SEPTEMBER 2019

Buena Vista GSA

Groundwater Sustainability Plan: Public Review Draft

Kern County Groundwater Subbasin

DRAFT

Buena Vista GSA

Public Review Draft
Groundwater Sustainability Plan

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September 2019

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1.1.1 Executive Summary

Introduction

The Buena Vista GSA (BVGSA, GSA) covers an agricultural area of Kern County located in the trough of California's southern San Joaquin Valley approximately sixteen miles west of the City of Bakersfield. The boundaries of the BVGSA coincide closely with those of the Buena Vista Water Storage District (BVWSD, District).

The BVGSA is bordered by the following GSAs:

- Kern Groundwater Authority GSA;
- Kern River GSA, and
- Semitropic GSA.

The BVGSA is made up largely of reclaimed swamp lands in and along the pre-development course of the lower Kern River which, after exiting the Southern Sierra Nevada mountains and flowing south and then southwest across the southern San Joaquin Valley, ran through the topographic axis of the valley toward its terminus at a drainage basin which was once Tulare Lake. The water conveyance systems in and around the GSA consist of a network of levees and diversions to control the high flows of the Kern River, as well as a system of canals for delivery of surface water. Of the GSA's total area of 50,560 acres, approximately 46,600 acres receive water service from the BVWSD. Of that acreage approximately 35,000 acres are farmed each year, primarily in tree and row crops, with this number fluctuating based on factors including water supply and market conditions. The GSA also encompasses the Community of Buttonwillow, three other public water systems and domestic users all of whom rely entirely on groundwater for domestic, municipal and commercial users

The BVWSD has successfully followed a conjunctive management policy by which surface water is recharged when available and stored in the principal aquifer system for recovery by pumping in years when surface water is insufficient to meet demands. Prior to the construction of the State Water Project, the Kern River was the BVWSD's sole source of surface water. Kern River water is now stored in Lake Isabella for release in response to water orders from the District. With construction of the State Water Project (SWP) regulated diversions from the Kern River have been supplemented by schedulable deliveries from the California Aqueduct, which runs immediately to the west of the GSA.

Conjunctive management within the BVGSA begins with deliveries of surface water from the Kern River and the California Aqueduct with these two sources generating an average annual supply sufficient to meet District-wide demands. Thus, during years when supplies are above average, surface water is recharged, and during years when supplies are limited, recharged water is pumped as a supplemental source of supply.

A high proportion of recharge in the BVGSA takes place through seepage from facilities constructed by the BVWSD including canals, laterals and recharge basins. By contrast, due to the low infiltration rate of topsoils in the area, deep percolation of precipitation and irrigation water from farmland is not an important contributor to recharge.

The conjunctive management program that has been central to the BVWSD's operations lies at the heart of the BVGSA's approach to sustainable groundwater management which begins with careful stewardship of surface water. While the principle of conjunctive management has been followed by the BVWSD since the District's inception, the specifics have been dynamic as the mechanisms used to recharge and recover groundwater have been adapted to respond to changes in surface water supplies, cropping patterns and demands, irrigation technologies and requirements of regulatory programs. Therefore, a second principle that has guided the BVWSD in the past and will guide the BVGSA during implementation of this GSP is adaptive management. Thus, the BVGSA's strategy to supporting sustainable groundwater management will rest on continued stewardship of groundwater and surface water resources by adapting the tools for conjunctive management through planning and implementation of projects and actions.

As documented throughout this GSP, due to the BVGSA's access to surface water, its operational practices and its distinctive geology and soils, the area within the GSA has maintained relatively stable groundwater elevations through wet periods and prolonged droughts. Nevertheless, the BVGSA also recognizes how projected reductions in the availability of water from the Kern River and the State Water Project coupled with projected increases in demand due to climate change, changes in cropping pattern and introduction of new crop varieties and production practices are all likely to increase demand for water. In response, the GSP presents a suite of projects and management actions designed to enable the GSA to adapt to these anticipated changes. This suite of activities includes some that have been completed or are now underway. Significant among those is the Palms Groundwater Banking Project which is now in its second phase of implementation and the BVWSD's program to install magnetic flow meters and totalizers on all production wells in the District, a program that has now been completed.

The BVWSD has two distinct service areas separated by 15 miles as shown in Figure 1-1 – Buena Vista GSA Boundaries. The Buttonwillow Service Area (BSA) occupies 91% of the District (46,200 acres), while the Maples Service Area (MSA) occupies the remaining 9% (4,360 acres)[1]. Both service areas lie within the lower Kern River watershed, where historic runoff created heavy clay soils from former swamp and overflow lands along the northern fringe of Buena Vista Lake. Because of the distance between these service areas, their boundaries have been used to define the Buttonwillow Management Area (BMA) and the Maples Management Area (MMA) of the BVGSA. (Figure 1-1 – Refer to Figures Tab)

This GSP emphasizes management of the BMA, which, as described throughout this document, is a distinct entity within the Kern County Subbasin with respect to its hydrogeologic features and management practices. For this reason, the BMA will be treated as a single unit to be managed using a uniform set of management objectives and sustainable management criteria. Because of the MMA's location within the Kern River GSA (KRGSA), the sustainable management criteria for this management area will align with those established for surrounding areas of the KRGSA.

Although land surface elevations, depths to groundwater and depths to the E-clay vary throughout the BMA, the overall relative uniformity of the management area aids in setting sustainable management criteria due to the following characteristics:

- The BMA is underlain by the E-clay at elevations ranging from approximately 10 ft AMSL to -215 feet AMSL with unconfined and semi-confined zones of the Tulare Formation lying above the E-clay and a confined zone extending beneath the clay layer to the base of fresh groundwater.
- Analysis of screened intervals indicates that wells for all uses extract water from a production zone above the E-clay.
- Water quality in the production zone above the E-clay is better than that found beneath this layer.
- The risk of inducing subsidence by extracting water from the zone above the E-clay is likely to be lower than the risk induced by extracting water from beneath the E-clay.
- The volume of groundwater in storage above the E-clay is likely to be adequate to meet the demands of the BMA under foreseeable conditions.
- Water use throughout the GSA is overwhelmingly agricultural, therefore, the spatial distribution of demands is uniform.

Both conjunctive management and sustainable groundwater management aim at providing a secure water supply to all users. This goal informs other elements of the GSP including the monitoring program and the communication and engagement plan. With respect to monitoring, the GSP describes monitoring networks now serving the BVWSD and the Buena Vista Coalition,

[1] 2016 Engineer's Assessment Report, in Support of Proposition 218 Assessment Ballot Proceeding, Buena Vista Water Storage District,

an entity formed to administer the Central Valley Regional Board's Irrigated Lands Regulatory Program, and how these networks have been used to establish sustainable management criteria. The GSP then describes how these monitoring networks will be expanded and strengthened for monitoring these criteria, for filling data gaps and for updating and improving the GSA's water budget.

Water Resources and Demand Budget

An important consideration for the BGVSA with respect to overall management of the Kern County Subbasin is the degree to which the GSA's supplies are expected to be in balance with its demands in 2020 and the extent BVWSD's water resouces and demands on these resources are projected to be in balance in 2030 and 2070. These questions that can be approached through a simple water budget that combines measured values with parameters that have been agreed upon by the Kern County Subbasin Coordinating Committee. Estimates of parameters such as groundwater extraction and subsurface cross-boundary fluxes are not included as the sole purpose of this budget is to combine water the BVGSA is entitled to receive from the Kern River and the SWP with water available from native yield and precipitation. These sources of supply are then compared with water exiting the GSA through the largest and best defined flow path, evapotranspiration.

Unlike the GSP water budget described in Section 6 – Water Supply Accounting – Water Budget, which tracks pathways for movement of water into and out of the BVGSA, this budget is based on native yield and precipitation, the BVWSD's current and projected surface water supplies, and current and projected demands and outflows. Therefore, while the flow paths presented in the GSP budget are affected by exchanges, transfers and banking agreements that alter the location and timing of flows entering and leaving the BVGSA, this budget rests on the underlying access to water and the demands expected to be placed on those resources.

The two basin-wide parameters used as a foundation for this analysis are native yield and precipitation. For the Subbasin, 0.15 AF/ac is a generally accepted value for native yield. Values for precipitation discussed by the Coordinating Committee range from 0.15 to 0.5 AF/ac with the BVGSA adopting 0.2 AF/ac, a number in the lower 15% of this range. Applied over the entirety of the BVGSA's two management areas, the Buttonwillow Management Area (BMA - 46,480 acres) and the Maples Management Area (MMA - 4,360 acres), use of these values for the 2020 estimate results in an average annual contribution of 7,626 AF of native yield and 10,168 AF of precipitation for a total contribution of 17,794 AF. The native yield has been held constant for the 2030 value, while precipitation, after adjustment for climate change, has been reduced by 18%. For 2070, the native yield has remained constant, while the value for precipitation is 16% below the 2020 baseline.

The BVWSD's diversions from the Kern River are based on an average entitlement of 156,000 AF/yr delivered by First Point interests to the Second Point of Measurement, undiminished by delivery losses (Krieger & Stewart, 2009). Buena Vista's entitlement is 96.044% of this flow or 149,828 AF/yr. This entitlement is expected to remain essentially intact during the period of

SGMA implementation with the BVGSA applying a future average annual entitlement of 147,000 AF/yr for the 2030 and 2070 budgets.

Deliveries of SWP water of 12,960 estimated for 2020 are based on the BVWSD's Table A allocation of 21,600 AF/yr after adjustment by DWR's 62% projected system reliability (State Water Project Final Delivery Capability Report, DWR, 2015). Under the 2030 climate change scenario, the 2020 Table A supply is reduced by 22.3% to 10,070 AF/yr. Under the 2070 scenario, the Table A supply is reduced by 25.6% to 9,642 AF/yr.

The BVWSD has historically taken an average of 1,800 AF/yr of Article 21 water. Because of the development of the Palms and the Corn Camp water banking projects described in Section 7 – Projects, Management Actions and Adaptive Management Actions, the amount of Article 21 water to be received by the GSA in 2040 and 2070 is expected to increase to 3,900 AF/yr.

As presented throughout the GSP, consumptive demand has fluctuated considerably during the period between 1993 and 2015. Some of this fluctuation is a response to variations in the weather. However, the factors having the greatest impact on demand have been changes in cropping, particularly conversion from seasonal field crops to permanent plantings and varietal improvements. As extensive plantings of orchards are now maturing in the BVGSA and further conversions of field crops to orchards and high production vineyards are anticipated, the increase in consumptive use due to climate change is likely to be exceeded by the factors described below.

- Irrigation demand measured by the BVWSD in 2019 is approximately 100,000 AF, an average of 2.14 AF/acre over the 43,643 acres eligible to receive water service. This value is comparable to the average total ETa observed over the BVGSA from 2006 through 2015. Demand in 2020 is expected to be comparable to 2019.
- Irrigation demand in 2030 is anticipated to reach 150,000 AF/yr (3.22 AF/acre served). This increase is due to the combined impacts of climate change, maturing orchards and vineyards, and continued conversions to permanent crops;
- Irrigation demand in 2070 is anticipated to reach 175,000 AF/yr (3.75 AF/acre served). This further increase is also driven by climate change, continued cropland conversion and introduction of higher yield crop varieties having lower consumptive demands relative to yield but higher water demands per acre. The average per acre served values can be compared with a current consumptive demand for high-yielding almonds grown in the San Joaquin Valley of 4.33 AF/acre.

Most surface water outflows from the BVGSA serve transfer agreements or exchanges that are captured in the values given above for entitlements to Kern River and SWP water. The historical exception are flows leaving the GSA via the Main Drain Canal. These flows have greatly diminished over the past 10 years as growers in Buena Vista have converted from gravity irrigation systems which produce substantial volumes of tailwater and tilewater to drip and micro-sprinkler systems which have essentially eliminated these sources of drainage. These reductions are illustrated by records showing that prior to 2013 the average annual outflow of the Main Drain Canal was 10,000 AF/yr, but that since June of 2013 there has been no recorded outflow, even during 2017 when flows on the Kern River were 270% of normal. As a result, Main Drain Canal outflows are not an element of the 2020 budget and are not included in the 2030 and 2070 budgets as future outflows are unlikely.

Table 1-1 presents the parameters and values described above with the 2020, 2030 and 2070 conditions each presented in a single column.

Table 1-1. 2020, 2030 and 2070 Resources vs. Demands

Year	2020	2030	2070
Water Resource		**Volume (AF/yr)**	
Native yield	7,626	7,626	7,626
Precipitation	10,168	8,338	8,541
Subtotal	17,794	17,794	17,794
Kern River	149,000	147,000	147,000
SWP Table A[1]	13,392	10,406	9,964
SWP - Article 21[2]	1,800	3,900	3,900
Subtotal	164,192	161,306	160,864
Available Resource	181,986	179,100	178,658
Water Demand		**Volume (AF/yr)**	
Evapotranspiration[3]	100,000	150,000	175,000
Main Drain Canal[4]	-	-	-
Total Demand	100,000	150,000	175,000
Balance	81,986	29,100	3,658

[1] Table A reduced by 22% in 2030 and by 26% in 2070

[2] Article 21 increased by 2,100 AF/yr due to completion of Palms and Corn Camp water banking projects

[3] 2020 estimate based 2019 water demands measured by BVWSD

[4] Based on average Main Drain Canal outflow since June 2013. A zero outflow is used because it represents current and expected future outflows.

The 2030 and 2070 projections indicate that the impacts of climate change are expected to do little to reduce BVWSD's entitlement to the Kern River. Therefore, as demands within the BVGSA increase, the current gap between the BVWSD's entitlement to the river and its diversions to serve internal demands is likely to shrink as the District reduces transfers to other users to meet its own growing demands in the face of diminishing SWP supplies.

The water budget table for 2020, 2030 and 2070 demonstrates that when applying agreed upon values for native yield, precipitation and climate change projections, the BVGSA is in surplus and will remain in surplus through 2070 albeit with the surplus diminishing due primarily to anticipated increases in irrigation demand with climate change being an important but secondary factor. Nevertheless, due largely to the BVWSD's entitlement to the Kern River and the District's history of conjunctive management, the BVGSA has the resources and the mechanisms to remain in balance internally and to contribute to achieving sustainability throughout the Kern County Subbasin.

Communication and Engagement

An important contribution of SGMA is its emphasis on communication and engagement with the public. The BVGSA's approach to public engagement is tailored to the area's size and demographics and relies both on distribution of information via the BVWSD's website and on face-to-face meetings between stakeholders and GSA decision makers. The focus on direct communications has been successful in developing a cooperative relation between key stakeholders including the Community of Buttonwillow and landowners in the formation of the BVGSA and in the development of the GSP. As well as engaging with local stakeholders, the GSA will also communicate actively with interested parties outside the area to inform these parties about implementation of the GSP and to educate them about the physical conditions and water management practices of the BVGSA.

A second contribution of SGMA is its aim of encouraging sustainable groundwater management throughout the Kern County Subbasin. To this end, although an independent agency and not a member of the Kern Groundwater Authority (KGA), the BVGSA engages actively with neighboring GSAs including agencies who are under the KGA umbrella. The BVGSA regularly participates in technical and planning meetings and forums with other GSAs and holds monthly GSA governance meetings to support planning and implementation of the GSP. These meetings welcome public input and began with an initial workshop in 2018, which focused on public involvement and sought input on approaches, such as formation of a Technical Advisory Committee, to regularly acquire feedback from a wide variety of stakeholders including the disadvantaged Community of Buttonwillow.

1.1.2 List of References and Technical Studies

Please refer to Section 10 - References and Technical Studies.

1.2 Agency information

1.2.1 GSA Mailing Address

Buena Vista GSA
525 North Main
P. O. Box 756
Buttonwillow, CA 93206

1.2.2 Organization and Management Structure

Responsibility for development and implementation of the GSP lies with the Governance Committee of the BVGSA which is composed of members of the Buena Vista Water Storage

District's Board of Directors. The Governance Committee is chaired by Tim Ashlock whose contact information is presented below.

The Governance Committee is the ultimate decision-making body for the GSA, and individuals on this committee are the principal points of contact between the GSA and stakeholders.

1.2.3 Contact Information of Plan Manager

Tim Ashlock, Manager
Buena Vista GSA
Email: tim@bvh2o.com
Phone: (661) 764-5510

1.2.4 Legal Authority of GSA

The Sustainable Groundwater Management Act (SGMA) requires that all basins designated as high-or-medium-priority basins that are subject to critical overdraft conditions are to be managed under a groundwater sustainability plan (GSP) or coordinated GSPs (section 10720.7). The Kern County Subbasin is a high-priority basin and is identified as having critical overdraft conditions.

The BVGSA has been created to manage groundwater for a portion of the Kern County Sub-basin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin and is the exclusive GSA within its territory with powers to comply with SGMA (SGMA, Section 10723[c][1][D]). The BVGSA notified the California Department of Water Resources (DWR) of its intent to undertake sustainable groundwater management under SGMA and was granted exclusive GSA status under SGM, Section 10723(c).

1.2.5 Estimate of Implementation Costs

Current anticipated costs for implementing projects Buena Vista GSA are presented in Section 7 – Projects, Management Actions and Adaptive Management Actions. In addition, the BVGSA anticipates participating with other GSAs into the Kern County Subbasin on basin optimization studies designed to aid in coordination of activities across the Subbasin. The BVGSA also anticipates exploring grant funding and other potential sources of revenue to expedite implementation of projects.

1.3 Maps

1.3.1 Map of BVGSA Boundaries

Figure 1-1 – Buena Vista GSA Boundaries displays the boundaries of the BVGSA and indicates the locations of the two management areas within the GSA, the Buttonwillow Management Area (BMA) and the Maples Management Area (MMA) (Figure 1-1 – Refer to Figures Tab).

1.3.2 Map of GSAs Within the Kern County Subbasin

Figure 1-2 – GSAs within Kern County Subbasin displays the locations of GSAs within the Kern County Subbasin (Figure 1-2 – Refer to Figures Tab).

1.3.3 Map of Jurisdictional Boundaries of Federal or State Land Within the BVGSA

Figure 1-3 – Federal and State Land within BVGSA displays the boundaries of state and federal lands neighboring the BVGSA. As shown on the map, no state or federal lands lie within the GSA boundaries (Figure 1-3 – Refer to Figures Tab).

1.3.4 Map of Density of Wells Per Square Mile Within the BVGSA

Figures 1-4a – Density per Square Mile of Production Wells; 1.4b – Density per Square Mile of Domestic Wells, and 1.4c – Density per Square Mile of Municipal Wells display the density of production wells, domestic wells and municipal wells, respectively within the BVGSA. Data presented on these three maps was developed from well completion report data cataloged by DWR (Figures 1-4a through c – Refer to Figures Tab).

1.4 Description of Plan Area

1.4.1 Summary of Jurisdictional Areas and Other Features

The jurisdictional area of the BVGSA closely matches that of the BVWSD. The alignment between the GSA and the WSD will facilitate sustainable groundwater management because of the close correspondence between the projects and management actions presented in this GSP and the conjunctive management operations of the District. Thus, the longstanding stewardship of surface and groundwater practiced by the District will benefit the GSA in attaining its sustainable management objectives.

1.5 Water Resource Monitoring and Management Programs

1.5.1 Description of Water Resources Monitoring and Management Programs

Established water resources monitoring and management programs within the BVGSA are primarily programs conducted by the Buena Vista Water Storage District. Most monitoring performed by the BVWSD provides information on water supplies and water use necessary for District operations. This data includes information on diversions of surface water from the Kern River and the State Water Project, deliveries to users, and groundwater extractions recorded by meters installed on all District and landowner production wells. Additional monitoring is performed by the Buena Vista Coalition to carry out their Groundwater Quality Trend

Monitoring Work Plan in compliance with the Irrigated Lands Regulatory Program. Monitoring is also carried out by the public water agencies within the GSA, notably the Buttonwillow County Water District (BCWD) which serves the Community of Buttonwillow.

The BVWSD, the BCWD, and the Buena Vista Coalition are the three organizations now responsible for performing water management planning and carrying out water management programs within the BVGSA.

1.5.2 Description of How the Monitoring Networks of Those Plans will be Incorporated Into the GSP

Section 4 – Monitoring Networks – describes how the network of District monitoring wells, and wells included in the network developed for the Groundwater Quality Trend Monitoring Work Plan have been included in the networks that will be used to monitor groundwater levels and groundwater quality throughout the BVGSA. Data on pumping rates and volumes of extraction recorded by the magnetic flow meters and totalizers installed on all production wells will be used to update the BVGSA water budget.

1.5.3 Description of How Those Plans May Limit Operational Flexibility in the Subbasin

Implementation of the water resources monitoring and management programs described above is expected to complement and support operational flexibility and SGMA compliance within the BVGSA and is unlikely to limit operational flexibility.

1.5.4 Description of Conjunctive Use Programs

The BVWSD has a well-established history of conjunctive management that has enabled it to withstand prolonged droughts while being able to maintain groundwater elevations and groundwater storage. As shown in hydrographs and water budgets presented later in this GSP, the ability to use surface water from the Kern River and the SWP to meet water demands and to recharge the principal aquifer system has proven to be an effective conjunctive management program that will serve as the keystone of the BVGSA's stewardship of water resources.

Section 7 – Projects, Management Actions, and Adaptive Management Actions– describes how the BVGSA plans to expand the use of unlined canals and dedicated recharge facilities to support groundwater elevations through recharge of surface water and to enhance the GSA's conjunctive management program to prepare for anticipated increases in crop water demand and the effects of climate change.

1.6 Land Use Elements or Topic Categories of Applicable General Plans

1.6.1 Summary of General Plans and Other Land Use Plans

The 2007 Kern County General Plan (www.co.kern.ca.us/planning) designates land use within the BVGSA as largely intensive agriculture. The notable exception is the Specific and Rural Community Plan prepared by the Community of Buttonwillow and approved by the County. Land uses designated within the specific plan area include Buttonwillow's central business district, greenbelt areas within transmission line easements, and areas zoned for single family residences.

1.6.2 Description of How Implementation of the GSP May Change Water Demands or Affect Achievement of Sustainability and How the GSP Addresses Those Effects

The Buena Vista GSP anticipates an increase in irrigation water demands due to the combined effects of improved crop production practices, changes in cropping patterns and climate change. However, the GSP includes projects and adaptive management actions designed to prepare for increased demands likely to occur with or without implementation of the GSP. Therefore, implementation of the GSP will increase the BVGSA's ability to manage groundwater sustainably in the face of changing conditions but will do nothing to affect the water supply assumptions of relevant land use plans.

1.6.3 Description of How Implementation of the GSP May Affect the Water Supply Assumptions of Relevant Land Use Plans

Water supply assumptions applied in the GSP are based historical and projected deliveries from the SWP and the Kern River. The projections are adjusted to account for the effects of climate change, assumptions that were not incorporated into the 2009 land use plan. However, by incorporating changes in water supply that may result from climate change, implementation of the GSP is intended to minimize the impacts of projected water supplies on land uses within the BVGSA and within the Kern County Subbasin. Therefore, implementation of the GSP is expected to improve the ability to match future supplies with future demands within the planning area.

1.6.4 Summary of the Process for Permitting New or Replacement Wells in the BVGSA

Well replacement and construction of new wells will proceed following the permitting and approval process established by Kern County. The BVWSD has adhered to the Kern County permitting process in the past, and the BVGSA will continue to follow this process during

SGMA implementation. The BVWSD supplies magnetic flow meters for installation on each production well drilled within the GSA.

1.6.5 Information Regarding the Implementation of Land Use Plans Outside the Subbasin that Could Affect the Ability of the BVGSA to Achieve Sustainable Groundwater Management

Because of the location of the BVGSA in the interior of the Kern County Subbasin, the implementation of land use plans outside the Subbasin are unlikely to affect the BVGSA's management of groundwater or the GSA's ability to attain its sustainable groundwater management goals.

1.7 Description of Actions Related To:

1.7.1 Control of Saline Water Intrusion

Intrusion of seawater is not a consideration in the BVGSA because of the GSA's location at the extreme southern end of the Central Valley. Mild inflows of saline groundwater from the west will be monitored by the GSA's groundwater quality monitoring network and blended with Kern River water delivered to the affected areas (see Section 2.2.4.5).

1.7.2 Wellhead Protection

The BVGSA adheres to Kern County's wellhead protection policies.

1.7.3 Migration of Contaminated Groundwater

Migration of contaminated groundwater will be detected and tracked by the BVGSA groundwater quality monitoring network described in Section 4 – Monitoring Networks. Migration of contaminants determined to result from irrigated agriculture will be addressed through the Irrigated Lands Regulatory Program. Contaminants contributed by municipal or industrial users will be addressed based on the permitting requirements governing the individual users.

1.7.4 Well Abandonment and Well Destruction Program

The BVGSA follows the well abandonment and well destruction protocols established by Kern County.

1.7.5 Replenishment of Groundwater Extractions

As described throughout this GSP, the BVGSA's stewardship of its water resources is based on a program of conjunctive management of surface water and groundwater. Implementation of this program has required, and will continue to require, replenishment of groundwater extractions through operation of dedicated recharge facilities and recharge of surface water delivered through unlined canals.

Groundwater replenishment will be complemented by expansion of the area able to receive deliveries of surface water and water conservation programs, both of which will reduce demand for groundwater.

1.7.6 Conjunctive Use and Underground Storage

As described in the preceding response, conjunctive use is the cornerstone of the BVGSA's water management program. Section 7 – Projects, Management Actions, and Adaptive Management Actions – describes conjunctive management projects including expansion of an existing groundwater recharge facility, development of new recharge facilities and use of unlined canals as linear recharge features. Each of these projects will increase the GSA's ability to place surface water in underground storage.

1.7.7 Well Construction Policies

All wells constructed in the BVGSA are permitted by Kern County. In addition to County well construction ordinances, the BVGSA's Minimum Thresholds, described in Section 5 – Measurable Objectives, Minimum Thresholds, and Interim Milestones – requires that pumping be restricted to zones above the E-clay to reduce the risks of inducing subsidence and of extracting poor quality water.

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

Section 7 – Project, Management Actions, and Adaptive Management Actions – presents an array of measures that have recently been completed, are now under construction or are in various stages of planning. These activities are divided into the following categories:

- Water measurement projects;
- Sustainability monitoring projects;
- Water distribution system improvement projects;
- Groundwater recharge and recovery projects; and
- Water conservation and treatment projects.

Projects included in these categories address improvements to the BVWSD's conjunctive management practices through diversion of surface water to recharge facilities and improvements to conveyance facilities such as conversion of open ditches to pipelines. These projects are intended to take advantage of the GSA's extensive capacity to store groundwater in the underlying principal aquifer system. Monitoring of groundwater extractions is the focus of the sustainability monitoring projects and the groundwater recharge and recovery projects include facilities to reduce localized drawdown from groundwater extraction by broadening the footprint over which groundwater will be extracted. Groundwater contamination cleanup and prevention of degradation of groundwater quality will continue to be governed by permits issued to individual municipal and industrial users and by compliance with the Irrigated Lands Regulatory Program for agricultural users.

1.7.9 Efficient Water Management Practices

The BVGSA is largely an agricultural area with the Community of Buttonwillow being the only town lying within the GSA's boundaries. For this reason, the efficient water management practices relevant to the BVGSA are those presented in the Buena Vista Water Storage District's 2015 Agricultural Water Management Plan (AWMP). The practices presented in this plan are being implemented within the boundaries of the BVGSA. The AWMP will be implemented at 5-year intervals and the Efficient Water Management Practices will be reviewed during each of these updates.

1.7.10 Relationships with State and Federal Regulatory Programs

The main regulatory program active in the BVGSA is the Central Valley Regional Board-administered Irrigated Lands Regulatory Program. Within the boundaries of the BVGSA, compliance with the ILRP is the responsibility of the Buena Vista Coalition. The BVWSD reports water usage to the Department of Water Resources as required for purveyors of agricultural water and participates in DWR's CASGEM program.

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

Land use within the BVGSA is predominately agricultural with the Community of Buttonwillow, an active participant in the GSA, being the only town lying within the GSA's boundaries. The inclusion of Buttonwillow in the GSA and ongoing coordination with Kern County and adherence to its general plan, provide the necessary coordination and oversight with respect to potential changes in land use that could introduce risk to groundwater quality or quantity.

1.7.12 Impacts on Groundwater Dependent Ecosystems

As describe in Section 2 – Basin Setting, no groundwater dependent ecosystems have been identified in the BVGSA. This condition exists because of the depths to groundwater prevalent in the GSA, the heavily agricultural land use, and the absence of streams and other surface water bodies within the GSA.

1.8 Notice and Communication

1.8.1 Description of Beneficial Uses and Users

Beneficial uses now served in the GSA include:

- Domestic,
- Municipal,
- Industrial, and
- Agricultural.

The preponderance of water use is for irrigated agriculture with this water supplied from both surface water and groundwater sources. Water supplied to other beneficial uses is exclusively groundwater. Most municipal and domestic users are supplied by the Buttonwillow County Water District or by private wells. Agricultural users are supplied surface water and groundwater distributed through the BVWSD's distribution system and groundwater delivered directly from landowner wells. Figure 1-5 – Permitted Public Water Systems is a map of public water systems identified in the BVGSA (Figure 1-5 – Refer to Figures Tab).

1.8.2 List of Public Meetings

See public meeting list in Section 8 – Communication and Engagement Plan.

1.8.3 GSP Comments and Responses

Comments on the draft GSP and responses to these comments are presented in Appendix A.

1.8.4 Decision-Making Process

The primary decision makers for the BVGSA are the members of the Governance Committee. As described in Section 9 – Communication and Engagement Plan, the decision-making process will be informed by input from stakeholders as successful stewardship of the resources under the GSP requires a program that is broadly understood and accepted by the GSA's stakeholders and that does not conflict with projects and management actions taken by other GSAs in the Kern County Subbasin.

1.8.5 Public Engagement

The BVGSA's approach to public engagement is tailored to the size and demographics of the area, factors that will enable the GSA to engage directly with the public who are well informed on local water management issues. The GSA will also communicate actively with members of the public not familiar with the area to educate these parties about the physical conditions and water management practices that distinguish the BVGSA from neighboring areas.

The primary opportunities for the BVGSA to engage with the public will be the monthly Governance Committee meetings that will be supplemented by workshops to be convened at major milestones during implementation of the GSP. Noticed public workshops and hearings will also be held before imposing or increasing fees and before implementing adaptive management actions that may restrict groundwater extraction or otherwise affect water users.

In addition to formal meetings and workshops, the BVGSA Governance Committee is open to meeting with members of the public interested in expressing concerns or perspectives in a one-on-one setting. Targeted outreach will also be organized to encourage involvement from groups such as residents of the Community of Buttonwillow who form a distinct population within the GSA.

1.8.6 Encouraging Active Involvement

The interested parties list included in Section 9 – Communication and Engagement Plan – will be maintained by the BVGSA and parties on this list will be notified in advance of all public meetings and alerted when the GSA posts documents to its website. Interested parties can add themselves to the list through the BVGSA website. As described above, the GSA will use a variety of meeting settings and communication tools to encourage active involvement across the spectrum of stakeholders.

1.8.7 Informing the Public on GSP Implementation Process

The goal of public engagement will be to develop an understanding of the positions held by various stakeholders regarding water management priorities and to convey information about the development and implementation of the GSP, the establishment of metrics such as minimum thresholds, and the long-term objectives of the BVGSA. Stakeholders will include beneficial users of groundwater and parties affected by groundwater within the BVGSA and in neighboring areas.

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2. Basin Setting

2.1 Introduction to Basin Setting

A conceptual understanding of subsurface conditions is essential for the sustainable management of groundwater resources in the Buena Vista Groundwater Sustainability Agency (BVGSA), an agency located in the western part of the Kern County Subbasin (Subbasin) whose boundaries correspond closely to those of the Buena Vista Water Storage District (BVWSD).

This Basin Setting is based on the numerous descriptions of geologic and hydrogeologic conditions available for the area, beginning in the 1950s. These references are the foundation for both the Hydrogeologic Conceptual Model (HCM) and the Groundwater Conditions portions of the Basin Setting. Figure 2-1 shows the location of the BVGSA (Figure 2-1 – Refer to Figures Tab). See Section 10 - References and Technical Studies for a bibliography.

2.2 Hydrogeologic Conceptual Model

2.2.1 Regional Geologic and Structural Setting

The Buena Vista GSA lies within the Tulare Lake Basin and the Kern County Subbasin as defined by the California Department of Water Resources (DWR) and as shown on Figure 2-2 – Kern County Subbasin Location (Figure 2-2 – Refer to Figures Tab)

2.2.1.1 Tulare Lake Basin

A brief description of the evolution of the Tulare Lake Basin is presented below to introduce the formation of the regional aquifer system that underlies the Buena Vista GSA.

The Sierra Nevada Mountains, which form the eastern side of the San Joaquin Valley (Valley), are the eroded edge of a huge tilted block of crystalline rock. Together with the Tehachapi Mountains to the south, these pre-Tertiary granitic and metamorphic formations crop out mostly along the eastern and southeastern flank of the Valley to form an almost impermeable boundary for the groundwater basin (Page, 1986). Valley fill overlies a westward-sloping surface of basement rocks that is the subsurface continuation of the Sierra Nevada.

Near the close of the Late Cretaceous Period, tectonic movements elevated portions of the Coast Range area to the west of the Valley while concurrently dropping the valley floor to create a marine embayment that extended over much of the area of the BVGSA. During the Tertiary Period, sea water advanced and retreated within this embayment, resulting in deposits of both continental and marine sediments. During the Pleistocene and Holocene epochs, the seas retreated, and continental deposits from alluvial and fluvial systems were deposited over Tertiary-age marine deposits, with some saline water migrating from the marine deposits into the overlying and adjacent continental deposits (Page, 1986).

The Pleistocene Epoch was dominated by the presence of several lakes, and coupled with the tectonic subsidence, the lake beds generated thick deposits of clay found throughout the upper Tulare Formation. Examples of this are the Corcoran Clay and its equivalents that have been identified beneath the western half of the Subbasin including in the BVGSA. These clays have been correlated with clays beneath the Kern and Buena Vista dry lake beds that lie to the south of the BVGSA, as well as the Tulare Lake sediments found at the northern boundary of Kern County (Wood and Dale 1964; Croft 1972). In portions of the BVGSA, these clay layers serve as impermeable to semipermeable barriers that separate shallower poor-quality groundwater from higher quality groundwater of the principal aquifer system.

Since the Pleistocene Epoch, streams and rivers have been the primary mechanisms for the deposition of continental sediments and have formed alluvial fans on both sides of the Valley. Page (1986) identified various depositional environments for the continental sediments, including flood-plain, lake, and marsh conditions on the western side resulting in the finer-grained deposits predominant in the BVGSA. Continental sediments at the southern end of the Valley have an average thickness of about 2,400 feet (Planert and Williams, 1995) and consist mostly of basin-fill or lake deposits of sand and gravel interbedded with clay and silt. These sediments comprise up to approximately 3,400 feet of the material along the Kern River near Tupman where the base of the fill is over 18,000 feet below ground surface (Davis et. al., 1959).

2.2.1.2 Geologic Features that Significantly Affect Groundwater Flow

The BVGSA lies near the western margin of the Kern Subbasin and occupies the overflow lands west of the Kern River alluvial fan within the Buttonwillow Syncline, lying between the Elk Hills and Buttonwillow Ridge (Dale, et al, 1966). Land surface elevations in the GSA range from 290 feet above sea level in the south to 235 feet above sea level in the north. The groundwater gradient, which is generally flat along a north-south alignment north of 7th Standard Road, steepens south of this boundary with a gradient of 5 to 6 feet per mile extending almost the entire distance to the southeast end of the GSA.

The GSA is made up largely of reclaimed swamp lands located in and along the pre-development course of the lower Kern River which, after flowing south and then southwest across the southern San Joaquin Valley, runs north through the topographic axis of the Valley toward its ultimate terminus at a drainage basin which was once Tulare Lake. The water conveyance systems in and around the GSA consist of a network of levees and diversions to control the high flows of the Kern River, as well as a system of canals that delivers surface water to the lands within the BVWSD.

Natural groundwater flow moves from the flanks toward the axis of the Valley and northwestward (Page, 1986) with the asymmetrical, northwestward-trending valley trough that runs through the center of the BVGSA being the principal structure controlling the occurrence and movement of groundwater with most of the confinement of groundwater occurring near the axis of the Valley due to extensive confining beds of the Corcoran Clay (Page 1986). Figure 2-3

– Approximate Thickness and Extent of the Corcoran Clay - presents the extent, depth, and approximate thickness of the Corcoran Clay as estimated by the USGS (Page, 1986) (Figure 2-3 – Refer to Figures Tab). Figure 2-4 – Geologic Units – is a general map of geologic features defining the BVGSA and surrounding lands in the Kern County Subbasin (Page 1986). (Figure 2-4 – Refer to Figures Tab)

2.2.2 Lateral Basin Boundaries

The lateral boundaries of the BVGSA are determined by the jurisdictional boundaries of the GSA. As shown in Figures 2-4, 2-15, 2-16, 2-17 and 2-18, the jurisdictional boundaries of the GSA align closely with geologic features and soil characteristics of the area. The GSA shares parts of its northern, eastern, and southern boundaries with the Semitropic- and Rosedale-Rio Bravo Water Storage Districts, the Kern-Delta Water District (KDWD), the Kern Water Bank Authority (KWBA) and the West Kern Water District (WKWD). The GSA shares its western boundary with undistricted lands which separate the GSA from the Belridge Water Storage District and oilfield properties farther to the west. Like districted lands in the valley floor, these undistricted lands fall within the jurisdiction of the County of Kern and the Kern County Water Agency (KCWA). Some undistracted lands lie within the boundaries of the BVGSA as shown on Figure 1-1 – Buena Vista GSA Boundaries. (Figure 1-1 – Refer to Figures Tab)

2.2.3 Bottom of the Basin

The base of fresh groundwater is commonly defined as the bottom of the basin, and measurements of specific conductance (SpC) and/or total dissolved solids (TDS) are often used to define fresh groundwater. The USGS (Page, 1973) utilized the SpC value of 3,000 micromhos per centimeter (µmhos/cm) or microsiemens per centimeter (µS/cm) and considered that value to be generally equivalent to a TDS concentration of 2,000 milligrams per liter (mg/l), which can be a limiting factor for irrigation. Note that the conversion factor (SpC to TDS) is 0.67, which is the midpoint of the typical range of 0.55 to 0.75 (Hem, 1985) with the appropriate conversion depending on the chemical composition of the groundwater.

Figure 2-5 – Base of Fresh Groundwater, illustrates that the base of fresh groundwater within the boundaries of the BVGSA is relatively uniform due to the GSA's compact size. The base of fresh groundwater in the BVGSA is approximately 400 feet below mean sea level (MSL) along the North-South alignment of the BMA. However, the base of fresh groundwater approaches sea level to the west of the BMA and dips abruptly to approximately 800 feet below MSL to the southeast. (Figure 2-5 – Refer to Figures Tab)

2.2.4 Principal aquifers and aquitards

The western portion of the Kern County Subbasin is underlain by an alluvial aquifer system that is heterogeneous in texture and structure. The aquifer system underlying the BVGSA features shallow, perched groundwater, unconfined and semi-confined aquifers and deeper confined groundwater beneath the Corcoran Clay.

2.2.4.1 Principal Aquifers Used for Water Production

The production horizons of the principal aquifer system in the BVGSA include unconfined, semi-confined and confined zones consisting of a sequence of interbedded, laterally discontinuous Tertiary and Quaternary age material. These sandy and silty sediments of non-marine origin from the Kern River and Tulare Formations overlay older marine deposits.

As discussed in the introduction of this GSP, the BVGSA is characterized as two distinct service areas: 91% of the acreage is in the Buttonwillow Service Area (BSA) with the remaining 9% lying in the Maples Service Area (MSA). The report *The Geology and Groundwater Hydrology of the Buena Vista Water Storage District, Buttonwillow, CA* (Sierra Scientific, 2013) describes the principal production aquifers of each service area. The MSA is underlain by Kern Fan-type non-marine sediments, i.e., mostly unconsolidated sands and silts, with the Corcoran Clay equivalent at a depth of about 500 feet bgs and the Paloma Clay at a depth of about 1,500 feet bgs (PGA, 1991). The aquifer under the BSA consists of a sequence of interbedded, laterally discontinuous, Quaternary sandy and silty sediments of non-marine origin. Down to a depth of about 200 feet, silty sediments tend to predominate, but from 200 to 600 feet bgs sandy and silty sediments occur in approximately equal proportion.

In the BSA, most irrigation wells exploit sandy strata and are completed to depths of between 200 to 500 feet bgs because of the better water quality and better productivity at these depths. The local irrigation wells have 200- to 300-foot-long screened intervals and deliver sustained flows of between 3.9 and 5.3 cfs at discharge/drawdown ratios in the range of 0.04 to 0.09 cfs/feet. In the northern half of the BSA, the near-surface sediments have significant clay content and create a separate, shallow perched water table 2 to 12 feet deep.

2.2.4.2 Formation Names

The sediments beneath the BVGSA are composed of inter-bedded material of non-marine origin which originated from separate sediment sources to the east and to the west. These sediments, which inter-finger under the GSA, are the thin, distal terminations of thicker deposits of differing textures and compositions and are characteristic of their separate sources. The alluvial, fluvial and lacustrine sediments from the east are part of the Kern River Formation and are characteristic of sediments derived from the igneous granitic bedrock of the Sierra Nevada range. The alluvial sediments from the west are part of the Tulare Formation and are characteristic of reworked marine sediments derived from the ranges to the west. A veneer of recent alluvium deposited by swamps, rivers, and lakes covers the Pleistocene deposits over most of the southern San Joaquin Valley producing a depositionally-complex and laterally-discontinuous stratigraphy that influences the movement and the chemistry of groundwater.

Although formations can be mapped at the surface, much of the material is not distinctive in the subsurface and designation of a formation is difficult. The following description of geologic formations is provided to explain the contribution of these formations to the groundwater system. From oldest to youngest, the deposits include the: Kern and the Tulare Formations, older alluvium, and younger alluvium and flood basin deposits (Page, 1986; DWR, 2006). Confining or semi-confining fine-grained beds include the Corcoran Clay of the Tulare Formation and other lesser clay layers.

Tulare (including Corcoran Clay) Formation

The Tulare Formation is Pliocene to Pleistocene in age and contains up to 2,200 feet of interbedded, oxidized to reduced sands; gypsiferous clays and gravels derived primarily from Coast Range sources (marine rocks). Sandy material is found from about 200 to 400 feet below ground surface (bgs) and is used by most wells in the region for water supply.

The Tulare Formation within the BVGSA is broken up by three distinct clay layers: A, C, and E-clay layers, which are described below:

- The A-clay is the uppermost of the clay layers. It occurs 20 to 30 feet bgs and is the cause of the shallow, perched groundwater identified in piezometers throughout the northern part of the GSA
- The C-clay is about 30 feet thick and occurs at a depth of about 200 feet bgs. The C-clay is laterally discontinuous and provides semi-confining conditions
- The E-clay occurs at depths ranging from 300 to 450 feet bgs in the BSA and is a known barrier to vertical flow of groundwater

These three clay layers create the three groundwater aquifers found throughout the BVGSA:

- The Perched Aquifer above the A-clay, found throughout the northern portion of the BSA
- The shallow aquifer between the A- and C-clays
- The deep aquifer between the C- and E-clays

As shown on Figure 2-3, the Corcoran Clay underlies almost the entirety of the BSA at depths ranging from 300 feet bgs in isolated areas in the northern part of the GSA to 450 feet bgs near Buttonwillow. The Corcoran Clay is generally very fine grained; however, isolated, coarser zones are possible, particularly where the clay is less than 20 feet thick, as identified by Page (1986). Laboratory tests indicate that the clay is highly susceptible to compaction (Faunt, et al, 2009).

Terrace Deposits

Overlying the Tulare Formation are older alluvium and Terrace Deposits composed of up to 250 feet of Pleistocene-age lenticular deposits of clay, silt, sand, and gravel that are loosely consolidated to cemented. This unit is moderately to highly permeable and yields large quantities of water. Because the Terrance Deposits are often indistinguishable from the underlying Tulare Formation, these formations together constitute the principal aquifer in the BVGSA (DWR 2006).

Younger Alluvium and Flood Basin Deposits

The Holocene-age younger alluvium and flood basin deposits vary in character and thickness. In the southwestern portion of the Subbasin the unit grades into fine-grained flood basin deposits underlying the historic beds of Buena Vista and Kern lakes which lie to the south of the BVGSA. The flood basin deposits consist of silt, silty clay, sandy clay, and clay interbedded with poorly permeable sand layers. These flood basin deposits are difficult to distinguish from underlying fine-grained older alluvium with the total thickness of both units being as great as 1,000 feet (Page, 1986; and DWR 2006).

Kern River Formation

The Kern River Formation is Miocene to Pliocene in age (possibly early Pleistocene age) and includes from 500 to 2,600 feet of poorly sorted, lenticular deposits of clay, silt, sand, and gravel derived from the Sierra Nevada Mountains. The formation crops out in a crescent-shaped belt about 50 miles long and up to 12 miles wide and reaches its maximum thickness of 2,600 feet in the subsurface west of the outcrop (Bartow, 1983). The formation consists of poorly sorted fluvial sandstone and conglomerate with interbeds of siltstone or mudstone and becomes finer grained northward and westward. Some of the thicker siltstone or mudstone interbeds may represent deposits from small ephemeral lakes or ponds (Bartow, 1983).

2.2.4.3 Physical Properties of Each Aquifer and Aquitard

Aquifer parameters within the BVGSA are available from both well pumping tests and calibrated groundwater models. Data are summarized on Figure 2-6 – Hydraulic Conductivity Values. Aquifer properties reported herein include hydraulic conductivity, which is a function of the capacity to move or transmit water (transmissivity) through an aquifer of a given saturated thickness, and specific yield (unconfined systems) and storage coefficient (confined systems), which are functions of an aquifer's ability to store and release water from storage (storativity).

Aquifer data derived from pumping tests were taken from three sources: 1) relatively short (1.5- to 5-hour) pumping tests by the USGS at irrigation wells during the late 1950s and 1960 (McClelland, 1962), 2) constant rate pumping tests from engineering consultants in the 2000s (Todd, 2018), and 3) aquifer tests performed by URS between late 2009 and early 2010 on seven irrigation wells located within about 1.2 miles of the intersection of 7th Standard Rd and Main Drain Rd. The depths of wells tested in the first two studies varied from 98 to 1,500 feet bgs (median: 650 feet bgs), and the pumping rates varied from 44 to 4,480 gallons per minute (gpm) (median: 2,500 gpm). The analysis included the use of water level recovery data from pumping wells and water levels from observation wells.

From these tests, the hydraulic conductivity was estimated to range between 3 to 250 feet per day (feet/day) (median: 60 feet/day), which is consistent with published ranges for clean, medium- to coarse-grained sand (Heath, 1983) or for a fine sand to coarse gravel (Schwartz and Zhang, 2003). These values also fall within the range of the groundwater models that were calibrated with these data (C2VSim; CVHM; Todd, 2018; and Todd, 2017). The tests performed by URS resulted in an estimated average transmissivity in the central part of the BSA of 18,200 ± 4,400 feet/day. Using the net sand thickness of the aquifer estimated from E-logs of the tested wells, these transmissivity values equate to hydraulic conductivities in the range of 30 to 80 feet/day, values within the range of those estimated by the earlier studies.

The Corcoran Clay varies in lithology from fine (clay and silt) to coarse (sand) texture. Faunt et. al. (2009), compiled and estimated horizontal hydraulic conductivities within the range of 0.0024 to 33 feet/day, which is consistent with the range expected for silt to fine/medium sand as shown on Figure 2-6. A range of vertical hydraulic conductivities was estimated from permeameters and field tests between 6.6 x 10-6 feet/day to 1.5 x 10-3 feet/day (Faunt et al, 2009). However, permeameter tests may underestimate hydraulic conductivity while "short circuiting" of intra-borehole flow may lead to overestimates.

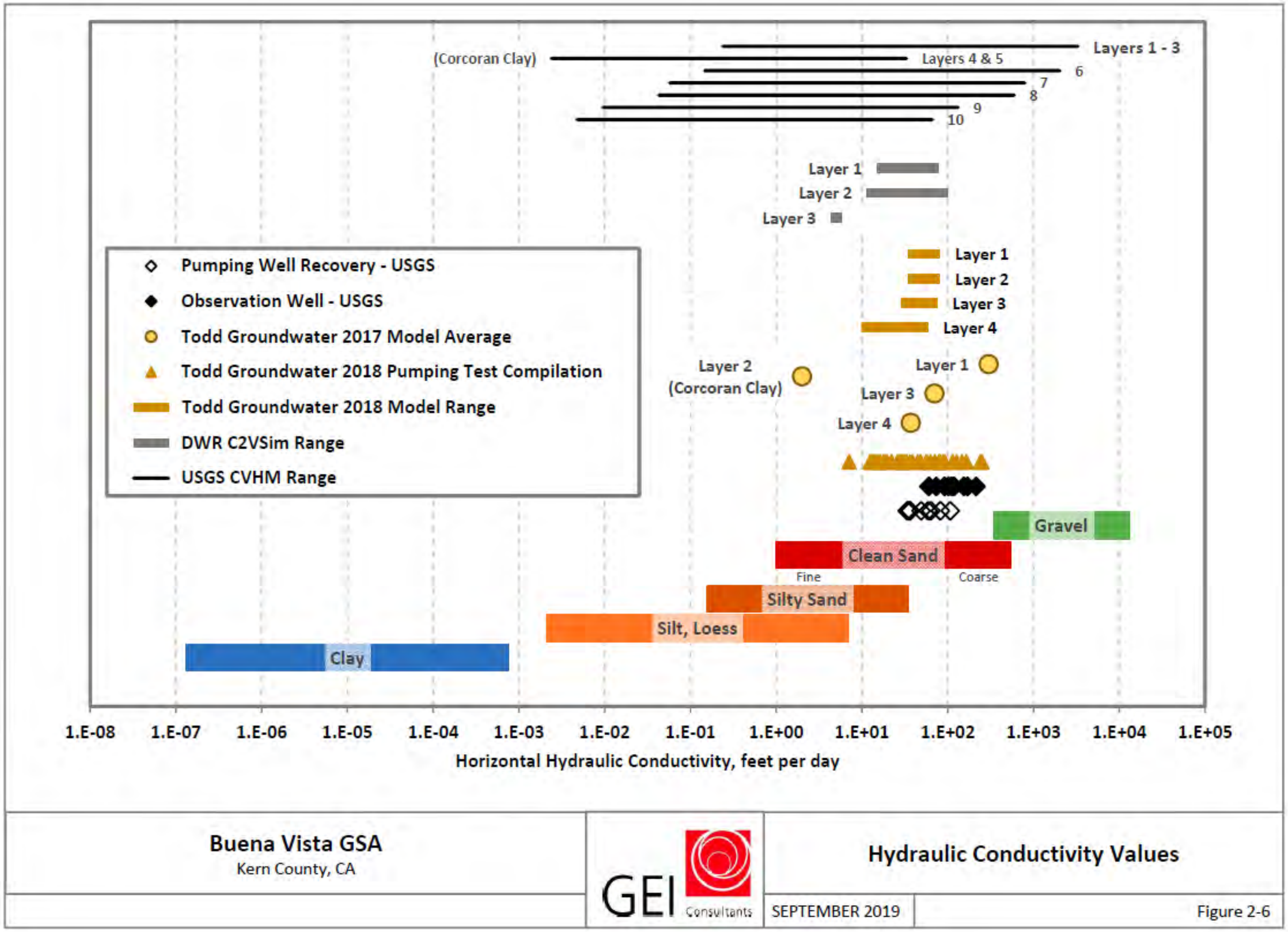

Figure 2-6. Hydraulic Conductivity Values

Specific Yield and Storage Coefficient

Aquifer storage is an important characteristic of the groundwater system and is defined as the volume of water released from or taken into storage per unit surface area of the aquifer per unit change in hydraulic head. For unconfined aquifers, specific yield is the term for storativity, while the storage coefficient is used for confined aquifers.

Gravity drainage is the primary mechanism for the release of water from the pore space of an unconfined aquifer. Total porosity is the sum of specific yield and specific retention where the latter is controlled by cohesion between water molecules and the adhesion of water to the aquifer particles. The expansion of water and compression of the aquifer are negligible components of storativity for an unconfined aquifer but quite important for a confined aquifer. Conversely, gravity drainage is not important to a confined aquifer unless that aquifer is dewatered in a specific area. As such, the unconfined storativity can be 100 to 10,000 time greater than confined storativity (Heath, 1983).

For confined systems, aquifer compressibility can be further divided between elastic and inelastic storage, where elastic storage is related to support by the water and inelastic storage is related to the skeletal support of the aquifer particles. For the Central Valley, the elastic storage may be 30 to several hundred times larger than the inelastic storage (Faunt et al., 2009; Ireland et al., 1984). When fine-grained layers are prominent in an aquifer system and for confining layers, significant volumes of water can be released from inelastic specific storage during over-pumping, and the compression of the skeletal particles will result in a permanent loss in storage capacity of fine-grained layers. This structural change will then be manifested at the surface as subsidence.

Specific yield of unconfined aquifers and the storage coefficient of confined aquifers within the area have been estimated by laboratory testing of sample cores, calculations based on lithology type, pumping tests, and groundwater modeling (Dale, 1966; Davis et al., 1959; Davis et al., 1964; Faunt et al., 2009; DWR, 2013; Todd, 2017 and 2018). A range is presented in Table 2-1 and is consistent with published values for similar grain sizes and lithology (Heath, 1983; Morris and Johnson, 1967).

Table 2-1. Aquifer Parameters for BVGSA

Data Source	Calculated Horizontal Hydraulic Conductivity (feet/day)	Vertical Anisotropy Kh/Kz	Storage Coefficient	Specific Yield
Kern Pumping Tests Compilation (Todd, 2018)	7 to 250	--	0.0008 to 0.034	--
USGS - Kern Pumping Tests (Observation Wells)	20 to 1600	--	0.0004 to 0.002	--
USGS - Kern Recovery Tests	100 to 800	--	--	--
URS – Aquifer Tests	30 to 80	--	--	--
USGS - CVHM Range	0.24 to 3300	--	--	0.09 to 0.40
DWR - C2VSim Range				
Layer 1	15 to 78	275 to 500	--	0.12 to 0.40
Layer 2	< 1 to 100	20 to 4000	5.E-07 to 8.E-06	--
Layer 3	3.0 to 7.0	60 to 100	--	--
Todd Groundwater 2018 Model Range				
Layer 1	32 to 85	10 to 200	--	0.15 to 0.25
Layer 2			3.E-02	0.02 to 0.21
Layer 3	29 to 75	50 to 500	1.4E-07 to 9.4E-07	0.00004 to 0.00022
Layer 4	10 to 70	500		0.0011 to 0.0019
Todd Groundwater 2017 Model Average				
Layer 1	300 to 335	1150 to 1200	--	0.21
Layer 2	2	1050 to 1250	8.6E-06 1.4E-05	--
Layer 3	67 to 70	1000	0.00024	--
Layer 4	22 to 37	2200 to 3700	0.00058	--
USGS - Water Supply Paper 1618				
USGS - Water Supply Paper 1618				
Clay and Fine-Grained Units	--	--	--	0.03
Silt, Gravelly Clay, Sandy Clay Units	--	--	--	0.05
Fine, tight sand, tight gravel	--	--	--	0.10
Loose, well sorted sand, gravel	--	--	--	0.25

Data Sources: Davis et al, 1959 and 1964; Dale et al, 1966; DWR, 2013; Faunt et al, 2009; McClelland, 1962; Todd, 2017 and 2018.

2.2.4.4 Structural Properties that Restrict Groundwater Flow

Fold structures are present in the older sediments on the western side of the Valley and help define the geological setting of the BVGSA. Most of the folds are anticlines which appear as ridges that crop out approximately 30 to 50 feet or more above the valley floor, including Buttonwillow Ridge, Semitropic Ridge, Lost Hills, and Elk Hills. (Bartow, 1991). Many anticlines are shown to be concealed beneath younger sediments along the San Joaquin Syncline and other lesser synclines. Similarly, several northwest-trending faults are concealed by the younger sediments but have also been mapped within some of the islands of older sediments as shone in Figure 2-4 (Figure 2-4 - Refer to Figures Tab).

Numerous faults are found near the BVGSA and have been grouped by age of displacement (CGS, 2010). Most of these faults are oriented toward the northwest, parallel to the San Andreas Fault, however several faults are oriented northeasterly. Overall, it is unclear how many of these faults are barriers to groundwater flow, although Faunt et. al. (2009), included four northwest-trending "potential horizontal flow barriers" in the Central Valley Hydrologic Model (CVHM) groundwater model.

The BSA is contained within the flanks of the doubly-plunging Buttonwillow Syncline (Figure 8. PGA, 1991, Plate IX detail, Structure Map on Base E-Clay) and is geologically separated from the main sub-basin to the east by the doubly-plunging Buttonwillow Anticline (PGA, 1991). There is no surface expression to the Buttonwillow Syncline, but the axial ridge of the Buttonwillow Anticline forms the 3-mile-wide Buttonwillow Ridge which is about 30 feet higher than the flat lands overlying the syncline. The presence of these geologic features is also expressed in the groundwater contours along the eastern flank of the BVGSA as illustrated in Figures 2-29a and 2-29b (Figures 2-29a and 2-29b - Refer to Figures Tab).

2.2.4.5 General water quality of principal aquifers

Introduction

The groundwater hydrology of the BVGSA is notable because of the complex interfingering of material from various sources influences both groundwater flow in the GSA and the mineral chemistry of the waters in the area. Most of the naturally occurring groundwater in the GSA is of one of three types:

- Low-moderate TDS, $Ca\text{-}HCO_3$ water;
- Moderate-high TDS, $Na/Ca\text{-}SO_4$ water, and
- High-very high TDS, Na-Cl water.

The areas where these distinct types of groundwater mix are characterized by waters of intermediate chemistry.

The chemistry of the low TDS, $Ca\text{-}HCO_3$ groundwater resembles the chemistry of Kern River water, the main source of recharge for most of the Subbasin. This water is referred to as east-side water because it is characteristic of surface waters which drain from the granitic Sierra Nevada Mountains. East-side water recharges the Subbasin along the Kern River recharge mound, and along Poso Creek during wetter years and is widespread across the interior of the Subbasin down to depths of 600 to 700 feet bgs (Crewdson, 2004).

The chemistry of the moderate-high TDS, Na/Ca-SO_4 groundwater resembles the chemistry of runoff that drains from outcrops of Miocene-Pliocene marine sediments and is primarily found along the western margin of the Subbasin for more than 60 miles. This type of water is referred to as west-side water based on the theory, originally advanced in the early 1960s by the U.S. Geological Survey (USGS), that the Miocene and younger marine sediments of the Coast Ranges are the source of poor-quality groundwaters observed along the western margin. Far less runoff occurs on the west side than on the east side resulting in less groundwater recharge being contributed from the west side. As such, west-side SO_4 groundwater is limited in comparison to the HCO_3 groundwater from the east side.

The high-TDS, Na-Cl groundwater is generally found in the deeper parts of the Subbasin, regardless of what type of groundwater it underlies. This saline groundwater is likely to be connate water trapped during the deposition of the marine sediments. Within the BVGSA, groundwater quality is influenced by each of these three main water types and has exhibited TDS values ranging from a minimum of 110 mg/L (4/9/1964) to a maximum of 6,640 mg/L (7/11/1989) with TDS varying by location and depth.

While TDS is a major component in the determination of groundwater quality beneath the BVGSA, both nitrate and arsenic concentrations are also monitored to ensure satisfactory water quality.

Nitrate (NO_3) is a polyatomic ion often naturally occurring in groundwater in low concentrations. These low concentrations can be increased by application of nitrogen fertilizer, runoff from feedlots and dairies, and percolation of industrial and septic wastewater. Two equivalent MCLs are commonly used for nitrate in drinking water: 10 mg/L for nitrate as nitrogen and 45 mg/L for nitrate as nitrate (CCR, 2014).

Although arsenic is a naturally occurring element, high concentrations of arsenic in drinking water are hazardous to humans. Its presence in groundwater is a result of the dissolution of arsenic minerals in sediments. The primary MCL for arsenic is 10 µg/L.

Data Gaps

Gaps in water quality data will be filled through continued monitoring performed as part of the Buena Vista Coalition's reporting under its Groundwater Quality Trend Monitoring Work Plan (GQTMWP) carried out for compliance with the Regional Board's Irrigated Lands Regulatory Program (ILRP) with data collected until this program entered into the GAMA database. Public water systems in the GSA will continue reporting to the State Drinking Water Information System (SDWIS). Data reported to both GAMA and SDWIS is available to the BVGSA to augment data collected through the BVGSA's groundwater quality monitoring network.

2.2.4.6 Maps and Description of General Water Quality from GAMA

Data from the GeoTracker-GAMA (Groundwater Ambient Monitoring and Assessment Program) database was downloaded to a data management system (DMS) to aid in assessment of water quality in the BVGSA and other GSAs in Kern County. Within the BVGSA, the DMS was populated with 172 records collected from 106 wells for TDS, 333 records collected from 122 wells for nitrate, and 268 records from 8 wells for arsenic. This data is drawn from a monitoring period that extends from 1937 through 2017. Table 2-2 summarizes the data within the DMS for BVGSA.

Table 2-2. Inventory of TDS and Nitrate Data within DMS

	TDS		Nitrate		Arsenic	
	Records Collected	No. of Wells	Records Collected	No. of Wells	Records Collected	No. of Wells
BVGSA	172	106	333	122	268	8

Salinity

Total Dissolved Solids (TDS) was selected as the primary index of salinity in groundwater. TDS is commonly included with initial groundwater quality assessments and routine water quality sampling events and is defined as the total quantity of inorganic salts and organic matter that remain after water from a sample has been evaporated. Because numerous individual constituents contribute to TDS, waters of similar TDS concentrations may differ in the composition of their salt loads. Electrical conductivity (EC) is an indirect measure of TDS and can be used as a surrogate where the TDS values equal approximately 2/3 of the EC value.

As described in the introduction to this section, natural sources contribute to TDS in the BVGSA and explain some of the variability in both TDS concentrations and the chemistry associated with salt loads. As well as natural sources, anthropogenic sources of salts such as deep percolation of irrigation water affect salt concentrations in groundwater.

The BVGSA is part of an inland groundwater basin with no significant outflow. Because salts imported into the area have no natural outlet, the complex hydrogeologic processes that dissolve, transport, dilute, concentrate, and precipitate salts have the net effect of increasing the mass of salts residing in the area (KCWA, 2012). The most prominent of these mechanisms involves salts conveyed in water imported via the California Aqueduct and applied to irrigated lands. As most of the applied water either evaporates or is transpired by plants, the imported salts concentrate in the remaining irrigation water, most of which percolates to groundwater. The same mechanism applies to water introduced by the Kern River. However, as the TDS of river water is lower than that of water imported from the Bay-Delta, its contribution to groundwater salinity is also lower.

Recharge of water from the California Aqueduct and the Kern River results in percolation of recharged water that is of higher quality than the underlying groundwater. Thus, recharge through unlined canals and recharge ponds dilutes the salt concentration in the groundwater underlying the GSA. However, the overall mass of salt stored in the regional and subbasin-wide aquifer system will increase because of the closed nature of the Subbasin.

For the purposes of salinity analysis, the BSA is separated into the Southern BBSA and the Northern BSA with 7th Standard Road forming the boundary between the two areas. In the Northern BSA, the TDS from tested wells varies from 208 to 6,640 mg/L, while in the Southern BSA, the TDS varies from 87 to 2,310 mg/L. The TDS of the shallow, perched zone in the Northern BSA ranges from 850 to 5,500 mg/L based on data from shallow piezometers. Groundwater salinity has generally been increasing over the past 20 years. The sources of salinity are not fully understood but may include groundwater inflow from the west.

Historical (prior to 2000) TDS concentrations are summarized below in Table 2-3. Minimum and maximum concentrations and the dates these values were sampled are recorded for the entire BSA, the Northern BSA, and the Southern BSA.

Table 2-3. Historical (prior to 2000) TDS Records

HISTORICAL [prior to 2000]				
Area	Minimum TDS		Maximum TDS	
	[mg / L]	[date]	[mg / L]	[date]
BVGSA	110	4/9/1964	6640	7/11/1989
Northern BSA	208	7/24/1976	6640	7/11/1989
Southern BSA	110	4/9/1964	2310	10/12/1964

Recent (2001 through 2017) TDS concentrations are summarized in Table 2.4, below.

Table 2-4. Recent (2001 through 2017) TDS Records

RECENT [2001 through 2017]				
Area	Minimum TDS		Maximum TDS	
	[mg / L]	[date]	[mg / L]	[date]
BVGSA	87	10/25/2007	1700	2/11/2015
Northern BSA	1030	7/16/2002	1700	2/11/2015
Southern BSA	87	10/25/2007	560	5/31/2012; 6/24/2015

TDS concentrations in the BVGSA are mapped in Figure 2-7 – Historical TDS Monitoring Results (2000 and Earlier) to indicate historical concentrations observed between 1937 and 2000 (137 records) and in Figure 2-8 – Recent TDS Monitoring Results (2001 through 2017) to show more recent concentrations observed between 2001 and 2017 (35 records). Partitioning the data into these two periods provides insights into the effect changes in cropping patterns and introduction of modern irrigation management practices may have had on TDS concentrations.

The distribution of maximum TDS concentrations in Figures 2-7 and 2-8 are displayed by circles of olive green at each sample location with the colors shading from light olive green for the lowest concentrations to dark olive green for the highest (Figures 2-7 and 2-8 – Refer to Figures Tab).

The recent data show the persistence of the highest TDS concentrations evident in the historic data along the western edge of the Subbasin, an area which includes the BSA and lands to the west. Observations of high TDS concentrations in this area are consistent with the theory that poor-quality waters are derived from sources to the west and are diluted and ion-exchanged as they mix with waters derived from the Sierra Nevada Mountains. This band of high-salinity water, together with its associated basin-ward decrease in salinity, can be followed for more than 60 miles along the western subbasin margin. These findings are also consistent with the KCWA Water Supply Reports, which illustrate historical salinity concentrations in the western portion of Kern County where the alluvial fan may thin and wells may be screened in bedrock formations rather than alluvium. (Figure 2-8 – Refer to Figures Tab)

Nitrate

Nitrate (NO_3) is a form of nitrogen that can be produced naturally by the atmosphere or by decomposing organic matter. Naturally occurring nitrate concentrations are generally less than 10 milligrams per liter nitrate as nitrogen and generally do not exceed 20 mg/L in groundwater (Todd, 2005 and Hounslow, 1995). However, naturally occurring concentrations can be augmented by application of nitrogen fertilizers, runoff from feedlots or dairies, percolation of wastewater and food processing waste, and leachate from septic systems (Harter, T. et al., 2012).

Two equivalent MCLs are commonly used for nitrate in drinking water: 10 mg/L for nitrate as nitrogen and 45 mg/L for nitrate as nitrate (CCR, 2014). The difference in the MCLs is due to the molecular weight of the oxygen atoms associated with nitrate. Because the State Water Resources Control Board's GAMA Program expresses the nitrate MCL in terms of nitrogen, the nitrate as nitrogen standard will also be applied in the GSP.

Treated wastewater from the Community of Buttonwillow is regulated by the RWQCB under an individual waste discharge requirement (WDR). Recharge from septic systems is present in the BVGSA but is not measured or estimated and is not believed to be significant due to the low number of households outside the Community of Buttonwillow. Recharge from wastewater generated by food processing, confined animal facilities, and other industries is also regulated under individual WDRs and is not believed to be significant.

As with salinity analysis, the BVGSA is separated into the Southern BSA and the Northern BSA. In the Northern BSA, the nitrate from tested wells varies from 0.05 to 46.08 mg NO_3-N / L; in the Southern BSA, the nitrate varies from 0.01 to 6.78 mg NO_3-N / L. Nitrate concentrations in groundwater have generally been steady for the last 20 years, apart from occasional spikes in concentration. The data shows that these spikes recover within 1-2 years.

Historical (prior to 2000) nitrate concentrations are summarized in Table 2-5, below. Minimum and maximum concentrations and dates the values were sampled are recorded for the full BVGSA, the Northern BSA and the Southern BSA.

Table 2-5. Historical (prior to 2000) Nitrate Records

HISTORICAL [prior to 2000]				
Area	Minimum Nitrate		Maximum Nitrate	
	[mg NO_3-N / L]	[date]	[mg NO_3-N / L]	[date]
BVGSA	0.0226	1955; 1956; 1959; 1964; 1966; 1969	46.0836	1989
Northern BSA	0.0452	1945; 1956; 1961; 1964	46.0836	1989
Southern BSA	0.0226	1956; 1959; 1964; 1966; 1969	2.2590	1964

Recent (2001 through 2017) nitrate concentrations are summarized in Table 2-6, below.

Table 2-6. Recent (2001 through 2017) Nitrate Records

RECENT [2001 through 2017]				
Area	Minimum Nitrate		Maximum Nitrate	
	[mg NO_3-N / L]	[date]	[mg NO_3-N / L]	[date]
BVGSA	0.0136	2014	8.7197	2007
Northern BSA	0.1000	2017	8.7197	2007
Southern BSA	0.0136	2014	6.7770	2012

As with TDS, nitrate concentrations in the BVGSA were mapped to indicate historic concentrations observed between 1942 and 2000 and more recent concentrations observed between 2001 and 2017 to provide insights into the effect changes in cropping patterns, fertilizer management and introduction of modern irrigation management practices may have had on nitrate concentrations.

The distribution of maximum concentrations of nitrate in wells during the period from 1947 to 2000 is shown on Figure 2-9 – Historical Nitrate Monitoring Results (2000 and Earlier), and more recent maximum nitrate concentrations reported between 2001 and 2017 are shown on Figure 2-10 – Recent Nitrate Monitoring Results (2001 through 2017). Maximum nitrate concentrations at each location are represented by circles shaded from olive to dark brown. While less data is available for the recent period, the spatial distribution observed in the recent data resembles that of the historic period. Both the historical and the current distributions show high concentrations in the northwest near Lost Hills and the Buttonwillow Ridge, and in the southwest just south of the Elk Hills (Figures 2-9 and 2-10 – Refer to Figures Tab).

Arsenic

In addition to TDS and nitrate, GeoTracker-GAMA data for arsenic were examined because of the importance of this constituent to drinking water safety. Arsenic is a naturally occurring element commonly found in alluvial sediments derived from volcanic sources. Its presence in groundwater is a result of the dissolution of arsenic minerals in sediments. The primary MCL for arsenic is 10 µg/L.

As with salinity and nitrate analyses, the BVGSA is separated into the Southern BSA and Northern BSA for analysis of arsenic. In the Northern BSA, the arsenic from tested wells varies from 2 to 870 µg / L and in the Southern BSA, the arsenic varies from 1.3 to 43 µg / L. Groundwater concentrations of arsenic have generally been steady for the last 20 years, except for occasional spikes in concentration around 1990 and 2010. The data shows that these spikes recover within 1-2 years.

Historical (prior to 2000) nitrate concentrations are summarized in Table 2-7, below. Minimum and maximum concentrations, in addition to the corresponding date of sampling are recorded for all of the BVGSA, the Northern BSA, and the Southern BSA.

Table 2-7. Historical (prior to 2000) Arsenic Records

HISTORICAL [prior to 2000]				
Area	Minimum Arsenic		Maximum Arsenic	
	[µg / L]	[date]	[µg / L]	[date]
BVGSA	4	1989; 1991	870	1989
Northern BSA	4	1989	870	1989
Southern BSA	4	1991	35	2000

Recent (2001 through 2017) arsenic concentrations are summarized in Table 2-8, below.

Table 2-8. Recent (2001 through 2017) Arsenic Records

RECENT [2001 through 2017]				
Area	Minimum Arsenic		Maximum Arsenic	
	[µg / L]	[date]	[µg / L]	[date]
BVGSA	1.3	2016	43	2006
Northern BSA	2	2012	9.3	2007; 2009
Southern BSA	1.3	2016	43	2006

Figure 2-11 – Historical Arsenic Monitoring Results (2000 and Earlier) - presents data preceding 2000 and Figure 2-12 – Recent Arsenic Monitoring Results (2001 to 2017) - displays data collected between 2001 and 2017. In each of these figures, circles shown in light to dark magenta signify maximum arsenic concentrations. The discussion of arsenic in Section 5 and shown on Figure 5-14 which maps recent maximum arsenic concentrations reported in the BMA provides additional background on the current distribution of arsenic in the area. (Figures 2-11, 2-12, and 5-14 – Refer to Figures Tab)

Table 2-9 summarizes data on TDS, nitrate, and arsenic for the BVGSA that is displayed in Figures 2-7 through 2-12.

Table 2-9. Basic Statistics on TDS, Nitrate and Arsenic Monitoring

Metric	TDS	Nitrate as Nitrogen	Arsenic
Number of wells monitored	109	122	8
Maximum concentration	6,640 mg/L	46.08 mg NO_3-N / L	870 μg/L
Minimum concentration	87 mg/L	0.014 mg NO_3-N / L	1.3 μg/L
First reading	1937	1942	1980

2.2.4.7 Primary Use of the Principal Aquifer System

Introduction

The Buena Vista GSA is comprised almost entirely of irrigated farmland with the Community of Buttonwillow being the only municipality within its boundaries. While a substantial proportion of agricultural demand is supplied by surface water, the Community of Buttonwillow and individual domestic and industrial users rely entirely on groundwater, with groundwater elevations sustained by agricultural operations that recharge surface water diverted from the Kern River and SWP. As detailed in other sections of this GSP, groundwater users rely on relatively shallow unconfined and semi-confined aquifer zones above the Corcoran Clay.

Agricultural Water Use

Kern River water began being used for irrigation in the late 1850's when small private ditches diverted water for the irrigation of grains. Development of land within the boundaries of what is now the BVGSA began with the formation of Swamp Land District No. 121 under the Swamp and Overflow Act of 1850. Created on December 22, 1870, District No. 121 hired engineers to survey, plan, design and construct drains, canals and other features necessary for land reclamation with the intent of diverting surface water from the Kern River and from surface storage within Buena Vista Lake to develop lands north of and surrounding the lake.

Although much of the land within the district could claim riparian water rights due to proximity to Buena Vista Slough, Kern Lake and Buena Vista Lake, the district also filed notices of appropriation for water rights for diversion of Kern River water for irrigation. On July 2, 1877, the district executed an agreement with the Kern Valley Water Company, which effectively transferred the appropriative water rights, canals, other assets and reclamation responsibilities from the district, a public agency, to the company, a private firm. Among the partners in the Kern Valley Water Company were two former meat supply merchants from San Francisco, Henry Miller and Charles Lux who had set out to build a cattle and sheep empire in the Southern San Joaquin Valley.

As the upstream diversions increased, controversies arose resulting in lengthy litigation between upper and lower river users. Much of today's California water law resulted from the California Supreme Court's decision in the historic case of Lux v. Haggin (69 Cal. 255; 10 P. 674; 1886). The ruling created what is now known as the "California Doctrine" which recognizes both riparian and appropriative water rights. Despite the court's decision, the dispute continued and was finally settled in the historic Miller-Haggin Agreement of July 1888. This agreement, as amended, continues to serve as the basis by which the flow of the Kern River is allocated among "First and Second Point" interests.

Under the Miller-Haggin Agreement, the Second Point interests, namely Miller and Lux, were granted an apportionment of approximately one-third of the Kern River flows from March through August. A subsequent amendment also granted Second Point interests some of the Kern River flows resulting from winter runoff. The Second Point water right amounted to an average entitlement of about 158,000 AF/yr, delivered by First Point interests to the Second Point of measurement, undiminished by delivery losses (Krieger & Stewart, 2009).

After the death of Henry Miller in 1916, the Miller and Lux Land Company began selling much of its land to its tenant farmers who were largely emigrants from Italy. The new landowners soon realized that an entity would be needed to succeed the company in representing the many interests vested in the water right and to provide irrigation service. The Buena Vista Water Storage District was organized in 1924 to fulfill this need and began operations following issuance of its 1927 Project Report. Upon its formation, the District became the owner and operator of the irrigation and drainage facilities developed by the Miller and Lux Land Company and, as the successor to the Second Point interests under the Miller-Haggin Agreement, became entitled to provide for the distribution of the Second Point water rights that were tied to the Company's lands.

Table 2-10 presents the total acreage within the BVGSA, and the number of acres typically devoted to irrigated agriculture. Table 2-11 presents the current distribution of major crops by acreage as reported in the BVWSD's 2015 Agricultural Water Management Plan. Table 2-12 presents the same information by percentage of irrigated acreage. The last column in Tables 2-11 and 2-12, Other, represents a variety of fruits, vegetables, and ornamental crops.

Table 2-10 Total and Irrigated Areas of the Buena Vista GSA (Acres)[2]

Total Area	Lands Receiving Service
50,560	46,643 (92%)

[2] 2016 Engineer's Assessment Report in Support of Proposition 218 Assessment Ballot Proceeding, Buena Vista Water Storage District

Table 2-11. Key Crops Grown in the Buena Vista GSA (irrigated acreage)

Nut Crops	Grain / Alfalfa	Grapes	Cotton	Other	Total
9,185	8,433	2,575	8,182	4,062	32,437

Table 2-12. Key Crops Grown in the Buena Vista GSA (% of irrigated acreage)

Nut Crops	Grain / Alfalfa	Grapes	Cotton	Other
28%	26%	8%	25%	13%

Agricultural land use and water use are closely linked and are subject to change due to a variety of factors. For example, the on-going conversion from annual to permanent crops has important implications to groundwater management. First, conversion to permanent crops represents a "hardening" of demand as crop water requirements must be met year in and year out regardless of hydrologic conditions with the consequence that fallowing land during dry periods becomes an increasingly costly practice. Second, conversion to drip and micro-sprinkler irrigation has accompanied the shift to permanent crops, which has resulted in irrigation applications more closely matching crop demands. The higher application efficiency of drip and micro-sprinkler irrigation has reduced the volumes of surface and groundwater deliveries needed to satisfy crop demands. Although the shift in irrigation practices has diminished deep percolation of irrigation water, deep percolation has always played a minor role in groundwater recharge due to the GSAs restrictive surface soils.

Municipal, Domestic and Industrial Water Use

As noted above, the BVGSA encompasses the Community of Buttonwillow. The Community has a total surface area of 6.9 square miles and a population of 1,508 living in 406 housing units at the time of the 2010 census and lies entirely within the Buttonwillow Management Area. Buttonwillow relies entirely on groundwater extracted from underlying aquifers with most domestic and municipal water uses being for landscape irrigation at homes, commercial properties, and parks. Data available from DWR identified 59 domestic wells within the BMA.

Municipal, commercial and industrial wells deliver approximately 1,500 AF to industrial customers, largely agricultural yards and processing facilities. A large proportion of this use is consumptive due partly to evapotranspiration of land applied wastewater.

2.2.5 Data Gaps

Because of the extensive metering of surface water supplies and usage within the BVGSA and the metering of all production wells in the GSA, the primary uses of the principal aquifer system and the contribution of water from this system to the GSA's overall water supply is well documented with no apparent data gaps.

2.2.6 Cross Sections

Cross sections were developed to illustrate the subsurface conditions of the BVGSA along its north-south axis and east-west axis. The cross sections rely on data from a USGS Water Supply Paper (Croft 1972) and Western Oil and Gas Association Westside Groundwater Study (Rector 1983). Figure 2-13a illustrates the path that both the north-south and east-west cross sections take through BVGSA. Figure 2-13b – North-South Cross Section G-G' is northeast-trending to be perpendicular to the numerous faults and folds within the Valley. Figure 2-13c – West-East Cross Section D-D' is west-trending to be parallel to the axis of the Valley. (Figures 2-13a through 2-13c – Refer to Figures Tab)

2.2.7 Principal Characteristic Descriptions and Maps

2.2.7.1 Topographic Information

Figure 2-14 – Topographic Features – is a topographic map of the Kern County Subbasin and of the BVGSA. As described previously, the GSA occupies low-lying lands that follow the topographic axis of the Subbasin. The lowest land surface elevations are approximately 210 feet AMSL and are located along the County line between Highway 43 and Interstate 5. Prominent topographic features bordering the GSA include the Elk Hills and the Buttonwillow and Semitropic ridges (Figure 2-14 – Refer to Figures Tab)

2.2.7.2 Surficial Geology

The surficial geology of the Subbasin has been documented in previous investigations and is presented on Figures 2-4, 2-15 and 2-16 (respectively Page, 1986; CGS, 2010; and Bartow, 1991). These investigations identify numerous faults and folds located within the Subbasin including features which influence and define the BVGSA.

According to the CGS (2010a), the formations within the BVGSA consist mainly of Pleistocene to Recent unconsolidated and semi-consolidated alluvial lake (Q of Figure 2-15 – Geology of Kern County Subbasin), playa, and terrace deposits. Older Pleistocene alluvium (Qao) is present in the eastern portion of the Subbasin on top of Pliocene-Pleistocene deposits (QPc) of sandstone, shale and gravel deposits, including the Kern River Formation. The QPc unit includes the Tulare Formation and occurs as islands, surrounded by recent alluvium, within the center of the northern Subbasin, along the western side and within the alluvium.

Bartow (1991) provides a similar map (Figure 2-16 – Generalized Geologic Units) - as the CGS map but refers to Quaternary alluvial and lacustrine sediments (Qs) on the valley floor and Tertiary sedimentary rocks (TS) along the flanks and for the islands of older rocks in the valley center. Bartow also identified portions of three types of structural regions shown on Figure 2-16.

The structure of the western portion of the Subbasin, including the BVGSA, is characterized by numerous northwest-trending folds that are subparallel to the nearby right-lateral, strike-slip San Andreas Fault. Most of the folds are anticlines which have been mapped in the older sediments (QPc; Ts) and appear as ridges that crop out approximately 30 to 50 feet or more above the valley floor, including the Buttonwillow and Semitropic ridges, Lost Hills, and Elk Hills. Many anticlines are shown to be concealed beneath younger sediments (Q; Qs) along with the San Joaquin Syncline and other lesser synclines. Similarly, several northwest-trending faults are concealed by the younger sediments but have also been mapped within some of the islands of older sediments (Figures 2-15 and 2-16 – Refer to Figures Tab).

Page (1986) provides a somewhat different interpretation of the surficial geology of the BVGSA and its surroundings (Figure 2-4). The center of the valley floor is underlain by Recent flood basin (Qb) – clay, silt, and some sand; and by Pliocene to Recent lacustrine and marsh deposits (QTl) – clay, silt, and some sand with extensive subsurface clay layers (A, C, E/Corcoran). The former unit is associated with the original Kern River drainage and flood basin while the latter unit is associated with the beds of the historical Kern Lake, Buena Vista Lake, and Goose Lake, and the southern edge of the Tulare Lake Bed. The remainder of the valley is underlain by Miocene to recent continental deposits (QTc) – a heterogenous mixture of gravel, sand, silt, and clay with some layers of conglomerate, sandstone, siltstone, and claystone.

2.2.7.3 Soil Characteristics

Introduction

Soils within the BVGSA and neighboring areas are generally fine-textured originating from the historic Buena Vista and Kern lakebeds and swamp and overflow lands which continue north along the historical drainage paralleling Goose Slough, Goose Lake, and the southern edge of the Tulare Lake depositional environment. These soils are typically saline and high in pH. For example, the northern portion of the Buena Vista WSD includes heavy, poorly-drained soils underlain by a shallow, perched water table containing groundwater with salinity exceeding 2,000 mg/L. These conditions result in poor infiltration, water encroaching into the root zone, and moderately saline soils (Soil Survey of Kern County, California, Northwestern Part, 1988). Detailed soil survey data can be found in two USDA reports: Soil Survey of Kern County, California (USDA, 1988 and 2007), including recent online updates.

The remainder of the GSA includes medium-textured soils which are relatively low in salinity and within the optimal pH range for crop production.

Hydrologic Soils Groups

For the purposes of SGMA, a useful index of a soil's capacity to infiltrate precipitation and applied irrigation water is the NRCS Hydrologic Soils Group classification. Hydrologic Soils Groups typical of the BVGSA are defined below and are displayed on Figure 2-17 – Hydrologic Soils Groups – which was developed using data from the NRCS' Soil Survey Geographic Database (SSURGO).

- Hydrologic Group A – "Soils in this group have low runoff potential when thoroughly wet. Water transmitted freely" (NRCS, 2012). Group A soils have a high infiltration rate due to well drained sands or gravelly sands and have the highest permeability and potential for contributing to groundwater recharge.

- Hydrologic Group B – "Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission is unimpeded" (NRCS, 2012). Group B soils are moderately well drained due to moderately fine to coarse textures and have the second highest potential permeability and potential for contributing to groundwater recharge.
- Hydrologic Group C – "Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission is somewhat restricted" (NRCS 2012). This group has restricted potential to contribute to groundwater recharge. Group C soils have a low infiltration rate due to their fine texture or because of a layer that impedes downward movement of water. These soils are present at various points along the northwestern side of the Kern County Subbasin including the BVGSA.
- Hydrologic Group D – "Soils in this group have high runoff potential when thoroughly wet. Water transmission is very restricted" (NRCS, 2012). This group has a very limited capacity to contribute to groundwater recharge. These soils have a very slow infiltration rate due to the presence of clay and are located primarily along the northern boundary of the BVGSA.

Taxonomic Soil Orders

Figure 2-18 – Taxonomic Soil Orders of the Kern County Subbasin – displays taxonomic soil orders present in the BVGSA as defined by SSURGO mapping obtained from the DWR SGMA Data Viewer website (2018). This figure shows the six soil orders present in the BVGSA, with the most prominent being Aridisols, Entisols and Inceptisols evident along the eastern highland mixed with Alfisols, Mollisols, and Vertisols (Figures 2-17 and 2-18 – Refer to Figures Tab).

Based on the NRCS publication Keys to Soil Taxonomy (NRCS, 12th edition, 2014), the following characteristics are associated with each of these soil types:

- Aridisols are dry soils characterized by a low humus, light colored surface horizon with a subsurface accumulation of soluble salts, silicate clays, and possibly a cemented layer of calcium carbonate, calcium sulfate (gypsum) or silica.
- Entisols are characterized by the absence of soil horizons due to recent deposition or active erosion under extreme wet or dry conditions.
- Inceptisols exhibit a weak appearance of soil horizons overlying a weathering-resistant parent material.
- Alfisols are characterized by well-developed soil horizons enriched with aluminum- and iron-bearing (Al/Fe) minerals but depleted of calcium carbonate. Translocated clays typically form a layer with relatively high amounts of mineral nutrients (calcium, magnesium, sodium, and potassium).
- Mollisols are characterized by a thick, dark surface horizon of humus, which typically originates from native grass vegetation with mineral nutrients present in most horizons.

- Vertisols are clay-rich soils (>30%) with significant cracking during the dry season due to the shrink-swell response of the clay minerals during the dry and wet seasons. The shrink-swell action produces significant vertical mixing of the soil.

2.2.7.4 Delineation of Recharge, Potential Recharge, and Discharge Areas

Introduction

Recharge to aquifers in the BVGSA occurs through several mechanisms that fit into two general categories:

- Direct recharge
- In-lieu recharge

Direct Recharge

Direct recharge takes place through operation of BVWSD facilities including unlined irrigation canals, and dedicated groundwater recharge projects. Due to the nature of the BVGSA's soils and irrigation practices, deep percolation of applied irrigation water contributes little to aquifer recharge. Key recharge facilities within the BVGSA are presented in Figure 2-19 – Existing Recharge and Spreading Centers (Figure 2-19 – Refer to Figures Tab)

In-lieu Recharge (Conjunctive Use)

In-lieu recharge refers to instances where surface water is applied to lands that otherwise would have been irrigated using groundwater. Because of the history of the BVWSD's use of water from the Kern River and the State Water Project, in-lieu recharge in the BVGSA can be viewed not as substitution of surface water for established groundwater use, but as avoidance of reliance on groundwater due to established use of surface water.

Existing and Potential Recharge Sites and Mechanisms

Existing and potential recharge mechanisms in the BVGSA include conversion of cropped land to recharge ponds, and infiltration of storm water through recharge facilities. Both mechanisms are exemplified by the Palms Project discussed in Section 7 – *Projects and Management Actions*.

2.2.7.5 Surface Water Bodies

Figure 2-20 – Surface Water Features – shows the location of surface water bodies in or bordering the BVGSA, including the Kern River, the California Aqueduct and the Buena Vista Aquatic Recreational Area (BVARA).

The most important local source of surface water for the GSA is the Kern River, which has been regulated by the Isabella Dam and Reservoir since 1954. The dam and reservoir are operated by the U.S. Army Corps of Engineers, and the distribution of water is administered by the Kern River Watermaster. (Kennedy/Jenks Consultants, 2011) (Figure 2-20 – Refer to Figures Tab).

2.2.7.6 Source and Point of Delivery for Imported Water Supplies

Introduction

The BVGSA conjunctively uses surface water from local and imported sources. The Kern River is the source of local supply, and the State Water Project (SWP) is the avenue for delivery of imported water.

Sources of Imported Water

Imported water is supplied by the State Water Project (SWP) conveyed through the California Aqueduct. For the purposes of this analysis, historical averages are based on the 26-year period extending from 1991 through 2016, unless noted otherwise. This period is of sufficient length to capture a wide range of water supply conditions and, as the facilities used to import water have been in place throughout this period, changes in infrastructure have not greatly affected the pattern of deliveries. Over the period from 1995 through 2005, water imported via the SWP supplied 36% of the surface water available to the BVGSA with the Kern River being the source of the remaining 64%. Kern River water is delivered to the BVGSA through the East Side Canal and, also, wheeled through the California Aqueduct through exchange with Kern River contractors further upstream.

The proportion of surface water and groundwater used on an annual basis varies widely depending on hydrologic conditions, and over the years, regulatory requirements have impacted the availability of imported water. Environmental constraints on pumping from the Sacramento/San Joaquin River Delta have limited the reliability of SWP supplies. The following section provides background on imported water delivered via the California Aqueduct to the BVGSA.

State Water Project

The Kern County Water Agency (KCWA) was formed in the 1960s to contract with the California Department of Water Resources (DWR) for the importation of SWP water to Kern County. The California Aqueduct, the SWP's principal conveyance feature, transports water from the Bay-Delta along the west side of the San Joaquin Valley to the Kern County Subbasin. Individual water districts, including the BVWSD, hold contracts with the KCWA for a share of the imported water. The BVWSD's contract with the KCWA provides for two types of water; relatively firm Table A water and surplus water (Article 21) delivered through six turnouts from the aqueduct. Figure 2-21 – California Aqueduct and Points of Delivery to BVWSD – displays the alignment of the California Aqueduct and the location of turnouts supplying the BSA. (Figure 2-21 – Refer to Figures Tab)

Table A Water takes its name from an exhibit to the contract between the DWR and the SWP contracting agencies that serves as the basis for allocating available water among the agencies. Table 2-13 shows the maximum annual Table A deliveries for the entire SWP service area, the San Joaquin Valley, and the BVWSD.

Table 2-13. Maximum Annual SWP Table A Amounts

(Source: SWP Delivery Reliability Report 2005) (Units: AF)		
SWP Service Area	**San Joaquin Valley**	**BVWSD**
4,172,786	1,133,556	21,300

Due to a variety of factors including hydrologic conditions, reservoir storage, and projected runoff, the SWP is unable to deliver full Table A amounts in most years. Accordingly, a percent allocation is set each year which is applied to each contractor's Table A amount. Table 2-14 shows the historical deliveries of Table A water to the KCWA from 1991 through 2016, along with Article 21 (surplus), carryover and turnback water for the same period.

Table 2-14 Historical Deliveries of SWP Water (AF) to Kern County Water Agency

(Source: SWP Delivery Reliability Reports for 2002, 2003, 2007, 2017)					
Year	**Table A**	**Article 21**	**Carryover**	**Turnback**	**Total**
1991	-	-	8,965	-	8,965
1992	480,462	-	2,758	-	483,220
1993	1,127,774	-	40,156	-	1,167,930
1994	598,685	58,474	-	-	657,159
1995	1,089,063	59,671	2,795	-	1,151,529
1996	1,117,060	15,653	52,350	-	1,185,063
1997	1,102,807	10,264	-	-	1,102,807
1998	856,906	-	1,684	-	858,590
1999	1,077,755	58,241	-	42,154	1,178,150
2000	825,856	78,908	13,193	233,202	1,151,159
2001	363,204	23,233	92,052	6,502	484,991
2002	670,884	21,951	15,680	20,543	729,058
2003	841,697	27,891	22,380	8,419	900,387
2004	640,190	86,513	40,120	5,075	771,898
2005	893,439	453,078	9,851	22,397	1,378,765
2006	961,882	256,634	5,418	18,610	1,242,544
2007	592,423	99,861	19,645	4,683	716,612
2008	275,555	-	2,896	883	279,334
2009	325,426	-	56,367	544	382,337
2010	411,821	-	55,419	3,044	470,284
2011	753,707	194,119	119,773	16,068	1,083,667
2012	560,969	-	32,477	2,180	595,626
2013	314,466	-	73,303	37,005	424,774
2014	1,393	-	24,717	520	26,630
2015	173,581	-	43,265	707	217,553
2016	458,759	-	-	3,533	462,292
Historical Average	**635,222**	**55,557**	**28,279**	**16,387**	**735,051**

Total deliveries of SWP water to the KCWA have averaged 735,051 AF per year during the period from 1991-2016, with these annual deliveries ranging from 8,965 AF and 26,630 AF in 1991 and 2014, respectively, to 1,378,765 AF in 2005.

Article 21 Water, unlike Table A water, cannot be scheduled; rather, it must be taken at the time it is declared to be available. The following conditions govern the availability of Article 21 water:

- Available only when deliveries do not interfere with Table A allocations and SWP operations
- Available only when excess water is available in the Delta
- Cannot be stored within the SWP system. Contractors must be able to use the Article 21 water directly or store it in their own system

Due to these conditions, Article 21 water is only available during wet months, typically December through March. The BVGSA is conditionally allocated 3,745 AF of any surplus supply.

Surface water deliveries enter the BVGSA through two flow paths: 1) California Aqueduct turnouts, and 2) the East Side Canal. Each of these points of entry is equipped with flow measurement to quantify the volume of water entering the BVGSA. It is important to note that water measured as being delivered through California Aqueduct turnouts is not entirely SWP allocation. This is the case because water transferred or exchanged between BVWSD and other agencies may be routed for delivery through the California Aqueduct.

Figure 2-22 – Historical Deliveries from CA Aqueduct Turnouts to BVGSA – shows total deliveries through turnouts from the SWP's CA Aqueduct to the BVGSA from 1993 through 2015. Figure 2-23 – Historical Surface Water Deliveries to BVGSA – shows both CA Aqueduct and East Side Canal deliveries from 1993 through 2015.

Section 6 – Water Supply Accounting – provides detailed information on SWP deliveries to the BVWSD used in the BVGSA's water budget.

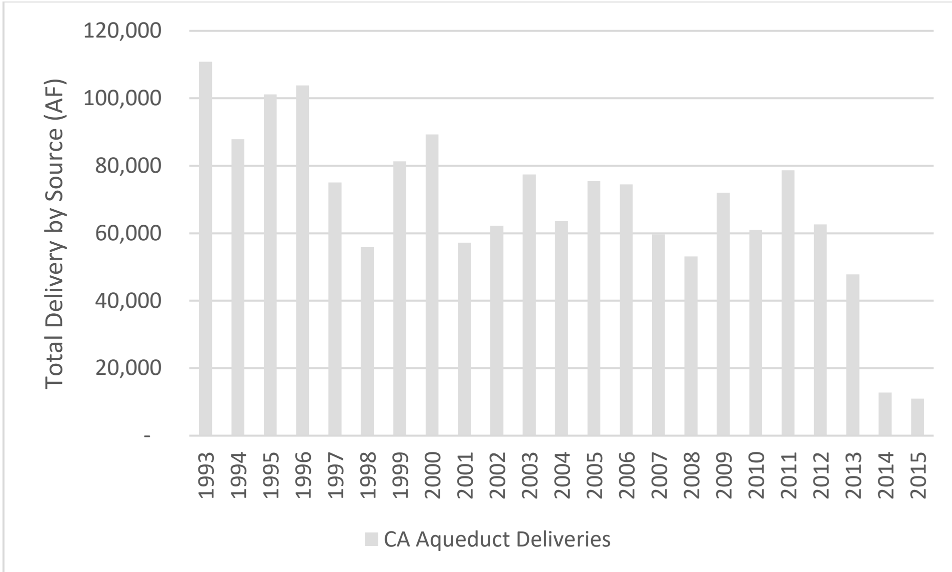

Figure 2-22. Historical Deliveries from CA Aqueduct Turnouts to BVGSA

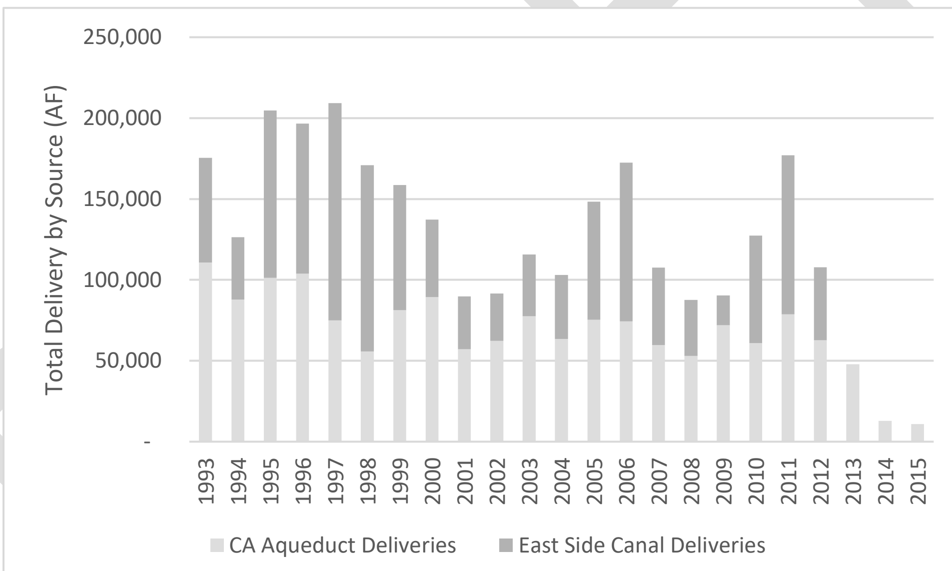

Figure 2-23. Historical Deliveries of Surface Water to the BVGSA

2.3 Groundwater Conditions

2.3.1 Description of Current and Historical Groundwater Conditions

Based on historical groundwater data from USGS and KCWA (Page, 1986; and KCWA), groundwater flows from the uplands along the south, east, and west margins of the Kern County Subbasin toward the center of the Subbasin and from the Kern River towards the north and south due to recharge by the river and from groundwater banking along the river. Groundwater in the BMA generally migrates in a southerly direction along the axis of the Subbasin that runs through the center of the GSA until it leaves the GSA as subsurface underflow or is captured by pumping wells for irrigation or potable consumption. Generally, groundwater levels observed over the past 20 years have been stable in the north while declining in the south which suggests the north-to-south gradient has been increasing.

2.3.2 Groundwater Elevation, Flow Directions, and Lateral/ Vertical Gradients

2.3.2.1 Groundwater Elevation Contour Maps for Each Principal Aquifer

Groundwater elevation contour maps for the main production zone of the aquifer system were prepared for Spring 2015 (seasonal high) (Figure 2-24 – Spring 2015 Groundwater Elevations) as well as Fall 2015 (seasonal low) (Figure 2-25 – Fall 2015 Groundwater Elevations) to provide a 'baseline' snapshot of groundwater flow trends across the BVGSA at the inception of SGMA. Because pumping extracts water from the aquifer above the E-clay, and only three district monitoring wells, all in the south of the BMA, observe groundwater levels beneath the E-clay, no maps were prepared for this lower zone. (Figures 2-24 and 2-25 – Refer to Figures Tab)

Groundwater elevations during Spring 2015 in the principal aquifer system ranged from less than 80 feet AMSL in the extreme south of the BMA to 200 feet AMSL in an area surrounding the Lerdo Highway.

Groundwater elevation data for the Fall 2015 were limited due to the high demand for pumping. However, general groundwater elevation trends are consistent with historical trends. Groundwater elevations in the principal aquifer system ranged from less than minus 50 feet AMSL to greater than 200 feet AMSL.

2.3.2.2 Hydrographs Capturing Historical Highs, Lows, and Vertical Gradients

Hydrographs for district monitoring wells reported to CASGEM by the BVWSD are provided as Figures 2-26a through 2-26m. The hydrographs represent the available data from 1992 to 2015 for each of the monitoring wells. Additional hydrographs presented in Appendix B, include:

- District Monitoring Wells (DMWs)
- District Wells
- Measured Landowner Wells
- Shallow Piezometers (Northern BSA)

Figure 2-26a. DMW01 Hydrograph

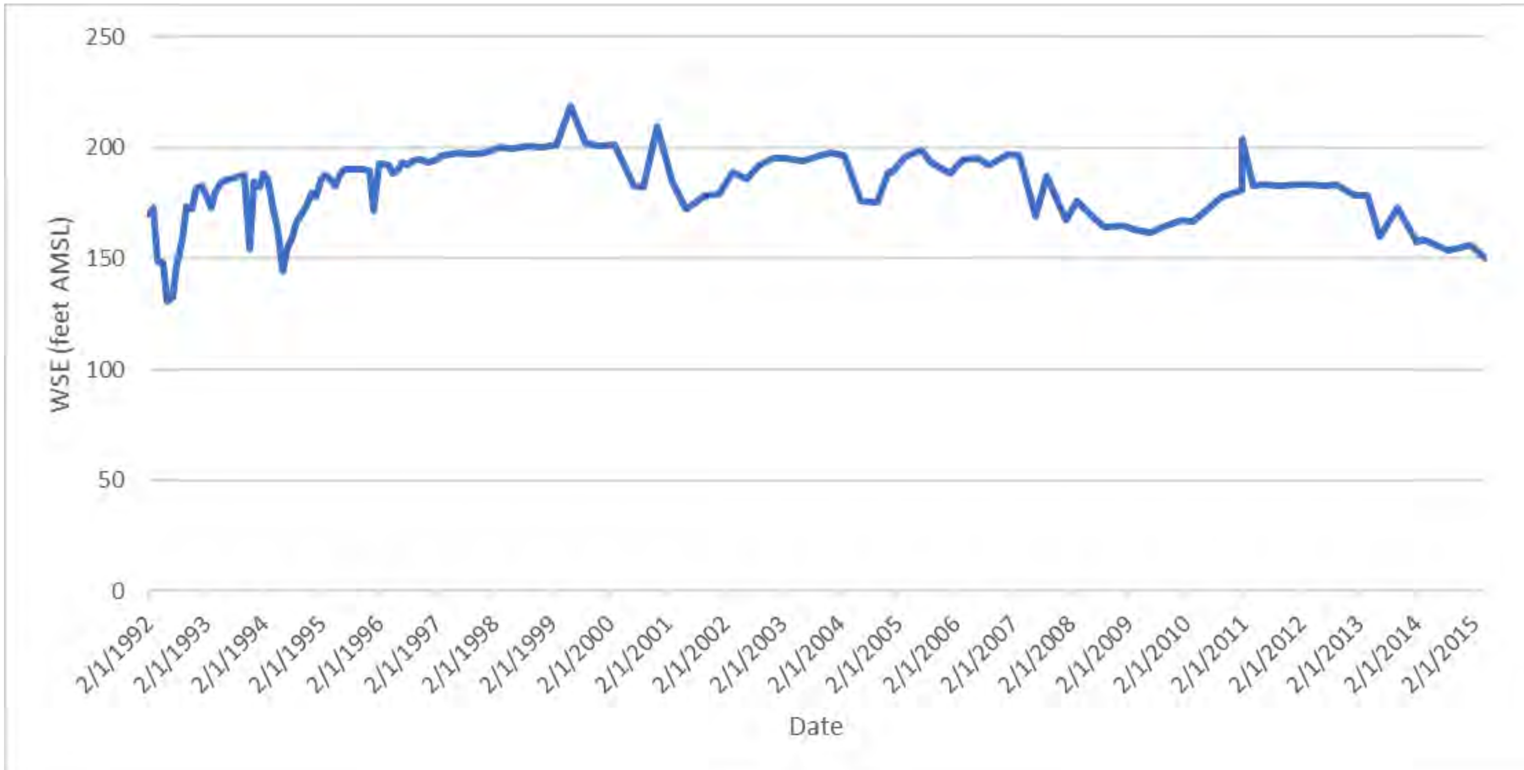

Figure 2-26b. DMW02 Hydrograph

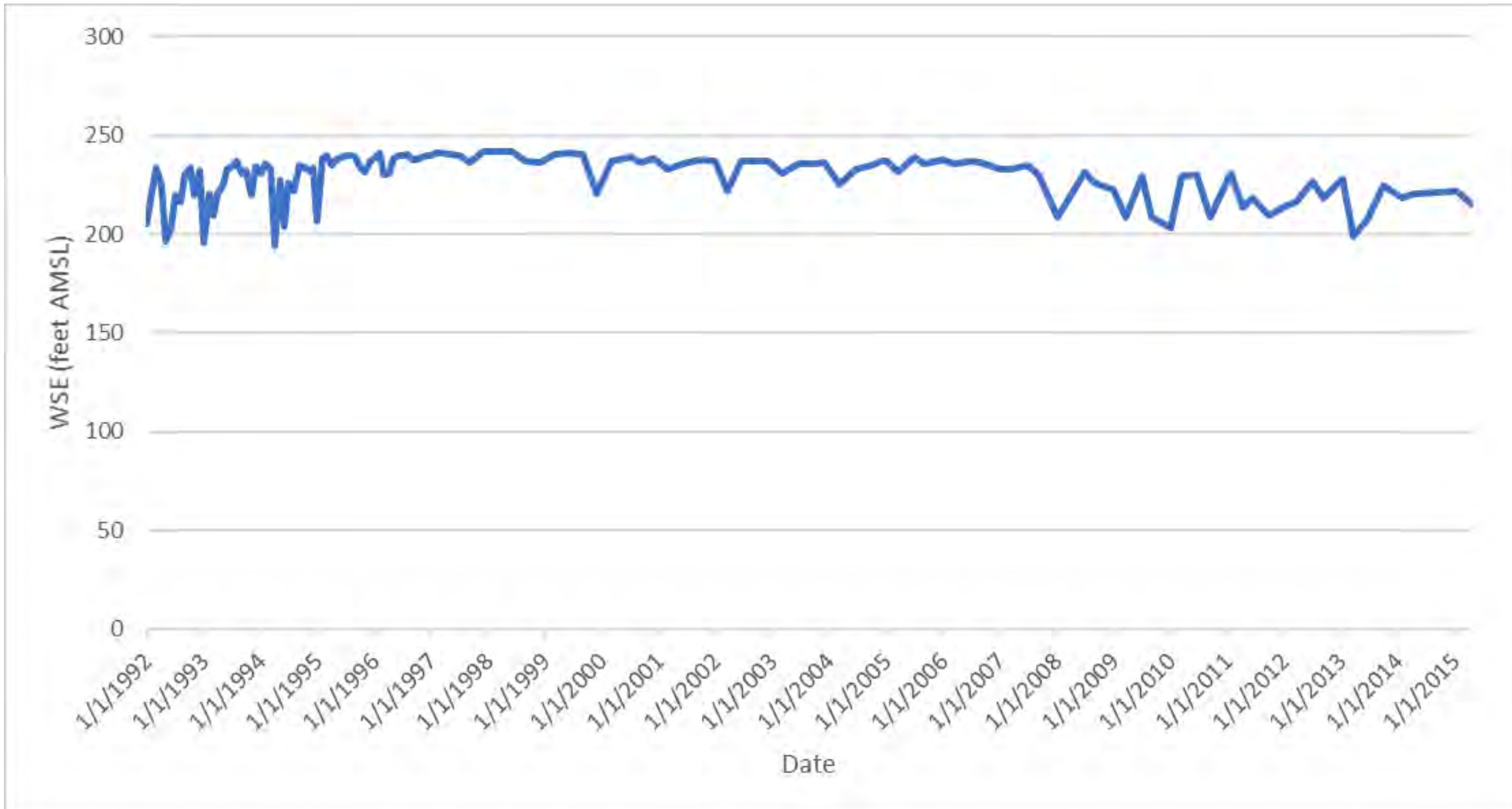

Figure 2-26c. DMW04 Hydrograph

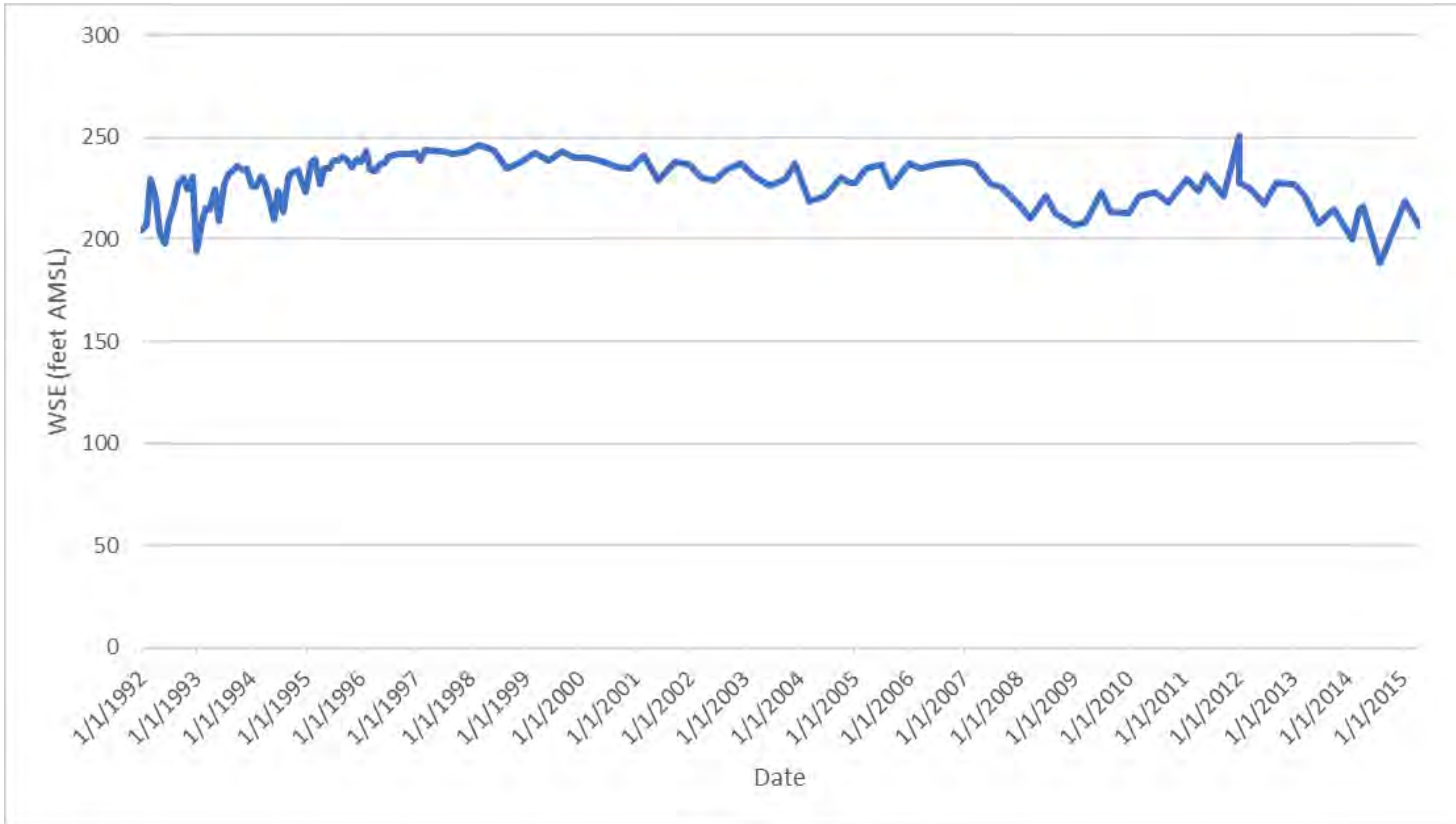

Figure 2-26d. DMW05 Hydrograph

Figure 2-26e. DMW06 Hydrograph

Figure 2-26f. DMW07 Hydrograph

Figure 2-26g. DMW08 Hydrograph

Figure 2-26h. DMW010a Hydrograph

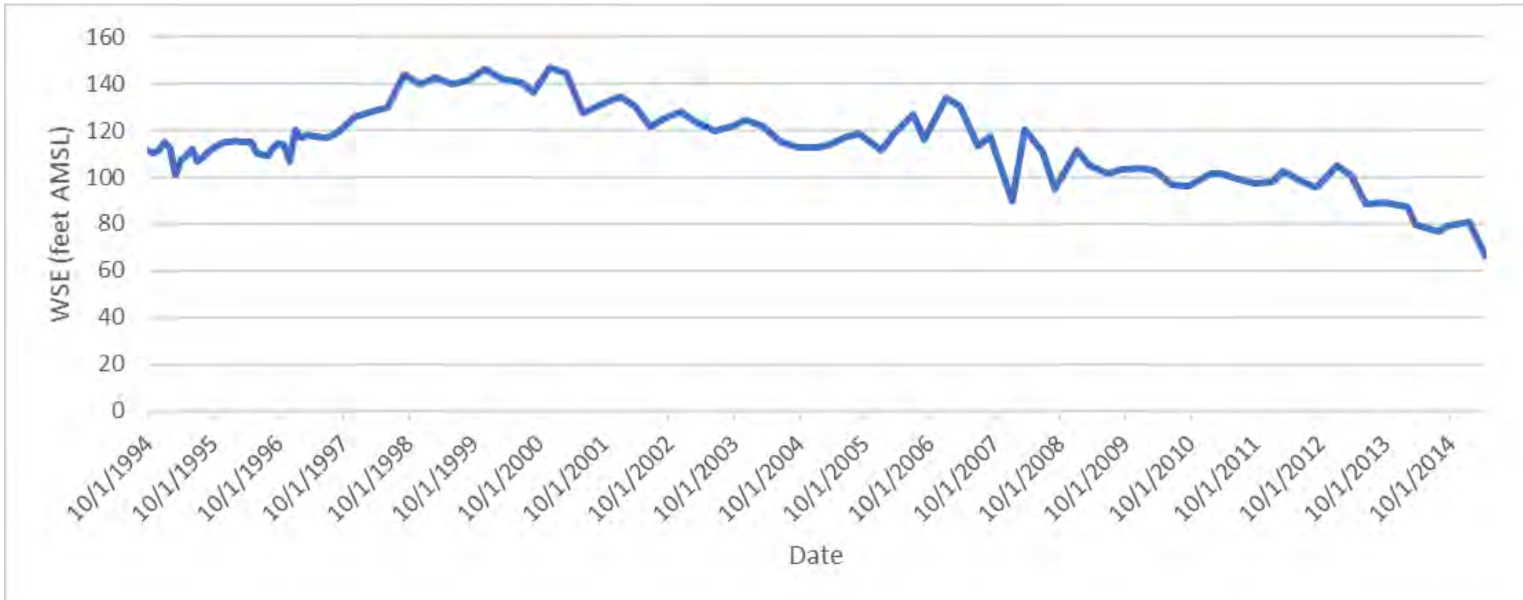

Figure 2-26i. DMW10b Hydrograph

Figure 2-26j. DMW12a Hydrograph

Figure 2-26k. DMW12b Hydrograph

Figure 2-26I. M01 Hydrograph

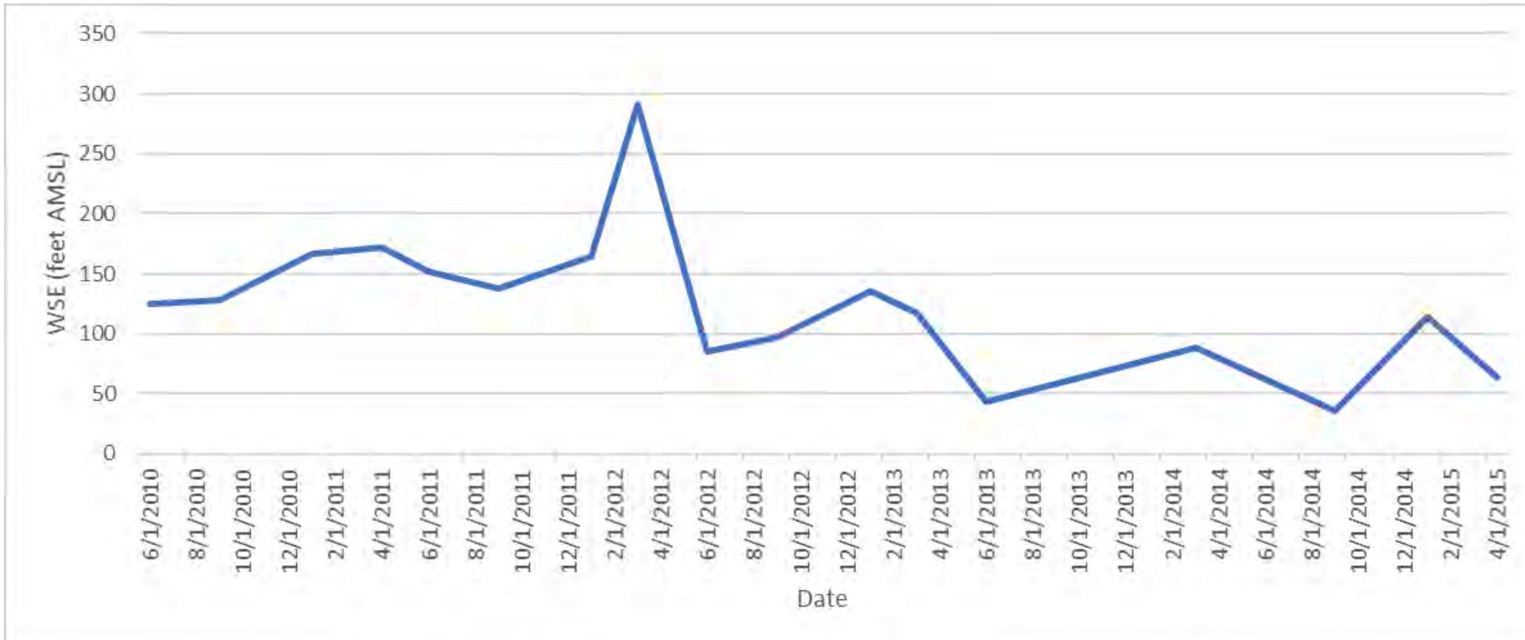

Figure 2-26m. M02 Hydrograph

2.3.3 Cumulative Change in Storage

An estimated change in groundwater storage for the BVGSA was calculated for two periods. The first period was between a "wet" water year (Spring 2011) and a "critically dry" water year (Spring 2015), and the second period was between Spring 2015 and Spring 2017. The change in groundwater elevations for the Spring highs were evaluated by superimposing data across the area that were available for 2011, 2015, and 2017. Differences in groundwater elevations for these periods were calculated using Microsoft Excel models that were then verified with the three-dimensional analysis capabilities of ArcGIS™ to estimate an overall volume of change.

Change in storage is the product of the volume of aquifer material lying between groundwater elevations at the beginning and end of the period over which the change takes place and 'storage' values representing the storage capacity of a unit of aquifer material. The heterogeneity of the lithology of the shallow, unconfined, and confined zones results in a wide range of values for storage: specific yield for unconfined zones and coefficient of storage for confined zones. As a result, change in groundwater storage was estimated using a reasonable range of values for unconfined zones of the aquifer system, as almost all groundwater extraction takes place above the confining C-clay. According to the USGS (1989), the Tulare Basin has a median value for specific yield of 0.101 for unconfined groundwater, based on ten subareas, including a value of 0.094 for the BVGSA (subarea 47). This value of specific yield is similar to the value of 0.15 developed by the BVWSD and confirmed in a California Energy Commission study[3] carried out for the now-terminated Hydrogen Energy California (HECA) project. Because of the uncertainty associated with specific yield, a range of 0.10 to 0.20 has been used when estimating change of storage within the BMA.

Figures 2-27a, 2-27b, and 2-27c display estimates of groundwater level contours for 2011, 2015, and 2017, respectively. Figure 2-27d shows the change in groundwater level contours between 2011 and 2015 and Figure 2-27e shows the change between 2015 and 2017. The resulting estimated change in storage for 2011 to 2015 varied from -132,389 AF to -264,777 AF for the 4-year period of drought. For 2015 to 2017, the estimated change in groundwater storage varied from 34,635 AF to 69,269 AF for the 2-year period of drought recovery. These estimates illustrate the degree of uncertainty now associated with estimating change in storage. (Figures 2-27a through 2-27e – Refer to Figures Tab)

To better account for aquifer heterogeneity, a groundwater model is being developed by Todd Groundwater for the Kern County Subbasin, based on the DWR's C2VSim fine-grid model. Change in storage estimates computed by the model will be compared with the estimates presented in this Basin Setting and, once validated, may be used to update the Basin Setting.

[3] Preliminary Water Supply Analysis, M. Conway; J. Fio; S. Deverel, California Energy Commission, 2013.

2.3.4 Annual Change in Storage, Considering Annual Use and Water Year Type

Section 6 – Water Supply Accounting – Water Budget presents an extensive analysis of water supplies available to the BVGSA and of the uses and destinations of these supplies. Based on this analysis the annual change in storage by water year type after consideration of use during these year types is as follows:

- Wet year – 35,772 AF;
- Above Normal year – 9,368 AF;
- Below Normal year – 24,409 AF;
- Dry year – 24,833 AF, and
- Critically Dry year – 73,535 AF.

As described in the water budget analysis, the period used for developing the water budget (1993 through 2015) was weighted at the extremes with Wet years being the most frequent year type (8 occurrences) and Below Normal years being the least frequent (2 occurrences).

2.3.5 Seawater Intrusion

The BVGSA is located over 60 miles from the Pacific Ocean and the Kern County Subbasin is bounded by the Coast Range mountains on the west side. Due to its location, seawater intrusion is not an issue for the BVGSA.

2.3.6 Groundwater Quality

Introduction

Section 2.2.4.5 – General Water Quality of Principal Aquifers provides a discussion of groundwater quality in the BVGSA that focuses on three constituents found in varying degrees throughout the GSA, salts (TDS), nitrate and arsenic. Each of these constituents is found in the parent material of local aquifers, and TDS and nitrate are also introduced through human activity. This section focuses on locations, identified by regulatory agencies, where groundwater quality has been degraded due to industrial and commercial activity.

2.3.6.1 Map and Description of Known Sites and Plumes

Locations of impacted groundwater were identified by reviewing information available on the SWRCB Geotracker website, the California Department of Toxic Substances Control (DTSC) EnviroStor website, and the Environmental Protection Agency's (EPA) National Priorities List (NPL). Cases that have been closed by the supervisory agency are not considered.

Figure 2-30 – Sites of Potential Groundwater Impacts – from EnviroStor and Geotracker databases, present the locations and details of known impacted groundwater or potentially impacted groundwater within the Kern County Subbasin. The sites were divided into the following categories based on regulatory designation (Figure 2-28 – Refer to Figures Tab):

- Other Sites with Corrective Action (Current)
- Sites Needing Evaluation (Active or Inactive)
- Federal Superfund-Listed Sites
- Leaking Underground Storage Tank (LUST) Cleanup Sites
- Sites in the DTSC Site Cleanup Program (Active)
- Produced Water Ponds Sites (Open Assessments or Inactive-Permitted)
- Underground Injection Control Sites (Open Assessment or In Review)

Of the 50 open cases within the boundaries of the Kern County Subbasin, 9 were identified as impacting groundwater within the Subbasin, however none were identified as impacting groundwater within the BVGSA.

2.3.7 Land Subsidence

Inelastic land subsidence is a major concern in areas of active groundwater extraction due to canal and infrastructure damage, permanent reduction in the groundwater storage capacity of the aquifer, well casing collapse, and increased flood risk in low lying areas.

Several processes contribute to land subsidence. These include, in order of decreasing significance: aquifer compaction by overdraft, hydrocompaction (shallow or near-surface subsidence) of moisture deficient deposits above the water table that are wetted for the first time since deposition, petroleum reservoir compaction due to oil and gas withdrawal, and subsidence caused by tectonic forces (Ireland et al., 1984).

