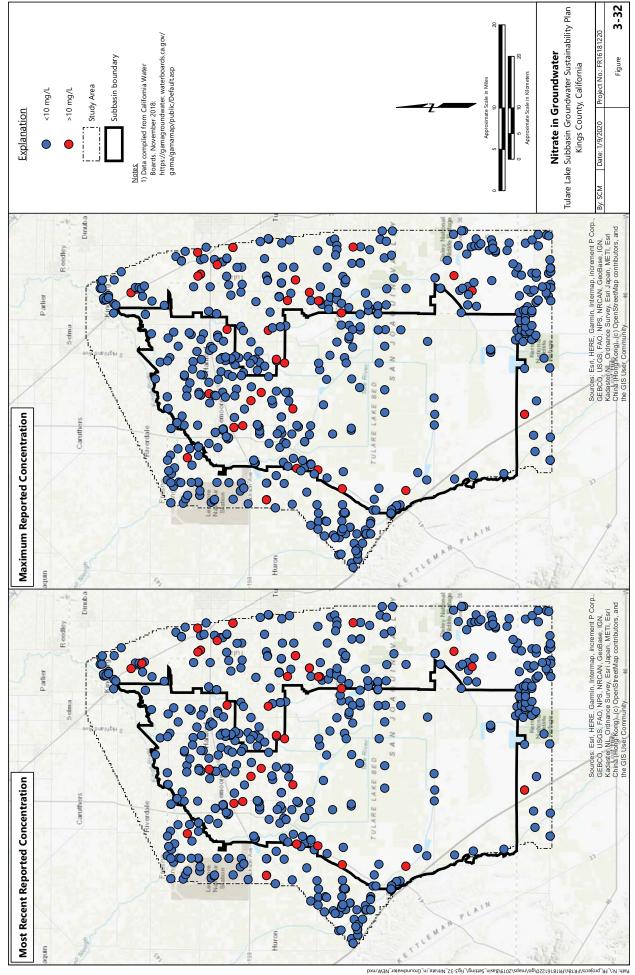


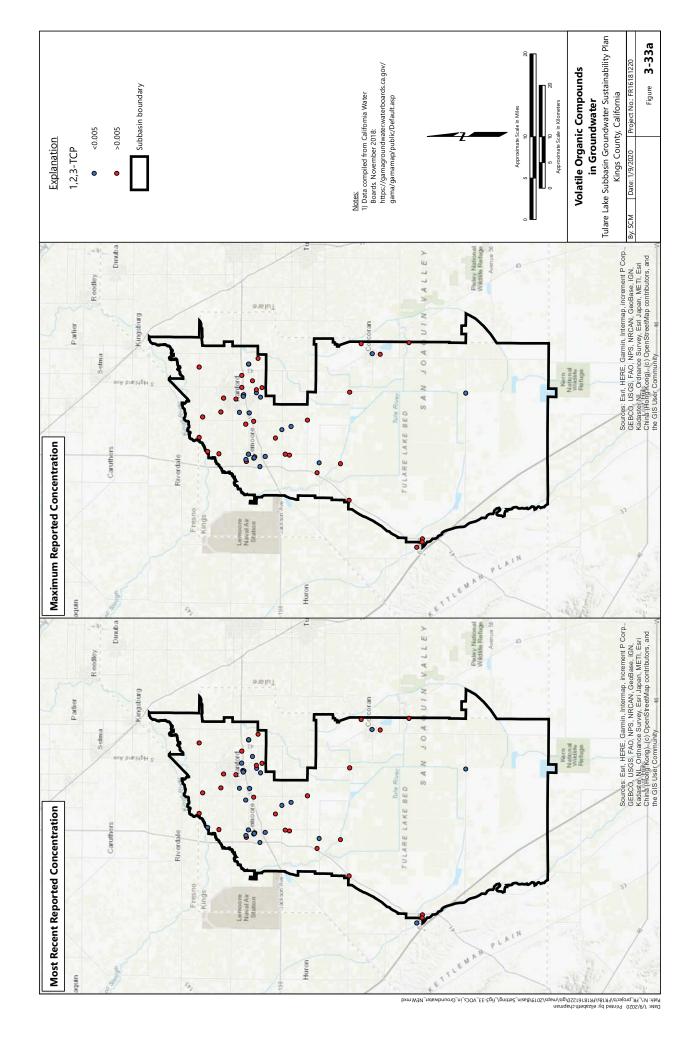


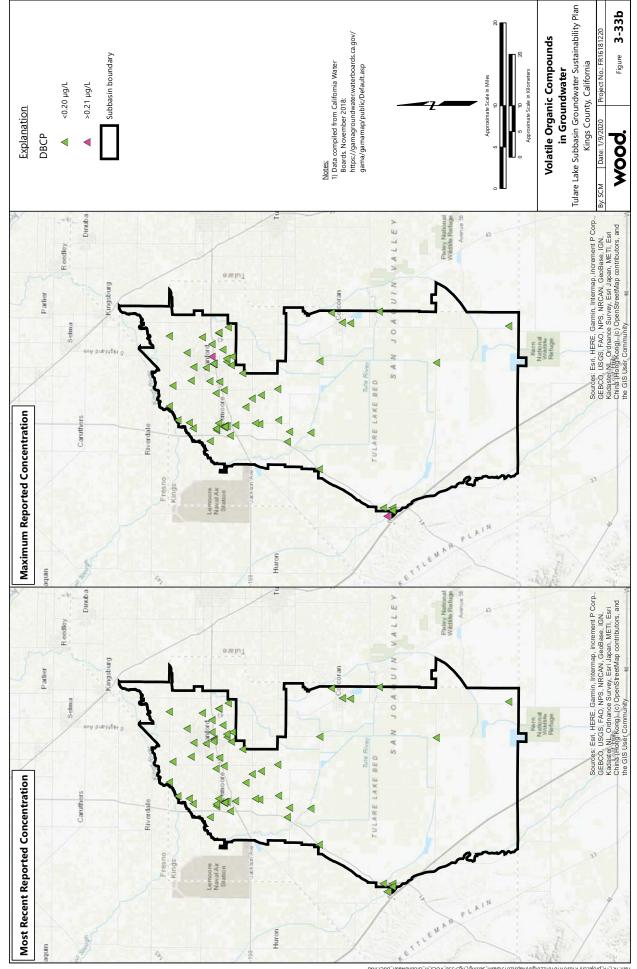


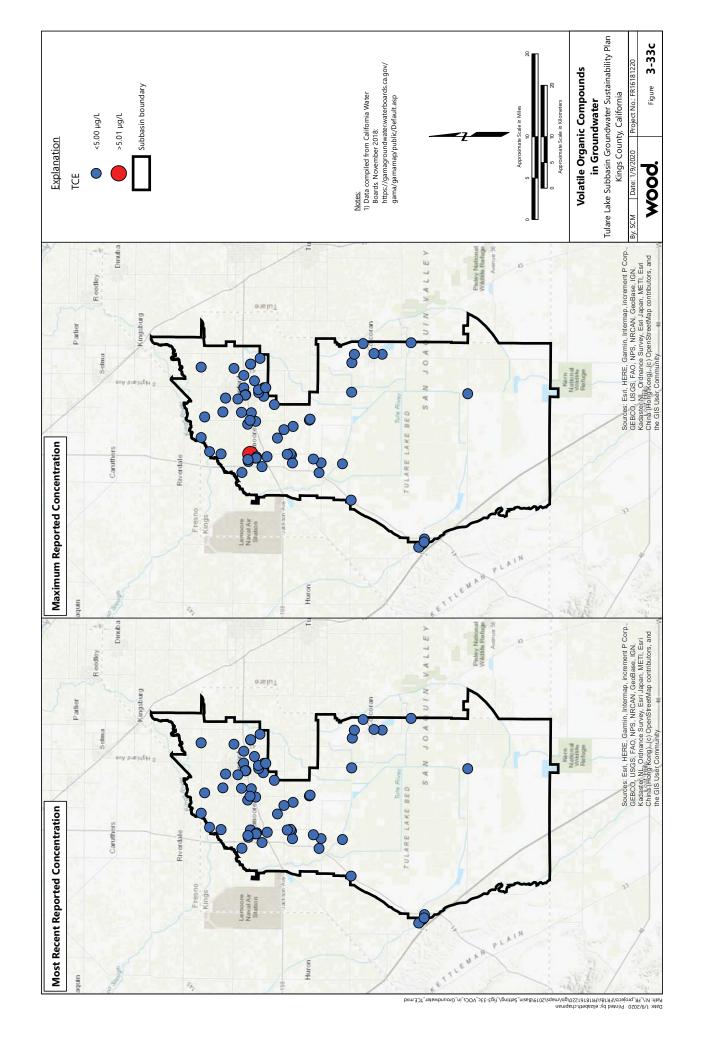


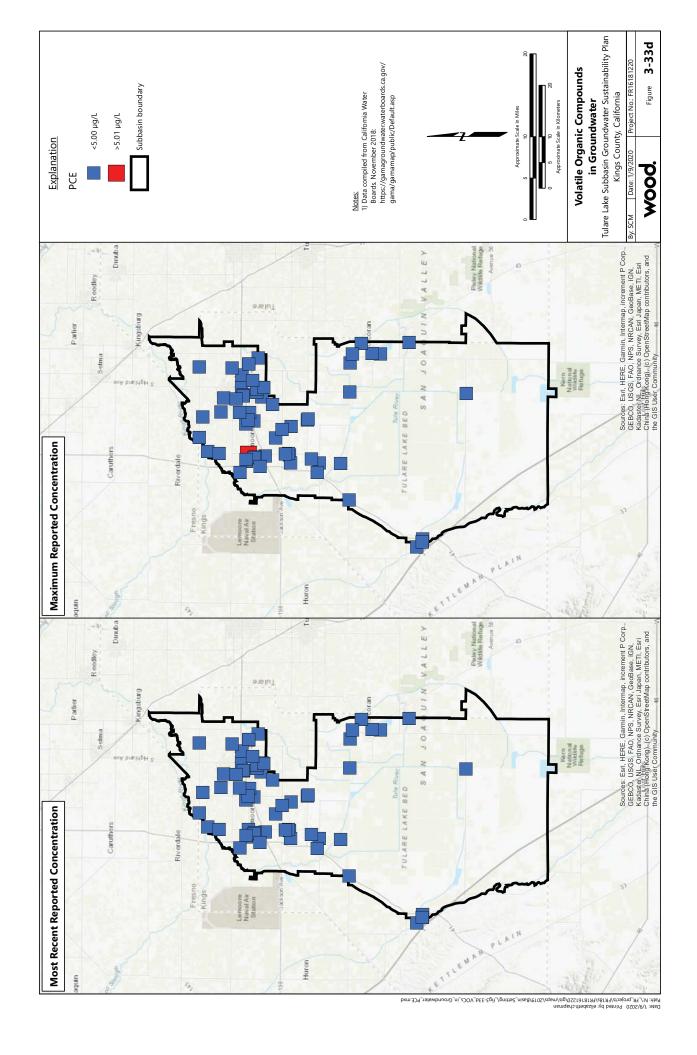


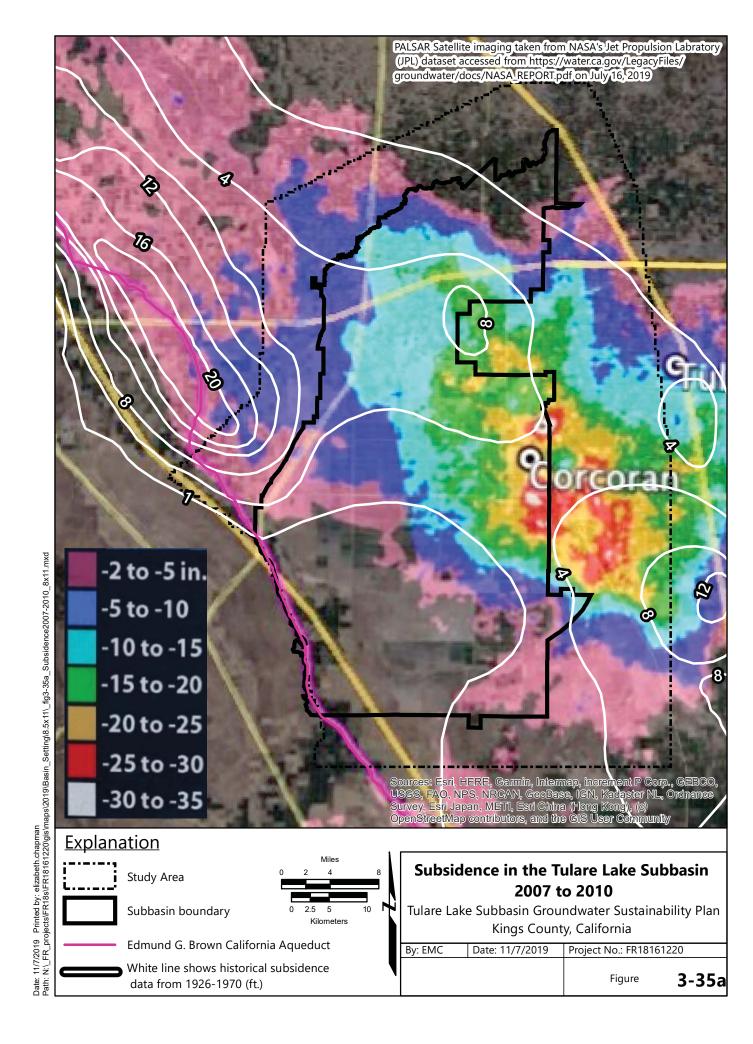


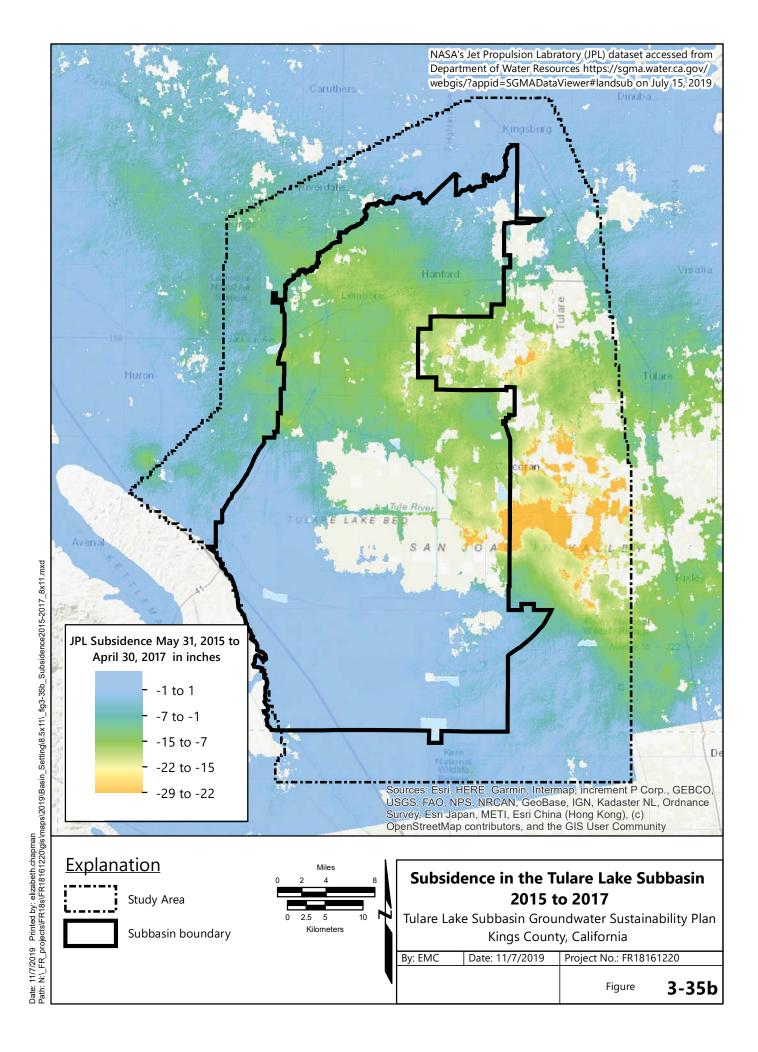


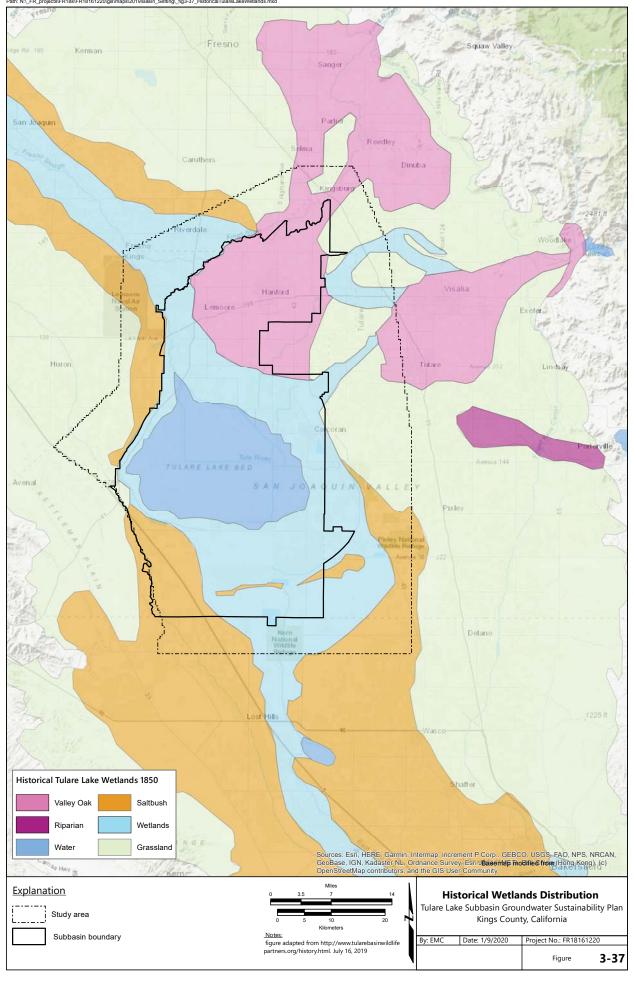


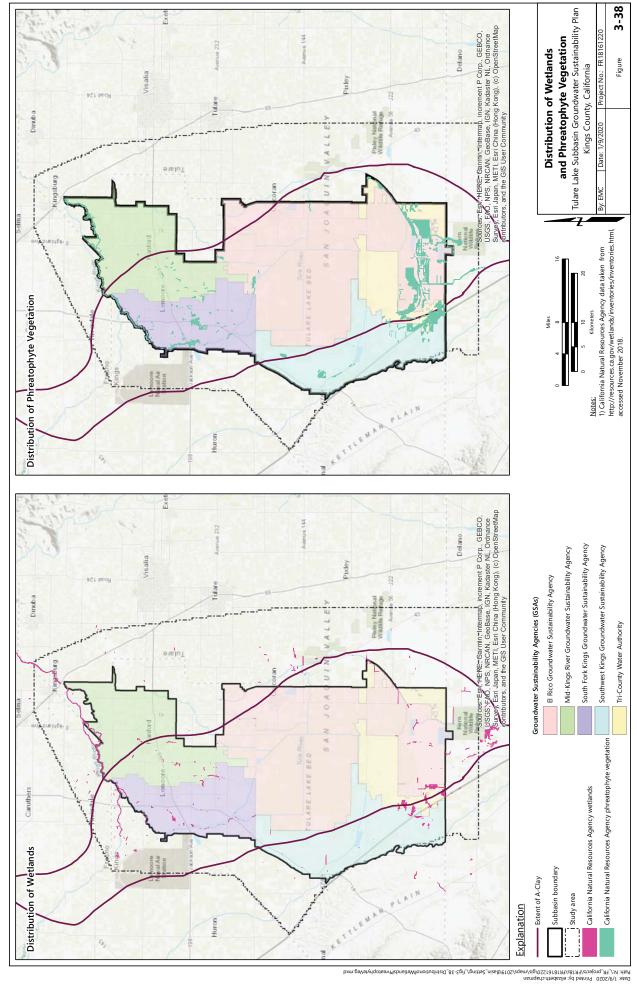


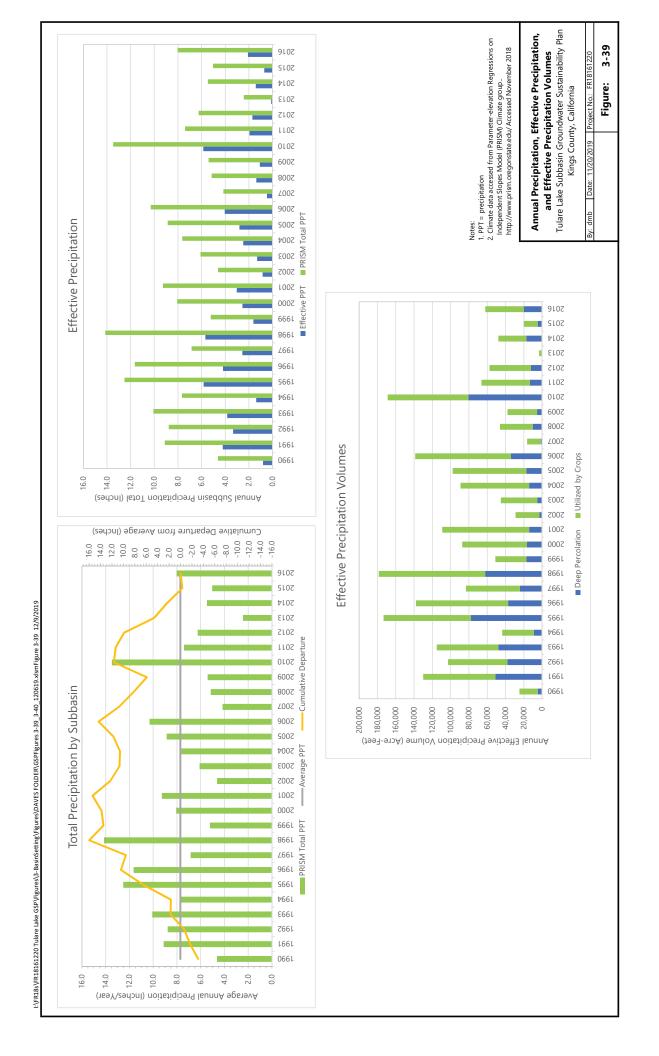


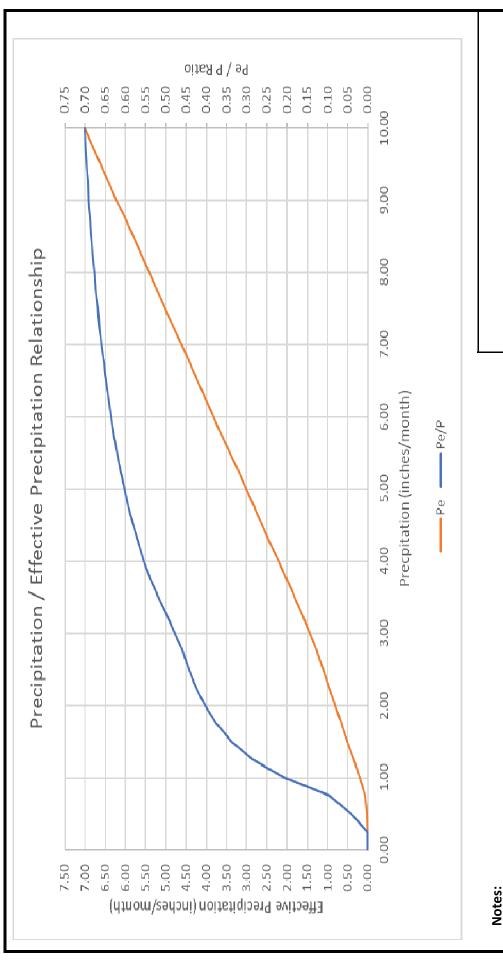












Precipitation Versus Effective Precipitation

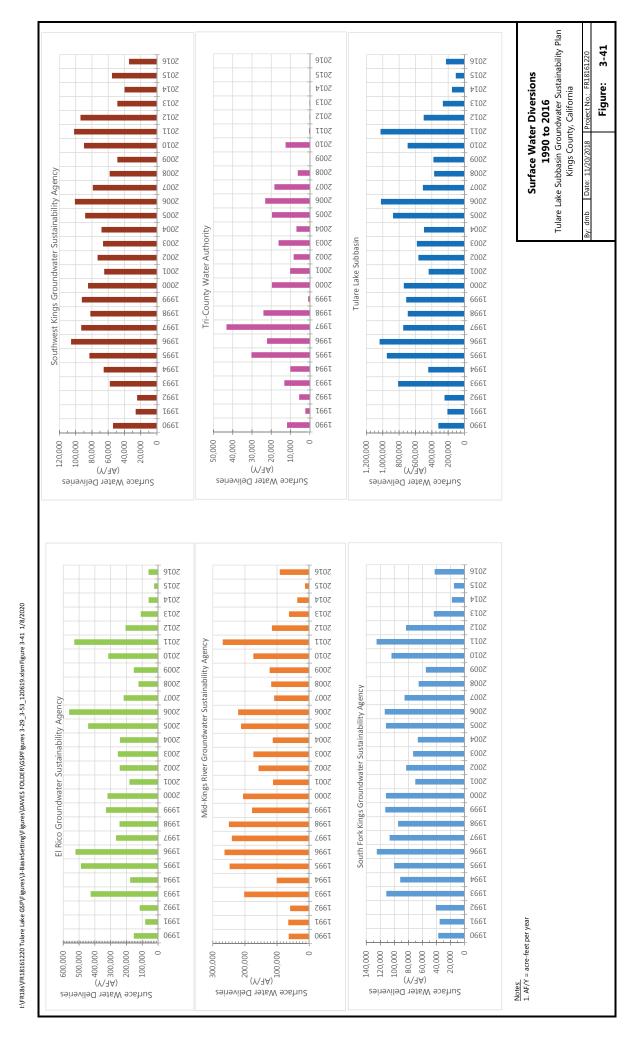
Fulare Lake Subbasin Groundwater Sustainability Plan Kings County, California By. GLK | Date: 11/20/2018 | Project No.: FR18161220 | Figure 3-40

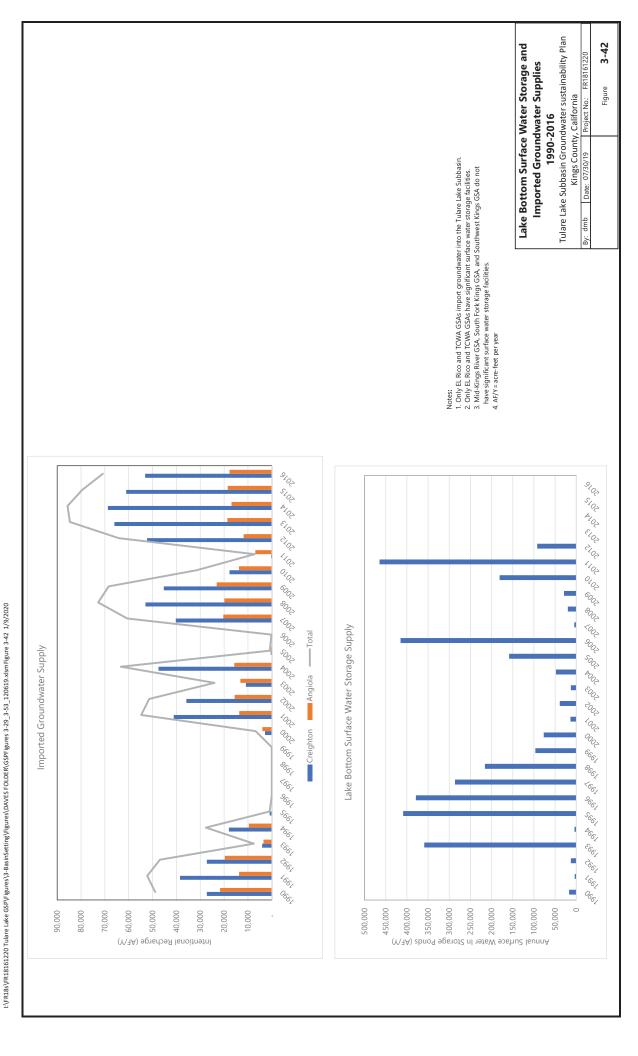
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United Nations Food and Agriculture Organization (FAO)

FAO 56, Chapter 3 Table 6

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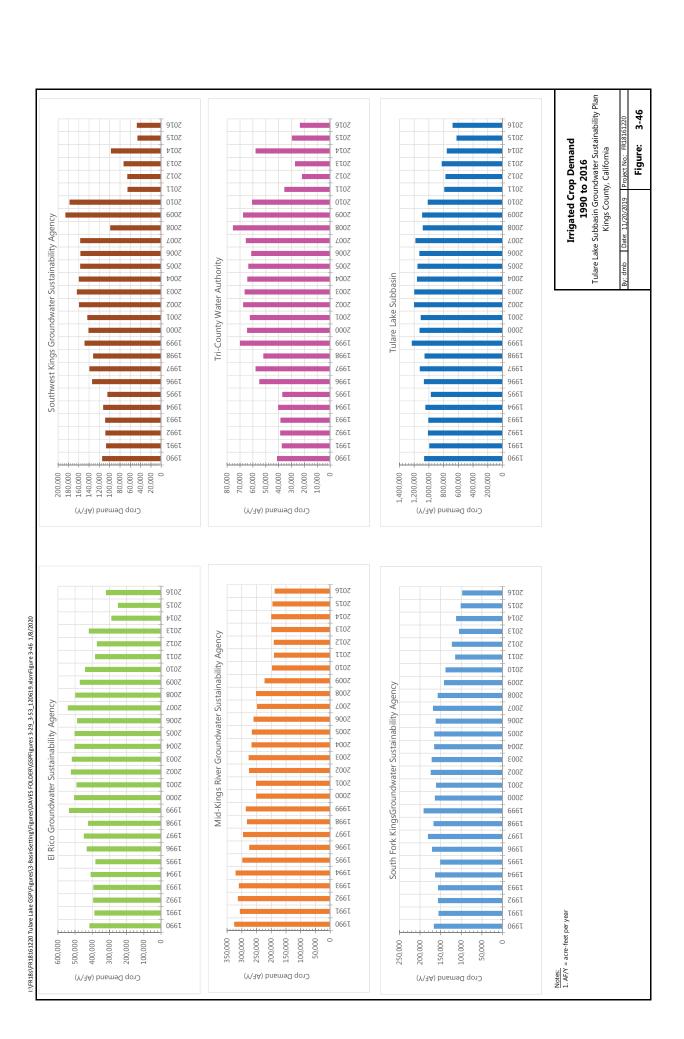


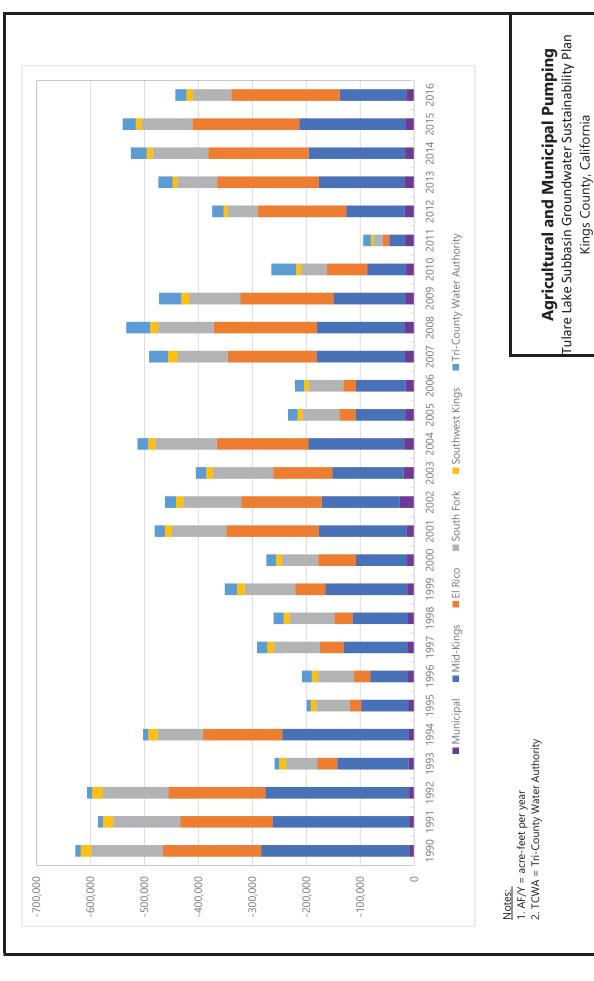


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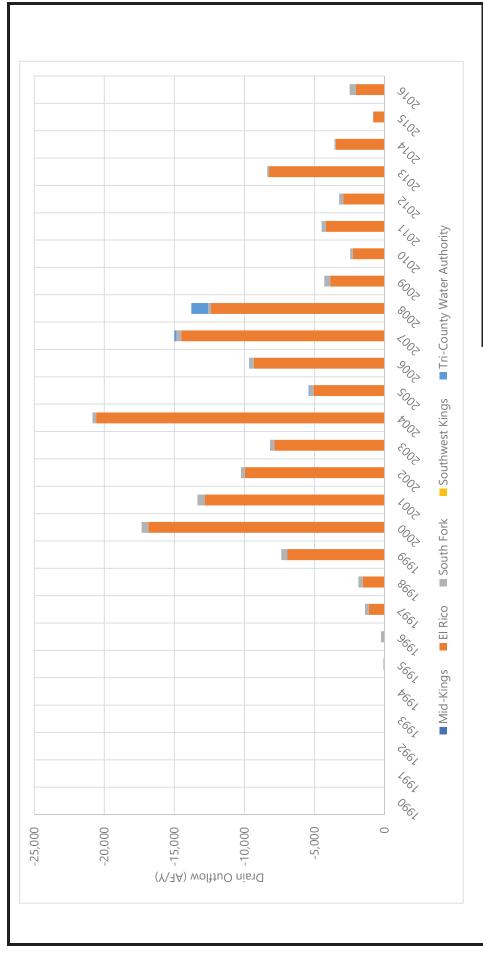
3-47

Figure

Project No.: FR18161220

Date: 11/20/2019

By: dmb



- 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

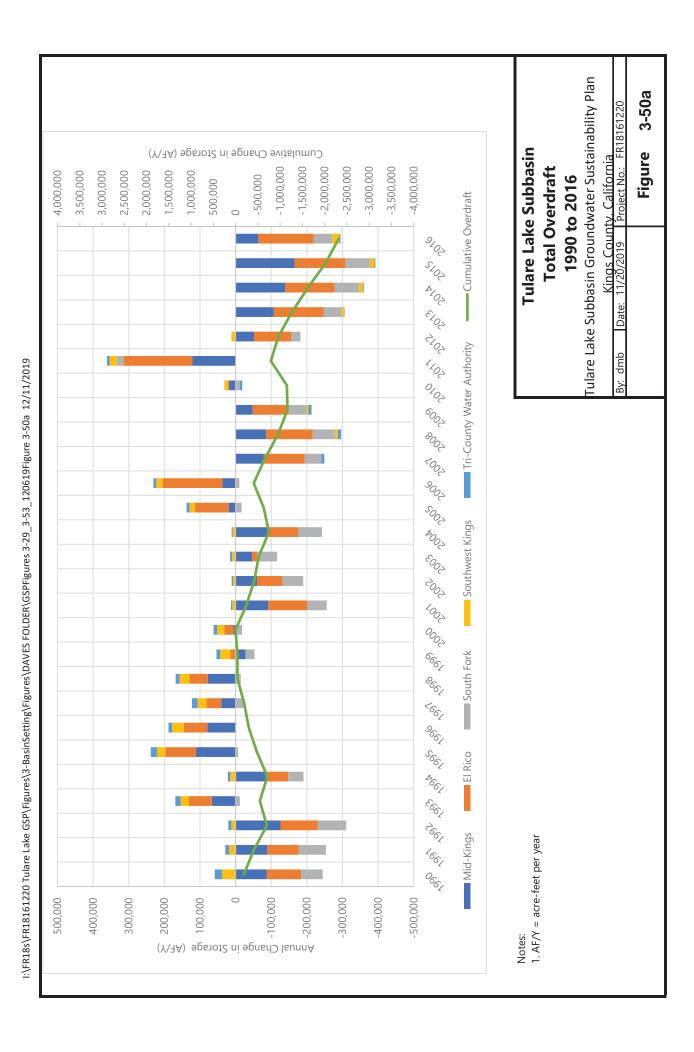
Tulare Lake Subbasin Agricultural Drainage Outflows 1990 to 2016

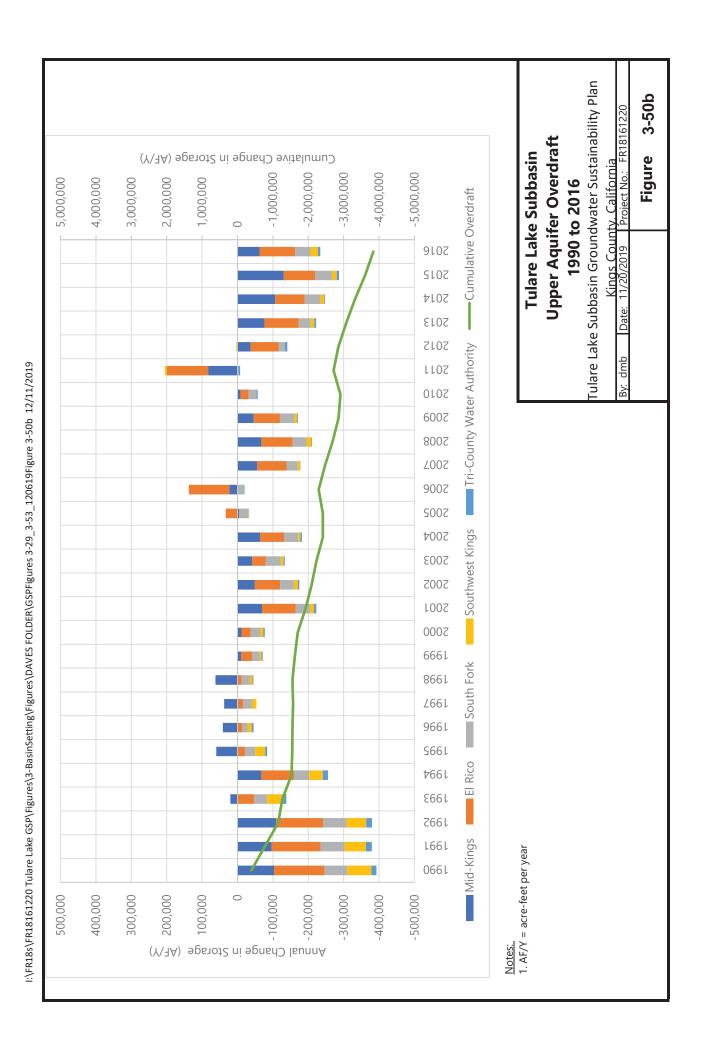
Tulare Lake Subbasin Groundwater Sustainability Plan

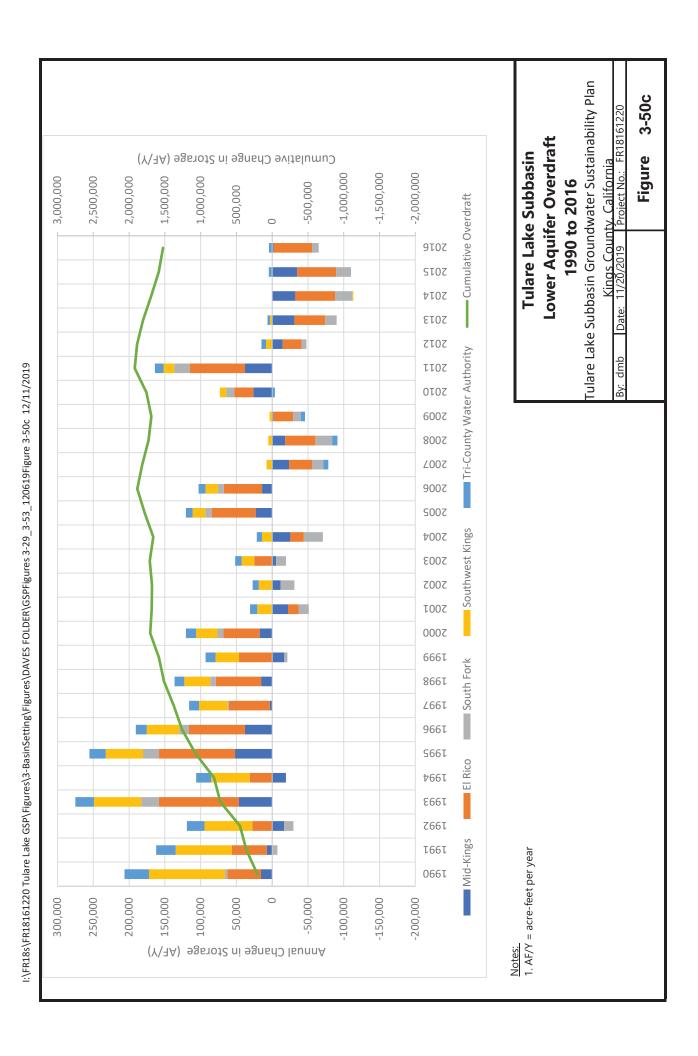
Project No.: FR18161220 Kings County, California By: dmb

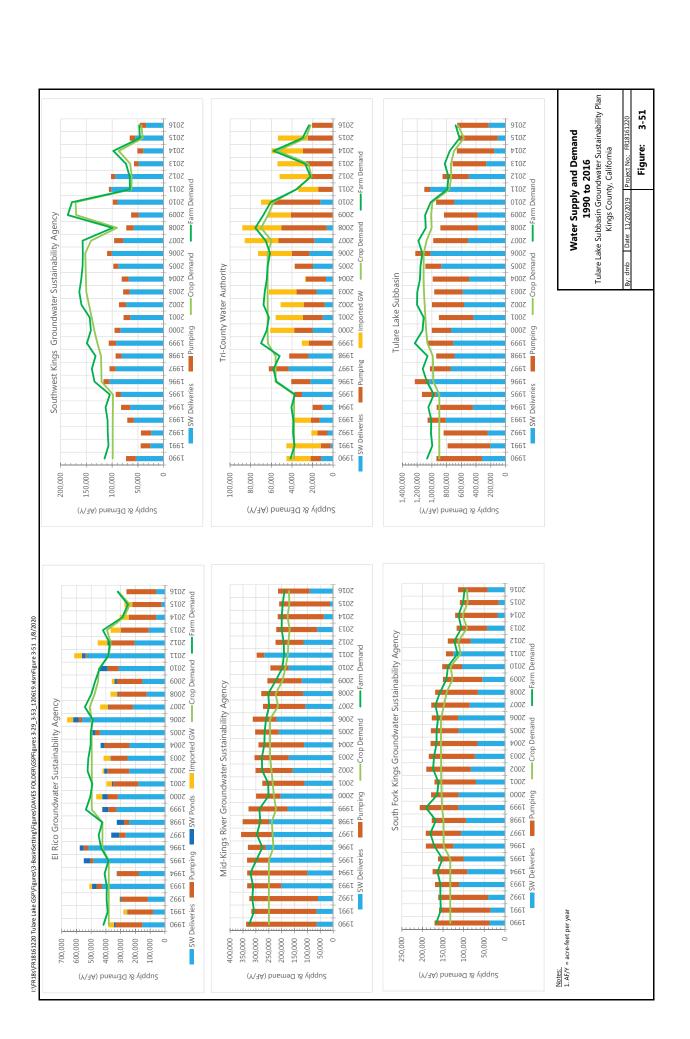
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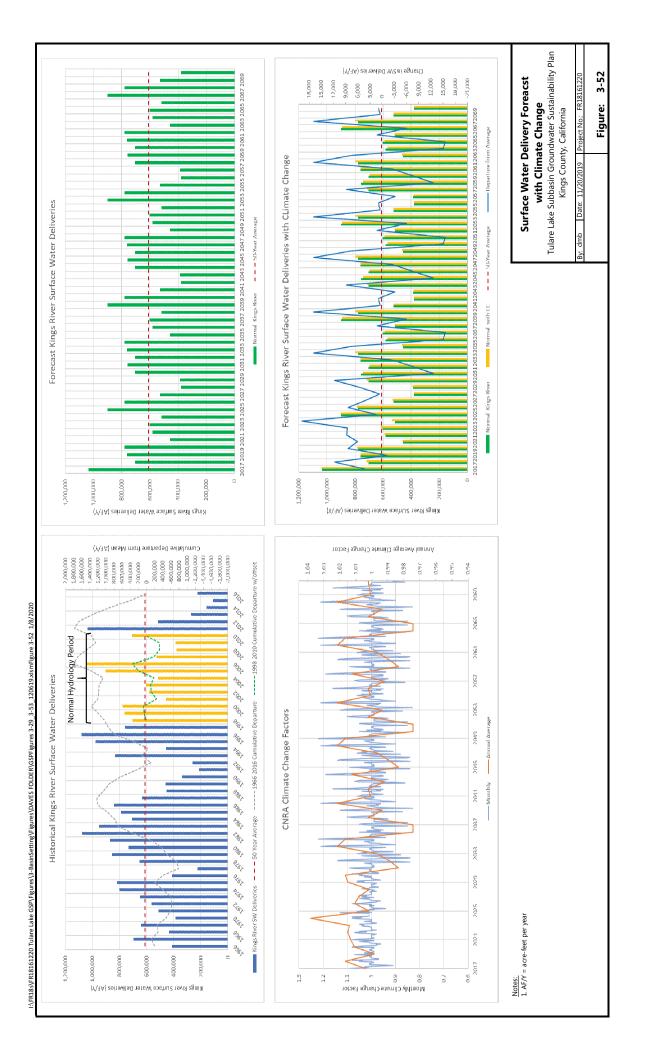
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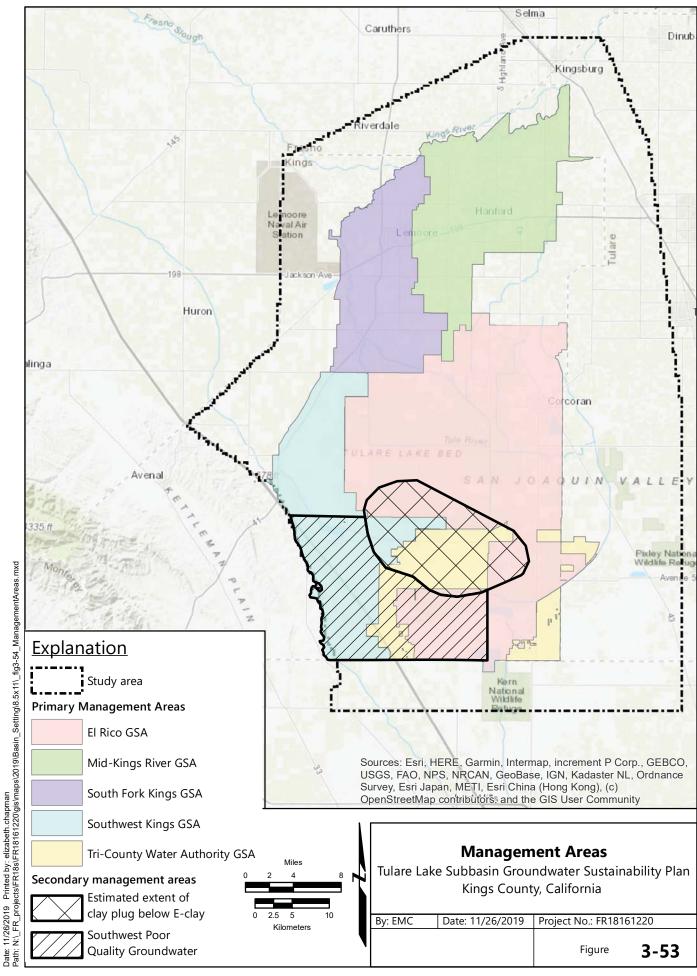




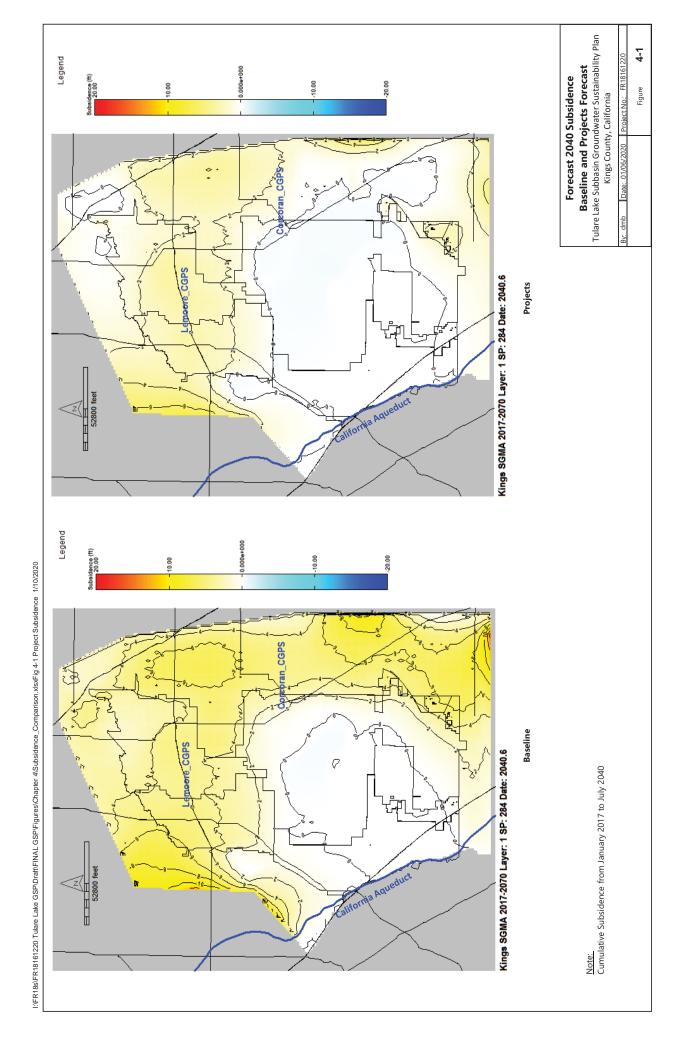




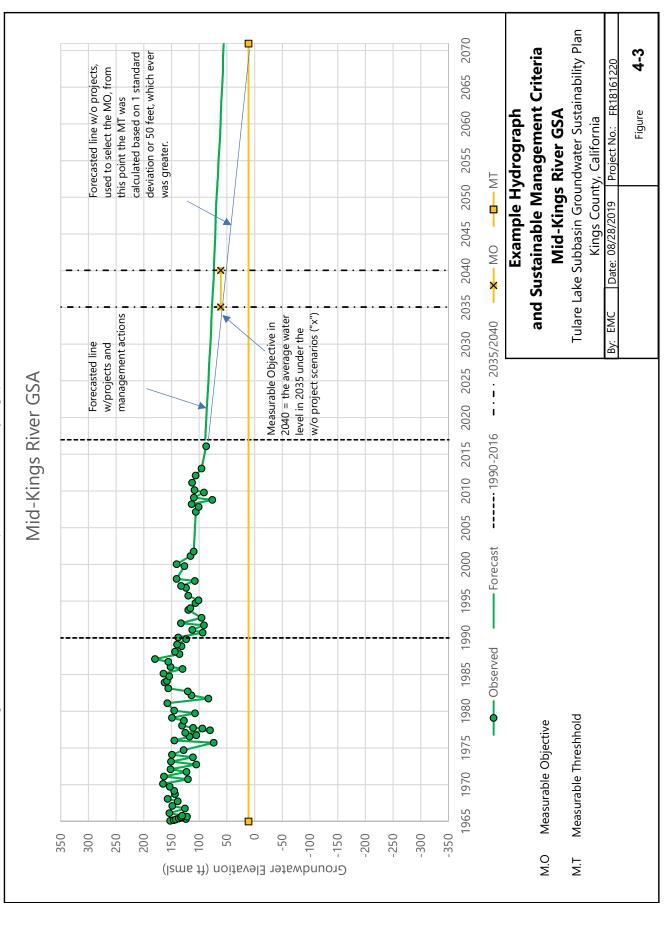




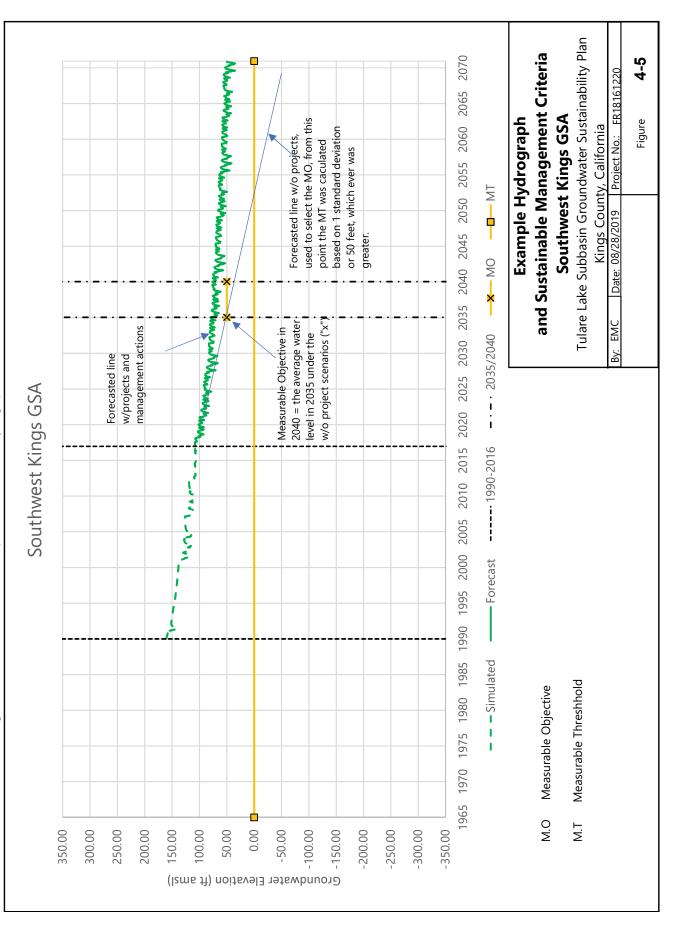
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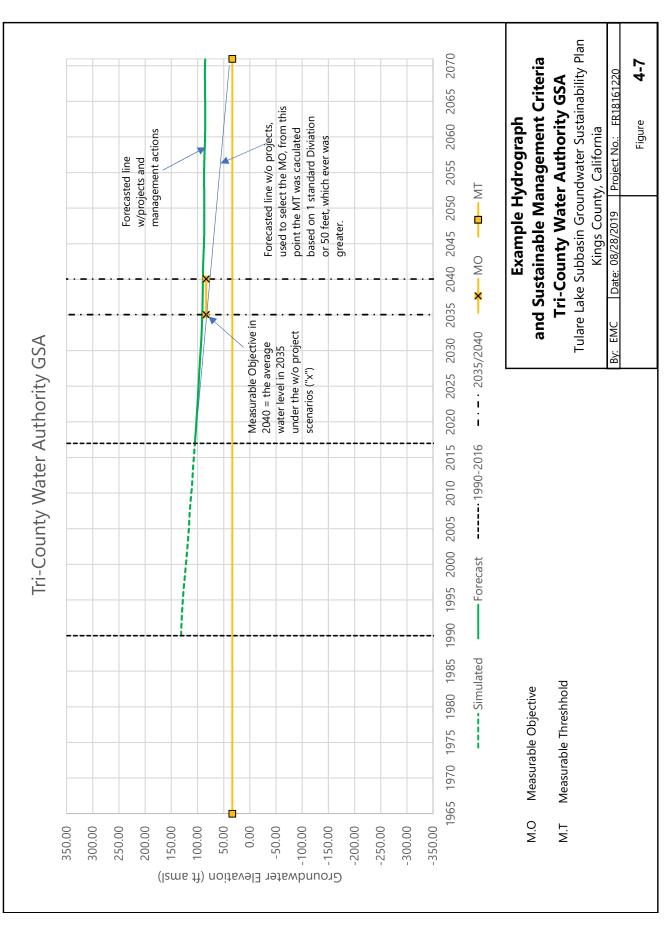
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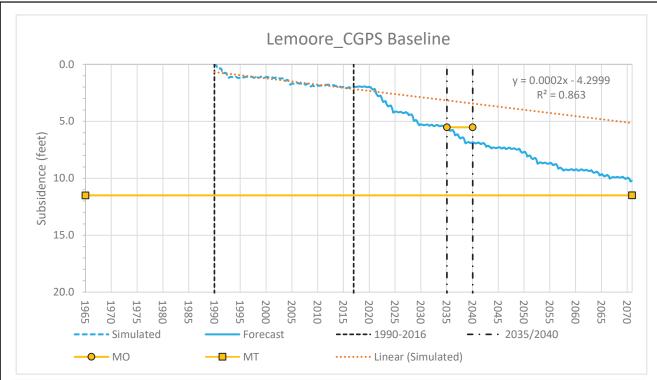


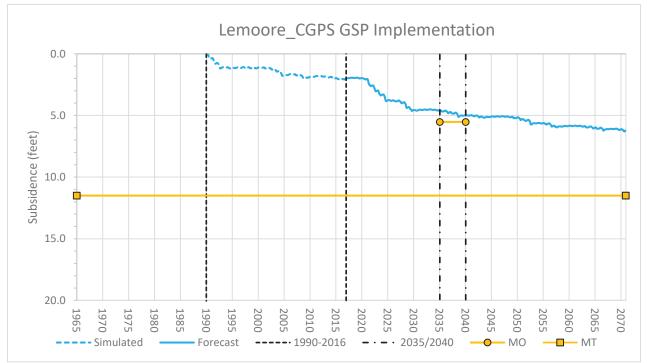
Tulare Lake Subbasin Groundwater Sustainability Plan and Sustainable Management Criteria 4-4 Date: 08/28/2019 | Project No.: FR18161220 Figure



Tulare Lake Subbasin Groundwater Sustainability Plan



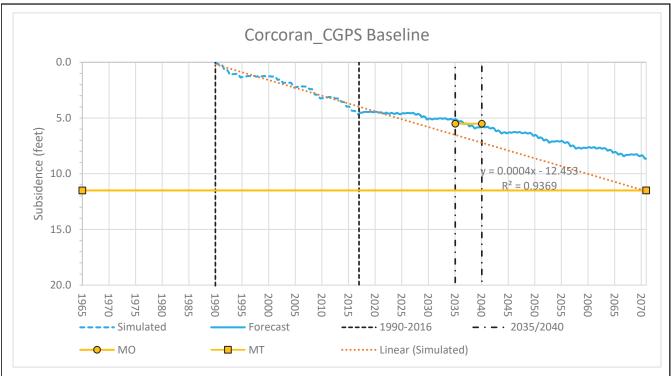


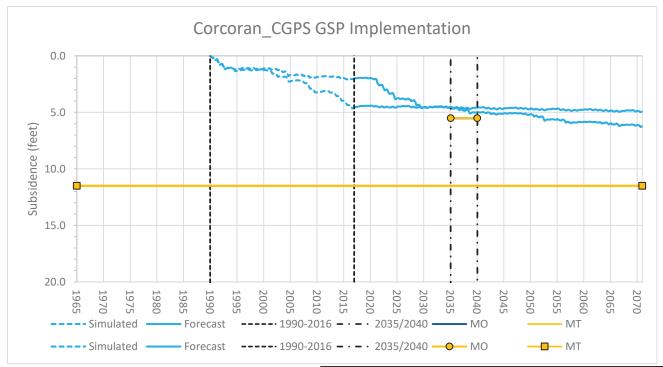


Forecast Land Subsidence under Baseline Conditions and with GSP Implementation Lemoore RMS

Tulare Lake Subbasin Groundwater Sustainability Plan Kings County, California

By: EMC	Date: 01/07/2020	Project No.:	FR18161220	
		Figu	re 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.: FR1	8161220
		Figure	4-9

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

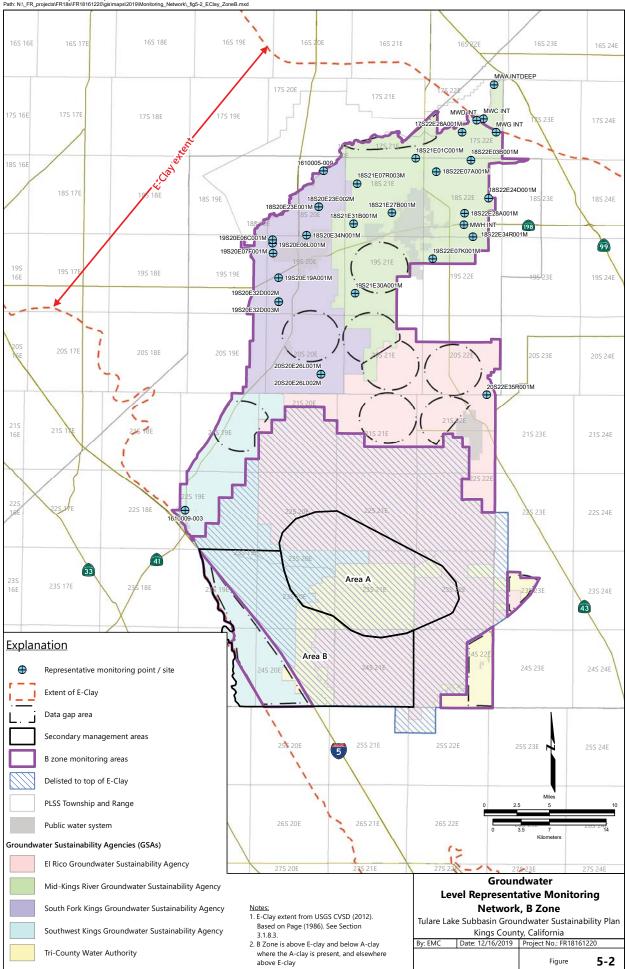
Southwest Kings Groundwater Sustainability Agency

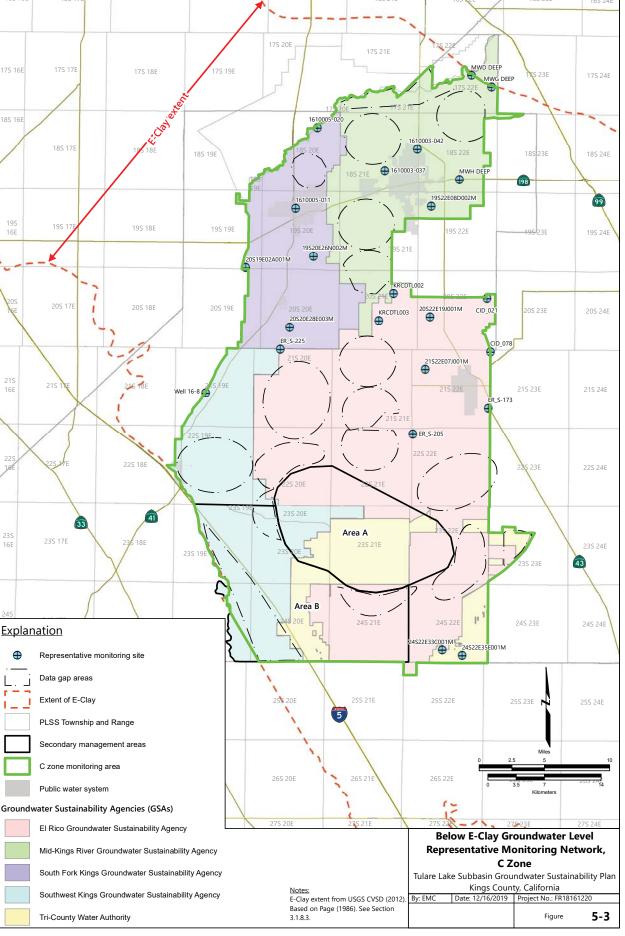
Tri-County Water Authority

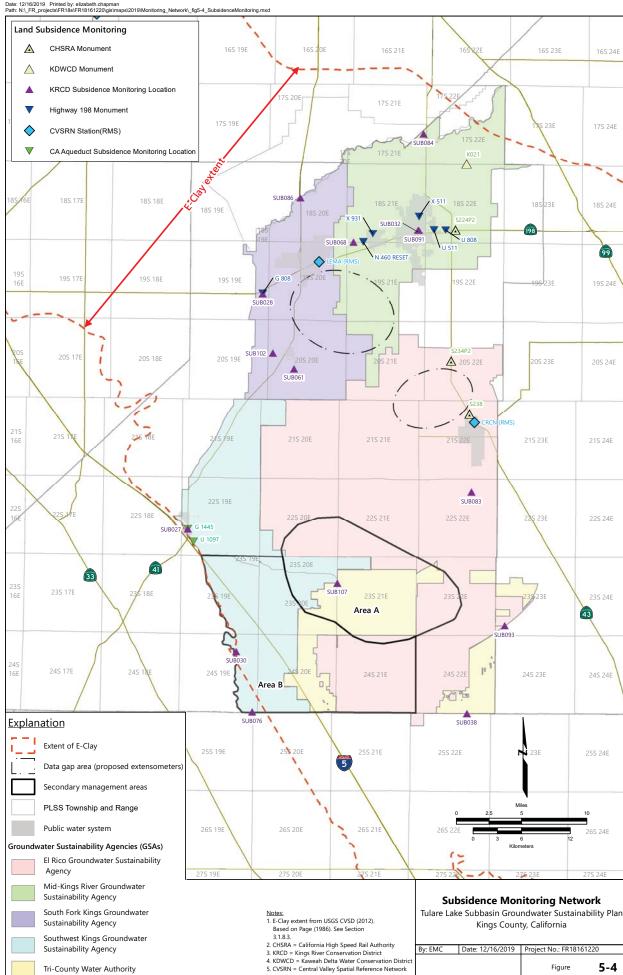
Kings County, California

Date: 12/17/2019 | Project No.: FR18161220

5-1







By: EMC

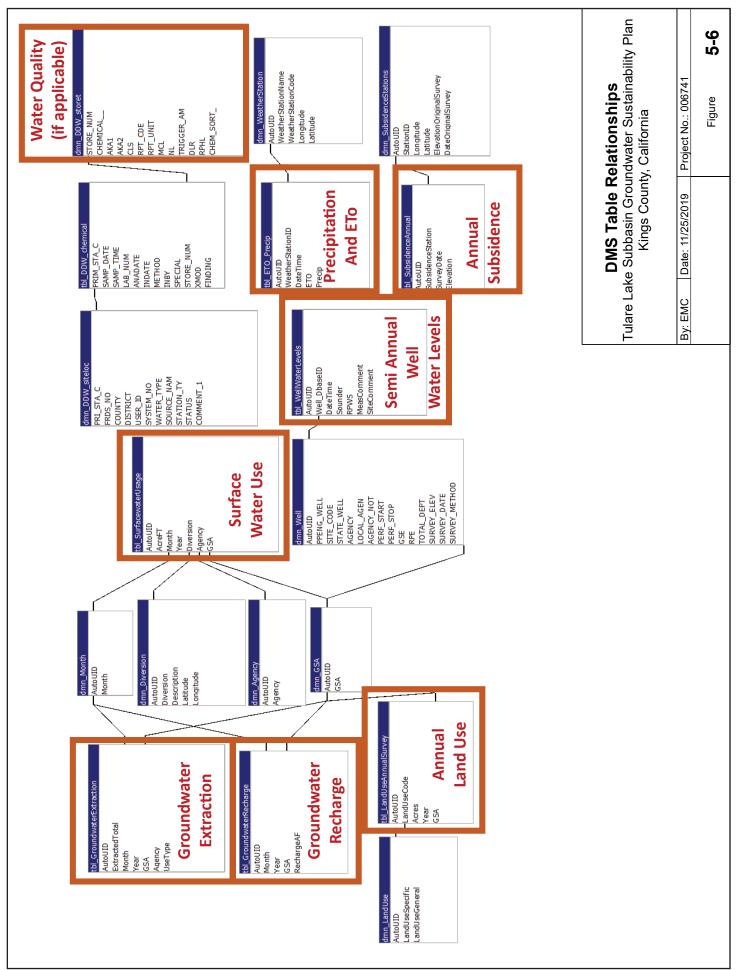
township, range, section designation

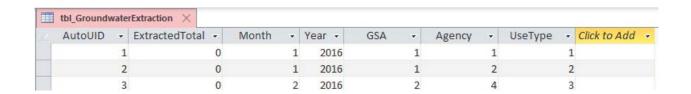
Date: 12/16/2019 | Project No.: FR18161220

5-5

Southwest Kings Groundwater Sustainability Agency

Tri-County Water Authority







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5313	3	581.7	7 2014	El Rico Groundwater Sustainability Agency		FIELD CROPS	
5306	5	44.3	2 2014	El Rico Groundwater Sustainability Agency		TRUCK, NURSERY AND BERRY CROPS	
5320)	451.0	2014	El Rico Groundwater Sustainability Agency		IDLE	

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2	SUB002		2010				
3	SUB003		2010				

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1225		1	2016	1	1	0	1	
1226		2	2016	1	1	207	1	
1227		3	2016	1	1	0	1	

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	361 357320N1196997W003	357320N1196997W001	Department of Water Re	1		Department of Water Resources		1 Water level accuracy is unknown	Unknown
	362 357320N1196997W001	357320N1196997W001	Department of Water Re			Department of Water Resources		1 Water level accuracy is unknown	Unknown

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Unknown		6.3	8.3	216.08	8.3	0	222.38	224.38	7/9/2010	852041	24614	
Unknown		5.7	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

y: EIVIC	Date: 11/20/2019	Project No.: FR 18 16	1220
		Figure	5-7

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

Table 1-3. GSA Member Agencies

GSA	GSA Meml	per Agencies
Mid-Kings River	Kings County Water DistrictCity 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 DistrictKings 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 DistrictKings County	Deer Creek Storm Water DistrictWilbur 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

Table 1-6. Estimate of Costs GSP Implementation

	Mid-Kings River	River	South Fork Kings	k Kings	El Rico	0	Southwest Kings	st Kings	Tri-County Water Authority	Water rity	
	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)	Total
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	27,700.00 \$28,000,000	7,000.00							\$121,000,000
Aquifer Storage and Recovery			\$15,000,000 13,000.00	13,000.00							\$15,000,000
Surface Storage and Reregulation			\$6,000,000	2,000.00	\$100,000,000 26,000.00	26,000.00			\$45,000,000		15,000.00 \$151,000,000
On Farm Flooding											\$0
Surface Water			\$5,000,000	5,000.00							\$5,000,000
Improvements											

Table 1-6. Estimate of Costs GSP Implementation (Continued)

	Mid-Kings River	River	South Fork Kings	k Kings	El Rico	0	Southwest Kings	st Kings	Tri-County Water Authority	Water ity	
	Annua Cost (Dollars) Yield (AF/yr	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)	Total
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	\$103,330,000 39,950 \$61,650,000 45,000 \$100,080,000 41,000	-	\$60,000		\$45,010,000	15,000	\$45,010,000 15,000 \$309,680,000

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.

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

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

Table 2-3. Summary of Applicable Plans

County	Plan	Online Source
	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/depa rtments/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
Kings County	Kettleman City Community Plan (2009)	https://www.countyofkings.com/home /showdocument?id=13509
Kings County	Stratford Community Plan (2009)	https://www.countyofkings.com/home /showdocument?id=3106
	City of Hanford – 2035 General Plan (April 2017)	http://www.cityofhanfordca.com/docu ment_center/Planning/Plans/Hanford %20General%20Plan/2035%20General %20Plan%20%20Policy%20Document. pdf
	City of Lemoore – 2030 General Plan (May 2008)	http://lemoore.com/communitydevelo pment/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/doc uments/GP/001Adopted%20Tulare%2 0County%20General%20Plan%20Mate rials/000General%20Plan%202030%20 Part%20I%20and%20Part%20II/GENER AL%20PLAN%202012.pdf
Kern County	Kern County – General Plan (September 2009)	https://kernplanning.com/planning/pl anning-documents/general-plans- elements/

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.

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.

Historical Hanford Precipitation (Inches), Tulare Lake Subbasin SGMA Model, Kings County, California Table 3-1.

Annual	M	Σ	Σ	Σ	4.57	10.11	7.14	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ
Anr	_	_	_	~	4.	10	7.	_	_	_	_	_	_	_	~	_	_	~	~	~	_	_	_	~	_	_	_
Dec	0.87	Σ	0.15	0.56	0.15	1.16	0.23	Σ	Σ	0.31	Σ	Σ	Σ	0.21	1.35	Σ	Σ	1.35	M	M	Σ	Σ	Σ	M	0.22	2.12	Σ
Nov	Μ	Μ	Σ	1.67	0.47	0.31	1.16	Σ	Σ	Σ	Σ	Μ	Σ	0.61	Μ	0.02	Σ	Μ	Μ	Μ	Δ	Σ	Σ	Μ	Σ	Σ	Σ
Oct	0.67	Μ	Т	0.36	0.05	0.84	0	0	Δ	Σ	Σ	M	Σ	0	Μ	0	Σ	1.09	Ν	0.12	Μ	Σ	Σ	Μ	Σ	0.65	Σ
Sep	0	M	1.04	0	0	2.48	0.07	0	M	M	M	M	M	0	M	0	Σ	0.47	M	0.88	M	M	M	M	M	0	0
Aug	M	M	Τ	M	0	0	0	0	M	Σ	Σ	M	Σ	0	0	0	Σ	0.28	M	M	M	Σ	Σ	Τ	Σ	⊢	Σ
lnf	Σ	Σ	Μ	0	0	0	0	0	M	Σ	Σ	M	Σ	0	0.08	0	Σ	M	M	M	M	Σ	Σ	M	Σ	Σ	0
Jun	Σ	Σ	Σ	Σ	0	0	0	0.02	Σ	Σ	Σ	M	Σ	0	90.0	1.06	Σ	Σ	Σ	Σ	Δ	Σ	Σ	Σ	Σ	Σ	Σ
May	M	M	M	0.09	0	0	0.65	2.06	M	Σ	Σ	M	Σ	0.27	0.76	Σ	Σ	0.16	0.31	M	0.1	Σ	0.87	M	Σ	0	Σ
Apr	Σ	1.04	Σ	0.47	0.5	0.72	0.56	0.62	Σ	Σ	Σ	M	Σ	1.52	0.78	0.11	1.37	Σ	Σ	Σ	0.15	0.24	Σ	Σ	2.43	Σ	Σ
Mar	M	1.18	M	1.78	1.71	2.05	2.1	4.05	M	Σ	Σ	M	Σ	3.24	0.34	0.37	0.3	M	M	3.43	1.01	3.05	Σ	M	Σ	1.86	1.58
Feb	Σ	0	Σ	2	0.38	2.03	1.09	1.92	Σ	Σ	Σ	Σ	Σ	0.02	1.55	1.25	Σ	Σ	Σ	4.5	Σ	2.72	0.89	Σ	Σ	Σ	Σ
Jan	M	1.38	M	0.4	1.31	0.52	1.28	1.59	M	M	M	M	N	M	1.26	4.36	Σ	4.68	M	M	M	M	M	M	N	Σ	Σ
Year	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925

Historical Hanford Precipitation (Inches), Tulare Lake Subbasin SGMA Model, Kings County, California (Continued) **Table 3-1.**

					-																						-	_	
Annual	10.21	10.25	5.94	4.32	6.28	5.6	68'5	26'9	7.16	10.21	11.59	9.34	13.29	2.58	12.77	14.45	M	6.37	9.31	85.8	9.51	3.37	5.02	5.18	29'9	7.04	10.18	3.97	8.09
Dec	9.0	82'0	1.69	0.42	6.0	2.54	6.03	1.01	1.84	68'0	2.87	2.16	1.42	0.22	3.61	3.11	1.1	1.03	26.0	1.51	2.06	0.51	66'0	89'0	1.06	2.39	96'7	60'0	1.61
Nov	3.67	1.63	1.47	0	29'0	1.36	0.28	0	2.15	0.4	0	0.21	0.19	90'0	T	25.0	0.43	0.22	2.25	1.15	1.1	0.29	0.01	9.0	69.0	1.11	9.0	1.01	99.0
Oct	92'0	1.67	T	0	20'0	0	0	0.15	1.06	0.51	1.84	0.11	0.19	25.0	98.0	6.0	0	0.03	0.23	0.71	1.33	0.59	0.03	0	0.34	0.08	90.0	0.02	0
Sep	0	T	0	0.03	0.38	0.08	0	0	0	90.0	0	0	0.13	0.04	0	0	0	0	0.02	T	0	T	0	0	0	0	0.17	0	0
Aug	0	0.04	0	0	0.02	80.0	0	0	0	0	0	0	0	0	0	T	M	0	0	0	0	0	0	T	0	0	0	0	0
Jul	0	0	0	T	0	0	0	0	0	60.03	0	0	20'0	0	0	0	0	0	0	0	0.11	0	0	0	80'0	0	T	T	0
Jun	0	T	0	0.24	0	1.12	0	20.0	0.14	0	T	0	0.17	0.12	T	T	0	0	0.23	0.17	0	0	0	0	0	0	0.02	0.02	0.08
May	T	90'0	0.1	0	28.0	0.2	0.13	0.41	0.22	0	T	0	0.11	T	T	T	0.16	0	0.28	0.1	0.41	0.41	0.54	0.53	0	20.0	0.01	0.29	0.34
Apr	2.67	0.18	0.08	0.81	0.15	0.91	0.71	0.28	0	2.05	0.55	0.22	1.15	0.82	0.18	2.41	1.19	0.87	98.0	0.16	0.07	0.11	1.55	0.07	0.4	1.17	0.79	0.83	0.52
Mar	0.2	2.04	1.55	1.4	1.66	0.07	0.47	0.72	0.05	2	0.97	2.23	4.59	1.44	0.99	2.05	0.94	3.35	0.22	1.81	2.56	0.56	1.46	1.94	1.1	0.22	2.18	0.34	2.21
Feb	1.44	2.52	96.0	0.61	1	0.72	1.52	0.16	1.53	1.77	4.7	2.46	3.51	0.77	3.61	3.9	0.88	1.14	2.97	2.71	1.53	0.49	0.44	0.85	1.13	0.76	0.27	0.27	0.78
Jan	0.82	1.33	0.09	0.81	1.66	2.32	1.85	3.12	0.17	2.5	99.0	1.95	1.76	1.54	3.53	1.51	1.21	2.73	1.28	0.26	0.34	0.41	0	0.51	1.93	1.24	3.08	1.1	1.89
Year	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954

Historical Hanford Precipitation (Inches), Tulare Lake Subbasin SGMA Model, Kings County, California (Continued) **Table 3-1.**

																			1		1								
Annual	Μ	4.11	7.42	11.62	3.67	88.9	5.21	90'.	10.45	6.45	7.73	5.75	Annual	6.93	6.74	14.88	8.14	4.99	4.62	Μ	7.15	Μ	8.94	65.5	15.49	9:22	7.27	7.71	11.65
Dec	4.67	0.15	1.41	0.16	0.17	0.03	1.28	0.19	0.29	1.44	1.97	2.57	Dec	0.5	1.64	0.7	1.23	1.87	0.65	Μ	1.4	0.22	96.0	2.85	0.5	0.41	0.2	0.29	0.71
Nov	0.92	0	1.39	0.23	0	2.61	1.11	0	1.23	1.31	2.15	1.28	Nov	1.99	0.98	0.51	2.4	0.41	2.9	Σ	0.24	0.05	1.15	99.0	0.79	0.62	0	1.08	2.15
Oct	0.02	0.72	0.2	0	0	0.53	0	0.1	0.75	0.95	0.05	0	Oct	0	1.33	0.05	Τ	90.0	0.21	Σ	0.65	Ν	0	0.05	0	0.41	0.09	0.76	1.03
Sep	0	0	0	0.88	0.11	0	0	0.01	0.33	0	0.07	0.29	Sep	0.31	0	0.15	0	0.04	0.24	0	0	96.0	1.47	0	1.1	0.08	0	0	0.64
Aug	Σ	0	0	Т	Τ	0	0	0	0	0.34	0.05	0	Aug	0	0	0	0	Τ	0	0	0	0	0.22	0	0	0	0	0	0
Jul	0	0	0	0	0	0.02	0	0	0	0	0	0.04	Jul	0	0	0.07	T	0	0	0	0	0	0	0	0	0.04	0	0	0.18
Jun	0	0	0	0	0	0	0	0	0.17	0	0	90.0	Jun	0.23	0	0.21	T	0	0	M	0	0	0.51	0.07	0	0	0	0	0.45
May	6.0	0.83	0.63	0.24	Τ	0	0.37	0.11	0.56	0.2	0	0.07	May	0.07	0.08	0.32	0	1.44	0	Μ	0	0	0.03	0.91	0	0	0.04	0.17	0
Apr	Σ	0.73	0.67	2.04	0.52	0.57	0.22	0	2.88	0.64	1.6	0	Apr	2.95	0.5	0.85	0.16	0.4	0.23	0.12	0.03	0.49	1.47	0	1.71	0.03	0.05	0.68	1.75
Mar	Σ	0.1	0.56	3.92	0.11	0.61	0.67	1.06	1.37	0.94	0.33	0.1	Mar	2.42	1	0.79	1.42	0.23	0	2.2	1.75	Σ	0.19	0.43	4.12	1.16	1.28	2.1	3.52
Feb	1.31	0.38	1.17	2.3	1.9	1.71	0.22	4.88	1.68	0.02	0.33	0.71	Feb	0.05	0.64	4.54	1.33	0.19	0.35	2.29	0.11	2.26	2.94	0.03	5.05	1.61	2.71	98.0	0.38
Jan	3.25	1.2	1.39	1.85	98.0	0.8	1.34	0.71	1.19	0.61	1.18	0.63	Jan	1.41	0.57	69.9	1.6	0.35	0.04	Σ	2.97	60.0	⊥	0.59	2.22	2.19	2.9	1.77	0.84
Year	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	Year	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982

Historical Hanford Precipitation (Inches), Tulare Lake Subbasin SGMA Model, Kings County, California (Continued) **Table 3-1.**

Annual	15.57	M	M	9.12	8.85	8.36	3.66	5.28	M	8.39	10.51	8.07	13.13	14.18	7.26	14.07	5.53	98'6	9.95	5.64	7.01	9.31	10.27	12.02	4.42	6.15	6.71	15.13	9.16
Dec	1.22	Σ	99.0	0.77	1.7	2.29	0	0.15	Μ	2.62	99.0	0.33	1.59	3.27	1.8	0.65	⊥	0.05	1.99	1.14	2	2.23	2.07	1.01	1.32	1.49	1.42	6.46	90.0
Nov	1.66	Μ	2.11	0.21	0.47	1.31	0.2	0.22	0.14	⊥	0.64	1.54	⊥	69.0	1.96	0.63	0.15	⊢	1.84	1.42	0.49	0.52	0.19	0.22	0.12	1.04	0.28	1.32	0.8
Oct	0.43	M	M	0	0.58	0	0.32	0.01	0.41	0.58	0.24	0.35	0	2.43	0.09	0.68	0	1.31	0.18	0	0	2.06	0.01	90.0	0.35	0.15	1.32	0.64	0.55
Sep	0.82	0	Τ	0.15	0	0	0.67	T	0.11	Τ	0	1.06	T	0	90.0	Τ	0.01	0.03	⊢	0	0	0	0.01	0	0.37	0	0.18	0	0.01
Aug	0.05	0	0	Т	0	0	T	T	0	0.01	0	0	0	0	0	0	T	0	0	0	0.07	0	Τ	0	0.12	0	0	0	0.08
lnf	0	0	M	Т	0	0	0	Τ	0	0.01	0	Τ	Τ	0	Τ	0	0	0	0.09	0	Τ	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0.05	0	0	0	0.12	0	0.3	0	0.04	Τ	Τ	0.44	0	0.35	0	0.82	0	0	0	0	0	0	0.22	0	1.04
May	0.04	0	0	0	0.13	0.07	0.39	0.87	T	T	0.08	99.0	0.87	0.1	0	1.31	0	0.48	0	0.01	0.62	0.01	0.83	0.53	0.01	0.11	0.41	0.17	0.4
Apr	1.63	0.18	0.12	0.5	90.0	1.99	0.02	0.97	0.19	0.1	0.07	0.72	0.65	0.85	0	1.68	1.37	0.97	1.12	0.03	1.5	0.02	0.71	3.39	0.33	0	0.02	1.65	0.3
Mar	3.39	0.27	0.7	3.43	2.02	0.93	0.85	0.3	6.62	0.85	2.16	1.02	4.77	2.27	0.21	2.63	0.43	1.59	1.24	1.04	1.01	0.29	2.24	2.72	0.26	Т	0.2	0.34	2.87
Feb	2.59	0.42	M	2.6	2.07	0.4	1.04	1.1	0.12	2.82	2.48	1.45	0.51	2.89	0.12	4.05	95.0	3.28	1.48	0.31	1.08	2.18	1.58	0.55	0.89	1.18	1.86	1.91	1.53
Jan	3.74	0.01	0.59	1.46	1.77	1.37	0.17	1.66	0.31	1.4	3.88	0.94	4.7	1.68	3.02	2	3.01	1.8	1.98	0.87	0.24	2	2.63	3.54	0.65	2.18	8.0	2.64	1.52
Year	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011

Historical Hanford Precipitation (Inches), Tulare Lake Subbasin SGMA Model, Kings County, California (Continued) **Table 3-1.**

Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1	Σ	1.39	0.03	M	⊢	0	0	0.28	0.49	1.9	M
0.48	0.79	80.0	0.17	0	0	0	0.01	T	0.33	0.16	Σ
1.38	0.27	0.35	T	0	0	0	0.03	0	0.94	2.52	5.79
0.72	0.02	0.77	0.1	0	0.45	0	0	0.38	0.91	1.4	4.83
0.58	1.99	0.57	0.02	60'0	0	0	0	92.0	0.4	1.6	8.57
2.8	0.31	1.02	98'0	0.01	0	0.01	0.17	90.0	0.21	0.08	8.73
1.5	1.47	0.75	0.25	60.0	0.01	0.01	0.15	0.38	0.82	1.24	8.28
5.05	6.62	3.39	5.06	1.12	0.45	0.34	2.48	2.43	3.67	6.46	15.57
1978	1991	2006	1906	1861	2015	1964	1904	1996	1926	2010	1983
	0	0	0	0	0	0	0	0	0	0	3.37
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

Historical Land Use, Tulare Lake Subbasin SGMA Model, Kings County, California Table 3-2.

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	6	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	909'68	65,169	85,144	889'66	90,192	152,391	172,697	172,486	195,172	237,790	200,972	136,159
Forest*	420	608	2,955	9	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	896'6	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	960'9	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	809
Potatoes, Sugar beets, Turnip etc	5,736	1	209	9		3		6		41		2	2	1,331
Riparian*		899	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	99	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	tal is by Calenda	ır Year												

Table 3-3. Generalized Stratigraphic Column for Tulare Lake Subbasin

System	Series	Geo	ologic Unit	Lithologic Character	Maximum Thickness (feet)	Water-Bearing Character	Areas Where Important
			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.
	Holocene		Younger Alluvium	Interstratified and discontinuous beds of clay, silt, sand, and gravel, primarily located on recent alluvial fans and along stream channels. Interfingers with floodbasin 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.
ARY			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.
QUATERNARY	Pleistocene	Tulare		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.
	īd	Formation	Lacustrine Deposits	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.
	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.
TERTIARY	<u>a</u>	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/O ligocene	Other Tertiary Sediments (undifferen- tiated)	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.

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	ı
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	ı
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

Table 3-5. Historical Kings River Diversions, Tulare Lake Subbasin SGMA Model, Kings County, California

		slstoT lsunnA		413,173	695,217	429,722	635,924	383,648	485,935	511,981	625,968	765,886	771,261	384,320	211,662	644,222	810,750	711,136	809,178	1,056,876	943,484	701,875
		γźnuoϽ-inT			9	3,690 4	1,041 6	œ.	17,028 4:	37,128 5	16,400 6	22,032	31,760 7	23,320 3	3,490 2	26,430 6	23,846 8	23,780 7	29,338 8	43,951 1.	38,815 9.	63,925 7
		Imported Water		0	0	3	1	0	П	e	1	2	e	2	3	2	2	2	2	4	9	9
ority		Other Water		Ė	'	_			-			0	0	- 0	-	_	- 0			_	. 0	0
er Auth		Kings River-Tri-County									İ	0	2,642 (9,154 (920	11,956 (6,575 (2,819	8,983	12,547 (0	0
Tri-County Water Authority		Valite River										0	0	0	0	1,000	0	009	0	1,887	4,050	6,601
i-Count		Deer Greek-70% of Deer Greek Total										0	0	0	0	2,000	0	4,200	0	13,207	28,350	46,210
F		Tule River-Tri-County					,	,				1,402	224	0	0	2,476	185	2,611	223	3,090	340	0
		TLBWSD Lateral B, T206 (State Water)-Assumed Full Entitlement- 75% to Lateral B				2,768	781	0	12,771	27,846	12,300	15,472	21,671	10,624	1,905	1,873	12,814	9,488	15,099	7,793	0	906
		JEWSD Lateral A, T200 (State Water)-Assumed Full Entitlement- Ass to Lateral A		-		923	260	0	4,257	9,282	4,100	5,157	7,224	3,541	635	624	4,271	3,163	5,033	2,598	0	303
		Роsо Сreek										0	0	0	0	1,500	0	006	0	2,830	6,075	9,902
		El Rico		127,884	321,919	151,775	339,477	120,248	178,091	224,849	244,723	309,845	342,042	151,071	71,762	237,179	334,337	259,729	415,677	589,793	644,159	309,830
		Imported Water																				
		Loan Oak/New Deal- Diversion of Last Chance, El Rico GSA Total		21,581	33,629	13,662	26,288	16,617	15,138	16,367	26,860	29,337	18,830	296	4,090	30,676	27,627	27,585	20,349	28,034	20,577	22,992
		Камеаћ River							Ţ	Ţ					Ţ		Ţ		78,485	171,808	114,301	120,846
		Tule River-El Rico													,				742	63,476	193,800	17,566
		Deer Creek-30% of Deer Creek Total					j		j							- 000		1,800		5,660 63	12,150 19	19,804 17
El Rico		Kern River			1							0 -	0 -	- 0	0 -		- 0	-μ -	0 -	٠.		- 15
		Melga Canal-Diversion of Peoples Canal, El Rico GSA Total		71,842	91,260	50,540	71,757	51,149	57,877	34,420	93,111	91,604	72,972	25,219	28,929	83,846	83,787	67,592	59,394	84,800	40,663	65,220
		Tulare Lake Canal		17,831	42,476	49,218	0	0	490	7,305	31,948	28,336	53,125	45,170	4,003	49,511	32,856	29,258	19,710	77,268	1,333	0
		Lakelands Canal-Total		14,225	71,671	17,218	40,568	52,483	28,610	0	19,101	55,482	41,833	3,493	0	31,904	34,336	772,78	9,180	54,659	21,919	42,516
		TLBWSD Lateral B, T206 (State Water)-Modified Total-(SWP Total for Lateral B minus Tri-County Entitlement)				10,256	2,893	0	47,329	103,195	45,583	56,123	89,737	47,863	21,197	3,073	97,690	34,131	140,237	36,788	522	1,917
		TLBWSD Lateral A, TZ00 (State Water)-Modified Total-(SWP Total for Lateral A minus Tri-County Entitlement, Then 20% taken	r)		Ť	6,208	1,751	0	28,648	62,463	27,591	34,058	53,639	28,360	11,813	2,139	55,518	20,733	78,820	21,698	278	1,265
		Empire Weir No. 2 (over #2 weir to river extension, River Water) Modified Total-(Empire Weir No. 2 minus Tri-County Kings River	feet per yea	404	2,883	673	196,219			1,099	530	14,906	11,905		732	3,029	523	1,353	761	209'9	38,616	7,704
		sgniX Isəwrİsno2	(acre-fee	20,559 2	29,187 8	43,416 4	28,771	36,366 0	47,469 0	59,119	53,973 5	98,069	109,602	77,906 0	34,930	79,494	121,876 2	125,710 4	108,800	91,130 4	72,577	68,144
		Imported Water, Angiola/Green Valley Well Fields, City of Lemoore and Westlands RD 761	_	20	29	43	28	36	47	56	53	36	10	77	34	75	12	12	10	91	72	89
	<u></u>	Dudley Ridge State Turnout (DR-3), T208			,	- 694	- 777,9	8,728	8,867	9,168	7,614	14,425 -	17,520 -	13,358 -	6,246	12,816 -	16,651	17,297	15,839	11,980	12,078	3,954 -
v	trict-Monthly ımed	Dudley Ridge State Turnout (Paramount), T207		·	'	9 5	11 6	15 8	15 8	15 9	13 7	24 1	29 1	22	10 6	21 1	28 1	29 1	26 1	20 1	20 1	23 1
st King	r District-I Assumed	Dudley Ridge State Turnout (DR-2), T205				11,388	13,554	17,456	17,735	18,335	15,228	28,849	35,040	26,716	12,493	25,632	33,302	34,594	31,677	23,960	24,157	706,72
Southwest	Dudley Ridge Water Dis Diversions Assu	POST ((AI-RG) fumount offste State Tumout (DR-IAI),				2,372	2,824	3,637	3,695	3,820	3,172	6,010	7,300	5,566	2,603	5,340	6,938	7,207	665'9	4,992	5,033	5,814
S	ey Ridg Div	Dudley Ridge State Turnout (DR-18), T202			,	949	1,130	1,455	1,478	1,528	1,269	2,404	2,920	2,226	1,041	2,136	2,775	2,883	2,640	1,997	2,013	2,326
	Dud	Dudley Ridge State Turnout (DR-1), T201				3,312	3,942	5,077	5,158	5,333	4,429	8,390	10,191	0/2/2	3,633	7,455	9,685	10,061	9,213	896'9	7,026	8,116
		TLBWSD Lateral C, T203				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Blakeley Canal-Kings River & Lateral A		20,559	29,187	19,692	534	0	10,521	20,920	22,249	37,966	36,603	22,247	8,903	26,094	52,496	53,639	42,806	41,213	22,250	10,003
		South Fork Kings River		106,612	128,753	123,153	97,659	111,538	121,210	101,065	108,534	130,081	134,463	91,940	48,545	103,774	140,549	136,165	118,790	139,389	78,926	108,496
		Imported Water																		,		
sgu	Lemoore Canal & Irrigation Company	Гетооге Сапа		96,079	109,323	91,478	87,537	93,441	96,498	80,465	86,382	102,115	104,388	70,925	42,067	80,567	107,578	103,714	89,111	100,153	58,631	99,362
South Fork Kings	70 = 8	Westlake Canal		3,604 96	5,861 10	12,718 91	6,056 87	7,305 93	10,280 96	5,133 80	6,543 86	10,508 10	10,939 10	5,004 70	557 42	9,312 80	9,523 10	11,566 10	9,437 89	20,983 10	10,389 58	3,800 99
South	ion ct	Emplire West Side Canal		4,770 3,	9,622 5,	13,636 12	2,878 6,	5,359 7,	4,665 10	6,188 5,	5,964 6,	9,291 10	8,763 10	5,915 5,	1,598 55	10,627 9,	15,449 9,	16,100 11	7,841 9,	9,396 20	6,097	2,801 3,
	Empire West Side Irrigation District	GWS mort latot OI ebi2 teeW eniqm3		4,	6	1,780 13	50 2,	3,548 5,	5,391 4,	5,216 6,	5,233 5,	4,085 9,	5,803 8,	5,811 5,	2,120 1,	409 10	1,565 19	805 16	′′ 996′′	4,379 9,	0 6,	0 2,
	Stratford Irrigation District	Stratford Canal		8																		
	Stra Irrig Dis			19 2,158	58 3,947	3,540	75 1,139	95 1,884	37 4,376	0 4,062	39 4,411	160 4,082	95 4,570	3 4,284	5 2,203	46 2,859	43 6,434	53 3,981	72 4,435	13 4,479	3,808	80 2,533
		Mid Kings		158,119	215,358	107,688	168,975	115,495	122,137	89,820	202,339	205,860	153,395	40,083	52,935	197,346	190,143	165,753	136,572	192,613	109,007	151,480
River		Imported Water																				
Mid Kings River	a se	амі әрізәярт																				
Mio	Last Chance Water / Ditch Co.	Last Chance Canal- MKRGSA Total		50,356	78,468	31,878	61,339	38,772	35,321	38,190	62,672	68,454	43,937	2,255	9,542	71,577	64,463	64,365	47,482	65,413	48,013	53,649
	Peoples Ditch Company	Peoples Canal- MKR65A Total		107,763	136,889	75,809	107,636	76,723	86,815	51,631	139,667	137,406	109,458	37,828	43,393	125,769	125,680	101,388	89,091	127,200	60,994	97,831
GSA	Agency	noisyeviQ		1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
		Kings River Water Years		71% 1	197% 1	49% 1	256% 1	78% 1	69% 1	50% 1	125% 1	122% 1	92% 1	32% 1	23% 1	201% 1	101% 1	178% 1	61% 1	181% 1	261% 1	115% 1

Notes provided on next page.

- Values highlighted have been modified.
 Values with "o" indicate no surface water delivery to the best of our knowledge.
 Values with "o" indicate no surface water delivery to the best of our knowledge.
 Values with "o" indicate no surface water delivery to the best of our knowledge.
 Values with "o" indicate no surface water delivery to the best of our knowledge.
 Last Chance obversion is split 50% between Mid Kings and El Rico.
 Blakeley has added State Water from Lateral A for Southwest.
 Total flow from Deer Creek split 30% to El Rico, 20% to Tir-County.
 Total flow from LaW3D Split Throughout Tir-County & Southwest kings.
 Kings River water in Tir-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.
 Kings River water flow data added for Tir-County.
 Additional Tule River flow data added for Tir-County.
 Empire West Side ID total from SWP reduce annual totals by 10%
 Dudley Ridge Water District reduce annual totals by 10%
 Lexanal A T7200) & Lateral B (T206) reduce annual totals by 10%

Lateral A (T200) & Lateral B (T206) reduce annu	Modifications to Peoples Canal and Last Chance
14.)	15.)

