The establishment of monitoring protocols is closely related to other GSP sections. Subarticle 4 of the GSP Emergency Regulations requires the establishment of a monitoring network that includes monitoring objectives, monitoring protocols, and data reporting requirements. The protocols must allow for the monitoring network to collect ample data to establish seasonal, short-term, and long-term trends in groundwater levels, groundwater quality, inelastic surface subsidence, and surface water flow and quality. In addition, monitoring protocols ensure that the methods used in future data collection – in support of measuring the achievement of sustainability goals or undesirable results (e.g. MT, MO, IM, etc.) are consistent with the methods used to establish these metrics. The boundaries of Buena Vista GSA is shown in Figure 1.

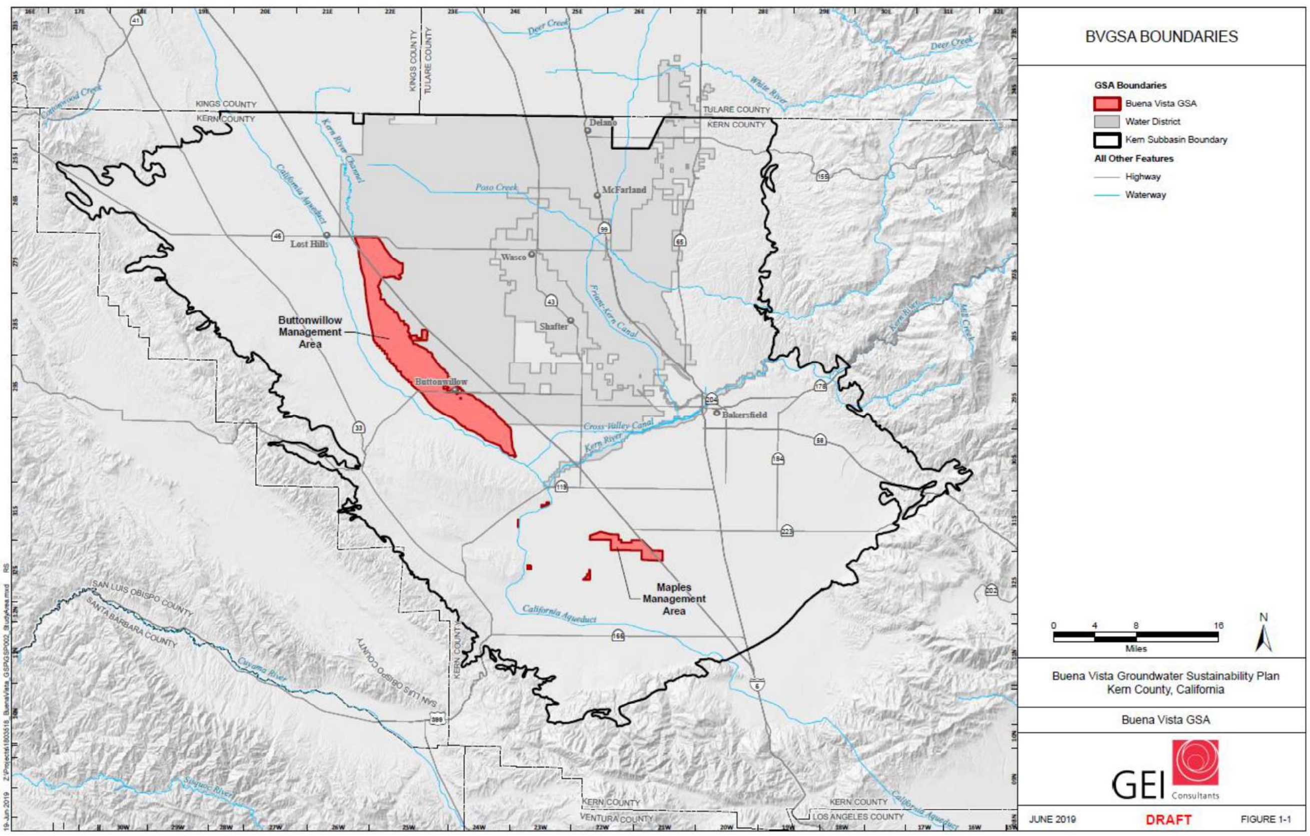


Figure 1. Buena Vista GSA Location

1.2 Goals and Objectives

The objectives of this monitoring protocol are to establish the purposes for monitoring groundwater, surface water, and subsidence with subbasins, and to set forth standard practices to be widely, and uniformly applied when collecting data from monitoring sites to provide a sound technical foundation for compliance with SGMA. This protocol provides necessary tools and procedures for any GSA to monitor groundwater and surface water conditions within their boundaries. The intent is that this protocol can also be applied throughout the Kern Suibbasin to form a standard approach to data collection that will provide uniform, reliable data in a format that can be easily consolidated and analyzed to assess groundwater, surface water, and subsidence conditions.

1.3 Description of Monitoring Protocol Structure

The DWR recommends that GSAs consider the adoption of existing monitoring protocols when possible. Section 2 – Existing Monitoring Protocol – provides information and background of existing monitoring protocols used by agencies in the Sacramento Valley for each of the following:

- Groundwater Level
- Water Quality
- Subsidence
- Streamflow

The adequacy of existing monitoring protocols will then be compared to the benchmarks established in DWR's *Monitoring Protocols, Standards, and Sites: Best Management Practices (BMP)*[2] document. Section 3 – Proposed Monitoring Protocol – provides field personnel with a practical guide to collect and manage groundwater level, water quality, subsidence, and streamflow data. This guide is adapted from existing monitoring protocols (Section 2) and then altered, as needed, to comply with the *BMP*.

The appendices to this protocol contain procedures or documents that are referenced in Sections 2 and 3.

2 Proposed Monitoring Protocol

This section provides a "how to" manual for field staff that emulates the content and format of DWR's *BMP* and is informed by applicable existing protocols discussed in Section 2 – Basin Setting of this GSP. Per the *BMP*, the collection of data should be based on the best available science and applied consistently across all basins to yield comparable data.

This section will explore the following:

- goals of the monitoring protocol;
- training requirements;
- data and reporting standards, and
- the proposed monitoring protocols for each data collection process.

If the proposed monitoring protocol presented in this document deviates from the *BMP*, an explanation of how the protocol will yield comparable data will be provided.

3.1 Goals of the Proposed Monitoring Protocol

The overarching goal of the proposed monitoring protocol is to provide agencies and field personnel with explicit instructions for the data collection, storage, and reporting of data to be included in GSPs. The adoption of these protocols allows for neighboring GSPs and, more broadly, GSPs statewide to have comparable data. The protocol will provide agencies the tools necessary to meet monitoring objectives described in the SGMA regulations. This includes the capture of data with a sufficient spatial distribution and temporal frequency to demonstrate short-term, seasonal, and long-term trends in basin conditions for each of the sustainability indicators.

3.1.1 Data Quality and Consistency

To be considered for inclusion in a GSP, data used to monitor sustainability indicators should be held to a quality standard. Quality data comes from a reputable source with known, documented methods of collection. The adoption of statewide and regional protocol allows for comparable data that is held to a similar quality standard.

This monitoring protocol also provides a template for consistent data collection for GSPs. If the quality of previous data collection is adequate, the same methods should be continued for future data collection to allow for accuracy in trend analysis. Where methods deviate, GSPs must be explicit in explaining the methods and potential data gaps.

3.1.2 Standardized Data and Reporting

The following data and reporting standards from §352.4 are relevant to the collection of monitoring data:

(1) Water volumes shall be reported in acre-feet.
(2) Surface water flow shall be reported in cubic feet per second and groundwater flow shall be reported in acre-feet per year.
(3) Field measurements of elevations of groundwater, surface water, and land surface shall be measured and reported in feet to an accuracy of at least 0.1 feet relative to NAVD88, or another national standard that is convertible to NAVD88, and the method of measurement described.
(4) Reference point elevations shall be measured and reported in feet to an accuracy of at least 0.5 feet, or the best available information, relative to NAVD88, or another national standard that is convertible to NAVD88, and the method of measurement described.
(5) Geographic locations shall be reported in GPS coordinates by latitude and longitude in decimal degree to five decimal places, to a minimum accuracy of 30 feet, relative to NAD83, or another national standard that is convertible to NAD83.

Pursuant to §352.4, all monitoring sites must include the following information:

(1) A unique site identification number and narrative description of the site location.
(2) A description of the type of monitoring, type of measurement taken, and monitoring frequency.
(3) Location, elevation of the ground surface, and identification and description of the reference point.
(4) A description of the standards used to install the monitoring site. Sites that do not conform to best management practices shall be identified and the nature of the divergence from best management practices described.

3.1.3 Data Management

Pursuant to §352.6, each agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the GSP and monitoring of the basin.

3.2 Training Requirements

Although not discussed in the *BMP*, the monitoring and data collection shall be completed by trained personnel working under the supervision of a Professional Civil Engineer, California Professional Geologist, or a Certified Hydrogeologist. The trained personnel must be familiar with SGMA requirements, the protocols described in this document, and the hydrology, geology, and geography of the locale in which their work is completed. The field personnel shall receive explicit written and verbal instruction from the Professional Civil Engineer, California Professional Geologist, or a Certified Hydrogeologist they are working under. This monitoring protocol and all field equipment instructions, equipment calibration instructions, safety manuals, and other reference documents discussed in this protocol must be available to all personnel that conduct monitoring or data collection activities. Any laboratory used for water quality analysis must be accredited by the California Environmental Laboratory Accreditation Program.

3.3 Proposed Protocols

The GSP Regulations require the use of the protocols discussed in the *BMP*, or the development of similar protocols. Where applicable, the technical protocols described in this proposed protocol are adopted in their entirety and reprinted from the *BMP*, which leverages existing professional standards that are often adopted in various groundwater-related programs. When the protocol deviates from the BMP, explanation for how the alteration or elaboration yields similar data will be provided. The protocol for the selection and maintenance of monitoring sites is described in Section 4 – Monitoring Network. All language that is taken directly from the *BMP is* shown in italics and any changes, additions, or edits are shown in standard font.

3.3.1 Groundwater Level: Proposed Protocol

The protocol for groundwater level monitoring described in the *BMP* is reprinted below.

Groundwater levels are a fundamental measure of the status of groundwater conditions within a basin. In many cases, relationships of the sustainability indicators may be able to be correlated with groundwater levels. The quality of this data must consider the specific aquifer being monitored and the methodology for collecting these levels.

The following considerations for groundwater level measuring protocols should ensure the following:

- *Groundwater level data are taken from the correct location, well ID, and screen interval depth;*
- *Groundwater level data are accurate and reproducible;*
- *Groundwater level data represent conditions that inform appropriate basin management DQOs;*
- *All salient information is recorded to correct, if necessary, and compare data, and*
- *Data are handled in a way that ensures data integrity.*

General Well Monitoring Information

The following presents considerations for collection of water level data that include regulatory required components as well as those which are recommended.

Groundwater elevation data will form the basis of basin-wide water-table and piezometric maps and should approximate conditions at a discrete period in time. Therefore, all *groundwater levels in a basin should be collected within as short a time as possible, preferably within a 1- to 2-week period.*

Depth to groundwater must be measured relative to an established Reference Point (RP) on the well casing. The RP is usually identified with a permanent marker, paint spot, or a notch in the lip of the well casing. By convention in open casing monitoring wells, the RP reference point is located on the north side of the well casing. If no mark is apparent, the person performing the measurement should measure the depth to groundwater from the north side of the top of the well casing.

The elevation of the RP of each well must be surveyed to the North American Vertical Datum of 1988 (NAVD88), or a local datum that can be converted to NAVD88. The elevation of the RP must be accurate to within 0.5 foot. It is preferable for the RP elevation to be accurate to 0.1 foot or less. Survey grade global navigation satellite system (GNSS) global positioning system (GPS) equipment can achieve similar vertical accuracy when corrected. Guidance for use of GPS can be found at USGS http://water.usgs.gov/osw/gps/. Hand-held GPS units likely will not produce reliable vertical elevation measurement accurate enough for the casing elevation consistent with the DQOs and regulatory requirements.

The sampler should remove the appropriate cap, lid, or plug that covers the monitoring access point listening for pressure release. If a release is observed, the measurement should follow a period of time to allow the water level to equilibrate.

Depth to groundwater must be measured to an accuracy of 0.1 foot below the RP. It is preferable to measure depth to groundwater to an accuracy of 0.01 foot. Air lines and acoustic sounders may not provide the required accuracy of 0.1 foot.

The water level meter should be decontaminated after measuring each well.

Measuring Groundwater Levels

Measure depth to water in the well using procedures appropriate for the measuring device. Equipment must be operated and maintained in accordance with manufacturer's instructions. Groundwater levels should be measured to the nearest 0.01 foot relative to the RP.

For measuring wells that are under pressure, allow a period of time for the groundwater levels to stabilize. In these cases, multiple measurements should be collected to ensure the well has reached equilibrium such that no significant changes in water level are observed. Every effort should be made to ensure that a representative stable depth to groundwater is recorded. If a well does not stabilize, the quality of the value should be appropriately qualified as a questionable measurement. In the event that a well is artesian, site specific procedures should be developed to collect accurate information and be protective of safety conditions associated with a pressurized well. In many cases, an extension pipe may be adequate to stabilize head in *the well. Record the dimension of the extension and document measurements and configuration.*

The sampler should calculate the groundwater elevation as:

$$GWE = RPE - DTW$$

Where:

- *GWE = Groundwater Elevation*
- *RPE = Reference Point Elevation*
- *DTW = Depth to Water*

The sampler must ensure that all measurements are in consistent units of feet, tenths of feet, and hundredths of feet. Measurements and RPEs should not be recorded in feet and inches.

Recording Groundwater Levels

The sampler should record the well identifier, date, time (24-hour format), RPE, height of RP above or below ground surface, DTW, GWE, and comments regarding any factors that may influence the depth to water readings such as weather, nearby irrigation, flooding, potential for tidal influence, or well condition. If there is a questionable measurement or the measurement cannot be obtained, it should be noted.

The sampler should replace any well caps or plugs, and lock any well buildings or covers.

All data should be entered into the data management system (DMS) as soon as possible. Care should be taken to avoid data entry mistakes and the entries should be checked by a second person for compliance.

Pressure Transducers

Groundwater levels and/or calculated groundwater elevations may be recorded using pressure transducers equipped with data loggers installed in monitoring wells. When installing pressure transducers, care must be exercised to ensure that the data recorded by the transducers is confirmed with hand measurements.

The following general protocols must be followed when installing a pressure transducer in a monitoring well:

- *The sampler must use an electronic sounder or chalked steel tape and follow the protocols listed above to measure the groundwater level and calculate the groundwater elevation in the monitoring well to properly program and reference the installation. It is recommended that transducers record measured groundwater level to conserve data capacity; groundwater elevations can be calculated at a later time after downloading.*

- *The sampler must note the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and cable serial number.*
- *Transducers must be able to record groundwater levels with an accuracy of at least 0.1 foot. Professional judgment should be exercised to ensure that the data being collected is meeting the DQO and that the instrument is capable. Consideration of the battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers should be included in the evaluation.*
- *The sampler must note whether the pressure transducer uses a vented or nonvented cable for barometric compensation. Vented cables are preferred, but nonvented units provide accurate data if properly corrected for natural barometric pressure changes. This requires the consistent logging of barometric pressures to coincide with measurement intervals.*
- *Follow manufacturer specifications for installation, calibration, data logging intervals, battery life, correction procedure (if non-vented cables used), and anticipated life expectancy to assure that DQOs are being met for the GSP.*
- *Secure the cable to the well head with a well dock or another reliable method. Mark the cable at the elevation of the reference point with tape or an indelible marker. This will allow estimates of future cable slippage.*
- *The transducer data should periodically be checked against hand measured groundwater levels to monitor electronic drift or cable movement. This should happen during routine site visits, at least annually or as necessary to maintain data integrity.*
- *The data should be downloaded as necessary to ensure no data is lost and entered into the basin's DMS following the QA/QC program established for the GSP. Data collected with non-vented data logger cables should be corrected for atmospheric barometric pressure changes, as appropriate. After the sampler is confident that the transducer data have been safely downloaded and stored, the data should be deleted from the data logger to ensure that adequate data logger memory remains.*

3.3.2 Groundwater Quality: Proposed Protocol

The protocol for groundwater quality monitoring described in the *BMP* is reprinted below.

All analyses should be performed by a laboratory certified under the State Environmental Laboratory Accreditation Program. The specific analytical methods are beyond the scope of this BMP but should be commensurate with other programs evaluating water quality within the basin for comparative purposes.

The following points are general guidance in addition to the techniques presented in the previously mentioned USGS National Field Manual for the Collection of Water Quality Data.

Standardized protocols include the following:

- *Prior to sampling, the sampler must contact the laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.*
- *Each well used for groundwater quality monitoring must have a unique identifier. This identifier must appear on the well housing or the well casing to avoid confusion.*
- *In the case of wells with dedicated pumps, samples should be collected at or near the wellhead. Samples should not be collected from storage tanks, at the end of long pipe runs, or after any water treatment.*
- *The sampler should clean the sampling port and/or sampling equipment and the sampling port and/or sampling equipment must be free of any contaminants. The sampler must decontaminate sampling equipment between sampling locations or wells to avoid cross-contamination between samples.*
- *The groundwater elevation in the well should be measured following appropriate protocols described above in the groundwater level measuring protocols.*
- *For any well not equipped with low-flow or passive sampling equipment, an adequate volume of water should be purged from the well to ensure that the groundwater sample is representative of ambient groundwater and not stagnant water in the well casing. Purging three well casing volumes is generally considered adequate. Professional judgment should be used to determine the proper configuration of the sampling equipment with respect to well construction such that a representative ambient groundwater sample is collected. If pumping causes a well to be evacuated (go dry), document the condition and allow well to recover to within 90% of original level prior to sampling. Professional judgment should be exercised as to whether the sample will meet the DQOs and adjusted as necessary.*
- *Field parameters of pH, electrical conductivity, and temperature should be collected for each sample. Field parameters should be evaluated during the purging of the well and should stabilize prior to sampling. Measurements of pH should only be measured in the field, lab pH analysis are typically unachievable due to short hold times. Other parameters, such as oxidation-reduction potential (ORP), dissolved oxygen (DO) (in situ measurements preferable), or turbidity, may also be useful for meeting DQOs of GSP and assessing purge conditions. All field instruments should be calibrated daily and evaluated for drift throughout the day.*
- *Sample containers should be labeled prior to sample collection. The sample label must include: sample ID (often well ID), sample date and time, sample personnel, sample location, preservative used, and analytes and analytical method.*
- *Samples should be collected under laminar flow conditions. This may require reducing pumping rates prior to sample collection.*
- *Samples should be collected according to appropriate standards such as those listed in the Standard Methods for the Examination of Water and Wastewater, USGS National Field Manual for the Collection of Water Quality Data, or other appropriate guidance. The specific sample collection procedure should reflect the type of analysis to be performed and DQOs.*

- *All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. Ensure that samples are appropriately filtered as recommended for the specific analyte. Entrained solids can be dissolved by preservative leading to inconsistent results of dissolve analytes. Specifically, samples to be analyzed for metals should be field-filtered prior to preservation; do not collect an unfiltered sample in a preserved container.*
- *Samples should be chilled and maintained at 4 °C to prevent degradation of the sample. The laboratory's Quality Assurance Management Plan should detail appropriate chilling and shipping requirements.*
- *Samples must be shipped under chain of custody documentation to the appropriate laboratory promptly to avoid violating holding time restrictions.*
- *Instruct the laboratory to use reporting limits that are equal to or less than the applicable DQOs or regional water quality objectives/screening levels.*

Special protocols for low-flow sampling equipment:

- *In addition to the protocols listed above, sampling using low-flow sample equipment should adopt the following protocols derived from EPA's Low-flow (minimal drawdown) ground-water sampling procedures (Puls and Barcelona, 1996). These protocols apply to low-flow sampling equipment that generally pumps between 0.1 and 0.5 liters per minute. These protocols are not intended for bailers.*

Special protocols for passive sampling equipment:

- *In addition to the protocols listed above, passive diffusion samplers should follow protocols set forth in USGS Fact Sheet 088-00.*

3.3.3 Subsidence: Proposed Protocol

The protocol for subsidence monitoring described in the BMP is reprinted below.

Evaluating and monitoring inelastic land subsidence can utilize multiple data sources to evaluate the specific conditions and associated causes. To the extent possible, the use of existing data should be utilized. Subsidence can be estimated from numerous techniques, they include: level surveying tied to known stable benchmarks or benchmarks located outside the area being studied for possible subsidence; installing and tracking changes in borehole extensometers; obtaining data from continuous GPS (CGPS) locations, static GPS surveys or Real-Time-Kinematic (RTK) surveys; or analyzing Interferometric Synthetic Aperture Radar (InSAR) data. No standard procedures exist for collecting data from the potential subsidence monitoring approaches. However, an approach may include:

- *Identification of land subsidence conditions.*
    - *Evaluate existing regional long-term leveling surveys of regional infrastructure, i.e. roadways, railroads, canals, and levees.*

  - *Inspect existing county and State well records where collapse has been noted for well repairs or replacement.*
  - *Determine if significant fine-grained layers are present such that the potential for collapse of the units could occur should there be significant depressurization of the aquifer system.*
  - *Inspect geologic logs and the hydrogeologic conceptual model to aid in identification of specific units of concern.*
  - *Collect regional remote-sensing information such as InSAR, commonly provided by USGS and NASA. Data availability is currently limited, but future resources are being developed.*
- *Monitor regions of suspected subsidence where potential exists.*
  - *Establish CGPS network to evaluate changes in land surface elevation.*
  - *Establish leveling surveys transects to observe changes in land surface elevation.*
  - *Establish extensometer network to observe land subsidence. An example of a typical extensometer design is illustrated in Figure 7. There are a variety of extensometer designs and they should be selected based on the specific DQOs.*

Various standards and guidance documents for collecting data include:

- *Leveling surveys must follow surveying standards set out in the California Department of Transportation's Caltrans Surveys Manual.*
- *GPS surveys must follow surveying standards set out in the California Department of Transportation's Caltrans Surveys Manual.*
- *USGS has been performing subsidence surveys within several areas of California. These studies are sound examples for appropriate methods and should be utilized to the extent possible and where available:*
  - *http://ca.water.usgs.gov/land_subsidence/california-subsidence-measuring.html*
- *Instruments installed in borehole extensometers must follow the manufacturer's instructions for installation, care, and calibration.*
- *Availability of InSAR data is improving and will increase as programs are developed. This method requires expertise in analysis of the raw data and will likely be made available as an interpretative report for specific regions.*

3.3.4 Streamflow: Proposed Protocol

The protocol for streamflow monitoring described in the BMP is reprinted below.

Monitoring of streamflow is necessary for incorporation into water budget analysis and for use in evaluation of stream depletions associated with groundwater extractions. The use of existing monitoring locations should be incorporated to the greatest extent possible. Many of these streamflow monitoring locations currently follow the protocol described below.

Establishment of new streamflow discharge sites should consider the existing network and the objectives of the new location. Professional judgment should be used to determine the appropriate permitting that may be necessary for the installation of any monitoring locations along surface water bodies. Regular frequent access will be necessary to these sites for the development of ratings curves and maintenance of equipment.

To establish a new streamflow monitoring station special consideration must be made in the field to select an appropriate location for measuring discharge. Once a site is selected, development of a relationship of stream stage to discharge will be necessary to provide continuous estimates of streamflow. Several measurements of discharge at a variety of stream stages will be necessary to develop the ratings curve correlating stage to discharge. The use of Acoustic Doppler Current Profilers (ADCPs) can provide accurate estimates of discharge in the correct settings. Professional judgment must be exercised to determine the appropriate methodology. Following development of the ratings curve a simple stilling well and pressure transducer with data logger can be used to evaluate stage on a frequent basis.

Streamflow measurements should be collected, analyzed, and reported in accordance with the procedures outlined in USGS Water Supply Paper 2175 [3], Volume 1. – Measurement of Stage Discharge and Volume 2. – Computation of Discharge. This methodology is currently being used by both the USGS and DWR for existing streamflow monitoring throughout the Stat

3 References

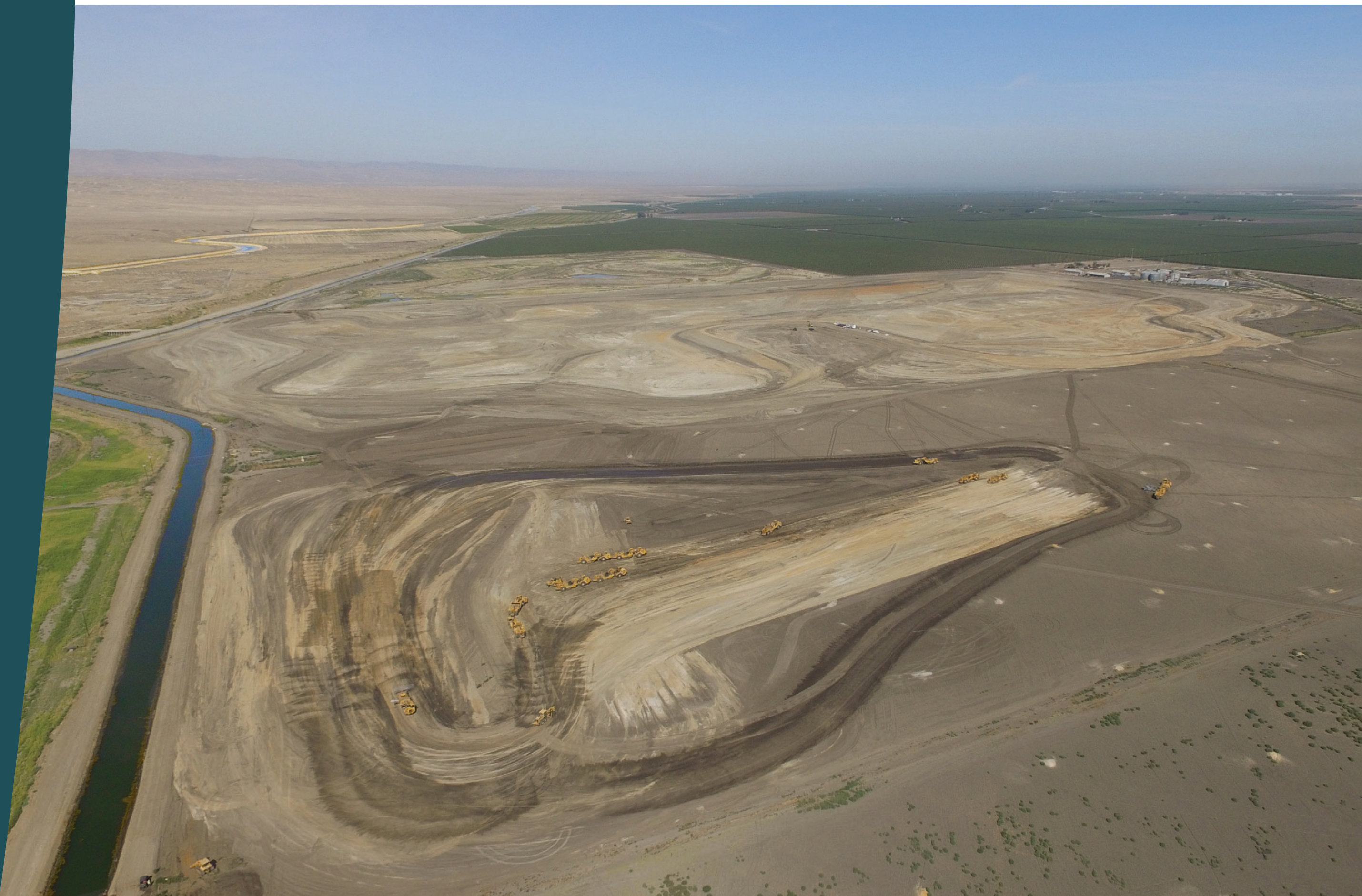
[1] California Department of Water Resources, May 2016. Sustainable Groundwater Management Act: GSP Emergency Regulations, https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GSP_Emergency_Regulations.pdf

[2] California Department of Water Resources, December 2016. Best Management Practices for the Sustainable Management of Groundwater: Monitoring Protocols, Standards, and Sites, https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Monitoring_Protocols_Final_2016-12-23.pdf

[3] United States Geological Survey, 2013. Water Supply Paper 2175, https://pubs.usgs.gov/wsp/wsp2175

Appendix E

Well Completion Reports



BVGSA Monitoring Well Template

DATA GAPS:

- Reference Point Elevation: Domestic Well
- Ground Surface Elevation: Domestic Well
- Elevation Method: PIEZ-015, PIEZ-023, PIEZ-034, PIEZ-035, DW03, DW05, DW06, Domestic Well, D15 (landowner)
- Elevation Accuracy: DMW10A, DMW10B, DMW12A, DMW12B, PIEZ-015, PIEZ-023, PIEZ-034, PIEZ-035, DW03, DW05, DW06, Domestic Well, D15 (landowner)
- Well Depth: Domestic Well, D15 (landowner)

MISSING (not required):

- State Well Numbers: DW03, DW05, DW06, Domestic Well, D15 (landowner)
- Well Completion Report Number: DMW10A, DMW10B, DMW12A, DMW12B, DW03, DW05, DW06, Domestic Well, D15 (landowner)
- Well Location Description: DMW10A, DMW10B, DMW12A, DMW12B, DW03, DW05, DW06, Domestic Well, D15 (landowner)
- Top Perforation: Domestic Well, D15 (landowner)
- Bottom Perforation: Domestic Well, D15 (landowner)

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 383660

State Well No. 27/22-8

Other Well No. ______

Notice of Intent No. ______

Local Permit No. or Date EH 375-91

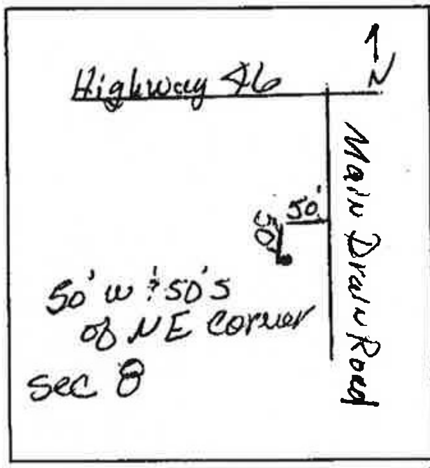
(2) LOCATION OF WELL (See instructions):

County Kern Owner's Well Number MW #1

Well address if different from above ______

Township 27S Range 22E Section 8

Distance from cities, roads, railroads, fences, etc. 1 Mi So of Hwy 46 on Main Drain Road



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Municipal ☐
Other ☒ MW
(Describe)

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size 4-12
Diameter of bore 12 1/4
Packed from 274 to 310 ft.

(7) CASING INSTALLED:
Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	280	2"	Sch 80	280	300	.020

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 50' ft.
Were strata sealed against pollution? Yes ☒ No ☐ Interval 30' ft.
Method of sealing Cement F0 to 50 240-274

(10) WATER LEVELS:
Depth of first water, if known 8' ft.
Standing level after well completion ______ ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☐ If yes, by whom? ______
Type of test Pump ☐ Bailer ☐ Air lift ☒
Depth to water at start of test ______ ft. At end of test ______ ft.
Discharge ______ gal/min after ______ hours Water temperature ______
Chemical analysis made? Yes ☐ No ☐ If yes, by whom? ______
Was electric log made Yes ☒ No ☐ If yes, attach copy to this report

(12) WELL LOG: Total depth ______ ft. Completed depth ______ ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	6	Coarse Brn Sand
6	114	Brn w/ white Rounded Gravel
114	144	Clay Gray w/ Blue Streaks
144	220	Coarse Brn & Gray Sand & Gravel
220	250	Blue Clay
250	340	Coarse Gravel w/ White Sand
340	348	Sandstone
348	384	Brn Sand w/ Streaks of Gray Clay
384	500	Gray Clay w/ Streaks of Sand

Work started 9-30-1991 Completed 10-2 1991

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed Bennie White (Well Driller)

NAME Melton Drilling Co
(Person, firm, or corporation) (Typed or printed)

Address 7101 Downing Ave

City Bakersfield ZIP Cal

License No. C57-508270 Date of this report 10/10/91

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

DWR 188 (REV. 12-86) 86 96355

27S/22E-23D

TRIPLICATE
Owner's Copy

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

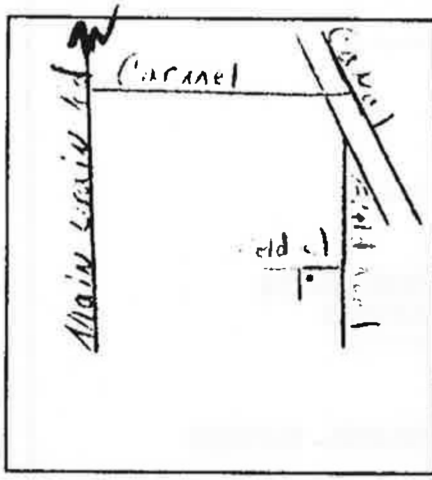
No. 383663

Notice of Intent No. ______
Local Permit No. or Date EH 374-91

State Well No. 27/22-23D
Other Well No. MW #2

(2) LOCATION OF WELL (See instructions):

County Kern   Owner's Well Number MW #2
Well address if different from above ______
Township 27 S   Range 22 E   Section 23
Distance from cities, roads, railroads, fences, etc. 2 Mi East of Main Drain Road 1 Mi South of Carmel thence 300' West



WELL LOCATION SKETCH

(3) TYPE OF WORK:

New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:

Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Municipal ☐
Other ☒ monitor (Describe)

(5) EQUIPMENT:

Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:

Yes ☒ No ☐ Size [illegible]
Diameter of bore 12 1/4
Packed from 250 to 305 ft.

(7) CASING INSTALLED:

Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS:

Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
-2	260	2"	Sch 80	260	300	.020

(9) WELL SEAL:

Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 50' ft.
Were strata sealed against pollution? Yes ☒ No ☐ Interval 125-245 ft.
Method of sealing Cement 5% Bentonite

(10) WATER LEVELS:

Depth of first water, if known 18' ft.
Standing level after well completion ______ ft.

(11) WELL TESTS:

Was well test made? Yes ☒ No ☐ If yes, by whom? ______
Type of test Pump ☐ Bailer ☐ Air lift ☒
Depth to water at start of test 60 ft. At end of test 120 ft.
Discharge ______ gal/min after ______ hours Water temperature ______
Chemical analysis made? Yes ☐ No ☒ If yes, by whom? ______
Was electric log made Yes ☒ No ☐ If yes, attach copy to this report

(12) WELL LOG:

Total depth 500 ft. Completed depth 300 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	22	Brn Coarse Sand
22	28	Fine Silty clay Brn to [illegible]
28	32	Silt Brn
32	38	Clay Gray
38	56	Silty Clay Gray to white
56	132	Clay Blue to Gray
132	148	Silty Sand Med White to [illegible]
148	156	Clay Gray
156	175	Fine Brn Sand
175	184	Brn Clay
184	196	Fine Sand Brn to Gray
196	201	Clay soft white
201	210	Fine Sand white
210	214	Silt White to Gray
214	244	Clay Gray
244	258	Silty clay Blue to Black
258	390	Coarse Sand Brn, White w/ Black Speckles
390	400	Brn Clay
400	416	Brn Silty Sand
416	422	Silty Clay Dark Brn to Red
422	432	Silty Sandy Clay Brn
432	500	Fine Silty Clay Brn to light Brn

Work started 2-6 1992 Completed 2-10 1992

WELL DRILLER'S STATEMENT:

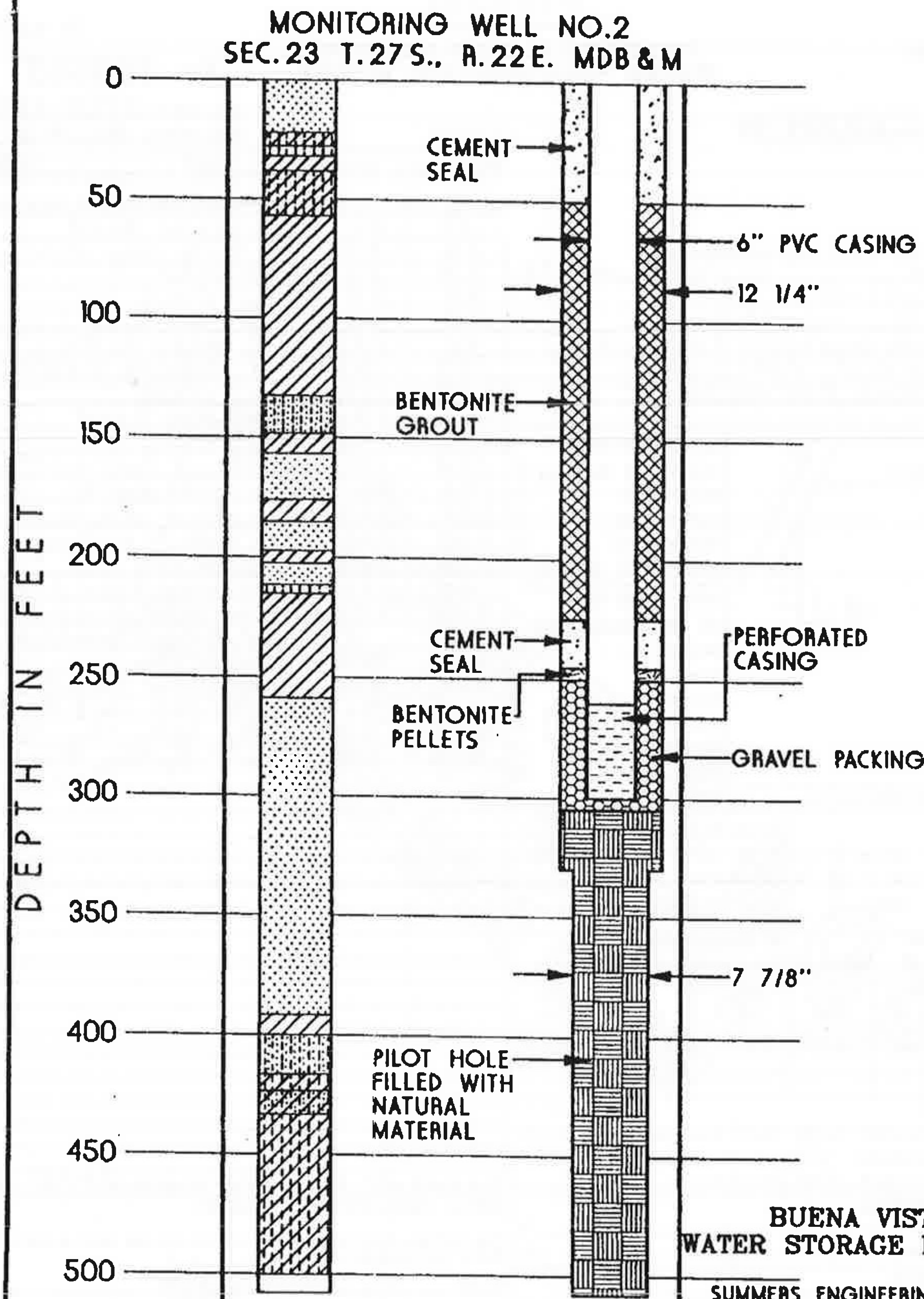
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed [signature] (Well Driller)
NAME Melton Drilling Co (Person, firm, or corporation) (Typed or printed)
Address 7101 Downing Ave
City Bakersfield Ca ZIP 93308
License No. C57 508270 Date of this report ______

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

27S/22E-23D

3/3



BUENA VISTA
WATER STORAGE DISTRICT

SUMMERS ENGINEERING INC.
Consulting Engineers
HANFORD CALIFORNIA

JUNE 1992

27S / 22E - 23D

3/3

MONITORING WELL SOIL LOG SYMBOLS

- TOP SOIL
- SAND
- CLAY
- SILT
- GRAVEL
- SANDSTONE
- SAND & CLAY
- SILT & CLAY
- SILT & SAND
- SAND & GRAVEL
- SILT & SANDSTONE
- SILT, SAND & CLAY

BUENA VISTA WATER STORAGE DISTRICT

SUMMERS ENGINEERING INC.
Consulting Engineers
HANFORD CALIFORNIA

JUNE 1992

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

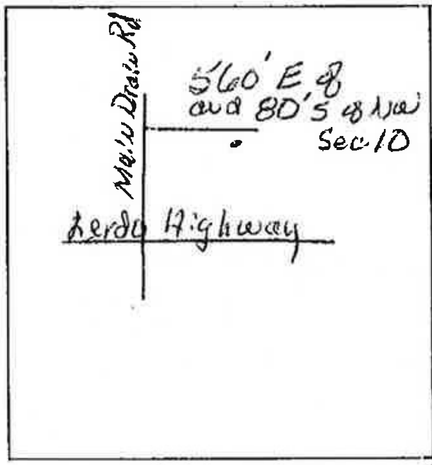
Do not fill in

No. 383658

State Well No. 28/22-10
Other Well No.

Notice of Intent No.
Local Permit No. or Date

(2) LOCATION OF WELL (See instructions):
County Kern Owner's Well Number MW #4
Well address if different from above
Township 28S Range 22E Section 10
Distance from cities, roads, railroads, fences, etc. 1 Mi North of Lerdo Highway, 1 Mi East of Main Drain Road



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Municipal ☐
Other ☒ MW
(Describe)

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size 4-16
Diameter of bore 12 1/4
Packed from 314 to 376 ft.

(7) CASING INSTALLED:
Steel ☐ Plastic ☐ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	334	2	Sch 80	334	384	.020

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 50 ft.
Were strata sealed against pollution? Yes ☒ No ☐ Interval 30 ft.
Method of sealing Cement

(10) WATER LEVELS:
Depth of first water, if known 80' ft.
Standing level after well completion 80' ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? MDC
Type of test Pump ☐ Bailer ☐ Air lift ☒
Depth to water at start of test 60 ft. At end of test 80 ft.
Discharge ____ gal/min after ____ hours Water temperature
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made Yes ☒ No ☐ If yes, attach copy to this report

(12) WELL LOG: Total depth 500 ft. Completed depth 382 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	28	Brn Coarse Sand
28	32	Brn Clay
32	62	Brn Sandy Clay
62	73	Brn Clay
73	97	Coarse White to Gray Sand
97	105	Blue Clay
105	176	Gray Clay W/Fine Silt
176	180	Blue Clay
180	252	Coarse Brn to White Sand
252	256	Sandstone
256	300	Coarse Brn to White Sand
300	309	Gray Silty Clay
309	321	Pebbly White to Gray Sand
321	338	Gray Clay
338	351	Blue Sand
351	364	Blue Clay
364	376	White to Gray Sand
376	384	Sandstone
384	428	White to Brn Sand
428	442	Brn to White Gravel
442	448	Gray Clay
448	471	White Gravel
471	483	Blue Clay
483	500	White Gravel

Work started 10-3 1991 Completed 10-5 1991

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed [signature]
(Well Driller)
NAME Melton Drilling Co
(Person, firm, or corporation) (Typed or printed)
Address 7101 Downing Ave
City Bakersfield Ca ZIP 93308
License No. C57-508270 Date of this report 10-10-91

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

DWR 188 (REV. 12-86) 86 96355

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

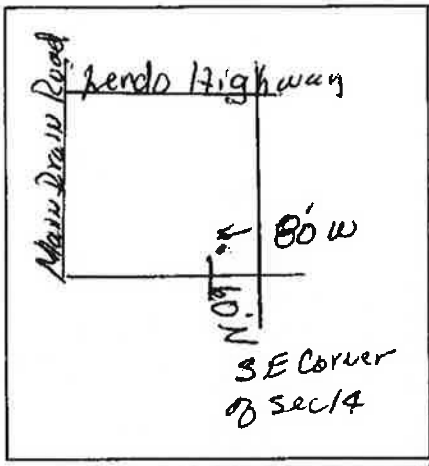
Do not fill in

No. 383661

State Well No. 28/22-14
Other Well No.

Notice of Intent No.
Local Permit No. or Date EH 373-91

(2) LOCATION OF WELL (See instructions):
County Kern Owner's Well Number MW #5
Well address if different from above
Township 28S Range 22E Section 14
Distance from cities, roads, railroads, fences, etc. 1 mi South of Lerdo Highway and 1.6 mi East of Main Drain Road



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Municipal ☐
Other ☒ MW
(Describe)

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size #3 x 16
Diameter of bore 12 1/4
Packed from 230 to 310 ft.

(7) CASING INSTALLED:
Steel ☐ Plastic ☐ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	240	4	Sch 80	240	310	.020

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 50 ft.
Were strata sealed against pollution? Yes ☒ No ☐ Interval 30 ft.
Method of sealing Cement

(10) WATER LEVELS:
Depth of first water, if known 8' ft.
Standing level after well completion 80' ft.

(11) WELL TESTS:
Was well test made? Yes ☒ No ☐ If yes, by whom? MDC
Type of test Pump ☐ Bailer ☐ Air lift ☒
Depth to water at start of test 80 ft. At end of test ft.
Discharge gal/min after hours Water temperature
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made Yes ☒ No ☐ If yes, attach copy to this report

(12) WELL LOG: Total depth 500 ft. Completed depth 310 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0	40'	Coarse Brown Sand
40	70	Gravel White to Gray to Brn
70	78	Blue clay
78	122	Gray Fine Sandy Clay
122	134	Brn Sand
134	222	Gray Clay
222	239	Blue Clay
239	254	Gravel & Sand Brn to occassional White
254	269	White to Gray Sandy Gravel
269	275	Silt
275	291	White to Gray Sand
291	300	Silt
300	319	White Sand & Gravel
319	360	Silt & Sandstone
360	414	White, Gray & Brn Sand & Gravel
414	420	Sandstone
420	428	Gray Sand
428	472	Blue Clay
472	490	White to Gray Gravel
490	500	Brn clay

Work started 10-7 1991 Completed 10-9 1991

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed [signature] (Well Driller)
NAME Melton Drilling Co (Person, firm, or corporation) (Typed or printed)
Address 7101 Downing Ave
City Bakersfield Ca ZIP 93308
License No. C57-508270 Date of this report 10-11-91

DWR 188 (REV. 12-86) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM 86 96355

ORIGINAL
File with DWR
Page 1 of 1
Owner's Well No. BV-6
Date Work Began 12-10-93, Ended 12-21-93
Local Permit Agency Kern County Environmental Health Dept.
Permit No. ______ Permit Date 12-7-93

28/27-31

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 480170

DWR USE ONLY — DO NOT FILL IN
28S23E
STATE WELL NO./STATION NO.
LATITUDE | LONGITUDE
APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER ______ (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	48	Sand & Clay
48	120	Clay with Fine Sand
120	131	Clay with some Sand
131	153	Fine Sand and Silt
153	182	Medium Sand with some Clay
182	190	Clay with Sand
190	194	Medium Sand
194	250	Medium Sand and Clay
250	254	Clay with some Sand
254	294	Sand and Clay
294	304	Clay with some Fine Sand
304	316	Medium Sand and some Clay
316	325	Clay with some Fine Sand
325	346	Fine and Medium Sand
346	375	Clay with some Fine Sand
375	382	Sand with some Clay
382	390	Clay and Sand
390	404	Medium Sand
404	409	Clay and Sand
409	420	Sand and some Clay
420	428	Sand and Clay
428	438	Medium Sand
438	474	Clay with some Fine Sand
474	480	Clay and Sand
480	486	Clay with some Sand
486	514	Clay
514	523	Clay and Sand
		Top Core @ 430 Uncon?

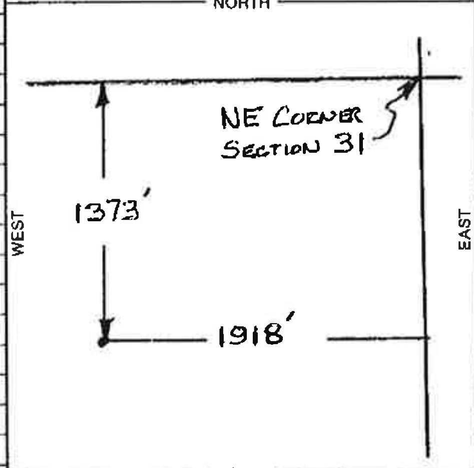
TOTAL DEPTH OF BORING 523 (Feet)
TOTAL DEPTH OF COMPLETED WELL 463 (Feet)

WELL OWNER

WELL LOCATION

Address 1/4 Mile South of Imperial Rd.&
City 3/4 Mile West of Corn Camp Rd.
County Kern
APN Book 87 Page 220 Parcel 08
Township 28S Range 23E Section 31G
Latitude ___ NORTH (DEG. MIN. SEC.) Longitude ___ WEST (DEG. MIN. SEC.)

LOCATION SKETCH



Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc.
PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)

___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

X MONITORING

WATER SUPPLY
___ Domestic
___ Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Mud

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL ______ (Ft.) & DATE MEASURED ______
ESTIMATED YIELD* ______ (GPM) & TEST TYPE ______
TEST LENGTH ______ (Hrs.) TOTAL DRAWDOWN ______ (Ft.)
* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE (✓) BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	410	12-3/4	x				PVC	5.761	Sch. 80	
410	440	12-3/4		x			PVC	5.761	Sch. 80	.020

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	50	x			
50	373		x		Grout
373	375			x	Sand
375	445			x	#3 Gravel
445	463		x		Grout

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ______

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Bakersfield Well & Pump Co.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

1600 E. California Ave. Bakersfield CA 93307
ADDRESS CITY STATE ZIP

Signed Joel B. Jeffrey 4/25/94 440537
WELL DRILLER/AUTHORIZED REPRESENTATIVE DATE SIGNED C-57 LICENSE NUMBER

DWR 188 REV. 7-90 IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

ORIGINAL
File with DWR 29/23-16

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. 480169

DWR USE ONLY — DO NOT FILL IN
29/23-16 — STATE WELL NO./STATION NO.
LATITUDE | LONGITUDE
APN/TRS/OTHER

Page ____ of ____
Owner's Well No. BV-7
Date Work Began 12/27/93, Ended 12/31/93
Local Permit Agency Kern County Environmental Health Dept
Permit No. ________ Permit Date 12-7-93

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER ______ (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	40	Sand
40	60	Sand Little Clay
60	70	Sand
70	80	Clay and Sand
80	90	Fine Sand
90	110	Medium Grain Sand
110	120	Medium and Fine Sand
120	130	Medium-Coarse SAND and Little Clay
130	140	Clay and Fine Sand
140	150	Clay
150	160	Clay and Fine Coarse Sand
160	180	Clay and Coarse Sand
180	190	Clay and Sand
190	200	Medium Sand
200	210	Coarse Sand
210	230	Clay
230	260	Clay with Fine Sand
260	280	Clay and Sand
280	300	Coarse Sand
300	350	Clay-Coarse Sand
350	450	Coarse Sand-Clay
450	470	Sand and Clay
470	480	Clay-Sand
480	490	Clay-Little Sand
490	500	Sand-Clay
500	510	Clay-Sand
		Top Core @ 510 Unconf

TOTAL DEPTH OF BORING 510 (Feet)
TOTAL DEPTH OF COMPLETED WELL 440 (Feet)

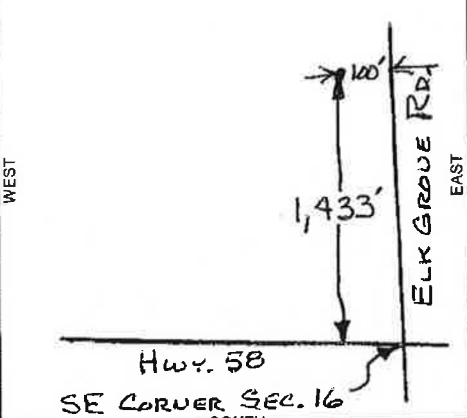
WELL OWNER

WELL LOCATION

Address 1/4 Mi. North of Hwy. 58 on
City West side of Elk Grove Rd.
County Kern
APN Book 100 Page 170 Parcel 30
or Township 29S Range 23E Section 16
or Latitude ___ NORTH (DEG. MIN. SEC.) Longitude ___ WEST (DEG. MIN. SEC.)