Inelastic subsidence typically occurs in the clay layers within aquifers and aquitards due to the withdrawal of water in storage within these layers during over-pumping, which induces the permanent rearrangement or collapse of the clay layer structure. Clay particles are supported by water at the time of deposition and over-pumping dewaters the clay. Groundwater cannot re-enter the clay structure after collapse. This condition represents a permanent loss of the storage volume in the clay layers due to a reduction of porosity in these layers. This storage reduction does not substantially decrease usable groundwater storage in the aquifer because the clay layers do not typically store significant amounts of recoverable groundwater (LSCE, 2014). However, the groundwater quality of the aquifers could be impacted by the lesser quality groundwater in the clay layers. The surface displacement of subsidence represents the reduced thickness of the impacted clay layers, and this vertical displacement causes damage to wells and structures.

Historical documentation of subsidence has relied on various types of data, including topographic mapping and ground surveys, declining groundwater levels, borehole extensometer, and continuous global positioning satellite (CGPS) stations. Recent subsidence studies have utilized satellite- and aircraft-based Interferometric Synthetic Aperture Radar (InSAR) within the Central Valley and along the California Aqueduct and Friant-Kern Canal. Much of the InSAR work has been led by the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL).

The USGS estimates that about 75 percent of the subsidence in the San Joaquin Valley occurred in the 1950s and 1960s, a period that coincides with extensive groundwater development (Galloway, et al., 1999). Importantly, water levels during this period were continuing to fall to then-historic lows each year, changing pore pressures in sediments for the first time, which would be associated with larger amounts of subsidence (Todd, 2017).

InSAR data published in a study commissioned by the California Water Foundation showed up to 0.5 feet of subsidence from 2007 to 2011 across most of the Kern County Subbasin north of the Kern River (LSCE, 2014). Portions of the California Aqueduct are located along the western boundary of the BVGSA and more focused InSAR data show variable conditions with up to 6 inches of subsidence in the area bounded by the aqueduct, Interstate 5, the Lerdo Highway and the Kern River Flood Channel Canal between April 2014 and June 2016, especially north of Buttonwillow. Note that InSAR data are subject to uncertainty and this aqueduct area showed up to 2 inches of uncertainty.

Five continuous CGPS stations are located in the Kern County Subbasin north of the Kern River and have been recording their location since late 2005 (stations P544, P563, and P565), 2006 (station 564), and 2007 (station P544). These stations are monitored as a part of UNAVCO's Plate Boundary Observation (PBO). Between 2008 and 2017, subsidence varied from 1.7 to 2.9 inches at three stations near the BVGSA along Interstate 5 (P544, P545, P563), and the rate decline was relatively steady.

According to the report "Land Subsidence from Groundwater Use in California" (Luhdorff & Scalmanini Consulting Engineers, 2014), subsidence is on-going and leading to significant impairment of the California Aqueduct. According to DWR (2014), the Kern County Subbasin was rated at a high risk for future subsidence due to 1) a significant number of wells (51%) with water levels at or below historic lows; 2) documented historical subsidence; and 3) documented current subsidence. However, the BVGSA has displayed little evidence of any of these tendencies. This may be due to the BVWSD's historical reliance on surface water. This access to surface water has supported groundwater elevations and limited the volume of groundwater extraction which has fueled subsidence in other parts of the Subbasin. Future subsidence will depend on whether water levels decline below previous low levels and remain low for a considerable length of time. A more complete analysis of subsidence in the BVGSA is presented in Section 5 – Minimum Thresholds, Measurable Objectives and Interim Milestones.

2.3.7.1 Cumulative Total Subsidence

The tabulated data shown in Table 2-15 includes cumulative inches of subsidence within the Subbasin and BVGSA and a calculated approximate annual rate for the period over the data collection period. The data for the entire Subbasin is sourced from 1926 through 1970 and the data specifically for BVGSA reflects more recent observations from 2006 through 2019. The more recent data is collected from UNAVCO CGPS unit P563 and approximate values are reported in Table 2-15 due to variations in daily CGPS solutions. An analysis of subsidence in the BVGSA is presented in Section 5 – Minimum Thresholds, Measurable Objectives and Interim Milestones.

Table 2-15. Cumulative Subsidence and Approximate Annual Rate of Subsidence

Subbasin Area	Date Range	Cumulative Subsidence (inches)	Calculated Annual Rate of Subsidence (inches/year)	Source
Kern County Subbasin	1926 - 1970	<12 – 120	<0.3 - 2.7	Polland, et al., 1975 Ireland, et al., 1984 Topographic Maps and Leveling Data.
BVGSA (P563)	2006 - 2019	~ 3.15	~ 0.24	UNAVCO CGPS Processed Daily Position Time Series, 2019

2.3.7.2 Annual Rate of Subsidence

Estimates of annual rates of subsidence are presented in Table 2-15 and in Figures 2-29 and 2-30.

2.3.7.3 Map of Subsidence Locations

Historical subsidence within the BVGSA is shown on Figure 2-29 – Historical Subsidence. Recent subsidence, as measured by recent studies and monitoring points, is plotted on Figure 2-30 – Recent Subsidence (2015-2016). This figure displays CGPS data locations, which are monitored continuously by UNAVCO and data from these locations are plotted with recent calculated rates of subsidence. The approximate extents of the UAVSAR and InSAR studies in the vicinity of the BVGSA are also displayed on Figures 2-29 and 2-30 (Figures 2-29 and 2-30 – Refer to Figures Tab).

2.3.8 Interconnected Surface Water Systems

Interconnected surface water systems are surface waters that are hydraulically connected by a continuous saturated zone to an underlying aquifer (DWR, 2016). Because no streams cross the boundaries of the BVGSA to feed lakes, ponds or other surface water bodies, natural surface water is not connected to the groundwater system.

Nearby surface water bodies, such as the Buena Vista Aquatic Recreation Area (BVARA) lakes, are situated in either natural or man-made depressions and are now dependent on managed water deliveries, principally from the Kern River and seepage that is recovered by wells and returned to the lakes.

2.3.9 Identify Groundwater Dependent Ecosystems

Introduction

Groundwater Dependent Ecosystems (GDEs) are ecological communities that depend on groundwater emerging from aquifers or groundwater occurring near the ground surface.

In the BVGSA, potential GDEs are likely to be associated with wetlands and riparian areas that are supported either by groundwater or by a combination of groundwater and surface water. Ephemeral wetlands covered by water seasonally are likely to be supported by irrigation deliveries and precipitation and are unlikely to be surface expressions of groundwater. Features such as groundwater recharge basins that are artificially flooded with surface water, although having the potential to provide habitat, also depend on diversion of surface water rather than groundwater.

Methodology

The distribution of GDEs in the BVGSA was assessed based on a series of research efforts beginning with the paper, Mapping Groundwater Dependent Ecosystems in California (Plos 1, 2010). This research was published by scientists at The Nature Conservancy of California (TNC) and used geospatial data to map hydrologic features characteristic of potential GDEs. The methodology applied in this research mapped the following variables as surrogates to represent ecosystem dependence on groundwater:

- Density of springs and seeps
- Density of groundwater dependent wetlands and associated vegetation alliances
- Percent of discharge from groundwater (baseflow) in streams.

Density of Springs and Seeps

Locations of seeps and springs were identified based on data extracted from the National Hydrography Dataset (NHD Plus) and were mapped as the top priority since all seeps and springs are GDEs. Because the NHD Plus maps springs and seeps as point data, these were evaluated by their density (number of springs and seeps per hectare). Although the data on springs and seeps does not contain information on the volume of flow discharged from these features, this is not believed to compromise the value of the analysis as mapping of springs and seeps is used to identify habitat areas rather than to assess their importance as water sources. For this reason, calculating the density of these features is believed to be sufficient to characterize their contribution to GDEs in the Kern County Subbasin.

Figure 2-31 – Location of Springs and Seeps, which displays the results of this mapping, shows a dense population of springs and seeps in the mountains and foothills on the flanks of the Kern County Subbasin but no springs or seeps are mapped in the BVGSA.

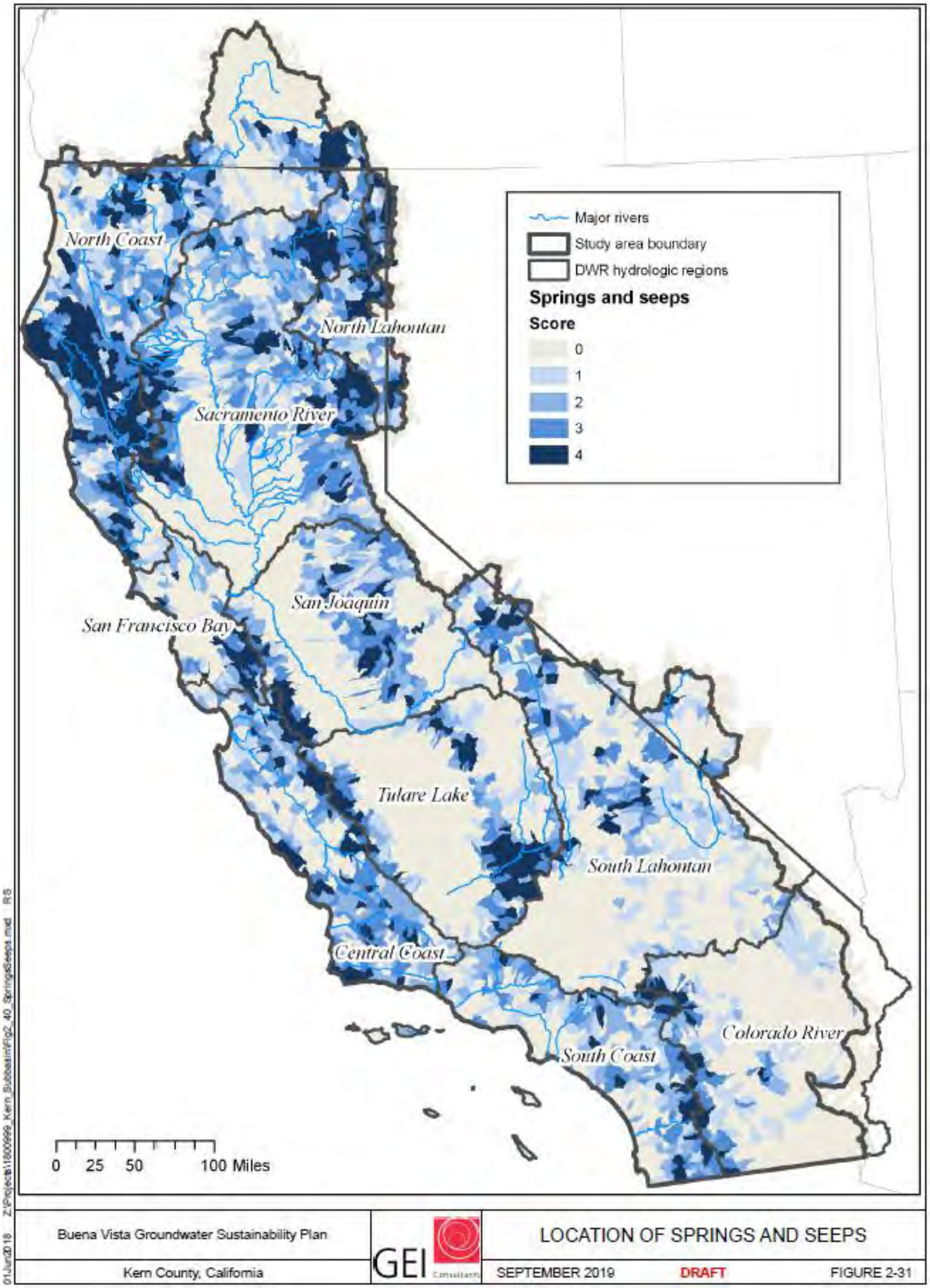

Figure 2-31. Location of Springs and Seeps

Density of Groundwater Dependent Wetlands

Areas where groundwater flow sustains wetlands were addressed in *Mapping Groundwater Dependent Ecosystems in California* using the following analytical sequence.

- Data on wetlands and groundwater dependent vegetation alliances were pooled from multiple sources to generate a single composite GIS layer. This layer was used to map all wetlands and vegetation types that may have some level of groundwater dependence as determined from the data source's metadata and consultation with ecologists familiar with the specific ecosystems.
- Although all springs and seeps are groundwater dependent features, the groundwater dependence of wetlands is a function of their hydrologic, geologic, and climatic setting. To screen data for wetlands that are supported by precipitation or surface water diversions and that may not be groundwater dependent, associations between wetlands and the presence of hydric or partially hydric soils were mapped using the NRCS STATSGO2 database. This step filtered out surface water dependent wetlands, such as vernal pools and wetlands fed from canal diversions, from consideration as GDEs.

Figure 2-32 – Groundwater Dependent Wetlands displays the results of this analysis. The figure shows a dense population of groundwater dependent wetlands in the mountains and foothills in the eastern and western flanks of the Kern County Subbasin, but much of the Central Valley floor south of Tulare Lake is mapped as having no groundwater dependent wetlands or as having a very low density of these wetlands. No areas within the BVGSA are mapped as having potential groundwater dependent wetlands.

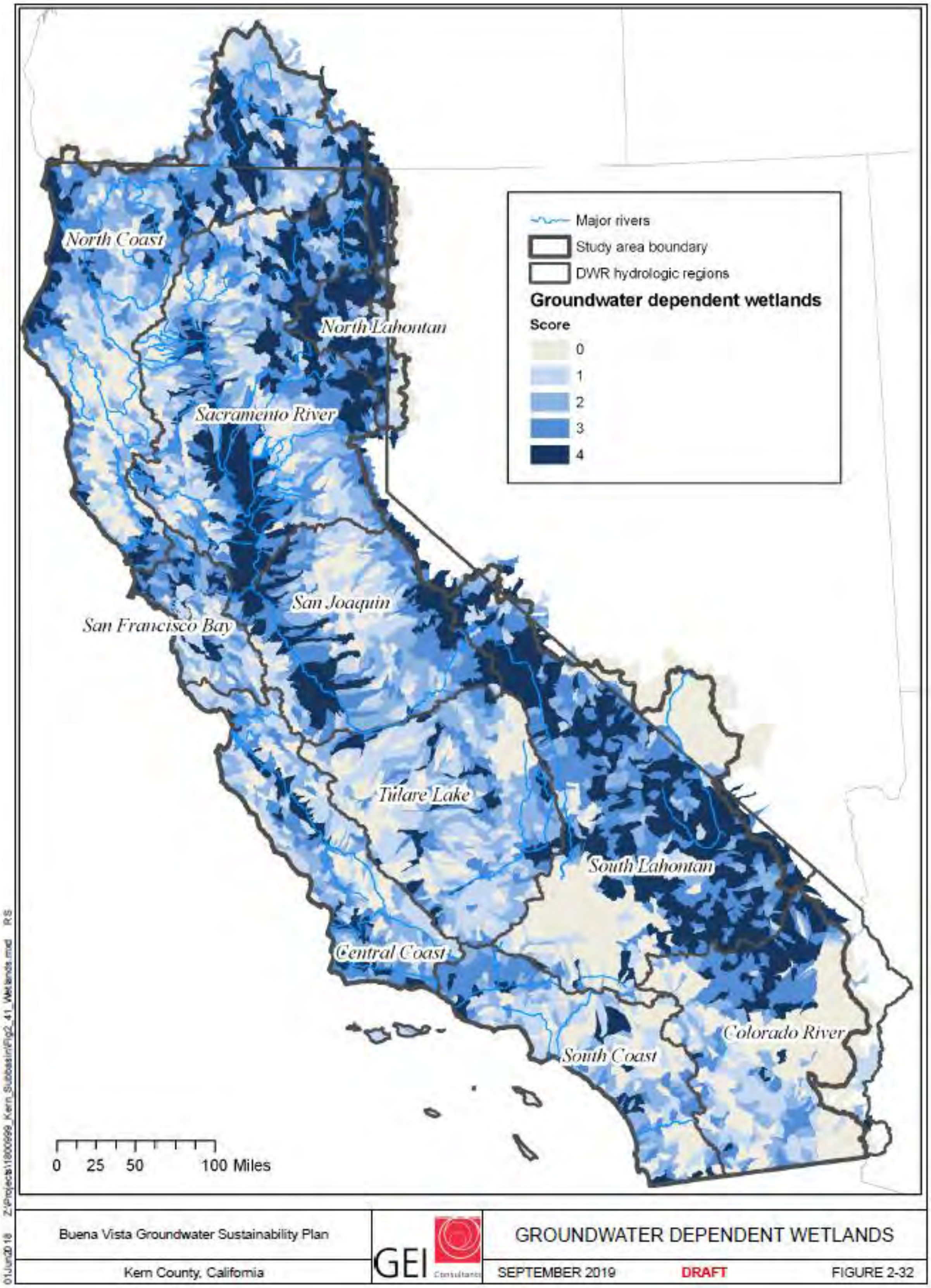

Figure 2-32. Groundwater Dependent Wetlands

Groundwater Dependent Streams

Groundwater dependent stream segments were identified in the research reported in *Mapping Groundwater Dependent Ecosystems in California* using the baseflow component of streamflow as an index of the degree to which groundwater discharge supports streamflow. This was accomplished by first mapping stream segments using NHD Plus data. Baseflow percentages associated with these segments were drawn from U.S. Geological Survey (USGS) data on the baseflow index (BFI) of individual stream segments, an index which defines the ratio of baseflow to total flow. This method estimates the annual base-flow volume of unregulated rivers and streams and computes an annual base-flow index for multiple years of data at one or more gage sites. BFI data were applied in two ways.

- In watersheds where a USGS stream gage was operational, BFI values were assigned from gage data. In watersheds with multiple stream gages, an average value was assigned.
- For watersheds where gaging data were not available, a BFI was assigned using interpolated values from a coterminous watershed.

As with the previous two factors used to determine the density of potential GDEs, Figure 2-33 – Base Flow Index shows base flow as being a contributor to stream flow in the mountains and foothills to the east of the valley floor. As no natural streams traverse the BVGSA, the association between baseflow and streamflow is not relevant for assessment of GDEs in the GSA.

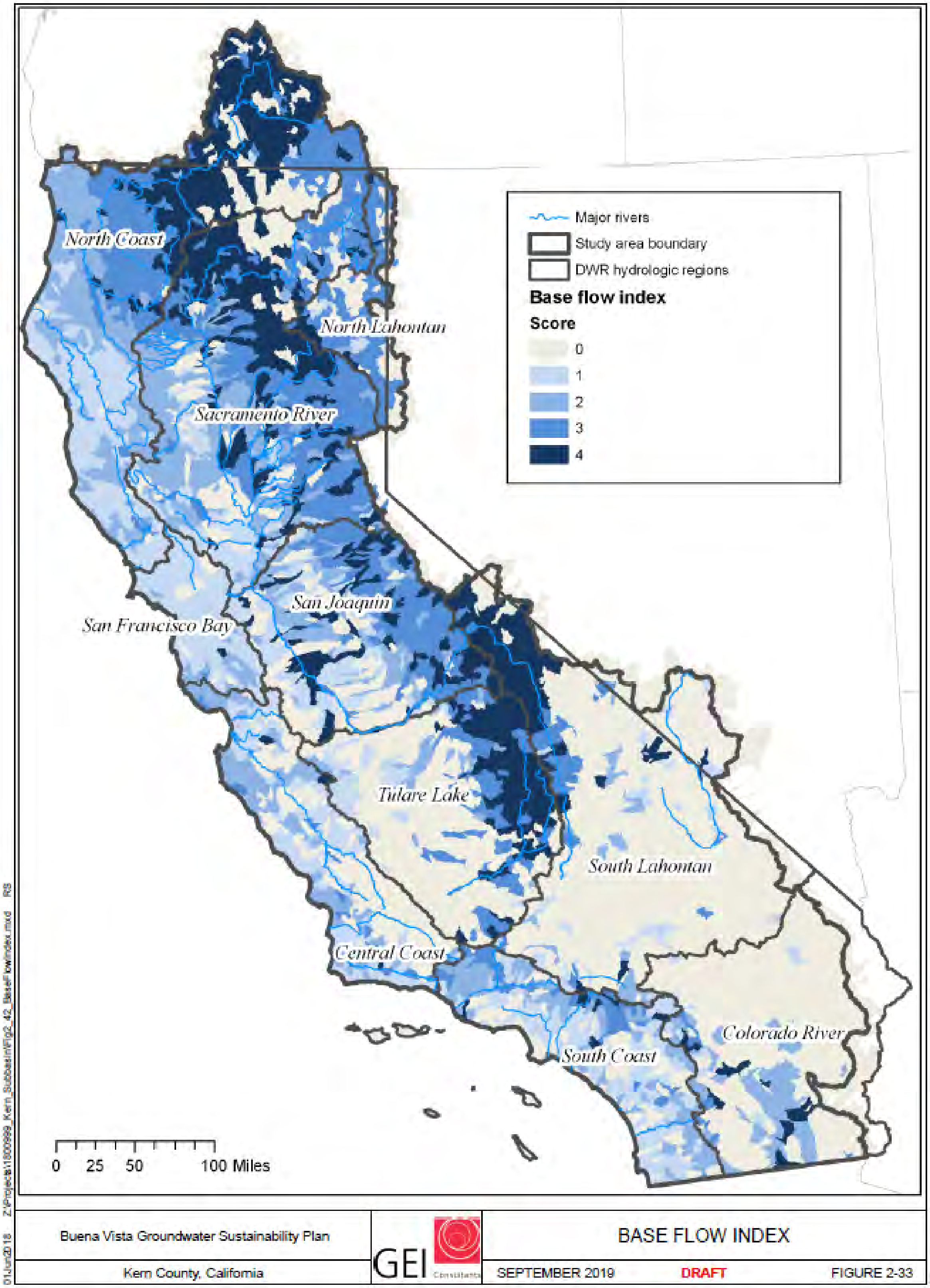

Figure 2-33. Base Flow Index

2.3.9.1 Define and Identify GDEs

The variables referenced in Mapping Groundwater Dependent Ecosystems in California were used to map overall ecosystem dependence on groundwater by combining rankings of the three variables (springs, wetlands, and streams). The results of this mapping of overall groundwater dependence of ecosystems in the Kern County Subbasin are displayed on Figure 2-34 – Groundwater Dependence. As evident in the earlier figures, there is a high level of groundwater dependence in the mountains and foothills on the east side of the Subbasin. However, except for riparian lands adjacent to the Kern River, mapped as having a medium ranking, all lands on the valley floor, including the BVGSA, are mapped as having either no groundwater dependence or very low groundwater dependence. Figure 2-35 – Groundwater Dependent Wetlands and Vegetation Alliances Scored by Groundwater Basin, displays how the Kern County Subbasin was scored in *Mapping Groundwater Dependent Ecosystems in California* relative to other California subbasins with respect to the prevalence of groundwater dependent wetlands and vegetation alliances (Figure 2-35 – Refer to Figures Tab).

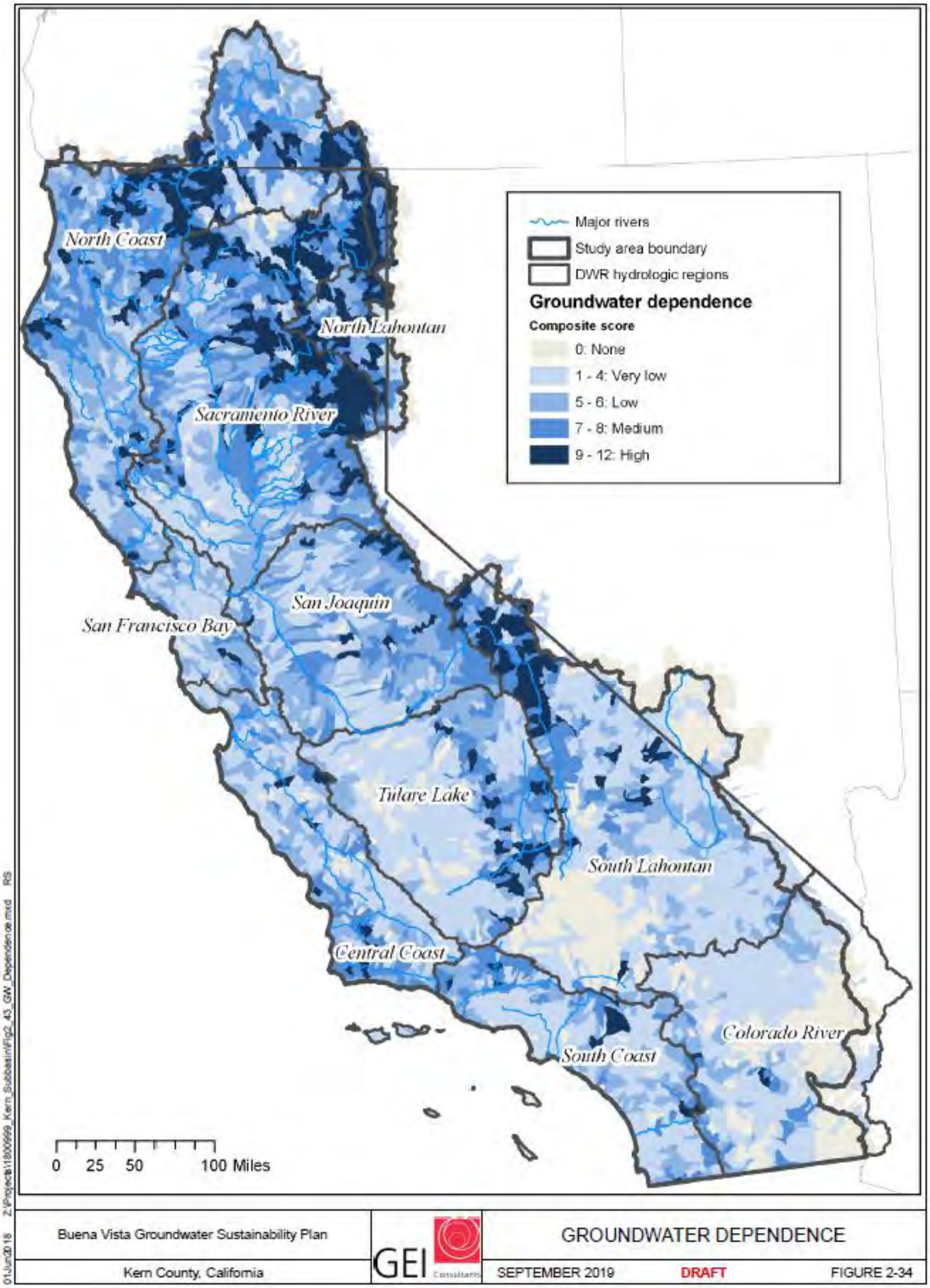

Figure 2-34. Groundwater Dependence

Mapping Groundwater Dependent Ecosystems in California predates the passage of the SGMA and uses a methodology that relies heavily on hydrologic data to indicate areas where hydrologic conditions may be suitable to support GDEs. The Nature Conservancy has recently developed the guidance document Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act (TNC, January 2018) which refines their earlier approach by incorporating detailed vegetation datasets not available in 2010.

Recognizing that detailed understanding of groundwater levels, hydrology and geology are not available at a statewide scale, TNC's new methodology emphasizes use of vegetation and wetland datasets to identify potential GDEs, with determination of which potential GDEs are truly groundwater dependent being based on local knowledge of geologic and hydrologic conditions. In the Central Valley, the new methodology relies heavily on high-resolution mapping by the California Department of Fish and Wildlife (DFW) as part of their Vegetation Classification and Mapping Program (VegCAMP) *www.wildlife.ca.gov/Data/VegCAMP*. This mapping and other data are used to flag potential GDEs by identifying wetlands and vegetation alliances that are commonly supported by groundwater. Maps based on these datasets were released in May 2018.

2.3.9.2 Mapping of Potential GDEs

Figure 2-36 – Potential Groundwater Dependent Ecosystems: Wetlands and Figure 2-37 - Potential Groundwater Dependent Ecosystems: Vegetation are extracted from The Nature Conservancy's May 2018 mapping for the BVGSA. As shown in the hydrographs presented in Figures 2.26a through 2.26m, water levels in areas mapped by the TNC as being potentially groundwater dependent are unlikely to be supported by groundwater. Therefore, the potential GDEs shown in Figures 2-36 and 2-37 are likely to overstate the prevalence of actual GDEs (Figures 2-36 and 2-37 – Refer to Figures Tab).

The preceding observations drawn from the TNC's 2018 mapping is supported by mapping produced using the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset developed by the California Department of Water Resources (DWR), The Nature Conservancy (TNC), and the California Department of Fish and Wildlife (CDFW).

The NCCAG dataset is based on 48 layers of publicly available data developed by state or federal agencies that map vegetation, wetlands, springs, and seeps in California (DWR, 2019). A technical working group with representatives from DWR, CDFW, and TNC reviewed the datasets compiled to assemble the NCCAG. The NCCAG dataset attempts to extract mapped vegetation and wetland features that have indicators suggesting dependence on groundwater. The data presented in NCCAG display vegetation polygons that have indicators of GDEs based on published and/or field observations of phreatophytic vegetation defined as a "deep-rooted plant that obtains water that it needs from the phreatic zone (zone of saturation) or the capillary fringe above the phreatic zone" (TNC, 2018b). The dominance of phreatophytic plant species in a mapped vegetation type is a primary indicator of GDEs.

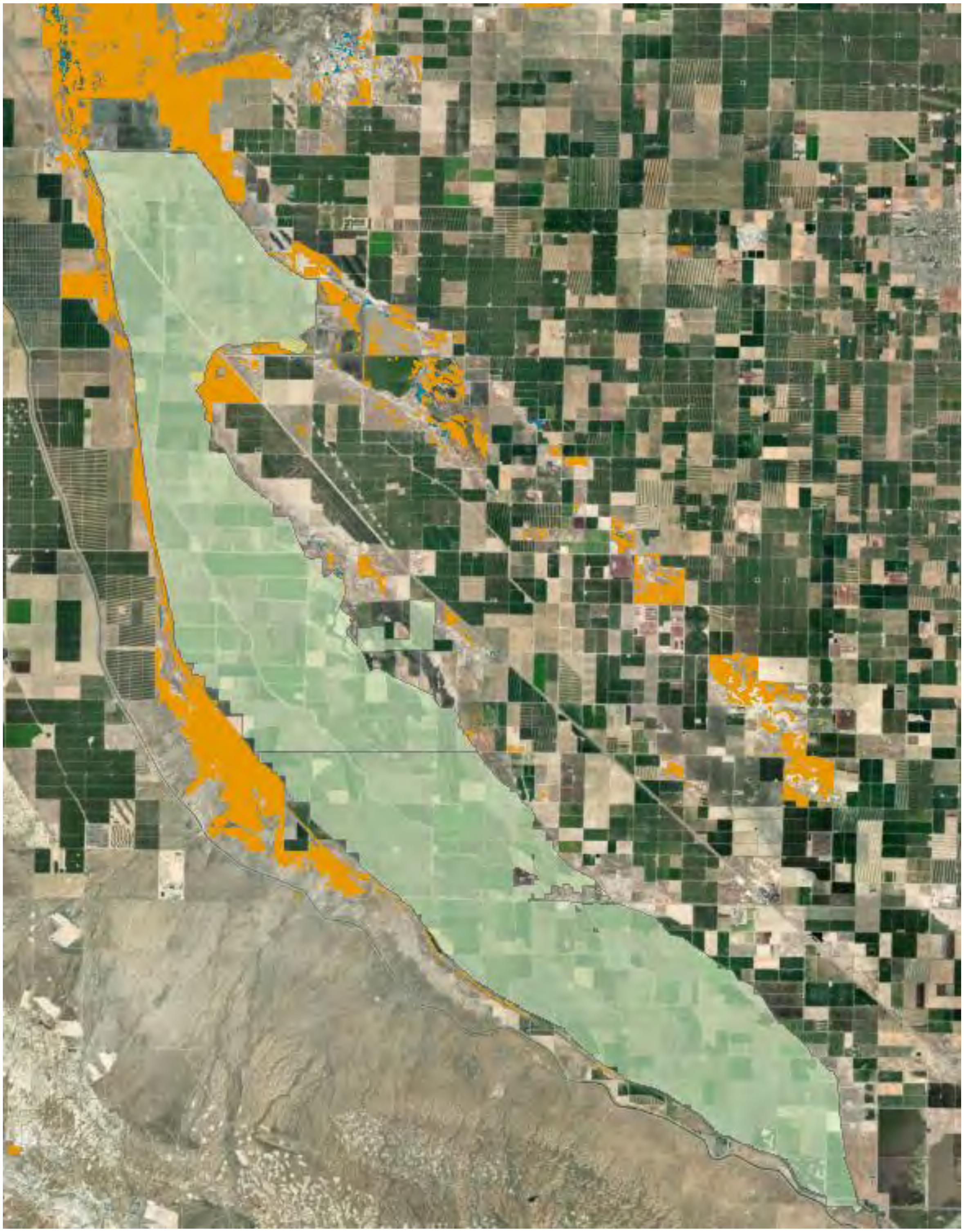

Figure 2-38. NCCAG Mapping of the Buttonwillow Management Area and Vicinity

A list of plant species considered to be phreatophytes based on peer-reviewed scientific literature on rooting depths, published lists of phreatophytes, expert field observations, and vegetation alliance descriptions is publicly available (Klausmeyer et al., 2018; TNC, 2018a).

While developing the NCCAG dataset of areas with indicators of GDEs, the technical working group attempted to exclude vegetation and wetland types and polygons that are less likely to be associated with groundwater (Klausmeyer et al. 2018). The working group attempted to remove any polygons that are not likely to be GDEs where they occurred in areas where they are likely to be supported by alternate artificial water sources (e.g. local seepage from agricultural irrigation canals), or where appropriate available data indicated the shallow groundwater depth is located well below the rooting zone (Klausmeyer et al., 2018).

Figure 2-38 – NCCAG Mapping of the Buttonwillow Management Area and Vicinity - shows the NCCAG data layer (orange and blue) in relation to the Buttonwillow Management Area (BMA) boundary (green). As is the case with older mapping presented in this section, the NCCAG mapping shows little overlap of the shapes, meaning that few potential GDEs or wetlands are mapped as lying within the BMA. The area mapped in Figure 2-40 along the western fringe of the BMA coincides with the location of the Kern River Flood Channel Canal. In addition, there are other areas mapped as GDEs that lie immediately to the east of the BMA.

2.3.9.3 Recommended Actions

The vegetation data presented in the NCCAG dataset is a latest available starting point for the identification of GDEs as the dataset includes the best available public datasets and has been screened to include only areas that have indicators of groundwater dependent vegetation. DWR has stated in the "Summary of the "Natural Communities Commonly Associated with Groundwater" Dataset and Online Web Viewer" (DWR, 2018) that use of the NCCAG dataset is not mandatory and does not represent DWR's determination of a GDE. Rather, NCCAG can provide a starting point for the identification of GDEs within a groundwater basin.

Additional information, such as near surface groundwater depth obtained from piezometers, information about subsurface stratigraphy and geology on confining layers, and information on local land use and hydrology can be used to confirm whether vegetation in areas identified by the NCCAG as potential GDEs is, in fact, reliant on groundwater.

2.3.10 Management Areas

The BVWSD has two distinct service areas separated by 15 miles. The Buttonwillow Service Area (BSA) occupies 91% of the District (46,200 acres; 43,710 receiving service), while the Maples Service Area (MSA) occupies the remaining 9% (4,360 acres; 2,933 receiving service)[4]. Because the locations of these service areas are not contiguous, their boundaries have been used to define the Buttonwillow Management Area (BMA) and the Maples Management Area (MMA).

[4] 2016 Engineer's Assessment Report, in Support of Proposition 218 Assessment Ballot Proceeding, Buena Vista Water Storage District,

This GSP emphasizes management of the BMA, which, as described throughout this document, is a distinct entity within the Kern County Subbasin with respect to its hydrogeologic features and management practices. For this reason, the BMA will be treated as a single unit to be managed using a uniform set of management objectives and criteria.

Because of the MMA's location within the KRGSA, Sustainable Management Criteria for this MA will align with those established for other areas of the KRGSA.

3. Sustainability Goal and Undesirable Results

3.1 Introduction and Definitions

Under SGMA, sustainable management of groundwater through attainment of a locally-defined sustainability goal is assessed though monitoring of six sustainability indicators presented in the SGMA legislation. Undesirable results occur when conditions related to any of the sustainability indicators become significant and unreasonable on a scale that jeopardizes sustainable groundwater management basin-wide. Therefore, determining whether a groundwater basin is being managed sustainably relies on monitoring of sustainability indicators at locations throughout the basin.

This section provides a narrative description of the sustainability goal and of undesirable results as they pertain to the BVGSA and describes some of the practices that have been applied to manage surface and groundwater supplies. Section 5 – Minimum Thresholds, Measurable Objectives and Interim Milestones describes the methodologies used to quantify minimum thresholds, and measurable objectives, the metrics used to monitor attainment of the sustainability goal and avoidance of undesirable results, as well as laying out interim milestones, the checkpoints established to measure progress.

3.2 Sustainability Indicators

The six sustainability indicators are guideposts used to warn of groundwater conditions occurring throughout a subbasin that, when significant and unreasonable, lead to undesirable results, as described in Water Code Section 10721 (x). The indicators are:

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued;
2. Significant and unreasonable reduction of groundwater storage;
3. Significant and unreasonable seawater intrusion;
4. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies;
5. Significant and unreasonable land subsidence that substantially interferes with surface land uses, and
6. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

In the BVGSA, undesirable results are likely to be associated with four of these sustainability indicators. Significant and unreasonable seawater intrusion is not relevant given the GSA's inland location in Kern County, and, as discussed in Section 2- Basin Setting, the potential for depletions of interconnected surface waters is small given the following factors:

- The absence of streams flowing into or through the BVGSA (see Section 2 – Basin Setting, Figure 2-20), and
- The depths of principal aquifers which make it unlikely that groundwater pumping has the potential to deplete surface water (see Section 2 – Basin Setting, Figures 2-5).

SGMA encourages local control of groundwater management. To this purpose, the four sustainability indicators of interest within the BVGSA have been defined to fit the conditions of the Kern County Subbasin using language agreed upon by each of the GSAs within the Subbasin, as follows:

- Chronic lowering of groundwater levels: The point at which significant and unreasonable impacts over the planning and implementation horizon, as determined by depth to water, affect the reasonable and beneficial use of, and access to, groundwater by overlying users.

  Declining groundwater levels during a prolonged drought are not alone sufficient to confirm a chronic lowering of groundwater levels. Extractions and groundwater recharge can be managed to ensure that reductions in groundwater levels or storage during a drought are offset by increases in groundwater levels during other periods.

- Significant and unreasonable reduction of groundwater storage: The point at which significant and unreasonable impacts, as determined by the amount of groundwater in the basin, affect the reasonable and beneficial use of, and access to, groundwater of overlying users over an extended drought period.
- Significant and unreasonable degraded water quality: The point at which significant and unreasonable impacts over the planning and implementation horizon, as caused by water management actions, affect the reasonable and beneficial use of, and access to, groundwater by overlying users.
- Significant and unreasonable subsidence: The point at which significant and unreasonable impacts, as determined by a subsidence rate in the Subbasin, that affect the surface land users or critical infrastructure.

The process for setting quantitative minimum thresholds for each of the above sustainability indicators is described in Section 5 – Minimum Thresholds, Measurable Objectives, and Interim Milestones.

3.3 Sustainability Goals

The central sustainability goal in the Kern County Subbasin is to maintain groundwater elevations in principal aquifers within a range that avoids the occurrence of undesirable results and that allows groundwater to remain a reliable source of water supply, particularly during prolonged droughts. Attainment of this goal in the BVGSA requires the establishment of measurable objectives at a level that will enable the GSA to operate during a prolonged drought before groundwater levels reach a minimum threshold.

Although groundwater overdraft has been observed to be less extreme in the Buena Vista GSA than in other parts of the Kern Subbasin, the ongoing transition from annual crops to orchards and vineyards is expected to both increase and harden demand within the GSA, amplifying the importance of effective management of both surface water and groundwater. The scale of investment, long life span, and increased demand associated with permanent crops coupled with concerns over the long-term reliability of both local and imported sources of surface water highlight the significance of sustainable groundwater management.

Thus, success in sustaining groundwater elevations within an operating range bounded by measurable objectives and minimum thresholds and observed through the GSAs monitoring network is of primary importance to meet the GSA's commitment to groundwater users to protect their ability to access the resource.

Improvement of water quality is a second aspect of the sustainability goal. As protection of beneficial uses of groundwater is the primary objective of the Central Valley Regional Water Quality Control Board's (CVRWQCB) Irrigated Lands Regulatory Program (ILRP), due to the high proportion of water and land use devoted to irrigated agriculture, the water quality aspects of the GSA's sustainability goal will be achieved through close coordination with implementation of the ILRP. Later, as the State Water Resource Control Board (SWRCB) and the CVRWQCB begin implementing the Central Valley Salinity Alternatives for Long-term Sustainability (CV-SALTS), attainment of the water quality aspect of the BVGSA's sustainability goal will also be closely coordinated with the CV-Salts program.

Protection against subsidence is a third aspect of BVGSA's sustainability goal. The primary cause of subsidence in this region is overdraft of groundwater. Groundwater withdrawals are considered to cause unreasonable and significant subsidence if subsidence affects critical infrastructure or "substantially interferes with surface land uses"[5]. In addition to threatening the stability of infrastructure such as highways and changing the gradient in water conveyance facilities, subsidence has the potential to directly impact groundwater users in the Buena Vista GSA as it reduces groundwater storage capacity by compacting material within the aquifer. In addition to groundwater withdrawal, oil and gas production and tectonic forces may contribute to subsidence in or near the BVGSA.

[5] CCR Title 23 Waters 354.28(c)(5)[5]

3.4 Undesirable Results within the BVGSA

3.4.1 Chronic Lowering of Groundwater Levels

The most significant undesirable result for the BVGSA is chronic lowering of groundwater levels, a condition that would increase the cost of pumping for all users and could lead to groundwater elevations falling below the levels of well-screens, a particular concern of domestic well owners because domestic wells are typically shallower than ag wells and the capacity to pay for deepening domestic wells is limited.

BVWSD has been monitoring groundwater levels since 1991 in both the perched aquifer and the principal production aquifer. The principal aquifer, although comprised of shallow and deep zones, has groundwater extracted primarily from the deep zone. For this reason, no existing monitoring wells are screened to observe only the shallow zone, however due to the connection between the shallow and deep zones, the shallow zone is assumed to behave similarly to the deep zone. The perched aquifer – prominent in the northern half of the GSA – is monitored with a network of 58 piezometers.

Historically, groundwater elevations within the BVGSA range from about 230 feet above mean sea level (AMSL) in the north, to -10 feet AMSL in the south[6]. This gradient suggests that groundwater flows from north to south. Furthermore, over the past 20 years, groundwater elevations in the north have remained stable, while elevations in the south have gradually declined as shown in Appendix B – Groundwater Hydrographs. Groundwater elevations in the GSA fluctuate in response to the hydrologic conditions that govern deliveries of surface water from the Kern River and the California Aqueduct and that influence patterns of demand. The fluctuations are moderated by the conjunctive management practices of the BVWSD.

The existing monitoring network that will be relied on initially for monitoring measurable objectives and detecting breaches of minimum thresholds is described in greater detail in Section 2 - Basin Setting and in Section 5 - Minimum Thresholds, Measurable Objectives, and Interim Milestones. The program for filling data gaps and developing a comprehensive network for monitoring measurable objectives and detecting undesirable results is described in Section 4 - Monitoring Network.

Historically, groundwater elevations within the BVGSA range from about 230 feet above mean sea level (AMSL) in the north, to -10 feet AMSL in the south[7]. This gradient suggests that groundwater flows from north to south. Furthermore, over the past 20 years, groundwater elevations in the north have remained stable, while elevations in the south have gradually declined as shown in Appendix B – Groundwater Hydrographs. Groundwater elevations in the GSA fluctuate in response to the hydrologic conditions that govern deliveries of surface water

[6] https://www.bvh2o.com/EngineersReport.pdf (p. 10)
[7] https://www.bvh2o.com/EngineersReport.pdf (p. 10)

from the Kern River and the California Aqueduct and that influence patterns of demand. The fluctuations are moderated by the conjunctive management practices of the BVWSD.

3.4.2 Reduction in Groundwater Storage

As well as maintaining pumping depths within an acceptable range, the minimum thresholds for groundwater elevations described in Section 5 - Minimum Thresholds, Measurable Objectives, and Interim Milestones are also intended to minimize the undesirable result of groundwater storage reduction. This loss of storage would constrain the amount of groundwater usable for industrial, municipal, domestic, and agricultural purposes, ultimately affecting all users in the BVGSA and in the Subbasin.

As with chronic lowering of groundwater elevations, the undesirable result of unreasonable and significant reduction of groundwater storage would occur during extended periods of groundwater production in excess of the sustainable yield. Changes in the volume of groundwater in storage will be monitored by tracking groundwater elevation.

3.4.3 Degraded Water Quality

Degradation of groundwater quality will lead to an undesirable result should the BVGSA fail to maintain concentrations of groundwater constituents at levels acceptable for designated beneficial uses. The minimum thresholds for these constituents are presented in Section 5 - Minimum Thresholds, Measurable Objectives, and Interim Milestones.

Groundwater quality will continue to be observed using existing monitoring wells. As described in Section 4 – Monitoring Networks, the water quality monitoring network will also include selected wells monitored through the Groundwater Quality Trend Monitoring Work Plan developed by the Buena Vista Coalition for compliance with the Irrigated Lands Regulatory Program (ILRP).

3.4.4 Subsidence

Land subsidence due to groundwater extractions within the BVGSA will lead to an undesirable result if these extractions jeopardize critical infrastructure. Historical subsidence within the BVGSA has been limited and has not been observed to have affected infrastructure. However, because of the potential for pumping within the BVGSA to damage facilities including the California Aqueduct, subsidence will be monitored as described in Section 4 – Monitoring Networks. In addition, the BVGSA discourages groundwater extraction from beneath the E-clay, in part, because of the potential for extraction from this confined zone to induce subsidence.

3.5 Application of Sustainable Management Criteria

Attainment of the sustainability goal and avoidance of undesirable results within the BVGSA will be guided by analysis of data generated from the GSA's monitoring network with the aim of managing groundwater levels, water quality and subsidence within the bounds set by measurable objectives and minimum thresholds established at each of the GSA's monitoring sites. The development of measurable objectives and minimum thresholds is presented in Section 5 - Minimum Thresholds, Measurable Objectives, and Interim Milestones.

Effective management will be particularly important during periods when groundwater production exceeds long-term sustainable yield, a condition that will be observed through monitoring to detect chronic lowering of groundwater levels, an undesirable result also associated with the occurrence of the following undesirable results:

- Significant and unreasonable reduction of groundwater storage;
- Significant and unreasonable degraded water quality, and
- Significant and unreasonable land subsidence.

Based on hydrographs presented in Appendix B – Groundwater Hydrographs, chronic lowering of groundwater levels is expected to be less pronounced in the Buena Vista GSA than in other areas of the Kern County Subbasin. This is attributable to two factors, which are described in detail in Section 2 - Basin Setting:

1. As discussed throughout this GSP, geologic, hydrologic and soils conditions in the BVGSA are distinct because the BVWSD was developed on reclaimed lake bed and swamp lands lying to the west of structural features such as the Buttonwillow and Semitropic ridges. These distinctions, illustrated in Section 2.2 - Hydrogeologic Conceptual Model, result in groundwater elevations that are typically higher than in areas to the east.
2. The BVWSD has rights to divert water from the Kern River and holds a contract with the Kern County Water Agency to receive deliveries from the State Water Project, whose major distribution facility, the California Aqueduct, runs along the western boundary of the BVGSA. Access to water from these sources has enabled the BVWSD to conjunctively manage its surface water entitlements and groundwater use. Conjunctive management has provided the BVWSD with an important tool for achieving its sustainability goal by protecting groundwater underlying the GSA for use during droughts when surface water supplies are limited and by providing the capacity to replenish groundwater storage that has been depleted by prolonged drought.

The BVWSD's surface water resources, aided by its physical setting, have been used to implement projects and management programs that carry out the BVWSD's long-term strategy of conjunctive management and have modified this strategy in response to changes in cropping patterns and irrigation practices. Throughout, conjunctive management has been the backbone of

BVWSD's operations and will serve as the umbrella for projects developed by the BVGSA to support sustainable groundwater management under SGMA. These projects are described in Section 7 – Project, Management Actions, and Adaptive Management Actions.

Currently, the Buena Vista GSA's primary mechanism for groundwater recharge is seepage from its unlined canals. Section 6 – Water Supply Accounting includes a water budget that documents the average rate of seepage from the 144 miles of unlined canal in the GSA as 31,141 acre-feet/year which equates to 0.67 feet of seepage for each acre within the GSA boundaries. The importance of canal seepage is underscored by the fact that in locations where canals are being replaced by pipelines to improve the efficiency of water delivery, rather than being abandoned, some reaches of canal are being retained as dedicated linear recharge facilities for use during wet years when surface water supplies exceed demands.

In addition, as deep percolation of applied irrigation water diminishes through the introduction of high-efficiency, low-volume application techniques such as drip and micro-sprinkler irrigation, the District is developing dedicated recharge and recovery projects such as the Palms Project, so that improvements to the BVWSD's conveyance facilities and in on-farm irrigation practices can proceed without jeopardizing the District's capacity for conjunctive management. The Palms Project, as with other projects described in Section 7 – Projects, Management Actions and Adaptive Management Actions shows how groundwater recharge in the BVWSD is transitioning from incidental seepage from canals toward use of dedicated facilities including canal reaches that have been converted to linear recharge basins and large-scale recharge and recovery projects such as the Palms Project.

The BVWSD is now in the process of implementing projects to expand the District's conjunctive management capabilities and is also offering programs to efficiently manage groundwater production capacity. A typical project is the Northern Area Pipeline, a phased effort to distribute surface water in the northern part of the District through pipelines rather than the original canal network. This project enables growers to better manage water deliveries and reduces groundwater pumping by

- Facilitating distribution of surface water;
- Increasing the efficiency of on-farm irrigation practices, and
- Extending the season during which surface water is typically available.

An example of a capacity management program is the "Landowner Well Use Program" which reimburses participating landowners for utilization of their unused well capacity during dry years. This use of privately-owned wells enables the District to avoid the need to construct new district-owned wells that would create capacity needed only during droughts[8].

[8] https://water.ca.gov/LegacyFiles/wateruseefficiency/sb7/docs/2014/plans/Buena_Vista_WSD.pdf (p. 38)

Furthermore, the 2016 draft of the Groundwater Monitoring Protocol for Buena Vista WSD[9] describes the District's program, now complete, to install magnetic flow meters on all production wells in the District, both district- and privately-owned. The comprehensive ability to measure groundwater pumping at all wells, other than small domestic wells, coupled with the District's on-going program to improve measurement of surface water deliveries, gives the BVGSA access to timely, accurate information on use of surface water and groundwater throughout the GSA.

[9] https://www.bvh2o.com/SGMA/(a)%20Groundwater%20Elevation.pdf (p. 10)

4. Monitoring Networks

4.1 Introduction

As outlined in DWR's GSP regulations and guidance documents, monitoring networks will be established to monitor each relevant sustainability indicator within the BVGSA. Section 2 - Basin Setting describes the monitoring networks that now exist in the BVGSA. This section discusses monitoring network objectives and monitoring rationales and describes the proposed monitoring network for each relevant sustainability indicator. Data gaps and planned actions to address these gaps are presented for each sustainability indicator.

4.2 Monitoring Network Objectives

The objective of the BVGSA Monitoring Networks is to gather spatial and temporal data on parameters including groundwater levels, groundwater quality and land surface elevations sufficient to characterize groundwater conditions as defined by locally-established management objectives and undesirable results as defined in Section 3 – Sustainability Goal and Undesirable Results and Section 5 – Minimum Thresholds, Measurable Objectives and Interim Milestones.

All monitoring network objectives were developed in accordance with the California Department of Water Resource's 23 CCR §354.34, which requires that monitoring networks:

- Demonstrate progress toward achieving measurable objectives described in the Plan;
- Monitor impacts to the beneficial uses or users of groundwater;
- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds, and
- Quantify annual changes in water budget components.

The monitoring networks created in this GSP are intended to monitor four, relevant undesirable results:

- Chronic lowering of groundwater levels;
- Reduction in groundwater storage;
- Degraded groundwater quality, and
- Land subsidence.

The section describes the monitoring networks developed by the BVGSA to monitor groundwater and subsidence. These networks will be used to characterize groundwater levels, quality, flow gradient and direction, and land surface elevations to provide a sound technical foundation for groundwater management. The monitoring networks developed for the GSA are consistent with networks developed by other GSAs within the Kern County Subbasin to form a coherent approach to data collection that will provide uniform, reliable data in a format that can be easily consolidated and analyzed to assess groundwater conditions and subsidence throughout the Subbasin. This data will be used to guide development and implementation of projects and programs needed to support basin-wide sustainability.

4.3 Description of Monitoring Networks

Groundwater within the BVGSA is influenced by groundwater extraction, subsurface flux, and recharge from distribution and application of irrigation water. The BVGSA's groundwater monitoring network is intended to quantify groundwater elevations; flow directions and gradients; and groundwater quality parameters in the principal aquifer system. In addition, all production wells are equipped with magnetic flow meters and totalizers, so groundwater extraction in the GSA is closely monitored.

As well as data compiled from monitoring groundwater elevations and metering well discharges, the BVGSA relies on CIMIS climatologic data, data on surface water deliveries from the California Aqueduct and the Kern River, and subsidence data from the Continuously Operating Reference Stations (CORS) network and Interferometric Synthetic Aperture Radar (InSAR) data distributed by DWR.

4.3.1 Collection of Sufficient Data

A goal of the BVGSA monitoring program is to establish networks of monitoring locations that capture the hydrologic, geologic, and land use differences across the GSA and that can be monitored at a frequency sufficient to detect changes in groundwater conditions throughout the GSA. Thus, the selection of wells included in the groundwater monitoring network is pivotal to the GSA's ability to monitor performance relative to the Sustainable Management Criteria described in Section 5 – Minimum Thresholds, Measurable Objectives and Interim Milestones.

Due to their distribution throughout the GSA, their period of record, and the confidence that can be placed in data collected from dedicated monitoring wells, the backbone of the GSA's initial monitoring network is the existing system of 11 District Monitoring Wells located at 9 sites throughout the Buttonwillow Management Area (BMA) described in Section 2 – Basin Setting. This network will be supplemented by selected wells drawn from network presented in the Buena Vista Coalition's Groundwater Quality Trend Monitoring Work Plan (GQTMWP) developed for compliance with the ILRP and a small number of district production wells and landowner wells. Wells in the GQTMWP network are located in areas where groundwater quality, particularly nitrate contamination, is a potential concern and are monitored following a protocol that includes both groundwater quality sampling and groundwater level measurement.

As discussed later in this section, the network of District Monitoring Wells will be supplemented by wells located in the southern portion of the BMA where extensive pumping occurs within the GSA and in neighboring areas immediately beyond the GSA's boundaries and, also, includes wells targeted to locations of uncertain or unknown groundwater conditions and to locations along the GSA's boundaries.

In addition to providing a representative characterization of conditions in the principal aquifer system, wells selected for the BVGSA's initial monitoring network have a period of record adequate to confirm their reliability as sources of water level and water quality data. The BVGSA has given preference to wells with regular monitoring schedules (limited data gaps) and long periods of record. These attributes facilitate interpretation of data by enabling groundwater conditions observed during the period preceding SGMA implementation to be compared with data collected going forward.

4.3.2 Implementation of Monitoring Networks

Data collected from the monitoring networks will be used to demonstrate progress towards the goals described above of:

- Monitoring impacts to beneficial uses or users of groundwater;
- Documenting changes in groundwater conditions relative to measurable objectives and minimum thresholds, and
- Quantifying annual changes in water budget components.

Achieving Measurable Objectives

For each sustainability indicator, measurable objectives presented in Section 5 – Minimum Thresholds, Measurable Objectives, and Interim Milestones will be assessed at 5-years intervals to confirm how measurable objectives compare with the interim milestones established by the GSA for attaining sustainability. The schedule for 5-year updates is as follows:

- 5-year update (2025);
- 10-year update (2030);
- 15-year update (2035), and
- 20-year update (2040).

Monitor Impacts to Beneficial Uses or Users of Groundwater

As described in Section 2 – Basin Setting, the beneficial users of groundwater within the BVGSA include agricultural pumpers, municipal users (Community of Buttonwillow), and dispersed domestic and industrial pumpers. While a substantial proportion of agricultural demand is supplied by surface water, the Community of Buttonwillow and individual domestic and industrial users subsist on groundwater, with groundwater elevations sustained through recharge of water delivered to the BVWSD from the Kern River and the SWP.

The BVGSA's monitoring network is designed to provide the information necessary to prevent impacts to beneficial uses and users of groundwater by collecting data on aquifer conditions, water quality and subsidence. This information will enable the GSA to associate changes in groundwater elevations with pumping intensity, monitor the risk of dewatering individual wells and make management decisions necessary to mitigate declines in groundwater elevations.

Monitor Changes in Groundwater Quality

As described in Section 2 - Basin Setting, undesirable groundwater quality includes high concentrations of total dissolved solids (TDS), nitrates, and arsenic. TDS has been and will continue to be managed to the tolerance levels of crops, and nitrates and arsenic will continue to be managed to the MCLs as discussed in Section 2.2.4.6 of the Basin Setting.

Water quality monitoring by the BVGSA will be performed in parallel with the monitoring and reporting performed by the Buena Vista Coalition under their GQTMWP. Water quality data collected by the network of monitoring wells will enable the BVGSA to avoid undesirable results by providing the capability to detect isolated contaminant plumes and to observe large-scale trends.

Quantify Annual Changes in Water Budget Components

Data from the monitoring networks will be used to update the GSA water budget described in Section 6 – Water Supply Accounting with the following components of the budget being measured directly by the GSA:

- Precipitation: source - spatial CIMIS;
- Evapotranspiration: source - ITRC METRIC;
- Surface inflows: sources – measured California Aqueduct deliveries, Kern River deliveries, and exchanges and transfers;
- Surface outflows: sources – measured exchanges and transfers, and outflows in the Main Drain Canal;
- Groundwater extraction: sources - flow totalizer data from all production wells within the GSA, and
- Change in groundwater storage: sources – observed changes in groundwater elevations and estimates of specific yield associated with the aquifer zones where changes in elevations are observed.

Groundwater elevation data collected by the GSA monitoring networks will be used, in tandem with data presented in the Section 2.2 – Hydrogeologic Conceptual Model and from numerical groundwater models, to monitor changes in storage in the principal aquifer system. Two schematic diagrams of the BVGSA water budget are shown in Figure 4-1 and Figure 4-2 and development of the water budget is described in detail in Section 6 - Water Supply Accounting. Figure 4-1 shows the Buena Vista GSA water budget (both surface water and groundwater systems) and Figure 4.2 shows the Buena Vista GSA groundwater budget (only groundwater system).

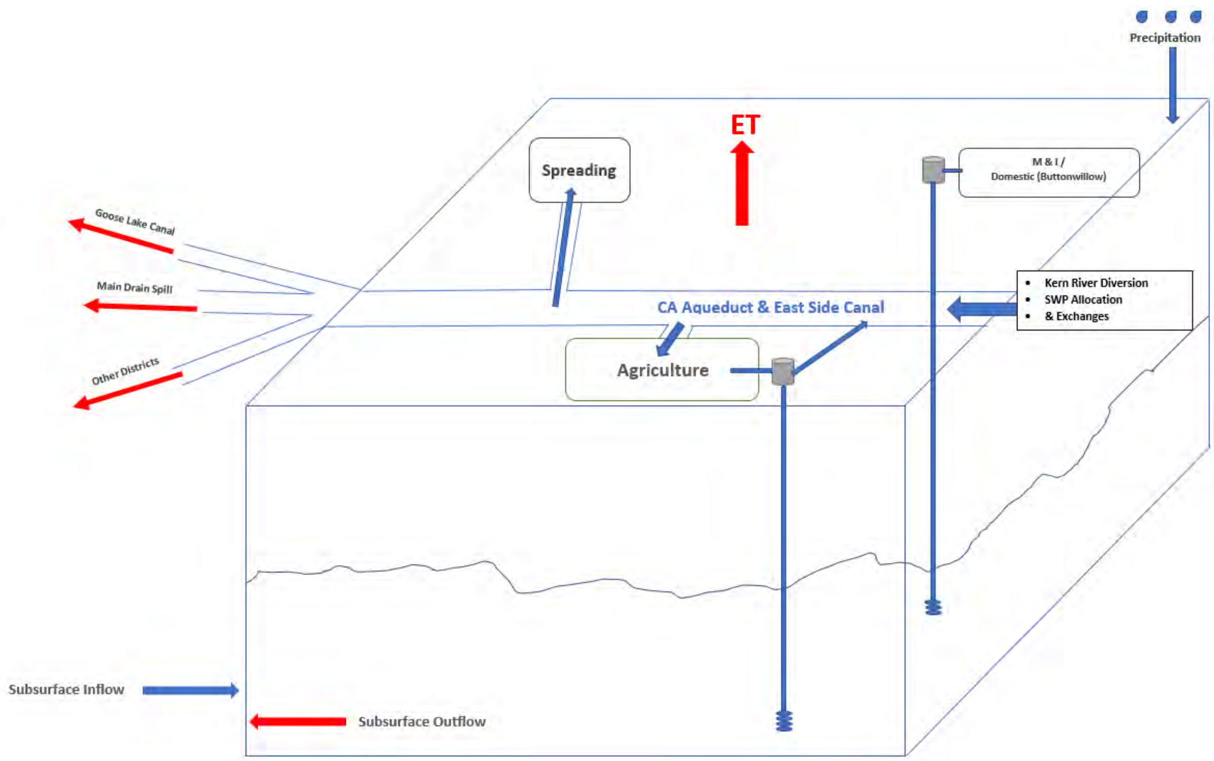

Figure 4-1. Buena Vista GSA Water Budget Diagram

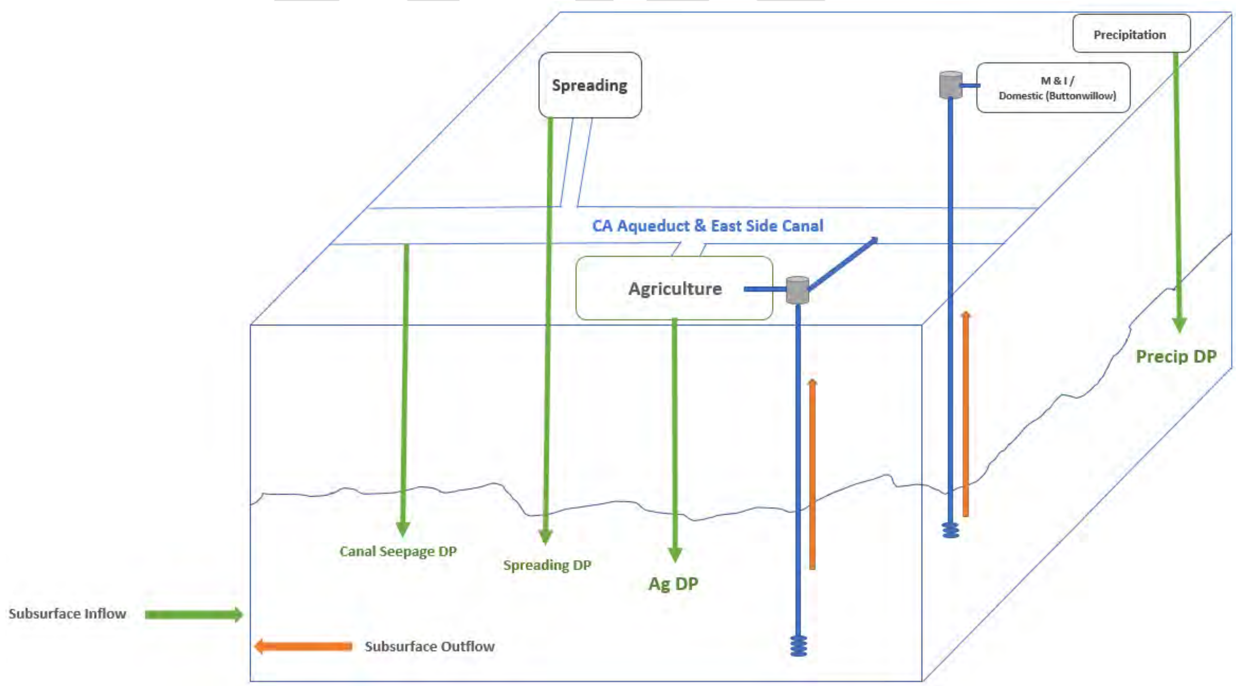

Figure 4-2. Buena Vista GSA Groundwater Budget Diagram

4.3.3 Monitoring Rationale and Site Selection

This section explains the rationale underlying the selection of wells included in the BVGSA monitoring networks and discusses the criteria considered for site selection.

The purpose of the monitoring networks is to observe each of the four sustainability indicators important to management of the BVGSA. To this end, the monitoring networks are designed to provide comprehensive coverage of the principal aquifer system underlying the GSA, with monitoring sites selected to observe specific sustainability indicators. Wells included in the networks emphasize observation of groundwater elevations to monitor changes in groundwater levels and as a proxy for assessing changes in groundwater storage with monitoring of groundwater quality being the other function of these wells.

The existing BVWSD monitoring program includes approximately 45 active shallow piezometers installed to monitor perched water conditions that affect irrigation operations in the District's northern area. While a selection of these piezometers is included in the Buena Vista Coalition's GQTMWP to monitor groundwater quality in first-encountered groundwater, only three piezometers are included in the monitoring networks established for SGMA as data on the perched aquifer is not directly relevant to sustainable management of the principal aquifer system. An exception to this approach is three piezometers that will serve as sentinels to detect the influence on water quality of shallow groundwater entering the GSA from the west.

The monitoring networks created for the Buena Vista GSP are designed to detect changes in groundwater conditions prior to the onset of undesirable results. With knowledge of changing conditions, the BVGSA can be managed to ensure that interim milestones and measurable objectives are achieved and that overall groundwater sustainability goals are met prior to 2040. If monitoring data shows the potential for undesirable results, the BVGSA can introduce projects or management actions that mitigate these issues.

Further explanation of the development and implementation of the network is presented below for each of the four relevant sustainability indicators. Each section includes the following sub-sections:

- Representative Monitoring;
- Monitoring Frequency;
- Spatial Density;
- Map of Monitoring Site Locations;
- Monitoring Protocols;
- Data Gaps, and
- Plan to Fill Data Gaps.

In general, selection of sites for monitoring wells follows criteria aimed at achieving adequate spatial distribution across the GSA, targeted monitoring in areas of uncertain conditions or intensive groundwater extraction, and adherence to SGMA regulations and BMPs.

Each of the following sub-sections addresses monitoring for an individual sustainability indicator and applies the criteria listed above to identify the locations best suited to monitoring that indicator. The budget and schedule associated with the creation and implementation of the monitoring networks are discussed in Section 7 - Projects and Management Actions.

4.3.4 Data Sources and Existing Monitoring

Section 2 – Basin Setting provides an overview of existing monitoring programs within the BVGSA and of wells that, although not currently used for monitoring, could be added to the existing monitoring network to provide supplemental data and fill data gaps.

4.4 Monitoring Networks for Sustainability Indicators

This section of the GSP provides a detailed explanation of the monitoring networks created to support sustainable groundwater management in the BVGSA. Descriptions are provided for monitoring each of the four relevant sustainability indicators, and data gaps are identified that will be addressed to complete the monitoring program.

4.4.1 Groundwater Level Monitoring

> ***§354.34(c)****: Each monitoring network shall be designed to accomplish the following for each sustainability indicator: (1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods: (A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer. (B) Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.*

4.4.1.1 Representative Monitoring

The network for monitoring groundwater levels will rest on the existing network of BVWSD monitoring wells, which are now used for CASGEM reporting. Currently there are 9 BVWSD monitoring well sites reported to CASGEM, with nested wells at two of the sites. All sites provide water level data for the principal aquifer system along the primary north-south axis of the BMA, and all are dedicated monitoring wells, so data collected at these locations is not influenced by pumping at the sites.

The monitoring network will be supplemented by inclusion of 3 BVWSD production wells all of which lie along the eastern boundary of the GSA and are now monitored under the Buena Vista

Coalition's GQTMWP. Lastly, 1 landowner well located in the southeastern portion of GSA is included in the monitoring network. While 3 monitoring wells are located in the north of the BMA, the monitoring network in this area includes no production wells because of the limited groundwater extraction from the area.

As noted in Section 2 – Basin Setting, a shallow perched water table is present in the northern portion of the BMA. Due to the presence of the perched aquifer, this area is managed so that perched groundwater does not intrude into the root zone of overlying crops, and the BVWSD uses a network of piezometers to aid in management of the affected area. Selected piezometers from the BVWSD's network are included in the monitoring network operated for the GQTMWP. However, the primary purpose of these piezometers is to manage a localized groundwater quality and agronomic problem that is not central to sustainable groundwater management in the BVGSA or the Kern County Subbasin. Therefore, while data from these piezometers is available to the BVGSA, the piezometers are not included in the GSA's monitoring network with the exception of the 3 intended to observe the quality of groundwater inflow from the west.

Table 4-1. BVGSA Groundwater Level Monitoring Well Locations

Well Name	Well Type	Latitude	Longitude
DMW01	District Monitoring	35.60135	-119.61765
DMW02	District Monitoring	35.57162	-119.58081
DMW04	District Monitoring	35.51369	-119.59844
DMW05	District Monitoring	35.48532	-119.56483
DMW06	District Monitoring	35.45265	-119.53460
DMW07	District Monitoring	35.40209	-119.50110
DMW08	District Monitoring	35.39058	-119.44817
DMW10a	District Monitoring	35.35362	-119.43412
DMW10b	District Monitoring	35.35362	-119.43412
DMW12a	District Monitoring	35.31847	-119.37473
DMW12b	District Monitoring	35.31847	-119.37473
DW03	District Production	35.38104	-119.41521
DW05	District Production	35.38929	-119.43253
DW06	District Production	35.39731	-119.44775
D15	Landowner	35.34627	-119.37374

4.4.1.2 Management Areas and Hydrologic Zones

The BVWSD has two distinct service areas separated by 15 miles, the Buttonwillow Service Area (BSA) and the Maples Service Area (MSA). Because the locations of these service areas are not contiguous, their boundaries have been used to define the Buttonwillow Management Area (BMA) and the Maples Management Area (MMA). This GSP emphasizes management of the BMA which will be administered using a uniform set of management objectives and minimum thresholds.

For the Maples Management Area (MMA), the initial monitoring plan relies on the two landowner irrigation wells, M01 and M02, now reported to CASGEM. As with other aspects of management of the MMA, improvements to the initial monitoring plan will be developed in coordination with the Kern River GSA, and monitoring data collected by this MA will be used to support the monitoring network established by the KRGSA.

To guide neighboring GSAs in establishing similar minimum thresholds and measurable objectives, GSAs in the Kern County Subbasin have created Hydrogeologic Zones as described in Section 5 – Minimum Thresholds, Measurable Objectives and Interim Milestones. The boundaries of these zones were informed by groundwater elevations and then further adjusted to group areas with similar groundwater quality and historic rates of land subsidence. Figure 4.3, displays Hydrogeologic Zones in the Subbasin and shows the close correspondence between the boundaries of the BMA and those of Hydrogeologic Zone 6 (HZ 6) while the MMA lies entirely within HZ 10 (Figure 4-3 - Refer to Figures Tab)

4.4.1.3 Monitoring Frequency

BVWSD will measure water levels at all wells in its monitoring network on a semi-annual basis – Spring and Fall. All wells will be measured within one week of one another following a schedule that will be developed by the BVGSA in coordination with other GSAs in the Kern County Subbasin. Groundwater pumping typically peaks during the summer growing season and slows in the winter. Therefore, spring levels represent an annual high prior to summer irrigation demands while fall levels represent an annual low.

Groundwater elevation data will be used to observe annual changes and for analysis of long-term trends. Analysis of groundwater level trends together with data on surface water deliveries and metered groundwater extractions available from all production wells will be important tools for tracking the GSA's progress in meeting its measurable objectives and in determining the appropriate management actions to support sustainable groundwater management.

4.4.1.4 Spatial Density

A total of 13 monitoring sites is included in the network for monitoring groundwater levels. This total consists of 9 district monitoring wells, 3 district production wells and 1 landowner well. These 13 wells are distributed over the 72 square-mile area of the BMA resulting in a monitoring network with a spatial density of one site per 5.5 square miles.

4.4.1.5 Map of Network for Groundwater Level Monitoring

Figure 4.4a is a map of the network for monitoring groundwater levels in the BMA. Figure 4.4b displays the wells in this network that have been selected for monitoring minimum thresholds and measurable objectives.

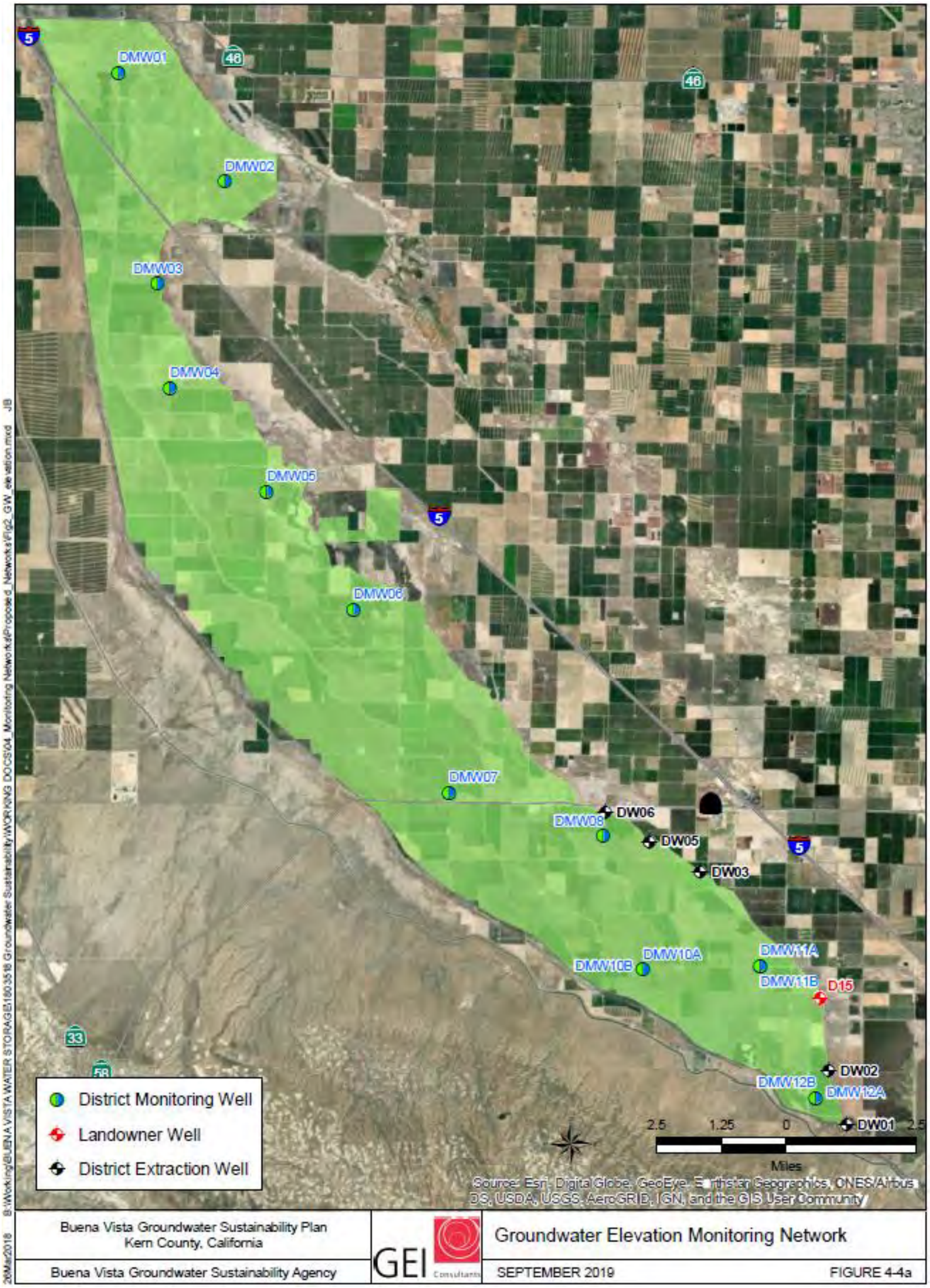

Figure 4-4a. Map of Network for Groundwater Level Monitoring

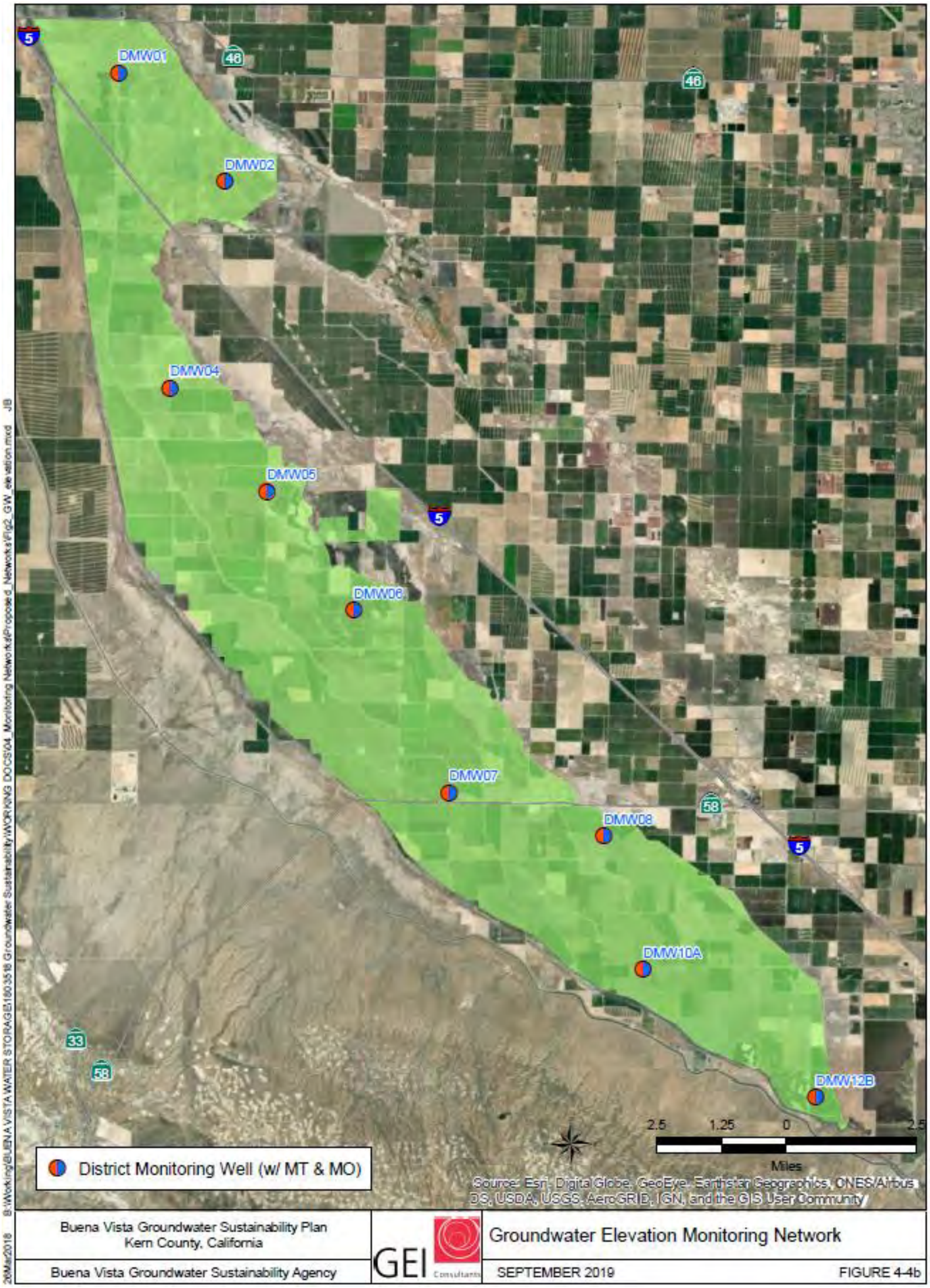

Figure 4-4b. Representative Wells for Minimum Thresholds and Measurable Objectives

4.4.1.6 Monitoring Protocols

Monitoring protocols used in the BVGSA will be consistent with those established throughout the Kern County Subbasin. Appendix C presents a draft protocol for the BVGSA.

4.4.1.7 Data Gaps

The initial plan for monitoring groundwater elevations includes 9 district monitoring wells, 3 district production wells and 1 landowner well. The BVGSA will evaluate the quality of data obtained from these wells and may identify data gaps based on data quality. The GSA has also identified a need to strengthen its monitoring program in the southern portion of the BMA as the Palms Project is developed.

4.4.1.8 Plans to Fill Data Gaps

The BVGSA will implement a program to install new monitoring wells in instances where data obtained from district and landowner production wells is of questionable quality. In addition, monitoring wells installed during development of the Palms Project will be incorporated into the monitoring network to increase coverage in the southern portion of the BMA.

4.4.2 Groundwater Storage Monitoring

> ***23 CCR §354.34(c)(2)****: Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.*

4.4.2.1 Representative Monitoring

The BMP for Groundwater Monitoring (DWR, 2017) notes:

> *While change in groundwater storage is not directly measurable, change in storage can be estimated based on measured changes in groundwater levels… and a clear understanding of the Hydrogeologic Conceptual Model…. The HCM describes discrete aquifer units and the specific yield values associated with these units. This data, together with information on aquifer thickness and connectivity, can be used to calculate changes in the volume of groundwater storage associated with observed changes in groundwater elevation.*

As suggested in the preceding passage from DWR's BMP on Groundwater Monitoring, measured changes in groundwater levels can serve as a proxy for changes in storage. For this reason, the network for monitoring changes in groundwater storage is the same network as that proposed for monitoring changes in groundwater levels. Table 4-2 presents the latitude and longitude of each of the 9 district monitoring wells, 3 district production wells, and 1 landowner well included in the GSA groundwater storage monitoring network.

Table 4-2. Groundwater Storage Monitoring Well Locations

Well Name	Well Type	Latitude	Longitude
DMW01	District Monitoring	35.60135	-119.61765
DMW02	District Monitoring	35.57162	-119.58081
DMW04	District Monitoring	35.51369	-119.59844
DMW05	District Monitoring	35.48532	-119.56483
DMW06	District Monitoring	35.45265	-119.53460
DMW07	District Monitoring	35.40209	-119.50110
DMW08	District Monitoring	35.39058	-119.44817
DMW10a	District Monitoring	35.35362	-119.43412
DMW10b	District Monitoring	35.35362	-119.43412
DMW12a	District Monitoring	35.31847	-119.37473
DMW12b	District Monitoring	35.31847	-119.37473
DW03	District Production	35.38104	-119.41521
DW05	District Production	35.38929	-119.43253
DW06	District Production	35.39731	-119.44775
D15	Landowner	35.34627	-119.37374

4.4.2.2 Management Areas

Data collected from the groundwater level monitoring network will be used to estimate changes in groundwater storage. Therefore, the management areas described above for groundwater level monitoring will apply to monitoring changes in groundwater storage.

4.4.2.3 Monitoring Frequency

Data collected from the groundwater level monitoring network will be used to estimate changes in groundwater storage. Therefore, the monitoring frequency used for groundwater level monitoring will apply to monitoring changes in groundwater storage.

4.4.2.4 Spatial Density

Data collected from the groundwater level monitoring network will be used to estimate changes in groundwater storage. Therefore, the spatial density of the groundwater level monitoring network will also apply to the network used to monitor changes in groundwater storage.

4.4.2.5 Map of Network for Groundwater Storage Monitoring

Figure 4.5a is a map of the network for monitoring changes in groundwater storage in the BMA. Figure 4.5b displays wells that have been selected for monitoring minimum thresholds and measurable objectives with respect to groundwater storage.

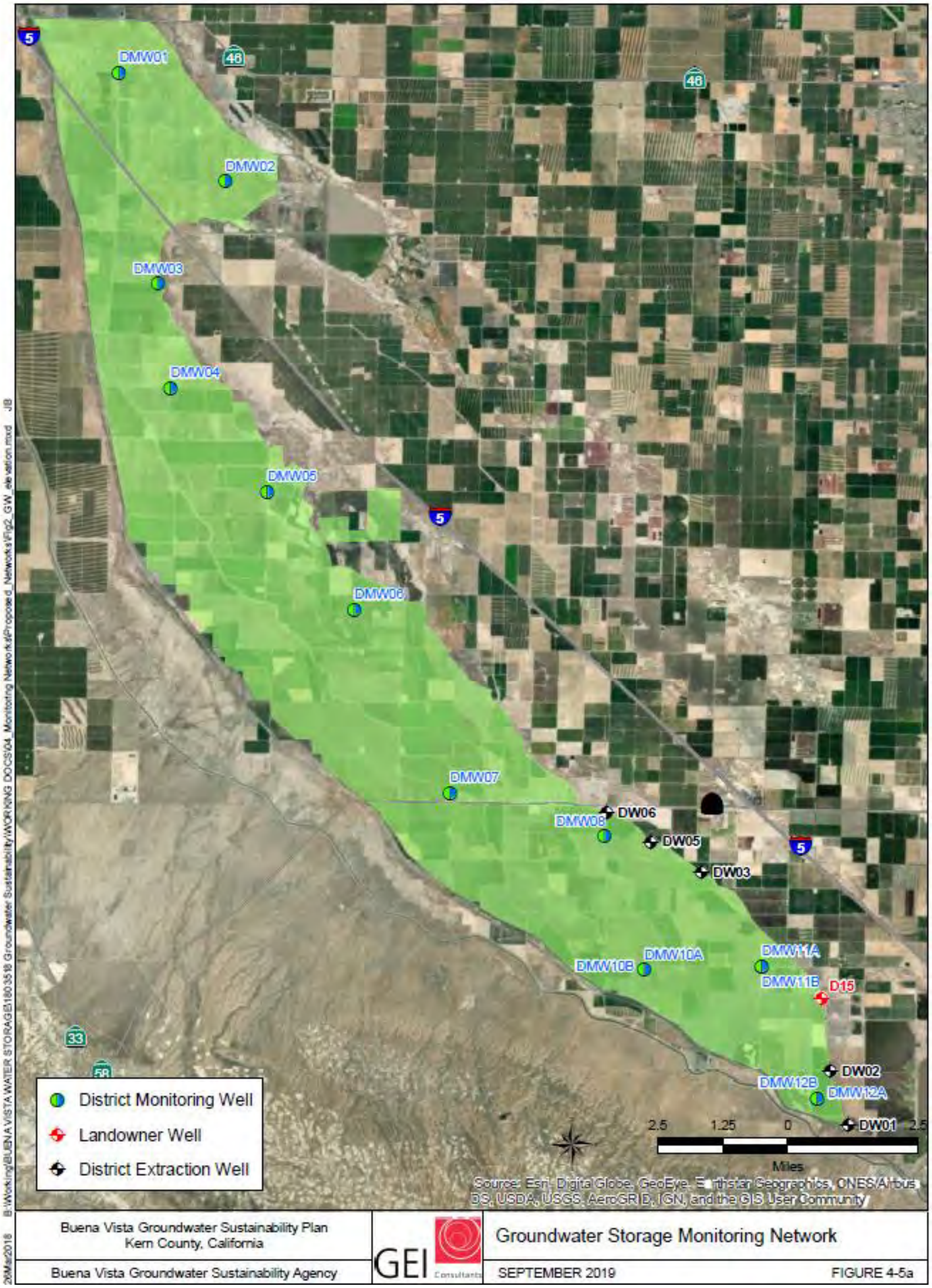

Figure 4-5a. Map of Network for Groundwater Storage Monitoring

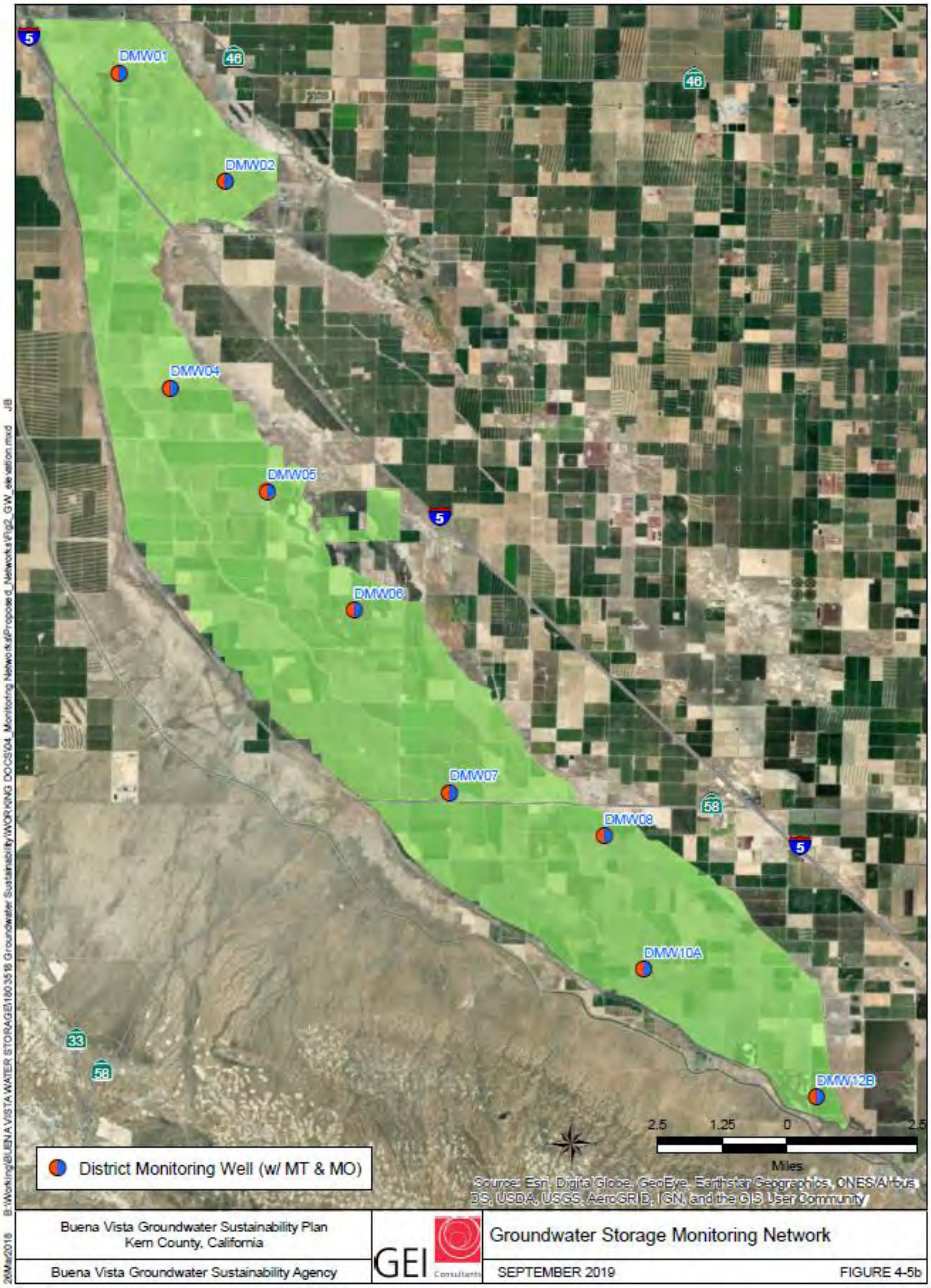

Figure 4-5b. Representative Wells for Minimum Thresholds and Measurable Objectives

4.4.2.6 Monitoring Protocols

Data collected from the groundwater level monitoring network will be used to estimate changes in groundwater storage. Therefore, the protocols used for monitoring groundwater levels will apply to monitoring changes in groundwater storage.

4.4.2.7 Data Gaps

The data gaps identified above for the groundwater level monitoring network also pertain to the network for monitoring changes in groundwater storage.

4.4.2.8 Plans to Fill Data Gaps

The recommendations noted above for the network for monitoring groundwater levels also pertain to the network for monitoring change in groundwater storage.

4.4.3 Groundwater Quality Monitoring

> ***23 CCR §354.34(c)(4)****: Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.*

4.4.3.1 Representative Monitoring

Monitoring of the groundwater quality sustainability indicator will be carried out in parallel with the GQTMWP that has been developed by the Buena Vista Coalition for compliance with the Central Valley Regional Board's Irrigated Lands Regulatory Program (ILRP). General Order R5-2013-0120 requires growers who are members of a third-party coalition within the Tulare Lake Basin to comply with the Waste Discharge Requirements (WDRs) of the ILRP. After approval of the General Order, the Buena Vista Coalition, which covers an area that corresponds closely with that of the BVGSA, received approval to act as a Third Party to implement the General Order.

Wells included in the monitoring network established for the GQTMWP target areas where data reported through the GAMA system has indicated active or incipient water quality concerns. While data reported by GAMA in other areas of the GSA indicate that water quality is not problematic, additional wells have been included in the initial SGMA groundwater quality monitoring network to observe the quality of groundwater flows in the following boundary areas:

- The southern boundary where groundwater flux is driven by pumping within the GSA and in neighboring water banks, and
- The northwestern flank where poor quality groundwater is believed to flow into the GSA. Because of the scarcity of deep wells in this area, the initial monitoring plan relies on 3 piezometers to observe the influence of water flowing from the west.

The southwestern flank of the GSA is not targeted for water quality monitoring because there is no need to coordinate with land users to the west. Similarly, monitoring is not necessary along much of the eastern flank because of the geological structures that obstruct groundwater flow in this area. The Hydrogeologic Conceptual Model presented in Section 2 – Basin Setting describes the geology of this boundary.

Table 4-3 presents the latitude and longitude of each of the 6 deep wells and the 4 piezometers included in both the GQTMWP and the GSA groundwater quality monitoring networks. The table also shows the locations of wells in the GSA network that will supplement those monitored by the Buena Vista Coalition. As shown in Figure 4-6, these monitoring locations are distributed so the greatest concentrations of sites are found either in areas that have experienced groundwater quality problems in the past or at locations where the monitoring point can serve as a sentinel for down-gradient areas.

Table 4-3. Groundwater Quality Monitoring Locations

Well Name	Well Type	Latitude	Longitude	GQTMWP
DMW01	District Monitoring	35.60140	-119.61755	No
DMW04	District Monitoring	35.51370	-119.59845	Yes
DMW06	District Monitoring	35.45265	-119.53460	No
DMW08	District Monitoring	35.39058	-119.44817	Yes
DMW12a	District Monitoring	35.31847	-119.37473	No
DMW12b	District Monitoring	35.31847	-119.37473	No
DW03	District Production	35.38104	-119.41521	Yes
DW05	District Production	35.38929	-119.43253	Yes
DW06	District Production	35.39731	-119.44775	Yes
Domestic Well	Domestic	35.37812	-119.44101	Yes
PIEZ-015	Shallow Piezometer	35.58645	-119.59749	Yes
PIEZ-023	Shallow Piezometer	35.55796	-119.61786	Yes
PIEZ-034	Shallow Piezometer	35.51404	-119.61547	Yes
PIEZ-035	Shallow Piezometer	35.49936	-119.61650	Yes

4.4.3.2 Management Areas

As discussed throughout this GSP, the BVGSA has been divided into two management areas, the Buttonwillow Management Area (BMA) with boundaries that closely parallel those of the BVWSD's Buttonwillow Service Area and the much smaller Maples Management Area (MMA), with boundaries identical to the BVWSD's Maples Service Area and which lies within the Kern River GSA (GSA). The two management areas are separated by approximately 15 miles with the MMA lying entirely within the Kern River GSA.

4.4.3.3 Monitoring Frequency

Following the GQTMWP developed for the Buena Vista Coalition, groundwater quality data collected for monitoring the groundwater quality sustainability indicator will be collected on a semi-annual basis.

4.4.3.4 Spatial Density

A total of 13 sites is included in the network for monitoring quality. This total consists of 5 District monitoring wells, 3 District production wells, 1 domestic and 4 piezometers. These 13 sites are distributed over the 72 square-mile area of the BMA resulting in a monitoring network with a spatial density of one site per 6.8 square miles.

4.4.3.5 Map of Network for Groundwater Quality Monitoring

Figure 4.6a is a map of the network for monitoring water quality in the BMA. Figure 4.6b displays wells selected for monitoring minimum thresholds and measurable objectives with respect to groundwater quality.

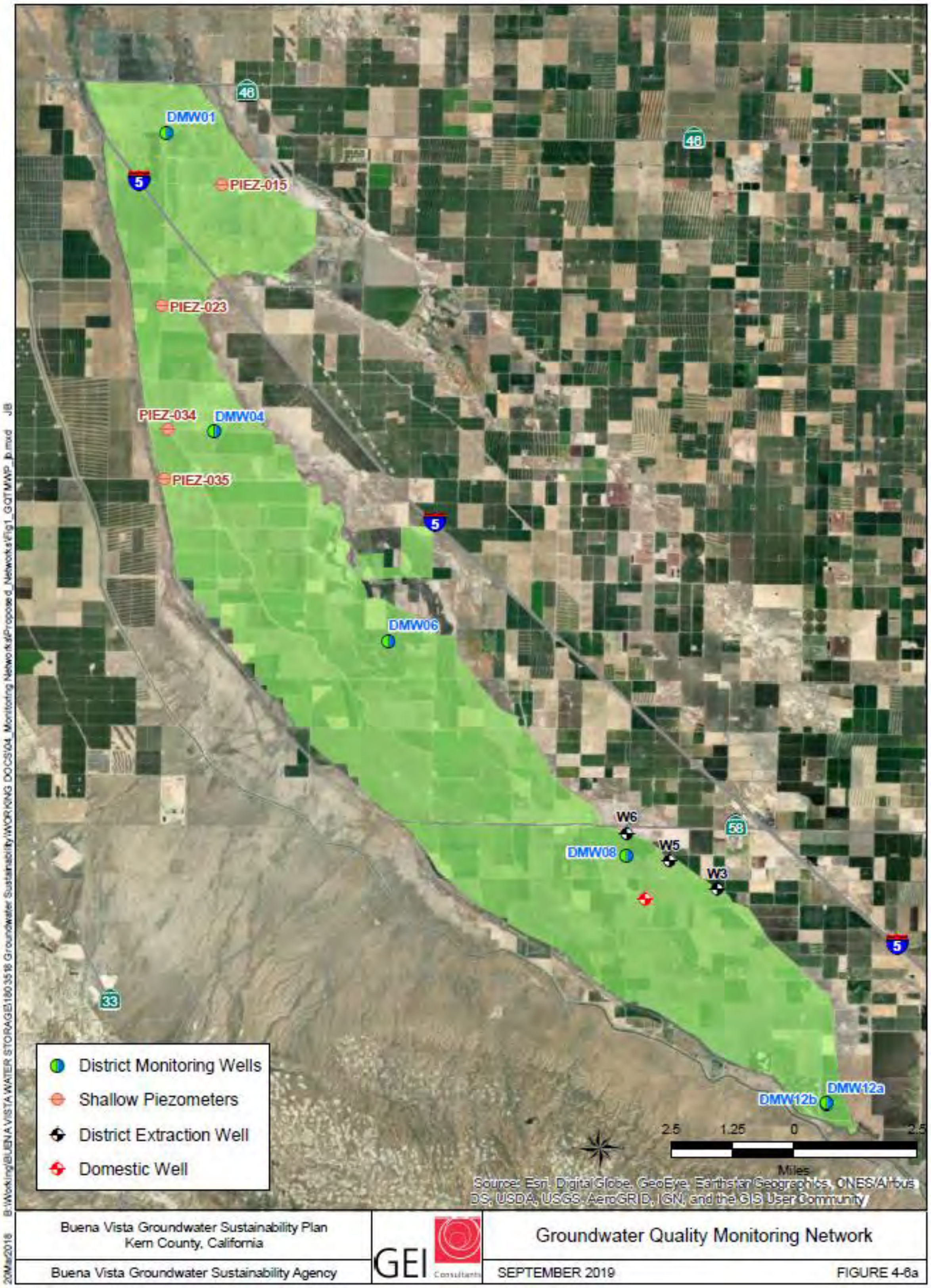

Figure 4-6a. Map of Network for Groundwater Quality Monitoring

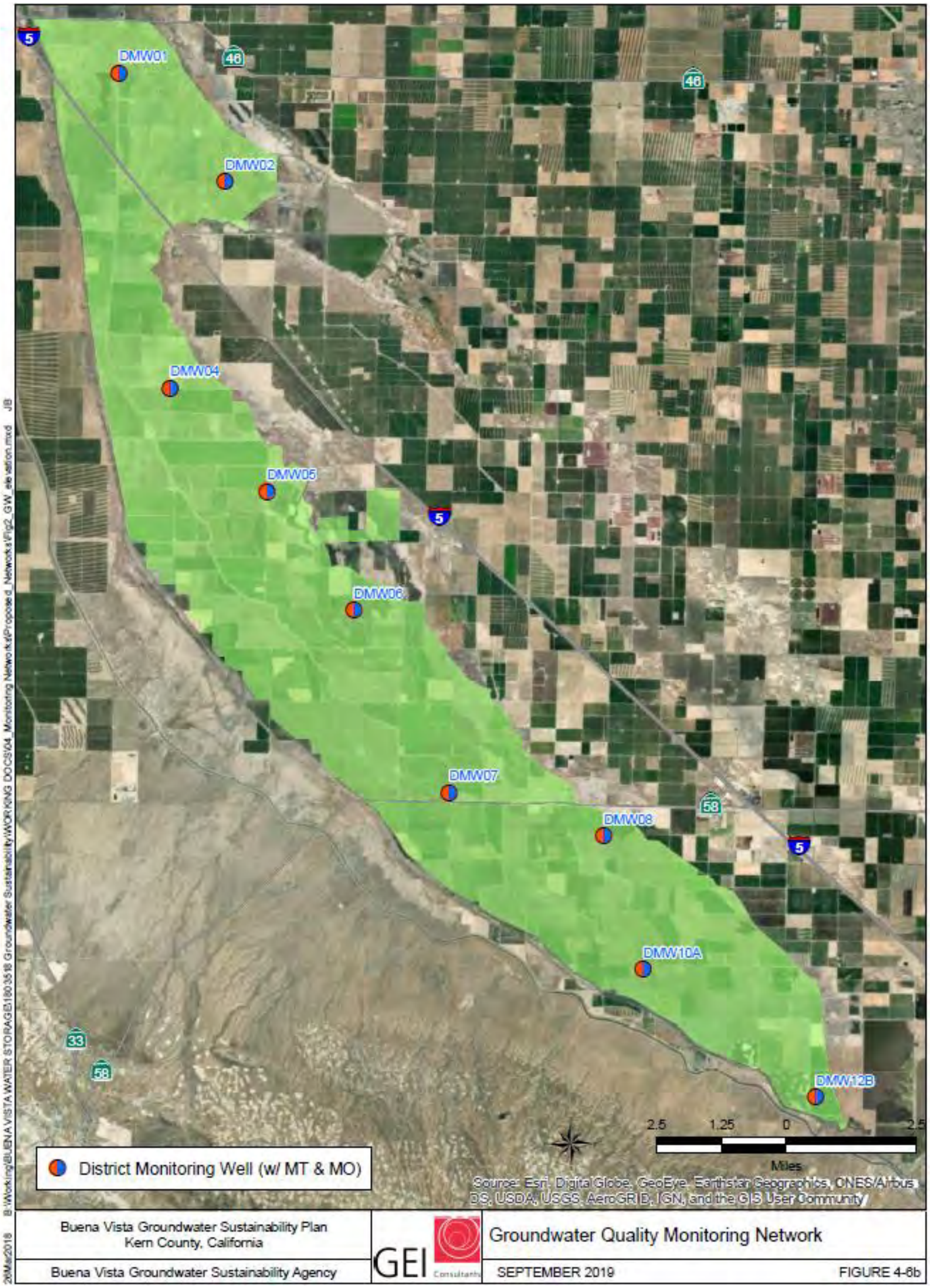

Figure 4-6b. Representative Wells for Minimum Thresholds and Measurable Objectives

4.4.3.6 Monitoring Protocols

Water quality samples will be analyzed by a third-party laboratory for the constituents shown below in Table 4-4.

Table 4-4. List of Water Quality Constituents Analyzed from Monitoring Program

Constituents		
Total alkalinity	Fluoride (F)	Potassium (K)
Bicarbonate (HCO_3)	Hardness as $CACO_3$	Sodium (Na)
Boron (B)	Iron (Fe)	Sodium adsorption (SAR)
Calcium (Ca)	Magnesium (Mg)	Electrical conductivity (EC)
Carbonate (CO_3)	Manganese (Mn)	Sulfate (SO_4)
Chloride (Cl)	Nitrate (NO_3)	Total dissolved solids (TDS)
Copper (CU)	pH	Zinc (Zn)

Water quality monitoring will include sampling and laboratory analysis of the nitrate concentration of the groundwater. Nitrate concentrations will be reported in units of milligrams per liter (mg/L) as nitrogen. Readings of selected water quality parameters will be taken in the field at the time of the sampling. Parameters to be measured in the field include electrical conductivity at 25 °C (EC) in µS/cm, pH, temperature (in °C), and dissolved oxygen (DO) in mg/L and anions and cations. Additional sampling protocols are included in Appendix C.

Every five years, wells used for monitoring groundwater quality will be tested for a suite of constituents that is more extensive than that tested on an annual basis. The constituents to be sampled and analyzed for reporting in the five-year GSP updates include total dissolved solids (TDS) and major cations such as boron, calcium, sodium, magnesium, and potassium and anions including carbonate, bicarbonate, chloride, and sulfate.

4.4.3.7 Data Gaps

Due to the predominance of irrigated agriculture as a land use in the BVGSA, groundwater quality monitoring conducted by the Buena Vista Coalition for compliance with the ILRP is likely to be protective of beneficial uses in the GSA. Therefore, the network for monitoring groundwater quality presented in this section is likely to be adequate for groundwater quality monitoring throughout the period of SGMA implementation. The one exception may be identification of existing wells or construction of new wells to replace the piezometers included in the proposed network to monitor the migration of poor-quality water from the west.

4.4.3.8 Plans to Fill Data Gaps

Data collected by the groundwater quality monitoring network will be examined to determine its effectiveness in supporting sustainable groundwater management. While no data gaps are now apparent, data gaps identified in the future will be addressed as needed.

4.4.4 Land Subsidence Monitoring

***23 CCR §354.34(c)(5)**: Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.*

4.4.4.1 Representative Monitoring

The principal objective of the subsidence monitoring program is to support the monitoring activities of Caltrans and DWR to avoid generating groundwater conditions within the BVGSA that might contribute to subsidence of Interstate Highway 5 and the California Aqueduct, two facilities of regional and statewide importance that run immediately adjacent to the BVGSA.

Infrastructure within the BVGSA includes state and county roads, power lines, and water conveyance and control facilities including earth-lined canals and pipelines. This infrastructure has not experienced damage from subsidence in the past. Given that the range of groundwater elevations expected during implementation of SGMA is within the range of elevations that has been experienced in the past, the GSA does not anticipate subsidence will result in damage to infrastructure within its boundaries in the future.

Subsidence is monitored directly at GPS stations P545 and P563, two participating stations of the Continuously Operating Reference Stations (CORS) network that provides Global Navigation Satellite System (GNSS) data. The two CORS stations are part of the National Geodetic Survey (NGS), an office of NOAA's National Ocean Service that manages the CORS network on behalf of a group of government, academic, and private organizations. As of August 2015, the CORS network included almost 2,000 stations, contributed by over 200 different organizations, that support three-dimensional positioning, meteorology, space, weather, and geophysical applications throughout the United States. CORS enhanced post-processed coordinates approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically.

Data from the two CORS stations, both located immediately east of the BVGSA, will be supplemented through monitoring of ground surface elevations using data provided by DWR from the Interferometric Synthetic Aperture Radar (InSAR) network that measures vertical ground surface displacement. InSAR data is collected by the European Space Agency Sentinel-1A satellite and processed by the National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory (JPL). This data currently provides cumulative vertical ground surface displacement from June 2015 to January 2017 for lands within the BVGSA.

4.4.4.2 Management Areas

As discussed throughout this GSP, the BVGSA has been divided into two management areas, the Buttonwillow Management Area (BMA) with boundaries that closely parallel those of the BVWSD's Buttonwillow Service Area and the much smaller Maples Management Area (MMA), with boundaries identical to the BVWSD's Maples Service Area. The two management areas are separated by approximately 15 miles with the MMA lying entirely within the Kern River GSA. Because of the lack of subsidence observed in the BVGSA, no additional management areas have established for targeted subsidence control.

4.4.4.3 Monitoring Frequency

Both the CORS network and InSAR monitor subsidence on a continuous basis. Cumulative InSAR data requires post processing, so the availability of these datasets is dependent on the work of NASA's JPL.

4.4.4.4 Spatial Density

The locations of CORS stations used for subsidence monitoring are shown in Figure 2-30 - Recent Subsidence (2015 to 2016) below. InSAR mapping is regional. (Figure 2-30 – Refer to Figures Tab)

4.4.4.5 Map of Network for Monitoring Subsidence

Figure 2-30 is a map of the recent subsidence in the BVGSA mapped using data from InSAR and showing the location of the CORS stations used for monitoring subsidence in the BMA.

4.4.4.6 Monitoring Protocols

Protocols for monitoring subsidence are established by the organizations that perform the monitoring, the National Geodetic Survey in the case of the CORS system and the JPL in the case of InSAR.

4.4.4.7 Data Gaps

As described in Section 2 – Basin Setting, little subsidence has been detected in the BVGSA, and subsidence has not been observed in buildings, canals, roads and other infrastructure within the GSA. Because control of subsidence is not now believed to be a problem, there are no plans to expand the BVSGA's subsidence monitoring system beyond the CORS stations and InSAR data described above.

4.4.4.8 Plans to Fill Data Gaps

For the reasons noted above, due to the lack of observed subsidence, there are now no plans to fill gaps in the monitoring system. Should evidence of subsidence be observed in facilities within or near the BVGSA, the GSA would initiate a topographic survey program to monitor the rate and extent of subsidence at the affected locations.

4.4.5 Seawater Intrusion Monitoring Network

> ***23 CCR §354.34(c)(3***): *Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.*

Monitoring of seawater intrusion into the BVGSA is not needed due to the isolation of the Kern County Subbasin from the ocean and from estuaries or other saline bodies of water connected to the ocean.

4.4.6 Depletions of Interconnected Surface Water Monitoring Network

> ***23 CCR §354.34(c)(6)****: Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions.*

Monitoring of depletions of interconnected surface waters is not needed in the BVGSA because there are no rivers, streams or lakes that lie within the GSA's boundaries. The Kern River Flood Channel Canal lies immediately west of the GSA but is used to convey floods waters only under exceptional circumstances and has not flowed since ____.

5. Minimum Thresholds, Measurable Objectives, and Interim Milestones

5.1 Introduction

The BVGSA has coordinated with other GSAs in the Kern County Subbasin to define sustainability objectives and undesirable results and to establish the three sustainable management criteria (SMCs): measurable objectives (MOs), minimum thresholds (MTs), and interim milestones (IMs). The objective of this coordination is to develop an approach to groundwater management within the BVGSA that will contribute to sustainable management throughout the subbasin. Figure 5-1, from the draft BMP for Sustainable Management Criteria (DWR, 2017), illustrates the relation between MTs, MOs, and IMs.

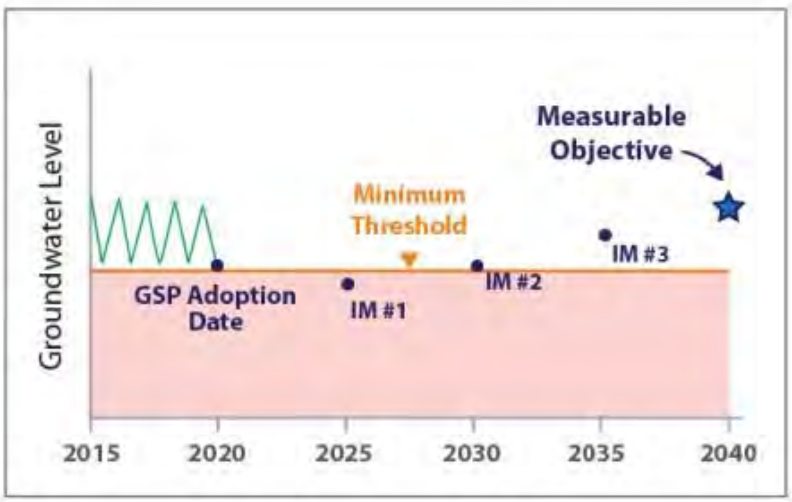

Figure 5-1. Example MT, IM, and MO

The minimum thresholds, measurable objectives, and interim milestones described and quantified in this section will be applied to avoid undesirable results related to the following sustainability indicators:

- Chronic lowering of groundwater levels;
- Significant and unreasonable reduction of groundwater storage;
- Significant and unreasonable degraded water quality, and
- Significant and unreasonable land subsidence.

As explained in Section 2 - Basin Setting and Section 3 - Sustainability Goal and Undesirable Results, the two remaining undesirable results are not considered to be relevant to management of the BVGSA.

- Significant and unreasonable sea water intrusion, and
- Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of surface water

The following are suggested considerations for all minimum thresholds presented in the draft BMP for Sustainable Management Criteria (DWR, 2017):

1. The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.
2. The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.
3. How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.
4. How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.
5. How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.
6. How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

5.2 Role of Hydrogeologic Zones

Coordinated development of measurable objectives and minimum thresholds for GSAs in the Kern County Subbasin begins with the concept of Hydrogeologic Zones (HZs). These zones, shown on Figure 5-2, have been agreed to by each of the GSAs located north of the Kern River to enable establishment of sustainable management criteria based on shared hydrogeologic characteristics and groundwater conditions such as depth to groundwater, base of fresh groundwater, attributes of principal aquifers, and water quality constituent concentrations (Figure 5-2 - Refer to Figures Tab). Definition of these HZs is the first step in the following three-tiered approach to establishment of SMCs.

- Tier 1: Establishment of MTs and MOs: MTs and MOs are defined for each monitoring site in an HZ which represents an area of common physical characteristics defined independently of GSA and district boundaries. Use of HZs to guide development of MTs and MOs enabled these metrics to be informed by the physical characteristics of the portion of the Subbasin within which they are located. HZs also provide overlying GSAs a shared frame of reference for defining and adjusting MTs and MOs in ways that avoid conflict with SMCs established in neighboring HZs.
- Tier 2: Management of MTs and MOs: GSAs overlying each HZ are collectively responsible for managing surface water and groundwater within each HZ to meet the mutually agreed upon MOs and avoid breaching MTs. The Tier 2 management responsibilities recognize that each GSA has unique tools such as surface water entitlements and recharge facilities it can deploy to manage the portion of the HZ for which it is responsible. Therefore, while the guidelines for setting MTs and MOs within an HZ are common to all overlying GSAs, each GSA has the flexibility to use the management tools at its disposal to maintain groundwater elevations, stored groundwater volumes, water quality constituent concentrations and ground surface elevations within the bounds set by the MTs and MOs.
- To provide each GSA the latitude to use the full range of available management options, interim milestones will be established by the GSAs with these milestones determined by the projects and programs each GSA will introduce to attain sustainable groundwater management by 2040. Because the GSAs overlying an HZ are likely to follow different paths in achieving their shared objectives, the IMs marking these paths are also likely to differ.
- Tier 3: Management Areas (MAs): When needed to aid in management of a sustainability indicator, management areas may be established with the MA boundaries based on the extent of the concern the MAs are designed to address (e.g., contaminant plume location, critical infrastructure alignment). Depending on the location of the undesirable result, MAs may lie within a single GSA or may span GSAs.

  The BVWSD has two distinct service areas separated by 15 miles, the Buttonwillow Service Area and the smaller Maples Service Area. Because the locations of the services areas are not contiguous, their boundaries have been used define the Buttonwillow Management Area, BMA, and the Maples Management Area, MMA.

In summary, the three-tiered structure established within the Kern County Subbasin:

- Defines MTs and MOs within HZ boundaries that have been delineated based on shared physical conditions;
- Manages MTs and MOs within GSAs boundaries that have been delineated by jurisdiction, and
- Allows for management of sustainability indicators through formation of MAs having boundaries delineated by the extent of the sustainability indicator of concern or, as in the case of the BVGSA, by physical separation between MAs.

5.3 Application of Three-tiered Structure in the BVGSA

As shown on Figure 5.2, the BVGSA falls largely within HZ 6 with the extreme southern portion of the BMA lying in HZ 10 along with the entirety of the MMA, an MA surrounded by the Kern River GSA. Section 2 - Basin Setting describes distinguishing features of HZ 6 including soil characteristics, base of fresh groundwater and location of the E-clay (Corcoran Clay). The correspondence between the boundaries of the BMA and HZ 6 further illustrates how the hydrogeology, soils, and other features that distinguish HZ 6 were among the factors that led to the development of land within what is now the BVWSD, development which began as a reclamation effort in the 1870s with the formation of Swamp Land District No. 121 under the Swamp and Overflow Act of 1850.

Figures 2-24 and 2-25 of the Basin Setting show groundwater elevations characteristic of HZ 6 and illustrate how groundwater elevations differ between HZ 6 and neighboring areas. These groundwater elevations were central to defining the boundaries of HZ 6 and demonstrate the need for monitoring to provide a foundation for coordination with neighboring GSAs.

The close correspondence between the boundaries of HZ 6 and the BMA simplifies definition of SMCs because the criteria fall primarily within the purview of a single GSA. Therefore, as the BVGSA will be the sole GSA involved in development of SMCs, there will be no need for internal coordination with other overlying GSAs. However, the responsibility remains for coordination between the BVGSA and its neighbors to confirm that the SMCs drafted within HZ 6 do not conflict with those established in adjacent areas or create mismatches at boundaries that compromise the effectiveness of the SMCs on either side of the boundaries.

The MMA, being a small area within the Kern River GSA (KRGSA), will follow the guidelines established by that GSA for setting MTs and MOs. Adherence to the guidelines of the KRGSA will avoid a situation where a small island of land under the jurisdiction of the BVGSA, complicates SGMA compliance on the part of the KRGSA.

Cooperation among GSAs in the Kern County Subbasin in preparing the Basin Setting and in establishment of HZs were early steps in coordinated management of the Subbasin. Continued coordination will be required to ensure that projects and practices proposed by the BVGSA do not lead to undesirable results in neighboring areas and that practices introduced in neighboring areas do not interfere with sustainable groundwater management within the BVGSA. Outreach and coordination efforts by the BVGSA are described in detail in Section 9 - Outreach and Engagement Plan.

With respect to formation of management areas, as described in Section 2 - Basin Setting, there are hydrogeologic and water quality differences within the BMA that could have led to subdivision of this portion of the GSA into two or more MAs. However, these differences have existed since the formation of the BVWSD, and the District has been managed in ways that recognize and accommodate these differences.

Because of the BVWSD's history of managing the Buttonwillow Service Area by sharing resources within this unit, the BVGSA will adopt the approach of cooperative management and will not subdivide this area into MAs. The rationale for the unified approach is described in the Engineer's Assessment Report prepared for a Proposition 218 (the Right to Vote on Taxes Act) process successfully completed in 2016[10]. This assessment report notes that the benefits of operations and capital improvements exercised by the BVWSD accrue to all persons who own land within the District because the benefits of the District's capital improvement projects enhance customer service and water management throughout the District. All lands within the District's Service Area have been identified as lands falling within this category and receiving the aforementioned benefits.

5.4 Chronic Lowering of Groundwater Levels

5.4.1 Minimum Thresholds

The draft BMP on Sustainable Management Criteria (DWR, 2017) provides the following definition of minimum thresholds and of the term as it pertains to chronic lowering of groundwater levels:

> Minimum thresholds are quantitative values for groundwater conditions at representative monitoring sites that, when exceeded individually or in combination with minimum thresholds at other monitoring sites, may cause an undesirable result(s). Thus, sustainability indicators become undesirable results when a GSA-defined combination of minimum thresholds is exceeded at a scale determined to compromise basin-wide sustainability. The minimum threshold metric for the chronic lowering of groundwater levels sustainability indicator shall be a groundwater elevation measured at the representative monitoring site.

[10] Buena Vista Water Storage District: 2016 Engineer's Assessment Report in Support of Proposition 218 Assessment Ballot Proceeding, June 2016.

5.4.1.1 Establishment

Initial MTs have been established for each of the representative monitoring sites discussed in Section 4 - Monitoring Networks. These initial values will be modified during SGMA implementation as data gaps are filled and as the monitoring network is refined.

Section 3 - Sustainability Goal and Undesirable Results presents avoidance of the undesirable result of chronic lowering of groundwater levels as a critical objective for the BVGSA. Minimum thresholds for this undesirable result were established at each of the representative monitoring sites through analysis of well and groundwater elevation data. These analyses were carried out in the following sequence.

- Hydrographs were developed for each of the 11 monitoring wells operated by the BVWSD and reported to CASGEM. These monitoring wells are located at nine sites throughout the BMA with two of the sites, DMW 10 and DMW 12, having dual completion monitoring wells. The hydrographs developed for each monitoring well extend from September 2011 through October 2018, a period that captures changes in groundwater elevations observed during California's recent drought. Projections of these trend lines from fall 2016 base observations ranged from an increase of 6 feet to a decline of 239 feet with projected groundwater levels ranging from 47 feet bgs, a decline of 20 feet (0.8 feet/year) to 593 feet bgs, a decline of 354 feet (14.7 feet/year) As these trend lines assume a continuation of the severe drought that characterized the period from 2011 through 2018, projecting these trends through 2040 represents a "worst case" scenario of the minimum threshold at each of these monitoring sites.
- The "worst case" representations were then adjusted to arrive at MTs that reflect operating conditions at each monitoring location. These adjustments were based on factors including depths of confining and semi-confining clay layers and well construction information for domestic, agricultural, municipal and industrial wells.

Table 5-1 shows the groundwater levels observed in the Fall of 2016 at each of the 11 district monitoring wells reported to CASGEM, the corresponding "worst case" MT at these sites and the slope of the hydrograph used to project water levels observed between 2011 and 2018 to the 2040 "worst case" condition.

Table 5-1. Fall 2016 Water Levels and Projected 2040 Levels

Well ID	Fall 2016 Levels (feet bgs)	Hydrograph Slope	2040 Projected Levels (feet bgs)
dmw01	60	-0.00878	137
dmw02	80	-0.00891	158
dmw04	27	-0.00229	47
dmw05	42	-0.00418	79
dmw06	75	0.00078	69
dmw07	93	-0.00028	95
dmw08	127	-0.00877	204
dwm10a[1]	157	-0.01171	260
dmw10b[2]	216	-0.02089	400
dmw12a[3]	225	-0.01744	378
dmw12b[4]	239	-0.04021	593

[1] Nested monitoring well DMW 10: screened above E-clay
[2] Nested monitoring well DMW 10: screened below E-clay
[3] Nested monitoring well DMW 12: screened below E-clay
[4] Nested monitoring well DWM 12: screened above E-clay

5.4.1.2 Considerations Used

- What are the historical groundwater conditions in the basin? Historical groundwater conditions in the BVGSA are presented in Section 2 - Basin Setting. Groundwater hydrographs included in the Basin Setting and in Appendix B - Groundwater Hydrographs, display the range of groundwater elevations observed in the GSA over the period extending from 1993 through 2015, a period that corresponds with that used for C2VSim modeling of the Subbasin.
- What are the average, minimum, and maximum depths of municipal, agricultural, and domestic wells? Table 5-2 displays mean, median, minimum, and maximum depths of municipal, agricultural, domestic and industrial wells identified using data provided by DWR. Industrial well users have been identified as agricultural yards and processors, municipal wells have been identified as being in or near the Community of Buttonwillow.

Table 5-2. Well Depth Data

Well Depth Statistics				
	Domestic (feet)	Industrial (feet)	Municipal (feet)	Agricultural (feet)
Maximum Well Depth	522	500	700	1101
Minimum Well Depth	150	150	443	138
Median Well Depth	360	346	498	460
Mean Well Depth	356	330	547	477

- What are the screen intervals of the wells? Figures 5-3 through 5-6 display average depths of tops and bottoms of screens for domestic, industrial, municipal, and agricultural. Maximum, minimum, median and mean length of screened intervals for the four well types are shown in Table 5-3.