Average Annual 816,660 423,464 686,577

Kings River Watershed Total

Average Precipitation **GSA Annual Totals**

WetYear Dry Year

10% 10% 18%

Table 3-6A. 1990 - 2016 Historical Water Balance Total Subbasin, Tulare Lake Subbasin SGMA Model, Kings County, California

	Cumulative Delta	Storage (AF)	-185,926	-410,391	-700,780	-543,501	-712,208	-480,786	-294,305	-193,519	-39,983	-39,461	4,177	-238,882	-417,275	-518,358	-749,480	-628,463	-407,814	-656,305	-952,581	-1,165,591	-1,152,462	-791,234	-961,181	-1,266,788	-1,627,140	-2,019,419	-2,313,744	-720,867	-535,575
	Tulare Lake	Total Net (AF/Y)	298	-1,273	-245	1,631	-2,370	8,131	12,774	11,582	13,428	8,567	12,669	13,602	17,210	18,229	13,215	13,527	14,152	13,841	15,124	18,226	17,294	15,170	16,520	14,998	15,626	13,276	-2,088	10,856	14,545
	Tulare Lake	TCWA Net (AF/Y)	-21,601	-20,376	-20,030	-18,642	-19,723	-16,753	-20,968	-21,209	-20,573	-23,190	-21,114	-21,506	-22,272	-22,046	-22,256	-20,768	-19,288	-26,536	-30,843	-31,210	-33,394	-16,355	-19,718	-22,907	-26,037	-21,609	-20,125	-22,261	-24,230
Tulare	Lake Southwest	Net (AF/Y)	22,658	24,852	26,835	24,396	936'87	24,809	23,951	25,376	26,305	26,326	26,034	27,329	28,055	29,364	29,378	27,026	24,221	26,046	28,346	28,060	26,354	22,355	22,062	24,044	26,111	26,751	26,620	25,838	27,142
Tulare	Lake South	Fork Net (AF/Y)	5,316	2,959	4,143	-857	2,695	-10,023	-16,866	-17,016	-19,305	-17,001	-16,122	-14,996	-18,209	-22,651	-14,260	-19,200	-20,925	-12,691	-14,493	-21,735	-18,014	-15,516	-14,082	-12,022	-17,973	-12,806	-11,101	-12,806	-17,893
Tulare	Lake El Rico	Net (AF/Y)	-6,672	-6,163	-10,703	-6,528	-4,557	-6,163	1,109	1,267	145	5,298	-1,467	-4,429	-4,785	-2,895	-6,077	-585	1,839	2,341	1,866	6,659	7,760	-5,654	-4,782	-4,112	2,274	-5,612	-11,753	-2,310	436
Tulare	Lake Mid-Kings	Net (AF/Y)	298	-1,273	-245	1,631	-2,370	8,131	12,774	11,582	13,428	8,567	12,669	13,602	17,210	18,229	13,215	13,527	14,152	13,841	15,124	18,226	17,294	15,170	16,520	14,998	15,626	13,276	16,359	11,539	14,545
	Tulare Lake	Kern Net (AF/Y)	56,971	38,693	34,904	36,736	30,426	33,217	29,250	29,090	29,362	39,384	36,279	28,791	29,448	30,749	28,416	29,728	29,895	16,990	23,191	14,527	23,078	30,840	25,299	22,304	20,529	24,986	22,257	29,457	27,680
	Tulare Lake	Tule Net (AF/Y)	-12,024	-14,187	-18,583	-13,496	-20,670	-14,705	-19,334	-21,396	-21,177	-23,234	-20,878	-19,402	-22,160	-23,580	-24,296	-20,294	-20,192	-25,274	-21,584	-18,590	-16,097	-11,696	-10,775	-13,933	-18,842	-15,383	-14,438	-18,379	-21,289
	Tulare Lake Kaweah	Net (AF/Y)	-3,467	4,376	2,987	-20,133	-8,114	-26,071	-32,867	-36,466	-31,067	-38,853	-24,256	-10,602	-17,484	-16,849	-9,952	-30,344	-40,403	-17,451	-14,428	-2,407	-13,379	-35,573	-25,720	-18,315	-18,684	-15,502	-23,497	-19,427	-20,575
	Tulare T Lake	Kings Net (AF/Y)	4,815	9,747	10,812	-4,219	1,210	-14,723	-17,826	-17,146	-18,649	-12,823	-14,008	-8,208	-14,310	-14,505	-13,320	-20,418	-22,451	-14,948	-12,181	-15,575	-25,818	-38,331	-25,065	-18,283	-13,313	-10,641	-33,115	-13,826	-15,939
Tulare	Lake Westside	Net (AF/Y)	23,632	13,271	11,225	7,344	7,647	5,564	6,788	10,524	13,146	15,099	9,202	7,046	4,116	7,968	7,475	4,993	4,446	7,330	1,856	-1,793	-5,091	-6,641	-6,733	-9,909	-11,151	-10,951	-9,455	3,961	5,830
Tulare	Lake Net Subsurface	Outflow (AF/Y)	-111,280	-112,589	-119,495	-122,683	-125,412	-130,598	-136,119	-139,610	-134,203	-141,114	-130,053	-130,759	-142,986	-140,750	-137,076	-138,073	-142,864	-142,905	-143,019	-142,215	-138,727	-144,621	-141,994	-143,219	-151,969	-141,493	-160,350	-111,280	-160,350
Tulare	, e	Inflow (AF/Y)	181,209	164,488	160,839	128,914	135,909	113,880	102,129	104,214	105,817	120,686	116,391	128,384	122,597	124,533	125,398	101,739	94,159	109,552	119,872	118,378	101,421	83,220	000'66	105,083	110,508	114,003	102,102	83,220	181,209
	Tulare Lake Storage S	Net (AF/Y)	-185,926	-224,464	-290,389	157,279	-168,707	231,421	186,481	100,786	153,536	522	43,638	-243,059	-178,393	-101,083	-231,122	121,017	220,649	-248,490	-296,277	-213,010	13,129	361,228	-169,947	-305,607	-360,352	-392,279	-294,325	-85,694	-73,765
	Tulare Lake Ti Farm	Demand (AF/Y)	-1,065,856	-994,832	-1,012,909	-1,008,709	-1,047,937	-973,503	-1,067,962	-1,123,726	-1,059,009	-1,232,448	-1,127,412	-1,111,506	-1,201,455	-1,198,411	-1,162,011	-1,155,548	-1,129,741	-1,183,096	-1,083,093	-1,091,697	-1,016,725	-791,090	-776,133	-826,405	-757,265	-624,647	-677,936	-1,018,558	-1,134,781
	Tulare Lake Tu Recharge	Net C (AF/Y)	150,920 -1	135,941	139,491 -1	167,981 -1	173,457 -1	235,917	238,753 -1	252,651 -1	266,380 -1	201,878 -1	172,534 -1	119,202 -1	128,082 -1	157,010 -1	138,732 -1	227,638 -1	339,860 -1	123,827 -1	117,419 -1	135,636 -1	171,969 -1	355,590	120,601	90,038	107,427	99,444	123,037	173,756 -1	176,936 -1
		Lake Net (AF/Y) (/	0 15	0 13	0 13	0 16	0 17	0 23	0 23	0 25	0 26	0 20	0 17	0 11	0 12	0 15	0 13	0 22	0 33	0 12	0 11	0 13	0 17	0 35	0 12	0	0 10	0	0 12	0 17	0 17
		et River Net) (AF/Y)	13 212,023	164,892	94 125,681	24 231,839	56 139,080	22 200,925	36 177,508	26 162,833	36 165,955	11 159,660	26 147,624	26 108,934	70 150,502	145,737	53 137,236	38 150,074	29 138,230	53 137,542	126,421	133,032	76 129,805	0 147,432	111,314	26 99,564	53 82,742	38 60,439	23 69,718	141,361	50 140,827
		t Well Net (AF/Y)	-618,843	-577,240	-596,994	-248,824	-491,956	-188,622	-195,586	-278,726	-249,086	-338,241	-260,726	-467,326	-435,270	-385,602	-494,263	-217,488	-205,429	-474,153	-515,546	-456,641	-249,776	-77,680	-357,301	-455,726	-508,253	-524,338	-428,423	-381,410	-365,350
	Tulare Lake	GHB Net (AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0 8	0	0 6	0	0	0 6	0	0	0	0	0	0	0	0	0	0	0
Tulare	Lake Drain	Net (AF/Y)	0	0	0	0	-26	-82	-251	-1,392	-1,870	-7,376	-17,343	-13,351	-10,253	-8,170	-20,849	-5,413	-9,651	-14,999	-13,795	-4,295	-2,440	-4,486	-3,226	-8,381	-3,579	-829	-2,497	16 -5,724	6-9,985
		Date	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	1990-2016 Average	1998-2010 Average

Table 3-6B. 1990 - 2016 Historical Water Balance Upper Aquifer, Tulare Lake Subbasin SGMA Model, Kings County, California

					:																	
	Tulare	girdin E			e de la company	ode lessel.T			Tulare Lake	Tulare	Tulare	e de la composition della comp	Tulare			ole Lovelin	o de la comp	Tulare Lake	94c 97c	Tulare		e i te
			Tulare Lake	Lake	Lake	Recharge	ë		ė	d)	a		· 	ā			Lake		Southwest			Delta
Date (Net GH (AF/Y) (A	GHB Net (AF/Y)	Well Net (AF/Y)	River Net (AF/Y)	Lake Net (AF/Y)	Net (AF/Y)	ET Net (AF/Y)	Storage Net (AF/Y)	Inflow (AF/Y)	Outflow (AF/Y)	Net (AF/Y)	Kings Net (AF/Y)	Net (AF/Y)	Tule Net (AF/Y)	Kern Net (AF/Y)	Net (AF/Y)	El Rico Net (AF/Y)	Net (AF/Y)	Net (AF/Y)	Net (AF/Y)	rotal Net (AF/Y)	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	2,068	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	626	-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	688	-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
2002	-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
- 5002	-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
- 5002	-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	696	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

Table 3-6C. 1990 - 2016 Historical Water Balance Lower Aquifer, Tulare Lake Subbasin SGMA Model, Kings County, California

	Cumulative Delta	Storage (AF)	206,511	361,463	450,947	726,011	813,124	1,068,522	1,259,026	1,375,059	1,511,420	1,583,317	1,703,855	1,683,515	1,679,807	1,712,271	1,662,878	1,783,378	1,886,285	1,815,767	1,730,191	1,687,954	1,757,415	1,921,299	1,888,486	1,804,883	1,691,836	1,586,335	1,526,021	1,439,910	1,707,542
		Total Net (AF/Y)	890'6	6,755	6,710	6,416	2,579	10,847	14,300	12,373	13,656	8,524	11,957	13,388	17,582	18,537	13,904	13,315	12,747	13,455	15,746	18,852	16,894	12,948	15,029	14,477	15,722	13,951	0	12,212	14,504
Tulare	Lake TCWA	Net (AF/Y)	-12,264	-13,191	-13,932	-12,489	-14,362	-11,896	-15,474	-16,606	-16,347	-18,031	-16,221	-16,985	-17,652	-17,468	-17,888	-16,321	-15,017	-22,326	-27,018	-27,626	-29,741	-12,702	-16,266	-19,426	-22,875	-18,876	-17,433	-17,646	-19,895
	Tulare Lake Southwest	Net (AF/Y)	19,535	21,251	23,124	20,957	20,484	21,378	20,385	21,976	22,838	22,726	22,261	23,458	24,270	25,538	25,533	23,231	20,543	22,545	25,088	24,881	23,260	19,208	18,951	21,031	23,115	23,645	23,614	22,401	23,552
Tulare	Lake South Fork	Net (AF/Y)	-1,752	-2,252	331	-3,226	573	-10,769	-16,439	-15,613	-17,169	-14,601	-13,144	-12,000	-15,543	-19,706	-11,614	-16,023	-17,157	-12,467	-11,613	-18,590	-14,456	-11,171	766,6-	-8,251	-14,285	-9,208	-7,363	-11,241	-14,929
		El Rico Net (AF/Y)	-14,587	-12,564	-16,232	-11,659	-9,275	-9,559	-2,772	-2,130	-2,978	1,382	-4,852	-7,861	-8,658	-6,900	-9,935	-4,201	-1,116	-1,207	-2,202	2,483	4,043	-8,283	-7,718	-7,831	-1,678	-9,511	-15,498	-6,344	-3,231
	Tulare Lake Mid-Kings	Net (AF/Y)	890'6	6,755	6,710	6,416	2,579	10,847	14,300	12,373	13,656	8,524	11,957	13,388	17,582	18,537	13,904	13,315	12,747	13,455	15,746	18,852	16,894	12,948	15,029	14,477	15,722	13,951	16,680	12,830	14,504
	Tulare Lake	Kern Net (AF/Y)	52,663	35,740	32,859	35,060	29,028	31,931	27,910	27,831	28,136	37,757	34,130	26,614	27,396	28,700	56,366	27,583	27,566	15,108	52,069	14,189	23,212	30,466	24,330	21,233	20,026	24,707	21,854	27,943	26,063
	Tulare Lake	Tule Net (AF/Y)	985'6-	-10,237	-13,187	-8,578	-14,288	-8,585	-13,721	-15,520	-14,922	-17,379	-14,625	-12,654	-15,405	-16,659	-16,894	-13,207	-13,243	-17,605	-13,423	-10,120	-7,919	-4,789	-3,389	-6,364	-10,580	-6,960	-6,068	-11,700	-14,158
Tulare	Lake Kaweah	Net (AF/Y)	-5,823	-2,475	-4,106	-24,934	-13,695	-29,662	-33,846	-35,256	-28,896	-37,432	-25,145	-12,559	-20,839	-19,527	-12,554	-29,037	-33,827	-13,691	-14,390	-3,368	-13,046	-28,999	-19,076	-13,742	-15,176	-12,338	-19,362	-19,363	-20,331
		Kings Net (AF/Y)	10,884	10,084	9,193	-4,082	585	-5,174	-10,470	-7,705	-3,865	-6,582	-8,738	-4,283	-11,518	-11,188	-10,629	-14,580	-11,184	-9,752	-8,438	-12,082	-21,050	-21,958	-17,585	-13,986	-10,727	-9,591	-18,575	-8,259	-10,299
Tulare	_ ₹	Net (AF/Y)	13,339	3,422	2,013	009-	550	-388	1,227	5,054	8,034	9,788	4,067	1,896	-883	3,210	2,789	692	475	2,925	-2,465	-6,514	-8,768	-9,463	-9,466	-13,015	-14,784	-14,531	-12,856	-1,269	1,173
Tulare	Lake Net Subsurface	Outflow (AF/Y)	-58,787	-68,123	-75,762	-80,157	-80,974	-79,891	996'88-	-89, 192	248'21	-93,144	-85,312	-85,202	68'26-	-94, 198	-90,221	-89,165	-86,840	-90,375	-93,253	-92,397	-91,016	-85,781	298'68-	-92,285	-100,472	-90,840	-100,280	-58,787	-100,472
Tulare Lake	Net Subsurface	Inflow (AF/Y)	120,265	104,657	102,535	77,023	83,154	68,012	90,09	63,597	67,063	79,296	75,001	84,217	76,591	78,735	79,299	60,617	56,625	67,360	76,606	74,501	63,446	51,038	64,180	66,410	69,232	72,128	65,273	51,038	120,265
Tulare	Lake Storage	Net (AF/Y)	206,511	154,951	89,485	275,064	87,113	255,398	190,504	116,032	136,362	71,897	120,539	-20,340	-3,708	32,464	-49,393	120,500	102,907	-70,518	-85,575	-42,237	69,461	163,884	-32,812	-83,604	-113,047	-105,501	-60,314	56,519	29,412
	Tulare Lake	ET Net (AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tulare Lake Recharge	Net (AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tulare Lake	Lake Net (AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tulare Lake	River Net (AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Tulare Lake	Well Net (AF/Y)	-254,873	-225,455	-251,686	690'6-	-181,901	17,015	-11,265	-73,758	-57,797	-111,192	-58,927	-202,438	-162,957	-130,332	-214,670	-22,996	-31,250	-209,499	-232,114	-187,798	-62,006	48,633	-152,288	-203,087	-231,859	-240,639	-179,866	-134,595	-129,537
	Tulare Lake	GHB Net (AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tulare	Lake Drain	Net (AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Date	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2002	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	1990-2016 Average	1998-2010 Average

Table 3-7. Historical and Current Water Balance, Tulare Lake Subbasin SGMA Model, Kings County, California

						Land Surface	Land Surface Water Budget						
					Inflows	S				Outflows	s		Net
Year	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	%89	О	78,722	209,568	3,793	52,225	568,130	912,439	0	994,832	125,674	1,120,507	-208,068
1992	41%	О	64,818	245,345	8,619	46,926	587,328	923,036	0	1,012,909	126,365	1,139,274	-186,238
1993	149%	>	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	20%	О	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%	*	95,479	948,773	42,079	905	177,847	1,265,083	82	973,503	116,897	1,090,481	174,601
1996	122%	z	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%	*	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%	>	116,167	806'869	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	9/8'/	1,232,448	151,647	1,391,471	-279,701
2000	%06	z	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	%69	Q	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	%29	Ω	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%	z	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%	≯	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%	Μ	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%	Q	14,800	508,886	4,613	809'09	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	%62	z	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%	Z	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

Table 3-7. Historical and Current Water Balance, Tulare Lake Subbasin SGMA Model, Kings County, California (Continued)

Introduction Precipitation Applied Water Stream Intentional Upper Lower Intitution Intituti								nsgns	Subsurface Water Budget	udget								
Vings Precipitation Applied Water Stream Intentional Upper Local Adult Inchigation (LA) Applied Water (LA) Stream Intentional Upper Local Adult Inchigation (LA) Applied Water (LA) Rechange Adult Adult Inchia (LA) (LA						-	nflows						Outflows					
Kolfey Precipitation Applied Water Stream Intentional Ray Intentional Aquifer Intentional Last Intenti					Deep Percol	ation		Interbas	in Inflow		Groundwat	ter Pumping	Interbasi	Interbasin Outflow		Annua	Annual Change in Storage	storage
Rick Particular Post Reduction Adultar Adultar Adultar Adul		Σ			Applied Water	Stream	Intentional	Upper	Lower	Total	Upper	Lower	Upper	Lower	Total	Upper	Lower	Total
40% D 11,012 132,933 222,466 1,021 60,944 120,265 55,460 363,970 44% D 10,310 125,674 149,106 0 59,832 104,657 449,578 331,785 44% D 13,215 125,654 149,106 0 58,834 102,535 445,798 331,785 149% W 43,949 124,472 178,243 61 51,892 77,023 475,994 33,795 202% W 58,569 116,897 160,315 60,372 45,888 68,012 20,5637 20,5637 122% W 58,569 116,342 161,750 32,081 42,064 60,065 50,2429 184,321 122% W 58,569 116,343 42,787 40,618 63,599 20,4969 124,347 18,648 161,750 32,081 40,618 63,599 20,4969 19,239 1818,48 W 56,946 116,089	Year	조 은			Infiltration (AF)	Leakage (AF)	Recharge (AF)	Aquifer (AF)	Aquifer (AF)	Inflows (AF)	Aquifer (AF)	Aquifer (AF)	Aquifer (AF)	Aquifer (AF)	Outflows (AF)	Aquifer (AF)	Aquifer (AF)	Aquifer (AF)
63% D 10,310 125,674 149,106 0 59,832 10,657 449,578 55,1785 41% D 13,215 126,865 122,515 0 58,304 10,535 422,934 48,307 419% N 43,499 112,447 23,540 51,755 83,154 43,1038 130,755 200% V 20,701 12,447 23,540 50,755 83,154 43,1038 31,755 202% W 58,664 116,897 16,1447 23,540 50,755 83,154 43,1038 130,032 20,5637 122% W 56,946 116,897 16,145 32,681 40,618 63,597 50,2429 184,321 1438 W 56,946 143,342 15,337 42,787 40,618 63,597 50,456 10,209 181% W 75,035 12,4376 0 41,191 70,488 27,049 181% W 56,138 11,439 <th>1990</th> <td>4</td> <td></td> <td>17,012</td> <td>132,933</td> <td>222,466</td> <td>1,021</td> <td>60,944</td> <td>120,265</td> <td>554,640</td> <td>363,970</td> <td>254,873</td> <td>52,493</td> <td>58,787</td> <td>730,124</td> <td>-392,438</td> <td>206,512</td> <td>-185,926</td>	1990	4		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
41% D 13,215 126,365 126,315 0 58,304 10,253 42,934 34,399 126,472 126,343 61 51,892 77,023 475,190 29,755 83,144 43,499 124,472 118,434 61 51,892 77,023 475,190 29,755 30,550 20,002	1991	9		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
199% W 43,499 124,472 178,243 61 51,892 77,023 475,190 239,755 202% D 20,701 129,432 121,447 25,540 52,755 83,154 431,028 310,055 122% N 58,569 116,897 160,315 60,372 45,868 66,012 510,032 20,563 155% N 78,864 127,604 161,750 32,081 42,064 60,065 50,2429 184,331 1813% W 66,946 127,604 161,750 37,881 42,064 60,065 50,2429 194,321 1813% W 75,095 128,533 42,787 40,068 66,062 50,2429 194,321 1813% W 75,095 128,533 42,787 40,068 60,065 50,0248 194,321 184% W 56,467 159,781 153,400 0 44,167 84,137 11,409 20,069 20,066 11,410 20,04	1992	4,		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
50% D 20,701 129,432 121,447 23,540 52,755 83,154 43,028 310,055 122% W \$8,569 116,897 166,315 66,372 45,868 68,012 510,032 20,583 122% N 78,864 127,604 161,750 32,081 42,064 60,065 502,429 184,321 1815% W 65,946 143,342 152,373 42,787 40,618 63,597 50,662 20,496 181% W 75,095 128,533 152,395 61,425 38,754 67,063 520,496 191,289 24,8 D 47,885 151,447 25,40 41,467 86,574 20,033 124,376 0 41,467 84,171 370,468 56,23 22,70 59% D 26,775 90,933 124,376 0 41,467 84,171 370,468 26,488 67% D 41,347 85,417 164,069 0	1993	14		43,499	124,472	178,243	61	51,892	77,023	475,190	239,755	690'6	42,526	80,157	371,507	-117,785	275,064	157,279
202% W 58,569 116,897 160,315 60,372 45,868 68,012 510,032 205,637 122% N 78,864 127,604 16,1750 32,081 42,064 60,065 502,429 184,321 155% W 65,946 137,342 153,373 42,787 40,618 63,597 509,662 204,969 181% W 75,095 118,533 122,395 61,425 38,754 67,063 520,429 184,321 181% W 75,095 118,647 180,710 0 41,889 79,266 500,928 220,496 90% N 51,238 15,647 180,710 0 41,889 79,266 500,928 220,498 59% N 51,238 15,1476 16,069 79,266 500,928 204,989 61% D 41,347 16,069 79,266 500,928 204,989 61% D 41,487 11,440 20,794	1994	25		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
152% N 78,864 127,604 161,750 32,081 42,064 60,065 502,429 184,317 155% W 65,946 143,342 153,373 42,787 40,618 63,597 509,662 204,969 181% W 75,095 128,533 122,335 61,425 38,754 67,063 523,264 191,289 184% D 47,885 151,647 180,710 0 41,389 79,296 500,928 227,049 59% D 47,384 95,624 180,710 0 44,134 70,091 46,006 70,209 101,289 61% D 41,347 85,417 164,069 0 44,187 26,188 70,201 61% D 41,347 86,874 164,069 0 44,186 107,00 46,000 70,299 41,440 27,312 183% W 61,28 10,425 10,700 46,000 70,299 41,440 27,312	1995	20		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
155% W 65,946 143,342 153,373 42,787 40,618 63,597 509,662 204,969 181% W 75,095 128,533 152,395 61,425 38,754 67,063 523,64 191,289 74% D 47,885 151,647 180,710 0 41,389 79,296 500,928 227,049 90% N 51,238 95,624 159,781 23,540 41,391 75,001 446,574 201,799 59% D 26,775 90,933 124,376 0 44,167 84,217 370,468 227,049 61% D 41,347 85,447 164,069 0 44,167 84,217 370,468 270,312 61% D 41,347 85,447 164,069 0 44,167 84,217 370,468 26,488 61% D 41,347 85,447 164,069 0 46,169 76,501 44,167 84,217 310,489 26,488 <th>1996</th> <td>12</td> <td></td> <td>78,864</td> <td>127,604</td> <td>161,750</td> <td>32,081</td> <td>42,064</td> <td>90'09</td> <td>502,429</td> <td>184,321</td> <td>11,265</td> <td>47,154</td> <td>996′88</td> <td>331,705</td> <td>-4,023</td> <td>190,504</td> <td>186,481</td>	1996	12		78,864	127,604	161,750	32,081	42,064	90'09	502,429	184,321	11,265	47,154	996′88	331,705	-4,023	190,504	186,481
181, W V 75,095 128,535 61,425 38,754 67,063 52,264 191,289 74% D 47,885 151,647 180,710 0 41,389 79,296 500,928 227,049 90% N 51,238 95,624 159,781 23,540 41,391 75,001 446,574 201,799 59% D 26,775 90,933 124,376 0 44,167 84,217 370,468 264,888 67% D 41,347 85,417 164,069 0 46,006 76,591 44,574 201,799 83% N 36,128 95,332 174,955 23,540 45,798 78,448 201,700 61% D 41,347 85,417 164,069 0 46,006 76,591 41,440 27,331 148% N 36,128 10,700 46,006 76,591 44,574 201,799 172% D 40,228 10,700 46,006	1997	15		65,946	143,342	153,373	42,787	40,618	265'89	509,662	204,969	73,758	50,417	89,192	418,336	-15,247	116,032	100,786
74% D 47,885 151,647 180,710 0 41,389 79,296 500,928 227,049 90% N 51,238 95,624 159,781 23,540 41,301 75,001 446,574 201,799 59% D 26,775 90,933 124,376 0 44,167 84,217 370,468 264,888 67% D 41,347 85,417 164,069 0 46,006 76,591 413,429 201,799 61% D 40,008 86,876 174,955 23,540 45,798 78,735 454,87 25,270 112% D 40,008 86,876 148,458 10,700 46,096 79,299 411,40 27,320 112% W 64,268 101,553 185,872 58,945 41,121 60,617 71,400 27,939 411,40 27,939 107% W 64,268 10,1533 174,019 0 46,096 79,299 411,410 71,412<	1998	18		75,095	128,533	152,395	61,425	38,754	690'29	523,264	191,289	57,797	55,626	78,577	383,288	17,175	136,362	153,536
90% N 51,238 95,624 159,781 23,540 41,391 75,001 446,774 201,799 59% D 26,775 90,933 124,376 0 44,167 84,217 370,468 264,888 67% D 41,347 85,417 164,069 0 46,006 76,591 413,429 272,312 61% D 41,347 85,417 164,069 0 46,006 75,991 413,429 272,312 61% D 40,008 86,876 148,458 10,700 46,099 79,299 411,440 275,321 112% W 64,268 10,1553 185,872 58,945 41,121 60,617 314,492 275,391 40% W 64,268 10,1553 186,570 170,266 37,534 510,409 779,492 41,417 41,417 40% D 20,332 174,019 0 41,121 60,617 314,492 77,179 40%	1999	7/		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
59% D 26,775 90,933 124,376 0 44,167 84,117 370,468 264,888 67% D 41,347 85,417 164,069 0 46,006 76,591 413,429 272,312 83% N 36,128 95,332 174,955 23,540 45,798 78,735 454,487 255,270 148% W 64,268 101,553 185,872 58,945 41,121 60,617 512,376 194,492 172% W 64,268 101,553 185,872 58,945 41,121 60,617 512,376 194,492 172% W 64,268 101,533 185,872 58,945 41,121 60,617 512,376 194,492 40% D 23,538 97,935 174,019 0 43,266 67,666 373,236 64,654 121% N 26,373 174,019 10,700 43,266 76,606 373,236 28,431 121% N </td <th>2000</th> <td>8</td> <td></td> <td>51,238</td> <td>95,624</td> <td>159,781</td> <td>23,540</td> <td>41,391</td> <td>75,001</td> <td>446,574</td> <td>201,799</td> <td>58,927</td> <td>44,741</td> <td>85,312</td> <td>390,779</td> <td>-76,900</td> <td>120,539</td> <td>43,638</td>	2000	8		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
67% D 41,347 85,417 164,069 0 46,006 76,591 413,429 27,312 83% N 36,128 95,332 174,955 23,540 45,798 78,735 454,487 25,270 61% D 40,008 86,876 148,438 10,700 46,099 79,299 411,440 279,533 142% W 64,268 101,553 185,872 58,945 41,121 60,617 512,376 194,492 172% W 57,791 108,496 169,501 170,266 37,534 56,625 600,213 174,179 40% D 23,538 97,935 174,019 0 43,266 37,346 56,625 600,213 174,179 127% D 26,373 89,622 137,369 0 43,266 37,346 46,574 264,554 121% N 29,563 94,173 167,126 10,700 43,266 76,606 375,346 14,179	2001	55		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
83% N 36,128 95,332 174,955 23,540 45,798 78,735 454,487 25,570 61% D 40,008 86,876 148,458 10,700 46,099 79,299 411,440 279,533 148% W 64,268 101,553 185,872 58,945 41,121 60,617 512,376 194,492 172% W 57,791 108,496 169,501 170,266 37,534 56,625 600,213 174,179 40% D 26,373 89,622 137,309 0 43,266 76,606 375,236 28,431 72% D 26,373 89,622 137,369 0 43,266 76,606 375,246 264,654 121% N 29,563 94,173 167,126 10,700 43,877 74,501 419,939 268,433 180% W 88,853 83,959 180,366 180,766 37,974 61,418 417,409 26,469 37,274	2002	9.		41,347	85,417	164,069	0	46,006	165'92	413,429	272,312	162,957	45,147	97,839	578,256	-174,685	-3,708	-178,393
61% D 40,008 86,876 148,458 10,700 46,099 79,299 411,440 279,593 148% W 64,268 101,553 185,872 58,945 41,121 60,617 512,376 194,492 172% W 57,791 108,496 169,501 170,266 37,534 56,625 600,213 174,179 40% D 25,338 97,935 174,019 0 42,192 67,360 405,044 264,654 72% D 26,373 89,622 137,369 0 42,192 67,360 405,044 264,654 79% N 29,563 94,173 167,126 10,700 43,877 74,501 419,939 268,433 180% N 29,563 94,173 167,126 10,700 43,877 74,501 419,393 268,433 180% W 88,853 83,959 180,036 180,066 37,346 41,130 317,209 25,639	2003	8		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
148% W 64,268 101,553 185,872 58,945 41,121 60,617 512,376 194,492 172% W 57,791 108,496 169,501 170,266 37,534 56,625 600,213 174,179 40% D 23,538 97,935 174,019 0 42,192 67,360 405,044 264,654 72% D 26,373 89,622 137,369 0 43,266 76,606 373,236 284,431 79% N 29,563 94,173 167,126 10,700 43,877 74,501 419,939 268,843 180% N 29,563 94,173 167,126 10,700 43,877 74,501 419,939 268,843 180% N 67,953 83,959 180,036 180,066 32,182 51,038 616,133 126,313 43% D 46,276 62,058 126,057 10,700 34,819 64,180 376,394 21% <	2004	.9		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
172% W 57,791 108,496 169,501 170,266 37,534 56,625 600,213 174,179 40% D 23,538 97,935 174,019 0 42,192 67,360 405,044 264,654 72% D 26,373 89,622 137,369 0 43,266 76,606 373,236 283,431 12% N 29,563 94,173 167,126 10,700 43,877 74,501 419,339 268,843 121% N 67,953 78,915 145,364 23,794 63,46 417,193 187,770 49% D 46,276 62,058 126,057 10,700 34,819 64,180 34,090 26,639 41% D 46,276 62,058 126,057 10,700 34,819 64,180 34,090 25,639 22% D 26,687 123,434 0 38,673 64,180 37,239 25,639 21% D 25,414	2005	14		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
40% D 23,538 97,935 174,019 0 42,192 67,360 405,044 264,654 72% D 26,373 89,622 137,369 0 43,266 76,606 373,236 283,431 79% N 29,563 94,173 167,126 10,700 43,877 74,501 419,939 268,843 121% N 67,953 78,915 145,364 23,540 37,974 63,446 417,193 187,770 180% W 88,853 83,959 180,036 180,066 32,182 51,038 616,133 126,313 49% D 46,276 62,058 126,057 10,700 34,819 64,180 34,090 205,013 41% D 23,005 65,687 123,434 0 38,673 64,180 317,209 25,639 21% D 20,546 62,755 92,469 23,320 41,277 69,232 309,598 276,394 21% <th>2006</th> <td>17</td> <td></td> <td>57,791</td> <td>108,496</td> <td>169,501</td> <td>170,266</td> <td>37,534</td> <td>26,625</td> <td>600,213</td> <td>174,179</td> <td>31,250</td> <td>56,025</td> <td>86,840</td> <td>348,293</td> <td>117,742</td> <td>102,907</td> <td>220,649</td>	2006	17		57,791	108,496	169,501	170,266	37,534	26,625	600,213	174,179	31,250	56,025	86,840	348,293	117,742	102,907	220,649
72% D 26,373 89,622 137,369 0 43,266 76,606 375,236 284,31 79% N 29,563 94,173 167,126 10,700 43,877 74,501 419,939 268,843 1121% N 67,953 78,915 145,364 23,540 37,974 63,446 417,193 187,770 1180% W 88,853 83,959 180,036 180,066 32,182 51,038 616,133 126,313 49% D 46,276 62,058 126,057 10,700 34,819 64,180 344,090 205,013 41% D 23,005 65,687 123,434 0 38,673 66,410 317,209 25,539 21% D 20,546 62,755 92,469 23,320 41,277 69,232 309,588 276,399 21% D 25,814 49,756 74,156 23,540 41,875 72,128 287,269 283,569	2007	4		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
79% N 29,633 94,173 167,126 10,700 43,877 74,501 419,939 268,843 121.% N 67,953 78,915 145,364 23,540 37,974 63,466 417,193 187,770 180% W 88,853 83,959 180,036 180,066 32,182 51,038 616,133 126,313 49% D 46,276 62,058 126,057 10,700 34,819 64,180 344,090 205,013 32% D 23,005 65,687 123,434 0 38,673 66,410 317,209 25,639 21% D 20,546 62,755 92,469 23,320 41,277 69,232 309,598 27,639 21% D 25,814 49,756 74,156 23,540 41,875 72,128 287,269 283,699 75% D 26,426 53,544 32,070 42,659 36,829 65,273 256,801 246,814 <	2008	7.		26,373	89,622	137,369	0	43,266	26,606	373,236	283,431	232,114	49,766	93,253	658,564	-210,701	-85,575	-296,277
121% N 67,953 78,915 145,364 23,540 37,974 63,466 417,193 187,770 180% W 88,853 83,959 180,036 180,066 32,182 51,038 616,133 126,313 49% D 46,276 62,058 126,057 10,700 34,819 64,180 344,090 205,013 32% D 23,005 65,687 123,434 0 38,673 66,410 317,209 25,639 21% D 20,546 62,755 92,469 23,320 41,277 69,232 309,598 27,639 21% D 25,814 49,756 74,156 23,540 41,875 72,128 287,269 283,699 75% D 26,426 53,544 32,070 42,659 36,829 65,273 256,801 24,814 91% 41,740 100,353 147,460 30,474 43,981 72,258 449,882 235,813	2009	7.5		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
180% W 88,853 83,959 180,036 180,066 32,182 51,038 616,133 126,313 49% D 46,276 62,058 126,057 10,700 34,819 64,180 344,090 205,013 41% D 23,005 65,687 123,434 0 38,673 66,410 317,209 25,639 21% D 20,546 62,755 92,469 23,320 41,277 69,232 309,598 276,394 21% D 25,814 49,756 74,156 23,540 41,875 72,128 287,269 283,699 75% D 26,426 53,544 32,070 42,659 36,829 65,273 256,801 248,557 96% 45,228 100,353 147,460 30,474 43,981 72,258 44,98,343 24,274 27,258 44,98,343	2010	12		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
49% D 46,276 62,058 126,057 10,700 34,819 64,180 344,090 205,013 41% D 23,005 65,687 123,434 0 38,673 66,410 317,209 25,639 21% D 20,546 62,755 92,469 23,320 41,277 69,232 309,598 276,394 21% D 25,814 49,756 74,156 23,540 41,875 72,128 287,269 283,699 75% D 26,426 53,544 32,070 42,659 36,829 65,273 256,801 248,557 96% 45,228 100,353 147,460 30,474 43,981 72,258 44,98,340 245,813	2011	18		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
41% D 23,005 65,687 123,434 0 38,673 66,410 317,209 225,639 32% D 20,546 62,755 92,469 23,320 41,277 69,232 309,598 276,394 21% D 25,814 49,756 74,156 23,540 41,875 72,128 287,269 283,699 75% D 26,426 53,544 32,070 42,659 36,829 65,273 256,801 248,557 91% 41,740 100,353 147,460 30,474 43,981 72,258 44,88,340 245,813 96% 45,228 100,389 160,307 29,435 42,274 72,258 44,98,812 235,813	2012	4,		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
32% D 20,546 62,755 92,469 23,320 41,777 69,232 309,598 276,394 21% D 25,814 49,756 74,156 23,540 41,875 72,128 287,269 283,699 75% D 26,426 53,544 32,070 42,659 36,829 65,273 256,801 248,557 91% 41,740 100,353 147,460 30,474 43,981 72,258 448,834 246,814 96% 45,228 100,389 160,307 29,435 42,274 72,258 449,892 235,813	2013	4.		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
21% D 25,814 49,756 74,156 23,540 41,875 72,128 287,269 283,699 75% D 26,426 53,544 32,070 42,659 36,829 65,273 256,801 248,557 91% 41,740 100,353 147,460 30,474 43,981 74,331 438,340 246,814 96% 45,228 100,389 160,307 29,435 42,274 72,258 449,892 235,813	2014	37.		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
75% D 26,426 53,544 32,070 42,659 36,829 65,273 256,801 248,557 91% 41,740 100,353 147,460 30,474 43,981 74,331 438,340 246,814 96% 45,228 100,389 160,367 29,435 42,274 72,258 449,892 235,813	2015	2.		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
91% 41,740 100,353 147,460 30,474 43,981 74,331 438,340 246,814 96% 45,228 100,389 160,307 29,435 42,274 72,258 449,892 235,813	2016	7.5		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
96% 45.228 100.389 160.307 29.435 42.274 72.258 449.892 235.813	1990-2016 Avg		%:	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		%5	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

Historical Evapotranspiration Demand, Tulare Lake Subbasin SGMA Model, Kings County, California Table 3-8.

Tulare Lake Subbasin	1990-1995 (AE/V)	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
T. Janes C. C. Carlotte and C. C. Carlotte and C. C. Carlotte and C. C. Carlotte and C. C. Carlotte and C. C. Carlotte and C. C. Carlotte and	(1/34/)	(1/14)	(41/1)	(41/14)	(1/14)	(41/17)	(1/14)	(41/11)	(1/14)	(1/14)	(41/17)	(1/14)	(1/14)	(1/14)
lulare 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	9		1		11
Carrot Single Crop								37	16	41	7	9	26	9
Citrus (no ground cover)			91		42	46	14	405	66	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	529	1,290	4,713	5,704	474
Pistachio (Mature)	15,229	12,354	12,341	17,831	2,680	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)											2	23	41	3
Pomegranates (Young)				11	303	66	52	901	210	376	237	292	746	141
Potatoes, Sugar beets, Turnip etc	18,604	4	929	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	6/	98	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	299	1,308
Tomatoes and Peppers	12,971	3,747	33,791	261	2	246	26	47,851	52,725	15,847	26,555	42,793	52,168	20,892
Urban, Industrial*														1
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*														1
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
	2000	102 070	1 050 551	1 072 443	1 002 603	1 010 305	002 018	762 584	735 624	741 315	698 299	564 117	929 679	888 148

Table 4-1. Groundwater Levels - Measurable Objectives, Minimum Thresholds, and Interim Milestones (elevation in feet above mean sea level)

Index	Well ID	МО	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

Table 4-1. Groundwater Levels - Measurable Objectives, Minimum Thresholds, and Interim Milestones (elevation in feet above mean sea level) (Continued)

Index	Well ID	МО	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

Table 4-1. Groundwater Levels - Measurable Objectives, Minimum Thresholds, and Interim Milestones (elevation in feet above mean sea level) (Continued)

Index	Well ID	мо	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

Table 4-2a. Land Subsidence @ Baseline - Measurable Objectives, Minimum Thresholds, and Interim Milestones – Lemoore RMS (feet of cumulative subsidence since 1990)

N 40	NAT		Inte	erim Milestones	;	
МО	MT	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	NAT		Inte	erim Milestones		
MO	MT	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)

МО	MT		Inter	im Milestones		
IVIO	IVII	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)

МО	MT		Inter	im Milestones		
IVIO	IVII	2017	2025	2030	2035	2040
8.90	11.5	4.51	4.49	4.54	4.59	4.57

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
Southwest Kings GSA El-Rico GSA	5 13	TBD TBD	0 1

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.

Table 5-2. Mid-Kings River GSA: Existing & Proposed Representative Monitoring Network

		М	id Kings Riv	er GSA			Facility				Aquifer Monitored
	State Well ID / System Well Number (if applicable)	Local Agency Well ID (if applicable)	Aquifer Zone	Township	Range	Section	Туре	Existing Program	Sustainability Indicator(s) ⁶	SGMA Monitoring Frequency	
	18S21E17N001M	18S21E17N001M	A Zone	185	21E	17	Unknown Use	KCWD	WL	Semiannual	Above A-Clay
	19S21E20N001M	19S21E20N001M	A Zone	195	21E	20	Unknown Use	KCWD	WL	Semiannual	Above A-Clay
		MW-A	B Zone	175	22E	1	Monitoring Well	KCWD	WL	Semiannual	Local
	17S22E28A001M	KRCDKCWD01	B Zone	175	22E	28	Irrigation Well	DWR	WL	Semiannual	Above E-Clay
	18S22E03B001M	18S22E03B001M	B Zone	185	22E	3	Unknown Use	KCWD	WL	Semiannual	Above E-Clay
	18S21E01C001M	18S21E01C001M	B Zone	185	21E	1	Unknown Use	KCWD	WL	Semiannual	Above E-Clay
	18S22E07A001M	18S22E07A001M	B Zone	185	22E	24	Unknown Use	USBR	WL	Semiannual	Above E-Clay
	18S22E24D001M	18S22E24D001M	B Zone	185	22E	24	Irrigation Well	Lakeside Irrigation WD	WL	Semiannual	Above E-Clay
ites	18S22E28A001M	KRCDKCWD08	B Zone	185	22E	28	Irrigation Well	KCWD	WL	Semiannual	Above E-Clay
ring 9	18S22E34R001M	18S22E34R001M	B Zone	185	22E	34	Residential	KDWCD	WL	Semiannual	Above E-Clay
Representative Monitoring Sites	19S22E07K001M	KRCDKCWD11	B Zone	195	22E	7	Unknown Use	Lakeside Irrigation WD	WL	Semiannual	Above E-Clay
tive N	18S21E27B001M	KRCDKCWD05	B Zone	185	21E	27	Irrigation Well	KCWD	WL	Semiannual	Above E-Clay
senta	18S21E07R003M	18S21E07R003M	B Zone	185	21E	7	Unknown Use	DWR	WL	Semiannual	Above E-Clay
epre	18S21E31B001M	18S21E31B001M	B Zone	185	21E	31	Unknown Use	KCWD	WL	Semiannual	Above E-Clay
-	19S21E30A001M	KRCDKCWD06	B Zone	195	21E	30	Irrigation Well	KCWD	WL	Semiannual	Above E-Clay
		MW-C	B Zone	175	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	185	22E	34	Monitoring Well	KCWD	WL	Semiannual	Above/Below E-Clay
	1610003-042/1	Well_48	C Zone	185	21E	13	Municipal Well	Hanford	WL/WQ ^{/3}	Semiannual	Below E-Clay
	1610003-037/1	Well 43	C Zone	185	21E	27	Municipal Well	Hanford	WL/WQ ^{/3}	Semiannual	Below E-Clay
	19S22E08D002M	19S22E08D002M	C Zone	195	22E	8	Observation	KDWCD	WL	Semiannual	Below E-Clay
	17S22E20D		B Zone	17S	22E	20	Domestic Well	ILRP	WQ ^{/4}	Annual	Above E-Clay ^{/5}
	17S22E33A		B Zone	175	22E	33	Domestic Well	ILRP	WQ ^{/4}	Annual	Above E-Clay ^{/5}
	18S21E14M		B Zone	185	21E	14	Irrigation Well	ILRP	WQ ^{/4}	Annual	Above E-Clay ^{/5}
	1610001-008			185	21E	32	Municipal Well	Armona CSD	WQ ^{/3}	Annual	
	1610001-009			195	21E	4	Municipal Well	Armona CSD	WQ ^{/3}	Annual	
	1610003-031		C Zone	185	21E	23	Municipal Well	Hanford	WQ ^{/3}	Annual	Below E-Clay
ites	1610003-039		C Zone	185	22E	30	Municipal Well	Hanford	WQ ^{/3}	Annual	Below E-Clay
ality S	1610003-036		C Zone	185	21E	22	Municipal Well	Hanford	WQ ^{/3}	Annual	Below E-Clay
Water Quality Sites	1610003-041			185	22E	19	Municipal Well	Hanford	WQ ^{/3}	Annual	
Wate	1610003-033		C Zone	185	21E	14	Municipal Well	Hanford	WQ ^{/3}	Annual	Below E-Clay
	1610003-040			185	21E	25	Municipal Well	Hanford	WQ ^{/3}	Annual	
	1610003-026			185	21E	36	Municipal Well	Hanford	WQ ^{/3}	Annual	
	1610003-038		C Zone	185	21E	14	Municipal Well	Hanford	WQ ^{/3}	Annual	Below E-Clay
	1610003-028		C Zone	185	21E	26	Municipal Well	Hanford	WQ ^{/3}	Annual	Below E-Clay
	1610003-043			185	22E	19	Municipal Well	Hanford	WQ ^{/3}	Annual	
	1610003-034			185	21E	23	Municipal Well	Hanford	WQ ^{/3}	Annual	
	1610003-034			185	21E	23	Municipal Well	Hanford	WQ ^{/3}	Annual	

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	Туре	Existing Program	Sustainability Indicator(s) ⁶	SGMA Monitoring Frequency	Aquifer Monitored
	SUB084			NA	NA	NA	Subsidence Monument	KRCD	LS	Semiannual	All
	K021			17S	22E	34	Subsidence Monument	KDWCD	LS	Semiannual	All
	S224P2			185	22E	28	Subsidence Monument	CHSRA	LS	Semiannual	All
	U 808			185	22E	29	Subsidence Monument	CalTrans	LS	Semiannual	All
Land Subsidence	U 511			185	22E	30	Subsidence Monument	CalTrans	LS	Semiannual	All
Subsi	X 511			185	21E	24	Subsidence Monument	CalTrans	LS	Semiannual	All
Land	U 157, SUB091			185	21E	36	Subsidence Monument	KRCD	LS	Semiannual	All
	Hanford RM1, SUB032			185	21E	36	Subsidence Monument	KRCD	LS	Semiannual	All
	X 931			185	21E	32	Subsidence Monument	CalTrans	LS	Semiannual	All
	N 460 RESET			185	21E	32	Subsidence Monument	CalTrans	LS	Semiannual	All
	SUB068			185	21E	31	Subsidence Monument	KRCD	LS	Semiannual	All
			B Zone	17S	22E	19	Monitoring Well		WL	Semiannual	Above E-Clay
			B Zone	175	22E	27	Monitoring Well		WL	Semiannual	Above E-Clay
S			B Zone	198	21E	16	Monitoring Well		WL	Semiannual	Above E-Clay
cilitie			B Zone	20S	21E	8	Monitoring Well		WL	Semiannual	Above E-Clay
sed Fa			C Zone	17S	21E	26	Monitoring Well		WL	Semiannual	Below E-Clay
Proposed Facilities			C Zone	185	22E	3	Monitoring Well		WL	Semiannual	Below E-Clay
-			C Zone	185	21E	3	Monitoring Well		WL	Semiannual	Below E-Clay
			C Zone	195	21E	8	Monitoring Well		WL	Semiannual	Below E-Clay
Notes			C Zone	195	21E	32	Monitoring Well		WL	Semiannual	Below E-Clay

- Representative Monitoring Sites that are also included for Water Quality

- Representative Monitoring Sites that are also included for Water Quality

 Proposed monitoring areas pending funding or collaboration with DWR or USGS

 State Water Resources Control Board Division (SWRCB) Division of Drinking Water (DDV)

 Kings River Water Quality Coalition (KRWQC), Irrigation Lands Regulatory Program (ILRP), samples annually, data will be retrieved annually

 Tentatively identified as B Zone Well
- Notes: /1 /2 /3 /4 /5 /6 WL -= water level, WQ = water quality, LS = land subsidence

Table 5-3. South Fork Kings GSA: Existing & Proposed Representative Monitoring Network

		South Fork K	ings River GSA				Facility			55144	
	State Well ID / System Well Number (if applicable)	Local Agency Well ID (if applicable)	Aquifer Zone	Township	Range	Section	Туре	Existing Program	Sustainability Indicator(s) ⁵	SGMA Monitoring Frequency	Aquifer Monitored
	18S20E23E003M ^{/1}	KRCDAC1S	A Zone	18S	20E	23	Monitoring Well	CASGEM	WL/WQ ^{/3}	Semiannual	Above A-Clay
	19S20E29E002M	19S20E29E002M	A Zone	195	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	185	20E	11	Municipal Well	Lemoore	WL/WQ ^{/3}	Semiannual	Above E-Clay
	18S20E23E002M ^{/1}	KRCDAC1M	B Zone	185	20E	23	Monitoring Well	CASGEM	WL/WQ ^{/4}	Semiannual	Above E-Clay
	18S20E23E001M	KRCDAC1D	B Zone	185	20E	23	Monitoring Well	CASGEM	WL	Semiannual	Above E-Clay
	18S20E34N001M	18S20E34N001M	B Zone	185	20E	34	Residential Well	DWR	WL	Semiannual	Above E-Clay
	19S20E06C001M	19S20E06C001M	B Zone	198	20E	6	Irrigation Well	DWR	WL	Semiannual	Above E-Clay
Sites	19S20E07F001M		B Zone	198	20E	7	Unknown Use	DWR	WL	Semiannual	Above E-Clay
oring	19S20E32D002M ^{/1}	KRCDAC3M	B Zone	195	20E	32	Monitoring Well	CASGEM	WL/ WQ ^{/4}	Semiannual	Above E-Clay
Jonit	19S20E32D003M	KRCDAC3D	B Zone	198	20E	32	Monitoring Well	CASGEM	WL	Semiannual	Above E-Clay
tive N	20S20E26L001M ^{/1}	KRCDAC5M	B Zone	20S	20E	26	Monitoring Well	CASGEM	WL/ WQ ^{/4}	Semiannual	Above E-Clay
senta	20S20E26L002M	KRCDAC5D	B Zone	20S	20E	26	Monitoring Well	CASGEM	WL	Semiannual	Above E-Clay
Representative Monitoring Sites	19S20E06L001M	19S20E06L001M	Composite	195	20E	6	Irrigation Well	DWR	WL	Semiannual	Above/Below E-Clay
	19S20E19A001M	19S20E19A001M	Composite	198	20E	19	Irrigation Well	DWR	WL	Semiannual	Above/Below E-Clay
	1610005-020/1	LEM_N-6	C Zone	185	20E	11	Municipal Well	Lemoore	WL/WQ ^{/3}	Semiannual	Below E-Clay
	1610005-011/1	LEM_12	C Zone	195	20E	9	Municipal Well	Lemoore	WL/ WQ ^{/4}	Semiannual	Below E-Clay
	19S20E26N002M	CU-ELEM SCHOOL	C Zone	195	20E	26	Municipal Well	Public Water Systems	WL	Semiannual	Below E-Clay
	20S19E02A001M	20S/19E-02A01	C Zone	205	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
	1610006-001		Composite	205	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			198	20E	8	Municipal Well	Lemoore	WQ ^{/3}	Annual	
6	1610005-007			195	20E	15	Municipal Well	Lemoore	WQ ^{/3}	Annual	
, Sites	1610005-010			185	20E	35	Municipal Well	Lemoore	WQ ^{/3}	Annual	
uality	1610005-003			185	20E	11	Municipal Well	Lemoore	WQ ^{/3}	Annual	
Water Quality Si	1610005-022			198	20E	8	Municipal Well	Lemoore	WQ ^{/3}	Annual	
Wa	1610005-005			185	20E	11	Municipal Well	Lemoore	WQ ^{/3}	Annual	
	1610005-018			198	20E	8	Municipal Well	Lemoore	WQ ^{/3}	Annual	
	1610005-008			195	20E	15	Municipal Well	Lemoore	WQ ^{/3}	Annual	
	1610005-006			198	20E	3	Municipal Well	Lemoore	WQ ^{/3}	Annual	
	19S20E11C			195	20E	11	Unknown Use		WQ	Annual	
	18S20E11D			185	20E	11	Public Well		WQ	Annual	

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	Туре	Existing Program	Sustainability Indicator(s) ⁵	SGMA Monitoring Frequency	Aquifer Monitored
	SOUTHFORK, SUB086			185	20E	16	Subsidence Monument	KRCD	LS	Semiannual	All
9	LEMA (RMS)			195	20E	10	Subsidence Monument	CVSRN	LS	Semiannual	All
iden											
Land Subsidence	G808	SUB028		195	19E	24	Subsidence Monument	CalTrans/KCRD	LS	Semiannual	All
La	SUB102			205	20E	18	Subsidence Monument	KRCD	LS	Semiannual	All
	SUB061			205	20E	21	Subsidence Monument	KRCD	LS	Semiannual	All
s	Proposed Well		A Zone	195	20E	32	Monitoring Well		WL	Semiannual	Above A-Clay
cilitie	Proposed Well		A Zone	20S	20E	26	Monitoring Well		WL	Semiannual	Above A-Clay
ed Fa	Proposed Well		B Zone	195	20E	26	Municipal Well		WL	Semiannual	Above E-Clay
Proposed Facilities	Proposed Well		C Zone	185	20E	27	Monitoring Well		WL	Semiannual	Below E-Clay
<u>-</u>	/2		All	198	20E	35	Extensometer		LS	Semiannual	All

Notes:

- /1 /2 /3 /4 /5
- Representative Monitoring Sites that are also included for Water Quality
 Proposed monitoring areas pending funding or collaboration with DWR or USGS
 State Water Resources Control Board Division (SWRCB) Division of Drinking Water (DDW)
 Kings River Water Quality Coalition (KRWQC), Irrigated Lands Regulatory Program (ILRP) samples annually, data will be retrieved annually
 WL -= water level, WQ = water quality, LS = land subsidence

Table 5-4. Southwest Kings GSA: Existing & Proposed Representative Monitoring Network

		Sout	thwest Kings GSA	4			Facility				
	State Well ID / System Well Number (if applicable)	Local Agency Well ID (if applicable)	Aquifer Zone	Township	Range	Section	Туре	Existing Program	Sustainability Indicator(s) ⁵	SGMA Monitoring Frequency	Aquifer Monitored
Representative Monitoring Sites	1610009-003/1	Becky Pease Well	B Zone	22\$	19E	19	Municipal Well	Kettleman City CSD	WL/WQ ^{/3}	Semiannual	Above E-Clay
Repre		Well 16-8	C Zone	215	19E	21	Irrigation Well		WL	Semiannual	Below E-Clay
Water Quality Sites	1610009-004	Maud St. Well	B Zone	225	19E	8	Municipal Well	Kettleman City CSD	WQ ^{/3}	Annual	Above E-Clay
a)	G 1445, SUB027			225	19E	30	Subsidence Monument	KRCD, California Aqueduct	LS	Semiannual	All
sidence	U 1097			225	19E	30	Subsidence Monument	California Aqueduct	LS	Semiannual	All
Land Subsidence	SUB030			245	19E	11	Subsidence Monument	KRCD	LS	Semiannual	All
يّ ا	SUB076			245	19E	36	Subsidence Monument	KRCD	LS	Semiannual	All
S			B Zone	215	19E	21	Monitoring Well		WL	Semiannual	Above E-Clay
Proposed Facilities	/2		B Zone	245	20E	19	Monitoring Well		WL	Semiannual	Above E-Clay
sed F			C Zone	225	19E	18	Monitoring Well		WL	Semiannual	Below E-Clay
Propo	/2		C Zone	235	20E	8	Monitoring Well		WL	Semiannual	Below E-Clay
	/2		C Zone	24S	20E	18	Monitoring Well		WL	Semiannual	Below E-Clay

- Representative Monitoring Sites that are also included for Water Quality
 Proposed monitoring areas pending funding or collaboration with DWR or USGS
 State Water Resources Control Board Division (SWRCB) Division of Drinking Water (DDW)
 Kings River Water Quality Coalition (KRWQC), Irrigated Lands Regulatory Program (ILRP) samples annually, data will be retrieved annually
 WL -= water level, WQ = water quality, LS = land subsidence
- Notes: /1 /2 /3 /4 /5

Table 5-5. El Rico GSA: Existing & Proposed Representative Monitoring Network

		Е	l Rico GSA				Facility				
	State Well ID / System Well Number (if applicable)	Local Agency Well ID (if applicable)	Aquifer Zone	Township	Range	Section	Туре	Existing Program	Sustainability Indicator(s) ⁵	SGMA Monitoring Frequency	Aquifer Monitored
	20S22E35R001M	20S22E35R001M	B Zone	205	22E	35	Irrigation Well	DWR	WL	Semiannual	Above E-Clay
		ER_S-225	C Zone	205	20E	32	Unknown Use		WL	Semiannual	Below E-Clay
tes		ER_S-173	C Zone	215	22E	25	Unknown Use		WL	Semiannual	Below E-Clay
Representative Monitoring Sites		ER_S-205	C Zone	225	22E	6	Unknown Use		WL	Semiannual	Below E-Clay
Monito		CID_078	C Zone	215	22	1	Unknown Use		WL	Semiannual	Below E-Clay
ntative	21S22E07J001M	21S22E07J001M	C Zone	215	22E	7	Observation	KDWCD	WL	Semiannual	Below E-Clay
epreser		CID 021	C Zone	20\$	22E	13	Irrigation Well	CID	WL	Semiannual	Below E-Clay
ž	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
ality	1610004-026			215	22E	12	Municipal Well	Corcoran	WQ ^{/3}	Annual	
Water-Quality	1610004-018			215	22E	2	Municipal Well	Corcoran	WQ ^{/3}	Annual	
_	1610004-019			215	22E	1	Municipal Well	Corcoran	WQ ^{/3}	Annual	
	S234P2			205	22E	16	Subsidence Monument	CHSRA	LS	Semiannual	All
dence	S238			215	22E	10	Subsidence Monument	CHSRA	LS	Semiannual	All
Land Subsidence	CRCN (RMS)			215	22E	11	Subsidence Monument	CVSRN	LS	Semiannual	All
Land	SUB083			225	22E	11	Subsidence Monument	KRCD	LS	Semiannual	All
-	SUB093			23S	23E	31	Subsidence Monument	KRCD	LS	Semiannual	All
			A Zone	205	21E	26	Monitoring Well		WL	Semiannual	Above A-Clay
			B Zone	205	21E	23	Monitoring Well		WL	Semiannual	Above E-Clay
			B Zone	20S	22E	21	Monitoring Well		WL	Semiannual	Above E-Clay
			B Zone	215	21E	21	Monitoring Well		WL	Semiannual	Above E-Clay
ties			B Zone	215	22E	9	Monitoring Well		WL	Semiannual	Above E-Clay
Proposed Facilities			C Zone	215	20E	10	Monitoring Well		WL	Semiannual	Below E-Clay
ropose			C Zone	215	21E	9	Monitoring Well		WL	Semiannual	Below E-Clay
-			C Zone	215	21E	27	Monitoring Well		WL	Semiannual	Below E-Clay
			C Zone	215	21E	21	Monitoring Well		WL	Semiannual	Below E-Clay
	/2		C Zone	225	21E	9	Monitoring Well		WL	Semiannual	Below E-Clay
	/2		C Zone	24S	21E	9	Monitoring Well		WL	Semiannual	Below E-Clay
Notes	/2		All	20S	22E	31	Extensometer		LS	Semiannual	All

Notes: /1 /2 /3 /4

Representative Monitoring Sites that are also included for Water Quality
Proposed monitoring areas pending funding or collaboration with DWR or USGS
State Water Resources Control Board Division (SWRCB) Division of Drinking Water (DDW)
Kings River Water Quality Coalition(KRWQC), Irrigated Lands Regulatory Program (ILRP) samples annually, data will be retrieved annually

Table 5-6. Tri-County Water Authority GSA Existing & Proposed Representative Monitoring Network

		Tri County	Water Authority	/ GSA			Facility				
	State Well ID / System Well Number (if applicable)	Local Agency Well ID (if applicable)	Aquifer Zone	Township	Range	Section	Туре	Existing Program	Sustainability Indicator(s) ⁵	SGMA Monitoring Frequency	Aquifer Monitored
ive	23S23E15M001M		A Zone	235	23E	15	Unknown Use	DWR	WL	Semiannual	Above A-Clay
Representative Monitoring Sites	24S22E35E001M		C Zone	245	22E	35	Unknown Use	DWR	WL	Semiannual	Below E-Clay
Rep	24S22E33C001M		C Zone	245	22E	33	Unknown Use	DWR	WL	Semiannual	Below E-Clay
sidence	SUB107			235	21E	18	Subsidence Monument	KRCD	LS	Semiannual	All
Land Subsidence	SUB038			245	22E	34	Subsidence Monument	KRCD	LS	Semiannual	All
ities			B Zone	245	22E	24	Monitoring Well		WL	Semiannual	Above E-Clay
Proposed Facilities			B Zone	235	23E	16	Monitoring Well		WL	Semiannual	Below E-Clay
Prop			C Zone	235	23E	16	Monitoring Well		WL	Semiannual	Above E-Clay

Notes: /1 /2 /3 /4 /5 Representative Monitoring Sites that are also included for Water Quality
Proposed monitoring areas pending funding or collaboration with DWR or USGS
State Water Resources Control Board Division (SWRCB) Division of Drinking Water (DDW)
Kings River Water Quality Coalition (KWRQC), Irrigated Lands Regulatory Program (ILRP) samples annually, data will be retrieved annually
WL -= water level, WQ = water quality, LS = land subsidence

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	AF/Y or CFS
Groundwater Flows	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

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

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		

Project and Management Actions Table 6-5.

§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 schaduled 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.

#	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)
m	Existing Infrastructure and/or Rehabilitation of New Construction	The Subbasin may adopt efforts to fund projects to rehabilitate existing facilities and construct new 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 sproject would any year out. However, the funding for the project is not yet certain.

#	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)
rv	Agricultura I 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 in wet years available for this area as well as the infrastructure to deliver it.
9	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	umplementation will occur after GSP approval and androwner 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 acrefect.	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 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.

#	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)
Assection 1	Assessment Pumpling fees for groundwater alrocation 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 acrefect.	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 SGNAA 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 overextractors 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. Intial 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.
7	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, lew 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. In itial 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.
1 1	Groundwater Allocation Hood Flows (spills into the Subbasin) include Tule River 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.

Level of Uncertainty Associated with the Basin Setting, 1=uncertain 5=certain (d)	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.	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.
Management of Groundwater Extraction and Recharge (b)(9)	Chronic lowering of groundwater levels or depletion of supply during periods of drought may be eliminated by implementation of sustainable change in groundwater allocation.	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.
Cost and Funding Options (b)(8)	Estimated \$100,000 cost to draft and adopt policy.	Estimated cost is \$100,000 to draft and adopt policy.
Explanation of Water Source and Reliability (b)(6)	The management action may be accomplished by Subbasin policy adoption. No external water source is used.	The management action may be accomplished by Subbasin policy adoption. No external water source is used.
Explanation of Benefits and Method of Evaluation (b)(5)	The expected benefits may mitigate overdraft by ensuring groundwater supplies are withdrawn in a sustainable manner. Extractions will be monitored.	The expected benefits include utilizing groundwater supplies within the Subbasin. Encourage demand reduction through fallowing. Groundwater levels and marketed volumes will be evaluated.
Status, Start, End, and Accrual of Benefits (b)(4)	Policy to be written by 2023 and implemented by 2025 and can be revised as needed.	The water marketing strategy grant has been approved by the USBR; Funding opportunity to close in May of 2019. Other grant solicitations are expected.
Permitting & Regulatory Process (b)(3)	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.	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.
Quantification of Demand Reduction (b)(2)	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.	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 will be used as the
Gircumstances of Implementation (b)(1)(A)	Policy to be written by 2023 and implemented by 2025.	Policy to be written by 2023 and implemented by 2025.
Measurable Objective (b)(1)	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 acreextraction in acreefect.	The goal is to set policy that policy that encourages water marketing within the Subbasin willed not causing undesirable results.
Description (b)(1)	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 Beachies or individual landowners.	This policy will include groundwater marketing. Marketing will include groundwater from within the Subbasin with options to market within the GSAs, between GSAs.
Management Action (b)(1) *	Development of groundwater allocation	Groundwater
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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)	Uncertainty Associated with the Basin Setting, 1=uncertain 5=certain (d)
1	1 Require new developments (non-de mininis 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 masures 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/dity to ensure the Subbasin has had the opportunity to review and comment on the environmental documents prior to county/dity approval. The Subbasin GSAs have the power as have the power as and related provisions to adopt ordinances. Potential incorporation into a peer review process.	Policy to be written and implemented by 2023.	The expected benefits 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 courtly/city. The Subasin may request county/city development procedures to include the circulation of environments 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 adata collection 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.
Monito	Monitoring Reporting											
1	Flood Flows (spills into the Subbasin) include Tule River, Deer Creek, Cross-Creeks and Kings	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 permits 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.

Level of Uncertainty Associated with the Basin the Basin Setting, 1 = uncertain 5 = certain (d)	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.	Level of uncertainty of uncertainty of the project is 3; ne in wet years there is water available for this area as well as the infrastructure to deliver it.
Management of Groundwater Extraction and Recharge (b)(9)	Fill data gaps and include this information in the calculation of the groundwater extraction proportionate share.	Fill data gaps and include this information in the calculation of the groundwater extraction proportionate share.
Cost and Funding Options (b)(8)	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.	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.
Explanation of Water Source and Reliability (b)(6)	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.	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.
Explanation of Benefits and Method of Evaluation (b)(5)	The expected benefits may mitigate overdraft by improving the Subasin'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 expected benefits may mitigate overdraft by improving the Subbasin's knowledge of groundwater extractions, 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 fillling data gaps.
Status, Start, End, and Accrual of Benefits (b)(4)	Policy to be written and implemented in 2023.	Policy to be written and implemented in 2023.
Permitting & Regulatory Process (b)(3)	The regulatory process may require cooperation from the county to ensure new well permits issued within the Subbasin adhere to the Subbasin policy. The Subbasin has the power as outlined in SGMA and related provisions to adopt ordinances.	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 penalities, and charge administrative fees.
Quantification of Demand Reduction (b)(2)	This policy will help fill data gaps and give a better understanding of the groundwater within the Subbasin.	This policy will help fill data gaps and give a better understanding of the groundwater within the Subbasin.
Circumstances of Implementation (b)(1)(A)	The policy may be implemented shortly after the adoption of the GSP and remain until the Subbasin's overfarft has ended or indefinitely. The county must also support the policy.	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.
Measurable Objective (b)(1)	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 goal is to improve the Subbasin's database of groundwater extractions, water level and quality monitoring network, and serve other management actions.
Description (b)(1)	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 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.
Management Action (b)(1) *	Registration of extraction facilities	Require self- reporting of groundwater extraction, water level, and water quality data
#	2	m

#	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)
	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 groundation of the extraction proportionate share.	Level of uncertainty of the project is 3; in wet years in wet years there is water available for this area as well as the infrastructure to deliver it.
	Existing Contracts Flood Flows (spills into the Subbasin) include Tule River, Deer 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 pollo. SVRCB is paying close attention to policies within a GSA that perfain 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.

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Note: The following sections were noted below because they apply to all management actions with very little variance.

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Public Notice (1)(1): The Subbasin may provide public notice may the provided to any person who requests email available on the Subbasin sorted may be provided to any person who requests email to notifications. The Subbasin shaden development of related provisions to adopt ordinances, levy financial penalties, and enforce programs.

Legal Authority (b)(7): The Subbasin administrative and operating costs may be funded through various financial avenues discussed further in GSP Chapter 7.2.

Table 7-1. Proposed SFK GSA GSP Implementation Timeline

	Current Year (2020)	YEAR 1	YEAR 1 (2021)	YEAR	YEAR 2 (2022)	YEAI	YEAR 3 (2023)	YEA	YEAR 4 (2024)
	Q1/2	Q3/4	Q1/2	Q3/4	Q1/2	Q3/4	Q1/2	Q3/4	Q1/2
			Administr	Administrative Actions					
Pumping Measurement Program	Landowner Well Survey	II Survey	Adopt measurement		Land		Land		Land
Land Use/Land Cover Program	Land Cover & Demand Study	nand Study	standards and reporting requirements		Use/Metering Update		Use/Metering Update		Use/Metering Update
Groundwater Accounting Program			Accounting Program White Paper	Public Outreach	Adopt GW Accounting System	Public Outreac h			
Monitoring Program									
Data Management Program	Annual Report		Annual Report		Annual Report		Annual Report		Annual Report
Annual Reports									
KRCD Admin + Legal									
GSP 5-Year Update									
	State/Federal							Adopt	
Funding Activities	Private/Foundation/ NGO						Current Funding Sunsets	New Funding	
	Other Mechanisms							Method	

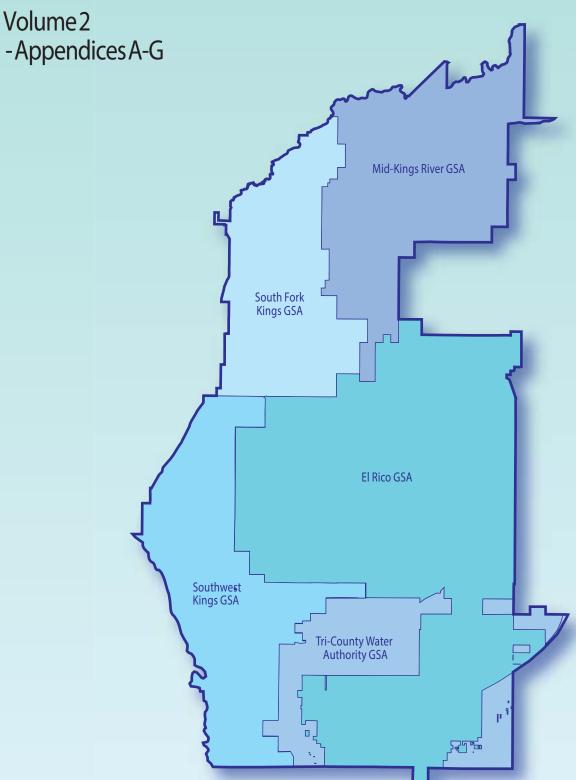
Table 7-1. Proposed SFK GSA GSP Implementation Timeline (Continued)

	Current Year (2020)	YEAR 1 (2021)	(2021)	YEAR	YEAR 2 (2022)	YEAR	YEAR 3 (2023)	YEAR	YEAR 4 (2024)
	Q1/2	Q3/4	Q1/2	Q3/4	Q1/2	Q3/4	Q1/2	Q3/4	Q1/2
			Demand Re	Demand Reduction Actions	us				
SW Delivery Improvements	SW Delivery Agreements	Surface Water Efficiency Study	:fficiency 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/Fallo	Public Outreach	Develop On- Farm Efficiency Targets and Dry- Farming/Fallo wing Program	Surfac Impro Impler	Surface Water Improvement Implementation	Surfa Impr Imple	Surface Water Improvement Implementation
			Supply Enhar	Supply Enhancement Actions	suc				
Aquifer Storage and Recovery	Work Plan			ASR Pilot Test		ASR	ASR CEQA	ASR Imp	ASR Implementation
Surface Recharge			- (Approve				
Surface Storage		Review & Coord Projects in Surr	Review & Coordinate Recharge Projects in Surrounding Basins		Surface Recharge Investments				

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

Tulare Lake Subbasin Groundwater Sustainability Plan



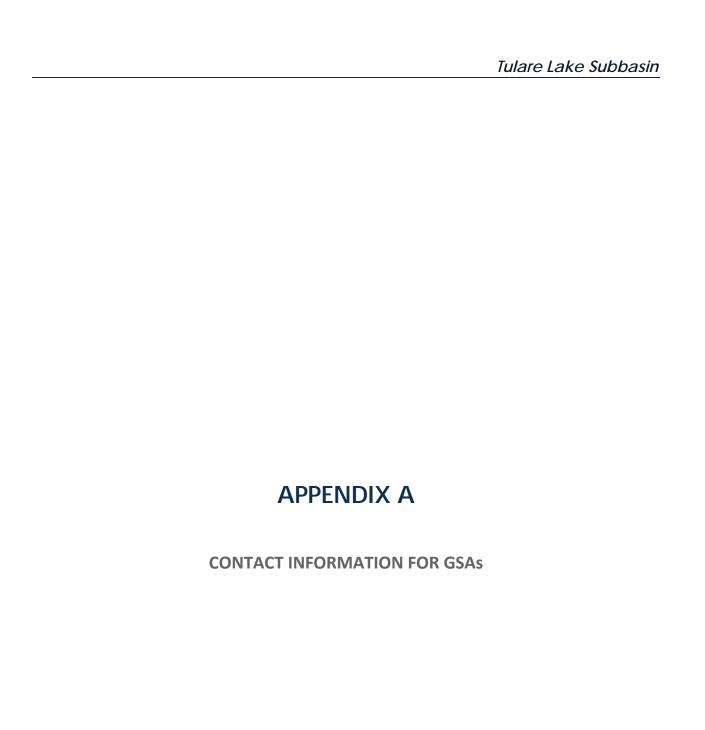












APPENDIX A

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 & 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.

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

Table 6. Tulare Lake Subbasin GSAs' Websites

- 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	 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) 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) 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) How knowledgeable do you consider yourself of local water issues? (Circle one – Extremely Knowledgeable to Not Very Knowledge) How knowledgeable do you consider yourself of the new groundwater regulation, the Sustainable Groundwater Management Act? (Circle one – Extremely Knowledgeable to Not Very Knowledge) Are you currently engaged in activity or discussions regarding groundwater management in your area? How important to you is information on anticipated impacts of new state regulations. (Circle one – Extremely Important to Not Very Important) 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) 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, mu		
Southwest Kings GSA	 Are you familiar with Sustainable Groundwater Management Act (SGMA) regulations? Are you currently engaged in activity of discussions regarding groundwater management in this region? Do you own or manage/operate land in this region? Do you manage water resources? If yes, what is your role? What is your primary interest in land or water resources management? Do you have concerns about groundwater management? If so, what are they? 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, 1	Notifications, F	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	
The Corcoran Journal	September 5, 2019; September 12, 2019	Notice of Public Review of Tulare Lake Subbasin
Hanford Sentinel	September 3, 2019; September 10, 2019	Draft GSP
Visalia Times Delta	September 3, 2019; September 10, 2019	
The Bakersfield Californian	October 19, 2019; October 25, 2019	
The Corcoran Journal	October 24, 2019; October 31, 2019	Notice of Public Hearing on Tulare Lake Subbasin
Hanford Sentinel	October 18, 2019; October 25, 2019	Draft GSP, scheduled for December 2, 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.

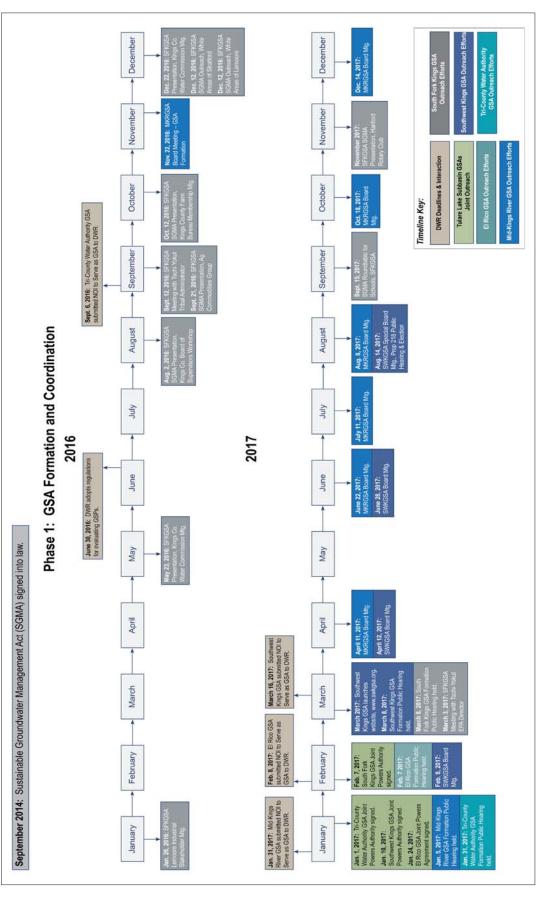


Figure 1. Tulare Lake Subbasin Communication & Engagement Timeline - Phase 1: GSA Formation and Coordination

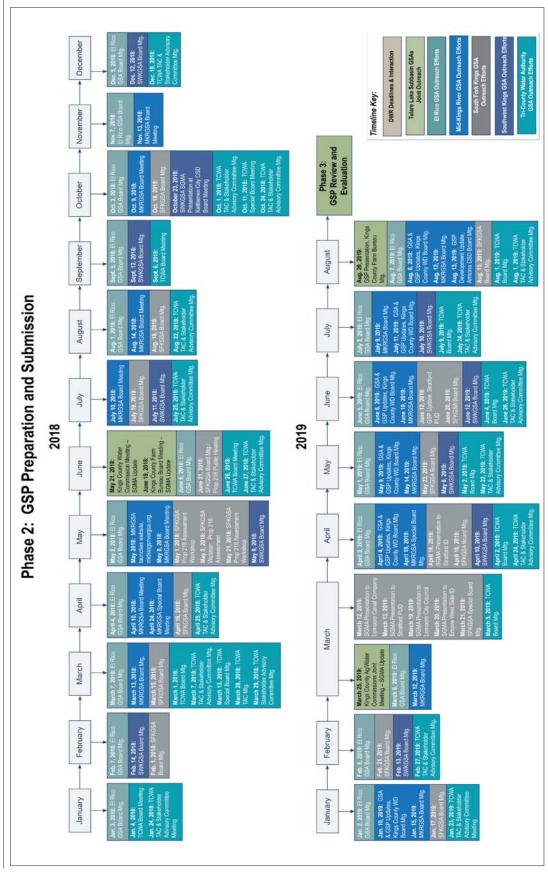


Figure 2. Tulare Lake Subbasin Communication & Engagement Timeline – Phase 2: GSP Preparation and Submission

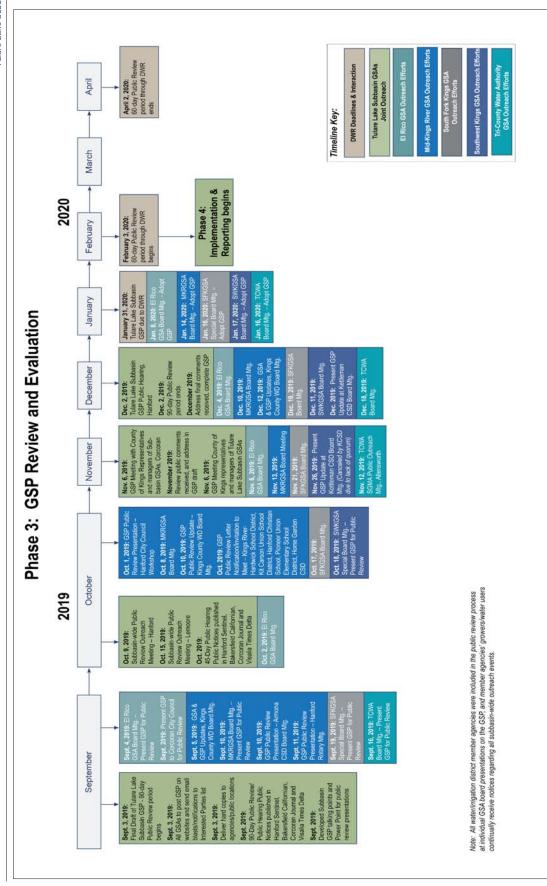


Figure 3. Tulare Lake Subbasin Communication & Engagement Timeline – Phase 3: GSP Review and Evaluation

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

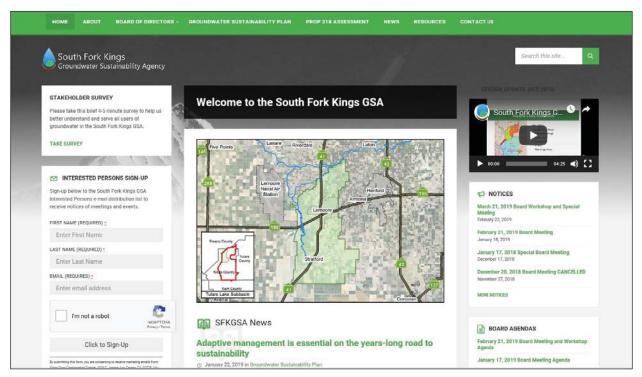
Event	Date
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., September 10, 2019
GSP Public Review Presentation at Armona CSD Board Meeting	6 p.m., September 10, 2019
GSP Public Review Presentation at Hanford Rotary Meeting	5:30 p.m., September 11, 2019
GSP Public Review Update – Kings County 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

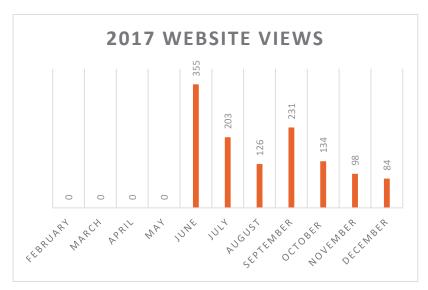


Table 14. 2018 SFKGSA Website Views

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

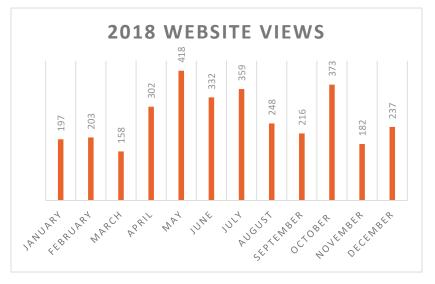
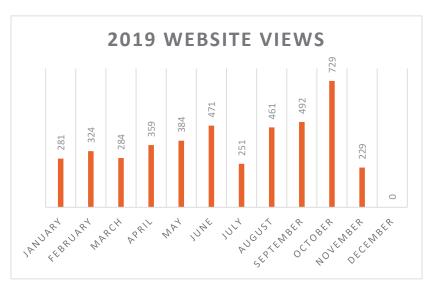


Table 15, 2019 SFKGSA Website Views

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



Southwest Kings Groundwater Sustainability Agency

With the passage of the California Sustainable Groundwater Management Act ("SGMA") in 2014, the Southwest Kings Groundwater Sustainability Agency ("SWKGSA") and its Board of Directors are participating in the implementation of the SGMA regulations and working to protect the interests of landowners within the SWKGSA boundaries. The SWKGSA is taking an active role in helping its landowners understand and comply with these new regulations as they are put into place.

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/news/; Calendar http://tcwater.org/news/; Calendar http://tcwater.org/news/;
- Contact the GSA



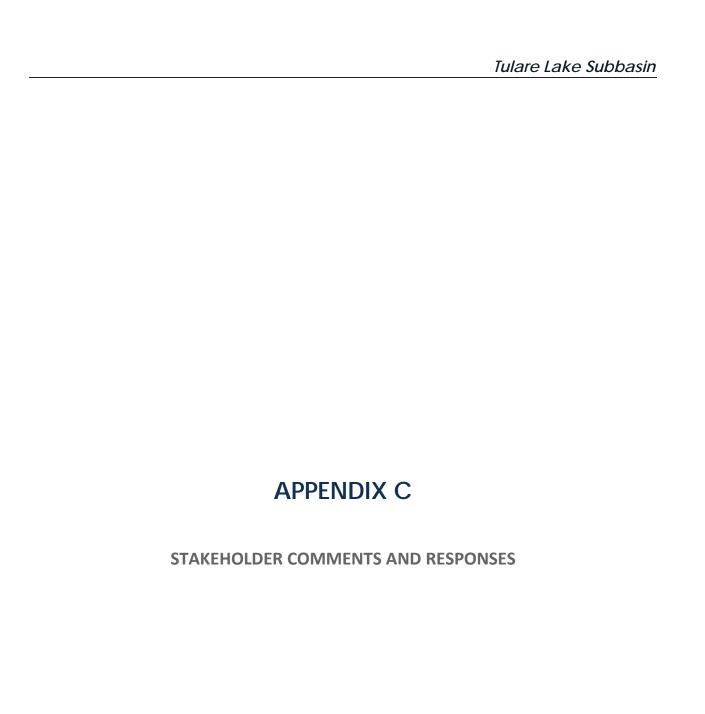
Picture 4. Screenshot of http://tcwater.org Homepage

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 - 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.

<u>Response:</u> 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.

<u>Response:</u> 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.

<u>Response:</u> 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 aguifer 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) aguifer 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 aguifers.

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.

Response: 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?

Response: 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?

Response: 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:

<u>Comment 1:</u> 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.

<u>Comment 3:</u> 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.



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!

1

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

2

RECEIVED K.R.C.D.

OCT 1 5 2019

South Fork Kings Groundwater Sustainability Agency 4886 E Jensen Avenue Fresno, CA 93725

File No.

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 rerouted 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

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

<u>GroundwaterResourceHub.org</u>. 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 groundwaterdependent 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-relatedto-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 online² 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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¹GDEs 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 Lookbook³ 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.

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 $^{^{3} \} Available \ online \ at: \ \underline{https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/}$

Thank you for fully considering our comments as you develop your GSP.

Best Regards,

Sandi Matsumoto

Associate Director, California Water Program

The Nature Conservancy



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 no	ot guarantee approv	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.	ntrol Board.
GSP P	GSP Plan Element*	GDE Inclusion in GSPs: Identification and Consideration Elements	Check Box
nimbA oîn l	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
	212to 214	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
ninnsI9 wemer	Description of Plan Area 23 CCR §354.8	Description of instream flow requirements, threatened and endangered species habitat, critical habitat, and protected areas.	ε
		Summary of process for permitting new or replacement wells for the basin, and how the process incorporates any protection of GDEs	4
	2.2.1	Basin Bottom Boundary: Is the bottom of the basin defined as at least as deep as the deepest groundwater extractions?	5
	Hydrogeologic Conceptual Model	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?	9
guiti	23 CCR §354.14	Basin cross sections: Do cross-sections illustrate the relationships between GDEs, surface waters and principal aquifers?	7
əs u	2.2.2	Interconnected surface waters:	8
issa	Current & Historical Groundwater	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).	6
	Conditions 23 CCR §354.16	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



12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Basin GDE map denotes which polygons were kept, removed, and added from NC Dataset (Worksheet 1, can be attached in GSP section 6.0).	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).	GDEs polygons are consolidated into larger units and named for easier identification throughout GSP.	Description of why NC dataset was not used, and how an alternative dataset and/or mapping approach used is best available information.		Historical and current groundwater conditions and variability are described in each GDE unit.	Historical and current ecological conditions and variability are described in each GDE unit.	rized as having high, moderate, or low ecological value.	Inventory of species, habitats, and protected lands for each GDE unit with ecological importance (Worksheet 2, can be attached in GSP section 6.0).	(e.g., evapotranspiration) of native vegetation and managed wetlands are included in the er budget.	conditions due to land use changes, climate change, and population growth to GDEs and din the projected water budget.	epresentatives were consulted.	Sustainability goal mentions GDEs or species and habitats that are of particular concern or interest.	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.	considered and whether the measurable objectives and interim milestones will help as it pertains to the environment.	Description of how GDEs and environmental uses of surface water were considered when setting minimum thresholds for relevant sustainability indicators:	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?	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?	e compiled and synthesized for each GDE unit:	Hydrological datasets are plotted and provided for each GDE unit (Worksheet 3, can be attached in GSP Section 6.0).	Baseline period in the hydrologic data is defined.
	If NC Dataset was used:		If NC Dataset was not used:	Description of GDEs included:	Historical and current groundwat	Historical and current ecological	Each GDE unit has been characterized	Inventory of species, habitats, ar in GSP section 6.0).	Groundwater inputs and outputs (e.g., evapotranspiration) basin's historical and current water budget.	Potential impacts to groundwater conditions due aquatic ecosystems are considered in the projecte	Environmental stakeholders/repre	Sustainability goal mentions GDE	Sustainability goal mentions whether the intention is to address por species and habitats that are of particular concern or interest.	Description of how GDEs were con: achieve the sustainability goal as i	Description of how GDEs and environmental unthresholds for relevant sustainability indicators:	Will adverse impacts to GDEs and/or aquatic ecosystems d water) be avoided with the selected minimum thresholds?	Are there any differences between the or habitats residing in GDEs or aquation	For GDEs, hydrological data are co	If hydrological data are available	within/nearby the GDE
									2.2.3	23 CCR §354.18	3.1	Sustainability Goal	23 CCR §354.24	3.2 Measurable Objectives 23 CCR §354.30	3.3	Minimum Thresholds	23 CCR §354.28	8.4	Undesirable Results	23 CCR §354.26
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			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	Data gaps/insufficiencies are described.	35
		within/nearby the GDE	Plans to reconcile data gaps in the monitoring network are stated.	36
		For GDEs, biological data are com	For GDEs, biological data are compiled and synthesized for each GDE unit:	37
		Biological datasets are plotted and proof trends and variability.	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	d.	39
		Plans to reconcile data gaps in the mor	nitoring network are stated.	40
		Description of potential effects on	GDEs, land uses and property interests:	41
		Cause-and-effect relationships between	en GDE and groundwater conditions are described.	42
		Impacts to GDEs that are considered to be "significant and unreasonable"	o be "significant and unreasonable" are described.	43
		Known hydrological thresholds or trigg significant impacts to relevant species	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 recreat	tional uses (e.g., fishing/hunting, hiking, boating).	45
		Property interests include and consider privat wildlife refuges, parks, and natural preserves.	Property interests include and consider privately and publicly protected conservation lands and opens spaces, including wildlife refuges, parks, and natural preserves.	46
ţu€	c u	Description of whether hydrological darage GDE unit.	ita are spatially and temporally sufficient to monitor groundwater conditions for each	47
ainab geme iteria	Monitoring	Description of how hydrological data g	laps and insufficiencies will be reconciled in the monitoring network.	48
Mana	23 CCR §354.34	Description of how impacts to GDEs and monitored and which GDE monitoring me relationships with groundwater conditions.	and environmental surface water users, as detected by biological responses, will be methods will be used in conjunction with hydrologic data to evaluate cause-and-effect ons.	49
:	4.0. Projects & Mgmt Actions to	Description of how GDEs will benefit f	Description of how GDEs will benefit from relevant project or management actions.	20
etoelor9 ImgM noitoA	Achieve Sustainability Goal	Description of how projects and mana mitigated or prevented.	igement actions will be evaluated to assess whether adverse impacts to the GDE will be	51
	20 CCR 8004:44			

* 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

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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 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 Lookbook⁴ 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.

Checklist Items 5 to 7 - Hydrogeologic Conceptual Model (23 CCR §354.14)

[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 aguifer. 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.
 - 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.

Checklist Items 11 to 15 - Identifying and Mapping GDEs (23 CCR §354.16)

[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;
 - 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:

- 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.
- 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.
- 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-depthsdatabase-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 some or all 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 emerging from aquifers or on groundwater occurring near 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 thought to rely on surface water and the perched areas are thought to not be directly 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 retained until data gaps are reconciled.

Checklist Items 16 to 20 - Describing GDEs (23 CCR §354.16)

[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.

Checklist Items 21 and 22 - Water Budget (23 CCR §354.18)

[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 all 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.

Checklist Item 26 - Measurable Objectives (23 CCR §354.30)

[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.

Checklist Item 27-29 - Minimum Thresholds (23 CCR §354.28)

[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.

Checklist Item 30-46 - Undesirable Results (23 CCR §354.26)

[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.
 - 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</u> <u>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/

[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. 2015⁵. 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 BIOS⁶ as well as on TNC's science website⁷.

	Legally Protected Status				
Scientific Name	Common Name	Federal	State	Other	
	BIRD	S			
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 mama Aythya valisineria	Canvasback		SSC	
			330	
Botaurus lentiginosus	American Bittern Bufflehead			
Bucephala albeola				
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	Bonaparte's Gull			
philadelphia				
Cistothorus palustris	Marsh Wren			
palustris				
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	Black-necked Stilt			
mexicanus				
Icteria virens	Yellow-breasted Chat		SSC	BSSC - Third
Limnodromus				priority
	Long-billed Dowitcher			priority
scolopaceus	Long-billed Dowitcher			priority
scolopaceus Lophodytes cucullatus				priority
Lophodytes cucullatus	Hooded Merganser			priority
Lophodytes cucullatus Megaceryle alcyon	Hooded Merganser Belted Kingfisher			priority
Lophodytes cucullatus Megaceryle alcyon Mergus merganser	Hooded Merganser Belted Kingfisher Common Merganser			priority
Lophodytes cucullatus Megaceryle alcyon	Hooded Merganser Belted Kingfisher Common Merganser Red-breasted			priority
Lophodytes cucullatus Megaceryle alcyon Mergus merganser Mergus serrator	Hooded Merganser Belted Kingfisher Common Merganser Red-breasted Merganser			priority
Lophodytes cucullatus Megaceryle alcyon Mergus merganser Mergus serrator Numenius americanus	Hooded Merganser Belted Kingfisher Common Merganser Red-breasted Merganser Long-billed Curlew			priority
Lophodytes cucullatus Megaceryle alcyon Mergus merganser Mergus serrator Numenius americanus Numenius phaeopus	Hooded Merganser Belted Kingfisher Common Merganser Red-breasted Merganser Long-billed Curlew Whimbrel			priority
Lophodytes cucullatus Megaceryle alcyon Mergus merganser Mergus serrator Numenius americanus	Hooded Merganser Belted Kingfisher Common Merganser Red-breasted Merganser Long-billed Curlew			priority

Pelecanus	American White		SSC	BSSC - First
erythrorhynchos	Pelican		330	priority
Phalacrocorax auritus	Double-crested			priority
Trialder George durings	Cormorant			
Phalaropus tricolor	Wilson's Phalarope			
Plegadis chihi	White-faced Ibis		Watch list	
Pluvialis squatarola	Black-bellied Plover		vvacen nsc	
Podiceps nigricollis	Eared Grebe			
Podilymbus podiceps	Pied-billed Grebe			
Porzana carolina	Sora			
Rallus limicola	Virginia Rail			
Recurvirostra	American Avocet			
americana	American Avocet			
Riparia riparia	Bank Swallow		Threatened	
Setophaga petechia	Yellow Warbler		Timeateriea	BSSC - Second
Setophaga peteema	Tellow Warblet			priority
Tachycineta bicolor	Tree Swallow			priority
Tringa melanoleuca	Greater Yellowlegs			
Tringa semipalmata	Willet			
Tringa solitaria	Solitary Sandpiper			
Xanthocephalus	Yellow-headed		SSC	BSSC - Third
xanthocephalus	Blackbird		330	priority
Adminiscophialas	CRUSTAC	FANS		priority
Branchinecta lindahli	Versatile Fairy Shrimp			
Dranelinicota inidami	HERP	S		
Actinemys marmorata	Western Pond Turtle		SSC	ARSSC, BLM,
marmorata				USFS
Ambystoma	California Tiger	Threatened	Threatened	ARSSC
californiense	Salamander			
californiense				
Anaxyrus boreas	Boreal Toad			
boreas				
Spea hammondii	Western Spadefoot	Under	SSC	ARSSC, BLM
		Review in		
		the		
		Candidate		
		or Petition		
		Process		
Thamnophis sirtalis	Common Gartersnake			
sirtalis				
	INSECTS AND OTHER	INVERTEBRAT	TES	I
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	baetis spp.		Not on any
columbiella			status lists
Caudatella spp.	Caudatella spp.		Status lists
• • • • • • • • • • • • • • • • • • • •			
Cinygmula gartrelli	A Mayfly		
Cinygmula spp. Doroneuria baumanni	Cinygmula spp. Cascades Stone		
Drunella coloradensis	A Mayfly		
Drunella doddsii	A Mayfly		
Drunella spinifera	A Mayfly		
Drunella spp.	Drunella spp.		
Enallagma	Tule Bluet		
carunculatum			
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			Not on any
corpulentus			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	SSC	
	Riffle Beetle		
Optioservus spp.	Optioservus spp.		
Oroperla barbara	Gilltail Springfly		
Pachydiplax	Blue Dasher	 	
longipennis			
Pantala flavescens	Wandering Glider		
Pantala hymenaea	Spot-winged Glider		
Parapsyche almota	A Caddisfly		
Parapsyche elsis	A Caddisfly		

Parapsyche spp.	Parapsyche spp.			
Rhionaeschna	Blue-eyed Darner			
multicolor				
Rhithrogena decora	A Mayfly			
Rhithrogena spp.	Rhithrogena spp.			
Rhyacophila	A Caddisfly			Not on any
acuminata				status lists
Rhyacophila spp.	Rhyacophila spp.			
Simulium anduzei	, acopa opp.			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			
	MAMM	ALS		
Castor canadensis	American Beaver			Not on any
				status lists
Ondatra zibethicus	Common Muskrat			Not on any
				status lists
	MOLLU	SKS		
Anodonta	California Floater		SSC	USFS
californiensis				
	PLAN'	TS		
Cephalanthus	Common Buttonbush			
occidentalis				
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	NA			Not on any
peploides				status lists
Myosurus minimus	NA			
Persicaria lapathifolia				Not on any
				status lists
Rorippa palustris palustris	Bog Yellowcress			
Salix gooddingii	Goodding's Willow			
Camin go carannigh	FISHE	S		
Catostomus	Sacramento sucker			Least Concern
occidentalis				- Moyle 2013
occidentalis				
Cottus asper ssp. 1	Prickly sculpin			Least Concern
				- Moyle 2013
Lavinia exilicauda	Sacramento hitch		SSC	Near-
exilicauda				Threatened -
				Moyle 2013
Oncorhynchus mykiss	Coastal rainbow trout			Least Concern
irideus				- Moyle 2013
Oncorhynchus	Central Valley fall	SSC	SSC	Vulnerable -
tshawytscha - CV fall	Chinook salmon			Moyle 2013
Oncorhynchus	Central Valley late fall	SSC		Endangered -
tshawytscha - CV late	Chinook salmon			Moyle 2013
fall				
Orthodon	Sacramento blackfish			Least Concern
microlepidotus				- Moyle 2013
Ptychocheilus grandis	Sacramento			Least Concern
Notoci	pikeminnow			- Moyle 2013

Notes:

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

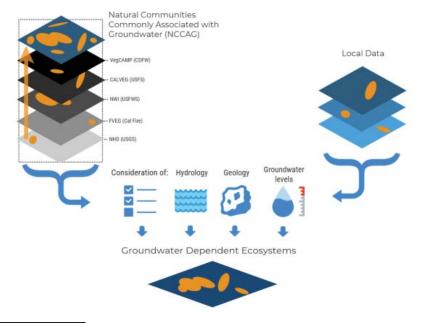


July 2019



IDENTIFYING GDEs UNDER SGMABest 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 California¹⁰. 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 dataset¹¹ on the Groundwater Resource Hub¹², 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.

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/qde-tools/qsp-quidance-document/

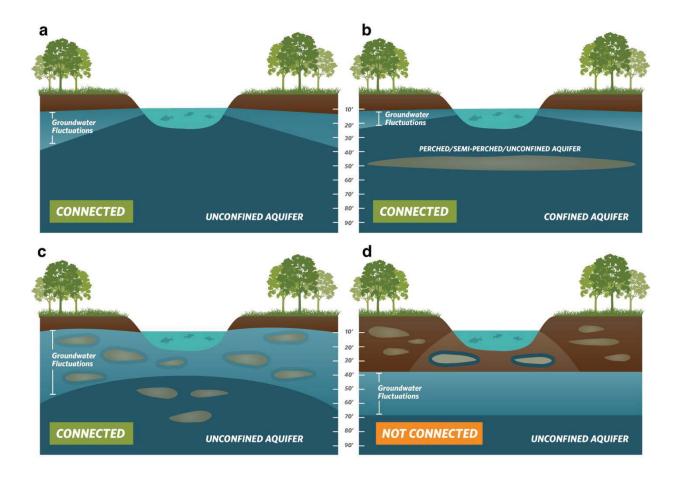


Figure 2. Confirming whether an ecosystem is connected to groundwater. Top: (a) Under the ecosystem is an unconfined aquifer with depth-to-groundwater fluctuating seasonally and interannually within 30 feet from land surface. (b) Depth-to-groundwater in the shallow aquifer is connected to overlying ecosystem. 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 budgets¹³ 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 baseline¹⁴ 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 approach¹⁵ 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 document⁴, 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 feet⁴ 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 Viewer¹⁶. However, if insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network (see Best Practice #6).

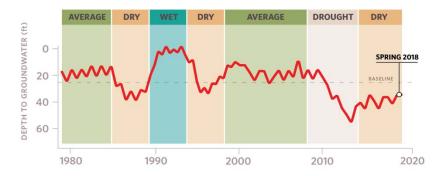


Figure 3. Example seasonality and interannual variability in depth-to-groundwater over time. Selecting one point in time, such as Spring 2018, characterize groundwater conditions in GDEs fails to capture what groundwater conditions are necessary to maintain the ecosystem status into the future so adverse impacts are avoided.

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." [23.00R 8351(a)]

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 GSPs⁴).

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 animals¹⁷, 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).

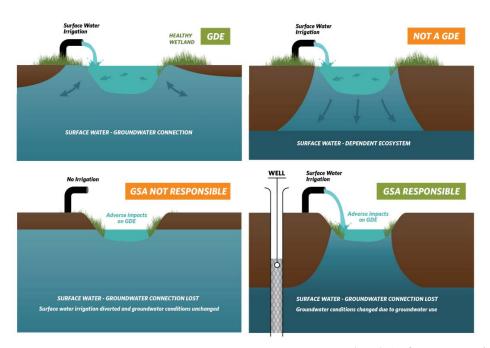


Figure 4. Ecosystems often depend on multiple sources of water. Top: (Left) Surface water and groundwater are interconnected, meaning that the GDE is supported by both groundwater and surface water. (Right) Ecosystems that are only reliant on non-groundwater sources are not groundwater-dependent. Bottom: (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.

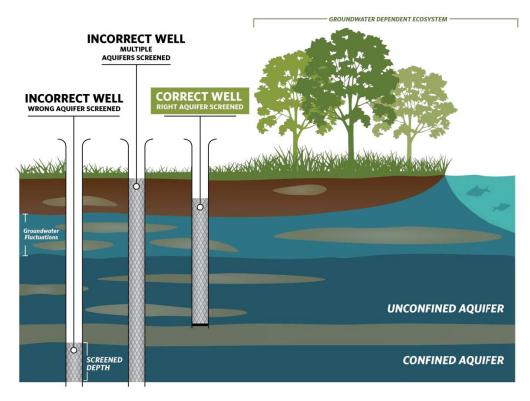
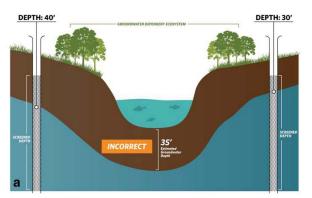


Figure 5. Selecting representative wells to characterize groundwater conditions near GDEs.

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.



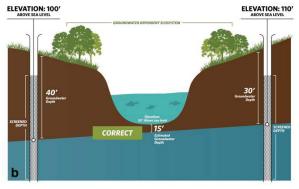


Figure 6. Contouring depth-to-groundwater around surface water features and GDEs. (a) Groundwater level interpolation using depth-to-groundwater data from monitoring wells. (b) Groundwater level interpolation using groundwater elevation data from monitoring wells and DEM data.

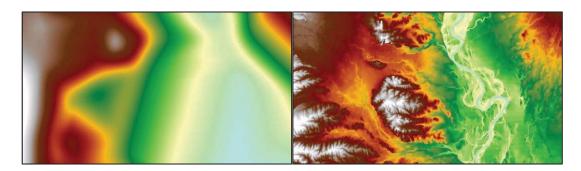


Figure 7. Depth-to-groundwater contours in Northern California. (Left) Contours were interpolated using depth-to-groundwater measurements determined at each well. (Right) Contours were determined by interpolating groundwater elevation measurements at each well and superimposing ground surface elevation 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. $23 \ CCR \ §341(q)(1)$

Groundwater dependent ecosystem (GDE) are ecological communities or species that depend on <u>groundwater emerging from aquifers</u> or on groundwater occurring <u>near the ground surface</u>. 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 <u>wells</u>, <u>springs</u>, <u>or surface water</u> 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.

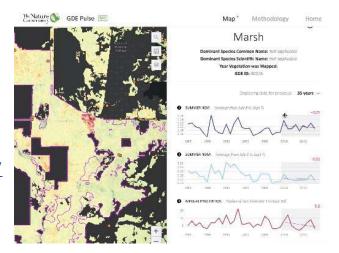
Attachment E

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.



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 Dataset¹⁹. 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 dataset²⁰. 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/



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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.

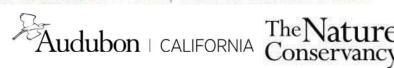
Very truly yours,

Biy mattos

Bill Mattos President









Leaders for Livable Communities

December 1, 2019

Sent via email to <u>djackson@tcwater.org</u> 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 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 SGMA².

¹ https://groundwaterresourcehub.org/

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

Danielle J. Dolan

Samantha Arthur

Working Lands Program Director

Audubon California

Sandi Matsumoto

Associate Director, California Water Program

The Nature Conservancy

Tulare Lake Subbasin (DWR 5-22-12) **Groundwater Basin/Subbasin:** Five GSAs (Mid-Kings River, South Fork Kings, Southwest Kings, El Rico, and the Tri-County Water Authority GSAs)

August 2019 Public Review Draft GSP Date:

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.

(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 GSP Element 2.2.2, "Groundwater Conditions" (§354.16):

(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. plumes.

(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.

	Rev	Review Criteria	s o	/ / Relevant Info per GSP	Location (Section, Page ¹)
1.	Do beneficial users (BUs) identified within the GSP	a. Disadvantaged Communities (DACs)	×	From Table 2-4, DACs include Armona, Home Garde, Hardwick, Community of Table 2-4, Page Stratford, Kettleman City, and City of Corcoran.	ity of Table 2-4, Page 94
	area include:	b. 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	ry is Appendix B, Page ited 373
				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	ne (ings
			>	GSA). A copy of the letter is included in the Appendix A of the Tulare Lake	20
			<u> </u>	attended one of the South Fork Kings GSA's board meetings, and has been on	uo u
				their Interested Parties List since April 2017, receiving regular updates about	out
				GSP development within the SFKGSA and the Tulare Lake Subbasin. In	
				addition, a Sacred Lands File & Native American Contacts List Request was also	ss also
				sent to the Native American Heritage Commission."	
		c. Small community public water		Public water systems such as Armona CSD and Home Garden CSD are included Table 2-4, Page	luded Table 2-4, Page
		systems (<3,300 connections)	×	in Table 2-4. It is not clear from the GSP which systems have fewer than 3,300	3,300 94
				connections.	
2.	What data were used to	d. DWR <u>DAC Mapping Tool</u> ²	×	Data source is not clear from the GSP.	
	identify presence or absence	i. Census Places	×		

Page numbers refer to the page of the PDF.

² DWR DAC Mapping Tool: https://gis.water.ca.gov/app/dacs/

			4.4.1.4, Page 248	4.4.1.4, Page 248		4.2.4, Page 239 4.4.2.4, Page 249		
			"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)."	See above. MCLs are only briefly discussed.		"The basic authority of the GSAs is to locally determine the sustainable amount of groundwater that can be pumped and to manage the transition 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."		
×	×	×		×	×		×	×
			×		a	×		
ii. Census Block Groups	iii. Census Tracts	Ot	. Drinking Water Quality	California Maximum Contaminant Levels (CA MCLs) ³ (or Public Health Goals where MCL does not exist, e.g. Chromium VI)	Office of Environmental Health Hazard Assessment Public Health Goal (OEHHA PHGs) ⁴	CA MCLs ³	. Water Quality Objectives (WQOs) in Regional Water Quality Control Plans	Sustainable Communities Strategies/ Regional Transportation Plans
of DACs?		e	Groundwater Conditions f. section includes discussion of:	ρġ	What local, state, and hederal standards or plans were used to assess drinking	water BUs in the development of Minimum Thresholds (MTs)?	·-	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \

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

l. County and/or City General Plans, x Zoning Codes and Ordinances
--

Summary/Comments

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 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 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

Location	(Section, Page) Appendix B. Page	368	2.5.1, Page 73	374, 377
	Appendix B: Stakeholder Communication and Engagement Plan (no date)		"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."	rts with disadvantaged communities (SDAC) was on of the Tulare Lake Water Resources' Best nmunicate to and engage the n of SGMA and soliciting nicated with DACs and gave tatives, while gathering their efforts during the ophases of the GSP, residents lback that could be crucial to ity within their communities.
`	4	`	· + ± 0 > 0 10	
z °				
	s ;	×	×	×
	Review Criteria Is a Stakeholder Communication and Engagement Plan (SCFP) included?	וז מ לנמתכווטותכן כסווווומווימנוטון מווע בווקמקבוווכוור דומון (לכבד) וווכומתכען	Does the SCEP or GSP identify that ongoing engagement will be conducted during GSP implementation?	Does the SCEP or GSP specifically identify how DAC beneficial users were engaged in the planning process?

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?	stakeholders, members of the Boards of Directors and arry Advisory Committees are direct representatives of their districts, ies and industries, and they continually gather feedback/input, and rns/needs of their constituents and report back to their respective Any stakeholder input received was reviewed by the GSA and echnical teams and taken into consideration during GSP ant." ler input was utilized during the GSA formation phase, as beneficial stakeholders with interests in groundwater usage within the GSAs's swere notified via public meeting notices as soon as the process goal of having the draft GSP before the end of the third quarter in 8 was primarily the technical development of the plan, while ith GSA Boards of Directors, technical teams/committees, and gement at the subbasin level, as well as stakeholders for feedback During the last quarter of 2018, the first round of public outreach and interaction with stakeholder groups and other community ons and entities was held with the purpose of educating and stakeholders about SGMA and the GSP process, while also soliciting and input from these groups to consider and possibly include and input into the GSP. Public outreach for this phase was completed vidual GSAs." daraft of the GSP was completed in September 2019, the public cess began. A 90-day comment period was held, with the GSP draft the Tulare Lake Subbasin GSAs' websites for all stakeholders to thy download and review and provide comments. Outreach were held during this phase both on subbasin-wide level, as well as tall GSAs. These meetings focused on an overview of the GSP hile giving stakeholders a public forum to provide their feedback ents."	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?

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:

including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section (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,

353.2, or the best available information.

GSP Element 3.5 Monitoring Network (§354.34)

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 (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 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

(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	× e N	z \ 4	Relevant Info per GSP	Location (Section, Page)
Does the GSP	a. Well Density	×		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
Related to Drinking Water Users?	 b. Domestic and Public Supply Well Locations & Depths 	×		The GSP does not appear to include information on domestic and public supply well locations and depths.	
	 Based on DWR Well Completion Report Map Application⁸? 		×		

DWR Well Completion Report Map Application: https://www.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37

		ii. Based on Other Source(s)?	ther !	Source(s)?		×		
2.	Does the GSP include maps of monitoring	a. Existing Monitoring Wells	oring	Wells	×		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
	TE(WOIKS :	b. Existing Monitoring Well Data		California Statewide Groundwater Elevation Monitoring (CASGEM)	×		"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
		sodices.	≔ਂ	Water Board Regulated monitoring sites			"Water quality data will be obtained from the below-mentioned coalitions: [] RWQCB - Regional Water Quality Control Board"	4.4.2.4, Page 250
					×		"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."	5.4.3, Page 291
			i	Department of Pesticide Regulation (DPR) monitoring wells	×		"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-Complia	ance l	SGMA-Compliance Monitoring Network	×		Figure 5-1 to Figure 5-5	Figure 5-1 to Figure 5-5, Page298-302
		i. SGMA Monitorin identified DACs?	hitorir ACs?	SGMA Monitoring Network map includes identified DACs?		×	DACs are not included. However, public water systems are shown on the maps.	
		ii. SGMA Monitorir identified GDEs?	nitorir 3DEs?	SGMA Monitoring Network map includes identified GDEs?		×	GDEs are not included.	

Summary/Comments

agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, 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 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 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 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.

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)

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 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 tabular and graphical form.

uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the 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 Guidance for Climate Change Data Use During GSP Development and Resource Guide DWR Water Budget BMP

Y Review Criteria	s e N	z \ <	/ A Relevant Info per GSP	Location (Section, Page)
 Are climate change projections explicitly incorporated in future/ projected water budget scenario(s)? 	×		"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
 Is there a description of the methodology used to include climate change? 	×		"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

DWR BMP for the Sustainable <management of Groundwater Water Budget:

nttps://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

https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management-Best-Management-Practices-and-Guidance-Documents/Files 10 DWR Guidance Document for the Sustainable Management of Groundwater Guidance for Climate Change Data Use During GSP Development: /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 a. DWR-Provided Climate Change Data and for climate change Guidance assumptions?	×	"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
4. Does the GSP use multiple climate scenarios?	< ×		
5. Does the GSP quantitatively incorporate climate change projections?	×	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 a. Inflows: i. Precipitation account for climate ii Surface Water	××	"The climate change factors were also applied to 54-year forecasts of monthly inflows (effective precipitation, surface water deliveries, lake	3.3.7.4, Page 143
ving III.	< × ×	bottom storage, and canal and river seepage) and outflows (agricultural demand) for the "normal hydrology" forecast."	
future/projected water b. Outflows: i. Evapotranspiration budget? ii. Surface Water Outflows (incl. Exports)	×	×	
iii. Groundwater Outflows (incl. Exports)	×		
 7. Are demands by these a. Domestic Well users (<5 connections) b. State Small Water systems (5-14 connections) 	× ×	"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	3.3.7.4, Page 143
in the future/projected C. Small community water systems (<3,300 connections)	×	and non-community water systems were considered. The GSP also does not identify the number of connections of the various	

[≟]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

public water systems present in the basin.		
>	<	×
>	<	×
d. Medium and Large community water	systems (> 3,300 connections)	e. Non-community water systems

Summary/Comments

Given the uncertainties of climate change, the GSP should include and analyze the effects of multiple climate change scenarios.

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 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 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 can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area 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 SGMA¹²

TNC's Groundwater Dependent Ecosystems under the SGMA, Guidance for Preparing GSPs ¹³

		> °	z `		Location
	Review Criteria	s S	Α	Relevant Info per GSP	(Section, Page)
1.	Does the GSP define one or more Management Area?			"In order to facilitate implementation of the GSP, management areas have	3.4, Page 144
		×		been created for the Subbasin. There are five Primary Management Areas and Figure 3-54, Page	Figure 3-54, Page
				two Secondary Management Areas."	220
5.	Were the management areas defined specifically to manage GDEs?			"Primary Management Areas have been formed from each of the five GSAs."	3.4, Page 144
				"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.	Were the management areas defined specifically to manage DACs?	×			
	a. If yes, are the Measurable Objectives (MOs) and MTs for				
	GDE/DAC management areas more restrictive than for the		×		
	basin as a whole?				
	b. If yes, are the proposed management actions for GDE/DAC				
	management areas more restrictive/aggressive than for the		×		
	basin as a whole?				
4.	Does the GSP include maps or descriptions indicating what DACs are	>		Table 2-4 describes DACs in each GSA area.	Table 2-4, Page
	located in each Management Area(s)?	<			94
5.	Does the GSP include maps or descriptions indicating what GDEs are	>		Figure 3-38. Distribution of Wetlands and Phreatophyte Vegetation	Figure 3-38, Page
	located in each Management Area(s)?	<			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_Groundwate r 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.

Location (Section, Page)	4.3.3, Page 245	
Relevant Info per GSP	er of of of of uture dd uture dd iill ched o he aches be rv." ext of rease ome	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
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> o s		
Review Criteria	Are DAC impacts considered in the development of Undesirable Results (URs), MOs, and MTs for groundwater levels and groundwater quality?	

le to	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			well construction to minimize future wells from becoming dry."	
"This GSP aims to manage groundwater resources to continue to provide an	This GSP aims to manage groundwater resources to continue to provide an			explicitly discuss how stakeholder input from DAC Inembers was considered in the development of URs, MOs, clearly identify and detail the anticipated degree of water from current elevations to the water level MOs and MTs? a. Is this information presented in table(s)? b. Is this information presented relative to the locations of DACs and domestic well users? c. Is this information presented relative to the locations of DACs and domestic well users? d. Is this information presented relative to the locations of ISW and GDEs? include an analysis of the anticipated impacts of water A MTs on drinking water users? a. On domestic well users? b. On small water system production wells? 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? 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 WOs? MITs?	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." The GSP does not explicitly discuss how stakeholder input from DACs was considered. X 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 X 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. X Due to the timely process of infrastructure development and program with the Subbasin. 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 depening to reach the water table. X 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 wells conditioned beginned beg
X X **This GSP aims to manage groundwater resources to continue to provide an adequate water continue to the continue	could be significant. X "This GSP aims to manage groundwater resources to continue to provide an	Was an economic analysis performed to assess the increased operation costs associated with increased iff as a result of water level decline?	Was an economic analysis performed to assess the	water quality MTs: "If water quality MTs: "If water quality wolld cause a buildup of salts and infraste in the surface layers of soil The best way to treat nutrient build up to veer-irrigating enough to push soluble contaminants through the soil column." The GSP does not explicitly discuss how stakeholder input from DAC a. Is this information presented in table(s)? b. Is this information presented relative to the increased on this if water levels read MTs, and on the surface layers. c. Is this information presented relative to the increase of mater include an analysis of the anticipated impacts of water water levels may be an analysis or divinking water users? 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 expected to be partially	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." The GSP does not explicitly discuss how stakeholder input from DACs was considered. X The GSP does not clearly identify the anticipated degree of water level decline. However, current 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_20520E07H001M, and SFK_C_LEM_12). Even MOs represent over 100 feet of decline below 2017 water levels in many areas of the Subbasin. "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." X Impacts on drinking water users are not experiently because in the pack of the design depth for wells will be water and require deeper.
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	Table 2-4. Beneficial Uses and Users by GSA	
	The sustainability goal does not include nature.	
manual / Commonwe		

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 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. ecommended 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 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

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, 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 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 evel 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 funding mechanisms and processes are identified that will ensure that the proposed projects and management actions are achievable and implementable? 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?

Selected relevant requirements and guidance

(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 GSP Element 4.0 Projects and Management Actions to Achieve Sustainability Goal (§ 354.44) 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

	Review Criteria	_ o ^	z \ 4	Relevant Info ner GSP	Location (Section Page)
7	1 Does the GSD identify handfits or impacts to DACs as a result of	,	:	The impacts to DACs are not explicitly discussed in the GSP	633 Page 373
i	שמים ווופ סטר ומפוונוון א שפוופווני סו ווווף שכני ניט שאכי מיז ש ופיזמוני סו	×			0.0.0, 1 age 02.0
	identified management actions?			Recharge projects are noted in the GSP as expected to improve water quality.	
۸i	2. If yes: a. Is a plan to mitigate impacts on DAC drinking water	>			
	users included in the proposed Projects and	<			

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			Management Actions?		1		
		<u>.</u>	Does the GSP identify costs to fund a mitigation		>		
			program?		<		
		ن	Does the GSP include a funding mechanism to		-;		
					×		
	Does the GSP projects and m	ider	Does the GSP identify any demand management measures in its projects and management actions?	×		Section 6.3 and 6.4 provide potential P/MAs options that may be utilized by 6 the GSAs. Table 6-1 to 6-4 in Section 6.5 list the P/MAs chosen for each GSA. 3	6.3, Page 317-330 6.4, Page 330-331
						9 8	6.5, Page 331-334
4.	If yes, does it	a.	Irrigation efficiency program		×		
	include:	ف	Ag land fallowing (voluntary or mandatory)	×		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."	
		ن	Pumping allocation/restriction	×		Groundwater allocation is listed as a potential management action in Section 6.4.	
		ö	Pumping fees/fines	×		Pumping fees for groundwater allocation exceedances and groundwater extractions are listed as potential management actions in Section 6.4.	
		oj.	Development of a water market/credit system	×		Groundwater marketing and trade is listed as a potential management action in Section 6.4.	
		<u>ټ</u>	Prohibition on new well construction		×		
		<u>0</u>	Limits on municipal pumping		×	It is not clear if there would be limits on municipal pumping.	
		۲.	Limits on domestic well pumping		×	It is not clear if there would be limits on domestic well pumping.	
		. <u></u>	Other	×		"Require new developments (non-de minimis extractors) to prove sustainable water supplies if land use conversion is not a conservation measure"	
2.	Does the GSP	ider	Does the GSP identify water supply augmentation projects in its projects				6.3, Page
	and management actions?	ient		×		the GSAS. Table 0-1 to 0-4 in Section 0.5 list the P/IVIAS chosen for each GSA. 3 3. Section 0.5 list the P/IVIAS chosen for each GSA. 3 3. Section 0.5 list the P/IVIAS chosen for GSA. 3	317-330 6.4, Page 330-331 6.5, Page 331-334
0	If yes, does it include:	b.	Increasing existing water 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."	
	5	٠.	Obtaining new water supplies		×		
		ن	Increasing surface water storage	×		Storage projects are identified by South Fork Kings GSA, El Rico GSA, and Tri-County Water GSA.	
		o	Groundwater recharge projects – District or Regional level	×		Recharge projects are identified by Mid-Kings River GSA and South Fork Kings GSA.	
		a.	On-farm recharge	×		On-Farm Improvements project is identified by South Fork Kings GSA.	
		انب	Conjunctive use of surface water	×		The recharge projects also involve conjunctive use of surface water.	
		တ်	Developing/utilizing recycled water		×		

Page 17 of 18

Appendix A Review of Public Draft GSP

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	II. Stormwater capture and reuse	<		
	 i. Increasing operational flexibility (e.g., new interties and conveyance) 	×	The Mid-Kings River GSA plans to pursue improvement to conveyance systems and expanded surface water delivery system.	
	j. Other	×		
11.7		×	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
~	 Do proposed management actions include any changes to local ordinances or land use planning? 	×	"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?	×	"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?	×	"As discussed in Section 3.2.8, Interconnected Surface Water and Groundwater [4.2.5, Page 240 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
\ I	11. If yes: a. Does the GSP identify costs to study the interconnectedness of surface water bodies?		×	
	b. Does the GSP include a funding mechanism to support the study of interconnectedness surface water bodies?		×	
_				

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

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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.

<u>Finding 1 (Page 3-27):</u> 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.

Tulare Lake Subbasin Draft Groundwater Sustainability Plan Page 2 of 5

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.

<u>Finding 3 (Page 3-93):</u> 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.

<u>Finding 4 (Page 3-87)</u>: 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

Tulare Lake Subbasin Draft Groundwater Sustainability Plan Page 4 of 5

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.

