

Appendices

Coordination Agreement

Kaweah Subbasin

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Appendix 2

Monitoring Network Summary

This appendix provides a summary of the monitoring networks for the management of groundwater resources within the Kaweah Subbasin in Tulare and Kings Counties. Groundwater management will be conducted by the Eastern Kaweah Groundwater Sustainability Agency (GSA), Greater Kaweah GSA, and the Mid-Kaweah GSA according to their respective groundwater sustainability plans (GSPs). Specific details of the monitoring networks can be found in the respective GSPs. This appendix will be revised periodically to reflect the expansion of the networks as data gaps are filled by ongoing management efforts.

The monitoring networks are focused on three of the six sustainability indicators, including Groundwater Levels, Water Quality, and Subsidence. Groundwater Storage will be addressed by Groundwater Levels by proxy. Seawater Intrusion is not applicable to the Kaweah Subbasin since the Pacific Ocean is located more than 80 miles to the west, beyond the Coast Mountains. Interconnected Surface Water has not been identified as applicable at this time in Mid-Kaweah and will be addressed by proxy via Groundwater Levels in the Eastern Kaweah GSA.

Groundwater Levels

Figure A-2-1 illustrates the location of monitoring wells that will be used for semi-annual measurements of groundwater levels and estimates of groundwater storage. Selected wells may be monitoring monthly within the MKGSA by the Cities of Tulare and Visalia. The three GSAs will utilize a total of 126 wells, as summarized below.

Purpose / GSA:	Greater Kaweah	Mid-Kaweah	Eastern Kaweah
Groundwater Levels	40	43	43

Groundwater Quality

Figure A-2-2 illustrates the location of wells that will be used for monitoring groundwater quality. The three GSAs will utilize a total of 285 wells, as summarized below. Most of these wells will be public supply wells which are sampled according to the requirements of the California Division of Drinking Water. Primary constituents of concern (COCs) as listed below.

<u>Metal</u>	<u>Anion</u>	<u>Organic Compound</u>
Arsenic	Nitrate	DBCP (1,2-dibromo-3-chloropropane)
Chromium-VI	Perchlorate	TCP (1,2,3-trichloropropane)
Sodium	Chloride	PCE (perchloroethylene/tetrachloroethylene)
Total Dissolved Solids (TDS)		

The data management system will accumulate all available data from the various sources of data but will focus on the primary COCs and their respective measurable objective and minimum threshold. Data sources include the Groundwater Ambient Monitoring and Assessment Program (GAMMA), Irrigated Lands Regulatory Program (ILRP), Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS), and other programs as the data become available.

Purpose / GSA:	Greater Kaweah	Mid-Kaweah	Eastern Kaweah
Groundwater Quality	60	110	70

Subsidence

Figure A-2-3 illustrates the location of stations that will be used for monitoring subsidence. The three GSAs will utilize a total of 32 stations, as summarized below.

Purpose / GSA:	Greater Kaweah	Mid-Kaweah	Eastern Kaweah
Subsidence	14	8	10

Figure A-2-1. Location Map for Monitoring Wells for Groundwater Levels

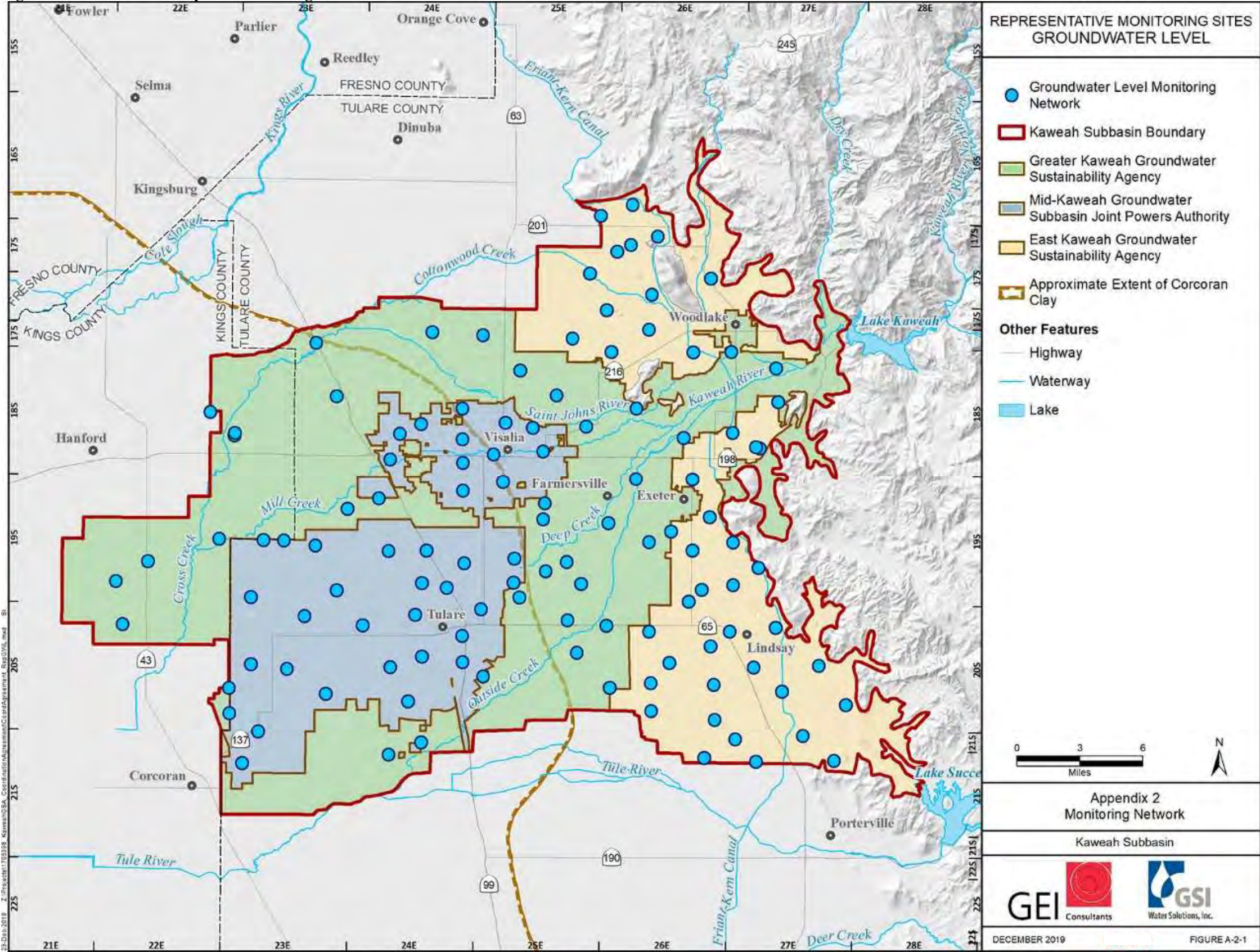


Figure A-2-2. Location Map for Supply Wells for Groundwater Quality Monitoring

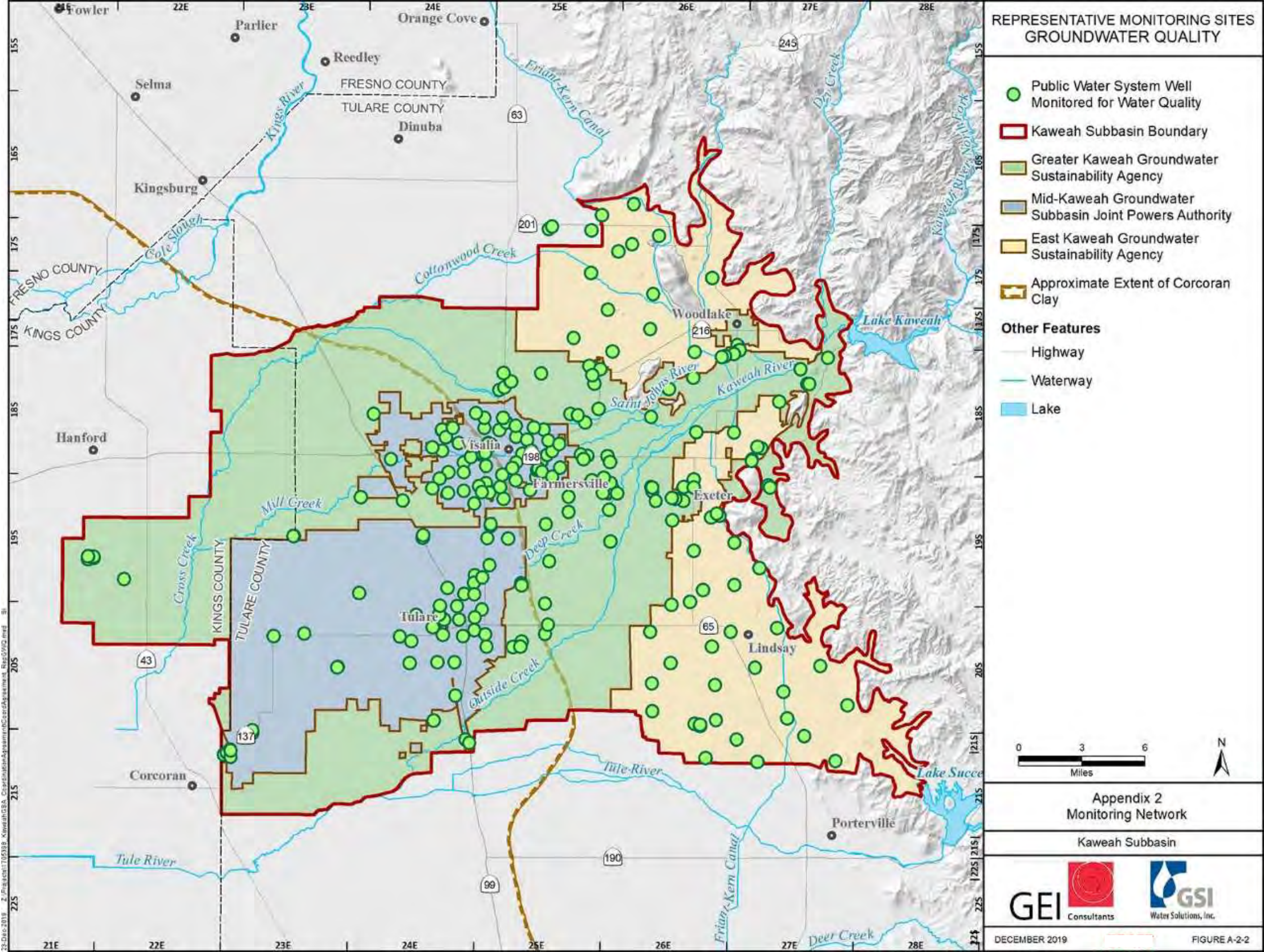
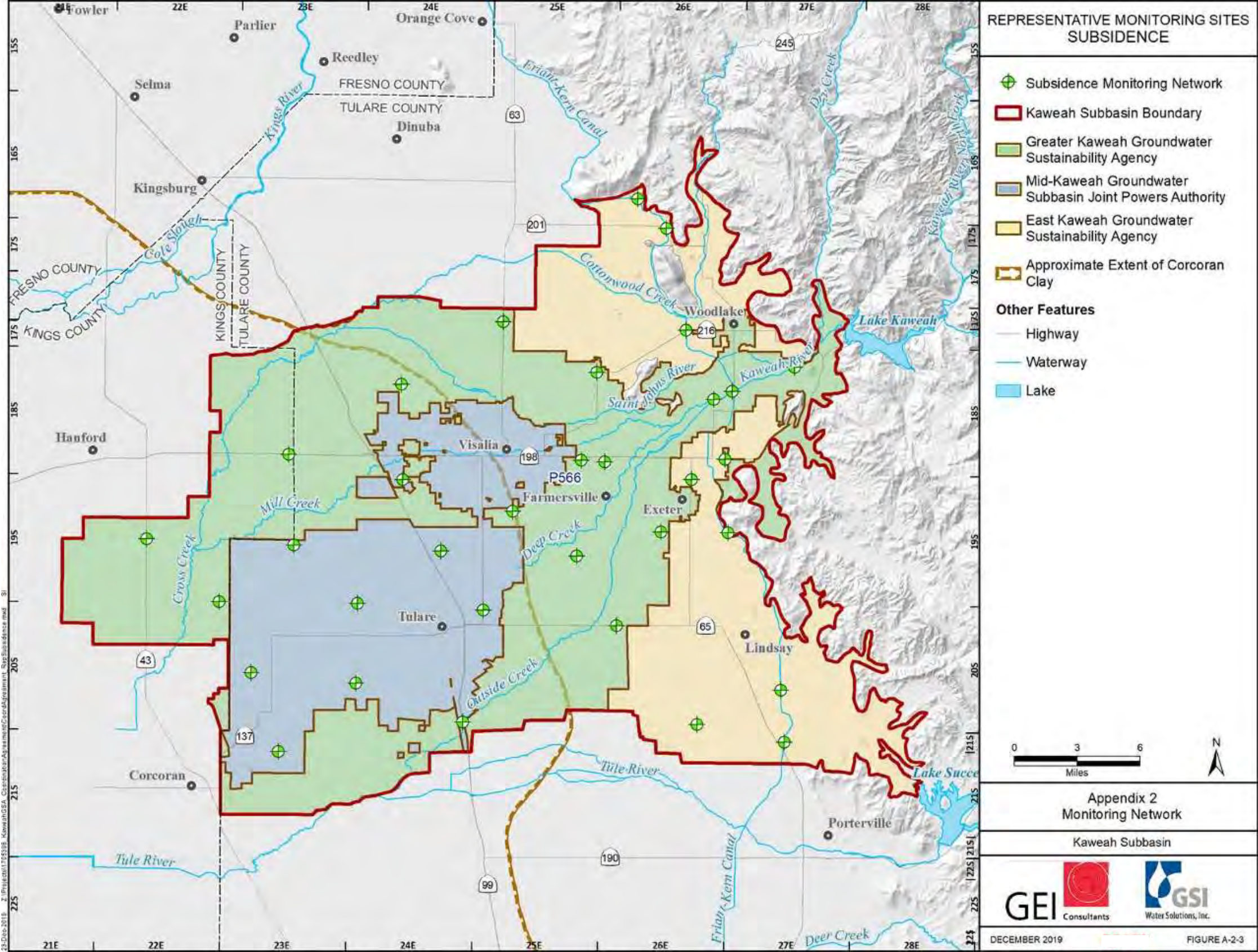


Figure A2-3. Location Map for Subsidence Monitoring Stations



Appendix 3

Water Accounting Framework Summary

Water Accounting Framework

Appendix 3 to Kaweah Subbasin Coordination Agreement

For purposes of creating a water budget pursuant to 23 Cal. Code Regs. §354.18, the GSAs in the Kaweah Subbasin have agreed that the Sustainable Yield for the Subbasin shall be divided amongst the GSAs for purposes of development of their GSPs as described in the Kaweah Subbasin water budget. The water budget is not an allocation of final determination of any water rights. This understanding is consistent with § 10720.5(b) of SGMA, which provides that nothing in SGMA or in a plan adopted under SGMA determines or alters surface or groundwater rights under common law or any provision of law that determines or grants surface water rights.

The Subbasin GSAs have discussed water budgets and have developed a means to account for various components of the water budget. These discussions accounting also included recognition of water storage and conveyance infrastructure within the Subbasin as owned/operated by various water management entities within each GSA.

These discussions culminated in an agreed-to methodology to assign groundwater inflow components to each GSA consistent with categories that recognize a native, foreign and salvaged portion of all such components. In general, this methodology defines the native portion of groundwater inflows to consist of those inflows which all well owners have access to on a pro-rata basis; the foreign portion to consist of all imported water entering the Subbasin from non-local sources under contract by local agencies or by purchase/exchange arrangements; and the salvaged portion to consist of all local surface and groundwater supplies stored, treated and otherwise managed by an appropriator/owner of the supply and associated water infrastructure systems (e.g. storm water disposal systems and waste water treatment plants).

The methodology and apportionment of groundwater inflow components is as shown in Table 3.1:

Table 3.1

Components of Groundwater Inflow

Native

- Percolation from rainfall
- Streambed percolation (natural channels) from Kaweah River watershed sources
- Agricultural land irrigation returns from pumped groundwater
- Mountain front recharge

Foreign

- Streambed percolation from imported sources
- Basin recharge from imported sources
- Ditch percolation from imported sources
- Agricultural land irrigation returns from imported sources

Salvaged

- Ditch percolation from previously appropriated Kaweah River sources
- Additional ditch/field recharge from over-irrigation
- Captured storm water returns
- Waste water treatment plant returns
- Basin percolation from previously stored Kaweah River sources
- Agricultural land irrigation returns from Kaweah River watershed sources

*Except for mountain front recharge, sub-surface inflows in and out of the Subbasin are excluded from this accounting methodology and no ownership claims are asserted nor disavowed per this methodology.

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Applying the accounting methodology in Table 6.1 to each GSA and their member entities that hold appropriative and contract water rights and/or salvaged water infrastructure systems results in the following quantification to each GSA, shown in Table 3.2:

Table 3.2
(values in acre-feet)

	Native Water			
	East	Greater	Mid	Total
Perc of Precip (Ag and 'Native' non-Ag land)	23,666	44,213	20,974	88,854
Streambed Perc from Kaweah River Sources	16,767	31,324	14,860	62,952
Irrigation Ret. Flow from Pumped GW	41,484	77,501	36,766	155,752
Mountain Front Recharge	14,976	27,978	13,273	56,227
Total Native	96,894	181,017	85,874	363,784
GSA % of Total Native	27%	50%	24%	
	Foreign Water			
	East	Greater	Mid	Total
Streambed Perc from Imported Sources	0	11,730	2,523	14,253
Ditch Perc from Imported Sources	0	1,204	21,745	22,949
Basin Perc from Imported Sources	0	1,050	14,305	15,355
Irrigation Ret. Flow from Imported Sources	12,073	1,241	7,140	20,453
Total Foreign	12,073	15,225	45,713	73,010
GSA % of Total Foreign	17%	21%	63%	
	Salvaged Water			
	East	Greater	Mid	Total
Ditch Perc from Kaw River Sources	8,835	49,771	34,880	93,486
Additional Recharge	226	6,892	5,697	12,815
Stormwater Return Flows	508	2,370	8,491	11,368
WWTP Return Flows	1,470	3,129	13,878	18,477
Basin Perc from Kaweah River Sources	0	16,005	23,479	39,484
Irrig. Ret. Flow from Kaweah River Sources	4,555	31,039	11,981	47,574
Total Salvaged	15,593	109,205	98,406	223,205
GSA % of Total Salvaged	7%	49%	44%	
	East	Greater	Mid	Total ^(*)
Grand Total	124,560	305,447	229,992	659,999
GSA % of Total	19%	46%	35%	
(*) Excludes net sub-surface inflow of 60 taf/yr				
Note: All data is derived from the Basin Setting and is based on water budget for the period Water Year 1997 to 2017 for the Kaweah Subbasin.				

As noted in Table 3.2, net sub-surface inflow is omitted from this quantification. Sub-surface inflows and outflows are discussed and quantified in the Basin Setting report (Appendix 1) and are embodied in scenarios of future groundwater conditions as simulated by application of

the Subbasin computer model. As discussed in that report, the Subbasin's safe yield is estimated to be about 720,000 AF, which amount includes net sub-surface inflow. As defined in SGMA however, the Subbasin's sustainable yield may be additionally impacted when considering undesirable results for other sustainability indicators. The Parties therefore have preliminarily determined that the sustainable yield may be something less and have agreed that the total groundwater inflow of 660,000 AF identified in Table 3.2 will constitute the sustainable yield, which amount does not take into consideration net sub-surface inflow from adjacent subbasins. The estimated sustainable yield will continue to be revised pursuant to the monitoring of sustainability indicators and avoidance of undesirable results.

At this stage, inter-basin discussions concerning water budgets and associated credits for such sub-surface flows are not to the point of delineating Subbasin assignments thereof. The quantification as described serves primarily to shape future discussions among the Kaweah Subbasin GSAs concerning mutual responsibilities in achieving sustainability by 2040.

As additional data becomes available and water budget components are refined, the Subbasin water budget and estimates of sustainable yield will be periodically reevaluated, no less frequently than two years. Likewise, the individual GSA water balances will also be reviewed as this reevaluation occurs at the Subbasin level.

Appendix 4

DMS Summary

Appendix 4 -DMS Summary



Memo

To: Kaweah Subbasin GSAs
Mike Hagman, East Kaweah GSA
Eric Osterling, Greater Kaweah GSA
Paul Hendrix, Mid-Kaweah GSA

From: Chris Petersen and Maria Pascoal, GEI Consultants

Date: [Status]

Re: Draft Specifications for the Kaweah Subbasin Data Management System

The Sustainable Groundwater Management Act (SGMA) regulations, established by the California Department of Water Resources (DWR), require that a Groundwater Sustainability Plan (GSP) must have a Data Management System (DMS) capable of securely storing and displaying information relevant to the development and implementation of the GSP. The Kaweah Subbasin will be managed by three Groundwater Sustainability Agencies (GSAs) under three GSPs. To effectively and cost-efficiently share data, the GSAs will use one DMS to store the Subbasin's SGMA data.

The DMS for the Kaweah Subbasin is currently being developed by GEI Consultants, Inc. (GEI) with data and analytical support from GSI Water Solutions (GSI). The purpose of this memorandum is to describe the specifications of the DMS. These specifications were developed based on the DMS development meeting held with the three GSAs in April 2018 and supported by Task Order KSB-05.2018 Amendment 2, Task 1 – Data Management System. This memorandum includes the following sections:

1. SGMA DMS Requirements
2. Data Structure
3. Data Contents
4. Web Interface
5. DMS Hosting
6. Summary

SGMA DMS Requirements

The Kaweah Subbasin DMS will be designed to meet the system and data requirements of SGMA.

1.1. System Requirements

The GSP Regulations (California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2) give broad requirements on data management, stating that a GSP must adhere to the following guidelines for a DMS:

§ 352.6. Data Management System

Each Agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the [Groundwater Sustainability] Plan and monitoring of the basin.

Note: Authority cited: Section 10733.2, Water Code.

Reference: Sections 10727.2, 10728, 10728.2, and 10733.2, Water Code.

§ 352.4. Data and Reporting Standards

(c) The following standards apply to wells:

(3) Well information used to develop the basin setting shall be maintained in the Agency's data management system.

Note: Authority cited: Section 10733.2, Water Code.

Reference: Sections 10727.2, 10727.6, and 10733.2, Water Code.

§ 354.40. Reporting Monitoring Data to the Department

Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.

Note: Authority cited: Section 10733.2, Water Code.

Reference: Sections 10728, 10728.2, 10733.2, and 10733.8, Water Code.

1.2. Data Requirements

SGMA defines sustainable groundwater management as “the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results.”¹ Furthermore, SGMA outlines six undesirable results as follows:²

One or more of the following effects caused by groundwater conditions occurring throughout the basin:

(1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic

¹ §10721(v)

² §10721(x)

lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.

(2) Significant and unreasonable reduction of groundwater storage.

(3) Significant and unreasonable seawater intrusion.







(4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.

(5) Significant and unreasonable land subsidence that substantially interferes with surface land uses.

(6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

The presence or absence of the six undesirable results in a groundwater basin is determined by examining the sustainability indicator data for each. The Kaweah Subbasin DMS will store data relevant to each sustainability indicator as appropriate. There are multiple metrics by which the sustainability indicators may be observed. These metrics, as defined in the GSP Regulations and described by DWR in the Sustainable Management Criteria Best Management Practice (BMP) document,³ are shown in **Figure 1**.

Figure 1. DWR's Sustainability Indicator Metrics

Sustainability Indicators	 Lowering GW Levels	 Reduction of Storage	 Seawater Intrusion	 Degraded Quality	 Land Subsidence	 Surface Water Depletion
Metric(s) Defined in GSP Regulations	<ul style="list-style-type: none"> • Groundwater Elevation 	<ul style="list-style-type: none"> • Total Volume 	<ul style="list-style-type: none"> • Chloride concentration isocontour 	<ul style="list-style-type: none"> • Migration of Plumes • Number of supply wells • Volume • Location of isocontour 	<ul style="list-style-type: none"> • Rate and Extent of Land Subsidence 	<ul style="list-style-type: none"> • Volume or rate of surface water depletion

³ https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Sustainable_Management_Criteria_2017-11-06.pdf.

The Kaweah Subbasin DMS is designed to store data for each of the six sustainability indicators. Each sustainability indicator may track one or more types of data, as shown in **Table 1**.

Table 1. DMS Data Types to Monitor the SGMA Sustainability Indicators

Sustainability Indicator	Tracking Data							
	Water Level	Extensometer	GPS	InSAR	Water Quality		Stream stages	Well* and/or Site Data
					Chloride	±10 constituents		
Subsidence	✓	✓	✓	✓				✓
Water levels	✓							✓
Groundwater storage	✓							✓
Seawater intrusion	Not applicable (per GSP development)							
Surface water/ groundwater interaction	✓						✓	✓
Water quality	✓				✓	✓		✓

*May include aquifer, construction, lithology, and/or screen data

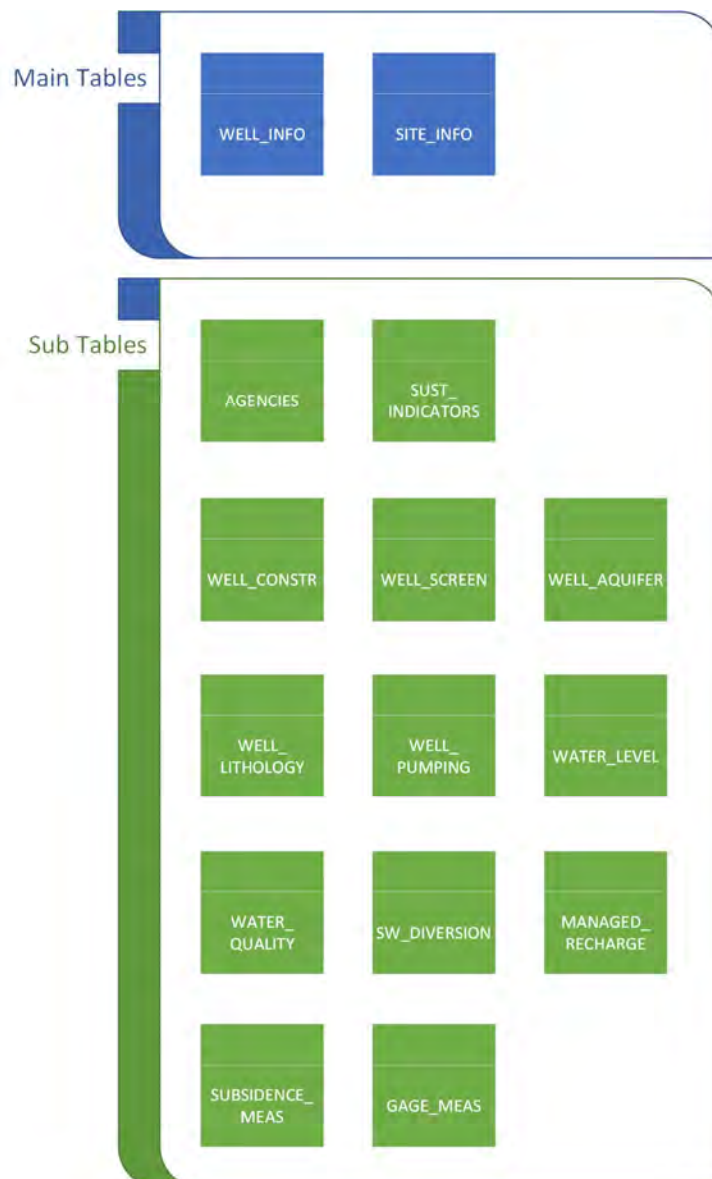
The Kaweah Subbasin DMS will accept the types of data shown in the columns of **Table 1**. However, the DMS will not necessarily be populated with historical data for each type. Data that was relied upon for 2020 GSP development is what will be uploaded in the DMS.

Data Structure

The DMS will consist of a database plus an online web viewer. Data stored in the DMS is separated by categories into tables. The tables contain columns and rows of data. Each field holds a specific type of data, such as a number, text, or date. The primary DMS data tables are shown as **Figure 2**. The figure is color-coordinated to show the relationship between tables:

- **Blue Tables** – Main tables that include point data with a unique identification and unique point location to be added to the database (e.g., Well_Info and Site_Info)
- **Green Tables** – Sub tables related to the main table that hold additional details about the well or site (e.g., correlation of a well point with water level or water quality)

Figure 2. Kaweah Subbasin DMS Tables – Main and Sub



A brief description of each main and sub table is provided in **Table 2**. There are lookup tables within each of the main and sub tables, but the lookup tables are very detailed and not outlined here. The lookup tables can be found in the upload templates described in the next section of this document.

Table 2. DMS Table Descriptions

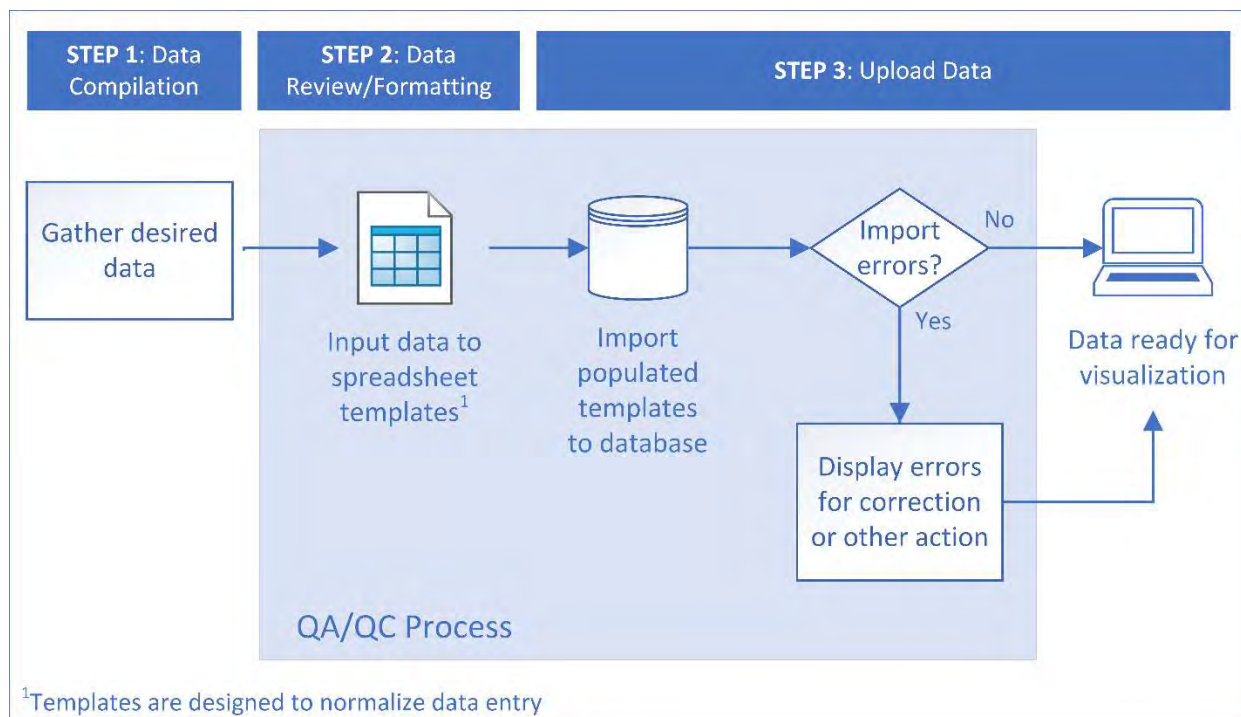
Table	Description
Main Tables	
Site Info	Information about type of station (well, recharge site, diversion, gage, extensometer, GSP) and geographic location
Well Info	General information about well, including identifiers used by various agencies
Sub Tables	
Agencies	Agency associated with the well and/or site or the collection of data at a well or site
Sustainability Indicators	Minimum Thresholds and Measurable Objectives set for monitoring network sites tracking Sustainable Management Criteria for SGMA compliance
Well Construction	Well construction information including depth, diameter, etc.
Well Construction Screen	Supplements 'Well Construction' with well screen information (one well can have many screens)
Well Geologic Aquifer	Information about the aquifer parameters of the well such as pumping test information, confinement, and transmissivity
Well Geologic Lithology	Lithologic information at a well site (each well may have many lithologies at different depths)
Water Level	Water level measurements for wells
Well Pumping	Pumping measurements for wells, annual or monthly
Managed Recharge	Recharge measurements for a recharge site, annual or monthly
SW Diversion	Diversion volume measurements for a diversion site, annual or monthly
Water Quality	Water quality data for wells or any other type of site
Subsidence Measurement	Elevation measurements from stations tracking land subsidence
Gage Measurement	Stage or discharge water level measurements from stream gages

Data Contents

Historical data will be populated into the DMS as needed to support the 2020 GSPs. State and Federal data available via online public databases will be brought directly from the data source to the DMS by the DMS development team.

Local Kaweah Subbasin data used to support GSP development will be collected by GEI and put into spreadsheet templates designed to normalize data entry. The templates will include a set of rules restricting formatting, alphanumeric properties, and other filters. This template process is shown as **Figure 3**.

Figure 3. Template Import Process for Local Data



The templates include validation parameters similar to CASGEM templates. CASGEM templates are shown in **Figure 4** as an example. The templates will have pop-up windows to describe what should be filled in for each column. If a specific filter must be applied, only values that meet the criteria will appear in a drop-down list. GEI will upload data to the DMS using these templates.

Figure 4. CASGEM Template Examples

CASGEM ID	Local or State Well Number	Date (MM/dd/yyyy)	24-hour Time, PST (hh:mm)	NM Code	QM Code
389011N1213514W001	Airport Well 4 MW	11/19/2018	6:49		
389011N12135	t Well 4 MW	12/14/2018	6:24		
389011N12135	t Well 4 MW	1/14/2019	7:23		
389011N12135	t Well 4 MW	2/14/2019	7:18		
389011N12135	t Well 4 MW	3/14/2019	7:44		
389011N12135	t Well 4 MW	4/16/2019	8:55		
388604N12135	-1	11/19/2018	9:15		

CASGEM ID	Local or State Well Number	Date (MM/dd/yyyy)	24-hour Time, PST (hh:mm)	NM Code	QM Code	Reading at RP
389011N1213514W001	Airport Well 4 MW	11/19/2018	6:49			43.950
389011N1213514W001	Airport Well 4 MW	12/14/2018	6:24			
389011N1213514W001	Airport Well 4 MW	1/14/2019	7:23			
389011N1213514W001	Airport Well 4 MW	2/14/2019	7:18			
389011N1213514W001	Airport Well 4 MW	3/14/2019	7:44			
389011N1213514W001	Airport Well 4 MW	4/16/2019	8:55			39.810

All the Main and Sub Tables listed in **Table 2** will have a template. The compiled data will be reviewed by GEI before it is migrated into the database. The data review process will be focused and limited in scope. It will include the following checks:

- Identifying outliers that may have been introduced during the original data entry process
- Removing or flagging questionable data

Once the data has been compiled, input to the templates, and reviewed, it will be uploaded to the DMS and displayed on a visualization tool (GIS map) interface.

Moving forward, the templates will be used by the Kaweah Subbasin GSAs to prepare future data for DMS input.

Web Interface

The DMS begins with a database, stored locally or online, and is accompanied by a viewer that allows administrators to see the data in a user-friendly interface. The proposed Kaweah Subbasin DMS is a database built in Oracle plus a web application designed in JAVA.

The web application will display well and other instrument (e.g., extensometer) locations, identifying which wells or instruments are part of a representative monitoring network for the SGMA sustainability indicators.

- Clicking on a well site will display available historical water level or water quality data on a hydrograph
- Clicking on other monitoring points (e.g., extensometers) will display available historical data in tabular and chart format

The map displaying the DMS data will include additional geographic features such as GSA, local agency, and Bulletin 118 basin boundaries to provide context and facilitate interaction with the data.

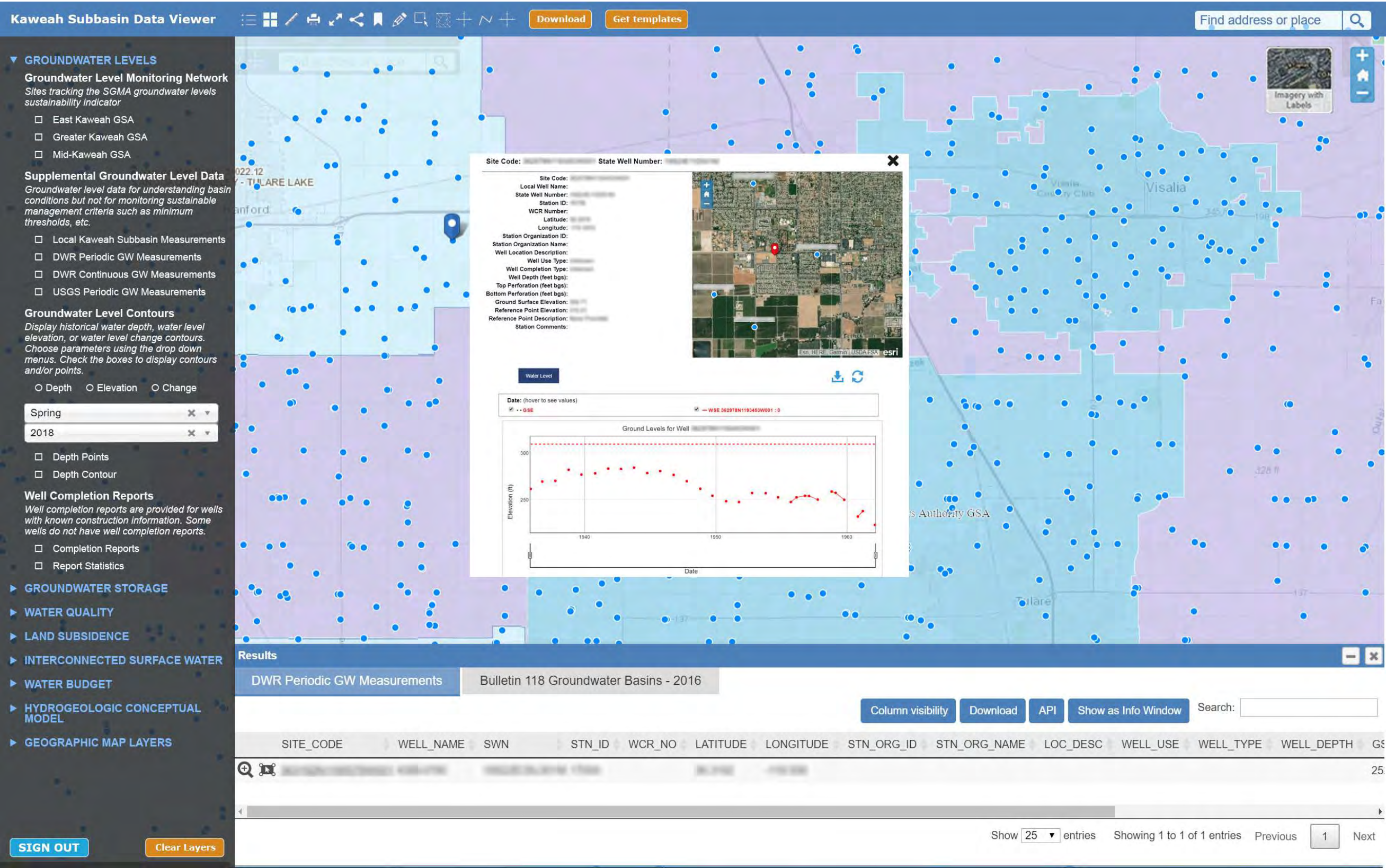
Representative monitoring network data will be made available for export to a spreadsheet format for analytical and reporting purposes. GSP Regulations Article 7 §356.2 outlines specific components to be reported annually (paraphrased):

- *General information including executive summary and location map (narrative)*
- Groundwater elevation contour maps (sourced by DWR) and hydrographs
- Groundwater extraction
- Surface water supply used or available for use, for groundwater recharge or in-lieu use
- *Total water use by water use sector and source (calculated)*
- Change in groundwater storage displayed in map and graph formats
- *Description of progress towards implementing the GSP (narrative)*

The items listed above are needed for each annual report to DWR. The Kaweah Subbasin DMS is designed to store all these items except for those shown in *italics*, which are either narratives or calculations that are done outside of the DMS.

See **Figure 5** for an example design for the Kaweah Subbasin data viewer.

Figure 5. Example Design for Kaweah Subbasin Data Viewer



DMS Hosting

GEI will host the DMS for the duration of the amended Task Order – through December 2019. After that time, hosting will be transferred to either a Kaweah Subbasin GSA or a participating agency. As of the April 2018 DMS Development Meeting, the GSAs decided to postpone choosing where the DMS would be hosted from the year 2020 forward. If needed, GEI may continue to host the DMS for a nominal fee.

Summary

The Kaweah Subbasin DMS will contain the information used to support GSP development. The data stored will be based on the requirements of SGMA and include relevant historical data collected during GSP development for each of the six sustainability indicators. The DMS will consist of an Oracle database with a web-based viewer designed using JAVA. Data will be available for export from the DMS using the web-based viewer. The DMS will be hosted on a GEI server through December 2019, after which time it will be hosted by a Kaweah Subbasin agency or stay with GEI for a fee.

Appendix 5

Data Gaps Summary

Appendix 5

Data Gaps Summary

This appendix provides a summary of the current data gaps in the Kaweah Subbasin. It represents the gaps that were identified at the time of 2020 GSP preparation by the Kaweah Subbasin GSAs: East Kaweah GSA (EKGSA), Mid-Kaweah GSA (MKGSA), and Greater Kaweah GSA (GKGSA).

The three abovementioned GSAs agreed to, at a minimum of every five years, provide an evaluation of data gaps and to make a good-faith effort to address data gaps. These commitments are documented in the Kaweah Subbasin Coordination Agreement.

In general, the Kaweah Subbasin GSPs identify a need for expanding the spatial extent and density of the monitoring networks for water levels, water quality, and subsidence. They also indicate a need for increased knowledge about the existing monitoring network including geological/hydrogeological information, well logs, and well construction information.

Table A-5-1 provides a summary of the primary data gap topics.

Table 5-1. Primary data gap topics by GSP

Data Gap Topic	EKGSA GSP	MKGSA GSP	GKGSA GSP
Geological/hydrogeological information	X	X	X
Well logs	X	X	X
Well construction information	X	X	X
Stream flow monitoring	X		
Spatial extent and density of water level monitoring network		X	X
Spatial extent and density of water quality monitoring network			X
Spatial extent and density of subsidence monitoring network	X	X	X
Groundwater-dependent ecosystems (GDEs)	X		X
Subsurface inflows and outflows	X		
Surface water deliveries	X		
Recharge basin data collection	X		
Irrigation demand	X		
M&I demand	X		
Accurate well count, type (domestic, irrigation, etc.), and status (active, inactive, abandoned[, destroyed])		X	X
Hydraulic parameters of principal aquifers based on pumping tests		X	X
Water quality information for domestic and agricultural wells		X	X
Interconnected surface water			X
Pumping records		X	
Rocky Hill Fault: evaluation of flow	X		
Intermontane Valley areas	X		
Septic system contamination (Nitrate)	X		

Each of the three Kaweah Subbasin GSPs contain a list of the principal data gaps for its respective GSA area. The summary lists extracted from each GSP are provided below.

East Kaweah

From the EKGSA GSP, **Section 2.6 – Identification of Data Gaps:**

“Identification of data gaps will continue to be a work in progress. The principal data gaps are listed below, which are subject to revision during the course of completion of this GSP.

- Geological/hydrogeological information for all areas of the EKGSA.
 - The SkyTEM effort should assist in filling this data gap
 - New and/or better well logging for monitoring and production wells can also be informative in locations with little or no data
- Well construction information such as: depth of well, perforation intervals, casing diameter, and use
 - Strongly encourage the Kaweah Subbasin GSAs and Tulare County [to] initiate a well canvas of the area to develop a better data set
 - Potential Drinking Well Observation Plan can assist with gathering well data for specific drinking water wells in the region
- Stream flow monitoring on Cottonwood, Yokohl, Lewis, and Frazier Creeks
 - Gauges are proposed to be constructed, especially for the creeks potentially to be used for recharge activities
 - Specific watershed studies for these creek watersheds can be performed to better inform the estimations of creek flows and seepage
- Consistent subsidence monitoring
 - Likely remedied with more consistent InSAR data
 - Specific infrastructure to be surveyed for subsidence impacts
- Presence of GDE
 - Likely linked with the added stream flow monitoring
 - More consistent groundwater level monitoring in the intermontane valleys
- Water Budget Components
 - Further development of subsurface inflows and outflows from the mountain front and neighboring subbasins
 - Improved understanding of surface water deliveries within district boundaries
 - Retention/Recharge basin data collection and tracking as more recharge is developed
 - Improved understanding of irrigation demand and method for crop and soil types within the Subbasin and EKGSA
 - Improved tracking of M&I demands.”

Greater Kaweah

From the GKGSA GSP, **Section 2. Basin Setting:**

“The following data gaps were identified for the GKGSA:

- Accurate count of wells in GKGSA area, including well type (domestic, irrigation, etc.) and status (active, inactive, abandoned, [destroyed]). A detailed reconnaissance survey is underway to verify location and operational status of wells within GKGSA’s jurisdiction but was not yet complete to inform this plan).
- Construction details of wells, especially production/screen interval(s). This data gap is significant and limits a comprehensive understanding of groundwater level and groundwater quality conditions above and below the Corcoran Clay.
- Lithologic composition of aquifer, including geophysical logs at strategic locations.
- Hydraulic parameters of principal aquifers based on pumping tests.
- Water quality data for domestic and irrigation wells.
- Measurements of subsidence within the GKGSA. The historical record of measured subsidence is incomplete and provides no information to inform an understanding of subsidence with depth.
- Groundwater elevation monitoring in areas with shallower groundwater levels to confirm whether or not the potential interconnected surface water and/or GDEs are present.”

Mid-Kaweah

From the MKGSA GSP, **Section 2. Basin Setting:**

“The following data gaps were identified for the MKGSA:

- Accurate count of wells in MKGSA area, including well type (domestic, irrigation, etc.) and status (active, inactive, abandoned[, destroyed])
- Construction details of wells, especially production/screen interval(s). This was a significant data gap that prevented a comprehensive understanding of groundwater level and groundwater quality conditions above and below the Corcoran Clay
- Groundwater production records from direct measurement and locally generated estimates of groundwater use in rural areas of the MKGSA. This information will improve the water budget.
- Lithologic composition of aquifer, including geophysical logs at strategic locations
- Hydraulic parameters of principal aquifers such as transmissivity, storativity and porosity based on pumping tests preferably. This information could then help with the interpretation of Aerial Electro-Magnetic (AEM) data recently collected.
- Water quality data for small rural community, domestic (rural residential home owners) and agricultural irrigation wells
- Understanding of groundwater quality trends with depth (i.e. between upper and lower principal aquifers and vertical changes within each principal aquifer). With this information, an improved understanding is possible regarding depth of base of freshwater throughout the MKGSA as well as the Kaweah subbasin as a whole.

- Measurements of subsidence within the MKGSA. The historical record of measured subsidence is incomplete and provides no information to inform an understanding of subsidence with depth. Correlation between subsidence and release of arsenic from clay mineralogy represents a data gap that needs to be filled through improved sampling and subsidence monitoring.
- Expanded monitoring of groundwater levels and groundwater quality in small rural communities and disadvantaged communities

A compilation of every reference to a data gap in any of the three Kaweah Subbasin GSPs or in the Kaweah Subbasin Basin Setting document is provided as **Table 5-2**. In general, the plan to fill a data gap is presented alongside or nearby the text where the gap is identified in the GSP or Basin Setting document.

Table 5-2. All Data Gap Reference Table

GSP	Section	Page	Data Gap
GKGSA	2.2	2-2	<p>Summary List</p> <p>The following data gaps were identified for the GKGSA:</p> <ul style="list-style-type: none"> • Accurate count of wells in GKGSA area, including well type (domestic, irrigation, etc.) and status (active, inactive, abandoned[, destroyed]). A detailed reconnaissance survey is underway to verify location and operational status of wells within GKGSA's jurisdiction but was not yet complete to inform this plan). • Construction details of wells, especially production/screen interval(s). This data gap is significant and limits a comprehensive understanding of groundwater level and groundwater quality conditions above and below the Corcoran Clay. • Lithologic composition of aquifer, including geophysical logs at strategic locations. • Hydraulic parameters of principal aquifers based on pumping tests. • Water quality data for domestic and irrigation wells. • Measurements of subsidence within the GKGSA. the historical record of measured subsidence is incomplete and provides no information to inform an understanding of subsidence with depth. • Groundwater elevation monitoring in areas with shallower groundwater levels to confirm whether or not the potential interconnected surface water and/or GDEs are present. <p>The data gaps will be addressed as GKGSA implements the Management Actions designed to close such gaps, as described in Section 7.4 to establish a subbasin-wide Monitoring Network as described in Section 4 of this Plan.</p>
GKGSA	4	4-1	<p>In areas where existing monitoring does not meet the SGMA requirements, this section identifies the data gaps and proposed measures to address these data gaps during the SGMA implementation period, so the monitoring improves with time. Any such improvement will be implemented as recognized and the results will be evaluated during the 5-year updates.</p>
GKGSA	4.10.1	4-20	<p>4.10.1: Data Gaps</p> <p>The following section describes data gaps for groundwater elevations, groundwater quality, and land subsidence.</p>

GSP	Section	Page	Data Gap
GKGSA	4.10.1.1	4-21	<p>4.10.1.1: Groundwater Elevation and Storage</p> <p>As referenced in Regulation §352.4, "If an Agency relies on wells that lack casing perforations, borehole depth, or total well depth information to monitor groundwater conditions as part of a Plan, the Agency shall describe a schedule for acquiring monitoring wells with the necessary information, or demonstrate to the Department that such information is not necessary to understand and manage groundwater in the basin.</p> <p>Well types and construction details will need to be determined to improve the monitoring network. Downhole well surveys and desktop surveys will be utilized for existing wells to fill in the well construction details gap. New dedicated monitoring wells and converted production wells will be utilized to fill in the monitoring network spatial extent and density. Improvement will occur during the initial few years of the implementation period, prior to the first 5-year update.</p> <p>Currently, the Kaweah Subbasin has a total of 14 SGMA compliant, dedicated monitoring wells that may be used for groundwater level monitoring. An additional six monitoring wells are proposed through the DWR's Technical Support Services (TSS) program. Two of the proposed six wells are located within the GKGSA. While the remainder of the wells used in the interim have been identified as Key Wells in the Basin Setting, they are not dedicated SGMA compliant monitoring wells. To address this GKGSA, in coordination with EKGSA and MKGSA, plans to expand the spatial coverage of groundwater level monitoring wells by adding SGMA compliant wells at or near the locations of existing Key Wells as shown in Figure 4 3. The full development of the SGMA-compliant monitoring network is scheduled to take place over the SGMA implementation period of 2020 to 2040.</p>
GKGSA	4.10.1.2	4-21	<p>4.10.1.2: Groundwater Quality</p> <p>Groundwater quality data are mostly available from the reoccurring sampling requirements for public water systems, primarily the Cities of Exeter, Farmersville, and Woodlake, but also for smaller systems within the GKGSA. Additional groundwater quality data will be available from the IRLP program and the upcoming CV-SALTS program and will provide further coverage in agricultural and rural areas. DWR will construct two new nested monitoring wells for the GKGSA as part of the Technical Services Support program. In addition, inactive production wells will be converted to monitoring wells to improve the spatial extent and density of the monitoring network. Improvement will occur during the initial few years of the implementation period, prior to the first 5-year review.</p> <p>As described in Section 4.9, groundwater quality monitoring under existing regulatory programs for public water systems currently provide adequate coverage for the Constituents of Concern listed in the Basin Setting. For areas lacking a public water system, the IRLP and CV-SALTS programs can be used to provide groundwater quality data in the interim. Dedicated SGMA compliant monitoring wells are also eligible for use in groundwater quality sampling and can be brought in to the monitoring network as they are completed.</p>

GSP	Section	Page	Data Gap
GKGSA	4.10.1.3	4-21	<p>4.10.1.3: Land Subsidence</p> <p>Land subsidence has been limited by the availability of data, notwithstanding the continuous GPS data for station P566 near Farmersville since 2005 and station CRCN near Corcoran since 2010, limited and variable coverage of InSAR data for 2007 to 2010 and 2015 to 2018, and the recent 2-year period (2016-2018) of KDWCD GPS data for various locations within and around GKGSA. The continued implementation of the KDWCD Land Surface Elevation Monitoring Plan will provide additional data on future subsidence at 12 locations within GKGSA and seven locations with MKGSA plus eight locations outside the Kaweah Subbasin. The GKGSA will coordinate with adjacent subbasins, especially in the southwestern portion of the subbasin where subsidence is greatest and could be affect surface infrastructure.</p> <p>The KDWCD Land Surface Elevation Monitoring Network and InSAR are adequate to address the requirements of SGMA, in terms of spatial distribution. Additional refinement to KDWCD may be considered as part of interbasin coordination efforts for areas which experience higher rates of subsidence.</p>
GKGSA	4.10.1.4	4-21	<p>4.10.1.4: Interconnected Surface Water</p> <p>As part of addressing the data gap of spatial distribution for SGMA-compliant groundwater level monitoring, the GKGSA and other GSAs of the Kaweah Subbasin will coordinate for the installation of SGMA-compliant groundwater level monitoring to validate existing data and confirm whether or not Interconnected Surface Waters are present in the Kaweah Subbasin in proximity to the Kaweah and St. Johns Rivers.</p> <p>As part of addressing the data gap of spatial distribution for SGMA compliant groundwater level monitoring, the GKGSA and other GSAs of the Kaweah Subbasin will coordinate for the installation of SGMA compliant groundwater level monitoring to validate whether or not Interconnected Surface Streams are present in the Kaweah Subbasin in proximity to the Kaweah and St. Johns Rivers.</p>
GKGSA	5.5.1	5-15	<p>The minimum threshold for land subsidence will be a rate of annual decline in land surface elevation. Land subsidence will be measured at the representative land subsidence monitoring network, as shown on Figure 4-5.</p> <p>In evaluating historic groundwater elevation data with subsidence data, an acceptable correlation was not evident, so the proxy use of groundwater levels is not possible. The absence of an acceptable correlation is notable because the mechanism for subsidence is relatively low groundwater levels and the associated compaction of clay units in response to the reduction in pore pressure. We believe the inability to establish this correlation stems from a high level of uncertainty due to:</p> <ul style="list-style-type: none"> • Incomplete subsidence records from existing monitoring stations. • Insufficient number of subsidence monitoring stations. • Lack of pumping records by well. • Insufficient well construction and lithologic information to correlate pumping depths with subsidence depths. • Subsidence is a more of a regional condition whereas groundwater levels are very local and can be quite variable due to local subsurface conditions. <p>These causes represent data gaps that will be filled through management actions during Plan implementation.</p>
GKGSA	8.1.2.1	8-3	<p>8.1.2.1: Groundwater Elevations in GKGSA, last paragraph: Groundwater contour maps submitted during the first five years may reflect a composite of the principal aquifers within the subbasin due to data gaps as discussed in the Basin Setting Report (Appendix 2A) of this Plan. As additional dedicated monitoring wells are installed, and as more knowledge is gained regarding subbasin hydrogeology, groundwater conditions within each separate aquifer will be better understood. The geophysical data collection project described in Section 7 will also aid in this regard.</p>

GSP	Section	Page	Data Gap
GKGSA	8.2	8-6	<p>In accordance with § 356.4 of the Regulations, the GKGSA will conduct a periodic evaluation of its Plan no less frequently than at five-year intervals and provide a written assessment to DWR of such evaluations. The assessments will include, but not be limited to, the following...</p> <ul style="list-style-type: none"> • Description of alterations to the monitoring network and its improvements to address data gaps...
GKGSA	8.2.1	8-7	<p>8.2.1: Monitoring Network Assessment and Improvement: The GKGSA recognizes that its initial monitoring network as described in Section 4 of this Plan includes existing monitoring sites lacking sufficient information such as well depth, screen intervals, and reliable well-log records, thereby reflecting significant data gaps. Assessing these data gaps is a priority and will be conducted in accordance with § 352.2 and § 354.38 of the Regulations. Specific elements of such an assessment are to include:</p> <ul style="list-style-type: none"> • Targeting areas where an insufficient number of monitoring sites exist or where sites are considered unreliable or do not meet monitoring network standards • Identifying data gap locations and reasons for their occurrence and surrounding issues that restrict monitoring and data collection • Actions to be undertaken to close identified data gaps, including the addition and/or installation of new monitoring wells or surface-water measuring facilities, closure of inadequate well density areas, and needed adjustments to monitoring and measurement frequencies
MKGSA	1.4.3.1	1-12	<p>1.4.3.1: County of Tulare General Plan</p> <p>The 2030 General Plan Update for the County of Tulare, adopted on August 28, 2018, does not have a specific update to address water usage and supply. However, the Tulare County 2012 General Plan has a Water Resources Element that requires the County to adopt ordinances and measures to:...</p> <ul style="list-style-type: none"> • Encourage responsible agencies and organizations to install and monitor additional groundwater monitoring wells in areas where data gaps exist

GSP	Section	Page	Data Gap
MKGSA	2.2	2-2	<p>Summary List</p> <p>The following data gaps were identified for the MKGSA:</p> <ul style="list-style-type: none"> • Accurate count of wells in MKGSA area, including well type (domestic, irrigation, etc.) and status (active, inactive, abandoned[, destroyed]) • Construction details of wells, especially production/screen interval(s). This was a significant data gap that prevented a comprehensive understanding of groundwater level and groundwater quality conditions above and below the Corcoran Clay • Groundwater production records from direct measurement and locally generated estimates of groundwater use in rural areas of the MKGSA. This information will improve the water budget. • Lithologic composition of aquifer, including geophysical logs at strategic locations • Hydraulic parameters of principal aquifers such as transmissivity, storativity and porosity based on pumping tests preferably. This information could then help with the interpretation of Aerial Electro-Magnetic (AEM) data recently collected. <ul style="list-style-type: none"> • Water quality data for small rural community, domestic (rural residential home owners) and agricultural irrigation wells • Understanding of groundwater quality trends with depth (i.e. between upper and lower principal aquifers and vertical changes within each principal aquifer). With this information, an improved understanding is possible regarding depth of base of freshwater throughout the MKGSA as well as the Kaweah subbasin as a whole. • Measurements of subsidence within the MKGSA. The historical record of measured subsidence is incomplete and provides no information to inform an understanding of subsidence with depth. Correlation between subsidence and release of arsenic from clay mineralogy represents a data gap that needs to be filled through improved sampling and subsidence monitoring. • Expanded monitoring of groundwater levels and groundwater quality in small rural communities and disadvantaged communities <p>The data gaps will be addressed as MKGSA implements the management actions designed to close such gaps, as described in Section 7.4.</p>
MKGSA	4	4-1	<p>4. Monitoring Networks</p> <p>The following chapter describes both the existing groundwater monitoring within the MKGSA area and the representative monitoring required by SGMA. In areas where existing monitoring does not meet the SGMA requirements, this chapter identifies data gaps and proposed measures to address these data gaps during the SGMA implementation period so the representative monitoring improves over time. Plan updates will reflect new information regarding improvements to representative monitoring. This Section 4 includes all information in compliance with §354.32 through §354.40 of the Regulations.</p>
MKGSA	4.10.1	4-14	<p>4.10 Monitoring Network Improvement Plan/ 4.10.1 Data Gaps</p> <p>The following section describes data gaps for groundwater elevations and storage, groundwater quality, and land subsidence.</p>

GSP	Section	Page	Data Gap
MKGSA	4.10.1.1	4-15	<p>4.10.1.1: Groundwater Elevation and Storage Data Gaps</p> <p>As referenced in Regulation §352.4, "If an Agency relies on wells that lack casing perforations, borehole depth, or total well depth information to monitor groundwater conditions as part of a Plan, the Agency shall describe a schedule for acquiring monitoring wells with the necessary information or demonstrate to the Department that such information is not necessary to understand and manage groundwater in the basin."</p> <p>Well types and construction details will need to be determined to improve the monitoring network. Downhole well surveys and desktop surveys will be utilized for existing wells to fill in the well construction details gap. New dedicated monitoring wells and converted production wells will be utilized to fill in the monitoring network spatial extent and density. Improvement will occur during the initial few years of the implementation period, prior to the first five-year update.</p>
MKGSA	4.10.1.2	4-15	<p>4.10.1.2: Groundwater Quality Data Gaps</p> <p>Groundwater quality information is currently collected for public water systems, primarily Visalia and Tulare. The groundwater quality new dedicated monitoring wells and converted production wells will be utilized to fill in the monitoring network spatial extent and density. Improvement will occur during the initial few years of the implementation period, prior to the first 5-year update. DWR will be constructing new multilevel monitoring wells at the locations shown on Figure 4-7 (at the end of this Section) as part of their Technical Support Services program. These wells will be used for both groundwater level and quality monitoring.</p>
			<p>4.10.1.3: Land Subsidence Data Gaps</p> <p>For the preparation of this initial plan, MKGSA lacked sufficient data to effectively correlate changes in groundwater levels within the MKGSA with historical land surface subsidence. This was problematic in developing accurate projections of potential future subsidence that may occur during the implementation period. Additionally, there was not sufficient data to find a good correlation between pumping and land surface subsidence. The implementation of KDWCD's Land Surface Elevation Monitoring Plan will provide additional data for future subsidence monitoring and evaluation of Sustainability Indicators. The MKGSA will explore other options for a secondary data source, especially where surface infrastructure in the southwestern portion of the subbasin could be affected.</p>
MKGSA	4	4-22	Figure 4-7: Proposed New Multilevel Monitoring Wells to Fill Data gaps
MKGSA	5.3.4.1	5-14	<p>In evaluating historic field-measured groundwater elevation data with field-measured subsidence data, an acceptable correlation was not evident. Such a technically defensible correlation was intended for the purpose of estimating the magnitude of future subsidence if groundwater levels were ever to reach minimum thresholds throughout the Subbasin. It was notable that an acceptable correlation did not emerge, since the mechanism for subsidence is declining groundwater levels below historic lows and the associated compaction of clay units in response to the reduction in pore pressure. We believe the inability to establish this correlation stems from a high level of uncertainty due to:</p> <ul style="list-style-type: none"> • Incomplete subsidence records from existing monitoring stations. • Insufficient number of subsidence monitoring stations. • Complete lack of pumping records by well. In some cases, pumping estimates were available by management area, but in most cases, there was no pumping data by well by year. • Insufficient well construction information to correlate pumping depth with observed subsidence. <p>These causes represent significant data gaps that will be filled through management actions during Plan implementation.</p>

GSP	Section	Page	Data Gap
MKGSA	8.1.2.1	8-2	Groundwater contour maps submitted during the first five years may reflect a composite of the principal aquifers within the subbasin due to data gaps as discussed in Section 2 of this Plan. As additional dedicated monitoring wells are installed, and as more knowledge is gained regarding subbasin hydrogeology, groundwater conditions within each separate aquifer will be better understood. The geophysical data collection project described in Section 7 will also aid in this regard.
MKGSA	8.2	8-5	<p>8.2 Five-Year Assessments</p> <p>In accordance with §356.4 of the Regulations, the MKGSA will conduct a periodic evaluation of its Plan no less frequently than at five-year intervals and provide a written assessment to DWR of such evaluations. The assessments will include, but not be limited to, the following:</p> <ul style="list-style-type: none"> • Description of alterations to the monitoring network and its improvements to address data gaps...
MKGSA	8.2.1	8-5	<p>8.2.1 Monitoring Network Assessment and Improvement</p> <p>The MKGSA recognizes that its initial monitoring network as described in Section 4 of this Plan includes existing monitoring sites lacking sufficient information such as well depth, screen intervals, and reliable well-log records, thereby reflecting significant data gaps. Assessing these data gaps is a priority and will be conducted in accordance with §352.2 and §354.38 of the Regulations. Specific elements of such an assessment are to include:</p> <ul style="list-style-type: none"> • Targeting GSA areas where an insufficient number of monitoring sites exist or where sites are considered unreliable or do not meet monitoring network standards • Identifying data gap locations and reasons for their occurrence and surrounding issues that restrict monitoring and data collection • Actions to be undertaken to close identified data gaps, including the addition and/or installation of new monitoring wells or surface-water measuring facilities, closure of inadequate well density areas, and needed adjustments to monitoring and measurement frequencies
EKGSA	2.2.6.1	2-25	According to DWR's Bulletin 118 (2003), there are no reported groundwater barriers restricting horizontal flow in and out of the Kaweah Subbasin. There is, however, the Rocky Hill fault zone that may affect groundwater flow inside of the Subbasin and potentially cross gradient of flow along the north and south boundaries. Located in the Eastern portion of the Subbasin, the Rocky Hill fault disrupts pre-Eocene deposits and may locally penetrate older alluvial deposits. The linearity of ridges in this area defines the fault line (Refer to Figure 2-4 for the Cross Section Location Map and Figure 2-7 and Figure 2-9 for Cross Sections DD' and gg'). The Rocky Hill fault does not offset younger alluvium based on water level data (Croft, 1968); however, lithology data from boreholes suggest that older alluvium may be offset or varied in thickness at the Rocky Hill fault. In addition, Fugro West (2007), suggested that the hydrologic connection of the oxidized alluvial aquifer may be restricted near the Rocky Hill fault; this represents a data gap in groundwater flow across the Rocky Hill fault, and should be evaluated in the future, both within the Subbasin and in association with the northern and southern boundaries of the Subbasin.
EKGSA	2.3.3	2-42	<p>2.3.3 Existing Land Subsidence Monitoring Past, recent and potential future monitoring of land subsidence in the Kaweah Subbasin are summarized in Table 2-5. Much of the historical data does not cover the EKGSA area. Newer data sets (2015-2017) provide more coverage. The EKGSA will strive to keep these newer data sets active to avoid data gaps in the future. While land subsidence isn't believed to be a major concern in the EKGSA, it will be monitored to avoid Undesirable Results.</p>

GSP	Section	Page	Data Gap
EKGSA	2.3.4	2-42	2.3.4 Existing Stream Flow Monitoring The most useful stream flow gauges monitored within the Subbasin are located outside the EKGSA. The closest water bodies regularly monitored are the Kaweah River, St. Johns River, and Yokohl Creek. The flow gauges are located in the GKGSA Kaweah GSA. Existing stream flow monitoring represents a data gap for the EKGSA to improve moving forward. Streams of interest for the EKGSA to improve monitoring data are: Cottonwood, Lewis, and Frazier Creeks.
EKGSA	2.4.1.2	2-49	2.4.1.2 Well Hydrographs Hydrographs of individual wells in and around the EKGSA are presented in Appendix 2-D. Figure 2-21 is a map showing locations of these wells. These hydrographs depict the span of time between 1981 and 2017. Hydrographs outside the borders of the EKGSA were included to establish boundary conditions. It is difficult to identify wells with records that are complete for the entire base period. The wells depicted often contain data gaps but represent the most complete information available at this time. The dataset used to create these hydrographs associates water levels with a season/year format (e.g. Spr1990) rather than with a specific date. For the purposes of plotting, spring levels were considered to have been taken on March 1, while fall levels were plotted on October 1. Nevertheless, these hydrographs are a useful tool for tracking water level patterns through time across the EKGSA.
EKGSA	2.4.1.2	2-50	Intermontane Valleys – This classification is included to showcase wells on the Eastern border of the EKGSA with significant bedrock outcrop to their west. These wells are located in the small valleys interfingering with the mountain-front and are drilled into shallow alluvium veneering relatively shallow bedrock, with ready access to recharge coming from the mountain-front. They have consistently shallow DTW and low seasonal and hydrological deviation. Typical WSEs within these wells are consistently within 50 ft of the surface. Well 17S26E14L002M is nearly within the Valley proper and likely has deeper alluvium, less-direct recharge, and plentiful irrigation nearby. This well's hydrograph is more akin to wells in the Cottonwood Creek Interfan area as defined above, with GKGSA overall DTW and increased variation between seasons of wet and dry. Average DTW for this grouping of wells was 26.9 ft based on the years with data. There are significant temporal data gaps for this region, during which time none or only one well provided data. Between fall of 2008 and fall of 2012 no data is recorded for any of these wells.
EKGSA	2.4.1.2	2-54	Well Depth: Construction data for wells in the EKGSA was evaluated in a summarized format. Evaluating well logs confidently and accurately to match reports with the actual corresponding well in the field is difficult due to the current nature of the data sets available. This is a data gap that will be filled going forward. Figure 2-24, Figure 2-25, and Figure 2-26 display the average completed well depths per section for agricultural, domestic, and public wells respectively. Appendix 2-E provides more figures for these three well types, including minimum and maximum completed depths and number of wells per section.

GSP	Section	Page	Data Gap
EKGSA	2.4.3.3.4	2-62	<p>Nitrate: Sources and Spatial Distribution in the EKGSA - The historical and current predominate land use in the EKGSA is for commercial irrigated agriculture with some interspersed dairy farms. While Burton et. Al (2012) reports nitrate contaminations correlates to areas of agriculture classified as orchard and vineyard land uses, USGS finds that these regions also have medium to high density septic systems. GKGSA than 50 percent of the land use in hydrogeologic zones 7, 8 and 9 are orchards or vineyards. Septic-system density GKGSA than the Subbasin median value of 5 septic systems in a 500-meter radius around each selected GAMA well occurred hydrogeologic zones 4-9, with very high density of 11.8 septic systems within 500 meters of the selected wells in zones 7, and 11.0 septic systems in zone 9. USGS data was used for this evaluation to develop a clearer understanding of potential sources of nitrate contamination. While previous reports point towards orchard and vineyard land uses, septic system density is an unquantified source of contamination. While the existence of septic systems does not necessarily mean that they are a contributing source of nitrate contamination within the aquifer. However, leaky, poorly maintained septic systems can be a serious source of localized nitrate contamination. It is currently unknown the amount of contamination associated with poorly maintained septic systems. This represents a data gap that the EKGSA and Subbasin will need to evaluate going forward. Data gathered by USGS (Report 2011-5218) was determined from housing characteristics data from the 1990 U.S. Census. The density of septic systems in each housing census block was calculated from the number of tanks and block area. To more precisely identify the nitrate sources, current data should be compiled and evaluated with proximity to domestic water wells. This effort is being made through the Disadvantaged Community Involvement Program is trying to identify septic system density and condition in the Tulare-Kern Funding Area.</p>
EKGSA	2.4.4.3	2-67	<p>2.4.4.3 Recent Land Subsidence</p> <p>Recent subsidence studies of the Central Valley have utilized satellite-based, remote sensing data from the Interferometric Synthetic Aperture Radar (InSAR) and aircraft-based L-band SAR or Unmanned Aerial Vehicle Synthetic Aperture Radar (UAVSAR) programs, led by NASA and Jet Propulsion Laboratory (JPL), as well as other international researchers. These datasets provide a continuous estimate of subsidence over a large portion of the Subbasin. Additionally, subsidence in the Subbasin and in the Tule Subbasin (to the south) can also be observed at point locations through continuous GPS (CGPS) stations and other land surface monitoring stations. Most of these are not located within the EKGSA, representing a data gap. These CGPS stations are monitored as a part of UNAVCO's Plate Boundary Observation (PBO), the California Real Time Network (CRTN) and California Spatial Reference Center (CSRC) of the Scripps Orbit and Permanent Array Center (SOPAC). Annual averages of CGPS or future extensometer data may permit a more meaningful comparison and/or calibration with InSAR data in the future.</p> <p>Recent and historical subsidence data is summarized in Table 2-7. The data presented includes a summary of InSAR data published in a subsidence study commissioned by the California Water Foundation (LSCE, 2014) and by JPL (Farr et al., 2015 and 2016). The InSAR data was collected from a group of satellites (Japanese PALSAR, Canadian Radarsat-2, and European Space Agency's (ESA) satellite-borne Sentinel-1A and -1B), from 2006 to 2017, however there is a data gap for the EKGSA prior to 2015 due to the limit of study and absence of satellite data collection data prior to the ESA Sentinel satellites in 2014 (Farr et. al., 2016).</p>

GSP	Section	Page	Data Gap
EKGSA	2.4.6	2-71	<p>2.4.6 Groundwater Dependent Ecosystems Where groundwater and surface water are separated by significant distances, as is the case with the majority of the EKGSA, the groundwater does not interact with the natural streams or manmade ditches, and therefore, no possibility exists for the presence of Groundwater Dependent Ecosystems (GDE). However, there are locations near the foothills of the Sierra Nevada where groundwater levels are closer to the surface.</p> <p>Areas where groundwater is within 30 feet of the ground surface are located along the Kaweah River (primarily in GKGSA), the Stone Corral ID area, and near Lewis Creek in the Lindsay-Strathmore ID area. Figure 2-28 represents areas where groundwater elevations as of the Spring of 2015 were within 30 feet of the ground surface. Wetlands within these areas may be considered GDE, however additional study and data are necessary. This data gap will be addressed as part of further study going forward.</p>
EKGSA	2.5.3.2	2-82	<p>2.5.3.2 Inflows to the Groundwater System - Natural Channels: The EKGSA lacks reliable, long-standing stream gauges on the four major tributaries that flow into the area from the Sierra Nevada foothills. There is a single stream flow gauge on Yokohl Creek, while the other water bodies Cottonwood, Lewis, and Frazier Creeks do not have permanent gauges. In the absence of data, streambed percolation for the EKGSA was determined by an alternate method. The percolation from these creeks was assumed to be included in the mountain-front recharge accounted for in the Subsurface Flow. This is a data gap that will be further evaluated going forward. In addition to these creeks, a portion of the St. Johns River runs along the boundary between the EKGSA and GKGSA. It is assumed percolation over this stretch enters both the EKGSA and GKGSA. Per these estimates, the average annual natural percolation into the EKGSA is 2,000 AFY as shown in Table 2-10.</p>

GSP	Section	Page	Data Gap
EKGSA	2.6	2-92	<p>Summary List</p> <p>2.6 Identification of Data gaps: Identification of data gaps will continue to be a work in progress. The principal data gaps are listed below, which are subject to revision during the course of completion of this GSP.</p> <ul style="list-style-type: none"> • Geological/hydrogeological information for all areas of the EKGSA. <ul style="list-style-type: none"> ○ The SkyTEM effort should assist in filling this data gap ○ New and/or better well logging for monitoring and production wells can also be informative in locations with little or no data • Well construction information such as: depth of well, perforation intervals, casing diameter, and use <ul style="list-style-type: none"> ○ Strongly encourage the Kaweah Subbasin GSAs and Tulare County initiate a well canvas of the area to develop a better data set ○ Potential Drinking Well Observation Plan can assist with gathering well data for specific drinking water wells in the region • Stream flow monitoring on Cottonwood, Yokohl, Lewis, and Frazier Creeks <ul style="list-style-type: none"> ○ Gauges are proposed to be constructed, especially for the creeks potentially to be used for recharge activities ○ Specific watershed studies for these creek watersheds can be performed to better inform the estimations of creek flows and seepage • Consistent subsidence monitoring <ul style="list-style-type: none"> ○ Likely remedied with more consistent InSAR data ○ Specific infrastructure to be surveyed for subsidence impacts • Presence of GDE <ul style="list-style-type: none"> ○ Likely linked with the added stream flow monitoring ○ More consistent groundwater level monitoring in the intermontane valleys • Water Budget Components <ul style="list-style-type: none"> ○ Further development of subsurface inflows and outflows from the mountain front and neighboring subbasins ○ Improved understanding of surface water deliveries within district boundaries ○ Retention/Recharge basin data collection and tracking as more recharge is developed ○ Improved understanding of irrigation demand and method for crop and soil types within the Subbasin and EKGSA ○ Improved tracking of M&I demands
EKGSA	3.4.2.2.1	3-28	<p>Description of Minimum Thresholds: Well monitoring data from Geotracker, and other sources, is currently not available at a granular enough level to allow for the mapping of specific contaminant plumes. Given these data gaps, the current level of water quality monitoring for the identified COCs needs to be enhanced by a network to track regional trends and to serve as a warning system for changes in water quality. More details on the EKGSA's monitoring network is provided in Chapter 4.</p>
EKGSA	4.3.1	4-4	<p>4.3 Groundwater Levels: 4.3.1 Monitoring Network Description</p> <p>Groundwater-level monitoring has been carried out for most of the past century. Existing groundwater wells with long monitoring histories make the best targets for continued monitoring. These wells are rare, and when they exist, their usefulness is often degraded by poor data quality. Most wells have incomplete temporal histories and lack consistent measurements for consecutive years throughout their operational lives. There is no recourse for historic temporal data gaps, but the temporal quality of future measurements in these wells can be ensured.</p>

GSP	Section	Page	Data Gap
EKGSA	4.3.1	4-5	4.3 Groundwater Levels: 4.3.1 Monitoring Network Description: Private wells: In several parts of the EKGSA there are gaps in the current monitoring well coverage, therefore, records from private wells may be used to initially satisfy the monitoring network needs. Use of these wells would require landowners to execute agreements with the EKGSA to allow access and conduct and oversee the monitoring. This process is anticipated to be time intensive, so this option is not the most preferred method.
EKGSA	4.3.1	4-5	Figure 4-1 shows the proposed locations for the initial groundwater level monitoring network for the EGKSA, and the different types of wells to be utilized. The two wells notated with stars in the northern portion of the EKGSA are proposed dedicated monitoring wells that are anticipated to receive Technical Support Services (TSS) assistance through DWR. The seven locations notated with large circles are locations with data gaps . The EKGSA will aim to obtain data from these regions (within half a mile) through agreement on private wells or through drilling dedicated monitoring wells during the first year(s) of implementation. It is understood that over the course of implementation the EKGSA will gradually convert the entire Monitoring Network to dedicated monitoring wells.
EKGSA	4.3.3	4-9	4.3.3 Review and Evaluation of Monitoring Network: The monitoring network will be assessed and reviewed for adherence to SGMA requirements at the end of each five-year period, with the first period beginning in 2020 and concluding in 2025. As the monitoring network currently stands there are a few data gaps that may affect the interim monitoring of the overall sustainability goal of the basin, however, these will be addressed within the first five years of monitoring.
EKGSA	4.3.3.3	4-10	4.3 Groundwater Levels/Monitoring Network - Identification of Data Gaps: Existing groundwater-level monitoring has provided data to prepare groundwater contour maps and identify groundwater level trends over the decades. The existing monitoring system relies heavily on the member irrigation districts, but this only provides data for a portion of the EKGSA. To better represent hydraulic gradient and flow direction within the EKGSA, about seven wells should be strategically placed for regular monitoring in the EKGSA. Figure 4-1 shows the approximate locations where additional monitoring wells are believed to be useful in accomplishing this goal and meeting the monitoring well density requirements set forth in the GSP. The EKGSA will try to fill these locations either through agreements with private landowners or by drilling new dedicated monitoring wells. Other data gaps exist in the fact that most of the proposed monitoring network wells are privately owned production wells that are used for monitoring. Specific well construction information, including depth and perforated interval, are not known for many of the wells. Also, depending on how and when the data was collected, data points in some (or all) years may be skewed. Utilizing a production well as a monitoring well runs the risk of potential influence from recent pumping that may affect the 'static' reading aimed to be captured. It is believed that much of the recorded well data within the EKGSA is credible, however the EKGSA will continue to improve this data set going forward.