Table 5-3. Well Screen Interval Characteristics

Well Screen Interval Statistics	Domestic (feet)	Industrial (feet)	Municipal (feet)	Agricultural (feet)
Maximum Screen Length	300	320	300	800
Minimum Screen Length	8	60	80	6
Median Screen Length	42	99	297	264
Mean Screen Length	65	131	226	262

Table 5-4 shows well screen locations relative to the top of the E-clay. This table presents data on well depths and screened intervals derived from CASGEM, from DWR's SGMA Data Viewer website and from well completion reports available from the BVGSA and DWR. The information presented in this table indicates that the main production zones are the unconfined and semi-confined aquifers above the E-clay. The numeric data used to estimate well depths is supported by notes in the well completion reports that describe how drillers frequently bore until encountering the E-clay and then screen above this layer. This practice appears to be particularly prevalent in agricultural wells.

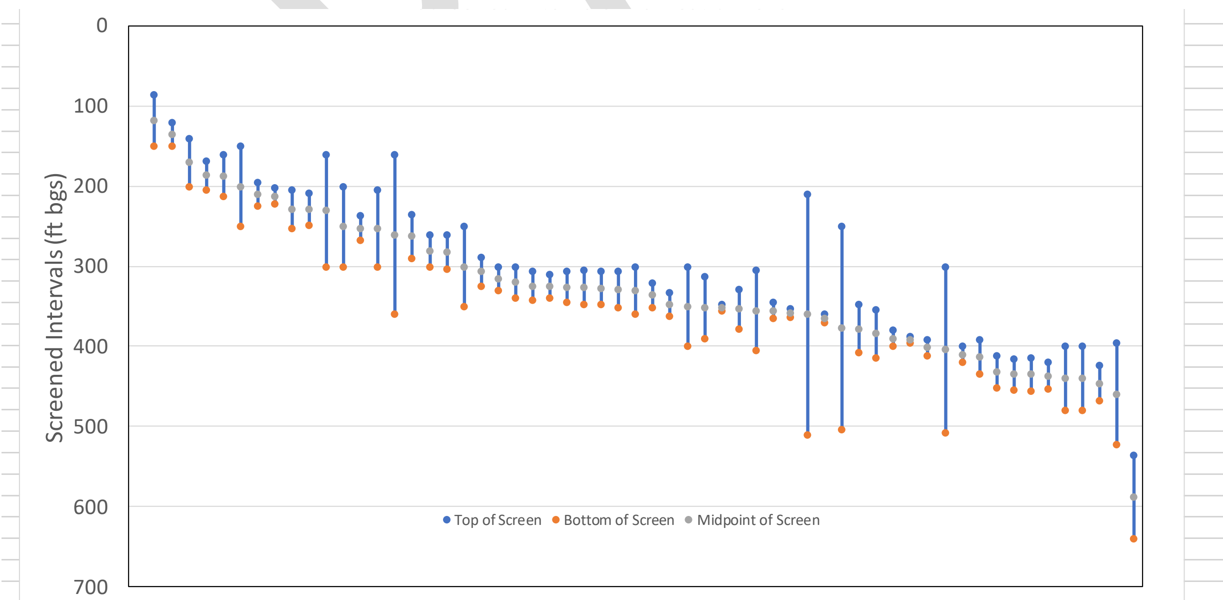

Figure 5-3. Screened Intervals: Domestic Wells

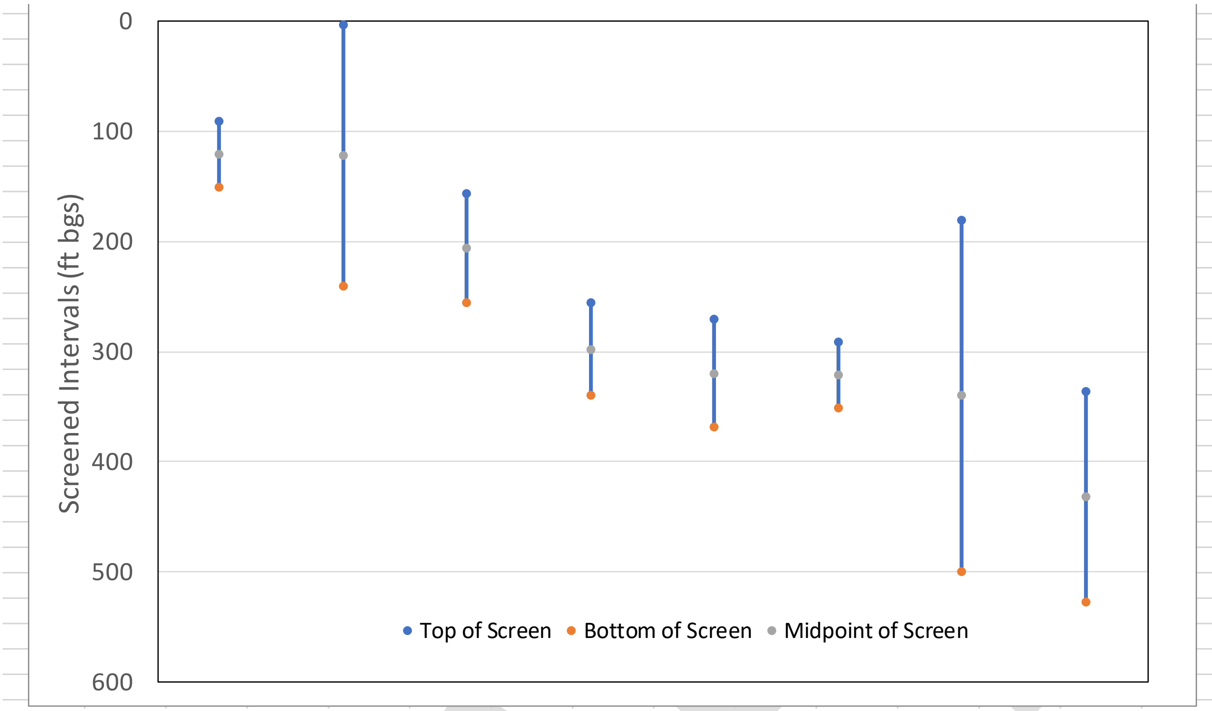

Figure 5-4. Screened Intervals: Domestic Wells

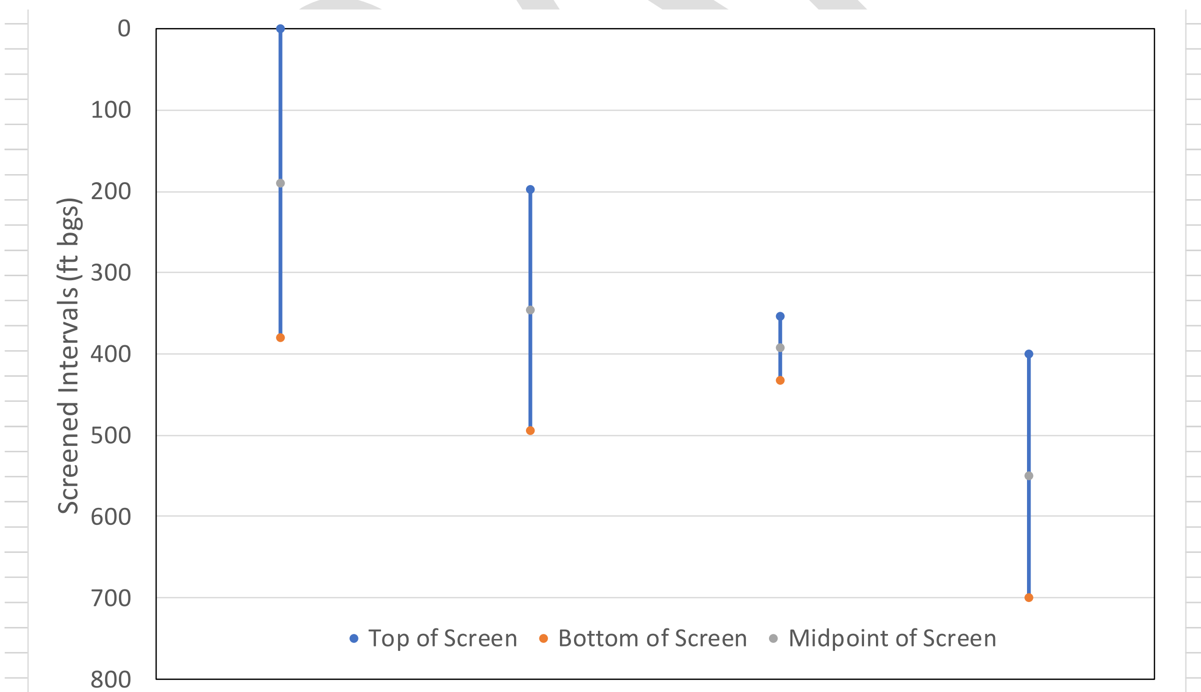

Figure 5-5. Screened Intervals: Municipal Wells

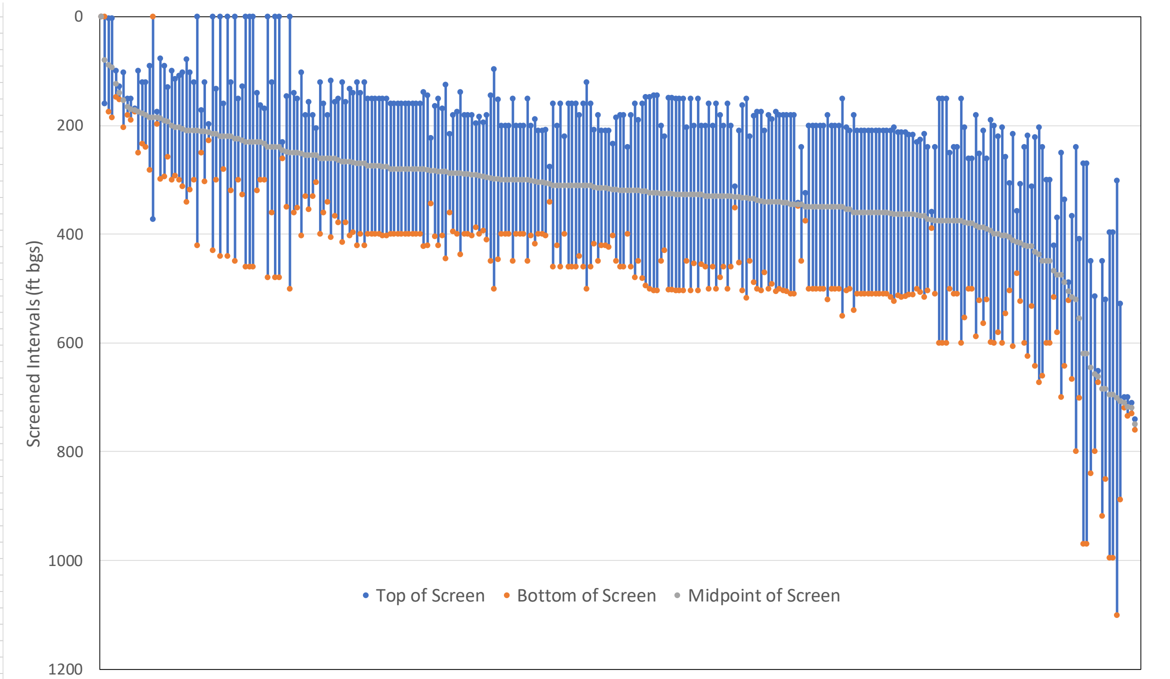

Figure 5-6. Screened Intervals: Agricultural Wells

Table 5-4. Well Screen Locations Relative to the E-clay

Screen Location Relative to E-clay								
	Domestic		Industrial [5]		Municipal [4]		Agricultural	
Above E-clay [1]	38	64%	5	71%	0	0%	57	22%
Near E-clay [2]	19	32%	2	29%	3	100%	198	75%
Below E-clay [3]	2	3%	0	0%	0	0%	8	3%
Total # of Wells / Total %	59	100%	7	100%	3	100%	263	100%

[1] Above E-clay: bottom perforation less than 400 feet below ground surface
[2] Below E-clay: top perforation greater than 500 feet below ground surface
[3] Near E-clay: bottom perforation between 400 and 500 feet below ground surface
[4] All municipal wells are in or near the community of Buttonwillow
[5] Industrial uses have been identified as agricultural yards and processing facilities

- What impacts do water levels have on pumping costs (e.g., energy cost to lift water)? Data provided by the BVWSD indicate that the energy cost to lift water in the BVGSA is approximately $30 / AF. Analysis that considered current PG&E costs, average irrigation well screened interval depth, and typical pumping costs per foot of lift per acre-foot (Lawrence Berkley National Laboratory, 2016) found the District estimate to be conservatively low.
- What are the adjacent basins' minimum thresholds for groundwater elevations? The BVGSA lies within the Kern County Subbasin and does not border any adjacent basins. Minimum thresholds for groundwater elevations in the adjacent Semitropic and Kern Groundwater Authority GSAs are???

- What are the potential impacts of changing groundwater levels on groundwater dependent ecosystems? As described in Section 2 - Groundwater Conditions, historical depths to groundwater are below elevations that have the potential to support groundwater dependent ecosystems (GDEs). Therefore, establishment of MTs below historical groundwater levels is unlikely to have any impact on GDEs.

- Which principal aquifer, or aquifers, are the representative monitoring sites evaluating? Based on information provided in Section 2 - Basin Setting, Section 4 – Monitoring Networks and information presented above in Tables 5.2 through 5.4, wells in the BVGSA monitoring network used as representative monitoring sites draw from zones of the Tulare Formation located above the E-clay, the principal production aquifer for the BVGSA. MTs were established at each of the representative monitoring wells to evaluate groundwater levels in this aquifer. In addition to the representative monitoring wells used to establish sustainable management criteria, the BVGSA's monitoring program includes three wells that extend beneath the E-clay. These wells, DMW 10b, DMW 11b and DMW 12a, are all included in nested pairs of wells with their counterpart wells, DMW10a, DMW11a, and DMW 12a all monitoring groundwater conditions above the E-clay.

5.4.1.3 Quantitative Minimum Thresholds

Although land surface elevations, depths to groundwater and depths to the E-clay vary throughout the BMA, the overall geometry of the management area, and of the corresponding HZ 6, aids in setting minimum thresholds due to the following characteristics:

- The BMA is underlain by the E-clay at elevations ranging from approximately 10 ft AMSL to -215 feet AMSL with unconfined and semi-confined zones of the Tulare Formation lying above the E-clay and a confined zone extending beneath the clay layer to the base of fresh groundwater.

- Analysis of screened intervals indicates that wells for all uses extract water from a production zone above the E-clay.

- Water quality in the production zone above the E-clay is better than that found beneath this layer.

- The risk of inducing subsidence by extracting water from the zone above the E-clay is likely to be lower than the risk induced by extracting water from beneath the E-clay.

- The volume of groundwater in storage above the E-clay is likely to be adequate to meet the demands of the BMA under foreseeable conditions.

- Water use throughout the GSA is overwhelmingly agricultural, therefore, the spatial distribution of demands is uniform.

Figure 5-7 - Longitudinal Cross Section of the BMA is based on Figure 2-13b and illustrates many of the points presented above. As well as showing the extent of the E-clay, the cross section illustrates the presence of the A- and C-clay lenses in the northern portion of the GSA that are described in Section 2 - Basin Setting (Figure 5-7 – Refer to Figures Tab). These three clay layers can be described briefly as follows:

- The A-clay occurs 20 to 30 feet bgs and is the cause of the shallow, perched groundwater identified in piezometers throughout the northern part of HZ 6.
- The C-clay is about 30 feet thick and occurs at a depth of about 200 feet bgs. The C-clay is laterally discontinuous and provides semi-confining conditions.
- The top of the E-clay occurs at depths ranging from 225 to 540 feet bgs and is a barrier to vertical flow of groundwater.

These clay layers create three aquifer zones:

- the perched aquifer above the A-clay, found throughout the northern portion of the BMA.
- the shallow, semi-confined aquifer lying between the A- and C-clays, and
- the deep aquifer lying between the C- and E-clays.

As the C-clay is perforated by numerous wells, it behaves as a semi-confining layer. Therefore, for the purposes of water accounting, the shallow and deep aquifers are grouped together as the principal production aquifer. Permeable sediments are also present below the E-clay, however because the water quality below the E-clay is poor and pumping from below the E-clay increases the risk of subsidence, most wells are constructed in the high yielding sands and silts above the E-clay, as shown in Table 5-4.

The hydrogeologic features of the BMA noted above and displayed in Figure 5-7 provide a physical setting for visualizing MTs and other management metrics. The Fall 2015 baseline groundwater elevations recorded in the 11 district monitoring wells and displayed on Figure 5-7 show shallow groundwater levels in district monitoring wells lying in the northern part of the area with depths to groundwater progressively increasing as the location of the wells moves south out of the semi-confined portion of the principal aquifer and as the depth to the E-clay increases. This progressive deepening of the fall 2015 groundwater levels is paralleled by a corresponding deepening of the “worst case” MTs.

Figure 5-7 also illustrates that in every instance, the “worst case” MTs lie above the top of the E-clay. Therefore, should groundwater levels breach these thresholds, the gap between the MT and the E-clay would provide an additional buffer for drought response that would not be likely to induce subsidence or diminish water quality. Therefore, continued reliance on the principal aquifer throughout SGMA implementation appears to be a practical approach to sustainable groundwater management.

Although the “worst case” MTs present useful first approximations, these MTs were refined based on the well construction data presented in tables 5-2 through 5-4 and other considerations when setting final MTs. The key objectives in refining the “worst case” MTs were:

- Determining sufficiently protective minimum thresholds in the southern portion of the GSA where the “worst case” MTs projected for 2040 are substantially lower than groundwater levels observed in 2015. The large difference between these levels is due to the steeply declining hydrographs used to compute the “worst case” condition. Because these hydrographs show the influence of groundwater banks located immediately outside the boundaries of the BVGSA, they represent a management condition that is beyond the full control of the GSA. To protect against triggering an undesirable result within the boundaries of the BVGSA due to the activities of an external party, MTs in these areas have been adjusted to conservative levels.
- Recognizing constraints on future operations in the northern portion of the BMA underlain by the A-clay where limited pumping during the baseline period resulted in high 2016 groundwater elevations and shallow hydrograph slopes leading to “worst case” MTs that may be overly restrictive.

For the reasons described above, the E-clay constitutes a physical floor for sustainable management of groundwater in the BMA. Limiting groundwater extraction to zones above the E-clay avoids the risks of degrading of water quality and inducing subsidence that may result from pumping beneath the E-clay, two undesirable results discussed in greater detail later in this section.

The operational impacts of the “worst case” MTs were assessed by examining the depths and screened intervals of active wells. As shown in Table 5-4, all municipal wells extend to the E-clay as do 75 percent of agricultural wells. The well depths and screened intervals reported for these wells suggest pumping from levels extending to the E-clay is economically viable. By contrast, only 29 percent of industrial wells and 32 percent of domestic wells extend to the E-clay. Moreover, while the mean screened interval of agricultural wells is 262 feet and of municipal wells is 226 feet, the mean screened intervals of domestic and industrial wells are much narrower (65 feet and 131 feet, respectively).

Using domestic and agricultural wells as examples, Figures 5-8a and 5-8b show the distribution of top perforations and bottom perforations of domestic wells and Figures 5-9a and 5-9b show these distributions for agricultural wells. Comparison of these two sets of figures reveals the narrow shift that illustrates the short screens (65-foot mean length) typical of domestic wells and the wider shift that illustrates the longer screens (262-foot mean length) typical of agricultural wells.

Domestic wells screens have top perforations at a mean depth of 300 feet bgs with 72 percent of screens having top perforations between 200 and 400 feet bgs. Agricultural well screens have shallower top perforations with a mean depth of 198 feet bgs and with 82 percent of screens having top perforations at between 100 to 300 feet bgs.

The mean depth of the bottom perforations of domestic wells is 365 feet bgs with 74 percent of wells having bottom perforations between 200 and 400 feet. The bottom perforations of agricultural wells are deeper with a mean depth of 459 feet bgs and with 79 percent of agricultural wells having bottom perforations between 350 and 550 feet bgs.

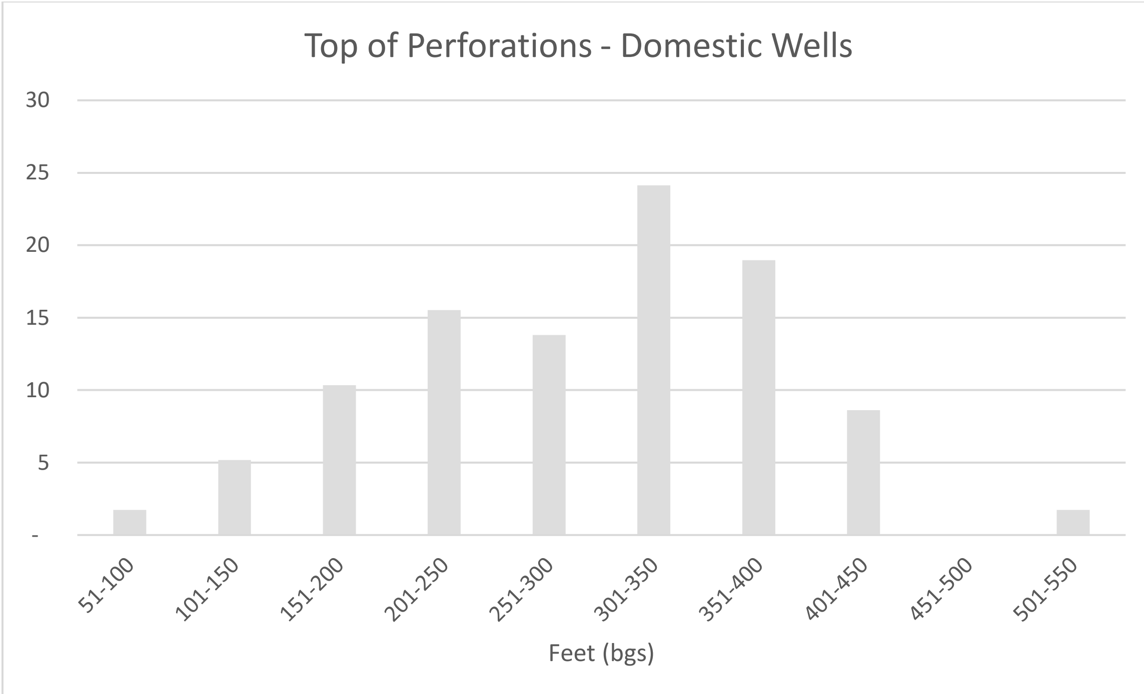

Figure 5-8a. Distribution of top perforations for domestic wells

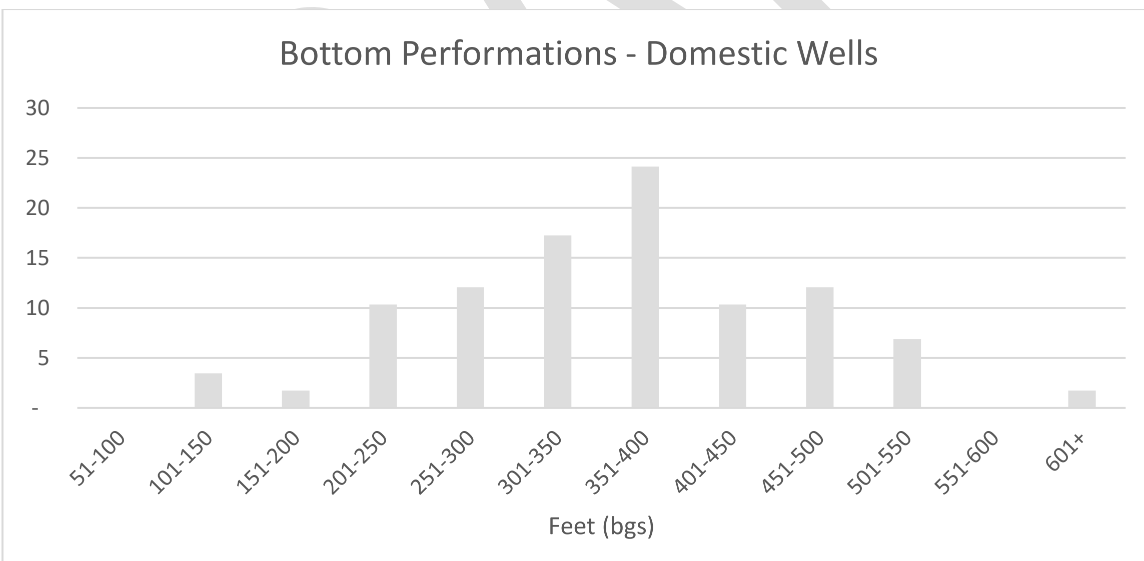

Figure 5-8b. Distribution of bottom perforations for domestic wells

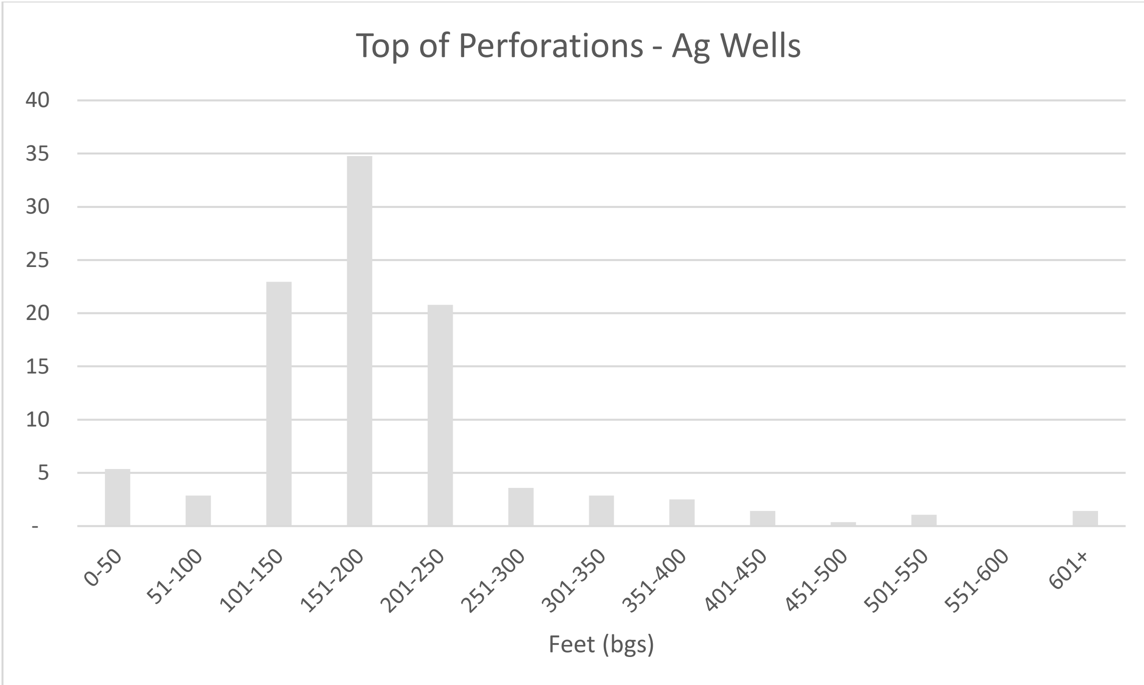

Figure 5-9a. Distribution of top perforations for agricultural wells

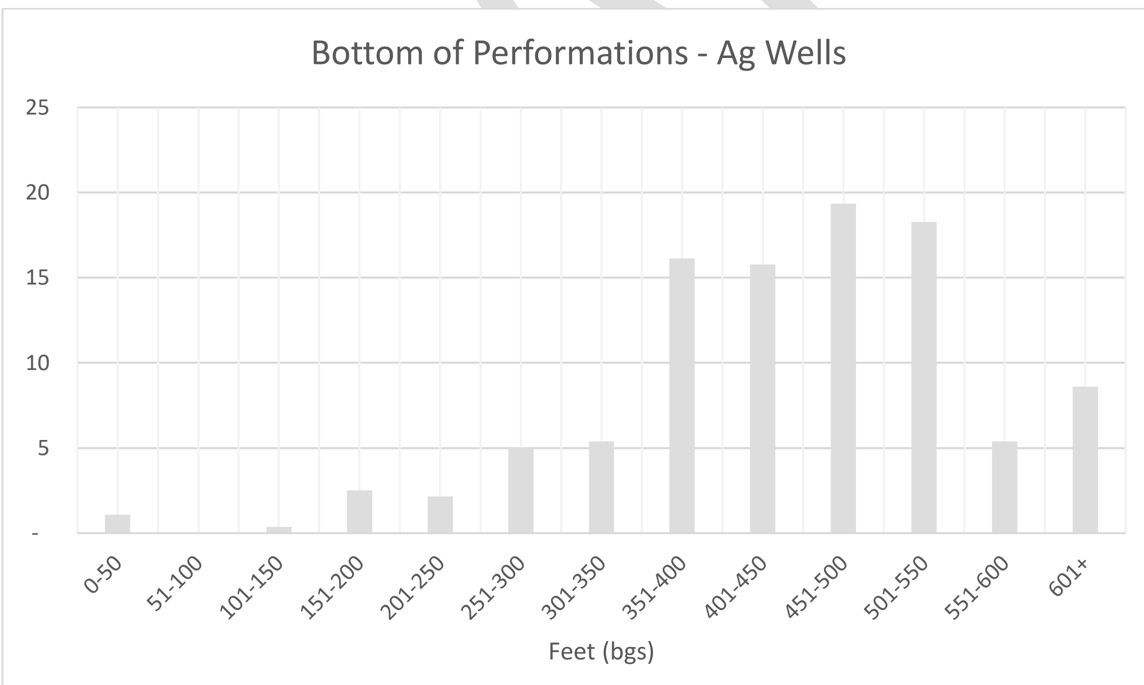

Figure 5-9b Distribution of bottom perforations for agricultural wells

Figures 5-10a through 5-10j apply data on domestic and municipal wells together with information on local hydrogeology to guide recommendations for final MTs for the network of monitoring wells. Each of the 10 charts in this series displays the clay sequences and 2015 groundwater elevations shown on Figure 5-7 together with the projected 2040 “worst case” MTs. Figures 5-10c through 5-10j also display the screened intervals of domestic wells with each domestic well shown on the figure associated with the nearest monitoring well. Figures 5-10g and 5-10h, which represent the monitoring location nearest the Community of Buttonwillow, show bars displaying the screened intervals for the Community’s domestic wells and municipal wells, respectively.

Figure 5-10a. Minimum Threshold and Measurable Objective Setting for DMW 01

Figure 5-10b. Minimum Threshold and Measurable Objective Setting for DMW 02

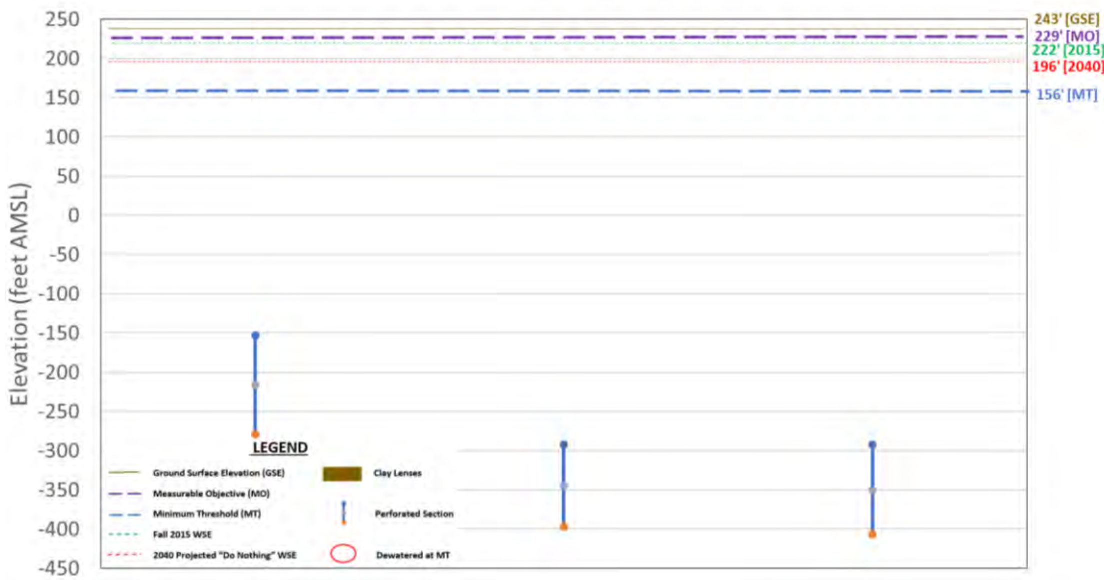

Figure 5-10c. Minimum Threshold and Measurable Objective Setting for DMW 04

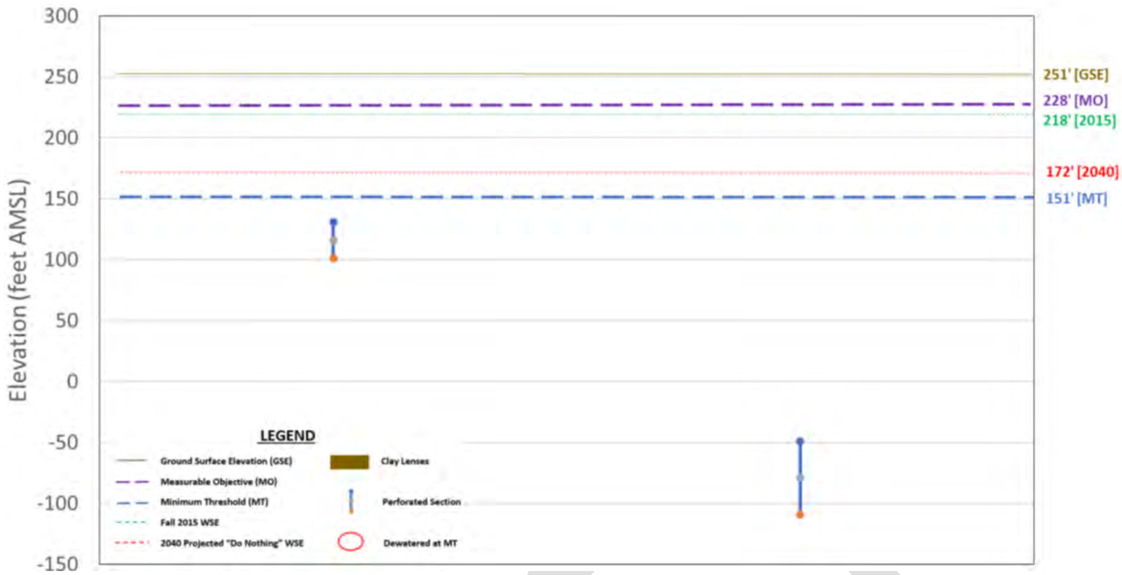

Figure 5-10d. Minimum Threshold and Measurable Objective Setting for DMW 05

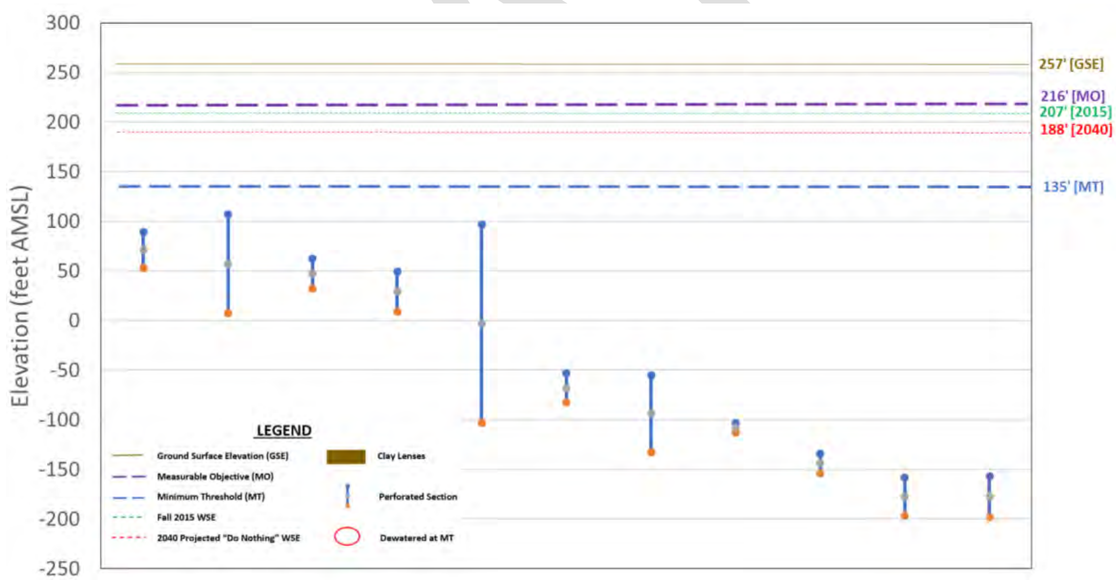

Figure 5-10e. Minimum Threshold and Measurable Objective Setting for DMW 06

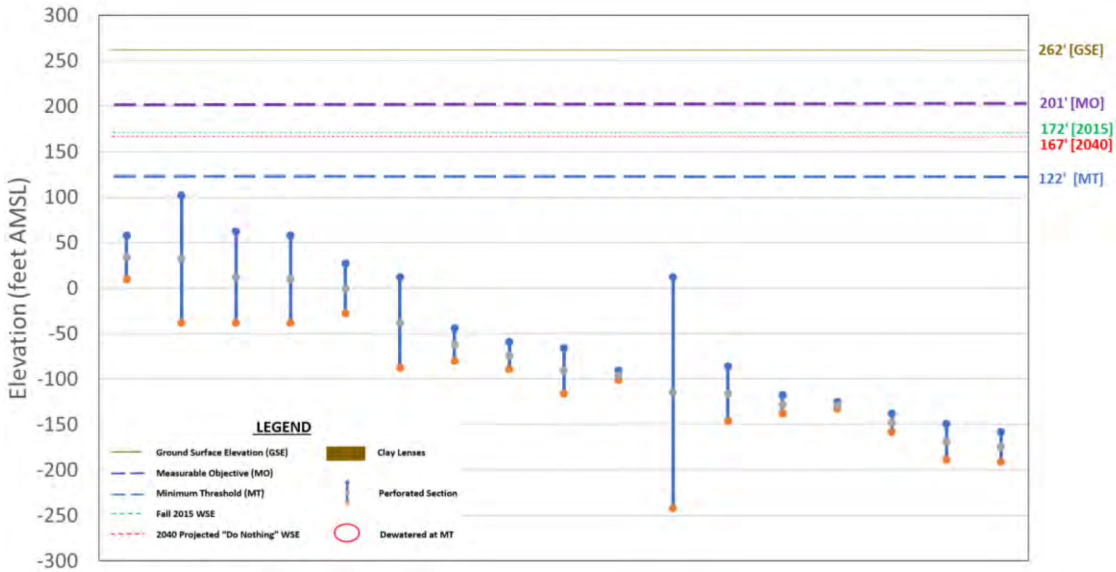

Figure 5-10f. Minimum Threshold and Measurable Objective for DMW 07

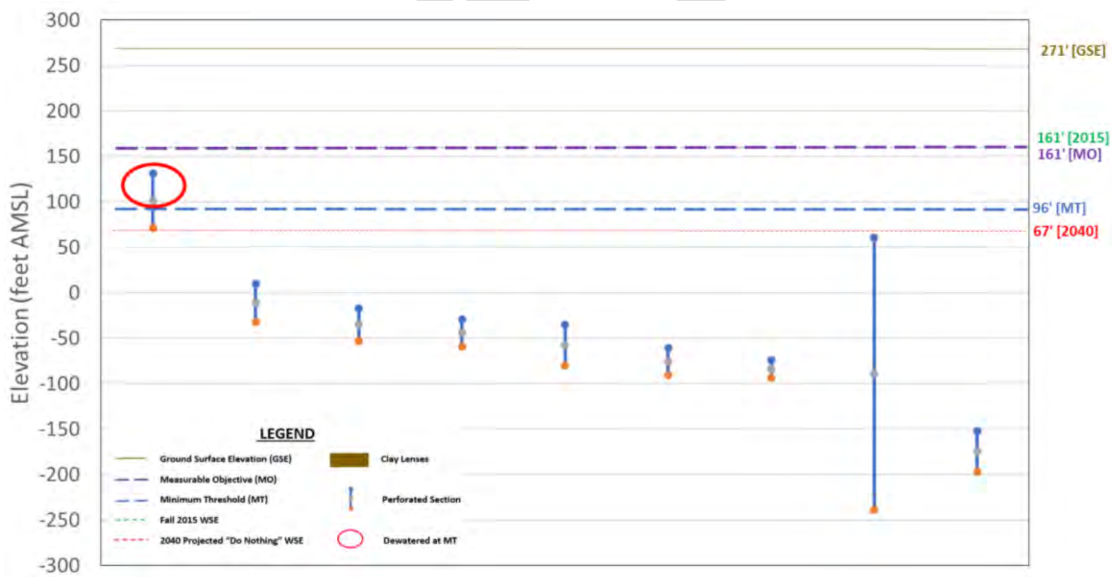

Figure 5-10g. Minimum Threshold and Measurable Objective for DMW 08 (Domestic Wells)

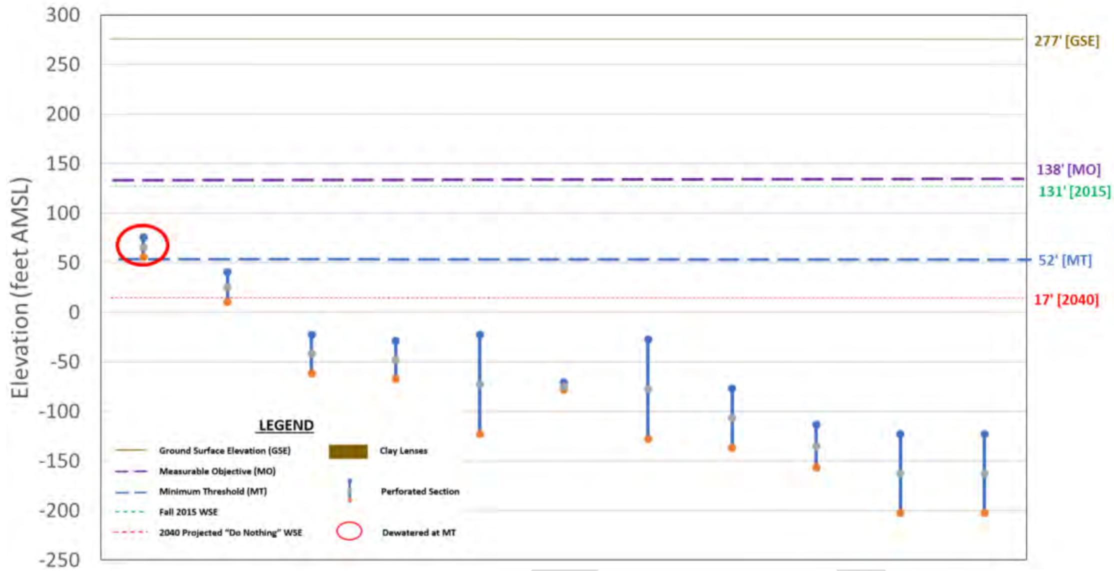

Figure 5-10i. Minimum Threshold and Measurable Objective for DMW 10a

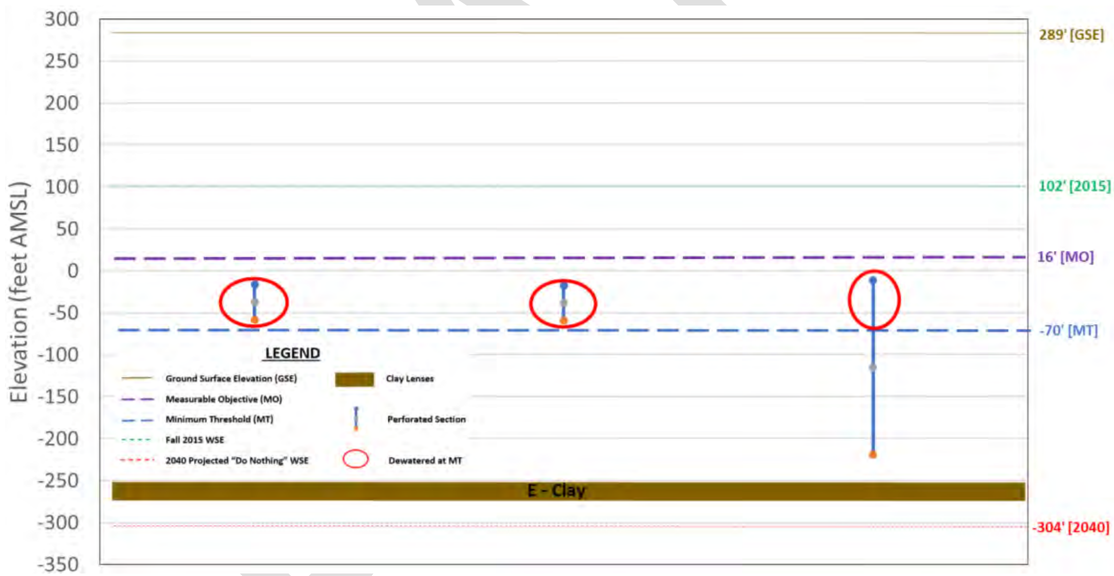

Figure 5-10i. Minimum Threshold and Measurable Objective Setting for DMW 12b

Table 5-5 summarizes the MTs recommended for each representative monitoring well based on the information presented in the preceding series of figures.

Table 5-5. Recommended MTs at Nine Monitoring Sites

DMW No.	Figure No.	Recommended MT Elevation (ft AMSL)	Difference from 2015 Water Level (ft)
DMW 01	5.10a	El 139 ft (97 ft bgs)	-50
DMW 02	5.10b	El 95 ft (140 ft bgs)	-61
DMW 04	5.10c	El 156 ft (87 ft bgs)	-66
DMW 05	5.10d	El 151 ft (100 ft bgs)	-67
DMW 06	5.10e	El 135 ft (122 ft bgs)	-72
DMW 07	5.10f	El 122 ft (140 ft bgs)	-50
DMW 08[1]	5.10g	El 96 ft (175 ft bgs)	-65
DMW 08[2]	5.10h	El 96 ft (175 ft bgs)	-65
DMW 10a[3]	5.10i	El 52 ft (225 ft bgs)	-79
DMW 12b[4]	5.10j	EL -70 ft (359 ft bgs)	-172

1 DMW 08 relative to Domestic Wells
2 DMW 08 relative to Municipal Wells
3 Nested monitoring well DMW 10: screened above the E-clay
4 Nested monitoring well DMW 12: screened above the E-clay

For wells screened above the E-clay at each monitoring site, recommended MTs were set according to the following criteria.

- No recommended MTs were set below the top of confining or semi-confining clay layers. In most instances the governing confining layer is the E-clay. However, in the northern portion of the BMA, the semi-confining C-clay layer governed based on well designs now being prepared for the City of Porterville. This criterion is intended to minimize the risk of subsidence of critical infrastructure, a potentially costly, irreversible undesirable result.

- Recommended MTs were targeted to minimize loss of production from existing domestic and municipal wells. The GSA will develop a mitigation plan for responding to situations where declining groundwater levels interfere with groundwater production. These mitigation plans will be modeled after plans that have been approved by DWR for mitigation of wells affected by pumping for groundwater substitution transfers.

- Recommended MTs are intended to retain existing groundwater gradients within the GSA by establishing a floor for groundwater extraction that parallels groundwater elevations observed in the Fall of 2015 as illustrated below in Figure 5-12.

5.4.2 Measurable Objectives and Interim Milestones

The SGMA regulations describe measurable objectives and how they relate to the sustainable management of groundwater in the California Code of Regulations:

§ 354.30. Measurable Objectives

(a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.
(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.
(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.
(d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.
(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

5.4.2.1 Establishment

As described above, measurable objectives are quantitative goals that represent the Subbasin's desired groundwater conditions and allow GSAs to achieve their sustainability goals within 20 years. These objectives are set for each sustainability indicator at every representative monitoring site and use the same metrics as minimum thresholds, allowing monitored groundwater elevations to be effectively compared to both the measurable objectives (the desired level) and the minimum thresholds (the trigger level for assessment of undesirable results) to determine the margin of operational flexibility available at a given point in time as illustrated in Figure 5.1.

The BVGSA has established measurable objectives at each representative monitoring site. These MOs, together with the recommended MTs discussed above, are designed to aid in sustainable management of groundwater by allowing the GSA to:

- Withstand droughts of durations of a minimum duration of 10 years without violating any of its recommended minimum thresholds;
- Minimize the risk of significant and unreasonable subsidence;
- Minimize the risks of significant and unreasonable impacts on water quality;

- Minimize the number of existing wells whose operation is compromised by reductions in groundwater elevations, and
- Provide a margin of operational flexibility that accommodates the impacts of climate change on water supply, water use and drought response.

5.4.2.2 Considerations Used

Figures 5.11a through 5.11i show spring groundwater elevations observed at each of the nine BVGSA monitoring sites from 1993 through 2018, a period beginning in the year used as the starting point for both the groundwater modeling being prepared for the Kern County Subbasin and with the ITRC METRIC data used to estimate evapotranspiration for water budgets developed by GSAs throughout the Subbasin.

These figures illustrate how effectively the conjunctive management policies established by the BVWSD have performed throughout most of the GSA in maintaining stable groundwater elevations over a broad range of hydrologic and water supply conditions and during a period of major changes in cropping patterns and irrigation practices, a transition driven by the shift from annual crops, such as cotton, to perennial fruit and nut plantings, such as pistachios and grapes. This series of figures also demonstrates the ample margin of operational flexibility that exists between observed water levels and the proposed minimum thresholds.

Figures 5-11h and 5-11i complement figures 5-10i and 5-10j in illustrating that groundwater levels in the southern area of the BVGSA fluctuate over a wider range than in other locations, a result, as noted above, due to subsurface outflows from the BVGSA and the influence of water banks that lie immediately beyond the GSA's boundaries. One of the objectives of the BVWSD's Palms Groundwater Recharge Project, described in Section 7 – Projects, Management Programs Actions and Adaptive Management Actions, is to store water diverted from the Kern River to dampen the fluctuations caused by these conditions. The first phase of this project entered operation in 2017.

In light of the BVWSD's ability to maintain an ample operational margin throughout the entire BMA between observed groundwater levels and the proposed minimum thresholds and because groundwater levels in the BVGSA are typically higher than in surrounding areas, recommendations for measurable objectives have been guided by the observed water levels. Use of existing groundwater levels to inform measurable objectives minimizes shifts in groundwater gradients within the BMA and facilitates coordination between the BVGSA and its neighbors by minimizing changes in gradients between the GSA and surrounding areas.

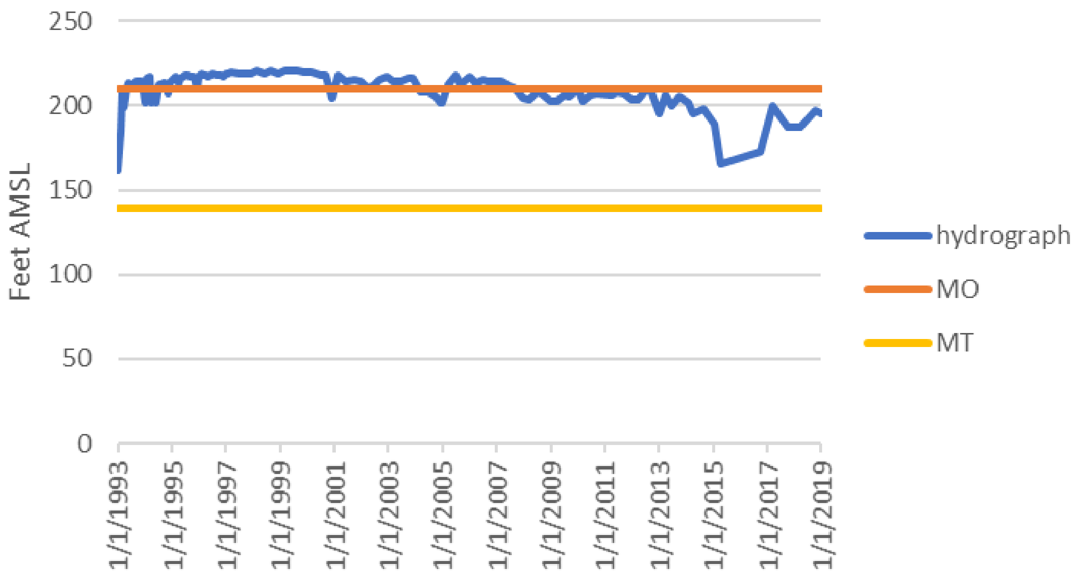

Figure 5-11a. DMW 01 Hydrographs [1993 – 2018], MO, and MT

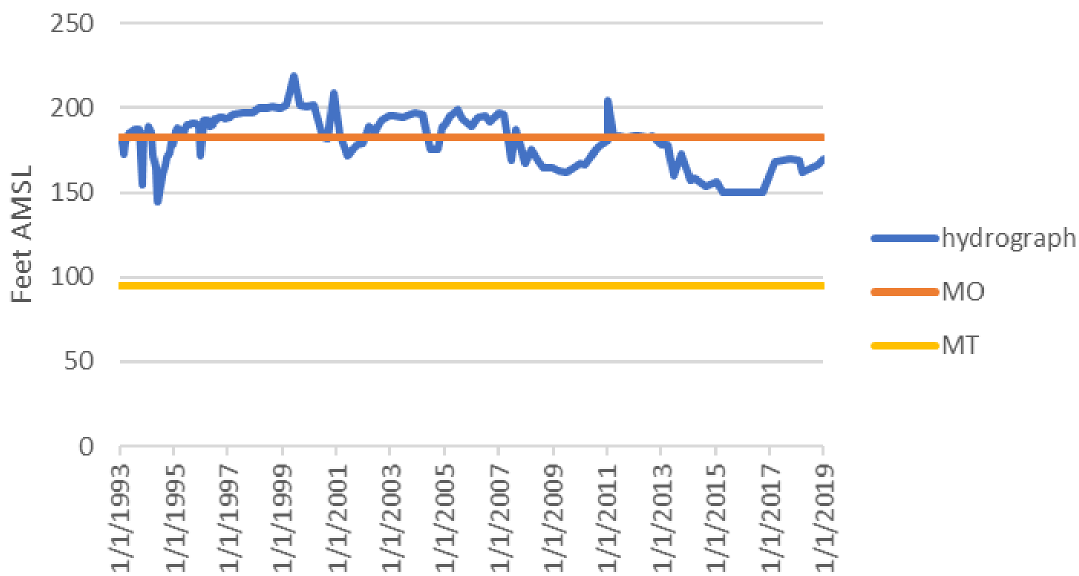

Figure 5-11b. DMW 02 Hydrographs [1993 – 2018], MO, and MT

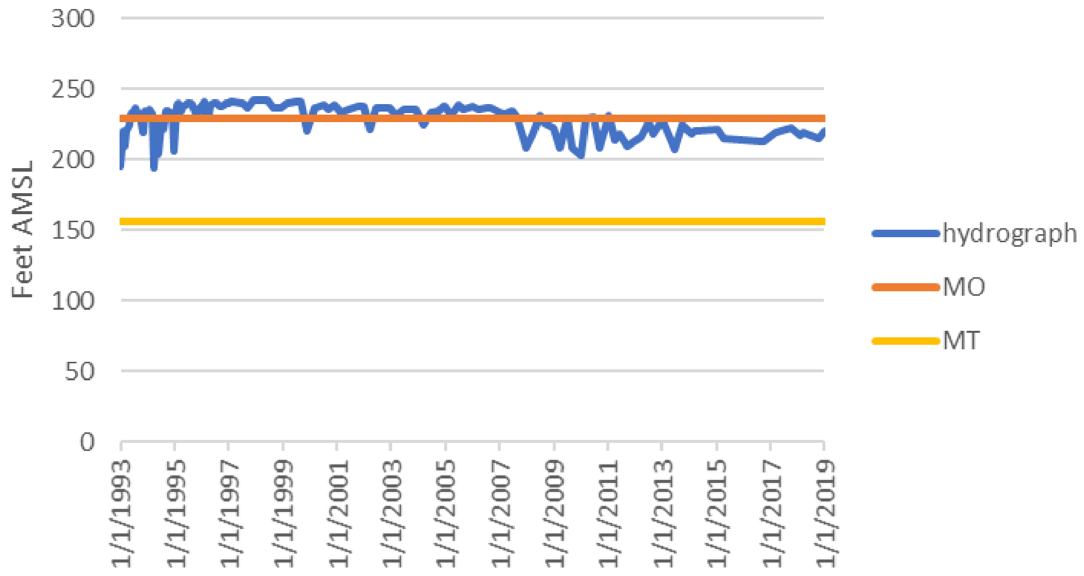

Figure 5-11c. DMW 04 Hydrographs [1993 – 2018], MO, and MT

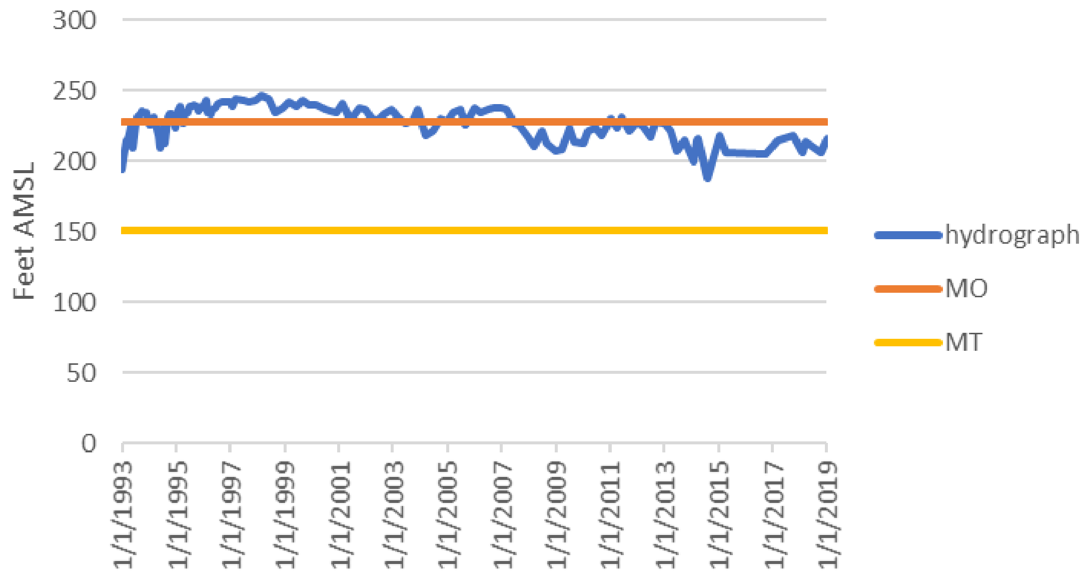

Figure 5-11d. DMW 05 Hydrographs [1993 – 2018], MO, and MT

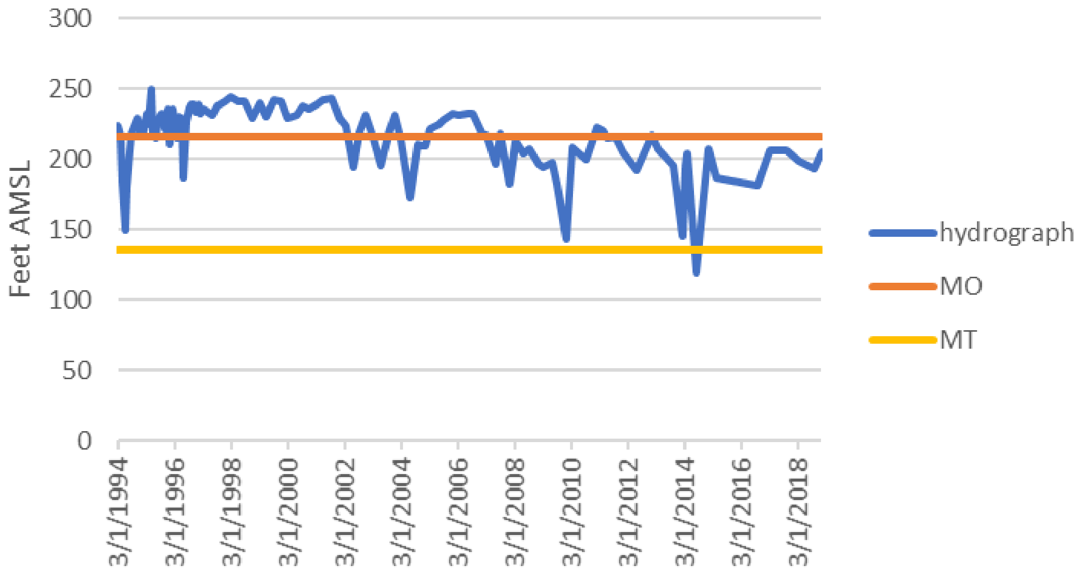

Figure 5-11e. DMW 06 Hydrographs [1993 – 2018], MO, and MT

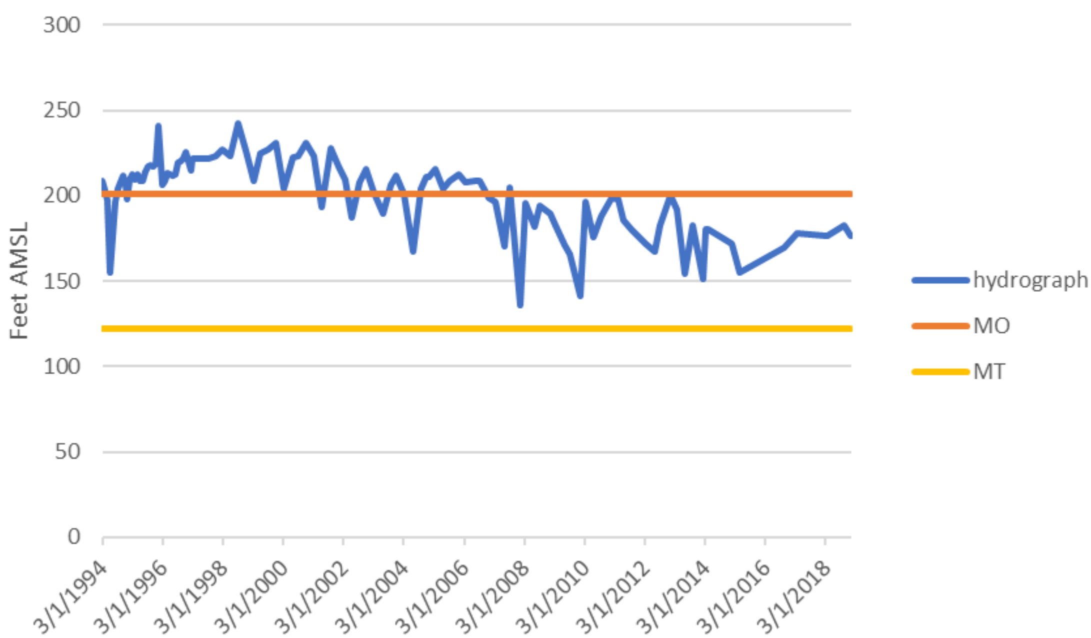

Figure 5-11f. DMW 07 Hydrographs [1993 – 2018], MO, and MT

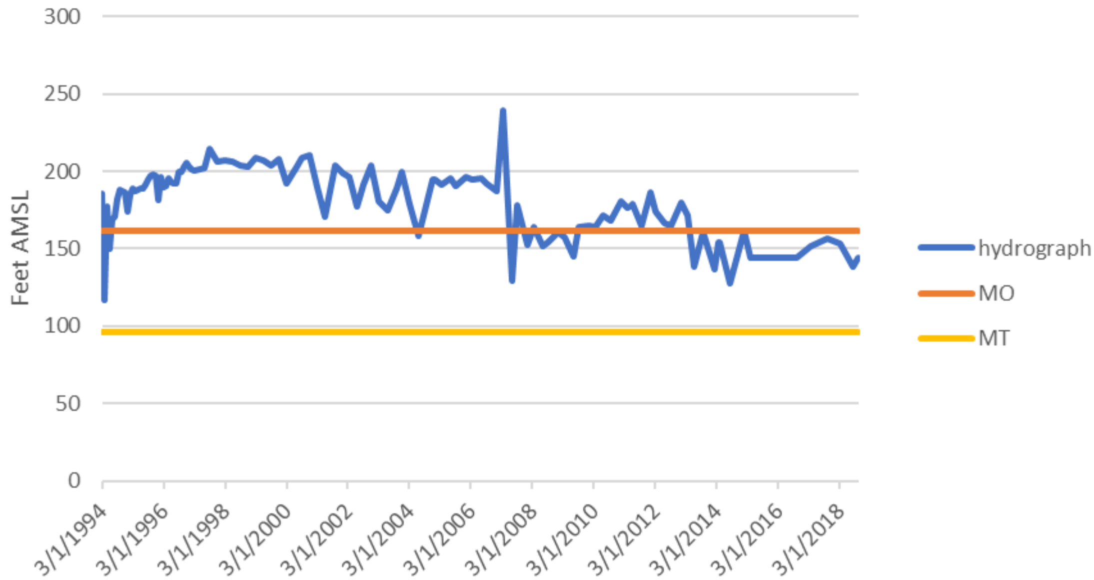

Figure 5-11g. DMW 08 Hydrographs [1993 – 2018], MO, and MT

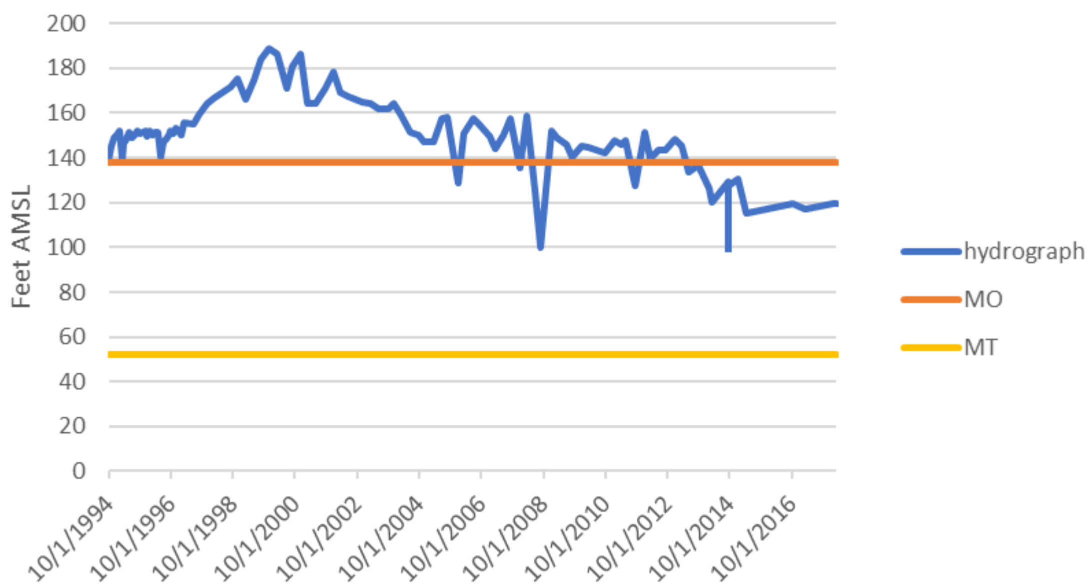

Figure 5-11h. DMW 10a Hydrographs [1993 – 2018], MO, and MT

Figure 5-11i. DMW 12b Hydrographs [1993 – 2018], MO, and MT

5.4.3 Margin of Operational Flexibility

The margin of operational flexibility within the BVGSA is the range in water levels established at each representative monitoring site between the measurable objective and the minimum threshold. The capacity to respond to droughts available within the margin of operational flexibility can be augmented during extreme drought by lowering groundwater elevations below the recommended MTs to the top of the E-clay. Although groundwater levels could be drawn below the recommended MTs on a temporary basis, operation below the MTs may require mitigation for well owners impacted during this period.

Table 5-6 summarizes the MOs, MTs, and margins of operational flexibility recommended at each of the 9 representative monitoring sites in the BVGSA network for observing chronic lowering of groundwater levels. Figure 5-12 is a graphical presentation of this data illustrating the relation between the January 2015 water levels, MOs and MTs and how the recommended margin of operational flexibility expands in the southern portion of the BMA because of the need to account for operations in adjacent areas.

Table 5-6. January 2015 Water Levels and Projected 2040 Levels

Well ID	January 2015 Levels (ft AMSL)	Recommended MOs (ft AMSL)	Recommended MTs (ft AMSL)	Margin of Operational Flexibility (ft)
dmw01	189	210	139	71
dmw02	156	182	95	87
dmw04	222	229	156	73
dmw05	218	228	151	77
dmw06	207	216	135	81
dmw07	172	201	122	79
dmw08	161	161	96	65
dwm10a[1]	131	138	52	86
dmw12b[2]	102	16	-70	86

1 Nested monitoring well DMW 10: screened above E-clay
2 Nested monitoring well DWM 12: screened above E-clay

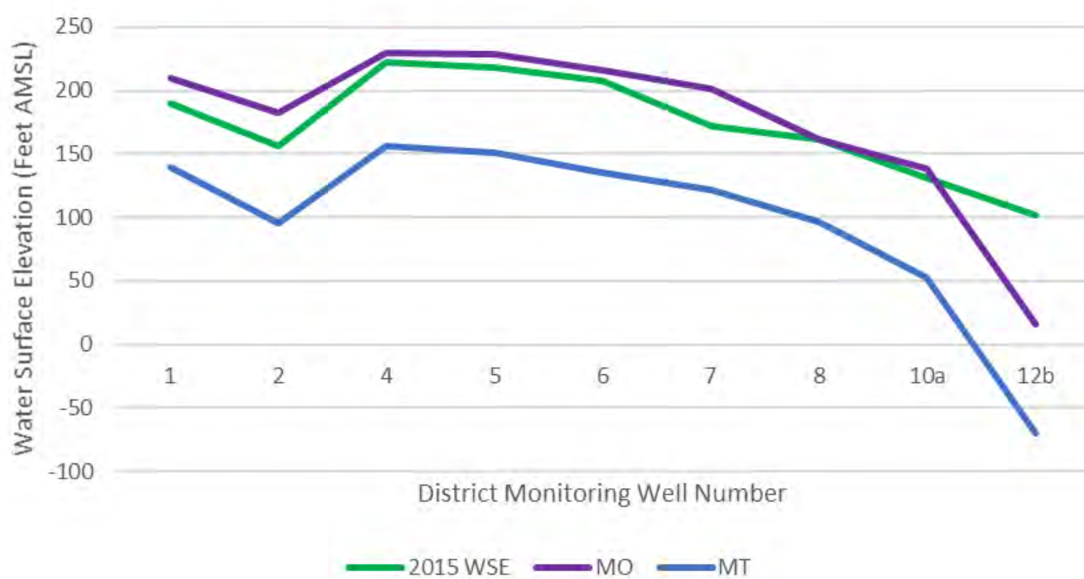

Figure 5-12. MT and MO Relative to 2015 WSE

5.4.4 Interim Milestones

Because the measurable objectives for groundwater elevations align closely with historic water levels in most of the BMA, no MA-wide interim milestones have been established to correct chronic lowering of groundwater elevations. In the extreme south of the BMA, the measurable objective has been set some distance below historic water levels because of the influence water banking activity in neighboring areas has on groundwater levels. Nevertheless, the margin of operational flexibility in this area is slightly higher than those set at most other representative monitoring locations. While no interim milestone has been set in this area, it is recognized that groundwater levels are likely to fluctuate over a wider range than in other locations because of the activity of neighboring water banks and in response to development and operation of the Palms Project described in Section 7 – Projects, Management Actions, and Adaptive Management Actions.

5.4.5 Representative Monitoring

As discussed in the preceding section, Sustainable Management Criteria for monitoring chronic lowering of groundwater levels were established at each of the BVGSA's 9 representative monitoring sites. These sites will be observed throughout the implementation of SGMA to monitor this sustainability indicator. A more complete discussion of the BVGSA's monitoring network is presented in Section 4 – Monitoring Networks.

5.4.6 Management Areas

The BVGSA has two management areas, the Buttonwillow MA (BMA) which aligns closely with the boundaries of the BVWSD's Buttonwillow Service Area and the Maples MA (MMA) whose boundaries match those of the BVWSD's Maples Service Area. The two MAs are physically distinct being separated by 15 miles. The MMA lies within HZ 10 and within the Kern River GSA (KRGSA). Because of the MMA's location within the KRGSA, Sustainable Management Criteria for this MA will align with those established for other areas of the KRGSA. As described throughout this GSP, the BMA is a distinct entity with respect to its hydrogeologic features and management practices. For this reason, the BSA will be treated as a single unit allowing groundwater levels to be monitored and managed consistently throughout the entire MA.

5.5 Reduction in Groundwater Storage

5.5.1 Minimum Thresholds

The draft BMP on Sustainable Management Criteria (DWR, 2017) defines the minimum threshold for significant and unreasonable reduction in groundwater storage as follows:

> The minimum threshold for reduction of groundwater storage is a volume of groundwater that can be withdrawn from a basin or management area, based on measurements from multiple representative monitoring sites, without leading to undesirable results. Contrary to the general rule for setting minimum thresholds, the reduction of groundwater storage minimum threshold is not set at individual monitoring sites. Rather, the minimum threshold is set for a basin or management area.

5.5.1.1 Establishment

Chronic lowering of groundwater levels is an undesirable result that increases the cost to access groundwater and, because of its local impacts, is governed using MTs established for individual monitoring sites. In contrast, significant and unreasonable reduction in groundwater storage constrains the amount of groundwater available at any cost. Both sustainability indicators have broad implications on the Kern County Subbasin's capacity to manage groundwater sustainably.

Since the primary causes of both chronic lowering of groundwater levels and significant reductions in groundwater storage are extended periods of extraction beyond the sustainable yield, the BVGSA has used data from wells included in the GSA's representative monitoring network to glean information on historic groundwater elevations. This information, together with data on the characteristics of the principal aquifer, was then used to define the volume of groundwater that can be extracted within the GSA's boundaries without leading to undesirable results.

5.5.1.2 Considerations Used

What are the historical trends, water year types, and projected water use in the basin? Historical trends in water use in the BVGSA's portion of the Kern County Subbasin have been shaped by agricultural land use and by water year types. As land and water uses within the BVGSA are projected to remain dominated by irrigated agriculture, the same factors that have influenced past trends are expected to extend into the future. Section 2 - Basin Setting provides an extensive discussion of water uses within the BVGSA and of historical and projected trends.

Table 5.7 lists water year types from 1993 through 2017 for the Sacramento Valley and San Joaquin Valley indices. Both indices are shown because of the BVWSD's access to water diverted from the Kern River and exported from the Sacramento-San Joaquin Delta.

Table 5-7. Sacramento Valley and San Joaquin Valley Water Year Types

Year	Year Type	
	Sacramento Valley	San Joaquin Valley
1993	AN	W
1994	C	C
1995	W	W
1996	W	W
1997	W	W
1998	W	W
1999	W	AN
2000	AN	AN
2001	D	D
2002	D	D
2003	AN	BN
2004	AN	D
2005	AN	W
2006	W	W
2007	D	C
2008	C	C
2009	D	BN
2010	BN	AN
2011	W	W
2012	BN	D
2013	D	C
2014	C	C
2015	C	C
2016	BN	D
2017	W	W

C - Critical
D - Dry
BN - Below Normal
AN - Above Normal
W - Wet

What groundwater reserves are needed to withstand future droughts? The elevation differences between the recommended measurable objectives and recommended minimum thresholds used to monitor chronic lowering of groundwater levels have been applied to estimate the volume contained between these two boundaries with this volume being the reserve capacity available to withstand future droughts. Surfaces for these groundwater elevations were created using numerical models and GIS techniques based on elevations from the monitoring sites and other wells within and adjacent to the BSA. The data was used to create surfaces for the MOs and MTs that defined the upper and lower bounds of the drought reserve portion of the principal aquifer system (the margin of operational flexibility). This volume, together with a range of specific yield estimates of the principal aquifer system [0.10 and 0.20], presented in Section 2 -

Basin Setting, resulted in a required drought reserve contained within the margin of operational flexibility that ranges from 362,000 AF to 724,000 AF, which, when combined with the reserve requirements for other areas of the Kern County Subbasin, form the basis for computing the volume of groundwater that can be withdrawn from the Subbasin without leading to undesirable results. Table 5-8 presents a summary of the calculation to arrive at an estimate for the drought reserve.

Table 5-8. Estimated Drought Reserve

Total Volume	3,620,000	AF
Specific Yield: Low	0.10	
Specific Yield: High	0.20	
Drought Reserve: Low	**362,000**	**AF**
Drought Reserve: High	**724,000**	**AF**
Drought Reserve: Average	**543,000**	**AF**

In addition to the drought reserve contained within the margin of operational flexibility, water stored within the aquifer zone lying between the recommended MTs and the top of the E-clay, estimated by the methods described above, yield an average value of 1,804,000 AF that can be accessed on a temporary basis to augment the storage available above the recommended MTs. During these extreme events, the recommended MTs will remain the primary metrics for avoidance of undesirable results. Table 5-9 presents a summary of the calculation to arrive at an estimate for water that is available for temporary access.

Table 5-9. Estimated Temporary Access Drought Reserve

Total Volume	12,029,000	AF
Specific Yield: Low	0.10	
Specific Yield: High	0.20	
Temporary Access: Low	**1,203,000**	**AF**
Temporary Access: High	**2,405,000**	**AF**
Temporary Access: Average	**1,804,000**	**AF**

- Have production wells ever gone dry? One production well, DW-1, in the extreme south of the BVGSA went dry in 2015 during the recent drought. Water levels in this well have since recovered, and the well is back in operation. The location of DW-1, in an oil field area near Tupman is not typical of other production wells in the GSA, and no other wells in the BVGSA have ever gone dry. The preceding tables of well depths and screened intervals for agricultural, municipal, domestic and industrial wells (Tables 5-2 and 5-3) show that minimum wells depths in all categories extend below groundwater levels observed during the recent drought with the exception of this one location.

- What is the effective storage of the basin? This may include understanding of the:

- Average, minimum, and maximum depth of municipal, agricultural, industrial and domestic wells.

Table 5-10 presents mean, median, minimum and maximum depths of municipal, agricultural, industrial and domestic wells, information also shown in Table 5-2.

Table 5-10. Well Depth Data (duplicate of Table 5-2)

Depth (ft)/ Use	Municipal	Agricultural	Domestic	Industrial
Maximum	700	1,101	522	500
Minimum	443	138	150	150
Median	498	460	360	346
Mean	547	477	356	330

- Impacts on pumping costs (i.e., energy cost to lift water).

The effective storage of the BMA portion of the Kern County Subbasin is defined as the storage capacity of the principal aquifer between pumping levels observed in 2015 and the top of the E-clay. This definition restricts effective storage to the aquifer zone that can be accessed without raising risks of significant and unreasonable levels of subsidence or reductions of groundwater quality. As displayed below in Table 5-11, the effective storage capacity of the principal aquifer between the January 2015 groundwater contour and the top of the E-clay is estimated to be 2,329,000 AF, 129 percent of the reserve requirement computed above.

Table 5-11. Estimated Effective Storage of the BMA

Total Volume	15,529,000	AF
Specific Yield: Low	0.10	
Specific Yield: High	0.20	
Effective Storage: Low	**1,553,000**	**AF**
Effective Storage: High	**3,106,000**	**AF**
Effective Storage: Average	**2,329,000**	**AF**

- What are the adjacent basin's minimum thresholds? The BVGSA lies within the Kern County Subbasin and does not border any adjacent basins. The minimum threshold now established for reduction in groundwater storage in the Kern County Subbasin is __.

5.5.2 Measurable Objectives and Interim Milestones

Based on the following language from the SGMA regulations governing measurable objectives, the BVGSA will use the representative measurable objectives described above for groundwater elevations to serve as a proxy for attainment of measurable objective related to groundwater storage within the boundaries of the GSA. The groundwater storage objectives established for the GSA will contribute to definition of the measurable objective for the Kern County Subbasin.

> *(d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.*
> *(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.*

5.5.2.1 Establishment

As described above, the measurable objectives for groundwater elevations align closely with elevations observed in 2015. As these groundwater elevations serve as proxies for groundwater storage, it follows that storage volumes estimated for 2015 will serve as proxies for measurable objectives within the BMA that can be used in development of the basin-wide measurable objectives for groundwater storage required by SGMA.

As described above, the measurable objectives and minimum thresholds at each of the 9 monitoring sites used in the BMA to observe chronic lowering of groundwater levels have been applied in the computation of the drought reserve requirements with this estimate contributing to determination of the overall groundwater reserve capacity for the Subbasin.

5.5.2.2 Considerations used

The primary consideration used in setting measurable objectives is to maintain groundwater storage adequate to enable the Kern County Subbasin to weather future droughts without leading to undesirable results. The margin of operational flexibility set for chronic lowering of groundwater levels was used in estimating the groundwater reserves available for responding to drought.

5.5.3 Margin of Operational Flexibility

The margin of operational flexibility within the BVGSA is the volume of effective storage between the recommended MOs and the recommended MTs defined for management of chronic lowering of groundwater elevations. This volume, displayed in Table 5-8 of approximately 543,000 AF, constitutes the GSA's drought reserve. As displayed in Table 5-9, the capacity to respond to droughts available within the margin of operational flexibility can be augmented by approximately 1,804,000 AF of temporary access storage available between the recommended MTs and the top of the E-clay. Although groundwater storage could be reduced below the volume maintained by adherence to the recommended MTs on a temporary basis, operation below the MTs may require mitigation for well owners impacted during this period.

5.5.4 Interim Milestones

While no interim milestones for chronic reduction of groundwater levels, the proxy for reduction of groundwater storage, have been set in the BMA, it is recognized that groundwater levels are likely to fluctuate in the southern portion of the MA which will result in fluctuations in groundwater storage due to the activity of neighboring water banks and in response to development and operation of the Palms Project. Therefore, groundwater conditions in the BVGSA are unlikely to affect setting of interim milestones for the Kern County Subbasin.

5.5.5 Representative Monitoring

Sustainable management criteria for reductions in groundwater storage are addressed using the same monitoring network and metrics as chronic lowering of groundwater levels using data collected throughout the Subbasin to monitor basin-wide minimum thresholds and measurable objectives.

An important data gap related to estimating reductions in groundwater storage is the completeness and reliability of aquifer parameters available to convert observed changes in groundwater levels to corresponding changes in storage. Continued development and calibration of groundwater models is expected to improve our understanding of these relations for various aquifer materials and conditions.

5.5.6 Management Areas

Because reduction of groundwater storage has sustainable Management Criteria set at a Subbasin scale, monitoring of groundwater levels in the BMA and in the KRGSA will be used to capture the influence of changes in storage within the BVGSA's two management areas on Subbasin-wide minimum thresholds and measurable objectives.

5.6 Water Quality

5.6.1 Minimum Thresholds

The minimum threshold metric for degraded water quality shall be water quality measurements that indicate degradation at the monitoring site. This can be based on migration of contaminant plumes, number of supply wells, volume of groundwater, or the location of a water quality isocontour within the basin. Depending on how the GSA defines the degraded water quality minimum threshold, it can be defined at a site, along the isocontour line, or as a calculated volume.

5.6.1.1 Establishment

The purpose of this section is to review groundwater quality conditions in the BVGSA that may affect the supply and beneficial uses of groundwater as stated under CCR §354.16. This section includes a discussion of water quality standards and information relevant to groundwater quality within the GSA.

Agricultural Wells

Agricultural wells are used to meet crop demands during periods when deliveries of surface water are insufficient. The Buena Vista Coalition monitors groundwater quality through its participation in the Irrigated Lands Regulatory Program (ILRP). Data collected for the (ILRP's) Groundwater Quality Trend Monitoring Work Plan (GQTMWP) and reported through the GAMA database will be a major source for monitoring water quality in agricultural wells.

Domestic Wells

Domestic wells are used exclusively to supply general household needs of the property owner and are typically shallower than municipal or agricultural wells. Therefore, domestic wells are the first to be impacted by surface contaminants leaching into the groundwater.

Currently, information about domestic wells is limited. However, there is an effort being led by the SWRCB, as well as multiple other agencies, to explore the best sources of information and conduct a Needs Assessment of domestic wells in areas vulnerable to contamination.

Public Water Systems

While land use within the BVGSA is predominately agricultural, 4 public water systems have been identified through the GAMA (Groundwater Ambient Monitoring and Assessment) data base. Two of these systems, the Buttonwillow County Water District and the Mirasol Company, are classified as community water systems, meaning there are at least 15 service connections, or 25 year-round residents are served. The remaining systems are non-transient, non-community (NTNC) water systems. Table 5-12 lists the 4 public water systems and their classification, estimated population served, number of connections and number of wells. Figure 1-5 – Permitted Public Water Systems shows their locations within the Buttonwillow Management Area (BMA). (Figure 1-5, Refer to Figures Tab)

Community and NTNC water systems are required to test for most regulated constituents at least once every 3 years. Water quality data from regulated drinking water systems is available through the State Drinking Water Information System (SDWIS).

Table 5-12. Public Water Systems Within the BVGSA

Water System #	Water System Name	Type	Population Served	Number of Connections	Number of Wells
1500152	Mirasol Company	C	29	13	2[2]
1510011	Buttonwillow CWD[1]	C	1,266	442	3
1500495	Aera Energy – LLC	NTNC	50	80	5[3]
1503671	Sunnygem Juice Plant	NTNC	60	7	1

C = Community water system
NTNC = Nontransient non-community water system
[1] Well #1 taken out of service because of TDS level of 1,100 mg/L
[2] Water quality data from 1 Mirasol Company well reported in SDWIS
[3] Water quality data from 2 Aera Energy wells reported in SDWIS

Source: Tulare Lake Basin Water Alliance

5.6.1.2 Considerations Used

- What are the historical and spatial water quality trends in the basin? Figures 2-7 through 2-12 are pairs of maps displaying the spatial distribution of three water quality constituents prominent in the BVGSA: Nitrate, TDS, and Arsenic. Each of the constituents is displayed in two figures, the first based on data covering the period up to 2000 and the second based on data from 2001 through 2017.

- What is the number of impacted supply wells? Only one production well, Buttonwillow CWD Well #1 has been taken out of service because of water quality limitations, high TDS levels. Two BVWSD production wells, DW-3 and DW-6, have reported nitrate readings that exceeded 40 mg/L. Both wells remain active and are in a High Vulnerability Area defined by the ILRP that is being managed under a Groundwater Quality Management Plan developed by the Buena Vista Coalition.

- What aquifers are primarily used for providing water supply? The principal aquifer system for the BVGSA lies in the Tulare Formation.

- What is the estimated volume of contaminated water in the basin? Although water in the principal production aquifer varies in quality, all water in this aquifer is generally suitable for domestic and agricultural purposes.

- What are the spatial and vertical extents of major contaminant plumes in the basin, and how could plume migration be affected by regional pumping patterns? There are no major contaminant plumes identified within the boundaries of the BVGSA.

- What are the applicable local, State, and federal water quality standards? Federal and state drinking water standards are often referenced when discussing water quality. However, because the predominant land use in the BVGSA is agriculture, the agricultural *Water Quality Goals* (Ag Goals) will also be considered for evaluation of groundwater quality, and the most applicable metric, Drinking Water Standard or Ag Goal, will be used as a reference point when discussing each constituent.

- What are the major sources of point and nonpoint source pollution in the basin, and what are their chemical constituents? Major sources of non-point source pollution in the BVGSA include irrigated agriculture and septic systems. There are no major point sources of pollution in the GSA.
- What regulatory projects and actions are currently established to address water quality degradation in the basin (e.g., an existing groundwater pump and treat system), and how could they be impacted by future groundwater management actions? The major regulatory program in force in the BVGSA is the Central Valley Regional Water Quality Control Board's Irrigated Lands Regulatory Program. This program addresses degradation of water quality resulting from practices associated with irrigated crop production.
- What are the adjacent basin's minimum thresholds? The BVGSA lies within the Kern County Subbasin and does not border any adjacent basins. Minimum thresholds for water quality in adjacent GSAs are??

5.6.2 Measurable Objectives and Interim Milestones

5.6.2.1 Establishment

As described in Section 2 – Basin Setting, the BVGSA is part of an inland groundwater basin with no significant outflow. Because salts imported into the area have no natural outlet, the complex hydrogeologic processes that dissolve, transport, dilute, concentrate, and precipitate salts have the net effect of increasing the mass of salts residing in the area (KCWA, 2012). The most prominent of these mechanisms involves salts conveyed in water imported via the California Aqueduct and applied to irrigated lands. Because of the dominance of irrigated agriculture in the GSA, the water quality conditions faced by the BVGSA are characteristic of rural areas with an absence of contaminate plumes or clean-up sites associated with more industrialized areas.

5.6.2.2 Considerations Used

Groundwater conditions in the BVGSA were evaluated using a combination of water quality data from representative wells (used to establish and monitor sustainable management criteria) and data on wells belonging to public water systems drawn from the 7 wells reported in the SDWIS system. All available water quality data was evaluated to identify constituents of concern. Not all constituents identified in Table 5-13 as being commonly found in the Kern County Subbasin are found at concerning concentrations in the BVGSA.

Table 5-13. List of Constituents and Standards

Constituent	Units*	Drinking Water Standard	Agricultural Water Quality Goal
Arsenic	ppb	10	100
Boron	ppb	1,000	700
Chloride	ppm	250	106
Dibromochloropropane (DBCP)	ppt	2	n/a
Hexavalent Chromium	ppb	n/a	n/a
Nitrate	ppm	10	n/a
Sodium	ppm	n/a	69
1,2,3-Trichloropropane (TCP)	ppt	5	n/a

*ppt = parts per trillion
ppb = parts per billion
ppm = parts per million

TCP, Cr6 and DBCP

TCP is a newly regulated synthetic organic chemical. The State Water Board reports that contamination in the Central Valley is predominately from legacy applications of certain soil fumigants. The drinking water MCL is 5 ppt; there is no Ag goal. While TCP contamination is widespread throughout the Subbasin, there appears to be less occurrence in areas such as the BVGSA where the E-clay is present. Of the 7 public supply wells tested, none have data reported on TCP. Similarly, all public water supply wells in the BVGSA report concentrations of Cr6 and DBCP that are below the levels of detection. None of these three constituents are monitored in wells reported in the BVWSD's STORM database.

Boron

Boron has not been reported for any of the 7 public water supply system wells in the SDWIS database. The boron levels reported in the STORM database are all below the Ag Goal of 700 ppb with a maximum reported reading of 385 ppb at DMW 03.

Nitrate

Nitrate contamination is a significant concern in rural communities, particularly where agriculture is the predominant land use. However, other significant sources of nitrate may include municipal water treatment plants and septic systems. Since municipal services (drinking water or wastewater collection systems) are available only for the Community of Buttonwillow, domestic and public wastewater disposal in most of the BVGSA is through onsite septic systems.

Nitrate can be naturally present at low concentrations in groundwater, typically less than 2 ppm. Moderate and high concentrations generally occur because of human activities. Septic systems typically contribute moderate concentrations between 5 and 15 ppm of nitrate as nitrogen. Typically, higher concentrations (greater than 20 ppm) are associated with fertilizers applied to crops. Nitrate contamination is a significant public health concern because of its acute health effects. High concentrations of nitrate are typically found in unconfined aquifers such as the BVGSA's principal aquifer system.

Examination of data from the BVWSD STORM database showed nitrate levels are generally well below the MCL with only 3 readings over the drinking water MCL. Two of these readings (10.23 mg/L and 10.62 mg/L) were recorded at DW06 and one (10.39 mg/L) was recorded at DW03. Both wells lie in the Southern High Vulnerability Area designated under the Irrigated Land Regulatory Program for the Buena Vista Coalition. A Groundwater Quality Management Plan has been developed for monitoring groundwater in this area and for correcting the causes of observed exceedances. The elevated nitrate concentrations observed in DW03 and DW06 and noted on Table 5-14 may result from agricultural practices, operation of a nearby waste water treatment plant or a combination of factors.

Table 5-14. Summary of Nitrate Prevalence in BVGSA Wells

Nitrate Concentrations (ppm) (# of readings)		
0-5	**6-10**	**>11**
83	8	3

Data from the SDWIS system for the 7 wells belonging to public water systems showed no readings above 5 ppm as shown in Table 5-15.

Table 5-15. Summary of Nitrate Prevalence Among Public Water Systems

	Nitrate Concentrations (# of readings)		
Water System	**0-5 ppm**	**6-10 ppm**	**>11 ppm**
1500152 – Mirasol Company	11	0	0
1510011 – Buttonwillow CWD [1]	30	0	0
1500495 – Aera Energy – LLC [2]	28	0	0
1503672 – Sunnygem Juice Plant	4	0	0
Total number of readings	73	0	0

[1] Total number of readings from 3 wells
[2] Total number of readings from 2 wells

Sodium and Chloride

Land uses within the BVGSA are predominately agricultural, and for this reason both the State Water Board's Ag goals and the drinking water standards are appropriate metrics. Sodium and chloride have an agricultural goal of 69 and 106 ppm, respectively. Drinking water standards do not apply a limit for sodium. The recommended drinking water limit for chloride is 250 ppm and the upper limit is 500 ppm.

Ag goals published in 1985 by the Food and Agriculture Organization of the United Nations are established to be protective of agricultural uses of water, including irrigation of various types of crops and stock watering. Water having constituent concentrations at or below the thresholds presented in the Water Quality Goals database should not have limitations for agricultural uses.

Because TDS is a focal point of the CV-SALTS and ILRP programs and the impacts of high sodium concentrations on soils can be managed through common agronomic practices such as application of gypsum, the focal point of this discussion will be on chloride because of its potential to limit both agricultural and domestic water uses. Tables 5-16 and 5-17 summarize chloride concentrations in representative monitoring wells and in wells belonging to public water systems. These tables indicate a strong spatial distribution of chloride within the GSA with high chloride levels characterizing readings from wells in the northern portion of the BMA with chloride levels declining as one moves south. This spatial distribution is evident both for wells belonging to public water systems and for wells monitored by the BVWSD. While two of the BVWSD's three sets of nested monitoring wells (DMW 10a, b and DMW 11a,b) show chloride concentrations below the Ag threshold above and below the E-clay, the southernmost of the nested monitoring wells, DMW 12a, b, show average chloride readings of 1,466 mg/L in the aquifer below the E-clay and 75 mg/L in the upper aquifer, an average reading similar to those of each of the other nested monitoring wells.

Table 5-16. Summary of Chloride Prevalence Within the BVGSA

Chloride Concentrations (ppm) (# of readings)			
< 106	**107-250**	**251-500**	**>500**
54	12	6	38

Table 5-17. Summary of Chloride Prevalence Among Public Water Systems

	Chloride Concentrations (# of readings)			
Water System	**< 106**	**107-250 ppm**	**251-500 ppm**	**> 500 ppm**
1500152 – Mirasol Company	2	2	0	0
1510011 – Buttonwillow CWD [1]	4	3	4	0
1500495 – Aera Energy – LLC [2]	0	0	1	9
1503672 – Sunnygem Juice Plant	0	0	0	1
Total number of readings	4	5	5	10

[1] Total number of readings from 3 wells
[2] Total number of readings from 2 wells

Figure 5-13 shows maximum chloride concentrations recorded in the STORM data base at each of the District Monitoring Wells and at the 7 public water system wells reported in SDWIS. This figure illustrates the distribution of chloride concentrations along the north/south axis of the BMA, a distribution also found for sodium. (Figure 5-13 - Refer to Figures Tab)

Arsenic

The most common sources of arsenic are natural geochemical processes that leach metals from sediments, particularly in the lakebed areas and where dark clay deposits occur. Studies conducted by USGS found that arsenic is in an easily exchangeable state where oxidizing geochemical conditions, caused by groundwater containing higher oxygen content, dissolve the pyrite (a mineral which can contain arsenic) and release arsenic into the groundwater. Smith et. al. (2018) found that over-pumping in areas of the San Joaquin Valley that have experienced land subsidence due to compaction of the lakebed deposits (clay layers) have resulted in the release of high arsenic pore water from the clay layers into the groundwater. The E-clay is present in a majority of the BVGSA, although, as noted throughout this GSP, groundwater is not extracted from beneath this confining layer and high rates of subsidence have not been observed.

There are clear differences in the arsenic concentrations reported for 7 public water system wells in SDWIS and in the BVWSD wells reported in STORM. For the BVWSD wells, all readings are below the 100 ppb Ag Goal, however, there are many instances where readings exceed the 10 ppb primary drinking water standard as shown on Table 5-18.

Table 5-18. Summary of Arsenic Prevalence Within the BVGSA

Arsenic Concentrations (ppb) (# of readings)		
0-10	**11-100**	**>100**
42	130	0

Data on public water system wells displayed in Table 5-19 show readings below the primary drinking water standard of 10 ppb for all wells except for the Sunnygem Juice Plant where all readings are close to or in excess of the 100 ppb Ag Goal.

Table 5-19. Summary of Arsenic Prevalence Among Public Water Systems

	Arsenic Concentrations (# of readings)		
Water System	**0-5 ppb**	**6-10 ppb**	**>10 ppb**
1500152 – Mirasol Company	0	4	0
1510011 – Buttonwillow CWD[1]	7	5	0
1500495 – Aera Energy - LLC[2]	11	21	0
1503672 – Sunnygem Juice Plant	0	0	11
Total number of readings	18	30	11

[1] Total number of readings from 3 wells
[2] Total number of readings from 2 wells

Figure 5-14 is a map showing maximum arsenic concentrations at each of the wells reported in the STORM and SDWIS databases. As Figure 5-14 illustrates, maximum arsenic concentrations in the BMA are below the drinking water and Ag Goal south of the Community of Buttonwillow and tend to fall between the 10 ppb drinking water standard and the 100 ppb Ag Goal further north. As the figure illustrates, Sunnygem Well No. 2 has recorded maximum arsenic concentrations at or above the Ag Goal and as shown in Table 5-18, all readings from this well are above the drinking water standard. District Monitoring Well 4, which lies near the Sunnygem facility also displays an elevated maximum arsenic reading while the Aera wells immediately to the east have maximum concentrations below the drinking water standard. (Figure 5-14, Refer to Figures Tab)

Contamination Plumes

A search of contamination plumes within the BVGSA was conducted using both GeoTracker and EnviroStor databases. Based on this search, no facilities were identified as having active cleanup efforts overseen by the Regional Board. Figure 2-28 – Sites of Potential Groundwater Impacts displays the results of this search. (Figure 2-28 – Refer to Figures Tab)

5.6.3 Margin of Operational Flexibility

No margin of operational flexibility has been established for water quality in the BVGSA because most constituents of concern are regulated by the Regional Board under the ILRP. Therefore, to avoid conflict in management approach, the BVGSA will delegate groundwater quality to the BV Coalition. At this time, no contaminant plumes have been identified in the GSA and there are no active cleanup sites. In the event that contaminants outside the purview of the ILRP are identified, the BVGSA will coordinate with the appropriate regulatory agency to determine a suitable response program including a margin of operational flexibility.

5.6.4 Interim Milestones

No interim milestones for groundwater quality have been established for the BVGSA as only isolated occurrences of problematic water quality constituent levels have been identified and these are being address under the Groundwater Quality Management Plans prepared by the BV Coalition.

5.6.5 Representative Monitoring

Groundwater quality within the BVGSA is now monitored at production and monitoring wells owned by the BVWSD, at a small number of private wells identified in the Buena Vista Coalition's Groundwater Quality Trend Monitoring Work Plan (GQTMWP), and at wells belonging to the public water systems listed in Table 5-12. Water quality data from these sources is available from the BVWSD's STORM data management system and from the EPA's STORETS data base. Groundwater elevations are available from STORM and from DWR's California Statewide Groundwater Elevation Monitoring (CASGEM) system.

Wells included in the existing groundwater quality monitoring network report data from locations throughout the GSA. Additional wells have been included in the SGMA groundwater quality monitoring network to observe the quality of groundwater flows in the following boundary areas:

- The southern boundary where groundwater flux is driven by pumping within the GSA and in neighboring water banks, and

- The northern area where poor quality groundwater is believed to flow into the GSA from the west. Because of the scarcity of deep wells in this area, the initial monitoring network includes 4 piezometers that will serve as sentries to observe the influence of water flowing from the west.

Table 5-20 presents the latitude and longitude of each of the 6 deep wells and the 4 piezometers included in both the GQTMWP and the GSA groundwater quality monitoring networks. The table also shows the locations of 4 District Monitoring Wells that will supplement those monitored by the Buena Vista Coalition. As shown in Figure 4-6a – Map of Network for Groundwater Quality Monitoring, these monitoring locations are distributed so the greatest concentrations of sites are found either in areas that have experienced groundwater quality problems in the past or at locations where the monitoring point can serve as a sentinel for down-gradient areas.

Table 5-20. Groundwater Quality Monitoring Locations

Well Name	Well Type	Latitude	Longitude	GQTMWP
DMW01	District Monitoring	35.60140	-119.61755	No
DMW04	District Monitoring	35.51370	-119.59845	Yes
DMW06	District Monitoring	35.45265	-119.53460	No
DMW08	District Monitoring	35.39058	-119.44817	Yes
DMW12a	District Monitoring	35.31847	-119.37473	No
DMW12b	District Monitoring	35.31847	-119.37473	No
DW03	District Production	35.38104	-119.41521	Yes
DW05	District Production	35.38929	-119.43253	Yes
DW06	District Production	35.39731	-119.44775	Yes
Domestic Well	Domestic	35.37812	-119.44101	Yes
PIEZ-015	Shallow Piezometer	35.58645	-119.59749	Yes
PIEZ-023	Shallow Piezometer	35.55796	-119.61786	Yes
PIEZ-034	Shallow Piezometer	35.51404	-119.61547	Yes
PIEZ-035	Shallow Piezometer	35.49936	-119.61650	Yes

5.6.6 Management Areas

The BVGSA has two management areas, the Buttonwillow MA (BMA) which aligns closely with the boundaries of the BVWSD's Buttonwillow Service Area and the Maples MA (MMA) whose boundaries match those of the BVWSD's Maples Service Area. The two MAs are physically distinct being separated by 15 miles. Because of the MMA's location within the Kern River GSA (KRGSA), Sustainable Management Criteria for water quality within this MA will align with those established for the surrounding KRGSA. Although groundwater quality varies within the BMA, the area will be treated as a single unit so that groundwater quality can be managed consistently throughout the entire MA.

5.7 Subsidence

5.7.1 Minimum Thresholds

The SGMA regulations define the minimum threshold metric for significant and unreasonable land subsidence to be the "rate and the extent of land subsidence".

As discussed above under the MT for chronic lowering of groundwater levels, avoidance of unreasonable subsidence is directly related to management of groundwater elevations and pumping rates. Unlike other sustainability indicators, the harmful effects of subsidence result from the damage it may cause to critical infrastructure and the costs of repairing or mitigating those damages. In the instance of the BVGSA, critical infrastructure that could be affected by subsidence includes the California Aqueduct and Interstate Highway 5. To avoid damage to these and other facilities, the MTs described earlier for chronic lowering of groundwater levels have been set at elevations that are intended to be protective of critical infrastructure. In addition, as discussed in Section 4 - Monitoring Network, subsidence will also be measured directly to eliminate the uncertainty associated with inferring subsidence from changes in groundwater elevations.

5.7.1.1 Establishment

Section 2.3.7 of the Basin Setting describes historic subsidence in the BVGSA. Subsidence is monitored directly through GPS stations P545 and P563, two participating stations of the Continuously Operating Reference Stations (CORS) network that provides Global Navigation Satellite System (GNSS) data. The two CORS stations lie along Interstate 5 which follows the crest of the Buttonwillow Ridge. Because of their placement along this geologic structure, there is some question regarding how well data collected from these stations represents ground movement in the BVGSA.

CORS stations P545 and P563 are part of the National Geodetic Survey (NGS), an office of NOAA's National Ocean Service that manages the CORS network, a multi-purpose cooperative endeavor involving government, academic, and private organizations. Each agency shares its data with NGS, and NGS in turn analyzes and distributes the data. As of August 2015, the CORS network contained almost 2,000 stations, contributed by over 200 different organizations, that support three-dimensional positioning, meteorology, space, weather, and geophysical applications throughout the United States. CORS enhanced post-processed coordinates approach a few centimeters relative to the National Spatial Reference System, both horizontally and vertically.

Data from the two CORS stations will be supplemented through monitoring of ground surface elevations using data provided by DWR from the Interferometric Synthetic Aperture Radar (InSAR) network that measures vertical ground surface displacement. InSAR data is collected by the European Space Agency Sentinel-1A satellite and processed by the National Aeronautics and Space Administration's Jet Propulsion Laboratory. This data provides cumulative vertical ground surface displacement from June 2015 to January 2017 for lands associated with the BVGSA.

Land surface elevations monitored using data available through CORS and InSAR will be analyzed together with data on groundwater levels to determine whether groundwater levels can serve as an indicator, and possible predictor, of subsidence. Initial analyses have relied heavily on data available from the CORS program, which has a period of record extending from 2011 through the present. Because of its short period of record, InSAR was used only to confirm relations identified through CORS data. However, during the period of SGMA implementation, the BVGSA may choose to expand its use of InSAR both for direct observation of land surface elevations and in efforts to correlate changes observed in these elevations with those observed in groundwater levels.

Preliminary analyses to identify correlations between changes in groundwater levels and changes in ground surface elevations were carried out as follows:

- Annual minimum groundwater elevations were plotted for the period from 2011 through 2018 and compared with annual minimum land surface elevations for the same period. The comparison of minimum values for both parameters focused the initial examination on identification of clear trends and mitigated differences in the timing of data collection.
- Figures 5-15a and 5-15b present an initial comparison between land surface elevations recorded at P545 and P563 and groundwater levels observed in district monitoring wells.

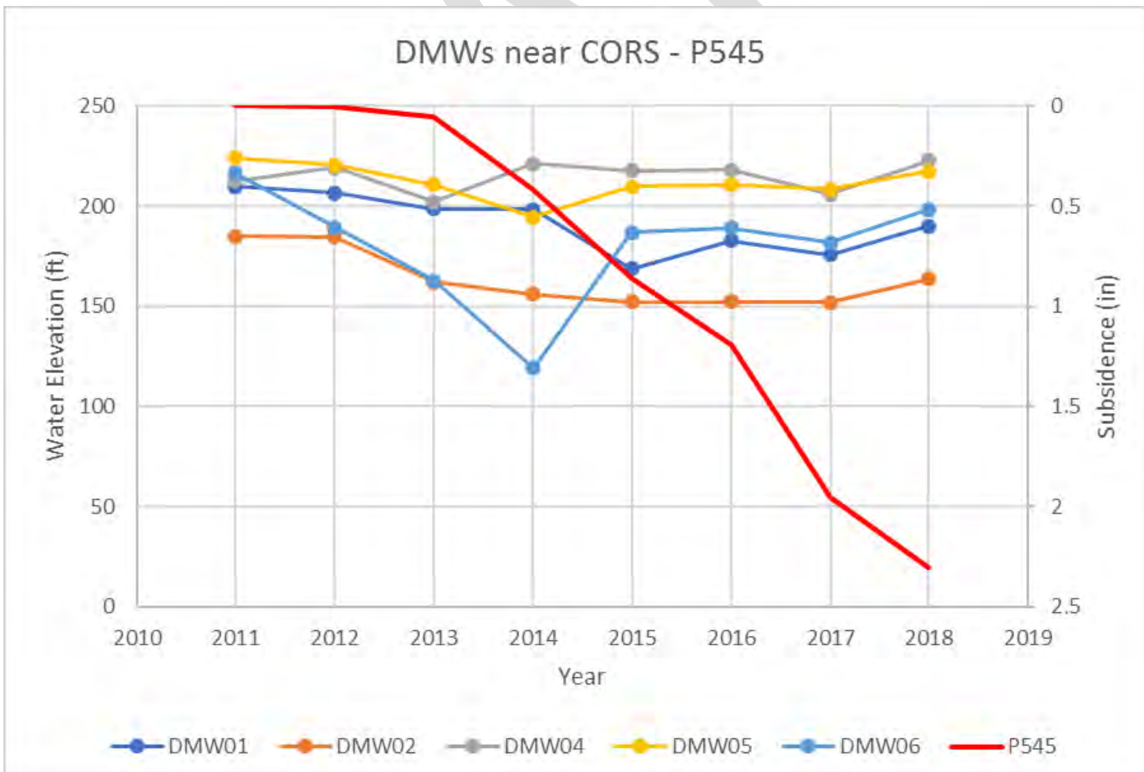

Figure 5-15a. District Monitoring Well levels versus cumulative subsidence – P545

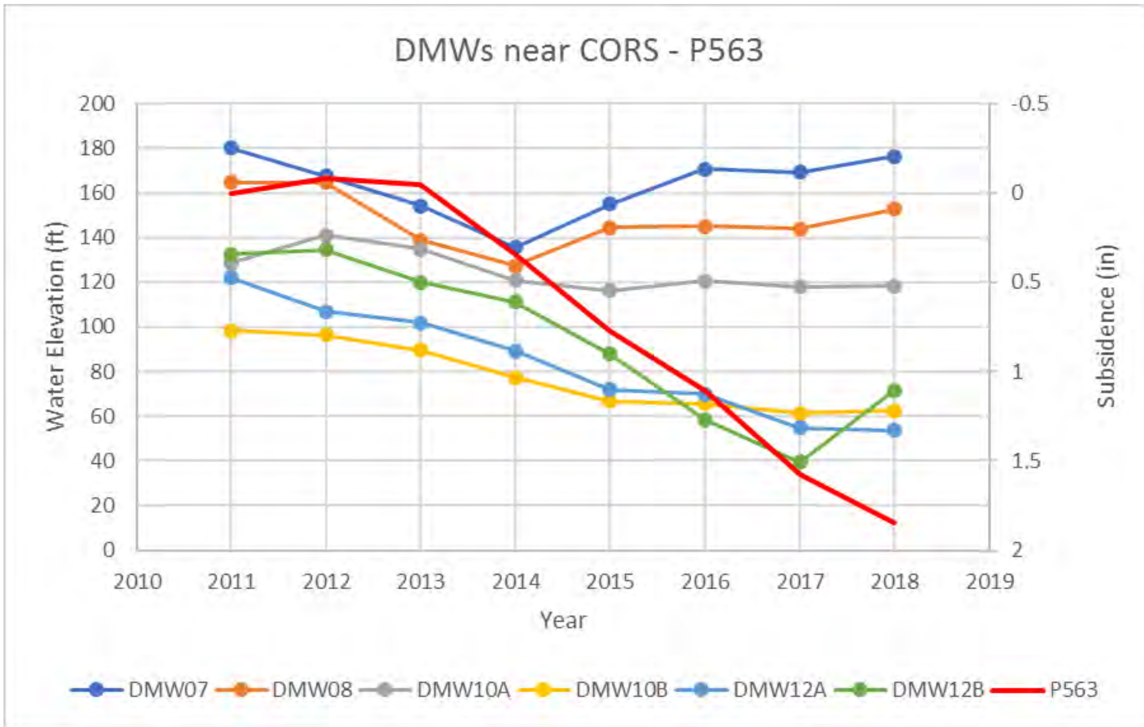

Figure 5-15b. District Monitoring Well levels versus cumulative subsidence – P563

- Based on the data plotted on figures 5-15a and 5-15b, the following wells were chosen to represent groundwater conditions at each station:
  - P545: DMW01 and DMW02
  - P563: DMW10A and DMW12B

Characteristics of each well are shown on Table 5-21.

Table 5-21. Characteristics of wells chosen for association with CORS land elevation data

Local Well	State Well	Total Well Depth	Top Perf	Bottom Perf	Nearest CORS	Distance to CORS (miles)	Direction to CORS (degrees)	WCR[1]
DMW01	27S22E08A001M	300	280	300	P545	4.40	315	X
DMW02	27S22E23D001M	300	260	300	P545	4.65	335	X
DMW10A	30S24E06B003M	450	?	?	P563	4.55	185	
DMW12B	30S24E14M003M	455	?	?	P563	7.4	150	

[1]Wells know to have Well Completion Reports (WCRs)

Cumulative changes in annual minimum water levels for DMW01 and DMW02 are plotted together with cumulative changes in annual minimum land surface elevations at P545 in figures 5-16a and 5-16b, and cumulative changes in annual minimum water levels in DMW10A and

DMW12B are plotted with cumulative changes in annual minimum land surface elevations at P563 in Figures 5-16c and 5-16d.

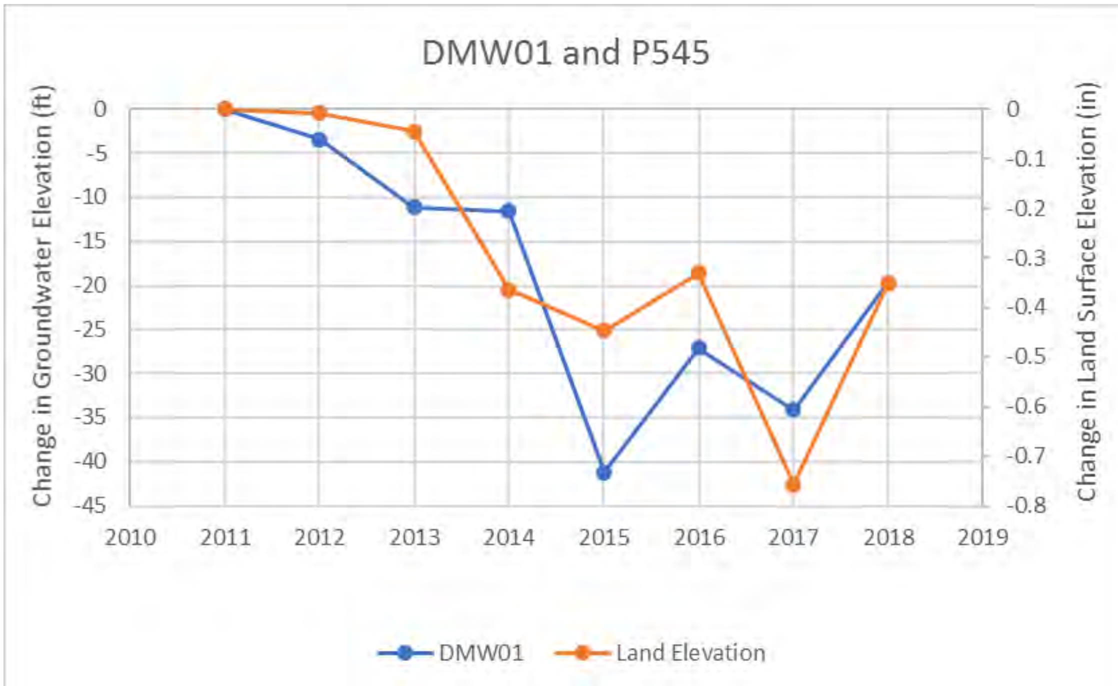

Figure 5-16a. Change in annual minimum groundwater and land surface elevations

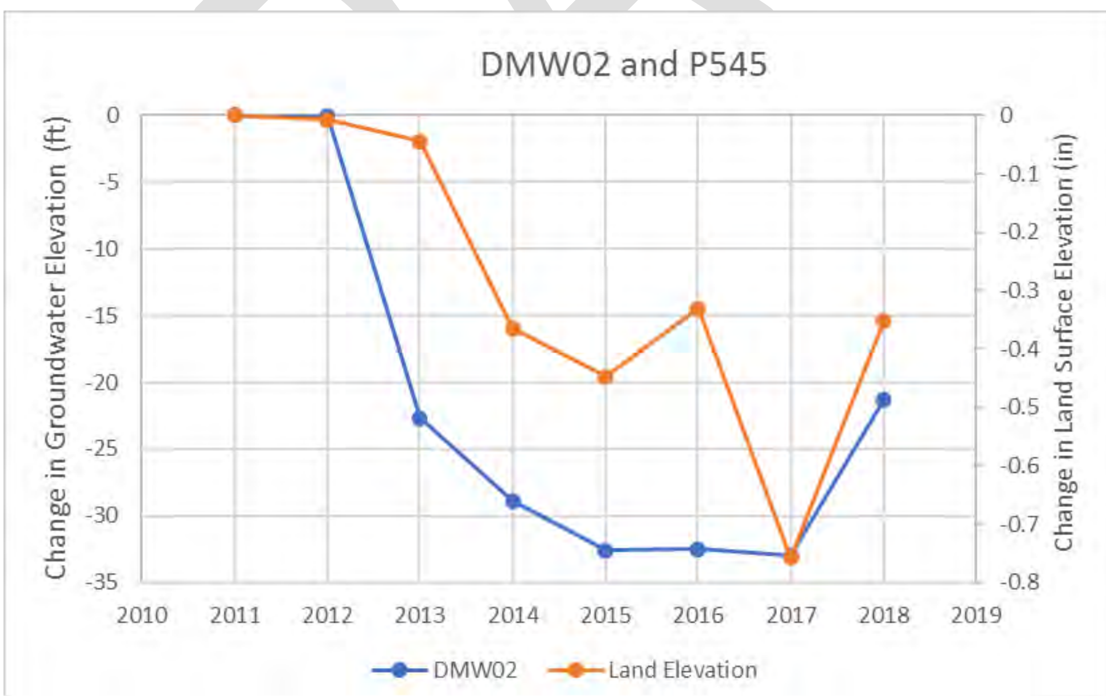

Figure 5-16b. Change in annual minimum groundwater and land surface elevations

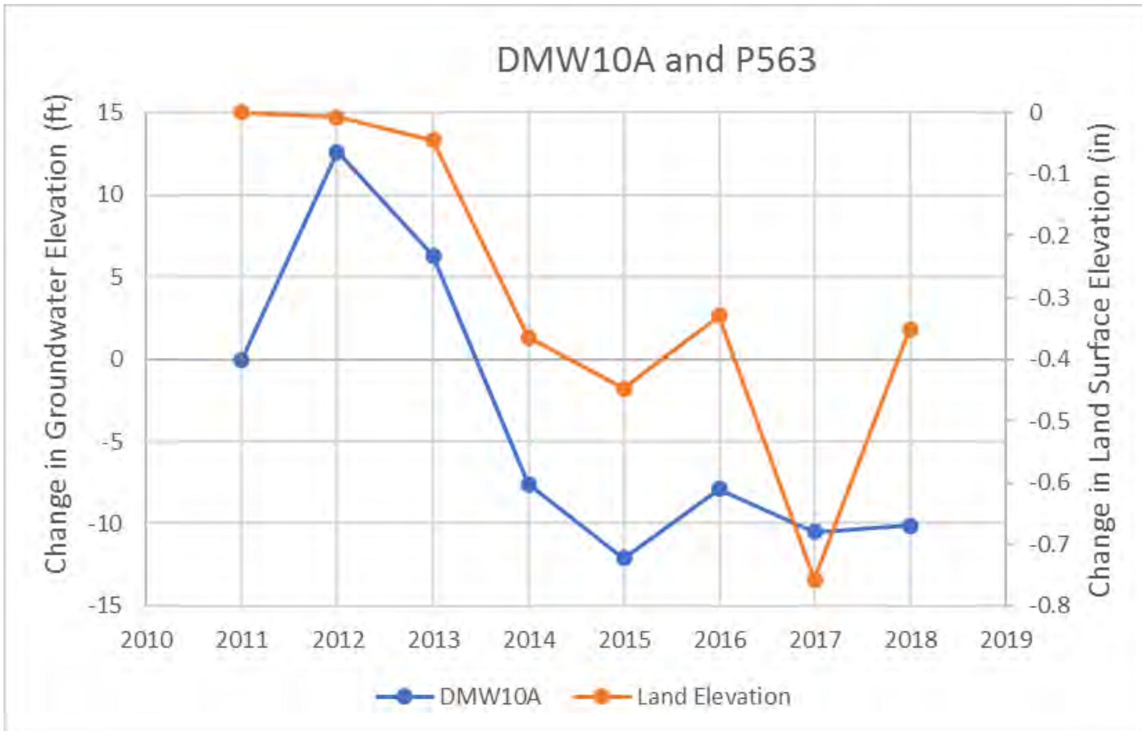

Figure 5-16c. Change in annual minimum groundwater and land surface elevations

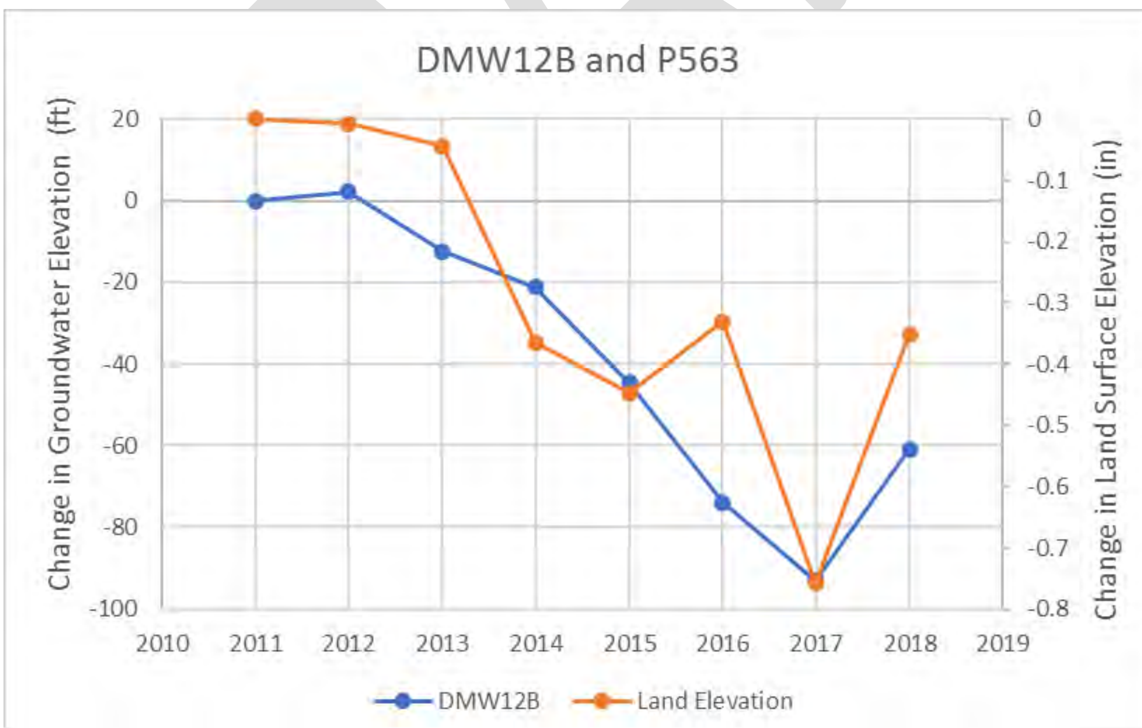

Figure 5-16d. Change in annual minimum groundwater and land surface elevations

Figures 5-16a through 5-16d show a distinct response in land surface elevation to changes in water level, a response that suggests a correlation between the two parameters. As more data is collected, the extent of this correlation both in terms of its magnitude and lags in response time will be examined using statistical packages capable of developing linear and non-linear response models.

As shown in Table 5-21, the district monitoring wells that would be used to develop these response models lie between 4.4 and 7.4 miles from the nearest CORS station. Because of the distance between the CORS stations and the nearest monitoring wells, InSAR data spanning the twenty months between June 2015 and January 2017 was analyzed to perform a supplemental analysis. InSAR data was downloaded in raster format from the California Natural Resources Agency (CNRA) website. Once downloaded, ArcGIS was used to extract elevation values at the site of each monitoring well on a monthly timestep, and cumulative changes in land elevations were then plotted together with groundwater elevations from the associated well as shown on Figures 5-17a and 5-17b.