<u>Finding 6 (Page 4-21):</u> 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,

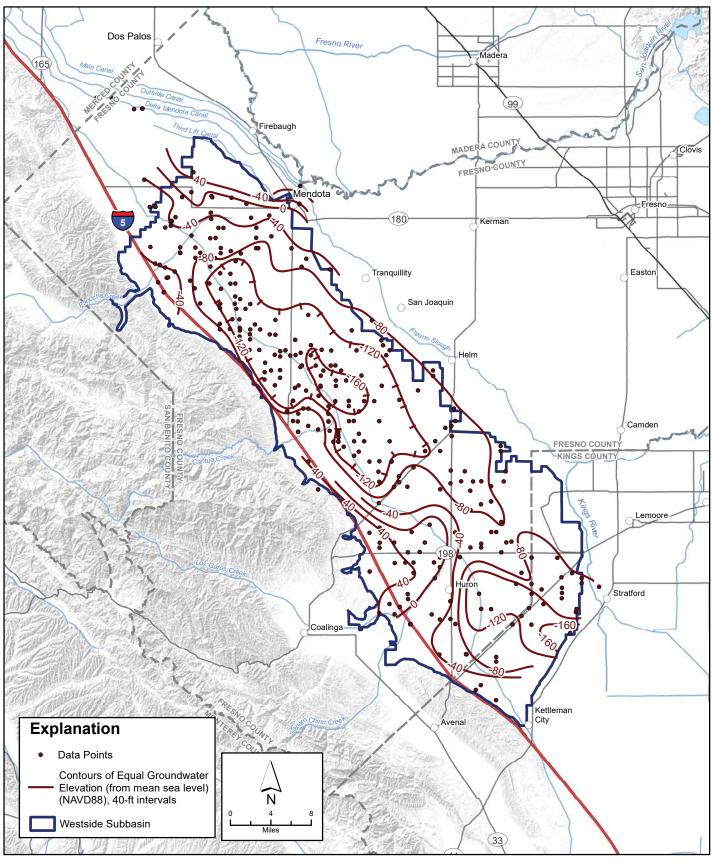
Russ Freeman, P.E.

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.

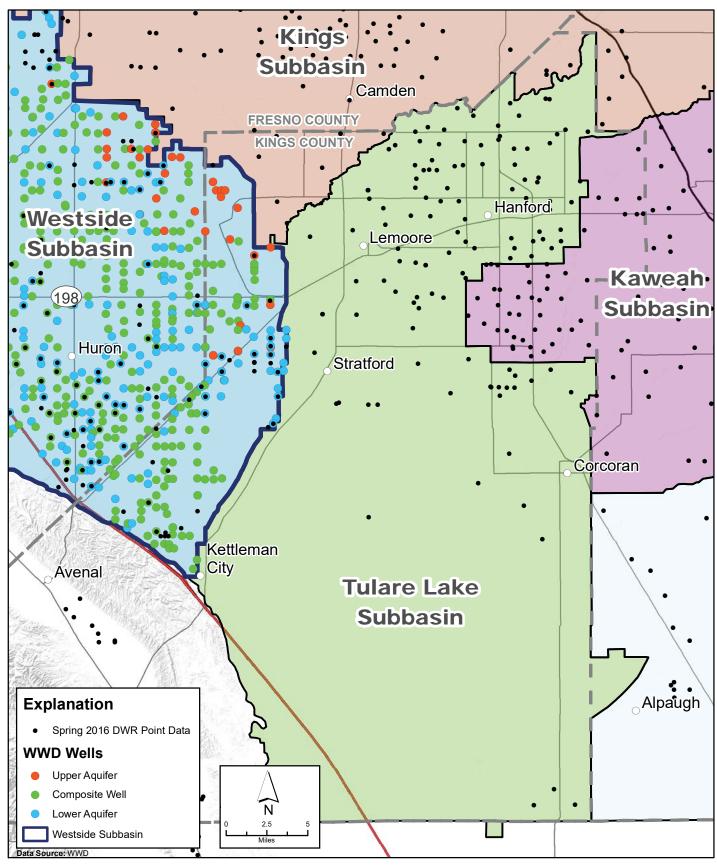
Figure 4



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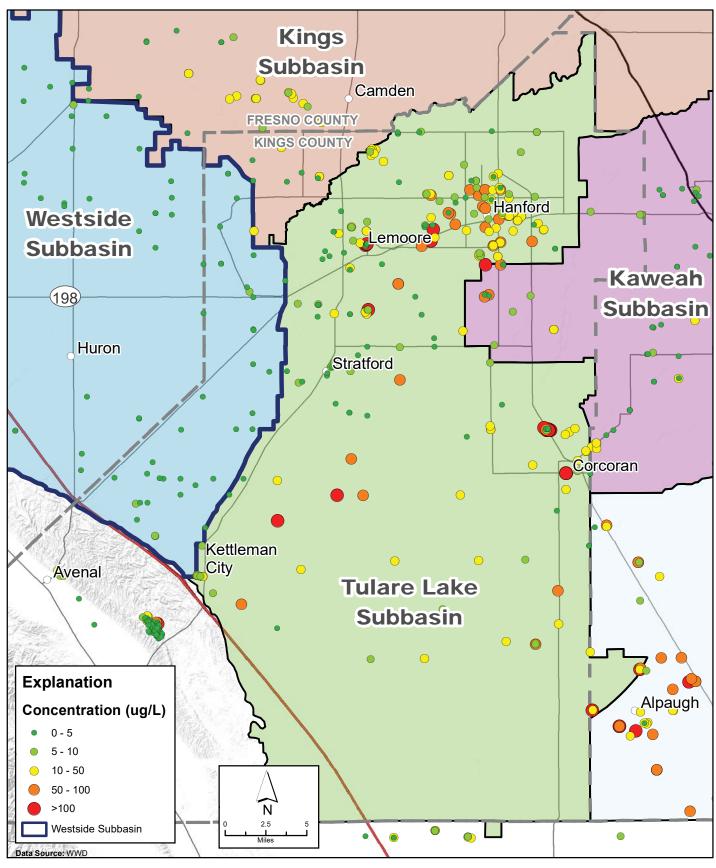
FIGURE 2-40 Contours of Equal Groundwater Elevation Lower Aquifer, Winter 2014/2015



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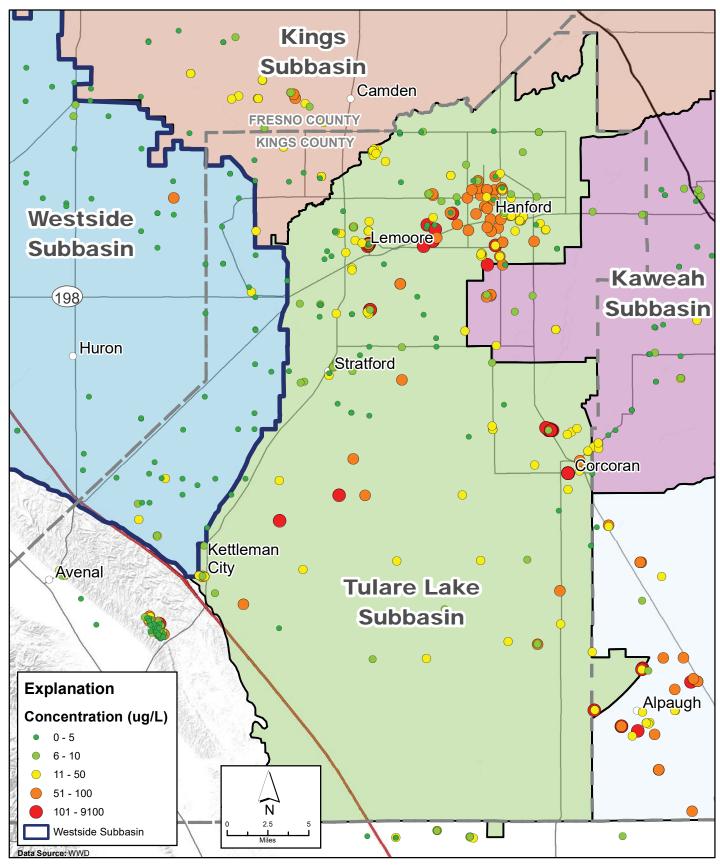
FIGURE 1



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FIGURE 2 Arsenic Concentration in Groundwater Wells Most Recent Reported Value



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FIGURE 3 Arsenic Concentration in Groundwater Wells Maximum Reported Value



Westlands Water District

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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.

<u>Finding 1 (Page 3-27):</u> 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.

Tulare Lake Subbasin Draft Groundwater Sustainability Plan Page 2 of 5

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.

<u>Finding 2 (Page 3-87)</u>: 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.

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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.

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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 South Fork 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 South Fork 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:

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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].)

Additionally, 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

Tulare Lake Subbasin Draft Groundwater Sustainability Plan Page 4 of 5

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,

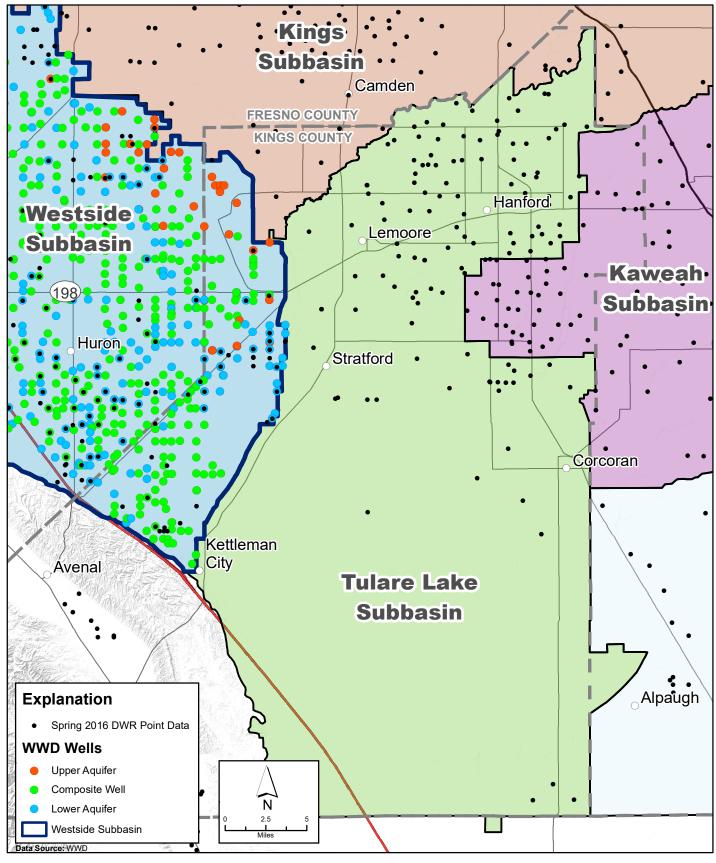
Russ Freeman, P.E.

Deputy General Manager – Resources

Westlands Water District

Rus Fremm

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.



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FIGURE 1

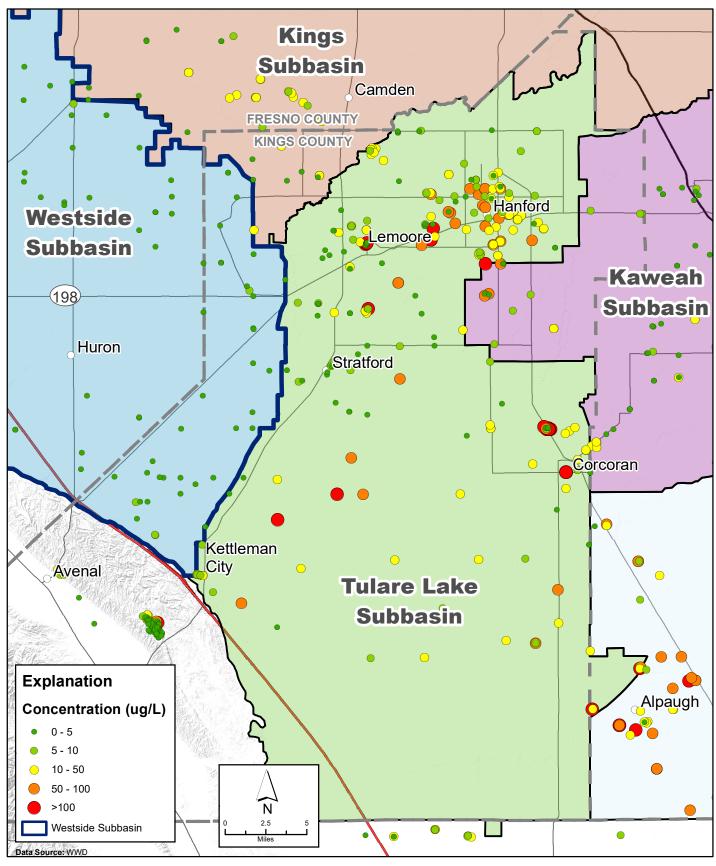




FIGURE 2 Arsenic Concentration in Groundwater Wells Most Recent Reported Value

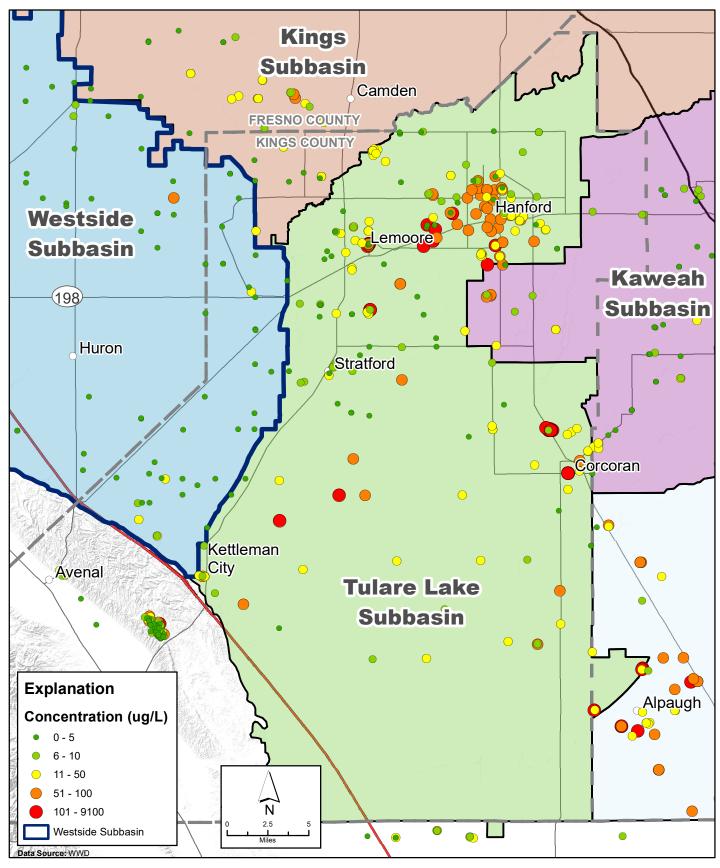
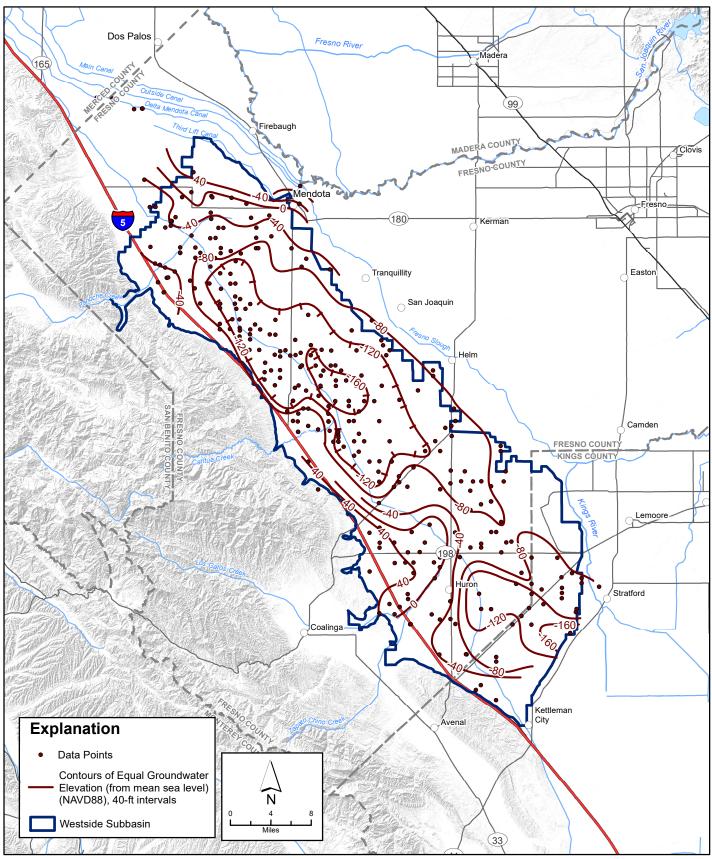




FIGURE 3 Arsenic Concentration in Groundwater Wells Maximum Reported Value

Figure 4



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FIGURE 2-40 Contours of Equal Groundwater Elevation Lower Aquifer, Winter 2014/2015



DOUG VERBOON

Supervisor District 3 **BOARD OF SUPERVISORS**

Kings County Government Center Hanford, CA 93230 Phone (559) 852-2366 Fax (559) 585-8047

December 2, 2019

Via Hand Delivery

Dennis Mills Mid-Kings River GSA 200 N. Campus Drive Hanford, CA 93230

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Dale Melville Southwest Kings GSA c/o Provost & Pritchard Consulting Group 286 W. Cromwell Avenue Fresno, CA 93711

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.

Comments on the Draft GSP December 2, 2019 Page 2

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,

Comments on the Draft GSP December 2, 2019 Page 3

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.

Comments on the Draft GSP December 2, 2019 Page 4

I am available to answer questions and discuss these concerns.

DOUG VERBOON Supervisor Name: Name: Jamelius Worn Name: Business: Business: 7 Business: ENW FARMS INC Business: Millers Name: TIM PAROLINI Business: YARO YW 1 Business: Wiscarder



130 N. Garden Street Visalia, CA 93291-6362 Tel: (559) 636-1166 Fax: (559) 636-1177

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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



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

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David M. Bean, PG, CHg Principal Hydrogeologist

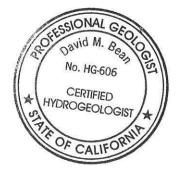


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Abbreviations and Acronyms

% 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

ft²/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
 Kh horizontal hydraulic conductivity
 Kv 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.
- 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) indicated 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 cellby-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 $1,320 \times 1,320$ feet ($\frac{1}{4}$ mile x $\frac{1}{4}$ 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 (fc) over 50-foot depth intervals. Figure D4-4 presents the fc for several of the model layers, and Figure D4-5 presents an oblique view of fc 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 Aguifer 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_{ν} 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_{ν} 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 6.8×10^{-4} /feet and 1.5×10^{-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 4.0×10^{-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 1.5×10^{-5} to 7.3×10^{-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 7.9×10^{-2} to 3.0×10^{-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 9.1×10^{-2} to 2.9×10^{-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,

Ski 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_v (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-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).

7.1.5.2 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 aguifer 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.

10.0 References

- Allen, R.G., L. S. Pereira, D. Raes, M. Smith, Crop Evapotranspiration Guidelines for Computing Crop Water Requirements FAO Irrigation and Drainage Paper 56, Food and Agriculture Organization of the United Nations, Rome, 1998 (Allen et al., 1998).
- Amec Foster Wheeler Environment & Infrastructure, Inc., 2018, Tulare Lake Groundwater Subbasin Hydrologic Model for SGMA Compliance: Preliminary Model Development, Calibration, and Predictive Simulations, Tulare Lake Subbasin Hydrologic Model, Kings County, California, July (AFW, 2018).
- Anderson, M., W. Woessner, and R. Hunt, 2015. Applied Groundwater Modeling Simulation of Flow and Advective Transport, Academic Press, 564 p (Anderson et al., 2015).
- Bartow, J. A., 1991, The Cenozoic Evolution of the San Joaquin Valley, California, U.S. Geological Survey Professional Paper 1501, 40 p (Bartow, 1991).
- Bear, J., 1972, Dynamics of Fluids in Porous Media, Volume 1, American Elsevier Publishing Company, 764 p (Bear, 1972).
- Boyce, S. E., R. T. Hanson, I. M. Ferguson, T. Reimann, W. Henson, S. Mehl, S. Leake, T. Maddock, 2016, MODFLOW-OWHM v2: The next generation of fully integrated hydrologic simulation software, American Geophysical Union, Fall General Assembly 2016 (Boyce et al., 2016).
- Brush, C. F., E. C. Dogrul, and T. N. Kadir, 2016, Development and Calibration of the California Central Valley Groundwater Surface Water Simulation Model (C2VSim), Version 3.02- CG, Bay-Delta Office, California Department of Water Resources (Brush et al., 2016).
- California Department of Water Resources, Land and Water Use Section, Land Use Surveys, Fresno County 1994 and 2000, Kern County 1990, 1998, and 2006, Kings County 1991, 1996, and 2003, Tulare County 1993 and 1999 (DWR, 2016a).
- California Department of Water Resources, California's Bulletin 118 Interim Update, https://water.ca.gov/LegacyFiles/groundwater/bulletin118/docs/Bulletin 118 Interim Update 2016.pdf (DWR, 2016b).
- California Department of Water Resources, Groundwater Elevation Contours 1960-2010, https://databasin.org/datasets/b05820cda86b4921a515065fa1deffcc (DWR, 2018).
- Croft, M. G., 1972, Subsurface Geology of the Tertiary and Quaternary Water-Bearing Deposits of the San Joaquin Valley, California, U.S. Geological Survey Water Supply Paper 1999- H, 29 p (Croft, 1972).
- Croft, M. G. and G. V. Gordon, 1968, Geology, Hydrology, and Quality of Water in the Hanford- Visalia Area, San Joaquin Valley, California, U.S. Geological Survey, Water Resources Division, Volume 68, Issue 67 of Open-file report (Croft and Gordon, 1968).
- Davis, G. H., J. H. Green, F. H. Olmsted, and D. W. Brown, 1959, Ground-Water Conditions and Storage Capacity in the San Joaquin Valley, California, U.S. Geological Survey Water-Supply Paper 1469, 287 p (Davis et al., 1959).
- ECORP Consulting, Inc., 2007, Tulare Lake Basin Hydrology and Hydrography: A Summary of the Movement of Water and Aquatic Species, prepared for: USEPA, Document 909R97002 (ECORP, 2007).
- Environmental Simulations, Inc., 2017. Guide to Using Groundwater Vistas Version 7 (ESI, 2017).

- Faunt, C. C., ed., 2009, Groundwater Availability of the Central Valley Aquifer, California: U.S. Geological Survey Professional Paper 1766, 225 p (Faunt el al., 2009).
- Freeze, R. A., and J. A. Cherry, 1979, Groundwater, Englewood Cliffs, New Jersey, Prentice- Hall Inc. (Freeze and Cherry, 1979).
- Fugro West, Inc., 2005, Numerical Groundwater Flow Model for the Kaweah Delta Water Conservation District (Fugro, 2005).
- Hanford Weather Station from 1899 to 2017, https://w2.weather.gov/climate/xmacis.php?wfo=hnx, (Hanford, 2017).
- Hanson, R. T., S. E. Boyce, Schmid, Wolfgang, J. D. Hughes, S. M. Mehl, S. A. Leake, T. Maddock III, and R. G. Niswonger, 2014, One-Water Hydrologic Flow Model (MODFLOW-OWHM): U.S. Geological Survey Techniques and Methods 6–A51, 120 p, https://dx.doi.org/10.3133/tm6A51. ISSN 2328-7055 (online) (Hanson et al., 2014).
- Harbaugh, A. W., 2005, MODFLOW-2005, the U.S. Geological Survey modular ground-water model -- the Ground-Water Flow Process: U.S. Geological Survey Techniques and Methods 6-A16 (Harbaugh, 2005).
- Irrigation Training and Research Center, 2003, California Crop and Soil Evapotranspiration for Water Balances and Irrigation Scheduling/Design. Prepared for: California Polytechnic State University (ITRC, 2003).
- Jet Propulsion Laboratory, 2012, InSAR Measurements of Subsidence in California's Central Valley (June 2007--December 2010), https://www.jpl.nasa.gov/spaceimages/details.php?id=PIA16293 (JPL, 2012).
- Jet Propulsion Laboratory, 2017, NASA Data Show California's San Joaquin Valley Still Sinking (May 2015-April 2017), https://www.ipl.nasa.gov/news/news.php?feature=6761 (JPL, 2017).
- McDonald, M. G., and A. W. Harbaugh, 1988, A modular three-dimensional finite-difference ground-water flow model: Techniques of Water-Resources Investigations of the United States Geological Survey, Book 6, Chapter A1, 586 p (McDonald and Harbaugh, 1988).
- Niswonger, R. G., Panday, Sorab, and Ibaraki, Motomu, 2011, MODFLOW-NWT, A Newton formulation for MODFLOW-2005: U.S. Geological Survey Techniques and Methods 6– A37, 44 p (Niswonger et al., 2011).
- Page, R. W, 1983, Geology of the Tulare Formation and Other Continental Deposits, Kettleman City Area, San Joaquin Valley, California, with a Section on Ground-Water Management Considerations and Use of Texture Maps. Prepared for: U.S. Geological Survey Water-Resources Investigations Report 83-4000, 24 p (Page, 1983).
- Page, R.W., 1986, Geology of the Fresh Ground-Water Basin of the Central Valley, California, With Texture Maps and Sections, Regional Aquifer-System Analysis, U.S. Geological Survey Professional Paper 1401-C (Page, 1986).
- PRISM Climate Group, 2017, Oregon State University, http://prism.oregonstate.edu, created January 17 (PRISM, 2017).
- Provost & Pritchard Consulting Group, 2009, Apex Ranch Conjunctive Use Project Groundwater Monitoring Program October 2008 through September 2009, Kings County Water District, prepared for Kings County Water District (P&P, 2009).

- Regional Water Quality Control Board, Central Valley Region, 2017, Amendment to the Water Quality Control Plan for the Tulare Lake Basin to Remove the Municipal and Domestic Supply (MUN) and Agricultural Supply (AGR) Beneficial Uses within a Designated Horizontal and Vertical Portion of the Tulare Lake Bed, Final Staff Report, December (RWQCB, 2017).
- Selker, J. S., C. K. Keller, J. T. McCord, 1999, Vadose Zone Processes, CRC Press, June (CRC Press, 1999).
- Spitz, K. and J. Moreno, 1996, A Practical Guide to Groundwater and Solute Transport Modeling, John Wiley & Sons, 461 p (Spitz and Moreno, 1996).
- Thomas Harder & Co., 2017, Hydrogeological Conceptual Model and Water Budget of the Tule Subbasin, August (Harder, 2017).
- United States Department of Agriculture, National Agricultural Statistics Service Cropland Data Layer, 2006-2016, Published crop-specific data layer [Online]. Available at http://nassgeodata.gmu.edu/CropScape/USDA-NASS, Washington, DC (USDA, 2016).
- Williamson, A. K, D. E. Prudic, L. A. Swain, 1989, Ground-Water Flow in the Central Valley, California, Regional Aquifer-System Analysis, U.S. Geological Survey Professional Paper Issue 1401-D.
- Woodring, W.P., R. Stewart, and R.W. Richards, 1940, Geology of the Kettleman Hills Oil Field, California, Stratigraphy, Paleontology, and Structure. Prepared for: U.S. Geological Survey Professional Paper 195, 170 p (Woodring et al., 1940)



Table D2-1 Historical Precipitation - Hanford, California¹

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1899	М	М	М	М	М	М	М	М	0	0.67	М	0.87	М
1900	1.38	0	1.18	1.04	М	М	М	М	М	М	М	М	М
1901	М	М	М	М	М	М	М	Т	1.04	Т	М	0.15	М
1902	0.4	2	1.78	0.47	0.09	М	0	М	0	0.36	1.67	0.56	М
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	М	М	М
1907	М	М	М	М	М	М	М	М	М	М	М	М	М
1908	М	М	М	М	М	М	М	М	М	М	М	0.31	М
1909	М	М	М	М	М	М	М	М	М	М	М	М	М
1910	М	М	М	М	М	М	М	М	М	М	М	М	М
1911	М	М	М	М	М	М	М	М	М	М	М	М	М
1912	М	0.02	3.24	1.52	0.27	0	0	0	0	0	0.61	0.21	М
1913	1.26	1.55	0.34	0.78	0.76	0.06	0.08	0	М	М	М	1.35	М
1914	4.36	1.25	0.37	0.11	М	1.06	0	0	0	0	0.02	М	М
1915	М	М	0.3	1.37	М	М	М	М	М	М	М	М	М
1916	4.68	М	М	М	0.16	М	М	0.28	0.47	1.09	М	1.35	М
1917	М	М	М	М	0.31	М	М	М	М	М	М	М	М
1918	М	4.5	3.43	М	М	М	М	М	0.88	0.12	М	М	М
1919	М	М	1.01	0.15	0.1	М	М	М	М	М	М	М	М
1920	М	2.72	3.05	0.24	М	М	М	М	М	М	М	М	М
1921	М	0.89	М	М	0.87	М	М	М	М	М	М	М	М
1922	М	М	М	М	М	М	М	Т	М	М	М	М	М
1923	М	М	М	2.43	М	М	М	М	М	М	М	0.22	М
1924	М	М	1.86	М	0	М	М	T	0	0.65	М	2.12	М
1925	М	М	1.58	М	М	М	0	М	0	М	М	М	М
1926	0.82	1.44	0.2	2.67	Т	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	Т	1.67	1.63	0.78	10.25
1928	0.09	0.96	1.55	0.08	0.1	0	0	0	0	Т	1.47	1.69	5.94
1929	0.81	0.61	1.4	0.81	0	0.24	Т	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	Т	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	Т	0.12	0	0	0.04	0.57	0.06	0.22	5.58
1940	3.53	3.61	0.99	0.18	Т	T	0	0	0	0.85	Т	3.61	12.77



Table D2-1
Historical Precipitation - Hanford, California¹

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	М	0	0	0.43	1.1	М
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	Т	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	Т	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	Т	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	Т	0	0.17	0.05	0.65	2.96	10.18
1953	1.1	0.27	0.34	0.83	0.29	0.02	Т	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	М	М	0.9	0	0	М	0	0.02	0.92	4.67	М
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	Т	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	Т	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	М	2.29	2.2	0.12	М	М	0	0	0	М	М	М	М
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	М	0.49	0	0	0	0	0.96	М	0.05	0.22	М
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	М	М	М	М
1985	0.59	М	0.7	0.12	0	0	М	0	T	М	2.11	0.66	М



Table D2-1
Historical Precipitation - Hanford, California¹

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	Т	0.67	0.32	0.2	0	3.66
1990	1.66	1.1	0.3	0.97	0.87	0	Т	Т	Т	0.01	0.22	0.15	5.28
1991	0.31	0.12	6.62	0.19	Т	0.12	0	0	0.11	0.41	0.14	М	М
1992	1.4	2.82	0.85	0.1	Т	0	0.01	0.01	Т	0.58	Т	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	Т	0	1.06	0.35	1.54	0.33	8.07
1995	4.7	0.51	4.77	0.65	0.87	0.04	Т	0	Т	0	Т	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	Т	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	Т	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	Т	5.53
2000	1.8	3.28	1.59	0.97	0.48	0.35	0	0	0.03	1.31	Т	0.05	9.86
2001	1.98	1.48	1.24	1.12	0	0	0.09	0	Т	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	Т	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	Т	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	М	М	М	1.39	0.03	М	T	0	0	0.28	0.49	1.9	М
2013	0.22	0.48	0.79	0.08	0.17	0	0	0	0.01	Т	0.33	0.16	М
2014	0.3	1.38	0.27	0.35	Т	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
141111	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
IVIUA	1948	1900	1972	2008	2018	2015	2017	2016	2016	2014	1980	1989	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

	1990-1995	1996-1998	1999-2006	2007	2008	5009	2010	2011	2012	2013	2014	2015	2016	Average
Tulare Lake Subbasin ¹	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)	(acres)
Alfalfa Hay and Clover	41,604	32,564	54,301	72,459	80,600	71,504	589'69	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								Н	2		0		2
Carrot Single Crop								11	5	12	2	2	16	2
Citrus (no ground cover)			25		13	14	4	120	29	100	88	22	6	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	909'68	65,169	85,144	889'66	90,192	152,391	172,697	172,486	195,172	237,790	200,972	136,159
Forest*	420	808	2,955	9	5	46	5			Н		4	0	952
Grain and Grain Hay	28,708	48,533	62,962	19,266	27,870	27,406	25,980	7,758	896'6	11,194	12,213	21,196	19,069	34,833
Melons	250	99	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	205	149	644	483
Open Water*	5,568	9,092	896′8	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	960'9	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)											m	16	27	2
Pomegranates (Young)				61	1,705	545	256	5,012	804	1,395	2,207	1,312	3,111	809
Potatoes, Sugar beets, Turnip etc	5,736	1	209	9		2		6		41		2	2	1,331
Riparian*		899	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	99	100	125	69	47	191	170	412
Stone Fruit (Mature)	7,070	4,985	3,854	1,314	544	168	18	Э	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

		sбиј <u>у</u> ұзәмцұлоς	(AF/Y)	20,559	43.416	28,771	36,366	59,119	53,973	109.602	77,906	79,4930	121,876	125,710	91,130	72,577	90,096	73,398	64,456	64,802	26,085	24,245	57,925	83,107	105,645	81,857	92,418	64.875	73,016	66,299	88,360	100,891	58,131	48,699	101 953	94,006	48,606	55,333	34,248	865'69
		Imported Water, Angiola/Green Valley Well Fields, City of Lemoore and Westlands RD 761	(AF/Y)								,										14,540	6,095	6,480	8,131	14,505	11,348	10,280	10,306	10,291	10,359	11,115	11,115	10,016	12,178	34.012	51,435	19,602	31,718	34,248	8,734
	peu	Dudley Ridge State Turnout (DR-3), T208	(AF/Y)		5.694	6,777	8,728	9,168	7,614	17.520	13,358	12.816	16,651	17,297	11,980	12,078	13,394	11,049	10,367	12,323	2.871	2,915	5,016	9,825	11,839	11,958	13,681	10,366	11,914	11,444	12,663	13,351	760,6	6,846	7,125	4,771	6,173	5,623		9,516
	Dudley Ridge Water District-Monthly Diversions Assumed	Dudley Ridge State Turnout (Paramount), T207	(AF/Y)			11	15	15	13	29	22	10	28	29	20	20	22	18	17	21	13	5	8 1	16	20	20	23	17	20	18	21	22	15	11	21 01	8	10	6	Τ.	16
Southwest Kings	Monthly Div	Dudley Ridge State Tumout (DR-2), T205	(AF/Y)		11.388	13,554	17,456	18,335	15,228	35,040	26,716	12,493	33,302	34,594	23,960	24,157	26,788	22,098	20,733	24,645	15,836	5,831	10,031	19,650	23,677	23,916	27,363	20,732	23,828	22,888	25,327	26,702	18,195	13,691	14,249	9,543	12,346	11,247		19,033
Southw	ater District	Dudley Ridge State Tumout (DR-1A), T204	(AF/Y)		2.372	2,824	3,637	3,820	3,172	7.300	5,566	2,603	6,938	7,207	4,992	5,033	5,581	4,604	4,166	5,134	3,299	1,215	2,090	4,094	4,933	4,982	5,701	4,319	4,964	4,768	5,276	5,563	3,791	2,852	2,969	1,988	2,572	2,343		3,965
	ley Ridge W	Dudley Ridge State Tumout (DR-18), T202	(AF/Y)		949	1,130	1,455	1,528	1,269	2,920	2,226	1,041	2,775	2,883	1,997	2,013	2,232	1,841	1,728	2,054	1,320	486	1 099	1,637	1,973	1,993	2,280	1,728	1,986	1,907	2,111	2,225	1,516	1,141	1,187	795	1,029	937		1,586
	Dnd	Dudley Ridge State Tumout (DR-1), T201	(AF/Y)		3.312	3,942	5,077	5,333	4,429	10,191	7,770	3,633	9,685	190'01	9,213	7,026	7,791	6,427	5,816	7,168	1.670	1,696	2,917	5,715	7 895	6,955	7,958	6,030	6,930	6,657	7,366	7,766	5,292	3,982	4,144	2,775	3,591	3,271		5,535
		TLBWSD Lateral C, T203	(AF/Y)		. 0	0	0	0	0	0	0	0 0	0	0	0 0	0	0	0	0	0	0	0	0 0	0	0 0	3,528	0	0	0	0 0	0	0	0	0	0 0	0	0	0		89
		Blakeley Canal-Kings River & Lateral A	(AF/Y)	20,559	19.692	534	10 531	20,920	22,249	36,900	22,247	8,903	52,496	53,639	42,806	22,250	34,288	27,361	28,582	13,458	5.941	6,003	30,546	34,039	41,813	17,157	25,132	11,377	13,083	8,256	24,480	34,147	10,209	7997	17,655	22,689	3,284	184		20,737
		South Fork Kings River	(AF/Y)	106,612	123.153	97,659	111,538	101,065	130.081	134,463	91,940	103 774	140,549	136,165	139,389	78,926	124,731	121,227	91,041	59,219	35,444	40,945	111,629	100,469	125,206	94,698	113,092	70,285	83,131	73,273	111,958	113,661	65,428	55,074	104,101	83,443	18,741	15,085	42,532	93,499
		Imported Water	(AF/Y)																																	Ī.				
s	Lemoore Canal & Irrigation Company	Lemoore Canal	(AF/Y)	96,079	91.478	87,537	93,441	80,465	86,382	104,388	70,925	42,067	107,578	103,714	100,153	58,631	103,148		76,554	56,519	34,465	37,968	91,166	85,049	105,398	75,590	95,504	58,979	74,196	63,511	98,279	96,857	59,988		109 605	71,207	43,206	14,759	42,532	77,554
South Fork Kings		Westlake Canal	(AF/Y)	3,604	12,718	9509	7,305	5,133	6,543	10,939	5,004	9312	9,523	11,566	20,983	10,389	5,800	16,723	2,949		. 964	0	8,612	1,410	5,778	8,447	3,624	2,680	2,202	3,362	1,946	2,368	1,081	1,771	2,900	2,289	0 0	0	0	5,315
So	est Side District	Empire West Side Canal	(AF/Y)	4,770	13.636	2,878	5,359	6,188	5,964	8.763	5,915	10.627	15,449	16,100	9,396	6,097	5,209	7,345	4,959	0	1.006	0	4,314	6,419	8,576	4,596	6,135	1,993	1,364	1650	2,664	5,417	1,470	1,811	3,644	4,594	0	0	0	4,804
	Empire West Side Irrigation District	GWZ most listot GI abi2 tzeW eniqm3	(AF/Y)		1.780	20	3,548	5,216	5,233	5.803	5,811	2,120	1,565	802	4,379	0	4,677	2,070	3,128	2,700	2,979	1,219	2,467	1,468	1,681	488	2,858	1,674	1,265	3.206	3,451	2,954	852	148	1 364	1,151	536	326		2,156
	Stratford Irrigation District	Stratford Canal	(AF/Y)	2,158	3.540	1,139	1,884	4,062	4,411	4,082	4,284	2,203	6,434	3,981	4,435	3,808	4,869	7,329	3,953	0	1760	1,759	5,070	6,123	6,774	5,578	4,971	4,336	4,104	4,356	5,619	6,065	2,037	2,047	4,318	4,203	0	0	0	3,669
		sgnið biM	(AF/Y)	158,119	107.688	168,975	115,495	89,820	202, 339	153,395	40,083	197 346	190,143	165,753	192,613	109,007	144,944	174,419	95, 158	80,514	63,201	58,755	200,860	246,085	262,103	248,841	176,830	111.467	156,751	172,605	210,539	219,748	117,128	122,189	267 154	114,929	36,236	12,430	90,863	143,240
		nateW bathorni	(AF/Y)																													1				Ī.				П
Mid-Kings River		ДWI эbiгэжь1	(AF/Y)																						20657	29,871	12,119	7,017	5,354	13,325	24,547	7	6,764	П	16,103	4,595	110	0	2,986	4,312
M	Last Chance Water Ditch Company	Last Chance Canal- MKRGSA Total	(AF/Y)	50,356	31.878	61,339	38,772	38,190	62,672	43.937	2,255	71 577	64,463	64,365	65,413	48,013	39,583	62,457	21,844	19,935	9,909	9,361	53,498	102,300	95,338	77,863	62,938	31.031	52,020	27.306	54,799	65,459	29,000	30,617	79 589	30,309	12,881		20,567	44,985
	Peoples Ditch W Company C	Peoples Canal- MKRGS Total	(AF/Y)	107,763	75.809	107,636	76,723	51,631	139,667	109,458	37,828	43,393	125,680	101,388	127,200	60,994	105,362	111,962	60,312	60,579	53,292	49,394	147,363	143,785	166,765	141,107	101,773	73,419	99,376	104,545	131,193	129,571	81,364	85,743	113,146	80,025	49,246	12,430	67,310	93,943
GSA	Agency	Diversion		1966	1968	1969	1970	1972	1973	1975	1976	1977	1979	1980	1981	1983	1985	1986	1988	1989	1990	1992	1993	1995	1996	1998	1999	2007	2002	2003	2002	2006	2008	2009	2010	2012	2013	2015	2016	Annual Averages
		Kings River Water Years		%17	49%	256%	78%	%05	125%	92%	32%	23%	101%	178%	61% 181%	261%	73%	190%	45%	53%	40%	41%	149%	202%	122%	181%	74%	20%	%29	83%	148%	172%	72%	79%	121%	49%	41%	21%	75%	



Table D2-3 Historical Kings River Diversions

		zleJoT lsunnA	(AF/Y)	695,217	429,722	635,924	383,648	511,981	625,968	771,261	384,320	644.222	810,750	711,136	1.056.876	943,484	701,875	820 207	604,366	431,730	319,638	209,115	244,987	443,205	1 035 700	748,244	693,058	740,630	437,390	563,493	582,626	495,419	1,019,418	508,584	370,440	693,453	1,025,466	498,360	154,035	107,068		590,701
		Vino-7T	(AF/Y)	0 0	3,690	1,041	17.028	37,128	16,400	31,760	23,320	26.430	23,846	23,780	43.951	38,815	63,925	34121	23,432	9,814	11.796	2,274	5,510	10,058	30,303	43.206	24,061	10,663	10,154	8,329	16,209	10,912	23,126	18,345	6,208	12,555	273	227	154	45	,	16,175
		Imported Water	(AF/Y)																																							
		Other Water	(AF/Y)						,	0	0	0	0	0	0	0	0	0	0	0	4.556	0	0 525	0	0	0	0	0 0	3,000	190	160	5,293	0	63	0	282						364
		Kings River-Tri County	(AF/Y)			,			,	2,642	9,154	11956	6,575	2,819	12.547	0	0	11.586	9,366	984	0 0	1,604	0 010	860'9	4,902	4.729	20	16/	3,044	0	6,652	10,632	14,253	18,083	4,756	10,587	0	0	0	0 0	>	3,333
In-County		neviR etirW	(AF/Y)						,	0	0	1,000	0	009	1887	4,050	6,601	1715	0	0	0	0	93	0	762	3.073	1,863	000	0	0	0	0 282	797	0	0	0	0	0	0	0	,	470
		Deer Creek-70% of Deer Creek Total	(AF/Y)							0	0	7.000	0	4,200	13.207	28,350	46,210	12 004	0	0	0	0	652	0	5,331	21,513	13,042	2 022	2,032	0	0	0 0	5,581	0	0	0	0	0 0	0	0 0		3,227
		Tule River-Tri County	(AF/Y)						. 1	224	0	2.476	185	2,611	3.090	340	0	1 701	0	0	0 0	604	1155	0	6,040	1701	2,083	1166	0	124	790	1 680	795	0	828	1.676						999
		TLBWSD Lateral B, T206 (State Water)-Assumed Full Entitlement-75% to Lateral B	(AF/Y)		2,768	781	17771	27,846	12,300	21,671	10,624	1,905	12,814	9,488	7.793	0	606	3 806	10,550	6,622	5,430	49	3,469	2,970	9,095	5,684	3,171	11 804	3,082	6,011	6,455	795	378	149	468	77	202	170	115	0	ŀ	5,446
		TLBWSD Lateral A, T200 (State Water) -Assumed Full Entitlement-25% to Lateral A	(AF/Y)		923	260	4 257	9,282	4,100	7,224	3,541	624	4,271	3,163	2.598	0	303	1 269	3,517	2,207	1.810	16	1,156	066	3,032	1,895	1,057	3 0 2 5	1,027	2,004	2,152	265	126	50	156	2	68	57	38	45		1,816
		Роѕо Стеек	(AF/Y)						,	00	0	1.500	0	006	2.830	6,075	9,902	2 572	0	0	0	0	140	0 0	1,142	4.610	2,795	435	0	0	0	0 084	1,196	0	0	0	0	0 0	0	0 0	2	705
		озія В	(AF/Y)	321919	151,775	339,477	1 78 001	224,849	244,723	342,042	151,071	237.179	334,337	259,729	589.793	644,159	309,830	361,048	299,874	184,264	153.181	81,060	115,532	175,829	487,891	265,690	243,601	329,217	180,610	242,267	254,241	241,003	561,992	217,420	123,545	315,091	530,567	100253	59,473	24,175	32/127	268,189
		Imported Water	(AF/Y)													ŀ			ŀ																				Ī			
		Loan Oak/New Deal- Diversion of Last Chance, El RicoGA2 Total	(AF/Y)	33.629	13,662	26,288	16,617	16,367	26,860	18,830	196	30.676	27,627	27,585	28.034	20,577	22,992	16,964	10,625	9,362	4.247	7,981	4,012																			10,052
		Камеаћ Říver	(AF/Y)											70 400	171.808	114,301	120,846	71 918	44,445	25,873	39,853	28,897	100 270	28,376	149,232	66,638	58,340	51,184	20,131	73,770	49,413	59,030	171,601	39,474	37,662	102,754	140,553	60,683				45,614
		озій ІЗ-тэvій эluT	(AF/Y)											CA7	63.476	193,800	17,566	43 384	0	0	0 0	0	0	0	13,777	40.122	26,731	2,235	0 80 80	490	1,748	1,106	17,135	153	158	5,059	11,316	200				8,586
		Deer Creek-30% of Deer Creek Total	(AF/Y)							0	0	3.000	0	1,800	5.660	12,150	19,804	5 144	0	0	0	0	279	0	2,285	9,220	5,590	0 871	0	0	0	1 767	2,392	0	0	0	0	0				1,383
EI MCO		кет Вічег	(AF/Y)																																							0
		Melga Canal-Diversion of Peoples Canal, El Rico GSA Total	(AF/Y)	91,260		71,757	51,149	34,420	93,111	72,972	25,219	83.846	83,787	67,592	84.800	40,663	65,220	74 641	46,938	40,208	35.528	30,436	32,930	38,072	75,670	65,232	75,570	49,810	38,433	45,043	48,228	40,719	69,623	46,218	41,851	55,771	83,250	39,616	12,461	2,493		54,847
		Tulare Lake Canal	(AF/Y)	42.476	49,218	0	0 007	7,305	31,948	53,125	45,170	49.511	32,856	29,258	77.268	1,333	0	29,821	57,023	17,816	0	2,870	44 555	49,718	48,240	25,047	16,707	13,492	38,045	7,942	45,168	16,768	74,920	31,676	5,282	37,297	78,409	15,977	0	0	>	26,107
		Lakelands Canal-Total			17,218				19,101	41,833	3,493	31 904	34,336	37,277	54.659	21,919	42,516	50,108	27,104	18,863	15.114	6,143	0 000 99	0	52,969	32,557	32,918	35,062	2,122	46,842	36,750	40,917	80,614	17,889	8,051	38,210	88,052	3,483	41,472	21,076	77777	31,229
		TLBWSD Lateral B, 1206 (State Water)-Modified Total-(SWP Total for Lateral B minus Tri County Entitlement)	(AF/Y)		10,256	2,893	0 0 0 0	103,195	45,583	89,737	47,863	3.073	97,690	34,131	36.788	522	1,917	84,042	60,441	40,544	37.168	2,855	35,181	28,204	59,720	2.107	17,487	140,451	39,067	33,324	44,894	75 546	52,463	39,927	11,833	32,026	25,964	43,921	3,681	0	ŀ	40,175
		Empire Weir No. 2 (over #2 weir to river extension, River Water) Modified Total-(Empire Weir No. 2 minus Tri County Kings River Water)		2,404	4,673	196,219	0 0	1,099	530	11,905	0	33.029	2,523	41,353	45.602	238,616	17,704	16,118	18,250	8,209	0	344	0 0 0	15,625	51,722	19,089	4,514	4,359	21,146	14,150	13,153	17,145	70,800	21,586	9,553	34,789	89,121	24,964	0	0		26,210
GSA	Agency	Dhension	Н	1966	1968	1969	1970	1972	1973	1975	1976	1978	1979	1980	1982	1983	1984	1985	1987	1988	1990	1991	1992	1994	1995	1997	1998	1999	2001	2002	2003	2004	2006	2007	2008	2010	2011	2012	2014	2015	2017	Annual Averages
	1	Kings River Water Years		197%	49%	256%	%8/	%05	125%	92%	32%	201%	101%	178%	181%	261%	115%	190%	45%	48%	40%	63%	41%	20%	202%	155%	181%	74%	%65	%4.9	83%	61%	172%	40%	72%	121%	180%	49%	32%	21%	204%	٩



Average Precipitation GSA Annual Totals Kings River Watershed 1	otal
Average Annual	
690,714	
494,326	
010000	



Dry Year	Average Precipitation	GSA Annual Totals	Kings River Watershed Total	Average Annual	690,714	494,326	

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Key	Wet Year	Dry Year	Average Precipitation	GSA Annual Totals	Kings River Watershed Total	
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0.000	Kings River Watershed Total	Average Annual	690,714	494,326	00000

Note:

1. Whete shiplighted have been modified.

2. Whete shiplighted have been modified with the best of our incondedge.

2. Whete shiplighted have been modified.

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4. Whete shiplighted have been modified.

5. In CLA Book of the shiplighted have been shiplighted been shiplighted have been shiplighted been shiplighted have been shiplighted been shiplighted the shiplighted have been shiplighted been ship



Table D2-4 Annual Specified Well Field Pumping¹

	El Rico GSA	Creighton Ranch	Corcoran ID	Angiola	Westlands	Municipal	Apex Ranch
	Well Field	Well Field	Well Field	Well Field	Well Field	Well Fields	Well Field
Date	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(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.





Reference Crop Evapotranspiration Values¹ Table D2-5

Tulare Lake Subbasin Hydrologic Model Kings County, California

	January	February	March	April	Mav	June	July	August	September	October	November	December
Crop Evapotranspiration	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)	(inches)	inches)	(inches)	(inches)	(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	00.0	0.00	0.00	00.00	0.00	0.00	0.00	00.00
Almonds	0.83	0.85	2.71	3.91	6.75	6.39	6.58	80.9	3.92	2.25	0.75	0.83
Pistachio	0.83	99.0	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	98.9	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	06.0
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	98.0
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	98.0
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	98.0
Wine Grapes with 80% canopy	0.84	99.0	2.17	1.42	4.18	90.9	00.9	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	00.00	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	06.0





Table D2-5 Reference Crop Evapotranspiration Values¹

Crop Evaportranspiration (#V.d)		January	February	March	April	May	June	July	August	September	October	November December	December
0 0	Crop Evapotranspiration	(ft/d)	(ft/d)	(ft/d)	(ft/d)	(ft/d)	(ft/d)	(ft/d)	(ft/d)	(ft/d)	(ft/d)	(ft/d)	(ft/d)
0 0	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
ay 0.000223 0.000758 0.00186 0.01815 0.01775 0.01769 0.01664 0.01069 0.000208 0.000228 ay 0.000223 0.000156 0.00034 0.00034 0.00024 0.00024 0.00024 0.000228 0.000228 0.000229 0.00024 0.000229 0.00024 0.000229 0.00024 0.000229 0.00024 0.000229 0.000229 0.00024 0.000229 0.00	Fallow Land	0	0	0	0	0	0	0	0	0	0	0	0
ay 0.00223 0.00156 0.00516 0.00516 0.00516 0.00516 0.00517 0.00524 0.00524 0.00524 0.00524 0.00524 0.00525 0.00525 0.00525 0.00525 0.00052 0.00525 0.00526 0.00052 0.00526 0.00526 0.00052 0.00526 0.00526 0.00052 0.00526 0.00526 0.00052 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
ay 0.00234 0.00622 0.01255 0.01906 0.01032 0.00039 0.00054 0.000024 0.00022 0.00019 0.00237 0.00190 0.00777 0.00232 0.00771 0.00232 0.00771 0.00232 0.00772 0.00322 0.00772 0.00322 0.00772 0.00232 0.00772 0.00322 0.00772 0.00322 0.00772 0.00322 0.00772 0.00322 0.00772 0.00322 0.00772 0.00322 0.00772 0.00322 0.00772 0.00322 0.00772 0.00322 0.00772 0.00322 0.00322 0.00323 0.00329 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00323 0.00324 0.00322 0.003224 0.00322 0.003224 0.00322 0.00322 0.00322 0.00322 0.00322 0.00322 0.00322 0.00322 0.00322	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
rightum 0.00237 0.00190 0.005056 0.00208 0.004356 0.001090 0.005056 0.002045 0.004356 0.000435 0.001090 0.000435 0.000190 0.00077 0.000435 0.000436 0.000436 0.000436 0.000448 0.000448 0.000448 0.000448 0.000448 0.000448 0.000448 0.000449 0.000448 0.000448 0.000448 0.000448 0.00048 0.000488 0.00048 0.00048 0.00048 0.00048 0.000498 0.000	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
rightum 0.00237 0.00190 0.00777 0.00322 0.00194 0.02136 0.00190 0.00777 0.00322 0.00703 0.02033 0.00203 0.00100 0.00021 0.00100 0.00021 0.00100 0.00021 0.00100 0.00021 0.00100 0.00021 0.00100 0.00021 0.00100 0.00021 0.00021 0.00010 0.00021 0.00010 0.00021 0.00010 0.00021 0.00010 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00021 0.00022 <t< td=""><td>Cotton</td><td>0.00237</td><td>0.00190</td><td>0.00505</td><td>0.00208</td><td>0.00435</td><td>0.01300</td><td>0.02196</td><td>0.02070</td><td>0.01486</td><td>0.00409</td><td>0.00217</td><td>0.00234</td></t<>	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
over 0.00237 0.00190 0.00777 0.00322 0.00458 0.02032 0.00232 0.00190 0.00777 0.00322 0.00486 0.00234 0.00233 0.000237 0.00033 0.00190 0.001499 0.01950 0.01704 0.01704 0.01704 0.001733 0.00052 0.00034 0.00048 0.001496 0.01950 0.01704 0.01704 0.001733 0.00054 0.00048 0.00048 0.00143 0.01436 0.01436 0.01212 0.00289 0.01747 0.00333 0.00428 0.001478 0.001478 0.001478 0.00148 0.001478 0.001478 0.001478 0.001478 0.00234 0.000447 0.00347 0.00344 0.00048 0.00048 0.00048 0.00048 0.00049 0.00048 0.00048 0.00048 0.00049 0.00048 0.00048 0.00049 0.00048 0.00048 0.00048 0.00048 0.00049 0.00049 0.00048 0.00048 0.00048 0.00049 0.00049 0.00049 0.00049 0.00049 0.00049	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
over 0.00237 0.00631 0.01159 0.01696 0.01949 0.01950 0.01884 0.01704 0.01333 0.00540 0.00328 Grasses 0.00239 0.00488 0.00966 0.01436 0.02105 0.02122 0.02081 0.01478 0.00498 0.00328 set, Turnip etc. 0.00237 0.00344 0.01867 0.02152 0.00238 0.00428 0.00498 0.00099 0.00498 0.00498 0.00498 0.00498 0.00498 0.00498 0.00499 0.00497 0.00499 0.00498 0.00498 0.00498 0.00498 0.00498 0.00498 0.00498 0.00498 0.00499 0.00	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
Grasses 0.00239 0.00488 0.00488 0.00486 0.00436 0.00488 0.00488 0.00488 0.00488 0.00488 0.00488 0.00488 0.00488 0.00488 0.00488 0.00488 0.00488 0.00488 0.00488 0.00488 0.00499 0.00499 <t< td=""><td>Alfalfa Hay and Clover</td><td>0.00237</td><td>0.00631</td><td>0.01159</td><td>0.01606</td><td>0.01949</td><td>0.01950</td><td>0.01884</td><td>0.01704</td><td>0.01333</td><td>0.00540</td><td>0.00369</td><td>0.00245</td></t<>	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
eets, Turnip etc. 0.00237 0.00384 0.01094 0.00345 0.00444 0.00038 0.00298 0.00428 0.00428 0.00428 0.00428 0.00428 0.00428 0.000428 0.000428 0.000428 0.000428 0.000428 0.000428 0.000428 0.000428 0.000428 0.000429 0.000424 0.001867 0.011867 0.01580 0.00158 0.00158 0.011867 0.00158 0.00186 0.011867 0.00158 0.00186 0.01186 0.00158 0.00186 0.00186 0.00186 0.00188 0.00189 <t< td=""><td>Pasture and Misc. Grasses</td><td>0.00239</td><td>0.00488</td><td>0.00906</td><td>0.01436</td><td>0.02105</td><td>0.02122</td><td>0.02081</td><td>0.01882</td><td>0.01478</td><td>0.00874</td><td>0.00328</td><td>0.00234</td></t<>	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
sets, Turnip etc. 0.00237 0.002474 0.00841 0.01867 0.02336 0.0238 0.00048 0.00022 0.00029 0.00024 cover) 0.00237 0.00560 0.01102 0.01522 0.01290 0.00158 0.00048 0.00022 0.00099 0.00372 cover) 0.00237 0.00589 0.011062 0.01390 0.01188 0.01180 0.00180 0	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
cover) 0.00237 0.00560 0.01102 0.01249 0.00158 0.00058 0.00059 0.00137 0.0023 0.00589 0.011005 0.011489 0.01600 0.01538 0.01409 0.01600 0.01538 0.01409 0.01600 0.01538 0.01409 0.01600 0.01538 0.01409 0.01600 0.01538 0.01409 0.01600 0.01509 0.01409 0.00409 0.00214 0.01409 0.01409 0.01409 0.01409 0.01409 0.01409 0.01409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 0.00409 <t< td=""><td>Potatoes, Sugar beets, Turnip etc.</td><td>0.00237</td><td>0.00274</td><td>0.00841</td><td>0.01867</td><td>0.02376</td><td>0.02383</td><td>0.02038</td><td>0.00048</td><td>0.00022</td><td>0.00099</td><td>0.00214</td><td>0.00231</td></t<>	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
cover) 0.00223 0.00589 0.01065 0.01340 0.01600 0.01538 0.01409 0.01086 0.01086 0.00040 0.00409 opers 0.00237 0.00188 0.00691 0.00134 0.01180 0.0256 0.00210 0.00022 0.00099 0.00214 0.00184 0.01184 0.01183 0.01296 0.00214 0.01296 0.01296 0.01283 0.01296 0.01283 0.01633 0.01296 0.01283 0.01639 0.01639 0.00296 0.00296 0.01296 0.01539 0.01639 0.01639 0.01639 0.01639 0.01639 0.01639 0.01639 0.00641 0.00394 0.00294 0.01639 0.01639 0.01639 0.00641 0.00490 0.00490 0.00641 0.00490 0.00641 0.00490 0.00641 0.00490 0.00490 0.00641 0.00490 0.00490 0.00490 0.00490 0.00490 0.00490 0.00490 0.00490 0.00490 0.00490 0.00490 0.00490 0.00490 0.00490 0.00490<	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
spers 0.00237 0.00188 0.00691 0.00194 0.01180 0.02256 0.01995 0.00210 0.000226 0.00188 0.01184 0.01683 0.01613 0.01296 0.000761 0.000198 0.00214 0.00188 0.00183 0.01613 0.01296 0.00761 0.01698 0.000761 0.00198 0.00124 0.00188 0.01214 0.01683 0.01637 0.01637 0.01637 0.01637 0.01637 0.01637 0.01637 0.01637 0.01637 0.00163 0.00163 0.00163 0.00163 0.00163 0.01637 0.01637 0.01637 0.01637 0.00163	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
80% canopy 0.00226 0.00196 0.00583 0.00394 0.01124 0.01683 0.01613 0.01296 0.00168 0.001698 0.000761 0.00108 0.00208 0.00276 0.00578 0.00936 0.01296 0.01211 0.01863 0.01659 0.01698 0.01698 0.01698 0.00697 0.00611 0.00344 0.01296 0.01211 0.01863 0.01657 0.01657 0.01657 0.01657 0.01657 0.01657 0.01657 0.00657 0.00676 0.00667 0.00768 0.00676 0.00676 0.00768 0.00676 0.00768 0.00676 0.00676 0.00769 0.00769 0.00671 0.00769 <td< td=""><td>Tomatoes and Peppers</td><td>0.00237</td><td>0.00188</td><td>0.00691</td><td>0.00194</td><td>0.01180</td><td>0.02256</td><td>0.01995</td><td>0.00210</td><td>0.00022</td><td>0.00099</td><td>0.00214</td><td>0.00231</td></td<>	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
opening 0.00276 0.00476 0.00844 0.01286 0.01288 0.01863 0.01657 0.00657 <t< td=""><td>Wine Grapes with 80% canopy</td><td>0.00226</td><td>0.00196</td><td>0.00583</td><td>0.00394</td><td>0.01124</td><td>0.01683</td><td>0.01613</td><td>0.01296</td><td>0.00761</td><td>0.00108</td><td>0.00208</td><td>0.00226</td></t<>	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
0.00274 0.00476 0.00844 0.01652 0.01288 0.01598 0.01657 0.01173 0.01027 0.00765 0.00490 0.00991	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
pping 0.00144 0.00416 0.00788 0.01226 0.01570 0.00998 0.00729 0.00950 0.00867 0.00700 0.00393 0.00144 0.00158 0.00877 0.01291 0.00958 0.01463 0.02115 0.01831 0.01029 0.00207 0.00165 0.00165 0.01291 0.01289 0.01228 0.02286 0.02242 0.02048 0.01595 0.01059 0.00239 0.00239 0.00229 0.00383 0.00858 0.01016 0.01270 0.01270 0.01869 0.01227 0.01491 0.01569 0.0138 0.00742 0.00293 0.00293 0.00293	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
pping 0.00158 0.00474 0.00877 0.01291 0.00958 0.01463 0.02115 0.01831 0.01029 0.00207 0.00165	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
0 0 0 0 0 0 0 0 0 0	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
0 0	Urban, Commercial	0	0	0	0	0	0	0	0	0	0	0	0
0.00000 0.00061 0.01210 0.01229 0.02286 0.02242 0.02242 0.02048 0.01611 0.01129 0.00439 0.00220 0.00228 0.00858 0.01016 0.01227 0.01491 0.01569 0.01589 0.00439 0.00439	Urban, Industrial	0	0	0	0	0	0	0	0	0	0	0	0
0.00220 0.00661 0.01210 0.01869 0.02290 0.02286 0.02242 0.02048 0.01611 0.01129 0.00439 0.00229 0.00383 0.00858 0.01016 0.01227 0.01491 0.01569 0.01138 0.00742 0.00420 0.00293 0.00293	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
0.00229 0.00383 0.00858 0.01016 0.01227 0.01491 0.01569 0.01138 0.00742 0.00420 0.00293	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

	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Average
Tulare Lake Subbasin ¹	(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)
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	9		1		11
Carrot Single Crop						_		37	16	41	7	9	26	9
Citrus (no ground cover)			91		42	46	14	405	66	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*														1
Forest*														1
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	С	16	10	1,182	27	128	275
Misc. field crops	40,450	30,296	121,265		2	_		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)						_					2	23	41	3
Pomegranates (Young)				11	303	66	52	901	210	376	537	292	746	141
Potatoes, Sugar beets, Turnip etc.	18,604	4	929	19		10		29		127		7	7	4,317
Riparian*														1
Small Vegetables	2,835	1,147	8,009	33	æ	20	340	227	212	330	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	299	1,308
Tomatoes and Peppers	12,971	3,747	33,791	261	2	246	56	47,851	52,725	15,847	26,555	42,793	52,168	20,892
Urban, Industrial*														1
Wine Grapes with 80% canopy Winter Wheat*	7,586	8,301	14,872	14,203	8,893	5,692	086'9	13,625	23,455	11,832	16,450	11,874	27,920	11,683
Tulare Lake Subbasin Irrigated ET Demand Trilare I ake Subbasin GSA Total 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
ומומופ במגל שמשמווו שש וטרמו בו הביוומוית	898,916	+00,010	T'OOO'T	1,0/2,442	1,002,000	T'OTO'TO'T	סדר,כרנ	۲۵۵,201	-30,001	141,010	000,000	/TT/40C	044,030	000,140

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.





Table D2-7 Historical Farm Demand¹

Date (AF/Y) (AF/Y) (AF/Y) Jan-90 1,728,732 1,065,856 379,829 Jan-91 1,614,099 994,832 358,828 Jan-92 1,628,359 1,012,909 343,450 Jan-93 1,625,686 1,008,709 347,335 Jan-94 1,667,754 1,047,937 339,746 Jan-95 1,518,505 973,503 292,869 Jan-96 1,576,024 1,067,962 313,585 Jan-97 1,680,694 1,123,726 337,872 Jan-98 1,549,840 1,059,009 286,711 Jan-99 1,691,385 1,237,448 339,665 Jan-90 1,445,415 1,127,412 284,814	(AF/Y) 425,121 401,725 406,535 404,875 419,143 389,226 384,546 377,306 377,306 344,390 370,000	(AF/Y) 552,538 514,334 528,115 524,762 544,830 502,007 482,623 511,503 480,381 535,160 457,426	(AF/Y) 256,615 233,176 241,481 240,425 251,521 229,979 304,804 317,630 294,124	(AF/Y) 114,629 106,035 108,779 108,288 112,514 1104,424 130,465 136,383 127,132 81,596	(AF/Y) 325,993 306,828 313,628 310,417 321,367 228,503 274,763 2282,666	(AF/Y) 417,055 388,094 395,489 394,078 409,642	(AF/Y) 166,690 155,314	(AF/Y) 114,789	(AF/Y) 41,329
1,728,732 1,065,856 1,614,099 994,832 1,628,359 1,012,909 1,625,686 1,008,709 1,667,754 1,047,937 1,518,505 973,503 1,576,024 1,067,962 1,680,694 1,123,726 1,691,385 1,23,448 1,445,415 1,127,412	425,121 401,725 406,535 404,875 419,143 389,226 344,546 377,306 377,306 361,492 407,814 349,602 344,390	552,538 514,334 528,115 524,762 544,830 502,007 482,623 511,503 480,381 535,160 457,426	256,615 233,176 241,481 240,425 251,521 229,979 304,804 317,630 294,124	114,629 106,035 108,779 108,288 112,514 104,424 130,465 136,383 127,132 81,596	325,993 306,828 313,628 310,417 321,367 298,503 274,763 296,047 282,666	417,055 388,094 395,489 394,078 409,642	166,690 155,314	114,789	41,329
1,614,099 994,832 1,628,359 1,012,909 1,627,754 1,047,937 1,518,505 973,503 1,576,024 1,067,962 1,680,694 1,123,726 1,549,840 1,059,009 1,691,385 1,23,448 1,445,415 1,127,412	401,725 406,535 404,875 419,143 389,226 344,546 377,306 361,492 407,814 349,602 344,390	514,334 528,115 524,762 544,830 502,007 482,623 511,503 480,381 535,160 457,426	233,176 241,481 240,425 251,521 229,979 304,804 317,630 294,124	106,035 108,779 108,288 112,514 104,424 130,465 136,383 127,132 81,596	306,828 313,628 310,417 321,367 298,503 274,763 296,047 282,666	388,094 395,489 394,078 409,642	155,314	107 036	27 EG1
1,628,359 1,012,909 1,625,686 1,008,709 1,667,754 1,047,937 1,518,505 973,503 1,576,024 1,067,962 1,680,694 1,123,726 1,549,840 1,059,009 1,691,385 1,23,448 1,445,415 1,127,412	406,535 404,875 419,143 389,226 344,546 377,306 361,492 407,814 349,602 344,390	528,115 524,762 544,830 502,007 482,623 511,503 480,381 535,160 457,426	241,481 240,425 251,521 2229,979 304,804 317,630 294,124	108,779 108,288 112,514 104,424 130,465 136,383 127,132 81,596	313,628 310,417 321,367 298,503 274,763 296,047 282,666	395,489 394,078 409,642		TO, '01	TOC' /C
1,625,686 1,008,709 1,667,754 1,047,937 1,518,505 973,503 1,576,024 1,067,962 1,680,694 1,123,726 1,549,840 1,059,009 1,691,385 1,232,448 1,445,415 1,127,412	404,875 419,143 389,226 344,546 377,306 361,492 407,814 349,602 344,390	524,762 544,830 502,007 482,623 511,503 480,381 535,160 457,426	240,425 251,521 229,979 304,804 317,630 294,124	108,288 112,514 104,424 130,465 136,383 127,132 81,596	310,417 321,367 298,503 274,763 296,047 282,666	394,078 409,642	156,526	108,443	38,824
1,667,754 1,047,937 1,518,505 973,503 1,576,024 1,067,962 1,680,694 1,123,726 1,549,840 1,059,009 1,691,385 1,232,448 1,445,415 1,127,412	419,143 389,226 344,546 377,306 361,492 407,814 349,602 344,390	544,830 502,007 482,623 511,503 480,381 535,160 457,426	251,521 229,979 304,804 317,630 294,124	112,514 104,424 130,465 136,383 127,132 81,596	321,367 298,503 274,763 296,047 282,666	409,642	156,684	108,853	38,677
1,518,505 973,503 1,576,024 1,067,962 1,680,694 1,123,726 1,549,840 1,059,009 1,691,385 1,232,448 1,445,415 1,127,412	389,226 344,546 377,306 361,492 407,814 349,602 344,390	502,007 482,623 511,503 480,381 535,160 457,426	229,979 304,804 317,630 294,124	104,424 130,465 136,383 127,132 81,596	298,503 274,763 296,047 282,666		163,677	112,809	40,442
1,576,024 1,067,962 1,680,694 1,123,726 1,549,840 1,059,009 1,691,385 1,232,448 1,445,415 1,127,412	344,546 377,306 361,492 407,814 349,602 344,390	482,623 511,503 480,381 535,160 457,426	304,804 317,630 294,124	130,465 136,383 127,132 81,596	274,763 296,047 282,666	382,014	151,236	104,578	37,172
1,680,694 1,123,726 1,549,840 1,059,009 1,691,385 1,232,448 1,445,415 1,127,412	377,306 361,492 407,814 349,602 370,000	511,503 480,381 535,160 457,426 447,420	317,630 294,124 327,150	136,383 127,132 81,596	296,047 282,666	432,798	171,197	134,163	55,041
1,549,840 1,059,009 1,691,385 1,232,448 1,445,415 1,127,412	361,492 407,814 349,602 344,390	480,381 535,160 457,426 447,420	294,124	127,132 81,596	282,666	449,362	180,958	139,428	57,931
1,691,385 1,232,448 1,445,415 1,127,412	407,814 349,602 344,390	535,160 457,426 447,420	227 150	81,596		424,886	167,423	132,138	51,896
1,445,415 1,127,412	349,602 344,390 370,000	457,426 447,420	OCT, 120		286,433	535,576	191,560	148,842	70,039
	344,390	447,420	279,949	73,623	251,153	506,236	164,195	141,354	64,475
Jan-01 1,448,592 1,111,506 309,426	370.000		273,032	74,325	252,107	492,321	161,311	143,460	62,308
Jan-02 1,541,594 1,201,455 318,210)))	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	680'66	75,531
Jan-09 1,579,778 1,091,697 349,701		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	986'59	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
624,647 428,	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	7 336,664	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	6 340,315	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

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



Table D5-1 Tulare Lake Subbasin Historical and Current Water Balance¹

					Lan	Land Surface Water Budget	r Budget						
					Inflows	ws				Outflows			Net
	Kings		Effective	Applied	Applied	Imported	Applied	Total	Drain	Farm Demand	Deep	Total	Inflow-
	River	Year	Precipitation	Precipitation Surface Water		Pond Water Groundwater	Groundwater	Inflows	Outflow	Evapotranspiration	Percolation	Outflows	Outflow
Year	Flows	Type	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)
1990	40%	۵	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	93%	۵	78,722	209,568	3,793	52,225	568,130	912,439	0	994,832	125,674	1,120,507	-208,068
1992	41%	۵	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%	≯	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	20%	۵	34,514	443,731	4,237	27,612	481,028	991,122	56	1,047,937	129,432	1,177,394	-186,272
1995	202%	≯	95,479	948,773	42,079	902	177,847	1,265,083	82	973,503	116,897	1,090,481	174,601
1996	122%	z	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%	≯	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%	≯	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%	۵	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	%06	z	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	29%	۵	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	%4.9	۵	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%	z	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	%19	۵	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
2002	148%	≯	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%	≯	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
2002	40%	۵	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%	۵	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%	z	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%	z	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%	≯	52,937	1,026,568	21,035	7,241	869'09	1,168,420	4,486	791,090	83,959	879,535	288,885
2012	49%	۵	45,317	498,937	20,785	64,173	339,834	969,046	3,226	776,133	62,058	841,417	127,629
2013	41%	۵	2,800	264,515	1,725	84,661	437,315	791,017	8,381	826,405	65,687	900,473	-109,456
2014	32%	۵	30,586	154,346	0	85,650	491,323	761,906	3,579	757,265	62,755	823,599	-61,693
2015	21%	۵	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	%16	:	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	-152,861
													ı

							Subsur	Subsurface Water Budget	get								
						Inflows						Outflows			Annual	Annual Change in Storage	torage
				Deep Percolation	colation		Interbas	Interbasin Inflow		Groundwater Pumping	સ Pumping	Interbasin Outflow	utflow				
	Kings		Precipitation	Applie	Stream	Intentional	Upper	Lower	Total	Upper	Lower	Upper	Lower	Total	Upper	Lower	Total
,	River	Year	Infiltration	Infiltration	Leakage	Recharge	Aquifer	Aquifer	Inflows	Aquifer	Aquifer	Aquifer	Aquifer	Outflows	Aquifer	Aquifer	Aquifer
Year	Flows	Type	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)	(AF)
1990	40%	۵	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%	۵	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%	Δ	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%	≯	43,499	124,472	178,243	61	51,892	77,023	475,190	239,755	690'6	42,526	80,157	371,507	-117,785	275,064	157,279
1994	%05	Δ	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%	≯	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%	z	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%	≯	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%	≯	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%	Δ	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	%06	z	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	%65	Δ	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	%/9	Δ	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%	z	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	%19	۵	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%	≯	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%	≯	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%	۵	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%	۵	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%	z	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%	z	67,953	78,915	145,364	23,540	37,974	63,446	417,193	187,770	900′29	47,711	91016	388,504	-56,332	69,461	13,129
2011	180%	≯	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%	۵	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%	Δ	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%	۵	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%	Δ	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		۵	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		:	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, $D = d\eta$, W = wet, and N = normal.



Table D7-1 2017 – 2070 Forecast Model Hydrology Sequence¹

Stress	Forecast	Hydrology	Normal Kings	CNRA Change	Kings River Flow
Period	Year	Conditions	River Flow (AF)	Factor	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 Sequence¹

Stress	Forecast	Hydrology	Normal Kings	CNRA Change	Kings River Flow
Period	Year	Conditions	River Flow (AF)	Factor	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 Yields¹

				Mid-Kings GSA	EI R	ico GSA	South Fork Kings GSA	TCWA GSA	New Project
				Proposed		Proposed	Proposed	Proposed	Total
	Kings River H	ydrology		Recharge	Existing Ponds	6,400 AC SW Pond	10,000 AC SW Pond	13,340 AC SW Pond	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% 59%		Construct 340 acres of Perc Basins	0	0	0	0	0	0
2021 2022	67%			0	0	0	0	0	0
2022	83%			0	0	0	0	0	0
2024	61%			o o	ő	ő	Ö	ő	Ö
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% 155%	Flood	Construct 340 acres of Perc Basins	0 150,000	0 71,000	0 40,000	0 60,000	0 80,000	0 180,000
2031 2032	181%	Flood Flood		150,000	71,000	40,000	60,000	80,000	180,000
2032	74%	11000		0	71,000	40,000	0	0	0
2034	90%			o 0	0	ő	0	o o	Ö
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 2041	90% 40%			0	0	0	0	0	0
2041	72%			0	0	0	0	0	0
2042	79%			0	0	0	0	0	0
2044	121%			0	ő	ő	o 0	ő	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 2051	67% 83%			0	0	0	0	0	0
2051	61%			0	0	0	0	0	0
2052	148%	Flood		200,000	71.000	40.000	60,000	80.000	180.000
2054	90%	11000		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% 181%	Flood Flood		200,000	71,000	40,000	60,000	80,000	180,000
2060 2061	181% 74%	FIOOd		200,000	71,000 0	40,000 0	60,000 0	80,000 0	180,000 0
2061	90%			0	0	0	0	0	0
2063	59%			0	0	0	0	0	0
2064	67%			0	Ö	ő	Ö	Ö	Ö
2065	83%	1		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.



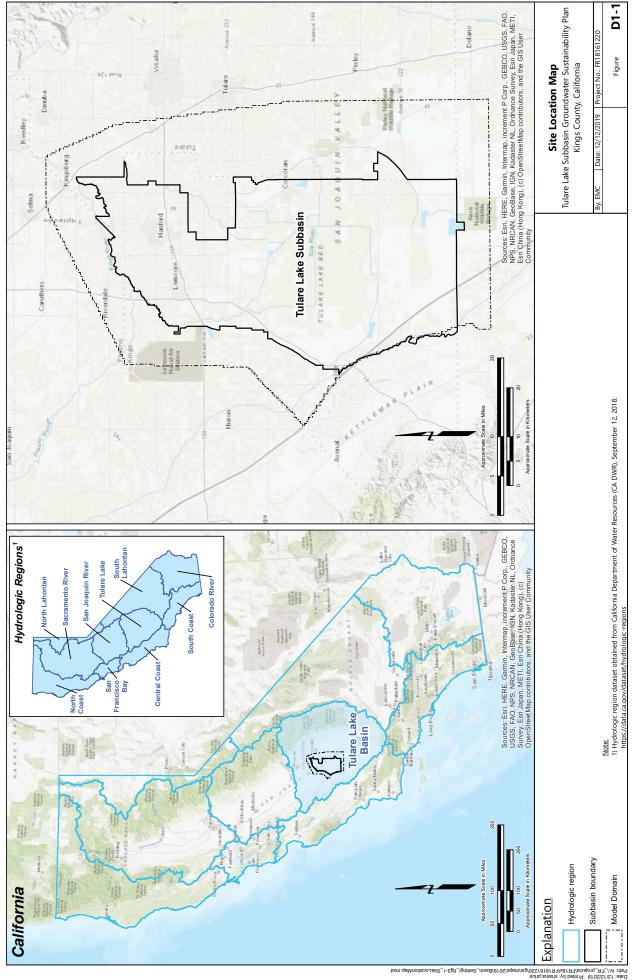


Table D7-3 Historical and Forecasts Groundwater Balance Comparison¹

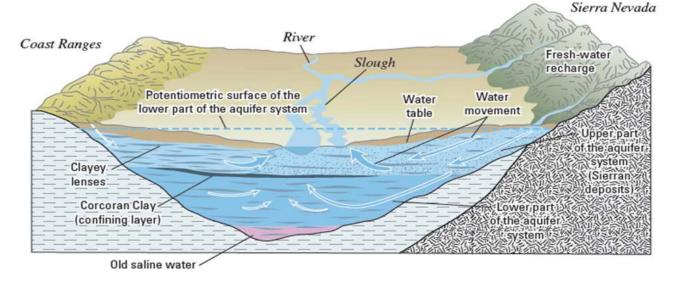
Simulation	Total Simulation Period	Tulare Lake Drain Net (AF/Y)	Tulare Lake Well Net (AF/Y)	Tulare Lake River Net (AF/Y)	Tulare Lake Recharge Net (AF/Y)	Tulare Lake Storage Net (AF/Y)	Tulare Lake Net Interbasin Flow (AF/Y)	Tulare Lake - Westside Net (AF/Y)	Tulare Lake - Kings Net (AF/Y)	Tulare Lake - 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	595'5-		992'2-	-64	8/9/9-	1,514
Baseline Forecast	2017-2070 Average	-2,915	-233,018	148,209	172,329	-91,547	-30,438		-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	886'9-	-67
Below Corcoran Clay												
Calibration	1990-2016 Average	0	-134,595	0	0	56,519	-12,648					27,943
Baseline Forecast Projects Forecast	2017-2070 Average 2017-2070 Average	0 0	-90,714	0 0	0 0	-51,440 -6,269	-108,636 -42,250	-24,350 -11,794	-25,894	-44,226 -27,202	-35,198	21,032
Total Acmifer)											
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	068'8-	-33,827	-13,587	7,778
		Tulare Lake	Tulare Lake	Tulare Lake	Tulare Lake	Tulare Lake	Tulare Lake	Tulare Lake -	Tulare Lake -	Tulare Lake -	Tulare Lake -	Tulare Lake -
	Normal Hydrology	Drain Net		River Net	Recharde Net	Storage Net	Net Interhasin Flow	Westside Net	Kings Net	Kaweah Net	Tule Net	Kern Net
Simulation	Period	(AF/Y)		(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)
Above Corcoran Clay												
Calibration	1998-2010 Average	-9,985	-235,813	140,827	176,936	-103,177	-6,741	4	-5,640	-244	-7,131	1,616
Baseline Forecast	2040-2048 Average	-1,986	-231,248	141,765	170,054	-104,055	-34,749		-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	2,687	-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

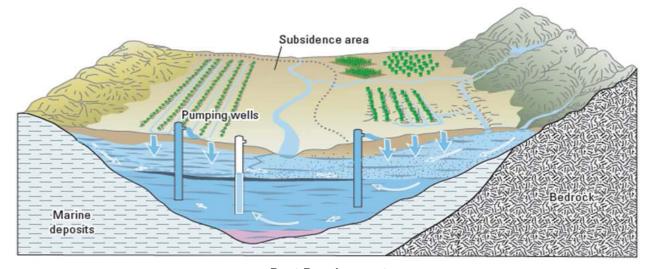
AF/Y = acre-feet per year.





Pre-Development





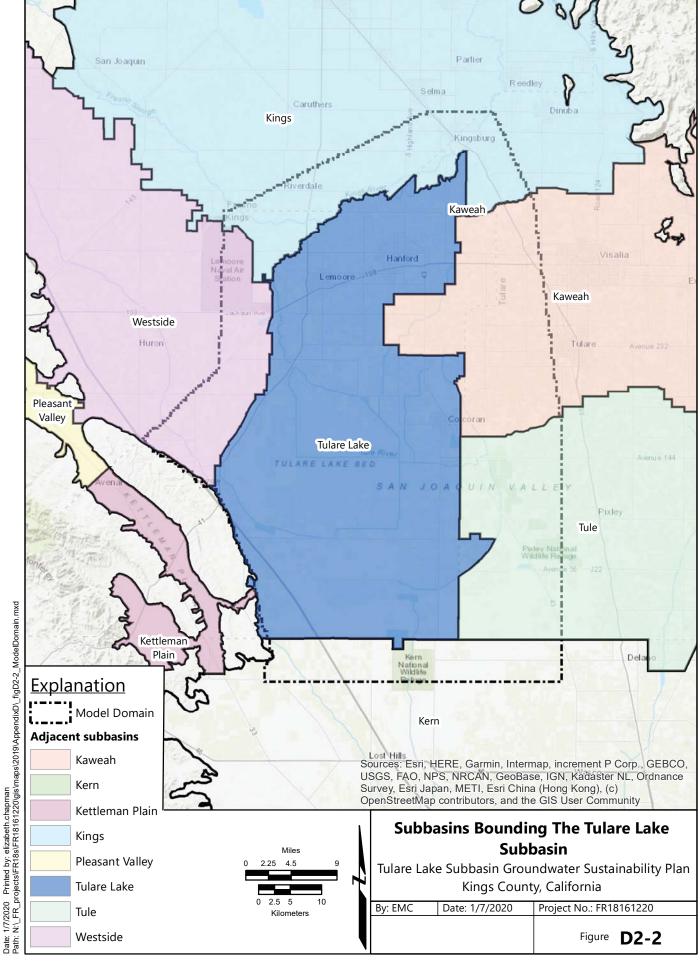
Post-Development

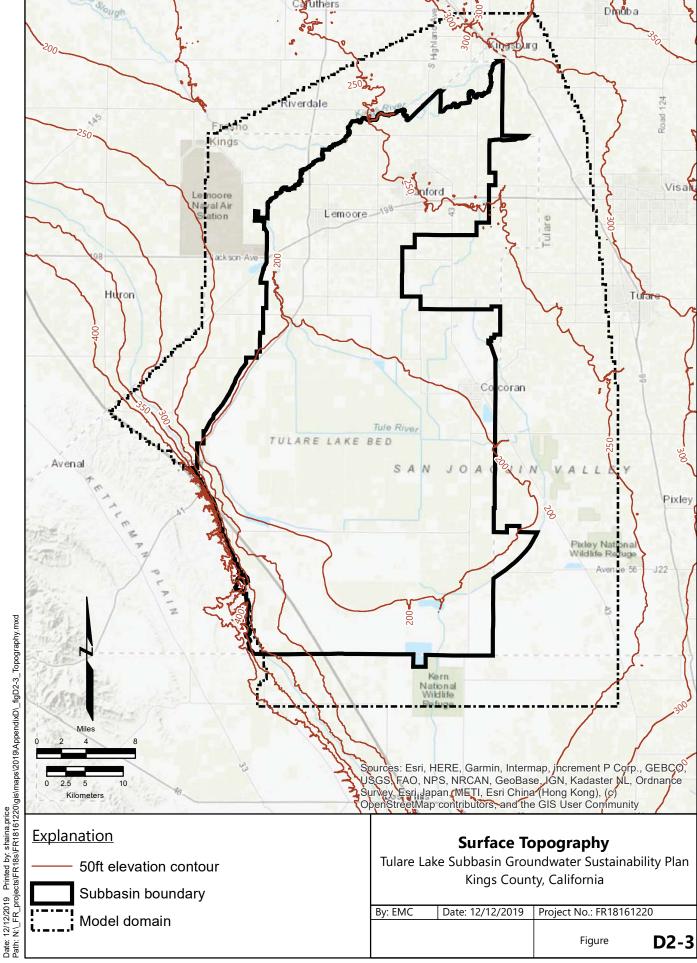
Pre-Development and Post-Development Hydrogeologic Conceptual Model for the San Joaquin Valley

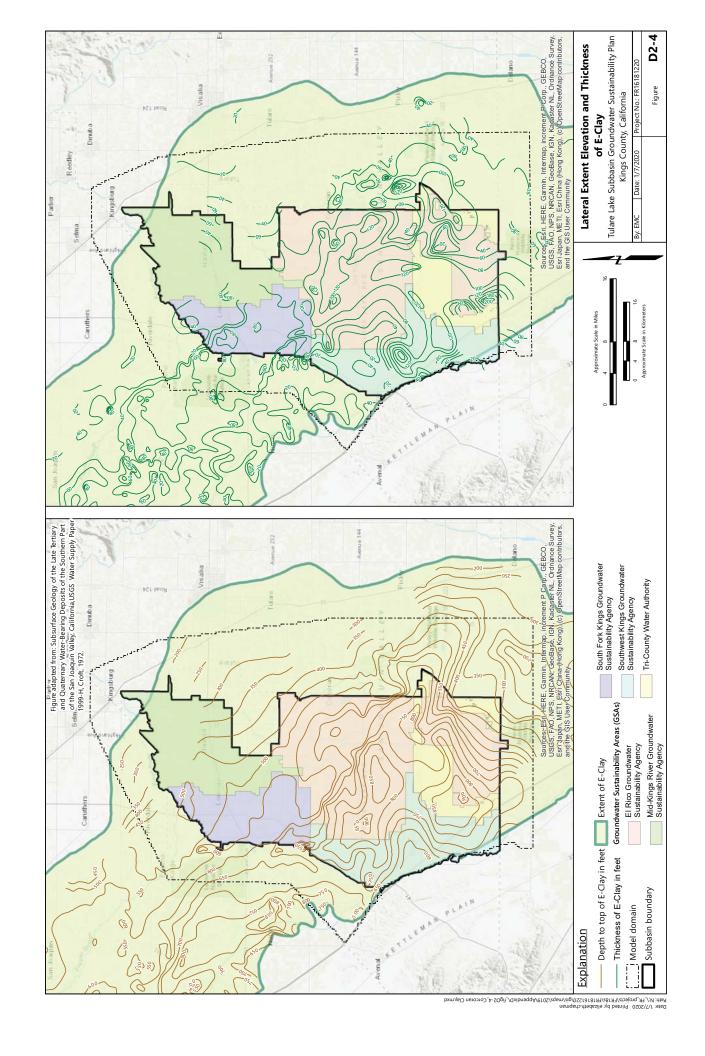
Tulare Lake Subbasin Groundwater Sustainability Plan Kings County, California

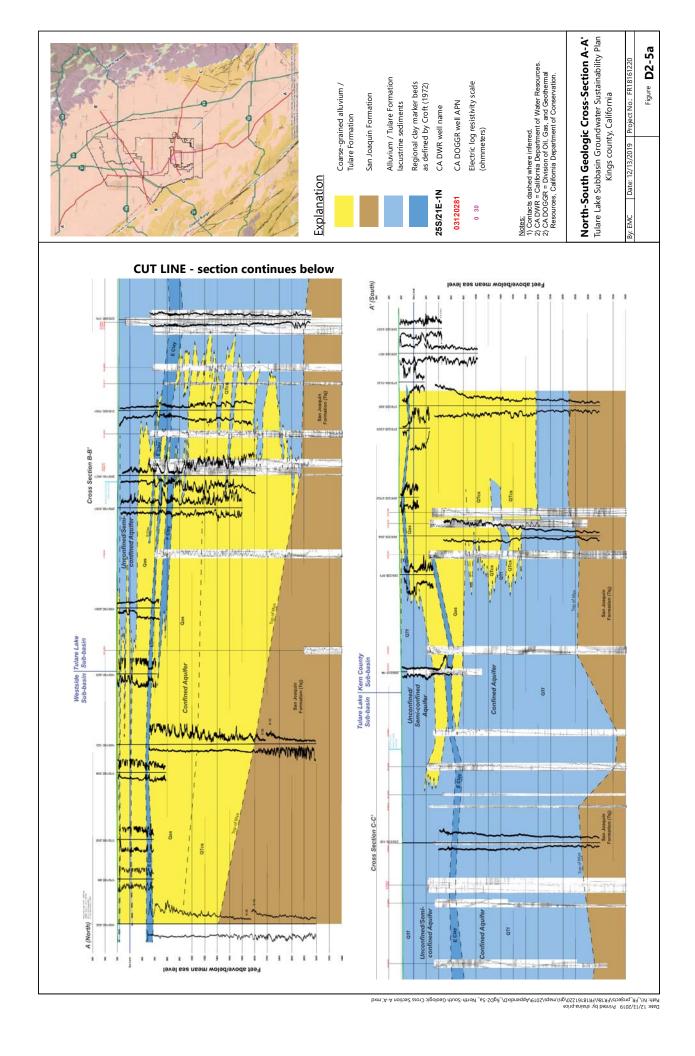
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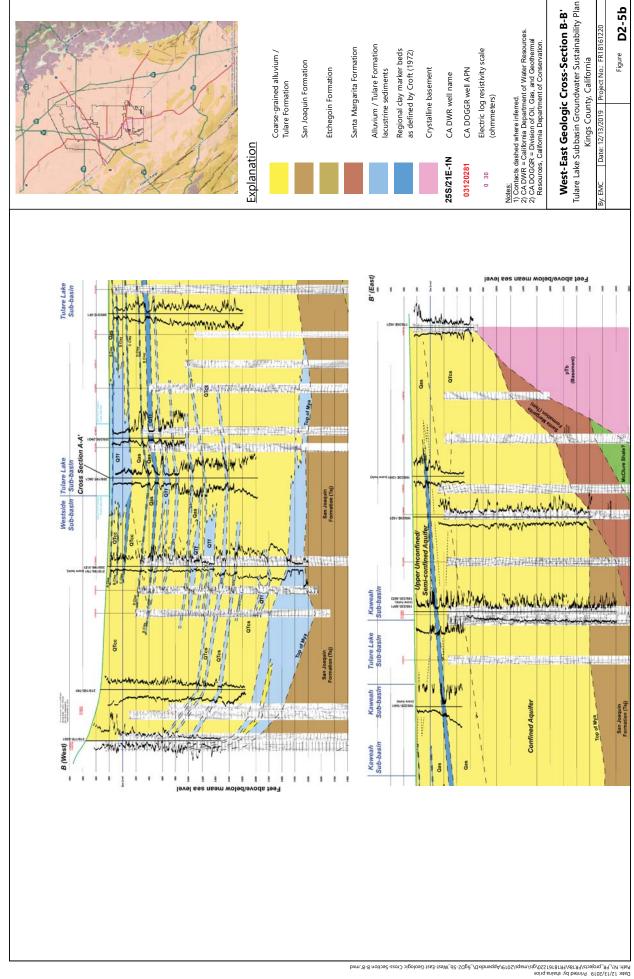
adapted from Fig. A9, USGS Prof. Paper 1766

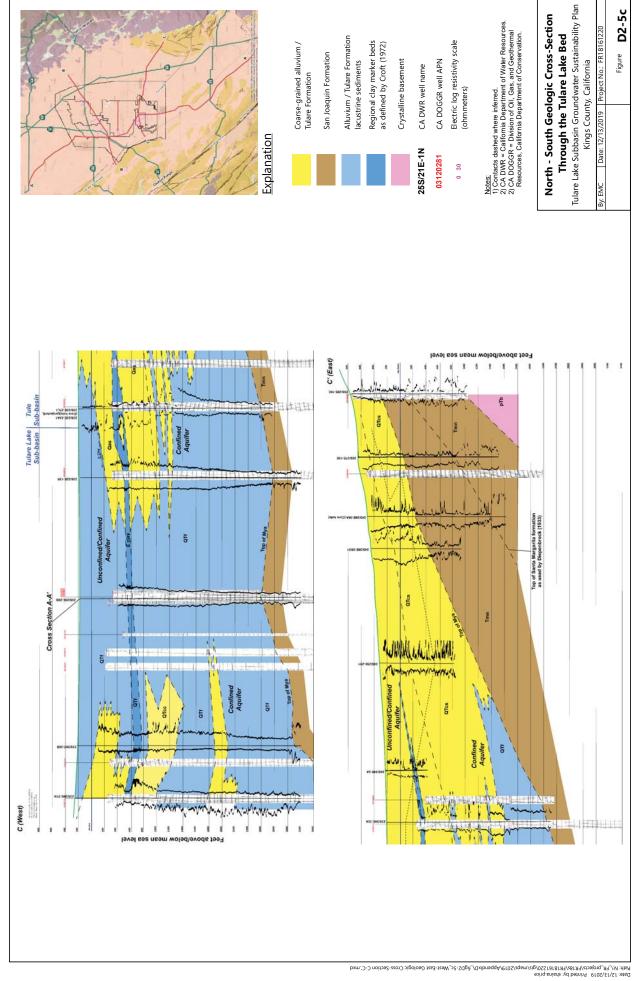


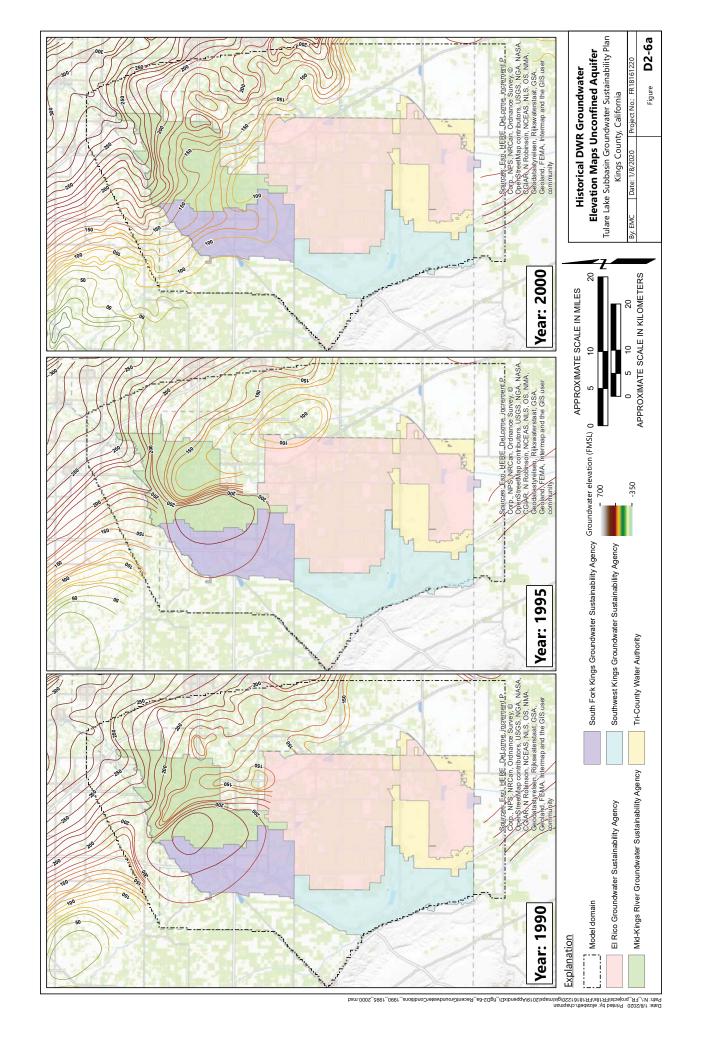


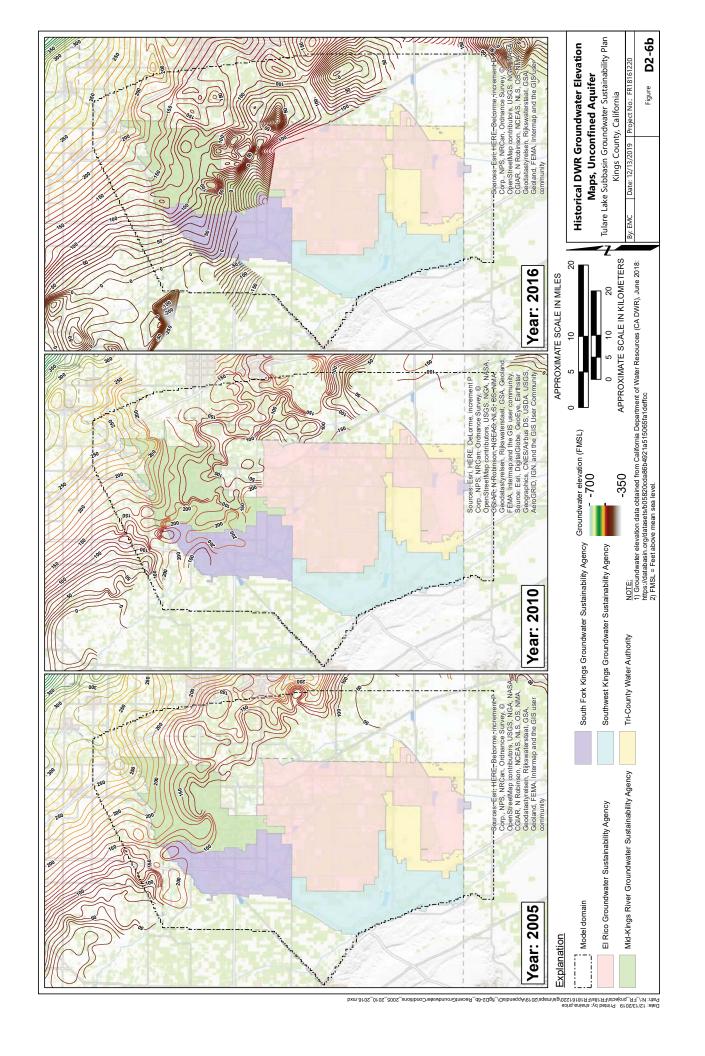






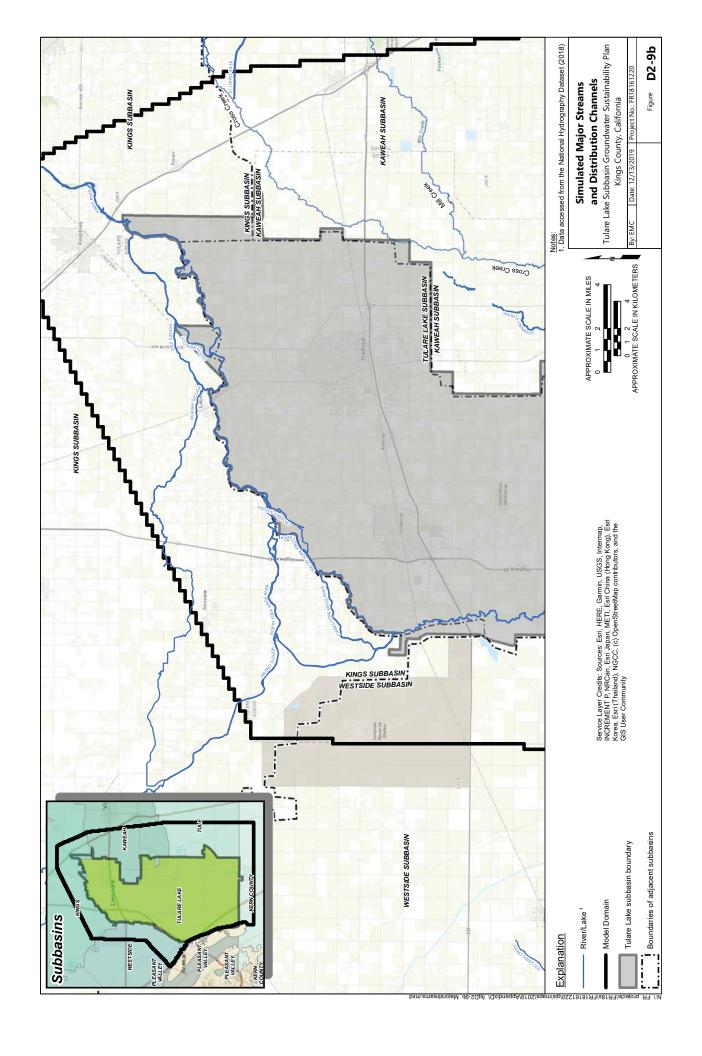


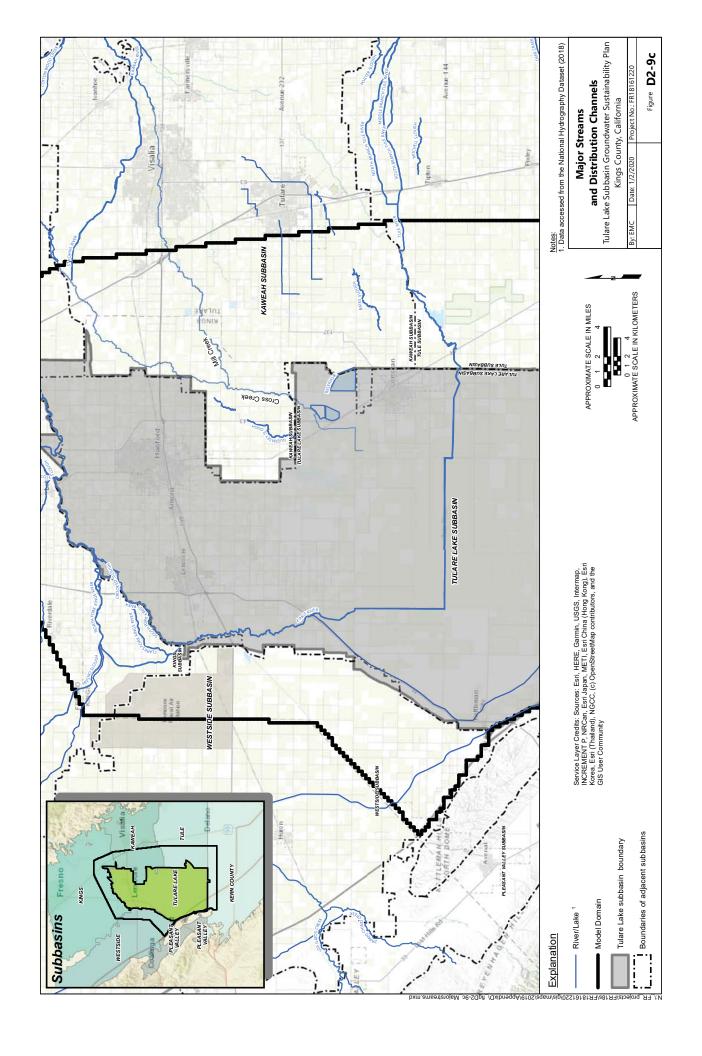


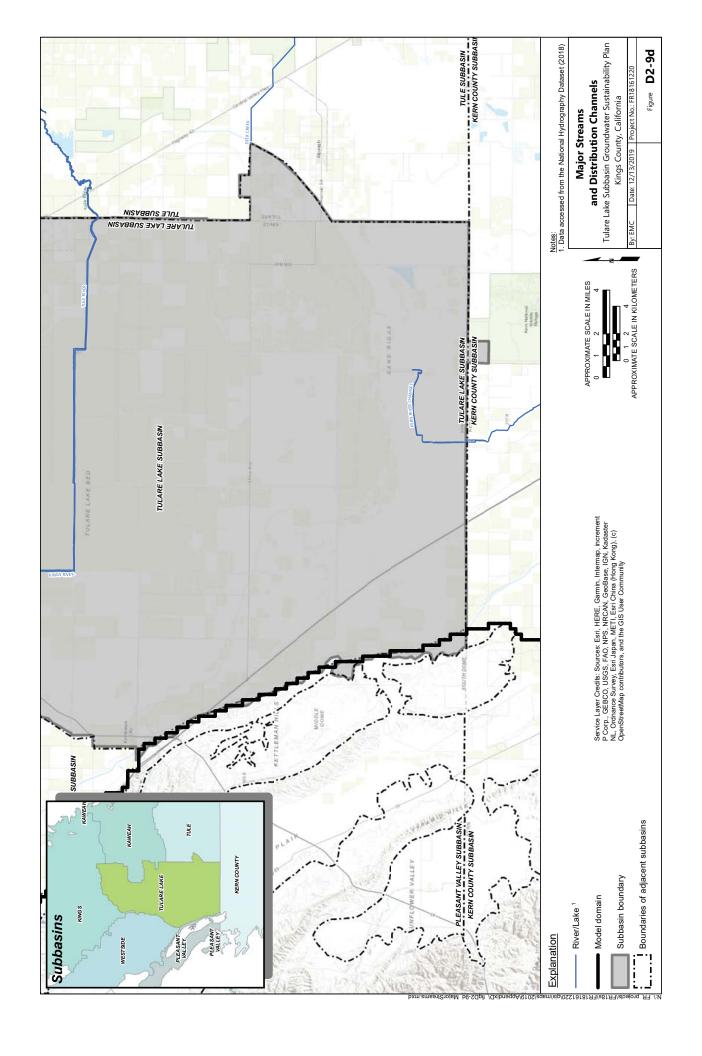


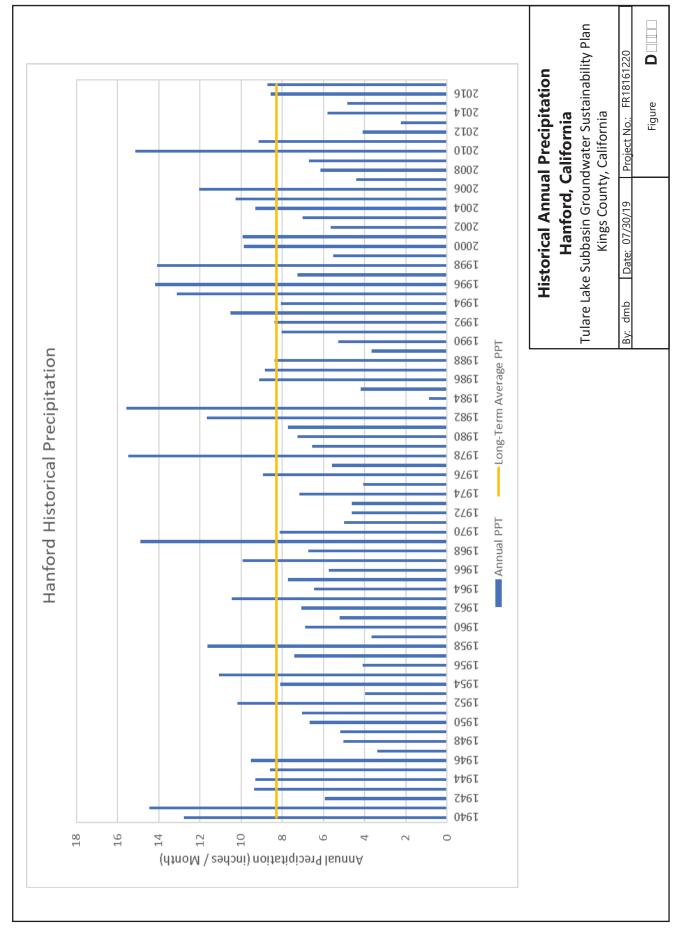
D2-9a

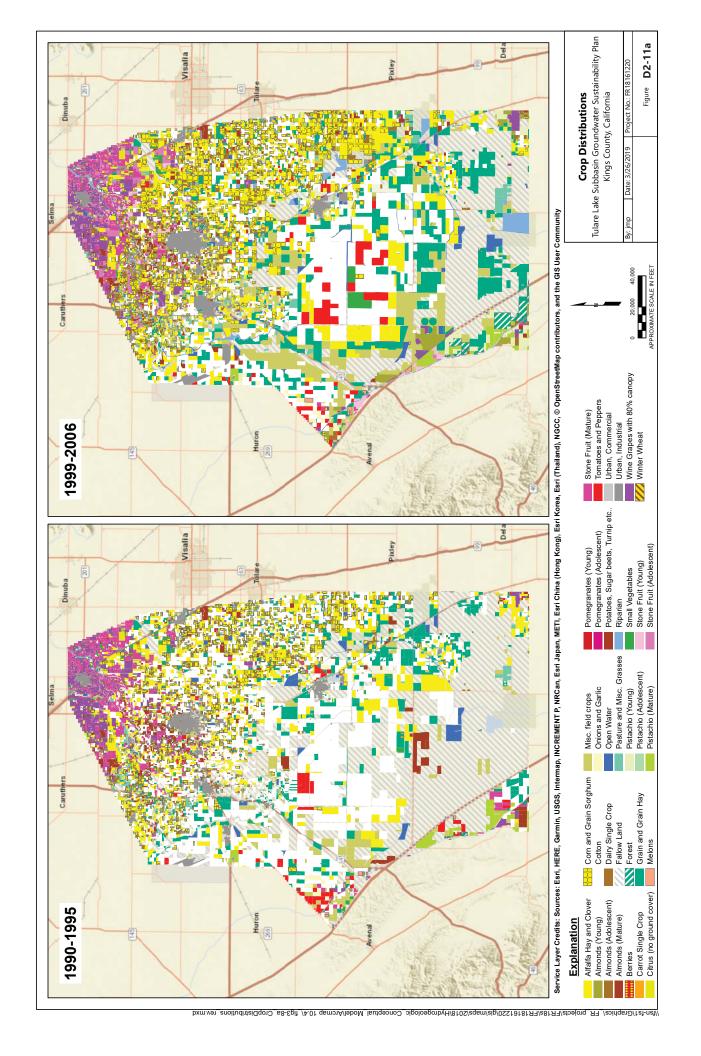
Figure

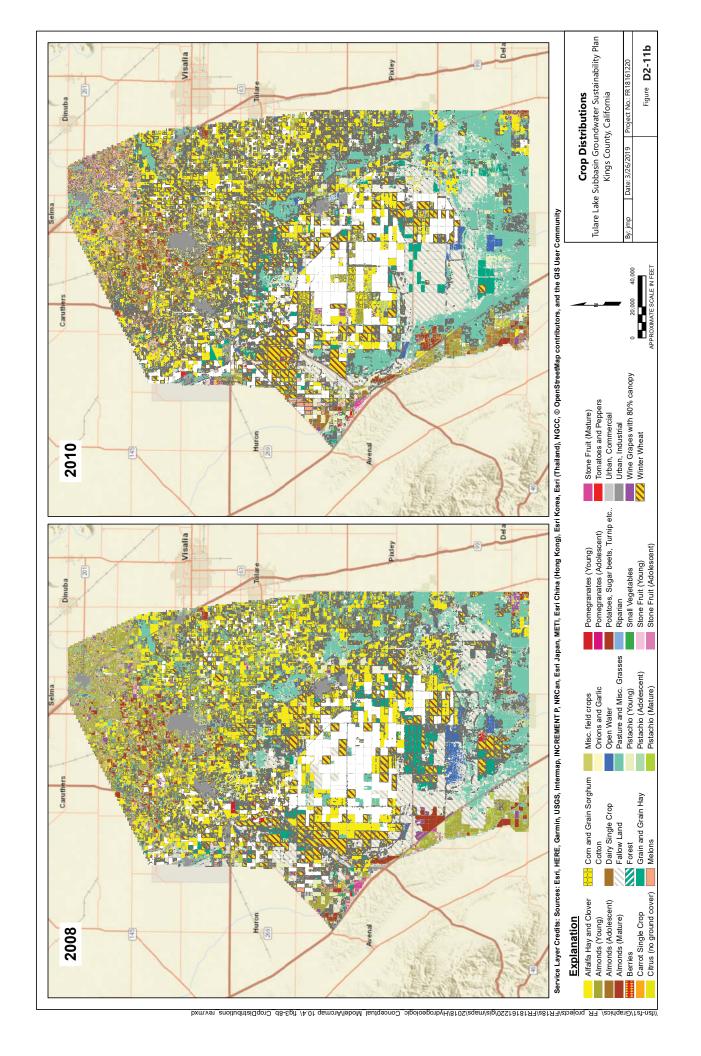


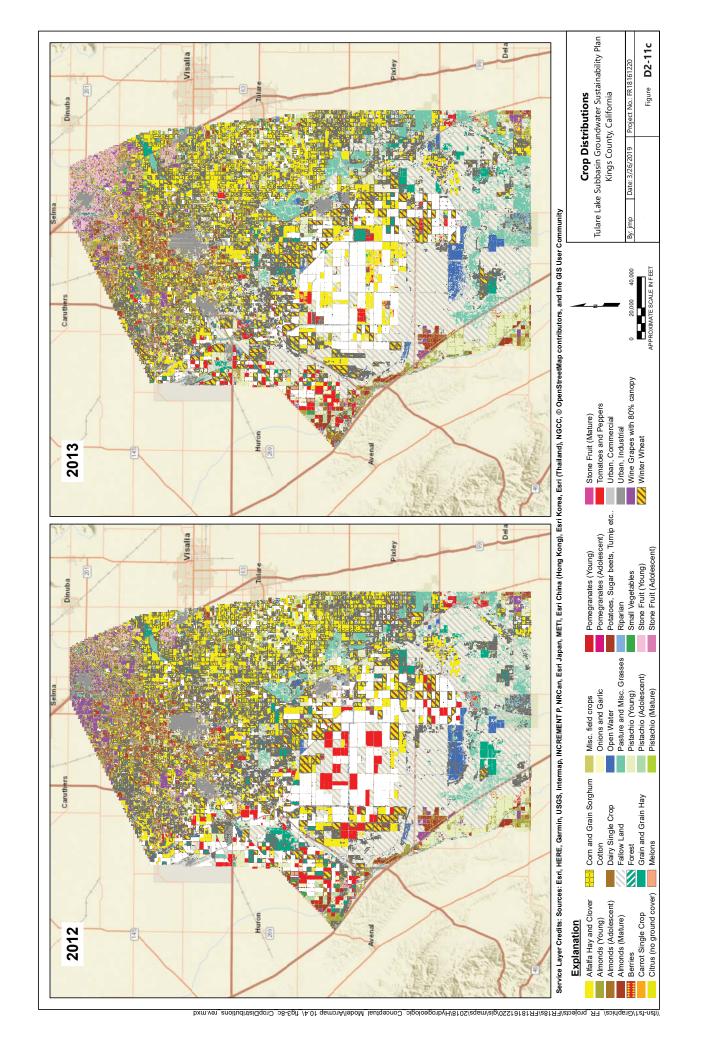


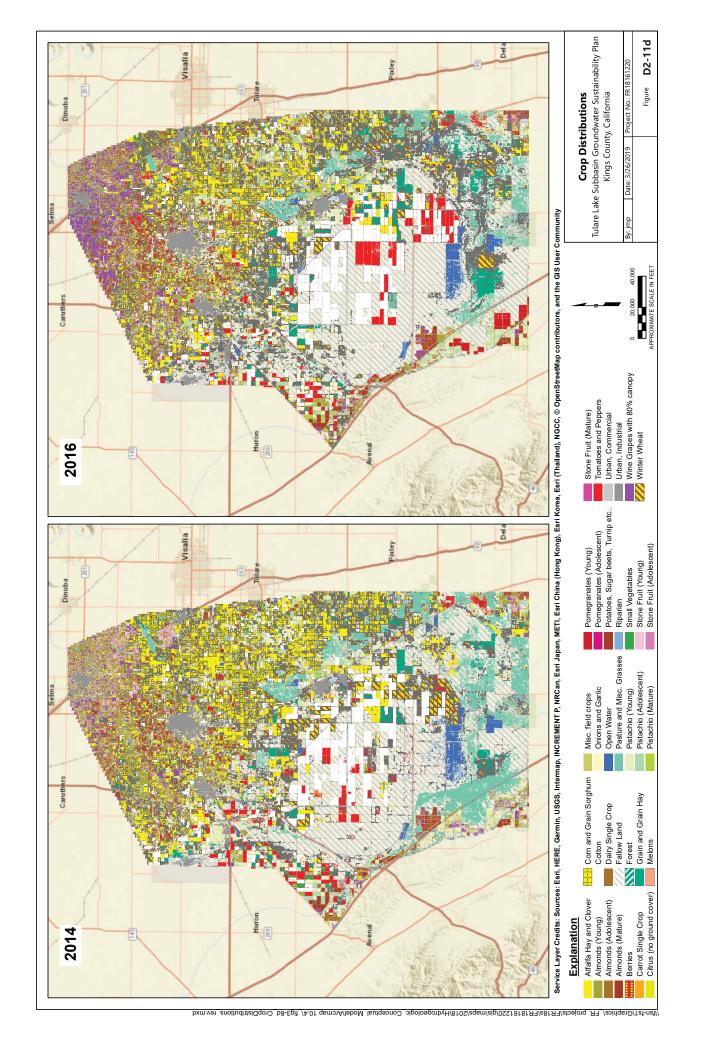












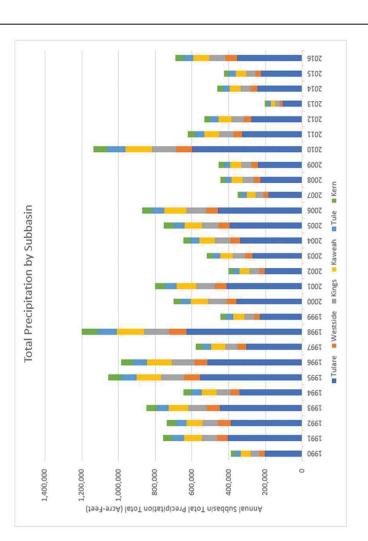
D2-12 Tulare Lake Subbasin Groundwater Sustainabilty Plan Historical Crop Acreage in Model Domain Fallow Land (Acres) Project No.: FR18161220 250,000 200,000 150,000 100,000 50,000 2016 Figure Kings County, California ■ Pasture and Misc. Grasses 2014 Grain and Grain Hay 2013 Date: 07/30/19 2012 2011 2010 2009 By: dmb Corn and Grain Sorghum 2007 2006 --Fallow Land 2005 **Tulare Lake Subbasin** Cotton 2004 2003 2002 2001 ■ Dairy Double Cropping 2000 1999 Pistachios 1998 Urban 1997 1996 1995 799A 1993 Pomegranates 1992 Row Crops Almonds 1991 1990 Crop Acreage (Acres) 0 200,000 50,000 250,000

