KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Final

Amended Groundwater Sustainability Plan (GSP)

Kern River Groundwater Sustainability Agency (KRGSA) Plan Area

July 2022

TODD GROUNDWATER

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July 23, 2022

TRANSMITTAL LETTER

To: Paul Gosselin, Deputy Director of Sustainable Groundwater Management
California Department of Water Resources

From: Rodney Palla, Chairman, Board of Directors
Kern River Groundwater Sustainability Agency (KRGSA)

Re: **Submittal of Amended KRGSA Groundwater Sustainability Plan (GSP)**
In Response to the *Statement of Findings regarding the Determination of Incomplete Status of the San Joaquin Valley – Kern County Subbasin Groundwater Sustainability Plans, State of California, Department of Water Resources, January 28, 2022*

The Kern River Groundwater Sustainability Agency (KRGSA) is pleased to submit this Amended KRGSA Groundwater Sustainability Plan (GSP) to the Department of Water Resources (Department) for review. Amendments have been developed in response to the Department's letter for an Incomplete Determination of the 2020 Groundwater Sustainability Plans (GSPs) in the San Joaquin Valley – Kern County Subbasin, sent to the Kern County Subbasin GSAs on January 28, 2022 (Determination Letter). In the Determination Letter, the Department determined that the five GSPs submitted in 2020 covering the Kern County Subbasin were collectively "incomplete" for not meeting all requirements of the Sustainable Groundwater Management Act (SGMA).

The Determination Letter outlined specific deficiencies and recommended Corrective Actions for the Subbasin GSPs; the deficiencies and Corrective Actions relevant to the KRGSA GSP were addressed in the attached **Amended KRGSA GSP**. This transmittal letter provides a roadmap of the Amended KRGSA GSP and directs the Department to specific portions of the document where the recommended Corrective Actions were incorporated.

The KRGSA is providing the Amended KRGSA GSP as both a tracked changes (redline) version and a separate complete clean version with appendices. Both versions have been posted on the KRGSA website since late June. The Amended KRGSA GSP was adopted by the KRGSA Board of Directors following a public hearing held July 7, 2022.

We appreciate the Department's thorough review, analysis, and detailed corrective actions for the Kern County Subbasin GSPs as provided in the Determination Letter. We also appreciate the time devoted by Department staff for consultation meetings with the Subbasin GSAs. We believe that the Amended KRGSA GSP addresses all the deficiencies and

Corrective Actions included in the Determination Letter and look forward to receiving approvals for the GSPs, and continuing GSP implementation for sustainable groundwater management throughout the Kern County Subbasin.

AMENDED KRGSA GSP SUMMARY

On January 28, 2022, the Department's Determination Letter provided the Kern County Subbasin GSAs with a Statement of Findings regarding an "incomplete" determination for the Kern County Subbasin GSPs. Although five separate GSPs[1] were submitted for the Subbasin in 2020, the Department reviews the GSPs collectively as "one plan."

Since receipt of the Determination Letter, the KRGSA has participated in a series of weekly coordination meetings with Kern County Subbasin GSAs, along with periodic meetings of the Kern County Subbasin Coordination Committee, the KRGSA Board of Directors, and other coordination groups. Collectively, these coordination meetings, supported by three consultation meetings with the Department, have produced a coordinated Subbasin-wide response to the Determination Letter as summarized in the revised appendices of the First Amended Kern County Subbasin Coordination Agreement.

- ***Please see Section 1.6 in the Amended KRGSA GSP for a discussion of the Subbasin coordination process and a summary of the KRGSA GSP amendments.***

- ***The First Amended Kern County Subbasin Coordination Agreement with revised appendices is being submitted separately by the Plan Manager.***

In addition to the amendments associated with the Determination Letter, the Amended KRGSA GSP also incorporates minor revisions[2] to the KRGSA and Plan Area boundaries. The Amended KRGSA GSP contains all of the required elements of a GSP to cover the entire revised Plan Area.

- ***Please see Section 1.6.3 in the Amended KRGSA GSP, including Table 1-3 and Figures 1-4 and 1-5, for details on the revised Plan Area. Additional details are provided in Appendix K, which was also included in the 2020 KRGSA GSP.***

The DWR Determination Letter identified three overall deficiencies in the collective Subbasin GSPs that required corrective actions. A summary is provided below of how the Amended KRGSA GSP addresses these deficiencies and incorporates the Corrective Actions.

[1] A sixth GSP has recently been added by the South of Kern River (SOKR) GSAs, which was formerly covered as Management Area Plans in the Kern Groundwater Authority GSP.

[2] As indicated in **Table 1-3** and on **Figures 1-4** and **1-5**, the revised KRGSA boundaries add approximately 1,699 acres to the Plan Area – less than one percent of the total number of acres in the GSP (232,499 acres). The revised boundaries were anticipated in the 2020 KRGSA GSP but had not yet been finalized – see Appendix K for an expanded discussion of the Plan Area revisions.

DEFICIENCY 1 – THE GSPs DO NOT ESTABLISH UNDESIRABLE RESULTS THAT ARE CONSISTENT FOR THE ENTIRE SUBBASIN.

Deficiency 1 notes the lack of Subbasin-wide coordinated definitions of undesirable results, including sufficient detail to allow Department Staff and stakeholders to clearly understand "when and how" Subbasin-wide undesirable results occur (Determination Letter, p. 12). There was also considerable confusion between Subbasin-wide (regional) undesirable results and Management Area (local) undesirable results. The Corrective Action in the Determination Letter requires the following actions[3]:

a. The Coordination Agreement must explain how undesirable results are consistent with SGMA and GSP regulations, how they are caused by groundwater conditions in the Subbasin, and how GSPs have used the same data and methodologies to define Subbasin-wide undesirable results.
b. GSAs must commit to comprehensively reporting on the status of minimum thresholds (MTs) exceedances in Management Areas for each annual report and describe potential impacts to beneficial users.
c. GSAs must adopt consistent terminology for undesirable results and the conditions under which they occur in the Subbasin. Maps and tables of management areas are recommended to illustrate conditions that trigger a "localized undesirable result."

KRGSA's responses to the Corrective Actions for Deficiency 1 in the Determination Letter are as follows:

a. The Coordination Agreement must explain how undesirable results are consistent with SGMA and GSP regulations, how they are caused by groundwater conditions in the Subbasin, and how GSPs have used the same data and methodologies to define Subbasin-wide undesirable results.

Coordinated undesirable results have been clarified in the revised Appendix 3 of the First Amended Kern County Subbasin Coordination Agreement and incorporated throughout this Amended KRGSA GSP. The Subbasin undesirable results are defined consistently at the Subbasin level. Any "localized undesirable result" associated with an individual Management Area is now consistently referred to in all GSPs as a "Management Area Exceedance." An exceedance of a minimum threshold – referred to as a "MT Exceedance" – is defined as an exceedance of the MT at a single representative monitoring well. The Subbasin also coordinated on revisions to monitoring protocols to ensure that all representative monitoring wells were routinely sampled to prevent a single MT Exceedance from being missed (due to access, for example).

Revised Appendix 3 of the First Amended Kern County Subbasin Coordination Agreement also provides examples of when and how a Management Area Exceedance occurs. This is

[3] Corrective Action 1 in the Determination Letter has been summarized for brevity. Please see the Determination Letter for the complete Corrective Action 1.

defined by the number of representative monitoring wells in a Management Area that are allowed to exceed the MT for a certain number of monitoring events before significant and unreasonable impacts would occur. The number of wells and monitoring events are referred to as *triggers*, as explained in revised Appendix 3[4]. This is consistent with GSP regulations §354.26 (2) that require quantitative criteria for triggering undesirable results and recognizes that an exceedance in one well for one monitoring event does not necessarily rise to the level of a Management Area Exceedance.

- ***Please see revised Appendix 3 in the First Amended Kern County Subbasin Coordination Agreement[5] for coordinated terminology, definitions, and Subbasin-wide details on Management Areas and triggers for a local Management Area Exceedance.***

- ***Please see Section 6.2.4 in the Amended KRGSA GSP, which includes Subbasin-coordinated revisions to monitoring protocols.***

- ***Please see Section 5.3 in the Amended KRGSA GSP, which explains the approach to Subbasin undesirable results and a local Management Area Exceedance.***

- ***Please see Table 5-2 in the Amended KRGSA GSP for a summary of MTs and triggers that define a Management Area Exceedance for each of the KRGSA GSP Management Areas.***

b. GSAs must commit to comprehensively reporting on the status of minimum thresholds (MTs) exceedances in Management Areas for each annual report and describe potential impacts to beneficial users.

KRGSA already committed to a management action that was included in the 2020 KRGSA GSP and requires documentation and investigation for each MT exceedance in any representative monitoring well. That management action – titled *Implement Action Plan if Water Levels Fall Below Minimum Thresholds* – provides a five-step plan for addressing exceedances of the shallow-most MT in any of the representative monitoring wells. The KRGSA has been following this management action, documenting exceedances in annual reports and implementing various mitigation measures to avoid a Management Area Exceedance. Accordingly, no additional response is needed in the Amended KRGSA GSP for this deficiency item.

- ***Please see Section 7.2.1 in the Amended KRGSA GSP – which has not been modified from the 2020 KRGSA GSP – for an explanation of this management action.***

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[4] Triggers are defined separately for each Management Area, but the Subbasin has coordinated on consistent triggers for most Management Areas, which match those established in the 2020 KRGSA GSP.

[5] The First Amended Kern County Subbasin Coordination Agreement with revised appendices is being submitted separately on the SGMA portal by the Plan Manager as required by the Department.

c. GSAs must adopt consistent terminology for undesirable results and the conditions under which they occur in the Subbasin. Maps and tables of management areas are recommended to illustrate conditions that trigger a "localized undesirable result."

The 2020 KRGSA GSP adopted triggers for a Management Area Exceedance (previously referred to as *local* undesirable results) in each of the three KRGSA GSP Management Areas. Triggers were selected to balance competing requirements for various beneficial uses and users of groundwater. In brief, the KRGSA intends to maintain relatively high local water levels to avoid exacerbation of subsidence, degradation of water quality, and widespread impacts to local wells. These benefits of relatively high groundwater levels are balanced against the need for relatively short-term water level declines due to increased reliance on groundwater during droughts. Specifically, local water level declines are needed to allow access to previously banked surface water, providing a critical water supply when local and imported surface water are limited. This optimization of conjunctive use is a cornerstone of the KRGSA GSP Sustainability Goal.

The triggers were more constrained in the Urban Management Area where most of the drinking water supply wells and critical infrastructure occur in the KRGSA Plan Area. Triggers were also more restrictive in the Banking Management Area adjacent to local municipal wells. Triggers were less restrictive in banking areas of the larger Agricultural Management Area, recognizing that beneficial uses were protected by the adjustments of higher MTs across other portions of the Agricultural Management Area, including areas of disadvantaged communities (DACs).

In summary, a Management Area Exceedance is triggered in the Urban Management Area and Banking Management Area when a representative monitoring well exceeds the MT for more than three consecutive monthly monitoring events. In the larger Agricultural Management Area, a Management Area Exceedance is triggered when 40 percent of the representative monitoring wells exceed the MT over four consecutive semi-annual monitoring events (reflecting regional rather than local water level declines).

In order to address the fragmented approach to triggers that had been adopted over the Kern County Subbasin, the Management Areas outside of the KRGSA Plan Area elected to adopt the triggers used in the KRGSA GSP Agricultural MA. In that manner, the triggers for a Management Area Exceedance are now coordinated across the Kern County Subbasin. The Urban Management Area and Banking Management Area in the KRGSA elected to maintain the more restrictive triggers from the 2020 KRGSA GSP due to factors discussed in the Amended KRGSA GSP and summarized above.

- ***Please see Section 5.10.2 in the Amended KRGSA GSP for more detailed explanation on the triggers for KRGSA GSP Management Area Exceedances.***
- ***Please see Table 5-2b in the Amended KRGSA GSP, which has been simplified to summarize the triggers of Management Area Exceedances for the three KRGSA Management Areas.***

DEFICIENCY 2 – THE PLAN DOES NOT SET MINIMUM THRESHOLDS FOR CHRONIC LOWERING OF GROUNDWATER LEVELS IN A MANNER CONSISTENT WITH THE REQUIREMENTS OF SGMA AND THE GSP REGULATIONS.

For deficiency 2, the Department provided helpful explanations and specific Corrective Actions for each of the Management Areas within the five GSPs originally submitted for the Kern County Subbasin. Those specific Corrective Actions were organized by GSP in Table 2 (DWR, pp. 20-35). At the end of Table 2, the Department described a Corrective Action applicable to all GSPs. How the Corrective Actions for Deficiency 2 were addressed by the Amended KRGSA GSP for each of the three Management Areas are summarized separately below. These responses are followed by how the Amended KRGSA GSP responded to the Correction Action for all GSPs.

KRGSA Urban Management Area:

The Determination Letter provides a good summary of the selection of MTs across the KRGSA GSP Urban Management Area. With respect to Corrective Actions, the Determination Letter states:

> *Department staff do not recommend any specific corrective actions at this time related to the KRGSA Urban Management Area definition of groundwater level minimum thresholds...*

Accordingly, no response has been added to the Amended KRGSA GSP for this deficiency and no changes have been made to MTs in the 2020 KRGSA GSP for this MA.

KRGSA Banking Management Area:

The Determination Letter provides a good summary of the selection of MTs across the KRGSA GSP Banking Management Area. With respect to Corrective Actions, the Determination Letter states:

> *Department staff do not recommend any specific corrective actions at this time related to the KRGSA Banking Management Area definition of groundwater level minimum thresholds...*

Accordingly, no response has been added to the Amended KRGSA GSP for this deficiency and no changes have been made to MTs in the 2020 KRGSA GSP for this MA.

KRGSA Agricultural Management Area:

The Determination Letter demonstrated a good understanding of how the KRGSA GSP MTs were set in the Agricultural Management Area and how the shallow-most MT would be the compliance water level for all representative monitoring wells. The Determination Letter also noted that the GSP acknowledges the presence of some small water systems and domestic wells that could be impacted by the MTs and notes the reference to a management action that addresses this issue. However, Department staff were unable to identify the management action referenced. With respect to Corrective Actions, the Determination Letter states:

> The Kern River GSP must provide clarification regarding the management action mentioned in the sustainable management criteria section of the GSP related to identification of well users, including domestic users and small water systems in the agricultural subareas of the Agricultural Management Area.

In response to this Corrective Action, the Amended KRGSA GSP contains an improved, stand-alone management action that is developed to avoid widespread impacts to domestic and small water system wells and has been expanded to include the entire Plan Area. This management action takes important steps to better identify, track, and manage potential impacts to active drinking water wells. The management action is targeted for Phase One of GSP implementation and initial steps are already underway.

- ***Please see Section 7.2.9 in the Amended KRGSA GSP describing the management action to avoid widespread impacts to domestic and small water system wells in the KRGSA Plan Area.***

- ***Please see Table 8-1, which has been amended to include the management action in Phase One of GSP implementation.***

Because the management action is based on details of small water systems and domestic wells, the Amended KRGSA GSP also provides an update on the number and depths of domestic wells that have been drilled in the KRGSA Plan Area over time. This information has been updated from the DWR Well Completion Report database and provides a more comprehensive dataset of potentially active domestic wells than had been previously available from Kern County electronic datasets. The data provide context for the management action and also support an updated well impacts analysis.

- ***Please see Section 2.4.6.2 in the Amended KRGSA GSP regarding updated data on the approximate number and locations of domestic wells in the KRGSA Plan Area.***

The database was used to develop an updated well impacts analysis that identifies the areas susceptible to potential small water system and domestic well failures. The analysis also noted the age of potentially-impacted wells and the need for an improved understanding of active domestic well locations and status throughout the KRGSA Plan Area. This analysis was used to develop the details of the management action described above.

- ***Please see Section 5.4.4.4 in the Amended KRGSA GSP for an expanded analysis regarding potential impacts to Small Water Systems and Domestic Wells.***

Corrective Action for All of the GSPs:

In addition to the specific information provided for the KRGSA Management Areas above and additional corrective actions applicable to other Subbasin Management Areas, the Determination Letter Table 2 contained a Corrective Action applicable to all of the GSPs as follows:

> All of the GSPs must demonstrate the relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the GSA has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

To address this Corrective Action, the Amended KRGSA GSP provides a summary of the MTs for each sustainability indicator, how they relate to one another, and how the MTs are being managed such that undesirable results can be avoided. In that summary, the Amended KRGSA GSP first reviews the considerations and rationale for setting MTs for each of the sustainability indicators and then examines the relationships among the MTs to select the shallow-most MT at each representative monitoring well for compliance with all sustainability indicators together. In that manner, all of the sustainability indicators are considered collectively in the sustainable groundwater management program.

These considerations result in higher MTs (at or close to historic low water levels) in areas of domestic wells in Disadvantaged Communities (DACs) and areas subject to historical inelastic land subsidence. The Amended KRGSA GSP also includes higher MTs for areas of municipal wellfields, water quality concerns, and most of the critical infrastructure in the Plan Area. MTs in adjacent Management Areas outside of the KRGSA Plan Area were also considered when setting the MTs in those areas of the KRGSA.

- ***Please see Section 5.10 in the Amended KRGSA GSP for this explanation.***

- ***Please see Table 5-2a in the Amended KRGSA GSP, which summarizes the MTs for various sustainability indicators and identifies the controlling (shallow-most) indicator that is used to develop MTs across each of the three KRGSA Management Areas.***

DEFICIENCY 3 – THE PLAN'S LAND SUBSIDENCE SUSTAINABLE MANAGEMENT CRITERIA DO NOT SATISFY THE REQUIREMENTS OF SGMA AND THE GSP REGULATIONS.

The Department noted that the Subbasin lacks a coordinated approach to subsidence, and some GSPs did not develop sustainable management criteria for this indicator across all management areas. Accordingly, the Determination Letter contained a detailed Correction Action for this deficiency. In brief, the Corrective Action requires GSAs to coordinate and collectively develop sustainable management criteria for land subsidence, including the conditions for undesirable results based on the rate and extent of subsidence and supported by predicted impacts to critical infrastructure. The revised Plan should explain the effects of implementing projects and management actions on subsidence MTs. And, if land subsidence is not applicable to parts of the Subbasin, the GSPs must provide supported justification.

In response, the Subbasin GSAs have met regularly on this deficiency including separate consultation meetings with the DWR California Aqueduct Subsidence Program (CASP) staff and Department SGMA staff. The Subbasin has coordinated on consistent terminology, developed definitions for *Regional Critical Infrastructure* (including the California Aqueduct and Friant-Kern Canal) and *Management Area Critical Infrastructure*, developed interim sustainable management criteria for the Regional Critical Infrastructure, reviewed 2020 investigations on Subbasin subsidence, commissioned additional expert assistance from Lawrence Berkeley Laboratory, and re-initiated a regional Subbasin-wide monitoring program. These materials are provided in revised appendices of the First Amended Kern County Subbasin Coordination Agreement and summarized in this Amended KRGSA GSP.

- ***Please see revised Appendix 3 in the First Amended Kern County Subbasin Coordination Agreement[6] for coordinated terminology, definitions, and Subbasin-wide details on interim sustainable management criteria and the proposed Subbasin-wide monitoring program.***

- ***Please see the first paragraph in Section 3.3.5.3 for revised text to coordinate with the Subbasin-wide definitions of Local and Regional Critical Infrastructure.***

- ***Please see revised Sections 5.8.1, 5.8.2, and 5.8.3 in the Amended KRGSA GSP for Subbasin-coordinated terminology, definitions, and selection of regional critical infrastructure.***

- ***Please see revised Section 6.2.6.4 in the Amended KRGSA GSP for Subbasin-coordinated information on land subsidence monitoring in the Subbasin.***

Even though the Determination Letter did not identify deficiencies or Corrective Actions in the KRGSA GSP for land subsidence, the KRGSA takes this opportunity to bolster the current discussion on land subsidence in the 2020 KRGSA GSP, which already appears to meet GSP regulations. The discussion has been amended slightly with recent data and studies relevant to the KRGSA Plan Area. None of this information changed the approach or values of the sustainable management criteria for land subsidence in the Amended KRGSA GSP.

- ***Please see the revised last two paragraphs in Section 3.3.5.2 for more recent subsidence rates and information for the KRGSA Plan Area.***

- ***Please see Section 5.8.4 for further clarification and justification on land subsidence sustainable management criteria.***

[6] The First Amended Kern County Subbasin Coordination Agreement with revised appendices is being submitted separately on the SGMA portal by the Plan Manager as required by the Department.

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KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Amended Kern River Groundwater Sustainability Plan (GSP)

Final

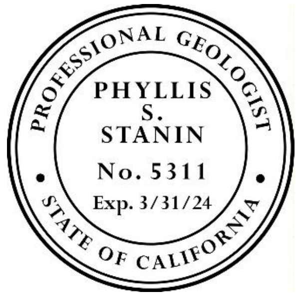
July 2022

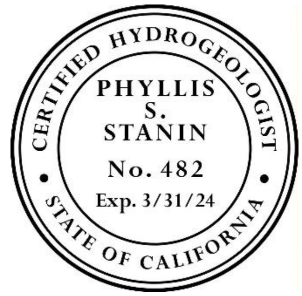
TODD GROUNDWATER

2490 Mariner Square Loop, Suite 215
Alameda, CA 94501
510.747.6920
www.toddgroundwater.com

PROFESSIONAL CERTIFICATION

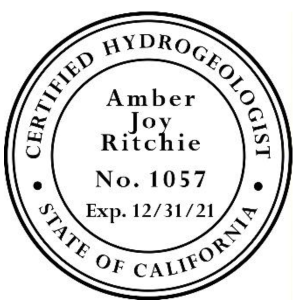
Phyllis S. Stanin, Vice President
Todd Groundwater, Alameda, CA
GSP Project Manager;
Amended KRGSA GSP





Maureen Reilly, Senior Engineer,
Todd Groundwater, Alameda, CA

Chad Taylor, Senior Hydrogeologist,
Todd Groundwater, Alameda, CA



Amber Ritchie, Associate Hydrogeologist
Todd Groundwater, Alameda, CA

Katherine White, Senior Engineer,
Todd Groundwater, Alameda, CA

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Attachments

List of Acronyms and Abbreviations

AEWSD	Arvin Edison Water Storage District
AF	acre-feet
AFY	acre-feet per year
AWMP	Agricultural Water Management Plan
bgs	below ground surface
BMP	Best Management Practices
BVWSD	Buena Vista Water Storage District
CDFW	California Department of Fish & Wildlife
C2VSim	California Central Valley Groundwater-Surface Water Simulation
C2VSimFG-Kern	California Central Valley Groundwater-Surface Water Simulation Model, Fine-Grid, Kern County Update for the Kern County and White Wolf Subbasin
Cal Poly	California Polytechnic State University, San Luis Obispo, California
Cal Water	California Water Service Company, Bakersfield District
CASGEM	California Statewide Groundwater Elevation Monitoring Program
CASP	California Aqueduct Subsidence Program
CCR	California Code of Regulations
CDMG	California Division of Mines and Geology (now California Geological Survey)
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CGS	California Geological Survey (formerly California Division of Mines and Geology)
CIMIS	California Irrigation Management Information System
City	City of Bakersfield
COB 2800	City of Bakersfield 2800 Acre Groundwater Banking Area
CPAD	California Protected Areas Database
CRTN	California Real Time Network
CSRC	California Spatial Reference Center
CVC	Cross Valley Canal
CVHM	Central Valley Hydrologic Model
CVP	Central Valley Project

CVRWQCB	Central Valley Regional Water Quality Control Board, also referred to as Central Valley Water Board
CWD	County Water District
DAC	Disadvantaged Communities
DBCP	1,2-Dibromo 3-chloropropane (also Dibromochloropropane)
DDW	Division of Drinking Water, SWRCB
DOGGR	California Division of Oil, Gas, and Geothermal Resources
DTSC	Department of Toxic Substances Control
DWR	California Department of Water Resources
EDB	Ethylene dibromide
ENCSD	East Niles Community Services District
ET	Evapotranspiration
ETo	Reference evapotranspiration
ft	feet
ft^2	square feet
FWA	Friant Water Authority
GAMA	Groundwater Ambient Monitoring and Assessment
GDE	Groundwater Dependent Ecosystem
GIS	Geographic Information System
GNSS	Global Navigation Satellite Systems
gpm	gallons per minute
GPS	Global Positioning System
Greenfield CWD	Greenfield County Water District
GSA	Groundwater Sustainability Agency
gse	ground surface elevation
GSP	Groundwater Sustainability Plan
GWE	Groundwater Elevation
GWMP	Groundwater Management Plan
ID	Irrigation District or Improvement District
ID4	Improvement District No. 4 of the Kern County Water Agency

ILRP	Irrigated Lands Regulatory Program
InSAR	Interferometric Synthetic Aperture Radar
IRWM	Integrated Regional Water Management
ITRC	Irrigation Training and Research Center
JPL	Jet Propulsion Laboratory
K	Hydraulic conductivity
KCWA	Kern County Water Agency
KDWD	Kern Delta Water District
KFMC	Kern Fan Monitoring Committee
KGA	Kern Groundwater Authority
KRGSA	Kern River Groundwater Sustainability Agency
KRWCA	Kern River Watershed Coalition Authority
KWB	Kern Water Bank
LPUD	Lamont Public Utilities District
LUST	Leaking Underground Storage Tank
M&I	Municipal and Industrial
MA	Management Area
MCL	maximum contaminant level
METRIC	Mapping EvapoTranspiration at high Resolution with Internalized Calibration
mgd	million gallons per day
mg/L	milligrams per liter or parts per million (ppm)
MO	Measurable Objective
MOU	Memorandum of Understanding
msl	mean sea level
MT	Minimum Threshold
NASA	National Aeronautics and Space Administration
NCCAG	Natural Communities Commonly Associated with Groundwater
NGO	Non-governmental organization
NKWSD	North Kern Water Storage District
NORMWD	North of the River Municipal Water District

OMWC	Oildale Mutual Water Company
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PUD	Public Utilities District
RPE	Reference Point Elevation
RRBWSD	Rosedale-Rio Bravo Water Storage District
RRID	Rosedale Ranch Improvement District
SCIGN	Southern California Integrated GPS Network
SEIR	Supplemental Environmental Impact Report
SGMA	Sustainable Groundwater Management Act
SOPAC	Scripps Orbit and Permanent Array Center
SSURGO	Soil survey Geographic Database
Subbasin	Kern County Subbasin, when capitalized
SWN	State Well Number
SWP	State Water Project
SWRCB	State Water Resources Control Board
T	Transmissivity
TCP	1,2,3-Trichloropropane
TDS	Total Dissolved Solids
TNC	The Nature Conservancy
UIC	Underground Injection Control Program
Umhos/cm	micromhos per centimeter
USACE	U.S. Army Corps of Engineers
USDW	Underground Source of Drinking Water
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UWMP	Urban Water Management Plan
µg/L	micrograms per liter or parts per billion (ppb)
VWC	Vaughn Water Company

WAP	Water Allocation Plan
WD	Water District
WDRs	Waste Discharge Requirements
WMP	Water Management Plan
WSD	Water Storage District
WRMWSD	Wheeler Ridge-Maricopa Water Storage District
WSA	Water Service Area
WY	Water Year, October 1 through September 30

AMENDED EXECUTIVE SUMMARY

In January 2020, the Kern River Groundwater Sustainability Agency (KRGSA) submitted the original KRGSA Groundwater Sustainability Plan (GSP) to the Department of Water Resources (DWR) in compliance with the Sustainable Groundwater Management Act (SGMA). The KRGSA GSP was one of five GSPs that were submitted through a Coordination Agreement to collectively cover the entire Kern County Subbasin. In January 2022, DWR sent a letter to the Kern County Subbasin GSAs that provided an evaluation of the Subbasin GPSs and determined that the GSPs were collectively "incomplete" in meeting all SGMA requirements (Determination Letter). DWR noted three separate deficiencies in the collective GSPs and provided Corrective Actions to address the deficiencies.

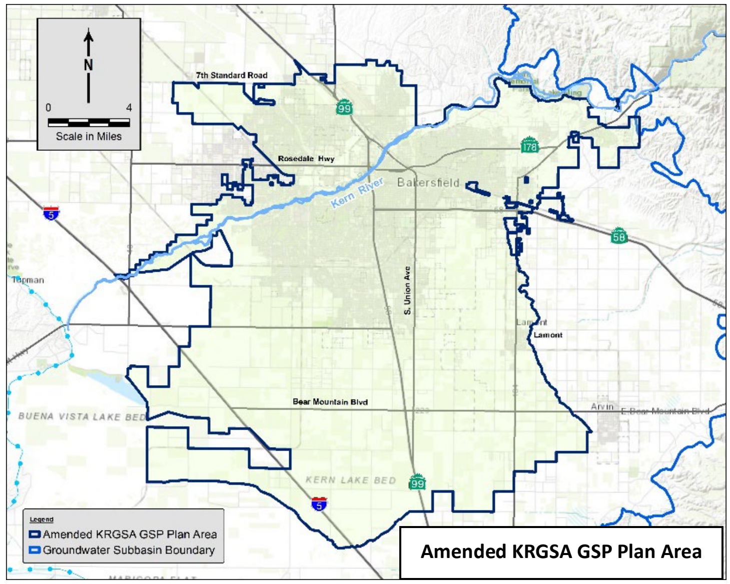
This Amended KRGSA GSP has been prepared to supplement the original 2020 KRGSA GSP in response to DWR comments. Amended sections are incorporated into the original KRGSA GSP to produce one complete document. To the extent practical, remaining portions of the original KRGSA GSP have not been modified. The process for developing the Amended KRGSA GSP is summarized in **Section 1.6**. The Amended KRGSA GSP sections with substantial amendments are summarized below.

Table ES1-1: Amended Sections of the Original KRGSA GSP

GSP Sections	Topic	Amendment Summary
1.6	DWR Evaluation and KRGSA GSP Amendments	GSP Amendment process, coordination with Subbasin GSAs, KRGSA/Plan Area boundary revisions
2.4.6.2	Groundwater Wells Update	Revised number and locations of domestic wells based on updated DWR database
3.3.5.2, 3.3.5.3	Land Subsidence Critical Infrastructure and Coordination	Updated subsidence rates and identified critical infrastructure using coordinated Subbasin definitions
5.1, 5.2, 5.3	Subbasin Sustainability Goal and Approach for Undesirable Results	Described coordinated approach for Subbasin definitions of Sustainability Goal, Undesirable Results and Management Area exceedances
5.4.4.4	Impacts of MTs on Beneficial Users	Expanded analyses of impacts to small water systems and domestic wells
5.8 and 6.2.6.4	Coordinated Subbasin-wide Inelastic Land Subsidence	Regional Critical Infrastructure, Sustainable Management Criteria, and monitoring
5.10	Interrelationships of Minimum Thresholds	Analyzes how MTs work together to avoid Management Area exceedances
6.2.4	Monitoring Protocols	Inserted Subbasin-coordinated procedures regarding inaccessible monitoring wells
7.2.9	Avoid Widespread Impacts to Domestic Wells	New Management Action to document, track, investigate, and adjust management activities to avoid widespread impacts to active domestic wells.

The primary amendment to the KRGSA GSP involves a management action to avoid widespread impacts to domestic wells in the KRGSA Plan Area (**Section 7.2.9**). The management action is based on an updated analysis of potential impacts to small water systems and domestic wells (**Section 5.4.4.4**). Additional minor amendments are also incorporated throughout the document for clarification and to adhere to consistent terminology, definitions, and information that have been coordinated with other Subbasin GSAs on a Subbasin-wide basis.

The Amended KRGSA GSP also includes updated KRGSA and Plan Area boundaries. In 2021 (after the 2020 submission of the KRGSA GSP), the boundaries of the KRGSA – and the resulting Plan Area – were officially revised with the addition of about 1,699 acres of un-districted adjoining lands and other minor boundary adjustments. All of these lands were covered by the 2020 KRGSA GSP as documented in Appendix K[1].



The KRGSA Plan Area (shown at right) increased from 230,800 acres to 232,499 acres, a difference of less than one percent of the total Plan Area[2]. Most of the revisions occurred along the eastern (near Lamont) and southwestern boundaries (see **Figure 1-4** in this Amended GSP for a summary of revised areas).

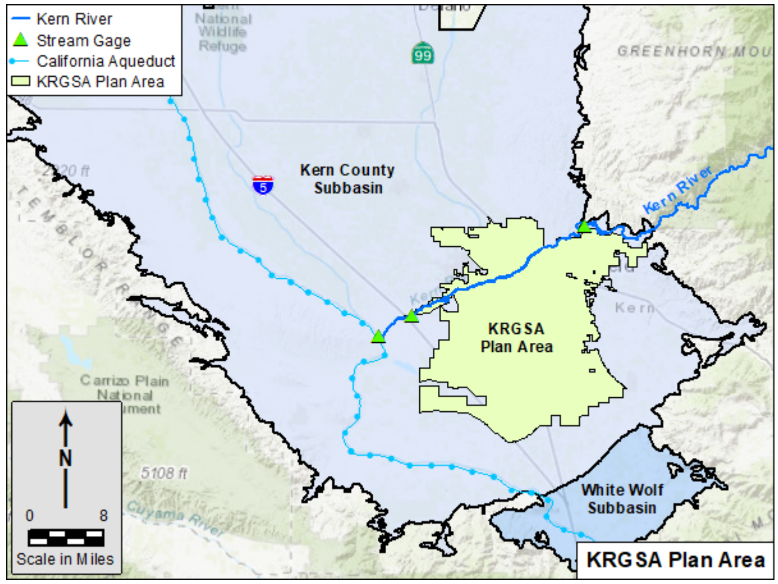
Due to the relatively small revisions made to the KRGSA and Plan Area boundaries – and in consideration of the large number of maps and other figures (more than 100) depicting the original KRGSA and GSP Plan Area boundaries in the 2020 GSP – figures from the original KRGSA GSP have not been updated with the amended boundaries. Nonetheless, the Amended KRGSA GSP covers all of the additional lands.

As mentioned above, most of the Amended KRGSA GSP remains unchanged from the original KRGSA GSP submitted in 2020. At the request of DWR, a redline version highlighting all changes to the original KRGSA GSP has also been prepared. Amendments have been incorporated into the document as seamlessly as practical, and the remaining unmodified text remains a part of the Amended KRGSA GSP for completeness. The original 2020 Executive Summary is also relevant to the Amended KRGSA GSP and is presented unmodified in the following sections.

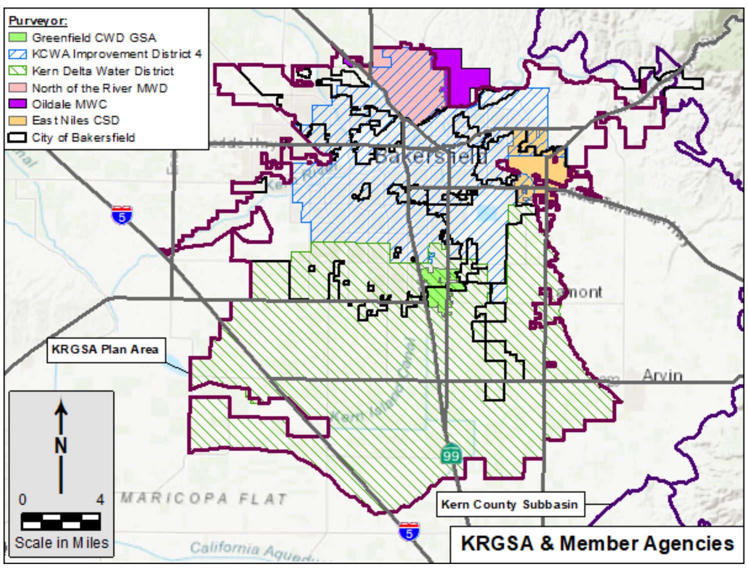
[1] Appendix K is presented in this Amended KRGSA GSP and has not been modified from the original version. It involved 1,847 acres, 1,822 acres of which were added to the final boundaries in 2021. Further boundary adjustments in the northern KRGSA removed about 123 acres, resulting in a net increase of 1,699 acres.

[2] See **Section 1.6.3**, including **Table 1-3** and **Figures 1-4** and **1-5**, in the Amended KRGSA GSP for more information.

The Kern River Groundwater Sustainability Agency (KRGSA) has prepared this Groundwater Sustainability Plan (GSP) to cooperatively manage shared groundwater resources in a sustainable manner. The GSP is being submitted in coordination with four additional GSPs that collectively cover the entire Kern County Subbasin, the largest groundwater subbasin in California. The KRGSA GSP Plan Area covers 361 square miles, about 13 percent of the 2,834-mile Subbasin.



ES-1 KRGSA Administrative Information and Sustainability Goal



The KRGSA is an exclusive Groundwater Sustainability Agency (GSA) composed of member agencies including the City of Bakersfield, Kern Delta Water District (KDWD), Kern County Water Agency (KCWA) Improvement District No. 4 (ID4), North of the River Municipal Water District/Oildale Mutual Water Company (NORMWD/OMWC), and East Niles Community Services District (ENCSD).

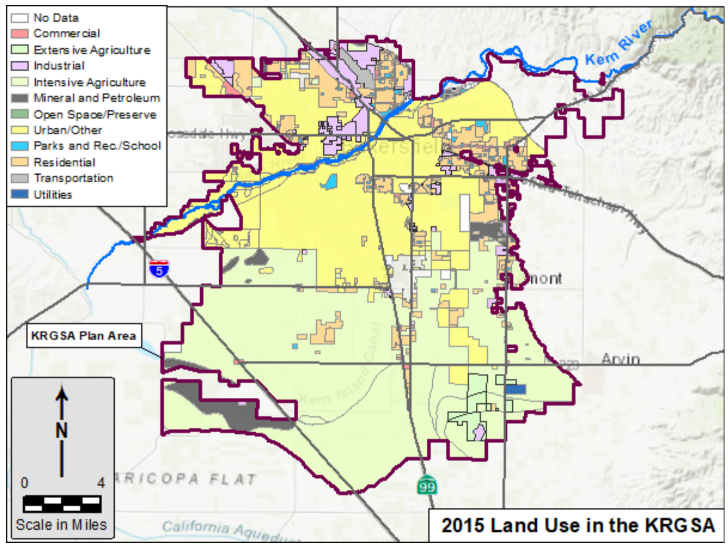
The Plan Area will be cooperatively managed by member agencies of the KRGSA along with Greenfield County Water District, which is its own GSA and is cooperatively participating in the KRGSA GSP. The KRGSA has a diverse portfolio of water sources managed by member agencies and other entities in the Plan Area. Local surface water from the Kern River, imported water from the State Water Project (SWP), recycled water, and other surface water sources provide about one-half of the total water supply to the Plan Area (about 327,786 AFY on an average annual basis) to support beneficial uses. These surface water sources are supplemented by groundwater (average of about 321,871 AFY) and managed conjunctively throughout the Plan Area.

The **Sustainability Goal** of the KRGSA GSP (Water Code §10721(u)) is to manage groundwater sustainably in the KRGSA Plan Area to:

- Support current and future beneficial uses of groundwater including municipal, agricultural, industrial, public supply, domestic, and environmental
- Optimize conjunctive use of surface water, imported water, and groundwater
- Avoid or eliminate undesirable results throughout the planning horizon.

This GSP also acknowledges the coordinated sustainability goal for the entire Kern County Subbasin and incorporates it into this GSP as a supplemental goal by reference.

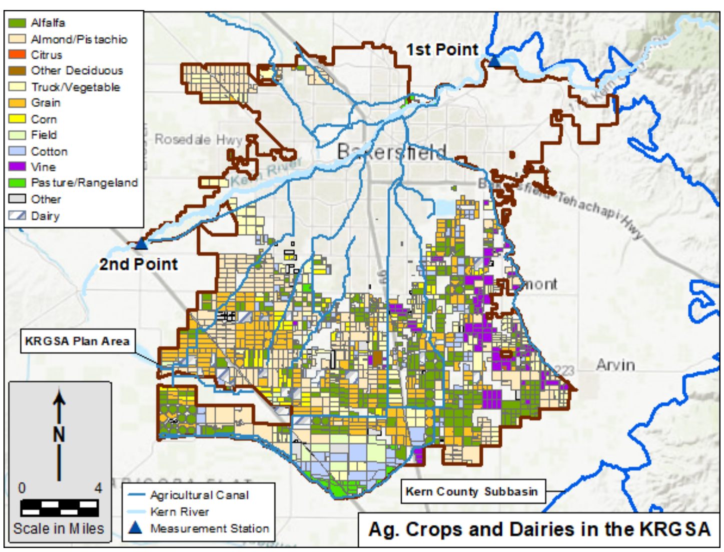
ES-2 PLAN AREA



The primary land uses in the KRGSA Plan Area are approximated as follows:

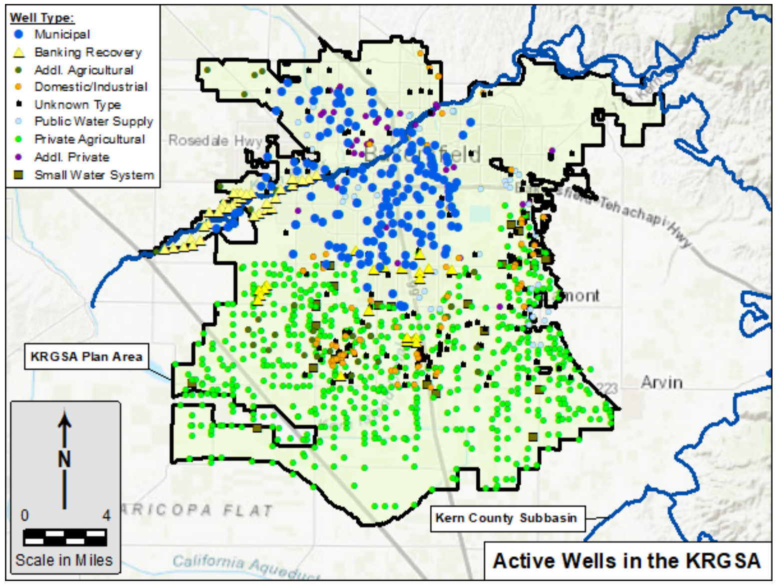
- 41% Agricultural
- 33% Urban/residential/industrial
- 26% Undeveloped

The northern KRGSA Plan Area includes most of the Bakersfield city limits with primarily urban land uses. Sparsely populated or undeveloped areas cover most of the northeast Plan Area. The west-central Plan Area is dominated by recharge basins and groundwater banking projects, mostly along the Kern River.

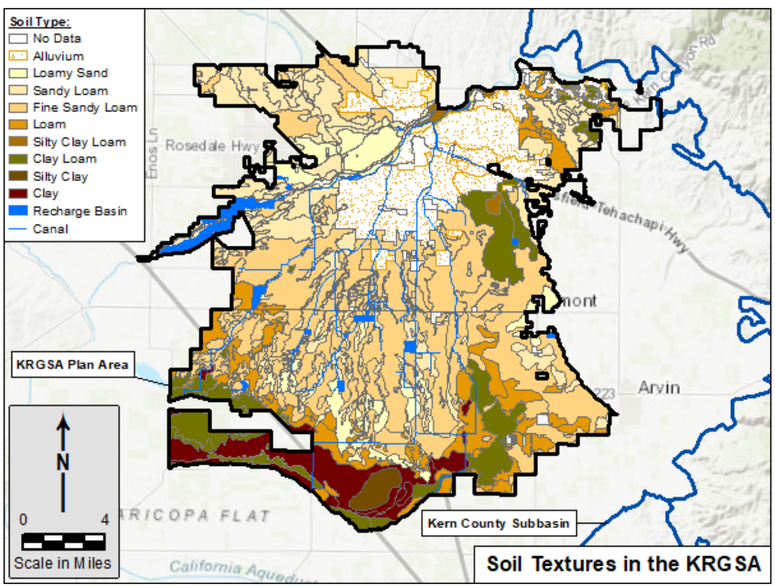


Agriculture is the primary land use in the southern Plan Area with small areas of additional agriculture in the north. About 90,000 acres and 16,000 acres of irrigated lands are farmed in the southern and northern Plan Area, respectively. The agricultural areas support a variety of crop types, including both perennial (e.g., vines and almonds) and annual (e.g., alfalfa, grains and field crops, cotton, and vegetables). Approximately 20 dairies also operate in the southern Plan Area, contributing to the local agricultural economy. Numerous businesses and industries in the Plan Area support these agricultural activities including three food processing plants and numerous equipment, supply, and processing facilities.

The KRGSA relies heavily on groundwater, including recovery of recharged and banked surface water supplies, with more than 1,000 active wells. Most northern wells are used for municipal supply (blue dots). Recovery wells at groundwater banking projects operate mostly in the west-central and central KRGSA (yellow triangles). Southern wells are mostly used for agricultural irrigation (green dots). Small community water systems and additional private wells occur throughout the Plan Area.



Fluvial and alluvial fan deposition has created a thick sequence of sediments beneath the KRGSA; the depositional history has influenced the soils and shallow alluvial sediments of the Plan Area. The map at left shows soils color-coded according to type and grain-size (texture), with more permeable alluvium and sandy soils indicated by shades of yellow and light orange. These are the dominant soil textures in the GSA and represent the areas of higher natural recharge. Soil textures are generally less permeable to the south and east, where clay soils are associated with paleo-lakebeds and flood basin deposits. The more permeable soils and shallow alluvial sediments along the Kern River create optimal conditions for managed groundwater recharge in the river channel and at groundwater banking projects as evidenced by the numerous recharge basins in the western Plan Area. Managed recharge also occurs along the numerous unlined canals and recharge basins as shown throughout the south-central Plan Area.



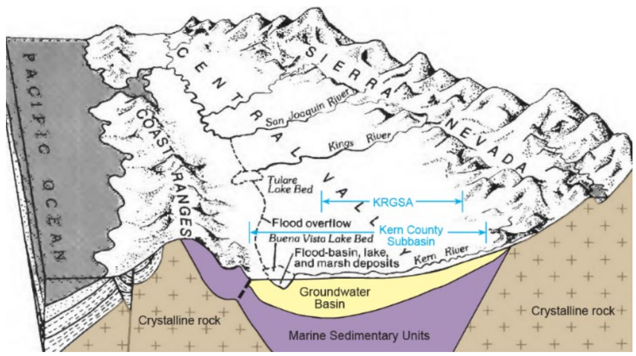
ES-3 BASIN SETTING

The basin setting of the Plan Area provides the foundation on which to evaluate sustainability indicators, select appropriate sustainability criteria, and develop management actions and projects to maintain sustainable groundwater management.

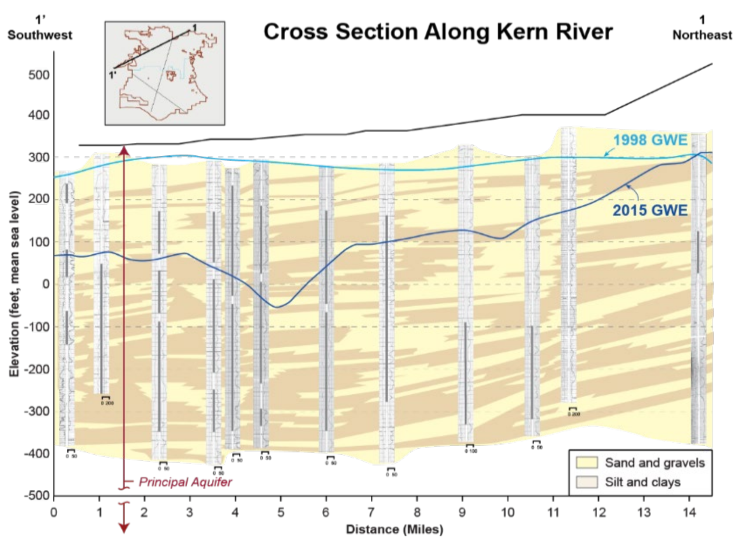
The Basin Setting is based collectively on three related analyses:

1. **Hydrogeologic Conceptual Model** - describes the physical conditions of the groundwater basin including the geologic setting, basin geometry, and aquifers and aquitards (GSP Section 3),
2. **Groundwater Conditions** - provides an understanding of groundwater occurrence and flow, groundwater quality, land subsidence, and interconnected surface water (GSP Section 3).
3. **Water Budgets** – analyzes the inflows, outflows, and changes in groundwater in storage for historical, current, and future conditions, including climate change analyses (GSP Section 4).

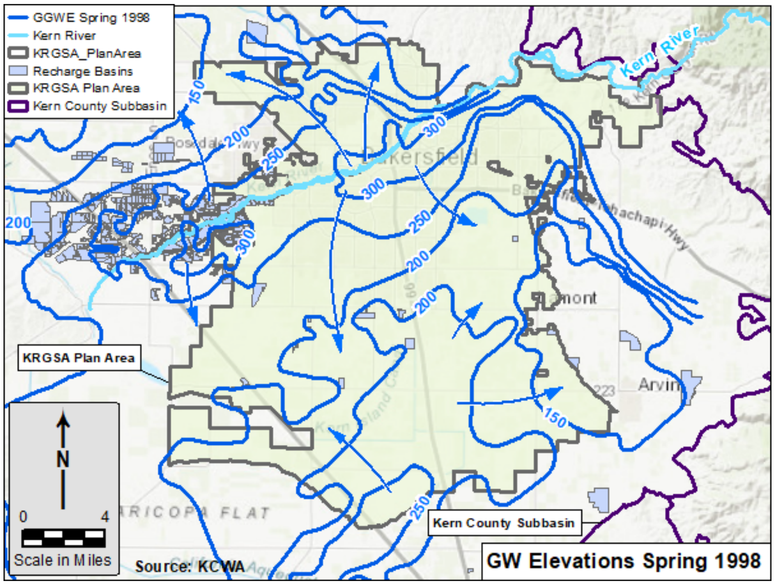
The Kern County Subbasin consists of the upper portion of a deep structural trough between the crystalline basement rocks of the Sierra Nevada and the Coast Ranges. The deeper portions of the trough contain mostly Miocene and older marine sedimentary units. The upper trough has been infilled over time with Upper Miocene/Pliocene and younger continental sediments, which contain most of the Subbasin groundwater.



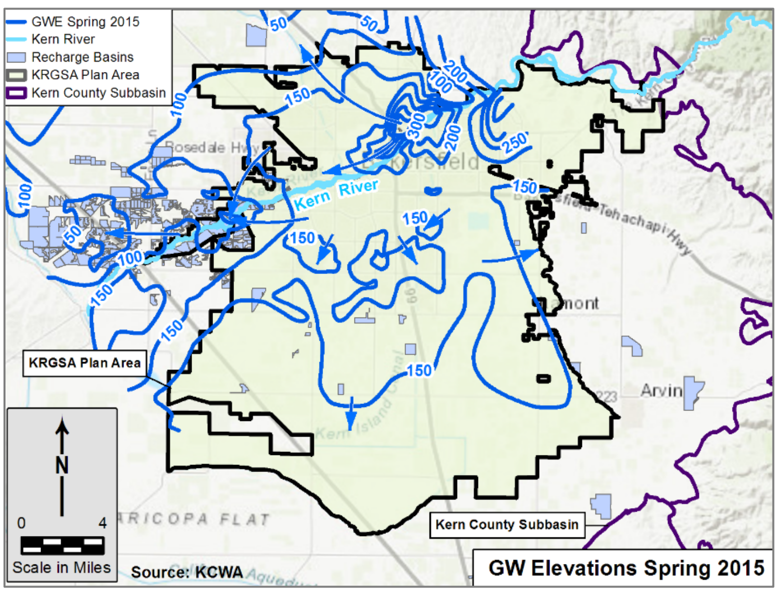
Groundwater beneath the Plan Area occurs under unconfined to semi-confined conditions in the continental sediments of the Kern River Formation and overlying alluvium, collectively forming the **Principal Aquifer**. The interbedded nature of the gravels, sands, silts, and clays of the Principal Aquifer are illustrated on the cross section below; although clay content generally increases with depth, clay layers are often discontinuous and most wells are screened over a large interval, making it difficult to clearly define more than one Principal Aquifer. The Subbasin extends several thousand feet beneath the Plan Area with the bottom defined by either the base of the Underground Source of Drinking Water (USDW, defined by USEPA), oilfield-exempted aquifers, or oil-producing zones, whichever is shallowest.



Trends and fluctuations in **groundwater elevations** are illustrated in the GSP by a series of hydrographs. Over time, water levels have declined and recovered during drought and wet periods with fluctuations of less than 50 feet to more than 150 feet (at groundwater banking areas). During the drought of 2013-2016, water levels declined an average of 50 feet across the Plan Area to reach historic lows. In some banking areas, the difference between the high water level (1998) and historic low water level (2015) is more than 350 feet as illustrated on portions of the cross section.



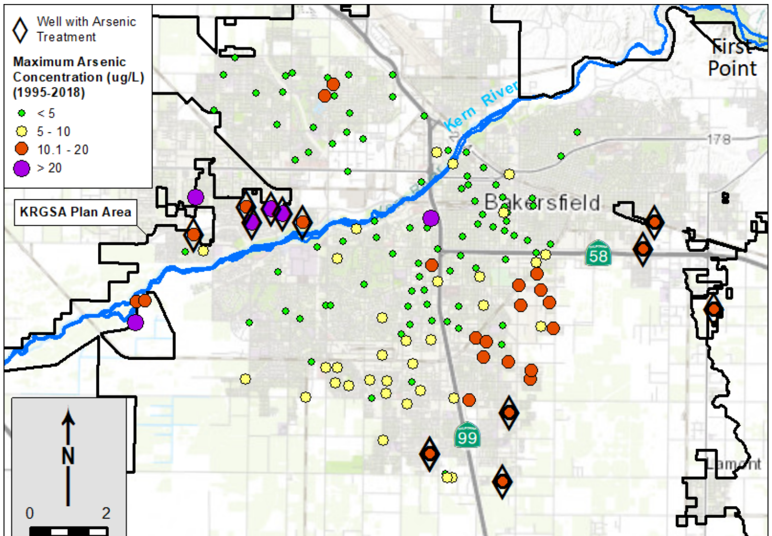
Groundwater elevations are illustrated by the KCWA Spring contour map for 1998 when water levels were the highest during the 20-year Study Period (WY 1995 – WY 2014). During the wet year of 1998, precipitation and Kern River flows were 223 percent and 236 percent of the long-term averages, respectively. As shown by the arrows, groundwater flows to the north and south away from the Kern River and away from downstream banking projects where mounding creates divergent flow patterns. Groundwater elevations are above 200 feet msl over most of the Plan Area in 1998. Throughout the Plan Area, groundwater elevations are influenced by recharge in the Kern River channel, unlined canals, and banking projects.



The groundwater elevation contour map for spring 2015 data illustrates the lowest water levels for any spring map during the Study Period. During spring 2015, groundwater elevations are lower than 200 feet msl over almost all of the Plan Area. Although groundwater elevations appear higher than 350 feet msl in the northeast, data are sparse, and contours are considered less accurate in this area. A comparison with the 1998 map shows that 2015 groundwater elevations are lower than 1998 elevations by about 50 feet to 100 feet throughout most of the Plan Area. The highest groundwater elevations along the Kern River are similar to 1998 levels, but cover a smaller area (e.g., areas higher than 300 feet msl).

During the drought of record, historic low water levels created significant management issues for the City and Cal Water, who collectively own more than 160 municipal supply wells in the northern Plan Area. Issues included declining capacity, well inefficiency, water levels falling below pump intakes, degraded water quality, and both pumping and static water levels falling below the top of well screens (i.e., cascading water). About 42 municipal wells (about 25 percent of the larger-capacity wells) were affected by cascading water primarily in the north-central KRGSA Plan Area.

These conditions required operational changes and significant capital expenditures by the City and Cal Water to re-distribute pumping, lower pumps, remove wells from service, secure supplemental supplies, and otherwise manage wellfield operations to meet water demands through the drought. Although the City and Cal Water were able to actively manage wells and secure supplemental supplies to meet demands during 2015 and 2016, numerous challenges remain with the municipal well system; only when water levels began to rise did the ongoing well problems subside. Future declines below the historic low water level may place more wells at risk.



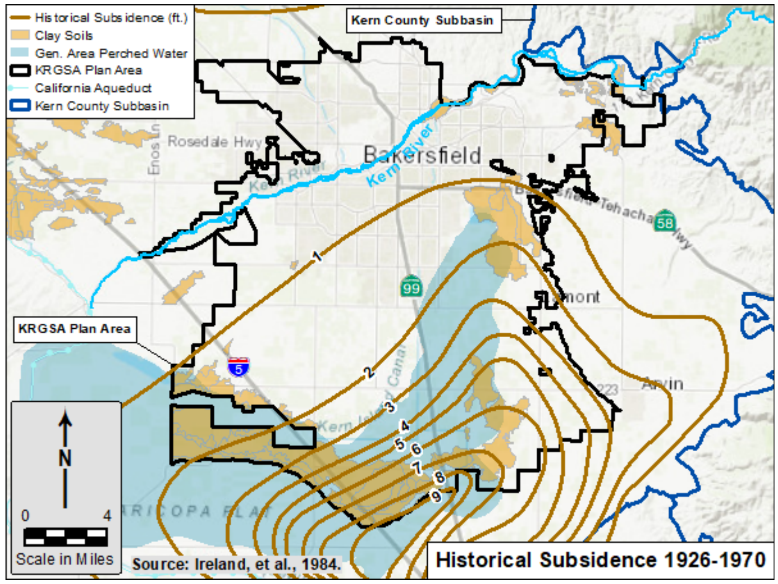
Arsenic Concentrations and Wellhead Treatment

The **water quality** of KRGSA groundwater is similar to local surface water with relatively low TDS levels resulting, in part, from decades of actively managed recharge of both local and imported surface water supplies in the Plan Area. In general, groundwater quality has been sufficient to meet designated beneficial uses including municipal, industrial, and agricultural water supply as well as recreational and environmental uses.

Two primary water quality constituents of concern have been identified in Plan Area drinking water – arsenic and 1,2,3-trichlorpropane (TCP). Arsenic is a naturally-occurring trace element in Subbasin groundwater with a California MCL of 0.010 mg/L (10 ug/L). In the northern Plan Area, numerous municipal wells have detected arsenic concentrations above the MCL (see red/purple dots on map above). Elevated arsenic concentrations are generally correlated with deeper groundwater as evidenced by the recent drought. Municipal well owners took costly measures to manage concentrations during this time including removing wells from service, blending, modifying well construction, and installing wellhead treatment facilities (black diamonds on map above). Even with these actions, many wells remain at risk if water levels continue to decline. KRGSA managers have determined chronic water level declines below the recent historic low levels to be an undesirable result, as defined by SGMA, for portions of the Plan Area.

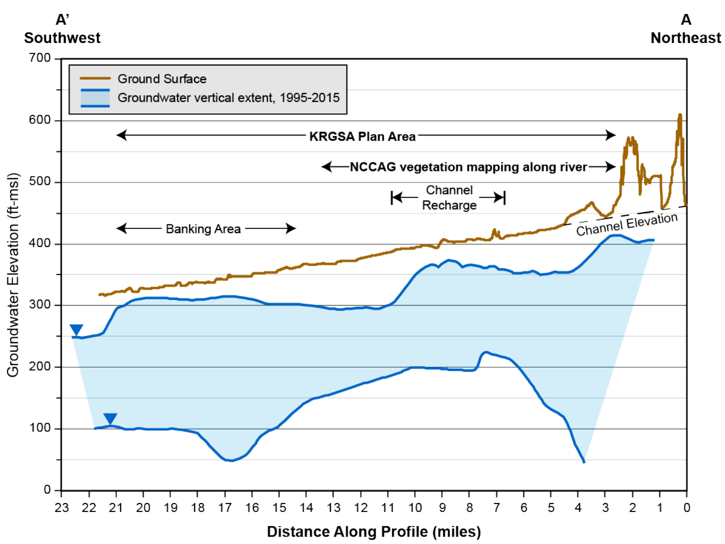
With regard to TCP, the 2017 adoption of a California MCL of .005 ug/L (5 parts per trillion) has resulted in increased sampling, lawsuits against soil fumigant manufacturers, and installation of numerous wellhead treatment facilities in the Plan Area, including those installed by the City and multiple other KRGSA water purveyors. Unlike arsenic, TCP concentrations do not appear to rise with declining water levels, but additional data are needed to characterize the nature and extent of TCP in the Plan Area. Public water supply wells will continue to be tested for TCP as required by the State; these data will be compiled periodically and reviewed by the KRGSA to ensure that management actions do not exacerbate the extent of TCP in groundwater.

The decline of water levels in the Plan Area, exacerbated by the recent drought, could contribute to **inelastic land subsidence** in susceptible areas. As water levels decline, dewatering and compaction of predominantly fine-grained clay deposits can cause the land surface to subside.



The USGS has mapped historical land subsidence in the southeastern KRGSA Plan Area where subsurface clay deposits are more prevalent. As indicated by the map, USGS estimated about two to eight feet of total land subsidence in the southeast as of 1970. Although satellite imagery indicates recent land subsidence, primarily in areas of historical subsidence, the rate and magnitude are uncertain. No surficial evidence or impacts to land use/critical infrastructure have been identified.

In the absence of adverse impacts to date, a multi-faceted approach to subsidence monitoring is proposed for the GSP, including control of water levels coupled with other local monitoring in the highest risk areas and participation with other GSAs in a Subbasin-wide monitoring program. In this manner, future risks from land subsidence can be more readily identified and managed.



The potential for **interconnected surface water and groundwater dependent ecosystems** (GDEs) in the KRGSA Plan Area was analyzed using mapped polygons provided by DWR, referred to as Natural Communities Commonly Associated with Groundwater (NCCAG). NCCAG maps contained 177 polygons of vegetation and 65 polygons for possible wetlands in the KRGSA Plan Area, most of which occurred along a 12-mile reach of the Kern River.

To analyze the NCCAG polygons along and near the Kern River channel, seasonal high water levels beneath the channel were plotted over a 20-year period, as shown by the profile above. The blue shading shows the range of high water levels for each year from WY 1995 through WY 2015. As indicated, only areas managed for groundwater recharge, including managed channel recharge and banking areas, have water levels generally shallower than 50 feet even during the wettest years.

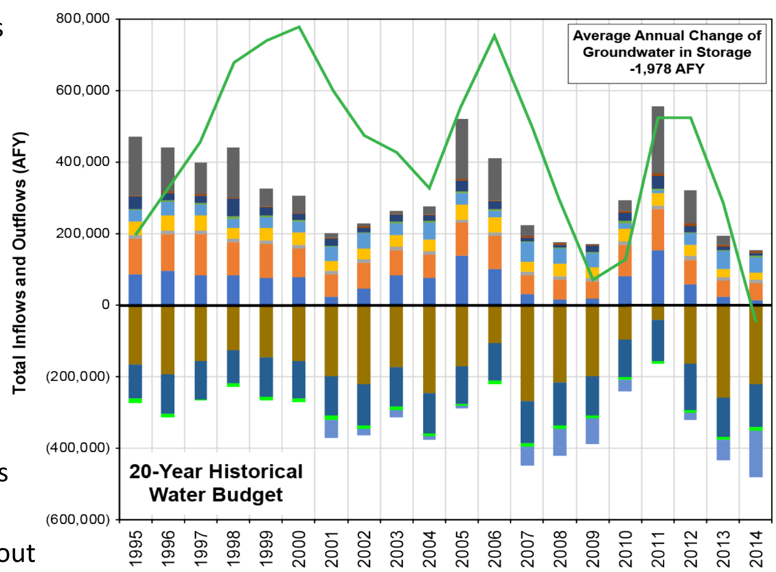
As described in the GSP, flows in the Kern River are managed through controlled reservoir releases and diverted into a complex network of canals just as the River enters the Plan Area. More than 80 percent of the flow is diverted above the Calloway Weir, leaving a mostly dry river channel for about two thirds of the NCCAG polygon areas. Upstream, the channel elevation rises into the basin uplands where water levels are even deeper. The riparian vegetation along the Kern River appears to be maintained by regulated releases and supplemented by surface water irrigation conducted in some areas by the City of Bakersfield. Water recharged in the channel does not appear to be interconnected surface water. A shallow monitoring well at the Calloway Weir is included in the GSP monitoring network to support future analyses, as needed.