GSP	Section	Page	Data Gap
EKGSA	4.3.3.4	4-10	<p>4.3 Groundwater Levels/Monitoring Network - 4.3.3.4 Plans to Fill Data Gaps</p> <p>The EKGSA will oversee the groundwater level monitoring network, including filling areas with data gaps. This will be especially useful for the regions that are not currently monitored, such as outside irrigation district boundaries. As previously stated, Figure 4-1 depicts the wells intended to fill spatial data gaps for initial implementation. The EKGSA will need to locate accessible private wells or drill new wells in the seven locations shown. Over time the EKGSA will transition to utilizing dedicated monitoring wells in its monitoring network.</p> <p>To address data quality gaps related to unknown construction information, the EKGSA will utilize the following options:</p> <ul style="list-style-type: none"> • Collect well completion reports. Accurate well Completion Reports (WCRs) can potentially provide missing well construction and completion information. These records could be collected from landowners or DWR. Due to the way that data is collected and dispersed, it is often difficult to correlate WCRs with actual wells. Locations of wells as reported on WCRs are often subjective, as they are based on the drillers' ability to convey spatial location. Multiple wells may exist within the area a well's log leads to. In some cases, wells have been destroyed or lost without documentation. Obtaining well logs directly from owners bypasses this confusion, though this is not a perfect solution. Private well owners may be unable or unwilling to provide logs for their wells. • Perform a video inspection of each well to obtain construction information. In the absence of verified well logs a video inspection can be performed on wells to determine the total completed depth and perforated interval(s). Each video inspection currently ranges in costs between \$2,500 and as much as \$15,000 if required to lift and reinstall a pump to obtain access in production wells. There would also be additional costs for administration and outreach to landowners. The EKGSA would need to enter into private agreements with individual well owners for the use of these wells; as an incentive for participation the EKGSA would cover the cost of the well video assessment. • Abandoned Wells. The EKGSA will assess the likelihood of monitoring former wells that have been abandoned. Use of these wells will potentially bolster the density of the monitoring network in areas with minimal coverage, likely involve less stringent access requirements, and are cheaper than drilling new wells. Additionally, since these wells are no longer in production, the monitoring of abandoned wells allows for better potential in gaining a static water level reading and better fulfill the requirements of Sub-Article 4. • Replace monitoring point with a dedicated monitoring well. Dedicated monitoring wells could be installed and used in place of private wells. The construction information would be known and since the EKGSA would locate these wells, access issues would not be an issue. Dedicated monitoring wells are expensive to construct, and their installation will depend on available funding. <p>Replace monitoring point with another private well. Private wells without documented construction information may potentially be replaced with other private wells that have verified well completion information. This option may be simpler and less costly than using video inspection and would be substantially less expensive than drilling new dedicated monitoring wells. This method of network repair would side-step the expense of drilling new wells but would still be subject to availability and limitations arising from the missing historical record.</p>
EKGSA	4.4.3.3	4-12	<p>Groundwater Storage/Monitoring Network - 4.4.3.3 Identification of Data Gaps</p> <p>Gaps in current groundwater level monitoring networks have created corresponding inadequacies in the ability to calculate change in storage. Data gaps associated with aquifer characteristics, such as specific yield values used for storage estimates, are anticipated to be improved through the completion of different projects and studies undertaken by the Kaweah Sub-basin and the EKGSA (i.e. SkyTEM).</p>

GSP	Section	Page	Data Gap
EKGSA	4.4.3.4	4-12	<p>Groundwater Storage/Monitoring Network - 4.4.3.4 Plans to Fill Data Gaps</p> <p>Significant data gaps will be filled using the same methods used to address data gaps in the groundwater level network, as spatial data coverage is a critical component in the change in storage calculations. Aquifer evaluation at a Sub-basin scale was performed through a SkyTEM electromagnetic analysis. The results from this analysis were not ready in time for this initial GSP but will be available for future updates and modeling to improve the general knowledge of the aquifer characteristics moving forward.</p>
EKGSA	4.5.2	4-15	<p>Water Quality/Monitoring Network - 4.5.2 Quantitative Values</p> <p>Threshold values for COCs are presented in Chapter 3. These values use MCL and prevalence data to provide minimum thresholds, measurable objectives, and interim milestones for each COC. Table 4-3 repeats the monitoring network wells table, but this time shows the baseline 10-year (2008-2017) COC averages for the wells in the network with water quality data available. By comparison, only 15 of the approximately 70 wells to be monitored for water quality have data for establishing a baseline. This represents a significant data gap, however the intent of the EKGSA monitoring will strive to remedy this gap over the first years of implementation. Water quality degradation will be evaluated by determining if the actions of the EKGSA degrade the beneficial use of water in the Subbasin.</p>
EKGSA	4.5.3.3	4-16	<p>Water Quality/Review of Monitoring Network - 4.5.3.3 Identification of Data Gaps</p> <p>The absence of groundwater level data across the entirety of the EKGSA is a data gap. Future monitoring will need to address this data gap so the EKGSA can properly evaluate how groundwater management actions are impacting groundwater quality.</p>
EKGSA	4.5.3.4	4-16	<p>Water Quality/Review of Monitoring Network - 4.5.3.4 Plans to Fill Data Gaps</p> <p>The EKGSA's proposal to monitor COCs across the groundwater level monitoring network intends to fill some of the significant data gaps with respect to groundwater quality data. Monitoring over the first five years of implementation should provide more insight on groundwater quality (location, trends, etc.) in the EKGSA. The EKGSA will also collaborate, where appropriate and feasible, with other agencies tasked with tracking and/or improving groundwater quality for additional assistance with data gaps.</p>
EKGSA	4.6.3.3	4-20	<p>Land Subsidence/Monitoring Network - 4.6.3.3 Identification of Data Gaps</p> <p>Beyond the specific proposed monitoring points, no other data gaps were identified for the land subsidence monitoring network for the EKGSA. Subsidence has been an ongoing issue in portions of the Central Valley, thus monitoring systems have been put in place to evaluate the impacts. Over time these tools and data have improved and become more widespread.</p>
EKGSA	4.6.3.3	4-20	<p>Land Subsidence/Monitoring Network - 4.6.3.4 Plans to Fill Data Gaps</p> <p>With the addition of survey points to critical infrastructure, and utilizing the InSAR data set as a backstop, the current subsidence monitoring network is believed to sufficiently cover the EKGSA.</p>
EKGSA	4.7.3.3	4-23	<p>Depletion of Interconnected Surface Water/Monitoring Network - 4.7.3.3 Identification of Data Gaps</p> <p>Due to the absence of historic monitoring specifically related to groundwater-surface water connection, there are data gaps beyond that of local experience. The new proposed monitoring effort laid out in this GSP will likely shed light on the areas considered to be 'gaining' streams or connected due to perched groundwater. The new monitoring network may indicate other areas to have possible connection. In these instances, the EKGSA will adapt the monitoring to allow for further evaluation.</p>

GSP	Section	Page	Data Gap
EKGSA	4.7.3.3	4-23	<p>Depletion of Interconnected Surface Water/Monitoring Network - 4.7.3.4 Plans to Fill Data Gaps</p> <p>The proposed additions to the groundwater level monitoring network is expected to be a benefit to the understanding of interconnected surface water. This will be especially beneficial in the portions of the EKGSA adjacent the foothills and ephemeral streams.</p>
EKGSA	5.2	5-3	<p>5.2 Projects: Implementation through this first GSP will focus on bolstering data sets to fill data gaps, and then projects fully developed based on current and projected conditions.</p>
EKGSA	5.3.2.6	5-36	<p>5.3.2. Wellhead Requirements Management Actions - 5.3.2.6 Benefit Realization and Evaluation WH1 - WH-5 (Sec. 354.44.b.5) - The expected benefits of water quality sample ports and analytical testing would fill data gaps and provide extractors with useful information.</p>
EKGSA	5.3.3	5-41	<p>Groundwater Allocation Management Actions: GA-3 Groundwater Allocation “Adaptive Management” Approach</p> <p>The EKGSA may adopt a policy which states an adaptive management approach, whereby the groundwater allocation may be reviewed, changed, and reestablished periodically or during extreme drought as necessary to achieve long term sustainability. It is prudent for the EKGSA to acknowledge the current level of uncertainty in the available data and existing data gaps by providing flexibility in initial groundwater allocations as more data is gathered and analyzed in the upcoming years. Adaptive management is an approach to resource management that “promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a ‘trial and error’ process, but rather emphasizes “learning while doing” (Environmental Defense Fund et al., 2017).</p>
EKGSA	6.1	6-1	<p>Plan Implementation/6.1 Estimate of GSP Implementation Costs - Plan to Fill Data Gaps (One-Time Cost)</p> <p>Proper implementation of this GSP, especially as it relates to execution of projects and management actions, is contingent upon filling current data gaps. This process will require determining which measures are necessary to build and maintain a comprehensive assessment of the water budget and ultimately verify groundwater sustainability. This plan to fill data gaps includes, but is not limited to, installing stream gauges, dedicated monitoring wells, and conducting a Proposition 218 vote. Costs are estimated to be approximately \$1,230,000.</p>
EKGSA	6.2	6-3	<p>6.2 Identify Funding Alternatives: The EKGSA and/or its member agencies or other Kaweah Subbasin GSAs will apply for various grant funding opportunities to offset some of the capital costs associated with implementation of the GSP, whether it be a water supply project or to fill an existing data gap. The EKGSA will explore federal and state grant funding opportunities and low interest loans to help finance the initial steps of plan implementation.</p>

GSP	Section	Page	Data Gap
Kaweah Subbasin Basin Setting	2.3.1.1	Q	<p>2.3.1.1 Key Wells: The key wells were chosen as a subset of the entire water level monitoring database to adequately represent the Subbasin both laterally and vertically. These key wells were used along with the other monitored wells for the creation of water level contour maps and water level hydrographs. Most of the known wells in the Subbasin are either missing or have limited well construction information. Therefore, the data gap will be addressed with the following the steps below.</p> <ol style="list-style-type: none"> 1. Further review of acquired well logs; 2. Conducting down-hole video surveys of wells; and 3. Installing additional monitoring wells as funds become available. <p>While there are limitations associated with using water level data from wells without construction information, we have performed an initial assessment of many of the available wells with a long period of record. This process allowed for the selection of wells that were used for developing an initial understanding of groundwater level variations throughout the Subbasin. It is understood that this snapshot of groundwater conditions is limited based on the unknown completion information about the wells and may change as construction data is obtained in the future.</p>
Kaweah Subbasin Basin Setting	2.3.4	50	<p>2.3.4 Existing Stream Flow Monitoring: The records of the stream groups impacting the facilities and stockholders of the ditch companies that they manage were acquired. Although data gaps exist, these may represent relatively small quantities of contributory flows. The records of the USGS are, for the most part, supplemental to the records of the Association and local agencies. The information that is published by the USGS, however, does fill some of the data gaps that exist in the information related to the local stream groups. Figure 20 shows the locations of stream flow gauges monitored within the Subbasin.</p>
Kaweah Subbasin Basin Setting	2.8.4	141	<p>2.8.4 Recent Land Subsidence: Recent and historical subsidence data are summarized in Table 43. It includes a summary of InSAR data published in a subsidence study commissioned by the California Water Foundation (LSCE, 2014), and by JPL. The InSAR data were collected from a group of satellites (Japanese PALSAR, Canadian Radarsat-2, and ESA's satellite-borne Sentinel-1A and -1B), from 2006 to 2017, with a data gap from 2011 to 2014 because there was a gap in satellite data collection until the ESA Sentinel satellites were launched in 2014.</p>

Appendix 6

Sustainability Goal and Undesirable Results

SUSTAINABILITY GOAL AND UNDESIRABLE RESULTS

Appendix 6 to Kaweah Subbasin Coordination Agreement

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6. Sustainability Goal and Undesirable Results

6.1 Introduction

This Section provides location-specific sustainable management criteria (SMC) for four of the six sustainability indicators, including establishing minimum thresholds and measurable objectives with integrated interim milestones. Section 3 of this GSP presents the Subbasin-scale SMC as required by 23 Cal. Code Regs. §§354.22-.26, i.e., the sustainability goal and a complete listing of undesirable results, including their causes, criteria and effects on beneficial uses and users. As discussed in Chapter 3, pursuant to 23 Cal. Code Regs §354.26(d) no sustainable management criteria need to set at this time for the undesirable results of Interconnected Surface Waters and Seawater Intrusion. Thus, pursuant to 23 Cal. Code Regs §354.26(e)¹, those undesirable results will not be discussed herein.

6.2 General Approach

As described later in this Section, the Subbasin identified minimum thresholds, based on declining groundwater levels (hereinafter “water level” or “level”) that would otherwise occur during the 20-year SGMA implementation period devoid of any GSP projects and management actions (pre-SGMA floor). Measurable objectives are similarly based using this trend line. The relationship of these measurable objectives and the long-term success in achieving the objectives is discussed in the context of neighboring GSAs in the Subbasin and their respective actions undertaken during GSP implementation.

The Subbasin developed SMC within a framework of data, which currently has gaps. If SMCs (such as minimum thresholds and measurable objectives) vary substantially between adjacent GSAs, then the GSAs will coordinate and endeavor to adjust the particular SMC as additional data becomes available so that the GSAs eliminate any substantial variance which could inhibit a GSA from implementing its GSP and achieving sustainability within its jurisdictional area.

The metrics and approaches to be employed by the Subbasin for the six sustainability indicators are shown in **Table 6-1**.







6.3 Sustainability Goal

23 Cal. Code Regs. § 354.24. <i>Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish and sustainability goal, a discussion of the measures that will be implemented to ensure that</i>

¹ 23 Cal. Code Regs §354.26(e) provides “An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.

the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

Table 6-1: Sustainable Management Criteria by Sustainability Indicator

SMC Summary for GKGSA			
Sustainability Indicators	Minimum Threshold	Measurable Objective	Optimal Objective ¹
 Water Level Declines	Pre-SGMA floor (2040 Intercept) ²	2030 Intercept ³	Water Added (P&MA) ⁴
 Reduction in Storage	Calculated based on water levels ⁵	Calculated based on water levels ⁵	Calculated based on water levels ⁵
 Land Surface Subsidence	Benchmark Surveys	Benchmark Surveys	NA
 Water Quality	Reference to other regulators ⁶	Reference to other regulators ⁶	NA
 Seawater Intrusion	Establish non-applicability	Establish non-applicability	NA
 Interconnected Surface Waters	Establish non-applicability	Establish non-applicability	NA

¹ Per section 354.30(g) of the GSP Regulations re improving basin conditions

² Pre-SGMA floor as determined by representative monitoring sites in Hydrogeologic Zones

³ 2030 intercept of Pre-SGMA floor projection as determined by representative monitoring sites in GSA

⁴ Estimated with by the numerical model or empirical analysis incorporating projects and management actions

⁵ Storage volume changes and associated SMC determined as function of water level changes

⁶ e.g. SWRCB Division of Drinking Water requirements for public supply wells, RWQCB Irrigated Lands Regulatory Program

The broadly stated sustainability goal for the Kaweah Subbasin is for each GSA to manage groundwater resources to preserve the viability of existing agricultural enterprises of the region, domestic wells, and the smaller communities that provide much of their job base in the Sub-basin, including the school districts serving these communities. The goal will also strive to fulfill the water needs of existing and amended county and city general plans that commit to continued economic and population growth within Tulare County.

This goal statement complies with §354.24 of the Regulations.

This Goal will be achieved by:

- The implementation of the EKGSA, GKGSA and MKGSA GSPs, each designed to identify phased implementation of measures (projects and management actions) targeted to ensure that the Kaweah Subbasin is managed to avoid undesirable results by 2040 or as may be otherwise extended by DWR.
- Collaboration with other agencies and entities to arrest chronic groundwater-level and groundwater storage declines, reduce or minimize land subsidence where significant and

unreasonable, decelerate ongoing water quality degradation where feasible, and protect beneficial uses.

- Application of the Kaweah Subbasin Hydrologic Model (KSHM) – incorporating the initial selection of projects and management actions by the Subbasin GSAs – and its simulation output is summarized in the Subbasin Coordination Agreement to help explain how the sustainability goal is to be achieved within 20 years of GSP implementation.
- Assessments at each interim milestone of implemented projects and management actions and their achievements towards avoiding undesirable results as defined herein.
- Continuance of projects and management action implementation by the three GSAs as appropriate through the planning and implementation horizon to maintain this sustainability goal.

6.4 Groundwater Levels

23 Cal. Code Regs § 354.26(a). *Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.*

The undesirable results are derived from the Basin Setting (Appendix 2A) and its characterization as described in the Hydrogeologic Conceptual Model, the historical, current, and projected groundwater conditions and trends, and stakeholder input. The three Subbasin GSAs have concurred with the undesirable results, their causes, determination criteria and effects, all as defined in this section. The sustainability indicators used to determine undesirable results are referenced herein. This section complies with §354.26 of the Regulations.

The terms “significant and unreasonable” are not defined by SGMA, and are left to GSAs to define within their GSPs. The process to define “significant and unreasonable” began with stakeholder and landowner discussions.

The GSAs within the Kaweah Subbasin have determined that undesirable results for groundwater levels may be significant and unreasonable when basinwide loss of industrial, municipal, and domestic pumping well capacity occurs due to lowering groundwater levels.

6.4.1 Causes leading to Undesirable Results

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*

Undesirable results associated with groundwater level declines are caused by over-pumping or nominal groundwater recharge operations during drought periods such that groundwater levels fall

and remain below minimum thresholds. Over-pumping and lack of recharge is area specific, and some GSA Management Areas experience greater adverse impacts than others.

6.4.2 Criteria to Define Undesirable results

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.*

With respect to water-level declines, undesirable results occur when one-third of the representative monitoring sites in all three GSA jurisdictions combined exceed their respective minimum threshold water level elevations. Should this occur, a determination shall be made of the then-current GSA water budgets and resulting indications of net reduction in storage. Similar determinations shall be made of adjacent GSA water budgets in neighboring subbasins to ascertain the causes for the occurrence of the undesirable result.

Groundwater elevations shall serve as the sustainability indicator and metric for chronic lowering of groundwater levels and, by proxy, for groundwater storage. Justification for use of groundwater elevations as a proxy in this instance is provided in Section 5.

It is the preliminary determination that the percentages identified herein represent a sufficient number of monitoring sites in the Subbasin such that their exceedance would represent an undesirable result for water-level declines, reduction in groundwater storage, land subsidence, and interconnected surface waters where applicable. Screen interval data for agricultural, municipal, and domestic wells, as identified in Section 5.3.2, has been scrutinized and a determination has been made that the percentage of wells completely dewatered by 2040 should the minimum thresholds not be exceeded would not constitute an undesirable result. Based on observed groundwater conditions in the future and not less frequently than at each five-year assessment, the GSAs will evaluate whether these percentages need to be changed.

6.4.1 Evaluation of Multiple Minimum Thresholds

23 Cal. Code Regs § 354.26 (c). *The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.*

The Subbasin, in coordination with other GSAs in the basin will utilize multiple wells to monitor and manage the GSA and basin. A detailed description of the GSA's monitoring network is included in Section 4 of this GSP.

6.5 Groundwater Storage

23 Cal. Code Regs § 354.26(a). *Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.*

The Groundwater Storage minimum thresholds are the same as groundwater levels and groundwater elevations across the GSA and subbasin were used to calculate the amount of groundwater in storage below the Minimum Thresholds to the base of the aquifer. An undesirable result in groundwater storage may be significant and unreasonable if the total amount of water in storage was less than the estimated amount of groundwater in storage below the Minimum Threshold or other factors identified in section 6.4 occur.

6.5.1 Causes leading to Undesirable Results

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*

Undesirable results associated with groundwater storage are caused by the same factors as those contributing to groundwater level declines. Given assumed hydrogeologic parameters of the Subbasin, direct correlations exist between changes in water levels and estimated changes in groundwater storage.

6.5.2 Criteria to Define Undesirable results

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.*

The water-level sustainability indicator is used as the driver for calculated changes in groundwater storage. As such, when one-third of the Subbasin representative monitoring sites for water levels exceed their respective minimum thresholds, an undesirable result for storage will be deemed to occur. Given assumed hydrogeologic parameters of the Subbasin, direct correlations exist between changes in water levels and estimated changes in groundwater storage, and water levels are to serve as a metric for groundwater storage reductions as well. As discussed in Section 5.3.1, the current estimated volume of groundwater in storage in the Subbasin of 15 to 30 MAF is sufficient such that further depletion over the implementation period is not of a level of concern such that an undesirable results would emerge during the GSP implementation period.

6.5.3 Potential Effects on Beneficial Uses and Users

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interest, and other potential effects that may occur or are occurring from undesirable results.*

The potential effects to beneficial uses and users of reductions in groundwater storage are essentially the same as for declines in water levels. In most cases, the direct correlation is with declines in levels; however, some beneficial uses may be tied more specifically to loss of groundwater in storage.

6.6 Land Subsidence

23 Cal. Code Regs § 354.26(a). *Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.*

Land subsidence may be considered significant and unreasonable if there is a loss of a functionality of a structure or a facility to the point that, due to subsidence, the structure or facility cannot reasonably operate without either significant repair or replacement.

6.6.1 Causes leading to Undesirable Results

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*

Undesirable results associated with subsidence are caused by over-pumping or nominal groundwater recharge operations during drought periods such that groundwater levels fall and remain below minimum thresholds. Over-pumping and lack of recharge are area specific, and some GSA Management Areas experience greater adverse impacts than others. Over-pumping during drought periods, which may result in new lows in terms of groundwater elevations, is of particular concern based on current scientific understanding of subsidence trends in this region. Regional correlations of groundwater levels versus subsidence trends remain difficult to ascertain because groundwater levels occur at a local scale and subsidence occurs at a broader/regional scale.

6.6.1 Criteria to Define Undesirable results

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.*

The primary criteria and metric will be the annual rate of reduction in land surface elevation and areal extent of such elevation changes. An undesirable result will occur when one-third of the Subbasin subsidence monitoring sites exceed their respective minimum thresholds. In addition, GKGSa will evaluate cumulative subsidence at each of the interim milestones as described in Section 5. The water-level sustainability indicator will be considered for differential land subsidence, although the current body of knowledge relative to subsidence and local and regional declines in water levels is limited. As set forth in Section 5.3.6, subsidence rates that represent minimum thresholds have been identified that reflect recent historical rates in the GKGSa region. Within the eastern portions of the Subbasin, the East Kaweah GSA has established minimum thresholds using a metric tied to loss of conveyance capacity in the Friant-Kern Canal which traverses from north to south through that GSA.

Subsidence becomes a land-surface problem when it is differential in nature i.e., elevation shifts across the areal extent of infrastructure deemed of high importance. For example, subsidence linearly along a major highway is manageable if gradual in its occurrence. In contrast, localized subsidence traversing across a highway, if sizable, would cause major cracking of the pavement surface and become a significant hazard to travelers. The same comparisons may be made for other infrastructure as well. For this reason, should an exceedance of a minimum threshold at a monitoring site occur, the applicable GSA will reach out to the County, cities, water districts, and others, both public and private, and inquire as to any infrastructure damages which may be occurring determine a corrective course of action if deemed necessary. A broad areal extent of land subsidence thus may not be of major concern, with the exception of the associated loss of aquifer system water storage capacity.

6.6.1 Potential Effects on Beneficial Uses and Users

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interest, and other potential effects that may occur or are occurring from undesirable results.*

Differential land subsidence may impact surface infrastructure such as building foundations, paved streets/highways, and water conveyance systems. While not considered alarming within the Kaweah Subbasin, subsidence along the Friant-Kern Canal elsewhere along its alignment has been an ongoing concern impacting beneficial users of that water supply source. Groundwater deep wells may be adversely impacted due to casing and column failures. Loss of groundwater storage space in the aquifer system can occur with compaction of clay layers within; however, the volume of dewatered and available space existing within the aquifer system is considered extensive and adequate for future recharge during GSP implementation.

6.6.1 Evaluation of Multiple Minimum Thresholds

23 Cal. Code Regs § 354.26 (c). *The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.*

The Subbasin, in coordination with other GSAs in the basin will utilize multiple wells to monitor and manage the GSA and basin. A detailed description of the GSA's monitoring network is included in Section 4 of this GSP.

6.7 Degraded Water Quality

23 Cal. Code Regs § 354.26(a). *Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.*

An undesirable result may be significant and unreasonable if groundwater quality is adversely impacted by groundwater pumping and recharge projects and these impacts result in groundwater no longer being generally suitable for agricultural irrigation and domestic use.

6.7.1 Causes leading to Undesirable Results

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.*

Undesirable results associated with water quality degradation can result from pumping localities and rates, as well as other induced effects by implementation of a GSP, such that known plumes and contaminant migration could threaten production well viability. Well production depths too may draw out contaminated groundwater, both from naturally occurring and man-made constituents which, if MCLs are exceeded, may engender undesirable results. Declining groundwater levels may or may not be a cause, depending on location. In areas where shallow groundwater can threaten the health of certain agricultural crops, rising water levels may be of concern as well.

6.7.2 Criteria to Define Undesirable results

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.*

Should one-third of all Subbasin designated water quality monitoring sites exhibit a minimum threshold exceedance, and those exceedances are all associated with GSA actions, an undesirable result will be deemed to occur. Groundwater quality degradation will be evaluated relative to established MCLs or other agricultural constituents of concern by applicable regulatory agencies. The metrics for degraded water quality shall be measured by MCL compliance or by other constituent content measurements where appropriate. These metrics will include measurements for the following constituents where applicable:

- Arsenic
- Nitrate
- Chromium-6
- DBCP
- TCP
- PCE
- Sodium
- Chloride
- Perchlorate
- TDS

As explained in Section 5.3.4, in regions where agriculture represents the dominant use of groundwater, Agricultural Water Quality Objectives will serve as the metric as opposed to MCLs within public water supply jurisdictions. An exceedance of any of the MCL or agricultural metrics as defined herein at any representative monitoring sites will trigger a management action within the applicable Management Area or GSA, subject to determination that the exceedance was caused by actions of the GSA. MCLs and water quality objectives are listed in **Appendix 3A** and these are subject to changes as new water quality objectives are promulgated by the State of California and the Federal EPA. The Subbasin will provide updates in our annual reports and GSP Updates throughout the implementation periods of 2020 to 2040.

6.7.3 Potential Effects on Beneficial Uses and Users

23 Cal. Code Regs § 354.26 (b). *The description of undesirable results shall include the following: (3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interest, and other potential effects that may occur or are occurring from undesirable results.*

The potential effects of degraded water quality from migrating plumes or other induced effects of GSA actions include those upon municipal, small community and domestic well sites rendered unfit for potable supplies and associated uses, and/or the costs to treat groundwater supplies at the well head or point of use so that they are compliant with state and federal regulations. Potential effects also include those upon irrigated agricultural industries, as certain mineral constituents and salt build-up can impact field productivity and crop yields.

6.7.4 Evaluation of Multiple Minimum Thresholds

23 Cal. Code Regs § 354.26 (c). *The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.*

The Subbasin, in coordination with other GSAs in the basin will utilize multiple wells to monitor and manage the GSA and basin. A detailed description of the GSA's monitoring network is included in Section 4 of this GSP.

6.8 Interconnected Surface Waters

6.8.1 Undesirable results

23 Cal. Code Regs § 354.26 (d) *An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.*

No interconnected surface waters as defined in SGMA have been identified in any Kaweah Subbasin GSAs as described more thoroughly in the basin setting. Some of the Plans have identified this issue as a data gap and have committed to increasing monitoring.

6.9 Seawater Intrusion

6.9.1 Undesirable results

23 Cal. Code Regs § 354.26 (d) *An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.*

There is no potential for seawater intrusion to occur in the Kaweah Subbasin as described more thoroughly in the basin setting. Thus, no criteria need be established.

Appendix 7

Groundwater Modeling Technical Memorandum



KAWEAH SUBBASIN GROUNDWATER MODELING REPORT

Final

12/31/19

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Introduction

This memorandum describes the application of the Kaweah Subbasin Hydrologic Model (KSHM) to analysis of future conditions in the Kaweah Subbasin during the GSP implementation period from 2020 to 2040. The model is applied to estimate future water deficit and water levels under base no-action scenarios. It is also applied to assess the impacts of projects and management actions proposed by the Subbasin GSAs. The modeling results helped inform the GSAs in finalizing their sustainable management criteria including articulation of a basin wide sustainability goal statement and verifying the reasonableness of the measurable objectives, minimum thresholds, and interim milestones set at each groundwater level representative monitoring well for the 20-year GSP implementation period. The results are also intended to inform collaboration with other agencies and entities to arrest chronic water-level and groundwater storage declines, reduce or minimize land subsidence where significant and unreasonable, decelerate ongoing water quality degradation where feasible, and protect beneficial uses. The modeling approach and results of verification runs have been previously described in an earlier report which is provided in Appendix 1 of this report.

Model Scenarios

The first modeling task initiated includes extending the duration of the model from the modeled period of water years 1999 to 2017 through the SGMA compliance period of water years 2020 to 2040. All modeling runs, from the no-action “Base Case” scenario through the projects and management action scenarios, incorporate climate change in accordance with DWR’s climate change direction. The base case was used to identify measurable objectives and to facilitate planning for projects and management actions. The set of model runs to be performed was determined through iterative discussions and summarized in a presentation to the Kaweah Subbasin management team on April 17, 2019. The model runs implemented consisted of the following:

- **Case 1, Base No-Action Scenario:** Base Case Run with averaged water year repeated and adjusted to account for long term trend due to climate projections
- **Case 2, Variable Base No-Action Scenario:** Base case with historical sequence of wet and dry years
- **Case 3, Reversed Variability Base No-Action Scenario:** Base case with reversed historical sequence of wet and dry years
- **Case 4, Future Management Actions Only:** Built on the Base No-Action Scenario but with Pumping Reductions
- **Case 5, Future Projects and Management Actions:** Built on the Base No-Action Scenario but with Pumping Reductions and Projects

Preparing Projected Hydrology

Projected climate conditions for the implementation period are important inputs for the determination of measurable objectives and ultimately the sustainability of the basin. The GSP Emergency Regulation which was issued by DWR to guide development of GSPs includes guidance for preparation of Project Hydrology for 2020 to 2040 implementation period. Section 354.18(c)(2)(B) of the GSP Emergency Regulation outlines the relevant requirements for preparing historical and projected water budgets.

For historical water budget, the regulation requires a quantitative assessment based on a

minimum of 10 years of data including with the most recently available information. The 20-year current period (1997 to 2017) used for the Kaweah basin historical water budget meets and exceeds this requirement. For projected hydrology, the regulation requires future hydrology to be established using 50 years of historical precipitation, evapotranspiration, and streamflow information as a baseline. The regulation also requires projected hydrology information to be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.

To support the development of a projected hydrology that meets the requirements of the regulation, DWR has provided a gridded, statewide dataset that contains over 89 years of detrended hydrologic time series (1922 to 2011) to capture variability. DWR has also computed the climate states at 1995, 2030 and 2070 using a combination of global climate models, and the climate states have been applied to the detrended time series to generate three future hydrologic time series. For estimation of imported water supplies such as those from the Friant-Kern system, DWR has simulated 82 years of future hydrologic time series using the CalSim model. Three climate time series, each 50 or more years long, were extracted from the DWR data and used to characterize projected hydrology in the Kaweah Basin under 1995, 2030 and 2070 conditions.

Case 1: Base Case of Future with Averaged Conditions and No Projects

To meet the GSP Emergency Regulation requirements, a base case of projected hydrology covering the 20-year period for 2020 to 2040 is developed based on historical monthly averages. The average monthly hydrologic conditions experienced between 1997 through 2017 (the “current period”) are assumed for each year of the compliance period, and annual change factors are applied to account for the long-term trend due to climate change. Future water supply projections (including Class I, II and other water deliveries) from the Friant Water Authority are included in the base case. Detailed steps for generating the projected hydrology time series are described in the following steps:

- **First Year (2020):** Projected hydrology for the first year (2020) are computed as the monthly averages of the current hydrology (1997 to 2017). An implied change factor of 1 is used for the first year of projected hydrology.
- **Early Years (2021 to 2030):** Projected hydrology for subsequent years from 2021 to 2030 are computed by applying a set of change factors to account for climate change. Twelve climate change factors are computed using the percent change of the mean monthly values between two DWR-provided climate projection datasets centered around years 1995 and 2030, respectively. The linear trend is used to incremental apply the monthly change factors to each year between 2021 and 2030, and the change factors are applied to the monthly averages of the current (2020) hydrology to generate the projected hydrology.
- **Later Years (2031 to 2040):** Projected hydrology for the later years from 2031 to 2040 are computed by similarly applying factors to account for climate change. The climate change factors for later years is computed using the rate of change of the mean monthly values between DWR-provided climate projection datasets centered around years 2030 and 2070, respectively. The trend is applied incremental to the monthly values beginning with 2030 hydrology to generate projected hydrology for each year between 2031 and 2040.

Table 1 shows the monthly change factors computed for use in projecting future precipitation, evapotranspiration and water supply in the Kaweah Subbasin. Separate change factor values are provided for use in 2030 and 2040. Since a value of 100% is assumed for the first year 2020, change factors are easily interpolated for all intermediate years between 2020 and 2040 using a linear trend. Different change factors are computed in each of the three GSAs, and different

change factors are also applied for water supplies from Kaweah Lake, Kings and the Friant Kern system.

Table 1: Monthly Hydrologic Change Factors Derived from DWR-Provided Climate Change Projections.

	Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Precipitation (Percent of 2020 Values)													
East Kaweah	2030	92	102	98	108	104	109	103	85	88	101	109	105
East Kaweah	2040	89	97	97	111	104	109	99	80	87	104	112	111
Greater Kaweah	2030	92	101	97	108	105	108	103	87	88	101	112	105
Greater Kaweah	2040	90	96	97	110	105	108	100	83	87	101	113	110
Mid-Kaweah	2030	92	101	96	108	105	108	103	87	88	100	109	105
Mid-Kaweah	2040	90	96	95	110	105	108	100	83	87	100	110	110
Evapotranspiration (Percent of 2020 Values)													
East Kaweah	2030	104	103	103	105	103	103	102	104	104	103	103	103
East Kaweah	2040	105	105	106	106	105	104	103	105	105	104	104	104
Greater Kaweah	2030	104	103	104	105	103	103	102	104	104	103	103	103
Greater Kaweah	2040	105	105	106	106	104	103	103	105	105	104	104	104
Mid-Kaweah	2030	104	103	104	105	103	102	102	104	104	103	103	103
Mid-Kaweah	2040	105	105	106	107	104	103	103	105	105	104	104	104
Water Supply (Percent of 2020 Values)													
Kaweah Lake	2030	102	106	110	125	121	119	105	82	58	64	91	99
Kaweah Lake	2040	99	101	111	131	128	124	104	75	51	61	90	102
Kings	2030	100	111	118	135	131	127	115	96	64	58	84	96
Kings	2040	97	107	122	144	142	137	119	92	57	53	81	99
Friant-Kern	2030	85	97	146	152	116	110	101	97	85	90	85	85
Friant-Kern	2040	83	94	144	157	118	112	102	93	82	87	81	83

To generate the projected hydrology, the monthly change factors are applied to the fluxes from the calibrated model for the current period. The precipitation, evapotranspiration and water supply change factors are applied to different fluxes as follows:

- Mountain Front Runoff (precipitation change factors)
- Agricultural Pumping (evapotranspiration change factors)
- Agricultural Irrigation Return Flow (evapotranspiration change factors)
- Ditch Percolation (future estimated surface water allocations)
- Precipitation Percolation (precipitation change factors)
- River Recharge (water supply change factors)

Case 2: Future with Interannual Variability and No Projects

The second modeling case is used to evaluate the impacts of interannual variability including extreme conditions such as wet and dry years and multi-year droughts which could impact water quality or induce subsidence. The projected hydrology is based on the historical hydrologic time series (1997 to 2017) with a climate adjustment applied to reflect climate conditions centered at 2030. This model run includes over 10 years of current hydrology and 50 years of projected hydrology as required by the GSP regulations. However, the results cannot be used for setting intermediate 5-year targets between 2020 and 2040 since the historical sequence of wet and dry years cannot be assumed to recur in the future. The results of this model run are used primarily to estimate the magnitude of uncertainty in future projections of performance targets.

Case 3: Future with Interannual Variability Reversed and No Projects

The third modeling case also uses the historical time series used in Case 2 to evaluate the impacts of interannual variability and extreme wet and dry years. However, the sequence of historical time series is reversed such the model run begins with the most recent historical years of data while the oldest year of data enters the model last. The time series reversal changes the sequencing of hydrologic years but preserves the seasonal patterns that occurred within each year. To account for the impacts of climate change, a set of 12 monthly change factors is computed from the DWR climate projections centered at 2030 and applied to each year of the reversed time series.

The results of Case 3 run are useful for assessing the sensitivity of projected hydrology and sustainability indicators to the sequence of future annual droughts and wet years. However, the results cannot be used for setting intermediate 5-year targets between 2020 and 2040 since the sequence of years cannot be assumed to recur in the future. The results of this model run are also used to assess the magnitude of uncertainty in future projections of performance targets.

Case 4: Altered Future with Management Actions

The fourth modeling case reflects a future scenario where only management actions would be employed to achieve sustainability. Management actions are to be implemented with the goal of reducing pumping and mitigating further decline in aquifer water levels. They include conservation and monitoring programs aimed at limiting extraction and reducing water use. They also include market-based mechanisms and external assistance programs to reduce the economic impact of reduced water use. Table 2 shows the list of near-term management actions to be implemented in the Kaweah Subbasin in Case 4 which does not include implementation of any projects, with the exception of relatively new and operating water exchanges within Mid-Kaweah GSA.

Table 2: List of Management Actions included in Case 4

Region	Management Actions
East Kaweah GSA	<ul style="list-style-type: none"> • 5% Demand Reduction • 2025 Demand Reduction Programs/Policies • 2030 Demand Reduction Programs/Policies • 2035 Demand Reduction Programs/Policies
Greater Kaweah GSA	<ul style="list-style-type: none"> • Modified Surface Water Deliveries • Fallowing Program
Mid-Kaweah GSA	<ul style="list-style-type: none"> • Extraction Measurement Program • Groundwater Extraction Allocation Implementation

Case 5: Altered Future with Management Actions and Projects

The fifth modeling case reflects a future scenario where projects and management actions would be employed to achieve sustainability. While management actions are aimed at reducing pumping, projects are proposed with the primary goal of increasing recharge. **Table 3** shows the list of initial projects and management actions included in Case 5. Case 5 is expected to generate the smallest water deficit since it reflects the combined impacts of recharge projects and pumping reduction from all the management actions previously listed in Case 4. Not all of the projects and management actions listed in table three

Table 3: List of Projects and Management Actions included in Case 5

Region	Management Actions	Projects
East Kaweah GSA	<ul style="list-style-type: none"> • 5% Demand Reduction • 2025 Demand Reduction Programs/Policies • 2030 Demand Reduction Programs/Policies • 2035 Demand Reduction Programs/Policies 	<ul style="list-style-type: none"> • Lewis Creek Delivery • Cottonwood Creek Delivery • Yokohl Creek Delivery • Micro-Basins • Lindsay Recharge Basin • Wutchumna Ditch Delivery • Rancho de Kaweah
Greater Kaweah GSA	<ul style="list-style-type: none"> • Modified Surface Water Deliveries • Fallowing Program 	<ul style="list-style-type: none"> • Cross Creek Layoff Basin • Improved LIWD Basins • New LIWD Basins • New Delta View Canal • Deliveries to Delta View Landowners thru Lakeland • On-Farm Recharge • Kings River Floodwater Arrangement • Buying Surplus Water in Wet Years • Paregien Basin • Basin No. 4 • Hannah Ranch • Lewis Creek Water Conservation • Ketchum Flood Control & Recharge • St Johns River Water Conservation • Peoples Recharge Expansion
Mid-Kaweah GSA	<ul style="list-style-type: none"> • Extraction Measurement Program • Groundwater Extraction Allocation Implementation 	<ul style="list-style-type: none"> • Cordeniz Recharge Basin • Okieville Recharge Basin • Tulare Irrigation District / GSA Recharge Basin • On-Farm Recharge Programs • McKay Point Reservoir • Kaweah Subbasin Recharge Facility • City of Visalia / Tulare Irrigation District Exchange Program • Sun World International / Tulare Irrigation District Exchange Program • City of Tulare / Tulare Irrigation District Catron Basin • Packwood Creek Water Conservation Project • Visalia Eastside Regional Park & Groundwater Recharge

Boundary Conditions

The Kaweah Subbasin numerical groundwater model is intended to be used as a valuable planning tool to guide groundwater managers in planning projects and management actions to

achieve sustainability within the implementation period. To achieve this goal, particular attention is paid to how the head boundary conditions are specified in the model. Within the groundwater model, the General Head Boundary (GHB) surrounds the Kaweah Subbasin model at a distance of approximately 3 miles beyond the KSB boundary, located within the neighboring subbasins to the north, west and south. The area between the GHB and the Kaweah Subbasin is considered a “buffer zone,” the purpose of which is to evaluate subsurface inflow and outflow (underflow) between the adjacent subbasins. Figure 1 shows the model extent with the General Head Boundary represented by the line marking the edge of the model extent.

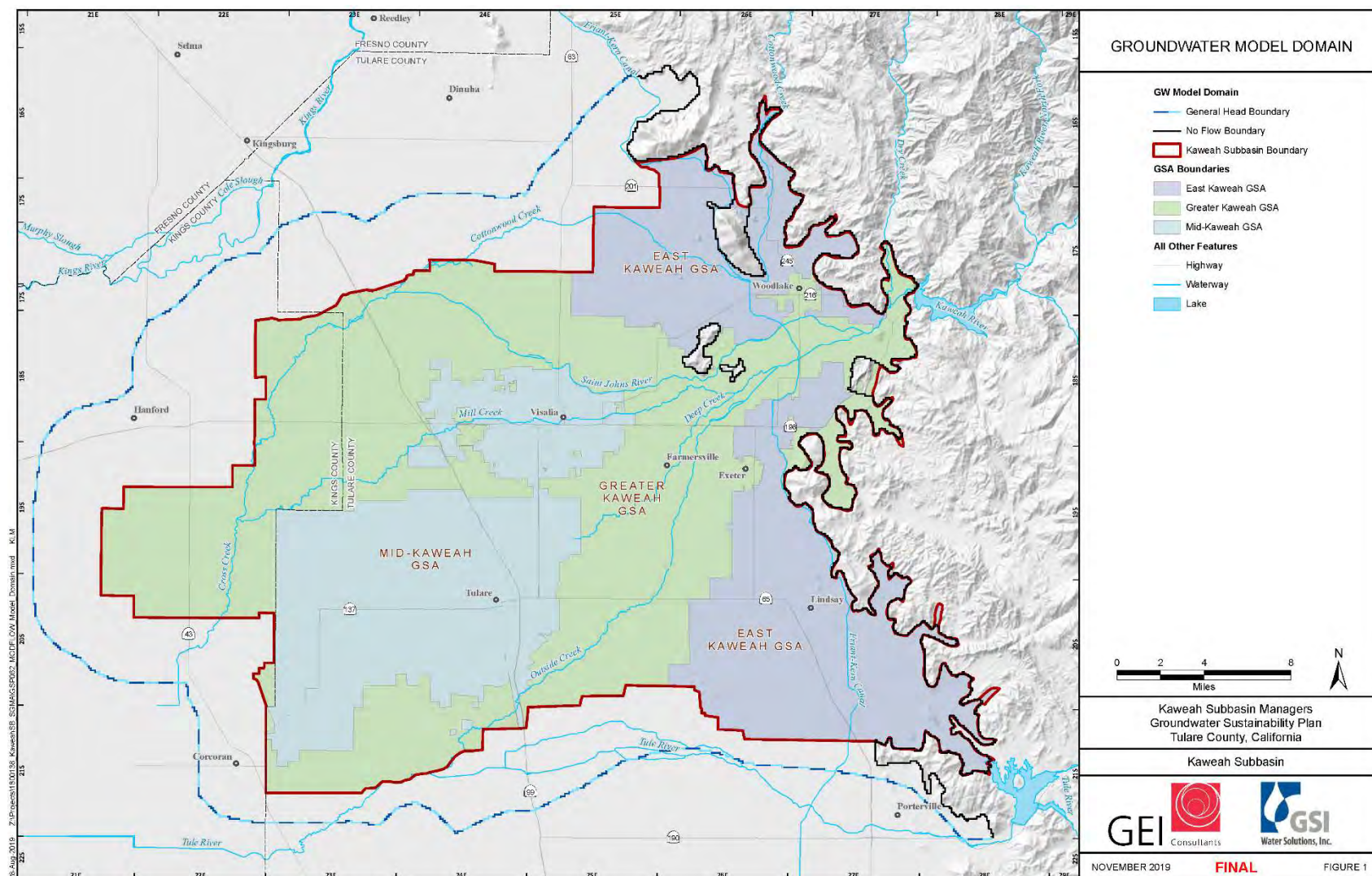


Figure 1: Kaweah Subbasin Model Domain

Head boundary conditions play an important role in modeling because, along with aquifer properties, they determine the magnitude of flows in and out of the subbasin. Boundary water levels for a modeling run must be specified for each month in the simulation period prior to each model run. They are difficult to specify accurately since they are based on water levels that respond to the change in fluxes due to actions in neighboring subbasins. However, they must be specified accurately enough to reflect changing fluxes entering and leaving the subbasin through the boundary.

In the Kaweah model, future water levels at the general head boundary are prescribed based on observed water elevations and simulated current hydrology (1997-2017) from the calibrated model. Future boundary water elevations from 2020 to 2040 were set by repeating the 12 average monthly values of the period from 1997 through 2017. This approach preserves the seasonal water level changes at boundary. It also ensures that the magnitude of underflow fluxes entering and leaving the basin for the base case are of the same order of magnitude as underflow fluxes for current hydrology. As projects and management actions are implemented within Kaweah and surrounding subbasins, the head boundary conditions and underflow will also change but these changes cannot be predicted without full knowledge of all projects and management actions in the region. The surrounding subbasins have the same modeling issues which can only be resolved in future by setting boundary conditions with modeled water levels from surrounding subbasins.

Figure 2 shows contours of the potentiometric surface for initial water levels at the start of the planning period in 2020. The elevation of the water table generally decreases from east to west. The highest water level elevations of between 300 and 400 ft occur in East Kaweah GSA at the transition from the Sierras to the valley floor. The lowest water levels of 40 ft or less occur along Cross Creek at the western edge of Greater Kaweah and Mid-Kaweah GSAs.

Figure 3 shows contours of the projected potentiometric surface changes between 2020 and 2040 under the base, no-project scenario. Contour values are generally negative indicating water levels in the Kaweah Subbasin would continue to decline without action to reduce extraction or increase supply. The largest declines would occur in the middle of the subbasin with declines exceeding 80 ft around Visalia. The region of decline is shaped like a cone centered around Visalia and extending over the entire subbasin.

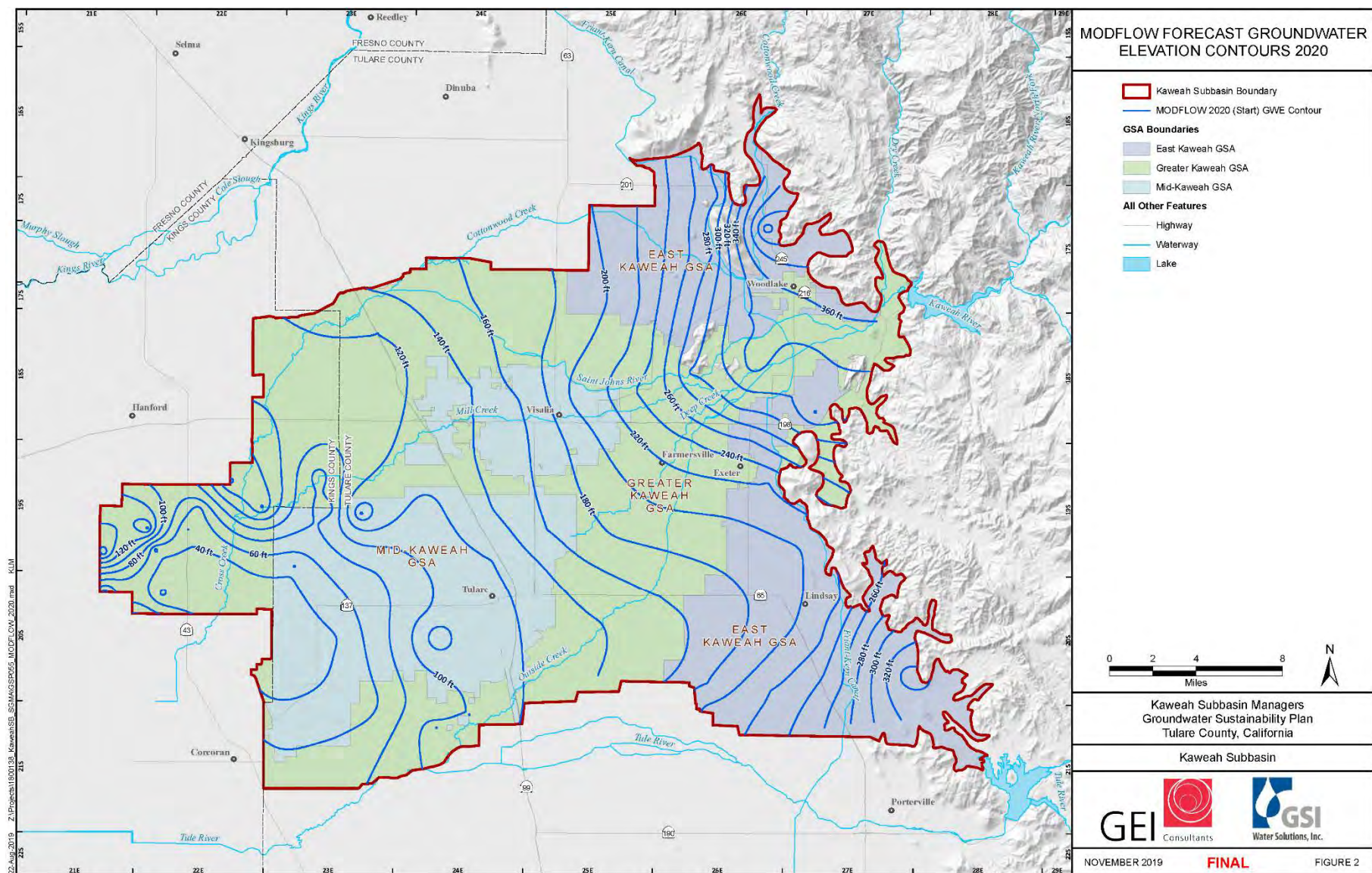


Figure 2: Potentiometric Surface Map showing Water Levels at the Beginning of the Simulation Period in 2020.

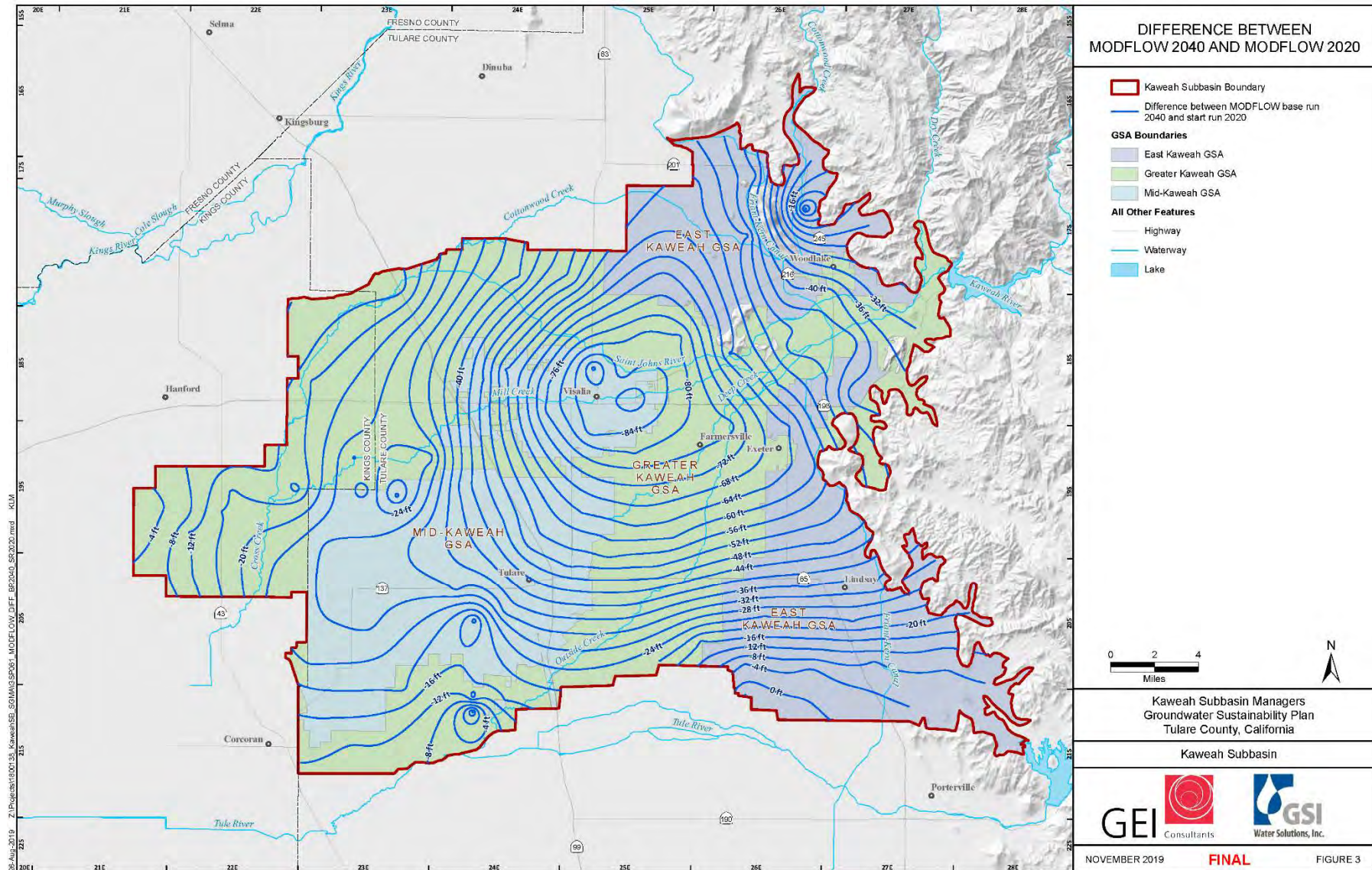


Figure 3: Map of Potentiometric Surface Changes from 2020 to 2040 under the Base Case with No Projects.

Recharge and Pumping Projections

As shown in the Basin Setting chapter of the GSP for the Kaweah Subbasin, climate change is projected to increase temperatures and evapotranspiration, leading to an equivalent increase in crop demands and groundwater pumpage. Percolation also increases with increases in the volume of applied irrigation water. The increase in evapotranspiration coupled with shifts in the seasonal patterns of precipitation could also affect changes to the quantity and timing of deep percolation and groundwater storage. With projected demands anticipated to increase by approximately 10 percent by 2040 (Table 34 of the Kaweah Basin Setting Report), a combination of demand management and recharge programs are required to close the deficit in the Projected Water Budget.

Surface water availability changes are incorporated as presented in the Projected Water Budget section of the Basin Setting document. This availability affects surface water delivery to crops and, by extension, groundwater pumpage to satisfy crop requirements. Surface water availability also impacts recharge along streams, ditches and recharge basins. Additional recharge (on-farm recharge) and recharge basins are included as future projects in the basin. In the interest of maximizing the surface water supply during wet periods, the future projects evaluated in modeling case 5 include on-farm recharge or other large-scale recharge projects.

Municipal pumping within each city and overall agricultural pumping within each GSA are adjusted as percentages of the base case scenario. Municipal pumpage is modeled as documented in the Basin Setting, in accordance with anticipated pumpage documented in urban water management plans. For the base period, irrigated agriculture demand averaged 1,055,700 AF/WY, which was satisfied by a combination of surface water and groundwater. Recent crop survey data indicate that this demand is from a variety of crops including almonds, alfalfa, citrus, cotton, grapes, olives, truck crops, walnuts, wheat and several others (Davids Engineering, 2018). Crop ET was derived for each of these crops for each year during the recent period of 1999 to 2017, based upon trends in water use for each crop. During the period, total water demand related to the growing of almonds has increased by 14 percent, while total water demand to satisfy miscellaneous field crops has declined by 18 percent. By considering all of the trends for a total of 16 crop categories on a net basis, the average change in crop water ET demand has been relatively unchanged, increasing modestly each year between 1999 and 2018. Future projection of crop demand to 2040 and 2070 indicates that agricultural demand will increase to 1,138,200 AF/WY in 2030 and 1,239,500 AF/WY in 2070, which includes projected climate change effects.

Changes in agriculture water use are implemented through cropping changes, land fallowing or other land-use conversion alternatives. Cropping changes are included in the no-action model runs (Case 1, 2 and 3) as presented in the Projected Water Budget section of the Basin Setting document. Land retirement is included as a management action in the fourth and fifth scenarios.

Each GSA is able to model separate reduced pumpage “ramp downs” and specific projects and management actions in increments of 5 years or less. The results of the numerical modeling are summarized at a GSA-level along with water level changes, hydrographs, and water budget components in 5-year increments from 2020 through 2040. The 5-year summaries allow the GSAs to determine the anticipated effectiveness of projects and management actions.

Agricultural pumping reductions are incorporated into the groundwater model relative to the baseline run for many of the predictive scenarios. Reductions in pumpage are specified in areas smaller than the GSA such as the scale of an entitlement holder or a water district. Pumpage reductions are also allowed to vary temporally. To accommodate these spatial and temporal

variations within the model, a shapefile is developed of the areas where pumpage reductions are proposed and used to assign a proportional reduction in pumpage for modeling areas. Likewise, reductions of pumpage are assigned evenly throughout the agricultural pumpage at the GSA scale. Temporally, these reductions are assigned in approximately 5-year periods (such as 2021 - 2025 or 2026 - 2030) to allow sufficient time for planning operational changes. A relative adjustment is also applied to irrigation return flows to maintain consistency with the prescribed agricultural pumping reductions.

Change in water levels from the baseline can readily be summarized over specified pumpage areas at the end of each 5-year period. However, the groundwater zone budget determining underflow, change in storage, other groundwater model fluxes, and objectives are only computed at the GSA level.

Water from Management Actions and Projects

The impacts of Management Actions and Projects on reducing average annual water deficits in the Kaweah Subbasin over the implementation period 2020 to 2040 are shown in Table 4. The water deficit reductions are provided in thousands of acre-feet per year. Separate values are shown for the Management Actions (Case 4) and the combined impact of Projects and Management Actions (Case 5) for East Kaweah GSA, Greater Kaweah GSA and Mid-Kaweah GSA. Summary results for the full Kaweah Subbasin are also provided. For Mid-Kaweah GSA, the proposed Management Actions are included in Case 4 while Case 5 includes only proposed Projects without Management Actions. This is because Management Actions in Mid-Kaweah GSA include reoperation of existing projects such as capturing and storing local or regional flood flows that would otherwise leave the subbasin and operating existing Packwood Creek recharge facilities.

Table 4: Water Deficit Reduction from Projects and Management Actions in Thousands of Acre-Feet per Year

Water Year	Water Deficit Reduction (1000 Acre-Feet/Year)							
	East Kaweah GSA		Greater Kaweah GSA		Mid-Kaweah GSA		Kaweah Subbasin	
	Case 4: Management Actions	Case 5: Total	Case 4: Management Actions	Case 5: Total	Case 4: Management Actions and Existing Projects	Case 5: Projects without Management Actions	Case 4: Management Actions	Case 5: Total
2020	0	1.8	3.3	12.7	5	5	8.3	19.5
2021	1.5	5.1	4.5	14.2	5	5	11	24.3
2022	1.5	8.3	4	13.7	5	5	10.5	26.9
2023	1.5	8.3	8	77.4	5	5	14.5	90.6
2024	1.5	11	4	14.2	5	5	10.5	30.2
2025	7.5	14.5	4.5	14.7	5.6	10	17.6	39.2
2026	7.5	23.5	16.3	26.4	6.3	10	30	59.9
2027	7.5	23.5	16.3	99.3	6.9	10	30.6	132.8
2028	7.5	23.5	16.3	26.6	7.5	10	31.3	60
2029	7.5	23.5	16.3	26.6	8.1	10	31.9	60
2030	16.5	27	16.3	26.6	8.8	15	41.5	68.5
2031	16.5	27	36	130.1	9.4	15	61.9	172.1
2032	16.5	27	36	46.5	10	15	62.5	88.4
2033	16.5	27	36	46.5	10.6	15	63.1	88.4
2034	16.5	27	36	46.5	11.3	15	63.8	88.4

2035	30	30.5	36	140	11.9	15	77.9	185.5
2036	30	30.5	65	75.6	12.5	15	107.5	121.1
2037	30	30.5	65	75.6	13.1	15	108.1	121.1
2038	30	30.5	65	75.6	13.8	15	108.8	121.1
2039	30	30.5	65	172.6	14.4	15	109.4	218
2040	30	30.5	65	75.6	15	15	110	121.1
Min	0	1.8	3.3	12.7	5	5	8.3	19.5
Max	30	30.5	65	172.6	15	15	110	218
Mean	14.6	21.9	29.3	58.9	9	11.4	52.9	92.2

The results show that proposed management actions (case 4) in the Kaweah Subbasin could yield approximately 52,900 acre-feet per year of reductions in water deficit. Case 5 results in a total water deficit reduction of 92,200 acre-feet annually on average and in the last five years the deficit reduction is 121,000 acre-feet which implies that the projects alone would yield 39,300 acre-feet per year. The Kaweah Subbasin Basin Setting Report estimates the basin Safe Yield at 720,000 acre-feet per year and the average annual groundwater pumping in the basin during the current water budget period is 798,000 acre-feet. Therefore, a reduction in deficit of 121,000 through the implementation of projects and management actions will ensure that we are operating within the safe yield of the basin. The Greater Kaweah GSA contributes to 64% of deficit reduction while East Kaweah and Mid-Kaweah contribute 24% and 12%, respectively. Implementation of most management actions increases gradually in each GSA over the 20-year planning horizon but with some stepped increases occurring approximate every five years. Projects in East Kaweah and Mid-Kaweah steadily reduce water deficits within their respective GSAs over the planning horizon. However, in Greater Kaweah, the projects yield gradually increasing volumes of water punctuated by large recharge volumes during wet years which are assumed to recur every four years.

Figure 4 shows contours of difference in 2040 water levels between the base no-action scenario and the scenario in which management actions are implemented but with no projects. The introduction of Management Actions would result in an overall rise in 2040 water levels relative to the no-action scenario. The largest improvements occur in the area between Cottonwood Creek and Saint Johns River with water levels rising up to 28 ft. Rises of over 20 ft are seen in other across the middle of the subbasin, stretching from areas along Mill Creek near Visalia to the Friant-Kern Canal near Lindsay.

Figure 5 shows contours of difference in 2040 water levels between the base no-action scenario and the scenario with full implementation of proposed projects and management actions. Under this scenario, the largest improvements in water levels of over 52 ft occur along Saint Johns River and Deep Creek, just west of McKays Point. Improvements of over 40 ft are also seen between Mill Creek and Cross Creek near Remnol.

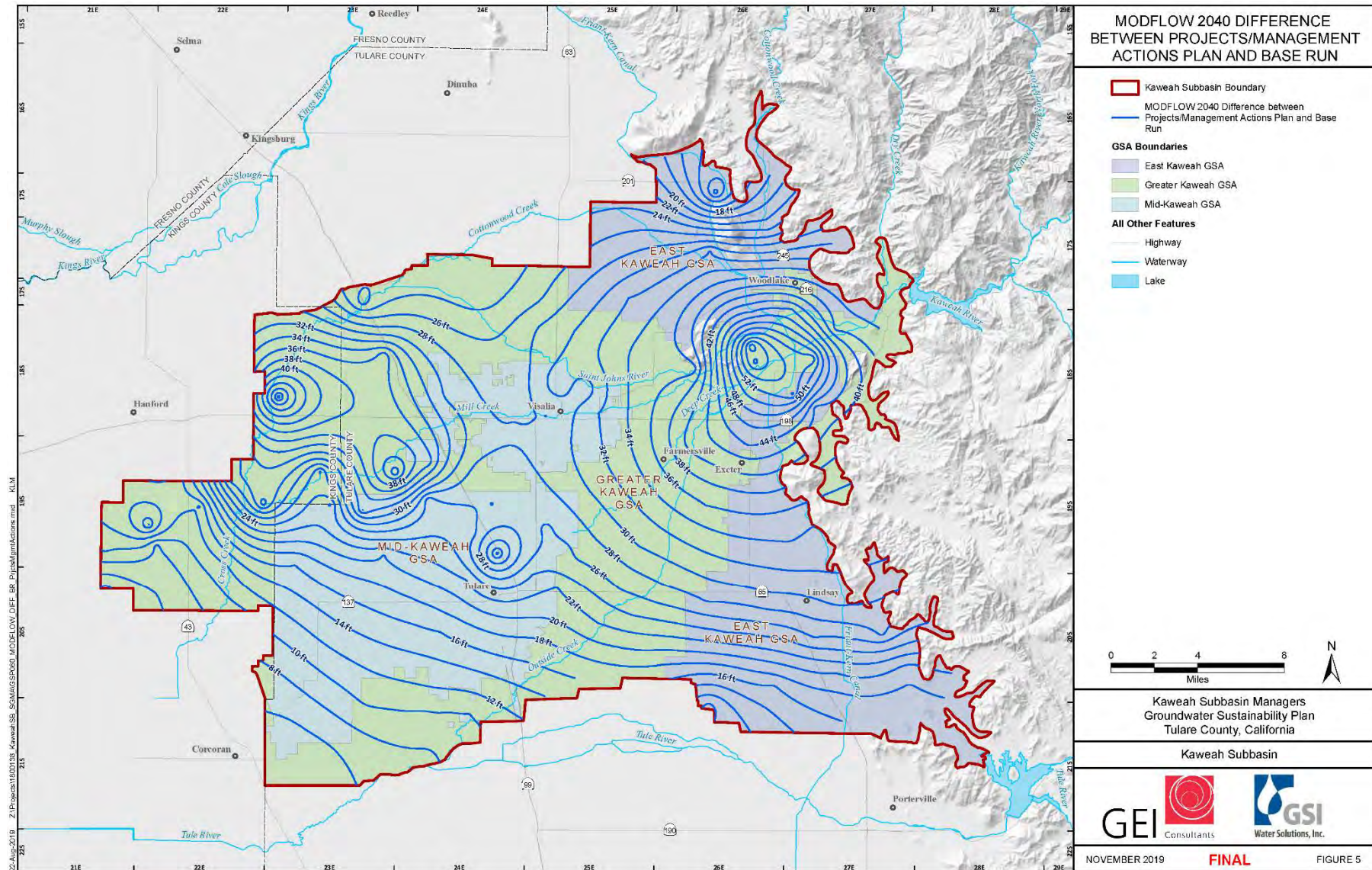


Figure 5: Map of Differences in Potentiometric Surfaces between the Base Case 1 with No Projects and Case 5 with Management Actions and Projects in 2040.

Summary Results for Kaweah Subbasin

The impacts of the management actions and projects on groundwater fluxes and storage in the basin for the five modeling cases analyzed are summarized in Table 5. For each run, fluxes are presented for the initial water year (2020) followed by average fluxes for the next 5-year period. Inflow fluxes presented include recharge, underflow entering the Kaweah Subbasin from surrounding buffer zone, and total inflow fluxes. Outflow fluxes presented include pumping from agricultural wells, aquifer discharge to streams, pumping from non-agricultural wells, underflow discharged from the Kaweah Subbasin to the surrounding buffer zone, and total outflow. Annual rates of change in storage and cumulative storage changes at the end of each period are also presented.

The results show that for Base Case 1, water deficits would continue to increase steadily through the planning horizon, reaching a cumulative storage decline of 1.5 million acre-feet by 2040. The deficits increase during the period because total inflows increase by 7.7% while total outflows increase by 14.7%. While their total recharge fluxes are identical, simulations for the variable Case 2 and reversed variability Case 3 result in values of cumulative storage declines that are over 1.2 million acre-feet apart by 2040. The difference is mostly due to a difference in underflow into the Kaweah Subbasin of over 1 million acre-feet between the two cases. The reversal of fluxes also changes the water balance dynamics and results in intermediate storage deficits that are more severe in Case 3 than in Case 2. While future sequences of wet and dry water years cannot be predicted, the results suggest that Kaweah GSAs could benefit from contingency planning for interim deficits resulting from unfavorable water year sequences.

The results for Case 4 show that implementation of Management Actions could yield a 6% reduction in pumping from agricultural wells, resulting in a 4.4% reduction in total outflow relative to Case 1. Over the 20-year planning horizon, this translates to a 46% reduction in cumulative storage decline. The combination of Projects and Management Actions in Case 5 yields an 8.3% increase in recharge and a 2.8% reduction in total outflow. The net impact of the changes from Case 5 is a 79.9% reduction of the average annual storage decline from 71,500 acre-feet/year (or 1,501,901 acre-feet in 21 years) to 15,100 acre-feet/year (or 316,370 acre-feet in 21 years) from January 2020 to December 2040.

Table 5: Impacts of Projects and Management Actions on Groundwater Fluxes and Storage in the Kaweah Subbasin.

Period in Water Years	Inflow (Acre-Feet/Year)			Outflow (Acre-Feet/Year)					Change in Storage (Acre- Feet/Year)	Cumulative Change in Storage (Acre-Feet)
	Recharge	Underflow Buffer to KSB	Total Inflow	Ag Pumping	Aquifer Discharge to Stream	Non-Ag Pumping	Underflow KSB to Buffer	Total Outflow		
Case 1: Base Case of Future with Averaged Conditions and No Projects										
2020	676,105	185,429	861,534	726,105	0	101,360	60,420	887,886	-26,352	-26,352
2021 - 2025	674,117	206,914	881,031	747,316	0	108,481	62,235	918,032	-37,001	-211,359
2026 - 2030	674,117	218,869	892,987	783,289	0	120,729	64,877	968,895	-75,908	-590,899
2031 - 2035	674,106	236,257	910,364	803,716	0	132,728	64,898	1,001,341	-90,977	-1,045,786
2036 - 2040	674,566	253,312	927,878	813,133	0	141,028	64,940	1,019,101	-91,223	-1,501,901
Case 2: Future with Interannual Variability and No Projects										
2020	927,137	157,959	1,085,096	503,909	0	94,915	68,183	667,008	418,089	418,089
2021 - 2025	709,912	206,077	915,990	680,497	521	99,663	57,998	838,678	77,311	804,646
2026 - 2030	653,687	203,723	857,410	765,822	229	123,965	71,984	962,000	-104,590	281,694
2031 - 2035	666,604	225,936	892,540	810,017	213	143,603	88,081	1,041,913	-149,373	-465,173
2036 - 2040	618,801	274,083	892,883	945,506	55	135,831	81,597	1,162,989	-270,106	-1,815,704

Case 3: Future with Interannual Variability Reversed and No Projects										
2020	1,191,324	173,864	1,365,188	507,156	43	143,667	103,103	753,969	611,219	611,219
2021 - 2025	479,819	243,678	723,498	1,040,180	239	143,185	85,176	1,268,779	-545,282	-2,115,190
2026 - 2030	659,066	281,360	940,425	821,914	179	137,714	68,758	1,028,566	-88,140	-2,555,892
2031 - 2035	671,770	308,325	980,094	719,378	72	113,587	50,052	883,089	97,005	-2,070,868
2036 - 2040	780,164	276,155	1,056,320	606,836	520	94,432	58,089	759,876	296,443	-588,650
Case 4: Altered Future with Management Actions										
2020	681,104	184,922	866,026	722,860	0	101,360	60,625	884,845	-18,819	-18,819
2021 - 2025	679,116	204,412	883,529	739,493	0	108,481	63,114	911,088	-27,560	-156,619
2026 - 2030	679,116	210,690	889,805	755,265	0	120,729	67,164	943,158	-53,353	-423,384
2031 - 2035	679,116	217,985	897,100	743,447	0	132,870	69,283	945,600	-48,500	-665,881
2036 - 2040	679,611	220,124	899,735	712,386	0	144,094	72,166	928,646	-28,911	-810,436
Case 5: Altered Future with Management Actions and Projects										
2020	693,019	184,909	877,928	722,860	0	102,029	60,664	885,553	-7,625	-7,625
2021 - 2025	709,227	199,605	908,833	740,079	0	108,555	64,540	913,174	-4,342	-29,332
2026 - 2030	728,472	199,572	928,043	760,614	0	120,771	70,815	952,199	-24,156	-150,112
2031 - 2035	753,547	201,107	954,655	756,950	0	133,173	77,059	967,182	-12,526	-212,744
2036 - 2040	738,199	201,171	939,369	734,500	0	144,715	80,879	960,094	-20,725	-316,370

Summary Results by GSA

Summary Results for East Kaweah GSA

Table 6 is a summary of predictive modeling results for East Kaweah over the 20-year planning horizon. Case 4 and Case 5 result in the lowest annual water deficit (noted as “Change in Storage” in Table 6 and subsequent tables). The results indicated that implementation of Management Actions in Case 4 could reduce well pumping by 13,900 acre-feet/year and reduce the annual water deficit from 16,200 acre-feet/year to 6,600 acre-feet/year. The combination of Management Actions and Projects in Case 5 increases total inflow by 8,900 acre-feet/year, and the annual water deficit falls to 3,000 acre-feet/year.

Table 6: Summary of Predictive Modeling Results for East Kaweah in Acre-Feet per Year

Summary Results for East Kaweah GSA	Base Case 1	Variable Base Case 2	Reversed Variable Case 3	Management Actions Case 4	Management & Projects Case 5
Recharge	118,096	118,064	117,445	118,107	126,632
Inflow from Buffer Zone	48,298	42,370	50,735	45,408	44,830
Inflow from Greater Kaweah	34,417	36,925	33,253	34,643	38,227
Total Inflow	200,811	197,360	201,434	198,159	209,689
Pumping from Ag Wells	166,025	166,324	164,666	152,120	159,167
Aquifer Discharge to Streams		0	0		
Pumping from Non-Ag Wells	2,842	2,669	2,652	2,842	2,796
Outflow to Buffer Zone	6,267	6,048	5,661	6,563	6,574
Outflow to Greater Kaweah GSA	41,843	44,553	42,017	43,278	44,121
Total Outflow	216,977	219,595	214,996	204,803	212,658
Annual Change in Storage	-16,166	-22,235	-13,563	-6,644	-2,969

Summary Results for Greater Kaweah GSA

Table 7 shows a summary of predictive modeling results for Greater Kaweah over the 20-year planning horizon. In Greater Kaweah, the Reversed Variable Case 3 achieves better reduction in water storage decline than the Management Actions Case 4. However, the results of Case 3 are unreliable for planning as the reductions occur due to significant increases in uncontrolled inflow from the buffer region relative to Case 2. The results for Case 4 indicate that implementation of Management Actions could reduce well pumping by 29,100 acre-feet/year relative to Case 1 and reduce the annual water deficit from 37,300 acre-feet/year to 20,800 acre-feet/year. The combination of Management Actions and Projects in Case 5 increases total inflow by 15,500 acre-feet/year relative to Case 1, and the annual water deficit falls to 5,400 acre-feet/year.