N:_FR_projects\FR18s\FR18161220\temp\DBean_Hydro_\Wood Figure TemplatesFig 2-12 HstoricalCrop Acreage 9/7/2019

ANNUAL TOTAL PRECIPITATION (ACRE-FEET)

Westside Kings 28,212 48,9	
57,267 83,913	
-	-
50,626 75,966	
85,801 126,208	***
70,468 123,183	
46,045 70,190	
94,415 137,547	
30,280 53,202	
53,273	
63,322 101,366	3.
30,798 53,013	
40,570 66,233	
53,188 82,590	
61,121 90,935	
64,091 108,085	-
26,460 44,432	
37,419 58,349	
36,916 55,236	
88,582 130,029	
46,550 76,276	
39,653 66,630	
15,048 22,376	
37,368 54,143	
29,592 51,681	
60,978 87,691	
15,048 22,376	
94,415 137,547	
51,370 79,793	

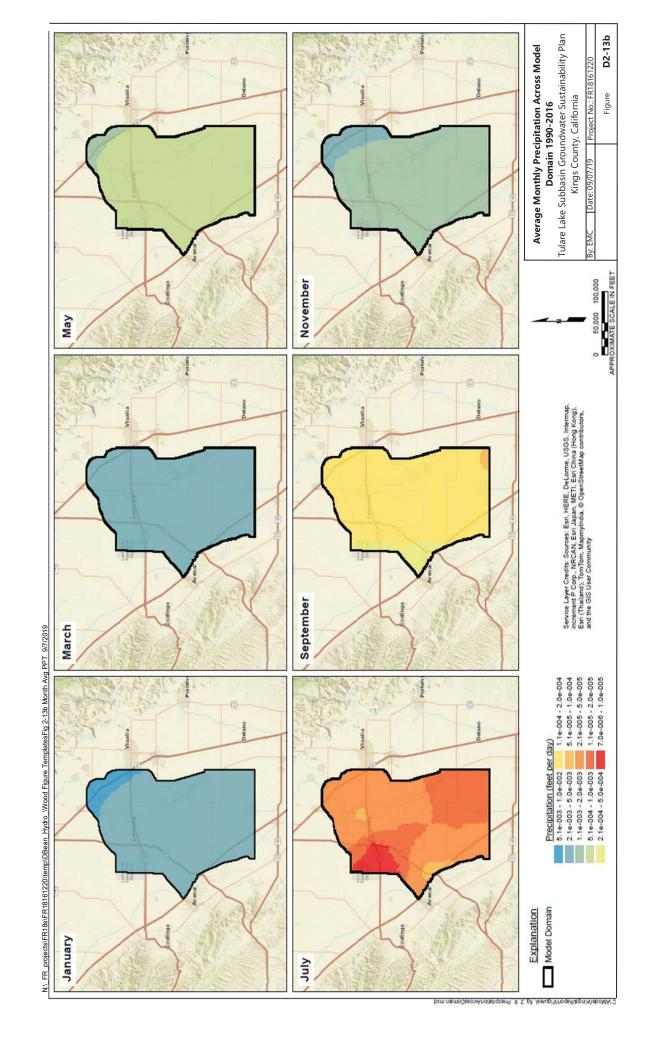
Annual precipitation totals are based on 4-kilometer grids of precipitation from the Oregon State University PRISM database. Monthly totals taken from January 1990 to December 2016



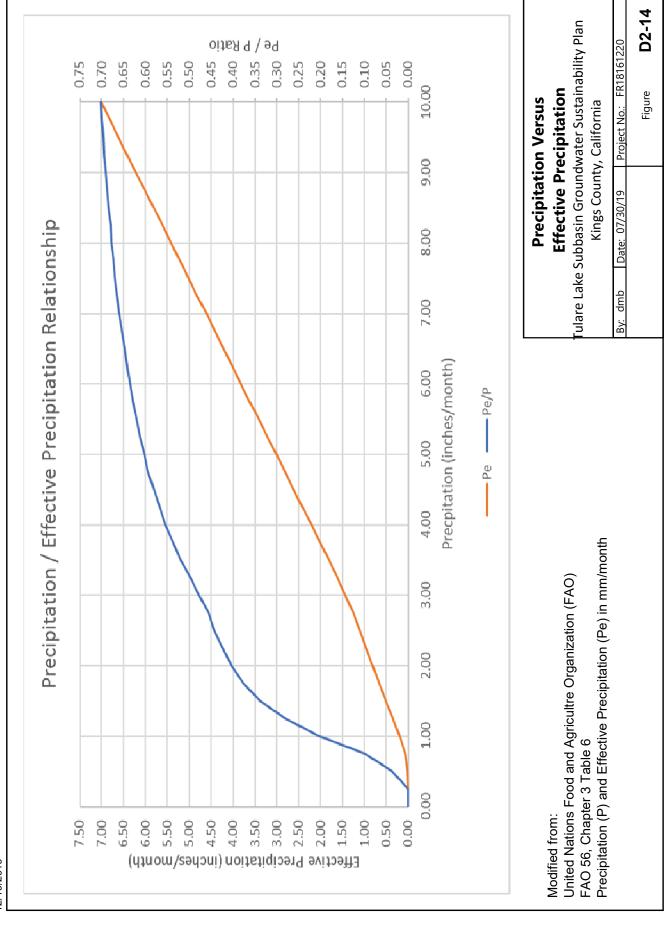
Estimated Annual Total

Precipitation by SubbasinTulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

nb	Date: 07/30/19	Project No.: FR18161220
		Figure D2-13a



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



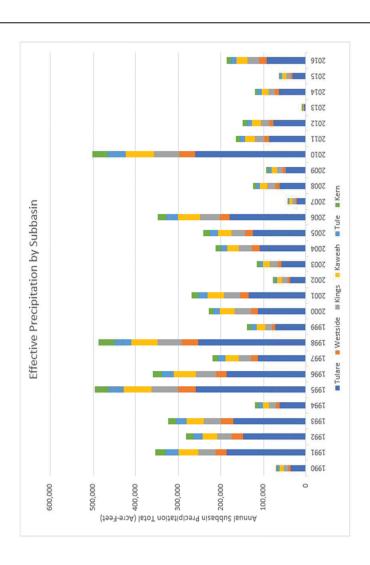
1:FR18sFR18sFR18161220 Tulare Lake GSPIFigures/8-Appendices/Figures/PendingReview/AppendixD\December2019\DRAFT_TLSB_SGWA_GWWodel_Figures_v3.xisxFig D2-15 Annual SB Eff PPT 12/19/2019

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
9661	186,149	24,278	48,754	51,487	27,483	21,442	359,593
1661	113,642	15,748	28,680	30,918	17,369	13,352	219,710
8661	252,323	38,854	56,898	60,724	41,542	36,341	486,681
6661	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	908'9	116,460
2004	109,787	18,411	29,462	28,012	14,496	12,064	212,232
2002	124,268	19,089	31,607	31,363	18,469	16,100	240,896
5006	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
5000	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

OoteD

Onual effeit.ib DredDitation totals are based
on CikiloD eter grids of DredDitation froD tDe
Oregon State DniErsity PUSM database and
Offeit.ib PredDitation CDart

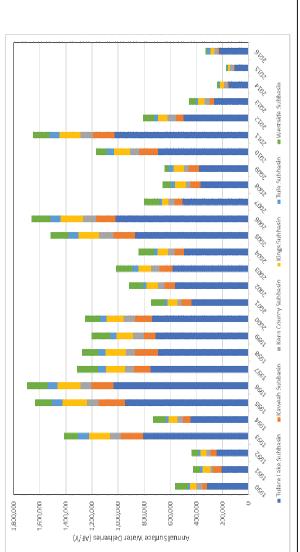


Estimated Annual Effective Precipitation by Subbasin

1:1F718sFR18161220 Tulare Lake GSPFigures8-Appendices/Figures/Pagures/PadingReviewAppendixD/December2019/DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D2-16 SW Diversions 12/19/2019

Annual Surface Water Deliveries (Acre-Feet / Year)

Date	Tulare Lake Subbasin K	aweah Subbasin	Kern County Subbasin K	ngs Subbasin	ule Subbasin V	Tulare Lake Subbasin Kaweah Subbasin Kern County Subbasin Kings Subbasin Tule Subbasin Westside Subbasin Total Model Domain	Model Domain
1990	319,638	34,691	46,977	47,706	14,494	101,753	565,259
1991	209,115	926,99	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	850'669	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	967 701	753 537	100 433	AE 030	100 660	1 055 130



Estimated Annual Surface Water Diversions by Subbasin

	_	_	
ility Plan		161220	D2-16
water Sustainab	, California	Project No.: FR18161220	Figure
Tulare Lake Subbasin Groundwater Sustainability Plan	Kings County, California	Date: 07/30/19	
Tulare Lake		By: dmb	

D2-17

Figure

1.FR18sFR18sFR18161220 Tulare Lake GSPIFigures8-Appendices/FiguresPendingReviewAppendxD\December2019\DRAFT_TLSB_SGWA_GWWodel_Figures_v3.xisxFig D2-17 SW Delvery Areas 12/19/2019

Location of Surface Water Storage Areas and Estimated Annual Lake Bottom

Storage
Tulare Lake Subbasin Groundwater Sustainability Plan
Kings County, California

BIIIO	Project No.: FR18161220	Figure D2-18
Nings County, Camounia	Date: 07/30/19	
	By: dmb	

Surface Water Ponds

Model Area



Total	(AF/Y)	0	0	0	0	23,540	23,540	23,540	23,540	23,540	0	23,540	0	0	23,540	10,700	53,500	147,660	0	0	10,700	23,540	147,660	10,700	0	23,320	23,540	0	616,100
Pond 9	(AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,700	0	0	0	0	10,700	0	0	0	0	0	21,400
Pond 8	(AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23,540	0	0	0	0	23,540	0	0	0	0	0	47,080
Pond 7	(AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12,840	0	0	0	0	12,840	0	0	0	0	0	25,680
Pond 6	(AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25,680	0	0	0	0	25,680	0	0	0	0	0	51,360
Pond 5	(AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21,400	0	0	0	0	21,400	0	0	0	0	0	42,800
Pond 4	(AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14,980	14,980	0	0	0	0	14,980	0	0	0	0	0	44,940
Pond 3	(AF/Y)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14,980	14,980	0	0	0	0	14,980	0	0	0	0	0	44,940
Pond 2	(AF/Y)	0	0	0	0	12,840	12,840	12,840	12,840	12,840	0	12,840	0	0	12,840	0	12,840	12,840	0	0	0	12,840	12,840	0	0	12,720	12,840	0	166,800
Pond 1	(AF/Y)	0	0	0	0	10,700	10,700	10,700	10,700	10,700	0	10,700	0	0	10,700	10,700	10,700	10,700	0	0	10,700	10,700	10,700	10,700	0	10,600	10,700	0	171,100
	Date	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2002	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total

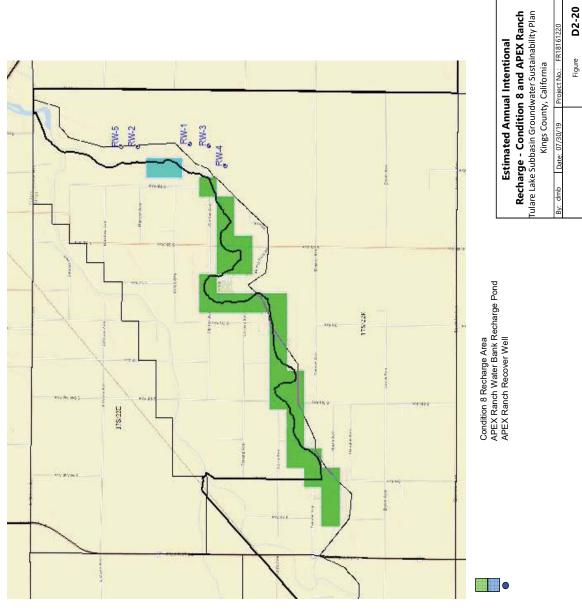
Estimated Annual Intentional Recharge - Corcorian Irrigation District

vater Sustainability Plan California	Date: 07/30/19 Project No.: FR18161220	5
fulare Lake Subbasin Groundwater Sustainability Plan Kings County, California	By: dmb Date: 07/30/19	

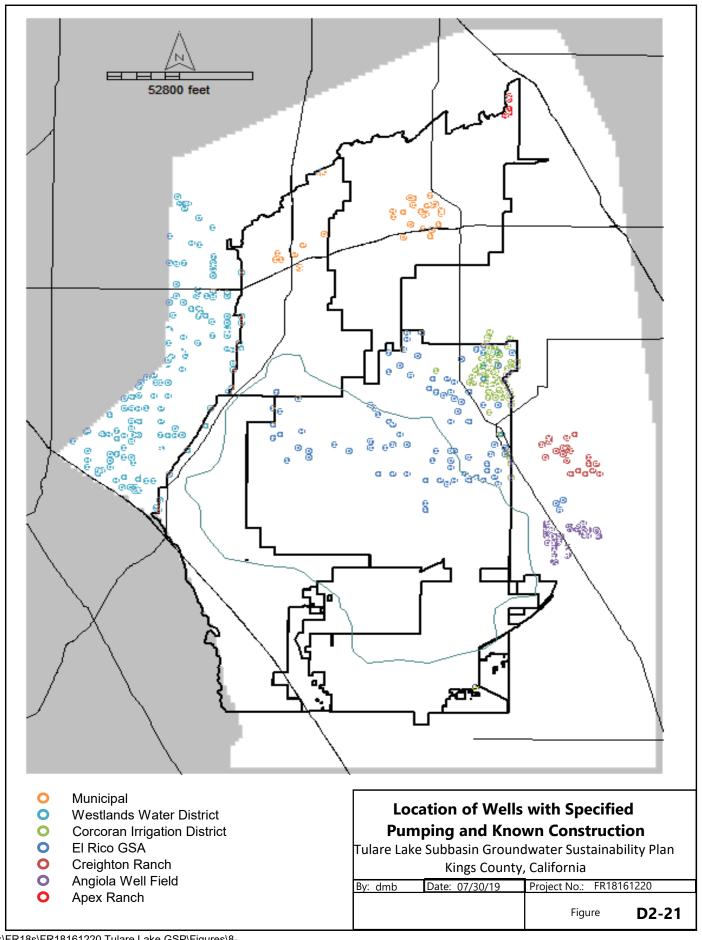
Project No.: FR18161220	Figure D2-19
vate: 07/30/19 Projec	

I:\FR188FR18161220 Tulare Lake GSP\Figures\B-Appendices\Figures\B-AppendixB-NewAppendixD\December2019\DR4FT1\B-SGMA_GWModel_Figures_v3.xlsx\Fig D2.20 APEX int RCH 1219\2019

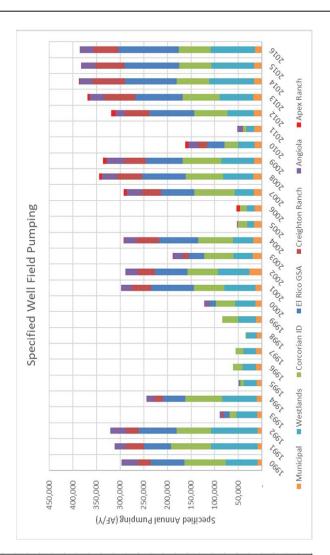
APEX	Storage (AF/Y)	1	1	1	1	1	ŀ	1	1	1	1	1	1	225	3,216	-912	10,994	5,213	-2,689	-2,643	1,837	2,809	10,292	-5,352	1,992	143	0	0	25,125
APEX	(AF/Y) (AF/Y) (AF/Y)	:	1	:	;	;	:	:	;	1	1	:	:	0	526	912	0	6,939	6,319	5,435	7,677	6,345	0	9,044	4,970	298	0	0	48,465
APEX	Recilaige (AF/Y)	:	ł	ł	ŀ	1	ł	ł	ŀ	ł	ł	ł	ł	225	3,742	0	10,994	12,152	3,630	2,792	9,514	9,154	10,292	3,692	6,962	441	0	0	73,590
Cond 8 /	(AF/Y)	1,021	0	0	61	0	36,806	8,541	19,259	37,879	0	0	0	0	0	0	5,442	22,611	0	0	0	0	32,441	0	0	0	0	42,672	206,732
	Date	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2002	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total



Figure



1	El Rico GSA	El Rico GSA Creighton Ranch Corcorian ID	Corcorian ID	Angiola	Westlands	Westlands Municipal Apex Ranch	Apex Ranch
	Well Field	Well Field	Well Field	Well Field	Well Field Well Field	Well Fields	Well Field
Date	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)
1990	70,716	27,222	87,977	34,500	67,131	9,370	ŀ
1991	57,509	38,484	84,438	23,396	98,656	9,109	1
1992	80,012	27,255	72,348	33,494	98,344	999'6	1
1993	11,395	4,035	14,248	5,956	44,056	10,208	3
1994	48,043	17,986	78,297	16,389	72,674	10,928	1
1995	2,897	902	7,145	-	27,589	10,775	1
1996	-	•	20,261	1	28,516	12,719	I
1997		30	15,586	1	27,000	12,775	1
1998			2,484		20,988	11,555	ı
1999			33,406		37,185	13,087	1
2000	14,910	2,849	40,672	6,784	43,392	13,421	1
2001	89,799	41,120	64,353	23,244	65,947	13,895	1
2002	68,933	35,843	64,736	26,537	66,530	26,701	ľ
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	4
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	909	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	99,002	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	7
2016	126,886	53,113	67,982	29,047	93,853	14,555	r



- 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

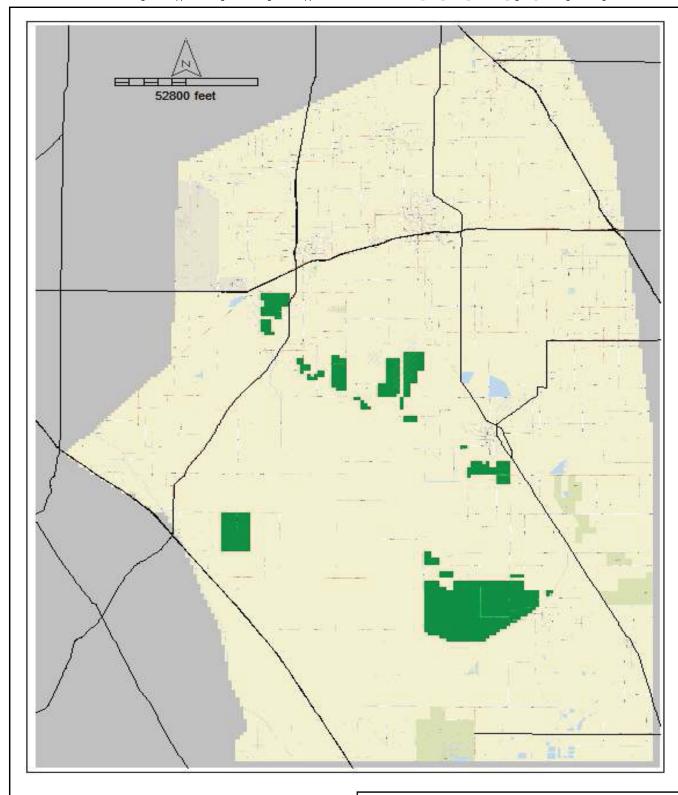
 4. Municipal pumping and Apex pumping provided by various municipalities and Kings River Water District

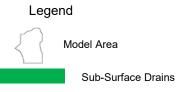
Annual Specified Pumping by Well Field Tulare Lake Subbasin Groundwater Sustainability Plan Kings County, California

	e D2-22	Figure		
_	FR18161220	Project No.: FR18161220	Date: 07/30/19	By: dmb

I:IFR18sIFR18161220 Tulare Lake GSPIFigures\8-Appendices\Figures\PendingReview\AppendixD\December2019\DRAFT_TLSB_SGMA_GWModel_Figures_v3.xlsxFig D2-23 Gross Water Balance 12/19/2019

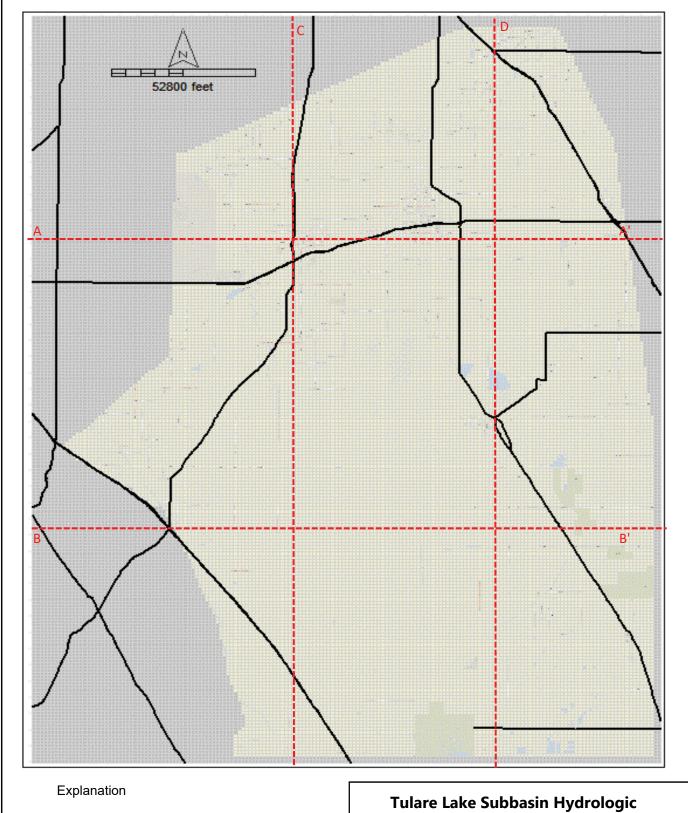
Annual Farm Demand (AF/Y)	Date TLSB Westside (Migs Res Annual TLB Kern Political Political Februaria Total Excess Political Pol	### 624 647 281,443 244,223 488,233 686,388 73,622.248 1990-2016 Average 1,134,781 311,846 340,315 455,289 297,640 136,487 2,676,299 1998-2010 Average 1,134,781 311,846 340,315 455,289 297,640 136,487 2,676,299 1,000,000 1,400,000
Annual Effective Precipitation Utilized by Crops (AF/Y)	Date TLSB Mestside IOINGS Kewesh Tubble Acta 1990 78,722 16,428 27,444 38,793 1,719 7,694 49,574 1992 64,818 20,008 25,068 10,134 4,021 1,244 49,574 1992 64,818 20,008 25,068 90,933 16,254 6,004 163,617 1994 34,514 61,23 14,487 15,929 7,877 2,808 16,254 6,004 163,617 1996 100,745 20,147 36,808 14,877 15,825 7,877 2,818 16,878 23,434 1987 10,745 20,41 3,833 44,875 24,361 36,32 23,440 1986 10,614 40,646 7,218 4,887 24,361 36,32 23,440 1987 10,649 1,649 40,667 7,218 4,887 24,41 1,887 1,411 28,87 1,411 28,87 1,211	Main 2,800 326 525 1,175 889 527 6,246
Annual Crop Demand (AF/Y)	Option T158 Westside Rings Alwareah Tutal Fort 1991 901,113 280,205 228,849 244,566 197,637 87.217 2.231,333 1992 902,016 284,489 284,566 197,637 87.217 2.225,880 1994 902,016 284,489 244,566 197,637 87.217 2.225,880 1994 900,719 288,465 284,566 197,637 87.217 2.225,880 1994 900,719 288,476 228,187 4.04,566 197,637 87.217 2.222,484 1996 900,719 286,485 226,187 4.04,562 264,567 107,481 2.202,484 1996 900,719 287,877 244,566 197,637 107,481 2.301,288 1997 900,719 288,823 296,187 440,466 2.26,437 107,481 2.301,288 1998 986,782 287,187 440,466 107,643 2.36,188 108,487 2.301,288	NAMI 566 889 243,070 202,452 317,724 123,009 31,010 247,467 27,3009 Naxa 1,141,369 243,070 202,452 317,724 129,12,20 247,645 2,246,776 1996-2016 Average 1,066,238 275,730 306,213 404,942 263,446 120,142 2,436,710 1997 201,618 47,539 280,075 38,889 277,325 104,451 26,455,710 1991 209,636 50,286 60,286 67,030 203,386 16,662 424,142 1992 20,956 50,286 60,286 67,030 20,388 14,511 4,673 4,673 4,674





Approximate Location of Sub-Surface Drainage Systems

By: dmb	Date: 07/30/19	Project No.: FR18	161220
		Figure	D2-24

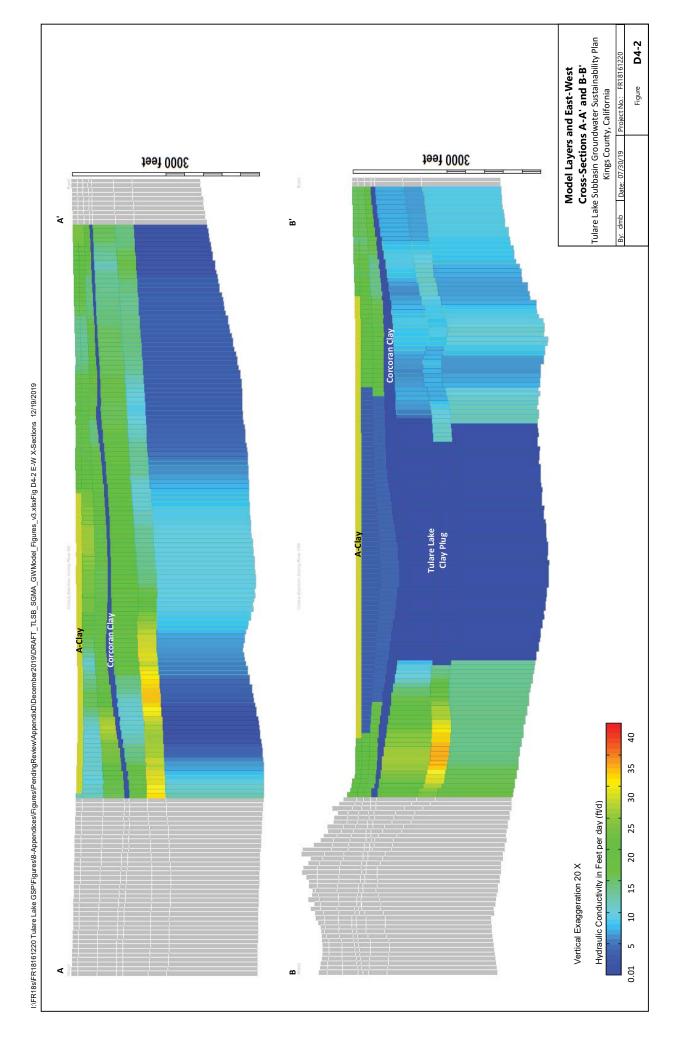


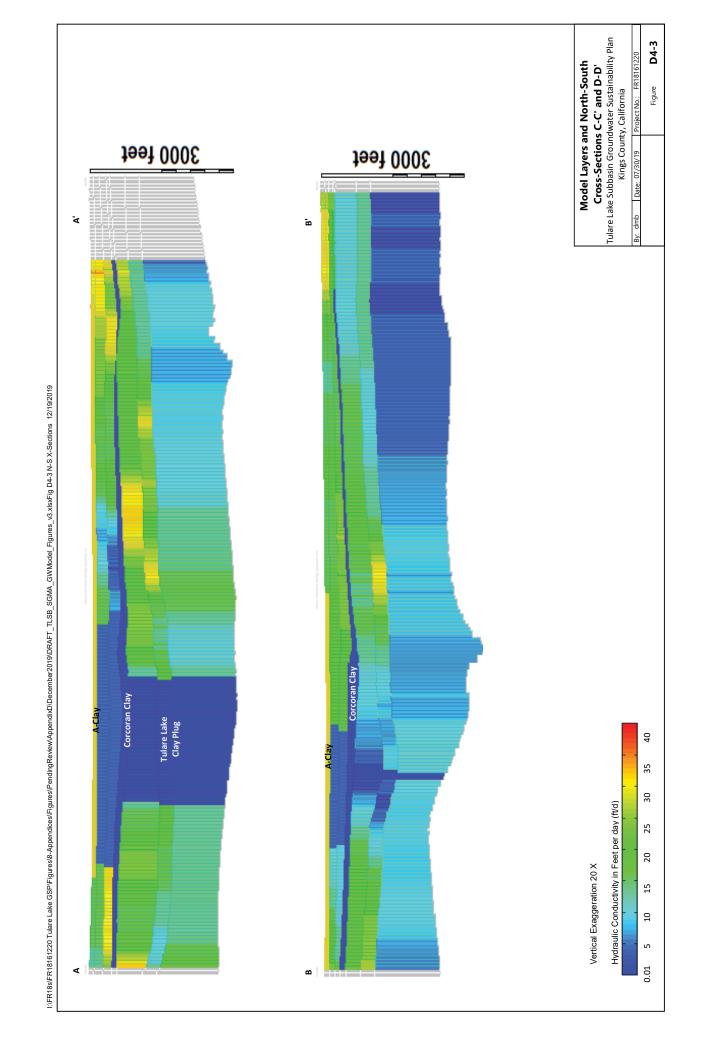


Cross Section Major Roads No Flow

Tulare Lake Subbasin Hydrologic Model Domain and Grid

By: dmb	Date: 07/30/19	Project No.: FR18	3161220
		Figure	D4-1



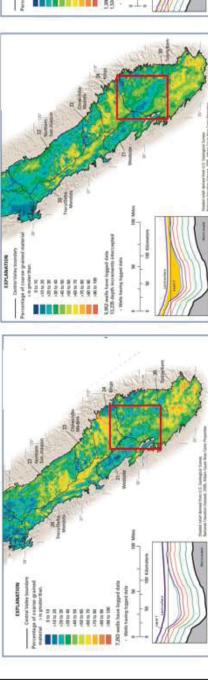


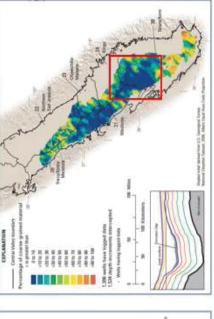
b. 50 - 200 foot depth interval

a. 0 - 50 foot depth interval

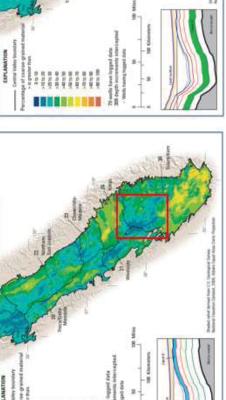
c. Corcoran Clay Depth interval

1:FR18sFR18161220 Tulare Lake GSP/Figures/8-Appendices/Figures/PendingReview/AppendixX)/December2019/DRAFT_TLSB_SGMA_GWModel_Figures_v3.xisxFig D4-4 Texture Model 12/19/2019

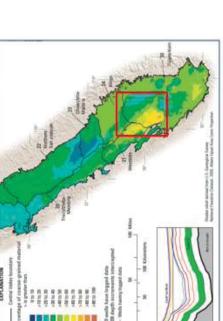




e. 200 foot depth interval from 400 to 700 feet bgs d. 100 foot depth interval immediately below Corcoran Clay



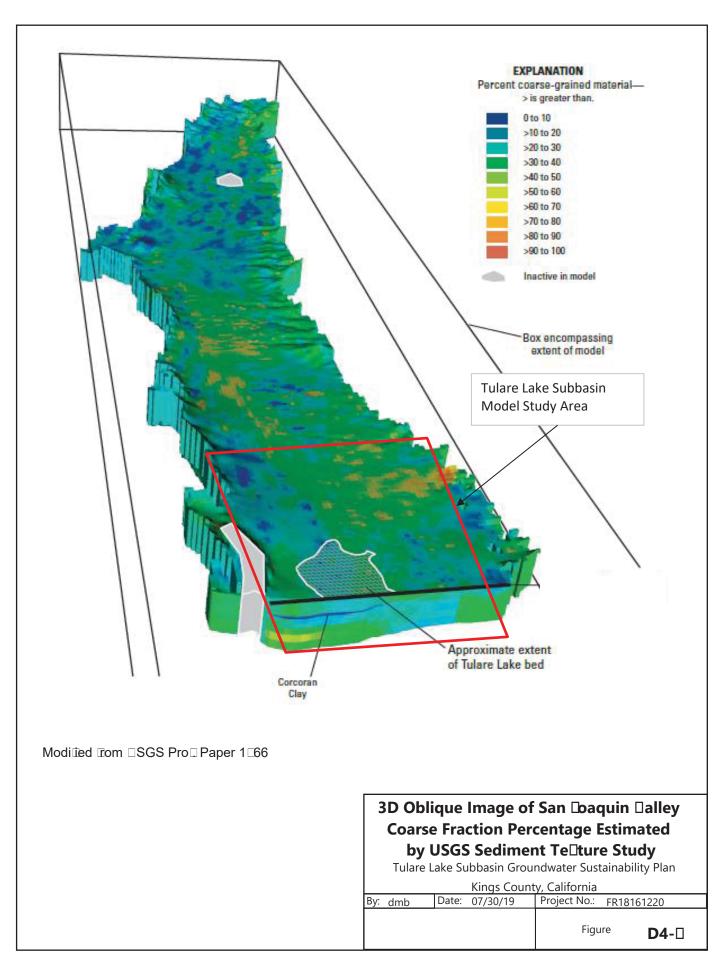
*adaptodfrom Fig. A12, USGS Prof. Papor 1766

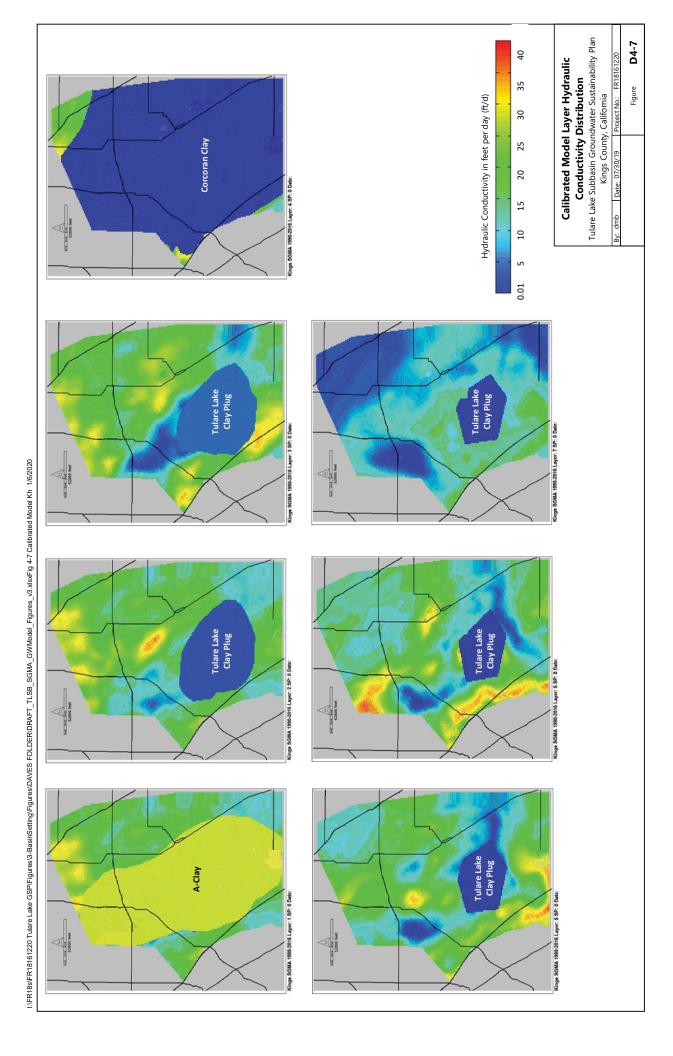


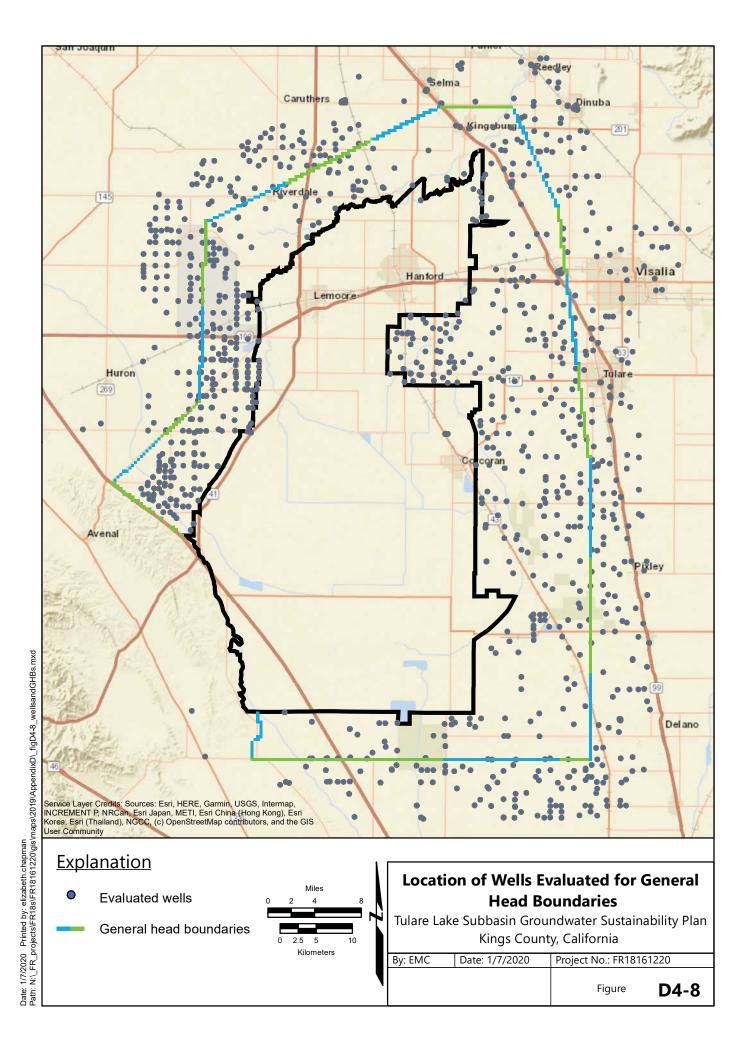
Tulare Lake Subbasin Hydrologic Model study area

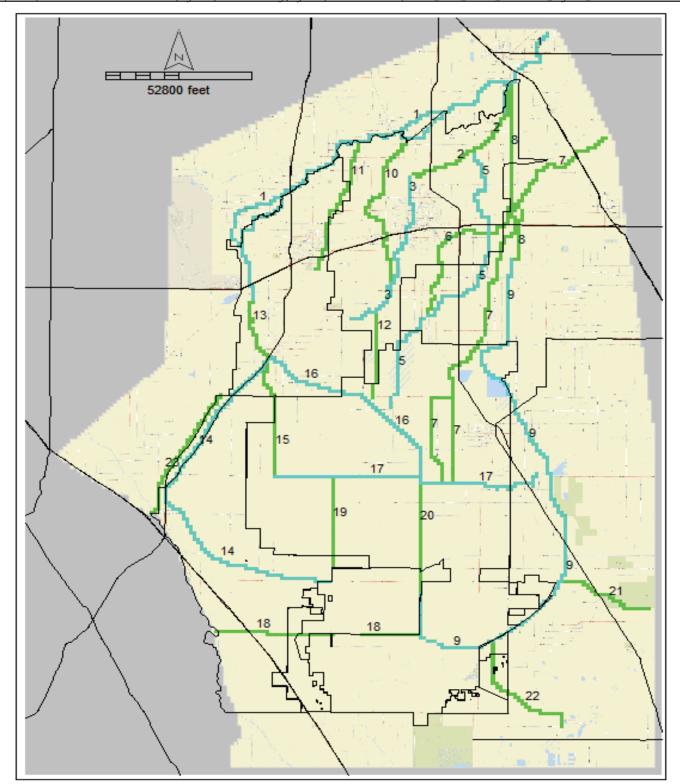
Sediments at Five Depth Intervals Tulare Lake Subbasin Groundwater Sustainability Plan **Kriged Distribution of Coarse Fraction** For San Joaquin Valley Basin-Fill

D4-4 Kings County, California Date: 07/30/19 Project No.: FR18161220 Figure







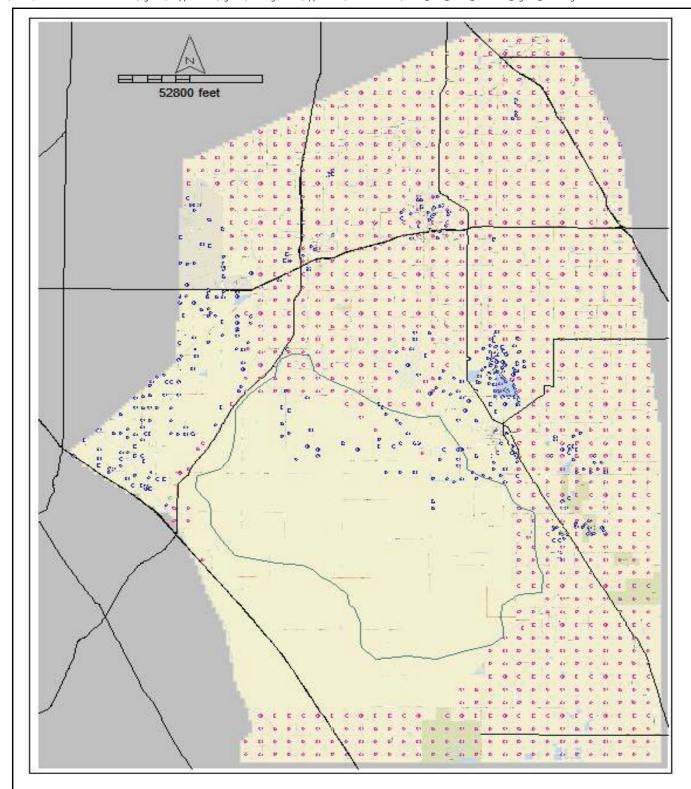


Notes:

- 1) Numbers shown are River Reaches
- 2) Colors delinate different reaches

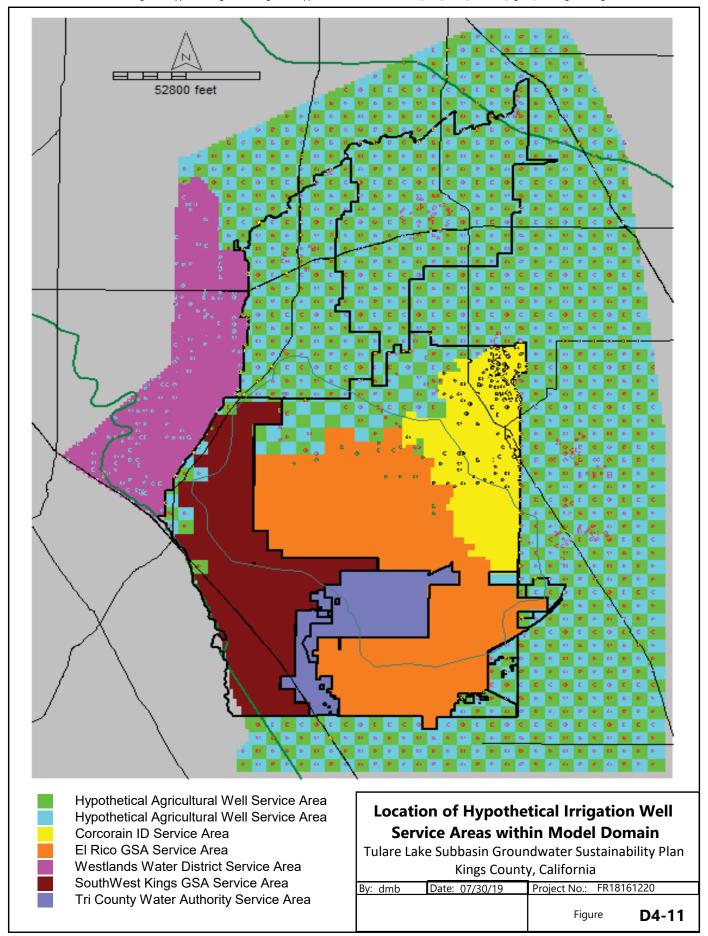
Location of Rivers, Streams, and Canals for River Boundaries

By: dmb	Date: 07/30/19	Project No.: FR181	161220
		Figure	D4-9



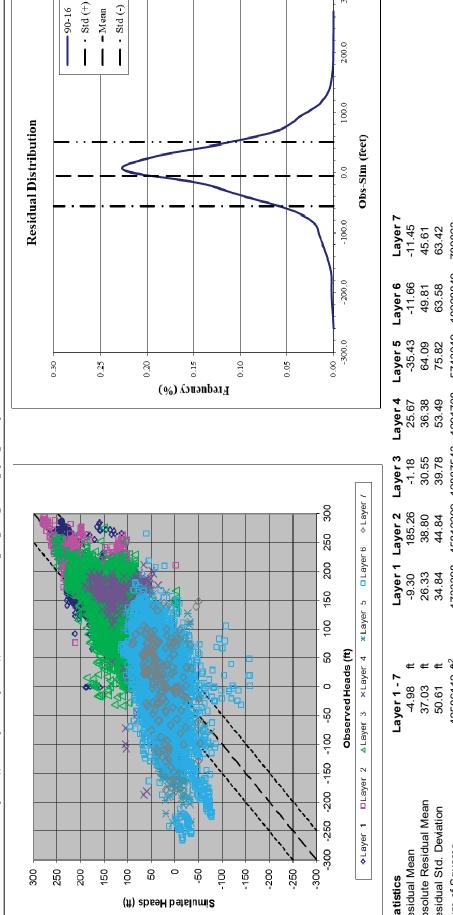
Location of Existing and Hypothetical Pumping Well within Model Domain

İ	By: dm	b Date:	07/30/19	Project No.:	FR181	61220
				Figu	ıre	D4-10





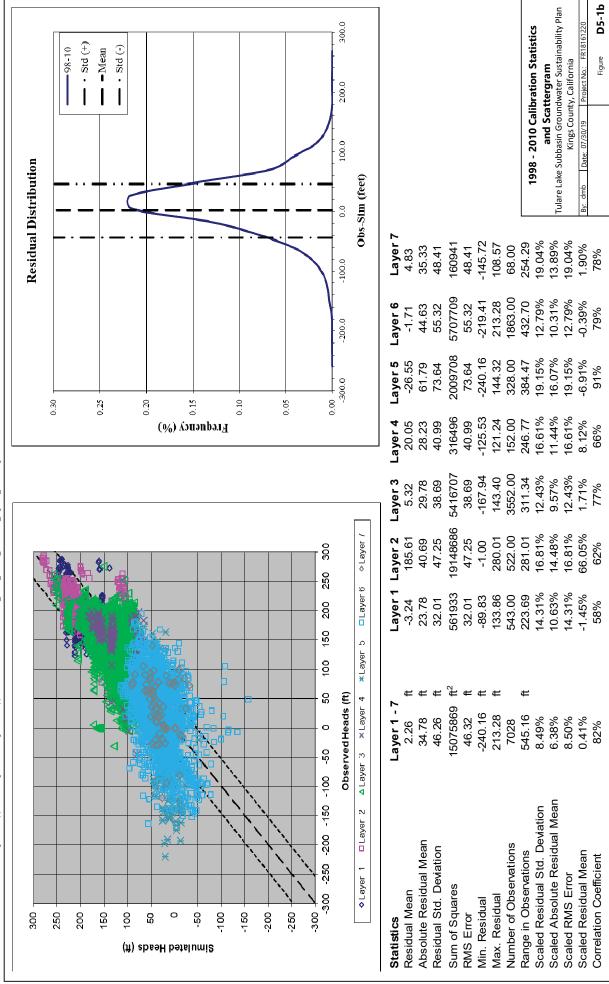
- 90-16

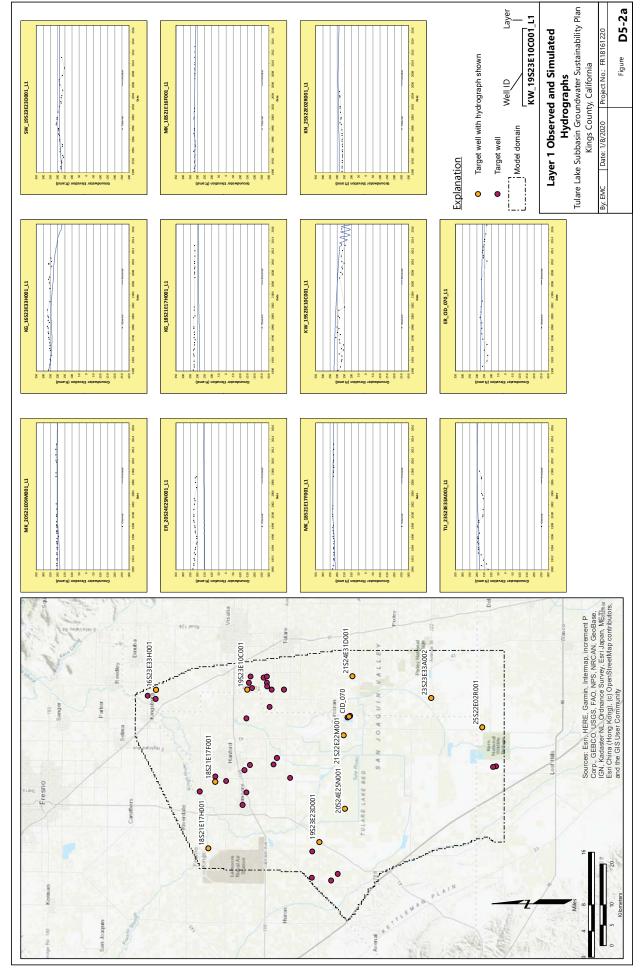


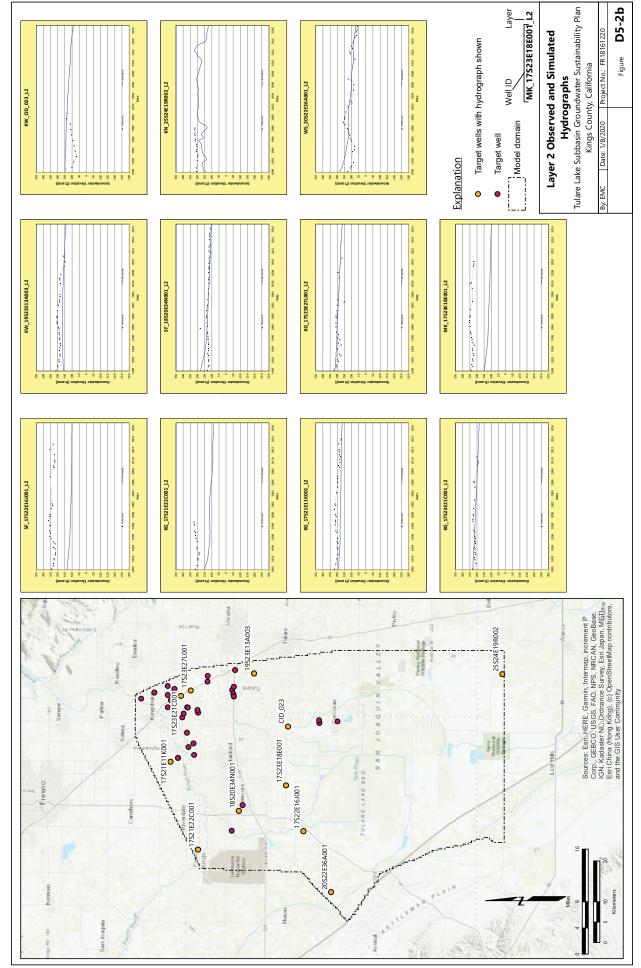
300.0

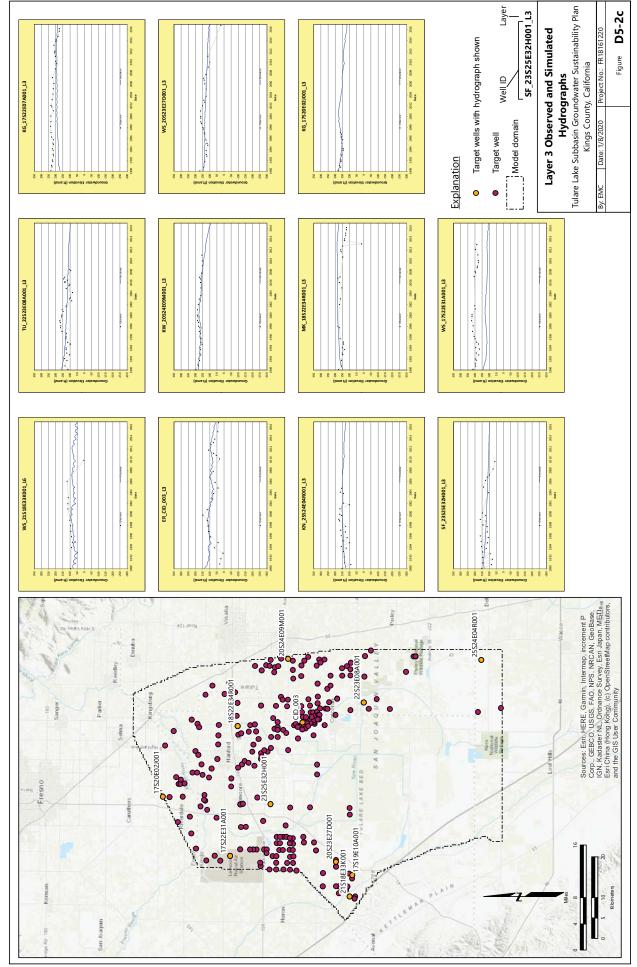
Statistics	Layer 1 - 7	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	Layer 6	Layer 7	
Residual Mean	4.98 ft	-9.30		-1.18	25.67		-11.66	-11.45	
Absolute Residual Mean	37.03 ft	26.33		30.55	36.38		49.81	45.61	
Residual Std. Deviation	50.61 ft	34.84	44.84	39.78	53.49	75.82	63.58	63.42	
Sum of Squares	42586112 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	11 17 17 17 17 17 17 17 17 17 17 17 17 1
Scaled Residual Std. Deviation	8.80%	10.49%	15.96%	12.25%	13.23%	19.22%	13.58%	16.06%	1990 - 2016 Calibration Statistics
Scaled Absolute Residual Mean	6.44%	7.93%	13.81%	9.40%	8.00%	16.24%	10.64%	11.55%	and Scattergram Tulare I ake Subbasia Groundwater Sustainability Plan
Scaled RMS Error	8.84%	10.49%	15.96%	12.25%	13.23%	19.22%	13.58%	16.06%	Kings County, California
Scaled Residual Mean	-0.87%	-2.80%	65.92%	-0.36%	6.35%	-8.98%	-2.49%	-2.90%	By: dmb Date: 11/20/19 Project No.: FR18161220
Correlation Coefficient	82%	%99	64%	74%	%92	%26	82%	82%	Figure D5-1a

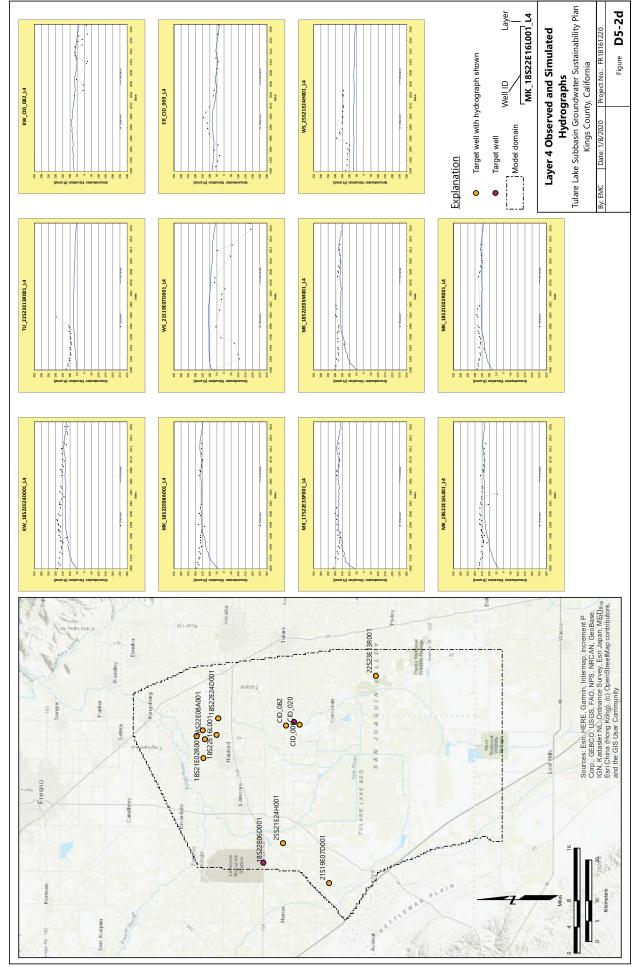


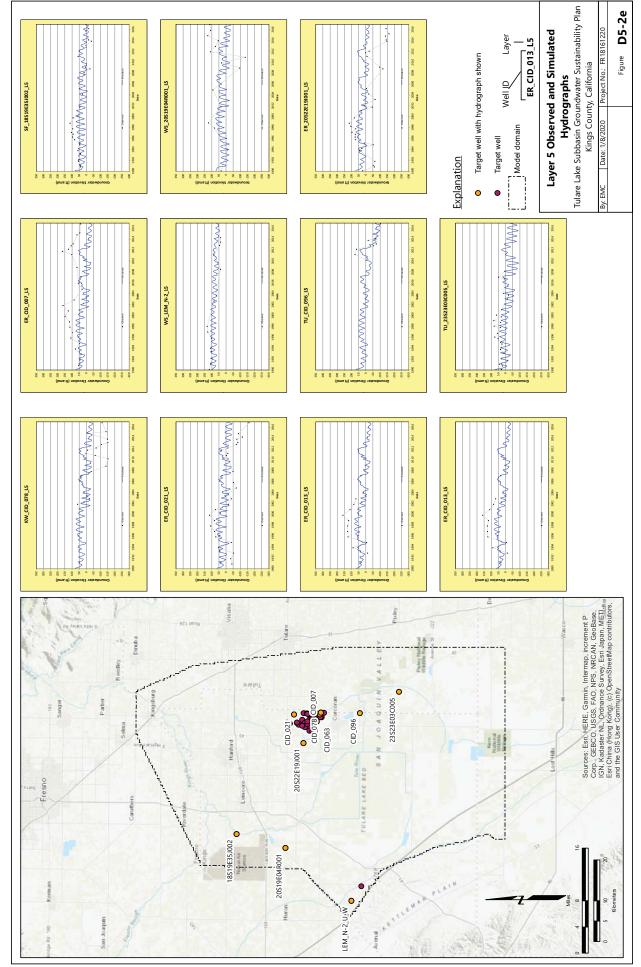


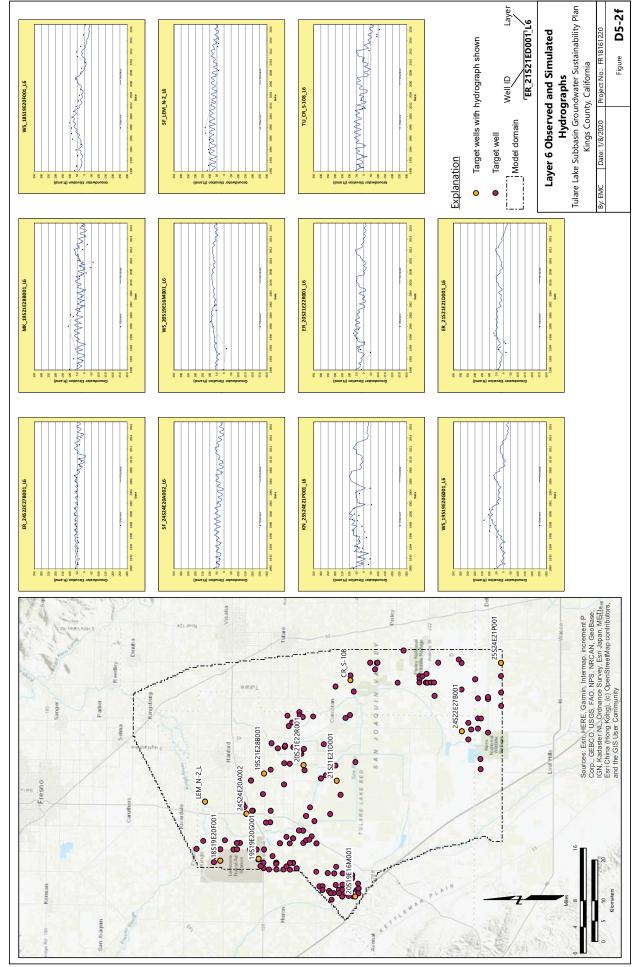


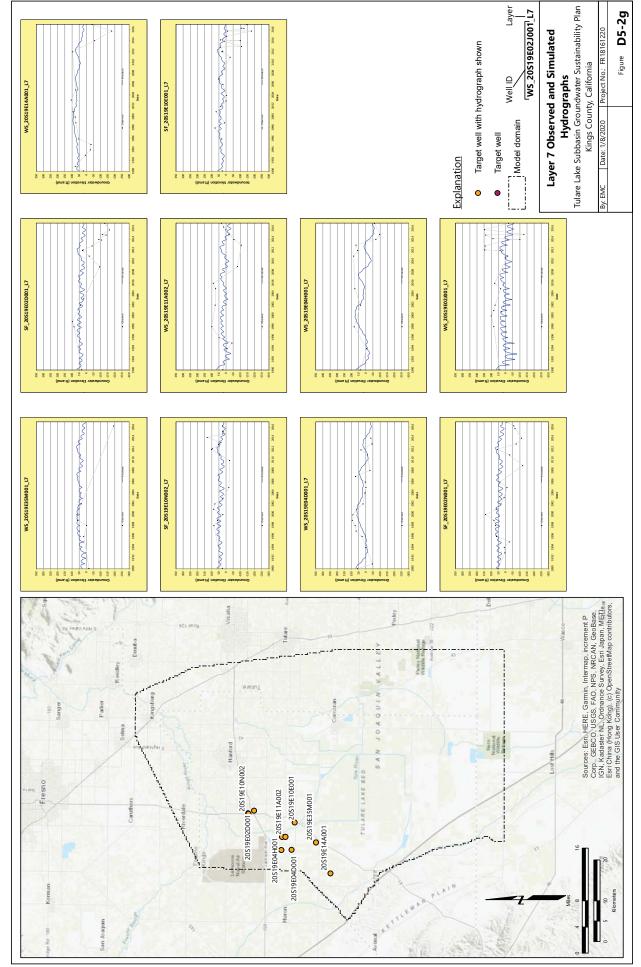


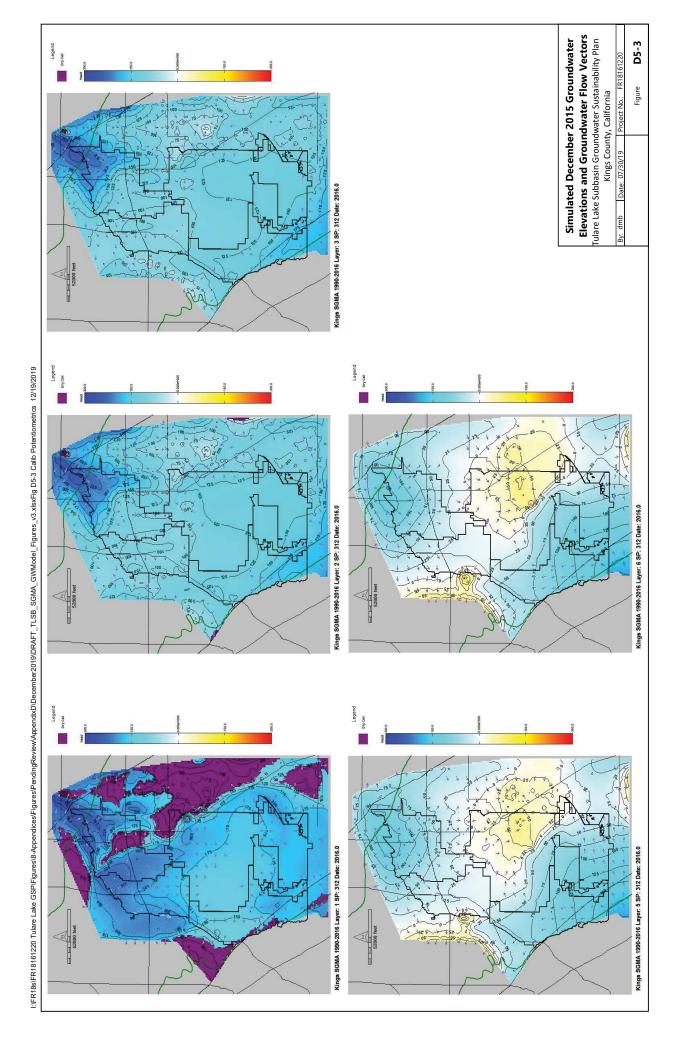


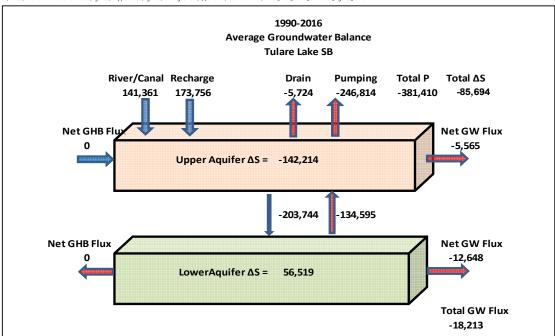






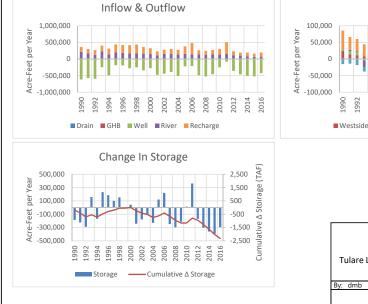


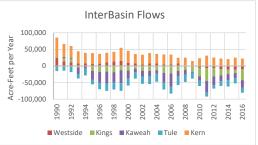




1990 - 2016 Tulare Lake Subbasin

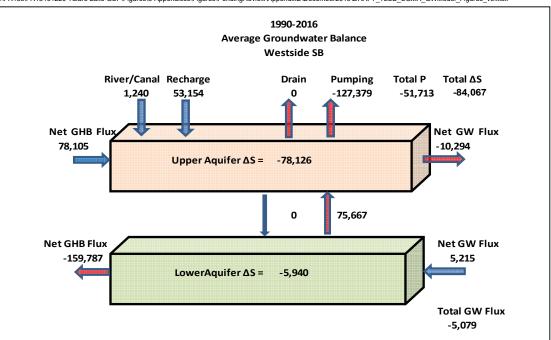
TulareLake	Net	Net	Net	Net	Net	Net	TulareLake	Westside	Kings	Kaweah	Tule	Kern
Date	Drain	GHB	Well	River	Recharge	Storage	Interbasin					-
1990	0	0	-618,843	212,023	150,920	-185,926	69,929	23,632	4,815	-3,467	-12,024	56,971
1991	0	0	-577,240	164,892	135,941	-224,464	51,899	13,271	9,747	4,376	-14,187	38,693
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





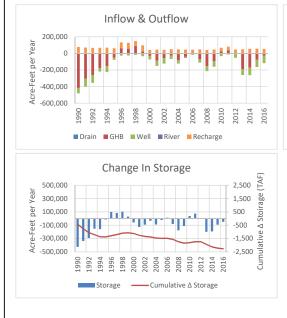
Groundwater Mass Balance Tulare Lake Subbasin

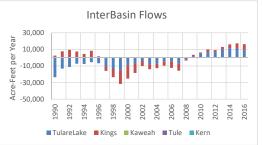
By: dmb	Date: 12/15/19	Project No.: FR18161220
		Figure D5-4



1990 - 2016 Westside Subbasin

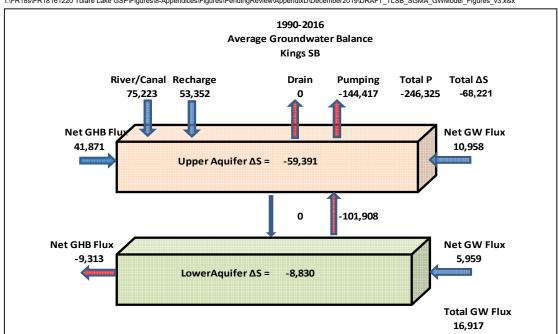
					VVCSISIU	e Subbasir						
TulareLake	Net	Net	Net	Net	Net	Net	Interbasin	Interbasin	Interbasin	Interbasin I	nterbasin I	nterbasin
Date	Drain	GHB	Well	River	Recharge	Storage	TulareLake	Westside	Kings	Kaweah	Tule	Kern
1990	0	-416,613	-64,299	1,305	75,411	-425,294	-23,632	0	2,518	0	0	0
1991	0	-306,833	-94,899	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





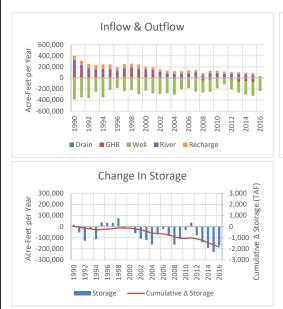
Groundwater Mass Balance Westside Subbasin

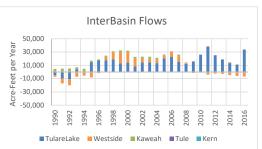
By: dmb	Date: 12/15/19	Project No.: FR18	3161220
		Figure	D5-5



1990 - 2016 Kings Subbasin

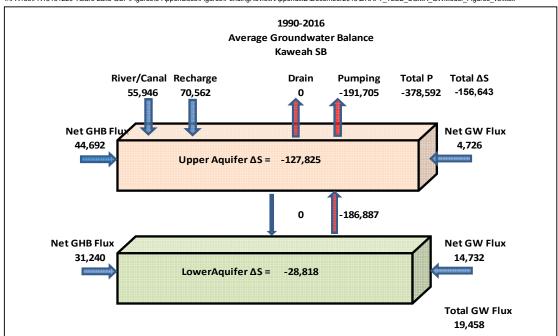
TulareLake	Net	Net	Net	Net	Net	Net	Interbasin	Interbasin	Interbasin	Interbasin I	nterbasin I	nterbasin
Date	Drain	GHB	Well	River	Recharge	Storage	TulareLake	Westside	Kings	Kaweah	Tule	Kern
1990	0	153,507	-384,337	169,046	79,741	15,208	-4,815	-2,518	0	4,504	0	0
1991	0	124,539	-348,796	107,577	75,776	-53,100	-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





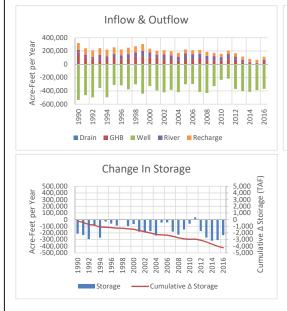
Groundwater Mass Balance Kings Subbasin

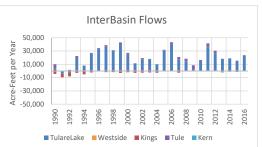
By: dmb Date: 12/15/19	Project No.: FR18161220
	Figure D5-6



1990 - 2016

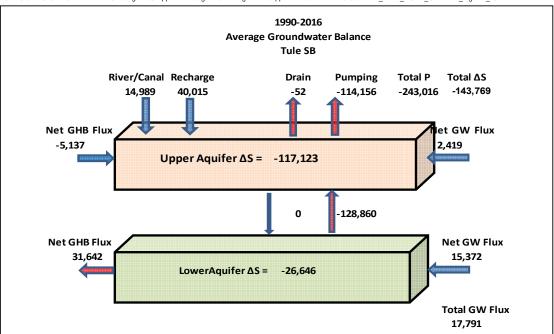
						n Subbasin						
TulareLake	Net	Net	Net	Net	Net	Net	Interbasin					
Date	Drain	GHB	Well	River	Recharge	Storage	TulareLake	Westside	Kings	Kaweah	Tule	Kern
1990	0	172,831	-537,159	42,496	103,609	-212,649	3,467	0	-4,504	0	6,568	0
1991	0	107,583	-463,728	36,764	96,709	-232,084	-4,376	0	-5,048	0	-11	0
1992	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





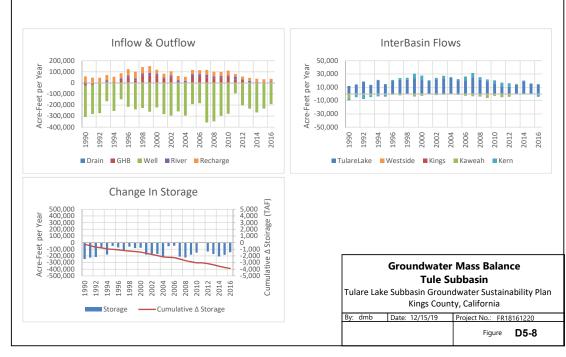
Groundwater Mass Balance Kaweah Subbasin

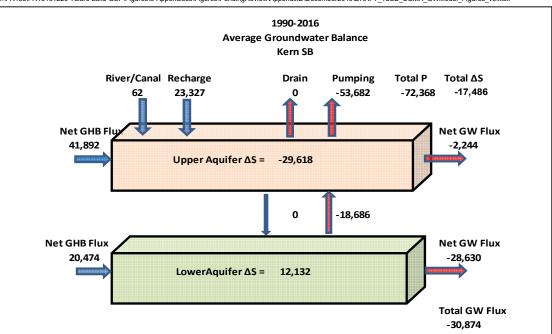
By: dmb Date: 12/15/19	Project No.: FR18161220
	Figure D5-7



1990 - 2016 Tule Subbasin

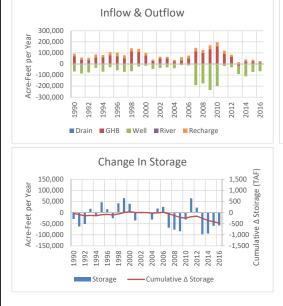
TulareLake	Net	Net	Net	Net	Net	Net	Interbasin	Interbasin I	nterbasin	Interbasin	Interbasin I	nterbasin
Date	Drain	GHB	Well	River	Recharge	Storage	TulareLake	Westside	Kings	Kaweah	Tule	Kern
1990	0	-23,566	-284,555	9,618	48,228	-247,845	12,024	0	0	-6,568	0	-3,025
1991	0	-18,667	-263,398	3,449	43,409	-225,953	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

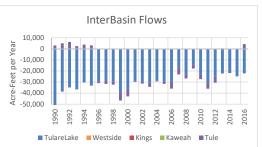




1990 - 2016 Kern Subbasin

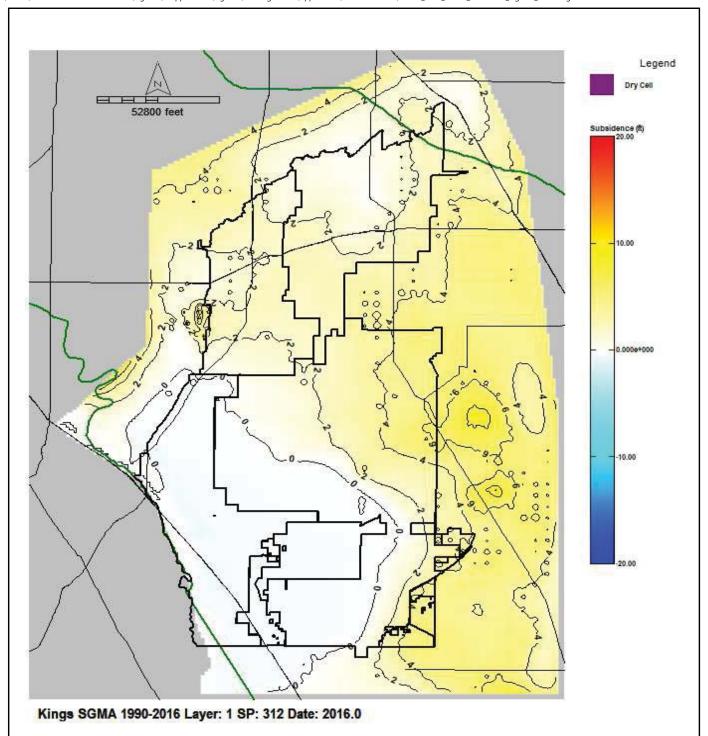
						Subbasin						
TulareLake	Net	Net	Net	Net	Net	Net	Interbasin					
Date	Drain	GHB	Well	River	Recharge	Storage	TulareLake		Kings	Kaweah	Tule	Kern
1990	0	69,796	-67,231	0	, .	-29,265	-56,971	0	0	0	3,025	0
1991	0	38,262	-87,211	0	20,006	-62,690	-38,693	0	0	0	4,946	0
1992	0	34,064	-77,917	187	20,626	-51,761	-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

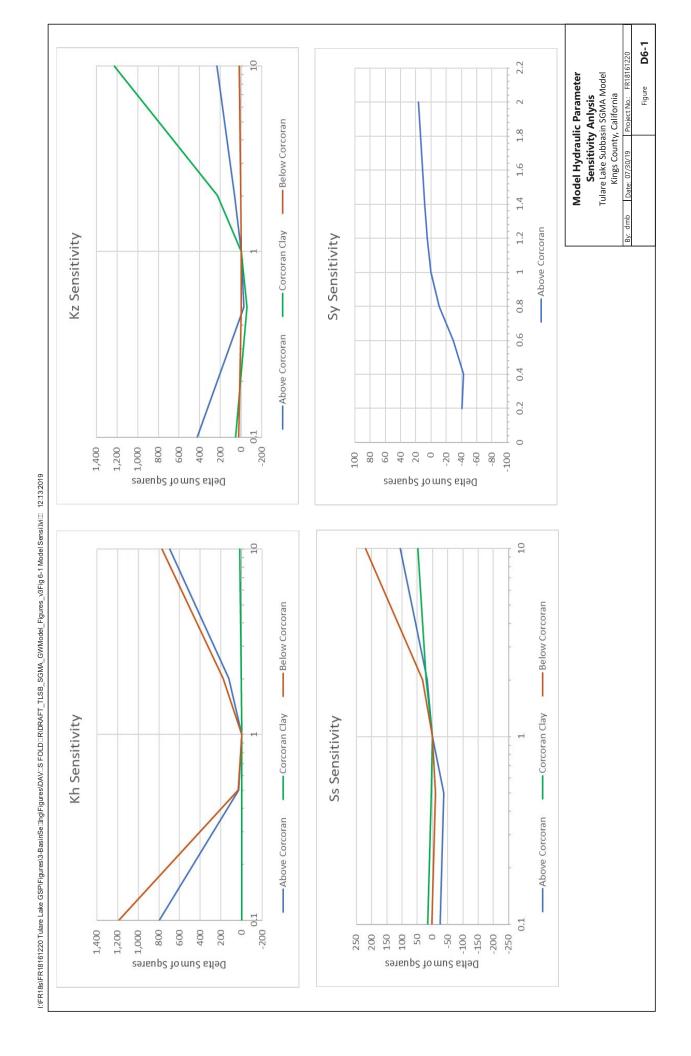
By: dmb	Date: 12/15/19	Project No.: FR18161220
		Figure D5-9

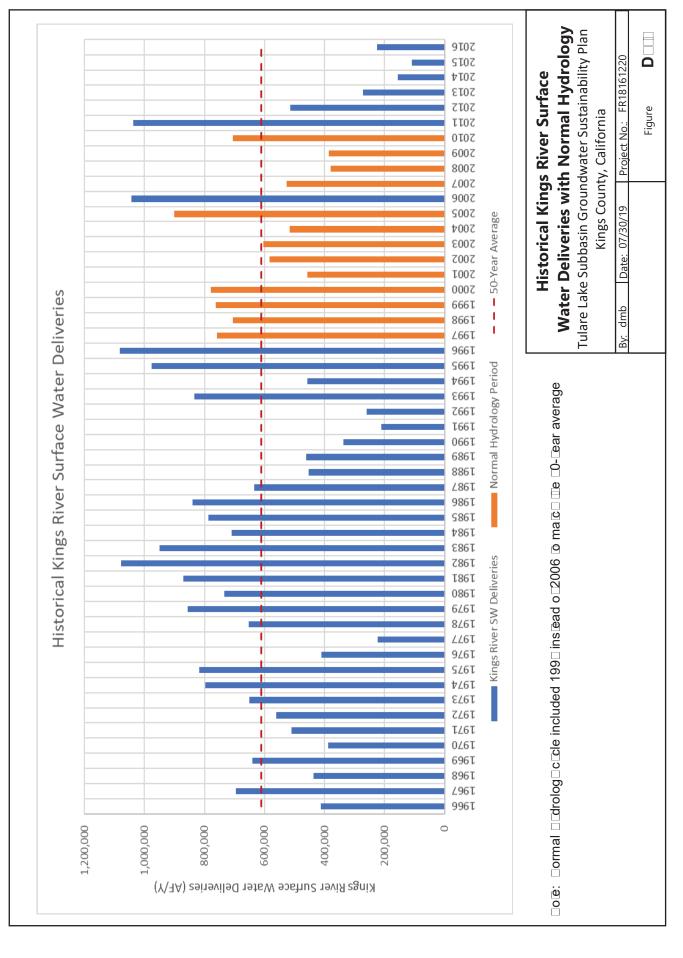


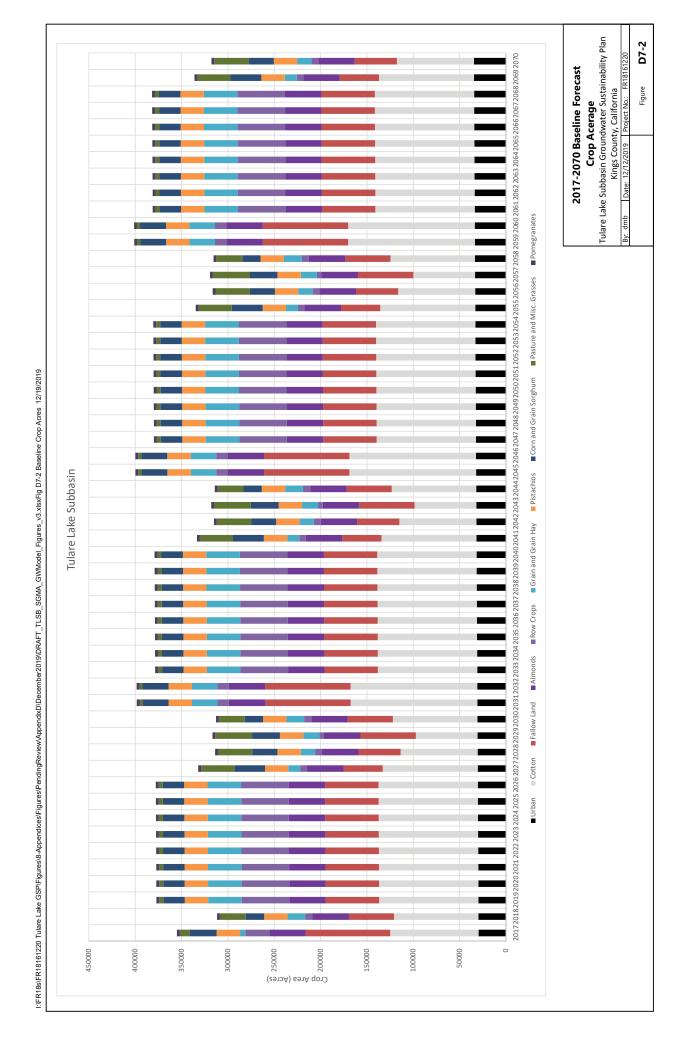
Simulated Subsidence 1990-2015

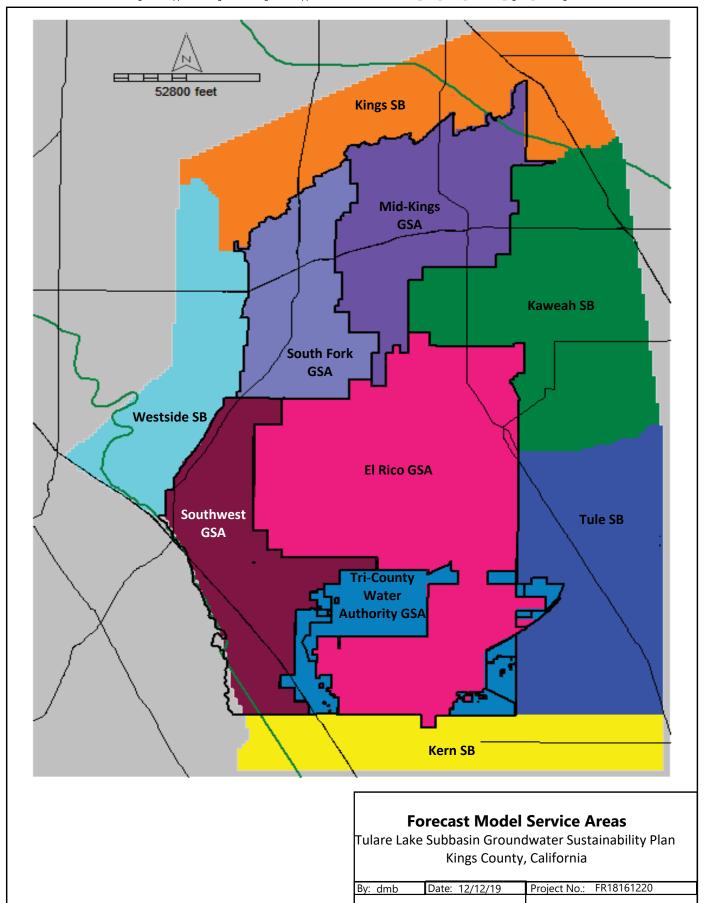
В	y: dmb	Date: 12/12/19	Project No.:	FR1816	1220
			Figu	ire	D5-10

I\/FR185\FR18161220 Tulare Lake GSP\Figures\8-Appendices\Figures\Prigures\Prigures\Prigures\9-Appendices\Figures\Prigure



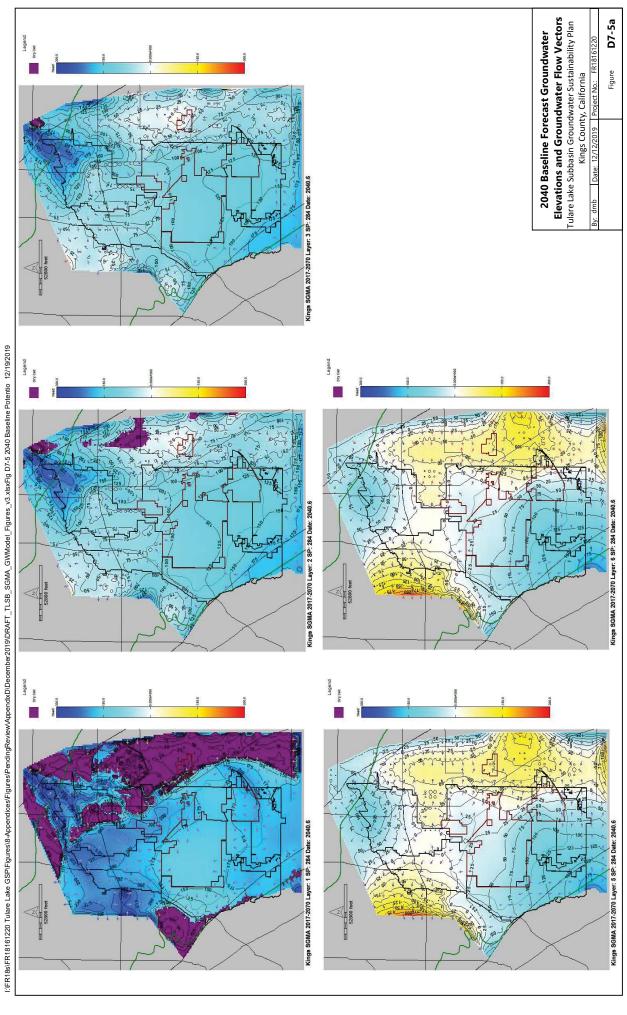


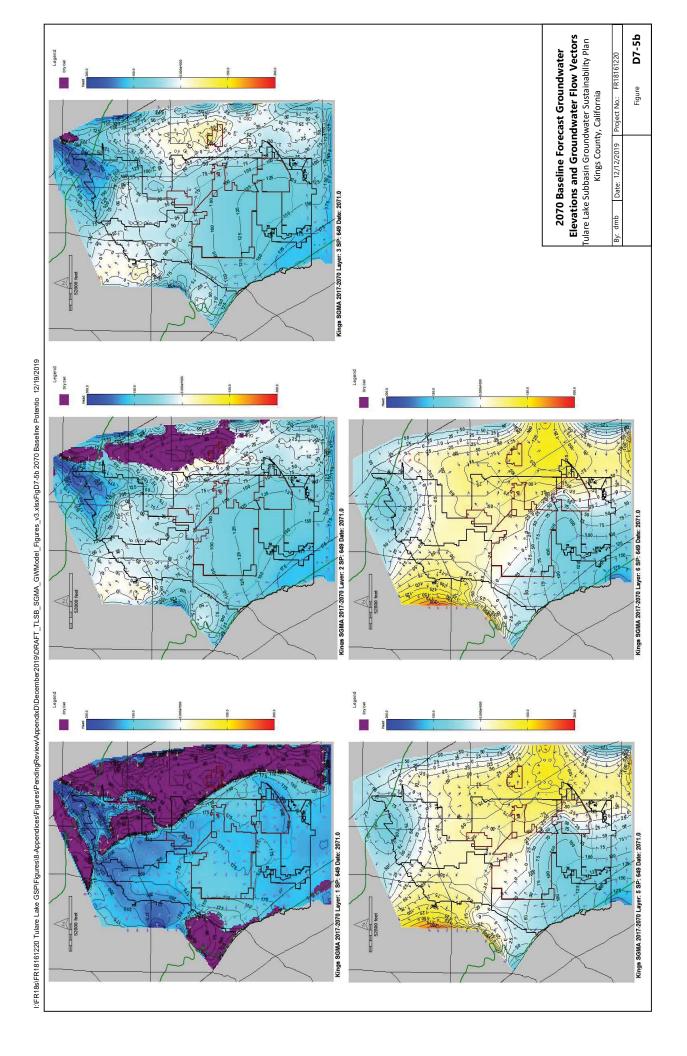


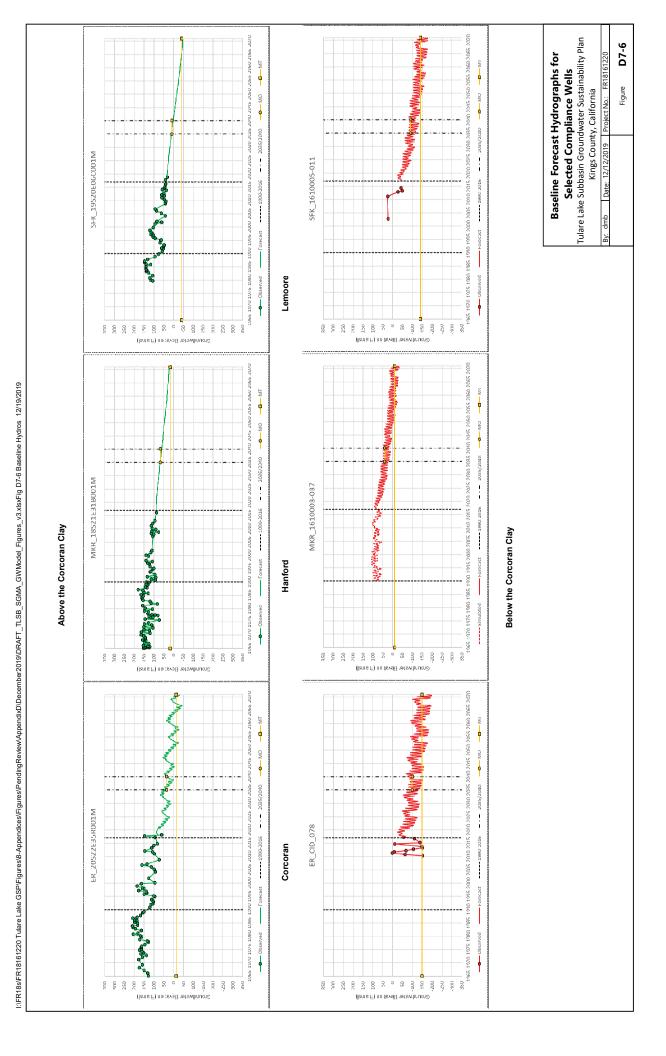


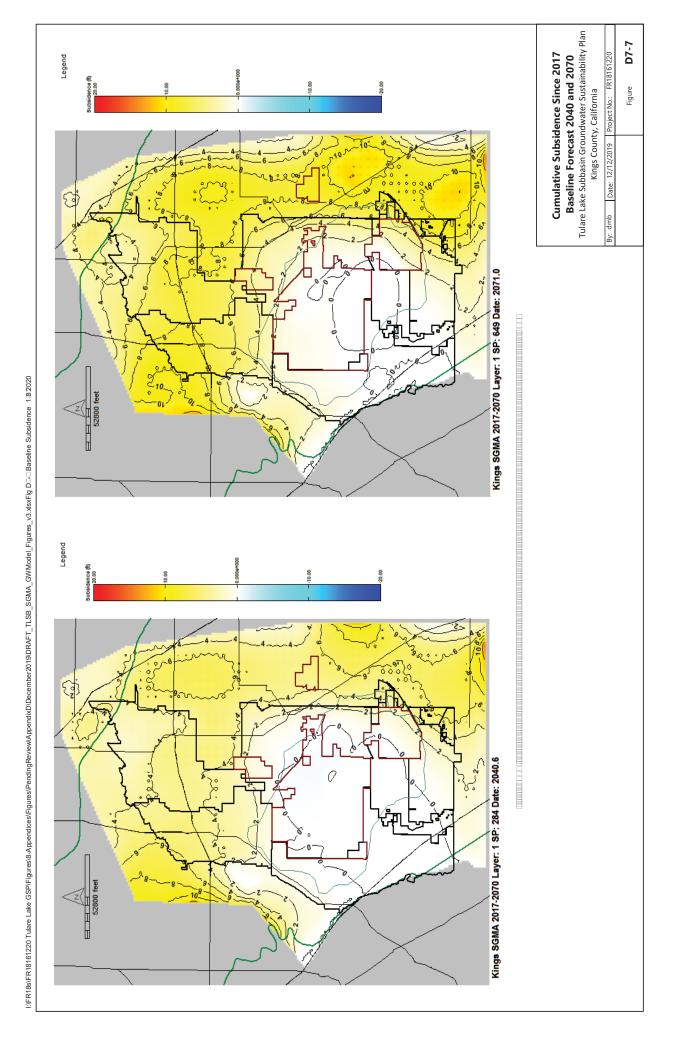
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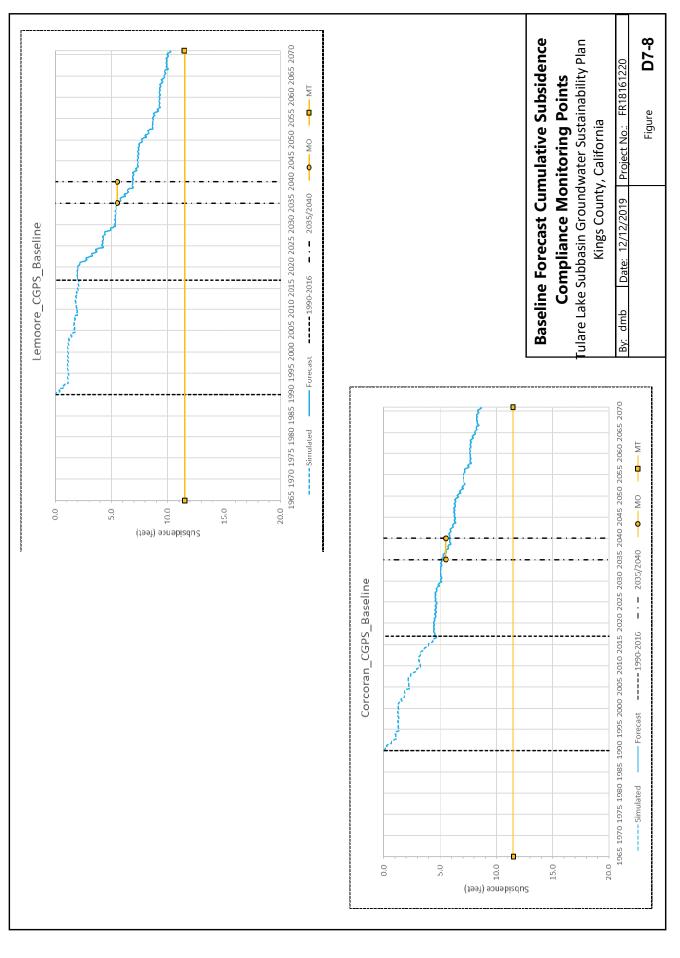
D7-3

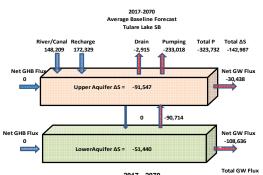






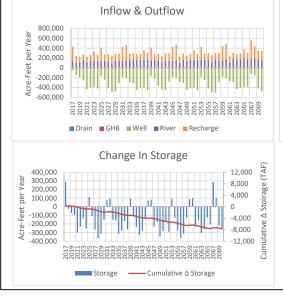


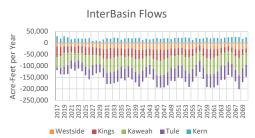




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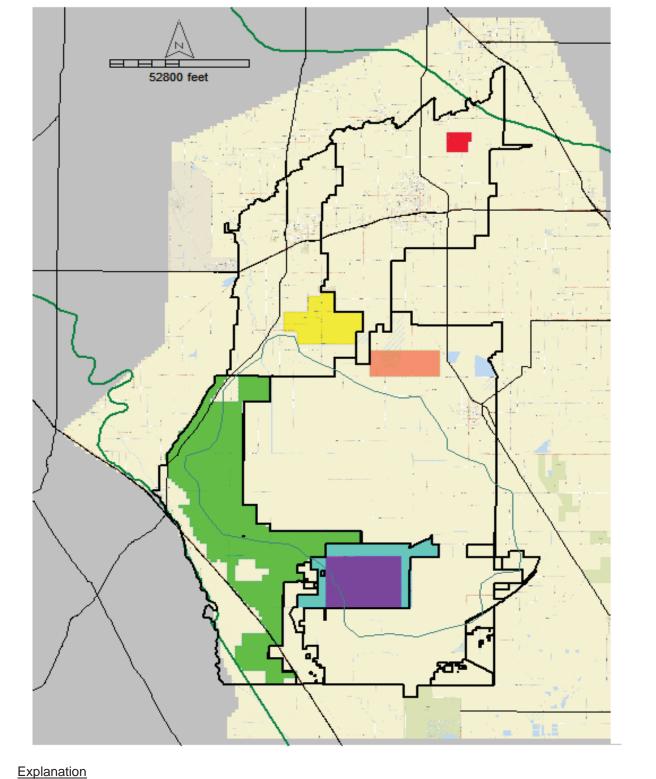
Tulare Lake Subbasin												
TulareLake	Net	Net	Net	Net	Net	Net					Interbasin	
Date	Drain	GHB	Well	River	Recharge	Storage	TulareLake	Westside	Kings	Kaweah	Tule	Kern
2017	-3,292	0	-50,431	129,387	298,093	287,496	0	-15,464	-46,141	-45,027	-11,808	29,206
2018	-750	0	-148,570	103,459	138,862	-24,232	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		0	-473,450	141,914	140,738		0	-22,944				
	-6,207					-313,258			-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	Ö	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
2047	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
2049	0	0	-444,243		114,030		0	-24,332				21,685
				163,797		-283,289			-31,754	-53,927	-56,321	
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	Ō	Ō	-390,901	190,501	191,607	-124,017	ō	-14,810	-21,614	-47,222	-56,154	24,170
2066	ō	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	Ö	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	-56,935	-53,012	24,403
2017-2070 Average	-2,915	0	-323,732	148,209	172,329	-142,987	0	-23,062	-19,259	-51,309	-48,534	19,860
		0					0					
2040-2048 Average	-1,986	U	-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

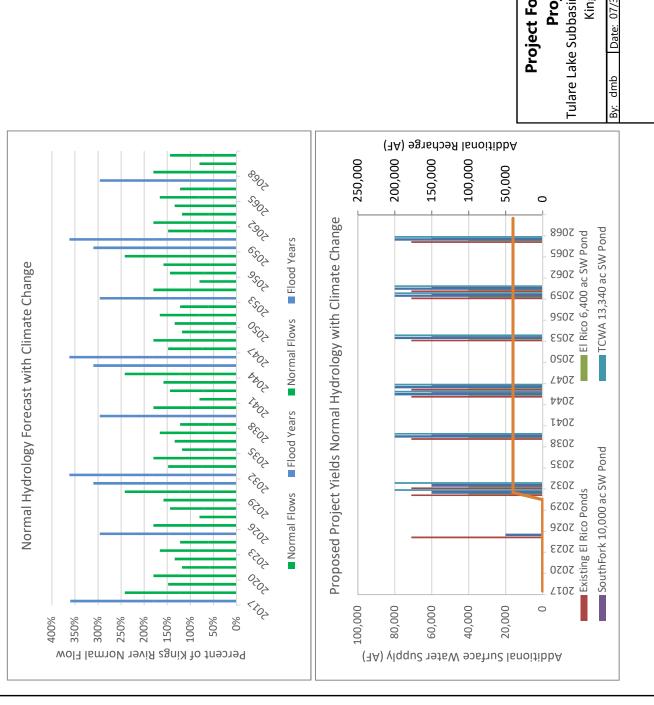
	8	,,,	
By: dmb	Date: 12/15/19	Project No.: FR18	3161220
		Figure	D7-9



- 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

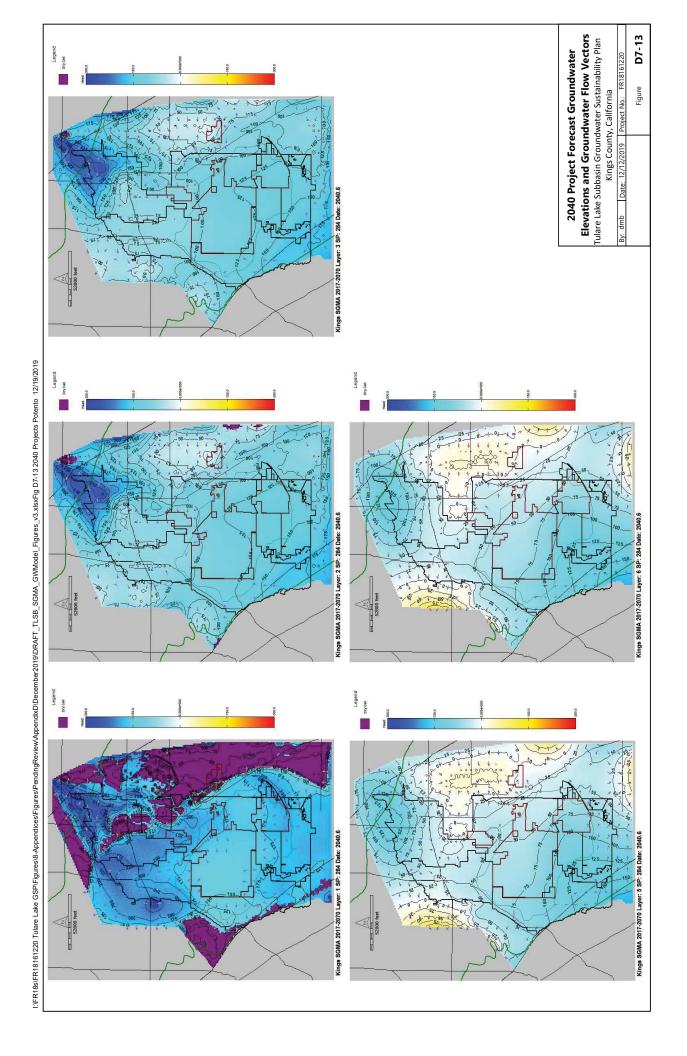
Forecast Project Areas

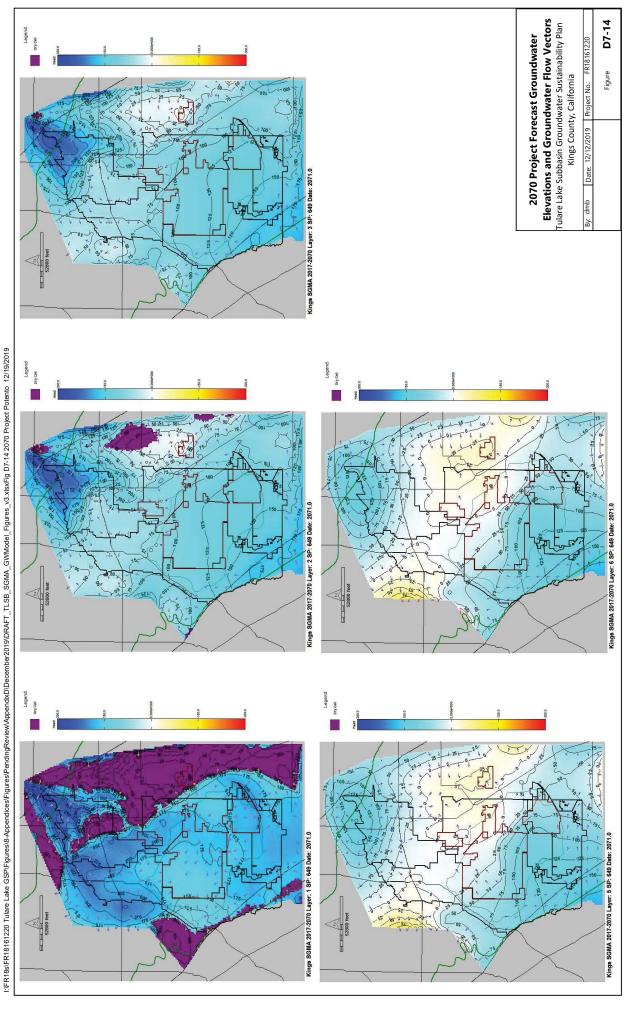
By: dmb	Date: 07/30/19	Project No.:	FR18161	1220
		Figu	ıre	D7-10

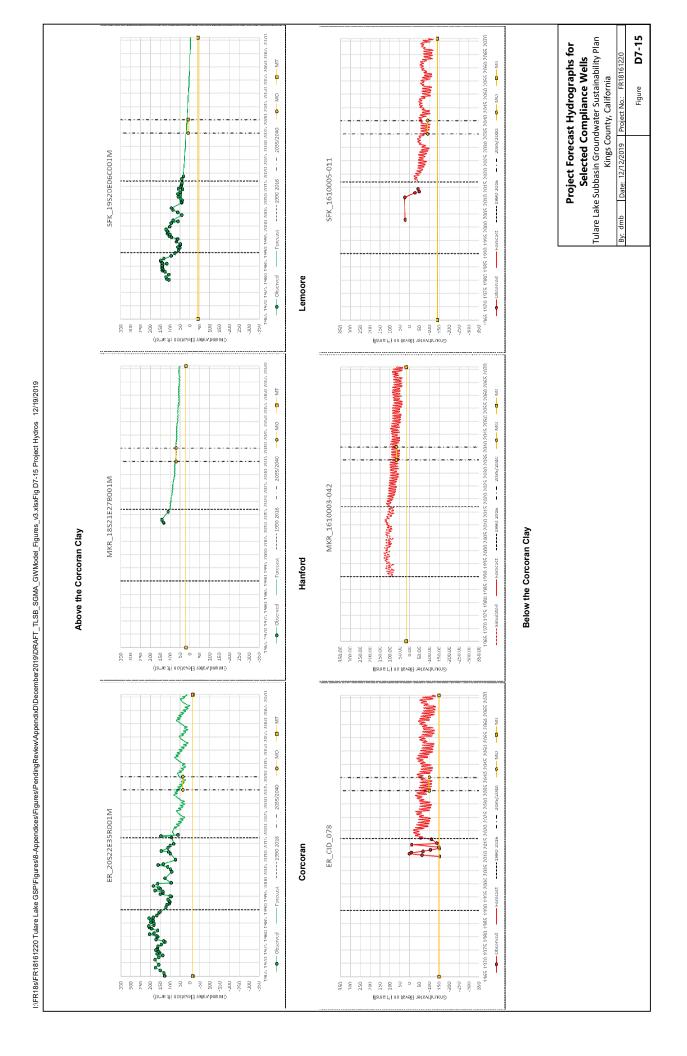


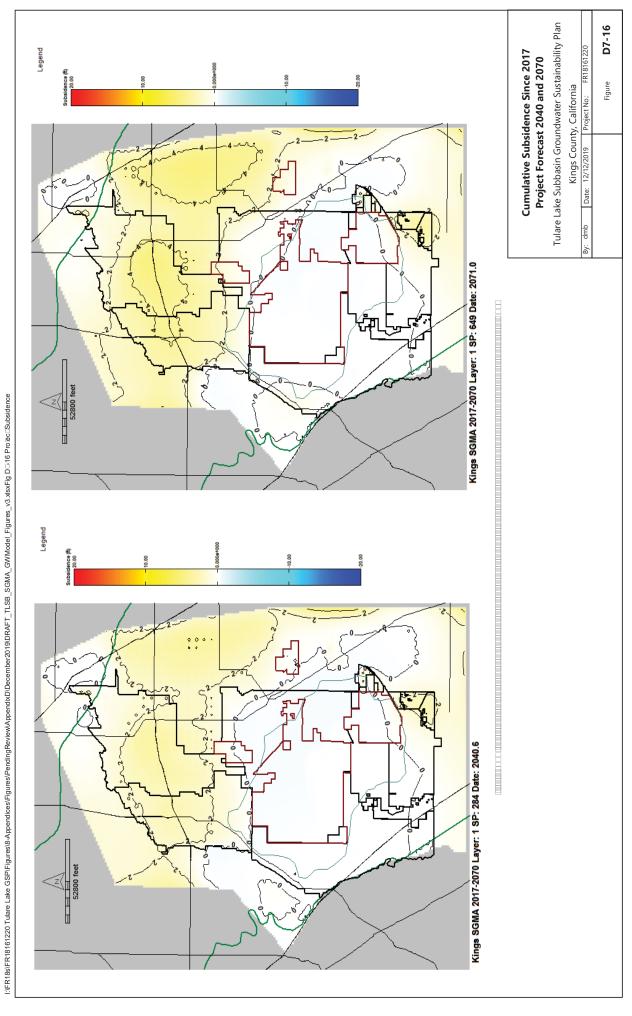
Project Forecast Flood Years and Project Performance

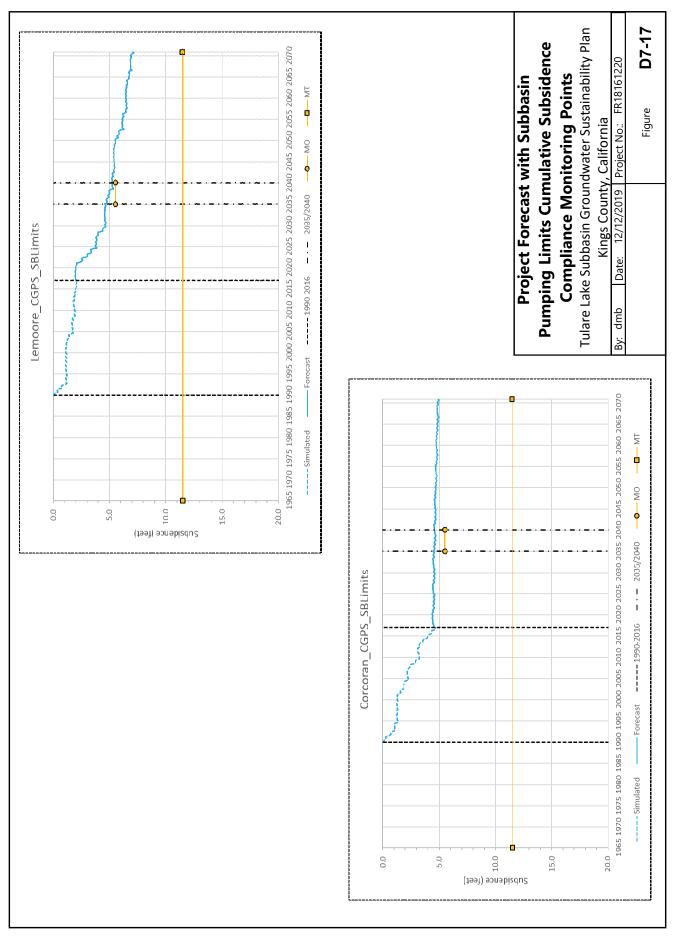
oility Plan	61220	D7-11
oasin Groundwater Sustainak Kings County, California	Project No.: FR18161220	Figure
Tulare Lake Subbasin Groundwater Sustainability Plan Kings County, California	Date: 07/30/19	
Tulare Lak	By: dmb	

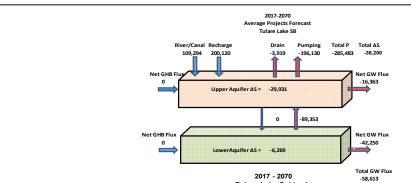






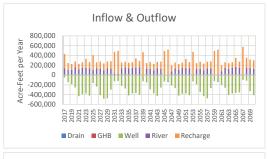


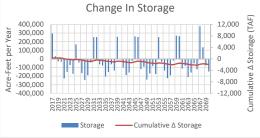


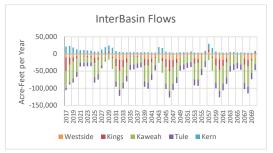


2017 - 2070

	Tulare Lake Subbasin											
TulareLake	Net	Net	Net	Net	Net	Net	Interbasin					
Date	Drain	GHB	Well	River	Recharge		TulareLake		Kings	Kaweah	Tule	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 2024	-2,081	0	-375,607 -409,790	144,279	186,092	-72,254	0	-6,559	-3,333	-14,772	-11,461	10,147
	-12,152	0	,	134,618	129,097	-173,684	0	-6,923	-3,333	-14,122	-11,585	9,682 6,934
2025 2026	-5,901 -6,425	0	-158,066 -231,683	103,591 138,003	300,300 120,755	167,712 -42,544	0	-11,065 -10,328	-15,504 -7,050	-41,827 -41,311	-15,388 -15,866	6,838
2027	-4,097	0	-408,650	128,404	144,489	-166,792	0	-9,442	-7,030	-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	-3,600 -4,776	0	-479,767	136,664	136,267	-190,413	0	-4,525	6,786	-11,984	-3,490 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	ō	-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 2059	-1,986 -1,441	0	-265,982 -124,741	132,665 1,848	145,904 487,775	-19,975 270,056	0	-8,004 -13,579	-4,928	-34,531 -49,951	-1,020 -16,865	17,529 6,926
2060	-1,441 -5,248	0	-124,741	-16,351	487,775 519,068	263,398	0	-13,579	-19,998 -30,525	-49,951 -60,325	-16,865 -19,196	6,926 4,327
2060	-5,246 -878	0	-207,328	77,986	119,694	-112,695	0	-16,253	-30,525	-50,528	-19,196	3,699
2062	-6,177	0	-207,326	141,942	117,940	-79,683	0	-13,385	-11,283	-50,528 -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	-2,104	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

By: dmb	Date: 12/16/19	Project No.: FR	18161220
		Figure	D7-18

wood.