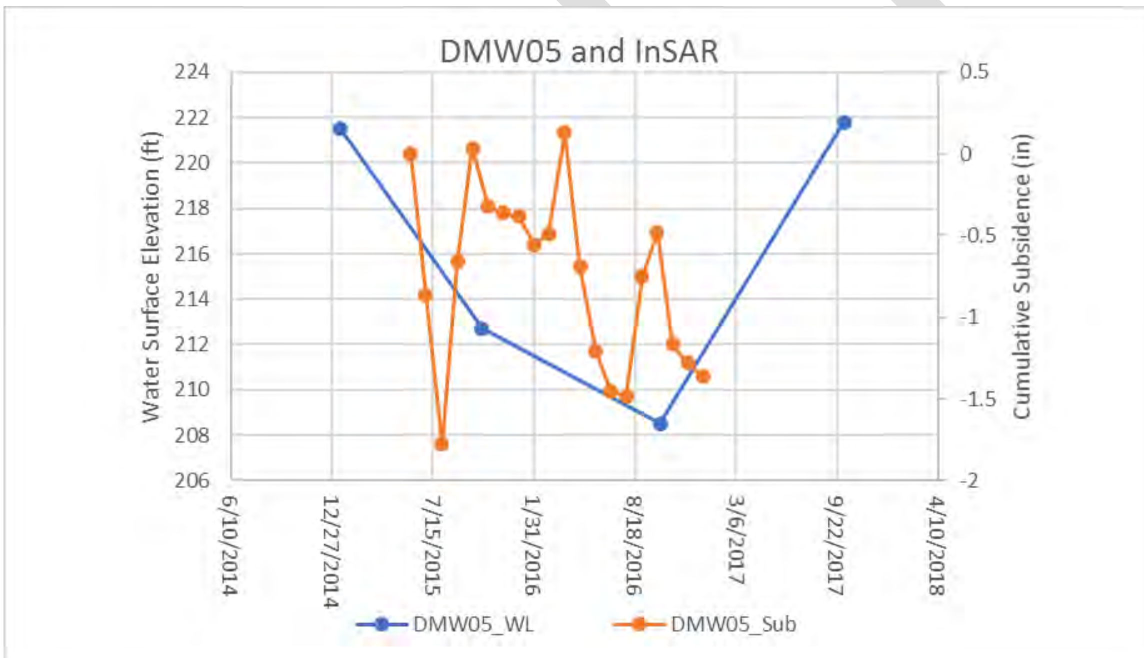

Figure 5-17a. Observed groundwater and land surface elevations

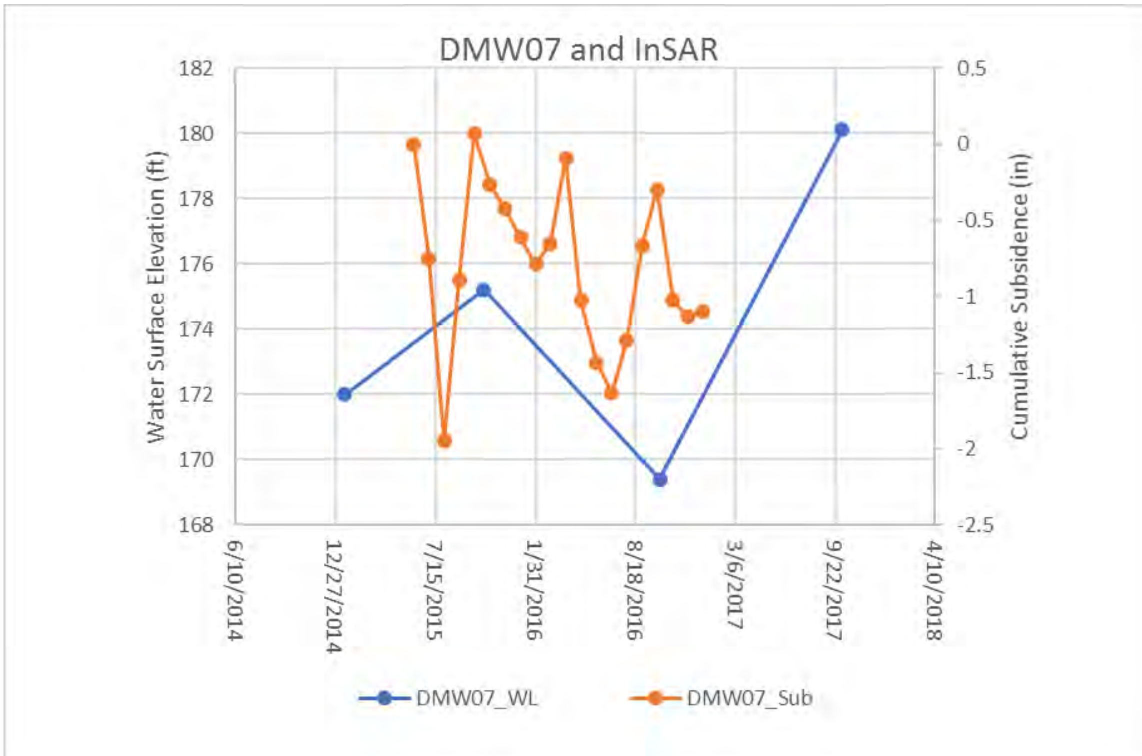

Figure 5-17b. Observed groundwater and land surface elevations

Unlike the CORS data where only annual minimums were plotted to highlight major tendencies in land surface elevations, the monthly InSAR data displays more "noise". Although DMW 05 and DMW 07 lie 9.5 miles apart, both show similar, cyclical patterns of change in land surface elevations with annual minimum elevations occurring in July, secondary minimums occurring in February and primary and secondary maximums in May and September. The timing of the minimum and maximum groundwater elevations appears counterintuitive as groundwater pumping that would be expected to cause subsidence typically continues after the annual July minimum land surface elevations are observed while maximum elevations occur not long after the peak period for groundwater pumping.

A possible explanation for the cycles of subsidence and rebound observed through InSAR lies in the soil types found in the Buttonwillow MA. Soils in the area originated from Coastal Range sedimentary rock formed on the sea bottom and are typically fine-textured and poorly drained. Classified as Alfisols, the soils result from weathering processes that leach clay minerals and other constituents out of the surface layer and into the subsoil, where they can hold and transmit moisture. Section 2 - Basin Setting provides more information on the characteristics of soils within the BVGSA.

Analysis of data from the CORS sites and from InSAR suggests that short-term oscillations in land surface elevations may result from swelling of the soil profile due to percolation of water from precipitation and irrigation and shrinkage during periods when the water content is being depleted by drainage and evapotranspiration.

This analysis suggests that the frequent fluctuations observed in land surface elevation may be caused by behavior of the soil profile that is independent of the mechanisms that drive subsidence. The preceding figures also show that minimum land surface elevations at wells in the BVGSA monitoring network are lower in 2015 than in 2016 indicating an overall recovery in land surface elevations that coincides with a period when water levels initially declined and then began to rise. Thus, in addition to the "noise" resulting from the oscillations described above, an overall uplift is evident when comparing all monthly levels for the two years. Figures 2-30 and 2-31 show longer term changes in land surface elevations also developed through data from the CORS and InSAR systems (Figures 2-30 and 2-31, Refer to Figures Tab).

5.7.1.2 Considerations Used

Considerations recommended in the BMP for Monitoring Networks and Identification of Data Gaps (DWR, 2017) when establishing minimum thresholds for land subsidence at a given representative monitoring site may include, but are not limited to:

- Do principle aquifers in the basin contain aquifer material susceptible to subsidence?

  The principal production aquifer in the BVGSA is the Tulare Formation. This formation is Pliocene to Pleistocene in age and contains up to 2,200 feet of interbedded, oxidized to reduced sands and gypsiferous clays and gravels derived primarily from Coast Range sources. Sandy material is found from about 200 to 400 feet below ground surface (bgs) and is used by most wells in the region for water supply. As described in Section 5.4 – Chronic Lowering of Groundwater Levels, most wells are screened to produce water from zones above the E-clay. Therefore, because of the characteristics of the aquifer material and the fact that groundwater extraction is concentrated in areas above the E-clay, the principal production aquifer is not susceptible to subsidence.

- What are the historical, current, and projected groundwater levels, particularly the historical lows?

  Data on groundwater levels for wells in the BVGSA's monitoring network are available from 1993 to the present. Historical groundwater elevations in the BMA have ranged between 145 and 246 feet AMSL in the Northern BMA (north of 7th Standard Road) and between 40 and 249 feet bgs in the Southern BMA (south of 7th Standard Road). Typical current (fall 2018) groundwater levels are 196 feet AMSL in the north (average of DMW01, DMW02, DMW04, and DMW05) and 142 feet AMSL in the south (average of DMW06, DMW07, DMW08, DMW10A, DMW12B).

  Projected groundwater levels are expected to remain within the historical range because of the BVWSD's access to surface water and continuously evolving conjunctive management practices. This assessment is supported by the groundwater elevations observed within the BVGSA during the recent drought.

- What is the historical rate and extent of subsidence?

Historical rates and extents of subsidence in the BVGSA are described in Section 2 - Basin Setting. Five continuous CORS stations are located north of the Kern River in the Kern County Subbasin and have been in operation since late 2005 (stations P544, P563, and P565), 2006 (Station 564), and 2007 (Station P544). These stations are monitored as a part of UNAVCO's Plate Boundary Observation (PBO) program. Between 2008 and 2017, cumulative subsidence varied from 1.7 to 2.9 inches at three stations near the BVGSA along Interstate 5 (P544, P545, P563), with subsidence occurring a relatively steady rate.

- What are the land uses and property interests in areas susceptible to subsidence?

  Wells in the BVGSA are screened above the E-clay as detailed in Section 5.4 – Chronic Lowering of Groundwater Levels. This fact, coupled with the hydrogeologic conditions and observed subsidence described in Section 2 - Basin Setting, suggests that observed subsidence has not been significant or unreasonable and that pumping-induced subsidence is unlikely to become significant or unreasonable given the BVGSA's intent to limit groundwater extraction within its boundaries to zones above confining clay layers.

- What is the location of infrastructure and facilities susceptible to subsidence (e.g., canals, levees, pipelines, major transportation corridors)?

  The main infrastructure susceptible to subsidence within or near the BVGSA are Interstate 5 and the California Aqueduct. Interstate 5 parallels the BVGSA's eastern boundary and bisects the GSA for approximately 4 miles in the northern portion of the BMA and 2.5 miles in the MMA.

  The California Aqueduct parallels the BVGSA's westerly boundary lying between 0.1 miles and 2 miles west of the BMA and approximately 7 miles west of the MMA.

- What are the adjacent basin's minimum thresholds? The BVGSA lies within the Kern County Subbasin and does not border any adjacent basins. Minimum thresholds for subsidence in adjacent GSAs are??

5.7.1.3 Quantitative Minimum Thresholds

Although land surface elevations, depths to groundwater, depths to the E-clay and extent of the C-clay vary throughout the BMA, the overall geometry of the GSA aids in setting minimum thresholds due to the following characteristics:

- The GSA is underlain by the E-clay at elevations ranging from approximately 10 ft AMSL to -215 feet AMSL with unconfined and semi-confined zones of the Tulare Formation lying above the E-clay and a confined zone extending beneath the clay layer to the base of fresh groundwater. The C-clay extends above the E-clay in the northern portion of the BMA.

- The risk of inducing subsidence by extracting water from the zone above the E-clay is likely to be lower than the risk induced by extracting water from beneath the clay. Similarly, extracting groundwater from beneath the C-clay may increase the risk of subsidence.

5.7.2 Measurable Objectives and Interim Milestones

5.7.2.1 Establishment

Because historical occurrence of subsidence in the BVGSA has been minimal, no measurable objectives or interim milestones have been established for control of subsidence. However, the minimum thresholds established for control of chronic reduction of groundwater levels are set above restrictive clay layers (C-clay and E-clay) to avoid future subsidence.

5.7.2.2 Considerations Used

Although lands within the BVGSA have not evidenced a history of inelastic land subsidence, the GSA recognizes the potential for subsidence to damage infrastructure with the GSA, and for chronic lowering of groundwater levels within the GSA to affect critical infrastructure that lies immediately outside the GSA's boundaries.

As described in Section 4 – Monitoring Networks, the BVGSA will monitor subsidence using data from CORS stations that lie to the east of the GSA supplemented by InSAR data. Although a clear relation between inelastic subsidence and changes in groundwater elevations has yet to be established in the GSA, the GSA will operate on the presumption that such a relation exists. Therefore, while changes in groundwater elevations will not be used at this time as a proxy for subsidence, the GSA will discourage groundwater extraction from confined aquifer zones underlying the C-clay and E-clay because of the potential for pumping from these zones to induce subsidence.

5.7.3 Margin of Operational Flexibility

No margin of operational flexibility has been established for subsidence due to the lack of observed subsidence and of any established correlation between changes in groundwater elevation and subsidence. Should subsidence be observed, and a correlation developed and confirmed between changes in groundwater elevations and inelastic subsidence, this may provide a basis for introducing a margin of operational flexibility.

5.7.4 Interim Milestones

No interim milestones have been developed as subsidence is an undesirable result to be avoided rather than corrected.

5.7.5 Representative Monitoring

Subsidence will be actively monitored within the BVGSA using data from the CORS and InSAR systems supplemented by observations from DWR on subsidence of the California Aqueduct and

Caltrans on I-5, the two critical infrastructure facilities having the potential to be affected by the operations of the BVGSA. Up to this point, subsidence has not been observed on infrastructure within the BVGSA. Should subsidence be detected on canals, control structures or roadways within the GSA, a surveying program will be implemented to monitor subsidence at affected facilities to ascertain the extent and cause.

5.7.6 Management Areas

The BVGSA has two management areas, the Buttonwillow MA (BMA) which aligns closely with the boundaries of the BVWSD's Buttonwillow Service Area and the Maples MA (MMA) whose boundaries match those of the BVWSD's Maples Service Area. The two MAs are physically distinct being separated by 15 miles. Because of the MMA's location within the Kern River GSA (KRGSA), the Sustainable Management Criteria for subsidence within this MA will align with those established for the surrounding KRGSA.

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6. Water Supply Accounting – Water Budget

6.1 Accounting for Total Water Use in SGMA

Careful accounting of water use is critical for developing a water budget of the accuracy needed to support sustainable groundwater management. While some elements of water use within the BVGSA are measured and can be used in a water budget with confidence, others are estimates that must be applied with care due to their uncertainty. The BVWSD has taken steps to reduce uncertainties related to quantification of water usage by installing magnetic flow meters on all production wells within the District and is also in the process of converting portions of its open ditch delivery system to pipelines, with magnetic flow meters being installed at each turnout. Both steps will improve water measurement within the District and will increase the accuracy with which flow paths fed by these deliveries, such as consumptive use by crops and wildlife refuges, can be estimated.

Water use is often grouped into two general categories: 1) consumptive use, and 2) non-consumptive use. These categories are discussed in Sections 6.2 and 6.3, below.

6.2 Consumptive Use

Consumptive uses, such as evapotranspiration (ET), remove water from the BVGSA and the Subbasin making it unavailable for other uses. This stands in contrast to non-consumptive uses, such as indoor domestic use, which may alter water quality but do not reduce the volume of available water.

6.2.1 Agricultural Use

By far, the greatest water use in the BVGSA is irrigated agriculture. Unlike measured water uses, agricultural consumption is estimated or inferred using a combination of two general methodologies described briefly below.

- Climate-based methods. These methods rely on measured evaporation (pan evaporation) or computed estimates of evapotranspiration based on factors such as temperature, solar radiation and wind speed to arrive at values for reference evapotranspiration (ETo), a parameter that represents consumption by a well-watered reference crop.

  Climate-based techniques then adjust ETo estimates by applying crop coefficients to arrive at evapotranspiration rates for individual crops (ETc) within a study area. ETc values can be computed on a seasonal basis or to target specific stages of crop development, and additional coefficients can be applied to further refine ETc estimates to represent a range of crops and growing conditions.

The climate-based approach is well documented in publications such as FAO 56[11] and is widely used in California where climatic data from the California Irrigation Management Information System (CIMIS)[12] is frequently relied on as the foundation for ETc estimates. The method is subject to error introduced both in estimation of ETo and in adjusting ETo to ETc values representative of particular crops and growing conditions.

- Energy balance methods. These methods compute the actual volume of water evaporated from land surfaces and transpired by crops (ETa for ET actual) by sensing conditions that are surrogates for evapotranspiration. In the case of methods such as METRIC (Mapping EvapoTranspiration at high Resolution with Internalized Calibration)[13] and SEBS (Surface Energy Balance System) which compute ETa from thermal spectrum satellite imagery, the surface energy balance equation is used to compute latent heat flux (LE) which is then converted to ETa.

The energy balance method was used to estimate consumptive use in the BVGSA water budget and is described in greater detail in Section 6.5 - Water Budget Overview. Section 357.4 of the final regulations on Groundwater Sustainability Plans (GSPs) requires neighboring agencies to coordinate to ensure that the data and analysis methodologies used within a basin are compatible. To this end, GSAs within the Kern County Subbasin agreed to use ITRC-METRIC provided under a contract with the County of Kern as a common standard for estimation of evapotranspiration. The METRIC files contain monthly ETa estimates in the form of raster files that were used to determine monthly ETa within the boundaries of the BVGSA.

6.2.2 Environmental Use

As is the case with agricultural water use, environmental water use is largely consumptive, however, a greater proportion of environmental water use is evaporation from free water surfaces. Because the coefficients used to convert ETo values to plant-specific estimates of ETc for native vegetation are less thoroughly researched than for major agricultural crops, techniques that compute ETa directly, such as those relying on satellite imagery, are well-suited to determining water uses in refuges, duck clubs and other environmental settings.

6.2.3 Municipal, Domestic, and Industrial Use

For the purposes of the historical water budget, flow measurements from industrial users for 2013-2014 were averaged and these volumes used to estimate annual deliveries to be approximately 1,500 AF. As described below, a large proportion of this use is consumptive due partly to evapotranspiration of land applied wastewater.

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[11] FAO Irrigation and Drainage Paper 56: Crop Evapotranspiration – Guidelines for Computing Crop Water Requirements, R.G. Allen, L.S. Pereira; D. Raes, M. Smith. FAO – Food and Agriculture Organization of the United Nations, Rome, 1998.

[12] CIMIS.water.ca.gov

[13] Basin-wide Remote Sensing of Actual Evapotranspiration and Its Influence on Regional Water Resources Planning, D.J. Howes; C.M. Burt, K. Feist. ITRC – Irrigation Training and Research Center, California Polytechnic State University. San Luis Obispo, CA., 2012.

Outdoor domestic and municipal water uses within BVGSA consist principally of landscape irrigation at homes, commercial properties, and parks. The sources of this water are the Buttonwillow County Water District (BCWD) and private wells. The evapotranspiration resulting from these consumptive uses is included in the evapotranspiration totals estimated using ITRC METRIC.

The amount of municipal and domestic water delivered by BCWD was estimated based on per capita consumption statistics in Kern County and census totals in the community of Buttonwillow. From 1991 through 2016, the average annual delivery was estimated to be 257 AF. Pumping data provided by the BCWD for 2017 and 2018 show groundwater production during those years to have been 298 AF and 210 AF respectively. Wastewater is collected by the BCWD for treatment at their wastewater treatment facility, a process that generates about 150 acre-feet of wastewater per year[14]. Data provided by the BCWD for 2018 shows a decline in the volume of treated wastewater to 105 AF for that year. The treated wastewater is applied to an adjacent 50-acre alfalfa field at a rate of 3 AF per acre. Because of the land application of wastewater and the use of municipal and domestic water for landscape irrigation, most municipal and domestic use is consumptive.

6.3 Non-consumptive Use

Non-consumptive uses, such as in-door domestic use, may alter water quality but do not reduce the volume of water available to the GSA or the Subbasin.

6.3.1 Municipal, Domestic, and Industrial Use

Non-consumptive uses include municipal, industrial, domestic, and commercial users, and standard coefficients can be applied to apportion water for each of these uses into consumptive and non-consumptive fractions. While indoor uses are often non-consumptive, this is not the case in the BVGSA due to the high proportion of the wastewater generated by indoor use that is consumed through application to land. Therefore, for the purposes of water use accounting, the volume of water attributed to non-consumptive uses is negligible.

6.4 Total Water Use

As detailed above, water used within the BVGSA is almost entirely delivered to meet the consumptive demands of agricultural, environmental, domestic and municipal uses. Deliveries originate from surface water supplied from the State Water Project and the Kern River and pumping from the principal aquifer system underlying the GSA.

Under the BVWSD's water rights to the Kern River, the District has diverted an average of 149,829 AF/yr[15], and the District's contract with the Kern County Water Agency (KCWA)

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[14] https://www.waterboards.ca.gov/centralvalley/board decisions/tentative orders/0912/buttonwillow/buttonwillow wwtf wdr.pdf

[15] 156,000 AF/yr flow at 2nd Point x 96.044% BVWSD portion of 2nd Point flow

entitles it to receive 21,300 AF/YR of Table A water from the State Water Project via the California Aqueduct. It should be noted that the volumes of water delivered to the District from its rights on the Kern River and its contract with the KCWA varies greatly depending on factors including water year type and has been decreasing in recent years. Table 6.1 provides the average deliveries, by location, for each of five water year types between 1993 and 2015.

Table 6-1. Average Surface Water Deliveries by Water Year Type [1993-2015]

Source	Wet	Above Normal	Below[1] Normal	Dry	Critically Dry
California Aqueduct Turnouts	84,417	77,204	74,728	61,403	45,376
East Side Intake Canal	97,427	63,848	28,363	36,669	20,169
Total Surface Deliveries	181,843	141,052	103,091	98,072	65,546

[1] Within the period of record only two years were characterized as Below Normal. For one of these years, 2009, a flow of only 18,418 AF was recorded in the East Side Intake Canal. This single low value and the small number of years available to compute an average explains why the average Below Normal flow in the East Side Intake Canal is lower than the Dry year average.

The BVWSD is now in the process of improving the accuracy with which deliveries for all uses are measured. In parallel to improved measurement, the BVWSD has leveraged maturing technologies for measurement of ETa with ITRC-METRIC, as discussed in previous sections. The combination of increasingly accurate metering of deliveries to agricultural and environmental uses and increasingly accurate estimation of ETa will yield better estimates of consumptive uses.

6.5 Water Budget Overview

Section 354.18 – (Water Budget) of the Groundwater Sustainability Plan Emergency Regulations, states,

> Each Plan (GSP) shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

To respond to the language of the regulations and to provide tools useful for management, this GSP includes a detailed water budget that describes the physical movement of water across GSA boundaries, accounts for changes in storage within the GSA and assesses factors that may affect flow paths captured in the water budget and resulting estimates of groundwater storage.

The BVGSA water budget covers an area that corresponds to the Buttonwillow Management Area (BMA). This area of 43,460 acres lies within the Kern River watershed and is characterized by heavy clay soils formed in the historic swamp and overflow lands on the northern fringe of Buena Vista Lake.

The water budget includes flow paths that represent surface water and groundwater flows within the GSA and across the GSA's boundaries. Historical BVWSD water budgets, together with other information on aquifer characteristics developed in Section 2.2 - Hydrogeologic Conceptual Model were used to quantify subsurface fluxes across the GSA boundaries.

6.5.1 Water Budget Structure

The water budget developed for the BVGSA uses a structure consistent with that recommended by DWR for basin-wide budgets and follows the basic water budget equation that is well suited to assessing historical, current and projected conditions:

Inflow - Outflow = Change in Storage

In accordance with SGMA Regulations and guidance provided in the Water Budget BMP (DWR, 2017), the BVGSA's water budget accounts for the total annual volume of groundwater and surface water entering and leaving the BVGSA by grouping inflows and outflows into four main categories:

- Total Surface Inflow;
- Total Groundwater Inflow;
- Total Surface Outflow; and
- Total Groundwater Outflow.

The water budget is based on historical water use within the BVGSA over a period extending from 1993 to 2015. This period captures a range of hydrologic conditions and aligns with the period of data available both from the ITRC-METRIC evapotranspiration data used to estimate ETa over the Kern County Subbasin and the groundwater modeling performed using the C2VSim platform (Todd Groundwater, 2019).

Selection of an analysis period represents one boundary condition for the water budget. A second boundary condition is the physical extent of the study area. In the case of the BVGSA, the water budget boundary conforms to that of the Buttonwillow Management Area because surface water inflows and outflows cross the BMA's boundaries at well-defined points of measurement while precipitation and evapotranspiration enter and leave the BMA from the land surface within the Agency's boundaries. As explained in Section 5 – Minimum Thresholds, Measurable Objectives and Interim Milestones, the BVGSA's second, smaller Management Area, the Maples Management Area (MMA), lies within the Kern River GSA, and the water budget of the MMA aligns with that of the larger KRGSA.

The water budget consists of two basic elements:

- A GSA water budget describing movement of water into and out of the boundaries of the BMA (GSA Component), and
- A groundwater budget describing movement of water into and out of the principal aquifer system underlying the BMA (Groundwater Component).

The objectives of accounting for inflows, outflows and changes in storage are to:

- Show whether the GSA is in surplus or deficit;
- Reveal flow paths important to achieving balance or that contribute to imbalances;
- Identify data gaps that compromise the accuracy or utility of the budget, and
- Aid in quantifying changes in groundwater storage.

Regardless of their complexity, water budgets are constructed as assemblages of flow paths with each path representing an inflow to or an outflow from the area being studied. Each flow path contains data that is subject to error. Therefore, understanding the uncertainty associated with both measured and calculated inflows and outflows is fundamental to constructing a reliable budget that can aid in achieving the objectives noted above. Table 6-2 presents the level of uncertainty associated with flow paths central to the two budget components.

Table 6-2. Selected Water Budget Flow Paths and Representative Levels of Uncertainty

Parameter	Source	Location	Uncertainty
Surface water inflows	Measured	Kern River, SWP	+/-5%
Landowner pumping	Closure term (now metered)	BMA irrigated area	+/- 25% (5%)
Reclamation/District/Landowner Pumping (to distribution system)	Metered	BMA area	+/- 5%
Precipitation	CIMIS data	BMA surface area	+/- 15%
Canal seepage	Calculated by District	Canal prisms	+/- 20%
Evapotranspiration	ITRC Metric	BMA area	+/- 15%
Deep percolation	District Estimates, Soil Moisture Analysis	BMA area	+/- 10%
Subsurface inflows and outflows (flux)	Closure term	BMA boundaries	+/- 25%
Change in storage	Calculated	BMA area	+/- 25%

The BVWSD has taken steps to reduce the uncertainty of inputs to future water budgets by installing magnetic flow meters on all wells within the District and on turnouts as the District converts portions of its open ditch delivery system to pipelines. It should be noted that the water budget for this GSP does not include measured discharges from privately-owned wells, as meter data from these wells is not available for the period from 1993 to 2015. However, this data will be available for updates of this GSP and will be particularly valuable as pumping from landowner wells is typically not metered or reported. Thus, unlike many areas, the BVGSA's access to metered values for both district-owned wells and private pumping will enable these flow paths to be input explicitly into the water budget rather than being approximated based on power usage or inferred from other data.

As the period of record for metered groundwater pumping and surface water delivery data increases, the error associated with these flow paths will decline. Similarly, use of groundwater modeling and continuing analysis of hydrogeologic data is expected to improve understanding of hydrogeologic parameters and increase the accuracy of estimated changes in groundwater storage and volumes of subsurface flux across GSA boundaries.

A parallel process to assessing the uncertainty of input flow paths is selection of the closure term, the flow path used to balance water budgets. The closure term is the term where measured or calculated inputs are either unavailable or have the greatest level of uncertainty. Therefore, water budgets typically have one of the two following structures:

- Budgets where all inflows and outflows are known with reasonable confidence have a conventional structure where inflow – outflow = change in storage and the budget closes on change in storage.
- Budgets where it is assumed there is no long-term change in storage or where change in storage can be estimated with greater confidence than one of the inflow or outflow parameters can be structured so that change in storage becomes an input and the budget closes on the most uncertain inflow or outflow term. For this type of budget, typical closure terms include subsurface cross boundary flow, or groundwater pumping from unmetered wells.

In the case of the BVGSA, due to the uncertainties associated with quantifying both groundwater fluxes and changes in storage, two estimation methods were compared as described in Appendix D - Closure Terms for Buena Vista GSA Water Budget:

- Method 1: uses data from various sources to estimate inflows to and outflows from the principal aquifer. The result of these computations (closure term) is an estimate of change in groundwater storage
- Method 2: uses data including changes in groundwater elevations to explicitly compute change in storage. The result of this series of computations is an estimate of net groundwater flux.

The two approaches yield similar average annual values for change in storage and groundwater flux which were compared with output from the C2VSim model under development for the Kern County Subbasin. However, Method 1, estimation of change of storage as a closure term, was determined to provide the most realistic water budget structure.

In addition to use in evaluating the water budget structure, results from C2VSim modeling have been applied to analyze how conditions such as climate change, operation of groundwater banks and introduction of new recharge facilities may affect future groundwater conditions.

6.6 Water Budget – GSA Component

Following SGMA regulations and the Water Budget BMP (DWR, 2017), the GSA Component of the water budget is divided into the following elements: surface inflows, subsurface inflows, surface outflows, subsurface outflows, and change in storage. This section will explain the methods used to develop the GSA component and summarize the annual volumes for each element of the GSA Component of the component. A schematic diagram for the GSA Component is shown below in Figure 6-1.

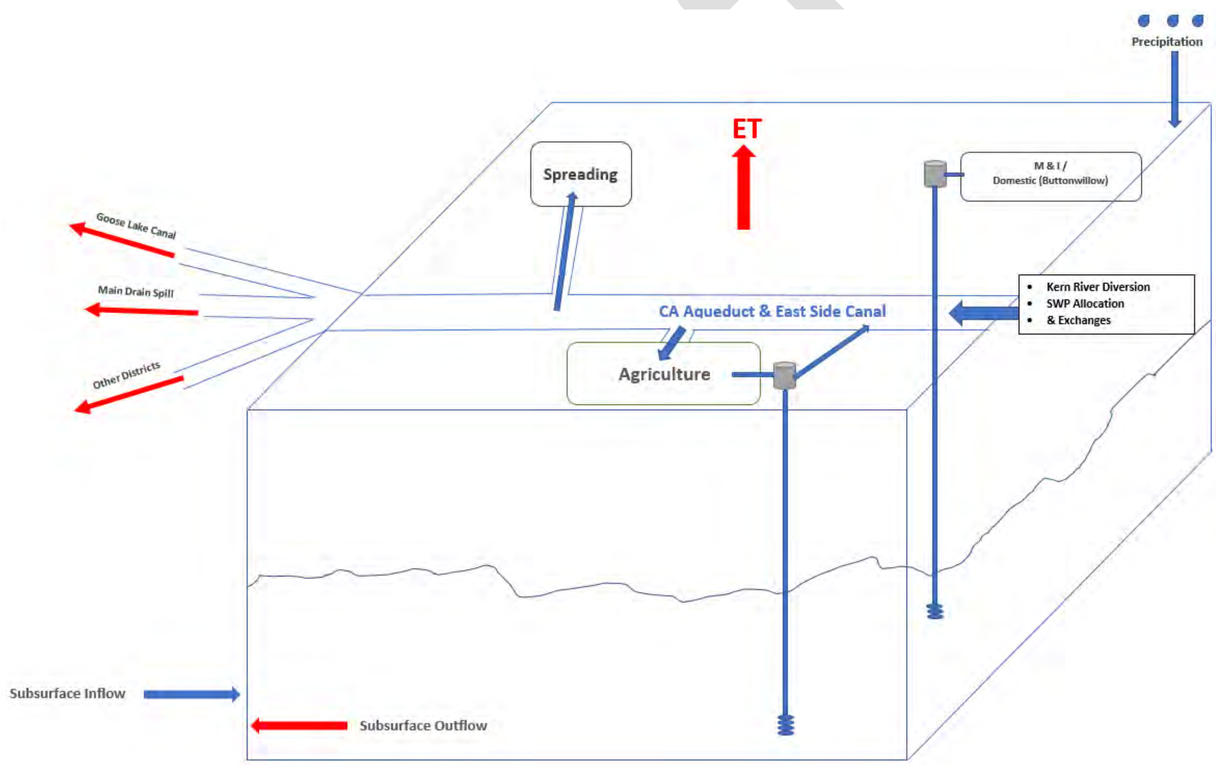

Figure 6-1. Water Budget Schematic – GSA Component

As noted above, historical data from 1993 through 2015 were used to develop the GSA Component. Whenever available, water budget inputs were drawn from direct measurements of flow paths leading to or from the BMA. For parameters that are not directly measured, estimates or inferences were made based on previous studies or deduction.

6.6.1 GSA Component Inflows

Inflows to the BMA include any water that enters the BMA either above or below the ground surface. Inflows include surface water from the Kern River and the California Aqueduct, precipitation and subsurface groundwater inflows from neighboring areas in the Kern County Subbasin.

6.6.1.1 Surface Water Inflows

Surface water inflows include:

- Kern River water delivered directly via the East Side Canal and indirectly by exchange via California Aqueduct turnouts;
- State Water Project water delivered to the BMA from California Aqueduct turnouts;
- CVP Friant-Kern Unit, transfer or exchange water delivered via either the East Side Canal or CA Aqueduct turnouts, and
- Precipitation – average annual precipitation of 6.85 inches according to nearby CIMIS stations.

As no rivers or streams cross the boundaries of the BVGSA, surface water inflows are restricted to water delivered from the sources listed above.

The BVGSA receives surface water from the Kern River (delivered at the East Side Canal), from the State Water Project via the California Aqueduct (diversions at turnouts; BV-1B , BV-2, BV-6, BV-8, B-3, HM-1 and the turnout to a 120" pipeline conveying water through the BVGSA to the Semitropic WSD) and occasionally through exchanges or transfers from neighboring districts conveyed across the GSA boundaries via the East Side Canal and the California Aqueduct. The two main sources of surface water are Kern River and SWP Table A water, with average annual diversion and contract allocations summarized in Table 6-3.

Table 6-3. Kern River Diversions and State Water Project Allocations

Type	Source	Diversion or Allocation
Local Surface Water	Kern River	158,000 AF/YR
Imported Surface Water	SWP – Table A	21,300 AF/YR
Imported Surface Water	SWP – Article 21	3,750 AF/YR
Total Diversion or Allocation	Kern River / SWP	183,050 AF/YR

Although the BVWSD diverts an average of 158,000 AF/YR from the Kern River and is entitled to receive 25,050 AF/YR of combined Table A and Article 21 water from the California Aqueduct, diversions from the Kern River fluctuate due to hydrologic conditions and allocations of SWP water seldom meet contracted entitlements. For this reason, annual deliveries measured and reported by the BVWSD were used as inputs for the water budget. All deliveries from the Kern River and the California Aqueduct are measured at the points of delivery. Table 6-4 below shows surface water inflows from 2006 - 2015. Figure 6-2 shows longer-term trends in surface water deliveries (1993 through 2015).

Table 6-4. Measured Surface Water Deliveries to BMA [2006-2015]

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
California Aqueduct (AF)	74,465	59,668	53,085	72,020	60,975	78,631	62,642	47,857	12,799	10,957
East Side Canal (AF)	97,955	47,914	34,549	18,418	66,441	98,416	45,173	-	-	-

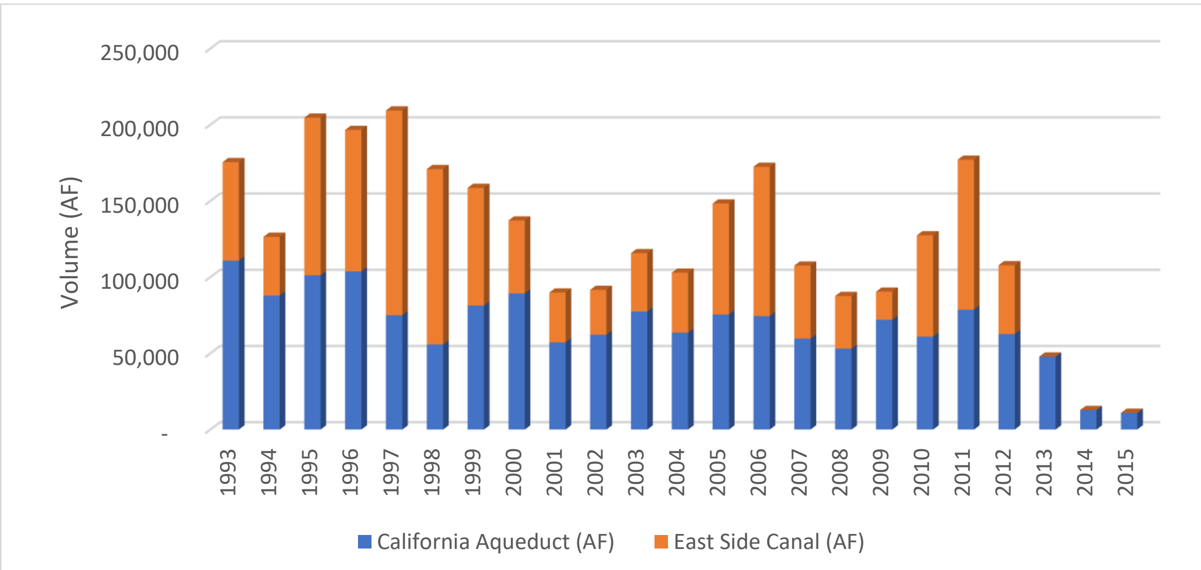

Figure 6-2. Measured Surface Water Deliveries to the BMA [1993-2015]

In addition to measured deliveries from the Kern River and the California Aqueduct, the BVGSA's other source of surface inflow is precipitation. Precipitation data was taken from the nearest operating California Irrigation Management Information System (CIMIS) station for each year. The closest CIMIS station to the BVGSA is Belridge (Station #146), and data from this site was used for the period extending from 1999 through 2015. Precipitation data for the remaining years (1993 through 1998) was taken from the second closest station, Shafter (Station # 5). CIMIS data provided yearly precipitation (inches), and the acreage of the BMA was used to convert these values to the equivalent volume of water in acre-feet. Table 6-5 presents a summary of precipitation to the BMA from 1993 through 2015.

Table 6-5. Precipitation Inflows to the BMA [1993 - 2015]

Year	BMA Precipitation (AF)	Station
1993	26,450	Shafter
1994	27,566	Shafter
1995	38,269	Shafter
1996	30,608	Shafter
1997	22,138	Shafter
1998	52,707	Shafter
1999	23,639	Belridge
2000	16,093	Belridge
2001	26,796	Belridge
2002	18,365	Belridge
2003	30,762	Belridge
2004	24,910	Belridge
2005	28,683	Belridge
2006	27,759	Belridge
2007	12,628	Belridge
2008	22,215	Belridge
2009	20,598	Belridge
2010	41,118	Belridge
2011	41,426	Belridge
2012	18,827	Belridge
2013	10,126	Belridge
2014	10,395	Belridge
2015	21,291	Belridge

6.6.1.2 Groundwater Inflows

Groundwater inflows to the BMA include deep percolation from precipitation, managed recharge, canal seepage, and deep percolation from irrigated agriculture in addition to subsurface groundwater inflow from neighboring locations in the Kern County Subbasin. The methods used to estimate the sources of groundwater inflows rely on District data and water budgets, groundwater modeling, and spreadsheet models.

Of these groundwater inflows, the greatest uncertainty surrounds the lateral inflow and outflow of groundwater (flux). Due to this uncertainty, two approaches for estimating subsurface inflows and outflows were applied and the results of the approaches were then compared. As discussed in the introduction of Section 6.5 – Water Budget Overview, the technical memo "Closure Terms for Buena Vista GSA Water Budget", found in the Appendix D, discusses the two approaches in detail.

Table 6-6 provides a summary of the results from the methods used to estimate subsurface flux. Positive values correspond with net groundwater inflow and negative values correspond with net groundwater outflow. The period considered for this analysis is 1995 – 2014, the same range as the C2VSim groundwater modeling effort.

Table 6-6. Subsurface Flux in BMA [1995 - 2014]

	GEI	Todd GW Model	Sierra Scientific
1995	(5,449)	(75,981)	(32,364)
1996	(5,226)	(65,329)	(32,364)
1997	636	(68,939)	(32,364)
1998	(22,835)	(73,279)	(32,364)
1999	11,552	(39,992)	(32,364)
2000	(30,029)	(19,811)	(32,364)
2001	31,258	(15,408)	(32,364)
2002	(7,828)	(9,289)	(32,364)
2003	(7,714)	(5,362)	(32,364)
2004	(20,191)	(2,598)	(32,364)
2005	44,044	(17,192)	(32,364)
2006	1,075	(24,574)	(32,364)
2007	(39,935)	(4,940)	(32,364)
2008	(82,443)	5,493	(32,364)
2009	(10,578)	1,598	(32,364)
2010	5,388	(22,553)	(32,364)
2011	(65,097)	(47,420)	(32,364)
2012	10,626	(18,922)	(32,364)
2013	35,782	15,709	(32,364)
2014	(6,051)	31,474	(32,364)
total [1995-2011]	(203,371)	(485,576)	(550,188)
total [1995-2014]	(163,014)	(457,316)	(647,280)
avg [1995-2011]	(11,963)	(28,563)	(32,364)
avg [1995 - 2014]	(8,151)	(22,866)	(32,364)
maximum [1995 – 2014]	44,044	31,474	NA
minimum [1995 – 2014]	(82,443)	(75,981)	NA
Difference [1995 – 2014]	126,487	107,455	NA
standard deviation [1995 – 2014]	30,721	30,233	NA

****** Assumes specific yield of 0.15 applied in GEI estimate of flux***

Note that subsurface flux can either be subsurface inflow (positive) or subsurface outflow (negative). Figure 6-3 shows total inflows to the BMA portion of the BVGSA by source.

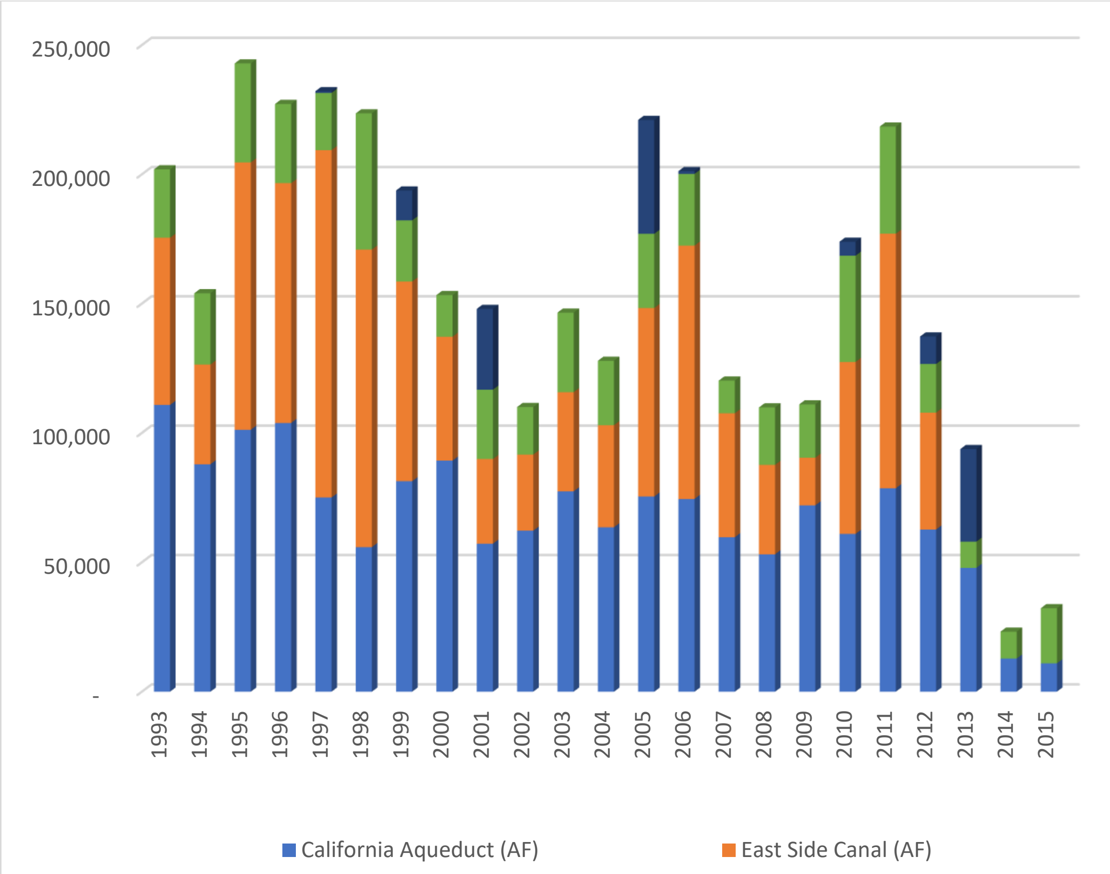

Figure 6-3. Total Inflows to the BMA by Source [1993 - 2015]

6.6.2 GSA Component Outflows

Outflows from the BMA include any water that leaves the boundaries of the Management Area either above or below the ground surface. Outflows include surface water flow paths such as canals and drains, subsurface groundwater outflow to neighboring areas in the Kern County Subbasin and evapotranspiration.

6.6.2.1 Surface Water Outflows

Surface water outflows include:

- Goose Lake Canal (deliveries to Kern National Wildlife Refuge),
- Main Drain Canal north of Hwy 46, and
- Surface flows that leave the BVGSA through defined channels (Semitropic Canal, West Side Canal) for delivery to neighboring districts.

Historically, the BVWSD has historically had large surface water outflows in both the Kern River Flood Channel Canal and in the Main Drain Canal. However, there have been no outflows in the Main Drain Canal since 2013 due to the following:

- reduction in drainage water due to conversion from row crops irrigated using gravity methods to permanent crops irrigated using low-volume drip irrigation;
- compliance with the ILRP encouraged reuse of drainage water, and
- compliance with SB7x7 caused the District to introduce volumetric water pricing in 2013. This action has achieved its intended purpose by encouraging growers to conserve water by reducing applications.

In spite of the extremely wet conditions in 2017 and 2019 and a reduction in storage capacity in Isabella Dam, no water flowed to the Kern River/SWP Intertie and none was carried in the Kern River Flood Channel Canal north of Highway 46. This was the result of:

- capture of Kern River water by water banking facilities within the BVWSD, and
- capture of Kern River water by banking facilities operated by other districts.

Surface water outflow data was taken from measurements reported in the BVWSD's annual Water Distribution Summaries for the years 1993 through 2015. Figure 6-4 provides a summary of surface water outflows by source. The average annual surface water outflow for this period from all BVGSA sources is estimated to be 37,740 AFY.

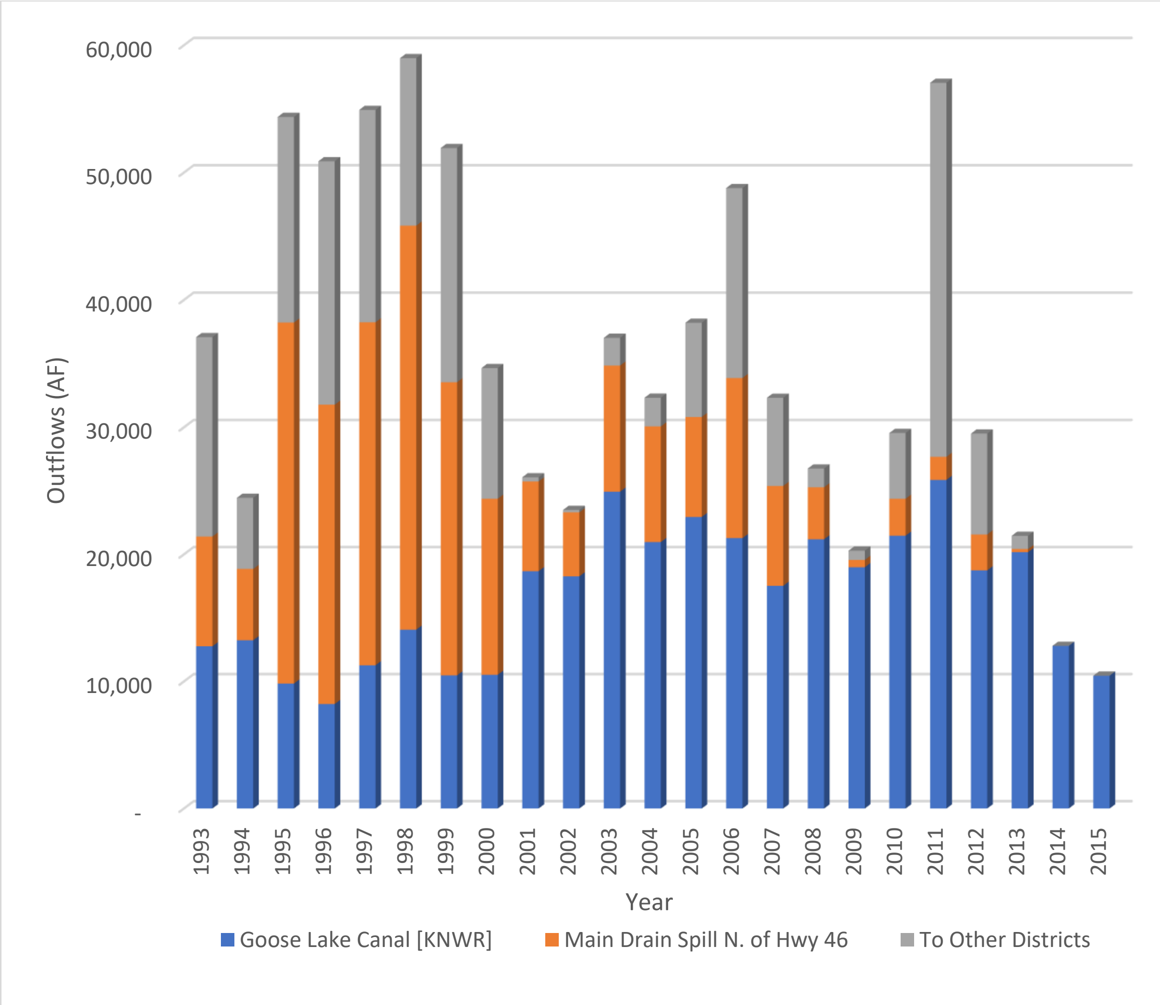

Figure 6-4. Surface Water Outflows from the BMA by Destination [1993 - 2015]

6.6.2.2 Groundwater Outflows

Groundwater outflows are either

- Pumping for agricultural, municipal, domestic and industrial uses, or
- Subsurface groundwater outflow.

Due to the recent installation of meters on all production wells, historical pumping was estimated using a water budget that considered known values for supply and demand to close on unmetered pumping. Subsurface fluxes across the boundaries of the BMA were estimated as the water budget closure term with negative fluxes designating outflows.

6.6.2.3 Evapotranspiration

By far the greatest flow path for water to leave the BVGSA is evapotranspiration by irrigated lands, native vegetation and open water surfaces. This consumptive use is fueled by both surface water and groundwater inflows into the BMA. Elements of evapotranspiration include:

- Consumptive use of surface water by agricultural and environmental users;
- Consumptive use of groundwater by agricultural and environmental users, and
- Consumptive use of groundwater by the Buttonwillow County Water District and other domestic and M&I users.

Evapotranspiration from the BMA was estimated using a combination of the climate-based and the energy balance methods introduced in Section 6.2. The surface energy balance equation can be expressed as:

$$LE = Rn - G - H$$

where Rn is net radiation at the surface; G is the soil heat flux; H is the sensible heat flux; and LE is calculated as a residual of the energy balance and then converted to ETa as a rate (typically mm/hour).

Satellite imagery-based energy balance methods require accurate satellite mapping of Rn from zones of the thermal radiation spectrum characteristic of vegetative activity and an understanding of the agronomic variables in a region. LandSAT Thermal Mapper images are the most common source of this imagery.

For the Buena Vista GSP, ITRC-METRIC, developed by the California Polytechnic State University's Irrigation Training and Research Center (ITRC), was used to estimate evapotranspiration. This method combines the climate-based and energy balance methods which allows ETa estimates from LandSAT imagery to be corrected with hourly climate data collected from surrounding CIMIS stations. This combined dataset is then refined with cloud masking techniques, QA/QC of hourly weather data, digital elevation maps, corrected grass reference ETo maps, and DWR land use data. In addition, land use data from the National Agricultural Statistics Service (NASS) was used to refine crop canopy aerodynamic resistance.

The temporal component of the water budget analysis for BVGSA is confined to the period for which ITRC-METRIC evapotranspiration data is available: 1993 through 2015. It should be noted that no data was available for 2012 due to a gap between the decommissioning of LandSAT 5 and the launch of LandSAT 8. To fill this gap, METRIC outputs from 2011 and 2013 were averaged and applied as a surrogate for the 2012 data based on the assumption that cropping patterns for 2011 and 2013 were representative of those for 2012.

The Buena Vista GSP also relies on ITRC-METRIC evapotranspiration data to estimate non-agricultural evapotranspiration using the same combined climate and energy balance approach applied to agricultural lands. The BVGSA has approached the ITRC to serve as a consultant to compare METRIC estimates of ETa with metered deliveries beginning in 2017 when the BVWSD completed metering of all production wells in the GSA.

Figure 6-5 summarizes the amount of evapotranspiration by all land uses within the BVGSA.

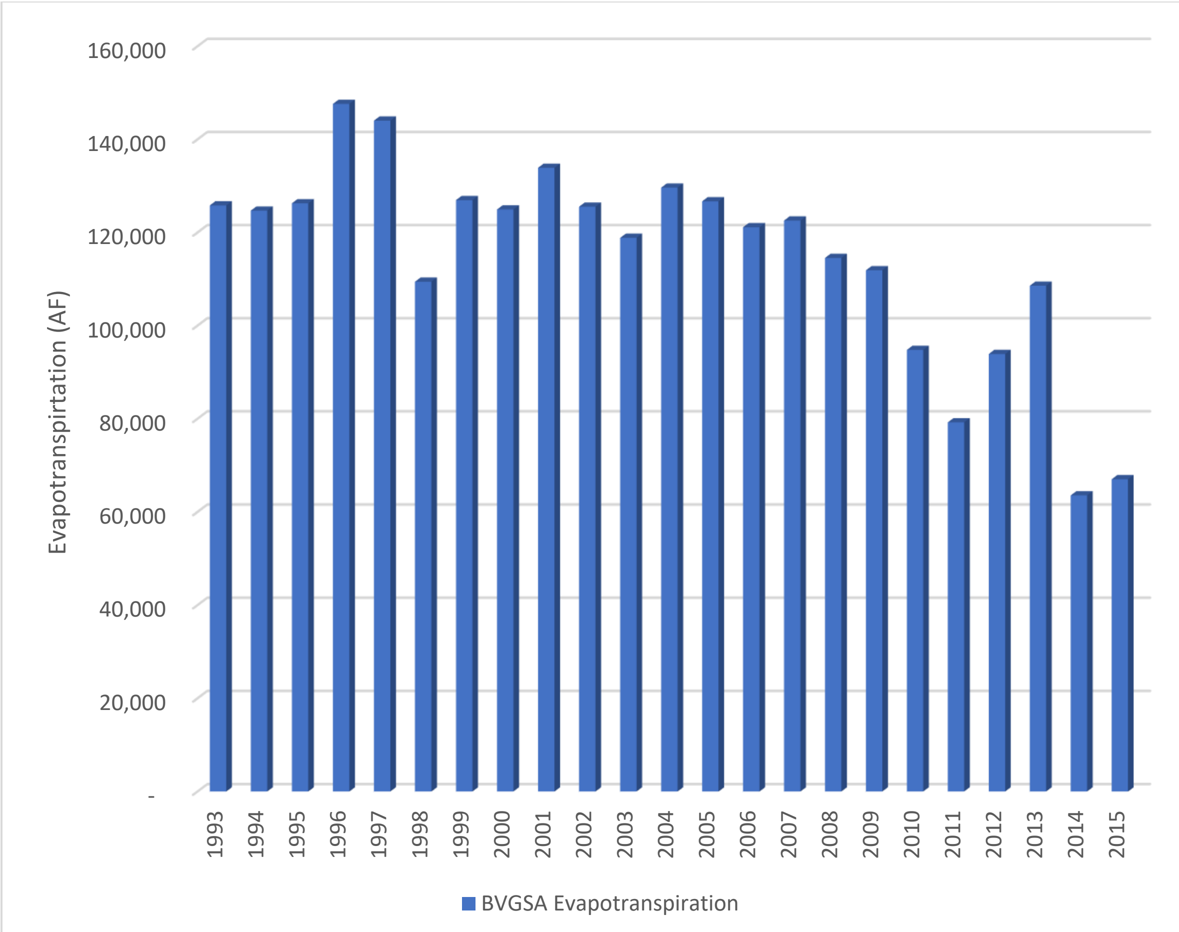

Figure 6-5. Evapotranspiration from the BMA [1993 - 2015]

The ITRC-METRIC data shows high ETa values in 1996 and 1997 and a decline in ETa from 2009 forward. The patterns observed in the annual ETa estimates are addressed in the report *1993-2015 ITRC-METRIC ETc for Kern County*[16] which was prepared for the Kern Groundwater Authority. The following is an excerpt from the report:

> Visually, significantly more non-cropped fields can be seen in 2015 than in 1993. Portions of Lost Hills Water District and Buena Vista WSD show much lower ET in 2015 than 1993. These areas were fallowed or not cropped during the drought. In other areas, young permanent crop plantings may be the cause of lower ET.
>
> While there is no definitive explanation for the variation in ETa values, a plausible reason stems from changes in cropping patterns (particularly new plantings of pistachios having very low water demands) and variations in weather. For example, 2011 had a cool growing season while 2013-2015 were drought years associated with higher levels of fallowing,

[16] Irrigation and Training Research Center, July 2017

delayed planting, low consumptive use by young orchards, deficit irrigation and less evapotranspiration from weeds than would be found in wetter years.

Figure 6-6 provides a summary of all BMA outflows by destination. This includes water that leaves via a defined channel, as evapotranspiration, or laterally as subsurface outflow. It should be noted that net outflow via the Goose Lake Canal is now zero.

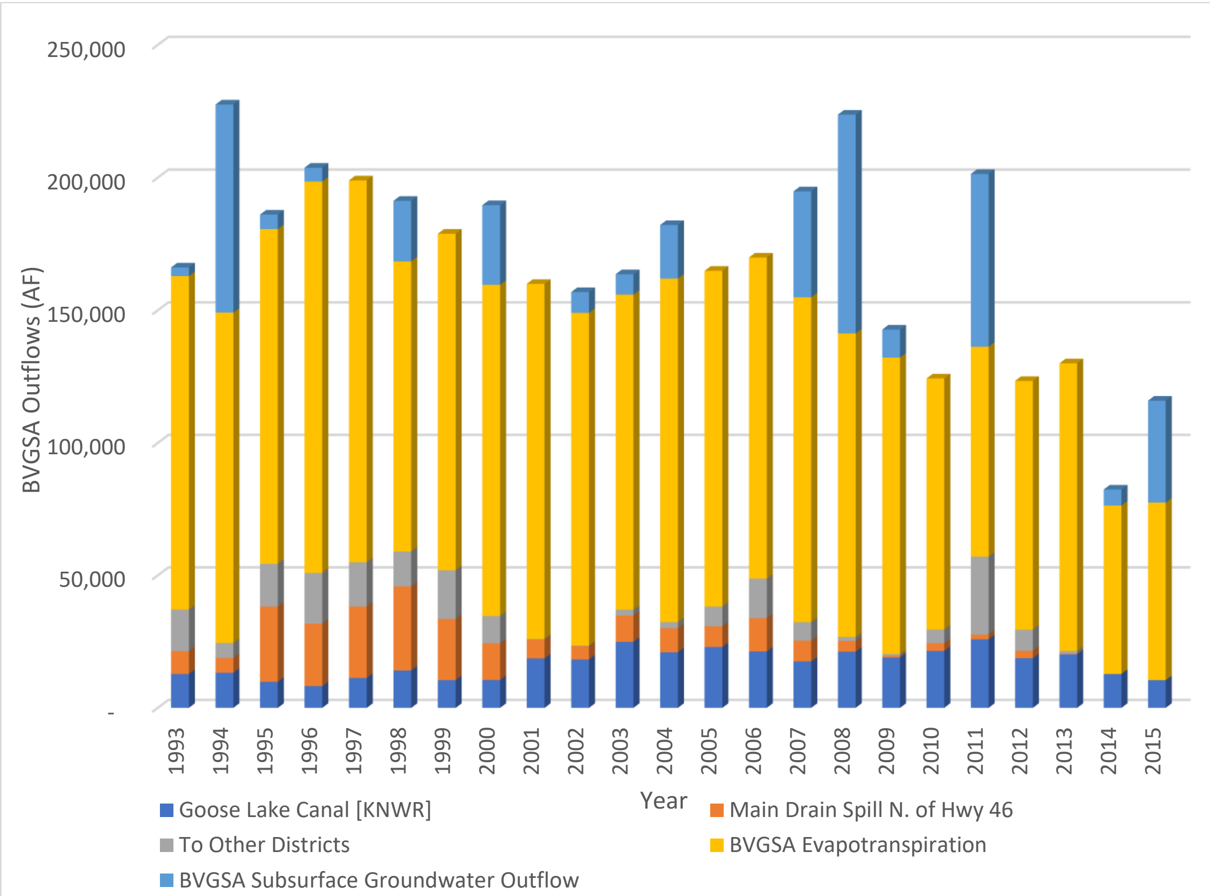

Figure 6-6. Total Outflows from the BMA by Destination [1993 - 2015]

6.6.3 Change in Storage

Because there is no surface water storage available to the BVGSA, all changes in storage occur in the aquifers underlying the GSA. Change in storage was estimated based on groundwater elevations observed in the BMA and an estimated average specific yield of the principal aquifer system of 0.15. Appendix D – Closure Terms for Buena Vista GSA Water Budget describes the methodology used to estimate change in storage. C2VSim modeling of the Kern County Subbasin (Todd, 2019) is available to refine estimated changes in groundwater storage.

6.7 Water Budget – Groundwater Component

The Groundwater Component of the water budget is nested within the GSA Component and is designed to capture movement of water into and out of the aquifer system underlying the BMA. Figure 6-7 is a schematic diagram of the Groundwater Component.

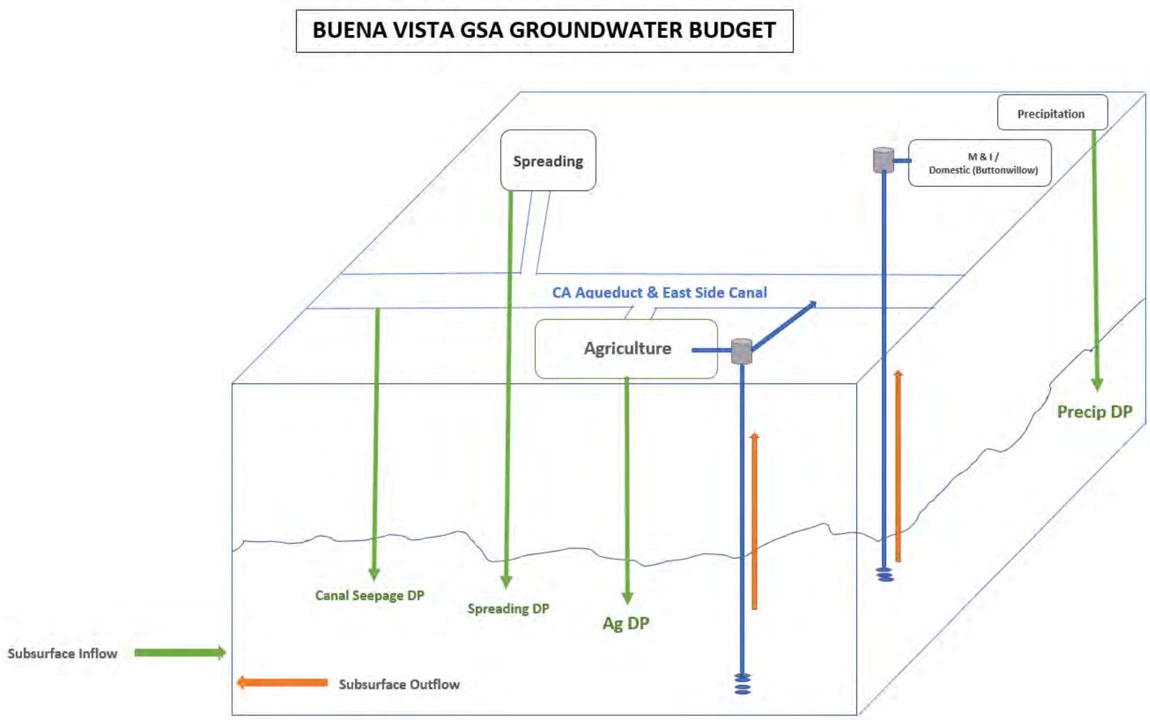

Figure 6-7. Water Budget Schematic – Groundwater Component

6.7.1 Groundwater Component Inflows

Inflows to the aquifer system underlying the BVGSA include both lateral subsurface inflows from neighboring areas and inflows that originate from infiltration of surface water that has entered the GSA via precipitation and surface water from the Kern River and the California Aqueduct. The flow paths taken by surface water to reach groundwater include: seepage from unlined canals, recharge from dedicated recharge facilities, and deep percolation of precipitation and applied irrigation water.

The period from 1993 through 2015 spans a range of hydrologic conditions which are reflected in the range of annual volumes of precipitation and deliveries of surface water captured in the GSA Component. This period also spans a time of changing farming practices as cropping patterns shifted from row crops to permanent crops. The shift in cropping was accompanied by a change in irrigation practices from surface irrigation techniques typical of row crops such as cotton and forage crops to low-volume drip and micro-spray techniques typical of permanent crops such as pistachios and grapes. Although the soils characteristic of the BMA restrict deep percolation of applied irrigation water, the change in irrigation practices has further reduced the proportion of applied water that leaves the field as deep percolation, a change represented in the Groundwater Component.

6.7.1.1 Surface Water Inflows

Two methods were evaluated to estimate the volume of deep percolation from precipitation, one based on Kern County Water Agency (KCWA) data and a second, analytical approach used to verify the KCWA method.

- KCWA approach: This approach applies estimates of historical effective precipitation presented in the KCWA's most recent published Water Supply Report (KCWA, 2011). Table 15 of this report presents annual values for effective precipitation over a period from 1970 through 2011 with an average of these annual values of 2.36 inches per acre. One third of the effective precipitation, 0.78 inches, was then assumed to percolate to groundwater giving an average annual contribution of approximately 3,000 AF.
- Analytical approach: The analytical approach consists of the following steps.
  - Assume 10 percent runoff for all rain events
  - Because most rain events occur outside of the irrigation season, a 35 percent Available Moisture Content was assumed for the end of the irrigation season.
  - NRCS soil mapping (Figure 6.8) was used to determine prominent soil types and develop estimates of the soil moisture holding capacity per foot of rooting depth. This assessment yielded an Available Moisture Holding Capacity of 2.2 inches per foot of rooting depth.
  - Cropping data provided by the BVWSD for 2013, 2014 and 2015 was used to estimate the average rooting depth of the cropping patterns. This analysis resulted in an average rooting depth of 4.5 feet
  - The average rooting depth and the average Available Moisture Holding Capacity were used to estimate an average Available Water Holding Capacity of the typical crop root zones of 9.85 inches.
  - Deep percolation of precipitation was calculated based on the assumption that precipitation exceeding the available root zone storage would flow to deep percolation. Table 6.7 shows the table used for this analysis, and Figure 6-9 displays these annual deep percolation values which average 2,687 AF per year (approximately 0.74 inches/acre).

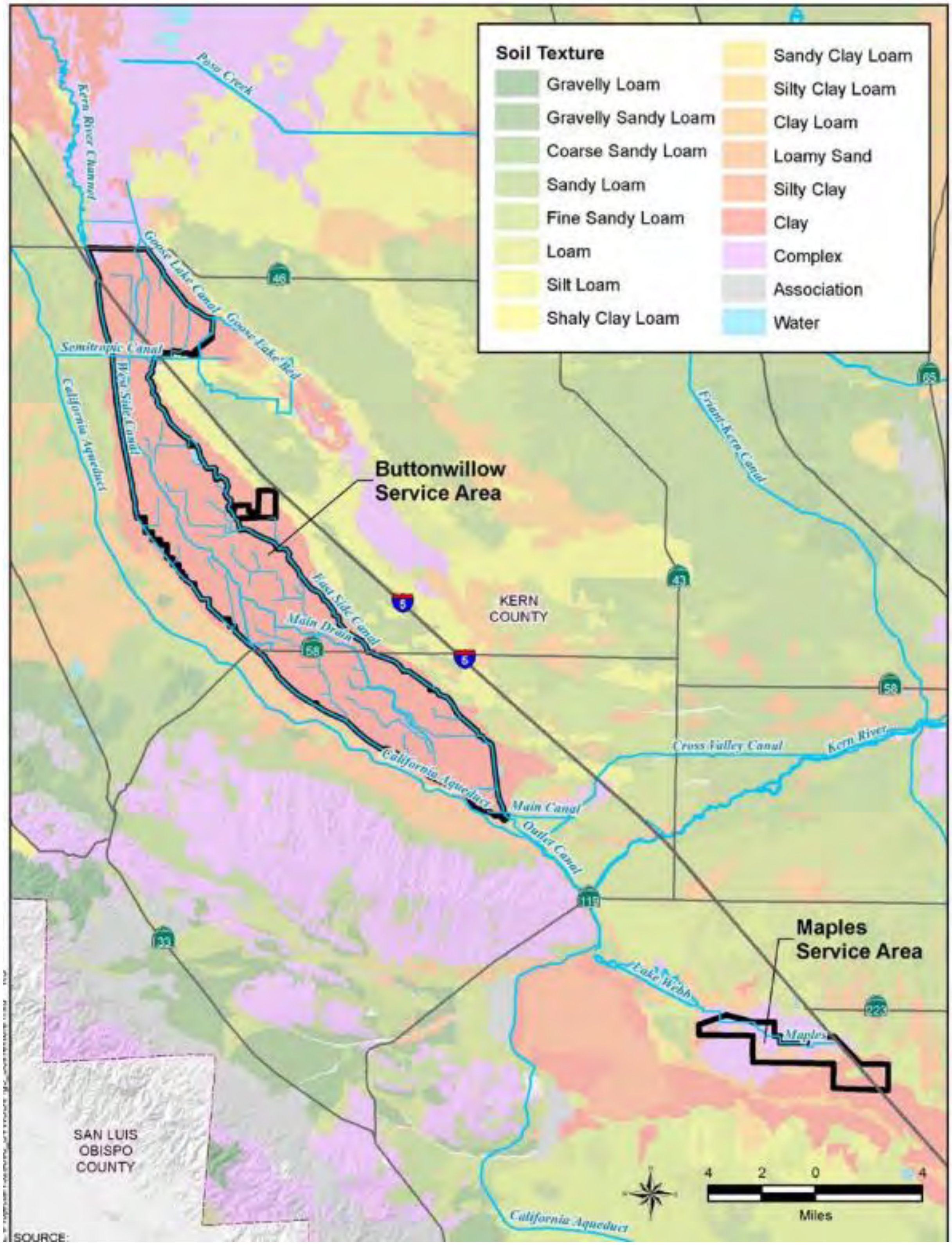

Figure 6-8. Soils Map for BVGSA

Table 6-7 Deep Percolation of Precipitation Analysis

Year	Root Zone AWHC (inches)	Available Storage @ MAD (inches)	Precipitation (inches)	Precipitation (less runoff) (inches)	Deep Percolation [Precipitation - Average Storage] (inches)	Remove Negatives (inches)	Estimated DP (AF)
1991	9.85	6.40	7.42	6.68	0.28	0.28	1,004
1992	9.85	6.40	7.35	6.62	0.21	0.21	774
1993	9.85	6.40	6.87	6.18	-0.22	0.00	-
1994	9.85	6.40	7.16	6.44	0.04	0.04	151
1995	9.85	6.40	9.94	8.95	2.54	2.54	9,265
1996	9.85	6.40	7.95	7.16	0.75	0.75	2,741
1997	9.85	6.40	5.75	5.18	-1.23	0.00	-
1998	9.85	6.40	13.69	12.32	5.92	5.92	21,558
1999	9.85	6.40	6.14	5.53	-0.88	0.00	-
2000	9.85	6.40	4.18	3.76	-2.64	0.00	-
2001	9.85	6.40	6.96	6.26	-0.14	0.00	-
2002	9.85	6.40	4.77	4.29	-2.11	0.00	-
2003	9.85	6.40	7.99	7.19	0.79	0.79	2,872
2004	9.85	6.40	6.47	5.82	-0.58	0.00	-
2005	9.85	6.40	7.45	6.71	0.30	0.30	1,102
2006	9.85	6.40	7.21	6.49	0.09	0.09	315
2007	9.85	6.40	3.28	2.95	-3.45	0.00	-
2008	9.85	6.40	5.77	5.19	-1.21	0.00	-
2009	9.85	6.40	5.35	4.82	-1.59	0.00	-
2010	9.85	6.40	10.68	9.61	3.21	3.21	11,691
2011	9.85	6.40	10.76	9.68	3.28	3.28	11,953
2012	9.85	6.40	4.89	4.40	-2.00	0.00	-
2013	9.85	6.40	2.63	2.37	-4.04	0.00	-
2014	9.85	6.40	2.70	2.43	-3.97	0.00	-
2015	9.85	6.40	5.53	4.98	-1.43	0.00	-
2016	9.85	6.40	9.08	8.17	1.77	1.77	6,445
Average							2,687

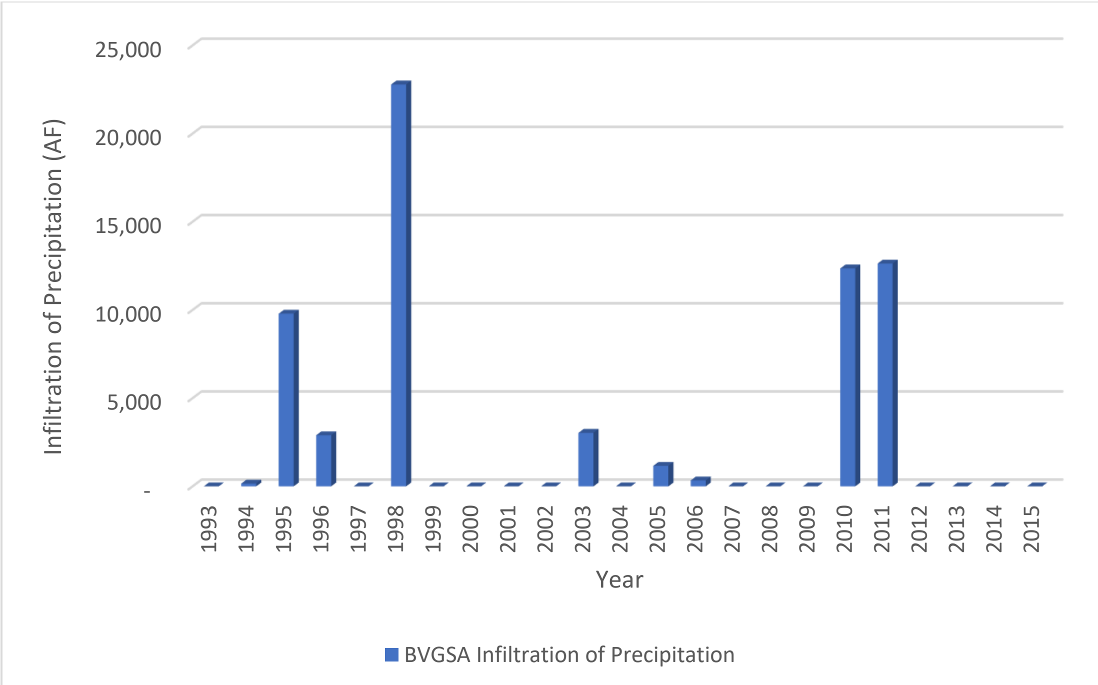

Figure 6-9. Annual Infiltration of Precipitation to Groundwater in BMA

6.7.1.2 Groundwater Inflows

As noted above, in addition to the contribution of precipitation to the groundwater system, there are other flow paths that convey surface water entering the BVGSA to groundwater. These flow paths are essential for operation of the BVWSD's conjunctive management program and include seepage from unlined canals, deep percolation of irrigation water applied to fields, and infiltration from dedicated groundwater recharge facilities.

Canal seepage

Canal seepage totals are based on data from the Water Distribution Summaries (Appendix E) provided by the BVWSD from 1993 through 2015. The District's estimates of canal seepage rates are supported by an audit performed in 2017 by the U.S. Bureau of Reclamation on the Angelo Canal[17], which determined that the method used for estimating seepage by the District was reliable at a 90 per percent level of confidence. Figure 6-10 displays the annual distribution of canal seepage within the BVGSA. As shown in Figure 6-10, seepage from unlined canals varies with hydrologic conditions ranging from 55,360 AF in 1995 to zero in 2014 and 2015, two years when the BVWSD received no Kern River water and relied on stored groundwater to satisfy irrigation demands. The average annual rate of canal seepage is 31,140 AF.

[17] U.S. Bureau of Reclamation, Water Conservation Verification of Buena Vista Water Storage District Canal Piping Project, March 2017

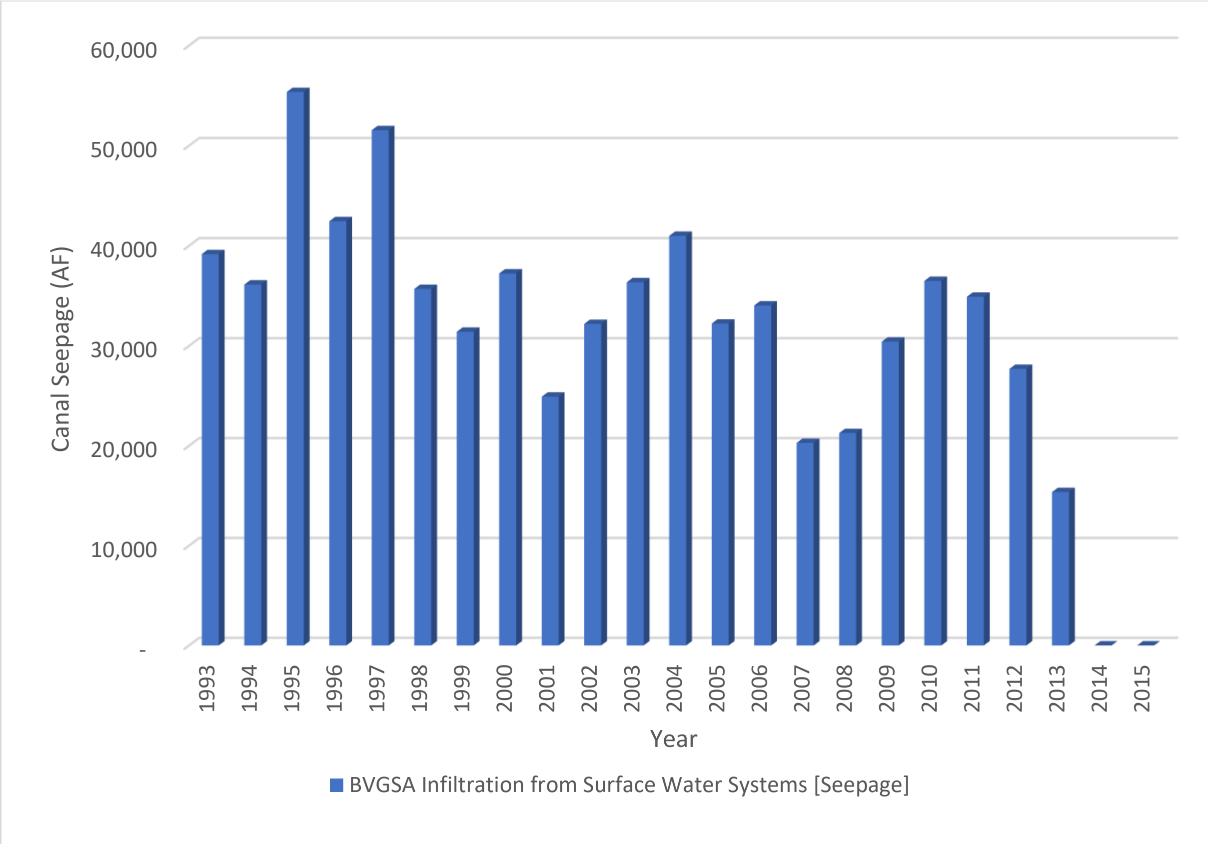

Figure 6-10. Canal Seepage in the BVGSA

Past analyses for agricultural deep percolation have been conducted (2015 AWMP) within the District for 2013 through 2015. Table 6-8, below, shows that deep percolation is estimated to be roughly 5 percent of the total volume of applied water, a value based on total crop ETa from ITRC-METRIC and an assumed irrigation application efficiency of 80 percent.

Table 6-8. Deep Percolation in Relation to Crop Evapotranspiration

	2013	2014	2015
Total ETa (AF)	108,567	63,557	67,015
Total Irrigation Demand (AF)	130,280	76,268	80,418
Deep Percolation	6,514	3,813	4,021

Using this methodology, the average agricultural deep percolation for the period from 1993 through 2015 is estimated to be 4,780 AFY.

Throughout its history, the BVWSD has practiced conjunctive management and continues to add infrastructure to recharge surface water supplies. Water Distribution Summaries for 1993 through 2015 were consulted to obtain annual gross spreading within the BVGSA. Average annual spreading (managed recharge) from 1993 through 2015 is estimated to be 24,350 AFY.

Subsurface groundwater inflow is an element common to both the GSA Component and the Groundwater Component. Therefore, the annual value for subsurface groundwater inflow presented previously for the GSA Component is also applied to this component. Figure 6-11 summarizes the total groundwater inflow to the aquifer(s) beneath the BVGSA.

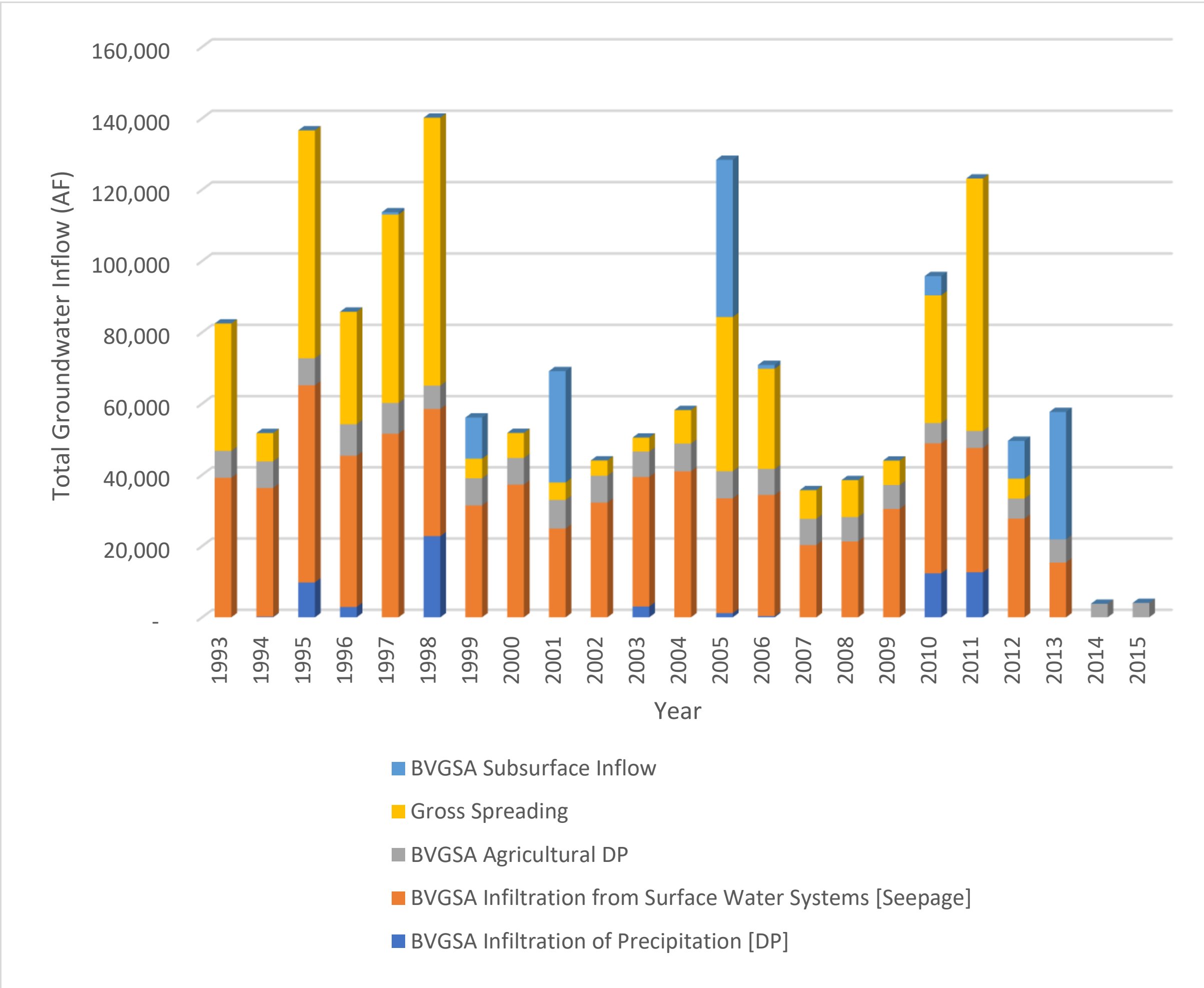

Figure 6-11. Groundwater Component Inflows by Source [1993 - 2015]

6.7.2 Groundwater Component Outflows

In addition to the subsurface outflows estimated in the GSA Component, a flow path common to both components, groundwater also leaves the GSA through extractions for domestic, agricultural, and M&I uses, flow paths captured only in the Groundwater Component. Groundwater extractions that return to the principal aquifer system through canal seepage, deep percolation of applied water and recharge from spreading basins are captured in the flow paths described above for these inflows to the Groundwater Component.

M&I Outflows

Municipal groundwater extraction is based on the per capita water usage of 179 gallons per capita per day in the Community of Buttonwillow. Based on 1990, 2000, and 2010 census data this per capita average is then used to arrive at an average annual requirement for municipal pumping of 257 AFY from 1993 through 2015. In addition, the District pumps 1,500 AF for industrial use. The totals for individual industrial and municipal uses are then combined into the M&I flow path of the Groundwater Component (see Figure 6-12). Given the small proportion of groundwater pumping devoted to domestic and M&I uses, and evapotranspiration of land applied wastewater from the Community of Buttonwillow and from irrigation of landscaping, the water budget assumes that all groundwater extracted for these purposes is consumed and becomes unavailable for future use.

Agricultural Outflows

Groundwater extraction from District wells has been reported by the BVWSD since 1981 but metering of private pumping by landowners has only been in place only since 2016. As a result, the best estimates of historical private pumping are derived by assuming that water demands are met by a combination of surface supply and groundwater pumping. Private pumping becomes the residual or "closure term" of the budget where inflow (supply) is assumed to equal outflow (demand). Inflows and outflows for this approach are defined below:

- Inflows: surface water deliveries, precipitation, metered pumping, and private pumping (closure term – now metered)
- Outflows: evapotranspiration, surface outflows, deep percolation (spreading/recharge, canals, agricultural)

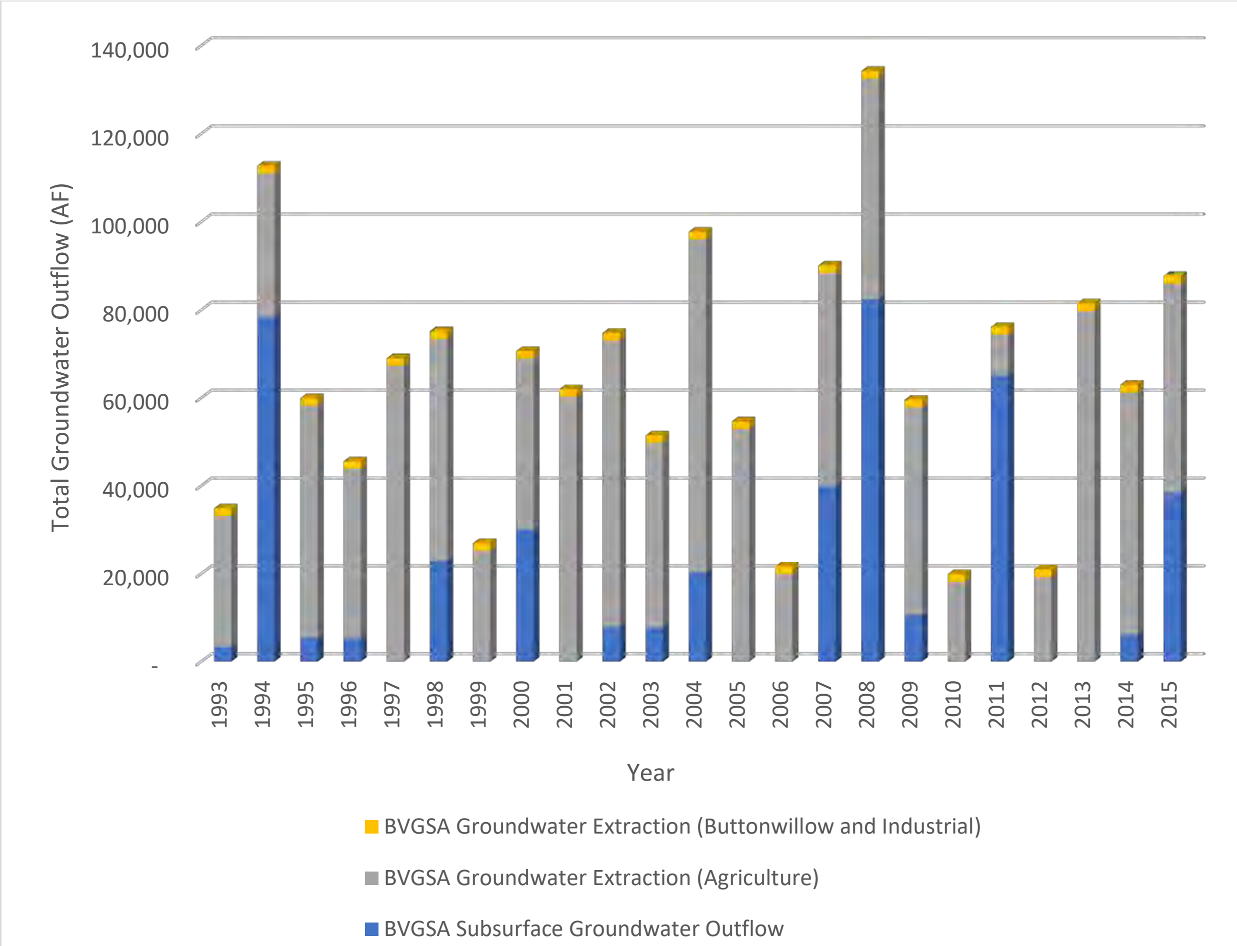

Figure 6-12. Groundwater Component Outflows by Destination [1993 - 2015]

6.7.3 Change in Storage

The change in the annual volume of groundwater in storage between seasonal high conditions, typically spring, has been computed by the three following methods:

- Estimate of change in groundwater storage as the "closure term" in both the groundwater budget and the BVGSA water budget. [Δ Storage = Inflows – Outflows]. This relies on estimates of other uncertain budget components.
- Comparing groundwater elevations between seasonal high conditions and using observed changes in elevations combined with data on specific yield to estimate changes in storage.
- Apply outputs of the C2VSim model for the Kern County Subbasin (Todd Groundwater, 2019). Outputs from this model for an area having boundaries that approximate those of the BMA, were used in Appendix D - Closure Terms for Buena Vista GSA Water Budget to compare charge of storage estimates from C2VSim modeling to those computed using the methods described above.

6.8 Water Budget Summary

The California Department of Water Resources maintains the chronological Reconstructed Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices. Water year type is determined based on measured unimpaired runoff and indexed to one of five classifications: wet, above normal, below normal, dry, and critically dry. Table 6-9 summarizes the total number of years that correspond with each classification from 1993 through 2015. In general, surface water deliveries and evapotranspiration decrease and groundwater pumping increases when dry years occur. The opposite phenomenon is noticed when wet years occur. It should be noted that the distribution of year types shown in Table 6-9 is weighted at the extremes as opposed to a bell-shaped normal distribution where values cluster in the center. As shown in Table 6-9, the skewed distribution of water year types exhibited in the analysis period used for the GSP is similar to the distributions for the complete series for both the Sacramento River (1906 through 2018) and the San Joaquin River (1901 through 2018).

Table 6-9. Frequency Distribution of Water Year Types (percentage)

Index	Wet	Above Normal	Below Normal	Dry	Critically Dry
GSP (23 years)	34.8	13.0	8.7	17.4	26.1
Sacramento River (113 years)	32.3	18.1	16.1	14.4	18.6
San Joaquin River (118 years)	31.9	13.3	19.5	21.2	24.2

Table 6-10 summarizes the water budget for the BVGSA from 1993 through 2015, by water year. It should be noted that unmetered groundwater pumping was determined as described in Section 6.7.2 and subsurface flux as the closure term in the BVGSA Water Budget, as described in Appendix D - Closure Terms for Buena Vista GSA Water Budget.

Table 6-10. Water Budget Summary Results with Corresponding Water Year Type

BVGSA WATER YEAR ANNUAL AVERAGES [1993-2015] (AF)					
INFLOWS	**Wet**	**Above Normal**	**Below Normal**	**Dry**	**Critically Dry**
Surface Water Inflow					
California Aqueduct (diversions)	84,417	77,204	74,728	61,403	45,376
East Side Canal	97,427	63,848	28,363	36,669	20,169
Precipitation	33,505	26,950	25,680	22,224	17,370
Subsurface Groundwater Inflow	5,719	5,647	-	10,471	5,964
Total GSA Component Inflow	**221,067**	**73,649**	**128,770**	**130,767**	**88,879**
Subsurface Groundwater Inflow	5,719	5,647	-	10,471	5,964
Infiltration of Precipitation [DP]	6,201	4,119	1,518	-	27
Infiltration from Surface Water Systems [Canal Seepage]					
Canals within BSA	40,677	35,049	33,395	31,454	15,511
Outlet Canal [conveys water from diversion to BSA][1]	13,018	8,382	3,929	5,984	4,433
Infiltration of Applied Water					
Agriculture DP (Based on BVWSD estimate of 5%)	7,351	6,933	6,922	7,245	6,009
Gross Spreading	50,180	16,132	5,399	6,060	6,598
Total Groundwater Component Inflow	**110,128**	**67,880**	**47,233**	**55,229**	**31,909**
OUTFLOWS	**Wet**	**Above Normal**	**Below Normal**	**Dry**	**Critically Dry**
Surface Water Outflow					
Goose Lake Canal [KNWR] (inflow = outflow)	15,783	14,160	21,964	19,169	15,899
Main Drain Spill N. of Hwy 46 (now zero)	17,700	13,275	5,244	6,004	2,970
To Other Districts	16,554	11,278	1,456	2,677	2,506
Evapotranspiration	122,524	115,558	115,370	120,745	100,156
Subsurface Groundwater Outflow	12,733	10,010	9,146	7,005	40,883
Total GSA Component Outflow	**185,295**	**164,280**	**153,179**	**155,599**	**162,414**
Subsurface Groundwater Outflow	(7,014)	(4,363)	(9,146)	3,466	(34,920)
Groundwater Extraction (Unmeasured Grower Wells)	46,362	31,536	46,166	55,131	52,276
Groundwater Extraction (BVWSD and Measured Grower Wells)	195	512	3,597	4,064	3,075
Groundwater Extraction (BVWSD and Grower Reclamation)	13,314	14,694	10,991	12,108	7,443
Groundwater Extraction (Buttonwillow and Industrial)	1,752	1,760	1,742	1,754	1,767
Total Groundwater Component Outflow	**74,356**	**58,512**	**71,642**	**80,062**	**105,444**
CHANGE IN GROUNDWATER STORAGE	**Wet**	**Above Normal**	**Below Normal**	**Dry**	**Critically Dry**
GSA Component: [inflow - outflow]	35,772	9,368	(24,409)	(24,833)	(73,535)
Groundwater Component: [inflow - outflow]	35,772	9,368	(24,409)	(24,833)	(73,535)

[1] Outlet Canal seepage occurs outside of BVGSA boundaries. Shown in this table for reference, but not included in calculations.

6.9 Impacts of Climate Change Projections

6.9.1 Overview of Regulations (§ 354.18 Water Budget)

The SGMA regulations that apply to the projected water budget are presented below:

> *(a)* ***Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including*** *historical, current and* ***projected water budget conditions****, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.*
>
> *(b)* ***Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components****. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:*
>
> > *(A)* ***Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition*** *for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.*
> >
> > *(B)* ***Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition*** *for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.*
> >
> > *(C)* ***Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply****. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.*

6.9.2 Components of Projected Water Budget

The flow paths for the projected water budget, illustrated below in Figure 6-13, are the same as those shown in previous figures for the historical water budget and include projected values for the following flow paths:

- Kern River Diversions;
- SWP Allocations;
- Precipitation, and
- Evapotranspiration.

Projected values of other flow paths, such as subsurface inflow and subsurface outflow will be influenced by future conditions in neighboring areas. However, these uncertainties are likely to be resolved as water budgets for the Kern County Subbasin are refined during the course of SGMA implementation. Projections for each of the four water budget components listed above are discussed in the following section.

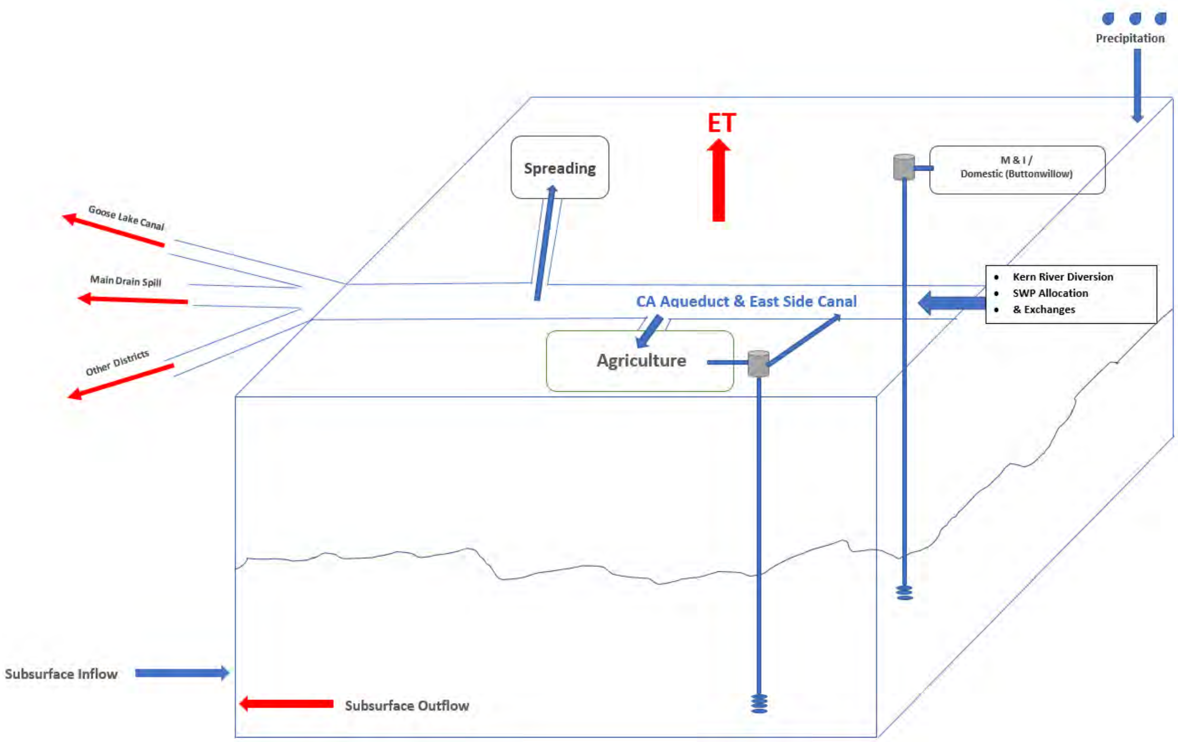

Figure 6-13. BVGSA Water Budget Flowpaths

6.9.2.1 Kern River Diversions

GEI has applied future climate scenarios to 55 years of historical data to predict the volume and timing of flows in the Kern River. For the 2030 and 2070 projections, the GEI analysis presents a decrease in runoff volume of 1.5% and 2.8%, respectively. The more important finding is the timing of Kern River flow is anticipated to change with peak flows occurring earlier resulting in a gap between the occurrence of peak flows and peak irrigation demands.

A separate investigation was conducted by Todd Groundwater as part of development of the C2VSim groundwater model produced for the Kern County Subbasin. Todd's analysis was based on a shorter period of record (20 years; 1995-2014) to match the historical water budget period for their analysis and found a lesser impact from climate change. Todd estimated the 2030 and 2070 flow volumes to decrease by 0.4% and 0.6%, respectively from their historical baseline.

Because of the longer period of record used in the GEI analysis and the more conservative results, this analysis has been applied for projection of Kern River flows. The decreases in flow of 1.5% (2030) and 2.8% (2070) and the shift in timing estimated for the Kern River were then applied to historical diversions by the BVWSD to project future diversions by the District.

As discussed in Section 7 – Projects, Management Actions and Adaptive Management Actions, one mechanism that may be applied to address projected reductions in Kern River diversions will be to reduce the volume of water available under the BVWSD's right to Kern River water that is now exchanged with or sold to other agencies and not used within the District.

6.9.2.2 SWP Diversions

Projected reductions in SWP diversions were based on analyses performed by Todd Groundwater that utilized "change factors" developed as inputs to the C2VSim groundwater model of the Kern County Subbasin. Among the "change factors" were values used to project Table A and Article 21 allocations for 2030 and 2070 to KCWA member agencies. Additional analyses were performed by the Provost & Prichard Consulting Group to estimate SWP allocations for three scenarios:

- under current contracts;
- under current contracts with 2030 climate change projections, and
- under current contracts with 2070 climate change projections.

Figures 6-14 and 6-15 illustrate the impact of the projections described above on SWP allocations to the BVWSD. Table 6-11 shows the annual average reduction in Table A supply. Figures 6-14 and 6-15 analyze both Table A and Article 21 allocations.

Table 6-11. Annual Average Reduction in Table A Supply (AF)

Baseline Climate Scenario	2030 Climate Scenario	2070 Climate Scenario
1,765	2,155	2,800

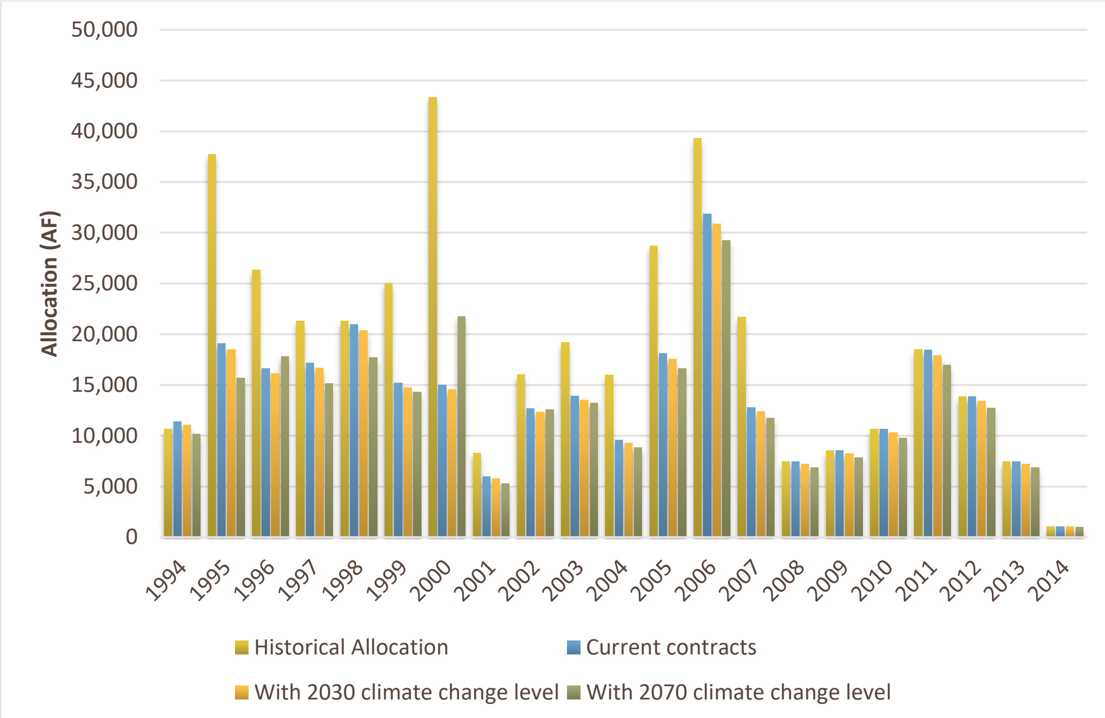

Figure 6-14. Impact of Climate Change on Total SWP Allocations to BVWSD

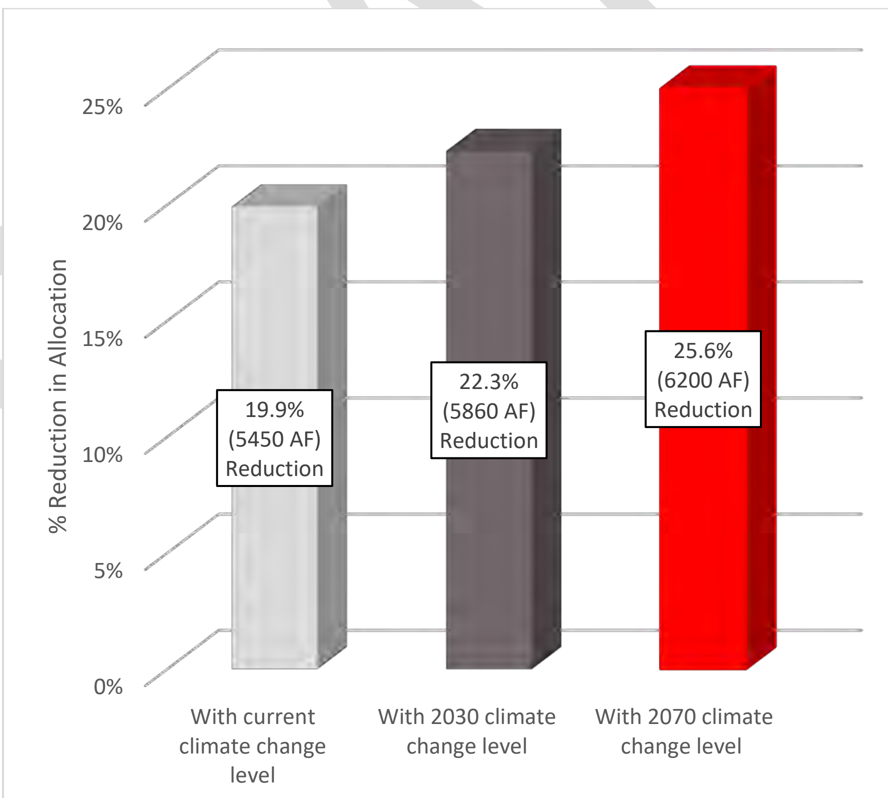

Figure 6-15. Percent Reduction in Total SWP Allocations with Climate Change Levels

Figure 6-15 indicates the degree to which historical deliveries from 1994 to 2014 are likely to be reduced in the future. The estimates from this analysis estimate that total SWP Table A and Article 21 allocations will be reduced by 22.3% and 25.6% under 2030 and 2070 climate change levels, respectively. Here again, the projects and actions presented in Section 7 – Projects, Management Actions and Adaptive Management Actions, are designed to anticipate reductions in water supply available from the SWP.

6.9.2.3 Precipitation and Evapotranspiration

California's Fourth Climate Change Assessment provides information on climate impacts, including temperature, wildfire, water, sea level rise, and governance (www.climateassessment.org). This report suggests that an increasing proportion of precipitation in the southern Sierra Nevada will fall as rain instead of snow accelerating and compressing the period of runoff from mountain watersheds. This shift in timing is likely to create a mismatch between peak flows in the Kern River and the peak diversion period to meet irrigation water demand.

For precipitation and evapotranspiration within BVGSA, analyses performed to support use of the C2VSim model to project the impacts of climate change on the Kern County Subbasin provided change factors for both precipitation and ET. These change factors were then applied to historical averages for the BVGSA to project future levels of precipitation and evapotranspiration. For precipitation, historical data was taken from CIMIS Station #146 (Belridge) (Table 6-5). The evapotranspiration change factor data was applied to ETa data developed using ITRC METRIC, described in Section 6.2.1. Tables 6-12 and 6-13 and figures 6-16 and 6-17 summarize annual precipitation and annual evapotranspiration after adjustment using the "change factors".

Table 6-12. Effects of Climate Change Scenarios on Annual Precipitation

Annual average precipitation: Baseline condition	**6.85**	**inches**
Annual average precipitation volume: Baseline condition	**25.0**	**TAF**
Annual average precipitation volume: 2030 climate scenario	**20.6**	**TAF**
Change from baseline condition: volume	**-4.4**	**TAF**
Change from baseline condition: percentage	**-18**	**%**
Annual average precipitation volume: 2070 climate scenario	**21.1**	**TAF**
Change from baseline condition: volume	**-3.9**	**TAF**
Change from baseline condition: percentage	**-16**	**%**

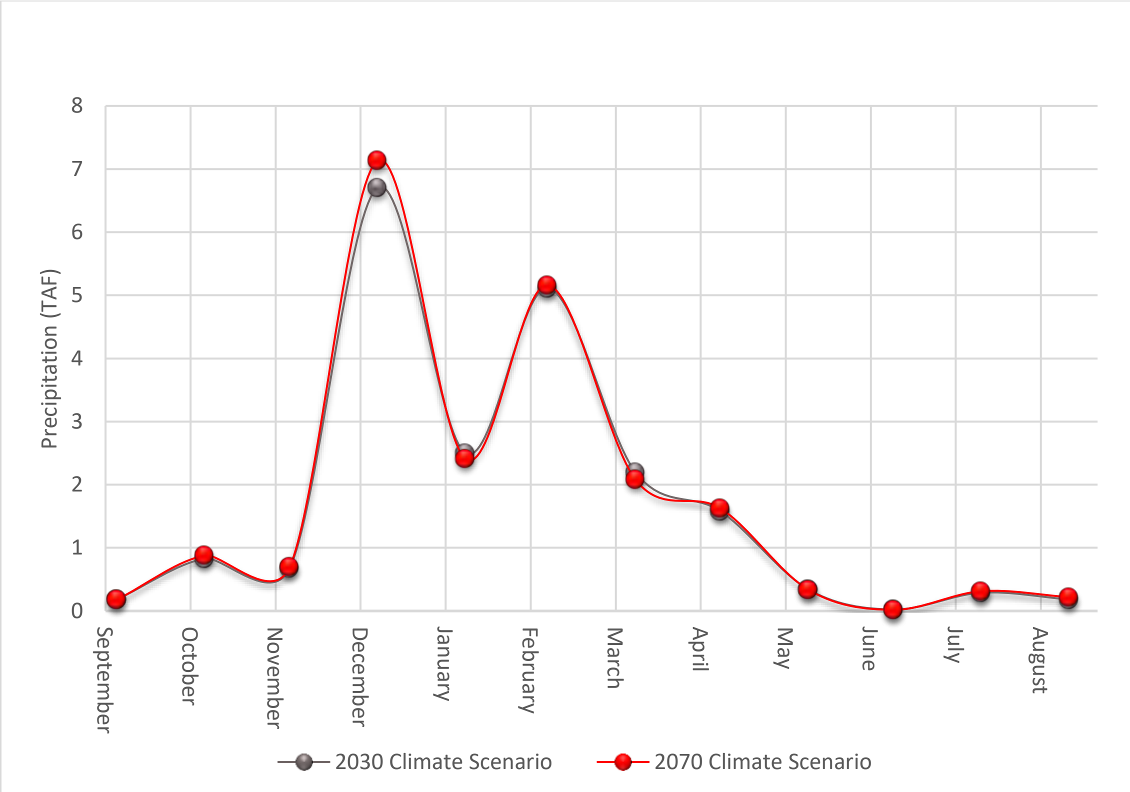

Figure 6-16. Average Monthly Variation of Precipitation (TAF)

Table 6-13. Effects of Climate Change Scenarios on Annual Evapotranspiration

Annual average ET: baseline condition	110.8	TAF
Annual average ET volume: 2030 climate scenario	114.1	TAF
Change from baseline condition: volume	3.32	TAF
Change from baseline condition: percentage	3.0%	%
Annual average ET volume: 2070 climate scenario	119.2	TAF
Change from baseline condition: volume	8.4	TAF
Change from baseline condition: percentage	7.6%	%

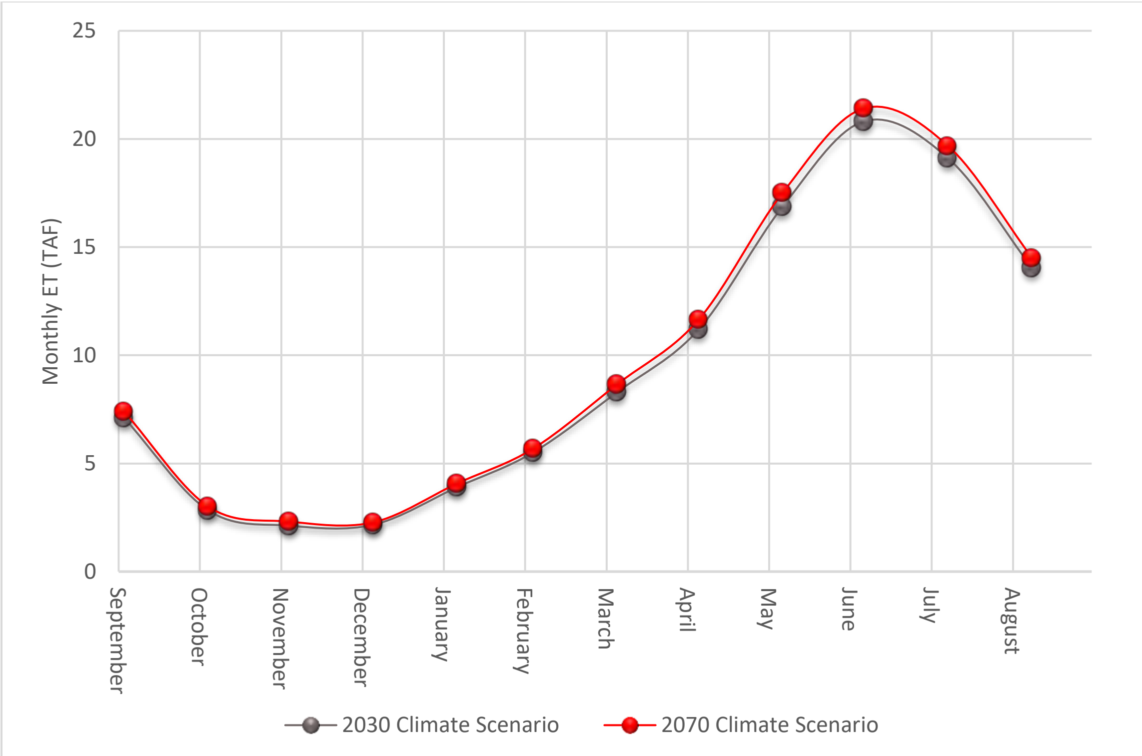

Figure 6-17. Average Monthly Variation of Evapotranspiration (TAF)

Tables 6-12 and 6-13 and figures 6-16 and 6-17 illustrate the projected effects on precipitation and evapotranspiration of climate change. The decreases in precipitation and increases in evapotranspiration, discussed here, together with the effects of increased planting density and changes in cropping, discussed in Section 7 – Projects, Management Actions and Adaptive Management Actions, are expected to increase consumptive use in the BMA during a period of declining supplies of surface water from both the Kern River and the SWP. The projects and programs presented in Section 7 are aimed at enabling the BVGSA to continue to serve its water users by preparing for these increases in demand and reductions in supply by improving facilities and management of the available supply.

6.10 Maples Management Area Water Budget

The second, smaller management area of the BVGSA is the Maples Management Area (MMA). This area covers 4,360 acres and is located about 15 miles south of the Buttonwillow Management Area (BMA). The MMA lies within the KRGSA, so all subsurface fluxes across MMA boundaries are between the MMA and the KRGSA and changes in groundwater levels and storage within the MMA are heavily influenced by conditions in the KRGSA. Because groundwater interactions between the MMA and the surrounding area are internal to the KRGSA and because Sustainable Management Criteria applied in the MMA will be determined by the KRGSA, subsurface fluxes are not tracked in this water budget.

Like the budget for the BMA, this water budget is based on historical water supplies and uses over a period extending from 1993 to 2015. In the case of the MMA, the objective of the water budget is to account for inflows of surface water and precipitation and outflow of crop consumptive use, the one water use of any significance. This analysis is intended to reveal whether the MMA is in surplus or deficit, identify data gaps that compromise the accuracy of the budget and indicate trends in water management that may lead to long-term benefits or liabilities.

The same levels of uncertainty assigned to flow paths in the BMA water budget are associated with the flow paths used in the MMA budget. Inflows are based on measured flow in the Maples Canal and rainfall data from a nearby CIMIS station. ETa data from the ITRC METRIC analysis performed for the Kern County Subbasin was used to estimate crop consumptive use.

6.10.1 Water Budget Flow Paths

Land use in the Maples Management Area almost entirely irrigated agriculture and fallowed land. A schematic water budget for MMA is shown in Figure 6-18.

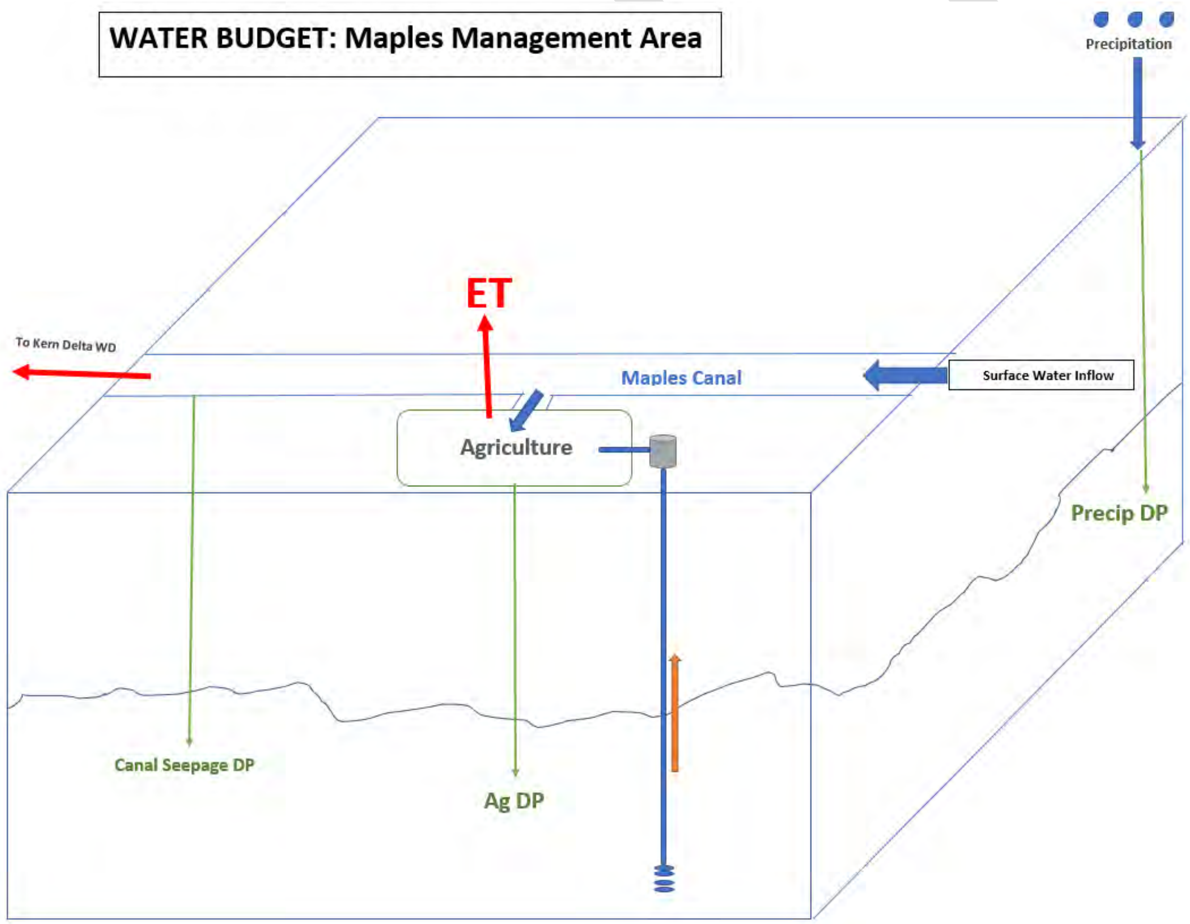

Figure 6-18. Simplified Water Budget Diagram for MMA

Inflows
Inflows to the MMA are based on the BVWSD's rights to Kern River water. Inflows to the MMA include:

- Kern River - delivered through the Maples Canal which begins at Lake Webb, and
- Precipitation.

As no rivers or streams cross the boundaries of the MMA, surface water inflows are restricted to water delivered via the Maples Canal. Table 6-14 below shows surface water inflows from 2006 - 2015. Figure 6-19 shows longer-term trends in surface water deliveries (1993 through 2015).

Table 6-14. Surface Water Deliveries to MMA [2006-2015]

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Maples Canal (AF)	12,977	6,654	4,991	3,045	1,232	571	2,933	2,174	-	-

Table 6-15 presents estimates of the volume of annual precipitation falling on the MMA from 1993 through 2015.

Table 6-15. Precipitation in MMA [1993 - 2015]

Year	MMA Precipitation (AF)	Station
1993	2,496	Shafter
1994	2,601	Shafter
1995	3,612	Shafter
1996	2,889	Shafter
1997	2,089	Shafter
1998	4,974	Shafter
1999	2,231	Belridge
2000	1,519	Belridge
2001	2,529	Belridge
2002	1,733	Belridge
2003	2,903	Belridge
2004	2,351	Belridge
2005	2,707	Belridge
2006	2,620	Belridge
2007	1,192	Belridge
2008	2,096	Belridge
2009	1,944	Belridge
2010	3,880	Belridge
2011	3,909	Belridge
2012	1,777	Belridge
2013	956	Belridge
2014	981	Belridge
2015	2,009	Belridge
Average (AF)	2,435	
Average (ft/ac)	0.56	

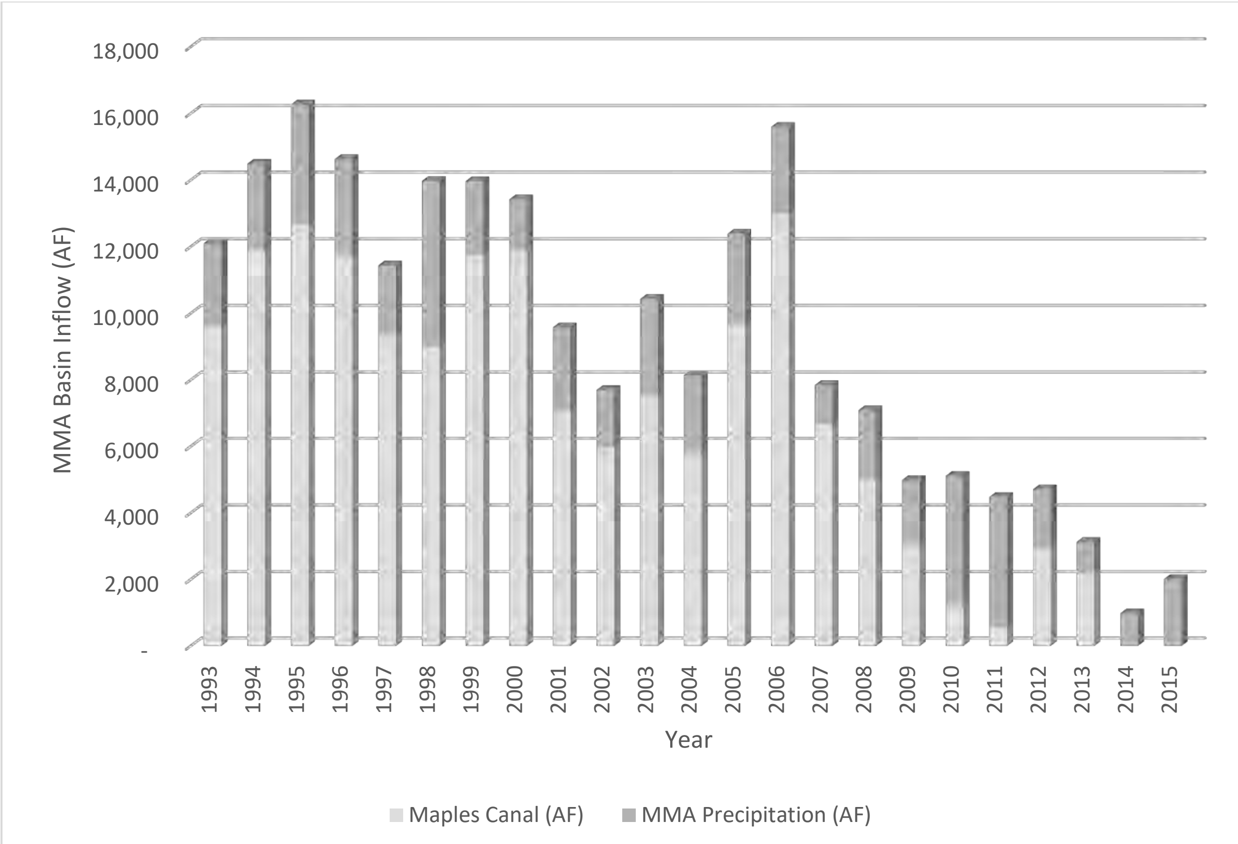

Figure 6-19. Inflows to MMA by Source [1993 - 2015]

Outflows

Outflows from the MMA include water that leaves the boundaries of the management area via surface water flow paths that include canals, drains, and evapotranspiration.