LOCATION SKETCH

NORTH



WEST — EAST — SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc. *PLEASE BE ACCURATE & COMPLETE.*

ACTIVITY (✓)

X NEW WELL
MODIFICATION/REPAIR
___ Deepen
___ Other (Specify)
___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USE(S) (✓)

X MONITORING
WATER SUPPLY
___ Domestic
___ Public
___ Irrigation
___ Industrial
___ "TEST WELL"
___ CATHODIC PROTECTION
___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Mud

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL ______ (Ft.) & DATE MEASURED ______
ESTIMATED YIELD* ______ (GPM) & TEST TYPE ______
TEST LENGTH ______ (Hrs.) TOTAL DRAWDOWN ______ (Ft.)
** May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	TYPE: BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	410	12¼	x				PVC	6 ID	Sch 80	
410	440	12¼		x			PVC	6 ID	Sch 80	.020

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	50	X			
50	385		X		Grout
385	390			X	Fine Sand
390	445			X	Gravel
445	465		X		Grout

ATTACHMENTS (✓)

___ Geologic Log
___ Well Construction Diagram
___ Geophysical Log(s)
___ Soil/Water Chemical Analyses
___ Other ______

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Bakersfield Well & Pump Co.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

ADDRESS 1600 E. California Ave. CITY Bakersfield STATE Ca ZIP 93307

Signed [signature] (WELL DRILLER/AUTHORIZED REPRESENTATIVE) DATE SIGNED 2/25/94 C-57 LICENSE NUMBER 440537

DWR 188 REV. 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

ORIGINAL
File with DWR

Page 1 of 1

Owner's Well No. BV-8

Date Work Began ________, Ended ________

Local Permit Agency Kern County Environmental Health Dept.

Permit No. ________ Permit Date 12-7-93

29/23-24

STATE OF CALIFORNIA

WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. 480171

DWR USE ONLY — DO NOT FILL IN

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) X VERTICAL ___ HORIZONTAL ___ ANGLE ___ (SPECIFY)

DEPTH TO FIRST WATER ______ (Ft.) BELOW SURFACE

DEPTH FROM SURFACE Ft.	to Ft.	DESCRIPTION *Describe material, grain size, color, etc.*
0	65	Sand with Clay
65	82	Clay with Sand
82	156	Sand with Clay
156	166	Medium Sand
166	170	Clay with Sand
170	190	Sand with Clay
190	214	Medium Sand
214	250	Fine Sand with Clay
250	265	Clay with Fine Sand
265	315	Fine Sand with Clay
315	330	Coarse Sand
330	340	Clay with Sand
340	350	Coarse Sand
350	380	Clay with Coarse Sand
380	410	Coarse Sand
410	416	Clay
416	428	Coarse Sand
428	430	Clay
430	446	Coarse Sand with some Clay
446	454	Clay with some Sand
454	462	Fine Sand
		Top Core @ 470 Unconf

TOTAL DEPTH OF BORING 462 (Feet)

TOTAL DEPTH OF COMPLETED WELL 429 (Feet)

WELL OWNER

WELL LOCATION

Address 1/2 South of Hwy.58 on West side of Wasco Way.

City ________

County Kern

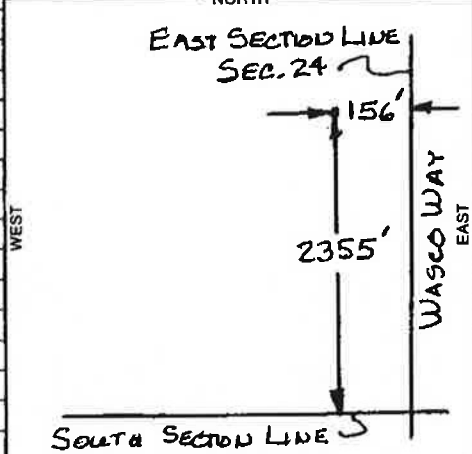
APN Book 102 Page 050 Parcel 02

Township 29S Range 23E Section 24 J

Latitude ___ NORTH (DEG. MIN. SEC.) Longitude ___ WEST (DEG. MIN. SEC.)

LOCATION SKETCH

NORTH



SOUTH

Illustrate or Describe Distance of Well from Landmarks such as Roads, Buildings, Fences, Rivers, etc. ***PLEASE BE ACCURATE & COMPLETE.***

ACTIVITY (✓)

X NEW WELL

MODIFICATION/REPAIR
- ___ Deepen
- ___ Other (Specify)

___ DESTROY (*Describe Procedures and Materials Under "GEOLOGIC LOG"*)

PLANNED USE(S) (✓)

X MONITORING

WATER SUPPLY
- ___ Domestic
- ___ Public
- ___ Irrigation
- ___ Industrial

___ "TEST WELL"

___ CATHODIC PROTECTION

___ OTHER (Specify)

DRILLING METHOD Rotary FLUID Mud

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH OF STATIC WATER LEVEL ______ (Ft.) & DATE MEASURED ______

ESTIMATED YIELD* ______ (GPM) & TEST TYPE ______

TEST LENGTH ______ (Hrs.) TOTAL DRAWDOWN ______ (Ft.)

* *May not be representative of a well's long-term yield.*

CASING(S)

DEPTH FROM SURFACE Ft.	to Ft.	BORE-HOLE DIA. (Inches)	BLANK	SCREEN	CON-DUCTOR	FILL PIPE	MATERIAL/GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
0	374	12-3/4	x				PVC	5.761	Sch.80	
374	404	12-3/4		x			PVC	5.761	Sch.80	

ANNULAR MATERIAL

DEPTH FROM SURFACE Ft.	to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	50	x			
50	334		x		Grout
334	338			x	Fine Sand
338	409			x	#3 Gravel
409	429		x		Grout

ATTACHMENTS (✓)

- ___ Geologic Log
- ___ Well Construction Diagram
- ___ Geophysical Log(s)
- ___ Soil/Water Chemical Analyses
- ___ Other ______

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME Bakersfield Well & Pump Co.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

1600 E. California Ave. BAkersfield CA 93307
ADDRESS CITY STATE ZIP

Signed Joel B. Jeffrey
WELL DRILLER/AUTHORIZED REPRESENTATIVE

4/25/94 DATE SIGNED

440537 C-57 LICENSE NUMBER

DWR 188 REV 7-90

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

Do not fill in 1/3

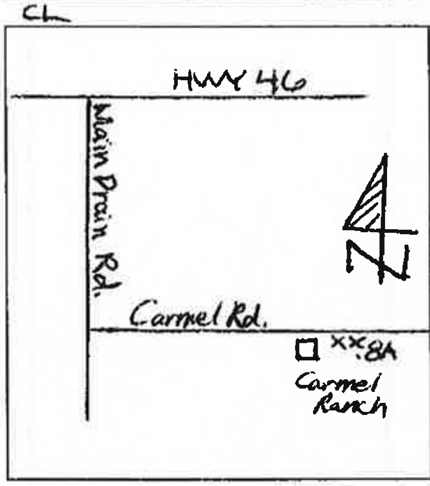
No. 373442

State Well No. 27/22-15P1
Other Well No.

Notice of Intent No.
Local Permit No. or Date

(12) WELL LOG: Total depth 21.3 ft. Completed depth 21.3 ft.
from ft. to ft. Formation (Describe by color, character, size or material)

(2) LOCATION OF WELL (See instructions):
County KERN Owner's Well Number BVWSD8A
Well address if different from above
Township 27S Range 22E Section 15P
Distance from cities, roads, railroads, fences, etc. 2 miles S/o HWY 46 & Main Drain Rd. intersection 1 mile E/B on Carmel Rd. located a 1 mile E/o Carmel Ranch 30' S/o Carmel Rd CL



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Municipal ☐
Other Piezometer ☒
(Describe)

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size Mont Sand #3
Diameter of bore 2"
Packed from 11.3 to 21.3 ft.

(7) CASING INSTALLED:
Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	21.3	2	SCH40	12.3	21.3	0.02"

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☐ No ☒ If yes, to depth ____ ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ____ ft.
Method of sealing

(10) WATER LEVELS:
Depth of first water, if known .3 ft.
Standing level after well completion ____ ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☒ If yes, by whom?
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ____ ft. At end of test ____ ft.
Discharge ____ gal/min after ____ hours Water temperature
Chemical analysis made? Yes ☒ No ☐ If yes, by whom? DWR
Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

Work started June 1990 Completed June 1990

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed ____ (Well Driller)
NAME Dept of Water Resources
(Person, firm, or corporation) (Typed or printed)
Address 3374 E Shields Ave.
City Fresno ZIP 93726
License No. ____ Date of this report ____

CONFIDENTIAL
NOT FOR PUBLIC USE
WATER CODE SEC. 13752

KRFC Project

DWR 188 (REV. 12-86) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM 86 96355

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

SHEET 27/ 22E of 2 1SDI
HOLE NO. BV # 8A
ELEV. ______ FEET
DEPTH ______ FEET

2/3

DRILL HOLE LOG

PROJECT Kern River Drainage
FEATURE Buena Vista WSD-shallow piezometers
LOCATION
CONTR. DWR-Jim Cooper
DRILL RIG straight flight auger
DATE DRILLED 5-90
ATTITUDE vertical
LOGGED BY K. Hoppe 6/90
DEPTH TO WATER

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0	CH	Fat Clay: very black, high plastic, 5% fine sand, moist, stiff			
1		same as above except is calcareous			
2					
3					
4	ML	silt: light olive grey, non plastic, moist contains $CaCO_3$ & Mn nodules with Fe staining			
5	ML	same as above except saturated			
6					
7					
8	SM	silty sand: yellowish brown, very fine grain, poorly graded, 15-20% fines, saturated			
9	ML	silt: yellowish brown mottled with reddish brown, non plastic, rapid dilentancy 10-15% fine sand, saturated			
10					
11					
12	CL	sandy clay: light olive brown, low plastic fines, contains 35-40% very fine sand, wet, stiff			
13					
14	CL	same as above except very stiff & calcareous			
15	SM	silty sand: light brown, fine grained, well graded, 30-35% fines, saturated			

DWR 885 (1) (Rev. 9-84)

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

27S/22E-15D1

SHEET 2 OF 2

HOLE NO. BV#8A 3/3

PROJECT & FEATURE

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
16	CL	Sandy Clay - light olive brown, low plastic, soft, contains 35-40% med. sand saturated,			
17	CH	Fat ClAY: light olive grey, high plastic 10% fine sand, stiff, moist			
18					
19	CH	same as above except contains 25-30% med. sand			
20					
21		BOH			
22					

DWR 885 (2) (Rev. 9-84)

Table 4-2. Groundwater Storage Monitoring Well Locations

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

Table 4-3. Groundwater Quality Monitoring Locations

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

Table 4-1. BVGSA Groundwater Level Monitoring Well Locations

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

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

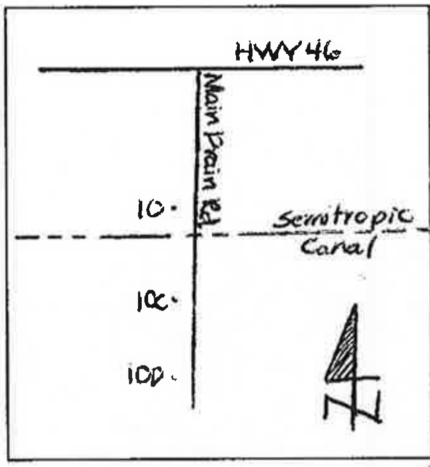
Do not fill in 1/3

No. 373448

State Well No. 27/22-29J1
Other Well No.

Notice of Intent No.
Local Permit No. or Date

(2) LOCATION OF WELL (See instructions):
County KERN Owner's Well Number # BVWSD 10D
Well address if different from above
Township 27S Range 22E Section 29J
Distance from cities, roads, railroads, fences, etc. 4.6 miles S/o HWY 46 & Main Drain Rd intersection 35' W/o Main Drain ℄



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Municipal ☐
Other Piezometer ☒
(Describe)

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size Mont. Sand #3
Diameter of bore 8"
Packed from 14 to 24

(7) CASING INSTALLED:
Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	24	2"	SCH40	15	24	0.02"

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☐ No ☒ If yes, to depth ______ ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ______ ft.
Method of sealing

(10) WATER LEVELS:
Depth of first water, if known 1.5 ft.
Standing level after well completion ______ ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☒ If yes, by whom?
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ______ ft. At end of test ______ ft.
Discharge ______ gal/min after ______ hours Water temperature
Chemical analysis made? Yes ☒ No ☐ If yes, by whom? DWR
Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 24 ft. Completed depth 24 ft.
from ft. to ft. Formation (Describe by color, character, size or material)

KRFC Project

Work started June 19 90 Completed June 19 90

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed ______ (Well Driller)
NAME Dept of Water Resources
(Person, firm, or corporation) (Typed or printed)
Address 3374 E Shields Ave
City Fresno ZIP 93726
License No. ______ Date of this report ______

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

DWR 188 (REV. 12-86) 86 96355

27S/22E-29J01

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES

DRILL HOLE LOG

SHEET 1 of 2

HOLE NO. BVWSD #10 D 2/3

ELEV. ______ FEET

DEPTH 20 FEET

PROJECT KERN RIVER DRAINAGE

DATE DRILLED 5/90

FEATURE Buena Vista - WSC Shallow Piezometers

ATTITUDE Vertical

LOCATION

LOGGED BY K. Hoppe 7-27-90

CONTR. DWR - J. Cooper

DRILL RIG Straight flight Auger

DEPTH TO WATER

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
0-1	CH	~~SANDY~~ FAT CLAY WITH SAND; brownish gray; high plast; dry & crumbly.			
1-4	CL	SILTY CLAY; pale olive; some very fine sand, micaceous; dry & crumbly. low plasticity soft @3' same as above, except has rust colored and black organic mottling			
4-5	CH	FAT CLAY; olive gray with dark gray black and rust colored mottling; high plast; contains some very fine sand - micaceous, contains lenses of non mottled pale olive clay			
5-	SM	Sandy silt; pale olive gray; non plastic; very fine sand (about 50%); micaceous; loose. @6' same as above, except contains rust col & black organic pseudo-laminar mottling.			
9-		SILTY SAND; moderate yellowish brown; fine & med grained (5-10% silt); abundant mica, loose.			

DWR 885 (1) (Rev. 9-84)

27S/22E-29J01

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

SHEET 2 OF 2

HOLE NO. BVWSD #10D

3/3

PROJECT & FEATURE

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	SAMPLE NO.	MODE	REMARKS
	SP	@10' SAND as above, except light brownish gray, very few fines with brownish gold mica			
		@12' SAND as above, except contains some reduced sand with silvery gray mica			
		@13' SAND as above, except no reduced sand all oxidized. rusty looking			
		@14' SAND as above except silty (10-15% fines)			
	SW	@16' SAND as above, except light brownish gray, fine, med, & some coarse grains; no fines - clean			
		@17' SAME AS ABOVE, EXCEPT few fines & no coarse			
		BOH @20'.			

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

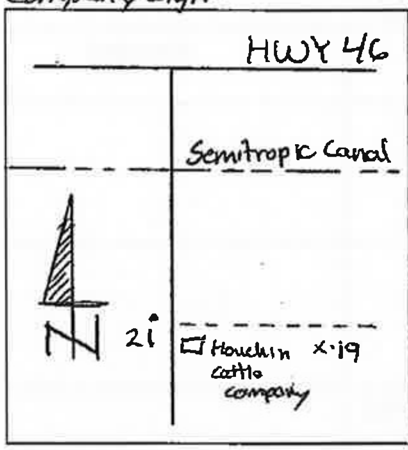
Do not fill in

No. 361522

Notice of Intent No. ____
Local Permit No. or Date ____

State Well No. 28/22-4N1
Other Well No. ____

(2) LOCATION OF WELL (See instructions):
County KERN Owner's Well Number ____
Well address if different from above BV 21
Township 28S Range 22E Section 4N
Distance from cities, roads, railroads, fences, etc. 7 miles S/O HWY46 & Main Drain Rd intersection Located 40' W/O Main Drain & Across Houchin Bros. Cattle company sign.



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Municipal ☐
Other Piezometer ☒
(Describe)

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size Monte Sand #3
Diameter of bore 8"
Packed from 10 to 20 ft.

(7) CASING INSTALLED:
Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	20	2"	SCH40	11	20	0.020"

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☐ No ☒ If yes, to depth ____ ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ____ ft.
Method of sealing ____

(10) WATER LEVELS:
Depth of first water, if known 4.2 ft.
Standing level after well completion ____ ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☒ If yes, by whom? ____
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ____ ft. At end of test ____ ft.
Discharge ____ gal/min after ____ hours Water temperature ____
Chemical analysis made? Yes ☒ No ☐ If yes, by whom? DWR
Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 20 ft. Completed depth 20 ft.
from ft. to ft. Formation (Describe by color, character, size or material)

KRFC Project

Work started June 19 90 Completed June 19 90

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed ____ (Well Driller)
NAME Dept of Water Resources (Person, firm, or corporation) (Typed or printed)
Address 3374 E. Shields Ave
City Fresno ZIP 93726
License No. ____ Date of this report ____

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

DWR 188 (REV. 12-86) 86 96355

State of California

The Resources Agency

DEPARTMENT OF WATER RESOURCES

SHEET: 1 of 1

HOLE NO.: BV21

DRILL HOLE LOG

PROJECT:

FEATURE:

LOCATION:

CONTR.:

DRILL RIG:

ELEV. (feet): ---

DEPTH (feet):

DATE DRILLED:

ATTITUDE: ---

LOGGED BY: JOHN, G.

DEPTH TO WATER: ---

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	REMARKS
0-3	CL	SILTY CLAY PALE GREEN LOW TO MEDIUM PLASTICITY STREAKS OF LIGHT BROWN CLAY	
3-8	CL	SILTY CLAY DARK GREEN STREAKS OF $CaCO_3$ LOW PLASTICITY	
8-11	SM	SILTY SANDS - VERY FINE SANDS DARK GREEN	
11-21	SW	FINE TO MEDIUM GRADED SANDS PALE GREEN	

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
WATER WELL DRILLERS REPORT

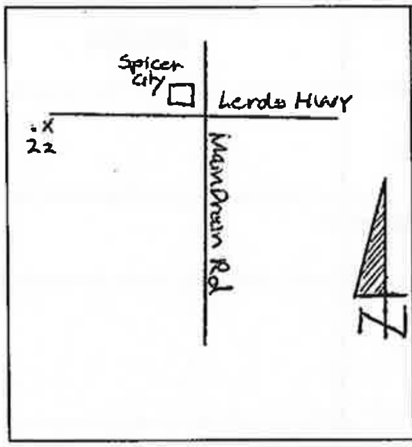
Do not fill in

No. 361523

State Well No. 28/22-16D1
Other Well No. ____

Notice of Intent No. ____
Local Permit No. or Date ____

(2) LOCATION OF WELL (See instructions):
County KERN Owner's Well Number BVWSD #22
Well address if different from above ____
Township 28S Range 22E Section 16D
Distance from cities, roads, railroads, fences, etc. 0.8 miles w/o Lerdo HWY & Main Drain intersection. 30' S/o Lerdo HWY



WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☐
Industrial ☐
Test Well ☐
Municipal ☐
Other ☒ Piezometer (Describe)

(5) EQUIPMENT:
Rotary ☒ Reverse ☐
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size Mont Sand #3
Diameter of bore 2"
Packed from 10 to 20 ft.

(7) CASING INSTALLED:
Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS:
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	20	2"	SCH40	11	20	0.02"

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☐ No ☒ If yes, to depth ____ ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ____ ft.
Method of sealing ____

(10) WATER LEVELS:
Depth of first water, if known 6.4 ft.
Standing level after well completion ____ ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☒ If yes, by whom? ____
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ____ ft. At end of test ____ ft.
Discharge ____ gal/min after ____ hours Water temperature ____
Chemical analysis made? Yes ☒ No ☐ If yes, by whom? DWR
Was electric log made Yes ☐ No ☒ If yes, attach copy to this report

(12) WELL LOG: Total depth 20 ft. Completed depth 20 ft.

from ft. to ft. Formation (Describe by color, character, size or material)

CONFIDENTIAL

NOT FOR PUBLIC USE
WATER CODE SEC. 13752

KRFC Project

Work started June 19 90 Completed June 19 90

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed ____ (Well Driller)
NAME Dept of Water Resources
(Person, firm, or corporation) (Typed or printed)
Address 3374 E. Shields Ave.
City Fresno ZIP 93726
License No. ____ Date of this report ____

DWR 188 (REV. 12-86) IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM 86 96355

State of California

The Resources Agency

DEPARTMENT OF WATER RESOURCES

SHEET: 1 of 1

HOLE NO.: BV 22

DRILL HOLE LOG

PROJECT:

FEATURE:

LOCATION:

CONTR.:

DRILL RIG:

ELEV. (feet): ---

DEPTH (feet):

DATE DRILLED:

ATTITUDE: ---

LOGGED BY:

DEPTH TO WATER: ---

DEPTH (ELEV.)	LOG	FIELD CLASSIFICATION AND DESCRIPTION	REMARKS
0-2	ML	SILT W/CLAY PALE GREEN LOW PLASTICITY CHUNKS OF ($CACO_3$)	
2-3	CL	CLAY, BLACK GREEN, MEDIUM PLASTICITY	
5-9	SM	SILTY SAND W/CLAY (MANOR) LIGHT GREEN COLOR	
12-13	SM	SILTY SAND, LIGHT GREEN	
13-17	SM	SILTY SAND, BROWN COLOR	
18-22	SM	SILTY SAND, VERY FINE LIGHT GREEN W/BROWN	

ORIGINAL
File with DWR

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 373832

State Well No. 29/24-29
Other Well No.

Notice of Intent No.
Local Permit No. or Date

BVWSD DW-3

(2) LOCATION OF WELL (See instructions):
County Kern Owner's Well Number BV#3 DH-150
Well address if different from above
Township 29 Range 24 Section 29B
Distance from cities, roads, railroads, fences, etc.

WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☒
Industrial ☐
Test Well ☐
Municipal ☐
Other ☒ (Describe)

(5) EQUIPMENT:
Rotary ☐ Reverse ☒
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size [illegible]
Diameter of bore 28
Packed from 0 to 460 ft.

(7) CASING INSTALLED:
Steel ☐ Plastic ☒ Concrete ☐

(8) PERFORATIONS: sawed
Type of perforation or size of screen

From ft.	To ft.	Dia. in.	Gage or Wall	From ft.	To ft.	Slot size
0	440	16	616	180	440	.50

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 50 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ft.
Method of sealing

(10) WATER LEVELS:
Depth of first water, if known ft.
Standing level after well completion ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☒ If yes, by whom?
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ft. At end of test ft.
Discharge gal/min after hours Water temperature
Chemical analysis made? Yes ☐ No ☒ If yes, by whom?
Was electric log made Yes ☒ No ☐ If yes, attach copy to this report

(12) WELL LOG: Total depth 460 ft. Completed depth 440 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0ft.	50ft.	Conductor
50	93	Clay
93	96	Sand
96	126	Clay
126	145	Sand & clay
145	220	Sand
220	250	Clay
250	270	Sand
270	284	Clay
284	311	Sand
311	360	Clay & sand
360	402	Sand & clay
402	428	Sand
428	442	Clay & sand
442	460	Sand

CONFIDENTIAL
NOT FOR PUBLIC USE
WATER CODE SEC. 13752

UNCONFINED

Work started 9-18 1991 Completed 9-20 1991

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed (Well Driller)
NAME Johnson Drilling Co. (Person, firm, or corporation) (Typed or printed)
Address [illegible]
City Bakersfield, Calif. ZIP 93303
License No. 298-6 Date of this report 9-20-91

DWR 188 (REV. 12-86)

IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

86 96355

TRIPLICATE
Owner's Copy

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WATER WELL DRILLERS REPORT

Do not fill in

No. 373832

Notice of Intent No. ______
Local Permit No. or Date ______

State Well No. ______
Other Well No. ______

(1) OWNER: Name Buena Vista Water Storage Dist.
Address P.O. Box 756
City Buttonwillow, Calif. ZIP 93206

(2) LOCATION OF WELL (See instructions): BV#3
County Kern Owner's Well Number EH-150
Well address if different from above ______
Township 29 Range 24 Section 29B
Distance from cities, roads, railroads, fences, etc. ______

WELL LOCATION SKETCH

(3) TYPE OF WORK:
New Well ☒ Deepening ☐
Reconstruction ☐
Reconditioning ☐
Horizontal Well ☐
Destruction ☐ (Describe destruction materials and procedures in Item 12)

(4) PROPOSED USE:
Domestic ☐
Irrigation ☒
Industrial ☐
Test Well ☐
Municipal ☐
Other ☐
(Describe)

(12) WELL LOG: Total depth 460 ft. Completed depth 440 ft.

from ft.	to ft.	Formation (Describe by color, character, size or material)
0ft.	to 50ft.	Conductor
50	93	Clay
93	98	Sand
98	126	Clay
126	145	Sand & clay
145	220	Sand
220	250	Clay
250	270	Sand
270	284	Clay
284	311	Sand
311	360	Clay & sand
360	402	Sand & clay
402	428	Sand
428	442	Clay & sand
442	460	Sand

(5) EQUIPMENT:
Rotary ☐ Reverse ☒
Cable ☐ Air ☐
Other ☐ Bucket ☐

(6) GRAVEL PACK:
Yes ☒ No ☐ Size BB
Diameter of bore 28
Packed from 0 to 460

(7) CASING INSTALLED:
Steel ☐ Plastic ☒ Concrete ☐

From ft.	To ft.	Dia. in.	Gage or Wall
0	440	16	616

(8) PERFORATIONS: sawed
Type of perforation or size of screen

From ft.	To ft.	Slot size
180	440	.50

(9) WELL SEAL:
Was surface sanitary seal provided? Yes ☒ No ☐ If yes, to depth 50 ft.
Were strata sealed against pollution? Yes ☐ No ☒ Interval ______ ft.
Method of sealing ______

(10) WATER LEVELS:
Depth of first water, if known ______ ft.
Standing level after well completion ______ ft.

(11) WELL TESTS:
Was well test made? Yes ☐ No ☒ If yes, by whom? ______
Type of test Pump ☐ Bailer ☐ Air lift ☐
Depth to water at start of test ______ ft. At end of test ______ ft.
Discharge ______ gal/min after ______ hours Water temperature ______
Chemical analysis made? Yes ☐ No ☒ If yes, by whom? ______
Was electric log made Yes ☒ No ☐ If yes, attach copy to this report

Work started 9-18 1991 Completed 9-20 1991

WELL DRILLER'S STATEMENT:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Signed ______ (Well Driller)
NAME Johnson Drilling Co.
(Person, firm, or corporation) (Typed or printed)
Address P.O. Box 1853
City Bakersfield, Calif. ZIP 93303
License No. 295856 Date of this report 9-20-91

CONFIDENTIAL — NOT FOR PUBLIC USE — WATER CODE SEC. 13752

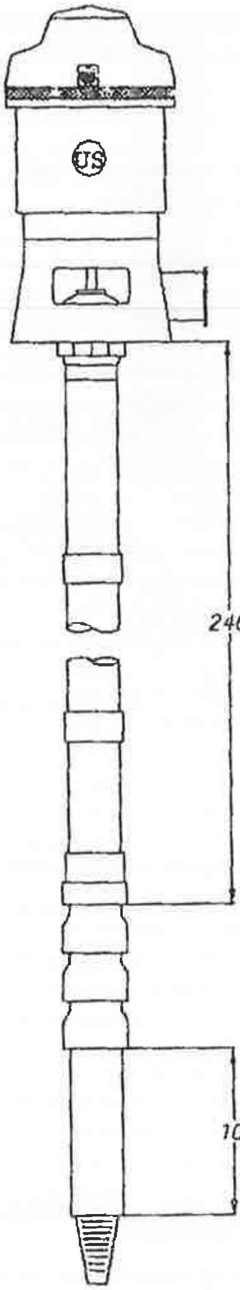
IF ADDITIONAL SPACE IS NEEDED, USE NEXT CONSECUTIVELY NUMBERED FORM

DISTRICT EXTRACTION WELL W-3

T29S, R24E, E 1/2 OF SEC 29

OWNER: BUENA VISTA WATER STORAGE DISTRICT

DATE COMPLETED: 4/92



MOTOR

MFGTR: US HP: 100 RPM: 1800

PHASE: 3 CY: 60 VOLT: 460

VHS:

PG&E ACCNT #: DTX33 44501-3

DISCHARGE HEAD

MFGTR: TYPE: SIZE:

PUMP

MFGTR: L&B TYPE: 12THC SIZE: 12"

NO. STAGES: 3 SETTING DEPTH: 240'

COLUMN SIZE: 10" LENGTH: 240'

TUBE SIZE: 2-1/2"

SHAFT SIZE: 1-11/16"

SUCTION LENGTH: 10' AIR LINE: YES

STRAINER: YES

PROJECT: WELL DRAWING		
LOCATION: BVWSD (EAST SIDE CANAL)		
DRAWN BY: DAN BARTEL		
DATE: 01/26/95	SCALE:	1 OF 1

BOYLE

5001 E. Commercenter Drive
Suite 100 (93309-1655)
P.O. Box 12030, Bakersfield, CA 93389-2030
TEL: (661)325-7253 • FAX: (661)395-0359
www.boyleengineering.com

#5

John Zimmerer
BAKERSFIELD WELL & PUMP CO.
7212 Fruitvale Ave.
Bakersfield, CA 93308

February 4, 2004
BK-821-103-04

BUENA VISTA WATER STORAGE DISTRICT
3-4 Recovery Well Project – Porter Well Design (Revised)

Revised final well construction details for the Porter Well are provided below:

A. 28-inch bore hole depth: 485 feet below finish grade

B. Blank PVC casing (16-inch O.D. x 0.941-inch):
   1.) +2 to 195 feet
   2.) 455 to 475 feet
   3.) PVC cap at 475 feet

C. Slotted PVC casing (16-inch O.D. x 0.941-inch): 195 to 455 feet

D. Slotted PVC casing shall have slot openings of 0.050 inches and slot length shall be 3 inches at the inside surface of the slotted casing.

E. 3-inch gravel chute: +2 to 180 feet

F. 2-inch sounding tube: +2 to 457 feet

G. Gravel Pack: 170 to 485 feet

H. Cement Seal: 0 to 170 feet

I. Gravel Pack Size: 8x20 Colorado Silica

Boyle Engineering Corporation

Joshua T. Nord, PE
Project Engineer

Copy to: D. Bartel
K. Schmidt

LTR/J ZIMMERER-PORTERDESIGNREVISED-020404 DOC

E. Service Conditions

1. Pump hydraulic performance characteristics shall be as shown below.

2. Pump Name: Porter

Location: Buttonwillow, California

Service: Outdoors environmental temperature range of 30°F to 120°F

Elevation: Porter – 279 feet± above mean sea level

Pump Data

Capacity (gpm)	Pump Total Head (feet)	Minimum Pump Efficiency (%)
2,000	246	78
2,250	210	81

Liquid pumped:	Groundwater (TDS ≤ 1300 mg/l)
Maximum pump speed:	1800 rpm
Minimum NPSH available:	70± feet
Motor horsepower (minimum):	200
Motor type (per Section 16150):	1 EHPRT
Minimum shaft diameter:	1-11/16 inches
Pump lubrication:	Enclosed lineshaft
Minimum discharge connection size:	12 inches
Minimum column size:	10 inches
Minimum column wall thickness:	0.375 inch
Discharge flange rating:	Class 150
Pump setting (base of discharge head to inlet of first pump stage):	300 feet
Bearing lubrication:	Oil
Suction strainer:	Yes
Manufacturers and models:	Layne, Model 12DEH (5-stage), Johnston Model 12RHC (4-stage)

BOYLE

5001 E. Commercenter Drive
Suite 100 (93309-1655)
P.O. Box 12030, Bakersfield, CA 93389-2030
TEL: (661)325-7253 • FAX: (661)395-0359
www.boyleengineering.com

#6

John Zimmerer
BAKERSFIELD WELL & PUMP CO.
7212 Fruitvale Ave.
Bakersfield, CA 93308

May 21, 2004
BK-B21-103-04

BUENA VISTA WATER STORAGE DISTRICT
3-4 Recovery Well Project – C.A. Houchin Well Design

Based upon the results of the formation sampling and geophysical logging of the C.A. Houchin Well pilot hole the following final well construction details are provided below:

A. 28-inch bore hole depth: 480 feet below finish grade

B. Blank PVC casing (16-inch O.D. x 0.941-inch):
   1.) +2 to 210 feet
   2.) 450 to 470 feet
   3.) PVC cap at 470 feet

C. Slotted PVC casing (16-inch O.D. x 0.941-inch): 210 to 450 feet

D. Slotted PVC casing shall have slot openings of 0.050 inches and slot length shall be 3 inches at the inside surface of the slotted casing.

E. 3-inch gravel chute: +2 to 185 feet

F. 2-inch sounding tube: +2 to 455 feet

G. Gravel Pack: 180 to 480 feet

H. Bentonite Seal: 0 to 180 feet

I. Gravel Pack Size: 6x20 Colorado Silica

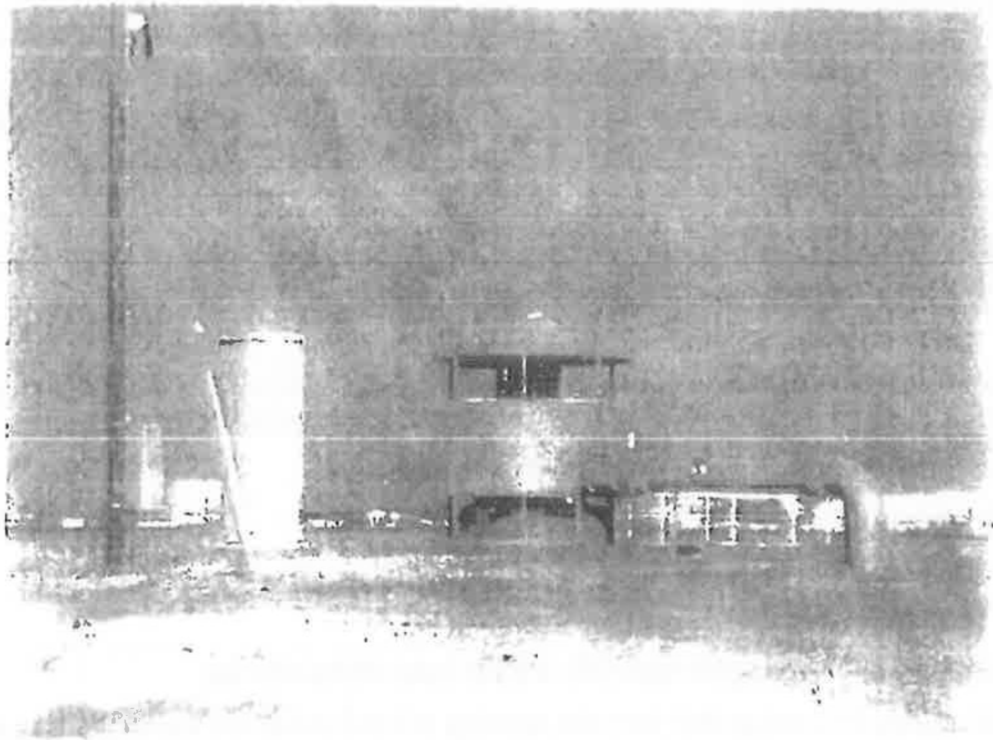
Boyle Engineering Corporation

Joshua T. Nord, PE
Project Engineer

Copy to: D. Bartel
K. Schmidt

LTR(J.ZIMMERER-HOUCHINDESIGN)052104.DOC

The Porter Well has been successfully drilled, sampled, logged, cased, air lifted, pump developed, tested, concrete work completed, electrical work complete, electrical service complete, pump installed, motor installed, discharge completed, well enclosure installed, and preliminarily tested.



E. Service Conditions

1. Pump hydraulic performance characteristics shall be as shown below.

2. Pump Name: C. A. Houchin

Location: Buttonwillow, California

Service: Outdoors environmental temperature range of 30°F to 120°F

Elevation: C.A. Houchin Trust – 276 feet± above mean sea level

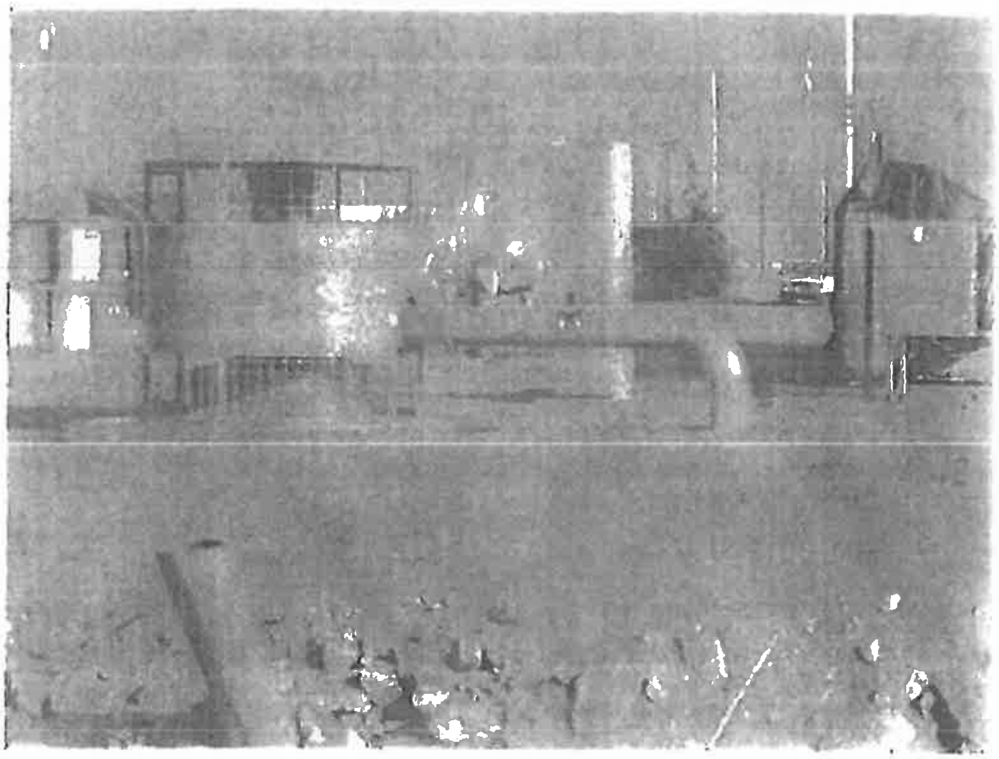
Pump Data

Capacity (gpm)	Pump Total Head (feet)	Minimum Pump Efficiency (%)
2,000	231	78
2,325	199	79

Liquid pumped:	Groundwater (TDS ≤ 1300 mg/l)
Maximum pump speed:	1800 rpm
Minimum NPSH available:	70± feet
Motor horsepower (minimum):	150
Motor type (per Section 16150):	1 EHPRT
Minimum shaft diameter:	1-11/16 inches
Pump lubrication:	Enclosed lineshaft
Minimum discharge connection size:	12 inches
Minimum column size:	10 inches
Minimum column wall thickness:	0.375 inch
Discharge flange rating:	Class 150
Pump setting (base of discharge head to inlet of first pump stage):	270
Bearing lubrication:	Oil
Suction strainer:	Yes
Manufacturers and models:	Layne, Model 12DEH (5-stage), Johnston Model 12RHC (4-stage)

#6

The **Houchin Well** has been successfully drilled, sampled, logged, cased, air lifted, pump developed, tested, concrete work completed, electrical work complete, electrical service complete, pump installed, motor installed, and discharge completed. The District closed escrow for the Houchin Well site on 7/30/04.



Appendix F

Minimum Thresholds from Kern Groundwater Authority GSP

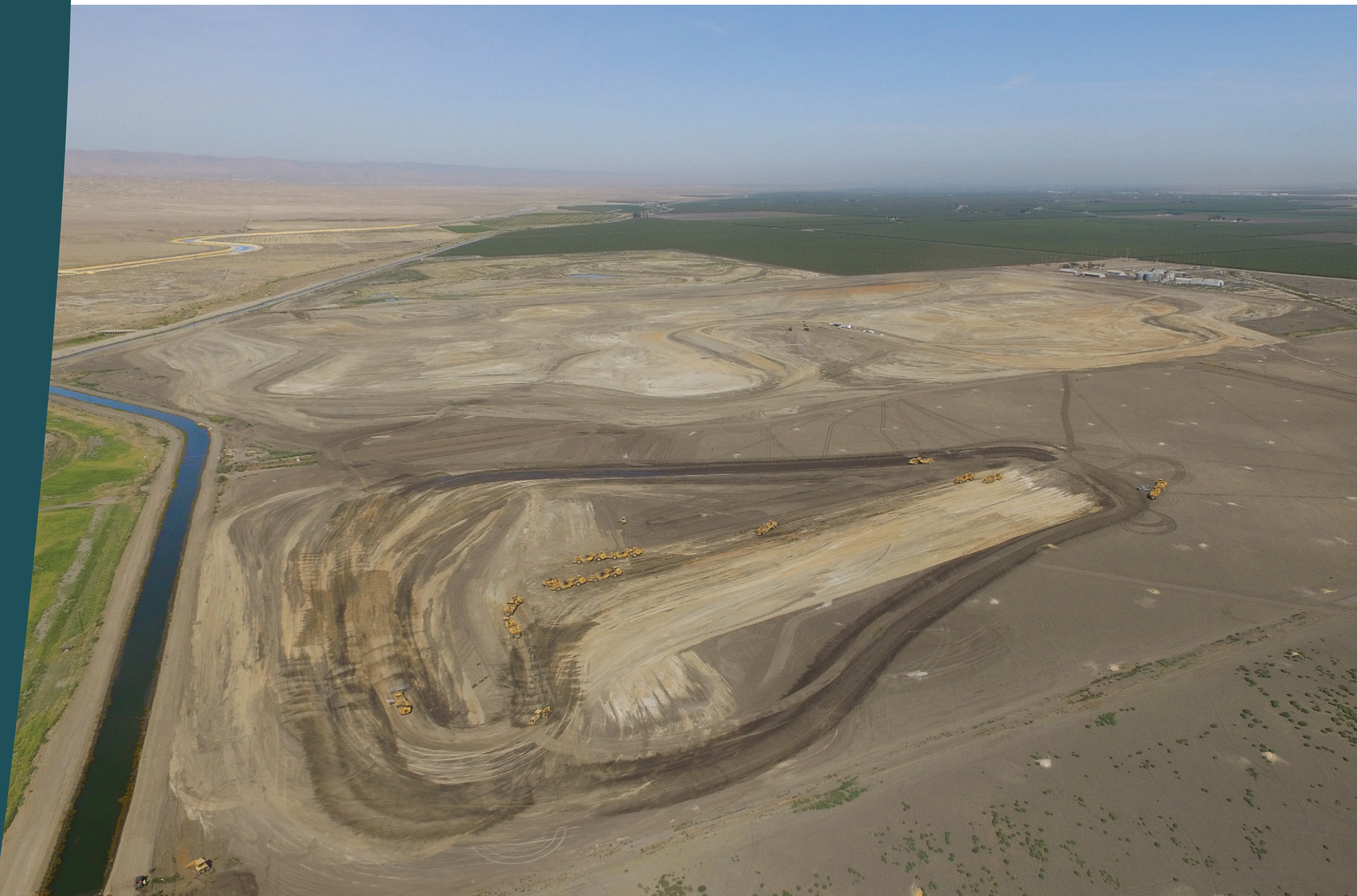


Table 3-1: Summary of Minimum Thresholds and Measureable Objectives

Monitoring Sites			Lowering of Groundwater Levels				Sustainability Indicators		
Member Agency	Zone/Management Area	Monitoring Site/Parameter	Minimum Threshold Value	Minimum Threshold Unit	Measureable Objective Value	Measureable Objective Unit	Reduction of Groundwater Storage	Degraded Water Quality (MT Value)	Unit
Arvin-Edison Water Storage Distict	North Canal	29S29E33N001M	50	ft msl	100	ft msl	X	X	ft msl
		30S29E29A001M	50	ft msl	100	ft msl	X	X	ft msl
		31S29E05E001M	50	ft msl	100	ft msl	X	X	ft msl
		31S29E12M001M	50	ft msl	100	ft msl	X	X	ft msl
		31S30E17K001M	50	ft msl	100	ft msl	X	X	ft msl
		31S30E30J001M	50	ft msl	100	ft msl	X	X	ft msl
	Edison	30S29E11N001M	250	ft msl	300	ft msl	X	X	ft msl
		30S30E19E001M	250	ft msl	300	ft msl	X	X	ft msl
	ACSD	31S29E34A001M	-70	ft msl	30	ft msl	X	X	ft msl
		ACSD Well No. 14	-70	ft msl	30	ft msl	X	X	ft msl
	South Canal	11N20W05J001S	0	ft msl	50	ft msl	X	X	ft msl
		12N20W36K001S	0	ft msl	50	ft msl	X	X	ft msl
		32S28E23H001M	0	ft msl	50	ft msl	X	X	ft msl
		32S29E12P001M	0	ft msl	50	ft msl	X	X	ft msl
		32S29E20H001M	0	ft msl	50	ft msl	X	X	ft msl
		32S29E31N001M	0	ft msl	50	ft msl	X	X	ft msl
Cawelo Water District	Cawelo Main Modified	Well 12H	25	ft msl	103	ft msl	X	X	ft msl
		Well 24R	-43	ft msl	35	ft msl	X	X	ft msl
		Well 11M	-81	ft msl	3	ft msl	X	X	ft msl
		Well 6C	-85	ft msl	-1	ft msl	X	X	ft msl
		Well 33C	-64	ft msl	20	ft msl	X	X	ft msl
		Well 28L	26	ft msl	110	ft msl	X	X	ft msl
	SSJMUD	Well 4R	-24	ft msl	60	ft msl	X	-3	ft msl

Monitoring Sites			Lowering of Groundwater Levels				Sustainability Indicators		
Member Agency	Zone/Management Area	Monitoring Site/Parameter	Minimum Threshold		Measureable Objective		Reduction of Groundwater Storage	Degraded Water Quality (MT Value)	Unit
			Value	Unit	Value	Unit			
Eastside Water Management Area	EWMA	EWMA #03	-86	ft msl	135	ft msl	X	X	ft msl
		EWMA #21	-110	ft msl	136	ft msl	X	X	ft msl
		EWMA #23	N/A	ft msl	N/A	ft msl	N/A	-71	ft msl
		EWMA #30	-228	ft msl	-71	ft msl	X	X	ft msl
		EWMA #37	132	ft msl	200	ft msl	X	X	ft msl
		EWMA #41	-41	ft msl	230	ft msl	X	X	ft msl
		EWMA #42	568	ft msl	588	ft msl	X	X	ft msl
		EWMA #06	-46	ft msl	48	ft msl	X	X	ft msl
Kern-Tulare Water District	KTWD	Well 30D	-150	ft msl	20	ft msl	X	X	ft msl
		Well 4P1	-150	ft msl	20	ft msl	X	X	ft msl
		Well 20C1	-150	ft msl	20	ft msl	X	X	ft msl
		Well 15P1	-150	ft msl	20	ft msl	X	X	ft msl
		Well 24Q1	-150	ft msl	20	ft msl	X	X	ft msl
		Well 32M1	-150	ft msl	20	ft msl	X	X	ft msl
		Well 8L1	-150	ft msl	20	ft msl	X	X	ft msl
North Kern Water Storage District	North Kern	88-03-009	-127.02	ft msl	-52	ft msl	X	X	ft msl
		88-09-009	-141.27	ft msl	-66	ft msl	X	X	ft msl
		88-21-005	-130.72	ft msl	-56	ft msl	X	X	ft msl
		88-29-014	-132.63	ft msl	-57	ft msl	X	X	ft msl
		99-00-003	-72.22	ft msl	4	ft msl	X	X	ft msl
		99-00-081	-192.10	ft msl	-114	ft msl	X	X	ft msl
		99-22-084	-213.09	ft msl	-135	ft msl	X	X	ft msl
		Shafter Well 18	-128.70	ft msl	-54	ft msl	X	N/A	ft msl
		Proposed Site 3	-238.53	ft msl	-154	ft msl	X	X	ft msl
Kern County Water Agency - Pioneer	Pioneer MA	Well 34	-12.5	ft msl	186	ft msl	X	X	ft msl
		Well 51	-24.8	ft msl	93	ft msl	X	X	ft msl
		Well 54	-24.8	ft msl	93	ft msl	X	X	ft msl
		Well 55	-51.4	ft msl	111	ft msl	X	X	ft msl