Appendix D1 Land Use and Crop Acreage

	7667 4	
2016	8919 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 6 2 2 2 6 2 2 2 6 2	2016
2015	118011 8 8 8 10 10 10 10 10 10	2015
2014	25431 g	2014 = fallow is not* = Pisacho (Young) 77
2013		2013 Boairy Single Cop* Patachio (Mature) Wire Gapter with 82% canopy
2012		2012 Corton Fostacho (Addrescent) Urban, industrial*
2011	110015 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2011 Corn and Grain Sorghum Pasture and Met. Grass es Tomaboe and Pepp es
APPENDIX D1-1 2010	13.1888 2.00 2.00 2.00 2.00 2.17234 2.	2010 Citus (to ground ones) Cytus (to ground ones)
2009	1965 107 107 108 108 108 108 108 108	2 009 If Carrot Single Crop O nions and Gallic Stone First (Mature) Stone First (Mature)
2008	94759 94759 1001 1001 1001 1008 1008 1008 1008 100	
2007	285 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Misc fe
	100 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1999-2006 2007 Almonth (Addecent) Libraroth (Matherd) Count and Cash Hay Relations, Sugar Berte, Turns etc. — Rigariant*
1999-2006	2000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
1996-1938		1596-1598 **Albifa Hay and Clover #*Forest** # Pompgrantes (Young)
1990-1995	se tod krigated, Arvual Total is B	19904995
Sum of Crop Acreage (Acres) Tulare Lake Subbasin	Allest Department 1783	

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15	110014 4 10016	919
2015	11841. 1970. 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	Data tariffer tariff
2014	111110 111110 1111	2014 **Black Selection Coap** **Black Sele
2013	11422 3000 3000 3000 3000 3000 3000 3000 3	2013 Chenny (Antare) (Photory) (Photory)
2012	11100 11100	g
2011		2011 B Common Technologybun Common Technologybun Technologybun
APPENDIX D1.2 2010	1779/09 (1779) (Mid-Kings River GSA 2010 201
2009	#** # * * * * * * * * * * * * * * * *	Mild-Ki Experiment of the Constitution of the
2008	110-65 7110 7110 7110 7110 7110 7110 7110 711	- Benedic Carle Outstand Carle Sone free plattere)
	17177 170000 170000 170000 170000 17000 17000 17000 17000 17000	Tool Toology (Sound) Toology (Sound) Toology (Sound) Toology (Sound) Toology (Sound)
2007	111900 2020 2020 2020 2020 2020 2020 202	Memorati Matanto) Se social Matanto) Se social Magazibes
1999-2006	8895 8895 8995 8995 8995 8995 8995 8995	1995
1996-1998		The state of the s
1990-1995	13077 13077	11990-1995 R Addat Ney R Foreit R P Gatton, SA
Sum of Crop Acreage (Acres) Tulare Lake Subbasin	Med sings from GSA Abstract Close Abstract Close Abstract Close Abstract Close Abstract Close Abstract Close Abstract Close Berrics Correct Sings Corre Correct Sings Corre Correct Sings Corre Correct Sings Corre Correct Sings Corre Correct Sings Corre Correct Sings Corre Correct Sings Corre Correct Sings Corre Correct Sings Correct Correct Sings Corr	(coop Acresge (Acres)) 10000000000000000000000000000000000

Sum of Lipp Activities (Activity) Tulane Lake Subbasin 1990-1995 1996-1998 1999	Anish be a bing (CRA) 4000 2002 Anish be a bing (CRA) 0 0 Anish by and (Crose) 0 0 1.88 Anish by and (Crose) 0 0 1.88 Anish (All Anish) 0 0 1.88 Anish (All Anish) 0 0 0 Anish (All Anish) 2772 0 0 Anish (All Anish) 0 0 0 Anish (All Anish) 0 0 0 Anish (All Anish) 0 0 0 Anish (00'00	00,000	00,000	20,000
1999-2006	9866 1372 1373 1376 1376 1376 1376 1376 1376 1376				
2007 2008	10000 1113 1113 1113 1113 1113 1113 111				
2009	1902.7 158 23.2 2.4 1972.7 159 24.4 1972.7 159 250 250.8 2.4 27.7 2.7 27.7 2.7 27.8	-			
2010	1400. 2431 1528 1529 1520 1520 1520 1520 1520 1520 1520 1520	South Fork Kings GSA			
2011	7,151, 100, 100, 100, 100, 100, 100, 100,				
2012 2013	8911 1231 1231 1231 12783 12783 12783 12783 12783 12783 12783 12783 12894 12895 12895 12996 1299				
.3 2014	588 588 588 588 588 588 588 588 588 588				
2015	10000000000000000000000000000000000000				
2016	200		ш		

1999-2006 2007 2008 2009 APPINIX D.14 2011 2012	4850 10001 10001 984 6238 3472 6480 450 40 988 2221 1046 1089 414 417 418 7271 1046 1089 414 417 418 7271 1046 1089 10 6 6 6 6 7 1080 10 6 7 6 6 7 1080 1080 10 6 7 6 6 6 6 10 <t< th=""><th>Southwest Kings GSA</th><th></th><th></th><th></th><th></th><th></th></t<>	Southwest Kings GSA					
1990-1995 1996-1998	Among belowered Among below Among belo	Notes Frieda with an Addresio, (*) are not friegand, Arenual Toda in by Calendar Year	000700	70,000	0000	2000	10000

2016	15.9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9		
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2015	666 670 670 670 670 670 670 670 670 670		5100
2014	54, 11 11 11 11 11 11 11 11 11 11 11 11 11		2004 # Forest*
2013			2013 2013 2013 2013 2013 2013
2012	5.58 10.00 10.		2012 2012 The first of the firs
2011	79 20 20 20 20 20 20 20 20 20 20 20 20 20		
510	600 600 600 600 600 600 600 600	r Authority GSA	2011 2011 2011 2011 2011
APPENDIX D1-5 2010	131 131 131 131 131 131 131 131 131 131	Tri-County Water Authority GSA	2010 2010 2010 2010 2010 2010 2010 2010
5008	N B N B y C C C C N O C B D C C C N C D D N D C B C N		2009 Citize for ground cover)
2008	1872 28 29 29 29 29 29 29 29 29 29 29 29 29 29		2008 Electri Singe Crop B Others and Gale Electric House Crop
2007	1400 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		2007 Ballonine (Young) Ballonine (Young) Ballonine (Young) Ballonine (Young)
1999-2006	2 20 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		
	488 68 68 68 68 68 68 68 68 68 68 68 68 6		1996 4-1998 11999-2000 199
1996-1998	7107 7107 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	/ Calendur Year	Ender hay and Coo.
1990-1995		not irrigated; Annual Total is b	9561 0661
Sum of Crop Acreage (Acres) Tulare Lake Subbasin	This county, Water Authority GSA Amano I trough Cook Amano I trough Cook Amano I trough Cook Amano I trough Cook Cook Cook Cook and Cook Cook and Cook Cook and Cook Cook Cook and Cook Cook Cook Cook Cook Cook Cook Cook	Notes: Fields with an Alberrisk (*) ser not Unigned; Amrusil Total is by Calendar Vea	(carsk) agestsA qorð

2016	2006 2005 2005 2005 2005 2005 2005 2005	
22	20000000000000000000000000000000000000	9902
2015	2000 0.0000 0.00000 0.0000 0.0000 0.0000 0.0000 0.0000 0.00000 0.00000	2015 # Sallow Lind* # Brown Lind*
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2013	2011 4 444 1464 1464 1464 1464 1464 1664 1770	Approximation of the control of the
2012	2002 2009 2009 2009 2009 2009 2009 2009	Totals of the state of the stat
2011		
APPENDIX D1-6 2010	one varieties and varieties an	2010 Table (Broad) participation (Broad) par
2009	**	2009 Christ Steps Cop Christ Steps Cop Christ Steps Cop Christ Steps Cop Christ Steps Cop Christ Steps Cop Christ Steps Cop
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2007	70007 72609 72609 72609 72609 72609 72609 72609 72609 72609 72609 72609 72709	2007 Ahmorsk (Young) Wolf, edd (You
1999-2006	2000 (1999-2000 A Annodi (Maturo) In Monor Tip de England
1996-1998	12564 12564 12564 12566 12666 1366666 1366666 13666666 136666666 1366666666	2005-2000 2009-2000 2009-2000 2009-2000 2009-2000 2009-2000 2009-2000 2009-2000 2009-2000 2009-2000 2009-2000 2009-2000 2009-2009-
		the control of the co
[Acres] 1990-1995	is in the control of	20,000 221,000 77,000 1,1900,1900
Sum of Crop Acreage (Acres) Tulare Lake Subbasin	Titute take subasen Take take subasen Attach they and coore Amond (loane Amond (loane Amond (loane Amond (loane Correct subglocope Correct	ageaby qoʻO

Sum of Crop Acreage (Acres) 1990-1995 199	A month of behavior 77800 A month (before med) 77800 A month (before med) 1780 A month (before med) 1780 A month (before med) 1780 B month (before med) 0 Child, Hope Copy 1320 Month, Hope Copy 1230 Chee, Walter Copy 1230 A month of Active Copy 1230 A month of Active Copy 1230 A month of Active Copy 1230 A month of Active Copy 1230 A month of Active Copy 1230 A month of Active Copy 1200 A month of	Notice: Fields with an Adential (*) are not impated, Amaual Toul is by Calendar Your	110.000 110.000 100.000 60.000 70.000 70.000
1996-1998	25468 2556 2567 267 267 267 267 267 267 267 267 267 2		8 800 1901
1999-2006	1777 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2		9002 446
2007	40005 1770 600 700 700 700 700 700 70		700
2008	40094 1148 S 1148 S 10 0 10 0 10 0 10 0 10 0 10 0 10 0 10		5007
APPENDIX D1-7 2009 2010	68666 1937 1937 1937 1937 1938 1938 1938 1938 1938 1938 1938 1938	Kaweah Subbasin	COMP
0X D1-7 2011	40.716 2006 2006 2006 2007 2007 2007 2007 200	sin	1100
2012	17111 1814 1817 1814 1814 1814 1814 1814		700
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2014	13800 1607 1607 1607 1607 1607 1607 1607 16		NO.
2015	20093 2466 2466 2566 27 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3		5500
2016	7 100 100 100 100 100 100 100 100 100 10		20 E

110
5.00
Kern County Subbasin

Sum of Crop Acreage (Acres)	1990,1995	1995.1998	1999,2006	3000	3008	3000	APPENDIX DI-9	2011	2012 2013	3 2016	2015	3016	
Kings Subbasin	200.00	210030	0.000	0.7770	***************************************	000000	1000	53000	2000	10000	10000		20101
Almonds (Addissorent)	0	O	3616	0	# CC772	10231	8056	3031	3819	5265	5193	4806	8502
Almonds (Mature)	4542	3495	3350	2386	4752	32.47	2623	5737	5882	3838	4426	6262	2962
Almonds (Young)	0 (3529	1164	26493	40739	14505	10844	19230	18486	16474	23168	29556	14910
Carrot Shale Cron	> 0	m 0	m 0	₽ a		0 0	0 0	0 95	Z =	7 P	⊃ %		D 60
Oftrus (no ground cover)	532	257	255	74	93	851	55	206	148	1165	2395	975	220
Com and Grain Sorghum	9963	14915	13000	5986	10644	6420	7212	13547	12495	9374	12586	9486	8811
Dairy Single Crop*	2549	2553	2615	0	0	0	0	o o	0	0	0	0	o o
Fallow Land*	9327	7519	8979	4149	1922	4614	3512	10692	11063	2699	5755	7343	8050
Forest* Grain and Grain Hav	413	230	200	1384	9 1109	22.20	3757	2 087	1365	3407	1774	2005	16
Melons	407	180	130	0	3	18	4	1	10	33	7	6	29
Misc. field crops	3315	3204	3954	0 ;	0 (т;	0 ;	0 !	۰,	0 (0 1	0 0	0
Onions and Sartic	° 6	0 88	106	72	58	3 2 2	18 <u>5</u>	175	22 23	18 12	SS 19	A 8	374
Pasture and Misc. Strasses	3833	2326	1914	9370	10809	1985	2559	1431	2865	2291	1789	1361	1172
Pistachio (Adolescent)	0	0	0	0	0	0	0	8	10	e	21	28	34
Pistachio (Mature)	172	109	109	8	73	8	8	8	28	28	8	8	34
Pistachio (Young)	0 0	50 0	121	1806	1999	3603	1931	5141	3223	3251	888 888 888	2899	4214
Potatoes, Sugar beets, Turnip etc	0	· #	233	1	0	2 2	976	9 0	0	0		2	0
Riparian*	0	- 30	821	417	0 40	, 24	3	280	110	147	219	1 52	67
Small Vege tables	1465	196	728	6	38	8	15	08	133	165	83	20	5.2
Stone Fruit (Adoles cent)	0	0	8693	0	0	6	87	120	241	326	234	311	141
Stone Fruit (Mature)	20143	16740	16500	1663	324	99	42	12	15	12	32	24	14
Stone Fruit (Young)	0 ;	8804	598	632	3153	3757	6595	4583	2872	14281	4299	3588	1501
Tomatoes and Meppers	75 FE	98	908	S c	e c	14/	27 0	250	- C	1011	***	388	1483
Urban, commercial	2007	0 99	0 00	8	D come	0 00 000	0 10 10 10 10 10 10 10 10 10 10 10 10 10	2013	0 00	0 00	0 000	0 000	0 0010
Whe Grapes with 80% can poy	20802	21532	21331	16829	6248	5113	8126	17826	21517	14294	17966	19448	34154
Winter Wheat*	0	0	0	7416	3000	9737	8888	5024	9699	8390	2883	4070	4153
Kings Subbasin Irrigated Crop Acre at Kines Subbasin Total Crop Acresee	101836	102501	102807	97542	104801	91860	97.580	94163	92742	93040	101794	98762	98160
Notes: Fields with an Asterisk (*) are not irrigated; Annual Total is by Calendar Year	igated; Armual Total is by Calendar Year												
						Kings Subbasin	obasin						
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0	1990-1995	1996.1998	1999.2006	2002	2,008	3000	3010	2013	2013	2018	3015	3016	
	7	0004-0004	000 100 01	Annua	00004			***************************************		ET COO	7 4000		
	Alfalfa than and Change	- Almont A deline	-	Control of the control of			Control Annual Control Control						
	III Forest*	■ Forest* Grain Hay		Misc. field crops	Onions and Garlic	■ Open Water*	Pasture and Misc. Grasses	■ Pistachio (Adolescent)	III Pistachio (Mature)	- Pistachio (Young)	Pomega nates (Young)		
	■ Potatoes, Sugar be ets, T	'umip etc Riparian*	Small Vegetables	Stone Fruit (Adolesc			 Tomatoes and Peppers 				Vinter Wheat*		

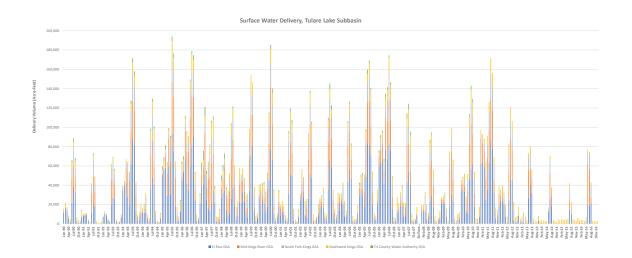
Sum of Crop Acreage (Acres) Tule Subbasin	1090.1095	1996, 1998	1999,2006	2002	3008	2009 AP PEND	AP PENDIX D1-10	2013	2013	2018	2015	3016	
Tule Subbasin													
Alfalfa Hay and Clover	11815	24766	24766	24935	23335	187.78	21039	12659	13696	12191	12634	10375	10831
Almonds (Adoles cent)	0 (0 ;	2 5	0 (0 (88 (32	un e	en c	9	48	86	413
Amonds (Wature)	ş	2 5	al c	9 88	200	0.01	900	2111	0 002	1330	0 1012	2180	1603
Berries	0	. 0		°	°	0	0	0	. 0	0	0	0	0
Carrot Single Crop	0	0	0	0	0	0	0	п	0	0	0	н	17
Otrus (no ground cover)	0	0	0	0	0	0 4	0	so (0	m (Con	4	2	1
Com and orann sorgnum	76378	13577	13827	1320	1507	2 28 28	5005	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	5.7622	52185	58262	47946	49332	40907
Forest*	88	6	6	0	0	13	0	0	0	0	0	0	0
Grain and Grain Hay	20747	22935	22934	3486	3875	4813	8244	6775	6675	7204	2/98	11225	13366
Melons	21	0 111	D :===	D (0 (in 4	D (2		8 "	w (27
Only and Godle	1909	7687	4,67	0 -		> 0	- s	- 5	o g	0 -	o •	- g	0 0
Onen Water*	3437	1273	1373	1 99	7	2 5 9	3 %	7 %	437	122	, 2	3 6	650
Pasture and Misc. Grasses	238	2419	2419	36249	38175	332.40	40.465	7292	14196	15170	18730	15904	11931
Pistachio (Adolescent)	0	C	C				0	459	371	439	624	900	1192
Pistachio (Mature)	0	0	0	901	67	41	33	33	33	33	33	338	398
Pistachio (Young)	0	201	201	1954	1313	31.70	3336	2747	3086	4184	4677	4328	9069
Pomegranates (Young)	0	0	0	2	80 60	19	17	1076	2311	1363	2648	2709	2393
Potatoes, Sugar beets, Turnip etc	626	2278	2278	0	0		0	1			4	7	1
Riparian*	0	2509	2509	199	121	23	183	186	28	158	89	83	47
Small Vegetables	0	517	517	1	1	s	204	10	33	31	22	43	236
Stone Fruit (Adolescent)	0	0	8	0	0	0	0	0	0	0	0	0	0
Stone Fruit (Mature)	o	0	0	0	0	0	0	0	0	0	0	0	0
Stone End (Young)		2			7.3			× ×	. 12		433	- 4	. 42
Tomatoes and Benners	. ~	18	9 00					8 6	108	* £	2 32	333	858
Tobas Industrial	7 030	1116	1116	1 900	0 350	1 150	2 17	3636	3116	2000	2221	2612	3403
Whon Granes with 80% craons	200	0777	9777	35	4230	23	(TT)	3030	3210	323	3/11	119	126
Winter Wheet*	7.0	15 0	15 0	33	15037	2 2	13.16.1	177	/81	8017	901	10005	21623
Tuto Cubbs do Indonted Ocos Accoun	0 61800	0.500	0.3636	11007	7007	55707	15151	5 3053	5000	70007	6000	10999	2,002
Tule Subba sin Trigated Crop Acreag	125218	125218	125218	125215	125214	1252 10	125 209	3,239	125207	125206	125206	125206	125205
Notes: Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year	igated; Annual Total is by Calendar Year												
						Tillo Siibhasin							
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	1990-1995	1996-1998	1999-2006	2007	2008 2009	2010	2011	2012	2013	2014	2015	2016	
	■ Affalfa Hay and Clover ■ Almonds (Adolescent)	 Almonds (Adolescent) 		■ Almonds (Young)		■ Carrot Single Crop	Citrus (no ground cover)	■ Com and Grain Sorghum ■ C		■ Dairy Single Crop* ■ Fal	■ Fallow Land*		
	■ Forest*	Grain and Grain Hay		■ Misc. field crops	 Onions and Garlic 				□ Pistachio (Mature) □ P		megranates (Young)		
	■ Potatoes, Sugar beets, Turni	etcRiparian*		■ Stone Fruit (Adoles cent)						Anter Wheat*			

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	1000 1000 1000 1000 1000 1000 1000 100	ST ST ST ST ST ST ST ST ST ST ST ST ST S
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2011	2015 1309 2016 1189 2016 1189 2016 1189 2017 2017 2018 2	1102
APPENDIX D1-11	989977177777777777777777777777777777777	Westside Subbasin
2008	7001 7001 8008 8008 8019 9019 9019 9019 9019 9	2000
3003		2007
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1005,1008	861 461	1865-1965 T
Sum of Crop Acreage (Acres) Westelde Subbseln 1990, 1992	p et Py A A State out impassion in just and impassion in the page of	(rop Acressgs (Acres)

Appendix D2 Monthly Surface Water Deliveries by GSA and Subbasin

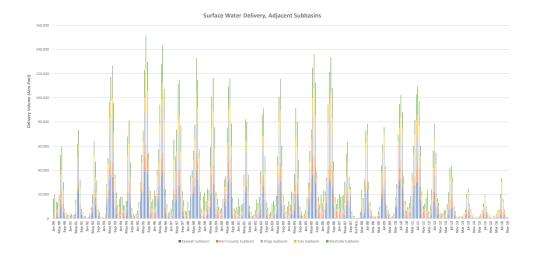
ce Water Delivery (Acre-Feet)	El Rico GSA	12096	Mid-Kings River GSA	0	South Fork Kings GSA	APPENDIX D2-1	Southwest Kings GSA	2753	Tri-County Water Authority GSA	12	Tulare Lake Subbasin Total	
10 00 00 00 00 00 00 00 00 00 00 00 00 0		1.2006 1.		532 183 0		799 389 0		2753 4646 3383 3008 3191 6343 8527 7059 4198 2760 2048 6100 1104 1727		439 136 136 159 2198 3431 3826 328 78 889 181 185 185 182 62 1		
90 0		1550 21777 38337		0 24810		0 10647 17294		3191 6343 8527		159 2198 3431		
90 90 90		32604 2580 789		21228 16448 0		0 10647 17294 8315 0		7059 4198 2760		3826 328 70		
- 90 10		1498 7192		0 0		0		2048 6100		164 889		
1 91		8679 8930 9149		0		0		1104 1727		181 185		
91 91		9149 3017 114		547 45 0		0		1291 1251 1304 2059 6390 4857 1793 1244 725 2339 920 1569 1126 1104 1157 3649 4383 4586 1607 1107 788 2247 1250 2577		182 62 1		
1		11492 20315		19825 29037 14618		8674 15627 11119		2059 6390		6 1621 21		
91 91 91		329 58		202		0 0		4857 1793 1244		3 1		
91 91		111 540		0		0		725 2339		1 8		
2 2 32		7246 10577 8589		0 299 0 0		0		920 1569 1176		273 546 352		
92		3607 1444		0 0 25477		0 0 12628		1104 1157		175 101		
2 1		19886 26610 26266		25477 18544 14436		12628 18112 10146		3649 4383 4586		434 1222 1475		
2		2425 733		0		17 0		1607 1107		210 50		
32 12		1399 6752 24625		0		42 0		788 2247		105 568		
3 33		38849 42588		1882 1049 15260 25934		1263 6536		2577 1765		606 484		
3 93 3		27978 19683 61633		25934 24280 34418		8549 7672 20707		1765 1783 2096 7760 12806 11805 11805 3878 2120 3408 6678 2961 4813 2370 2327 2408 9249 14823		190 49 2909		
3		87698 81214		38923 36099		27999 24734		12806 11805		3881 3983		
3 3 3		14088 2877 3993		24220 34418 38923 38923 38099 14353 4303 3868 490 2575 324 3460 1453 1617 33759 33368		10776 0 580		3878 2120 3408		252 24 51		
3		11465 10334		490 2575		1753 689		6678 2961		277 7		
4 34 4		11346 12003 4798		324 3460 1453		3923 13518 468		4813 2370 2377		240 74 74		
34 4		2215 36961		1617 33759		63 16145		2408 9249		87 2660		
• 04 4		48822 2209		38358 18407 284		25402 6397		14823 13274 4309		3141 2948 208		
4 94		589 1124		18407 284 0 0		0		14823 13274 4309 2259 1123 5487 2742 5234 3136		43 90		
* H H H H H H H H H H H H H H H H H H H		5419 50543 56193		0 1489 1601 12501		0 872 1274		5487 2742 5234		486 4002 4718		
35 5		57904 29106		22707		3713 6177		3136 3981		4209 1644		
5 5		59386 30642 93097		2918U 33398 54051		4/86 15773 24738		3452 9446 17192		2211 1637 4769		
16 5		75149 18055		29180 33398 54051 55594 28881 5460 0		25997 10439		14978 6469		4617 600		
95 15		3250 2410 12155		5460 0 1222		4122 1993 586		3981 3452 9446 17192 14978 6469 4404 2751 9321 8505 5587 5191 9367 7192 13079 16679		130 275 1489		
6 505.5 ; 505.5 5 515.6 6 605.		44804 53068		1222 3917 1691 28082 32997 40058 51099 52174		4812 6610		8505 5587		2349 3070		
6 6 96		0//24 41794 34362		20/82 32997 40058		7981 10433 8963		9367 7192		2808 1218 410		
6		58752 79092		51099 52174		24996 27425		13079 16679		1533 3469		
nb 6 6		89843 24394 2515		40906 10256 415 0		24649 8963 373		14773 9114 5858		4495 940 131		
6 6		4276 21009		0 507				14773 9114 5858 1720 8581 2864 6744 6310		7.77 7.		
7 17 18		38642 40362 51972		507 12784 16730 41932		0 2192 11303		2864 6744 6310		9282 9729 9411		
7 97		24596 16136		12751 29820		9437 12593		5063 5395		3232 166		
7		12763 20865 24090		12751 29820 36157 41549 38432 2208		19809 24488 19975		5063 5395 12465 17688 15742 6062 3743 1392		842 2223		
7 7		20520 2187		2208 0		7805 294		6062 3743		2594 581		
97 17		1598 1959		0 4010 2947		0		1392 9663		172 931		
o 8 38		31844 34696		15587 24491		1993 4235		5453 3483		6191 6014		
77 77 77 77 77 77 77 77 77 77 77 77 78 8 8 8 8 8 8 8 8		14460 8776		2947 9019 15587 24491 14200 17329 23256 42068		3219 3981		9663 7448 5453 3483 3832 4124 7449 12083		2058 109		
15 15 18		25767 37026		42068 49842		22992 21467		12083 11524		1124 1358		
38 (88 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8 8		18449 4362		49842 21166 4005 9537 18341 22424 12418 10239 4682 9519 34956 41958 32271 3880		13410 5516		11524 7283 3488 3536 12154 3790 6632 4919 4310		192 45		
98 98 9		7941 22517 21858		9537 18341 22424		3900 3602		35.96 12154 3790		528 92		
9 99		32889 22875		12418 10239		5423 9343		6632 4919		105 89		
99 99		6892 34267		9519 34956		9693 18737		5002 10197		8 60		
9		70847 80450		41958 32271		24375 19217		5002 10197 16565 14414 7652 5179		114 173		
9 9		2379 5597		0 1225		306 223		7652 5179 3566		87 4 9		
9		26748 19168		0 1225 3260 16688 5154 6407 6319 18463 37946 63999 33841 7067		3 0		3566 10193 3981		47 1203		
0 0		24248 20602 11770		6407 6319		9117 10455		3981 7221 5813 4060 3963 10132 15187 13197		2132 1472 687		
00 0		17655 44925		18463 37946		12305 20771		3963 10132		345 1476		
) 10 10		66535 10350		35841 7067		24480 19517 11589		15187 13197 5866		4158 5017 714		
0		2705 6375		0 1920		0 167		3524 1939		169 357		
999 99 99 99 99 99 99 99 99 99 99 99 99		18044 8961 12104		1920 4739 6643 5840		0 3492 9117 10455 12305 20771 24480 19517 11589 0 167 148 306 413		5866 3524 1939 9827 3439 4738		1933 7 249		
1		9359 3836		3393 1392		955 0		5022 3725		77 77		
1		31309 50997		521 35031 33980		19672 20650		7838 10499		2141 3334		
01 1 10 1 1 1 1 1 1 1 1		49055 2898 809		3393 1392 621 35031 33980 24248 319 0		0 19672 20650 20927 7363 0 0		5022 3725 3302 7838 10499 9909 4769 3235 1047 7351		3350 186		
1		1545 7472		0		0		1047 7351		93 505		
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2		23954 34366 27522		3915 7194 5518		0		2950 5270 2070		50 523 197		
2 12		8687 6720		3915 7194 5518 535 10074 40777 51345 31068 974		11211 9845 4546 15782 19135 13428		4403 4164		163 176		
2		25952 51918 47781		40777 51345 31068		15782 19135 13478		9963 13258 10907		815 2180 2618		
2 2		3024 753		974 0		0		5499 3507		364 86		
12 2 3		93199 8 9319 8 9319		282.6 25.14 6180 3997 3997 3997 3997 3997 3997 3997 399		0 0 178		2950 2950 2950 2950 2970 2070 20		777 777 777 777 777 777 777 777 777 77		
3 8		18975 16464		3997 3997		356 12382		5205 4018		759 398		
3 13 3		6235 3104 35955		1332 2694 48545		536 180 14774		3573 3447 7877		240 189 2655		
3		65530 58315		42356 30398		20487 19584		11279 10022		5552 4429		
s 3 3		10724 5060 3534		14051 6628 3270		4602 0		5418 3235 1849		390 93 195		
3		13310 21193		8954 6202		246 887		7783 2469		1057 169		
\$ 4		22630 19750		2751 1700 567		421 16892		5211 4331		232 188		
14		7649 43669		1847 36111		202 15703		4028 8761		23 1864		
4		56276 46550 7892		39905 20059		15616 4869		12716 9753 5244		2044 2102		
1 4		2095 1143 2473		0 426 1234 1915 8681 8543 7573 14774 32390		0 27		3106 1335		48 11 24		
4		9313 28328		1915 8681		630 318		7305 3073		130 2183		
9 15 5		34297 29485 17953		6543 7573 14774		∠11 9716 12322		5698 3712 4882		2211 2191 736		
05 5		48534 83212		32390 42082		9719 19626		4539 10292		2573 4362		
5		83212 81301 71251 20198 4823 3751 18891 59292 63754 64764 41883 76704 67064 82441 75475 15527		42082 45958 30263 12158 2388 1321 4407 10338		24885 21741 12151		14477 15052 8680		2262 2244 770		
5		4823 3751		2388 1321		126 193		3795 3261		5 10		
5 6		18891 59292 63754		4407 10338 12505		951 592 6676		10899 3257 6422		57 2512 2541		
06 6		64764 41883		12505 17538 13691 32999 38328 45232 31743 12043		6973 3840		9422 4837 5137		2541 2663 2833		
1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2		76704 67064		32999 38328		11252 21556		8857 12485		5127 2077		
) 06 16		82441 75475 15527		45232 31743 12043		27164 21761 11907		17302 15341 9365		2425 2036 807		
36 66 66 66 66 67 77 77 77 77 77 77 77 77		1262 2510		853 1310		149 156		4680 1921		33 11		
6 7 7		11319 13171 18115		3168 2716 4927		1686 1406 4753		11288 4102 47%		62 0		
, 17 7		18252 7207		4158 3220		4753 11450 7950		4776 3792 3630		2061 4		
7		8494 42957 53600		8585 37657 38767		313 17154 20120		3894 10846		5784 6100		
7		1262 2510 11319 13171 18115 18252 7207 8494 42957 53608 40221 3237 1095 2519 8543		853 1310 3168 2716 4927 4158 3220 8585 37657 14702 0 474 1514 1666		0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		10292 14477 15052 8680 3776 3781 10887 3261 10887 3261 10887 3267 1378 1378 1385 17302 1485 17302 1485 17302 1485 17302 1485 17302 4070 4070 4070 4070 4070 4070 4070 40		4562 2264 2244 770 5 10 5 10 5 10 5 10 5 10 5 10 5 10 5 1		
7		1095 2519		474 1514		0		2879 1013		2 5		
		0345				U						

			APPENDIX D2-1 (Co	ont)		
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-08 Feb-08 Mar-08	12877 12794 12030	4236 2358	0	2158 4154	249 286	19521 19592 32806
Mar-08 Apr-08	12030 4310	2029 676	15452 12129	4154 3035 2975	260 94 14	32806 20185
May-08 Jun-08	2848 23201	4804 37252	280 14023	2918 9327	14 3063	10863 86866
Jul-08	28911 17737	36960 21618	15430	11570	1795 321	94666 55857
Aug-08 Sep-08	17737 1686	21618 1694	8115 0	8066 4266	321 28	7674
Oct-08 Nov-08	535 2311	324 2600	0	2614 966	28 7 14 77	3479 5891
Dec-08	4305	2578	ō	6083	14 77	13042
Jan-09 Feb-09	20714 21578	4035 3528	0	1996 3511	0 2	26745 28619
Mar-09	20219	2386 583	7422 5834	2559 2571	1	32585
Apr-09 May-09	6912 626	0	0		1	15900 3432
Jun-09 Jul-09	18684	37791 44275	12420	6179	3 7	75077 90175
Aug-09	29891 24119	44375 21353	14955 13859	9897 7115	9	99125 66454
Sep-09 Oct-09	992 662	513	583 0	3621 2362	1 0	5197 3537
Nov-09 Dec-09	4030 4435	5151 2475	0	1119 4964	1 3	10300 11878
Jan-10 Feb-10	33578 35716	6591 6121	0	4533 6119	503 503	45205 48460
Feb-10 Mar-10	35716 33280	6121 5202 2285	0 7720	6119 5041 4939	503	48460 51746
Apr-10 May-10	11965 10826	2285 23142	8767 11452	4939 5874	168	28125 51294
Jun-10	45995	35698	18042	11282	2611	113628
Jul-10 Aug-10	56367 61845	47091 30709	23080 19039	12815 13661	3684 4026	143036 129280
Sep-10 Oct-10	17793 417	13208	13979	8270 5071	556 Q	53806
Nov-10	1053	0 221	736 221	3629	0	6224 5126
Dec-10 lan-11	6255	1797 26805	1065	8405 4336	1	17524 96704
Feb-11	62292 63568	19954	3271 3729	5631	0 17	92899
Mar-11 Apr-11	58959 24884	17047 21763	6734 9084	5266 8007	5 5	88011 63744
May-11	34998 63404	33281 33286	13176 18476	9466	6	90927
Jun-11 Jul-11	86173 77137	47788	25799	10767 17245	26 72 87	125958 171578
Aug-11 San-11	77137 21900	40417 13857	22548 13793	15888	87	156077 69114
Sep-11 Oct-11	31800 4824	1194	6244	9652 4587	12 3	16851
Nov-11 Dec-11	4056 18473	4435 12326	2415 750	3445 7661	6 34	14358 39243
Jan-12 Feb-12	23492 23705	5381 4034	289 5923	6088 6199	34 0 14	35250 39875
Mar-12	19686 7287	1379 460	5543 6581	5520 5292	4 4	32131
Apr-12 May-12	7287 1402	0	6581 454	5644	4 5	
Jun-12 Jul-12	24802 45234	27755 42066	16731 19057	13201 14465	5 21 60	7504 82510 120883
Aug-12	45391	30434	18014	12409	50 72	106320
Sep-12 Oct-12	3441 777	840 123	9880 405	8366 5250	72 10 2 5	22537 6556
Nov-12	2219	1192	59	4525	5	8001
Dec-12 Jan-13	8318 893	1267 1266	508 330	7047 2519	28 0	17168 5009
Feb-13 Mar-13	2596 1013	939 33	7 8164	3906 3040	14 4	7463 12254
Apr-13	613 717	11	3540	3028	4	7196
May-13 Jun-13		0 29510	0 11863	3016 5136	5 22	3738 72707
Jul-13	39994	17398	15372	5136 7502	5 22 61 74 11 2 5	80327
Aug-13 Sep-13	31989 1222	12980 0	4464 0	6522 4031	74 11	56030 5264
Oct-13 Nov-13	371 665 3004	0	0	2910 1723	2 5	3284 2393
Dec-13 Jan-14	3004 31	99 27	0	5274 2773	29 0	2393 8405 2831
Feb-14 Mar-14	331 231	0	7	27/3 3338 2791	9	3686 3163
Mar-14 Apr-14	231 170	138	0	2791 2745	3 3	3163 2869
May-14	120 141 13183	0	0	2745 2816 3744		2959 16941
Jun-14 Jul-14	25975	0 26500	0 13175	4647	14 41	70337
Aug-14 Sep-14	18326 246	9961 0	4790 90	4555 3414	49 7	37681 3757
Oct-14	71 138	0	0	2751 2041	2	2824
Nov-14 Dec-14	681	0	0	4106	3 19	2182 4806
Jan-15 Feb-15		0	0	3439	0	3443
Mar-15	32 45	0	31	4691 3836	2 3	4725 3915
Apr-15 May-15	27	0	11 0	3764 3840	2 2	3804 3874
Jun-15	32 55 14382 9458	0	65	5326	4	5451
Jul-15 Aug-15	1438Z 9458	10880 1549	9816 5162	6779 6539	10	41868 22718
Aug-15 Sep-15 Oct-15	23	0	0	6539 4764 2742	2	4788
Nov-15	17 25	o o	0	3743 2725	1 2	3761 2752
Dec-15 Jan-16	75 0	0 896	0	5887 2854	6 0	5968 3750
Feb.16	116 0	1103	0	2854 2854	0	4073
Mar-16 Apr-16 May-16	0	896 299 2004	n n	2854 2854 2854 2854	0	3750 3153 7089
May-16 Jun-16	672 19693	2004 41699	1559 12988	2854 2854	0	7089 77234
Jul-16	18328	38082	14830		0	74094
Aug-16 Sep-16	20982 0	5884 0	13154 0	2854 2854	0	42874 2854
Oct-16	0	0	0	2854 2854 7854	0	2854 2854 2854
Nov-16 Dec-16	0	0	0	2854 2854	0	2854 2854
and the second s						



urface Water Delivery (Acre-Feet)	Kawaah Subbasia	Kern County Subbasia	APPENDIX D2-2 Kines Subbasin	Tule Subharin	Westsiya Subbavia
	Lawash Subbasin	Kern County Solbassian 1377 1377 1377 1377 1378 1379	APPENIX CD 2 2 Kings Subbasis 1647 1247 1247 1247 1247 1247 1247 1247 1247 1248	Tute Sobbasies Separate Sepa	Westside Subbasia 144 456 467 468 469 469 470 471 471 472 473 474 475 477 477 477 477 477

			APPENDIX D2-2 (Cont)		
Surface Water Delivery (Acre-Feet)	Kaweah Subbasin	Kern County Subbasin	Kings Subbasin	Tule Subbasin	Westside Subbasin
Jan-08 Feb-08	18 76	152 852	246 802	83 552	902 3112
Mar-08 Apr-08	7172 2395	1651 2361	2476 2802	4489 424	8384 9010
May-08	4395	3761	13361	934	10147
Jun'08 Jul-08	21269 24815	6219 7612	24490 26919	10546 9910	10365 9325
Aug-08 Sep-08	9279	5128	8168 2429	1262	6755 3966
Oct-08	3121 1277	3576 2028	1254	849 566	1414
Nov-08 Dec-08	205 80	549 454	529 359	250 50 81	602 502
Jan-09 Feb-09	228	401 767 1077	302 377 1194	81 200	756 680
Mar-09	94 988	1077	1194	244	2448
Apr-09 May-09 Jun-09	2213 16510	2440 4280	1660 6848	416 10204 3994	3365 6105 7381
Jun-09 Jul-09	19393	6669 6562	23889 28183	3994 11783	7381
Aug-09	23418 13001	6562 6142	12501	9198	5651 2372 1515
Sep-09 Oct-09	3185 1964 98	3051 2051	2110 1283	827 551	1515
Nov-09 Dec-09	98 52	2051 627 348 193 784	533 244	1747 48	1004 945 967 1524 2815
Jan-10 Feb-10	9 91	193	118 555	75 203	1524
Mar-10	9084 9661	1151 2259	2912 8354	2390 5168	1932 3111
Apr-10 May-10	9661 27630	2259 5169	8354 20455	5168 9836	3111 6608
Jun-10 Jul-10	31224 32344	10058 15684	26047 23806	8433 11894	19120 18808
Aug-10	24931	13524	24152	12023	13783
Sep-10 Oct-10	7017 1650	9882 5379	8430 3908	3200 511	6138 3096
Nov-10 Dec-10	55 1501	3811 3942	363 1547	226 46	2129 2707
Jan-11	199	4763 4746	2695	829	4520
Feb-11 Mar-11	452 10065	6270	1734 10124	2065 3745	9670 7657
Apr-11	21424 26993	6019 7494	20262 25764	5438 9322	7172 11941
May-11 Jun-11	29531	9935	29828	12067	21540
Jul-11 Aug-11	30783 26314	14434 14932	24313 20716	16092 14640	23798 20960
Sep-11 Oct-11	15653	10223 6062	16679 4893	9216 4634	8234 3188
Nov-11	3935 193	5978	1164	247	2826
Dec-11 Jan-12	101 583	6460 3300	1375 1743	49 82 204	4443 11629
Feb-12 Mar-12	583 260	3300 4623	2325	204	16398
Apr-12	442 441	1161 2454	1600 2814	248 1126	2847 4631
May-12 Jun-12	3353 13499	5228 8711	5466 16026	1221 3763	9250 14397
Jul-12 Aun-12	21816	12788	22698 14638	8687	12811
Aug-12 Sep-12	9476 3692	11893 6552	2578	9194 840	9482 3343
Oct-12 Nov-12	3264 108 18 36 152 574	5333 2295	1361 520 252	559 247	2483 1604
Dec-12 Jan-13	18 36	1308 1248	252 396	49 82	1642 2969
Feb-13 Mar-13	152	1411 1361	396 828 1343	204 248	4297 3226
Mar-13 Apr-13 May-13	574 1043 2885	2932 4727	1343 2598 4167	248 419 923	5102 9255
May-13 Jun-13	2885 7655	4727 8186	4167 14386	923 1376 2653	9255 9966
Jul-13 Aug-13	8922 9089	8924 5862	13925 4616	2653 10351	9966 9178 4590
Sep-13	2433	3503	2168	840	1332
Oct-13 Nov-13	2433 782 82	2414 597	1215 423	559 247	963 375
Dec-13 Jan-14	59 109	378 361	269 701	49 82	431 559
Feb-14	22	840	299 202	204 248	616
Mar-14 Apr-14	22 18 63	840 523 1566	438	419	704 1138
May-14 lun-14	269 3386	2973 4293	990 7480	923 1376	2222
Jul-14	2612	4990	12797	1604	3990 3047
Aug-14 Sep-14	940 647	4270 2565	4563 2645	1248 840	1399 729
Oct-14 Nov-14	287 108	1166 413	906 376	559 247	381 177
Dec-14	287 108 22 59 27	272 272 336 805 1076	291	49 82	729 381 122 184 70 225 433
Jan-15 Feb-15	27	3.36 805	607 325 416	82 204 248	225
Mar-15		1076	416	248	433
Apr-15 May-15	154 266	1989 3394	413 693	419 923	793 1440
Jun-15 Jul-15	1336 3306	4267 5141	2704 7295	1376 1604	2637 1975
Aug-15 Sep-15	852 610	3915 2046	2958 1250	1248 840	937 528
Oct-15	610 287 108	1166 413	906 376	559 247	381 263
Nov-15 Dec-15	108 22 109	413 272 361	376 291 701	247 49 142	263 155 559
Jan-16 Feb-16	109	361 840	701 299	142 477	559
Mar-16	22 18 63 269 3386	840 523	299 202	477 2211	616 704
Apr-16 May-16	63 269	1566 2973	438 990	3442 923	1138 2222
Jun-16 Jul-16		4293 4990	7480 12797	1376	3990 3047
Aug-16 Sep-16	940	4270 2565	4563 2645	4806	1399
Oct-16	940 647 287 108	1166	2645 906	4806 840 559 247	1399 729 381
Nov-16 Dec-16	108 22	413 272	906 376 291	247 49	122 184
	22	4/2	474	49	104



Appendix D3 Summary of Crop Demand

Sum of Crop ET Demand (Acre-Feet/Year)							APPENDIX D3-1							
Tulare Lake Subbasen	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
El Rico GSA														
Alfalfa Hay and Gover	70729	78296		117038 13	18221	14393.2			66396 68927		105292	48856	36930	31810
Almonds (Addles cent)	0	0	_	0	0	0					2	18	ın	10
Almonds (Mature)	0	0			0	0					0	0	0	0
Amonds (Young)		ی د			188	140					4//	179	183	1163
Office foo amount cases		, .										» c	0 **	70
Com and Grain Sorghum	2018	14258			41343	26375					7015	9740	7639	9806
Cotton	264279	292007		252807 27	70755	211744					1373	149263	99964	178223
Dairy Single Crop*	1445	1847			0 0	0 0					0 0	0 0	0 0	0 0
Forest*														0
Grain and Grain Hay	26296	25753			14205	18440					2247	12207	21158	17961
Melans	0	0			0	0					2	728	4	93
Misc. field crops	4755	9999		22248	0 0	40 0					0 0	o p	0 4	0 ;
Onen Water*	ope C										ş -	2 9	740	III
Pasture and Misc. Grasses	1917	7962			20107	77436					286	39902	32424	31157
Pistachio (Adolescent)	0	0				0					370	687	1003	1370
Pistachio (Mature)	0	0			1232	1293					847	842	1184	1122
Pistachio (Young)	0	23			322	376					1140	1492	1535	1315
Pomegranates (Young)	0	0			0	91					33	148	164	162
Potatoes, Sugar beets, Turnip etc	1508	0			14	0					4	0	m i	en i
Riparian *	0	٥			0	0					0	0	0	0
Small Vegetables	1430	228			0	0					107	103	00	116
Stone Fruit (Mature)	0	0			0	0					0	0	0	0
Stone Fruit (Young)	0	0			2	6					1	2	40	28
Tomatoes and Peppers	7907	3135			11	2					956	19043	35729	42194
Urban, Industrial*	0	0			0	0					0	0	0	0
Wine Grapes with 80% canopy	0	88			407	362					35	246	472	958
Winter Wheat*	0	0			0	0					0	0	0	0
El Rico GSA Irrigated ET Demand	380445	424208		494716 51	513807	4802.09	456451 450	450445 3834	383463 36875		394364	280539	238594	316952
Notes: Fields with an Asterisk (*) are not irrigated; Annual Total is by Calendar Yoar); Annual Total is by Calendar Year													
							430 ccia							
							EI KICO GSA							
225,000														
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c														
	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
	1 1	Attata Hay and Clover	Amonds (Addrescent)		Almonds (Toung)	Carrot single crop	Citrus (no ground cover)	Bacture and Micr Grasses	E Cotton Distachio (Adolescent)	Bistachio (Mahus)				
	3d III	■ Pome granates (Young)	■ Potatoes, Sugar beets, Turnip	rip etc Riparian*	Small Vegetables	Stone Fruit (Mature)	Stone Fruit (Young)	■ Tomatoes and Peppers	■ Urban, Industrial*	■ Wine Grapes with 80% canopy	■ Winter Wheat*			

	35779 36813 36813 114 114 31353 12573 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	
2016	44731 11957 11956 11966 11966 11966 11966 11969	9 102
2015	60033 310094 310004 310	[During] statuted and a state of the state o
2014	46683 11128 1029 46975 7001 7001 7001 0 0 0 0 0 0 0 0 0 0 0 0 0 0	THE
2013	47797 9461 9515	2013 S013
2012	46096 46655 46655 7200 70 470 4700 70 70 70 70 70 70 70 70 70 70 70 70	2012
2011	74524 19524 19525 8004 10 0 10 0 10 0 10 0 10 0 10 0 10 0 1	and Payers and Payers
APPENDIX D3-2 2010	EAS 12 25 25 25 25 25 25 25 25 25 25 25 25 25	- AKINGS RI
2009	72777 22048 12859 12859 12859 12850 12950 12050 12	2000
2008	70000 7000	2008
2007	7723.7724.7724.7724.7724.7724.7724.7724.	DOOT Service S
1999-2006	7714 2023 2025 2026 2020	1959-200
1996-1938	\$ 5425 1	1996-1
eet/Year) 1990-1995	~~	15 90 1.59
Sum of Crop ET Demand (Acre-Feet/Year) Tulare Lake Subbasin	Medicine from City. Altito his print City. Almonic (Manual City. Almonic (Manual City. Almonic (Manual City. Com and Central Control Control Co	Mores Treeds with a Assertation of More-feet) 200,000 2

Sum of Crop ET Demand (Acre-Feet/Year) Tulare Lake Subbasin	1990-1995	1996-1938	1999-2006	2007	2008	APP 2009	APPENDIX D3-3 2010	2011 2012		2013 20	2014 2	2015 2016	و
South Fork Kings GSA	Other t	10011	***************************************	0.000.0	o cocce.	S	0.00	***************************************	00000	1	Section 9	20000	20100
Arraita Hay and Clover	16/09	11994	20008	89079	0000	5/340	36.328	29/44	20000	13963	42768	33380	23185
Amonds (Adobus)	0 892	009	423	980	1311	1 20	9/57	1,1	1902	2121	2323	19/4	303
Almonds (Young)	2	131	1 10	813	1981	1330	1546	1631	1236	355	2843	2414	4677
2012	. 0	0	0	0	0	. 0	0	0	-	0	0	-	0
Carrot Single Crop	0	0	0	0	0	0	0	4	2	_	0	9	26
Otrus (no ground cover)	. 0	. 0	17	. 0	. 0	. 0	. 0	34	ım	18	. 0	- 2	2
Com and Grain Sorghum	7027	19269	13851	13800	12846	13062	7622	14201	2009	8717	7123	4889	4232
Cotton	72878	81246	39915	32470	31210	19953	40.263	4 2989	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	10.285	993	3255	1869	4921	8414	8207
Melans	0	0	0	0	0	0	00		2	2	448	0	15
Misc. field crops	7159	1270	21466	0	0	0	0	T .	0	0	0	0	0
Onions and Garlic	228	0	8	0	0	80	495	467	112	108	283	7	795
Open Water*	0	0	0	0	0	0	0	0	0	0	0	0	0
Pasture and Misc. Grasses	5165	8008	13288	28562	16311	22322	11169	3302	5982	5766	6903	6334	3180
Pistachio (Adolescent)	0	0	0	0	0	0	0	0	19	R	99	506	282
Pistachio (Mature)		0	0	311	306	176	184	200	199	181	168	162	17.7
Pistachio (Young)	0	6	83	196	206	442	246	390	878	1028	1600	1130	1957
Pomegranates (Adoles cent)	0	0	0	0	0	0	0	0	0	0	un	23	41
Pomegranates (Young)	0	0	0	2	176	19	41	196	121	161	294	393	140
Potatoes, Sugar beets, Turnip etc	1518	0	929	0	0	s	0	0	0	119	0		1
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	0
Small Meastables	1 2/2			000		. "	. 60	. 22	. 8	. 8		. 6	44
Stripe Fruit (Adoles centil						1		-			. 6		σ
Shope Engl (Adahina)	1463	1135	889										
Stores Engl (Vorice)	0	5	200	n ye		· G	, <u>ē</u>	. 5	. 8	, 2	· 8	9	30
Tomatons and Benners	, 8	117		302		: =	*	500	9189	1110	t ces	985	6122
lichan Industrial*						; =	1 9						
Wine States with 8th canony	, Æ	816	4390	2477	1278	, 46	. 25	, 85 %	9 99	3205	4771	° g	0.005
Winter Wheat*		or c	0						0		1	4	0
South Fork Kings GSA Irrigated ET D.	127983	144955	148720	146777	140400	126381	131035	10 7022	112547	90701	101735	25768	90754
South Fork Kings GSA Total ET Demi	131720	147804	151645	146777	140400	126381	131035	10 7022	112547	10/06	101735	89454	90754
						South Fork	South Fork Kings GSA						
160,000													
140,000													
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	1990-1995	1996-1998	1999-2006	2007 20	2008 20	2009 2010	10 2011	2012	2013	2014	2015	2016	
	Alfalfa Hay and Clover	Almonds (Adolescent)	() Almonds (Mature)	Mmonds (Young)	Berries	■ Carrot Single Crop	Citrus (no ground cover)	Corn and Grain Sorghum	Cotton	■ Dairy Single Crop*	Fallow Land*		
	III POTEST	Ordan and Grain Hay	Order and Grant Ray Monday Monday	MISC. TIERS CIS DS	- Change Sand Coallic	Specifical Material	Pasture and Misc. Orasses				Pomegranates (Addressent)		
	■ POTPERTATES (1 coung)	■P OTBTOES, SNIger uverse	S, Turnip etc # Kipanan -	■ Small Vegetables	Stane Huit (Address, en.)	Stone Fruit (Mature)	Stone munt roungs				Winter winear		

	28.51 29.52 29	
	2007 2007 2007 2007 2008	2016
•	1716 11177 1117 1117 11177 11177 11177 11177 11177 11177 11177 11177 11177 11177 117	2015 Political Land* Political Land*
i	14899 4603.1 1990.0 199	2014 Dairy Single Crop* E Ratacho (Young) E No Worker Wheat*
•	13154 - 13154	2013 E. Cotton Principle (Makure) Principle (Makure) With Grapes with 80% chropy
1	14777 11 12 17 17 17 17 17 17 17 17 17 17 17 17 17	2012 Corn and Grain Sorghum Excern and Gra
D3-4	25. 25. 25. 25. 25. 25. 25. 25. 25. 25.	2011 Citus (ho ground cown) P But e and Mice, Cacaces Tonatoes and Peppers
APPENDIX D3-4	24609 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	2010 Corror Single Crop Corror Water* Some Full (Young)
1	4023 8 5090 3 50	2009 Blendes Onlore and Gaffic Stone Frist (Mature)
1	42036 42036 10.00	2008 Adminods (Young) Misser field crops Stone fruit (Addescent)
1	20110 2017	06 2007 = Ahmonti (hature) = Small Vogetables
	2587 6 9 7 0 8 6 7 8 7 8 7 8 7 8 7 8 8 7 8 8 8 7 8 8 8 8	1999-20
		15 1996-4998 15
and (Acre-Feet/Year)	page 1	1990-190
Sum of Crop ET Demand (Acre-Feet/Year)	Sandment tring 6.54 Althoris live and close Administrating 6.54 Althoris live and close Administration (1964) Bennical (1964)	

	659 50 50 50 50 50 50 50 50 50 50 50 50 50	
2016	13166 6 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	10 m 10 m 10 m 10 m 10 m 10 m 10 m 10 m
2015	1904. 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	2012
2014	2254 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2014 Enforced*
2013		2013 = Mission tark = Mission tark = Mission tark
2012	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2012 Doby Calcade Co.P. Broadcaning Market
2011	31006 300 300 300 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4	11 And And And And And And And And And And
APPENDIX D3-5 2010	1941 6 4 6 6 7 200 9 7 9 6 9 6 9 7 9 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9	Tri-County Water Authority GSA 2010 2010 To receive and desire depture To consider and desire depture To consider and desire depture To consider and desire depture To consider and depture
2009	770 0 1 1 1 1 2 0 1 1 2 1 2 0 1 1 2 2 0 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2	TTH-COUR
2008	(603) 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	
2	2008 90 90 90 90 90 90 90 90 90 90 90 90 90	2008 Commission of the special of t
2007	130 to 13	2007 A Sharm of Young) B Asharm of Young) S mall young safety
1999-2006	2022 2020	1599-2006 B Anno d's (Adolocent) B Anno d's (Adolocent)
1996-1938		Seed, 18 00 18 18 18 18 18 18 18 18 18 18 18 18 18
oar) 1990-1995	130077 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	is enganed; AnnualTotal is by Cab
Sum of Crop ET Demand (Acre-Feet/Year) Tulare Lake Subbasin	This cannot whene Annothing GAA Annothing Company and Company Annothing Company Annothing Company Comp	(0,000 CT Production with the rest tringshed; Area of Tringshed; Area

Sum of Crop t. T. Demand (Acre-Feet/Year) Tulare Lake Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	APPENDIX D3-6 2010	2011	2012	2013	2014	2015	2016
Tula re Lake Subbasin													
Affaita Hay and Clover	172519	135032	225167	300041	333752	296086	288555	160621	174457	204219	148325	122839	1003
Almonds (Adolescent)	0	0	8113	0	0	11218	19864	8127	10631	18529	16937	15155	137
Amonds (Mature)	26/91	18278	15869	47030	43122	35832	30537	30976	39450	41/20	46956	54809	980
Amontos (roung)	92	0	0000	79071	2075	C TOWN	1,000	19991	7	90000	179/1	15/79	ana
Carrot Single Crop	. 0	0	. 0		0	0	0	37	16	41		1 9	
Oltrus (no ground cover)	0	0	16	0	42	46	14	405	8	335	300	74	
Com and Grain Sorghum	36877	100450	75793	101418	82027	89467	59478	87236	75344	71190	58462	48619	449
Cotton	463179	525386	362232	320870	258511	212071	287383	308970	260527	261476	185559	130368	2158
Dairy Single Crop*	14290	15268	16421	0 (0 1	0 (0 1	0 (0 (0 (0 (0 (
FallowLand	D (D (D (0 (D (0 (D (D (0 (0 (0 (D (
POTEST*	0 29603	D 11070	1100036	0 22500	0 00000	0	0 120 39	0 95570	12360	10000	0 00000	0	3330
Melons	, orno,	11000	10000	2/222	50000	98	452/1	12310	16	10	1183	222	12
Misc field cross	40450	300	121365		o w		3 9	, -	q	g	2007	i c	**
Opine and Godle	803	907706	1350		n o	0 5	2440	7331	2 8	9 5	" 8	9 32	114
Onen Water*	ì		0	o c	0	40	C C				200	0	PATT
Pasture and Misc. Grasses	10799	21236	34256	218974	191082	288198	229306	63417	5778	2899	144942	80018	2865
Pistachio (Adolescent)	0	0	0	0	0	0	0	213	315	828	1280	4713	005
Pistachio (Mature)	15229	12354	12341	17831	38	2825	1236	1288	1237	1135	1075	1412	137
Pistachio (Young)	0	394	2265	1091	1370	2454	2395	3729	5770	7498	8281	8231	206
Pomegranates (Adoles cent)	0	0	0	0	0	0	0	0	0	0	ın	23	
Pomegranates (Young)	0	0	0	11	303	8	52	106	210	376	537	295	74
Potatoes, Sugar beets, Turnip etc	18504	4	9/9	19	0	10	0	23	0	127	0		
Riparian*	0	0	0	0	0	0	0	0	0	0	0	0	
Small Vegetables	2832	1147	8000	E .	m (RI	370	722	212	330	264	126	м.
Stone Fruit (Address cent)	0	0	857%	0	0	P	8 :	787	152	1/1	97	#T#	a v
Stone Fort (Marate)	0	1310	3001	999	1234	1217	187.0	0101	8 5	1250	1186	93	4 25
Tomatoes and Peopers	12971	3747	33791	261	5	246	2	47851	52725	1587	26555	42793	5216
Urban, Industrial*	0	0	0	0	0	0	0	0	0	0	0	0	
Wine Grapes with 80% canopy	7586	8301	14872	14203	8893	2692	0869	13625	23455	11832	16450	11874	2793
Winter Wheat*	0	0	0	0	0	0	0	0	0	0	0	0	
Tulare Lake Subbasin Irrigated ET De	884626	964336	1044130	1072442	1002603	10103 05	993918	76.2584	7.35624	741315	662869	564117	642636
Tulare Lake Subbasin GSA Total ET D	898916	973604	1060551	1072442	1002603	1010305	993 918	762584	735624	741315	662869	564117	64263
Notes: Fields with an Asterisk (*) are not irrigaled; Armual Total is by Calendar Yoar	ed; Annual Total is by Calendar Year												
						Tulare	Tulare Lake Subbasin						
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■ Citrus (no ground cover) ■ Corn and Grain Sorghum
■ Pasture and Mac. Grasses ■ Pistach is (Adolescent)
■ Stone Fruit (Young) ■ Tomatoes and Poppers

■ Berries
■ Chiors and Garilic
■ Open Water*
■ Stone Fruit (Adels seem)
■ Stone Fruit (Adels seem)

■ Almonds (Young)
■ Misc. field crops
■ Small Vegetables

Alfalfa Hay and Clove r — Forest* — Pomegsa nates (Young)

90	11119 1458 1458 1458 1458 1458 1458 1458 1458	
2016	1118655 10775 17775 17775 1 1 1 1 1 1 1000010 19000010 19000010 19000010 19000010 19000010 19000010 1900000000	9 102
2015	15540 1566 1566 1566 1566 1566 1566 1566 156	5192
2014	д д° ° жж	100
2013	132011 7020 7020 7020 7020 7020 7020 7020	1120
12	110000 2012 401 602 603 603 604 605 605 605 605 605 605 605 605	
2012	113462 27243 27244 2724 2724 2724 2727 2727 2	6100
2011	31313 3131 31313 3131 31313 31	N 117
2010	88 28	Kaweah Subbasin
2009	1100212 10022	Kaw
2008	170164 5140 5140 51534 6	
2	1778446 (633) (633	88
2007	171100 17171	000
1999-2006	H H & M & M & M & M & M & M & M & M & M &	9002 64 51
1996-1998	110590 884 0 885 0 897 0 111111 111111 111111 111111 111111 1111	1506-1504
1995	115466 10094 10094 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	9561
1990-1995	115466	400,000 400,000 100,000 100,000 100,000 100,000 100,000 100,000 100,000 100,000 100,000
Sum of Crop Acreage (Acres) Kaweah Subbasin	A sea to desire the sea of the se	(Acre-Feet) (Acre-Feet)

Sum of Crop ET Demand (Acre-Feet/Year)	2001 1001	1000	3000 0000		***************************************		APPENDIX D3-8						
Kem County Subbasin													
Alfalfa Hay and Clover Almonds (Addiescent)	20321	18273	2266	19380	15803	2222	27373	833	5772	12561	3094	1258	12071
Almonds (Mature)	6857	3611	1401	9968	8694	7583	6160	6105	6889	6838	6847	9333	9610
Berries	• •	0	0	0	0	0	0	0	0	18	0	0	0
Citrus (no ground cover)	1988	0 0	0 0	o •	0 440	935	0 0	H 9	- 2	P ^	510	n e	n m
Com and Grain Sorghum Cotton	603	31076	1135	1640	2267	1302	5962	2488	3062	2200	1269	1586	371
Dairy Single Crop*	en c	0 0	1239	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
Forest*	0	0		0		0	0				0		0
Grain and Grain Hay Melons	7623	20168	14436	881	1817	1460	2931	3387	2394	2208	1878	1953	4984
Misc. field crops	5473	3458	4354	. 0	0	. 0	0	. 0	. 0	0	. 0	. 0	0
Onlons and Garlic	230	8 -	0 0	0 0	0 0	e C	16	25 0	127	88 0	28	8 -	181
Pasture and Misc. Grasses		13517	12338	154954	140349	1965 76	190751	35338	38717	65695	80646	46771	40224
Pistachio (Adolescent)		0 300	0 823	0	0 40	0 -	0 (0 0	0 0	2 0	E °	996	1205
Pistachio (Young)		476	2322	266	174	174	300	1350	2464	3525	2025	2939	2940
Pomegranates (Young)		0	0	0	63	0	0	921	158	42	35	16	629
Potatoes, Sugar beets, Turnip etc	222	0 (0 (0 (0 (2	0 (₩ 6	2	0 (9 0	17	2
Riparian **		0 0	0 8	0 0	0 6	0 0	0 2	0 4	0 9	0 2	0 0	0 12	0 0
Stone Fruit (Adolescent)		0	3 %	0	10	0	10		10	, 0	10	, 0	-
Stone Fruit (Mature)	5735	877	227		0					. 0	. 0		. 0
Stone Fruit (Young)	0	19	2	4	98	22	10	90	11	18	174	22	85
Tomatoes and Peppers		1763	0	0	0	2	0	185	178	37	8.	83	283
Urban, Industrial* Wine Grapes with 80% canopy		7112	0 6/65	9085	4185	2166	3657	D 25%	4212	P 88	2651	3603	3413
Winter Wheat*		0	0	0	0	0	0	0	0	0	0	0	0
Kem County Subbasin Irrigated ET D Kem County Subbasin Total ET Dem	87287	107253	61474 62713	20399.2	1845.26 1845.26	235758	245611	66619	72486	95264	118867	82269	80017
Notes: Fields with an Asterisk (*) are n.	Notes: Fields with an Asseriak (*) are not triggated; Amnual Total is by Calendar Year												
						Kern Co.	Kern County Subbasin						
250.000													
200,000													
neer's size													
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1994-													
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pueu													
i∋G T:													
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	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010 2011	1 2012	2013	2014	2015	2016	
	Alfalfa Hay and Clover	Almands (Adolescent)		Almonds (Young)			■ Otrus (no ground cover)				Fallow land*		
	Forest*	■ Forest*	Melons	Misc. field crops	Onions and Garle	■ Open Water	Pasture and Misc. Gras ses	■ Pistachio (Adole scent)	■ Pistachio (Mature)	Pistachio (Young)	■ Pome granates (Young)		
	■ Potatoes, Sugar beets, Tut	mip etc III Riparian*		Stane Fruit (Adolescu			■ Tomatoes and Peppers			Winter Wheat*			

401 101 <th> 1</th> <th>Sum of Cron FT Demand (Acre. Fast Near)</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>APPENDIX D2.9</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th>	1	Sum of Cron FT Demand (Acre. Fast Near)							APPENDIX D2.9							
Control Control <t< th=""><th> 11 12 13 13 13 13 13 13</th><th>Kings Subbasin</th><th>1990-1995</th><th>1996-1998</th><th>1999-2006</th><th>2007</th><th>2008</th><th>2009</th><th>2010</th><th>2011</th><th>2012</th><th>2013</th><th>2014</th><th></th><th>2015</th><th>2016</th></t<>	11 12 13 13 13 13 13 13	Kings Subbasin	1990-1995	1996-1998	1999-2006	2007	2008	2009	2010	2011	2012	2013	2014		2015	2016
Colored 61 pt <	10 10 10 10 10 10 10 10	Mines Subhasin														
144 1158 1159	10	Alfalfa Hay and Clover	6761	7	58132	101357	5588					~	98888	72022	58974	50664
1841 1184 1184 1842 <th< td=""><td> 1</td><td>Almonds (Adolescent)</td><td>_</td><td></td><td>9525</td><td>0</td><td></td><td></td><td></td><td></td><td></td><td></td><td>13168</td><td>13348</td><td>11819</td><td>19720</td></th<>	1	Almonds (Adolescent)	_		9525	0							13168	13348	11819	19720
4 4	1	Almonds (Mature)	1584.		11683	19642	1732						13995	16138	22835	21754
4 8 8 9	1	Almonds (Young)	_	0 2461	812	19323	4348						15125	20298	30152	15595
11 10 11<	10	Berries	_	8 0	60	0							38	0	0	0
111. 50.00	10	Carrot Single Crop	_			0						10	7	126	0	30
5100 5801 5801 1864 1869 <th< td=""><td> 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,</td><td>Oltrus (no ground cover)</td><td>191.</td><td></td><td></td><td>249</td><td>ě</td><td></td><td></td><td></td><td></td><td>10</td><td>3915</td><td>8050</td><td>3278</td><td>1915</td></th<>	1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,	Oltrus (no ground cover)	191.			249	ě					10	3915	8050	3278	1915
956 950 950 134 2466 1364 136	1, 10, 10, 10, 10, 10, 10, 10, 10, 10,	Com and Grain Sorghum	2418.			15458	2742					90	24209	32503	24496	22755
966 966 <td> 1</td> <td>Cotton</td> <td>5169.</td> <td></td> <td></td> <td>9225</td> <td>108.</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>8521</td> <td>12370</td> <td>7650</td> <td>9240</td>	1	Cotton	5169.			9225	108.						8521	12370	7650	9240
50 60<	Color Colo	Dairy Single Crop*	954.			0							0	0	0	0
500 600 <td> 10 10 10 10 10 10 10 10</td> <td>Fallow Land*</td> <td>_</td> <td></td> <td></td> <td>0</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>0</td> <td>0</td> <td>0</td> <td>0</td>	10 10 10 10 10 10 10 10	Fallow Land*	_			0							0	0	0	0
910. 4684 6684 610 130 620 170 510 510 520<	1	Forest*	_			0							0	0	0	0
755 756 757 756 757 756 757 756 757 756 757 756 757 756 757 756 757 756 757 756 757 756 757 <td> 1</td> <td>Grain and Grain Hay</td> <td>576.</td> <td></td> <td></td> <td>2412</td> <td>197</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>9665</td> <td>3092</td> <td>3579</td> <td>1179</td>	1	Grain and Grain Hay	576.			2412	197						9665	3092	3579	1179
The color of the	10 10 10 10 10 10 10 10	Melans	.09			0						10	48	11	14	42
1	10	Misc. field crops	783			0							0	0	0	0
100 100 60 60 53.0 52.0<	10	Onions and Garlic				47	ĭ						116	269	190	420
10	10	Open Water*				0							0	0	0	0
58 35 58 25 25 14 14 14 14 15 15 64 15 </td <td> 10</td> <td>Pasture and Misc. Grasses</td> <td>1655</td> <td></td> <td></td> <td>40480</td> <td>466.</td> <td></td> <td></td> <td></td> <td></td> <td>~</td> <td>8686</td> <td>7730</td> <td>298</td> <td>2061</td>	10	Pasture and Misc. Grasses	1655			40480	466.					~	8686	7730	298	2061
0.0 1.0 <td> 1</td> <td>Pistachio (Adolescent)</td> <td></td> <td></td> <td></td> <td>0 1</td> <td>2</td> <td></td> <td></td> <td></td> <td></td> <td>m 6</td> <td>4 6</td> <td>22</td> <td>8 (</td> <td>200</td>	1	Pistachio (Adolescent)				0 1	2					m 6	4 6	22	8 (200
Column C	1	Pistachio (Wature)	8			507	7						797	1001	183	THE CASE
1	10	Postachio (Foung				55 22						0 10	110	7007	25 8	600
200 10	170 170	Portations Sugar hearts Turnin air-				1 "								100	, 00	8 -
256 170 180 18	100 125	Sparian.*	9										. 0			
71.0 0.0 91.0 91.0 11.0	Color Colo	small Vegetables	259.			15	,					~	345	102	32	84
72.20 (0.01) 9.00 9.70 1.15 7.25 1.44 4.05 7.1 1.10 1.15 7.25 1.44 4.05 1.10 <	COURT STORE STOR	Stone Fruit (Adoles cent)	_			0						4	747	529	673	329
1	10 10 10 10 10 10 10 10	Stone Fruit (Mature)	X223			5770	11.					1	41	111	28	48
17 187	100 100	Stone Fruit (Young)	_			439	22:					-	10498	4070	2798	1273
Color Colo	1	Tomatoes and Peppers	111.			33						00	2452	1235	1090	3304
0 0	State Stat	Urban, Commercial*	,	0 0	0	0							0	0	0	0
STOIL SCAN SEAS ALT75 LEGG LEGG SCAN SEAS	SAM SAM	Urban, Industrial*	_		0	0							0	0	0	0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	28956 3100-0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	Wine Grapes with 80% canopy	5301		54892	42775	158					0	36332	45665	49431	60898
3,0564 3,0559 25/93 25/94 25,046 3,0240 11/966 22794 20154 20154 20154 20155 3	25054 2505	Winter Wheat*	,			0							0	0	0	0
190127 20156 118040 257951 256747 256445 282441 121986 277951 20247 259711 224256 2	Nings Subbasin Kings Subbasin	ings Subbasin Irrigated ET Demand	3 2028			257993	2567-					_	203247	239711	224256	241575
		Kings Subbasin Total ET Demand	33012			257993	2567	.,					203247	239711	224256	241575
		Votes: Fields with an Asterisk (*) are not Irrigate	ed; Annual Total is by Cale	endar Year												
diods rise the with the Aderick (i), it is not or furghal ker's farmal rise is to furghal ker's farmal rise is to farmal ker and it is a																
ONE: Feel with an Anderson (F) Live ord Implied Annual ord India Annual Order Annua																
dies Fede with in Activation by the cost implication from the cost of the cost																
OKE FIRST with an Authority of a teach in things but January and an an article of the anti-								_	Kings Subbasin							
		900 000														
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	8000															
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Sum of Crop ET Demand (Acre-Feet/Year)							AP PENDIX D3-11			į				
Westside subdesin	1990-1995	1936-1938	1999-2006	/007	9707	SMA	7010	2011	7077	2013	2014	2015	7079	
Westside Subbasin														
Affalfa Hay and Gover	14783											7847	2223	5318
Almonds (Adolescent)	ž											3691	1847	1898
Almonds (Young)												2597	2396	3486
Berries												0	0	7.1
Carrot Single Crop												01 00	8 8	0 6
Com and Grain Sorghum	1249	2078										32,	8 8	115
Cotton	1139	1										15497	11995	15476
Fallow Land*	•	0												
Forest*	0											0	0	0
Grain and Grain Hay	86.5											6523	3310	4086
Misc field crops	130												0	0
Onions and Garlic	35.											8099	2699	7539
Open Water*		0										0	0	0
Pasture and Misc. or asses												380/	3443	1171
Pistachio (Mature)												0	1971	2172
Pistachio (Young)												3446	2046	1707
Pomegranates (Adoles cent)												0	0	0
Pomegranates (Young)		0										2	08	42
Potatoes, Sugar beets, Turnip etc												0 0	0 0	۰. ٥
Specifical Memorables												0 00	0 919	1303
Shipe Fruit (Adolescent)												113	010	707
Stone Fruit (Mature)		3100 255										92	. 0	0
Stone Fruit (Young)												8	2	41
Tomatoes and Peppers	10971											20685	14607	13747
Urban, Commercial*												0	0	0
Urban, Industrial*												0	0	0 (50
Wife or appear with 80% candy/												4/81	3203	440.2
Westside Subbas in Irrigated ET Dem	177626	326 178498		182172 130	130889	110499 101	1146	114687 120333	33 127387		101365	92746	69345	76682
Westside Subbas in Total ET Deman:												92746	69345	76682
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	1990-1995	1996-1998	1999-2006	2007	2 008	2009	2010	2011	2012	2013	2014	2015	2016	
	Alfalfa Hay and Clover	Almonds (Adolescent)	Almonds (Mature)	- Almonds (Young)	Berries	Carrot Single Crop		Corn and Grain Sorghum	Cotton	■ Dairy Single Crop*	■ Fallow Land*	■ Forest*		
	Riparian*	■ Small Vegetables	■ Stone Fruit (Adolescent)	■ On or s and Garne ■ Stone Fruit (Mature)	Stone Fruit (Young)	■ Pasture and Misc. Grasses ■ Tomatoes and Peppers	■ Urban, Commercial*	■ Mystacmo (Mature)	■ Wine Grapes with 80% canopy	■ Pomegranates (Adolescent) ■ Winter Wheat*	Nomegranates (Toung)	Potatoes, sugar beets, fur	rmp etc	

Appendix D4 Annualized Specified Pumping by Well Field

Mathematical No. Mathematica
Name
(M. M.) (M. M.) <t< td=""></t<>
(477) (477) <th< td=""></th<>
1991 1992 1993 1993 174273 106339 18908 174273 106399 174273 174273 174273 174273 174273 174273 174273 174

		2016	0.00	0.00	0.00	1,772.13	0.00	0.00	0.06	485.09	0.0	0.00	0.00	0.00	0.00	263.73	0.00	3/0.48	0.00	11.72	1,652.10	96.40	1,804.77	2.97	2,816.01	1,830.73	1,614.97	1,718.73	4,282.34	03.62	3,619.99	4,306.07	16.25	4,497.61 4,292.27	4,406.65	3,970.97	35.35	80.64	2,191.19	864.59	0.00	0.0	0.00	0.00	0.00
		2015 20	0 0	0.00	0.00				1,396.80 1,2		0.00	0.00	0.00	0.00	0.0	367.38 2							1,8				2,169.81 1,6				4,068.25 3,6			4,318.93 4,4 4,278.81 4,2		1,924.61 3,9					22.95	1,103.14	0.00	1,031.41	0.00
			0.00	0.81	0.00			0.00				0.00		0.00					0.00		3,114.65 3,0 730.78 6				2,966.75 2,8						4,387.34 4,0			1,757.98 4,3 1,118.39 4,2	98.85 4,4 0.00 4,2	0.00 1,9	0.00	0.00	0.00			1,810.23 1,1		17.05 1,0	0.00
			0:00																								2,870.49 2,7							0.00	0.00	0.00	0.00	0.00	0.00		1,622.35 1,00			,306.66 1,5	0.00
		2012 20										38.47 1,221.08 1,14							0.00								2,759.92 2,87				0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				0.00		1,646.97 2,30	0.00
		2011 20			4.13 1,37	0.04 2,02	4.94 1,07 7.96 2,15	9.32	6.3/ 1,6, 1.45 67	2.88 82	0.00		0.00		0.00	2.08 52		7.00 1,92			10.23 2,95 7.94 1,85	3.33 75									0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00		8 0 0				7.04 1,64	
			616.54			784.63	257.02 862.97	537.82	655.2/ 280.26	5.46	0.00	0.00	0.00	0.00	0.00	0.80			0.00		998.67	8.20	6.58				1,105.84					0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.0			0.00	17.64	0.00
		2009 20					1,549.94 25						238.69						0.00												00.00	0.00	0.00	0.00	0.00	0.00	0.00					399.48		1,778.14 94	
			1,736.03 1,54											i												1,213.84 2,60			0.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			1,471.77 35		12.79 1,7	0000
		2007 20										738.93 93 999.00 74										985.80 1,50			0.00 1,46			0.0	0.00	0.00	0.00	0.00	0.00	0.00	00.0	0.00	00.00	0.00	0.00			585.19 1,47		2,213.87 2,24	0000
		2006 20																							0.00	0.00	0.0	0.00	0000	00.0	00:0	0.00	00.0	0.00	00.0	0.00	00.00	0.00	0.00			0.00 58			0000
		2005 20	<u>.</u>		000																										0000												0.00	0.00	0000
		2004 20		71.99	31.00	17.00	2,174.00	56.00	34.00	02.00	0.00	32.00	443.00	92.00	1,640.00	678.00	1,964.00	99.99	0.00	52.99	59.99 58.99	000	000	0000	000	000	000	000	000	000	0000	0.00	000	0000	0000	000	000	0.00	000	0.00	34.00	1,430.00	31.00	2,166.00	0.00
			846.00 1,13	51.65 2,2	19.00 1,41	1,1	15.10 2,17 17.92 2,07	56.00 72	2,1 00.11 39.00 1,1	31.00 1,10	17.00	37.00 98 14.00 4:	0.00	80.00	520.00 1,6 0.00							0.00	00.00	0.00	0000	00.0	0.00	0.00	0.00	00.0	00:00	0.00	000	0.00	00.0	0.00	00.00	0.00	000			208.00 1,4			
	g.	2002 20					1,755.43 6-							154.00								0.00						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0000					0.00 20		2,039.00	
D4-2	Annualized Specified Pumping		661.00 1,40	0.00 18.72 1,91	35.99 1,34 19.66 2.14	7,1 67.75	24.11 1,75 75.19 1,68	12.99 1,50	74.00 1,04	77.00 1,12	0.00	74.00 87							1,461.00 31				00'0		0.00	0.00	0.00	0.00	0.00	0.00	0000	0.00	0.00	0.00		0.00	0.00					0.00		1,761.00 2,00	
Appendix D4-2	ılized Speci	00 20	0000	9.11 3,04	73.73 2,39	5.06 2,66	25.67 2,72 37.88 2,53	13.99 2,44	35.20 2,33 35.20 1,67	3.54 1,57	0.00	56.07 1,37 0.00		0.00								0.00			0.00	0.00	0.00	0.00	0.00	0.00	0000	0.00	0.00	0.00	0.00	0.00	0.00				-	0.00			
	Annus	99 20	000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00															0.00	0.00	0.00	0.00	0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		1998 19				_				0.00			00:00	0.00	0000	0.00	0.00	0.00	0.00												0.00												0.00	0.00	0.00
		1997 19	0 0	0.00	00:00	00:00	0.00	0.00	0.00	0.00	0.00	0.00	00:00	0.00	0000	0.00	0.00	0.00													0.00												0.00	0.00	0.00
		1996 19	Š									0.00																														0.00	0.00	0.00	0.00
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			2,238.99 13																												0.00										2,574.99 31				3,312.99 38
		91 19	7.82 2,23	0.00 1,84	0.00 1,68	0.00 1,25	0.00 1,38	0.00	0.00	0.00	0.00	0.00	14.00 1,86	1.00 2,14	.0.93 1,86	3.27 9	1.31 2,91	6.86 1,62 2.27 2,01	0.00	8.86 1,62																						0.00		9.82 3,05	8.96 3,31
		90 19	2,232.55 1,52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00																															0.00			3,306.20 2,23
		19	2,23									2,26	1,86	2,14	1,80	9 21	2,90	2,01	1,04	1,62																					2,56			30'8	3,30
		Well_ID	M-158	M-161	M-163	M-168	M-169 M-170	M-171	M-1/2 M-175	M-176	M-179	_M-181 R-26	R-27	_R-35	S-111	_S-113	S-127	_s-160 _s-162	_S-164 S-165	S-167	_S-173 _S-174	_S-188 S-191	S-192 S-193	S-194	_S-195 _S-196	_S-198 S-199	_s-200	_s-202	S-203 S-205	_S-206 S-209		5-214	5-216	_S-217 _S-218	_S-219 _S-220	_S-221 _S-222	S-223 S-224	_S-225	S-227	_S-228 _S-229	SR-13	ER_SR-14	2.SR-5	_T-155	_T-157
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	2016 (AF/Y) 0.00 0.00 0.00	1,320.74 289.28 289.28 289.28 889.28 889.28 2513.38 889.28 1,068.44 0.00 1,1317.23 1,165.28 1,1317.29 1,106.38 1,134.44 1,107.38 1,134.44 1,134.28 1,134.67 1,134.68 1,134.67 1,134.68 1,134.69	0.00
		1,705.11 437.91 1,008.35 1,008.35 1,008.35 1,007.09	0.00
		1,489,64 1,480,64 1,500,23 1,500,	0.00 0.00
	2013 (AF/Y) 0.00 756.61 0.00		122.48 0.00 1,309.51
	2012 (AF/Y) 0.00 518.39 1,302.55	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	307.92 0.00 1,244.58
		0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	0.00
	2010 (AF/Y) 0.00 118.30 0.00	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	0.00
		0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	151.65 0.00 1,463.99
		0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	172.01 0.00 1,473.27
	2007 (AF/Y) 0.00 2,364.40 0.00	0.00 0.00 0.000	465.51 0.00 1,389.98
		0.000 0.000	12.85 1.67 101.82
	2005 (AF/Y) 0.00 0.00 0.00	0.000 0.000	58.85 7.69 408.94
	2004 (AF/Y) 707.00 1,235.00 874.00	0.000 0.000	580.81 199.39 448.95
	2003 (AF/Y) 389.17 664.00 523.48	0000 0000 0000 0000 0000 0000 0000 0000 0000	336.36 52.11 488.25
mping	2002 (AF/Y) 975.13 1,842.00 424.18	0.000 0.000	613.15 0.12 1,247.56
pecified Pu	2001 (AF/Y) 928.17 1,705.00 0.00	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	
nnualized 9		0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	108.71 106.72 1,242.18
٩		000 000 000 000 000 000 000 000 000 00	102.53 77.11 818.02
	1998 (AF/Y) 0.00 0.00		0.00
	1997 (AF/Y) 0.00 0.00	00000000000000000000000000000000000000	0.00
	1996 (AF/Y) 0.00 0.00	000 000 000 000 000 000 000 000 000 00	84.55 28.90 499.85
	1995 (AF/Y) 0.00 0.00	0000 0000 0000 0000 0000 0000 0000 0000 0000	0.00 36.12 206.88
	1994 (AF/Y) 0.00 0.00	0000 0000 0000 0000 0000 0000 0000 0000 0000	420.81 351.59 1,293.32
	1993 (AF/Y) 0.00 303.00	0000 0000 0000 0000 0000 0000 0000 0000 0000	35.58 23.03 176.79
	1992 (AF/Y) 0.00 0.00 3,227.99	0000 0000 0000 0000 0000 0000 0000 0000 0000	471.33 425.90 975.15
	1991 (AF/Y) 0.00 0.00 1,635.00		681.20 547.86 1,386.96
	1990 (AF/Y) 0.00 0.00 3,222.89	0.000 0.000	983.35 533.37 1,278.44
	.		
	Well_ID ER_T-177 ER_T-182 ER_T-61	CR, CR, 2 CR, CR, 3 CR, CR, 3 CR, CR, 5 CR, EC, 3 CR, EC, 3 CR, S, 100 CR, S, 100	CID_015 CID_016 CID_017
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	2016 (AF/Y)	187.85	26.58	28.61	0.00	0.00	95.89	38.76	14.07	94.65	0.00	0.00	185.37	53.53	04.38	78.24	0.00	69.57	0.00	0.00	99'29	0.00	33.10	33.84	0.0	0.00	81.65	98.90	83.85	01.17	67.14	0.00	0.00	26.40	000	0.00	0.00	89.35	81.47	77.51	90.79	37.06	0.04	0.0	76.86	0.36	72.24	07.46	85.55	27.54	87.79	0.0	21.31	0.00	127.48
	2015 2 (AF/Y) (A																																																						27.48 1,469.65 1,1
	2014 20 (AF/Y) (AF																																																						26.26 1,8
	2013 20 (AF/Y) (AF																																																						
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	2012) (AF/Y)																																																						.00 342
	2011 (AF/Y)																																																						
	2010 (AF/Y)																																																						7 467.
	2009 (AF/Y)																																																						5 1,291.8 4 1,767.7
	2008 (AF/Y)																																																						
	2007 (AF/Y)	1,480.59	1,279.65	1.377.89	0.00	0.00	7 11780	2,049.11	332.03	2,370.25	00.00	423.17	0.00	1,773.95	1,283.75	1,215.38	1,532.13	2,221.00	000	454.23	1,578.76	637.83	1,157.39	522.10	0.00	00:0	1,370.48	1,168.23	1,189.35	1,244.66	1,492.46	0.00	657.44	1,246.42	0.00	164.30	1,868.28	1,146.88	1,539.70	1,379.68	1,038.21	189.28	000	226.31	978.03	2,196.13	982.56	1,309.95	1,271.28	1,239.63	834.67	1,886.07	1,827.95	1,263.58	0.0
	2006 (AF/Y)	96.06	199.99	220.09	0.00	0.00	311 44	217.92	76.24	671.10	0.00	132.28	0.00	125.60	62.81	251.08	351.38	484.89	000	26.96	288.09	57.82	260.08	286.09	0.00	000	464.85	0.00	309,93	122.34	565.44	382 14	390.39	156.67	0.00	2.41	538.72	290.66	352.57	256.87	151.90	7.54	6.65	16.64	91.83	380.38	144.84	197.09	78.55	186.05	93.35	296.53	378.71	0.00	0.00
	2005 (AF/Y)	489.30	306.71	264.05	0.00	0.00	36919	693.28	366.41	347.32	0.00	113.97	271.47	337.36	129.75	304.18	582.54	645.71	000	112.37	303.24	104.03	403.80	357.23	00.0	000	365.02	63.77	409.15	257.76	132.10	0.00	435.74	83.63	0.00	64.98	550.79	294.10	518.70	541.95	142.86	17.42	7.98	22.48	111.55	57.46	308.50	325.61	152.23	245.95	183.58	534.63	0.00	000	0.00
	2004 (AF/Y)	919.52	1,415.36	1,039.10	0.00	0.00	1,441.63	1,420.85	388.57	2,119.73	0.00	451.74	633.74	1,217.83	999.16	897.62	1,878.90	1,318.42	000	708.61	867.66	758.02	757.22	471.23	0.00	0000	1,506.57	1,150.74	1,556.32	963.95	1,746.33	0.00	2,152.07	1,203.38	0.00	526.07	1,750.63	1,208.47	1,760.36	738.11	1,335.06	197.92	3.58	163.85	1,757.47	1,835.78	1,482.16	1,342.88	1,538.22	1,287.24	125.95	0.00	0.00	0.00	0.00
	2003 (AF/Y)	810.87	896.51	1,357.01	0.00	0.00	951.18	309.84	693.76	2,267.13	0.00	794.13	301.13	1,515.12	654.28	1,160.17	1,484.38	1,740.78	0.00	239.43	1,081.34	1.084.36	1,415.47	505.35	0.00	0.00	938.81	695.86	704.16	920.54	2,007.08	0.00	1,368.91	483.03	548.08	304.33	1,438.93	912.87	1,384.98	1,248.29	1,334.52	230.30	0.00	202.04	1,362.63	1,356.17	1,606.41	1,824.40	1,518.23	315.07	0.00	0.00	0.00	0.00	0.00
mping	2002 (AF/Y)																																																						
ecified Pu	2001 (AF/Y)	674.14	940.79	1,049.50	0.00	462.32	1,348.60	1,398.85	1,400.45	3,244.34	0.00	311.91	0.00	1,373.09	1,259.83	1,700.40	741.83	2,101.25	0.00	283.99	1,448.33	1.556.49	1,420.29	971.73	0.00	0.00	772.26	750.62	750.07	873.06	2,607.04	240.95	701.85	444.63	305.96 749.72	49.06	0.00	0000	1,311.76	2,016.68	834.92	22.15	119.09	243.11	1,173.34	225.90	1,668.87	1,735.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
nualized Sp	2000 (AF/Y)																																																						
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	1993 1 (AF/Y) (A	52.18	30.18	73.31 1,1 61.22 1,2	41.75 (0.00	37.66 13	32.41 1,9	12.16 1,0	84.68 2,6	0.00	25.94 (43.81 1,9	06.02 1,4	20.41 1,0	92.35 1,1	60.64 1,7	60.78 2,6	22.95	66.00 1,1	50.66 1,5	9.1 76.90	11.27 1,0	29.56	0.00	76.14 1,6	57.36 1,7	13.28	0.00	79.69 1,4	41.19 1,3	30.66	72.68 1,4	29.92	24.75	74.78	64.94 1,7	8.49 1,6	41.96 2,0	0.90	83.78	27.69	36.91	67.77 97.13 1.3	25.46	000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1992 19 (AF/Y) (AF							2,044.83 3									1,250.45 2					1.637.63 7			64.32						1,476.88 4							2,012.33					109.90											0.00	
	1991 19 (AF/Y) (AF																					2,100,06 1.6			533.05				1.344.56 1.10					789.51 8												0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1990 199 (AF/Y) (AF,																									1,2									-	-	2 -		2		-														
	199 (AF/	94	1,14	76	66	82	1,83	2,05	1,34	1,75	1,00	74	2,47	1,37	1,61	99	1,34	2,13	92.	1,72	1,69	2.02	1,22	86	73	1,53	83	1,26	1,99	1,45	2,36	73	78	1,06	1,18	1,51	2,11	1,94	89	20	99	18													
	۵_	0.18	019	021	022	023	024	026	_027	028	030	031	032	033	034	980	037	038	040	041	042	240	045	046	047	049	050	051	053	054	055	920-	0.58	650	061	062	-063	590	990	790_	690	070_	072	073	075	077	0.78	080	081	082	084	980	780	880	CID_090
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	2016 (AF/Y)	1,53.67 1,674.79 1,674.79 1,427.72 2,220.52 2,220.52 1,427.89 1,884.87 1,884.87 0,00 0,00 0,00	178 H 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	728.1 728.1 728.1 728.1
	2015 (AF/Y)	1,298.44 1,298.44 1,674.79 1,427.72 3,510.53 2,290.52 1,473.69 5,17.23 1,884.87 975.48 0.00 0.00	111 11 12 13 14 15 15 15 15 15 15 15	711.26 711.26 711.26 711.26
	2014 (AF/Y)	1,066.16 1,066.16 1,475.47 1,510.39 2,159.80 2,159.80 1,209.37 74.34 0.00 0.00 0.00	728 11 72	728.11 728.11 728.11 728.11
	2013 (AF/Y)	1,103.04 1,103.04 1,738.69 1,293.26 3,420.23 3,085.52 1,056.92 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	600.17 60	600.17 600.17 600.17 600.17
	2012 (AF/Y)	1,141.08 1,171.04 1,171.05 1,171.05 1,172.90 317.46 1,072.90 0.00 0.00 0.00 0.00 0.00 0.00 0.00	497 87 497 89 49	497.87 497.87 497.87 497.87
		145.25 145.25 145.25 145.26 54.99 0.00 0.00 0.00 0.00 0.00 0.00 0.00	215.57 21	215.27 215.27 215.27 215.27
	2010 (AF/Y)	372.01 372.01 573.14 38.47 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0	978 89 978 978	378.80 378.80 378.80 378.80
	2009 (AF/Y)	1,550.38 1,650.38 1,662.93 1,662.93 0,00 0,00 0,00 0,00 0,00 0,00 0,00 0,	659 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	659.00 659.00 659.00 659.00
		9896.47 741.70 896.47 627.84 0.00 0.00 0.00 0.00 0.00 0.00	663 10 (653 10	653.10 653.10 653.10 653.10
	2007 (AF/Y)		470 25 47	470.25 470.25 470.25 470.25
	2006 (AF/Y)	0000	2005 46 2005 4	205.46 205.46 205.46 205.46
	2005 (AF/Y)		199 55 55 199 55 55 55 59 59 59 59 59 59 59 59 59 5	199.55 199.55 199.55
	2004 (AF/Y)		964, 28 964,	364.24 364.24 364.24 364.24
			978.27 97	378.27 378.27 378.27 378.27
mping	2002 (AF/Y)		6883 37 6883 3	68837 68837 68837 68837
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	2000 (AF/Y)		512.00 51	512.10 512.10 512.10 512.10
⋖	1999 (AF/Y)		4 (1311) 4 (413.11 413.11 413.11 413.11
	1998 (AF/Y)	0000 0000 0000 0000 0000 0000 0000	253.88 12.33.81 2.33.8	253.81 253.81 253.81 253.81
	1997 (AF/Y)	3	925.08 92	325.08 325.08 325.08 325.08
	1996 (AF/Y)		960.23 96	360.23 360.23 360.23 360.23
	1995 (AF/Y)	0000 0000 0000 0000 0000 0000 0000	338.2.1 338.2.	338.21 338.21 338.21 338.21
	1994 (AF/Y)	0000 0000 0000 0000 0000 0000 0000	765.21 76	765.21 765.21 765.21 765.21
	1993 (AF/Y)	0000 0000 0000 0000 0000 0000 0000	66177 6617	461.72 461.72 461.72 461.72
	1992 (AF/Y)		941.28 941.28	941.26 941.26 941.26 941.26
	1991 (AF/Y)		997.05 997.05	957.05 957.05 957.05 957.05
	1990 (AF/Y)	0000 0000 0000 0000 0000 0000 0000	25.1116 25.	686.94 686.94 686.94 686.94
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		2013 20 AF/Y) (AI 600.17 7																																				01.68 5 01.68 5 01.68 5
		2012 20 AF/Y) (AI 497.87 6																																				310.36 4 310.36 4 310.36 4
		2011 20 AF/Y) (AI 215.27 4																																				34.49 3 34.49 3 34.49 3
		2010 20 AF/Y) (AI 378.80 2																																				36.64 36.64 36.64
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		2007 20 AF/Y) (AI 470.25 6																																				
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		2005 24 AF/Y) (A 199.55 2																																				35.99 35.99 35.99
		2004 20 AF/Y) (A 364.24 1																																				
		2003 24 AF/Y) (A 378.27 3																																				
		2002 2 AF/Y) (A 688.37 3																																				
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Appendix D5 Observed and Simulated Target Well Hydrographs