Table 7: Summary of Predictive Modeling Results for Greater Kaweah in Acre-Feet per Year

Summary Results for Greater Kaweah GSA	Base Case 1	Variable Base Case 2	Reversed Variable Case 3	Management Actions Case 4	Management & Projects Case 5
Recharge	375,882	376,172	375,755	375,946	412,038
Inflow from Buffer Zone	177,354	180,487	219,638	165,516	153,823
Inflow from East Kaweah	41,843	44,553	42,017	43,278	44,121
Inflow from Mid-Kaweah	78,872	95,441	77,646	80,407	79,441
Total Inflow	673,950	696,653	715,056	665,148	689,424
Pumping from Ag Wells	469,694	470,276	468,868	440,620	440,625
Aquifer Discharge to Streams	-	242	242	-	-
Pumping from Non-Ag Wells	41,251	40,544	41,703	41,573	41,676
Outflow to Buffer Zone	48,322	58,435	53,653	51,085	55,910
Outflow to East Kaweah GSA	34,417	36,925	33,253	34,643	38,227
Outflow to Mid-Kaweah GSA	117,527	133,587	131,464	117,982	118,389
Total Outflow	711,211	740,010	729,182	685,903	694,826
Annual Change in Storage	-37,261	-43,357	-14,126	-20,755	-5,402

Summary Results for Mid-Kaweah GSA

Table 8 shows a summary of predictive modeling results for Mid-Kaweah over the 20-year planning horizon. In Mid-Kaweah, the Reversed Variable Case 3 achieves better reduction in water storage decline than Case 4 and Case 5. However, the results of Case 3 are unreliable for planning as the reductions occur due to significant reductions in uncontrolled outflows to Greater Kaweah. The results for Case 4 indicate that implementation of Management Actions could reduce well pumping by 4,000 acre-feet/year relative to Case 1 and reduce the annual water deficit from 18,100 acre-feet/year to 11,100 acre-feet/year. The combination of Management Actions and Projects in Case 5 increases total inflow by 5,300 acre-feet/year relative to Case 1, and the annual water deficit falls to 6,700 acre-feet/year.

Table 8: Summary of Predictive Modeling Results for Mid-Kaweah in Acre-Feet per Year

Summary Results for East Kaweah GSA	Base Case 1	Variable Base Case 2	Reversed Variable Case 3	Management Actions Case 4	Management & Projects Case 5
Recharge	180,338	180,627	180,391	185,275	191,817

Inflow from Buffer Zone	1,120	1,288	2,077	1,027	975
Inflow from Greater Kaweah	117,527	133,587	131,464	117,982	118,389
Total Inflow	298,985	315,503	313,932	304,284	311,181
Pumping from Ag Wells	148,251	149,738	149,738	144,204	147,046
Aquifer Discharge to Streams	-	-	-	-	-
Pumping from Non-Ag Wells	80,488	81,083	78,895	80,930	81,152
Outflow to Buffer Zone	9,466	10,111	7,995	9,936	10,236
Outflow to Greater Kaweah GSA	78,872	95,441	77,646	80,407	79,441
Total Outflow	317,077	336,373	314,274	315,477	317,875
Change in Storage	-18,092	-20,870	-342	-11,193	-6,694

Conclusions and Recommendations

The Kaweah Subbasin Basin Setting Report estimates the basin Safe Yield at 720,000 acre-feet per year and the average annual groundwater pumping in the basin during the current water budget period is 798,000 acre-feet. Therefore, a reduction in deficit of 121,000 acre-feet through the implementation of projects and management actions will ensure that we are operating within the safe yield of the basin.

Through the five-year GSP assessment process and continued dialogue with neighboring subbasins as to their role in influencing the changes in storage within the Kaweah Subbasin, we expect to have improvements in our understanding of boundary conditions. Future updates to the groundwater model are expected to show stabilized groundwater levels through the implementation of the projects and management action considered in the GW modeling study. If residual storage reductions remain from these future modeling scenarios analyzed at the five year update, the GSAs will take further action to stabilize groundwater levels and reductions in storage with the implementation of additional projects and/or accelerated implementation of management actions designed to reduce groundwater extractions.

Under some modeling scenarios (such as the Reversed Variable Case 3), water levels within the buffer region can become misaligned with changing water levels within the subbasin. The misaligned water levels can significantly alter the amount of inflow or outflow moving across the buffer region or between neighboring GSAs, altering the patterns of water storage declines. Such transboundary flows are not sustainable over the long term and should not be relied upon to achieve sustainability targets. Future groundwater modeling efforts should identify approaches to account for transboundary flows to ensure reduction in water storage decline are achieved through sustainable approaches.

The Kaweah Subbasin groundwater model produced a fit between measured and model-generated data with a relative error of 3% in layer 1 and 10.7% in layer 3 during model calibration. This was determined to be an adequate fit for the planning model for GSP development. As the Kaweah Subbasin GSAs move from plan development to implementation, it is recommended that further resources be dedicated to the calibration of the model to enhance its accuracy and reliability as a decision-making tool.

Appendix 1: Model Approach and Verification

Introduction: Kaweah Groundwater Modeling

The purpose of this update is to communicate the current progress of the groundwater modeling efforts for Kaweah Subbasin. It was compiled from materials originally published on the Kaweah Subbasin website in March 2017 under the heading “Review of Existing Kaweah Subbasin GW Models and Approach for Model Development to Support GSP”.

Early in 2017, the GEI Consultants, Inc. (GEI) and GSI Water Solutions, Inc. (GSI) teams prepared a Technical Memorandum (TM) to evaluate the groundwater models available for use in development of the Groundwater Sustainability Plans (GSP) for the three Groundwater Sustainability Agencies (GSA) in the Kaweah Sub- Basin (Subbasin). That TM, dated March 8, 2017, presented the significant comparative details of three numerical groundwater flow models that cover the Sub- Basin, including:

- Kaweah Delta Water Conservation District (KDWCD) Groundwater Model,
- Central Valley Hydrologic Model (CVHM), and
- California Central Valley Groundwater-Surface Water Simulation Model (C2VSim) coarse grid and fine grid variants.

The March 2017 TM identified the water budget from the most recent update of the KDWCD Water Resources Investigation (WRI) as an accounting "model", but it is essentially a water accounting analysis that uses water consumption and soil moisture models. It is not a three-dimensional, numerical groundwater flow model, but is a valuable analysis that will be used as primary inputs to the groundwater model. The March 2017 TM recommended use of the KDWCD Groundwater Model as the preferred tool for Sustainable Groundwater Management Act (SGMA) applications based upon its relative ability to address the potential model needs cited in SGMA regulations. Model selection criteria used in the TM included: model availability; cost of development and implementation; regulatory acceptance; suitability for GSP-specific analyses; and relative abilities to assess Subbasin water budget components, future undesirable results, and impacts of future management actions and projects.

More recently, the Kaweah Management Team, consisting of the East Kaweah, Greater Kaweah, and Mid-Kaweah Groundwater Sustainability Agencies (EKGSA, GKGSA, and MKGSA) approved a scope of work to develop a Subbasin wide numerical groundwater model to support GSP development and implementation. Efforts related to groundwater model development and use of the calibrated tool were generally defined within three tasks, as follows:

- Task 1 – Perform a technical assessment of existing groundwater models that cover the Kaweah Subbasin, with emphasis on the KDWCD Model, and develop an approach to update and revise the selected source model as required to support the objectives of the GSP.
- Task 2 – Perform model revisions and updates for the selected groundwater model as documented in Task 1, with a focus on supporting GSP objectives.
- Task 3 – Apply the updated model predictively for each GSA and cumulatively for the entire Subbasin to simulate future conditions, with and without potential management actions and projects proposed to support GSP implementation.

This TM documents the results of Task 1. GEI and GSI (the Modeling Team), as part of supporting Subbasin SGMA compliance, have evaluated the existing KDWCD Groundwater Model for update

to simulate the entire Subbasin and relevant adjacent areas. The following presents technical details and performance aspects of the KDWCD Model and proposes a general approach for utilizing the model to support development of the GSP. Specifics of this approach may change over the course of model development as dictated by data constraints and improved conceptualization provided by the updated Subbasin Basin Setting developed through the Management Team. This TM and associated analyses satisfy Task 1 requirements, including:

- Perform a detailed evaluation of the existing KDWCD groundwater model inputs and outputs, including test runs and simulations, comparisons with water budget data, and a general comparison with regional C2VSim and CVHM models.
- Develop a plan to move forward with the model update, including assessment of status of required hydrogeologic data, updates to model area, parameters, fluxes, spatial framework, stress periods, validation periods, and calibration periods and general approach for the model domain.
- Prepare a TM summarizing the path forward for modeling support of the GSP, including technical coordination with adjacent basin GSA representatives regarding groundwater modeling methods and assumptions.

Additionally, the Modeling Team will present the key findings of this TM in a workshop for representatives of the Subbasin GSAs. This working session will allow GSA representatives to better understand the model design and capabilities as well as provide a forum for discussion of current, future, and outstanding data as well as planning needs for model development and predictive simulations.

After submittal of this proposed modeling approach and path forward, the Modeling Team will execute the recommended actions described in this document. Once updated, the Modeling Team is recommending adoption of the name Kaweah Sub- Basin Hydrologic Model (KSHM) for this new SGMA tool to differentiate it from the previous modeling efforts and to reflect the fact that it includes complex hydrologic analyses in addition to groundwater flow.

The Modeling Team previously performed a cursory review of pertinent aspects affecting the efficient use of the three major groundwater modeling tools that cover the Subbasin. This TM is built upon that analysis and includes a more in-depth assessment of the newly released beta version of the C2VSim model provided by the California Department of Water Resources (DWR). Although the results of the March 2017 analysis were reinforced with findings from this review, the Modeling Team also looked at the datasets contained within these valuable, regional modeling tools to see if they may be of use in the development of the KSHM.

CVHM is an 11-layer model that covers the entire Central Valley. It has a spatial resolution of one square mile and includes both a coupled lithologic model and Farm Process module (model) that are used to estimate hydraulic parameters and agricultural groundwater demand and recharge, respectively. The CVHM was previously deemed not to be a viable modeling alternative for the Subbasin analyses by the Modeling Team due to several factors. Most significant of these is the fact that the model data is only current to 2009, well before the SGMA-specified accountability date of 2015. The model resolution is also not suitable to reflect all water budget components at the precision required to assess past and current groundwater responses to water management within each GSA. The CVHM is also not suitably calibrated nor reflective of the hydrostratigraphy in the Subbasin and does not match the higher resolution and more accurate crop and related groundwater pumping estimates produced by Davids Engineering, Inc. (Davids Engineering) time-series analysis of evaporation and applied water estimates for the KDWCD; soon to be provided for the entire Subbasin through water year 2017.

Lastly, the use of the Farm Process is cost prohibitive, given the fact that it would have to be rigorously calibrated to the evapotranspiration and deep percolation estimates already provided by the Davids Engineering analysis.

The DWR-supported C2VSim Fine Mesh Beta Version was assessed in greater detail as part of the development of this modeling approach. Like CVHM, the C2VSim fine mesh does not include the high resolution of crop demands and surface water deliveries that are in the existing KDWCD model and can be easily updated with the KSHM. It also does not have the element resolution, flexibility to change fluxes, cost savings, and GSA-level accuracy of a sub-regional model designed to incorporate the highest resolution and locally accurate consumptive use and recharge information available. The Modeling Team assessed model layering, significant water budget components, storage change, and groundwater level elevation changes used in C2VSim relative to KDWCD monitoring well locations. The previous KDWCD model produced a better match for the data and estimates from the WRI, and at a significantly higher resolution. Simulated storage change within the Sub- Basin was greater than that estimated by C2VSim by over 20,000 acre-feet per year (AFY); without documentation of how the quantification of water budget components was performed. Calibration of regional flow directions and gradients were reasonable but not as accurate nor locally refined as that observed with the KDWCD modeling efforts.

The beta version of the C2VSim model is not currently considered to be calibrated in a quantitative sense, and no documentation is publicly available to assess the resolution or accuracy of the model inputs for the Subbasin. Because of our analysis and comparison of the C2VSim Fine Mesh Beta Model with the water budget and groundwater conditions from the WRI and the draft Basin Setting; the C2VSim was deemed to be a viable source of regional information to supplement development of the KSHM. However, relative to a modeling approach using the KSHM, the C2VSim model would not provide a more accurate or cost-efficient option for satisfying SGMA regulations.

The KDWCD Groundwater Model was originally developed by Fugro Consultants, Inc. (Fugro) under the direction and sponsorship by KDWCD. Model development was documented in the report "Numerical Groundwater Flow Model for the Kaweah Delta Water Conservation District, Final Report" (April 2005). The objective of the model was to simulate the water budget estimates as refined under the WRI in 2003 and evaluate calibrated groundwater elevations, and modeled fluxes to and from adjacent subbasins.

In May 2012, the KDWCD model was expanded to the east and southeast by Fugro to include the service areas of the Cities of Lindsay and Exeter, and adjacent irrigation districts, including: the Lewis Creek Water District; some unincorporated land and significant portions of Exeter Irrigation District, Lindmore Irrigation District, and Lindsay-Strathmore Irrigation District. The purpose of this effort was to update only the geographic extent, and it did not include updates to the simulation period or the calibration. The model was intended to be updated, refined, and improved in the coming years to provide a rigorously calibrated model over this larger extent, but this proposed work was not performed prior to initiation of SGMA and GSP development efforts.

Modeling Code and Packages

The KDWCD model was developed using MODFLOW 2000. MODFLOW, developed and maintained by the United States Geological Survey (USGS), is one of the most commonly used groundwater modeling codes in the world and is considered an industry standard. The pre- and post-processing of groundwater model data was performed using Groundwater Vistas, a third-party graphical user interface (GUI) that is among the most commonly used software in the groundwater industry to facilitate the use of MODFLOW.

The previous two KDWCD model variants used the following MODFLOW modules, or "packages":

- Well Package (WELL) Recharge
- Package (RCH)
- General Head Boundary (GHB) Package

MODFLOW utilizes large text files of numerical values as input files that provide the model with the

values of various physical parameters and fluxes; all incorporated into the three-dimensional (3D) model structure. Much of the pre-processing and spatial organization of the data used to develop the MODFLOW input files was accomplished by Fugro using customized FORTRAN routines, as well as a geographic information system (GIS). Because of more recently available evapotranspiration and applied water estimates from Davids Engineering, the use of these FORTRAN routines is no longer necessary; providing a significant cost and time savings.

A summary of the construction and implementation of various water budget components into these model packages is discussed in following sections.

Model Extent and Discretization

The spatial extent of the KDWCD model is presented in Figure 1. The figure displays the original model extent as well as the expanded extent to the east from the 2012 update. The model extends approximately twelve miles from east to west and 7.5 miles from north to south. It is composed of uniform 1,000 foot by 1,000- foot model cells for each layer.

There are some areas of the Subbasin that are not currently within the model domain (Figure 1), including much of what is now the EKGSA area. To evaluate the entire Subbasin area, in support of SGMA, it will be necessary to expand the model area to include all of the areas within the Subbasin. The updated model must also have shared boundaries and shared buffer zones with all adjacent groundwater sub- basins, as well as an evaluation of subsurface inflow and outflow (underflow) between the subbasins. Figure 2 shows the proposed, expanded model grid for the new KSHM extent.

Model Layers

The KDWCD model is vertically discretized into three layers as shown on hydrogeologic cross sections shown on Figures 3, 4, and 5. These hydrogeologic cross sections show the principal aquifers, aquitard, and associated geologic units located throughout the Subbasin. Layer 1 represents the unconfined, basin sediments from the ground surface down to the Corcoran Clay in the western portion of the model domain or deeper; also including some older Quaternary alluvial deposits in the eastern portion of the domain. Layer 2 represents the Corcoran Clay, which is the primary aquitard in the Subbasin, where it is present in the western portion of the domain. In the eastern portion of the model area, where the Corcoran Clay pinches out, Layer 2 is simply represented with a minimal thickness and hydraulic parameters comparable to those of Layer 1. Layer 3 represents the largely confined basin sediments below the Corcoran Clay, where it is present, and deeper unconsolidated sediments to the east of the occurrence of this regional confining unit.

Although some of the regional models covering large areas of the Central Valley (i.e., CVHM and C2VSim) have a more highly discretized vertical layering, the Modeling Team believes that the three-layer conceptual model represented in the KDWCD model is justified given the available data and therefore suitable for the primary modeling objectives that support GSP development.

Model Simulation Time Periods

The KDWCD model was originally set up with 38 6-month stress periods to simulate the 19-year (calendar) calibration period of 1981 through 1999. Water budget components as documented in the 2003 WRI were used as input into the model and spatially distributed to the degree feasible given the spatial resolution and precision of the data sources and model grid.

It is likely that, after any recommended changes to the KDWCD model are implemented into the KSHM, the Modeling Team will calibrate the model through water year 2017 and perform validation simulations to confirm that the previous calibration developed with the historic WRI information is a suitable starting point the new simulation period. After validation, additional model

refinements and updates can proceed to further improve the predictive capabilities of the KSHM using the aforementioned recent, high-resolution datasets as well as updated Basin Setting information.

Model Parameters

- Hydraulic Conductivity/Transmissivity.** Hydraulic conductivity values are documented in the 2005 Model Report as well as in previous iterations of the WRI and conform with industry-standard literature values for the types of aquifer materials encountered at these depth intervals. Calibrated, horizontal hydraulic conductivities for Layer 1 (upper, unconfined aquifer) range from 50 feet/day (ft/d) to 235 ft/d, with the highest values in the southwest portion of the model area. Horizontal hydraulic conductivities for the portion of Layer 2 representing the Corcoran Clay were set at 0.024 ft/d. In the eastern area of Layer 2, where the Corcoran Clay pinches out, hydraulic conductivity values range from 50 to 150 ft/d and are essentially equal to the values assigned to the same area in Layer 1. Horizontal hydraulic conductivities for Layer 3 range from 25 ft/d to 125 ft/d. This distribution of hydraulic conductivity is consistent with previously published estimates from both the WRI and industry-standard literature estimates for the lithologies encountered.
- Vertical Hydraulic Conductivity.** Vertical hydraulic conductivity in the model is set to a ratio of the estimated horizontal hydraulic conductivity, or an anisotropy ratio of 1:1. This means that the vertical hydraulic conductivity of the Corcoran Clay was assumed to be equal to its horizontal conductivity and was apparently based upon the extensive perforation of the Corcoran Clay and other aquifer units by fully penetrating wells. This perforation of the regional aquitard allows for greater hydraulic connection between the upper and lower aquifer units. The Modeling Team will assess the validity of this anisotropy ratio during the validation simulation and adjust where merited.
- Storage Parameters.** Specific yields in the unconfined aquifer (Layer 1) range from approximately 8% to 14%. Storage coefficients for the confined areas were set at an order of magnitude of approximately 1×10^{-4} . The storage coefficients used for the unconfined and the confined portions of the model are typical of those found in the basin and documented in the WRI as well as other commonly referenced literature for large basin fill valleys.

Model Boundary Packages and WRI Water Budget Components

As mentioned previously, the KDWCD model uses three MODFLOW packages: WELL, RCH, and GHBs. A discussion of how those packages are used follows below.

- Well Package (WELL).** As currently constructed, the KDWCD model represents the following WRI water budget components; which were calculated outside of the model Groundwater Vistas graphical user interface (GUI) using GIS and a FORTRAN routine that are unavailable to the Modeling Team. The flux values specified in the WELL package input files are essentially "lumped" fluxes representing the sum of the following water budget components:
 - Well pumpage (outflow)
 - Rainfall-based recharge (inflow)
 - Irrigation return flows (inflow)
 - Ditch loss (inflow)
 - Recharge basins (inflow)

The compilation of multiple water budget components into a single MODFLOW package makes tracking and assessment of the individual water budget components from model simulations difficult. Additionally, this model flux accounting approach and design makes evaluation of

possible changes in the water budget because of management actions, changes in water demand or availability, and groundwater projects problematic. Because of this lumping of separate water budget components, every cell in Layer 1 is represented in the WELL Package. This makes the exact validation of the test runs and verification of the calibration with the WRI challenging. Without access to the spatial and temporal distributions of all water budget components utilized by Fugro, it is not possible to recreate the exact WELL package input file. However, the gross water budget inflow, outflow and storage values from the earlier WRI's match those simulated by the model and were reproduced by the Modeling Team.

- **Recharge Package (RCH).** The natural stream channels of the St. John's and the Lower Kaweah Rivers are represented in the model using the MODFLOW RCH Package. The RCH package applies a flux (ft/yr) in the surficial (shallowest) cells at the location where applied. The natural seepage flux values (or groundwater recharge) applied to the model correspond to the values of stream infiltration spatially estimated for these rivers and documented in the WRI.
- **General Head Boundaries (GHB).** The KDWCD model has GHBs assigned to all cells on the exterior perimeter of the model, as seen on Figure 1. GHBs are commonly used to represent the edges of a model domain within a larger aquifer extent. Reference heads (groundwater elevations) and "conductance" terms for adjacent aquifers just outside the model domain are used by this package to calculate fluxes in and out across the boundary. The Modeling Team generally agrees with the use of GHBs in the north, south, and west portions of the Subbasin. However, we propose the removal of the GHBs along the eastern portion of the subbasin at the Sierra Nevada mountain front. Conceptually, the eastern model boundary, especially with the expansion and inclusion of the EKGSA area, is not a head-dependent boundary, but a flux-dependent one based on mountain front recharge and seepage from natural drainages and streams adjacent to relatively impermeable material. Thus, this boundary is better represented using a no-flow condition coupled with a recharge or prescribed underflow component.

Previous WRIs have included estimates of inflow and outflow across the study boundaries, and comparisons between modeled and calculated values vary significantly both spatially and by magnitude. However, there are several variables that directly impact estimated underflow values that have not been sufficiently constrained, due to the focus of previous work being on the interior of the KDWCD area. Recently updated basin conditions, improved understanding of appropriate regional groundwater conditions adjacent to the Subbasin and use of an expanded model area will significantly improve the certainty of these underflow estimates.

- **Model Calibration.** Calibration of the KDWCD model for the historic simulation period of 1981-1999 is discussed in the April 2005 model report. These include charts of observed versus modeled water levels for three different time periods and transient hydrographs for 30 target well locations. The density of calibration targets was deemed adequate by the Modeling Team for a model of this area and with the resolution of the model input datasets. Detailed calibration statistics are not documented in the report, but qualitative inspection of the hydrographs indicates that the calibration is adequate for future use in predictive simulations. Additionally, an open-source and industry-standard parameter estimation and optimization algorithm and code (PEST) was used to enhance model calibration. This is a common and robust industry practice that typically improves model calibration statistics.

Adequacy of the KDWCD Groundwater Model for GSP Development

Layering Scheme. The 3-layer model layering scheme incorporated into the KDWCD model was deemed adequate by the Modeling Team for use in GSP analyses, and likely does not need significant revision prior to use. This decision was based upon the agreement of the model

layers with the hydrogeologic conceptual model for the Subbasin as well as the ability of the previous model to simulate historic fluctuations in groundwater elevations over an extensive spatial extent and temporal period. However, should the refinement of the lithologic and stratigraphic understanding of the basin and identification of specific pumping intervals require additional vertical resolution, both Layer 1 and Layer 2 can be split into two layers to improve the model's ability to match and describe key vertical gradients and changes in groundwater level elevations and pressures near prominent pumping centers. At present, this vertical refinement is not required nor supported by data.

Model Area. The model area will need to be expanded so that the entire Subbasin is included in the model. In addition, at the request of and in coordination with the technical groups for both Kaweah and adjacent subbasins, a buffer zone will be included outside the defined Subbasin boundaries so that adjacent models will overlap and share model input and monitoring data. This overlap will assist in reconciling differences between the direction and magnitude of groundwater gradients along subbasin boundaries. The preliminary extent of this buffer zone is proposed to be approximately 3 miles; however, this value will be revised in areas based on of the estimated locations of pervasive groundwater divides or apparent hydrologic boundaries.

Cell Size. The 1,000 feet square cell size appears to be adequate for the data density for most model inputs. However, due to improvements in computing speed and power, the Modeling Team recommends initially using a smaller cell size of 500 feet square to 1) accommodate improvements in assigning real world boundaries to the model grid, and 2) leverage the improved resolution of crop demand and evapotranspiration data available for this effort.

Parameters. Hydraulic conductivity and storage parameters will remain unchanged at the start of model revisions and calibration scenarios. These will be adjusted if the Modeling Team determines it is necessary during the model validation run or if model calibration standards require parameter refinements.

Stress Periods. The previous temporal discretization of the model incorporated 6- month stress periods. To appropriately characterize seasonal rainfall, surface water delivery and pumping patterns; one-month stress periods should be adopted for predictive simulations. This decision will be finalized after review and conditioning of the input groundwater demand and recharge datasets.

With these revisions to the model framework and geometry of the KDWCD model to support the development of the KSHM will be adequate for use to support GSP analyses. The following section summarizes additional, recommended revisions to the organization of the model inputs, parameters, boundary conditions, and MODFLOW packages.

Proposed Revisions to KDWCD Groundwater Model and Model Approach

The Modeling Team concludes that the KDWCD model is suitable to support GSP development if the following revisions and refinements to the model are performed to develop the KSHM. As mentioned above, once updated, the Modeling Team is recommending adoption of the name Kaweah Subbasin Hydrologic Model for this new SGMA tool. This nomenclature is based upon that fact that this model incorporates more than simply a groundwater model in the final analysis. It also incorporates crop demand/evapotranspiration (with precipitation modeling) and applied water models.

The Modeling Team recommends that the relationships between the water budget components, as defined in the WRI (December 2003, revised July 2007), and the MODFLOW modeling packages currently available, be re-organized such that lumping of different water budget components within single MODFLOW packages is minimized. Some degree of aggregation may be unavoidable, but efforts will be made to apply unique water budget components from the updated WRIs and associated water budget components to more appropriate and recent MODFLOW packages.

Additionally, we will utilize features of MODFLOW and Groundwater Vistas that allow for tracking of unique components within a single model package when possible. The current and proposed revised conceptual assignments of water budget components to MODFLOW packages are summarized below.

A major change and advantage of this effort relative to previous modeling work involves the availability and use of time-series evapotranspiration and applied water estimates from 1999 through water year 2017, provided by Davids Engineering. This data set uses remote sensing imagery from Landsat satellites to estimate agricultural water demand throughout the Subbasin at a very high resolution (approximately 30 meters). This information was not available for previous model builds, and its use will not only improve the understanding and accuracy of agricultural water requirements relative to the previous land use and soil moisture balance calculations that have been used, but also enhance the spatial calibration and predictive capability of the updated and expanded KSHM. The Davids Engineering dataset also includes estimates of deep percolation of applied water and precipitation. During the review of the KDWCD model and development of this modeling approach, the Modeling Team performed testing of the use of this dataset and was able to readily develop crop requirements and associated pumping estimates at a resolution even finer than the proposed model resolution.

Well Pumping. Groundwater pumpage will be the dominant water budget component represented in the WELL package. Other, more limited fluxes may also be used to represent mountain front fluxes or other unforeseen fluxes that are specified but do not have a specific package that is appropriate. All pumpage will be coded within the WELL package input files to identify the pumping by source, use, or entity. Municipal wells will be specifically located and simulated when well permits and required data reports are accessible and provide data specific to each well. Agricultural well pumpage will likely be spatially averaged, or "spread across", irrigated areas because of the uncertainty associated with irrigation well location, construction, and monthly or seasonal pumping rates.

Precipitation-based recharge. The Modeling Team proposes to represent this water budget component using the Recharge package.

Natural channel infiltration. Infiltration of surface water in the natural stream channels of the St. John's and the Lower Kaweah Rivers is currently assigned to the Recharge Package. The Modeling Team proposes to maintain this data in the recharge package along the spatial location of the courses of the rivers. If deemed appropriate and more beneficial the latest version of the Stream Package (SFR2) may be used for localized reaches of continuously flowing water, where gages do not adequately monitor seepage that can be applied directly as recharge. The Stream package calculates infiltration (inflow) to the aquifer based on defined parameters regarding bed geometry and vertical conductivity, and this will likely involve some iterative re-definition of STREAM package components to accurately portray the calculated water budget component flux. Native evapotranspiration (ET), where relevant, will be subtracted from either the precipitation or natural channel infiltration modules. The inclusion of natural, riparian ET will be addressed specifically upon finalization of the water budget for the Subbasin.

Man-made channel recharge. (i.e., ditch and canal loss). This is currently incorporated with four other water budget components as a single summed value in the Well Package. The Modeling Team proposes to represent this water budget component using either the Recharge package or another Type 3 boundary condition type, such as a prescribed stage above land surface. Should another more advanced MODFLOW module prove to be more effective in simulating this flux, it will be utilized, and the reasoning documented in the model development log.

Irrigation Return Flows. Irrigation return flows are the component of the water budget that infiltrates into the subsurface due to over-watering of crops. This is currently incorporated with four other water budget components as a single summed value in the Well Package. The Modeling Team proposes to represent this water budget component using the Recharge

package, but to differentiate it from precipitation-based recharge within Groundwater Vistas by assigning zone identifiers that are different from the rainfall-based recharge.

Artificial Recharge Basins. This is currently incorporated with four other water budget components as a single summed value in the Well Package. Recharge basins are likely to be a common management strategy to help achieve sustainability in the Subbasin. As such, the model should be able to individually represent each recharge basin. These could be represented in the Recharge Package or other more sophisticated module if specifically merited.

Lateral Model Boundaries. These are currently simulated using the GHB Package. We will maintain this concept, but the locations of the GHBs will be moved to locations beyond the edge of the Subbasin up to the extent of the expanded model area. Assigned reference heads for the GHB cells will be based on observed groundwater elevations from historic groundwater elevation maps. GHB head assignments for predictive runs may be lowered over time if current trends indicate declining water levels over the next 20-40 years. These head assignments were finalized in consultation and coordination with adjacent subbasin technical groups as well as any regional modeling or State-derived predictive information.

Mountain Front Recharge. Currently, a GHB is assigned to the eastern edge of the Subbasin, along the front of the Sierra Nevada foothills. The modeling team will remove this GHB and represent mountain front recharge using the Recharge Package. Conceptually, mountain front recharge is not a head-dependent boundary, but a specified flux-dependent boundary.

Calibration Period and Validation Period. As discussed previously, the original model was calibrated to a 19-year calibration period using 6-month stress periods. The Modeling Team suggests that upon completion of the KSHM model, a validation run simulating the time period of 1999-2017 be made to assess that the model is still adequately calibrated. Upon assessment of the validation simulation, the KSHM will undergo the calibration process using both qualitative and quantitative measures, such as parameter estimation software (PEST), to produce the final calibrated simulation modeling tool to be used to refine the Subbasin water budget and be used for predictive simulations. Moving forward, the updated groundwater model for the Kaweah Subbasin will begin in 1999 and continue to be updated as new GSP updates are required and deemed necessary by the GSAs. This new start date is due to the substantially increased accuracy and spatial resolution of water budget features, primarily crop demand and surface water deliveries that result in agricultural pumping estimates, beginning with the first year that high quality satellite imagery and associated evapotranspiration/soil moisture balance models were provided by Davids Engineering. This modeling effort can be updated in the future with newer and more accurate local and regional data from neighboring GSAs to benefit required SGMA reporting, refinements, and optimization of the GSPs within the Subbasin.

Predictive Simulations. Predictive simulations through the SGMA timeframe of 2040 and beyond are performed using the same monthly stress period interval and are developed using the projected climate dataset provided by DWR. Correlations between this climatic projection and previously quantified groundwater demands and surface water deliveries are developed to produce a suitable baseline predictive simulation that will serve as a starting point for assessing the impacts of various adaptive management actions and groundwater projects.

Simulations are performed for individual GSAs, but also the cumulative effects of future groundwater management in the Subbasin are assessed relative to the baseline predictive simulation.

Collaboration with Neighboring Subbasins

The Modeling Team collaborated with neighboring subbasin technical representatives during the update and application of the KSHM, with permission from the Kaweah Subbasin GSAs. The

purpose for this coordination is to accomplish the following objectives:

- Receive input from GSAs' representatives on modeling tools and approaches in adjacent basins.
- Exchange data and information for consistency between tools.
- Agree on boundary conditions including both gradients and heads located at and outside of the boundaries of the Subbasin.
- Ensure that the KSHM integrates well, to the extent possible, with adjacent tools that our approaches for Kaweah Subbasin will not result in conflicting boundary conditions or water budgets.

The Modeling Team recommends that inter-basin model coordination meetings begin in August of 2018 and continue until the simulations required for use in developing the draft GSP is are completed. We anticipate the need for four (4) focused meetings on this approximate schedule:

1. KSHM Approach Meeting – Mid September 2018
2. KSHM Update Meeting – Late October 2018
3. KSHM Model Baseline Run and Boundary Flux Meeting – Late November 2018
4. KSHM Model Simulation Results Meeting – January 2019

The Modeling Team attended one meeting with the Tulare Lake Subbasin modeling group on June 15th, 2018 to facilitate data transfer between the two modeling efforts and improve agreement and conceptual consistency between the Sub- Basins. Upon request from the Kaweah Subbasin managers and committees, the Modeling Team will continue to collaborate and improve consensus with adjacent modeling groups to improve model agreement and sub-regional consistency between calibrated and predictive simulations. The Modeling Team is also prepared to develop and share baseline predictive simulation results with neighboring basins and accept in-kind data sharing to further improve predictive accuracy and understanding on adaptive management and project options and collaboration. These activities are approved by GSA representatives prior to the Modeling Team sharing any information or data.

Conclusions and Recommendations Regarding Model Updates

In general, the Modeling Team believes that the KDWCD model provides an adequate precursor model that is suitable for use in GSP development if the following revisions and updates are incorporated.

Groundwater Vistas Version 7 will be the processing software package utilized. We will maintain MODFLOW as the basic code and will update to MODFLOW-USG or MODFLOW-NWT to take advantage of advances in numerical solution techniques that are available in these updated MODFLOW revisions.

1. **Extent.** The model will need to be expanded to fill the area between the general head boundary of the current model and the Subbasin boundary shown in Figure 1 to include the entire area of the Kaweah Subbasin.
2. **Layers.** The model layering scheme depicting two water-bearing layers above and below the Corcoran Clay is suitable for the objective of supporting the GSP development.
3. **Historical Simulations.** The KDWCD model has been calibrated to the 1981- 1999 hydrologic period. Based on inspection of the hydrographs presented in the 2005 modeling report and the 2012 Model update report, observed water levels are adequately simulated to consider this model effectively calibrated. The objective is to have a model suitable to simulate projected management actions through the entire Subbasin. No changes will be made to the inputs to the 1981-1999 run. Therefore, it is already calibrated to that period. We are just re-organizing the assignment of water budget components to different MODFLOW packages from 1999-2017, and beyond. Monthly stress periods will be used.

4. **Assignment of water budget components to MODFLOW Packages.** The Modeling Team proposes to revise the conventions used in the KDWCD model. This will be the most involved part of the model revision. The updated water budget values that have been generated by the GSA will continue to be the primary input as far as flux values go. However, we propose to organize them into more readily identifiable currently available MODFLOW packages to help with the analyses of potential water budget changes that may correspond to management actions in the future.
5. **Recharge Components.** Spatial distribution of such water budget components as percolation of precipitation, irrigation return flow, recharge basins, etc., will be updated based on the most currently available data.
6. **Model Parameters.** Hydraulic conductivity (horizontal and vertical) and storage coefficient will initially stay unchanged during the validation period simulation. If the calibration target hydrographs for the validation period indicate that a suitable match is retained between observed and modeled water levels, the existing parameters will be retained.
7. **Flow Boundaries.** In areas where the existing GHB boundaries are within the Kaweah Subbasin, they will be expanded approximately 1-2 miles, or at locations of any likely groundwater divides from the Subbasin boundary on the north, south, and west sides of the Subbasin. The assigned heads for these GHBs for the 1999-2017 verification run will be based on published groundwater elevations in the vicinity as depicted in contour maps published by DWR. Seasonal variability in assigned GHB heads can be incorporated.
8. **No-Flow Boundaries.** The eastern GHB along the base of the Sierra foothills will be removed. Instead, the flux in the Recharge Package will be increased along this boundary to represent mountain front recharge. The flux volume from the GHB will be evaluated, and this flux volume will be approximated using the Recharge Package.

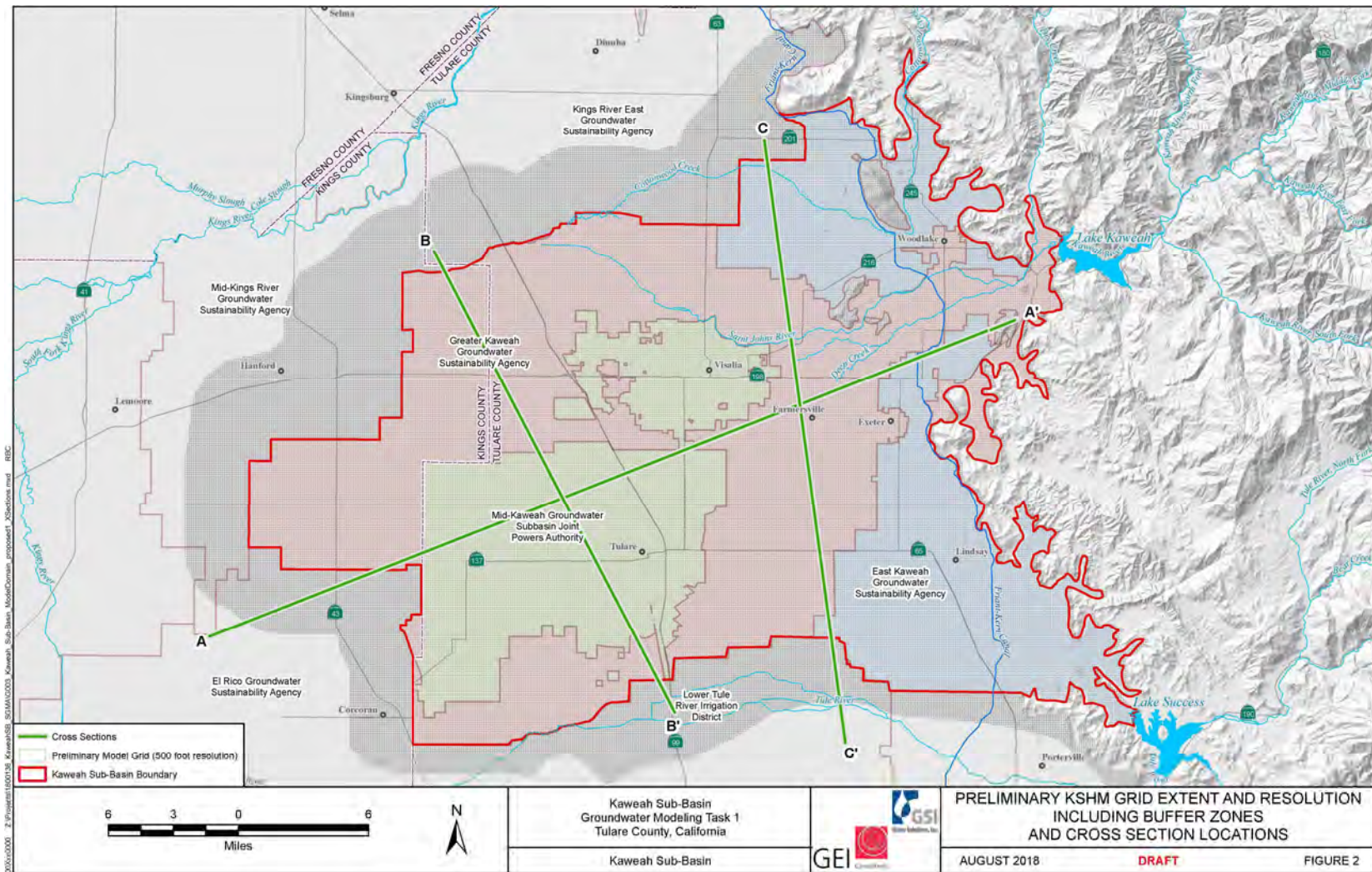
Estimated Schedule of Model Update Activities

The Modeling Team proposes the following schedule for the major groundwater model update activities. Estimated timeframes for key inter-basin model coordination meetings and updates are also included in the following table to provide a more comprehensive schedule and to facilitate meeting planning. Specific model development and simulation tasks may shift to earlier or later timeframes, but it is the intention of the Modeling Team to comply with the overall schedule and satisfy deadlines for the final deliverable of the calibrated modeling tool and associated predictive scenarios. Should information not be available to the Modeling Team in time to use them in development of the calibrated model simulation or predictive simulations, the data will either not be included, or the schedule may be adjusted to accommodate their inclusion, per guidance from Sub-Basin GSA leadership.

Updates and presentations on the status of the groundwater modeling efforts will occur at regular intervals during Coordinated Subbasin and individual GSA meetings, per the scope of work for the groundwater modeling task order.

Modeling Activity	Estimated Completion
Refinement and expansion of model domain and boundary conditions	Early September 2018
Update water budget with David's Engineering and EKGSA data	Early September 2018
Development of calibration targets	Mid-September 2018
Parameterization of model layers	Mid-September 2018
Refinement of groundwater fluxes	Mid-September 2018
Inter-basin KSHM Approach Meeting (inter-basin)	Mid-September 2018

Adjust boundary conditions, fluxes, and parameters using any new adjacent basin data	Late September 2018
Initiate Formal Calibration Process	Early October 2018
Inter-basin KSHM Update Meeting	Late October 2018
Complete initial calibration process	Early November 2018
Calibration and model refinements and preparation for predictive simulations	Late November 2018
Inter-basin KSHM Calibrated Model and Boundary Flux Meeting	Late November 2018
Develop predictive baseline scenario — Subbasin level	Early December 2018
Develop GSA specific predictive simulations	Mid December 2018
Cumulative Subbasin simulations	Early January 2019



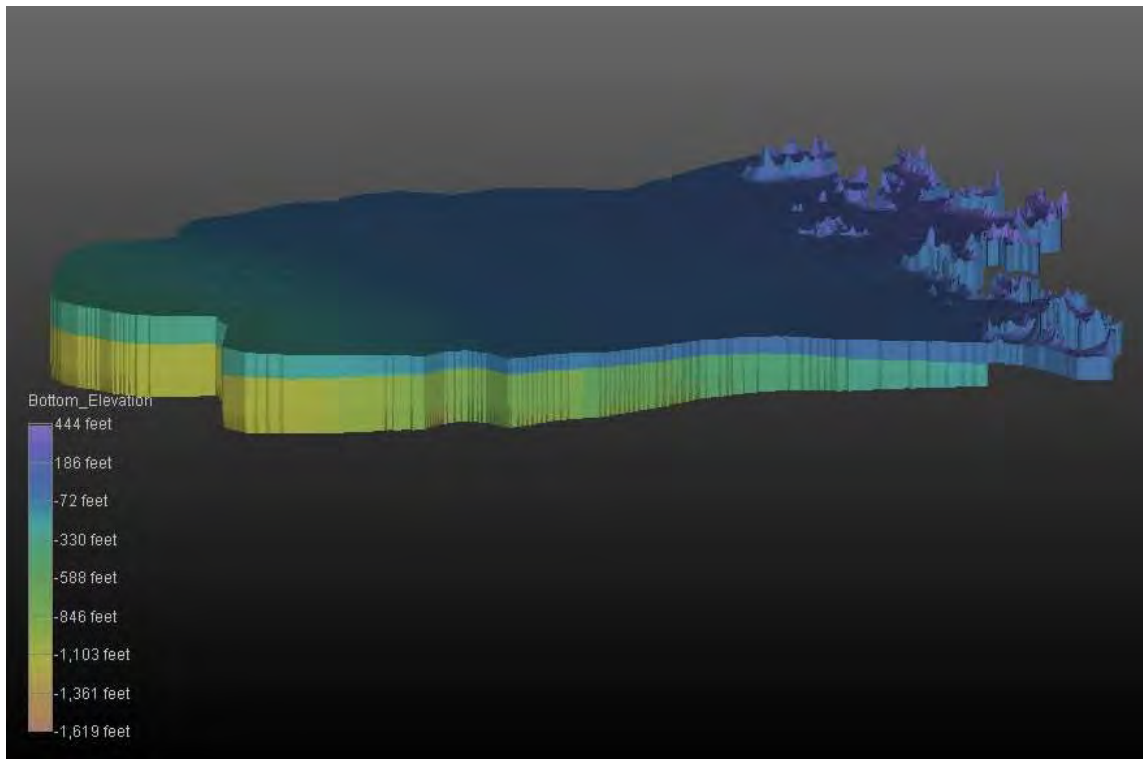
Groundwater Model Modifications

Modifications were made to the Kaweah Subbasin Hydrologic Model (KSHM) by the groundwater modeling team during the period of July through September 2018. The modifications which were reported first reported in Progress Report Number 1- November 2018 include the following.

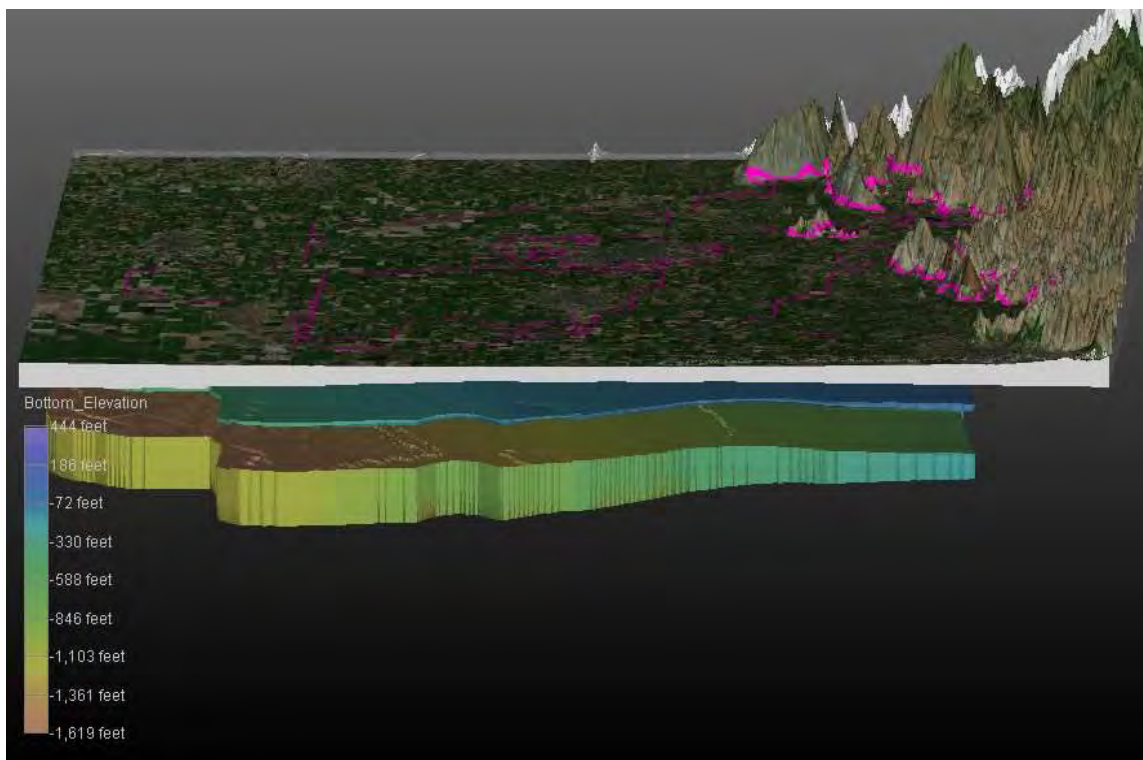
- I. Added the general head boundaries
 - a. What is a general head boundary? Water levels are fixed, and fluxes change
 - The General-Head Boundary package is used to simulate head-dependent flux boundaries. In the General-Head Boundary package the flux is always proportional to the difference in head.
 - b. The general head boundary condition is set on the north, west and south boundaries of the model and in model layers 1, 2, and 3.
2. Set the agricultural pumping based on Davids Engineering crop demand analysis for the period 1999 to 2017.
3. Distributed surface water delivery information spatially.
4. Refined the model grid from 1000 to 500-foot grids.
5. Refined stress periods from 6-month to 1-month step stress periods.
6. Expanded model layers into East Kaweah GSA area and up to the Eastern edge of the Kaweah Subbasin. Total model thickness in the east determined by the evaluation of the wells penetrating into the bedrock.
7. Added mountain front recharge and distributed recharge volumes proportionally based on upstream watershed size.
8. Increased the thickness of model layer three by lowering the base to near the bottom of the Tulare Formation.

Exploded View of Groundwater Model Layers

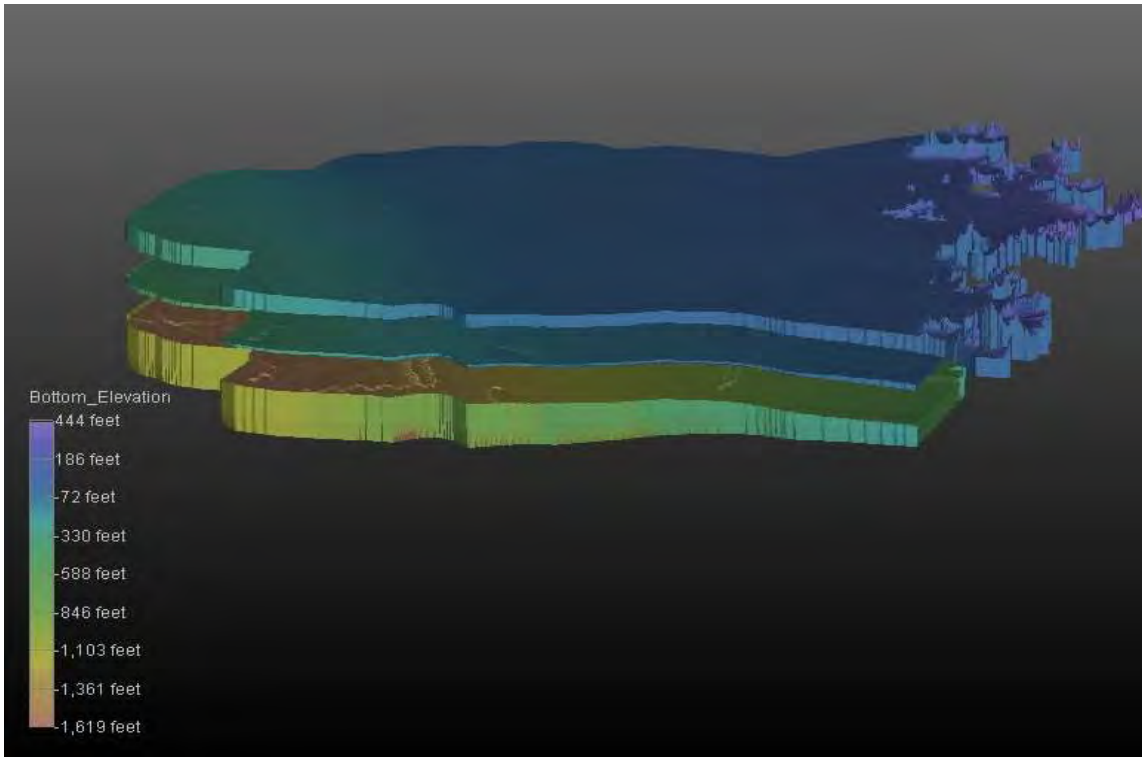
3-Dimensional Oblique Elevation of Entire Model Domain



3-Dimensional Oblique Elevation w/Aerial Photo and GSA Boundary Outlined

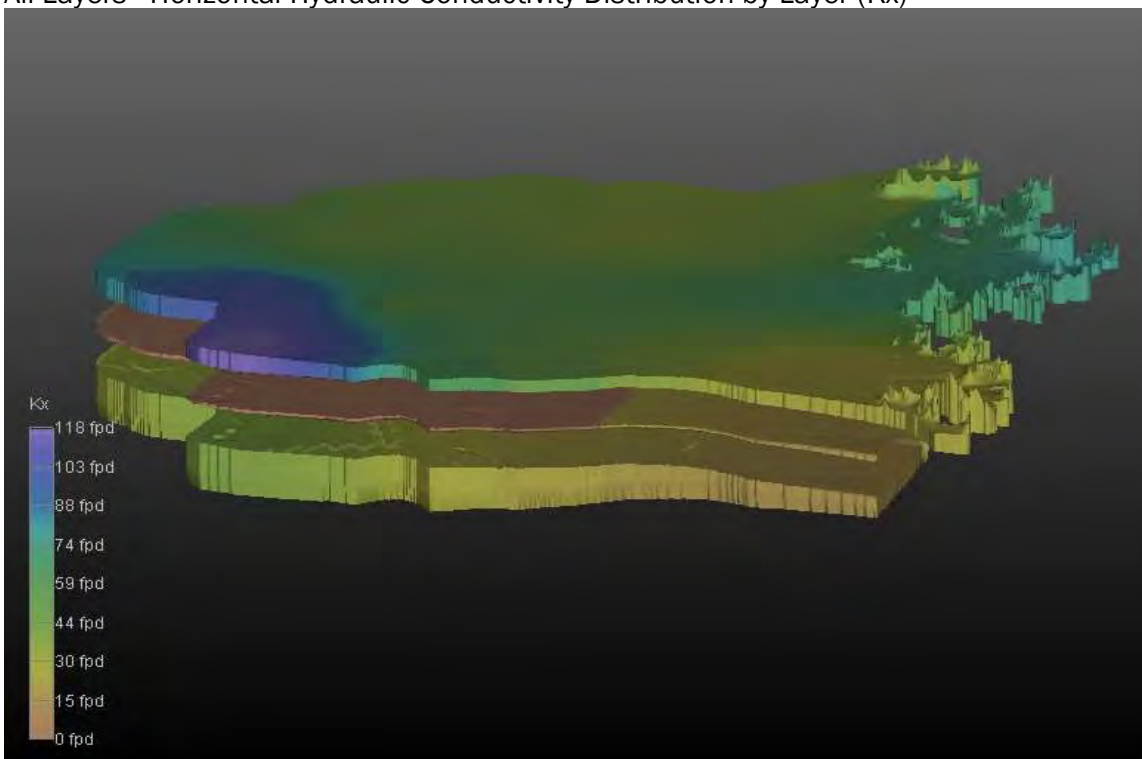


Exploded View of Groundwater Model Layers

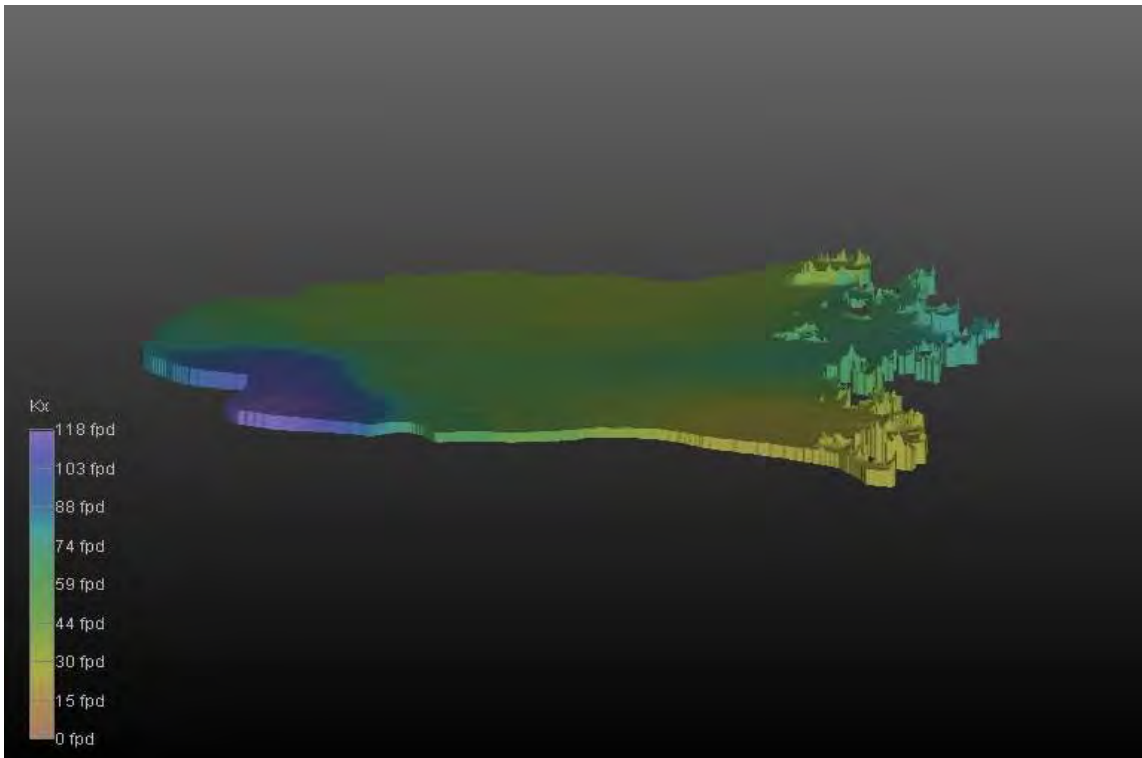


Horizontal Hydraulic Conductivity Distribution by Layer (Kx)

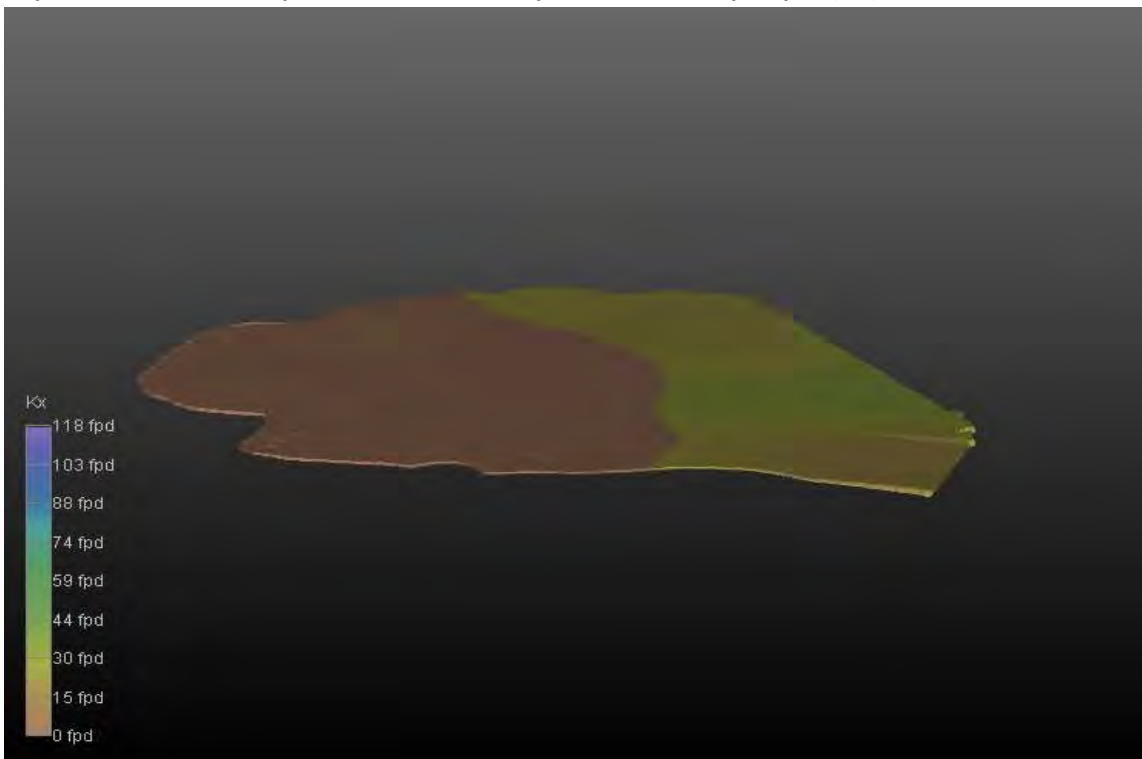
All Layers - Horizontal Hydraulic Conductivity Distribution by Layer (Kx)



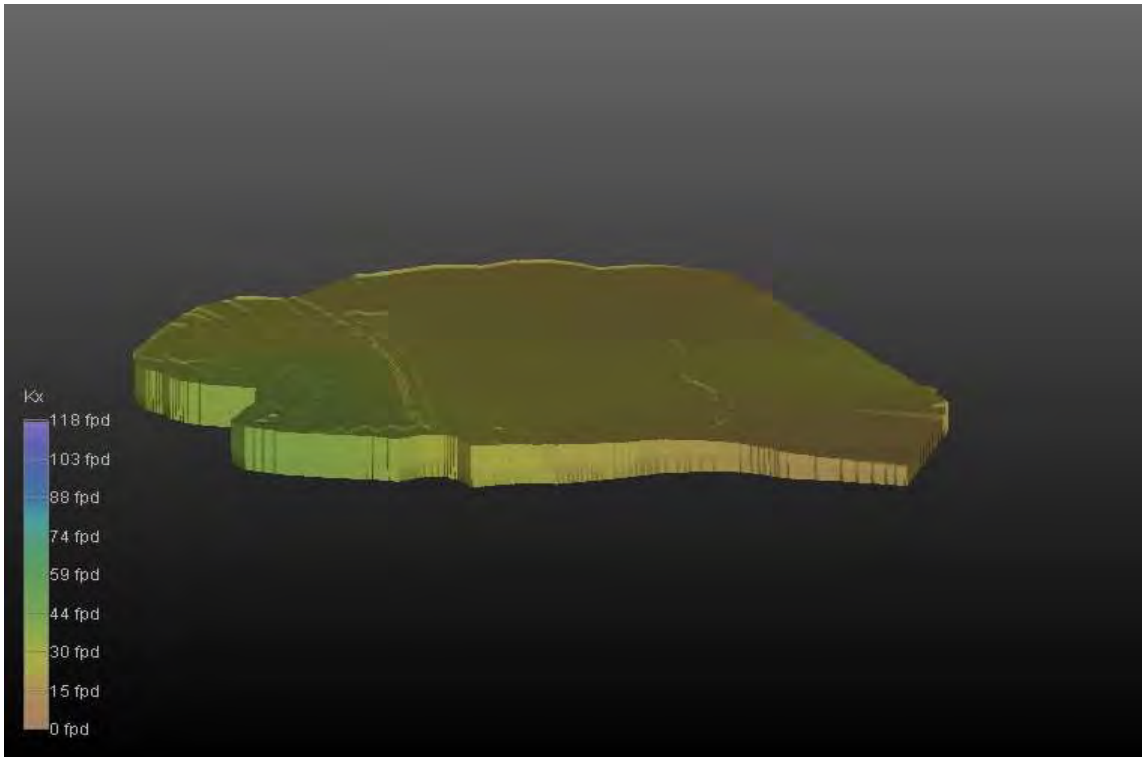
Layer 1 - Horizontal Hydraulic Conductivity Distribution by Layer (Kx)



Layer 2 - Horizontal Hydraulic Conductivity Distribution by Layer (Kx)

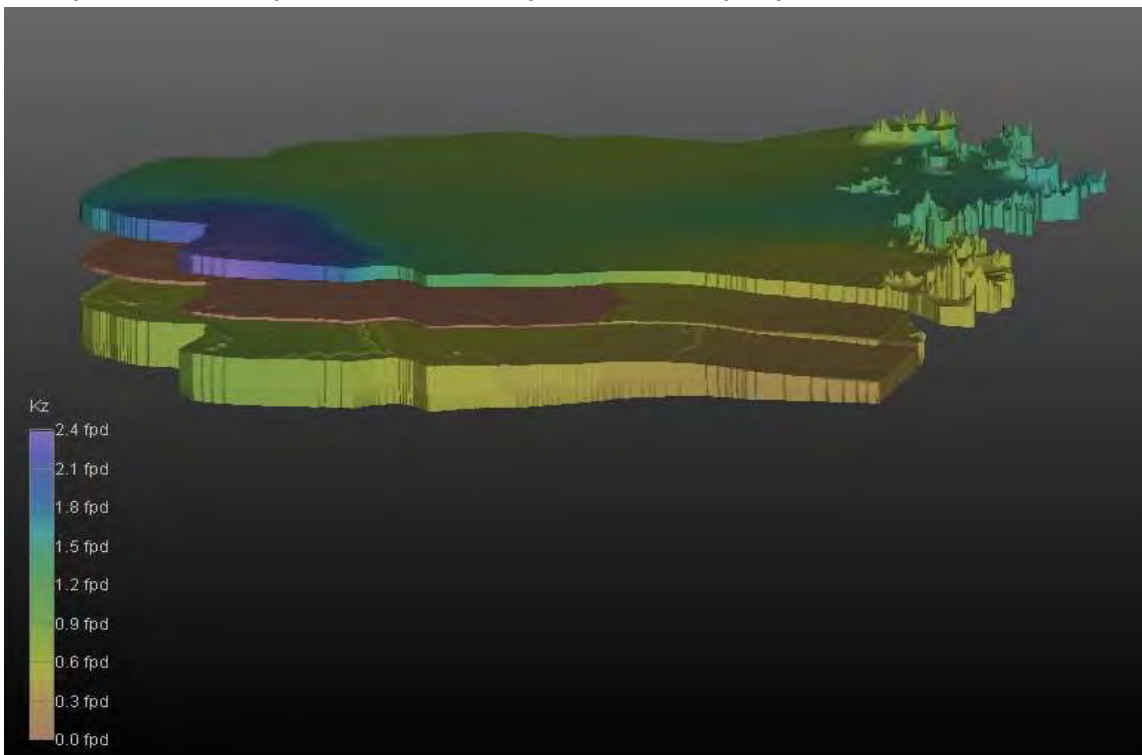


Layer 3 - Horizontal Hydraulic Conductivity Distribution by Layer (Kx)

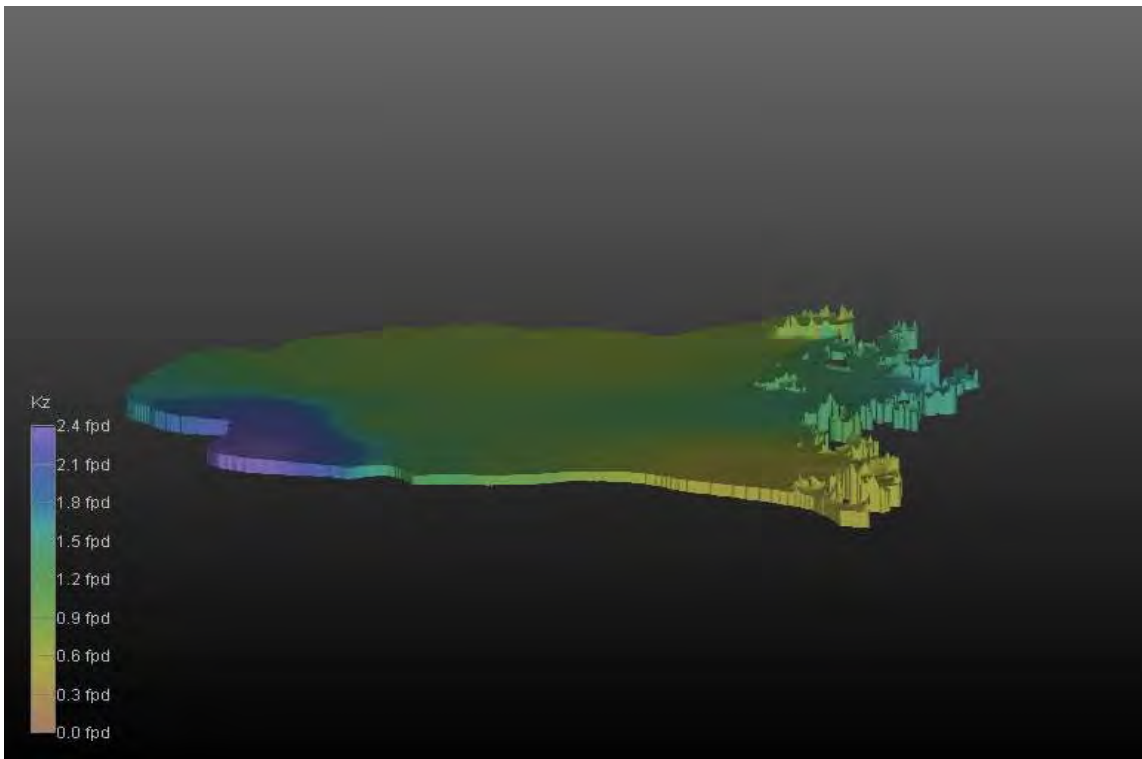


Vertical Hydraulic Conductivity Distribution by Layer (Kz)

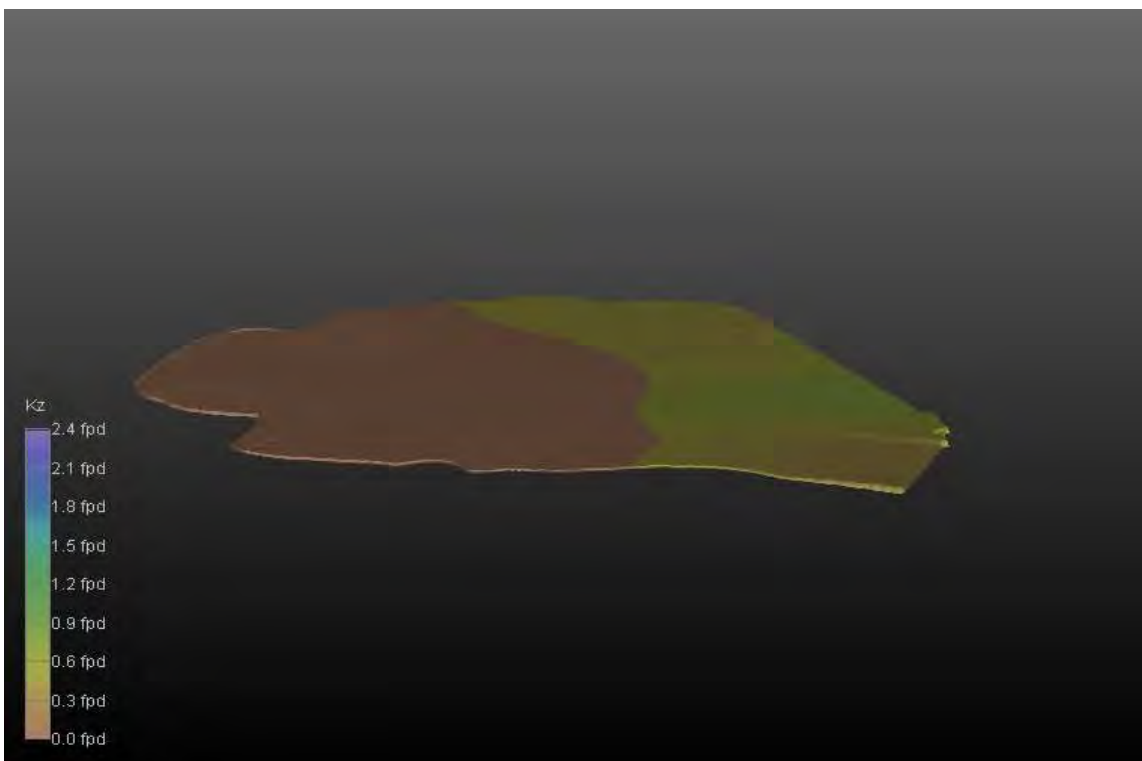
All Layers - Vertical Hydraulic Conductivity Distribution by Layer (Kz)



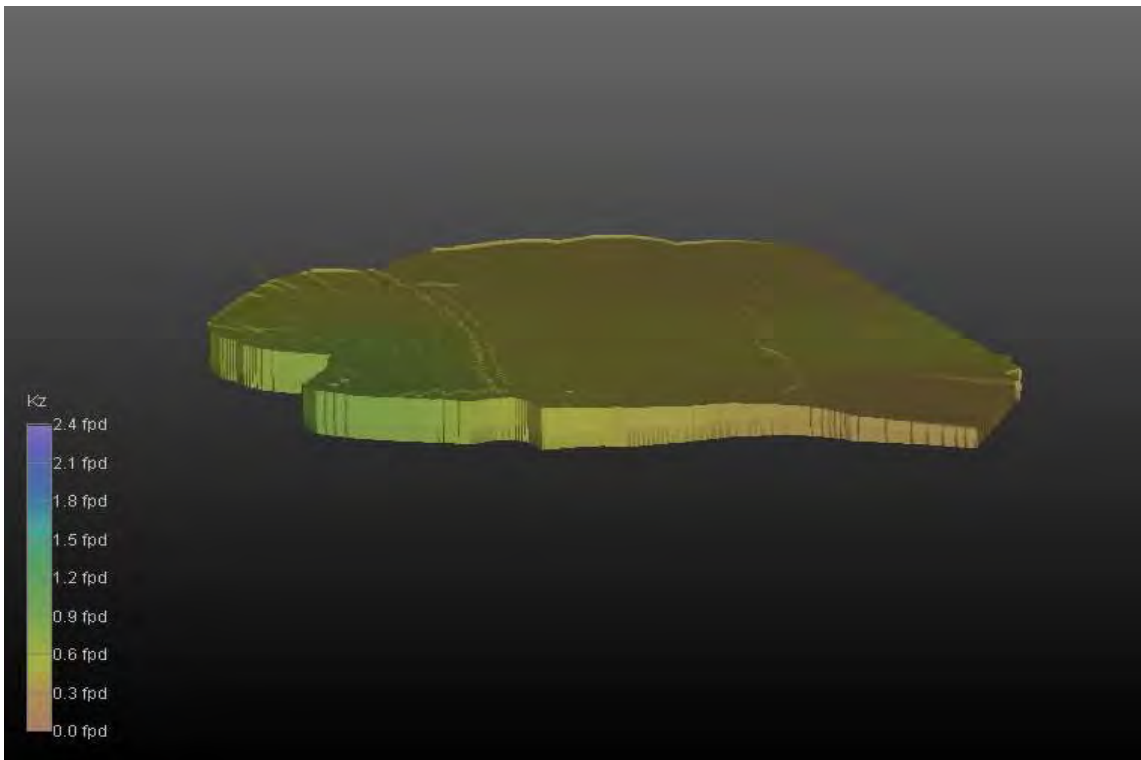
Layer 1 - Vertical Hydraulic Conductivity Distribution by Layer (Kz)



Layer 2 - Vertical Hydraulic Conductivity Distribution by Layer (Kz)



Layer 3 - Vertical Hydraulic Conductivity Distribution by Layer (Kz)



Process of Model Verification

1. The groundwater modeling team performed verifications model runs from 1999 to 2017. The purpose of these simulations was to verify the accuracy of the model to match the new water budget and observed groundwater elevations throughout expanded grid area.
2. The modeling team adjusted the vertical hydraulic conductivity in all three layers to improve the match.
3. Storage values from the previous model were unchanged.

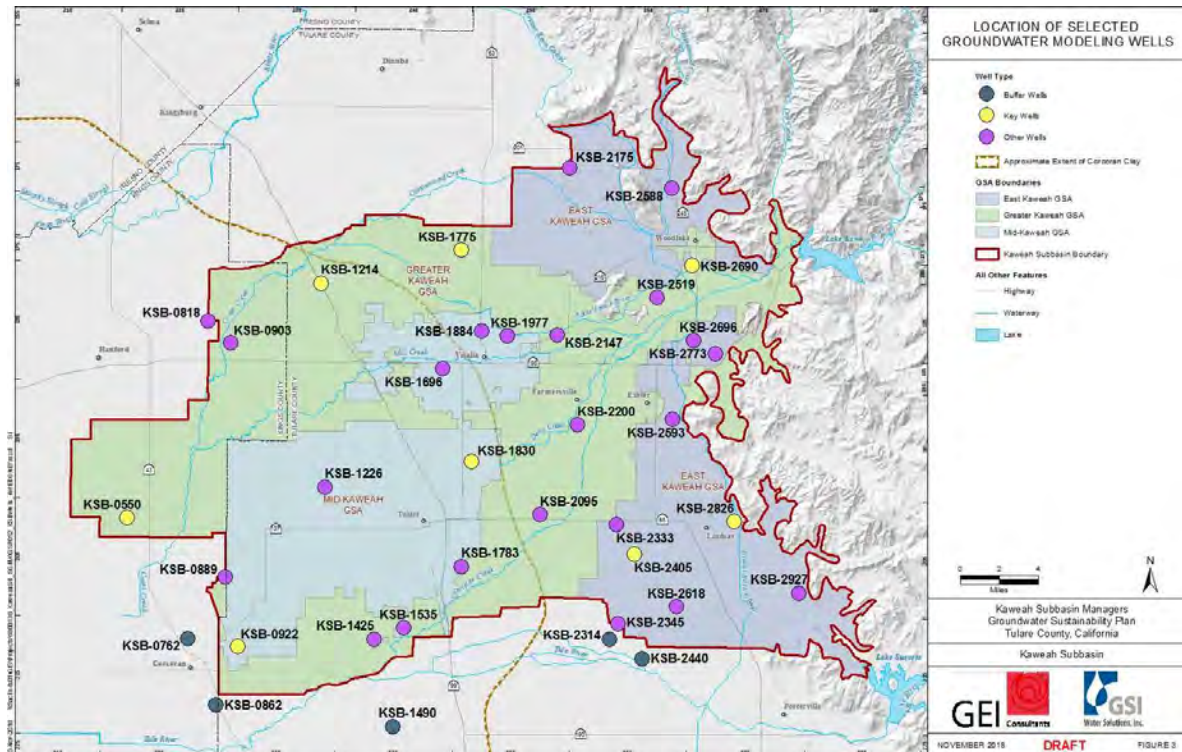
Results of Verification

The groundwater modeling team increased the number of calibrated targets from 30 in the 2012 update to over 900 in the KSHM. All 900 of these targets have been included in the calibration statistics that follow the presentation of key well hydrographs.