In the southern Plan Area, many of the NCCAG polygons were associated with recharge facilities, irrigation canal spills, locally constructed ski lakes on clay soils, and other human-constructed features. Shallow perched water from agricultural return flows on clay sediments could be supporting other local vegetation. The perched zone is not pumped due to its sporadic occurrence and the low permeability of the clay deposits; it is not part of a Principal Aquifer. The perched zone is likely to continue to contain water from ongoing surface water irrigation.

ES-4 WATER BUDGETS

Historical (WY 1995 – WY 2014), current (WY 2015), and projected (WY 2020 – WY 2070) water budgets were analyzed to provide an understanding of average annual change in groundwater in storage associated with past and current inflows and outflows and the projected changes in these flows under specified future conditions including climate change.

Three independent water budget methods indicate slightly negative (-1,978 AFY as indicated on graph) to slightly positive changes for groundwater in storage over the historical period, and collectively indicate no significant reduction in groundwater in storage over average hydrologic conditions (see Table ES4-1 on the following page). This conclusion suggests that there were no undesirable results occurring beneath the KRGSA as of the SGMA baseline of January 2015 for this sustainability indicator. The water budget analysis indicates a sustainable yield of about 321,871 AFY.



However, when adjusted for banking obligations outside of the KRGSA and recharge inside of the KRGSA attributable to others, a negative change in groundwater in storage was identified at about -29,153 AFY (see **Table ES4-1** below), suggesting a lower sustainable yield of about 290,740 AFY. In order to protect against future overdraft, this deficit is added to potential future deficits for planning purposes.

Table ES4-1: Average Annual Change in Groundwater in Storage – Comparison of Methods

Water Budget Method	Change in Groundwater in Storage (AFY)	Comments
Checkbook	-1,978 AFY	Tabulates recharge and pumping for the physical groundwater system beneath the KRGSA Plan Area (Table 4-3, Figure 4-1)
C2VSimFG-Kern Model	4,055 AFY	Simulated inflows and outflows as above, but also includes subsurface flows (Tables 4-6 and 4-7, Figure 4-5)
Groundwater Elevation Contour Maps	-2,912 AFY	Subtraction of spring groundwater elevation contour maps over average conditions for the KRGSA Plan Area (Figure 3-28)
Adjusted Checkbook	-29,153 AFY	Removes recharge and pumping attributable to non-KRGSA parties; also removes banking obligations outside of KRGSA. Adds outside banking attributable to KRGSA agencies (Table 4-5)

Historically, KRGSA agencies have also relied on about 326,321 AFY of local and imported surface water. For future planning, the total amount of surface water supplies controlled by KRGSA agencies is more than 437,780 AFY, as tabulated on **Table ES4-2** below (described more fully in GSP Section 4.6.1).

Table ES4-2: Total Surface Water Supplies Managed by the KRGSA

Agency	Average Annual Surface Water Supplies	Description
City of Bakersfield	163,139 AFY	Kern River entitlement (incl. KRC&I and South Fork)
	29,171	Recycled water and stormwater conservation
Kern Delta Water District	201,943 AFY	Kern River entitlement
	15,765 AFY	SWP, Table A SWP Allocation – Current Conditions
	1,257 AFY	11% "leave behind" from Groundwater Banking Program
Improvement District No. 4	51,281 AFY	SWP Table A Allocation – Current Conditions
	1,432 AFY	SWP Article 21 Allocation – Current Conditions
	9,000 AFY	Kern River, Lower River Water Right (KCWA)
		Additional miscellaneous surface supplies not quantified
		Not all water budget components included in table
TOTAL	437,780 AFY	(see additional explanations in GSP Table 4-12 footnotes)

Table ES4-2 repeats GSP Table 4-12, which contains numerous explanatory footnotes that document the supply amounts above. As summarized by Table 4-12 footnotes and described in Section 4.6.1, amounts in **Table ES4-2** represent average annual conditions, do not include all components of the water budget (e.g., precipitation), and do not quantify additional surface water that may also be available for future use (such as Kern River released water). The footnotes also acknowledge that a relatively small portion of this water (less than 10 percent of the total) is obligated to others both inside and outside of the

KRGSA. Notwithstanding these qualifications, the table documents a substantial amount of surface water that is managed by the KRGSA and is available for optimizing conjunctive use and achieving sustainable groundwater management.

In order to analyze future supply requirements, a projected future water budget was developed. This analysis evaluated three future projected scenarios (including baseline, 2030, and 2070 climate change conditions) to identify a range of future supplies and demands. Those amounts were compared to historical amounts to estimate potential future deficits from decreased supplies or increased demands. Potential future deficits are tabulated in Table ES4-3 and combined with historical deficits (-29,153 AFY in Table ES4-1) for GSP project planning.

Table ES4-3: Projected Water Budget Components and Potential Deficits (Checkbook Method)

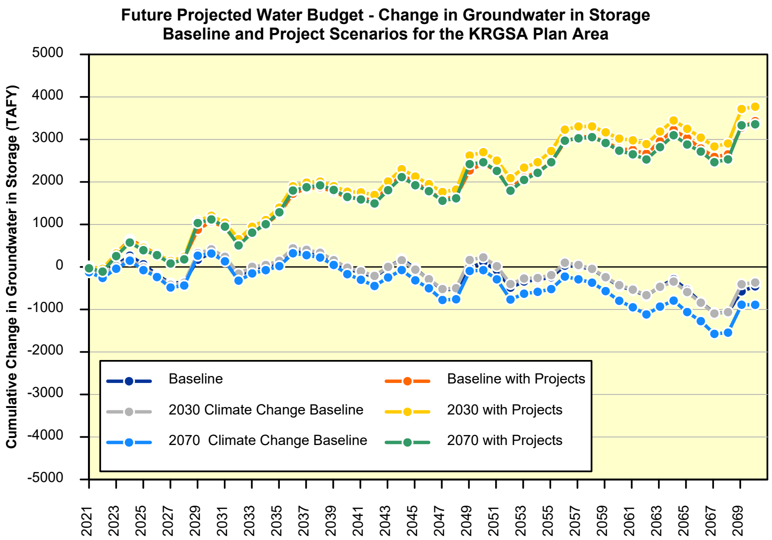
Water Budget Component	Historical Average Annual Amounts (AFY)	Baseline Conditions (AFY)	2030 Climate Change Conditions (AFY)	2070 Climate Change Conditions (AFY)
SWP[1] – ID4	74,035	52,758	51,182	48,759
SWP - KDWD	18,655	15,765	15,294	14,537
TOTAL SWP	92,690	68,523	66,476	63,296
Net decrease in SWP from historical:		**24,167**	**26,214**	**29,394**
Agriculture Demand	261,019	261,019	271,460	281,460
Urban Demand[2]	167,970	182,290	178,115	254,117
TOTAL DEMAND	428,989	443,309	449,575	535,577
Net increase in demand from historical:		**14,320**	**20,586**	**106,588**
Potential Future Water Budget Deficits[3]:		-38,487	-46,800	-135,982
Deficit from Historical Water Budget[4]:		-29,153	-29,153	-29,153
Combined Future Water Budget Deficits:		**-67,640**	**-79,953**	**-165,135**

[1] *Table A Allocation and Article 21 water*

[2] *Baseline Conditions urban demand from WY 2013. Urban demand for 2030 based on area-weighted population growth (average 1.1% annually) and per capita water demand estimates from UWMPs (average 248 gpcd). Population growth rates for the County (0.8% annually) used for years 2040 through 2070.*

[3] *Sum of net decrease in SWP and net increase in demand from data in upper table.*

[4] *Remaining average annual deficits from adjusted checkbook method of the historical water budget; see* ***Table 4-5****.*

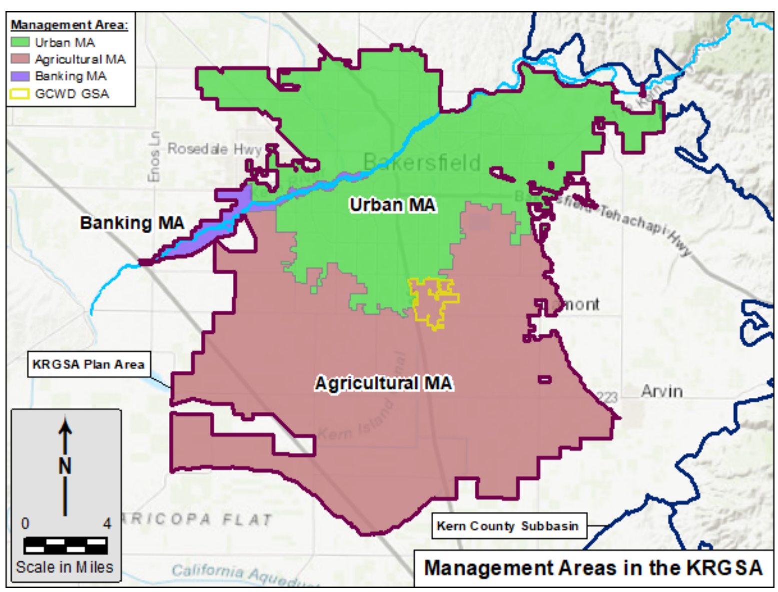


GSP projects were developed to address the combined future water budget deficits quantified above; projects were analyzed with the C2VSimFG-Kern model. As shown by the graph at left, the three baseline conditions (blue/gray lines) indicate ongoing future deficits and overdraft conditions. However, with the addition of GSP projects (green/orange lines), those conditions are mitigated. In this manner, future projections indicate sustainable groundwater management (i.e., positive changes in groundwater in storage).

The modeling analysis contains both recharge and recovery in the KRGSA attributable to others, which suggests more positive changes in the physical groundwater system than would occur from KRGSA management activities alone. Nonetheless, the significant increase of groundwater in storage as demonstrated by the model – even during drought and banking recovery operations – illustrates the ability of the KRGSA to mitigate future potential overdraft. As documented in Section 7.1, the additional supply associated with GSP projects demonstrates that projected future deficits can be mitigated.

ES-5 Management Areas and Sustainable Management Criteria

In order to better manage the KRGSA for sustainable management criteria, three Management Areas (MAs) have been delineated based on land use and primary groundwater use across the KRGSA Plan Area. As indicated on the map at right, the MAs are designated as the Urban Management Area (Urban MA), the Agricultural Management Area (Agricultural MA), and the Banking Management Area (Banking MA).



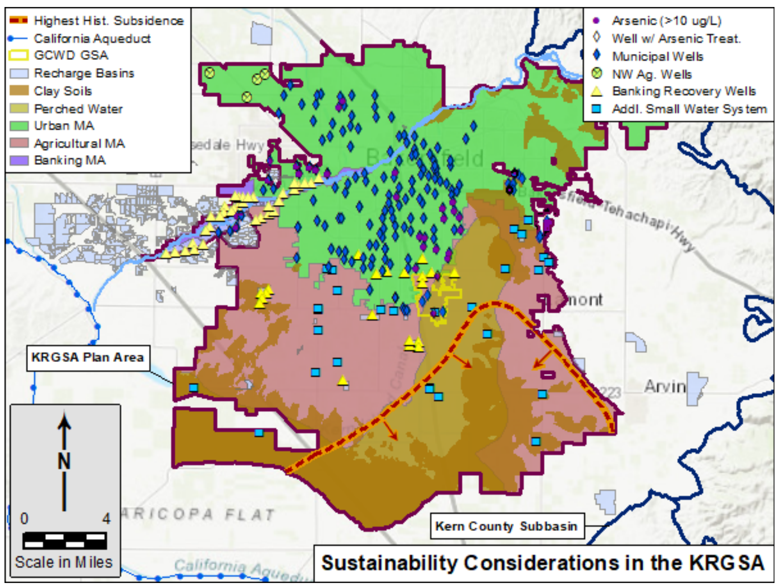
It is noted that there are urban areas in the Agricultural MA, banking areas in both the Urban and Agricultural MAs, and urban wells in the Banking MA. Accordingly, the sustainable management criteria varies across each MA to consider this overlap and provide operational flexibility so that conjunctive use and groundwater management can be best optimized.

Conditions in the Plan Area MAs were evaluated for each of the applicable sustainability indicators shown in Table ES5-1 (two sustainability indicators – seawater intrusion and interconnected surface water – are not applicable as dicussed in GSP **Section 5.6** and **5.9**). Undesirable results are defined at the Subbasin level. If any of the sustainability indicators are determined to be significant and unreasonable for the KRGSA Plan Area, it would trigger a Management Area Exceedance, which could contribute to undesirable results in the Subbasin.

Amended Table ES5-1: Sustainability Indicators for the KRGSA Plan Area

Chronic Lowering of Water Levels	**Reduction of Groundwater in Storage**	**Degraded Water Quality**	**Inelastic Land Subsidence**

To assist with the analysis, key issues in the Plan Area were identified and considered with regard to each sustainability indicator. Issues are illustrated on the map at right. As explained in the section on groundwater levels, historic low water levels during the recent drought adversely affected a number of municipal wells, resulting in undesirable results as defined by SGMA. As discussed in the section on groundwater quality, arsenic has been problematic for municipal wells when water levels are lowered, also potentially creating an undesirable result. As indicated in the section on land subsidence, the southeastern KRGSA is susceptible to future subsidence if water levels are significantly lowered.



Sustainability Considerations in the KRGSA

Notwithstanding all of these considerations that indicate the need to maintain higher water levels, numerous banking recovery wells throughout the KRGSA need to draw water levels down during droughts to obtain critical stored supplies; not being able to do so could result in undesirable results for those wells. As indicated by the potentially conflicting need for high water levels in some areas and lower water levels in others, the sustainable management criteria were balanced for each MA and to meet the needs for local sustainable management.

As indicated above, each sustainability indicator relevant to the KRGSA is related to water levels; accordingly, water levels are used as a proxy for setting the sustainable management criteria, including minimum thresholds (MTs) and measurable objectives (MOs), for all of the indicators.

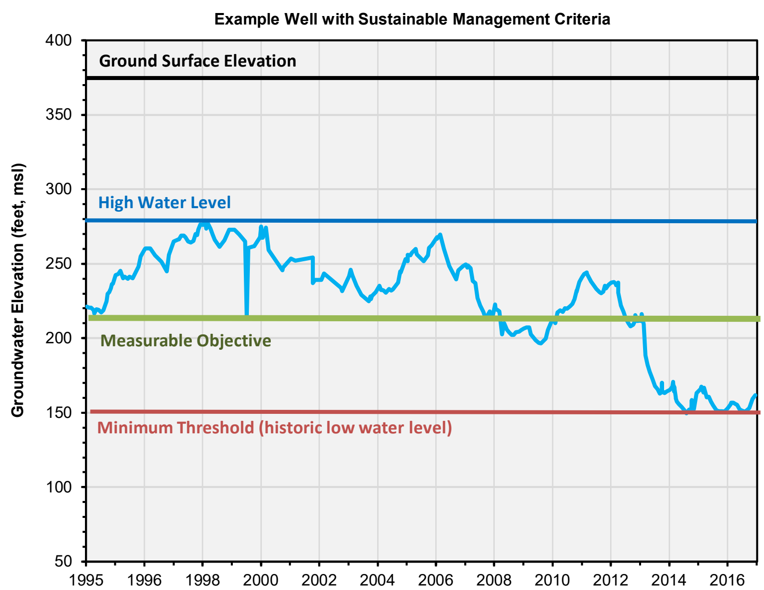
Table ES5-2 summarizes the analysis for setting MTs and defining undesirable results in various areas of the MAs. Because water levels are used as the MT for each sustainability indicator, the shallow-most indicator is the controlling MT for any representative monitoring well. Also, because water levels can drop below the MTs for a certain number of wells and time period before undesirable results occur, a percentage of wells and duration of exceedances are incorporated into the definition of the undesirable results.

Amended Table ES5-2: Summary of Undesirable Results Definition for the KRGSA

KRGSA Management Area (MA)	MA Subarea and Considerations for Management		Sustainability Indicator and Minimum Threshold (MT)			
			Chronic Lowering of Water Levels	Reduction of Groundwater in Storage	Degraded Water Quality	Land Subsidence
KRGSA Urban MA	Central/South	Municipal wellfields	Historic Low WL	Historic Low WL	Historic Low WL	Historic Low WL
	Northeast	ENCSD wellfield	50' below Historic Low WL	50' below Historic Low WL	50' below Historic Low WL	50' below Historic Low WL
	Northwest corner	Transition to agricultural lands	20' below Historic Low WL	20' below Historic Low WL	20' below Historic Low WL	20' below Historic Low WL
KRGSA Agricultural MA	Along southern Urban MA	Transition with municipal wells	Historic Low WL	50' below Historic Low WL	Historic Low WL	Historic Low WL
	North-Central	Greenfield CWD wells	Historic Low WL	50' below Historic Low WL	Historic Low WL	Historic Low WL
	West and Northwest	Agricultural and recovery wells	50' below Historic Low WL	50' below Historic Low WL	50' below Historic Low WL	50' below Historic Low WL
	Southeast	Subsidence potential	50' below Historic Low WL	50' below Historic Low WL	50' below Historic Low WL	20' below Historic Low WL
	East	Transition to small system wells	Historic Low WL	50' below Historic Low WL	Historic Low WL	Historic Low WL
KRGSA Banking MA	Kern River Channel	ID4/KCWA/City recovery activities	20' below Historic Low WL	Not applicable	20' below Historic Low WL	20' below Historic Low WL
	Berrenda Mesa	KCWA operational area	Historic Low WL	Not applicable	Historic Low WL	Historic Low WL
	COB 2800 Facility	City of Bakersfield municipal wells	Historic Low WL	Not applicable	Historic Low WL	Historic Low WL

Historic low water level (WL) is the lowest level observed in an area during the recent drought of 2013-2016.
Measurable Objective (MO) for each sustainability indicator is the average of the MT and the historical high groundwater elevation during the historical Study Period.
Highlighted green cell indicates the controlling sustainability indicator(s) for that area in each MA.
MTs are set in each Representative Monitoring Well (RMW) as documented in Chapter 6 and shown in Appendix J.

Although not included on **Table ES5-2**, the MO for each well is defined as the average of the historic high water level during the Study Period (usually 1998) and the MT for each well. This midpoint approach for the MO provides a target within an operational range that would indicate ongoing sustainable management over average hydrologic conditions.



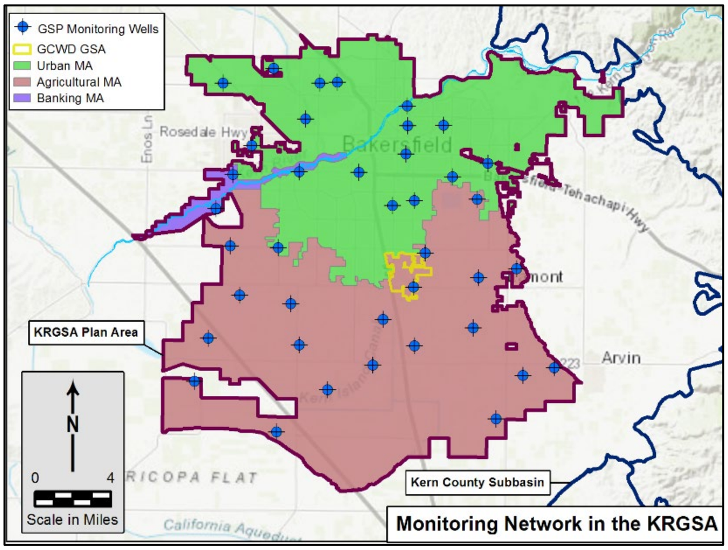
An example hydrograph at left illustrates the process by which MTs and MOs were set for each of the representative monitoring wells. For this particular example monitoring well, the MT is set at the historic low water level. The MO is defined as the average between the MT and the historic high water level.

ES-6 MONITORING NETWORKS

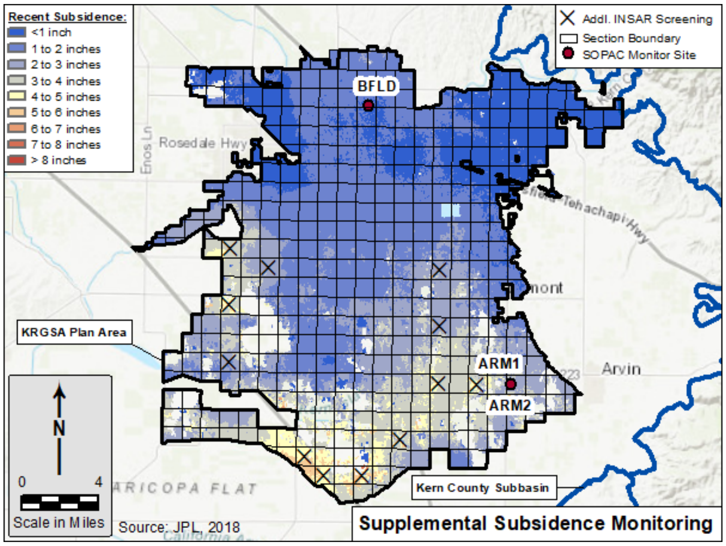
The KRGSA GSP monitoring network is designed to support the KRGSA GSP Sustainability Goal by providing the ability to detect undesirable results as defined in Section 5. The monitoring network also allows performance monitoring for GSP implementation. As provided in GSP regulations, the monitoring network, when implemented, is designed to accomplish the following:

- Demonstrate progress toward achieving MOs.
- Monitor impacts to the beneficial uses or users of groundwater.
- Monitor changes in groundwater conditions relative to MOs and MTs.
- Quantify annual changes in water budget components. (§354.34).

The GSP monitoring network, shown at right, includes 39 wells where water level monitoring will be conducted. A MT and MO are set at each monitoring well for ongoing analysis of undesirable results.



Wells in other monitoring programs were prioritized to take advantage of site access, long established records, and publicly-available data for transparency and multiple uses. Subbasin GSAs have coordinated on water level monitoring protocols; those protocols are adopted into the KRGSA GSP.



Although no adverse impacts from land subsidence have been identified in the KRGSA, a multi-faceted approach for land subsidence monitoring has been developed for the GSP monitoring network. Water level monitoring is supplemented with data from two KRGSA GPS monitoring sites, shown by the red dots on the map at left. In addition, KRGSA managers will download and evaluate publicly-available InSar data as published periodically by DWR. InSar monitoring will focus on susceptible square mile areas as shown by the "X" on the map at left. Finally, the land subsidence monitoring program will include KRGSA participation in the coordinated Subbasin-wide monitoring program for regional critical infrastructure of Subbasin-wide importance.

ES-7 Projects, Management Actions and GSP Implementation

Multiple projects and management actions have been identified to support the KRGSA and Kern County Subbasin sustainability goals. *Projects* involve substantial efforts that provide an increase in water supply, increased recharge and groundwater storage, or a reduction in demand for the KRGSA. *Actions* provide a framework for groundwater management including establishing GSP policies and filling data gaps. Phase One projects and management actions will begin during the first five years of GSP implementation; Phase Two projects will be initiated after the first two five-year evaluations in 2030, as needed for sustainable management.

The KRGSA already has under its control sufficient Kern River and imported SWP water to achieve sustainability under a variety of future demand scenarios. By using its available Kern River entitlement conjunctively with imported water and recycled water supplies, the KRGSA intends to implement Phase One projects that collectively provide:

- Increases in recharge and banking to offset potential future deficits and avoid overdraft.
- Decreases and re-distribution of municipal and agricultural pumping.
- Improvements in drinking water quality for disadvantaged communities.
- Mitigation for the potential of land subsidence in the KRGSA.
- Optimal conjunctive management of imported SWP water and local Kern River water with groundwater resources through direct use and groundwater banking and recovery.

Imported SWP Water

Kern River Water

Groundwater Banking and Recovery

Six Phase One projects are summarized in **Table ES7-1**, followed by primary attributes of three key projects. Collectively, Phase One projects provide an additional water supply of up to about 150,823 AFY to eliminate projected future deficits associated with baseline and 2030 Climate Change conditions. Additional Phase Two projects will be implemented for more extreme 2070 Climate Change conditions, as needed.

Table ES7-1: Phase One Project Summary for KRGSA GSP

Project	Description	Project Water Supply
Water Allocation Plan	KDWD plans to use its full Kern River entitlement as prioritized in its Water Allocation Plan (WAP) for the Agricultural MA. The WAP total average supply has been corrected for planned sales to NKWSD.	20,797 AFY
Kern River Optimized Conjunctive Use	The City plans to use its available Kern River entitlement for increased banking in the River channel and banking projects to mitigate undesirable results for water levels and water quality in the Urban MA.	89,619 AFY
Expand Recycled Water Use in the KRGSA	The City will increase recycled water use inside of the KRGSA from its WWTP No. 3 in 2026 when a contract for use outside of the KRGSA expires (about 72% currently used outside of the KRGSA).	11,556 to 13,407 AFY
Conversion of Agricultural Lands to Urban Use	Approximately 10,000 acres of current KRGSA agricultural lands is expected to be urbanized; this future urban demand is already included in the projected water budget, so 100% of this agricultural water use represents a demand reduction.	27,000 AFY
ENCSD North Weedpatch Highway Water System Consolidation	Up to six small water systems in the northeast KRGSA will be consolidated into the ENCSD system for benefits to drinking water quality, including to disadvantaged communities (DACs).	No new supply; improved water quality to DACs
Possible Water Exchange	KRGSA member agencies can perform exchanges of surface water and groundwater for benefits to water quality, including to DACs.	No new supply; improved water quality to DACs

Attributes and benefits of the Water Allocation Plan, the Kern River Optimized Conjunctive Use, and the ENCSD North Weedpath Highway Water System Consolidation projects are summarized below as examples of:

- Additional water supply to the Agricultural MA,
- Optimized water supplies to avoid undesirable results in the Urban MA, and
- Water quality improvements for drinking water in KRGSA disadvantaged communities, respectively.

Water Allocation Plan


Recharge in unlined canals

- Optimizes managed Kern River recharge over the entire Agricultural MA using canals and spreading basins.
- Provides irrigation water to reduce agricultural pumping.
- Allows local maintenance of water levels to avoid undesirable results.
- CEQA compliance completed in 2018; implementation has begun.

Kern River Optimized Conjunctive Use


Managed Recharge in the COB 2800 Facility

- Prioritizes use of City's available Kern River water for future demands.
- Water availability increases over the implementation and planning horizon.
- Increases recharge and groundwater banking in the Kern River channel and banking projects for subsequent recovery and use.
- Reduces and manages municipal pumping to avoid undesirable results.
- Meets future projected water budget deficits.

East Niles CSD North Weedpatch Water System Consolidation


TCP Treatment

- Consolidates up to 6 small water systems with ENCSD to address water quality concerns.
- Reduces nitrate concentrations in drinking water.
- Provides for 1,2,3-TCP and arsenic treatment to improve drinking water for disadvantaged communities.

GSP Phase One Management Actions

Management actions provide a framework for overall groundwater management including establishing GSP policies and filling data gaps. Ten management actions have been identified for implementation in Phase One as listed below:

- 5-Step Action Plan if Minimum Thresholds are exceeded.
- Optimize Conjunctive Use in the KRGSA.
- Implement a Well Metering Program.
- Implement a Groundwater Extraction Reporting Program.
- Support California Delta Conveyance to Preserve Imported Supplies.
- Incorporate Climate Change Adaptation Strategies.
- Support Sustainable Groundwater Supplies for KRGSA Disadvantaged Communities.
- Improve Groundwater Monitoring in the KRGSA Plan Area.
- Incorporate a Policy of Adaptive Management in the GSP Process.

GSP Phase Two Projects and Management Actions

Phase Two projects and actions involve early expansion of a surface water treatment plant, re-negotiations of banking projects, capital improvements to municipal wells, expanded recharge facilities, improvements to monitoring, a series of demand reductions involving an allocation of agricultural supply, urbanization of agricultural lands, and additional urban conservation measures. It is recognized that demand reduction projects could have a detrimental impact on the local economy, livelihood of residents and business owners, and the well-being of Metropolitan Bakersfield and Kern County. Therefore, potential demand reductions are targeted for later in the implementation period (i.e., Phase Two) to allow water supply projects the opportunity to sustainably support current and projected growth in the beneficial uses of groundwater.

Future Reporting and Evaluation

In accordance with GSP regulations, the KRGSA will coordinate with the Subbasin on Annual Reporting and Five-Year re-evaluation of the GSP. Implementation of the GSP is summarized in Section 8.

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1 ADMINISTRATIVE INFORMATION

The Kern River Groundwater Sustainability Agency (KRGSA) covers approximately 361 square miles of the critically-overdrafted Kern County Subbasin (5-022.14), where numerous water and irrigation districts, municipalities, industries, mutual water companies, small water systems, and Kern County all rely on the shared groundwater resources. In compliance with the Sustainable Groundwater Management Act (SGMA), the KRGSA was formed to cooperatively manage local groundwater in a sustainable manner within the KRGSA boundaries as shown on **Figure 1-1**.

The KRGSA is an exclusive Groundwater Sustainability Agency (GSA) in the Kern County Subbasin. KRGSA member agencies include the City of Bakersfield, Kern Delta Water District (KDWD), Kern County Water Agency (KCWA) Improvement District No. 4 (ID4), North of the River Municipal Water District/Oildale Mutual Water Company (NORMWD/OMWC), and East Niles Community Services District (ENCSD). A Notice of Decision by these agencies to become a GSA is included in **Appendix A**. Service areas of these agencies are shown on **Figure 1-2**.

Greenfield CWD is a separate GSA coordinating with the KRGSA to prepare this Groundwater Sustainability Plan (GSP) through a memorandum of understanding (MOU); Greenfield CWD service area is also shown on **Figure 1-2**. In addition, some small pockets of unincorporated lands managed by Kern County are outside of the KRGSA boundaries but are included in this GSP through an MOU with the County. These KRGSA GSP agencies are cooperating with other agencies in the Subbasin for the development of Groundwater Sustainability Plans that collectively cover the entire Subbasin as required by SGMA. A Notice of Intent to Prepare a Groundwater Sustainability Plan was filed with the Department of Water Resources on May 19, 2017 and included in **Appendix B**. The MOUs with Greenfield CWD and Kern County to coordinate on the GSP are included in **Appendix C**.

KRGSA boundaries were developed to generally coincide with Bakersfield city limits and jurisdictional boundaries of other member service areas. A small area of the city limits in the northeast is excluded from the GSA and covered by Olcese Water District (**Figure 1-2**). Since GSA formation, the KRGSA boundaries have been modified slightly to cooperate with and accommodate boundaries being developed by other GSAs. This process ensured that all areas of the Subbasin were covered by a Groundwater Sustainability Plan.

The KRGSA excludes small areas internal to the outer KRGSA boundary that coincide with unincorporated County lands or other water agencies that have been included in other GSAs (**Figure 1-2**). The largest such area is the Greenfield County Water District (Greenfield CWD), a GSA covering about 2,200 acres in the central KRGSA. Additional lands excluded from the KRGSA occur in unincorporated Kern County (**Figure 1-2**). Although these excluded lands are outside of the KRGSA, Greenfield CWD GSA and most of the County lands within the KRGSA boundary (unless covered by another agency) are included in the KRGSA GSP Plan Area as described in **Section 2**.

The KRGSA has also coordinated the preparation of the GSP with other GSAs in the Kern County Subbasin. There are currently 11 exclusive GSAs in the Subbasin including the KRGSA, as shown on **Figure 1-3.** Subbasin-wide coordination has been documented in a single coordination agreement that covers the entire basin. The coordination agreement is being submitted separately with the Subbasin GSPs; information on the coordination agreement is summarized in **Appendix D**.

1.1 PURPOSE AND ADOPTION OF THE GROUNDWATER SUSTAINABILITY PLAN

The Kern County Subbasin has been designated a high priority, critically-overdrafted groundwater subbasin by the Department of Water Resources (DWR) (DWR, 2016a). As required by Water Code Section 10720.7, GSAs in critically overdrafted subbasins are required to prepare Groundwater Sustainability Plan (GSPs) for submittal to DWR by January 31, 2020. The purpose of the KRGSA GSP is to comply with this requirement by assessing groundwater conditions within the KRGSA Plan Area, selecting appropriate sustainable management criteria, and developing projects and management actions to achieve and maintain long-term groundwater sustainability throughout the Plan implementation and planning horizon, pursuant to Water Code Section 10727 et seq.

This KRGSA GSP was adopted by the KRGSA Board of Directors on December 5, 2019 after holding a public hearing and considering public comments on the Review Draft GSP. Comments included those made at the hearing, as well as written and verbal comments provided to the KRGSA previously on the Review Draft GSP and during community workshops, stakeholder meetings, and other outreach activities. Please see Section 1.6 regarding the July 2022 adoption of amendments to the original KRGSA GSP.

1.2 SUSTAINABILITY GOAL

The Sustainability Goal of the KRGSA GSP, as defined in Water Code Section 10721(u), is to manage groundwater sustainably in the KRGSA Plan Area to:

- Support current and future beneficial uses of groundwater including municipal, agricultural, industrial, public supply, domestic, and environmental
- Optimize conjunctive use of surface water, imported water, and groundwater
- Avoid or eliminate undesirable results throughout the planning horizon.

The KRGSA has also coordinated with other GSAs in the Subbasin to develop a consistent Subbasin-wide sustainability goal to ensure that all GSAs are striving towards common goals. This goal is presented as an additional goal of this GSP. The coordinated sustainability goal of the Kern County Subbasin is to:

- Achieve sustainable groundwater management in the Kern County Subbasin through the implementation of projects and management actions at the member agency level of each GSA.
- Maintain its groundwater use within the sustainable yield of the basin as demonstrated by monitoring and reporting of groundwater conditions.

- Operate within the established sustainable management criteria, which are based on the collective technical information presented in the GSPs in the Subbasin.
- Collectively bring the Subbasin into sustainability and to maintain sustainability over the implementation and planning horizon.

Details regarding development and achievement of these sustainability goals are discussed in **Section 5** of this KRGSA GSP.

1.3 AGENCY INFORMATION

KRGSA formation events include:

- March 1, 2016 - KDWD held a public hearing to determine whether to become a GSA, and on March 15, 2016 - adopted Resolution No. 2016-03 electing to jointly become a GSA with the City of Bakersfield and ID4.
- March 2, 2016 - the City of Bakersfield held a public hearing to determine whether to become a GSA and on March 30, 2016 adopted Resolution No. 039-16 electing to jointly become a GSA with KDWD and ID4.
- March 21, 2016 - East Niles Community Services District held a public hearing and adopted Resolution No. 2016-04 to join the GSA.
- March 30, 2016 - City of Bakersfield, KDWD, and ID4 sign an MOU to form the KRGSA and manage groundwater resources sustainably within the GSA boundary.
- March 31, 2016 - ID4 held a public hearing to determine whether to become a GSA, and on March 31, 2016 adopted Resolution No. 11-16 electing to jointly become a GSA with the City of Bakersfield and KDWD.
- April 6, 2016 - NORMWD held a public hearing and adopted Resolution No. 2016-2 to join the GSA.
- April 12, 2016 - The City of Bakersfield, KDWD, and ID4 jointly submit a *Notice of Decision to Become a Groundwater Sustainability Agency* and were subsequently determined to be an Exclusive GSA by DWR.

As required by Sections 354.6 and 10723.8, the Notice of Decision to become a GSA is included in **Appendix A**. The appendix includes the MOU, resolutions, list of interested parties, and a preliminary service area boundary map. Since the original formation of the GSA, the KRGSA boundaries have been revised slightly to those shown on **Figures 1-1** and **1-2** in coordination with surrounding agencies.

The KRGSA point of contact and Plan Manager is:

Art Chianello, Water Resources Manager
Kern River Groundwater Sustainability Agency
1000 Buena Vista Road
Bakersfield, CA 93311

661-326-3715
achianel@bakersfieldcity.us

GSA Program Coordinators, serving as Plan Managers, are:

Art Chianello, Water Resources Manager
Water Resources Department
(661) 326-3715
achianel@bakersfieldcity.us

Steven Teglia, General Manager
Kern Delta Water District
(661) 834-4656
steven@kerndelta.org

David Beard, ID4 Manager
Kern County Water Agency
Improvement District No. 4
(661) 634-1400
dbeard@kcwa.com

As previously stated, Greenfield CWD is cooperating with KRGSA in development of its GSP through an MOU (**Appendix C**). Greenfield CWD is also an exclusive GSA in its service area and has a long-standing relationship of coordination with KDWD. The Greenfield CWD Board of Directors approved a resolution (2016-01) to form a GSA on March 14, 2016. The district filed its Notice of Intent (NOI) to serve as a GSA on April 21, 2016 and was subsequently deemed an exclusive GSA by DWR. This provides Greenfield CWD with the legal authority to participate in the GSP development in the KRGSA Plan Area, which includes all of the Greenfield CWD GSA boundaries.

1.3.1 Organization and Management Structure of the Groundwater Sustainability Agency

As Parties to the MOU, Member Agencies of the KRGSA have the following roles and responsibilities:

- Working jointly to fulfill the Purpose of the MOU, SGMA, and the development and implementation of a GSP within the boundaries of the KRGSA.
- Meeting regularly to discuss SGMA, GSP development and implementation activities, assignments, and ongoing work progress.
- Forming committees as necessary to discuss issues that impact the KRGSA.
- The City of Bakersfield and ID4 are jointly responsible for implementing the GSP in areas of the KRGSA that are within both City limits and ID4 boundaries.
- KDWD is responsible for implementing the GSP in agricultural areas within KDWD boundaries.

Unanimous consent of the Parties is the intent for all actions undertaken by the KRGSA; however, if unanimous consent is not achieved, a majority vote is sufficient and required. As stated in the MOU, in the event of an impasse or disagreement, the Parties shall use their best efforts to find a mutually agreeable result. To this effect, the Parties shall consult and negotiate with each other in good faith to reach a solution that is mutually satisfactory. If the Parties do not reach a solution, then the matter shall be submitted to non-binding arbitration or mediation within a reasonable period of time.

To manage the ongoing activities of the KRGSA, Plan Managers meet regularly, typically twice monthly. The Plan Managers guide GSP development, oversee GSA finances, set Board agenda items, and carry out Board actions. Plan Managers also monitor ongoing GSP activities by other GSAs in the Subbasin and coordinate GSP activities as needed.

The KRGSA is governed by a Board of Directors, one from each of the three largest member agencies, the City of Bakersfield, ID4, and KDWD. Currently, KRGSA Board meetings are held monthly at City Hall in Bakersfield on the first Thursday of each month. KRGSA Board meetings are public meetings held in accordance with the Ralph M. Brown Act (California Government Code sections 54950 et seq.) to encourage participation and facilitate communication and collaboration among all KRGSA Members, stakeholders, and other interested parties. Additional information on the KRGSA organization and governance is summarized in **Appendix F** (see Section 2).

1.3.2 Legal Authority of the GSA

The City of Bakersfield, KDWD, and ID4 are all local public agencies overlying portions of the Kern County Subbasin and each is qualified to become a GSA.

- The City of Bakersfield is a California charter city; its charter was ratified and approved in 1915, with subsequent amendments (see http://www.qcode.us/codes/bakersfield/). Title 14 of the City Municipal Code sets forth the City water use regulations, domestic water service area, Fairhaven water service area, duty to supply pure water, and other requirements and obligations related to the City's water service to more than 365,000 residents.
- Kern Delta Water District is a California Water District formed in 1965 under Division 13 of the State Water Code for the purposes of protecting the Kern River Water Rights serving certain lands within the District. KDWD also contracts with the Kern County Water Agency for State Project Water.
- Kern County Water Agency (KCWA) was established by a special act of the Legislature in 1961 (Statutes of 1961, Chapter 1003) to establish a single entity in Kern County to negotiate and administer a water supply contract for State Water Project supply. ID4 was formed by a resolution adopted by the Agency Board on December 21, 1971 to provide a supplemental water supply for portions of the metropolitan Bakersfield area.

As stated in Water Code Section 10723.6 and identified in the MOU, the KRGSA has the power to develop and implement SGMA, including a GSP. The KRGSA can adopt standards for measuring and reporting water use, develop and implement policies designed to reduce or eliminate overdraft within the boundaries of the GSA, develop and implement conservation best management practices, and develop and implement metering, monitoring and reporting related to groundwater pumping.

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

The KRGSA has prepared this stand-alone GSP for managing groundwater within its boundaries (**Appendix B)**; member agencies have cooperatively shared costs of preparing the Plan. The KRGSA contracted with Todd Groundwater to develop the GSP. KRGSA also contracted with Horizon Water and Environment for Subbasin coordination, assistance with preparation of the GSP, a communication plan, and initial community outreach. Todd Groundwater's amended contract to develop the GSP is $723,029 and Horizon's contract is $192,000.

The KRGSA is also coordinating with the Kern Groundwater Authority (KGA) and other GSAs in the Kern County Subbasin to ensure Subbasin-wide SGMA compliance. In addition to coordination meetings and agreements, the KRGSA, KGA, and other Subbasin GSAs have cooperated in the development of a local Subbasin numerical model, which is based on a regional model referred to as C2VSim developed by the Department of Water Resources (DWR). The local Subbasin model, referred to as C2VSimFG-Kern, has been used to develop historical, current and future projected water budgets for the Kern County Subbasin and adjacent White Wolf Subbasin. The cost for this work was shared among subbasin GSAs and totaled $431,957 for the historical and current water budgets and $335,000 for the projected water budgets. KRGSA paid approximately 17 percent of the total Subbasin modeling costs.

KRGSA Member Agencies are collectively funding the GSP development and providing financial resources on an as needed basis. Plan Managers and their staff have also committed a significant amount of time and resources to support GSP efforts including both Plan preparation and Subbasin coordination. In addition to these local funding sources, the GSP is being partially funded through a DWR grant under the Proposition 1 Sustainable Groundwater Planning Grant (SGPG) program.

Costs to implement the GSP include ongoing monitoring, annual reporting, and development of projects and management actions. Estimation of costs of the Phase One projects required for implementation over the next five years are estimated in **Section 7** of the GSP along with the means for KRGSA to fund project implementation. Ongoing GSP implementation costs are estimated at approximately $400,000/year and will be shared among the KRGSA member agencies. Member agencies will initially fund ongoing activities of GSP implementation through their normal operating funds. Additionally, each of the three primary member agencies will provide in-kind resources for data collection and management. As provided in SGMA, GSAs have been granted financial authority to impose fees, including but not limited to, permit fees and fees on groundwater extraction or other regulated activity, to fund the costs of a groundwater sustainability program (CWC §10730). Such fees are not being imposed at this time and will be explored over the implementation period, if needed. Additional information on GSP implementation activities and costs are summarized in **Section 8**.

1.4 GOVERNING REGULATIONS AND GUIDANCE DOCUMENTS

The KRGSA GSP is being developed to comply with requirements of the Sustainable Groundwater Management Act as codified in the California Water Code, amended in 2015, and effective January 1, 2016. GSP preparation follows the GSP regulations (CCR, Title 23, Division 2., Chapter 1.5, Subchapter 2). The analyses and information provided herein also consider the Best Management Practice Framework documents prepared by DWR to provide Best Management Practices (BMPs) for the sustainable management of groundwater (DWR, 2018 and 2019). As defined by the GSP regulations:

> "Best management practice" refers to a practice, or combination of practices, that are designed to achieve sustainable groundwater management and have been determined to be technologically and economically effective, practicable, and based on best available science (§351(i).

BMPs provide guidance and clarification for GSP regulations and also provide examples to assist with the primary components of a GSP. BMPs are voluntary and alternative methods and analyses are acceptable when shown how they also achieve GSP regulatory compliance. DWR has also provided Guidance Documents for assistance in GSP preparation. Once such document includes a Preparation Checklist for GSP submittal to serve as an optional guide for verifying that all requirements of the GSP regulations have been met. A completed Preparation Checklist for GSP Submittal is provided in **Appendix E** to provide references and page numbers in the KRGSA GSP to facilitate review of the document.

1.5 GSP ORGANIZATION

This GSP is organized to follow the GSP regulations (23 California Code of Regulations §§ 350 et seq.) to provide consistency among Subbasin GSPs and facilitate DWR review. Major sections include:

- Executive Summary
- Administrative Information
- Plan Area
- Basin Setting
    - Hydrogeologic Conceptual Model
    - Groundwater Conditions
    - Water Budgets
- Sustainable Management Criteria
- Monitoring Networks
- Projects and Management Actions
- Plan Implementation
- References and Technical Studies

Numerous appendices provide supplemental information regarding the contents of the KRGSA GSP.

1.6 DWR Evaluation Process and GSP Amendments

This Amended KRGSA GSP is being prepared to supplement the analyses in the original 2020 KRGSA GSP in response to DWR comments. Amended sections are being incorporated into the original KRGSA GSP to produce one complete document. The amendments are also presented in a *redline* format at DWR request to allow any changes to the original text to be readily identified and reviewed. To the extent practical, remaining portions of the original KRGSA GSP have not been modified. The process for developing the Amended KRGSA GSP is summarized in this new **Section 1.6**.

Specifically, Article 6 of the GSP regulations requires DWR to review all GSPs within two years of submittal to determine if the GSP adequately satisfies SGMA requirements (§355.2(e)). When there are multiple GSPs in a Subbasin – such as in the Kern County Subbasin[1] – DWR reviews the GSPs collectively as "one plan." The original KRGSA GSP, along with the other four Kern County Subbasin GSPs, was submitted to DWR in January 2020 in compliance with SGMA deadlines. Accordingly, the two-year DWR evaluation of the Kern County Subbasin GSPs was due in January 2022.

On January 28, 2022, DWR provided a Determination Letter to the Kern County Subbasin finding that the five GSPs were collectively incomplete and required specific corrective actions to address deficiencies (DWR, 2022). Although the Determination Letter provided only one KRGSA-specific corrective action, additional corrective actions were to be addressed by all GSPs. After substantial coordination with the other Kern County Subbasin GSPs, as well as consultation with DWR, additional analyses and clarifying text in response to the corrective actions were developed.

Based on the Determination Letter and the coordinated GSP revisions, the KRGSA – in cooperation with Greenfield County Water District GSA – has prepared this Amended KRGSA GSP. Amendments document how the DWR corrective actions have been incorporated into the Plan to achieve and maintain sustainable groundwater management throughout the implementation and planning horizon.

1.6.1 Amended Sections of the Original KRGSA GSP

The redline version of the Amended KRGSA GSP has been developed to facilitate DWR and stakeholder review. Both redline and complete clean versions of the Amended KRGSA GSP will be posted on the KRGSA website. Specific portions of the original KRGSA GSP that contain the most substantial amendments are summarized in **Table 1-1**.

[1] The KRGSA GSP is one of five GSPs that collectively cover the entire Kern County Subbasin. The remaining four GSPs were prepared by the Kern Groundwater Authority (KGA), Buena Vista Water Storage District GSA, Henry Miller Water District, and Olcese GSA. As part of the Subbasin 2022 amendments, a sixth GSP will be submitted by GSAs collectively referred to as South of Kern River for their portion of the original KGA GSP. As with the original five GSPs, the six GSPs will collectively cover the entire Kern County Subbasin without overlap.

Table 1-1: Amended Sections of the Original KRGSA GSP

GSP Sections	Topic	Amendment Summary
1.6	DWR Evaluation Process and GSP Amendments	GSP Amendment process, coordination with Subbasin GSAs, KRGSA/Plan Area boundary revisions
2.4.6.2	Groundwater Wells Update	Revised number and locations of domestic wells based on updated DWR database
3.3.5.2, 3.3.5.3	Land Subsidence Critical Infrastructure and Coordination	Updated subsidence rates and identified critical infrastructure using coordinated Subbasin definitions
5.1, 5.2, 5.3	Subbasin Sustainability Goal and Approach for Undesirable Results	Described coordinated approach for Subbasin definitions of Sustainability Goal, Undesirable Results and Management Area exceedances
5.4.4.4	Impacts of MTs on Beneficial Users	Expanded analyses of impacts to small water systems and domestic wells
5.8 and 6.2.6.4	Coordinated Approach to Subbasin-wide Inelastic Land Subsidence	Identification of Regional Critical Infrastructure, Sustainable Management Criteria (**Section 5.8**), and monitoring plan (**Section 6.2.6.4**)
5.10	Interrelationships of Minimum Thresholds	Analyzes how MTs work together to avoid Management Area exceedances, including quantitative criteria (referred to herein as *triggers*)
6.2.4	Monitoring Protocols	Inserted Subbasin-coordinated procedures regarding inaccessible monitoring wells
7.2.9	Avoid Widespread Impacts to Domestic Wells	New Management Action to document, track, investigate, and adjust management activities to avoid widespread impacts to active domestic wells.

As summarized in the table above, amendments include an updated analysis of wells and potential impacts of sustainable management criteria on beneficial users (**Sections 2.4.6** and **5.4.4.4**), and how the criteria for each of the applicable sustainability indicators are interrelated (**Section 5.10**). Additional amendments are made to **Sections 3.3.5, 5.8** and **6.2.6.4** as part of the Subbasin-wide coordination efforts on regional land subsidence (see also, **Section 1.6.2** below). Finally, the Amended KRGSA GSP also includes a new management action (**Section 7.2.9**) that describes the ongoing process for identifying, tracking, and assisting small water systems and active domestic wells that have the potential to be affected by GSA management of water levels and extractions.

In addition to the substantive amendments summarized above, additional edits (redlines) are made throughout the text of the original KRGSA GSP to align existing sections with amendments and to produce a more cohesive Amended KRGSA GSP. In particular, much of the text in Chapter 5, Sustainable Management Criteria, has been revised to incorporate coordinated terminology and definitions included in the revised appendices of the First Amended Kern County Subbasin Coordination Agreement.

1.6.2 Coordination Within the Subbasin

As part of the DWR evaluation and GSP amendment process, the KRGSA met with the other Subbasin GSAs, participating agencies, and local stakeholders to discuss DWR deficiencies and recommended corrective actions. Subbasin GSAs also met with DWR for three consultation sessions on the Determination Letter. A summary of these coordination efforts is provided in **Table 1-2**.

Table 1-2: Coordination and Outreach for the Amended KRGSA GSP

No. of Meetings	Meeting Types	Topics
23	Subbasin-wide GSA Managers and Representatives	Coordination on deficiencies described in DWR Determination Letter
3	DWR Consultation Meetings	Clarification and updates on deficiencies and Corrective Actions
1	Outreach Meetings with KRGSA Plan Area Purveyors	KRGSA GSP requirements, monitoring network, water use information, water quality data, and water budgets
4	Coordination Meetings with adjacent Management Areas	MTs comparisons with North Kern Water Storage District (NKWSD), Rosedale-Rio Bravo Water Storage District (RRBWSD), Shafter-Wasco Irrigation District (SWID), and Pioneer Project
5	Subbasin Coordination Committee	Review and comment on process to address DWR Corrective Actions and GSP Implementation activities
6	KRGSA Board Meetings	Manager reports on progress of DWR Corrective Actions and Amended KRGSA GSP
2	Subbasin GSA Meetings with DWR CA Aqueduct Subsidence Program (CASP) staff	Potential locations and causes of land subsidence along the CA Aqueduct and the need for additional data
2	KRGSA Agricultural Stakeholders	Water Supply and KRGSA GSP Status Update
1	Public Hearing on the Amended KRGSA GSP (July 7, 2022).	Presentation of the Amended KRGSA GSP and opportunity for public comments. Consideration and adoption by the Board of Directors.

In addition to, and as part of, the meetings summarized above, the KRGSA coordinated with the other Kern County Subbasin GSAs on a variety of the GSP amendments included in this document. The more significant amendments that were part of the Subbasin-wide coordination efforts included the following:

- Submitted GIS shapefiles of the KRGSA Management Areas and wells to support Subbasin compilation of acreages and representative monitoring wells, which were used to assist with Subbasin definitions of Management Area exceedances and undesirable results.
- Developed similar quantitative criteria for most Management Areas in the Subbasin *to define when and where the effects of the groundwater conditions cause undesirable results* as required by the GSP regulations (§356.26(b)(2)). These criteria consist of the number and duration of MT exceedances that would trigger a Management Area exceedance and contribute to Subbasin undesirable results (referred to herein as *triggers*).
- Coordinated information and definitions of beneficial uses and users throughout the Subbasin.
- Coordinated with Subbasin GSAs to protect the functionality of regional critical Infrastructure from undesirable results due to inelastic land subsidence caused by groundwater extractions. These efforts included the following:
    - identification of regional critical infrastructure with Subbasin-wide importance,
    - analysis and selection of sustainable management criteria, and
    - development of a Subbasin-coordinated monitoring plan for inelastic land subsidence near regional critical infrastructure.

These and other GSP amendments are discussed in more detail in **Chapters 2**, **5**, **6**, and **7**, as indicated in **Table 1-1** above.

1.6.3 Updated KRGSA and Management Area Boundaries

In addition to the KRGSA GSP amendments associated with the DWR evaluation process, an additional amendment involves the KRGSA and Plan Area boundaries. Since the submittal of the KRGSA GSP in January 2020, the boundaries of the KRGSA – and the resulting Plan Area – have been officially revised with the incorporation of some un-districted adjoining lands and other minor boundary adjustments. Revised boundaries were finalized in coordination with adjoining GSAs in April 2021 and were officially modified by DWR on December 3, 2021 (https://sgma.water.ca.gov/portal/gsa/all).

Most of these changes were anticipated and documented in the original KRGSA GSP (see **Appendix K**), which discussed the addition of about 1,847 acres of new lands to the original GSP Plan Area of about 230,800 acres. These additions occurred late in the GSP process after the draft document had been prepared; further, additions were not finalized until after the GSP had been submitted. Accordingly, the maps and analyses within the 2020 KRGSA GSP focused on the original 230,800 acres. Nonetheless, the GSP analysis was expanded by **Appendix K** to cover the new lands in the GSP as soon as the boundaries were officially modified by DWR.

Since that time, additional minor revisions have been made to the KRGSA boundaries based on details of interspersed or overlapping member agency service areas with adjacent agencies. Once KRGSA boundaries had been finalized, the boundaries of the GSP Management Areas[2] were adjusted to cover

[2] The coverage, justification and intended use of each KRGSA Management Area are provided in **Section 5.2**.

the entire area of the revised KRGSA GSP. None of the revisions affected the boundary between the KRGSA and the Greenfield CWD GSA; these two GSAs collectively define the KRGSA GSP Plan Area.

The final coordinated boundaries added about 1,699 acres to the original KRGSA (about 148 acres less than analyzed in **Appendix K**). A tabulation of original and revised acres by GSA and by Management Area within the KRGSA GSP Plan Area are summarized in **Table 1-3**.

Table 1-3: Original and Amended KRGSA and Management Area Boundaries

GSAs and Management Areas	Original KRGSA/GSP January 2020 (acres)	Amended KRGSA/GSP April 2021 (acres)	Difference (acres)
KRGSA Boundary	228,598	230,297	1,699
Greenfield CWD GSA Boundary	2,202	2,202	0
TOTAL PLAN AREA	230,800	232,499	1,699
Agricultural Management Area	132,282	134,104	1,822
Banking Management Area	5,045	5,045	0
Urban Management Area	93,473	93,350	(123)
TOTAL PLAN AREA	230,800	232,499	1,699

The 2021 revised boundaries of the KRGSA are shown by the dark blue lines on **Figure 1-4**. Previous KRGSA boundary lines (2018) are also shown on **Figure 1-4** (red lines) to highlight areas of significant boundary changes. Specifically, the visible red boundary lines are former boundaries that indicate areas that have been added to, or adjusted by, the revised KRGSA boundaries. These adjusted areas are also labeled on **Figure 1-4** to facilitate the comparison.

As shown on **Figure 1-4**, revisions occurred primarily along the eastern and southwestern KRGSA boundaries. Some minor adjustments are too small to visualize at the report-level scale of the figure. The details of the amended KRGSA boundaries can be viewed at multiple scales on the DWR SGMA portal Map Viewer of exclusive GSAs[3]. That map also provides detailed viewing of how adjoining GSAs align with the KRGSA. The KRGSA boundary can also be downloaded from the portal as a geographical information system (GIS) shapefile[4].

[3] https://sgma.water.ca.gov/portal/gsa/all

[4] https://sgma.water.ca.gov/portal/gsp/preview/54

As noted on **Figure 1-4**, no changes were made to the boundary between Greenfield CWD GSA and the KRGSA (see central portion of the map). As noted previously, the KRGSA lands surround the Greenfield CWD GSA. Collectively, the Greenfield CWD GSA and the surrounding revised KRGSA boundaries define the *Amended KRGSA GSP Plan Area*. For clarity, the Amended KRGSA GSP Plan Area is shown on **Figure 1-5.**

Due to the relatively small revisions made to the KRGSA and Plan Area boundaries – and in consideration of the large number of maps and other figures (more than 100) depicting the original KRGSA and GSP Plan Area boundaries in the 2020 GSP – figures from the original GSP have not been updated with the amended boundaries (e.g., see **Figure 2-1**). However, the 2022 Amended KRGSA GSP covers the entire area of the adjusted Plan Area boundaries as shown on **Figure 1-5**.