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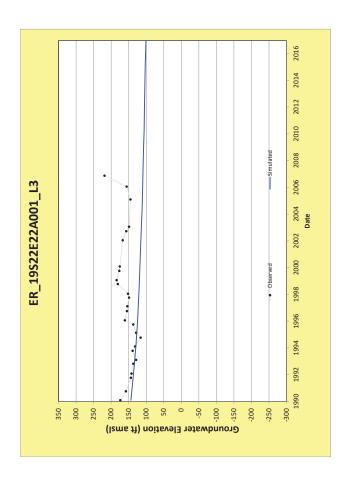
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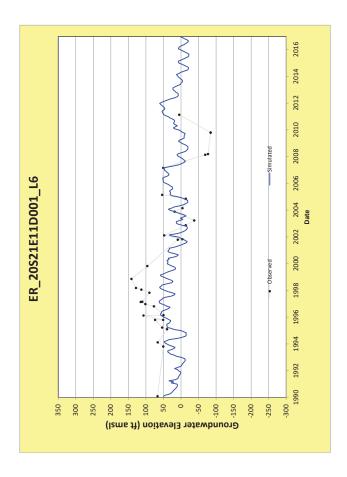
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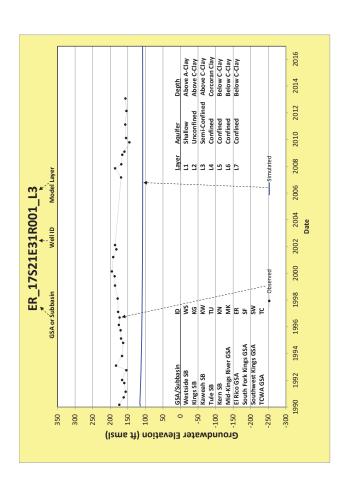
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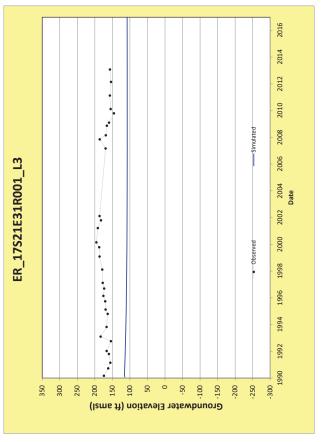
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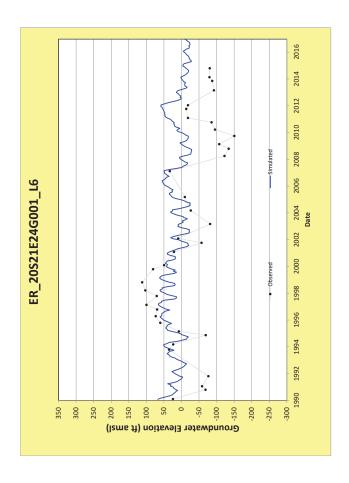


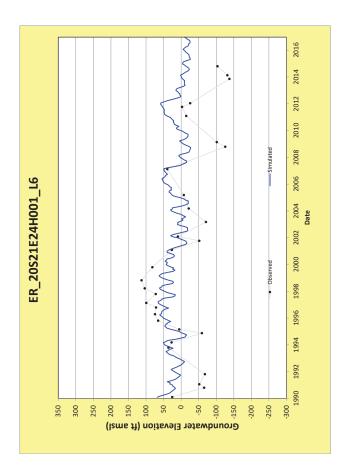


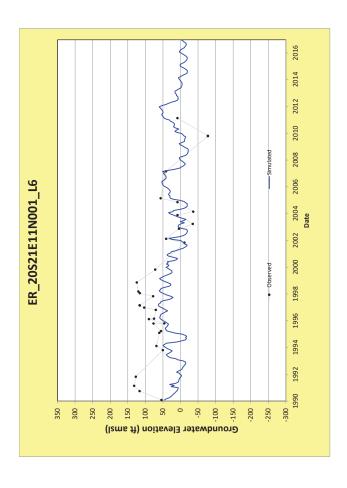


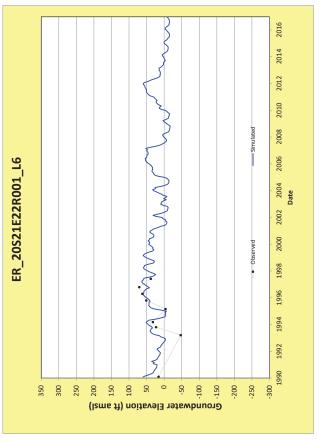


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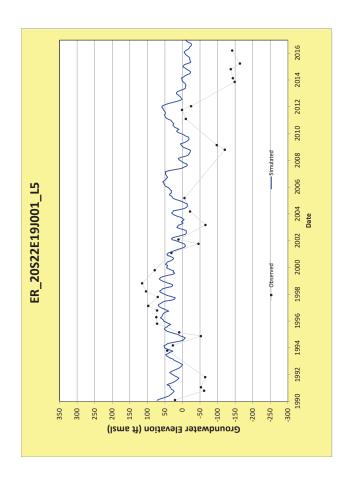


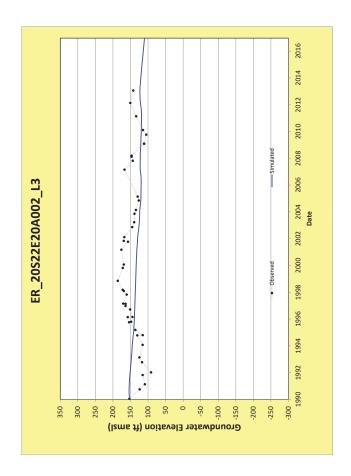


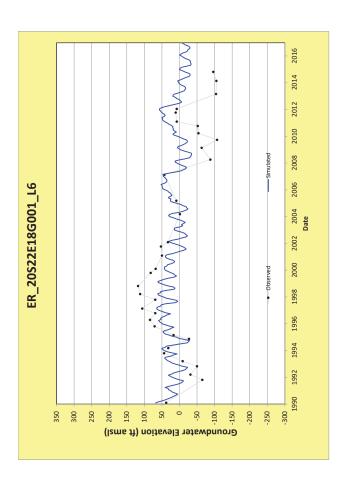


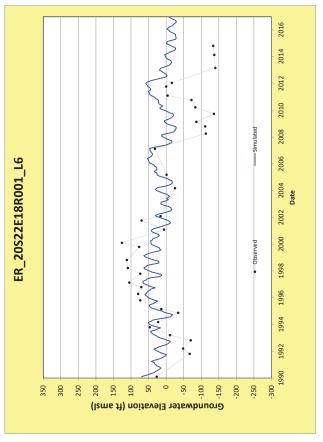


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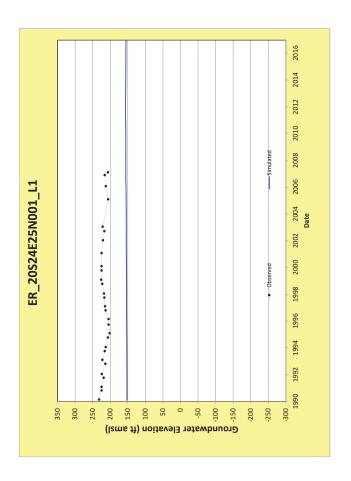


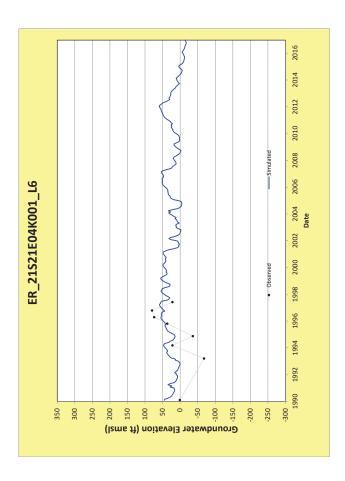


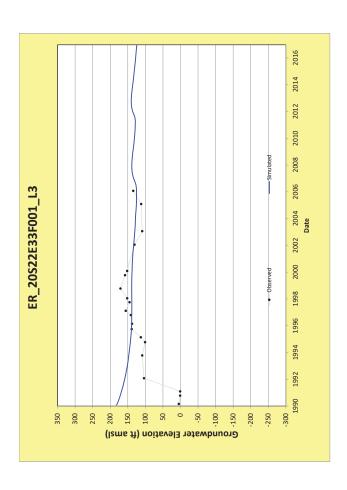


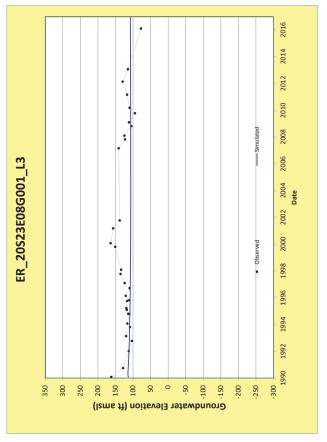


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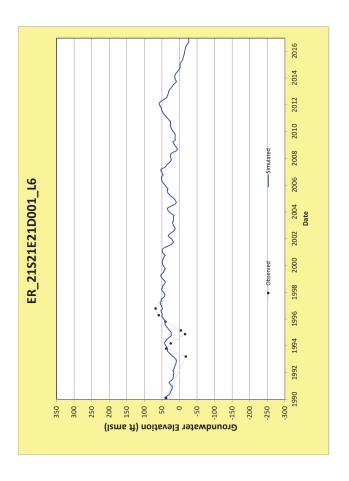


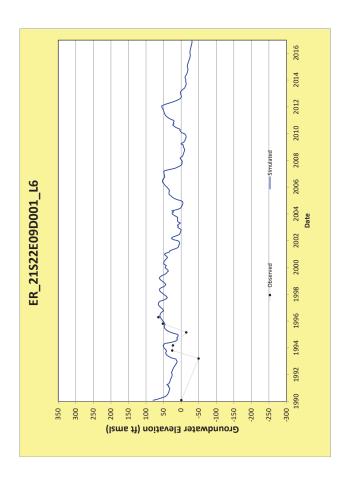


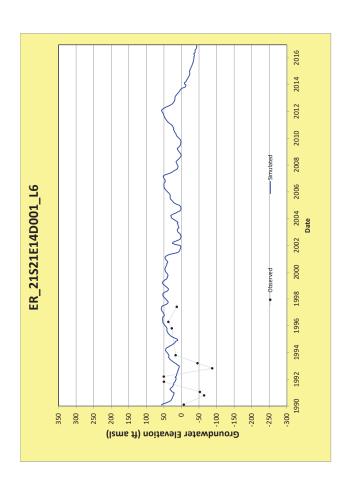


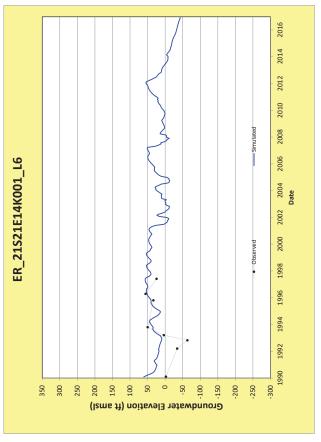


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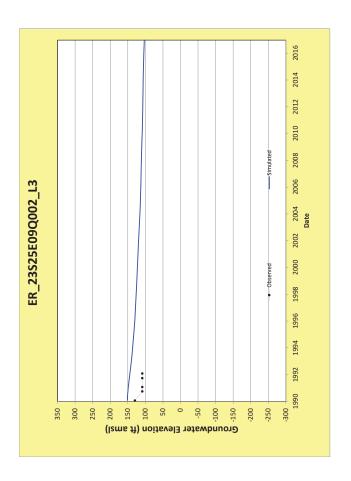


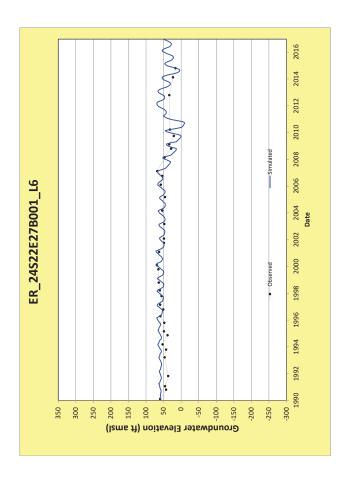


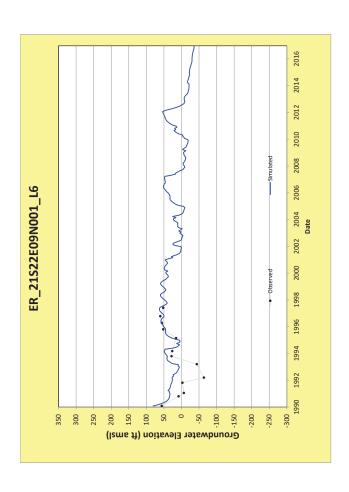


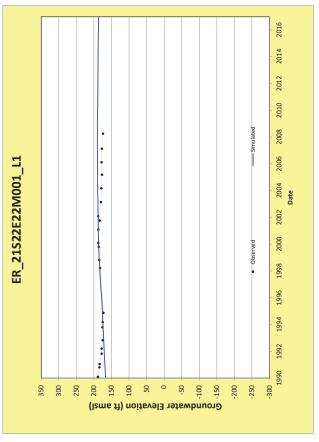


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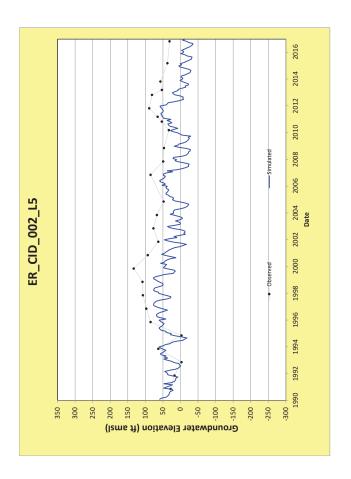


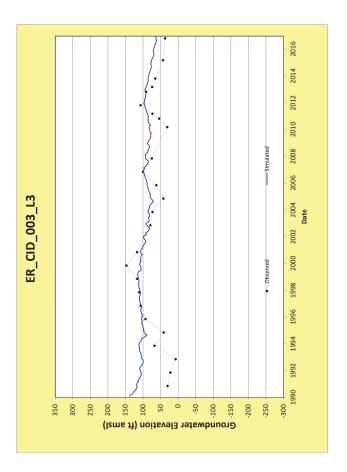


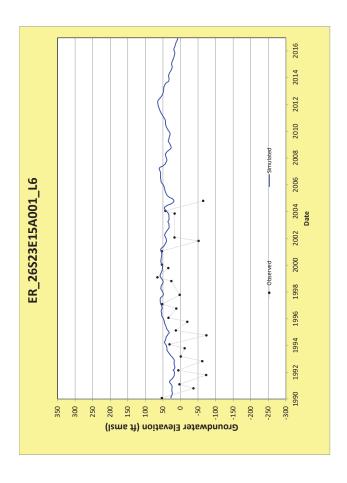


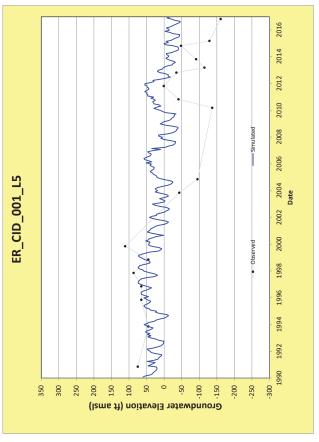


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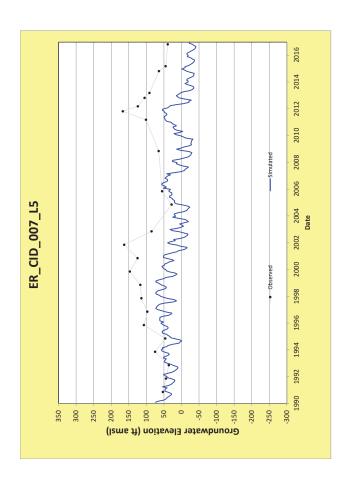


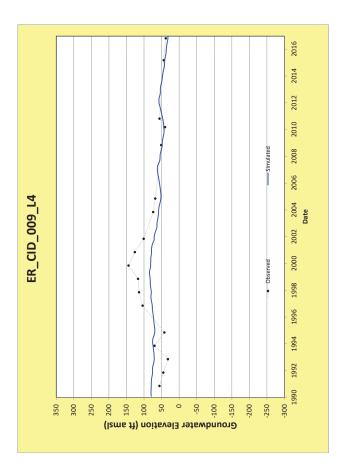


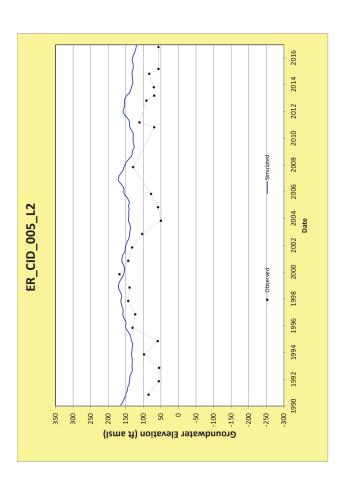


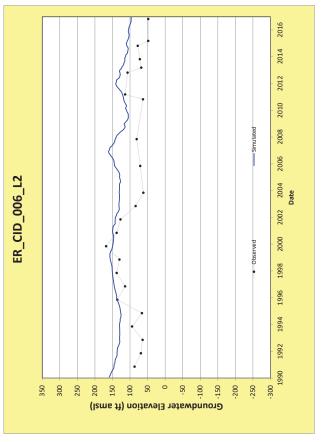


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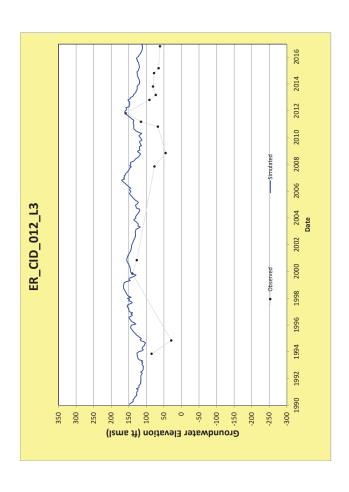


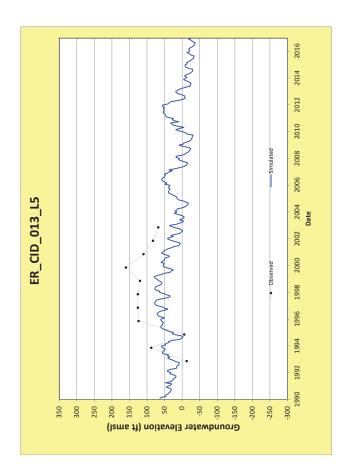


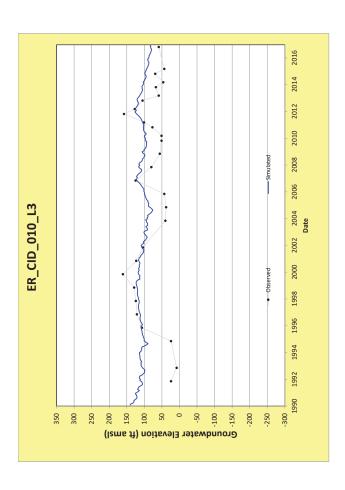


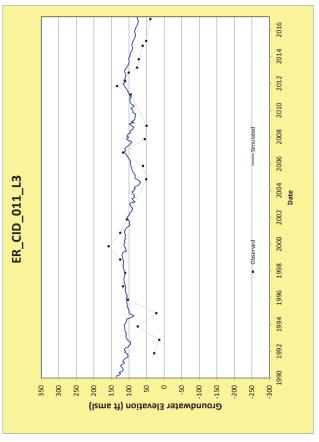


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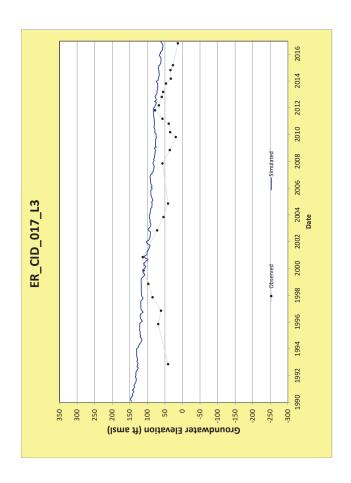


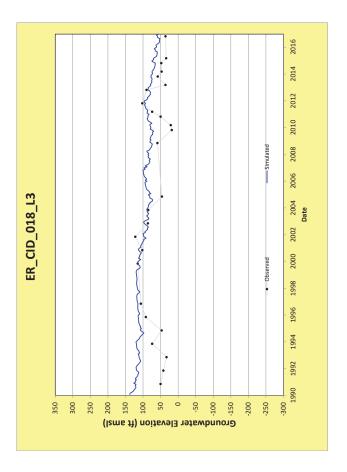


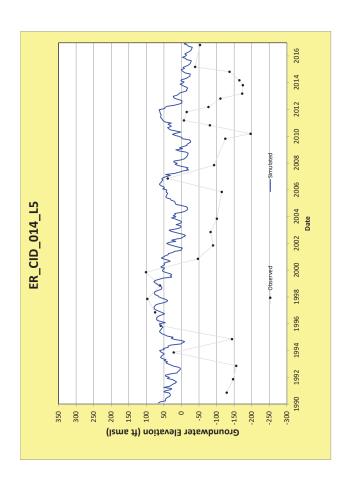


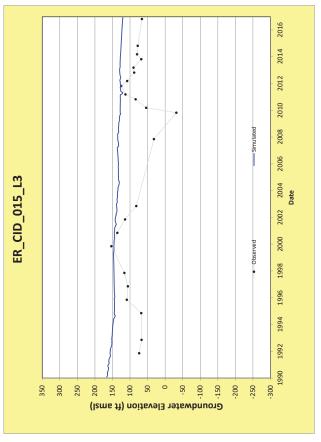


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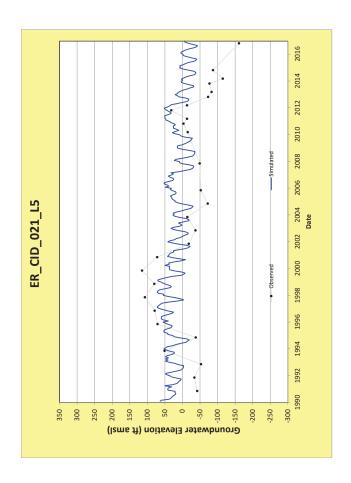


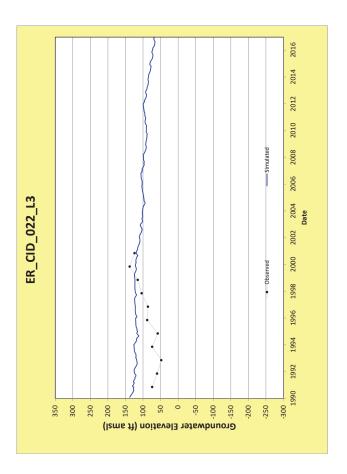


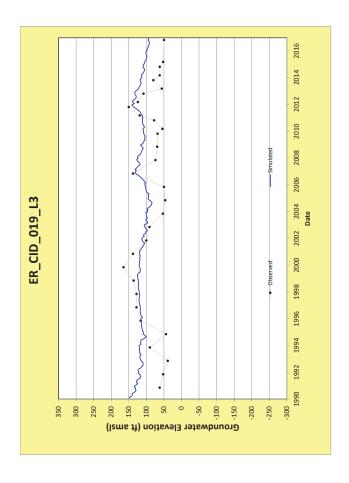


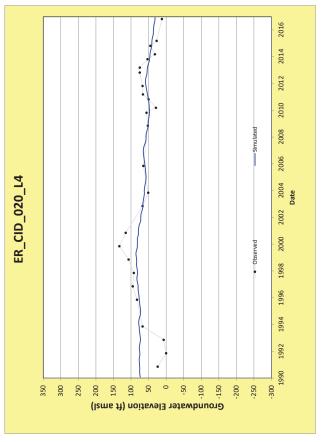


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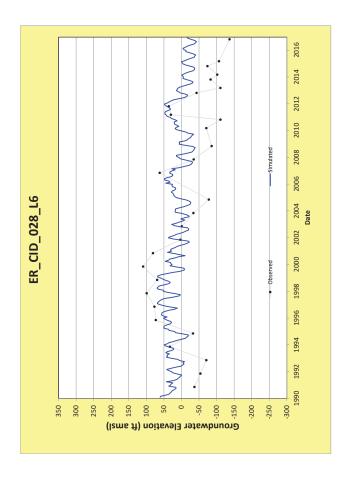


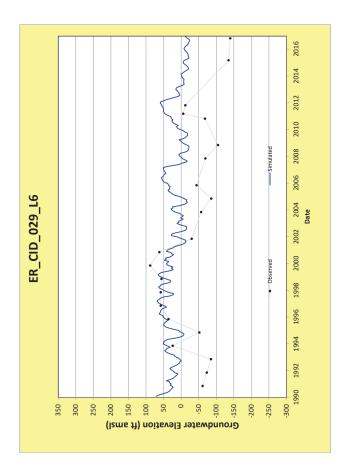


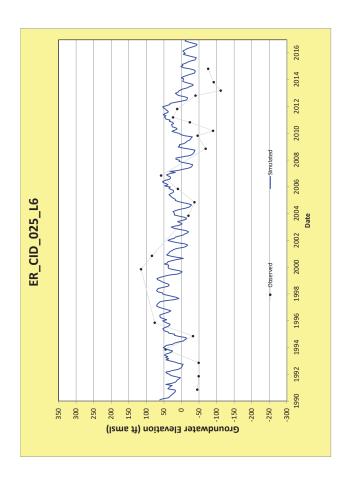


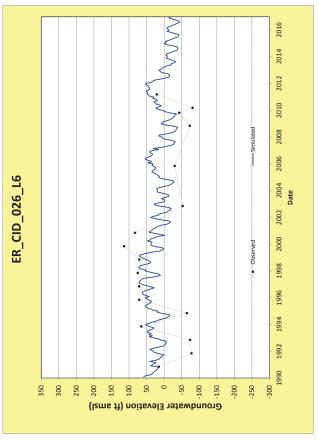


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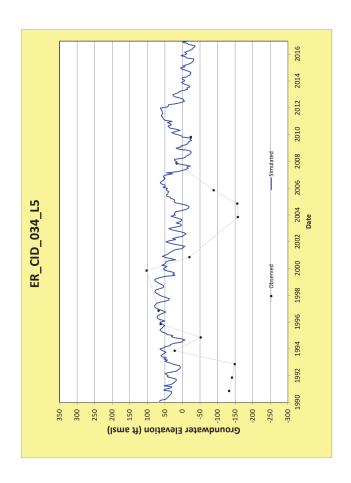


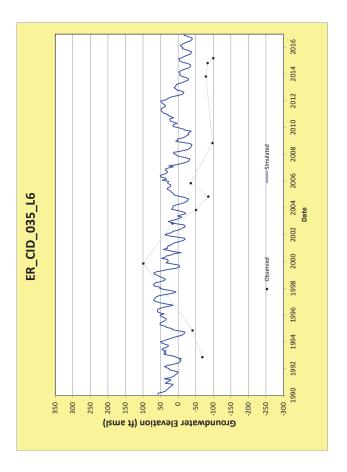


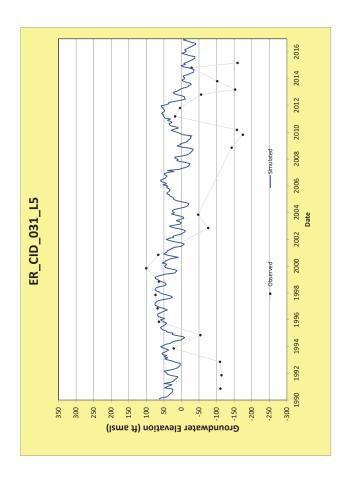


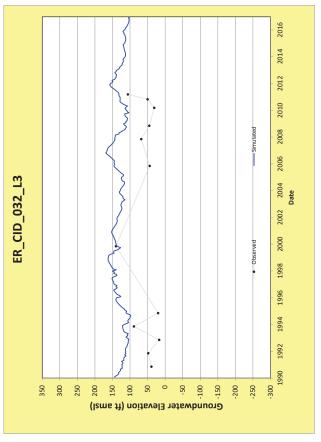


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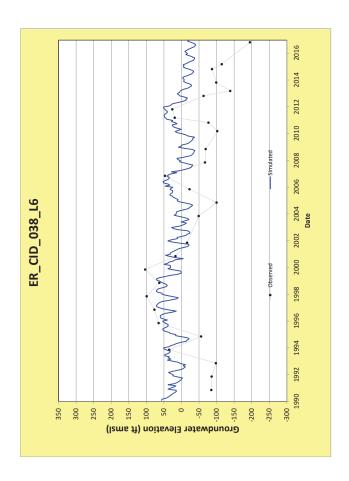


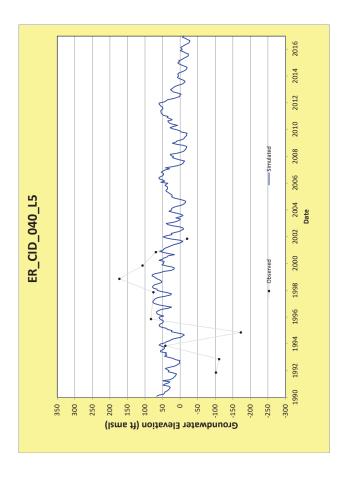


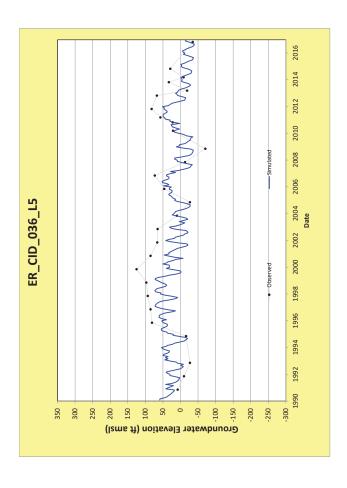


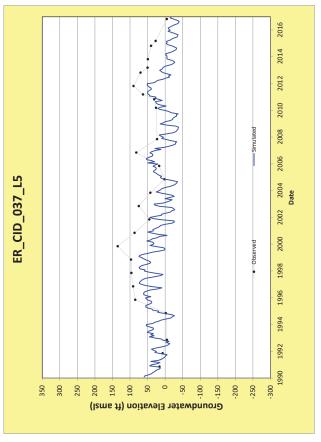


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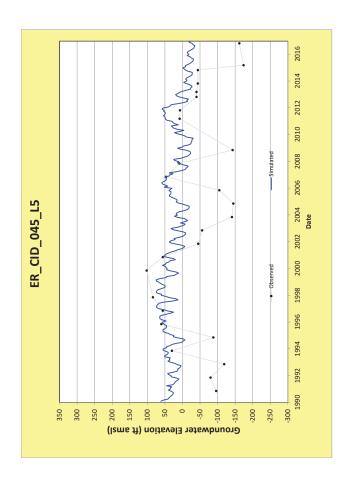


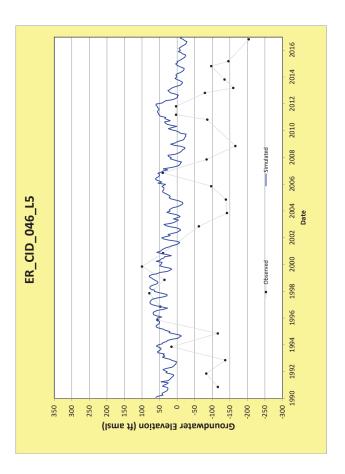


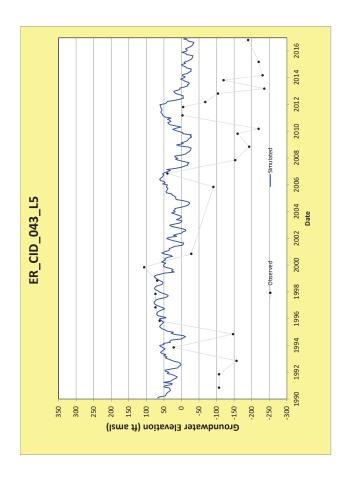


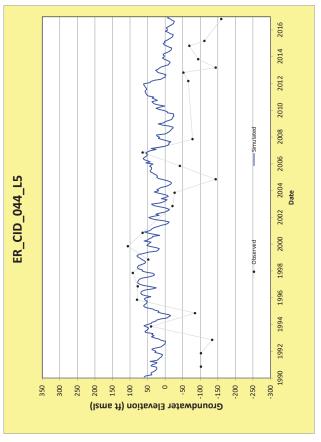


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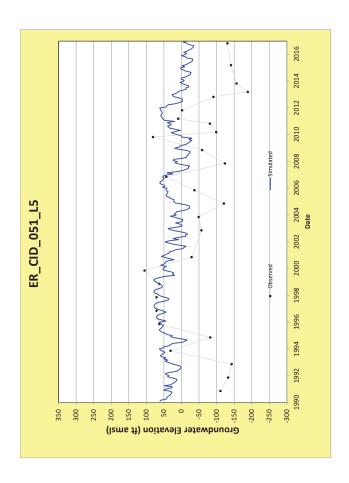


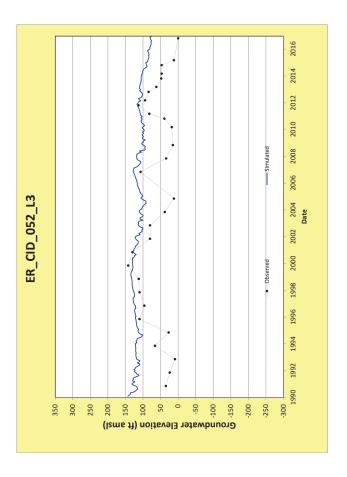


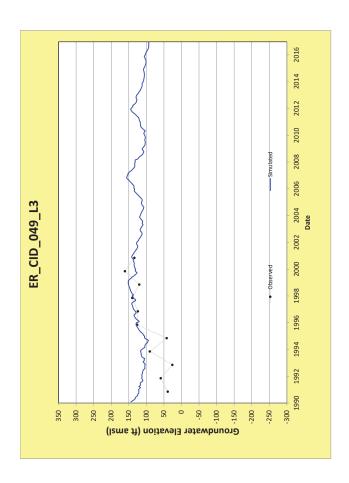


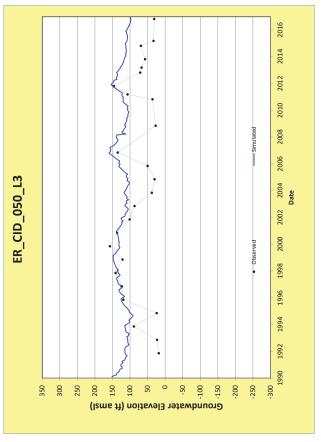


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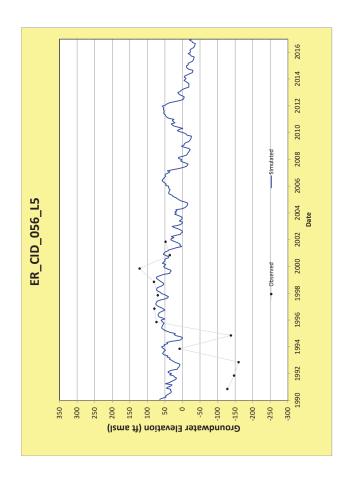


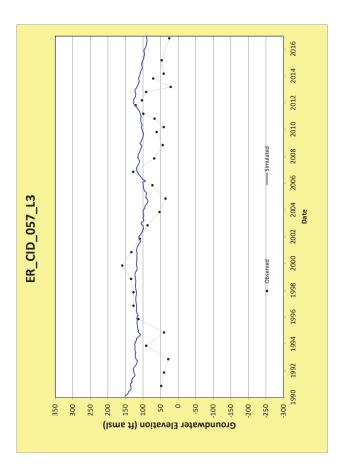


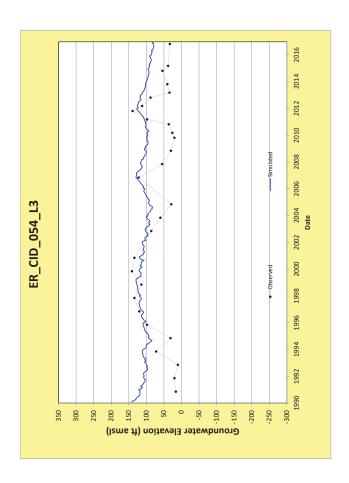


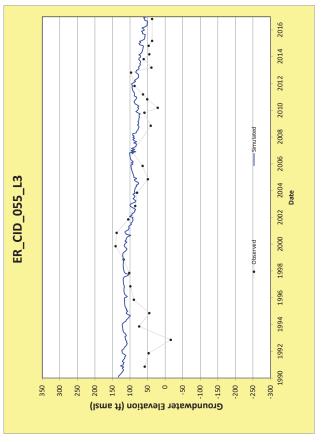


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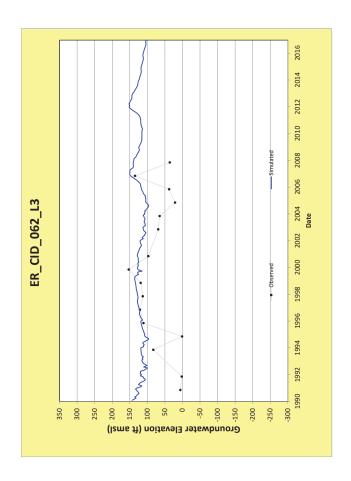


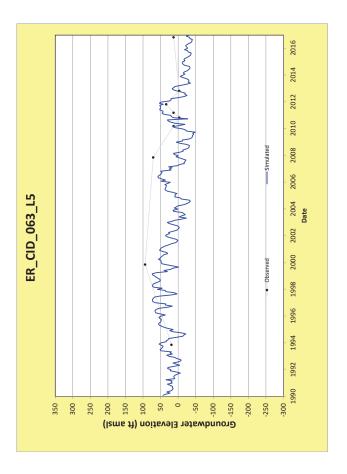


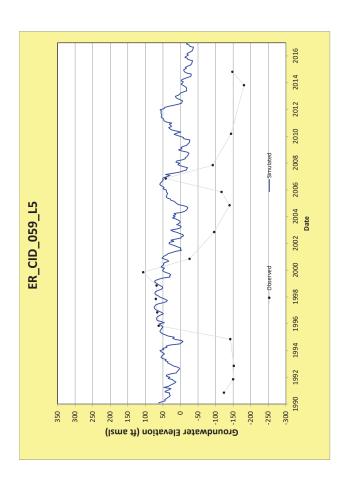


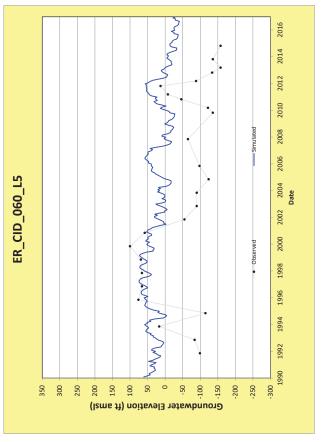


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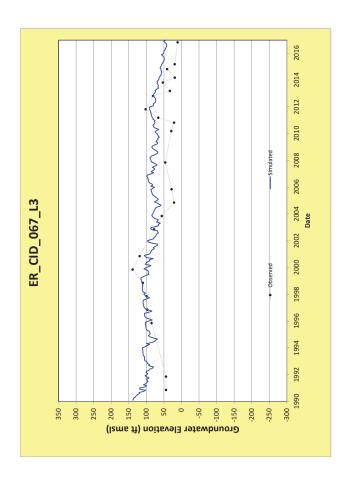


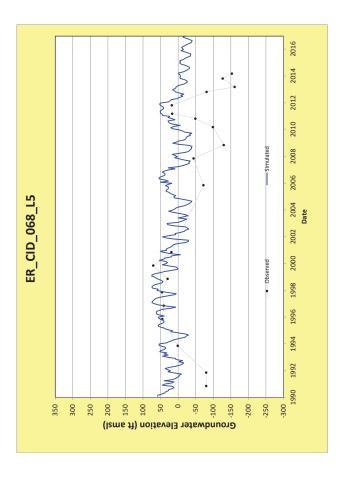


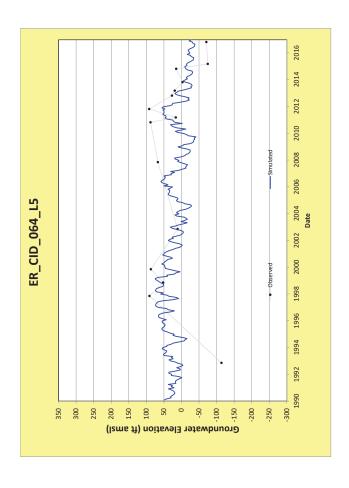


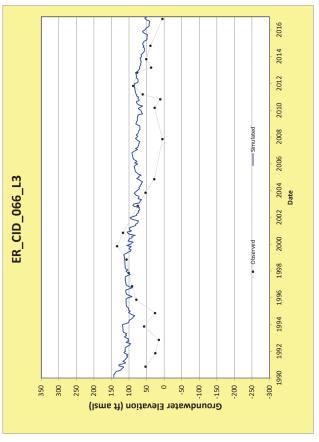


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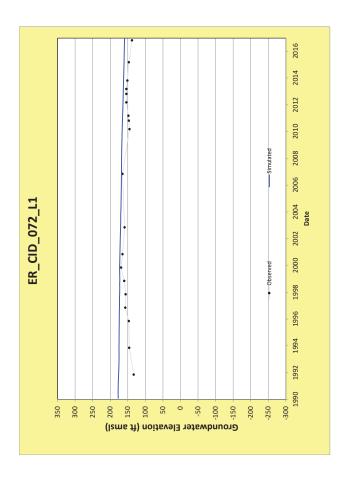


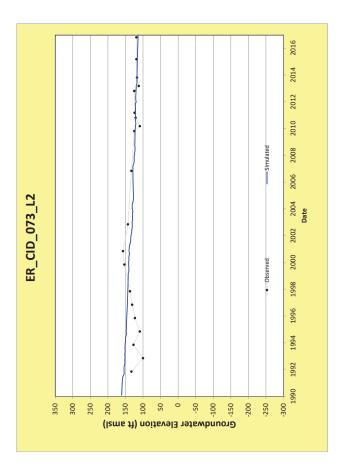


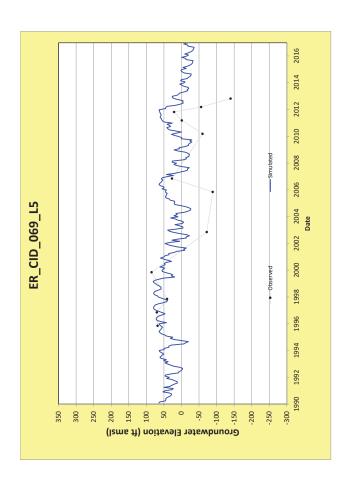


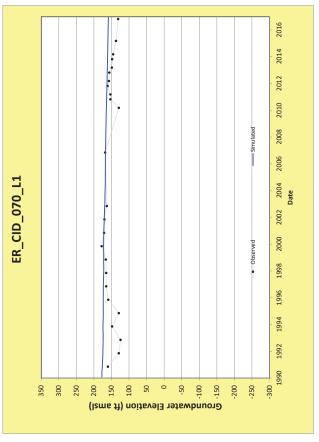


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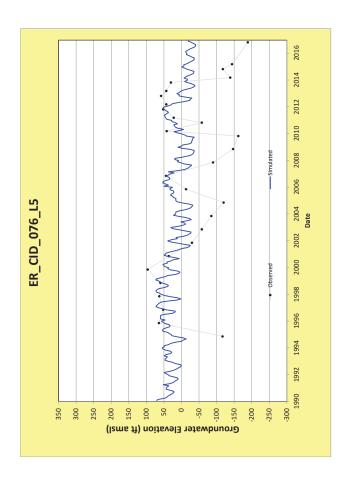


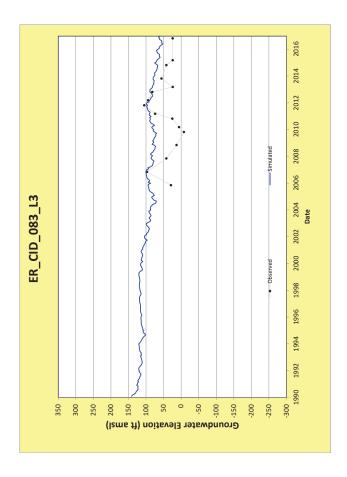


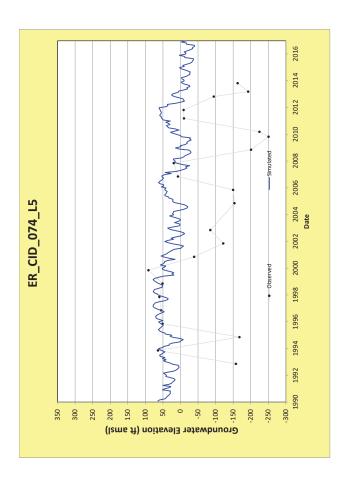


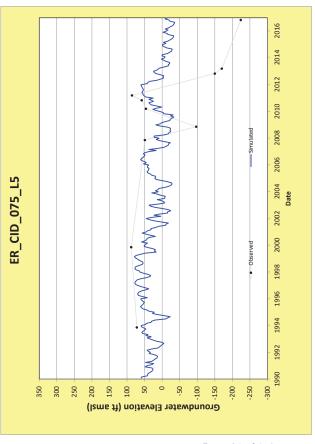


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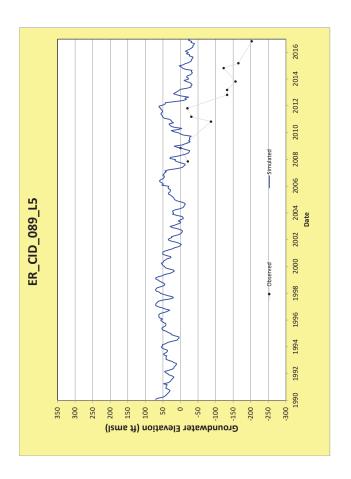


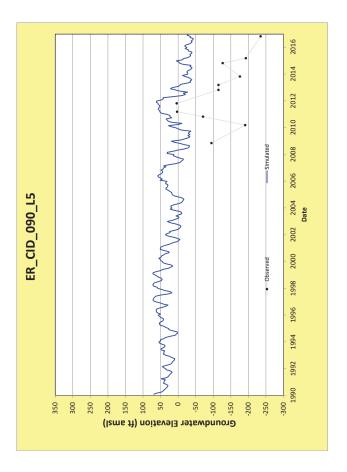


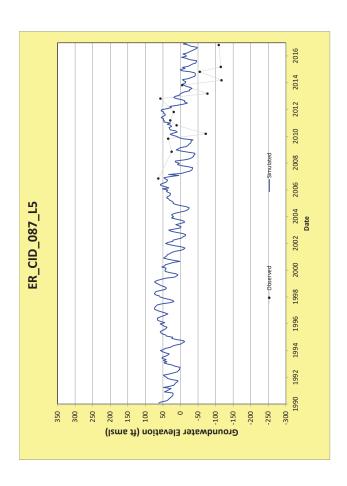


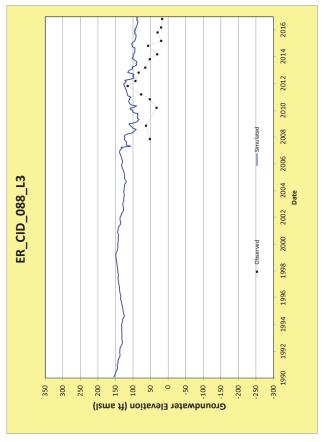


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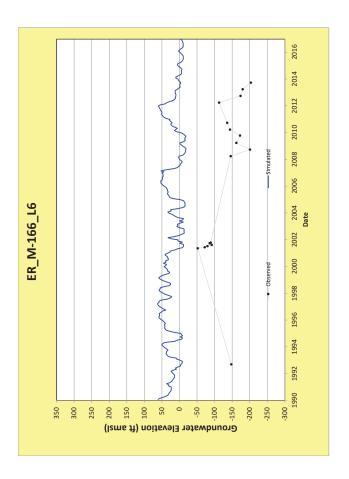


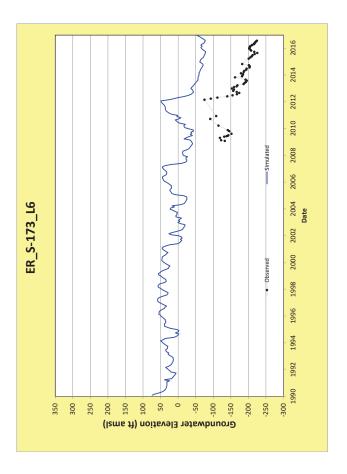


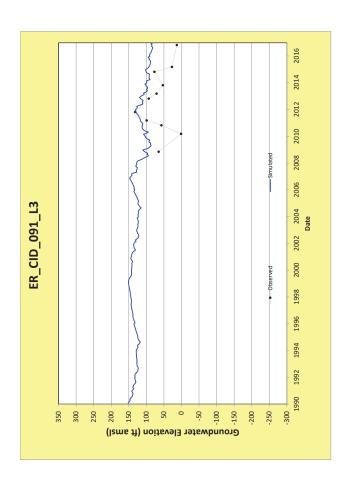


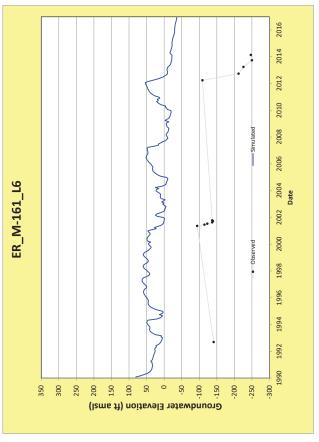


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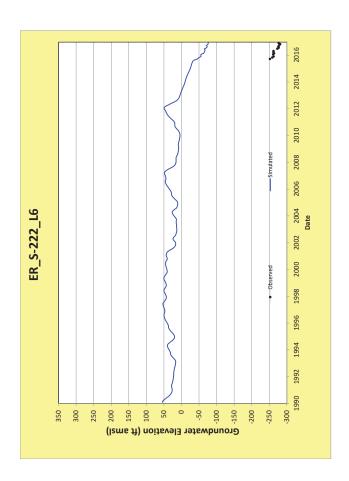


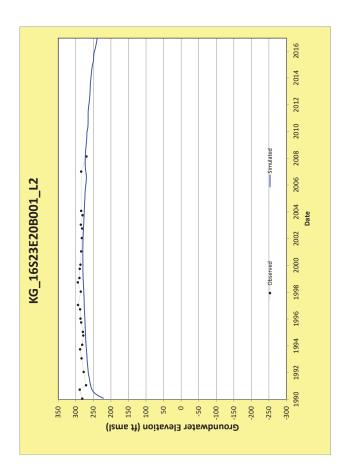


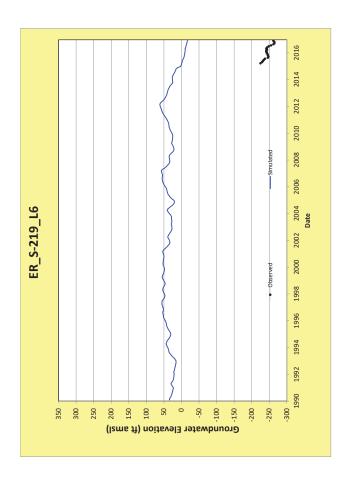


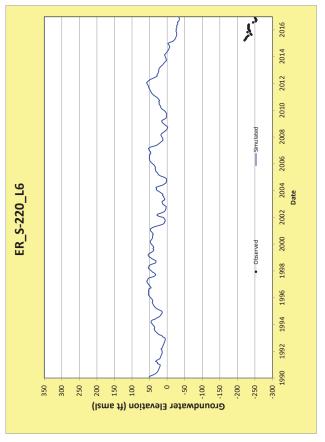


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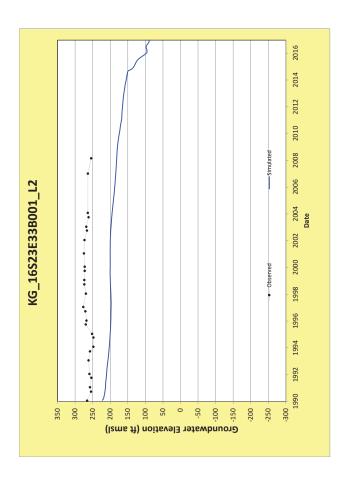


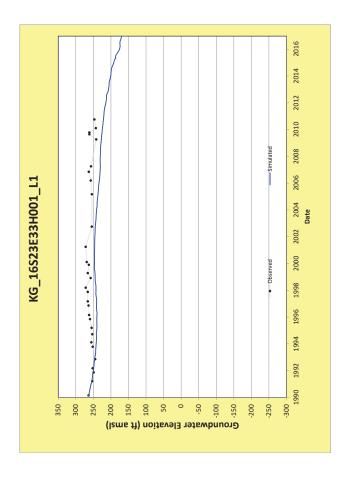


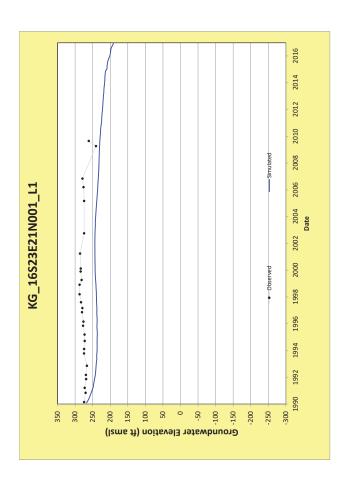


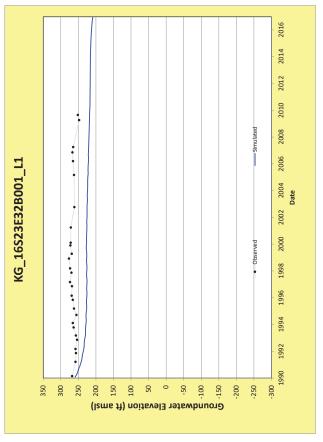


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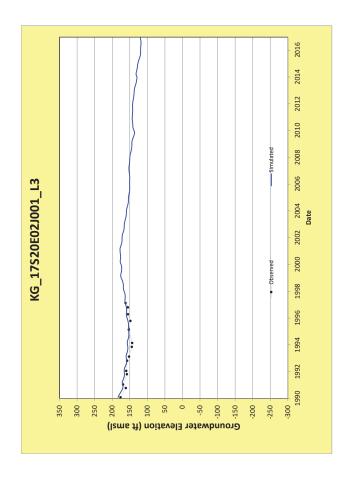


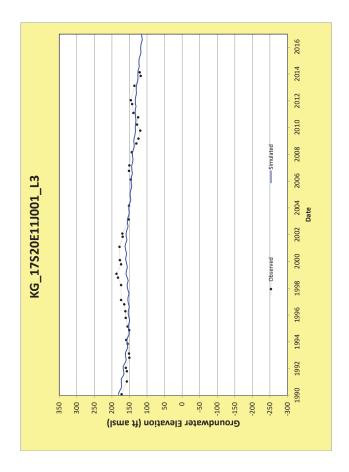


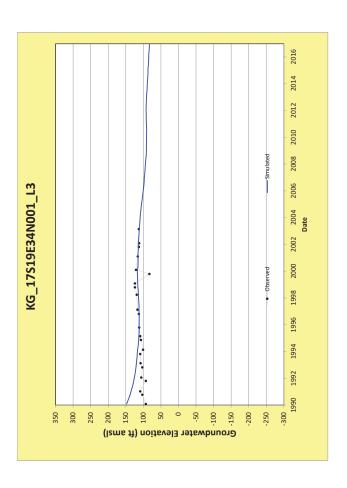


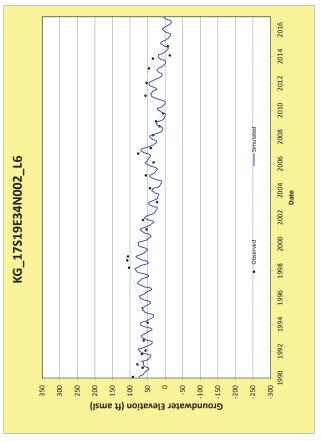


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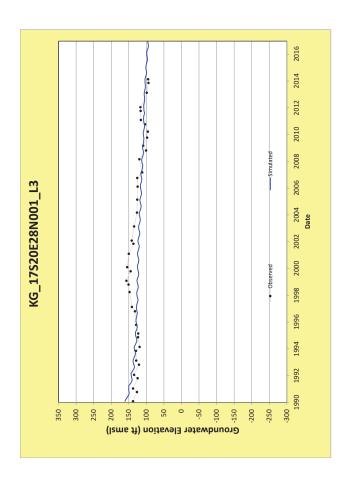


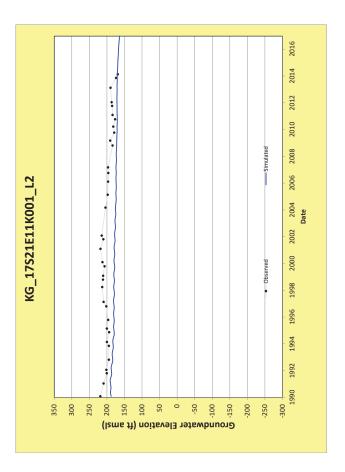


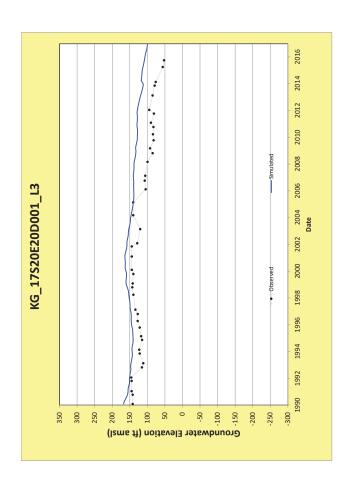


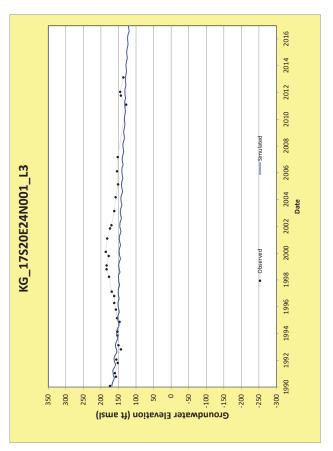


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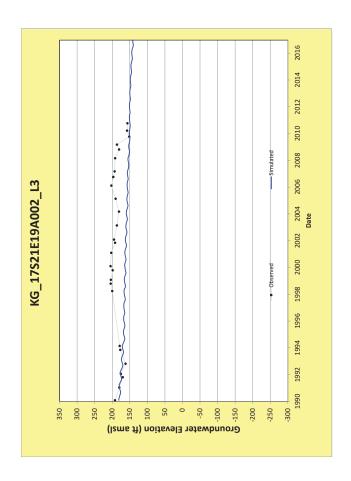


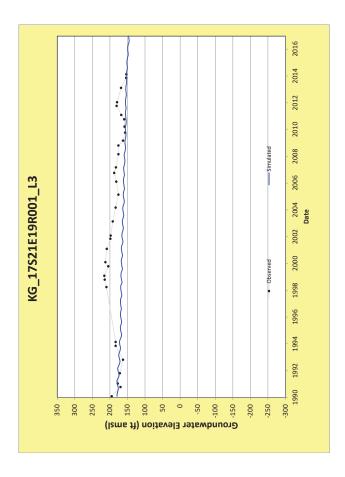


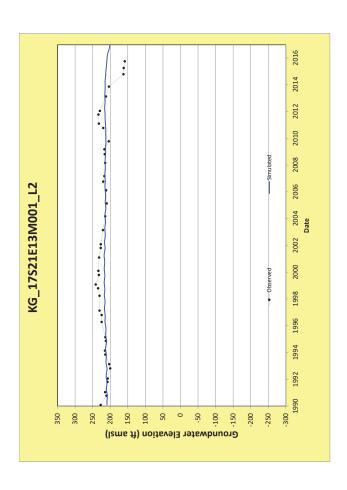


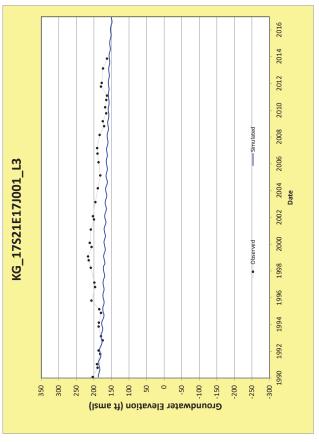


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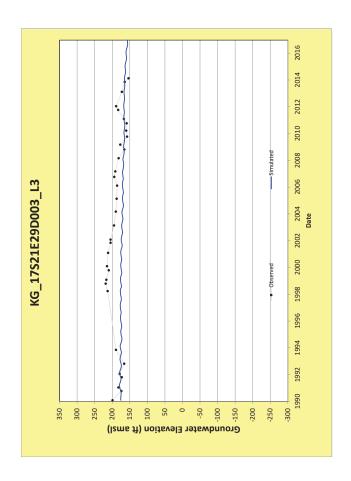


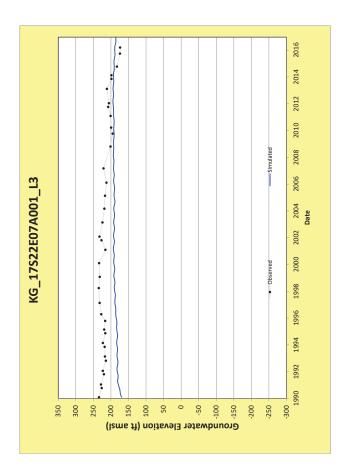


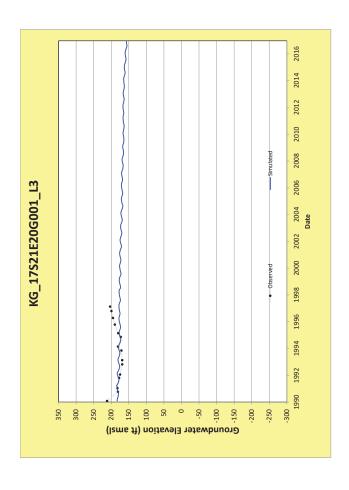


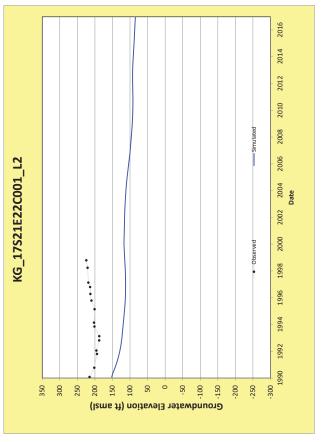


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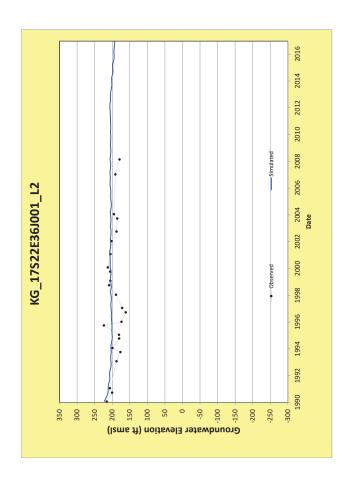


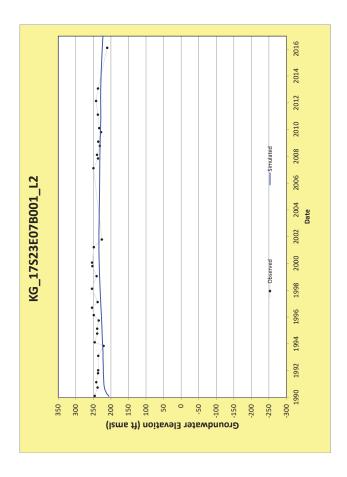


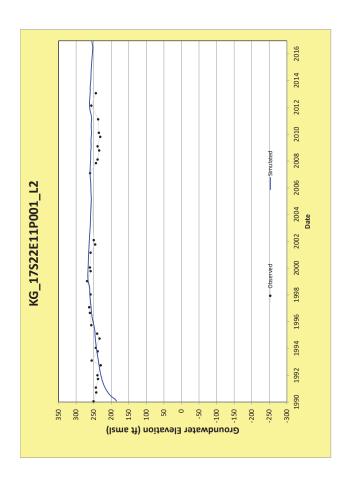


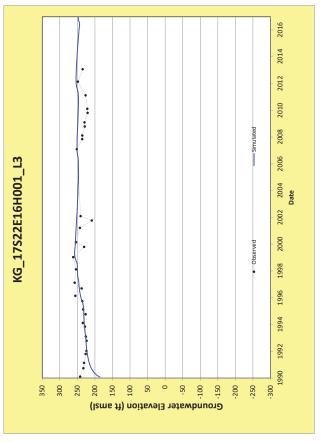


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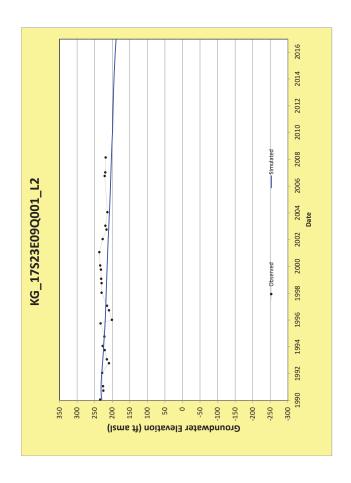


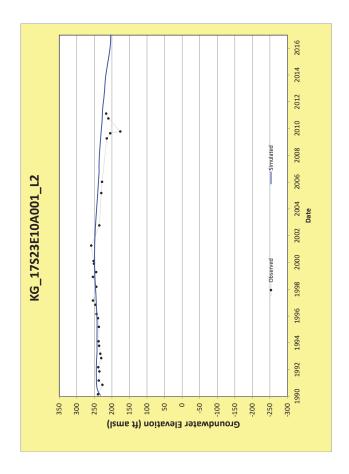


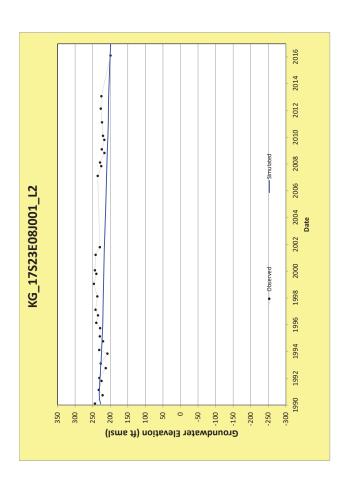


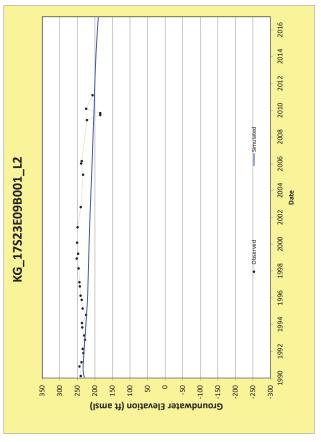


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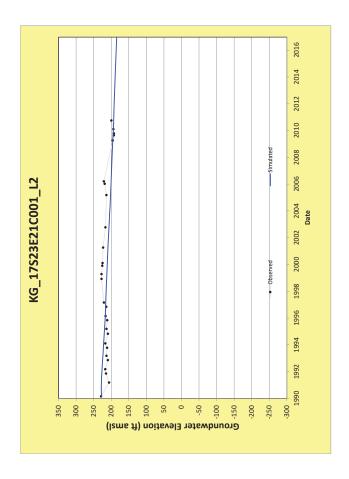


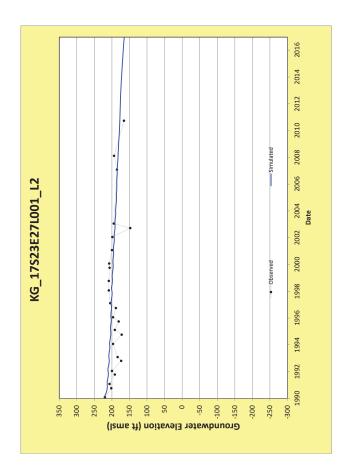


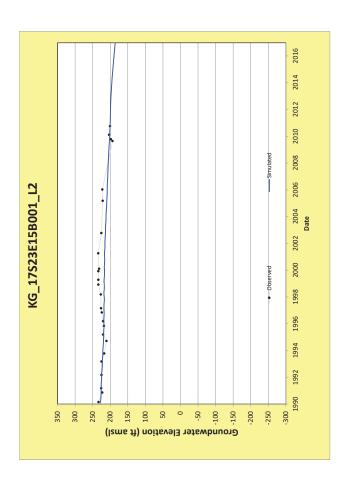


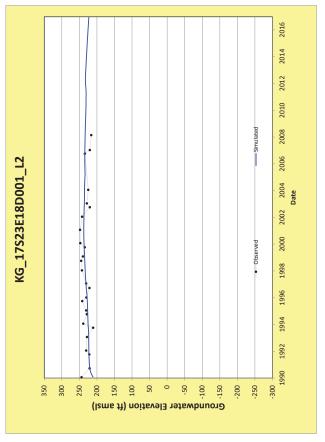


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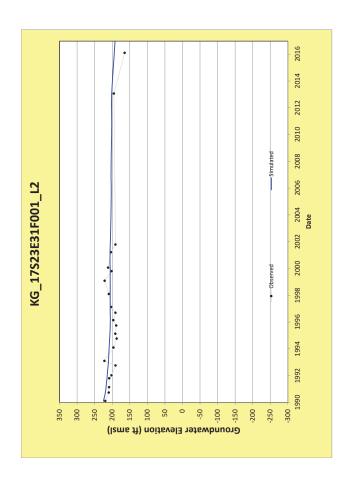


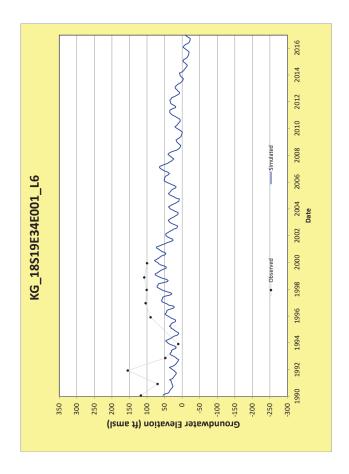


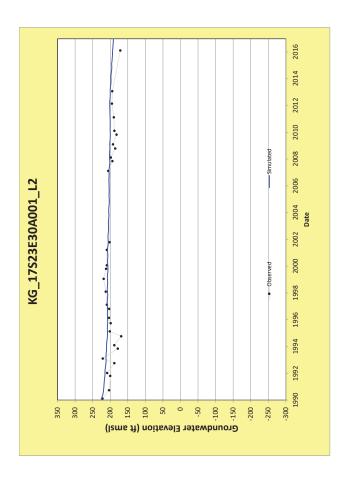


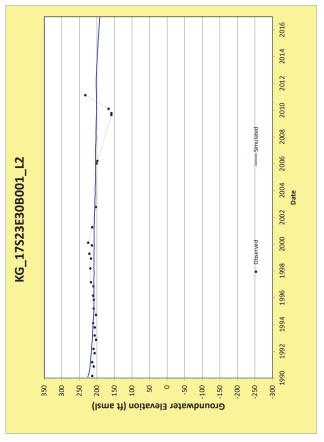


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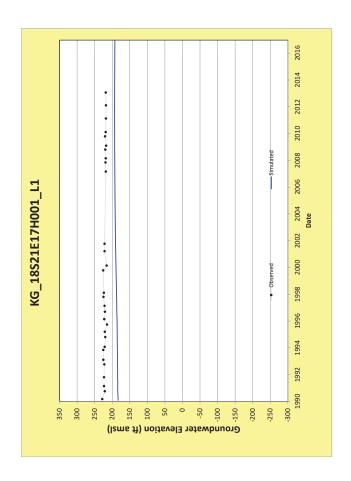


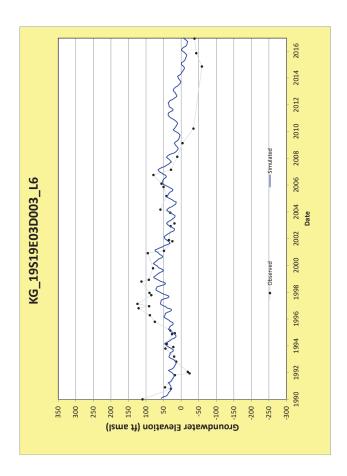


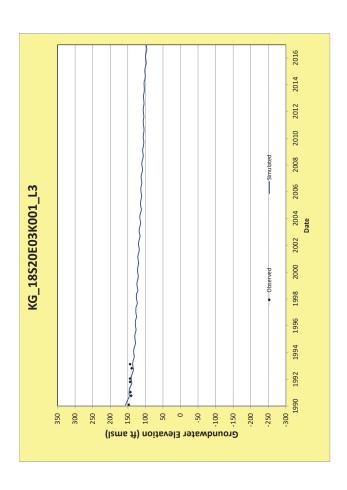


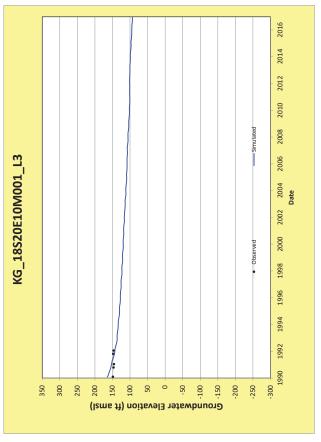


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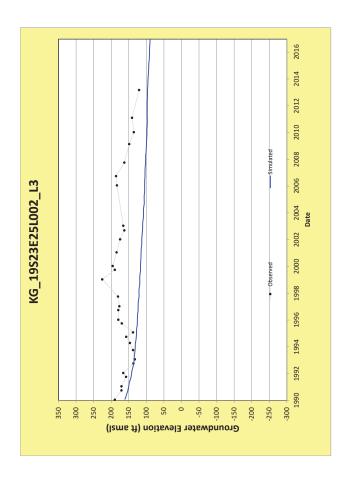


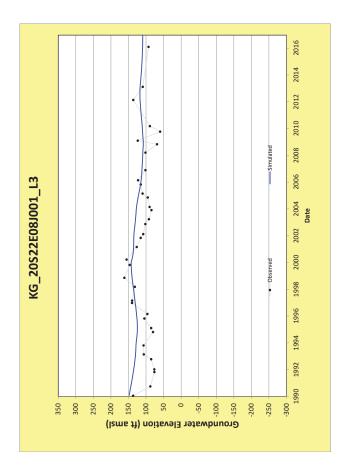


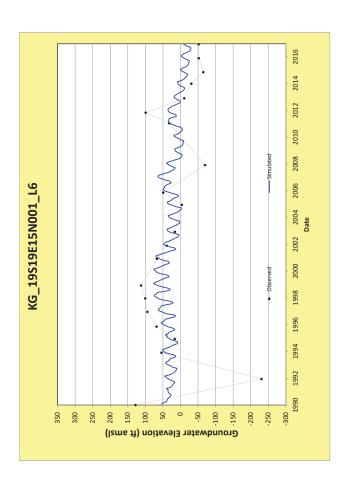


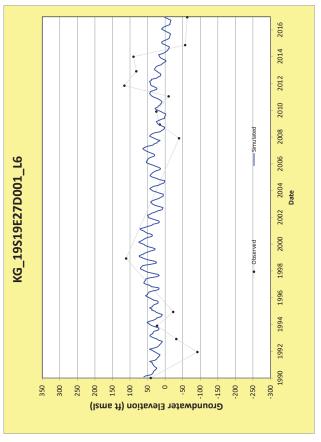


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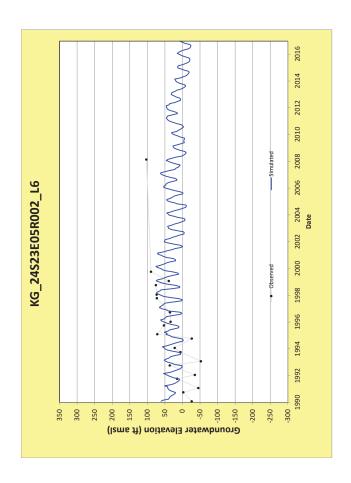


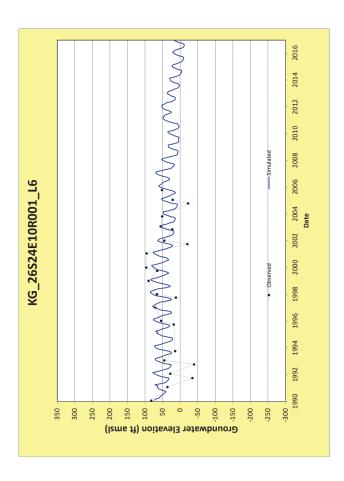


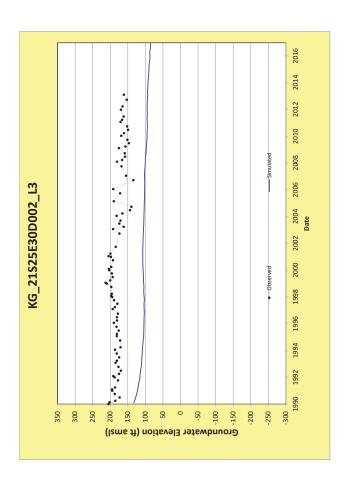


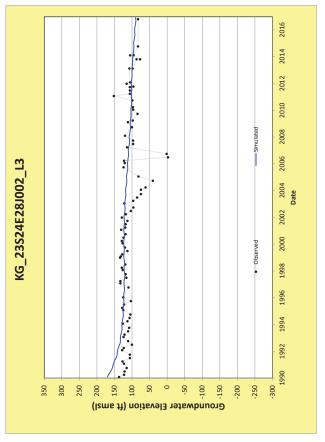


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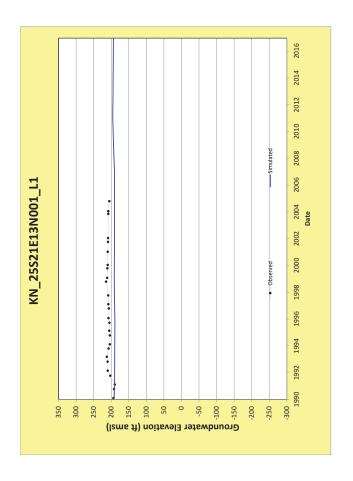


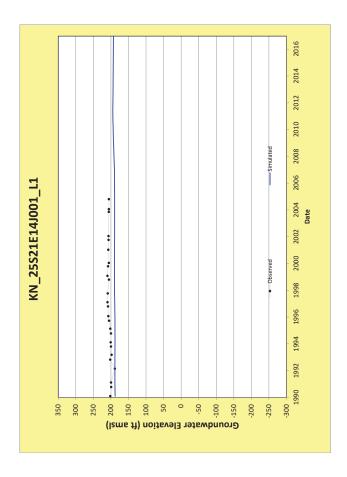


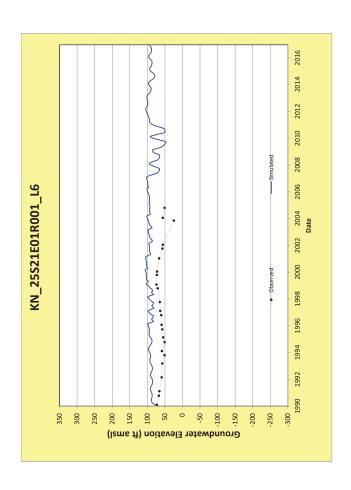


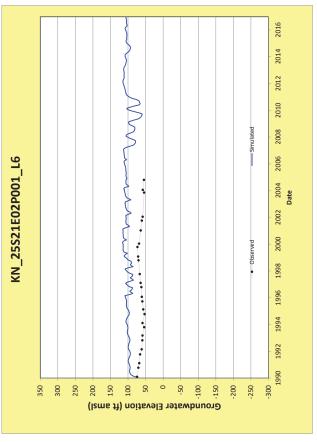


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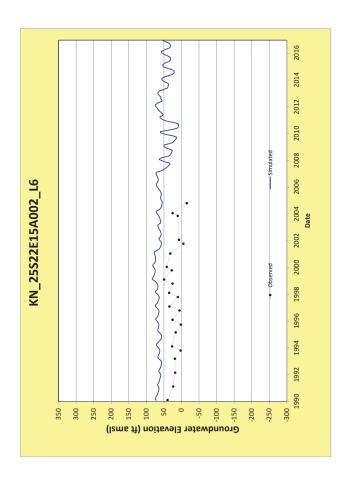


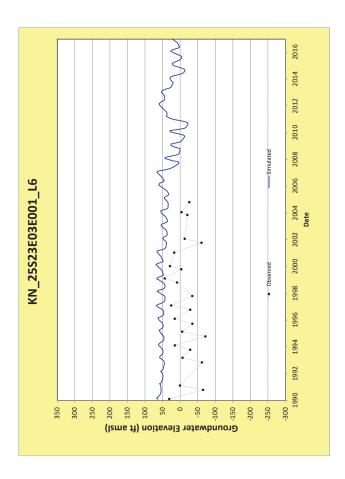


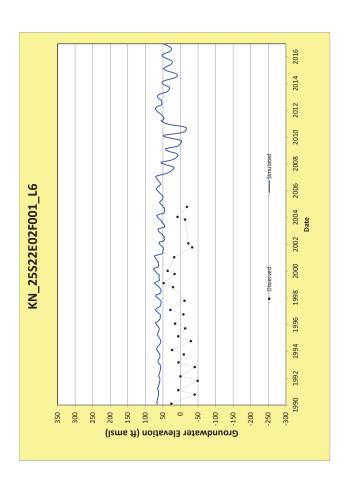


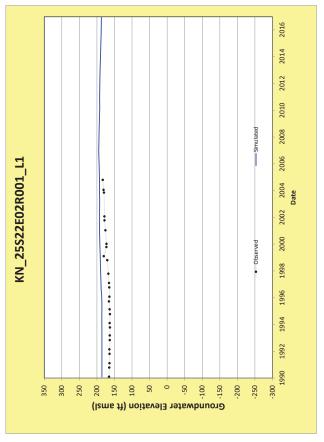


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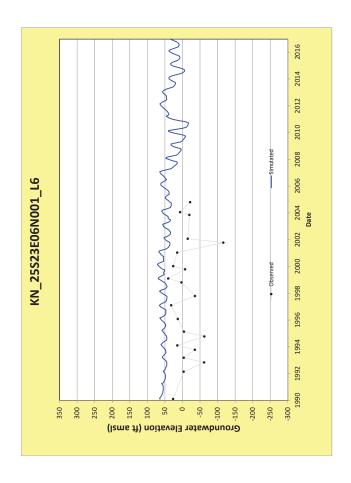


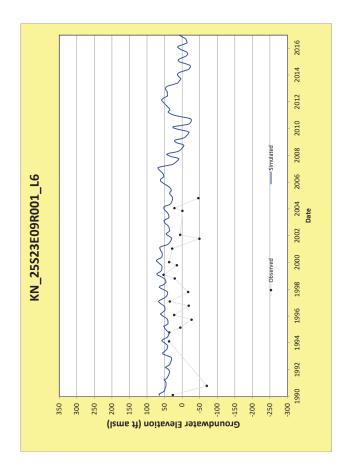


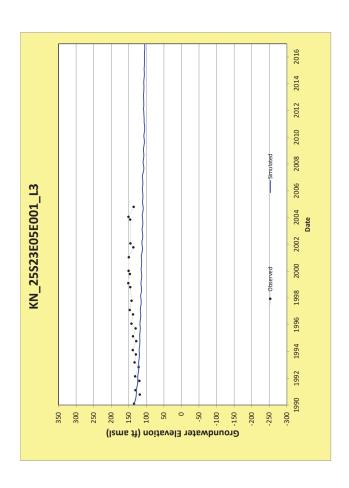


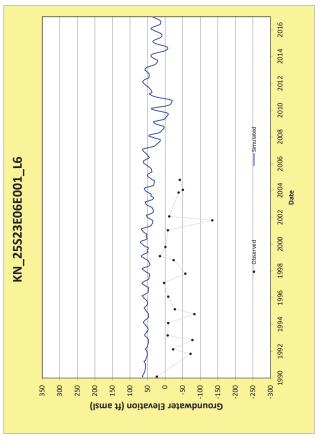


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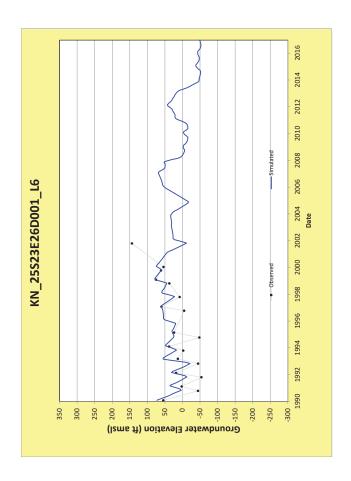


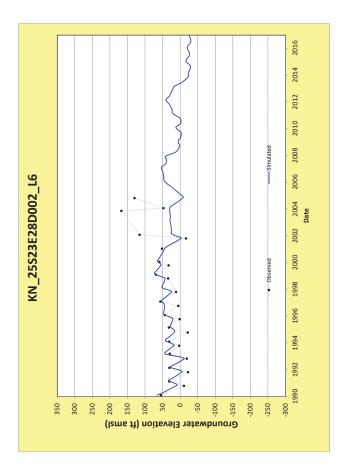


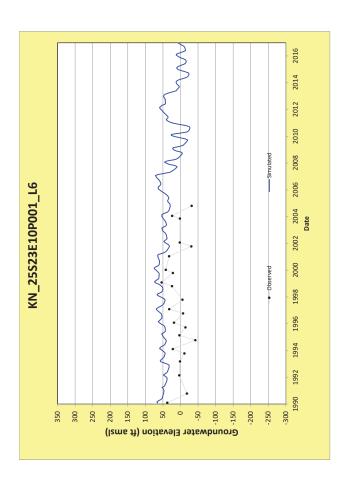


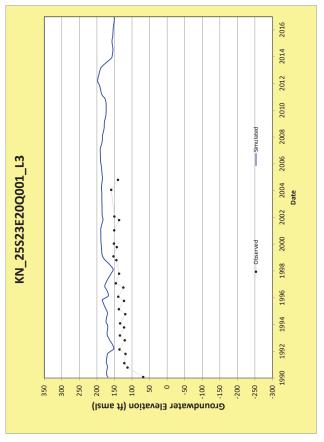


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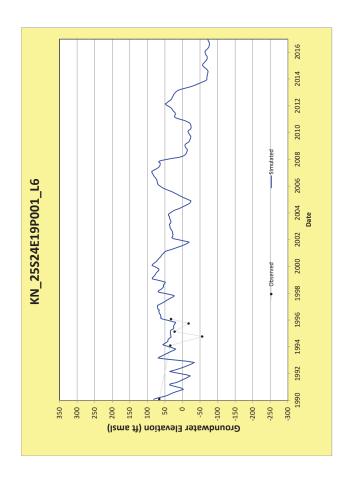


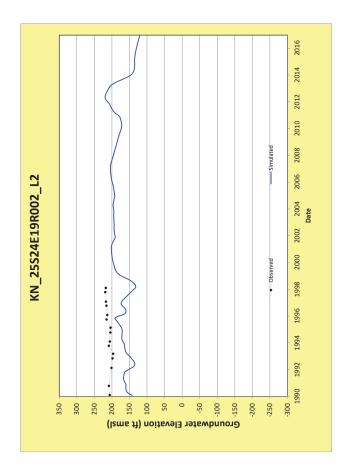


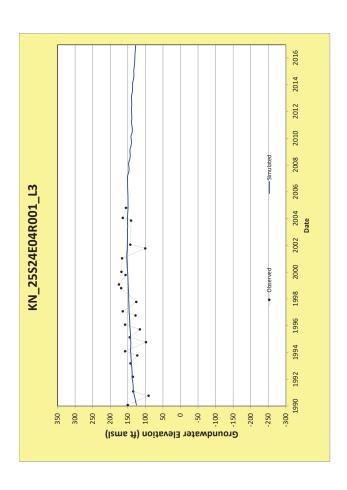


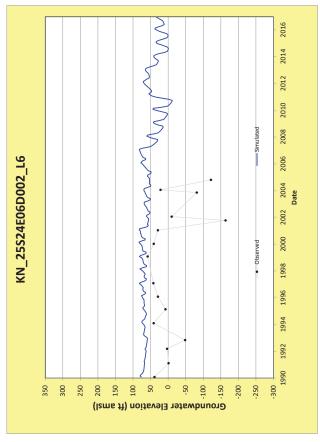


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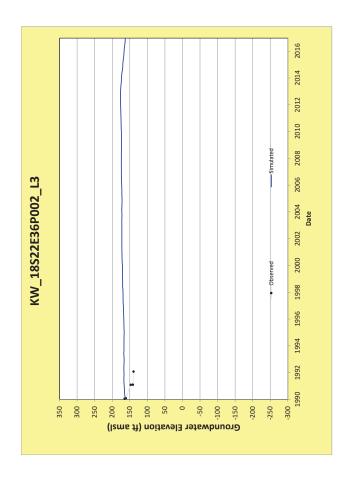


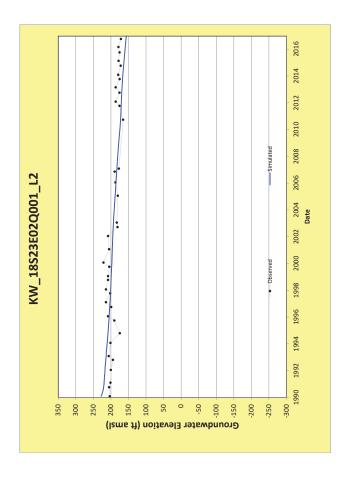


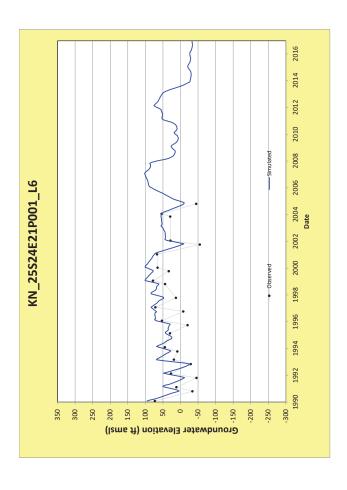


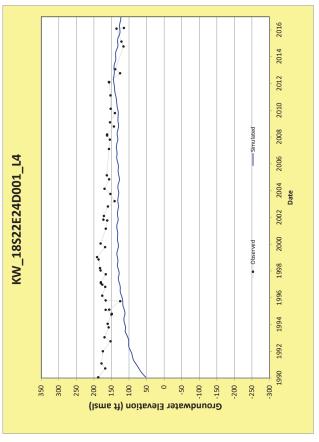


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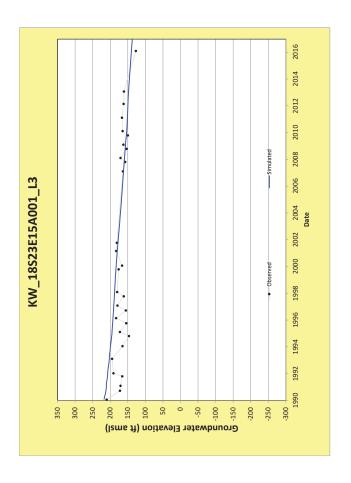


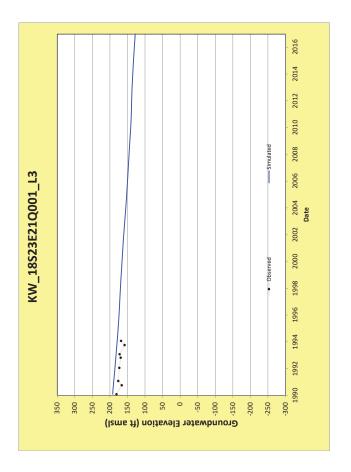


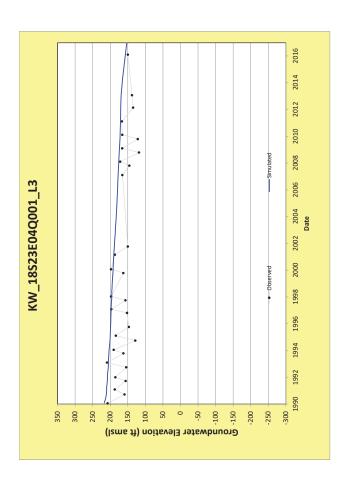


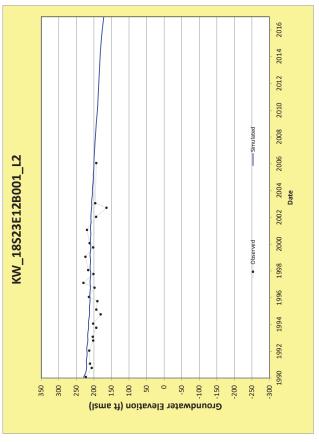


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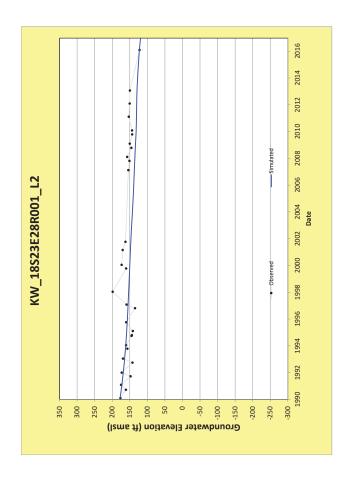


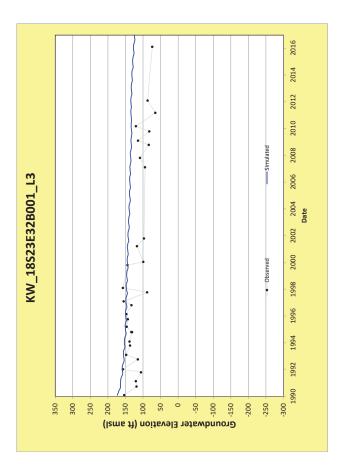


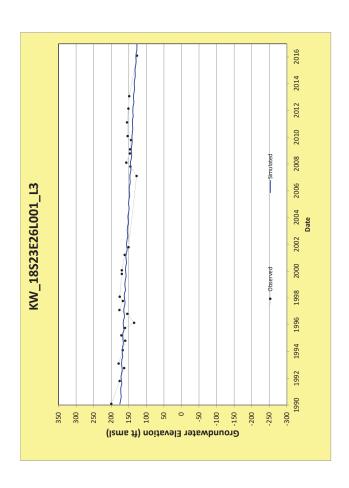


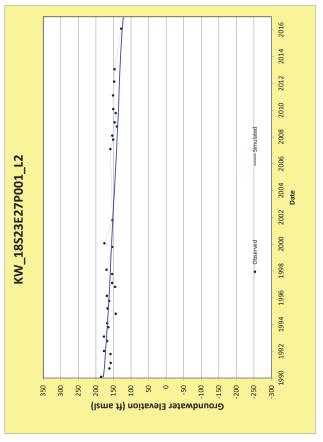


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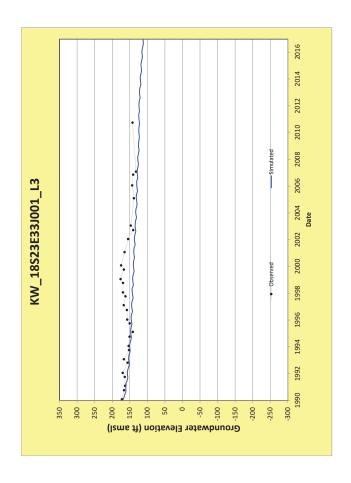


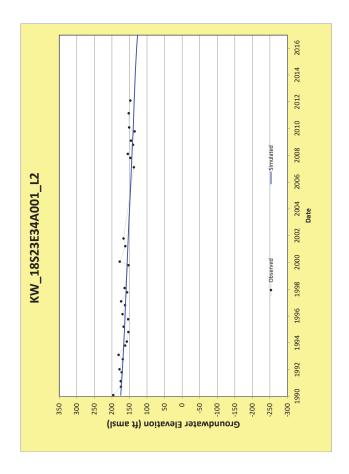


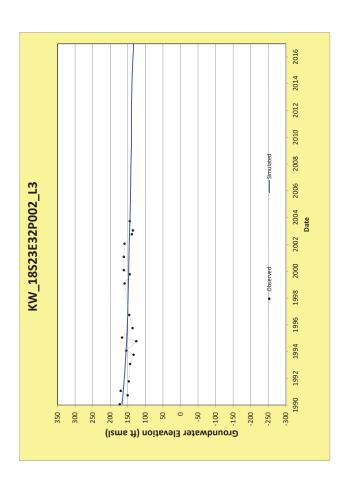


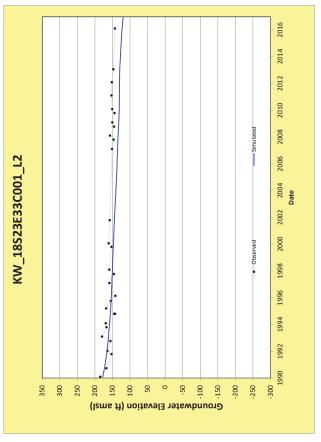


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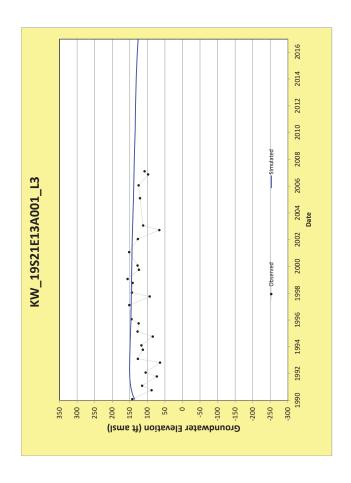


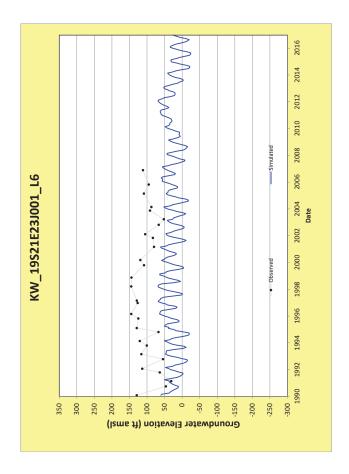


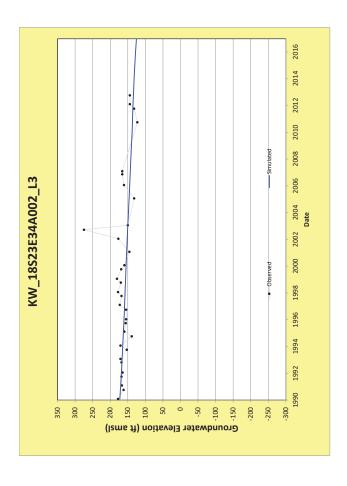


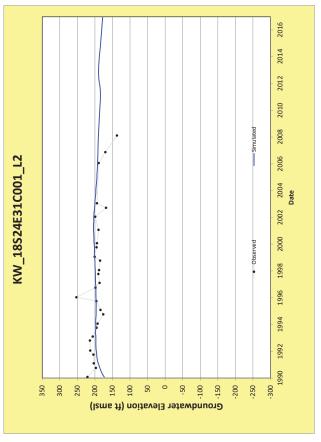


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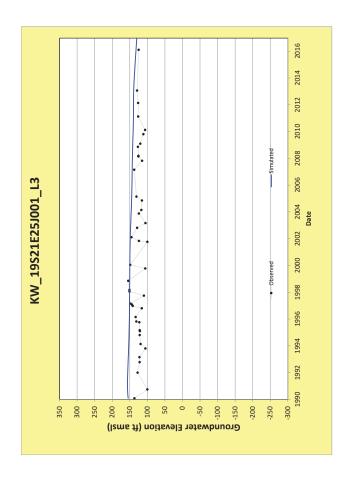


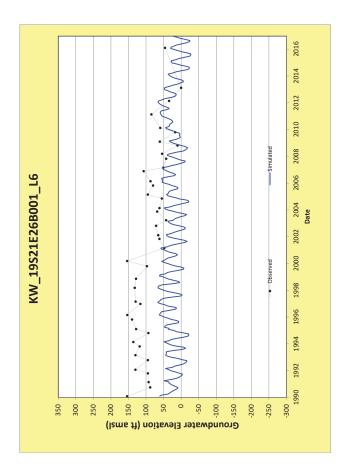


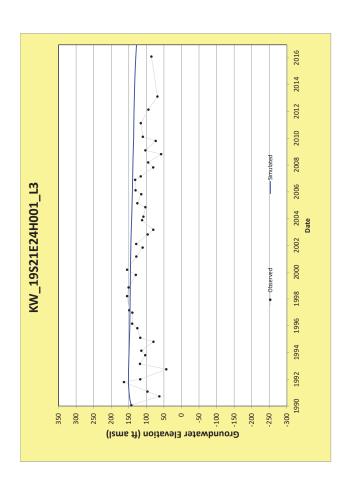


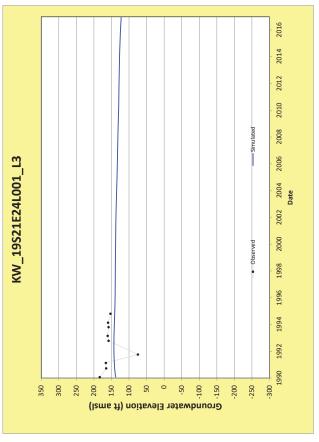


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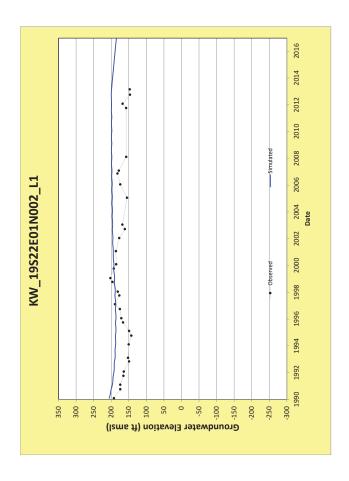


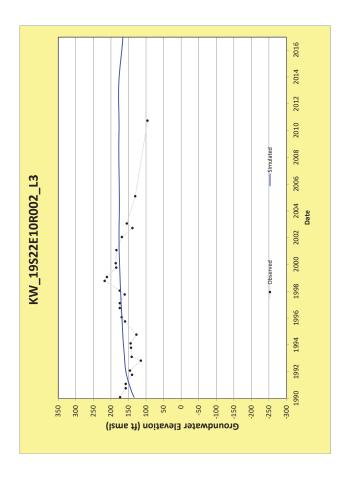


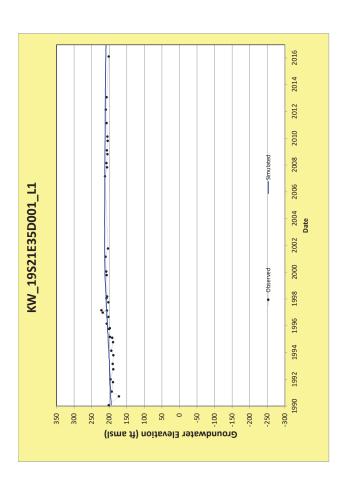


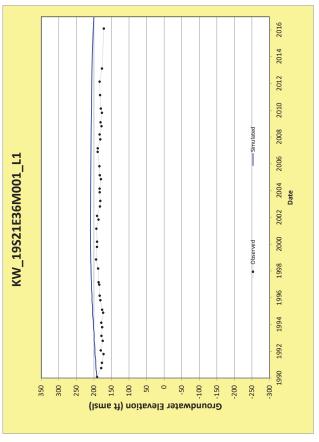


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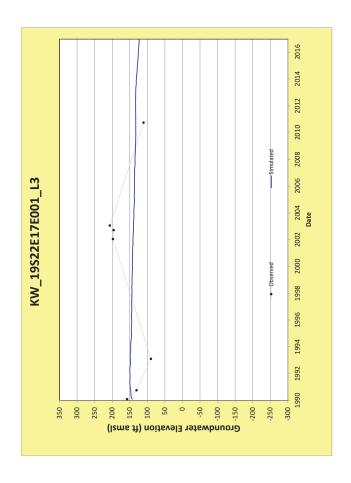


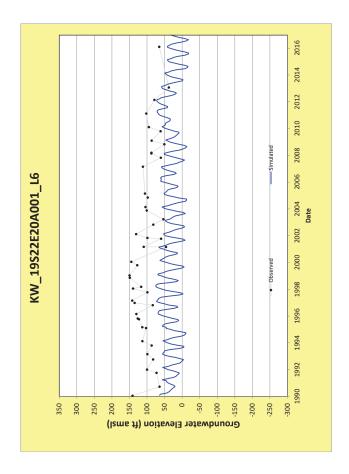


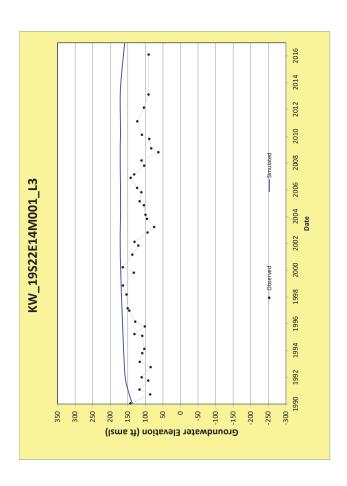


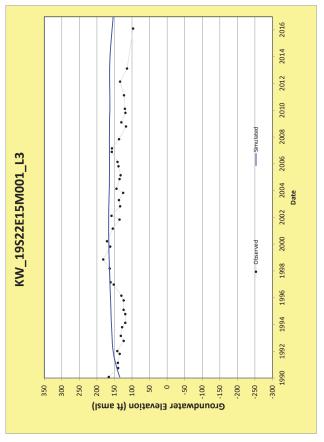


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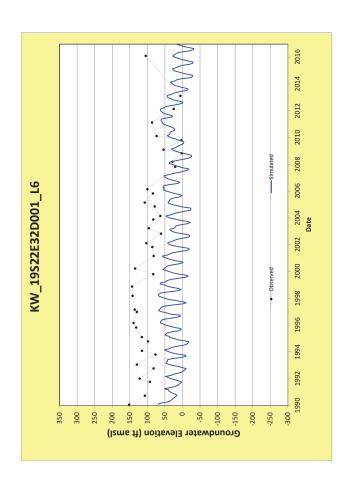


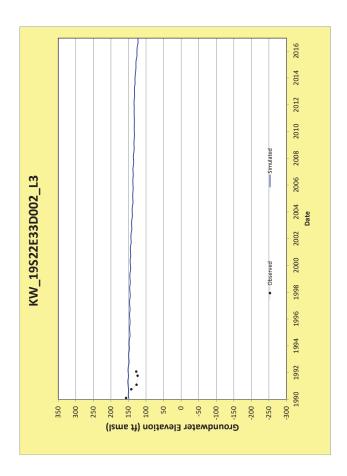


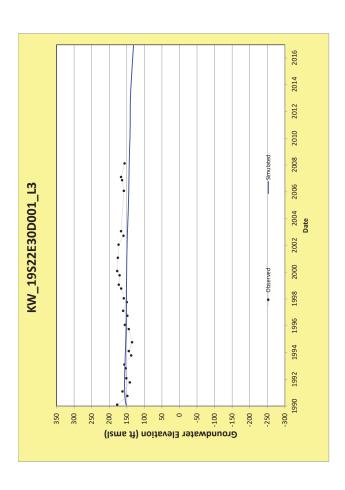


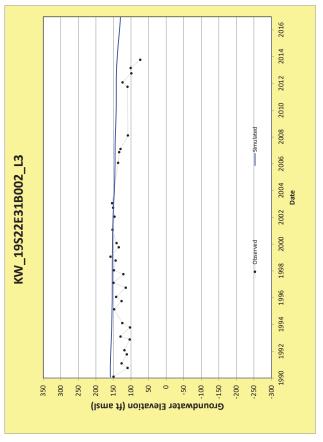


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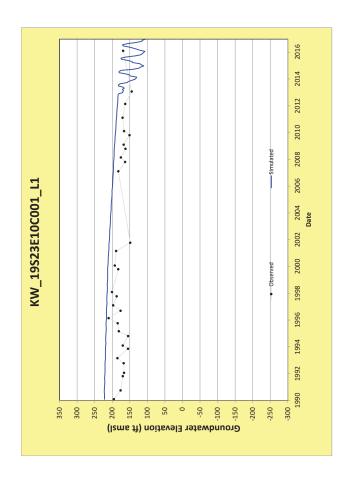


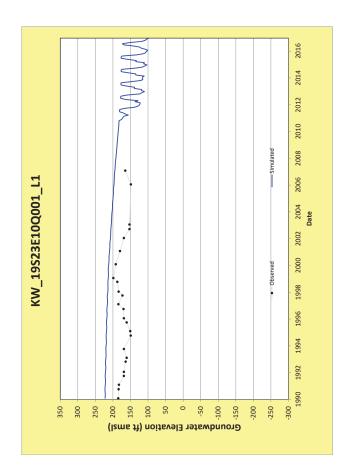


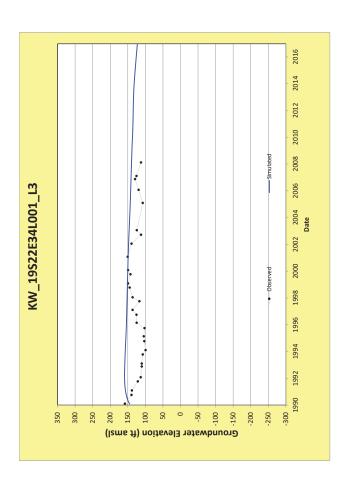


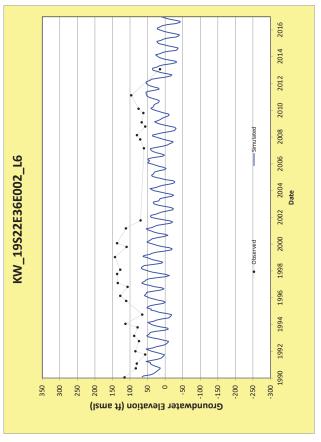


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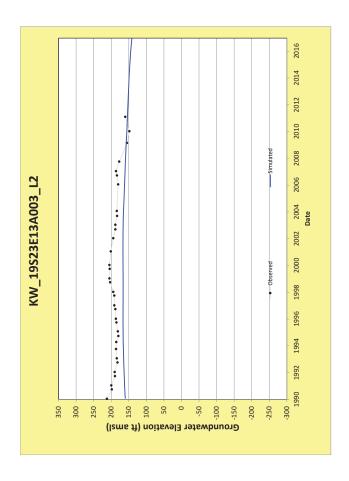


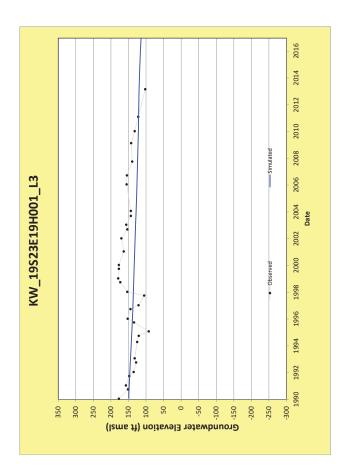


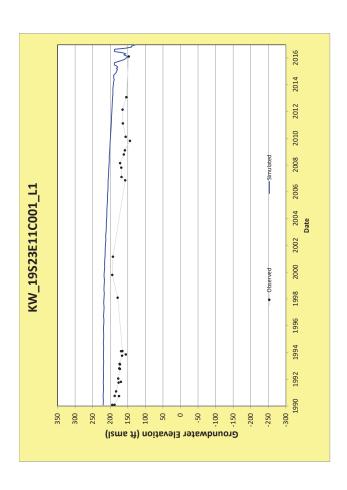


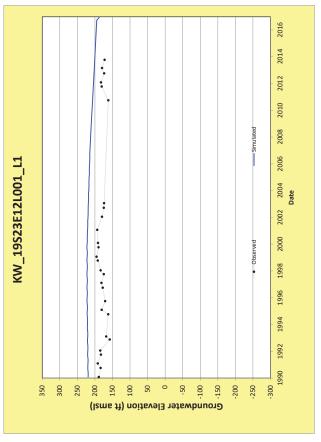


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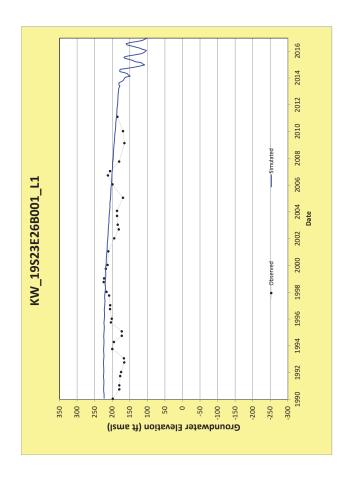