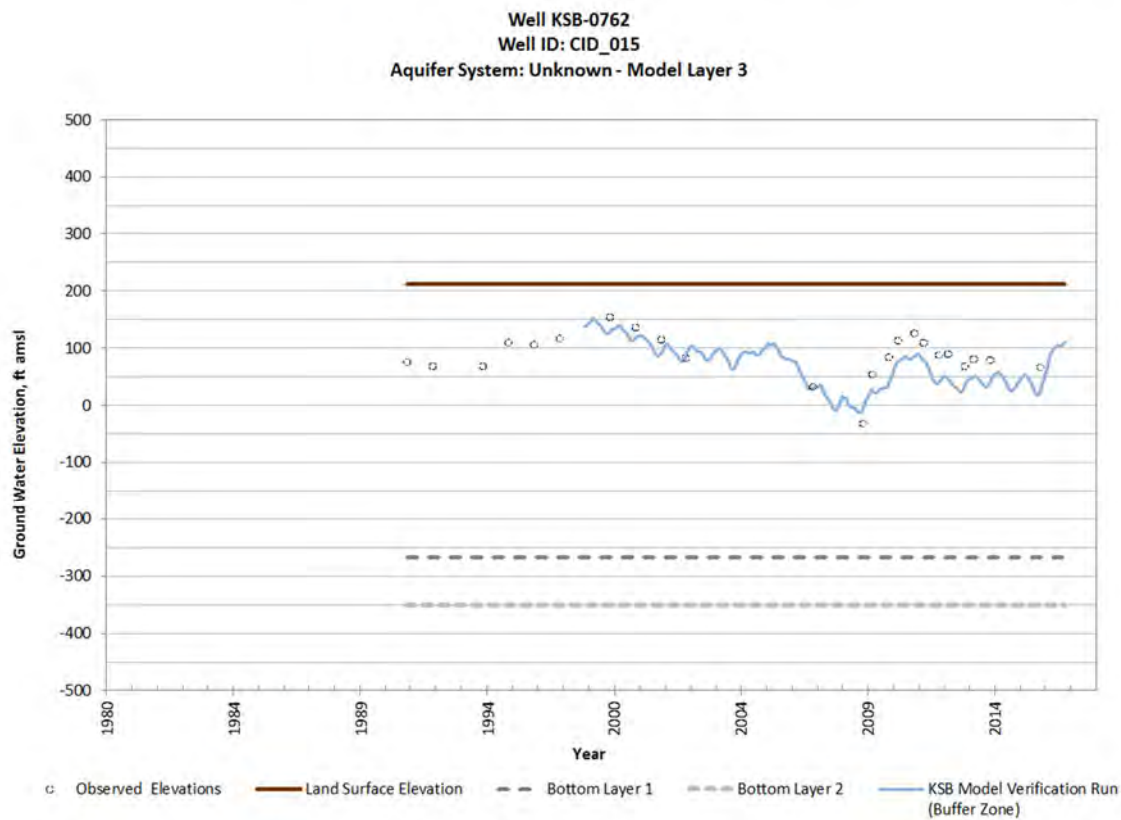
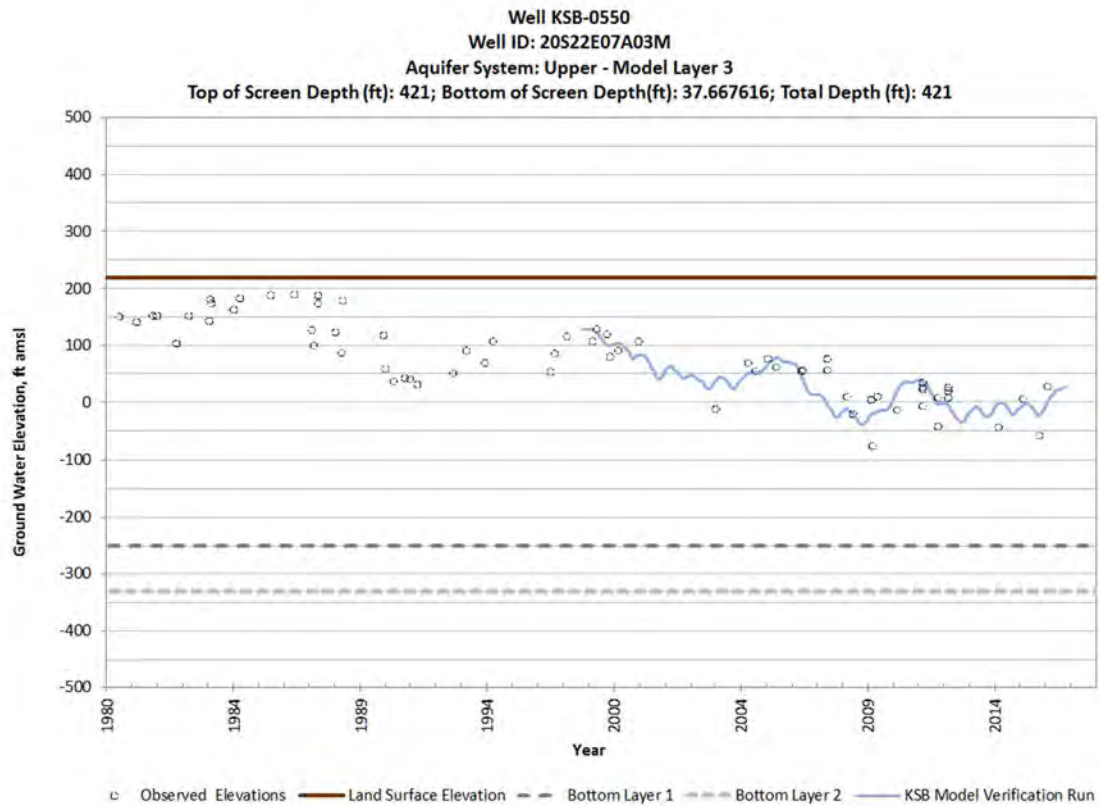
Included below is a map showing the locations of a group of key wells throughout the basin showing the match between observed and model simulated groundwater levels.

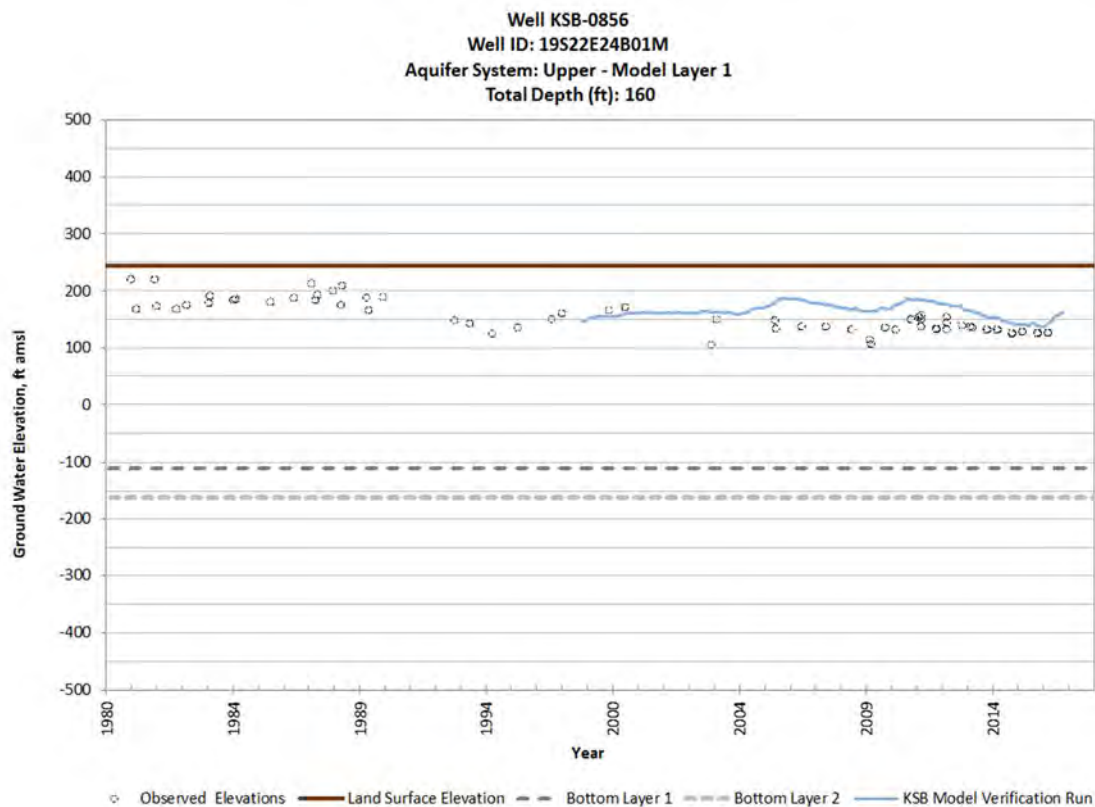
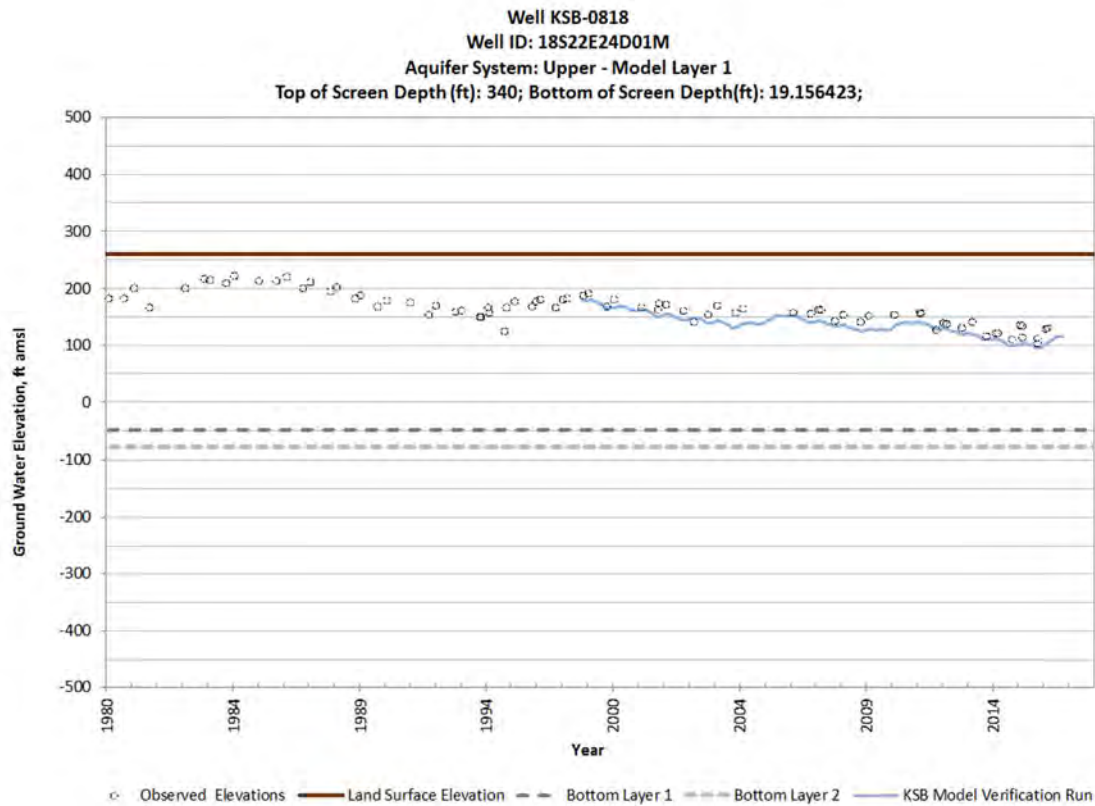
Hydrograph Wells

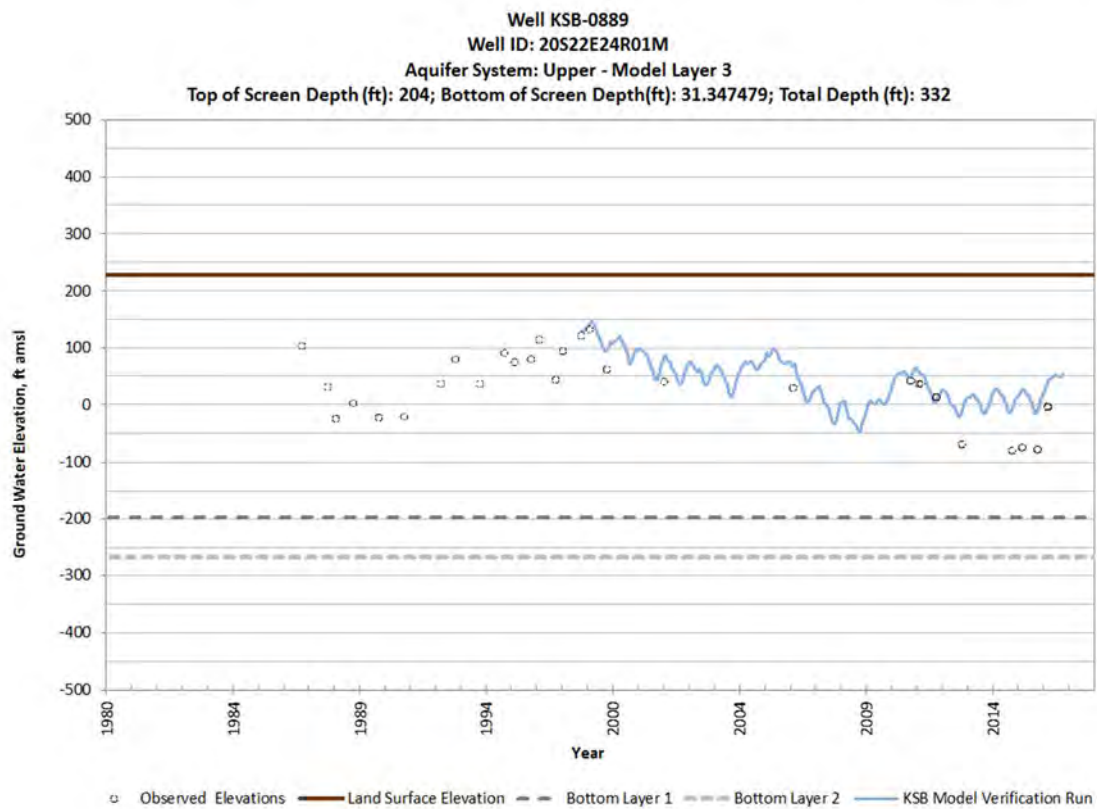
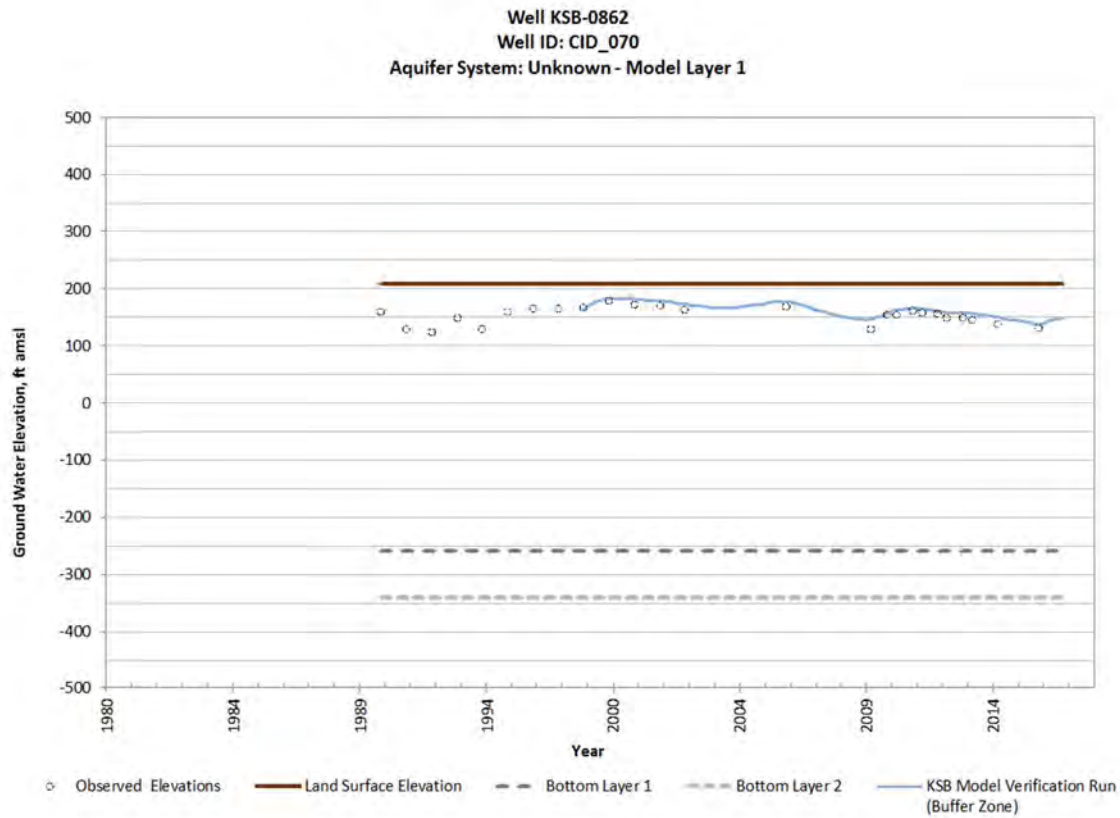
WELL LOCATIONS

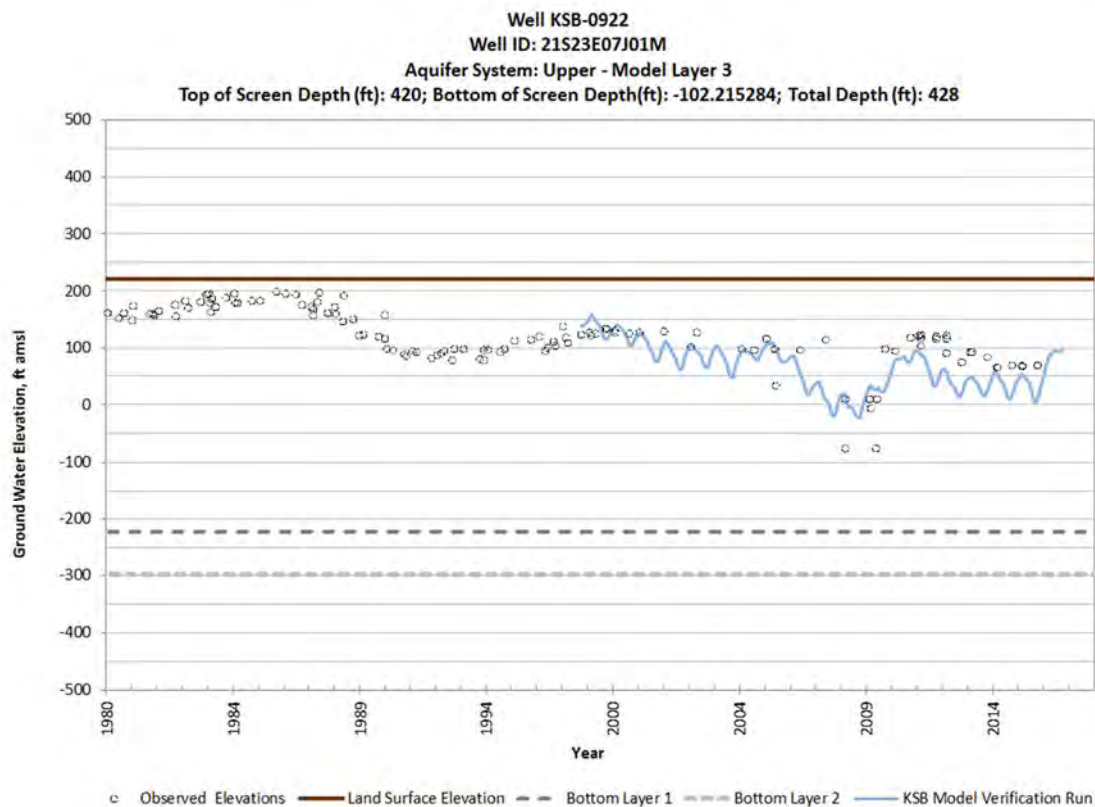
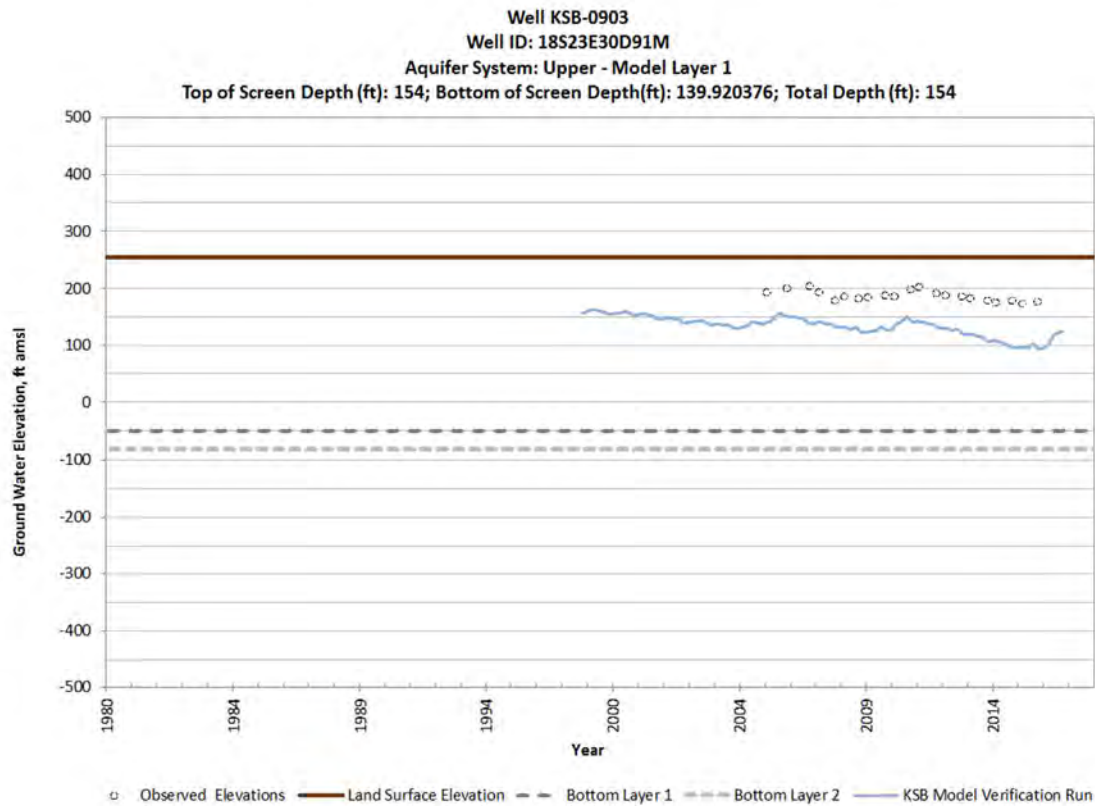


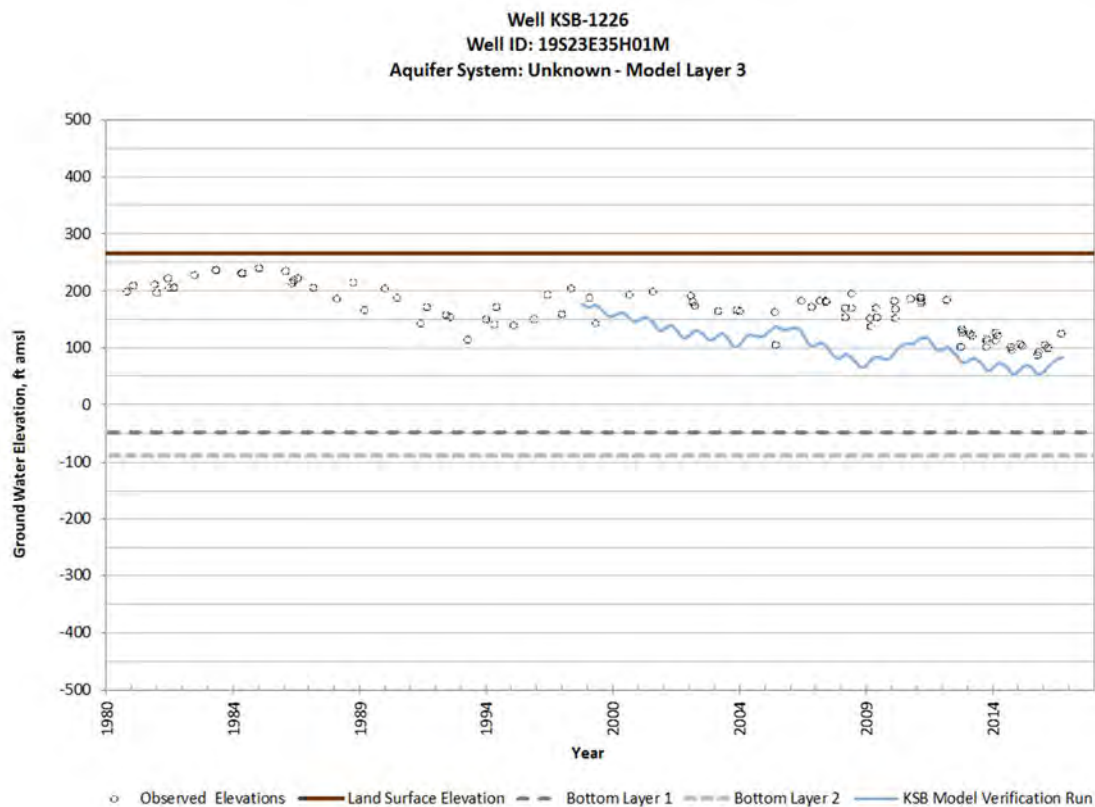
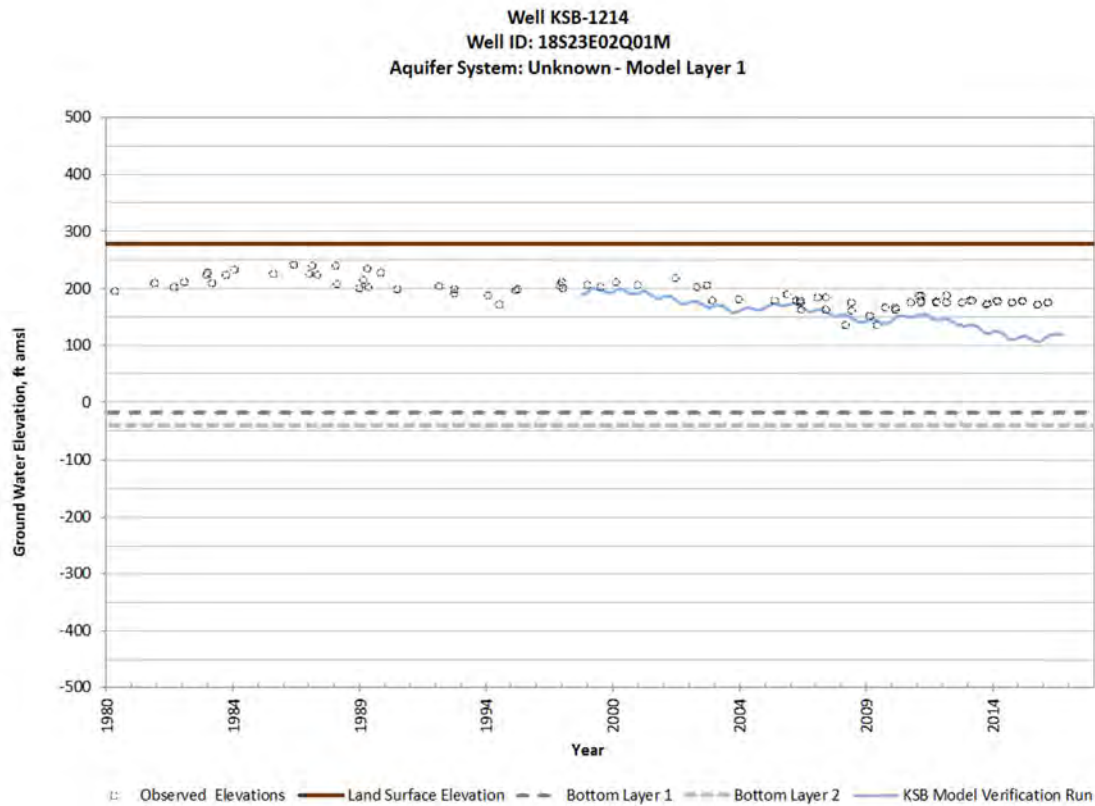
Hydrographs showing the match between observed and modeled groundwater elevations are presented for 37 key wells in the Kaweah Subbasin. Similar hydrographs have also been computed for over 900 wells within the subbasin and 200 wells within the model domain outside the subbasin. These additional hydrographs are available on demand but have been excluded from the report for brevity.

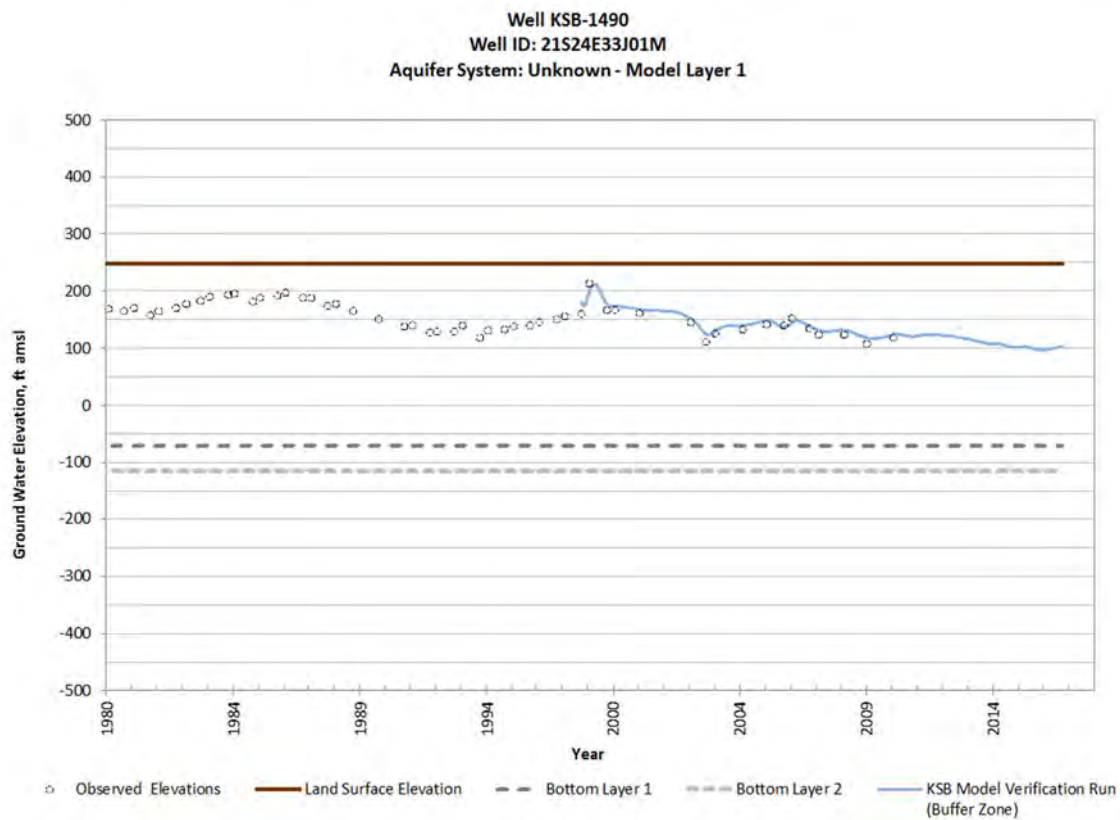
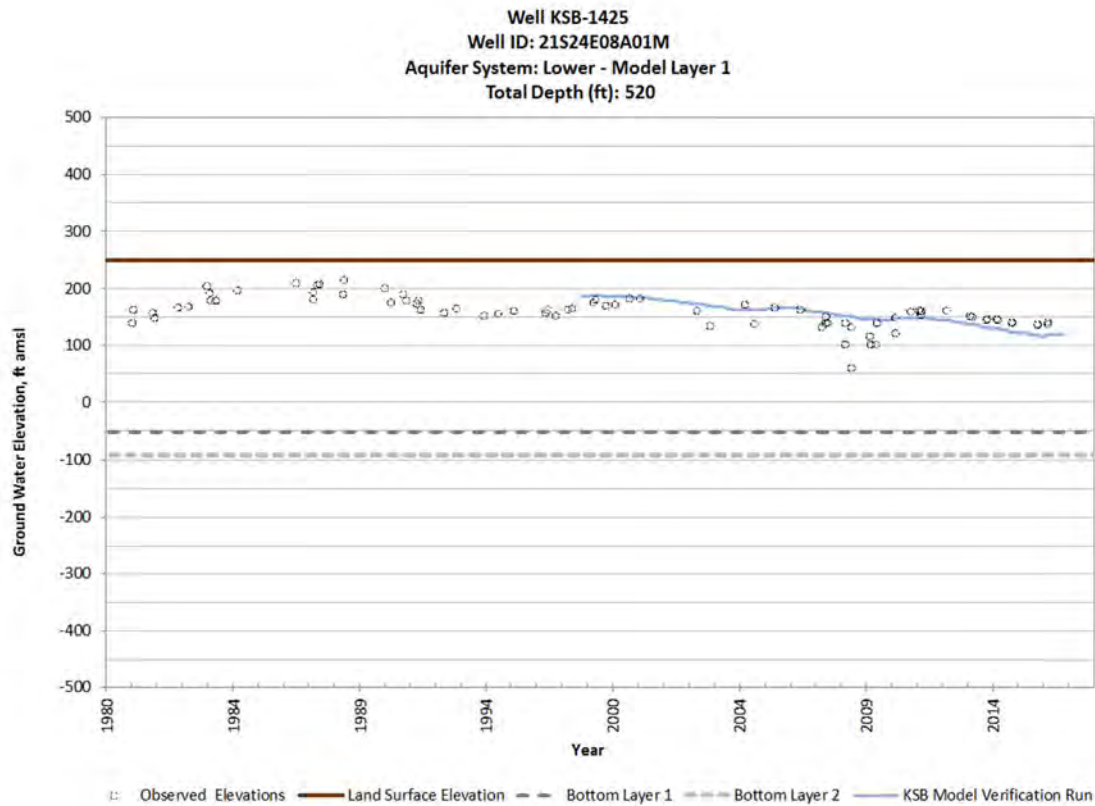


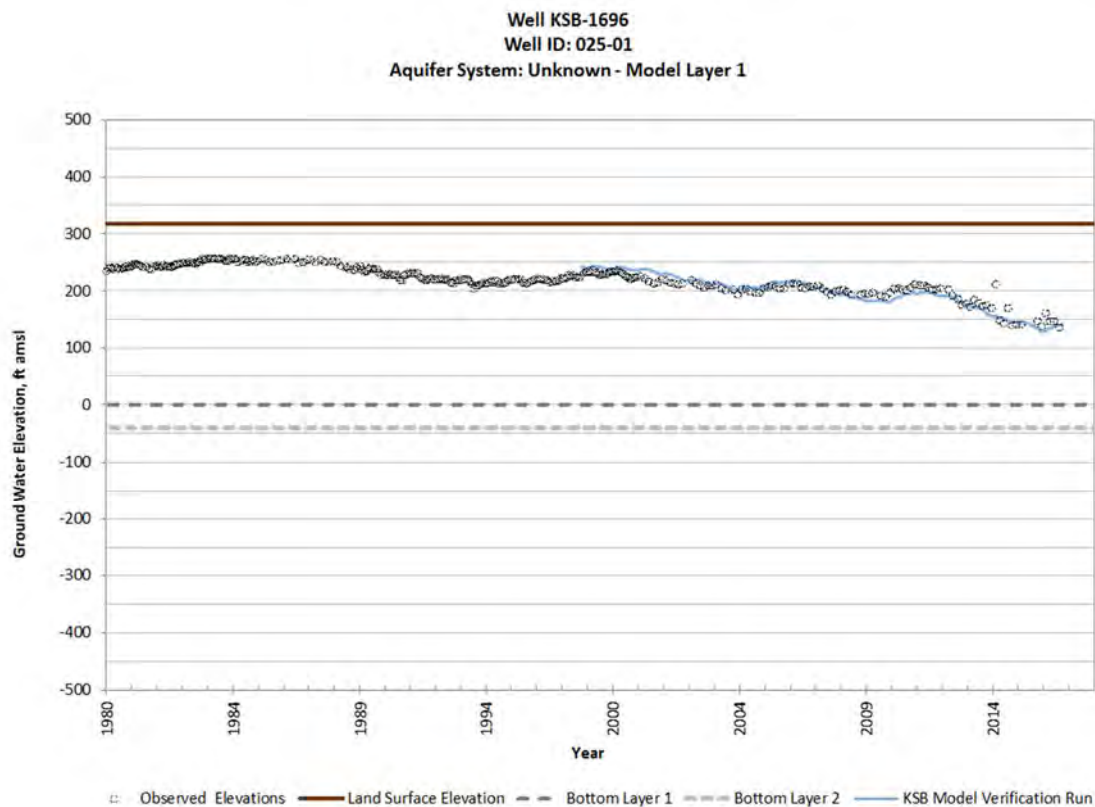
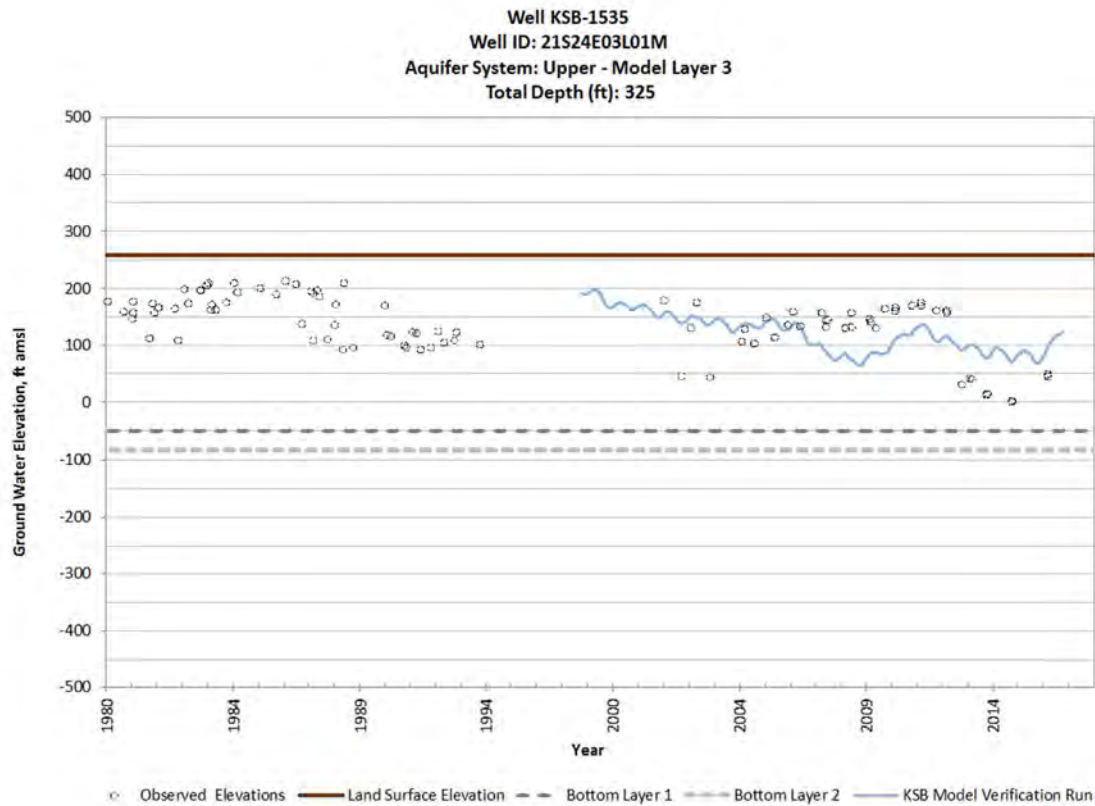


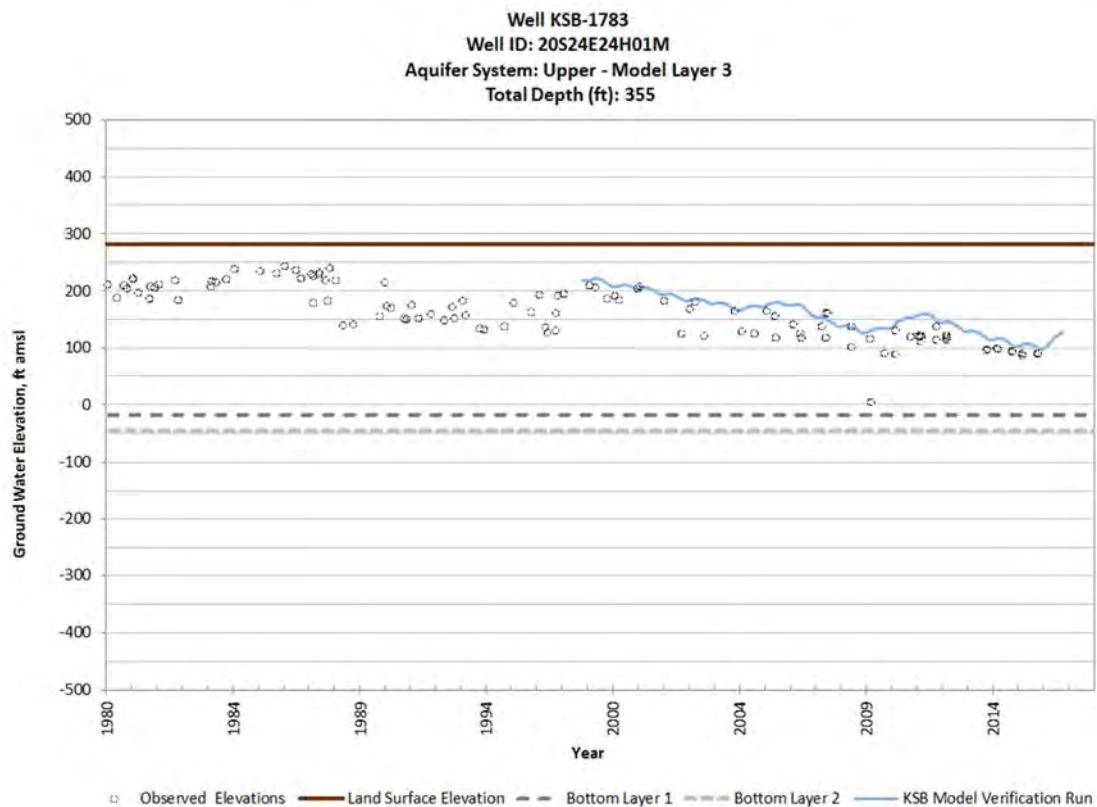


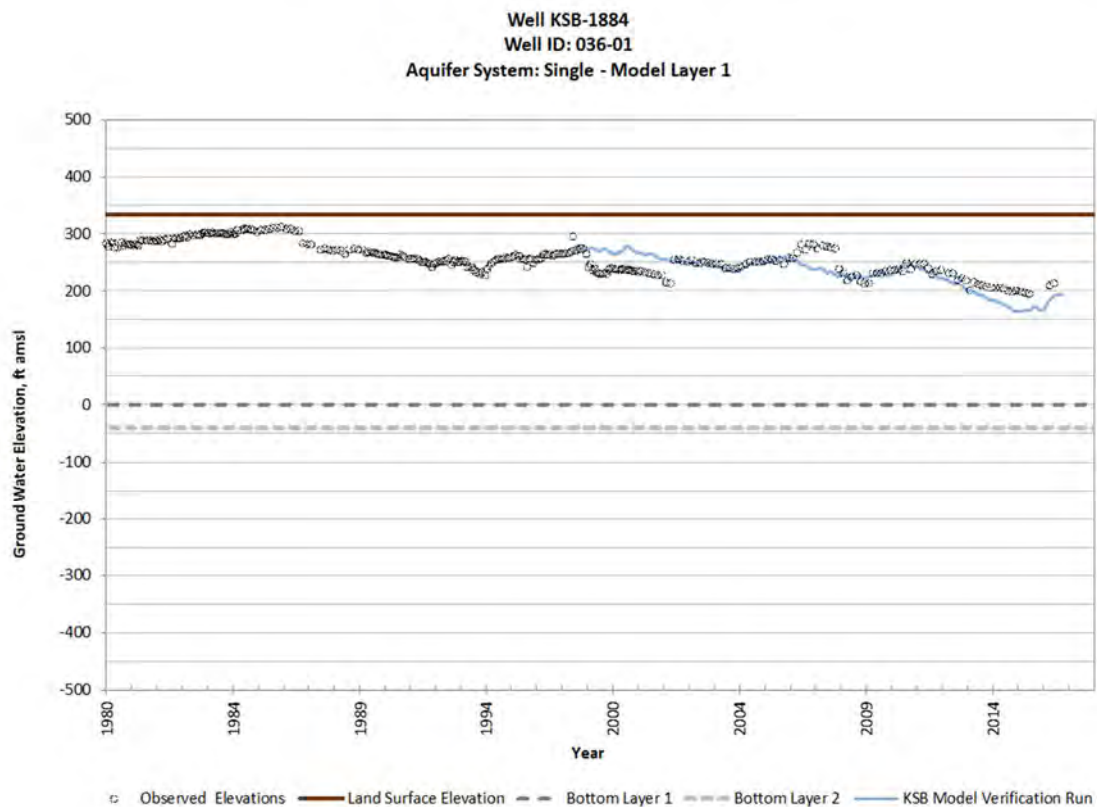
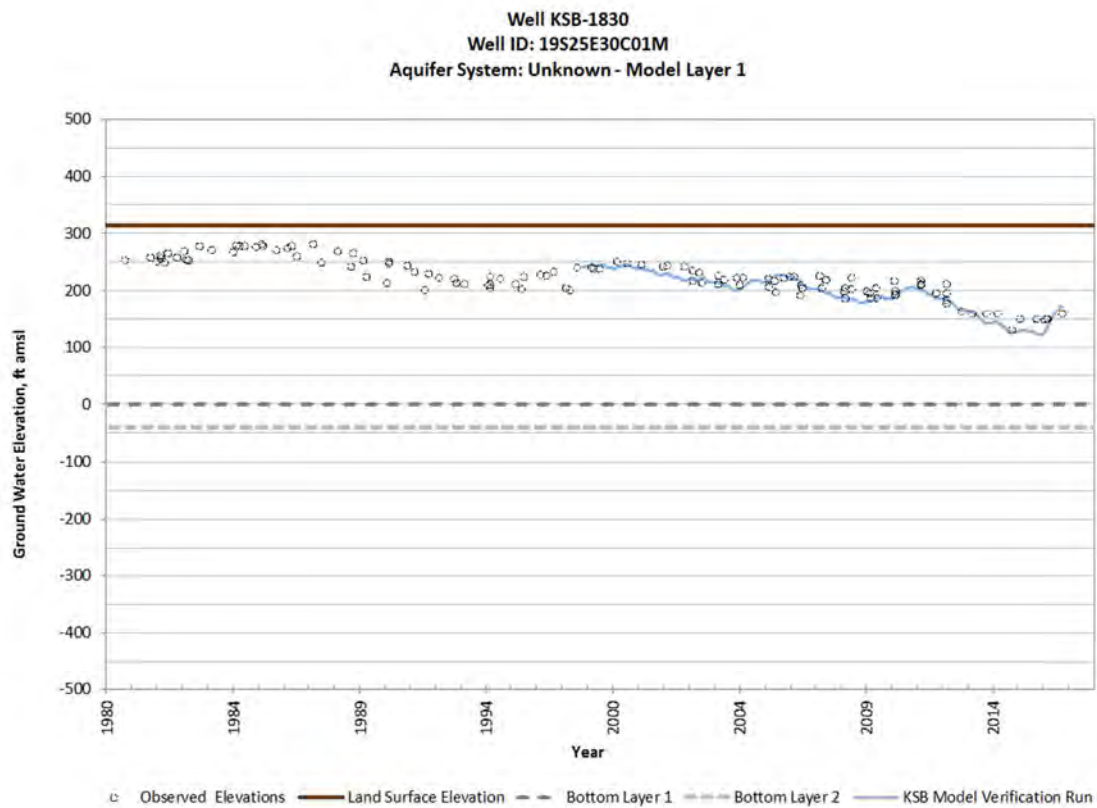


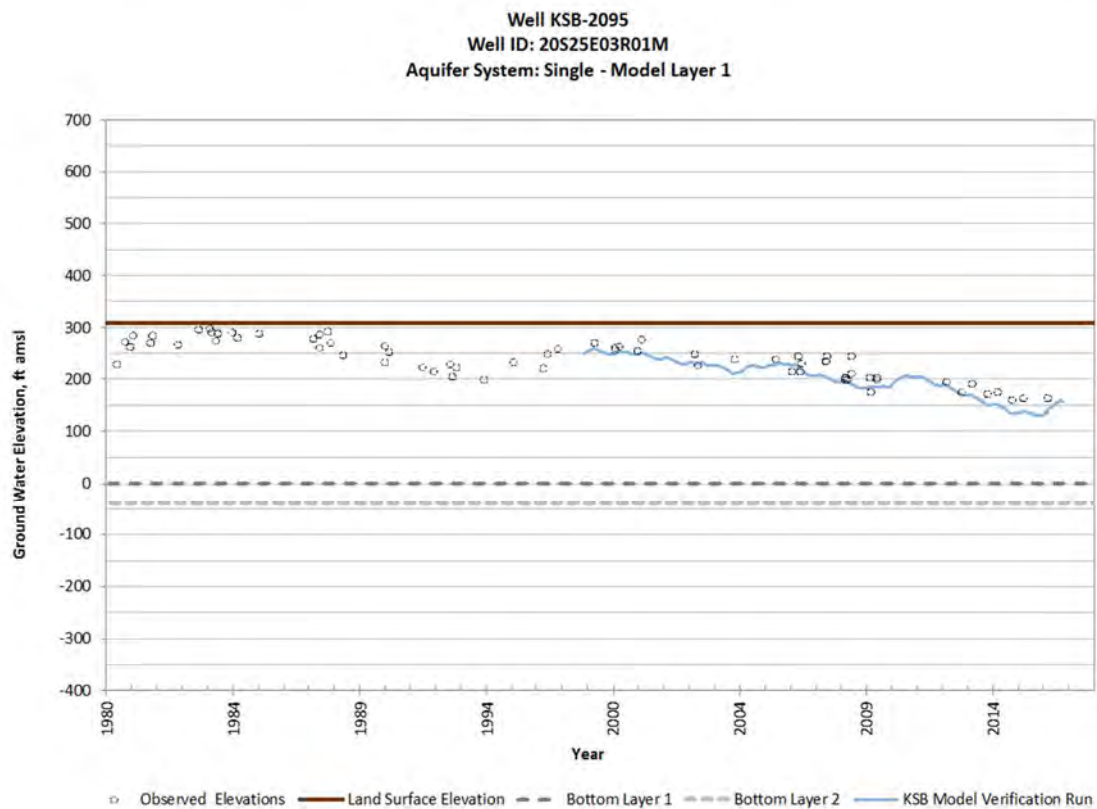
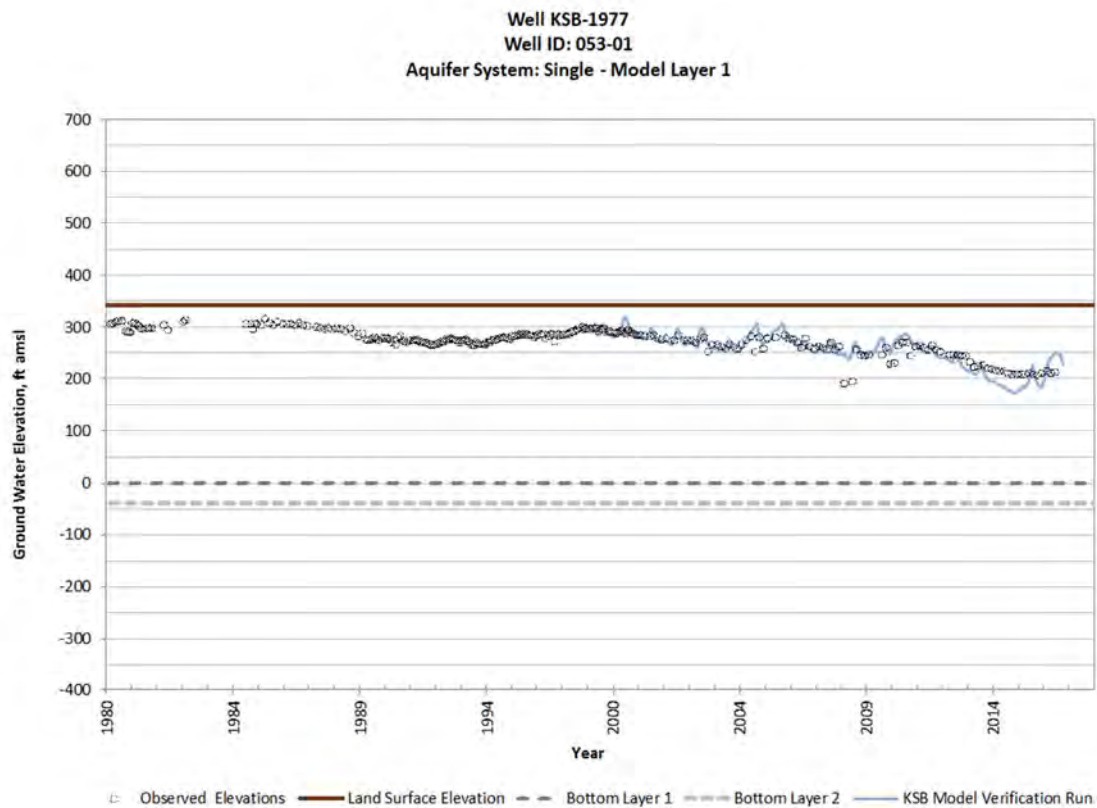








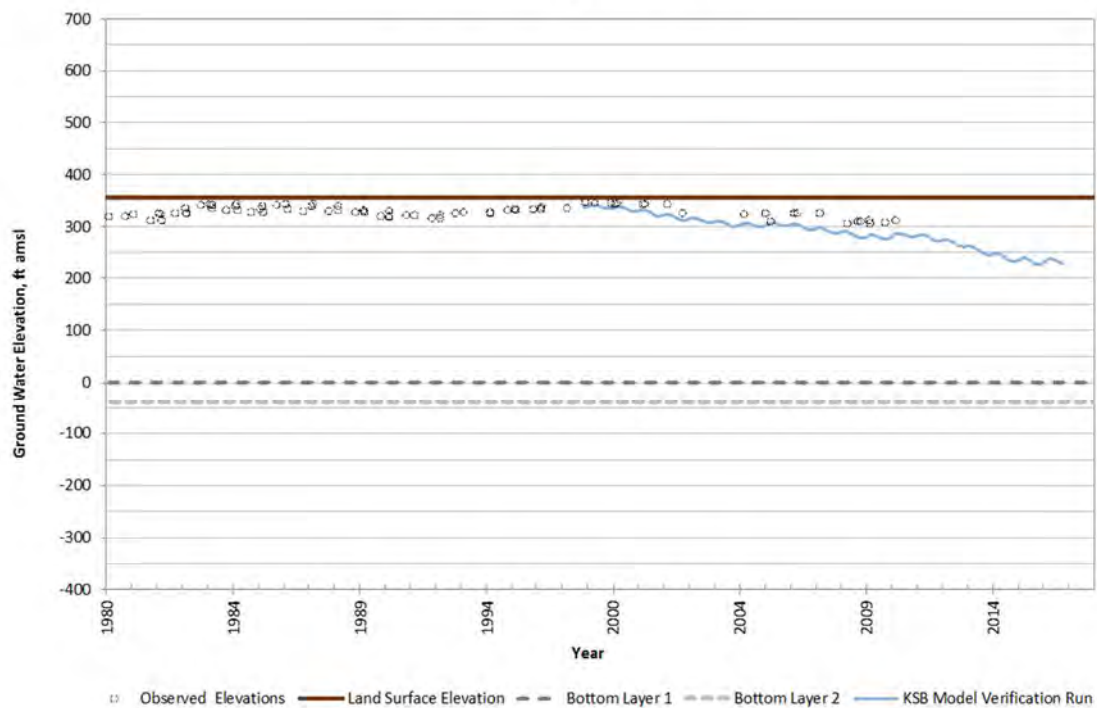


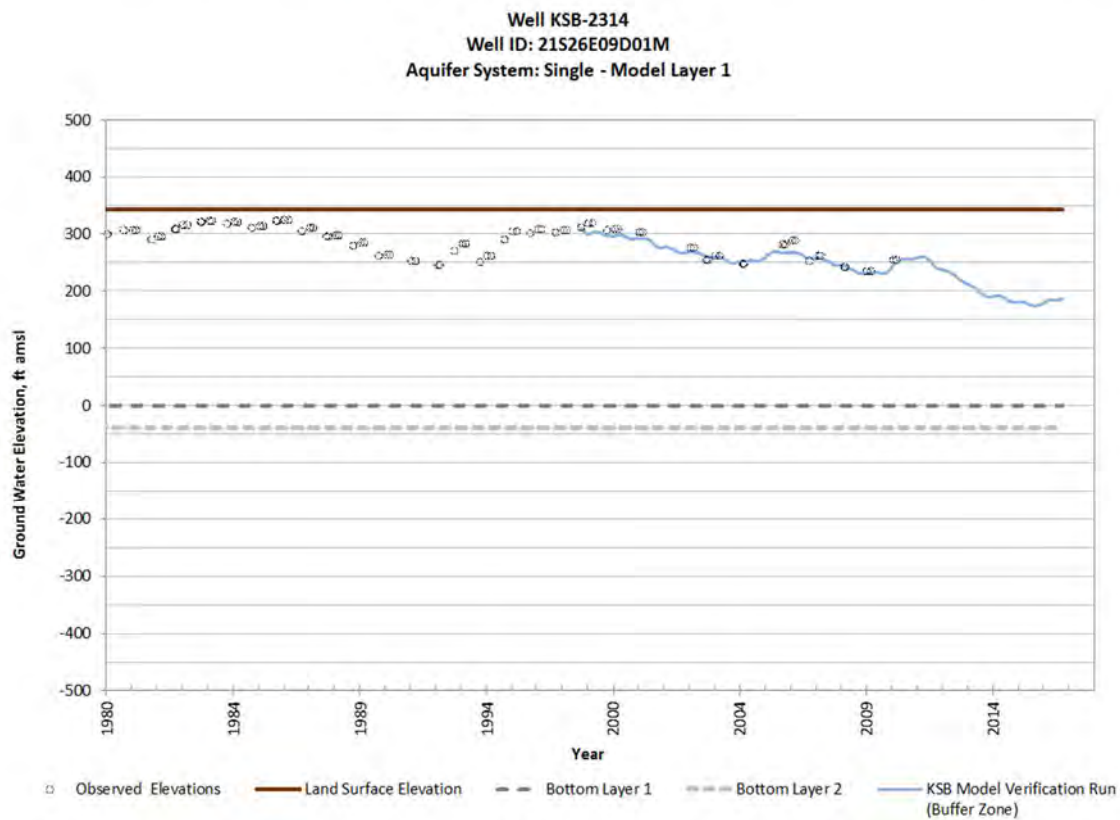
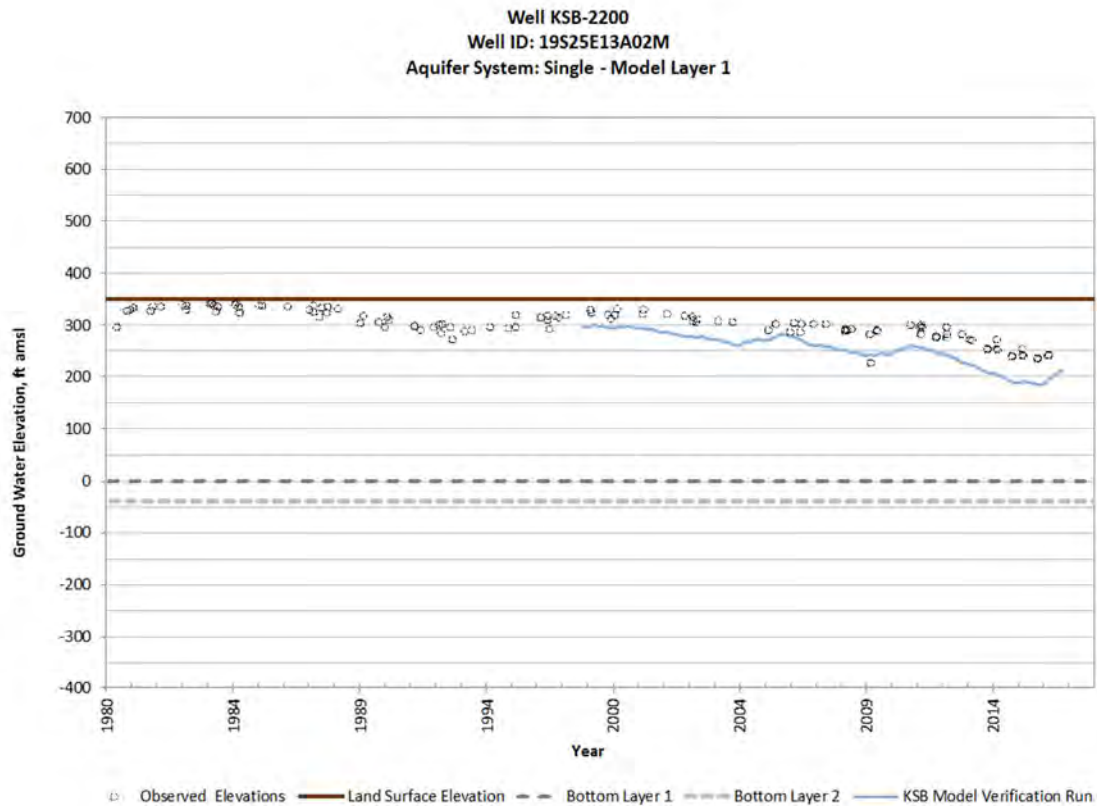


Well KSB-2147
Well ID: 18S25E23J01M
Aquifer System: Single - Model Layer 1

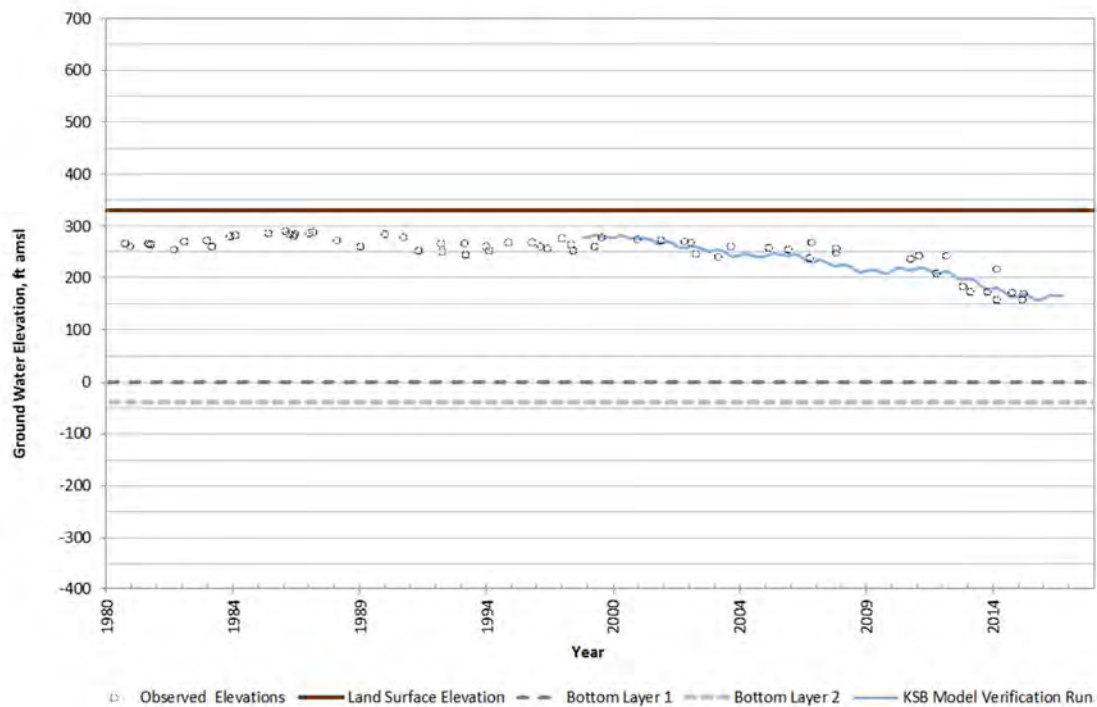


Well KSB-2175
Well ID: 17S25E01P01M
Aquifer System: Single - Model Layer 1

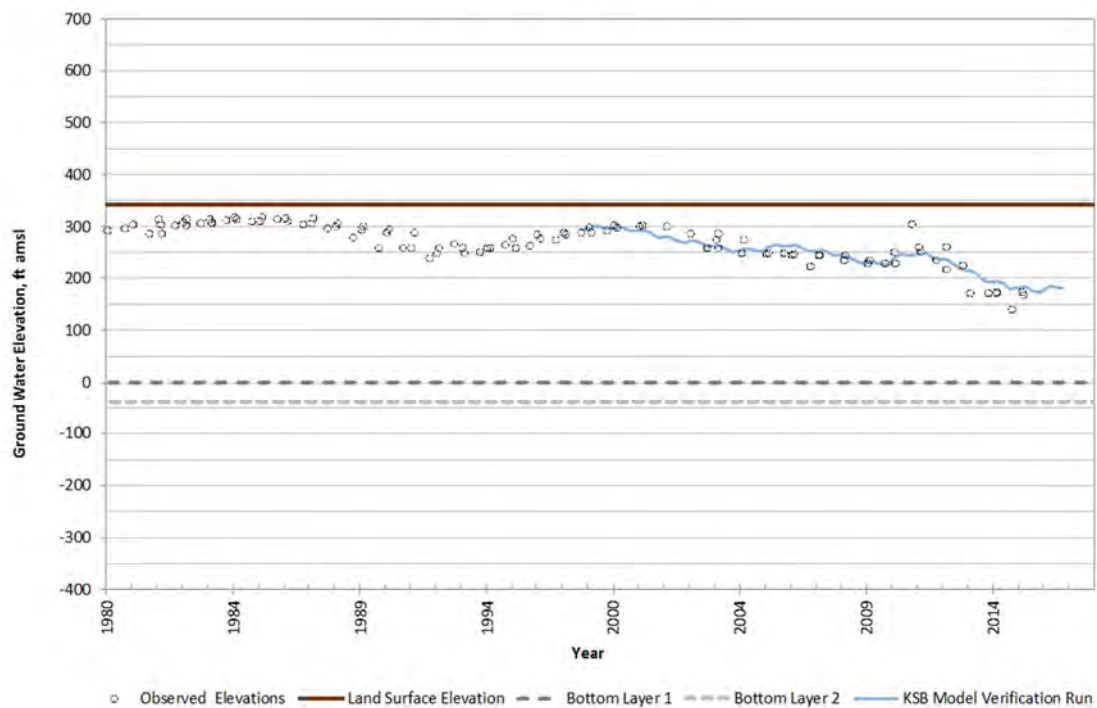


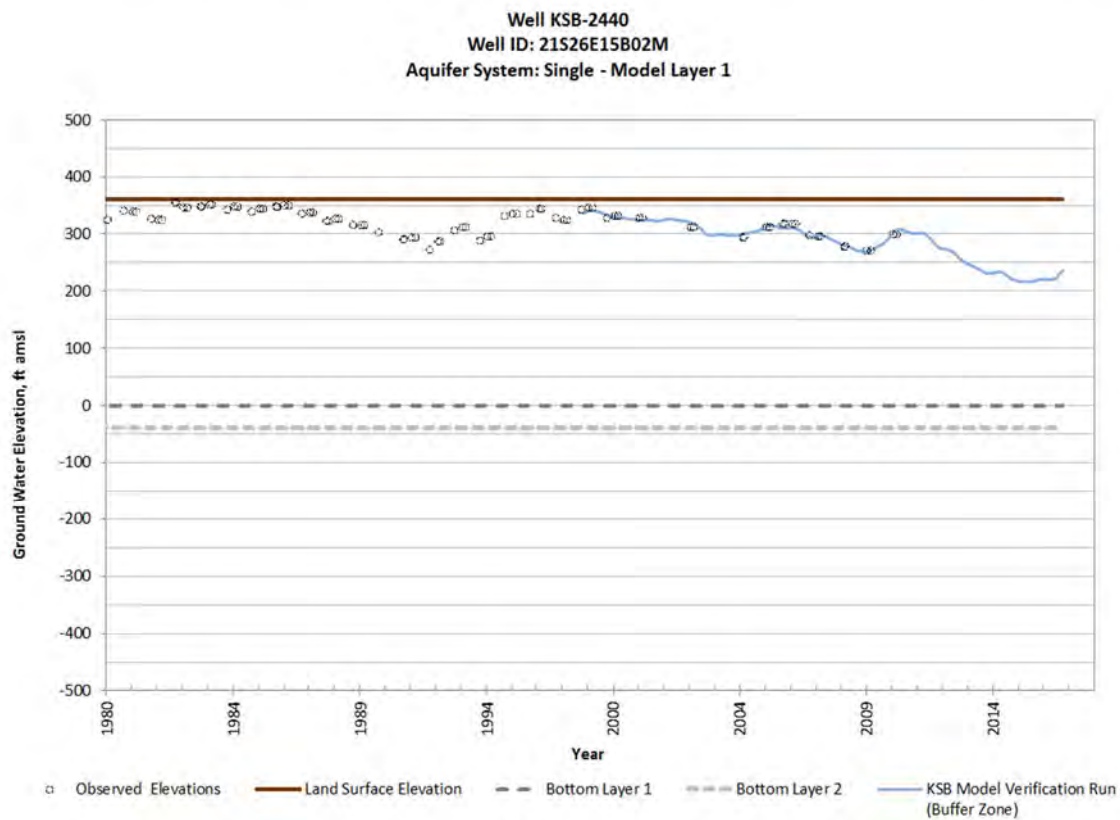
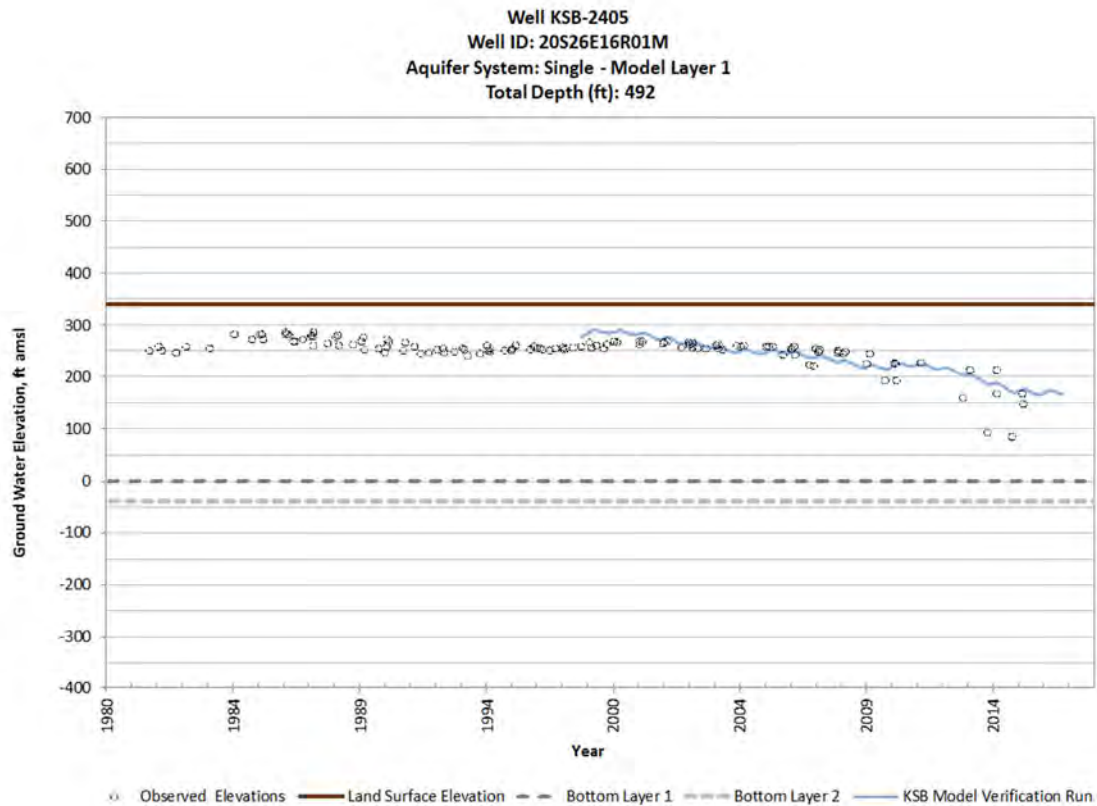


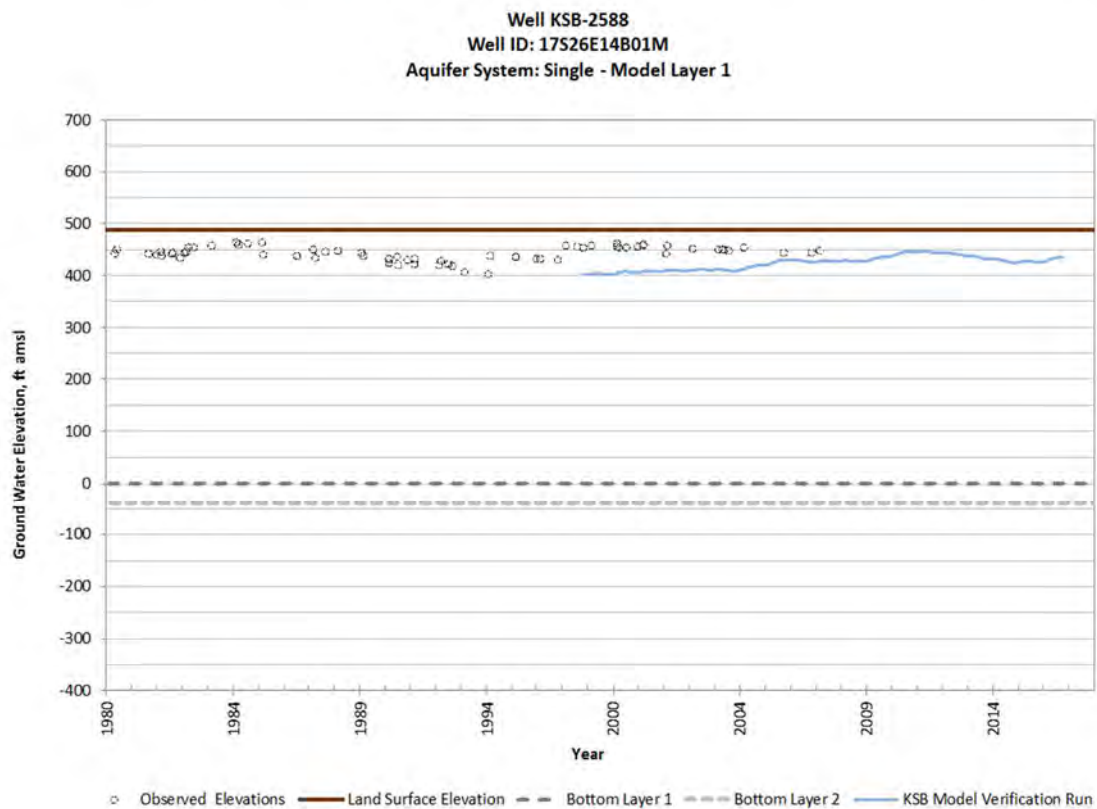
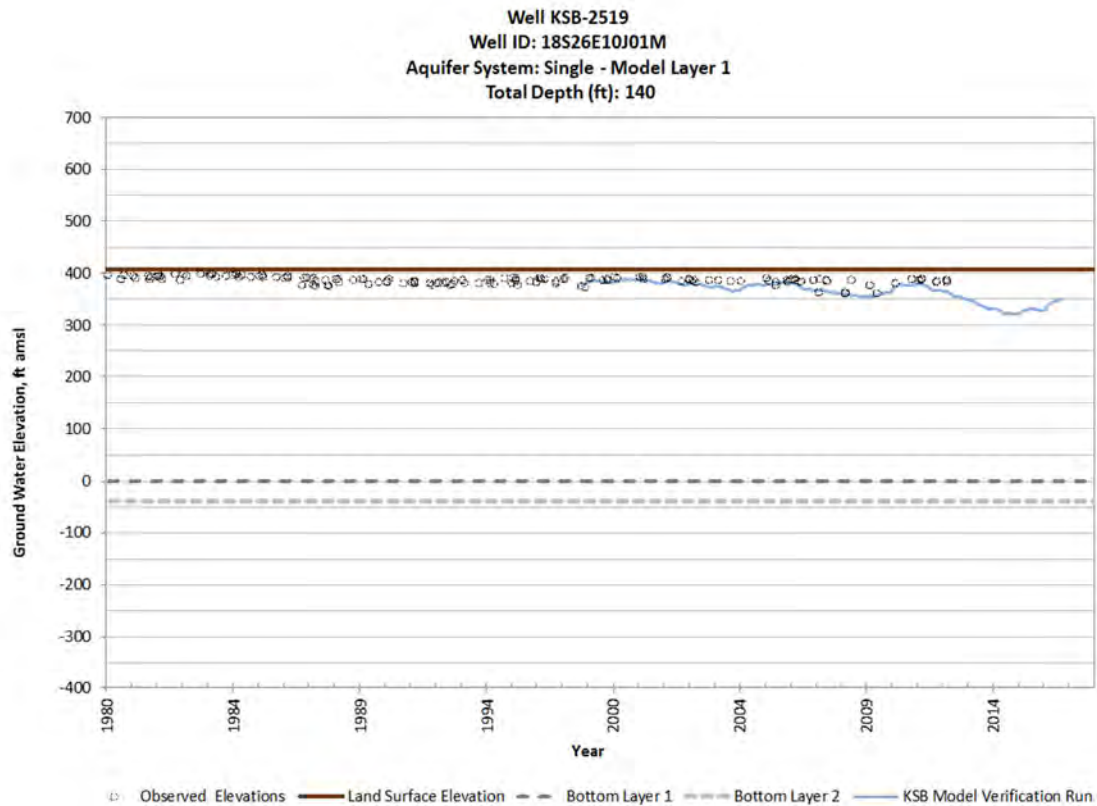
Well KSB-2333
Well ID: 20S26E08H01M
Aquifer System: Single - Model Layer 1