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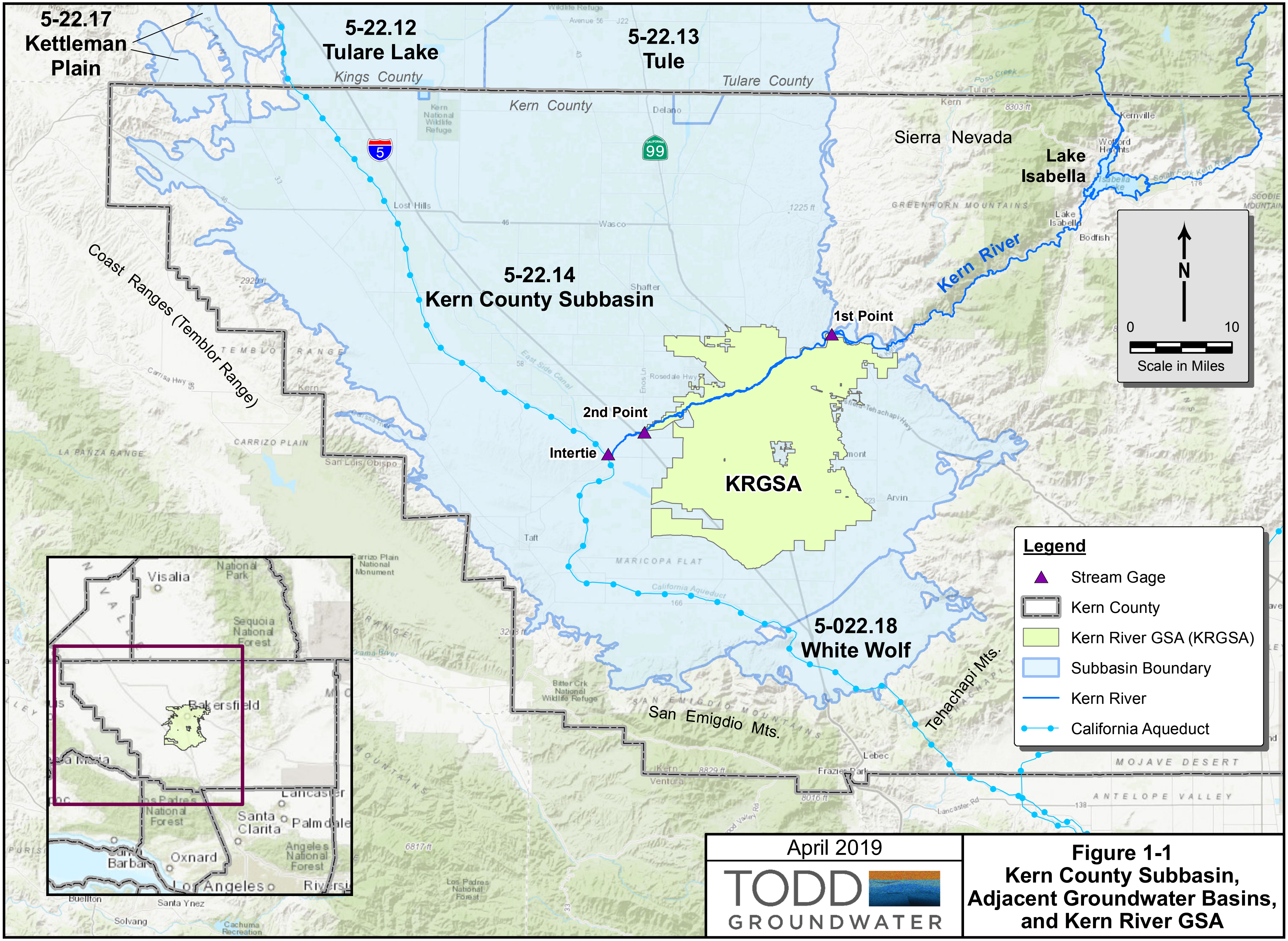
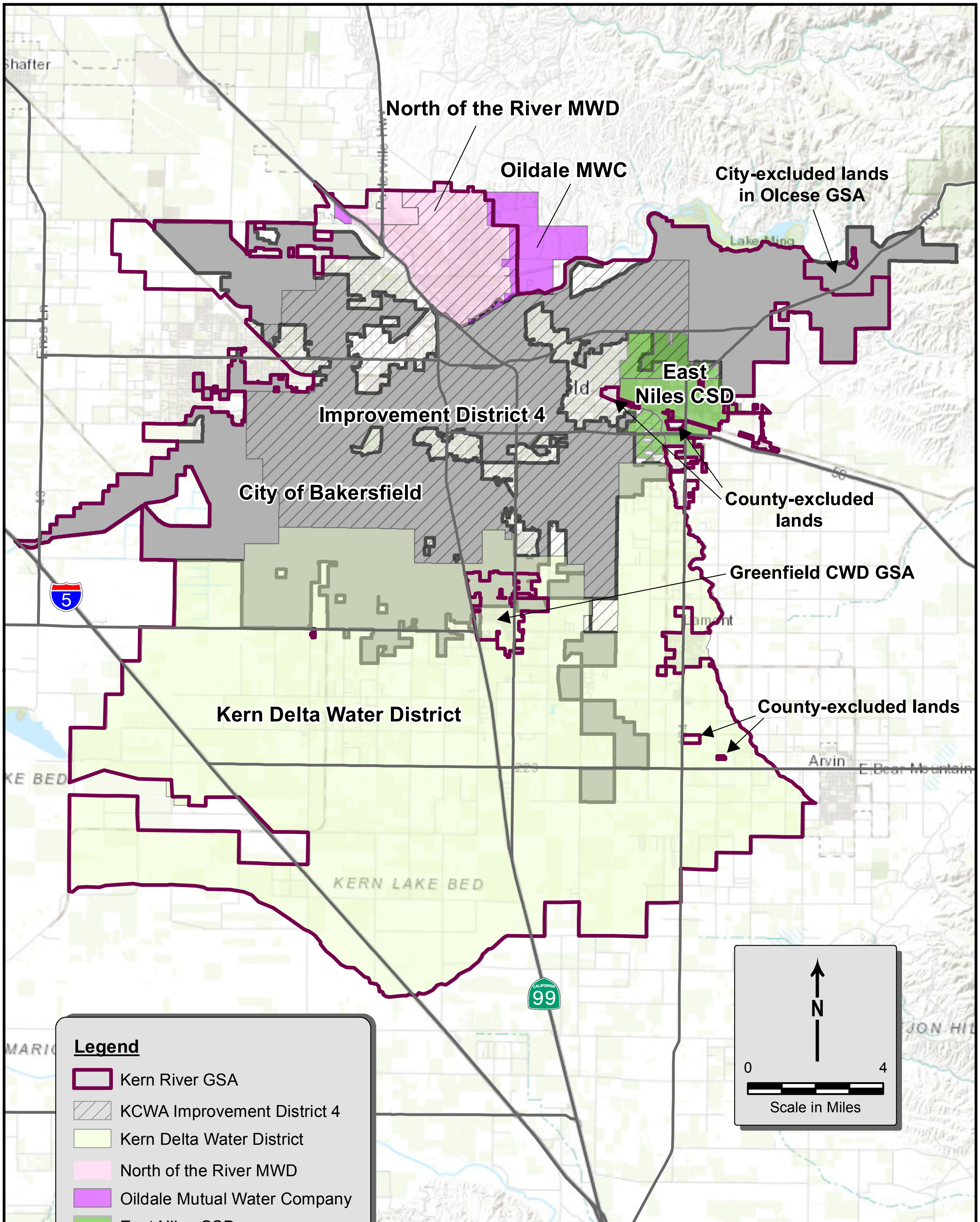


Figure 1-1
Kern County Subbasin,
Adjacent Groundwater Basins,
and Kern River GSA



April 2019

TODD GROUNDWATER

Figure 1-2
Kern River GSA (KRGSA) and Member Agencies

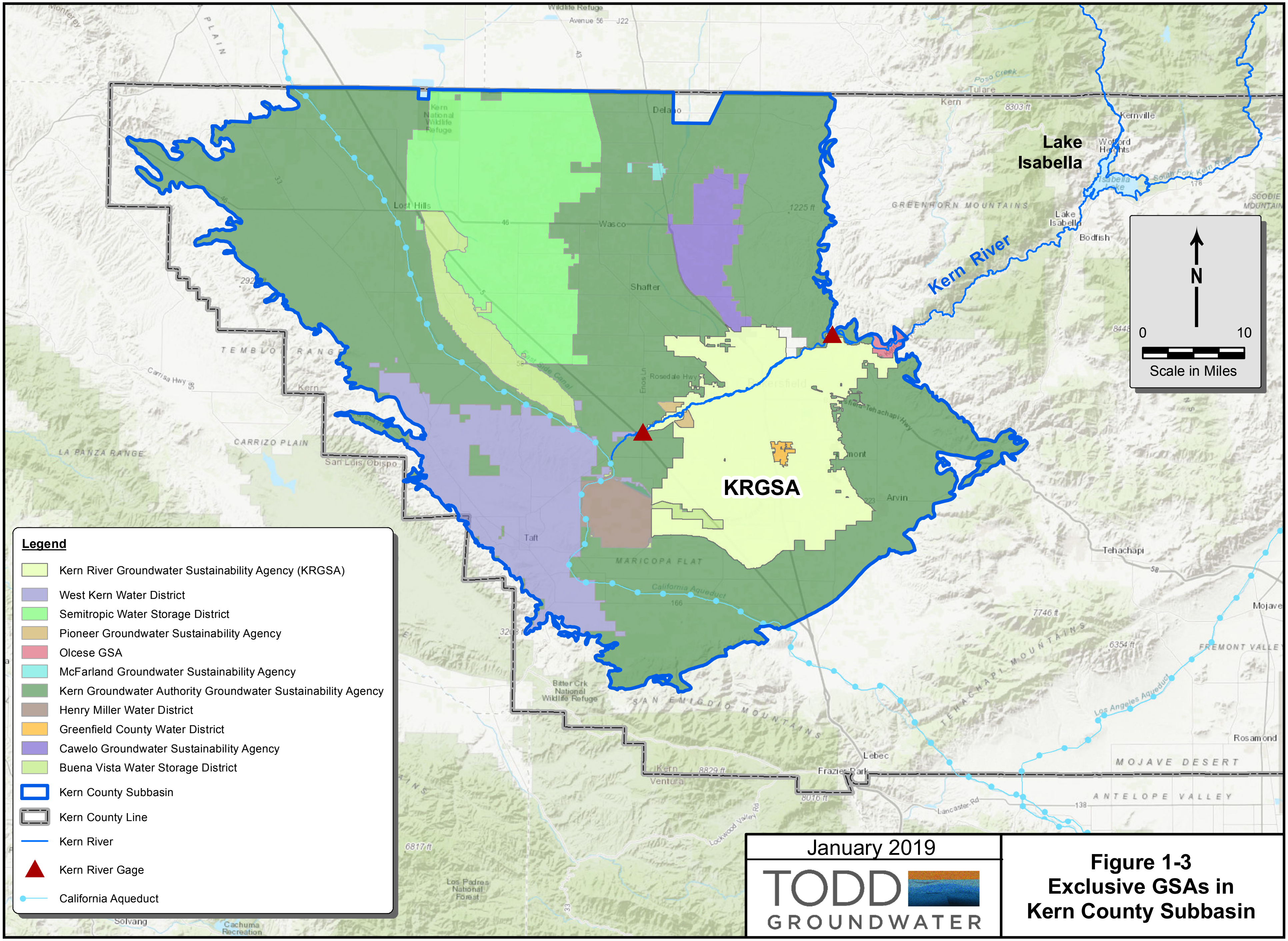
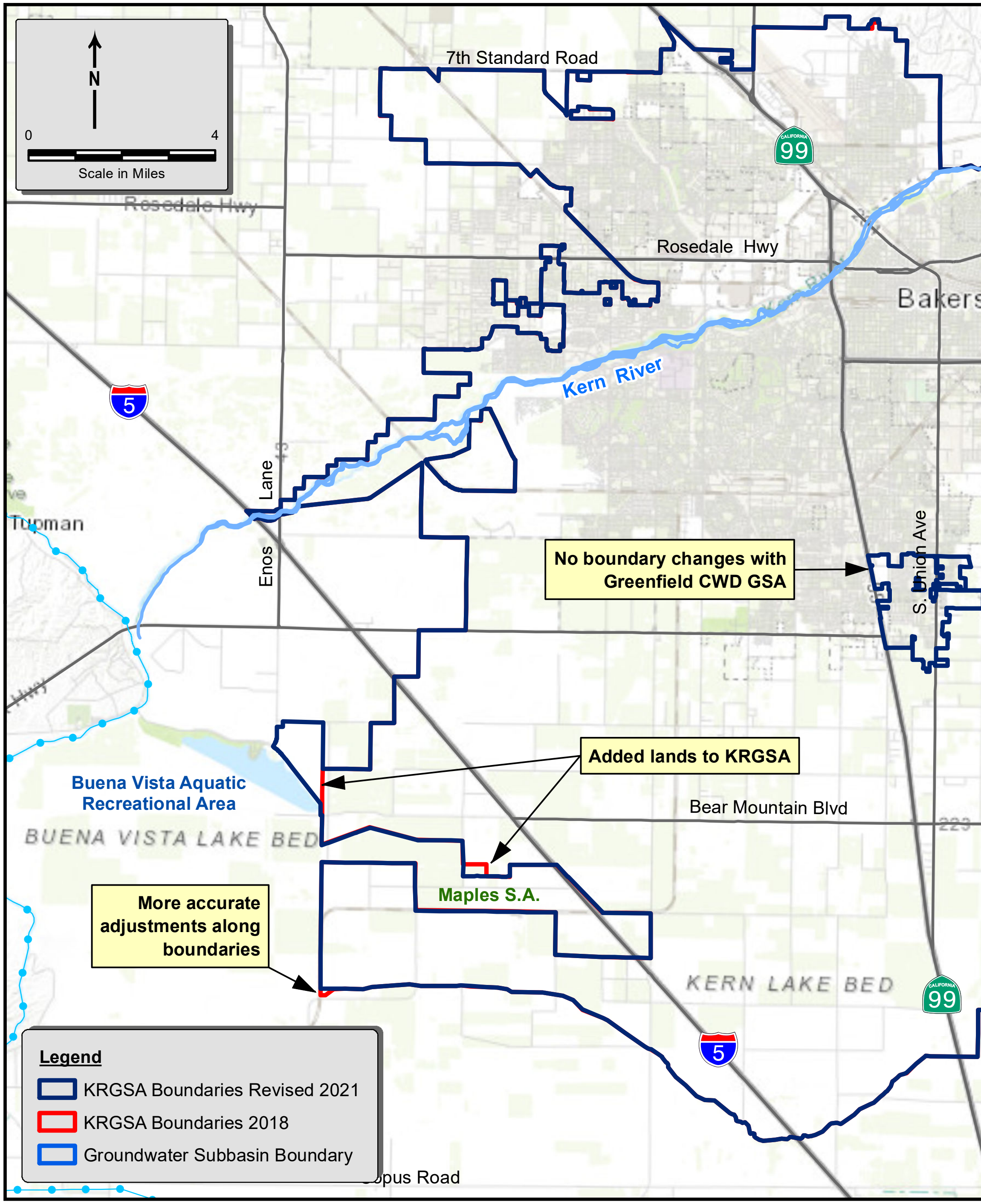


**Figure 1-3
Exclusive GSAs in
Kern County Subbasin**



May 2022

TODD GROUNDWATER

Figure 1-4
Revised KRGSA Boundaries

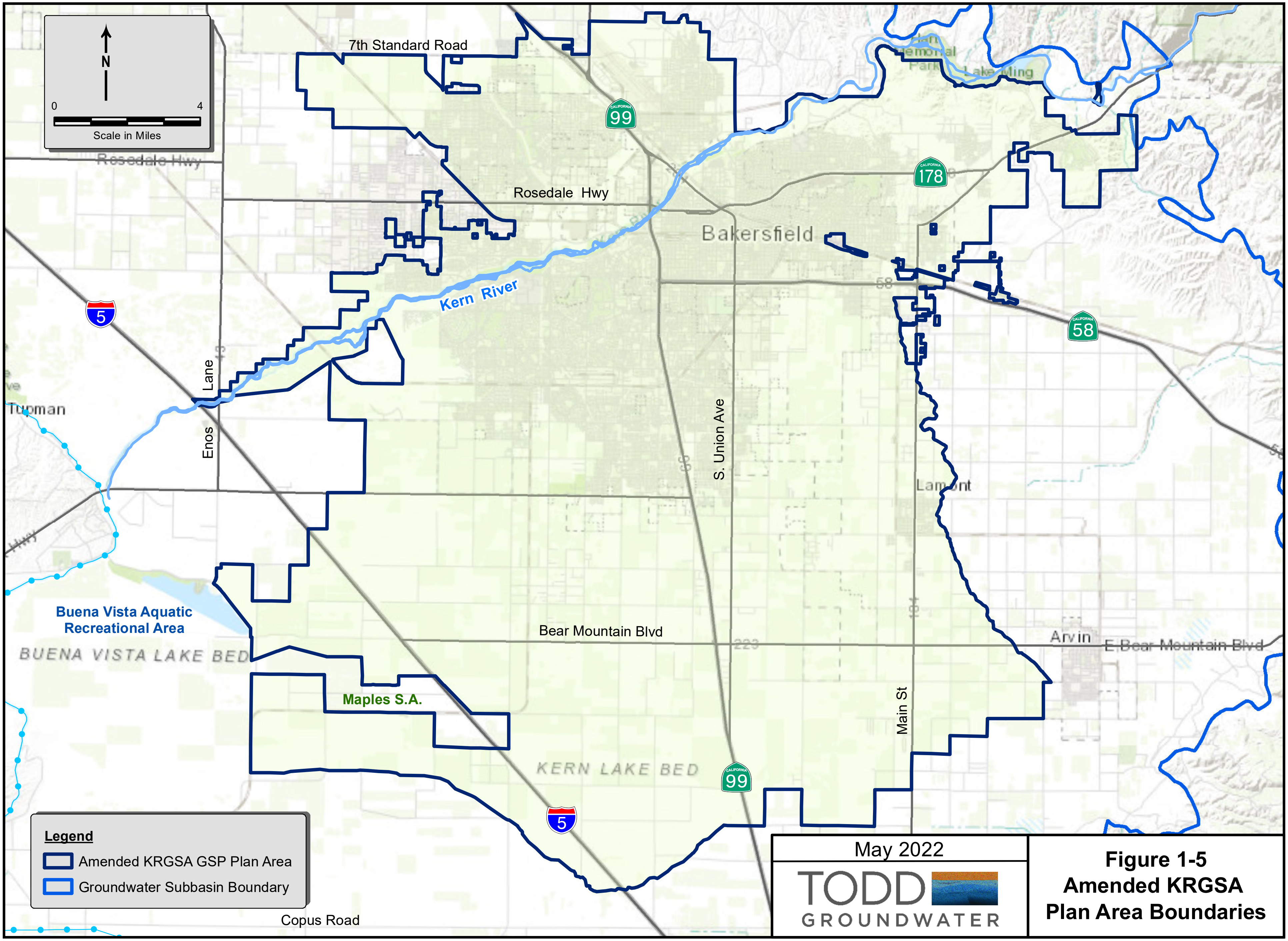


Figure 1-5
Amended KRGSA
Plan Area Boundaries

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2 PLAN AREA

This 2020 KRGSA GSP covers about 361 square miles (approximately 230,830 acres) within the outer KRGSA boundaries (also referred to herein as the KRGSA Plan Area or Plan Area) as shown on **Figure 2-1**. As mentioned previously, the Plan Area includes most of the Bakersfield City Limits and is traversed by portions of Highway 99 and Interstate 5. The northwestern boundary is along 7th Standard Road; the Plan Area extends to the south almost to Copus Road. The communities of Arvin and Lamont are located along the southeastern boundary. The Plan Area contains most of the Kern River from the area where it reaches the valley floor near the Beardsley Canal Diversion weir (about four miles downstream from 1st Point) to the 2nd Point measuring station near I-5 (**Figure 2-1**).

The Plan Area is slightly larger than the size of the KRGSA because it includes small areas within the outer boundary that were excluded from the KRGSA but are now included in the GSP; these lands include the Greenfield CWD GSA and portions of Kern County that are located within the outer KRGSA boundary as described in **Section 1** (see **Figure 1-2**). Greenfield CWD and Kern County are cooperating with the KRGSA to develop one GSP for the entire area within the outer KRGSA boundary. Some small areas within the larger boundary remain in other GSAs and are not included in the KRGSA Plan Area (e.g., see small areas along Highway 58 in the northwestern portion of the KRGSA that are part of the Kern Groundwater Authority GSA and therefore excluded from the KRGSA Plan Area).

As an exclusive GSA, the KRGSA exclusively manages groundwater within the KRGSA boundaries. For areas in the Plan Area that are excluded from the KRGSA, groundwater management will be coordinated with GSAs associated with those lands, including Greenfield CWD, the KGA GSA, and others. In addition, the KRGSA notes that some areas currently outside of the KRGSA boundaries may also be managed by the KRGSA in the future through a Management Agreement, including some areas of contiguous lands that occur both inside and outside of the KRGSA boundaries.

In August 2019, the KRGSA and Plan Area boundaries were revised to incorporate new lands that were contiguous with the KRGSA. These lands, covering about 1,840 acres in the southwestern and southeastern Plan Area had previously been included in the GSP process as non-district white lands under Kern County authority. Property owners requested to be included in the KRGSA boundaries for convenience. For example, one property owner farms lands on connected parcels that previously occurred both inside and outside of the KRGSA boundaries. At the time of the boundary revisions, the Draft KRGSA GSP had already been released for public review and the revised Plan Area boundaries weren't yet finalized with adjacent GSA boundaries. To avoid numerous revisions to the Draft GSP and to meet the expedited schedule for the KRGSA GSP submittal, the new KRGSA lands are analyzed and incorporated into the GSP as **Appendix K**.

In 2021, KRGSA and Plan Area boundaries were finalized to incorporate 1,822 acres of the Appendix K lands and removed about 123 acres along other KRGSA boundaries for a net gain of 1,699 acres, a change of less than one percent from the original KRGSA and Plan Area boundaries (see **Section 1.6.3**, **Table 1-3**, and **Figure 1-5**). The Amended KRGSA GSP Plan Area covers about 363 square miles (232,499 acres). Because the additional coverage of the Amended KRGSA GSP Plan Area only changes the original 2020 Plan Area by less than one percent, the numerous figures from the 2020 GSP showing the 2020 Plan Area have not been modified. All new figures have the final Plan Area boundaries (see also **Figures 1-4** and **1-5**).

2.1 DESCRIPTION OF THE PLAN AREA

The Plan Area is in the Kern County Subbasin (DWR Basin No. 5-022.14), located in the southern San Joaquin Valley Groundwater Basin (5-022) and the southern portion of the DWR-defined Tulare Lake Hydrologic Region. Covering about 2,834 square miles, the Kern County Subbasin (Subbasin) is the largest groundwater subbasin in California, extending from the Tehachapi and San Emigdio Mountains in the south to the northern Kern County line (**Figure 1-1**). The Subbasin is bounded by the Sierra Nevada on the east and the Coast Ranges (Temblor Range) on the west.

As indicated on **Figure 1-1**, the KRGSA Plan Area comprises approximately 12.7 percent of the Subbasin. Adjacent groundwater subbasins of the larger San Joaquin Valley Basin (DWR Basin No. 5-022) include:

- Kettleman Plain (5-022.17)
- Tulare Lake (5-022.12)
- Tule (5-022.13)
- White Wolf (5-022.18)

Figure 1-3 shows the boundaries of the 11 GSAs in the Kern County Subbasin at the time of the original 2020 GSP submittal, including the 2020 KRGSA boundary. Additional GSAs include:

- Buena Vista Water Storage District GSA
- Cawelo GSA
- Greenfield County Water District
- Henry Miller Water District GSA
- Kern Groundwater Authority (KGA) GSA
- McFarland GSA
- Olcese Water District GSA
- Pioneer GSA
- Semitropic Water Storage District GSA
- West Kern Water District GSA

No adjudicated areas exist in the Kern County Subbasin, and no Alternative Plans as defined by SGMA have been submitted.

2.2 AGENCIES AND JURISDICTIONAL BOUNDARIES

Numerous agencies and entities with jurisdictional boundaries in the KRGSA Plan Area share responsibilities for water management and land use. As the sole municipality in the KRGSA, the City of Bakersfield has significant water management and land use responsibilities within the KRGSA Plan Area.

In some areas, city limits extend beyond the KRGSA boundary; jurisdictional boundaries of the City within the KRGSA are shown on **Figure 2-2**. Land use and water management in this area is described in the Metropolitan Bakersfield General Plan and, in particular, the Kern River Element; these documents are summarized in **Section 2.6.1**, and **2.6.2**, respectively.

As described previously and illustrated on **Figure 1-1**, the Kern County Subbasin and the KRGSA are located within west central Kern County. Through the Kern County Planning & Community Development Department, Kern County has jurisdiction for land use planning in unincorporated areas of the County. The County also has responsibility for well permitting through its Department of Public Health. The Kern County General Plan and well permitting activities are discussed in **Section 2.6.3** and **2.6.4**, respectively.

2.2.1 Jurisdictional Boundaries of Federal and State Lands in KRGSA

The web-based DWR Water Management Planning Tool provides jurisdictional boundaries for other agencies and entities with water management and/or land use responsibilities, including state and federal lands. Jurisdictional boundaries of federal and state lands in the KRGSA Plan Area are shown on **Figure 2-2**. Federal lands include a small area owned by the Bureau of Land Management in the northeastern uplands of the Plan Area, south of the Kern River (about 1,000 feet south of Hart Park). Other scattered areas of federal lands are also indicated in the southern portion of **Figure 2-2**, with areas mapped both inside and outside of the KRGSA by the DWR Water Management Planning Tool.

State lands include several ecological reserves administered by the California Department of Fish & Wildlife (CDFW) to protect the endangered Bakersfield Cactus (*Opuntia treleasei*). Five of these reserves are in northeastern KRGSA, specifically in the upland Kern bluff area south of the Kern River (**Figure 2-2**). In addition to the CDFW lands, the DWR Water Management Planning Tool also identifies lands designated as California Protected Areas (CPA); the state provides these lands in the CPA database (CPAD). These lands are owned in fee and protected for open space purposes by other public agencies and non-profit organizations. As shown on **Figure 2-2**, CPAD lands in the KRGSA are located primarily in the northeaster uplands south of the Kern River and on the northern KRGSA boundary.

No other state or federal agencies are known to administer land in the KRGSA Plan Area, such as military installations, United States Forest Service lands or other federal lands not on **Figure 2-2**, or state parks. No tribal lands are documented in the DWR Water Management Planning Tool or are known to exist in the KRGSA Plan Area.

2.2.2 Water and Irrigation District Boundaries

In addition to member agencies within the KRGSA, numerous water and irrigation districts surround, and in some cases overlap with, the KRGSA. Jurisdictional boundaries of those districts are shown on **Figure 2-3**. Most of these agencies provide primarily agricultural water within their respective service areas. Some of the district boundaries on **Figure 2-3**, such as Kern Water Bank and the Pioneer Project, involve agencies that operate large-scale groundwater banking projects.

The Subbasin also includes portions of the Kern County Water Agency (KCWA) service area, an agency created in 1961 by a special act of the California State legislature to serve as the local contracting entity for the State Water Project (SWP). The agency also conducts a wide variety of water management activities including water quality, flood control, canal operation and treatment plant construction and operation, and groundwater banking.

2.2.3 Water Purveyors

The Plan Area contains all or portions of numerous water purveyors, which provide water supply to residents within or adjacent to the KRGSA. Service areas of the primary water purveyors in the Plan Area are shown on **Figure 2-4**. Sources of water available in the KRGSA and activities of the KRGSA water purveyors are described in **Section 2.4.5** and throughout this GSP document.

2.3 EXISTING LAND USE

The Plan Area encompasses 361 square miles in Kern County and includes a large urban center (the Bakersfield Metropolitan area), highly developed agricultural areas, riparian ecosystems, and open space, including private lands held in public trust, such as the Panorama Vista Preserve, and municipal parks such as the Kern River Parkway.

Figure 2-5 shows general Land Use Planning Designations of the Kern County General Plan. As illustrated, the KRGSA Plan Area encompasses a broad variety of land uses including urban (e.g., commercial, parks and recreation/school, residential), industrial (also mineral and petroleum, transportation, utilities), agricultural (intensive, extensive), and open space.

A more detailed view of the land use within the City of Bakersfield is provided in the Metropolitan Bakersfield General Plan and shown on **Figure 2-6**. This figure provides details on residential, commercial, and industrial land use, as well as public facilities and open space. Agricultural areas surrounding the southern urban areas are also noted on **Figure 2-6**.

Areas designated by the California Department of Conservation, Farmland Mapping and Monitoring Program (FMMP) as Important Farmland emphasizes the importance of local agriculture on land use in the southern Plan Area. Various designations of Important Farmland categories are shown on **Figure 2-7.** The FMMP identifies lands with agricultural value on statewide maps in its Important Farmlands Inventory (IFI). IFI classifies land based upon its productive capabilities such as fertility, slope, texture, drainage, depth, salt content and availability of water for irrigation. Farmland categories are based on their suitability for agriculture as summarized below:

- **Prime Farmland.** This land has the best combination of physical and chemical characteristics for crop production. When treated and managed, its soil quality, growing season, and irrigation supply produce sustained high crop yields.

- **Unique Farmland.** This land does not meet the criteria for Prime Farmland or Farmland of Statewide Importance but has produced specific crops with high economic value.
- **Farmland of Statewide Importance.** This is land that does not qualify as Prime Farmland but has a good combination of irrigation and physical and chemical characteristics for crop production.
- **Farmland of Local Importance.** This land is either currently producing crops or has the capability to produce crops but does not meet the criteria of the categories above.
- **Grazing Land.** This is land with vegetation that is suitable for grazing livestock.

Other lands include confined animal agriculture and semi-agricultural land and rural communities.

Agricultural Preserves and agricultural lands protected under the Williamson Act also occur in the southern Plan Area as highlighted on **Figure 2-8**. These designated lands are overlain on a recent aerial photograph to show the additional agricultural land use within and surrounding the Plan Area[5]. The Williamson Act (California Land Conservation Act of 1965, Section 51200) was adopted to encourage preservation of the state's agricultural lands and to discourage its conversion to urban uses. This Act established an agricultural preserve contract procedure whereby any county or city would levy taxes on Agricultural Preserve contract land at a lower rate than its unrestricted market value using a scale based on the actual use of the land for agricultural purposes. In return, landowners guarantee that these properties would remain under agricultural production for a ten-year period. This contract is renewed automatically unless a Notice of Non-Renewal is filed by the owner. In this manner, each agricultural preserve contract (at any given date) is always operable at least nine years into the future. While contracts can be cancelled earlier than the ten-year period (with specific approvals and fees), the Williamson Act provides some stability for agricultural land use.

Agricultural crop types and dairies in the KRGSA Plan Area are shown on **Figure 2-9** (2016 land use). The southern KRGSA is characterized by a variety of crops, including both perennial crops (e.g., vines and almonds) and annual crops (e.g., alfalfa, grains and field crops, cotton, and vegetables). In addition to crops, approximately 20 dairies operate in the Plan Area, contributing to the local agricultural economy. Numerous businesses and industries in the Plan Area support these agricultural activities including three food processing plants and numerous equipment, supply, and processing facilities.

2.4 WATER SOURCES AND USE

Water supply for the KRGSA Plan Area is sourced from groundwater, Kern River surface water, banked and recharged water, imported water (SWP and Federal Central Valley Project (CVP)[6]), and recycled water. A summary of these water sources and associated uses are provided below.

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[5] Williamson Act lands outside of the KRGSA Plan Area are not shown.

[6] Federal CVP water used within the KRGSA is Section 215 water which is a temporary supply of CVP water made available in large water supply years. The KRGSA does not contain any direct CVP contractors.

2.4.1 Groundwater

Groundwater is an important source of agricultural, domestic, and municipal supply, which is managed conjunctively with numerous surface water supplies in the Plan Area. The KRGSA is located in the Kern County Subbasin of the San Joaquin Valley Groundwater Basin as defined by DWR (Subbasin 5-22.14, DWR, 2006) (**Figure 1-1**). The Subbasin is the largest in the state, covering approximately 2,834 square miles (1,813,630 acres) and containing more than 40,000,000 AF of groundwater in storage (DWR, 2006; 2016c).

2.4.2 Kern River

The Kern River originates northeast of Bakersfield in the Inyo and Sequoia National Forests and the Sequoia National Park at the base of Mt. Whitney. For more than 150 years, the Kern River has provided most of the natural surface water supply to the Subbasin, including water for agricultural irrigation, drinking water, and other uses. The Kern River channel enters the Plan Area from the northeast and traverses southwest across the north-central KRGSA Plan Area, to the stream gage shown as Second Point on **Figure 1-1**).

2.4.2.1 Kern River Allocation and Operation

Flows in the River consist of regulated and managed releases from Lake Isabella, approximately 25 miles upstream of the Plan Area (**Figure 1-1**). Isabella dam and Lake Isabella were constructed by the U.S. Army Corp of Engineers (USACE) in 1953 to address downstream flooding. Since that time, Isabella Dam has been operated for flood control, hydroelectric power, water supply, and conservation storage. Reservoir storage and Kern River flow management are coordinated by the Kern River Watermaster, working with the USACE, participating water districts, and the City of Bakersfield. Except for periods of high runoff, releases from Lake Isabella are regulated through requests, or “calls” for water by the City on behalf of the Kern River Watermaster.

Distribution of water within the First Point service area of the Kern River was adjudicated in the 1900 Shaw Decree. Over the years, Kern River water has been apportioned based on entitlements determined through canal company consolidations, water rights transfers and acquisitions, court decisions, and agreements. In 1888, two permanent stream gage stations, First Point and Second Point, were established to measure flow in the Kern River on a real-time basis (**Figure 1-1**). The First Point daily discharge is used to allocate water among various Kern River interests, referred to as First Point diverters, Second Point diverters, and Lower River diverters. The Second Point of measurement is approximately 20 miles downstream and is used to check upstream water use (and entitlements) with diversion rights on the Lower River (Boyle, 1975). Second Point is shown on **Figure 1-1** and marks the western edge of the KRGSA Plan Area.

KDWD and City of Bakersfield are successors-in-interest to all First Point water rights holders. Buena Vista Water Storage District (BVWSD) is successor-in-interest to all Second Point water right holders. KCWA is successor-in-interest to all Lower River water right holders (downstream of Second Point). The

City monitors, manages, and records flows and diversions in the River on behalf of the Kern River Watermaster for all water users.

A third stream gage on the Kern River is located downstream of Second Point (near Tupman) at an intertie between the River and the California Aqueduct (**Figure 1-1**). The Intertie was constructed in 1977 to convey Kern River flood waters into the aqueduct to prevent flooding of downstream lands.

2.4.2.2 Kern River Flows

Flows in the Kern River are highly variable, subject to both flooding and drought. Since 1893, natural flows at First Point have ranged from 138,740 acre-feet per year (AFY) in 2015 to 2,520,149 AFY in 1916, with a long-term mean of 711,649 AFY (Bakersfield, 2016). To provide a means of comparison between current flows and long-term average flow conditions, an annual river index is calculated and included in annual Kern River Hydrographic Reports. An index of 100 percent is representative of the long-term average flow in the River. The annual indices for a 22-year period from 1995 through 2016 are provided on **Figure 2-10.** During that time, the annual Kern River Index ranged from 19 percent (2015) to 236 percent (1998), with an average of 94 percent.

The 20-year period from 1995 through 2014 has an average index of 100 percent, indicating that this period is representative of the long-term average hydrologic conditions (**Figure 2-10**). Based in part on this average river index, the 20-year period 1995 through 2014 has been selected as a Study Period for GSP analyses. Numerous other factors were also considered for criteria in the Study Period selection including data availability, local water operations, and average precipitation. The selection of the 1995-2014 Study Period and it use in this GSP is described in more detail in **Section 3.1**.

2.4.2.3 Kern River Treatment Plants

Surface water from the Kern River is treated prior to distribution for municipal use. California Water Service Company (Cal Water) purchases Kern River water from the City of Bakersfield and treats it at the Northeast Bakersfield Water Treatment Plant (WTP) or the North Garden WTP for use within its service area (Cal Water, 2016a). Additional micro-filtration treatment occurs at the North West WTP plant, located in the North Garden WTP. About one-half of the water treated in the North West WTP is supplied to the City of Bakersfield under contract with Cal Water.

2.4.2.4 Banked and Recharged Water

KRGSA members actively recharge and bank surface water supplies, including Kern River supplies and imported water supplies, for later extraction and use. Spreading, banking and recharge of surface water supplies occurs within dedicated water banking areas, such as the City of Bakersfield's (COB) 2800 Acre recharge facility, and through managed and regulated recharge in conveyance facilities, such as unlined canals and the Kern River channel, and through other dedicated recharge and recovery efforts and projects. Recovered recharged and banked water supplies constitutes a significant source of supply for the KRGSA members, particularly in connection with the City's domestic water supply.

2.4.3 Imported Water

Imported surface water is also an important source of supply in both the Subbasin and the KRGSA Plan Area. Water is available from the State Water Project (SWP), which distributes flows from northern California through a series of aqueducts, reservoirs, and pump stations, including the California Aqueduct shown on **Figure 1-1**. SWP water is conveyed from the California Aqueduct into the KRGSA Plan Area via the Cross Valley Canal (CVC). SWP water has been available to the Subbasin through KCWA, a state-water contractor since 1968. The Central Valley Project (CVP), operated by the U.S. Bureau of Reclamation, has provided water supply to CVP contractors in the Subbasin since 1951 with the completion of the Friant-Kern Canal. While no direct CVP contractors are in the KRGSA Plan Area, CVP water is available for purchase in wet years (Section 215 water) and has been purchased by KRGSA member agencies when available.

The Henry C. Garnett Water Purification Plant (HCGWPP), owned and operated by ID4, primarily treats imported water for municipal use. SWP water is conveyed directly to the plant as needed. When excess SWP water is available, ID4 recharges it – both inside and outside of the KRGSA Plan Area – for subsequent recovery and treatment at the HCGWPP. ID4 also diverts Kern River water and CVP water to the plant through exchanges. Water from the HCGWPP is distributed to Cal Water, City of Bakersfield, ENCSD, and NORMWD.

2.4.4 Recycled Water

The City of Bakersfield treats municipal wastewater for a variety of reuses in the Plan Area. Tertiary treated wastewater is recycled to irrigate parkland and sports fields within the KRGSA Plan Area that would have otherwise used potable water (about 733 AFY in 2015). Recycled water use is projected to increase to about 2,240 AFY by 2020 (Stetson, 2017). Secondary treated effluent is used for crop irrigation both inside and outside KRGSA boundaries (about 10,000 AFY in 2015), and de-nitrified secondary treated wastewater is used to recharge groundwater via unlined ponds (7,936 AFY in 2015) (Stetson, 2017).

In addition to the City of Bakersfield, other agencies collect and/or treat wastewater within the Plan Area including ENCSD, Kern County (through Kern Sanitation Authority and Kern County Service Area No. 71), North of the River (NOR) Sanitary District, and Lamont Public Utilities (LPUD). ENCSD sends their effluent to the City of Bakersfield for treatment at its WWTP No.2. The Kern Sanitation Authority operates a treatment plant for wastewater flows in unincorporated east Bakersfield. Plant effluent is used to irrigate 1,100 acres of adjacent farmland; 100 percent of the effluent process at the plant is reused. Effluent from the NOR Sanitary District and LPUD is also used for irrigation of fodder and fiber crops (non-human consumption).

Wastewater outside of the sewer service areas are primarily handled through onsite wastewater treatment systems (e.g., residential septic systems). For new development in unincorporated areas within the northern Plan Area, an OWTS is only allowed for parcels not within close proximity to a sewer trunk line of the City of Bakersfield or NOR Sanitary District. Onsite septic systems occur primarily within the southern and southeastern Plan Area outside of the city limits. In the south, most of the OWTSs are located north of Bear Mountain Blvd.

Table 2-1 summarizes information on the wastewater treatment plants, wastewater use, and recycling in the Plan Area.

Table 2-1: Wastewater Treatment and Recycling within KRGSA Plan Area

Facility	WWTP Capacity/ Average Flow	Service Area	Treatment Facilities and Wastewater Use
City of Bakersfield WWTP #2	25 mgd/ 13.9 mgd	East of Highway 99	Primary and secondary treatment; storage ponds, clarifiers, solids processing facilities, trickling filters, digesters, and methane recovery and cogeneration facilities. ENCSD and Kern Sanitation Authority also discharges to WWTP #2
City of Bakersfield WWTP #3	32 mgd / 17.6 mgd	West of Highway 99	Primary, secondary and tertiary treatment; storage ponds, clarifiers, solids processing facilities, activated sludge, digesters, and methane recovery and cogeneration facilities. Tertiary treated water (1,120 AFY currently) irrigates adjacent State Farm Sports Village. Secondary treated denitrified water (6,645 AFY currently) recharges groundwater in unlined ponds. An average of about 11,321 AFY of recycled water is exported for irrigation at Green Acres Farm (west of I-5). Kern Sanitation Authority also discharges to WWTP #3
Kern Sanitation Authority (KSA)	7 mgd/ 4 mgd	East Bakersfield	Wastewater treatment facilities include a screening unit, two primary clarifiers, an anaerobic digester, two trickling filters, two secondary clarifiers, and recirculation pumps.
North of River Sanitary District No. 1 (NORSD-1)	7.5 mgd / 5 mgd	North-northwest KRGSA. Oildale area north of the Kern River and west of Hwy 99.	Treatment facilities include screens, a lift station, a vortex grit removal system, addition of coagulant (Ferric Chloride) and Polymer, a primary clarifier, a plastic media trickling filter, a secondary clarifier, primary and secondary sludge digesters, 14 unlined sludge drying beds, and storage ponds (capacity 1,488 AF). The effluent is used to irrigate various crops for nonhuman consumption. Also treats some CSA-71 wastewater.
Kern County Service Area 71 (CSA-71)		Northwest KRGSA; north of the Kern River.	A centralized dry sewer system for developed area (7 square miles) and on-site septic systems. Most of the area has been developed with dry sewer systems. The dry sewers are connected to main trunk line sewers to transport the waste to a City of Bakersfield WWTP.
Lamont Public Utilities District (LPUD)	2.0 mgs / 1.4 mgd	Southeast KRGSA	Secondary wastewater treatment effluent is recycled at a nearby Green Waste Compositing facility and also used for irrigation of non-human consumption crops (silage, winter wheat, alfalfa) on 130 acres of land owned by the District.
Septic		Northwest, south, and southeast KRGSA	Unincorporated northwest Bakersfield, southern and southeastern Plan Area primarily served by private septic systems. Newer developments have dry sewer systems. Limited to areas not in close proximity to main sewer trunk lines for City of Bakersfield or North of the River Sanitary District.

2.4.5 Water Purveyors

Numerous water purveyors provide water supply for municipal, industrial or agricultural water uses in the KRGSA Plan Area. The entire Plan Area is also within the jurisdictional boundaries of the Kern County Water Agency and the Central Valley Regional Water Quality Control Board.

Figure 2-4 shows the boundaries of the larger local water purveyors within the Plan Area, including:

- California Water Service Company-Bakersfield (Cal Water)
- City of Bakersfield-Domestic Water System (City Domestic Water System)
- East Niles Community Services District (ENCSD)
- Kern County Water Agency (KCWA) Improvement District No. 4 (ID4)
- Kern Delta Water District (KDWD)
- North of the River Municipal Water District (NORMWD)/Oildale Mutual Water Company (OMWC)
- Vaughn Water Company (VWC) (portion of service area only)
- Greenfield County Water District
- Lamont Public Utilities District (LPUD)

Although Greenfield CWD is a separate GSA, the district is cooperating through an MOU with the KRGSA for the GSP and is included in the Plan Area (see MOU in **Appendix C**). Additionally, the Lamont Public Utility District (LPUD) is also part of a separate GSA (Kern Groundwater Authority GSA), although 70 percent of its service area overlies portions of the Plan Area (see **Figure 2-4**).

Table 2-2 provides a list of water purveyors in the KRGSA Plan Area including the larger purveyors listed above and additional smaller public and private water purveyors. Of those listed in **Table 2-2**, the City of Bakersfield, KDWD, ID4, ENCSD, and NORMWD/OMWC are members of the KRGSA. Information on the water supply portfolio for each purveyor also is provided.

Table 2-2: Water Supply Portfolios for Water Purveyors within KRGSA

Purveyors	Ground-water	Surface Water			Recycled	Other/ Notes	M & I / Residential	Whole-sale	Ag.
		Kern River	SWP	Section 215*					
Athal Mutual Water System	X						X		
Bear Mountain RV Park Water System	X						X		
California Water Service Company	X	X	X		X	SWP from ID4	X	X	
Casa Loma Water Company	X					Purchase from City	X		
City of Bakersfield-Domestic Water System	X	X	X		X	SWP from ID4	X	X	
East Niles CSD	X		X			SWP from ID4	X		
East Wilson Road Water Company	X						X		
El Adobe POA, Inc.	X						X		
Fuller Acres MWC	X						X		
Gosford Road WC	X						X		
Greenfield CWD	X	X					X		
Kern County Water Agency - ID4	X	X	X	X				X	X
Kern Delta Water District	X	X	X	X	X				X
North of the River Municipal Water District	See OMWC		X			ID4 wholesaler	X	X	
Oasis Property Owners Association	X						X		
Oildale Mutual Water Company	X		X				X		
Old River MWC	X						X		
Palm Mutual (data uncertain)	X						?		
Panama Road Property Owners Association	X						X		
Plainview PUD (data uncertain)	X						?		
Rancho Del Rio MWC	X						X		
Redbank Water System	X						X		
Ski West Village Water System	X					Ski Lakes	X		
South Kern MWC	X						X		
Stockdale Annex	X						X		
Stockdale Mutual	X						X		
Vaughn Water Company, Inc.	X						X		
Wini MWC	X						X		

No direct CVP or Oil Field water use within KRGSA boundaries.

* Section 215 water is a temporary (not to exceed one year) supply of CVP water made possible as a result of an annually large water supply not otherwise storable for project purposes, or infrequent and otherwise unmanaged flood flows of short duration.

Table 2-3 summarizes estimated annual water use by source for the larger water purveyors in the KRGSA Plan Area (listed in alphabetical order). Most of the water use data was compiled from published planning documents including Urban Water Management Plans (UWMPs), Groundwater Management Plans, and Agricultural Water Management Plans (AWMPs). Some data sets were provided directly from the agency. Data in this table are provided for general context of water use in the Plan Area; more detailed data are provided in the water budget analysis in **Section 4** of this GSP.

Table 2-3: Estimated Water Use by Larger Water Agencies in KRGSA Plan Area

Larger Water Purveyors in KRGSA Plan Area	Estimated Groundwater Use (AFY)	Estimated Kern River Water Use (AFY)	Estimated Imported or Purchased Water Use (AFY)
California Water Service Company (Cal Water)	33,388 (2015)	9,149 (2015)	12,496 (2015)
City of Bakersfield	32,210 (avg)	4,500 (avg)	6,500 (avg)
East Niles Community Services District	2,929 (2015)	0	4,573 (2015)
Greenfield County Water District	1,999 (2015)	0	3,322 (2015)
Kern County Water Agency Improvement District 4 (ID4)	Recovery of banked water only	9,000 (avg) (Lower River right or by exchange)	17,103 (2015)
Kern Delta Water District	165,000 (1995-2014)	174,074 (1995-2014)	18,443 (1995-2014)
North of the River Municipal Water District (NORMWD)/ Oildale Mutual Water Company (OMWC)	341 (2015)	0	7,574 (2015 from NORMWD/ID4)
Vaughn Water Company	9,847 (2015)	0	0

As indicated in the table, groundwater, which also includes some banked and recharged surface water for the purpose of this table, provides most of the supply in the KRGSA Plan Area. Given the large-scale conjunctive use operations and banking programs throughout the Plan Area, most groundwater extractions by the KRGSA agencies include banked and intentionally recharged water. Purveyor operations and provision of water supply to the Plan Area are summarized below.

2.4.5.1 California Water Service Company Water Supply

Cal Water is the largest municipal water supplier in Bakersfield. Its system serves a large portion of the City and segments of unincorporated lands adjacent to the City (**Figure 2-4**). Cal Water's Bakersfield District was formed with the purchase of Bakersfield Water Works in 1926 (Cal Water, 2016b).

Between 2011 and 2015, Cal Water provided water supply from the following sources (Cal Water, 2016a):

- Groundwater (including recovery of banked and recharged water) – 58 percent
- Untreated Kern River water purchased from the City – 21 percent
- Treated SWP and Kern River water purchased from wholesaler KCWA ID4 – 21 percent.

Groundwater: Groundwater (including banked water) has historically supplied up to 80 percent of demands in the Cal Water service area (Cal Water, 2016a). Cal Water currently operates about 77 active wells to supply Bakersfield customer needs (Cal Water, 2016b). In recent years, Cal Water has replaced a portion of its groundwater and banked surface water supply with treated Kern River water as treatment plant capacity has increased. From 2007 to 2015, Cal Water reduced groundwater pumping from 53,889 AFY to 33,388 AFY (Cal Water, 2011 and 2016a).5

Kern River Water from the City: Cal Water has a long-term supply agreement with the City of Bakersfield for 67,200 AFY of Kern River water. Cal Water owns and operates the Northeast Bakersfield Water Treatment Plant, which can treat 22,400 AFY. Future expansions of the plant will increase its capacity to 67,200 AFY. The North Garden Water Treatment Plant has a capacity to treat 8,960 AFY of Kern River water. Half of this amount (4,480 AFY) is supplied to the City under contract. Additional water treatment plants (Southwest Bakersfield WTP and Rosedale Ranch and Seventh Standard Corridor WTP) are proposed to provide additional capacity in staged phases, with some portion of the water committed to the City. Source water for these WTPs will be Kern River water from long-term contracts with the City (Cal Water, 2016b).

SWP and Kern River Water from KCWA ID4: ID4 provides wholesale water to Cal Water from the SWP and from Kern River flows. Water is recharged or treated in the Henry C. Garnett Water Purification Plant and conveyed to three retail suppliers including Cal Water (Cal Water, 2016b). Cal Water's contract for SWP from ID4 is for 20,500 AFY.

2.4.5.2 City of Bakersfield Domestic Water System Water Supply

The City Domestic Water System service area covers about 35 percent of the western portion of Bakersfield (about 38 square miles) (**Figure 2-4**) and provides supply from multiple water sources including groundwater, Kern River water, imported SWP water, and recycled water. The City contracts with Cal Water to operate its municipal water distribution system.

In 2015, the City Water System supplied water from the following sources (Stetson, 2017):

- Groundwater (including banked water) – 86 percent
- Treated water from Cal Water's North Garden Treatment Plant – 3 percent
- Treated SWP and Kern River water purchased from wholesaler KCWA ID4 – 9 percent
- Recycled Water from WWTP#3 for Sports Village irrigation – 2 percent

Groundwater: The City has about four wells per square mile within the City's Domestic Water System service area. Between 2011 and 2015, wells pumped between 30,806 AFY and 38,073 AFY for municipal water supply (Stetson, 2017). The City also owns recharge ponds along the Kern River, termed the 2800 Acre Groundwater Banking Area and uses the Kern River channel and other portions of the City for recharge of surface water supplies.

Kern River Water: The City holds pre-1914 appropriative Kern River water rights that average about 163,193[7] AFY Since its 1976 purchase of the canal company that was the former record keeper for these rights, the City of Bakersfield has taken over Kern River operations and record keeping. The Kern River water is treated for domestic use, provided for agricultural use in accordance with various City's water supply contracts, or used for recharge, including the 2800 Acre recharge ponds, the Kern River channel, and the Carrier Canal.

Recycled Water: The City uses tertiary treated wastewater to irrigate parkland within City boundaries that would have otherwise used potable water. In 2015, this use amounted to 733 AFY. An additional 7,936 AF of secondary treated water was recharged via effluent storage ponds and 9,924 AF was exported outside City boundaries for local irrigation in 2015 (Stetson, 2017). Recycled water use within City boundaries is expected to increase to 2,240 AFY by 2020 (Stetson, 2017).

2.4.5.3 East Niles Community Services District Water Supply

ENCSD is a public water supplier that formed in 1954 to provide water distribution services to residents within its boundaries. Its 6,202-acre service area is largely residential with intermixed areas of commercial, industrial, and agricultural (MKN, 2016). The ENCSD supply is derived from its seven groundwater wells and imported water from ID4. ID4, the City of Bakersfield, KDWD, and Arvin-Edison Water Storage District (AEWSD) underlie portions of its service area.

In 2015, groundwater provided 2,929 AF of supply and ID4 provided 4,573 AF of water. ENCSD's well pumping capacity is about 8,550 AFY. Its ID4 contract amounts to 11,000 AFY of water (MKN, 2016).

2.4.5.4 Greenfield County Water District Supply

Greenfield CWD provides drinking water supply to residential areas covering about 2,200 acres in unincorporated Kern County and the City of Bakersfield (lands within the KRGSA Plan Area). Currently, Greenfield CWD provides groundwater from five local wells serving about 3,000 connections (QK, 2016). Facilities include three booster pump stations and five water storage tanks; two additional wells and arsenic treatment facilities are currently in design (QK, 2016). In 2015, Greenfield CWD delivered 1,999 AFY of groundwater supply.

2.4.5.5 Kern County Water Agency ID4 Water Supply

KCWA was established in 1961 to negotiate and administer a water supply contract for State Water Project supply. ID4 was formed subsequently in 1971 to provide SWP water supply for portions of the metropolitan Bakersfield area. ID4 is a participant in the Cross Valley Canal, which conveys water from the California Aqueduct, and utilizes the 21.5 mile facility to move water into the ID4 service area and adjacent groundwater banking areas. Water delivered to ID4 is either directly recharged to replenish the groundwater basin or delivered to the Henry C. Garnett Water Purification Plant where it is treated and

[7] The City's Kern River entitlement averaged 163,139 AFY from WY 1995 through WY 2014, representing average hydrologic conditions for the Kern River (see **Section 4.6.1**). During that period, annual entitlements ranged from 23,476 AFY (WY 2014) to 408,717 AFY (WY 1998).

then delivered to four water purveyors. These retail purveyors include the California Water Service Company, City of Bakersfield, East Niles Community Services District, and North of the River Municipal Water District which wholesales to Oildale Mutual Water Company. The 103 million gallon-per-day facility serves about 185,000 residents of the metropolitan Bakersfield area. During calendar year 2016, about 33,860 AF of surface water was treated and delivered to water purveyors in ID4.

ID4 also conducts groundwater recharge utilizing imported SWP or exchanged Kern River water. Recharge made possible by water exchanges with Kern River interests commenced in 1971 and recharge using SWP water commenced in 1975 with the completion of the Cross Valley Canal. Actual annual amounts of recharge may vary from about 8,000 AF of unavoidable seepage losses to over 90,000 AF, depending on local and SWP water conditions and regulation afforded by exchanges. ID4 also is responsible for groundwater monitoring and reporting, most notably through its annual Report on Water Conditions within ID4.

In addition to its SWP supply, ID4 can receive Kern River water through KCWA rights for the Lower River. Historically, KCWA has allocated some portion of its available Lower River water right to ID4 during wet years; since about 2011, KCWA has allocated the first 40,000 AF of this right to ID4. Estimates for future Lower River supply available to ID4 have been developed based on Kern River annual indices covering a 20-year average hydrologic period. During that time, ID4 would have received an average annual 9,000 AFY, based on the current allocation. This amount is used for water supply planning as described in **Section 4.6.1** (see **Table 4-12**).

2.4.5.6 Kern Delta Water District Water Supply

For more than 130 years, canal systems located within the KDWD boundary have delivered water to support the agricultural economy on District lands south of the Kern River. These systems were first developed as separate canal companies, each with its own Kern River water right and defined service area and were later consolidated. KDWD was formed in 1965 to provide a public entity that secures and manages a diverse portfolio of water supplies conjunctively to benefit water users and to preserve the service areas' existing water rights to the Kern River. Facilities and Kern River water rights were subsequently acquired by the District in 1976. The KDWD boundary covers approximately 129,000 acres, about 100,000 of which are irrigated agriculture. Of that amount, about 90,000 acres are planted with about 10,000 acres fallowed each year. KDWD water supply includes groundwater (including banked surface water), Kern River water, and SWP water.

<u>Groundwater</u>. Significant quantities of conveyed water percolate beneath the permeable bottoms of the unlined canals, providing recharge to the groundwater basin. Additional recharge occurs through irrigation in excess of crop consumptive use (referred to as return flows). Beginning in the early 1900s, groundwater (including recharged water) has been developed to supplement surface water supply; demand for this water supply has increased over time and currently represents more than one-half to about two-thirds (in dry years) of the District's total applied surface irrigation supply. Municipal demand has also increased within KDWD as the City of Bakersfield has expanded into the northern portions of the District. Small community water systems, including Greenfield CWD and Lamont PUD, also pumps

groundwater from the KDWD service area. Groundwater use (including banked water) has been estimated to average about 165,000 AFY, based on data from WY 1995 through WY 2014 (see **Section 4.3**).

Kern River Water. Distribution of water within the First Point service area of the Kern River was adjudicated in the 1900 Shaw Decree. Over the years, Kern River water has been apportioned among many users based on entitlements determined through canal company consolidations, water rights acquisitions, court decisions, and agreements. Kern River surface water use by KDWD averaged 174,074[8] AFY from WY 1995 through WY 2014 and has ranged between about 110,268 AF (WY 2014) and 228,957 AFY (WY 1997).

State Water Project Water. In 1972, KDWD contracted with KCWA to receive 30,000 AFY of SWP water imported into the county via the California Aqueduct. KDWD's SWP contract included a buildup schedule that reached the maximum amount in 1990, consisting of 25,500 AF of firm supply and 4,500 AF of unregulated surplus supply to be delivered during four winter months on an as-available basis. In 1994, the surplus water was eliminated as part of the Monterey Agreement, revising the District's SWP maximum amount to 25,500 AFY. The SWP water supply is used to reduce the area's groundwater overdraft and provide supplemental surface water deliveries to the various portions of the District.

In the absence of a readily-available means to convey SWP water into the District, KDWD executed exchange agreements with Buena Vista Water Storage District (BVWSD) to allow BVWSD access to KDWD's SWP allotment for an equal amount of BVWSD water supply on the Kern River. This arrangement allowed KDWD to divert its SWP allotment from the Kern River using existing facilities while BVWSD accessed the SWP water directly from the California Aqueduct.

Since the early 1990s, the availability of SWP water has declined. For the 14-year period of 1998 through 2011, the District's full allotment of SWP water was available during only one year.

2.4.5.7 North of the River Municipal Water District/Oildale Mutual Water Company Water Supply

In 2014, the retail portion of NORMWD's service area was merged into OMWC's service area. NORMWD continues to be a wholesaler of water to OMWC and has contracted with ID4 for 15,000 AFY of treated water from ID4's Henry C. Garnett Water Purification Plant.

OMWC derives additional supply from eight active groundwater wells (SWRCB, 2017). These wells can provide over 50 percent of current average daily water demand (Dee Jaspar, 2016a). In 2015, OMWC provided 7,915 AF of water to 10,254 connections. Groundwater supplied 341 AF of this water with ID4 water from NORMWD making up the remainder (Dee Jaspar, 2016a and 2016b).

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[8] This average reflects actual use and incorporates Reed Decision water right restrictions starting in 2008.

2.4.5.8 Vaughn Water Company Water Supply

The Vaughn Water Company (VWC) provides groundwater to users within its service area with 12 active wells. In 2015, it served a population of 32,257 through 9,956 connections, with 96 percent of these connections being residential (Dee Jaspar, 2016c). Groundwater use in 2015 was 3,209 AF over the entire VWC service area. Portions of VWC's service area overlie the City of Bakersfield and ID4, and thus are within the KRGSA; the remainder overlies the Rosedale Rio-Bravo Water Storage District and is within the Kern Groundwater Authority GSA (**Figure 2-1**).

2.4.6 Water Supply Wells

For almost 100 years, wells have been used in the KRGSA to supplement surface water with groundwater supplies (which also includes banked surface water). Data from DWR well completion reports indicate that several thousand wells have been drilled throughout the Plan Area, with most of the early wells providing agricultural water supply along the Kern River and extending throughout the southern KRGSA. Data indicate that about 60 percent of the wells in the southern Plan Area were drilled in the 1950s and 1960s; about 75 percent were drilled before 1980.

2.4.6.1 Active Water Supply Wells in the Plan Area

DWR has compiled statistical data from well completion reports on a series of maps to illustrate well densities and varying well depths on a square mile basis across the state. These maps combine large amounts of data with inherent limitations such as incomplete or inaccurate data, duplicate or missing records, and significant uncertainty associated with both location and status (e.g., whether the well is currently active). Regardless of these issues, the DWR maps provide the best available data for a first approximation of relative well densities in the Plan Area.

Three of the DWR well density maps for the KRGSA Plan Area have been downloaded from the DWR online Well Completion Report Map Application. **Figure 2-11** shows the density of production wells estimated in the KRGSA including agricultural, municipal, industrial, and other public water supply wells. The well density map is color-coded based on the number of wells that have been drilled in each square mile across the area using Public Land Survey System sections. As shown on **Figure 2-11**, at least one production well per square mile is indicated throughout the Plan Area. Most of the production wells are concentrated in the northwest KRGSA (north of the Kern River) and in the central portion of the KRGSA. One map cell located on and north of the River indicates 25 production wells. Although this square mile contains known municipal and industrial wells, 25 active production wells cannot be confirmed. These maps appear most useful to indicate relative well densities across the area.

A similar DWR well density map showing the number of public water supply wells per square mile is provided on **Figure 2-12**. As shown on the map, most of the public water supply wells in the Plan Area are located in the northern half of the Plan Area and represent municipal wells in the Bakersfield city limits. The few public water supply wells in the southern Plan Area are associated with Greenfield CWD, Lamont PUD, and other small water systems. As indicated on **Figure 2-12**, there are generally less than 5 public water supply wells per square mile, with only 1 well in most sections where such wells have been drilled. One exception is a section located south of the Kern River in the north-central KRGSA where a cluster of six public water supply wells has been estimated from well completion reports (29S/28E-19).

The density of domestic wells drilled in the Plan Area is shown on **Figure 2-13**. Although the map indicates that domestic wells have been drilled throughout the Plan Area, most of the domestic wells have been drilled in the northwestern Plan Area (north of the Kern River) and the central Plan Area – a distribution similar to that shown for the production wells (**Figure 2-11**). In those areas, several sections contain 25 to 37 wells per square mile (the highest density in the Plan Area). Although some homeowners retain domestic wells, the area is covered by the City of Bakersfield municipal water service (see **Figure 2-4**). Two additional sections in the southern Plan Area contain between 20 and 30 wells per square mile. These areas appear to contain pockets of industrial, commercial, and residential development. Small water systems surround the area and could be providing residential water in lieu of older domestic wells (see **Figure 2-4**).

Although these three DWR well density maps are useful to illustrate the large number of wells that have been drilled in certain areas over time, maps do not necessarily reflect the density of active wells that are being relied on currently for water supply. To provide a better estimate of active wells, numerous additional data sources have been relied upon to supplement the DWR well completion reports.

Well data were compiled directly from the KRGSA member agencies and other larger water purveyors in the Plan Area in support of the KRGSA GSP (see **Figure 2-4** for water purveyor service areas). Locations of smaller water systems and other active wells have been compiled from public resources. ID4 provided information on well locations and production in its service area. KDWD provided well survey data to estimate locations of active agricultural and/or domestic wells in the southern Plan Area. Recovery wells associated with various recharge and banking programs within and adjacent to the Plan Area were provided by KCWA, ID4, City of Bakersfield, and KDWD.

Finally, a well database compiled by Kern County was used to supplement these KRGSA sources. Although the status of wells in the County is less certain, the database provides a source of domestic/industrial wells and agricultural wells in areas not readily available from other sources. The County database also contained a relatively large number of wells (184) in the KRGSA that did not have a well-use classification; although it is recognized that some of these wells are likely the same wells identified from other resources, many of the wells identified by the County did not plot on or near other well locations. Accordingly, these wells are also included in the active well analysis for completeness.

Wells from data sources described above have been compiled into GIS shapefiles and are mapped in the KRGSA on **Figure 2-14**. As illustrated on **Figure 2-14**, there are likely about 1,260 active supply wells located in the Plan Area.

- 642 agricultural wells
- 162 municipal wells (including wells temporarily offline)
- 67 public water supply and Small Water System wells

- 151 industrial, domestic, and other private wells
- 54 recovery wells
- 184 wells with unknown well type (may duplicate some wells above).

As shown on **Figure 2-14**, most of the agricultural wells are located in the southern Plan Area (in KDWD). Most drinking water wells are located in the northern Plan Area including municipal wells in the City of Bakersfield and other public water supply wells associated with smaller water systems. Domestic wells are scattered throughout the Plan Area but are mostly outside of the Bakersfield city limits. Monitoring wells are not included in the analysis and are described separately in **Section 2.5** and subsequent sections of this GSP.

2.4.6.2 Amended Information on Domestic Wells

In order to use the best information available and support ongoing analyses, updated datasets regarding domestic wells have been obtained for the Amended KRGSA GSP. As described in **Section 1.6**, focused datasets are being targeted to address the corrective actions in the DWR evaluation letter of January 28, 2022. This **Section 2.4.6.2** has been added to the Amended KRGSA GSP to supplement the original domestic well analysis with updated data.

As noted in the discussion in **Section 2.4.6.1** above, the estimated number and locations of the municipal, agricultural, and banking (recovery) water supply wells were provided by KRGSA agencies and are considered the best available data for the GSP analysis. However, the number and location of private domestic wells were estimated from older County datasets and were less certain with respect to well details and status (**Figure 2-14**). The County data did not contain information on the year each well was drilled or well depth. Also, as summarized above, information from DWR on the density of domestic wells per square mile was also incomplete (**Figure 2-13**). These data gaps made it difficult to evaluate beneficial uses from domestic wells.

Since the time of the original analysis in the 2020 GSP, DWR has updated its Well Completion Report (WCR) database through WY 2021, which provides more information on both historical and recent installations of domestic wells in the KRGSA Plan Area. Those data have been reviewed to amend the GSP with more information on domestic wells, including an analysis of potential impacts on beneficial users with a domestic well (see **Section 5.4.4.4**).

According to the DWR WCR database, about 1,071 domestic wells have been drilled in the KRGSA Plan Area through 2021. Approximate locations of these wells are presented on **Figure 2-15**. Except for one well record dated 1931, records for these domestic wells generally date back to the 1950s. More than one-half of the domestic wells were drilled before 1980 (more than 40 years ago); it is unknown how many of these older wells are still in use.

Although about nine percent of the well records do not include a date indicating when the well was drilled, the database clearly shows that the number of domestic wells drilled in the Plan Area has decreased systematically over time. For example, more than 250 domestic wells were drilled in the

1950s and more than 150 wells were drilled in the 1970s; yet less than 50 wells have been drilled in the most recent decade since 2011. This decline in number of domestic wells over time is consistent with the increasing urbanization of the Plan Area and the associated expansion of public water system service areas.

Estimated locations of the 1,071 domestic wells are shown on **Figure 2-15**. Most of the domestic well records in the DWR database are not associated with accurate location coordinates. More than 90 percent of the 1,071 domestic wells have been located in the center of the township-range-section in which the well was originally reported. This is evident in the grid-like pattern of well locations shown on **Figure 2-15**. Only five of the 1,071 domestic wells have an accurate location (within about 50 feet) in the database. In addition, multiple wells are placed at identical locations, accounting for the relatively small number of well dots shown on **Figure 2-15** compared to the large number of well records (1,071).

The estimated depth of the completed well casing is indicated by color categories on **Figure 2-15**. As illustrated in the legend, relatively shallow wells (<200 feet deep) are shown in blue, with deeper wells shown as green (<300 feet deep), orange (<400 feet deep), and red (>400 feet deep). When multiple wells are plotted at the same location, the shallow-most well color is displayed on the map. About four percent of the wells are less than 100 feet deep and almost one half are less than 300 feet deep.

Although domestic wells of variable depths are indicated throughout the KRGSA, the shallower wells appear to be clustered along the Kern River in the north and generally within the central portions of the KRGSA south of the River. Water levels have been historically higher in these areas due to managed recharge occurring along the Kern River channel, in unlined surface water conveyance canals, and in local areas of groundwater banking. In general, deeper wells are clustered along the east-central boundary (north of Lamont) and scattered throughout both the southern-most and northern-northwestern areas of the KRGSA (**Figure 2-15**).

2.5 WATER RESOURCES MONITORING AND MANAGEMENT PROGRAMS

Water resources monitoring and management programs have a long history in the KRGSA Plan Area. Such programs are conducted by local water agencies and municipal water suppliers at regional and local scales, ranging from participation in State programs (e.g., CASGEM[9]) and regional plans (e.g., Integrated Regional Water Management Plan) to individual water system monitoring by local water suppliers.

2.5.1 Water Resources Monitoring

Water resource monitoring programs considered in the KRGSA GSP address:

- Climate
- Groundwater levels

[9] CASGEM – California Statewide Groundwater Elevation Monitoring program

- Wells and groundwater pumping
- Imported water deliveries
- Surface water flows and deliveries
- Groundwater banking
- Wastewater discharge and recycled water delivery
- Land use and cropping
- Groundwater, surface water, imported water, and wastewater/recycled water quality
- Land subsidence

Multiple agencies are involved in water resources monitoring, with data shared through several key annual reports. KCWA has assumed a major role in the collection of data on groundwater and surface water supplies and water quality in the Subbasin. Since its formation in 1961, KCWA has collected information on water supply and demand in the Kern County Subbasin and since 1977, has published this information in its annual Water Supply Report. Other key and regularly published documents are the Kern River *Hydrographic Annual Reports* produced by the City of Bakersfield, the *Report on Water Conditions* prepared by ID4, and the *Kern Fan Area Operations and Monitoring Report* produced by the Kern Fan Monitoring Committee (KFMC).

Member agencies also monitor drinking water supplies in compliance with a variety of SWRCB monitoring programs. In addition, Kern Delta Water District has documented its monitoring activities of surface water and groundwater in its Groundwater Management Plan (Todd, 2013), providing monitoring objectives, methods, protocols, locations, and data management.

These and other Kern Subbasin organizations involved in monitoring and reporting are also summarized in **Section 6** of this GSP and considered for incorporation into the KRGSA GSP monitoring networks.

Groundwater levels. Groundwater levels have been recorded in the Subbasin outside of formal monitoring programs since at least the 1920s, but data before the 1950s and 1960s are sparse. Water levels are currently monitored in the KRGSA Plan Area as part of the DWR California Statewide Groundwater Elevation Monitoring Program (CASGEM). Local CASGEM monitoring entities in the KRGSA Plan Area include ID4 for its service area and the Kern River Fan Group, which involves Kern Delta Water District. Available data from a variety of programs have been compiled into large data sets by KCWA, who conducts water level monitoring and/or water level data compilation across the Kern County Subbasin for a variety of activities.

For example, KCWA monitors semiannual groundwater levels in approximately 800 production wells and 200 monitoring wells within the Kern County Subbasin and monitors monthly groundwater levels in about 240 production and monitoring wells within the Kern River alluvial fan area. Data have been analyzed and reported in the KCWA publication, *Report on Water Conditions*, which includes long-term hydrographs of key wells, maps of spring groundwater elevation contours, depth to groundwater in wells, and change in groundwater depth (spring to spring). KCWA Water Supply Reports from past years also present similar hydrographs and maps. KCWA also conducts water level monitoring in the vicinity of groundwater banking projects on the Kern

Fan as part of the requirements of the Kern Fan Monitoring Committee, discussed in more detail in the section on groundwater banking below.