- Deliveries to the Kern Delta Water District through the Maples Canal, and
- Agricultural consumptive use.

Figure 6-20 summarizes surface water outflows from the MMA and Figure 6-21 summarizes evapotranspiration leaving the MMA.

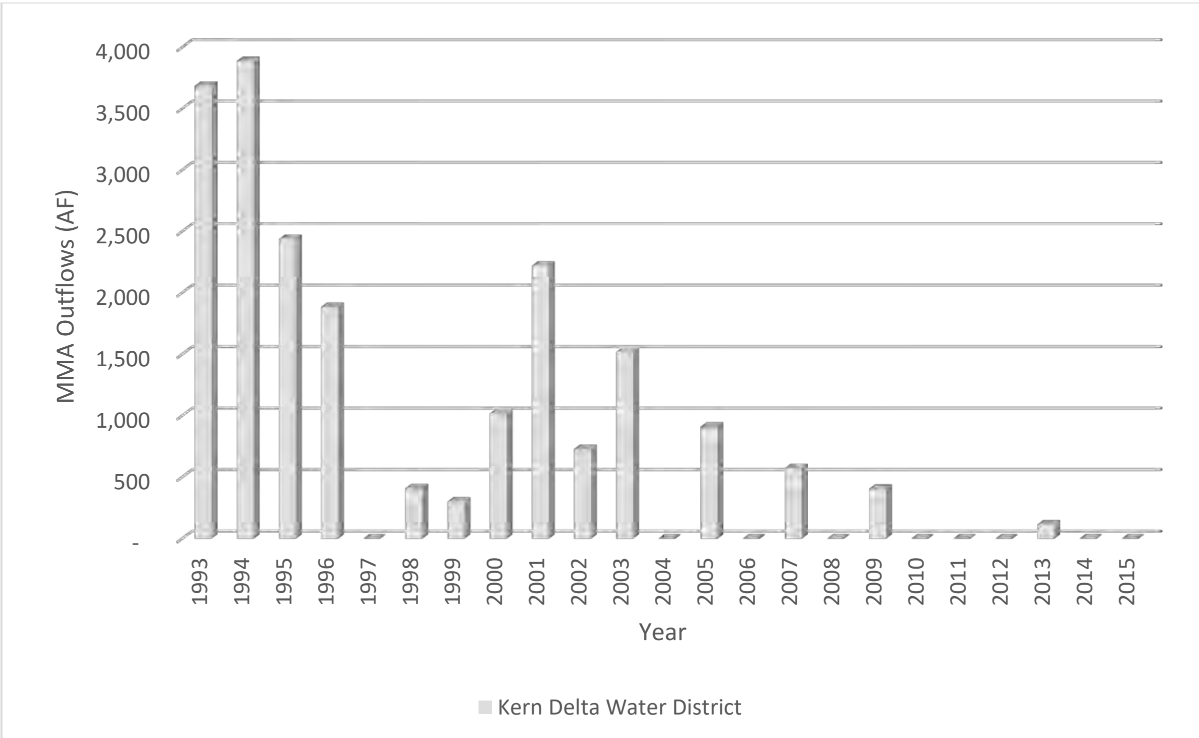

Figure 6-20. Outflows from MMA by Destination [1993 - 2015]

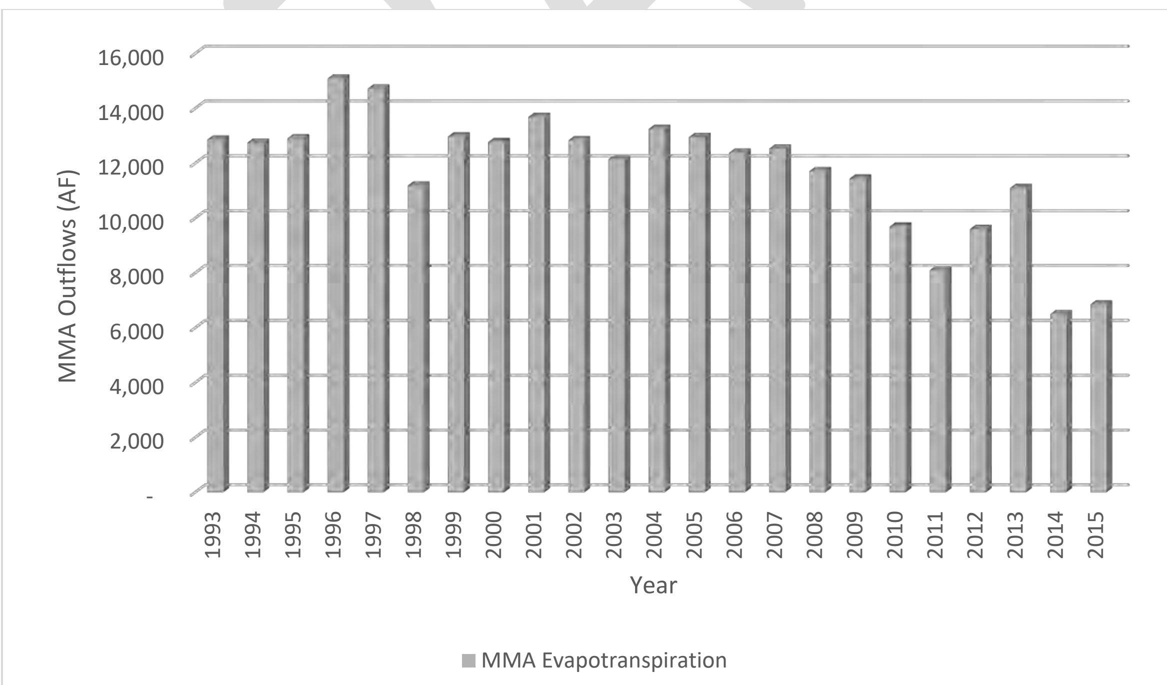

Figure 6-21. Evapotranspiration in MMA [1993 - 2015]

It should be noted that the ITRC-METRIC evapotranspiration data for the MMA displays the same decline in values after 2009 described earlier for the BMA.

Table 6-16 presents the results of the analysis of deep percolation of precipitation described earlier for the BMA. This analysis yields an average annual value for deep percolation of precipitation of 0.07 feet (0.79 inches). Figure 6-22 illustrates how percolation of precipitation has ranged over the period of study.

Table 6-16. Percolation of Precipitation

Year	Estimated Percolation (AF)
1991	107.79
1992	83.14
1993	-
1994	16.24
1995	995.13
1996	294.41
1997	-
1998	2315.58
1999	-
2000	-
2001	-
2002	-
2003	308.50
2004	-
2005	118.35
2006	33.84
2007	-
2008	-
2009	-
2010	1,255.70
2011	1,283.87
2012	-
2013	-
2014	-
2015	-
2016	692.31
Average (AF)	288.53
Average (ft/ac)	0.07

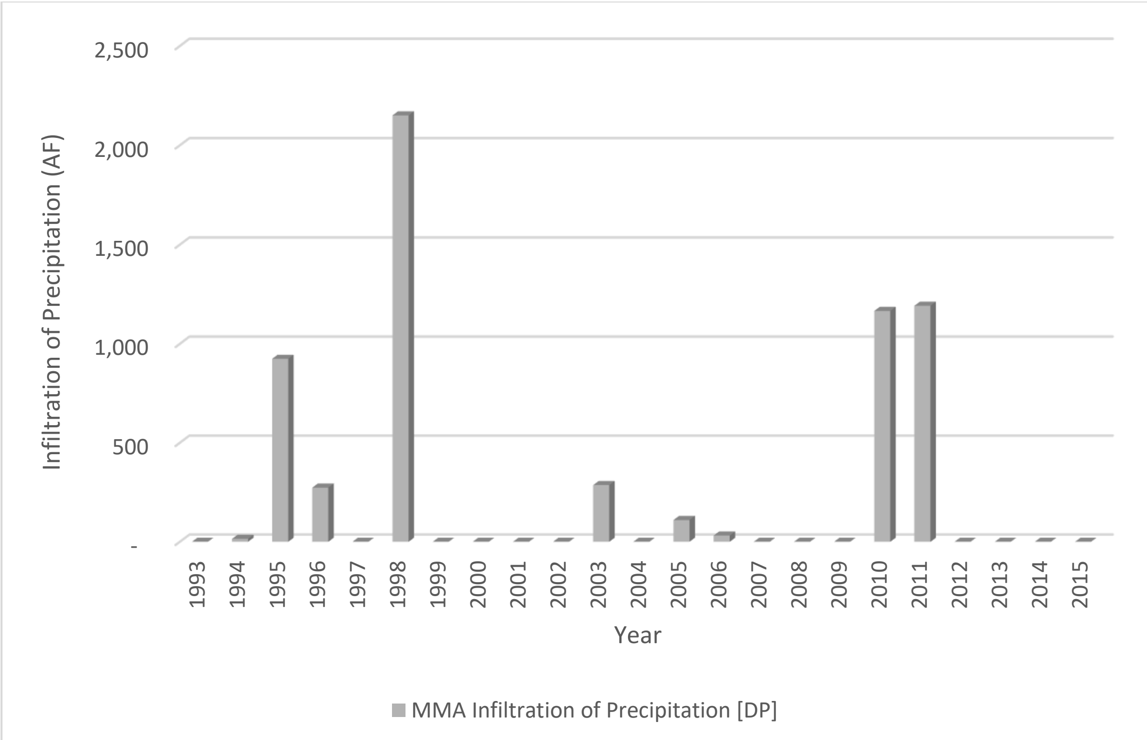

Figure 6-22. Infiltration of Precipitation in MMA

As noted above, in addition to the contribution of precipitation to the groundwater system, there are other flow paths that convey surface water entering the MMA to groundwater. These flow paths are essential for the BVWSD's program of conjunctive management and include seepage from unlined canals and deep percolation of irrigation water applied to fields and are the same in the MMA as in the BMA.

Canal seepage

Canal seepage totals are based on data from Water Distribution Summaries provided by the BVWSD from 1993 through 2015. Figure 6-23 summarizes the amount of canal seepage within the MMA. As shown in Figure 6-23, seepage from unlined canals varies from 3,168 AF in 2000 to zero in 2014 and 2015, two years when BVWSD received no surface water and relied exclusively on stored groundwater to satisfy irrigation demands. The average annual rate of canal seepage was 1,644 AF.

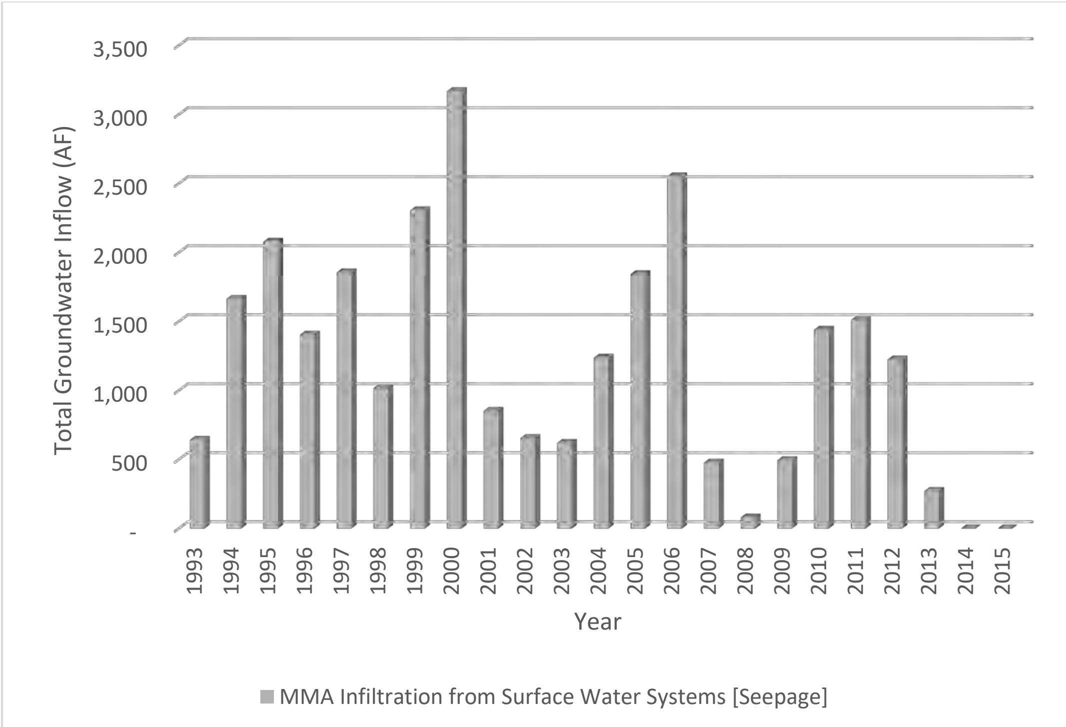

Figure 6-23. Canal Seepage in MMA

Deep Percolation

Agricultural deep percolation has been estimated within the BVWSD for 2013 through 2015 in the District's Agricultural Water Management Plan (2015 AWMP). As is the case with the BMA, deep percolation in the MMA has been estimated to be roughly 5 percent of total crop irrigation demand. This value was reached by adjusting the ITRC-METRIC annual actual evapotranspiration (ETa) values to account for a typical irrigation efficiency and taking 5 percent of this total. Using this methodology, the annual average agricultural deep percolation for the period from 1993 through 2015 is estimated to be 587 AF.

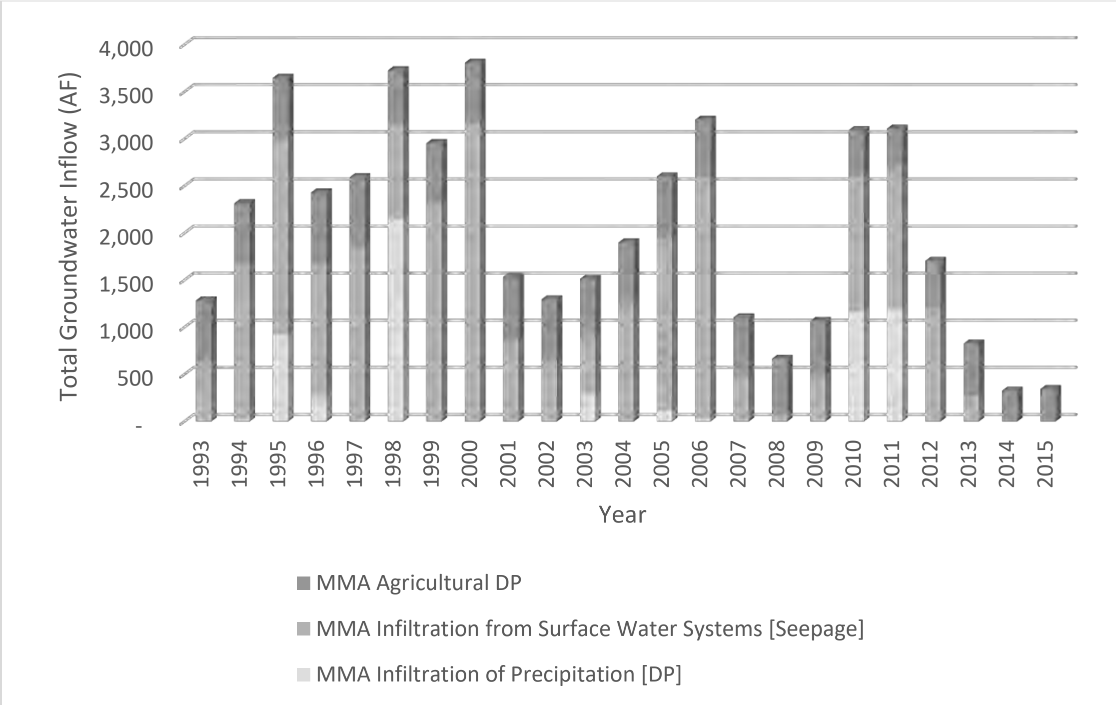

Figure 6-24. MMA Groundwater Inflows by Source [1993 - 2015]

6.10.2 MMA Water Budget Summary

Table 6-17 summarizes the water budget for the MMA from 1993 through 2015 by water year. Unknowns in the water budget include subsurface cross-boundary flux with the KRGSA and extractions by private pumpers that were not metered over the period used to construction this water budget but are now metered under the BVGSA metering program.

Table 6-17. Water Budget Summary

INFLOWS	Wet	Above Normal	Below Normal	Dry	Critically Dry
Surface Water Inflow					
Maples Canal	9,448	8,290	5,287	5,436	4,285
Precipitation	3,447	2,772	2,642	2,286	1,787
Total MA Inflow	**12,894**	**11,062**	**7,929**	**7,722**	**6,072**
Infiltration to Groundwater					
Infiltration of Precipitation	585	389	143	-	3
Canal Seepage	2,626	2,304	701	913	807
Infiltration of Applied Water	587	587	587	587	587
Total Groundwater Inflow	**3,798**	**3,280**	**1,431**	**1,500**	**1,397**

OUTFLOWS	Wet	Above Normal	Below Normal	Dry	Critically Dry
Surface Water Outflow					
Kern Delta Water District	1,166	440	963	738	763
Evapotranspiration	8,424	7,945	7,932	8,301	6,886
Total MMA Outflow	**9,590**	**8,385**	**8,894**	**9,039**	**7,649**
Groundwater Extraction (BVWSD and Measured Grower Wells)	2,892	4,851	4,878	5,129	3,155
Groundwater Extraction (BVWSD and Grower Reclamation)	-	307	-	-	-
Total Measured Groundwater Outflow	**2,892**	**5,158**	**4,878**	**5,129**	**3,155**

6.11 BVGSA Resources Accounting Budget

An important consideration for the BGVSA with respect to overall management of the Kern County Subbasin is the degree to which the GSA's supplies are in balance with its demands, a question that can be approached by constructing a simple water budget that combines measured values with parameters that have been agreed upon by the Kern County Subbasin Coordinating Committee. Estimates of parameters such as groundwater extraction and subsurface cross-boundary fluxes are not included as the sole purpose of this budget is to combine water the BVGSA is entitled to receive from the Kern River and the SWP with water available from native yield and precipitation. These sources of supply are then compared with water exiting the GSA through the largest and best defined flow path, evapotranspiration.

Unlike the GSP water budget which tracks pathways for movement of water into and out of the BVGSA, this budget is based on native yield and precipitation, the BVWSD's current and projected surface water supplies, and current and projected demands and outflows. Therefore, while the flow paths presented in the GSP budget are affected by exchanges, transfers and banking agreements that alter the location and timing of flows entering and leaving the BVGSA, this budget rests on the underlying access to water and the demands expected to be placed on those resources.

6.11.1 Budget Inputs

The following section describes the basic inputs into the water budget. Because the purpose of the budget is to assess the difference between inflows and outflows, there is no need for a closure term to bring the budget into balance.

6.11.1.1 Native Yield and Precipitation

The two basin-wide parameters used as a foundation for this analysis are native yield and precipitation. For the Subbasin, 0.15 AF/ac is a generally accepted value for native yield. Values for precipitation discussed by the Coordinating Committee range from 0.15 to 0.5 AF/ac with the BVGSA adopting 0.2 AF/ac, a number in the lower 15% of this range. Applied over the entirety of the BVGSA's two management areas, the Buttonwillow Management Area (BMA - 46,480 acres) and the Maples Management Area (MMA - 4,360 acres), use of these values for the 2020 estimate results in an average annual contribution of 7,626 AF of native yield and 10,168 AF of precipitation for a total contribution of 17,794 AF. The native yield has been held constant for the 2030 value, while precipitation, after adjustment for climate change, has been reduced by 18%. For 2070, the native yield has remained constant, while the value for precipitation is 16% below the 2020 baseline.

6.11.1.2 Kern River Water Right

The BVWSD's diversions from the Kern River are based on an average entitlement of 156,000 AF/yr delivered by First Point interests to the Second Point of measurement, undiminished by delivery losses (Krieger & Stewart, 2009). Buena Vista's entitlement is 96.044% of this flow or 149,828 AF/yr. This entitlement is expected to remain essentially intact during the period of SGMA implementation with the BVGSA applying a future average annual entitlement of 147,000 AF/yr for the 2030 and 2070 budgets. This reduction lies between the 1.5% reduction due to climate change projected for 2040 and the 2.8% reduction projected for 2070.

6.11.1.3 SWP Deliveries

Deliveries of SWP water of 12,960 estimated for 2020 are based on the BVWSD's Table A allocation of 21,600 AF/yr after adjustment by DWR's 62% projected system reliability (State Water Project Final Delivery Capability Report, DWR,2015). Under the 2030 climate change scenario, the 2020 Table A supply is reduced by 22.3% to 10,070 AF/yr. Under the 2070 scenario, the Table A supply is reduced by 25.6% to 9,642 AF/yr.

The BVWSD has historically taken an average of 1,800 AF/yr of Article 21 water. Because of the development of the Palms and the Corn Camp water banking projects described below, the amount of Article 21 water to be received by the GSA in 2040 and 2070 is expected to increase to 3,900 AF/yr.

6.11.1.4 Demand and Surface Water Outflow

As presented throughout the GSP, consumptive demand has fluctuated considerably during the period between 1993 and 2015. Some of this fluctuation is a response to variations in the weather. However, the factors having the greatest impact on demand have been changes in cropping, particularly conversion from seasonal field crops to permanent plantings and varietal improvements. As extensive plantings of orchards are now maturing in the BVGSA and further conversions of field crops to orchards and high production vineyards are anticipated, the increase in consumptive use due to climate change is likely to be exceeded by the factors described below.

- Irrigation demand measured by the BVWSD in 2019 is approximately 100,000 AF, an average of 2.14 AF/acre over the 43,643 acres eligible to receive water service. This value is comparable to the average total ETa observed over the BVGSA from 2006 through 2015. Demand in 2020 is expected to be comparable to 2019.
- Irrigation demand in 2030 is anticipated to reach 150,000 AF/yr (3.22 AF/acre served). This increase is due to the combined impacts of climate change, maturing orchards and vineyards, and continued conversions to permanent crops;
- Irrigation demand in 2070 is anticipated to reach 175,000 AF/yr (3.75 AF/acre served). This continued increase is also driven by climate change, continued cropland conversion and introduction of higher yield crop varieties having lower consumptive demands relative to yield but higher water demands per acre. The average per acre served values can be compared with a current consumptive demand for high-yielding almonds grown in the San Joaquin Valley of 4.33 AF/acre.

Most surface water outflows from the BVGSA serve transfer agreements or exchanges that are captured in the values given above for entitlements to Kern River and SWP water. The historical exception are flows leaving the GSA via the Main Drain Canal. These flows have greatly diminished over the past 10 years as growers in Buena Vista have converted from gravity irrigation systems which produce substantial volumes of tailwater and tilewater to drip and micro-sprinkler systems which have essentially eliminated these sources of drainage. This reduction is illustrated by flow records showing that prior to 2013 the average annual outflow in the Main Drain Canal was 10,000 AF/yr, but that since June of 2013 there has been zero outflow, even with 2017 flows on the Kern River being 270% of normal. As a result, Main Drain Canal outflows are not an element of the 2020 budget and are not included in the 2030 and 2070 budgets as future outflows are unlikely.

6.11.1.5 Projects

Palms Water Banking Project

Completion of the Palms Groundwater Banking Project, described in Section 7 – Projects, Management Actions and Adaptive Management Action, will remove approximately 1,160 acres from agricultural production. Therefore, although water will evaporate from the project area during periods when the water bank is recharging, the retirement from irrigated land use is expected to lower evapotranspiration by 3.0 AF/ac. Secondly, the Palms will enable the BVWSD to double the volume of Article 21 water the District is now able to accept from the California Aqueduct from 1,800 AF/yr to approximately 3,600 AF/yr. These two adaptations will increase net inflow to the GSA by approximately 5,280 AF/yr.

Corn Camp Water Banking Project

The BVWSD is currently developing a second in-District banking facility on land owned by Chevron at the intersection of Corn Camp Road and Highway 58. This 85-acre project is expected to increase banking of Article 21 water by an estimated 300 AF/yr. In the case of the Corn Camp Project, there will be no reduction in demand, as Chevron will continue to have access to the "Ag Water" associated with this property.

6.11.1.6 Water Resource and Demand Distribution

Table 6-18 presents the parameters and values described above with the 2020, 2030 and 2070 conditions each presented in a single column.

Table 6-18. 2020, 2030 and 2070 Resources and Demands

BVGSA Resource vs Demand	2020	2030	2070
Water Resource		**Volume (AF/yr)**	
Native yield	7,626	7,626	7,626
Precipitation	10,168	8,338	8,541
Subtotal	17,794	17,794	17,794
Kern River	149,000	147,000	147,000
SWP Table A[1]	13,392	10,406	9,964
SWP - Article 21[2]	1,800	3,900	3,900
Subtotal	164,192	161,306	160,864
Available Resource	181,986	179,100	178,658
Water Demand		**Volume (AF/yr)**	
Evapotranspiration[3]	100,000	150,000	175,000
Main Drain Canal[4]	-	-	-
Total Demand	100,000	150,000	175,000
Balance	81,986	29,100	3,658

[1] Table A reduced by 22% in 2030 and by 26% in 2070

[2] Article 21 increased by 2,100 AF/yr due to completion of Palms and Corn Camp water banking projects

[3] 2020 estimate based 2019 water demands measured by BVWSD

[4] Based on average Main Drain Canal outflow since June 2013. This value is used because it represents current and expected future outflows.

The 2020 budget is based on the native yield and precipitation values agreed to by the coordinating committee. Kern River and SWP values are based on the BVWSD's entitlement to the Kern River and its Table A contract amount adjusted to conform to DWR projections of water supply reliability. Values for Article 21 water and for irrigation demand are based on 2019 measurements and the value for Main Drain Canal outflow is the average of measurements taken between 2006 and 2015, as well as BVWSD records that extend for nearly 100 years.

As described above, the 2030 projection holds native yield constant while precipitation has been reduced by 18% to 8,338 AF/yr. Diversions from the Kern River have been reduced by 1.8% to 147,000 AF, Table A diversions have been reduced by 22% and Article 21 inflows have been increased by 2,100 AF/yr to account for the capacity of the Palms and the Corn Camp water banking projects to accept Article 21 water. Crop consumption has been increased by 50% which includes a 3.0% increase in response to climate change with the additional increase due to other factors described above. Outflows via the Main Drain Canal credited to the inflows described above are expected to be negligible with any measurable outflows resulting from runoff of precipitation in excess of the precipitation value credited to the GSA.

The 2070 projection continues to hold native yield constant while precipitation has been reduced by 16% from the 2020 baseline to 8,451 AF/yr. The Kern River entitlement is projected to remain the same as that presented for 2030, 147,000 AF/yr. Article 21 inflows used in the 2070 budget are the same as those shown for 2030 while Table A deliveries have been further restricted due to climate change. The Buena Vista Water Storage District expects to participate in the Delta Conveyance Project, and, as a result, should not suffer Article 21 reductions. Irrigation demand is projected to increase to 175,000 AF/yr, 17% greater than the demand estimated for 2030 with 4.6% of this increase attributed to climate change. This is a conservative estimate anticipating continued conversion to higher value permanent crops and their associated higher demand.

6.11.1.7 Summary

The 2030 and 2070 projections indicate that the impacts of climate change are expected to do little to reduce BVWSD’s entitlement to the Kern River. Therefore, as demands within the BVGSA increase, the current gap between the BVWSD’s entitlement to the river and its diversions to serve internal demands is likely to shrink as the District reduces transfers to other users to meet its own growing demands in the face of diminishing SWP supplies.

The water budget table for 2020, 2030 and 2070 demonstrates that when applying agreed values for native yield, precipitation and climate change projections, the BVGSA is in surplus and will remain in surplus through 2070 albeit with the surplus diminishing due primarily to anticipated increases in irrigation demand with climate change being an important but secondary factor. Nevertheless, due largely to the BVWSD’s entitlement to the Kern River and the District’s history of conjunctive management, the BVGSA has the resources and the mechanisms to remain in balance internally and to contribute to achieving sustainability throughout the Kern County Subbasin.

The BVWSD has other projects, such as the McAllister Ranch Water Banking Project and future internal pipeline projects, which will provide the GSA opportunities to stay in balance should projected increases in demand be underestimated, or should the changes occur more rapidly than now anticipated. To a large degree, the water needed to address these contingencies is already available to the District, and the projects needed to manage this water are under development.

7. Projects, Management Actions, and Adaptive Management Actions

7.1 Management Program

As documented in preceding sections, due to the BVWSD's geologic setting and its conjunctive management of surface water and groundwater, the BVGSA has maintained stable groundwater elevations while supporting irrigated agriculture with most of the GSA showing little fluctuation in depths to groundwater between wet periods and droughts. Although the GSA does not need to construct projects and introduce management actions to correct a history of unsustainable groundwater use, it has developed an integrated program of measures that will enable the GSA to continue to manage groundwater effectively to achieve the goal of supporting water users in the Kern County Subbasin in the face of changing conditions. Foreseeable changes include both increasing demands within the BVGSA and external forces likely to change the timing and volumes of surface water available from the Kern River and the State Water Project.

Two principles that have guided the BVWSD in the past and will continue to guide the District and the BVGSA during implementation of SGMA are:

- Conjunctive management of surface water and groundwater, and
- Adaptive management.

The application of these principles is illustrated by the program of pipeline and groundwater recharge projects now underway that are adapting the District's facilities and operations from a period characterized by reliable surface water deliveries and farming of seasonal crops to an era of highly variable surface water supplies and expanded plantings of permanent crops. In this light, the on-going efforts to introduce projects and management actions needed to provide a secure water supply for the future are consistent with actions needed to protect the groundwater resource.

Internal Changes

The BVGSA anticipates that land use within the BMA will remain predominately irrigated agriculture and that the irrigated acreage will remain stable. This stability in land use and acreage notwithstanding, the GSA anticipates crop water demands to increase and harden during the period of SGMA implementation as the percentage of land devoted to permanent crops increases and because of the likelihood that new plantings of vineyards and tree crops will be at higher densities to increase productivity. The effects of climate change are projected to increase evapotranspiration by 3 percent between the baseline period and 2040 with a further 5 percent increase between 2040 and 2070 thereafter (DWR, 2019). However, the relation between predicted increases in temperature and consumptive use are not well understood because increased rates of consumptive use may lead to shorter growing seasons and other changes in plant phenology. Increases in crop consumption caused by climate change are expected to be accompanied by increases in demands resulting from changes in cropping patterns and improvements in farming practices. Total increases in consumptive use for mature plantings may reach 8 percent above the baseline period by 2040 and 15 percent above the baseline by 2070. As described later in this section, the Palms Groundwater Banking and Recharge Project will replace 1,160 irrigated acres, approximately 3 percent of the irrigated acreage in the BMA, with spreading grounds.

Responses to Internal Changes

The goal of the BVGSA's program of projects and management actions is to continue to prepare for a future characterized by higher water demands. Because the cropping pattern anticipated in the GSA is likely to have a higher concentration of permanent crops than under the baseline condition, this continuing shift will leave fewer opportunities to reduce demand during prolonged droughts by land fallowing. However, because of the resilience of some permanent crops to deficit irrigation, incentives to reduce irrigation applications will remain a management action that can be instituted as a direct response to drought.

External Changes

The primary forces driving external changes are the potential consequences of climate change on the volume of water delivered by the SWP and Kern River and on the timing of Kern River flows. Although the magnitude of these potential shifts in the volumes and timing of surface water supplies remains uncertain, the BVGSA and landowners within the GSA are cognizant of the impacts changes in water supply may have on their operations.

Responses to External Changes

For conjunctively managed areas such as the BVGSA, the ability to sustainably manage groundwater depends on sound management of surface water supplies, coordinated use of surface water and groundwater facilities and continual refinement of facilities and operational practices to conform with the availability of surface water and with changes in cropping patterns and farming practices. The five major elements of the BVGSA's program for sustainable groundwater management are:

- Capture and recharge of water received from the Kern River and the SWP in facilities constructed within the boundaries of the BMA and in partnerships with neighboring GSAs.
- Improve distribution facilities to expand the ability to deliver surface water throughout the GSA as a means of reducing reliance on groundwater.
- Measurement of:
  - Surface water deliveries;
  - Water pumped from district-owned and landowner wells; and

- Water distributed to farm fields and recharge facilities.

- Monitoring of groundwater elevations and water quality.
- Water conservation and treatment.

Projects and management actions described in this section were developed by the BVWSD and by stakeholders. While each of these actions addresses sustainability indicators introduced by the SGMA legislations, none were formulated specifically as responses to SGMA. For example, the BVWSD's program to install meters on all production wells was completed before the formation of the BVGSA. In short, sustainable groundwater management is not a concept that has been introduced by SGMA, but rather, is an expression of the BVWSD's mission to serve its water users. Important contributions of the SGMA legislation have been to require that the BVGSA quantify the performance of its conjunctive management program through establishment and monitoring of minimum thresholds and measurable objectives and that the GSA coordinate management of its water resources with other GSAs to promote sustainable management of groundwater in the Kern County Subbasin.

Given the BVWSD's history of successful conjunctive management under a wide range of water supply conditions, the GSA intends to continue to implement projects to prepare for changing conditions. One of the objectives of the GSA's emphasis on anticipation and preparation is to minimize reliance on emergency demand management actions taken in response to breaches of trigger conditions such as minimum thresholds. The emphasis on long-term planning is possible because of the following factors:

- As presented in Section 5 – Minimum Thresholds, Measurable Objectives and Interim Milestones, the BVGSA is estimated to have a drought reserve of 362,000 AF with substantially greater volumes of groundwater that can be accessed in a drought emergency;
- BVWSD has a well-established history of conjunctive management that has enabled it to withstand prolonged droughts with little change in groundwater storage, and
- The extensive commitment by landowners to planting of permanent crops favors a program of projects and management actions that emphasizes preparation for future conditions and predictability of water supply.

In the unlikely event that long-term planning is insufficient to prevent breaches of minimum threshold, the BVGSA has established a sequence of adaptive management actions to reverse adverse conditions. These adaptive management actions, detailed in Section 7.4, are based on actions including curtailment of transfer and exchanges of BVWSD, fallowing of lands in annual crops, securing supplemental water through transfer and exchange, and curtailment of pumping for wells within a specified radius of the locations where breaches of minimum thresholds have been observed.

Activities already under development are included in 2040 and 2070 water budget projections. Also included in these projections are management actions anticipated to capture Kern River flood flows anticipated under 2040 and 2070 climate change scenarios.

7.1.1 Sustainability Goal

The six sustainability indicators defined by SGMA are guideposts that warn of groundwater conditions occurring throughout a subbasin which, when significant and unreasonable, lead to undesirable results. As described in Water Code Section 10721 (x), the six sustainability indicators are:

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued;
2. Significant and unreasonable reduction of groundwater storage;
3. Significant and unreasonable seawater intrusion;
4. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies;
5. Significant and unreasonable land subsidence that substantially interferes with surface land uses, and
6. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

In the BVGSA, undesirable results are likely to be associated with four of these sustainability indicators. Significant and unreasonable seawater intrusion is not relevant given the GSA's inland location in Kern County, and, as discussed in Section 2 - Basin Setting, the potential for depletions of interconnected surface waters is small given the following factors:

- The absence of streams flowing into or through the BVGSA;
- The depth of the principal aquifer system which makes it unlikely that groundwater pumping has the potential to deplete surface water, and
- The absence of groundwater dependent ecosystems (GDEs) mapped within the boundaries of the BVGSA.

7.1.2 Development Process

7.1.2.1 Project Identification

The BVGSA's approach to sustainable groundwater management is to emphasize continued development of projects that will recharge available surface water and provide efficient, metered extraction and distribution of stored groundwater and effective application of water to irrigated lands to minimize losses resulting from evaporation and runoff.

7.1.2.2 Management Action Identification

The BVGSA will exercise management actions when needed to prevent dewatering of wells should water tables drop below well screens or breach minimum thresholds. These actions will focus on protection of owners of shallow domestic wells, the groundwater users most vulnerable to declines in well production.

7.1.2.3 Adaptive Management Identification

As uncertainties and data gaps are reduced with information and insights obtained from the GSA's monitoring networks and from assessment of the performance of newly implemented projects, management actions will be amended accordingly. Furthermore, if in the future DWR mandates certain corrective actions, the GSP will be adjusted to accommodate those new requirements[18]. In this way, projects and management actions can be pursued which reflect the evolving condition of groundwater management within the GSA and the Subbasin, and the current status of SGMA regulations.

7.1.2.4 Evaluation of Projects and Actions

Projects presented in this section have been developed and evaluated largely through the Integrated Regional Water Management (IRWM) process. Projects developed through this process do not focus exclusively on meeting SGMA goals. However, they do evolve through a regional water management framework centered on sustainable management of surface and groundwater resources applying a process that considers factors including land use and the impacts of climate change. Therefore, while IRWM planning does not specifically reference the regulatory aspects of SGMA, projects evaluated and prioritized through the IRWM process are based on a regional perspective and are well suited to the goal of sustainable groundwater management.

The adaptive management actions presented in this GSP resemble those presented in earlier groundwater management plans, in being phased actions triggered by chronic lowering of groundwater levels and the consequent depletion of groundwater storage.

7.2 Projects

Projects that will enable the BVGSA to sustainably manage groundwater fall into five categories:

- Water measurement projects;
- Sustainability monitoring projects;
- Water distribution system improvement projects;

[18] https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Groundwater-Sustainability-Plans/Files/GSP/GSP-Emergency-Regulations-Guide.pdf (p. 4)

- Groundwater recharge and recovery projects, and
- Water conservation and treatment projects.

Projects falling under each of these categories are discussed below.

7.2.1 Water Measurement Projects

7.2.1.1 Summary of Projects

The BVWSD has installed magnetic flow meters on all production wells in the BVGSA. As described below under Water Distribution System Improvements, the District is also in the process of converting portions of its canal system to pipelines with magnetic flow meters installed at each turnout and is improving measurement of water delivered from canals by upgrading gates as detailed in the District's Agricultural Water Management Plan (AWMP, 2016). Each of these activities improves the performance of the conjunctive management program and reduces the uncertainty of inputs to the GSA's groundwater budget. The meters now installed on all production wells will enable the GSA to give an exact accounting of groundwater extractions for annual reports required by SGMA and as inputs to the GSA's water budget. The improvements in water measurement instituted by the District have been accompanied by the implementation of volumetric pricing which provides a mechanism for introducing pricing tiers to incentivize water conservation.

All improvements to water measurement facilities within the BVGSA are being funded through the activities of the BVWSD and place no payment obligations on the BVGSA.

7.2.1.2 Public Notice and Outreach Process

Installation of meters on pipeline turnouts was a component of construction projects approved by the Board of the BVWSD and noticed for public comment as part of the environmental review process. Installation of meters on district-owned and landowner production wells was carried out after the approval of all affected parties. Installation of improved gates on canal turnouts is being carried out during routine system maintenance by the BVWSD as part of the measurement improvement program described in the District's Agricultural Water Management Plan (BVWSD, 2016).

7.2.1.3 Permitting and Regulatory Process

All necessary permits have been obtained for improvements to measurement facilities. Meters installed on pipeline turnouts were all permitted under the pipeline construction projects. Installation of magnetic flowmeters on wells required no permitting as no site disturbance or construction was needed. Installation of improved gates on canal turnouts also required no permitting as this work was a routine maintenance activity.

7.2.1.4 Benefits and Affected Sustainability Indicators

The benefits of improved water measurement tie directly to improvements in conjunctive management and detection of changed conditions that drive formulation of projects to adapt facilities and operating practices to changing conditions. As noted throughout this section, the BVGSA's goal is to identify fundamental changes in factors ranging from hydrology to farming practices and use tools such as the BVGSA's water budget to plan responses that preserve the District's ability to manage its resources sustainably so that it may continue to serve water users.

7.2.1.5 Source and reliability of Water

Given projected supplies available to the BVWSD from the Kern River and the State Water Project, the BVGSA is confident adequate supplies of surface water will be delivered under predicted conditions to meet future demands. However, changes in demands and in the timing and volume of supplies will require that the BVWSD develop new facilities and modify operational practices to accommodate the anticipated changes in ways that will minimize their impacts both within the GSA and within the Kern County Subbasin. Improved measurement of deliveries to the GSA and of distribution of surface water and groundwater within the GSA will be important for identifying changing conditions and for operating facilities in ways that will respond to those changes.

7.2.1.6 Legal Authority Required

The BVWSD has the responsibility and the authority to measure water resources within its boundaries.

7.2.1.7 Costs and Funding

As described above, extensive improvements to water measurement facilities have recently been completed within the BVGSA, notably installation of magnetic flow meters and totalizers on district-owned and landowner production wells and on turnouts from planned and newly completed pipelines. Costs for the water measurement projects are covered by the BVWSD.

7.2.1.8 Schedule

Magnetic flowmeters have been installed on all district-owned and landowner production wells within the BVGSA with installation having been completed in 2016. Magnetic flowmeters have also been installed on turnouts from all completed pipeline projects and will continue to be installed as pipeline projects are approved and constructed.

7.2.1.9 CEQA/NEPA Considerations

Measurement facilities on pipeline projects are installed as a component of pipeline construction projects that commence after completion of CEQA documentation and, in the case of projects receiving federal funding, after NEPA documentation has also been completed. Improvements to gates at canal turnouts are implemented as routine canal maintenance activities that are generally exempt from CEQA. Similarly, installation of meters on district-owned and landowner production wells is typically regarded as a routine improvement and is exempt from CEQA.

Future expansion of or improvement to measurement facilities will be performed after completion of the appropriate level of CEQA documentation. Any projects having a Federal nexus, for example due to award of Reclamation grant funding, will have NEPA documentation completed as a requirement of the Reclamation funding.

7.2.1.10 Uncertainty Assessment

Measurement of water is central to reducing the uncertainty of the BVGSA's water budget and of the water distribution and use within the GSA. The BVWSD's investment in metering groundwater extracted from all production wells within the GSA's boundaries expresses the commitment of local water users to minimizing the uncertainty associated with water use. The BVGSA foresees no impediments to carrying out its planned program of improved water measurement.

7.2.2 Sustainability Monitoring Projects

7.2.2.1 Summary of Projects

Section 4 – Monitoring Networks, describes existing monitoring networks within the BVGSA. The role of the BVGSA will be to meet SGMA reporting requirements by collecting data gathered through monitoring programs operated by the BVWSD and the Buena Vista Coalition. Should data gaps become apparent in monitoring of groundwater levels or groundwater quality for the purposes of SGMA, the GSA will develop a plan for filling these gaps by collecting data at additional locations or through installation of new monitoring wells. Additional monitoring wells are included in the plans for new and expanded recharge facilities being developed by the BVWSD and are described below under Groundwater Recharge and Recovery Projects.

7.2.2.2 Public Notice and Outreach Process

The existing facilities of the BVGSA monitoring networks rely on district monitoring wells that are part of the CASGEM system, monitoring wells and piezometers that are elements of the monitoring network developed for the Buena Vista Coalition's Groundwater Quality Trend Monitoring Work Plan, piezometers now monitored by the BVWSD in the northwest of the BMA and a landowner well in the southeast. All production wells in the BVGSA's network are metered and all monitoring wells are part of established monitoring programs. For this reason, no further public notice and outreach is required beyond the public outreach program described in Section 9 – Public Outreach and Engagement.

7.2.2.3 Permitting and Regulatory Process

No new facilities are needed to implement the BVGSA's initial monitoring program. Should the need for construction of supplemental monitoring sites be established to fill data gaps within the GSA, the necessary permitting and regulatory processes will be followed prior to construction of these facilities.

7.2.2.4 Benefits and Affected Sustainability Indicators

Operation of the facilities in the existing monitoring networks and expansion of these networks to fill data gaps identified during the period of SGMA implementation provides the foundation for monitoring attainment of measurable objectives and avoidance of minimum thresholds. Thus, there is a direct connection between this project and the sustainability indicators to be observed by the monitoring networks.

7.2.2.5 Source and Reliability of Water

Given projected supplies available to the BVWSD from the Kern River and the State Water Project, the BVGSA is confident adequate surface water will be available under predicted conditions to meet future demands. However, changes in demands and in the timing and volume of supplies will require that the BVWSD develop new facilities and modify operational practices to accommodate the anticipated changes and their impacts both within the GSA and within the Kern County Subbasin. By improving observation of sustainability indicators, data generated by this project will contribute to guiding water management practices in the BVGSA in ways that will support sustainable groundwater management in the GSA and in the Kern County Subbasin. The BVWSD will also consider participation in the Delta Conveyance Project (DCP) to improve volume and reliability of deliveries from the SWP.

7.2.2.6 Legal Authority Required

Facilities included in the BVGSA's monitoring networks are all either wells owned and maintained by the BVWSD, subsidence monitoring locations maintained by state or federal agencies or private wells whose owners have agreed to allow their wells to be included in the monitoring networks.

7.2.2.7 Costs and funding

The facilities included in the existing monitoring program have been constructed and most are operated by the BVWSD and the Buena Vista Coalition. The BVGSA will bear the cost for consolidating information from these sources into the reporting format specified by SGMA and followed within the Kern County Subbasin. The GSA will also be responsible for gathering data from wells not now monitored by other agencies. Funding for new monitoring facilities, should they be required, will be obtained from internal resources and from grant programs administered by DWR and by Reclamation.

7.2.2.8 Schedule

There is no schedule now defined for expansion or improvement of the monitoring network. The need for these activities will be based on performance of the existing network and identification of data gaps.

7.2.2.9 CEQA/NEPA Considerations

Future requirements for CEQA and NEPA compliance will be determined based on the need for inclusion of new facilities to expand the GSA monitoring networks, the types of facilities and the sources of funding. All new projects will be constructed after completion of the required level of CEQA documentation. Projects having a Federal nexus due to award of Reclamation grant funding will have NEPA documentation completed as a requirement of the Reclamation funding.

7.2.2.10 Uncertainty Assessment

Establishment and operation of effective monitoring networks is central to SGMA compliance and to effective conjunctive management of surface water and groundwater. For these reasons, while the specifics of future modifications to the monitoring networks are not known, the BVGSA is committed to maintaining networks able to perform the needed functions and anticipates no obstacles that would jeopardize the GSA's capacity to make improvements needed to fill data gaps that may be identified during the course of SGMA implementation.

7.2.3 Water Distribution System Improvement Projects

7.2.3.1 Summary of Projects

This group of projects is being implemented to improve and expand distribution of surface water from the SWP and the Kern River to areas in the north of the BMA using pipeline systems that replace existing unlined canals and ditches. The BVWSD has been actively engaged in this suite of projects for the past ____ years. Elements of the water distribution improvement project include the:

- Northern Area Pipeline (completed);
- Northern Area Pipeline - Southern Extension (completed);
- Northern Area Pipeline - Eastern Extension (completed);
- 7th Standard Road Project (under construction);
- The Palms Recovery Wells and Pipelines (CEQA documentation under preparation);
- Wasco Way Pipeline (planned);
- Elk Grove Pipeline (planned);
- Belridge Pipeline (planned), and
- Brite Road Pipeline and Pump Station (planned).

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The purposes of the pipelines are to:

- Expand the area in the northern portion of the BMA able to receive surface water;
- Extend the season during which surface water can be distributed to these areas;

- Reduce the need for groundwater pumping to supplement surface water supplies;
- Provide water users with conveyance and distribution facilities having the responsiveness and flexibility to supply the drip and micro-spray systems now prevalent on farms in the BVGSA, and
- Separate groundwater recharge from irrigation delivery.

In addition to their stated purposes, coupled with the expansion of the drip and micro-spray on-farm irrigation systems, the pipeline projects have altered the BVGSA's water budget by reducing the volume of drainage water collected in the Main Drain Canal that flows north out of the District.

As shown in the Section 6 – Water Accounting, the BVGSA's water budget includes an average annual volume of 31,141 AF of canal seepage [1993 – 2015] that percolates to groundwater. To mitigate the loss of this recharge capacity resulting from conveyance of water through pipelines rather than canals, selected canals removed from service as distribution facilities are being retained as linear recharge features that receive surface water during years of adequate supply. The goal is to maintain the quantity of water now recharged through canals, but to shift the timing of recharge by not having recharge tied to the delivery of irrigation water.

7.2.3.2 Public Notice and Outreach Process

The elements of the Distribution Improvement Project have been developed though and supported by regional planning efforts and meet the criteria set forth by local and state plans, including the Kern County Integrated Regional Water Management Plan, BVWSD 2015 Agricultural Water Management Plan, Governor's Water Action Plan, BVWSD Groundwater Management Plan, and California Water Plan. No opposition has been expressed to completed or on-going phases and none is anticipated for future phases.

7.2.3.3 Permitting and Regulatory Process

The BVWSD adhered to the permitting and regulatory process required by the County of Kern for the Northern Area Pipeline and for other pipeline conversion efforts that have been completed or are now under construction. The District will continue to adhere to these requirements for future phases of the project.

7.2.3.4 Benefits and Affected Sustainability Indicators

Using pipelines instead of unlined canals extends the area that can be served with surface water and prolongs the season of delivery. In addition, as described under the water measurement project, converting distribution facilities from canals to pipelines enables more accurate measurement of deliveries at turnouts by replacing gates with magnetic flow meters, an improvement which also supports volumetric billing. Benefits of the Distribution System Improvement Projects include:

- reduced canal seepage;

- extended land area served with surface water and extended delivery season reducing reliance on groundwater;
- potential to distribute high-quality water from the SWP and the Kern River throughout the BMA, and
- conversion of retired canals to dedicated linear recharge facilities.

The water system distribution improvement projects affect several sustainability indicators including:

- Chronic reduction in groundwater levels: As mentioned above, improved distribution and application of surface water supports groundwater elevations by reducing the need to extract groundwater for irrigation;
- Reduced Groundwater Storage: This project protects stored groundwater by reducing the need to pump groundwater to meet irrigation demands;
- Diminished Groundwater Quality: This project is expected to help control the possible migration of saline groundwater into the northern portion of the GSA as reduced reliance on groundwater may prevent a worsening of the gradient drawing saline water from the west.
- Subsidence: Although only limited subsidence has been observed in the BVGSA, pipelining of canals is expected to limit the likelihood of future subsidence by reducing reliance on groundwater extraction to satisfy agricultural water demands.

7.2.3.5 Source and Reliability of Water

Given projected supplies available to the BVWSD from the Kern River and the State Water Project, the BVGSA is confident adequate surface water will be available under predicted conditions to meet future demands. However, changes in demands and in the timing and volume of supplies will require the BVWSD to develop new facilities and modify operational practices to accommodate the anticipated changes and their impacts within both the GSA and the Kern County Subbasin. The Water Distribution System Improvement Project is being implemented in anticipation of predicted changes in the reliability of surface water to improve the efficiency and effectiveness of these water supplies.

7.2.3.6 Legal Authority Required

This group of projects is proceeding based on authorization by the BVWSD Board of Directors. All water distributed through the improved distribution system is available to the District under its contracted allocation of SWP water through the Kern County Water Agency or water diverted from the Kern River under the District's established water right.

7.2.3.7 Costs and Funding

The total cost of completed water system distribution projects (Northern Area Pipeline (NAP), NAP Eastern Extension, and NAP Southern Extension) have been paid in full. The 7th Standard

Pipeline, now under construction, has all material purchased and will have BVWSD crews install the pipeline. Funding for each of these phases has been provided through the BVWSD and from grant funding received from DWR and from Reclamation. The cost of developing the McAllister Ranch (a future water bank), and the Palms (an in-district water bank) and been paid. The District has established a banking relationship for short- and medium-term funding of projects. Therefore, it is not anticipated that bond offerings will be needed for development of future projects.

7.2.3.8 Schedule

The schedule for projects in the Distribution System Improvement Category will be based on the need for and benefits of pipeline construction projects that are identified during the period of SGMA implementation. As noted above, planned pipeline conveyance facilities include the Belridge, Brite Road, Wasco Way, and Elk Grove pipelines, the Palms Recovery Wells and Pipelines and pipelines associated with the McAllister Ranch Water Bank.

7.2.3.9 CEQA/NEPA Considerations

All projects in the Distribution System Improvement Projects category that have been completed to date or are now under construction have been performed in compliance with CEQA through completion of Mitigated Negative Declarations. Projects that have had a Federal nexus due to award of Reclamation grant funding also complied with CEQA and had Environment Assessments completed to comply with NEPA before the commencement of construction. The same level of CEQA and NEPA compliance is anticipated for future phases of this project.

7.2.3.10 Uncertainty Assessment

Based on the success of the BVWSD in funding, environmental compliance, permitting and construction of projects in the Distribution System Improvement category, the District does not anticipate any unforeseen risks to development and completion of future projects in this category.

7.2.4 Groundwater Recharge and Recovery Projects

7.2.4.1 Summary of Projects

Farmland in the BVGSA is characterized by tight (non-permeable) top soils overlying permeable subsoils as described in Section 2 – Basin Setting. Therefore, deep percolation of applied irrigation water contributes little groundwater recharge, and conversion from gravity irrigation systems to low-volume pressurized on-farm systems has less impact on groundwater recharge than have such conversions in areas having more permeable soils.

While top soils limit infiltration from the soil surface in the southern portion of the BMA, apart from this surface layer there are no confining layers that obstruct water from percolating to the principal aquifer system. For this reason, facilities constructed in the BMA that place water in contact with soils below the surface layer are effective mechanisms for aquifer recharge.

In addition to continuing to rely on canals as recharge facilities, both in combination with conveyance functions or as dedicated linear recharge features, the BVWSD is now developing a groundwater banking facility, the Palms Project, within its boundaries and is the lead agency in development of the Corn Camp Water Bank, which will also lie within the GSA boundaries. The BVWSD is also involved in the development of the McAllister Ranch banking facilities that lie outside of the GSA.

The most important on-going project in the Groundwater Recharge and Recovery Category is the Palms Project. This project will function as a water bank with groundwater levels increasing during periods when water is recharged and decreasing when groundwater is pumped. However, the project will be managed so that groundwater elevations will increase, over the long-term, from historic levels. The annual water recovery will be limited to no more than 25,000 acre-feet.

An alternative method of groundwater recovery will be to provide flexibility to landowners by allowing private pumping in lieu of surface water deliveries. Landowners would have the option to utilize on-farm wells to either pump water for irrigation needs or continue to receive surface water deliveries through the District canals and pipelines. No additional facilities would need to be constructed for this delivery option and all eligible wells are metered, so volumes of pumping under the program would be accurately reported. Interested landowners would be required to sign up for the program, and participation would be limited by the amount of water available for recovery, no more than 25,000 acre-feet per year.

The Palms Project has the following primary objectives:

- Increase conjunctive management on the west side of Kern County by expanding the area’s ability to accept surface water for groundwater recharge during periods when surface water is available. Groundwater stored by the Project will be available to meet demands during periods when surface water is limited.
- Reduce agricultural demand by replacing 1,160 acres of irrigated farmland with spreading grounds.
- Sustain groundwater elevations in the extreme south of the BMA, an area where groundwater elevations are influenced by banking operations lying immediately outside the BVGSA.

7.2.4.2 Public Notice and Outreach Process

In January 2016, the District approved construction of the Palms Project. The public has been engaged in development of the Palms Project through scoping meetings and other outreach efforts conducted through the environmental compliance process.

On October 26, 1995, the Kern Water Bank Authority and its Member Entities, as the "Project Participants," and Buena Vista Water Storage District, Rosedale-Rio Bravo Water Storage District, Kern Delta Water District, Henry Miller Water District and West Kern Water District, as the "Adjoining Entities," entered into an agreement based on a Memorandum of

Understanding (MOU). In this MOU, Paragraph 8 states that "any future project within the Kern Fan Area, the Parties hereto shall use good faith efforts to negotiate an agreement substantially similar in substance to this MOU." In accordance with Paragraph 8, the District will develop an MOU, to be negotiated with adjoining entities, which will address the operation and monitoring of the Palms Groundwater Recovery Project. This project-specific MOU will be substantially similar in substance to the 1995 MOU.

7.2.4.3 Permitting and Regulatory Process

As with other construction projects undertaken by the BVWSD, the District obtained all necessary construction and environmental permits prior to construction of phases 1 and 2 of the Palms Project and will follow similar procedures in obtaining permits and complying with regulations for future project phases and for other groundwater recharge and recovery projects.

7.2.4.4 Benefits and Affected Sustainability Indicators

The District has recharged approximately 30,190 acre-feet diverted under its Kern River water right in the project over the last two years (16,000 acre-feet recharged from canals in the Palms project area and 14,190 acre-feet in the constructed recharge basins). High quality Kern River water recharged by the Palms Project flows to aquifers that are sources for domestic and municipal wells providing water to residents of Taft and Tupman, to the disadvantaged community of Buttonwillow, and to replenish groundwater under the Tule Elk Reserve.

Water recovered from the Palms Project will be distributed to district water users, exchanged with other districts, or made available to industrial or municipal users. The project may also discharge to the California Aqueduct to satisfy existing and future water contracts between the District and other public water agencies.

Project benefits fall into three primary categories: 1) benefits to groundwater users and prospective banking partners, 2) habitat benefits as a result of greater availability of water for transfer to the Tule Elk Reserve, and 3) water quality improvements due to retirement of project land from agricultural production resulting in reduced leaching of contaminants to groundwater. These benefits are described in greater detail below.

1. Water supply and energy savings will result from a general increase in groundwater elevations in the Project area. Although the Palms Project will function as a banking project with groundwater levels increasing during periods when water is recharged and declining when groundwater is pumped to meet local demands or for delivery to agricultural users and banking partners, the Project will contribute to SGMA compliance within the Kern County Subbasin by supporting groundwater elevations in and around the project area and will enable groundwater pumpers including local domestic and municipal users to reduce pumping lifts.

2. Banking of groundwater in an area immediately adjacent to the Tule Elk Reserve will strengthen the BVGSA’s ability to provide water to the reserve.

3. Groundwater recharge facilities within the BVGSA are typically constructed on lands that were previously irrigated farmland. By removing acreage from agricultural production, the project both lessens water demand and reduces the leaching of contaminants introduced through farming practices.

7.2.4.5 Source and Reliability of Water

Given projected supplies available to the BVWSD from the Kern River and the State Water Project, the BVGSA is confident adequate surface water will be available to meet future demands. However, changes in demands and in the timing and volume of supplies will require that the BVWSD develop new facilities and modify operational practices to accommodate the anticipated changes and their impacts both within the GSA and within the Kern County Subbasin. The suite of groundwater recharge and recovery projects described above will improve the BVGSA's capability to store groundwater when water is available to be placed in storage, to recover stored groundwater when needed and to monitor inflows and outflows to facilitate effective operation of these storage and recovery projects.

7.2.4.6 Legal Authority Required

Groundwater recharge and recovery project are proceeding based on authorization by the BVWSD Board of Directors. All water banked in these facilities will be available to the District under its contracted allocation of SWP water through the Kern County Water Agency, water diverted from the Kern River under the District's established water right, or water made available for storage under agreements with banking partners.

7.2.4.7 Costs and Funding

Construction of new water banks and expansion of the existing Palms Project will be funded primarily through the resources of the BVWSD. State and federal grant programs are likely to provide supplemental funding; however, the timing for implementation of these projects is not contingent on the timing of grant programs. The BVWSD has established a banking relationship that allows the District access to short-term loans for project construction. In the past six years, the District has invested $95,000,000 in land acquisition and project development and has issued $3,500,000 in debt.

7.2.4.8 Schedule

The Palms and the Corn Camp groundwater banking project are both scheduled for completion within five years with the exact date of completion contingent on environmental review. Other groundwater banking projects will continue to be developed and placed into operation throughout the period of SGMA implementation.

7.2.4.9 CEQA/NEPA Considerations

An Initial Study/Mitigated Negative Declaration (SCH # 2015121030) was prepared in 2015, and the Notice of Determination was filed in January 2016 addressing construction and operation of Stages 1 and 2 of the Palms Project. Additional CEQA documentation is now being prepared for future stages of the project. Discussions are underway regarding CEQA compliance for the McAllister Ranch Groundwater Banking Project (outside boundaries of the BVGSA) and the Corn Camp Water Banking Project, which is to be constructed within the BVGSA.

7.2.4.10 Uncertainty Assessment

Stages 1 and 2 of the Palms Project were completed in 2017 and have been in operation since that time. Additional environmental documentation and coordination is being performed on the remaining stages. Given the successful performance of the completed stages and the value these elements have demonstrated by capturing and recharging available flows from the Kern River, the BVGSA sees no major impediments to completion of future project stages. The BVGSA is continuing to advance planning for the McAllister Ranch and Corn Camp projects

7.2.5 Conservation and Water Treatment Projects

7.2.5.1 Summary of Projects

The Brackish Groundwater Remediation Project (BGRP) is being implemented to improve the quality of shallow, perched groundwater in the northern area of the BMA by recovering brackish groundwater for blending with low salinity water prior to application to crops. This project is expected to contribute up to 12,000 AF of additional water resources to the GSA per year. The project includes approximately 60 wells, placed about 200 feet apart following an alignment parallel to the right-of-way of the recently completed Northern Area Pipeline[19].

7.2.5.2 Public Notice and Outreach Process

The outreach process for the project followed the BVGSA's normal public notice and outreach process as well as the public notification requirements of CEQA.

7.2.5.3 Permitting and Regulatory Process

No major permits or third-party approvals where required from local, State, or federal agencies other than county well drilling permits and road easements, and formal easements from landowners.

7.2.5.4 Benefits and Affected Sustainability Indicators

This project is designed to increase water supply by augmenting supplies of surface water through blending with groundwater that otherwise would not be used because of its marginal quality. As a result of the intended increase in water resources made available to the GSA from this project, and the subsequent reduced groundwater pumping, the primary affected sustainability indicator will be chronic lowering of groundwater levels and its corollary, reduction of groundwater storage.

[19] https://www.usbr.gov/mp/nepa/includes/documentShow.php?Doc_ID=23030 (p. 53)

7.2.5.5 Source and Reliability of Water

Operation of the Brackish Groundwater Recovery Project relies on shallow, groundwater underlying the project area and surface water imported via the State Water Project and diverted from the Kern River. One of the project objectives is to blend the fresh surface water with brackish groundwater to augment the reliability of the overall supply.

7.2.5.6 Legal Authority Required

The project was approved by the BVWSD Board of Directors and was constructed following completion of CEQA compliance requirements.

7.2.5.7 Costs and Funding

The total budget for the project was $3,088,690. Of this, the State Share of $2,100,000 was dedicated to construction costs. The remaining $988,690, provided by BVWSD, supported the remaining construction costs and other items including staff and consultants, environmental documentation, easements[20].

7.2.5.8 Schedule

Construction of this project was completed in 2018.

7.2.5.9 NEPA Considerations

The Brackish Groundwater Recovery Project was implemented after completion of CEQA and NEPA compliance requirements. A mitigated negative declaration was prepared for CEQA and an Environmental Assessment was completed for NEPA.

7.2.5.10 Uncertainty Assessment

The Brackish Groundwater Recovery Project is now operational, and a high degree of certainty can be assigned to its continued operation.

7.3 Management Actions Planned as Part of GSP to be Implemented Regardless of Conditions

As described in the previous sections, the BVGSA has projects that have recently been completed, are now under construction or are in the various stages of planning. Together these projects constitute a comprehensive program to provide a reliable, actively managed water supply that supports sustainable groundwater management in the GSA and prepares the GSA to maintain measurable objectives and avoid breaches of minimum thresholds.

By expanding recharge facilities, modernizing distribution features and enhancing monitoring and measurement of surface water and groundwater, these projects will improve the flexibility

[20] https://water.ca.gov/LegacyFiles/wuegrants/AGAwards/24-BVWSD.pdf (p. 15)

and responsiveness of the BVWSD's conjunctive management practices. These improvements are intended to provide water users within the GSA a stable, predictable water management landscape for agricultural, municipal, industrial and domestic land and water users that provides a foundation for prudent management decisions on the water users.

7.3.1.1 Summary of Actions

The Landowner Well Use Program is an existing management action which reimburses participating landowners for utilization of their unused well capacity during dry years. The ability to mobilize privately-owned wells enables the BVWSD to avoid the need to construct district-owned wells that would create capacity needed only during droughts. This Program is operated within the framework of the District's conjunctive management policy which encourages use of groundwater recharged through District facilities during wet years to augment the diminished supplies available during dry years.

7.3.1.2 Public Notice and Outreach Process

The outreach process for the Program followed the BVGSA's normal public notice and outreach process. Additional outreach will take when the BVWSD is interested in identifying interested landowners.

7.3.1.3 Permitting and Regulatory Process

No major permits or third-party approvals where required from local, State, or federal agencies.

7.3.1.4 Benefits and Affected Sustainability Indicators

This Program is an element of the BVWSD's conjunctive management strategy that provides a low-cost means to bridge short-term gaps in water supply available to growers. The affected sustainability indicator will be chronic lowering of groundwater levels and its corollary, reduction of groundwater storage. During periods when the Program is operational, the effects of Program activity will be tracked by the GSA's monitoring network.

7.3.1.5 Source and Reliability of Water

Operation of the Landowner Well Use Program relies on water pumped from the principal aquifer system. Groundwater is extracted from wells owned by program participants to augment the supply available for distribution throughout the BMA.

7.3.1.6 Legal Authority Required

The Landowner Well Use Program was approved by the BVWSD Board of Directors and was initiated following completion of CEQA compliance requirements.

7.3.1.7 Costs and Funding

This Program is funded by the BVWSD and is implemented at the District's discretion. The extent of program participation varies with hydrologic conditions and with the degree of landowner interest and participation. During years when the Program is not active, the District bears no costs. During years when grower participation is high, typical Program costs are $___ and volumes of water produced are typically ___ AF.

7.3.1.8 Schedule

This program was initiated in __ and remains active.

7.3.1.9 NEPA Considerations

The Landowner Well Use Program is being implemented in compliance with CEQA.

7.3.1.10 Uncertainty Assessment

The Landowner Well Use Program is now operational, and a high degree of certainty can be assigned to its continued operation.

7.4 Adaptive Management Actions Planned as part of GSP

Each GSP is required to include contingency projects or management actions to be implemented in the event groundwater conditions do not adequately respond to the projects and management actions planned for implementation. The actions described in this section are intended to be implemented if measurable objectives have not been met and to correct breaches of minimum thresholds before they lead to the occurrence of undesirable results[21].

7.4.1 Adaptive Management Action Description

7.4.1.1 Summary of Adaptive Management Actions

In the event implementation of the projects described above is insufficient to prevent breaches of minimum thresholds, the BVGSA has developed a suite of adaptive management actions that can be implemented to quickly reverse adverse conditions. The adaptive management program entails the following four types of actions:

- Curtailment of on-going transfers and exchanges of Kern River water to other entities;
- Fallowing of land planted in annual crops;
- Transfers or exchanges to bolster surface water supplies;
- Limiting extractions from agricultural and industrial wells within a specified radius of the monitoring sites where minimum thresholds have been breached, and

[21] https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Groundwater-Sustainability-Plans/Files/GSP-Regulations-Development/DRAFT_GSP_Regulations_Guide.pdf?la=en&hash=1FF9DAAD2FD67B9CA5D22BA92730DA7F77F7E70D (p. 15)

- Proposition 118 process would allow doubling of current assessments and tripling of current water rates.

A fourth adaptive management action is a program the GSA will establish to deepen or otherwise rehabilitate or replace wells where the ability to extract groundwater has been compromised by groundwater elevations that have dropped below minimum thresholds. This action is designed to rapidly restore the capacity of affected wells.

Curtailment of Transfers and Exchanges

Because of the BVWSD's water rights on the Kern River, the District has access to large quantities of Kern River water in wet years. Under the Water Exchange Project (WEP), the District delivers a portion of its surplus wet-year supplies to other entities with those entities later returning a predetermined or negotiated quantity of their regulated water to the District, with or without an additional financial consideration. Current and potential participants in the WEP include Poso Creek Water Company, Cawelo WD, Kern Delta WD, West Kern Water District (WKWD), North Kern WSD, Rosedale-Rio Bravo WSD, Semitropic WSD, Castaic Lake Water Agency (CLWA), and Improvement District No. 4 of the Kern County Water Agency.

In addition to transfers with other entities, the BVWSD facilitates certain types of transfers within the District provided that these transfers do not injure other landowners or impair District operations. Categories of intra-district transfers include the following:

- Transfer within a farming unit;
- Transfer of water generated by intentional fallowing;
- Transfer of reclaimed water, and
- Minor transfers

In addition to these general categories, for the duration of an emergency, the District will make every reasonable and prudent effort to provide needed additional water service to any water user to prevent crop loss or other damages.

The BVWSD's policies on transfers and exchanges provide a foundation for the initial adaptive management action the BVGSA would implement to correct unsustainable groundwater management conditions. These actions could include both curtailment of transfers to partner agencies and use of intra-district transfers to relieve breaches of minimum thresholds at representative monitoring sites.

Land Fallowing

This adaptive management action will fallow land planted in annual crops to reduce demand for irrigation water. The program targets a reduction of 15,000 AF/year of ET, (12 percent of the average annual ETa of 121,000 AF estimated over the period from 1993 through 2011) but is scalable based on the need to reduce demand and the ability to enroll willing participants.

Growers will be invited to enroll land in an acreage pool to become eligible for participation. If conditions necessitate activation of the program, a reverse auction will be held where owners of lands enrolled in the program may bid to accept payments of a specified dollar amount per acre of land fallowed. The BVGSA will review bids and accept those up to the threshold needed to reach the demand reduction target. To fallow the targeted acreage at the lowest cost, bid acceptance will begin with the low bid and include increasingly higher bids until the target acreage has been reached. The term of the agreement will typically be for one year subject to extension if the GSA determines groundwater conditions warrant and participating growers agree to continue to forego planting. Enrollment of eligible fields will be refreshed each year with growers having the opportunity to enroll fields or to discontinue enrollment during an annual sign-up period.

The objective of this adaptive management action is to reduce the volume of groundwater and surface water applied to farm lands. The reverse auction approach is intended to maximize the reduction in demand that can be achieved through available funding. In addition, by giving priority to the lowest bids, the reverse auction is likely to minimize impacts on agricultural production within the GSA by targeting the least productive fields.

The program will be monitored using the standard crop reporting procedures now employed by the BVWSD, and rules for management of lands fallowed under the program will be based on those developed by the Palo Verde Irrigation District (PVID) as part of the land fallowing program that is carried out in partnership with the Metropolitan Water District of Southern California (MWD).

The effectiveness of the fallowing program in reducing consumptive use will be monitored using satellite imagery-generated estimates of actual evapotranspiration (ETa) based on remote sensing algorithms such as Mapping Evapotranspiration at High Resolution using Internal Calibration (METRIC) or Surface Energy Balance System (SEBS). The selected algorithm will be used to establish a 5-year baseline ETa for program-eligible fields, and this baseline will be used as a basis for comparison with ETa from fallowed fields.

Water Transfers and Exchanges

A second adaptive management option is water transfers and exchanges. These actions give the GSA the ability to increase water users' access to surface water thereby reducing their reliance on groundwater.

Water transfers and exchanges are a well-established element of BVWSD operations and are among the tools the District uses to support its conjunctive management program. The BVGSA will expand its portfolio of water transfer and exchange options by developing banking agreements with its partners in the groundwater recharge projects such as the Palms that will be managed by the BVWSD and are described above. Both in instances where the banking facilities are located within the BVGSA and in instances where the facilities lie outside the GSA, agreements with banking partners lying outside the Kern County Subbasin will include provisions allowing the GSA to access banked water in exchange for long-term repayment with terms expressed as replenishment of banked water or monetary compensation.

This approach will provide short-term support for groundwater levels in the BVGSA and in the Subbasin as a whole because the relevant banking partners will be located outside the Subbasin so water extracted under these conditions will not be water banked by neighboring GSAs.

Pumping Curtailment

Curtailment of pumping is the third adaptive management action included in the GSA's program. Of the suite of actions, this is the action best suited to quickly correcting adverse conditions observed at representative monitoring sites.

Minimum thresholds have been set at all wells in the GSA's groundwater level monitoring network that are used to monitor two important sustainability indicators:

- Chronic lowering of groundwater levels, and
- Reduction of groundwater storage.

Should groundwater levels drop below the minimum threshold at any well in this network, and it can be determined that the decline can be attributed to extraction occurring within the BVGSA, the GSA will curtail pumping through the following series of steps to be taken after notification that groundwater levels have breached a minimum threshold.

1. Verification measurements will be made within 72-hours, after ensuring that no nearby wells are actively pumping.
2. If the verification measurement is still below the established minimum threshold, groundwater levels at nearby monitoring wells in the BVGSA and neighboring GSAs will be checked to confirm that the breach is the result of localized extraction and is not due to extraction from neighboring areas.
3. If determined that the breach is primarily due to localized pumping, a curtailment notice will be sent to all agricultural and industrial well operators within a 1-mile radius of the relevant monitoring site. Wells subject to curtailment will be identified through GIS software and known locations of production wells.
4. Weekly groundwater level measurements will be taken at the affected monitoring site to observe the impact of the curtailment.
5. Pumping will be allowed to resume if the water level rises above the established minimum threshold and is sustained for 2 consecutive weeks. The volume of pumping may be limited by the BVGSA based on trends in groundwater levels observed prior to and after implementation of the curtailment.

6. If groundwater levels continue to decline or are unchanged after imposition of a 1-mile radius pumping restriction, the radius of the restriction will be increased to a distance the BVGSA determines adequate based on assessment of regional groundwater elevations and modeling of the likely impacts of extending or prolonging the restriction.
7. Pumping restrictions are enforceable through monitoring of the magnetic flow meters now installed on all production wells in the BVGSA.

Depending upon the cause of the reduction in groundwater levels that trigger a pumping curtailment, the BVGSA may choose to combine the curtailment with actions to make supplemental surface water available to the affected area to substitute for the reduced access to groundwater.

Well Rehabilitation

The BVGSA will maintain a fund for the purpose of deepening or otherwise rehabilitating wells whose production has been substantially reduced by chronic lowering of groundwater levels.

Losses in well production believed to result from lowering of groundwater levels will be reported to the BVSGA and reporting will trigger the following actions:

1. Within five business days, a representative of the GSA will meet with the claimant to develop a full understanding of the basis for the reported impact.
2. The GSA, and, if necessary, a technical specialist, will investigate the reported impact to assess the extent of the impact and determine whether the impact is the result of lowered groundwater elevations or other factors unrelated to groundwater elevations such as deterioration of the well, pump and motor. This investigation will include analysis of groundwater elevations, pumping data, and inspection of the well.
3. Based on the results of the investigation, if the reduction in pumping capacity is confirmed to have been caused by lowered groundwater levels, remediation measures will be developed and promptly implemented. These measures may include: deepening or replacement of the well; lowering of pump bowls; and other corrective measures. During the period of discussion, investigation and remediation, the owner of the affected well may receive deliveries of water from other sources, or other measures necessary to relieve the reduction in pumping capacity. Mitigation measures will be developed through consultation with the claimant and will be approved by the GSA and the County of Kern. The BVGSA will strive to develop and implement the agreed upon mitigation measures as quickly as reasonably possible.
4. Implementation of remediation measures will be confirmed, and the results of the implementation program will be monitored.

The BVGSA will maintain adequate financial resources to cover impact assessment studies, well repairs and other reasonably anticipated remediation needs.

7.4.1.2 Public Notice and Outreach Process

The outreach process used for implementation of adaptive management actions will follow the BVGSA's normal public notice and outreach process as well as complying with the public notification requirements of CEQA.

7.4.1.3 Permitting and Regulatory Process

No major permits or third-party approvals are expected to be required from local, State, or federal agencies for implementation of adaptive management actions.

7.4.1.4 Benefits and Affected Sustainability Indicators

Implementation of the suite of adaptive management actions will be triggered by groundwater elevations that fall below minimum thresholds at sites in the BVGSA's monitoring network that are determined to be the result of groundwater extraction within the GSA. These actions will directly affect two sustainability indicators:

- Chronic lowering of groundwater levels, and
- Reduction of groundwater storage.

These actions have not been designed to be triggered by or to correct degradation in water quality. While the Groundwater Quality Monitoring Network is intended to detect exceedances in contaminant concentrations, management actions to correct exceedances will be implemented under the auspices of the Irrigated Lands Regulatory Program or permits held by individual industrial users and by the Community of Buttonwillow.

7.4.1.5 Source and Reliability of Water

Two of these adaptive management actions are mechanisms to reduce demand that do not depend on sources of water or reliability of supply. The third, use of transfers or exchanges to augment water supplies, would be a combination of "spot market" transactions and agreements with banking partners that would enable the GSA to rapidly access banked water in exchange for long-term repayment.

7.4.1.6 Legal Authority Required

The Board of Directors of the BVWSD has the legal authority to institute each of the adaptive management practices described in this section.

7.4.1.7 Costs and Funding

Implementation of adaptive management actions would be paid for using a reserve fund established by the BVGSA specifically to support these actions.

7.4.1.8 Schedule

The schedule for implementation of adaptive management actions will be determined by the occurrence of conditions that trigger implementation of these actions.

7.4.1.9 CEQA/NEPA Considerations

CEQA requirements will vary with the nature and extent of the adaptive management action. Each of these actions have been successfully used in previous water transfer, water conservation and water banking programs so no obstacles are seen to CEQA compliance. NEPA compliance will also be based on precedents, with the need for NEPA depending on the existence of a federal nexus.

7.4.1.10 Uncertainty Assessment

The adaptive management actions are direct approaches to correcting symptoms of unsustainable groundwater management by targeting the causes. The mechanisms used by these actions are the following:

- Reducing demand for water by reducing irrigated acreage through land fallowing,
- Reducing demand for groundwater by providing a substitute water source through transfer and exchanges, and
- Reducing extraction of groundwater within the GSA boundaries by curtailing pumping.

Each of these actions will improve adverse groundwater conditions with a high degree of certainty. Groundwater modeling will be used to predict the degree of improvement likely to result from given levels of demand reduction and pumping curtailment. Groundwater level observations taken at affected monitoring sites will determine whether the actions have generated the intended result and whether the actions should be continued, expanded or relaxed.

7.5 Summary

7.5.1 Table of Projects, Management Actions, and Adaptive Management Actions

Table 7-1 is a summary of the projects and management actions described above.

Table 7-1. Summary of Projects and Management Actions

Project	Status
Water Measurement	
Magnetic flow meters on all production wells	Completed
Magnetic flow meters on pipeline turnouts	Progressing with construction of pipeline projects
Upgrading delivery gates	Under construction
Sustainability Monitoring	
New monitoring wells	To be implemented as required
Water Distribution System Improvement	
Northern Area Pipeline	Completed
Northern Area Pipeline - Southern Extension	Completed
Northern Area Pipeline - Eastern Extension	Completed
7th Standard Road Project	Under construction
Belridge Pipeline	Planned
Groundwater Recharge and Recovery	
Palms Project	Under development
Corn Camp Water Bank	Under development
McAllister Ranch Banking Project	Under development
Conservation and Water Treatment	
Brackish Groundwater Remediation Project	Completed
Management Actions	
None	
Adaptive Management Actions	
Curtailment of transfers and exchanges from GSA	To be implemented as required
Land fallowing	To be implemented as required
Expansion of transfers and exchanges to GSA	To be implemented as required
Pumping curtailment	To be implemented as required
Deepen/rehabilitate wells	To be implemented as required

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8. GSP Reporting

8.1 Annual Reports

As part of GSP implementation, the BVGSA will submit annual reports to DWR by April 1st of each year following the adoption of the plan. The goal of these reports is to provide updates on conditions within the BVGSA, including groundwater elevations, groundwater extraction, groundwater quality, surface water deliveries, total water use, and change in groundwater storage. In addition to groundwater conditions, a description of progress on implementation of the plan will compare data on existing conditions with interim milestones (established in Section 5 – Thresholds, Objectives, Milestones) and provide updates regarding the status of projects and management actions, and any adaptive management actions instituted during the reporting period.

8.1.1 BVGSA Conditions

Annual Reports of groundwater conditions in the BVGSA will rely on data collected from the monitoring networks described in Section 4 – Monitoring Networks. Data that is not specific to monitoring wells (e.g. surface water deliveries) will be measured using the same methods as were used for collecting data input into the BVGSA budget presented in Section 6 – Water Supply Accounting with the exception of groundwater extraction data that will be measured directly using the magnetic flow meters and totalizers now installed on all production wells in the BVGSA. When applicable, groundwater conditions will be compared to minimum thresholds, measurable objectives, and interim milestones.

8.1.1.1 Groundwater Elevation

Groundwater elevations collected at each of the locations in the groundwater level monitoring network will continue to be measured quarterly, and the hydrograph for each monitoring well will be updated using data collected during the most recent measurement cycle. Trends observed in the groundwater level measurements will be analyzed and used to inform decisions on modification of operations or the need to institute adaptive management actions to achieve sustainable groundwater management.

In addition to updating hydrographs, contour maps will be generated from the seasonal high and seasonal low groundwater elevations at each monitoring well. These maps will be compared with maps generated during the same period of the previous year to detect changes in conditions that will be described in the reporting.

8.1.1.2 Groundwater Extraction

Magnetic flow meters and totalizers are installed on all production wells in the BVGSA. Therefore, reporting of volume of groundwater extraction will be based on direct measurement.

The cumulative volume from all wells will be reported to DWR and will also be used to update and refine the GSA water budget.

To gain understanding of the spatial distribution of pumping, wells will be assigned to polygons within the BVGSA and the relative pumping density will be indicated by color for each polygon.

8.1.1.3 Surface Water

Surface water deliveries to the BVGSA will continue to be measured and reported using the methods described in Section 6 – Water Supply Accounting. Surface water that enters the BVGSA is measured on the East Side Canal and at each of the turnouts from the California Aqueduct. Surface water entering the BVGSA will be partitioned into the following categories in annual reports:

- Deliveries to fields,
- Delivery to other districts and Main Drain Canal outflows, and
- Recharge through canal seepage and spreading basins.

8.1.1.4 Total Water Use

The total water used consumptively by the BVGSA will be reported to DWR. Total water use will be displayed in tabular format to summarize the total water use by sector, water source type, and identifies the method of measurement (direct or indirect).

8.1.1.5 Change in Groundwater Storage

Based on groundwater elevations observed at each of the BVGSA monitoring wells, groundwater contours will be generated to estimate the depth to groundwater beneath the BVGSA boundary. These contours and the contours presented in the preceding annual report will be used to generate a map of the change in groundwater storage. Applying the specific yield discussed in Section 5 – Minimum Thresholds, Measurable Objectives, and Interim Milestones, a volume of water between the two surfaces will be calculated that will represent the change in storage.

In addition to this map, a table summarizing water year type, groundwater use, annual change in groundwater storage, and cumulative change in groundwater storage (beginning in January 1, 2015) will be provided in the annual reporting.

8.1.2 Description of Plan Implementation Progress

The annual report will include a description of progress towards implementing projects and management actions described in the Buena Vista Groundwater Sustainability Plan. Reporting will describe progress toward attainment of interim milestones and implementation of projects or management actions since the preceding annual report.

8.1.2.1 Interim Milestones

As discuss in Section 5 – Minimum Thresholds, Measurable Objectives and Interim Milestones, because of groundwater conditions in the BVGSA, interim milestones set at most monitoring locations do not vary between the 5-year reporting periods as the purpose of the milestones is to confirm that water levels are being maintained at representative monitoring sites in the face of the predicted increases in demand for water and declines the reliability of surface water supplies.

In the event groundwater elevations are not maintained, the BVGSA will rectify this trend by implementing additional projects and/or the program of management actions described in Section 7 – Projects, Management Actions and Adaptive Management Actions. Should interim milestones be introduced in the future, GSP reporting will assess the progress the GSA is achieving in attaining the measurable objectives introduced to support the GSA's 2040 sustainability goals. Any new interim milestones will be established in 5-year increments and current groundwater levels will be benchmarked to the upcoming or current milestone.

8.1.2.2 Implementation of Projects

Projects identified in Section 7 – Projects, Management Actions and Adaptive Management Actions will be implemented as the Buena Vista WSD secures funding, whether internally or from State and Federal grant programs. The annual report will inform DWR of the progress for each of the projects described in the GSP, including any additional projects that have been identified or started outside of those established in the initial Plan. Updates will include, but are not limited to: planned start date, planned completion date, and project status / phase (feasibility, design, construction, etc.).

Commentary will be included to discuss the observed benefits from implementation and any changes in groundwater conditions believed to be attributed to the implementation of projects undertaken by the GSA.

8.1.2.3 Implementation of Adaptive Management Actions

To respond to adverse water elevation or water quality conditions, the BVGSA has developed a program of adaptive management actions presented in Section 7 – Projects and Management Actions. This suite of temporary actions is designed to:

- Reduce demand,
- Bolster surface water supplies, and
- Curtail groundwater use.

Adaptive management actions that are put into effect during the reporting year will be brought to DWR's attention by describing 1) the management action that was taken, 2) when the management action was taken, and how long it is anticipated to last, and 3) the action's performance with respect to relieving the adverse condition that triggered its implementation.

8.2 5-Year Evaluation by Agency

In accordance with the SGMA regulations, the BVGSA will evaluate its GSP every 5 years and whenever the plan is amended and provide a written assessment to DWR. The purpose of these updates is to describe whether plan implementation, including projects and management actions, is meeting the sustainability goal(s) set forth in the GSP.

8.2.1 Sustainability Evaluation

Each 5-year Evaluation will be based on data collected through the monitoring networks described in Section 4 – Monitoring Networks. Data collected by the monitoring networks will be used to compare conditions observed during the reporting period with the sustainable management criteria defined at each of the monitoring locations and presented in Section 5 – Minimum Thresholds, Measurable Objectives and Interim Milestones.

8.2.2 Reconsideration of GSP Elements

8.2.2.1 Basin Setting

Section 2 – Basin Setting provides a conceptual understanding of subsurface conditions based on the numerous descriptions of geologic and hydrogeologic conditions available for the Kern County Subbasin. One of the benefits of SGMA will be to increase understanding of the Kern County Subbasin's geologic structure, hydrogeologic conditions and water use.

The BVGSA will use the 5-year evaluations as an opportunity to apply the improved understanding of the Subbasin to fill data gaps identified in preceding versions of the GSP and to update data and assumptions presented in the Basin Setting. Therefore, 5-year updates may present new information on elements of the Basin Setting including: soil properties, aquifer parameters, water quality trends, and land and water use. Any time series data presented in the Basin Setting will be updated.

8.2.2.2 Management Areas

As described in earlier sections of this GSP, the BVGSA is divided into two management areas. The Buttonwillow Management Area (BMA) is the focus of this GSP. The smaller, Maples Management Area (MMA) is separated by about 15 miles from the BMA, lies entirely within the Kern River GSA (KRGSA) and will be managed in a way that conforms with the management objectives of this GSA. Therefore, data reported for the MMA will be collected by the BVGSA, but data will be submitted as part of the KRGSA's reporting.

If conditions change within the BVGSA, or it is determined that the BMA can be better managed by subdivision into management areas, the 5-year evaluations will provide the opportunity to make required adjustments.

8.2.2.3 Undesirable Results Narrative

Section 3 – Sustainability Goal and Undesirable Results describes the six sustainability indicators used to warn of groundwater conditions occurring throughout a subbasin that, when significant and unreasonable, lead to undesirable results. Of these six, four or recognized as undesirable results that could occur within the BVGSA:

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued;
2. Significant and unreasonable reduction of groundwater storage;
3. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies, and;
4. Significant and unreasonable land subsidence that substantially interferes with surface land uses.

The 5-year evaluation will be used to assess these sustainability indicators, and any updates will be applied to the narrative describing the sustainability indicators and their relationship to undesirable results.

8.2.2.4 Monitoring Network, Minimum Thresholds, Measurable Objectives, and Interim Milestones

Should the sustainability evaluation described in Section 8.2.1, above, reveal an inadequacy with a minimum threshold or a measurable objective or a deficiency in a monitoring network, the BVGSA will utilize the 5-year update to document modifications that have been put in place.

Monitoring over the 5-year interval between plan updates will reveal trends and data gaps, which will inform the need to modify the monitoring networks and to revise the sustainable management criteria. Changes to the monitoring networks may include, but would not be limited to, the addition of monitoring in areas of concern, increased spatial density of monitoring sites, or increased frequency of data collection. The initial values for minimum thresholds, measurable objectives, and interim milestones are not anticipated to be changed, but the 5-year evaluation will document changes in groundwater conditions and modifications to the sustainable management criteria that may be recommended.

8.2.3 Monitoring Network Description

A description of the monitoring networks within the BVGSA will be provided, focusing on any modifications that have taken place during the reporting periods and data gaps or areas within the BVGSA that have been identified as represented by data that do not satisfy the requirements of Sections 352.4 and 354.34(c).

8.2.3.1 Data Gaps

An assessment of monitoring network function, as described in Section 4 – Monitoring Networks, will be conducted as part of the 5-year evaluation. The goal of this assessment is to analyze data collected to date, identify data gaps, and describe the actions that will be taken by the BVGSA to improve the monitoring network in ways that will fill data gaps, consistent with the requirements of Section 354.38 of the GSP Regulations.

8.2.3.2 Plan to Fill Data Gaps

If BVGSA identifies data gaps, the 5-year evaluation will describe a program for the acquisition of additional data. This program will include the timing of the data acquisition and when the newly obtained information will be incorporated into the GSP. In the formation of this program, the BVGSA will prioritize the installation of new data collection facilities and analysis of new data based on the needs of the GSA.

8.2.4 New Information and Plan Amendments

The 5-year evaluation will provide a description of any significant new information that has become available since the GSP adoption, or since the last 5-year evaluation. If the new information warrants changes or amendments to the GSP, the BVGSA will explain what changes will be made. New information may warrant changes to the basin setting, measurable objectives, minimum thresholds, or the criteria defining undesirable results.

The BVGSA will also provide details of any amendments to the GSP, describing what the amendment is and how it will further the sustainability goal of the GSA.

8.2.5 Legal and Enforcement Actions

Information describing any enforcement and/or legal actions taken by the BVGSA to ensure the achievement of the GSP's sustainability goals will be provided in the 5-year evaluation.

8.2.6 Coordination

The BVGSA coordinated with surrounding GSAs in the development of the BVGSP, and continued coordination will occur with GSAs throughout the Kern County Subbasin. A summary of coordination that occurred between other Kern County Subbasin GSAs and BVGSA will be documented as part of the 5-year evaluation.

9. Communication and Engagement Plan

9.1 Introduction

SGMA is groundbreaking, not only in its regulation of groundwater but also for the process it outlines to sustainably manage the resource. Under SGMA, groundwater basins are required to establish Groundwater Sustainability Agencies (GSAs) responsible for developing Groundwater Sustainability Plans (GSPs). GSAs have broad powers over local water- and land-use management that will impact a wide range of stakeholders, including agricultural, industrial, recreational, Tribal, and environmental interests; large and small drinking water systems; and individual homeowners relying on private wells.

Because SGMA requires that these parties participate in the implementation process, GSAs need to engage these varied interests to determine how their input will be integrated into the decision-making, coordination, and management processes necessary to form GSAs and to craft and implement GSPs.

9.2 Geography and Surrounding Basins

9.2.1 GSA Overview

The Buena Vista GSA is comprised almost entirely of irrigated farmland with the Community of Buttonwillow being the only municipality within its boundaries. Groundwater is the Community of Buttonwillow's sole source of water supply while agricultural water is diverted from the Kern River and the State Water Project. Groundwater serves as a supplemental supply with the level of extraction varying with demand and hydrologic conditions. Since the BVGSA lies within a high-priority basin in a critical condition of overdraft, it is required to develop and adopt a GSP by January 31, 2020, and, through implementation of the GSP, to achieve sustainability by 2040.

9.2.2 GSA Extents

The Buena Vista Groundwater Sustainability Agency (BVGSA) is located in the western part of the Kern County Subbasin (Subbasin) whose boundaries correspond closely to those of the Buena Vista Water Storage District (BVWSD). The BVGSA lies within the Tulare Lake Basin and the Kern County Subbasin as defined by the California Department of Water Resources (DWR) as shown in Figure 1-1 – Buena Vista GSA Boundaries. (Figure 1-1 – Refer to Figures Tab)

The BVGSA shares parts of its northern, eastern, and southern boundaries with the Semitropic- and Rosedale-Rio Bravo water storage districts (SWSD and RRBWSD), the Kern-Delta Water District (KDWD), the Kern Water Bank Authority (KWBA) and the West Kern Water District

(WKWD). The GSA shares its western boundary with undistricted lands which separate the GSA from the Belridge Water Storage District and oilfield properties farther to the west. SGMA compliance for these undistricted lands falls within the jurisdiction of the County of Kern and the Kern County Water Agency (KCWA).

9.2.3 Surrounding Basins

The Kern County Subbasin comprises of 24 agencies, including 3 cities, with groundwater management responsibilities. By the GSA formation deadline, these agencies had formed 11 GSAs, as illustrated in Figure 1-2 – GSAs within Kern County Subbasin (Figure 1-2 – Refer to Figures Tab). The 11 GSAs are listed in Table 9-1.

Table 9-1. Kern Subbasin GSAs

District		GSA
1.	Buena Vista Water Storage District	BVGSA
2.	Cawelo GSA*	KGA
3.	Kern River GSA	KRGSA
4.	Olcese GSA	OGSA
5.	Pioneer GSA*	KGA
6.	Greenfield County Water District	KRGSA
7.	Henry Miller Water District	HMGSA
8.	Kern Groundwater Authority GSA*	KGA
9.	McFarland GSA*	KGA
10.	Semitropic Water Storage District*	KGA
11.	West Kern Water District*	KGA

The GSAs marked with an asterisk (*) agreed to work directly with the Kern Groundwater Authority GSA (KGA) to submit one high-level ("umbrella") GSP with individual chapters for each GSA. Kern County is responsible for the remaining "white areas," which are areas not covered by one of the above GSAs. Although the BVGSA is an independent agency and not a member of the KGA, the BVGSA engages actively with neighboring GSAs including agencies who are under the KGA umbrella. The GSAs preparing individual GSPs in the Kern County Subbasin are the following, and a map of these GSPs is included in Appendix G – Coordination Agreement:

- Buena Vista GSA;
- Kern River GSA;
- Henry Miller GSA;
- Olcese GSA, and
- Kern Groundwater Authority GSA.

9.3 Goal and Objectives of Stakeholder Engagement Plan

9.3.1 Purpose

Stakeholder engagement is defined as efforts made to understand and involve stakeholders and their concerns in the activities and decision-making of an organization or group and is an important tool for fostering acceptance, trust, and compliance in decision-making settings.

While stakeholder engagement requires time and resources in the short term, the benefits of improved outcomes, optimized allocation of resources, broad support and reduced conflict can make these efforts invaluable in the long term. As such, stakeholder engagement and collaboration are key components to achieving the objectives of the BVGSA.

9.3.2 Goal

The goal of this Stakeholder Engagement Plan is to enable the BVGSA to involve stakeholders in developing a comprehensive understanding of issues relevant to sustainable management of groundwater and to guide BVGSA leadership in its efforts to coordinate with other GSAs in the Subbasin.

9.3.3 Desired Outcomes

To meet the goal of transparent development and coordinated leadership, the BVGSA has adopted this Stakeholder Engagement Plan to achieve the outcomes listed below:

- Underscore the importance of stakeholder participation while clearly communicating how public input will be used in GSP development;
- Encourage active involvement of diverse social, cultural, and economic elements of the population by identifying and providing multiple and varied opportunities for public participation;
- Educate the public about SGMA and the reason for a GSP; providing comprehensive, accurate, and timely information about GSP development;
- Provide a roadmap for BVGSA leadership to follow regarding stakeholder engagement, with the aim of developing widespread support for adoption and implementation of the BVGSA's GSP, and
- Ensure that public participation is facilitated by the implementation of an inclusive Stakeholder Engagement Plan and that meaningful public input is sustained.

Figure 9-1 – Objectives of Stakeholder Engagement Plan, illustrates both the objectives and the continuous process necessary for successful stakeholder engagement.

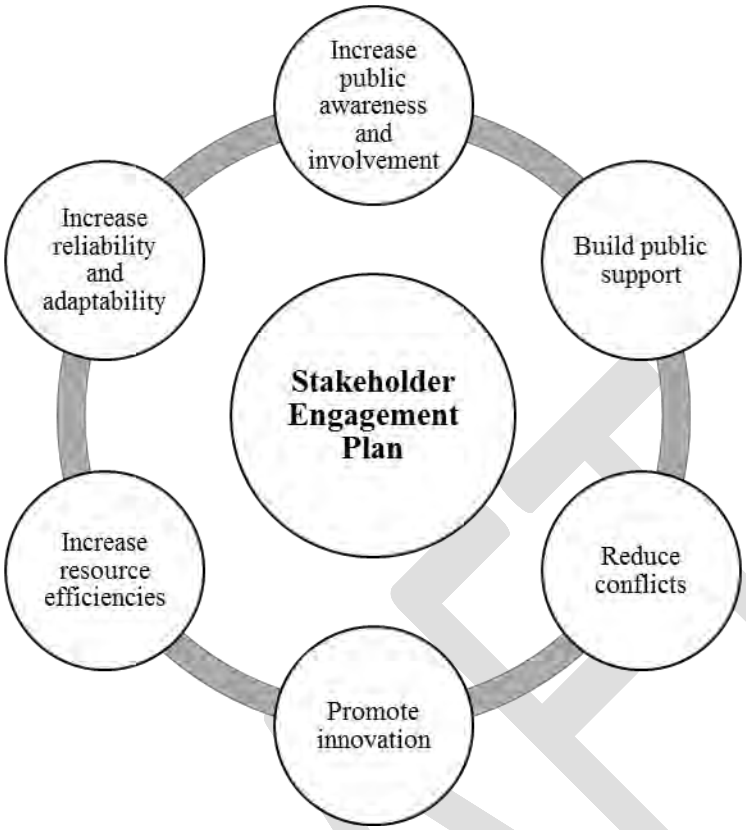

Figure 9-1. Objectives of Stakeholder Engagement Plan

9.4 Plan Requirements

SGMA has established statutory requirements for public notice and participation through public hearings and development and maintenance of an interested parties list. Within this framework, the SGMA legislation allows individual GSAs to develop the mechanisms that will enable these agencies to "consider the interests of all beneficial uses and users of groundwater" and to "encourage the active involvement of diverse social, cultural, and economic elements of the population" with these mechanisms being expressed through the Stakeholder Engagement Plan. The Stakeholder Engagement Plan described in this section offers a spectrum of options from notifying the public of intended actions to more active forms of engagement such as stakeholder consultation and establishing collaborative decision-making models.

9.4.1 Statutory Specifications

According to the DWR's "GSP Stakeholder Communication and Engagement Guidance Document", (DWR, 2017) and the Community Water Center's paper "Collaborating for Success: Stakeholder Engagement for Sustainable Groundwater Management Act Implementation" (Community Water Center, 2015), the following statutory requirements for Stakeholder Engagement under SGMA have been outlined:

- A groundwater sustainability agency may adopt or amend a groundwater sustainability plan after a public hearing (CA Water Code Sec. 10728.4).
- Prior to imposing or increasing a fee, a groundwater sustainability agency shall hold at least one public meeting (CA Water Code Sec. 10730(b)(1)).
- The groundwater sustainability agency shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents (CA Water Code Sec. 10723.4).
- Any federally recognized Indian Tribe… may voluntarily agree to participate in the preparation or administration of a groundwater sustainability plan or groundwater management plan … A participating Tribe shall be eligible to participate fully in planning, financing, and management under this part (CA Water Code Sec. 10720.3(c)).
- The groundwater sustainability agency shall make available to the public and the department a written statement describing the manner in which interested parties may participate in the development and implementation of the groundwater sustainability plan (CA Water Code Sec. 10727.8(a)).
- The groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater (CA Water Code Sec. 10723.2).
- The groundwater sustainability agency shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin (CA Water Code Sec. 10727.8(a)).

9.4.1.1 Public Notice and Participation

SGMA requires GSAs to communicate directly with interested persons, be they individuals or organizations/agencies, by creating, maintaining, and employing a list of interested persons, which the GSA must submit to DWR. BVGSA's list of interest parties is presented in Section 9.6.7 below.

9.4.1.2 Beneficial Users

Broad public participation and transparency are critical to fostering the benefits of stakeholder engagement, and opportunities for engagement that extend beyond the baseline of 'inform and consult' are essential. The following ten categories of beneficial users to be included in stakeholder communication and engagement are described in Section 10723.2 of the SGMA regulations:

- Holders of overlying groundwater rights, including agricultural users and domestic well owners;
- Municipal well operators;
- Public water systems;

- Local land use planning agencies;
- Environmental users of groundwater;
- Surface water users, if there is a hydrologic connection between surface and groundwater bodies;
- The federal government, including, but not limited to, the military and managers of federal lands;
- California Native American Tribes;
- Disadvantaged communities (DACs), including, but not limited to, those served by private domestic wells or small community water systems, and
- Entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or a part of a groundwater basin managed by the groundwater sustainability agency.

9.4.2 Principles for Effective Stakeholder Engagement

In addition to the statutory requirements for public notification and participation and engagement of all beneficial users, the SGMA regulations include broader, overarching substantive requirements meant to lead to the engagement of all stakeholders. Unlike the public notice requirements, these requirements are not prescriptive. Rather, GSAs are given the latitude to tailor their approach to fit local needs.

Because of the small geographic area and limited population of the BVGSA, the approach to communication and engagement will rely heavily on face-to-face meetings between stakeholders and GSA decision makers. This emphasis on direct communications has been successful in developing a cooperative relation between key stakeholders including the Community of Buttonwillow and landowners in the formation of the BVGSA and in the development of the GSP. Concepts adopted by the BVGSA to achieve effective stakeholder engagement are:

- Conduct periodic stakeholder identification and assessments and update the list of interested parties;
- Expand the reach of stakeholder engagement and communication to new and diverse groups;
- Hold regular, broadly advertised public hearings, workshops, and meetings;
- Regularly update the C&E Plan so opportunities for engagement continue to meet the changing needs of stakeholders including vulnerable and under-represented groups;
- Ensure that decision makers engage directly with advisory committees and in other forums where recommendations are made;
- Seek feedback on engagement, outreach, and communication efforts;

- Offer options for communication and information sharing beyond electronic communications;
- Engage stakeholders in technical issues;
- Use online databases and documents to increase access to information and to make information used to develop and implement the GSP readily accessible;
- Provide for extended comment periods on documents and proposals and actively encourage feedback by creating varied opportunities and methods;
- Provide stakeholders opportunities to meet and discuss issues collectively with the GSA as well as allowing stakeholders the ability to communicate individually with decision makers. Establish formal collaborative fact finding conducted by a technical advisory committee (TAC). The role of the TAC will be to solicit and incorporate stakeholder feedback throughout plan development and implementation.

The BVGSA's approach to communication and engagement is designed to encourage multi-stakeholder dialogue as well as allowing stakeholders direct access to decision makers. Providing a variety of channels for communication between stakeholders and decision makers has proven to be effective in administration of the Buena Vista Coalition for implementation of the Irrigated Lands Regulatory Program by providing settings for both vocal and reticent stakeholders to present their views.

9.5 Outreach Efforts

9.5.1 Previous and Current Efforts

The BVGSA is an exclusive GSA engaged in coordination and outreach efforts across the Kern County Subbasin, as well as within the GSA's boundaries. The BVGSA actively participates in technical and planning meetings and forums with other GSAs in the Subbasin and holds monthly GSA governance meetings to support planning and implementation of the GSP. These meetings welcome public input and began with an initial workshop in 2018, which focused on public involvement and sought input on approaches, such as formation of a Technical Advisory Committee, to regularly acquire feedback from a wide variety of public stakeholders including the disadvantaged Community of Buttonwillow.

9.5.2 On-going and Future Activities

Although the SGMA legislation defines interests are to be considered by the BVGSA's C&E Plan, the form that this engagement takes is determined by the GSA. As noted above, the BVGSA's approach to public engagement is tailored to the size and demographics of the area, factors have enabled the GSA to engage directly with local stakeholders who are well informed on local water management issues. The GSA will also communicate actively with stakeholders not familiar with the area to educate these stakeholders about the physical conditions and water management practices that distinguish the BVGSA from neighboring areas.

As documented in preceding sections, due to the BVGSA's setting and its conjunctive management of surface water and groundwater, the area is characterized by groundwater elevations that have shown little fluctuation between wet periods and droughts. As a result, the GSA does not need to construct projects and introduce management actions to correct historic or current unsustainable groundwater use. However, Section 7 – Projects, Management Actions, and Adaptive Management Actions presents a program of measures that will enable the GSA to continue to manage groundwater effectively to support local water users and to advance groundwater sustainability in the Kern County Subbasin in the face of changing conditions. Foreseeable changes include both increasing demands within the BVGSA and external forces likely to change the timing and volume of surface water supplied from the Kern River and the State Water Project.

The measures described Section 7 were developed by the BVWSD and by stakeholders. While each of these actions addresses sustainability indicators presented by SGMA, none were formulated specifically as responses to SGMA. For example, the BVWSD's program to install meters on all production wells was completed before the formation of the BVGSA. In short, sustainable groundwater management is not a concept that has been introduced by SGMA, but rather is an expression of the BVWSD's mission to serve its water users through good stewardship of the resources the District, and now the GSA, have been charged to manage. Important contributions of the SGMA legislation have been to require the BVGSA to quantify the performance of its conjunctive management program through establishment and monitoring of minimum thresholds and measurable objectives and to coordinate with other GSAs to promote sustainable groundwater management throughout the Kern County Subbasin.

9.6 Roadmap for Stakeholder Engagement

9.6.1 Roles and Responsibilities

Responsibility for implementation of the C&E Plan lies with the Governance Committee of the BVGSA which is composed of members of the Buena Vista Water Storage District's Board of Directors. The point of contact is Tim Ashlock, 525 North Main Street, Buttonwillow, CA 93206 who can be reached at (661) 764-2901 or tim@bvh2o.com.

The Governance Committee is the ultimate decision-making body for the GSA, and individuals on this committee are the principal points of contact between the GSA and stakeholders. Committee members will consider and record input from interested stakeholders and will weigh the interests of all beneficial uses and users of groundwater in decision making.

The following technical experts will be available to the governance committee to communicate facts about the GSA and adjacent areas and will advise on benefits and consequences of potential projects and adaptive management actions:

9.6.2 Decision-Making Process

The primary decision makers for the BVGSA are the members of the Governance Committee. The decision-making progress will be informed by input from the C&E program as successful stewardship of the resources managed by the BVWSD and successful implementation of the GSP by the BVGSA both require a program of projects and adaptive management actions that is broadly understood and accepted by the GSA's stakeholders and that does not conflict with projects and management actions taken by other GSAs in the Kern County Subbasin.

9.6.3 Stakeholder Engagement Opportunities

The BVGSA's approach to stakeholder engagement is tailored to the size and demographics of the area, factors that enable the GSA to engage directly with stakeholders who are well informed on local water management issues. The GSA will also communicate actively with stakeholders not familiar with the area to educate these parties about the physical conditions and water management practices that distinguish the BVGSA from neighboring areas.

The primary opportunities for the BVGSA to engage with stakeholders will be the monthly Governance Committee meetings to be held on the 3rd Wednesday of each month at the office of the BVWSD in Buttonwillow. These regularly scheduled meetings will be supplemented by public workshops to be convened at major milestones during implementation of the GSP. Among these milestones are GSP adoption and amendment and consideration of modifications to the GSP to be documented in 5-year updates. Noticed public workshops and hearing will also be held before imposing or increasing fees and before implementing adaptive management actions that may restrict groundwater extraction or otherwise affect stakeholders. A key goal of each of these interactions is to solicit public comments that will be used to inform the GSP development process and implementation of projects and adaptive management actions presented in the GSP.

In addition to formal meetings and workshops, the BVGSA Governance Committee is open to meeting with stakeholders interested in expressing concerns or perspectives in a one-on-one setting and to targeted outreach to encourage involvement from groups such as residents of the Community of Buttonwillow who form a distinct population within the GSA.

The BVGSA has already begun a series of educational workshops for interested parties and the general public living, working and operating farms and businesses within its boundaries. These workshops are designed to educate attendees on the overall role and purpose of the GSA, describe the method and process used to develop the GSP and solicit input on the plan and its objectives.

Unlike many agricultural areas, the interests of private pumpers are represented by those of the agricultural landowner community at large, with all privately-owned wells being metered and providing data to the BVGSA. Similarly, the DAC community is largely represented by the Community of Buttonwillow, so outreach targeted at residents of Buttonwillow will be an effective vehicle for communication with disadvantaged households. Tribal governments will be contacted as part of the CEQA process necessary for implementation of projects, but no tribal lands lie within the BVGSA.

9.6.4 Communication Tools and Information Materials

The BVGSA has established a link on the BVWSD website at: http://bvh2o.com. This website is already actively in use and will provide the public with key information regarding the GSA and the GSP development process including the dates of public meetings and workshops. The BVGSA website also makes its resource planning and GSP documents available to the public.

Communication and engagement will be conducted through the website, mailings and the various types of meetings described above. C&E activities and participation in these activities will be recorded through meeting minutes, sign-up sheets and other standard communication and reporting tools. The BVGSA's website will be used to post a groundwater calendar, and occasional fact sheets, FAQs, and newsletters.

9.6.5 Communication and Engagement Schedule

The principal events in the BVGSA's schedule for stakeholder communication are the monthly Governance Committee meetings. As described above, other workshops and educational events will be held to address particular issues, inform stakeholders on GSP development and implementation, present the status of updates to the GSP and solicit stakeholder feedback. Should the GSA need to introduce any of the adaptive management actions described in Section 7, the GSA will hold special outreach events to coordinate implementation of these actions with affected stakeholders. All events will be displayed on the groundwater calendar posted on the BVGSA webpage and public meetings and hearings will be advertised as appropriate.

9.7 Interested Parties List, Stakeholder Survey and C&E Assessment

9.7.1 Interested Parties List

The goal of stakeholder engagement will be to develop an understanding of the positions held by various stakeholders regarding water management priorities and to convey to stakeholder's information about the development and implementation of the GSP, the establishment of metrics such as minimum thresholds and the long-term objectives of the BVGSA. Stakeholders will include beneficial users of groundwater, and parties affected by groundwater within the BVGSA and in areas neighboring the GSA.

The interested parties list, presented in Appendix F – Interested Parties List, will be maintained by the BVGSA and parties on this list will be notified in advance of all public meetings hosted by the GSA and will be alerted when the GSA posts documents to its website. Interested parties can add themselves to the interested parties list through the BVGSA website.

9.7.2 Stakeholder Survey

The BVGSA will conduct one-on-one stakeholder meetings where stakeholders will be asked a prepared set of questions designed to determine issues, interests, and challenges related to SGMA held by individual stakeholders. The questions posed to stakeholders will be based on the survey template available on the DWR SGMA website and will be tailored to characteristics of the BVGSA. Information collected through this survey process will be used to inform the GSA Governance Committee on stakeholder interests and concerns.

9.7.3 Evaluation and Assessment

The BVGSA will evaluate the success of the C&E efforts on an on-going basis. The two general yardsticks that will be used to assess the C&E program will be feedback from stakeholders and the success of the overall implementation of the GSP. Both measures will be used to modify the GSP with adjustments to the plan being incorporated as needed and documented in the 5-year updates.