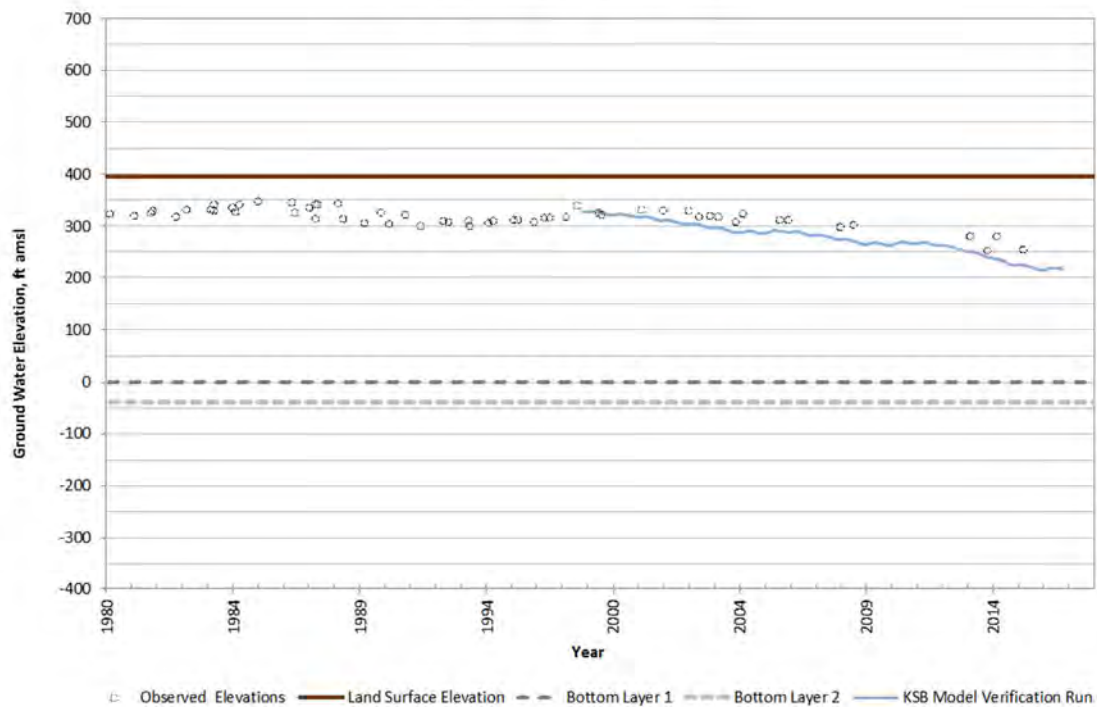
Well KSB-2345
Well ID: 21S26E04F01M
Aquifer System: Single - Model Layer 1



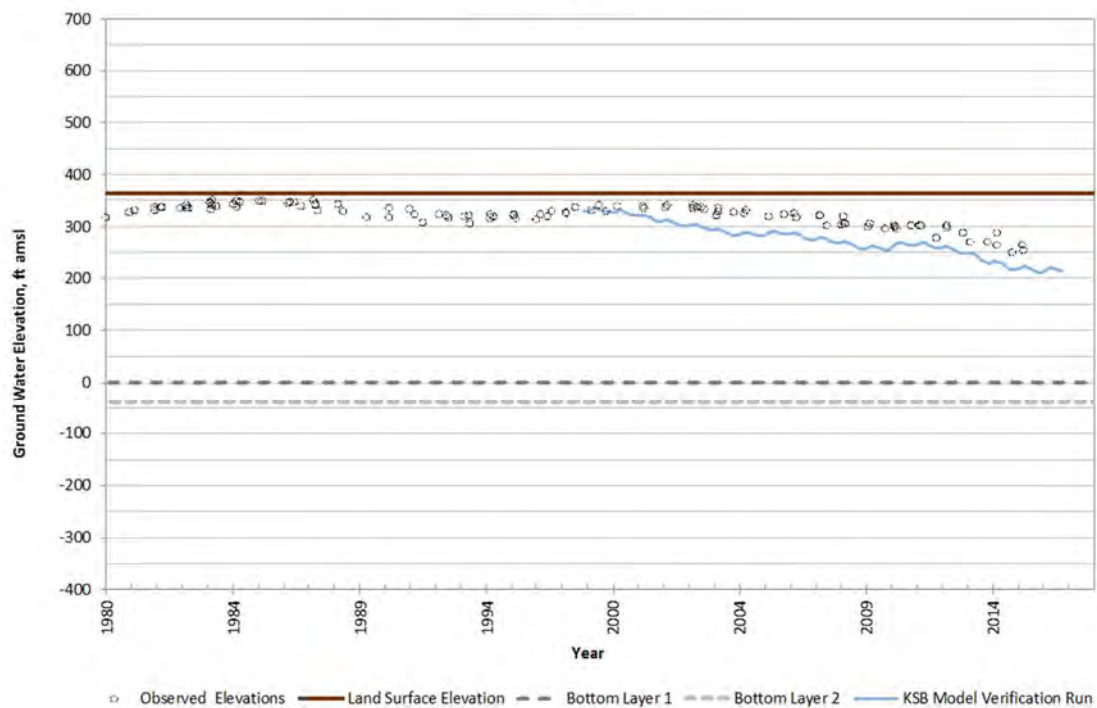


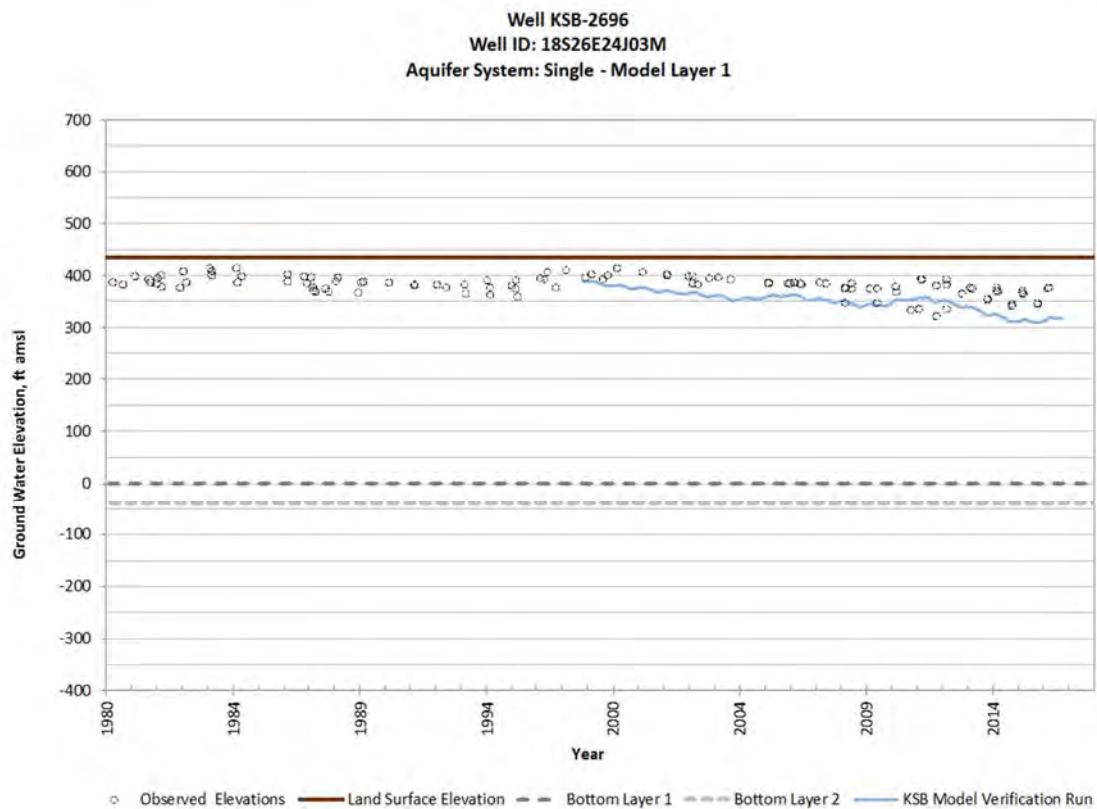
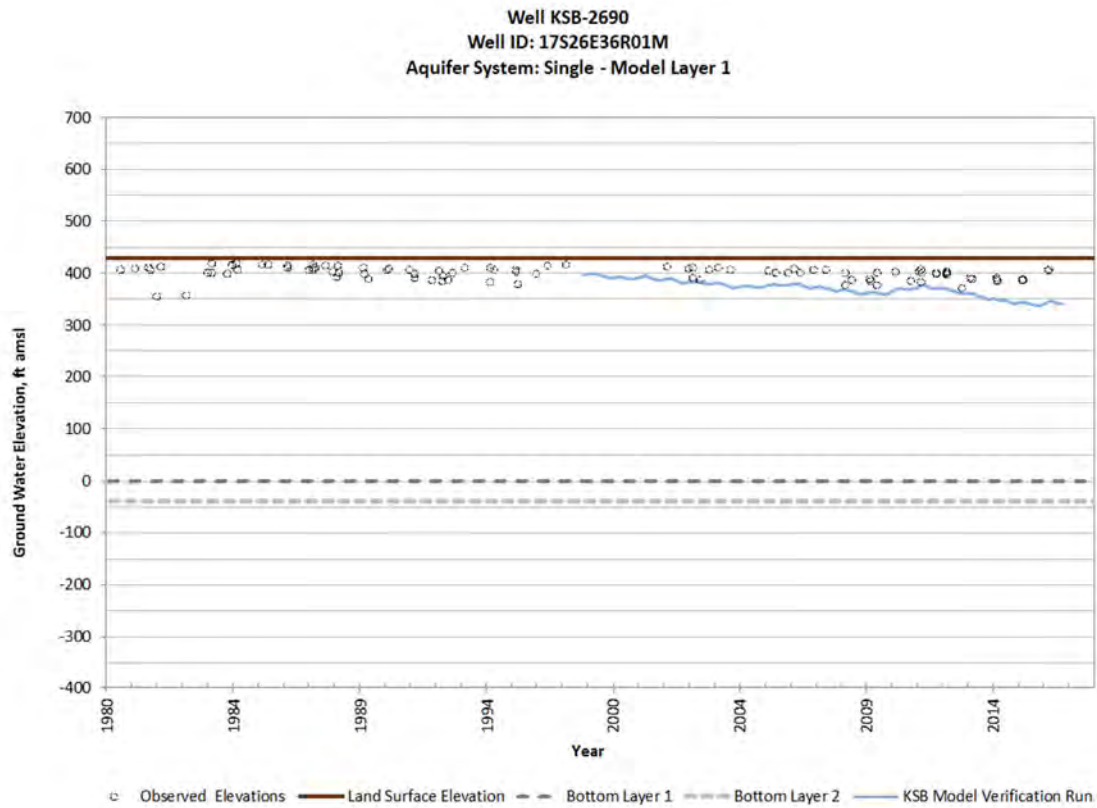


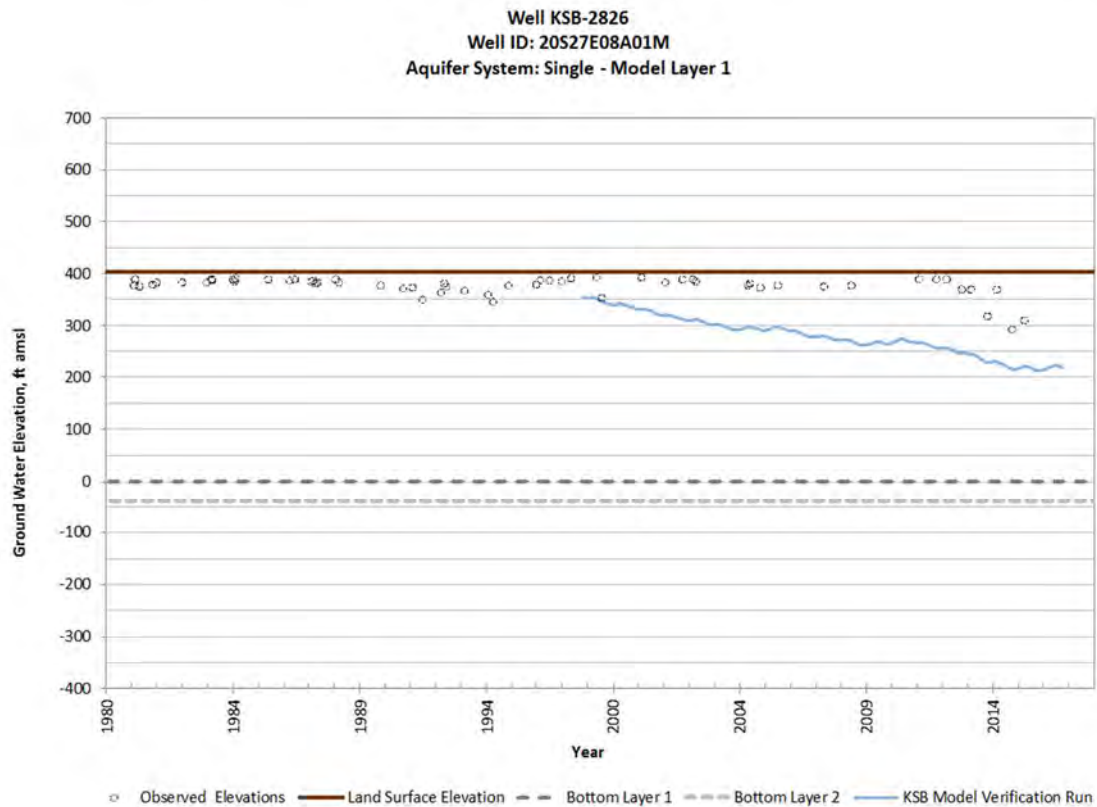
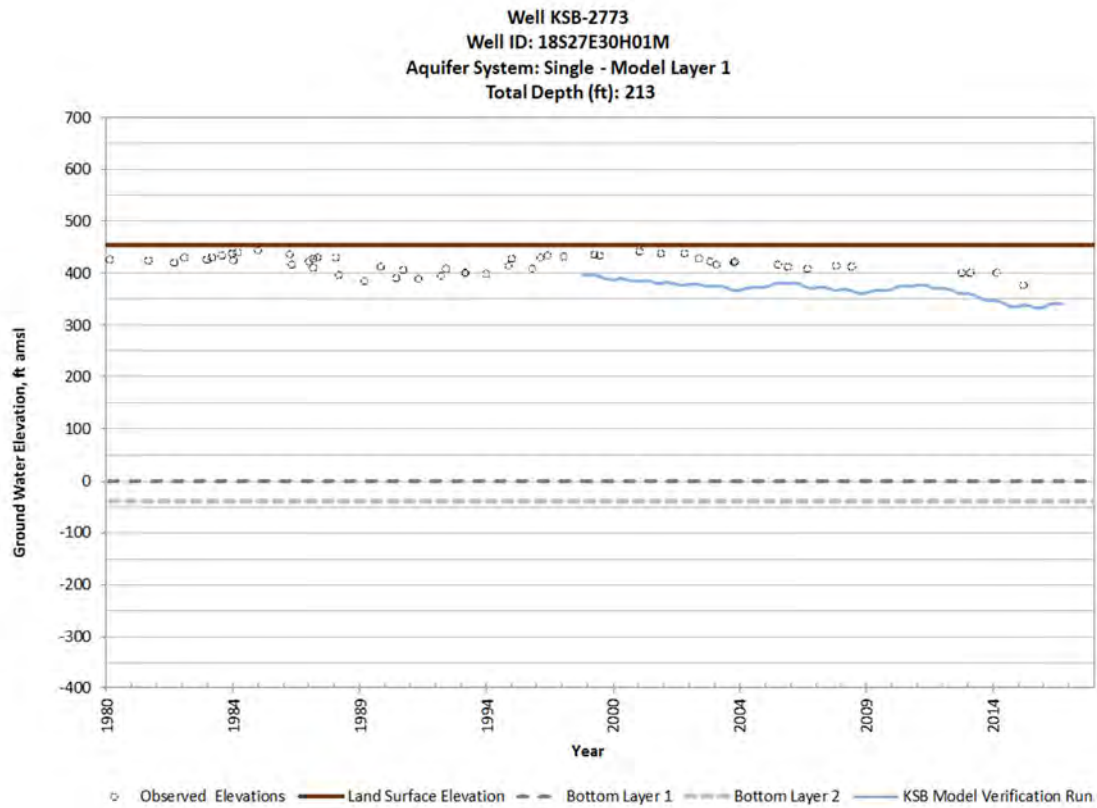
Well KSB-2593
Well ID: 19S26E11R01M
Aquifer System: Single - Model Layer 1

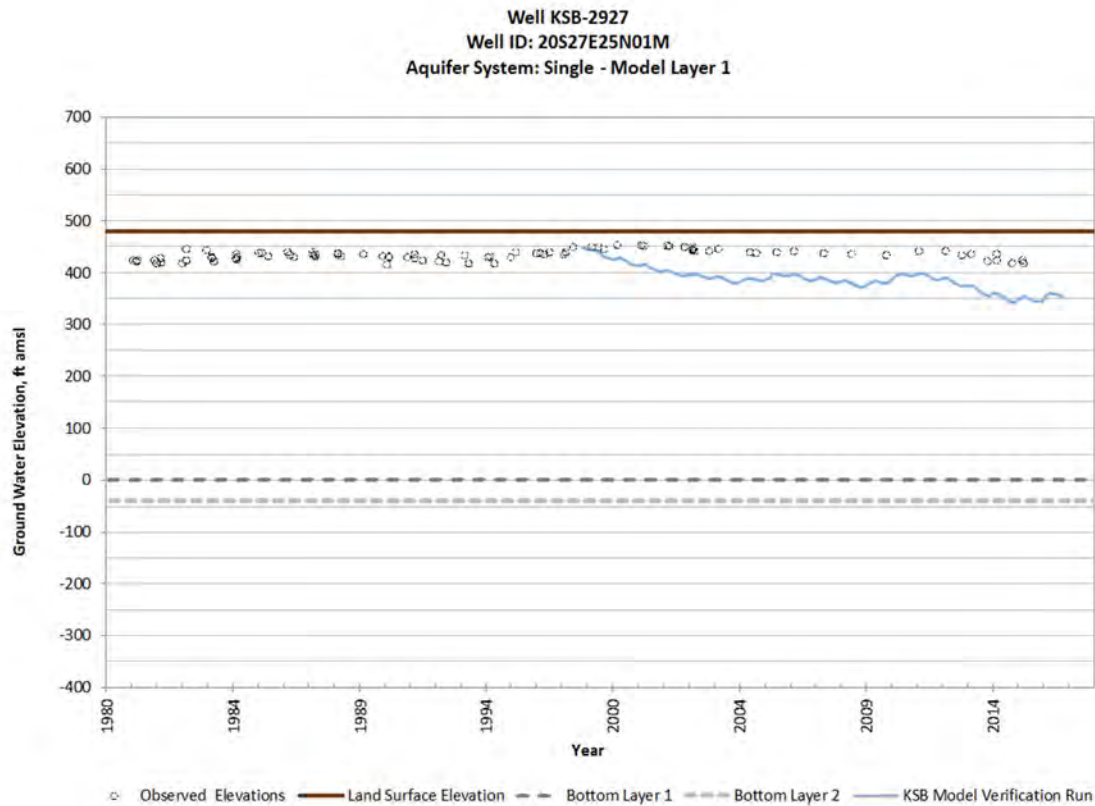


Well KSB-2618
Well ID: 20S26E35H01M
Aquifer System: Single - Model Layer 1









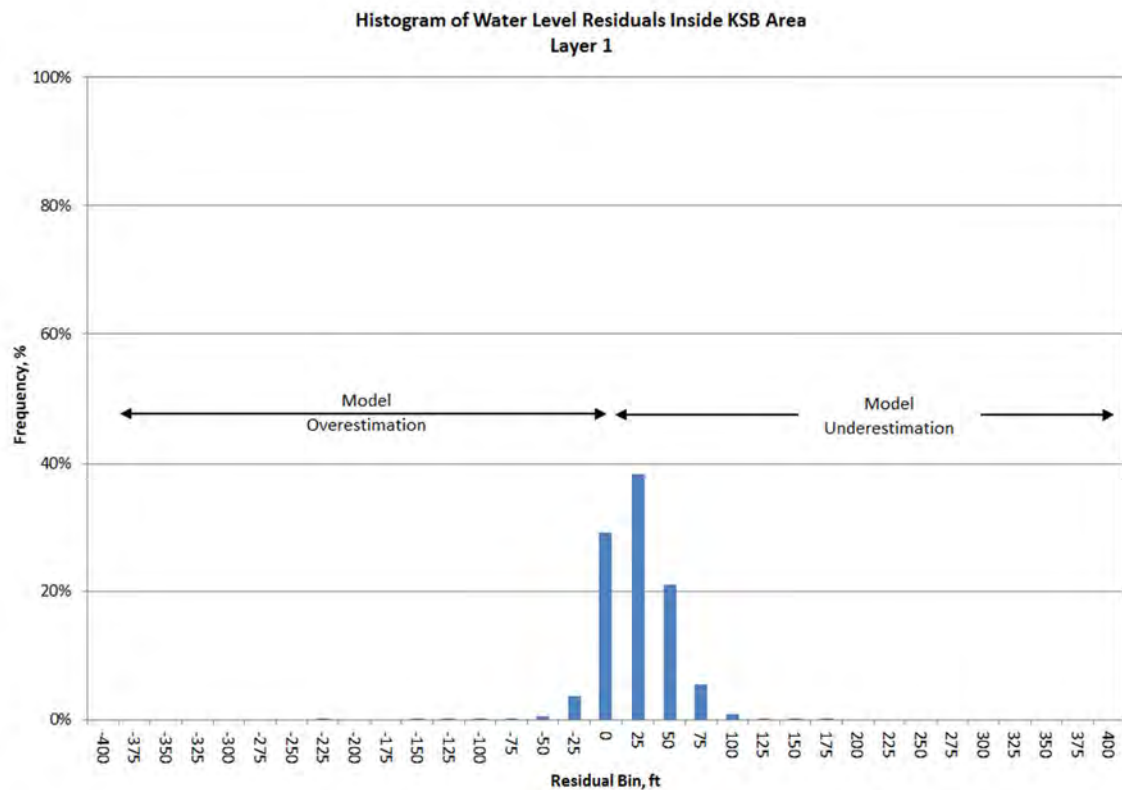
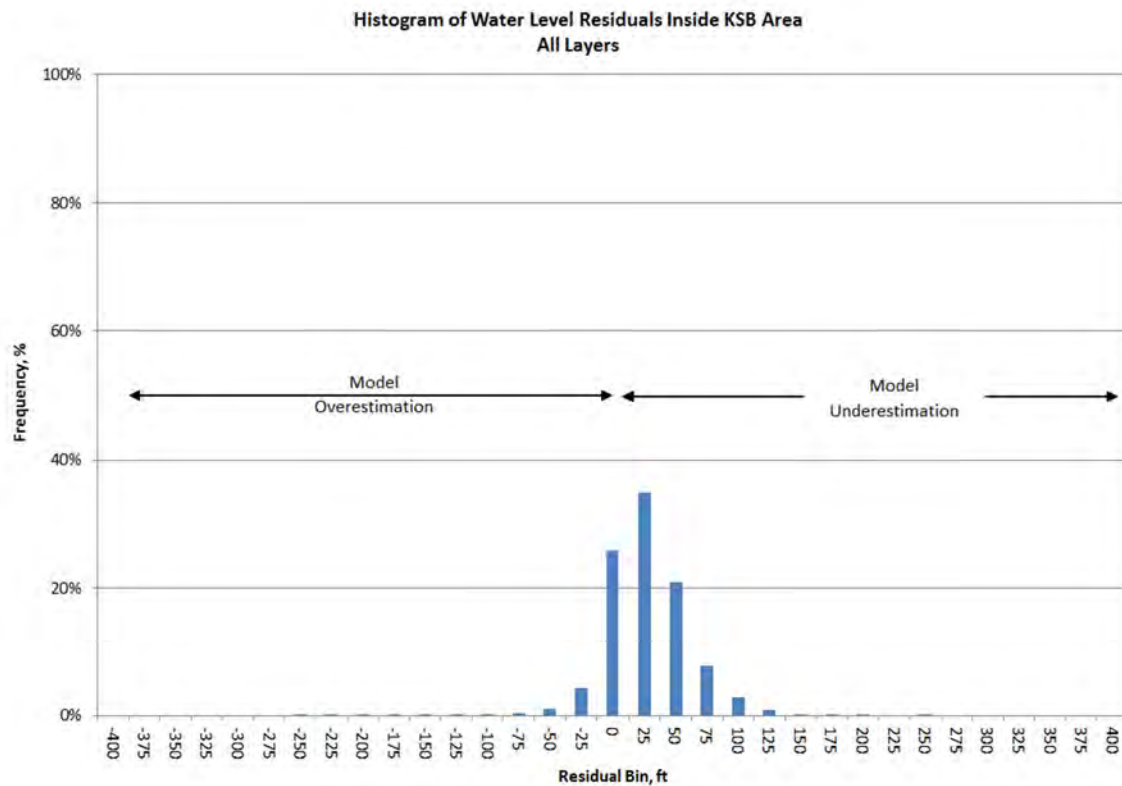
Model Statistics

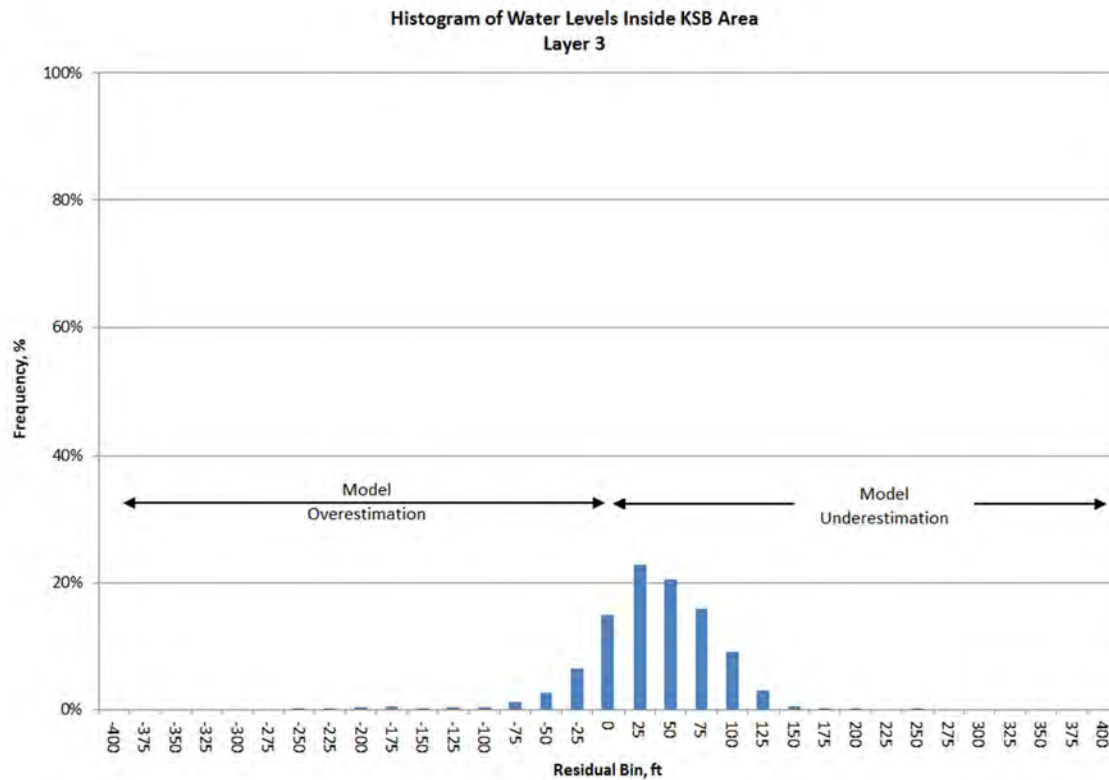
Wells in Kaweah Subbasin

The graphs below show trends and comparisons of the groundwater model data. The data is shown for All Layers (all wells), Layer 1 (wells in layer 1), and Layer 3 (wells in Layer 3). The three main graphs in each section are as follows:

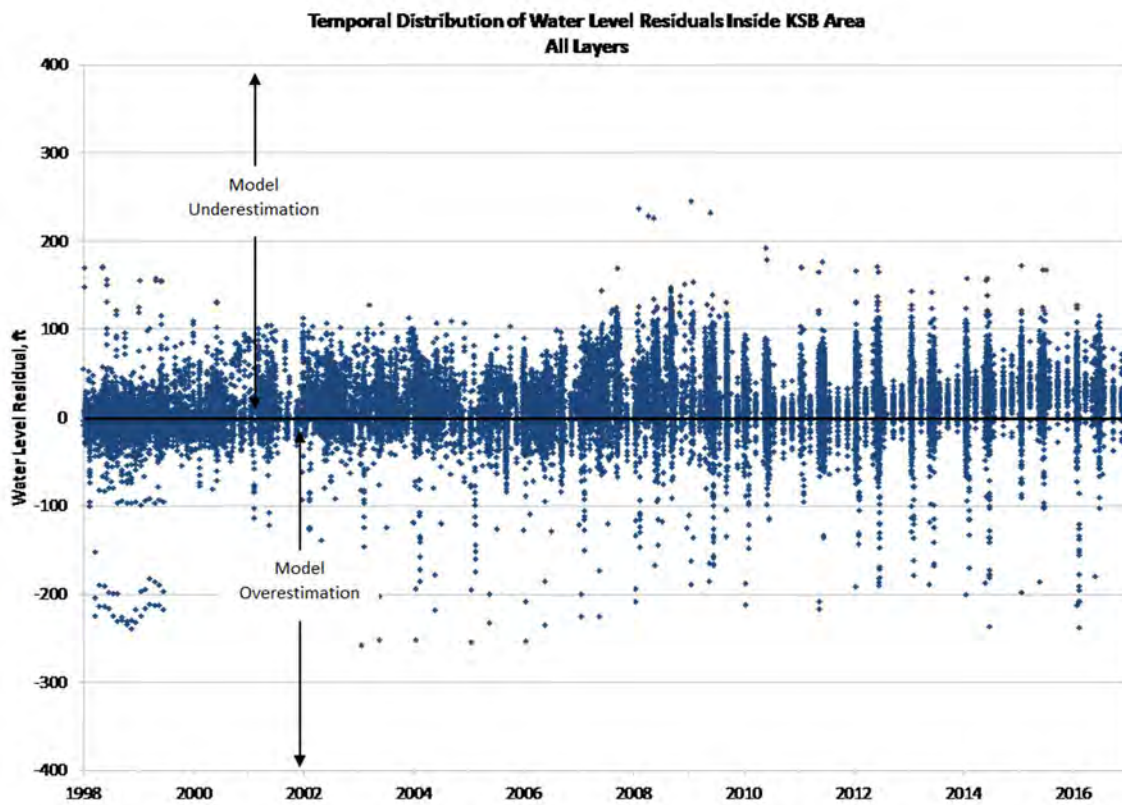
1. Histogram of Water Level Residuals
2. Temporal Distribution of Water Level Residuals
3. Measured vs Model- Calculated Water Levels

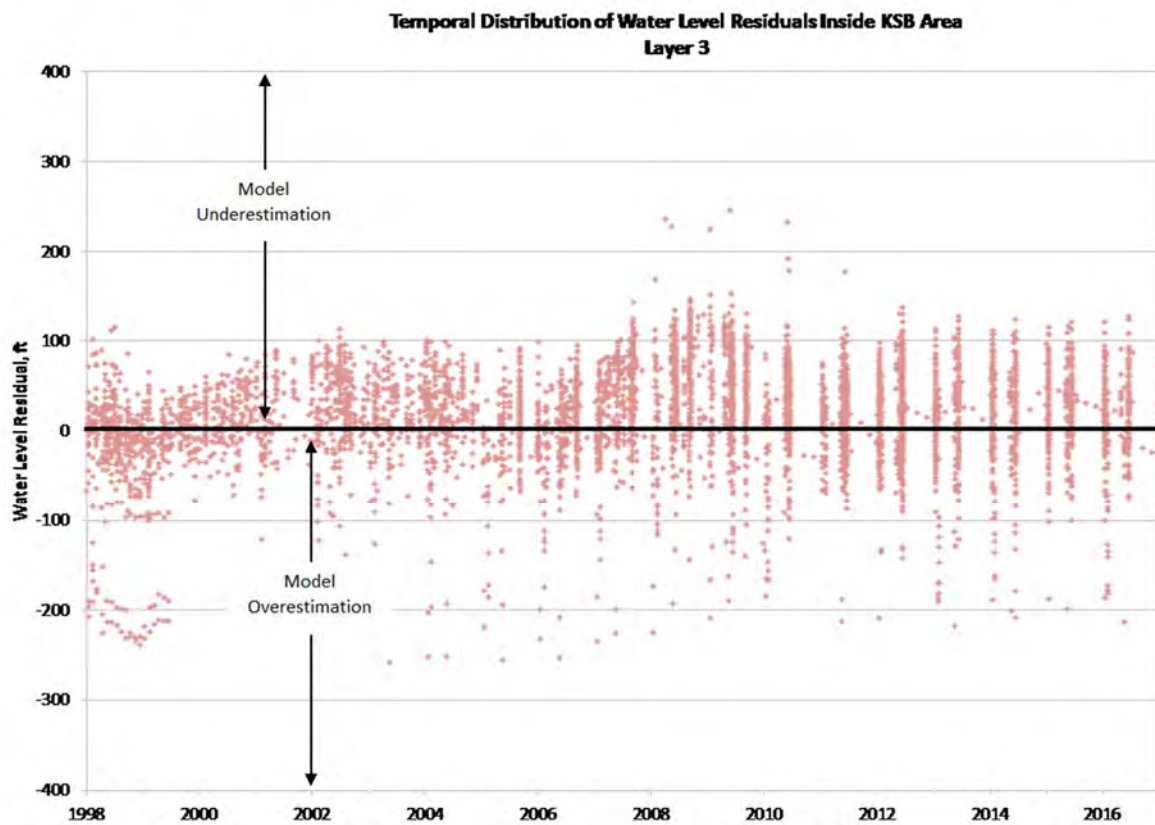
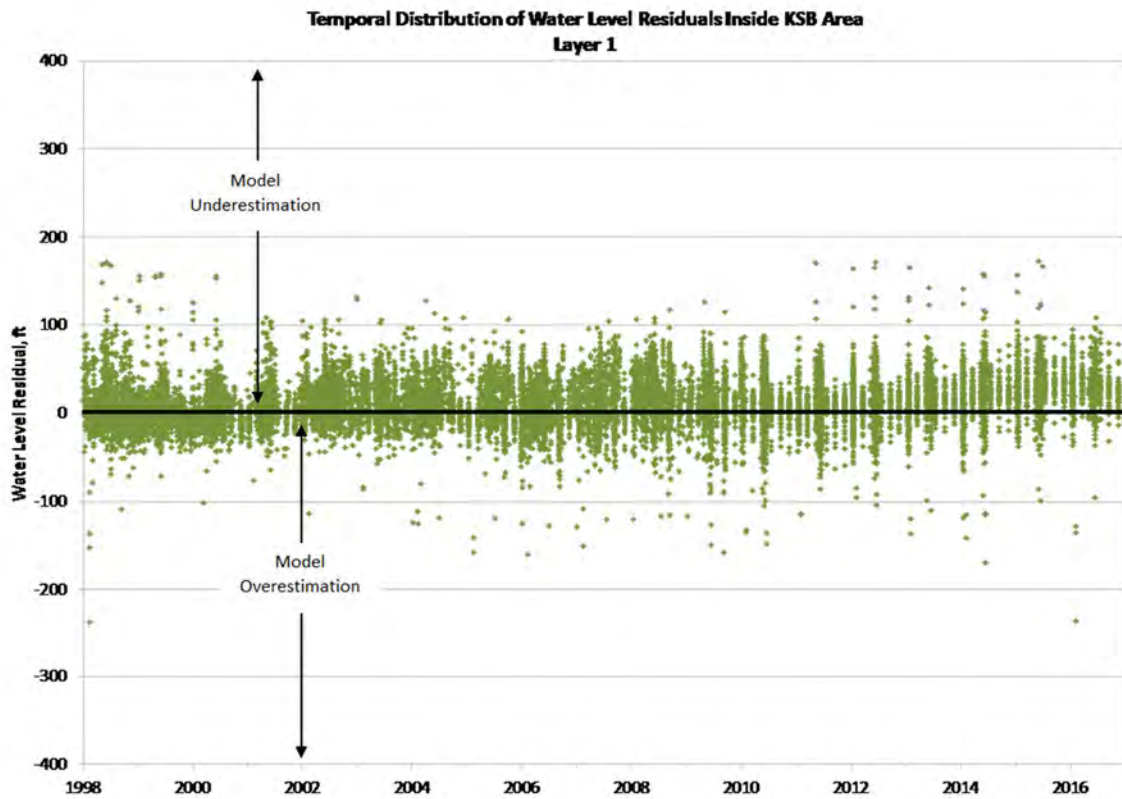
Histogram of Water Level Residual



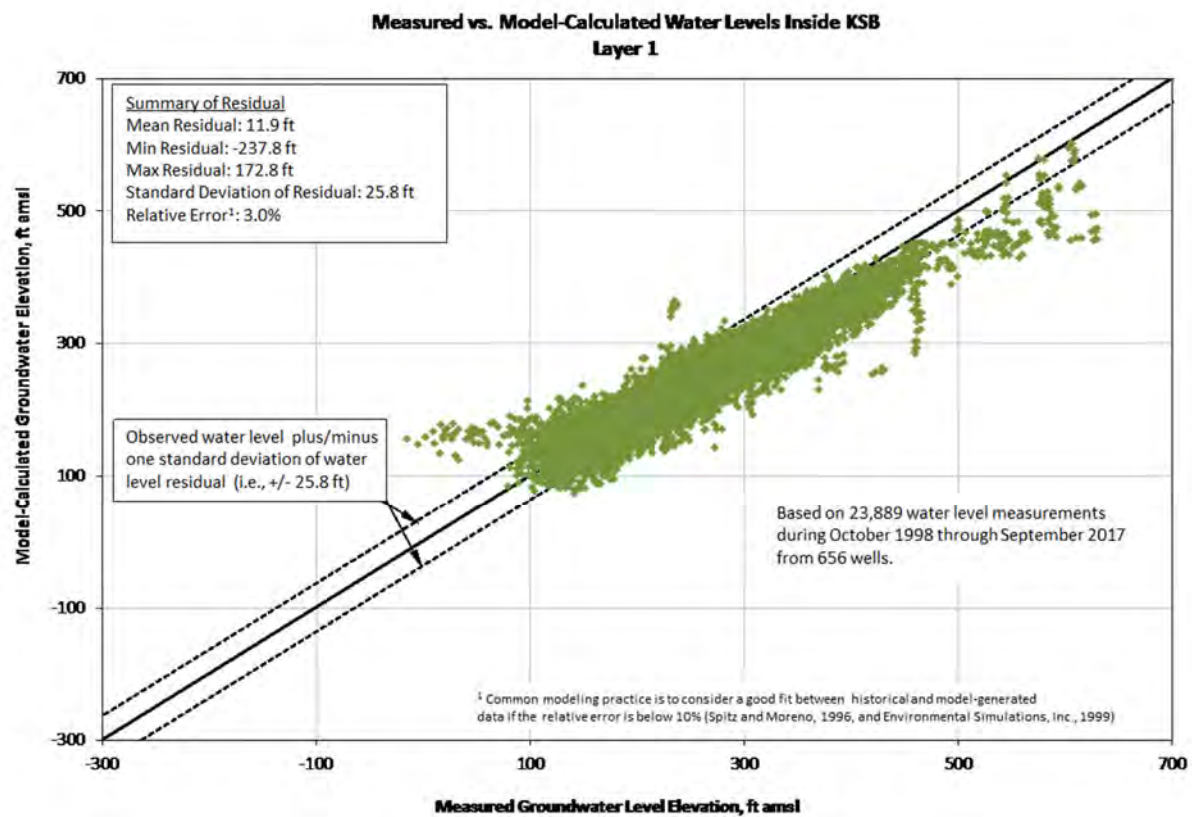
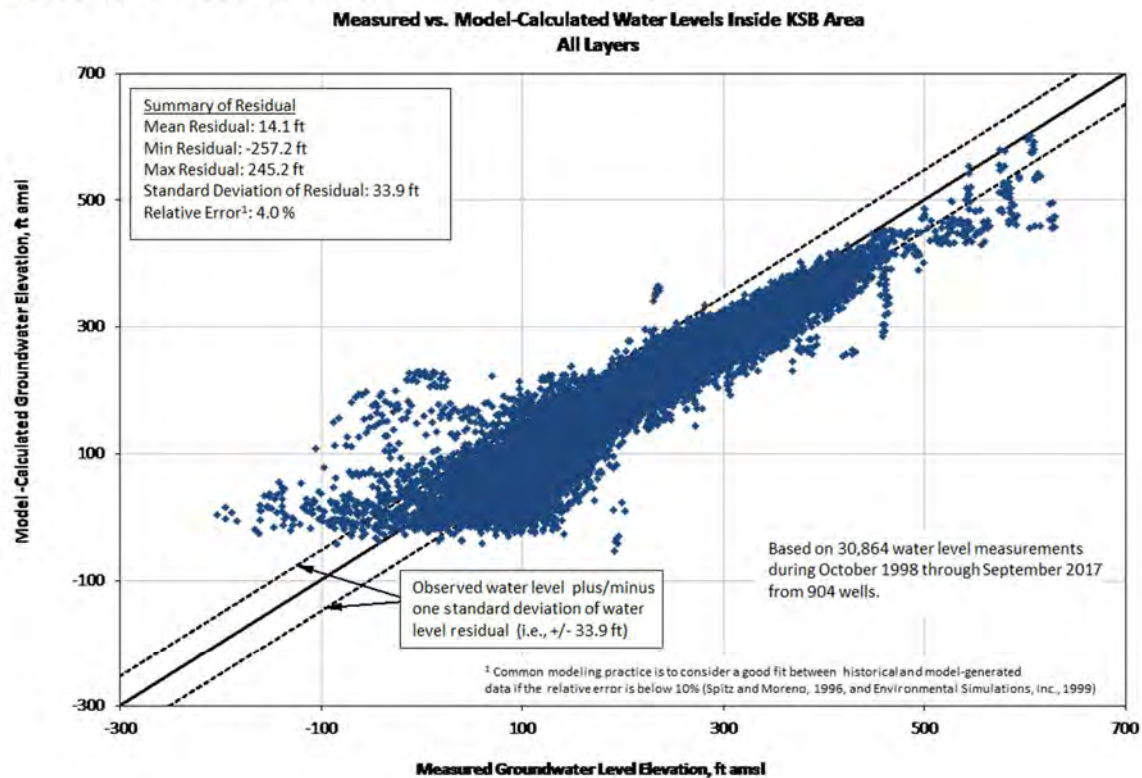


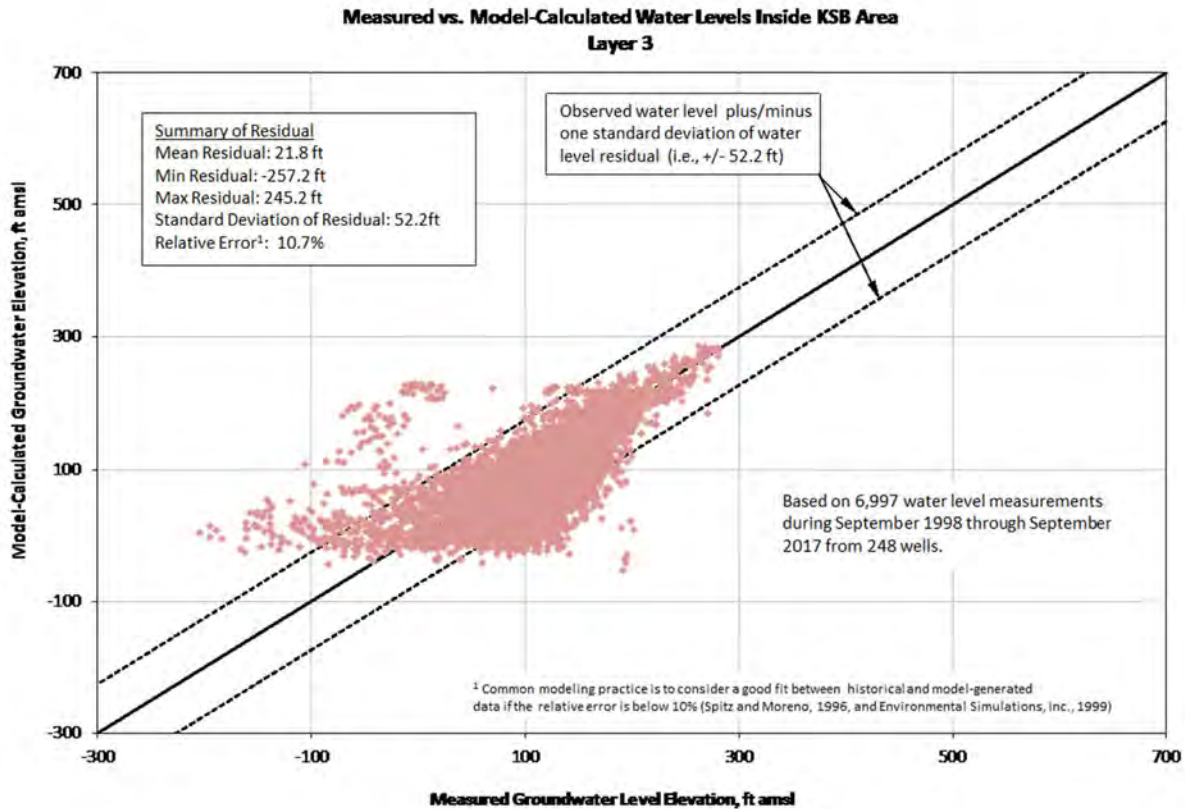
Temporal Distribution of Water Level Residuals





Measured vs Model-Calculated Water Levels





Comparing the Residual Layers

The residual from measured and modeling results are computed for 23,889 water level measurements from 656 wells between October 1998 through September 2017. Based on the values of relative error, we can conclude that there is a good fit between measured and model-generated data since the relative error is 3% in layer 1 and just over 10% in layer 3.

Summary of Residual	KSB Layer 1	KSB Layer 3	All Layers
Mean Residual (ft)	11.9	21.8	
Min Residual (ft)	-237.8	-257.2	
Max Residual (ft)	172.8	245.2	
Standard Dev. of Residual (ft)	25.8	52.2	
Relative Error (%)	3.0	10.7	

**Note common modeling practice is to consider a good fit between historical and model-generated data if the relative error is below 10%. (Spitz and Moreno, 1996, and Environmental Simulation, Inc., 1999)*

Appendix 2: Full Kaweah Subbasin Results

Full Results for Case 1: Base Case of Future with Averaged Conditions and No Projects

Water Year	Inflow (Acre-Feet/Year)			Outflow (Acre-Feet/Year)					Storage	
	Recharge	Underflow Buffer to KSB	Total Inflow	Ag Pumping	Aquifer Discharge to Streams	Non-Ag Pumping	Underflow KSB to Buffer	Total Outflow	Change in Storage (Acre-Feet/Year)	Cumulative Change in Storage (Acre-Feet)
2020	676,105	185,429	861,534	726,105	0	101,360	60,420	887,886	-26,352	-26,352
2021	673,620	203,678	877,298	732,860	0	103,682	59,393	895,935	-18,637	-44,989
2022	673,620	205,414	879,035	739,458	0	106,216	61,291	906,965	-27,930	-72,920
2023	673,620	206,638	880,258	747,097	0	108,525	62,616	918,238	-37,980	-110,900
2024	676,105	208,646	884,751	755,303	0	110,849	63,749	929,901	-45,151	-156,050
2025	673,620	210,193	883,814	761,862	0	113,133	64,127	939,122	-55,309	-211,359
2026	673,620	212,602	886,222	768,886	0	115,649	64,536	949,071	-62,849	-274,208
2027	673,620	215,400	889,020	776,094	0	118,164	64,784	959,042	-70,022	-344,230
2028	676,105	218,919	895,024	782,900	0	120,927	65,156	968,984	-73,960	-418,189
2029	673,620	221,930	895,550	791,008	0	123,195	64,942	979,145	-83,595	-501,784
2030	673,620	225,496	899,117	797,556	0	125,708	64,967	988,231	-89,114	-590,899
2031	673,620	229,677	903,297	800,937	0	127,891	64,713	993,540	-90,244	-681,142
2032	676,099	233,290	909,388	801,646	0	130,418	65,071	997,136	-87,747	-768,890
2033	673,608	236,093	909,701	803,611	0	132,652	64,880	1,001,142	-91,441	-860,330
2034	673,606	239,534	913,140	806,077	0	135,154	64,870	1,006,100	-92,960	-953,291
2035	673,599	242,693	916,292	806,308	0	137,524	64,955	1,008,787	-92,495	-1,045,786
2036	676,068	246,934	923,002	811,192	0	138,989	65,077	1,015,258	-92,256	-1,138,041
2037	673,581	249,855	923,436	812,030	0	139,192	64,817	1,016,039	-92,603	-1,230,644
2038	673,578	253,266	926,844	813,739	0	141,351	64,797	1,019,887	-93,044	-1,323,688
2039	673,572	256,382	929,954	813,325	0	143,285	64,862	1,021,472	-91,518	-1,415,206
2040	676,029	260,125	936,154	815,379	0	142,321	65,149	1,022,849	-86,695	-1,501,901
Average 2020-2040	674,316	226,771	901,087	783,970	0	124,580	64,056	972,606	-71,519	-650,990

Full Results for Case 2: Future with Interannual Variability and No Projects

Water Year	Inflow (Acre-Feet/Year)			Outflow (Acre-Feet/Year)					Storage	
	Recharge	Underflow Buffer to KSB	Total Inflow	Ag Pumping	Aquifer Discharge to Streams	Non-Ag Pumping	Underflow KSB to Buffer	Total Outflow	Change in Storage (Acre- Feet/Year)	Cumulative Change in Storage (Acre-Feet)
2020	927,137	157,959	1,085,096	503,909	0	94,915	68,183	667,008	418,089	418,089
2021	1,186,432	212,662	1,399,094	450,049	44	97,438	47,322	594,852	804,242	1,222,330
2022	602,179	212,753	814,933	635,499	1,805	92,423	37,741	767,469	47,464	1,269,794
2023	688,052	195,456	883,509	677,926	548	92,275	56,153	826,902	56,607	1,326,401
2024	509,897	198,662	708,559	800,353	205	104,082	76,157	980,797	-272,239	1,054,163
2025	563,000	210,854	773,854	838,657	2	112,096	72,617	1,023,371	-249,517	804,646
2026	596,378	211,899	808,276	762,498	74	113,199	86,234	962,005	-153,729	650,917
2027	474,937	220,772	695,709	913,175	282	127,425	80,387	1,121,269	-425,560	225,356
2028	914,170	208,284	1,122,455	549,253	0	113,285	49,995	712,533	409,922	635,278
2029	820,036	183,763	1,003,799	564,464	0	119,950	47,269	731,683	272,116	907,394
2030	462,915	193,897	656,812	1,039,718	791	145,966	96,036	1,282,511	-625,700	281,694
2031	597,824	195,972	793,796	894,045	0	149,384	107,367	1,150,796	-357,000	-75,306
2032	514,239	219,117	733,356	951,074	102	148,989	105,343	1,205,508	-472,152	-547,458
2033	774,102	230,418	1,004,520	658,256	3	140,618	82,814	881,690	122,830	-424,628
2034	950,150	240,907	1,191,058	573,989	0	131,217	53,043	758,248	432,809	8,181
2035	496,704	243,265	739,969	972,719	959	147,809	91,836	1,213,323	-473,354	-465,173
2036	569,699	264,392	834,091	1,106,537	120	151,409	101,256	1,359,323	-525,232	-990,405
2037	407,524	274,466	681,990	1,185,193	99	144,434	80,170	1,409,897	-727,907	-1,718,312
2038	390,111	279,092	669,202	1,110,319	0	130,837	74,606	1,315,762	-646,559	-2,364,871
2039	536,273	259,803	796,076	822,968	15	125,676	82,866	1,031,525	-235,449	-2,600,320
2040	1,190,394	292,662	1,483,056	502,512	43	126,799	69,085	698,439	784,616	-1,815,704
Average 2020-2040	674,864	224,146	899,010	786,339	242	124,297	74,594	985,472	-86,462	-104,663

Full Results for Case 3: Future with Interannual Variability Reversed and No Projects

Water Year	Inflow (Acre-Feet/Year)			Outflow (Acre-Feet/Year)					Storage	
	Recharge	Underflow Buffer to KSB	Total Inflow	Ag Pumping	Recharge	Non-Ag Pumping	Underflow KSB to Buffer	Total Outflow	Change in Storage (Acre- Feet/Year)	Cumulative Change in Storage (Acre-Feet)
2020	1,191,324	173,864	1,365,188	507,156	43	143,667	103,103	753,969	611,219	611,219
2021	536,675	139,383	676,058	825,712	15	138,916	128,162	1,092,805	-416,747	194,472
2022	390,020	204,314	594,334	1,111,323	0	134,171	86,604	1,332,097	-737,764	-543,292
2023	407,240	252,324	659,565	1,185,336	99	145,928	73,509	1,404,873	-745,308	-1,288,600
2024	569,142	293,988	863,131	1,106,310	120	152,440	77,974	1,336,844	-473,714	-1,762,313
2025	496,017	328,383	824,400	972,217	959	144,469	59,633	1,177,277	-352,877	-2,115,190
2026	949,363	307,692	1,257,054	573,330	0	127,457	40,626	741,413	515,641	-1,599,549
2027	773,345	238,922	1,012,267	657,424	3	135,945	85,382	878,754	133,513	-1,466,036
2028	513,644	247,525	761,169	949,938	102	142,955	91,055	1,184,050	-422,881	-1,888,917
2029	596,916	276,709	873,624	892,780	0	141,484	73,496	1,107,761	-234,136	-2,123,053
2030	462,063	335,951	798,013	1,036,097	791	140,731	53,233	1,230,852	-432,839	-2,555,892
2031	818,253	341,336	1,159,589	559,479	0	115,896	30,396	705,771	453,818	-2,102,074
2032	912,126	287,218	1,199,344	544,284	0	109,023	43,026	696,332	503,011	-1,599,063
2033	473,254	287,541	760,795	905,896	282	123,092	66,352	1,095,623	-334,828	-1,933,891
2034	594,562	305,782	900,344	755,785	74	109,375	61,840	927,074	-26,730	-1,960,621
2035	560,653	319,746	880,399	831,448	2	110,548	48,648	990,645	-110,247	-2,070,868
2036	507,841	332,929	840,771	792,976	205	103,656	50,825	947,661	-106,890	-2,177,758
2037	684,705	338,231	1,022,937	670,552	548	91,453	36,860	799,412	223,524	-1,954,233
2038	600,005	328,445	928,450	628,835	1,805	91,473	26,874	748,988	179,462	-1,774,771
2039	1,183,943	215,572	1,399,515	443,711	44	94,145	75,152	613,051	786,464	-988,307
2040	924,327	165,600	1,089,927	498,108	0	91,431	100,732	690,270	399,657	-588,650
Average 2020-2040	673,591	272,450	946,042	783,271	242	123,250	67,309	974,073	-28,031	-1,508,923

Full Results for Case 4: Altered Future with Management Actions

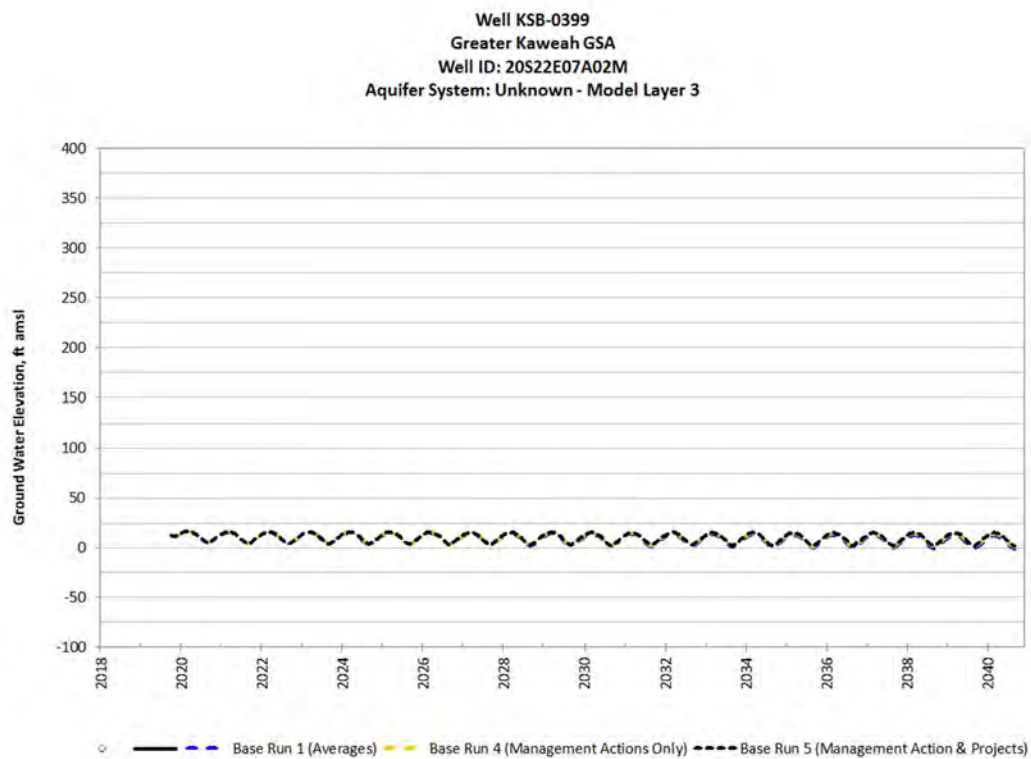
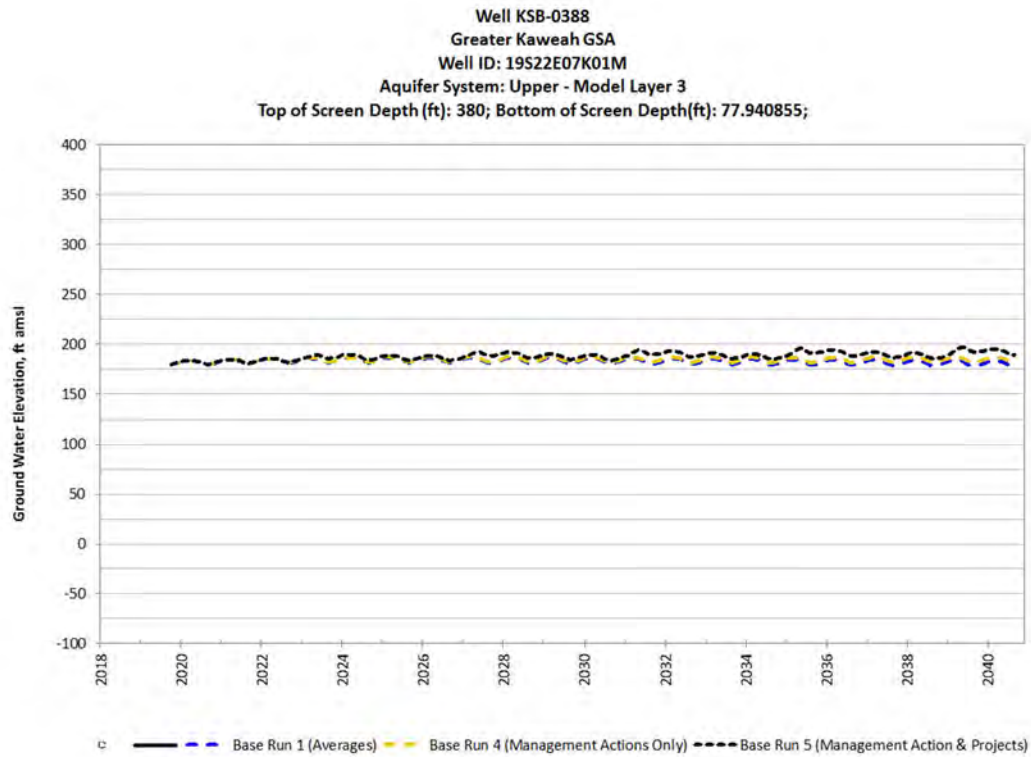
Water Year	Inflow (Acre-Feet/Year)			Outflow (Acre-Feet/Year)					Change in Storage	
	Recharge	Underflow Buffer to KSB	Total Inflow	Ag Pumping	Recharge	Non-Ag Pumping	Underflow KSB to Buffer	Total Outflow	Change in Storage (Acre-Feet/Year)	Cumulative Change in Storage (Acre-Feet)
2020	681,104	184,922	866,026	722,860	0	101,360	60,625	884,845	-18,819	-18,819
2021	678,620	202,314	880,934	726,854	0	103,682	59,930	890,466	-9,533	-28,351
2022	678,620	203,514	882,134	733,956	0	106,216	62,002	902,174	-20,041	-48,392
2023	678,620	203,884	882,504	737,608	0	108,525	63,549	909,682	-27,178	-75,570
2024	681,103	205,774	886,877	749,801	0	110,849	64,740	925,390	-38,513	-114,083
2025	678,619	206,575	885,194	749,246	0	113,133	65,350	927,730	-42,536	-156,619
2026	678,619	206,752	885,371	743,893	0	115,649	66,298	925,840	-40,469	-197,088
2027	678,619	208,208	886,826	750,498	0	118,164	66,838	935,499	-48,673	-245,761
2028	681,103	210,711	891,814	756,665	0	120,927	67,448	945,041	-53,226	-298,988
2029	678,619	212,763	891,381	764,160	0	123,195	67,480	954,835	-63,454	-362,441
2030	678,619	215,014	893,632	761,110	0	125,708	67,757	954,574	-60,942	-423,384
2031	678,619	215,454	894,073	744,144	0	128,224	68,307	940,675	-46,602	-469,986
2032	681,103	216,576	897,680	744,268	0	130,665	69,183	944,117	-46,437	-516,423
2033	678,619	217,589	896,208	745,654	0	132,652	69,351	947,657	-51,450	-567,872
2034	678,619	219,522	898,140	747,494	0	135,154	69,585	952,233	-54,092	-621,965
2035	678,619	220,782	899,400	735,676	0	137,654	69,988	943,317	-43,917	-665,881
2036	681,103	219,464	900,567	711,641	0	140,439	71,296	923,376	-22,809	-688,691
2037	678,617	218,732	897,349	711,957	0	142,655	71,750	926,363	-29,014	-717,705
2038	678,617	219,591	898,208	712,953	0	144,381	72,133	929,467	-31,259	-748,964
2039	678,617	220,552	899,169	711,698	0	145,124	72,518	929,340	-30,171	-779,135
2040	681,102	222,282	903,384	713,679	0	147,871	73,135	934,686	-31,301	-810,436
Average 2020-2040	679,328	211,951	891,280	736,944	0	125,344	67,584	929,872	-38,592	-407,455

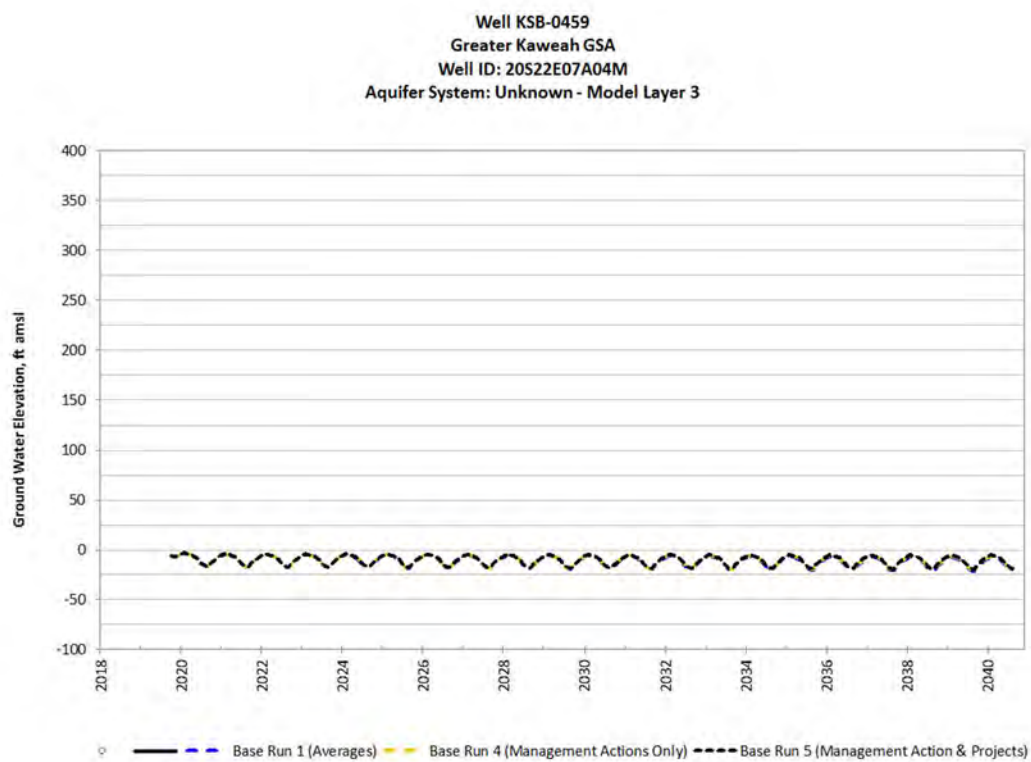
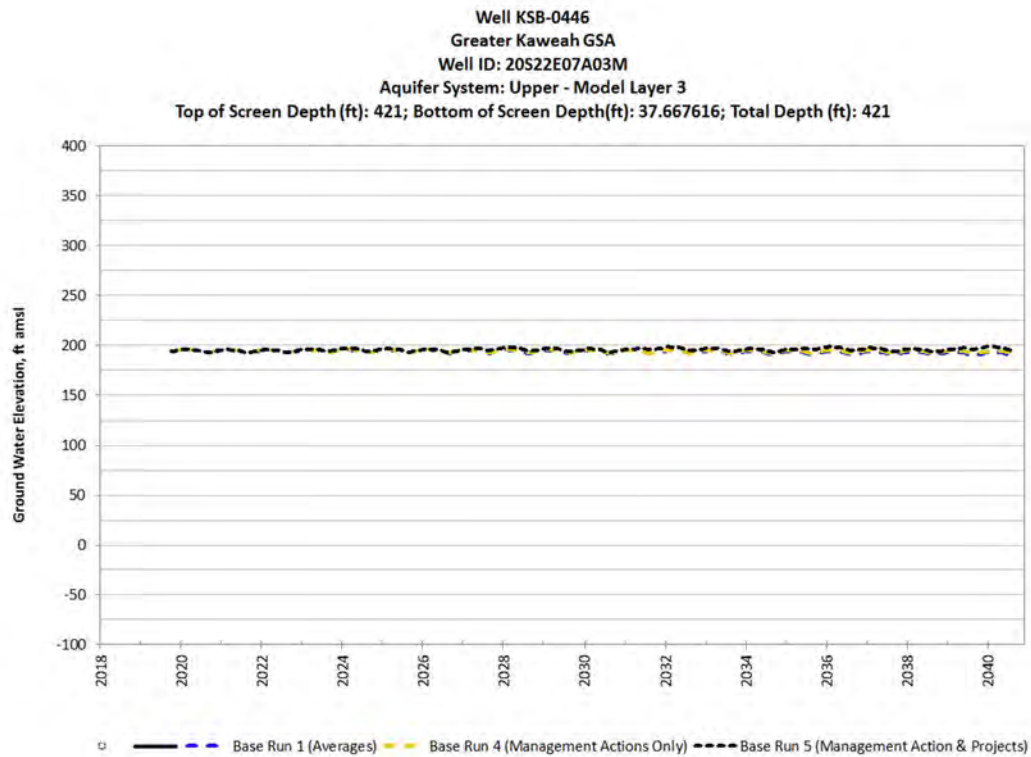
Full Results for Case 5: Altered Future with Management Actions and Projects

Water Year	Inflow (Acre-Feet/Year)			Outflow (Acre-Feet/Year)				Change in Storage (Acre-Feet/Year)	
	Recharge	Underflow Buffer to KSB	Total Inflow	Ag Pumping	Non-Ag Pumping	Underflow KSB to Buffer	Total Outflow	Change In Storage (Acre-Feet/Year)	Cumulative Change in Storage (Acre-Feet)
2020	693,019	184,909	877,928	722,860	102,029	60,664	885,553	-7,625	-7,625
2021	692,081	201,840	893,921	726,854	103,847	60,091	890,792	3,129	-4,496
2022	695,135	202,679	897,814	733,956	106,285	62,280	902,522	-4,708	-9,203
2023	754,786	195,768	950,555	737,608	108,573	66,823	913,005	37,550	28,347
2024	700,811	197,706	898,518	749,801	110,894	66,641	927,335	-28,817	-470
2025	703,322	200,034	903,356	752,178	113,174	66,866	932,218	-28,862	-29,332
2026	712,321	200,571	912,892	747,271	115,688	67,844	930,802	-17,911	-47,243
2027	785,165	194,160	979,325	754,312	118,204	73,946	946,461	32,864	-14,379
2028	714,945	196,846	911,791	760,919	120,970	71,326	953,215	-41,424	-55,803
2029	712,463	201,420	913,883	768,855	123,239	70,436	962,530	-48,646	-104,449
2030	717,464	204,861	922,324	771,713	125,753	70,521	967,988	-45,663	-150,112
2031	801,229	197,492	998,722	755,179	128,271	78,944	962,394	36,328	-113,784
2032	720,097	198,739	918,836	755,733	131,062	74,994	961,789	-42,952	-156,737
2033	717,619	202,972	920,591	757,560	133,316	73,816	964,691	-44,100	-200,837
2034	717,626	206,231	923,858	759,855	135,482	73,658	968,996	-45,138	-245,975
2035	811,166	200,103	1,011,270	756,425	137,733	83,881	978,039	33,231	-212,744
2036	720,276	199,062	919,338	732,921	140,537	78,918	952,376	-33,038	-245,782
2037	717,812	202,242	920,054	733,653	142,773	77,386	953,812	-33,758	-279,540
2038	717,828	204,926	922,753	735,098	145,291	77,091	957,480	-34,727	-314,267
2039	814,808	199,028	1,013,835	734,198	147,012	88,871	970,081	43,754	-270,513
2040	720,268	200,596	920,864	736,631	147,962	82,129	966,721	-45,857	-316,370

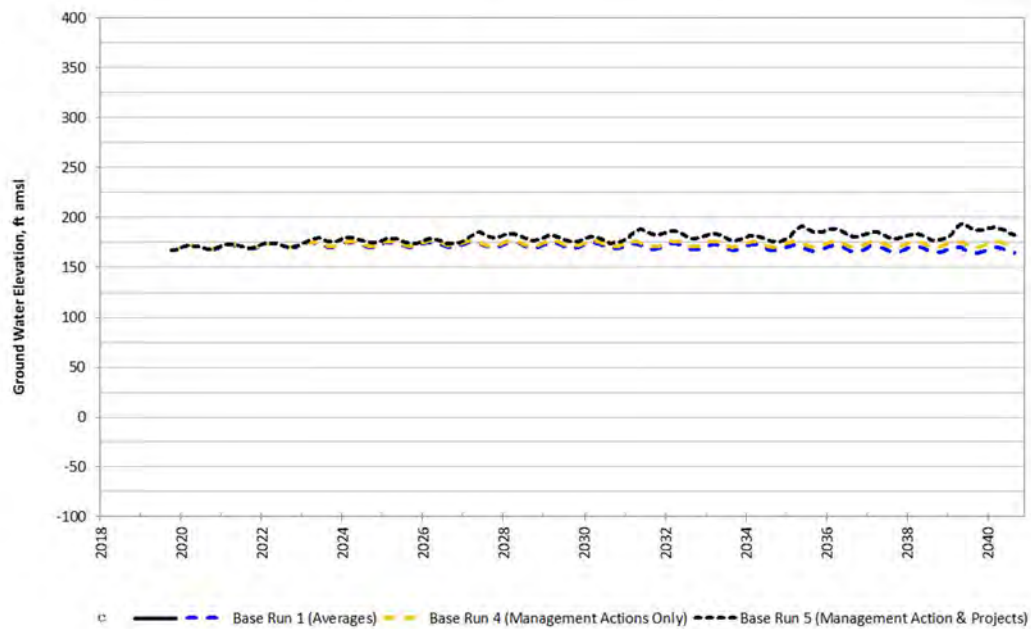
Average 2020-2040	730,488	199,628	930,116	746,837	125,624	72,720	945,181	-15,065	-131,015
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Appendix 3: Modeling Results for Monitoring Wells