Since 1989, KDWD has conducted a groundwater level monitoring program involving approximately 100 to 150 wells for in-district analysis. Typically, semi-annual measurements are made in Spring and Fall. Eight key wells have been selected for more systematic water level monitoring as part of the CASGEM program.

Wells and groundwater pumping. Groundwater extractions are reported to ID4 within its service area on a semi-annual basis. This program includes most of the municipal wellfields and accounts for a significant percentage of the active wells in the Plan Area. Wells within ID4 are registered and the number of wells and well uses (commercial, domestic, irrigation, purveyor) are tabulated in the ID4 *Report on Water Conditions* (e.g., KCWA, 2019). Extractions are reported based on either well meters, if available, or other estimates including electrical records or land use.

Imported water deliveries. As wholesaler for SWP water, ID4 regularly accounts for and reports its SWP supplies in the *Report on Water Conditions* within ID4 (e.g., KCWA, 2019). KCWA monitors all turnouts from the California Aqueduct in Kern County and all turnouts along the Cross Valley Canal. Measurements are taken daily (KCWA, Initial Water Management Plan, 2001).

Surface water flows and deliveries. The City of Bakersfield monitors surface water flow at First Point on the Kern River and at various locations along the Carrier and River canals. Measurements of the Kern River at First Point date back to October 1893. The City of Bakersfield compiles and reports the data in Kern River annual Hydrographic Reports. These reports provide accounting of monthly diversions, deliveries, and loss along the canals among all First Point diverters with records extending back to the 1890s, per files from the City of Bakersfield Water Resources Department.

KDWD monitors daily Kern River diversions at four monitoring points and daily water deliveries from KDWD main canals and laterals, allowing estimates of groundwater recharge along the unlined canals. These surface water flow and diversion monitoring data are provided to the City of Bakersfield for compilation into the Hydrographic Annual Reports.

Groundwater banking. The Kern Fan Monitoring Committee (KFMC) was established by MOU among certain participants in local groundwater banking projects (including the Kern Water Bank, Berrenda Mesa, and Pioneer Project) and adjoining entities. The KFMC is responsible for collecting data from participants/adjoining entities and reporting that data in the KFMC's *Kern Fan Area Operations and Monitoring Report*. The KFMC typically monitors more than 50 monitoring wells and about 85 recovery wells (KFMC, 2018). Published data include deliveries for recharge and recovery pumping, groundwater levels (hydrographs and maps of groundwater elevations and depth to groundwater), groundwater and surface water quality sampling results.

Wastewater discharge and recycled water delivery. Metropolitan Bakersfield is served by four wastewater treatment plants. The City of Bakersfield operates two of the treatment plants: Wastewater

Treatment Plant 2 (WWTP 2) and Wastewater Treatment Plant 3 (WWTP 3); the Kern Sanitation Authority and the North of River Sanitary District No. 1 each operate plants. Monitoring of WWTP discharges and quality is regulated by the Central Valley Regional Water Quality Control Board.

Groundwater, surface water, imported water, and wastewater/recycled water quality. The City of Bakersfield monitors surface water quality at various locations along the Carrier and River canals. ID4 also produces or participates in updating Watershed Sanitary Surveys for the Cross Valley Canal, Friant-Kern Canal, Kern River and State Water Project. The City of Bakersfield compiles and reports the data in its annual Hydrographic Reports. Groundwater quality data are collected by various agencies and often in response to various groundwater management and regulatory programs and requirements; these include federal and state programs protecting drinking water quality and the Irrigated Lands Regulatory Program (ILRP) that addresses water quality in agricultural areas.

In the *Report on Water Conditions* prepared by ID4 (KCWA, 2019), extensive documentation is provided on water quality from the Henry C. Garnett Water Purification Plant, including source water and treated water in terms of bacteria, inorganic constituents, and organic chemicals. Consistent with federal and state requirements, local potable water providers monitor water quality. Public water systems (consistent with the California Health and Safety Code) regularly sample water quality and annually prepare an Annual Consumer Confidence Report. The Kern County Public Health Services Department administers the Small Water System Program that includes monitoring of small public water systems (2-14 connections) and nonpublic water systems (1-5 connections).

The ILRP issues Waste Discharge Requirements (WDRs) or conditional waivers of WDRs (orders) to growers that require water quality monitoring of receiving waters. The Kern River Watershed Coalition in the Tulare Lake Basin has created a database with over 100,000 records for total dissolved solids (TDS), nitrate, and pesticides over the 1909 through 2014 period (P&P, et al., 2015).

The Kern Fan Monitoring Committee (KFMC) evaluates groundwater quality in and around the Kern Water Bank and other Kern Fan banking projects.

Land use. KCWA has conducted annual land use surveys since 1972. The land use information has been reported in the Report on Water Conditions (e.g., KCWA, 2019) (and in the KMFC's *Kern Fan Area Operations and Monitoring Report*) and used, in part, to estimate groundwater production. Annual cropping data also are available from the Kern County Agricultural Commission and Kern Delta Water District.

Land subsidence. Subsidence has occurred mostly to the north and south of the KRGSA area and has been documented through a series of key studies by the USGS and DWR. The Friant-Kern Canal, which extends through NKWSD to the Kern River, is monitored by the U.S. Bureau of Reclamation via two multi-port monitoring wells in NKWSD (and other monitoring points outside of the Plan Area) to track the ongoing potential for subsidence-related problems.

Incorporation of existing monitoring into GSP. As documented above and as recognized in the Kern Integrated Regional Water Management Plan (IRWMP) (K/J, 2011), monitoring and data collection have not been centralized. Various types of data are collected by a variety of public and private entities, at state, regional, and local levels. Data have not been compiled into a central database, although the KCWA Water Supply Report has attempted to serve at least part of that function. Review of monitoring programs in the IRWM Plan suggests that methods for data collection are similar and thus support creation of regional datasets and databanks. Kern County Subbasin GSAs have recently coordinated on a grant application for development of a Subbasin-wide Data Management System (DMS); results of potential grant funding are pending.

The monitoring program for the KRGSA GSP is described in **Section 6**. This program makes best use of the multiple monitoring networks that are already in place in the KRGSA Plan Area. Each member agency of the KRGSA already conducts groundwater monitoring and/or participates in other local monitoring programs in its service area. These programs have already selected wells with appropriate construction (when known) and historical data records. Accordingly, these wells have been prioritized for incorporation into the KRGSA GSP monitoring network and are supplemented as required to monitor the established sustainable management criteria described in more detail in **Section 5**. None of these plans should impact operational flexibility for monitoring and management in the GSP; rather, these programs collectively provide an extensive monitoring network to assist with GSP monitoring.

2.5.2 Water Resources Management Programs

Numerous planning documents provide details on the myriad of water resources management programs in the KRGSA Plan Area. In brief, daily coordination among water managers, an interconnected web of conveyance canals and pipelines, and numerous water sources to balance and manage on a real-time basis have provided KRGSA Plan Managers with the tools for flexible and reliable water management programs. Water management plans have been developed by KCWA (Initial Water Management Plan, 2001) and KDWD (Groundwater Management Plan, 2015). Urban Water Management Plans (UWMPs) have been prepared by the City of Bakersfield, California Water Service Company (Cal Water), ID4, Oildale MWC, ENCSD, Lamont PUD, and other local water suppliers in the KRGSA. Separately, each plan describes numerous policies and programs being implemented by KRGSA member agencies for conjunctive management of surface water and groundwater; collectively, the plans demonstrate coordination at an intricate level to maximize use of water resources.

While some local water suppliers in the Plan Area rely solely on groundwater, most agencies (City of Bakersfield, California Water Service Company, ID4, KDWD, ENCSD, NORWD/OMWC) have multiple water sources including groundwater, local Kern River surface water, banked and recharged surface water, and/or imported water (sources described previously in **Section 2.4** and in **Table 2-2**). These sources have been successfully managed and used conjunctively for decades; the Kern River Fan is recognized for its active recharge and banking programs. In addition, KCWA is an acknowledged long-time leader in water exchanges and transfers.

Descriptions and details of the conjunctive management programs including conveyance, distribution, recharge and use are provided in other sections of this GSP. Many of these programs were introduced in the discussions of water supplies in the KRGSA Plan Area, **Section 2.4**. Information on surface water conveyance and conjunctive management of Kern River water, SWP water, and water associated with local banking programs is provided in **Section 3.2.4.3**. Inflows and outflows associated with these conjunctive management programs are provided in the description of water budgets in **Section 4**.

Examples of local conjunctive use include (but are not limited to) the following:

- Storage space in Isabella Reservoir is managed for Kern River water and, by exchange, imported SWP water.
- Recycled water is used for recharge and irrigation.
- The City of Bakersfield maintains over 340 storm water drainage basins to capture and recharge stormwater throughout the City.
- Kern River water is regulated and managed for recharge within the Kern River channel.
- Kern River water is intentionally discharged to unlined canals to promote surface water seepage and groundwater recharge.
- Recharge basins and banking programs in the KRGSA Plan Area include the City of Bakersfield 2800 Acres project (COB 2800); Berrenda Mesa Spreading Grounds, Kern Delta Water District recharge basins; and managed recharge in the Kern River Channel.
- Water banking programs are active with participation by local agencies and out-of-basin agencies.

Recognizing the intensity of local conjunctive use, recharge, and banking operations, numerical models have been developed and/or applied by local agencies. Two existing regional models cover the entire Kern River Area and beyond. These are the USGS Central Valley Hydrologic Model (CVHM) (Faunt, 2009) and the DWR California Central Valley Groundwater-Surface Water Simulation (C2VSim) Model (Brush, Dogrul and Kadir, 2013). In addition, several local models have been developed for specific purposes by the various water agencies in the area. The Beta version of the updated DWR C2VSim (released in May 2018) provided the best available tool for simulating integration of surface water and groundwater throughout the entire Kern County Subbasin. That model has been obtained and revised to reflect these water management programs in the KRGSA Plan Area (and remaining areas in the Kern County Subbasin) for application to water budget analyses included in this GSP.

The water resources programs are coordinated among agencies for optimized use of water resources. Kern River water and SWP are managed through exchanges and sales to others. Banking programs, including intentional recharge along canals, provide flexibility for storing water when available and recovering water for use during times of water scarcity. These programs also incorporate monitoring networks to measure performance and avoid adverse impacts. These issues are also being addressed through regional coordination of sustainable management criteria for the entire Kern County Subbasin.

2.6 GENERAL PLANS AND LAND USE ELEMENTS

Implementation of existing land use plans by various jurisdictions has important ramifications for water supply sustainability. Urban, rural and agricultural growth tends to increase water demand, but land use policies and programs can support sustainable water supply planning through water conservation, conjunctive use of surface water and groundwater supplies, water recycling, and stormwater management.

Land use planning within the KRGSA Plan Area is guided by the General Plan for the City of Bakersfield metropolitan area, by the Kern County General Plan for unincorporated areas, and by the Kern River Plan Element. Unincorporated Kern County within the Metropolitan Bakersfield Sphere of Influence Area is addressed in the Metropolitan Bakersfield General Plan. Land use designations and policies within the metropolitan planning area are different than those within the Kern County General Plan.

2.6.1 Metropolitan Bakersfield General Plan

The Metropolitan Bakersfield General Plan (City of Bakersfield, 2002) covers the northern portion of the KRGSA. Zoning designations include agricultural, industrial, and commercial land uses as shown on **Figure 2-6**.

The General Plan was adopted originally in December 2002 and was most recently updated in January 2016 per Resolution Nos. 018-16, 019-16, and 020-16. Two sections are most relevant to the GSP: the Water Resources section of the Conservation Element and Water Distribution section of the Public Services and Facilities Element. **Table 2-4** summarizes goals, policies, and implementation measures for these sections. As a summary, this table may not include all General Plan policies relevant to the GSP; accordingly, specific issues will likely involve consultation with Planning Department staff.

The *Water Resources* section of the Conservation Element recognizes three long-standing issues:

- The conservation and effective utilization of planning area water resources is complicated by multi-jurisdiction control over such resources.
- There are portions of the planning area which are water deficient and/or in which there are problems with water quality.
- Water transport, groundwater recharge needs, recreational usage of water resources, and the preservation and enhancement of water-related natural habitat all compete for the usage of scarce water resources in the planning area.

These issues are addressed through the Goals, Policies, and Implementation Measures summarized in the Water Resources section of **Table 2-2.** Similarly, the Public Services and Facilities Element of the Metropolitan Bakersfield General Plan includes a Water Distribution Section that addresses the following water distribution issues:

- Provision of adequate water service to the planning area.

- Coordination of water purveyors and water rights holders.

Sections on Sewer Service and Stormwater in the 2002 Metropolitan Bakersfield General Plan are oriented toward wastewater and water disposal, but do not address water recycling or recharge.

2.6.2 Kern River Plan Element

The Kern River Plan Element was adopted in July 1985 as an integral part of the City of Bakersfield General Plan and the Kern County General Plan. The plan element covers the primary and secondary floodways of the Kern River and was incorporated by reference into the updated Metropolitan Bakersfield General Plan when it was adopted in 2002. **Table 2-5** provides a summary of key goals, policies, and implementation measures relevant to the KRGSA GSP.

Table 2-4: Selected Bakersfield Metropolitan Area General Plan Policies

Goal	Policy	Implementation Measure
Water Resources		
Goal 1. Conserve and augment the available water resources of the planning area. **Goal 2.** Assure that adequate groundwater resources remain available to the planning area. **Goal 3.** Assure that adequate surface water supplies remain available to the planning area. **Goal 4.** Continue cooperative planning for and implementation of programs and projects which will resolve water resource deficiencies and water quality problems. **Goal 5.** Achieve a continuing balance between competing demands for water resource usage. **Goal 6.** Maintain effective cooperative planning programs for water resource conservation and utilization in the planning area by involving all responsible water agencies in the planning process.	**Policy 1.** Develop and maintain facilities for groundwater recharge in the planning area. **Policy 2.** Minimize the loss of water which could otherwise be utilized for groundwater recharge purposes and benefit planning area groundwater aquifers from diversion to locations outside the area. **Policy 3.** Support programs to convey water from other than San Joaquin Valley basin sources to the planning area. **Policy 4.** Support programs and policies which assure continuance or augmentation of Kern River surface water supplies. **Policy 5.** Work towards resolving the problem of groundwater resource deficiencies in the upland portions of the planning area. **Policy 6.** Protect planning area groundwater resources from further quality degradation. **Policy 7.** Provide substitute or supplemental water resources to areas already impacted by groundwater quality degradation by supporting facilities construction for surface water diversions. **Policy 8.** Consider each proposal for water resource usage within the context of total planning area needs and priorities-major incremental water transport, groundwater recharge, flood control, recreational needs, riparian habitat preservation and conservation. **Policy 9.** Encourage and implement water conservation measures and programs.	**Measure 1.** Maintain, and utilize to the fullest extent possible, the City of Bakersfield's 2800-Acre spreading facility and all other existing recharge facilities and channels in or serving the planning area groundwater resource, including the Kern River channel through Bakersfield. **Measure 2.** Support all financially feasible and practical groundwater projects, for the augmentation of groundwater recharge for the south San Joaquin Valley basin by the construction and operation of additional recharge facilities or the importation of additional water for basin recharge. **Measure 3.** Oppose the diversion or exportation of water resources which would unduly diminish the availability of such resources for planning area groundwater recharge. **Measure 4.** Provide necessary legislative advocacy and/or funding for the Planning area. **Measure 5.** Initiate and/or support planning, financing, construction and implementation programs for supplying upland portions of the planning area having groundwater deficiencies with an adequate water supply. **Measure 6.** Support the provision of adequate wastewater collection systems and treatment reclamation and disposal facilities which will prevent groundwater degradation by on-site wastewater systems. **Measure 7.** Maintain industrial waste discharge regulation and monitoring programs which protect the planning area groundwater from contaminants. **Measure 8.** Provide supplemental or replacement water supplies (such as the City's conjunctive use project) to metropolitan area distribution systems which utilize currently or potentially degraded water supplies. **Measure 9.** Utilize the Kern River Plan Element as a policy guide for consideration of competing water resource needs, including water for municipal, industrial, direct irrigation, groundwater recharge, habitat restoration and multi-purpose recreational uses. **Measure 10.** Support additional water conservation measures and programs of benefit to the planning area.
Water Distribution		
Goal 1. Ensure the provision of adequate water service to all developed and developing portions of the planning area.	**Policy 1.** Reach agreement regarding mutually beneficial improvements in domestic water service and distribution facilities as required to improve overall metropolitan water service capabilities. **Policy 2.** Continue to provide domestic water facilities which are contributed directly by developers, through development and/or availability fees. Policy 3. Require that all new development proposals have an adequate water supply available.	**Measure 1.** Utilize the Kern County Water Agency's Urban Bakersfield advisory committee for coordination of planning efforts. **Measure 2.** Implement the Urban Water Management Plan prepared by ID4 (1985). **Measure 3.** Review, and modify as required, existing fee structures and ordinances to assure desired system financing and policy implementation. **Measure 4.** Study alternatives to provide an adequate water supply to the northeastern "non- district" area.

Table 2-5: Kern River Plan Element of the Bakersfield Metropolitan Area General Plan and the Kern County General Plan

Goal	Policy	Implementation Measures
Open Space		
Goal 3.2.2: To ensure that the open spaces of the Kern River are maintained and enhanced as a unique and valuable resource for the Bakersfield metropolitan area.	**Policy 3.2.3.5:** Natural topography, vegetation, and scenic features shall be retained to the greatest feasible extent in future development along the River.	Short-term implementation measures for all policies involve land trades, transfer of development rights (TDRs), easements, gifts, maintenance of existing open space, and land acquisition by responsible parties, plus developing education, promoting acquisition of funding, and continuing design review, and the planning and approval process.
Riparian Vegetation and Wildlife Habitat		
Goal 3.3.2: To protect and enhance endangered and nonendangered indigenous wildlife and wildlife habitat of the River.	**Policy 3.3.3.8:** The County of Kern, the City of Bakersfield, and the Kern County Water Agency, and appropriate water districts shall consult with each other, and the City Department of Water Resources shall report to the City Council and Board of Supervisors on the potential for establishing and maintaining a minimum annual flow of water within the Kern River between Manor Street and the Stockdale Highway Crossing.	Long-term implementation measures for all policies involve application for State and federal funding and/or funds under the Quimby Act for open space preservation and acquisition of lands essential for plan implementation. Additional measures consider formation of a special purpose district or a special assessment district.
Floodplain Management		
Goal 3.4.2: To maximize and fully utilize the groundwater recharge potential of the Kern River, its floodplains, and other potential recharge aquifers.	**Policy 3.2.3.7:** Agricultural land preparation, vegetative plantings, and minor structural improvements or appurtenances shall blend with and enhance the open space qualities of the River corridor to the greatest extent possible. **Policy 3.4.3.12:** Groundwater recharge shall be considered a principal allowable use of both primary and secondary floodways. The continued groundwater recharge program involving properties owned by the City are of paramount importance.	

2.6.3 Kern County General Plan

The general Land Use Planning Designations of the Kern County General Plan (Kern County, 2009) are shown on **Figure 2-5**. An update of the Kern County General Plan is underway; this process was initiated in October 2016 and is anticipated to extend through 2019. As part of this effort, the water element for the update is considering reliable long-term water supply, water quality, watershed and groundwater protection and conservation. Staff of the Kern County Planning and Natural Resources Department are assessing the county's water supply and facilities and drafting policies that reflect future growth and goals.

Consistent with the California Government Code, portions of the Land Use, Open Space, and Conservation Element were developed in coordination with KCWA and other local water agencies. Groundwater management is addressed in four sections of the Land Use, Open Space, and Conservation Element: Physical and Environmental Constraints, Public Facilities and Services, Resource, and General Provisions. For each, the relevant goals, policies, and implementation measures are summarized in **Table 2-6**. This table is a summary and may not include all General Plan policies relevant to the GSP; accordingly, specific issues will likely involve consultation with Planning Department staff.

Table 2-6: Selected Kern County General Plan Goals, Policies, and Implementation Measures

Goal	Policy	Implementation Measure
***Physical and Environmental Constraints* (Shallow groundwater within 15 feet of the land surface is considered a constraint.)**		
Goal 1. To strive to prevent loss of life, reduce personal injuries, and property damage, minimize economic and social diseconomies resulting from natural disaster by directing development to areas which are not hazardous.	**Policy 1.** Kern County will ensure that new developments will not be sited on land that is physically or environmentally constrained	**Measure C**. Cooperate with the Kern County Water Agency to classify lands in the County overlying groundwater according to groundwater quantity and quality limitations.
***Public Facilities and Services* (Relevant to water supply development and groundwater protection.)**		
Goal 5. Ensure that adequate supplies of quality (appropriate for intended use) water are available to residential, industrial, and agricultural users within Kern County. **Goal 9.** Serve the needs of industries and Kern County residents in a manner that does not degrade the water supply and the environment and protect the public health and safety by avoiding surface and subsurface nuisances resulting from the disposal of hazardous wastes, irrespective of the geographic origin of the waste. **Goal 11.** Reduce residential contamination of groundwater by encouraging sanitary sewer systems.	**Policy 2.** The efficient and cost-effective delivery of public services and facilities will be promoted by designating areas for urban development which occur within or adjacent to areas with adequate public service and facility capacity. • Ensure that water quality standards are met for existing users and future development. • Ensure that adequate storage, treatment, and transmission facilities are constructed concurrently with planned growth. • Ensure the maintenance and repair of existing water systems. • Encourage utilization of wastewater treatment facilities which provide for reuse of wastewater. • Encourage the consolidation or elimination of small water systems. • Encourage the conversion of private sewer systems (septic tanks) to public systems. • Ensure that adequate collection, treatment, and disposal facilities are constructed concurrently with planned growth. • Ensure that appropriate funding mechanisms are in place to fund the needed improvements which result from development and subsequent growth.	**Measure K.** The appropriate agency should develop sewer and water master plans in areas where these services are lacking or deficient and in areas where urban development exists or is designated.
Resources (Agriculture is vital to the future of Kern County and development of major water projects has greatly increased the amount of land in agricultural production.)		
Goal 2: Protect areas of important mineral, petroleum, and agricultural resource potential for future use. **Goal 5**: Conserve prime agriculture lands from premature conversion.	**Policy 10:** To encourage effective groundwater resource management for the long-term economic benefit of the County the following shall be considered: • Promote groundwater recharge activities in various zone districts. • Support for the development of Urban Water Management Plans and promote Department of Water Resources grant funding for all water providers. • Support the development of groundwater management plans. • Support the development of future sources of additional surface water and groundwater, including conjunctive use, recycled water, conservation, additional storage of surface water and groundwater and desalination.	**Measure F:** Prime agricultural lands, according to the Kern County Interim-Important Farmland map produced by the Department of Conservation, which have Class I or II soils and a surface delivery water system, shall be conserved through the use of agricultural zoning with minimum parcel size provisions.

Selected Kern County General Plan Goals, Policies, and Implementation Measures, continued		
Goal	**Policy**	**Implementation Measure**
General Provisions **(includes a specific subsection on surface water and groundwater.)**		
Goal 1. Ensure that the County can accommodate anticipated future growth and development while maintaining a safe and healthful environment and a prosperous economy by preserving valuable natural resources, guiding development away from hazardous areas, and assuring the provision of adequate public services.	**Policy 33**. Water related infrastructure shall be provided in an efficient and cost-effective manner. **Policy 34**. Ensure that water quality standards are met for existing users and future development. **Policy 35**. Ensure that adequate water storage, treatment, and transmission facilities are constructed concurrently with planned growth. **Policy 36**. Ensure that appropriate funding mechanisms for water are in place to fund the needed improvements resulting from growth and subsequent development. **Policy 37**. Ensure maintenance and repair of existing water systems. **Policy 38**. Encourage utilization of wastewater treatment facilities which provide for the reuse of wastewater. **Policy 39**. Encourage the development of the County's groundwater supply to sustain and ensure water quality and quantity for existing users, planned growth, and maintenance of the natural environment. **Policy 40**. Encourage utilization of community water systems rather than the reliance on individual wells. **Policy 41**. Review development proposals to ensure adequate water is available to accommodate projected growth. **Policy 42**. Encourage water supply purveyors to prepare master water plans for those areas of the County approaching existing design thresholds, including documentation of areas in need of system maintenance and repair. **Policy 43**. Drainage shall conform to the Kern County Development Standards and the Grading Ordinance. **Policy 44**. Discretionary projects shall analyze watershed impacts and mitigate for construction-related and urban pollutants, as well as alterations of flow patterns and introduction of impervious surfaces as required by California Environmental Quality Act (CEQA), to prevent the degradation of the watershed to the extent practical. **Policy 45**. New high consumptive water uses, such as lakes and golf courses, should require evidence of additional verified sources of water other than local groundwater. Other sources may include recycled stormwater or wastewater. **Policy 46**. In accordance with the Kern County Development Standards, tank-truck hauling of domestic water for land developments or lots within new land developments is not permitted.	**Measure T**. The Kern County Environmental Health Services Department will develop guidelines which will establish criteria for development of proposed new water systems when an existing water system, within a reasonable distance, is able to supply water. **Measure U**. The Kern County Environmental Health Services Department will develop guidelines for the protection of groundwater quality which will include comprehensive well construction standards and the promotion of groundwater protection for identified degraded watersheds. **Measure V**. Water and sewer purveying agencies should develop long-term sewer and water master plans in areas where these services are lacking or deficient and in areas where urban development exists or is designated. **Measure W**. Applications for General or Specific Plan Amendments will include sufficient data for review to facilitate desirable new development proposals consistent with General Plan policies, using the following criteria and guidelines: • The provision of adequate water, sewer, and other public services to be used. • The provision of adequate on-site nonpublic water supply and sewage disposal if no public systems are available or used. **Measure X**. Encourage effective groundwater resource management for the long-term benefit of the County through the following: • Promote groundwater recharge activities in various zone districts. • Support for the development of Urban Water Management Plans and promote Department of Water Resources grant funding for all water providers. • Support the development of Groundwater Management Plans. • Support the development of future sources of additional surface water and groundwater, including conjunctive use, recycled water, conservation, additional storage of surface water, and groundwater and desalination. **Measure Y**. Promote efficient water use by utilizing measures such as: • Requiring water-conserving design and equipment in new construction. • Encouraging water-conserving landscaping and irrigation methods. • Encouraging the retrofitting of existing development with water conserving devices. **Measure Z**. General Plan Amendments subject to environmental review and not otherwise subject to California Water Code Section 10910 shall demonstrate through a water supply assessment that a long-term water supply for a 20-year timeframe is available. The water assessment shall include, but not be limited to, the following: • Source and quantity of historical water use on the site. • Estimated water consumption of the proposed development. • Estimated storage, if any, in meeting the projected need. • Recommendations for additional sources of water to address demand shortage. Such measures may include, but are not limited to, development of future sources of additional surface water and groundwater, including water transfers, conjunctive use, recycled water, conservation, and additional storage of surface water, groundwater, and desalination. Written acknowledgement that water will be provided by a community or public water system with an adopted Urban Water Management Plan shall constitute compliance with this requirement.

2.6.4 Kern County Environmental Health Services and Well Permitting

Permitting of new or replacement water supply wells in Kern County is administered by the Kern County Public Health Services Department through the Environmental Health Services (EHS) Water Well Program. The Kern County Ordinance Code, Chapter 14, provides for the design, construction, repair, and reconstruction of agricultural wells, domestic wells, cathodic protection wells, industrial wells, monitoring wells, observation wells, geothermal heat exchange wells, and test wells in such a manner that the groundwater of the county will not be contaminated or polluted, and that water obtained for beneficial uses will not jeopardize the health and safety or welfare of the people of Kern County.

Well permitting policies, procedures, and guidelines are presented on the EHS website for Water Wells & Small Water Systems and in the Water Well Permits Policy Manual; links are provided below:
http://kernpublichealth.com/water/water-wells-small-water-systems/
http://kernpublichealth.com/wp-content/uploads/2016/03/EHSWellPolicyManual_2008_09_11_08.pdf

The Manual presents the procedures to obtain, complete and apply for a water well permit. To summarize, the application is reviewed by EHS staff to determine if an annular seal would be required, accounting for location and groundwater quality data indicating differences in quality between unconfined and confined aquifers. One or more site inspections is conducted by EHS staff. Water quality testing is required of the applicant with submittal and review by EHS.

EHS staff forwards water well permit applications to KCWA under certain conditions Including when the proposed well is within the extent of Corcoran Clay or shallow groundwater. Conditions also include location within a one-mile radius of:

- a public drinking water supply well
- sphere of influence of any Kern County municipality
- established or proposed groundwater recharge/recovery facility
- proposed dairy or feedlot operation
- biosolids composting, disposal, or land application area
- known or suspected hazardous waste site
- active or inactive sanitary landfill, burn dump, or hazardous materials facility
- known area of poor water quality
- active or proposed fruit or vegetable processing facility.

All water well destruction permit applications should be reviewed by KCWA and any water district or public entity having jurisdiction for the site. The Water Well Permits Policy Manual also specifies approved sealing materials for well construction and well destruction.

The Kern County EHS also has established Standards and Rules and Regulations for Land Development that address sewage disposal, water supply, and preservation of environmental health (Kern County EHS, 2010). Chapter III, Water Supply, lists requirements for domestic water supply systems that mandate documentation of an adequate supply, provision of water quality meeting drinking water standards, and compliance with water well drilling standards and setbacks and the Kern County Zoning Ordinance.

The policy in the local, adopted land use plans that is most pertinent to well permitting is the Kern County Policy 40, which encourages utilization of community water systems rather than the reliance on individual wells.

2.6.5 Nexus of Land Use Plans and Sustainable Groundwater Management

This GSP considers and complements the current land use plans that cover the KRGSA as prepared by the City and County. The City General Plan goals, policies, and implementation measures for water resources (**Table 2-4**) all align well with both the Sustainability Goal and proposed projects and management actions in this GSP. In particular, policies support increased groundwater recharge, importation of SWP water, resolution of any groundwater deficiencies, and preservation of riparian habitats, all of which are supported by increased recharge along the Kern River channel and other GSP projects and actions. The Bakersfield Kern River Element reinforces the common goals of riparian habitat along the River and increased groundwater recharge (**Table 2-5**).

The Kern County General Plan also recognizes the need for water supply development and groundwater protection (**Table 2-6**). Shallow groundwater (within 15 feet of the land surface) is considered a constraint for new development, but this can be managed through monitoring and operations of recharge facilities, including the Kern River channel. The General Plan also recognizes that agriculture is vital to the future of Kern County and includes a goal to conserve prime agricultural lands from premature conversion. This GSP assumes some limited urbanization of agricultural lands as City growth continues, but also includes assurances for adequate agricultural water supplies for the future.

This GSP development included review and consideration of the UWMPs developed by the water purveyors in the Plan Area. Data and information from the UWMPs were incorporated into this GSP including estimates for population growth, conservation and decreases in per capita demand, expansion of water treatment facilities, and increased reliability of imported supplies. In this manner, the GSP coordinates and complements both local land use and water supply planning efforts in the KRGSA Plan Area. Finally, land use plans outside of the Kern County Subbasin are not expected to have any effect on GSP actions in the KRGSA.

2.6.6 Additional GSP Elements

The California Water Code contains a checklist for preparation of GSPs, which provide groundwater management elements that may be applicable for incorporation into the KRGSA GSP. Most management programs relevant to this checklist are described in **Section 2.5** above; programs are summarized below for each topic to ensure that the additional plan elements listed in the GSP regulations (Section 354.8 (g)) have been considered.

(a) *Control of saline water intrusion*. Seawater intrusion is not applicable because this is not a coastal Subbasin. Saline water at depth is discussed in **Section 3.2.5.2**, Base of Fresh Water.

(b) *Wellhead protection areas and recharge areas*. KRGSA wells are discussed in **Section 2.4.6**. Managed aquifer recharge and conjunctive use activities are summarized in **Section 2.5.2**. More information on areas of natural recharge is discussed in **Section 3**.

(c) *Migration of contaminated groundwater*. KRGSA will ultimately coordinate with responsible parties and regulatory agencies to oversee the investigation and remediation of contaminated groundwater and will inform local agencies of the status of such work. The oversight agencies may include the Central Valley Regional Water Quality Control Board, the State Department of Toxic Substances Control (DTSC), or the County Department of Environmental Health. More information on regulated environmental sites is provided in **Section 3.4.6**.

(d) *A well abandonment and well destruction program.* Well abandonment and destruction programs are implemented by Kern County in cooperation with both KCWA and local water districts, as summarized in **Section 2.6.4**.

(e) *Replenishment of groundwater extractions.* Significant replenishment and managed aquifer recharge projects are conducted on an ongoing basis throughout the KRGSA as summarized in **Section 2.5.2** above.

(f) *Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage*. Conjunctive use and managed aquifer recharge are active groundwater management strategies being implemented by numerous agencies in the Subbasin as summarized in **Section 2.5.2.** above.

(g) *Well construction policies*. The well permitting program is conducted by Kern County in cooperation with local agencies. Kern County Ordinance Code, Chapter 14 ensures proper well design and construction (see **Section 2.6.4.**).

(h) *Measures addressing groundwater contamination cleanup, groundwater recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and extraction projects*. Local agencies in the Plan Area cooperate with state and county regulators on contaminated sites; more information is provided in **Section 3.4.6**. Groundwater recharge, in-lieu, and other managed aquifer recharge programs are summarized in **Section 2.5.2** and discussed throughout this GSP. Water recycling is discussed in **Section 2.4.4** and summarized on **Table 2-1**. Intentional recharge along unlined canals illustrates the use of conveyance for groundwater replenishment.

(i) *Efficient water management practices, as defined in Section 10902, for the delivery of water and water conservation methods to improve the efficiency of water use*. Efficient water practices are provided in the UWMPs and AWMPs of the Plan Area local agencies.

(j) *Efforts to develop relationships with state and federal regulatory agencies*. Such relationships are implicit in many local efforts. These include, for example, the cooperation of local agencies with state and federal agencies on contamination sites, local efforts toward SGMA compliance in cooperation with DWR and the State Water Resources Control Board (SWRCB), cooperation with USEPA and USACE on the Kern River and wetlands with respect to the federal Clean Water Act, and cooperation with US Fish & Wildlife Service and CDFW (among others) on environmental issues and endangered species.

(k) *Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity.* As the sole municipality in the Plan Area, the City of Bakersfield coordinates land use planning and groundwater quantity and quality. The City is actively involved in groundwater protection and replenishment as summarized in **Section 2.5.2** and on **Tables 2-4** and **2-5**, which describe numerous land use planning activities for the protection of groundwater including management of municipal wastewater and implementation of an industrial waste discharge program.

(l) *Impacts on groundwater dependent ecosystems (GDEs).* Groundwater elevation data collected as part of the groundwater level monitoring programs described in **Section 2.5.1** will be enhanced and used to analyze the interconnectedness of surface water and groundwater and potential impacts on groundwater dependent ecosystems (GDEs). These data will supplement other analyses in the GSP for interconnected surface water and GDE impacts.

2.7 NOTICE AND COMMUNICATION

The importance of groundwater and banked and recharged surface water as sources of supply for water purveyors, landowners, residents, business owners, disadvantaged communities, small water systems and multiple other stakeholders is well-documented throughout this GSP. Recognizing the need to communicate and engage with these and other stakeholders for GSP development and implementation, KRGSA developed a Communication and Engagement Plan to support the GSP process. This plan serves as a living document to guide how the KRGSA engages with the community and stakeholders and provides a basis to receive input from the community regarding the GSP. The KRGSA Communication and Engagement Plan is included in the GSP as **Appendix F**.

The Communication and Engagement Plan in **Appendix F** provides an overview of stakeholder outreach via the KRGSA website, regular and special KRGSA Board meetings, public meetings and technical workshops, general outreach and audience mapping, and targeted meetings with interested parties. Activities that the KRGSA has undertaken to date in each of these categories are summarized in the attachments to the Communication and Engagement Plan (**Appendix F**). These activities inform stakeholders and the public about the GSP development and implementation process and encourage active involvement by interested parties.

Outreach has focused on landowners reliant on groundwater for their agricultural business and livelihood; businesses and industries essential to the economic vitality of Metropolitan Bakersfield; and members of the public who depend on a safe and reliable water supply. An Interested Party list has expanded outreach to state agencies, including the California Department of Fish and Wildlife (CDWF) and other interests in potential environmental users of groundwater. In particular, focused outreach has involved the disadvantaged communities (DACs) within the KRGSA service are; the KRGSA recognizes that these communities are dependent on groundwater yet may have limited means to address issues relating to groundwater quality and supply. The distribution of DACs in the KRGSA Plan Area by census place, tract and block is shown on **Figure 2-16**.

Specifically, the Communication and Engagement Plan identifies a series of meetings that were held during the GSP development process to inform and seek input from DACs within the KRGSA service area (**Appendix F, Section 3**). These interactive workshops were arranged with the assistance of Self Help Enterprises (SHE), a nonprofit organization that specializes in communicating with DACs about water quality and reliability issues. SHE identifies target communities, coordinates publicity, provides bilingual informational materials, and makes Spanish-speaking translators available at the meetings. In addition, the organization has specific expertise with SGMA.

Two DAC meetings were conducted during the early stages of GSP development to gather input and suggestions regarding any issues or concerns that could be addressed in the plan. Two additional community workshops were held with DACs during the Draft GSP review period to provide an opportunity for feedback from under-represented communities. In addition, two separate Grower Outreach Meetings were held at KDWD, which also included attendees from the DACs, to review specific KRGSA GSP actions that would directly impact local stakeholders. Those meetings provided the opportunity for discussion and feedback from stakeholders/homeowners who rely on shared domestic wells. As indicated in the materials provided in the Communication and Engagement Plan in **Appendix F**, these various outreach meetings have been well attended and attendees have been actively engaged in discussing issues related to SGMA and groundwater use in the Subbasin.

The KRGSA has also been actively coordinating with all GSAs in the Subbasin throughout the GSP development process. Members of the KRGSA participate in weekly Subbasin-wide Managers Meetings organized by the KGA. KRGSA Board members are also members of the Subbasin Policy Subcommittee. These Subbasin activities have produced a common Sustainability Goal for the Subbasin, a coordinated technical approach for development of a Subbasin-wide numerical model for GSP analyses, consistent sustainable management criteria (including definitions of undesirable results for the Subbasin) and coordinated monitoring efforts to support implementation of the Subbasin GSPs.

Collectively, these outreach activities have resulted in active and ongoing discussions and engagement on GSP issues with interested parties and stakeholders throughout the Subbasin. In addition to verbal comments addressed directly during local outreach meetings, a series of written comments were received late in the public review period and addressed in the Public Hearing on December 5, 2019 prior to GSP adoption. Specifically, written comments were received from the following entities[10]:

- Leadership Counsel of Justice & Accountability (Leadership Counsel)
- California Department of Fish and Wildlife (CDFW)
- City of Los Angeles

A more complete list of all written comments received regarding the KRGSA GSP, along with a summary of responses, is provided in **Attachment F.6 of Appendix F**. Responses are also summarized below.

Comments were addressed directly during a Public Hearing held by the KRGSA Board of Directors on December 5, 2019. Regarding the City of Los Angeles comments, amounts and availability of recycled water were edited in the Draft GSP as requested in the comment letter. Clarifying sentences and information on interconnected surface water and groundwater dependent ecosystems (GDEs) were added to the Draft GSP in response to the comments by CDFW. Comments provided by the Leadership Counsel involved a series of technical comments, which were analyzed and addressed directly in the Public Hearing presentation (see **Attachment F.6 of Appendix F**). Both the Leadership Counsel and technical experts attended the Public Hearing where detailed explanations were provided regarding their concerns and how those concerns had been addressed in the GSP. Representatives of the Leadership Counsel were invited to provide additional comments during the Public Hearing; only one clarifying question was asked, and it was addressed through a specific revision to the Draft GSP as summarized below and discussed in **Section 5.4.4.2.** In brief, the KRGSA changed the Draft GSP sustainable management criteria in the eastern Agricultural MA to address a concern from small water suppliers in the DACs (see also **Attachment F.6 of Appendix F**).

In summary, outreach and coordination meetings have provided notice and communication to stakeholders throughout the entire GSP process. During GSP development, outreach efforts were focused on contacting as many of the stakeholder groups, interested parties, and potentially affected community groups and individuals as possible. These efforts have provided the public with information about SGMA, the purpose and contents of the KRGSA GSP, and opportunities for input. After preparing the Draft GSP, meetings were held to discuss the Plan; comments were addressed, and revisions were made to the Draft GSP in response to stakeholder input. Now that the GSP has been revised and adopted, KRGSA will continue to seek input and provide updates on the status of groundwater monitoring and groundwater quality at Board meetings, in website postings, and by other means as appropriate. The KRGSA looks forward to a continuing dialog with interested parties and stakeholders as the GSP implementation moves forward.

[10] Comments were also received in October via email from Chevron NA and were addressed to the satisfaction of both Chevron NA and the KRGSA through direct edits to the Draft GSP.

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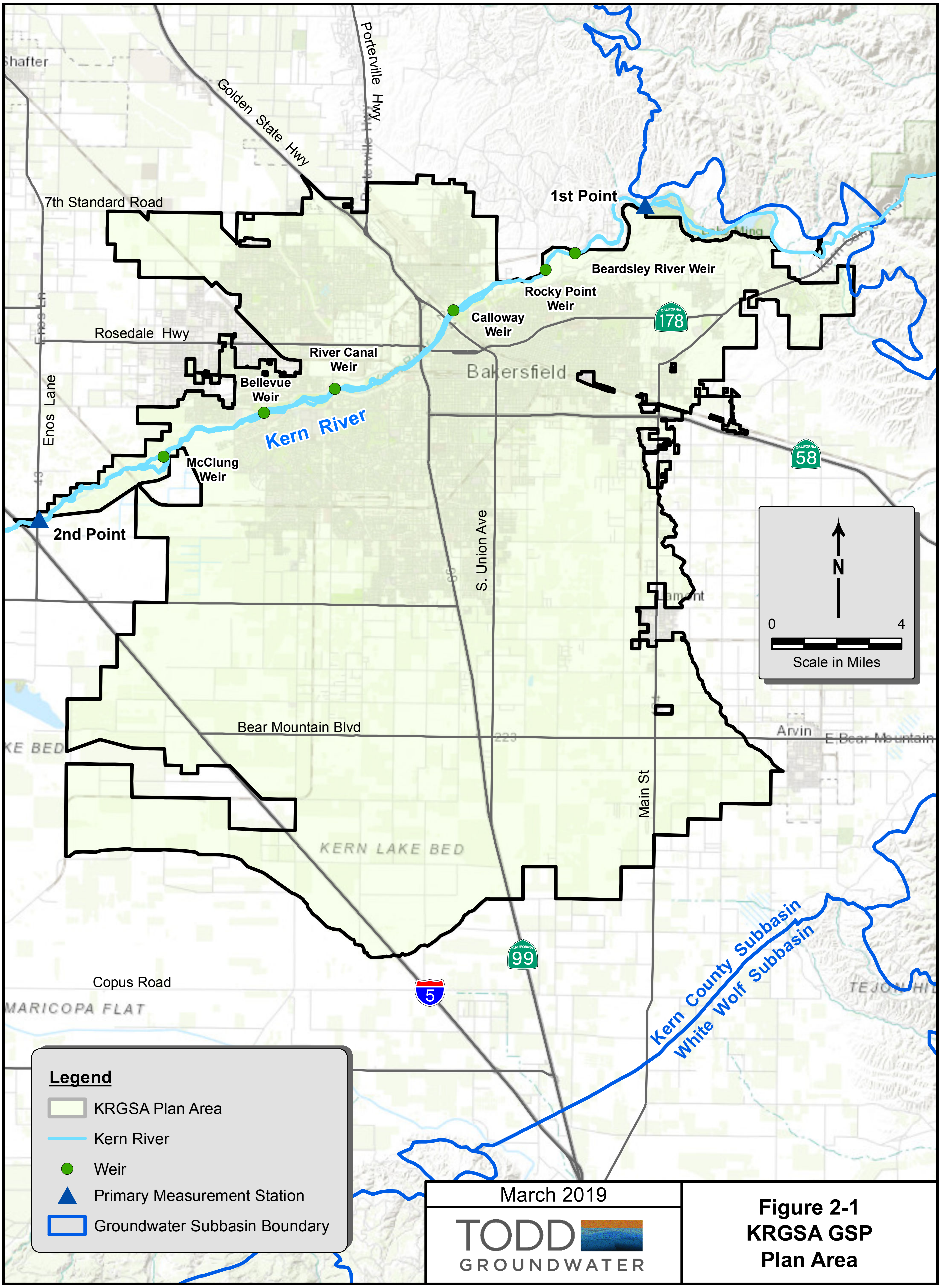
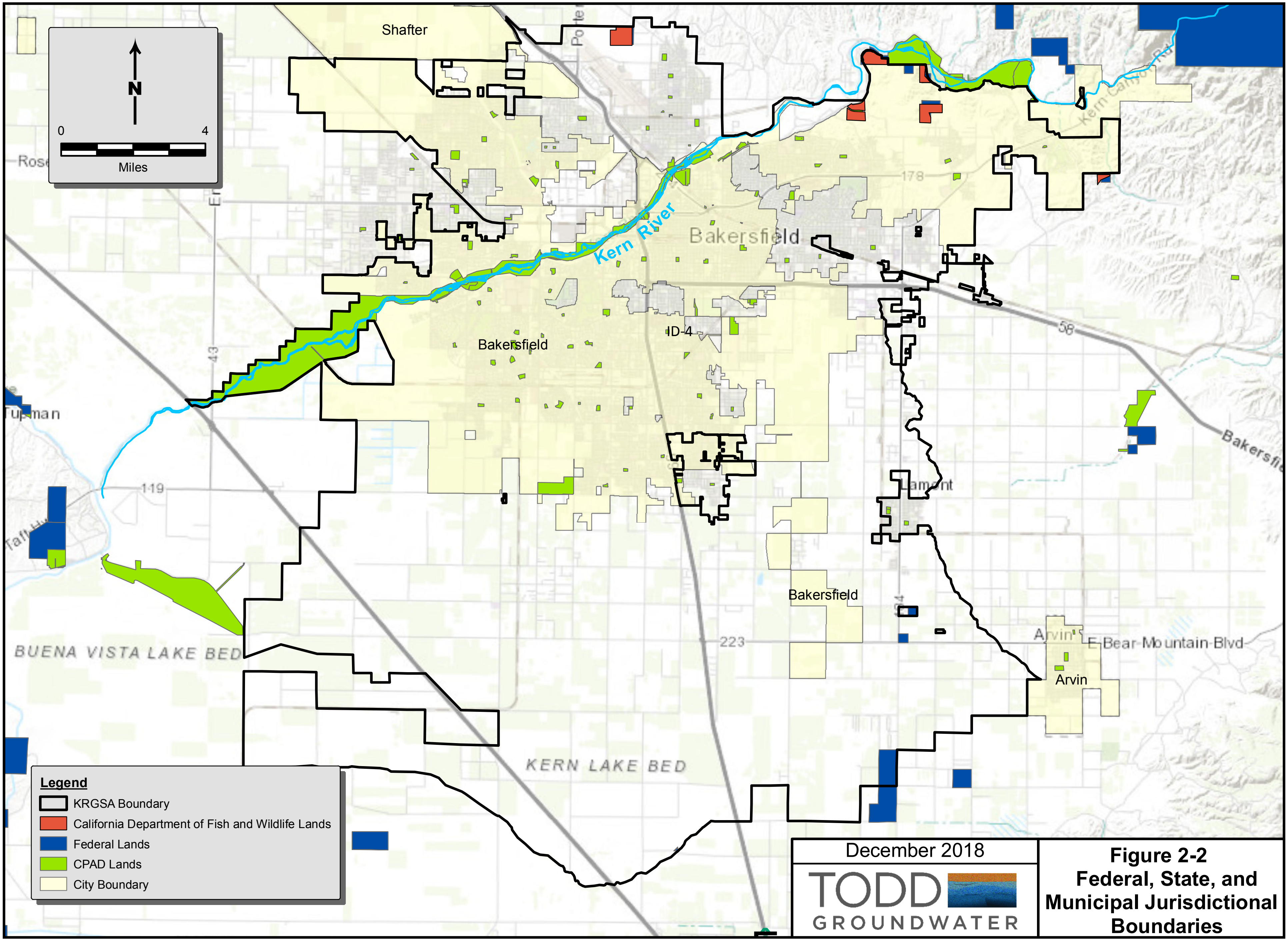


Figure 2-1
KRGSA GSP
Plan Area



December 2018

TODD GROUNDWATER

Figure 2-2
Federal, State, and Municipal Jurisdictional Boundaries

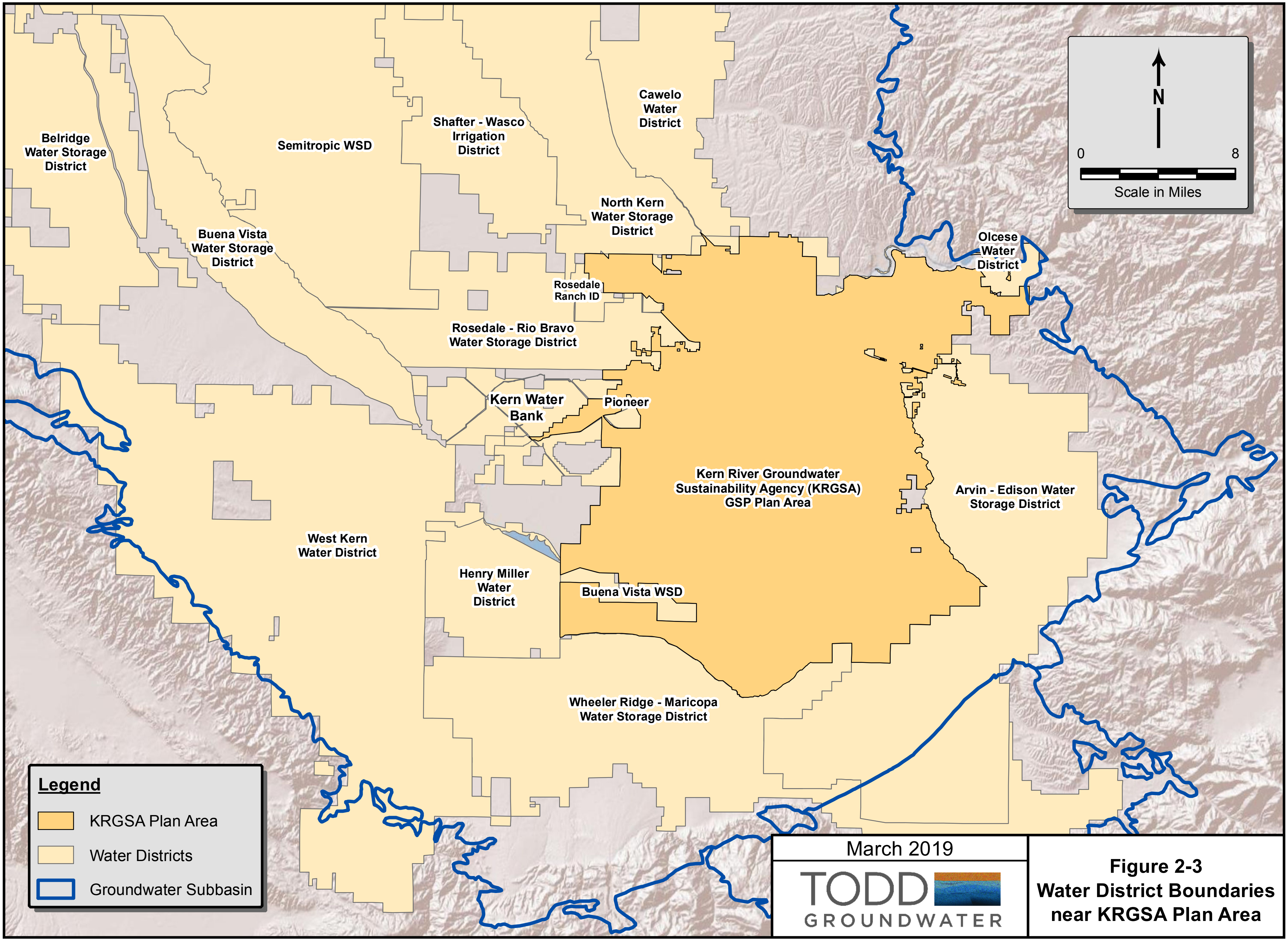


Figure 2-3
Water District Boundaries near KRGSA Plan Area

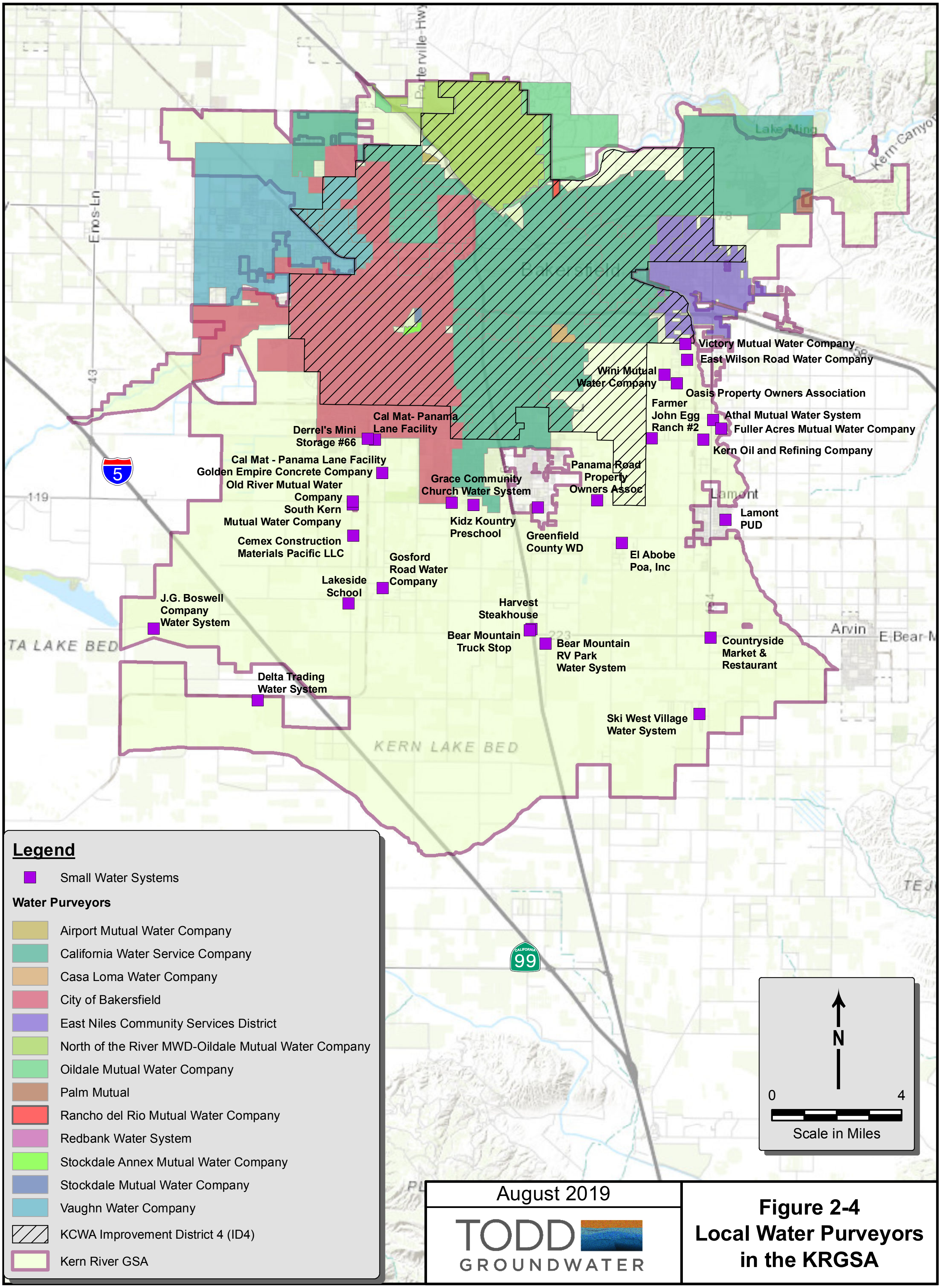


Figure 2-4
Local Water Purveyors in the KRGSA

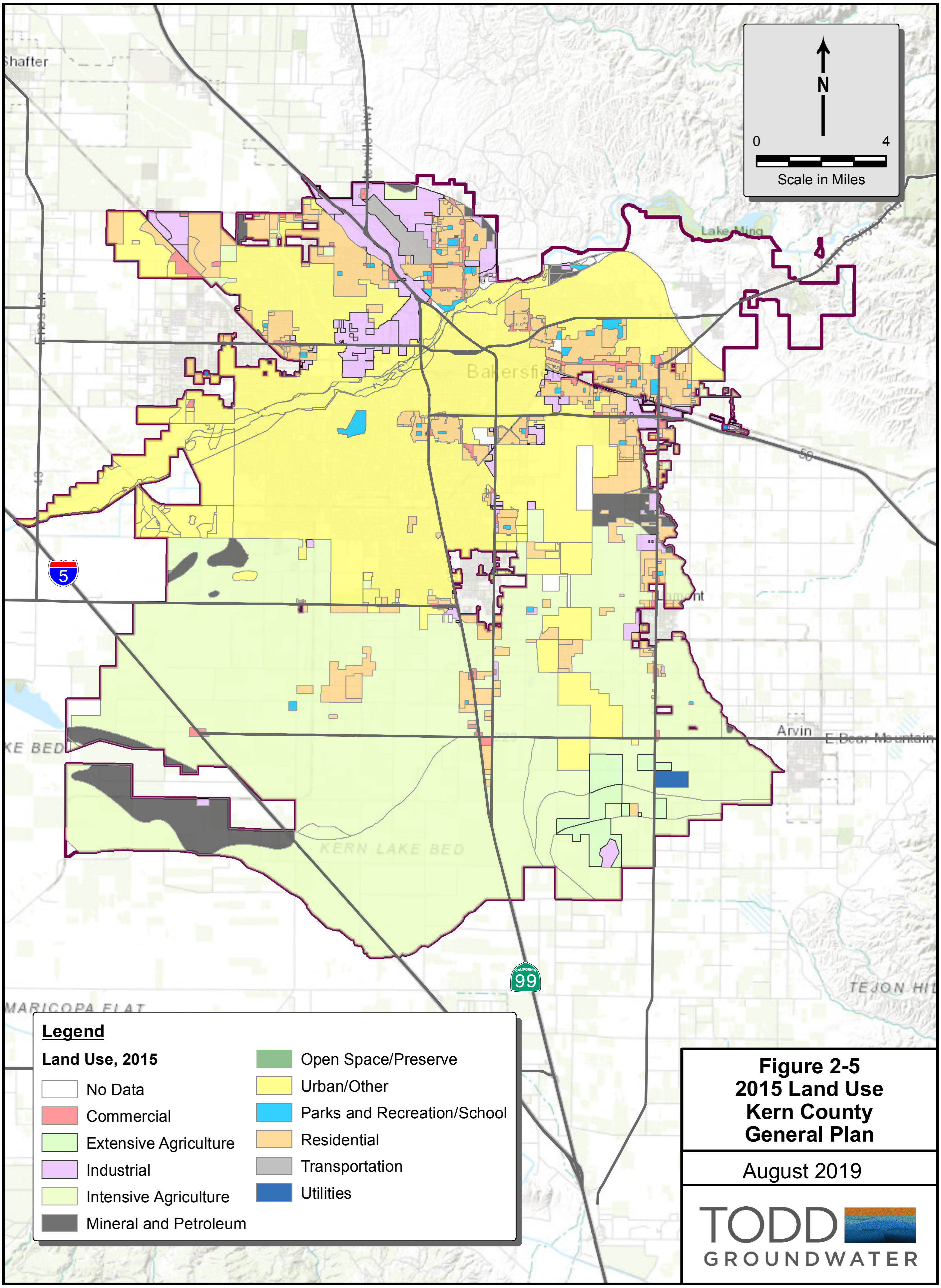
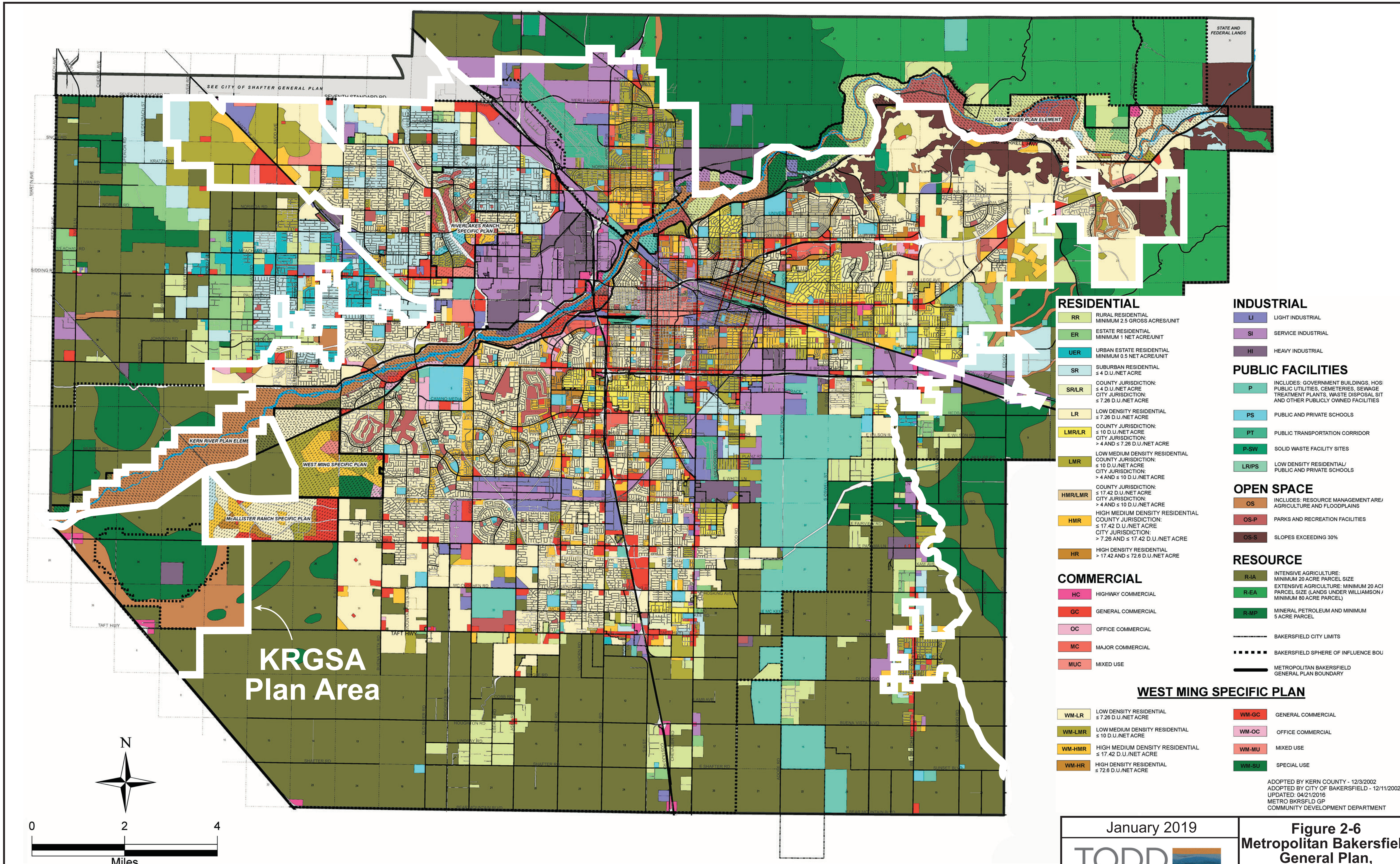


Figure 2-5
2015 Land Use
Kern County
General Plan

August 2019



January 2019

TODD GROUNDWATER

Figure 2-6
Metropolitan Bakersfield General Plan, City of Bakersfield and Kern County