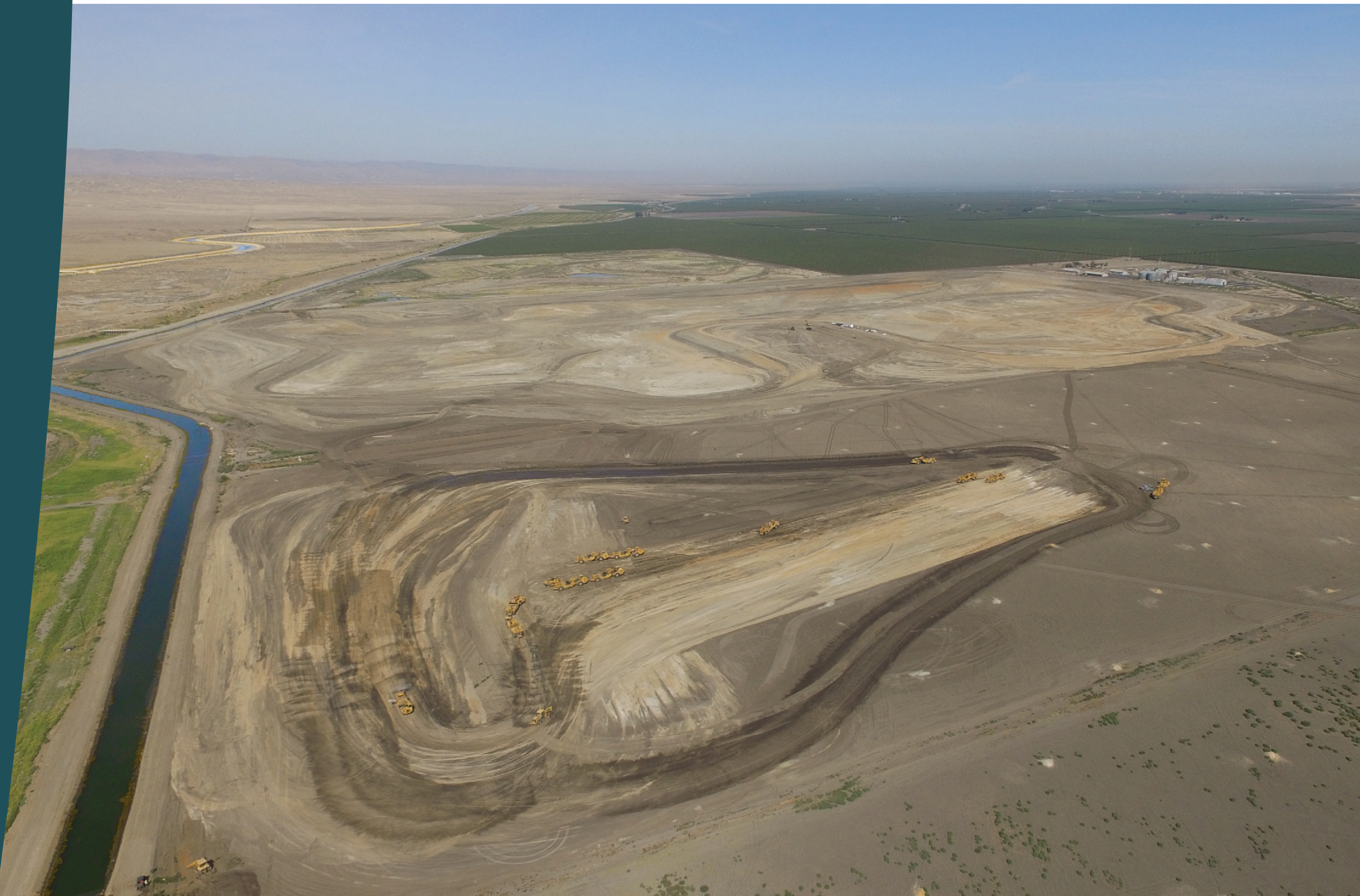
Monitoring Sites			Lowering of Groundwater Levels				Sustainability Indicators		
Member Agency	Zone/Management Area	Monitoring Site/Parameter	Minimum Threshold		Measureable Objective		Reduction of Groundwater Storage	Degraded Water Quality (MT Value)	Unit
			Value	Unit	Value	Unit			
Rosedale-Rio Bravo Management Area	North Zone	Bushnell	-33.1	ft msl	48	ft msl	X	X	ft msl
		L.R. Stout	-2.7	ft msl	78	ft msl	X	X	ft msl
		RGB School	3.5	ft msl	85	ft msl	X	X	ft msl
	Central Zone	Cauzza	8.3	ft msl	82	ft msl	X	X	ft msl
		P. Enns Domestic	41.9	ft msl	116	ft msl	X	X	ft msl
		Section 18	16.3	ft msl	90	ft msl	X	X	ft msl
		Blacco HW New	9.2	ft msl	83	ft msl	X	X	ft msl
	South Zone	Parsons	28.3	ft msl	127	ft msl	X	X	ft msl
		West I-5	43.6	ft msl	143	ft msl	X	X	ft msl
		Virgil Bussell	49.1	ft msl	148	ft msl	X	X	ft msl
		Mayer Double	55.3	ft msl	154	ft msl	X	X	ft msl
		Enos Double	68.6	ft msl	168	ft msl	X	X	ft msl
	East Zone	Chet Reed	108.2	ft msl	216	ft msl	X	X	ft msl
		Home Place	88.4	ft msl	196	ft msl	X	X	ft msl
		Greeley Double	84.1	ft msl	192	ft msl	X	X	ft msl
		Harvest Ranch	96.9	ft msl	205	ft msl	X	X	ft msl
		Shop Double	107.1	ft msl	215	ft msl	X	X	ft msl
	South of the River Zone (East)	28J Triple	151.7	ft msl	214	ft msl	X	X	ft msl
	South of the River Zone (West)	32N Triple	131.4	ft msl	193	ft msl	X	X	ft msl
Southern San Joaquin Municipal Utility District	Tayolor Well	INAC2016	-117.1	ft msl	-42	ft msl	X	X	ft msl
	City of Delano	Well 14	-197	ft msl	-105	ft msl	X	N/A	ft msl
		Well 23	-215	ft msl	-113	ft msl	X	N/A	ft msl
		Well 30	-101	ft msl	-8	ft msl	X	N/A	ft msl
	SSJMUD Wells	8	-329	ft msl	-227	ft msl	X	X	ft msl
		14	-136	ft msl	-57	ft msl	X	X	ft msl
		23	-278	ft msl	-183	ft msl	X	X	ft msl
		42	-123	ft msl	-48	ft msl	X	X	ft msl
		53	-131	ft msl	-55	ft msl	X	X	ft msl
		59	-112	ft msl	-37	ft msl	X	X	ft msl
		62	-83	ft msl	-7	ft msl	X	X	ft msl
Shafter-Wasco Irrigation District - 7th Standard Annex	SWID - 7th Standard	KB 3	-137	ft msl	-79	ft msl	X	X	ft msl
		22866	N/A	ft msl	N/A	ft msl	N/A	X	ft msl
		33 G	N/A	ft msl	N/A	ft msl	N/A	X	ft msl
		28S/25E-31J	-137	ft msl	-79	ft msl	X	X	ft msl
		28S/24E-35C	-137	ft msl	-79	ft msl	X	X	ft msl

Monitoring Sites			Lowering of Groundwater Levels				Sustainability Indicators		
Member Agency	Zone/Management Area	Monitoring Site/Parameter	Minimum Threshold		Measureable Objective		Reduction of Groundwater Storage	Degraded Water Quality (MT Value)	Unit
			Value	Unit	Value	Unit			
Shafter-Wasco Irrigation District	SWID	Proposed-001	-215.31	ft msl	-134	ft msl	X	X	ft msl
		Proposed-002	-186.28	ft msl	-108	ft msl	X	X	ft msl
		2A	-258.9	ft msl	-171	ft msl	X	X	ft msl
		9	-221.86	ft msl	-141	ft msl	X	X	ft msl
		Well 15 Active AG	-147	ft msl	-68	ft msl	X	X	ft msl
		Well 7 Inactive	-163	ft msl	-85	ft msl	X	X	ft msl
		Shafter Well 12	-158.5	ft msl	-81	ft msl	X	N/A	ft msl
		Shafter Well 15	-146.9	ft msl	-67	ft msl	X	N/A	ft msl
		Wasco 12	-242.9	ft msl	-159	ft msl	X	N/A	ft msl
		Wasco Shafter Well 14	-144	ft msl	-67	ft msl	X	N/A	ft msl
Semitropic Water Storage District	Buttonwillow Improvement District	S-02	-200	ft msl	-127	ft msl	X	X	ft msl
		S-04	-144.1	ft msl	-76	ft msl	X	X	ft msl
		S-05	-241.6	ft msl	-161	ft msl	X	X	ft msl
		948L02	-179.6	ft msl	-101	ft msl	X	X	ft msl
		Proposed-003	-179.6	ft msl	-101	ft msl	X	X	ft msl
		Proposed-004	-267.6	ft msl	-185	ft msl	X	X	ft msl
	Groundwater Dependent Ag.	S-11	-257.9	ft msl	-195	ft msl	X	X	ft msl
		S-12	-260.5	ft msl	-194	ft msl	X	X	ft msl
		Proposed-002	-292.3	ft msl	-219	ft msl	X	X	ft msl
		25S/23E-07B02	-377.55	ft msl	-270	ft msl	X	X	ft msl
	Pond-Poso Improvement District	S-06	-306	ft msl	-209	ft msl	X	X	ft msl
		S-09A	-226.7	ft msl	-146	ft msl	X	X	ft msl
		S-13A	-371.2	ft msl	-269	ft msl	X	X	ft msl
		S-14A	-334.5	ft msl	-233	ft msl	X	X	ft msl
		S-14B	-334.5	ft msl	-233	ft msl	X	X	ft msl
		S-15A1	-345.3	ft msl	-244	ft msl	X	X	ft msl
		Proposed-001	-217.3	ft msl	-148	ft msl	X	X	ft msl
	SWID	S-08A	-331.3	ft msl	-229	ft msl	X	X	ft msl
Tejon-Castac Water District	TCWD	RMS-1 (Caratan Well)	50	ft msl	100	ft msl	X	X	ft msl
West Kern Water District		Well 19	68	ft msl	162	ft msl	X	X	ft msl
		Well 24	-42	ft msl	106	ft msl	X	X	ft msl
		Well 29	-72	ft msl	121	ft msl	X	X	ft msl
		Well 40	37	ft msl	163	ft msl	X	X	ft msl
		Well 81	-54	ft msl	115	ft msl	X	X	ft msl
		Well 87	-8	ft msl	132	ft msl	X	X	ft msl
		Well 100	-82	ft msl	125	ft msl	X	X	ft msl

Monitoring Sites			Lowering of Groundwater Levels				Sustainability Indicators		
Member Agency	Zone/Management Area	Monitoring Site/Parameter	Minimum Threshold		Measureable Objective		Reduction of Groundwater Storage	Degraded Water Quality (MT Value)	Unit
			Value	Unit	Value	Unit			
	North Project MA	Well 107	14	ft msl	70	ft msl	X	X	ft msl
		Well 108	32	ft msl	99	ft msl	X	X	ft msl
Westside District Water Authority	Sentry Zone #1	25S21E01R001M	-115	ft msl	-62	ft msl	X	X	ft msl
	Sentry Zone #2	28S21E16	56	ft msl	112	ft msl	X	X	ft msl
		27S22E30H001M	59	ft msl	101	ft msl	X	X	ft msl
		Well 7106-63	59	ft msl	127	ft msl	X	X	ft msl
Wheeler Ridge-Maricopa Water Storage District	Western	11N22W06H001S	100	ft msl	200	ft msl	X	X	ft msl
		32S25E30D001M	100	ft msl	200	ft msl	X	X	ft msl
	Northeastern	32S26E20G001M	-50	ft msl	0	ft msl	X	X	ft msl
		32S26E24K001M	-50	ft msl	0	ft msl	X	X	ft msl
		32S27E30N001M	-50	ft msl	0	ft msl	X	X	ft msl
		32S27E35R001M	-50	ft msl	0	ft msl	X	X	ft msl
		32S26E34P001M	-50	ft msl	0	ft msl	X	X	ft msl
		32S26E36P002M	-50	ft msl	0	ft msl	X	X	ft msl
		32S28E16P001M	-50	ft msl	0	ft msl	X	X	ft msl
	Southeastern	11N22W01D001S	0	ft msl	75	ft msl	X	X	ft msl
		11N21W16E001S	0	ft msl	75	ft msl	X	X	ft msl
		12N21W34Q001S	0	ft msl	75	ft msl	X	X	ft msl
		11N21W09C001S	0	ft msl	75	ft msl	X	X	ft msl
		12N21W35Q001S	0	ft msl	75	ft msl	X	X	ft msl
		12N21W34Q001S	N/A	ft msl	N/A	ft msl	N/A	X	ft msl

Appendix G

Closure Term for BVGSA Water Budget



Closure Terms for Buena Vista GSA Water Budget

This memo provides the methods used to quantify the inflows, outflows, and change in storage associated with the water budget created to comply with Sustainable Groundwater Management Act (SGMA) regulations (§ 354.18 Water Budget).

The water budget includes 19 years of data [1995-2014], which corresponds with the period where both ITRC evapotranspiration data and C2VSim groundwater model outputs were available. Source data for the analysis includes the following: evapotranspiration (ET) from the Irrigation Training and Research Center (ITRC), Buena Vista WSD Historical Water Budgets and Water Distribution Summaries, census data, and California Irrigation Management Information System (CIMIS) weather data. The report *The Geology and Groundwater Hydrology of the Buena Vista Water Storage District, Buttonwillow, CA* (Sierra Scientific, 2013) and draft output from the Todd Groundwater C2VSim modeling of the Kern County Subbasin (Todd Groundwater, 2019) were also used as references and checks.

Per SGMA regulations, water budgets were created for both the GSA boundaries and the underlying groundwater aquifer. All inputs for the budget were taken from the sources noted above, except for the following three variables: subsurface flux, change in storage, and unmeasured groundwater pumping. The methods described in the following sections are intended to infer these variables.

Unmeasured Groundwater Pumping

Unmeasured groundwater pumping was used as the closure term to solve a mass balance, equating demands within the Buttonwillow Management Area (BMA) to the supply. This mass balance assumes that all inflows (surface water, groundwater pumping, precipitation) meet demands (ET, deep percolation, losses), an assumption that implies negligible long-term change in storage. Using this method, pumping from historically unmeasured landowner wells over the period from 1993 through 2015 is estimated to average 47,480 AF per year. Table 1 summarizes the annual estimates of landowner pumping by water year type.

Table 1. Unmeasured groundwater pumping (closure term) by water year type

	Wet	Above Normal	Below Normal	Dry	Critically Dry
# of Water Years	8	3	2	4	6
Unmeasured Groundwater Pumping (AF)	46,362	31,536	46,166	55,131	52,276
Measured Groundwater Pumping (AF)	15,261	16,966	16,330	17,926	12,285

With the uncertainty of landowner pumping diminished, only two variables remain: change in storage and subsurface flux. Given the two remaining variables, it was necessary to use estimates of one to solve for the other as the closure term of the water budget. Due to the uncertainty associated with both variables, the water budget equation was expressed in two ways, one solving for each variable allowing the results of the two equations to be compared:

1. Close on subsurface flux, and
2. Close on change in storage.

Equation 1 was drawn from the *Water Budget BMP* (DWR, 2016) and was configured to solve for the two closure terms described above.

Eq 1. Inflow (a, b, c) – Outflow (a, b, c) = Change in Storage

Close on Subsurface Flux

To close on subsurface flux, annual changes in storage were estimated based on analysis of annual changes in water elevations from District Monitoring Wells (DMWs). Fall groundwater elevations from 1995 through 2014 for nine DMWs were used to create groundwater surfaces for each of these years with these surfaces being used to estimate volumes between the surfaces for consecutive years. A specific yield of 0.15 was applied to these volumes to determine the annual change in groundwater storage. The process was completed for each year; an example is shown below in Figure 1 for 1995.

	1	2	4	5	6	7	8	10a	12b
Fall 1994 (ft AMSL)	214	171	234	233	223	208	188	139	125
Fall 1995 (ft AMSL)	217	191	233	239	232	218	197	151	132
1995 Δ	3	20	-1	5	9	10	9	12	7
Average Δ:		8	feet						
Acres (BSA):		46,200	acres						
Total Volume		378,840	acre-feet						
Specific Yield: High		0.15							
Δ Storage: High		**56,826**	**acre-feet**						

Figure 1. Annual change in storage calculation [1995]

Using known variables, including estimates for annual change in storage from the method used in Figure 1, Equation 1 was configured to solve for annual subsurface flux. Table 2 provides a summary of the resulting annual subsurface fluxes, which are compared to the values found in the Todd groundwater model and in the Sierra Scientific report referenced earlier. The cumulative totals and averages at the bottom of Table 2 span two ranges (1995 through 2014 and 1995 through 2011) to account for the influence of the recent drought on groundwater conditions.

Table 2. Net Subsurface Flux

	GEI	Todd GW Model	Sierra Scientific
1995	(5,449)	(75,981)	(32,364)
1996	(5,226)	(65,329)	(32,364)
1997	636	(68,939)	(32,364)
1998	(22,835)	(73,279)	(32,364)
1999	11,552	(39,992)	(32,364)
2000	(30,029)	(19,811)	(32,364)
2001	31,258	(15,408)	(32,364)
2002	(7,828)	(9,289)	(32,364)
2003	(7,714)	(5,362)	(32,364)
2004	(20,191)	(2,598)	(32,364)
2005	44,044	(17,192)	(32,364)
2006	1,075	(24,574)	(32,364)
2007	(39,935)	(4,940)	(32,364)
2008	(82,443)	5,493	(32,364)
2009	(10,578)	1,598	(32,364)
2010	5,388	(22,553)	(32,364)
2011	(65,097)	(47,420)	(32,364)
2012	10,626	(18,922)	(32,364)
2013	35,782	15,709	(32,364)
2014	(6,051)	31,474	(32,364)
total [1995-2011]	(203,371)	(485,576)	(550,188)
total [1995-2014]	(163,014)	(457,316)	(647,280)
avg [1995-2011]	(11,963)	(28,563)	(32,364)
avg [1995 - 2014]	(8,151)	(22,866)	(32,364)
maximum [1995 – 2014]	44,044	31,474	
minimum [1995 – 2014]	(82,443)	(75,981)	
Difference [1995 – 2014]	126,487	107,455	
standard deviation [1995 – 2014]	30,721	30,233	
****** Assumes specific yield of 0.15***			

Table 3 is a summary of the closure values computed using Equation 1 formulated to close on subsurface flux.

Table 3. Summary of subsurface flux

	Subsurface Flux [AF]
total [1995 - 2011]	(203,371)
total [1995 - 2014]	(163,014)
avg [1995-2011]	(11,963)
avg [1995-2014]	(8,151)

Figures 2 and 3 provide the average annual flow paths for inflows (blue) and outflows (red) for the two date ranges, respectively: 1995 through 2014 and 1995 through 2011. Likewise, the orange flow path represents average annual subsurface flux for the two date ranges.

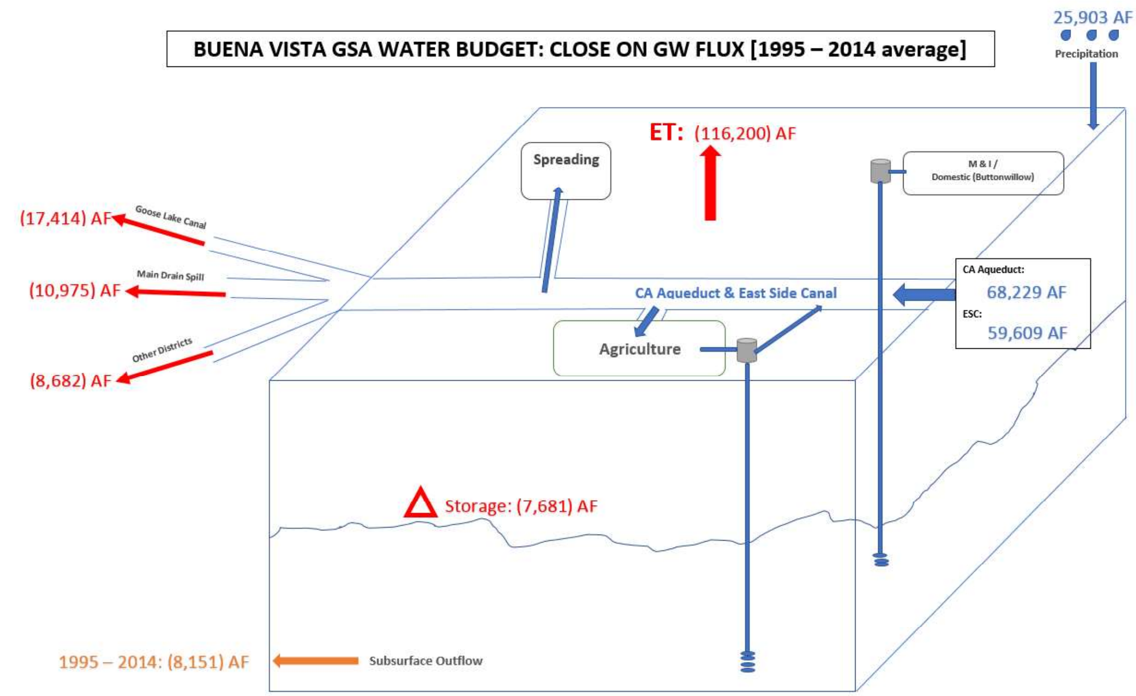


Figure 2. Water budget flow paths: average annual closure on subsurface flux [1995 – 2014]

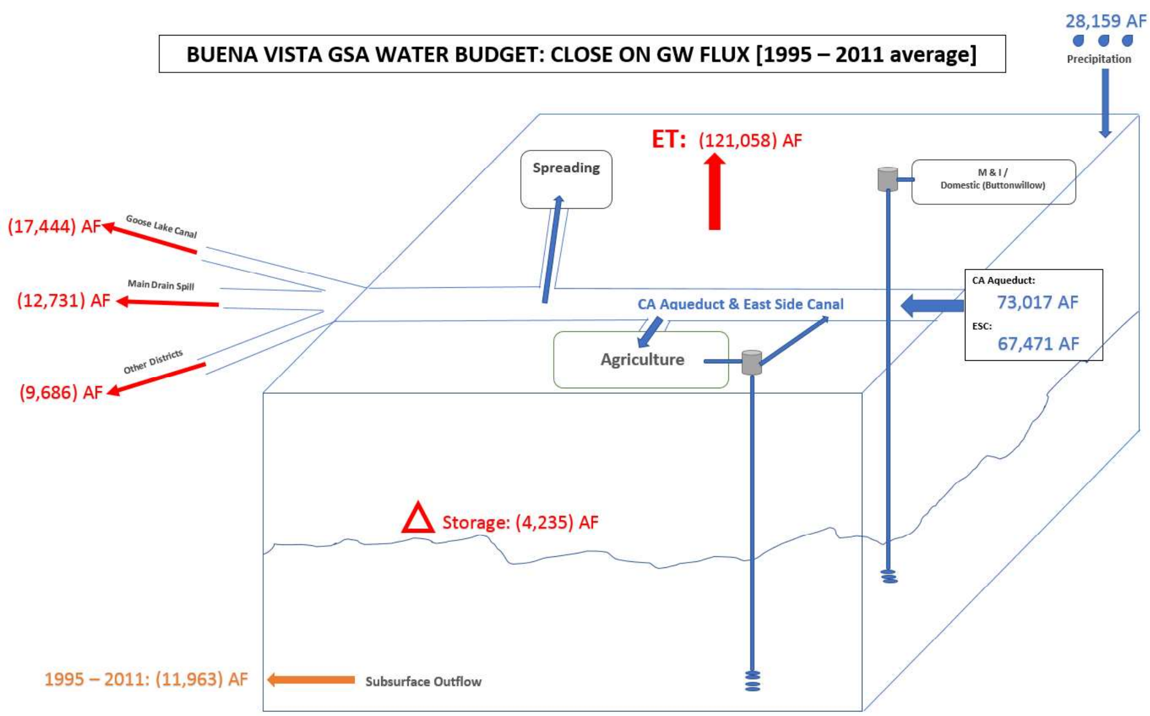


Figure 3. Water budget flow paths: average annual closure on subsurface flux [1995 – 2011]

Close on Change in Storage

To close on change in storage, annual subsurface flux must be estimated. Two methods were employed to estimate these values:

1. Sierra Scientific Method: This approach is drawn from the Sierra Scientific report referenced above. This report estimates an average annual net subsurface outflux of 32,364 AF, as shown in the calculation shown in Figure 4.

	Sierra Scientific Calculation:		
	Observed Average Annual Groundwater Storage Change (1974 - 2013)[1]	+4,600	AF / year
(-)	Average Annual Net Contribution to Groundwater Storage (1970 - 2007)[2]	+36,964	AF / year
	Average Annual Groundwater Flux	**(32,364)**	**AF / year**
	[1] based on 19 water level hydographs and specific yield of 0.15		
	[2] based on District Water Balance (Yearly Water Balance Column)		

Figure 4. Estimate of Subsurface Outflow (Sierra Scientific, 2013)

2. Modified Sierra Scientific Method. This method uses the structure presented by Sierra Scientific but applies updated inputs from the BVGSA Water Budget for 1995 through 2014 to account for recent cropping patterns and current irrigation practices. This modified approach estimates an average net groundwater outflow of 14,293 AF per year as illustrated in Figure 5.

	GEI Calculation:		
	Obsreved Average Annual Groundwater Storage Change (1995 - 2014)[1]	(7,681)	AF / year
(-)	Net Average Annual contribution to Groundwater Storage (1995-2014)[2]	6,612	AF / year
	Average Annual Subsurface Flux	**(14,293)**	**AF / year**
	[1] based on DMW water level hydographs and specific yield of 0.15		
	[2] based on BVGSA Water Buget (total deep percolation - total groundwater pumping)		

Figure 5. Modified Estimate of Subsurface Flux

Using estimates for subsurface flux from both methods described above, the water budget equation shown in Figure 1 was used to solve for change in storage. Table 4 provides a summary of the resulting annual change in storage using both methods of estimating subsurface flux and compares these values with output from the Todd groundwater model.

Table 4. Estimated Annual Change in Storage

Year	**GEI**	**Sierra Scientific**	**Todd Groundwater**
1995	47,982	29,911	92,768
1996	14,418	(3,653)	1,422
1997	18,258	187	49,727
1998	40,882	22,811	71,759
1999	(10,984)	(29,055)	(60,059)
2000	(20,608)	(38,679)	(55,232)
2001	(57,563)	(75,634)	(54,122)
2002	(53,358)	(71,429)	(55,846)
2003	(23,673)	(41,744)	(22,799)
2004	(48,387)	(66,458)	(35,560)
2005	(2,204)	(20,275)	79,728
2006	15,971	(2,100)	24,019
2007	(48,971)	(67,042)	(68,454)
2008	(45,733)	(63,804)	(82,864)
2009	(35,439)	(53,510)	(53,912)
2010	29,907	11,836	21,401
2011	67,898	49,827	142,652
2012	(11,059)	(29,130)	(81,522)
2013	(86,342)	(104,413)	(134,371)
2014	(67,455)	(85,526)	(125,978)
total [1995-2011]	(111,605)	(418,812)	(5,370)
total [1995-2014]	(276,461)	(637,881)	(347,240)
avg [1995-2011]	(6,565)	(24,636)	(316)
avg [1995 - 2014]	(13,823)	(31,894)	(17,362)
maximum [1995 – 2014]	76,898	49,842	142,652
minimum [1995 -2014]	(86,342)	(104,413)	(134,371)
difference [1995 – 2014]	154,240	154,240	277,023
standard deviation [1995 – 2014]	42,262	42,264	75,206

The cumulative totals and averages at the bottom of Table 4 span varying year ranges to allow for comparisons across the data sets:

Table 5 is a summary of the average annual change in groundwater storage determined by the GEI developed "close on groundwater storage" method which is the average over the period from 1995 through 2014.

Table 5. Summary of Change in Groundwater Storage

	GEI Estimate Δ Storage
total [1995 - 2011]	(111,605)
total [1995 - 2014]	(276,461)
avg [1995-2011]	(6,565)
avg [1995-2014]	(13,823)

Figure 6 and 7 provide the average annual flow paths for inflows (blue) and outflows (red) for two date ranges, respectively: 1995 through 2014 and 1995 through 2011. The orange flow path represents average annual subsurface outflow for the two date ranges.

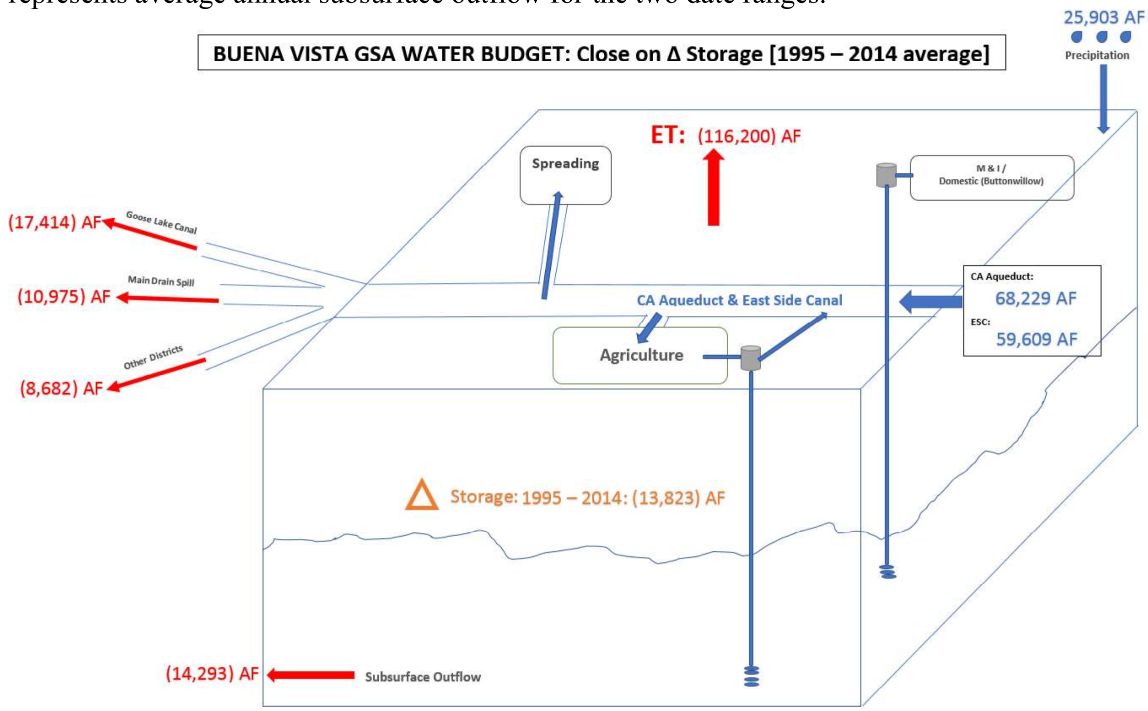


Figure 6. Water budget flow paths: close on change in storage [1995 – 2014 average]

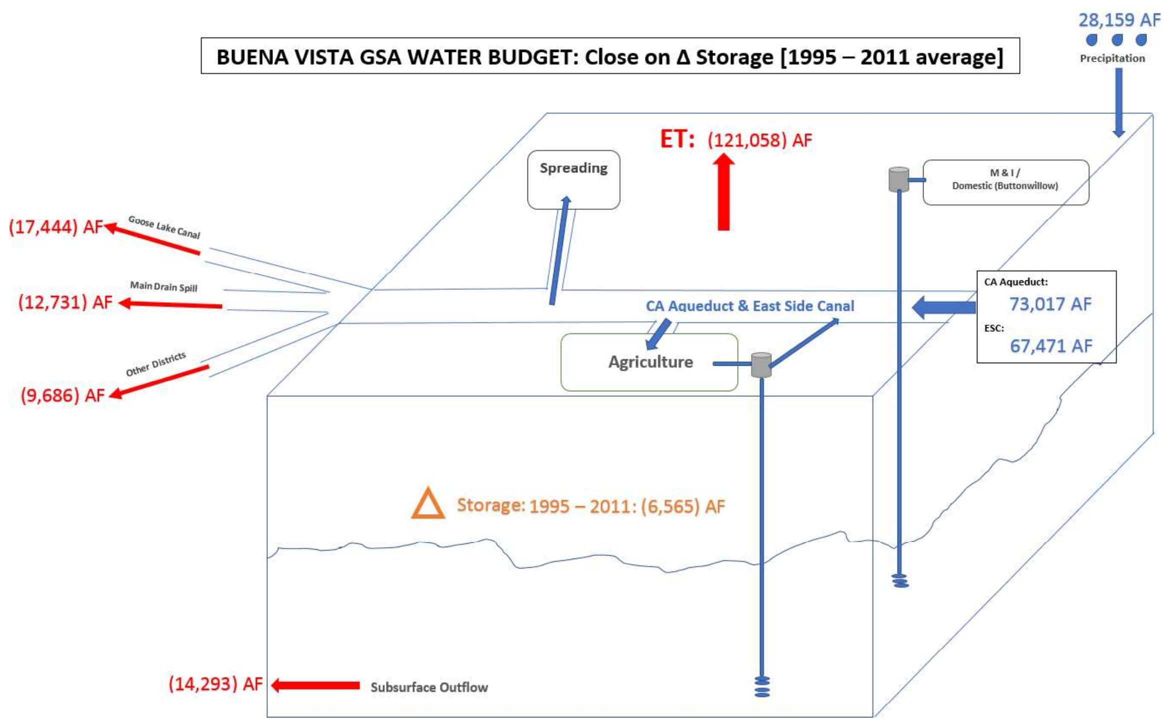


Figure 7. Water budget flow paths: close on change in storage [1995 – 2011 average]

Comparison of Methods

Table 6 compares the two methods by summarizing the average annual landowner pumping, average annual subsurface flux, and average annual change in storage for 1995 through 2015.

Table 6. Method comparison: average annual volumes [1995 through 2014]

	Method	
	Close on Flux [AF]	**Close on Δ Storage [AF]**
Subsurface Flux	(8,151)	(14,293)
Δ Storage	(7,681)	(13,823)

Table 7. Method comparison: average annual volumes [1995 through 2011]

	Method	
	Close on Flux [AF]	**Close on Δ Storage [AF]**
Subsurface Flux	(11,963)	(14,293)
Δ Storage	(4,235)	(6,565)

Conclusions and Recommendation

The results shown in Table 6 and Table 7 illustrate that both closure methods yield similar subsurface flux and change in storage values for the respective date ranges of 1995 – 2014 and 1995 – 2011. It should be noted that both subsurface flux and change in storage averages are less negative when 1995 – 2011 data is used when compared to 1995 – 2015 data, likely due to drought conditions that lowered groundwater elevations and altered gradients. For both date ranges, the method of closing on change in storage yields subsurface flux and change in storage values that are more negative than the method of closing on subsurface flux.

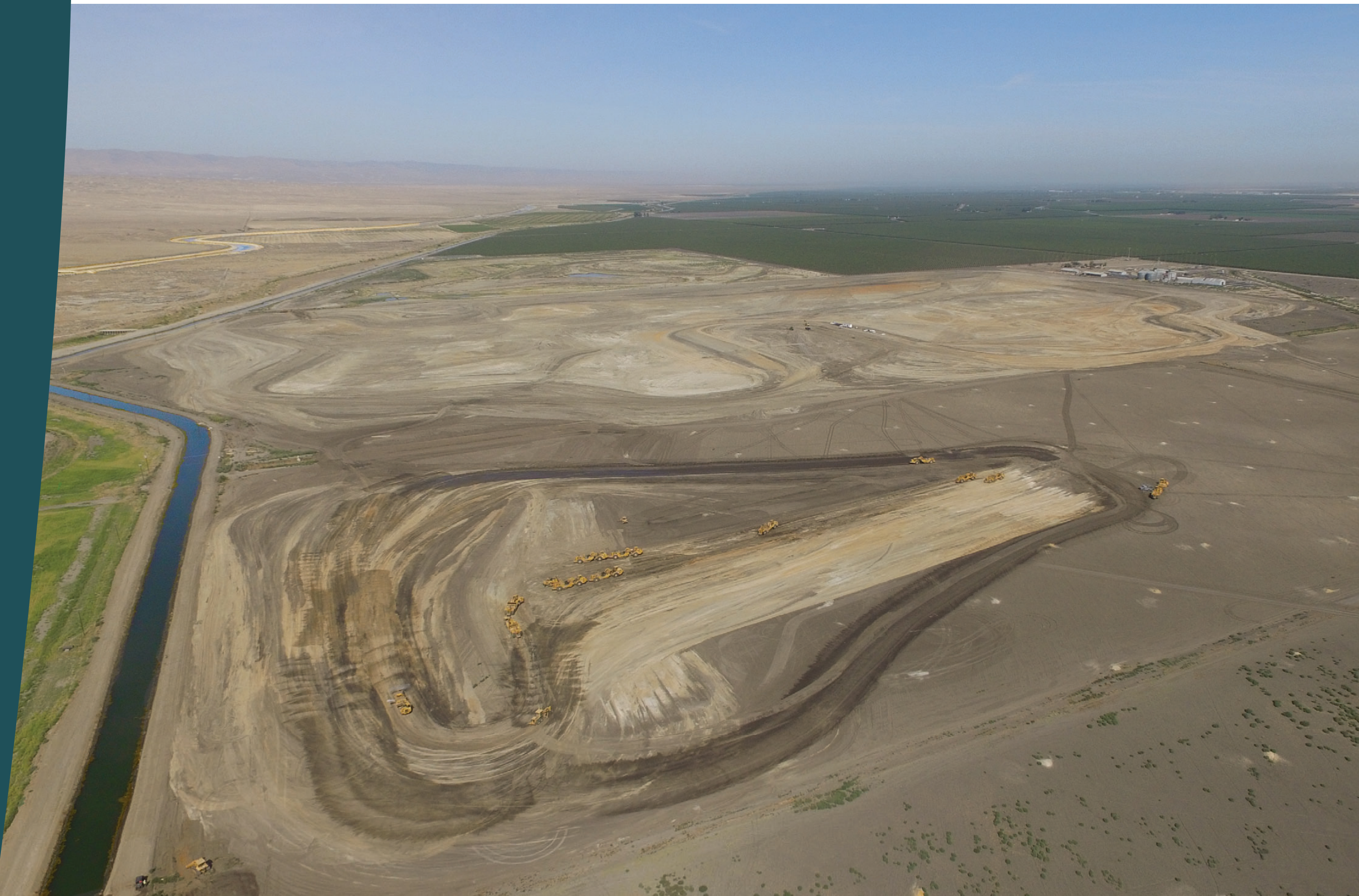
It is recommended that the BVGSA water budget close on subsurface flux, using source data from 1995 – 2011 to assume the change in storage (as explained in Figure 1). This recommendation results in a change in storage closest to zero, which is what historical pre-drought groundwater elevation data suggests are the actual conditions. The subsurface flux is estimated to be approximately (12,000) AF, which is less water leaving BVGSA than the Sierra Scientific estimate concluded. The discrepancy can be explained by the GEI estimate using more current input data, which reflect changes in cropping patterns and irrigation techniques. Table 8 summarizes the recommendation.

Table 8. Recommendation for closure method [1995 through 2011]

	Close on Flux [AF]
Subsurface Flux	(11,963)
Δ Storage	(4,235)

Appendix H

Todd Groundwater Report (2019)



TODD GROUNDWATER

REVIEW DRAFT

August 30, 2019

MEMORANDUM

To: Mark Mulkay, Kern River GSA
Patty Poire, Kern Groundwater Authority GSA

From: Michael Maley, Todd Groundwater
Charles Brush, Hydrolytics LLC

Re: **Historical and Projected Future Water Budget Development with C2VSimFG-Kern**
Kern County Subbasin SGMA Compliance

1. INTRODUCTION

The Sustainable Groundwater Management Act (SGMA) regulations require that water budget analyses for Groundwater Sustainability Plans (GSPs) be conducted on a basin-wide basis. The California Central Valley Groundwater-Surface Water Simulation Model (C2VSim) is anticipated to be DWR's primary tool for evaluating water management in the Central Valley and is specifically referenced in the GSP regulations for application to GSP water budgets (§354.18(f)); therefore, utilizing C2VSim was deemed to be advantageous for GSP compliance.

DWR released the C2VSim Fine Grid Public Beta model (C2VSimFG-Beta) on May 18, 2018. C2VSimFG-Beta generally has good historical precipitation, stream inflow, land use and crop acreage for the entire Central Valley. Historical water supply and demand data are generally good in the Sacramento Valley and San Joaquin River hydrologic regions; however, it is considered less reliable in the Tulare Lake hydrologic region including Kern County. To address this concern, Todd Groundwater has updated the Kern County portion of C2VSimFG-Beta for the water years (WY) 1985-2015. This updated version of C2VSim for Kern County (C2VSimFG-Kern) was used to develop historical and current water budgets for the Kern County Subbasin SGMA compliance.

The groundwater sustainability agencies (GSAs) in the Kern County Subbasin (**Figure 1**) agreed to update C2VSimFG-Beta with locally derived data on managed water supply and demand to provide water budgets for GSP development. The Central Valley portion of Kern County holds two groundwater subbasins, the Kern County Subbasin (5-022.14) and the White Wolf Subbasin (5-22.18). All of the agencies that deliver water in White Wolf Subbasin also deliver water in the Kern County Subbasin and participated in the C2VSim update. The White Wolf Subbasin portion of the C2VSim model was included in this update to ensure coordination of groundwater conditions assessment in the two subbasins however the two basins are considered separate under SGMA and only the model results for the Kern County Subbasin are evaluated and reported here.

1.1 General Approach

The current C2VSim model has a detailed finite element mesh that closely follows local hydrologic features. As a regional model, the C2VSimFG-Beta may over-generalize local conditions within the Kern County Subbasin. As a result, C2VSim results may not be consistent with local site-specific data and knowledge. To address this concern, the general approach is to update managed water supply and demand inputs to better represent the local water balance. To do this, the more general assumptions in C2VSimFG-Beta were replaced with local data and knowledge that are regionally or locally significant over the 1995-2015 Hydrology Period. Our approach is to collect local managed water supply input data (e.g., surface water deliveries, land use, irrigation demand, return flows, and groundwater banking) and apply this to C2VSim. Improvement of Kern County data focused on incorporating:

- Surface water delivery volumes, application areas and use by water district
- Groundwater banking recharge, recovery and application of recovered water
- Irrigation demand from recent remote sensing analyses in the Kern County Subbasin based on ITRC METRIC data
- Urban demand for the subbasin focusing on Metropolitan Bakersfield
- Data on other water sources and demands of local significance to individual Districts/GSAs

Todd Groundwater updated the Kern County portion of C2VSimFG-Beta for the water years (WY) 1995 to 2015. Data were provided by local GSAs based on their own water budget data to improve model accuracy on a local basis. The managed water supply and demand revisions required major structural changes to C2VSimFG-Beta. Todd Groundwater also coordinated data collection and model revision efforts with a Technical Peer Review Team and local agencies to ensure input data were accurately represented in the model. Tabulated input data, model files and model-derived water budgets were provided to the Technical Peer Review Team for review of accuracy and appropriateness. Model input data and results were also provided to Kern County Subbasin water districts and local purveyors for their review. Comments and data issues were reconciled and incorporated into the revised C2VSimFG-Kern model.

1.2 Acknowledgements

These regional model revisions were enhanced by the participation of the many agencies that provided local water budget input data. Todd Groundwater worked with the member agencies, and their consultants, of the Kern River Groundwater Sustainability Agency (KRGSA), Kern Groundwater Authority (KGA), Henry Miller Water District GSA, Olcese Water District GSA, and Buena Vista Water Storage District GSA to coordinate acquisition of input data from other agencies in formats that could be easily incorporated into the C2VSim model. On-going review of interim model results by these agencies, including local zonal water budgets, groundwater hydrographs and other model results, helped ensure that the revised model reproduced local mass balance estimates across the subbasin.

Todd Groundwater also worked with Woodard & Curran throughout the model development process as Woodard & Curran conducted an on-going peer review of model input files. The updated C2VSimFG-Kern input files for the Kern County Subbasin were provided to DWR for incorporation into future C2VSim public releases.

2. C2VSIM

C2VSim simulates the full hydrologic cycle, calculating water demands and tracking water movement through surface water and groundwater systems, and is well suited to GSP development. C2VSim uses DWR's modeling code Integrated Water Flow Model (IWFM) and covers the entire California Central Valley (**Figure 2**).

2.1 C2VSim Background

DWR developed C2VSim to simulate water demands and supplies in the Central Valley. Kern County is located at the far southern end of the Central Valley (**Figure 2**). C2VSim is an application of DWR's Integrated Water Flow Model (IWFM) software. IWFM is an integrated hydrologic model that simulates water flows on the linked land surface, unsaturated zone, groundwater, and surface water flow systems. A key feature of IWFM is DWR's agricultural and urban water supply and demand management module that dynamically simulates the delivery of both surface water and groundwater supplies based on both water availability and calculated water demands, as affected by usage and climatic conditions.

The groundwater flow system is modeled in IWFM using the finite element method and uses a highly efficient solver developed at UC Davis. The IWFM land surface simulation process was developed with input from California irrigation management professionals. Given DWR's emphasis on water management, detailed water budgets produced by C2VSim provide strong representations of the surface water and groundwater flow systems and make it a preferred platform for developing water budgets.

2.2 C2VSImFG-Beta Model

The C2VSim Fine Grid Beta Model (C2VSimFG-Beta) is derived from a series of Central Valley hydrologic models developed by DWR and other agencies beginning in the early 1990s. Each model in this series has incorporated significant improvements over the previous version. C2VSimFG Beta includes historical input data for WY1922-2015. These data include monthly precipitation and annual land use for each model element and estimated monthly evapotranspiration for each modeled land use type and agricultural crop. Historical surface water data include monthly surface water inflow for each river entering the model boundary and monthly surface water diversions.

The C2VSimFG-Beta finite element grid divides the Central Valley into 32,537 model elements (**Figure 2**). Element areas are small near streams and in developed areas and expand to larger sizes in undeveloped areas. Element sizes average 407 acres and range from 4 to 1,770 acres. Central Valley rivers and streams are represented with a network of 110 stream reaches. Surface water and groundwater inflows from uplands along the model boundary are simulated with 1,033 small watersheds. The groundwater aquifer system is represented with four layers.

Land surface altitude and groundwater layer thicknesses vary across the model domain. Within the Kern County Subbasin, the land surface altitude varies from 208 feet above sea level in the north to 3,922 feet above sea level in the foothills. The aquifer thickness in the Kern County Subbasin varies from 857 to 9,054 feet and the deepest aquifer location is 8,752 feet below sea level. The Central Valley aquifer is simulated with the following hydrostratigraphic layers, listed from top to bottom:

- Shallow, unconfined aquifer
- Regional confining layers
- Active confined aquifer (contains high level of pumping)
- Inactive confined aquifer (contains limited pumping), and
- Saline confined aquifer.

C2VSimFG-Beta includes annual land use and crop acreages and monthly precipitation, evapotranspiration, stream inflows, surface water deliveries and groundwater pumping rates for WY1922-2015. C2VSim uses this information to dynamically calculate distributed monthly water demands, allocate available water supplies to meet these demands, and calculate any additional groundwater pumping that may be required to satisfy unmet demands. C2VSimFG-Beta produces detailed monthly water budgets for arbitrary sets of elements grouped into zones.

Water demands are calculated dynamically for each model element for agricultural, urban, native and riparian land use types. Agricultural land use is specified for 20 upland crops and two ponded crops. Urban demands are calculated based on population and per-capita water demands. Water demands for other land uses are calculated from monthly evapotranspiration rates. Water demands are then satisfied from soil moisture (partly derived from precipitation), specified surface water applications and specified groundwater pumping. If water demands in an element are not satisfied from these sources, the C2VSim model can adjust groundwater pumping to eliminate any deficit.

C2VSimFG Beta was released after a preliminary model calibration. The distribution of aquifer parameters was based on a texture analysis of lithologic well logs compiled by the US Geological Survey (USGS 2009) from Well Completion Reports submitted to DWR by well drillers. The texture analysis interpolated the percentage of coarse-grained material at each well location and depth of the C2VSimFG-Beta mesh. Aquifer parameters were then calculated for the model mesh based on the percentage of coarse-grained material and estimated properties for pure coarse- and fine-grained materials. Transmissivities were estimated using specific capacity tests, where available. Soil properties for each model element were derived from digitized soil maps published by the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS 2018).

3. KERN COUNTY UPDATES

C2VSimFG Beta input files have been modified to incorporate locally-derived managed water supply and demand data to better represent the local water balance for the Kern County Subbasin (**Figure 3**). The following provides a summary of the model revisions.

3.1 C2VSimFG-Kern Model

C2VSimFG Beta input files have been modified to incorporate locally-derived managed water supply and demand data to better represent local water balances. Historical surface water diversions, water bank recharge and water bank withdrawal information were collected from Kern County water purveyors. The revised model that includes the Kern County revisions is referred to as C2VSimFG-Kern, which includes revised data for the Kern County and White Wolf subbasins to better represent local water conditions. C2VSimFG-Kern was not changed for areas outside of the Kern County Subbasin.

Historical surface water diversion, water bank recharge and water bank withdrawal information were collected from Kern County water purveyors. Urban land use was restricted to developed areas, and urban populations and per-capita water demands were updated. Model structure (elements, streams, stratigraphy, etc.) was not modified. Model parameters were not calibrated, although some model parameters were adjusted to improve model performance in specific geographic areas.

3.2 Simulation Time Period

The period of interest for this study is WY1995 to WY2015. The C2VSimFG-Beta simulation period ran from October 1973 through September 2015 (WY1974 to WY2015). The C2VSimFG-Kern simulation period is WY1985 to WY2015.

GSP requirements indicate a need to identify an average hydrologic Study Period for purposes of the groundwater analyses in the basin-wide water budgets. In order to select a consistent study period, the Kern County Subbasin GSAs agreed on an average hydrologic study period covering WY1995 through WY2014. The historical average hydrologic study period of WY1995 through WY2014 covers 20 years on a water year basis, from October 1, 1994 through September 30, 2014. The selection of the study period was based on a variety of technical criteria including:

- 100 percent of the long-term average streamflow conditions on the Kern River, as indicated by an average annual Kern River Index of 100 percent (**Figure 4**)
- About 104 percent of long-term average precipitation (NOAA Bakersfield Meadows Field Airport Station)
- Sufficiently short time period associated with widely-available and higher-quality data
- Inclusion of recent time periods to capture ongoing water management practices and more recent land use patterns
- Covers at least 10 years consistent with GSP regulations (§354.18(c)(2)(B))
- Contains 10 years characterized as above normal or wet years based on precipitation; also contains 10 years of below normal or dry years, including 4 critically-dry years
- Begins in a time of relatively stable water levels (October 1994)
- Overlaps time period with consistently-developed basin-wide contour maps by Kern County Water Agency (KCWA).

For the historical water budget, it is desirable to define a base period when natural hydrology represents average conditions. C2VSimFG-Kern incorporates this 20-year base period of WY1995 through WY2015 with a 10-year spin-up period (WY1985 to WY1994). Kern County water agencies provided high-quality water budget data for WY1995 to WY2015 for this study. Good-quality water budget data for WY1984 to WY1994 was also collected, but detailed water budget data for WY1974 to WY1983 were not available. The simulation period was set to WY1986 to WY2015, allowing a 10-year spin-up before the period of interest.

3.3 Data Compilation

Participating agencies compiled water budget input data sets (using their staff, consultants or other resources) and provided them to Todd Groundwater. Where appropriate, Todd Groundwater developed data templates that conformed to IWFM model data needs and used them to facilitate obtaining input data from local agencies. This included monthly data for the following:

- Surface water imports and diversions (inflows and outflows) by source, conveyance and application area,
- Groundwater banking and managed aquifer recharge by water district or agency,
- Groundwater banking pumping for export from the basin,
- Metered district groundwater recovery pumping,
- Urban area population and per capita water use, and
- ET rates based an analysis of satellite data.

In addition, groundwater banking data were compiled for the large Kern Fan banking projects. Recently-developed crop evapotranspiration rates derived from remote sensing data were used to develop monthly crop evapotranspiration rates for agricultural crops. Urban land use was restricted to developed areas, urban populations and per-capita water demands were updated, and urban wastewater recharge operations were added.

3.4 Surface Water Diversions

Kern County surface water diversions in C2VSimFG-Beta were grouped by project or water source, and some surface water deliveries were applied to large regions rather than to individual districts. In addition, some local surface water deliveries were missing from C2VSimFG-Beta. For C2VSimFG-Kern, the 43 Kern County surface water diversions to the Kern County and White Wolf subbasins from C2VSimFG-Beta were replaced with 113 surface water diversions developed with data provided by local agencies.

3.4.1 Data Compilation

Monthly surface water diversion data for WY1995 to WY2015 were collected for 21 agencies and recharge projects in Kern County. The data from each water district or agency included monthly surface water inflow by source and monthly surface water outflow by destination.

The monthly surface water inflow and outflow data collected for this study did not have sufficient detail to track this water and create an accurate historical water balance for each canal for each month. The data do provide sufficient information to identify monthly surface water diversions from each source and deliveries to each end use. Therefore,

- All diversions from the Kern River were exported from the model and treated as imports at delivery locations,
- Diversions from Poso Creek and the Kern River Flood Channel (or Main Drain) were diverted from the appropriate stream nodes, and
- All other surface water deliveries (SWP, CVP, oil field recovery water, etc.) were treated as imports.

Each C2VSim surface water diversion is linked to two groups of model elements: the elements of the end use and the elements receiving the recoverable losses. A single set of elements was used for both purposes in C2VSimFG-Kern. Model elements for agricultural, urban and refuge deliveries were selected by overlaying the model grid on delivery areas maps. Model elements for recharge diversions were selected by overlaying the model grid on recharge basin maps.

3.4.2 Surface Water Diversions

Monthly water delivery data for the State Water Project (SWP), Central Valley Project (CVP) and Kern River were also provided by the agencies. Monthly turnout-level deliveries for the SWP were compiled from the monthly SWP Report of Operations published by DWR. Monthly CVP deliveries were compiled from the USBR Report of Operations. Monthly Kern River flow and diversions were compiled from Kern River Hydrologic Reports. Water agencies in the Kern County subbasin trade and wheel water in real time to maximize water utilization, minimize waste and energy consumption, and meet immediate water needs. Water delivery reports from water suppliers (such as the CVP and SWP) generally identify the owner of delivered water, not where it was actually delivered.

Some surface water conveyances discharge water into stream or river channels for re-diversion downstream. A key part of the surface water system in Kern County is the Kern River. Kern River operations data were reviewed for 1970 to 2015. While Table 1 summarizes surface water deliveries, **Table 2** summarizes Kern River diversions by turnout location as applied in C2VSimFG-Kern.

3.4.3 Surface Water Deliveries

Water flow through the Kern River and its associated canal system is very complex. Water is diverted from the Kern River into a parallel canal system at several locations, with some diverted water flowing back to the river. Some water from the CVP and SWP are discharged into the Kern River for diversion downstream. Some water agencies are served from multiple diversion points along the Kern River. Several canals that receive water diverted from the Kern River also exchange water with other canals and receive some water from groundwater pump-in, so deliveries from many canals cannot be attributed to a single source.