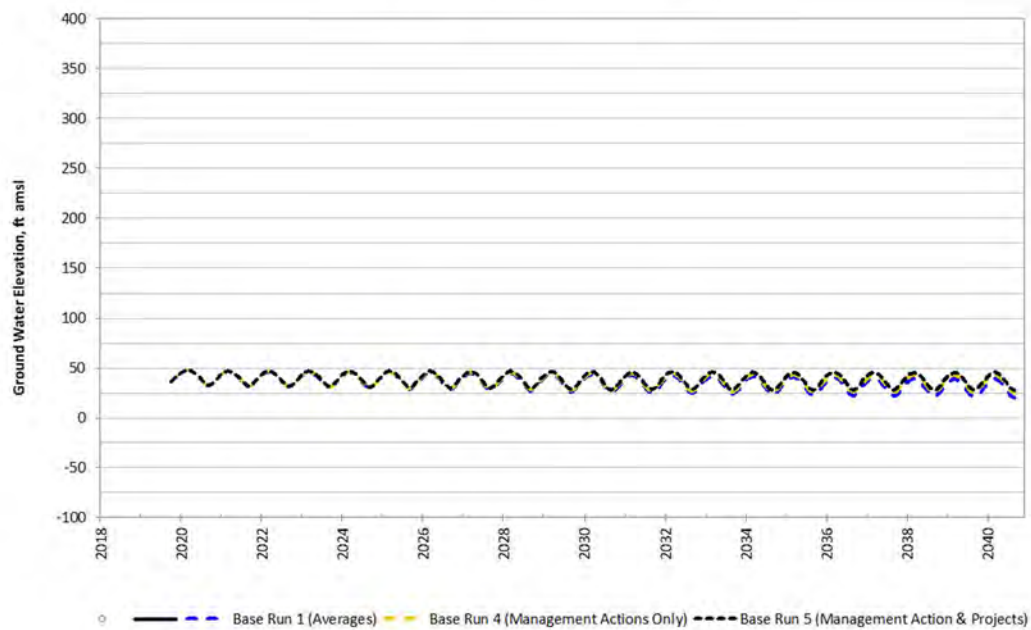




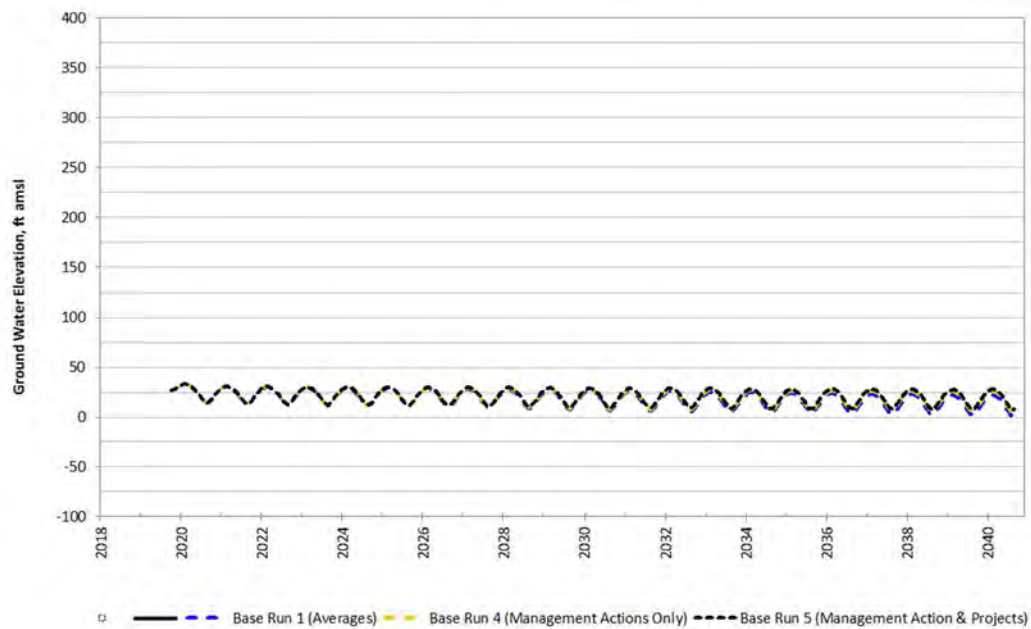
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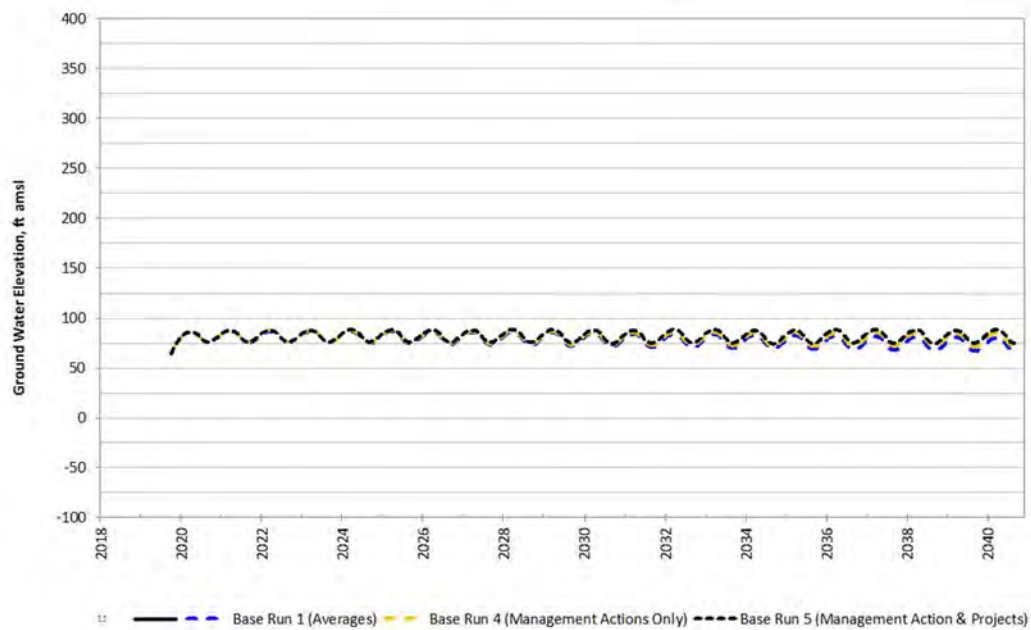
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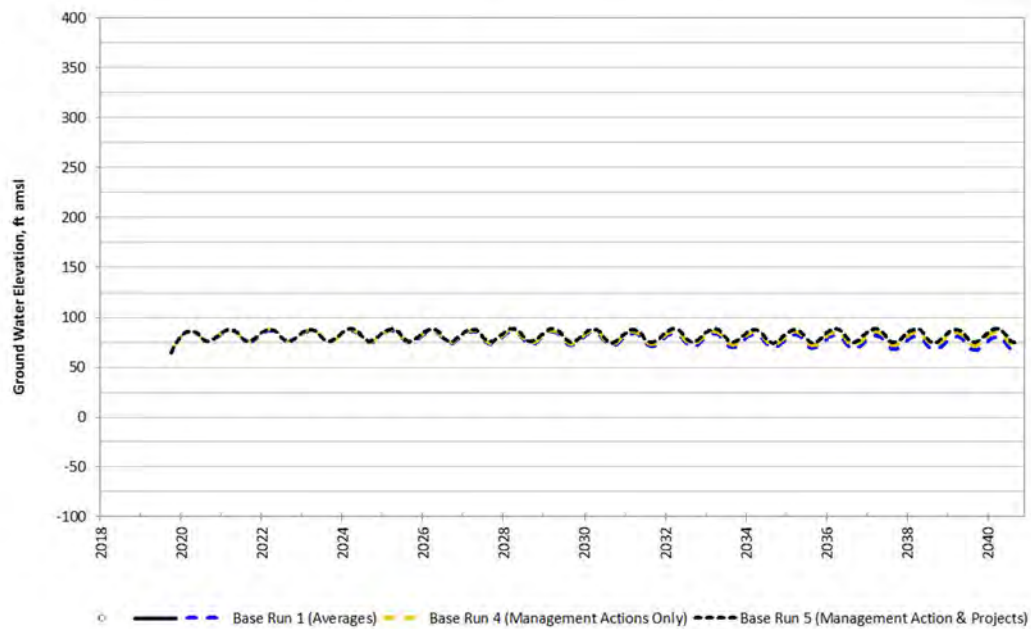
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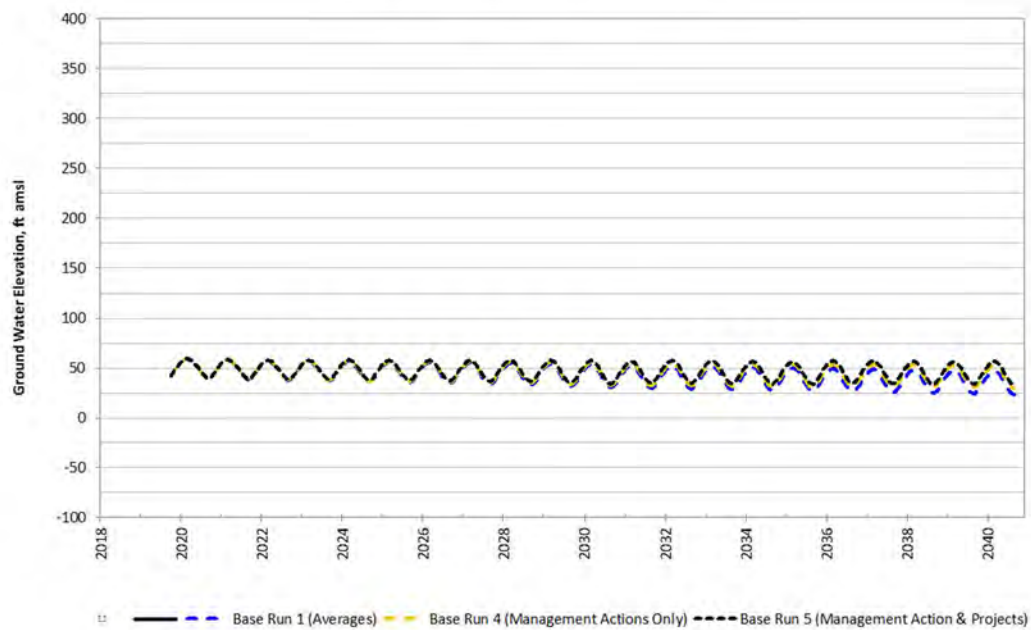
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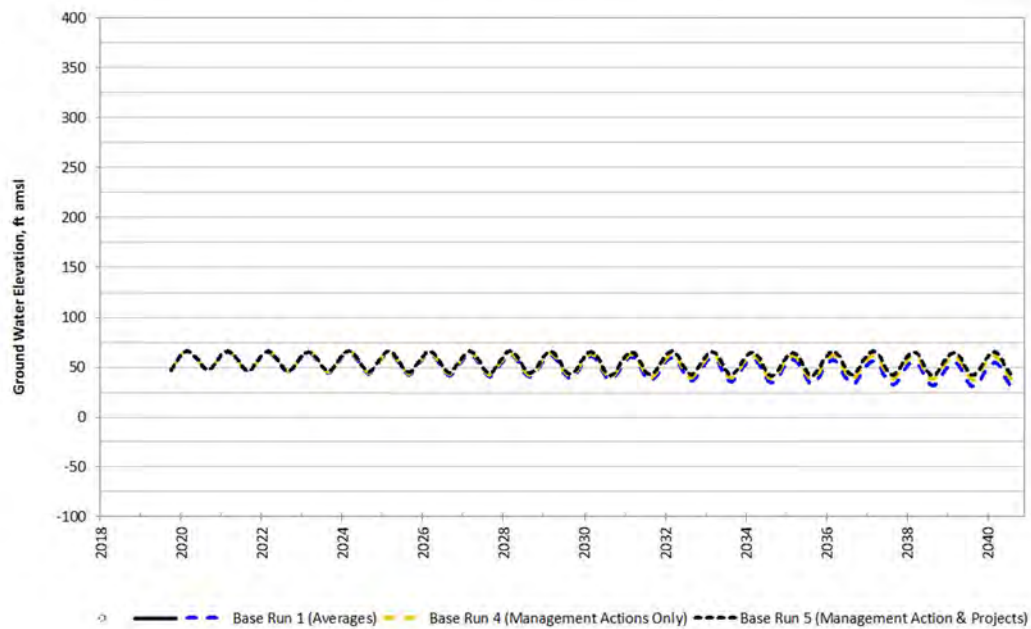
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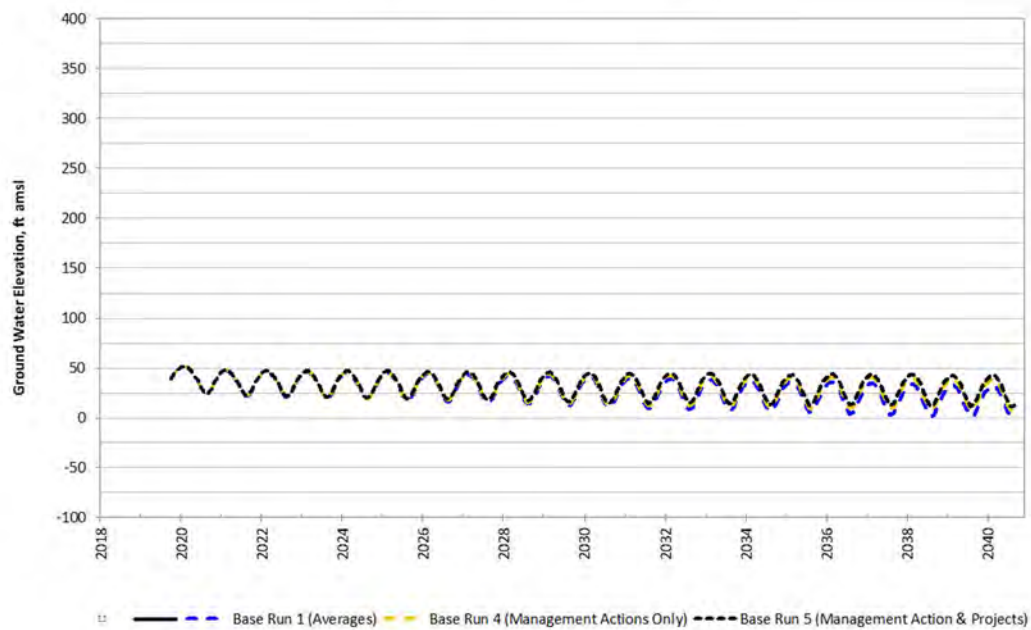
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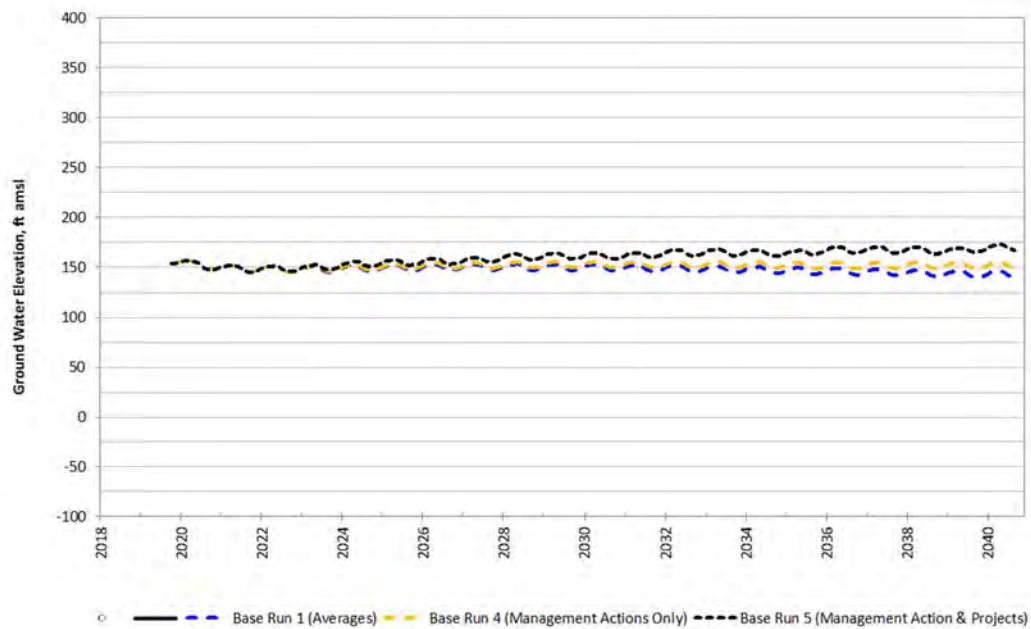
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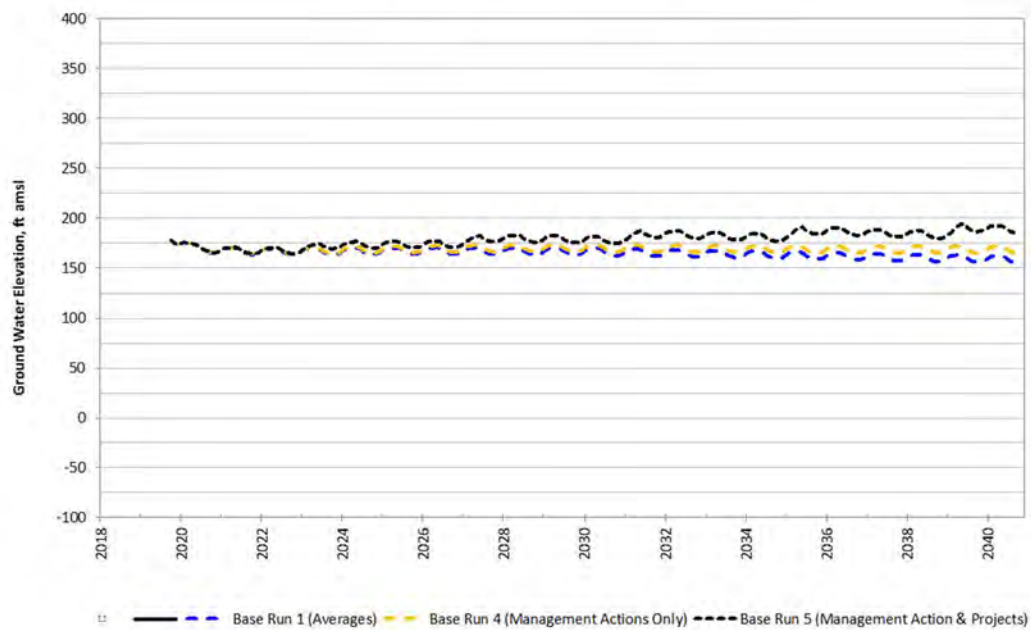
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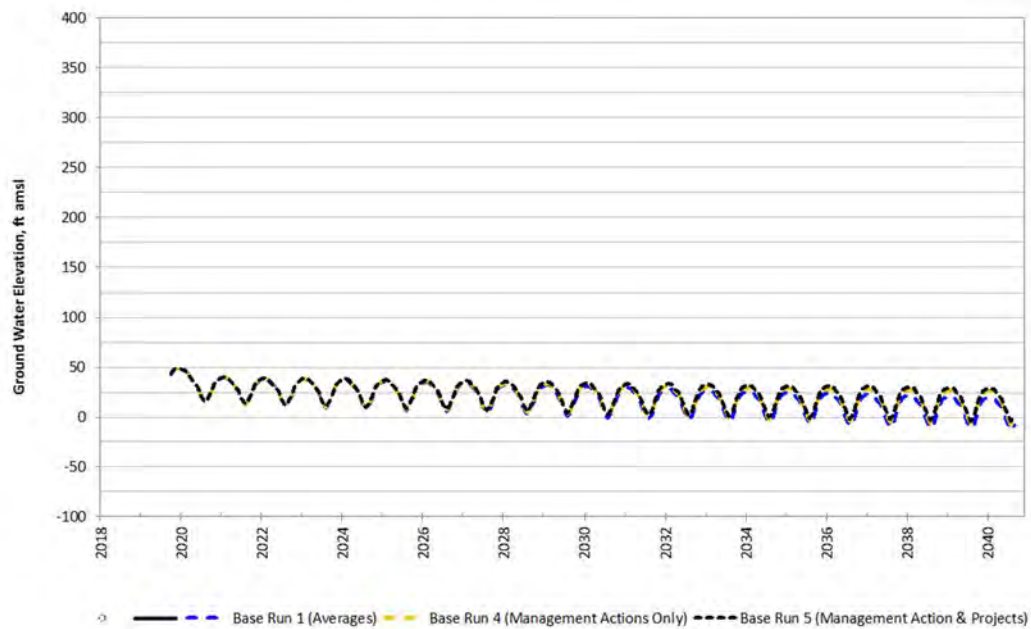
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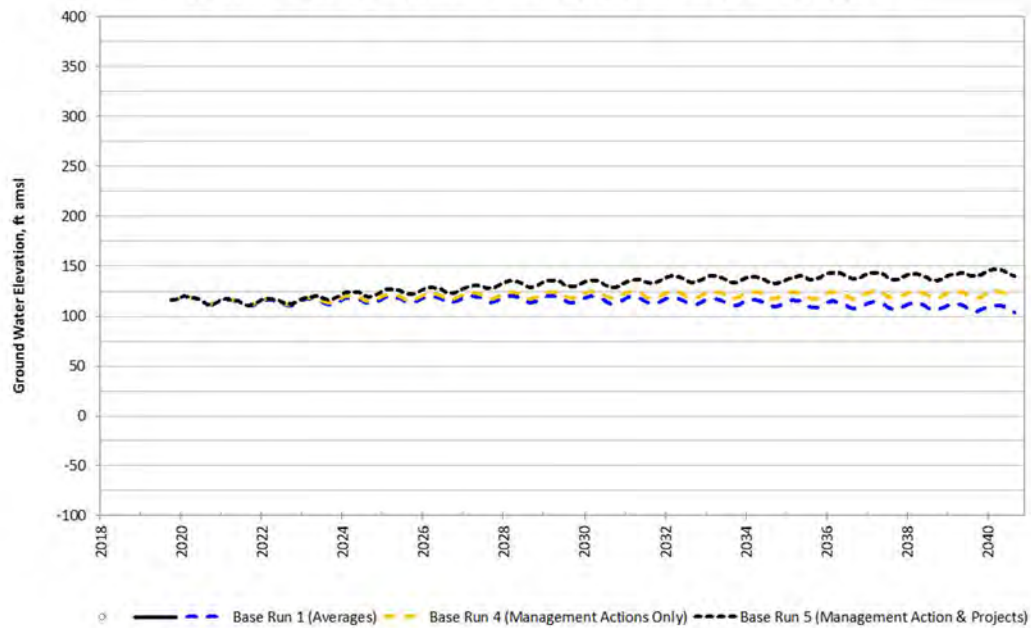
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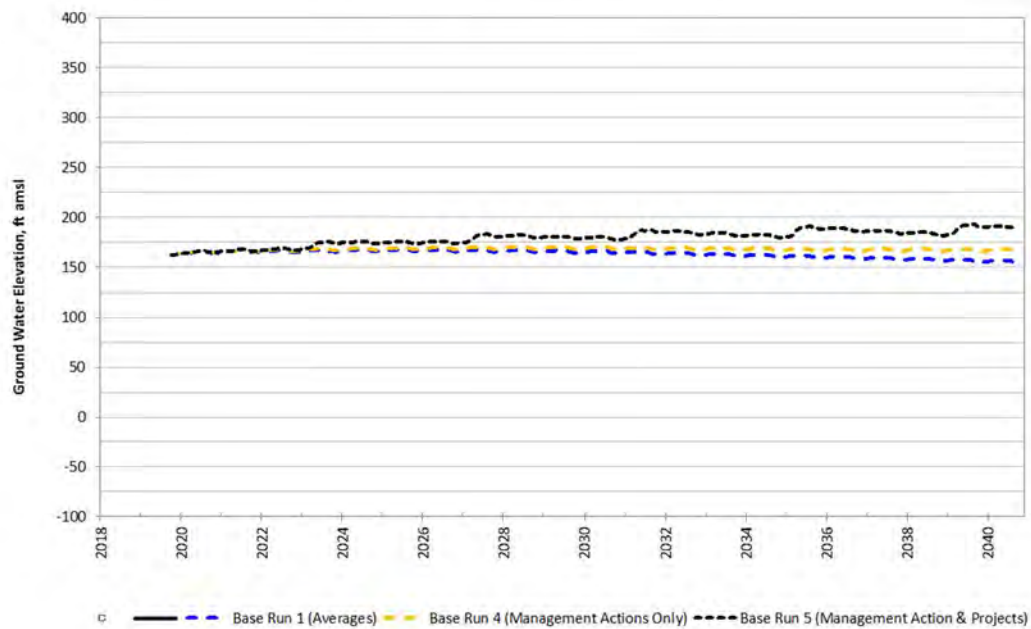
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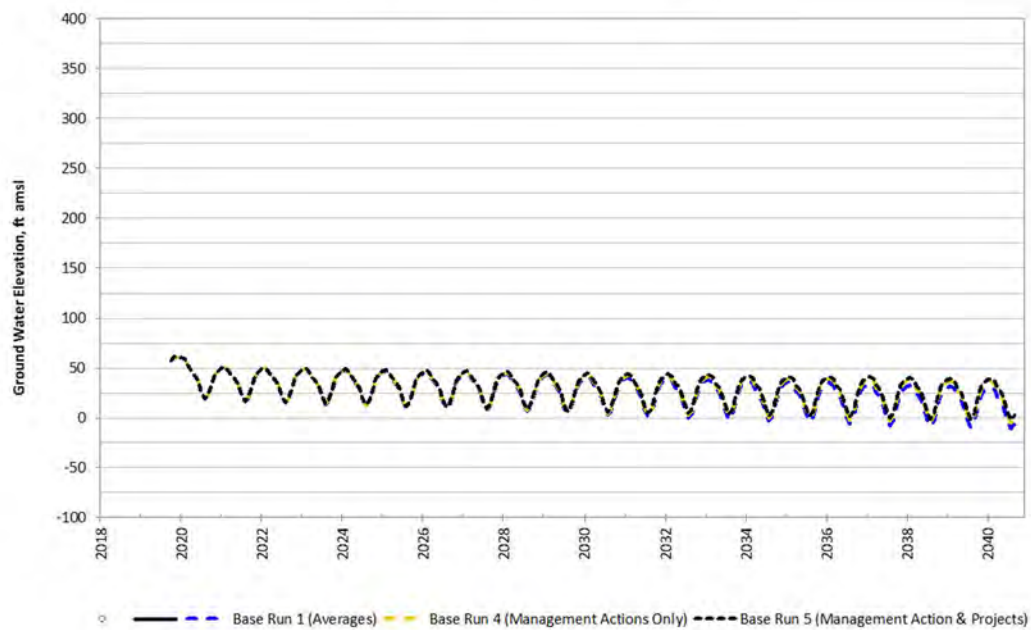
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Top of Screen Depth (ft): 360; Bottom of Screen Depth(ft): 42.369663; Total Depth (ft): 362



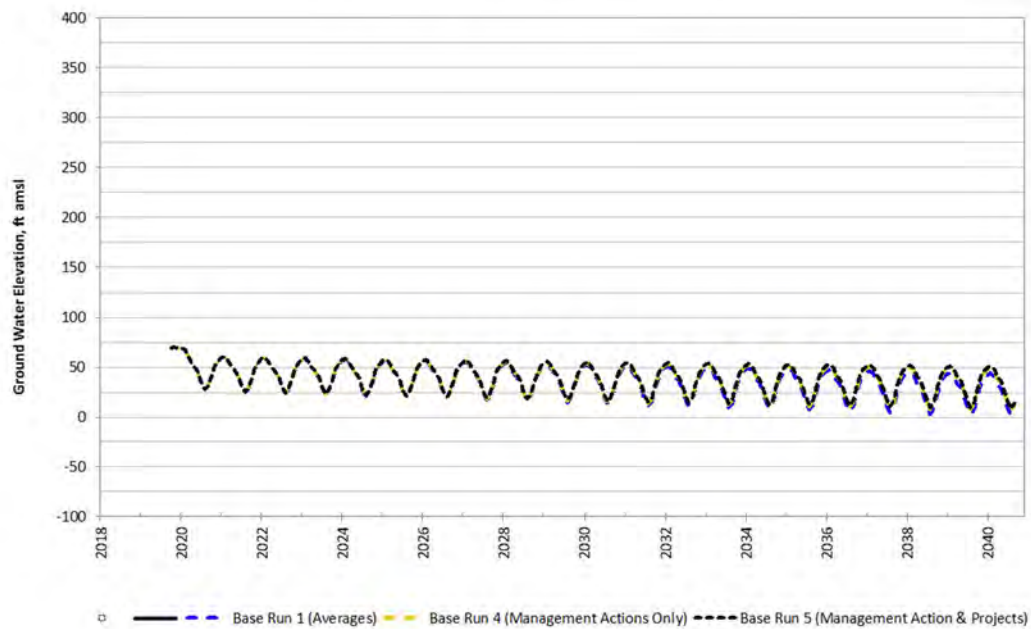
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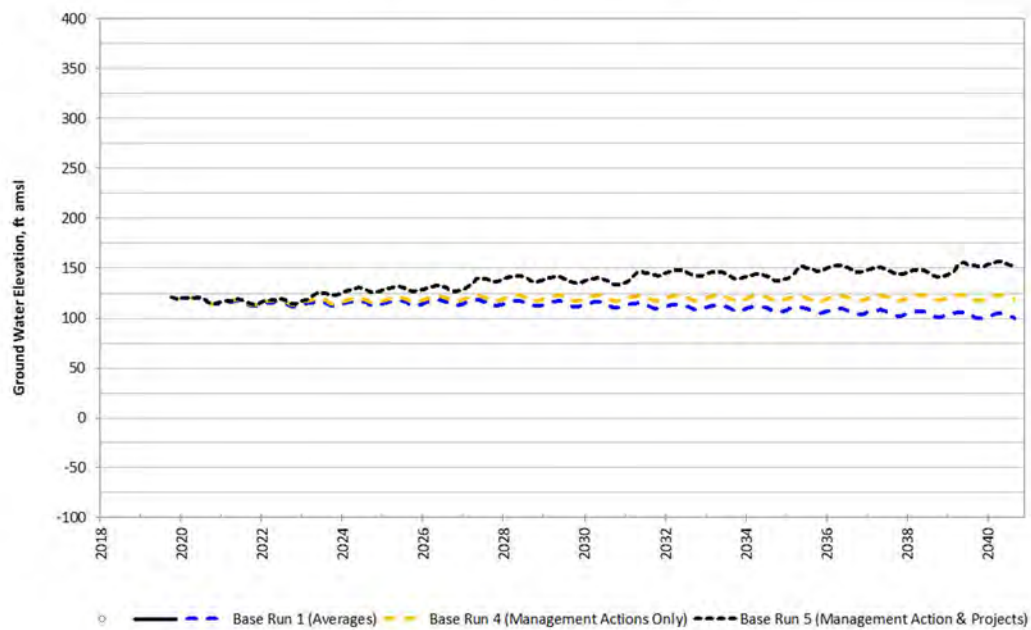
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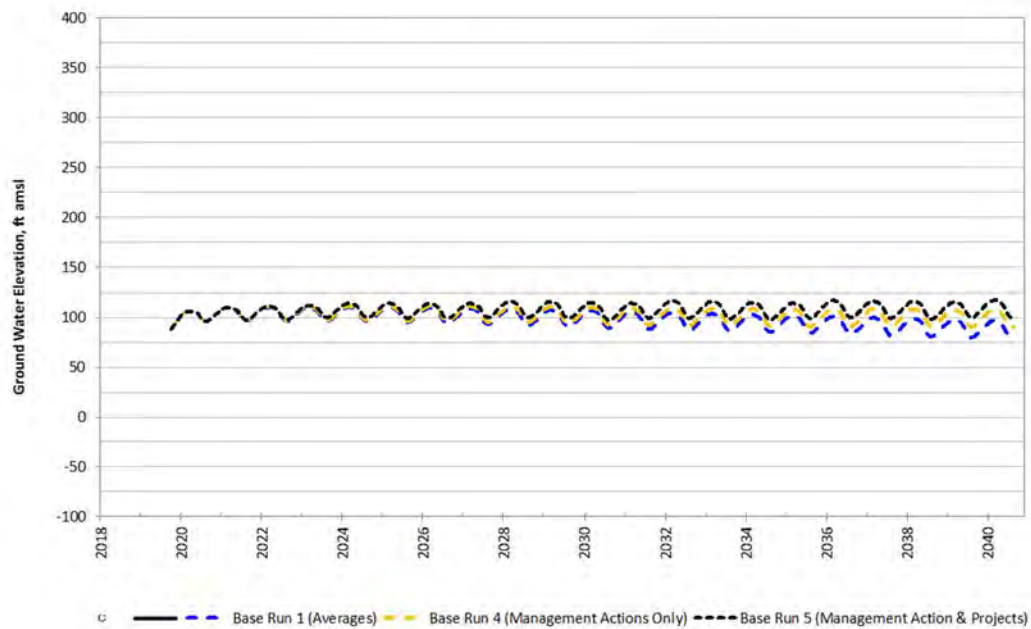
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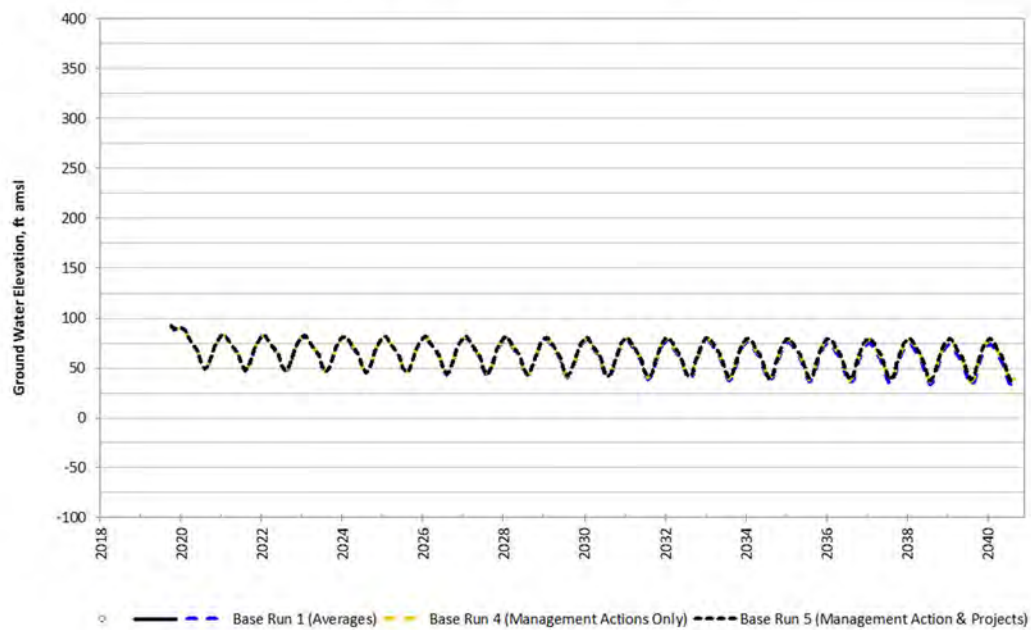
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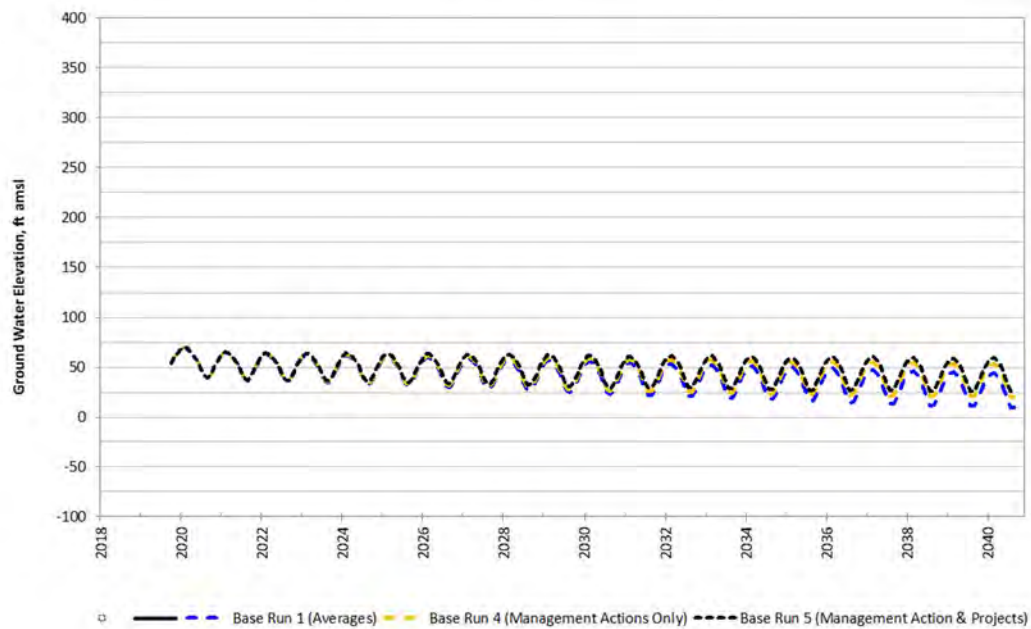
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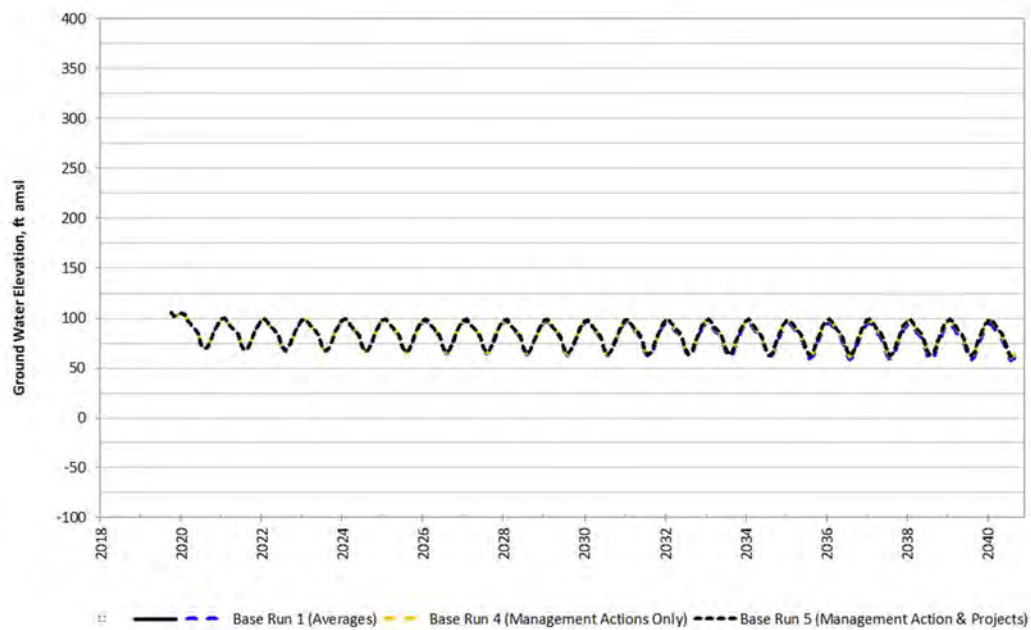
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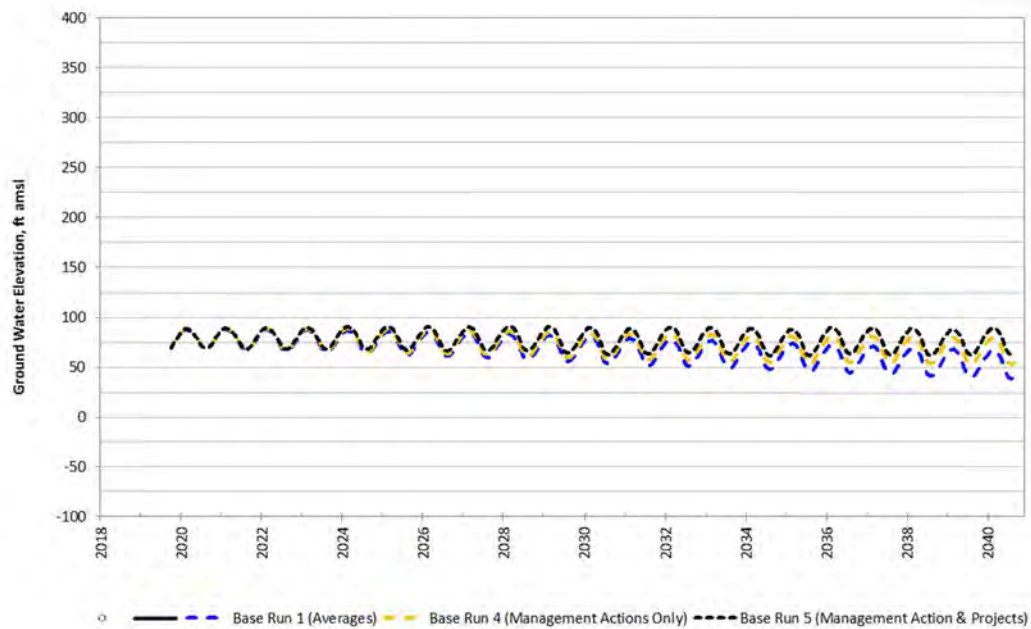
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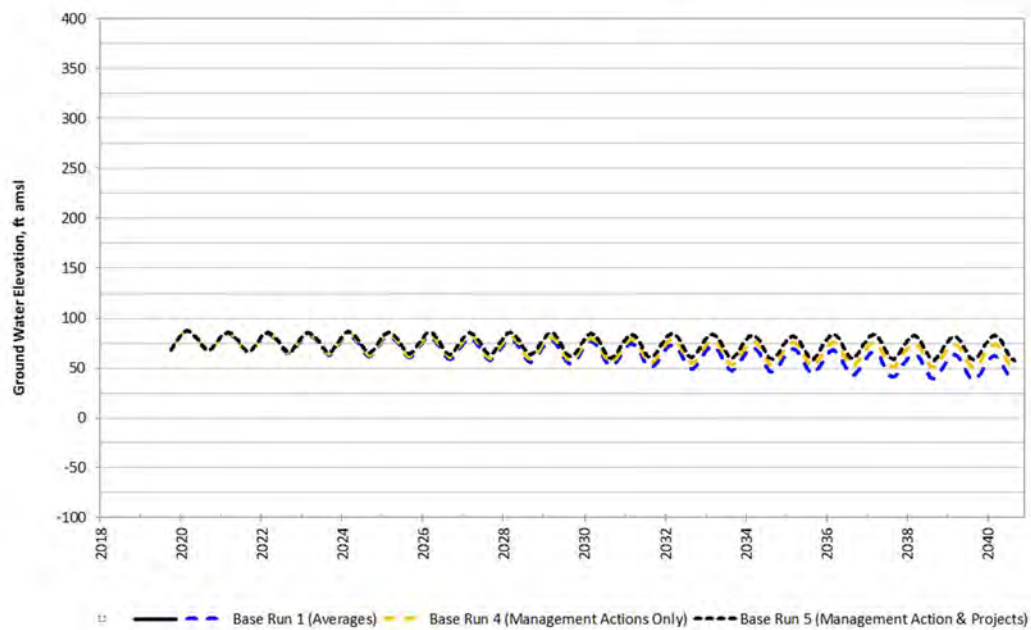
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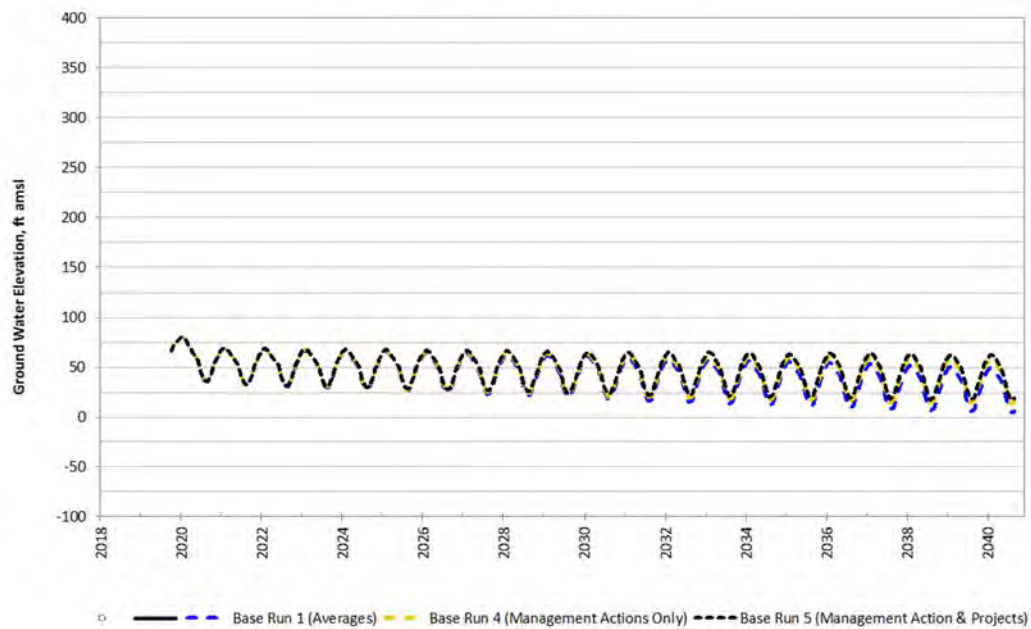
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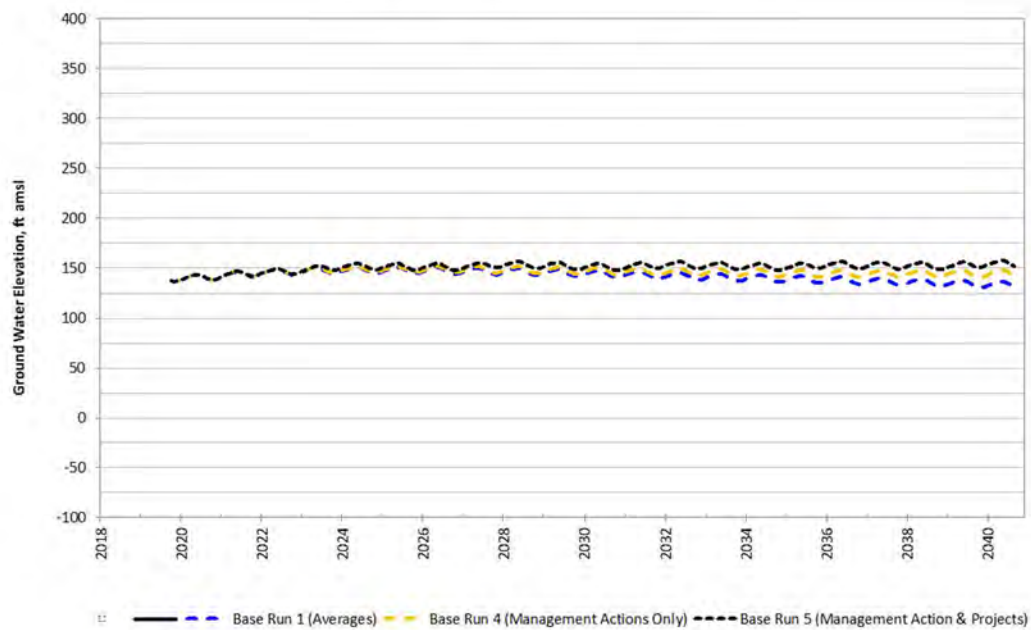
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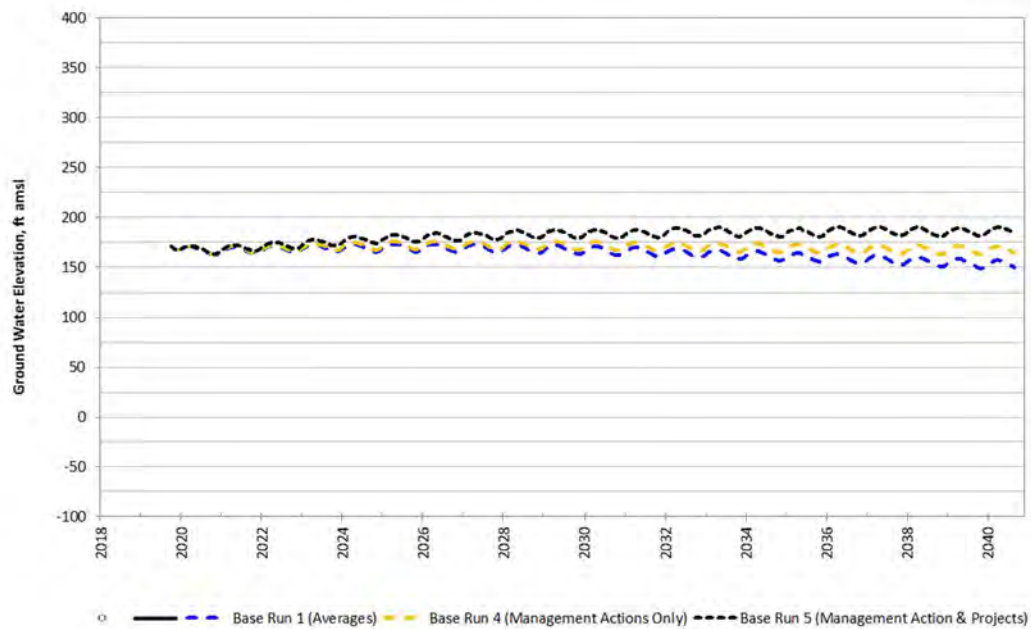
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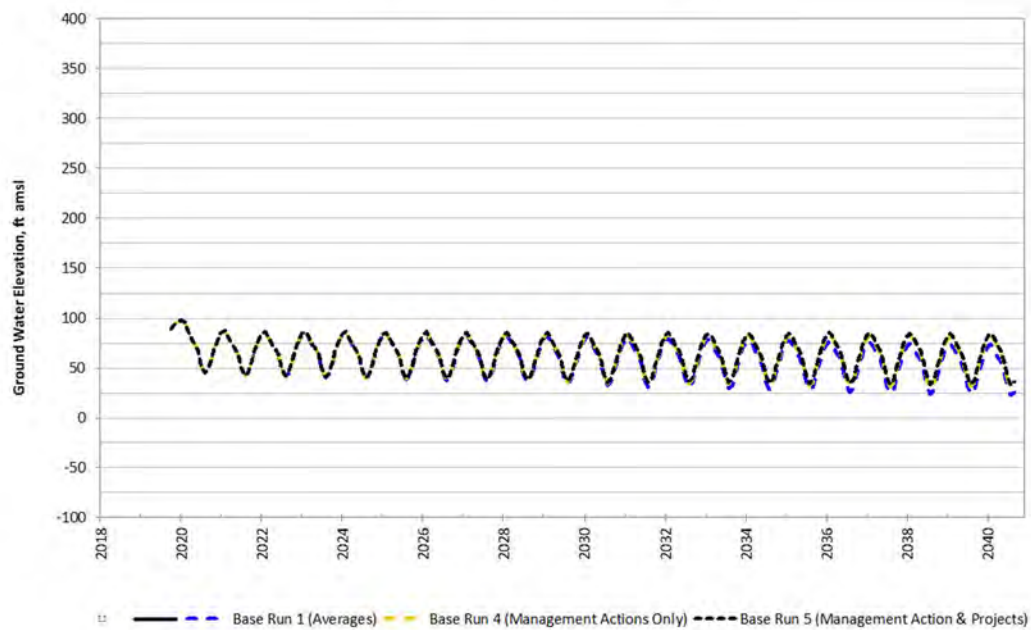
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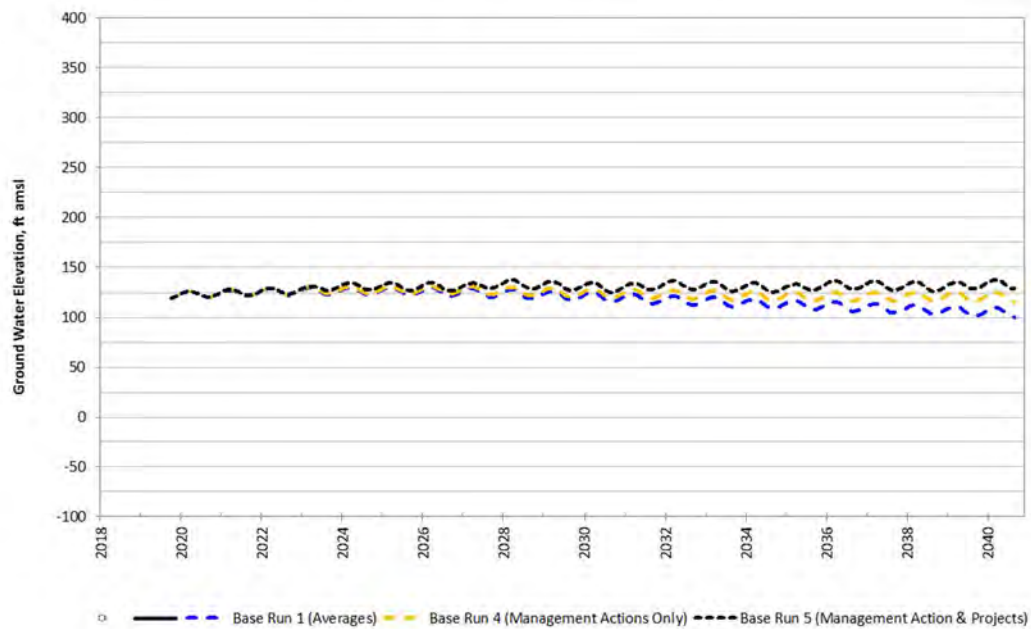
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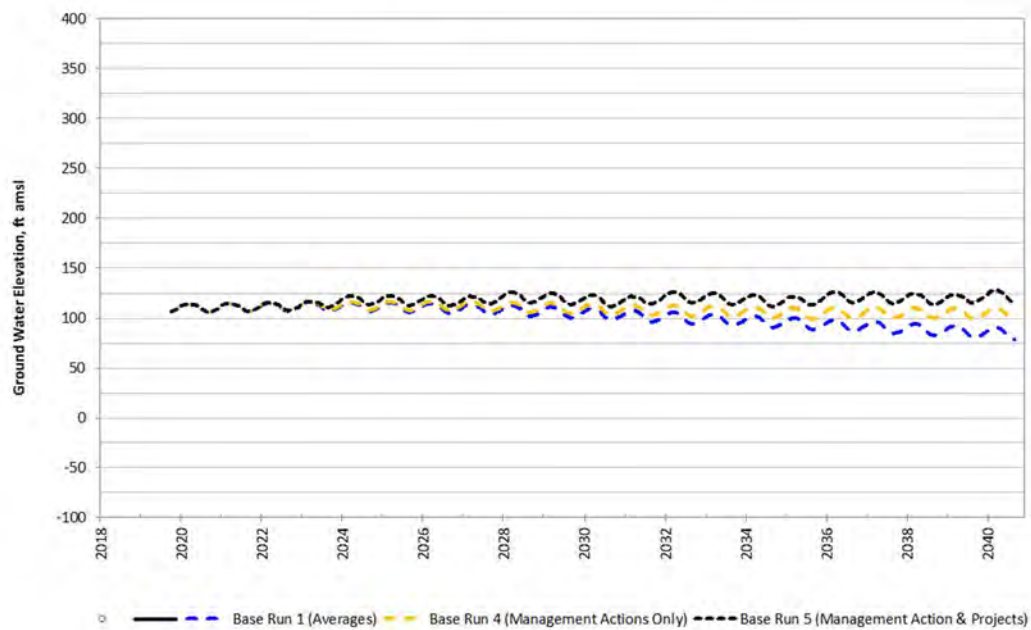
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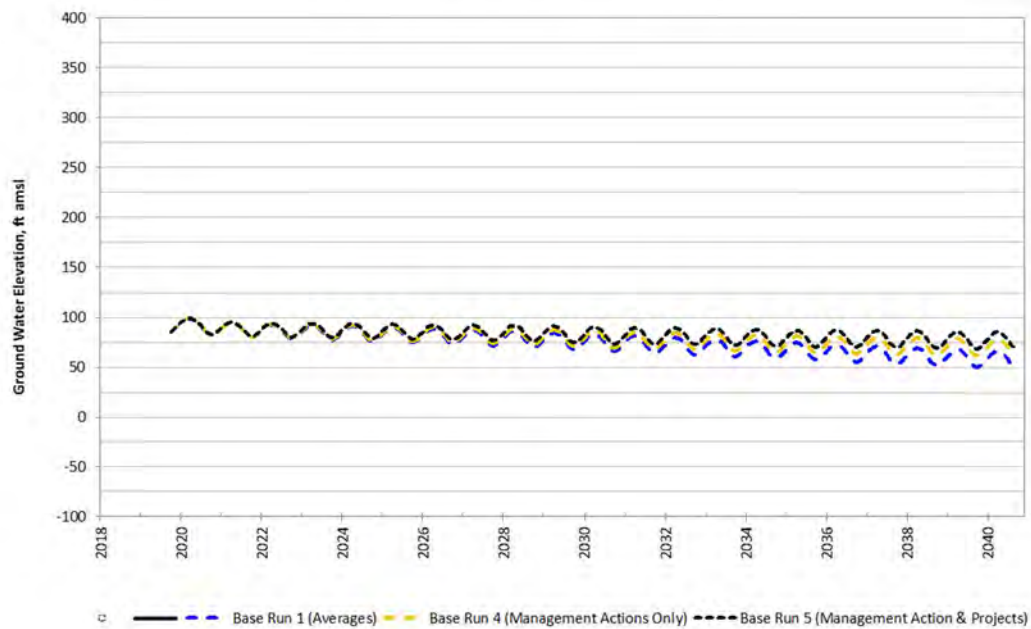
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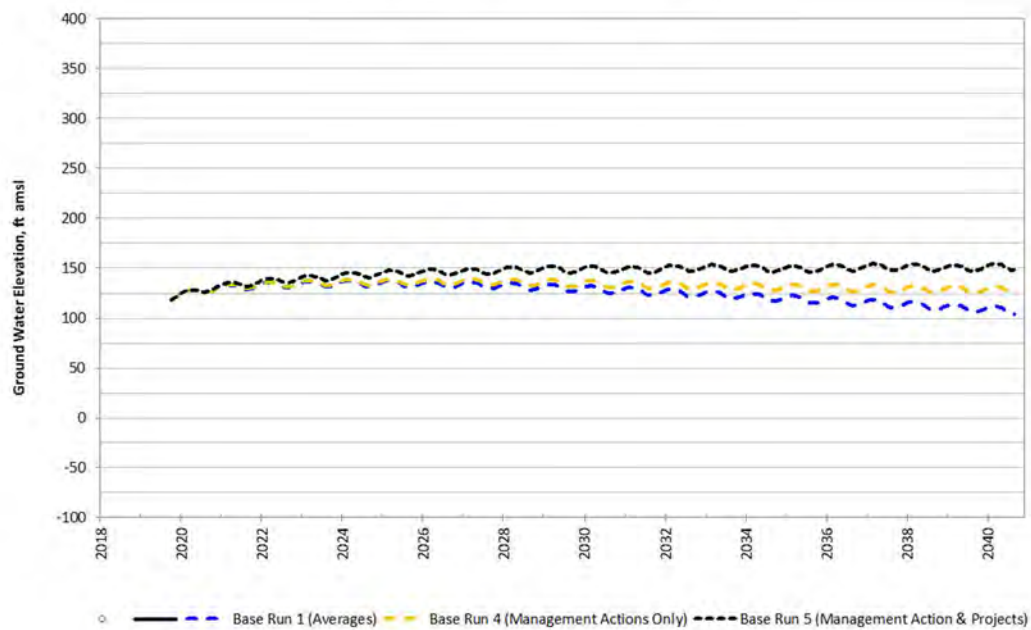
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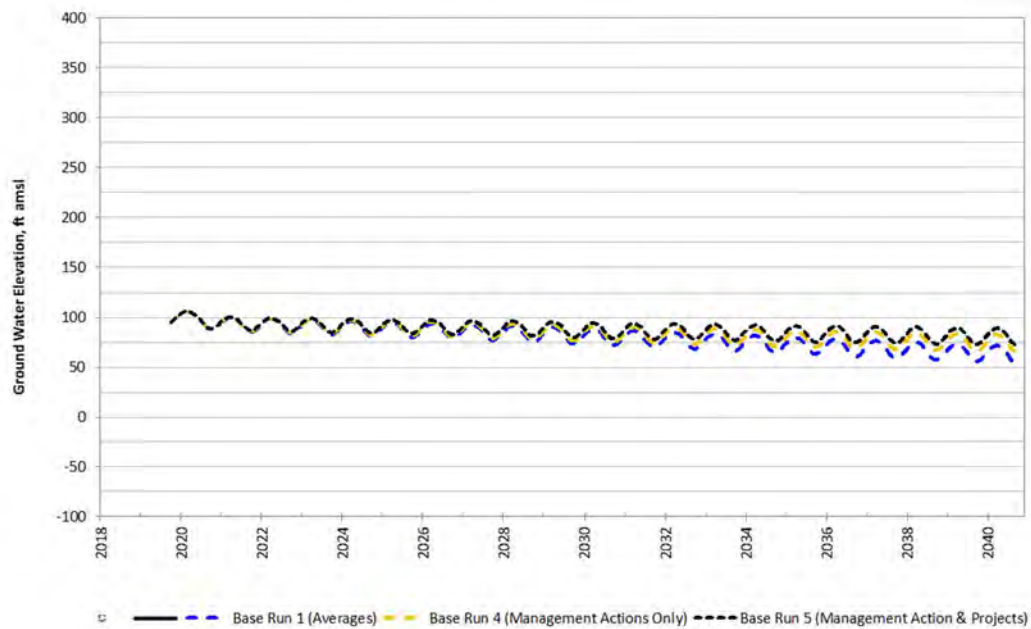
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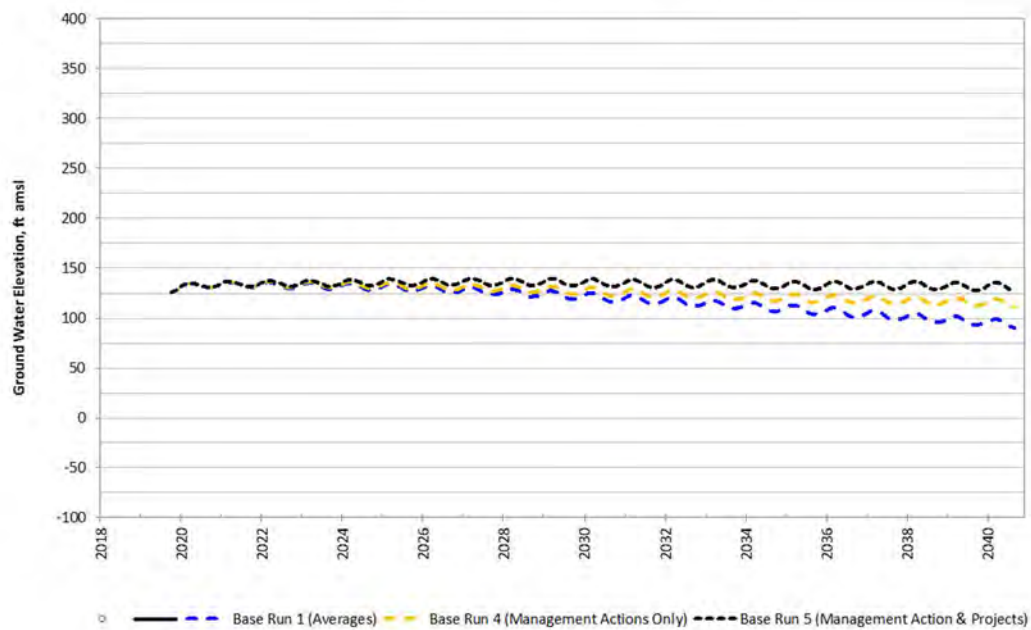
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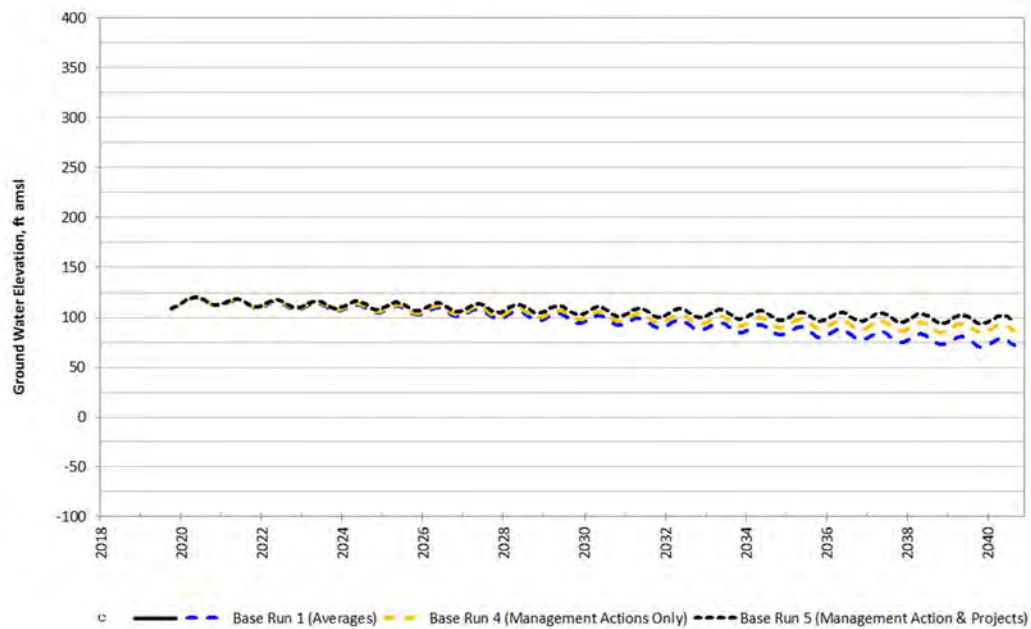
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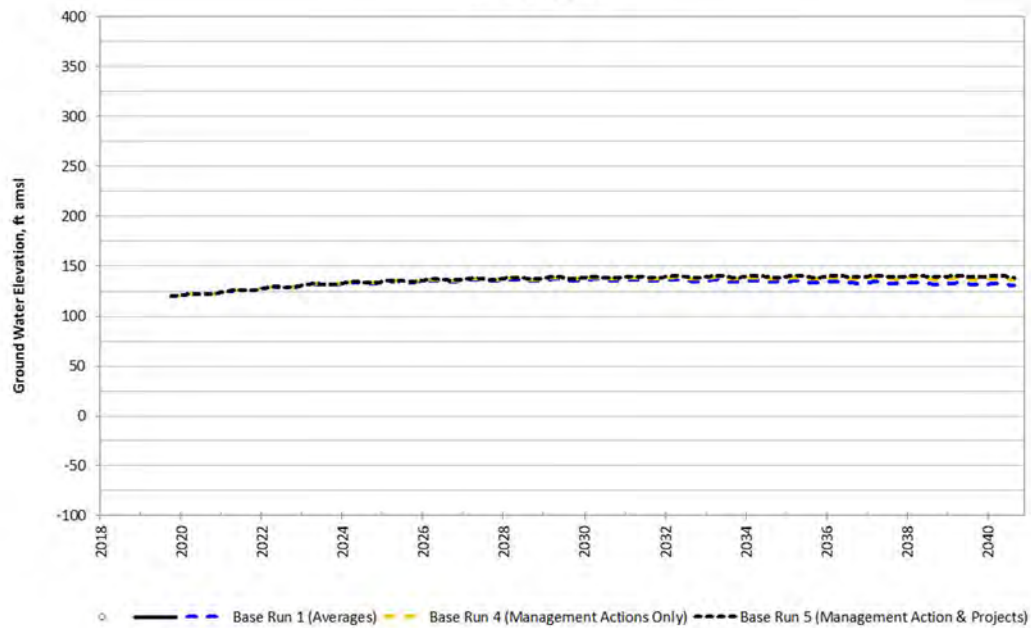
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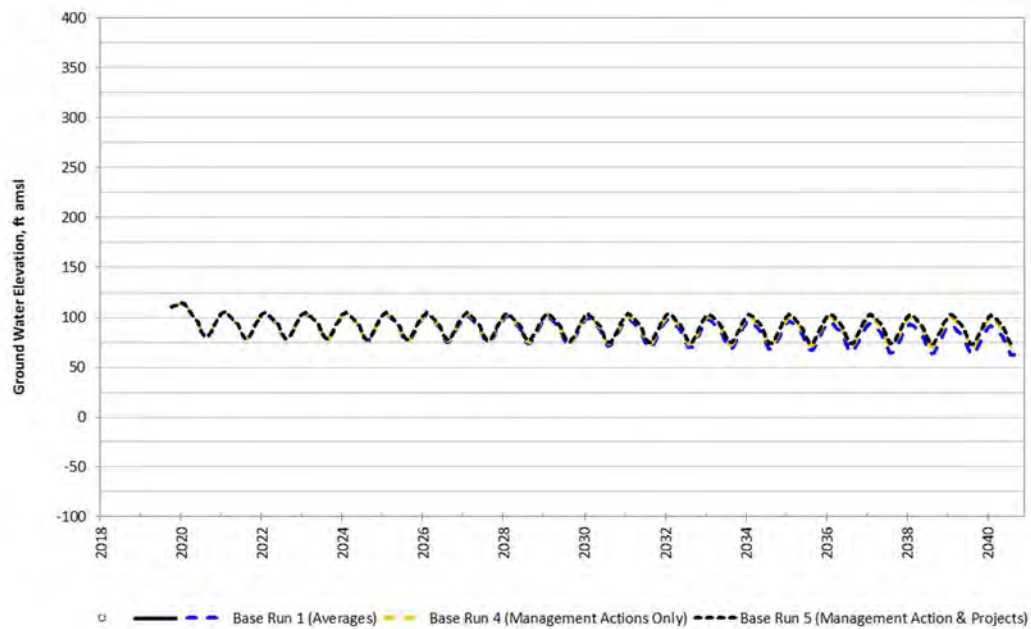
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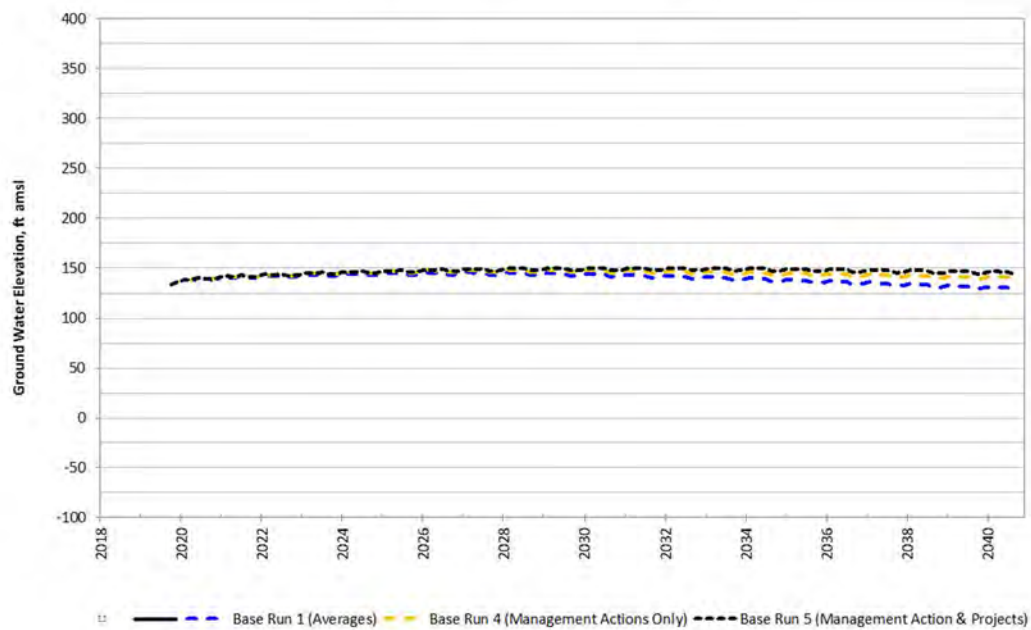
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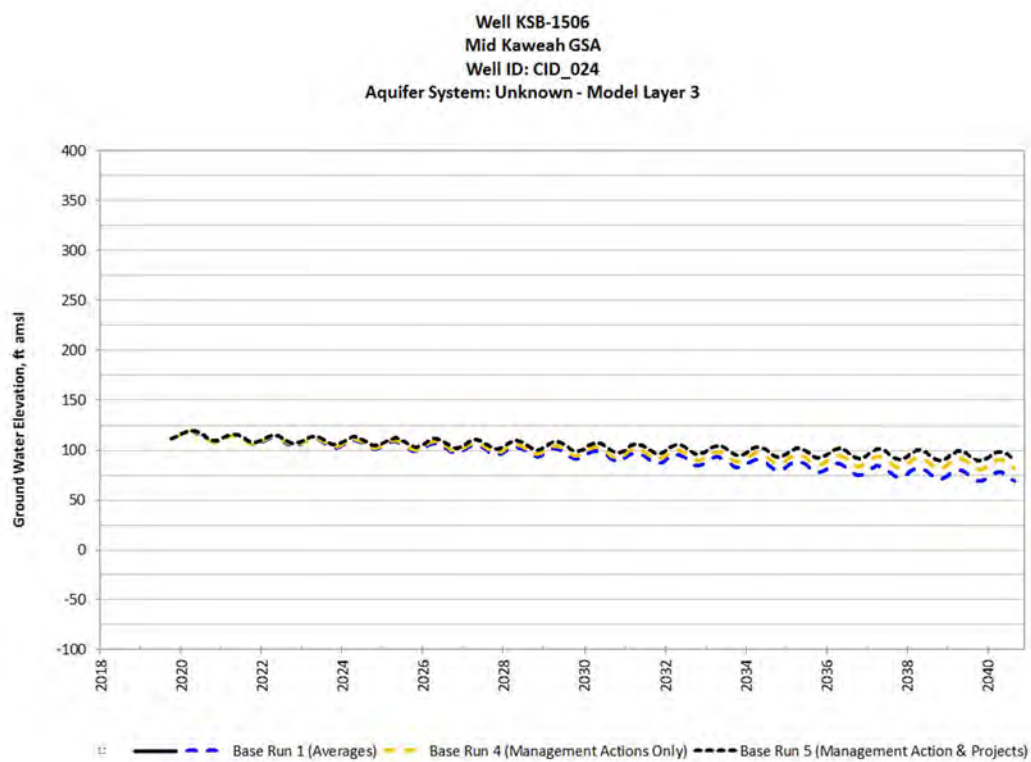
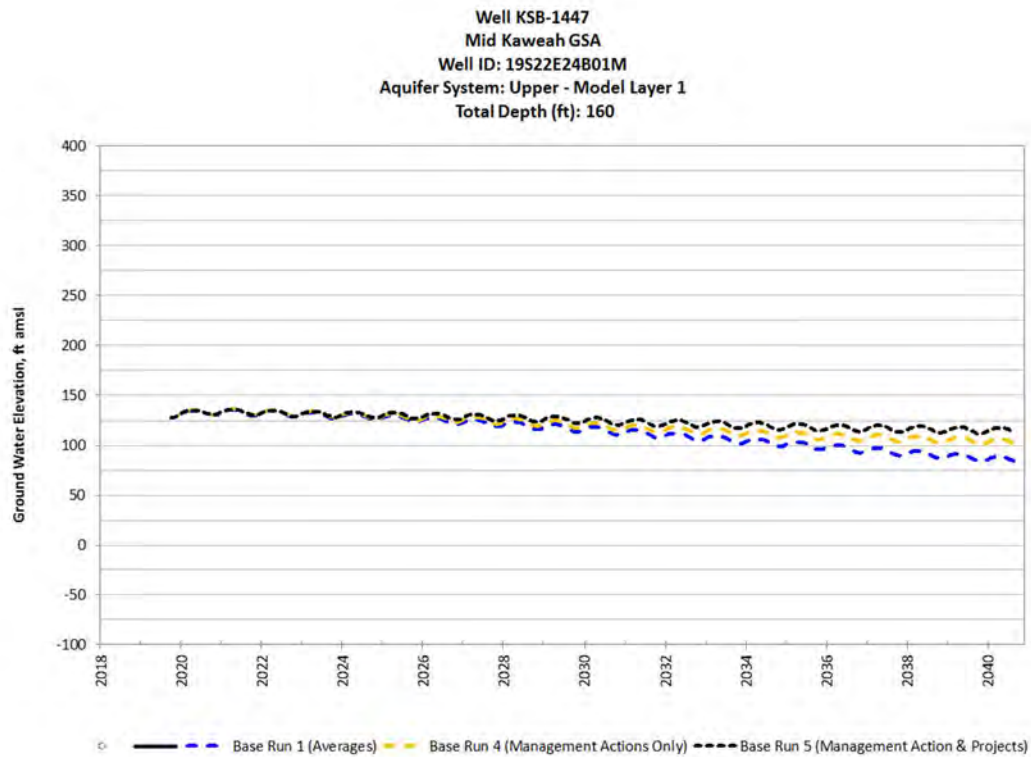


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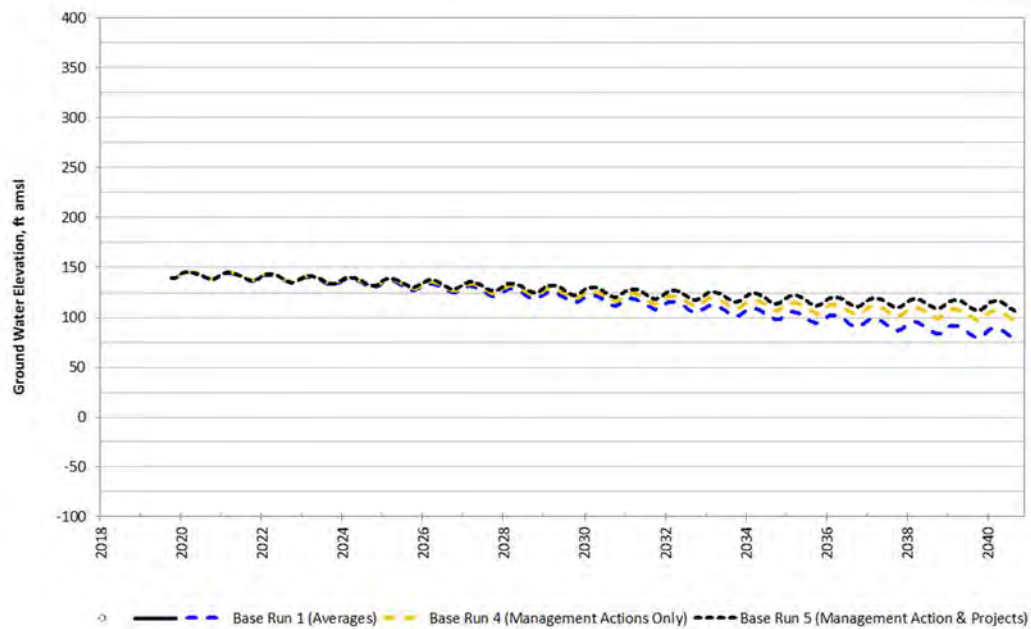