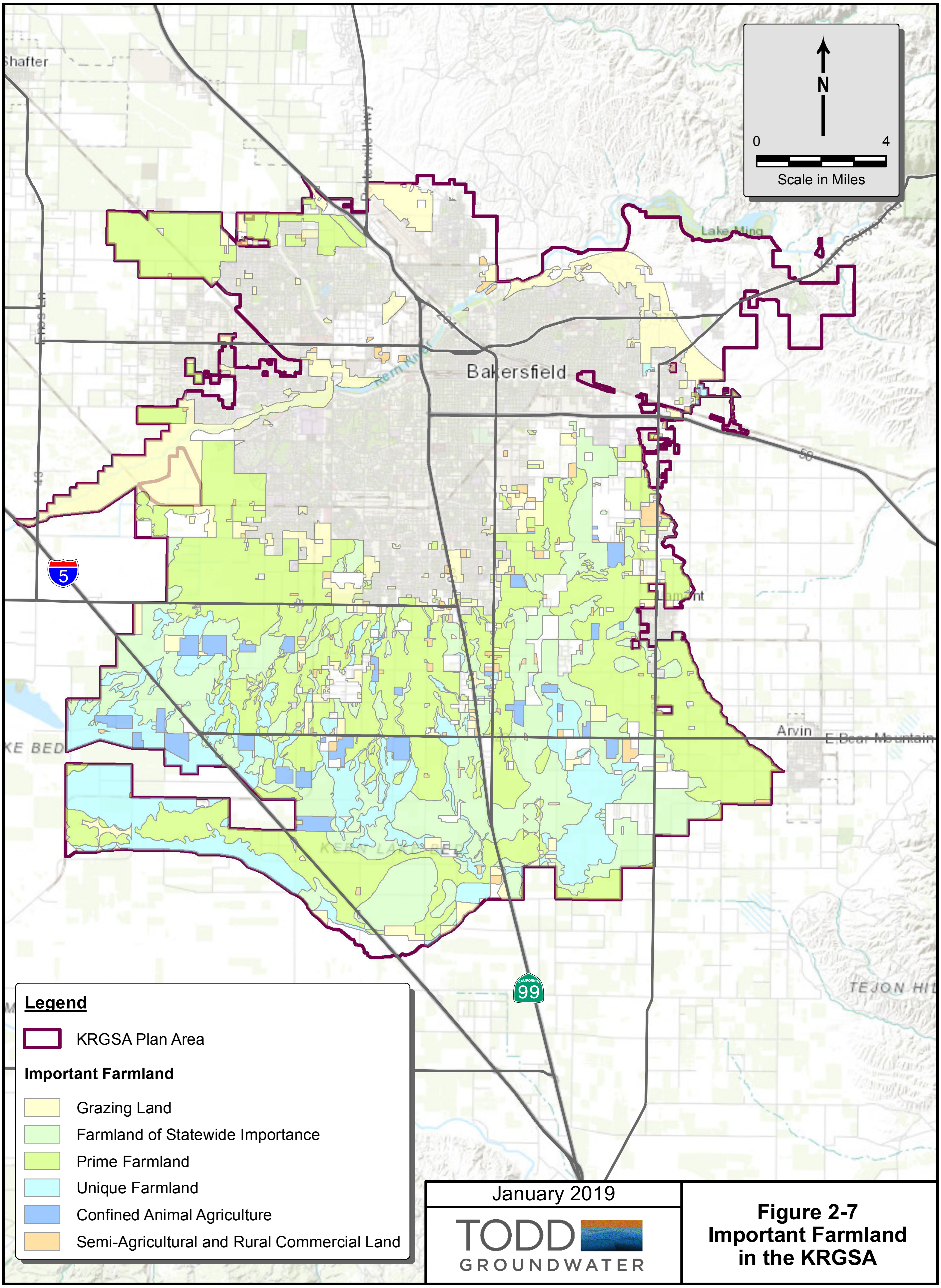
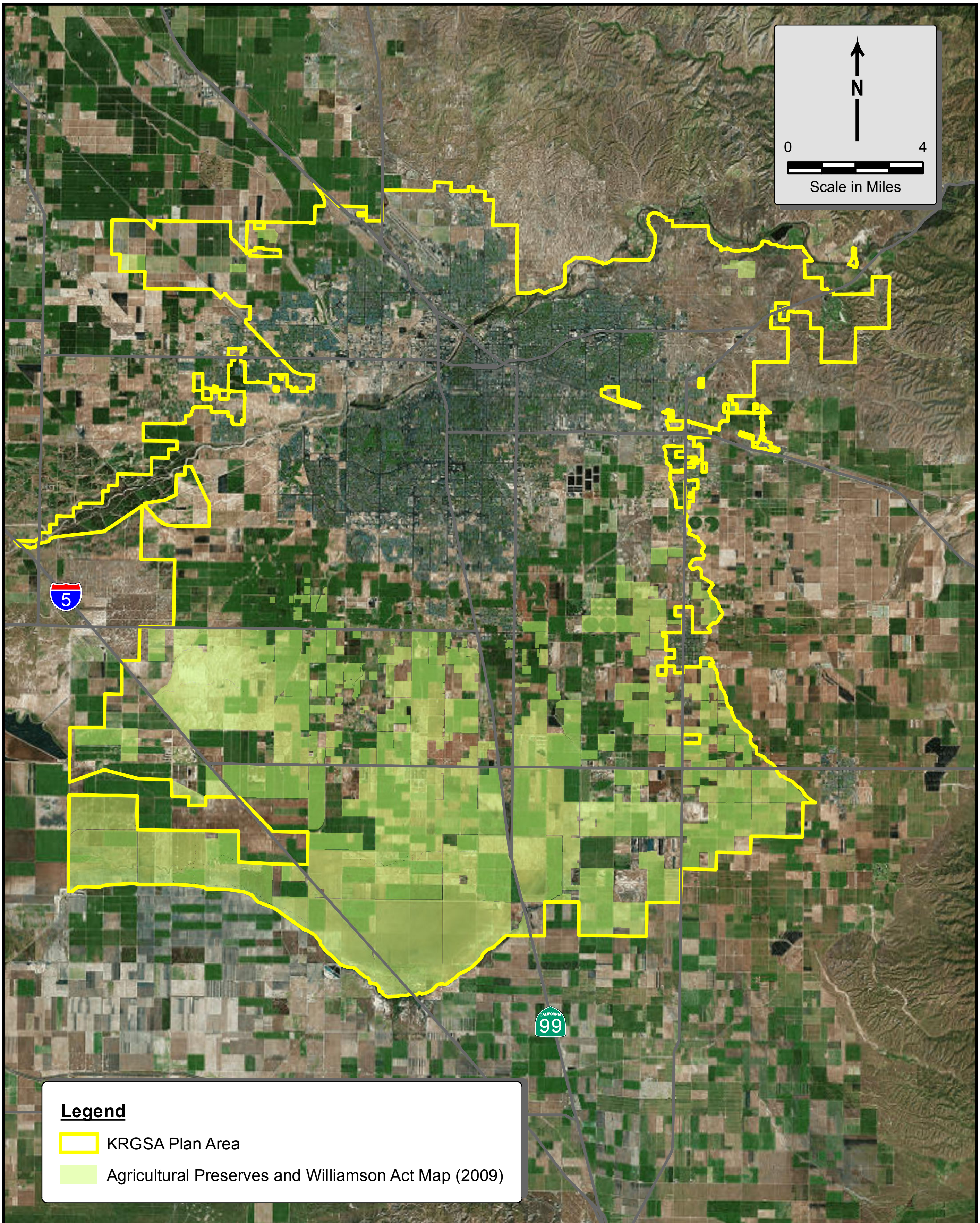


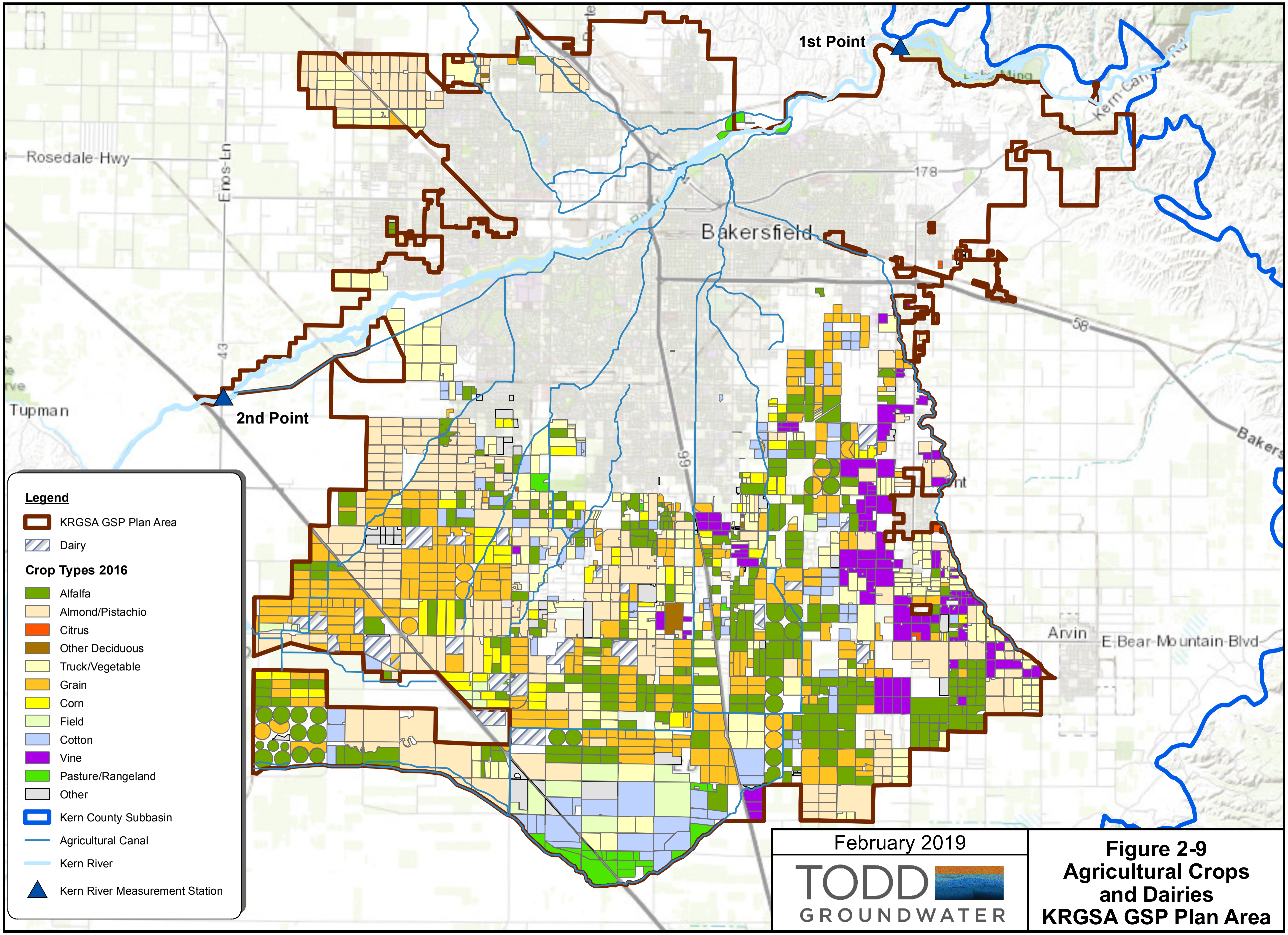
Figure 2-7
Important Farmland in the KRGSA



January 2019

TODD GROUNDWATER

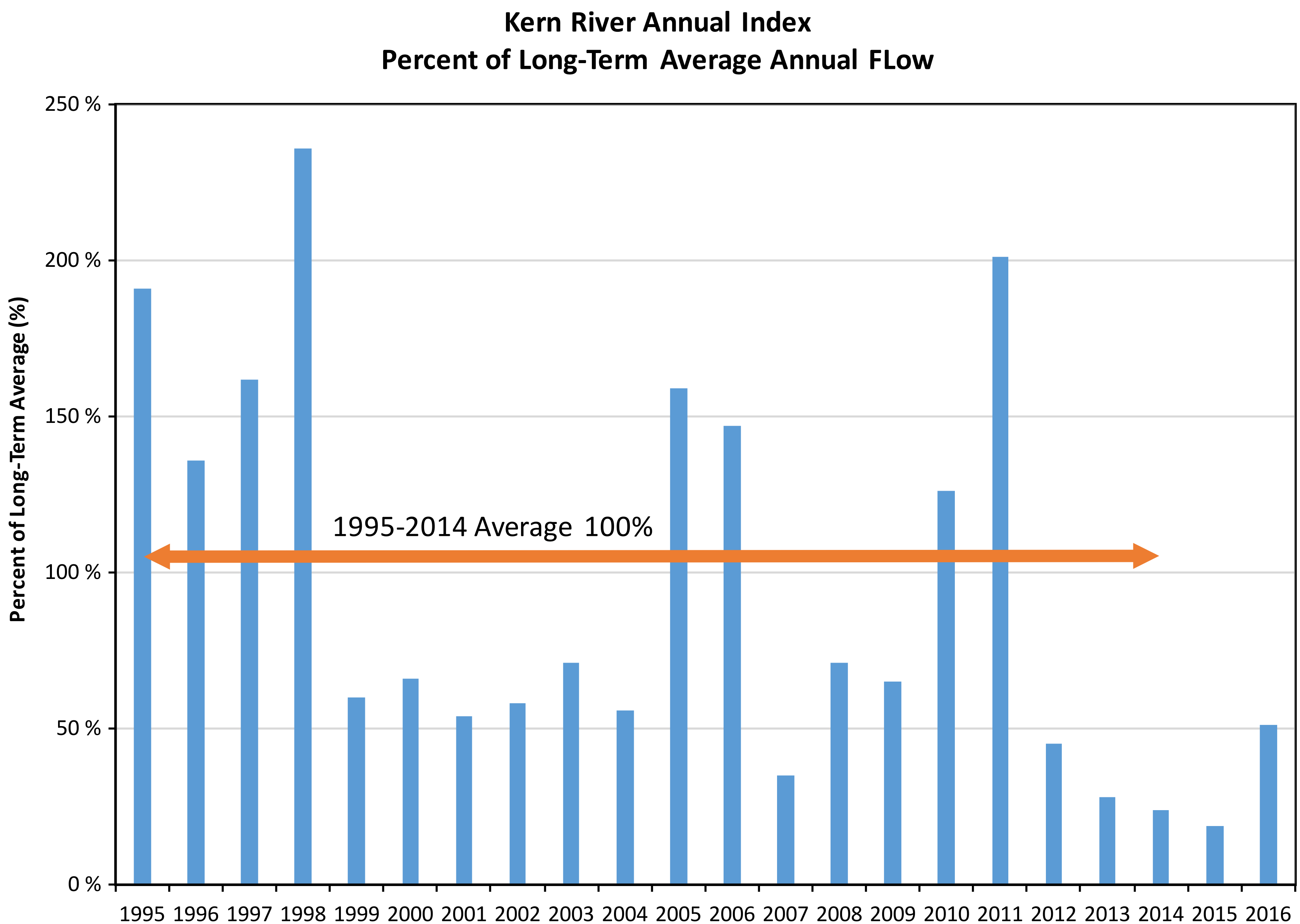
Figure 2-8
Agricultural Preserves
Williamson Act Map
KRGSA Plan Area



February 2019

TODD GROUNDWATER

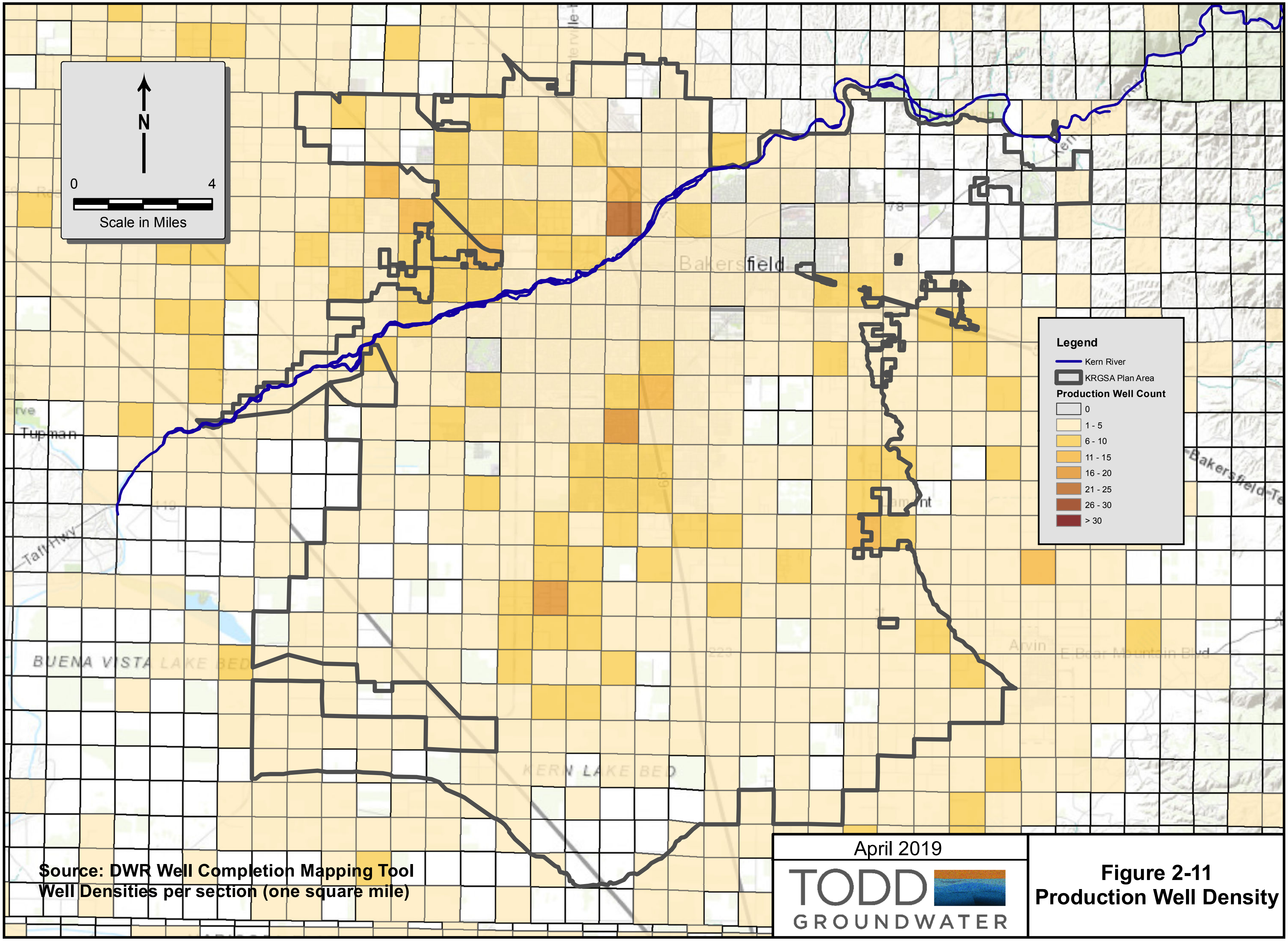
Figure 2-9
Agricultural Crops and Dairies
KRGSA GSP Plan Area



February 2019

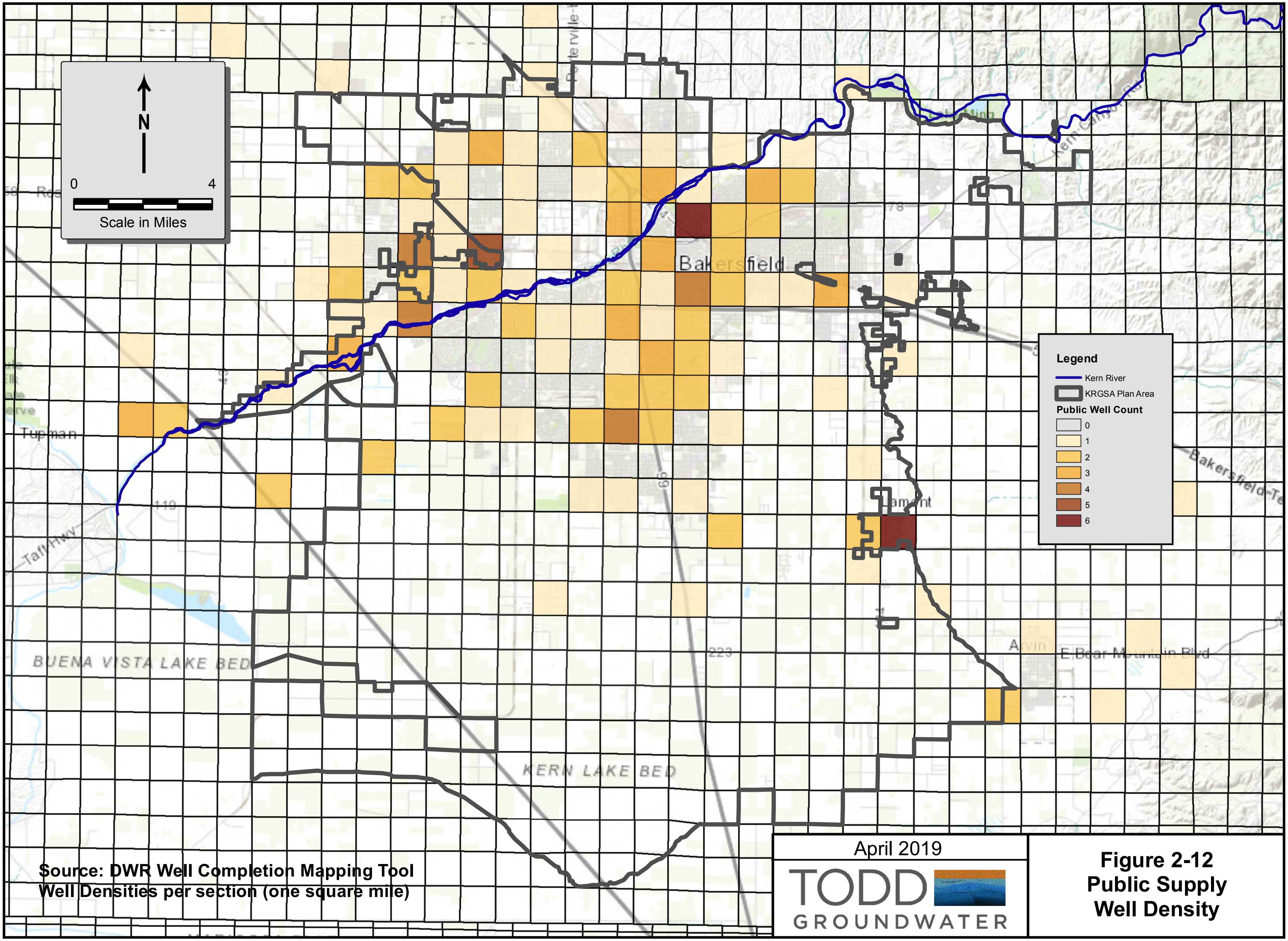
TODD GROUNDWATER

Figure 2-10
Kern River Annual Indices 1995 - 2016



Source: DWR Well Completion Mapping Tool
Well Densities per section (one square mile)

Figure 2-11
Production Well Density



Source: DWR Well Completion Mapping Tool
Well Densities per section (one square mile)

April 2019

TODD GROUNDWATER

Figure 2-12
Public Supply Well Density

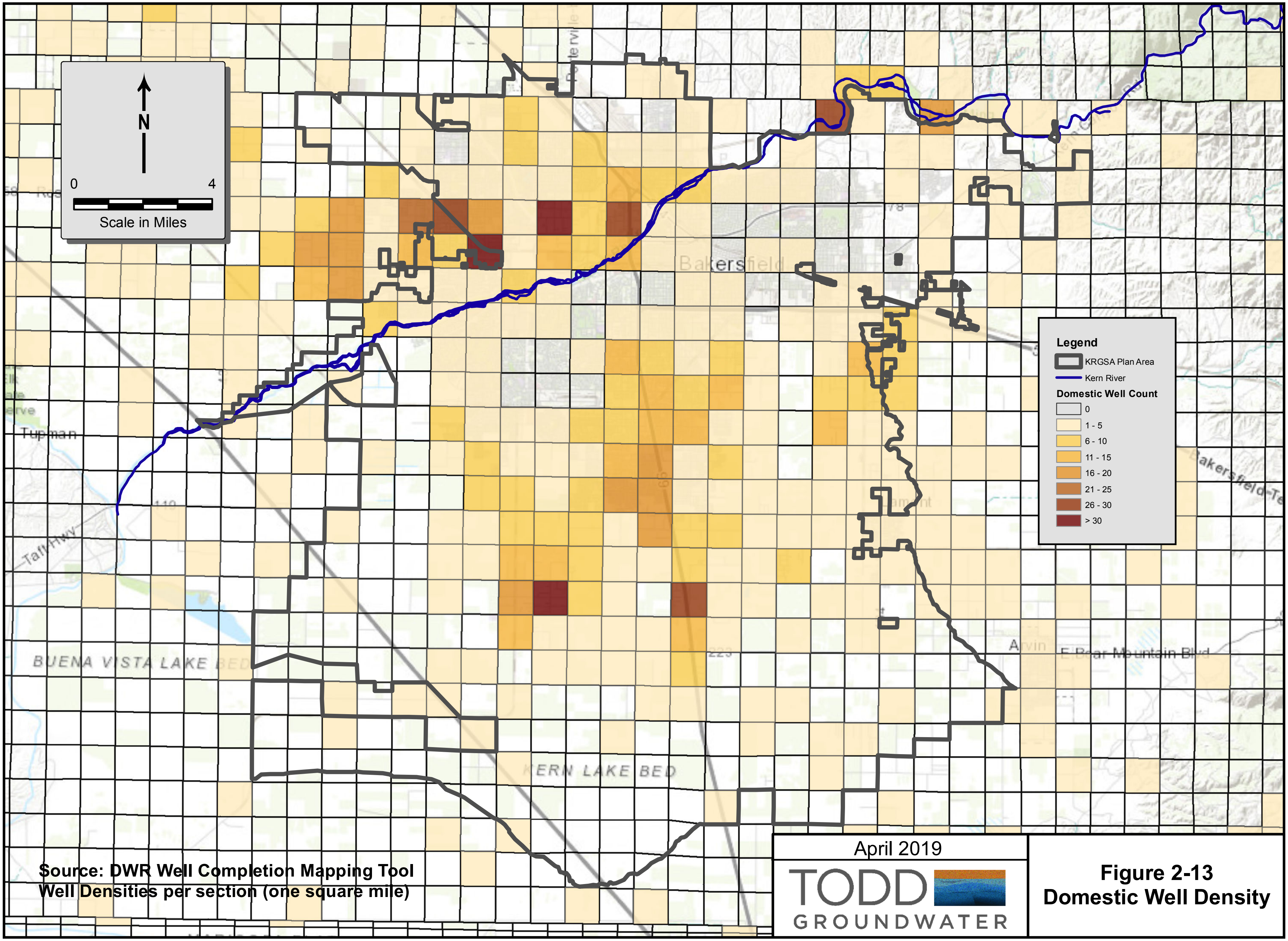
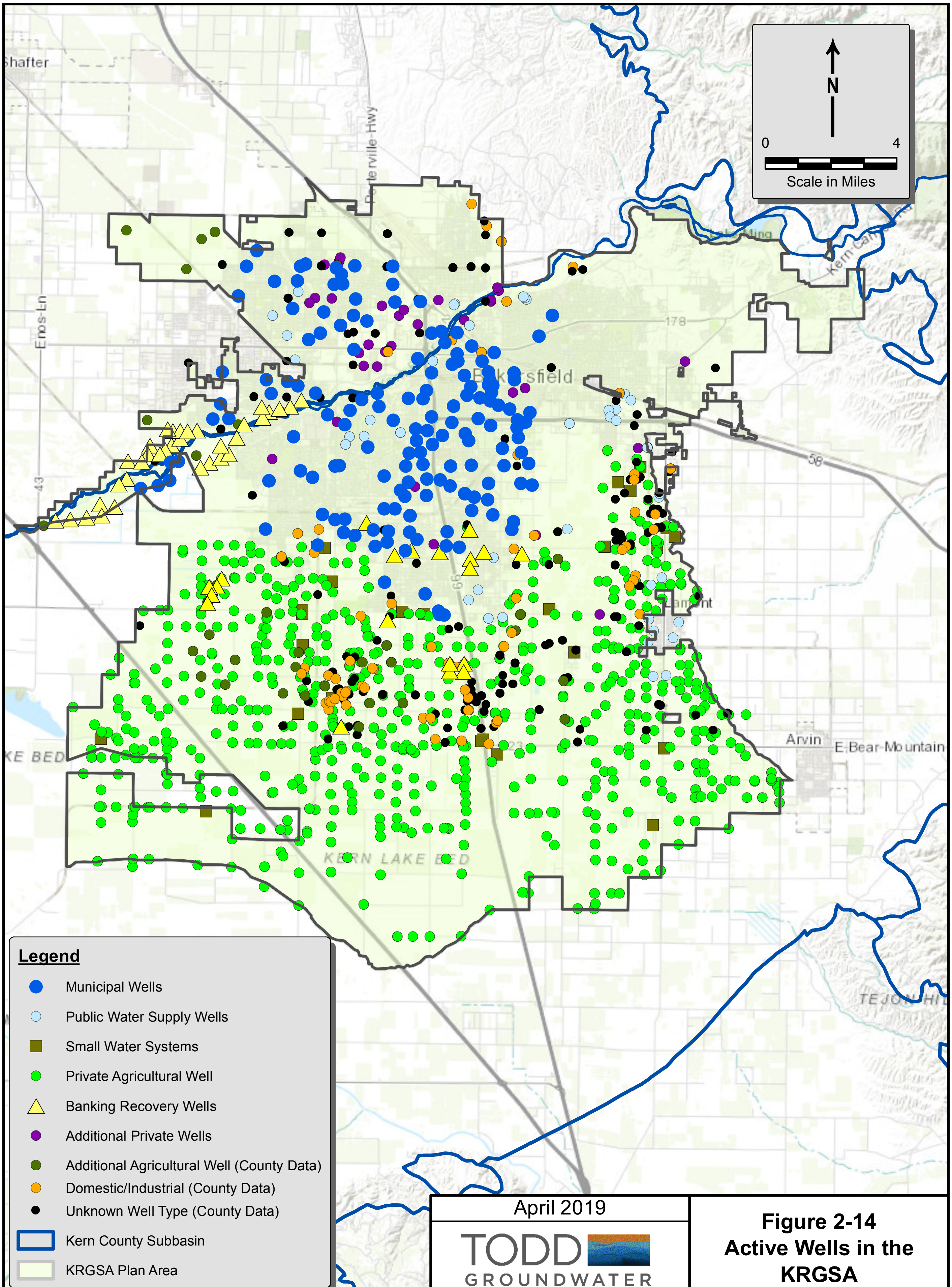


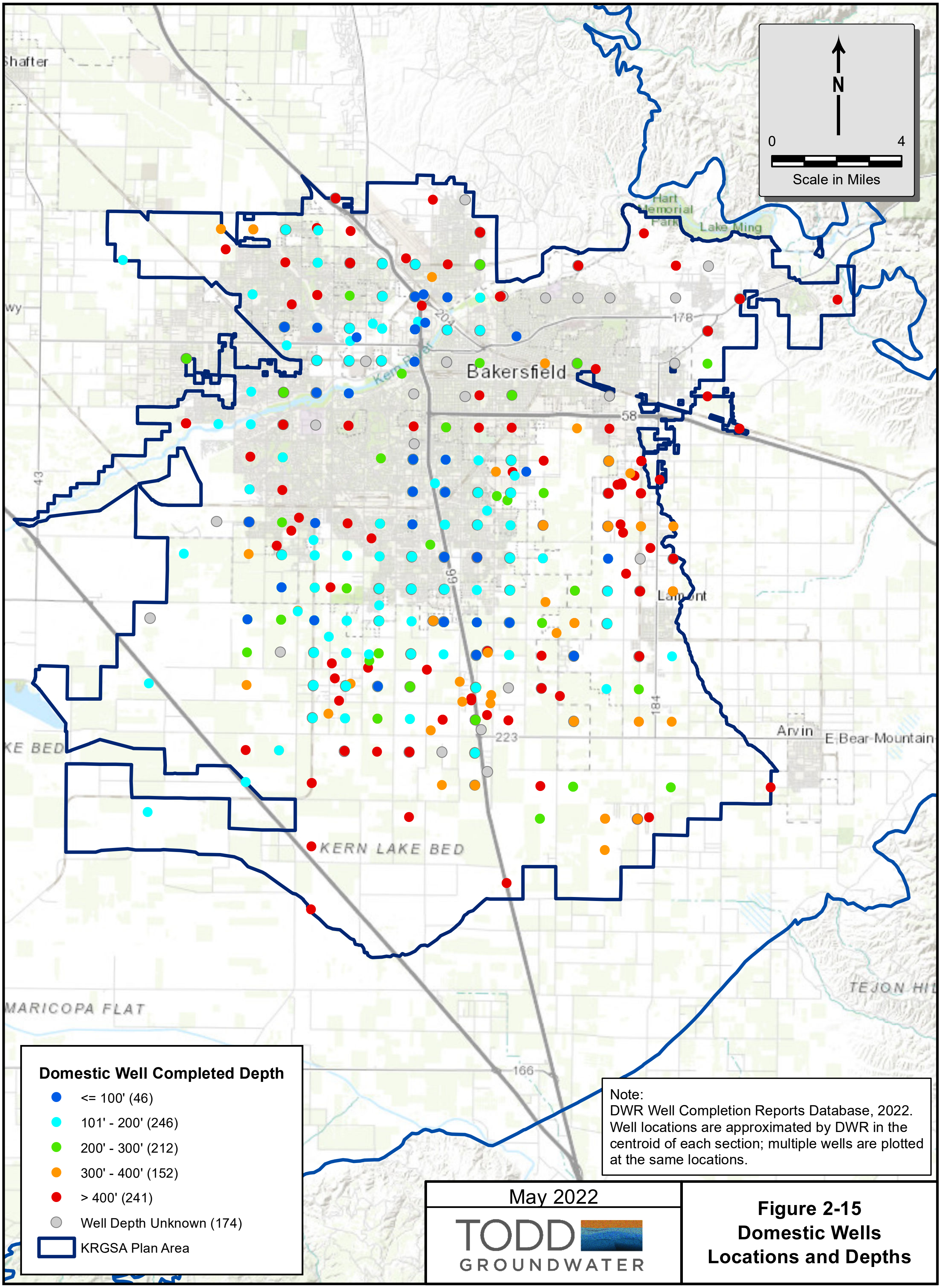
Figure 2-13
Domestic Well Density



April 2019

TODD GROUNDWATER

Figure 2-14
Active Wells in the KRGSA



May 2022

TODD GROUNDWATER

Figure 2-15
Domestic Wells
Locations and Depths

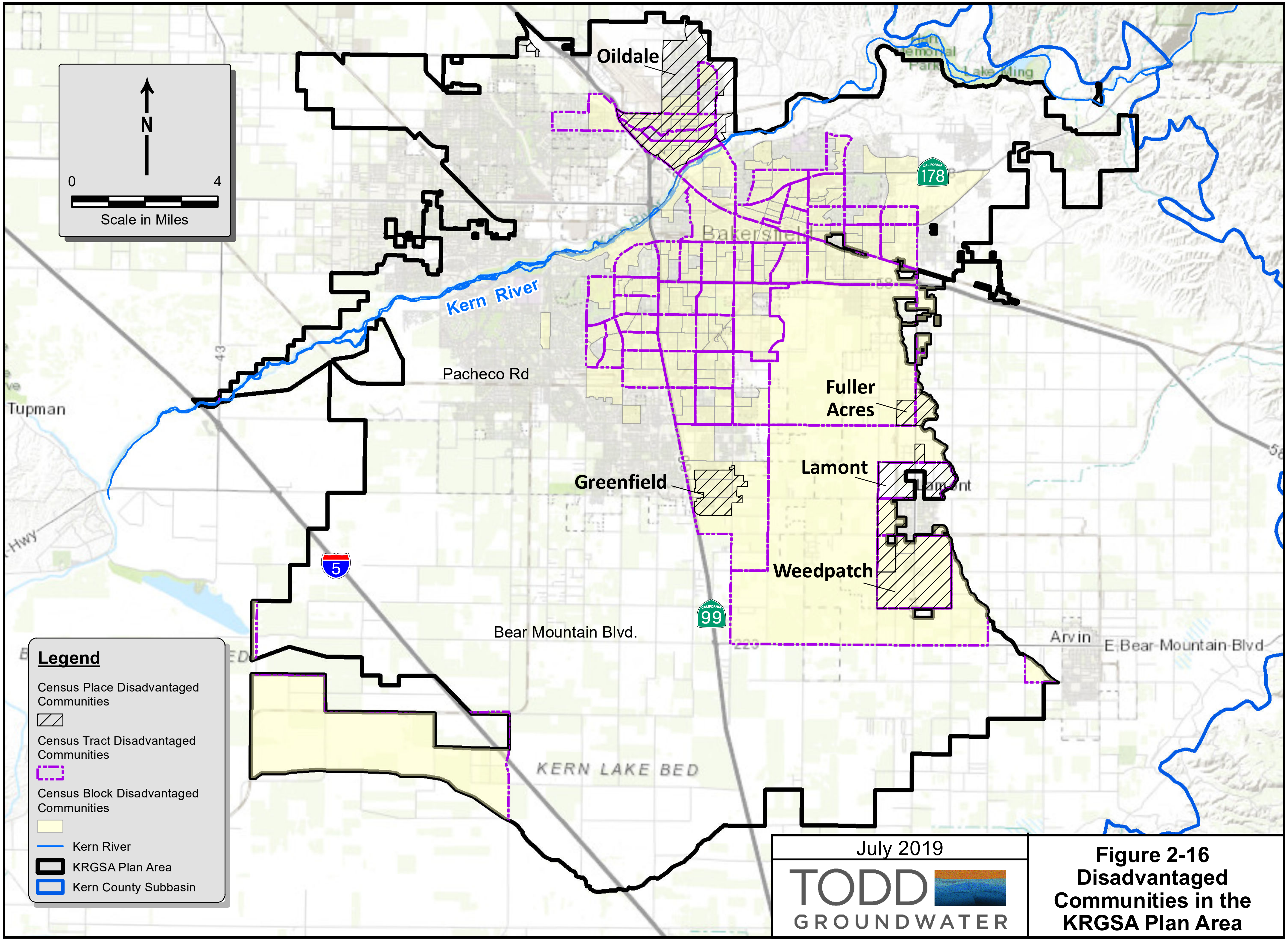


Figure 2-16 Disadvantaged Communities in the KRGSA Plan Area

3 HYDROGEOLOGIC CONCEPTUAL MODEL AND GROUNDWATER CONDITIONS

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

1. **Hydrogeologic Conceptual Model**, which describes the physical conditions of the groundwater basin including: its regional geologic and structural setting; topography and soils; surface hydrology and related surface features and infrastructure; basin geometry including lateral sides and bottom; and the aquifers and aquitards that control groundwater recharge, storage, and movement.
2. **Groundwater Conditions,** which provides an understanding of groundwater[11] occurrence and flow, groundwater levels, including trends and fluctuations, groundwater quantity and quality, and interconnected surface water, if any.
3. **Water Budgets**, which provides an accounting of inflows and outflows of the groundwater system including an analysis of historical and current conditions. The water budget analysis also provides a baseline on which to project the water budget analysis into the future using projected water supplies and reasonable estimates of land use and water demand. Projected future water budgets are analyzed with various management actions and projects – as described in **Section 7** of this GSP – to determine how best to achieve and maintain sustainability goals for the future.

The first two analyses are provided in **Section 3**; historical, current, and projected water budgets (including future baseline analyses with climate change factors) are provided in **Section 4**.

Each of these Basin Setting analyses is being coordinated among the various GSPs being prepared in the Subbasin. For example, the KGA is providing a regional analysis of the hydrogeologic conceptual model and groundwater conditions as part of a large coordinated GSP covering about 70 percent of the Subbasin. Individual agencies participating in the KGA GSP are providing more detailed information on these analyses in their local service areas. In addition, water budgets are being developed for the entire Subbasin using a locally-modified surface water/groundwater numerical model based on the DWR regional model C2VSim. The local C2VSim, referred to herein as C2VSimFG-Kern, has been revised with agency-specific water budget data provided by the KRGSA and other GSAs in the Subbasin.

The KRGSA is coordinating with these regional efforts and does not intend for this GSP to duplicate, contradict, or replace detailed regional information being developed by others; however, some of the

[11] Recognizing the extensive conjunctive use and managed aquifer recharge activities in the KRGSA Plan Area, groundwater necessarily includes banked surface water supplies, which are tracked separately by the water managers.

Subbasin regional information is described herein to provide context for the local KRGSA GSP Plan Area analyses.

3.1 STUDY PERIODS

Various study periods are being employed in the KRGSA GSP depending on the requirements of specific analyses and available data. GSP regulations indicate a need to identify an average hydrologic Study Period for purposes of the groundwater analyses in a critically over-drafted basin and for the basin-wide water budgets (§354.16(b); §354.18(5)). In order to coordinate on both local and Subbasin-wide analyses, the KRGSA, KGA, and others have selected an average hydrologic Study Period covering a recent 20-year period from WY 1995 through WY 2014.

The coordination is consistent with GSP regulation requirements which generally require all GSAs in a subbasin to use the "same data and methodologies" for development of multiple GSPs (§357.4(a)). In particular, GSP regulations require that the water budgets be coordinated for the entire subbasin (§357.4(b)(3)(B)). It was also acknowledged that the use of this study period does not preclude any of the KRGSA GSP analyses – or analyses done by others – from incorporating data from a different time period when available and necessary for the GSP development.

The historical average hydrologic Study Period of WY 1994 through WY 2014 covers 20 years on a water year basis, from October 1, 1994 through September 30, 2014. The selection of the study period was based on a variety of technical criteria:

- 100 percent of the long-term average streamflow conditions on the Kern River (as indicated by an average annual Kern River Index of 100 percent – see **Figure 2-10**)
- 102 percent of long-term average precipitation (NOAA Bakersfield Meadows Field Airport Station)
- Makes best use of METRIC analysis of monthly evapotranspiration (ET) data, which was available for all but one year of the entire study period
- Sufficiently short time period associated with other widely-available, higher-quality data
- Inclusion of recent time periods to capture ongoing water management practices and more recent land use patterns
- Covers at least 10 years consistent with GSP regulations (§354.18(c)(2)(B))
- Contains 10 years characterized as above normal or wet years based on precipitation; also contains 10 years of below normal or dry years, including 4 critically-dry years (see **Section 3.2.4.1** Climate)
- Begins in a time of relatively stable water levels (October 1994)
- Overlaps time period with consistently-developed basin-wide contour maps by KCWA.

The recent water year (WY 2015 and, as applicable, WY 2016) is used for current conditions throughout this GSP. This Study Period was proposed in 2016 when GSPs were first being initiated in the Subbasin; accordingly, WY 2016 data were not yet widely available. In addition, WY 2016 is not included in the

Beta version of the C2VSim model, which represented the best available data when the model was released by DWR in Spring 2018. Collectively, the entire historical and current study periods are also the most recent 21 years of the C2VSim model; this allows coordination and calibration of the model to the most recent land use and management conditions available so that the model will be more accurate for application to projected future water budgets.

It is recognized that this Study Period ends in the drought of record at a time when then-current water levels were at or near historic lows (and continued to decline as drought conditions persisted in 2015 and 2016). Ending a study period in drought will almost always result in a decline of groundwater in storage on a cumulative basis from the beginning to the end of the Study Period. However, the cumulative decline alone does not necessarily indicate overdraft conditions. Even though the overall period represents average hydrologic conditions, resulting changes in groundwater in storage from the beginning to the end can be either positive or negative depending on the order of the dry and wet years in the period. Although cumulative changes in storage are included in the analysis, the sustainability analysis also focuses on average annual changes in storage.

More recent data were also compiled to ensure that analyses considered the drought conditions of 2015-2016. The analyses were conducted over several years, with much of the work being conducted in 2018 or earlier. Accordingly, most analyses cover either the 20-year Study Period or extend into more recent years through 2017.

3.2 HYDROGEOLOGIC CONCEPTUAL MODEL

The KRGSA is located near the eastern and southern margins of the southern San Joaquin Valley and in the south-southeast portion of the Kern County Subbasin. The groundwater basin beneath the KRGSA Plan Area consists of unconsolidated to consolidated alluvial sediments deposited in the Upper Miocene through Holocene epochs. Most of the groundwater supply in the Plan Area occurs in the unconsolidated alluvium and underlying semi-consolidated Kern River Formation[12], which crops out in the northern and northeastern Plan Area. These aquifers were deposited in fluvial and alluvial fan environments associated with the Kern River and other ancestral drainageways (Robbins, 2014). Lower portions of the Kern River Formation produce oil in the Kern River oilfield north of the Kern River. The regional geologic and structural setting, along with a more complete description of the hydrogeologic conceptual model, is provided in the following sections.

3.2.1 Regional Geologic and Structural Setting

The Kern County Subbasin consists of the upper portion of a deep structural trough between the crystalline rocks of the Sierra Nevada and the basement rocks of the Coast Ranges. The deeper portions

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[12] Lower portions of the Kern River Formation produce oil in the Kern River oilfield north of the Kern River and are considered below the bottom of the groundwater basin in this area as discussed in more detail in Section

of the trough contain mostly Miocene and older marine sedimentary units. The upper trough has been infilled over time with mostly Late Miocene and younger continental sediments.

The structural trough and groundwater basin are illustrated on the schematic diagram in **Figure 3-1** with the Kern County Subbasin depicted in the southern San Joaquin Valley portion of the Central Valley. The estimated extent of the Kern County Subbasin and the KRGSA Plan Area are noted on **Figure 3-1**. As shown on the block diagram, deep marine sediments (purple) of pre-Pliocene age transition upward to Pliocene and younger deposits, mostly of continental origin (light yellow). These younger sediments contain most of the groundwater in the Subbasin.

The structural and depositional setting of the KRGSA is controlled in the deep subsurface by the Bakersfield Arch, a homocline[13] of basement rocks below the northern KRGSA Plan Area that plunges to the southwest. This arch and southwesterly dip of basement rocks created a deep trough for infill of sediments (depocenter), mostly during the Neogene period (Miocene and younger) (Bartow, 1991).

3.2.1.1 Regional Surface Geology and Depositional Environments

A regional geologic map shown on **Figure 3-2** illustrates the age and composition of surficial deposits in the Subbasin (Page, 1986). As shown, most of the Subbasin is covered with continental deposits of Quaternary age and is flanked by Miocene and pre-Miocene marine sedimentary units and basement rocks on the eastern and western margins of the valley.

The youngest surficial deposits in the KRGSA Plan Area include Holocene fluvial deposits along the Kern River channel. As shown on **Figure 3-2**, the KRGSA contains most of the Kern River channel, which traverses across the northern Plan Area through the City of Bakersfield. Prior to development, the Kern River continued to flow southwest before turning north near the Elk Hills uplands and flowed about 40 miles to its terminus at the Tulare Lake Bed, near the Kern County line (**Figure 3-2**). Since the regulation of River flows and the construction of Isabella Dam in the early 1950s, the Tulare Lake Bed only rarely receives surface water flood flows and has mostly been converted to agriculture.

In the KRGSA, Quaternary-age and underlying Pliocene-age sediments consist of comingled alluvial fans that were deposited by the ancestral and present-day Kern River (Dale, et al., 1966, Bartow and Pittman, 1983; Page, 1986) and other local drainageways (Robbins, 2014). A portion of the large Kern River Fan covers most of the KRGSA Plan Area. The present-day canals south of the Kern River were developed along the ancestral sloughs and drainageways of the alluvial fan and illustrate the fan-like geometry of the deposits (see canals in the KRGSA on **Figure 3-2**). The southern and eastern margins of the Kern River Fan are defined by fine-grained flood-basin and paleo-lake bed deposits, which were the ancestral terminus of local streams and flood waters (see Buena Vista Lake Bed, Kern Lake Bed, and brown-shaded flood-basin deposits – labeled Qb – on **Figure 3-2**).

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[13] A geologic structure that dips uniformly in a single direction.

The north-south flood-basin deposits in the eastern KRGSA Plan Area (Qb on **Figure 3-2**). represent the inter-fan area between the Kern River Fan and the smaller alluvial fans originating from the east (Dale, et al., 1966). These and other flood-basin deposits beneath the Kern and Buena Vista Lake Beds are associated with thick clay layers that locally impede surface recharge and vertical flow, creating perched conditions in the shallow subsurface and confined groundwater conditions at depth.

3.2.1.2 Surface Geology and Faulting in the KRGSA Plan Area

Surface geologic units have been compiled statewide on the *Geologic Map of California* by the California Geological Survey (CGS, formerly Division of Mines and Geology) (Jennings, et al., 2003); a portion of this map[14] is shown on **Figure 3-3** to further examine local contacts and geologic faulting in the vicinity of the KRGSA.

The yellow shading on **Figure 3-3** shows the previously-discussed alluvial deposits of Holocene and Pleistocene age (Quaternary Period, labeled Q), which cover most of KRGSA Plan Area. The Kern River Formation underlies the Quaternary alluvium and consists of a consolidated to semi-consolidated unit of predominantly sandstone (mostly Pleistocene and Pliocene age) that crops out in the northeastern region of the KRGSA Plan Area (labeled QPc on **Figure 3-3**). Similar age formations exist on the western side of the valley, west of the KRGSA Plan Area (labeled QPc on the western portion of **Figure 3-3**). Collectively, the surface alluvium and underlying Kern River Formation compose the principal aquifer system beneath the KRGSA Plan Area.

Older, finer-grained sediments (generally of pre-Pliocene age that represent the transition from continental deposits to marine sedimentary units) are present along the northeast corner of the KRGSA. Both continental and marine deposits (labeled Mc and M, respectively on **Figure 3-3**) lie between the younger deposits and the crystalline basement rocks of the Sierra Nevada (labeled grMz on **Figure 3-3**) on the east.

Geologic faults are also shown on the CGS map on **Figure 3-3** (Jennings, et al., 2013). As indicated on the figure, most of the faulting occurs close to the subbasin margins east and south of the KRGSA Plan Area. Several northwest-trending faults appear to extend into the northeastern KRGSA Plan Area with most faults trending northwest. Displacements along these faults are mapped mostly as normal (tensional) faults associated with deformation along the valley margin by Bartow (1991). However, Bartow notes the occurrence of some northwest-trending surface lineaments in the Kern River area that are unrelated to basement faulting. The ability of these upland faults to impede groundwater flow is unknown, but such impedance would not significantly affect groundwater throughout the KRGSA Plan Area. Although the Edison fault east of the Plan Area (see **Figure 3-2**) has been described as affecting groundwater, no such faults have been documented in the KRGSA.

[14] Some older units outside of the groundwater subbasin have been combined on Figure 3-3 for simplicity, but most geologic unit labels have been preserved from the source.

A geologic map of the Bakersfield area (Smith, 1964) on **Figure 3-4** shows similar geologic units and faults as previous **Figures 3-2** and **3-3** but provides more local detail in the KRGSA Plan Area. The map shows detailed contacts for units previously discussed including the Quaternary-age stream channel deposits (Qsc) along the Kern River channel, alluvial fan deposits (Qf) throughout the Plan Area, basin deposits (Qb) along the western, eastern and southern regions of the Plan Area and Quaternary lake deposits (Ql) forming the Kern Lake Bed along the southern edge of the KRGSA Plan Area.

The north-south trending flood-basin deposits (Qb) that occur parallel to the eastern boundary of the KRGSA on **Figure 3-4** represent an inter-fan trough of fine-grained sediments between the Kern River Fan and the Caliente Creek Fan, which originated from the eastern valley margin along the Caliente Creek drainageway (**Figure 3-4**). The inferred boundary between the Kern River and the Caliente Creek alluvial fans (Dale, et al., 1966) occurs in the eastern KRGSA Plan Area and is shown by the green dashed line on **Figure 3-4**. The low-permeability flood basin deposits at western terminus of the Caliente Creek Fan impede surface recharge and affect local groundwater as discussed in more detail in **Section 3.2.6** of this GSP.

Geologic units cropping out in the northern and northeastern regions of the KRGSA Plan Area are Pleistocene nonmarine (Qc) and Plio-Pleistocene nonmarine (Qp) sedimentary rocks. Quaternary nonmarine terrace deposits (Qt) are present along the upstream reaches of the Kern River.

3.2.1.3 Geologic Framework Geologic Map and Cross Sections

An additional map compiled by Bartow (1983) is provided as **Figure 3-5** to allow an examination of the Subbasin geometry across the eastern margin of the valley. The map shows additional detail of the geologic units at the Subbasin boundary and is accompanied by cross sections that illustrate the geologic framework of the boundary. Two cross sections C-C’ and D-D’, as highlighted on **Figure 3-5**, illustrate the subsurface geometry from the Sierra Nevada crystalline (basement) rocks across the Kern County Subbasin boundaries and into the groundwater basin beneath the KRGSA Plan Area both north and south of the Kern River.

Cross Sections C-C’ and D-D’ by Bartow (1983) are reproduced on **Figure 3-6**. Cross section C-C’ is located north of the Kern River and shows the framework of the basement rocks of the Sierra Nevada (pink) on the east (right side). The eastern boundary of the Kern County Subbasin is coincident with the outcrop of the continental deposits of the Kern River Formation. Although this unit serves as part of the aquifer system further west in the groundwater basin, the Kern River Formation is the oil reservoir for the Kern River oilfield. The top of the oil reservoir would serve as a bottom of the groundwater basin locally as discussed in more detail in **Section 3.2.5**. A small portion of the Kern River oilfield extends into the KRGSA Plan Area along the cross section as shown on C’C. The surface alluvial deposits of the KRGSA are also shown on the section. Collectively, the Alluvium and Kern River Formation reach a thickness of about 3,250 feet beneath the western boundary of the KRGSA at Rosedale Highway.

Cross Section D-D’ on the lower portion of **Figure 3-6** also shows the subsurface geometry across the Kern County Subbasin boundary. The section extends from the Sierra Nevada crystalline rocks (pink) on the east to the KRGSA on the west, although it does not extend very far into the Plan Area. Along this section, the Kern County Subbasin includes an outcrop of Miocene alluvial fan deposits (shown in blue and labeled Tba and Tbp) that aren't present on the C'C'. The section also intersects a series of northwest-trending faults extending up into the Kern River Formation, similar to faults mapped in the northeastern KRGSA Plan Area. At the terminus of the section in the eastern KRGSA Plan Area, the Alluvium and Kern River Formation are approximately 2,800 feet thick. Additional information on the bottom of the subbasin and aquifer thickness and characteristics beneath the Plan Area is provided in **Sections 3.2.5** and **3.2.6** of this GSP, respectively.

3.2.2 Topography

The KRGSA Plan Area extends from the edge of the Sierra Nevada foothills in the northeast to the San Joaquin Valley floor. The Kern River, with headwaters in the Sierra Nevada, cuts across the valley floor through the northern region of the KRGSA. A Digital Elevation Map (DEM) of the topography based on the United States Geological Society (USGS) National Elevation Dataset (NED) is illustrated on **Figure 3-7**.

Ground surface elevations in the Kern River GSA slope to the southwest, ranging from approximately 280 feet mean sea level (msl) to more than 1,000 feet msl. The higher surface elevations are in the northeast within the foothills of the Sierra Nevada. The lowest ground surface elevations (below 300 feet msl) are in the south and southwest coincident with paleo-lakebeds that have been drained and placed into agricultural production.

The Kern River exits the dissected uplands in the northeast at an elevation of about 420 feet, forming the apex of the alluvial fan. The alluvial fan complex covers most of the KRGSA, with ground surface elevations between about 400 and 280 feet msl. From northeast to southwest, the alluvial fan surface has a slope of about 7 to 8 feet per mile.

3.2.3 Soils

The depositional history of the Kern River has influenced the shallow subsurface sediments and soil profile beneath the Kern River GSA. The terminus of the Kern River was historically at large inland lakes. The ancestral Kern River flowed from east to west across the valley and then turned north toward the Tulare Lake Bed approximately 40 miles away. During flood stage in the main east-west channel, flows spilled to the south through the Kern River GSA and flowed into Kern Lake, in the southern region of the GSA, and Buena Vista Lake, west of the GSA. These two now-dry lakebeds received thick deposits of fine-grained sediments as flood flows diminished and dropped their bed load. Since the regulation of River flows with the construction of Isabella Dam in the early 1950s, the lakebeds no longer receive regular surface water inflow and have been converted to agriculture.

These depositional patterns have resulted in thick sequences of coarse-grain sediments (sand) in the central region of the GSA and fine-grained deposits (silt and clay) in the paleo-lakebeds, as shown on the soil texture map on **Figure 3-8**. This soil texture map is from the Soil Survey Geographic (NRCS 2018) database for Kern County, developed by the U.S. Department of Agriculture, Natural Resources

Conservation Service, and covers most of the GSA except for small regions in the northern and northeastern edges of the GSA. Soil textures are color-coded and listed in the legend by decreasing grain size (texture). Loamy sands, sandy loams, and fine sandy loams, shown by shades of yellow and light orange, are the dominant soil textures in the GSA. Alluvium is present along, and primarily to the south of, the present-day Kern River. Loams to clay, shown in dark orange, green, brown, and dark red, are the primary soil textures along the southern boundary of the GSA. An additional north-south band of fine-grain textures also is present in the eastern GSA.

Figure 3-8 also illustrates the canals and recharge ponds within the GSA. The recharge ponds are operated by the City of Bakersfield and Kern Delta Water District, and for the most part, located in areas of coarse-grained soils (loamy sands to fine sandy loams). A recharge pond in the western GSA appears to be primarily on loamy soil.

3.2.4 Hydrologic Setting

The local hydrologic setting is dominated by the Kern River, which provides significant water supply to the KRGSA Plan Area. Deep percolation of precipitation and local stormwater runoff provide additional natural water sources. These surface water supplies are augmented with imported water, supported by associated infrastructure of diversions, conveyance, treatment, and delivery. All of these supplies are actively managed in the KRGSA Plan Area to optimize conjunctive use and groundwater recharge. Details of the local hydrologic setting are provided below.

3.2.4.1 Climate

The climate of the Plan Area is characterized by hot, dry summers and cool, moist winters. The mean annual temperature is 65° F and summer highs frequently exceed 100° F. On average, about 70 percent of the precipitation occurs in December through March. The long-term average precipitation at the Bakersfield Field Meadows Airport station (located in the northern KRGSA Plan Area) is approximately 6 inches per year (NOAA, 2019). Annual precipitation – displayed by Water Year[15] (WY) - is shown on **Figure 3-9**, covering a 52-year period from WY 1966 – WY 2017. As shown on the figure, annual precipitation is highly variable, ranging from 2.26 inches in WY 2008 to 14.99 inches in WY 1998. Average annual precipitation during the period is 6.13 inches.

Each Water Year shown on **Figure 3-9** is color-coded based on the San Joaquin Valley water year hydrologic classification indices (CDEC, 2018): wet (blue), above normal (green), below normal (yellow), dry (orange), and critically dry (dark brown). The San Joaquin Valley water year indices do not always correlate with precipitation measured at the Bakersfield airport station because they are based on runoff in the Stanislaus, Tuolumne, Merced, and San Joaquin Rivers, all north of Kern County. Based on a discussion with DWR, these hydrologic classifications are the best available

[15] A Water Year (WY) is defined as October 1 through September 30.

information for Kern County because DWR does not calculate runoff indices for the Tulare Basin (DWR, personal communication, 2018).

Figure 3-9 shows that the wettest water years in the last 50 years are associated with precipitation totals above 10 inches per year; using this definition, wet years occurred in WYs 1978, 1983, 1995, 1998, and 2011. The driest water years, with precipitation less than 4 inches per year, occurred in WYs 1970, 1972, 1984, 1990, 2002, 2007-2008, and 2013-2014.

The Plan Area is also characterized by relatively high referenced evapotranspiration rates. Over the 20-year Study Period, reference evapotranspiration[16] (ETo) averaged about 60 inches per year. Monthly averages range from an ETo of 1.5 inches in January to 9.1 inches in July (CIMIS, 2018). These rates indicate that much of the local precipitation would be evaporated (or transpired by local vegetation), with relatively small amounts contributing to deep percolation and recharge.

However, most of the precipitation and runoff in the KRGSA Plan Area is actively managed to maximize recharge. The City of Bakersfield maintains almost 400 small stormwater retention facilities (referred to as sumps) that are all open-bottomed and are managed for recharge of urban runoff (Carollo Engineers, 2015). Collectively, these small basins cover more than 500 acres, are sited throughout the entire Metropolitan Bakersfield area. Almost all of these facilities reside on relatively permeable soils and underlying sediments and capture about 16,000 AFY of stormwater runoff, on average. Additional recharge of precipitation is accomplished by diversion and management of runoff into unlined canals and larger recharge/banking facilities.

3.2.4.2 Kern River

The Kern River is the primary surface water body in the KRGSA Plan Area and crosses about 16 miles of the northern region of the KRGSA (see **Figures 1-1 and 2-1**). The River enters the Kern County Subbasin at the Kern Gorge fault, runs parallel to the northeastern boundary of KRGSA, and crosses into the KRGSA Plan Area as it reaches the valley floor. The Kern River is about 165 miles long and drains snowmelt and runoff from a watershed of approximately 2,400 square miles. The watershed extends to high elevations near Mt. Whitney in the Sierra Nevada (DBS&A, 2012). Since 1953, flows in the Kern River have been regulated at Isabella dam, about 25 miles upstream from the KRGSA Plan Area (**Figure 1-1**). Rights to the Kern River and allocations of flow are summarized in **Section 2.4.2**.

Daily inflows to Lake Isabella are illustrated on the top graph of **Figure 3-10** for wet (1983), dry (2015), and average (1979) years. A Kern River Index is established for runoff between April and July, representing a percentage of the long-term average flow for those months. As indicated on **Figure 3-10**, the wet, dry, and average years selected for illustration of reservoir inflows reflect Kern River flows of 339 percent, 92 percent, and 13 percent, respectively, of the long-term average flow. The large

[16] Reference evapotranspiration (ETo) refers to ET from a hypothetical reference surface, such as grass, which would potentially occur if unlimited amounts of water were available. It is used to estimate the evaporative demand of the atmosphere independent of crop type.

variability of inflows associated with water year type is illustrated by the differences in the May peak flow rates between a wet year (14,038 cfs), an average year (3,355 cfs), and a dry year (373 cfs).

As described previously in **Section 2.4.2**, two permanent stream gage stations, First Point and Second Point, were established to measure flow in the Kern River (see **Figures 1-1 and 2-1**). The record of daily discharge at First Point is used to allocate water among the various Kern River interests, referred to as First Point diverters, Second Point diverters, and Lower River diverters (as described in **Section 2.4.2**). The Second Point of measurement is approximately 20 miles downstream and is used to check upgradient water use (and entitlements) with diversion rights downgradient of Second Point (Boyle, 1975).

Regulated Kern River flows at First Point are shown in the lower graph on **Figure 3-10**. Data are included for the 20-year Study Period 1995-2014 and extended through 2016 to show more recent conditions. During this period, regulated flows at First Point have ranged from 1,568,932 AFY (1998) to 139,890 AFY (2015). The low flows observed in 2015 represent the historical low flow condition for First Point measurements dating back to 1954.

3.2.4.3 Surface Water Channels, Canals, and Management

The Kern River, along with imported surface water sources, is actively managed for optimized recharge and conjunctive use in the KRGSA Plan Area and other areas. Surface water is managed and regulated using the Kern River channel, weirs, diversion structures, and a web of unlined and lined canals and pipelines that connect regional facilities for operational flexibility. Major lined and unlined canals are shown on **Figure 3-11**. The main Kern River channel is managed with the canal systems for conveyance and intentional recharge; the channel is shown in brown to allow differentiation from the intricate canal system depicted on **Figure 3-11**. The primary weirs and measurement stations in the River are also included on **Figure 3-11**.

Since 1976, the City of Bakersfield has managed the Kern River channel to improve both flood control and water supply operations, including monitoring and recording of River flows and water use. The City accounts for all diversions and inputs into the Kern River system from First Point to Second Point (**Figure 3-11**). Data are recorded in annual Kern River Hydrographic Reports that also provide information on entitlements and amounts of water diverted or released to others.