Each surface water diversion is allocated to a specified destination and water use. Five water use types are simulated in C2VSimFG-Kern: agricultural, urban, refuge, recharge and export. Agricultural and refuge diversions are applied to a group of model elements that corresponds to a surface water service area within a specific water agency or refuge (**Figure 5**). Urban diversions are allocated to an urban service area. Groundwater recharge diversions are allocated to the model element or elements where the receiving recharge basin is located. Three delivery fractions apportion each surface water diversion to application, loss to groundwater (recoverable loss), and loss to evaporation (non-recoverable loss). **Table 1** summarizes the annual surface water deliveries for agricultural use by water district in Kern County. **Table 3** summarizes surface water diversions for urban use, wastewater land disposal and wildlife refuge management in Kern County.

3.5 Groundwater Banking and Managed Aquifer Recharge Operations

In our preliminary discussions with the C2VSim developers at DWR, it was revealed that significant model uncertainty was related to incomplete data regarding groundwater banking and other managed aquifer recharge (MAR) operations in the Kern County Subbasin. Recognizing the importance of these groundwater banking projects on simulating groundwater conditions, the approach is to update data for groundwater banking and MAR operations using the earliest available records.

3.5.1 Recharge and Recovery Data

A monthly time-series of recharge rates was determined for each recharge project. Recharge rates were allocated to individual recharge basins using the initial data whenever possible or were shared proportionally between basins based on historical rates. All Kern County recharge basin surface water deliveries were simulated as imports.

Recharge basin locations and recovery well locations were provided by each agency or project (**Figure 6**). The C2VSim finite element grid was overlaid onto a map of recharge basins to determine the model elements for each recharge location. Well location coordinates were added to C2VSimFG-Kern.

Monthly volumes for recharge at groundwater banking and managed aquifer recharge facilities were compiled for 16 agencies and projects (**Table 4**). This information originated from multiple sources, and included data provided by agencies, compiled from agency reports, and compiled from Kern River Hydrologic Reports. The data include monthly recharge for years prior to 1995 for many projects. Several agencies and projects provided data for multiple recharge basins. Some groundwater wells used for recovery of banked water are also used for other purposes such as supplementing agricultural or urban surface water deliveries.

Recognizing that several of the large groundwater banking projects (especially those on the Kern Fan) pre-date the 20-year base period, and that future studies might simulate periods prior to 1985, all available historical data for groundwater banking operations was reviewed and updated. This included incorporating pre-1985 data for banking operations at

- Arvin-Edison WSD (1966-2015),
- Berrenda Mesa Project (1977-2015),
- Buena Vista WSD (1963-2015),
- City of Bakersfield 2800 Recharge Facilities (1973-2015)
- North Kern WSD (1956-2017) and
- Rosedale-Rio Bravo WSD (1980-2015).

3.5.2 Groundwater Recovery

Two types of recovery wells were added to the C2VSimFG-Kern. These include District-operated water wells that were used for out-of-district transfers or out-of-basin exports of groundwater, and wells used for recovering banked groundwater and distributing the pumped groundwater via the district's water conveyance system to provide water supply, typically for agricultural use, within the district. The locations of the specified groundwater recovery wells are shown on **Figure 6**. The specified groundwater recovery pumping input into C2VSimFG-Kern is summarized as follows:

- 229 time series for Kern County groundwater banking withdrawals was added;
- 313 simulated pumping wells and 225 pumping time series for local groundwater pumping by district-operated recovery wells were added; and
- Elemental agricultural, refuge and urban pumping was eliminated in areas where it has not historically occurred.

Recharge and withdrawal data for the Kern Fan banking projects, including the Kern Water Bank, Berrenda Mesa Project, Pioneer Project, and the City of Bakersfield 2800 Recharge Facilities were shared with the local banking authorities for verification. Banking data for district-specific groundwater banking projects were provided by these districts. A summary of the data input for groundwater recovery pumped added to C2VSimFG-Kern is provided in **Table 5**.

3.5.3 Model Application

A separate diversion was created to deliver surface water to each recharge basin or set of geographically close jointly managed basins. A diversion time series of monthly application rates was then created for each recharge diversion from the available data. Each recharge diversion delivers water to the model elements coinciding with the receiving recharge basin(s). Recharge basins were simulated in C2VSimFG-

Kern by setting the application delivery fraction to zero, the recoverable loss fraction to 94% and the evaporation loss to 6%.

Monthly groundwater recovery was generally provided by well field and destination (e.g. agriculture, urban, canal pump-in, or export). This information was used to develop a pumping time series for each well field and destination. Groundwater pumped for export from the Kern County Subbasin is summarized in **Table 6**. Recovery well locations and screen intervals were used to enter each recovery well into C2VSimFG-Kern. Recovery pumping time series were then allocated equally to all of the wells in each field.

Some well fields supply water to two different end uses, for example supplementing surface water deliveries within the district in some months and exporting water from the district in other months. This is handled in C2VSimFG-Kern by entering the well two times. Each entry is associated with a separate time series of pumping rates and delivery destination.

3.5.4 Groundwater Banking Obligations

The general operation of groundwater banking facilities is to recharge excess available surface water supplies during wet years by recharging to the groundwater, and recovered this water by pumping in dry years when surface water supplies are limited. Groundwater banking programs store water in the Kern County Subbasin for use by local agencies and also export water to out-of-basin entities.

For evaluating the groundwater sustainability, any water stored in the Kern County Subbasin that is contractually obligated to an out-of-basin entity does not contribute the long-tern groundwater sustainability because the owner of that water could call for its return at any time. However, this can be difficult to track because a common practice is to recover groundwater for local use to replace imported surface water that was sent to the out-of-basin entity.

C2VSimFG-Kern does not have a mechanism to track these complex contractual exchanges, so the tracking is done as a post processing step by assigning the portion of the groundwater recharge as an out-of-basin banking obligation.

The Kern County Subbasin GSAs provided the total out-of-basin banking obligation for their operations as of September 2014 for the historical assessment. As of September 2014, the out-of-basin banking obligation for the Kern County Subbasin totaled of 1,719,307 acre-feet, which, when averaged over the 20-year period, was 85,965 acre-feet per year (AFY). The 85,965 AFY is applied during post-processing of C2VSimFG-Kern historical water budget results.

3.6 Urban Water Demand

C2VSim calculates urban water demands for specified urban delivery zones, allocates specified surface water and groundwater supplies to meet these demands, and can optionally pump additional groundwater to satisfy unmet urban demands in each zone. Urban demands were represented with nine urban zones in C2VSimFG-Beta. These zones were reconfigured, and a tenth urban zone was added representing Metropolitan Bakersfield in C2VSimFG-Kern. Historical urban populations and per capita water use rates were reviewed and updated.

3.6.1 Urban Zones

C2VSimFG-Kern dynamically calculates urban water demands for urban zones using time-series data of urban populations and monthly per capita water use. The urban delivery zones of C2VSimFG-Beta were modified to better represent Kern County population centers, jurisdictional boundaries and urban water sources. Although Kern County urban water delivery systems are operated by many diverse entities, their water generally comes from two sources: surface water deliveries and agency-operated groundwater wells.

The nine Kern County urban zones in C2VSimFG-Beta for Kern County were numbered 97-105. The Urban Zone boundaries were adjusted, as shown on **Figure 7**, as follows:

- Portions of Urban Zones 97, 99, 100, and 102 in C2VSimFG-Beta were used to create Urban Zone 106 representing the Metropolitan Bakersfield area;
- Urban Zone 98 was extended southeast to near the Stockdale Highway to include unincorporated urban areas;
- The boundary of Urban Zone 99 was extended eastward to California State Route 65 to include small communities in this area, removing them from Urban Zone 100; and
- The northern boundary of Urban Zone 104 was moved north to correspond to the West Kern WD service area.

3.6.2 Urban Population and Per Capita Use

Historical annual urban populations for the ten urban zones were estimated using United States Census total population data from 1990, 2000 and 2010 (US Department of Commerce). Tabular historical census data and census block shapefiles were obtained from the IPUMS National Historical Geographic Information System Database. These data were combined to produce maps of the geographic distributions of populations within Kern County. The historical populations for each Urban Zone were estimated by mapping census block centroids to the ten Urban Zones using ArcGIS. The 1990, 2000 and 2010 population of each Urban Zone was then estimated as the sum of the populations of the associated census blocks. Populations for other years were estimated using interpolation and extrapolation. The population values by urban zone used for C2VSimFG-Kern are listed in **Table 7**.

3.6.3 Urban Water Use Specifications

Monthly historical urban water demands for Urban Zone 106 were calculated using water delivery data from the water purveyors in the Metropolitan Bakersfield area. Monthly historical urban water demands for the other urban zones in the Kern County Subbasin were estimated using available water use data from published urban water management plans for the communities served in those zones. The historical monthly water use in each zone was then divided by the historical population to obtain the monthly per capita urban water demand. Monthly historical per capita water demands for zones without urban water management data were estimated using the per capita water demand from zones with similar demographics.

The urban water use specifications indicate the portion of total urban water that is used indoors. In C2VSimFG-Kern, the portion used indoors becomes urban return flow, and the remainder is added to the urban root zone where it contributes to evapotranspiration and deep percolation. C2VSimFG-Beta included monthly urban water use specifications for each model subregion. The urban per capita water use was based on local water supply data and urban water management plans. **Table 8** lists the per capita water use data used for C2VSimFG-Kern.

3.6.4 Model Application

Historical annual urban population estimates were placed in the C2VSimFG-Kern urban population input file. Historical monthly urban per capita water demand estimates for each urban zone were placed in the C2VSimFG-Kern urban per capita water use file. Urban demand was calculated by C2VSimFG-Kern and the water supply was met first by specified surface water and groundwater pumping deliveries for urban use. The remaining water demand in each model element as calculated by C2VSimFG-Kern was met with groundwater pumped from the aquifer portion of that element.

3.7 Agricultural Crop Water Demand

C2VSim dynamically calculates agricultural crop water demands and allocates supplies to meet these demands for each model element. Agricultural demands are calculated for 20 crops using historical crop acreage data and crop evapotranspiration (ETc) rates. Crop water demands in each model element are first met with stored soil moisture, surface water deliveries and specified groundwater deliveries. If the agricultural demands are not satisfied, the model can optionally calculate the additional groundwater pumping required to satisfy the unmet demands and extract that water from the groundwater component of the model element.

C2VSimFG-Beta contained one set of monthly ETc rates for each model subregion that were repeated each year. New monthly ETc rates for three model subregions (northeast, northwest, south) in Kern County were calculated for 1993-2015 using monthly remote sensing imagery and detailed annual crop maps. ETc for 1974-1992 were estimated from 1993-2015 values by using the values for similar water year types based on the San Joaquin Index. Satellite data were not available for 2012, so ITRC was unable to provide METRIC data for 2012. In C2VSimFG-Kern, 2013 was applied as an appropriate proxy for ETc data in 2012 because of their hydrologic similarity.

A remote sensing study of historical ETc rates across the entire Kern County Subbasin by the Irrigation and Training Research Center (ITRC 2017) provided detailed basin-wide agricultural demands that corresponded to the WY 1995-2014 base period. These data were used to develop monthly ETc rates for the Kern County portion of the model.

3.7.1 ET Rates

The Irrigation Training and Research Center (ITRC) at California Polytechnic State University, San Luis Obispo, has developed a procedure to use remote sensing imagery from Landsat satellites to calculate historic ETc rates (ITRC 2017). The Mapping of Evapotranspiration with Internal Calibration (METRIC) method was originally developed by Richard Allen of the University of Idaho. ITRC made several modifications to the original METRIC method to better match California data and conditions (named the ITRC-METRIC method). These modifications include using grass for reference evapotranspiration (ETo), incorporating a semi-automated calibration procedure and spatially interpolating ETo rates. An example of the METRIC ET data for the total annual ET in 2013 is provided in **Figure 8**.

ITRC used Landsat imagery for 1994-2015 (except 2012 when no imagery was available) and the ITRC-METRIC method to develop monthly raster maps of ETc at 30 x 30 meter resolution for the Kern County portion of the Central Valley (ITRC 2017). The monthly ETc raster maps were used with annual DWR crop maps to calculate the average ETc by crop type for the three Kern County C2VSim subregions. ITRC-METRIC raster data were used to determine the exact areas of applied irrigation and total annual ETc. A raster pixel was assumed to be irrigated if the total annual ETc was greater than 20 inches.

The following data processing steps were used to determine monthly ETc rates for each crop and C2VSim subregion:

- Create irrigation coverages – ITRC-METRIC monthly ETc raster data were summed to calculate total annual ETc for each year for each raster location. The ArcGIS Reclassify tool was then used on each annual ETc raster to create a binary polygon coverage for each year for 1994-2015 (except 2012), setting the attribute “IRR” to 1 if total annual ETc was over 20 in/year, and to 0 if total annual ETc was equal to or less than 20 in/year.
- Create land use coverages – Annual DWR land use rasters were converted to polygon coverages with the attribute “Crop” set to the corresponding integer crop value used in C2VSimFG-Kern. The land use rasters were checked against GIS maps produced by the Kern County Agricultural Commissioner and consistent errors in the DWR land use rasters were corrected. DWR land use maps for 1994-1997 were missing large areas of data, so the 1998 land use map was used to approximate the land use for 1994-1997.
- Create monthly zone maps – One Zone shapefile was created for each month by using the ArcGIS Union tool to combine a shapefile of the three C2VSim subregions with the irrigation coverage (produced in step 1) and the land use coverages (produced in step 2). Each monthly zone polygon shapefile has three attributes: C2VSim subregion, binary irrigation indicator, and a land use crop value. The dissolve function was used to combine zones with identical parameters.
- Calculate average monthly ETc for each zone – The ArcGIS Zonal Statistics by Table tool was used to calculate the average ETc value for each zone for each month. The individual pixels in each monthly ETc raster were averaged within each zone (produced in step 3). ITRC-METRIC data for 2013 were used in place of missing data for 2012.
- Combine tables – The MS Access Append function was used to combine the monthly ETc tables into a master table of monthly ETc by crop and C2VSim subregion.
- Output data – Data from the Access database was exported in a form consistent with the C2VSimFG-Kern input files. The output was also summarized to show the average monthly ETc for the irrigated area of each crop type in each model subregion.

The monthly ETc rates for the three Kern County subregions for WY 1993-2015 were then replaced with the monthly ETc rates calculated using ITRC-METRIC data. The annual ETc rates applied to C2VSimFG-Kern by crop are listed in **Table 9**.

3.7.2 Irrigation Periods

The C2VSim Irrigation Periods file contains monthly parameters for each crop and subregion that indicate whether or not the crop is irrigated in that month. C2VSimFG-Beta irrigation periods for the three Kern County subregions were adjusted to match crop irrigation practices from ITRC-METRIC water usage. Refuge irrigation periods for the three Kern County subregions were also adjusted to match Kern NWR practices. Simulated irrigation water usage for the C2VSimFG-Kern better reflects observed irrigation practices.

3.8 Local Changes

Several locally significant issues were identified that affected the historical water budget, and these were modified in C2VSimFG-Kern to improve the model performance. A summary of these changes is provided below.

3.8.1 Kern River Streambed Parameters

For much of the Kern River, the amount of streambed seepage is estimated based on daily weir information. Initial streambed parameters did not allow for this measured seepage to occur. The streambed parameters were manually adjusted until a reasonable approximation of the measured streambed seepage was provide by C2VSimFG-Kern.

3.8.2 Poso Creek Inflow

C2VSimFG-Beta contained Poso Creek inflows for WY 1961-1986. Poso Creek inflows for WY 1987-2015 were estimated from flow records for the Coffee Creek gage and were added to C2VSimFG-Kern.

3.8.3 Small Watershed Runoff

Small watershed contribution to the area was considered to be too high. Although this was not part of the originally-planned model revisions, it is affecting the model results. Todd Groundwater revised the corresponding model parameters to be more representative of the local arid conditions in Kern County.

3.8.4 Root Zone Parameters

Areas of overly high root zone hydraulic parameters led to high volumes of deep percolation that required additional groundwater pumping to meet the overall water demand for irrigation. This issue was noted by local water district staff who recognized that the groundwater pumping and deep percolation from preliminary model results were significantly higher than what was found in practice. A review found areas of overlying hydraulic conductivity and other hydraulic parameters that caused this high percolation rate. Two types of issues were found. First, very high parameters were found in parts of the basin that were not consistent with local soil data. Second, the root zone parameters for lake bed and other heavy clay soil areas were too high. These areas were manually adjusted to be more in line with observed conditions. A more rigorous development of root zone parameters should be considered in the future as this issue demonstrates that it is a sensitive parameter.

3.8.5 Land Use Modifications

The agricultural land use and crop type distribution in the model for early period (1974-1990, and 1992-1996) from C2VSimFG-Beta used a regional distribution and did not accurately represent historical practices. This resulted in agricultural water use being distributed across the entire Kern County Subbasin including areas that did not have irrigated agriculture. To correct for this, land use and crop type data were modified to conform with irrigated agricultural areas in the early 1990s. The crop types were adjusted to be consistent with the Kern County Agricultural Commissioner reports for these years.

3.8.6 Westside Pumping Limits

Western Kern County contains several areas with poor groundwater quality. Little or no agricultural or urban groundwater pumping occurs in these areas. Groundwater pumping in C2VSimFG-Beta was turned off in the areas with poor groundwater quality in western Kern County. Pumping was enabled in a limited area where groundwater pumping occurs; this poor-quality water is mixed with surface water. The pumping rate in this area was estimated to be 10% of the surface water deliveries. Automated groundwater pumping adjustment was also turned off for these areas.

3.8.7 Kern Wildlife Refuge pumping

C2VSimFG-Beta enabled groundwater pumping in the model elements representing the Kern National Wildlife Refuge. The Kern National Wildlife Refuge Water Management Plan (USBR 2011) indicates that during the simulation time period, the refuge was sustained entirely on imported surface water and occasional diversions of Poso Creek flood waters. No groundwater was pumped at the refuge during the simulation period 1985-2015. Groundwater pumping was used at some time in the past. Groundwater pumping and automated groundwater pumping adjustment were turned off for all model elements in the Kern National Wildlife Refuge.

3.9 C2VSimFG-Beta Modifications

Minor changes were made to the C2VSimFG-Kern hydrogeological conceptual model and natural water budget components and are listed in **Table 10**. The architecture of the model including layering, discretization, boundary conditions, and aquifer properties was not revised. Aquifer parameters were adjusted in several areas to better match observed historical conditions, especially in areas with high historic recharge volumes such as the Kern Fan. Extremely high soil hydraulic conductivities in a small set of elements were reduced to more reasonable values. Stream-bed conductance values were modified in some stream reaches to better match simulated stream gains and losses to observed values. Minor adjustments to small watershed parameters were also made to match surface runoff to observed values. A rigorous calibration of Kern Subbasin parameters should be considered in the future.

4. Historical and Current Water Budgets from C2VSimFG-Kern

C2VSimFG-Kern was used to develop historical (WY1995 to WY2014) and current (WY2015) water budgets for the Kern County Subbasin. The following summarizes the simulated water budgets from C2VSimFG-Kern. A summary of these results are provided below.

4.1 Historical and Current Water Budget

The simulated historical and current water budgets based on C2VSimFG-Kern are presented in **Tables 11A and 11B** and are presented graphically on **Figures 9 and 10**. The results for the historical water budget are summarized under the following categories that are defined as:

- **Deep Percolation** – Precipitation and applied water that reaches the groundwater after simulated transport across the unsaturated zone. The simulated historical 20-year average is a net inflow of 669,398 AFY.
- **Managed Recharge and Canal Seepage**- Combined groundwater recharge from managed aquifer recharge operations, groundwater banking, and seepage from canals and other conveyance. The simulated historical 20-year average is a net inflow of 583,598 AFY.
- **Net Groundwater-Surface Water (GW/SW) Interactions** - Net volumetric exchange of surface water and groundwater between the aquifer and streams: Positive represents a net groundwater recharge, and negative represents a net groundwater discharge to the stream. The simulated historical 20-year average is a net inflow of 98,606 AFY.
- **Groundwater (GW) Pumping** - Total groundwater pumping by wells. Groundwater banking recovery pumping is specified as fixed input values and agricultural and municipal pumping is calculated by C2VSimFG-Kern based on demand minus surface water diversions. The simulated historical 20-year average is a net outflow of 1,590,373 AFY.

- **Small Watershed Inflow** – Runoff, small stream inflow and subsurface inflow from the small watersheds and areas surrounding the groundwater basin. The simulated historical 20-year average is a net inflow of 48,760 AFY.
- **Subsurface Flow with Adjacent Groundwater (GW) Basins** - Net subsurface groundwater flow to and from the Kern County Subbasin with adjoining groundwater basins: negative is a net flow out of the subbasin and positive is a net flow into the subbasin. The simulated historical 20-year average is a net outflow of 87,102 AFY.
- **Change in Groundwater Storage** - Sum of the inflow components (positive numbers) plus the outflow components (negative numbers): positive is an increase in storage typified by a rise in groundwater levels whereas a negative is a decrease in storage typified by a decline in groundwater levels. The simulated historical 20-year average is a decline in groundwater storage of 277,114 AFY.

Figure 10 presents the average annual historical water budget for the Kern County Subbasin. This includes the out-of-basin groundwater banking obligation of 85,965 AFY. This is shown by reassigning the out-of-basin banking obligations from the Managed Recharge and Canal Seepage.

The simulated change in groundwater storage varies over the 20-year historical period and is closely related to climatic conditions and surface water supply availability (**Figure 11**). During the periods WY1995 to WY2000, WY2005 to WY2006 and WY2010 and WY2011, the groundwater storage volume was stable to increasing and correlates to the above average rainfall and surface water availability during these times. During the periods WY2001 to WY2004, WY2007 to WY2009 and WY2012 to WY2015, groundwater storage volume decreased, correlated to periods of drought and low surface water availability. The simulated historical groundwater recharge also reflects this climatic pattern with high deep percolation to groundwater and steep increases in managed aquifer recharge and canal seepage during the above average rainfall periods and lower groundwater recharge during the drought years (**Figure 12**).

Groundwater pumping for agriculture shows a general increasing trend from WY1995 to WY2014; however, groundwater pumping is lower in above average rainfall years and higher during droughts (**Figure 13)**. This general increasing trend follows a comparable decreasing trend in surface water deliveries over this same period. As shown on **Figure 14**, surface water deliveries show a general decreasing trend from WY1995 to WY2014; however, the surface water deliveries are higher in the above average rainfall years and lower during the droughts.

4.2 Sustainable Yield

Section 354.18(b)(7) of the GSP Regulations requires that an estimate of the basin's sustainable yield be provided in the GSP (or in the coordination agreement for basins with multiple GSPs). SGMA defines "Sustainable yield" as:

> "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable e result."

SGMA does not incorporate sustainable yield estimates directly into sustainable management criteria. Sustainable yield is referenced in SGMA as part of the estimated basinwide water budget and as the outcome of avoiding undesirable results. Basinwide pumping within the sustainable yield estimate is neither a measure of, nor proof of, sustainability. Sustainability under SGMA is only demonstrated by avoiding undesirable results for the six sustainability indicators.

To determine the sustainable yield for the Kern County Subbasin, the results of the C2VSimFG-Kern model were used with two methods to estimate the amount of groundwater pumping that would avoid the undesirable result of a reduction in groundwater storage over the historical base period 1995 to 2014. The results are shown in **Table 12** and are summarized below:

- **Sustainable Yield from Groundwater Pumping –** The model results produced an average annual groundwater pumping in the Kern County Subbasin of 1,416,077 AFY with a decline in groundwater storage of 277,114 AFY. In addition, 85,965 AFY of out-of-basin groundwater banking obligations were documented remaining in the Subbasin. Subtracting the groundwater storage decline and out-of-basin groundwater banking obligations from groundwater pumping produced a sustainable yield of approximately 1,052,998 AFY.

- **Sustainable Yield from Groundwater Recharge –** The model results produced an average annual groundwater recharge in the Kern County Subbasin of 1,351,602 AFY. The combined groundwater banking exports, out-of-basin banking obligations along with the subsurface outflow from the GSA total 347,339 AFY. Subtracting these losses from the groundwater recharge produced a sustainable yield of approximately 1,004,262 AFY.

Sustainable yield estimates are part of SGMA's required basinwide water budget. In general, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. This sustainable yield estimate can be helpful for estimating the projects and programs needed to achieve sustainability. Although the SGMA regulations require a single value of sustainable yield calculated basinwide, it should be noted that the sustainable yield can be changed by implementation of recharge projects, variations in climate, or changes in stream flow conditions.

Using WY 1995-2015 as the base period, C2VSimFG-Kern results show declining groundwater levels and long-term reduction of groundwater storage. During this period, average annual inflow to the aquifer is 1.47 MAF, and outflow is 1.74 MAF. This yields an average annual deficit of 0.26 MAF. Based on these historical C2VSimFG-Kern results, the sustainable yield of the basin is approximately 1,050,000 AFY, plus or minus 10%.

4.2.1 Native Yield

Although not a SGMA requirement, the native yield is being used in Kern County GSAs for determining a portion of the groundwater allocation within the basin. The native yield is comparable to the sustainable yield except that the only recharge that is included in the calculation is the natural, unallocated portion of the groundwater recharge. For the Kern County Subbasin, this includes the groundwater recharge derived from precipitation or runoff from unallocated streams. The Kern River and Poso Creek, however, are allocated streams where specific agencies or parties have rights to specific volumes of flow.

The C2VSimFG-Kern model results over the historical base period 1995 to 2014 was again used for estimation of native yield. The model results were used to determine the amount of precipitation recharge over irrigated agricultural areas and the native/urban/undeveloped areas. The total and average annual volume of precipitation that percolates to groundwater during the 1995 to 2014 base period are listed in Table 13. The basinwide contribution is the relative proportion of the runoff along the basin margins from small, unallocated watersheds and inflow from the surrounding basin margin (from areas not defined as DWR groundwater basins). The results of this assessment based on the C2VSimFG-Kern results are shown in **Table 13** and are summarized below:

- The volume of precipitation that recharge the groundwater in the irrigated agricultural areas is 77,780 AFY.
- The volume of precipitation that recharges groundwater in the other areas is 132,981 AFY.
- The volume of inflow from unallocated small watersheds that recharges the groundwater in the irrigated agricultural areas is 48,760 AFY.

Totaling these inputs results in a native yield for the Kern County Subbasin is 259,520 AFY. The annual contribution per acre of approximately 0.144 acre-feet per acre is estimated by dividing the average annual contribution by the total area of the Kern County Subbasin (**Table 13**).

Similar to the sustainable yield, the native yield at this time is based on the available data. However, as data gaps are eliminated and management actions/plans are implemented, the native yield could change, and any changes to native yield will be included in future GSP amendments.

5. Approach for Projected Future Water Budgets

Projected future baseline water budgets for the Kern County Subbasin were developed using the C2VSimFG-Kern. These projected water budgets establish expected baseline conditions to evaluate the impacts of GSP implementation. Three predictive scenarios were developed for the Kern County Subbasin, each representing a different expected future hydrologic condition, by adapting C2VSimFG-Kern as follows:

- Future Baseline Conditions: Repeat historical hydrology with expected future water supply
- 2030 Climate Conditions: Adjust historical hydrology for 2030 climatic conditions and expected water supply
- 2070 Climate Conditions: Adjust historical hydrology for 2070 climatic conditions and expected water supply

Projected future water budgets were developed for Baseline conditions and expected 2030 Climate Conditions and 2070 Climate Conditions over a 50-year planning and implementation horizon. These scenario models provide a basis of comparison for evaluating proposed sustainability management actions and projects over the SGMA planning and implementation horizon.

5.1 Assumptions

C2VSimFG-Kern was modified to incorporate projected future hydrology and land use using analog data from the historical C2VSimFG-Kern model. This approach meets GSP requirements using:

- A 50-year time-series of historical precipitation, evapotranspiration and stream flow information as the future baseline hydrology conditions;

- The most recent land use, METRIC-based evapotranspiration, crop coefficient and urban population growth information as the baseline condition for estimating future water demands;
- The most recent water supply projections as the baseline condition for estimating future surface water supply;
- DWR Climate Change Guidance and Data Sets to incorporate estimated climate change conditions for the Kern County Subbasin;
- Specialized analysis of the Kern River watershed and estimated runoff volumes under climate change conditions;
- Specialized analysis of CVP deliveries to Kern County under climate change conditions incorporating implementation of the San Joaquin River Restoration Program;
- Specialized analysis of SWP deliveries to Kern County under climate change conditions incorporating implementation of the OCAP Biological Opinion and recent changes in Table A and Article 21 allocations.

5.2 Projected Future SGMA Projects

Projected water budgets for the Kern County Subbasin were developed using the C2VSimFG-Kern to evaluate the performance of proposed management actions with respect to achieving groundwater sustainability. Participating agencies provided a list of projected future management actions to be implemented between WY 2021 and 2040. These projects were simulated under Baseline conditions, 2030 Climate Conditions and 2070 Climate Conditions using the C2VSimFG-Kern.

Proposed future projects and management actions were provided by participating agencies. The types of proposed SGMA projects and management actions are summarized as follows:

- Demand Reduction is the volume of water reduced by changing the land use. These include:
    - Agricultural demand reduction projects through incentives or actions to reduce crop water use
    - Fallowing of agricultural land and conversion of agricultural land to recharge basins, and
    - Conversion of agricultural land to urban land.
- New Supply groups together planned increases in imported water supplies. These include:
    - Increased surface water imports generally resulting from projected water purchases.
    - New water conveyance facilities including pipelines and reservoirs to increase flexibility, and expansion of surface water delivery areas to reduce groundwater usage.
- Other Supply groups together proposed projects to increase local water supplies. These include:
    - Recharging treated waste waters derived from both urban areas and oil production operations. Increased recharge occurs in both existing and new locations.
    - Increased stream flow diversions; these include exercising riparian water rights and diverting flood flows.
    - Reallocation of water; generally reducing sales of surface water and banked groundwater and using this water within the agency.
    - Brackish groundwater in areas not currently overdrafted will be treated and mixed with surface water to augment surface water supplies.

Some management actions are implemented gradually over many years, with savings increasing each year over the implementation period. Some management actions are implemented only in certain years (wet years, for example). The anticipated annual water supply benefit of the proposed SGMA projects and management actions steadily increases over the 20-year period from 2021 to 2040 to represent the implementation of the Kern County Subbasin GSPs as follows:

- about 87,000 AFY after the first five-year period (2021-2025)
- about 168,000 AFY after the second five-year period (2026-2030)
- about 300,000 AFY after the third five-year period (2031-2035)
- about 330,000 AFY after the fourth five-year period (2036-2040)

The anticipated water supply benefit of the proposed SGMA projects and management actions included in the C2VSimFG-Kern projected future simulations is 405,000 AFY over the period from 2041 to 2070. Implementation of these projects and management actions is staged over the 20-year implementation period are summarized in **Figure 15**.

6. PROJECTED FUTURE BASELINE DEVELOPMENT

Projected water budgets are required by GSP regulations to represent future conditions over a 50-year GSP planning and implementation horizon. A baseline condition was developed that projects water supply, demand and operations based on current land use and expected water supply availability over 50 years. The baseline then serves as a basis of comparison for evaluating proposed sustainability management actions and projects for achieving sustainability over the planning and implementation horizon. Each predictive scenario model simulates the 50-year planning and implementation period WY 2021-2070. Development of the projected future baseline conditions is summarized below.

6.1 Projected Future Time Period Development

Water years 1995-2014 were chosen as a historical hydrology period because detailed demand and supply data are available for this period, and most subbasin water delivery infrastructure was fully developed by the middle of this period. The average Kern River inflow for this period is also very close to the long-term average Kern River inflow.

The projected future simulation period is based on repeating the WY1995 to WY2014 historical study period. This period is only 20 years long, so a 50-year sequence of historical hydrology was developed by repeating data from this period in the sequence as shown in **Table 14**. The development of this sequence is summarized as follows:

- Simulation period WY2021 to WY2032 used the historical period WY2003 to WY2014.
- Simulation period WY2033 to WY2052 used the historical period WY1995 to WY2014.
- Simulation period WY2053 to WY2070 used the historical period WY1995 to WY2012.

This sequence was developed to match long-term average flows on the Kern River, and to ensure that the baseline does not end in an extreme drought or extreme wet year. By starting the projected future simulation time sequence with WY2003, the 50-year hydrology period has approximately 100 percent of the long-term average streamflow conditions on the Kern River, as indicated by an average annual Kern River Index of 100 percent. The sequence includes the appropriate range of hydrologic conditions including extremely wet years and extended periods of drought.

C2VSimFG-Kern simulation results for the last timestep for the historical simulation (for September 30, 2015) were used as initial conditions for all projected future simulations, including initial conditions for the root zone, saturated and unsaturated aquifer zones, and small watersheds. Since the Historical C2VSimFG-Kern simulation period ends with WY 2015, all projected future scenarios also include estimated hydrology for WY 2016-2020. Model input data for WY 2016-2020 was developed by repeating model input data for recent years based on correlation with the San Joaquin Index (DWR, 2019).

6.2 Development of Key Baseline Data Sets

Key required components for the Projected Future Baseline, as summarized in the DWR Water Budget BMP, include the following:

- The projected baseline hydrology conditions are based on 50-years of historical precipitation and streamflow.
- Surface water supplies are based on available information from DWR and others to project future water imports from the State Water Project (SWP), Central Valley Project (CVC) - Friant-Kern Canal (FKC) and Kern River diversions. For the Kern River, recent diversion practices based on entitlements are used to develop a water use consistent with the baseline hydrology.
- WY2013 land use was used as current land use for all scenarios as drought conditions likely reduced agricultural production in 2014 and 2015.
- Consumptive use for agriculture and undeveloped lands was based on the recent land use and METRIC-based evapotranspiration. Following DWR guidance, METRIC data over the baseline period was varied according to varying hydrologic conditions (e.g., water year type).
- Urban water demand was based on projections from recent urban water management plans and recent regulations for estimating future water use. Urban demand was estimated in the model based on projected urban population growth and per capita water demand information (including recent regulatory guidance).
- Small watershed inflows used the same parameters as the historical C2VSimFG-Kern model; however, volumes would vary based on changes in the precipitation and ET under the 2030 and 2070 climate change conditions.

Time-series input data were first developed for the Baseline scenario model for WY2021-WY2070. The following time-series data were developed for each scenario:

- Precipitation rates
- Evapotranspiration rates
- Surface water inflow rates
- Surface water diversion and delivery rates
- Specified groundwater pumping rates

Development of this time-series input data generally involved repeating time-series data from the historical C2VSimFG-Kern in the appropriate sequence. Baseline scenario model time-series data files were then modified following DWR guidelines to produce time-series input data for the 2030 Climate Conditions and 2070 Climate Conditions scenario models. C2VSim input data were modified only in Kern County. C2VSim input data for areas outside of Kern County were not modified. Details on how each data set was modified are provided below.

6.2.1 Precipitation Rates

Precipitation rates for the Baseline scenario model were developed by repeating input precipitation rates from C2VSimFG-Kern in the appropriate sequence. DWR provided monthly change factors for precipitation under 2030 and 2070 central tendency climatic conditions on a 6 km x 6 km VIC grid for calendar years 1915 through 2011. The VIC grid ID for each C2VSim element in the Kern County Subbasin Zone of Interest was identified and the Baseline scenario precipitation rates were multiplied by the appropriate factors to produce time-series precipitation rates for the 2030 Climate Conditions and 2070 Climate Conditions scenarios. Factors for calendar years 1959-1961 were used as analogs for 2012-2014.

6.2.2 Evapotranspiration Rates

Evapotranspiration rates for the Baseline scenario model were developed by repeating input evapotranspiration rates from C2VSimFG-Kern in the appropriate sequence. DWR provided monthly change factors for ETo values under 2030 and 2070 central tendency climatic conditions on a 6 km x 6 km VIC grid for calendar years 1915 through 2011. The VIC grid IDs for each C2VSim subregion in the Kern County Subbasin Zone of Interest were identified and area-weighted monthly ETo change factors were calculated for each subregion. Baseline scenario ETc rates for each subregion were then multiplied by the appropriate area-weighted ETo change factors to produce time-series ETc rates for the 2030 Climate Conditions and 2070 Climate Conditions scenarios. Factors for calendar years 1959-1961 were used as analogs for 2012-2014.

6.2.3 Surface Water Inflow Rates

Surface water inflow rates for the Baseline scenario model were developed by repeating input inflow rates from C2VSimFG-Kern in the appropriate sequence. DWR provided unimpaired streamflow change factor datasets for Central Valley streams, and an Excel spreadsheet tool to modify basin unimpaired streamflow using these change factors. The unimpaired streamflow change factors and spreadsheet were used to modify Baseline inflows to produce 2030 Climate Conditions and 2070 Climate Conditions scenario time series inflows for Poso Creek and White River.

Kern River flows at First Point for the Baseline scenario model were developed by repeating historical inflow rates from C2VSimFG-Kern in the appropriate sequence. Flows on the Kern River are regulated, so the unimpaired streamflow method was not appropriate for estimating future flows under 2030 and 2070 climatic conditions. Projected Kern River flows at First Point under 2030 and 2070 central tendency conditions were estimated by GEI (2018) for calendar years 1956-2010 hydrology. This analysis considered the impacts of changed runoff in each sub-watershed contributing to the Kern River to develop revised streamflow estimates for Kern River at First Point. Future scenario Kern River at First Point flows for 2011-2014 were estimated using flows for analog years with similar annual flows and monthly flow pattern. Analog years 1986, 1991, 1990 and 1961 respectively were used for 2011-2014 in the future scenarios.

6.2.4 Surface Water Deliveries

Surface water delivery rates for the Baseline scenario model were developed by first repeating input surface water delivery rates from the C2VSimFG-Kern in the appropriate sequence, and then modifying selected data sets. Surface water deliveries from in-basin sources such as Oil Field Recovery were held constant at 2015 rates for all future scenarios.

The Kern County Subbasin is served by both the CVP and the SWP. Recent changes in CVP and SWP operations and their impacts on future surface water supplies are reflected in surface water diversion rates for the three scenarios. Future CVP deliveries will be affected by implementation of the San

Joaquin River Restoration Program (SJRRP) that included the 2008 U.S. Fish & Wildlife Service biological opinion (BO) on the Long-Term Operational Criteria and Plan (OCAP) for coordination of the CVP and SWP. Future SWP deliveries will be affected by operational changes implemented between 2004 and 2008 including the OCAP BO, reduced Table A contract amounts and reduced Article 21 deliveries. DWR provided projected future deliveries from the CVP and SWP for water years 1922-2003, derived from CalSim-II modeling conducted for WSIP. DWR's CVP projections as provided do not fully incorporate these SJRRP operational changes. The CALSIM-II 1922-2003 projections include the OCAP BO operational constraints, the reduced Table A amounts and reduced Article 21 Water. The adjustments for those factors were made only to the historical data.

The Friant Water Authority (2018) used CalSim-II to develop projected surface water deliveries with SJRRP implementation under hydrological conditions representing the Current Baseline, 2030 and 2070 climate conditions by delivery class for water years 1922-2003, and estimated allocations to each CVP contractor (FWUA 2018). The 2015.c data set was used for Baseline scenario CVP deliveries, the 2030.c data set was used for 2030 Climate Conditions scenario CVP deliveries, and the 2070.c data set was used for the 2070 Climate Conditions scenario CVP deliveries. CVP deliveries for water years 2004-2014 were estimated using deliveries for analog years 1951-1961; these analog years have a similar distribution of water availability.

The SWP projections representing 2030 and 2070 climatic conditions provided by DWR were modified to incorporate the impacts of SWP operational changes in the three scenarios. 2019 SWP Table A contract amounts were used to allocate these SWP deliveries to individual districts. In summary:

- Baseline Hydrologic Conditions
    - WY1995 to WY2003 conditions are based on 2030-Level CALSIM increased by 3.03 %
    - WY2004 to WY2007 conditions are based on historical data adjusted for OCAP BO
    - WY2008 to WY2014 conditions are based on historical data with the assumption that OCAP BO adjustments are already factored into the data
- 2030 Climate Change Hydrologic Conditions
    - WY1995 to WY2003 conditions are based on 2030-Level CALSIM Projection
    - WY2004 to WY2007 conditions are based on OCAP BO adjustment reduced by 3.03 %
    - WY2008 to WY2014 conditions are based on historical data reduced by 3.03%
- 2070 Climate Change Hydrologic Conditions
    - WY1995 to WY2003 conditions are based on 2070-Level CALSIM Projection
    - WY2004 to WY2007 conditions are based on OCAP BO adjustment reduced by 8.09%
    - WY2008 to WY2014 conditions are based on historical data reduced by 8.09%

Within the Kern County Subbasin, water users engage in complex real-time water trading and wheeling activities to maximize water utilization, minimize waste and energy consumption, and meet immediate water needs. It would be difficult to project future surface water deliveries in the Kern County Subbasin without the use of a surface water allocation model that simulates these water trading and wheeling activities. Therefore, for this modeling effort, monthly future scenario agricultural, urban and recharge deliveries from sources originating outside the basin were estimated by adjusting historical deliveries by the ratio of (total scenario inflows)/(total historical inflows) for each month, where total inflows are the sum of CVP deliveries, SWP deliveries and Kern River at First Point. In addition, Kern River at First Point flows above historical flows under the 2030 Climate Conditions and 2070 Climate Conditions scenarios were proportionally added to selected recharge deliveries. This method is deemed adequate for subbasin-level future scenario analyses.

Some future scenario data sets did not cover the entire period from October 1994 through September 2014. In these cases, data from an analog historical period with similar water availability was used to fill in the missing data. The analog years for each data type are summarized as:

- For CVP deliveries (CalSim-II data), water years 1951 through 1961 were used as analogs for missing water years; these analog years have a similar distribution of water availability.
- Projected future Kern River at First Point flows for calendar years 1986, 1991, 1990 and 1961 were used as analogs to missing years 2011 through 2014; each of these analog years had a similar historical annual flow volume and monthly distribution.
- For climatic data adjustment factors, calendar years 1959-1961 were used as analogs to 2012-2014.

6.3 Development of Climate Change Conditions

Input data for the C2VSimFG-Kern were modified to simulate three future climatic scenarios. Historical precipitation, evapotranspiration, land use, population, surface water inflow and surface water delivery rates were replaced with projected future values for WY 2016-2070 for Future Baseline Conditions. The Future Baseline Conditions for WY 2021-2070 were then modified to simulate 2030 Climate Conditions and 2070 Climate Conditions. Water management agencies in the Kern County Subbasin provided a broad suite of proposed water management and conservation projects to increase water supplies and reduce water management demands. These projects are added to the C2VSimFG-Kern to assess the long-term impacts of these projects under the Baseline, 2030 Climate Conditions and 2070 Climate Conditions scenarios.

Projected water budgets under Future Baseline Conditions, 2030 and 2070 Climate conditions are used to evaluate the potential effects of future baseline and extended dry conditions with respect to achieving sustainability. DWR published a *Modeling Best Management Practices* Guidance Document (DWR 2016B) that outlines DWR recommendations for developing and running predictive scenarios. The C2VSimFG-Kern was modified following these recommendations to develop the Baseline scenario model. DWR also issued the *Guidance for Climate Change Data Use During Sustainability Plan Development* Guidance Document (DWR 2018A) that outlines how DWR recommends that climate change be addressed under SGMA. Baseline scenario data sets were modified using DWR climate change data sets for Kern County following procedures outlined in the Guidance Documents to develop the 2030 Climate Conditions and 2070 Climate Conditions scenario models. The adjustment factors for Baseline, 2030 Climate Change and 2070 Climate Change for SWP deliveries were developed based on consistent CALSIM operations studies at current, 2030 and 2070 climate levels developed for Bay Delta Conservation Plan evaluation and provided by DWR Bay Delta Office staff. The WSIP studies provided on DWR's SGMA web site were not used due to the unavailability of a baseline study with assumptions consistent with the 2030 and 2070 climate change studies.

6.3.1 Groundwater Banking Assumptions

Groundwater banking operations are simulated in the C2VSimFG-Kern with surface water diversions to recharge basins and specified pumping rates for groundwater extractions. All surface water deliveries were adjusted under the Baseline, 2030 Climate Conditions and 2070 Climate Conditions scenarios. Surface water deliveries to recharge basins were first adjusted by the same amount as other surface water deliveries, then increased if Kern River flows were greater than historical flows. Specified pumping rates for groundwater extraction were not modified.

The out-of-basin banking obligations were assumed to follow a similar pattern where groundwater banking recharge would be affected by the limitation on surface water deliveries, but that banking recovery would remain similar to historical volumes. Therefore, the historical groundwater banking obligations were adjusted under the Baseline, 2030 Climate Conditions and 2070 Climate Conditions scenarios by the same percentage as the surface water deliveries; however, the groundwater banking recovery was assumed to remain the same. For the projected future scenarios, the out-of-basin banking obligations were calculated as follows:

- For the Baseline scenarios, the out-of-basin banking obligations were calculated as 69,632 AFY based on surface water deliveries of about 81% of historical deliveries.
- For the 2030 Climate scenarios, the out-of-basin banking obligations were calculated as 67,913 AFY based on surface water deliveries of about 79% of historical deliveries.
- For the 2070 Climate scenarios, the out-of-basin banking obligations were calculated as 64,474 AFY based on surface water deliveries of about 75% of historical deliveries.

Tracking of banked groundwater obligations was done using the same post processing process as applied to the historical groundwater assessment by assigning the portion of the groundwater recharge as an out-of-basin banking obligation.

7. PROJECTED FUTURE C2VSIMFG-KERN SIMULATION RESULTS

The C2VSimFG-Kern was run for three scenarios that estimate hydrologic conditions of Baseline, 2030 Climate Conditions and 2070 Climate Conditions scenarios both with and without the proposed SGMA projects and management actions for a total of six projected future scenarios.

7.1 Projected Future Water Budgets

C2VSimFG-Kern calculates water budget components each month of the simulation period for each future scenario. Projected future water budgets developed based on the C2VSImFG-Kern simulation results with the proposed SGMA management actions were then compared to results for the baseline future scenarios without the management actions to assess how these changes enhance groundwater sustainability within the Kern County Subbasin.

The average annual value of each water budget component summarizes the impacts over 50 years with current water demands. The water budget results for the six Projected Future Scenarios are presented in **Tables 15 through 20**, and include averages over three different periods, which include:

- **WY2021 to WY2040** – Implementation Period representing the 20-year period required by the SGMA regulations to implement projects and management actions to achieve sustainability.
- **WY2041 to WY2070** – Sustainability Period representing the 30-year hydrologic period following the Implementation Period to assess the long-term sustainability of the proposed projects and management actions with variable climatic conditions including periods with above average rainfall and extended droughts.
- **WY2021 to WY2070** – Simulation Period representing the entire 50-year projected future hydrologic conditions.

Changes to surface water diversions included monthly increases or reductions to 37 model diversions and the addition of 7 new diversions. Ten new groundwater pumping wells were added to simulate a new groundwater pumping program. Agricultural land use was converted to native vegetation in ten management areas, and to urban land use in three management areas. The projects and management actions included in the C2VSimFG-Kern scenarios with SGMA projects are described in the individual GSPs and management area plans. These changes were applied to a series of six C2VSimFG-Kern scenarios for Baseline, 2030 Climate Conditions and 2070 Climate Conditions both with and without SGMA projects. The results of these simulations are summarized in **Table 15**.

Table 15: Summary of Simulated Change in Groundwater Storage Results over the 2041 to 2070 Sustainability Period

C2VSimFG-Kern Model Scenario	Change in Groundwater	
	C2VSimFG-Kern Model Results	Adjusted Model Results
Historic	-277,114	-277,114
Baseline	-354,970	-347,970
Baseline with Projects	34,614	72,963
2030 Climate Change	-413,519	-407,276
2030 Climate with Projects	-17,170	34,012
2070 Climate Change	-521,517	-507,637
2070 Climate with Projects	-114,560	-51,099

Baseline simulation results indicate that the Kern County Subbasin has an average annual overdraft of 354,970 acre-feet per year. By implementing the proposed projects and management actions, the subbasin is forecasted to achieve sustainability by 2040 with an estimated 34,614 acre-feet of annual surplus. With adjustments to account for limitations in the simulation (discussed in Section 7.2.1), the adjusted change in storage increases to 72,963 AFY.

Collectively, the C2VSimFG-Kern simulations results indicate that the currently-proposed SGMA projects and management actions, once fully implemented, provide a reasonable approach to achieve sustainable management of the groundwater basin and can be adaptively managed to meet future challenges as necessary. A brief summary for each of the six projected future water budgets is provided below. The following provides a summary of the projected future simulations using C2VSimFG-Kern.

7.1.1 Baseline Condition Water Budgets

The Baseline Scenarios simulate how the Kern County Subbasin aquifer would respond if the recent hydrology were repeated with current expected surface water availability and current land use. The Baseline Scenarios were run both with and without SGMA Projects.

For the Baseline Scenario without SGMA Projects, the groundwater budget for WY2021 to WY2040 (**Table 16**) repeats the 20-year historical hydrologic period so it provides a direct comparison of the differences between the projected future baseline without SGMA Projects and the historical condition. The primary difference between historical conditions and the projected future baseline is a nearly 20% decrease in imported surface water deliveries primarily from the SWP due to the OCAP Biological

Opinion. This is replaced with additional groundwater pumping. As a result, total net aquifer outflows increase by about 43,000 AFY and total net aquifer inflows decrease by about 101,000 AFY. This is mostly because of increased groundwater pumping and decreased managed aquifer recharge due to a decline in imported SWP water. Over this period, the average groundwater pumping of 1,634,816 AFY, which includes agricultural pumping, urban pumping and exported water. As a result, the change in groundwater storage results in an additional loss of about 144,000 AFY over the 20 year period for projected future baseline.

The Baseline Scenario with SGMA Projects simulates the proposed SGMA projects and management actions applied to the Baseline Scenario. No other changes were made except for the addition of the SGMA projects to provide a direct comparison of the relative benefits of the over 400,000 AFY of proposed SGMA projects and management actions. The groundwater budget for the Baseline Scenario with SGMA Projects is provided in **Table 17**. Comparing the groundwater budget for WY2041 to WY2070 (**Table 17**) with the same period from the Baseline Scenario (**Table 16**) provides an evaluation of groundwater conditions after the SGMA projects and management actions have been fully implemented. As a result, total net aquifer inflows increase about 109,000 AFY due to increased managed aquifer recharge and deep percolation. The total net aquifer outflows decrease about 281,000 AFY due mostly to decreased groundwater pumping with agricultural demand reduction management actions.

The change in groundwater storage for projected future baseline with SGMA Projects improves by about 390,000 AFY. This change results in a net gain in groundwater in aquifer storage over the WY2041 to WY2070 sustainability period of about 35,000 AFY. A comparison of the annual change in groundwater storage over the 50-year hydrologic period is presented in **Figure 16**. The time series shows that change in groundwater storage has stabilized to slightly increasing over the period from WY2041 to WY2070.

A comparison of the average annual water budget components for the two different Baseline Scenarios is presented in **Figure 17**. Over this period, the average groundwater pumping of 1,294,485 AFY for the Baseline Scenario with SGMA Projects (which includes agricultural pumping, urban pumping and exported water) is over 300,000 AFY less than in the Baseline Scenario.

7.1.2 2030 Climate Change Water Budgets

The 2030 Scenarios simulate how the Kern County Subbasin aquifer would respond assuming hydrologic conditions representing a potentially drier climate and are based on the DWR Climate Change Guidance (DWR 2018A). The 2030 DWR climate change factors were applied to the Baseline Scenario Conditions. Additional adjustments were made to the imported surface water supplies from the SWP, CVP and Kern River, accounting for about an additional 2% decrease from the Baseline Conditions. The 2030 Climate Change Scenarios were run both with and without SGMA Projects. Results for climate change budgets are illustrated in **Figures 18, 19, and 20**.