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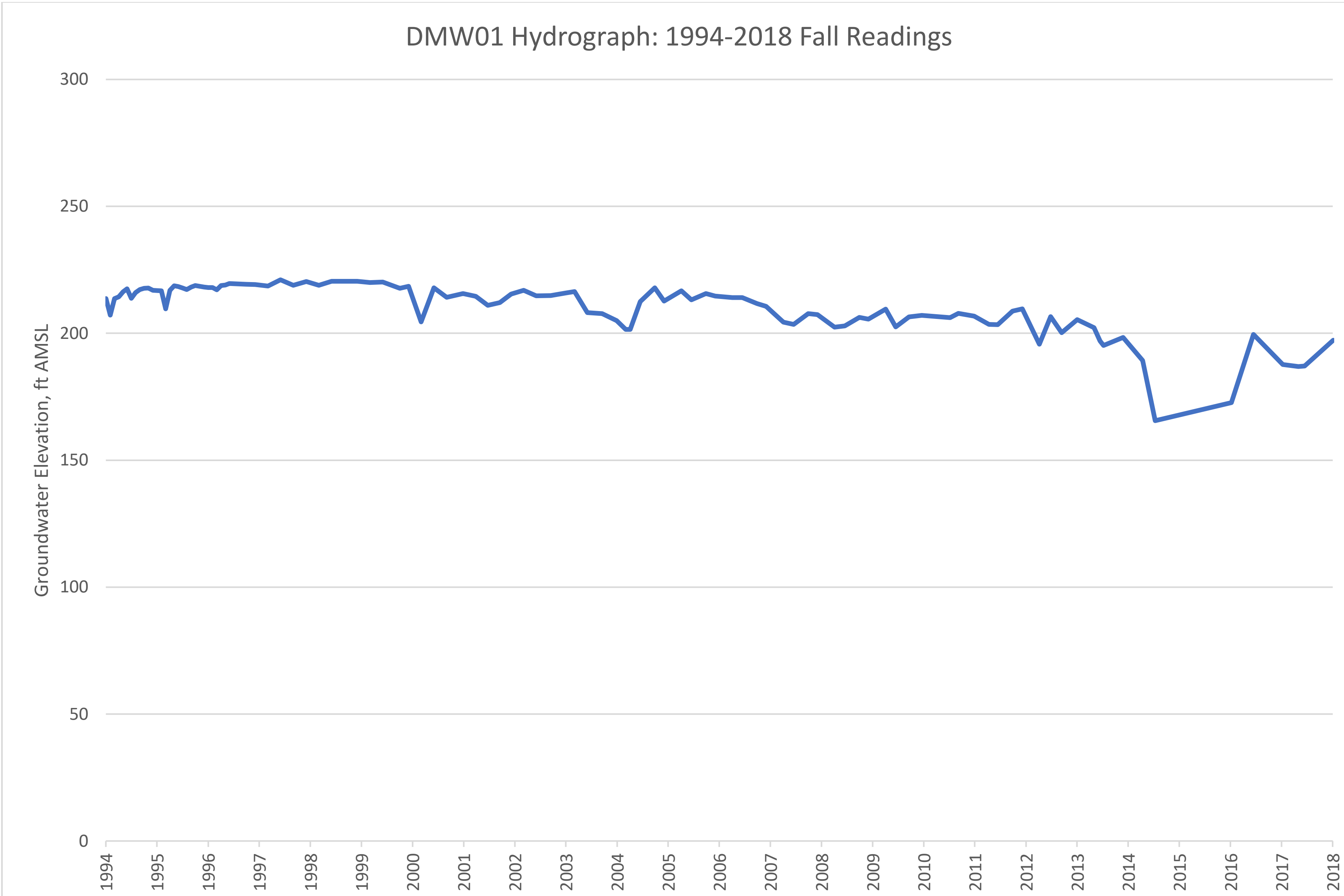
Appendix A

Comments and Responses on Internal Review Draft GSP

Appendix B

Groundwater Hydrographs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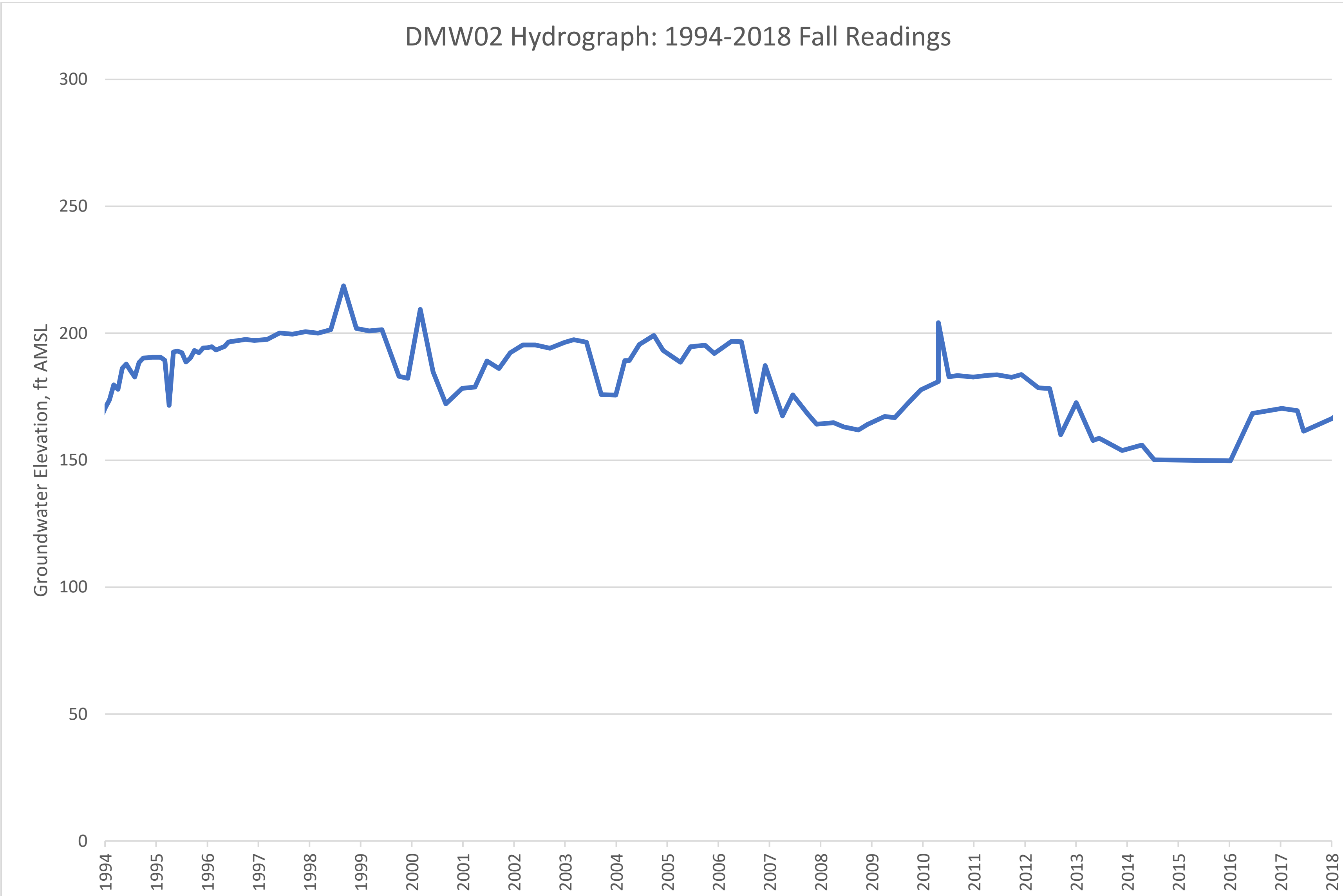
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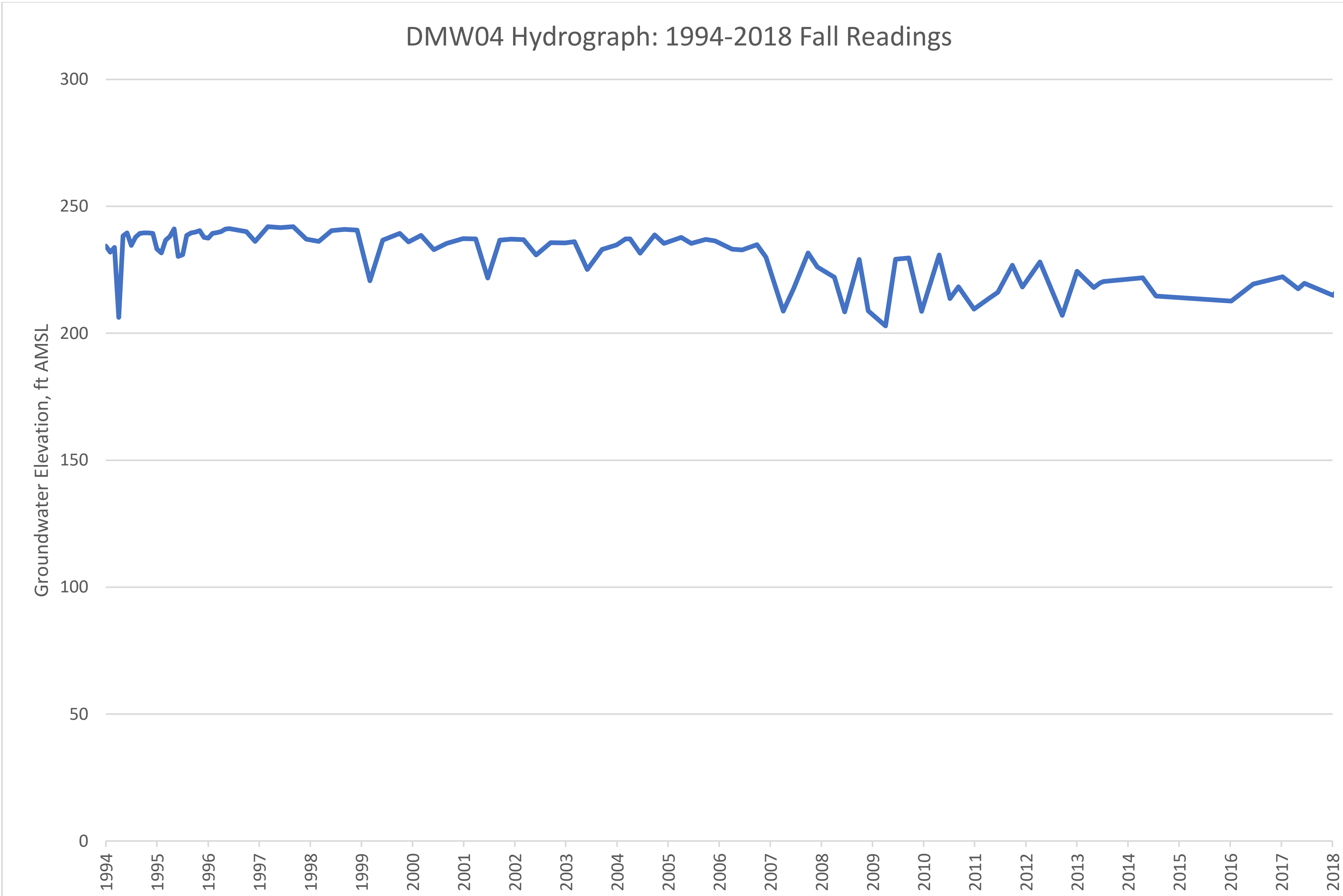
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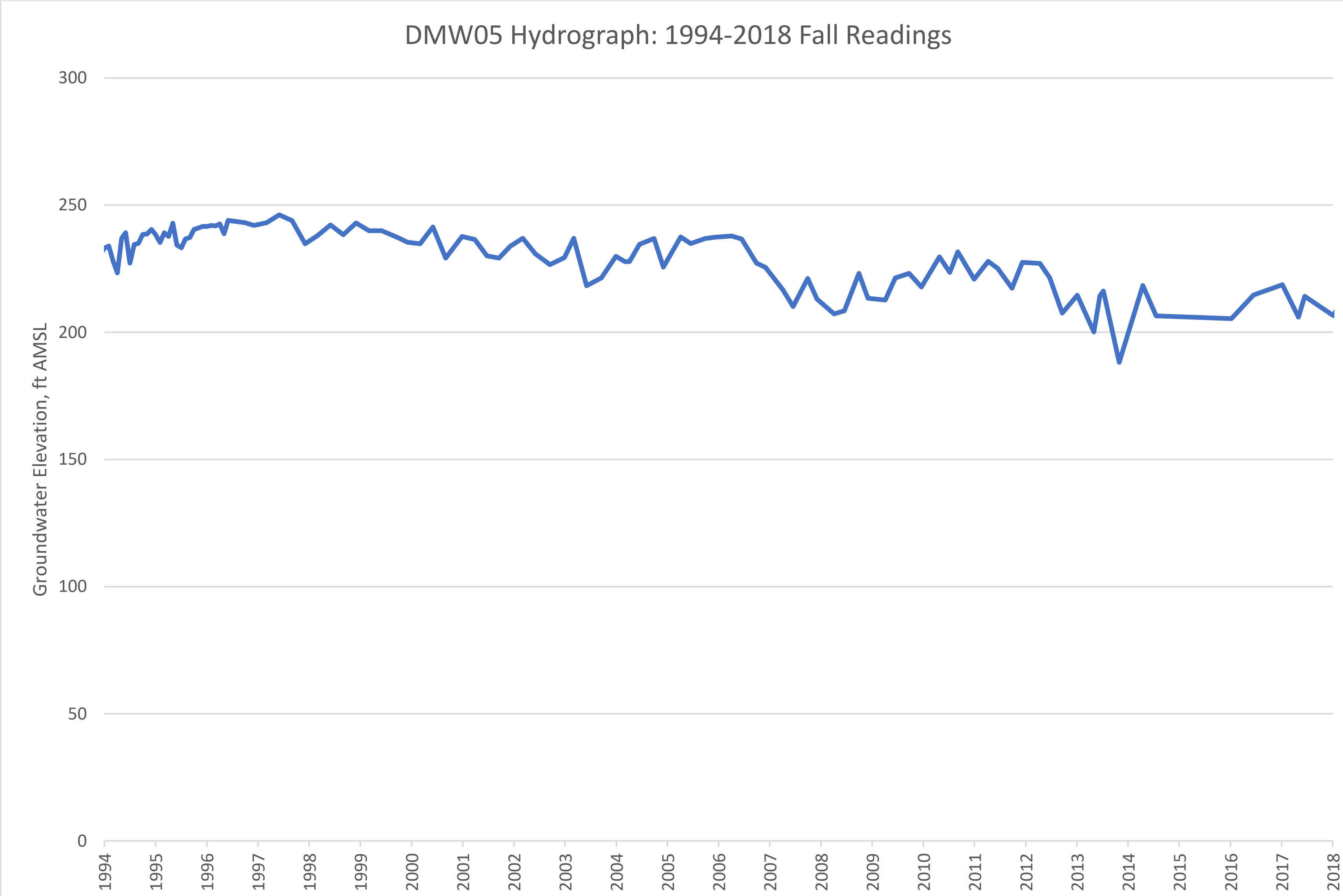

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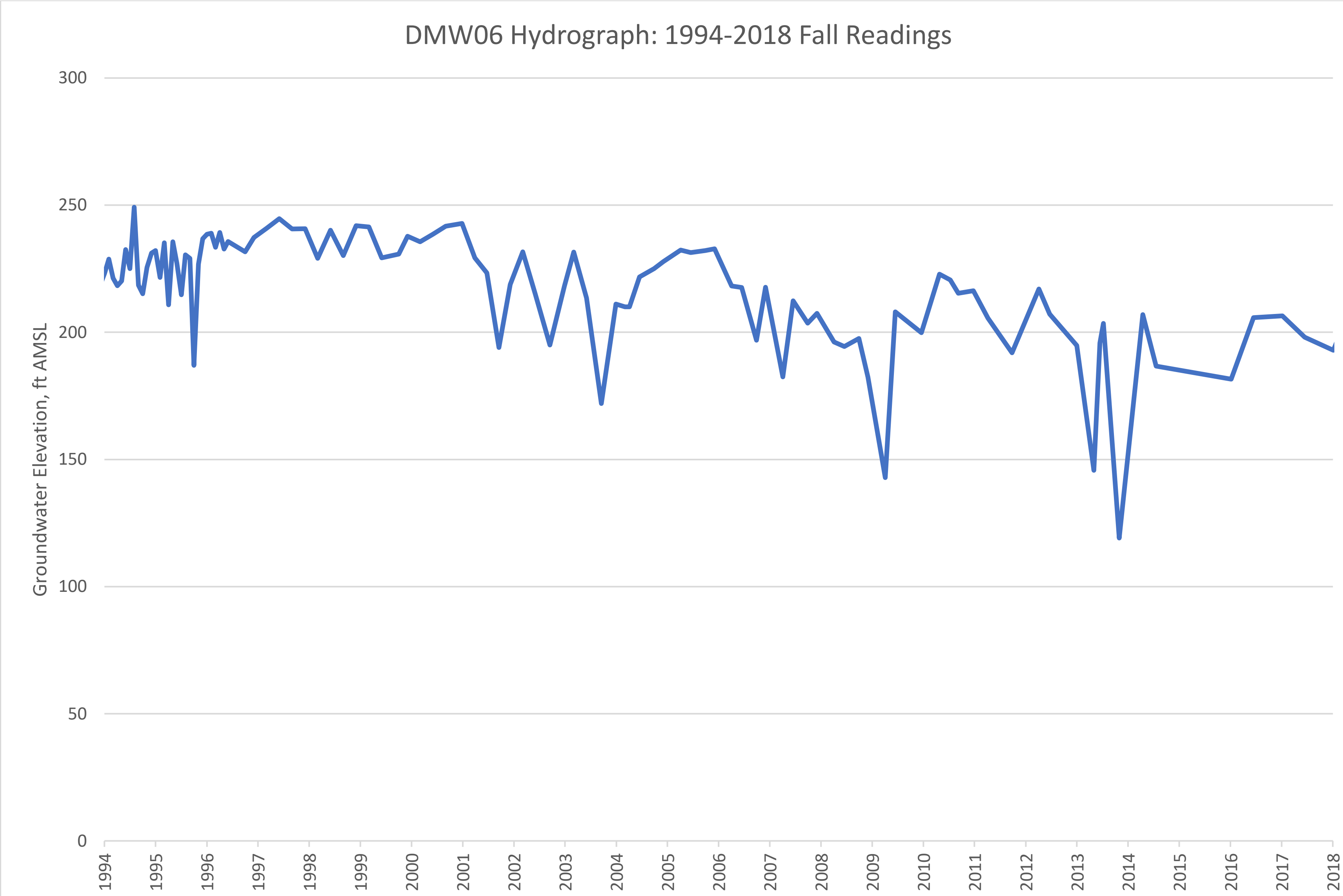
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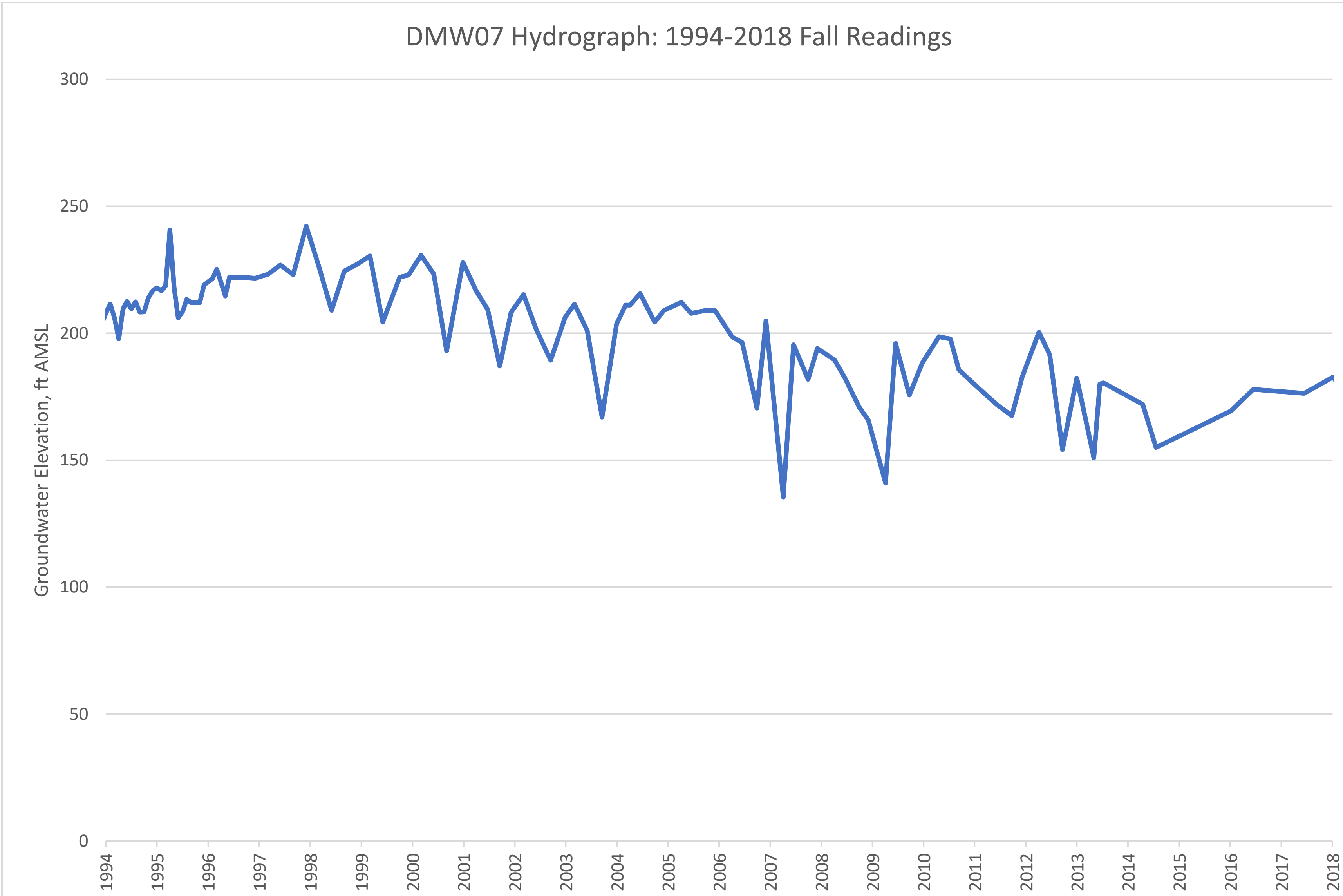
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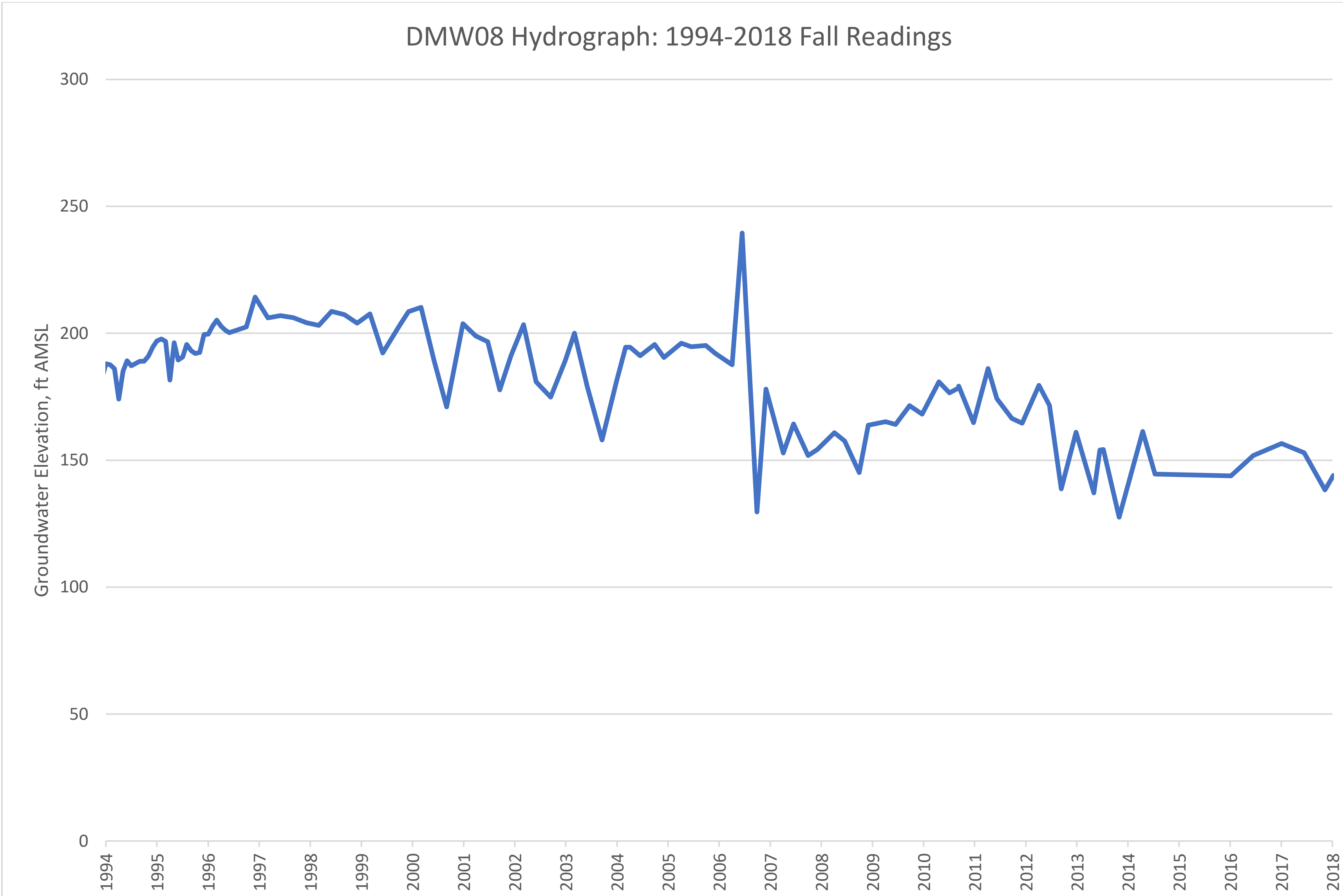

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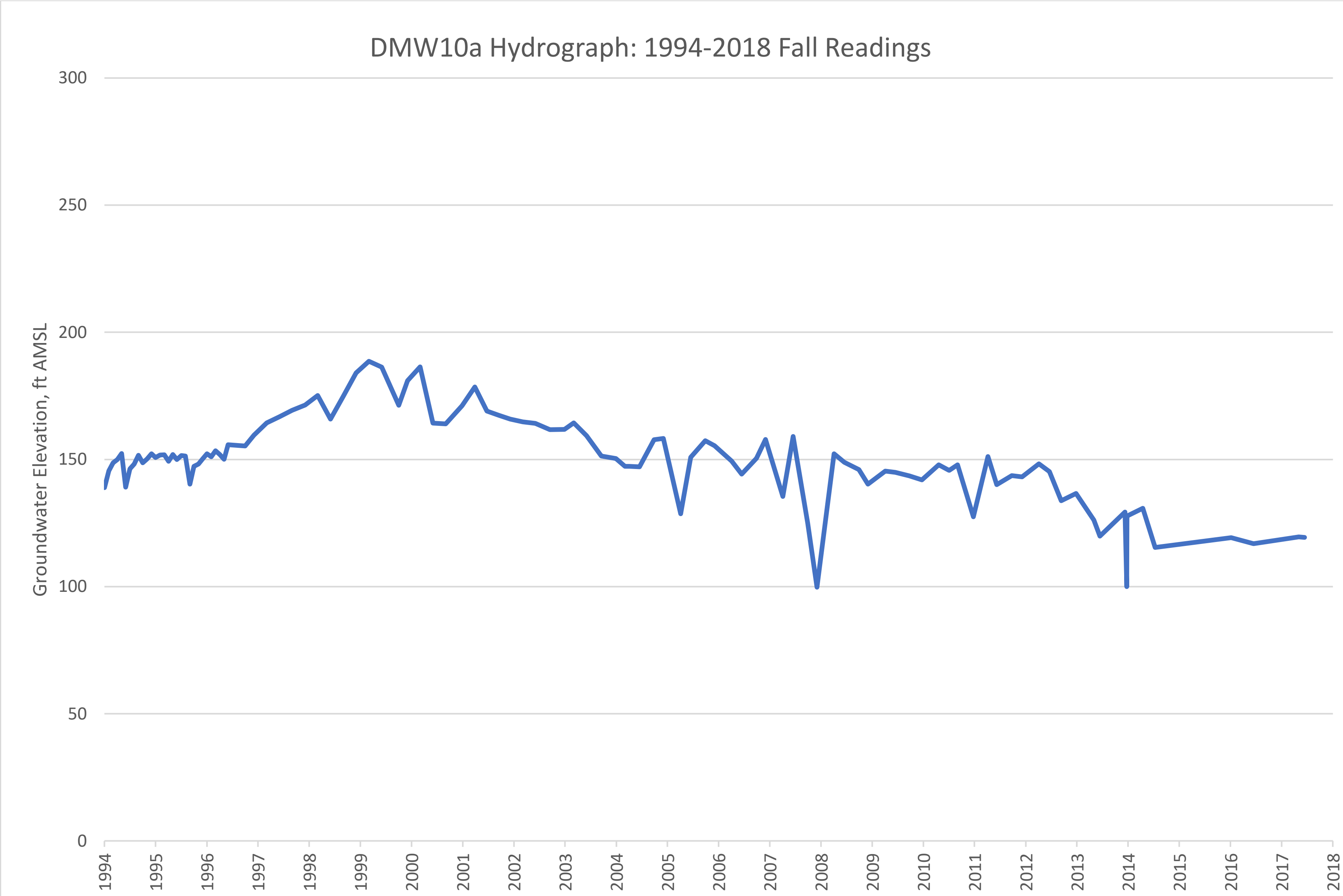
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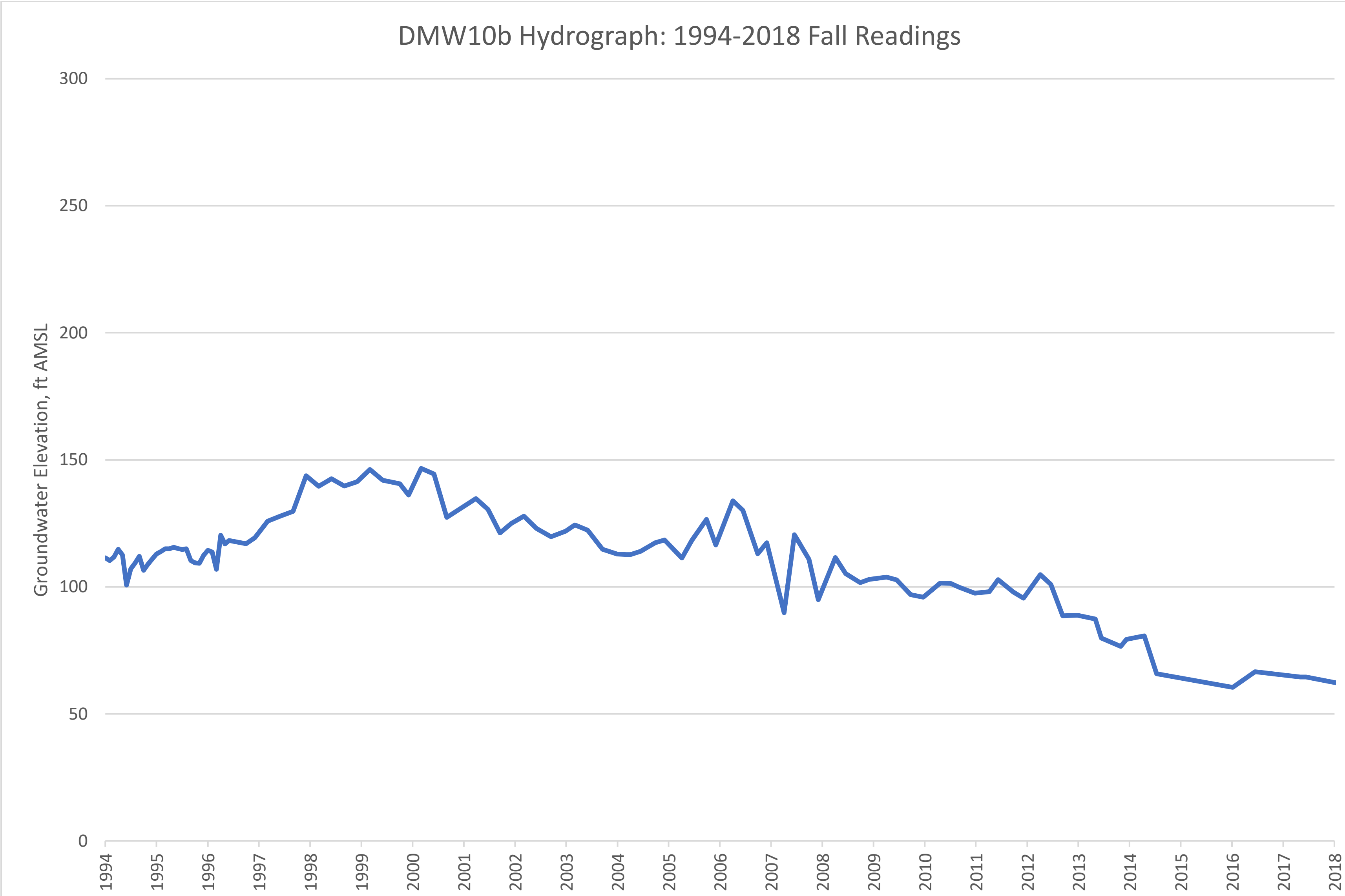
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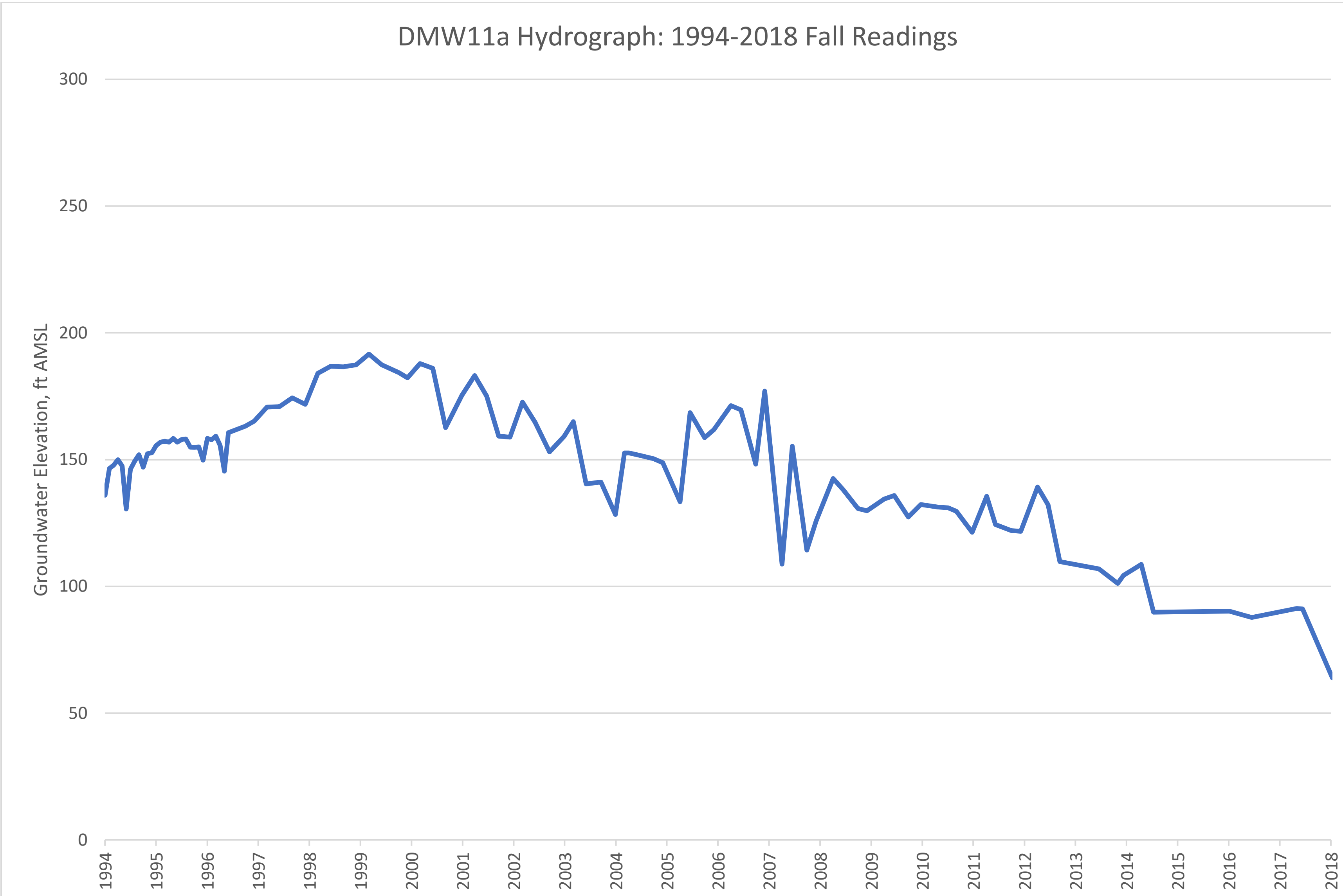

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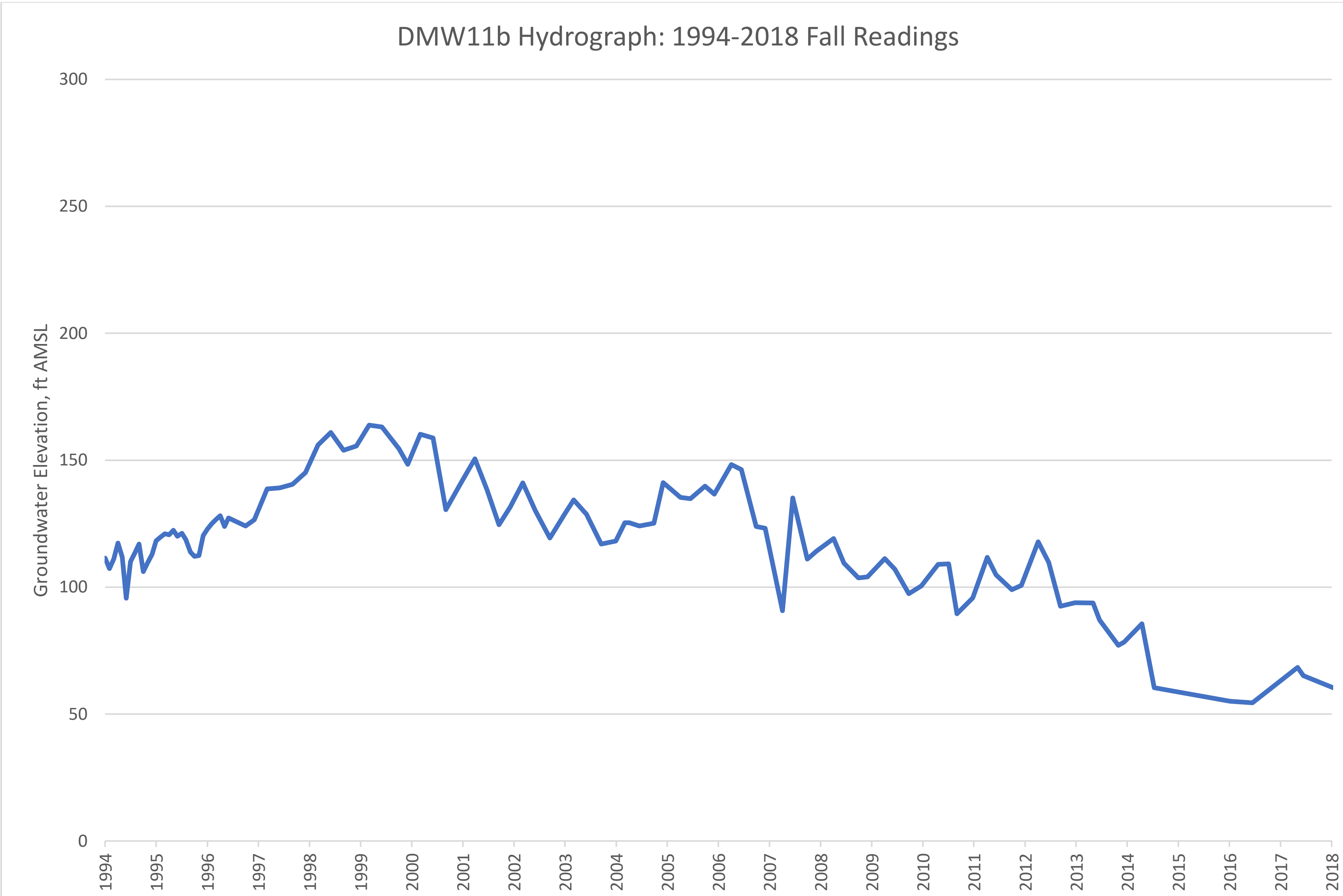

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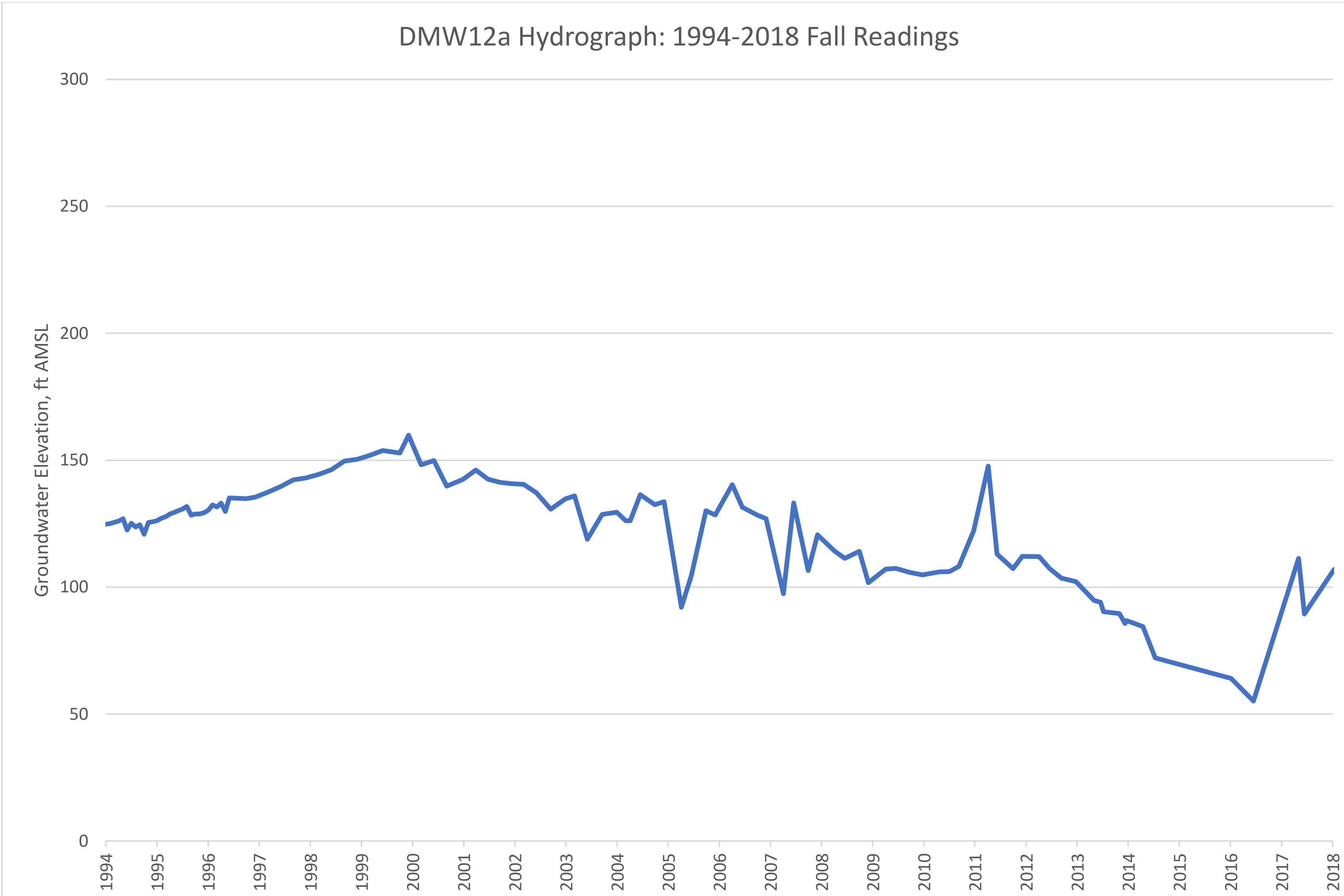

DMW12a Hydrograph: 1994-2018 Fall Readings
Groundwater Elevation, ft AMSL
300
250
200
150
100
50
0
1994
1995
1996
1997
1998
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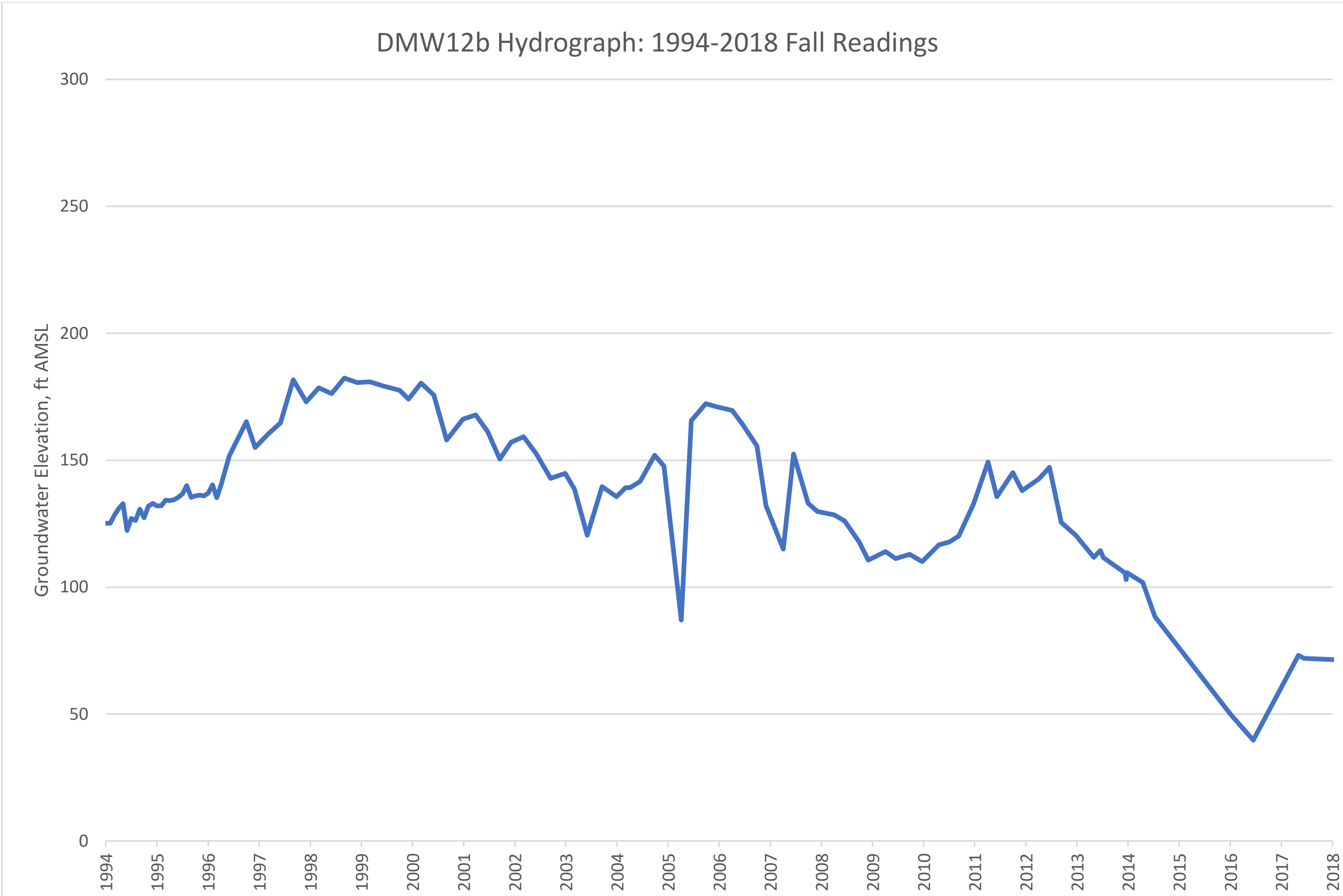

DMW12b Hydrograph: 1994-2018 Fall Readings
Groundwater Elevation, ft AMSL
300
250
200
150
100
50
0
1994
1995
1996
1997
1998
1999
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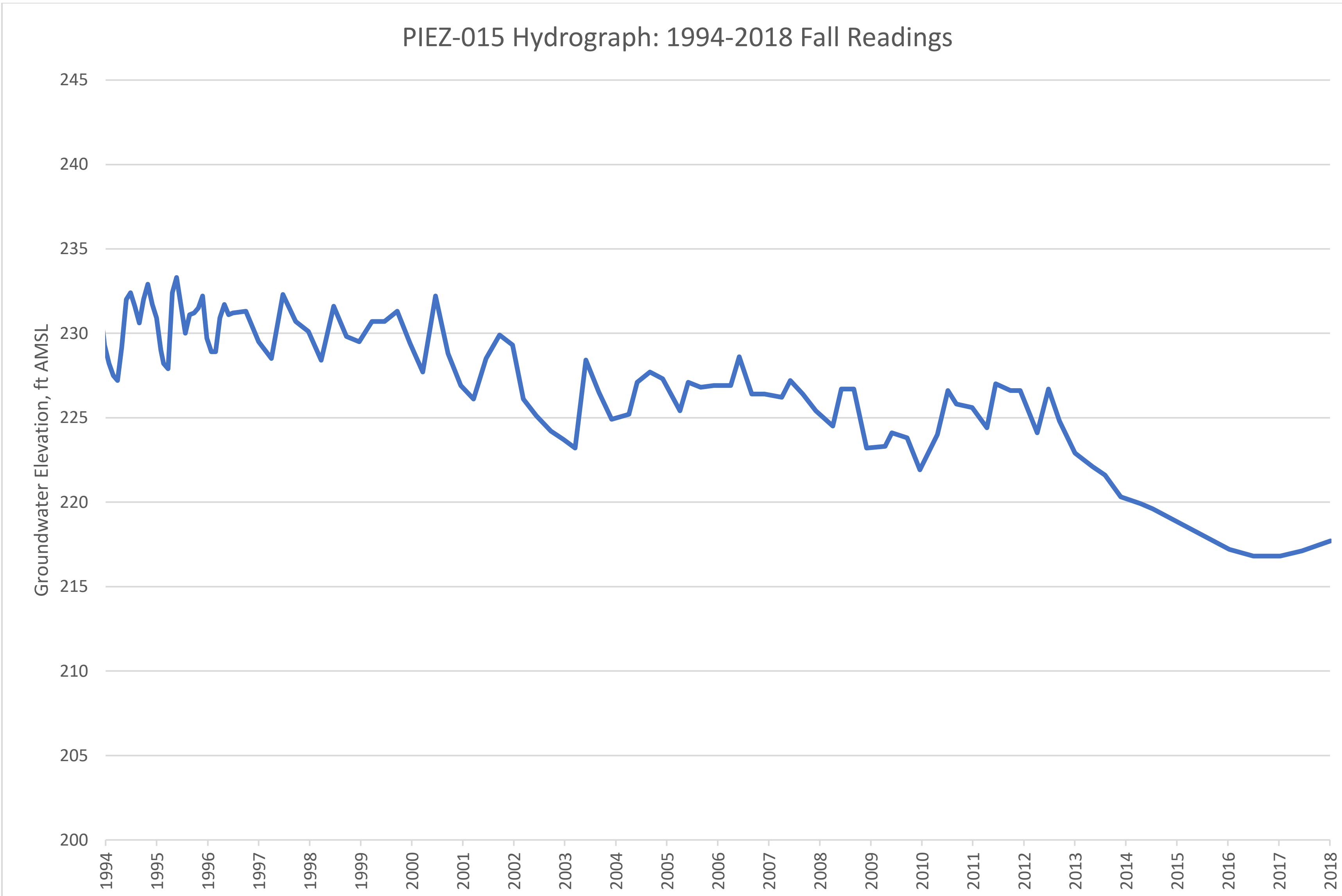
PIEZ-015 Hydrograph: 1994-2018 Fall Readings
Groundwater Elevation, ft AMSL
245
240
235
230
225
220
215
210
205
200
1994
1995
1996
1997
1998
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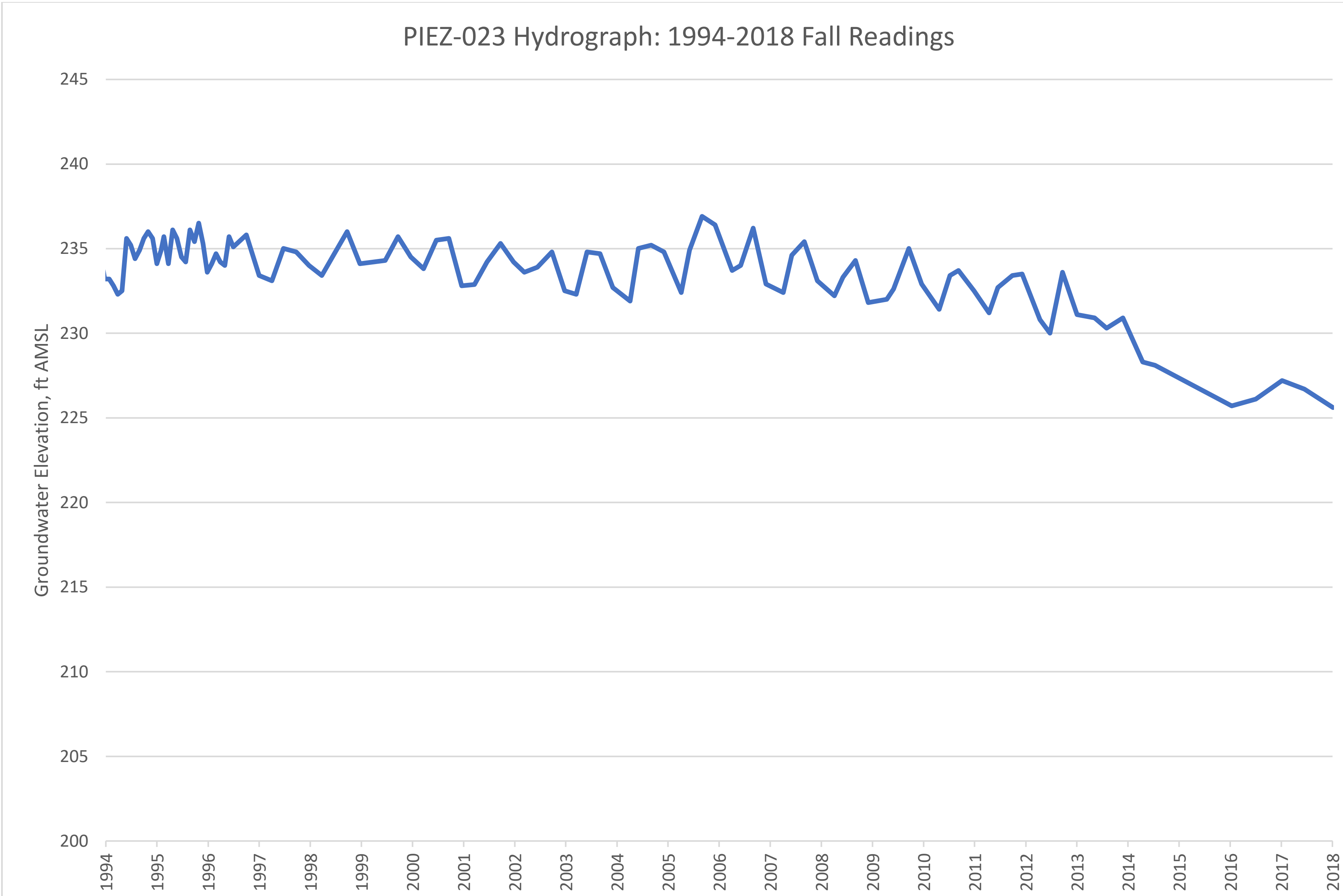
2017
2018



PIEZ-023 Hydrograph: 1994-2018 Fall Readings
Groundwater Elevation, ft AMSL
245
240
235
230
225
220
215
210
205
200
1994
1995
1996
1997
1998
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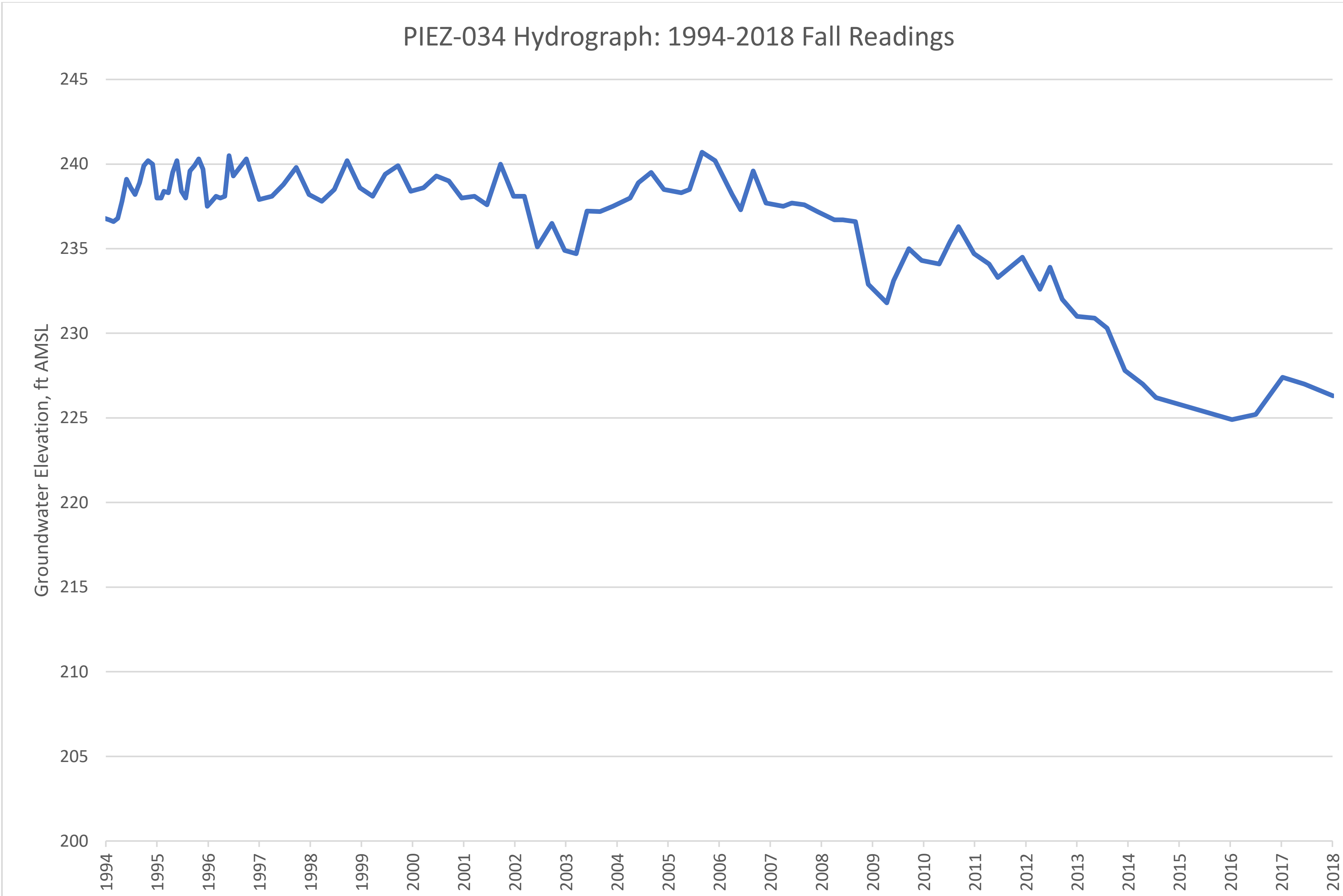
PIEZ-034 Hydrograph: 1994-2018 Fall Readings
Groundwater Elevation, ft AMSL
245
240
235
230
225
220
215
210
205
200
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1996
1997
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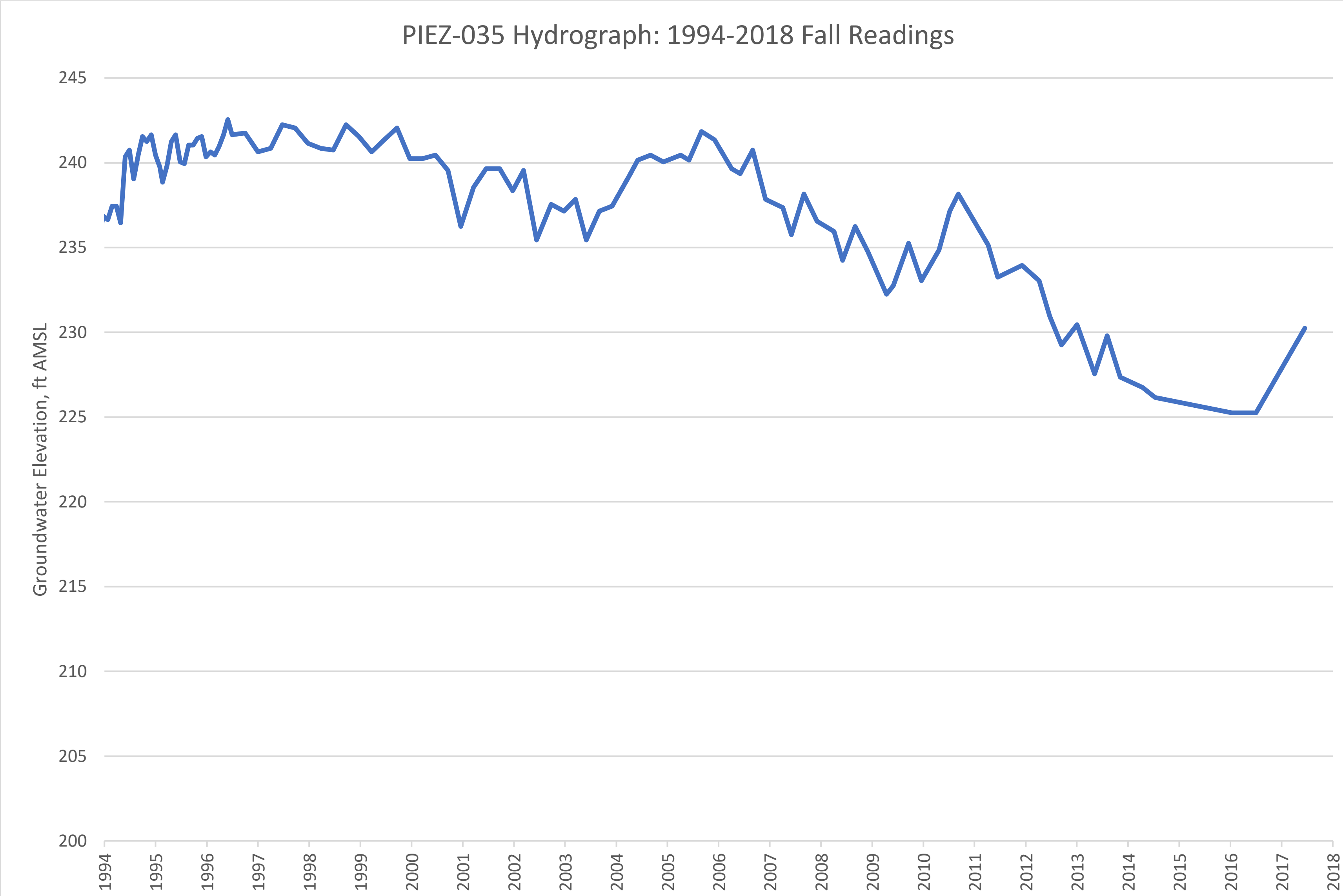

PIEZ-035 Hydrograph: 1994-2018 Fall Readings
Groundwater Elevation, ft AMSL
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240
235
230
225
220
215
210
205
200
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1996
1997
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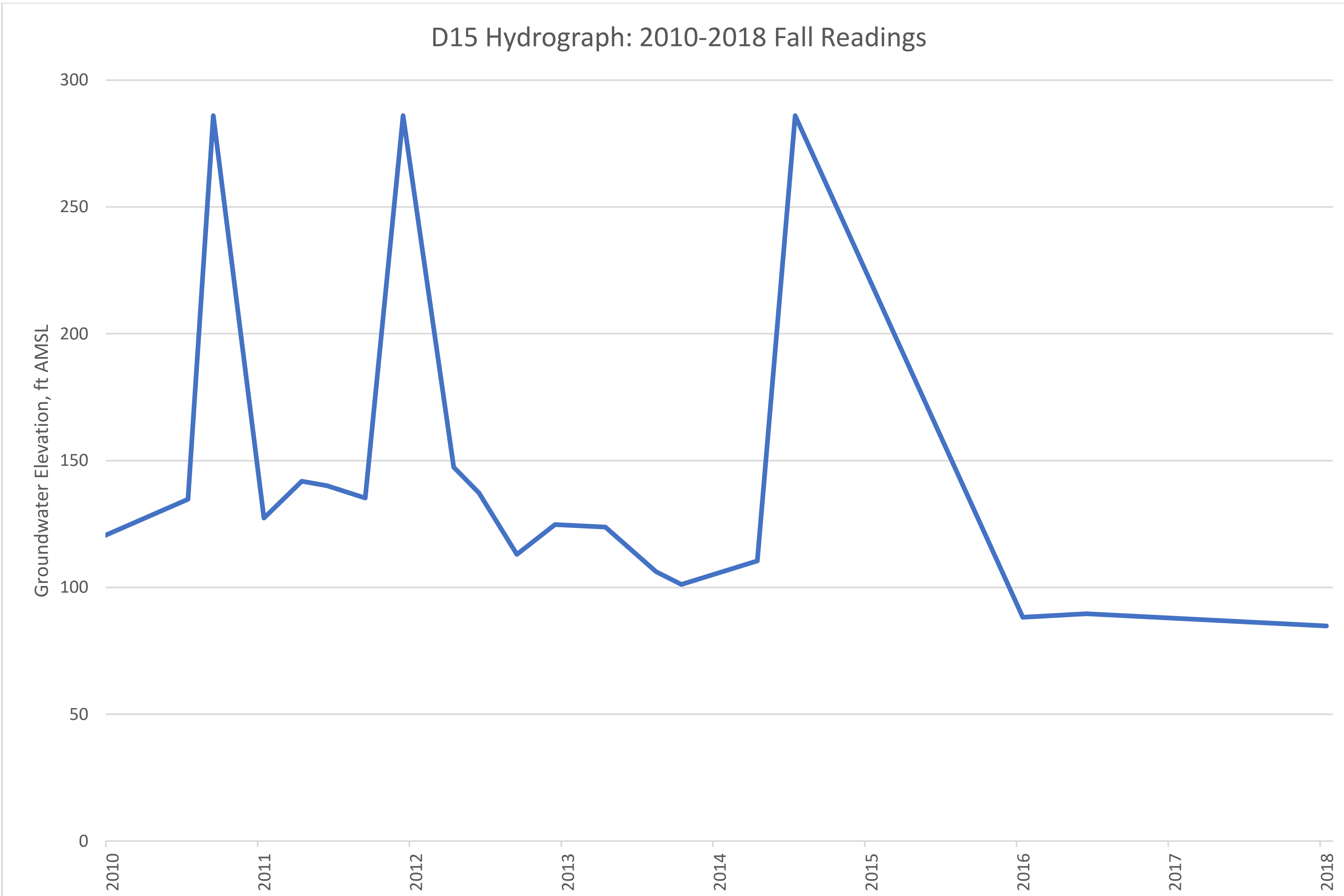


D15 Hydrograph: 2010-2018 Fall Readings
Groundwater Elevation, ft AMSL
300
250
200
150
100
50
0
2010
2011
2012
2013
2014
2015
2016
2017
2018

Appendix C

Draft Monitoring Protocol

Draft Monitoring Protocol for Buena Vista GSA

Submitted to:
Buena Vista GSA

Date: August 2019

Table of Contents

1 Introduction

1.1 Regulations and Purpose of Monitoring Protocols

This document describes the protocols for the collection, recording, and storage of geologic and hydrologic data for the Buena Vista GSA, which is within the Kern County Subbasin. These monitoring protocols were initially developed for Buena Vista GSA but can be adapted for other agencies interested in applying a uniform protocol for geologic and hydrologic monitoring to support the implementation of Groundwater Sustainability Plans (GSPs) required by the Sustainable Groundwater Management Act (SGMA). The rationale of monitoring network design and site selection is discussed in Chapter 4 – Monitoring Network.

Pursuant to §352.2 and §10727.2 of the SGMA Emergency Regulations [1], shown below, monitoring protocols for data collection and management must be adopted to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence, and surface water flow and quality. The monitoring protocols described in this document are informed by existing monitoring protocols, when possible, and are intended to provide practical guidance for field personnel in the collection and management of data.

§ 352.2: Monitoring Protocols
Each Plan shall include monitoring protocols adopted by the Agency for data collection and management, as follows:

- *(a) Monitoring protocols shall be developed according to best management practices.*
- *(b) The Agency may rely on monitoring protocols included as part of the best management practices developed by the Department or may adopt similar monitoring protocols that will yield comparable data.*
- *(c) Monitoring protocols shall be reviewed at least every five years as part of the periodic evaluation of the Plan and modified as necessary.*

§ 10727.2 Required Plan Elements

- *(f) Monitoring protocols that are designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin. The monitoring protocols shall be designed to generate information that promotes efficient and effective groundwater management.*

The establishment of monitoring protocols is closely related to other GSP sections. Subarticle 4 of the GSP Emergency Regulations requires the establishment of a monitoring network that includes monitoring objectives, monitoring protocols, and data reporting requirements. The protocols must allow for the monitoring network to collect ample data to establish seasonal, short-term, and long-term trends in groundwater levels, groundwater quality, inelastic surface subsidence, and surface water flow and quality. In addition, monitoring protocols ensure that the methods used in future data collection – in support of measuring the achievement of sustainability goals or undesirable results (e.g. MT, MO, IM, etc.) are consistent with the methods used to establish these metrics. The boundaries of Buena Vista GSA is shown in Figure 1.

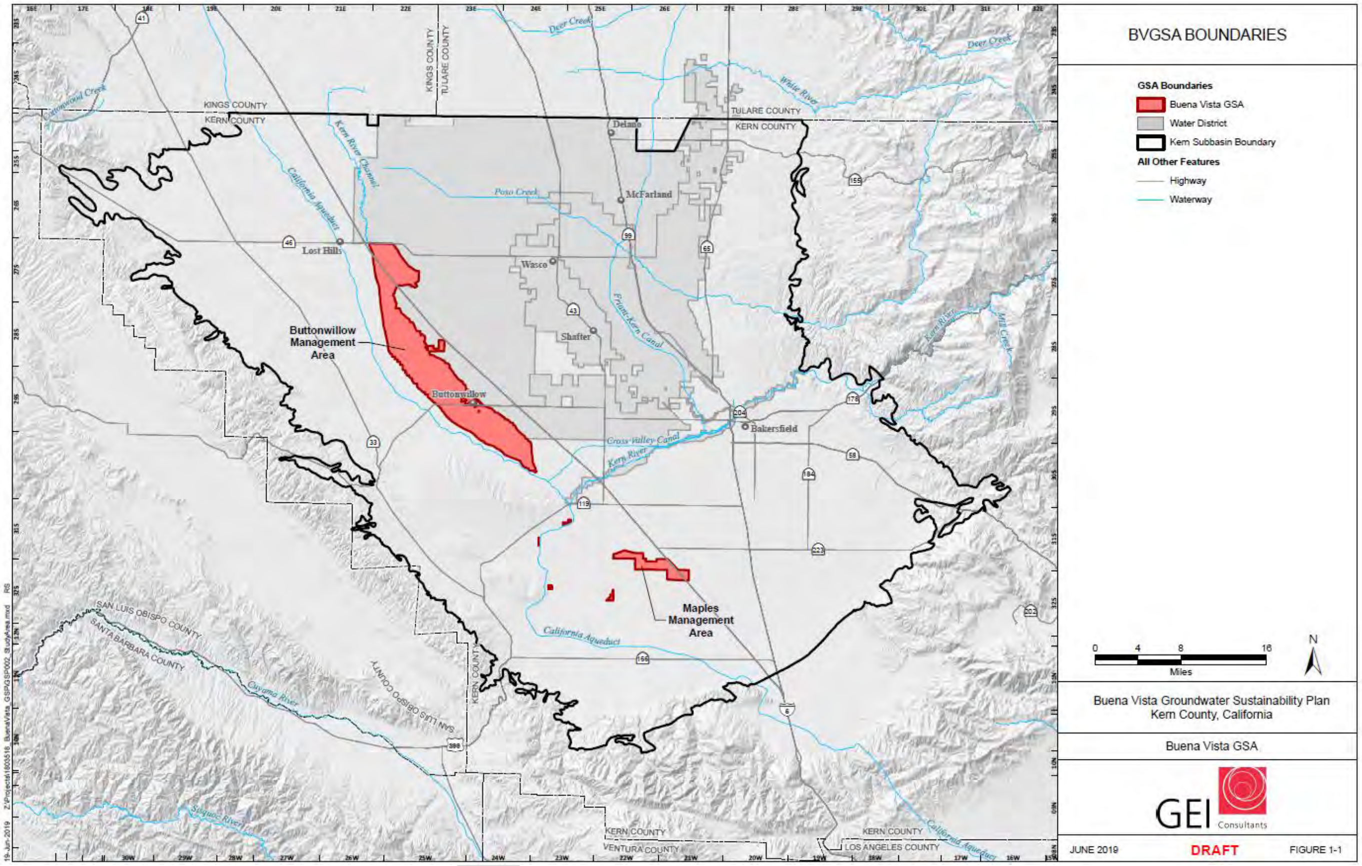


Figure 1. Buena Vista GSA Location

1.2 Goals and Objectives

The objectives of this monitoring protocol are to establish the purposes for monitoring groundwater, surface water, and subsidence with subbasins, and to set forth standard practices to be widely, and uniformly applied when collecting data from monitoring sites to provide a sound technical foundation for compliance with SGMA. This protocol provides necessary tools and procedures for any GSA to monitor groundwater and surface water conditions within their boundaries. The intent is that this protocol can also be applied throughout the Kern Suibbasin to form a standard approach to data collection that will provide uniform, reliable data in a format that can be easily consolidated and analyzed to assess groundwater, surface water, and subsidence conditions.

1.3 Description of Monitoring Protocol Structure

The DWR recommends that GSAs consider the adoption of existing monitoring protocols when possible. Section 2 – Existing Monitoring Protocol – provides information and background of existing monitoring protocols used by agencies in the Sacramento Valley for each of the following:

- Groundwater Level
- Water Quality
- Subsidence
- Streamflow

The adequacy of existing monitoring protocols will then be compared to the benchmarks established in DWR's *Monitoring Protocols, Standards, and Sites: Best Management Practices (BMP)*[2] document. Section 3 – Proposed Monitoring Protocol – provides field personnel with a practical guide to collect and manage groundwater level, water quality, subsidence, and streamflow data. This guide is adapted from existing monitoring protocols (Section 2) and then altered, as needed, to comply with the *BMP.*

The appendices to this protocol contain procedures or documents that are referenced in Sections 2 and 3.

2 Proposed Monitoring Protocol

This section provides a "how to" manual for field staff that emulates the content and format of DWR's *BMP* and is informed by applicable existing protocols discussed in Section 2 – Basin Setting of this GSP. Per the *BMP*, the collection of data should be based on the best available science and applied consistently across all basins to yield comparable data.

This section will explore the following:

- goals of the monitoring protocol;
- training requirements;
- data and reporting standards, and
- the proposed monitoring protocols for each data collection process.

If the proposed monitoring protocol presented in this document deviates from the *BMP*, an explanation of how the protocol will yield comparable data will be provided.

3.1 Goals of the Proposed Monitoring Protocol

The overarching goal of the proposed monitoring protocol is to provide agencies and field personnel with explicit instructions for the data collection, storage, and reporting of data to be included in GSPs. The adoption of these protocols allows for neighboring GSPs and, more broadly, GSPs statewide to have comparable data. The protocol will provide agencies the tools necessary to meet monitoring objectives described in the SGMA regulations. This includes the capture of data with a sufficient spatial distribution and temporal frequency to demonstrate short-term, seasonal, and long-term trends in basin conditions for each of the sustainability indicators.

3.1.1 Data Quality and Consistency

To be considered for inclusion in a GSP, data used to monitor sustainability indicators should be held to a quality standard. Quality data comes from a reputable source with known, documented methods of collection. The adoption of statewide and regional protocol allows for comparable data that is held to a similar quality standard.

This monitoring protocol also provides a template for consistent data collection for GSPs. If the quality of previous data collection is adequate, the same methods should be continued for future data collection to allow for accuracy in trend analysis. Where methods deviate, GSPs must be explicit in explaining the methods and potential data gaps.

3.1.2 Standardized Data and Reporting

The following data and reporting standards from §352.4 are relevant to the collection of monitoring data:

(1) Water volumes shall be reported in acre-feet.
(2) Surface water flow shall be reported in cubic feet per second and groundwater flow shall be reported in acre-feet per year.
(3) Field measurements of elevations of groundwater, surface water, and land surface shall be measured and reported in feet to an accuracy of at least 0.1 feet relative to NAVD88, or another national standard that is convertible to NAVD88, and the method of measurement described.
(4) Reference point elevations shall be measured and reported in feet to an accuracy of at least 0.5 feet, or the best available information, relative to NAVD88, or another national standard that is convertible to NAVD88, and the method of measurement described.
(5) Geographic locations shall be reported in GPS coordinates by latitude and longitude in decimal degree to five decimal places, to a minimum accuracy of 30 feet, relative to NAD83, or another national standard that is convertible to NAD83.

Pursuant to §352.4, all monitoring sites must include the following information:

(1) A unique site identification number and narrative description of the site location.
(2) A description of the type of monitoring, type of measurement taken, and monitoring frequency.
(3) Location, elevation of the ground surface, and identification and description of the reference point.
(4) A description of the standards used to install the monitoring site. Sites that do not conform to best management practices shall be identified and the nature of the divergence from best management practices described.

3.1.3 Data Management

Pursuant to §352.6, each agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the GSP and monitoring of the basin.

3.2 Training Requirements

Although not discussed in the *BMP*, the monitoring and data collection shall be completed by trained personnel working under the supervision of a Professional Civil Engineer, California Professional Geologist, or a Certified Hydrogeologist. The trained personnel must be familiar with SGMA requirements, the protocols described in this document, and the hydrology, geology, and geography of the locale in which their work is completed. The field personnel shall receive explicit written and verbal instruction from the Professional Civil Engineer, California Professional Geologist, or a Certified Hydrogeologist they are working under. This monitoring protocol and all field equipment instructions, equipment calibration instructions, safety manuals, and other reference documents discussed in this protocol must be available to all personnel that conduct monitoring or data collection activities. Any laboratory used for water quality analysis must be accredited by the California Environmental Laboratory Accreditation Program.

3.3 Proposed Protocols

The GSP Regulations require the use of the protocols discussed in the *BMP*, or the development of similar protocols. Where applicable, the technical protocols described in this proposed protocol are adopted in their entirety and reprinted from the *BMP*, which leverages existing professional standards that are often adopted in various groundwater-related programs. When the protocol deviates from the BMP, explanation for how the alteration or elaboration yields similar data will be provided. The protocol for the selection and maintenance of monitoring sites is described in Section 4 – Monitoring Network. All language that is taken directly from the *BMP is* shown in italics and any changes, additions, or edits are shown in standard font.

3.3.1 Groundwater Level: Proposed Protocol

The protocol for groundwater level monitoring described in the *BMP* is reprinted below.

Groundwater levels are a fundamental measure of the status of groundwater conditions within a basin. In many cases, relationships of the sustainability indicators may be able to be correlated with groundwater levels. The quality of this data must consider the specific aquifer being monitored and the methodology for collecting these levels.

The following considerations for groundwater level measuring protocols should ensure the following:

- *Groundwater level data are taken from the correct location, well ID, and screen interval depth;*
- *Groundwater level data are accurate and reproducible;*
- *Groundwater level data represent conditions that inform appropriate basin management DQOs;*
- *All salient information is recorded to correct, if necessary, and compare data, and*
- *Data are handled in a way that ensures data integrity.*

General Well Monitoring Information

The following presents considerations for collection of water level data that include regulatory required components as well as those which are recommended.

Groundwater elevation data will form the basis of basin-wide water-table and piezometric maps and should approximate conditions at a discrete period in time. Therefore, all *groundwater levels in a basin should be collected within as short a time as possible, preferably within a 1- to 2-week period.*

Depth to groundwater must be measured relative to an established Reference Point (RP) on the well casing. The RP is usually identified with a permanent marker, paint spot, or a notch in the lip of the well casing. By convention in open casing monitoring wells, the RP reference point is located on the north side of the well casing. If no mark is apparent, the person performing the measurement should measure the depth to groundwater from the north side of the top of the well casing.

The elevation of the RP of each well must be surveyed to the North American Vertical Datum of 1988 (NAVD88), or a local datum that can be converted to NAVD88. The elevation of the RP must be accurate to within 0.5 foot. It is preferable for the RP elevation to be accurate to 0.1 foot or less. Survey grade global navigation satellite system (GNSS) global positioning system (GPS) equipment can achieve similar vertical accuracy when corrected. Guidance for use of GPS can be found at USGS http://water.usgs.gov/osw/gps/. Hand-held GPS units likely will not produce reliable vertical elevation measurement accurate enough for the casing elevation consistent with the DQOs and regulatory requirements.

The sampler should remove the appropriate cap, lid, or plug that covers the monitoring access point listening for pressure release. If a release is observed, the measurement should follow a period of time to allow the water level to equilibrate.

Depth to groundwater must be measured to an accuracy of 0.1 foot below the RP. It is preferable to measure depth to groundwater to an accuracy of 0.01 foot. Air lines and acoustic sounders may not provide the required accuracy of 0.1 foot.

The water level meter should be decontaminated after measuring each well.

Measuring Groundwater Levels

Measure depth to water in the well using procedures appropriate for the measuring device. Equipment must be operated and maintained in accordance with manufacturer's instructions. Groundwater levels should be measured to the nearest 0.01 foot relative to the RP.

For measuring wells that are under pressure, allow a period of time for the groundwater levels to stabilize. In these cases, multiple measurements should be collected to ensure the well has reached equilibrium such that no significant changes in water level are observed. Every effort should be made to ensure that a representative stable depth to groundwater is recorded. If a well does not stabilize, the quality of the value should be appropriately qualified as a questionable measurement. In the event that a well is artesian, site specific procedures should be developed to collect accurate information and be protective of safety conditions associated with a pressurized well. In many cases, an extension pipe may be adequate to stabilize head in *the well. Record the dimension of the extension and document measurements and configuration.*

The sampler should calculate the groundwater elevation as:

$$GWE = RPE - DTW$$

Where:

- *GWE = Groundwater Elevation*
- *RPE = Reference Point Elevation*
- *DTW = Depth to Water*

The sampler must ensure that all measurements are in consistent units of feet, tenths of feet, and hundredths of feet. Measurements and RPEs should not be recorded in feet and inches.

Recording Groundwater Levels

The sampler should record the well identifier, date, time (24-hour format), RPE, height of RP above or below ground surface, DTW, GWE, and comments regarding any factors that may influence the depth to water readings such as weather, nearby irrigation, flooding, potential for tidal influence, or well condition. If there is a questionable measurement or the measurement cannot be obtained, it should be noted.

The sampler should replace any well caps or plugs, and lock any well buildings or covers.

All data should be entered into the data management system (DMS) as soon as possible. Care should be taken to avoid data entry mistakes and the entries should be checked by a second person for compliance.

Pressure Transducers

Groundwater levels and/or calculated groundwater elevations may be recorded using pressure transducers equipped with data loggers installed in monitoring wells. When installing pressure transducers, care must be exercised to ensure that the data recorded by the transducers is confirmed with hand measurements.

The following general protocols must be followed when installing a pressure transducer in a monitoring well:

- *The sampler must use an electronic sounder or chalked steel tape and follow the protocols listed above to measure the groundwater level and calculate the groundwater elevation in the monitoring well to properly program and reference the installation. It is recommended that transducers record measured groundwater level to conserve data capacity; groundwater elevations can be calculated at a later time after downloading.*

- *The sampler must note the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and cable serial number.*
- *Transducers must be able to record groundwater levels with an accuracy of at least 0.1 foot. Professional judgment should be exercised to ensure that the data being collected is meeting the DQO and that the instrument is capable. Consideration of the battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers should be included in the evaluation.*
- *The sampler must note whether the pressure transducer uses a vented or nonvented cable for barometric compensation. Vented cables are preferred, but nonvented units provide accurate data if properly corrected for natural barometric pressure changes. This requires the consistent logging of barometric pressures to coincide with measurement intervals.*
- *Follow manufacturer specifications for installation, calibration, data logging intervals, battery life, correction procedure (if non-vented cables used), and anticipated life expectancy to assure that DQOs are being met for the GSP.*
- *Secure the cable to the well head with a well dock or another reliable method. Mark the cable at the elevation of the reference point with tape or an indelible marker. This will allow estimates of future cable slippage.*
- *The transducer data should periodically be checked against hand measured groundwater levels to monitor electronic drift or cable movement. This should happen during routine site visits, at least annually or as necessary to maintain data integrity.*
- *The data should be downloaded as necessary to ensure no data is lost and entered into the basin's DMS following the QA/QC program established for the GSP. Data collected with non-vented data logger cables should be corrected for atmospheric barometric pressure changes, as appropriate. After the sampler is confident that the transducer data have been safely downloaded and stored, the data should be deleted from the data logger to ensure that adequate data logger memory remains.*

3.3.2 Groundwater Quality: Proposed Protocol

The protocol for groundwater quality monitoring described in the *BMP* is reprinted below.

All analyses should be performed by a laboratory certified under the State Environmental Laboratory Accreditation Program. The specific analytical methods are beyond the scope of this BMP but should be commensurate with other programs evaluating water quality within the basin for comparative purposes.

The following points are general guidance in addition to the techniques presented in the previously mentioned USGS National Field Manual for the Collection of Water Quality Data.

Standardized protocols include the following:

- *Prior to sampling, the sampler must contact the laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.*
- *Each well used for groundwater quality monitoring must have a unique identifier. This identifier must appear on the well housing or the well casing to avoid confusion.*
- *In the case of wells with dedicated pumps, samples should be collected at or near the wellhead. Samples should not be collected from storage tanks, at the end of long pipe runs, or after any water treatment.*
- *The sampler should clean the sampling port and/or sampling equipment and the sampling port and/or sampling equipment must be free of any contaminants. The sampler must decontaminate sampling equipment between sampling locations or wells to avoid cross-contamination between samples.*
- *The groundwater elevation in the well should be measured following appropriate protocols described above in the groundwater level measuring protocols.*
- *For any well not equipped with low-flow or passive sampling equipment, an adequate volume of water should be purged from the well to ensure that the groundwater sample is representative of ambient groundwater and not stagnant water in the well casing. Purging three well casing volumes is generally considered adequate. Professional judgment should be used to determine the proper configuration of the sampling equipment with respect to well construction such that a representative ambient groundwater sample is collected. If pumping causes a well to be evacuated (go dry), document the condition and allow well to recover to within 90% of original level prior to sampling. Professional judgment should be exercised as to whether the sample will meet the DQOs and adjusted as necessary.*
- *Field parameters of pH, electrical conductivity, and temperature should be collected for each sample. Field parameters should be evaluated during the purging of the well and should stabilize prior to sampling. Measurements of pH should only be measured in the field, lab pH analysis are typically unachievable due to short hold times. Other parameters, such as oxidation-reduction potential (ORP), dissolved oxygen (DO) (in situ measurements preferable), or turbidity, may also be useful for meeting DQOs of GSP and assessing purge conditions. All field instruments should be calibrated daily and evaluated for drift throughout the day.*
- *Sample containers should be labeled prior to sample collection. The sample label must include: sample ID (often well ID), sample date and time, sample personnel, sample location, preservative used, and analytes and analytical method.*
- *Samples should be collected under laminar flow conditions. This may require reducing pumping rates prior to sample collection.*
- *Samples should be collected according to appropriate standards such as those listed in the Standard Methods for the Examination of Water and Wastewater, USGS National Field Manual for the Collection of Water Quality Data, or other appropriate guidance. The specific sample collection procedure should reflect the type of analysis to be performed and DQOs.*

- *All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. Ensure that samples are appropriately filtered as recommended for the specific analyte. Entrained solids can be dissolved by preservative leading to inconsistent results of dissolve analytes. Specifically, samples to be analyzed for metals should be field-filtered prior to preservation; do not collect an unfiltered sample in a preserved container.*
- *Samples should be chilled and maintained at 4 °C to prevent degradation of the sample. The laboratory's Quality Assurance Management Plan should detail appropriate chilling and shipping requirements.*
- *Samples must be shipped under chain of custody documentation to the appropriate laboratory promptly to avoid violating holding time restrictions.*
- *Instruct the laboratory to use reporting limits that are equal to or less than the applicable DQOs or regional water quality objectives/screening levels.*

Special protocols for low-flow sampling equipment:

- *In addition to the protocols listed above, sampling using low-flow sample equipment should adopt the following protocols derived from EPA's Low-flow (minimal drawdown) ground-water sampling procedures (Puls and Barcelona, 1996). These protocols apply to low-flow sampling equipment that generally pumps between 0.1 and 0.5 liters per minute. These protocols are not intended for bailers.*

Special protocols for passive sampling equipment:

- *In addition to the protocols listed above, passive diffusion samplers should follow protocols set forth in USGS Fact Sheet 088-00.*

3.3.3 Subsidence: Proposed Protocol

The protocol for subsidence monitoring described in the BMP is reprinted below.

Evaluating and monitoring inelastic land subsidence can utilize multiple data sources to evaluate the specific conditions and associated causes. To the extent possible, the use of existing data should be utilized. Subsidence can be estimated from numerous techniques, they include: level surveying tied to known stable benchmarks or benchmarks located outside the area being studied for possible subsidence; installing and tracking changes in borehole extensometers; obtaining data from continuous GPS (CGPS) locations, static GPS surveys or Real-Time-Kinematic (RTK) surveys; or analyzing Interferometric Synthetic Aperture Radar (InSAR) data. No standard procedures exist for collecting data from the potential subsidence monitoring approaches. However, an approach may include:

- *Identification of land subsidence conditions.*
  - *Evaluate existing regional long-term leveling surveys of regional infrastructure, i.e. roadways, railroads, canals, and levees.*

  - *Inspect existing county and State well records where collapse has been noted for well repairs or replacement.*
  - *Determine if significant fine-grained layers are present such that the potential for collapse of the units could occur should there be significant depressurization of the aquifer system.*
  - *Inspect geologic logs and the hydrogeologic conceptual model to aid in identification of specific units of concern.*
  - *Collect regional remote-sensing information such as InSAR, commonly provided by USGS and NASA. Data availability is currently limited, but future resources are being developed.*
- *Monitor regions of suspected subsidence where potential exists.*
  - *Establish CGPS network to evaluate changes in land surface elevation.*
  - *Establish leveling surveys transects to observe changes in land surface elevation.*
  - *Establish extensometer network to observe land subsidence. An example of a typical extensometer design is illustrated in Figure 7. There are a variety of extensometer designs and they should be selected based on the specific DQOs.*

Various standards and guidance documents for collecting data include:

- *Leveling surveys must follow surveying standards set out in the California Department of Transportation's Caltrans Surveys Manual.*
- *GPS surveys must follow surveying standards set out in the California Department of Transportation's Caltrans Surveys Manual.*
- *USGS has been performing subsidence surveys within several areas of California. These studies are sound examples for appropriate methods and should be utilized to the extent possible and where available:*
  - *http://ca.water.usgs.gov/land_subsidence/california-subsidence-measuring.html*
- *Instruments installed in borehole extensometers must follow the manufacturer's instructions for installation, care, and calibration.*
- *Availability of InSAR data is improving and will increase as programs are developed. This method requires expertise in analysis of the raw data and will likely be made available as an interpretative report for specific regions.*

3.3.4 Streamflow: Proposed Protocol

The protocol for streamflow monitoring described in the BMP is reprinted below.

Monitoring of streamflow is necessary for incorporation into water budget analysis and for use in evaluation of stream depletions associated with groundwater extractions. The use of existing monitoring locations should be incorporated to the greatest extent possible. Many of these streamflow monitoring locations currently follow the protocol described below.

Establishment of new streamflow discharge sites should consider the existing network and the objectives of the new location. Professional judgment should be used to determine the appropriate permitting that may be necessary for the installation of any monitoring locations along surface water bodies. Regular frequent access will be necessary to these sites for the development of ratings curves and maintenance of equipment.

To establish a new streamflow monitoring station special consideration must be made in the field to select an appropriate location for measuring discharge. Once a site is selected, development of a relationship of stream stage to discharge will be necessary to provide continuous estimates of streamflow. Several measurements of discharge at a variety of stream stages will be necessary to develop the ratings curve correlating stage to discharge. The use of Acoustic Doppler Current Profilers (ADCPs) can provide accurate estimates of discharge in the correct settings. Professional judgment must be exercised to determine the appropriate methodology. Following development of the ratings curve a simple stilling well and pressure transducer with data logger can be used to evaluate stage on a frequent basis.

Streamflow measurements should be collected, analyzed, and reported in accordance with the procedures outlined in USGS Water Supply Paper 2175 [3], Volume 1. – Measurement of Stage Discharge and Volume 2. – Computation of Discharge. This methodology is currently being used by both the USGS and DWR for existing streamflow monitoring throughout the Stat

3 References

[1] California Department of Water Resources, May 2016. Sustainable Groundwater Management Act: GSP Emergency Regulations, https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf

[2] California Department of Water Resources, December 2016. Best Management Practices for the Sustainable Management of Groundwater: Monitoring Protocols, Standards, and Sites, https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Monitoring_Protocols_Final_2016-12-23.pdf

[3] United States Geological Survey, 2013. Water Supply Paper 2175, https://pubs.usgs.gov/wsp/wsp2175

Appendix D

Closure Term for BVGSA Water Budget

Closure Terms for Buena Vista GSA Water Budget

This memo provides the methods used to quantify the inflows, outflows, and change in storage associated with the water budget created to comply with Sustainable Groundwater Management Act (SGMA) regulations (§ 354.18 Water Budget).

The water budget includes 19 years of data [1995-2014], which corresponds with the period where both ITRC evapotranspiration data and C2VSim groundwater model outputs were available. Source data for the analysis includes the following: evapotranspiration (ET) from the Irrigation Training and Research Center (ITRC), Buena Vista WSD Historical Water Budgets and Water Distribution Summaries, census data, and California Irrigation Management Information System (CIMIS) weather data. The report *The Geology and Groundwater Hydrology of the Buena Vista Water Storage District, Buttonwillow, CA* (Sierra Scientific, 2013) and draft output from the Todd Groundwater C2VSim modeling of the Kern County Subbasin (Todd Groundwater, 2019) were also used as references and checks.

Per SGMA regulations, water budgets were created for both the GSA boundaries and the underlying groundwater aquifer. All inputs for the budget were taken from the sources noted above, except for the following three variables: subsurface flux, change in storage, and unmeasured groundwater pumping. The methods described in the following sections are intended to infer these variables.

Unmeasured Groundwater Pumping

Unmeasured groundwater pumping was used as the closure term to solve a mass balance, equating demands within the Buttonwillow Management Area (BMA) to the supply. This mass balance assumes that all inflows (surface water, groundwater pumping, precipitation) meet demands (ET, deep percolation, losses), an assumption that implies negligible long-term change in storage. Using this method, pumping from historically unmeasured landowner wells over the period from 1993 through 2015 is estimated to average 47,480 AF per year. Table 1 summarizes the annual estimates of landowner pumping by water year type.

Table 1. Unmeasured groundwater pumping (closure term) by water year type

	Wet	Above Normal	Below Normal	Dry	Critically Dry
# of Water Years	8	3	2	4	6
Unmeasured Groundwater Pumping (AF)	46,362	31,536	46,166	55,131	52,276
Measured Groundwater Pumping (AF)	15,261	16,966	16,330	17,926	12,285

With the uncertainty of landowner pumping diminished, only two variables remain: change in storage and subsurface flux. Given the two remaining variables, it was necessary to use estimates of one to solve for the other as the closure term of the water budget. Due to the uncertainty associated with both variables, the water budget equation was expressed in two ways, one solving for each variable allowing the results of the two equations to be compared:

1. Close on subsurface flux, and
2. Close on change in storage.

Equation 1 was drawn from the *Water Budget BMP* (DWR, 2016) and was configured to solve for the two closure terms described above.

Eq 1. Inflow (a, b, c) – Outflow (a, b, c) = Change in Storage

Close on Subsurface Flux

To close on subsurface flux, annual changes in storage were estimated based on analysis of annual changes in water elevations from District Monitoring Wells (DMWs). Fall groundwater elevations from 1995 through 2014 for nine DMWs were used to create groundwater surfaces for each of these years with these surfaces being used to estimate volumes between the surfaces for consecutive years. A specific yield of 0.15 was applied to these volumes to determine the annual change in groundwater storage. The process was completed for each year; an example is shown below in Figure 1 for 1995.

	1	2	4	5	6	7	8	10a	12b
Fall 1994 (ft AMSL)	214	171	234	233	223	208	188	139	125
Fall 1995 (ft AMSL)	217	191	233	239	232	218	197	151	132
1995 Δ	3	20	-1	5	9	10	9	12	7
Average Δ:		8	feet						
Acres (BSA):		46,200	acres						
Total Volume		378,840	acre-feet						
Specific Yield: High		0.15							
Δ Storage: High		**56,826**	**acre-feet**						

Figure 1. Annual change in storage calculation [1995]

Using known variables, including estimates for annual change in storage from the method used in Figure 1, Equation 1 was configured to solve for annual subsurface flux. Table 2 provides a summary of the resulting annual subsurface fluxes, which are compared to the values found in the Todd groundwater model and in the Sierra Scientific report referenced earlier. The cumulative totals and averages at the bottom of Table 2 span two ranges (1995 through 2014 and 1995 through 2011) to account for the influence of the recent drought on groundwater conditions.

Table 2. Net Subsurface Flux

	GEI	Todd GW Model	Sierra Scientific
1995	(5,449)	(75,981)	(32,364)
1996	(5,226)	(65,329)	(32,364)
1997	636	(68,939)	(32,364)
1998	(22,835)	(73,279)	(32,364)
1999	11,552	(39,992)	(32,364)
2000	(30,029)	(19,811)	(32,364)
2001	31,258	(15,408)	(32,364)
2002	(7,828)	(9,289)	(32,364)
2003	(7,714)	(5,362)	(32,364)
2004	(20,191)	(2,598)	(32,364)
2005	44,044	(17,192)	(32,364)
2006	1,075	(24,574)	(32,364)
2007	(39,935)	(4,940)	(32,364)
2008	(82,443)	5,493	(32,364)
2009	(10,578)	1,598	(32,364)
2010	5,388	(22,553)	(32,364)
2011	(65,097)	(47,420)	(32,364)
2012	10,626	(18,922)	(32,364)
2013	35,782	15,709	(32,364)
2014	(6,051)	31,474	(32,364)
total [1995-2011]	(203,371)	(485,576)	(550,188)
total [1995-2014]	(163,014)	(457,316)	(647,280)
avg [1995-2011]	(11,963)	(28,563)	(32,364)
avg [1995 - 2014]	(8,151)	(22,866)	(32,364)
maximum [1995 – 2014]	44,044	31,474	
minimum [1995 – 2014]	(82,443)	(75,981)	
Difference [1995 – 2014]	126,487	107,455	
standard deviation [1995 – 2014]	30,721	30,233	
****** Assumes specific yield of 0.15***			

Table 3 is a summary of the closure values computed using Equation 1 formulated to close on subsurface flux.

Table 3. Summary of subsurface flux

	Subsurface Flux [AF]
total [1995 - 2011]	(203,371)
total [1995 - 2014]	(163,014)
avg [1995-2011]	(11,963)
avg [1995-2014]	(8,151)

Figures 2 and 3 provide the average annual flow paths for inflows (blue) and outflows (red) for the two date ranges, respectively: 1995 through 2014 and 1995 through 2011. Likewise, the orange flow path represents average annual subsurface flux for the two date ranges.

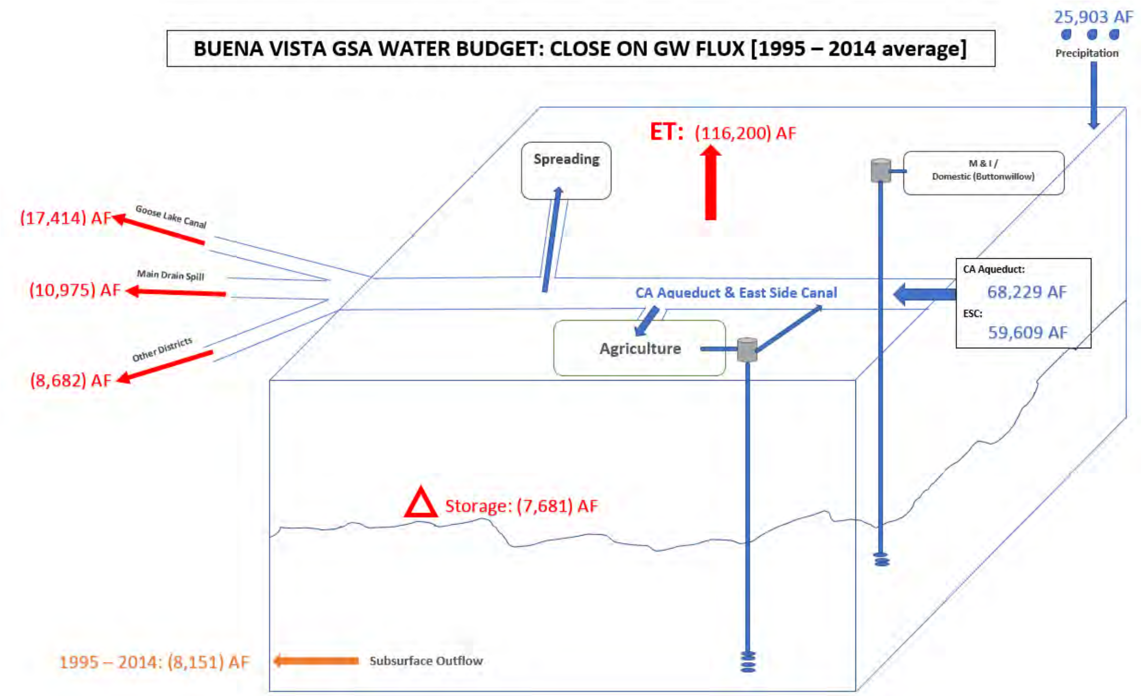


Figure 2. Water budget flow paths: average annual closure on subsurface flux [1995 – 2014]

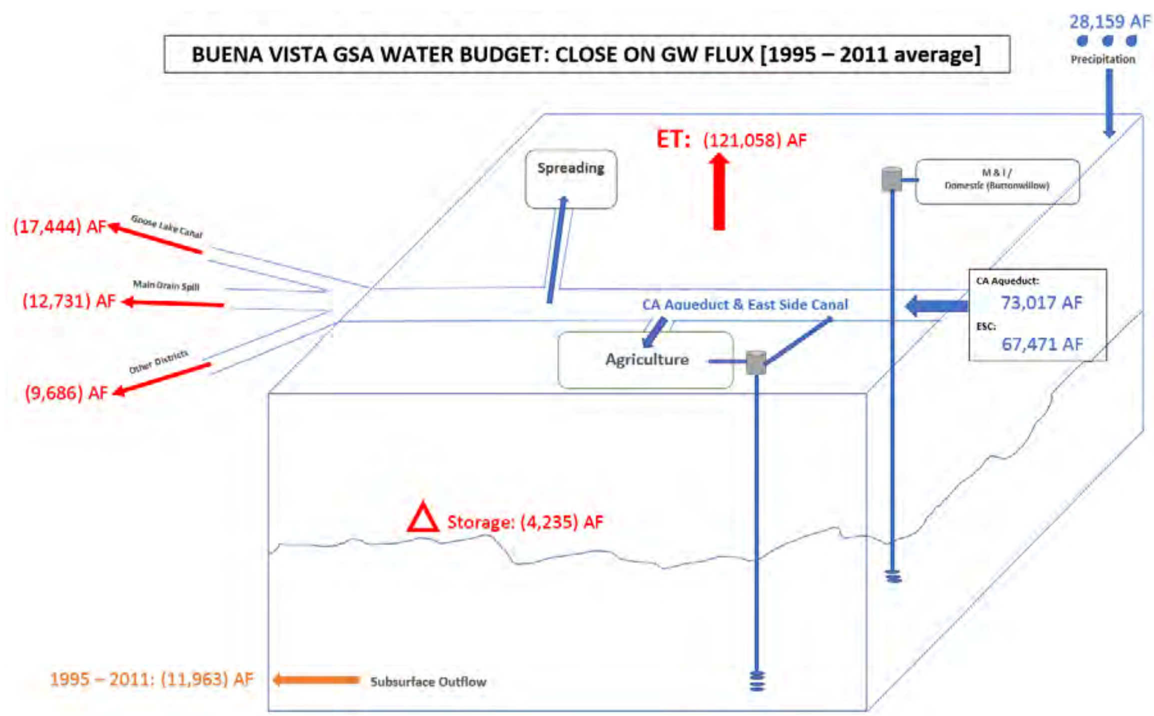


Figure 3. Water budget flow paths: average annual closure on subsurface flux [1995 – 2011]

Close on Change in Storage

To close on change in storage, annual subsurface flux must be estimated. Two methods were employed to estimate these values:

1. Sierra Scientific Method: This approach is drawn from the Sierra Scientific report referenced above. This report estimates an average annual net subsurface outflux of 32,364 AF, as shown in the calculation shown in Figure 4.

	Sierra Scientific Calculation:		
	Observed Average Annual Groundwater Storage Change (1974 - 2013)[1]	+4,600	AF / year
(-)	Average Annual Net Contribution to Groundwater Storage (1970 - 2007)[2]	+36,964	AF / year
	Average Annual Groundwater Flux	**(32,364)**	**AF / year**
	[1] based on 19 water level hydographs and specific yield of 0.15		
	[2] based on District Water Balance (Yearly Water Balance Column)		

Figure 4. Estimate of Subsurface Outflow (Sierra Scientific, 2013)

2. Modified Sierra Scientific Method. This method uses the structure presented by Sierra Scientific but applies updated inputs from the BVGSA Water Budget for 1995 through 2014 to account for recent cropping patterns and current irrigation practices. This modified approach estimates an average net groundwater outflow of 14,293 AF per year as illustrated in Figure 5.

	GEI Calculation:		
	Obsreved Average Annual Groundwater Storage Change (1995 - 2014)[1]	(7,681)	AF / year
(-)	Net Average Annual contribution to Groundwater Storage (1995-2014)[2]	6,612	AF / year
	Average Annual Subsurface Flux	**(14,293)**	**AF / year**
	[1] based on DMW water level hydographs and specific yield of 0.15		
	[2] based on BVGSA Water Buget (total deep percolation - total groundwater pumping)		

Figure 5. Modified Estimate of Subsurface Flux

Using estimates for subsurface flux from both methods described above, the water budget equation shown in Figure 1 was used to solve for change in storage. Table 4 provides a summary of the resulting annual change in storage using both methods of estimating subsurface flux and compares these values with output from the Todd groundwater model.

Table 4. Estimated Annual Change in Storage

Year	**GEI**	**Sierra Scientific**	**Todd Groundwater**
1995	47,982	29,911	92,768
1996	14,418	(3,653)	1,422
1997	18,258	187	49,727
1998	40,882	22,811	71,759
1999	(10,984)	(29,055)	(60,059)
2000	(20,608)	(38,679)	(55,232)
2001	(57,563)	(75,634)	(54,122)
2002	(53,358)	(71,429)	(55,846)
2003	(23,673)	(41,744)	(22,799)
2004	(48,387)	(66,458)	(35,560)
2005	(2,204)	(20,275)	79,728
2006	15,971	(2,100)	24,019
2007	(48,971)	(67,042)	(68,454)
2008	(45,733)	(63,804)	(82,864)
2009	(35,439)	(53,510)	(53,912)
2010	29,907	11,836	21,401
2011	67,898	49,827	142,652
2012	(11,059)	(29,130)	(81,522)
2013	(86,342)	(104,413)	(134,371)
2014	(67,455)	(85,526)	(125,978)
total [1995-2011]	(111,605)	(418,812)	(5,370)
total [1995-2014]	(276,461)	(637,881)	(347,240)
avg [1995-2011]	(6,565)	(24,636)	(316)
avg [1995 - 2014]	(13,823)	(31,894)	(17,362)
maximum [1995 – 2014]	76,898	49,842	142,652
minimum [1995 -2014]	(86,342)	(104,413)	(134,371)
difference [1995 – 2014]	154,240	154,240	277,023
standard deviation [1995 – 2014]	42,262	42,264	75,206

The cumulative totals and averages at the bottom of Table 4 span varying year ranges to allow for comparisons across the data sets:

Table 5 is a summary of the average annual change in groundwater storage determined by the GEI developed “close on groundwater storage” method which is the average over the period from 1995 through 2014.

Table 5. Summary of Change in Groundwater Storage

	GEI Estimate Δ Storage
total [1995 - 2011]	(111,605)
total [1995 - 2014]	(276,461)
avg [1995-2011]	(6,565)
avg [1995-2014]	(13,823)

Figure 6 and 7 provide the average annual flow paths for inflows (blue) and outflows (red) for two date ranges, respectively: 1995 through 2014 and 1995 through 2011. The orange flow path represents average annual subsurface outflow for the two date ranges.

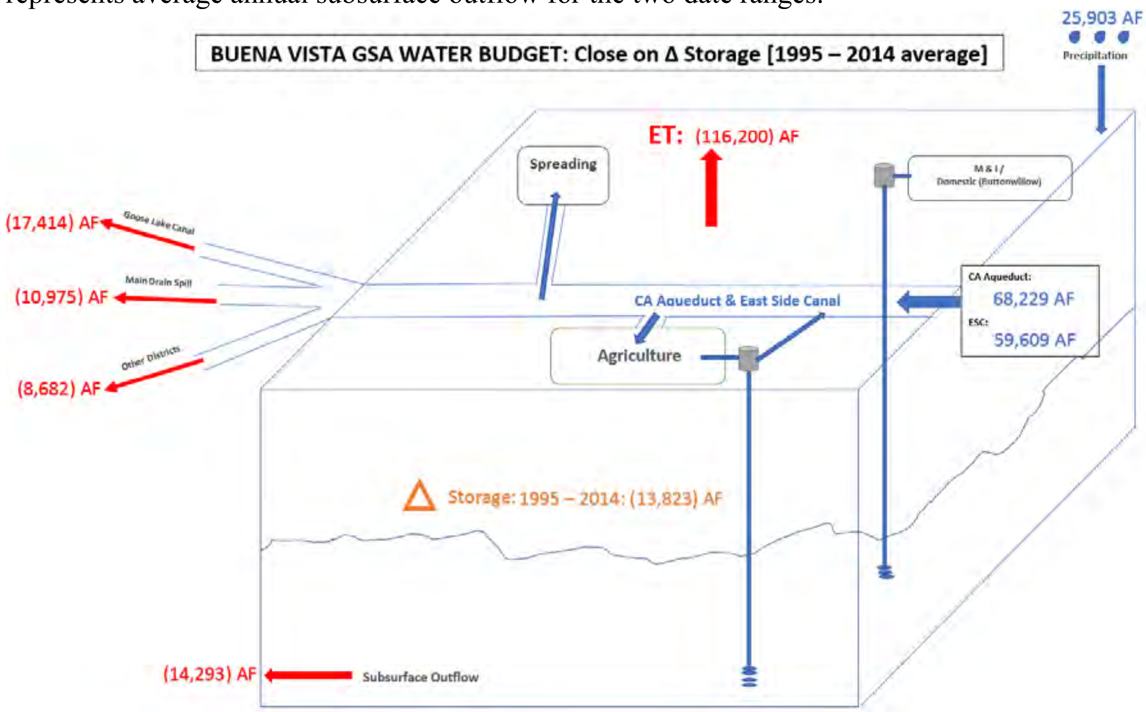


Figure 6. Water budget flow paths: close on change in storage [1995 – 2014 average]

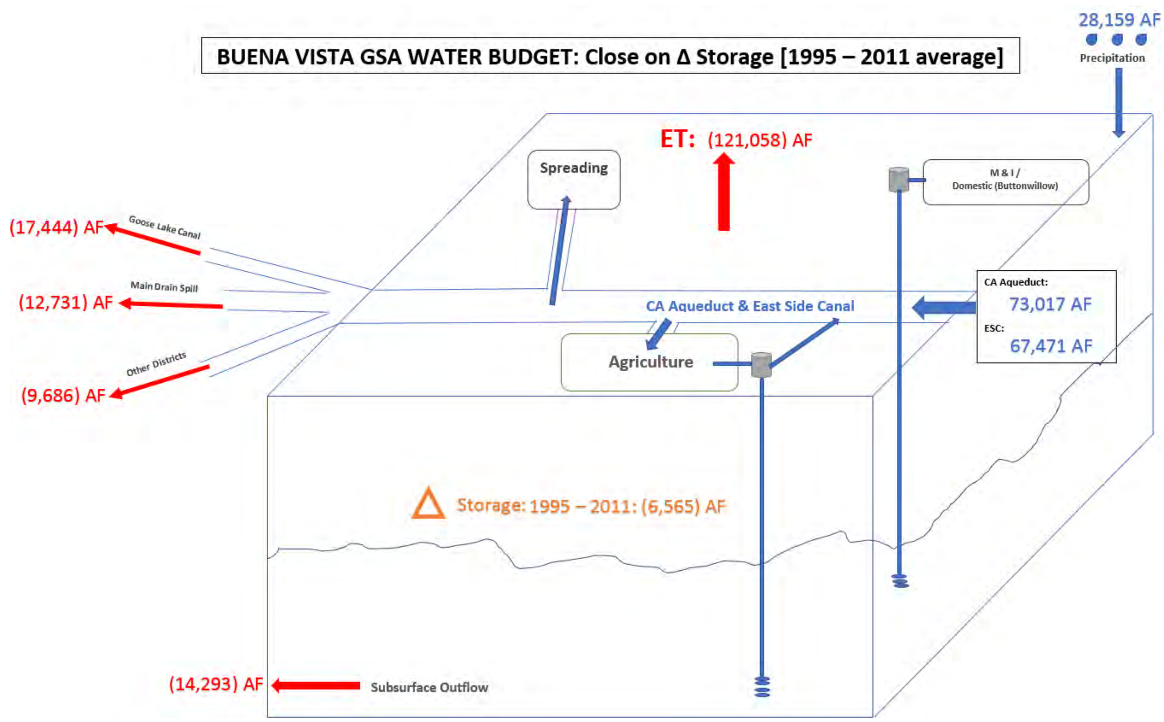


Figure 7. Water budget flow paths: close on change in storage [1995 – 2011 average]

Comparison of Methods

Table 6 compares the two methods by summarizing the average annual landowner pumping, average annual subsurface flux, and average annual change in storage for 1995 through 2015.

Table 6. Method comparison: average annual volumes [1995 through 2014]

	Method	
	Close on Flux [AF]	Close on Δ Storage [AF]
Subsurface Flux	(8,151)	(14,293)
Δ Storage	(7,681)	(13,823)

Table 7. Method comparison: average annual volumes [1995 through 2011]

	Method	
	Close on Flux [AF]	Close on Δ Storage [AF]
Subsurface Flux	(11,963)	(14,293)
Δ Storage	(4,235)	(6,565)

Conclusions and Recommendation

The results shown in Table 6 and Table 7 illustrate that both closure methods yield similar subsurface flux and change in storage values for the respective date ranges of 1995 – 2014 and 1995 – 2011. It should be noted that both subsurface flux and change in storage averages are less negative when 1995 – 2011 data is used when compared to 1995 – 2015 data, likely due to drought conditions that lowered groundwater elevations and altered gradients. For both date ranges, the method of closing on change in storage yields subsurface flux and change in storage values that are more negative than the method of closing on subsurface flux.

It is recommended that the BVGSA water budget close on subsurface flux, using source data from 1995 – 2011 to assume the change in storage (as explained in Figure 1). This recommendation results in a change in storage closest to zero, which is what historical pre-drought groundwater elevation data suggests are the actual conditions. The subsurface flux is estimated to be approximately (12,000) AF, which is less water leaving BVGSA than the Sierra Scientific estimate concluded. The discrepancy can be explained by the GEI estimate using more current input data, which reflect changes in cropping patterns and irrigation techniques. Table 8 summarizes the recommendation.

Table 8. Recommendation for closure method [1995 through 2011]

	Close on Flux [AF]
Subsurface Flux	(11,963)
Δ Storage	(4,235)

Appendix E

Water District Summaries

Appendix E. Water District Summaries

Water District Summaries are provided for 2010, 2011, and 2012 as examples. Summaries for additional water budget years are available upon request.

DISTRIBUTION INPUTS **SUPPLIES** Inputs **2010** 5/1/2014

SECOND POINT SUPPLY (Including Deliveries Via Buena Vista Canal) **Units in Acre Feet**

Via / To / DAY	1st Pt KR	1st Pt 2nd Pt (KD) KR	1st Pt FK CANAL FK-X	1st Pt 2800 KR-X	1st Pt 2800 WELL	1st Pt Spill KR	HWD DUE @2ndPt KR	HWD @2nd Pt KR	HWD FK	HWD WELLS	BVWSD DUE @2ndPt KR	BVWSD @2ndPt KR	BVWSD FK CANAL @2ndPt FK-X	BVWSD 2800 @2ndPt WELLS	TOTAL SUPPLY At 2nd Point KR	FK	WELL	STATE	TOTAL SUPPLY
JAN					5534									99			5633		5633
FEB					845									135			980		980
MAR					2218						1022	1022		502	1022		2720		3742
APR					1922						9215	9215		875	9215		2797		12012
MAY					1502						23514	23514		17	23514		1519		25033
JUN		2000									38609	38609			40609				40609
JUL											10764	10764			10764				10764
AUG											16201	16201			16201				16201
SEP																			
OCT																			
NOV																			
DEC						3703					3876	3876			7579				7579
AF		2000			12021	3703					103201	103201		1628	108904		13649		122553

Note : January 2010 - Part of Olcese Wells in the first part of the year were billed to users up North during Advanced 2010 Pre-Irrigation.

Note: June 2010 - KDWSD sold WKWD 2,000 AF that went into Kern River Pipeline for West Kern spreading in the KWB Spreading Ponds.

DISTRIBUTION INPUTS (MISC SUPPIES)

5/1/2014

2010

MISC WATER - WELLS & RECLAMATION PUMPS Below 2nd Pt.

Units in Acre Feet

DAY Via DAY	HMWD BVARA WELLS	BV LAKE AREA WELLS	BV LAKE AREA RECL	DISTRICT GROWER Maples WELLS	Maples RECL	BVWSD BW WELLS	BVWSD BW RECL	GROWER BW WELLS	GROWER BW RECL	TOTAL SUPPLY Below 2nd Pt KR	WELL	STATE	RECL	TOTAL
JAN	1701					44			267		1745		267	2012
FEB	748					232	575		399		980		974	1954
MAR	371					119			189		490		189	679
APR						109			452		109		452	561
MAY	793						195		446		793		641	1434
JUN						99	2102		557		99		2659	2758
JUL						79	2741		1099		79		3840	3919
AUG							2876		1150				4026	4026
SEP									190				190	190
OCT														
NOV														
DEC	369		1144								369		1144	1513
AF	3982		1144			682	8489		4749		4664		14382	19046

DISTRIBUTION INPUTS (STO)

STO

5/1/2014

2010

STATE TURNOUTS

Units in Acre Feet

DAY	SUPPLY BV 1B STATE	WELL	KR-X	BR REC	BV 6 STATE	KR-X	BV 2 STATE	KR-X	BV 7 STATE	KR-X	BV 3 STATE	KR-X	BV 5 STATE	KR-X	BV 4 STATE	KR-X	BV 5 TO BV LAKE STATE	KR-X	SEMITROPIC STATE	KR-X	BR REC	TOTAL STATE	WELL	KR-X	BR REC
JAN				1204																					1204
FEB		920		1807									512									512	920		1807
MAR				67																					67
APR			248	70		393		432																1073	70
MAY			341	290		1345		2200				1132												5018	290
JUN			737			4448	27	5162		165	2588	134	2691		1900							7206		10646	
JUL			1142			6438	50	5231		18318	4505		1334		1455							7344		31129	
AUG			217	1319		3893	13	5409		10903	2553		1664		2119							6349		20422	1319
SEP				4988							390		38		196							624			4988
OCT	56			4760																		56			4760
NOV	316			4663							1367		353		467							2503			4663
DEC	99			2597			93				2731		1405		1838							6166			2597
AF	471	920	2685	21765		16517	183	18434		29386	14134	1266	7997		7975							30760	920	68288	21765

Note: December 2010 water in BV#2 is for West Kern for spreading in their Northern Project Area.

DATA SHEET - DISTRIBUTION - SECOND POINT(WD1)

WD1

5/1/2014

2010

Units in Acre Feet

DAY	SUPPLY SECOND POINT				TOTAL FLOW	DIVERSIONS ALEJ CANAL			KR OUTLET WEIR			KWB - MAIN CANAL			INLET WEIR			INTERTIE			KWBA SPREADING ALEJ & MAIN			BVWSD SPREADING MAIN.BYPASS & RIVER			LOSSES TRANSPORTATION LOSSES		
	KR	FK	WELL	S-X		KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL
JAN			5633		5633									5631															2
FEB			980		980									976															4
MAR	1022		2720		3742	855		52				167		2663															5
APR	9215		2797		12012	5730						3485		2797															
MAY	23514		1519		25033	16618						3066		1519										3830					
JUN	40609				40609	24541						8663									2000			5405					
JUL	10764				10764	5341						609												4814					
AUG	16201				16201	9505						2739												3957					
SEP																													
OCT																													
NOV																													
DEC	7579				7579	3265			1831															2483					
AF	108904		13649		122553	65855		52	1831			18729		13586							2000			20489					11

NOTE:

DATA SHEET - DISTRIBUTION - BVARA (WD2A)

WD2A

5/1/2014

2010

Units in Acre Feet

DAY	SUPPLY: ALEJ CANAL, BV #3, OTHER				HMWD IRR.	DIVERSIONS: MAPLES CANAL				LCM METER				CELL 2R METER				NORTH RIM METER				DIVERTED TO BV LAKE VIA NR & 2R			DIVERTED CO KERN SALE/CREDIT			
	KR & X	FK	WELL	STATE	WELL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	STATE	KR & X	FK	WELL	STATE
JAN					1701											1251				461								
FEB					748											795				46								
MAR	855		52		371											510												
APR	5730								256	5944																		
MAY	17750				793	985		52	244	15376				1277		615												
JUN	24675			2588		1683			642	20251				2535			1908	680										
JUL	5341			4505		2340				1234				1646			3781	260			726							
AUG	9505			2553		1507			38	4764				1601			2404	363			434							
SEP				390													403				22							
OCT																	54											
NOV				1367													623				922							
DEC	3265			2731	369					3047						369	1444				905							
AF	67121		52	14134	3982	6515		52	1180	50616				7059		3540	10617	1303		507	3009							

DATA SHEET - DISTRIBUTION - BVARA (WD2B)

WD2B **2010** 5/1/2014

Units in Acre Feet

DAY	RESERVIOUR LOSSES								STORAGE					NET CHANGE				
					DISTRICT ASSUMED				BVARA									
									KR & X	FK	WELL	STATE	TOTAL	BVARA				
	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	472		65	500	1037	KR & X	FK	WELL	STATE	TOTAL
JAN									472		54	500	1026			11		11
FEB									472		-39	500	933			93		93
MAR									1327		-126	500	1701	-855		87		-768
APR									1113		-126	244	1231	214			256	470
MAY									1225				1225	-112		-126	244	6
JUN									751			38	789	474			-38	436
JUL									612			36	648	139			2	141
AUG									1882			-287	1595	-1270			323	-947
SEP									1882			-322	1560				35	35
OCT									1882			-376	1506				54	54
NOV									1882			-554	1328				178	178
DEC									2100			-171	1930	-218			-381	-599
AF									2100			-171	1930	-1628		65	673	-890

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3A)

WD3A

2010

5/1/2014

Units in Acre Feet

DAY	TOTAL SUPPLY						DIVERSIONS														
	BVARA-BV LAKE WD1-WD2-WD4-WD6-STOS						WASTE WEIR SPILLS OR DELIVERY IN FLOOD CHANNEL					WASTE WEIR SPREADING IN CHANNEL					BV LAKE OUTLET GATES REVERSE FLOWS TO BUENA VISTA LAKE				
	KR & X	FK	WELL	DW#1	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																					
FEB																					
MAR																					
APR	5944																				
MAY	15376																				
JUN	20416																				
JUL	19552																				
AUG	15667																				
SEP																					
OCT																					
NOV																					
DEC	4878					1144						2723				16					
AF	81833					1144						2723				16					

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3B)

WD3B

2010 5/1/2014

Units in Acre Feet

DAY	SPREADING CHANNEL OR ELK PEN					OUTLET CANAL SPREADING				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN										
FEB										
MAR										
APR										
MAY										
JUN										
JUL	149									
AUG	286									
SEP										
OCT										
NOV										
DEC	615				139					
AF	1050				139					

DAY	OUTLET CANAL LOSSES					OUTLET TOTAL LOSSES	PB-BV#7 TO AQUEDUCT					EAST SIDE INTAKE CANAL HEAD				
	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																
FEB																
MAR																
APR	1908					1908						4036				
MAY	3060					3060						12316				
JUN	2374					2374						18042				
JUL	1692					1692						17711				
AUG	1045					1045						14336				
SEP																
OCT																
NOV																
DEC	1539				990	2529										
AF	11618				990	12608						66441				

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4A)

WD4A | **2010** | 5/1/2014

Units in Acre Feet

DAY	SUPPLY										DIVERSIONS															
	OUTLET-MAIN-STOS						INTERNAL				OUTSIDE DELIVERIES						SPILL TO OUTLET					SPILL TO MAIN CANAL				
	STO, WD3 & WD7						DIST.	DIST.	GROWER	GROWER	ST-RRB-KNWR						WD 3					WD 7				
	KR & X	FK	WELL	STATE	RECL	BR RECL	WELLS	RECL	WELLS	RECL	KR & X	FK	WELL	STATE	RECL	BR REC	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN						1204	44			268						1204										
FEB			920			1807	232	575		399						1807										
MAR						67	119			189						67										
APR	5109					70	109			452						70										
MAY	16202					290		195		446	69															
JUN	28389			27			99	2102		557	670			27	846											
JUL	30522			50			79	2741		1099	118			50	1157											
AUG	23855			13		1319		2876		1150	686			13	975	1319										
SEP						4988				190						4988										
OCT				56		4760								56		4760										
NOV				316		4663								316		4663										
DEC				192		2597								192		2597										
AF	104077		920	654		21765	682	8489		4750	1543			654	2978	21475										

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4B)

WD4B

5/1/2014

2010

Units in Acre Feet

DAY	SPILL AT HWY 46					FIELD DELIVERIES BUTTONWILLOW					Total FD	CANAL LOSSES INTERNAL SYSTEM					Total Losses
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	
JAN								44		268	312						
FEB								1091		605	1696			61		369	430
MAR								119		189	308						
APR						1513		109		452	2074	3596					3596
MAY						8647				446	9093	7486				195	7681
JUN						20225		99		557	20881	7494				1256	8750
JUL						22088		79		1099	23266	8316				1584	9900
AUG						18932				1150	20082	4237				1901	6138
SEP										190	190						
OCT																	
NOV																	
DEC																	
AF						71405		1541		4956	77902	31129		61		5305	36495

DATA SHEET - DISTRIBUTION - MAPLES (WD5)

WD5 **2010** 5/1/2014

Units in Acre Feet

DAY	SUPPLY: BVARA-BV LAKE WD2 & WD6 KR & X	FK	WELL	STATE	RECL	BV CANAL KR	GROWER WELLS	RECL	USE: KDWD DELIVERIES KR & X	FK	STATE	RECL	SPILL OR DELIVERIES BV LAKE KR & X	FK	WELL	STATE	RECL
JAN																	
FEB																	
MAR																	
APR				256													
MAY	985		52	244													
JUN	1683			642													
JUL	2340																
AUG	1507			38													
SEP																	
OCT																	
NOV																	
DEC																	
AF	6515		52	1180													

DAY	BVWSD FIELD DELIVERIES KR & X	FK	WELL	STATE	RECL	Total FD	SYSTEM CANAL LOSS KR & X	FK	WELL	STATE	RECL	Total Losses
JAN												
FEB												
MAR												
APR				69		69				187		187
MAY	676		52	139		867	309			105		414
JUN	1463			584		2047	220			58		278
JUL	2017					2017	323					323
AUG	1269			38		1307	238					238
SEP												
OCT												
NOV												
DEC												
AF	5425		52	830		6307	1090			350		1440

DATA SHEET - DISTRIBUTION - BV LAKE (WD6A)

WD6 **2010** 5/1/2014

Units in Acre Feet

DAY	SUPPLY					USE														
	BVARA-OUTLET-STOS WD1, WD2,WD3,MISC & STO					MAPLES CANAL					OUTLET GATES					HMWD IRRIGATION				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																				
FEB																				
MAR																				
APR																				
MAY																				
JUN																				
JUL																				
AUG																				
SEP																				
OCT																				
NOV																				
DEC					1144										1144					
AF					1144										1144					

DATA SHEET - DISTRIBUTION - BV LAKE (WD6B) 2010

Units in Acre Feet

DAY	RESERVIOUR LOSSES					STORAGE					NET CHANGE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN															
FEB															
MAR															
APR															
MAY															
JUN															
JUL															
AUG															
SEP															
OCT															
NOV															
DEC															
AF															

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7)

WD7A

5/1/2014

2010

Units in Acre Feet

DAY	SUPPLY																													
	WD1-WD4-Misc					Used By KERN WATER BANK					Used By COUNTY OF KERN & HM					SPREADING (M1&M7) CHANNEL & 160 ACRES					KWB CANAL (BV) / EAST & WEST POOL LOSSES IN CANAL					DIVERTED TO CALIFORNIA AQUEDUCT BV					CANAL HEAD ES INTAKE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN			5631					5534															7					90							
FEB			976					845															7					124							
MAR	167		2663					2218													30		74			137		371							
APR	3485		2797					1922			1438										220		35			1827		840							
MAY	3066		1519					1501			125										486					2455		17							
JUN	8663															686					300					7677									
JUL																																			
AUG																																			
SEP																																			
OCT																																			
NOV																																			
DEC																																			
AF	15381		13586					12020			1563					686					1036		123			12096		1442							

Note : April-May 2010 - 1,563 AF went into Aqueduct for HMWD

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7B) / EAST TO WEST

WD7B

5/1/2014

2010

Units in Acre Feet

DAY	TOTAL SUPPLY					BUENA VISTA WSD DIVERSIONS												
						BVWSD - WK - BV PONDS / RIVER					BV- OTHER PONDS (M1 & M7)					BV- LOSSES (KWB CANAL)		
																EAST	WEST	BV
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	POOL	POOL	TOTAL
JAN																		
FEB																		
MAR																		
APR																		
MAY			885					885										885
JUN																		
JUL	609										399					119	91	609
AUG	2739										2553					184	2	2739
SEP																		
OCT																		
NOV																		
DEC																		
AF	3348		885					885			2952					303	93	4233

DAY	OTHER DIVERSIONS																
	WEST KERN - WK - BV PONDS & LOSSES							KWB - PONDS									
				Del	Loss-KWB												
	KR & X	FK	WELL	STATE	STATE	RECL	TOTAL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																	
FEB																	
MAR																	
APR																	
MAY																	
JUN																	
JUL																	
AUG																	
SEP																	
OCT																	
NOV																	
DEC																	
AF																	

NOTE: BVWSD took 885 AF of Westside Mutual water into East Main Intake down into the BV/WK Ponds when the River Canal concrete panels broke. BVWSD gave them credit back in the State Aqueduct in May 2010.

DATA SHEET - DISTRIBUTION - HMWD IRRIGATION USE

WD8

5/1/2014

2010

Units in Acre Feet

DAY	USE											TOTAL					
	DIRECT		VIA					VIA				USE					
	BV 4&5		BV LAKE					BVARA									TOTAL
	KR & X	STATE	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	RECL	ALL
JAN										1712				1712			1712
FEB		512								841				841	512		1353
MAR										510				510			510
APR																	
MAY								1277		615		1277		615			1892
JUN		4591						3215			1908	3215			6499		9714
JUL		2789						1906			4507	1906			7296		9202
AUG		3783						1964			2838	1964			6621		8585
SEP		234									425				659		659
OCT											54				54		54
NOV		820									1545				2365		2365
DEC		3243								369	2349			369	5592		5961
AF		15972						8362		4047	13626	8362		4047	29598		42007

DISTRIBUTION INPUTS **SUPPLIES** Inputs **2011** 5/1/2014

SECOND POINT SUPPLY (Including Deliveries Via Buena Vista Canal) **Units in Acre Feet**

Via / To / DAY	1st Pt KR	1st Pt 2nd Pt (KD) KR	1st Pt FK CANAL FK-X	1st Pt 2800 KR-X	1st Pt 2800 WELL	1st Pt Spill KR	KCWA Spill FK	KCWA Spill S-X	Via RTO 1 Others @2nd. Pt. S-X	HWD DUE @2ndPt KR	HWD @2nd Pt KR	HWD FK	HWD WELLS	BVWSD DUE @2ndPt KR	BVWSD @2ndPt KR	BVWSD FK CANAL @2ndPt FK-X	BVWSD 2800 @2ndPt WELLS	TOTAL SUPPLY At 2nd Point KR	FK	WELL	STATE	TOTAL SUPPLY
JAN						591			220					5631	5631			6222			220	6442
FEB														17613	17613			17613				17613
MAR			101			317	216	492						11589	11589			11906	317		492	12715
APR			50				107	90		946	946			27130	27130			28076	157		90	28323
MAY	16619					1456				16397	16397			37446	37446			71918				71918
JUN	6949									2623	2623			49369	49369			58941				58941
JUL	1216													18035	18035			19251				19251
AUG														9478	9478			9478				9478
SEP														151	151			151				151
OCT																						
NOV																						
DEC																						
AF	24784		151			2364	323	582	220	19966	19966			176442	176442			223556	474		802	224832

Note: March 2011 KCWA spilled FK & State Water and BVWSD used it for spreading.

Note: Lower Kern River Water Sale in July 2011 (HMWD 393 Af & BVWSD 1,547 AF) &(WKWD also purchased 1,216 AF that was used for spreading)

DISTRIBUTION INPUTS (MISC SUPPIES)

5/1/2014

2011

MISC WATER - WELLS & RECLAMATION PUMPS Below 2nd Pt.