Kern River water is diverted primarily for drinking water and agricultural irrigation purposes and is also used in water exchanges to facilitate deliveries of other water sources or supplement local supplies. Between 1970 and 2010, about 80 percent of the water measured at First Point had been diverted above the Calloway Weir (DBS&A, 2012) (**Figure 3-11**).

Canal and pipeline conveyance systems can move Kern River water to any of three regional water purification plants (WPP) for treatment and delivery of drinking water to KRGSA Plan Area customers. Two of these plants, North Garden WPP and North East WPP, are operated by Cal Water and designed to treat Kern River water for distribution in the municipal water system (**Figure 3-11**).

The Henry C. Garnett WPP (HCGWPP), located in the north central Plan Area (**Figure 3-11**), is operated by ID4 for the treatment of imported SWP water. The HCGWPP also receives and treats Kern River water through exchanges, as well as groundwater that has been recovered from local groundwater banking projects both inside and outside of the KRGSA. SWP water is conveyed from the California Aqueduct to the HCGWPP via the Cross Valley Canal[17] for treatment, distribution, and use (**Figure 3-11**). ID4 also banks water in several banking facilities (including the Kern River Channel) via the Cross Valley Canal or other conveyance; recovered water is pumped back into the canal for conveyance to the HCGWPP. Conveyed water is also recharged along the unlined portions of the Cross Valley Canal; this recharge is tabulated and recovered for future use, as needed (KCWA, 2018).

KDWD conveys Kern River water via canals that connect to regional facilities including the Carrier Canal, the Kern River Canal, and the Arvin-Edison Intake Canal (all shared with other users). The facilities allow conveyance of water to the KDWD distribution system consisting of five main canals and laterals covering about 150 miles and associated with the five separate service areas. These canals are shown on **Figure 3-11** and, from west to east, include the Buena Vista Canal, Stine Canal, Farmers Canal, Kern Island Canal (including the main canal and the Central Branch), and Eastside Canal. Canals are mostly unlined; small reaches through some urban areas consist of either concrete-lined canals or pipelines.

KDWD provides intentional and measured groundwater recharge through the unlined canals during conveyance of water deliveries during the irrigation season. KDWD also manages a groundwater replenishment program outside of the irrigation season by diverting water to the unlined canals during winter months when both recharge water and canal capacity are available (Todd, 2013).

In additional to the intentional recharge in canals and basins, recharge also occurs from the use of surface water for agricultural irrigation. Because applied irrigation water may percolate through the root zone too quickly for efficient crop use, a certain percentage of the applied water will percolate to the water table. When groundwater is used to irrigate crops, irrigation inefficiency results in some of the applied groundwater circulating back to the groundwater system, a process referred to as return flows. When the irrigation source water is surface water, the portion of the applied water that percolates to groundwater represents a new source of recharge. KDWD estimates an average irrigation efficiency of about 80 percent in the southern Plan Area – an estimate consistent with recent surface water-groundwater modeling – indicating that about 20 percent of the surface water deliveries to agriculture represent recharge to the groundwater basin. Irrigation inefficiency also results in recharge to the urban areas where outside irrigation occurs, such as lawns, parks, sports fields, and other areas.

Since the late 1980s, large-scale groundwater recharge/banking operations have been constructed along the Kern River. The first major banking project, the City's 2800-acre spreading area (referred to herein as the COB 2800), is located within the GSA on the western edge of Bakersfield with ponds both north and south of the River (**Figure 3-11**). The City's COB 2800 extends about 6 miles, covers approximately 1,470 acres of basins within the larger 2800 acre property, and includes old River channels, overflow lands and

[17] The Cross Valley Canal is also used to convey CVP exchange water into the Subbasin.

constructed spreading basins. During the 20-year Study Period WY 1995 – WY 2014, an average of about 13,000 AFY has been recharged at the facility for KRGSA member agencies[18] (ID4 and the City).

An additional banking program, the Berrenda Mesa project, operates east and adjacent to the COB 2800 facility in the KRGSA Plan Area (**Figure 3-11**). The Berrenda Mesa groundwater bank consists of six recharge areas on about 369 acres immediately adjacent to the Kern River channel and downstream of the Bellevue Weir. Stored groundwater is recovered using 14 extraction wells, 9 of which are inside the KRGSA Plan Area. The project is jointly-operated by KCWA and Berrenda Mesa Water District for the benefit of four Kern County water districts (project participants) located outside of the KRGSA Plan Area. During the 20-year Study Period, an approximate average annual of 9,200 AFY was recharged in the groundwater bank.

In the southern KRGSA Plan Area, KDWD has operated a managed aquifer recharge and groundwater banking program since 2003. The program involves approximately 814 acres of spreading basins to allow for groundwater replenishment of surplus district water and for storing water on behalf of its banking partners, which include Metropolitan Water District of Southern California and San Bernardino Valley Municipal Water District. SWP water is received from banking partners using the Cross Valley Canal either directly or via the Arvin-Edison canal; Kern River water can also be banked for partners through an SWP water exchange with BVWSD. The terms of the banking agreement allow KDWD to also use the spreading basins for recharge of its own surface water. Locations and names of in-district recharge basins are shown on **Figure 3-11** (basins in areas south of the Arvin-Edison canal on the figure). Banking for out-of-district partners during six years over the 20-year Study Period (2003, 2005, 2006, 2010, 2011, and 2012) totaled about 245,245 AF.

The Kern River channel is also managed as a recharge and recovery facility by the City, KCWA, and others. The City records River flows and recharge on a daily basis, allocating the amount recharged by each party to track River flow and recharge in accordance with water rights.

In addition to the large number of banking projects in the KRGSA Plan Area, several major banking projects operate adjacent to the east-central KRGSA Plan Area including the Pioneer Project (2,233-acres operated by KCWA) and the Kern Water Bank, (about 20,000 acres operated by the Kern Water Bank Authority) as shown on **Figure 3-11**. As previously mentioned, ID4 uses these facilities for recharge and recovery of SWP water in addition to in-district banking. Also, KDWD is a participant in the Pioneer Project.

Finally, also shown on **Figure 3-11** are numerous recharge basins in adjacent water districts outside of the KRGSA Plan Area that are used locally for groundwater replenishment and banking for outside-District partners. These basins outside of the KRGSA Plan Area are not meant to be comprehensive of

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[18] KCWA also banks water in the COB 2800 facility for parties outside of the KRGSA Plan Area; those totals are not included here.

the large number of additional managed aquifer recharge facilities in the Kern County Subbasin but are provided to illustrate examples of nearby recharge areas.

3.2.4.4 Additional Surface Water Drainageways

In addition to the Kern River, one small drainage – Caliente Creek – flows into the southeastern KRGSA Plan Area during wet years. The Caliente Creek drainageway is shown on **Figure 3-4**. Caliente Creek originates in the Sierra Nevada foothills on the eastern Subbasin margin and flows across Arvin Edison WSD and the community of Lamont. During wet years, the creek floods the valley floor and extends into KDWD, creating problems of erosion and flooding. In 2016, Kern County commissioned a feasibility study to better manage flood waters in the area; options from that study are being evaluated (AECOM, 2017). Although this flood water likely provides some groundwater recharge in KDWD when present, the amount is assumed to be small because most of the flooded area occurs over lower permeability flood basin deposits discussed in **Section 3.2.1.2** and shown on **Figure 3-4**.

3.2.4.5 Recharge Areas in the KRGSA

The primary areas and conditions that promote groundwater recharge as discussed above are shown on the Plan Area map on **Figure 3-12**. Recharge areas include the sandy Kern River channel, unlined canals used for intentional recharge, and other managed aquifer recharge facilities including recharge basins, stormwater basins, and concentrated banking operations. **Figure 3-12** also highlights the occurrence of the more permeable soils discussed in **Section 3.2.3**, where surface water is readily recharged. The occurrence of these higher permeability soils and sediments along the Kern River channel, including unconsolidated alluvial deposits of sand and gravel, illustrate why the channel is used for managed recharge by numerous agencies in the KRGSA. Although soil textures along the southern rim of the Plan Area are finer-grained, local sand lenses allow for some infiltration of surface water (and groundwater return flows) applied for crop irrigation (see areas of agricultural irrigation shown on **Figure 2-9**).

Given the depth to groundwater, there are no known active springs, seeps, or wetlands in the KRGSA Plan Area; some areas of shallow groundwater occur where applied water becomes perched in low permeability soils and drains slowly to the underlying water table; groundwater occurrence and levels are discussed in more detail in **Section 3.3.1 and 3.3.2**. Additional management and recharge of surface water was discussed previously in **Section 3.2.4.3** above. Amounts and locations associated with these and other recharge components are provided in the water budget analysis in **Section 4**.

3.2.5 Basin Geometry and Basin Bottom

The top and lateral sides of the Kern County Subbasin have been defined by DWR (DWR, 2006 and 2016c). As described in DWR's Bulletin 118, the Subbasin is "bounded on the west, southwest, and east by the bedrock formations of the Coast Range, San Emigdio Mountains, and Sierra Nevada, respectively. It is separated by the White Wolf Subbasin on the southeast by the White Wolf Fault. The northern boundary is generally coincident with the County line." (DWR, 2016c).

As shown on **Figure 3-3** (and other figures), the northeastern boundary of the KRGSA Plan Area is close to or coincides with the eastern Subbasin boundary. In that area, the KRGSA Plan Area boundary abuts the outcrop of Miocene marine sedimentary units (see **Figure 3-3**), which have been excluded from the groundwater Subbasin by DWR. One small segment of the KRGSA Plan Area northeastern boundary abuts these units at the surface and, if projected vertically, would also intersect these units at depth.

The bottom of the Subbasin has not been well-defined and will likely vary significantly across the subbasin based on changes in basin geometry, structural features at depth, and groundwater quality. Previous Central Valley studies have observed saline groundwater in various areas and depths and have used water quality as the effective bottom of groundwater subbasins. Some references define the groundwater basin as consisting of continental deposits as an effective boundary, suggesting that the top of the marine sediments could be used to define the basin bottom. This usage also suggests a change in water quality and assumed saline water in the marine sediments. However, because some of the marine sediments crop out and are capable of producing fresh water, the base of the Subbasin beneath the KRGSA Plan Area is evaluated on available information of water quality changes with depth. Issues affecting deep groundwater quality as related to the bottom of the basin are described in the sections below. Overall groundwater quality within the subbasin is described in **Section 3.3.4**.

3.2.5.1 Oil Fields

The KRGSA Plan Area overlies all or portions of about 23 active or abandoned oil fields[19]. The presence of petroleum hydrocarbon reservoirs indicates that the geologic formation is isolated at depth without the ability to be readily replenished by groundwater recharge (a condition required to trap the hydrocarbons). In addition, the occurrence of petroleum hydrocarbons in the formation would inherently limit the use of formation water. Although water produced from some Kern County oil fields is being separated and treated for beneficial uses in other areas, this formation water would not be connected to the groundwater system and not be considered part of the groundwater basin pursuant to groundwater management. In addition, most of the local oil fields have been exempted from the USEPA definition of protected groundwater (discussed in more detail in **Section 3.2.5.3**). Therefore, the shallow-most top of oil production in an oil field would provide a conservative estimate of the bottom of the Subbasin, where present.

The locations of oil fields are available for download from the California Division of Oil, Gas, and Geothermal Resources (DOGGR) website; administrative boundaries and productive limits of these oil fields are mapped on **Figure 3-13**. As shown on the map, most of the oil fields beneath the KRGSA Plan Area are located along the margins of the boundary with only a small portion of their productive limits in the KRGSA (e.g., see Mountain View and Edison oil fields on the east, and Ten Section and Rosedale on the west, **Figure 3-13**). Nonetheless, oil fields with any productive limits that overlap the KRGSA Plan Area are included in the basin bottom analysis for completeness. Using this criterion, portions of about 24 oil fields extend beneath the KRGSA Plan Area.

[19] The term "oil fields" is used generically herein to include both oil and gas fields.

The location of a regional geologic cross section line (labeled C-D) that crosses the KRGSA Plan Area and some of these oil fields is shown on **Figure 3-13**. The cross section, with modifications, is provided as **Figure 3-14**. This section was prepared by DOGGR (1998) to show the subsurface geology beneath the oil fields in the southern San Joaquin Valley. It has been modified to include the average depth of the shallowest oil-producing zone in the oil fields (indicated by the red triangles on **Figure 3-14**). The general extent of the KRGSA Plan Area and the Kern County Subbasin are shown for reference. As indicated on the cross section, the shallowest hydrocarbon zone in most of the oil fields occurs within older marine sedimentary units (purple shading) of the Subbasin. Two exceptions include shallow productive hydrocarbon zones at the Kern River and Elk Hills oil fields on the eastern and western sections of the cross section, respectively. In the Kern River and Elk Hills fields, oil production occurs in the continental and continental/marine deposits of the Kern River Formation and the San Joaquin Formation, respectively. Although the shallowest production in the Kern River oil field is at about 400 feet deep, the depth to the production zone at the location of the cross section is the depth depicted on **Figure 3-14** (more than 1,000 feet deep).

Other oil fields illustrated on **Figure 3-14** that are at least partially located beneath the KRGSA, include Fruitvale, Bellevue, McClung, Strand, and Canal fields. Although many of these fields do not appear to be within the KRGSA on the cross section, portions of these fields occur beneath the KRGSA in other areas (see **Figure 3-13**). As illustrated on the cross section, the top of the hydrocarbon zone at the Fruitvale field is within the marine sedimentary units at an approximate depth of 3,200 feet. Depths to the shallowest production zone for fields beneath the KRGSA range from about 1,000 feet to more than 10,000 feet deep (including oil fields not included on the cross section).

3.2.5.2 Base of Fresh Water

An additional consideration in defining the bottom of the groundwater Subbasin is the increasing salinity of groundwater with depth beneath the KRGSA Plan Area. Groundwater quality investigations in the Central Valley have used various methods to delineate the base of fresh water (Berkstresser, 1973; Page, 1973). One such map developed by a USGS investigator (Page, 1973) provides elevation contours on the base of fresh water that covers the KRGSA Plan Area and is reproduced on **Figure 3-15**. Recognizing that there are several definitions for *fresh water* (Todd and Mays, 2005), this map was based on a specific conductance value of 3,000 micromohs per centimeter (umhos/cm), which is equivalent to a concentration of total dissolved solids (TDS) of about 2,000 to 2,880 milligrams per liter (mg/L), varying with temperature and differences in water chemistry.

As shown on **Figure 3-15**, the base of fresh water extends below an elevation of -3,000 feet msl over most of the KRGSA Plan Area. Considering ground surface elevations of about 400 feet msl over this area (**Figure 3-7**), the -3,000 feet msl elevation also represents a depth of about 3,400 feet. The base of fresh water is shallowest in the northeastern KRGSA and along the western boundary, with elevations between about -1,600 feet msl on the west to -2000 feet msl in the northeast (based on limited northeastern data). Between those boundaries, the base of fresh water deepens significantly in the central KRGSA, extending below an elevation of -4,400 feet in the south-central portion of the KRGSA

Plan Area. The map does not extend into the uplands above the valley floor in the northeastern KRGSA Plan Area.

In 1992, the Society of Petroleum Engineers published a study estimating the base of fresh water from resistivity values on more than 70 electric logs in nearby oil and gas field wells (O'Bryan, 1992). This methodology included a definition for the base of fresh water consistent with Page (1973) (i.e., about 2,000 mg/L TDS). The O'Bryan map (not shown) covers an approximately eight square mile area southwest of Bakersfield and overlaps the southwestern region of the Page map, including most of the KRGSA. A comparison of these two maps indicate relatively good agreement for the KRGSA Plan Area although the 1992 map indicates slightly deeper fresh water in the southern KRGSA. Near the southern boundary, the 1992 map shows fresh water below an elevation of -5,000 feet, msl, about 600 feet deeper than the deepest elevation mapped by Page (1973) (O'Bryan, 1992).

3.2.5.3 Base of Underground Source of Drinking Water (USDW) and Exempt Aquifers

As set forth in the Safe Drinking Water Act, the U.S. Environmental Protection Agency (USEPA) has defined groundwater to be protected as part of the Underground Injection Control (UIC) program (CFR, Title 40, Chapter 1, Subchapter D, Part 144.A.). This definition of protected groundwater, referred to as the Underground Source of Drinking Water (USDW), is reproduced below:

> *Underground source of drinking water (USDW) means an aquifer or its portion:*
> *(a) (1) Which supplies any public water system or*
> *(2) Which contains a sufficient quantity of ground water to supply a public water system and*
> *(i) Currently supplies drinking water for human consumption or*
> *(ii) Contains fewer than 10,000 mg/L total dissolved solids; and*
> *(b) Which is not an exempted aquifer. (40 CFR §144.3).*

In general, this definition indicates that any formation containing groundwater with less than 10,000 mg/L outside of an exempted aquifer (including oil-producing zones) would qualify as a USDW if it contains a sufficient quantity of groundwater.

A SWRCB resolution (88-63, as amended by 2006-0008) provides policy on sources of drinking water. According to that guidance, groundwater with a TDS of less than 3,000 mg/L may reasonably be expected to supply a public water system, if aquifer yield is sufficient (more than 200 gallons/day), the supply is not contaminated or beyond reasonable treatment, and the groundwater is not exempted by 40 CFR §146.4 (SWRCB, 2006). This suggests that the use of the base of fresh water represents a usable supply of groundwater; as such, that surface is considered in the definition of the bottom of the basin. Although groundwater quality below the base of fresh water represents a higher salinity, the base of the USDW may also represent additional groundwater supply. Accordingly, both the base of fresh water and the base of the USDW are incorporated into the definition of the bottom of the groundwater basin.

The depth of USDW has recently been defined in the southern San Joaquin Valley by a team of researchers from California State University, Bakersfield (Gillespie, et al., 2017). The group used geophysical log analyses to estimate the depth where water salinity increased above the 10,000 mg/L threshold included in the USDW definition. This map, showing the depth to a water salinity of 10,000 mg/L, was designated as the base of the USDW by the investigators; the map is shown as **Figure 3-16**.

As shown on **Figure 3-16**, the contours defined by water salinity are very deep beneath the KRGSA and extend below 9,000 feet deep in the southwestern portion of the Plan Area. While it seems highly unlikely that groundwater would be extracted from such depths, there is no basis for assuming that USDW could not extend that deep. Further, depths in the western KRGSA Plan Area range from about 3,000 feet to 4,000 feet deep, which are similar to depths associated with the base of fresh water (compare **Figures 3-15** and **3-16**).

It is recognized that the method used to create the USDW map did not consider whether the salinity mapping resulted in depths below an exempt aquifer and/or the top of an oil producing zone (Gillespie, et al., 2017); this suggests that the USDW may be shallower than mapped in some areas. To correct the map for shallow exempt aquifer zones, information on exempt aquifers was downloaded from the EPA and DOGGR websites and considered in the analysis with the oil field data.

Aquifer exemptions are approved by USEPA and typically represent formations that will receive oil field wastewater (also referred to as produced water). A typical method of produced water disposal is to inject it back into the oil zone where it originated or into another isolated subsurface zone. Consistent with the methodology of excluding oil fields and Exempt Aquifers from the groundwater basin, the USDW map requires correction if oil fields or exempt aquifers occur at shallower depths than indicated on **Figure 3-16**.

3.2.5.4 Basin Bottom Delineation and Groundwater in Storage Definition

Based on the maps and analysis described above, the bottom of the Subbasin beneath the KRGSA Plan Area is defined as groundwater outside of a hydrocarbon zone that contains no more than 10,000 mg/L TDS unless that water has been determined to be an exempt aquifer pursuant to the Code of Federal Regulations, Title 40 part 146.4. It is further assumed that the Subbasin would be a continuous unit from the surface down to the basin bottom; no formations below the shallowest oil producing zone or shallowest exempt aquifer would be included.

This approach to modifying the base of fresh water and USDW beneath the KRGSA Plan Area and defining the bottom of the groundwater Subbasin is illustrated by the conceptual diagram on **Figure 3-17**. Specifically, the bottom of the groundwater Subbasin beneath the KRGSA Plan Area will follow the base of the USDW as mapped by Gillespie, et al. (2017, **Figure 3-16**) but will be modified by the top of oil fields and exempt aquifers where shallower than the base of the USDW. In addition, the Base of Fresh Water will also be modified by the top of oil fields and exempt aquifers where shallower that the elevation of fresh water as mapped by Page (1973, **Figure 3-15**). As indicated on **Figure 3-17**, the adjusted base of fresh water will be used to define the usable fresh water storage of the groundwater basin. The adjusted USDW will be used to define the bottom of the Subbasin and allow for an emergency water supply.

To determine where adjustments to these maps are required, data from the 24 oil fields that wholly or partially overlap the KRGSA Plan Area are provided on **Table 3-1**. For each of the oil fields, the shallowest productive limits within or closest to the KRGSA Plan Area were estimated using oil field data from DOGGR (1998). Both elevations (column C) and depths (column F) of the productive limits are included on the table using ground surface elevations (**Figure 3-7**) at the oil field area of interest.

Several of the oil fields on **Table 3-1** are associated with approved Exempt Aquifers that may be shallower than an oil-producing zone but all Exempt Aquifers except one were either at the same depth or deeper than the oil producing zones. For the Kern River Oilfield, the Kern River Formation is an exempt aquifer and occurs at a shallow depth on the northern boundary of the KRGSA Plan Area. In this area, the exempt aquifer significantly limits the thickness of groundwater supply. Except for the Kern River Oilfield, no adjustments were made to the base of fresh water or USDW maps for Exempt Aquifers.

Table 3-1: Oilfields and Adjustments to Subbasin Bottom in the KRGSA Plan Area

Oil and Gas Field in KRGSA Plan Area	Adjustments to Base of Fresh Water			Adjustments to USDW			Exempt Aquifers
	Elevation Base of Fresh Water in KRGSA (ft, msl)	Shallowest Elevation of Production in KRGSA (ft, msl)	Elevation Base of Fresh Water Adjusted for Oil Production (ft, msl)	Depth to Base of USDW in KRGSA (ft)	Average Depth to Production or Exempt Aquifer in KRGSA	Depth to Bottom of USDW Basin Adjusted for Oil Production	
Ant Hill	-2000	-1200	-1200	6000	2525	2525	
Bellevue	-2000	-5500	-2000	3250	6560	3250	
Canal	-1400	-7500	-1400	2500		2500	
Canfield Ranch	-2600	-5850	-2600	3250	7146.5	3250	
Edison	-2000	0	0	6000	1540	1540	Chanac, Wicker
	-2900	-2400	-2400	6000	3540	3540	Santa Margarita Transition
Fruitvale	-2400	-2300	-2300	4750	3305	3305	Santa Margarita
Greeley	-2200		-2200	3500		3500	
Kern Bluff	-2000	0	0	6000	1065	1065	
Kern Front	-2000	-600	-600	5500	2110	2110	Vedder, Chanac
Kern River	-2000	400	400	5750	100	100	Kern River Formation (100')
Kernsumner (Abd)	-3400	-8600	-3400	6500	9165.5	6500	
Lakeside (Abd)	-2600	-7600	-2600	3000	8328.5	3000	
Lakeside, South (Abd)	-2800	-9400	-2800	3500	10312	3500	
McClung (Abd)	-1800	-6550	-1800	3000	7100	3000	
Mountain View	-3400	-4600	-3400	6000	5392	5392	Kern River, Chanac
	-3200	-7600	-3200	8250	8000	8000	
Paloma	-2400	-11200	-2400	3250	11592	3250	
Rosedale	-2400	-4000	-2400	3500	4361	3500	
Rosedale Ranch	-2200	-3600	-2200	3750	4183.3	3750	Chanac
Round Mountain	-2000		-2000	6000		6000	Walker, Vedder
							Pyramid Hill, Jewett
Seventh Standard	-2400	-6820	-2400	3500	7482.7	3500	
Stockdale	-3200	-5100	-3200	4250	5518.2	4250	
	-3200	-9500	-3200	4250	10218.2	4250	
Strand	-1600	-7450	-1600	2500	7787.8	2500	
Ten Section	-2200	-7150	-2200	2750	7734	2750	
Union Ave.	-3800	-4460	-3800	6000	4960	4960	

Table 3-1 also lists the elevations of the base of fresh water at each of the productive areas in the KRGSA (column D). A comparison of the base of fresh water to the elevation top of the productive limits shows that most of the oil production is significantly below the base of fresh water (compare columns B and D). However, there are 6 of the 24 oil fields on **Table 3-1** that indicate oil production at a shallower

depth than the base of fresh water (see elevations for Ant Hill, Edison, Fruitvale, Kern Bluff, Kern Front, and Kern River on **Table 3-1**). This suggests that water in these oil and gas reservoirs is relatively fresh with possible TDS values less than about 2,000 mg/L. Rather than re-contouring the base of fresh water around these shallower oil fields, the contour map is simply adjusted by assigning one elevation to each applicable oil field and ending the contours at that field boundary; this methodology is shown on **Figure 3-18**.

As shown on **Figure 3-18**, most of the fields with shallower fresh water elevations generally occur in the northeast and east portions of the KRGSA Plan Area; several are located mostly outside of the KRGSA in the uplands of the eastern Subbasin. In the northeast, Subbasin aquifers are thin and shallow and the base of fresh water compared to the local shallow oil production is less certain. The Page analysis of the base of fresh water ends at the edge of the Kern River and Kern Front oil fields. In this area, the basin bottom is likely to be limited by the top of the shallow oil production rather than groundwater salinity.

Table 3-1 also lists the depths to the base of the USDW at each of the productive areas in the KRGSA Plan Area (column E). A comparison of the depth of the USDW with the depth of oil field production indicates that 8 of the 24 oil fields are shallower than the currently mapped depth for the USDW (compare column C to column E). These include the 6 oil fields that were shallower than the base of fresh water and also includes Mountain View and Union Ave. Similar to the methodology applied for the base of fresh water, the depth to the USDW map is modified by assigning one depth to the portion of the oil field in the KRGSA Plan Area and ending the previously-mapped contours at that location. This adjusted map is shown on **Figure 3-19**.

Collectively, these two maps are used in the definition of the Subbasin bottom. **Figure 3-18** defines the elevation on the bottom of usable fresh groundwater in storage. Figure 3-19 represents the bottom of the groundwater Subbasin beneath the Plan Area and serves as the base of an emergency supply. Because the oil bearing zones are defined as beneath the bottom of the Subbasin, there would be no decrease of groundwater in storage associated with water in the oil bearing zones.

3.2.6 Principal Aquifers and Aquitards

Almost all of the groundwater production from the KRGSA Plan Area occurs in the upper 1,200 feet of the aquifer system, consisting of the Quaternary alluvium and the Kern River Formation. Collectively, these two formations are considered the Principal Aquifer for groundwater management purposes. This single designation is appropriate because most production wells are screened in both units, the two units are difficult to differentiate on subsurface logs, and the two formations appear to be hydraulically connected without an intervening, regionally-extensive aquitard.

Groundwater age dating by USGS provides additional support for a single Principal Aquifer. In a groundwater quality study that included 14 wells located throughout the KRGSA Plan Area, USGS found relatively young groundwater (i.e., post-1953 Modern age) in most Plan Area wells screened from about 350 feet to 700 feet (Burton, et al., 2012). This suggests that recently recharged water extends throughout much of the Principal Aquifer including the primary production zones. Several wells along the western Plan Area boundary appeared to have older groundwater with a mix of Pre-Modern- and Modern-age water. This is likely an area where some older subsurface inflow from the Subbasin margin occurs.

The hydraulic connectivity of the Principal Aquifer is supported across the entire Plan Area. The aquifer system is primarily unconfined throughout most of the northern and central Plan Area and transitions to semi-confined and confined in the southern Plan Area and with depth. As discussed previously, the productive sands in the south are confined below silts and clays associated with distal alluvial fan deposits and paleo-lakebeds. As this transition is gradual and complex in areas with heterogeneous deposits, groundwater in the Quaternary Alluvium and Kern River formations functions as one continuous aquifer system throughout the Plan Area.

In brief, the Principal Aquifer reflects a geologic history of Quaternary-Pliocene fluvial deposition on the coalescing Kern River and Caliente Creek alluvial fans, entrenching of those fans by streams and rivers, and subsequent deposition of recent alluvial deposits. With this complex history, identification of single alluvial fan sequences and distinct depositional packages in the subsurface is difficult (Dale, et al., 1966). However, because there is likely no direct relationship between these coalescing alluvial fan packages and overall water-bearing properties of the units, differentiation does not appear necessary for groundwater management.

Nonetheless, it is noted that an abrupt slope change at the convergence of the Caliente Creek fan and the Kern River Fan results in the deposition by Caliente Creek of poorly-sorted heterogeneous material (Dale, et al., 1966). These flood basin deposits are significant to surface recharge and percolation to the underlying groundwater system, as indicated by perched conditions extending along the southern and southwestern KRGSA and beneath the Kern dry lake bed.

Lithology and textures that characterize the two formations composing the Principal Aquifer are described below.

3.2.6.1 Shallow Alluvial Deposits

The surficial distribution of alluvial deposits is shown in **Figures 3-4** and **3-5** and includes younger alluvium presently being deposited along the Kern River and Caliente Creek, flood-basin deposits, and older alluvium. The shallow alluvial deposits, estimated to be up several hundred feet thick in the northern and southern KRGSA, overlie the eroded surface of the Kern River Formation. Deposited by both the Kern River and Caliente Creek, the shallow alluvial deposits are not easily differentiated in the subsurface except for slope angles on the older and younger surfaces and the presence of paleo-soils (Dale, et al., 1966).

3.2.6.2 Kern River Formation

The Kern River Formation crops out on the eastern margin of the valley as shown in **Figure 3-5**. As shown in **Figure 3-6**, the Kern River Formation ranges in thickness from 500 – 2,600 feet thick and overlies the marine Etchegoin and Chanac formations. The Kern River Formation is described (Bartow,

1983) as Pliocene/Upper Miocene nonmarine, semi-consolidated, coarse-grained and pebbly sandstone and conglomerate, containing beds and lenses of siltstone and mudstone; it generally is coarser with decreasing depth and to the east, indicating a source in Sierran granites. Most coarse-grained units are south of the Kern River.

In some areas around the margin of the KRGSA Plan Area, the lower Kern River Formation contains commercial quantities of petroleum hydrocarbons. This occurrence is illustrated on Cross Section C-C' as shown on **Figure 3-6**. Although most of the Kern River Oilfield production occurs outside of the KRGSA Plan Area, the margins of the field, along with the Kern River Bluff and the Kern River Front oilfields overlap a portion of the northeastern KRGSA Plan Area (see production limits of the oilfields on **Figure 3-13**).

3.2.6.3 Aquifer Textures and Cross Sections

Characteristics and textures of the Principal Aquifer system in the KRGSA Plan Area are illustrated on three scaled cross sections shown on **Figures 3-20**, **3-21**, and **3-22**. Cross Section 1-1' (**Figure 3-20**) was constructed along the present-day Kern River to illustrate textures (e.g., sands and clays) associated with the local fluvial deposits. Cross Section 2-2' (**Figure 3-21**) was constructed from northeast to southwest across the approximate direction of alluvial deposition to illustrate the nature of the alluvial fan deposits. Cross Section 3-3' (**Figure 3-22**) was constructed approximately parallel to alluvial fan deposition to illustrate progradation of the alluvial fan deposits over time. These cross sections are described in more detail below. Also included on the cross sections are the groundwater levels representing the historical high levels (WY 1998) and low levels (WY 2015) over the last 50 years (see precipitation and water year types in **Figure 3-9**). Although precipitation was lower in WY 2014 than in WY 2015, most of the historical low water levels occurred during WY 2015 in the KRGSA Plan Area, resulting from the historical low flows on the Kern River (see **Figure 3-10**).

Cross Section 1-1' on **Figure 3-20** illustrates geologic textures and wells on an approximate 18-mile profile along the Kern River in the northern Plan Area. Resistivity logs shown on the section are used to differentiate more permeable textures – such as sand and gravel (in yellow) – from less permeable textures, such as silt and clay (in tan). Approximate resistivity values of 12 to 18 ohm-meters were used as the upper limit for the definition of silt and clay on the logs. As shown on the section, upper units generally contain more sand than deeper units, although the transition is subtle. In addition, clay content generally tends to increase to the southwest. Nonetheless, numerous permeable sand packages occur locally throughout the entire aquifer system as shown.

Water levels for 1998 and 2015 are shown on **Figure 3-20** to illustrate both general groundwater gradients and water level changes from relatively wet conditions to the recent drought of record. Although the section is generally oriented downgradient from northeast to southwest, local water levels are influenced by significant pumping and recharge both along and adjacent to the section. Low water levels in the northeast are affected by pumping to the north of the section (Miles 15 – 17 on **Figure 3-20**). In the southwest, water levels rise due to local banking at the COB 2800 recharge facilities and adjacent banking projects. The difference in banking operations from 1998 to 2015 results in the significant difference in water levels in the southwest (Miles 0 – 3). Specifically, water was being recharged in 1998 and recovered in 2015. Water levels in 2015 are also lower east of the banking areas (near Mile 5) due to local recovery of banked water along the channel (**Figure 3-20**).

Cross Section 2-2' on **Figure 3-21** illustrates the change in textures from the northern Plan Area to the southern Plan Area. The increase in clay content is evident in the south[20]. The cross section also indicates that the southern aquifer system also contains relatively permeable sand packages scattered throughout the vertical section, indicating the heterogeneous nature of the sediments. Water levels for 1998 and 2015 indicate overall lower water levels during the drought, but the changes in water levels from 1998 are generally smaller than seen on Cross Section 1-1.' In the northern Plan Area, water level declines of more than 100 feet are indicated in some northern areas where municipal pumping occurs. In southern agricultural areas, the declines in water levels associated with the drought were generally less than 50 feet.

Cross section 3-3' on **Figure 3-22** provides additional texture data in the southern Plan Area, but in a more conceptual manner. This cross section was modified from the KDWD GWMP, where the section was interpreted more conceptually. The purpose was to identify generalized areas where textures contained more clay or sand, as reflected by representative resistivity logs. As a result, only five resistivity logs are used on the cross section. The increasing clay content in the southeastern Plan Area is illustrated on the section (note the scale changes on the resistivity logs at the bottom of each log). The increased surface and subsurface clays likely result in confined conditions and a larger change in water levels during the drought. The clays also result in perched water as previously discussed and illustrated by an estimated perched water level on **Figure 3-22**.

3.2.6.4 Aquifer Hydraulic Properties

Information on the hydraulic properties for the Principal Aquifer have been compiled from numerous resources including local agencies and publications (Dale, et al, 1966, among others). In particular, pumping test data were compiled and analyzed by Todd Groundwater as part of Kern Fan model development (Todd Groundwater, 2018). These pumping tests were originally conducted by KCWA, City of Bakersfield, Kern Water Bank (KWB) and other local water agencies and provided to KCWA/Todd Groundwater in support of the model project. At the time of compilation, these tests represented the most recent and most reliable data[21] available for determination of aquifer properties. Specifically, most tests consisted of constant-rate pumping tests with observation wells and accurate interpretation of the pumping test data to estimate aquifer transmissivity and hydraulic conductivity. **Table 3-2** presents information from this data set for pumping tests in the KRGSA.

To supplement these data and examine changes in aquifer properties in other portions of the KRGSA, data have been compiled from six additional pumping tests conducted by the USGS in the 1960s (Dale,

[20] USGS has designated some deep clays in this area as the Corcoran Clay but does not extend the designation throughout the entire southern Plan Area.
[21] Based on documentation of test parameters and results.

et al., 1966). Data from the six USGS tests are summarized in **Table 3-3**. The locations of the pumping tests in **Tables 3-2** and **3-3** and the distribution of transmissivity values from the tests are illustrated on **Figure 3-23**.

As shown on **Figure 3-23**, most of these pumping tests were conducted in the western half of the KRGSA, many near the Kern River and the Kern Water Bank. Pumping tests clustered near the Kern River indicate relatively high transmissivity values. Although data are sparse, the wells farthest from the River have lower transmissivity values.

Table 3-2: Hydraulic Properties from Recent Pumping Tests in the KRGSA Plan Area

Well Identification	Date Drilled	Perforated Interval (feet)	Well Depth (feet)	Total Length of Perforations (feet)	Tested By	Date of Test	Test Type	Data Analysis Method	Pumping Rate (gpm)	Transmissivity (T) (ft^2/day)	Hydraulic Conductivity (K) (ft/day) (T/perf length)
29S/26E-14H		730-1171		441	Kenneth D. Schmidt and Associates	8/1/2005	Unknown	Cooper-Jacob Straight Line[1]	1,230	6,684	15
29S/26E-36K	12/15/2006	200-450, 500-680	720	530	Kenneth D. Schmidt and Associates	4/1/2007	Unknown	Cooper-Jacob Straight Line[1]	4,080	41,975	87
29S/26E-36K01	12/15/2006	200-450, 500-680	720	430	KCWA / KWB	4/18/2007	Constant Rate	Cooper-Jacob Straight Line	4,976	46,000	107
29S/26E-36L01	12/15/2006	200-550, 590-700	740	460	KCWA / KWB	5/10/2007	Constant Rate	Cooper-Jacob Straight Line	5,000	39,000	85
30S/26E-02J03	6/8/1991	224-304, 384-724	740	420	KCWA / KWB	7/27/2001	Constant Rate	Cooper-Jacob Straight Line	2,737	27,000	64
30S/26E-04E03	9/8/2009	280-480, 540-740	820	400	KCWA / KWB	11/12/2009	Constant Rate	Cooper-Jacob Straight Line	1,700	17,800	45
30S/26E-10R01	1/1/1999	160-340, 380-480, 540-730	770	470	KCWA / KWB	2/3/1999	Constant Rate	Cooper-Jacob Straight Line	3,802	16,000	34
30S/26E-11A		210-690		480	Kenneth D. Schmidt and Associates	12/1/2007	Unknown	Cooper-Jacob Straight Line[1]	3,530	24,196	50
30S/26E-11A01				440	KCWA / KWB	12/4/2007	Constant Rate	Cooper-Jacob Straight Line	3,010	22,000	50
30S/26E-11G		200-780		580	Kenneth D. Schmidt and Associates	11/1/2007	Unknown	Cooper-Jacob Straight Line[1]	3,560	29,543	51
30S/26E-11G01					KCWA / KWB	11/16/2007	Constant Rate	Cooper-Jacob Straight Line	3,035	36,000	75
30S/26E-11M		200-780		580	Kenneth D. Schmidt and Associates	12/1/2007	Unknown	Cooper-Jacob Straight Line[1]	3,530	12,165	21
30S/26E-11M01				200	KCWA / KWB	12/5/2007	Constant Rate	Cooper-Jacob Straight Line	3,003	9,400	47
30S/26E-17B01	8/7/1999	170-290, 330-550, 590-690	710	440	KCWA / KWB	9/10/1999	Constant Rate	Cooper-Jacob Straight Line	3,511	19,000	43
30S/26E-17C01	7/20/1999	168-248, 268-308, 328-628, 648-688	708	460	KCWA / KWB	8/23/1999	Constant Rate	Cooper-Jacob Straight Line	3,759	18,000	39
30S/26E-18R01	7/7/1999	160-260, 300-400, 420-620, 640-680	700	440	KCWA / KWB	9/27/1999	Step-Discharge	Step-Drawdown of Single Well	2,008	10,000	23
30S/26E-22P03		280-390		184	Kenneth D. Schmidt and Associates	11/1/2006	Unknown	Cooper-Jacob Straight Line[1]	1,460	10,962	100
30S/26E-23M		270-455		185	Kenneth D. Schmidt and Associates	11/1/2006	Unknown	Cooper-Jacob Straight Line[1]	1,230	31,014	168
30S/27E-19J01	12/7/1948	449-770	712	321	Kenneth D. Schmidt and Associates	4/1/2007	Unknown	Cooper-Jacob Straight Line[1]	1,560	28,607	89
30S/27E-19R		550-710		160	Kenneth D. Schmidt and Associates	3/1/2008	Unknown	Cooper-Jacob Straight Line[1]	1,540	17,512	109
30S/27E-20D		479-669		190	Kenneth D. Schmidt and Associates	4/1/2009	Unknown	Cooper-Jacob Straight Line[1]	1,570	18,448	97
30S/27E-20P	8/15/2006	475-730	750	30	Kenneth D. Schmidt and Associates	9/1/2006	Unknown	Cooper-Jacob Straight Line[1]	1,360	20,854	82
30S/27E-22N		410-620		210	Kenneth D. Schmidt and Associates	1/1/2007	Unknown	Cooper-Jacob Straight Line[1]	1,250	32,217	153
30S/27E-30C		545-670		50	Kenneth D. Schmidt and Associates	3/1/2008	Unknown	Cooper-Jacob Straight Line[1]	1,230	17,378	139
31S/27E-16H		440-505		24	Kenneth D. Schmidt and Associates	5/1/2007	Unknown	Cooper-Jacob Straight Line[1]	485	9,892	152
31S/27E-19A		420-510		190	Kenneth D. Schmidt and Associates	10/1/1991	Unknown	Cooper-Jacob Straight Line[1]	230	6,818	36
									count	26	26
									minimum	6,684	15
									maximum	46,000	168
									average	21,864	75

1 - Test results available in graphical form only; detailed drawdown data not available for review.

Table 3-3: Supplemental Aquifer Test Data in the Plan Area

Well Identification	General Location in KRGSA	Total Length of Perforations (feet)	Transmissivity (ft²/day)		Hydraulic Conductivity (ft/day)	
			Minimum[1]	Maximum[2]	Minimum[1]	Maximum[2]
29S/26E-4D1	Northwest corner	362	21,388	61,489	59	170
30S/26E-26G1	West-central	700	N/A	48,122	N/A	69
30S/26E-35K01	West-central	699	43,042	65,098	62	93
31S/26E-31A1	Southwest	290	6,684	14,036	23	48
31S/28E-31N1	South-central to Southeast	600	8,555	38,765	14	65
32S/26E-2F1	Southwest corner	573	7,486	26,734	13	47

[1] Most minimum values calculated from recovery data in pumped well
[2] Most maximum values calculated from test data in observation wells
N/A - not available
Modified from Dale, et al., 1966, Table 7

As summarized on **Table 3-2**, 26 wells within the KRGSA provide reliable pumping test data to estimate aquifer parameters. **Table 3-2** summarizes the transmissivity values (at lower right); as shown T values within the KRGSA range from approximately 6,700 to 46,000 ft^2 per day, with an average of approximately 21,900 ft^2 per day. The transmissivity values were divided by the total sand screened in each well to estimate horizontal hydraulic conductivity (K) values for the aquifer. As shown on **Table 3-2**, these horizontal hydraulic conductivity values range from around 15 to 170 feet per day. The average hydraulic conductivity is 75 feet per day, which is representative of clean sand (Todd and Mays, 2005).

Table 3-3 summarizes data from six pumping tests conducted by USGS in the 1960s. The first three tests listed on **Table 3-3** were conducted in the northwest and west-central portions of the KRGSA in areas near the more recent pumping tests described in **Table 3-2**. Average T and K values are higher than more recent pumping tests (47,000 ft/day and 75 feet per day, respectively), which may be affected by test parameters (pumping rates and duration not available for review) and/or the different method of data analyses. Nonetheless, values for the first three tests on **Table 3-3** indicate permeable sands with relatively high transmissivity similar to the more recent test results. The three remaining USGS tests were conducted in the southern and southeast portions of the KRGSA where increasing clay deposits have been mapped. As shown on **Table 3-3**, T and K values for these wells are lower, indicating the presence of less permeable material throughout the Principal Aquifer.

3.3 GROUNDWATER CONDITIONS

Current and historical groundwater conditions are described in this section to provide context and a basis on which to analyze sustainability indicators, develop sustainable criteria, and identify actions and projects to achieve and maintain sustainable groundwater management. The response of the groundwater system to various hydrologic conditions over time is examined using water level hydrographs, groundwater elevation maps, and estimates of changes in groundwater storage. Historical groundwater conditions are analyzed over the 20-year Study Period (WY 1995 – WY 2014) and current conditions are represented by 2015.

3.3.1 Groundwater Occurrence and Flow

Groundwater beneath the KRGSA Plan Area occurs under unconfined to semi-confined conditions in the northern and central KRGSA. Groundwater conditions transition to more confined in the southern KRGSA where shallow clays impede surface recharge. The Principal Aquifer contains a water table that fluctuates seasonally primarily due to managed recharge and groundwater pumping; surface water and groundwater has been managed conjunctively in the Plan Area for more than 120 years.

Groundwater flow in the KRGSA Plan Area is highly influenced by the Kern River. A groundwater mound forms beneath the River during wet periods reflecting surface recharge along the River channel, banking facilities, and unlined canals. Mounding beneath the River results in divergent flow directions to the north and south of the River. When the channel is dry, the mound dissipates, allowing groundwater to flow beneath the River and from one side to the other controlled by hydraulic gradients.

Groundwater levels are generally lower north of the Kern River, controlling subsurface flow to the north. South of the Kern River, groundwater generally flows to the south across the KRGSA. However, local gradients are dynamic and groundwater flow directions are also influenced by local pumping and groundwater banking operations both inside and adjacent to the KRGSA Plan Area. Data and analyses used to further examine groundwater conditions are described below.

3.3.2 Groundwater Elevations

Trends and fluctuations of groundwater elevations in the KRGSA Plan Area are evaluated over the last 50 years using hydrographs constructed from water levels in Plan Area wells. Groundwater elevation contour maps are used to analyze and describe groundwater flow conditions for the historical Study Period (WY 1995 through WY 2014) and recent conditions. A set of Subbasin-wide groundwater elevation contour maps were available to analyze flow directions and horizontal hydraulic gradients. Maps were also used to estimate changes in groundwater in storage over the Study Period.

3.3.2.1 Hydrograph Development

Water levels have been measured within the KRGSA since at least the 1920s, but data availability increases significantly starting in the 1960s, providing a more complete record of water level trends and fluctuations over the last 55 years. Long-term records of water levels in wells within the KRGSA are maintained by several agencies, including KCWA, DWR, and the California Statewide Groundwater Elevation Monitoring (CASGEM) program (also managed by DWR).

Water level data were available at approximately 1,100 wells within the KRGSA. Draft hydrographs were generated electronically for approximately 160 of these wells based on the availability of at least 100 water level measurements. After additional analysis and review, 20 of the hydrographs were selected to illustrate representative long-term trends and fluctuations throughout the KRGSA Plan Area; selected hydrographs are illustrated on **Figure 3-24**. The hydrographs are identified by their unique state well number and also numbered consecutively from 1 to 18 (two graphs show a paired well scenario) for reference. Hydrographs show each well's respective historical water level record between 1965 and 2017. Data are presented as elevation, referenced to mean sea level (msl). The vertical scale of the hydrographs is standardized on **Figure 3-24** from 0 (sea level) to 450 feet msl to facilitate comparisons. The ground surface elevation and depths to the screened intervals are added to the hydrographs when available.

3.3.2.2 Water Level Trends and Fluctuations

Long-term trends in Kern County Subbasin water levels are controlled by both changes in groundwater use and the occurrence of wet and dry hydrologic cycles over time. Although surface water had been used for agricultural irrigation since the late 1800s, an increase in groundwater production occurred in the 1940s associated with increased agricultural production and population growth. Water levels in the KRGSA began a long and sustained decline of about 150 feet from 1945 through the drought of 1977. The portion of this decline from 1965 to 1977 is best illustrated by the long and most complete record on Hydrograph 14 on the lower left of **Figure 3-24**.

The decline through 1977 was arrested, in part, by the wet hydrologic conditions between 1978 and 1983, which allowed water levels to recover across the basin, as illustrated by hydrographs 1, 7, 11 through 14, and 17 (among others). In addition, the widespread availability of imported surface water in the late 1970s contributed to some of the water level recovery across the Subbasin and in the eastern KRGSA. Water levels declined during the drought period of the late 1980s and early 1990s, and then rose in the late 1990s during wet conditions. Water levels declined in the early 2000s and rose slightly during the wet period in 2010 and 2011. After 2011, water levels declined as the result of a severe drought and historic low water levels were reached from 2013 to 2017. Most wells declined about 40 to 50 feet during this recent drought. Wells in the western Plan Area declined more than 50 feet during this period due to increased recovery pumping in many of the groundwater banking areas (see the concentrated areas of recharge basins in and adjacent to the western Plan Area on **Figure 3-24**).

These groundwater banking facilities create larger fluctuations in groundwater elevations than occur elsewhere in the Plan Area (e.g., see hydrographs 16 and 17). As shown on hydrograph 16, wells adjacent to the banking projects can fluctuate more than 200 feet from recharge to recovery operations. The trends and fluctuations near the banking projects typically mirror hydrologic wet and dry cycles because projects generally have more water for recharge during wet periods and need to recover that water for banking partners during droughts. Influences from the banking projects are seen in most wells in the west-central portion of the KRGSA (**Figure 3-24**).

Water levels in wells that are close to the Kern River and away from the groundwater banks (hydrographs 2 through 5) have lower fluctuations and exhibit a distinct seasonal response. The water levels typically peak in the spring and reach their lowest levels in the fall. Groundwater is relatively shallow in wells within close proximity to the River, as illustrated on Hydrograph 3.

Wells on **Figure 3-24** that are farther from the Kern River and groundwater banking facilities are mostly influenced by regional hydrologic cycles and trends and fluctuations are often less pronounced. Some fluctuations appear anomalous and may be due to local pumping. Nonetheless, almost all hydrographs here exhibit a declining trend in water levels with levels at or near historic lows during the recent drought of record (2013-2016). Hydrographs 1, 2, 9 through 15, 17, and 18 show these basin-wide responses.

Hydrographs, 6, 7, and 8 illustrate representative water levels at wells in the eastern KRGSA. Water levels in this area indicate an overall decline from the 1960s to the early 1980s and then generally flatten with small overall fluctuations. SWP water became available for irrigation near this area in the early 1980s and could have some influence on these levels. Hydrograph 6 shows basin-wide water level trends until 1982, then relatively even pumping cycles until the late 1990s. After 1998, these cycles are less evident and water levels become relatively stable. Hydrographs 7 and 8 show water levels that generally follow regional trends until about 1987, but then become relatively steady until they decline around 2015. Hydrograph 8 may be influenced by a local pond. Water levels at these hydrographs may also be influenced by the lower permeability soils and subsurface clay in this area.

As shown on the hydrograph location map on **Figure 3-24**, there is an area where shallow water levels have been observed in the southern and eastern regions of the KRGSA. This area generally coincides with the low permeability flood basin and lake bed deposits as discussed previously in **Section 3.2**. In particular, the geologic maps on **Figures 3-2** and **3-4** show the location of flood basin and lake bed deposits in the Plan Area; these clay-rich units are also reflected on the soil textures map on **Figure 3-8**. In these areas, the shallow clay-rich sediments impede the downward percolation of agricultural irrigation and other surface water applications. Water is trapped temporarily creating perched conditions locally. This water surface is irregular, varies with local irrigation and local conditions, and does not reflect a water table or a separate Principal Aquifer. Rather these clay-rich sediments represent the only mappable aquitard in the local groundwater system. Cross Sections 2-2' (**Figure 3-21**) and 3-3' (**Figure 3-22**) show the occurrence of these clays in the subsurface and Cross Section 3-3' illustrates the area of perched water (**Figure 3-22**). Hydrographs 9 and 10 on **Figure 3-24** show a grouping of two closely-spaced wells, one within the perched zone and one just outside of the zone. Wells screened in the perched water zone have shallow groundwater levels with minimal fluctuations while nearby wells outside of the perched zone (and in some areas below the zone) have deeper groundwater levels that are more representative of basin-wide water levels.

3.3.2.3 Groundwater Elevation Contour Maps

Groundwater elevation contour maps prepared by KCWA have been used to examine groundwater flow patterns in the KRGSA Plan Area. KCWA prepares annual contour maps from water levels measured in the spring, prior to the summer irrigation season when numerous cones of depression complicate local groundwater flow and make consistent mapping difficult. Electronic files of annual Spring groundwater elevation contour maps were obtained from KCWA for 1995 through 2015, except for 1996 and 1997 when no electronic contour maps were available; these maps are reproduced in **Appendix G**. Maps representing wet and dry groundwater conditions are described in more detail below.

3.3.2.4 Groundwater Elevations and Flow

The KCWA Spring contour map for 1998 is provided as **Figure 3-25** to illustrate groundwater flow patterns in the KRGSA Plan Area when water levels were the highest during the 20-year Study Period (WY 1995 – WY 2014). During the wet year of 1998, precipitation and Kern River flows were 223 percent and 236 percent of the long-term averages, respectively (see **Figures 3-9 and 2-10**). As shown on **Figure 3-25**, groundwater elevations range from above 300 feet msl along the Kern River and in groundwater banking areas to below 150 feet msl in the northwest and southeast edges of the Plan Area. The recharge mound near the River creates divergent flow to the north and south, with water levels above 200 feet msl over almost all of the Plan Area. The higher water levels above 200 feet in the southern KRGSA may be influenced by local perching conditions. As groundwater levels rise, it becomes more difficult to differentiate the water table from perched water in low-permeability clays.

As indicated by **Figure 3-25**, subsurface outflows occur along the northern and southeastern KRGSA boundaries. Elevated water levels in the banking areas both inside and adjacent to the west-central KRGSA cause both subsurface inflows and outflows in that area. Subsurface flows along the southern Plan Area boundary are complicated due to subsurface clay deposits and the dynamic and changing groundwater flow conditions in the southern KRGSA resulting from recharge in basins and canals, and local pumping.

The groundwater elevation contour map for spring 2015 data is shown on **Figure 3-26** and illustrates the lowest water levels for any spring map during the Study Period. During spring 2015, groundwater elevations are lower than 200 feet msl over almost all of the KRGSA. Although groundwater elevations on **Figure 3-26** appear higher than 350 feet msl in the northeast, data are sparse, and contours are considered less accurate in this area on most of the maps. A comparison of the two maps on **Figures 3-25** and **3-26** shows that groundwater elevations in 2015 are lower than elevations in 1998 by about 50 feet to 100 feet throughout most of the KRGSA. The highest groundwater elevations along the Kern River are similar to 1998 levels, but cover a smaller area (e.g., areas higher than 300 feet msl).

Although water levels are lower in spring 2015 than in 1998, the levels in 2015 are generally higher than surrounding areas. As such, subsurface outflows are indicated along most of the KRGSA Plan Area boundary (**Figure 3-26**).

Groundwater elevations during these two time periods illustrate that groundwater flow is highly influenced by recharge along the Kern River and by activities at the groundwater banking facilities. Although water levels on the 1998 map are significantly higher throughout most of the KRGSA Plan Area than in 2015, general groundwater flow patterns within the Plan Area are similar. Groundwater mounds beneath the eastern stretch of the River cause divergent flow to the north and south away from the River. During the 1998 wet period, this mound extended along the extent of the Kern River causing divergent flow away from the River throughout the entire stretch within the GSA. But, during the drier periods such as in 2015, the mound covers a smaller area and does not extend to the western reach of the River. Subsurface flows are dynamic and vary over hydrologic conditions and the operations (recharge and recovery) at local banking facilities both inside and adjacent to the KRGSA Plan Area.

3.3.2.5 Current Conditions and Historic Low Groundwater Levels

Although groundwater conditions during spring 2015 represent the lowest water levels for spring conditions during the Study Period, hydrographs on **Figure 3-24** indicate that historic low levels were observed during fall 2015 conditions for many of the representative wells. To further examine water levels during the historic low time period, an additional map was constructed using data from fall 2015 for GSP analysis. This map, shown on **Figure 3-27**, indicates that groundwater elevations are lower than the spring 2015 levels by up to about 50 feet in some areas. For example, groundwater elevations at the northwest boundary of the Plan Area are about 100 feet msl in spring (**Figure 3-26**) and below 50 feet msl in the fall (**Figure 3-27**).

During fall 2015, groundwater elevations were below 150 feet msl over most of the Plan Area and below 100 feet msl in areas along the southern KRGSA border (**Figure 3-27**). In contrast, the area below 150 feet msl during fall 2015 (**Figure 3-27**) was generally below the 250-foot contour in spring 1998 (**Figure 3-25**), indicating water levels about 100 feet lower than high water levels associated with wet years. These historic low water levels in the northern Plan Area impacted municipal wells. During this time period, water levels dropped below the top of screens and, in some cases, below well pump intakes in dozens of municipal wells. Most of the impacted wells were located adjacent to and east of Highway 99 and clustered on both sides of Highway 58. In this area, a groundwater elevation of 150 feet msl is equivalent to a water depth of about 250 (i.e., ground surface elevation of 400 feet msl), lower than the top of screens in almost one-half of the local City and Cal Water municipal wells (with an average top of well screen at about 290 feet below ground surface). Water levels in spring 2015 (**Figure 3-26**) were close to well screens but slightly higher than in fall 2015.

There is significant uncertainty in comparing the two maps from 2015 on **Figures 3-26** (spring) and **3-27** (fall). The spring 2015 map was prepared by KCWA on a specific subset of wells used for consistent spring mapping throughout the Subbasin. The fall 2015 map was prepared using additional data from DWR and KDWD. Although KDWD has maintained a water level monitoring program for many years, many program wells are production wells with incomplete data on ground surface elevation and well construction. KDWD is working on improvements to the in-district monitoring program including identification of dedicated monitoring wells with construction data and measurements of reference point elevation. When completed, those wells will be selected for inclusion in the GSP monitoring networks for minimum thresholds, as appropriate.

3.3.3 Estimate of Change in Groundwater in Storage

Groundwater elevation contour maps prepared for spring conditions over the 20-year Study Period (WY 1995 through WY 2015) have been evaluated to estimate the change in groundwater in storage. The KCWA spring maps were chosen for the analysis because they provide the most complete set of groundwater elevation maps that use methodologies and data sets across the Subbasin. These maps are designed to represent seasonal high groundwater conditions.

The analysis used GIS to electronically subtract groundwater elevations on one map from elevations on the previous map in the time series to provide an average net change in water levels across the contoured area. This net change in water levels was multiplied by an estimated value of aquifer storativity. Because the changes are interpreted to occur primarily in the unconfined zone of the Principal Aquifer, the storativity parameter is represented by a specific yield (generally equivalent to effective porosity, expressed in percent). An average specific yield of 10 percent was applied, given that most of the Plan Area is underlain by relatively permeable soils and sediments.

A graph depicting the estimated annual and cumulative changes in groundwater in storage is included on **Figure 3-28**. The graph covers 19 years of the 20-year period because there wasn't a map available for 1994; as such, the graph begins with the change from spring 1995 to spring 1996. Because the change from spring 1994 to spring 1995 represents a change from a critically dry year to a wet year, the resulting change in groundwater in storage would likely be positive; therefore, the exclusion of the change from 1994 to 1995 is considered conservative. Also, as mentioned previously, individual spring maps for 1996 and 1997 were unavailable. Accordingly, the change that was estimated from 1995 to 1998 (about 580,000 AF) has been partitioned equally among the first three change periods of 1995-1996, 1996-1997, and 1997-1998 (**Figure 3-28**). This methodology was determined to be reasonable based on a consistent annual rise in water levels during each of these years as observed on many representative hydrographs in the Plan Area.

As shown on **Figure 3-28**, annual changes in groundwater in storage range from 435,539 AFY (2011-2012) to -533,901 AFY (2012-2013). Over the 230,830 acres of the Plan Area and using an average specific yield of 10 percent, an annual change in groundwater in storage of about 500,000 AFY represents an average rise (positive number) or decline (negative number) in water levels of about 22 feet. Because these numbers represent annual *changes*, the graph does not always reflect the actual annual hydrologic condition. For example, 2005 was a wet year with a Kern River Index and annual precipitation of 159 percent and 150 percent of the long-term average, respectively. However, groundwater elevations over the KRGSA Plan Area for spring 2005 were very similar to elevations for spring 2004; accordingly, there was only a small change of groundwater in storage from 2004 to 2005 as indicated on **Figure 3-28**, even though overall annual conditions of water availability may have improved.

The cumulative change of groundwater in storage is shown by the red curve on **Figure 3-28**. This curve sums previous change estimates and provides a running total of the overall change in storage. As shown on the graph, the cumulative change in groundwater in storage was -55,325 AF at the end of the Study Period. In general, the pattern illustrated by the cumulative change curve is consistent with the trends and fluctuations observed for the Study Period on representative hydrographs (e.g., see hydrograph 15 on **Figure 3-24**). This check suggest that the analysis results are reasonable.

The negative cumulative change in storage is expected, given that the Study Period begins in a wet year and ends in a critically dry year during the recent severe drought. However, conditions at the beginning and end of a Study Period do not necessarily reflect unsustainable conditions; rather, the average annual change over the Study Period is more relevant to this analysis. As noted on **Figure 3-28**, the average annual change of groundwater in storage is estimated at -2,912 AFY. Although negative, this volume of groundwater in storage is sufficiently small to be well within the uncertainty of the analysis as discussed below.

As requested in the GSP regulations, the water year type for each year in the analysis is also included on the graph. As discussed in **Section 3.2.4.1** and noted on **Figure 3-9**, the water year type is based on the San Joaquin Valley indices that do not exactly align with wet and dry periods in Kern County. Further, water conditions in the KRGSA Plan Area are related more to surface water availability than precipitation.

The analysis contains inherent uncertainties. A review of the contour maps indicates portions of the Plan Area where contours do not extend due to inadequate water level data (for example, see the northeastern portion of the KRGSA Plan Area on **Figures 3-25, 3-26** and **3-27**). To remove bias in these areas, only the contoured area from each map was included in the analysis. Because groundwater elevations range over several hundred feet across the KRGSA Plan Area, the contour interval on the groundwater elevation maps is relatively large (50 feet). This introduces significant uncertainty due to the inability to detect small changes in water levels across large areas. The specific yield is not known with certainty and other reasonable estimates of specific yield would result in different values of change in groundwater in storage. Finally, because of the regional nature of the contour maps, the application of an average specific yield and an average change in elevation across the contoured area, while appropriate, is not precise.

This analysis provides an independent method for estimating changes in groundwater in storage beneath the KRGSA Plan Area over time. However, given the uncertainties, the method cannot be relied on solely for the sustainability analysis. Two additional methods – a "checkbook" accounting of inflows/outflows and groundwater modeling – are also used to estimate changes in groundwater in storage for further analysis and comparisons. Annual groundwater use and other water budget components of inflows and outflows for the Study Period are included in the water budget discussion in **Section 4**.

3.3.4 Groundwater Quality

The water chemistry of KRGSA groundwater is similar to local surface water and contains relatively low TDS levels resulting, in part, from decades of actively managed recharge of both local and imported surface water supplies in the Plan Area. In general, groundwater quality in the Plan Area has been sufficient to meet designated beneficial uses in the Plan Area including municipal, industrial, and agricultural water supply and recreational/environmental uses.

Groundwater quality constituents of concern vary among beneficial uses. Large municipal wellfields in the urbanized northern Plan Area and smaller community water systems throughout the Plan Area rely on groundwater supplies for drinking water. For these systems, state-level drinking water standards apply as provided in Title 22 of the California Code of Regulations. For the large agricultural areas in the southern KRGSA Plan Area, salinity and specific ion toxicity to crops are of more concern. The SWRCB publishes a compilation of Water Quality Goals (SWRCB, 2016), including numeric thresholds such as maximum contaminant levels (MCLs) or Public Health goals. Agricultural Water Quality Thresholds are also included in the Water Quality Goals for various agricultural uses of water including irrigation of various crop types and livestock watering.

Recently, two water quality constituents of concern for drinking water – 1,2,3-trichlorpropane (TCP) and arsenic – have been detected above the MCL in numerous KRGSA wells. These detections have required increased management of wellfields including taking wells offline, wellhead treatment, and, in some cases, groundwater litigation. Locations and concentrations of these constituents, information on local groundwater chemistry, water quality data sources, and other constituents of concern are described in the following sections as the foundation for establishing sustainable management criteria and developing appropriate management actions relating to groundwater quality.

USGS has conducted numerous regional water quality investigations in the southern San Joaquin Valley and Kern County (e.g., Dale et al., 1966; Shelton, et al., 2008; Burton, et al., 2012) that provide information on groundwater chemistry in the KRGSA Plan Area. In addition, various regulatory programs administered by the Central Valley Water Board and the California Department of Toxic Substances Control (DTSC) have generated local water quality data and information within portions of the Plan Area including the Irrigated Lands Program and various environmental investigation and clean-up programs. Finally, water quality monitoring in municipal wells and the related preparation of Consumer Confidence Reports also provides data and information on local groundwater quality. Although these programs all vary with respect to objectives and regulatory standards, each provides a source of groundwater quality data for the characterization of groundwater quality conditions in the Plan Area.