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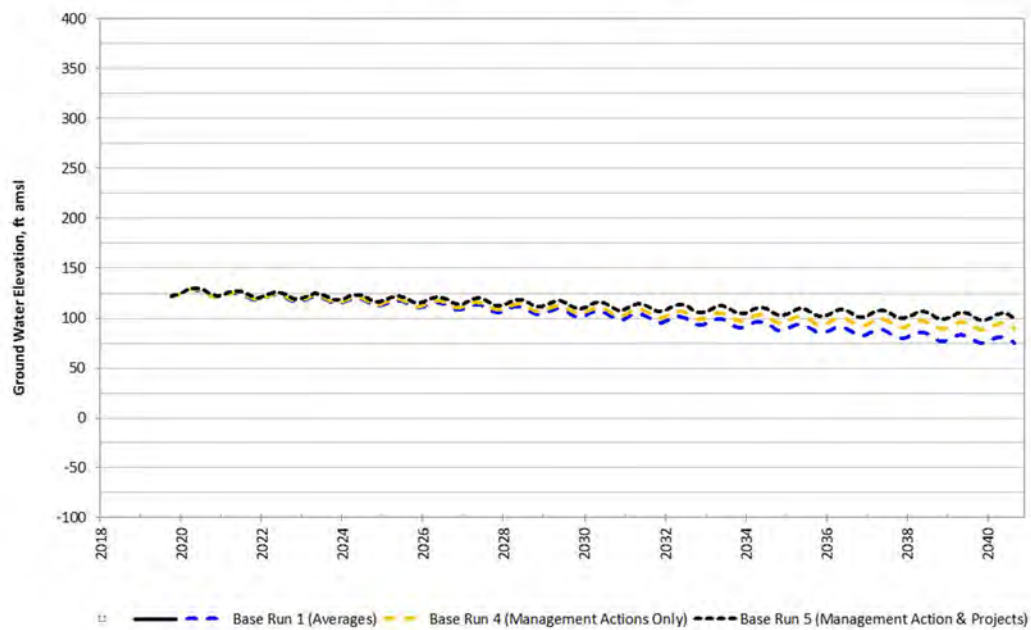




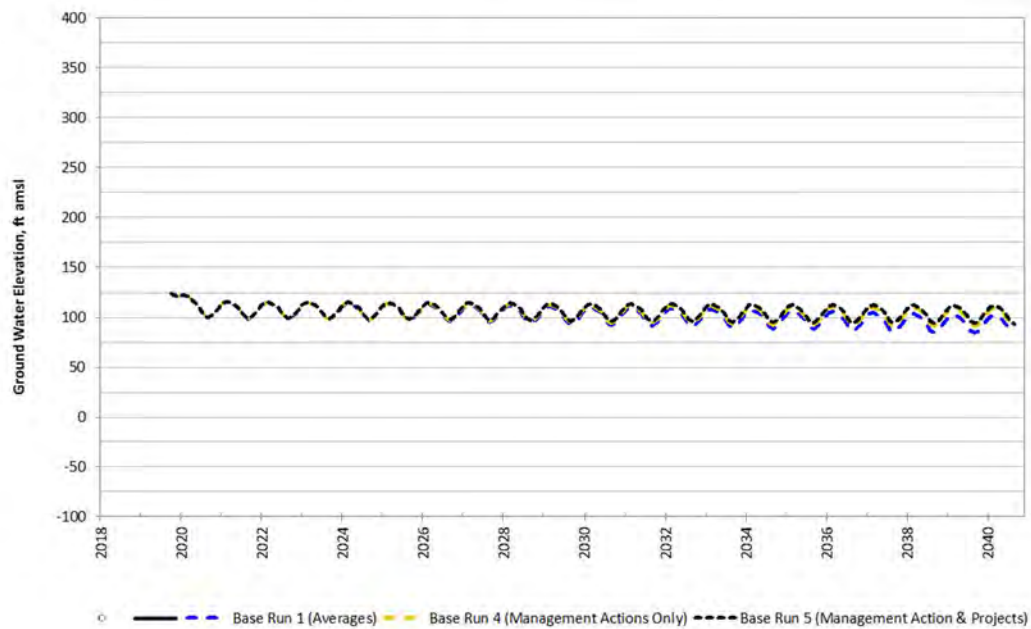
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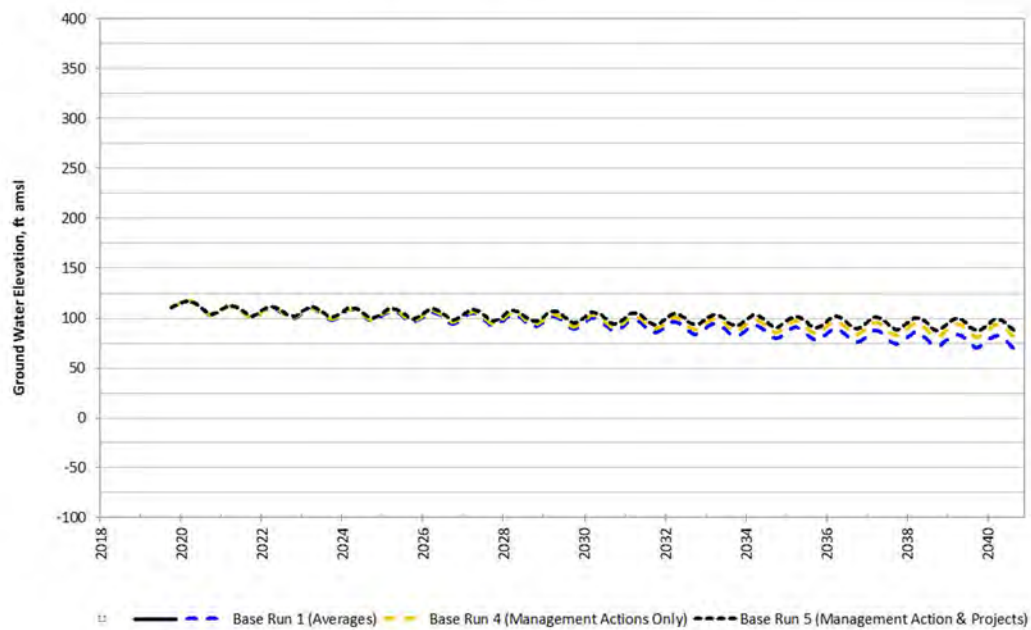
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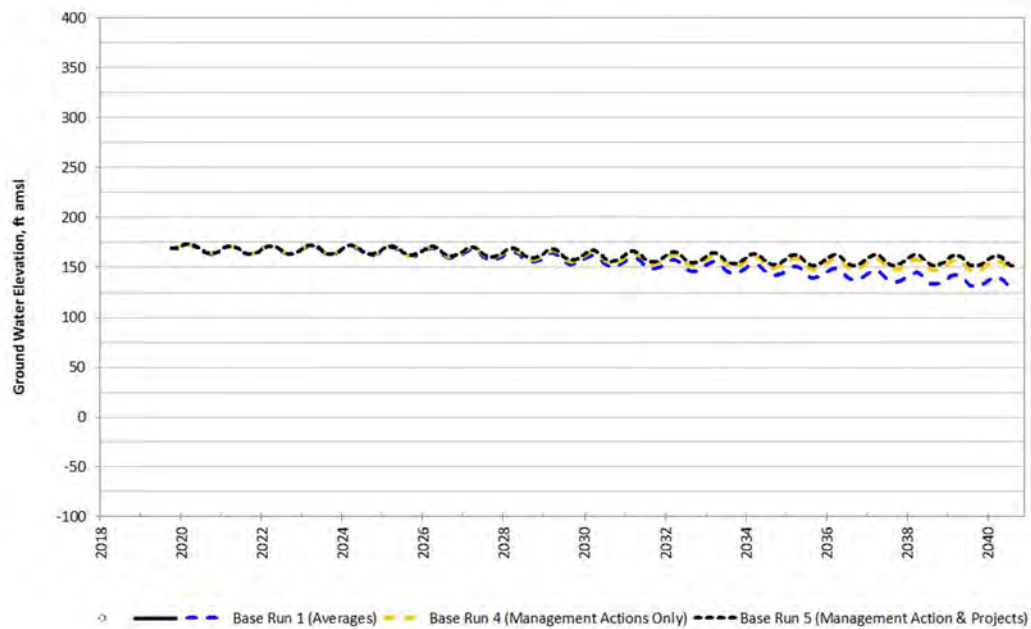
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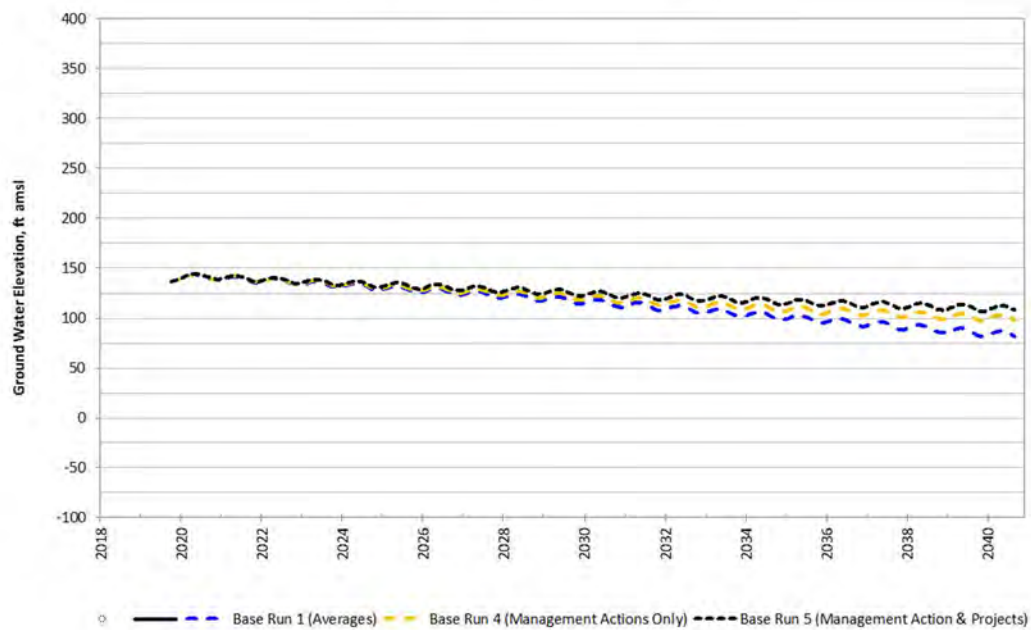
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Well ID: 18S22E01C01M
Aquifer System: Unknown - Model Layer 1



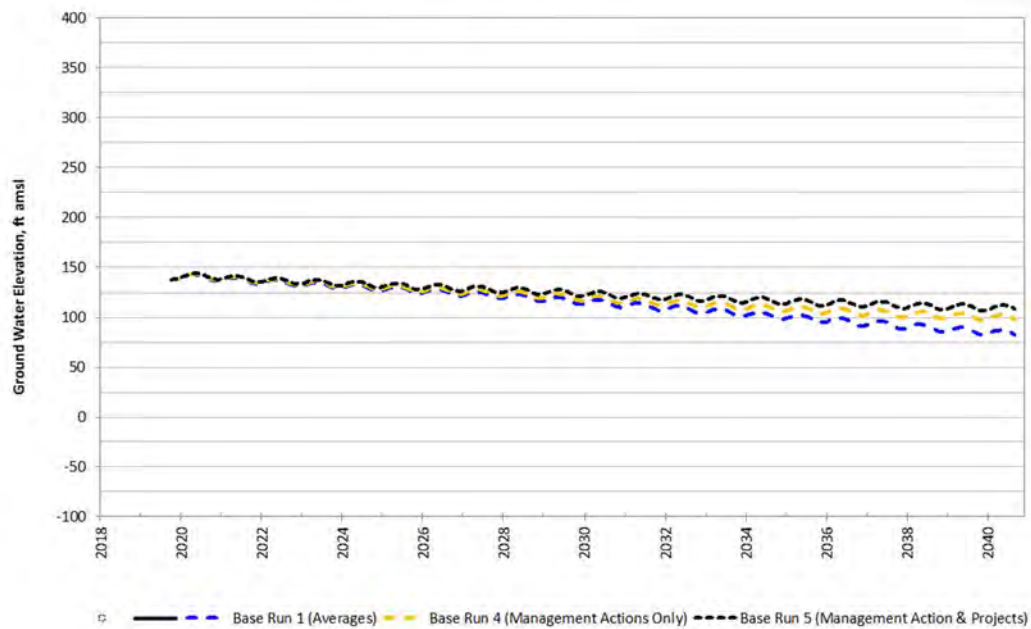
Well KSB-1580
Greater Kaweah GSA
Well ID: 19S22E34L01M
Aquifer System: Unknown - Model Layer 3



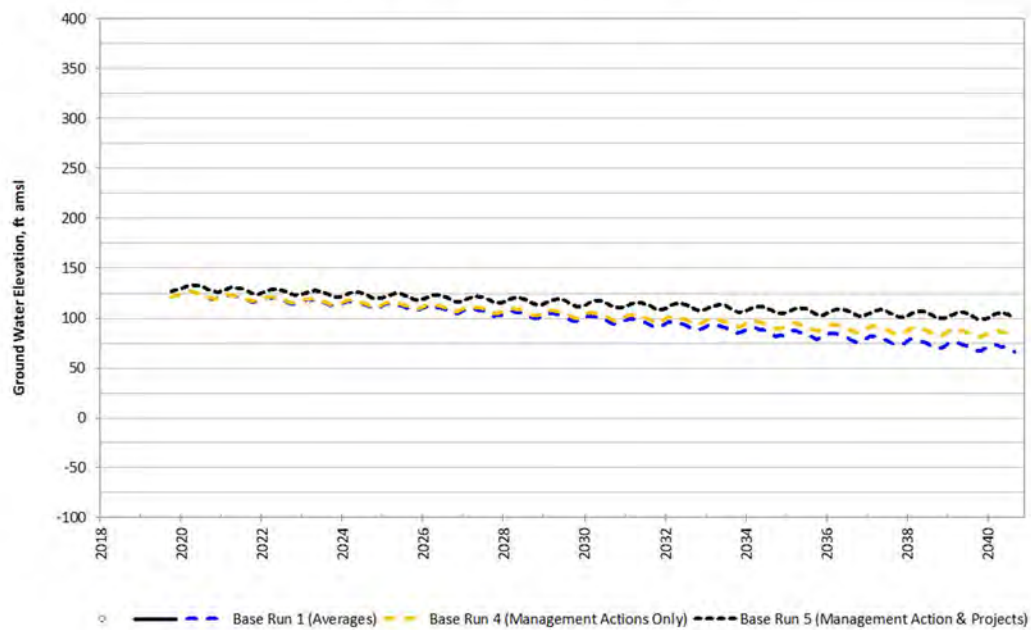
Well KSB-1585
Greater Kaweah GSA
Well ID: 20S22E03G01M
Aquifer System: Unknown - Model Layer 3



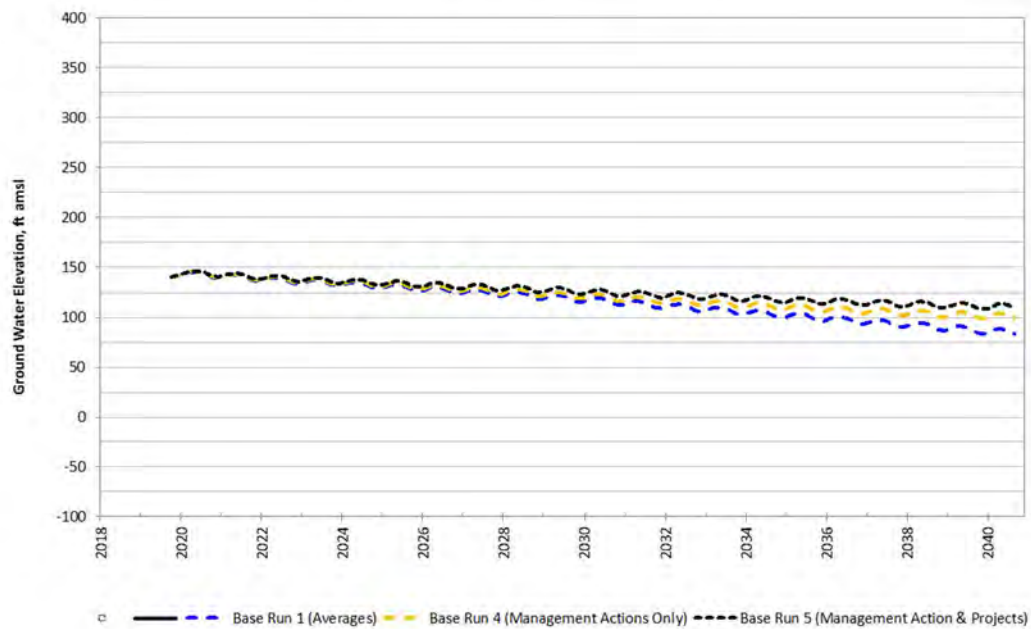
Well KSB-1613
Mid Kaweah GSA
Well ID: 20S22E01Q01M
Aquifer System: Unknown - Model Layer 3



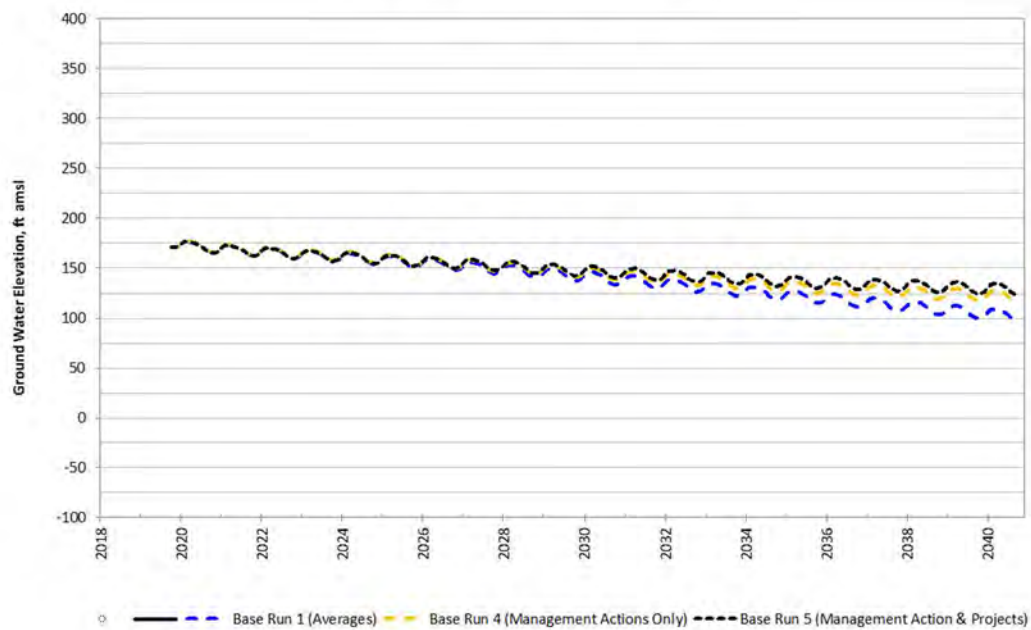
Well KSB-1628
Mid Kaweah GSA
Well ID: CID_078
Aquifer System: Unknown - Model Layer 3



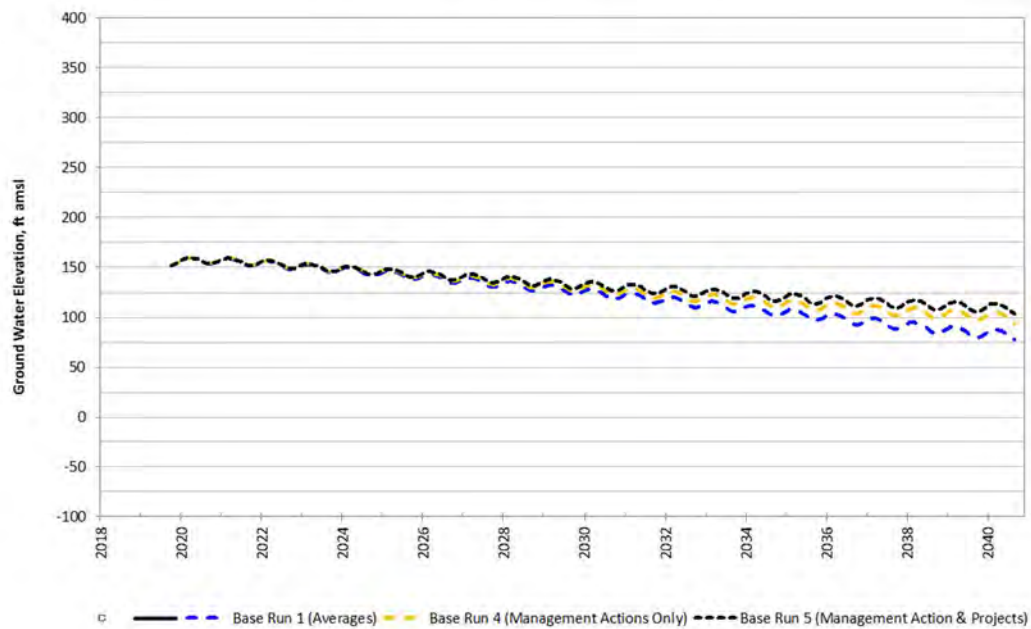
Well KSB-1634
Mid Kaweah GSA
Well ID: CID_079
Aquifer System: Unknown - Model Layer 3



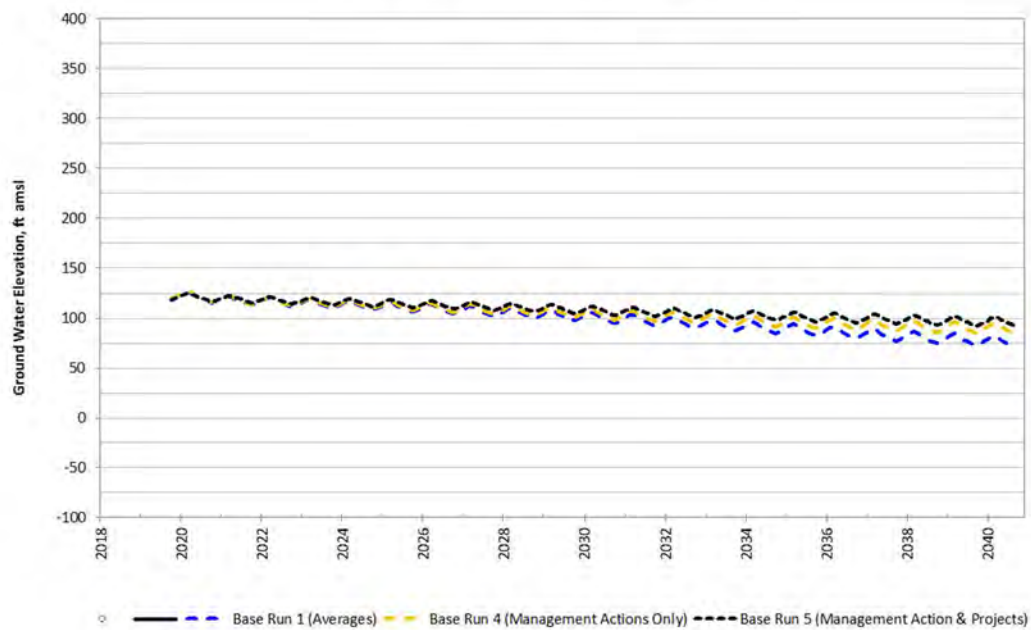
Well KSB-1689
Mid Kaweah GSA
Well ID: CID_080
Aquifer System: Unknown - Model Layer 3



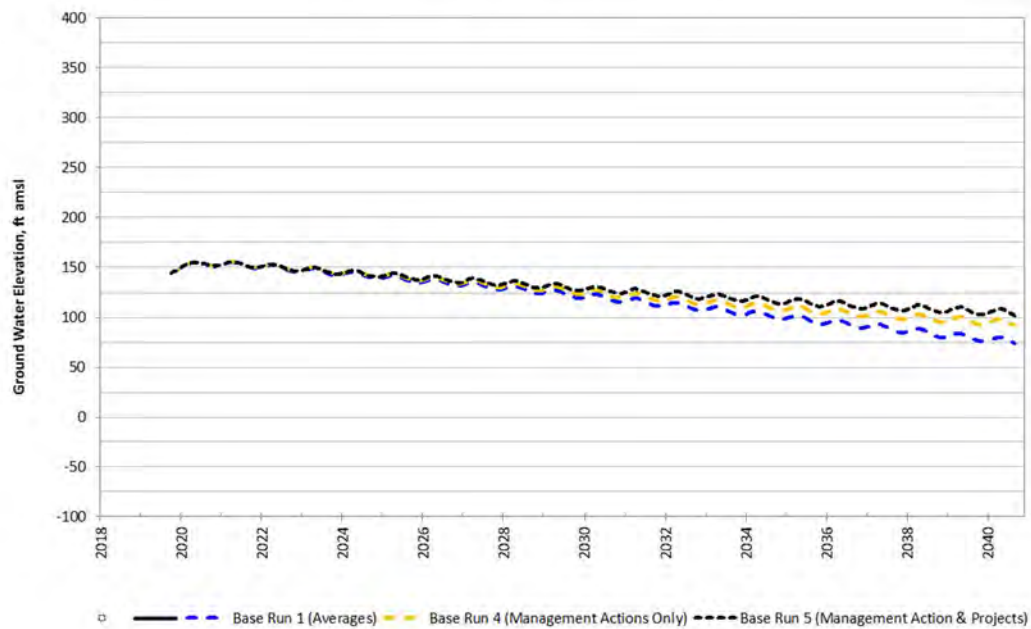
Well KSB-1690
Mid Kaweah GSA
Well ID: CID_081
Aquifer System: Unknown - Model Layer 3



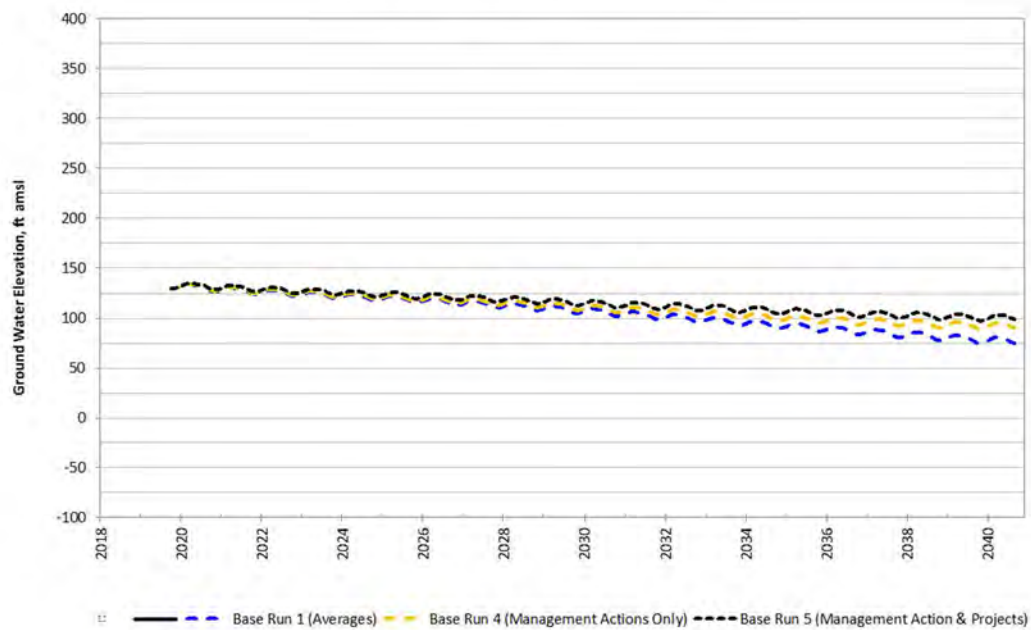
Well KSB-1695
Mid Kaweah GSA
Well ID: CID_085
Aquifer System: Unknown - Model Layer 3



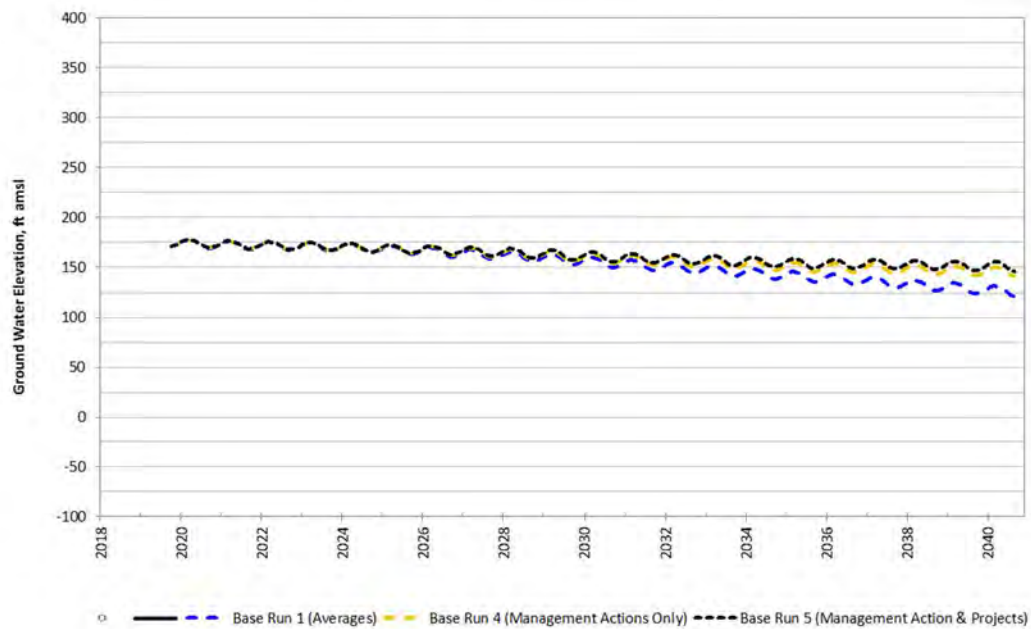
Well KSB-1696
Mid Kaweah GSA
Well ID: 21S23E18N02M
Aquifer System: Unknown - Model Layer 3



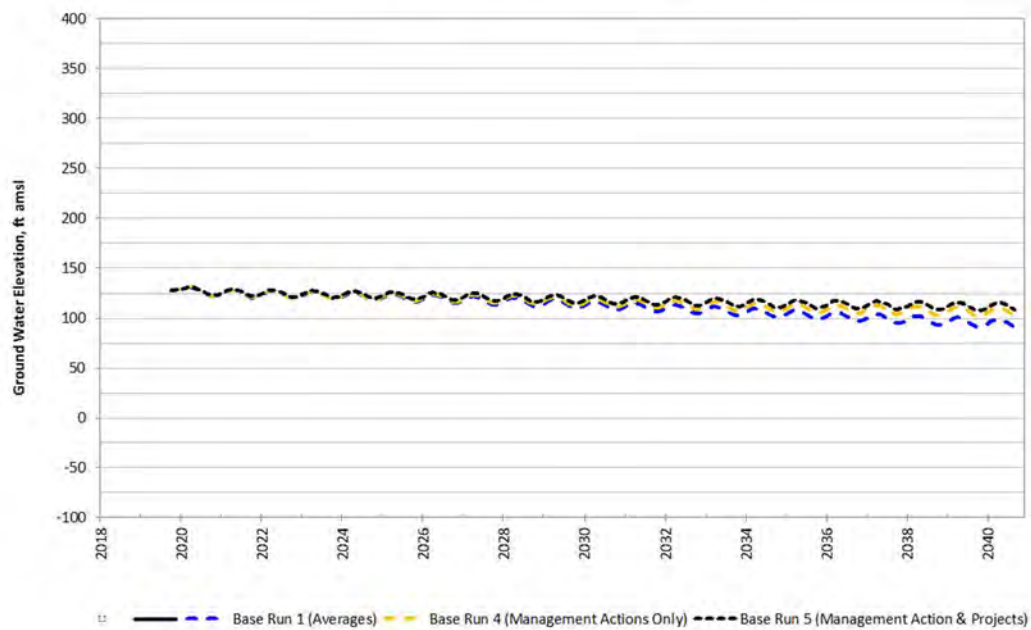
Well KSB-1770
Mid Kaweah GSA
Well ID: 21S23E18N01M
Aquifer System: Unknown - Model Layer 1



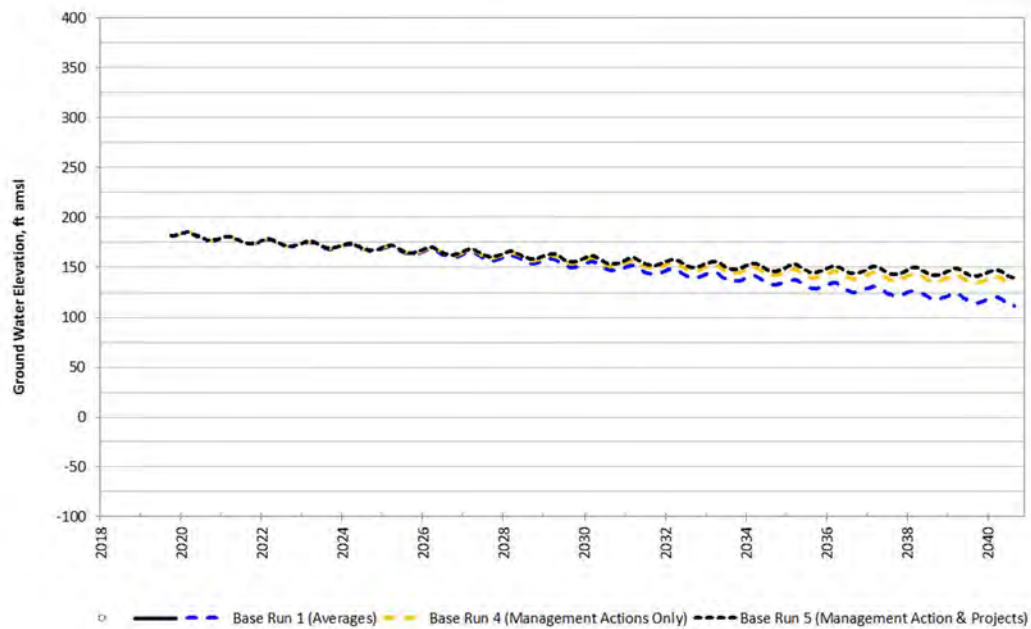
Well KSB-1775
Greater Kaweah GSA
Well ID: 20S22E03K01M
Aquifer System: Unknown - Model Layer 3



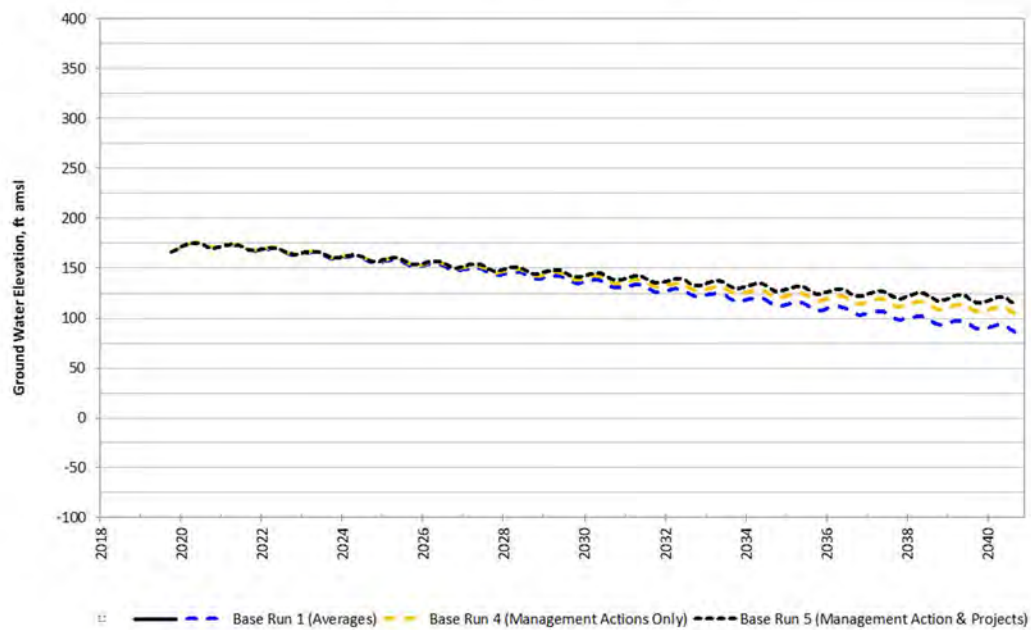
Well KSB-1783
Greater Kaweah GSA
Well ID: 20S22E03B01M
Aquifer System: Unknown - Model Layer 3



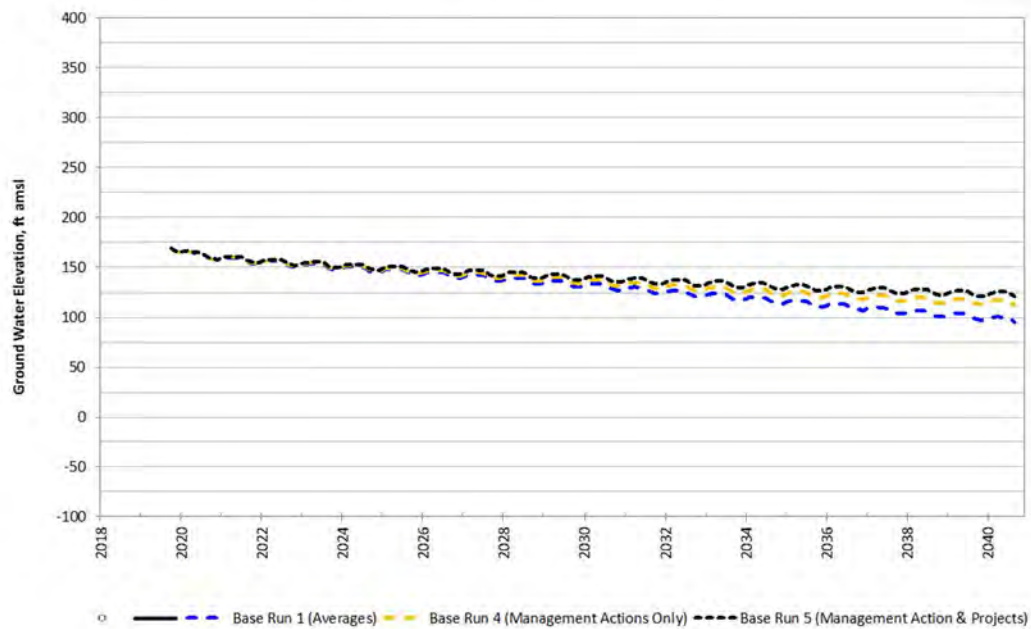
Well KSB-1809
Greater Kaweah GSA
Well ID: 19S22E27A01M
Aquifer System: Unknown - Model Layer 3



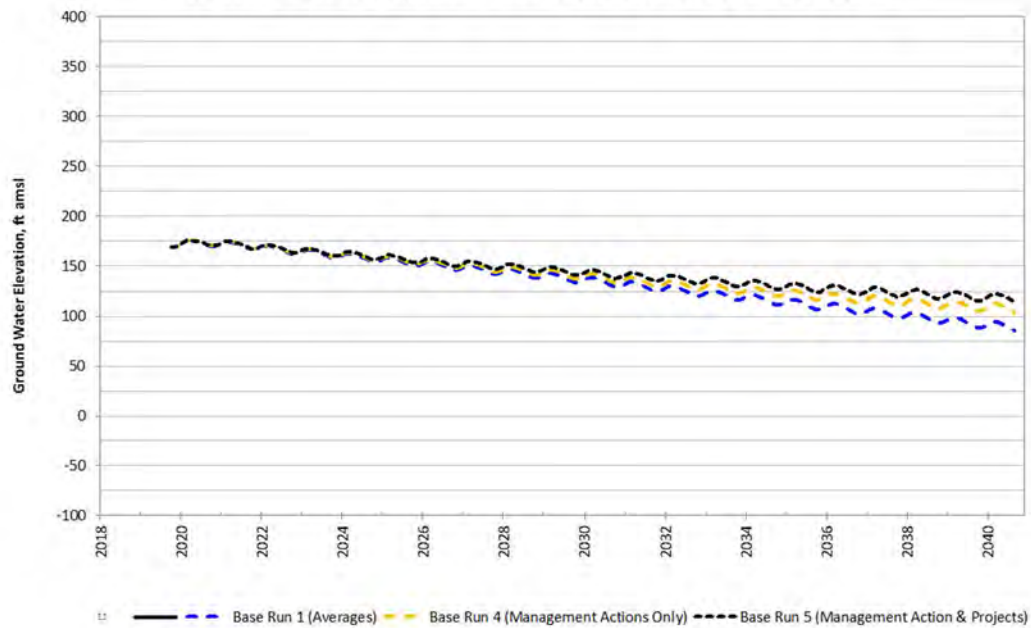
Well KSB-1819
Mid Kaweah GSA
Well ID: 20S22E01H01M
Aquifer System: Unknown - Model Layer 3



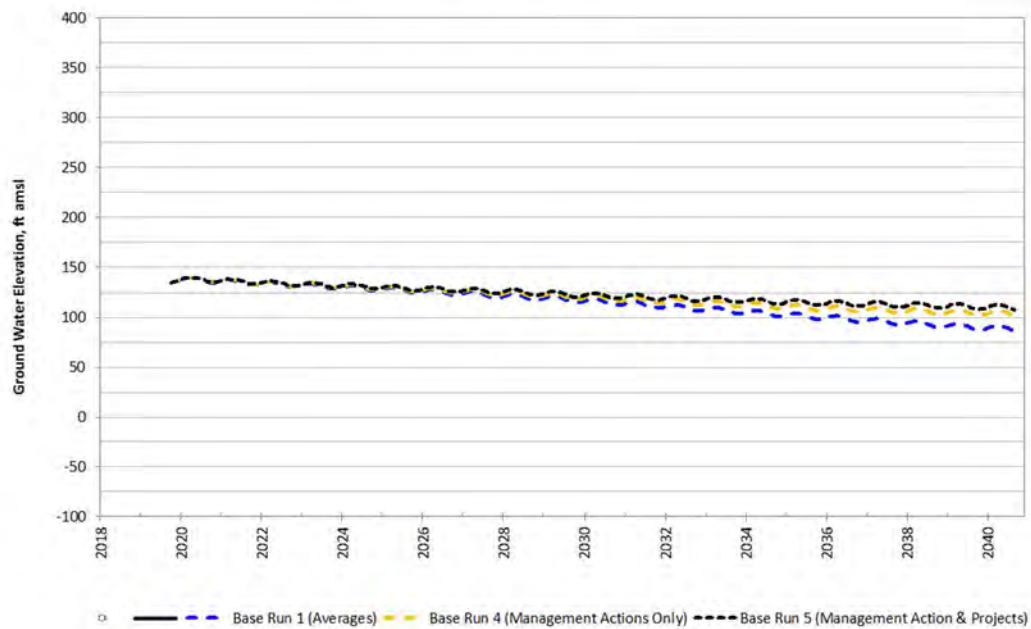
Well KSB-1830
Mid Kaweah GSA
Well ID: CID_017
Aquifer System: Unknown - Model Layer 3



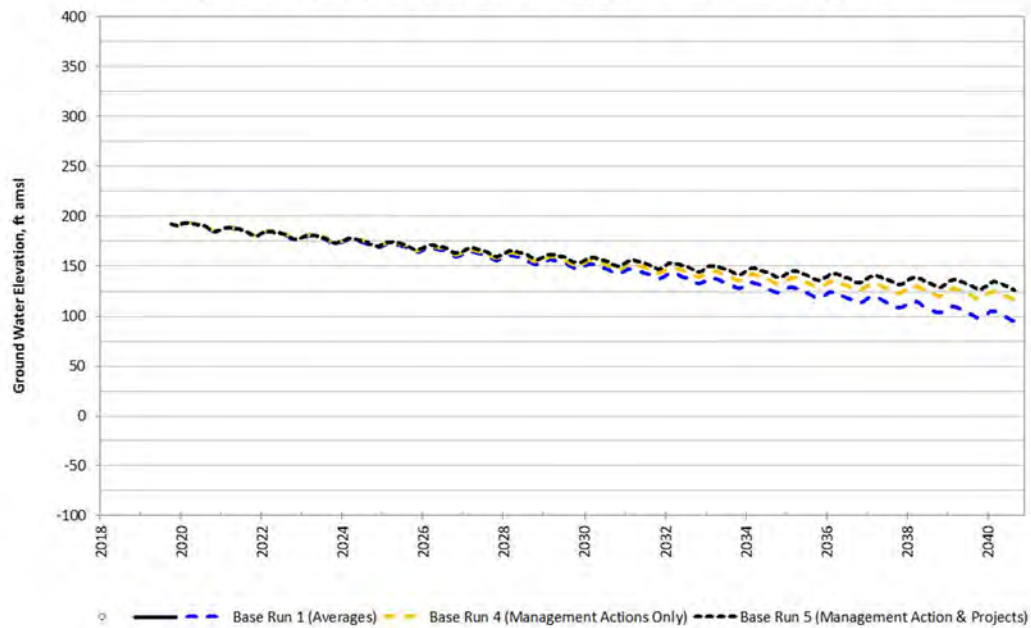
Well KSB-1862
Mid Kaweah GSA
Well ID: 20522E24R01M
Aquifer System: Upper - Model Layer 3
Top of Screen Depth (ft): 204; Bottom of Screen Depth(ft): 31.347479; Total Depth (ft): 332



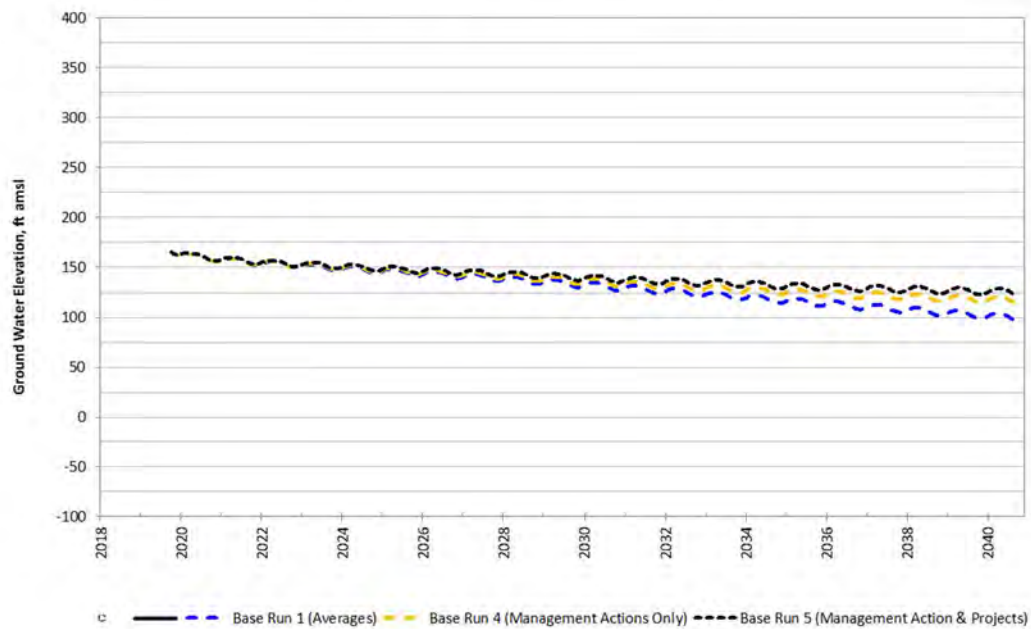
Well KSB-1873
Greater Kaweah GSA
Well ID: CID_033
Aquifer System: Unknown - Model Layer 3



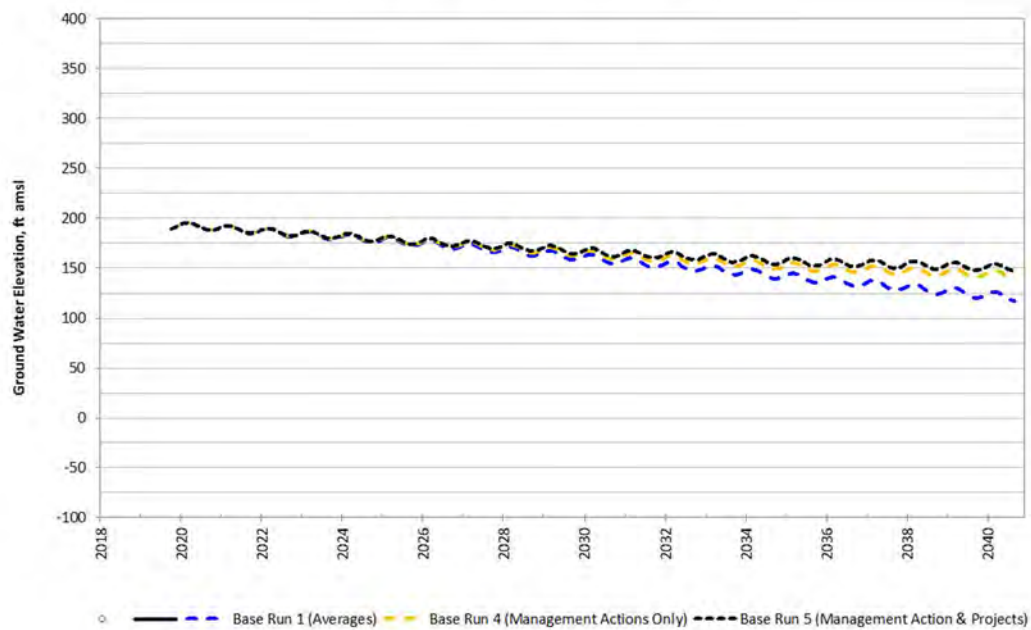
Well KSB-1884
Mid Kaweah GSA
Well ID: 20522E36A01M
Aquifer System: Upper - Model Layer 3
Top of Screen Depth (ft): 206; Bottom of Screen Depth(ft): 68.51899; Total Depth (ft): 210



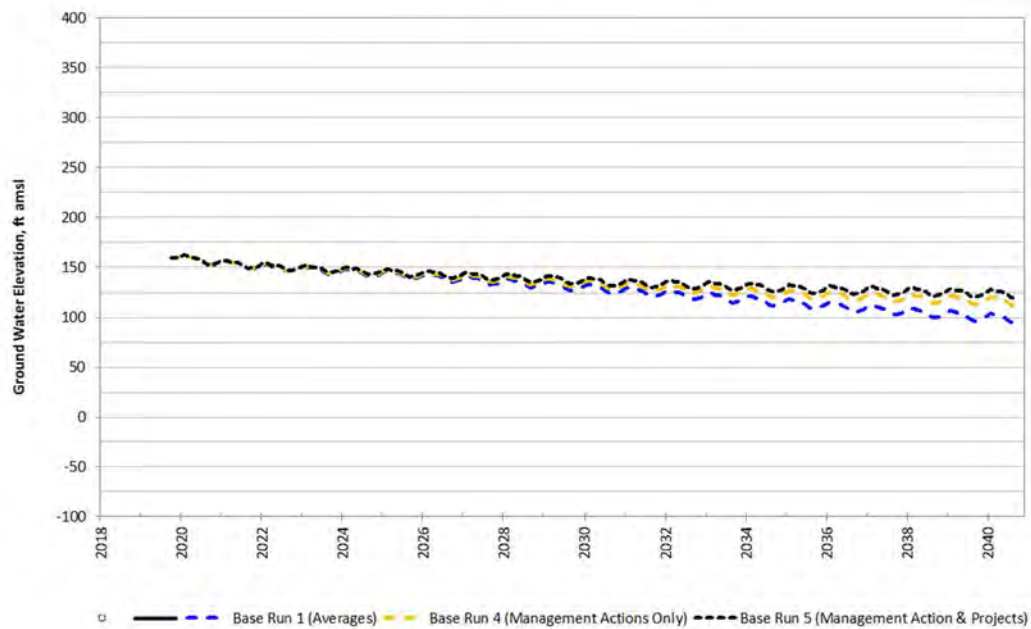
Well KSB-1903
Mid Kaweah GSA
Well ID: 20S22E36H01M
Aquifer System: Unknown - Model Layer 3



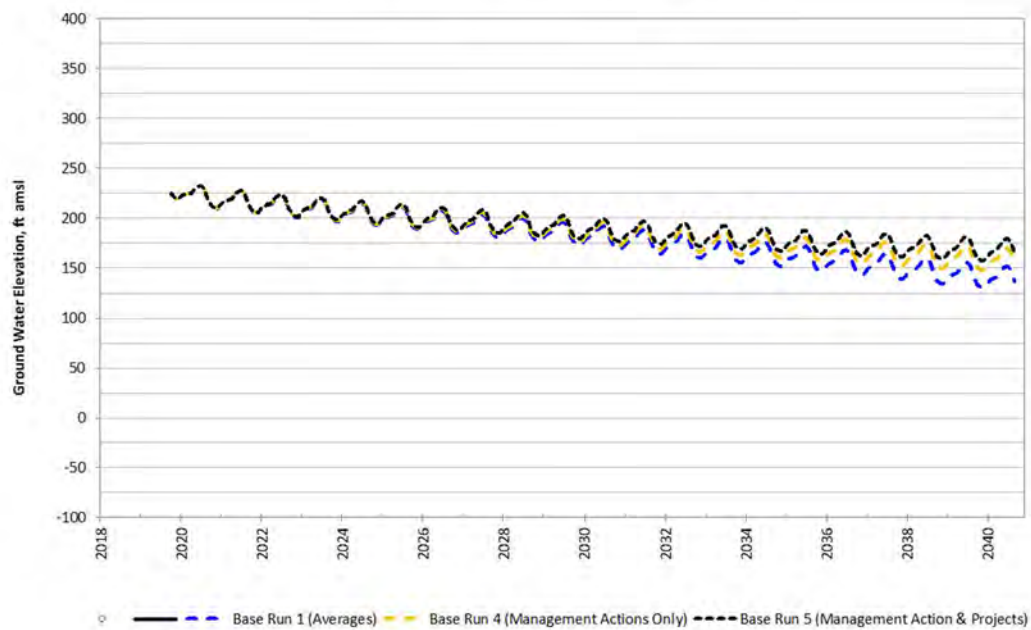
Well KSB-1936
Greater Kaweah GSA
Well ID: CID_084
Aquifer System: Unknown - Model Layer 3



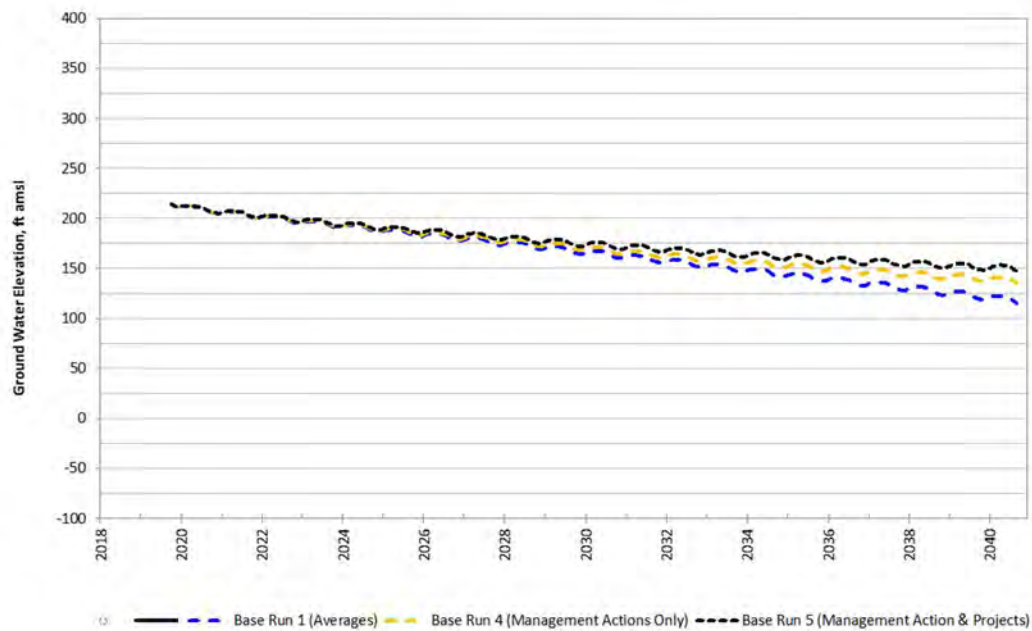
Well KSB-1937
Greater Kaweah GSA
Well ID: 19S22E22A01M
Aquifer System: Unknown - Model Layer 1



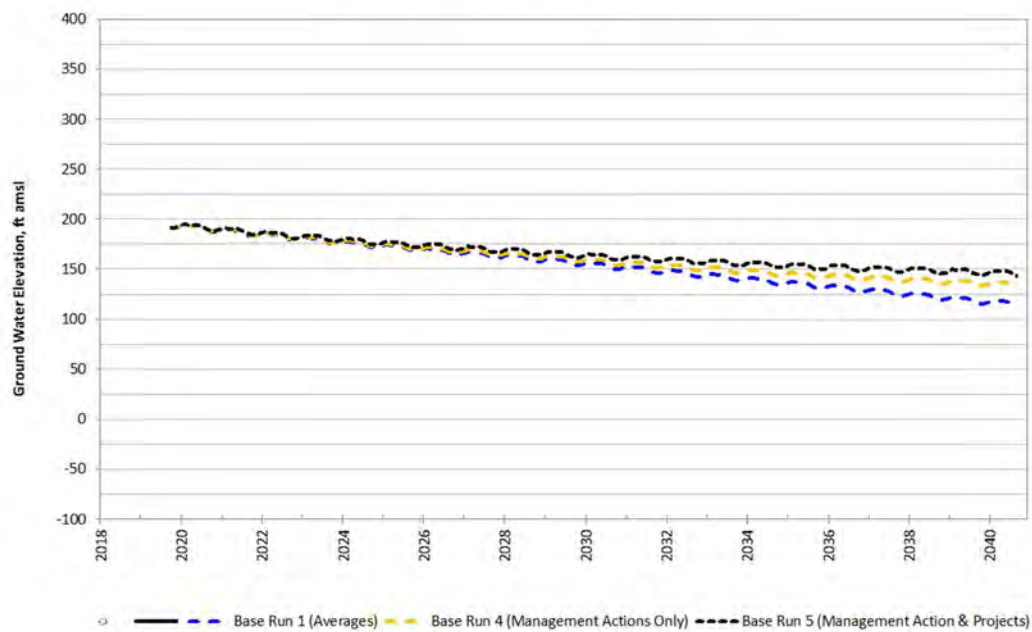
Well KSB-1977
Mid Kaweah GSA
Well ID: 20S22E25R01M
Aquifer System: Unknown - Model Layer 3



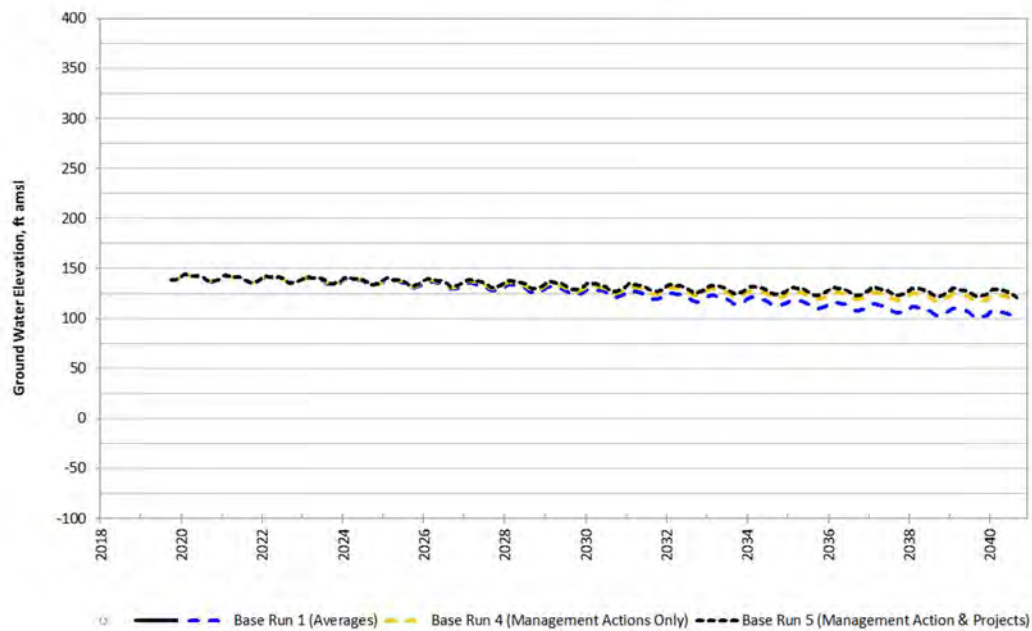
Well KSB-2014
Mid Kaweah GSA
Well ID: CID_028
Aquifer System: Unknown - Model Layer 3



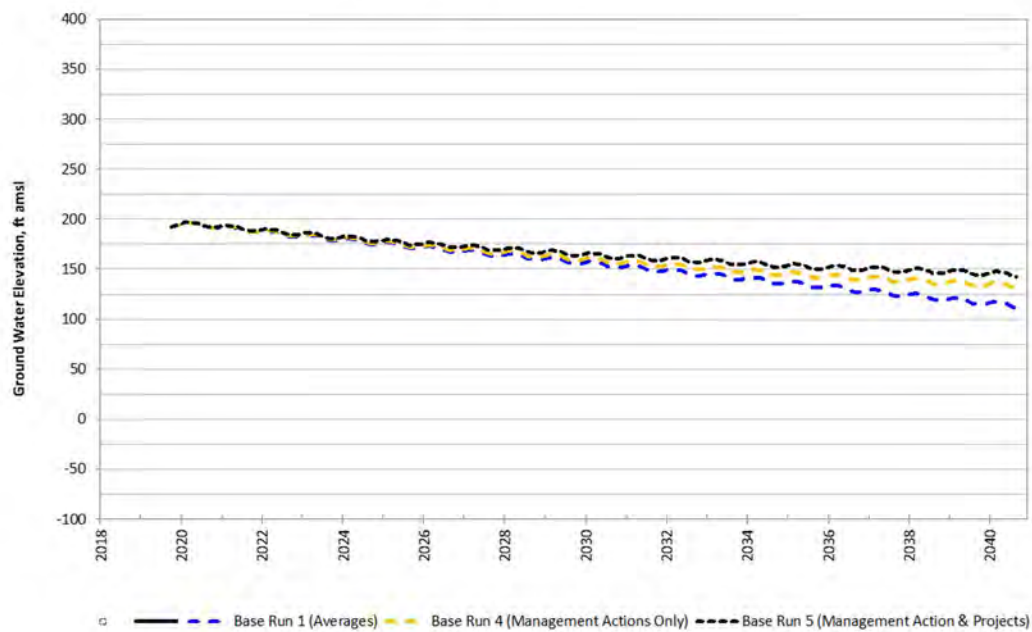
Well KSB-2015
Greater Kaweah GSA
Well ID: CID_023
Aquifer System: Unknown - Model Layer 1



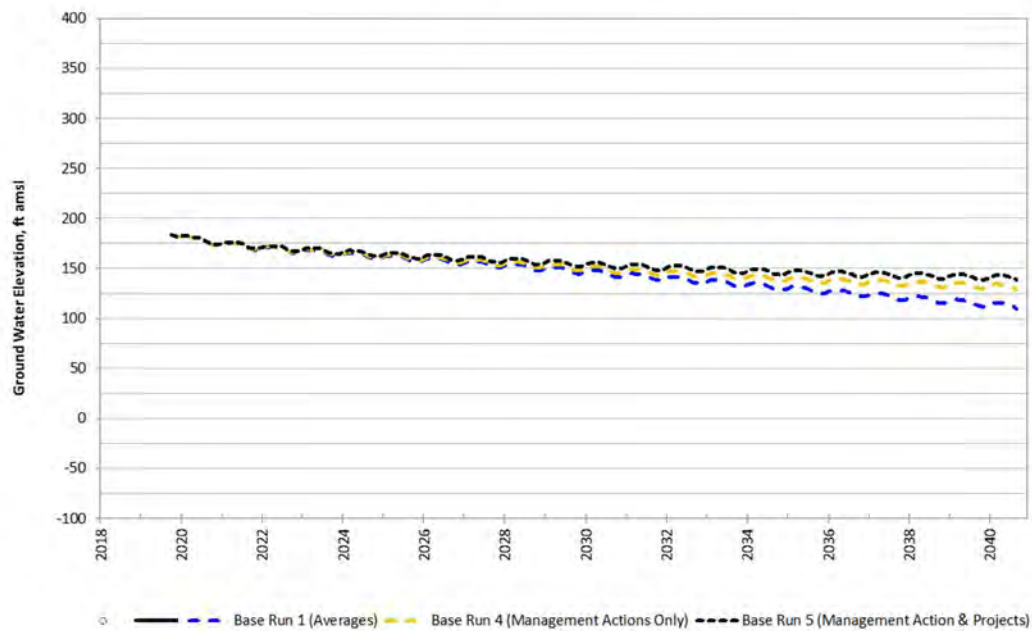
Well KSB-2016
Greater Kaweah GSA
Well ID: CID_082
Aquifer System: Unknown - Model Layer 3



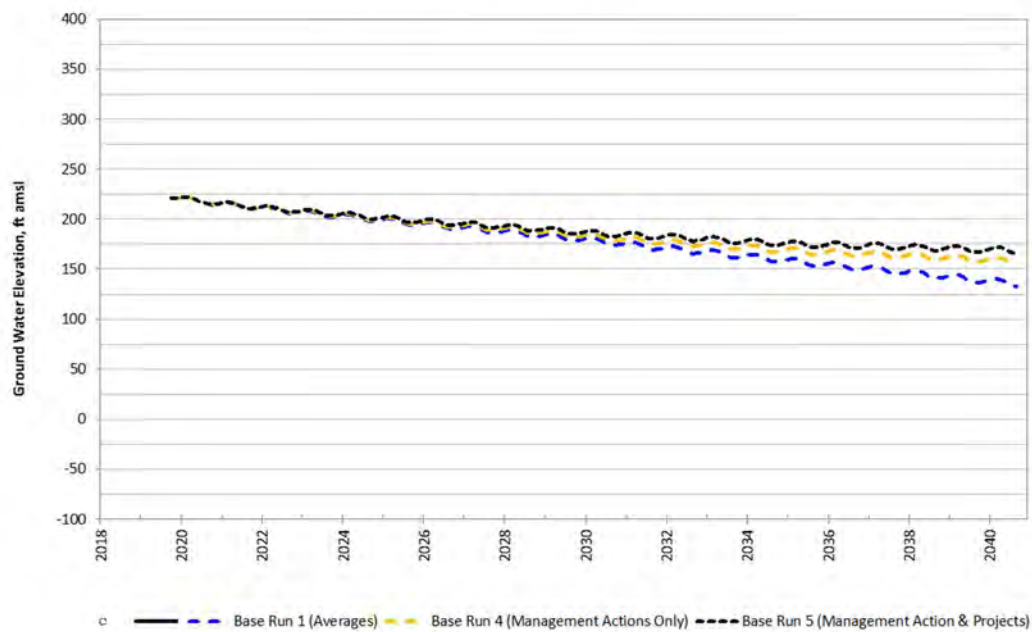
Well KSB-2017
Greater Kaweah GSA
Well ID: 20S22E10J01M
Aquifer System: Unknown - Model Layer 3



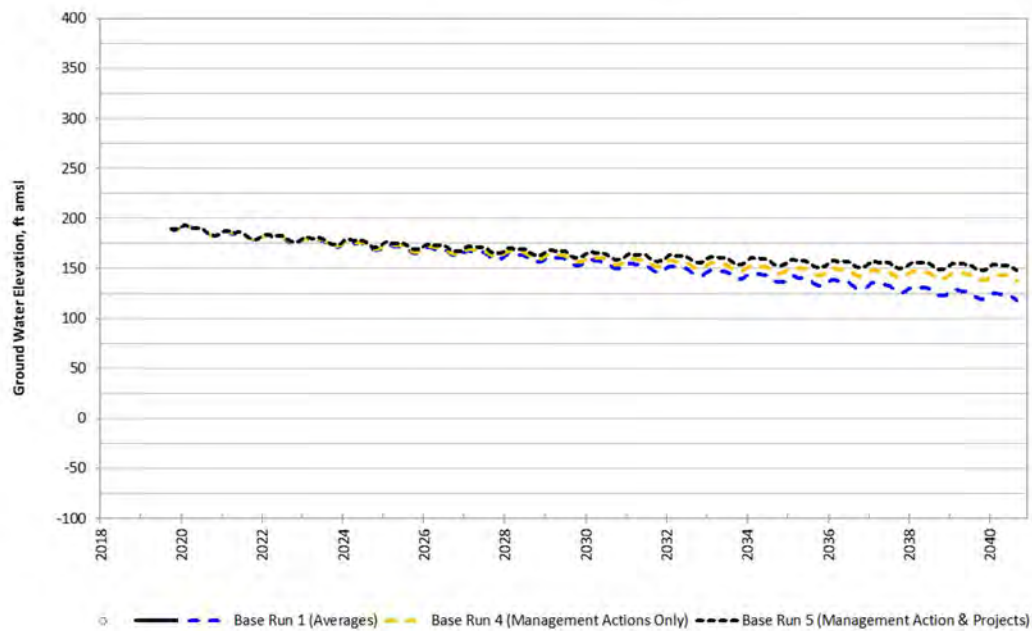
Well KSB-2021
Greater Kaweah GSA
Well ID: 19S22E10R02M
Aquifer System: Unknown - Model Layer 1



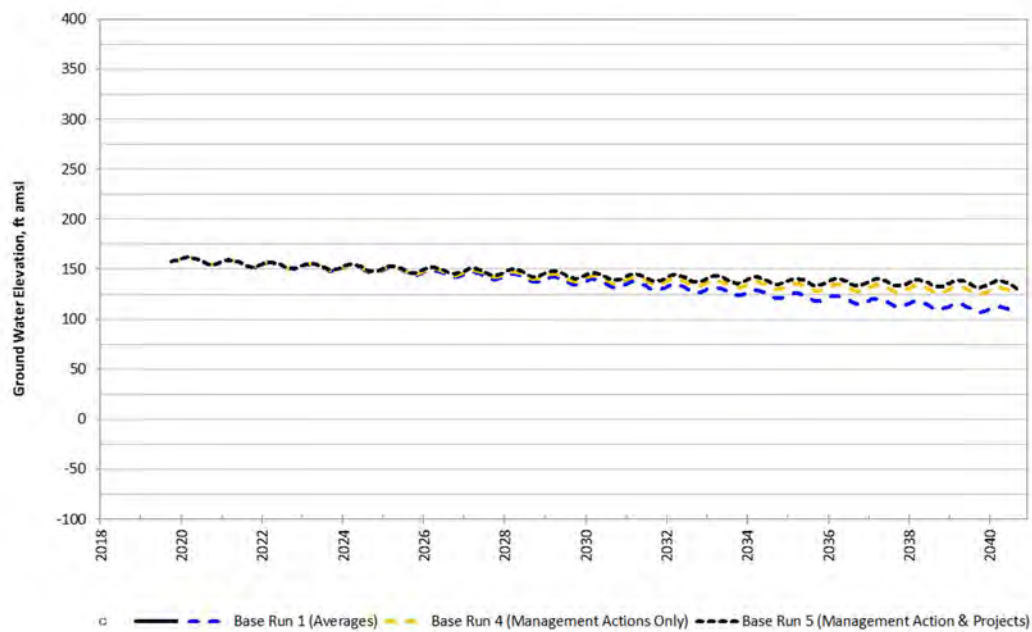
Well KSB-2058
Greater Kaweah GSA
Well ID: 19S22E14N01M
Aquifer System: Unknown - Model Layer 3



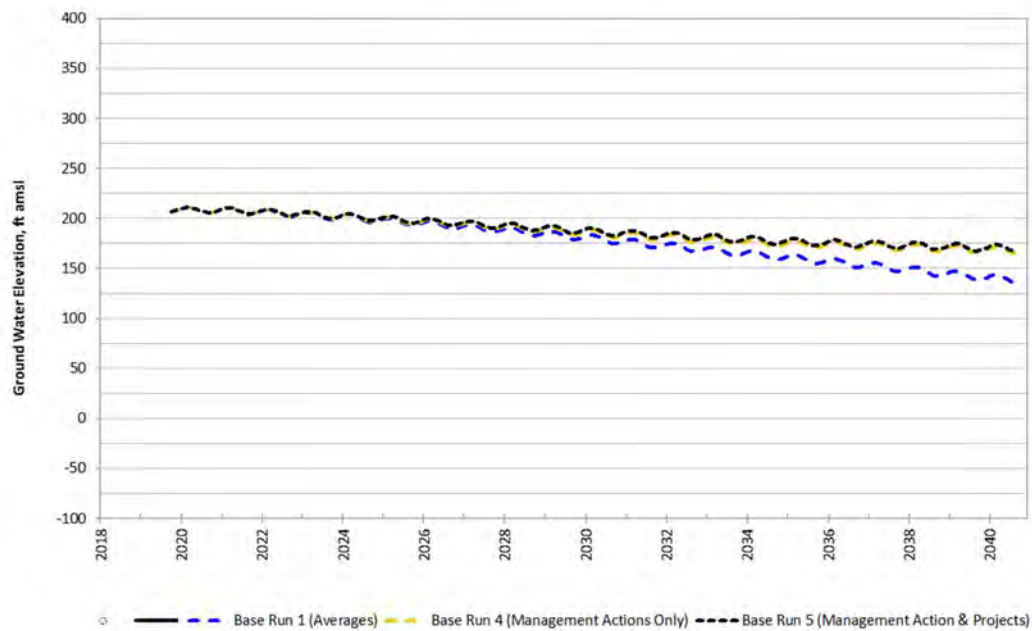
Well KSB-2089
Greater Kaweah GSA
Well ID: CID_042
Aquifer System: Unknown - Model Layer 3



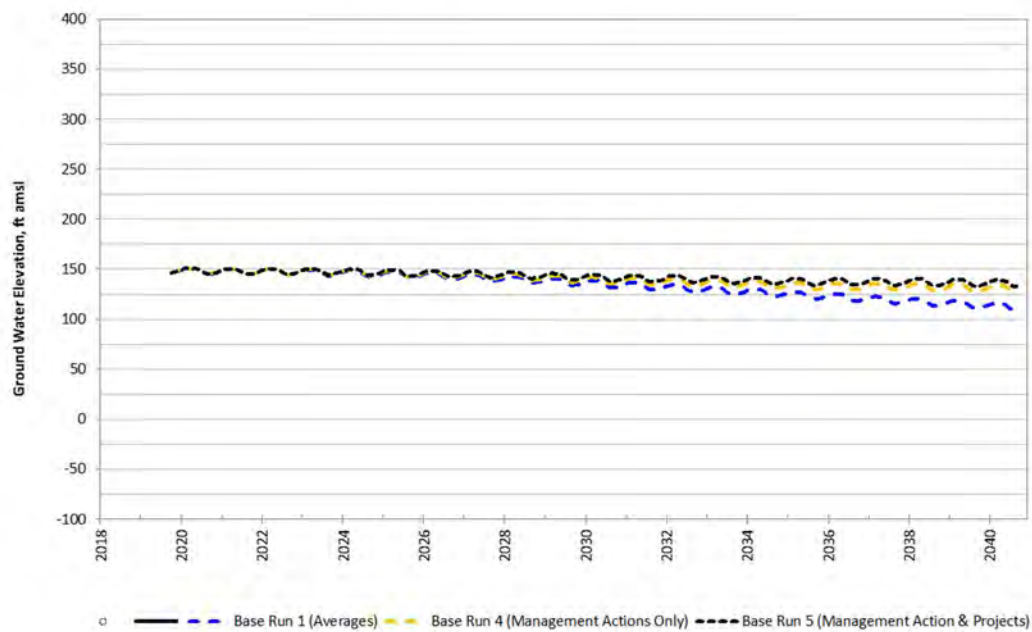
Well KSB-2095
Greater Kaweah GSA
Well ID: 19S22E14M01M
Aquifer System: Unknown - Model Layer 3