Units in Acre Feet

DAY Via DAY	HMWD BVARA WELLS	HMWD BV LAKE AREA WELLS	HMWD BV LAKE AREA RECL	DISTRICT GROWER Maples WELLS	DISTRICT GROWER Maples RECL	BVWSD BW WELLS	BVWSD BW RECL	GROWER BW WELLS	GROWER BW RECL	TOTAL SUPPLY Below 2nd Pt KR	WELL	STATE	RECL	TOTAL
JAN														
FEB						73	1224	50	540		123		1764	1887
MAR							715	8	135		8		850	858
APR							831						831	831
MAY							3290		22				3312	3312
JUN							2411		538				2949	2949
JUL							3327	16	853		16		4180	4196
AUG							1724	113	865		113		2589	2702
SEP						60	153		175		60		328	388
OCT						32					32			32
NOV						30					30			30
DEC						24	39		6		24		45	69
AF						219	13714	187	3134		406		16848	17254

2011

STATE TURNOUTS

Units in Acre Feet

DAY	SUPPLY BV 1B				BV 6			BV 2			BV 7		BV 3		BV 5		BV 4		BV 5 TO BV LAKE		SEMITROPIC			TOTAL			
	STATE	WELL	KR-X	BR REC	STATE	BR REC	KR-X	STATE	BR REC	KR-X	STATE	KR-X	STATE	KR-X	STATE	KR-X	STATE	KR-X	STATE	KR-X	STATE	KR-X	BR REC	STATE	WELL	KR-X	BR REC
JAN			30	957				620		1773			502		1046		124							2292		1803	957
FEB				549	2796		1762	4053		2688			3045				152							10046		4450	549
MAR			40	534				777																777		40	534
APR				734						643				858												1501	734
MAY				1485																							1485
JUN			575	637			274								335		1395							1730		849	637
JUL			980	460			6143			5490		11515	1985		951		1002							3938		24128	460
AUG				2714		1622	4531			5190		17520	4975		611		1262							6848		27241	4336
SEP			121	3884		505		721	178	387		1969	1391		261		155				110		320	2638		2477	4887
OCT			232	4455						3307											141		493	141		3539	4948
NOV			451	4046						2860			2894				347							3241		3311	4046
DEC	123			2288	141		2000	1861		3014			5350		1319		815							9609		5014	2288
AF	123		2429	22743	2937	2127	14710	8032	178	25352		31004	20142	858	4523		5252				251		813	41260		74353	25861

DATA SHEET - DISTRIBUTION - SECOND POINT(WD1)

WD1

5/1/2014

2011

Units in Acre Feet

DAY	SUPPLY					DIVERSIONS																									LOSSES			
	SECOND POINT				TOTAL FLOW	ALEJ CANAL				KR OUTLET WEIR				KWB - MAIN CANAL (KWB HEAD GATE & KR-PIPELINE)				INLET WEIR			INTERTIE			KWBA SPREADING MAIN.BYPASS & RIVER			BVWSD SPREADING MAIN.BYPASS & RIVER				TRANSPORTATION LOSSES			
	KR	FK	WELL	S-X		KR	FK	S-X	WELL	KR	FK	S-X	WELL	KR	FK	S-X	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	S-X	WELL	KR	FK	S-X	WELL
JAN	6222			220	6442	541		14		260		131		815													4606		75					
FEB	17613				17613	12287								1208													4118							
MAR	11906	317		492	12715	5332								1944	101	8											4630	216	484					
APR	28076	157		90	28323	19966				1353				2239	50	46											4518	107	44					
MAY	71918				71918	22712				7505				37014													4687							
JUN	58941				58941	32692				9667				11865													4717							
JUL	19251				19251	14862				536														1216			2637							
AUG	9478				9478	4403								910													4165							
SEP	151				151	151																												
OCT																																		
NOV																																		
DEC																																		
AF	223556	474		802	224832	112946		14		19321		131		55995	151	54								1216			34078	323	603					

NOTE:

DATA SHEET - DISTRIBUTION - BVARA (WD2A)

WD2A

5/1/2014

2011

Units in Acre Feet

DAY	SUPPLY					DIVERSIONS																						
	ALEJ CANAL, BV #3, OTHER				HMWD IRR.	MAPLES CANAL				LCM METER				CELL 2R METER				NORTH RIM METER				DIVERTED TO BV LAKE VIA NR & 2R			DIVERTED CO KERN SALE/CREDIT			
	KR & X	FK	WELL	STATE	WELL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	STATE	KR & X	FK	WELL	STATE
JAN	541			516					482	502			34				109											
FEB	12287			3045		607			89	14368							26				248							
MAR	5332									4330							589				446							
APR	20824					113				18490							1137											
MAY	22712					883				18910				1129			121	692			108							
JUN	32692					2057				21544				5617				1497							1000			
JUL	14862			1985		2073				11147				2805			1767	522			97							
AUG	4403			4975		1716				2221							4258	357			1273							
SEP	151			1391		60											676				305							
OCT																	478											
NOV				2894													1714											
DEC				5350													4185				962							
AF	113804			20156		7509			571	91512			34	9551			15060	3068			3439				1000			

DATA SHEET - DISTRIBUTION - BVARA (WD2B)

WD2B **2011** 5/1/2014

Units in Acre Feet

DAY	RESERVIOUR LOSSES								STORAGE					NET CHANGE				
					DISTRICT ASSUMED				BVARA									
									KR & X	FK	WELL	STATE	TOTAL	BVARA				
	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	2100			-171	1929	KR & X	FK	WELL	STATE	TOTAL
JAN									2139			-280	1859	-39			109	70
FEB									-549			2402	1853	2688			-2682	6
MAR									453			1367	1820	-1002			1035	33
APR									2674			230	2904	-2221			1137	-1084
MAY									3773				3773	-1099			230	-869
JUN									4750				4750	-977				-977
JUL									3065			121	3186	1685			-121	1564
AUG									3174			-435	2739	-109			556	447
SEP									3265			-25	3240	-91			-410	-501
OCT									3265			-503	2762				478	478
NOV									3265			677	3942				-1180	-1180
DEC									3267			877	4144				-202	-202
AF									3267			877	4144	-1165			-1050	-2215

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3A)

WD3A

2011

5/1/2014

Units in Acre Feet

DAY	TOTAL SUPPLY						DIVERSIONS														
	BVARA-BV LAKE WD1-WD2-WD4-WD6-STOS						WASTE WEIR SPILLS OR DELIVERY IN FLOOD CHANNEL					WASTE WEIR SPREADING IN CHANNEL					BV LAKE OUTLET GATES REVERSE FLOWS TO BUENA VISTA LAKE				
	KR & X	FK	WELL	DW#1	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN	762				165																
FEB	14368																				
MAR	4330																				
APR	19843											2212									
MAY	26415						1456					2648									
JUN	31211											2235									
JUL	23198											375									
AUG	19741																				
SEP	1969																				
OCT																					
NOV																					
DEC																					
AF	141837				165		1456					7470									

Note: 1,456 AF of 1st Pt. water making 2nd. Pt. got spilled in the Flood Channel over the New Concrete Weir in May 2011.

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3B)

WD3B

2011 5/1/2014

Units in Acre Feet

DAY	SPREADING CHANNEL OR ELK PEN					OUTLET CANAL SPREADING					OUTLET CANAL LOSSES					OUTLET TOTAL LOSSES	PB-BV#7 TO AQUEDUCT					EAST SIDE INTAKE CANAL HEAD				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN	367			14							395			151		546										
FEB	1781										2430					2430						10157				
MAR											940					940						3390				
APR	2866										3086					3086						11679				
MAY	3606										2753					2753						15952				
JUN	3201										2579					2579						23196				
JUL	3160										1940					1940						17723				
AUG	3195										1690					1690						14856				
SEP	468										38					38						1463				
OCT																										
NOV																										
DEC																										
AF	18644			14							15851			151		16002						98416				

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4A)

WD4A

2011

5/1/2014

Units in Acre Feet

DAY	SUPPLY										DIVERSIONS															
	OUTLET-MAIN-STOS						INTERNAL				OUTSIDE DELIVERIES						SPILL TO OUTLET					SPILL TO MAIN CANAL				
	STO, WD3 & WD7						DIST.	DIST.	GROWER	GROWER	WK - ST - RRB - KNWR						WD 3					WD 7				
	KR & X	FK	WELL	STATE	RECL	BR RECL	WELLS	RECL	WELLS	RECL	KR & X	FK	WELL	STATE	RECL	BR REC	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN	1803			620		957					1803			620		957										
FEB	14607			6849		549	73	1224	50	540				3176	286	549										
MAR	3430			777		534		715	8	135	22			722	166	534										
APR	12322					734		831			1137				585	734										
MAY	15952					1485		3290		22	1101				3290	1486										
JUN	24045					637		2411		538	649				1261	637										
JUL	30336					460		3327	16	853	867				2395	460										
AUG	24577					4336		1724	113	865	856					4336										
SEP	1971			831		4887	60	153		175	152			831		4887										
OCT	3539			141		4948	32				3209			141		4948										
NOV	3311					4046	30				3037					4046										
DEC	5014			2125		2288	24	39		6	3015			50		2288										
AF	140907			11343		25861	219	13714	187	3134	15848			5540	7983	25862										

2011

Units in Acre Feet

DAY	SPILL AT HWY 46 KR & X	FK	WELL	STATE	RECL	WKWD Spreading STATE	FIELD DELIVERIES BUTTONWILLOW KR & X	FK	WELL	STATE	RECL	Total FD	CANAL LOSSES INTERNAL SYSTEM KR & X	FK	WELL	STATE	RECL	Total Losses
JAN																		
FEB							11064		123	3673	540	15400	3543				938	4481
MAR							3539		8		307	3854	-131			55	377	301
APR							5593					5593	5592				246	5838
MAY							6317				22	6339	8534					8534
JUN							19285				538	19823	4111				1150	5261
JUL							25063		16		861	25940	4406				924	5330
AUG							21834		113		879	22826	1887				1710	3597
SEP							2237		60		175	2472	-418				153	-265
OCT							330		32			362						
NOV							274		30			304						
DEC							482		24	1793	6	2305	1517			282	39	1838
AF							96018		406	5466	3328	105218	29041			337	5537	34915

DATA SHEET - DISTRIBUTION - MAPLES (WD5) WD5 **2011** 5/1/2014

Units in Acre Feet

DAY	SUPPLY: BVARA-BV LAKE WD2 & WD6 KR & X	FK	WELL	STATE	RECL	BV CANAL KR	GROWER WELLS	GROWER RECL	USE: KDWD DELIVERIES KR & X	FK	STATE	RECL	SPILL OR DELIVERIES BV LAKE KR & X	FK	WELL	STATE	RECL
JAN				482													
FEB	607			89													
MAR																	
APR	113																
MAY	883																
JUN	2057																
JUL	2073																
AUG	1716																
SEP	60																
OCT																	
NOV																	
DEC																	
AF	7509			571													

DAY	BVWSD FIELD DELIVERIES KR & X	FK	WELL	STATE	RECL	Total FD	SYSTEM CANAL LOSS KR & X	FK	WELL	STATE	RECL	Total Losses
JAN				325		325				157		157
FEB	591					591	16			89		105
MAR												
APR	34					34	79					79
MAY	601					601	282					282
JUN	1724					1724	333					333
JUL	1805					1805	268					268
AUG	1444					1444	272					272
SEP	46					46	14					14
OCT												
NOV												
DEC												
AF	6245			325		6570	1264			246		1510

DATA SHEET - DISTRIBUTION - BV LAKE (WD6A) 2011

Units in Acre Feet

DAY	SUPPLY					USE														
	BVARA-OUTLET-STOS WD1, WD2,WD3,MISC & STO					MAPLES CANAL					OUTLET GATES					HMWD IRRIGATION				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																				
FEB																				
MAR																				
APR																				
MAY																				
JUN																				
JUL																				
AUG																				
SEP																				
OCT																				
NOV																				
DEC																				
AF																				

DATA SHEET - DISTRIBUTION - BV LAKE (WD6B) 2011

Units in Acre Feet

DAY	RESERVIOUR LOSSES					STORAGE					NET CHANGE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN															
FEB															
MAR															
APR															
MAY															
JUN															
JUL															
AUG															
SEP															
OCT															
NOV															
DEC															
AF															

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7) WD7A 5/1/2014

2011

Units in Acre Feet

DAY	SUPPLY WD1-WD4-Misc					Used By KERN WATER BANK					Used By COUNTY OF KERN & HM					SPREADING KWB & (M1&M7) CHANNEL & 160 ACRES (BVWSD)					KWB CANAL (BVWSD) EAST & WEST POOL LOSSES IN CANAL					DIVERTED TO CALIFORNIA AQUEDUCT BV					CANAL HEAD ES INTAKE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																																			
FEB																																			
MAR																																			
APR																																			
MAY	37014					35796										69					783					366									
JUN	11865					10451										476					603					335									
JUL																																			
AUG																																			
SEP																																			
OCT																																			
NOV																																			
DEC																																			
AF	48879					46247										545					1386					701									

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7B) / EAST TO WEST

WD7B

5/1/2014

2011

Units in Acre Feet

DAY	TOTAL SUPPLY					BUENA VISTA WSD DIVERSIONS												
						BVWSD - WK - BV PONDS / RIVER					BV- OTHER PONDS (M1 & M7)					BV- LOSSES (KWB CANAL)		
																EAST	WEST	BV
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	POOL	POOL	TOTAL
JAN	815										406					409		815
FEB	1208										1168					40		1208
MAR	1944	101		8							1851					93		1944
APR	2240	50		46		1187										107		1294
MAY																		
JUN																		
JUL	1837										922					491	424	1837
AUG	1049										706					343		1049
SEP																		
OCT																		
NOV																		
DEC																		
AF	9093	151		54		1187					5053					1483	424	8147

DAY	OTHER DIVERSIONS																
	WEST KERN - WK - BV PONDS & LOSSES							KWB - PONDS					KCWA (others)				
				Del	Loss-KWB												
	KR & X	FK	WELL	STATE	STATE	RECL	TOTAL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																	
FEB																	
MAR														101		8	
APR													946	50		46	
MAY																	
JUN																	
JUL																	
AUG																	
SEP																	
OCT																	
NOV																	
DEC																	
AF													946	151		54	

Note : JULY 2011 : Have to get all information from the KCWA Records. As part of an operational exchange, Semitropic WSD and Dudley Ridge WD delivered SWP supplies to BVWSD on the KWB Canal for a like amount of BVWSD Kern River supplies through the Trestle Turnout off the Kern River Channel. (Total 1,837 AF : SWSD 1,470 AF & DRWD 367 AF)

Note : AUGUST 2011 : Have to get all information from the KCWA Records. As part of an operational exchange, Semitropic WSD,Belridge WSD and Wheeler-Ridge Maricopa WSD delivered SWP supplies to BVWSD on the KWB Canal for a like amount of BVWSD Kern River supplies through the Trestle Turnout off the Kern River Channel. (Total 139 AF : SWSD 53 AF, BWSD 58 AF, WRMWSD 28)

DATA SHEET - DISTRIBUTION - HMWD IRRIGATION USE

WD8

5/1/2014

2011

Units in Acre Feet

DAY	USE											TOTAL					
	DIRECT		VIA					VIA				USE					
	BV 4&5		BV LAKE					BVARA									TOTAL
	KR & X	STATE	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	RECL	ALL
JAN		1170									109				1279		1279
FEB		152									274				426		426
MAR											1035				1035		1035
APR											1137				1137		1137
MAY								1821			229	1821			229		2050
JUN		1730						7114				7114			1730		8844
JUL		1953						3327			1864	3327			3817		7144
AUG		1873						357			5531	357			7404		7761
SEP		416									981				1397		1397
OCT											478				478		478
NOV		347									1714				2061		2061
DEC		2134									5147				7281		7281
AF		9775						12619			18499	12619			28274		40893

DISTRIBUTION INPUTS **SUPPLIES** Inputs **2012**

SECOND POINT SUPPLY (Including Deliveries Via Buena Vista Canal) **Units in Acre Feet**

Via To DAY	1st Pt KR	1st Pt 2nd Pt (KD) KR	1st Pt FK CANAL FK-X	1st Pt 2800 KR-X	1st Pt WELL	1st Pt Spill KR	KCWA Spill FK	KCWA Spill S-X	Via RTO 1 Others @2nd. Pt. S-X	HWD DUE @2ndPt KR	HWD @2nd Pt KR	HWD FK	HWD WELLS	BVWSD DUE @2ndPt KR	BVWSD @2ndPt KR	BVWSD FK CANAL @2ndPt FK-X	BVWSD 2800 @2ndPt WELLS	TOTAL SUPPLY At 2nd Point KR	FK	WELL	STATE	TOTAL SUPPLY
JAN																						
FEB																						
MAR					4931									2844	2844			2844		4931		7775
APR					6061									4856	4856		1711	4856		7772		12628
MAY					2350									1208	1208		1714	1208		4064		5272
JUN					2196									5968	5968		1632	5968		3828		9796
JUL														5986	5986			5986				5986
AUG																						
SEP																						
OCT					1000															1000		1000
NOV																						
DEC																						
AF					16538									20862	20862		5057	20862		21595		42457

DISTRIBUTION INPUTS (MISC SUPPIES)

Misc

2012

MISC WATER - WELLS & RECLAMATION PUMPS Below 2nd Pt. **Units in Acre Feet**

DAY Via DAY	HMWD BVARA WELLS	BV LAKE AREA WELLS	RECL	DISTRICT GROWER Maples WELLS	Maples RECL	BVWSD BW WELLS	BVWSD BW RECL	GROWER BW WELLS	GROWER BW RECL	TOTAL SUPPLY Below 2nd Pt KR	WELL	STATE	RECL	TOTAL
JAN						129	97		456		129		553	682
FEB						188	331		597		188		928	1116
MAR						18			190		18		190	208
APR						173			152		173		152	325
MAY	152					311			371		463		371	834
JUN	1051					89	1706	238	742		1378		2448	3826
JUL	343					103	3124	264	1000		710		4124	4834
AUG						55	3112	58	819		113		3931	4044
SEP						125			151		125		151	276
OCT						30			18		30		18	48
NOV	1071					40					1111			1111
DEC	1293					20					1313			1313
AF	3910					1281	8370	560	4496		5751		12866	18617

DISTRIBUTION INPUTS (STO)

STO

2012

Units in Acre Feet

STATE TURNOUTS

DAY	SUPPLY BV 1B				BV 6			BV 2			BV 7		BV 3		BV 5		BV 4		BV 5 TO BV LAKE		SEMITROPIC			TOTAL			
	STATE	WELL	KR-X	BR REC	STATE	BR REC	KR-X	STATE	BR REC	KR-X	STATE	KR-X	STATE	KR-X	STATE	KR-X	STATE	KR-X	STATE	KR-X	STATE	KR-X	BR REC	STATE	WELL	KR-X	BR REC
JAN			16	1585	518			3858					1187				579							6142		16	1585
FEB	1252			1609				600									810							2662			1609
MAR															286		259							545			
APR	54														105		501							660			
MAY	311			400	581			680							1334		157							3063			400
JUN			1194				4513	276		3482	8200	4096	3653		2964		1756							16849		13285	
JUL	1032				125		5500	629		5185	1000	12166	4745		1992		2402							11925		22851	
AUG	1420						3838	424		3966		13468	3029		3255		2556							10684		21272	
SEP	214			3575									448				220							882			3575
OCT			153	5128						2649											114			114		2802	5128
NOV	73		625	3337											1513		928				179			2693		625	3337
DEC	35		693	3112											514		711				149			1409		693	3112
AF	4391		2681	18746	1224		13851	6467		15282	9200	29730	13062		11963		10879				442			57628		61544	18746

DATA SHEET - DISTRIBUTION - SECOND POINT(WD1)

WD1

2012

Units in Acre Feet

DAY	SUPPLY SECOND POINT				TOTAL FLOW	DIVERSIONS ALEJ CANAL				KR OUTLET WEIR				KWB - MAIN CANAL (KWB HEAD GATE & KR-PIPELINE)				INLET WEIR			INTERTIE			KWBA SPREADING MAIN.BYPASS & RIVER			BVWSD SPREADING MAIN.BYPASS & RIVER				LOSSES TRANSPORTATION LOSSES (BVWSD only)			
	KR	FK	WELL	S-X		KR	FK	S-X	WELL	KR	FK	S-X	WELL	KR	FK	S-X	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	S-X	WELL	KR	FK	S-X	WELL
JAN																																		
FEB																																		
MAR	2844		4931		7775	109								2735			4931																	
APR	4856		7772		12628									4856			7772																	
MAY	1208		4064		5272	587			343					621			3721																	
JUN	5968		3828		9796	5968			1541								2287																	
JUL	5986				5986	5986																												
AUG																																		
SEP																																		
OCT			1000		1000				1000																									
NOV																																		
DEC																																		
AF	20862		21595		42457	12650			2884					8212			18711																	

NOTE:

DATA SHEET - DISTRIBUTION - BVARA (WD2A)

WD2A

2012

Units in Acre Feet

DAY	SUPPLY					DIVERSIONS																				
	ALEJ CANAL, BV #3, OTHER				HMWD IRR.	MAPLES CANAL				LCM METER				CELL 2R METER				NORTH RIM METER				DIVERTED TO BV LAKE VIA NR & 2R			DIVERTED CO KERN SALE/CREDIT			
	KR & X	FK	WELL	STATE	WELL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	STATE	KR & X	FK	WELL	STATE
JAN				1187													651				137							
FEB																	980											
MAR	109																				44							
APR																												
MAY	587		343		152	111				399		343				152	366											
JUN	5968		1541	3653	1051	468		1541		5578						694	2848			357	403							
JUL	5986			4745	343	2471				5849						343	4090				242							
AUG				3029		946			962	4							1065				859							
SEP				448					430								103				44							
OCT			1000														187				248						1000	
NOV					1071											857	266			65								
DEC					1293											1236				217								
AF	12650		2884	13062	3910	3996		1541	1392	11830		343				3282	10556			639	1977						1000	

DATA SHEET - DISTRIBUTION - BVARA (WD2B)

WD2B

2012

Units in Acre Feet

DAY	RESERVIOUR LOSSES				DISTRICT ASSUMED				STORAGE BVARA				TOTAL	NET CHANGE BVARA				TOTAL
	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE		KR & X	FK	WELL	STATE	
									3267			877	4144					
JAN									3267			1277	4544				-400	-400
FEB									3267			298	3565				979	979
MAR									3376			254	3630	-109			44	-65
APR									3376			254	3630					
MAY									3453			-111	3342	-77			365	288
JUN									3376			292	3668	77			-403	-326
JUL									1041			704	1745	2335			-412	1923
AUG									91			847	938	950			-143	807
SEP									91			718	809				129	129
OCT									91			283	374				435	435
NOV									91		149	18	258			-149	265	116
DEC									91		-12	18	97			161		161
AF									91		-12	18	97	3176		12	859	4047

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3A) WD3A **2012**

Units in Acre Feet

DAY	TOTAL SUPPLY						DIVERSIONS														
	BVARA-BV LAKE WD1-WD2-WD4-WD6-STOS						WASTE WEIR SPILLS OR DELIVERY IN FLOOD CHANNEL					WASTE WEIR SPREADING IN CHANNEL (WKWD)					BV LAKE OUTLET GATES REVERSE FLOWS TO BUENA VISTA LAKE				
	KR & X	FK	WELL	DW#1	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN					3021										305						
FEB					600										62						
MAR																					
APR																					
MAY	399		343																		
JUN	9674		8		8200																
JUL	18015		10		1000																
AUG	13472																				
SEP																					
OCT																					
NOV																					
DEC																					
AF	41560		361		12821										367						

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3B)

WD3B

2012

Units in Acre Feet

DAY	SPREADING CHANNEL OR ELK PEN (WKWD)					OUTLET CANAL SPREADING (WKWD)					OUTLET CANAL LOSSES					OUTLET TOTAL LOSSES	PB-BV#7 TO AQUEDUCT					EAST SIDE INTAKE CANAL HEAD				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN				2353					363																	
FEB				465					73																	
MAR																										
APR																										
MAY											399		343			742										
JUN											2102					2102						7572		8	8200	
JUL											2100					2100						15915		10	1000	
AUG											1004					1004						12468				
SEP																										
OCT																										
NOV																										
DEC																										
AF				2818					436		5605		343			5948						35955		18	9200	

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4A)

WD4A

2012

Units in Acre Feet

DAY	SUPPLY									
	OUTLET-MAIN-STOS						INTERNAL			
	STO, WD3 & WD7						DIST.	DIST.	GROWER	GROWER
	KR & X	FK	WELL	STATE	RECL	BR RECL	WELLS	RECL	WELLS	RECL
JAN	16			4376		1585	129	97		456
FEB				1852		1609	188	331		597
MAR							18			190
APR				54			173			152
MAY				1572		400	311			371
JUN	16761		8	8476			81	1706	238	742
JUL	26600		10	2786			93	3124	264	1000
AUG	20272			1844			55	3112	58	819
SEP				214		3575	125			151
OCT	2802			114		5128	30			18
NOV	625			252		3337	40			
DEC	693			184		3112	20			
AF	67769		18	21724		18746	1263	8370	560	4496

DAY	DIVERSIONS															
	OUTSIDE DELIVERIES						SPILL TO OUTLET					SPILL TO MAIN CANAL				
	WK - ST - RRB - KNWR						WD 3 (WKWD)					WD 7				
	KR & X	FK	WELL	STATE	RECL	BR REC	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN	16					1585				3021						
FEB						1609				600						
MAR																
APR																
MAY						400										
JUN				276	654											
JUL				629	1506											
AUG				286	1512											
SEP				4		3575										
OCT	2506			114		5128										
NOV				252		3337										
DEC				184		3112										
AF	2522			1745	3672	18746				3621						

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4B)

WD4B

2012

Units in Acre Feet

DAY	SPILL AT HWY 46					FIELD DELIVERIES BUTTONWILLOW					Total FD	CANAL LOSSES INTERNAL SYSTEM					Total Losses
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	
JAN								129	1140	456	1725				215	97	312
FEB								188	1252	597	2037					331	331
MAR								18		190	208						
APR								173	46	152	371				8		8
MAY								311	182	371	864				1390		1390
JUN						8680		327	8200	742	17949	8081				1052	9133
JUL						18208		367	2157	1000	21732	8392				1618	10010
AUG						15385		113	1558	952	18008	4887				1467	6354
SEP								125	147	151	423				63		63
OCT						296		30		18	344						
NOV						625		40			665						
DEC						593		20			613	100					100
AF						43787		1841	14682	4629	64939	21460			1676	4565	27701

DATA SHEET - DISTRIBUTION - MAPLES (WD5)

WD5

2012

Units in Acre Feet

DAY	SUPPLY								USE																				
	BVARA-BV LAKE WD2 & WD6					BV CANAL	GROWER		KDWD DELIVERIES				SPILL OR DELIVERIES BV LAKE					BVWSD FIELD DELIVERIES					Total FD	SYSTEM CANAL LOSS					Total Losses
	KR & X	FK	WELL	STATE	RECL	KR	WELLS	RECL	KR & X	FK	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	
JAN																													
FEB																													
MAR																													
APR																													
MAY	111																							111					111
JUN	468		1541															268		1313			1581	200		228			428
JUL	2471																	2071					2071	400					400
AUG	946			962														639			863		1502	307			99		406
SEP				430																	323		323				107		107
OCT																													
NOV																													
DEC																													
AF	3996		1541	1392														2978		1313	1186		5477	1018		228	206		1452

DATA SHEET - DISTRIBUTION - BV LAKE (WD6A)   WD6   2012

Units in Acre Feet

DAY	SUPPLY					USE														
	BVARA-OUTLET-STOS WD1, WD2,WD3,MISC & STO					MAPLES CANAL					OUTLET GATES					HMWD IRRIGATION				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																				
FEB																				
MAR																				
APR																				
MAY																				
JUN																				
JUL																				
AUG																				
SEP																				
OCT																				
NOV																				
DEC																				
AF																				

DATA SHEET - DISTRIBUTION - BV LAKE (WD6B)

2012

Units in Acre Feet

DAY	RESERVIOUR LOSSES					STORAGE					NET CHANGE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN															
FEB															
MAR															
APR															
MAY															
JUN															
JUL															
AUG															
SEP															
OCT															
NOV															
DEC															
AF															

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7)

WD7A

2012

Units in Acre Feet

DAY	SUPPLY WD1-WD4-Misc KR & X	FK	WELL	STATE	RECL	Used By KERN WATER BANK KR & X	FK	WELL	STATE	RECL
JAN										
FEB										
MAR	2735		4931					4931		
APR	4856		7772					6061		
MAY	621		3721					2350		
JUN			2287					2196		
JUL										
AUG										
SEP										
OCT										
NOV										
DEC										
AF	8212		18711					15538		

DAY	Used By COUNTY OF KERN & HM KR & X	FK	WELL	STATE	RECL	SPREADING KWB & (M1&M7) CHANNEL & 160 ACRES (BVWSD) KR & X	FK	WELL	STATE	RECL
JAN										
FEB										
MAR										
APR										
MAY										
JUN										
JUL										
AUG										
SEP										
OCT										
NOV										
DEC										
AF										

DAY	KWB CANAL (BVWSD) EAST & WEST POOL LOSSES IN CANAL KR & X	FK	WELL	STATE	RECL	DIVERTED TO CALIFORNIA AQUEDUCT BV KR & X	FK	WELL	STATE	RECL
JAN										
FEB										
MAR	80					2655				
APR	127		38			4729		1673		
MAY	14		14			607		1357		
JUN								91		
JUL										
AUG										
SEP										
OCT										
NOV										
DEC										
AF	221		52			7991		3121		

DAY	CANAL HEAD ES INTAKE KR & X	FK	WELL	STATE	RECL
JAN					
FEB					
MAR					
APR					
MAY					
JUN					
JUL					
AUG					
SEP					
OCT					
NOV					
DEC					
AF					

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7B) / EAST TO WEST

WD7B

2012

Units in Acre Feet

DAY	TOTAL SUPPLY					BUENA VISTA WSD DIVERSIONS													OTHER DIVERSIONS																
						BVWSD - WK - BV PONDS / RIVER					BV- OTHER PONDS (M1 & M7)					BV- LOSSES (KWB CANAL)			WEST KERN - WK - BV PONDS & LOSSES							KWB - PONDS					KCWA (others)				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	EAST POOL	WEST POOL	BV TOTAL	KR & X	FK	WELL	Del STATE	Loss-KWB STATE	RECL	TOTAL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																																			
FEB																																			
MAR																																			
APR																																			
MAY																																			
JUN																																			
JUL																																			
AUG																																			
SEP																																			
OCT																																			
NOV																																			
DEC																																			
AF																																			

DATA SHEET - DISTRIBUTION - HMWD IRRIGATION USE

WD8

2012

Units in Acre Feet

DAY	USE											TOTAL					
	DIRECT		VIA					VIA				USE					
	BV 4&5		BV LAKE					BVARA									TOTAL
	KR & X	STATE	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	RECL	ALL
JAN		579									788				1367		1367
FEB		810									980				1790		1790
MAR		545									44				589		589
APR		606													606		606
MAY		1491								152	366			152	1857		2009
JUN		4720								1051	3251			1051	7971		9022
JUL		4394								343	4332			343	8726		9069
AUG		5811									1924				7735		7735
SEP		220									147				367		367
OCT											435				435		435
NOV		2441								922	266			922	2707		3629
DEC		1225								1453				1453	1225		2678
AF		22842								3921	12533			3921	35375		39296

Appendix F

Interested Parties List

Preliminary Interested Parties List

The BVGSA has been engaged routinely with the interested parties listed below. This list now consists largely of other GSAs engaged in SGMA implementation in the Kern County Subbasin. The Buttonwillow County Water District, which lies entirely within the BVGSA, has been an active cooperator.

- Buttonwillow County Water District
- Cawelo GSA
- City of Bakersfield
- Greenfield County Water District
- Henry Miller Water District (HMGSA)
- Kern Groundwater Authority GSA (KGAGSA)
- Kern River GSA (KRGSA)
- Kern Water Bank Authority
- McFarland GSA
- Olcese GSA
- Pioneer GSA
- Rosedale-Rio Bravo Water Storage District
- Semitropic Water Storage District
- Todd Groundwater
- West Kern Water District

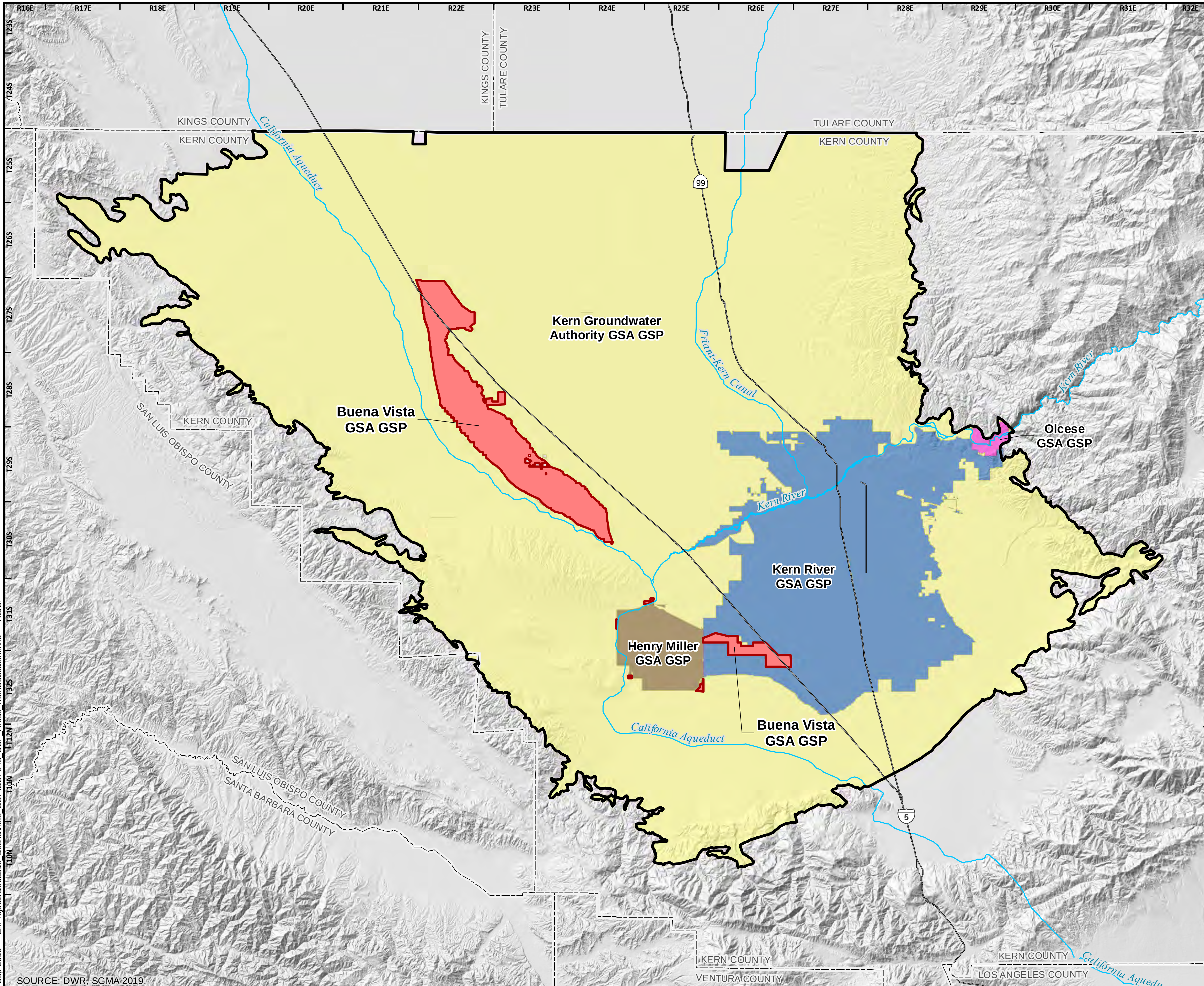
The BVGSA is also represented on the Basin Coordination Committee consisting of KGAGSA, KRGSA, HMGSA, and the Olcese GSA and on the Basin Technical Committee consisting of KGA, individual members of KGA, and KRGSA, HMGSA, and Olcese GSA and all the consultants serving these GSAs.

The BVWSD regularly updates its webpage with information relevant to development and implementation of the GSP. Information on SGMA-related meetings can also be accessed by interested parties via the website which stores meeting minutes and attendance records and hosts the interested parties list. Entities interested in registering as interested parties can sign up through the website.

Appendix G

Coordination Agreement

GSPS WITHIN KERN COUNTY SUBBASIN



Kern Subbasin Boundary

GSP Boundaries

Buena Vista GSA GSP

Kern Groundwater Authority GSA GSP

Henry Miller GSA GSP

Kern River GSA GSP

Olcese GSA GSP

All Other Features

Highway

Waterway

0 4 8 16
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

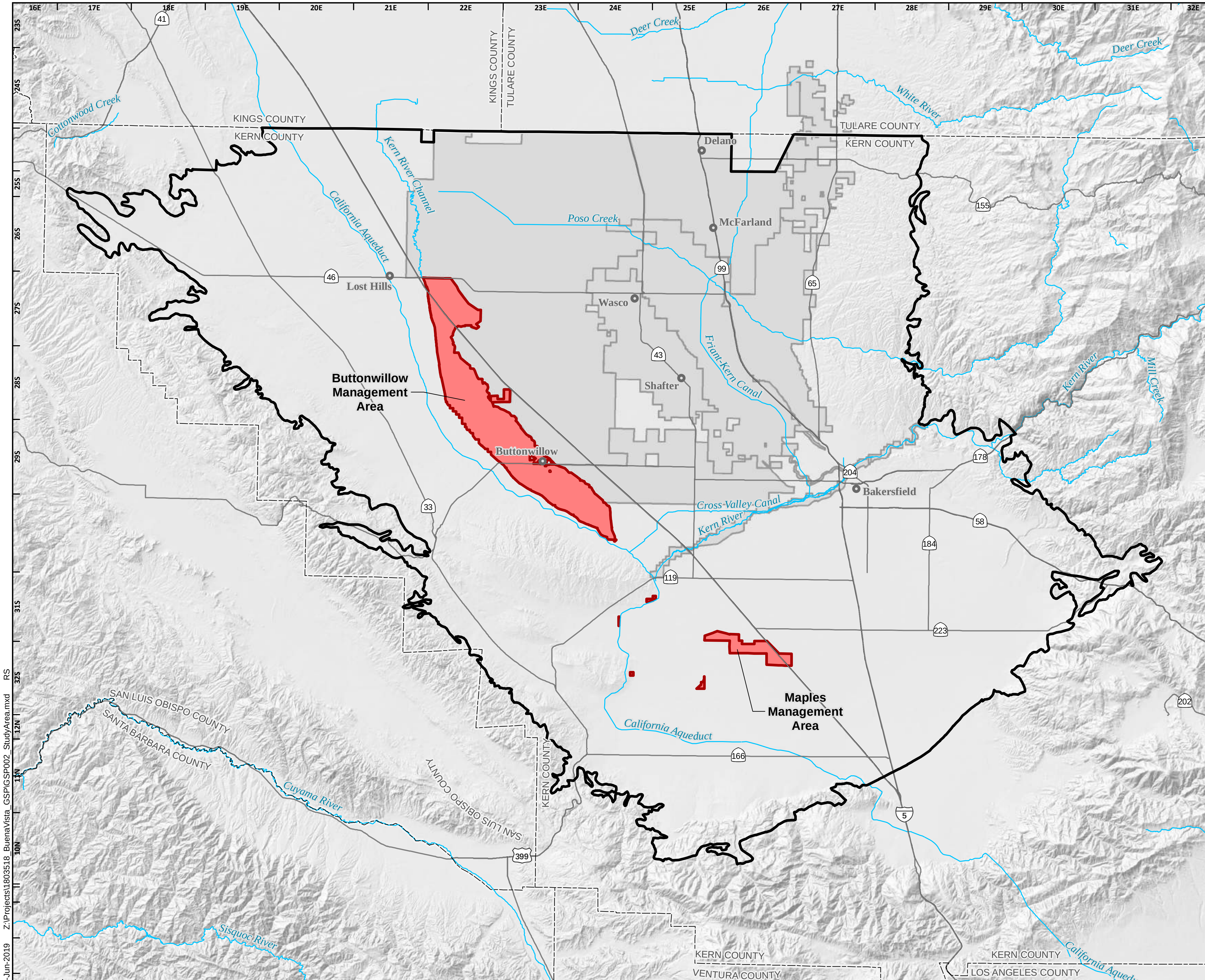
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 DRAFT APPENDIX G

04-Sep-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP048_GSP_Areas_KernSubbasin.mxd RS/SI

Figures Tab



BVGSA BOUNDARIES

GSA Boundaries

- Buena Vista GSA
- Water District
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway

0 4 8 16
Miles

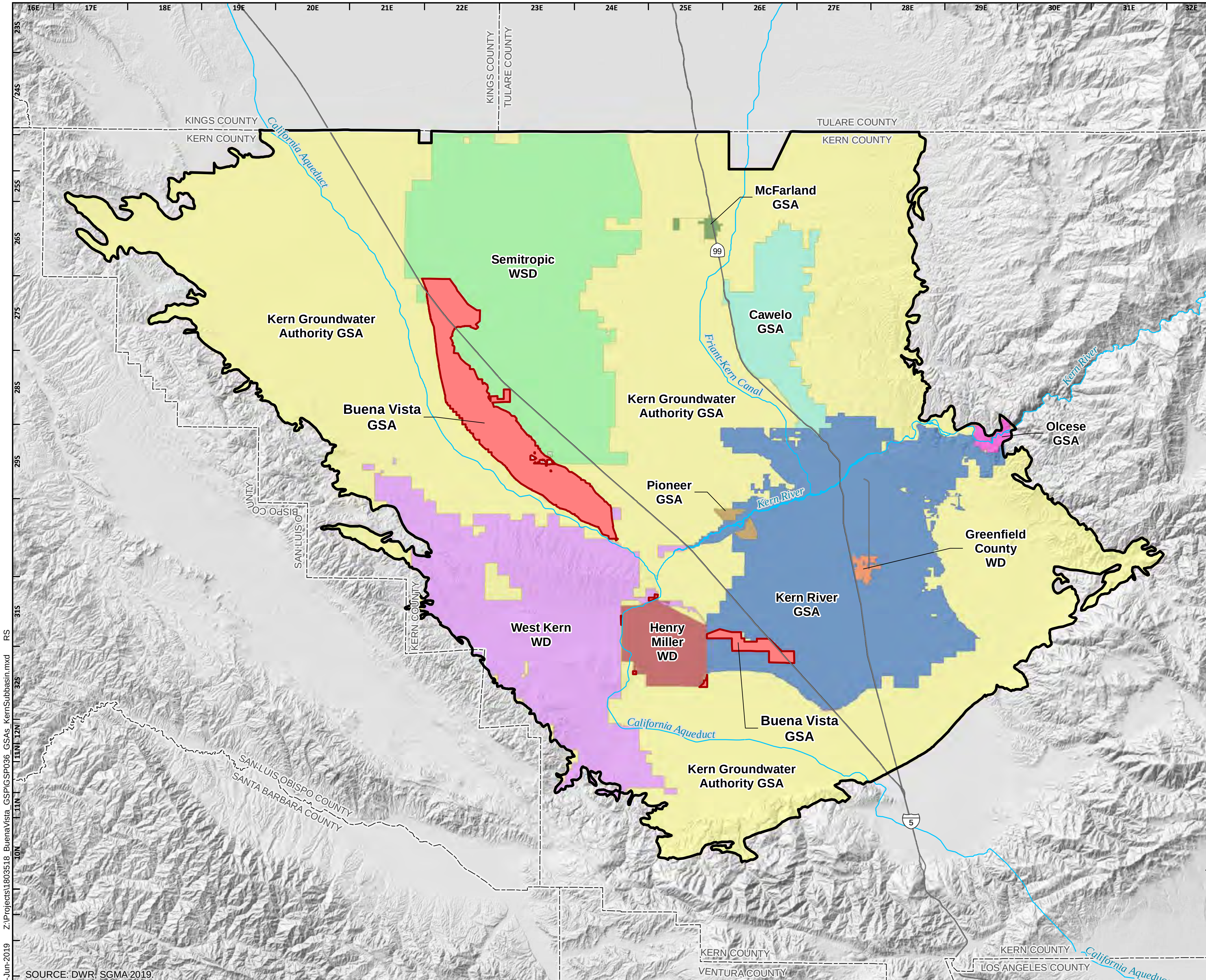
N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 1-1

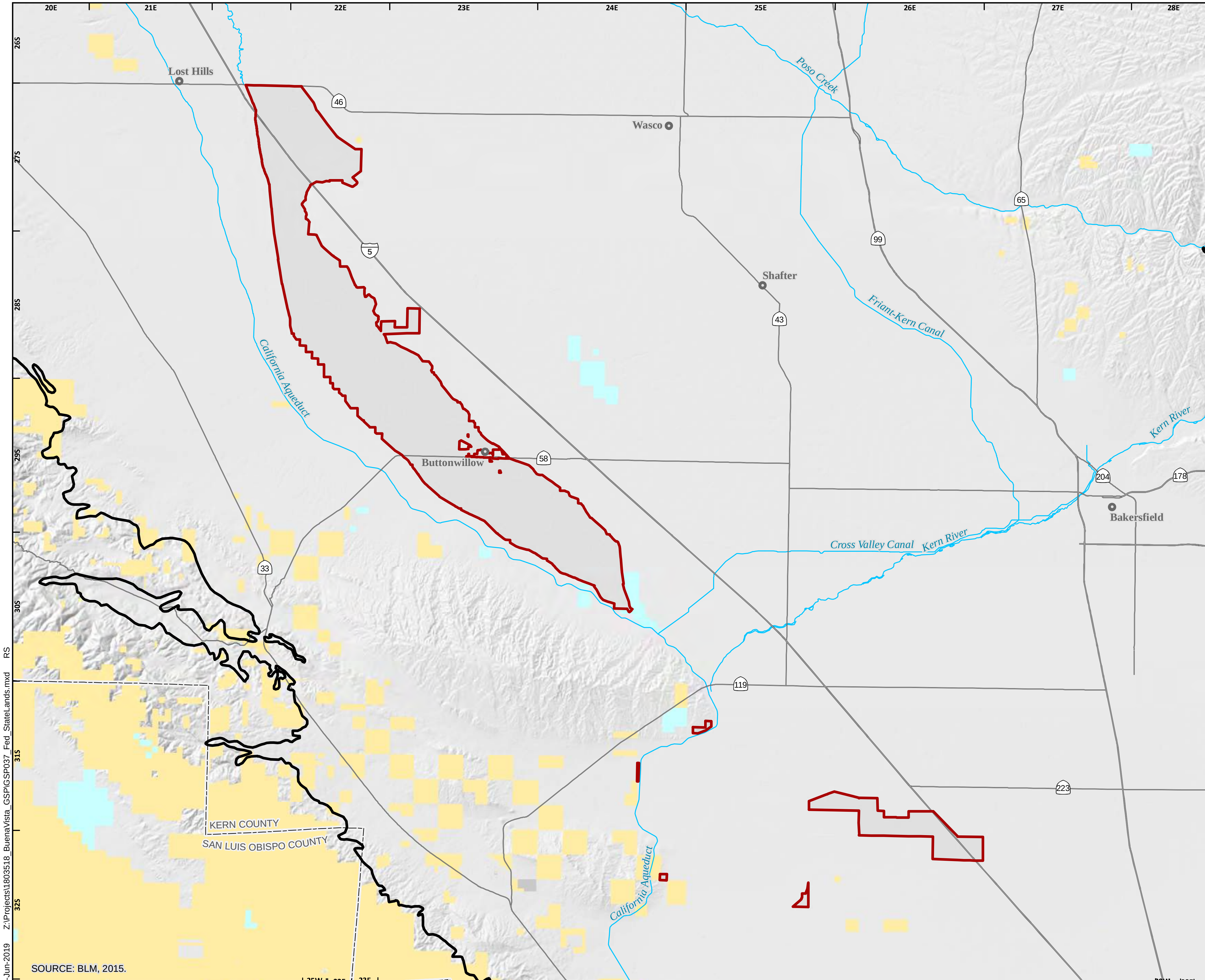


Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 DRAFT FIGURE 1-2

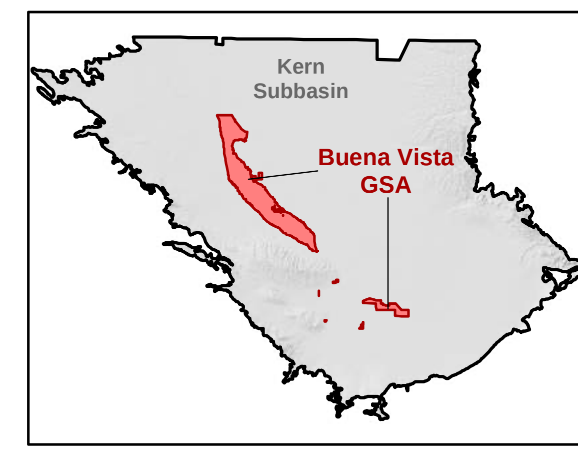


FEDERAL AND STATE LANDS WITHIN BVGSA

Government Lands
- Bureau of Land Management
- Other Federal
- State
- Local Government

GSA Boundaries
- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features
- Highway
- Waterway



0 2 4 8
Miles
N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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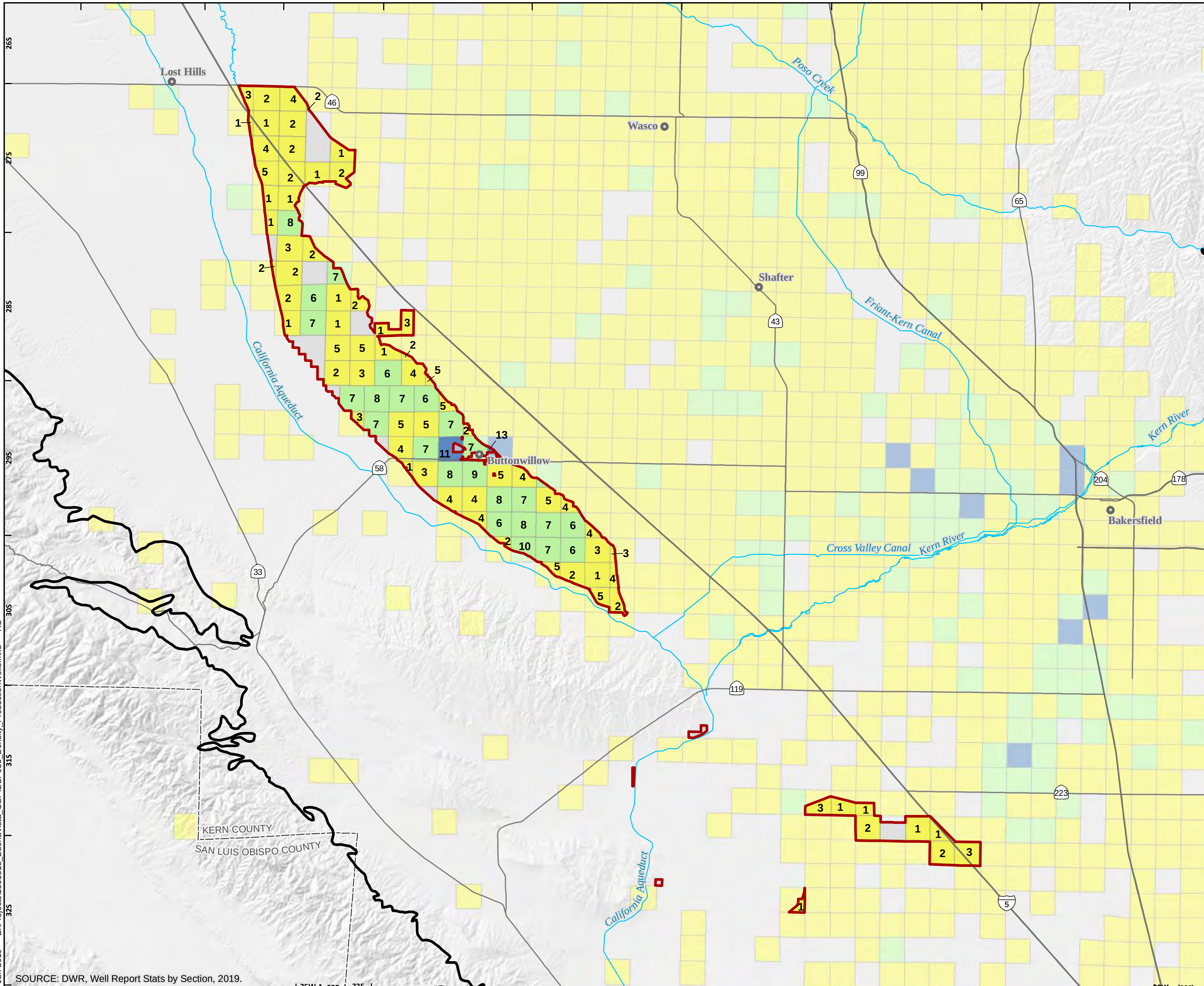
SEPTEMBER 2019 **DRAFT** FIGURE 1-3

DENSITY OF PRODUCTION WELLS PER SQUARE MILE



SOURCE: DWR, Well Report Stats by Section, 2019.

Density of Production Wells per Square Mile

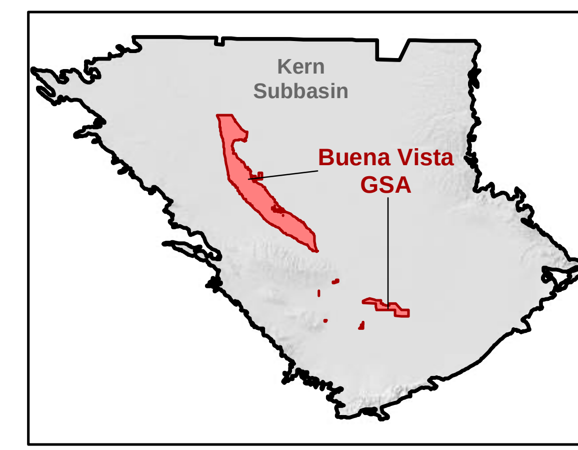
- > 10
- 6 - 10
- 1 - 5

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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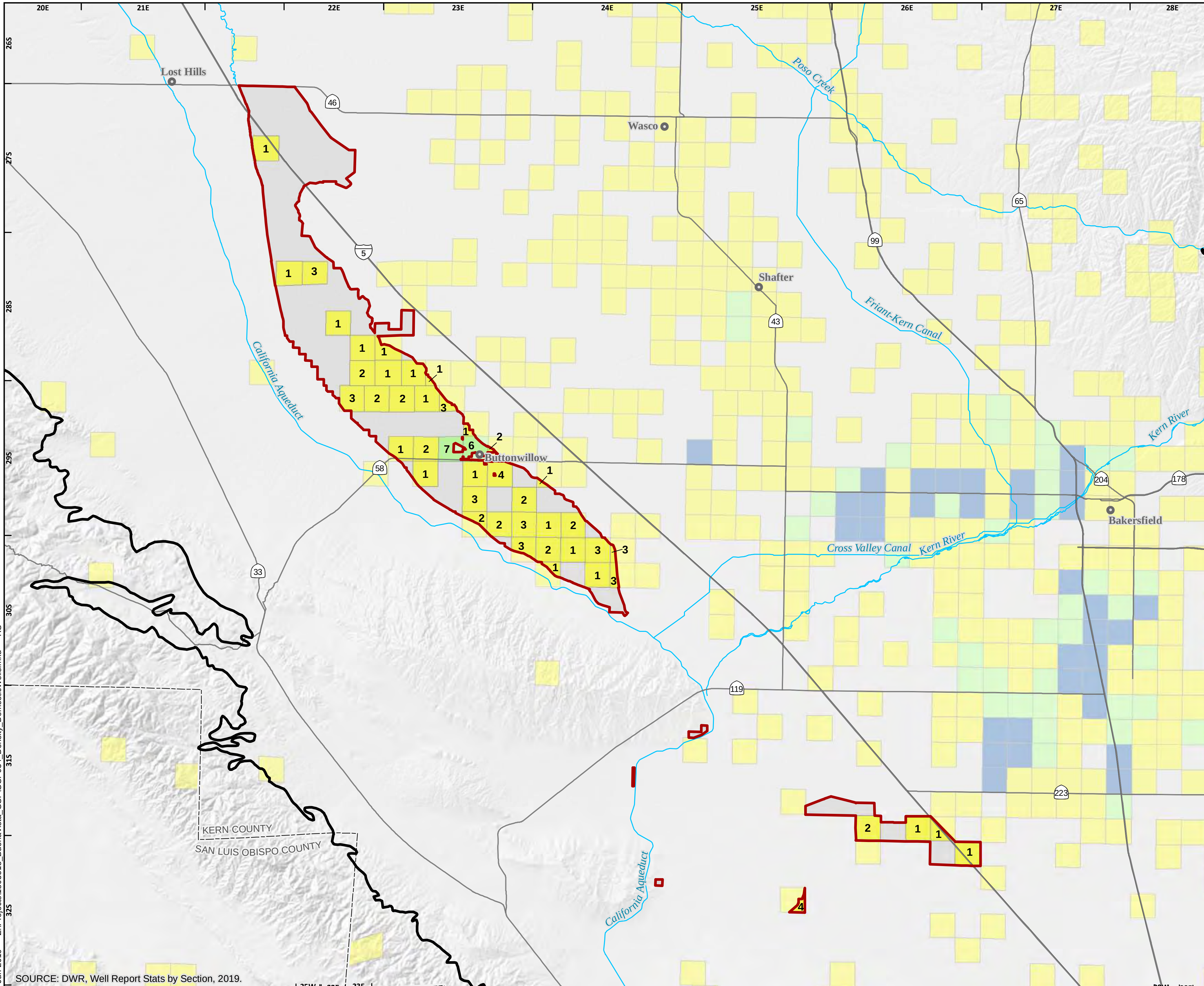
SEPTEMBER 2019 **DRAFT** FIGURE 1-4A

18-Jun-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP033_Density_ProductionWells.mxd RS

DENSITY OF DOMESTIC WELLS PER SQUARE MILE

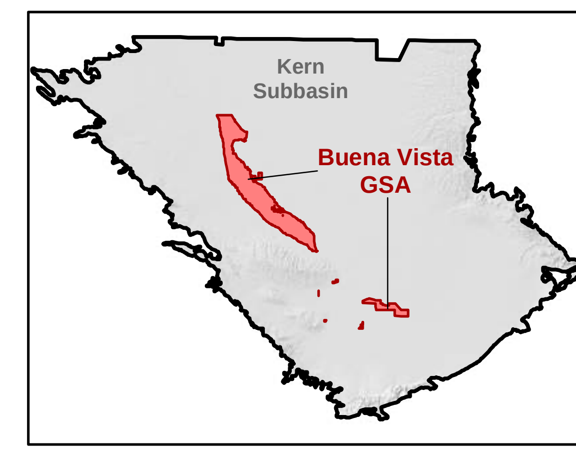


SOURCE: DWR, Well Report Stats by Section, 2019.

Density of Domestic Wells per Square Mile
- > 10
- 6 - 10
- 1 - 5

GSA Boundaries
- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features
- Highway
- Waterway



0 2 4 8
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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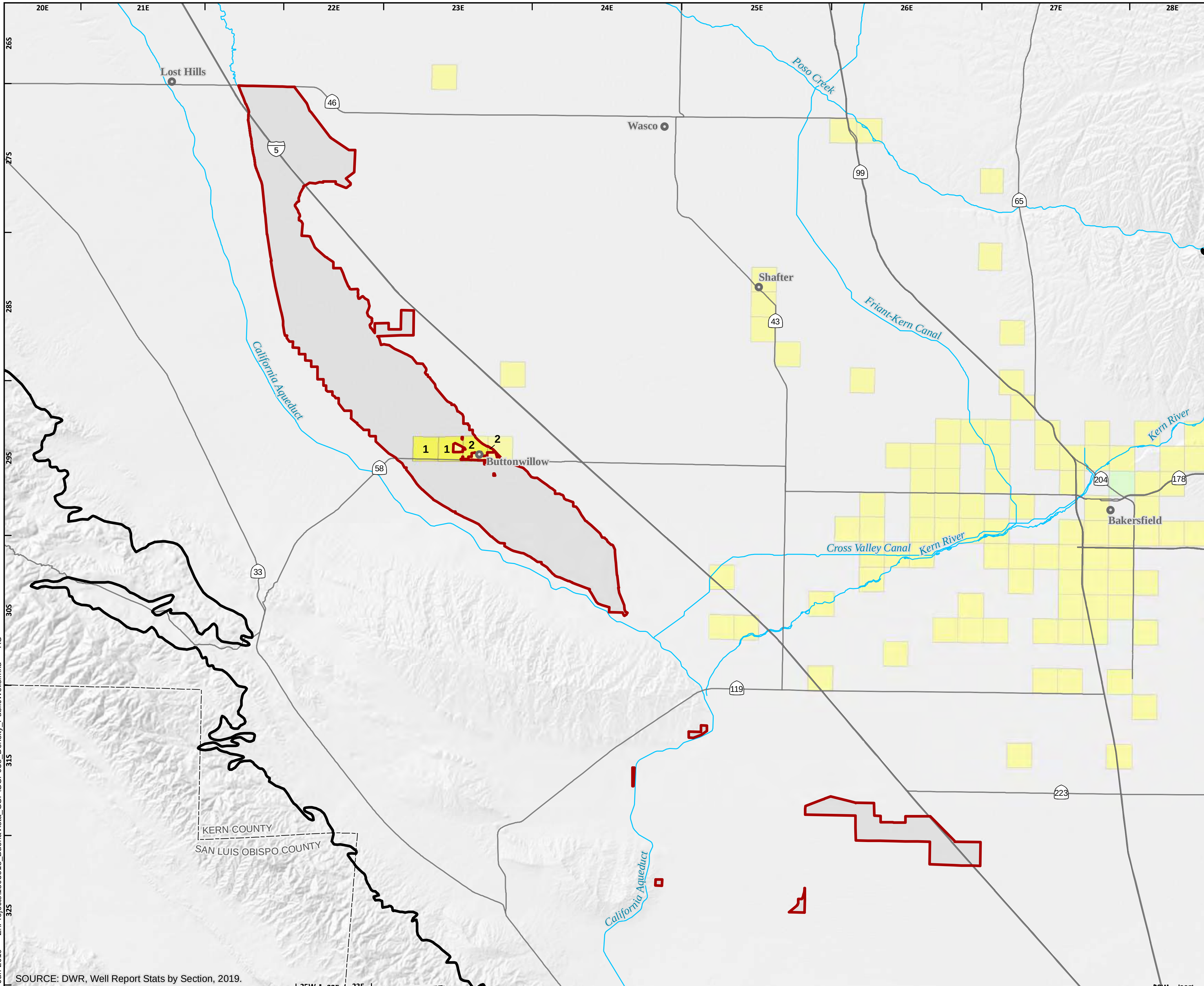
SEPTEMBER 2019 **DRAFT** FIGURE 1-4B

18-Jun-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP034_Density_DomesticWells.mxd RS

DENSITY OF MUNICIPAL WELLS PER SQUARE MILE



Density of Municipal Wells per Square Mile

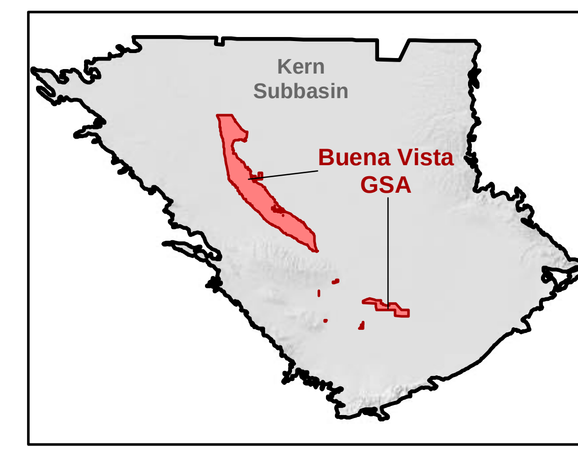
- > 10
- 6 - 10
- 1 - 5

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8
Miles
N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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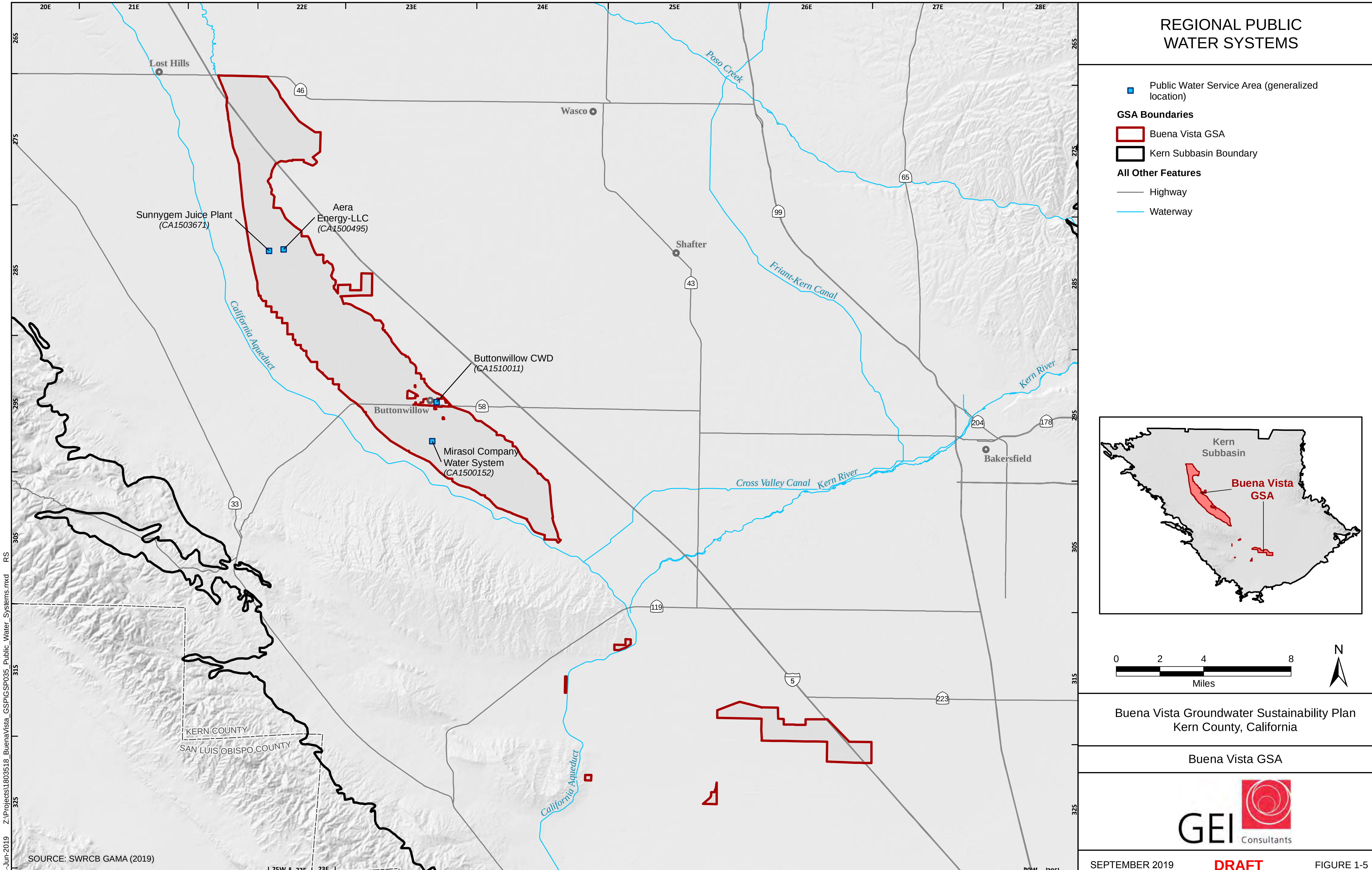
SEPTEMBER 2019 **DRAFT** FIGURE 1-4C



REGIONAL PUBLIC WATER SYSTEMS

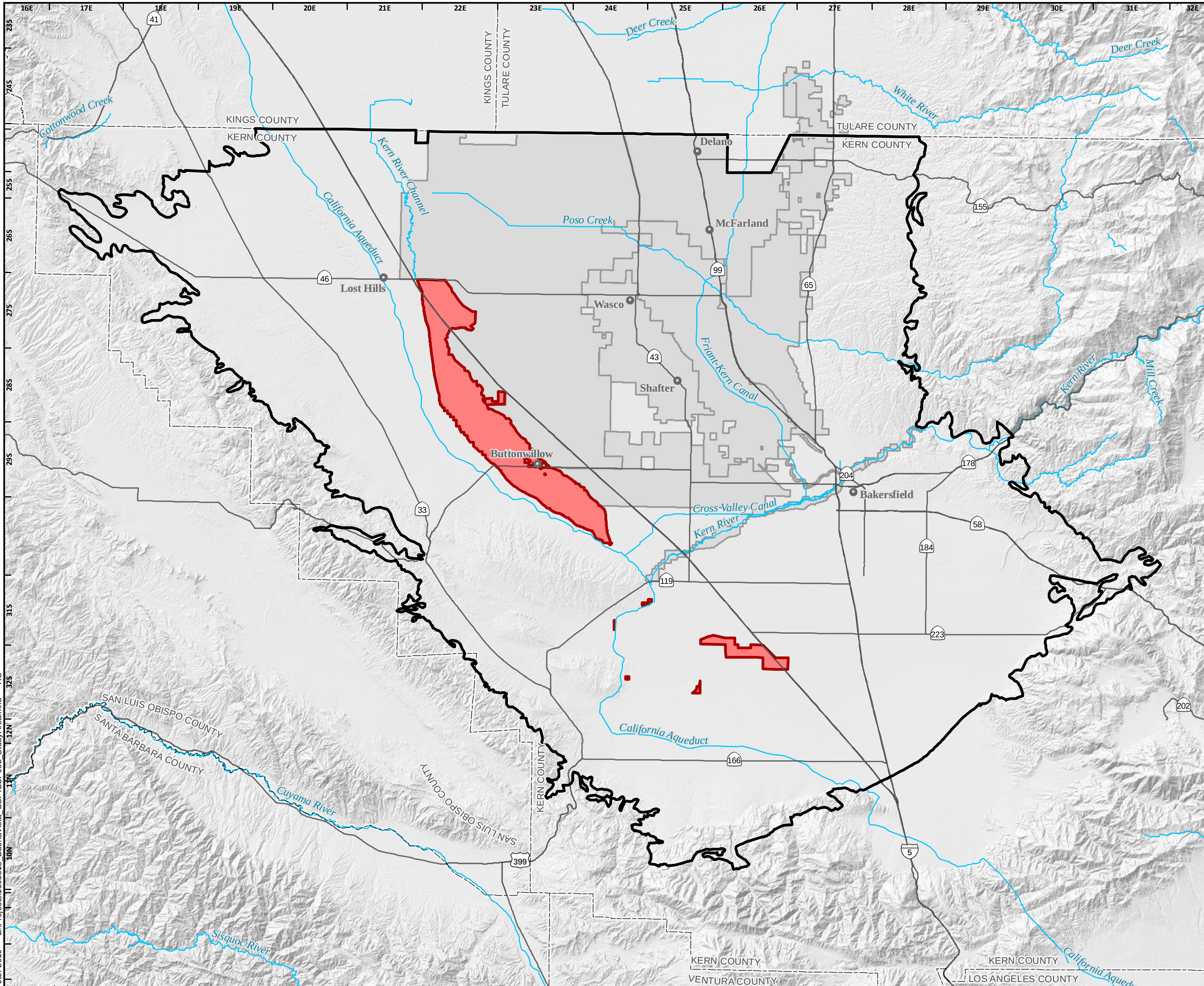
Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 DRAFT FIGURE 1-5

STUDY AREA



GSA Boundaries

- Buena Vista GSA
- Water District
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway

0 4 8 16
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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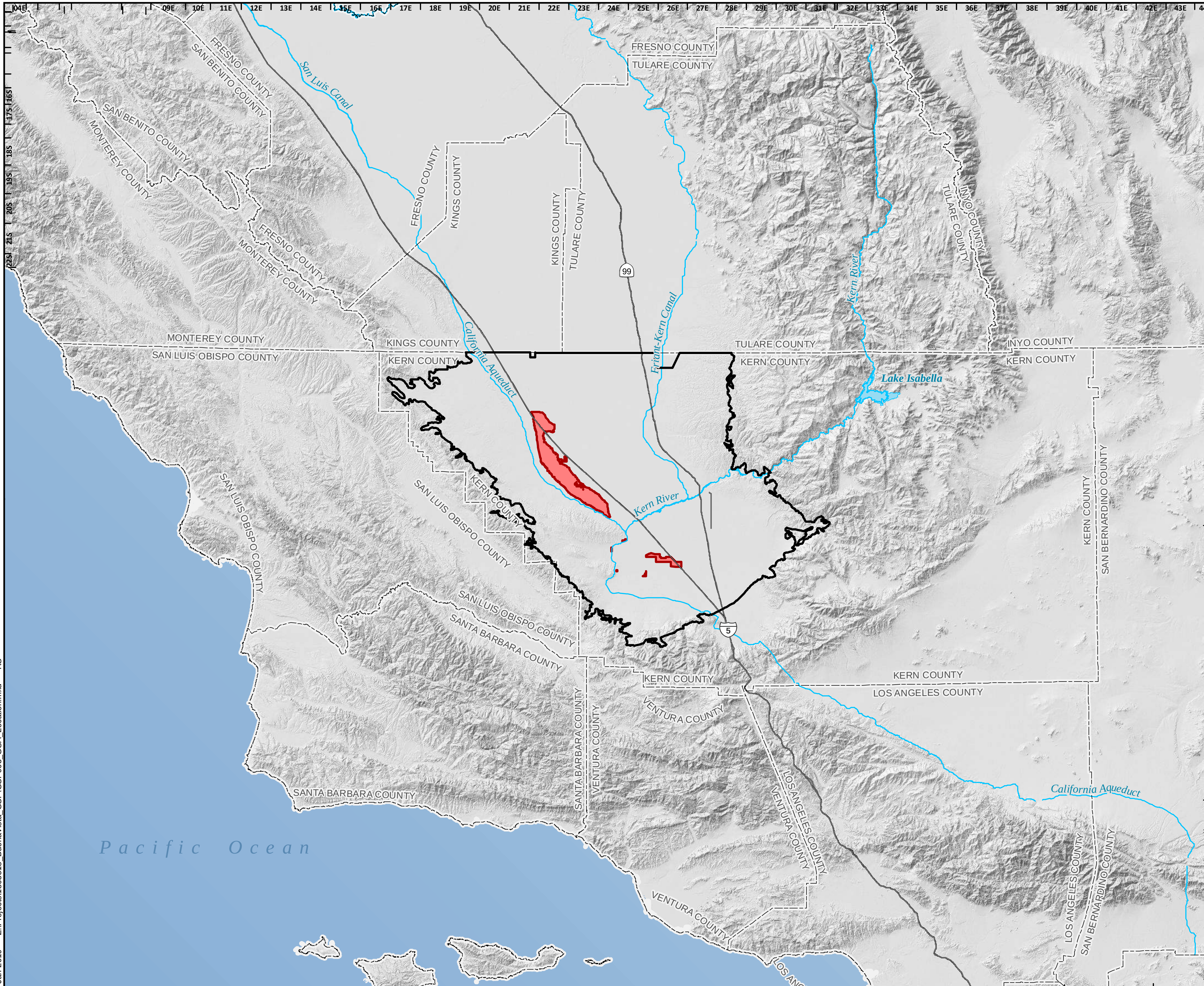
SEPTEMBER 2019 DRAFT FIGURE 2-1

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP002_StudyArea.mxd RS

BUENA VISTA GSA LOCATION

GSA Boundaries
- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features
- Highway
- Waterway
- Lake



Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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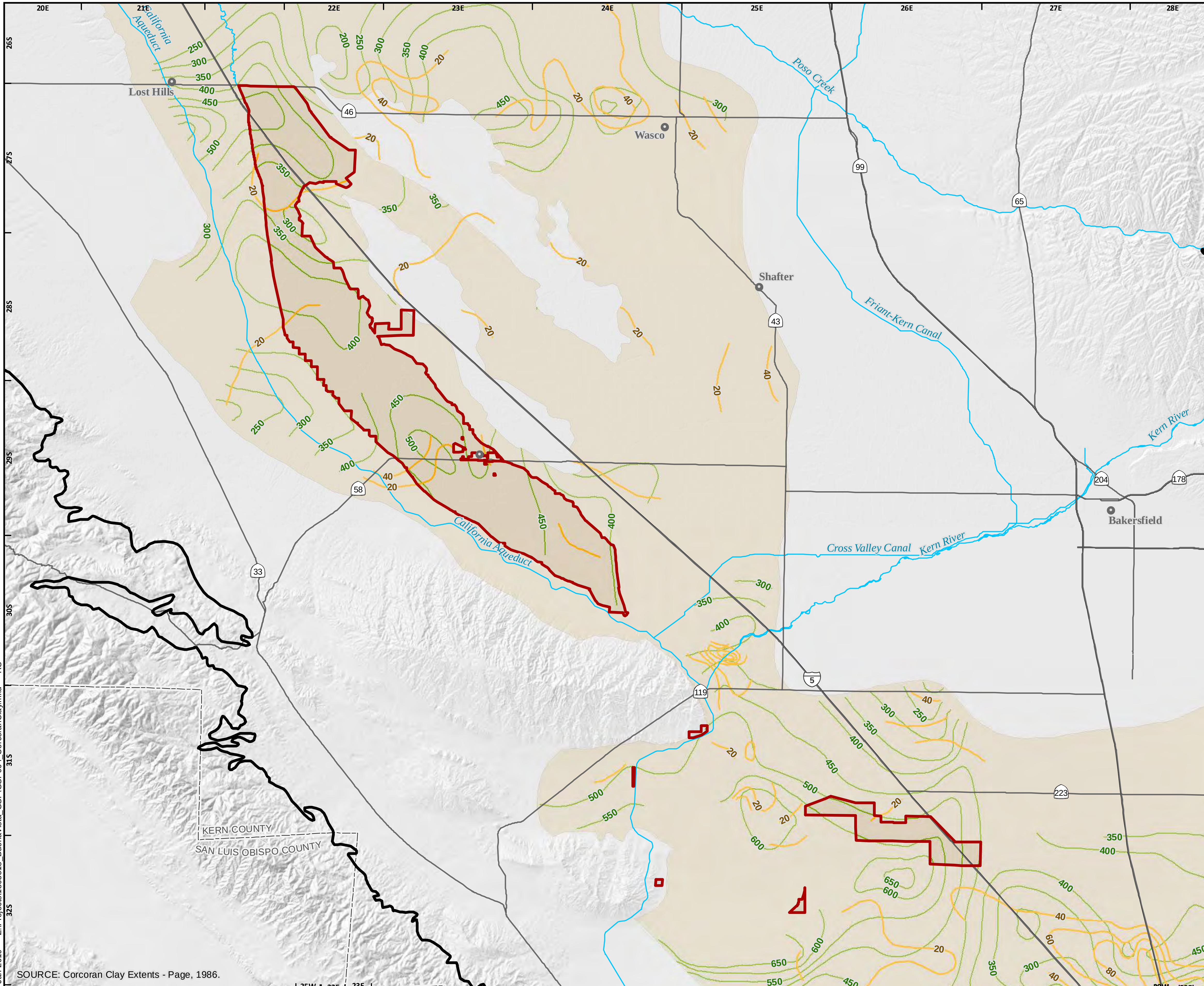
SEPTEMBER 2019 **DRAFT** FIGURE 2-2

22-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP003_GSA_Location.mxd RS



APPROXIMATE THICKNESS AND EXTENT OF CORCORAN CLAY

- USGS Corcoran Clay Thickness (ft)
- USGS Corcoran Clay Depth (ft)
- USGS Extent of Corcoran Clay

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway

0 2 4 8 Miles

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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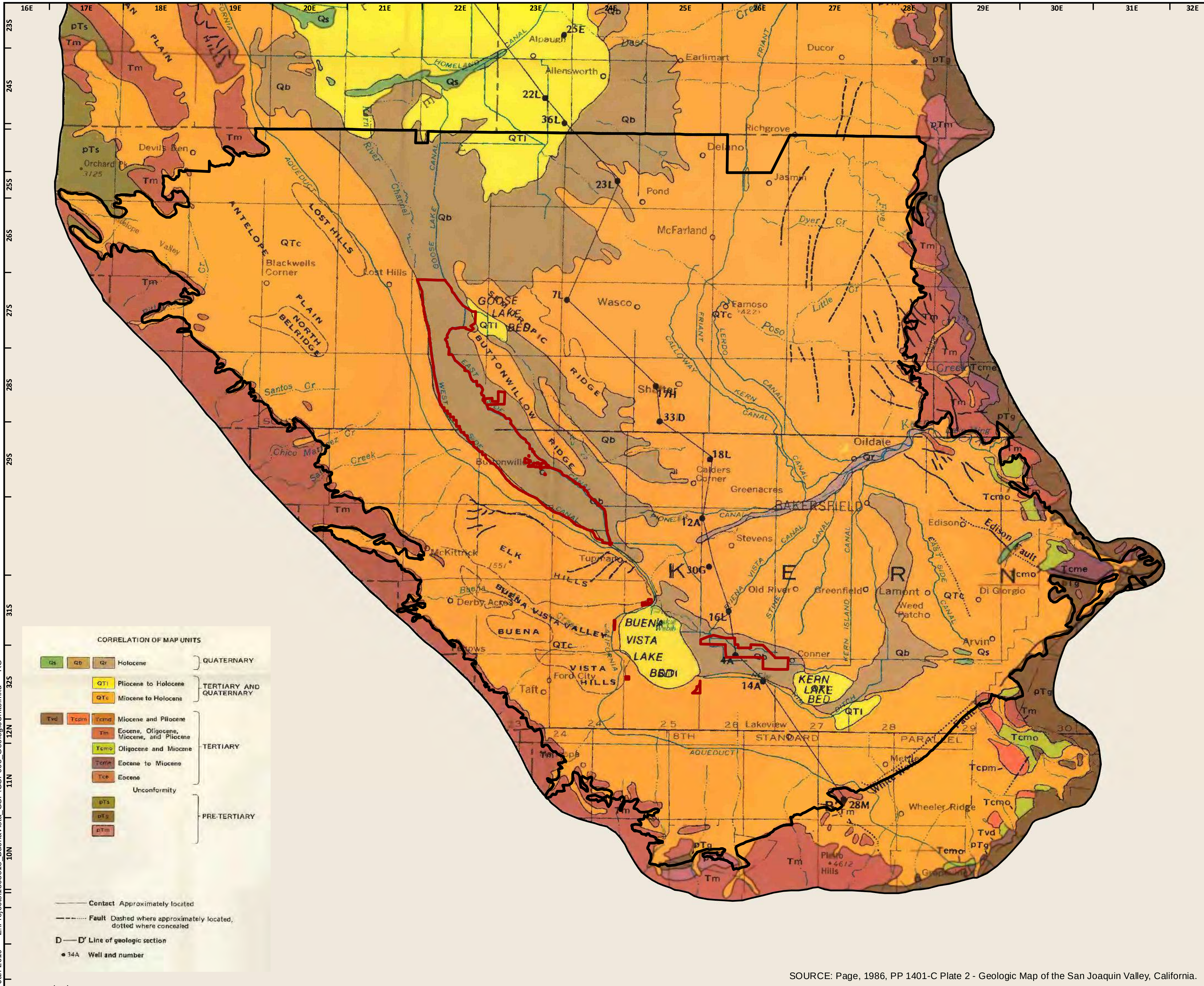
SEPTEMBER 2019 **DRAFT** FIGURE 2-3

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP004_CorcoranClay.mxd RS



GEOLOGIC UNITS

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

DESCRIPTION OF MAP UNITS

Qs **Sand dunes (Holocene)** Windblown sand and dune sand

Qb **Flood-basin deposits (Holocene)** Clay, silt, and some sand; near Stockton consist of muck, peat, and other organic soils. In places may include part of the Modesto Formation (Pleistocene)

Qr **River deposits (Holocene)** Gravel, sand, silt, and minor amounts of clay; deposited along channels, flood plains, and natural levees of main streams. In places may include part of Modesto Formation (Pleistocene)

QTl **Lacustrine and marsh deposits (Pliocene to Holocene)** Clay, silt, and some sand; in subsurface include three widespread clays: A clay (Pleistocene and Holocene?); C clay (Pleistocene); and modified E clay (Pleistocene), includes Corcoran Clay Member of Tulare and Turlock Lake Formations

QTc **Continental rocks and deposits (Miocene to Holocene)** Heterogeneous mix of generally poorly sorted clay, silt, sand, and gravel; some beds of claystone, siltstone, sandstone, and conglomerate. Include some informal units: younger alluvium (Holocene), older alluvium (Pleistocene and Holocene?) and continental deposits (Pliocene and Pleistocene); three formations of Pleistocene age: Modesto, Riverbank, and Turlock Lake; Tulare Formation (Pliocene and Pleistocene) on western side of valley, Laguna Formation (Pliocene) on eastern side, and Kern River Formation (Miocene to Pleistocene?) on southeastern part

Tvd **Volcanic rocks and deposits (Miocene and Pliocene)** Massive tuff with large fragments of vesicular basalt northwest of Tracy; tuff, and volcanic breccia at south end of valley

Tcpm **Continental rocks and deposits (Miocene and Pliocene)** Gravel, sand, silt, clay, conglomerate, sandstone, siltstone, and claystone, contain andesitic material. Principally Mehrten Formation (Miocene and Pliocene) on eastern side of valley; include continental equivalents of Etchegoin Formation (Miocene and Pliocene) on western side of valley, and Chanac Formation (Miocene) on southern part

Tcmd **Continental and marine rocks and deposits (Miocene and Pliocene)** Gravel, sand, silt, clay, silty sandstone, and siltstone. Include continental and marine equivalents of San Joaquin Formation (Pliocene) and Etchegoin Formation (Miocene and Pliocene)

Tm **Marine rocks and deposits (Eocene, Oligocene, Miocene, and Pliocene)** Sand, clay, silt, sandstone, shale, mudstone, and siltstone. On western side of valley include the San Joaquin and Etchegoin Formations, Temblor Formation (Oligocene and Miocene) and Kreyenhagen Formation (Eocene). On southeastern side include the Santa Margarita Formation of various authors, the Round Mountain Silt, the Olcese Sand, the Freeman Silt, and the Jewett Sand (including the Pyramid Hill Sand Member) (all Miocene), and the Vedder Sand (Oligocene)

Tcmo **Continental rocks and deposits (Oligocene and Miocene)** Gravel, conglomerate, sand, tuffaceous sand, clay, and sandy clay; contain rhyolitic material on eastern side of valley. Principally Valley Springs Formation (Oligocene and Miocene) on eastern side of valley; unnamed fanglomerates (Miocene) and Bena Gravel (Miocene) in the southern part

Tcme **Continental rocks and deposits (Eocene to Miocene)** Conglomerate, sandstone, consolidated fanglomerate, claystone, tuff and tuff breccia; near Fresno consist of tuffaceous sand and gravel. Near Bakersfield include the Bealville Fanglomerate (Oligocene and Miocene) and the Walker Formation (Eocene to Miocene)

Tce **Continental rocks and deposits (Eocene)** Conglomerate and sandstone; along eastern side of valley contain anauxite. Principally Ione Formation (Eocene) on eastern side of valley

Unconformity

pTs **Marine rocks (Pre-Tertiary)** Sandstone, shale, siltstone, and some limestone, chiefly on western side of valley; in places contain abundant secondary gypsum. Include Moreno Formation (Cretaceous and Paleocene) and Panoche Formation (Cretaceous)

pTg **Granitic rocks (Pre-Tertiary)** Chiefly granitic rocks on eastern side of valley, in places consists of mafic intrusive rocks

pTm **Metamorphic rocks (Pre-Tertiary)** Metasedimentary, metavolcanic and other metamorphic rocks on eastern side of valley

0 4 8 16

Miles

N

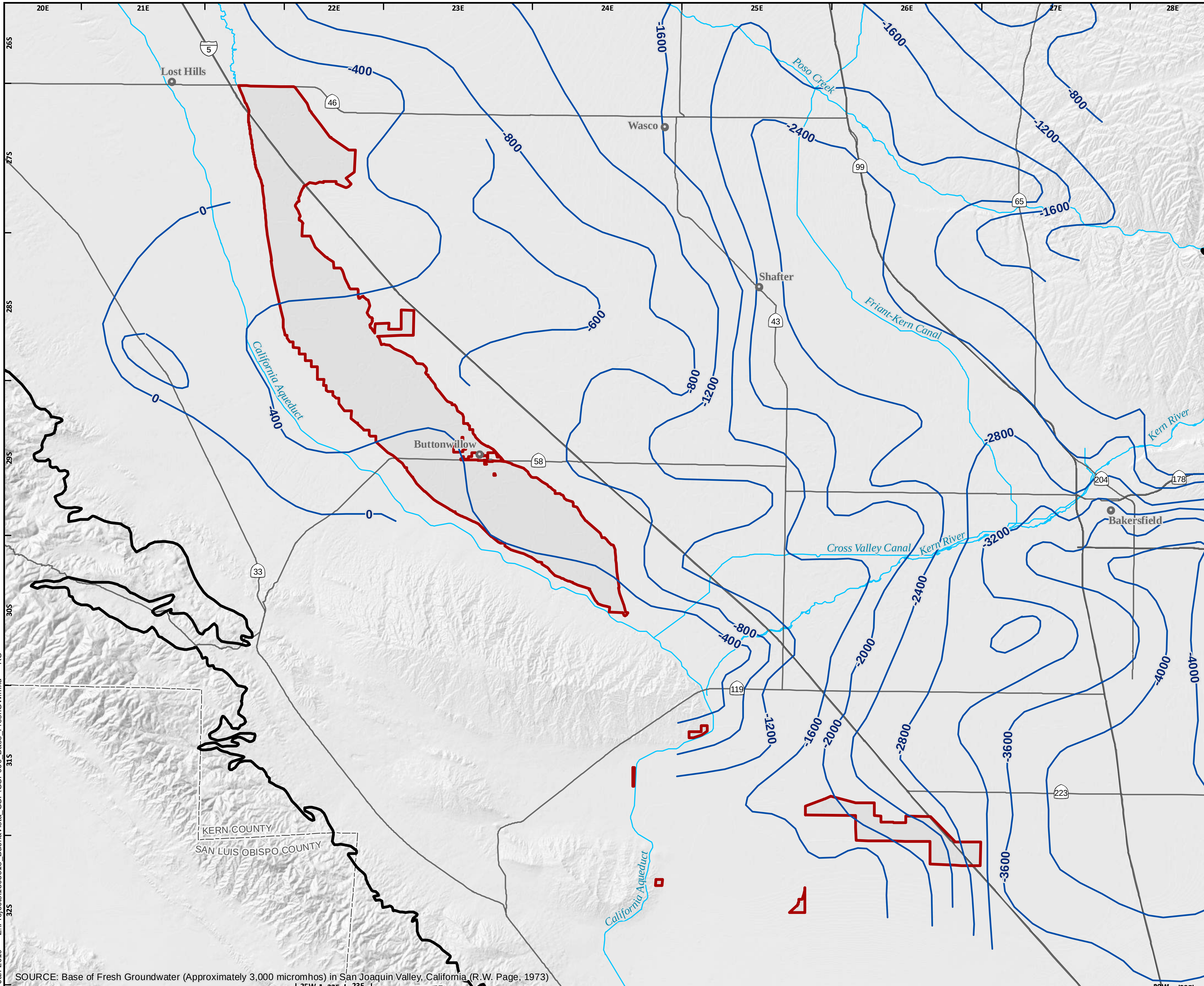
Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-4

BASE OF FRESH GROUNDWATER



Approx. elevation of base of fresh water (ft msl)

GSA Boundaries

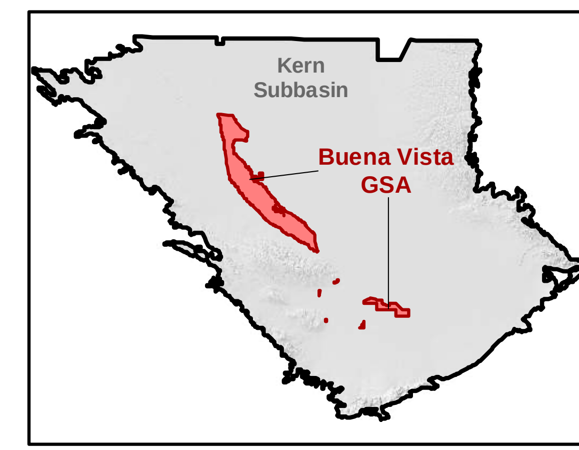
Buena Vista GSA

Kern Subbasin Boundary

All Other Features

Highway

Waterway



0 2 4 8 Miles

N

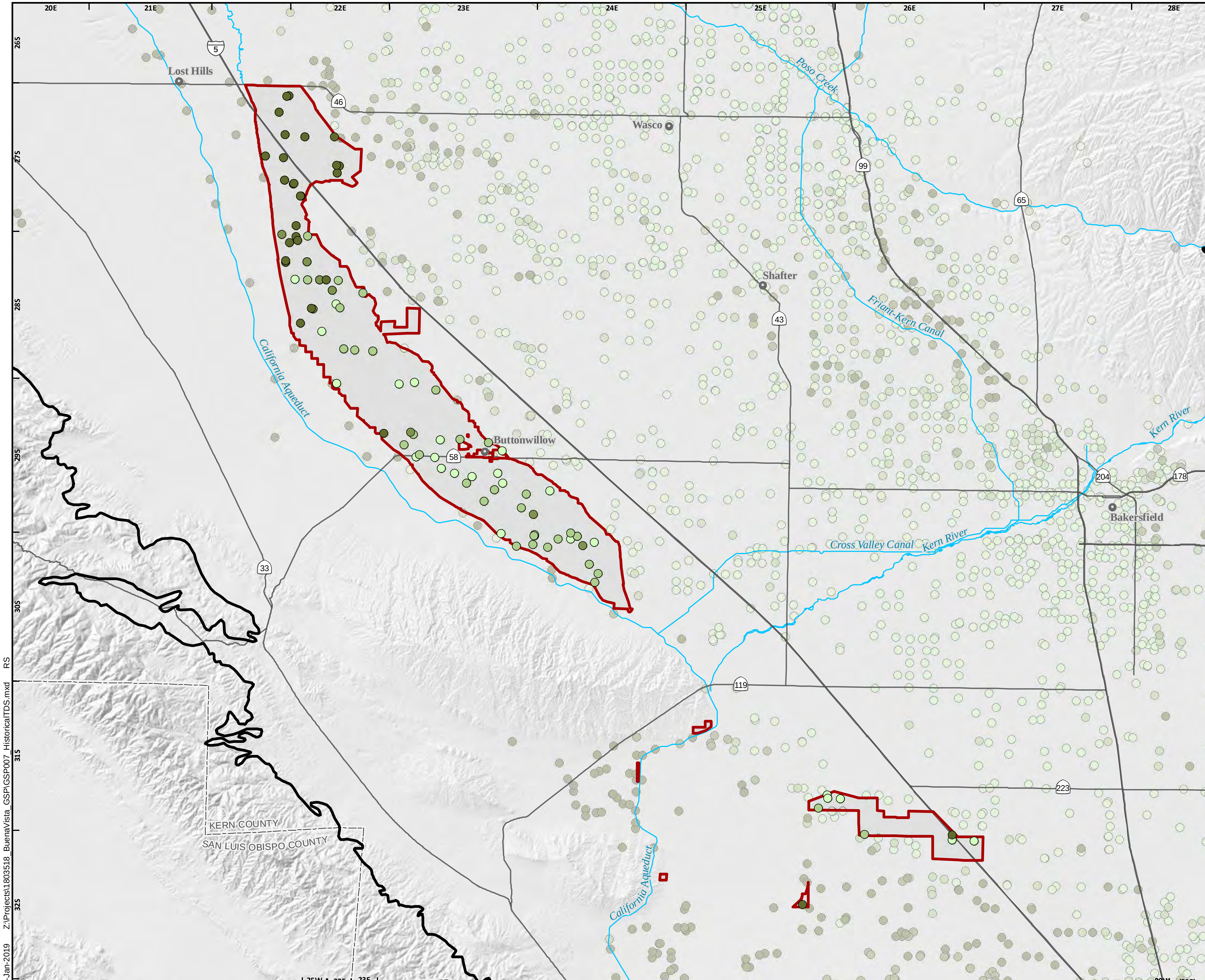
Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 DRAFT FIGURE 2-5

HISTORICAL TDS MONITORING RESULTS (2000 AND EARLIER)



Maximum Concentrations (TDS)

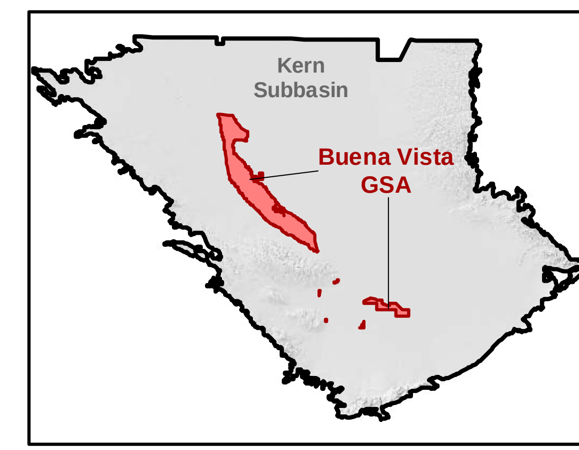
- Recommended Secondary MCL (<= 500 mg/L)
- Upper Secondary MCL (<= 1000 mg/L)
- Short Term MCL (<=1,500 mg/L)
- Above Short Term MCL (>1,500 mg/L)

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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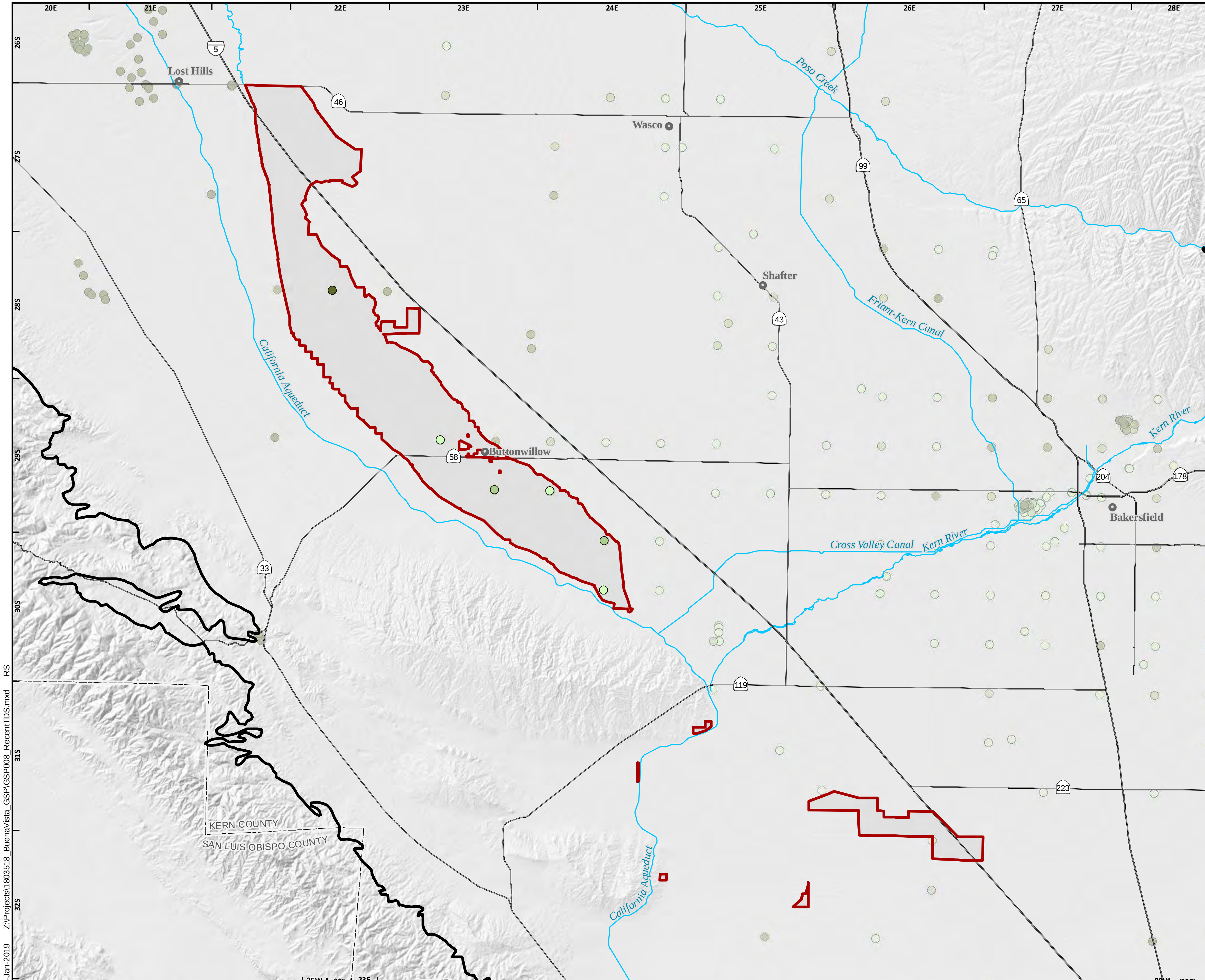
SEPTEMBER 2019 DRAFT FIGURE 2-7

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP007_HistoricalTDS.mxd RS



RECENT TDS MONITORING RESULTS (2001 THROUGH 2017)

Maximum Concentrations (TDS)

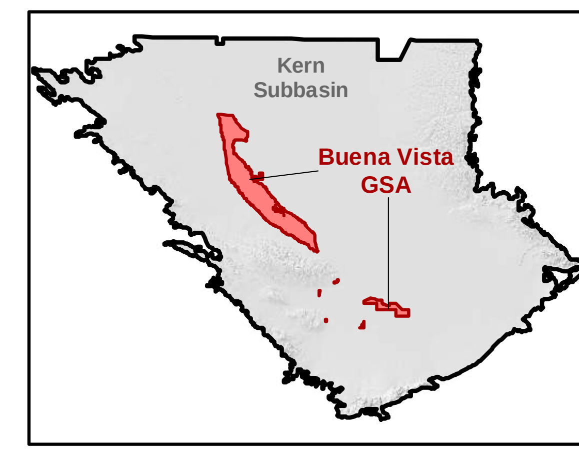
- Recommended Secondary MCL (<= 500 mg/L)
- Upper Secondary MCL (<= 1000 mg/L)
- Short Term MCL (<=1,500 mg/L)
- Above Short Term MCL (>1,500 mg/L)

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8
Miles
N

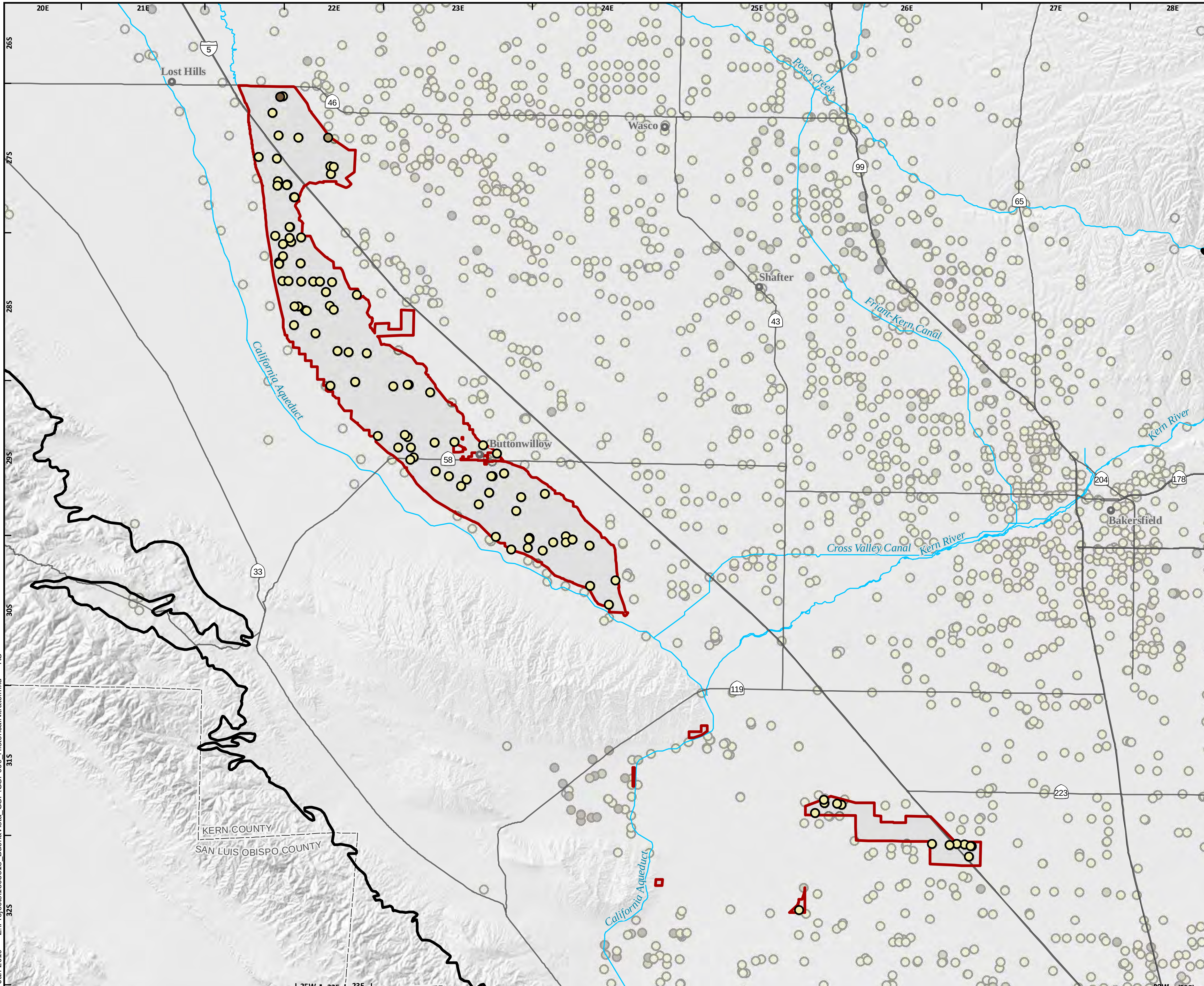
Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 DRAFT FIGURE 2-8

HISTORICAL NITRATE MONITORING RESULTS (2000 AND EARLIER)



Maximum Concentrations (Nitrate as N)

MCL = 10 mg/L

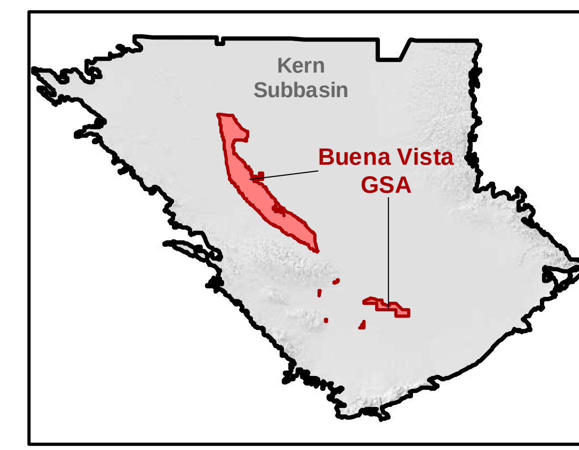
- 0 to 10 mg/L
- 10 to 20 mg/L
- 20+ mg/L

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

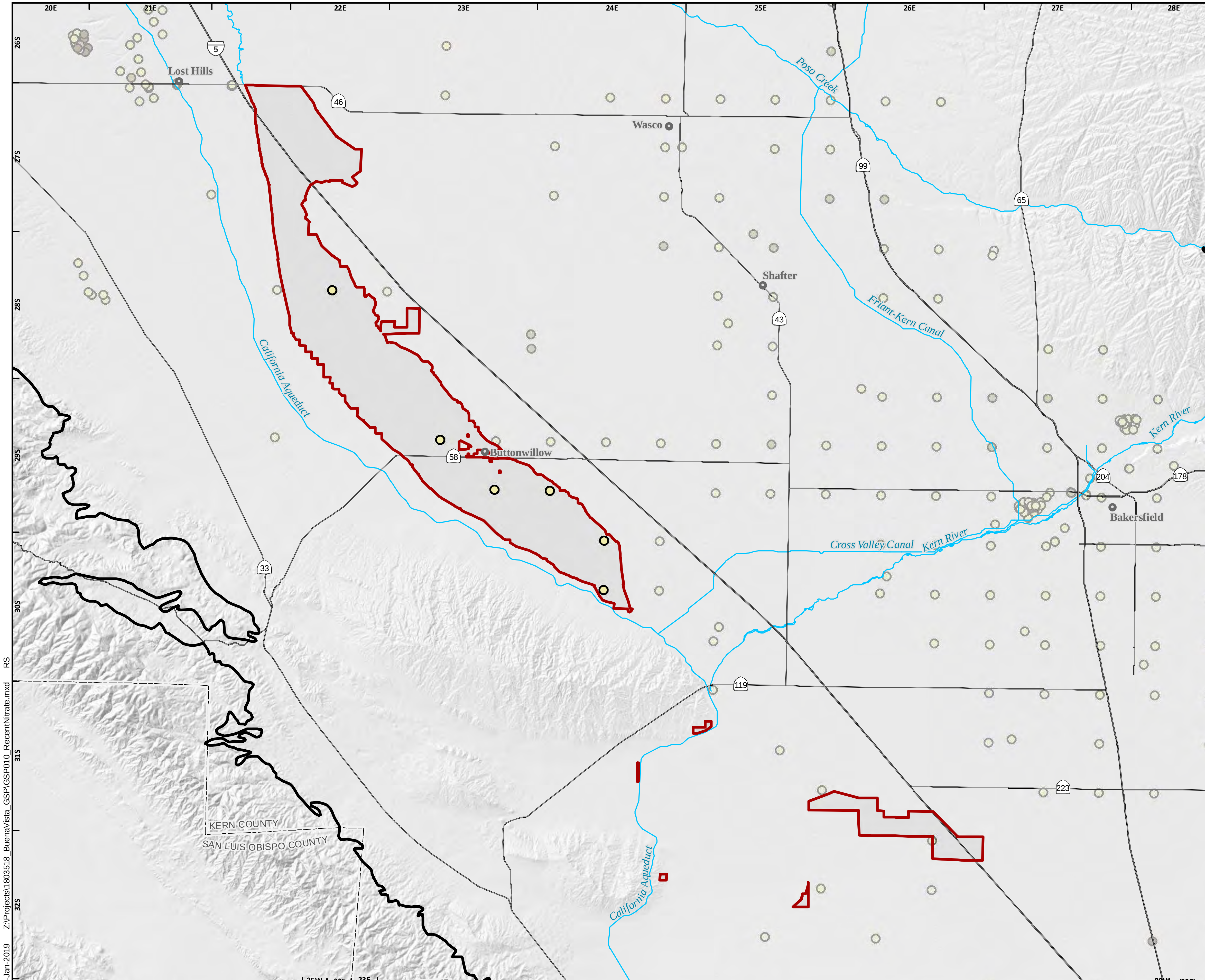
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-9

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP009_HistoricalNitrate.mxd RS

RECENT NITRATE MONITORING RESULTS (2001 THROUGH 2017)



Maximum Concentrations (Nitrate as N)

MCL = 10 mg/L

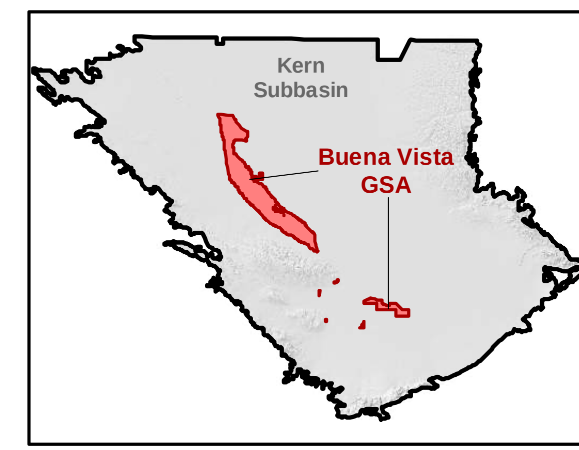
- 0 to 10 mg/L
- 10 to 20 mg/L
- 20+ mg/L

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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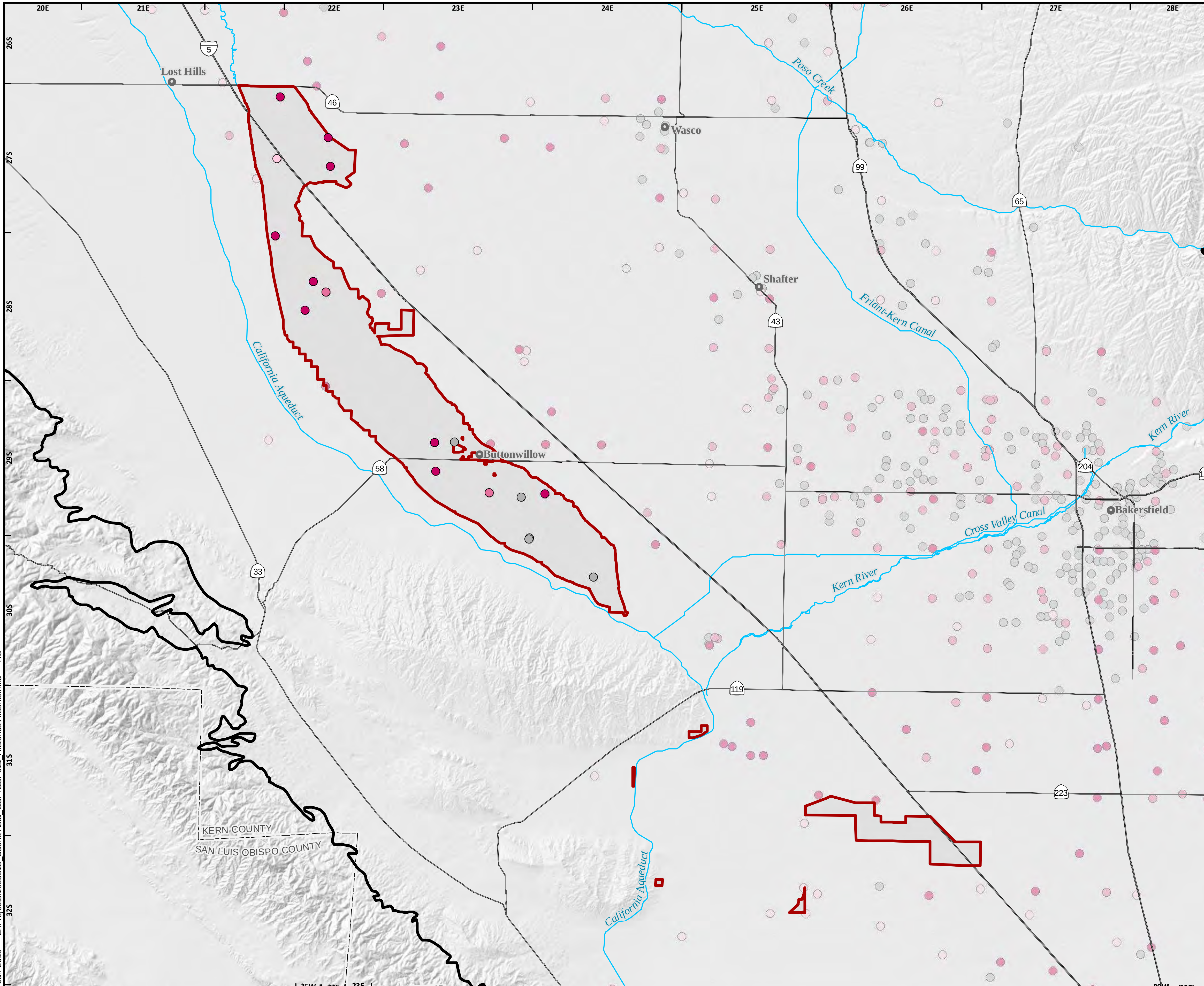
SEPTEMBER 2019 **DRAFT** FIGURE 2-10

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP010_RecentNitrate.mxd RS

HISTORICAL ARSENIC MONITORING RESULTS (2000 AND EARLIER)



Maximum Concentrations (Arsenic)

MCL = 10 ppb

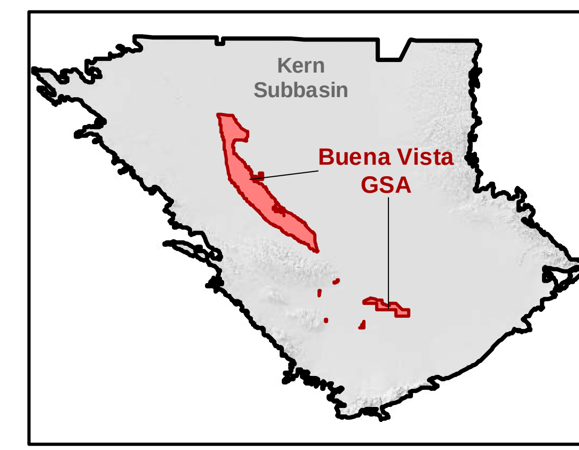
- Non-Detect
- 0 - 5 ppb
- 5 - 10 ppb
- 10+ ppb

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8

Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

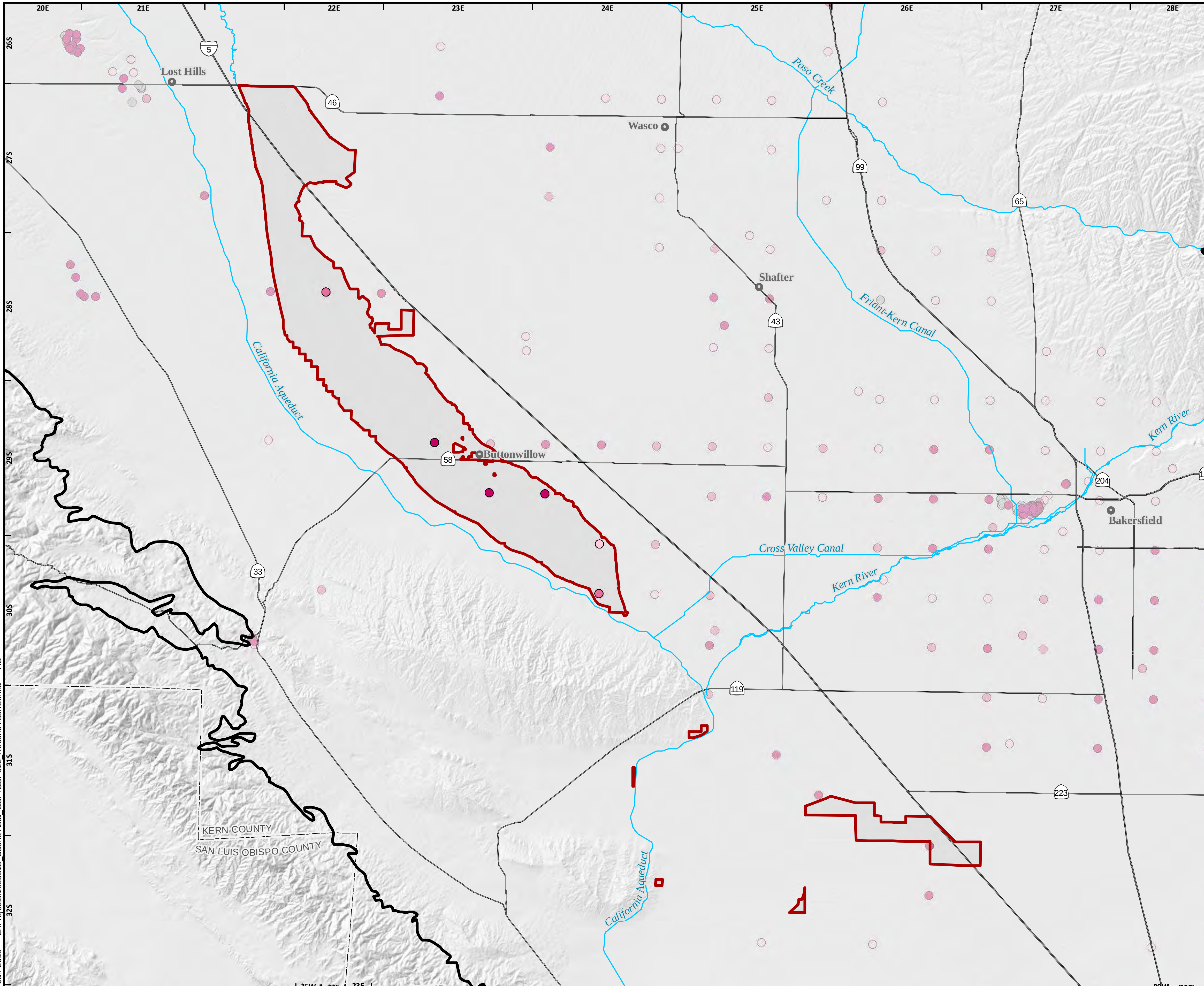
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-11

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP011_HistoricalArsenic.mxd RS

RECENT ARSENIC MONITORING RESULTS (2001 THROUGH 2017)



Maximum Concentrations (Arsenic)

MCL = 10 ppb

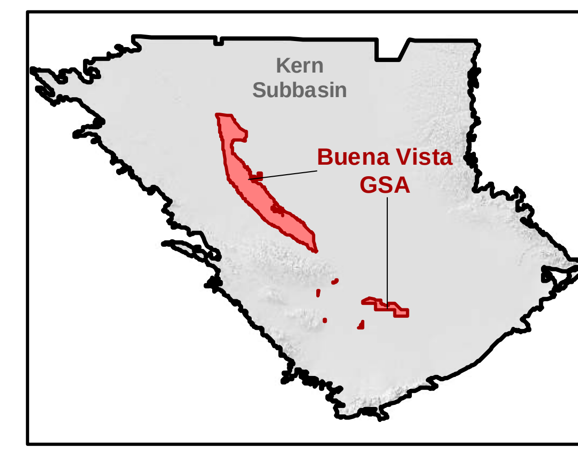
- Non-Detect
- 0 - 5 ppb
- 5 - 10 ppb
- 10+ ppb

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8
Miles

N

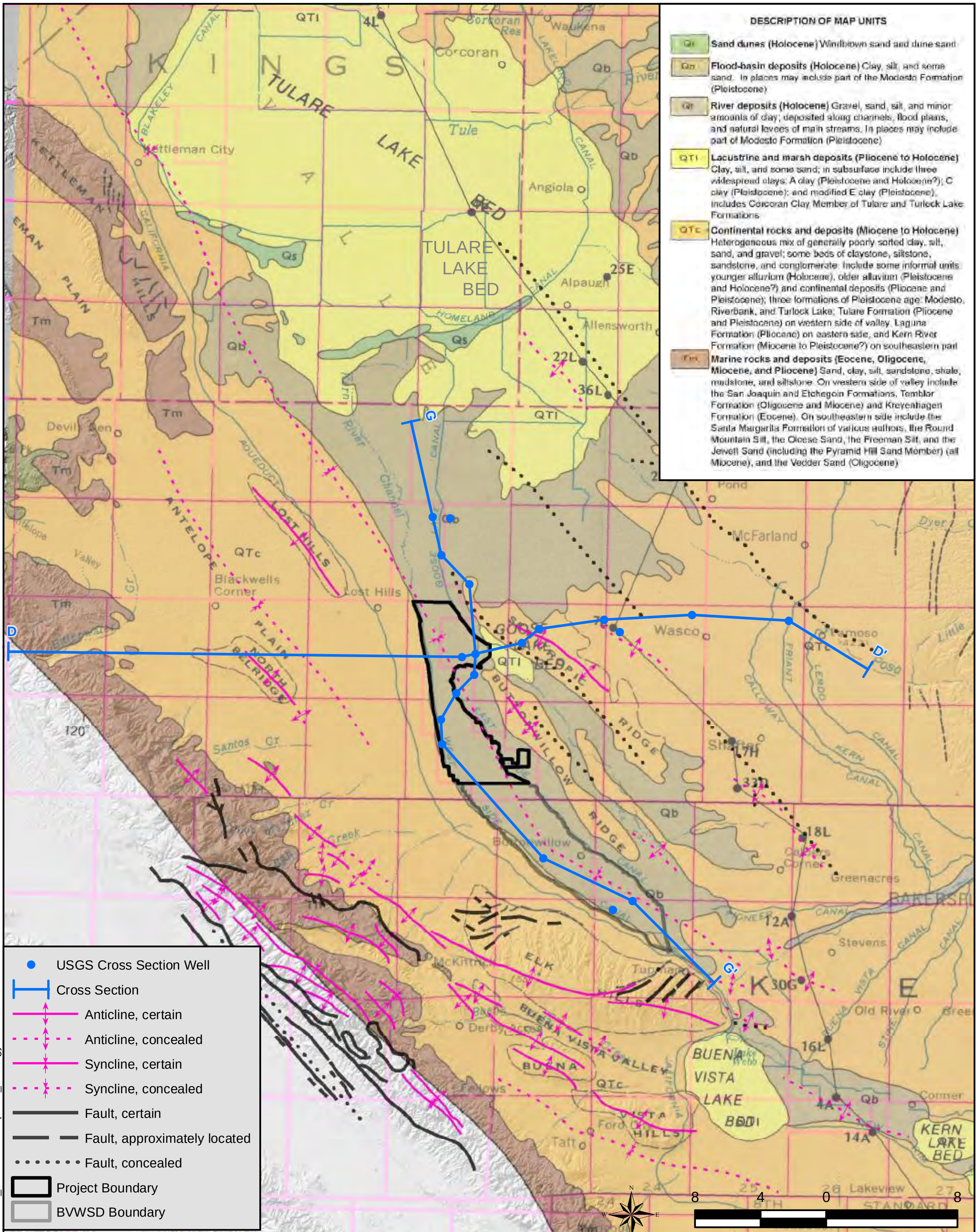
Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-12