3.3.4.1 Regional Groundwater Chemistry

USGS has identified regions of similar groundwater chemistry in the southern San Joaquin Valley based on distances from the valley margins; spatial groups of groundwater chemistry are categorized as *east side* (including the KRGSA Plan Area), *west side*, and *axial trough of the valley* (Dale et al., 1966). East side groundwater quality, including the KRGSA Plan Area, is characterized as a bicarbonate type with relatively low TDS, reflecting the geologic units in the groundwater source areas of the granitic Sierra Nevada (Dale et al., 1966). Groundwater quality in the KRGSA Plan Area also reflects the quality of the Kern River, the primary source of recharge to the KRGSA aquifers. Geochemical plots of Kern River and groundwater samples confirm the bicarbonate-carbonate chemistry in the KRGSA Plan Area (DBS&A, 2012).

West side groundwater chemistry (outside and west of the KRGSA) is defined as a sulfate or chloride type with higher TDS concentrations than the east side groundwater. Groundwater chemistry on the west side reflects the quality of the surface waters that drain the Miocene-Pliocene marine sediments of the Temblor Range west of the basin (Dale et al., 1966; Wood and Dale, 1964). Because of the smaller amount of surface water runoff in the west, the sulfate type of groundwater is less prevalent than the bicarbonate type.

Groundwater quality in the axial trough (near the southwestern KRGSA) is a mixture of east side and west side groundwater, as well as surface water that percolates to the aquifer. Groundwater is sodium type but varies in concentration and chemical character. The boundary between the axial trough and west side groundwater is approximated along the West Side Canal, located west of the KRGSA Plan Area (Dale et al., 1966).

3.3.4.2 Local Groundwater Chemistry

Recent USGS groundwater quality analyses involving wells located throughout the KRGSA Plan Area provide additional information on local groundwater chemistry (Shelton, et al., 2008; Burton, et al., 2012). As mentioned previously, USGS dated groundwater beneath the KRGSA Plan Area as primarily of Modern age (post 1953) associated with recharge of the Kern River and other surface waters. Older groundwater (mix of Modern and Pre-Modern) was indicated in deeper wells and in the southern KRGSA Plan Area where shallow clays produce more confined groundwater conditions.

USGS also evaluated redox conditions in local groundwater to identify areas of oxic (oxidized) and anoxic (reduced) geochemical environments (Shelton, et al, 2008; Burton, et al., 2012). The redox state of groundwater can affect the occurrence and concentrations of both naturally-occurring and human-related contaminants. As part of that study, USGS concluded that groundwater in the northern and central Plan Area occurs under oxic conditions (well screens from about 350 to 700 feet) with relatively high dissolved oxygen content, especially below the Kern River and other local groundwater banking projects. Although no wells in the southern Plan Area were included in the sampling, anoxic conditions are indicated just south of the Plan Area, consistent with the presence of the clay soils and sediments at and beneath the paleo-lakebeds. In this area, clay soils limit recharge and exposure of the groundwater to oxygenated (atmospheric) conditions. Anoxic conditions were also observed in deeper wells along the eastern Plan Area boundary. In addition, anoxic conditions, groundwater pH, and elevations of trace metals such as arsenic tended to increase with depth (Burton, et al., 2012).

A 2015 groundwater quality assessment of salts, nutrients and pesticides in Kern County provides additional information to characterize local groundwater quality (P&P, et al., 2015). This study, titled *Groundwater Quality Assessment Report* (GAR) was conducted by the Kern River Watershed Coalition Authority as part of the Irrigated Lands Program for the Central Valley Water Board. The study included compilation of a database containing more than 100,000 records of TDS, nitrate, and pesticide concentrations from 1909 to July 2014 (P&P, et al., 2015). Data sources for the database include California Department of Public Health (CDPH, now California Division of Drinking Water as part of the SWRCB), DWR, KCWA, USGS, and other sources. Todd Groundwater, as a subconsultant to Provost and Pritchard (P&P), analyzed these data to support a groundwater vulnerability assessment for the GAR. The GAR database, along with additional references and data, was used to characterize these constituents in the KRGSA Plan Area as discussed below.

3.3.4.3 Total Dissolved Solids

Total dissolved solids (TDS) represents the total concentration of anions and cations in groundwater and is used as an indicator of mineralization, salt content, and overall water quality. TDS concentrations up to 1,000 mg/L are typically defined as fresh water, although USGS has defined concentrations up to about 2,000 mg/L as fresh water in other studies (Page, 1973). California has identified 1,000 mg/L as the upper range for a secondary MCL for drinking water, with a recommended secondary MCL[22] of 500 mg/L. TDS concentrations below 450 mg/L are recommended for irrigation of salt sensitive crops.

The TDS content in Plan Area groundwater is influenced by local recharge of both the Kern River and SWP water. From 1995 to 2007, TDS concentrations of the Kern River have ranged from 28 mg/L to 215 mg/L with an average of 97 mg/L (DB&A, 2012; KFMC, 2011). TDS in SWP water imported into Kern County[23] has averaged about 245 mg/L over the 20-year historical Study Period (WY 1995 – WY 2014) with slightly lower averages in wet years and higher averages in dry years. During the drought conditions of WY 2015 – WY 2016, the average monthly TDS in SWP water increased slightly to about 301 mg/L.

TDS concentrations compiled for the GAR study (P&P, et al., 2015) for the 20-year Study Period are illustrated on **Figure 3-29.** Concentrations are illustrated as yellow circles (below the secondary maximum contaminant level (MCL) of 500 mg/L), green circles (between 500 and 1,000 mg/L), blue circles (between 1,000 and 1,500 mg/L), and red circles (above 1,500 mg/L). In order to readily identify any areas of concern, the highest TDS concentration at any given well is represented on **Figure 3-29**.

TDS concentrations in the Kern County Subbasin average between 400 and 450 mg/L but can range up to 5,000 mg/L (DWR, 2006). As shown on **Figure 3-29**, TDS concentrations in groundwater throughout most of the KRGSA are below 1,000 mg/L. Concentrations of TDS are lowest (less than 500 mg/L) in the vicinity of the Kern River and south of the Kern River extending through most of the southern Plan Area. TDS concentrations are higher (above 1,000 and 1,500 mg/L), along the southern rim and extending northward in the southeastern KRGSA. In general, elevated TDS concentrations occur within and near the area where perched water has been observed (**Figure 3-29**) and may indicate concentrations of salts in the clay soils where surface water does not readily infiltrate into the subsurface.

Recent TDS concentrations from municipal wells in Metropolitan Bakersfield are consistent with historical values and average about 208 to 244 mg/L (Cal Water, 2017). During 2017, TDS concentrations in municipal wells ranged from 120 mg/L to 860 mg/L. TDS concentrations are slightly higher in deeper wells and increase with distance from the River, especially north of the River. TDS is also higher in the northeastern Plan Area, consistent with data presented on **Figure 3-29**.

3.3.4.4 Nitrate

Nitrate is a naturally occurring form of nitrogen that can be produced in relatively low concentrations from the atmosphere or from decomposing organic matter (P&P, et al., 2015). Sources of nitrate in

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[22] A secondary MCL is not related to public health and typically refers to the odor, taste, and appearance of drinking water.
[23] California Aqueduct samples near Highway 119 (Check 29), from KFMC, 2018.

groundwater include excess application of nitrogen fertilizer in irrigated areas, feedlot and dairy drainage, leaching from septic systems, wastewater percolation, industrial wastewater, aerospace activities, and food processing wastes. Elevated nitrate in groundwater in the Tulare Lake Basin has been linked primarily to crop and animal agricultural activities with urban wastewater, septic systems, and other sources identified as significant in localized areas (Viers, et al., 2012). Nitrate (as NO_3) has an MCL of 45 mg/L for drinking water.

Concentrations of nitrate (as NO_3) from the GAR database are shown on **Figure 3-30** for the KRGSA Plan Area. Also included on the figure for reference are areas of irrigated agriculture, dairies, and wastewater treatment plants. Nitrate concentrations represent maximum values over the Study Period and are illustrated as yellow circles (below its primary MCL of 45 mg/L), orange circles (between 45 and 90 mg/L) and dark red circles (greater than 90 mg/L). As shown on the figure, most nitrate concentrations are below the MCL throughout the Plan Area. Localized areas have a well that has exceeded the MCL at least once during the Study Period. Most of the elevated detections in the southern Plan Area are in agricultural areas with some detections near a dairy or a wastewater treatment facility. In addition, the detections are in rural areas where domestic septic systems may also be a contributing factor.

There is also an area of nitrate detections exceeding the MCL in the northwestern Plan Area, generally north of the Kern River and west of Highway 99, which is outside of agricultural areas (**Figure 3-30**). In addition, most of the highest concentrations (more than twice the MCL concentration) are located along the eastern margin of the Plan Area; a 2015 study found that areas of elevated nitrate concentrations occurred all along the eastern margin of the Subbasin including areas north of the KRGSA Plan Area (P&P, et al., 2015).

In the east-central KRGSA Plan Area, several small water systems have detected elevated nitrate in drinking water wells (AECOM 2019). The State of California is planning to fund the consolidation of these systems with ENCSD, where nitrate levels in groundwater are relatively low (average of 3.2 mg/L in 2019 samples for all wells) (project described in **Section 7.1.4**).

The source of each elevated nitrate concentration shown on **Figure 3-30** is not known. However, a 1970 study by DWR identified elevated nitrate concentrations in many of these same areas using historical water quality data from 1966 through 1970 (DWR, 1970). The GAR produced an overlay of the elevated nitrate from the DWR study (P&P, et al., 2015). The observation that these areas have been associated with elevated nitrate since the 1960s suggests that some of the concentrations may be legacy issues that occurred from early inefficient agricultural practices or other historical sources. In the eastern and southern KRGSA, clay soils and underlying sediments would be expected to impeded vertical movement of nitrogen in the vadose zone, delaying the transport of nitrate to groundwater by decades (P&P, et al., 2015).

Nitrate in KRGSA groundwater is best handled through Best Management Practices (BMPs) for nitrate application. Ongoing nitrate monitoring and BMPs for nitrate management are regulated by the Central Valley Water Board through its Irrigated Lands Regulatory Program (ILRP). These efforts are being coordinated on a semi-regional basis by the Kern River Watershed Coalition Authority (KRWCA). The

KRWCA consists of a collection of agricultural water districts in the Kern County Subbasin including KDWD. This GSP intends to cooperate and coordinate with this program to compile and analyze nitrate data and encourage BMPs for nitrate management throughout the KRGSA.

3.3.4.5 Pesticides

Pesticide impacts to groundwater can result from over-application in agricultural areas, landscaping/lawn and garden areas, and along roads and railways for weed control (P&P, et al., 2015). Although pesticides are typically soluble in water, these compounds can be highly sorptive to soils, which may impede migration to underlying groundwater. For the GAR study, investigators focused on any pesticide concentration in groundwater that had exceeded its respective MCL, public health goal, or other numeric standard (P&P 2015). Detections of approximately 60 pesticides were included in the GAR database. For completeness, data also included chemicals commonly associated with pesticides (e.g., naphthalene) even though some of these are also found in industrial/non-pesticide constituents.

Pesticide data in the KRGSA Plan Area are displayed on **Figure 3-31**. Concentrations are shown as yellow circles for samples where no pesticides were detected and orange circles for samples that detected one or more pesticides. As shown on the figure, pesticides were detected at various locations throughout the Plan Area both inside and outside of agricultural areas. As noted on **Figure 3-31**, none of the detections exceeded the respective MCL.

Almost all detections represent two soil fumigants, dibromochloropropane (DBCP) and ethylene dibromide (EDB). These pesticides have previously been detected in groundwater in the northwestern portion of the Plan Area and areas of impacts have been noted in the Kern Fan Monitoring Committee reports (KFMC, 2011). Because these detections occur in areas with current agricultural wells, the concentrations are being managed locally.

A cluster of detections at the east-central boundary of the Plan Area (on East Panama Lane north of Lamont) is associated with industrial operations rather than agriculture. These detections involve concentrations of xylenes and are associated with oil refining activities in this area. While xylenes are found in some pesticide formulations, they are also associated with petroleum hydrocarbons.

An additional contaminant associated with soil fumigants, 1,2,3-tricholorpropane (TCP) has been detected in numerous wells, including municipal wells, and is discussed separately below as a specific constituent of concern in the Plan Area.

3.3.4.6 Constituents of Concern

In addition to the salts, nutrients, and pesticides discussed above, other constituents of concern have been identified as a potential threat to water quality in the KRGSA Plan Area. Some constituents have been identified through groundwater quality monitoring in municipal wells in compliance with California Division of Drinking Water requirements. The City of Bakersfield, California Water Service Company, ENCSD, and Greenfield CWD, among others, have identified and addressed various constituents over time, most recently 1,2,3-trichloropropane (TCP) and arsenic; these two constituents are discussed in more detail below.

Also included below is a discussion of constituents associated with certain commercial and industrial sites as identified by the Central Valley Water Board and the California Department of Toxic Substances Control (DTSC). Information from these regulatory programs was reviewed for the potential for additional constituents of concern in the KRGSA Plan Area.

1,2,3-Trichloropropane (TCP)

1,2,3-Trichloropropane (TCP) is a chlorinated hydrocarbon that occurs as an intermediate in chemical manufacturing. It has also been used directly as a cleaning and degreasing solvent. TCP has also been formulated into a soil fumigant, which was used by the agricultural community through most of the 1980s (Burton, et al., 2012). Although TCP was banned from pesticides in the 1990s, its widespread occurrence in Kern County groundwater has been documented in agricultural areas. As part of the GAMA sampling program, USGS detected TCP at levels in excess of its MCL in all eight of the wells tested in Kern County (Shelton, et al., 2008).

In 2017, the State of California adopted an MCL of 0.005 ug/L, or 5 parts per trillion (ppt) for drinking water. Accordingly, many water supply systems are now beginning to monitor regularly for TCP at sufficiently low detection levels commensurate with the newly-adopted MCL. Data from the publicly-available CDPH database were reviewed for TCP detections in the Plan Area. In addition, Cal Water provided TCP data and information for the City of Bakersfield and Cal Water municipal wells dating back to 2002. Greenfield CWD also provided data for TCP concentrations in its production wells from September 1989 to January 2019. Only limited historical TCP samples are available from these data sources; more than two-thirds of the data were collected after 2009.

TCP data are compiled on **Figure 3-32**. Data are color-coded to reflect the maximum concentration detected at any given well. Green and yellow dots represent wells that have either not detected TCP or have detected it at concentrations below the 0.005 ug/L MCL. Red and purple dots represent wells with maximum detections up to twice the MCL and more than twice the MCL, respectively. TCP treatment facilities have been installed on many impacted municipal wells as shown by the black diamonds on **Figure 3-32**.

As shown on **Figure 3-32**, TCP has been detected above the MCL in municipal wellfields in the northern KRGSA, along the eastern KRGSA boundary, and in other locations in the southern Plan Area. Many of the detections outside Metropolitan Bakersfield are associated with small water systems. Since 1989, Greenfield CWD has detected TCP above the MCL in eight samples from two of its water supply wells (see the two southernmost red dots east of and adjacent to Highway 99 on **Figure 3-32**). These detections occurred in 2012 through 2014; five total samples were greater than the MCL. In the eastern Plan Area, just south of Highway 58, ENCSD and several other local mutual water companies have also reported TCP detections above the MCL in multiple water supply wells (**Figure 3-32**).

The City of Bakersfield and Cal Water have detected TCP at concentrations above the MCL in 65 municipal wells, covering a broad area of the municipal wellfields (**Figure 3-32**). The occurrence of green dots in the central municipal wellfields reflect numerous wells that have not detected TCP even though construction of those wells is similar to impacted wells. The pattern of detections and non-detections in the municipal wellfields appears to correlate roughly to now-urbanized areas that were more recently used for irrigated agriculture (into the 1980s). As such, these detections are considered a legacy issue associated with a broad area of historical "non-point" sources and are not considered to be distinct plumes of contaminants.

In 2017, the City and Cal Water settled a lawsuit against the Dow Chemical Company and Shell Oil Company, the manufacturer of the TCP-contaminated soil fumigant, for damages relating to TCP contamination. The case was brought by the City and Cal Water to recover cleanup and treatment costs for impacted municipal wells. To date, Cal Water and the City have installed granular activated carbon (GAC) treatment on 56 of the 65 wells to treat elevated concentrations of TCP throughout their systems; wells with TCP treatment are highlighted on **Figure 3-32**. Ongoing wellhead treatment, along with blending and redistribution of pumping, is expected to manage this constituent of concern in the urban areas. Greenfield CWD and ENCSD have similar lawsuits pending. In addition, ENCSD has secured a State grant that will address TCP concentrations, if detected, as several small local water systems are being consolidated into the ENCSD system (AECOM, 2019). This project, described in **Section 7.1.4**, includes several of the exceedances of TCP in small water systems along the eastern border of the Northern Plan Area (**Figure 3-32**).

The nature and extent of TCP in the remaining portions of the Plan Area are not yet well understood due to a lack of historical data. As a fumigant applied at the surface, higher concentrations have generally been observed in the shallower wells. TCP has been detected in most of the non-municipal wells with TCP analyses. Concentrations of TCP in agricultural wells are not expected to adversely impact the beneficial use of those wells. Public water supply wells will continue to be tested for TCP concentrations as required by the SWRCB, Division of Drinking Water; these data will be compiled periodically and reviewed by the KRGSA to ensure that management actions do not exacerbate the extent of TCP in groundwater.

Arsenic

Arsenic is a naturally-occurring trace element in the rocks, soils, and groundwater of the Kern County Subbasin and the Plan Area. Arsenic occurs through dissolution of iron or manganese oxyhydroxides under reducing conditions. Dissolved arsenic can also result from pH-dependent desorption under oxic conditions. In general, elevated arsenic concentrations are correlated to deeper groundwater where the dissolved oxygen content is low, and pH is high. The occurrence of elevated arsenic concentrations in the KRGSA Plan Area is generally consistent with these conditions, but these conditions are not always associated with elevated arsenic concentrations (Burton, et al., 2012). This suggests that arsenic can also occur in oxic groundwater with elevated pH, conditions that have also been documented in the Plan Area. USGS also suggests that arsenic is more widespread in the distal portions of the Kern County Subbasin (Burton, et al., 2012) referring to the downstream portions of the alluvial fans at the Kern and Buena Vista lakebeds in the southern Plan Area. The California MCL for arsenic is 0.010 mg/L (10 ug/L).

Elevated arsenic concentrations have been detected in municipal wells in the northwest and east-central Plan Area. **Figure 3-33** shows detections of arsenic in Bakersfield municipal wells (including wells owned by the City and Cal Water). Data are represented by the highest concentration detected over the last 25 years; the date associated with the maximum arsenic detection is also provided on the figure. Concentrations are color-coded with green and yellow dots indicative of wells that have either not detected arsenic or detected it at lower levels only (below the MCL). Red dots and purple dots indicate about 27 wells that have detected arsenic at levels up to twice the MCL (20 ug/L) and above, respectively. Arsenic treatment facilities have been installed on eleven wells as shown by the black diamonds on **Figure 3-33** (one treatment facility currently is in design).

Data on **Figure 3-33** indicate primary areas of elevated arsenic concentrations including a cluster of wells southeast of the intersection of Highways 58 and 99 and additional wells in the western Plan Area north of the Kern River and in the groundwater banking areas. For the wells in the southeastern portion of the map, most of the elevated arsenic concentrations occurred in the 1990s. This occurrence may be attributable more to older laboratory methods for analysis of arsenic than actual elevated concentrations. Concentrations after about 2009 are generally below the MCL in almost all of these wells and most data do not support increasing trends. However, water supply wells farther south, owned by Greenfield County Water District GSA, have detected arsenic in past samples and two wells are being equipped with arsenic treatment (see southern-most wells on **Figure 3-33**, east of Highway 99). An additional municipal well in the area west of Highway 99 is also being treated for arsenic. Farther east, several wells owned by ENCSD exhibited increasing arsenic detections during the recent drought (see ENCSD wells on **Figure 3-33**, north of Highway 58 on the eastern portion of the map). In general, arsenic concentrations are lower west of Highway 99 and south of the Kern River.

For arsenic detections in the northwest (**Figure 3-33**), maximum concentrations have generally occurred in recent years when water levels have been declining. Many of these wells suggest an inverse relationship between arsenic concentrations and water levels; that is, arsenic concentrations increase as water levels decrease. These wells are screened across 300 feet of the alluvial aquifer from 400 feet to 700 feet. As water levels decline, deeper zones may be contributing more water to each well's total production, especially in wells where pumps have been lowered to accommodate declining water levels. The occurrence of naturally-occurring arsenic in deeper wells has been documented by others in the groundwater banking areas (Swartz, 1996) and generally confirmed by recent USGS sampling results (Burton, et al., 2012).

This relationship is best illustrated by the co-plotting of a hydrograph and arsenic chemograph from a northwestern well – City of Bakersfield Well 27 – as shown on **Figure 3-34** (see **Figure 3-33** for the well location). As indicated on the graph, arsenic levels tend to rise and fall in response to water level trends and fluctuations. When water levels declined below about 150 feet msl in 2012-2013, arsenic concentrations began to increase; concentrations ultimately rose above the MCL in 2015 when water levels were at historic lows.

Although some data are incomplete, this relationship can be seen from data in several of the arsenic-impacted wells in the northwest Plan Area. One deep well drilled in this area – screened from 970 feet to 1,270 feet – has detected arsenic above the MCL in all samples from 2005 to 2018, with concentrations up to 17 mg/L. Wellhead treatment was installed on six of the northwestern arsenic-impacted wells during the recent drought. If water levels decline below the historic low levels in the future, arsenic concentrations may increase in these and additional wells.

There may be an opportunity to optimize new well construction to lower arsenic concentrations in the future. Two replacement wells recently drilled by Greenfield CWD to a depth of 900 feet found that arsenic was primarily concentrated in zones around 620 feet to 680 feet; arsenic concentrations were lower below a depth of about 700 feet. The wells have been completed with blank casing in these zones to lower overall arsenic concentrations in wells (QK, 2016). Zone sampling would be conducted in either new test wells or existing production wells to determine if modified well construction would assist in achieving arsenic water quality objectives.

Constituents Associated with Environmental Cleanup Sites

Numerous local and state programs provide regulation and oversight of potential impacts to groundwater quality. The State Water Resource Control Board (SWRCB) (and associated Regional Water Boards) and the Department of Toxic Substances Control (DTSC) conduct programs involving groundwater investigation and cleanup relating to environmental or public health impacts. The SWRCB maintains a web-based portal, referred to as Geotracker, where water quality information and data on these programs are stored. DTSC maintains a similar web-based storage site for program information referred to as Enivrostor.

Information and data from Geotracker and Envirostor were downloaded for various regulatory programs to identify potential water quality impacts that may affect the GSP. There are 32 of these regulated sites in the KRGSA Plan Area that are currently active, including 3 sites from the leaking Underground Storage Tank (LUST) program, 8 DTSC-regulated sites, and 21 sites in the SWRCB Site Cleanup Program. Sites are listed on **Table 3-1** and shown on **Figure 3-35**. The map number in the table corresponds to the site number on the figure to facilitate location of the regulated sites. Programs are summarized below.

The SWRCB and regional Water Boards provide regulation and oversight of underground tanks through the Underground Storage Tank (UST) Program. For leaking tanks (LUST), the program requires environmental investigations and remediation, as needed. Leaks involve primarily petroleum hydrocarbons but also include releases of any hazardous substances. The three leaking underground storage tank investigations identified in the Plan Area are listed as sites 1 – 3 on **Table 3-1** and identified by squares (numbers 1 – 3) on **Figure 3-35**.

The DTSC mission is "to protect California's people and environment from harmful effects of toxic substances by restoring contaminated resources, enforcing hazardous waste laws, reducing hazardous waste generation, and encouraging the manufacture of chemically safer products." The agency provides state response actions for sites on the federal National Priorities List (NPL, Superfund sites), oversees activities and corrective actions on sites permitted under the Resource Conservation and Recovery Act (RCRA), and provides assessment and cleanup activities at school sites under the Brownfields Restoration and School Evaluation Branch. There are eight sites associated with the NPL, RCRA Corrective Action, and School programs in the KRGSA Plan Area as listed on **Table 3-4** (sites 4 - 11) and shown by triangles (numbers 4 – 11) on **Figure 3-35**.

The regional Water Boards oversee the investigation and cleanup of unauthorized releases of pollutants to the environment (including groundwater) through the Site Cleanup Program. Regulated sites and activities include industrial and chemical manufacturing, dry cleaners, pesticide facilities, rail yards, ports, refineries, chemical handling and storage, and numerous other activities. The Site Cleanup Program has 21 sites in the KRGSA Plan Area as listed on **Table 3-4** (sites 12 – 32) and shown as diamond symbols (numbers 12 – 32) on **Figure 3-35**.

Table 3-4: Environmental Investigation and Cleanup Sites in the Plan Area

Open/Active Regulated Sites in KRGSA Plan Area				
Map No.	**Site Name**	**Type**	**Address**	**Chemicals of Concern**
1	Francisco Navarro Property	LUST	9270 S Union Ave, Bakersfield	Gasoline
2	Howards Mini Market	LUST	3300 Planz Road, Bakersfield	Benzene, Gasoline
3	Wholesale Fuels, Inc.	LUST	2200 East Brundage Lane, Bakersfield	BTEX, MTBE, Naphthalene
4	Assured Transportation Site	State/NPL	3228 Gibson St, Bakersfield	PCE
5	Benham and Johnson	State/NPL	340 Daniels Ln, Bakersfield	Lead, Pesticides, PCBs
6	K & D Salvage	State/NPL	600 South Union Avenue, Bakersfield	PCBs
7	Kern County SOS-Aurora Program School	School	7900 Niles Street, Bakersfield	Under Investigation
8	KW Plastics of California	Corrective Action	1861 Sunnyside Ct, Bakersfield	Lead
9	Proposed Career and Technical Education Regional Training Center	School	Southwest Of Berkshire Road and Old River Road, Bakersfield	Arsenic, TPH-Diesel
10	Proposed School Site #5	School	NE/S. Fairfax & E. Wilson Rd., Bakersfield	Under Investigation
11	San Joaquin Drum Company	State/NPL	3930 Gilmore Avenue, Bakersfield	Acetone, Metals, Pesticides, PAHS, PCE
12	Bakersfield Airport Business Park (Chevron Land/D)	Cleanup Program	Unicorn Rd. At Hwy 99/65, Bakersfield	Petroleum
13	Bakersfield Refinery - Area 3	Cleanup Program	3663 Gibson Street, Bakersfield	Petroleum
14	Chevron Chem Co – Bakersfield	Cleanup Program	200 E. Minner Ave, Bakersfield	DDD/DDE/DDT
15	Chevron - Kern Pump Station	Cleanup Program	1138 China Grade Loop (Sect 6, T29s/R28e), Bakersfield	Petroleum
16	Garriott Cropdusters	Cleanup Program	2010 S Union Ave, Bakersfield	Pesticides, Fertilizers
17	Golden State Metals, Inc.	Cleanup Program	2000 E Brundage Lane, Bakersfield	Metals, PCBs
18	Independent Detail (Auto Shop)	Cleanup Program	4106 Wible Rd., Bakersfield	Petroleum
19	Western Farm Service Inc	Cleanup Program	1610 Norris Rd, Bakersfield	Chlorinated Hydrocarbons
20	Witco Refinery (Oildale)	Cleanup Program	1134 Manor Street, Bakersfield	Petroleum
21	Bakersfield Refinery	Cleanup Program	6451 Rosedale Highway, Bakersfield	BTEX, MTBE, Petroleum
22	Chevron USA (Aka: Chevron Refinery & Wait Tank Yd)	Cleanup Program	2525 North Manor Street, Bakersfield	Benzene, Crude Oil, Lead, Petroleum
23	J. R. Simplot – Edison	Cleanup Program	430 Pepper Dr., Edison, Bakersfield	DBCP, Fertilizer, Pesticides
24	Kern Oil & Refining	Cleanup Program	7724 E Panama Lane, Bakersfield	Gasoline, BTEX, Diesel, MTBE, Petroleum
25	PG&E Kern Power Plant (former Coffee Rd. Overpass)	Cleanup Program	2401 Coffee Road, Bakersfield	Benzene, Crude Oil, Petroleum
26	San Joaquin Refining Co - Fruitvale Refinery	Cleanup Program	Standard Street, Bakersfield	Diesel
27	Sunland Refining Corporation	Cleanup Program	2152 Coffee Road, Bakersfield	Crude Oil, Gasoline, MTBE/TBA
28	A-1 Battery	Cleanup Program	1230 S. Union Ave, Bakersfield	Metals
29	Kern County Department of Airports	Cleanup Program	1401 Skyway Drive, Bakersfield	Pesticides, Herbicides
30	Sabre Refinery	Cleanup Program	W. Bakersfield-Rosedale Area, Bakersfield	TPH
31	Ten Section Farming Company	Cleanup Program	Township 30 S Range 26 E Section 30 MDB&M, Bakersfield	Petroleum
32	Paloma Station Property	Cleanup Program	17731 Millux Road, Bakersfield	None Specified

LUST – leaking underground storage tanks; NPL – National Priorities List; BTEX – Benzene, toluene, ethylbenzene, and xylene; MTBE – methyl tert-butyl ether; PCE – tetrachloroethylene; PCB – polychlorinated biphenyl; TPH – total petroleum hydrocarbons; PAH – polycyclic aromatic hydrocarbons; DDD - dichlorodiphenyldichloroethane; DDE - dichlorodiphenyldichloroethylene; DDT - dichlorodiphenyltrichloroethane; DBCP – 1,2-Dibromo-3-chloropropane; TBA – tertiary butyl alcohol.

As indicated in **Table 3-4**, constituents of concern at about one-half of the sites involve petroleum hydrocarbons including crude oil, gasoline, and associated products (BTEX, MTBE, TPH, TBA). These sites include refineries, oil companies, transportation sites, schools (with fuel tanks), as well as the three LUST sites. There are five sites located both north and south of the Kern River on the urban fringe that are primarily associated with pesticides and fertilizers (including DBCP and DDT). Remaining sites with constituents of concern are associated with chlorinated hydrocarbons (PCE, PCBs) and metals.

As shown on **Figure 3-35**, almost all of the sites are located in Metropolitan Bakersfield or on the urban fringe. Sites occur both north and south of the River. Most of the Cleanup Program Sites are more tightly clustered in industrial and commercial areas north of the River. Most of these sites are more than a mile from the closest municipal well, but sites south of the River (east of the Highway 99) are more closely interspersed among municipal wells. Although most of the constituents of concern have not been detected at elevated levels in municipal wells to date, the potential impact of these sites will be coordinated with the state agencies for early identification of groundwater contaminant plumes that could impact water supply.

Additional Constituents

Other potential constituents of concern have been identified in KRGSA groundwater over the 20-year Study Period including Radiometric parameters such as uranium and radon, iron, and manganese. These constituents are naturally-occurring, detected at relatively low levels in local areas, and generally managed by water suppliers via pumping distributions and blending, as needed.

3.3.5 Land Subsidence

The decline of water levels in the Plan Area, exacerbated by the recent drought, could contribute to subsidence of the ground surface in susceptible areas, especially in the southern and eastern KRGSA Plan Area where clay deposits are more prevalent. As water levels decline in the subsurface, dewatering and compaction of predominantly fine-grained deposits (such as clay and silt) can cause the overlying ground surface to subside.

This process is illustrated by two conceptual diagrams shown on **Figure 3-36**. The upper diagram depicts an alluvial groundwater basin with a regional continuous clay layer and numerous smaller discontinuous clay layers. Because clays are most affected by the compaction, the area with the thicker continuous clay layer is associated with the largest land subsidence. Water level declines associated with pumping decrease water pressure within the pore space (pore pressure) of the aquifer system (Galloway, et al., 1999). Because the pore pressure helps support the weight of the overlying aquifer, the pore pressure decrease causes more weight of the overlying aquifer to be transferred to the grains within the structure of the sediment layer. The difference between the water pressure in the pores and the weight of the overlying aquifer is referred to as the effective stress. If the effective stress borne by the sediment grains exceeds the structural strength of the sediment layer, then the aquifer system begins to deform.

This deformation consists of re-arrangement and compaction of fine-grained units[24], as illustrated on the lower diagram of **Figure 3-36**. The tabular nature of the fine-grained sediments allows for preferred alignment and compaction. As the sediments compact, the ground surface can sink, as illustrated by the 2nd column on the lower diagram of **Figure 3-36**.

Land subsidence due to groundwater withdrawals can be temporary (elastic) or permanent (inelastic). Elastic deformation occurs when sediments compress as pore pressures decrease but expand by an equal amount as pore pressures increase. A decrease in water levels from groundwater pumping causes a small elastic compaction in both coarse- and fine-grained sediments; however, this compaction recovers as the effective stress returns to its initial value. Because elastic deformation is relatively minor and fully recoverable, it is not considered an impact.

Inelastic deformation occurs when the magnitude of the greatest pressure that has acted on the clay layer since its deposition, or pre-consolidation stress, is exceeded. This occurs when groundwater levels in the aquifer reach a historically low water level. During inelastic deformation, or compaction, the sediment grains rearrange into a tighter configuration as pore pressures are reduced. This causes the volume of the sediment layer to reduce, which causes the land surface to subside. Inelastic deformation is permanent because it does not recover as pore pressures increase. Clay particles are often planar in form and more subject to permanent realignment (and inelastic subsidence). In general, coarse-grained deposits (e.g., sand and gravels) have sufficient intergranular strength and do not undergo inelastic deformation within the range of pore pressure changes encountered from groundwater pumping.

The volume of compaction is equal to the volume of groundwater that is expelled from the pore space, resulting in a loss of storage capacity. This loss of storage capacity is permanent but may not be of practical significance because clay layers do not typically store significant amounts of usable groundwater (LSCE, et al., 2014). Inelastic compaction, however, may decrease the vertical permeability of the clay resulting in minor changes in vertical flow.

The following potential impacts have been associated with land subsidence due to groundwater withdrawals (modified from LSCE, et al., 2014):

- Damage to infrastructure including foundations, roads, bridges, or pipelines;
- Loss of conveyance in canals, streams, or channels;
- Diminished effectiveness of levees;
- Collapsed or damaged water well casings; and
- Land fissures.

Damage to SWP and CVP infrastructure related to historical land subsidence has been documented north of the Kern County Subbasin. In 1976, subsidence along the Tulare-Wasco reach of the Friant-Kern Canal was determined to have interfered with operations (Prokopovich, 1984). A 17-mile segment of the

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[24] Although extraction of groundwater by pumping wells causes a more complex deformation of the aquifer system than discussed herein, the simplistic concept of vertical compaction is often used to illustrate the land subsidence process (Galloway, et al., 1999; LSCE et al., 2014).

canal required rehabilitation and raising of three pumping plants. In 1984, post-construction land subsidence along the damaged reach was reported to be more than about five feet. A more recent study by DWR documented about 6.9 inches of subsidence along a portion of the California Aqueduct that has decreased freeboard and capacity (Pool 20 in the San Luis Field Division, located north of the Kern County Subbasin) (DWR, 2017). Smaller amounts of recent subsidence were also documented along portions of the Aqueduct in the Kern County Subbasin (DWR, 2017).

Land subsidence in the San Joaquin Valley has been documented for more than 90 years and recent investigations using satellite imagery indicate continuing problems in some areas. Although the areas with the most documented subsidence are generally north of Kern County Subbasin, both historical and recent subsidence have been documented in several areas across the Kern County Subbasin including portions of the KRGSA Plan Area. According to DWR (2014), the estimated potential for future land subsidence to occur within Kern County is high.

3.3.5.1 Historical Land Subsidence in the KRGSA Plan Area 1900 - 1970

Historical subsidence dating back to the early 1900s was evaluated in a 1983 USGS study of surface deformation, including tectonic uplift and land subsidence, in the area around Oildale (Castle, et al., 1983). Although the study was focused on oilfields located generally north of the KRGSA Plan Area, about a dozen benchmarks in the northern Plan Area were included. Specifically, the report indicated "virtually no subsidence associated with ground-water withdrawals" beneath central Bakersfield (Castle, et al., 1983). The study did, however, indicate that about 2 inches of subsidence may have occurred at a benchmark close to the northern boundary of the KRGSA from 1903 to 1968. In addition, there could have been several inches of historical subsidence associated with the oil and gas withdrawals in the late 1920s in the Fruitvale oilfield (see **Figure 3-13**).

This USGS study was followed by a more foundational study by Ireland (Ireland, et al., 1984), which evaluated subsidence amounts and locations from 1926 to 1970. The amount of historical land subsidence estimated by this study in the KRGSA is illustrated on **Figure 3-37** (Ireland, et al., 1984). As shown on the map, land subsidence occurred south of the Kern River and was focused along the southeastern and southern boundaries of the Plan Area and offsite to the south. Subsidence extended northeast to the vicinity of Highway 58 where about one foot of subsidence is estimated to have occurred during the 44-year period (**Figure 3-37**). The largest amount of land subsidence is estimated at about nine feet, occurring at the far southern extent of the KRGSA Plan Boundary (**Figure 3-37**).

Although data represent the accumulated subsidence over a 45-year period, USGS estimates that about 75 percent of the subsidence occurred in the 1950s and 1960s because of extensive groundwater development (Galloway, et al., 1999). Applying the 75 percent factor to the range of subsidence from one foot to nine feet (0.75 feet to 6.75 feet), a rate of subsidence is estimated at 0.04 to 0.34 feet per year (0.48 to 4.1 inches per year) over the 20-year period (1950s and 1960s).

Areas of clay soils and subsurface clay sediments – as indicated by an arcuate area of perched water – coincide with the primary areas of historical subsidence in the KRGSA Plan Area (**Figure 3-37**). Clay soils in this area are related to the fine-grained materials associated with the flood basin deposits and paleo-lake beds discussed previously (see **Sections 3.2.1** and **3.2.3** in this document) and illustrated by the surficial clay soil mapping on **Figure 3-8**.

Pre-1945 water level records are sparse, but available information indicates that water level declines were more significant after the mid-1940s. A period of significant water level decline apparently occurred between 1945 and 1977, with water levels reaching new historical lows during the late 1970s drought. During that 33-year period, water levels may have declined as much as 150 feet along the Kern River (about 4.5 feet per year). Assuming similar declines in the areas of historical land subsidence, the rate of subsidence of 0.04 to 0.34 feet per year roughly correlates to about 0.009 feet (0.11 inches) to 0.076 feet (0.91 inches) per foot of water level decline.

These calculated subsidence rates are general estimates and do not account for the variability of land subsidence and water level declines through time and space across the KRGSA Plan Area. They are provided as a rough approximation to compare to other historical subsidence estimates and future subsidence monitoring measurements.

3.3.5.2 Land Subsidence in the KRGSA Plan Area 1961 - 2020

There are insufficient published subsidence data to fully bridge the time gap between the end of the Ireland study and the more recent subsidence investigations beginning in about 2014. However, the USGS conducted model simulations of land subsidence in the Central Valley for the historical period 1961 through 2009 (Faunt and Phillips, 2014), overlapping a key portion of the Ireland study period (Ireland, et al., 1984) and updating it over an additional 47 years. The modeling suggested maximum subsidence of 2 to 10 feet over the northern and central Plan Area and up to 20 feet in the area of the largest historical subsidence mapped by Ireland. The analysis suggests that significant land subsidence has continued since the Ireland study and that most of the subsidence is coincident with the areas of historical subsidence mapped by Ireland. These estimates indicate that the amount of subsidence over this period is approximately twice the amount that had occurred by 1970, suggesting that subsidence continued throughout the Plan Area at overall similar or lower rates than had occurred prior to 1970.

More recently, DWR commissioned investigators from the U.S. National Aeronautics and Space Administration (NASA), Jet Propulsion Laboratory (JPL) to conduct a detailed investigation of land subsidence in the San Joaquin Valley using radar remote sensing techniques. Investigators compared multiple satellite and airborne Interferometric Synthetic Aperture Radar (InSAR) images dating back to 2006 to document how subsidence had varied over space and time over a recent decade (Farr, et al., 2017). The NASA-JPL study produced a progress report that analyzed InSAR data from March 2015 to September 2016 (Farr, et al., 2017). Maps from that report indicated land subsidence in the range of 1 to 4 inches over most of the KRGSA Plan Area and reached a maximum of 4 to 8 inches in the southern are where historical subsidence had been documented.

These data sets were recently updated and accessed through December 2016 from the JPL website (JPL, 2018). Because most of the water level declines occurred in the Plan Area during 2015 and 2016, data from a 19-month period from May 2015 through December 2016 were used to develop a recent Plan Area subsidence map as shown on **Figure 3-38**. As indicated by the color bar in the legend of **Figure 3-**

38, land subsidence of more than 25 inches was estimated during this period for areas outside of the Plan Area and north of the Kern County Subbasin (not shown). The color ramp on the legend of **Figure 3-38** is difficult to interpret locally because most of the subsidence (or potential tectonic uplift indicated by the +5.9 inches in the legend), are outside of the data range of the KRGSA Plan Area. Rather than modify the valley-wide legend here, data were reviewed and summarized by the labels on **Figure 3-38**.

As indicated by the labels and the range of blues and greens on the color-coded figure, subsidence over this period has ranged from less than one inch in the northern Plan Area up to about eight inches in the southern Plan Area. Although the color scheme on **Figure 3-38** is subtle, a comparison with **Figure 3-37** indicates that most of the recent subsidence appears to be occurring in areas of historical subsidence. The estimate of 4 to 8 inches of subsidence over the 19-month period is equivalent to about 2.5 to 5 inches per year, a rate similar to the previous estimates of up to about 4.1 inches per year estimated from the Ireland (1984) data.

Although recent satellite data indicate continued land subsidence (on the order of inches/year) in the southern KRGSA Plan Area, there are uncertainties associated with this interpretation. When data are examined on a finer scale than shown on **Figure 3-38**, changes in the land surface vary significantly on a parcel by parcel basis. Most of the impacts are associated with agricultural fields with little to no subsidence indicated on adjacent or nearby parcels without farming activities. If subsidence were associated with an overall water level decline beneath the southern Plan Area, such localized differences on a parcel basis would not be expected. It is postulated that some of the impact, measured in inches, could be more closely related to wetting and drying of surficial clay soils or changes in elevation due to land re-working with the planting and harvesting of crops.

Since the submittal of the 2020 KRGSA GSP, DWR has provided data on its SGMA data viewer website[25] from two high-quality global positioning system (GPS) stations in the area of relatively high rates of historical land subsidence in the KRGSA (see stations ARM1 and ARM2 on **Figure 6-4**) (DWR, 2021). More details on these stations are provided in the description of subsidence monitoring networks in **Section 6.2.6.2**. Data from those two stations from 2000 to 2020 indicated a total of about 19 inches of land subsidence over that period and a 20-year rate of subsidence of about 0.95 inches per year.

This 20-year period contained a variety of wet and dry cycles, includes recent critical drought conditions, and extends up to the time of GSP submittal. This rate may be slightly higher than a long-term average given that this 20-year period is drier than normal. Nonetheless, this data set represents the best available long-term rate for the area of highest inelastic land subsidence in the KRGSA prior to the submission of the 2020 GSP.

This rate is measured in the southeastern Agricultural MA where some of the highest rates of subsidence have been observed historically; most areas of the KRGSA have experienced lower to almost no amounts of historical subsidence. In fact, InSAR data has indicated some areas of uplift within the

[25] https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub

Plan Area, primarily in the northern KRGSA. A recent Subbasin-wide study by Lawrence Berkeley Laboratory (LBL)[26] commissioned by the Subbasin GSAs illustrated these conditions (Vasco, 2022).

That study estimated average rates of vertical displacement including both subsidence and uplift over a recent six-year period (2015 through 2021) in four regions of the Subbasin (Vasco, 2022). The southern region included most of the KRGSA Plan Area as well as areas with high rates of subsidence outside of the Plan Area. For the six-year study period, average annual rates of vertical displacement in that region ranged from +0.265 inches/year of uplift to -0.838 inches per year of subsidence. These data illustrate the uplift in portions of the KRGSA Plan Area and are also generally consistent with the subsidence rate of 0.95 inches per year as measured at the GPS stations discussed above.

Subsidence would be expected to continue for some period into the future as local clay sediments on the paleo-lakebeds continue to compact, especially since water levels reached then-historic lows in 2015-2016. A recent Central Valley study predicts that compaction of subsurface clay layers such as those in the southern KRGSA would continue to compact even if water levels were stable (Lees, et al., 2022). That study indicates that "residual compaction of clays is a process that continues for decades-to-centuries." If future water levels decline significantly below historic lows, more inelastic land subsidence could be triggered than would otherwise occur. Although subsidence could potentially occur in any area with declining water levels, the areas of historical subsidence are considered most vulnerable because of the thick local clay deposits.

3.3.5.3 Regional and Management Area Critical Infrastructure

Given the magnitude of historical subsidence within the Kern County Subbasin, as well as in the KRGSA Plan Area, there has been a potential for impacts to land use involving damage to critical infrastructure. As explained in more detail in **Section 5.8.2**, the Kern County Subbasin GSPs have coordinated on definitions of r*egional* critical infrastructure for the purposes of evaluating sustainable management criteria for land subsidence. Although the Subbasin GSAs coordinated on land subsidence issues and monitoring for the 2020 GSP submittals, a more focused coordination process was initiated in early 2022 in response to the DWR Determination Letter, which identified deficiencies with regards to a Subbasin-wide coordinated management approach to land subsidence (Deficiency No. 3, DWR, 2022, see **Section 1.6**). In brief, the Subbasin developed coordinated definitions that differentiate between *Regional Critical Infrastructure* of Subbasin-wide importance (such as the California Aqueduct and the Friant-Kern Canal) and local critical infrastructure that is specific to a Management Area[27] within a Subbasin GSP – defined as *Management Area Critical Infrastructure*. For this Amended KRGSA GSP, infrastructure within the KRGSA Plan Area that may be impacted by inelastic land subsidence is referred to as Management Area Critical Infrastructure.

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[26] The original draft study from Lawrence Berkeley Laboratory (Vasco, 2022) is included in the First Amended Kern County Subbasin Coordination Agreement, Appendix 3, submitted separately on the SGMA Portal.

[27] As explained in **Section 5.2**, the KRGSA Plan Area has been subdivided into three Management Areas. Critical infrastructure in each of these Management Areas is considered for sustainable management criteria as explained in **Section 5.8.3** and in the First Amended Kern County Subbasin Coordination Agreement, Appendix 3.

A preliminary map identifying Management Area critical infrastructure for the KRGSA Plan Area is provided on **Figure 3-39**; it is recognized that this map does not include all infrastructure in the Plan Area, but the widespread nature of the network of canals and conveyance facilities indicate that there could be infrastructure damage throughout the Plan Area if significant inelastic subsidence were to be exacerbated.

For the KRGSA Plan Area, it is recognized that the City of Bakersfield contains a myriad of critical infrastructure including municipal wells, water and other utility pipelines, roads, buildings, associated appurtenances and numerous other facilities that may be at risk if inelastic subsidence occurred in the city. The three water treatment facilities in the Bakersfield area are also specifically recognized as critical infrastructure (**Figure 3-39**). Accordingly, the Bakersfield city limits covering most of the northern Plan Area are identified as containing critical infrastructure for the purposes of protection from subsidence (**Figure 3-39**). Other critical infrastructure exists outside of the City limits and/or away from urban centers including the Bakersfield Meadows Field Airport, industrial pipelines/conduits, and other features (**Figure 3-39**). Major roadways including Highway 99 and Interstate 5 also traverse the Plan Area and are considered critical infrastructure, especially in areas of historical subsidence in the southern Plan Area.

Water conveyance facilities including pipelines and canals are critical for conveyance and provision of surface water supplies and can be damaged from inelastic land subsidence. As shown on **Figure 3-39**, numerous local canals serve the Plan Area. Two important regional canals cross portions of the KRGSA and represent critical infrastructure for the KRGSA, the Subbasin, and the State. The Friant-Kern Canal – a primary component of the Federal CVP – enters the KRGSA and terminates at the Kern River near Coffee Road. The Cross Valley Canal (CVC) in the northwestern and northern KRGSA provides critical infrastructure for importation and conveyance of SWP water and other critical supplies across the KRGSA and the Subbasin. Although not located in the KRGSA, the California Aqueduct is one of the most critical canals for water conveyance in the state and significant damage from subsidence would have state-wide ramifications. As shown on **Figure 3-39**, the aqueduct is more than four miles from the southern KRGSA Plan Area. Nonetheless, KRGSA member agencies all rely on the aqueduct for water supply conveyance.

Damage to water well casings could also be considered Management Area critical infrastructure, especially if the damage were sufficient to impact the beneficial use of groundwater. If the well could be reasonably modified or its function in not impeded, then the impact to one well could be considered minimal.

Although historical and recent subsidence has been indicated from local and regional satellite and other data in the KRGSA Plan Area, no adverse impacts to land use have been noted and no damage to Management Area critical infrastructure relating to land subsidence from groundwater withdrawal has been identified. As noted above, some ground elevation changes may not be indicative of inelastic land subsidence and rather related to either surficial clay soils or changes in surface elevation with farming activities. Further, if land subsidence occurs relatively evenly over a broad area, infrastructure may not be damaged, or the use of the infrastructure may not be affected. Nonetheless, if water levels are managed at or near historic low levels in this area, exacerbation of current land subsidence can be avoided in the future.

3.3.6 Interconnected Surface Water and Groundwater Dependent Ecosystems

GSP Regulations define interconnected surface water as surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted (California Code of Regulations Title 23). Groundwater Dependent Ecosystems (GDEs) collectively refer to plant, animals, and natural communities that rely on groundwater to sustain all or part of their water needs (TNC, 2018). GDEs occur in areas where groundwater either discharges to the surface (springs, seeps, or wetlands) or the water table is sufficiently shallow to support natural communities. This includes vegetation with rooting depths sufficiently deep to draw a water supply from the underlying water table, referred to as phreatophytes. GDEs can occur along interconnected surface water but can also occur in any area where natural communities are supported by shallow groundwater.

The KRGSA sustainability goal includes support for current and future beneficial users of groundwater, including the environment. To assist the KRGSA with an understanding of potential environmental reliance on groundwater in the Plan Area, data and maps provided by DWR were used. Specifically, DWR created the Natural Communities Commonly Associated with Groundwater dataset (hereafter referred to as the NCCAG or Natural Communities dataset). This dataset is a compilation of 48 publicly available State and Federal agency datasets that map vegetation, wetlands, springs, and seeps in California. A working group composed of DWR, the California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC) reviewed the compiled dataset and conducted a screening process to exclude vegetation and wetland types less likely to be associated with groundwater and to retain types commonly associated with groundwater. Two habitat classes are included in the Natural Communities dataset: (1) wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions; and (2) vegetation types commonly associated with the sub-surface presence of groundwater (phreatophytes). DWR notes that the data included in the Natural Communities dataset do not represent DWR's determination of a GDE but are a starting point for identifying GDEs.

The NCCAG mapped areas of vegetation and wetlands are provided as polygons in GIS shapefiles, which also contain information on vegetation types and species; rooting depths and local habitat are available in separate databases developed by TNC (TNC, 2018). These maps were evaluated along with local groundwater conditions to identify potential interconnected surface water and GDEs in the Plan Area. In this manner, current and future potential uses of groundwater by the environment were estimated.

The NCCAG mapping of the KRGSA Plan Area indicates 177 polygons of vegetation and 65 additional polygons for wetlands; areas are shown on **Figure 3-40**. Most of these wetlands and vegetation areas occur along a 12-mile reach of the Kern River, beginning about one-half mile upstream of the Beardsley River Weir (where the River enters the Plan Area) and extending just downstream of the Bellevue Weir.

Additional polygons are mapped away from the River, consisting primarily of small local drainageways in the northeast and undeveloped areas in the south (**Figure 3-40**). The number of polygons by community type (vegetation and wetlands) are summarized in **Table 3-5** for the northern and southern Plan Area.

Table 3-5: NCCAG-Mapped Natural Communities Polygons in KRGSA Plan Area

Natural Communities	Vegetation (number of polygons)	Wetlands (number of polygons)	Total Natural Communities Areas
Northern Plan Area	110	52	162
Southern Plan Area	67	13	80
Total in KRGSA	177	65	242

For the KRGSA Plan Area, the evaluation of interconnected surface water is focused on the Kern River and other smaller drainageways identified for additional study. The analysis of potential GDEs extends into the southern Plan Area, focusing on depth to water, groundwater conditions, and local land use. Although potential impacts to interconnected surface water and GDEs represent new analyses required under SGMA, published data along the Kern River are available to support these initial analyses. Surface water flows and losses in the River channel – and along an interconnected web of adjacent unlined canals – are monitored to allocate River water diversions by surface water rights holders in the KRGSA. Data are published in annual hydrographic reports prepared by the City of Bakersfield on behalf of the Kern River Watermaster. The City also actively manages and maintains the River channel throughout the entire Plan Area to prevent flooding and to enhance groundwater recharge as described in previous sections (**Sections 3.2.4.2** and **3.2.4.3**).

Operations and management of the Kern River by the City of Bakersfield, including measurements along the channel from First Point to Second Point, have demonstrated that the Kern River is a losing stream across the KRGSA Plan Area. In a separate Kern County Subbasin GSP, the KGA GSA has conducted a basin-wide evaluation for the potential of interconnected surface water and concluded that the Kern River was not interconnected with the underlying groundwater downstream of First Point (**Figure 3-40**). A comparison of stream gage data upstream between First Point and Isabella Dam (40 miles upstream of First Point) indicated that groundwater is likely contributing to baseflow somewhere along this reach, indicating some interconnected surface water. Although the location of this contribution could not be determined, the analysis suggested that baseflow is more likely to occur outside of the Subbasin boundary in the Kern River canyon as evidenced by the presence of local springs.

In addition to the KGA GSP upstream study, the Kern Water Bank has also documented losing stream conditions downstream of the KRGSA Plan Area, concluding that the River is not interconnected with local groundwater (reference KGA GSP, 2019 when available). For GSP coordination, the results of those two studies are incorporated into this GSP and not repeated here. Additional information and analyses relating to the potential for interconnected surface water and GDEs in the KRGSA Plan Area are discussed in the sections below.

3.3.6.1 Kern River Monitoring and Management

The Kern River is a highly-managed system throughout the KRGSA Plan Area. The City implements a channel maintenance program, which includes the removal of sand, soil, and vegetation within the designated floodway; channel alignment within the designated and secondary floodway; and maintenance and operations of designated weirs and diversion structures (QUAD, 1985). These activities preserve the carrying capacity of the River and permit passage of an intermediate regional flood. Throughout the urban area of Bakersfield, the channel is contained by continuous levees constructed and maintained for flood management. Downstream of the urban area, the River is contained by natural banks and/or low discontinuous levees. The channel has a sandy, shifting bottom; channel clearing, sand removal, and levee repair is a part of the continuous channel maintenance program (QUAD, 1985). Most of the maintenance occurs from the Bellevue Weir to upstream of the Calloway Weir, covering most of the River in the Plan Area (**Figure 3-40**).

Riparian vegetation along the Kern River is supported by regulated releases from Isabella Reservoir, as well as surface water and imported water that is intentionally released into the channel for groundwater banking and/or replenishment of groundwater to support local wellfields. The River channel is used extensively for managed aquifer recharge, along with adjacent recharge basins and unlined canals. Quantities of released and recharged water into the channel are managed by the City. A series of stream gage and weir data are maintained by City staff and documented in annual Kern River Hydrographic Reports. These reports also record entitlements and diversions in accordance with pre-1914 surface water rights as modified by court decisions over the years. The primary gages and weirs along the River channel are shown on **Figure 3-40**.

For more than 100 years, the River has been diverted for agricultural, drinking water, and other beneficial uses. Early diversions occurred along natural sloughs and ditches associated with depositional drainageways related to alluvial fan development. Over the last 50 years, River water has been conveyed with constructed lined and unlined canals. Numerous diversion canals connect to the channel throughout the KRGSA Plan Area for conveyance of River water throughout the Plan Area – and beyond – for beneficial use. Canals are also used to release water into the River channel along dry reaches for managed aquifer recharge. Surface water rights holders coordinate with holders of other water sources to optimize supplies through numerous and complex water exchanges. Volumes of water diverted to and from the channel are measured at weirs and other devices at canal and pipeline turnouts and recorded by the City between First Point and Second Point.

3.3.6.2 Kern River Flow Conditions Downstream of the Calloway Weir

Diversions on the Kern River typically create low flow conditions or dry reaches in the channel. Between 1970 and 2010, about 80 percent of the River flow at First Point was diverted above the Calloway Weir (DBS&A, 2012) (see the location of First Point and the Calloway Weir on **Figure 3-40**). A graph of recorded annual flows at First Point and the Calloway Weir is shown on **Figure 3-41**. As indicated by the graph, the River was dry at the Calloway Weir during an entire year for more than 25 percent of the years in the period, including recent years of 2007 and 2009. In addition, if periods of very low flow are also considered, then little to no flow occurs downstream of the Calloway Weir for almost one-half of the time. During years with relatively low total flows, the River would have produced very few discharge events to sustain a wet channel very far downstream. This condition was intensified during the recent drought of 2013 – 2016, when River flows and groundwater levels both reached historic lows. In 2015, regulated flows at First Point were only about 13 percent of the long term average (see also **Figures 2-10 and 3-10** and **Section 3.2.4.2**). Given that natural surface water is often depleted in the Kern River channel downstream of the Calloway Weir for long stretches of time (months to years), the River below the weir is not interconnected surface water.

3.3.6.3 Groundwater Elevations at the Calloway Pool

Upstream of the Calloway weir is a relatively flat area of the River channel, referred to as the Calloway Pool, where water is allowed to back up behind the weir for storage and diversion. The reach of the River upstream of the Calloway Weir to Rocky Point Weir (**Figure 3-40**) is typically the most consistently wetted part of the channel in the Plan Area. According to an evaluation of the River's biological resources, this relatively short reach of the River supports the most extensive, vigorous, and biodiverse riparian habitat of the River within the KRGSA Plan Area (City of Bakersfield, 2012). The reach includes portions of the Kern River Parkway and the Panorama Vista Preserve. Habitat includes stands of mature cottonwood-sycamore riparian forest, the most continuous riparian corridor in the Plan Area, and the greatest diversity of riparian trees and shrubs (City of Bakersfield, 2012).

At Rocky Point Weir (**Figure 3-40**), the unlined Carrier Canal is used to divert Kern River water for agricultural use in the southern Plan Area. The Carrier Canal runs parallel to the River before turning south at the Calloway Pool. Flow measurements on the River and the canal indicate that this entire reach from Rocky Point Weir to the Calloway Weir is a losing stream. Recharge at the Calloway Pool and along the Carrier Canal is recorded in annual hydrographic reports.

Despite the relatively large quantities of recharge, the depth to groundwater adjacent to the River is typically more than 50 feet deep in this area. Water levels at the Calloway Pool are measured by ID4 in a dedicated monitoring well (ID4 No. 13) located in the Kern River Parkway on the south side of the Calloway Pool and the Kern River channel; the location of the well is shown on **Figure 3-40** (and also on **Figure 3-24**, see Hydrograph 3). Groundwater elevations in the well are shown in the hydrograph on **Figure 3-42**. The top of the well screen is relatively shallow and capable of measuring the local water table (i.e., when water levels are low, the water table is below the top of the screen). As shown by the hydrograph, water levels from 2000 through 2017 have been relatively stable, ranging from elevations of about 320 to 360 feet msl. The highest elevations were recorded during the summer and fall of 2017 (**Figure 3-42**). Since monitoring began in 2000, the average depth to the water table has been more than 80 feet. The depth to water was about 60 feet during 2017. This separation between the water table and the River demonstrates that there is no interconnected surface water at the Calloway Pool. With ground surface elevations rising upstream, groundwater is expected to be even deeper above Rocky

Point Weir to the edge of the Plan Area. Given these conditions, the Kern River does not appear to be interconnected surface water in the KRGSA Plan Area.

3.3.6.4 Hydrologic Profiles Along the Kern River

To further evaluate potential surface water/groundwater interactions beneath the Kern River, groundwater elevations over time along the entire reach of the River in the Plan Area are incorporated into the analysis. Profiles of groundwater elevations were developed along an approximate 23-mile transect between First Point and Second Point. The transect location is shown on **Figure 3-40** and labeled A to A' from First Point to just past Second Point, respectively. Because the transect is a straight line, it deviates from the River channel in numerous locations. For those deviations, the actual elevations in the River channel were checked against the profile and incorporated into the discussion below. The largest differences in ground surface elevation between the transect and the channel occur primarily outside of the KRGSA Plan Area in the northern portion of the transect. These deviations also affect the groundwater elevations, creating uncertainty in several areas of the transect including those areas outside of the KRGSA Plan Area.

Profiles were created in GIS based from annual groundwater elevation contour maps developed by KCWA for the Principal Aquifer, as discussed in **Section 3.3.2.3 and 3.3.2.4**. Maps are prepared using spring data and represent the high groundwater elevation for that year. There are numerous limitations recognized for this analysis that could cause water levels to be higher or lower than represented by the profiles. It is recognized that the contour maps are not sufficiently precise to determine the exact height of the groundwater mound beneath the River in spring in every small segment of the River, given the relatively large contour intervals. In addition, the northeastern portion of the transect contains limited data and water levels in that area are less certain. Finally, many of the wells used for contouring are water supply wells with long screens that may represent a lower water level than at the water table.

These limitations suggest that spring groundwater elevations could be higher beneath the River than shown by the maps and the associated profiles. However, elevations could also be lower than mapped as evidenced by the number of municipal wells close to the River, most of which are not included in the contouring (see **Figure 2-14**). In addition, groundwater elevations decline significantly following the spring highs as groundwater and available surface water use increases with summer demands. Notwithstanding these limitations, the KCWA contour maps represent the best available understanding of groundwater elevations in the Plan Area over a 20 year period for the purposes of this analysis.

A groundwater elevation profile developed for each annual spring map is plotted on **Figure 3-43** in relation to the ground surface elevation. (The ground surface elevation is based the USGS DEM shown on **Figure 3-7** and checked against channel surveys). The profiles are color-coded according to DWR Indices for the San Joaquin Valley water year type, which are not always coincident with water year type in Kern County (discussed in **Section 3.2.4.1**). Although the large number and crisscrossing nature of the profiles make it difficult to follow any single profile, the clustered nature of the data provide a method of viewing a wide range of spring water levels over 20 years beneath the River. The range of groundwater elevations and the amount of groundwater separation from the ground surface can be readily seen on **Figure 3-43**, regardless of the year type or the actual year.

The profiles on **Figure 3-43** suggest that groundwater elevations occur well below the entire reach of the Kern River within the Plan Area throughout the 20-year Study Period and indicate an absence of interconnected surface water. Although it is difficult to discern the pattern of a profile in any specific year, **Figure 3-43** illustrates that there is always a separation between the bottom of the Kern River channel and groundwater in the Principal Aquifer even at the highest elevation of each year, which the profiles represent.

Collectively, the crossing profiles on **Figure 3-43**, indicate a relatively consistent pattern of areas along the River reach with high and low groundwater elevations. In the northeast from Mile 0 to Mile 3, groundwater elevations are relatively high for most profiles although the depth to groundwater is typically deeper than 50 feet below the channel as ground surface elevations rise into the western uplands (note the River channel elevation extrapolated onto the northeastern portion of the transect on **Figure 3-43**). The low groundwater elevations from Mile 3 to Mile 5 are in an area north of the River where contours are being controlled by much lower groundwater elevations to the northwest.

From Mile 5 to Mile 11, groundwater rises relatively close to the channel, especially in wet years (**Figure 3-43**). This area includes recharge at the Calloway Pool but extends downstream of the Calloway Weir, where the channel is often dry. Accordingly, these high water levels are not the result of natural recharge. As discussed above, water is held above the weir in the Calloway Pool for groundwater recharge and diversion. Downstream of the weir, recharge continues in numerous unlined canals over a broad area moving away from the channel. In addition to managed recharge in the channel and canals, imported water is also being banked in this area through an unlined portion of the Cross Valley Canal. Recovery wells along the River channel downstream are used to extract this banked water when imported water is less available, creating lower groundwater elevations to the southwest. At Mile 10.8 of the transect, the sandy River channel is crossed by a complex system of lined and unlined canals including the Friant Kern Canal, which brings CVP water into the Subbasin. Referred to as the “Spaghetti Bowl” the channel is actively managed to optimize flexibility in conveying various water sources in many directions.