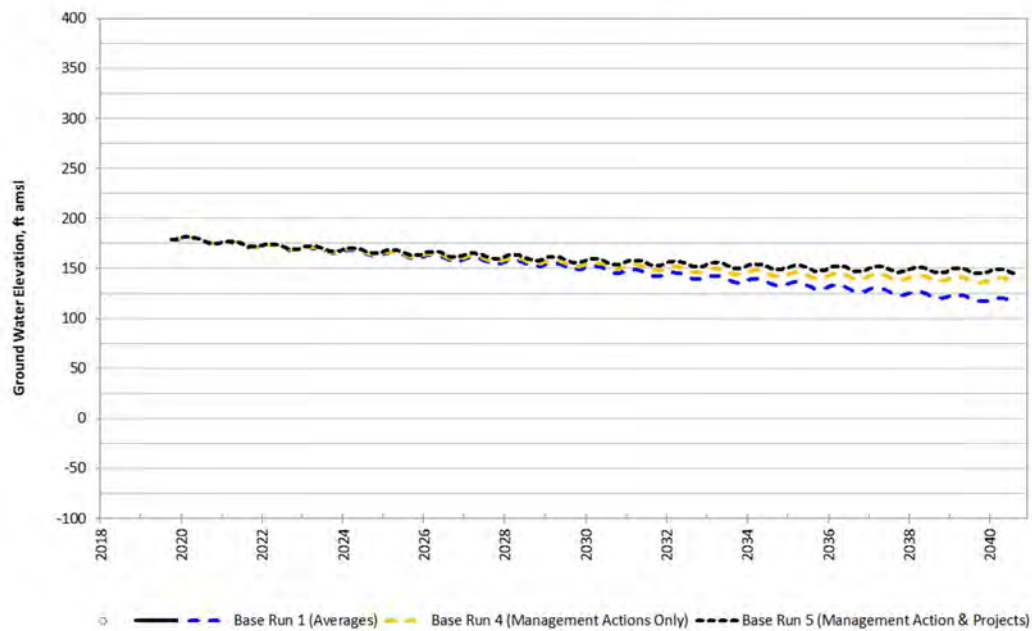
Well KSB-2107
East Kaweah GSA
Well ID: 19S21E15R01M
Aquifer System: Unknown - Model Layer 1



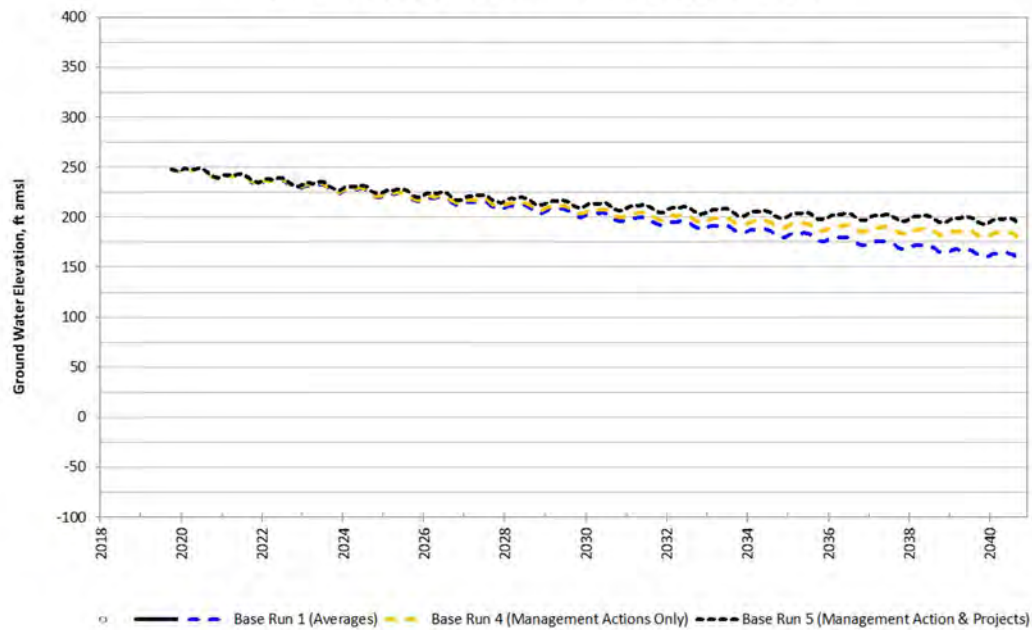
Well KSB-2114
Greater Kaweah GSA
Well ID: CID_025
Aquifer System: Unknown - Model Layer 3



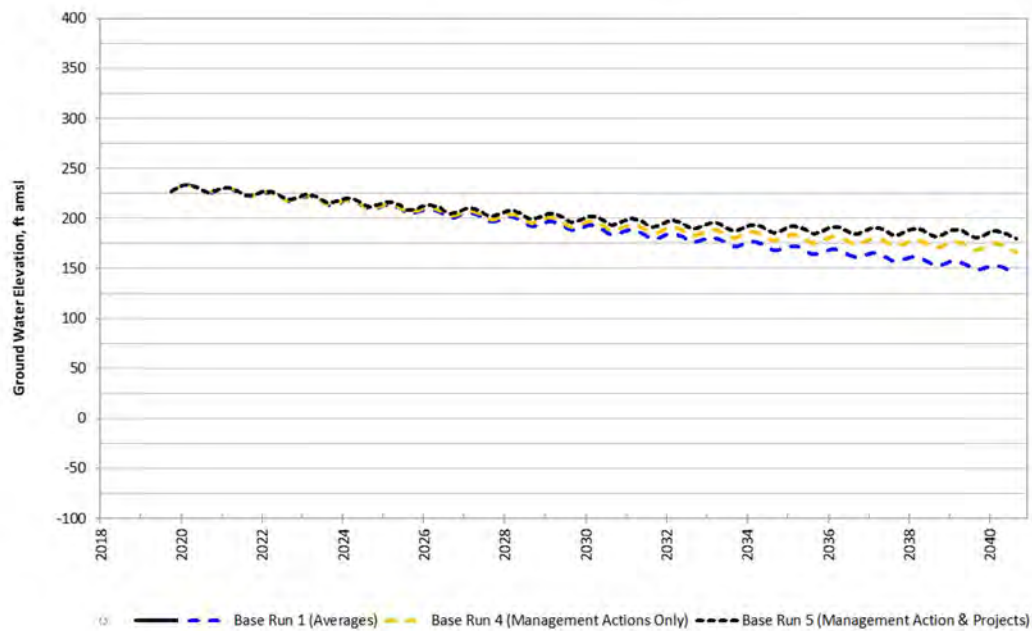
Well KSB-2139
Greater Kaweah GSA
Well ID: 20S22E02C01M
Aquifer System: Unknown - Model Layer 3



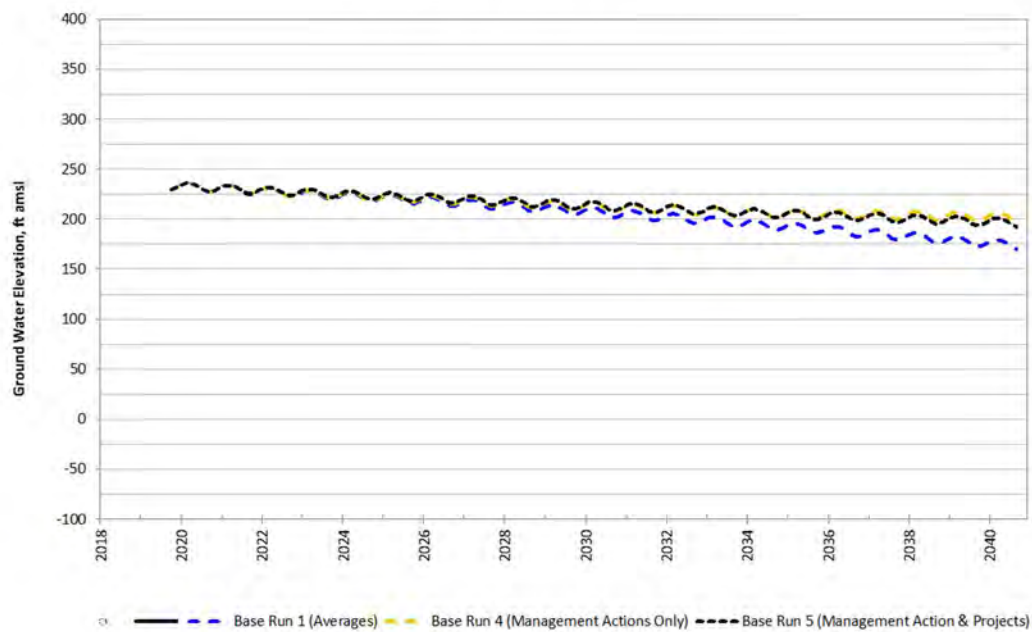
Well KSB-2147
Greater Kaweah GSA
Well ID: 20S22E14C01M
Aquifer System: Lower - Model Layer 3
Top of Screen Depth (ft): 1600; Bottom of Screen Depth(ft): -96.127631;



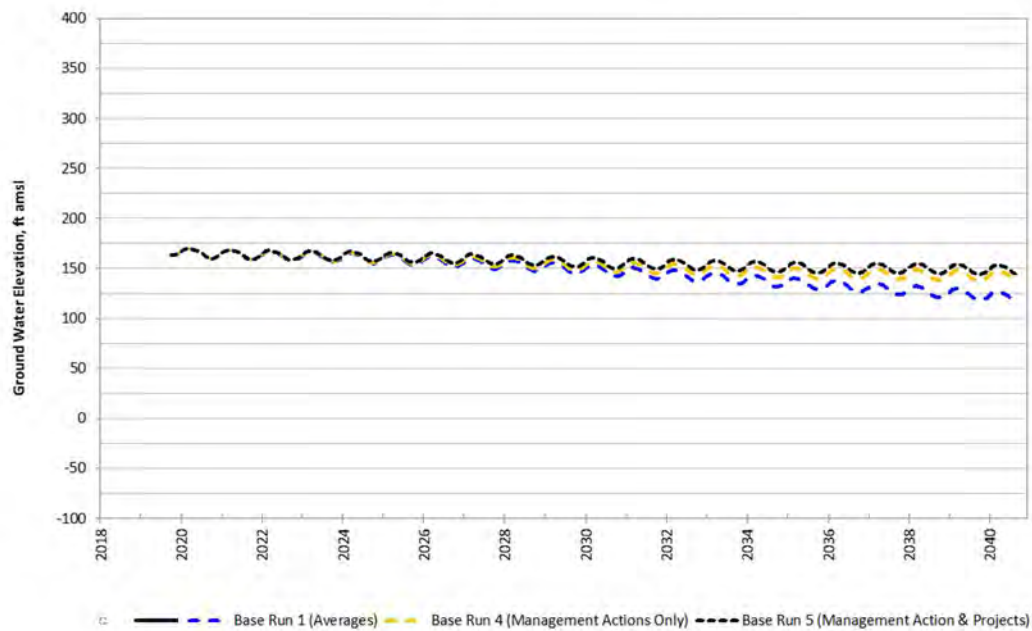
Well KSB-2149
Greater Kaweah GSA
Well ID: CID_046
Aquifer System: Unknown - Model Layer 3



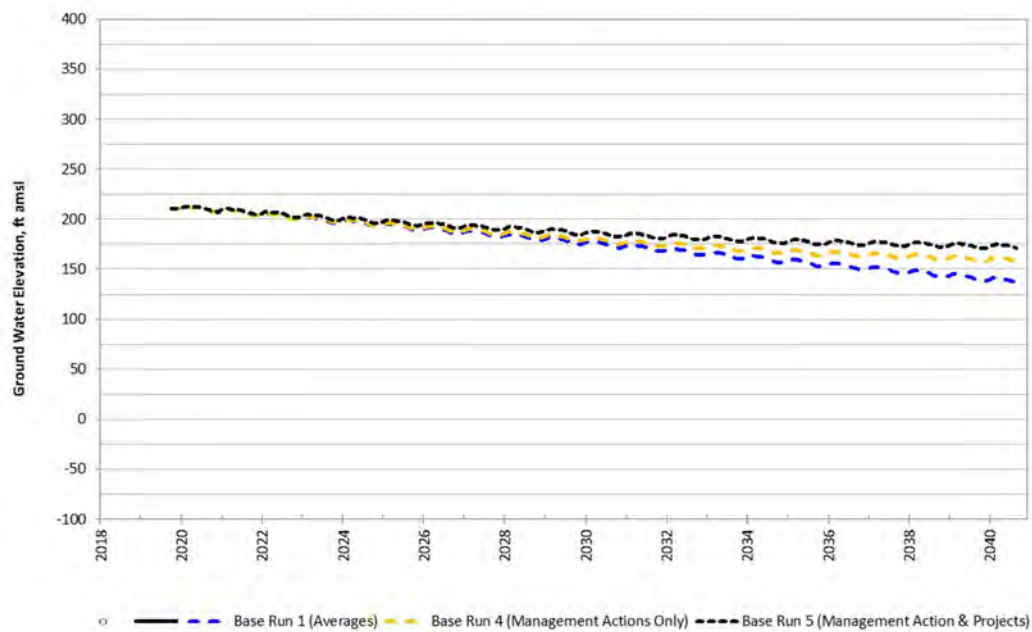
Well KSB-2175
East Kaweah GSA
Well ID: 19S21E35D01M
Aquifer System: Unknown - Model Layer 1

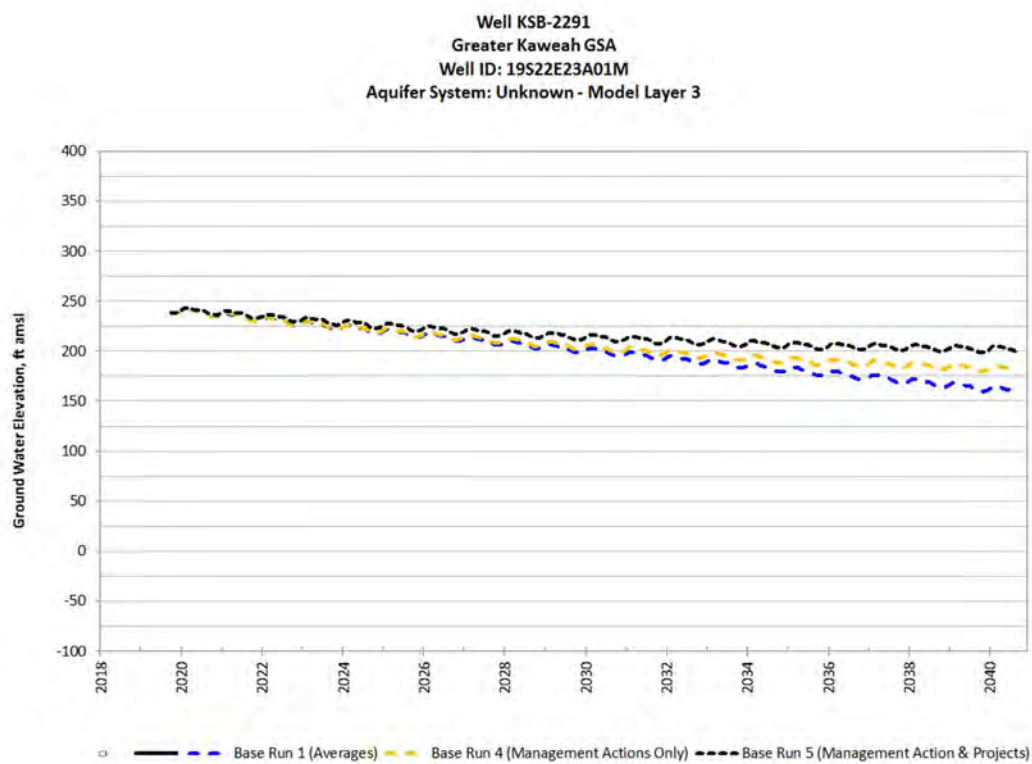
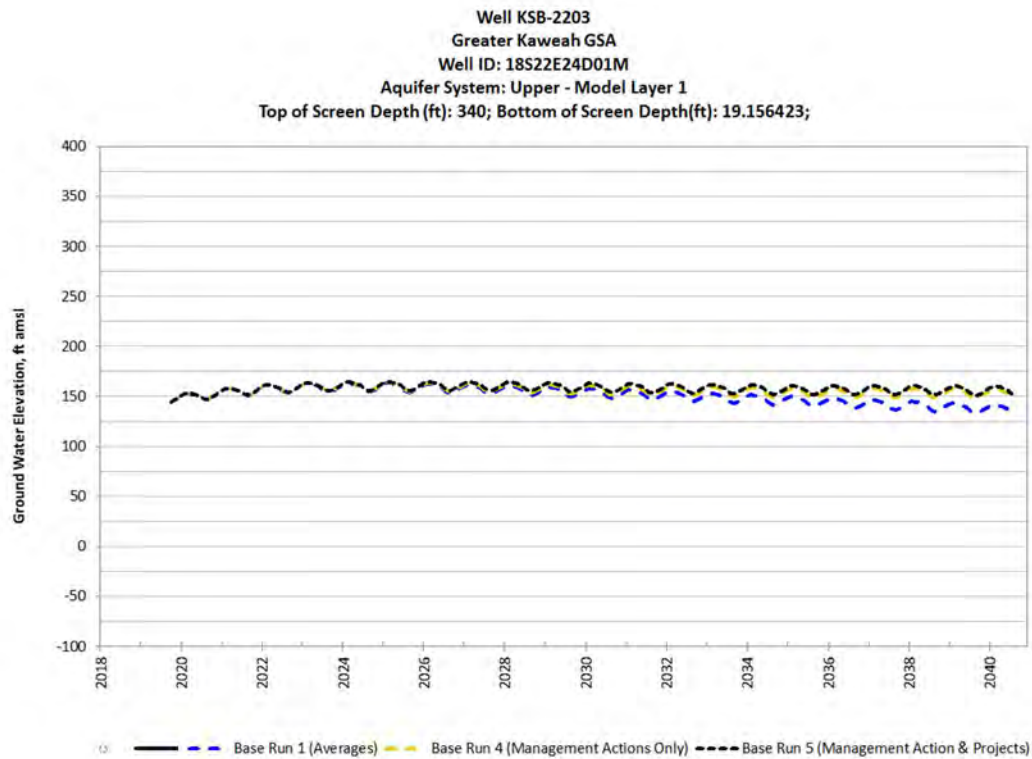


Well KSB-2197
Greater Kaweah GSA
Well ID: 19S22E02K01M
Aquifer System: Unknown - Model Layer 1

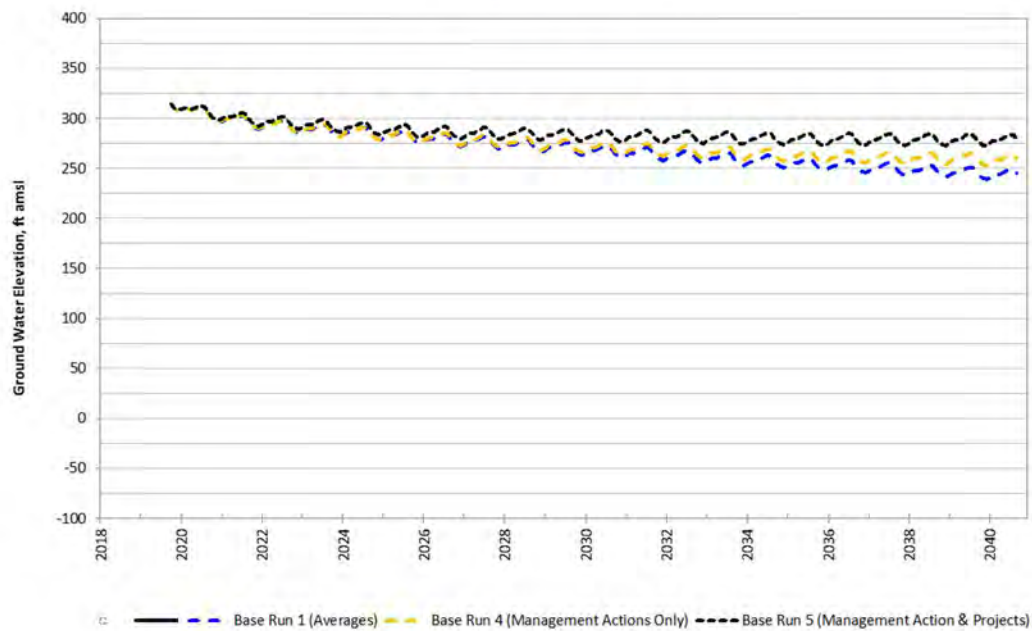


Well KSB-2200
Greater Kaweah GSA
Well ID: CID_040
Aquifer System: Unknown - Model Layer 3

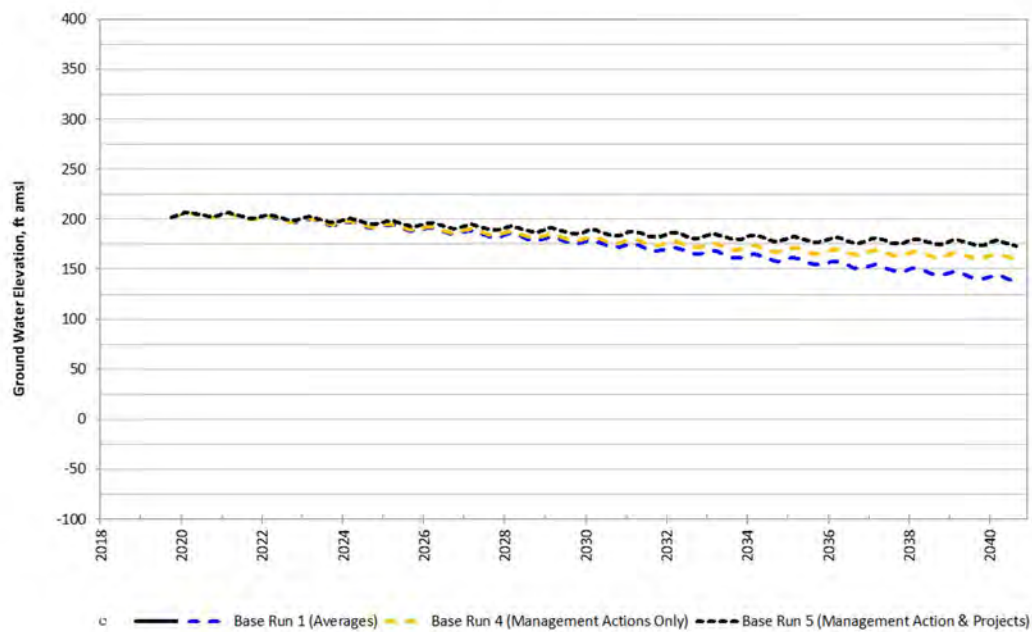




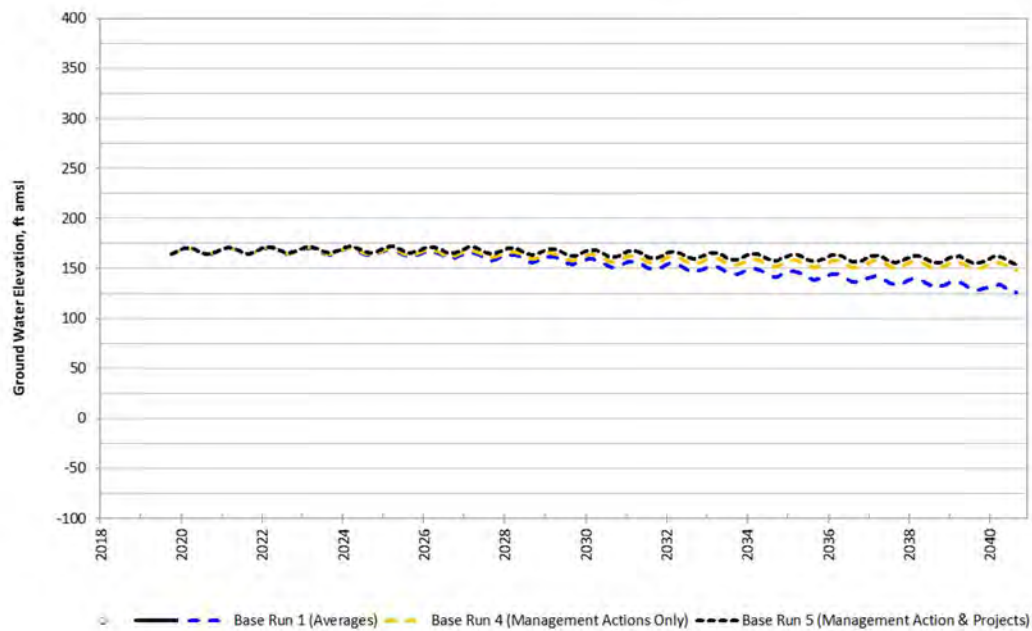
Well KSB-2297
Greater Kaweah GSA
Well ID: CID_065
Aquifer System: Unknown - Model Layer 3



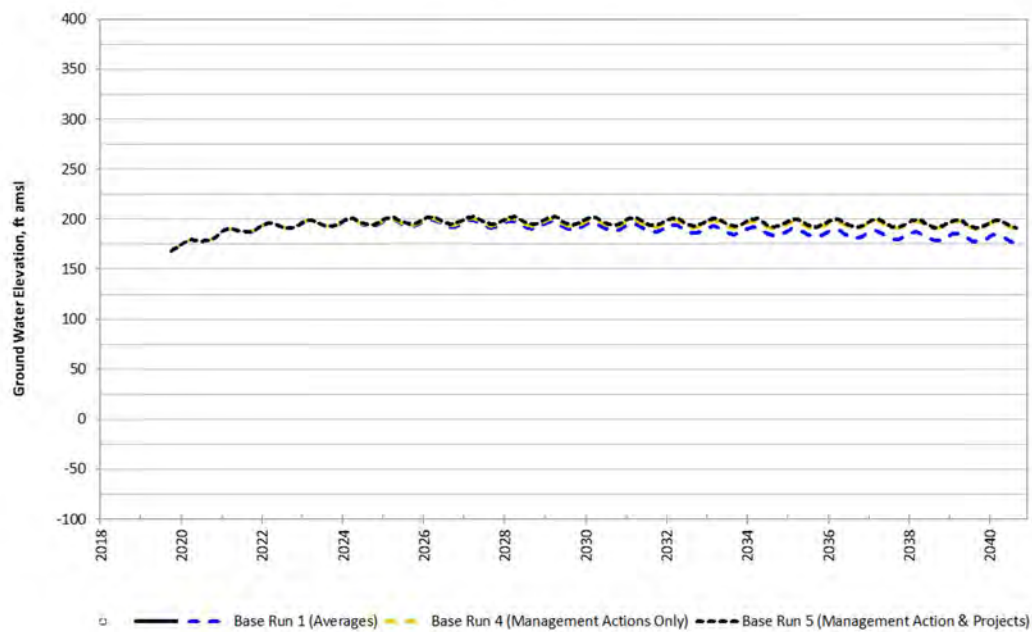
Well KSB-2322
Greater Kaweah GSA
Well ID: 19S22E36E01M
Aquifer System: Unknown - Model Layer 3



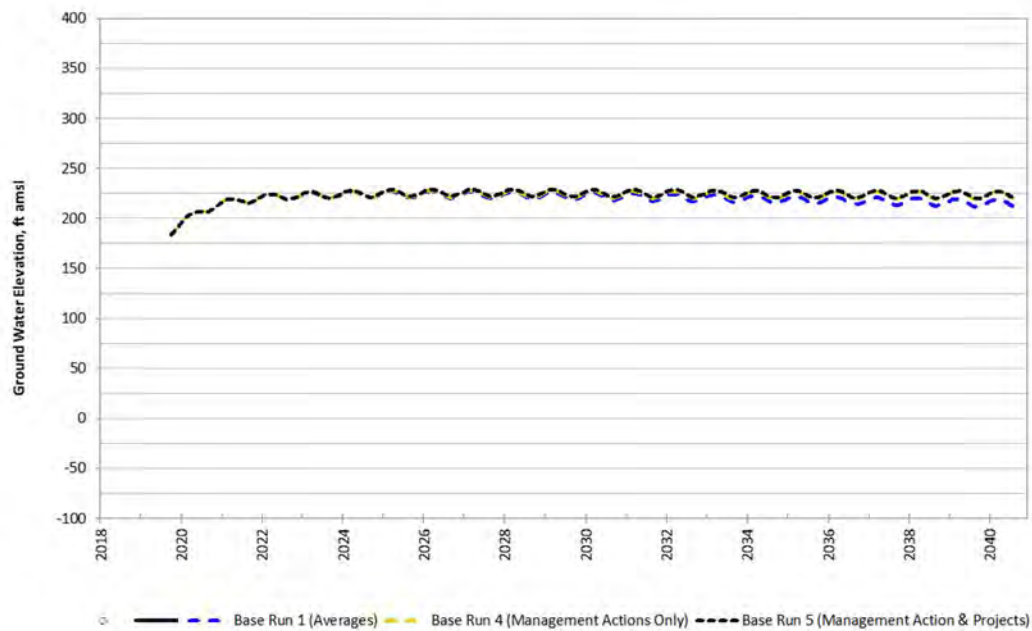
Well KSB-2333
East Kaweah GSA
Well ID: 20S21E11D01M
Aquifer System: Unknown - Model Layer 3



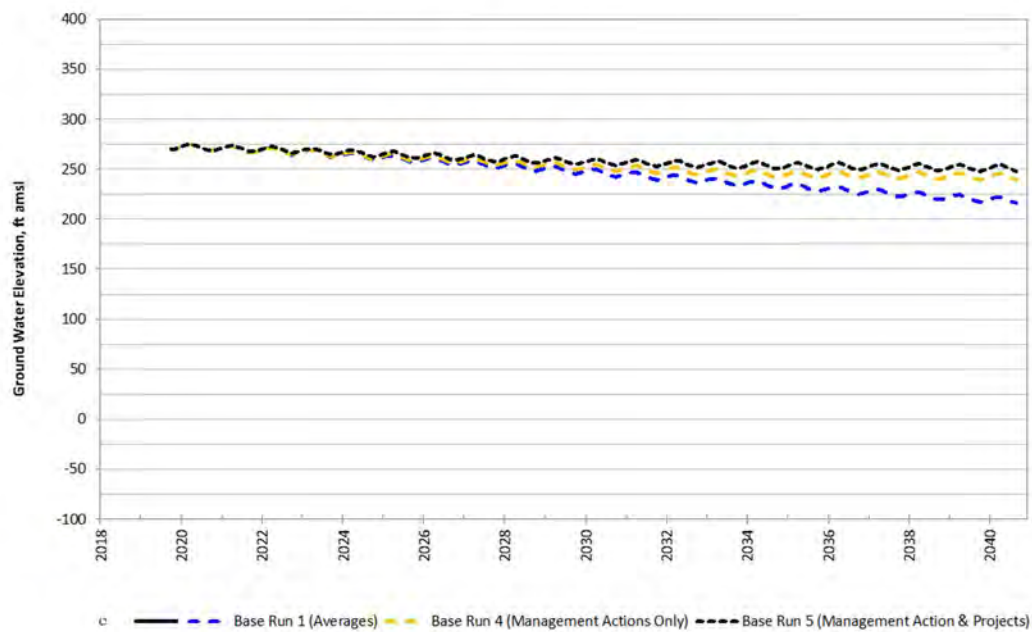
Well KSB-2344
East Kaweah GSA
Well ID: 19S21E26B01M
Aquifer System: Unknown - Model Layer 3



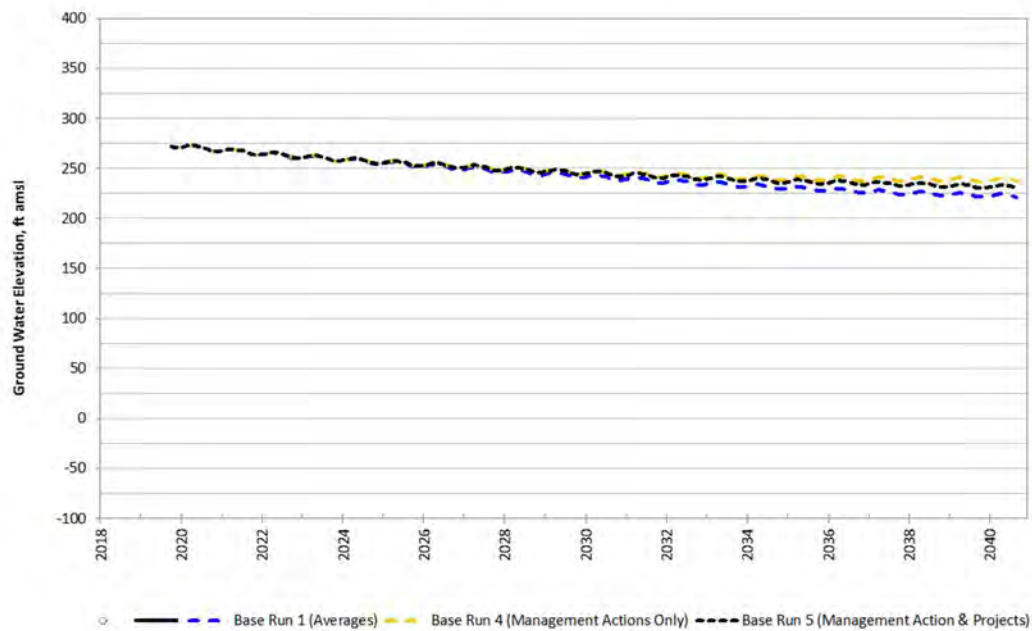
Well KSB-2345
East Kaweah GSA
Well ID: 19S21E23J01M
Aquifer System: Unknown - Model Layer 3



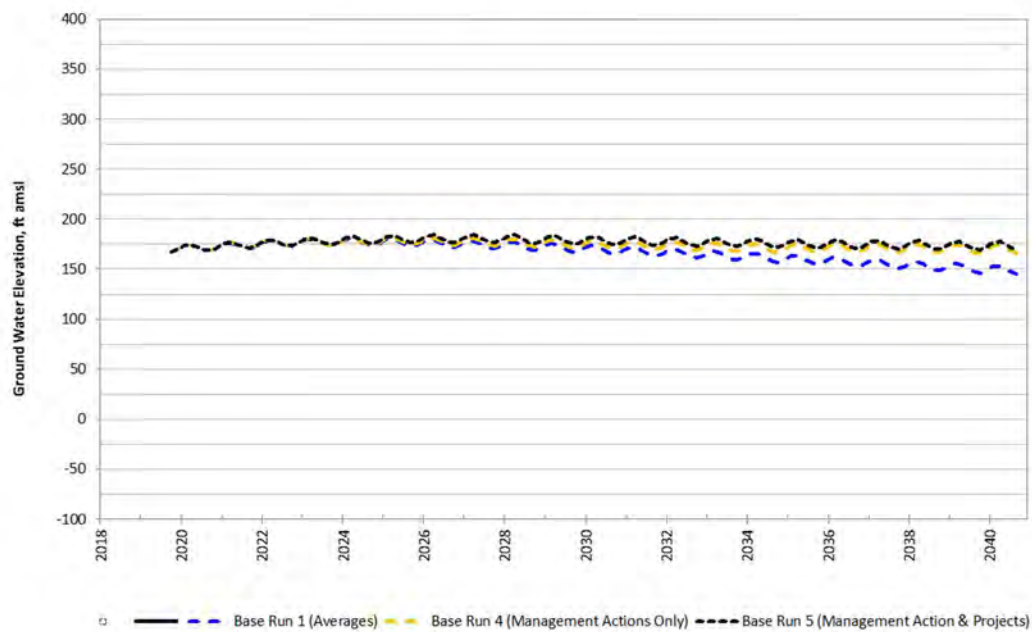
Well KSB-2354
East Kaweah GSA
Well ID: 19S21E36M01M
Aquifer System: Unknown - Model Layer 1



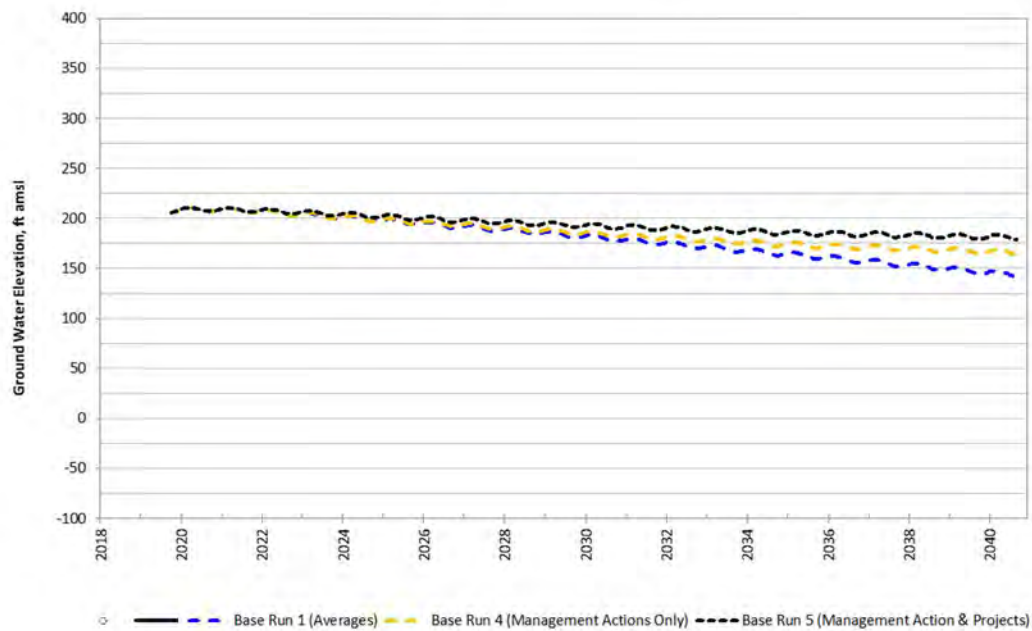
Well KSB-2369
East Kaweah GSA
Well ID: 19S21E13C03M
Aquifer System: Unknown - Model Layer 3



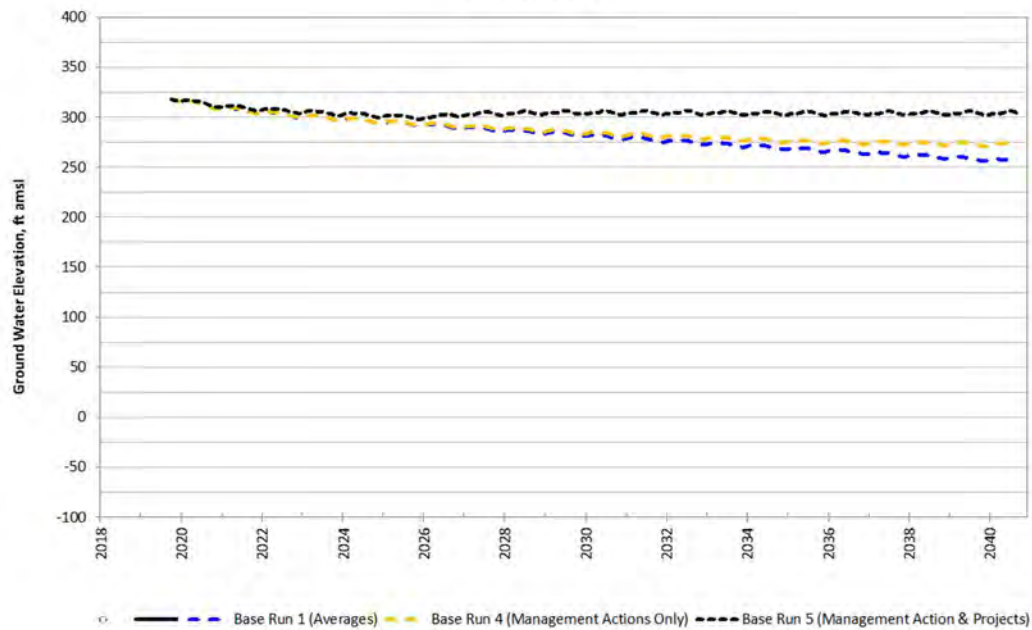
Well KSB-2405
East Kaweah GSA
Well ID: 20S21E01L01M
Aquifer System: Unknown - Model Layer 3



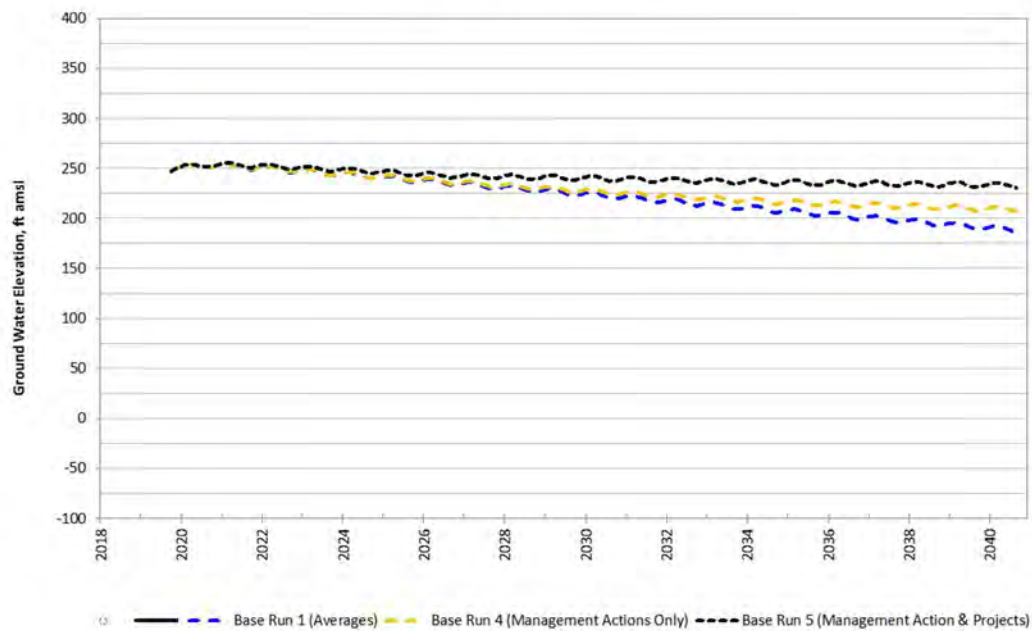
Well KSB-2411
East Kaweah GSA
Well ID: 20S21E12P01M
Aquifer System: Unknown - Model Layer 3



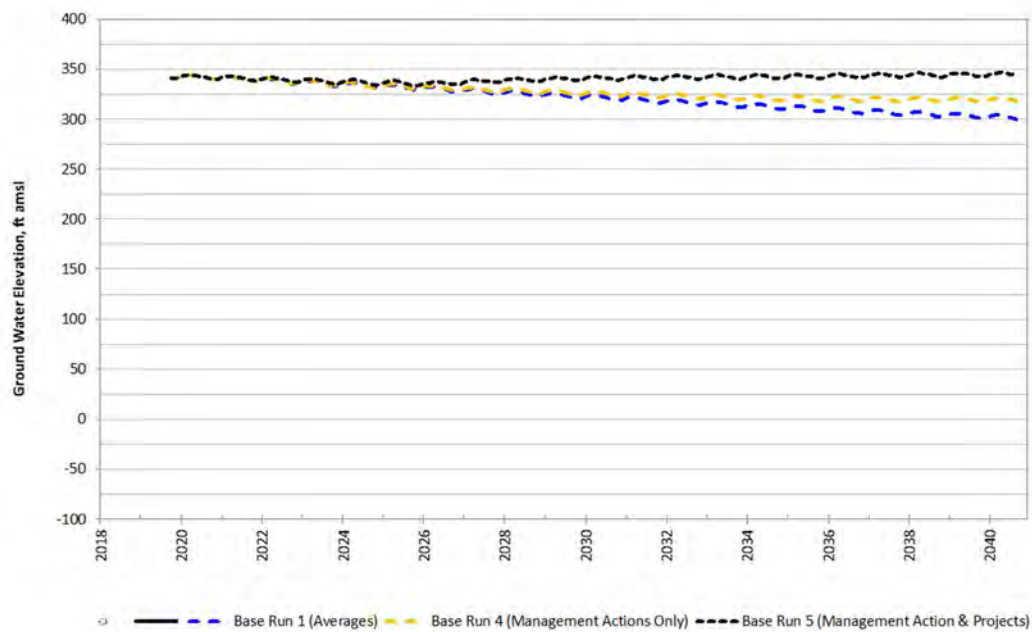
Well KSB-2466
Greater Kaweah GSA
Well ID: 19S22E01N02M
Aquifer System: Upper - Model Layer 1
Total Depth (ft): 138



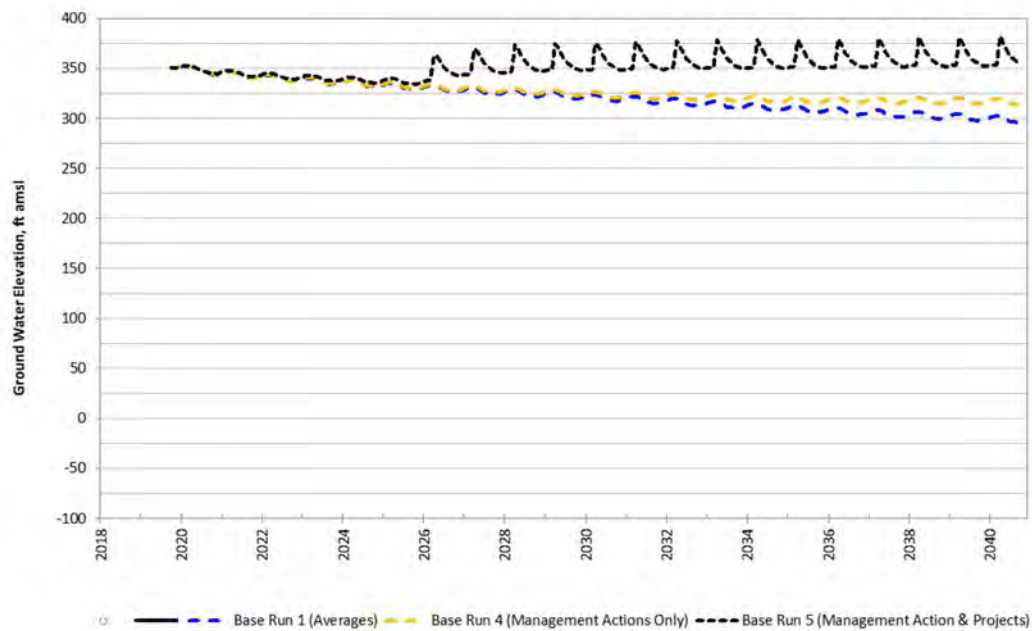
Well KSB-2507
East Kaweah GSA
Well ID: 19S21E12Q01M
Aquifer System: Unknown - Model Layer 1



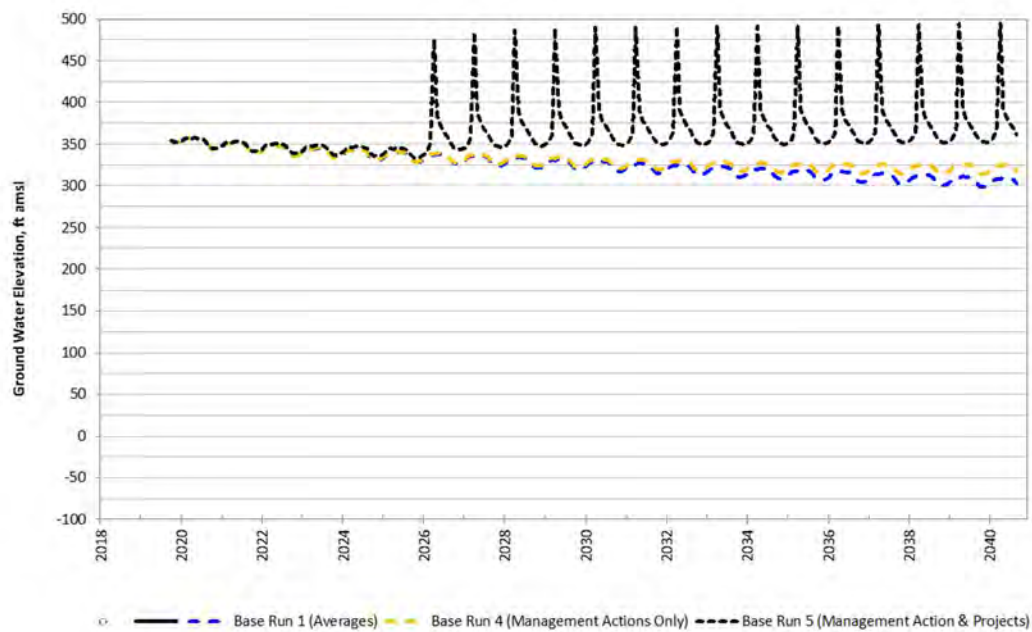
Well KSB-2513
East Kaweah GSA
Well ID: 19S21E24K01M
Aquifer System: Unknown - Model Layer 1



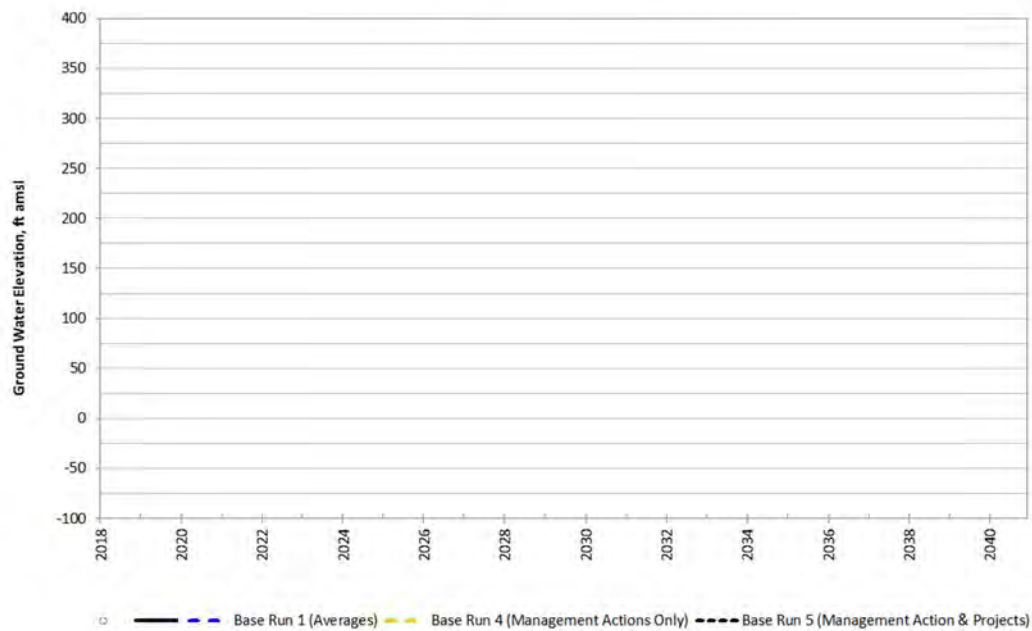
Well KSB-2519
Greater Kaweah GSA
Well ID: 19S22E36E02M
Aquifer System: Unknown - Model Layer 3



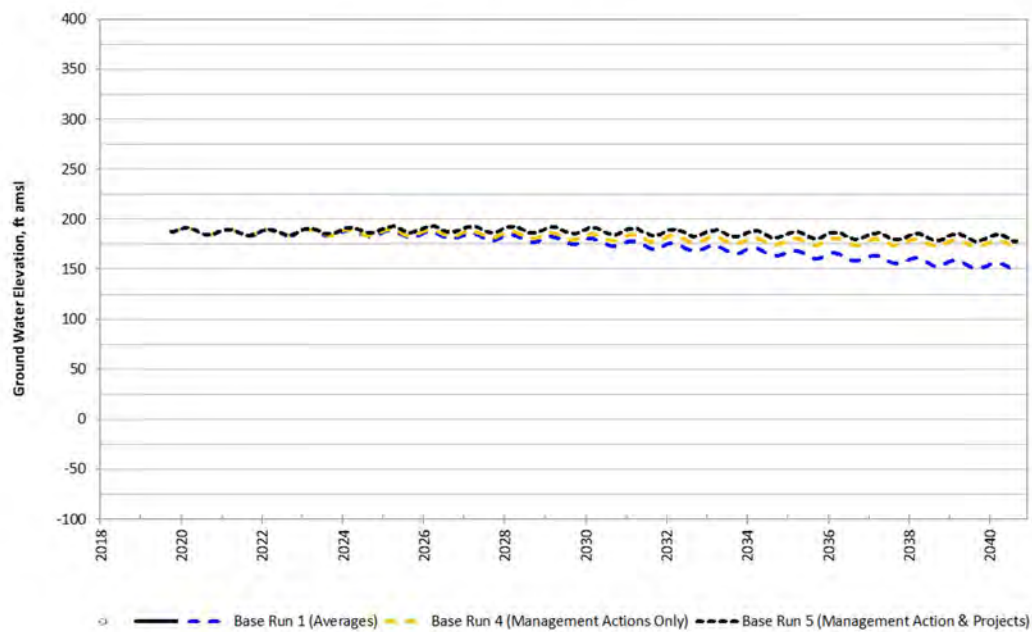
Well KSB-2539
Greater Kaweah GSA
Well ID: CID_041
Aquifer System: Unknown - Model Layer 3



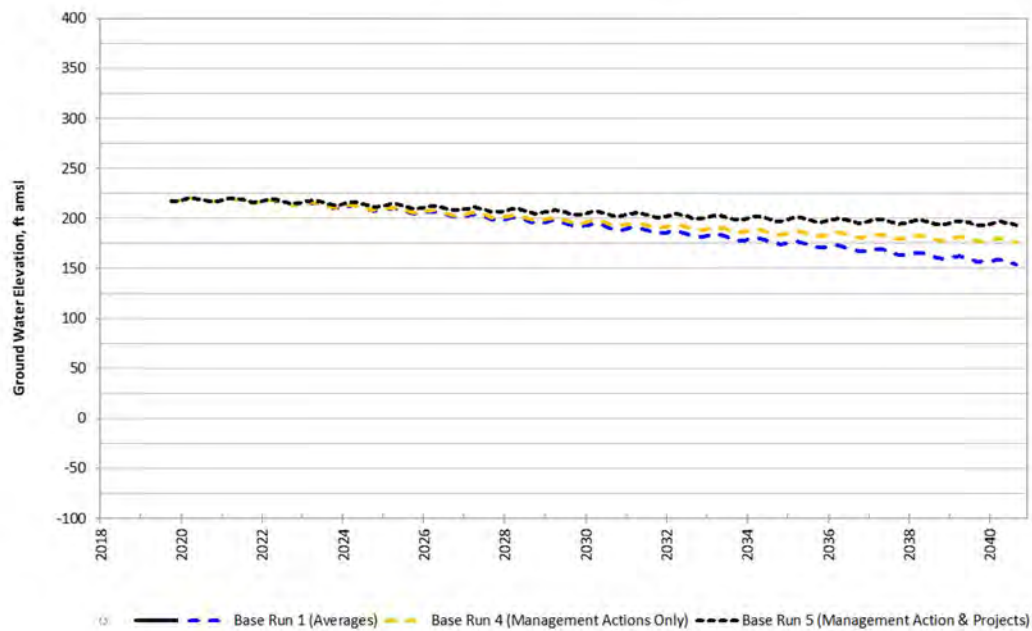
Well KSB-2588
East Kaweah GSA
Well ID: 20S21E13B01M
Aquifer System: Unknown - Model Layer 1



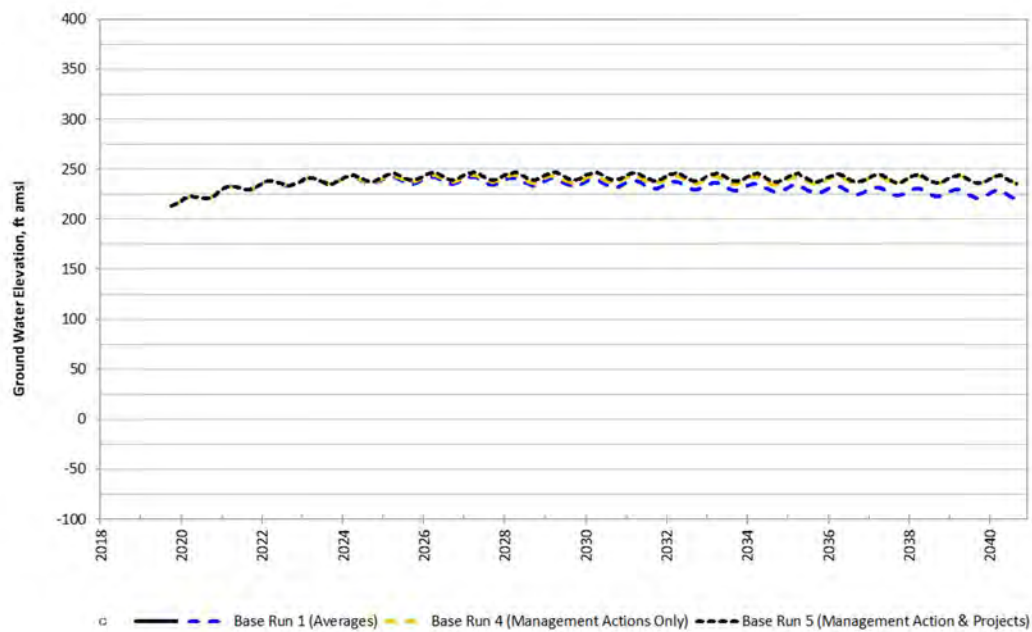
Well KSB-2590
East Kaweah GSA
Well ID: 19S21E24H01M
Aquifer System: Unknown - Model Layer 3



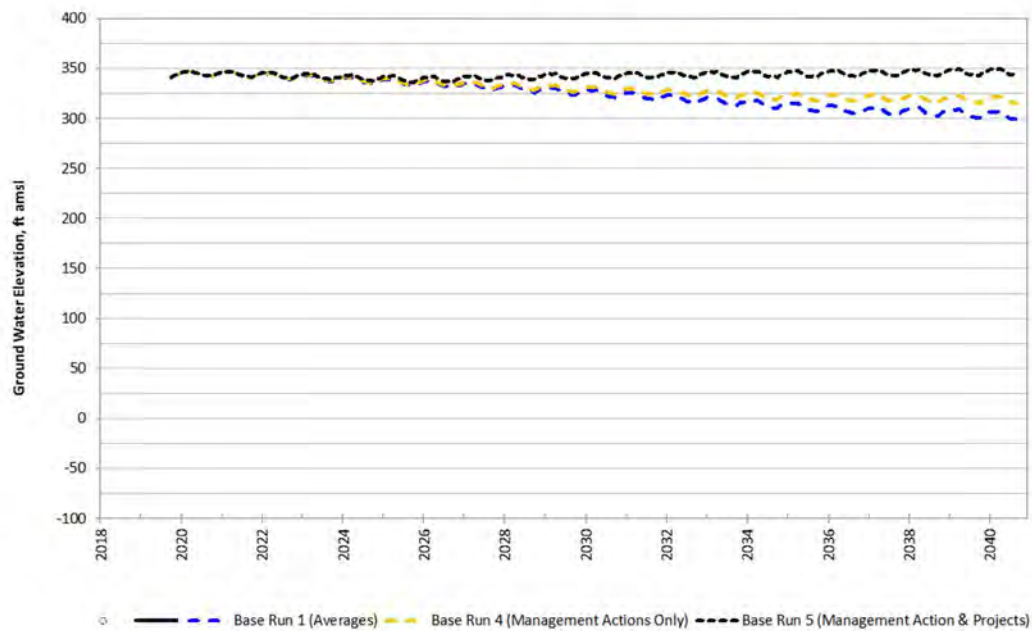
Well KSB-2593
East Kaweah GSA
Well ID: 20S21E01A01M
Aquifer System: Unknown - Model Layer 3



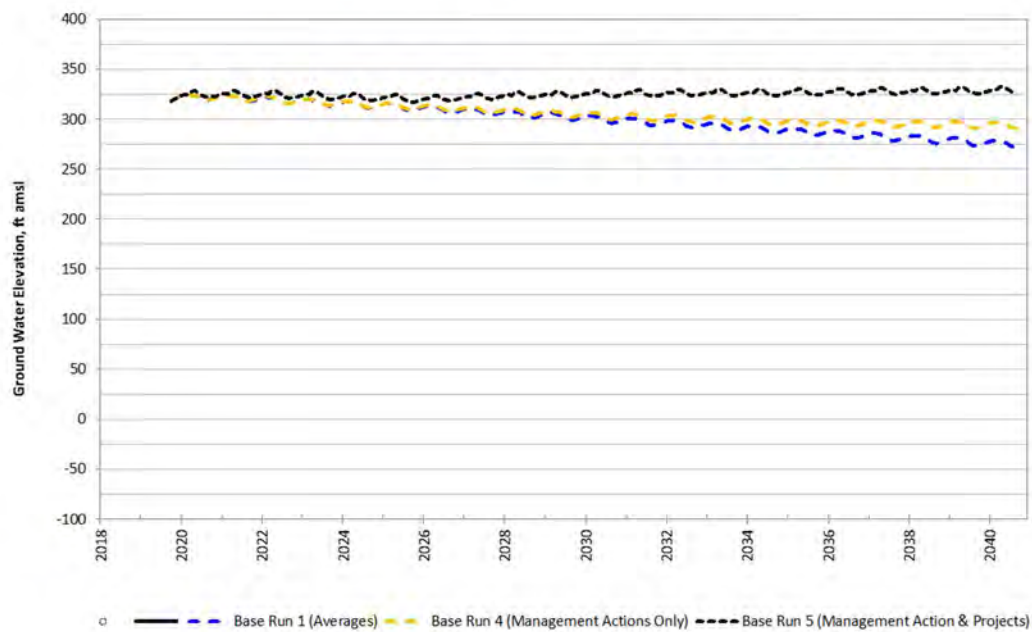
Well KSB-2618
East Kaweah GSA
Well ID: 19S21E13J01M
Aquifer System: Unknown - Model Layer 1



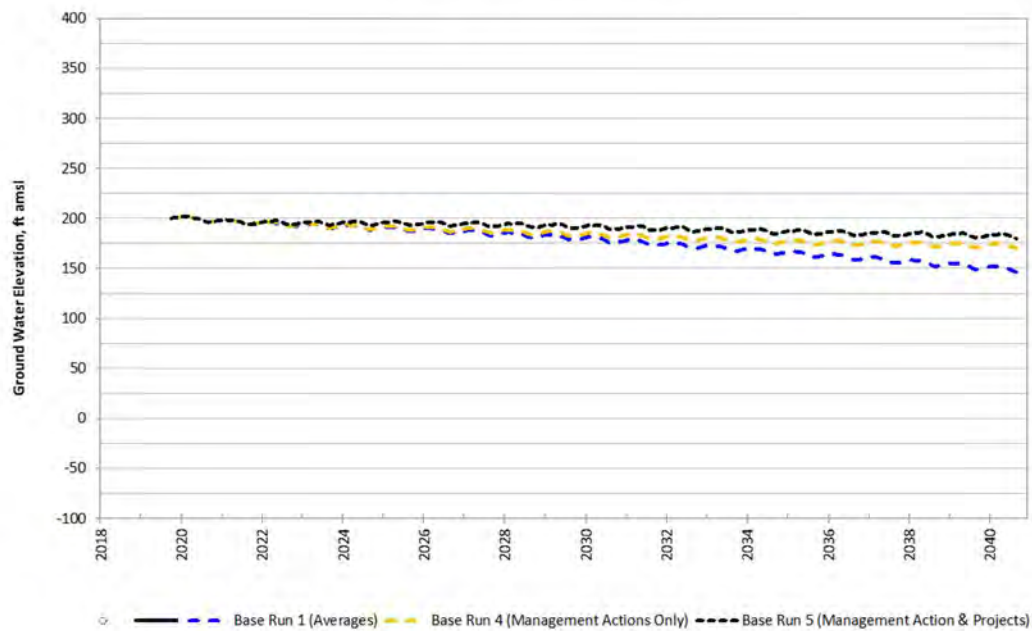
Well KSB-2690
Greater Kaweah GSA
Well ID: CID_100
Aquifer System: Unknown - Model Layer 3



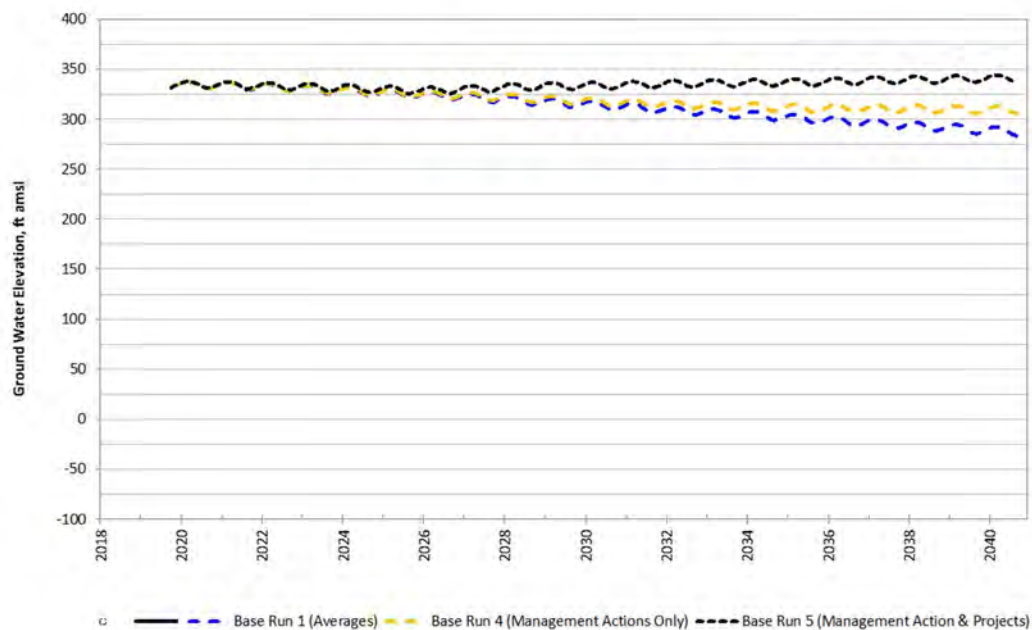
Well KSB-2696
East Kaweah GSA
Well ID: 19S21E13A01M
Aquifer System: Unknown - Model Layer 3



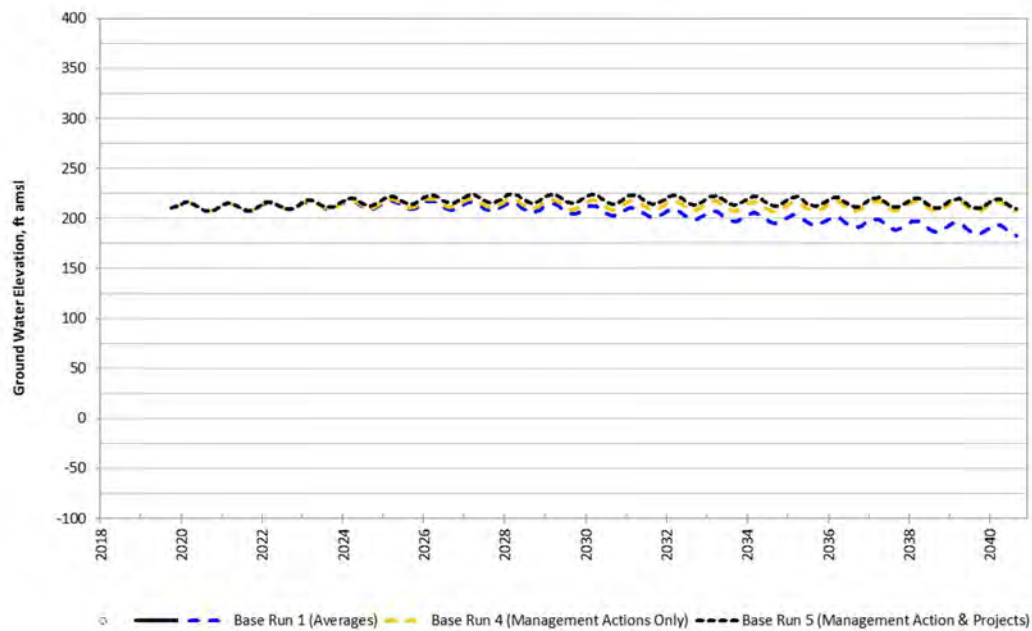
Well KSB-2697
East Kaweah GSA
Well ID: 19S21E25J01M
Aquifer System: Unknown - Model Layer 3



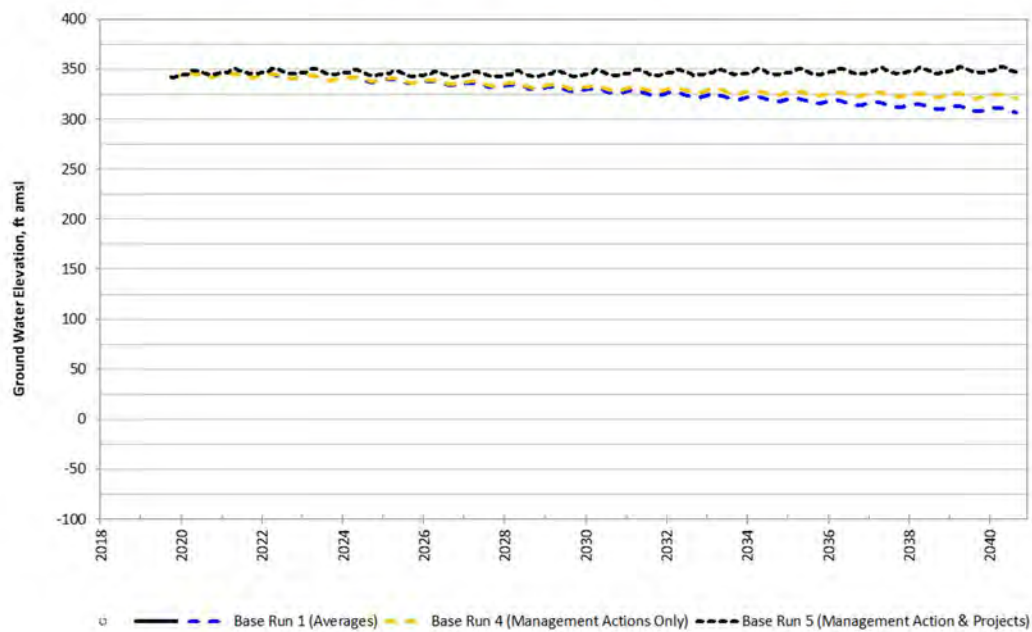
Well KSB-2765
Greater Kaweah GSA
Well ID: CID_067
Aquifer System: Unknown - Model Layer 3



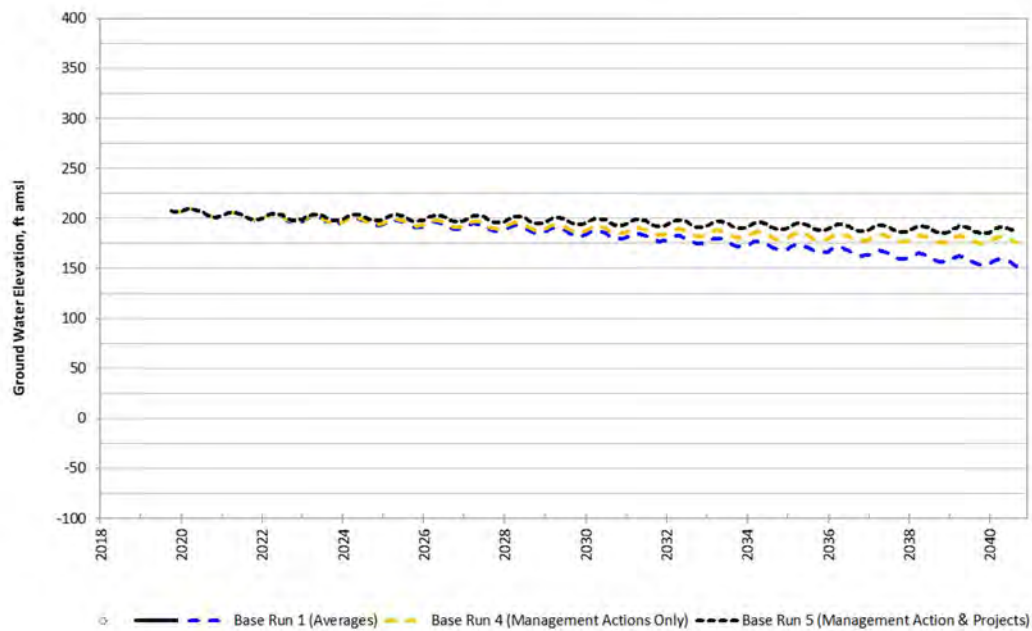
Well KSB-2769
East Kaweah GSA
Well ID: 20S22E06N01M
Aquifer System: Unknown - Model Layer 3



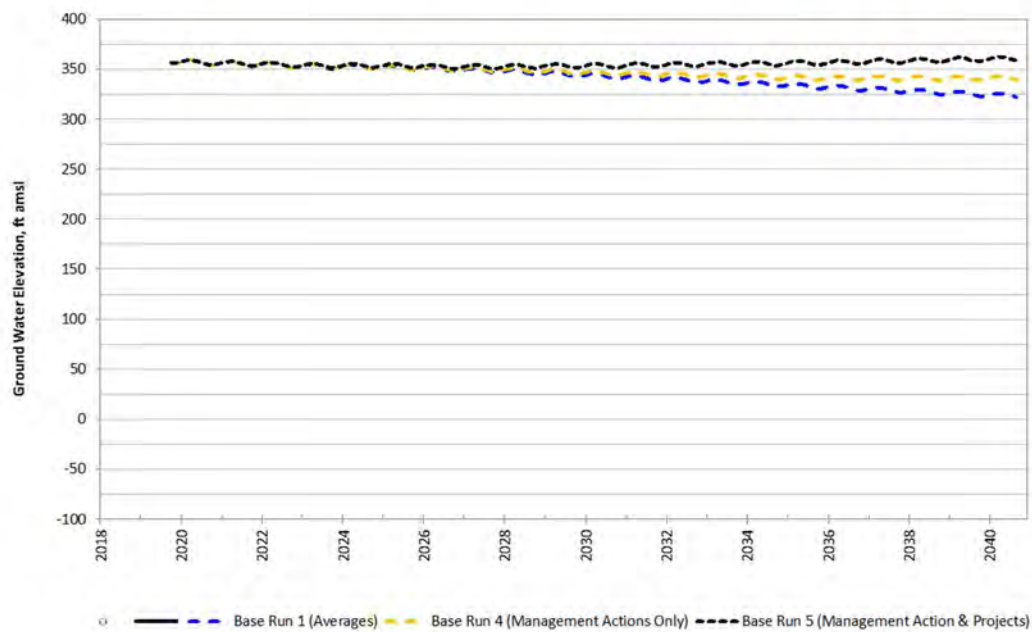
Well KSB-2773
East Kaweah GSA
Well ID: 19S22E19M01M
Aquifer System: Unknown - Model Layer 3



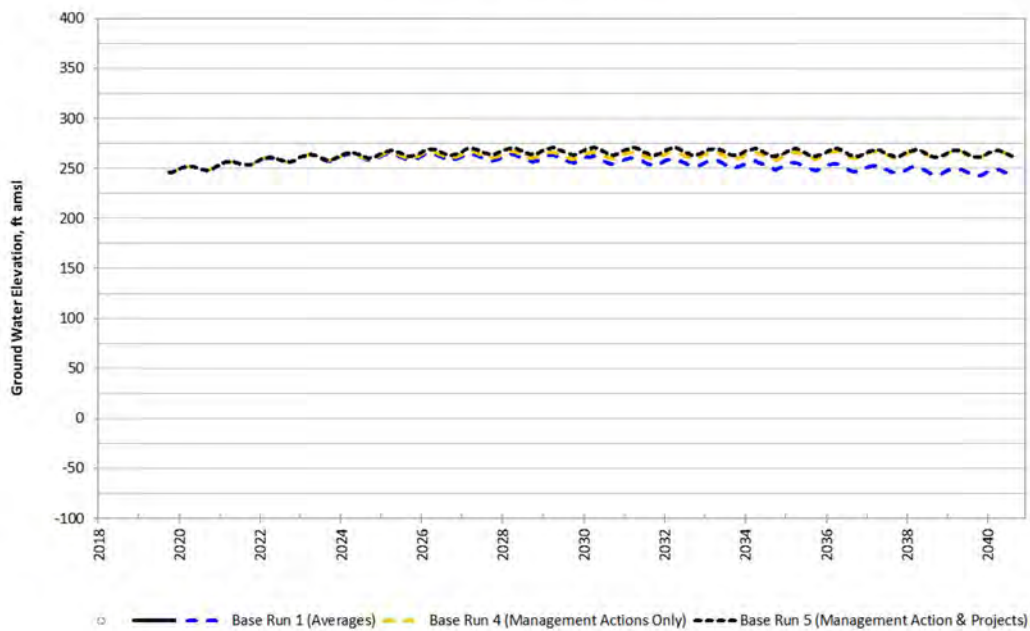
Well KSB-2790
East Kaweah GSA
Well ID: 19S22E30D01M
Aquifer System: Unknown - Model Layer 1



Well KSB-2822
Greater Kaweah GSA
Well ID: CID_021
Aquifer System: Unknown - Model Layer 3



Well KSB-2823
East Kaweah GSA
Well ID: 20S22E07M01M
Aquifer System: Unknown - Model Layer 1



Well KSB-2826
East Kaweah GSA
Well ID: 20S22E06C01M
Aquifer System: Unknown - Model Layer 3