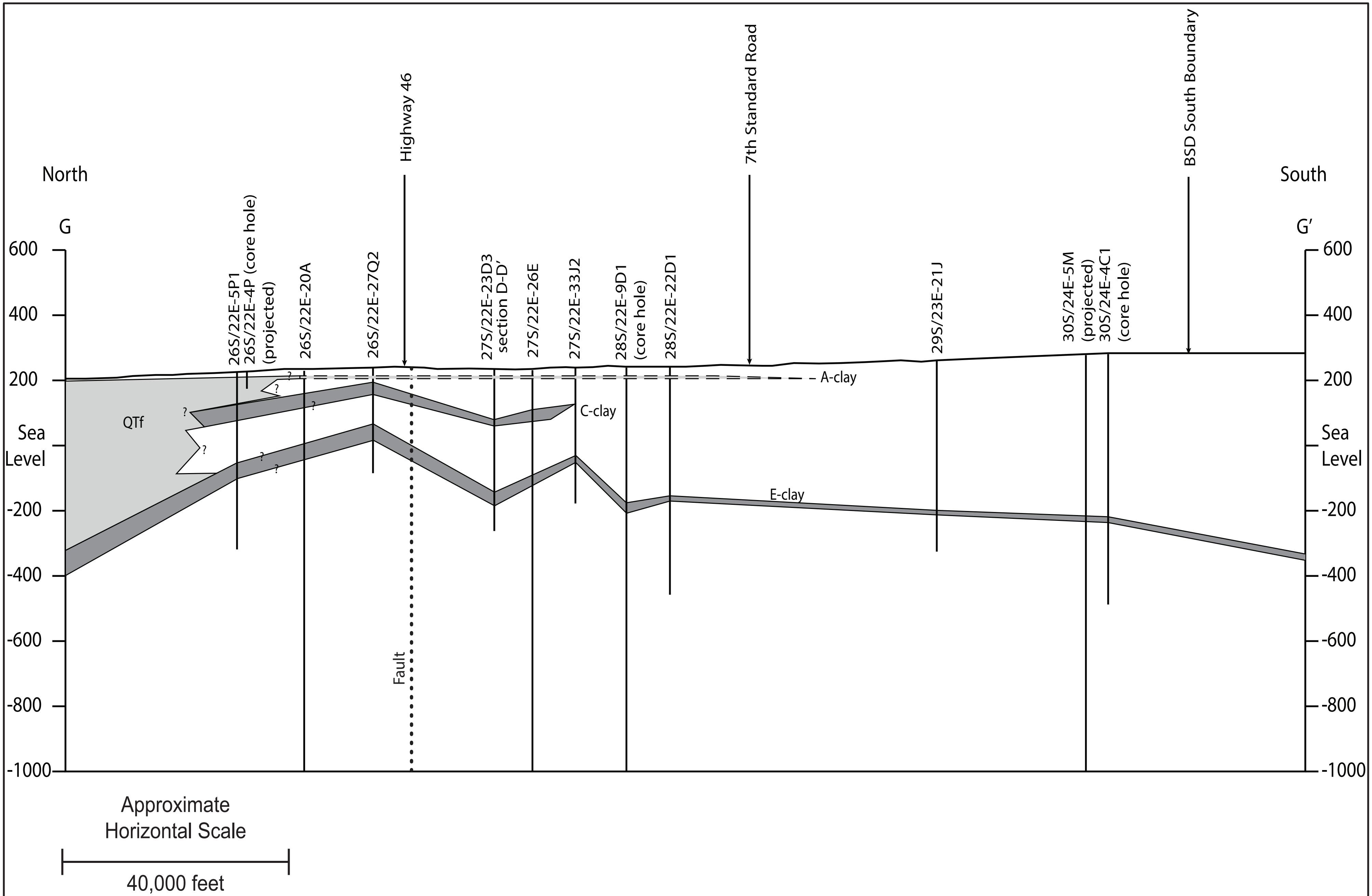
21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP012_RecentArsenic.mxd RS



SOURCES: Background geology image from USGS 1986
Structures and Faults from USGS 2010
Cross Section Locations from USGS (1974) and Western Oil and Gas Association (1983), respectively

Z:\Projects\126580_McAllister\DeepWell_Geology.mxd DLF
14-Sep-2016

Deep Well Groundwater Quality Management Plan	GEI Consultants	Regional Geology
Buena Vista Coalition		SEPTEMBER 2019 FIGURE 2-13a



Source: Adapted from USGS Water Supply Paper 1999-H (Croft 1972)

Buena Vista Groundwater Sustainability Plan
Kern County, California

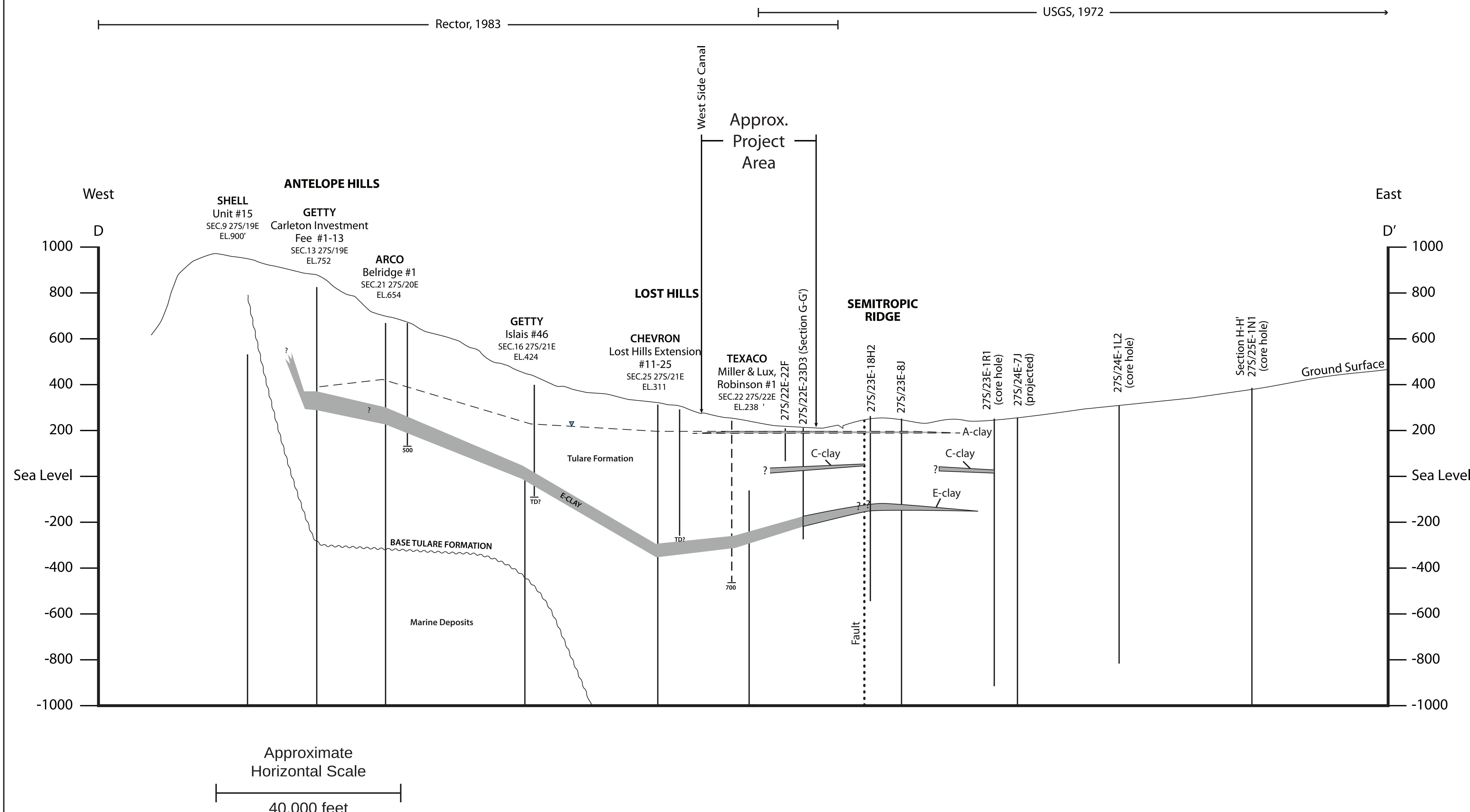
Buena Vista Groundwater Sustainability Agency

GEI Consultants

North-South Cross Section G-G'

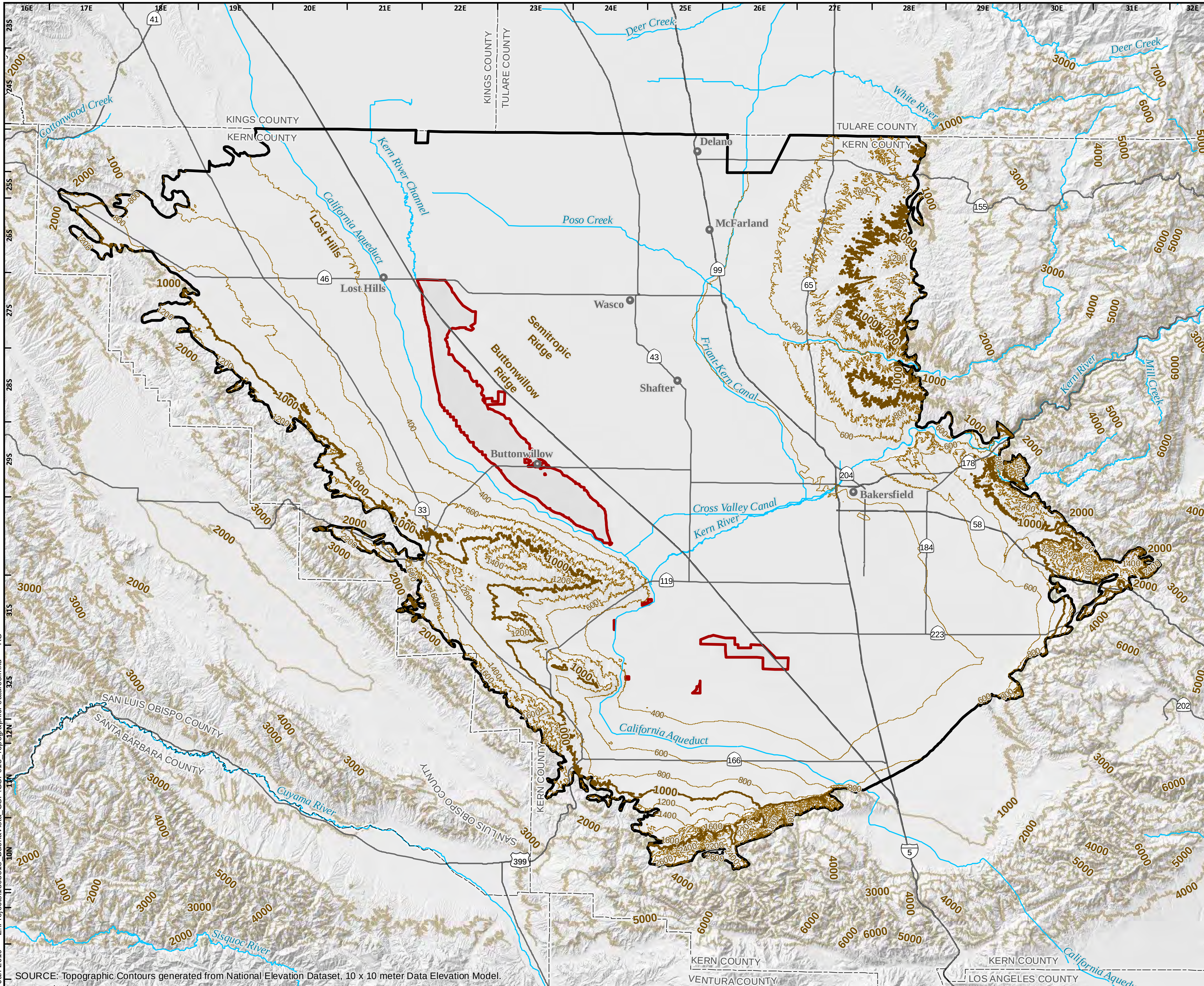
SEPTEMBER 2019

FIGURE 2-13b



Sources: Adapted from a combination of USGS Water Supply Paper 1999-H (Croft 1972) and Cross section 27S from Western Oil and Gas Association Westside Groundwater Study (Rector 1983)

Northern Pipeline Project Kern County, California	GEI Consultants	West-East Cross Section D-D'
Buena Vista Water Storage District		SEPTEMBER 2019 FIGURE 2-13c



TOPOGRAPHIC FEATURES

Elevation Contours

- Minor (200 ft)
- Major (1,000 ft)

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway

0 4 8 16
Miles

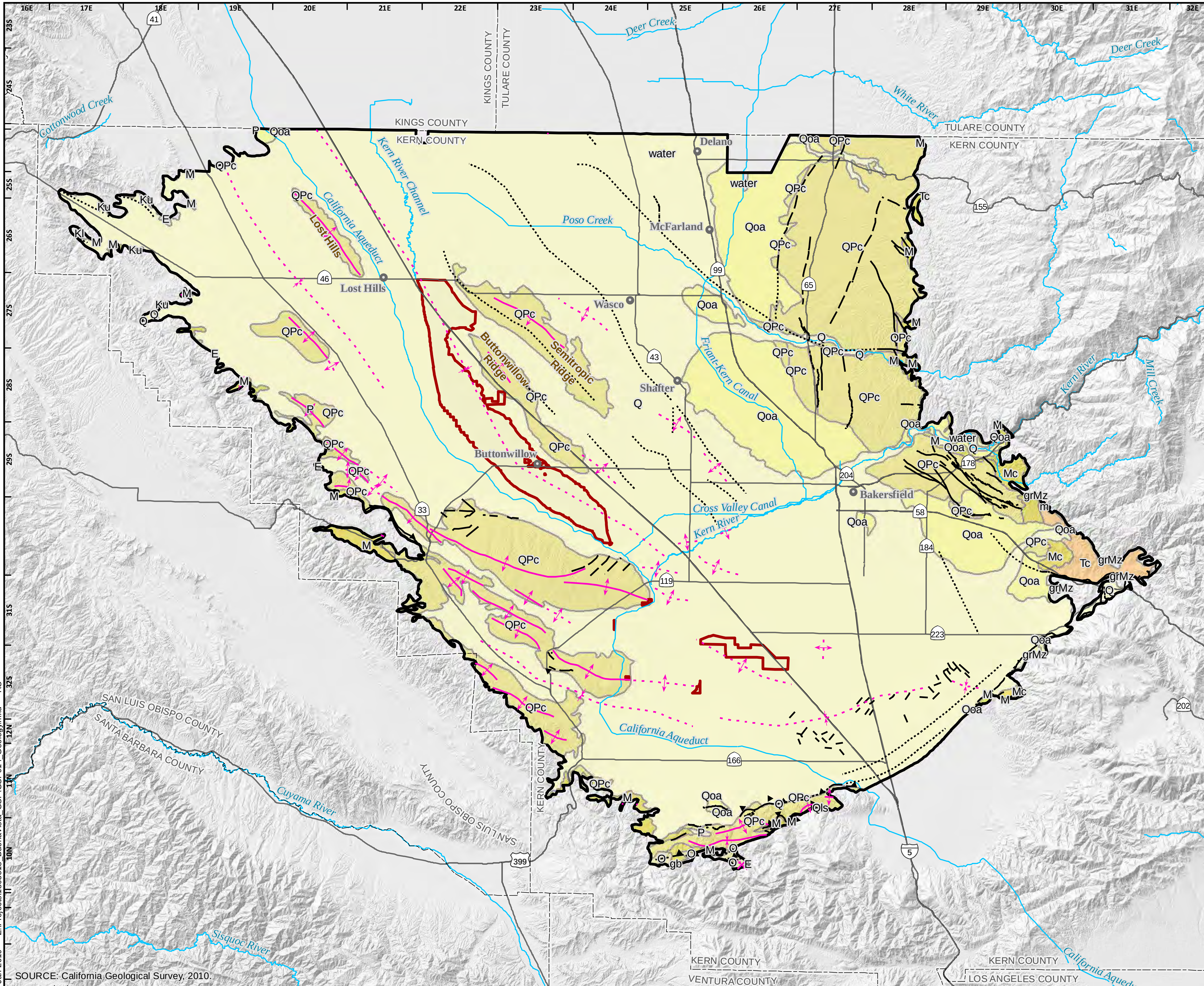
N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-14



GEOLOGIC UNITS OF BV GSA AND SURROUNDING AREA

Geologic Features

- Fault, certain
- Fault, approx. located
- Fault, concealed
- Thrust fault, certain
- Thrust fault, approx. located
- Thrust fault, concealed
- Reverse fault, certain
- Anticline, certain
- Anticline, concealed
- Syncline, certain
- Syncline, concealed

Geologic Units

- **Q** - Pleisto-Holocene: alluvium, lake, playa and terrace deposits; unconsolidated and semi-consolidated
- **Qoa** - Quaternary: older alluvium, lake, playa and terrace deposits
- **QPc** - Plio-Pleistocene: sandstone, shale and gravel deposits; mostly loosely consolidated
- **P** - Pliocene: sandstone, siltstone, shale and conglomerate; mostly moderately consolidated
- **Mc/M** - Miocene: sandstone, shale, conglomerate and fanglomerate; moderately to well consolidated
- **O** - Oligocene: sandstone, shale and conglomerate; mostly well consolidated
- **TC** - Undivided Tertiary: sandstone, shale, conglomerate, breccia and ancient lake deposits

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway

0 4 8 16
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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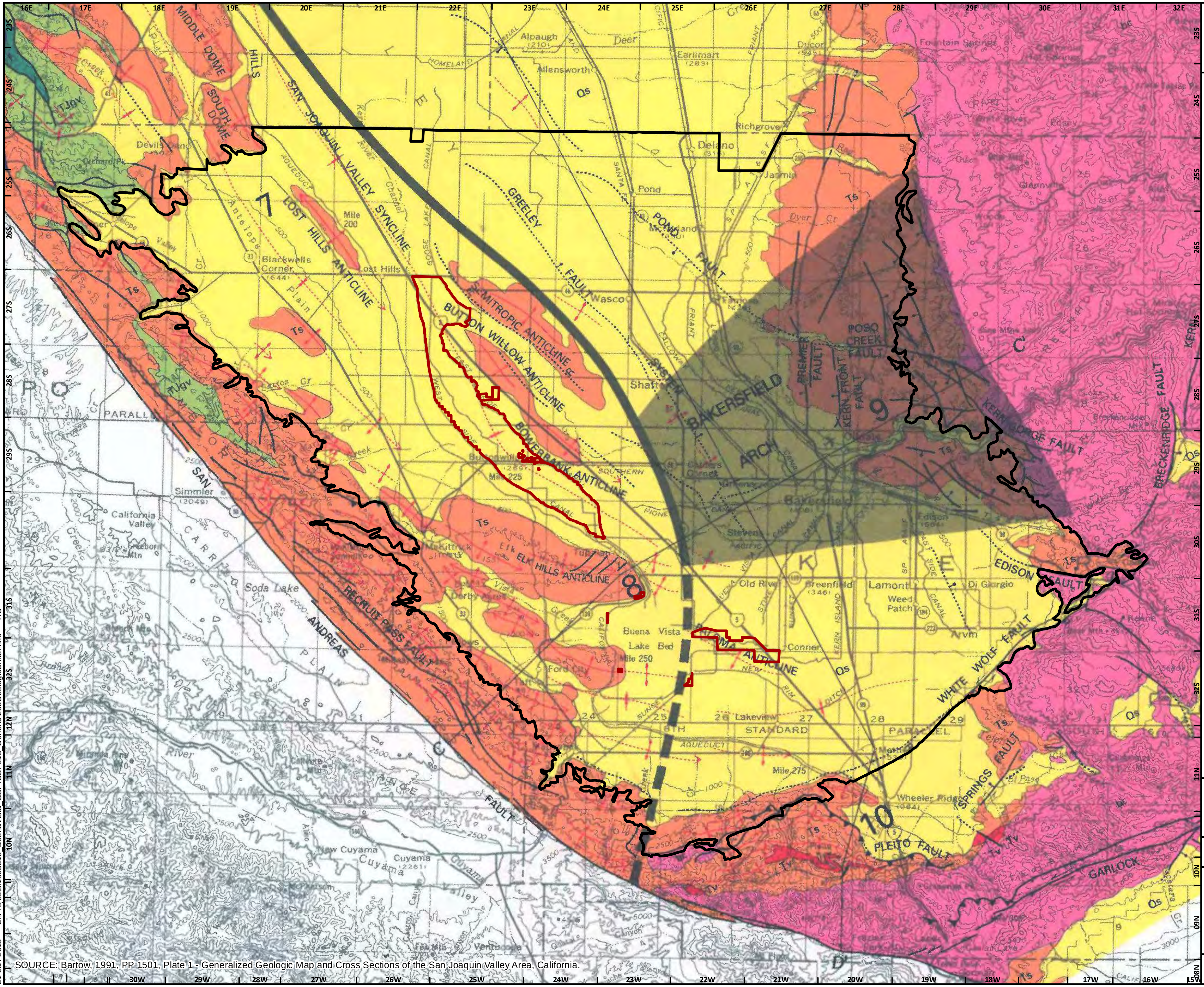
SEPTEMBER 2019 **DRAFT** FIGURE 2-15

GENERALIZED GEOLOGIC UNITS



SOURCE: Bartow, 1991, PP 1501, Plate 1 - Generalized Geologic Map and Cross Sections of the San Joaquin Valley Area, California.

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

CORRELATION OF MAP UNITS

Tv, Qs, Ts	QTs	Neogene / Paleogene — QUATERNARY, TERTIARY	CENOZOIC
TJgv	f	CRETACEOUS AND JURASSIC	MESOZOIC
um			
bc			MESOZOIC AND PALEOZOIC

DESCRIPTION OF MAP UNITS

- Qs — **Alluvial and lacustrine sediments (Quaternary)**
- QTs — **Alluvial deposits, sedimentary rocks, and minor volcanic rocks, undivided (Quaternary and Tertiary)**—Used on cross sections only and consists of units Qs and Ts. Dashed line shows approximate boundary between Paleogene and Neogene
- Tv — **Volcanic rocks (Tertiary)**
- Ts — **Sedimentary rocks (Tertiary)**—Marine and nonmarine rocks. Dashed line shows approximate boundary between Paleogene and Neogene
- TJgv — **Great Valley sequence (Tertiary to Jurassic)**—Melanges of sedimentary rocks
- f — **Franciscan Complex (Tertiary to Jurassic)**—Melanges of sedimentary rocks, serpentinite, and blueschist in a sheared matrix and coherent sedimentary rocks
- um — **Ultramafic rocks (Cretaceous and Jurassic)**
- bc — **Crystalline rocks of the basement complex (Mesozoic and Paleozoic)**
- **Approximate area of structural arch**
- **Contact**—Queried where uncertain in cross sections only
- **Fault**—Dashed where approximately located; dotted where concealed; queried where uncertain. Bar and ball on downthrown side; R on upthrown side of reverse fault; arrows indicate direction of relative movement. Relative lateral movement on cross sections only: A, away from observer; T, toward observer
- **Thrust fault**—Dotted where concealed. Sawteeth on upper plate
- **Fold**—Dotted where concealed. Showing approximate trace of axial plane; arrows indicate direction of plunge
  - **Anticline**
  - **Syncline**
- **Boundary of structural region (see text)**—Dashed where approximately located
- 5 — **Location of stratigraphic column**—Number refers to column number on plate 2

0 4 8 16
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

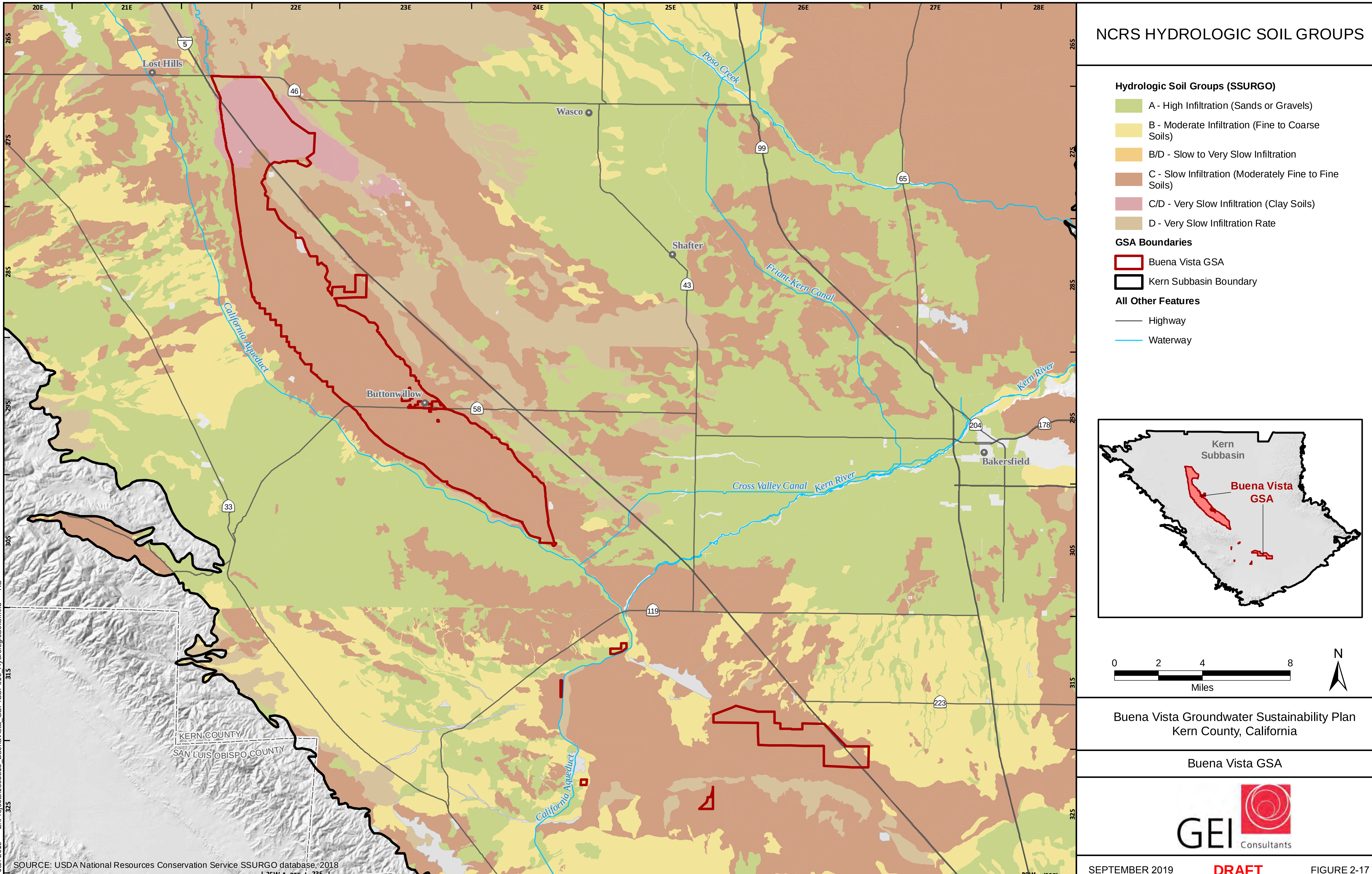
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 | DRAFT | FIGURE 2-16

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP015_GeneralizedGeologicUnits.mxd RS

NCRS HYDROLOGIC SOIL GROUPS

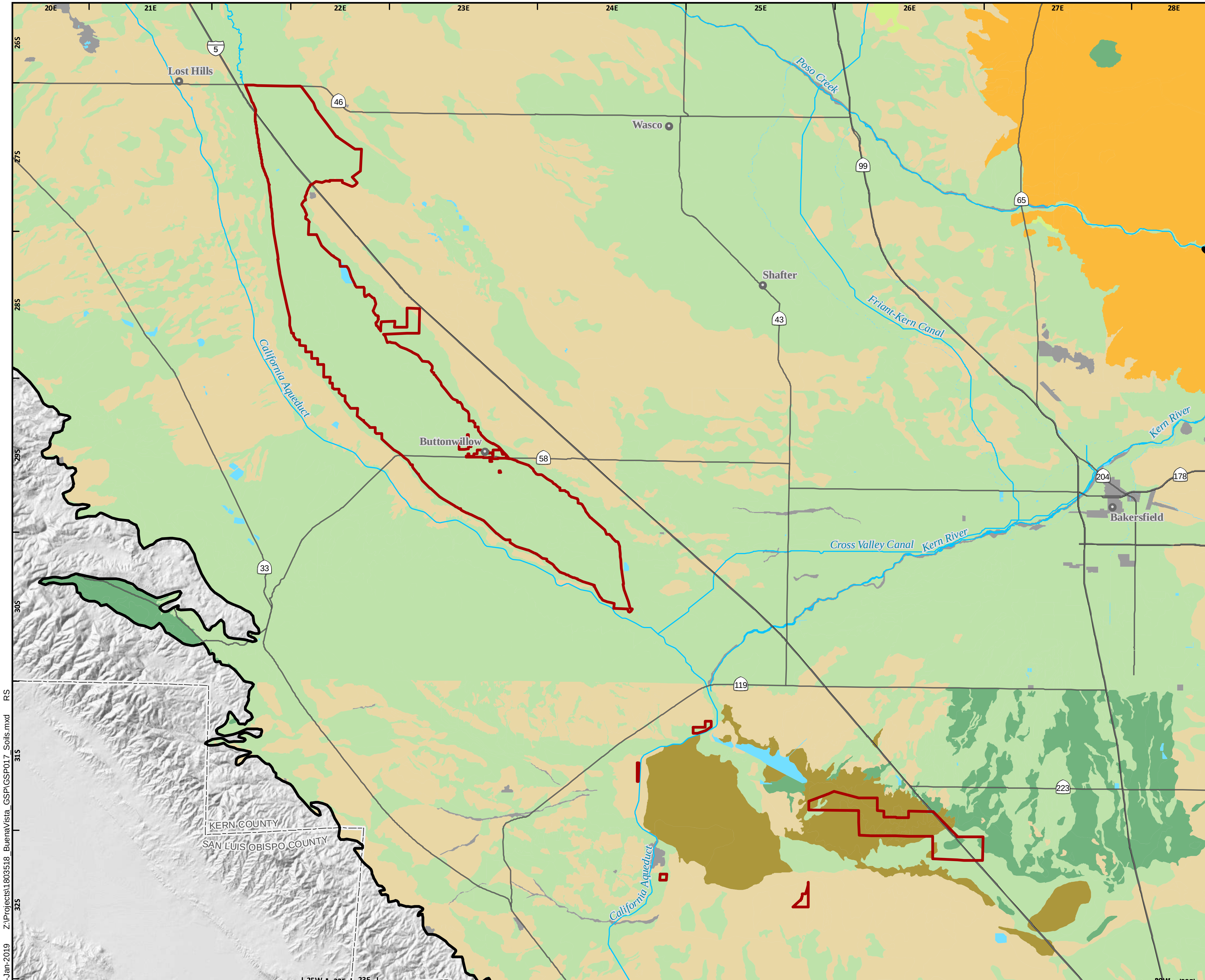


Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-17



TAXONOMIC SOIL ORDERS OF THE KERN COUNTY SUBBASIN

Soil Classification
- Alfisols
- Aridisols
- Entisols
- Inceptisols
- Mollisols
- Vertisols
- No Soil Data
- Water

GSA Boundaries
- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features
- Highway
- Waterway

0 2 4 8
Miles

Buena Vista Groundwater Sustainability Plan
Kern County, California

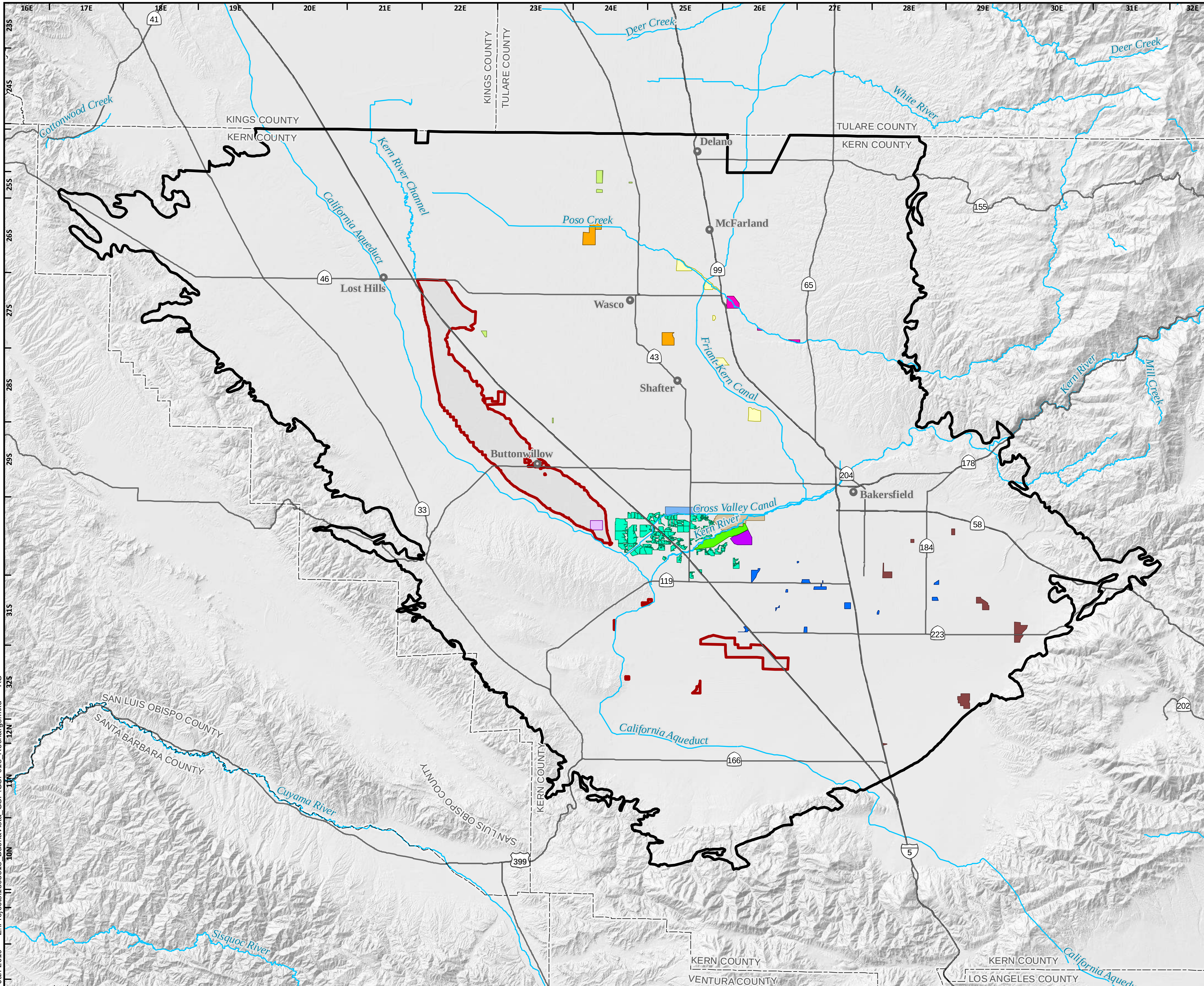
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 DRAFT FIGURE 2-18

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP017_Soils.mxd RS

EXISTING RECHARGE AND SPREADING CENTERS



Arvin-Edison WSD Recharge Basin
Buena Vista WSD - Palms Recharge Project
Cawelo WD Spreading Pond
Kern Delta WD Recharge Basin
Kern Water Bank Authority Recharge Basin
North Kern WSD Spreading Pond
Pioneer Central / City of Bakersfield 2800
Pioneer North / Berrenda Mesa
Pioneer South
Rosedale-Rio Bravo Recharge Basin
Semitropic WSD Spreading Basin
Shafter-Wasco ID Recharge Basin

GSA Boundaries

Buena Vista GSA
Kern Subbasin Boundary

All Other Features

Highway
Waterway

0 4 8 16
Miles
N

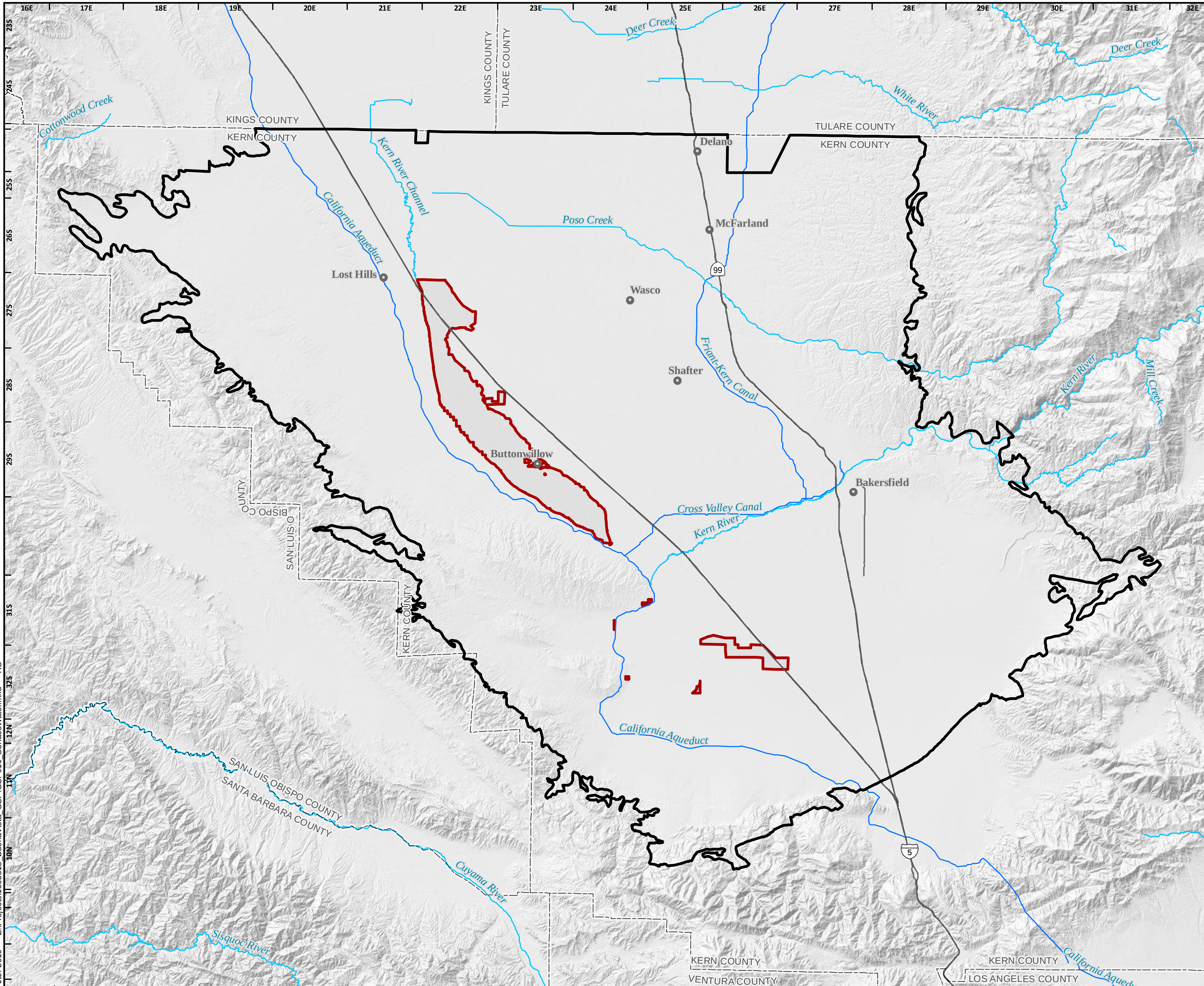
Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-19

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP018_Recharge.mxd RS



SURFACE WATER FEATURES

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- River, Creek or Ephemeral Stream
- Major Canal

0 4 8 16
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

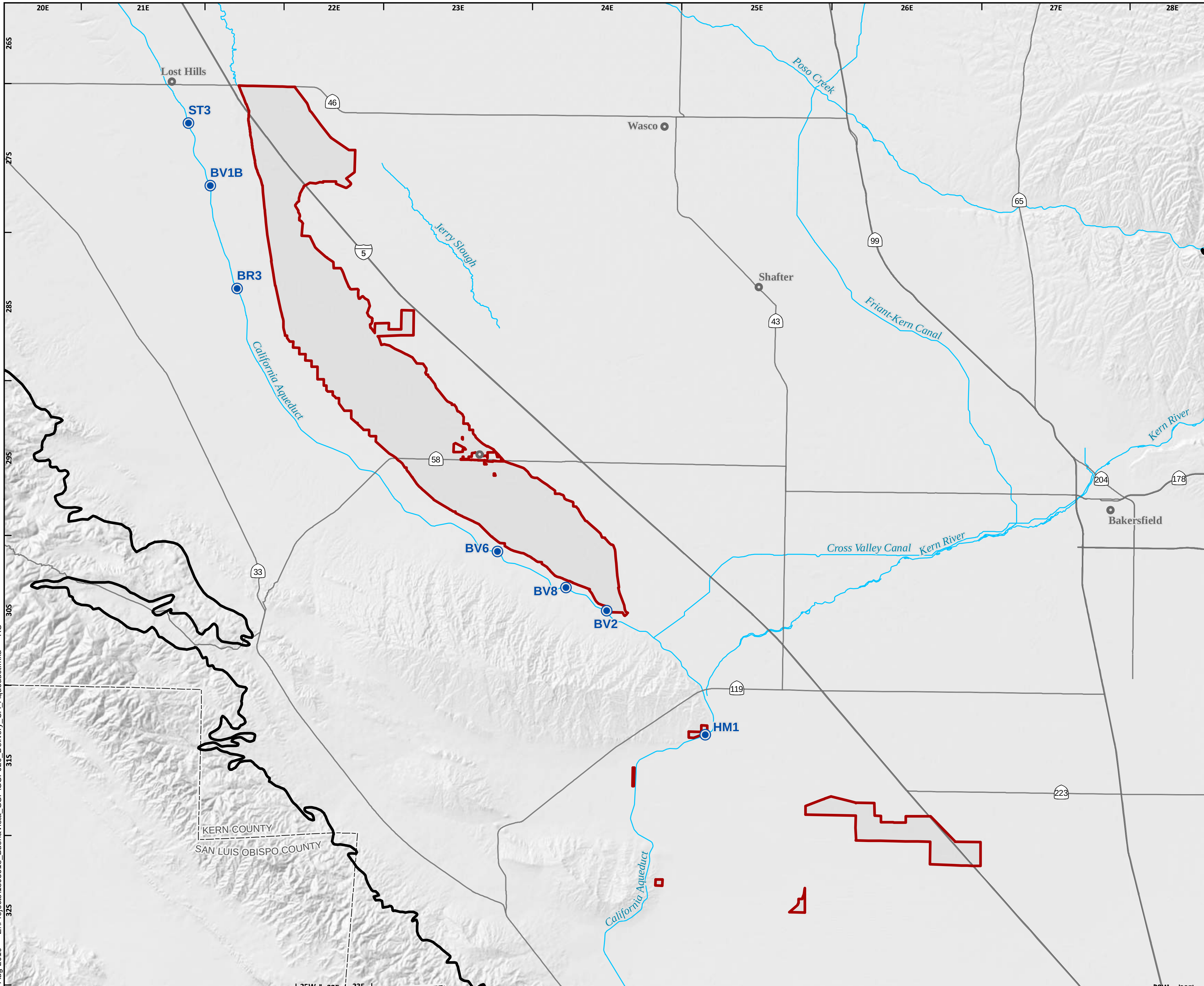
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-20

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP019_SurfaceWater.mxd RS

CALIFORNIA AQUEDUCT AND LOCATION OF TURNOUTS SERVING BUENA VISTA GSA



California Aqueduct Turnout

GSA Boundaries

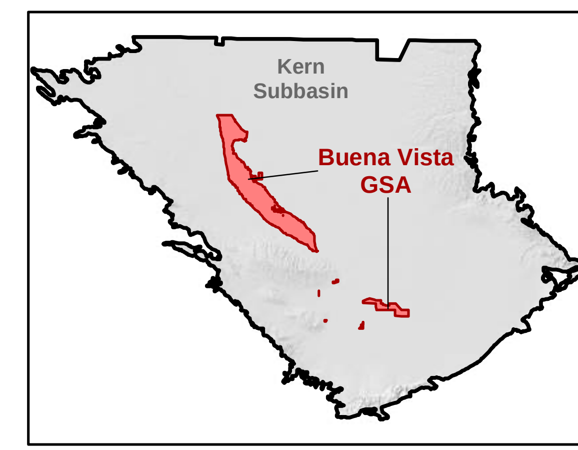
Buena Vista GSA

Kern Subbasin Boundary

All Other Features

Highway

Waterway



0 2 4 8

Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 DRAFT FIGURE 2-21

15-Aug-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP020_Delivery_CA_Aqueduct.mxd RS

GROUNDWATER ELEVATIONS SPRING 2015

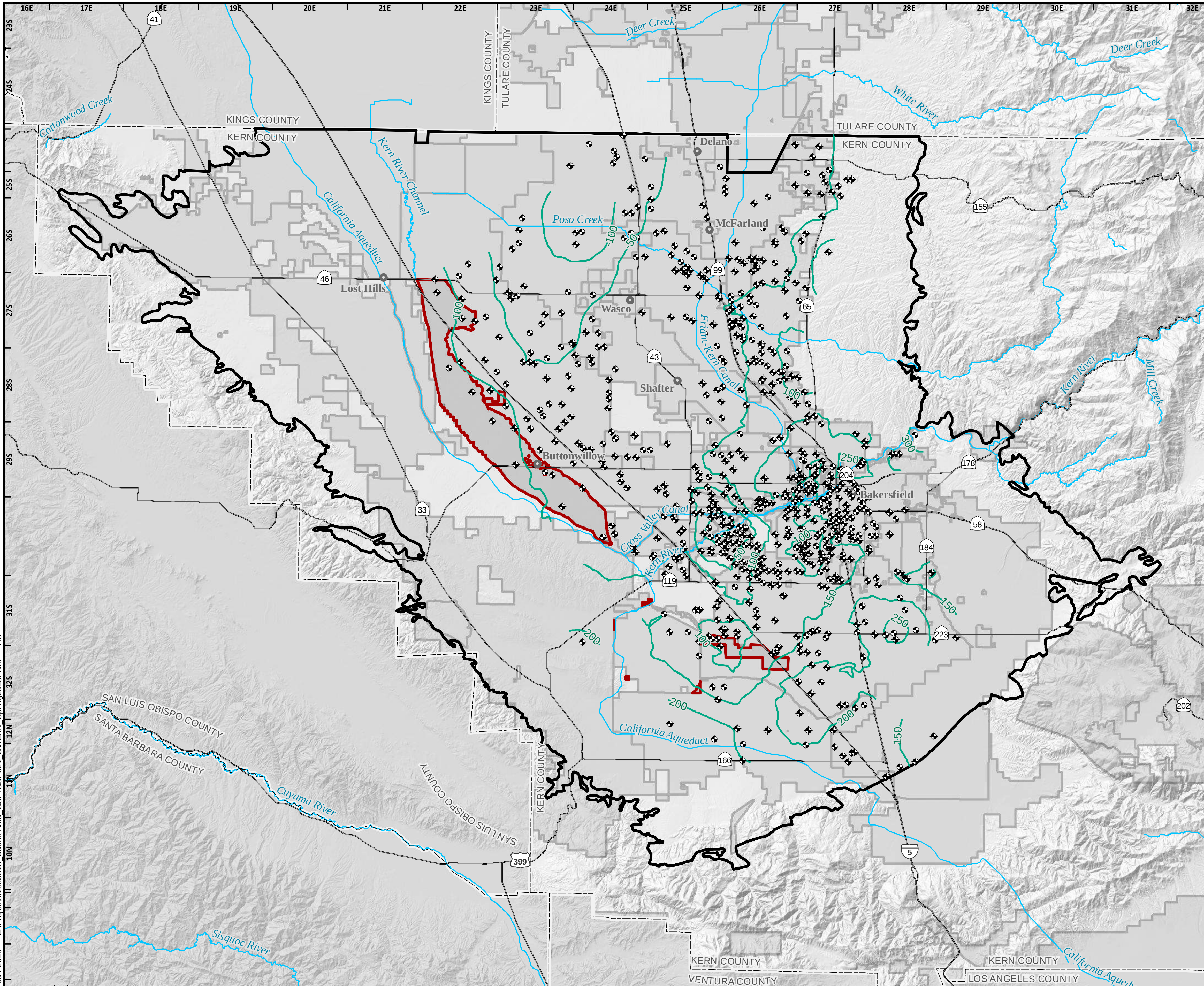
- Well Location
- Groundwater Elevation Contour (ft MSL)

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary
- Water Agency

All Other Features

- Highway
- Waterway



0 4 8 16
Miles
N

Buena Vista Groundwater Sustainability Plan
Kern County, California

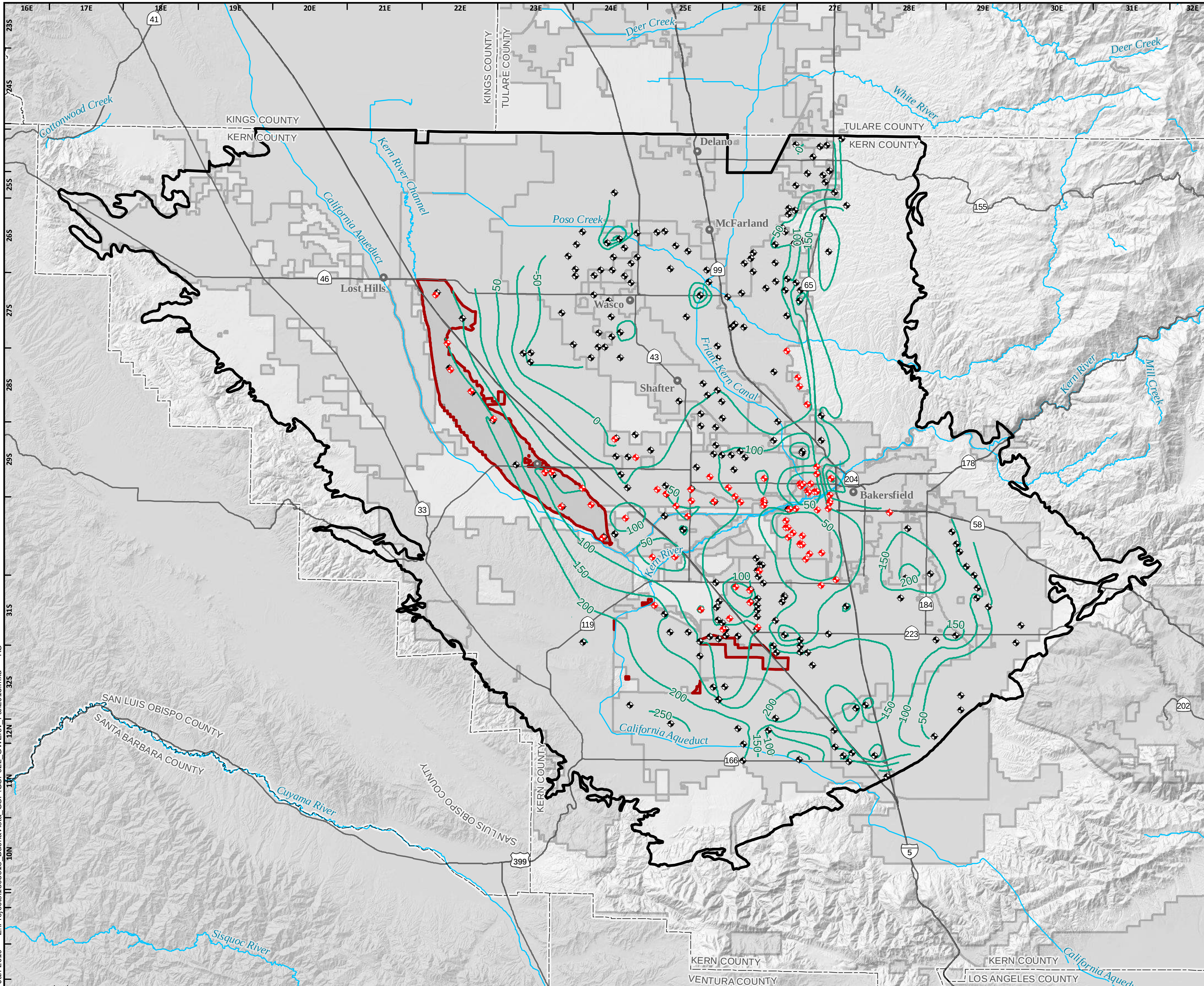
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-24

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP021_GWElev_Spring2015.mxd RS

GROUNDWATER ELEVATIONS FALL 2015



- CASGEM Well
- KCWA Well
- Groundwater Elevation Contour (ft MSL)

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary
- Water Agency

All Other Features

- Highway
- Waterway

0 4 8 16
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

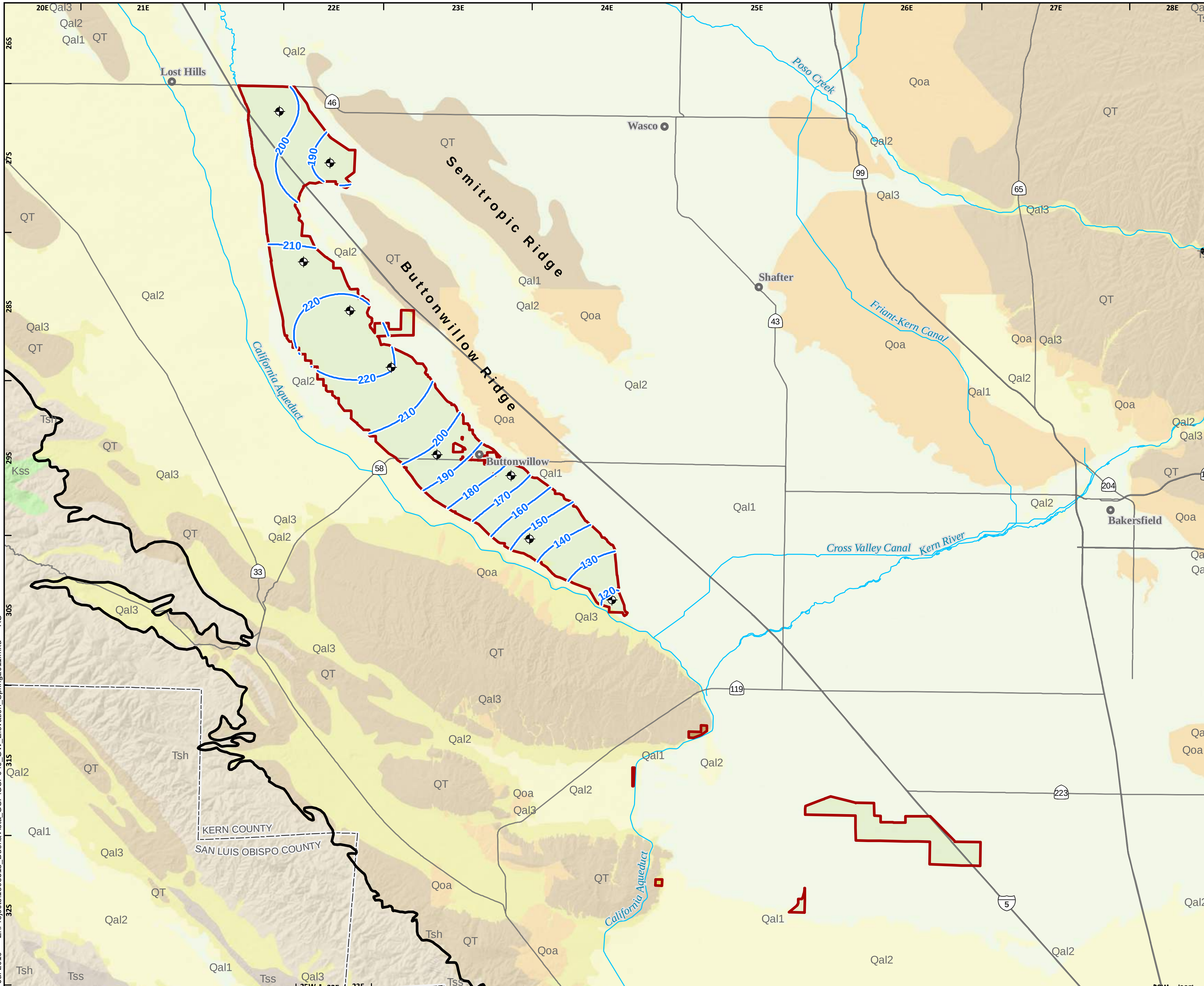
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-25

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP022_GWElev_Fall2015.mxd RS

GROUNDWATER ELEVATION SPRING 2011



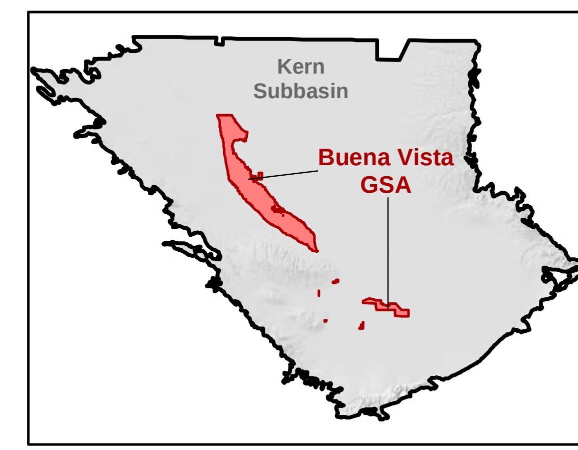
- District Monitoring Well
- Groundwater Elevation Contour (Spring 2011)

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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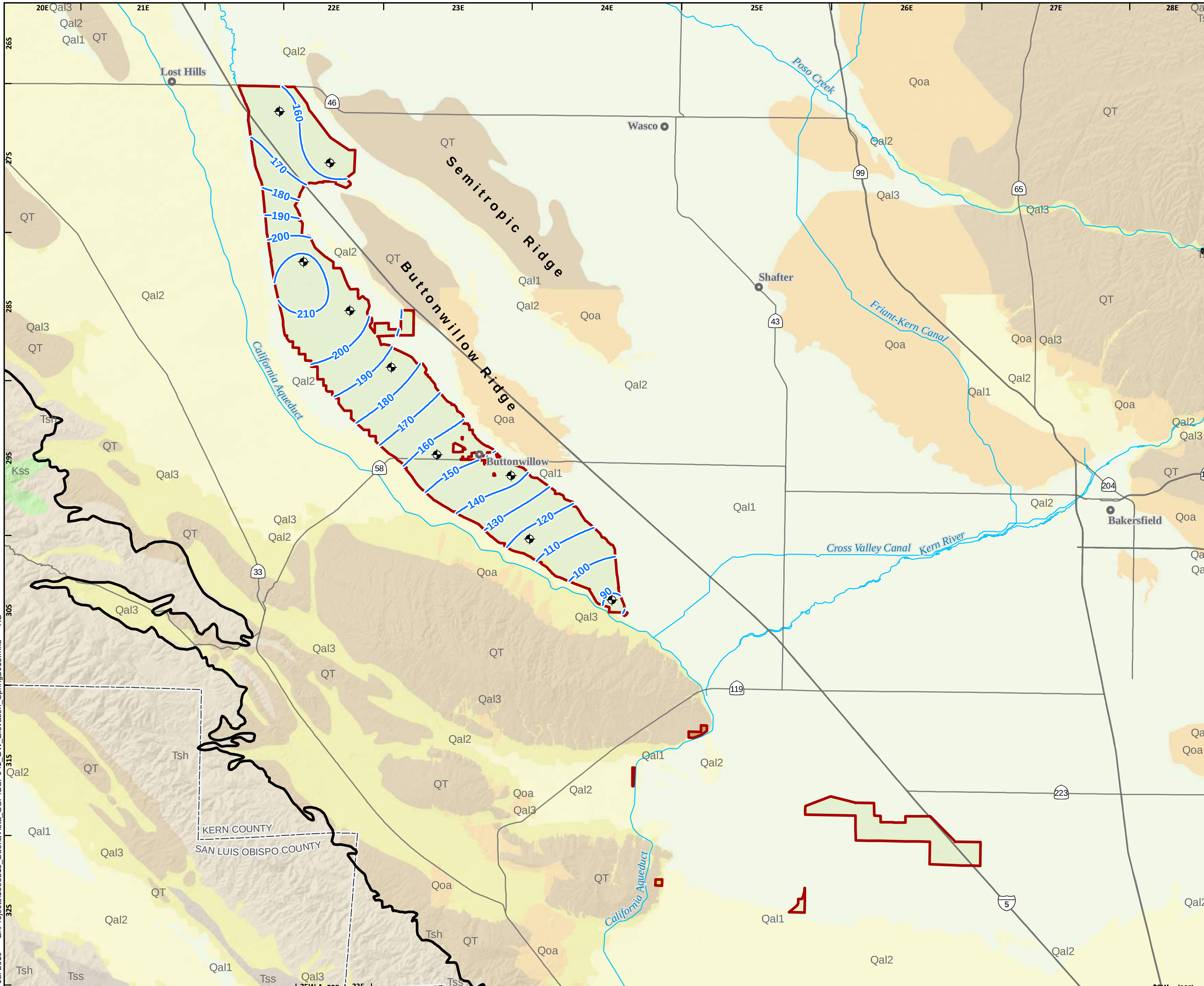
SEPTEMBER 2019 DRAFT FIGURE 2-27A

31-Jul-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP040_GW_Elevation_Spring2011.mxd RS



GROUNDWATER ELEVATION SPRING 2015

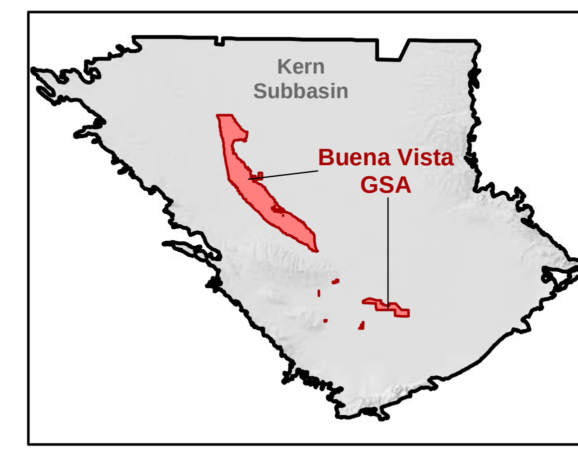
- District Monitoring Well
- Groundwater Elevation Contour (Spring 2015)

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8

Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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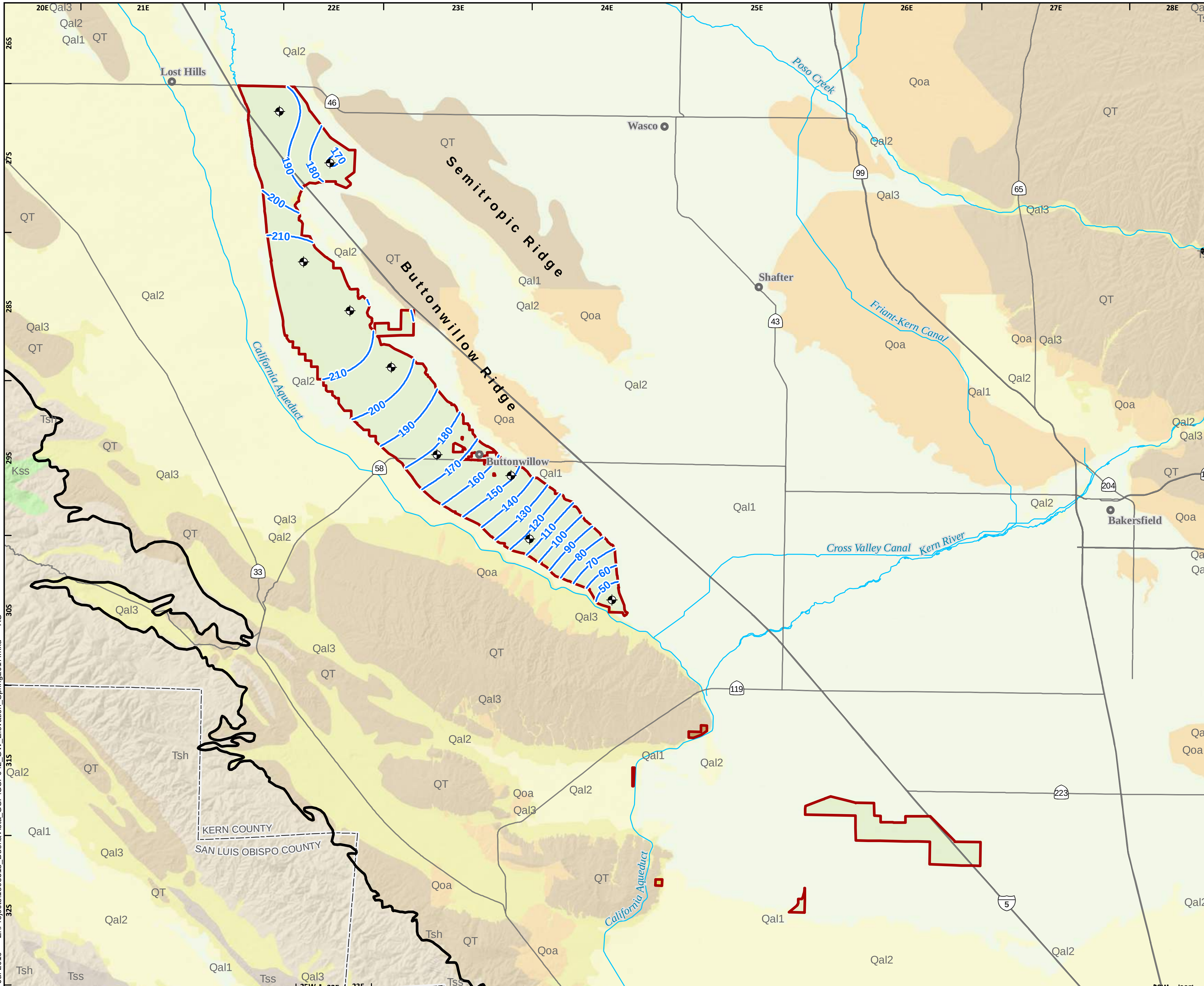
SEPTEMBER 2019 **DRAFT** FIGURE 2-27B

GROUNDWATER ELEVATION SPRING 2017



District Monitoring Well

Groundwater Elevation Contour (Spring 2017)

GSA Boundaries

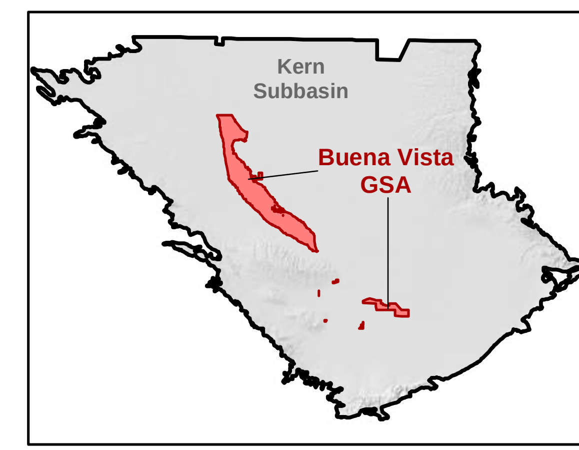
Buena Vista GSA

Kern Subbasin Boundary

All Other Features

Highway

Waterway



0 2 4 8

Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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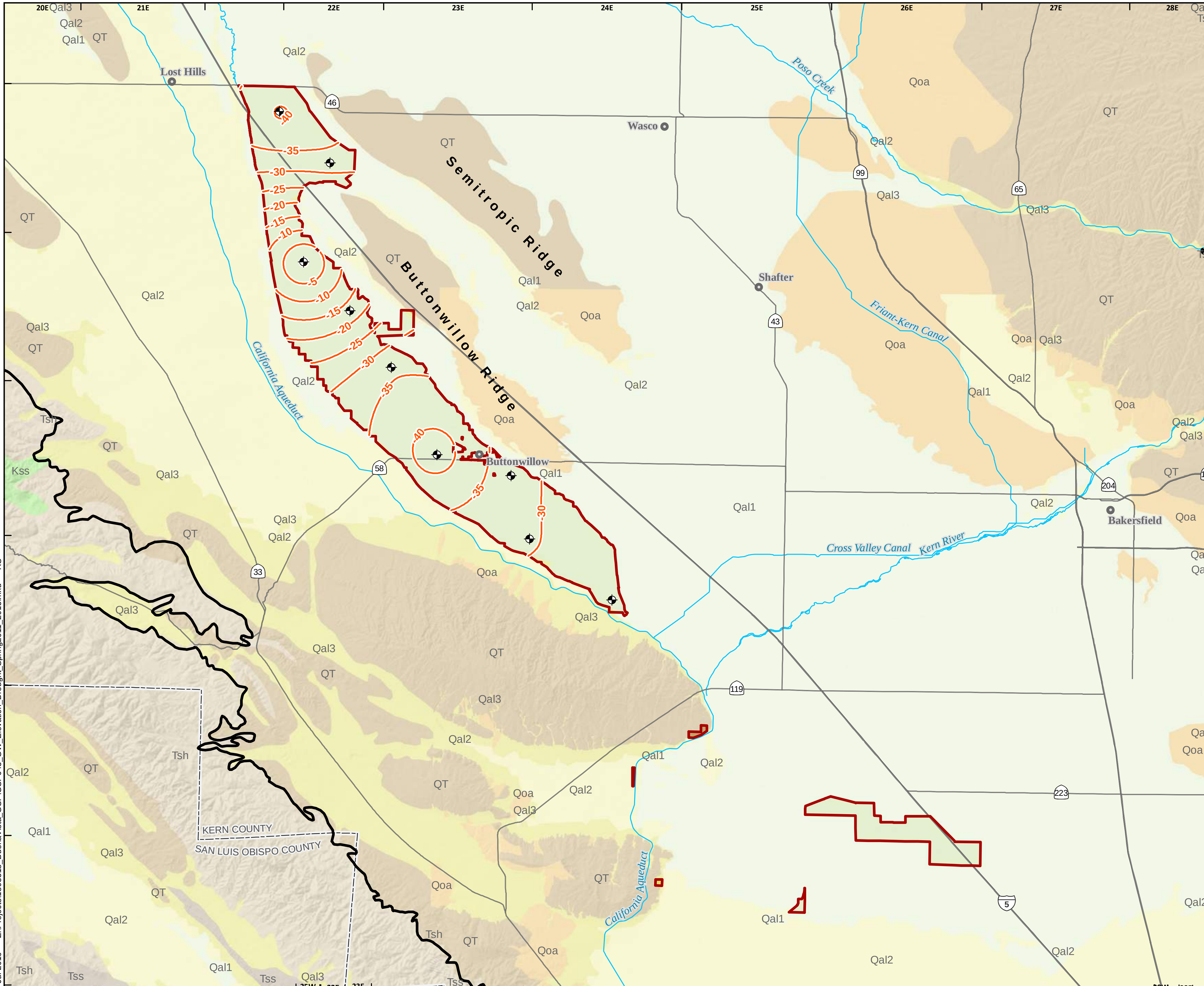
SEPTEMBER 2019 **DRAFT** FIGURE 2-27C

31-Jul-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP042_GW_Elevation_Spring2017.mxd RS

GROUNDWATER ELEVATION CHANGE DROUGHT: SPRING 2011 TO SPRING 2015



District Monitoring Well

Groundwater Elevation Contour - Drought (Spring 2011 - Spring 2015)

GSA Boundaries

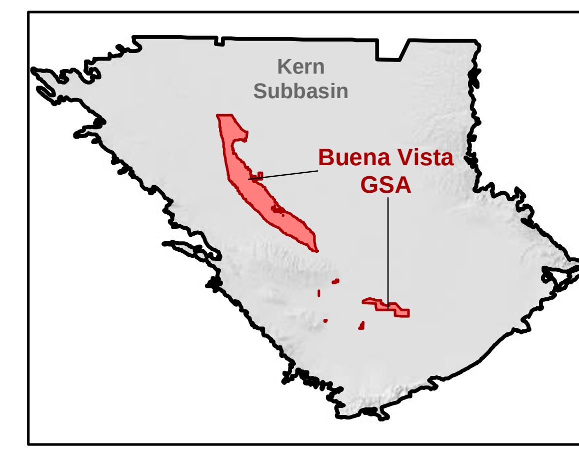
Buena Vista GSA

Kern Subbasin Boundary

All Other Features

Highway

Waterway



0 2 4 8

Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

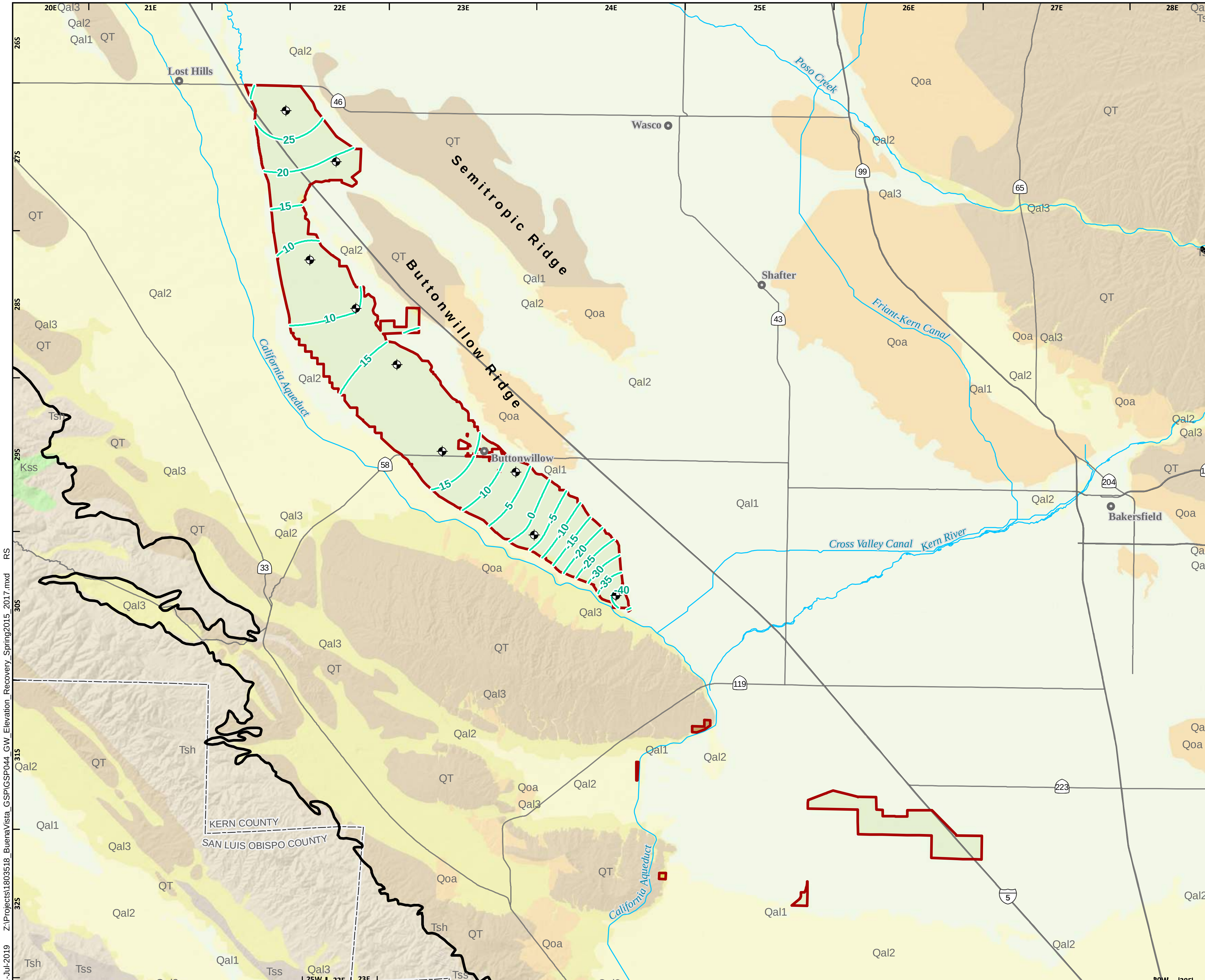
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-27D

31-Jul-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP043_GW_Elevation_Drought_Spring2011_2015.mxd RS

GROUNDWATER ELEVATION CHANGE DROUGHT RECOVERY: SPRING 2015 TO SPRING 2017



District Monitoring Well

Groundwater Elevation Contour - Drought Recovery (Spring 2015 - Spring 2017)

GSA Boundaries

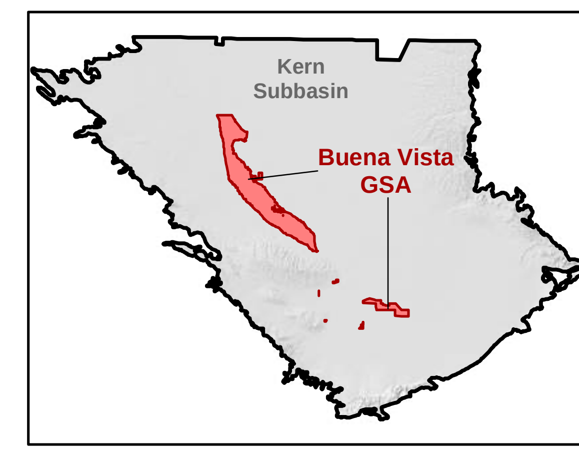
Buena Vista GSA

Kern Subbasin Boundary

All Other Features

Highway

Waterway



0 2 4 8

Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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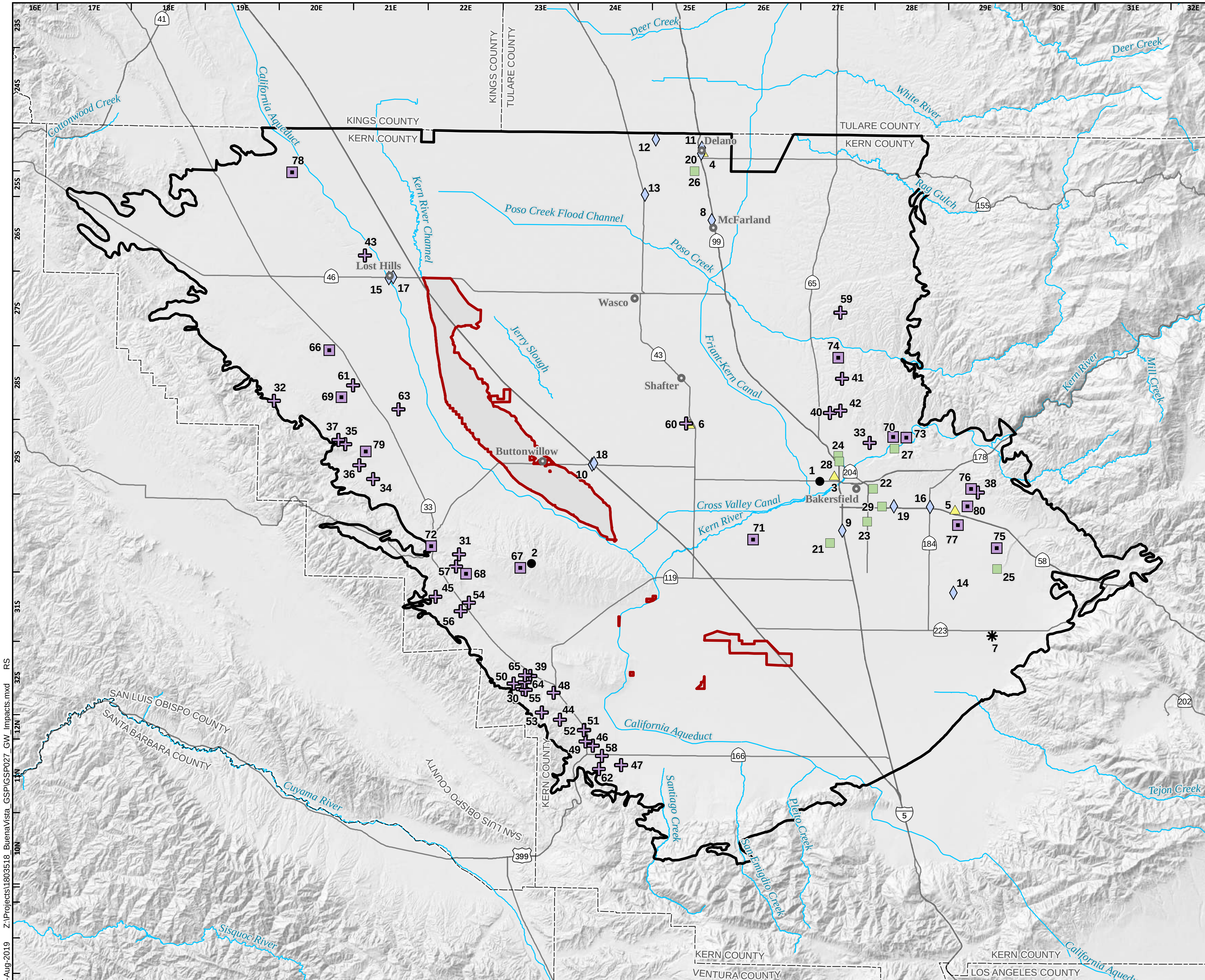
SEPTEMBER 2019 DRAFT FIGURE 2-27E

31-Jul-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP044_GW_Elevation_Recovery_Spring2015_2017.mxd RS



SITES OF POTENTIAL GROUNDWATER IMPACTS

Site Types from Envirostor and Geotracker Database

(Map IDs cross-referenced with data table)

- Corrective Action (Current)
- Other Evaluation (Current or Inactive)
- Federal Superfund - Listed
- LUST Cleanup Site
- DTSC Site Cleanup Program (Active)
- Produced Water Ponds
- Underground Injection Control

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway

0 4 8 16
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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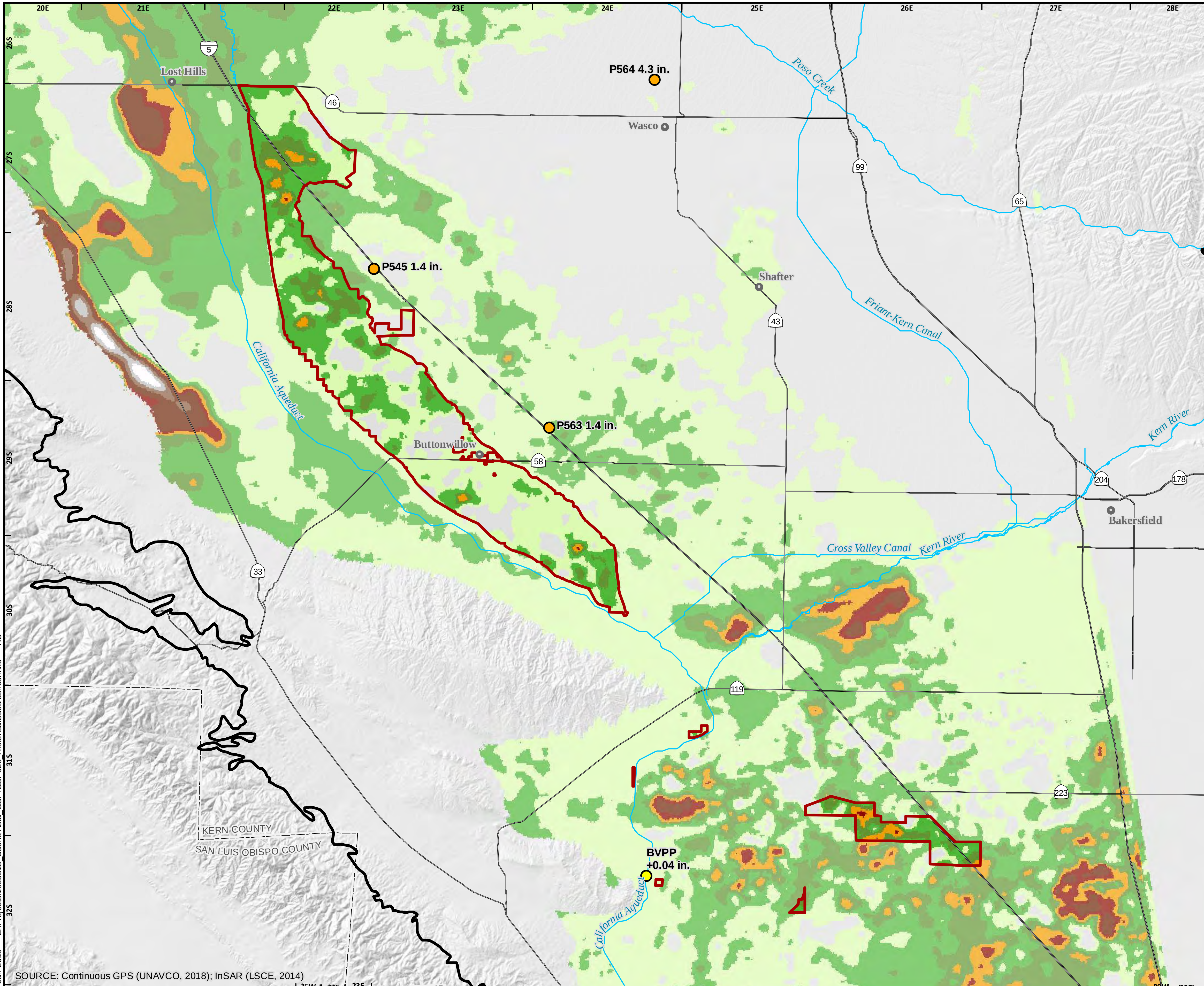
SEPTEMBER 2019 DRAFT FIGURE 2-28



HISTORICAL SUBSIDENCE

Subsidence Jan 2007 to Mar 2011

Continuous GPS

- Subsidence
- Uplift

Interferometric Synthetic Aperture (InSAR)

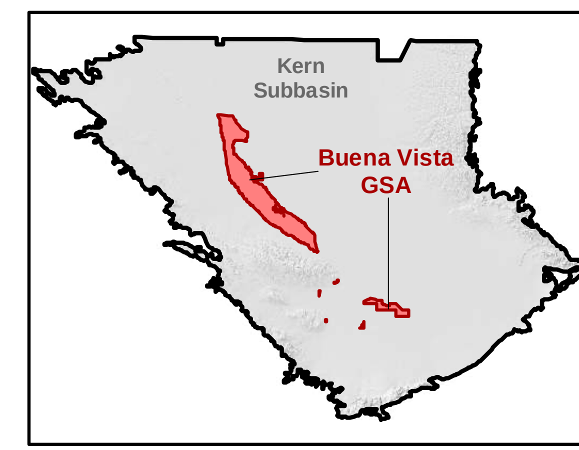
- 0
- 0-1 in
- 1-2 in
- 2-3 in
- 3-4 in
- 4-5 in
- 5-10 in
- 10-15 in
- 15-20 in
- 20-25 in

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2 4 8
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

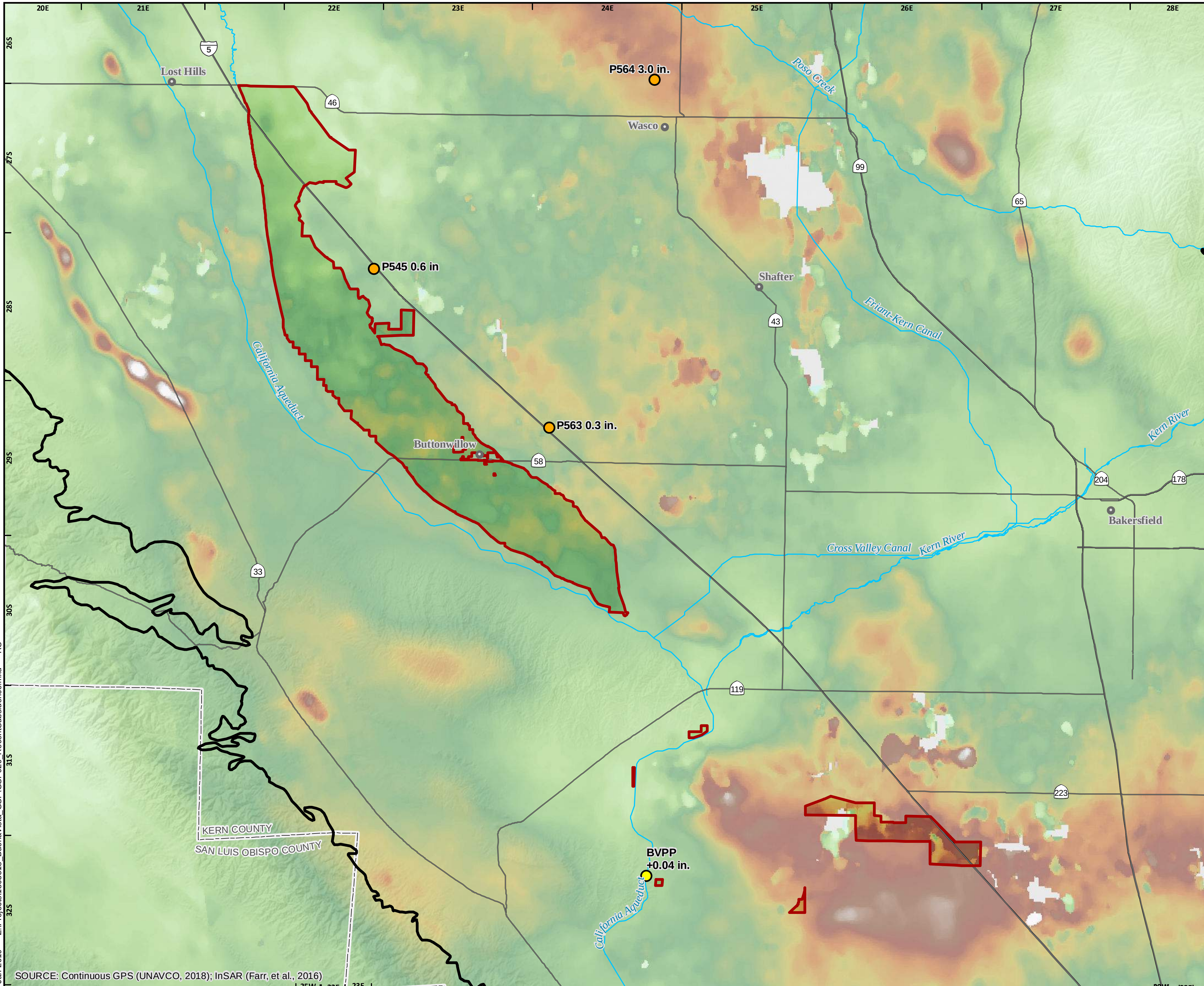
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-29

21-Jan-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP028_HistoricalSubsidence.mxd RS

RECENT SUBSIDENCE (2015 TO 2016)



Subsidence May 2015 to September 2016

Continuous GPS

- Subsidence
- Uplift

Interferometric Synthetic Aperture (InSAR)

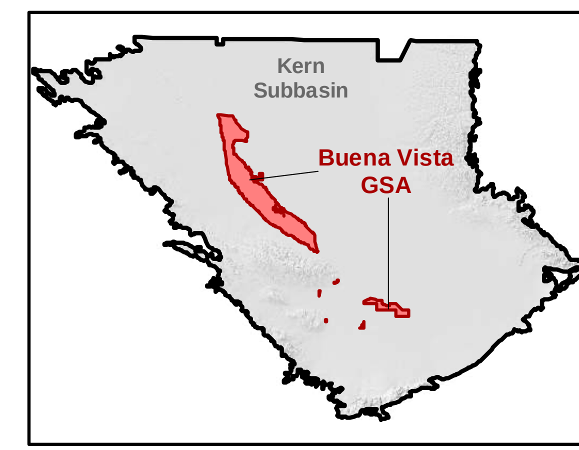
High : 10
9 in
8 in
7 in
6 in
5 in
4 in
3 in
2 in
1 in
Low : 0

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



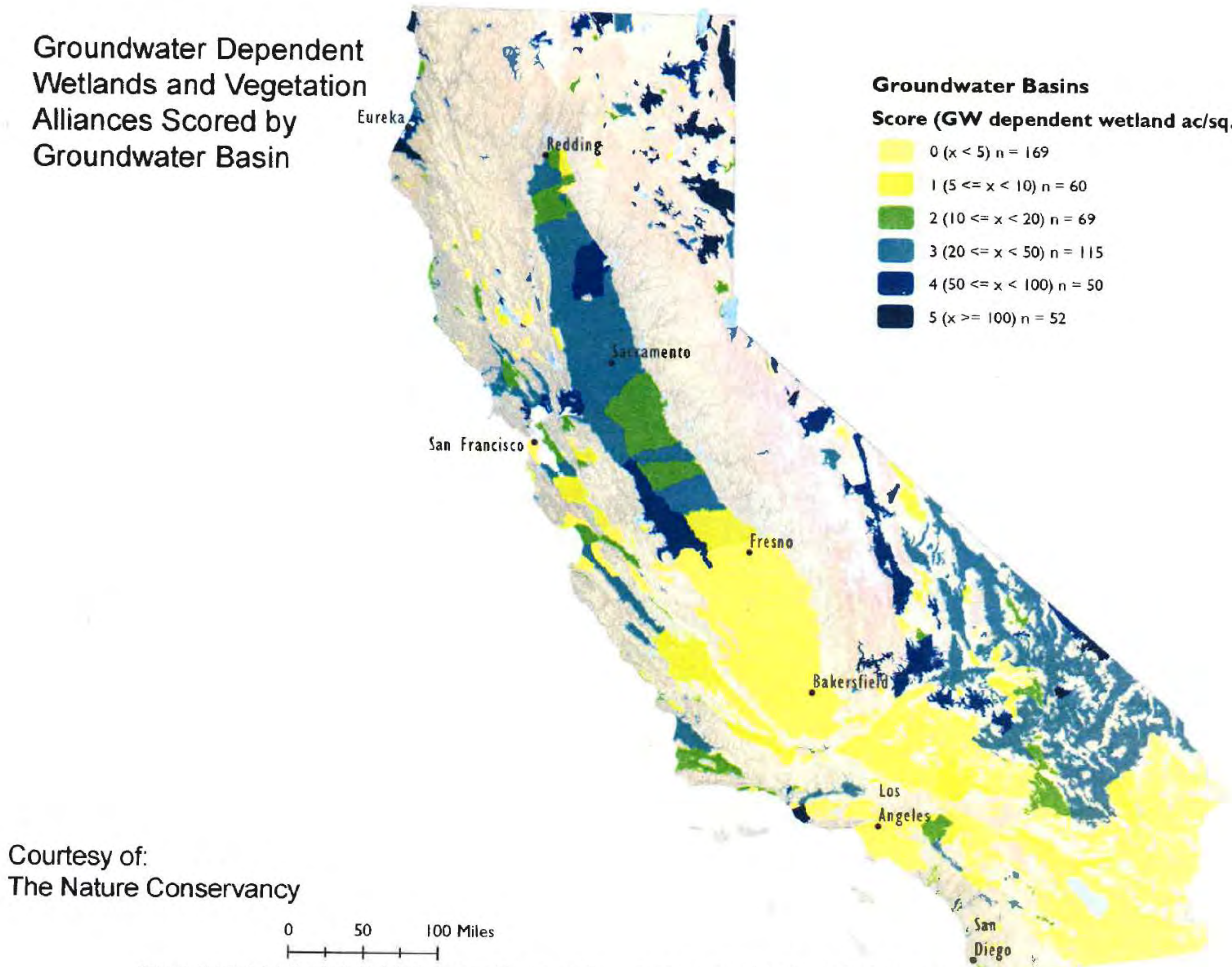
0 2 4 8
Miles
N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-30



Source: *Howard, J. & Merrifield, M. (2010). Mapping Groundwater Dependent Ecosystems in California. PLoS One, 5, e11249.*

SOURCE:

120 60 0 120
Miles

N W E S

North of the Kern River Area
Basin Setting

Kern County, California

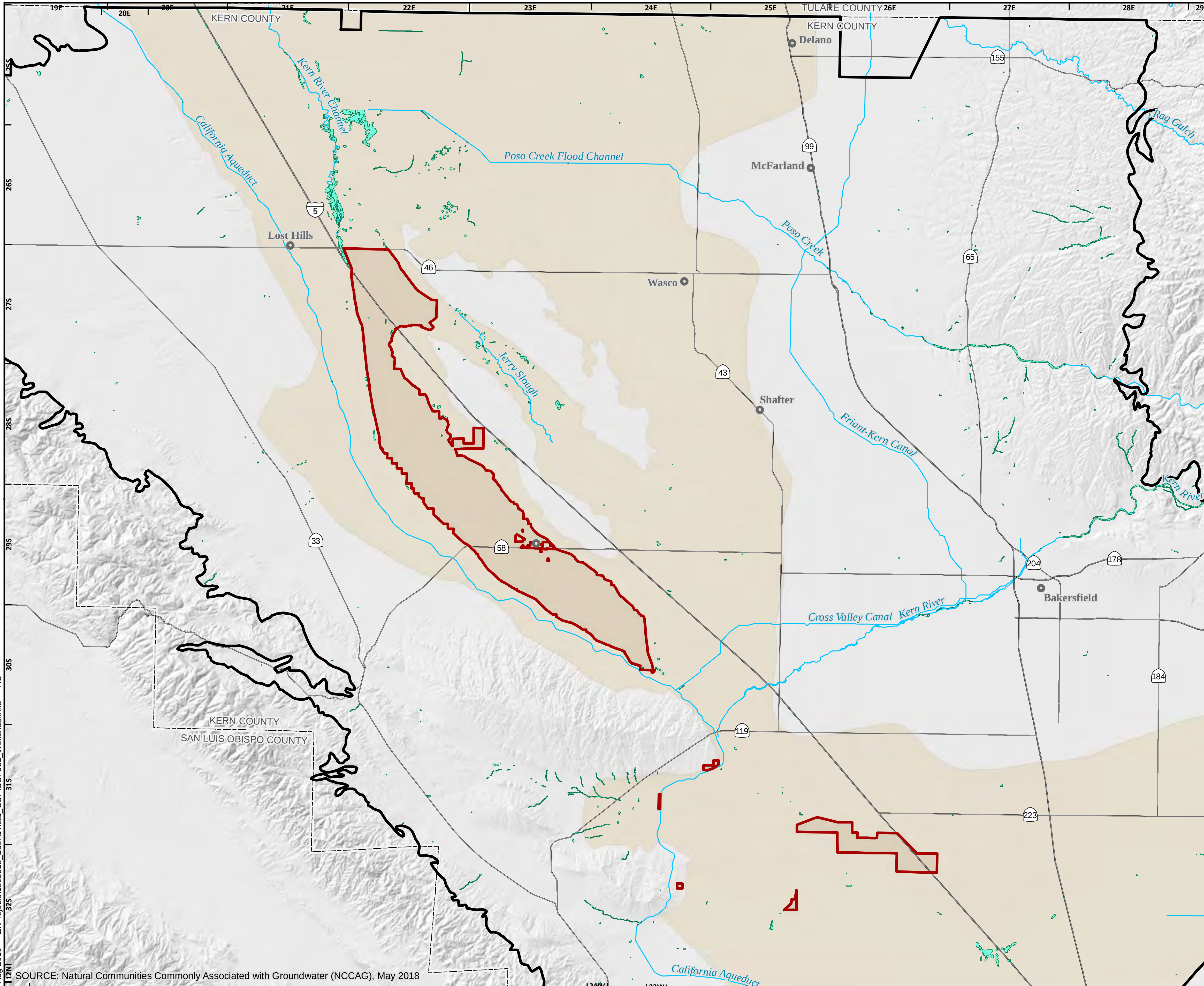
GEI Consultants

GROUNDWATER DEPENDENT WETLANDS AND VEGETATION ALLIANCES SCORED BY GROUNDWATER BASIN

SEPTEMBER 2019 | DRAFT | FIGURE 2-35

01Jun2018 Z:\Projects\1800999_Kern_Subbasin\Fig2_44_Wetlands_Vegetation.mxd RS

POTENTIAL GROUNDWATER DEPENDENT ECOSYSTEMS: WETLANDS



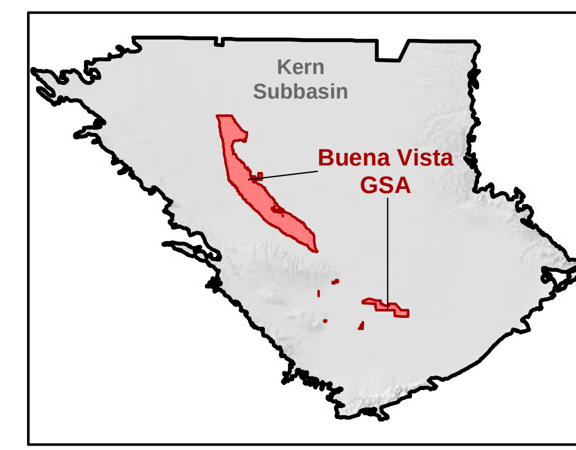
- Wetlands (NCCAG)
- USGS Extent of Corcoran Clay

GSA Boundaries

- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features

- Highway
- Waterway



0 2.5 5 10
Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

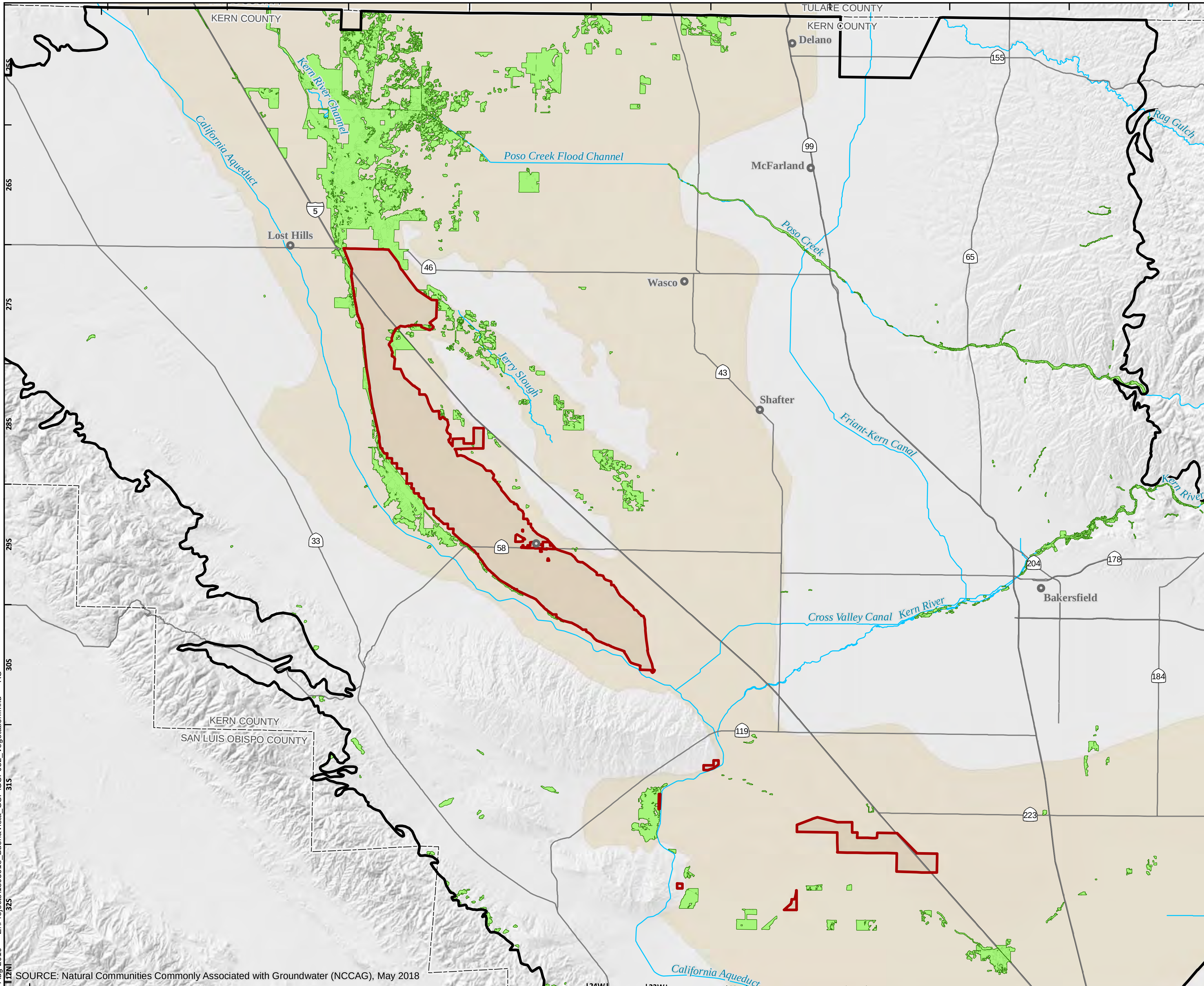
Buena Vista GSA

GEI Consultants

SEPTEMBER 2019 **DRAFT** FIGURE 2-36

12-Aug-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP031_Wetlands.mxd RS

POTENTIAL GROUNDWATER DEPENDENT ECOSYSTEMS: VEGETATION



Vegetation (NCCAG)

USGS Extent of Corcoran Clay

GSA Boundaries

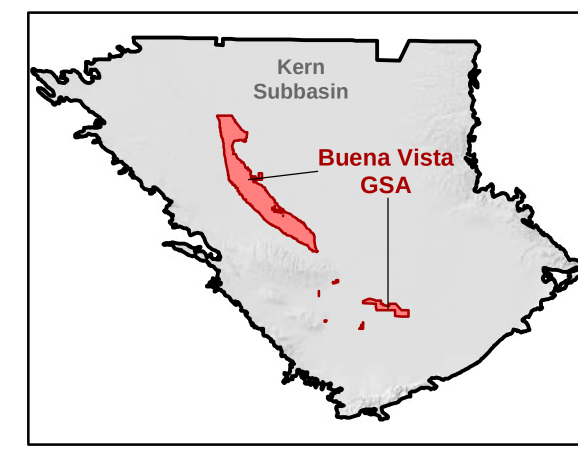
Buena Vista GSA

Kern Subbasin Boundary

All Other Features

Highway

Waterway



0 2.5 5 10

Miles

N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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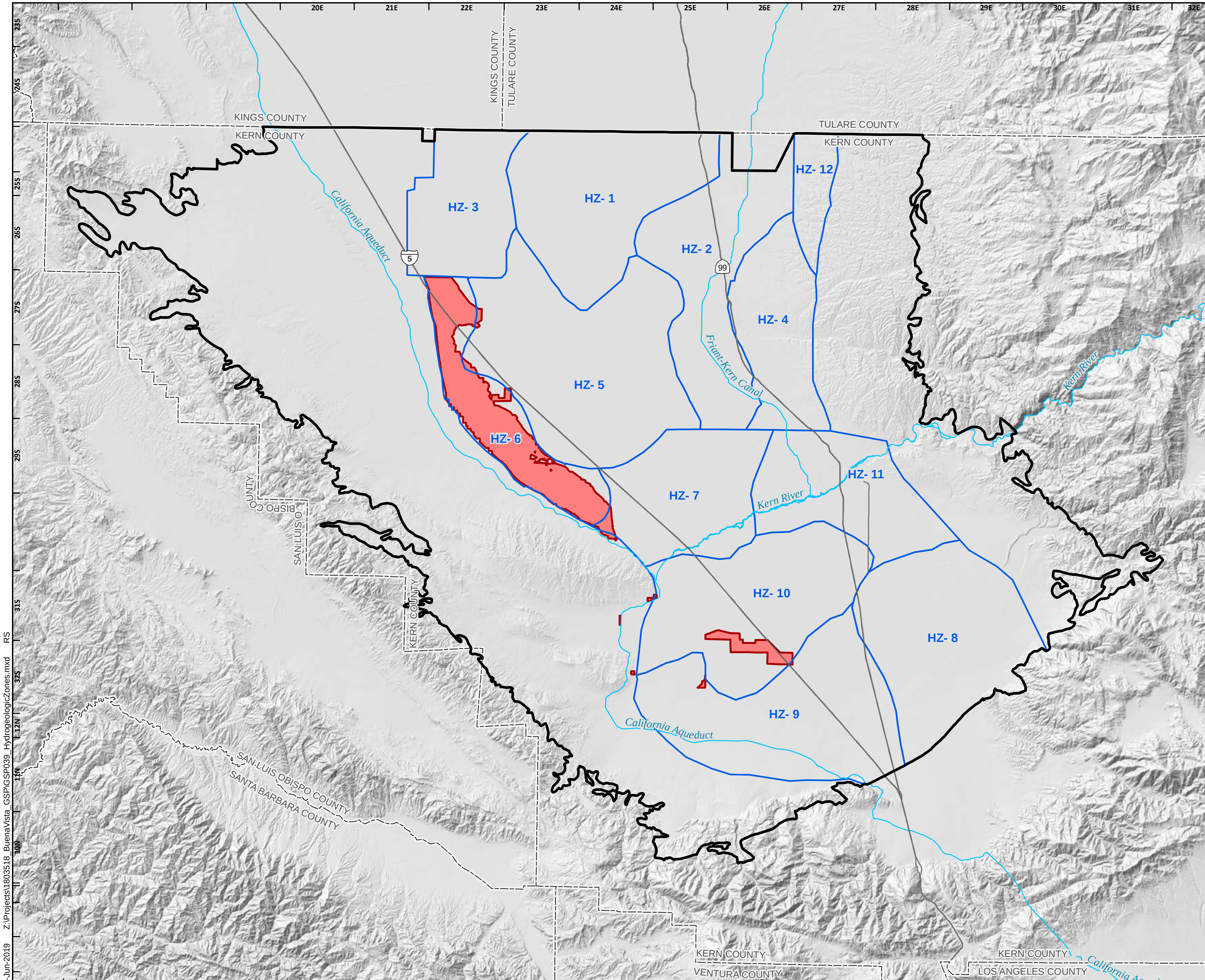
SEPTEMBER 2019 **DRAFT** FIGURE 2-37

HYDROGEOLOGIC ZONES OF THE KERN COUNTY SUBBASIN



Hydrogeologic Zone

GSA Boundaries

Buena Vista GSA

Kern Subbasin Boundary

All Other Features

Highway

Waterway

0 4 8 16

Miles

N

Z:\Projects\1803518_BuenaVista_GSP\GSP039_HydrogeologicZones.mxd RS

19-Jun-2019

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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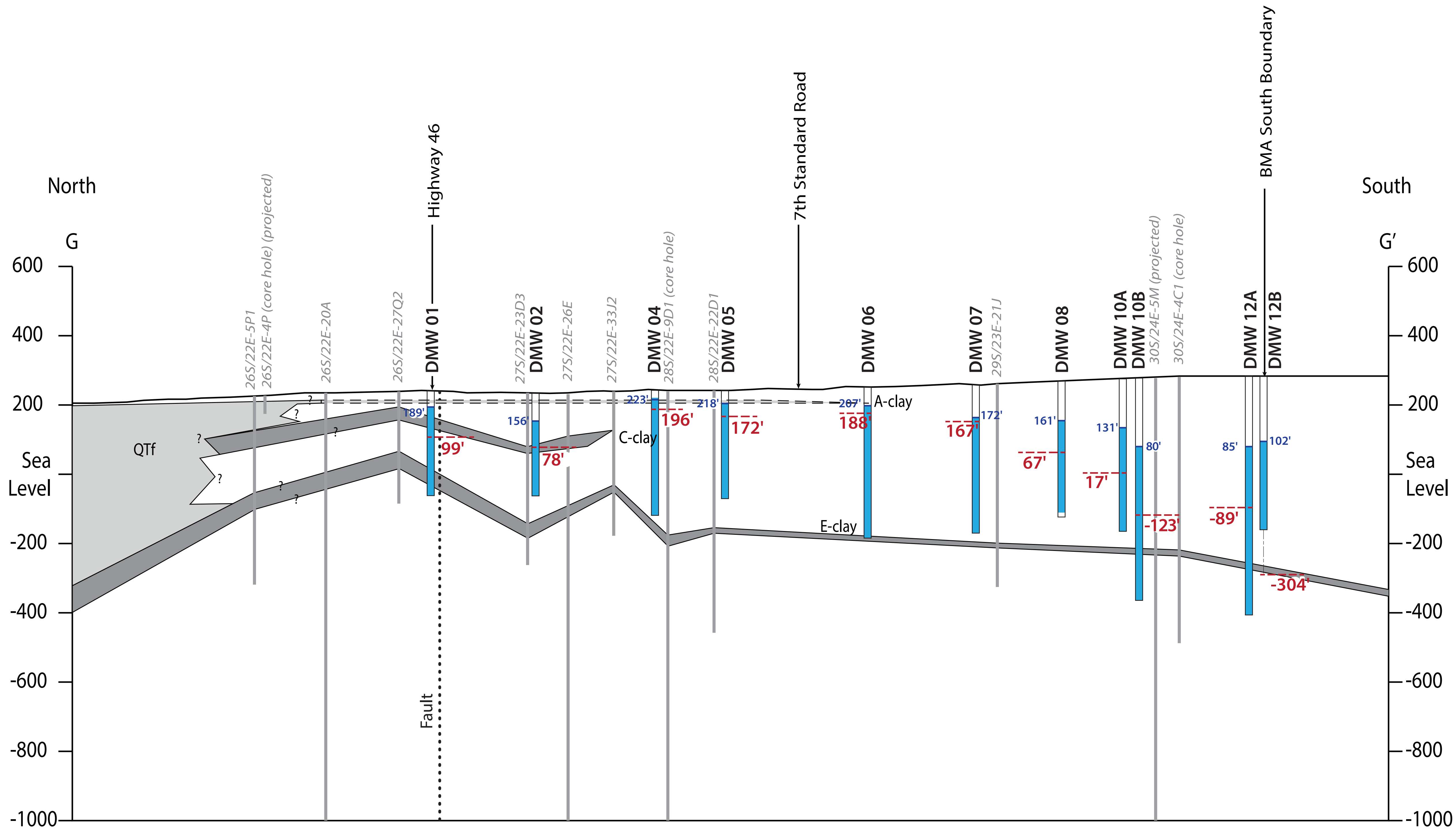
SEPTEMBER 2019 **DRAFT** FIGURE 4-3



Approximate Horizontal Scale

40,000 feet

Source: Adapted from USGS Water Supply Paper 1999-H (Croft 1972)

Legend

- Water level (2040 projection)
- Portion of casing below water level (2015)
- Wells used in USGS source cross-section

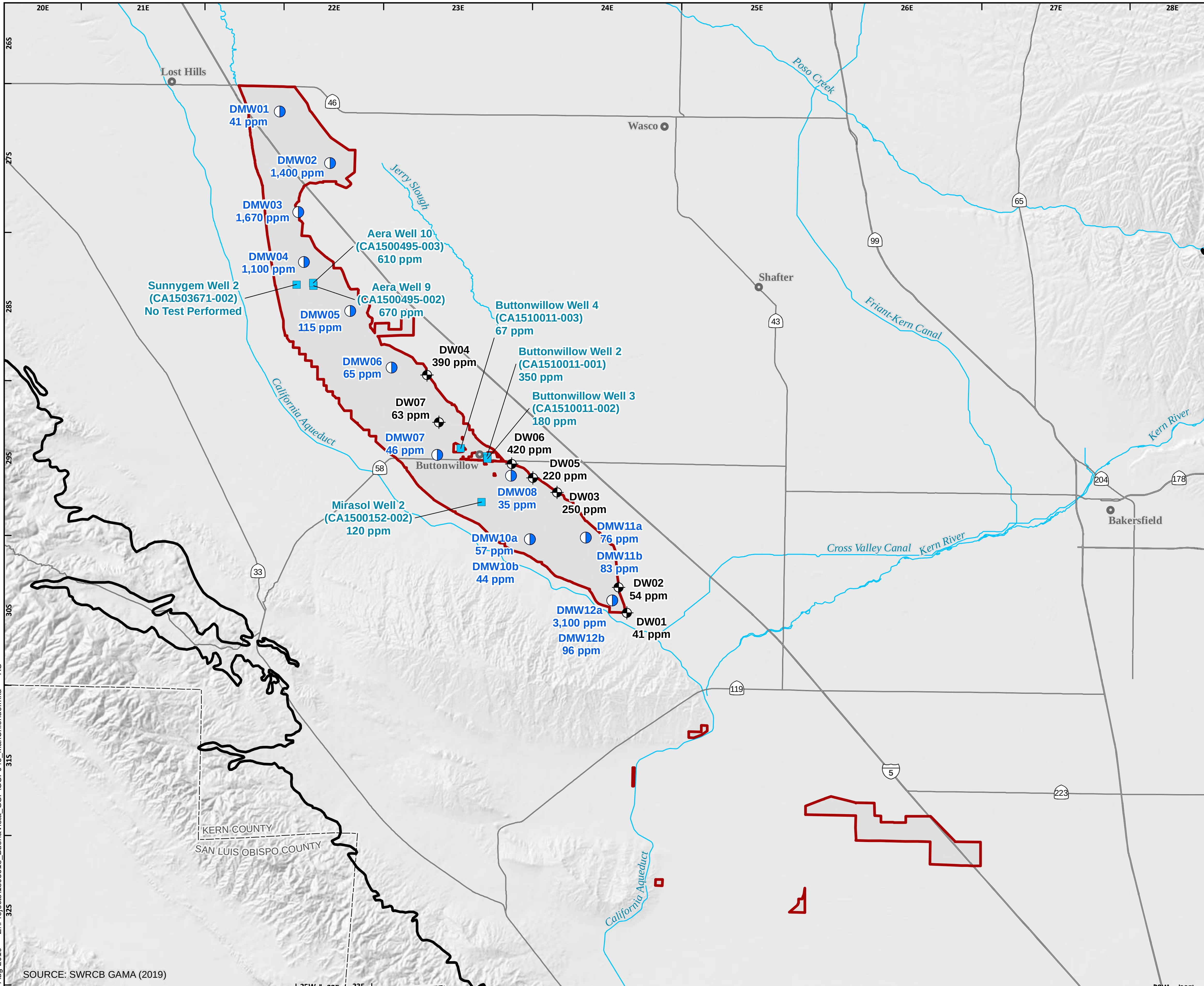
Buena Vista Groundwater Sustainability Plan Kern County, California	GEI Consultants	Longitudinal Cross Section of BMA
Buena Vista Groundwater Sustainability Agency		SEPTEMBER 2019 FIGURE 5.7

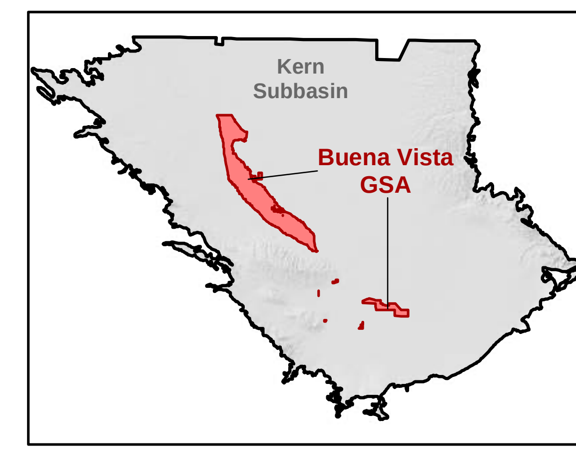
MAXIMUM CHLORIDE

Wells
- District Extraction Well
- District Monitoring Well
- Public Water System Well

GSA Boundaries
- Buena Vista GSA
- Kern Subbasin Boundary

All Other Features
- Highway
- Waterway





0 2 4 8
Miles
N

Buena Vista Groundwater Sustainability Plan
Kern County, California

Buena Vista GSA

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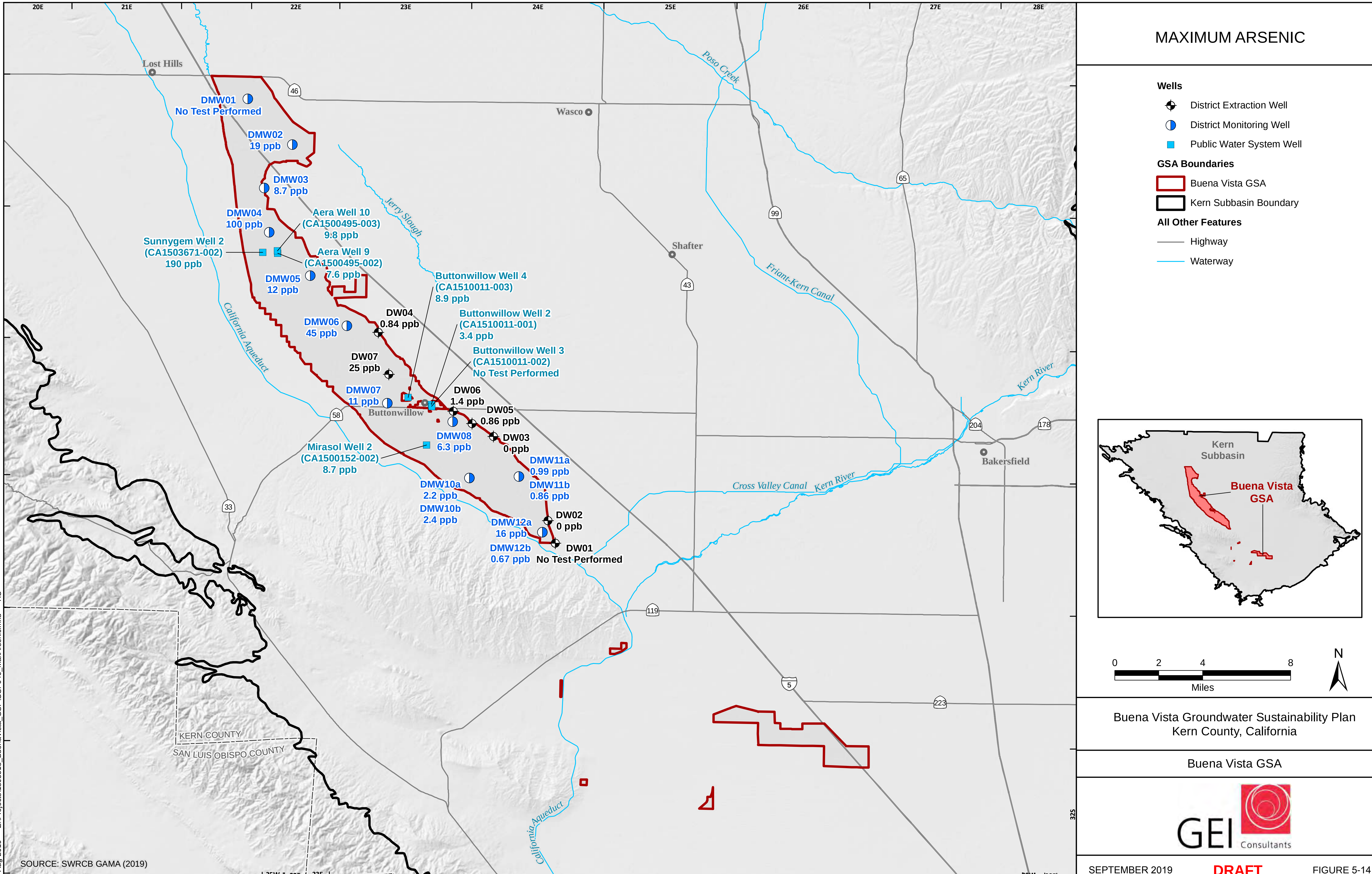
SEPTEMBER 2019 **DRAFT** FIGURE 5-13

12-Aug-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP045_MaxChloride.mxd RS



09-Aug-2019 Z:\Projects\1803518_BuenaVista_GSP\GSP046_MaxArsenic.mxd RS