The groundwater budget for the 2030 Climate Scenario without SGMA Projects for WY2041 to WY2070 (**Table 18**) is compared the same period for the Baseline Scenario without SGMA Projects to assess the relative change due to the climate change assumptions. The results show a net increase in aquifer inflows of about 45,000 AFY, however, the aquifer net outflows increase by about 104,000 AFY. This is mostly attributed to the climate shift to earlier rainfall making more surface water available for managed aquifer recharge during the winter but less available for irrigation in the summer resulting in higher groundwater pumping. The net change in groundwater storage is an additional decline of about 59,000 AFY due to the climate change impacts.

The 2030 Climate Scenario with SGMA Projects simulates the proposed SGMA projects and management actions applied to the 2030 climate change conditions. No other changes were made to this scenario. The groundwater budget for the 2030 Climate Scenario with SGMA Projects is provided in **Table 19**. Comparing the groundwater budget for WY2041 to WY2070 (**Table 18**) between the two 2030 Climate Scenarios, the total net aquifer inflows increase about 93,000 AFY due to increased managed aquifer recharge and deep percolation. The total net aquifer outflows decrease about 302,000 AFY due mostly to decreased groundwater pumping with agricultural demand reduction management actions.

The change in groundwater storage for the 2030 Climate Scenario with SGMA Projects improves by about 396,000 AFY. This change results in a net decline in groundwater in aquifer storage over WY2041 to WY2070 of about 17,000 AFY. A comparison of the annual change in groundwater storage over the 50-year hydrologic period is presented in **Figure 20**. The time series shows that change in groundwater storage has stabilized to slightly increasing over the period from WY2041 to WY2070, but at a level below the results for the Baseline Scenario with SGMA Projects.

A comparison of the average annual water budget components for the two 2030 Climate Scenarios is presented in **Figure 18**. Over this period, the average groundwater pumping of 1,384,263 AFY for the 2030 Climate Scenario with SGMA Projects, which includes agricultural pumping, urban pumping and exported water, is over 340,000 AFY less than in the 2030 Climate Scenario without SGMA Projects.

7.1.3 2070 Climate Change Water Budgets

The 2070 Scenarios simulate how the Kern County Subbasin aquifer would respond assuming hydrologic conditions representing a potentially very dry climate and are based on the DWR Climate Change Guidance (DWR 2018A). The 2070 DWR climate change factors were applied to the Baseline Scenario Conditions. Additional adjustments were made to the imported surface water supplies from the SWP, CVP and Kern River, but these accounted for an additional 6% decrease from the Baseline Conditions. The 2070 Climate Change Scenarios were run both with and without SGMA Projects.

The groundwater budget for the 2070 Climate Scenario without SGMA Projects over WY2041 to WY2070 (**Table 20**) is compared the same period for the Baseline Scenario without SGMA Projects to assess the relative change due to the climate change assumptions. The results show a net increase in aquifer inflows of about 68,000 AFY, however, the net aquifer outflows increase by about 235,000 AFY. This is mostly attributed to an even greater climate shift to earlier rainfall making more surface water available for managed aquifer recharge during the winter but less available for irrigation in the summer resulting in higher groundwater pumping. The net change in groundwater storage is an additional decline of about 167,000 AFY due to the climate change assumptions.

The 2070 Climate Scenario with SGMA Projects simulates the proposed SGMA projects and management actions applied to the 2070 climate change conditions. No other changes were made to this scenario. The groundwater budget for the 2070 Climate Scenario with SGMA Projects is provided in **Table 21**. Comparing the groundwater budget for WY2041 to WY2070 (**Table 20**) between the two 2070 Climate Scenarios, the total net aquifer inflows increase about 80,000 AFY due to increased managed aquifer recharge and deep percolation. The total net aquifer outflows decrease about 327,000 AFY due mostly to decreased groundwater pumping due to agricultural demand reduction management actions.

The change in groundwater storage for 2070 Climate Scenario with SGMA Projects improves by about 407,000 AFY. This change results in a net decline in groundwater in aquifer storage over the WY2041 to WY2070 of about 115,000 AFY. A comparison of the annual change in groundwater storage over the 50-

year hydrologic period is presented in **Figure 20**. The time series shows that change in groundwater storage has stabilized to slightly increasing over the period from WY2041 to WY2070, but at a level below the results for the Baseline and 2030 Scenarios with SGMA Projects.

A comparison of the average annual water budget components for the two different 2070 Climate Scenarios is presented in **Figure 19**. Over this period, the average groundwater pumping of 1,491,837 AFY for the 2070 Climate Scenario with SGMA Projects, which includes agricultural pumping, urban pumping and exported water, is over 360,000 AFY less than in the 2070 Climate Scenario without SGMA Projects.

7.2 Projected Future Sustainability Assessment

To assess the sustainability of the proposed GSP plans, the C2VSimFG-Kern model future scenario input files were modified to incorporate all of the proposed SGMA projects and management actions.

7.2.1 Change in groundwater storage

Groundwater sustainability for the Kern County Subbasin was assessed using annual changes in groundwater storage. As discussed in Section 7.1, the decline in groundwater storage of the three future baseline scenarios is significantly mitigated by the implementation of the proposed SGMA projects and management actions. An assessment of the projected future groundwater storage change for the six projected future scenarios is summarized in **Table 22**.

The Change in Net Operational Budget presented in **Table 22** provides the net difference in aquifer inflows and outflows without consideration of subsurface flow to and from adjacent groundwater basins. This provides a measure of the natural and managed water supply within the groundwater basin without being influenced either positively or negatively by the subsurface flow. For the Kern County Subbasin, the net operational flow varies by about 50,000 to 80,000 AFY indicating that most of the groundwater storage change is due to conditions within the basin.

The Adjustments to Groundwater (GW) Storage Change are made to account for limitations in either the underlying conceptual model of C2VSimFG-Kern or the setup of the projected future scenarios. The two adjustments made to the projected future water budgets include:

- **Adjustment for Excess Basin Outflows** is the difference in simulated basin outflow that is attributed to addition of SGMA projects in Kern County without comparable SGMA projects added to adjacent basins. Adjustment assumes that this difference is due to limitation of the simulation, and that this difference would remain in Kern County Subbasin when SGMA projects from adjacent basins are included in the simulation.
- **Adjustment for Excess Kern River Outflow** is the increase in simulated groundwater outflows to the Kern River relative to Baseline condition that are attributed to SGMA Projects and Climate Change. The model is not optimized for river management. Because the Kern River is a highly managed system, the assumption is that in practice this water would be recovered for beneficial use rather than be tolerated as a loss of water from the basin.

These adjustments resulted in an overall improvement in the change in groundwater storage for the projected future water budgets. For the scenarios that include the SGMA Projects, the change in groundwater storage improves by 38,000 AFY (Baseline), 51,000 AFY (2030 Climate Change), and 63,000 AFY (2070 Climate Change). As a result of these adjustments, the adjusted change in groundwater storage for the 2030 Climate Scenario with SGMA Projects changes from a decline of 17,170 AFY to an increase of 34,012 AFY.

7.2.2 Sustainability Assessment

As defined by SGMA, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. Although the SGMA regulations require that a single value of sustainable yield must be calculated basinwide, it should be noted that the sustainable yield can be changed with implementation of recharge projects, variations in climate, or changes in stream flow conditions. For the projected future scenarios, both the climate and the managed water supply operations are significantly affected which would lead to a change in the sustainable yield for the basin.

For the sustainability assessment, the sustainable yield was recalculated using the method described in Section 4.2, and the results are presented in **Table 23**. Without the SGMA projects and management actions, the percentage of the Average Annual Difference to the total groundwater pumping provides context to compare the significance of the level of groundwater pumping for the basin. For the scenarios without SGMA projects and management actions, the groundwater pumping exceeds the sustainable yield on the order of 40% to 50% (**Table 23**). However, with the proposed SGMA projects and management actions, the groundwater pumping is equal or nearly equal to the sustainable yield of the subbasin for the baseline and 2030 climate scenarios and is within 10% of the sustainable yield for the 2070 climate scenario (**Table 23**). This assessment indicates that the proposed SGMA projects and management actions are of sufficient magnitude that, if fully implemented, would lead to groundwater sustainability for the Kern County Subbasin after 2040.

7.2.3 Minimum Thresholds and Measurable Objectives

Another requirement of SGMA is for groundwater levels not to cross their minimum thresholds to the extent that undesirable results would occur in the basin, and moreover, that proposed SGMA projects and management actions would lead to meeting the measurable objectives. For the Kern County Subbasin, 190 representative monitoring locations have been defined by each of the GSAs across the Kern County Subbasin. Each of these 190 locations has a minimum threshold and measurable objective assigned to it.

The C2VSimFG-Kern results were used to assess whether the simulated groundwater levels would meet the minimum threshold and measurable objective for each well. Because C2VSimFG-Kern is not fully calibrated, the results are presented as relative change (which does not require calibration) instead of simulated groundwater levels. Future change in groundwater level was determined for each of the 190 locations for each of the six projected future simulations. The change was calculated from the simulated March 2015 groundwater levels from the model. The change in groundwater level was then applied the measured March 2015 groundwater level at the monitoring location.

Figure 21 provides four representative examples of the simulated hydrographs using this method. Hydrographs of the simulated groundwater levels relative to the minimum thresholds and measurable objectives for all 190 locations that were provided to the various GSAs and water districts for inclusion their respective GSPs. In general, across most areas of the basin, groundwater levels fall near or below the minimum thresholds without the SGMA projects but are typically above the minimum threshold for the simulations that include the SGMA projects.

Some locations, especially along the eastern and western basin margins, show an unusual pattern that is likely influenced by issues with the conceptual model incorporated into C2VSimFG-Kern for these locations. The hydrographs for these areas are not considered to be representative of actual conditions that would physically occur. This is a limitation to the model that should be addressed in the future.

8. Validation of C2VSimFG-Kern Performance

The C2VSimFG-Kern performs well within the central part the Kern County Subbasin and the White Wolf Subbasin. The model does not perform as well east of the Friant-Kern Canal or west of the California Aqueduct. The geologic and hydrogeologic conceptual models within the central part of the Kern County Subbasin and the White Wolf basin appear to be generally realistic. The geologic and hydrogeologic conceptual models appear to be very poor in the areas where the model does not perform well.

8.1 C2VSimFG-Kern Validation

One of the concerns for the modeling is the overall calibration of C2VSimFG-Beta in Kern County. As discussed above, the assumption is that C2VSimFG-Beta was developed using reasonable care in developing the geologic framework and developing a consistent regional methodology for determining aquifer properties. An identified weakness of the C2VSimFG-Beta is the quality of data used in developing the overall water balance such as the extent of the groundwater banking operations in Kern County. The issues with the water balance are considered the primary contributing factor affecting the calibration of the C2VSimFG-Beta; the hydrogeologic conceptualization is reasonably accurate for a regional planning analysis.

To address these concerns, a validation analysis was performed for C2VSimFG-Kern by comparing simulations results to field measured groundwater level data collected during the Study Period and comparing those to a similar set of residuals from the C2VSimFG-Beta model. The statistical results of this analysis should be comparable, if not better, for C2VSimFG-Kern compared to the C2VSimFG-Beta results.

The analysis used 42,058 groundwater levels measurements collected from 558 monitoring wells in the Kern County and White Wolf Subbasins. The data were collected by Kern County Water Agency, the Kern Fan Monitoring Committee, the DWR Water Data Library, and local agencies. For each location, the residual was calculated as the simulated groundwater level minus the measured groundwater level based on the well measurement date. A brief summary of the statistical measures used to evaluate the calibration results (shown on **Table 24**) is provided below:

- The residual mean is computed by dividing the sum of the residuals by the number of residual data values. The closer this value is to zero, the better the calibration especially as related to the water balance and estimating the change in aquifer storage. The residual mean of 17.3 feet for C2VSimFG-Kern is an improvement of 47% over the 32.6 feet from C2VSimFG-Beta.
- The absolute residual mean is the arithmetic average for the absolute value of the residual, so it provides a measure of the overall error in the model. The absolute residual mean of 37.4 feet for C2VSimFG-Kern is an improvement of 34% over the 56.8 feet from C2VSimFG-Beta.
- The residual standard deviation evaluates the scatter of the data. A lower standard deviation indicates a closer fit between the simulated and observed data. The standard deviation is 45.5

feet for C2VSimFG-Kern, which is an improvement of 16% over the 54.0 feet from C2VSimFG-Beta.

- The Root Mean Square (RMS) Error is the square root of the arithmetic mean of the squares of the residuals and provides another measure of the overall error in the model. The RMS Error is 50.0 feet for C2VSimFG-Kern, which is an improvement of 32% over the 73.5 feet from C2VSimFG Beta.
- The correlation coefficient ranges from 0 to 1 and is a measure of the closeness of fit of the data to a 1 to 1 correlation. A correlation of 1 is a perfect correlation. The correlation coefficient of 0.76 for C2VSimFG-Kern is an improvement of 47% over the 0.52 from C2VSimFG Beta.
- Another statistical measure is the ratio of the standard deviation of the mean error divided by the range of observed groundwater elevations. This ratio shows how the model error relates to the overall hydraulic gradient across the model. The ratio for C2VSimFG-Kern is 0.061 feet, which is an improvement of 34% over the 0.92 from C2VSimFG Beta.

Considering these results in context with the overall range of measurements of 616 feet, the residual mean of 17.3 feet represents a relative percentage difference of less than three percent. For the absolute residual mean of 37.4 feet, the relative percentage difference is about six percent. Despite this improvement in model performance, the model is not considered fully calibrated. However, C2VSimFG-Kern is reasonably validated for assessing groundwater level changes on the subbasin scale for the purposes of SGMA planning.

8.2 Sensitivity Analysis

The C2VSimFG-Kern model was not formally calibrated. Some physical parameters were adjusted to improve model performance in specific areas. A sensitivity analysis was conducted on the adjusted model to understand how variations in model parameters affect model results. Eight physical parameter sets were systematically varied and model results compared to the base model for a selected group of groundwater hydrographs. Sensitivity parameters modified and evaluated for Kern County Subbasin. These include:

- Horizontal hydraulic conductivity of aquifer (Kh)
- Vertical hydraulic conductivity of aquifer (Kv)
- Vertical hydraulic conductivity of Corcoran Clay aquitard (Kcorc)
- Streambed conductance of Kern River (Cstm)
- Specific storage of aquifer (Ss)
- Specific yield of aquifer (Sy)
- Soil hydraulic conductivity in root zone (Ksoil)
- Soil pore size distribution index in root zone (λ)

The root mean squared error between observed and simulated values was calculated for the original parameter set and after varying each parameter set upward and downward by a set factor. Results are presented in **Figure 22**. This sensitivity analysis shows that the hydrologic parameter values in the C2VSimFG-Kern model are generally within an acceptable range. A full model calibration would likely improve model performance.

8.3 Peer Review Process

Todd Groundwater worked with Woodard and Curran (W&C) throughout the model development process as W&C conducted an on-going peer review of model input files. W&C staff have developed several IWFM-based models and worked with DWR to develop C2VSimFG-Beta. Their reviews helped ensure that the model update used best practices when incorporating new data. The peer review process was documented in a series of meeting summaries to the KGA and KRGSA. The updated C2VSimFG-Kern input files for the Kern County Subbasin were shared with DWR for incorporation into future C2VSim public releases.

The more general assumptions in C2VSimFG-Beta were replaced with local data and knowledge that are regionally or locally significant for WY 1995-2015. This update employed a phased approach with regular peer reviews.

1) Phase 1 revisions address components of Regional Significance that require significant changes to the overall model input file structure. These include
    a) Surface water delivery volumes, application areas and use by water district
    b) Groundwater banking recharge, recovery and application of recovered water
    c) Evapotranspiration rates and irrigation demand based on ITRC METRIC data (ITRC 2017);
    d) Urban population and per capita demand, including addition of an urban zone for Metropolitan Bakersfield; and
    e) Addition of groundwater extraction wells for groundwater banking projects.
2) Interim Review
    a) The Woodard & Curran Peer Review Team
    b) Kern County Subbasin water districts and purveyor's local data review
    c) Stakeholder input
3) Phase 2 revisions address components of Local Significance that generally require modifications of parameters within the existing C2VSim model input file structure.
    a) Local water sources and demands of significance to individual Districts/GSAs;
    b) District pumping for in-district delivery via surface water canals where significant;
    c) District recharge operations utilizing canals, stream channels, and basins;
    d) Wastewater disposal and land application; and
    e) Review and limited adjustment of model parameters.
4) Interim Review by same reviewers listed in item 2
5) Phase 3 revisions include addressing comments and incorporating new data from the Interim Reviews
6) Interim Review by same reviewers listed in item 2
7) Tabulate model-derived water budgets for Peer-Review and GSP Use

In each update phase, current and historical water budgets for zones representing water agency service areas were produced with the revised C2VSimFG-Kern model incorporating corrected local data. These water budgets were shared with participating agencies for review, to ensure that C2VSimFG-Kern correctly represented local water balances. Where necessary, participating agencies provided additional data which was incorporated into C2VSimFG-Kern.

8.4 Limitations to C2VSimFG-Kern

The C2VSimFG-Kern performs well in the Kern County Subbasin, producing simulated water budget components that generally match historical values compiled by local agencies. C2VSimFG-Kern simulated groundwater levels provide a reasonable approximation of observed groundwater levels in the central part of the Kern County Subbasin. The model is well suited to estimating the impacts of management actions on subbasin groundwater storage.

The C2VSimFG-Kern update was limited in scope, and some model components do not perform well. These components do not reduce model capabilities with respect to GSP development but limit the usefulness of the model for other types of studies. The Kern County Subbasin portion of C2VSimFG-Kern is not calibrated, and although the land surface water budget components are generally accurate, groundwater conditions and stream flows are poorly simulated in much of the subbasin; this is not significant as it is a very small volume.

The C2VSimFG-Kern is a reliable and defensible tool to support planning future groundwater conditions and estimating the potential hydrological impacts of future climate conditions and management actions at the subbasin level. DWR recommends updating and refining models used in GSPs to incorporate new data including that in annual GSP updates. Refining Kern County Subbasin hydrologic modelling tools to replicate district-level historical conditions will provide a reliable means of assessing future effects of management actions at the district level for future GSP development. The following actions and model improvements are recommended:

- **Improve streamflow simulations of the Kern River and Poso Creek.** Flows in the Kern River channel, including local stream-groundwater interactions, are not well replicated and surface water diversions are not dynamically simulated. Some rejected recharge occurs in the Kern Fan area in very wet years, with significant outflow of groundwater to the Kern River especially in the Kern Fan banking area (i.e., rejected recharge). This has been an ongoing issue and needs to be addressed for the projected future water budgets so that banking recharge volumes can be better matched in the model.
- **Improve the geologic and hydrogeologic conceptual model of the Kern County portion of the Central Valley.** A hydrogeologic conceptual model is a framework for understanding where groundwater exists, where it flows, and how groundwater interacts with surface water bodies and the land surface. A geologic conceptual model provides a framework for understanding the geologic features that control groundwater movement. Quantitative analysis of Kern County Subbasin groundwater flow is severely hampered by the lack of detailed geologic and hydrogeologic conceptual models of the areas outside the central alluvial basin. Geologic and hydrogeologic conceptual models will provide a foundation for the quantitative analysis of the groundwater flow system, and the framework for modeling the system. Key steps are:
    - Develop detailed geologic and hydrogeologic conceptual models of the Kern County Subbasin.
    - Identify the locations and characteristics of natural features that affect groundwater recharge and movement (faults, ridges, clays).
    - Understand water occurrence and movement in areas outside the central Kern County Subbasin.
    - Develop water quality maps (natural constituents and anthropogenic constituents).
    - Modify the Kern County Subbasin model to conform to the updated conceptual models.

- **Simulation of deep percolation and small watersheds.** Unreasonably high deep percolation (return flows) of the applied water in some areas has led to unreasonably elevated pumping rates to compensate. One problem is high root zone hydraulic parameter values in certain areas that were identified and corrected to better reflect local soil conditions. Because the excess pumping was returning to groundwater, the change has little effect on the basin change in storage, but the pumping and deep percolation are now more in line with local estimates. Root zone hydraulic parameters should be redeveloped throughout the subbasin to assure model values are representative of actual values.
- **Investigate development of a stand-alone Kern County Subbasin model.** The C2VSim model provided by DWR and updated with local data is adequate for GSP preparation. However, this model may not meet all of the groundwater modeling needs of Kern County Subbasin stakeholders. In addition, running a full Central Valley simulation model imposes longer model run times and reduces model flexibility. Stakeholders should undertake a comprehensive study to develop a list of their integrated (groundwater and surface water) modeling needs, and then decide whether further improving C2VSimFG-Kern or developing a new integrated hydrologic model is the best way to address subbasin modeling needs. This decision should be made before the end of 2020 to allow sufficient time to develop a new model or improve C2VSimFG-Kern in time for use in development of the 2025 GSP.
- **Adjust the finite element grid to honor water management boundaries.** The C2VSimFG-Kern model grid is a randomly generated grid that does not conform to any local features other than natural surface water channels. This limits the spatial accuracy of model inputs and the precision and flexibility of water budget outputs. Adjusting the grid to match district and agency boundaries, historical delivery areas, water management units within districts, and geologic and hydrologic features would greatly enhance model capabilities.
- **Quantify boundary flows.** Significant uncertainty exists regarding the rates and timing of groundwater flows into the Kern County Subbasin from surrounding watersheds, and groundwater flows from the Kern County Subbasin to Kings and Tulare counties to the north. Reliable estimates of boundary flows will improve model performance in boundary areas.
- **Kern County Subbasin Boundary.** The GSAs in the basin should consider when DWR opens the Bulletin 118 in 2020 to investigate the "actual" Kern County Subbasin and to remove those peripheral lands where aquifer connectivity does not exist.
- **Utilize more complex water management features of IWFM.** The Kern Update process modified information within the existing C2VSimFG-Beta model structure to improve model performance within the Kern County Subbasin. The IWFM application has several features that could be further utilized to improve model performance.
    - Adjust the agricultural crops to better match the Kern County crop mix (for example, create separate crop categories for carrots, young and mature almonds, young and mature pistachios, etc.).
    - Implement multi-cropping with semiannual or quarterly land use.
    - Some C2VSim data are organized by DWR subregions, which represent heterogeneous areas with homogeneous data. Developing Kern County Subbasin subregions and organizing model input data by these subregions may provide a better representation of local hydrologic conditions.

- **Calibrate the improved model for the Kern County Subbasin**. DWR did not fully calibrate the Kern County portion of the C2VSim model, owing to both poor historical input data and a lack of calibration data sets. The Kern Update process significantly improved the historical data in the model, developed some calibration data sets, and included limited adjustment of model parameters. The updated model performs adequately in the central part of the Kern County Subbasin and poorly in areas outside the central part of the basin. Once the above improvements are completed, the Kern County portion of the resulting model should be fully calibrated to ensure that it performs well throughout the Kern County Subbasin.

9. CONCLUSIONS

This brief summary provides an overview of the findings and conclusions of the modeling results for the Kern County Subbasin using C2VSimFG-Kern.

9.1 Findings of the C2VSimFG-Kern Application and Results

The subbasin-wide update of C2VSimFG-Kern incorporated data from many local agencies. Each participating agency provided data for their jurisdiction for use in improving the model. This included managed water supply data (e.g., surface water deliveries, land use, irrigation demand, return flows, and groundwater banking), stream and groundwater monitoring data, geologic data, and other relevant data. This information was compiled and used to improve C2VSimFG-Kern performance in the Kern County Subbasin.

The C2VSimFG-Kern model development and the water budget analysis were designed to fulfill the GSP requirement for a coordinated subbasin-wide water budget analysis, while also providing information required to fulfill other GSP requirements. The C2VSimFG-Kern was provided to DWR so the Kern County Subbasin revisions can be incorporated into their master version of the C2VSim model.

The historical water budget analysis indicates that the Kern County Subbasin was in a state of overdraft equivalent to the long-term decline in groundwater storage from WY1995 to WY2014 of 277,144 AFY. Projected Future simulations indicate that the proposed SGMA projects and management actions in the Kern County GSPs are sufficient for the Kern County Subbasin to achieve sustainability under Baseline and 2030 Climate Change conditions.

9.2 Limitations and Uncertainty of C2VSimFG-Kern

The C2VSimFG-Kern performs well in the Kern County Subbasin, producing simulated water budget components that generally match historical values compiled by local agencies. C2VSimFG-Kern simulated groundwater levels provide a reasonable statistical approximation of observed groundwater levels in the Kern County Subbasin. The model is well suited as a planning tool to estimate the impacts of the proposed SGMA projects and management actions on groundwater conditions in the Kern County Subbasin.

The C2VSimFG-Kern update was limited in scope, and some model components do not perform well. These components do not reduce model capabilities with respect to GSP development but limit the usefulness of the model for other types of studies. Flows in the Kern River channel, including local stream-groundwater interactions, are not well replicated and surface water diversions are not dynamically simulated. The Kern County Subbasin portion of the C2VSimFG-Kern is not calibrated, and although the land surface water budget components are generally accurate, groundwater conditions and stream flows are poorly simulated in much of the subbasin. Some rejected recharge occurs in the Kern Fan area in very wet years, but this is not significant as it is a very small volume.

9.3 Applicability of C2VSimFG-Kern Simulation Results

Based on the model validation, C2VSimFG-Kern provides a useful planning tool to evaluate potential future trends in groundwater in the Kern County Subbasin. The model validation demonstrated the capability of C2VSimFG-Kern to reasonably simulate the groundwater elevations and trends during the period from 1995 through 2015 based on the comparison to measured data.

The ability to reasonably simulate historical conditions provides confidence that C2VSimFG-Kern can be used to simulate potential future conditions. The model has the capability to simulate the most beneficial application of water projects that would provide the long-term benefit to the area. For the future case scenarios, the general practice is to evaluate model results with respect to long-term trends. Therefore, as a planning tool, it is most beneficial to run the model in relation to a base case and to evaluate the relative difference between the model scenario and the base case. The base case would assume a selected set of climatic, hydrologic and pumping conditions. Commonly, the calibration base period is assumed to repeat; however, any number of variations can be constructed.

It is important to note that in some cases the model results may vary from those measured in individual wells due to the geologic complexity of the Kern County Subbasin. However, the model is capable of evaluating the impacts of changes in pumping and water use practices in the Kern County Subbasin that are useful for SMGA planning purposes.

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TABLES

TABLE 1 - Summary of data input for surface water diversion to agriculture by water district applied to C2VSimFG-Kern Historical simulation

Water Year	Arvin-Edison WSD	Belridge WSD	Berrenda Mesa WSD	Buena Vista WSD	Cawelo WD	Kern River Canal Co.	Henry Miller WD	Kern Delta WD	Kern-Tulare WD	Lost Hills WD	North Kern WSD	Rosedale Rio Brave WSD	Semi-tropic WSD	Shafter-Wasco ID	So. San Joaquin MUD	Wheeler Ridge - Maricopa WSD	Olcese WD	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	144,722	106,293	90,909	162,444	78,084	14,994	43,242	183,471	27,131	103,268	198,865	0	74,487	149,252	112,888	177,348	1,493	1,668,891
1987	127,333	106,293	90,909	142,274	89,117	12,113	43,242	137,458	27,131	123,981	112,432	0	53,753	172,161	76,193	161,949	1,493	1,477,832
1988	114,321	106,293	90,909	141,152	77,106	4,203	43,242	135,078	27,131	111,872	81,580	0	47,071	164,192	71,243	154,030	1,417	1,370,840
1989	114,591	106,293	90,909	150,341	85,190	11,096	43,242	140,360	27,131	122,044	61,797	0	50,495	190,990	94,729	178,129	1,480	1,468,817
1990	70,816	106,293	90,909	124,845	67,867	14,757	43,242	114,531	27,131	88,963	51,926	0	34,381	49,992	73,000	170,693	1,480	1,130,826
1991	40,698	106,293	90,909	100,517	50,621	10,416	43,242	117,287	27,131	9,553	28,931	0	40,595	7,926	11,683	31,030	1,480	718,312
1992	52,839	106,293	90,909	108,874	54,406	9,909	43,242	118,190	27,131	52,853	34,291	0	45,851	94,467	65,310	96,514	1,480	1,002,559
1993	137,479	93,344	85,549	151,653	75,490	11,596	43,973	174,003	26,034	77,793	181,920	5,040	72,120	226,462	108,767	137,221	1,425	1,609,869
1994	171,856	110,017	93,092	125,084	62,968	13,862	53,471	132,865	28,017	87,636	117,580	2,362	47,111	110,951	83,680	151,368	1,685	1,393,606
1995	134,559	110,993	78,521	189,797	73,155	6,600	29,047	159,595	27,333	85,963	174,020	5,591	62,105	235,347	108,778	153,783	1,425	1,636,611
1996	166,288	112,412	115,132	184,597	90,229	11,591	39,539	179,052	28,749	145,349	202,199	5,722	72,231	313,420	128,865	189,454	1,987	1,986,816
1997	185,820	143,146	97,233	197,871	88,202	11,134	50,584	179,388	29,998	122,140	191,871	4,563	67,407	313,717	124,456	188,455	1,778	1,997,763
1998	120,808	79,387	85,885	152,455	69,758	4,959	30,260	124,464	24,422	80,845	153,662	4,756	53,064	240,072	89,373	148,174	849	1,463,194
1999	152,909	101,786	93,199	142,271	86,667	10,085	53,858	141,626	28,093	108,563	146,395	4,679	57,625	307,686	110,686	166,018	1,248	1,713,394
2000	158,008	111,057	87,200	135,689	87,894	12,833	44,302	152,338	29,948	119,828	133,872	3,920	61,358	315,833	119,597	179,278	1,382	1,754,337
2001	158,432	91,642	65,734	76,718	70,873	10,048	31,379	113,044	30,109	68,302	74,725	0	48,772	70,879	98,104	136,390	1,588	1,146,739
2002	158,197	107,617	63,705	78,735	75,042	9,058	31,724	116,181	25,443	67,574	62,006	0	55,121	165,448	103,849	133,652	1,702	1,255,054
2003	139,412	103,724	64,267	96,601	75,749	8,371	33,941	161,162	24,120	62,007	106,436	1,000	55,511	265,110	106,779	120,733	2,041	1,426,964
2004	155,531	118,543	68,902	86,119	78,558	9,383	39,101	138,664	25,541	67,607	99,610	1,739	58,351	174,605	106,537	138,771	1,637	1,369,199
2005	136,887	105,523	69,372	125,522	78,101	6,037	39,248	169,747	21,445	60,844	207,612	2,784	58,711	294,595	109,716	127,846	1,939	1,615,929
2006	140,411	115,146	84,869	149,851	96,249	5,317	46,538	172,882	22,525	73,422	199,626	0	68,468	332,115	120,106	150,416	2,048	1,779,988
2007	158,526	118,036	102,971	91,196	70,811	4,574	48,482	112,341	23,348	83,116	89,195	552	37,391	146,826	75,642	164,924	1,496	1,329,426
2008	157,604	114,525	86,217	70,032	62,437	4,380	18,156	145,633	22,788	74,554	86,051	0	47,623	29,675	87,776	168,211	1,700	1,177,361
2009	145,184	113,385	86,439	73,530	67,340	4,340	12,129	126,039	21,803	83,740	84,727	0	44,265	30,808	116,967	159,502	1,781	1,171,979
2010	132,462	117,589	88,556	102,109	76,351	3,604	29,694	166,787	19,272	88,191	171,744	1,543	65,238	168,870	120,394	159,162	1,756	1,513,322
2011	130,306	121,808	87,344	121,329	88,617	4,617	39,642	192,069	20,213	92,149	173,305	4,466	74,413	337,724	124,678	156,216	1,530	1,770,425
2012	148,146	130,559	87,953	96,407	89,745	3,988	41,553	195,763	21,682	91,720	81,584	1,329	35,369	227,901	81,602	168,753	1,783	1,505,837
2013	159,887	138,131	93,311	33,558	49,978	3,585	18,533	94,682	22,252	93,322	23,343	0	26,194	81,279	58,923	170,033	1,966	1,068,977
2014	144,605	123,390	82,731	410	41,223	2,645	2,246	70,367	14,067	82,546	11,290	0	8,303	5,748	14,249	152,372	1,238	757,429
2015	114,350	117,357	81,535	134	38,195	2,663	0	68,228	10,274	80,631	9,901	0	0	12,226	3,020	145,842	1,462	685,817

TABLE 2 - Summary of data input for surface water diversion from Kern River at different diversion and turnouts applied to C2VSimFG-Kern Historical simulation

Water Year	Kern River to Beardsley Canal	Kern River to Carrier Canal at Rocky Point	Kern River to Carrier Canal at Calloway Weir	Kern River to CVC at Turnout #4	Kern River to River Canal	Kern River to Rio Vista at River Walk	Kern River to Rosedale Channel	Kern River to North Lake	Kern River to Pioneer Canal	Kern River to Berrenda Mesa WSD	Kern River to Pioneer Project	Kern River to Kern Water Bank	Kern River to Kern Water Bank	Kern River to 2800 Acre Facility	Kern River to Buena Vista WSD BSA	Kern River to Aqueduct at Intertie	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	291,715	199,035	238,877	181,392	0	0	65,684	0	63,232	0	0	0	0	97,866	86,736	0	1,224,537
1987	190,539	76,888	179,876	58,811	0	0	19,893	0	756	0	0	0	0	21,592	86,736	0	635,091
1988	111,679	25,813	163,938	21,851	0	0	345	0	0	0	0	0	0	0	86,736	0	410,362
1989	98,796	28,696	168,926	23,291	0	0	0	0	0	0	0	0	0	0	86,736	0	406,445
1990	77,389	5,373	128,753	6,577	0	0	0	0	0	0	0	0	0	0	86,736	0	304,828
1991	69,736	180,189	56,331	13,944	0	0	5,869	0	0	0	0	0	0	0	86,736	0	412,805
1992	71,521	194,315	690	11,008	0	0	3,598	0	0	0	0	0	0	0	86,736	0	367,868
1993	213,099	241,104	43,555	59,099	50,897	0	54,936	0	27,803	0	0	0	0	64,852	64,488	0	819,833
1994	187,380	213,631	18,103	26,829	67	0	0	0	0	9,882	0	0	0	28,046	38,745	0	522,683
1995	256,234	248,113	65,360	144,230	136,516	0	91,721	0	40,366	23,822	45,284	0	0	60,476	103,429	11,850	1,227,401
1996	315,988	255,792	105,845	108,405	119,999	0	78,824	0	14,286	17,382	55,074	0	0	24,037	92,768	0	1,188,400
1997	288,746	280,471	123,771	130,336	123,333	0	62,841	0	23,271	14,977	45,600	0	0	27,212	134,320	52,848	1,307,726
1998	312,857	244,337	143,422	131,398	23,346	0	95,706	0	51,802	18,483	69,637	0	0	95,160	115,019	188,048	1,489,215
1999	214,847	180,856	71,974	46,274	58,082	0	33,938	0	839	6,915	21,343	0	0	17,891	77,220	0	730,179
2000	175,718	169,844	38,793	31,596	38,147	0	20,213	0	0	1,396	15,929	0	0	30,660	47,882	0	570,178
2001	130,052	188,404	23,762	14,050	4,631	0	3,177	0	2,179	0	0	0	0	0	32,686	0	398,941
2002	91,980	203,010	4,149	23,609	7,878	0	581	0	199	431	871	0	0	0	29,404	0	362,112
2003	164,112	206,448	15,893	14,088	31,451	0	12,306	0	0	1,045	0	0	0	0	38,307	0	483,650
2004	153,148	198,769	29,338	18,247	2,301	589	1,503	165	0	2,545	2,005	0	0	0	39,412	0	448,022
2005	236,776	228,885	73,215	62,146	60,019	0	141,022	1,442	1,942	39,702	102,111	21,548	23,125	77,127	72,865	0	1,141,925
2006	257,590	247,806	53,872	122,931	33,872	3,942	87,318	1,442	9,962	24,636	116,108	25,165	34,358	42,587	97,955	0	1,159,544
2007	135,525	189,169	1,049	10,483	7,752	2,746	0	0	0	13,099	17,809	7,507	0	4,568	47,914	0	437,621
2008	137,813	229,304	53,824	22,700	0	544	0	0	0	0	0	0	0	0	34,549	0	478,734
2009	139,246	238,103	31,342	28,635	115	712	109	0	0	0	0	0	0	0	18,418	0	456,680
2010	196,135	241,876	70,315	68,944	60,087	820	10,816	776	1,775	1,165	0	0	0	13,748	66,441	0	732,898
2011	298,003	266,684	75,784	160,243	90,048	1,752	101,209	787	20,479	26,223	121,857	23,951	47,187	84,876	98,416	0	1,417,499
2012	148,513	241,953	20,495	55,303	409	1,001	10,998	0	0	7,594	20,162	582	0	7,871	45,173	0	560,054
2013	45,141	153,474	706	25,758	0	247	0	0	0	3,529	0	0	0	155	0	0	229,010
2014	26,041	122,044	0	8,356	0	283	0	0	0	0	0	0	0	0	0	0	156,724
2015	16,883	104,841	0	0	0	195	0	0	0	0	0	0	0	0	0	0	121,919

TABLE 3 - Summary of data input for surface water diversions for various purposes applied to C2VSimFG-Kern Historical simulation

Water Year	Metro Bakersfield Urban Water Supply	Metro Bakersfield Wastewater Land Disposal	Kern Nat'l Wildlife Reguge SWP Supply	Kern Nat'l Wildlife Reguge Surface Water Inflows	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	24,416	29,235	0	1,611	30,846
1987	25,298	30,832	0	247	31,079
1988	28,563	32,304	0	65	32,369
1989	27,818	33,785	0	136	33,921
1990	27,426	35,756	0	0	35,756
1991	20,959	36,837	0	123	36,960
1992	25,867	37,801	0	10	37,811
1993	30,261	38,774	120	852	39,746
1994	29,111	39,684	16,861	95	56,640
1995	27,248	40,709	12,097	896	53,702
1996	28,261	41,667	12,776	4,536	58,979
1997	19,216	40,832	7,964	13,811	62,607
1998	11,036	40,355	12,268	90,926	143,549
1999	26,996	39,629	14,827	1,876	56,332
2000	30,963	41,497	7,489	58	49,044
2001	28,611	41,559	13,179	0	54,738
2002	30,185	42,043	19,299	1	61,343
2003	32,206	42,962	20,945	22	63,929
2004	56,861	43,735	23,461	0	67,196
2005	43,727	44,021	23,310	9,025	76,356
2006	40,294	44,614	21,829	11,734	78,177
2007	55,334	44,643	21,607	2,440	68,690
2008	56,335	44,936	17,728	18	62,682
2009	58,834	45,416	19,494	9	64,919
2010	61,314	45,527	21,808	536	67,871
2011	64,388	46,429	26,599	7,691	80,719
2012	68,013	46,666	18,451	9	65,126
2013	66,998	45,513	23,701	0	69,214
2014	55,692	44,645	13,877	0	58,522
2015	44,981	43,256	9,203	0	52,459

TABLE 4 - Summary of data input for surface water diversion to Groundwater Banking and Managed Aquifer Recharge for different facilities applied to C2VSimFG-Kern Historical simulation

Water Year	Arvin-Edison WSD	Berrenda Mesa Project	Buena Vista WSD	Cawelo WD	Kern Delta WD	Kern River GSA	North Kern WSD	Rosedale-Rio Bravo WSD	Semi-tropic WSD	West Kern WD	City of Bakers-field	Pioneer Project	Kern Water Bank	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	63,708	0	28,948	0	0	107,936	115,498	103,384	0	25,559	164,861	0	0	609,894
1987	18,800	0	7,487	0	0	62,084	47,206	47,731	0	23,249	50,585	0	0	257,142
1988	1,434	0	227	0	0	49,926	11,171	19,026	0	24,594	18,294	0	0	124,672
1989	3,358	0	3,532	0	0	58,640	804	27,984	0	28,604	14,148	0	0	137,070
1990	4,660	0	0	0	0	35,825	0	11,530	0	22,368	9,564	0	0	83,947
1991	2,404	0	0	0	0	54,577	1,224	5,931	0	14,754	19,768	0	0	98,658
1992	3,886	0	799	0	0	48,497	10,236	11,880	0	10,368	23,482	0	0	109,148
1993	99,714	0	19,229	0	0	83,472	25,220	88,065	0	24,420	126,544	0	0	466,664
1994	28,968	0	11,485	0	0	60,217	12,333	26,016	0	29,233	67,418	0	0	235,670
1995	87,910	17,808	49,623	0	0	98,122	149,948	119,339	0	28,201	143,019	62,274	121,465	877,709
1996	69,472	23,398	18,253	0	0	102,034	103,277	116,704	0	37,351	75,468	51,330	232,355	829,642
1997	58,069	9,801	38,015	7,524	0	103,578	102,050	108,711	0	18,555	53,470	38,169	132,457	670,399
1998	97,098	9,493	63,868	9,136	0	90,233	196,469	136,250	0	23,133	149,426	57,357	236,320	1,068,783
1999	81,398	11,489	8,904	6,110	0	83,858	69,080	78,941	0	29,249	41,516	21,884	116,663	549,092
2000	95,786	1,027	238	3,446	0	74,926	163	44,501	0	23,082	51,444	22,032	36,551	353,196
2001	38,774	0	99	2,683	0	59,411	0	5,653	0	8,747	22,005	1,253	10,029	148,654
2002	4,437	0	1,065	2,596	0	63,427	0	1,404	0	19,467	11,840	0	13,439	117,675
2003	44,030	0	424	3,314	4,177	73,362	367	27,154	0	17,766	20,133	0	5,369	196,096
2004	7,160	3,172	0	5,172	1,380	65,335	3,039	9,626	0	3,513	22,480	10,768	53,070	184,715
2005	100,311	19,663	33,153	7,882	7,274	98,474	74,241	151,136	0	29,552	164,991	93,466	308,092	1,088,235
2006	90,722	28,268	22,966	4,219	1,224	95,246	138,698	174,051	0	14,385	113,166	64,388	308,877	1,056,210
2007	20,012	15,292	0	5,241	488	51,678	80,467	20,348	0	4,209	31,534	19,386	70,553	319,208
2008	4,409	0	0	5,069	0	53,118	0	0	92	0	8,787	0	0	71,475
2009	34,000	0	3,000	5,239	0	48,217	2,596	2,354	0	5,075	18,730	0	0	119,211
2010	101,606	323	19,127	6,252	11,038	97,829	18,377	76,399	0	10,419	40,113	0	8,272	389,755
2011	99,559	19,373	73,880	29,630	46,690	158,694	147,576	227,775	17,276	24,880	144,869	132,320	397,029	1,519,551
2012	27,799	20,055	0	7,162	54,573	83,460	60,613	88,019	1,865	30,166	37,046	27,293	83,991	522,042
2013	3,947	5,750	0	9,345	14,726	46,298	5,078	5,622	22	2,500	11,518	0	0	104,806
2014	3,518	0	0	2,102	0	46,654	0	0	0	0	9,176	0	0	61,450
2015	401	0	0	5,893	0	40,368	4,768	0	22	0	18,840	0	0	70,292

TABLE 5 - Summary of data input for groundwater recovery pumping for local water supply by water district applied to C2VSimFG-Kern Historical simulation

Water Year	Arvin-Edison WSD	Berrenda Mesa Project	Buena Vista WSD	City of Bakers-field	Cawelo WD	KCWA ID4	Kern Delta WD	Kern Water Bank	Lost Hills PUD	North Kern WSD	Olcese WD	Pioneer Project	Rosedale Rio Brave WSD	Semi-tropic WSD	West Kern WD	Wheeler Ridge - Maricopa WSD	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	1,955	0	0	0	0	0	0	0	274	0	101	0	0	0	12,073	0	14,403
1987	21,660	0	0	0	0	0	0	0	278	41,963	101	0	0	0	12,195	0	76,196
1988	27,486	0	960	0	0	0	0	0	281	67,609	138	0	0	0	12,316	0	108,790
1989	38,231	0	2,507	0	0	0	0	0	285	79,674	132	0	0	0	12,438	0	133,266
1990	78,769	0	2,605	0	957	0	0	0	292	73,635	132	0	0	0	12,560	0	168,949
1991	82,566	0	2,511	0	4,666	0	0	0	307	80,432	132	0	0	0	12,546	0	183,160
1992	94,444	0	4,146	0	7,124	0	0	0	306	72,926	132	0	0	0	12,533	5,419	197,029
1993	21,035	0	222	0	3,469	0	0	0	308	3,950	66	0	0	0	12,530	150	41,730
1994	67,679	0	1,732	0	7,805	0	0	0	321	37,251	123	0	0	0	12,078	2,705	129,693
1995	14,191	0	73	0	4,628	0	0	0	322	4,176	66	0	0	0	11,638	0	35,094
1996	1,095	0	175	0	2,475	0	0	0	322	4,726	143	0	0	2,373	13,642	0	24,950
1997	0	0	0	0	2,406	0	0	0	322	4,261	112	0	0	5,824	13,962	0	26,887
1998	245	0	0	0	1,008	0	0	0	307	318	232	0	0	1,499	13,404	76	17,089
1999	915	0	0	0	2,099	0	0	0	333	773	105	0	0	1,241	14,692	2,806	22,963
2000	2,119	0	855	0	6,406	0	0	0	336	15,864	81	0	0	689	17,125	0	43,475
2001	100,492	19,482	6,115	13,950	8,533	0	0	86,404	350	61,988	103	52,034	0	0	15,714	6,507	371,673
2002	86,809	3,436	4,453	13,972	10,047	0	0	24,664	360	70,804	94	9,578	0	2,082	16,247	0	242,545
2003	30,906	0	1,619	3,211	5,484	1,892	0	53,591	364	21,811	56	16,181	0	2,828	17,733	24	155,699
2004	75,399	0	3,848	7,147	8,920	3,345	0	27,736	393	49,888	120	1,985	0	2,879	20,809	41	202,510
2005	25,104	589	430	0	3,563	0	0	21,553	400	6,121	111	12,951	0	2,145	20,843	0	93,809
2006	174	0	228	0	4,202	0	0	0	416	2,645	77	0	0	156	22,108	0	30,007
2007	101,515	23,022	5,858	10,000	11,039	6,220	0	167,291	419	88,841	149	54,150	2,302	0	23,107	0	493,914
2008	141,081	27,850	6,066	13,400	12,222	9,478	9,744	246,249	423	100,465	115	77,533	7,470	0	22,340	0	674,436
2009	128,043	29,745	5,315	9,086	742	5,582	15,117	166,703	389	111,798	144	78,033	6,001	449	21,629	0	578,777
2010	37,081	15,117	841	3,896	2,078	1,886	4,466	97,576	362	20,897	112	41,021	0	375	21,334	0	247,041
2011	445	0	290	0	146	0	0	0	378	683	115	0	0	500	20,801	1,037	24,395
2012	43,589	6,362	1,835	3,960	2,058	1,319	3,148	94,381	393	103,236	107	14,257	0	0	21,107	14,579	310,330
2013	123,971	1,379	4,261	5,571	20,994	2,252	19,809	171,627	373	146,543	118	41,743	14,231	0	19,494	16,518	588,883
2014	146,319	23,891	3,269	7,997	18,120	30,884	34,160	183,235	359	133,769	472	78,603	21,604	0	33,129	16,020	731,830
2015	123,618	26,298	1,267	3,516	24,146	38,294	32,918	154,687	358	118,342	109	56,634	17,237	0	20,344	13,857	631,624

TABLE 6 - Summary of data input for groundwater pumping for basin export by water district applied to C2VSimFG-Kern Historical simulation

Water Year	Arvin-Edison WSD to Aqueduct	DWR to Aqueduct	North Kern WSD to Friant-Kern Canal	Rosedale Rio Brave WSD to CVC	Semi-tropic WSD to Aqueduct	Wheeler Ridge - Maricopa WSD to Aqueduct	County of Kern to BVARA	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	0	0	0	0	0	0	0	2,056
1987	0	0	0	0	0	0	673	63,724
1988	0	0	0	0	0	0	6,301	96,193
1989	0	0	0	0	0	0	5,879	120,544
1990	0	0	0	0	0	0	8,836	156,097
1991	0	0	0	0	0	0	22,114	170,307
1992	0	0	0	0	0	0	25,025	184,191
1993	0	0	0	0	0	0	7,521	28,892
1994	0	0	0	0	0	0	3,261	117,295
1995	0	2,319	0	0	0	0	4,748	23,134
1996	0	0	0	0	0	0	0	10,986
1997	0	0	0	0	0	0	0	12,603
1998	0	0	0	0	0	0	0	3,378
1999	0	0	0	0	0	0	0	7,938
2000	0	0	0	0	0	0	56	26,013
2001	0	0	0	0	1,457	638	10,024	355,608
2002	0	0	0	0	21,819	0	22,402	225,938
2003	12,380	0	0	0	0	0	9,886	137,602
2004	11,573	0	0	0	8,965	0	13,643	181,308
2005	13,939	0	0	0	19,103	0	6,071	72,567
2006	0	0	0		0	0	0	7,482
2007	7,609	0	7,276	0	6,282	0	10,437	470,388
2008	42,615	0	4,612	0	92,169	0	17,351	651,673
2009	43,080	0	5,880	0	86,194	7,243	7,786	556,758
2010	56,229	0	73	0	37,995	12,404	7,019	225,345
2011	16,065	0	0	0	0	0	369	3,217
2012	10,010	0	6,803	0	0	1,340	1,889	288,831
2013	15,111	0	7,471	12,116	5,610	3,815	9,786	569,016
2014	45,195	0	12,071	28,818	95,611	18,236	21,567	698,342
2015	67,142	0	9,752	26,314	89,453	26,943	23,330	610,923

0

TABLE 7 - Summary of population data input by Urban Zone applied to C2VSimFG-Kern Historical simulation

Water Year	Urban Zone 97	Urban Zone 98	Urban Zone 99	Urban Zone 100	Urban Zone 102	Urban Zone 103	Urban Zone 104	Urban Zone 105	Urban Zone 106	Total	Annual Growth Rate
	Population	Population	Population	Population	Population	Population	Population	Population	Population	Population	percent
1985	18,266	4,545	54,766	199	11,589	1,845	15,756	443	229,085	336,493	
1986	18,506	4,565	56,021	184	11,631	1,868	16,127	443	245,095	354,441	5.3%
1987	18,747	4,586	57,277	170	11,673	1,892	16,498	443	261,105	372,389	5.1%
1988	18,987	4,607	58,532	155	11,715	1,915	16,869	442	277,114	390,337	4.8%
1989	19,227	4,627	59,788	141	11,758	1,939	17,240	442	293,124	408,285	4.6%
1990	19,467	4,648	61,043	126	11,800	1,962	17,611	442	309,134	426,233	4.4%
1991	19,808	4,662	64,110	132	12,190	2,023	17,570	475	316,532	437,502	2.6%
1992	20,150	4,676	67,178	138	12,581	2,084	17,528	507	323,930	448,771	2.6%
1993	20,491	4,690	70,245	144	12,971	2,145	17,487	540	331,328	460,041	2.5%
1994	20,832	4,704	73,313	150	13,362	2,206	17,445	572	338,726	471,310	2.4%
1995	21,174	4,718	76,380	156	13,752	2,268	17,404	605	346,124	482,579	2.4%
1996	21,515	4,732	79,447	161	14,142	2,329	17,363	637	353,522	493,848	2.3%
1997	21,856	4,746	82,515	167	14,533	2,390	17,321	670	360,920	505,117	2.3%
1998	22,197	4,760	85,582	173	14,923	2,451	17,280	702	368,318	516,387	2.2%
1999	22,539	4,774	88,650	179	15,314	2,512	17,238	735	375,716	527,656	2.2%
2000	22,880	4,788	91,717	185	15,704	2,573	17,197	767	383,114	538,925	2.1%
2001	23,154	4,887	94,141	193	16,313	2,601	17,609	742	395,409	555,047	3.0%
2002	23,429	4,985	96,564	200	16,922	2,628	18,020	717	407,703	571,169	2.9%
2003	23,703	5,084	98,988	208	17,532	2,656	18,432	692	419,998	587,291	2.8%
2004	23,977	5,182	101,412	215	18,141	2,683	18,844	667	432,292	603,413	2.7%
2005	24,252	5,281	103,836	223	18,750	2,711	19,256	643	444,587	619,536	2.7%
2006	24,526	5,379	106,259	230	19,359	2,738	19,667	618	456,882	635,658	2.6%
2007	24,800	5,478	108,683	238	19,968	2,766	20,079	593	469,176	651,780	2.5%
2008	25,074	5,576	111,107	245	20,578	2,793	20,491	568	481,471	667,902	2.5%
2009	25,349	5,675	113,530	253	21,187	2,821	20,902	543	493,765	684,024	2.4%
2010	25,623	5,773	115,954	260	21,796	2,848	21,314	518	506,060	700,146	2.4%
2011	25,815	5,802	117,403	261	21,959	2,862	21,474	519	512,386	708,482	1.2%
2012	26,009	5,831	118,871	261	22,124	2,877	21,635	521	518,791	716,919	1.2%
2013	26,204	5,860	120,357	262	22,290	2,891	21,797	522	525,275	725,458	1.2%
2014	26,400	5,889	121,861	263	22,457	2,905	21,961	523	531,841	734,102	1.2%
2015	26,598	5,919	123,385	263	22,626	2,920	22,125	525	538,489	742,850	1.2%