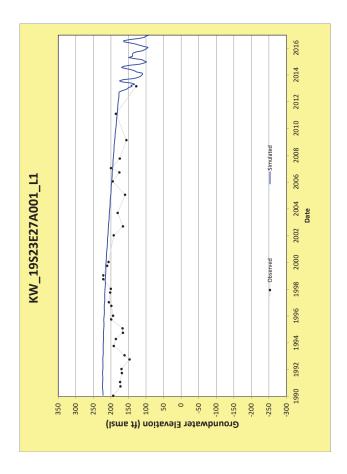


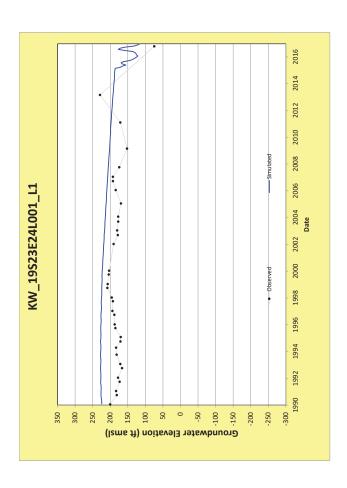


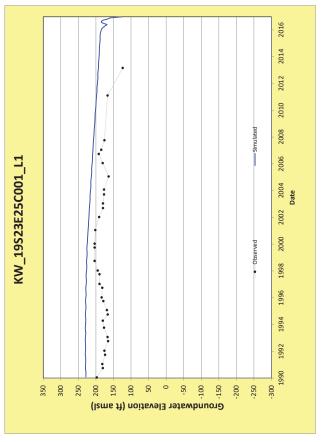


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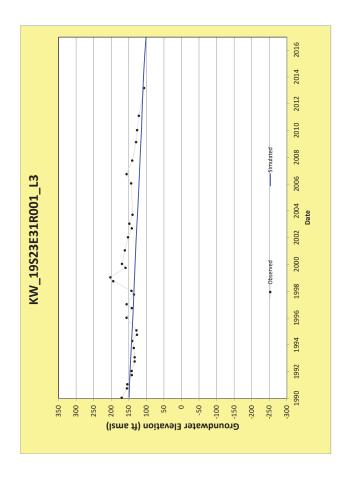


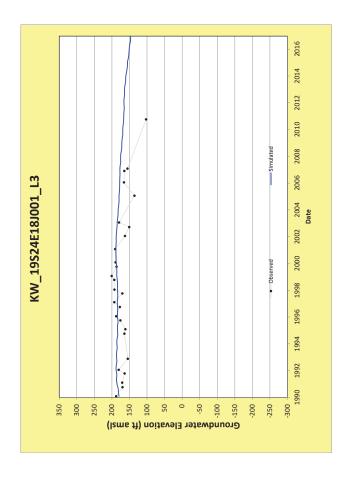


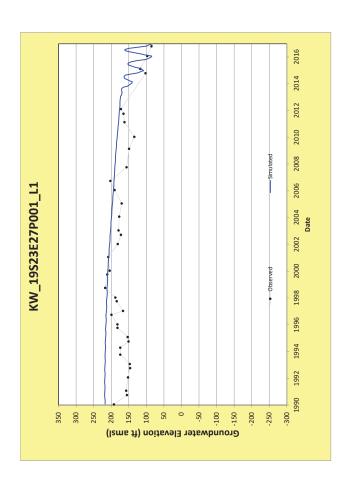


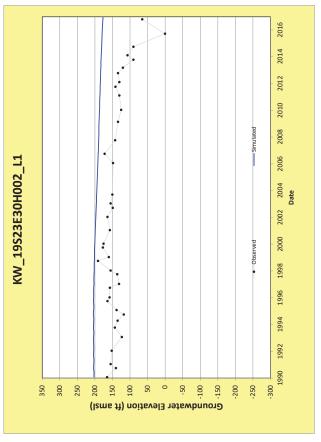


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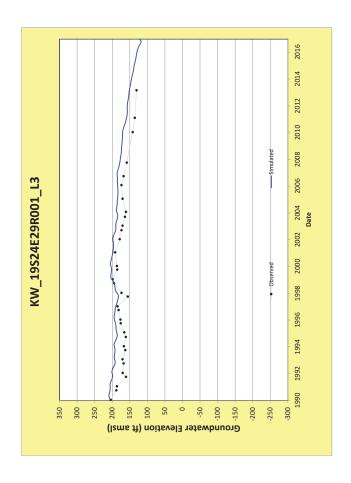


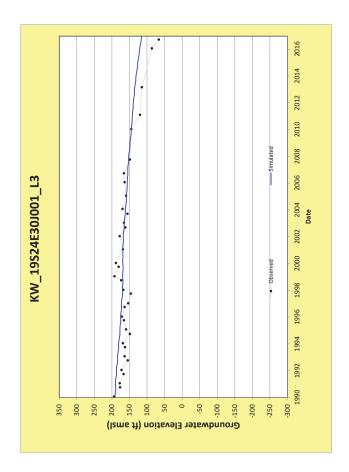


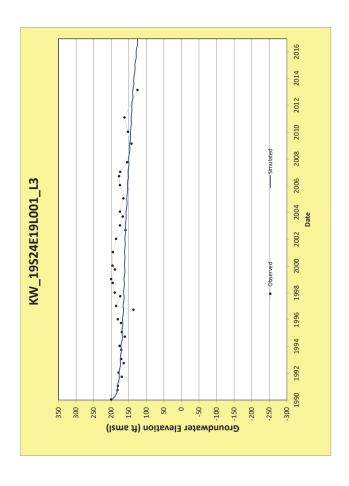


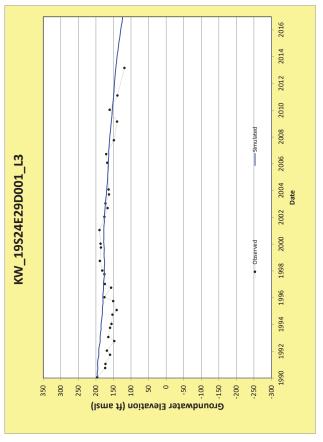


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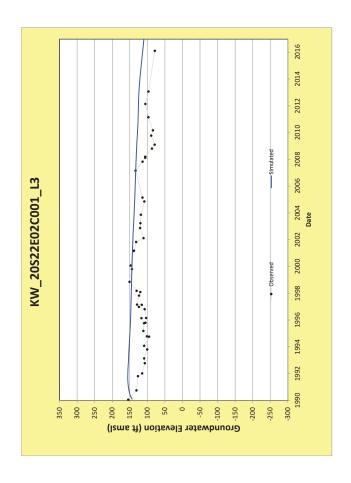


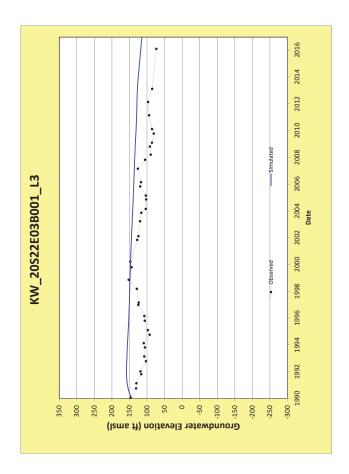


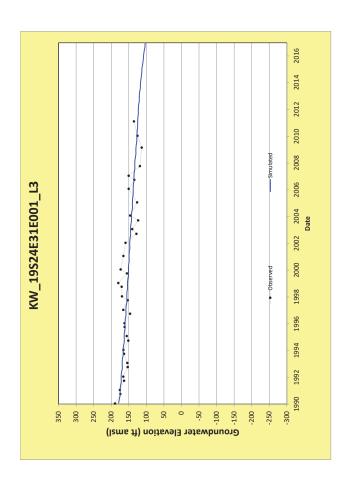


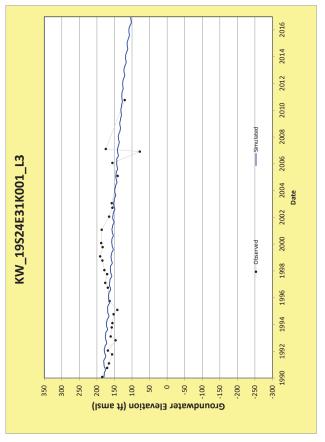


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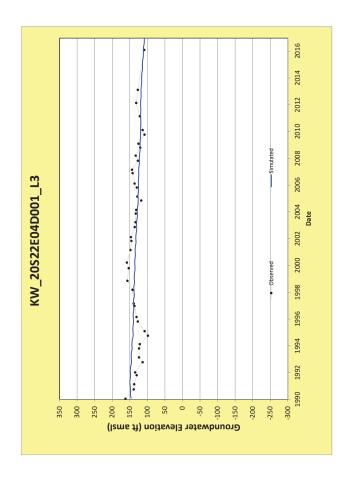


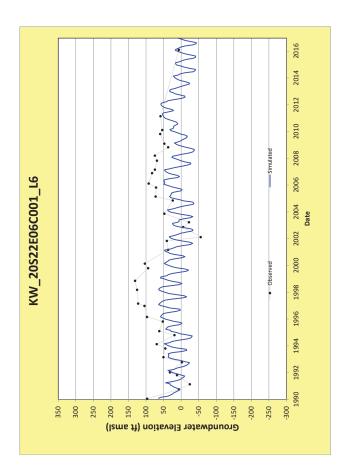


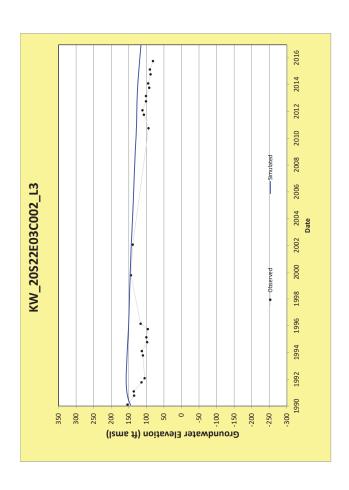


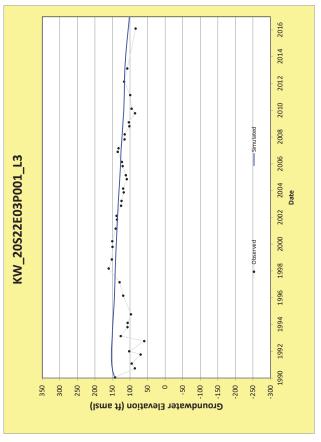


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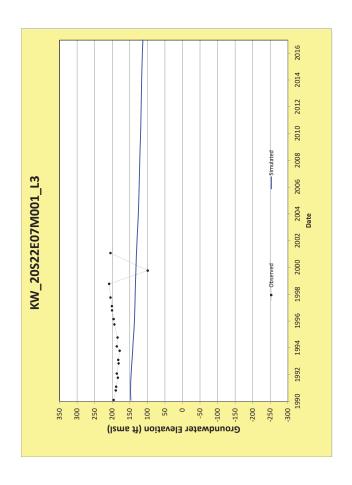


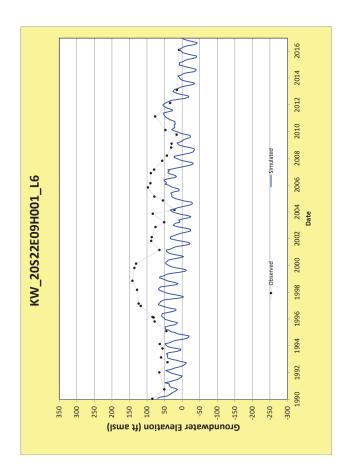


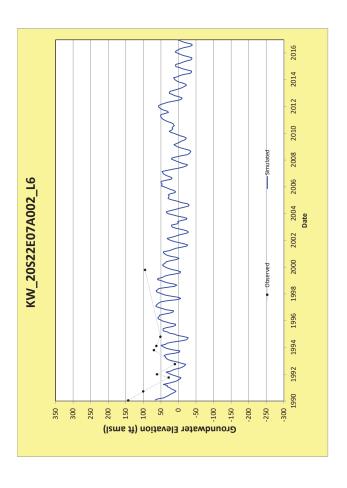


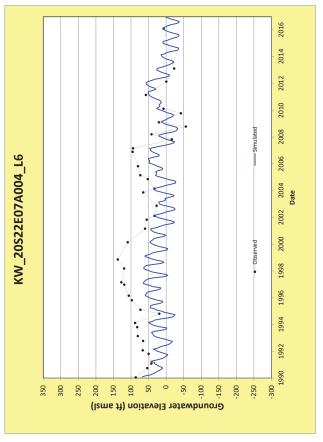


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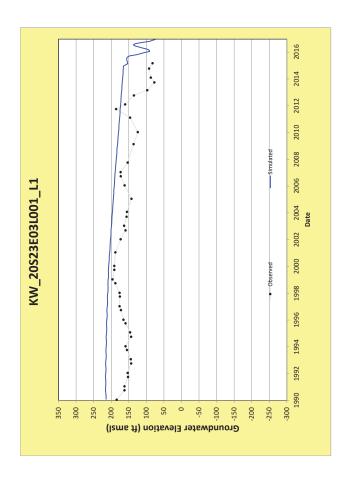


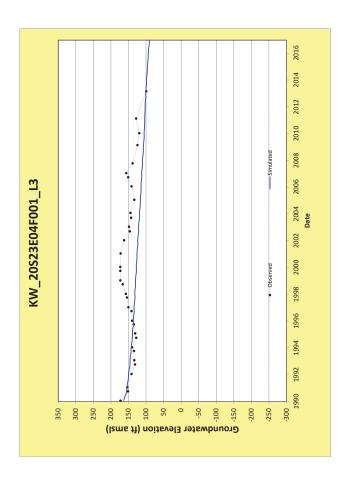


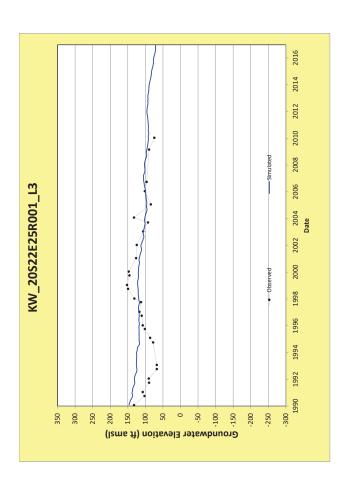


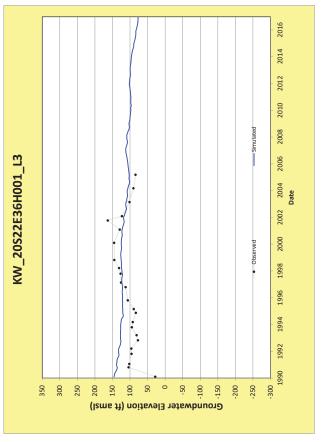


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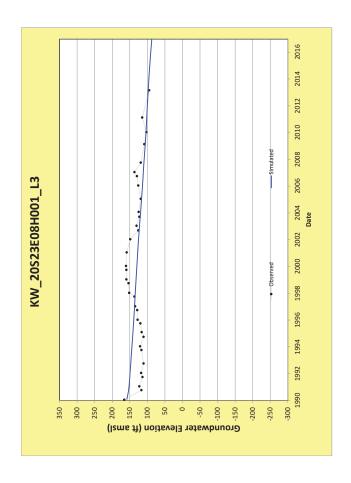


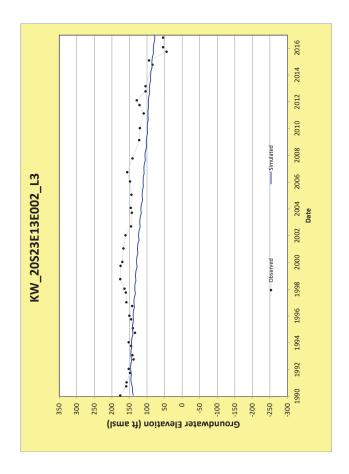


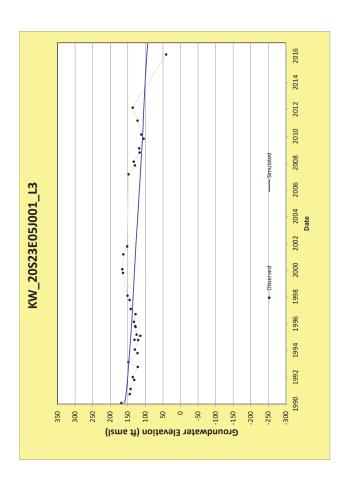


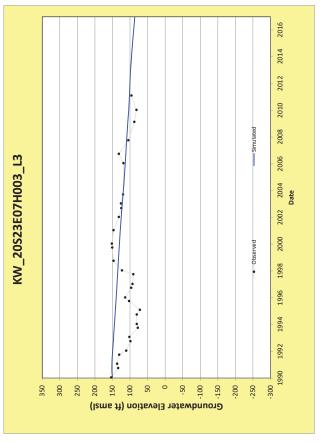


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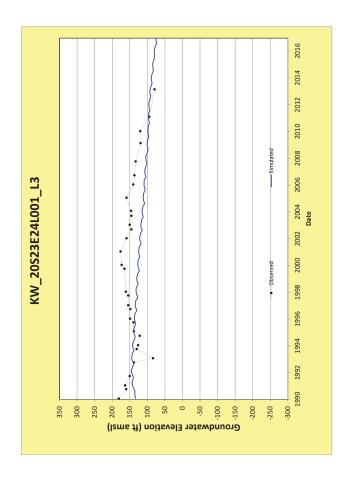


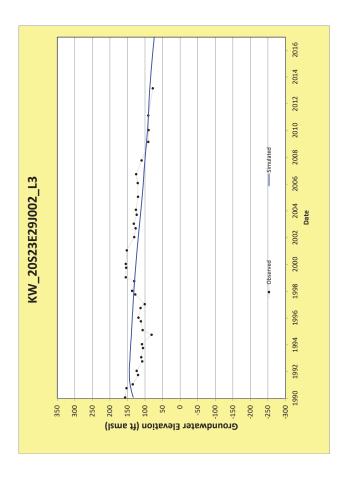


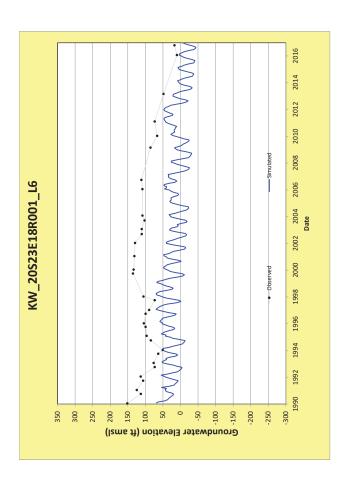


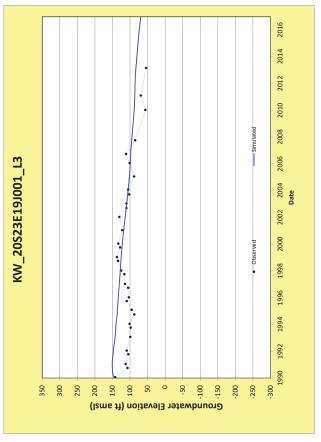


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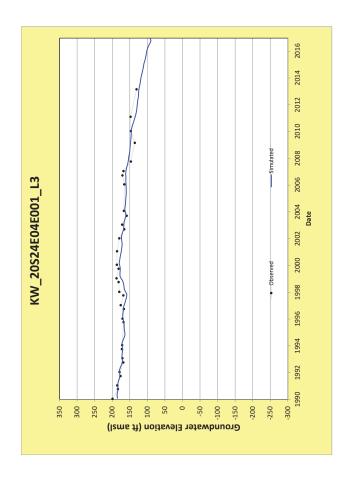


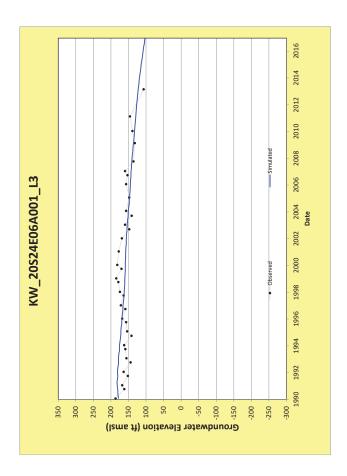


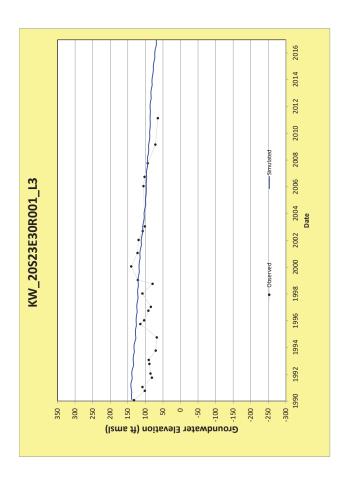


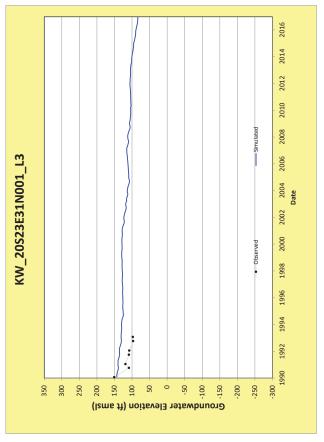


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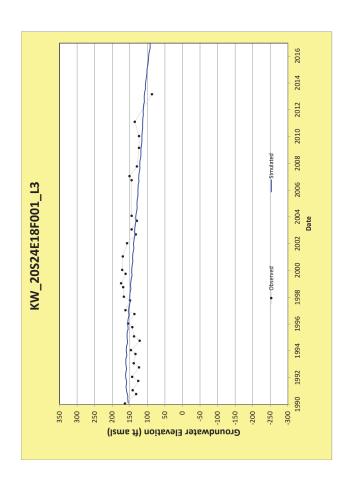


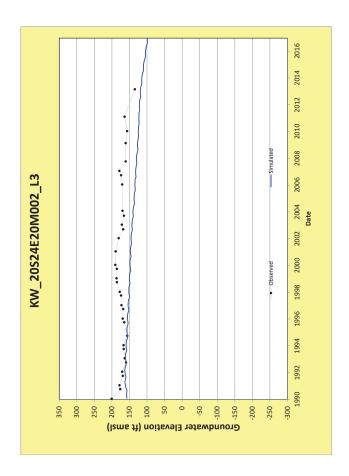


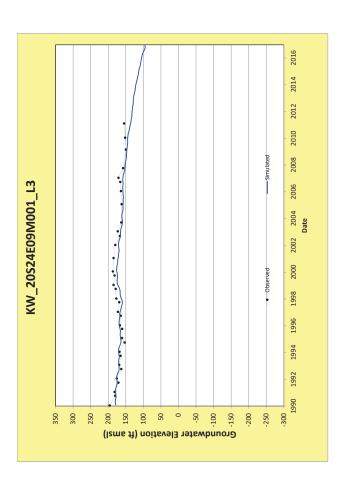


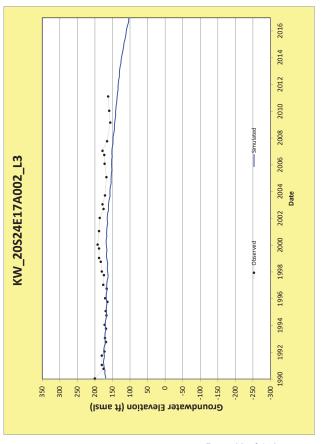


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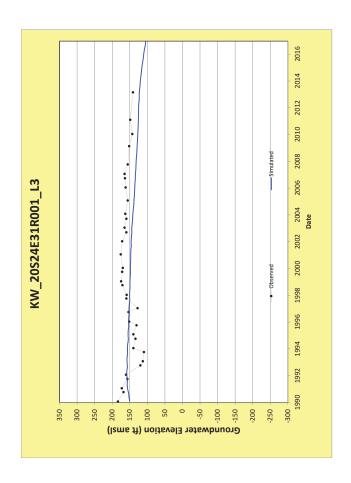


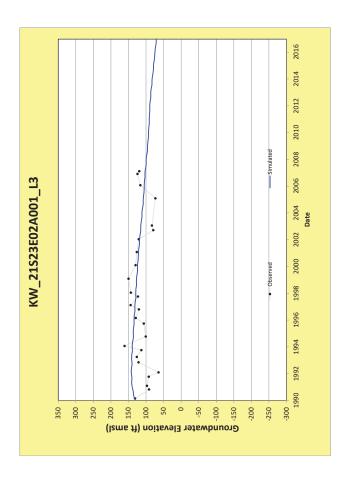


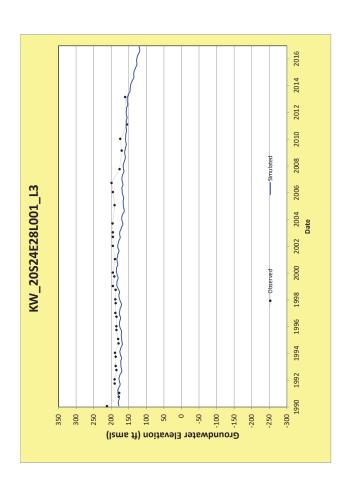


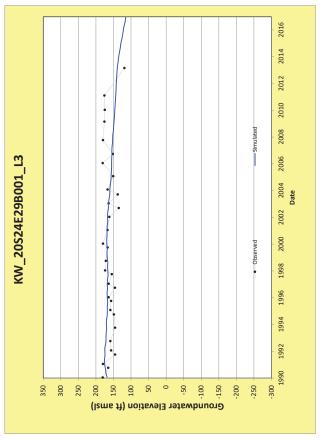


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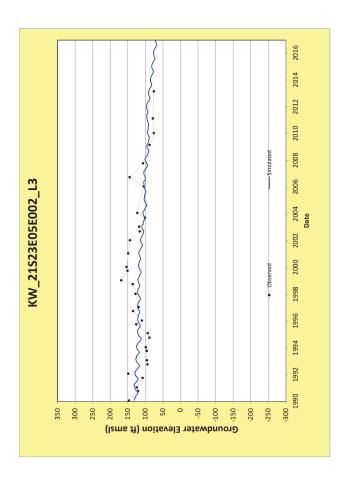


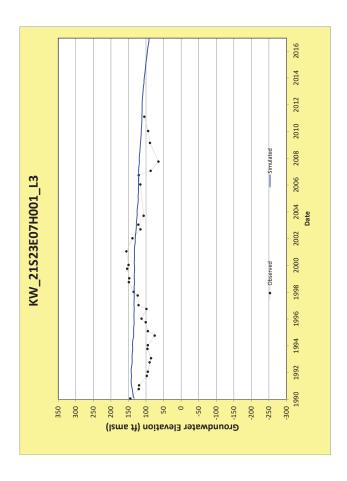


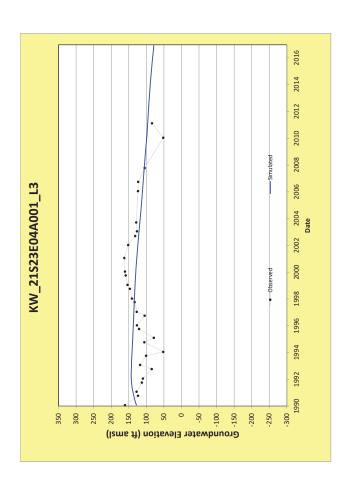


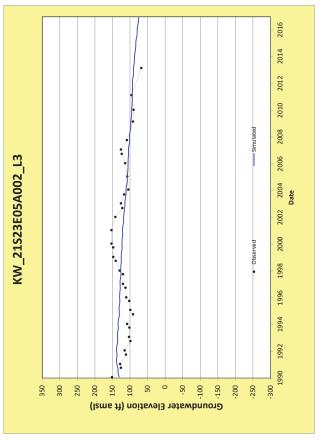


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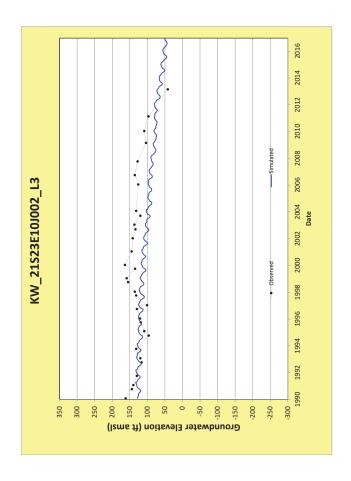


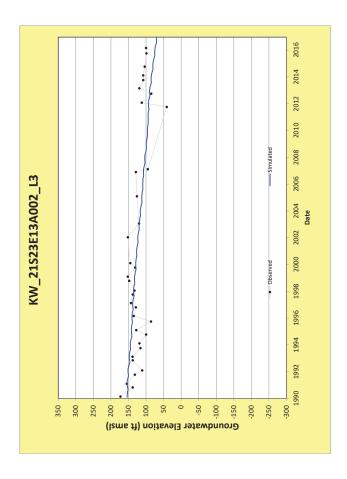


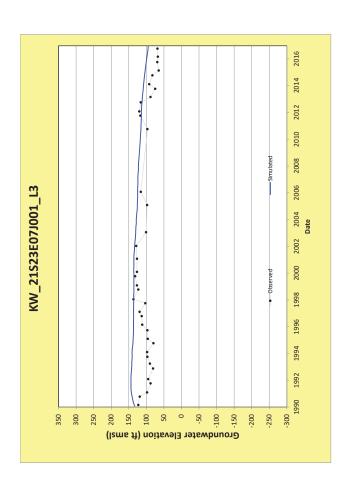


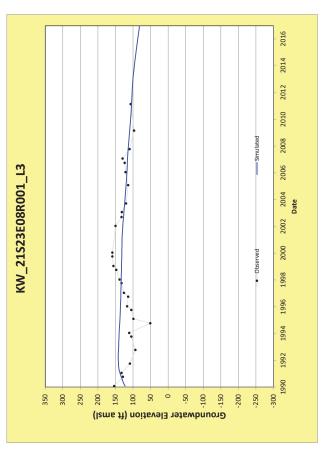


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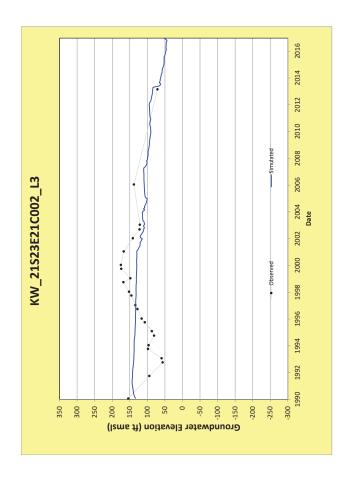


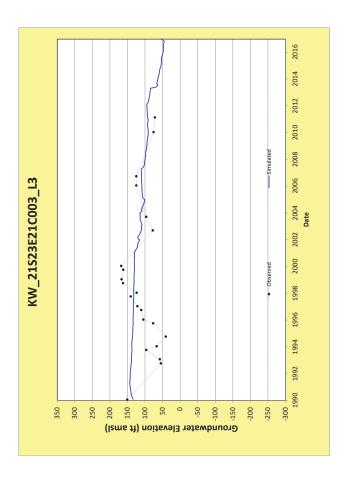


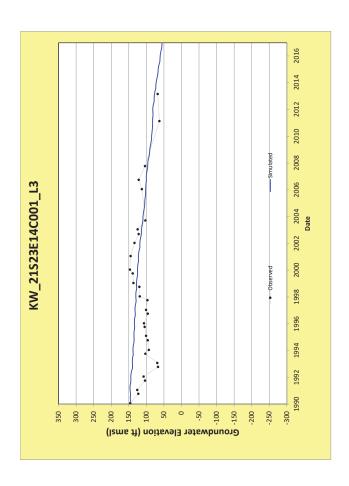


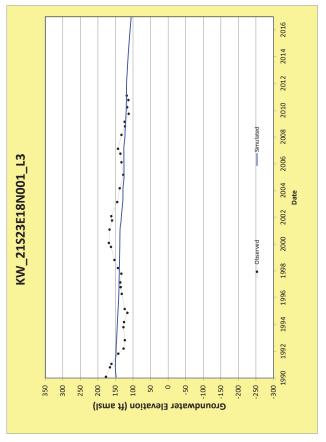


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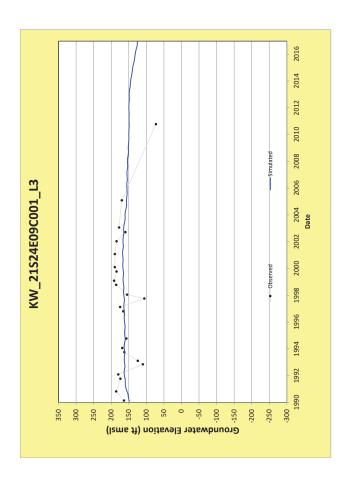


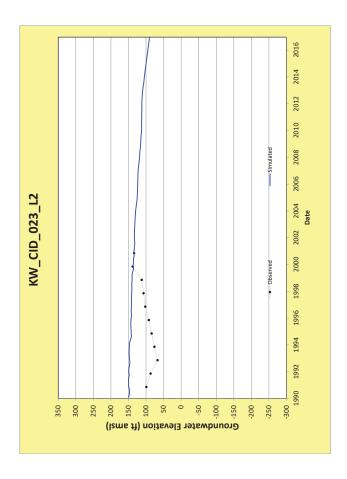


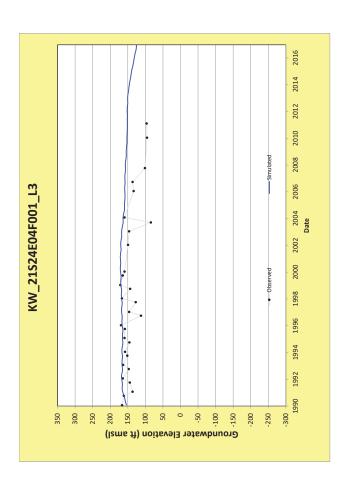


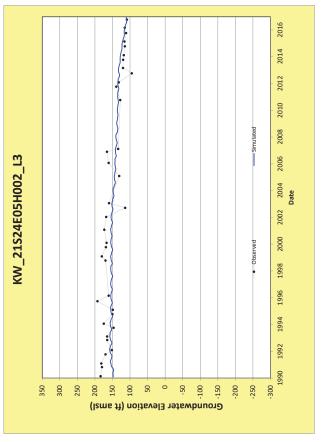


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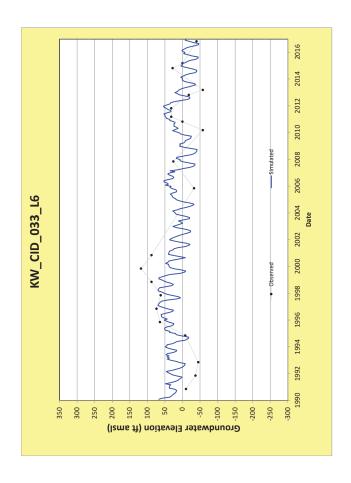


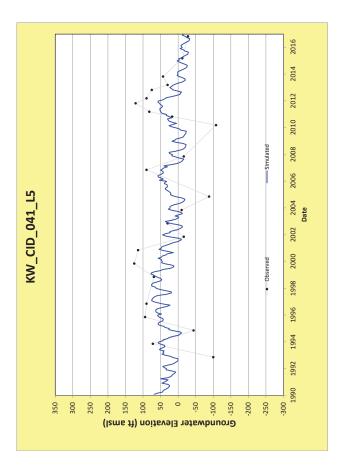


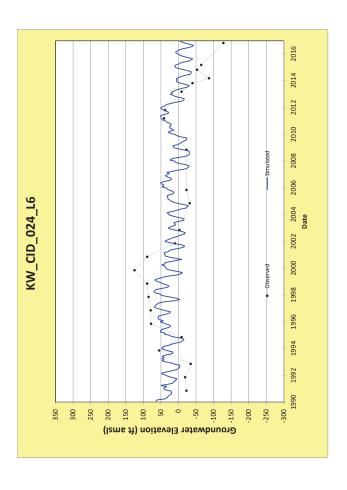


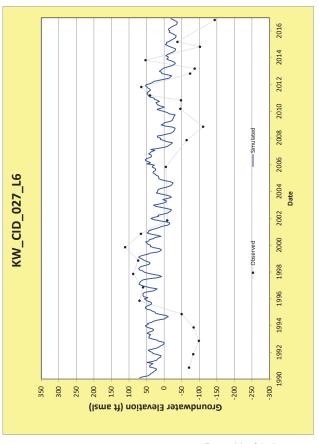


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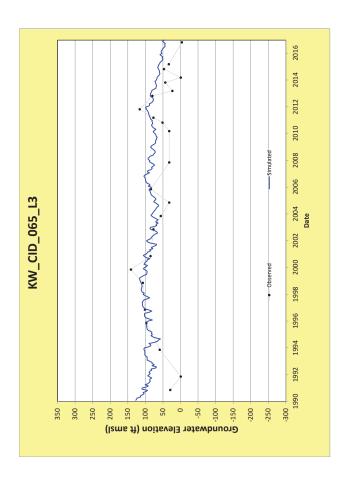


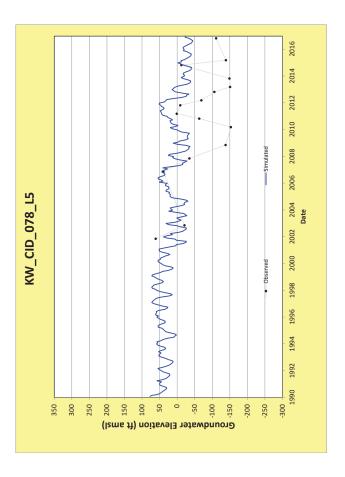


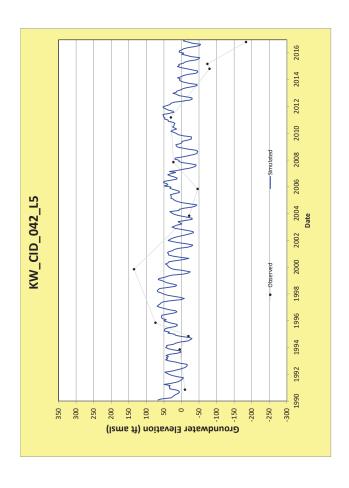


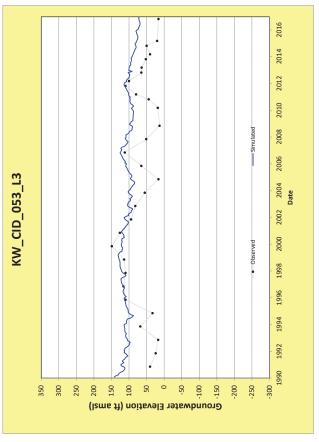


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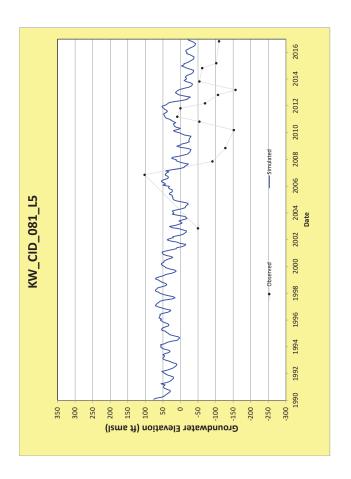


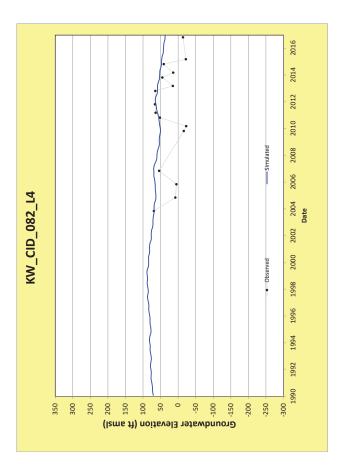


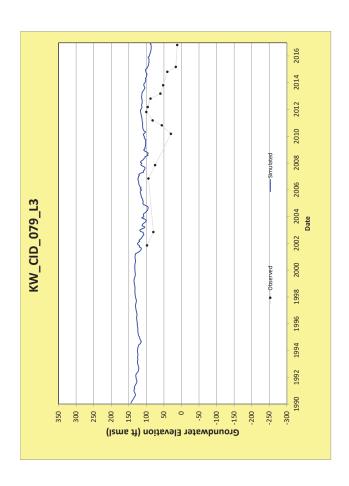


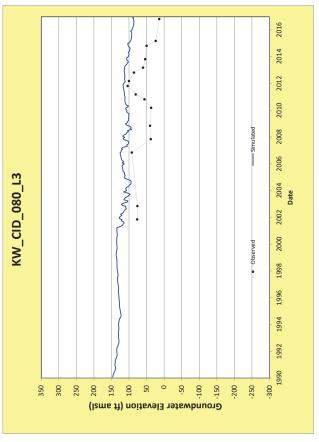


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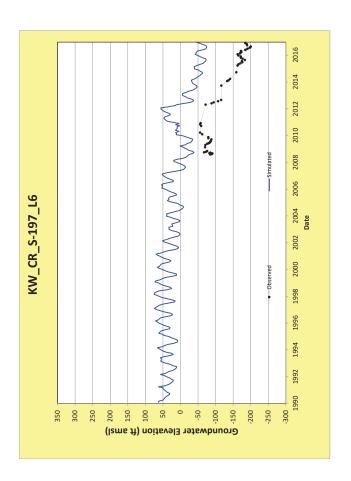


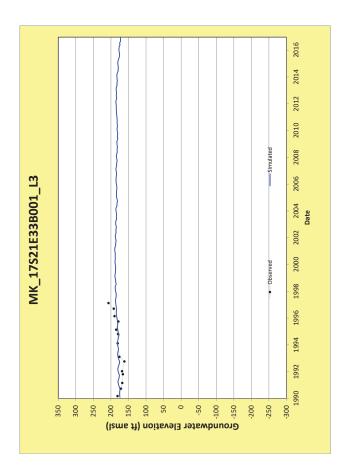


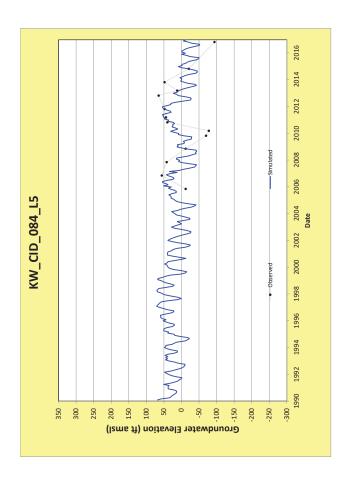


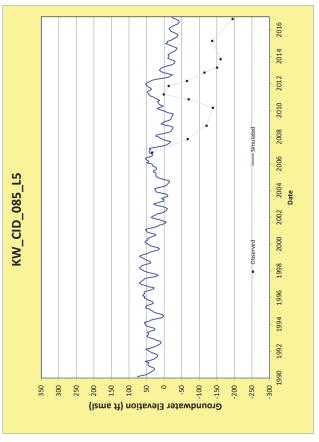


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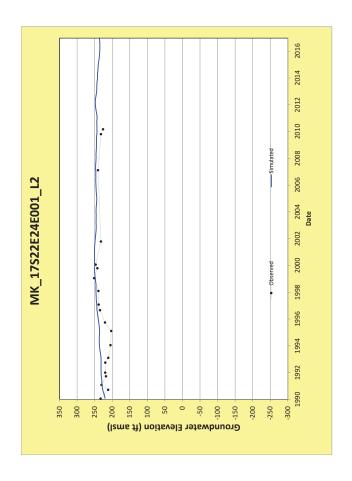


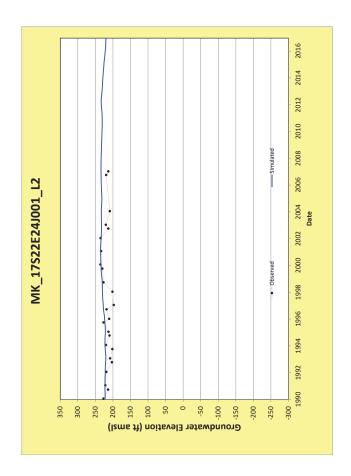


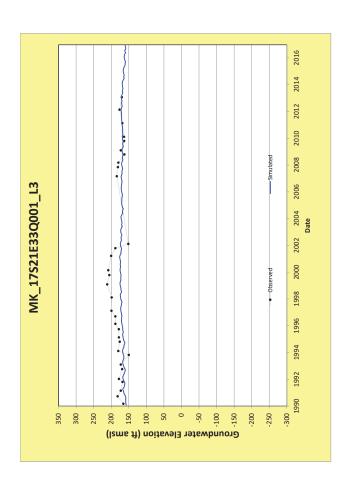


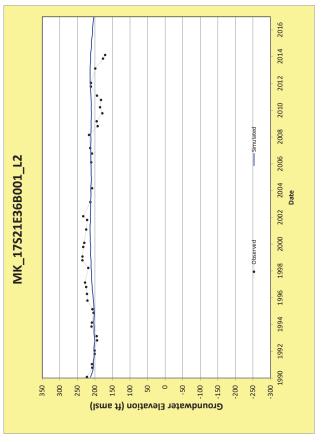


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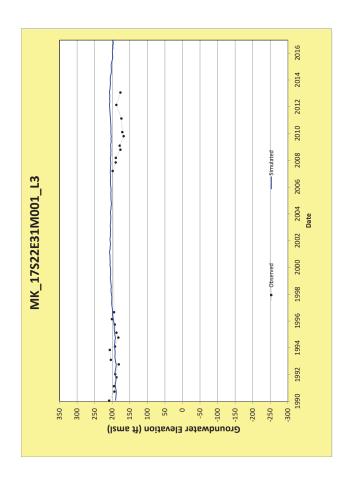


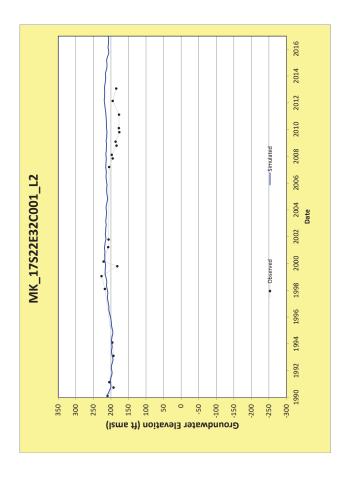


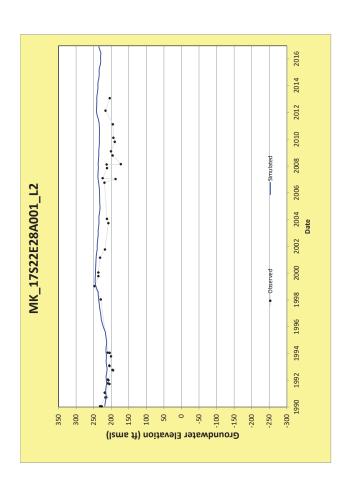


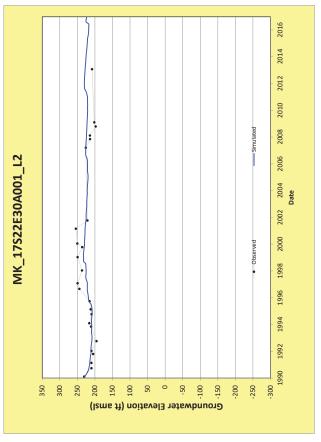


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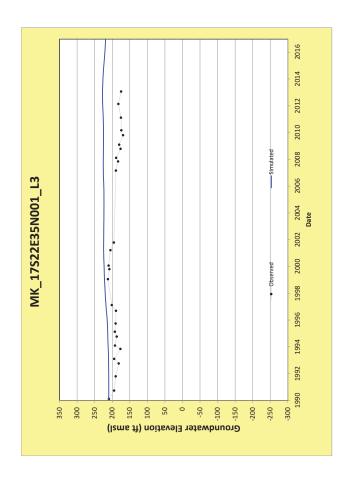


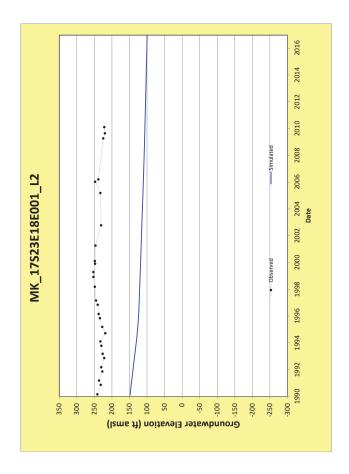


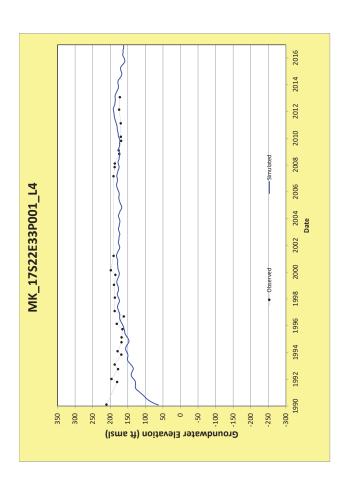


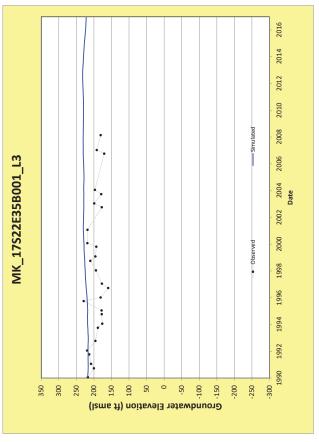


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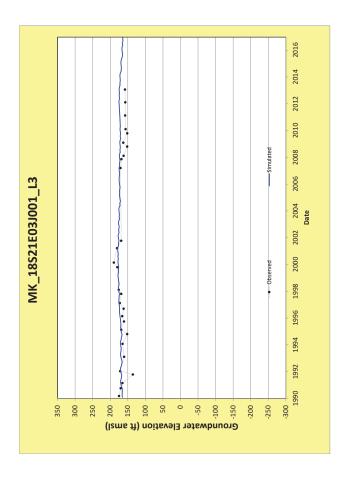


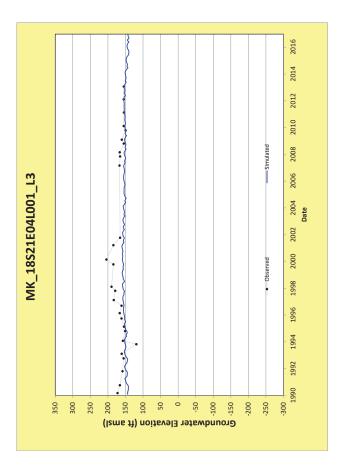


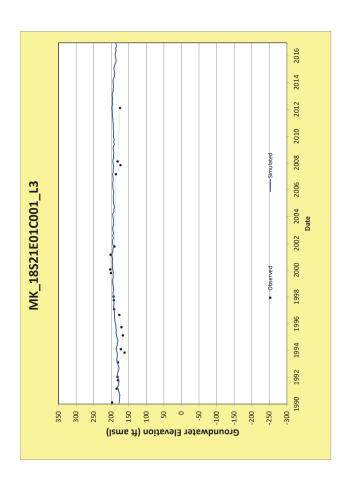


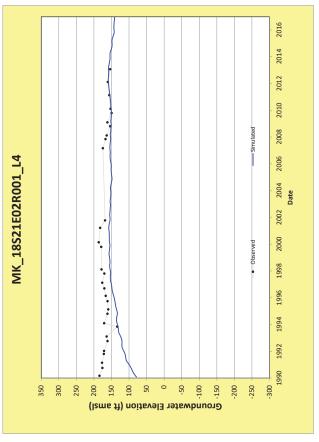


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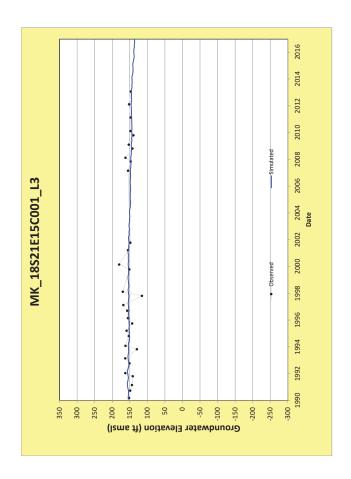


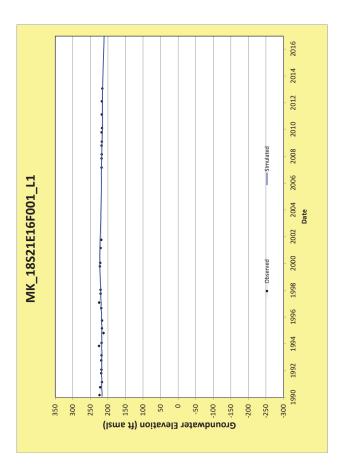


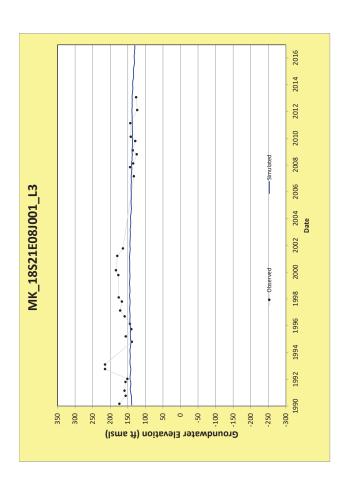


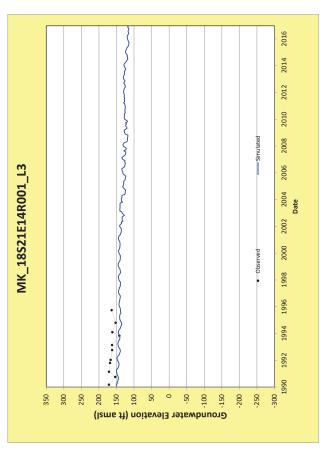


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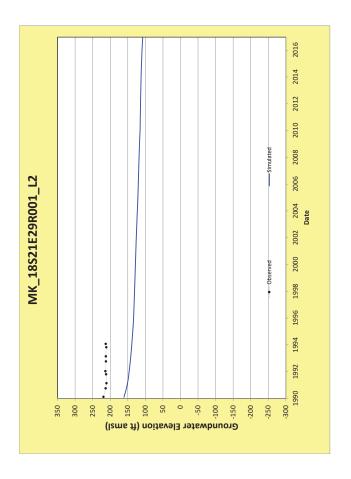


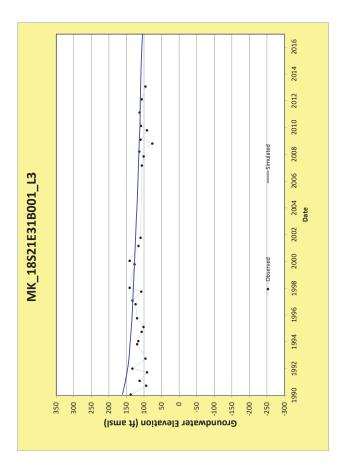


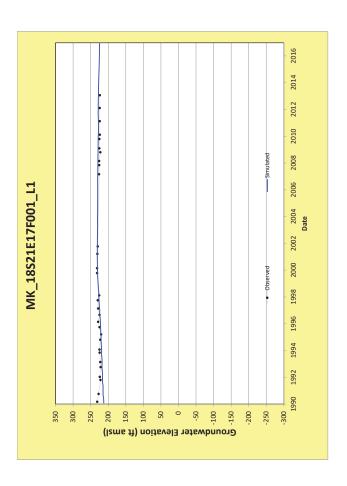


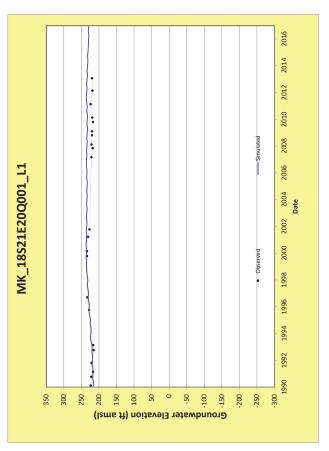


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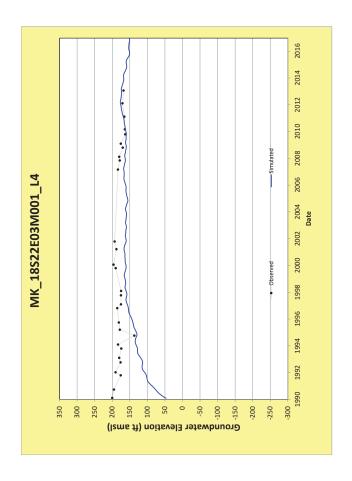


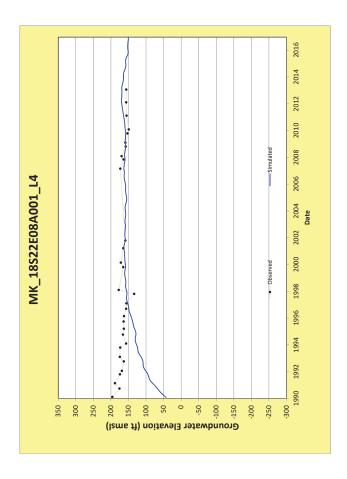


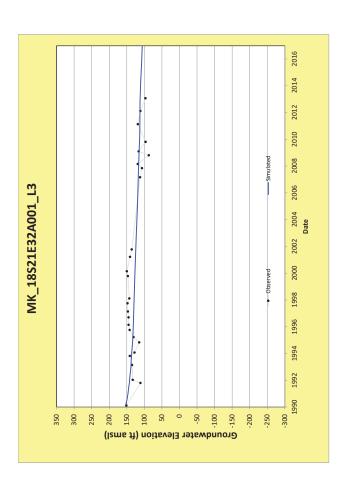


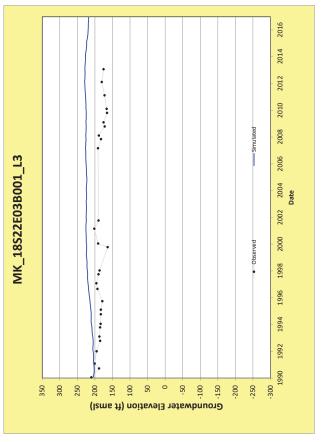


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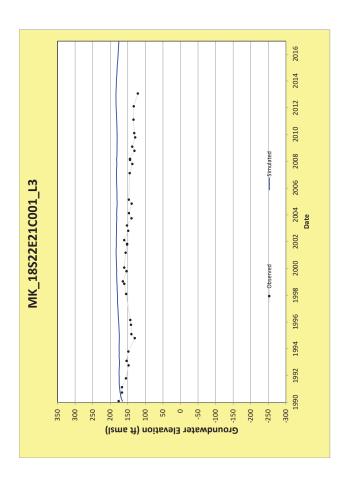


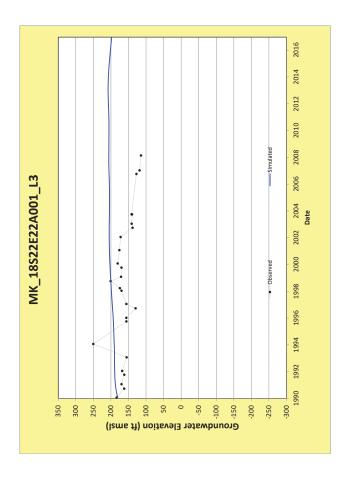


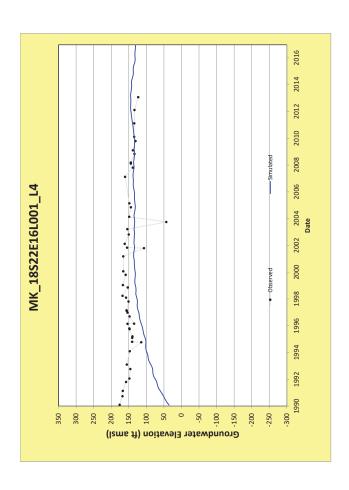


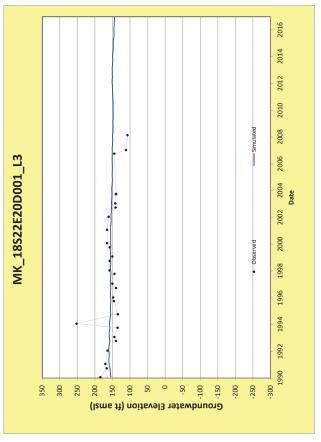


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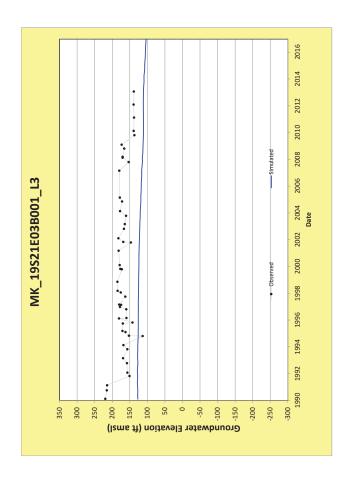


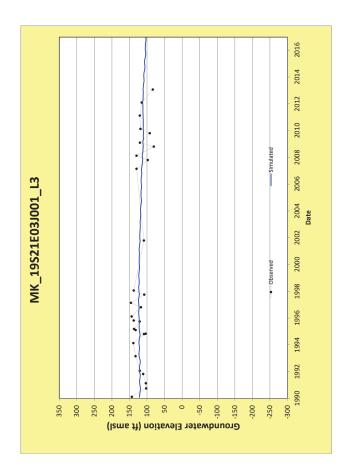


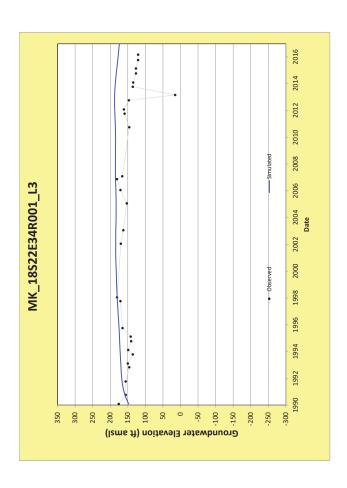


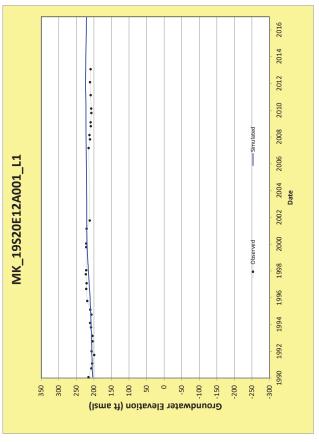


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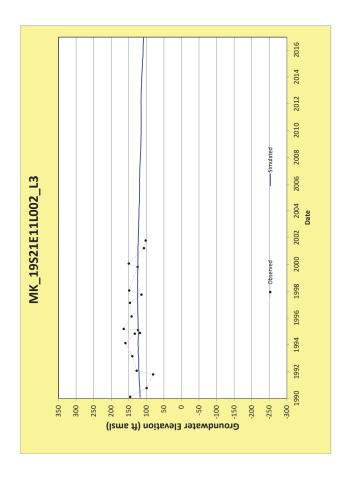


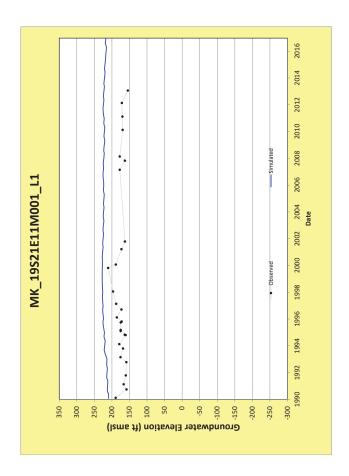


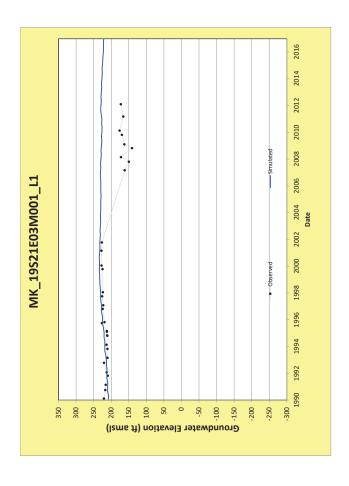


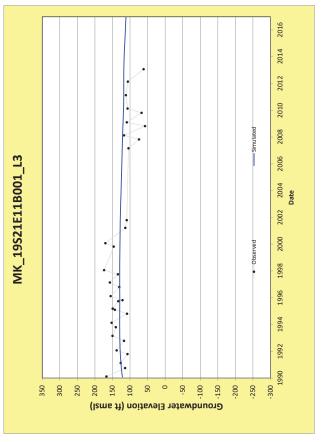


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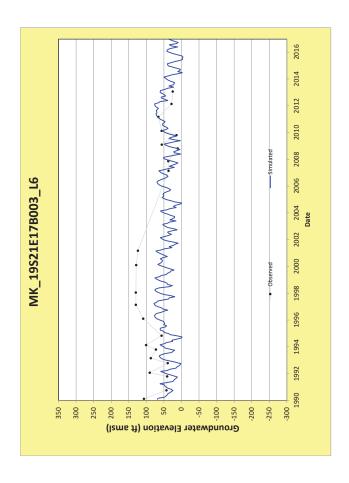


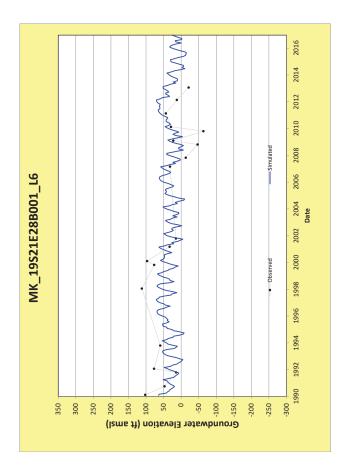


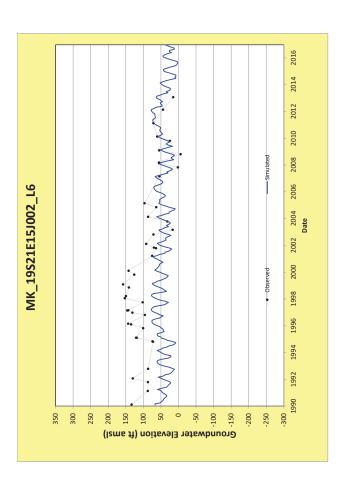


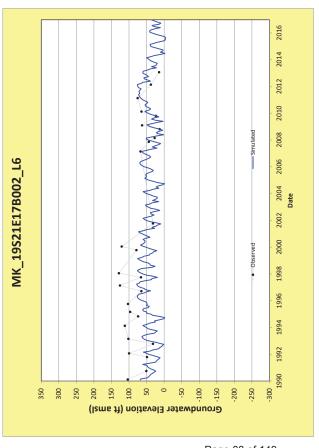


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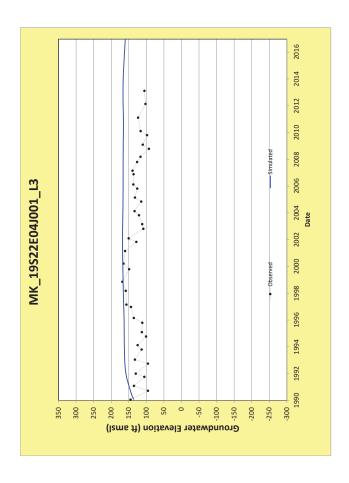


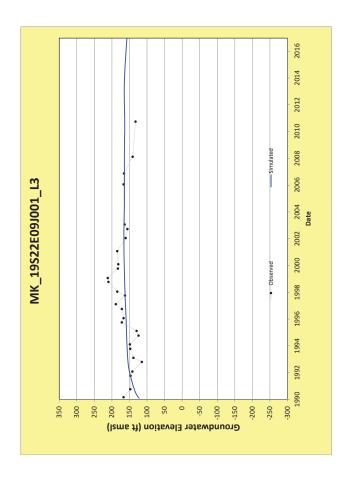


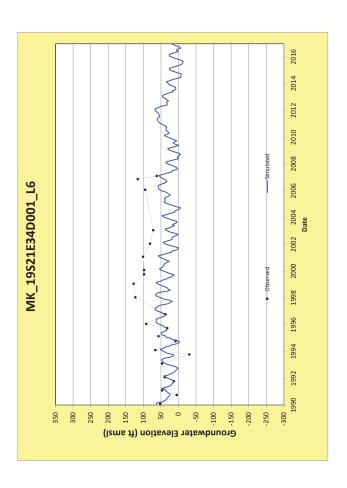


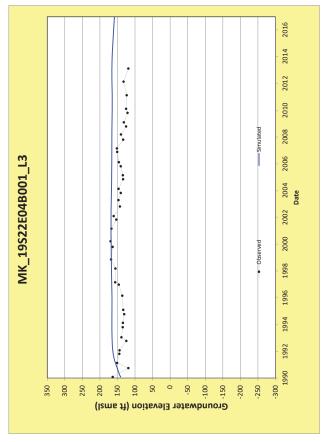


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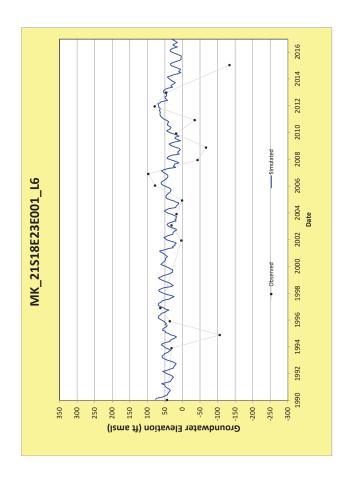


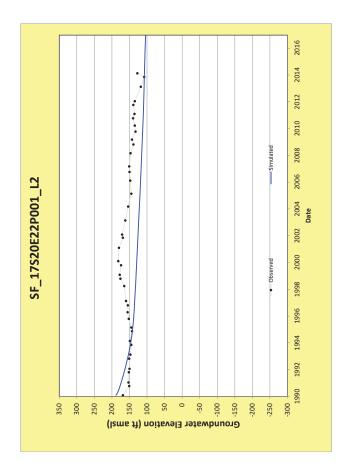


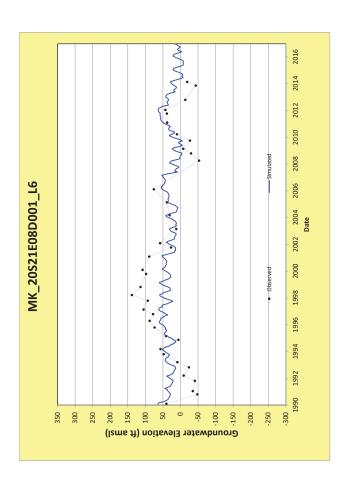


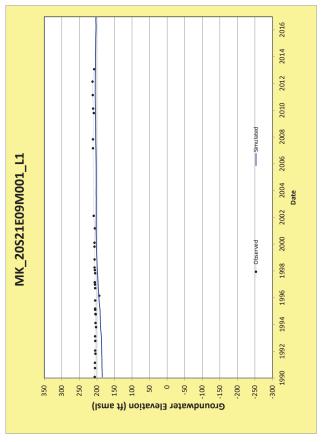


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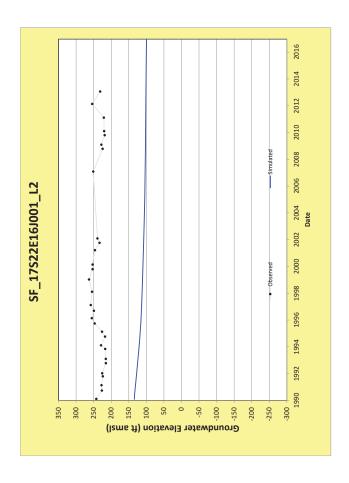


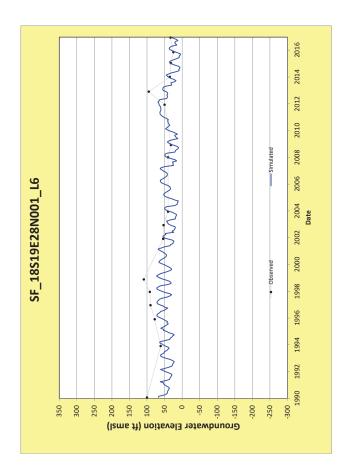


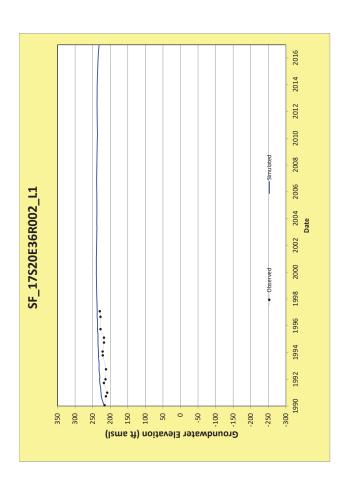


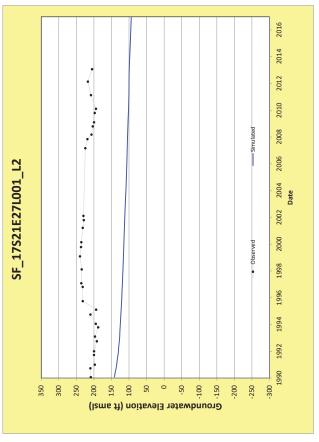


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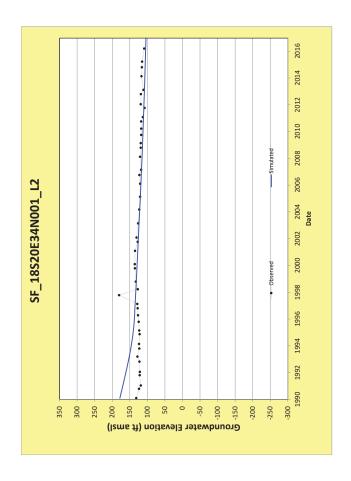


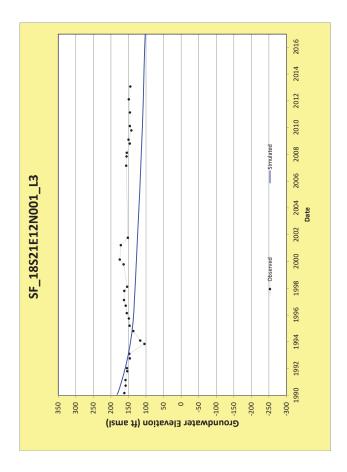


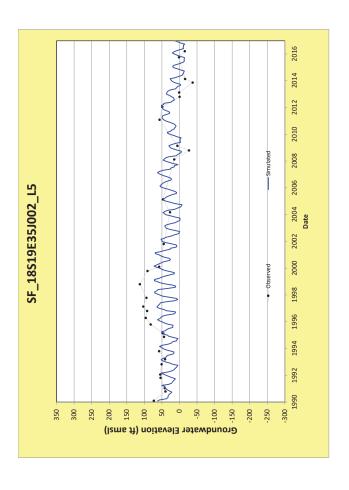


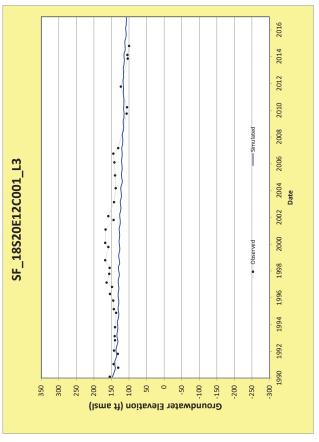


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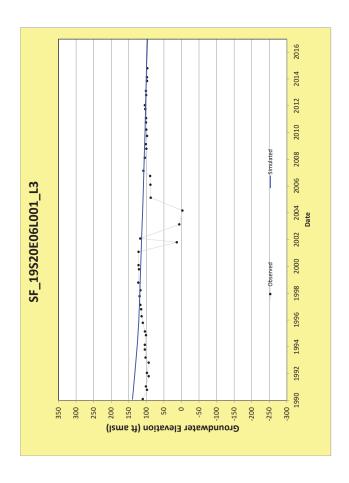


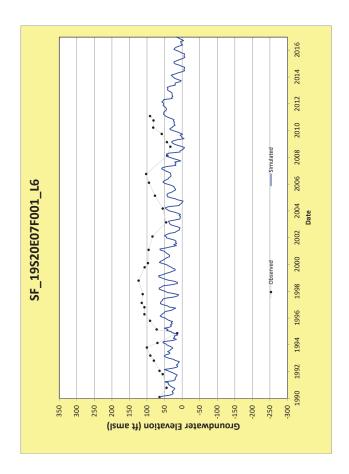


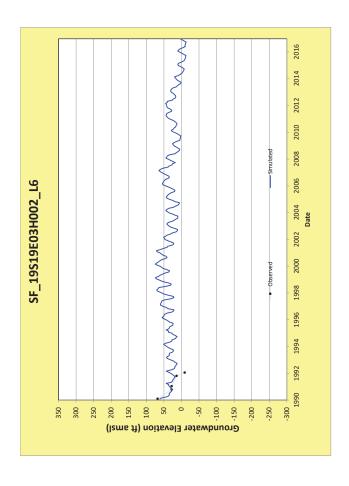


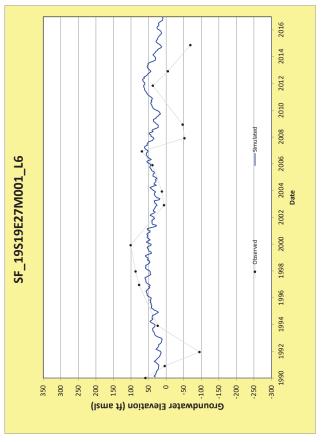


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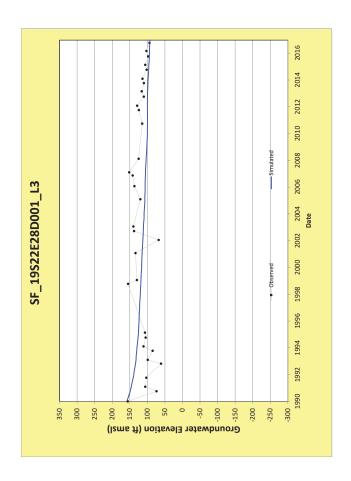


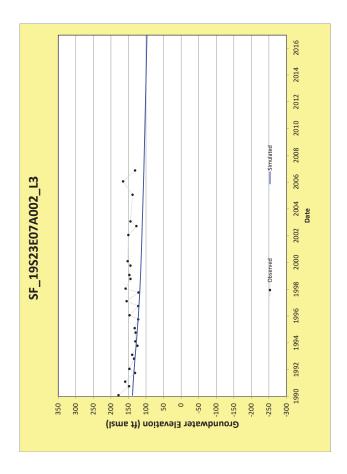


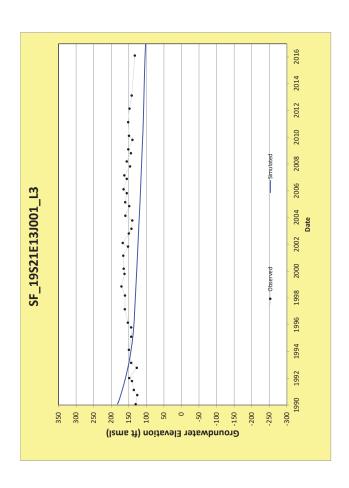


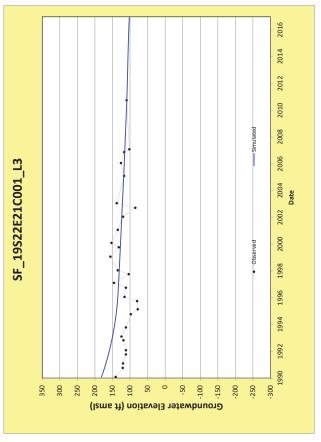


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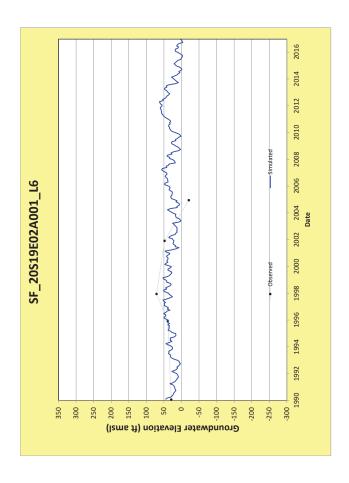


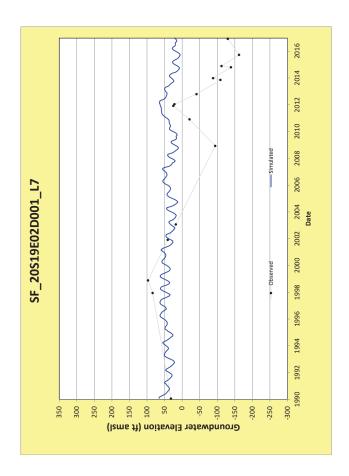


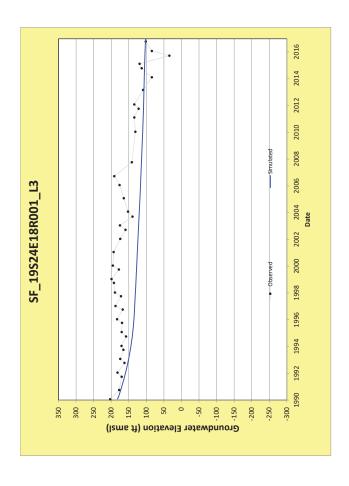


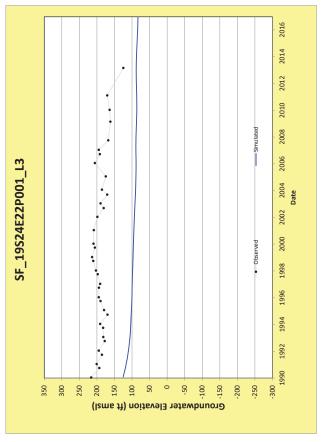


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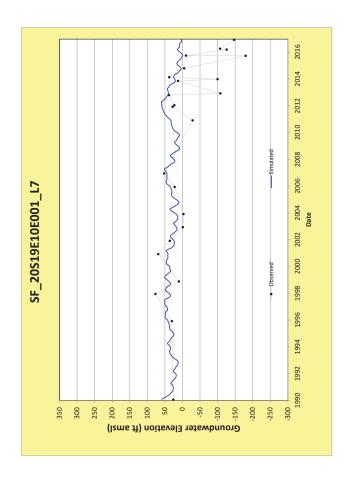


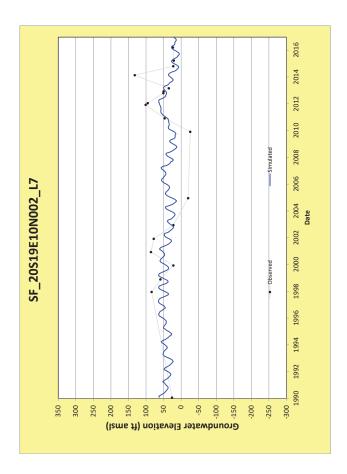


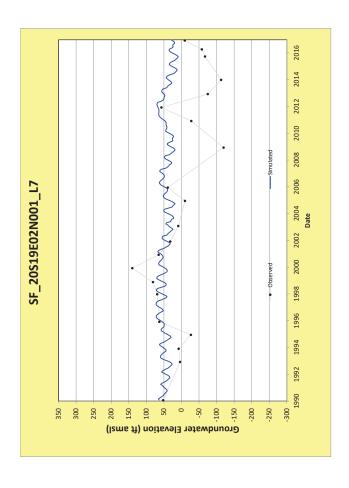


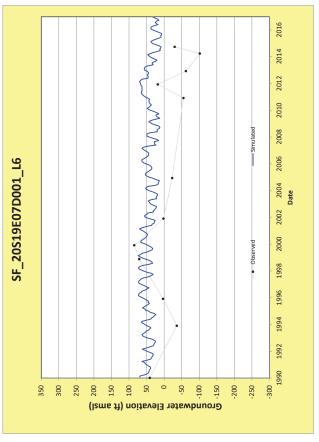


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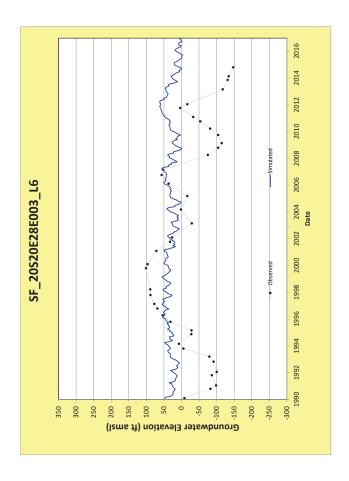


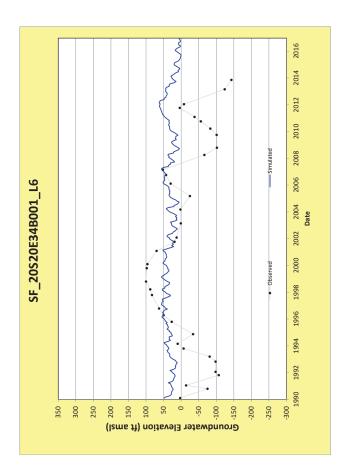


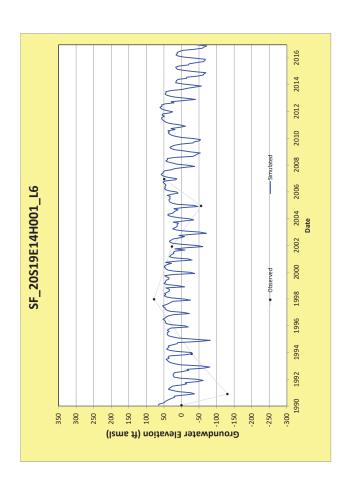


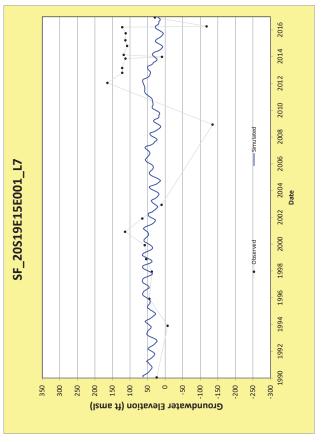


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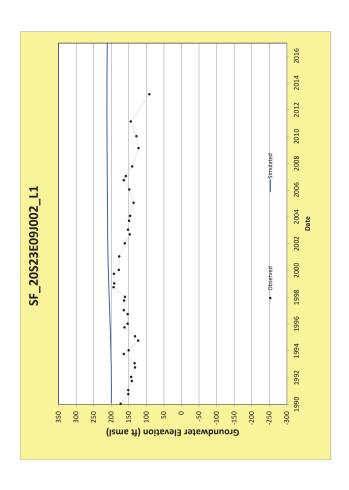


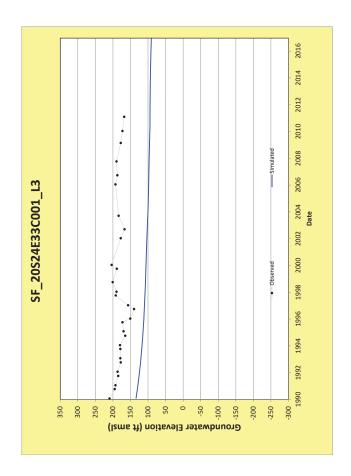


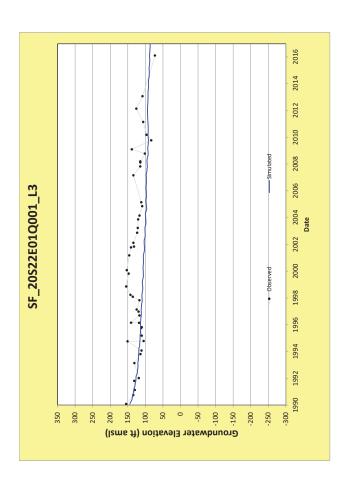


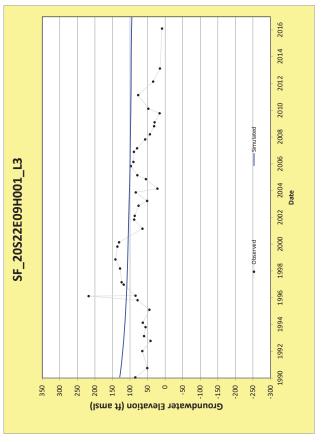


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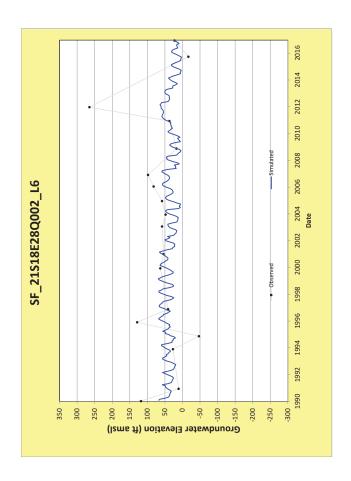


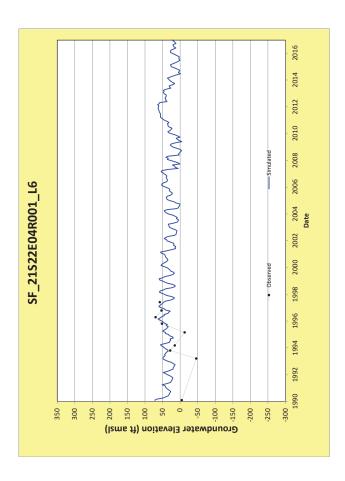


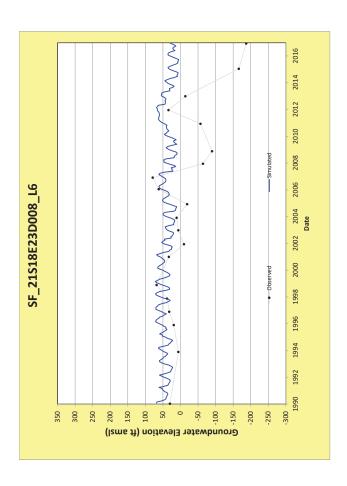


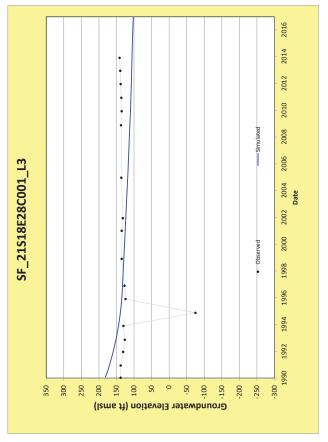


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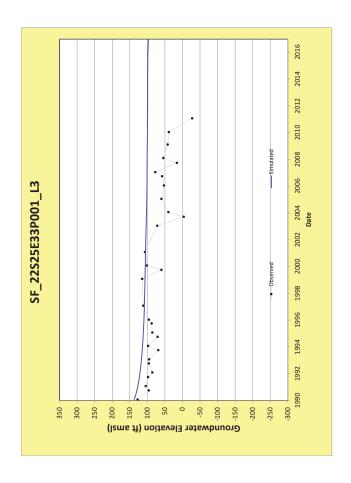


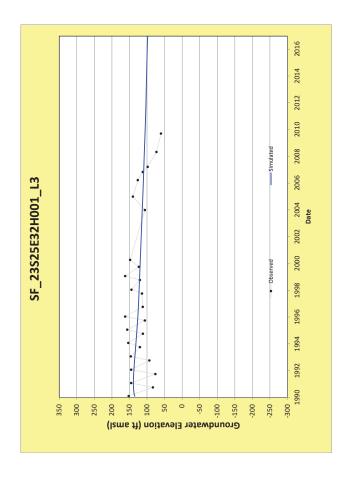


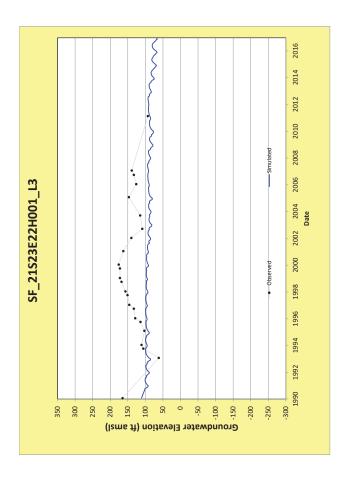


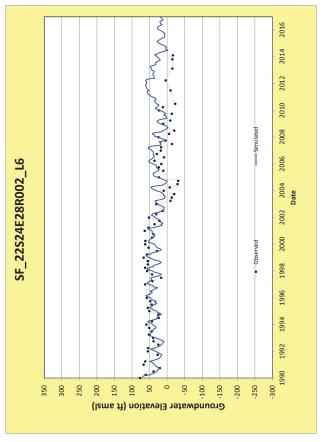


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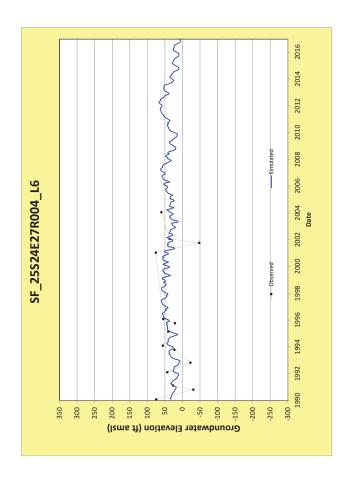


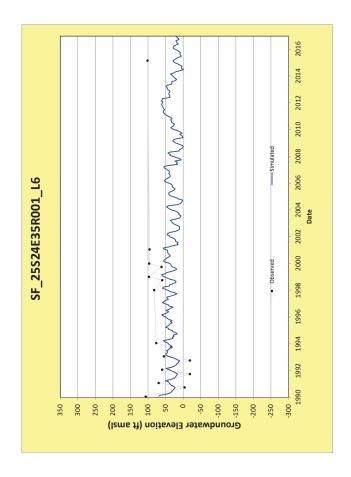


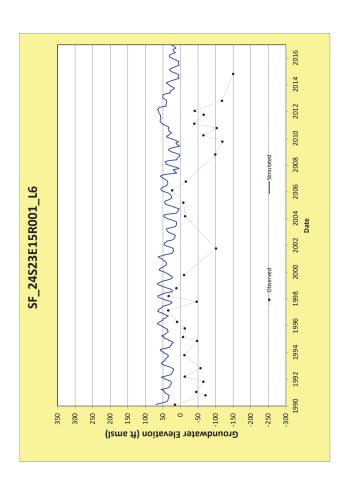


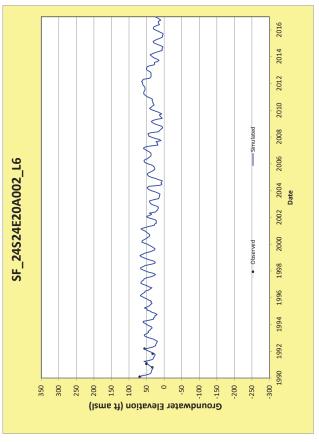


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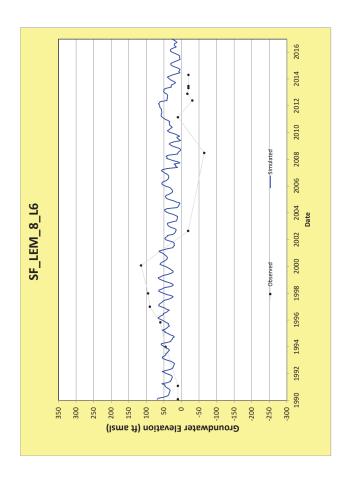


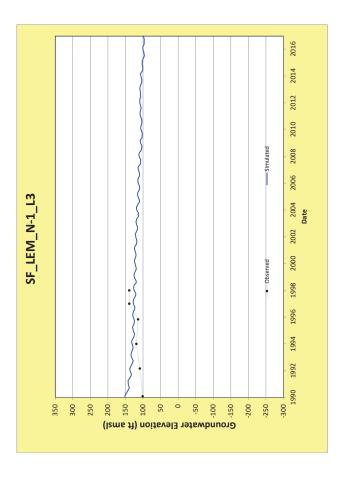


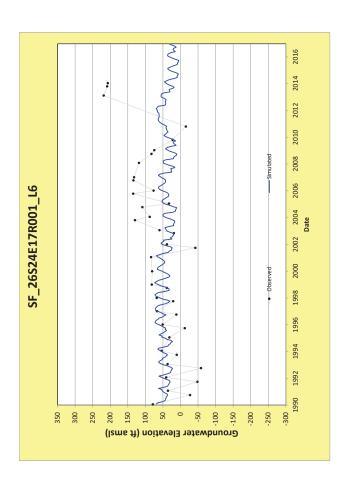


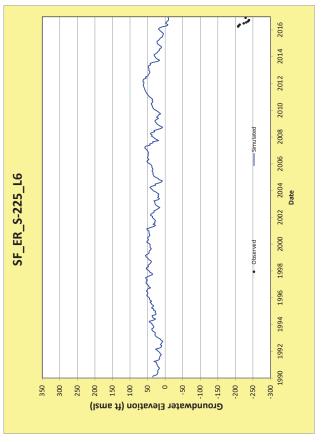


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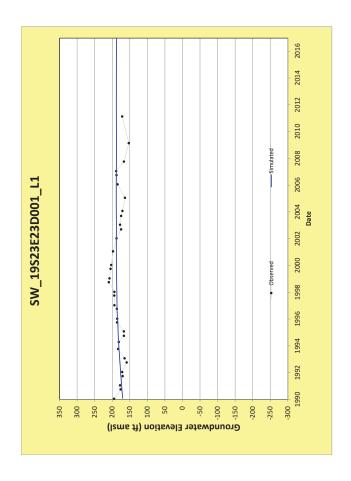


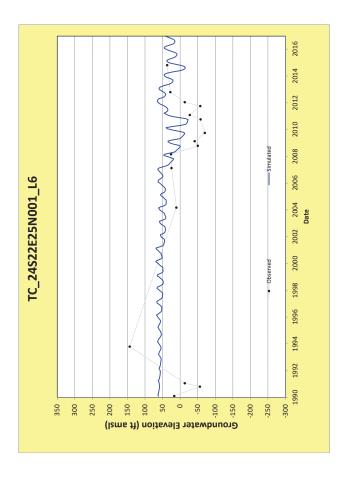


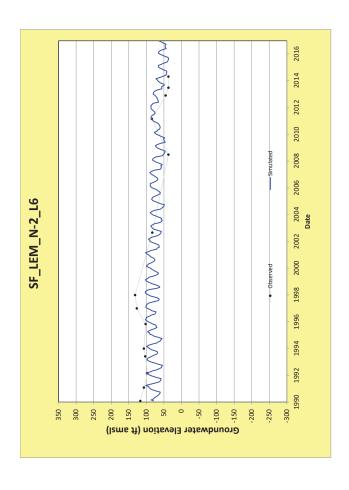


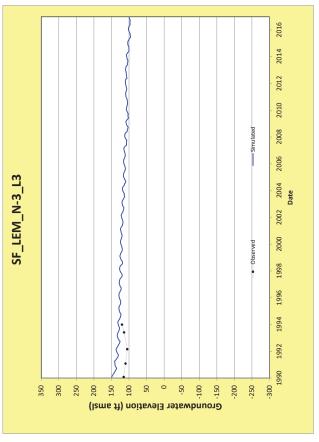


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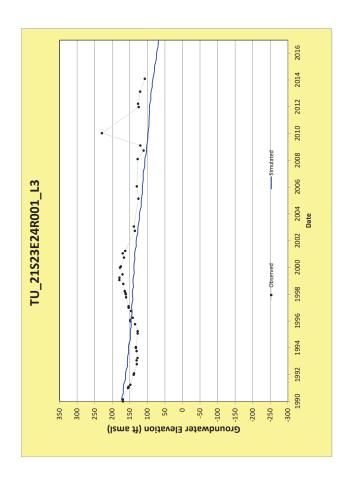


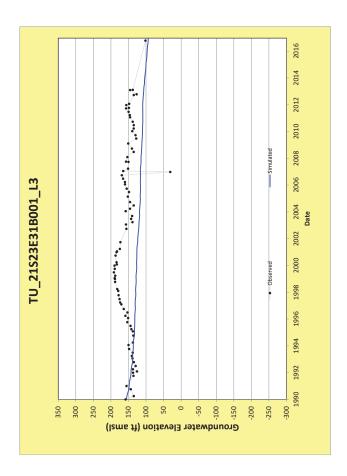


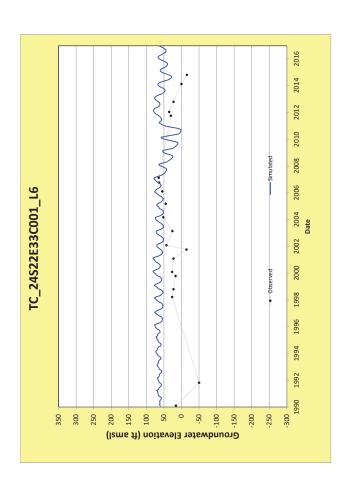


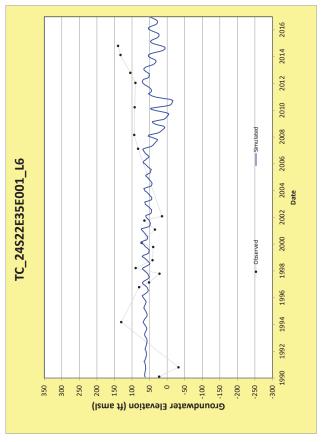


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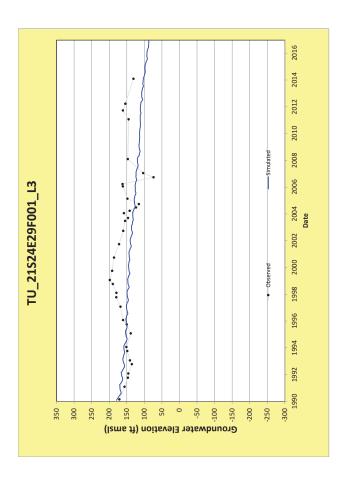


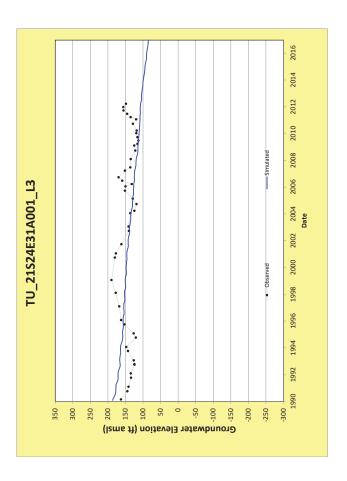


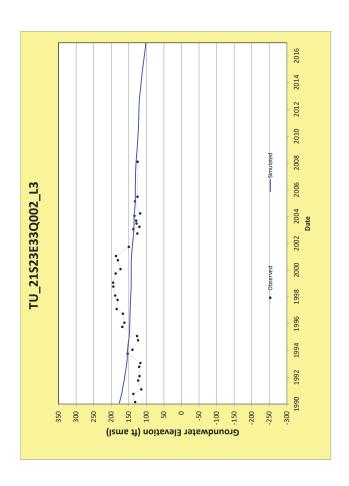


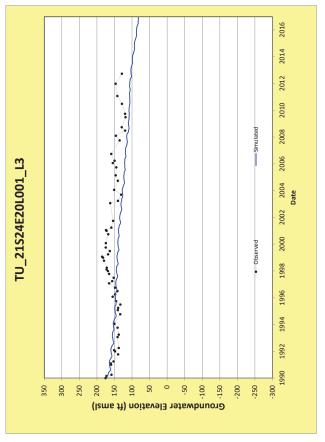


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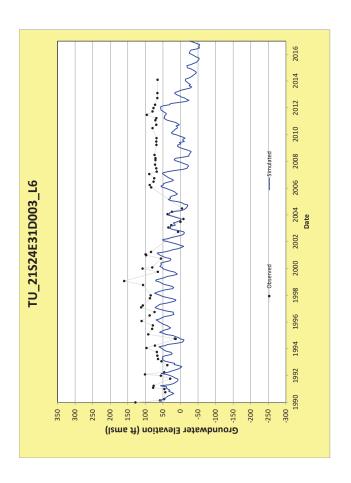


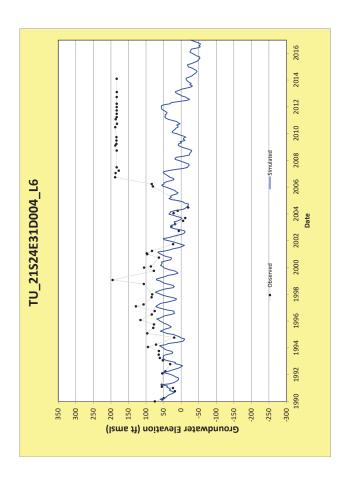


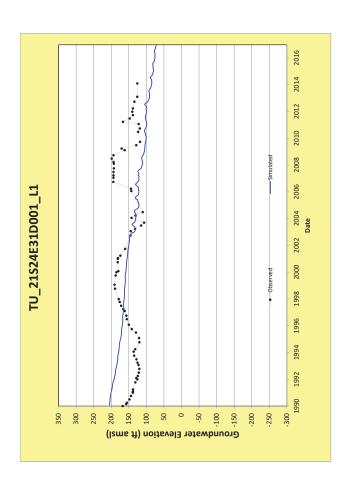


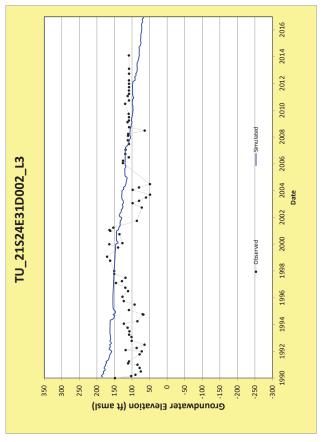


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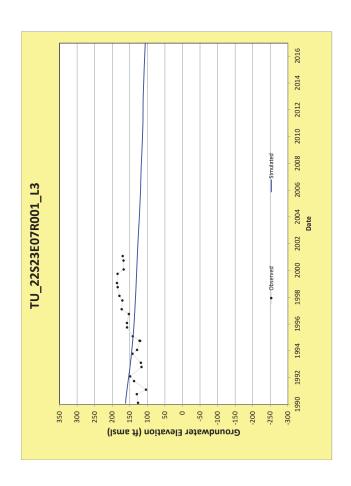


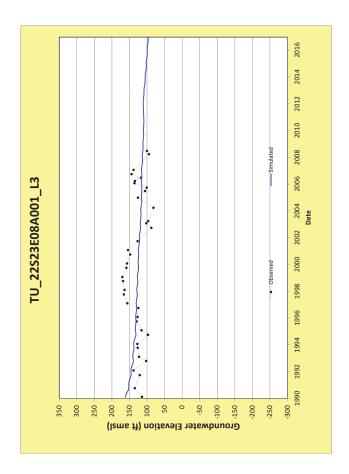


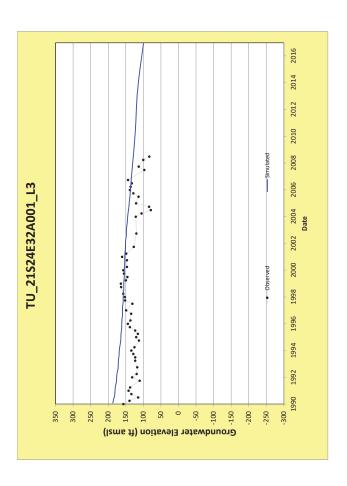


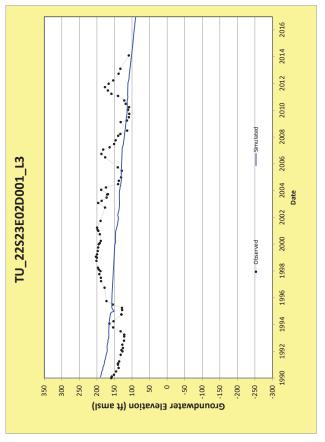


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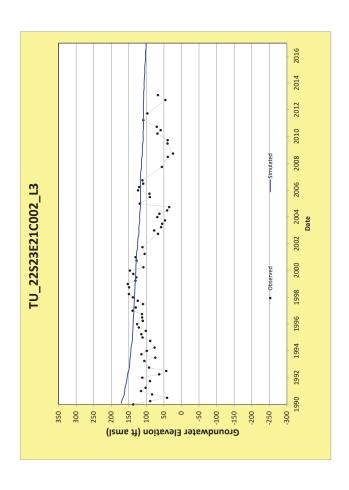


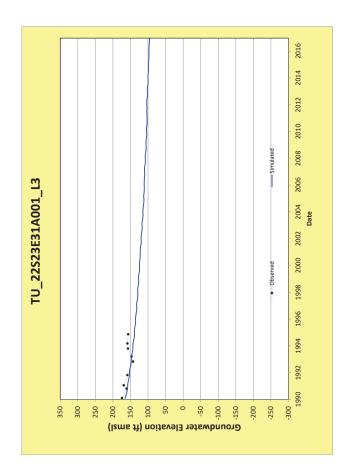


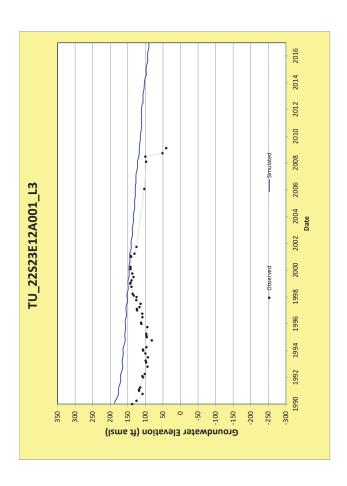


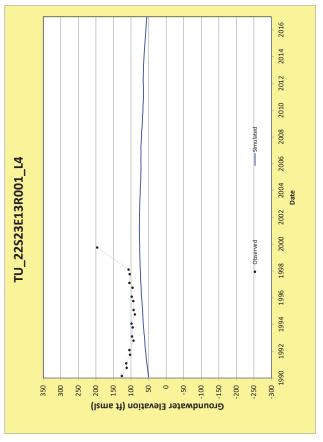


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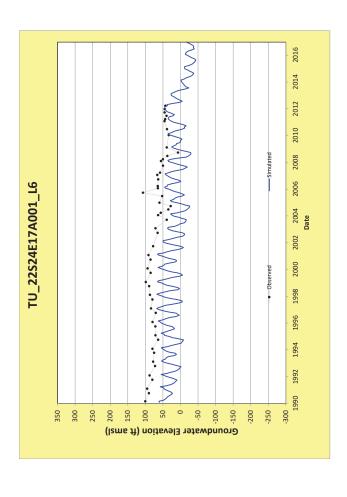