Groundwater elevations between Mile 5 and Mile 11 appear to rise within about 20 feet of the bottom of the channel during the spring of wet years (**Figure 3-43**). However, in dry years, water levels fall to 50 feet or more below the channel elevation. Fluctuations in groundwater elevations of more than 150 feet are indicated between wet and critically dry years (**Figure 3-43**). This wide fluctuation is attributable to the difference in the amount of surface water (imported and Kern River water) available for managed recharge along the channel.

Groundwater elevations generally decline over the next few miles until the transect reaches the eastern extent of numerous groundwater banking projects near Mile 14.5, including Berrenda Mesa and the COB 2800 recharge facilities in the Plan Area (**Figure 3-43**), as well as the adjacent Pioneer Project and the Kern Water Bank. Profiles indicate groundwater mounding during recharge operations and groundwater declines when banked water is being recovered. This area contains the largest water level fluctuations (more than 250 feet) observed in the Plan Area (**Figure 3-43**).

Collectively, the hydrologic profiles across the KRGSA Plan Area do not indicate interconnected surface water or sufficiently high water levels to support GDEs along the Kern River. Although groundwater levels may rise within 20 feet of the base of the channel in some areas, this appears to occur only in wet years and/or as a result of intentional recharge along the channel. The profiles corroborate the information in the annual Kern River hydrographic reports, which show the Kern River channel to be a losing stream from First Point to Second Point (approximate area from Mile 2.5 to Mile 21 on **Figure 3-43**). This includes the area along the River where TNC has mapped vegetation and wetlands (Mile 2.5 to Mile 13.4 on **Figure 3-43**). This riparian vegetation appears to be supported by surface water in the River channel (when and where it occurs), local irrigation and runoff, and local infiltration of water on sides and bottoms of nearby unlined canals and recharge basins; the vegetation does not appear to be supported by groundwater.

3.3.6.5 Depth to Water for Spring 1998

To assess NCCAG-mapped vegetation away from the Kern River channel, a regional depth to water map was constructed from the Spring 1998 groundwater elevation contour map developed by KCWA. That map was evaluated electronically in GIS with the USGS DEM of ground surface elevations to create a depth to water raster as shown on **Figures 3-44** and **3-45** for the northern and southern Plan area, respectively. Spring 1998 conditions were chosen because it was a wet year with relatively high water levels. Water levels for 1998 are not the highest water levels observed everywhere beneath the River channel; water levels continued to rise in 1999 and 2000. In addition, the regional raster is not sufficiently detailed beneath the River for precise analysis. However, 1998 groundwater elevations are higher overall across the Plan Area and represent the best period for analysis of potential GDEs away from the River. The 1998 map was also chosen because it was based on a large data set with more complete contouring over the area than some of the other wet-year maps.

The 1998 depth to water beneath the northern Plan Area is shown on **Figure 3-44**. The regional map indicates deeper groundwater beneath the uplands in the northeast where ground surface elevations rise above 900 feet msl (more than 500 feet above the valley floor). Although there are few wells to confirm groundwater elevations over the entire upland area, wells with water levels deeper than 250 feet were used to confirm the conceptualization of deeper groundwater in the upland areas. For the remaining area shown on **Figure 3-44**, spring 1998 data indicate groundwater depths from about 50 to 200 feet deep, with the shallower depths indicated along the River (**Figure 3-44**).

The depth to groundwater for spring 1998 conditions in the southern Plan Area is shown on **Figure 3-45**. In general, groundwater is shallower in the southern Plan Area with most of the groundwater ranging from 150 feet to 50 feet deep. This condition is mostly related to lower ground surface elevations toward the south with the lowest ground surface elevations at the paleo-lakebed of Kern Lake on the southern boundary; most of this area is now cultivated for agriculture. Groundwater is estimated to be within about 50 feet of the ground surface beneath the Kern Lake. This area contains clay soils and underlying clay sediments that impede surface water infiltration and create perched water. As discussed previously, a broad area of perched water has been mapped in the southern Plan Area over time as shown on **Figure 3-45**. This area of perched water was discussed previously and correlated the distal portions of alluvial fans and paleo lakes in the area (see previous discussions in **Sections 3.2.3** and **3.3.2.2**).

Two hydrographs provided on **Figure 3-46** allow a comparison of perched water elevations (31S/28E-28D01) and groundwater elevations in the Principal Aquifer (31S/27E-25D01). Well locations are shown on **Figure 3-45**. As shown on the graph, the perched water averages about 18 feet below ground surface. During the recent drought, perched water declined to about 30 feet below ground surface. Although wells with long-term records in the perched zone are sparse, the zone has been observed at depths of about 20 feet to 50 feet. The perched zone appears to be hydraulically separated from the Principal Aquifer and does not typically respond with variations seen in deeper wells, as evidenced by the pair of wells on **Figure 3-46** and other wells (e.g., see Hydrograph 10 on **Figure 3-24**). As shown by the hydrograph from the Principal Aquifer on **Figure 3-46**, depth to water in the Principal Aquifer ranges from about 75 feet below ground surface to more than 150 feet below ground surface.

3.3.6.6 Local NCCAG-Mapped Areas

To further examine the large number of NCCAG-mapped vegetation and wetlands polygons, four local areas have been selected for both the northern and southern Plan Area to allow detailed viewing on a 2016 aerial photograph. The extents of the four local-scale maps for the northern and southern Plan Area areas are shown on **Figures 3-44** and **3-45**, respectively. The local-scale maps are shown on **Figures 3-47** and **3-48**, as panels a though d.

Northern Plan Area

There are about 110 areas with vegetation commonly associated with groundwater and 52 wetland areas mapped in the northern Plan Area (**Figure 3-44**), most of which can be characterized as occurring along the Kern River corridor or in upland drainageways. The four local-scale areas for the northern Plan Area cover 82 vegetation and 34 wetland polygons to allow examination of about 70 percent of the total mapped areas in more detail; these are shown on **Figure 3-47** as **Figure 3-47a** through **3-47d**.

Figure 3-47a covers an approximate one-half-mile segment of the Kern River upstream of the Bellevue Weir. Mapped vegetation in this area includes Red Willow, Mule Fat, Fremont Cottonwood, and Narrowleaf Willow shown by the shaded polygons in the Kern River channel. A riverine wetland (semi-permanently flooded) has also been mapped within the channel. The River is rimmed by the Cross Valley Canal to the north and the Kern River Canal to the south. The City maintains recharge basins that are shown on the western portion of the map and include Aera Park north of the River and two small basins in the Park at River Walk south of the River[28]. In addition to maintaining the recharge basins, the City also provides River channel maintenance in this area involving sand and vegetation removal for flood

[28] An additional City recharge facility, referred to as Truxtun Lakes, is located about 1.5 miles upstream and not shown on Figure 3-47a.

control. As discussed above, the channel in this area is typically dry as shown on this 2016 aerial photograph. KCWA monitors water levels in a nearby well (30S/27E-05D01), located about 800 feet south of the channel (**Figure 3-47a**). With the top of the well screen at 58 feet below ground surface, the well is a reliable monitoring point for the local water table. Since 1995, the water table has always been deeper than 70 feet below ground surface. During 2015, the water table was measured at a depth of 198 feet below ground surface.

Figure 3-47b shows the Calloway Weir and the Calloway Pool as discussed above. During this period in 2016, the River channel is partially wetted with several braided channels shown on the map. As shown, vegetation and wetlands have been mapped within and adjacent to the channel. Vegetation includes Goodding's Willow, Fremont Cottonwood, Mule Fat, Red Willow, Common Elderberry, Arrow-weed, and riparian evergreen and deciduous woodland. As discussed above, this area of the River is the most wetted and supports the most diverse habitat with riparian vegetation in the KRGSA Plan Area. This is also an area of significant recharge both in the pooled area of the River as well as in the adjacent unlined canals such as the Carrier Canal (**Figure 3-47b**). As discussed above, water levels in monitoring well ID4 No. 13, adjacent to the pool, have been about 80 feet deep on average since monitoring began in 2000 (see **Figure 3-42**).

Figure 3-47c includes a reach of the Kern River downstream of the Beardsley Weir. The lined Beardsley Canal lies north of the River and the unlined Carrier Canal diverts from the channel at the Rocky Point Weir. The ground surface elevation is higher in this upstream area; the approximate channel elevation at the eastern edge of the map is about 443 feet msl. The ground surface profile on **Figure 3-43** shows that this elevation is transitioning into the western uplands of the River. The soils associated with this reach of River include silty loam, which is less permeable than the downstream sandy loams and sand and holds more water in the River. Mapped vegetation along this reach consists primarily of Fremont Cottonwood, California Sycamore, Goodding's Willow, and Common Elderberry. **Figure 3-47c** also illustrates the land uses surrounding the vegetation areas, including the Kern River Oil Field. Although water level data are limited in this area, nearby water supply wells at the oil fields indicate water depths of more than 100 feet in the area. Shallow wells drilled in the 1960s along the channel indicate shallow water levels of about 10 to 20 feet.

Figure 3-47d shows an area about 7 miles upstream of First Point on the Kern River. An isolated "island" of the Plan Area is shown north of the River and the larger portion of the Plan. The "island" contains development along Rancheria Road north of the River and includes an area of mapped vegetation including Fremont Cottonwood and Scalebroom. The map also includes two examples of NCCAG-mapped vegetation and wetlands along drainageways in the northwestern uplands of the Plan Area. The eastern most drainage, Cottonwood Creek, contains mapped wetlands, Fremont Cottonwood, and Mule Fat. These upland drainages extend from high elevations in the south (800 to 900 feet, msl) down to the River channel in the north at ground surface elevations of about 550 to 600 feet, msl. Although no water level data are available for these drainageways in the Plan Area, it seems unlikely that the water table could be sufficiently high to support vegetation. These drainageways are more likely located along relatively less permeable consolidated sediments and hold enough local runoff to support vegetation and wetted areas.

Southern Plan Area

For the southern Plan Area, four local areas shown by the map extents on **Figure 3-45** were selected for closer examination on **Figure 3-48**. These local areas include more than 70 percent of the total number of vegetation and wetlands polygons in the southern Plan Area.

Figure 3-48a includes four areas of vegetation with dominant species of Narrowleaf Willow and Goodding's Willow. As shown on the photo, this vegetation grows along and within a recharge basin developed by KDWD for replenishment of groundwater and groundwater banking in the far southwestern Plan Area. Vegetation within the area is controlled to maximize recharge capacity.

Figure 3-48b in an area in the south central Plan Area north and south of Di Giorgi Road. The area is surrounded by cultivated agriculture and two small communities served by El Adobe POA and Panama Road Homeowners Association water systems. Part of the undeveloped land in the north contains the Greenfield Flyers, a radio control aircraft club. Vegetation in this area includes primarily Iodine Bush, Alkali Goldenbush, and Tamarisk (a non-native invasive species). The unlined Central Branch Canal is located just off the map to the west and runs parallel to the mapped vegetation. Although the entire area is likely within the area of perched water, groundwater in the Principal Aquifer is about 150 feet deep. As indicated on Figure 3-48b, much of the NCCAG-mapped areas do not appear to contain a dense natural community of vegetation in 2016.

Figure 3-48c contains areas of mapped vegetation with dominant species of Tamarisk (an invasive non-native), Alkali Goldenbush, Shrubby Seepweek and Iodine Bush. As shown on **Figure 3-45**, this area is located in the far southeastern Plan Area where underlying clay soils allow retention of ponded water used for recreation as water ski lakes. The land, owned by Ski West Village, has developed the land for housing and recreation. A mapped wetland on the southern portion of the property appears to be an additional developed lake.

Figure 3-48d includes private property surrounding the New Rim Ditch Canal bordering the southern Plan Area boundary. Wetlands, invasive tamarisk, and other vegetation are mapped along a constructed and maintained canal are not natural communities. The canal is used to convey agricultural water around the southern Plan Area. NCCAG-mapped area is referred to as the Kern Lake Preserve. The area apparently contains Quailbush, Iodine Bush, and willows, which receive agricultural tailwater. Perched water west of I-5 has been observed to contain elevated salt content and high concentrations of TDS. Although perched water has been mapped in the area, groundwater in the Principal Aquifer is more than 50 feet deep in this area. None of the local vegetation is supported by groundwater.

3.3.6.7 Summary

Information regarding Kern River operations and flow, channel elevation, and groundwater elevation data over a 20-year period indicate that the Kern River is not interconnected surface water in the KRGSA

Plan Area. Riparian vegetation along the River is supported primarily by regulated flows from Lake Isabella, pooled water to support River operations (above the Calloway Weir), and managed aquifer recharge in the River channel and adjacent unlined canals. The Plan Area also contains a small segment of riparian vegetation along the River above First Point (**Figure 3-47d**), which is limited to a small area in the northeastern Plan Area where data are insufficient to determine surface water-groundwater interactions. However, this area also is characterized by regulated flows in the River.

Data on groundwater depth and other local conditions do not indicate the presence of GDEs in the Plan Area. Irrigation water infiltration and agricultural return flows could be contributing to local vegetation water use in the southern Plan Area. In this area, infiltration of irrigation water and agricultural return flows are impeded by clay soils and subsurface clay sediments; this creates shallow perched water conditions that appear disconnected from regional groundwater. If GDEs are being supported by locally perched water, this condition will likely continue under the GSP as surface water continues to be an important source for irrigation in the southern Plan Area.

3.4 DATA AND KNOWLEDGE GAPS

GSP regulations define "data gap" as "a lack of information that significantly affects the understanding of the basin setting or evaluation of the efficacy of Plan implementation and could limit the ability to assess whether a basin is being sustainably managed." This definition recognizes the importance of identifying the data gaps that specifically relate to sustainable groundwater management and does not necessarily include all missing or incomplete data.

In general, well construction information is unknown for many wells currently monitored, especially for private wells being monitored in the southern Plan Area. Efforts to match known active wells to construction data have been difficult. In particular, the area of perched water in the southern Plan Area indicates complications with respect to intervals of well screens. Although well completion reports indicate that most wells are similarly-constructed, water levels in some areas appear to be associated with locally high water levels even if well completion reports in the area are associated with deep screens. A systematic approach to better link water level response to well construction throughout the Plan Area would provide useful information.

Although the northern Plan Area is associated with a large amount of water quality data, results of local environmental investigations are not well known. Multiple cleanup sites in the KRGSA are listed in **Table 3-4**. Sites within municipal wellfields are prioritized for review of more detailed information. Coordination and communication with the Central Valley Water Board may be the most efficient method for identifying and prioritizing sites to watch. These sites often have monitoring wells installed and a regulatory order to conduct monitoring. It would be helpful to the KRGSA to compile a list of these wells and download data from the more relevant monitoring wells as available.

In addition, the widespread detection of TCP across the KRGSA should be better understood. Tens of wells have installed wellhead treatment facilities to manage the problem. However, because the MCL was only recently adopted, many smaller water systems are analyzing TCP at sufficiently low detection levels for the first time. Coordination with DDW and data from the SWRCB/Geotracker would be helpful in making sure that TCP concentrations are well-managed.

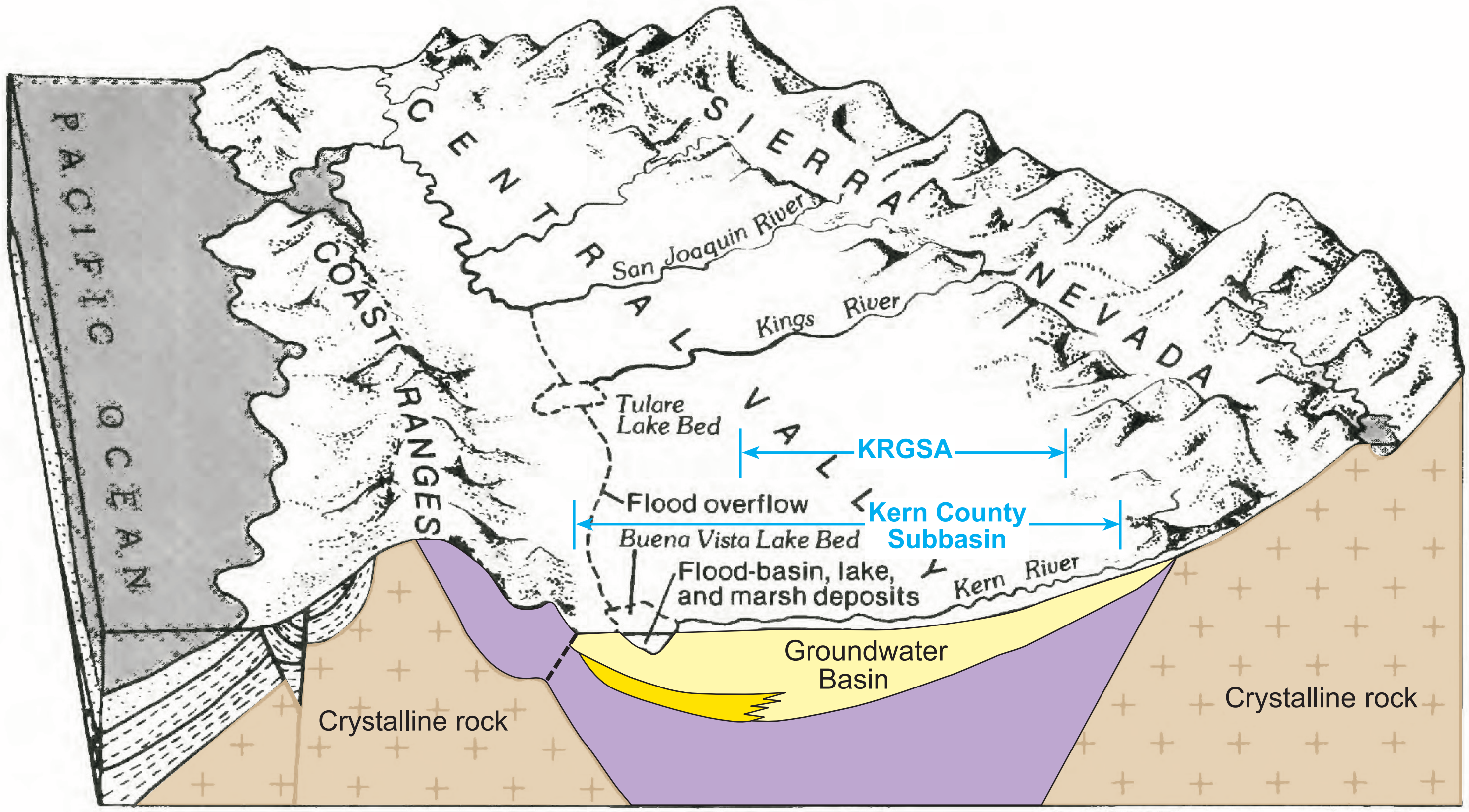
Finally, the northeastern Plan Area contains few wells and sparse water level data. This portion of the KRGSA consists of a large upland area covering about 15,000 acres (northeastern area above about 700 feet msl on **Figure 3-7**). The area contains large areas of undeveloped lands including more than 4,000 acres of oilfield lands. Some portions contain low density residential development, relying primarily on domestic wells.

Although this northeastern upland area is within Metropolitan Bakersfield (**Figure 1-2**), only a few active municipal wells are nearby (**Figure 2-14**). KCWA has added private wells to its water level monitoring program when candidate wells could be found. For the GSP, a few of these currently-monitored wells are being incorporated into the monitoring program, but long-term access is uncertain. There may be a need to locate additional existing wells or install new wells in this area. At this time, local groundwater production can likely be considered de minimis. However, this uncertainty would be prioritized if urban development and associated well drilling increases in this area.

Data and knowledge gaps for the hydrogeologic conceptual model and groundwater conditions are summarized in **Table 3-6**.

Table 3-6: Data Gaps for the Hydrogeologic Conceptual Model and Groundwater Conditions

Issue	Area	Groundwater Management	Actions to Address
Well Construction	Southern and southeastern Plan Area	Vertical gradients, water levels, and primary production zones in Principal Aquifer	Improvements to monitoring network; match construction data to monitoring wells, where possible
Water Quality	Primarily northern Plan Area	Impacts from Environmental Sites	Coordinate with Water Board; ongoing document/data review
Water Quality	Entire KRGSA Plan Area	Water level impacts on 1,2,3-TCP and other constituents of concern	Coordinate with SWRCB and Community Water Systems; ongoing evaluation of water supply well data
Northeastern KRGSA Plan Area	12,000 acres with limited aquifer and groundwater data	NE corner of ID4 and areas to northeast of ID4 service area	Research existing wells in the area and identify priority areas for monitoring; work with City planning to identify potential growth in the area and plan for new monitoring wells, as needed



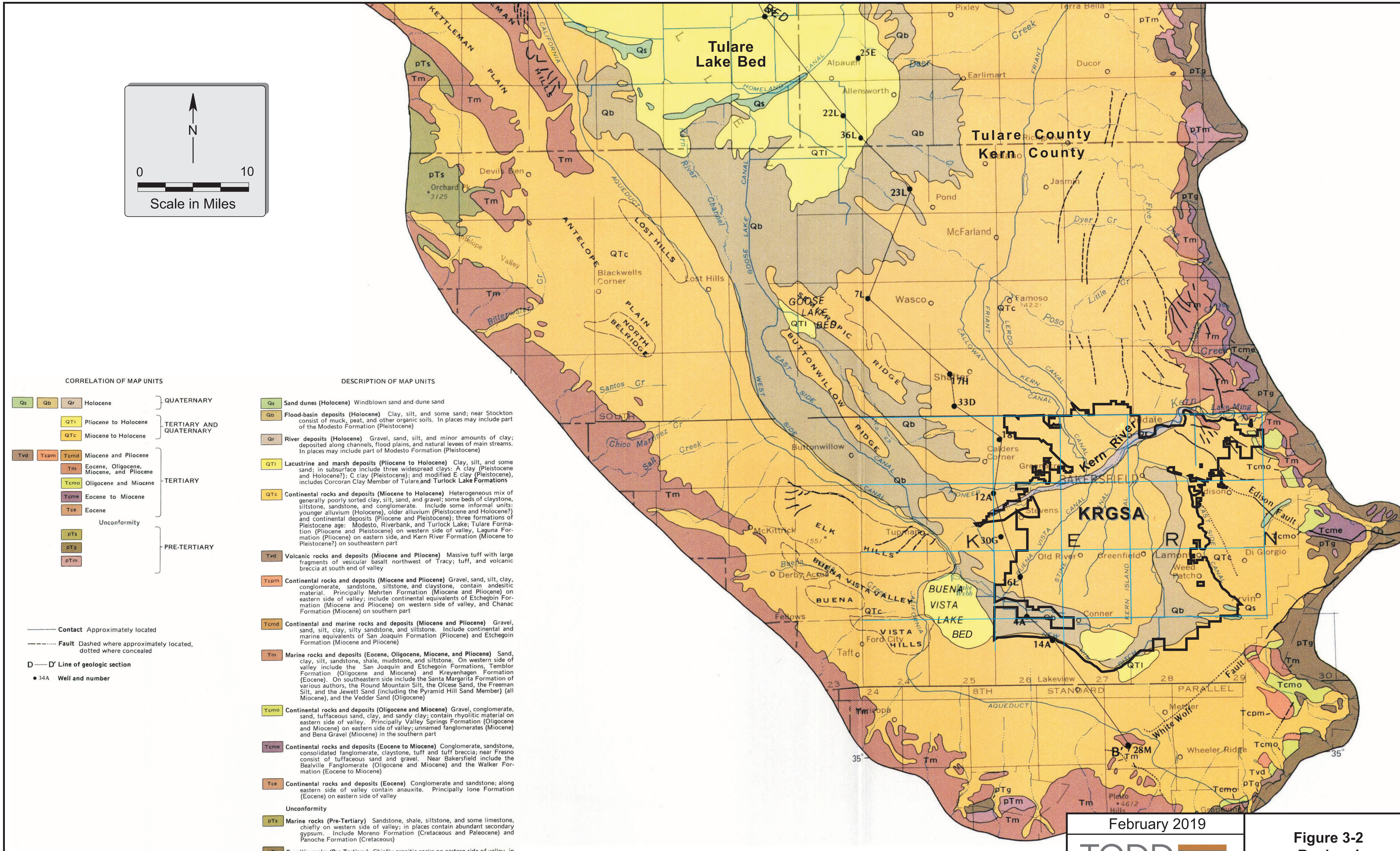
(yellow swatch)	Continental Deposits
(gold swatch)	San Joaquin Formation (transition from marine to continental deposits)
(purple swatch)	Marine Sedimentary Units

Source: Modified from Page, 1986 and DOGGR, 1998.

February 2019

TODD GROUNDWATER

Figure 3-1
Schematic Diagram Regional Setting Kern County Subbasin



Sources: Page, 1986.

February 2019

TODD GROUNDWATER

Figure 3-2
Regional Geologic Setting

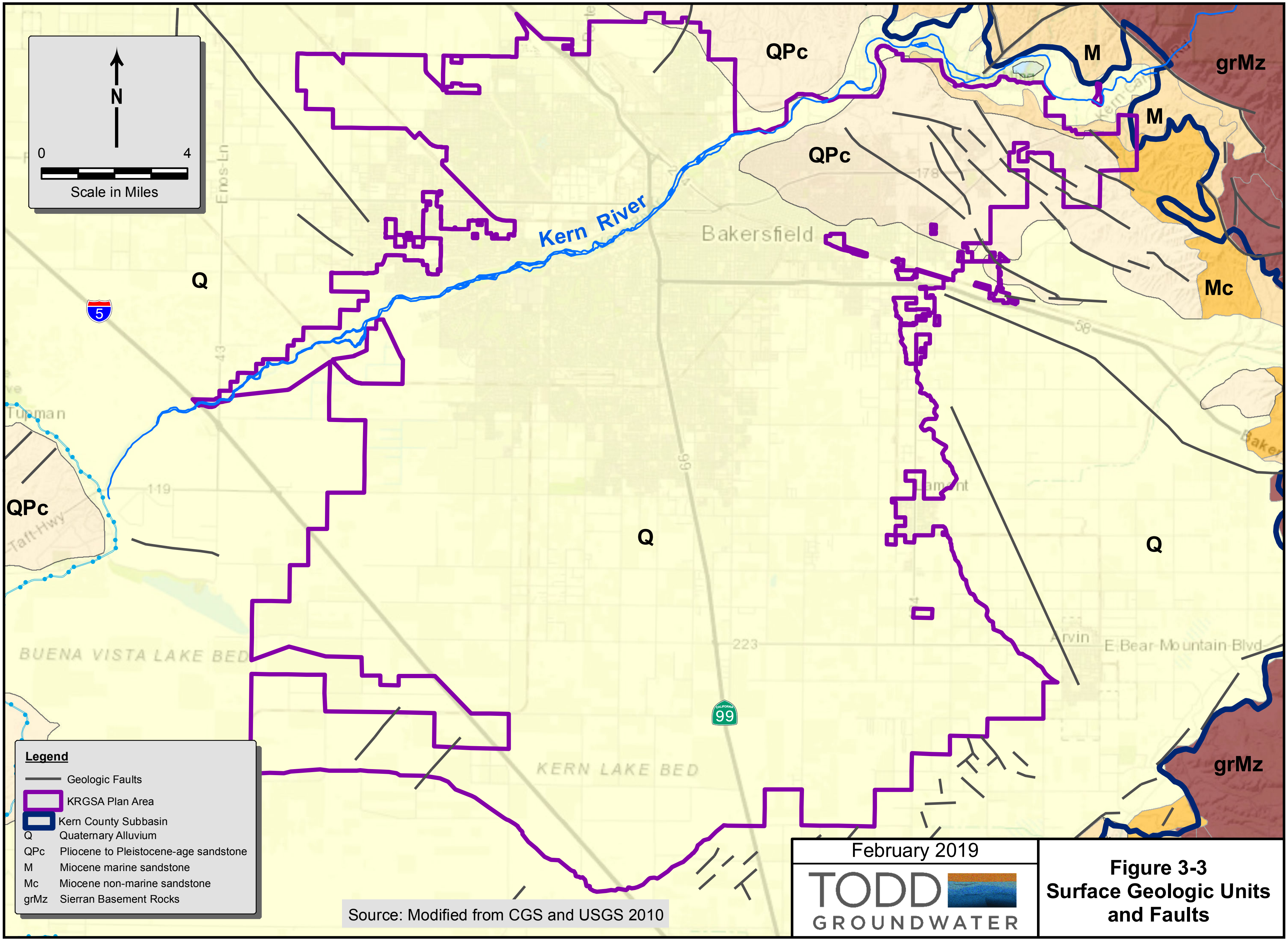


Figure 3-3
Surface Geologic Units and Faults

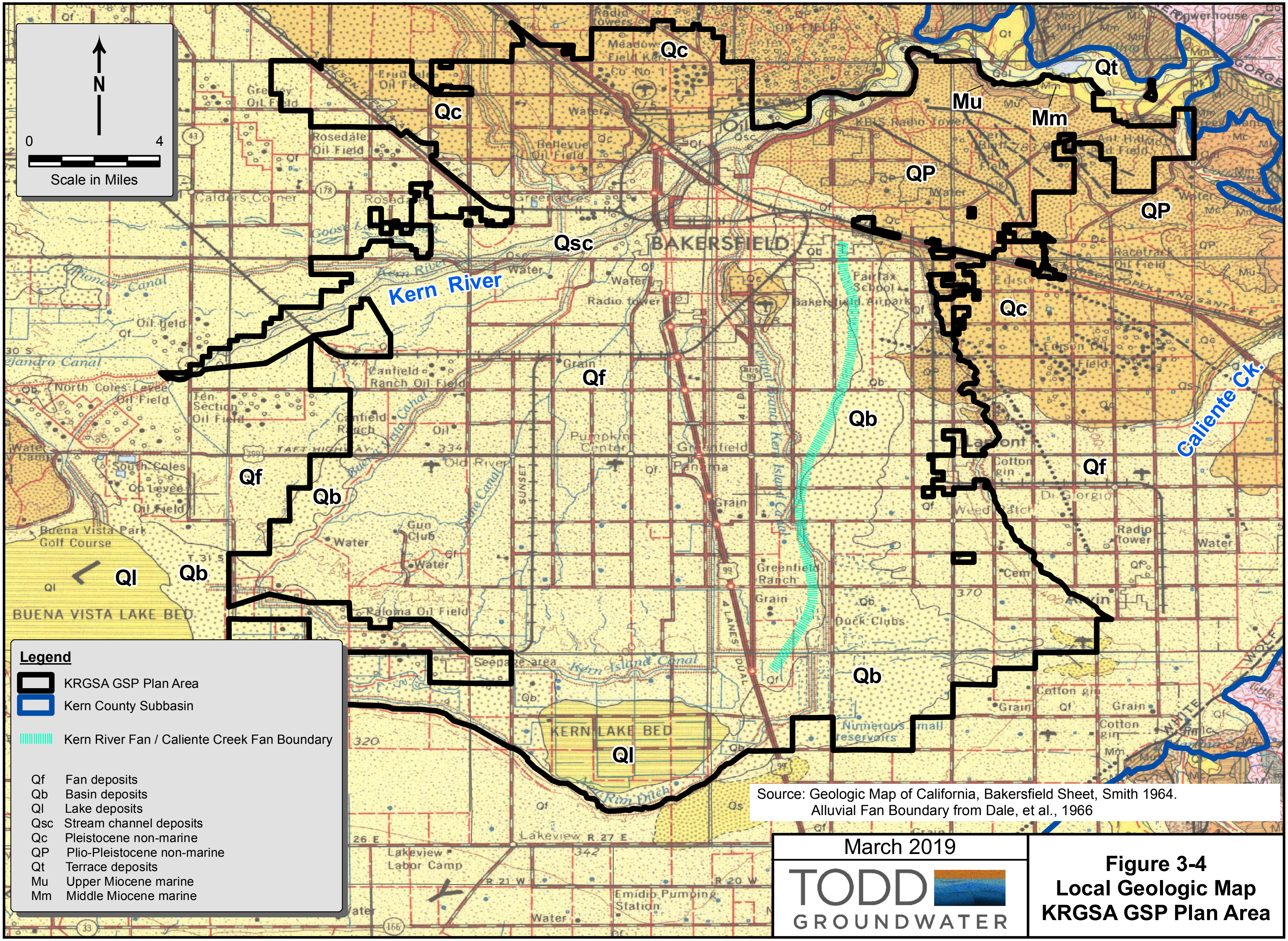
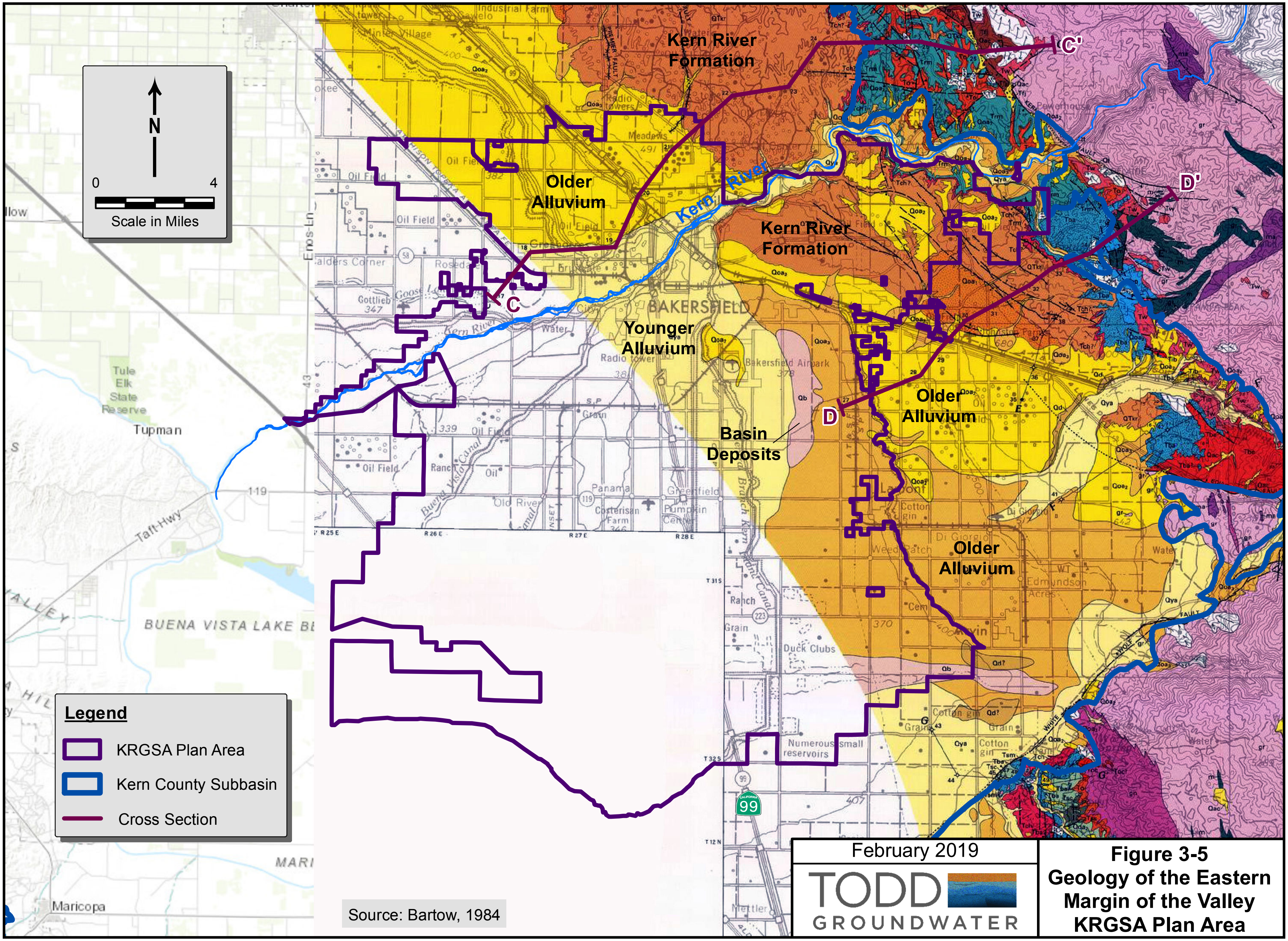


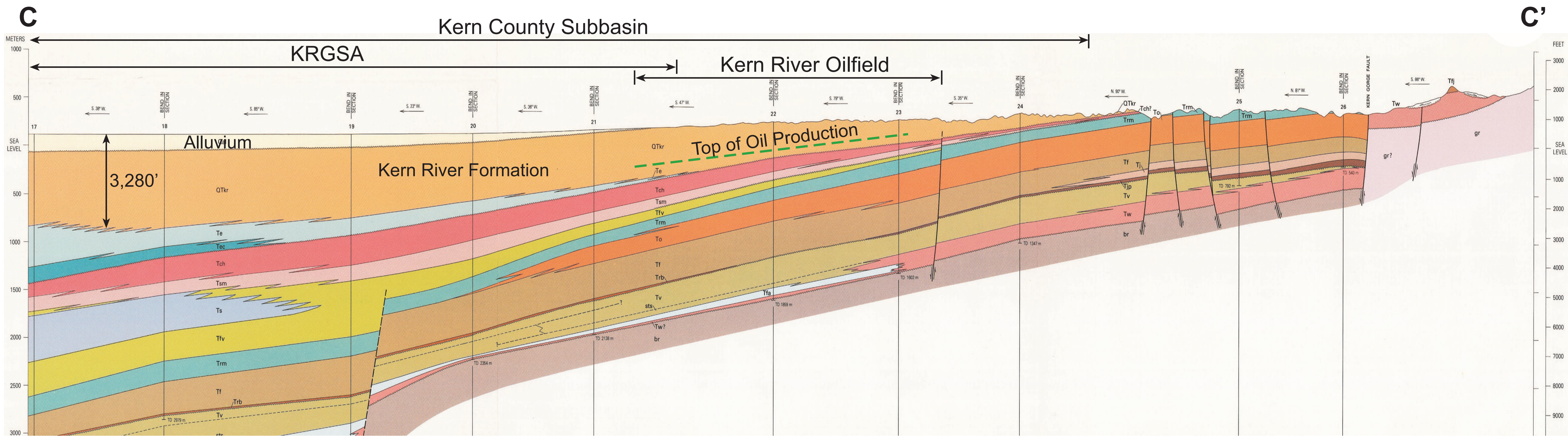
Figure 3-4
Local Geologic Map
KRGSA GSP Plan Area



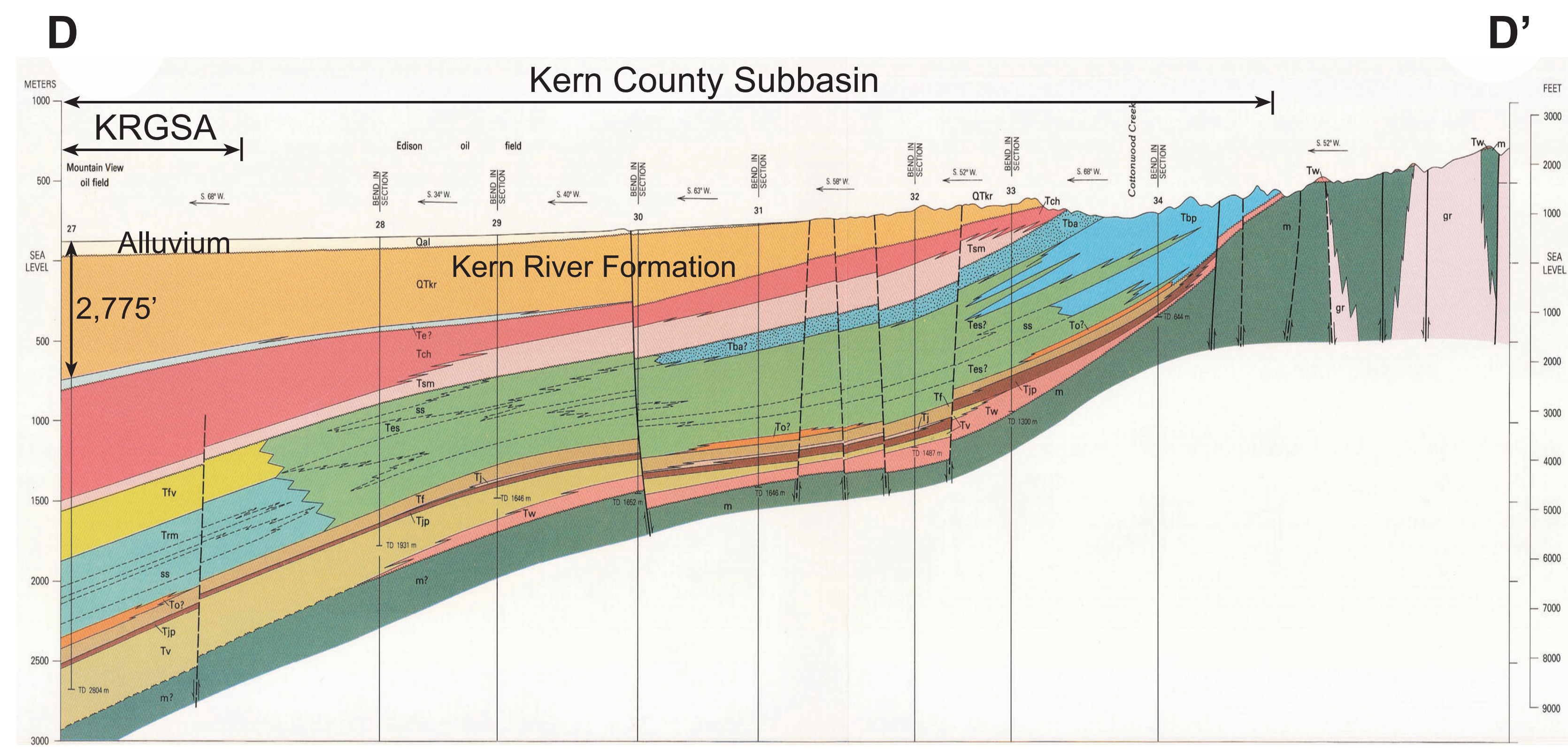
February 2019

TODD GROUNDWATER

Figure 3-5
Geology of the Eastern Margin of the Valley
KRGSA Plan Area



North of the Kern River

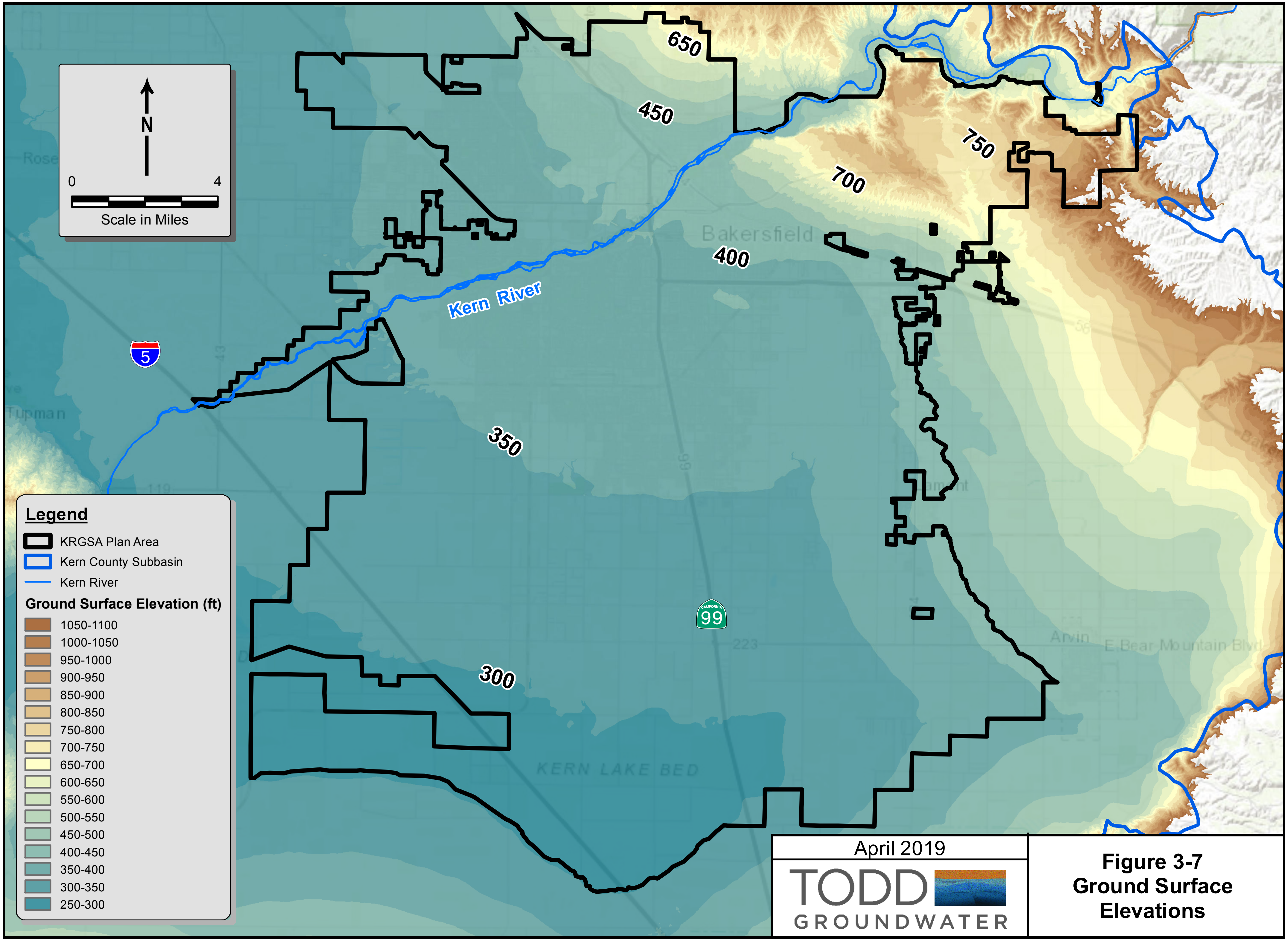


South of the Kern River

April 2019

TODD GROUNDWATER

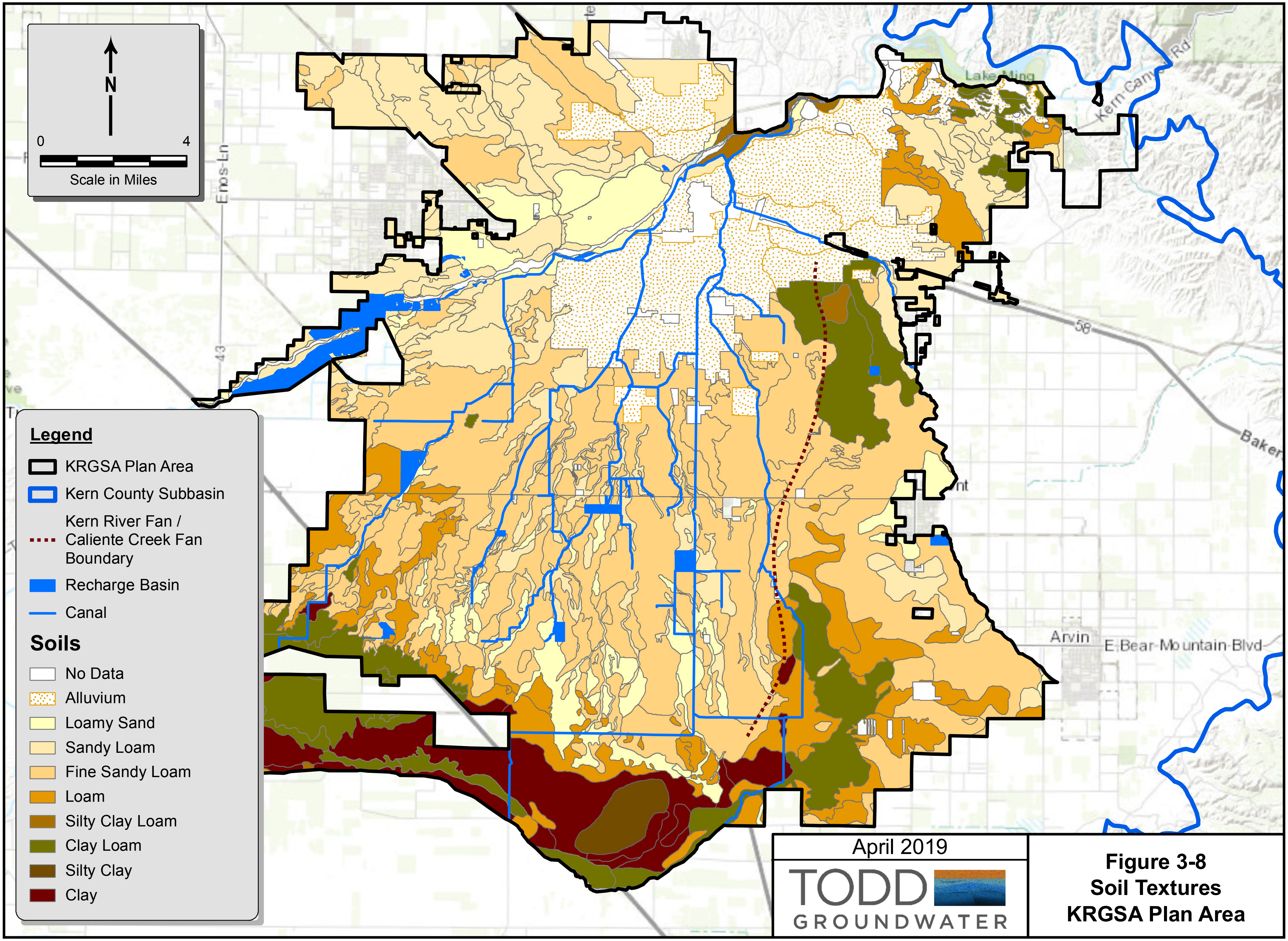
Figure 3-6
Subbasin Geometry Eastern Margin Cross Sections



April 2019

TODD GROUNDWATER

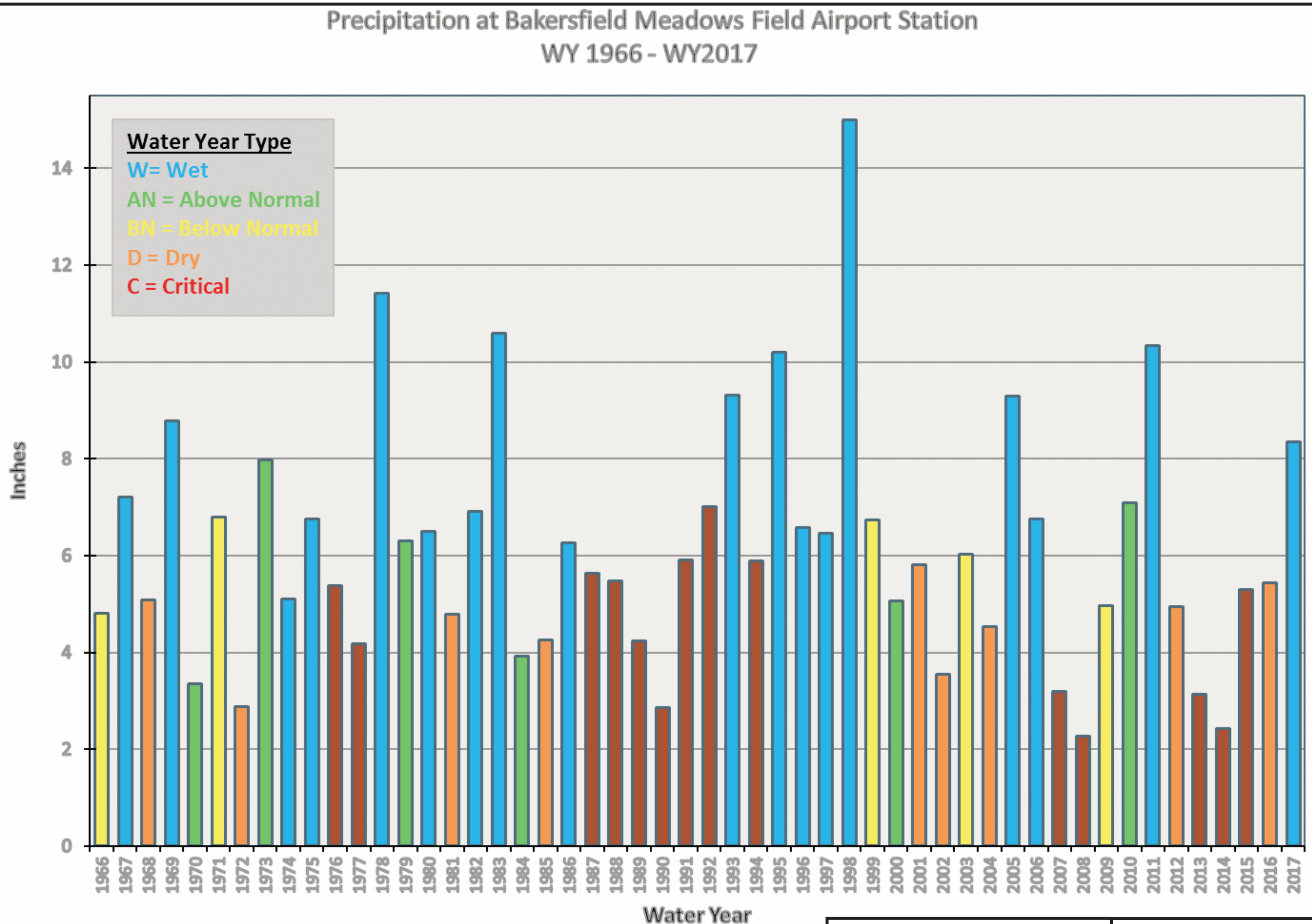
Figure 3-7
Ground Surface Elevations



April 2019

TODD GROUNDWATER

Figure 3-8
Soil Textures
KRGSA Plan Area

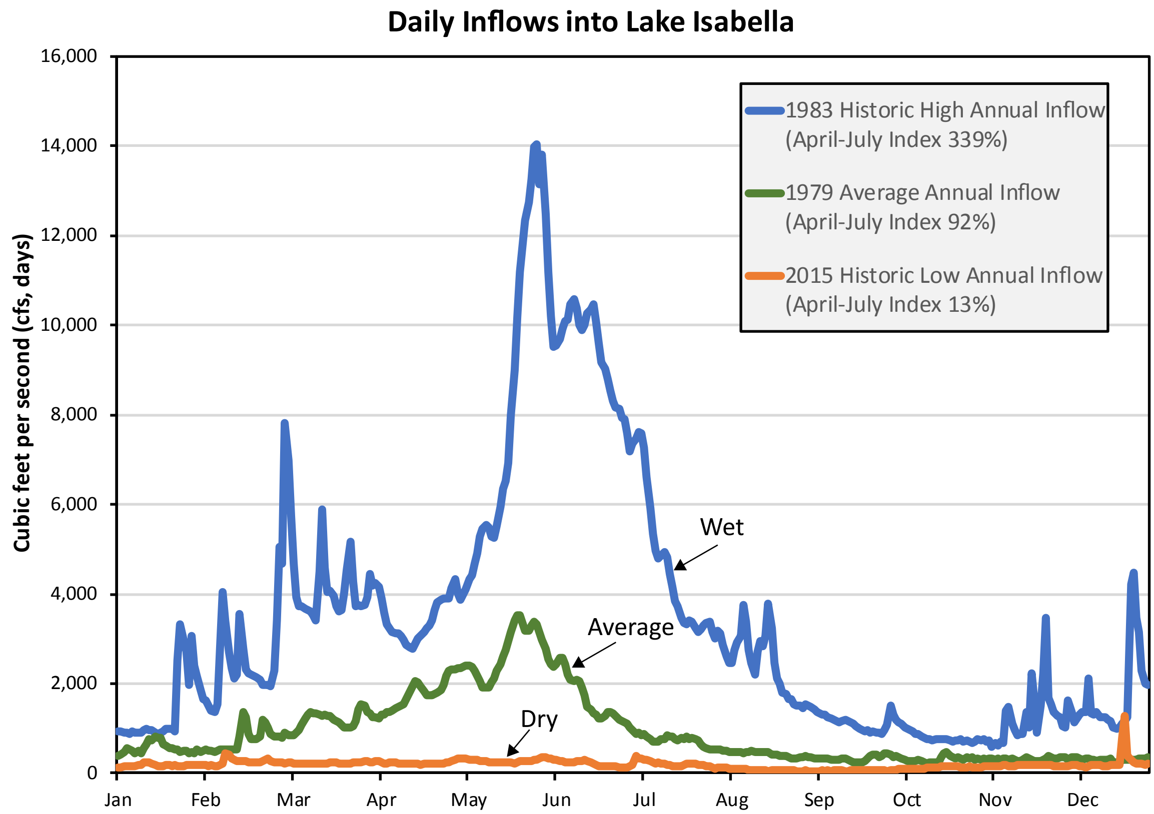


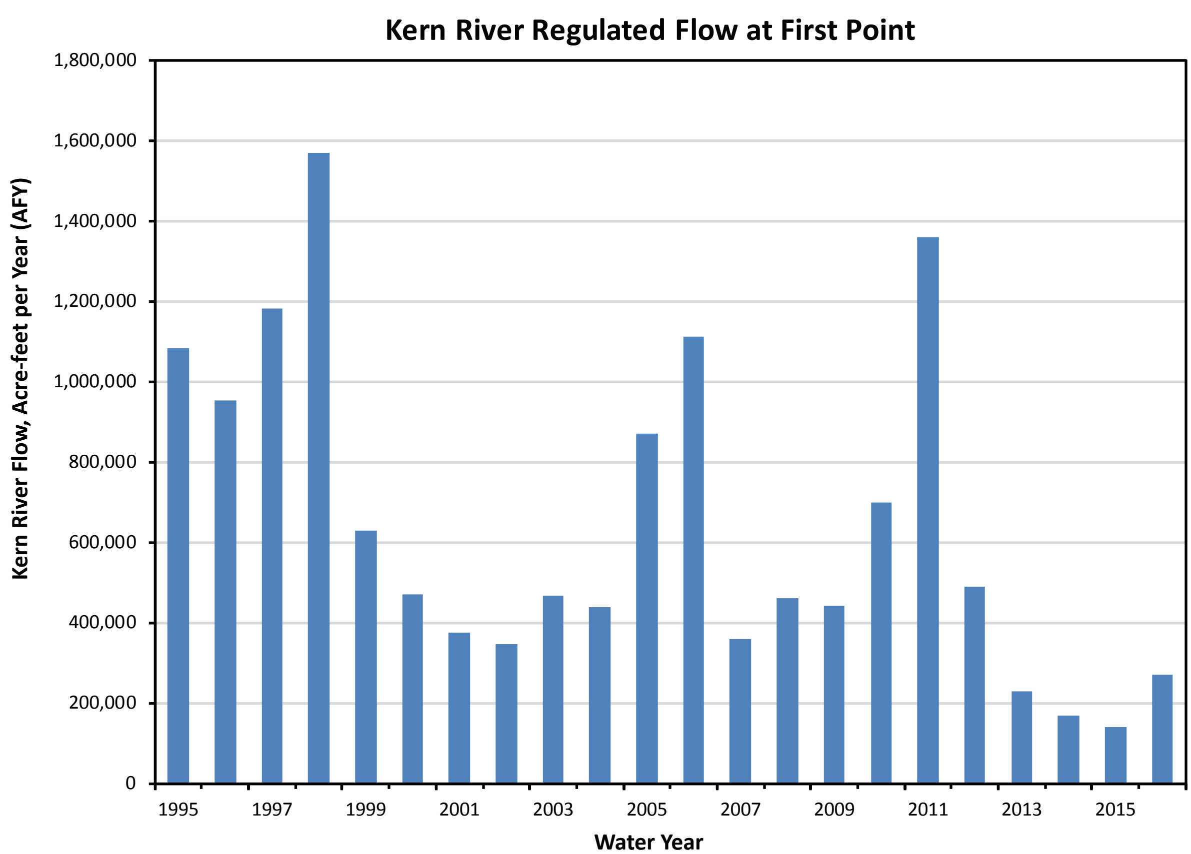
Sources: Precipitation - NOAA, 2018
Water Year Type - DWR, San Joaquin Valley Indices

February 2019

TODD GROUNDWATER

Figure 3-9
Precipitation and Water Year Type





March 2019

TODD GROUNDWATER

Figure 3-10
Kern River Flows

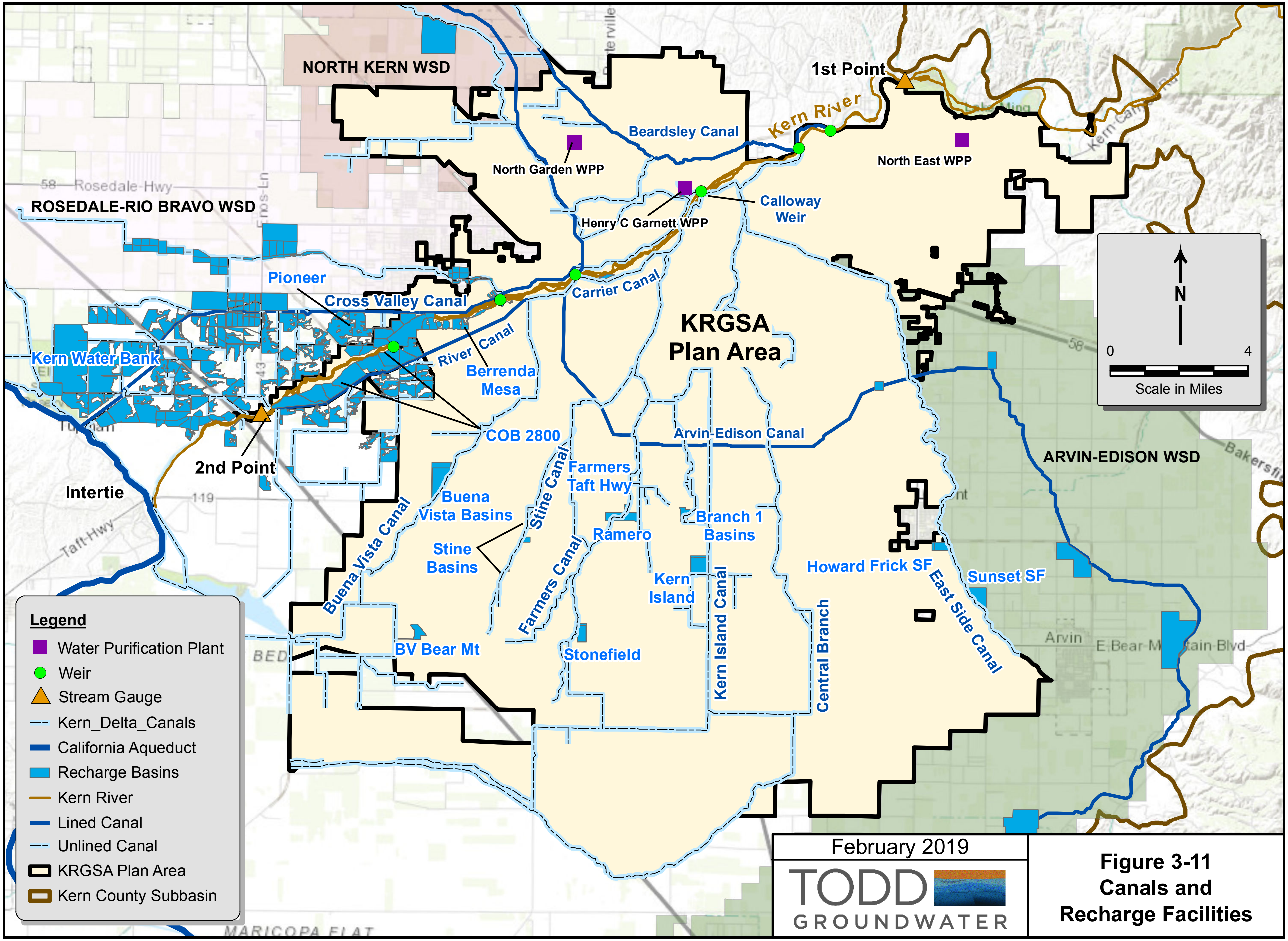


Figure 3-11
Canals and Recharge Facilities