TABLE 8 - Summary of data input of Per Capita Water Use by Urban Zone applied to C2VSimFG-Kern Historical simulation

Water Year	Urban Zone 97	Urban Zone 98	Urban Zone 99	Urban Zone 100	Urban Zone 102	Urban Zone 103	Urban Zone 104	Urban Zone 105	Urban Zone 106
	gdpc	gdpc	gdpc	gdpc	gdpc	gdpc	gdpc	gdpc	gdpc
1985	228	196	245	159	180	159	293	159	508
1986	228	196	245	159	180	159	293	159	480
1987	228	196	245	159	180	159	293	159	450
1988	228	196	245	159	180	159	293	159	439
1989	228	196	245	159	180	159	293	159	419
1990	228	196	245	159	180	159	293	159	438
1991	228	196	245	159	180	159	293	159	409
1992	228	196	245	159	180	159	293	159	417
1993	228	196	245	159	180	159	293	159	414
1994	228	196	245	159	180	159	293	159	421
1995	228	196	245	159	180	159	293	159	381
1996	228	196	245	159	180	159	293	159	401
1997	228	196	245	159	180	159	293	159	348
1998	228	196	245	159	180	159	293	159	304
1999	228	196	248	159	159	159	237	159	388
2000	228	196	248	159	159	159	237	159	367
2001	228	196	248	159	159	159	237	159	364
2002	228	196	248	159	159	159	237	159	362
2003	228	196	248	159	159	159	237	159	358
2004	228	196	248	159	159	159	237	159	386
2005	228	196	248	159	159	159	237	159	314
2006	228	196	248	159	159	159	237	159	338
2007	228	196	248	159	159	159	237	159	375
2008	228	196	248	159	159	159	237	159	367
2009	228	196	248	159	159	159	237	159	344
2010	228	196	248	159	159	159	237	159	328
2011	228	196	248	159	159	159	237	159	351
2012	228	196	248	159	159	159	237	159	378
2013	228	196	248	159	159	159	237	159	330
2014	228	196	248	159	159	159	237	159	314
2015	228	196	248	159	159	159	237	159	261

TABLE 9 - Summary of data input for crop evapotranspiration (ET) by crop type based on METRIC satellite data applied to C2VSimFG-Kern Historical simulation

Water Year	Grain	Cotton	Sugar Beets	Cotton	Dry Beans	Saf-flower	Other Field Crops	Alfalfa	Pasture	Tomoto-Processed	Tomato-Fresh	Curcubits	Onions & Garlic	Potatoes	Other Truck	Almonds & Pistachios	Orchards	Citrus	Vineyards	Idle	Rice	Refuge	Urban	Native
Units	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr
1985	30.0	31.6	34.6	35.4	30.8	28.0	27.9	38.9	35.8	28.8	27.3	24.9	28.7	27.6	29.3	31.6	29.7	36.5	25.0	27.4	35.8	31.6	28.1	27.5
1986	28.2	28.9	36.4	32.8	28.0	26.2	29.2	39.3	35.5	29.8	28.8	27.7	26.5	26.2	27.9	35.1	33.6	36.8	26.9	27.1	39.3	36.2	27.8	26.8
1987	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
1988	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
1989	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
1990	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
1991	30.0	31.6	34.6	35.4	30.8	28.0	27.9	38.9	35.8	28.8	27.3	24.9	28.7	27.6	29.3	31.6	29.7	36.5	25.0	27.4	35.8	31.6	28.1	27.5
1992	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
1993	28.2	28.9	36.4	32.8	28.0	26.2	29.2	39.3	35.5	29.8	28.8	27.7	26.5	26.2	27.9	35.1	33.6	36.8	26.9	27.1	39.3	36.2	27.8	26.8
1994	29.5	34.0	36.9	37.0	31.9	24.0	36.5	37.6	31.4	32.4	27.3	27.4	34.1	28.7	31.6	37.2	37.5	38.7	29.1	33.3	26.6	23.9	27.0	27.3
1995	30.1	32.4	35.8	34.4	30.7	26.6	30.7	36.6	32.6	29.4	29.0	28.1	33.1	27.4	30.2	35.8	35.5	35.8	28.7	32.2	31.6	36.3	27.5	29.6
1996	35.0	37.1	39.7	39.2	38.2	32.6	35.8	42.3	38.7	36.1	32.7	28.7	35.3	30.4	33.0	39.3	40.1	39.4	32.1	32.8	34.1	36.4	30.2	31.0
1997	31.3	35.5	39.1	37.7	33.9	29.3	37.2	43.5	36.0	33.2	28.1	28.8	29.7	28.8	30.1	33.7	34.0	38.1	26.1	30.6	34.1	34.0	28.1	31.1
1998	28.2	28.9	36.4	32.8	28.0	26.2	29.2	39.3	35.5	29.8	28.8	27.7	26.5	26.2	27.9	35.1	33.6	36.8	26.9	27.1	39.3	36.2	27.8	26.8
1999	30.0	31.6	34.6	35.4	30.8	28.0	27.9	38.9	35.8	28.8	27.3	24.9	28.7	27.6	29.3	31.6	29.7	36.5	25.0	27.4	35.8	31.6	28.1	27.5
2000	31.1	34.6	36.0	33.2	29.4	28.7	33.8	44.0	38.6	32.2	32.3	27.3	30.5	29.4	29.5	37.0	34.6	41.0	28.9	27.6	41.2	31.4	32.3	33.0
2001	31.9	33.4	36.3	32.0	29.3	27.2	32.1	44.5	33.8	30.2	29.9	26.5	28.8	28.1	28.8	39.9	36.0	40.7	29.7	28.0	41.7	30.8	30.5	31.6
2002	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
2003	33.0	35.5	35.6	33.2	33.5	28.0	31.7	42.9	30.6	31.0	26.2	27.8	29.7	27.2	28.4	39.6	32.8	38.8	30.4	29.7	37.0	32.1	28.5	30.4
2004	34.5	36.6	37.3	33.5	33.3	32.8	35.6	46.4	36.1	33.1	26.4	26.1	32.4	30.3	33.1	44.2	36.7	40.0	33.1	35.5	39.0	31.5	30.1	32.4
2005	31.8	35.4	40.6	30.5	31.8	27.8	33.0	40.7	32.3	28.4	23.7	26.8	29.6	28.4	28.0	35.1	30.2	34.8	28.0	29.6	37.3	34.1	28.2	30.0
2006	30.9	33.7	33.7	31.4	31.3	24.9	31.1	41.4	33.2	25.4	26.9	29.5	26.9	31.9	28.2	33.9	28.6	35.0	27.6	27.3	39.6	39.3	27.9	29.0
2007	34.3	36.5	33.9	36.1	31.6	28.9	35.3	44.1	35.3	29.4	24.4	26.7	29.1	27.8	32.5	34.5	29.6	37.6	29.6	29.7	38.0	34.0	27.7	31.5
2008	35.2	34.1	30.6	35.3	29.7	25.1	36.0	43.8	37.2	28.0	25.1	25.7	29.7	29.1	31.3	33.2	31.5	37.9	29.6	26.9	34.2	29.9	28.3	31.4
2009	35.3	34.1	25.1	34.2	32.4	32.6	33.9	42.2	30.9	26.5	24.4	24.9	27.1	29.3	29.6	34.5	31.9	37.8	30.4	28.9	35.8	30.5	27.9	32.0
2010	31.6	28.9	25.8	30.2	28.5	23.7	29.8	38.7	26.8	23.2	23.4	26.2	25.4	26.5	27.0	37.3	31.0	35.5	32.3	28.3	33.7	30.8	27.1	30.2
2011	30.1	28.2	23.9	28.3	27.0	21.8	29.6	36.0	25.1	22.6	27.0	24.4	25.5	25.8	25.2	36.2	32.0	33.6	30.9	26.6	38.1	33.6	26.9	32.7
2012	30.2	27.3	22.5	28.7	26.3	23.0	31.0	35.8	26.1	22.6	28.1	24.3	25.8	26.1	26.1	36.6	31.7	33.9	31.2	26.0	38.4	33.8	27.5	33.0
2013	35.7	35.5	28.0	34.7	32.7	33.2	36.4	44.0	33.1	27.2	30.7	29.1	32.4	30.1	30.1	43.6	35.5	39.9	38.6	29.5	36.3	36.8	29.1	35.2
2014	33.9	33.6	25.2	32.9	28.4	28.8	36.0	40.4	28.8	25.2	28.2	28.3	28.6	28.7	29.8	42.5	33.0	37.8	34.1	28.5	36.0	35.8	29.2	34.2
2015	33.4	34.2	28.3	36.3	31.9	33.9	37.0	43.2	29.0	24.0	26.4	27.1	34.8	27.5	30.7	38.8	31.8	38.3	31.0	28.1	29.6	32.2	27.9	32.4
Average	**32.4**	**33.4**	**33.0**	**33.4**	**30.9**	**27.8**	**32.9**	**41.5**	**33.0**	**28.8**	**27.5**	**26.9**	**29.3**	**28.5**	**29.5**	**37.3**	**33.3**	**37.7**	**30.3**	**29.1**	**37.1**	**33.6**	**28.8**	**31.3**
BETA	**21.6**	**39.8**	**39.2**	**32.3**	**31.1**	**34.9**	**36.4**	**48.0**	**50.4**	**31.6**	**40.6**	**32.0**	**36.5**	**35.4**	**31.6**	**48.1**	**45.9**	**42.5**	**42.0**	**57.1**	**50.2**	**76.1**	**52.0**	**57.1**
Difference	**10.8**	**-6.4**	**-6.3**	**1.1**	**-0.2**	**-7.2**	**-3.5**	**-6.5**	**-17.4**	**-2.8**	**-13.0**	**-5.0**	**-7.2**	**-6.9**	**-2.1**	**-10.9**	**-12.6**	**-4.8**	**-11.7**	**-28.0**	**-13.1**	**-42.6**	**-23.2**	**-25.8**

TABLE 10 - Summary of Other C2VSimFG Beta Modifications in the Kern County Update

File Name	Change to Model Input File
C2VSimFG.in	
*	Change simulation starting time to 09/30/1985_24:00
C2VSimFG_Unsat.dat	
*	Replaced initial condition values with more representative values for revised starting time
C2VSimFG_Groundwater1985.dat	
*	Added hydrologic flow barrier at White Wolf Fault
*	Set Corcoran Clay thickness to 0 ft in areas where it is not present
*	New 10/1/1985 initial condition
*	Modified hydraulic conductivity and specific storage in Layer 1 in the Kern Water Bank area based on local calibrated model data to improve groundwater-surface water interactions along the Kern River to better match measured data in this key area.
C2VSimFG_BypassSpecs.dat	
*	Removed bypass #17
C2VSimFG_RootZone.dat	
*	Native return flow is sent to either nearby stream nodes as runoff or out-of-model as ET loss due to internal drainage to old lake beds
C2VSimFG_ReturnFlowFrac.dat	
*	Changed return flow fraction of Kern Ag to 0.06 as a slightly more conservative assumption that helps with overall validation to groundwater levels.
C2VSimFG_Urban_Area.dat	
*	Changed Kern County oil fields from urban to native vegetation
C2VSimFG_Urban_WaterUseSpecs.dat	
*	Set fractions for SRs 19-21 based on local info
C2VSimFG_NonPondedCrop.dat	
*	Return flow = 0 for Kern County
C2VSimFG_PondedCrop_Area.dat	
*	Modified distribution of rice to be limited to areas in northwest Kern County with historical rice production rather than uniform distribution across county
C2VSimFG_NativeVeg_Area.dat	
*	Rebalanced native veg distribution after redistribution of non-ponded crop area to maintain 1997 to 2017 native veg distribution

Table 11A - Historical Groundwater Budget for the Kern County Subbasin for Water Years 1995 to 2014 based on the C2VSimFG-Kern Historical Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	GW Pumping	Small Watershed Inflow	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1995	880,480	944,800	185,777	-946,782	122,287	-75,299	1,111,263
1996	801,572	926,537	106,692	-1,247,471	41,190	-84,675	543,845
1997	766,667	771,510	126,405	-1,068,169	50,548	-87,372	559,587
1998	1,034,867	1,097,180	121,413	-884,593	155,312	-87,515	1,436,665
1999	755,674	633,676	39,704	-1,109,310	32,155	-85,211	266,692
2000	617,018	462,522	91,454	-1,375,733	25,956	-83,759	-262,541
2001	551,880	222,131	66,647	-1,839,000	24,633	-81,896	-1,055,605
2002	466,463	202,687	76,147	-1,760,186	18,882	-83,943	-1,079,950
2003	502,831	297,019	118,149	-1,492,816	34,003	-85,638	-626,452
2004	488,327	284,862	83,294	-1,860,344	27,959	-89,250	-1,065,153
2005	799,614	1,147,287	132,785	-1,108,382	93,557	-89,912	974,946
2006	839,390	1,125,277	44,657	-1,149,877	40,846	-96,591	803,702
2007	560,860	403,611	26,260	-2,099,953	17,882	-91,566	-1,182,908
2008	463,721	146,763	78,841	-2,341,780	36,058	-86,260	-1,702,659
2009	485,234	186,548	73,848	-2,206,377	21,586	-85,764	-1,524,923
2010	599,434	467,683	141,715	-1,470,205	58,145	-94,664	-297,892
2011	1,073,963	1,530,123	259,404	-984,968	118,303	-94,981	1,901,842
2012	713,826	580,590	88,581	-1,583,369	19,020	-93,041	-274,395
2013	538,356	156,704	59,483	-2,447,479	19,043	-83,619	-1,757,511
2014	447,782	84,456	50,857	-2,830,674	17,832	-81,081	-2,310,831
Total	**13,387,959**	**11,671,966**	**1,972,113**	**-31,807,470**	**975,198**	**-1,742,039**	**-5,542,280**
Average	**669,398**	**583,598**	**98,606**	**-1,590,373**	**48,760**	**-87,102**	**-277,114**

Table 11B - Current Groundwater Budget for the Kern County Subbasin for Water Year 2015 based on the C2VSimFG-Kern Historical Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	GW Pumping	Subsurface Flow within GW Basin	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
2015	429,983	89,744	46,344	-2,740,237	0	-51,201	-2,225,366

NOTES:

Deep Percolation	Precipitation and applied water that reaches the groundwater after simulated transport across the unsaturated zone
Managed Recharge and Canal Seepage	Combined groundwater recharge from managed aquifer recharge operations, groundwater banking, and seepage from canals and other conveyance
Net GW/SW Interactions	Net volumetric exchange of surface water and groundwater from streams: Positive represents a net groundwater recharge, and negative represents a net groundwater discharge to the stream
GW Pumping	Total groundwater pumping by wells. Groundwater banking recovery pumping is specified input whereas agricultural and municipal pumping is calculated by C2VSim based on demand
Subsurface Flow within GW Basin	Net subsurface groundwater flow into a neighboring water district or area within the Kern County Subbasin: negative is a net flow out of the district and positive is a net flow into the district
Subsurface Flow with Adjacent GW Basins	Net subsurface groundwater flow from the Kern County Subbasin with an adjoining groundwater basin: negative is a net flow out of the Basin and positive is a net flow into the Basin
Change in Groundwater Storage	Sum of the inflow components (positive numbers) plus the outflow components (negative numbers): positive is an increase in storage typified by a rise in GW levels whereas a negative is a decrease in storage typified by a decline in GW levels

TABLE 12: Sustainable Yield for Kern County Subbasin for WY1995 to WY2014 Base Period based on C2VSimFG-Kern Historical Simulation

Water Year	Total Average Annual Volume	Agricultural Average Annual Volume	Agricultural Average Annual Volume per Ag Acre	Urban Average Annual Volume
Units	Acre-ft	Acre-ft	ft/acre	Acre-ft
	Sustainable Yield from Groundwater Pumping			
Groundwater Pumping	1,416,077	1,239,931	1.59	176,146
Percentage of Pumping		88%		12%
Change in Groundwater in Storage	-277,114	-242,644	-0.31	-34,470
Out-of-Basin Banking Obligations	-85,965	-75,272	-0.10	-10,693
Percentage of Pumping		-20%		-20%
Sustainable Yield	**1,052,998**			
Average Annual Difference	**-363,079**			
Percent Difference	**-34%**			
	Sutainable Yield from Basin Recharge and Outflow			
Groundwater Recharge	1,351,602	1,183,476	1.52	168,126
Groundwater Banking Exports	-174,272	-152,595	-0.20	-21,678
Out-of-Basin Banking Obligations	-85,965	-75,272	-0.10	-10,693
Subsurface Outflow	-87,102	-76,267	-0.10	-10,835
Sustainable Yield	**1,004,262**			
Average Annual Difference	**-411,815**			
Percent Difference	**-41%**			

NOTES:

Sustainable Yield from Groundwater Pumping Approach assumes that adjusting total groundwater pumping by the change in storage provides an reasonable approximation of the Basin Sustainable

Sutainable Yield from Basin Recharge and Outflow Approach assumes that the Basin Sustainable Yield can be reasonably approximated by adding up the different recharge components and non-

TABLE 13: Assessment of Potential Native Yield for Kern County Subbasin for WY1995 to WY2014 based on C2VSimFG-Kern Historical Simulation

	Ag Precipitation Recharge			Other Area Precipitation Recharge			Small Watershed Inflows			
Water Year	**Precipitation in Agricultural Area**	**Precipitation to ET Demand**	**Precipitation to Groundwater in Agricultural Area**	**Precipitation in Other Areas**	**Precipitation to ET Demand**	**Precipitation to Groundwater in Other Areas**	**Small Watershed Subsurface Inflow**	**Small Watershed Runoff Percolation**	**Small Watershed Recharge to Groundwater**	**Native Yield**
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1995	702,794	521,974	180,820	1,108,386	824,558	283,828	17,540	104,746	122,287	586,934
1996	381,496	351,540	29,956	526,809	422,541	104,268	17,512	23,679	41,190	175,414
1997	482,117	356,589	125,528	637,266	487,128	150,138	17,524	33,024	50,548	326,214
1998	966,485	663,632	302,853	1,492,576	1,024,918	467,658	17,840	137,472	155,312	925,823
1999	433,456	400,669	32,786	589,454	464,061	125,393	17,812	14,343	32,155	190,334
2000	384,158	357,496	26,661	476,308	398,994	77,315	17,757	8,200	25,956	129,933
2001	431,757	353,840	77,917	579,440	488,081	91,358	17,722	6,911	24,633	193,908
2002	255,111	227,877	27,234	382,463	317,069	65,394	17,679	1,203	18,882	111,510
2003	400,953	331,300	69,653	599,314	506,451	92,863	17,683	16,320	34,003	196,519
2004	301,023	275,258	25,765	422,514	339,652	82,862	17,661	10,298	27,959	136,586
2005	653,833	486,132	167,701	964,382	785,465	178,917	17,808	75,750	93,557	440,175
2006	499,756	447,319	52,437	657,647	546,950	110,697	17,783	23,063	40,846	203,981
2007	216,658	227,752	-11,095	292,814	241,483	51,331	17,725	157	17,882	58,119
2008	189,035	170,649	18,385	305,703	248,514	57,189	17,697	18,361	36,058	111,633
2009	268,010	221,348	46,663	405,160	336,116	69,044	17,674	3,913	21,586	137,293
2010	457,031	346,082	110,949	683,456	543,580	139,876	17,731	40,414	58,145	308,969
2011	649,878	441,717	208,161	1,023,701	692,781	330,919	17,932	100,370	118,303	657,382
2012	335,227	299,191	36,036	446,686	372,675	74,012	17,851	1,169	19,020	129,067
2013	214,951	203,005	11,946	303,560	246,644	56,916	17,787	1,257	19,043	87,906
2014	167,800	152,566	15,234	263,824	214,181	49,642	17,713	120	17,832	82,708
Total	**8,391,529**	**6,835,938**	**1,555,591**	**12,161,462**	**9,501,842**	**2,659,620**	**354,429**	**620,769**	**975,198**	**5,190,409**
Average	**419,576**	**341,797**	**77,780**	**608,073**	**475,092**	**132,981**	**17,721**	**31,038**	**48,760**	**259,520**
Use (ft/acre)	**0.54**	**0.44**	**0.10**	**0.59**	**0.46**	**0.13**	**0.01**	**0.02**	**0.03**	**0.144**

NOTES:

Simulation of Recharge	IWFM applies two processes to simulate the movement of water from the surface to the groundwater. The root zone simulates calculates the volume of water that will percolate below the root zone based on local soil properties. This water bases to the unsaturated zone that applies a 1-D vadose zone flow that simulates the rate that water will reach the groundwater based on subsurface properties and soil moisture content.
Percolation from Agricultural Area	Total volume of rainfall and applied water calculated to meet the total agricultural demand that percolates below the root zone in irrigated agricultural areas based on C2VSim simulation.
Percolation from Urban Area	Total volume of rainfall and applied water calculated to meet urban outdoor use that percolates below the root zone in urban areas based on C2VSim simulation.
Percolation from Native, Undeveloped or Fallow Areas	Total volume of rainfall and applied water that percolates below the root zone in native, undeveloped and fallow areas based on C2VSim simulation.
Percolation to Unsaturated Zone	Total volume of rainfall and applied water that percolates below the root zone from all areas based on C2VSim simulation.
GW Recharge from Unsaturated Zone	Volume of water going from the unsaturated zone to groundwater
GW Banking, Managed Recharge and Canal Seepage	Managed aquifer recharge and groundwater banking is simulated in C2VSim by applying a high recoverable loss factor for surface water diversions. For Kern County, these operations generally assumes that 88% to 94% of surface water deliveries physically recharge groundwater. This recharge is applied directly to the groundwater without passing through the unsaturated zone.
Net GW/SW Interactions	Net volumetric exchange between surface water in Kern River or Poso Creek and the groundwater. A positive number is surface water to groundwater, and a negative is groundwater discharge to the stream. This recharge is applied directly to the groundwater without passing through the unsaturated zone.
Total GW Recharge	Total volume to water reaching the groundwater as recharge

Table 14 - Hydrologic Year Correlation with Relevant River Indices for Projected Future Simulation Period

Project Year	Hydrology Year	Annual Kern River Index	San Joaquin River Index
2021	**2003**	71	Below Normal
2022	**2004**	56	Dry
2023	**2005**	159	Wet
2024	**2006**	147	Wet
2025	**2007**	35	Critical
2026	**2008**	71	Critical
2027	**2009**	65	Below Normal
2028	**2010**	126	Above Normal
2029	**2011**	201	Wet
2030	**2012**	45	Dry
2031	**2013**	28	Critical
2032	**2014**	24	Critical
2033	**1995**	191	Wet
2034	**1996**	136	Wet
2035	**1997**	162	Wet
2036	**1998**	236	Wet
2037	**1999**	60	Above Normal
2038	**2000**	66	Above Normal
2039	**2001**	54	Dry
2040	**2002**	58	Dry
2041	**2003**	71	Below Normal
2042	**2004**	56	Dry
2043	**2005**	159	Wet
2044	**2006**	147	Wet
2045	**2007**	35	Critical
2046	**2008**	71	Critical
2047	**2009**	65	Below Normal
2048	**2010**	126	Above Normal
2049	**2011**	201	Wet
2050	**2012**	45	Dry
2051	**2013**	28	Critical
2052	**2014**	24	Critical
2053	**1995**	191	Wet
2054	**1996**	136	Wet
2055	**1997**	162	Wet
2056	**1998**	236	Wet
2057	**1999**	60	Above Normal
2058	**2000**	66	Above Normal
2059	**2001**	54	Dry
2060	**2002**	58	Dry
2061	**2003**	71	Below Normal
2062	**2004**	56	Dry
2063	**2005**	159	Wet
2064	**2006**	147	Wet
2065	**2007**	35	Critical
2066	**2008**	71	Critical
2067	**2009**	65	Below Normal
2068	**2010**	126	Above Normal
2069	**2011**	201	Wet
2070	**2012**	45	Dry

Table 16 - Projected Future Groundwater Budget for Kern County Subbasin under Baseline Conditions with NO SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	30,942,871	26,407,594	6,504,806	2,457,805	-81,187,349	-4,201,244	**-19,075,537**
Average	618,857	528,152	130,096	49,156	-1,623,747	-84,025	**-381,511**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	11,951,352	10,419,890	2,658,980	948,239	-32,696,313	-1,708,561	**-8,426,431**
Average	597,568	520,995	132,949	47,412	-1,634,816	-85,428	**-421,322**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	18,991,518	15,987,704	3,845,827	1,509,566	-48,491,035	-2,492,683	**-10,649,106**
Average	633,051	532,923	128,194	50,319	-1,616,368	-83,089	**-354,970**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	431,092	257,161	124,707	38,770	-1,673,022	-90,042	-911,335
2022	475,816	310,451	81,251	28,596	-1,968,878	-87,024	-1,159,794
2023	654,987	865,602	188,611	97,803	-1,150,982	-84,077	571,939
2024	755,746	916,321	261,679	67,141	-1,054,808	-89,930	856,146
2025	487,187	300,980	76,771	18,060	-2,054,989	-86,462	-1,258,455
2026	441,440	153,041	79,202	36,473	-2,354,582	-76,814	-1,721,244
2027	503,691	251,642	74,302	21,942	-2,088,012	-76,503	-1,312,939
2028	577,793	486,698	142,758	35,496	-1,540,870	-79,169	-377,289
2029	1,000,215	1,465,457	112,006	119,558	-919,492	-90,199	1,687,546
2030	679,312	559,960	65,194	19,157	-1,431,696	-90,169	-198,241
2031	552,058	159,876	110,399	19,161	-2,469,186	-84,621	-1,712,314
2032	430,890	109,862	67,123	18,134	-2,887,650	-74,477	-2,336,117
2033	716,021	804,684	191,530	126,420	-1,082,677	-80,985	674,993
2034	615,806	746,086	205,884	42,156	-1,428,698	-88,747	92,487
2035	698,211	678,351	313,314	52,652	-1,137,639	-92,037	512,853
2036	843,395	1,059,047	202,784	103,683	-895,891	-93,743	1,219,275
2037	617,698	522,642	112,063	32,114	-1,246,673	-92,793	-54,950
2038	531,115	385,956	107,663	26,241	-1,397,233	-88,354	-434,612
2039	500,386	192,061	66,474	25,370	-1,931,072	-83,306	-1,230,087
2040	438,493	194,012	75,262	19,311	-1,982,263	-79,110	-1,334,294
2041	479,844	257,242	125,640	34,980	-1,631,792	-77,464	-811,551
2042	528,753	310,511	81,592	28,467	-1,960,174	-77,542	-1,088,393
2043	715,343	865,642	187,950	100,835	-1,144,519	-76,758	648,492
2044	817,195	916,342	243,192	68,630	-1,049,968	-84,464	910,927
2045	521,353	300,980	73,340	18,136	-2,050,665	-82,645	-1,219,502
2046	467,689	153,041	79,662	36,599	-2,350,525	-74,132	-1,687,666
2047	523,562	251,642	74,726	22,117	-2,084,572	-74,541	-1,287,067
2048	597,206	486,698	143,075	35,645	-1,536,980	-77,817	-352,174
2049	1,020,598	1,465,459	113,006	121,871	-916,413	-89,595	1,714,926
2050	691,733	559,960	65,288	19,216	-1,428,479	-90,136	-182,419
2051	567,327	159,876	110,671	19,218	-2,464,464	-84,725	-1,692,096
2052	447,074	109,862	67,348	18,007	-2,850,102	-74,614	-2,282,424
2053	724,472	804,684	191,978	127,393	-1,079,363	-81,325	687,840
2054	621,450	746,086	206,284	42,236	-1,424,676	-89,360	102,020
2055	697,310	678,351	313,884	52,738	-1,133,782	-93,038	515,463
2056	931,689	1,059,143	211,748	169,221	-844,773	-94,849	1,432,180
2057	655,811	522,642	112,759	33,376	-1,242,088	-94,073	-11,573
2058	554,562	385,956	107,881	26,454	-1,393,471	-89,712	-408,330
2059	518,487	192,061	66,598	25,586	-1,926,935	-84,290	-1,208,493
2060	455,206	194,012	75,379	19,353	-1,919,531	-80,126	-1,255,706
2061	491,662	257,242	125,741	34,990	-1,628,261	-78,506	-797,132
2062	540,767	310,511	81,687	28,658	-1,956,080	-78,583	-1,073,040
2063	730,572	865,642	188,317	103,344	-1,141,145	-77,884	668,846
2064	776,159	916,342	246,850	42,092	-1,080,869	-86,054	814,520
2065	513,728	300,980	74,551	18,276	-2,046,249	-84,491	-1,223,205
2066	470,743	153,041	79,921	36,483	-2,346,330	-76,100	-1,682,242
2067	528,523	251,642	74,935	22,151	-2,080,910	-76,831	-1,280,490
2068	661,663	486,698	142,804	60,396	-1,436,648	-79,047	-164,134
2069	1,040,160	1,465,459	113,460	123,705	-913,375	-91,621	1,737,788
2070	700,878	559,960	65,558	19,394	-1,427,896	-92,362	-174,470

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Table 17 - Projected Future Groundwater Budget for Kern County Subbasin under Baseline Conditions WITH SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	33,387,078	29,420,682	5,852,965	2,457,805	-67,979,441	-5,642,551	**-2,503,487**
Average	667,742	588,414	117,059	49,156	-1,359,589	-112,851	**-50,070**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	12,673,404	11,430,370	2,465,543	948,239	-29,144,885	-1,914,551	**-3,541,904**
Average	633,670	571,518	123,277	47,412	-1,457,244	-95,728	**-177,095**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	20,713,673	17,990,313	3,387,422	1,509,566	-38,834,555	-3,728,000	**1,038,418**
Average	690,456	599,677	112,914	50,319	-1,294,485	-124,267	**34,614**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	438,506	285,229	124,696	38,770	-1,588,405	-92,056	-793,259
2022	484,943	332,923	81,401	28,596	-1,869,400	-89,635	-1,031,173
2023	747,565	929,925	181,044	97,803	-1,055,850	-86,957	813,528
2024	822,429	979,290	228,277	67,141	-970,427	-93,017	1,033,691
2025	485,883	305,310	74,786	18,060	-1,922,678	-90,920	-1,129,567
2026	428,742	193,801	78,064	36,473	-2,246,543	-81,991	-1,591,454
2027	488,986	295,184	72,924	21,942	-1,980,297	-83,041	-1,184,303
2028	589,504	560,246	139,196	35,496	-1,411,249	-86,090	-172,895
2029	1,117,096	1,534,485	97,777	119,558	-766,833	-97,039	2,005,045
2030	679,411	565,264	63,373	19,157	-1,290,734	-98,635	-62,164
2031	541,540	162,351	110,189	19,161	-2,282,247	-96,146	-1,545,155
2032	441,935	112,432	67,508	18,134	-2,691,050	-90,556	-2,141,604
2033	859,254	919,119	182,854	126,420	-870,791	-94,090	1,122,766
2034	668,322	822,664	192,280	42,156	-1,173,675	-101,692	450,056
2035	784,526	798,773	284,615	52,652	-897,225	-105,253	918,089
2036	1,034,843	1,210,706	153,014	103,683	-650,599	-108,011	1,743,636
2037	644,248	560,331	94,651	32,114	-1,006,357	-108,561	216,426
2038	516,204	433,971	97,288	26,241	-1,129,713	-106,833	-162,843
2039	489,932	215,829	66,245	25,370	-1,664,753	-103,525	-970,903
2040	409,536	212,534	75,360	19,311	-1,676,059	-100,504	-1,059,821
2041	453,324	299,058	124,597	34,980	-1,341,636	-100,007	-529,684
2042	502,042	341,354	81,470	28,467	-1,640,917	-101,775	-789,360
2043	814,606	983,531	170,389	100,835	-895,370	-101,316	1,072,674
2044	910,857	1,034,642	180,887	68,630	-835,118	-109,430	1,250,469
2045	521,915	315,448	64,301	18,136	-1,739,889	-109,783	-929,871
2046	441,299	203,570	78,166	36,599	-2,059,728	-102,966	-1,403,060
2047	508,422	304,623	73,192	22,117	-1,807,101	-105,348	-1,004,096
2048	627,841	599,489	138,742	35,645	-1,279,707	-109,328	12,682
2049	1,207,124	1,582,570	92,749	121,871	-699,689	-120,788	2,183,838
2050	715,904	572,082	62,576	19,216	-1,147,620	-123,585	98,574
2051	566,731	169,466	109,535	19,218	-2,098,372	-122,310	-1,355,733
2052	460,099	118,999	67,410	18,007	-2,475,354	-117,801	-1,928,640
2053	911,979	930,151	181,291	127,393	-779,720	-120,542	1,250,552
2054	706,309	828,896	186,647	42,236	-1,026,541	-129,010	608,538
2055	815,225	808,705	273,436	52,738	-820,029	-132,486	997,588
2056	1,220,307	1,220,810	143,076	169,221	-583,006	-134,619	2,035,787
2057	728,598	563,409	84,816	33,376	-925,334	-135,590	349,275
2058	575,169	435,811	93,112	26,454	-1,041,644	-134,076	-45,174
2059	537,607	217,172	65,865	25,586	-1,522,045	-130,703	-806,518
2060	443,476	214,412	75,216	19,353	-1,486,408	-127,955	-861,906
2061	476,733	299,707	124,039	34,990	-1,256,091	-127,367	-447,988
2062	522,517	342,004	81,198	28,658	-1,494,732	-129,480	-649,837
2063	842,570	984,995	164,987	103,344	-865,981	-128,285	1,101,631
2064	912,864	1,036,106	168,792	42,092	-824,554	-136,560	1,198,740
2065	536,563	316,098	60,871	18,276	-1,633,199	-137,469	-838,861
2066	459,136	204,216	77,908	36,483	-1,928,338	-130,987	-1,281,582
2067	523,840	305,272	72,906	22,151	-1,681,701	-133,885	-891,417
2068	756,365	600,955	138,230	60,396	-1,152,716	-136,113	267,118
2069	1,256,008	1,584,033	90,058	123,705	-677,244	-147,778	2,228,780
2070	758,243	572,731	60,963	19,394	-1,114,770	-150,662	145,898

Table 18 - Projected Future Groundwater Budget for Kern County Subbasin under 2030 Climate Conditions with NO SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	30,406,971	29,339,119	6,327,055	2,517,393	-86,788,414	-3,819,475	**-22,017,372**
Average	608,139	586,782	126,541	50,348	-1,735,768	-76,389	**-440,347**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	11,794,171	11,577,682	2,566,294	967,011	-34,895,955	-1,620,997	**-9,611,815**
Average	589,709	578,884	128,315	48,351	-1,744,798	-81,050	**-480,591**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	18,612,800	17,761,437	3,760,762	1,550,382	-51,892,459	-2,198,478	**-12,405,557**
Average	620,427	592,048	125,359	51,679	-1,729,749	-73,283	**-413,519**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	429,801	266,621	147,726	42,134	-1,760,507	-89,485	-963,710
2022	495,782	350,434	98,398	31,229	-2,063,486	-85,888	-1,173,532
2023	657,377	938,152	192,323	100,122	-1,262,715	-83,042	542,211
2024	699,315	964,377	183,699	64,551	-1,207,497	-88,046	616,394
2025	453,515	298,894	70,475	18,068	-2,099,053	-84,337	-1,342,442
2026	438,475	211,691	132,834	37,800	-2,421,834	-74,881	-1,675,915
2027	475,056	242,088	116,257	23,732	-2,243,832	-73,567	-1,460,266
2028	584,278	554,269	191,570	39,445	-1,707,009	-74,319	-411,764
2029	1,184,130	1,838,027	119,236	122,295	-1,141,893	-85,285	2,036,509
2030	551,212	516,323	55,121	19,641	-1,526,323	-84,001	-468,028
2031	515,256	195,193	77,160	18,143	-2,435,739	-79,350	-1,709,339
2032	412,101	141,644	46,910	17,968	-2,917,906	-68,881	-2,368,165
2033	705,949	858,275	183,650	122,210	-1,221,991	-75,654	572,438
2034	608,912	835,355	151,564	45,764	-1,553,837	-82,718	5,039
2035	736,051	805,594	299,717	55,297	-1,318,053	-86,250	492,354
2036	856,734	1,179,748	139,319	102,926	-1,048,605	-88,527	1,141,594
2037	549,368	496,346	84,153	32,384	-1,359,301	-86,074	-283,124
2038	517,749	434,834	86,857	27,413	-1,508,027	-81,722	-522,896
2039	486,869	213,407	87,775	26,084	-2,058,425	-76,725	-1,321,014
2040	436,242	236,409	101,552	19,804	-2,039,923	-72,244	-1,318,160
2041	468,388	265,794	147,815	39,151	-1,718,118	-70,242	-867,212
2042	539,545	352,187	98,721	31,228	-2,054,079	-69,819	-1,102,217
2043	708,149	936,725	187,725	103,193	-1,256,110	-69,228	610,454
2044	752,733	964,701	141,049	65,724	-1,202,714	-76,356	645,137
2045	478,985	298,488	59,556	18,138	-2,094,488	-74,534	-1,313,855
2046	460,252	211,504	133,158	37,870	-2,417,639	-66,341	-1,641,195
2047	491,476	242,301	116,368	23,946	-2,240,282	-66,079	-1,432,270
2048	598,731	553,200	191,811	39,636	-1,702,832	-67,702	-387,155
2049	1,195,910	1,840,650	110,980	124,949	-1,138,391	-79,663	2,054,435
2050	559,732	517,261	52,409	19,693	-1,522,960	-79,133	-452,999
2051	523,154	195,193	77,219	18,193	-2,431,497	-74,903	-1,692,640
2052	422,530	137,917	46,976	17,931	-2,886,044	-64,842	-2,325,533
2053	707,015	859,779	184,316	123,682	-1,218,433	-72,058	584,301
2054	609,414	833,943	150,995	45,880	-1,549,633	-79,575	11,025
2055	732,232	805,822	298,010	55,392	-1,314,039	-83,611	493,807
2056	928,888	1,178,928	149,824	169,164	-993,641	-86,087	1,347,076
2057	576,909	493,935	84,196	33,640	-1,355,384	-83,745	-250,448
2058	538,662	437,650	87,066	27,628	-1,504,171	-79,389	-492,554
2059	503,402	214,796	87,753	26,299	-2,054,234	-74,306	-1,296,288
2060	451,522	236,977	101,432	19,792	-1,984,344	-70,103	-1,244,725
2061	478,796	265,975	147,869	39,158	-1,714,445	-68,401	-851,049
2062	550,809	351,281	98,718	31,426	-2,049,977	-68,093	-1,085,837
2063	722,818	938,420	188,697	104,939	-1,252,649	-67,820	634,404
2064	715,791	963,206	146,069	41,649	-1,229,743	-75,400	561,571
2065	475,418	298,806	61,265	18,289	-2,090,191	-73,868	-1,310,281
2066	465,005	211,102	133,136	37,782	-2,413,360	-65,953	-1,632,289
2067	498,090	242,117	116,493	23,923	-2,236,433	-65,997	-1,421,808
2068	670,255	553,410	192,083	65,542	-1,609,843	-66,655	-195,208
2069	1,217,773	1,839,574	115,521	126,664	-1,135,132	-79,491	2,084,909
2070	570,417	519,795	53,528	19,883	-1,521,656	-79,082	-437,115

Table 19 - Projected Future Groundwater Budget for Kern County Subbasin under 2030 Climate Conditions WITH SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	32,439,318	32,289,237	5,616,681	2,517,393	-72,758,546	-5,302,496	**-5,198,445**
Average	648,786	645,785	112,334	50,348	-1,455,171	-106,050	**-103,969**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	12,469,935	12,560,244	2,378,883	967,011	-31,230,653	-1,828,732	**-4,683,343**
Average	623,497	628,012	118,944	48,351	-1,561,533	-91,437	**-234,167**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	19,969,383	19,728,994	3,237,798	1,550,382	-41,527,893	-3,473,764	**-515,102**
Average	665,646	657,633	107,927	51,679	-1,384,263	-115,792	**-17,170**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	441,652	292,996	147,069	42,134	-1,671,535	-91,596	-839,279
2022	503,391	371,339	98,721	31,229	-1,962,336	-88,496	-1,046,156
2023	753,413	1,002,660	184,247	100,122	-1,165,732	-85,624	789,081
2024	759,876	1,024,098	159,689	64,551	-1,120,136	-90,877	797,201
2025	450,559	302,266	67,803	18,068	-1,965,427	-88,796	-1,215,531
2026	427,255	252,554	132,707	37,800	-2,311,777	-79,914	-1,541,375
2027	476,442	285,312	116,391	23,732	-2,129,441	-80,216	-1,307,785
2028	591,734	625,082	188,060	39,445	-1,574,434	-81,148	-211,265
2029	1,289,576	1,905,958	98,151	122,295	-976,046	-92,153	2,347,781
2030	542,503	521,613	50,945	19,641	-1,379,429	-92,754	-337,488
2031	501,396	197,443	77,459	18,143	-2,252,423	-90,623	-1,548,606
2032	426,472	144,335	47,362	17,968	-2,715,519	-84,772	-2,164,155
2033	864,855	970,952	180,158	122,210	-999,603	-88,821	1,049,751
2034	649,853	908,366	135,371	45,764	-1,291,972	-95,791	351,590
2035	815,853	925,239	267,880	55,297	-1,067,406	-99,481	897,381
2036	1,040,723	1,329,469	101,824	102,926	-786,905	-102,460	1,685,577
2037	556,956	534,420	62,036	32,384	-1,113,410	-102,222	-29,835
2038	500,495	478,749	73,664	27,413	-1,237,898	-100,665	-258,241
2039	475,271	235,303	87,425	26,084	-1,780,634	-97,586	-1,054,138
2040	401,662	252,089	101,921	19,804	-1,728,590	-94,737	-1,047,853
2041	444,635	305,751	148,046	39,151	-1,417,821	-93,784	-574,022
2042	511,794	381,811	98,698	31,228	-1,732,709	-94,600	-803,778
2043	814,085	1,054,879	164,977	103,193	-981,693	-94,228	1,061,212
2044	840,227	1,081,322	89,637	65,724	-951,613	-101,997	1,023,300
2045	469,643	312,573	47,742	18,138	-1,792,701	-102,528	-1,047,133
2046	435,603	262,180	132,908	37,870	-2,120,184	-95,827	-1,347,449
2047	486,874	294,995	116,428	23,946	-1,946,133	-97,562	-1,121,453
2048	607,958	663,346	188,107	39,636	-1,411,843	-99,958	-12,754
2049	1,352,884	1,956,195	71,870	124,949	-850,441	-112,046	2,543,410
2050	551,433	529,184	41,023	19,693	-1,229,490	-113,831	-201,988
2051	512,537	204,559	77,384	18,193	-2,067,798	-113,040	-1,368,166
2052	429,928	147,354	47,320	17,931	-2,501,030	-108,107	-1,966,604
2053	904,991	983,485	179,758	123,682	-884,881	-111,900	1,195,134
2054	672,032	913,349	123,349	45,880	-1,118,165	-120,278	516,169
2055	838,683	935,521	251,597	55,392	-953,395	-124,317	1,003,480
2056	1,179,632	1,338,655	91,523	169,164	-689,640	-126,838	1,962,496
2057	615,797	535,086	49,219	33,640	-1,010,391	-126,902	96,449
2058	549,760	483,296	65,719	27,628	-1,125,055	-125,593	-124,246
2059	509,922	237,931	86,168	26,299	-1,633,859	-122,678	-896,216
2060	426,496	254,555	101,961	19,792	-1,541,056	-120,134	-858,386
2061	460,712	306,605	148,114	39,158	-1,322,148	-119,371	-486,930
2062	524,936	381,579	98,394	31,426	-1,601,565	-120,728	-685,959
2063	835,547	1,057,875	157,729	104,939	-945,160	-119,767	1,091,162
2064	842,924	1,081,555	77,039	41,649	-935,533	-127,694	979,940
2065	480,247	313,450	44,212	18,289	-1,670,834	-128,903	-943,540
2066	447,484	262,406	132,774	37,782	-1,985,427	-122,696	-1,227,678
2067	494,592	295,496	116,447	23,923	-1,814,397	-125,148	-1,009,086
2068	739,200	665,024	188,483	65,542	-1,281,311	-125,683	251,254
2069	1,401,442	1,956,602	63,193	126,664	-825,735	-137,931	2,584,235
2070	587,384	532,378	37,980	19,883	-1,185,886	-139,694	-147,956

Table 20 - Projected Future Groundwater Budget for Kern County Subbasin under 2070 Climate Conditions with NO SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	29,855,454	31,748,130	5,838,562	2,495,122	-93,484,380	-3,716,462	**-27,263,599**
Average	597,109	634,963	116,771	49,902	-1,869,688	-74,329	**-545,272**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	11,667,139	12,563,708	2,365,431	960,586	-37,578,197	-1,596,743	**-11,618,097**
Average	583,357	628,185	118,272	48,029	-1,878,910	-79,837	**-580,905**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	18,188,315	19,184,423	3,473,131	1,534,536	-55,906,182	-2,119,719	**-15,645,502**
Average	606,277	639,481	115,771	51,151	-1,863,539	-70,657	**-521,517**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	416,481	252,197	140,505	38,275	-1,916,977	-89,491	-1,159,011
2022	479,395	367,510	96,033	30,903	-2,196,603	-85,085	-1,307,854
2023	664,962	1,025,761	190,043	97,206	-1,442,091	-82,544	453,337
2024	724,274	1,071,819	165,600	64,640	-1,325,764	-88,575	611,993
2025	437,410	310,633	66,267	18,095	-2,191,088	-84,783	-1,443,470
2026	453,984	314,891	142,497	42,165	-2,485,140	-75,450	-1,607,054
2027	442,110	216,204	111,416	22,713	-2,402,106	-72,832	-1,682,495
2028	574,563	607,420	195,132	37,491	-1,835,239	-73,491	-494,127
2029	1,202,516	1,957,433	104,229	120,391	-1,309,793	-83,999	1,990,777
2030	513,581	494,042	52,038	18,406	-1,660,571	-82,431	-664,937
2031	502,891	213,163	80,419	18,510	-2,511,904	-77,804	-1,774,725
2032	393,359	107,286	41,452	17,864	-3,092,461	-66,511	-2,599,013
2033	696,126	930,068	185,421	124,666	-1,400,033	-73,829	462,419
2034	634,583	972,610	136,241	48,403	-1,641,946	-81,216	68,676
2035	739,613	887,147	260,766	52,829	-1,536,041	-84,062	320,252
2036	824,846	1,288,751	80,025	95,355	-1,252,333	-86,150	950,494
2037	522,211	536,271	63,057	33,462	-1,479,140	-83,545	-407,683
2038	538,747	524,392	76,691	30,839	-1,626,331	-79,651	-535,314
2039	491,330	261,821	87,605	29,526	-2,123,486	-75,076	-1,328,280
2040	414,155	224,291	89,995	18,846	-2,149,151	-70,217	-1,472,081
2041	438,445	251,405	141,679	34,801	-1,877,457	-67,674	-1,078,801
2042	509,477	369,168	96,294	30,811	-2,187,705	-66,710	-1,248,664
2043	696,160	1,024,387	177,104	99,819	-1,435,142	-66,441	495,888
2044	756,947	1,072,105	106,435	65,709	-1,320,828	-74,548	605,820
2045	457,262	310,212	51,441	18,140	-2,186,589	-72,831	-1,422,366
2046	474,254	314,643	142,906	42,210	-2,480,901	-64,826	-1,571,714
2047	456,940	216,525	111,535	22,758	-2,398,002	-63,398	-1,653,643
2048	586,068	606,321	195,452	37,553	-1,830,906	-65,169	-470,681
2049	1,188,964	1,960,048	91,267	122,702	-1,306,273	-76,827	1,979,882
2050	517,131	494,976	48,720	18,437	-1,656,734	-76,179	-653,649
2051	510,486	213,163	80,487	18,541	-2,507,662	-72,026	-1,757,012
2052	403,735	103,564	41,526	17,846	-3,061,164	-61,436	-2,555,929
2053	695,014	931,618	185,940	125,947	-1,396,428	-69,356	472,735
2054	633,902	971,316	135,132	48,546	-1,637,822	-77,280	73,794
2055	732,625	887,092	261,025	53,236	-1,531,884	-80,730	321,364
2056	900,739	1,288,161	93,033	163,750	-1,192,877	-83,188	1,169,618
2057	545,822	533,858	64,903	34,610	-1,476,198	-80,687	-377,693
2058	554,199	527,156	78,060	31,051	-1,622,403	-76,836	-508,777
2059	505,085	263,151	87,864	29,722	-2,119,167	-72,159	-1,305,505
2060	430,917	224,893	90,023	18,987	-2,096,758	-67,709	-1,399,646
2061	450,288	251,640	141,681	34,761	-1,873,608	-65,447	-1,060,686
2062	521,238	368,299	96,344	30,984	-2,183,668	-64,671	-1,231,474
2063	708,640	1,025,986	180,653	100,139	-1,431,345	-64,816	519,256
2064	718,253	1,070,667	117,470	41,720	-1,344,539	-73,390	530,181
2065	452,517	310,495	54,738	18,277	-2,181,935	-72,048	-1,417,957
2066	477,892	314,225	142,888	41,907	-2,476,370	-64,278	-1,563,735
2067	463,710	216,282	111,638	22,808	-2,394,356	-63,020	-1,642,938
2068	662,509	606,642	195,649	66,128	-1,739,184	-63,466	-271,721
2069	1,210,375	1,958,939	100,259	124,017	-1,302,864	-76,483	2,014,244
2070	528,721	497,487	50,984	18,619	-1,655,415	-76,092	-635,695

Table 21 - Projected Future Groundwater Budget for Kern County Subbasin under 2070 Climate Conditions WITH SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	31,493,119	34,676,204	5,023,196	2,495,122	-78,465,457	-5,281,242	**-10,059,104**
Average	629,862	693,524	100,464	49,902	-1,569,309	-105,625	**-201,182**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	12,261,512	13,537,356	2,149,791	960,586	-33,710,341	-1,821,159	**-6,622,296**
Average	613,076	676,868	107,490	48,029	-1,685,517	-91,058	**-331,115**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	19,231,606	21,138,848	2,873,405	1,534,536	-44,755,117	-3,460,083	**-3,436,808**
Average	641,054	704,628	95,780	51,151	-1,491,837	-115,336	**-114,560**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	422,584	279,759	140,794	38,275	-1,825,598	-91,619	-1,035,805
2022	488,253	387,562	96,265	30,903	-2,091,767	-87,769	-1,176,558
2023	760,000	1,090,884	181,941	97,206	-1,338,893	-85,110	706,028
2024	773,005	1,131,177	139,187	64,640	-1,234,584	-91,304	782,116
2025	434,474	313,620	63,094	18,095	-2,054,146	-89,407	-1,314,285
2026	445,787	355,840	141,941	42,165	-2,372,644	-80,742	-1,467,659
2027	439,786	259,693	111,505	22,713	-2,274,718	-80,113	-1,521,134
2028	583,608	676,951	191,628	37,491	-1,697,617	-80,739	-288,677
2029	1,303,985	2,026,066	79,306	120,391	-1,131,751	-91,248	2,306,749
2030	503,719	499,229	45,905	18,406	-1,499,669	-91,675	-524,087
2031	490,364	215,537	80,773	18,510	-2,320,939	-90,191	-1,605,946
2032	403,661	110,577	41,677	17,864	-2,869,425	-84,801	-2,380,448
2033	842,198	1,041,181	181,775	124,666	-1,160,289	-88,517	941,013
2034	666,308	1,042,279	113,056	48,403	-1,373,274	-95,543	401,229
2035	798,592	1,006,455	226,577	52,829	-1,274,011	-98,591	711,850
2036	1,003,079	1,437,909	43,126	95,355	-970,366	-101,265	1,507,839
2037	517,484	574,060	39,346	33,462	-1,219,067	-101,319	-156,042
2038	522,992	565,610	57,977	30,839	-1,340,898	-100,165	-263,645
2039	476,901	282,303	83,746	29,526	-1,835,107	-97,127	-1,059,757
2040	384,733	240,665	90,169	18,846	-1,825,578	-93,914	-1,185,079
2041	415,234	291,710	141,934	34,801	-1,558,507	-92,234	-767,063
2042	488,101	398,308	96,079	30,811	-1,853,284	-92,666	-932,652
2043	795,992	1,142,687	149,122	99,819	-1,130,721	-92,492	964,407
2044	827,366	1,187,351	53,341	65,709	-1,040,595	-101,396	991,776
2045	446,716	324,312	38,470	18,140	-1,865,630	-102,037	-1,140,029
2046	454,194	365,422	142,233	42,210	-2,175,138	-95,467	-1,266,545
2047	444,486	269,482	111,552	22,758	-2,081,680	-96,538	-1,329,940
2048	602,382	715,182	191,735	37,553	-1,523,098	-98,688	-74,935
2049	1,322,298	2,075,690	44,846	122,702	-980,786	-110,495	2,474,256
2050	506,042	506,798	33,881	18,437	-1,348,791	-112,175	-395,808
2051	497,261	222,653	80,767	18,541	-2,135,563	-111,952	-1,428,294
2052	412,782	113,602	41,562	17,846	-2,646,693	-107,795	-2,168,698
2053	878,381	1,053,760	180,055	125,947	-1,020,278	-111,749	1,106,115
2054	680,355	1,047,604	96,547	48,546	-1,201,766	-120,116	551,169
2055	808,384	1,016,456	211,305	53,236	-1,126,260	-123,937	839,183
2056	1,103,522	1,447,318	34,076	163,750	-841,985	-126,343	1,780,338
2057	560,571	574,729	27,201	34,610	-1,104,554	-126,628	-34,071
2058	554,438	570,084	51,089	31,051	-1,215,417	-125,923	-134,678
2059	500,014	284,874	80,658	29,722	-1,681,951	-122,984	-909,668
2060	403,999	243,162	90,080	18,987	-1,629,275	-120,297	-993,343
2061	427,754	292,603	141,811	34,761	-1,441,130	-119,027	-663,230
2062	497,998	398,114	95,618	30,984	-1,716,447	-119,828	-813,562
2063	812,053	1,145,589	142,445	100,139	-1,073,331	-119,247	1,007,647
2064	825,436	1,187,643	45,517	41,720	-1,020,722	-128,395	951,199
2065	448,678	325,153	36,161	18,277	-1,751,430	-129,714	-1,052,875
2066	461,891	365,635	142,103	41,907	-2,036,884	-123,666	-1,149,015
2067	458,166	269,922	111,553	22,808	-1,942,466	-125,187	-1,205,203
2068	717,810	716,972	192,414	66,128	-1,381,278	-125,575	186,470
2069	1,353,720	2,076,064	37,797	124,017	-944,642	-137,837	2,509,119
2070	525,583	509,971	31,455	18,619	-1,284,815	-139,693	-338,879

TABLE 22: Evaluation of Change in Groundwater Storage Model Results for Kern County Subbasin

	Model Results 2041-2070 Sustainability Period		Adjustments to GW Storage Change 2041-2070 Sustainability Period			Adjustments for Banking 2041-2070 Sustainability Period	
Scenario	**Change in Groundwater Storage**	**Change in Net Operational Budget**	Adjustment for Excess Basin Outflows	Adjustment for Excess Kern River Outflow	**Adjusted Change in GW Storage**	Adjusted Banking Obligation	**Δ Total Operational Storage**
units	**AFY**	**AFY**	AFY	AFY	**AFY**	AFY	**AFY**
Historic	**-277,114**	**-190,012**	0	0	**-277,114**	85,965	**-363,079**
Baseline	**-354,970**	**-271,881**	0	0	**-354,970**	69,632	**-424,602**
Base Projects	**34,614**	**158,881**	28,894	9,454	**72,963**	69,632	**3,331**
2030 Climate	**-413,519**	**-340,236**	0	6,242	**-407,276**	67,913	**-475,189**
2030 Projects	**-17,170**	**98,622**	29,952	21,230	**34,012**	67,913	**-33,901**
2070 Climate	**-521,517**	**-450,859**	0	13,879	**-507,637**	64,474	**-572,111**
2070 Projects	**-114,560**	**776**	32,076	31,385	**-51,099**	64,474	**-115,573**

NOTE:
"Change in *Groundwater Storage*" DOES include both subsurface flow with adjacent basins
"*Operational Storage*" DOES NOT include subsurface flow with adjacent basins
"Adjustment for *Excess Basin Outflows*" is the difference in simulated basin outflow that is attributed to addition of SGMA
"Adjustment for *Excess Kern River Outflow*" is the increase in simulated groundwater outflows to Kern River relative to Baseline
"*Adjusted Banking Obligation*" assumes that recharge operations are affected by reductions in imported water sources, but that banking recovery would be comparable to historical, resulting in decreased excess banking obligations in future conditions.
"*Δ Total Operational Storage*" is the Adjusted Change in GW Storage reduced by the volume of stored groundwater obligated to out-of-basin agencies.