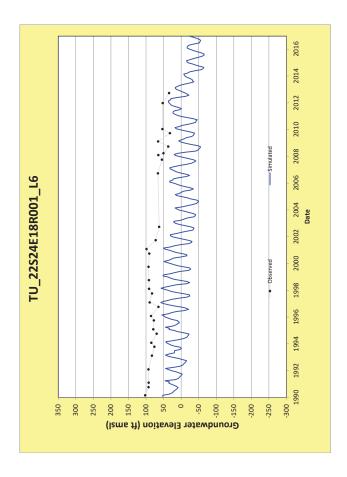


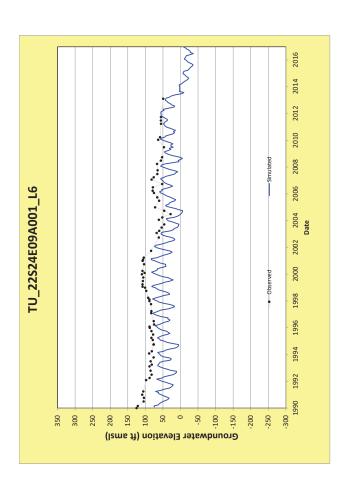


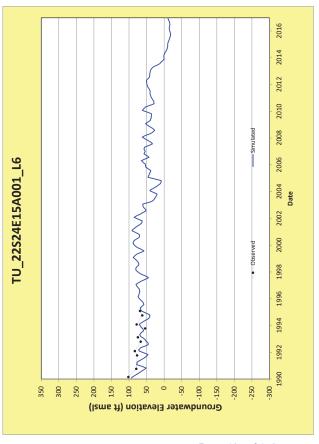


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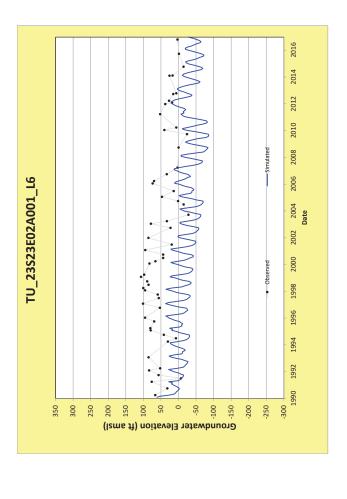


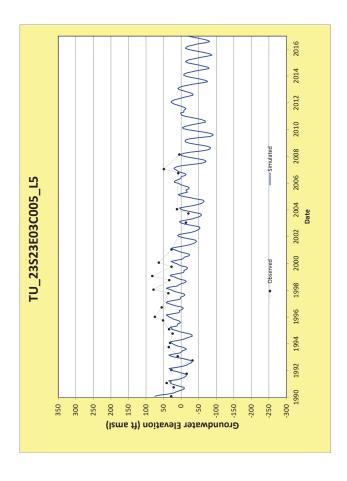


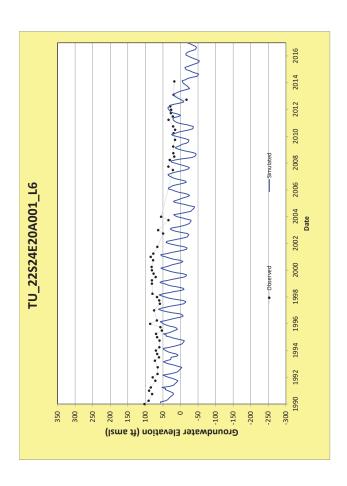


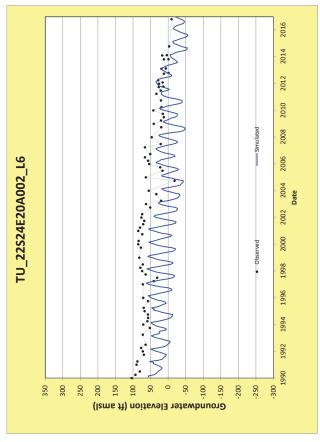


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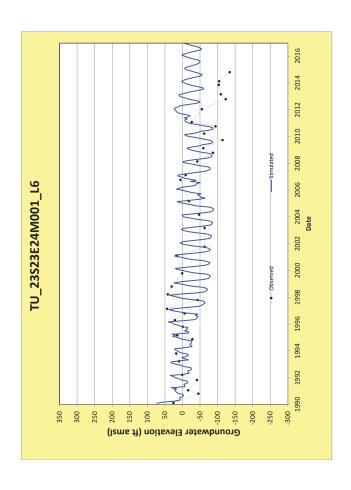


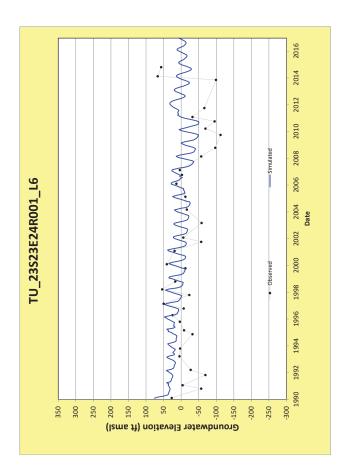


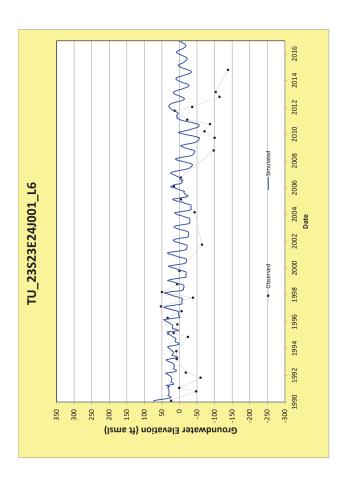


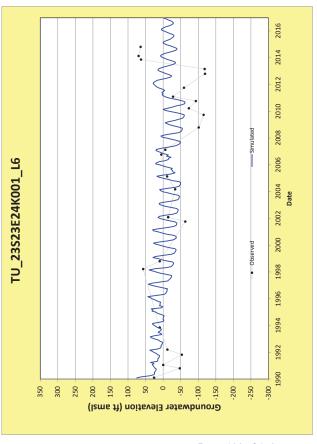


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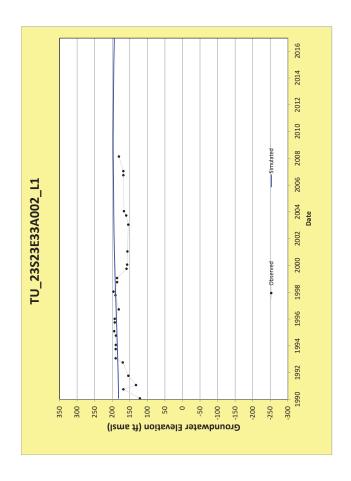


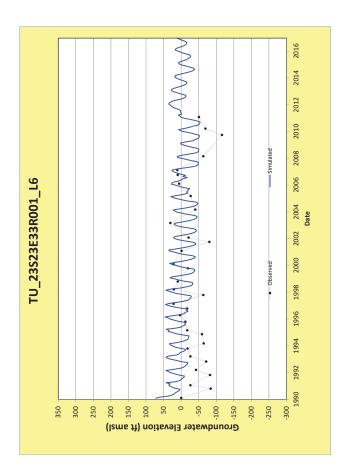


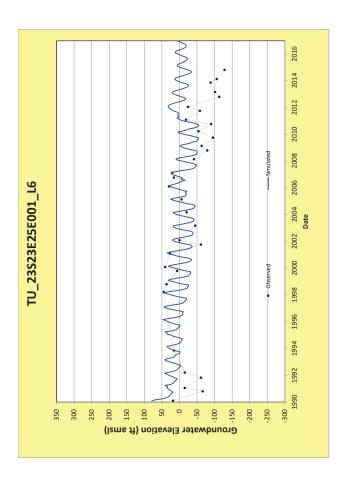


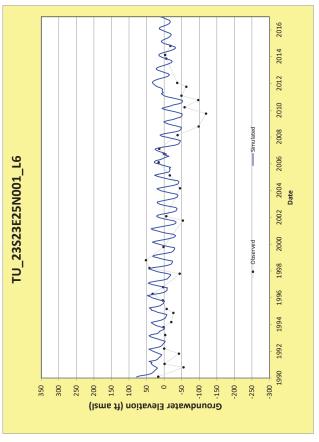


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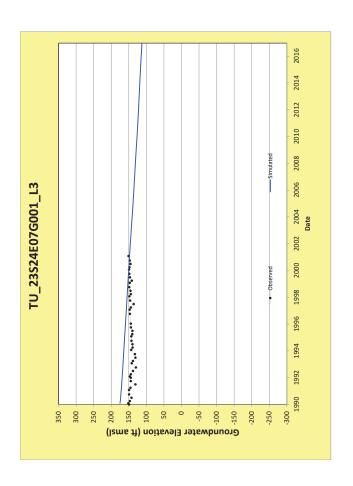


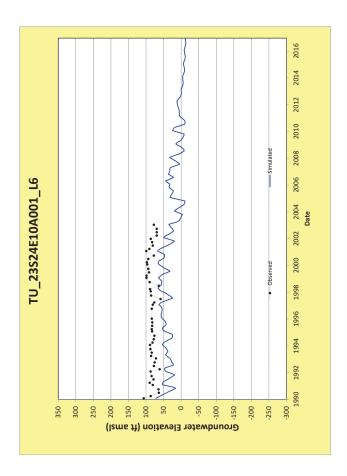


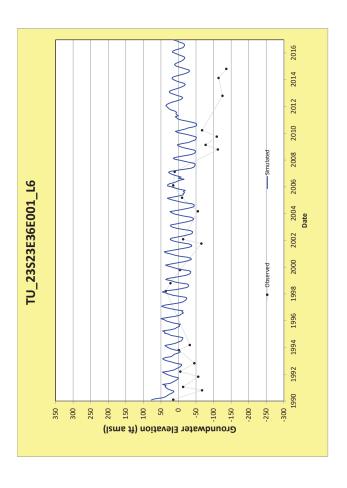


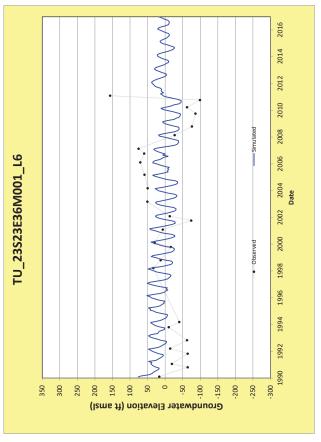


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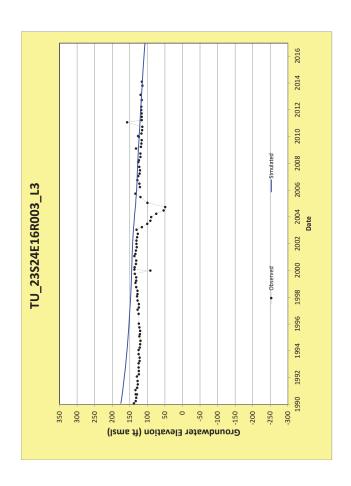


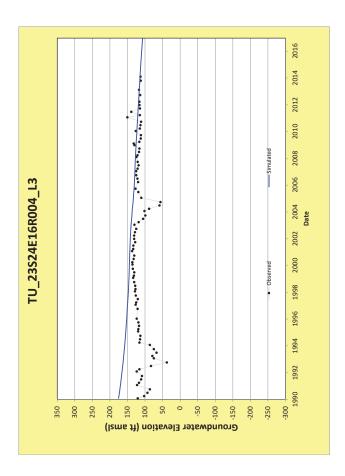


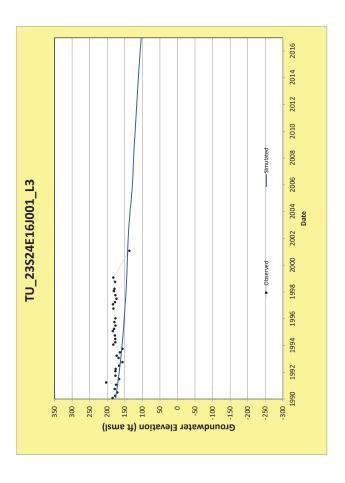


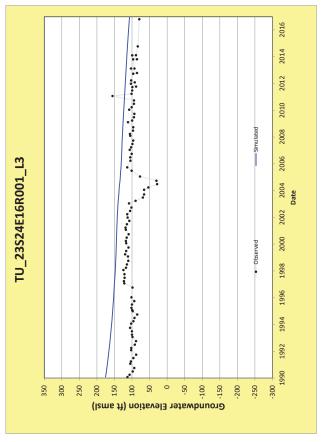


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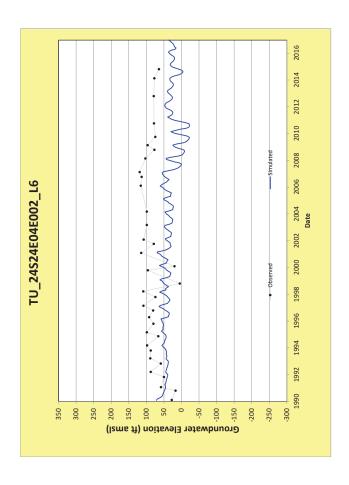


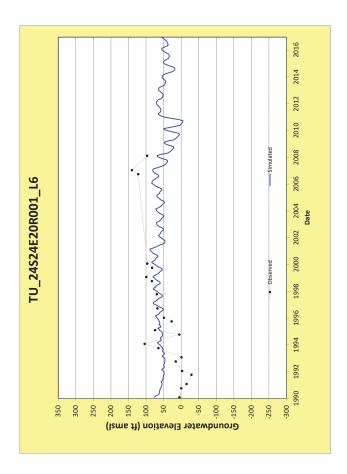


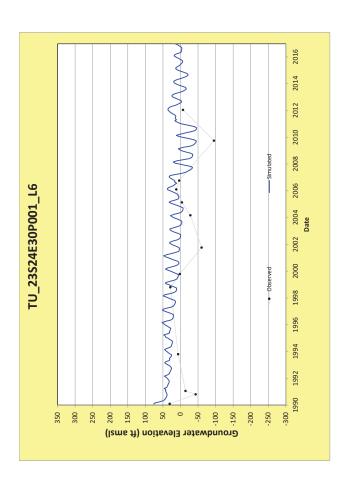


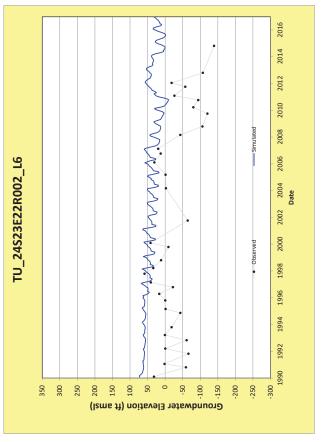


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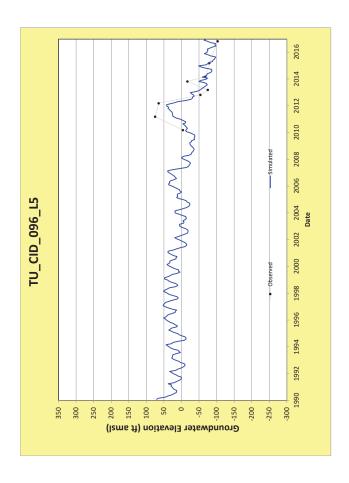


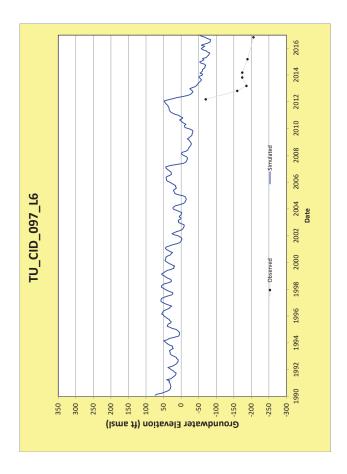


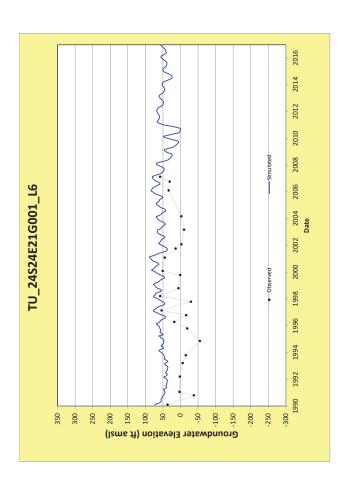


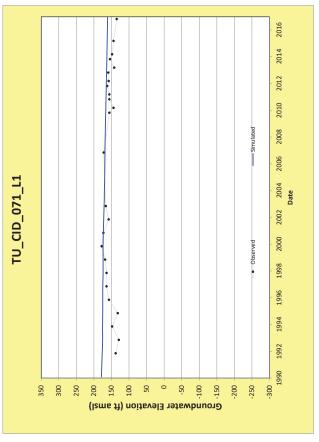


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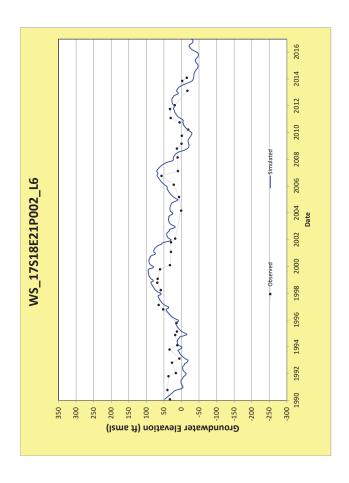


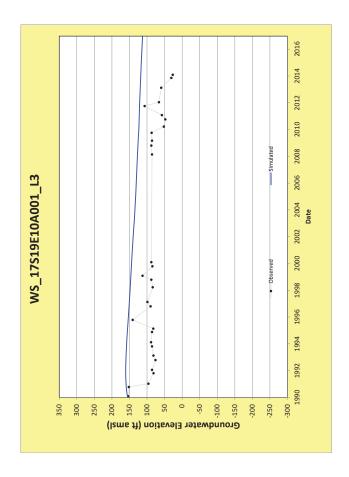


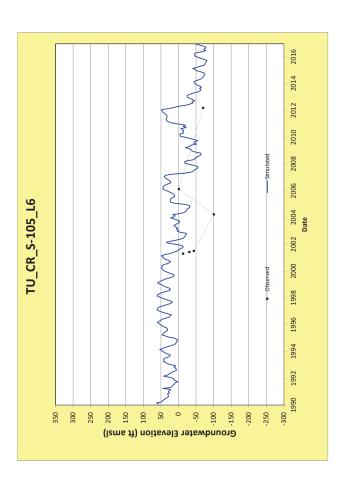


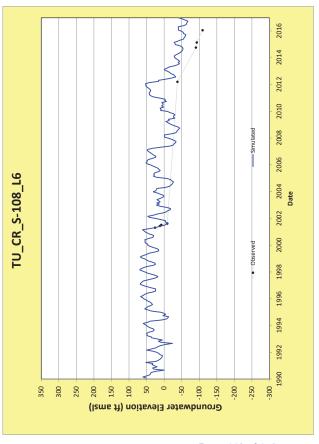


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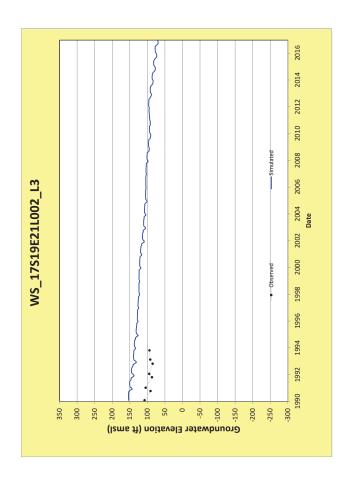


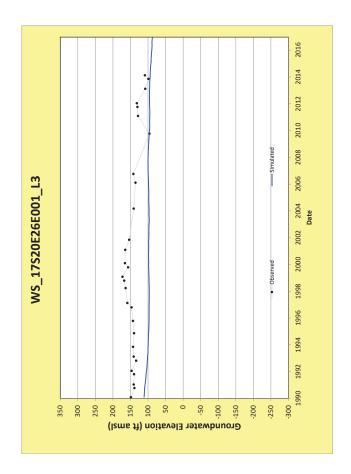


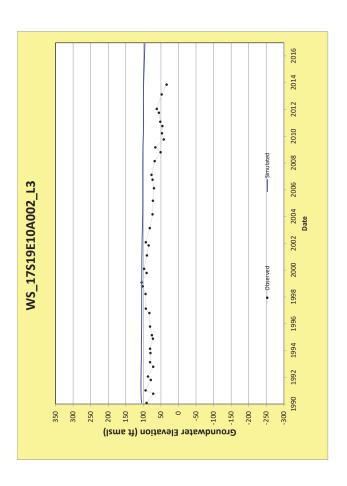


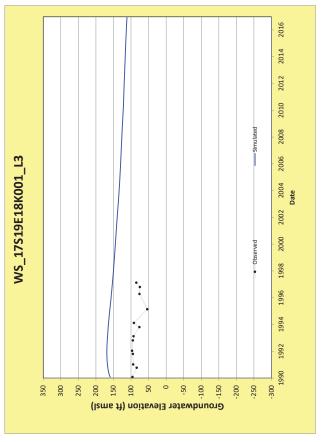


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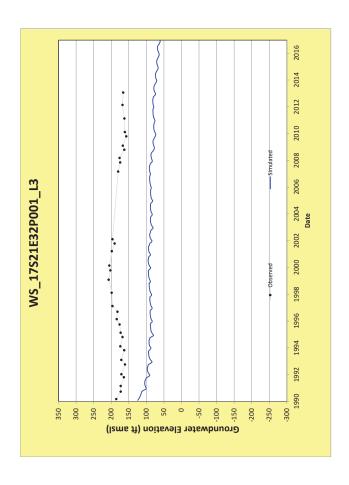


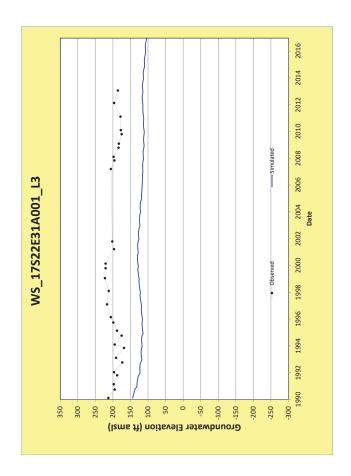


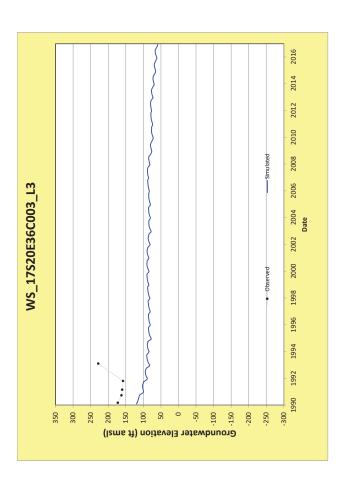


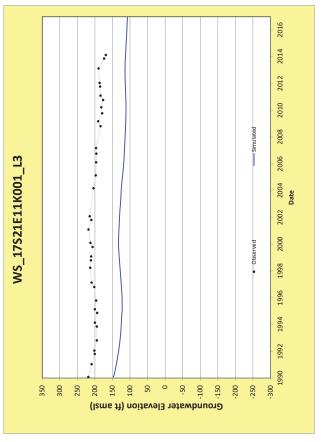


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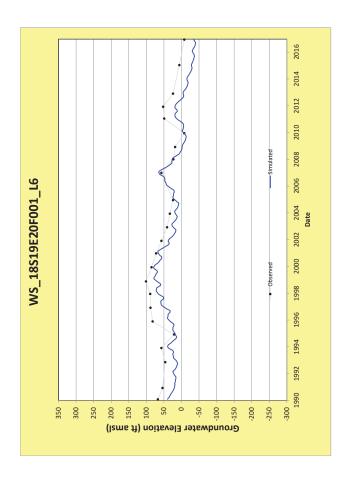


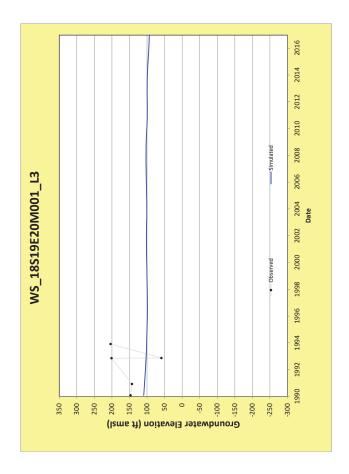


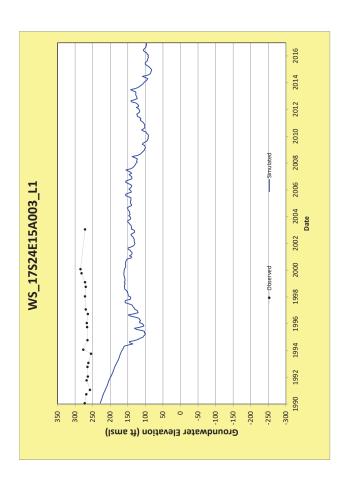


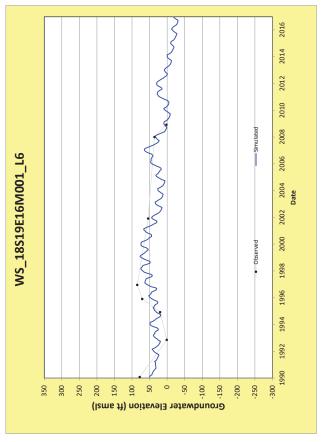


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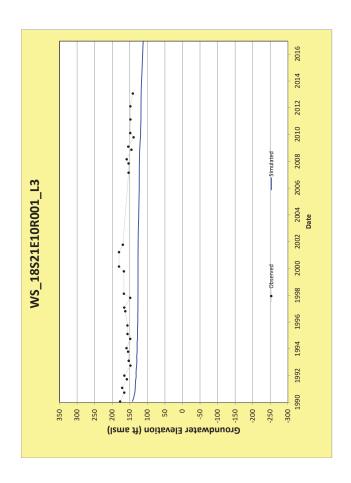


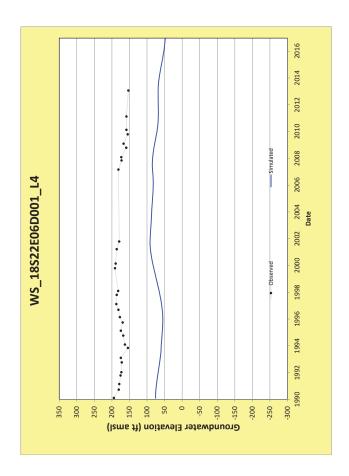


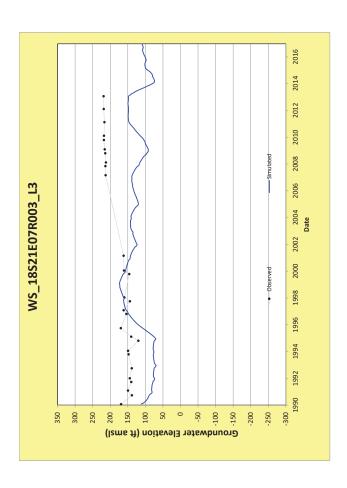


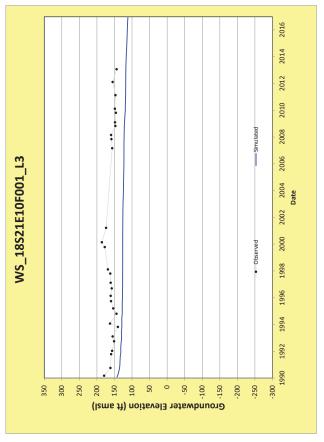


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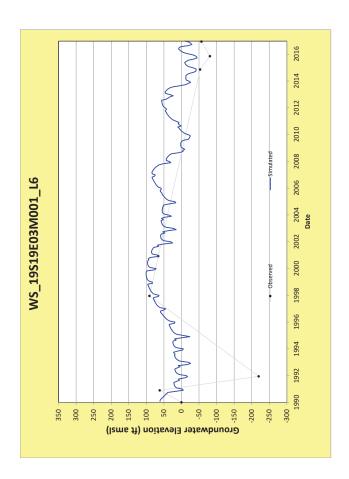


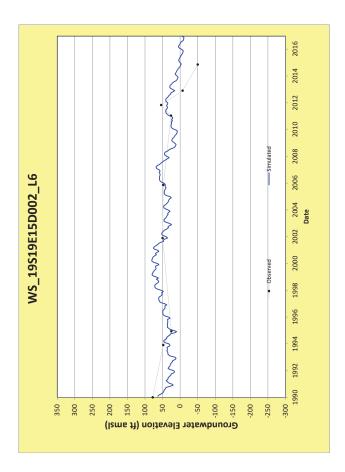


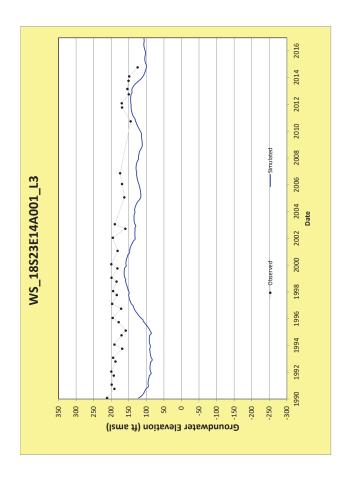


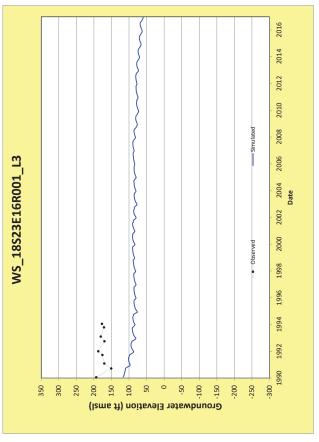


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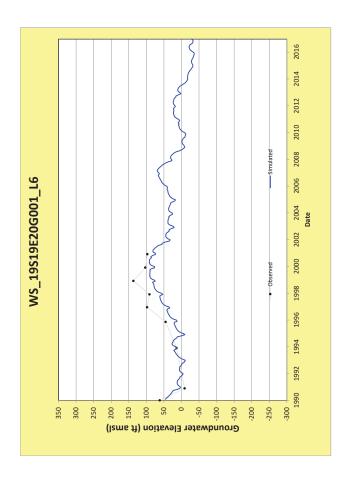


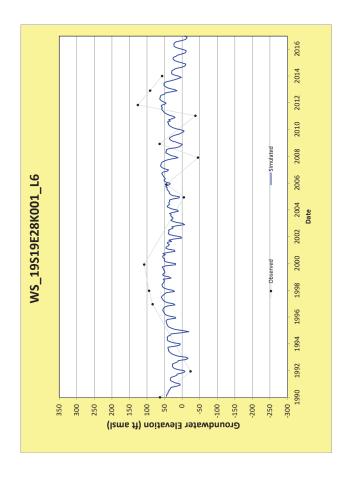


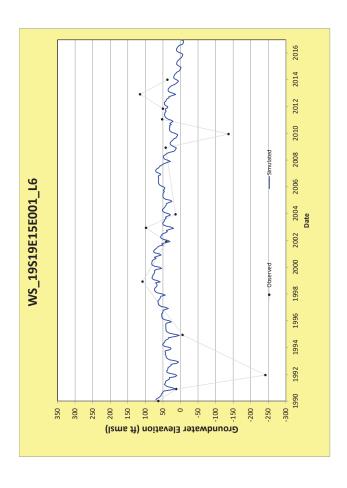


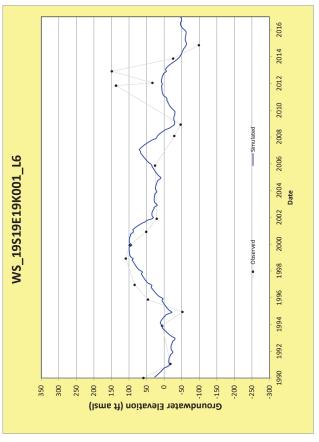


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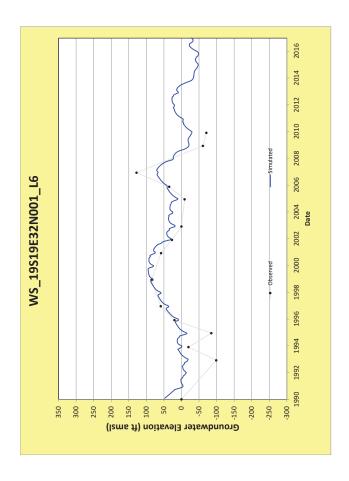


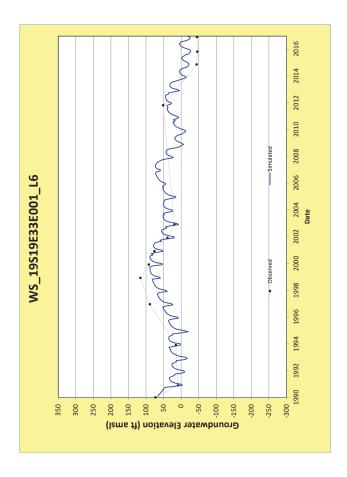


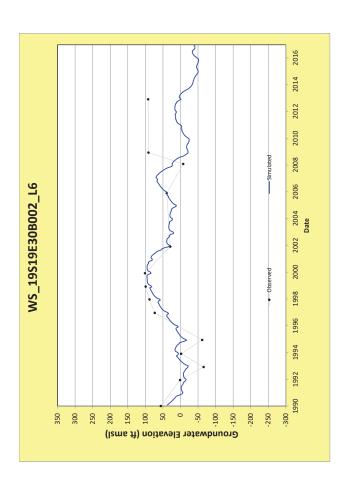


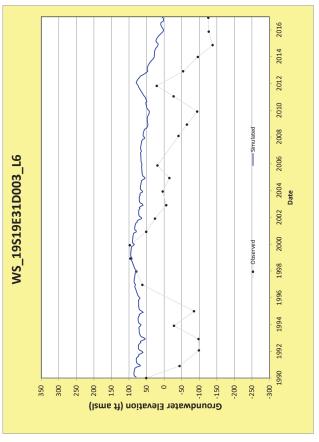


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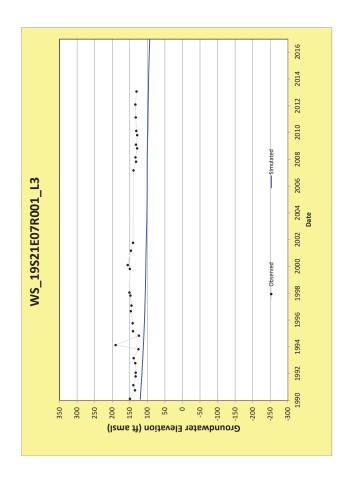


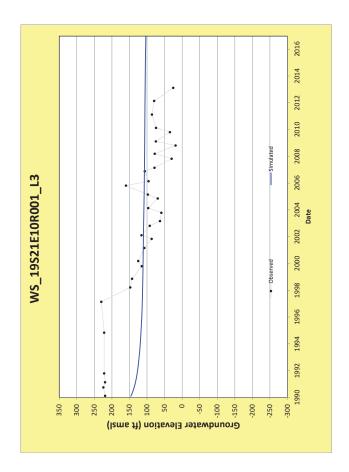


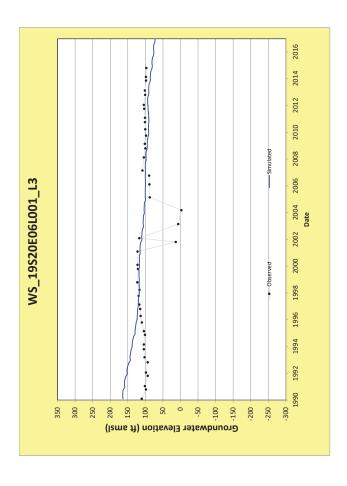


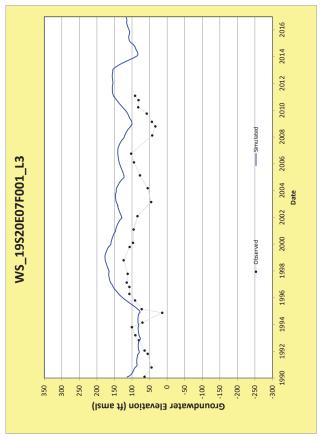


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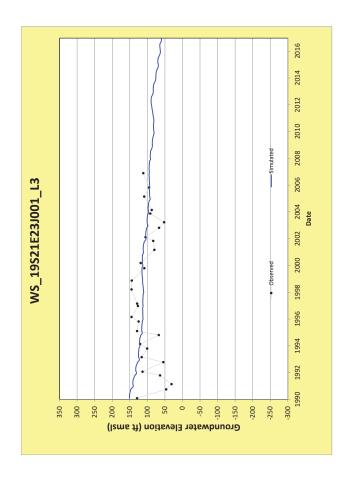


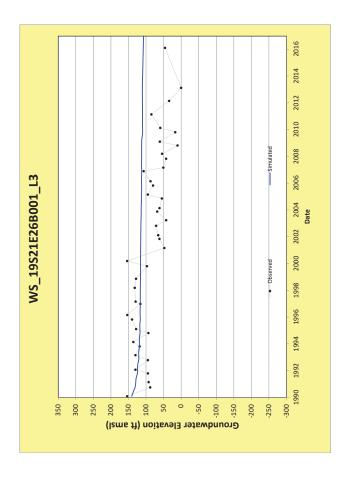


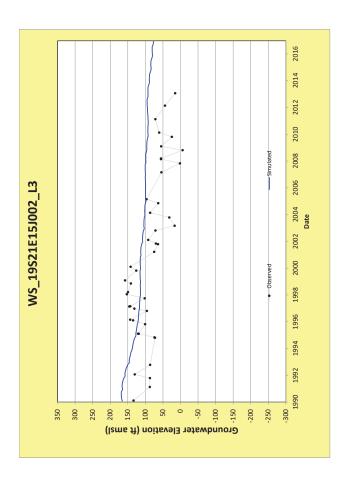


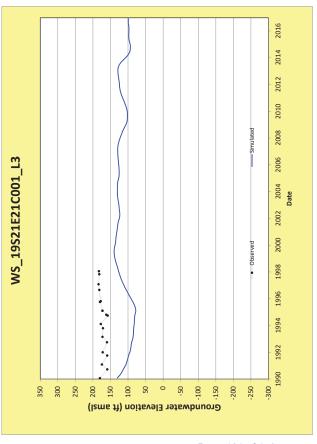


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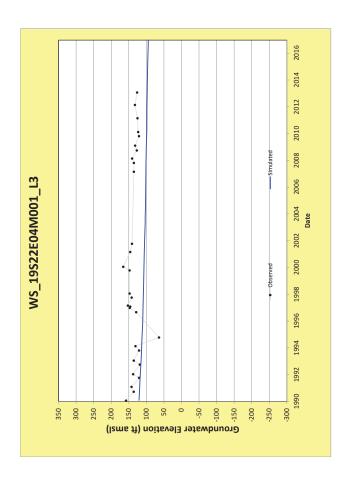


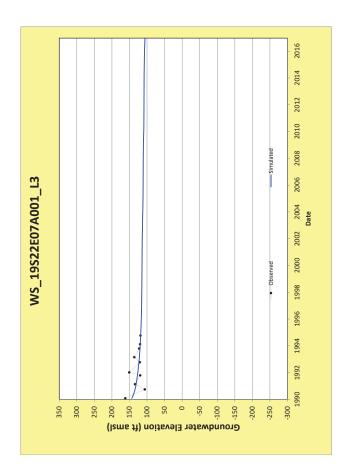


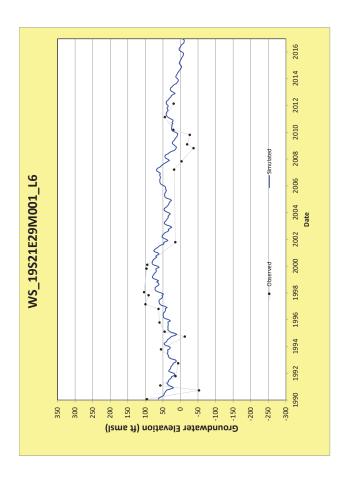


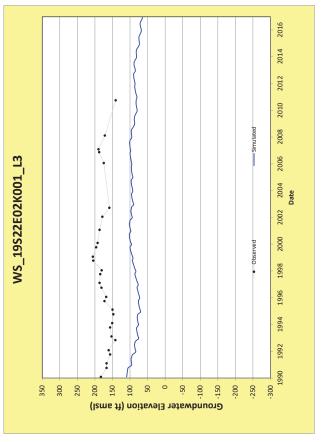


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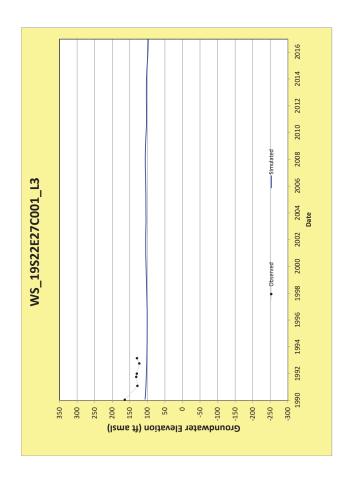


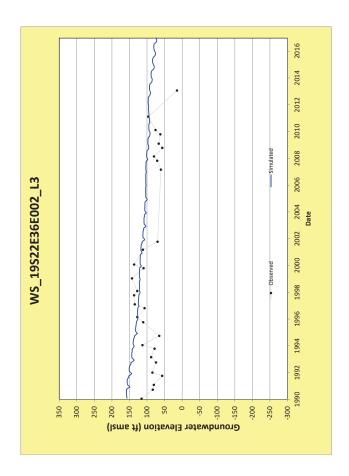


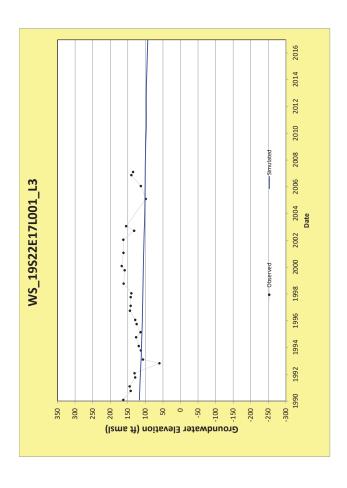


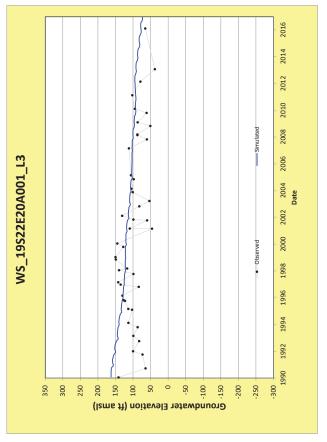


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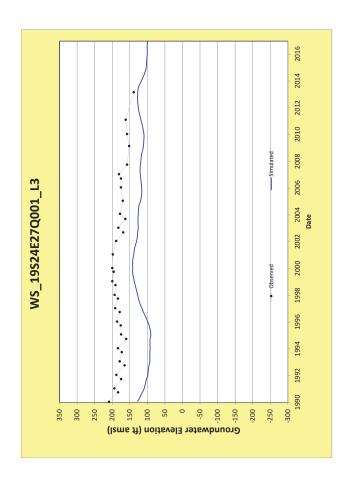


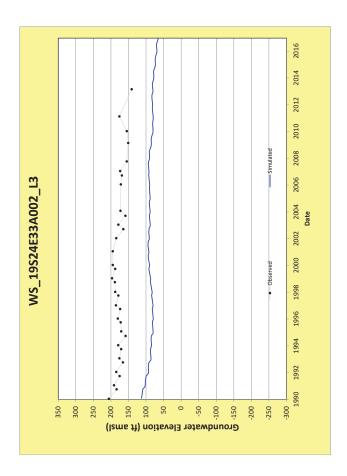


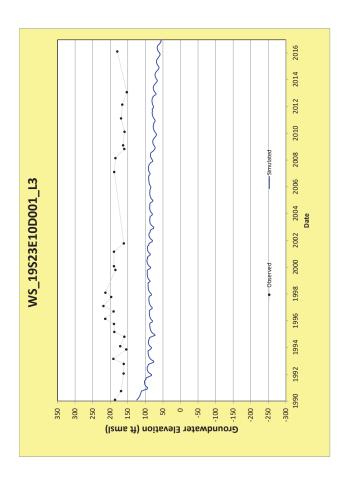


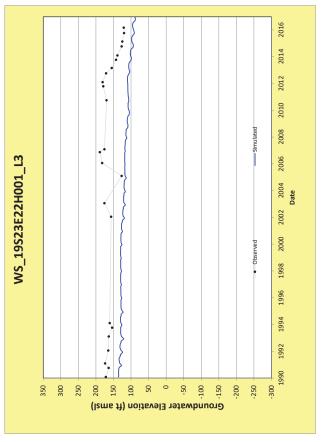


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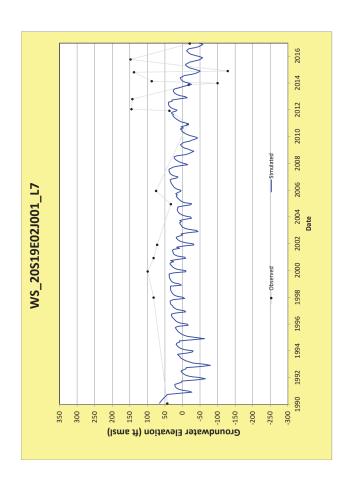


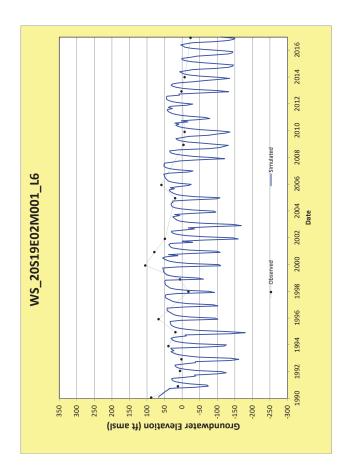


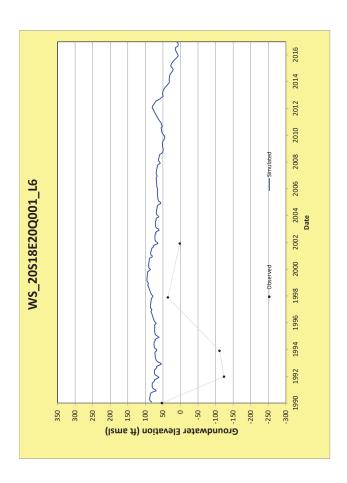


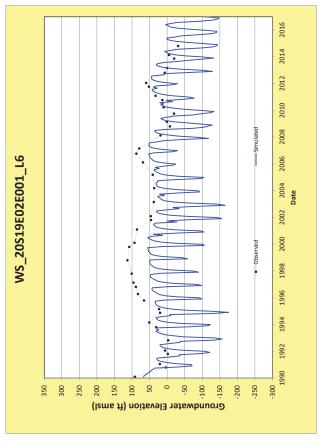


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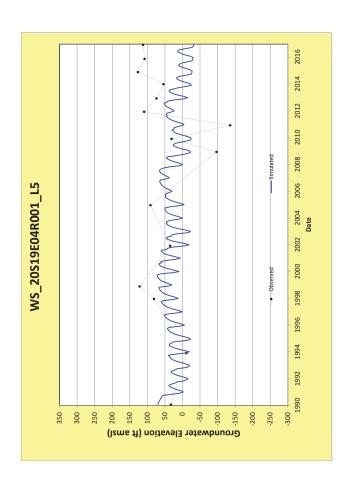


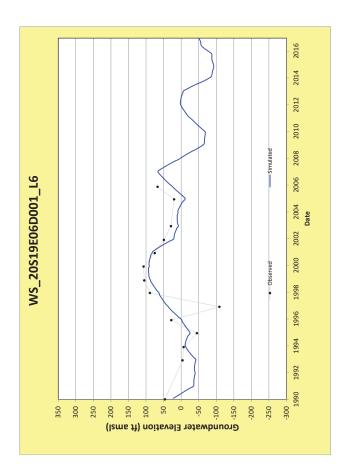


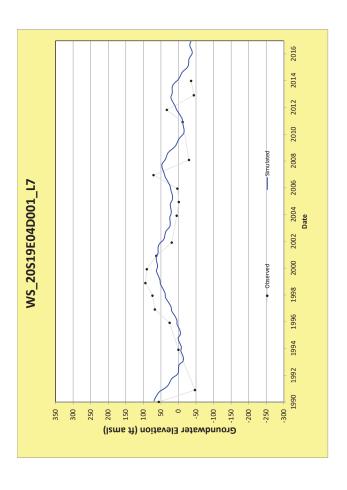


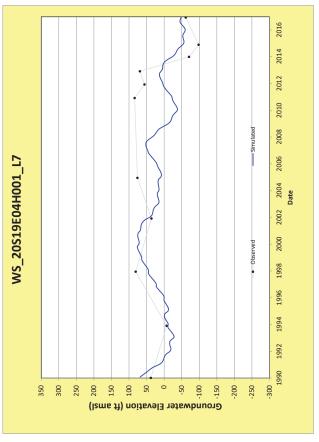


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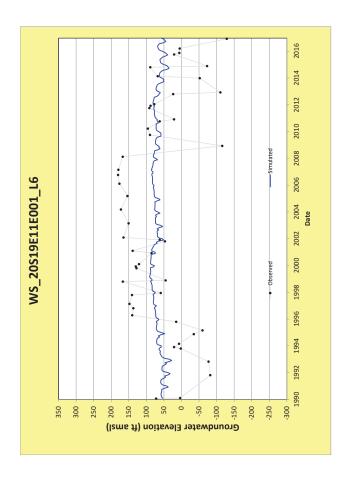


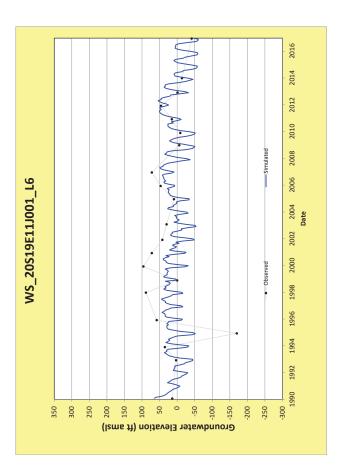


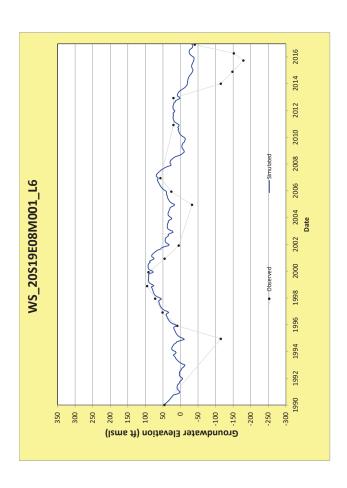


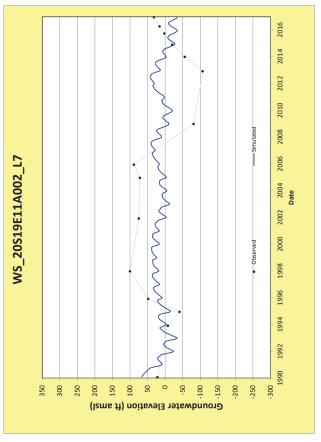


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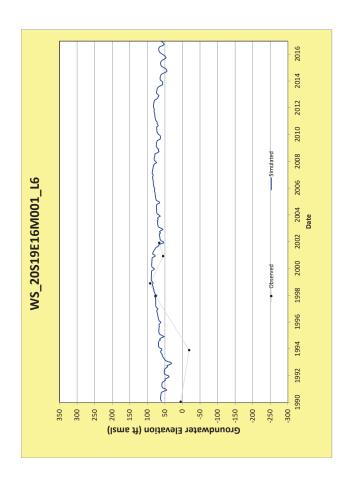


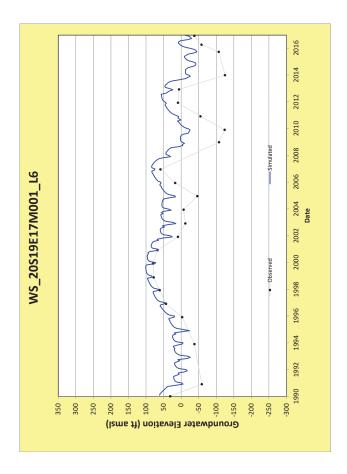


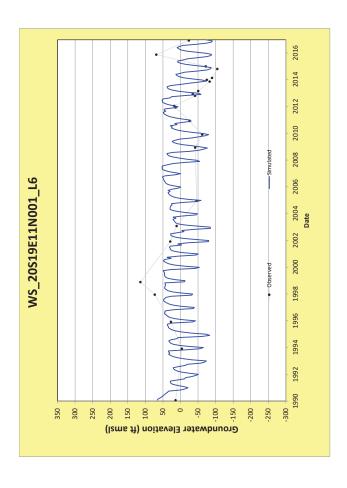


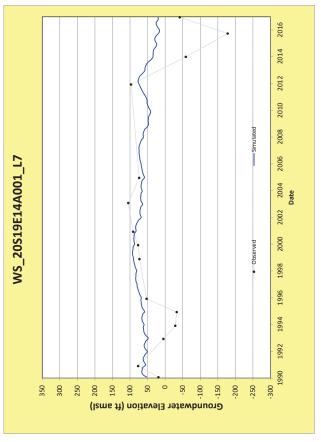


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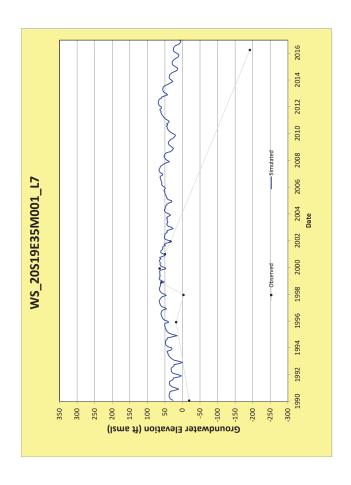


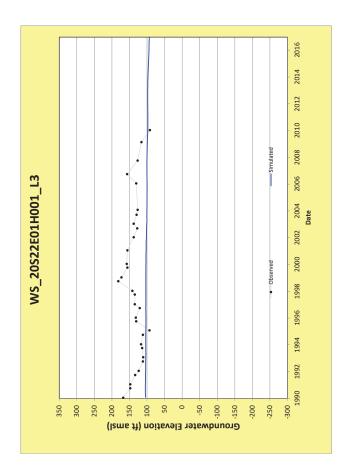


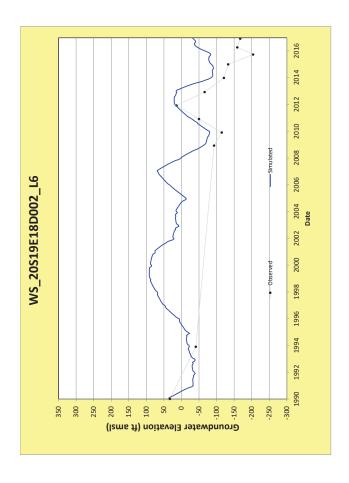


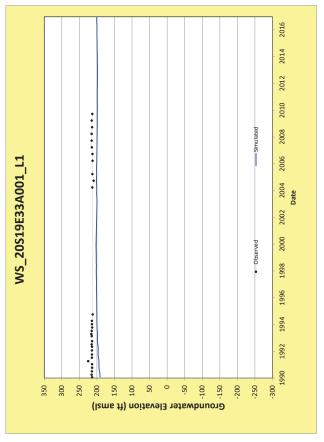


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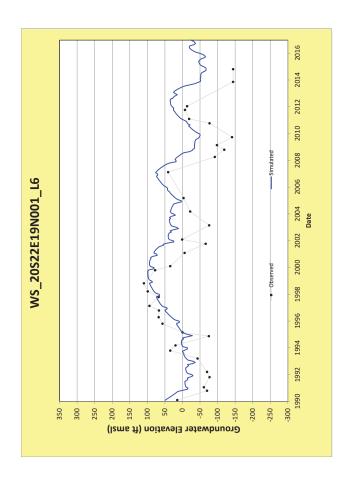


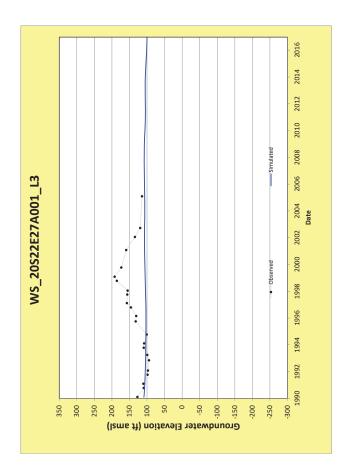


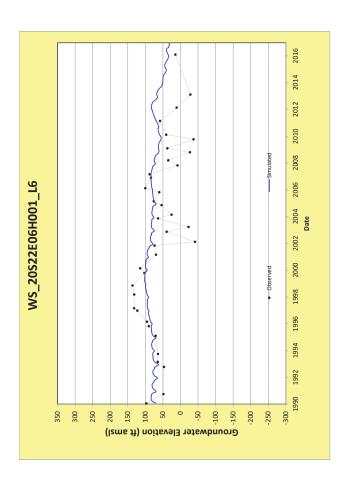


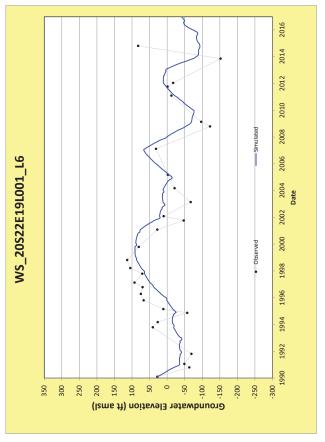


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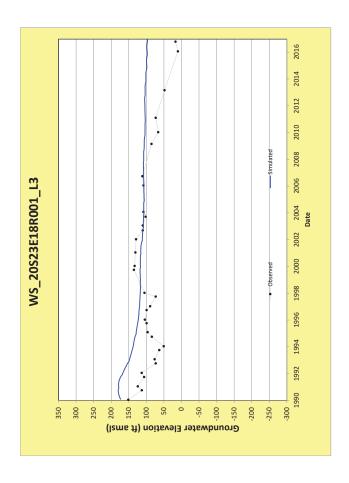


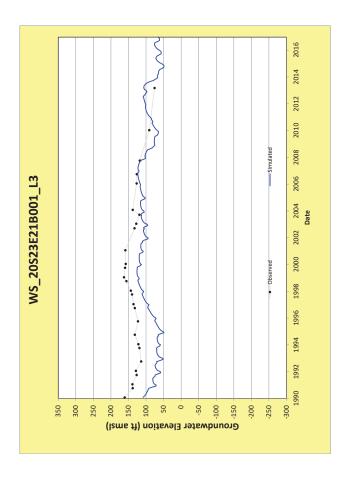


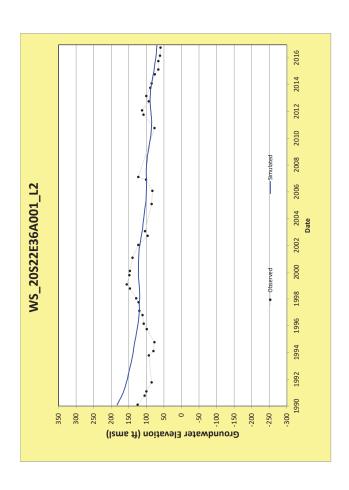


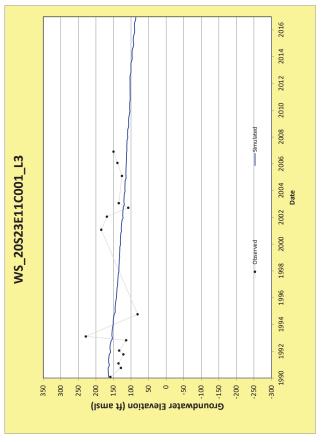


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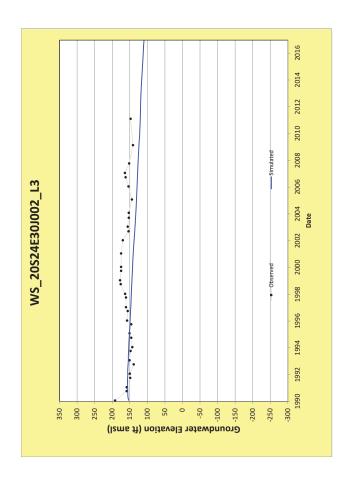


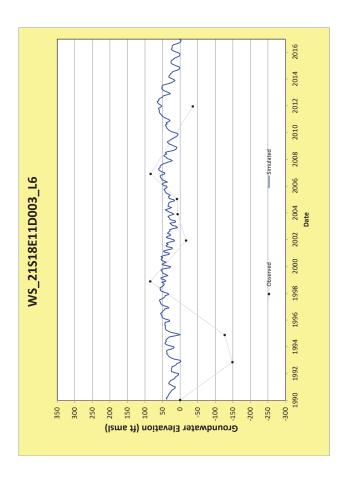


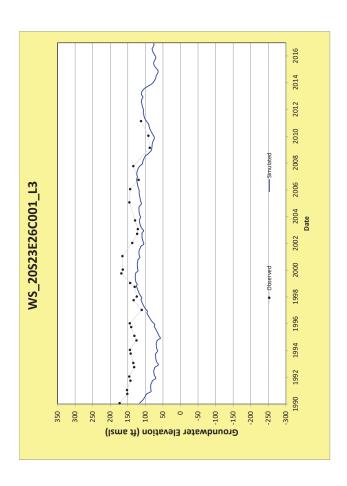


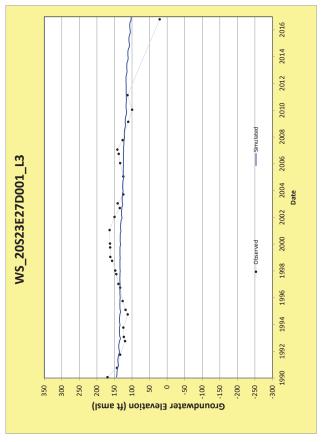


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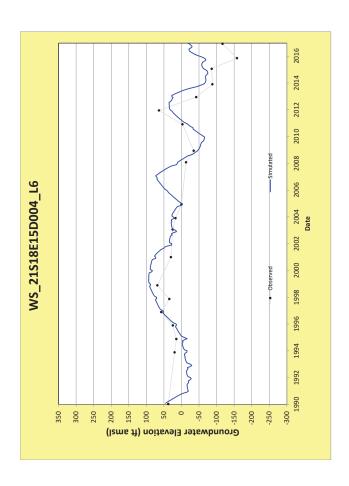


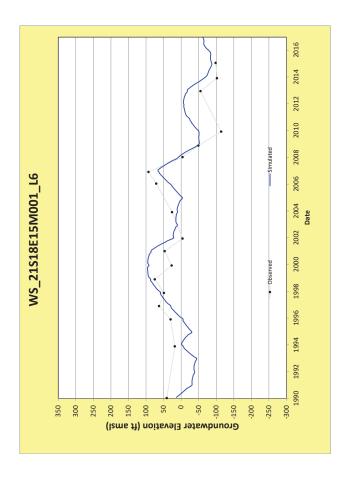


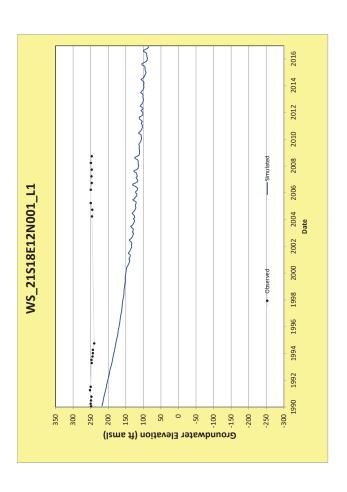


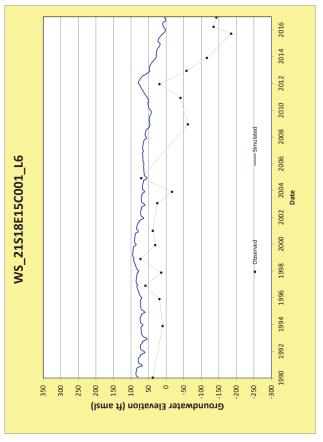


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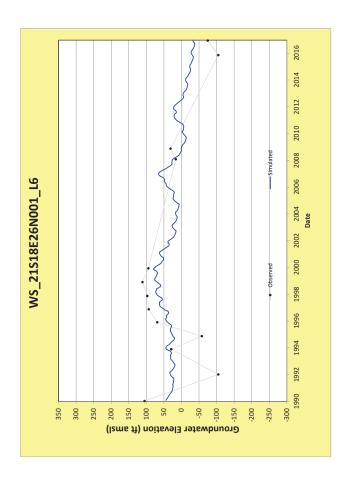


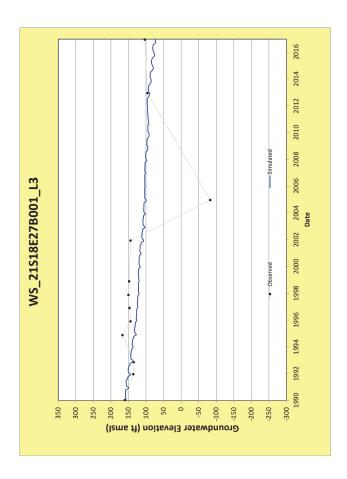


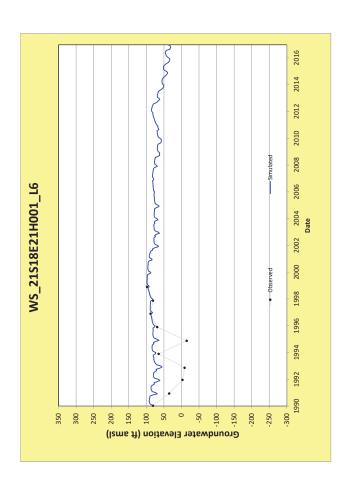


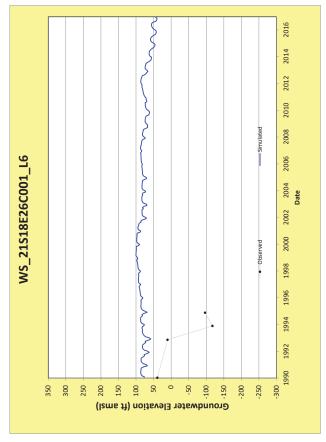


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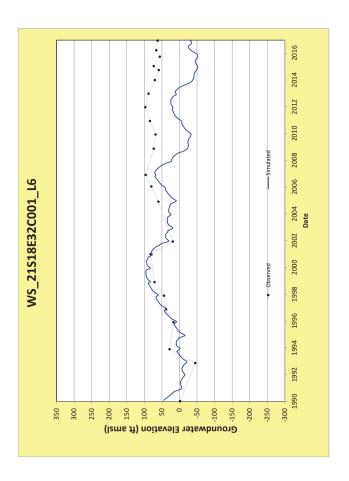


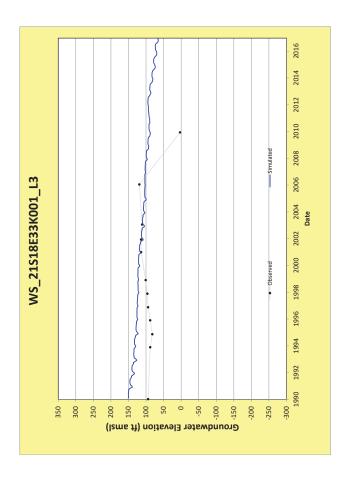


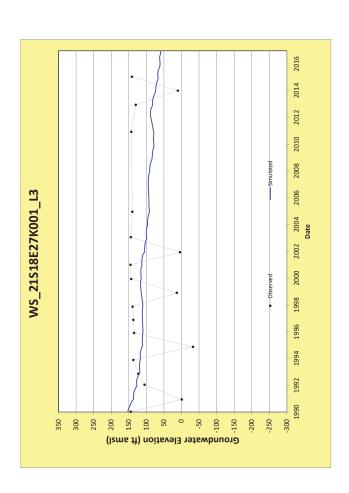


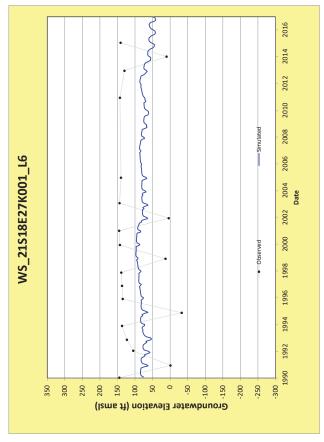


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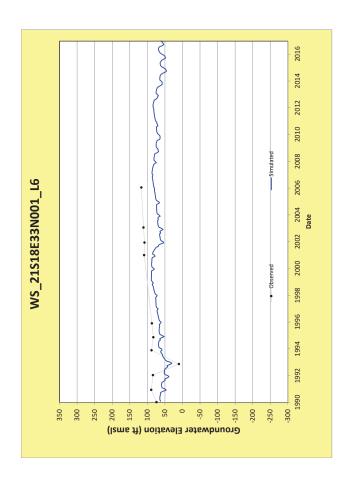


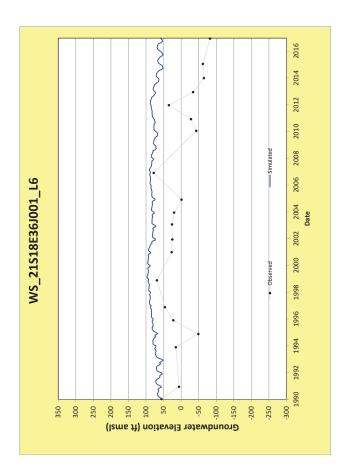


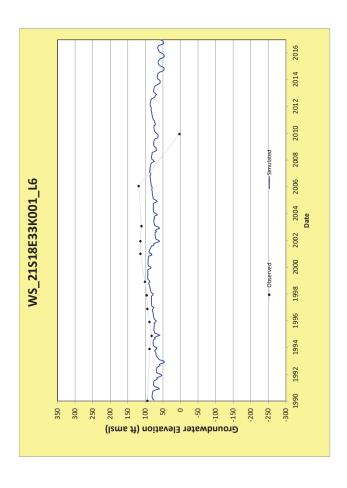


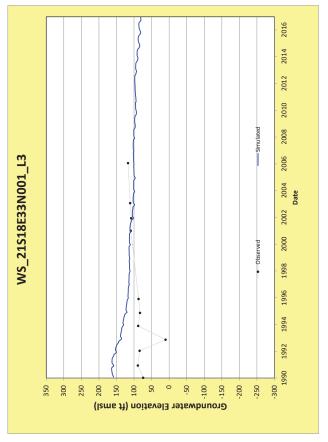


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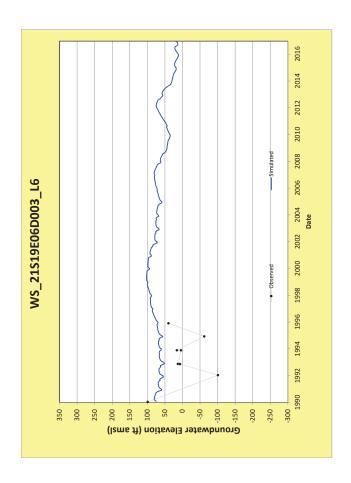


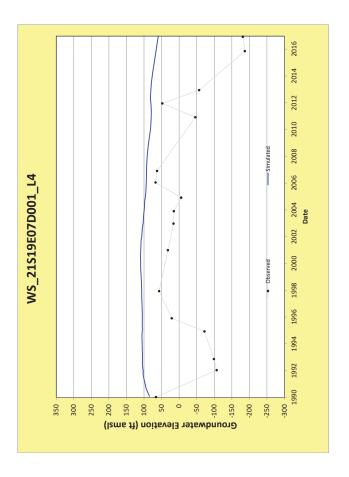


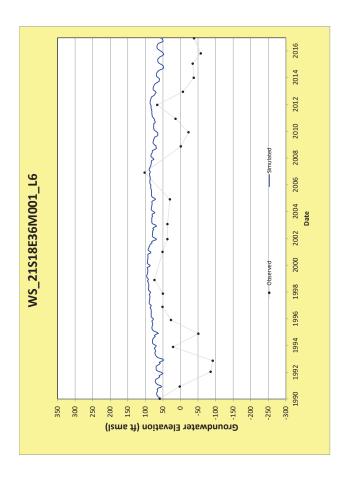


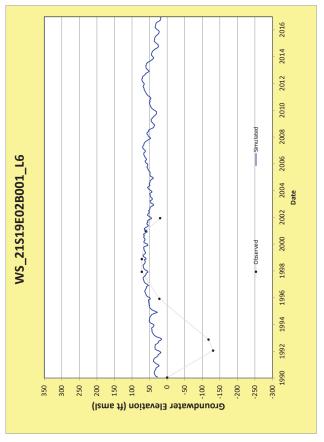


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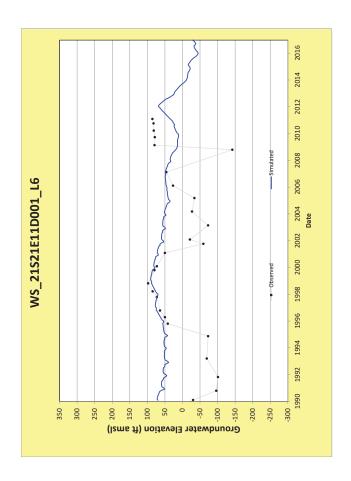


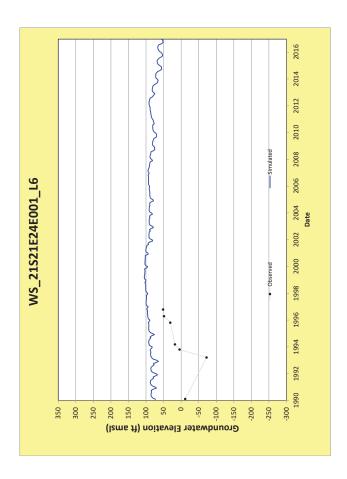


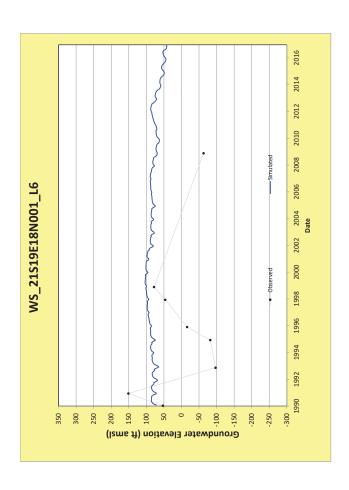


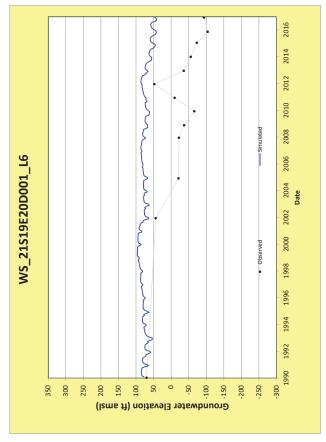


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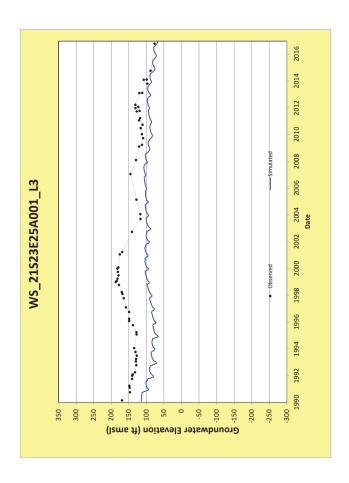


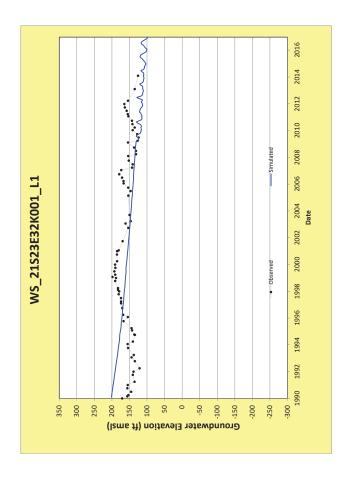


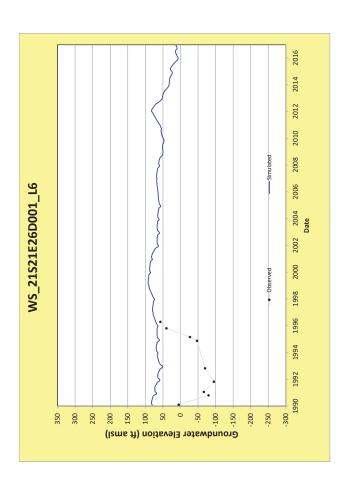


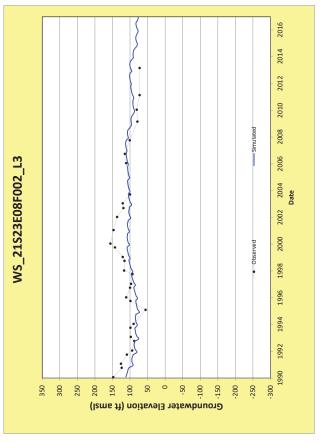


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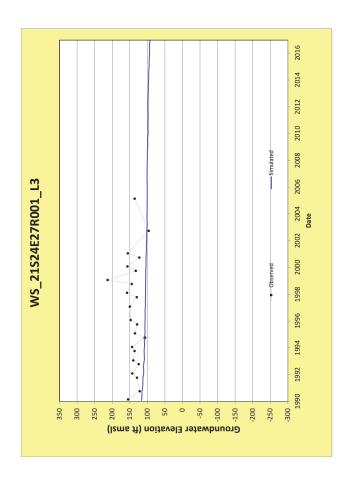


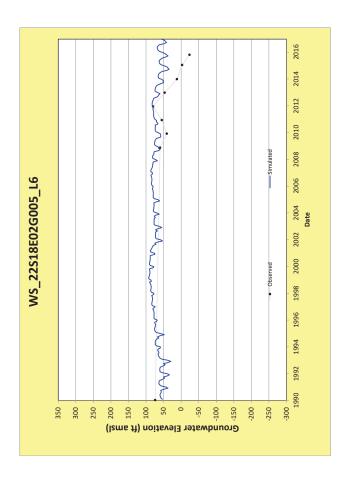


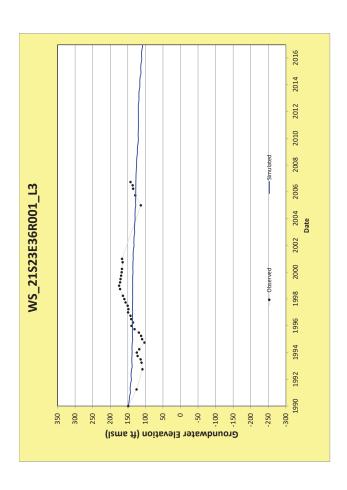


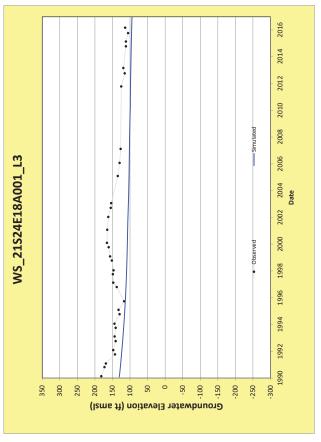


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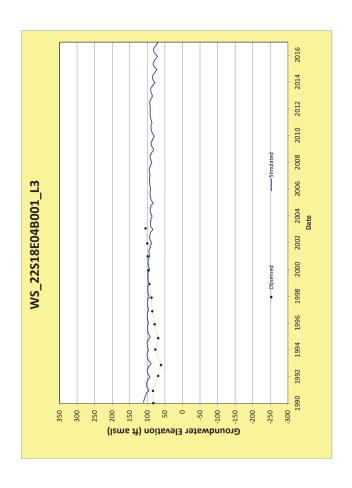


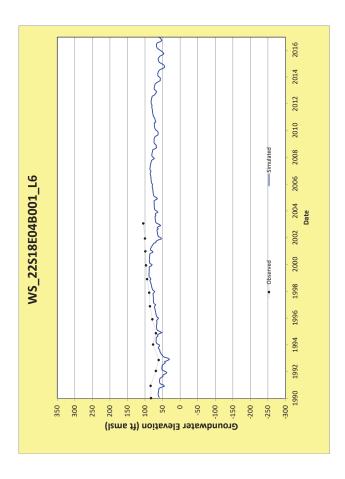


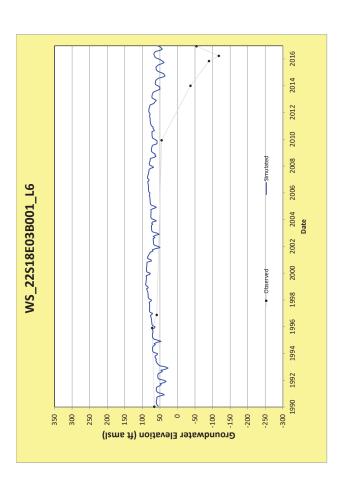


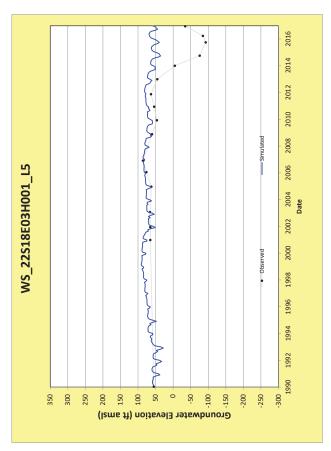


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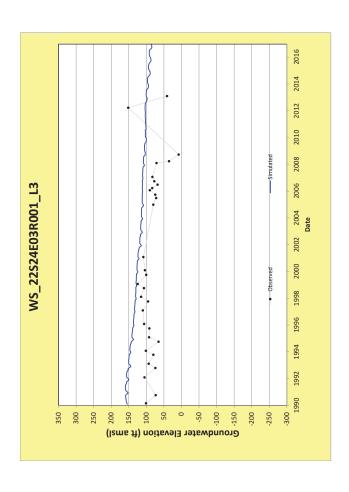


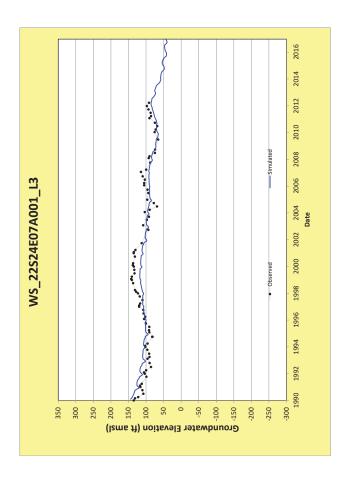


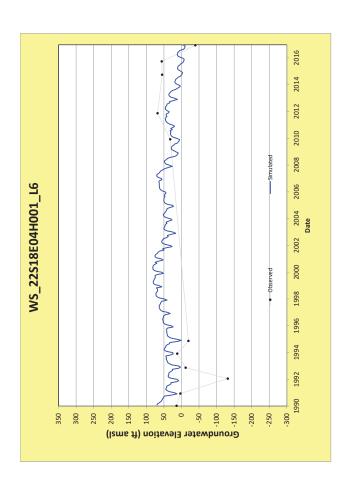


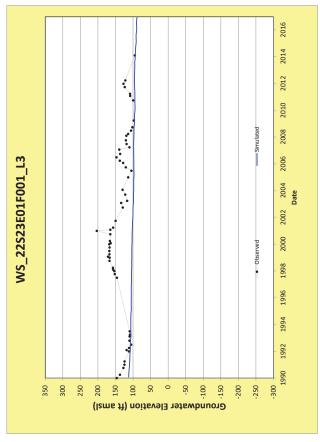


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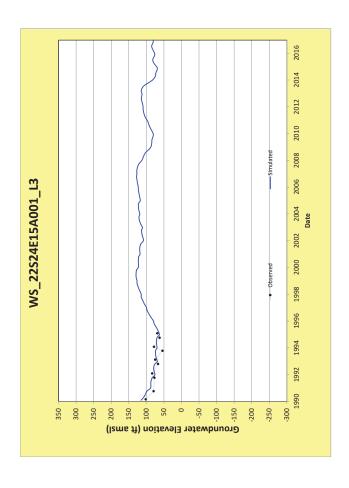


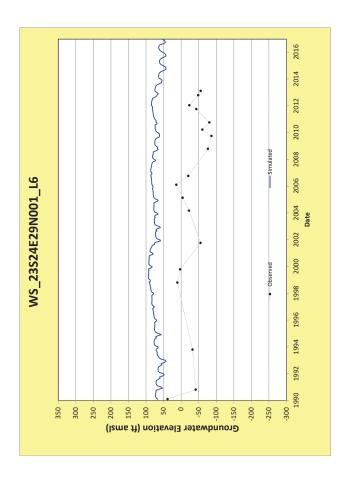


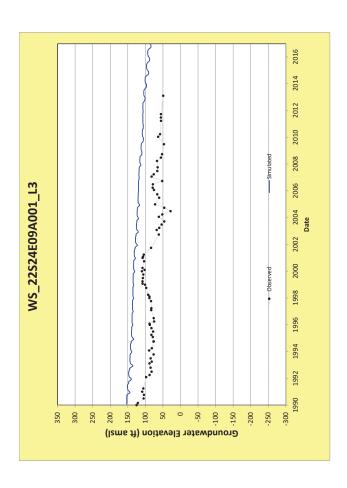


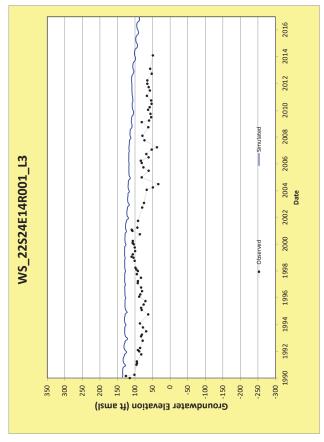


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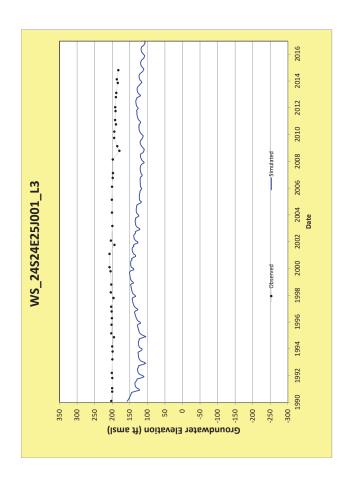


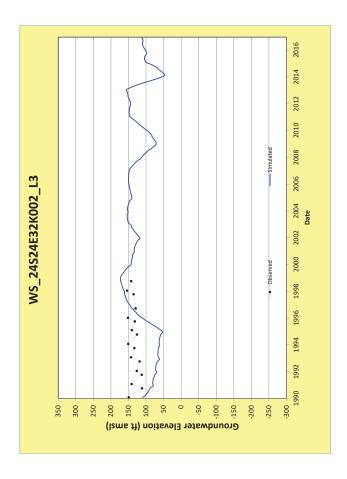


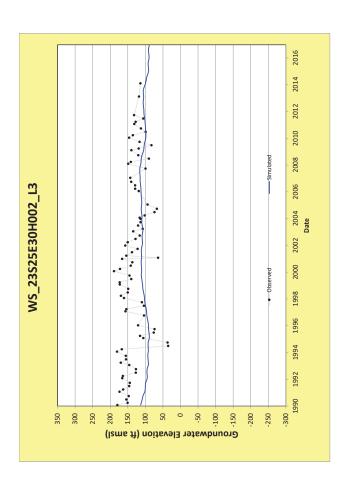


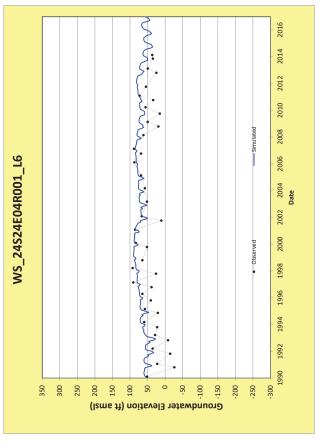


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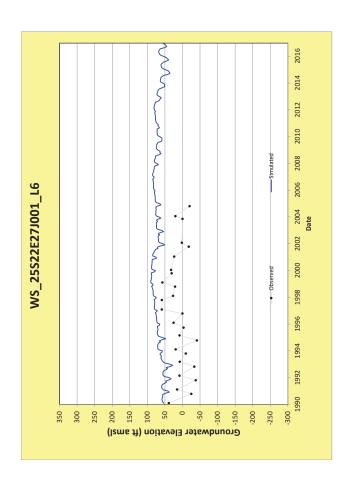


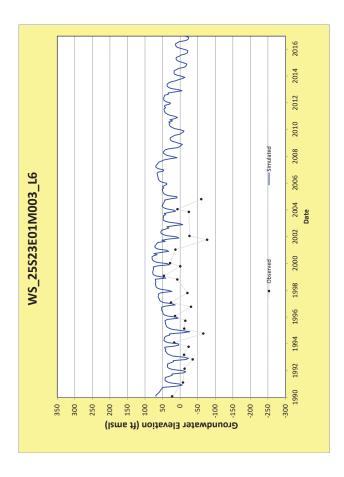


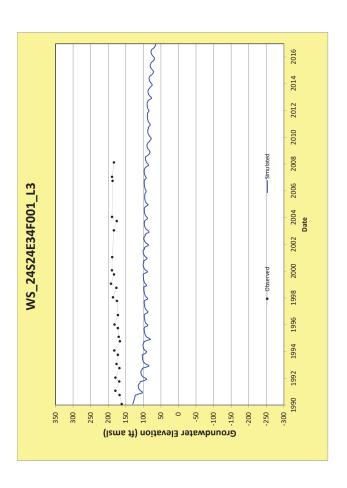


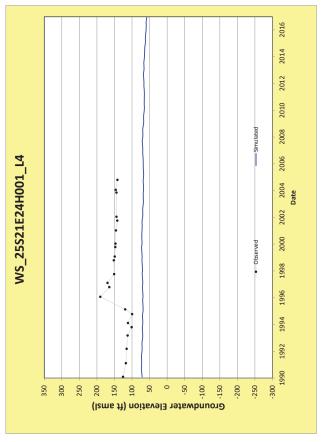


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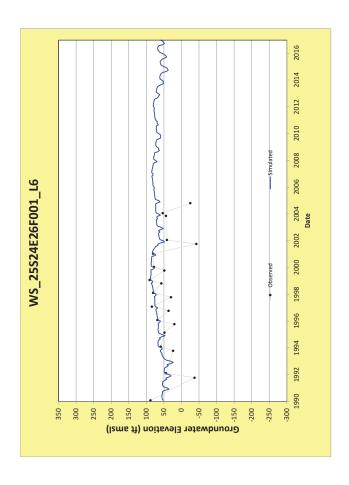


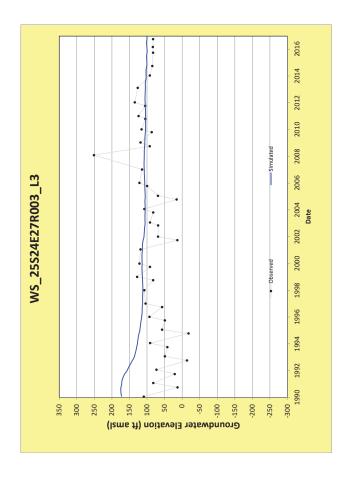


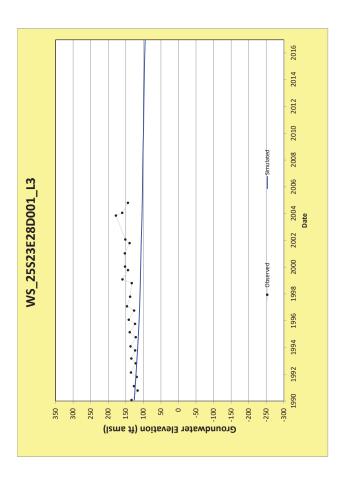


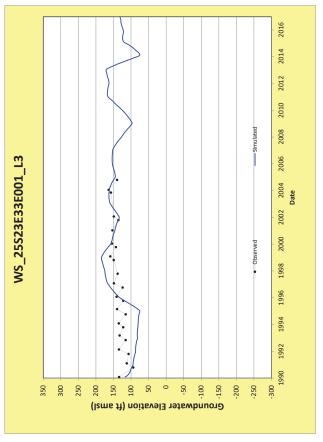


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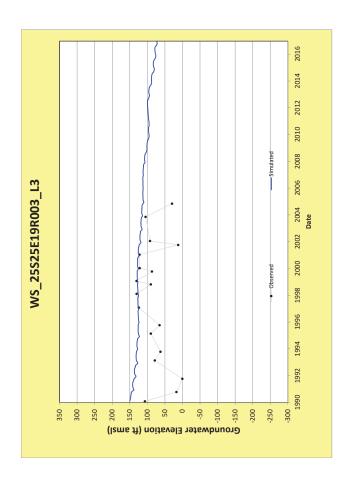


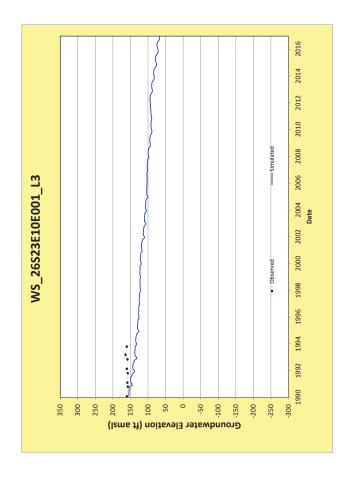


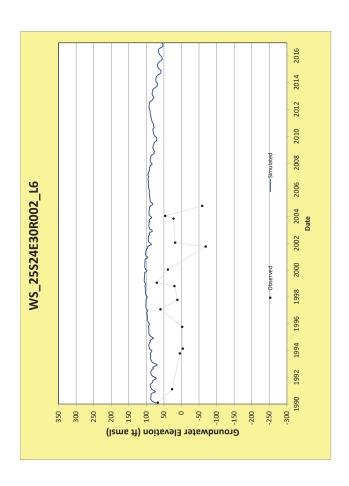


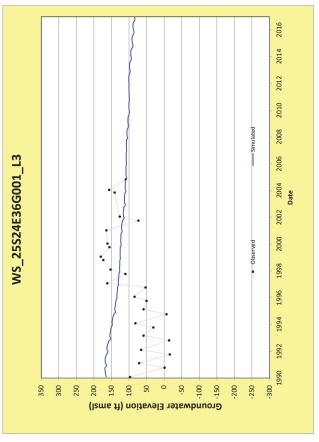


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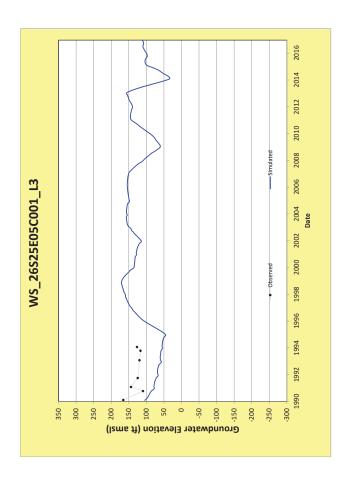


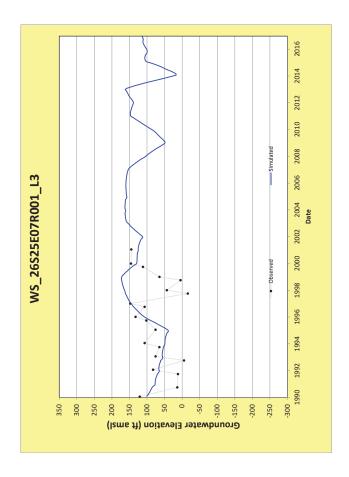


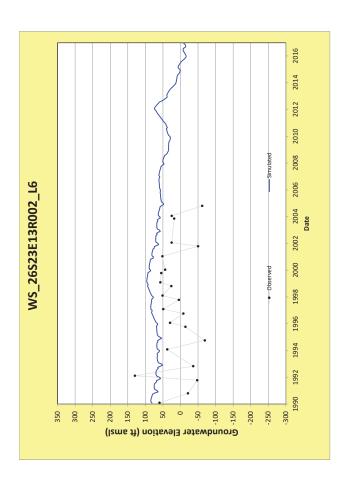


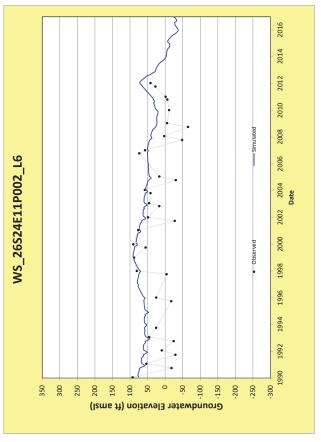


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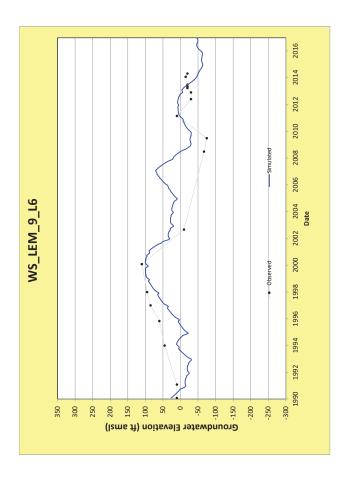


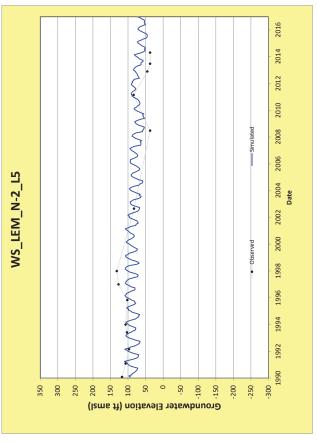






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wood.

Appendix D6 Peer Review of TLSBHM



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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.

Model Objectives

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).

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,

Jim McCord, PhD, PE
Principal Hydrogeologist

Tulare Lake Subbasin

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, Suba	Article 5. Plan Contents, Subarticle 1. Administrative	rative Information	
354.4	10733.2	General	a. Executive Summary- written in plain language	a. Executive Summary p. ES-1 to ES-40
		Information	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	b.Ch. 8, References p. 8-1 to 8-12
354.6	10733.2	Agency	a. GSA Mailing Address	a. Appendix A
		Information	 b. Organization and Management Structure including persons with management authority for Groundwater Sustainability Plan (GSP) implementation 	b. Section 1.4.1 (p. 1-6) c. Appendix A
			c. Contact Information of Plan Manager	d. Section 1.4.2 (p. 1-6)
			d. Legal Authority of GSA	e. Section 1.4.3 (p. 1-7)
			e. Estimate of Implementation Costs	
354.8.(a)	10733.2	Map(s)	1. Area covered by GSP	1. Chapter 2 (p. 2-1)
			2. Adjudicated areas, other agencies within the basin, and areas covered by an Alternative	2. Section 2-1, (p. 2-3)
			3. Jurisdictional boundaries of federal or state land	
			4. Existing Land Use Designations & identification of water use sector/water source type	5. Chapter 2 (p. 2-2)
			5. Density of wells per square mile	
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	 Summary of general plans and other land use plans Description of how implementation of the GSP may change water demands or affect achievement of sustainability and how the GSP addresses those effects Description of how implementation of the GSP may affect the water supply assumptions of relevant land use plans Summary of the process for permitting new or replacement wells in the basin 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
			 Explanation of GSA's decision making process Identification of opportunities for public engagement and how public input will be used How agencies will encourage diverse active involvement from community How the GSAs will inform the public about progress of the GSP 	 Section 2.5.2 (p. 2-27) Section 2.5.4 (p. 2-29) Section 2.5.5 (p. 2-31) Section 2.5.4 (p. 2-29)
Article 5. Plan	Contents, Suba	Article 5. Plan Contents, Subarticle 2. Basin Setting	tting	
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: Regional geologic and structural setting of the Subbasin, as well as surrounding areas Lateral basin boundaries including major geologic features Definable bottom of the basin pofinable bottom of the basin principal aquifers and aquitards including: formation names physical properties of aquifers and aquitards 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 3.1.1 (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	нсм, марs	 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. 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: Total surface water entering and leaving the Subbasin (by water source type) Inflow to the groundwater system by water source type Outflows from the groundwater system by water use sector Change in annual volume of groundwater in storage sector Change in annual volume of groundwater in storage socionitions Water year and water supply conditions compared to average conditions Water year type associated with annual supply, demand, and change in groundwater T. 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	d. Section 3.3 (p. 3-40) 1. Section 3.3.6 (p. 3-52)
			 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	

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: Reason for creation of each management area MO/MTs for each management area and why those values were selected if vary from Subbasin Level of monitoring and analysis in each management area Why MO/MTs can differ without causing undesirable results 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, Suba	rticle 3. Sustaina	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,	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
			 Potential effects of Undesirable Results on beneficial uses and users of groundwater 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 4.3.2 (p. 4-16) 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
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, Suba	Article 5. Plan Contents, Subarticle 4. Monitoring Network	ng 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: Demonstrate progress towards achieving MOs Monitor impacts to beneficial uses or users of groundwater Monitor changes in groundwater conditions relative to MOs and MTs 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) 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
			 Consistency with data and reporting standards Corresponding sustainability indicator, MTs, MOs, and interim milestone 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 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)

Tulare Lake Subbasin

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 **IMPLEMENT** SUBBASIN TO DEVELOP AND Α 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) sustainableyield (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) entities¹ 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. <u>Term.</u> 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 <u>Withdrawal.</u> 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 <u>Construction of Terms.</u> 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 <u>Good Faith</u>. 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 <u>Rights of the Parties and Constituencies</u>. 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 <u>Counterparts.</u> 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 <u>Governing Law</u>. 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 <u>Waiver</u>. 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 <u>Recitals and Exhibits.</u> The Recitals and Exhibits are incorporated into the Agreement.

SECTION 5. CONFIDENTIALITY PROVISIONS

- 5.1 <u>Confidential Information</u>. 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 <u>Duty to Protect</u>. 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 <u>Limited Use</u>. The Parties shall use the Confidential Information only for the purposes set forth in this Agreement.
- 5.4 <u>Limited Disclosure</u>. 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 <u>Allowable Disclosure</u>. 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.

(the remainder of this page has been intentionally left blank)

Mid-Kings River Groundwater Sustainability Agency	
By: Bory Mentel	Title: Chairman
Name: Barry M Cutches	ń
South Fork Kings Groundwater Sustainability Agency	
By:	Title:
Name:	Title:
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:	

Sustainability Agency	
Ву:	Title:
Name:	
South Fork Kings Groundwater Sustainability Agency	
By: Joe Meves Name: Joe Neves	Title: Chairman
Name: Joe Neves	nuc.
El Rico Groundwater Sustainability Agency	
Ву:	Title:
Name:	
Southwest Kings Groundwater Sustainability Agency	
By:	Title:
Name:	
Tri-County Water Authority	
Ву:	Title:
Name:	
Alpaugh Irrigation District	
Ву:	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: Name: Description D	Title: CHAIRMAN
Southwest Kings Groundwater Sustainability Agency	
Ву:	Title:
Name:	-
Tri-County Water Authority	
Ву:	Title:
Name:	-
Alpaugh Irrigation District	
Ву:	Title:
Name:	

Agency	
Ву:	Title:
Name:	
South Fork Kings Groundwater Sustainability Agency	
Ву:	Title:
Name:	
El Rico Groundwater Sustainability Agency	
By:	Title:
Name:	
Southwest Kings Groundwater Sustainability Agency	
Ву:	Title: President
Name: Wicham & PHILLIMOTES	
Tri-County Water Authority	
Ву:	Title:
Name:	
Alpaugh Irrigation District	
Ву:	Title:
Name:	1100.

Mid Kings Groundwater Sustainability Agency	
Ву:	Title:
Name:	
South Fork Kings Groundwater Sustainability Agency	
By:	Title
Name:	Title:
El Rico Groundwater Sustainability Agency	
Ву:	Title:
Name:	
Southwest Kings Groundwater Sustainability Agency	
Ву:	Title:
Name:	
Tri-County Water Authority By: Matth H	Title: Chairman
Name: MATTHEN H. HURLEY	
Alpaugh Irrigation District	
Ву:	Title:
Name:	

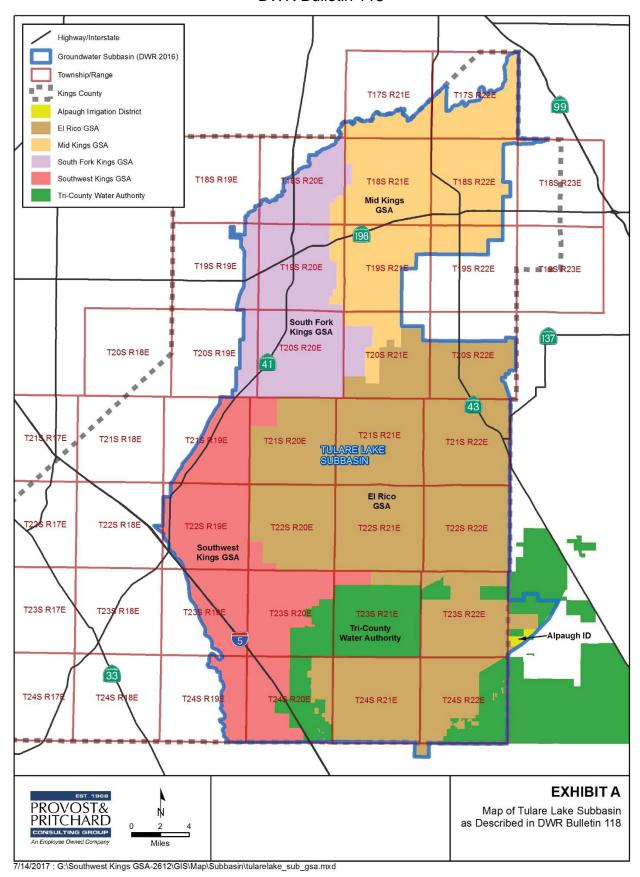
Sustainability Agency	
By:	Title:
Name:	
South Fork Kings Groundwater Sustainability Agency	
By:	Title:
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El Rico Groundwater Sustainability Agency	
By:	Title:
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Southwest Kings Groundwater Sustainability Agency	
By:	Title:
Name:	
Tri-County Water Authority	
By:	Title:
Name:	
Alpaugh Irrigation District	
By: Su Munt	Title: 6.M.
Name: Bruce Howard	

Mid-Kings River Groundwater

Exhibit "A"

Map of Tulare Lake Subbasin as Described in

DWR Bulletin 118



2011056v2 / 20142.0001



APPENDIX G

REPRESENTATIVE MONITORING SITES FORECAST HYDROGRAPHS WITH PROJECTS

Representative Monitoring Site	Page #	Representative Monitoring Site	Page #
ER_CID-021	1	MKR_1610003-042	25
ER_Proposed_B2	1	MKR_MWD_DEEP	25
ER_Proposed_B3	2	MKR_MWG_DEEP	26
ER_Proposed_B4	2	MKR_MWH_DEEP	26
ER_20S21E11N001M	3	MKR_Proposed_C1	27
ER_20S21E24F001M	3	MKR_Proposed_C2	27
ER_20S22E14C001M	4	MKR_Proposed_C3	28
ER_21S22E07J001M	4	MKR_Proposed_C4	28
ER_CID_078	5	MKR_Proposed_C5	29
ER_KRCDTL002	5	SFK_18S20E23E003M	29
ER_KRCDTL003	6	SFK_19S20E29E002M	30
ER_M-140	6	SFK_20S19E25A003M	30
ER_S-173	7	SFK_Proposed_A1	31
ER_S-205	7	SFK_Proposed_A2	31
ER_S-225	8	SFK_1610005-009	32
ER_Proposed_C1	8	SFK_18S20E23E001M	32
ER_Proposed_C2	9	SFK_18S20E23E002M	33
ER_Proposed_C3	9	SFK_18S20E34N001M	33
ER_Proposed_C4	10	SFK_19S20E19A001M	34
ER_Proposed_C5	10	SFK_19S20E06C001M	34
ER_Proposed_C6	11	SFK_19S20E06L001M	35
ER_Proposed_C7	11	SFK_19S20E07F001M	35
ER_Proposed_C8	12		36
MKR_18S21E17N001M	12	SFK_19S20E32D003M	36
MKR_19S21E20N001M	13	SFK_20S20E26L001M	37
MKR_17S22E28A001M	13	SFK_20S20E26L002M	37
MKR_18S21E01C001M	14	SFK_Proposed_B1	38
MKR_18S21E07R003M	14	SFK_19S20E26N002M	38
MKR_18S21E27B001M	15	SFK_20S19E02A001M	39
MKR_18S21E31B001M	15	SFK_20S20E07H001M	39
MKR_18S22E03B001M	16	SFK_20S20E28E003M	40
MKR_18S22E07A001M	16	SFK_1610005-020	40
MKR_18S22E24D001M	17	SFK_1610005-011	41
MKR_18S22E28A001M	17	SFK_Proposed_C1	41
MKR_18S22E34R001M	18	SWK_1610009-003	42
MKR_19S21E30A001M	18	SWK_Proposed_B1	42
MKR_19S22E07K001M	19	SWK_Proposed_B2	43
MKR_MWA_INTDEEP	19	SWK_Well_16-8	43
MKR_MWC_INT	20	SWK_Proposed_C1	44
MKR_MWD_INT	20	SWK_Proposed_C2	44
MKR_MWG_INT	21	SWK_Proposed_C3	45
MKR_MWH_INT	21	TCWA_23S23E15M001M	45
MKR_Proposed_B1	22	TCWA_Proposed_B1	46
MKR_Proposed_B2	22	TCWA_24S22E33C001M	46
MKR_Proposed_B3	23	TCWA_24S22E35E001M	47
MKR_Proposed_B4	23	TCWA_Proposed_C1	47
 MKR_19S22E08D002M	24	TCWA_Proposed_B2	48
_ MKR_1610003-037	24	- · -	
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