TABLE 23: Evaluation of Sustainable Yield based on C2VSimFG-Kern Model Results for Kern County Subbasin

	Model Results 2041-2070 Sustainability Period			
Scenario	**Groundwater Pumping**	**Sustainable Yield**	**Average Annual Difference**	**Percent Difference**
units	**AFY**	AFY	AFY	**AFY**
Historic	**1,416,077**	**1,052,998**	**-363,079**	**-34%**
Baseline	**1,430,885**	**1,006,283**	**-424,602**	**-42%**
Base Projects	**1,103,639**	**1,106,970**	**3,331**	**0%**
2030 Climate	**1,544,256**	**1,069,067**	**-475,189**	**-44%**
2030 Projects	**1,193,412**	**1,159,511**	**-33,901**	**-3%**
2070 Climate	**1,678,037**	**1,105,925**	**-572,111**	**-52%**
2070 Projects	**1,300,977**	**1,185,404**	**-115,573**	**-10%**

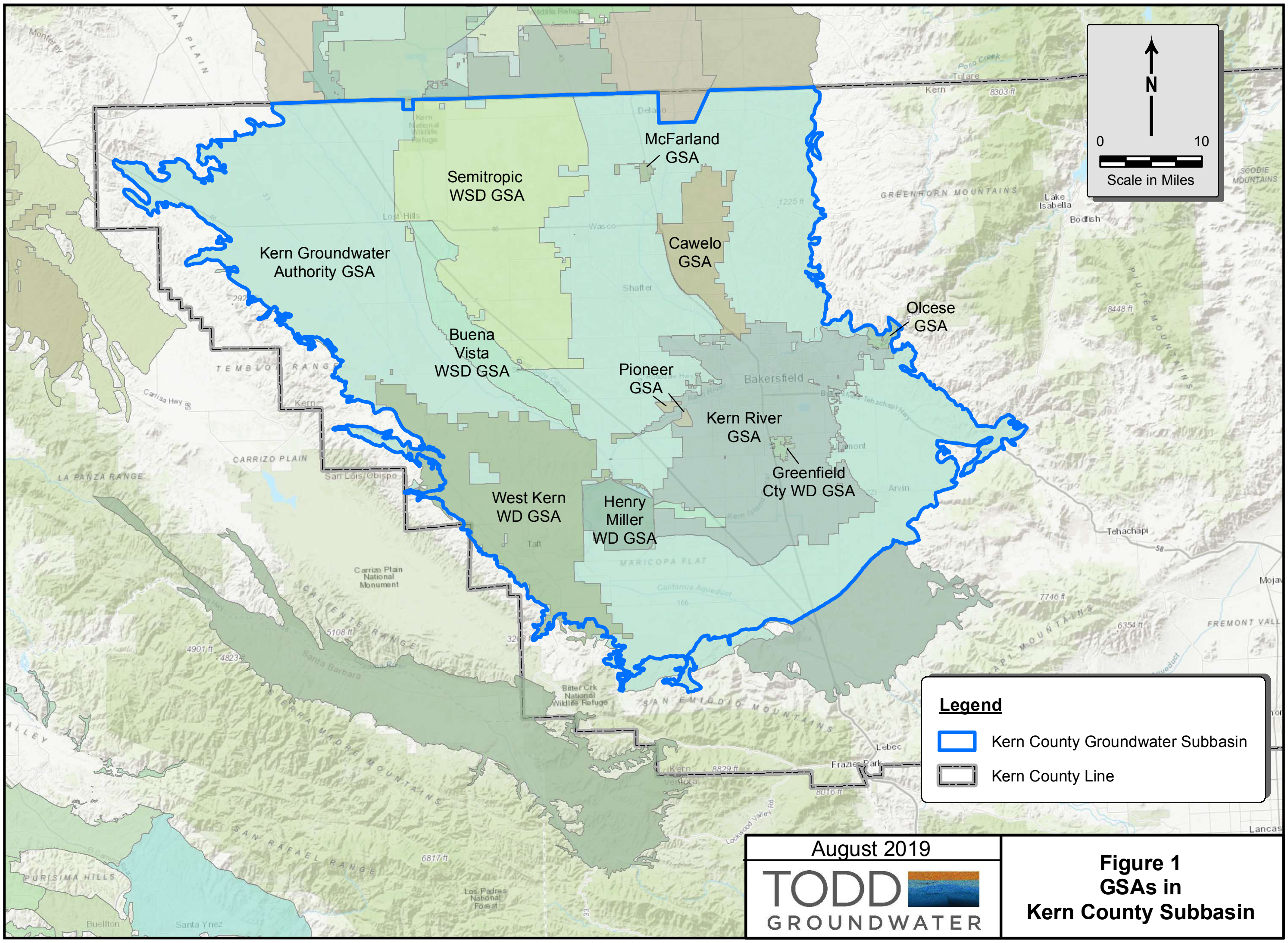
NOTES:

Sustainable Yield from Groundwater Pumping	Approach assumes that adjusting total groundwater pumping by the change in storage provides an reasonable approximation of the Basin Sustainable Yield
Sutainable Yield from Basin Recharge and Outflow	Approach assumes that the Basin Sustainable Yield can be reasonably approximated by adding up the different recharge components and non-pumping outflow components
Sutainable Yield	Sustainable yield is defined is the amount of pumping that can be
Average Annual Difference	The difference between the sustainable yield and the simulated groundwater pumping. A negative value is pumping in excess of the
Percent Difference	The percentage of the Average Annual Difference to the total groundwater pumping to provide context and a method to compare the

TABLE 24: Summary of Statistical Analysis for Validation of C2VSimFG-Kern Historical Simulation

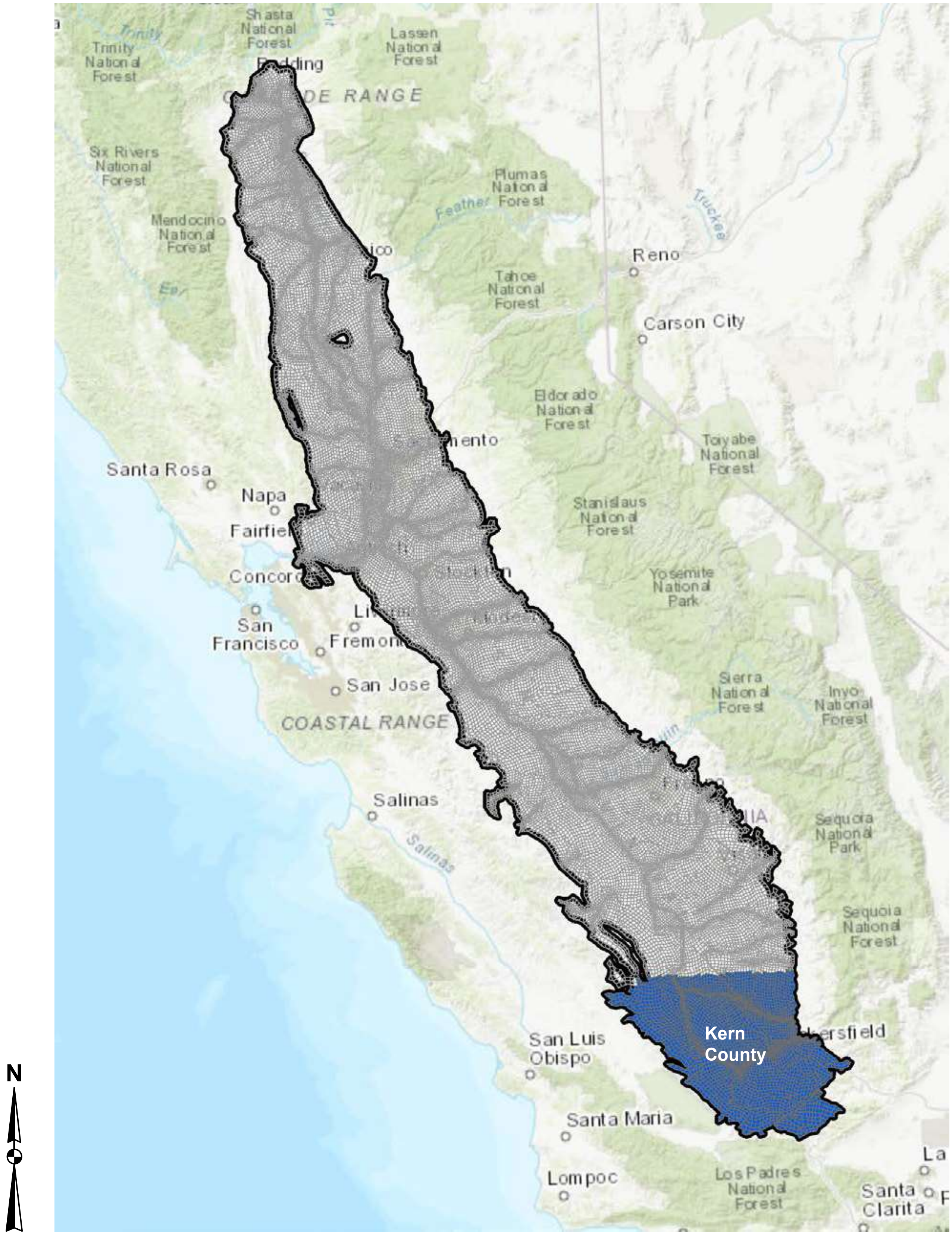
Validation Measure	C2VSimFG-Kern	C2VSimFG-Beta	Percent Change
Units	Feet	Feet	Percent
Residual Mean	17.3	32.6	47%
Residual Standard Deviation	45.5	54.0	16%
Absolute Residual Mean	37.4	56.8	34%
Root Mean Square (RMS) Error	50.0	73.5	32%
Scaled Absolute Residual Mean	0.061	0.092	34%
Correlation Coefficient	0.76	0.52	47%
Number of Monitor Wells	558	558	same
Number of Observations	42,075	42,075	same

FIGURES



August 2019

Figure 1
GSAs in
Kern County Subbasin



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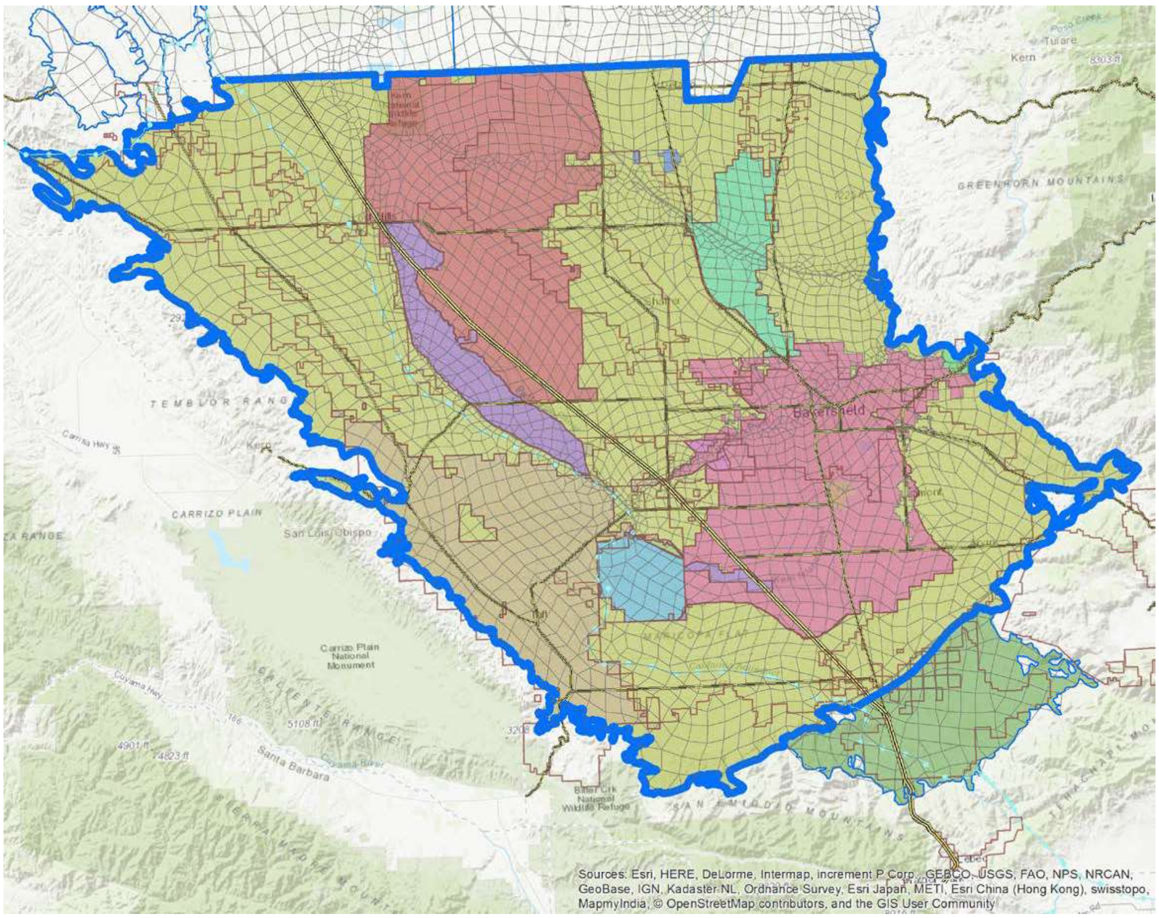
August 2019	Figure 2
TODD GROUNDWATER	C2VSimFG Simulation Grid for Central Valley Showing Kern County Subbasin



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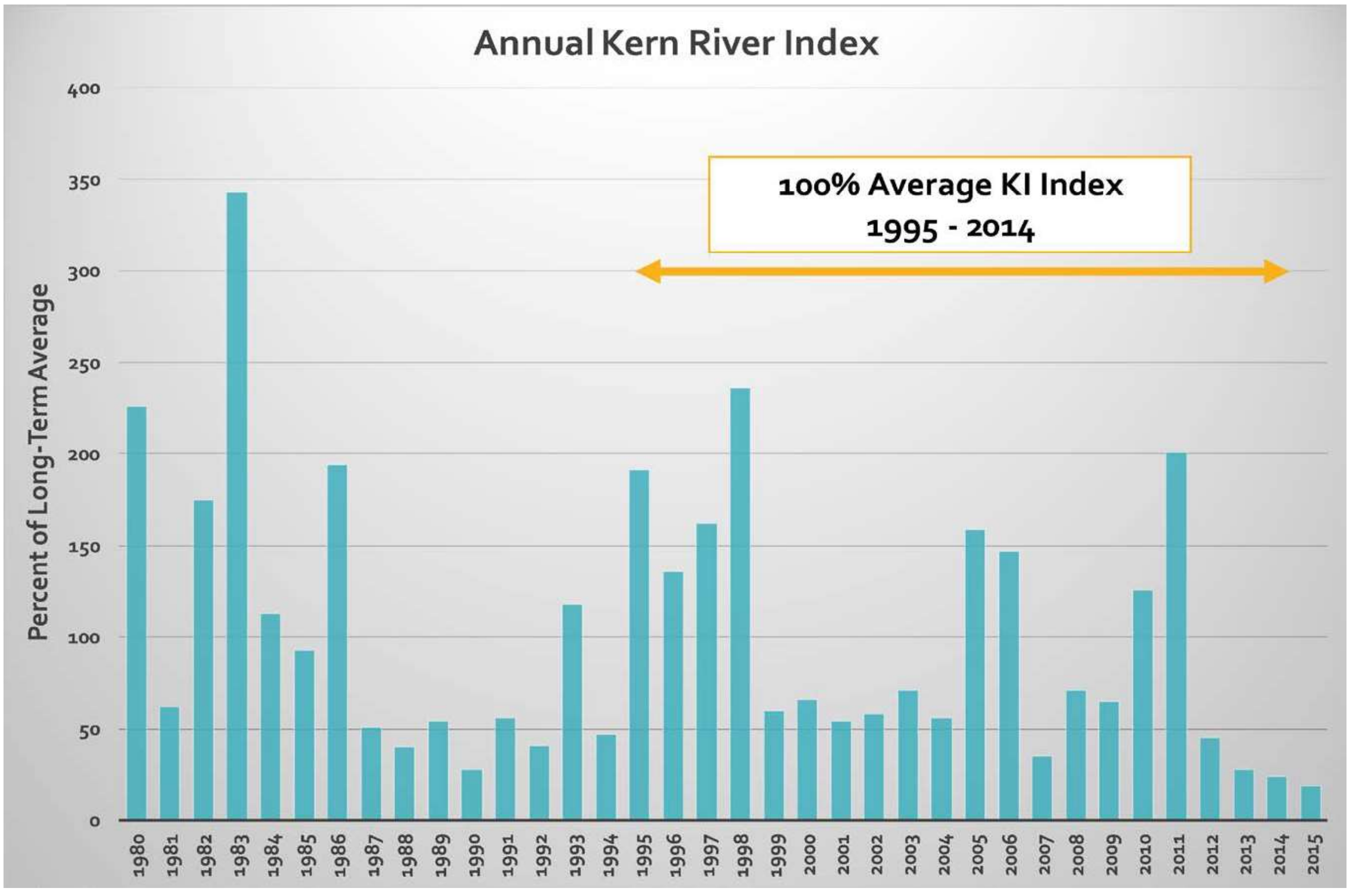
August 2019	Figure 3 C2VSimFG-Kern Simulation Grid with Kern County Subbasin GSAs
TODD GROUNDWATER	



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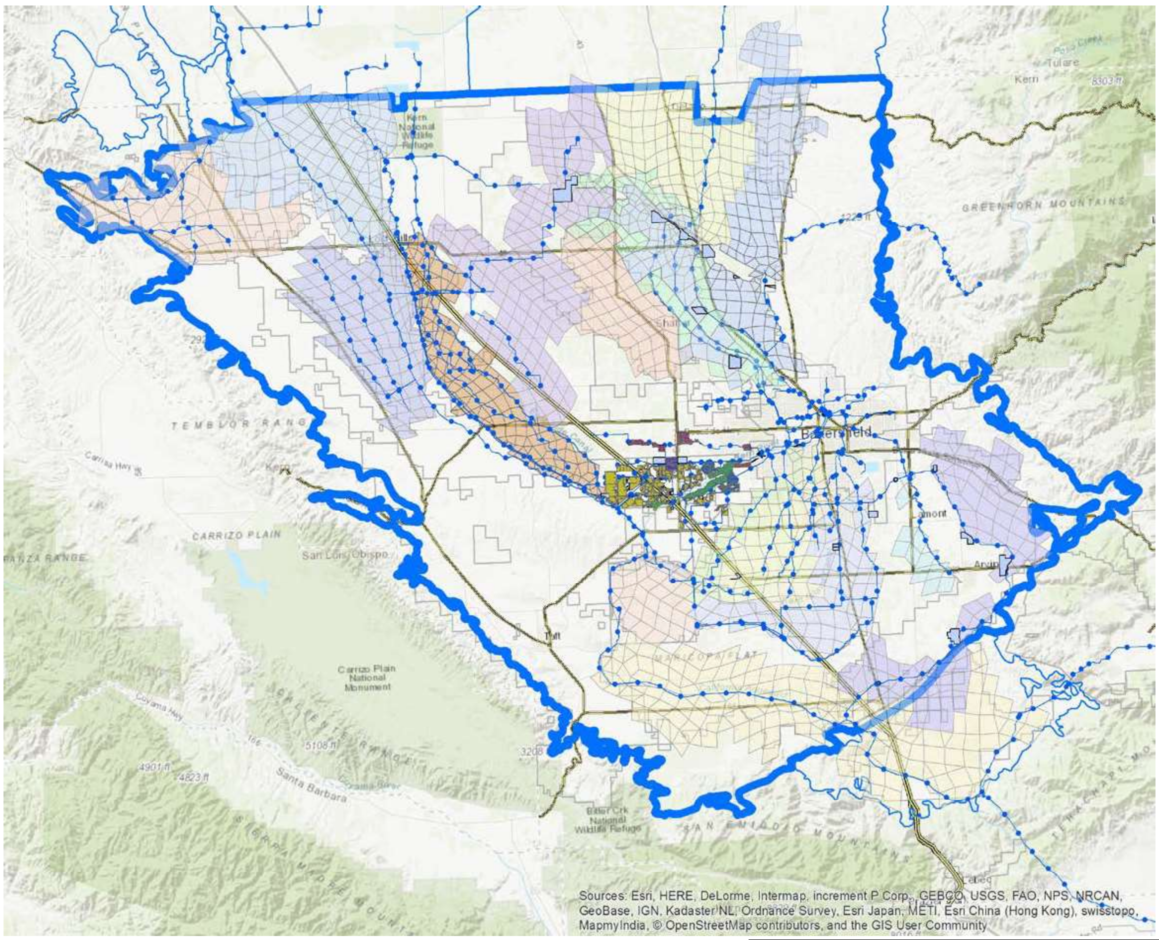
August 2019	Figure 4
TODD GROUNDWATER	Annual Kern River Index used to Define 20-Year Historical Study Period



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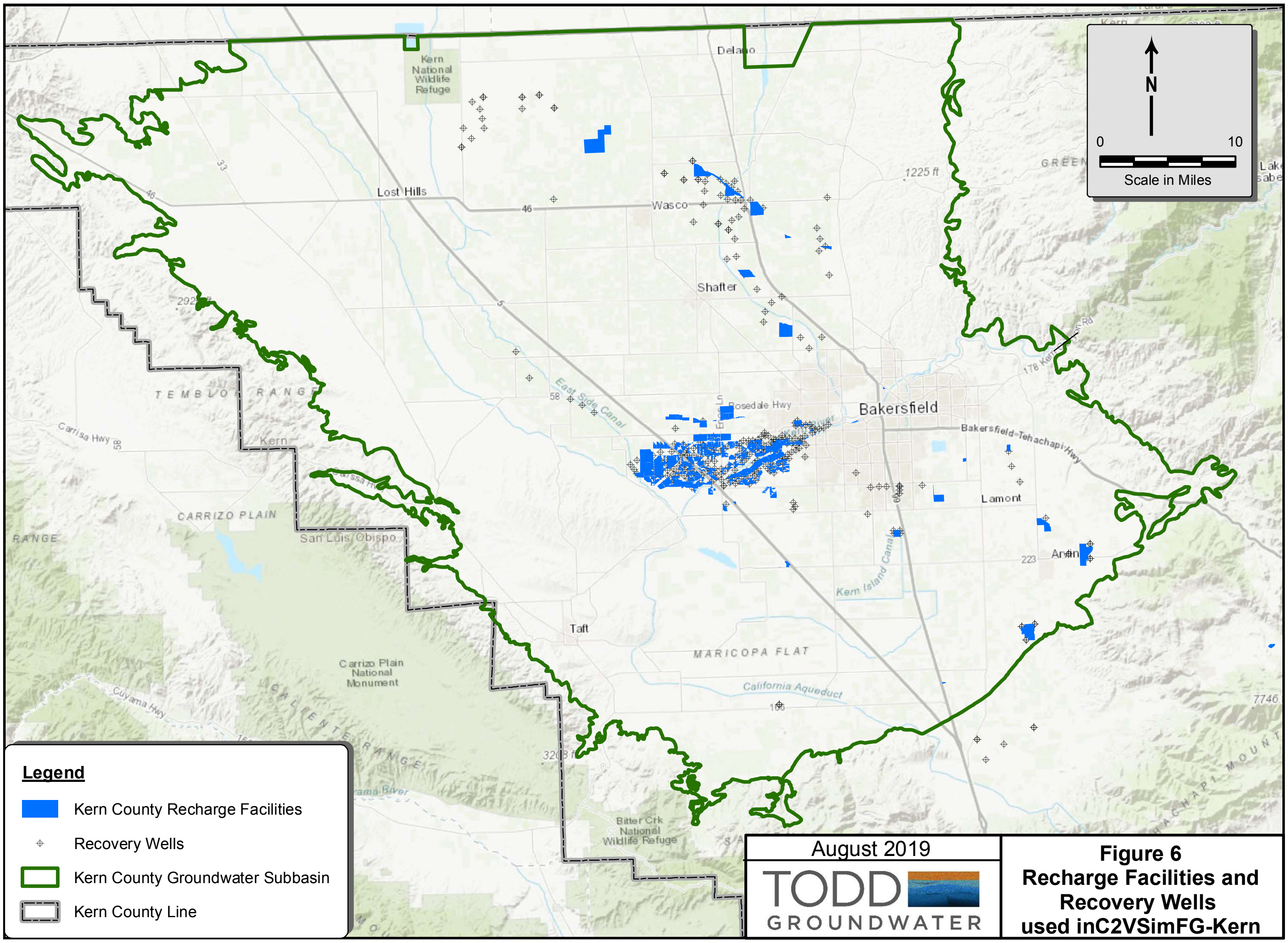
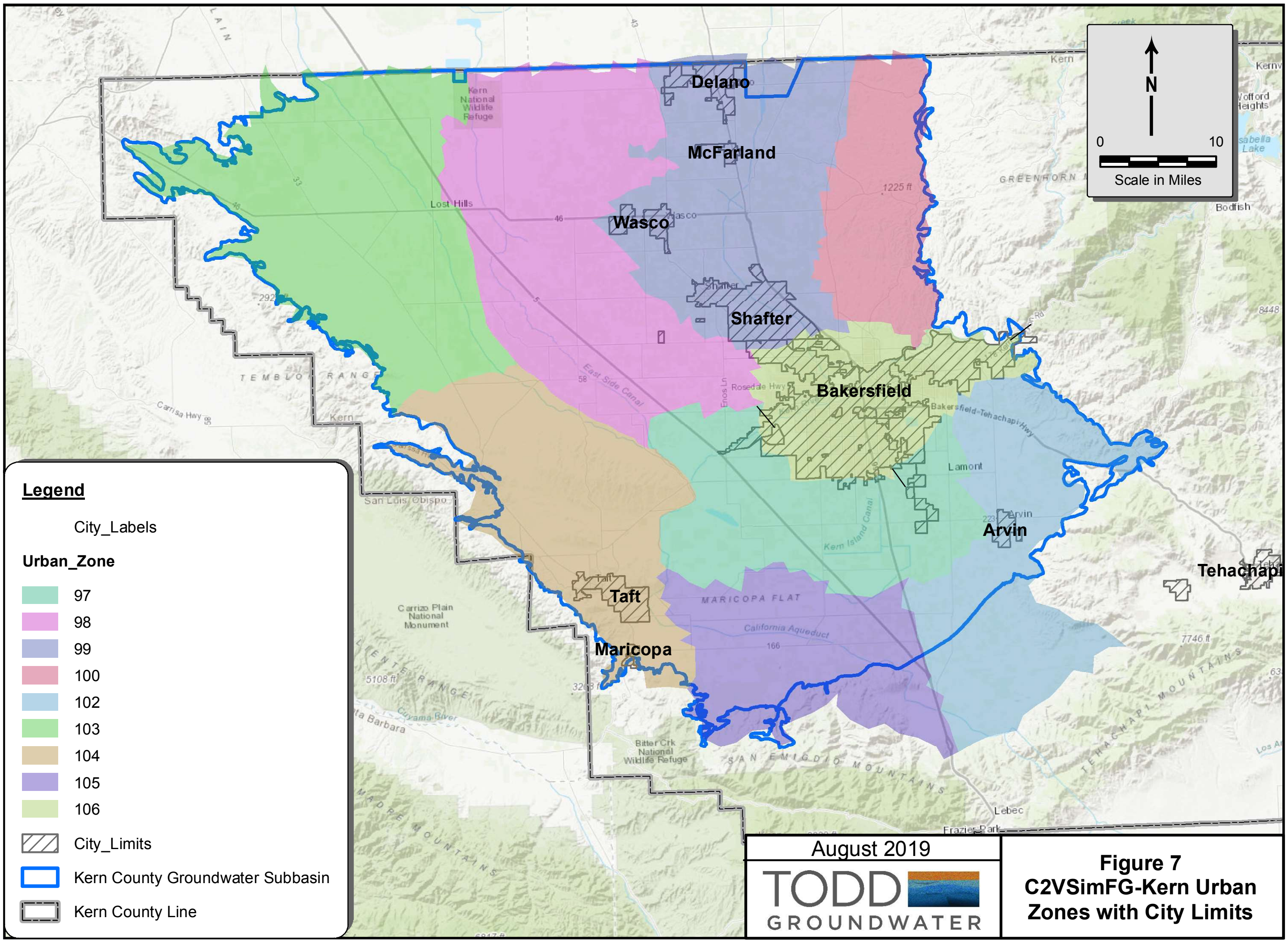
August 2019	Figure 5
TODD GROUNDWATER	C2VSimFG-Kern Simulation Surface Water Application Areas with Conveyance



August 2019

TODD GROUNDWATER

Figure 6
Recharge Facilities and Recovery Wells used inC2VSimFG-Kern



August 2019

TODD GROUNDWATER

Figure 7
C2VSimFG-Kern Urban Zones with City Limits

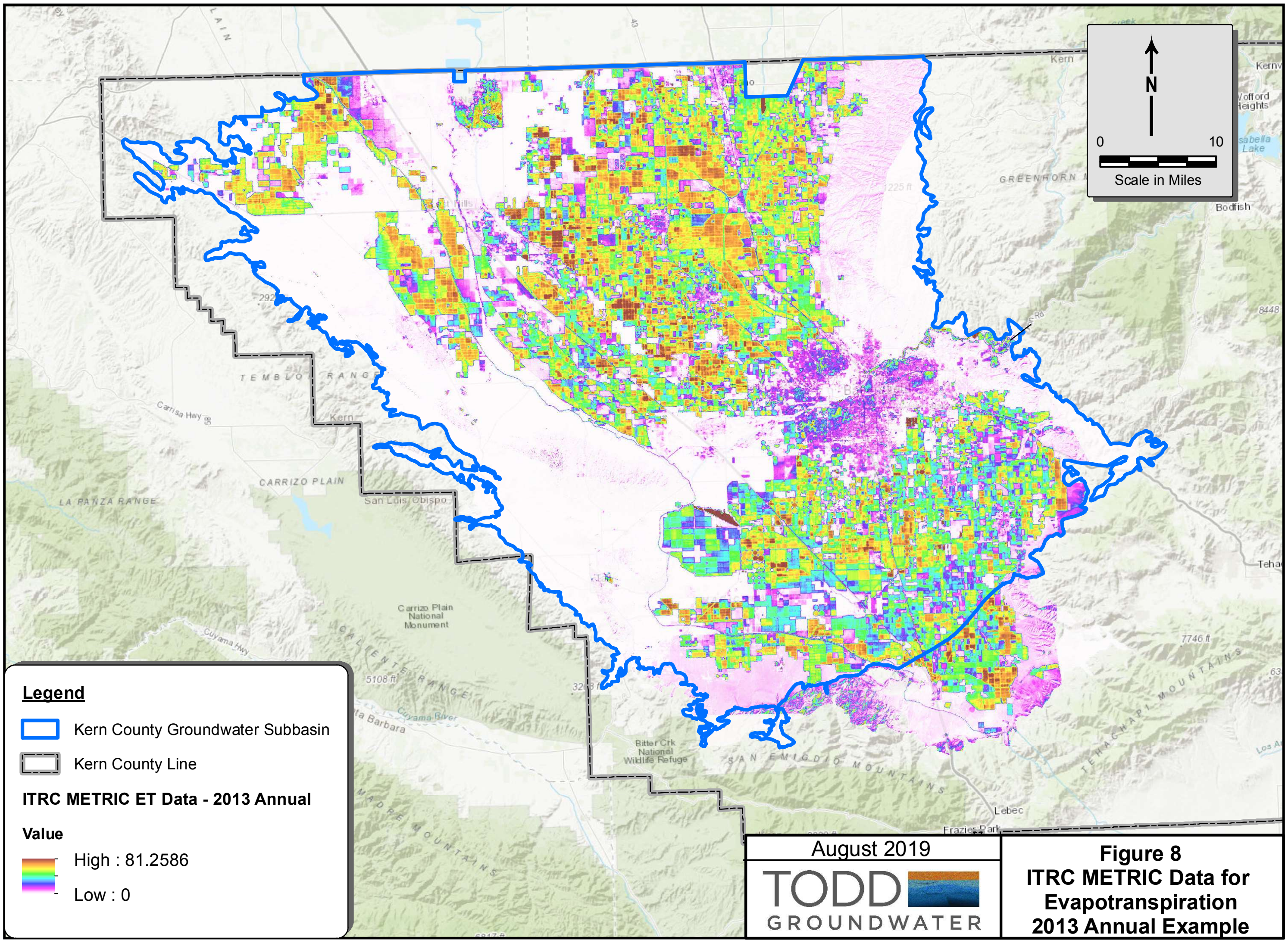
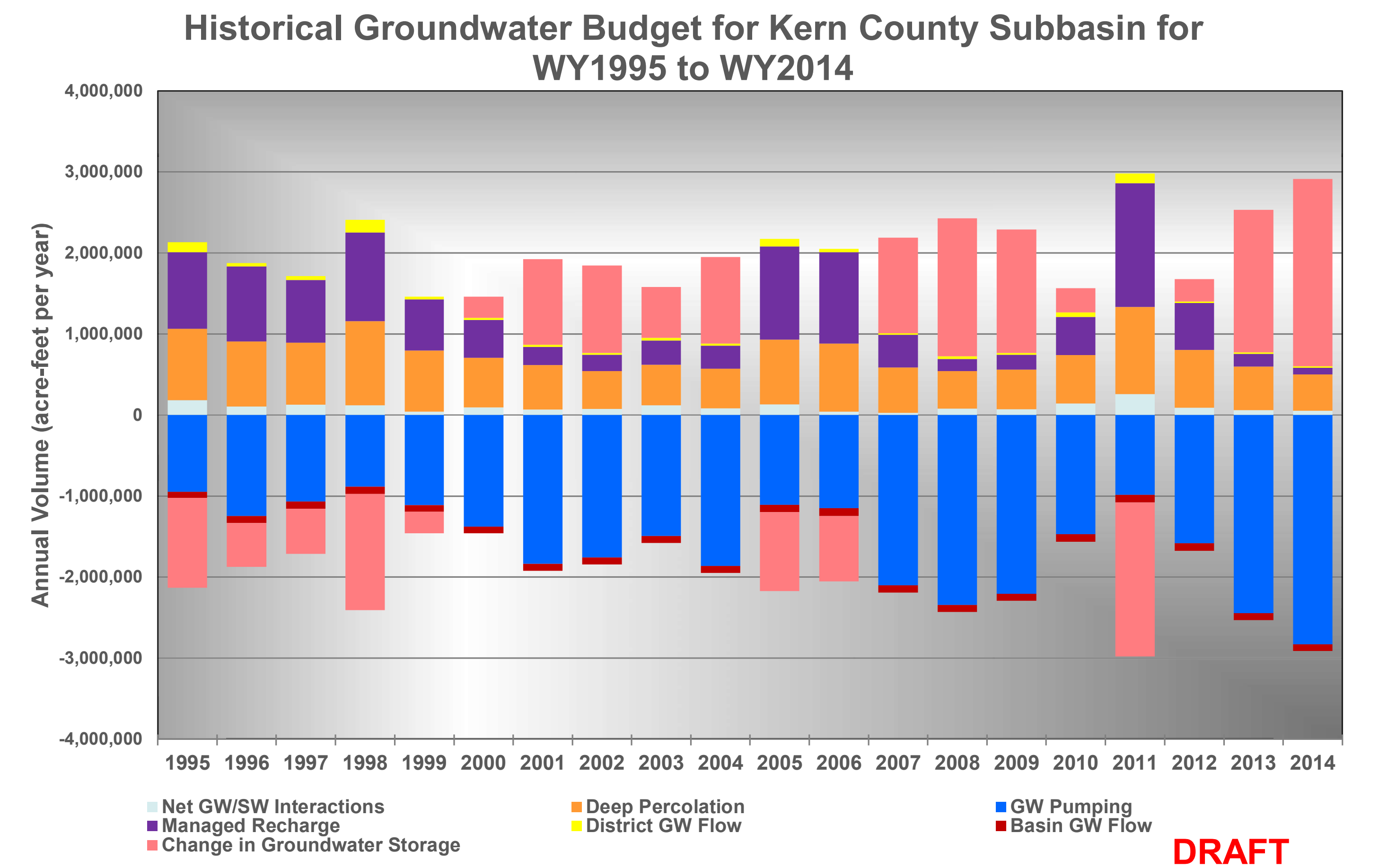


Figure 8
ITRC METRIC Data for Evapotranspiration 2013 Annual Example



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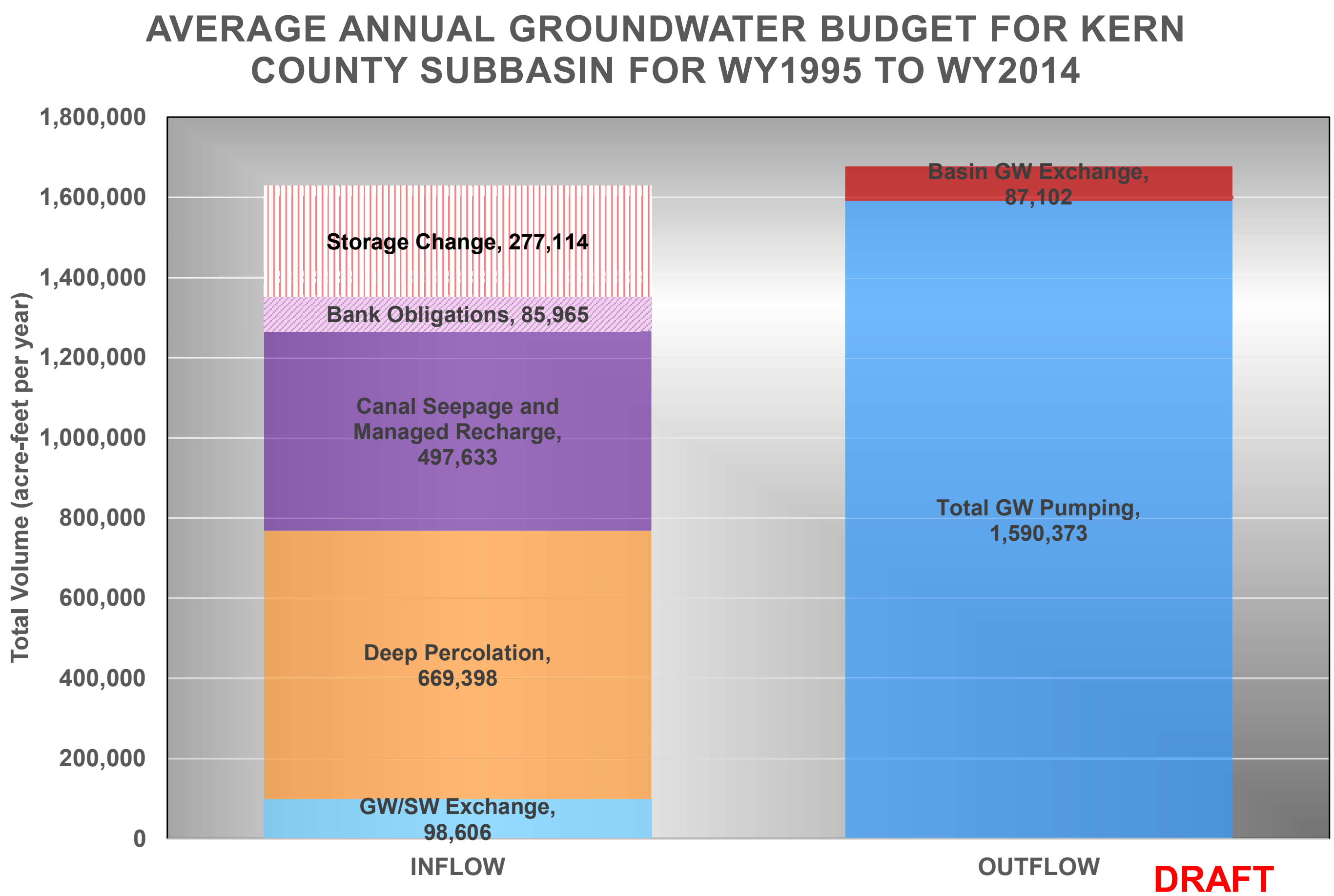
August 2019	Figure 9 C2VSimFG-Kern Historical Groundwater Budget for Kern County Subbasin
TODD GROUNDWATER	



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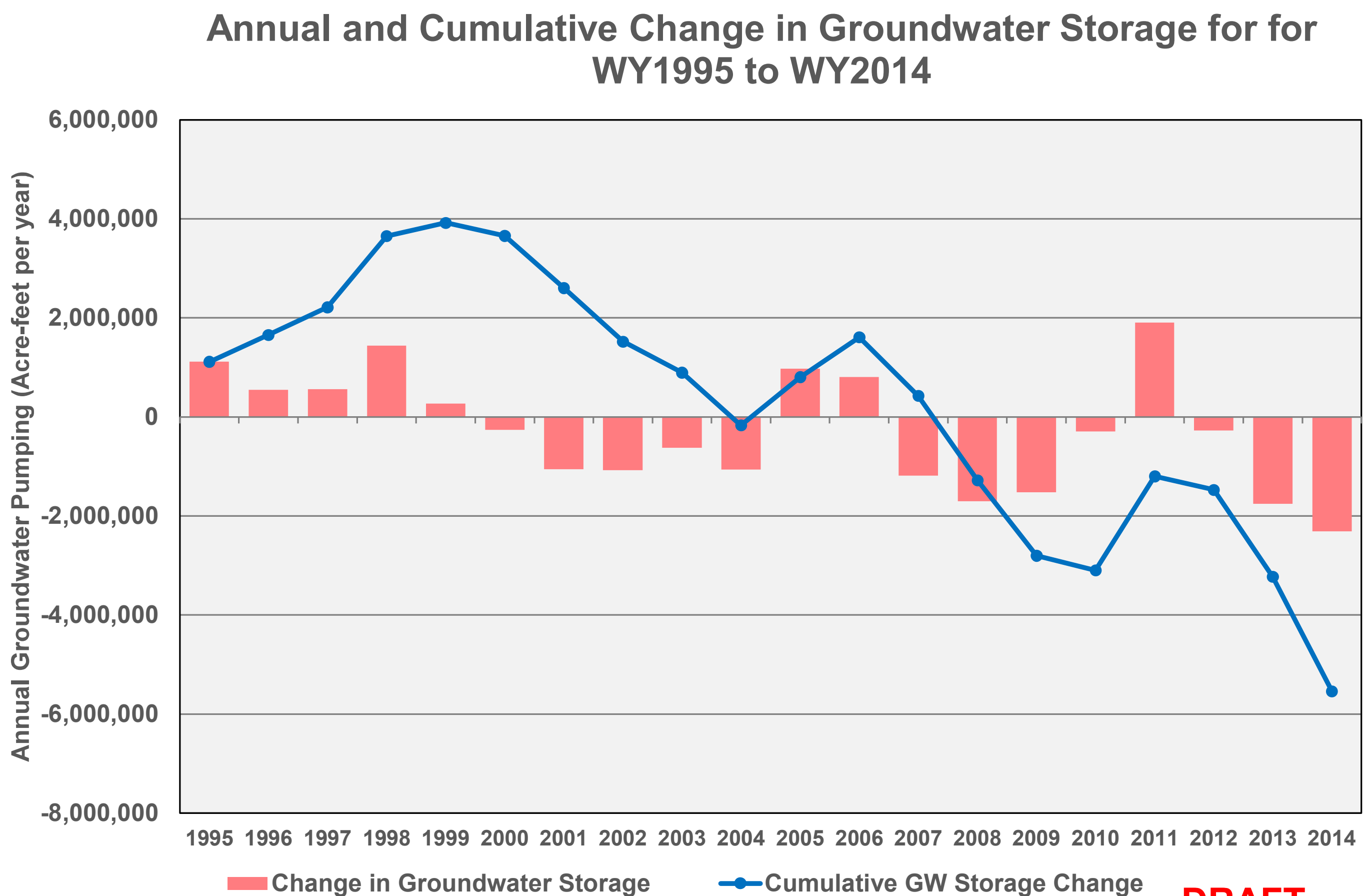
August 2019	Figure 10 C2VSimFG-Kern Average Annual Water Budget for Kern County Subbasin
TODD GROUNDWATER	



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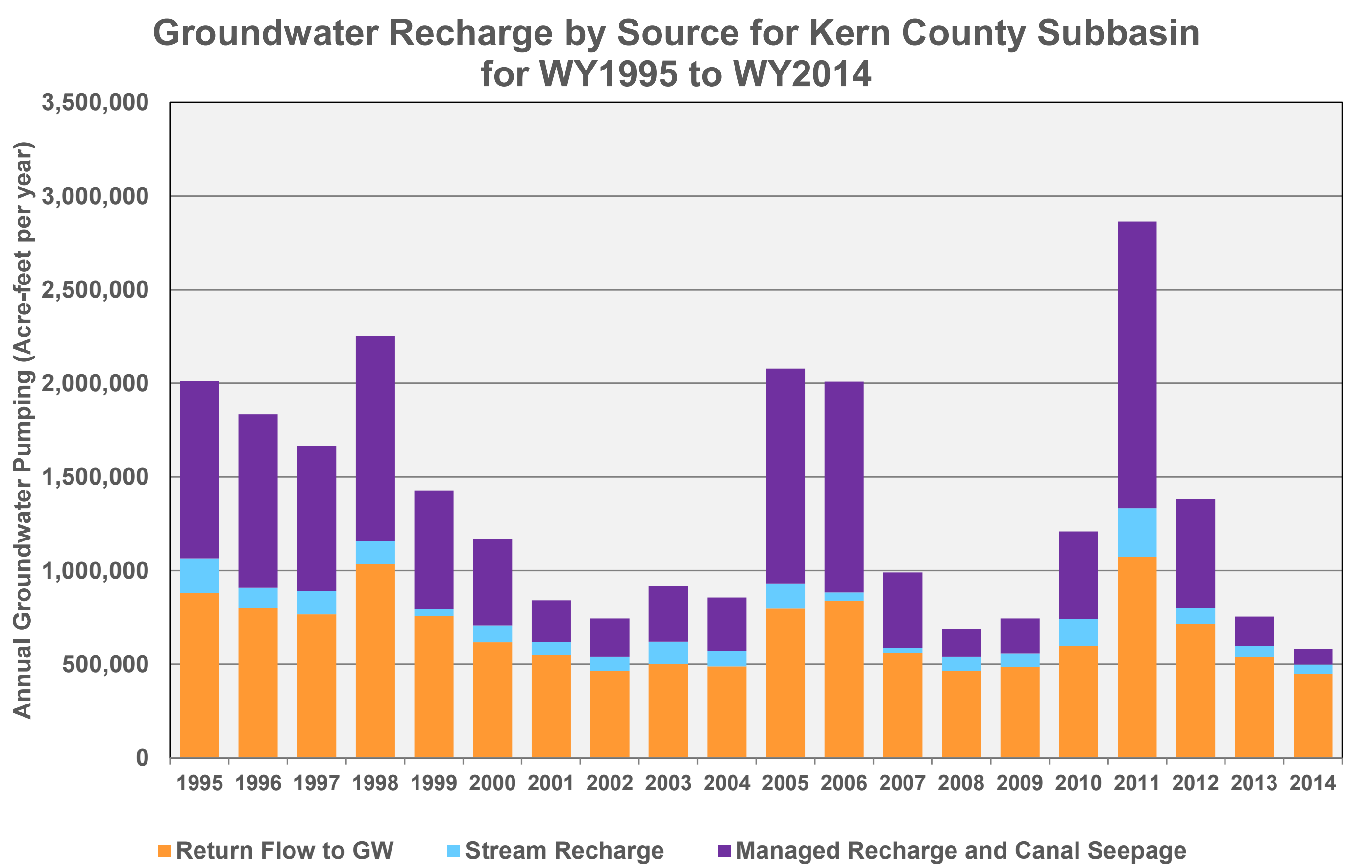
August 2019	Figure 11 Simulated Historical Change in Groundwater Storage for Kern County Subbasin
TODD GROUNDWATER	



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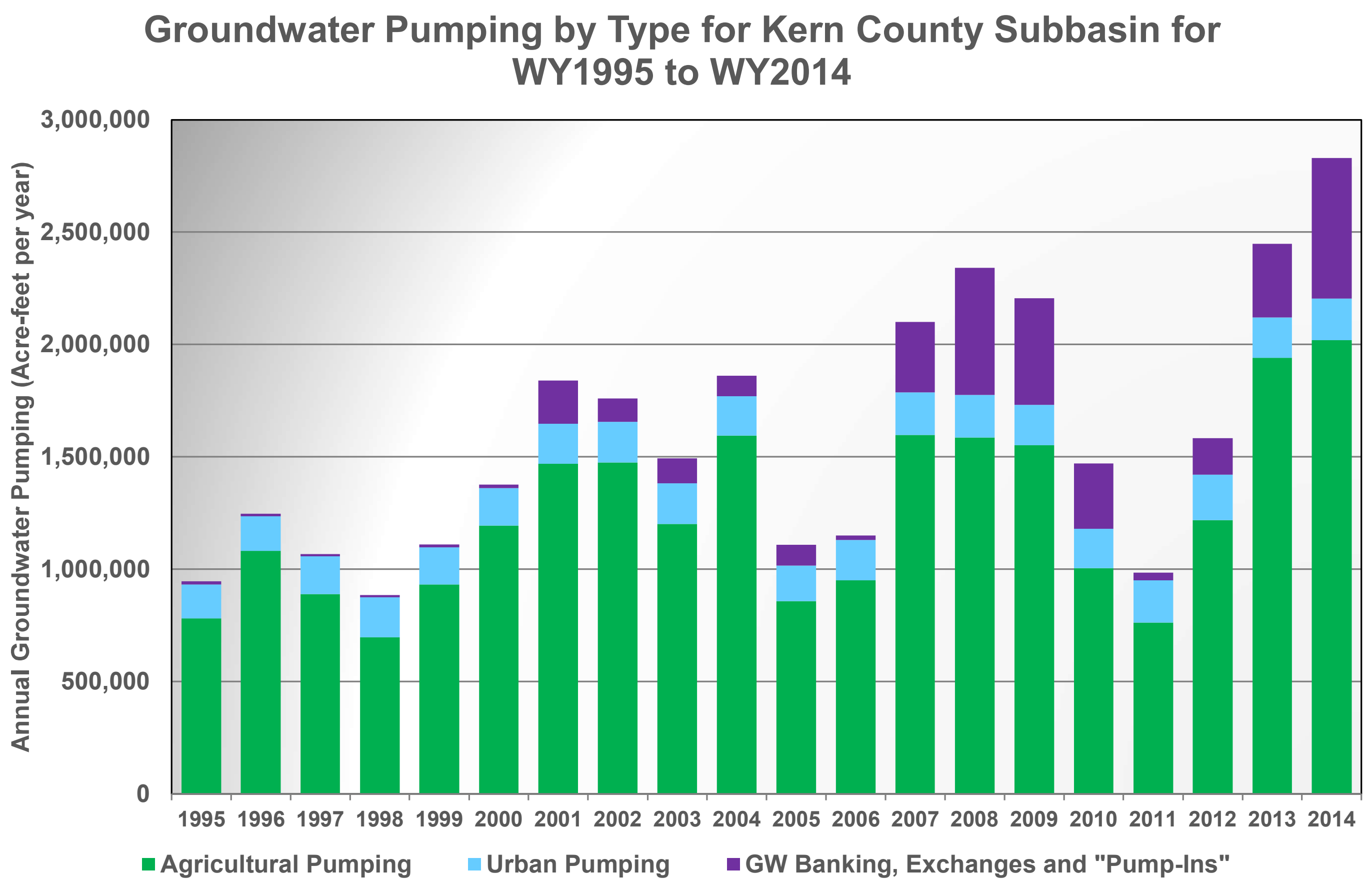
August 2019	Figure 12 Simulated Historical Recharge Operations for Kern County Subbasin
TODD GROUNDWATER	



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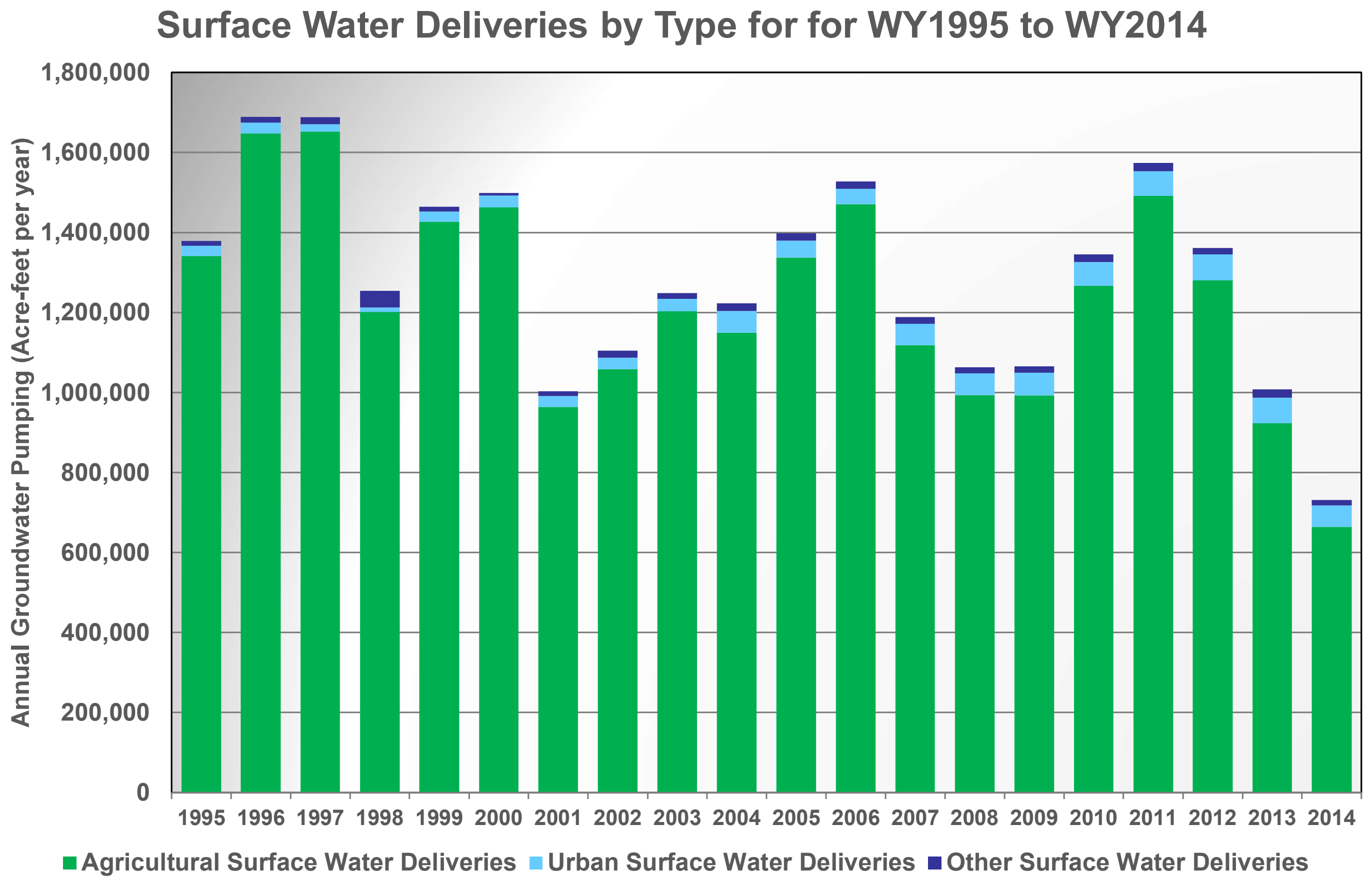
August 2019	Figure 13
TODD GROUNDWATER	Simulated Historical Groundwater Pumping for Kern County Subbasin



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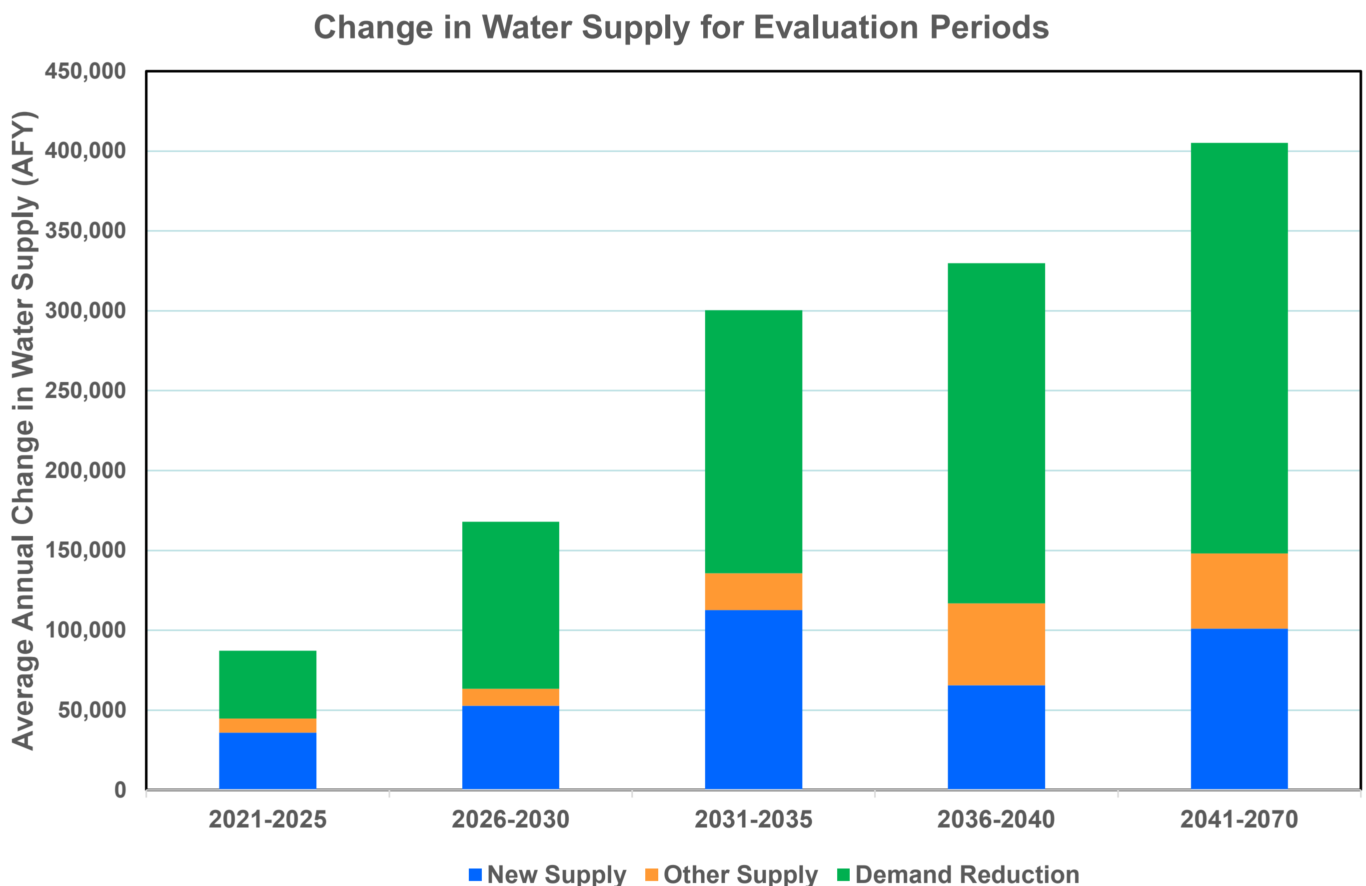
August 2019	Figure 14 Simulated Historical Surface Water Deliveries for Kern County Subbasin
TODD GROUNDWATER	



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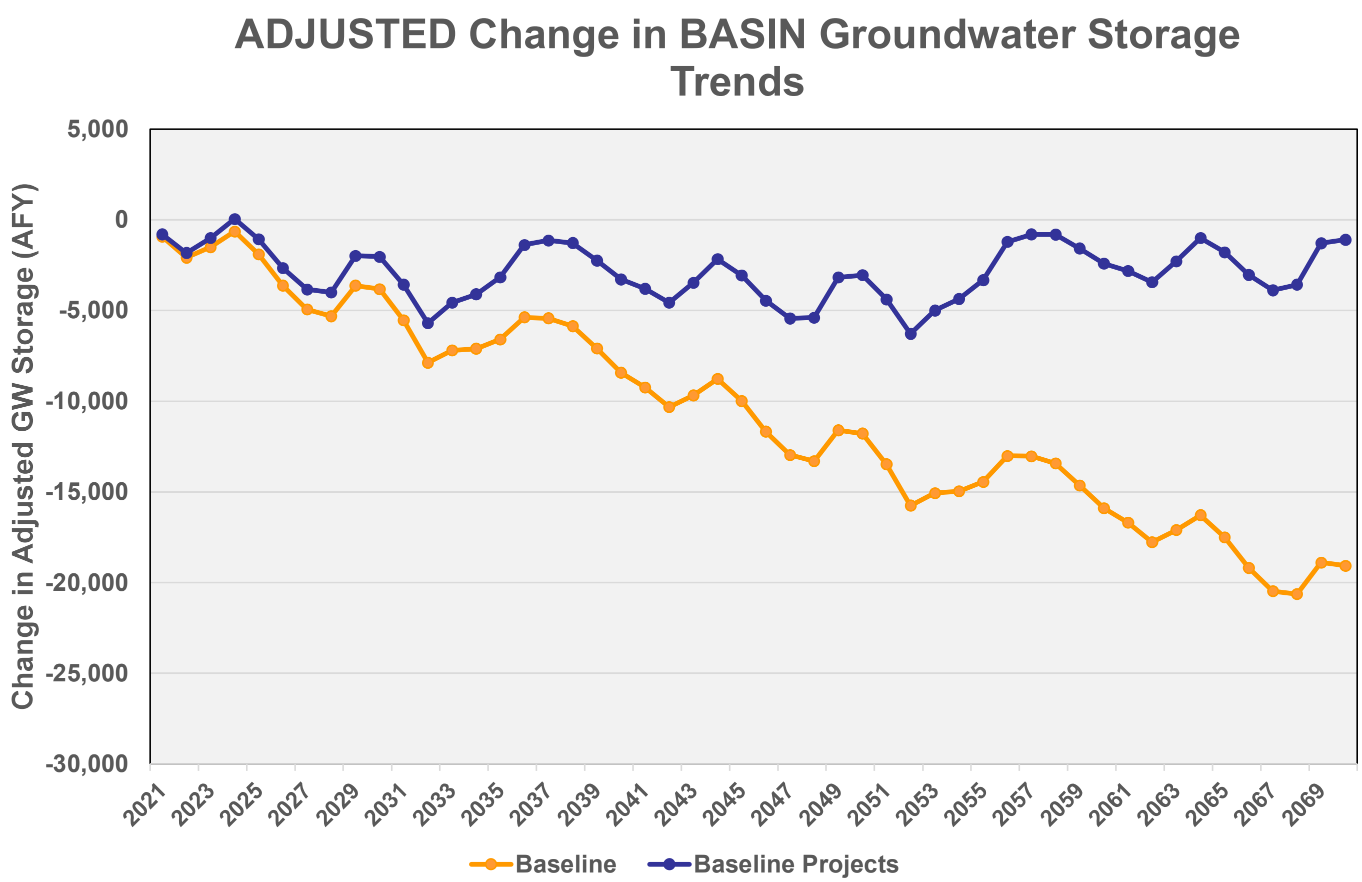
August 2019	Figure 15 Average Annual Benefit of Proposed SGMA Projects and Management Actions
TODD GROUNDWATER	



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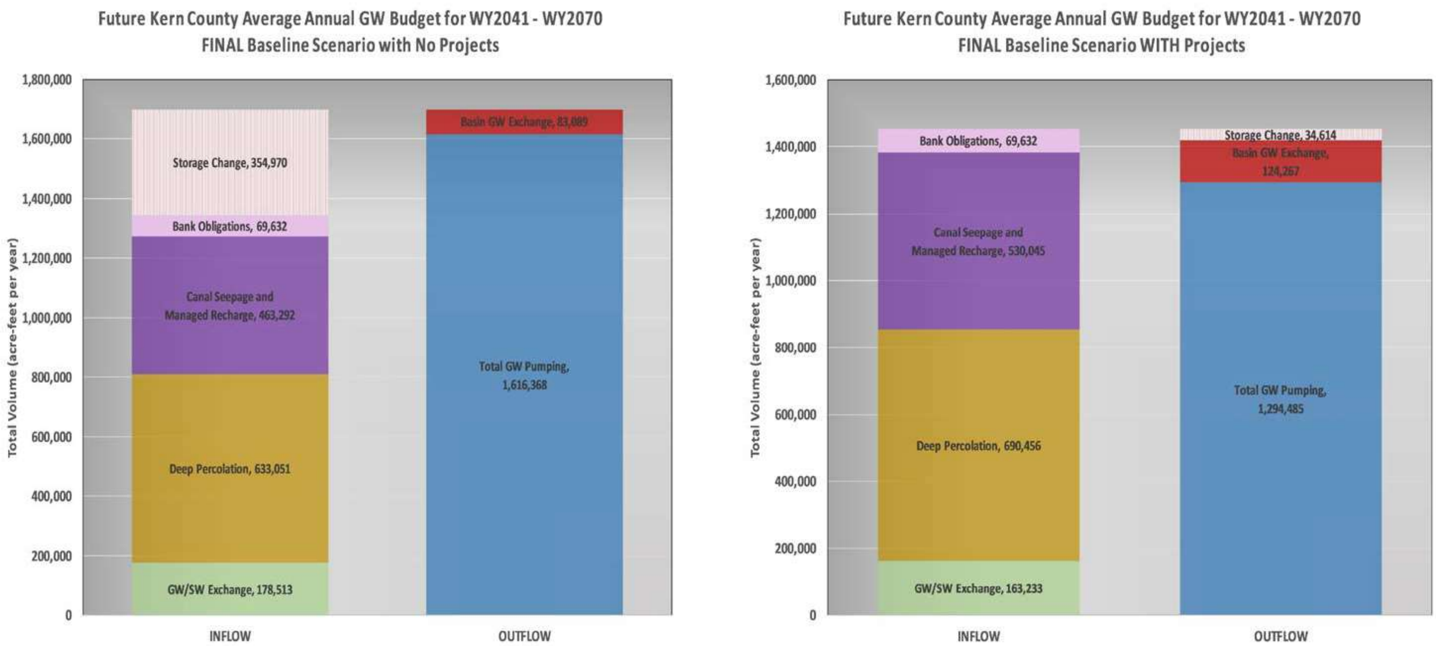
August 2019	Figure 16
TODD GROUNDWATER	Projected Future Change in Groundwater Storage for Baseline Conditions



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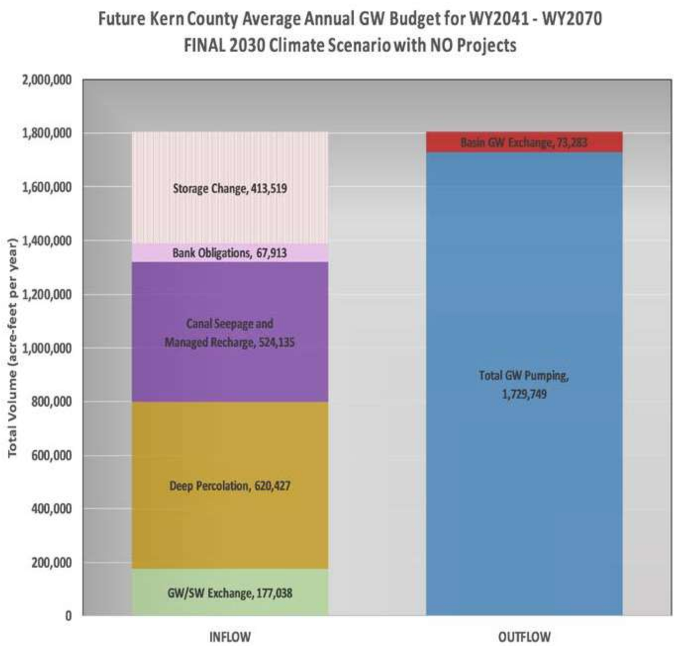
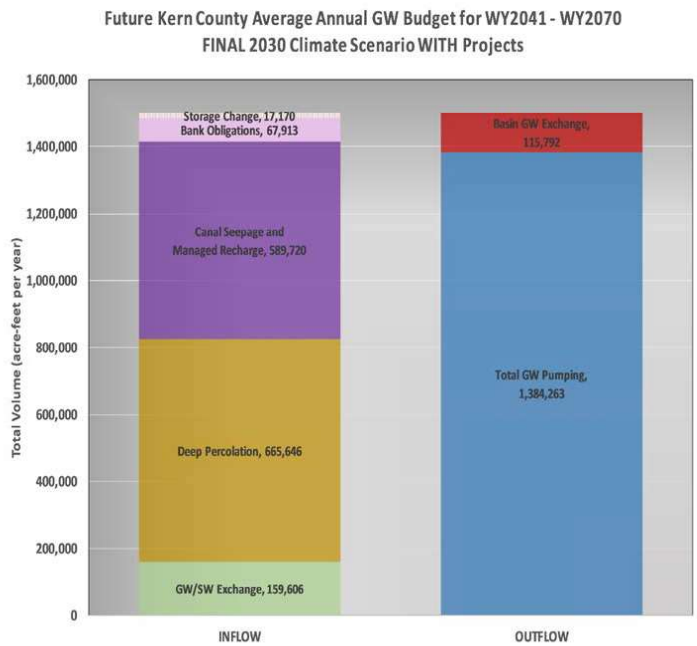
August 2019	Figure 17 Baseline Projected Future Average Annual Groundwater Budget for WY2041-2070
TODD GROUNDWATER	





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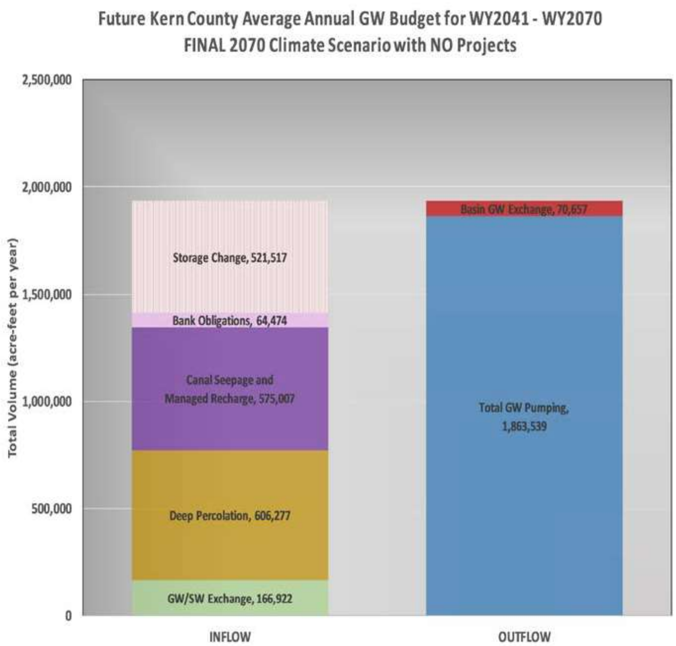
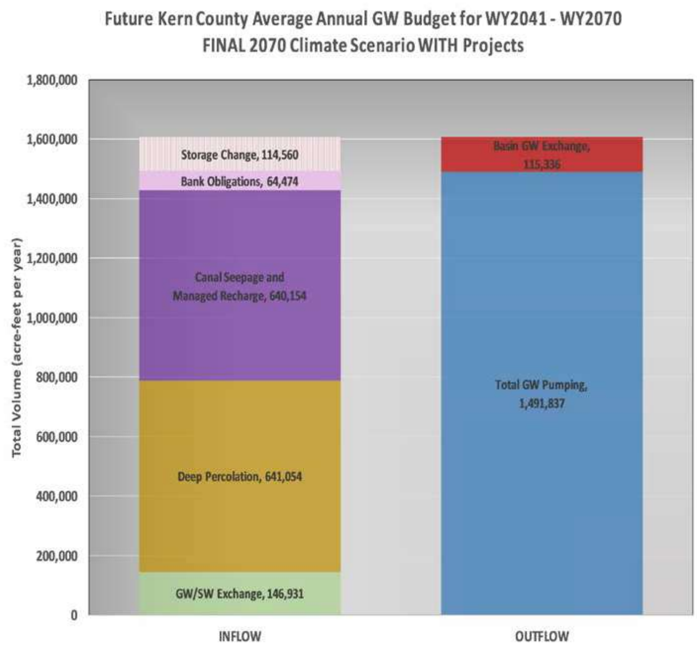
August 2019	Figure 18
TODD GROUNDWATER	2030 Climate Projected Future Average Annual Groundwater Budget for WY2041-2070





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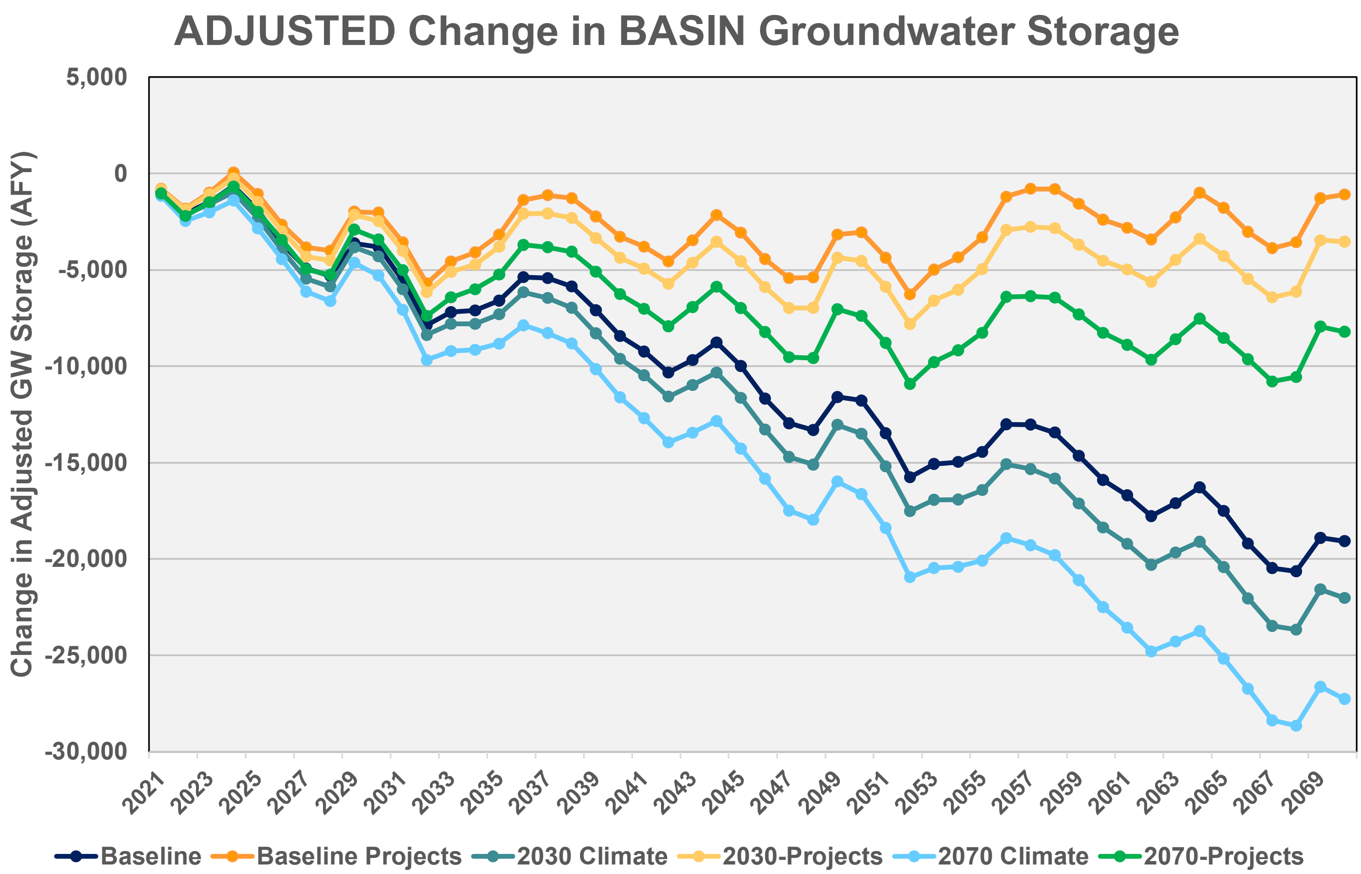
August 2019	Figure 19
TODD GROUNDWATER	2070 Climate Projected Future Average Annual Groundwater Budget for WY2041-2070



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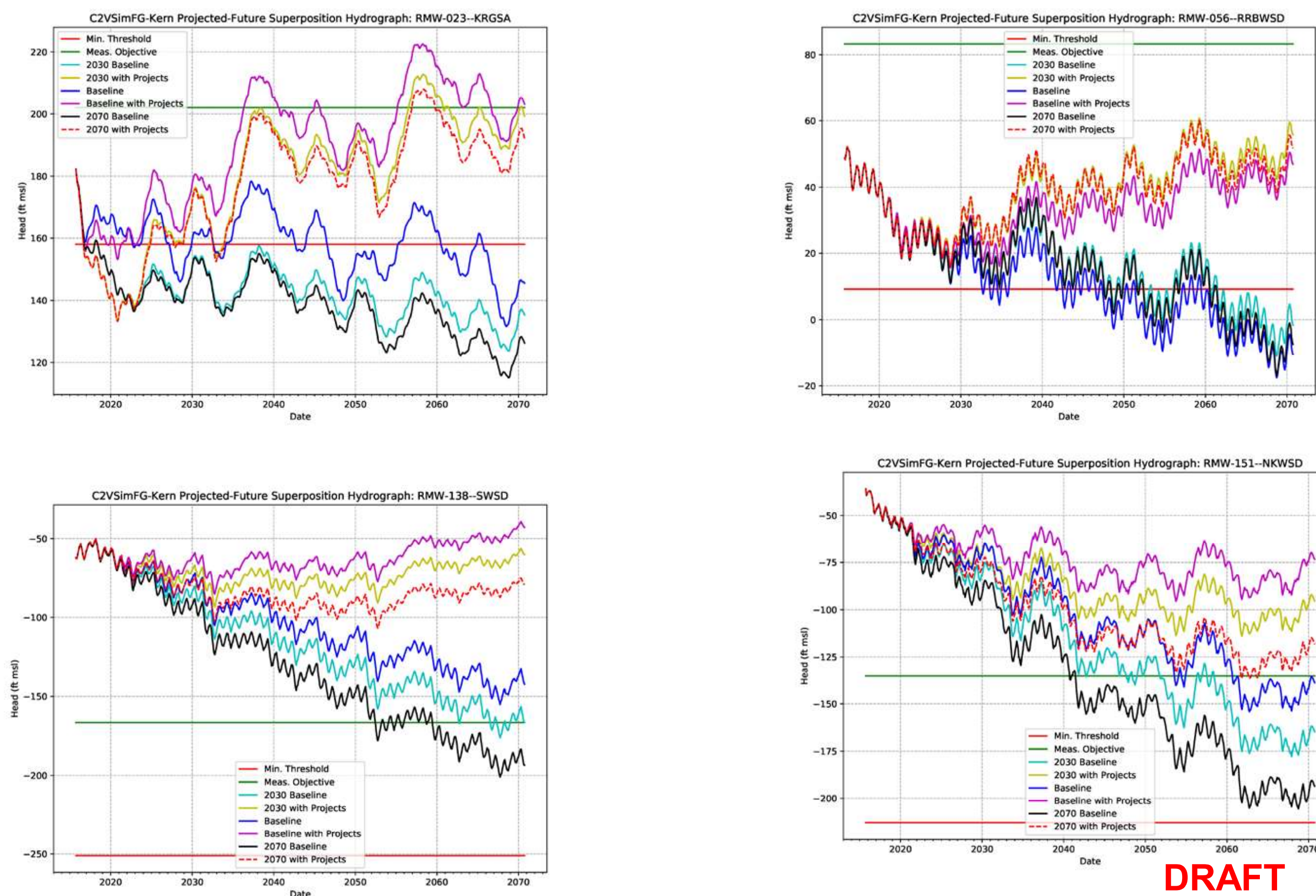
August 2019	Figure 20 Projected Future Change in Groundwater Storage for All Conditions
TODD GROUNDWATER	



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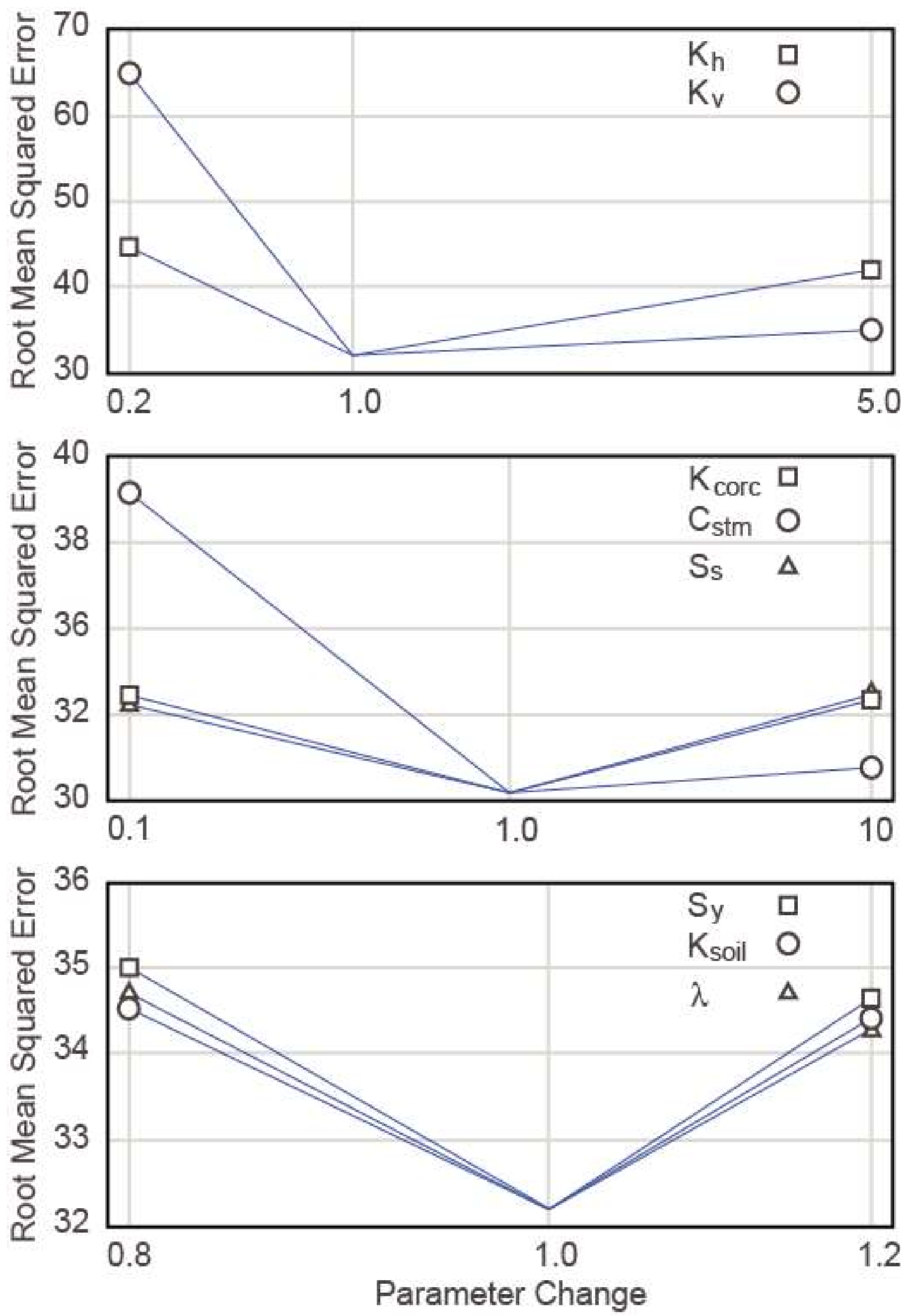
August 2019	Figure 21 Hydrographs for all Projected Future Conditions with SGMA Sustainability Criteria
TODD GROUNDWATER	



Notes:
Sensitivity parameters modified and evaluated for Kern County Subbasin
Kh – horizontal hydraulic conductivity of aquifer
Kv – vertical hydraulic conductivity of aquifer

Kcorc - horizontal hydraulic conductivity of Corcoran Clay aquitard or equivalent
Cstm – streambed conductance of Kern River and Poso Creek
Ss – specific storage of aquifer

Sy – specific yield of aquifer
Ksoil –soil hydraulic conductivity in root zone
Λ –soil pore size distribution index in root zone

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August 2019

TODD GROUNDWATER

Figure 22
C2VSimFG Sensitivity Analysis Results

Appendix I

Water District Summaries

DISTRIBUTION INPUTS **SUPPLIES** Inputs **2010** 5/1/2014

SECOND POINT SUPPLY (Including Deliveries Via Buena Vista Canal) **Units in Acre Feet**

Via To DAY	1st Pt KR	1st Pt 2nd Pt (KD) KR	1st Pt FK CANAL FK-X	1st Pt 2800 KR-X	1st Pt 2800 WELL	1st Pt Spill KR	HWD DUE @2ndPt KR	HWD @2nd Pt KR	HWD FK	HWD WELLS	BVWSD DUE @2ndPt KR	BVWSD @2ndPt KR	BVWSD FK CANAL @2ndPt FK-X	BVWSD 2800 @2ndPt WELLS	TOTAL SUPPLY At 2nd Point KR	 FK	 WELL	 STATE	TOTAL SUPPLY
JAN					5534									99			5633		5633
FEB					845									135			980		980
MAR					2218						1022	1022		502	1022		2720		3742
APR					1922						9215	9215		875	9215		2797		12012
MAY					1502						23514	23514		17	23514		1519		25033
JUN		2000									38609	38609			40609				40609
JUL											10764	10764			10764				10764
AUG											16201	16201			16201				16201
SEP																			
OCT																			
NOV																			
DEC						3703					3876	3876			7579				7579
AF		2000			12021	3703					103201	103201		1628	108904		13649		122553

Note : January 2010 - Part of Olcese Wells in the first part of the year were billed to users up North during Advanced 2010 Pre-Irrigation.

Note: June 2010 - KDWSD sold WKWD 2,000 AF that went into Kern River Pipeline for West Kern spreading in the KWB Spreading Ponds.

DISTRIBUTION INPUTS (MISC SUPPIES)

Misc

5/1/2014

2010

MISC WATER - WELLS & RECLAMATION PUMPS Below 2nd Pt.

Units in Acre Feet

DAY Via	HMWD BVARA	BV LAKE AREA		DISTRICT GROWER Maples	 Maples	 BVWSD BW	 BVWSD BW	 GROWER BW	 GROWER BW	TOTAL SUPPLY Below 2nd Pt				
DAY	WELLS	WELLS	RECL	WELLS	RECL	WELLS	RECL	WELLS	RECL	KR	WELL	STATE	RECL	TOTAL
JAN	1701					44			267		1745		267	2012
FEB	748					232	575		399		980		974	1954
MAR	371					119			189		490		189	679
APR						109			452		109		452	561
MAY	793						195		446		793		641	1434
JUN						99	2102		557		99		2659	2758
JUL						79	2741		1099		79		3840	3919
AUG							2876		1150				4026	4026
SEP									190				190	190
OCT														
NOV														
DEC	369		1144								369		1144	1513
AF	3982		1144			682	8489		4749		4664		14382	19046

DISTRIBUTION INPUTS (STO)

STO

5/1/2014

2010

Units in Acre Feet

STATE TURNOUTS

DAY	SUPPLY BV 1B STATE	WELL	KR-X	BR REC	BV 6 STATE	KR-X	BV 2 STATE	KR-X	BV 7 STATE	KR-X	BV 3 STATE	KR-X	BV 5 STATE	KR-X	BV 4 STATE	KR-X	BV 5 TO BV LAKE STATE	KR-X	SEMITROPIC STATE	KR-X	BR REC	TOTAL STATE	WELL	KR-X	BR REC
JAN				1204																					1204
FEB		920		1807									512									512	920		1807
MAR				67																					67
APR			248	70		393		432																1073	70
MAY			341	290		1345		2200				1132												5018	290
JUN			737			4448	27	5162		165	2588	134	2691		1900							7206		10646	
JUL			1142			6438	50	5231		18318	4505		1334		1455							7344		31129	
AUG			217	1319		3893	13	5409		10903	2553		1664		2119							6349		20422	1319
SEP				4988							390		38		196							624			4988
OCT	56			4760																		56			4760
NOV	316			4663							1367		353		467							2503			4663
DEC	99			2597			93				2731		1405		1838							6166			2597
AF	471	920	2685	21765		16517	183	18434		29386	14134	1266	7997		7975							30760	920	68288	21765

Note: December 2010 water in BV#2 is for West Kern for spreading in their Northern Project Area.

DATA SHEET - DISTRIBUTION - SECOND POINT(WD1)

WD1

5/1/2014

2010

Units in Acre Feet

DAY	SUPPLY SECOND POINT				TOTAL FLOW	DIVERSIONS ALEJ CANAL			KR OUTLET WEIR			KWB - MAIN CANAL			INLET WEIR			INTERTIE			KWBA SPREADING ALEJ & MAIN			BVWSD SPREADING MAIN.BYPASS & RIVER			LOSSES TRANSPORTATION LOSSES		
	KR	FK	WELL	S-X		KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL
JAN			5633		5633									5631															2
FEB			980		980									976															4
MAR	1022		2720		3742	855		52				167		2663															5
APR	9215		2797		12012	5730						3485		2797															
MAY	23514		1519		25033	16618						3066		1519										3830					
JUN	40609				40609	24541						8663									2000			5405					
JUL	10764				10764	5341						609												4814					
AUG	16201				16201	9505						2739												3957					
SEP																													
OCT																													
NOV																													
DEC	7579				7579	3265			1831															2483					
AF	108904		13649		122553	65855		52	1831			18729		13586							2000			20489					11

NOTE:

DATA SHEET - DISTRIBUTION - BVARA (WD2A)

WD2A

5/1/2014

2010

Units in Acre Feet

DAY	SUPPLY					DIVERSIONS																						
	ALEJ CANAL, BV #3, OTHER				HMWD IRR.	MAPLES CANAL				LCM METER				CELL 2R METER				NORTH RIM METER				DIVERTED TO BV LAKE VIA NR & 2R			DIVERTED CO KERN SALE/CREDIT			
	KR & X	FK	WELL	STATE	WELL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	STATE	KR & X	FK	WELL	STATE
JAN					1701											1251				461								
FEB					748											795				46								
MAR	855		52		371											510												
APR	5730								256	5944																		
MAY	17750				793	985		52	244	15376				1277		615												
JUN	24675			2588		1683			642	20251				2535			1908	680										
JUL	5341			4505		2340				1234				1646			3781	260			726							
AUG	9505			2553		1507			38	4764				1601			2404	363			434							
SEP				390													403				22							
OCT																	54											
NOV				1367													623				922							
DEC	3265			2731	369					3047						369	1444				905							
AF	67121		52	14134	3982	6515		52	1180	50616				7059		3540	10617	1303		507	3009							

DATA SHEET - DISTRIBUTION - BVARA (WD2B)

WD2B **2010** 5/1/2014

Units in Acre Feet

DAY					RESERVIOUR LOSSES				STORAGE					NET CHANGE				
					DISTRICT ASSUMED				BVARA									
									KR & X	FK	WELL	STATE	TOTAL	BVARA				
	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	472		65	500	1037	KR & X	FK	WELL	STATE	TOTAL
JAN									472		54	500	1026			11		11
FEB									472		-39	500	933			93		93
MAR									1327		-126	500	1701	-855		87		-768
APR									1113		-126	244	1231	214			256	470
MAY									1225				1225	-112		-126	244	6
JUN									751			38	789	474			-38	436
JUL									612			36	648	139			2	141
AUG									1882			-287	1595	-1270			323	-947
SEP									1882			-322	1560				35	35
OCT									1882			-376	1506				54	54
NOV									1882			-554	1328				178	178
DEC									2100			-171	1930	-218			-381	-599
AF									2100			-171	1930	-1628		65	673	-890

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3A)   WD3A   2010   5/1/2014

Units in Acre Feet

DAY	TOTAL SUPPLY BVARA-BV LAKE WD1-WD2-WD4-WD6-STOS						DIVERSIONS WASTE WEIR SPILLS OR DELIVERY IN FLOOD CHANNEL					WASTE WEIR SPREADING IN CHANNEL					BV LAKE OUTLET GATES REVERSE FLOWS TO BUENA VISTA LAKE				
	KR & X	FK	WELL	DW#1	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																					
FEB																					
MAR																					
APR	5944																				
MAY	15376																				
JUN	20416																				
JUL	19552																				
AUG	15667																				
SEP																					
OCT																					
NOV																					
DEC	4878					1144						2723				16					
AF	81833					1144						2723				16					

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3B)

WD3B

2010 5/1/2014

Units in Acre Feet

DAY	SPREADING CHANNEL OR ELK PEN					OUTLET CANAL SPREADING					OUTLET CANAL LOSSES					OUTLET TOTAL LOSSES	PB-BV#7 TO AQUEDUCT					EAST SIDE INTAKE CANAL HEAD				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																										
FEB																										
MAR																										
APR											1908					1908						4036				
MAY											3060					3060						12316				
JUN											2374					2374						18042				
JUL	149										1692					1692						17711				
AUG	286										1045					1045						14336				
SEP																										
OCT																										
NOV																										
DEC	615				139						1539				990	2529										
AF	1050				139						11618				990	12608						66441				

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4A) WD4A **2010** 5/1/2014

Units in Acre Feet

DAY	SUPPLY										DIVERSIONS															
	OUTLET-MAIN-STOS STO, WD3 & WD7						INTERNAL				OUTSIDE DELIVERIES ST-RRB-KNWR						SPILL TO OUTLET WD 3					SPILL TO MAIN CANAL WD 7				
	KR & X	FK	WELL	STATE	RECL	BR RECL	DIST. WELLS	DIST. RECL	GROWER WELLS	GROWER RECL	KR & X	FK	WELL	STATE	RECL	BR REC	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN						1204	44			268						1204										
FEB			920			1807	232	575		399						1807										
MAR						67	119			189						67										
APR	5109					70	109			452						70										
MAY	16202					290		195		446	69															
JUN	28389			27			99	2102		557	670			27	846											
JUL	30522			50			79	2741		1099	118			50	1157											
AUG	23855			13		1319		2876		1150	686			13	975	1319										
SEP						4988				190						4988										
OCT				56		4760								56		4760										
NOV				316		4663								316		4663										
DEC				192		2597								192		2597										
AF	104077		920	654		21765	682	8489		4750	1543			654	2978	21475										

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4B)

WD4B

5/1/2014

2010

Units in Acre Feet

DAY	SPILL AT HWY 46 KR & X	FK	WELL	STATE	RECL	FIELD DELIVERIES BUTTONWILLOW KR & X	FK	WELL	STATE	RECL	Total FD	CANAL LOSSES INTERNAL SYSTEM KR & X	FK	WELL	STATE	RECL	Total Losses
JAN								44		268	312						
FEB								1091		605	1696			61		369	430
MAR								119		189	308						
APR						1513		109		452	2074	3596					3596
MAY						8647				446	9093	7486				195	7681
JUN						20225		99		557	20881	7494				1256	8750
JUL						22088		79		1099	23266	8316				1584	9900
AUG						18932				1150	20082	4237				1901	6138
SEP										190	190						
OCT																	
NOV																	
DEC																	
AF						71405		1541		4956	77902	31129		61		5305	36495

DATA SHEET - DISTRIBUTION - MAPLES (WD5)

WD5 **2010** 5/1/2014

Units in Acre Feet

DAY	SUPPLY: BVARA-BV LAKE WD2 & WD6					BV CANAL	GROWER		USE: KDWD DELIVERIES				SPILL OR DELIVERIES BV LAKE					BVWSD FIELD DELIVERIES					Total FD	SYSTEM CANAL LOSS					Total Losses
	KR & X	FK	WELL	STATE	RECL	KR	WELLS	RECL	KR & X	FK	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	
JAN																													
FEB																													
MAR																													
APR				256																	69		69				187		187
MAY	985		52	244														676		52	139		867	309			105		414
JUN	1683			642														1463			584		2047	220			58		278
JUL	2340																	2017					2017	323					323
AUG	1507			38														1269			38		1307	238					238
SEP																													
OCT																													
NOV																													
DEC																													
AF	6515		52	1180														5425		52	830		6307	1090			350		1440

DATA SHEET - DISTRIBUTION - BV LAKE (WD6A)

WD6 **2010** 5/1/2014

Units in Acre Feet

DAY	SUPPLY					USE														
	BVARA-OUTLET-STOS WD1, WD2,WD3,MISC & STO					MAPLES CANAL					OUTLET GATES					HMWD IRRIGATION				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																				
FEB																				
MAR																				
APR																				
MAY																				
JUN																				
JUL																				
AUG																				
SEP																				
OCT																				
NOV																				
DEC					1144										1144					
AF					1144										1144					

DATA SHEET - DISTRIBUTION - BV LAKE (WD6B) 2010

Units In Acre Feet

DAY	RESERVIOUR LOSSES					STORAGE					NET CHANGE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN															
FEB															
MAR															
APR															
MAY															
JUN															
JUL															
AUG															
SEP															
OCT															
NOV															
DEC															
AF															

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7)

WD7A

5/1/2014

2010

Units in Acre Feet

DAY	SUPPLY WD1-WD4-Misc					Used By KERN WATER BANK					Used By COUNTY OF KERN & HM					SPREADING (M1&M7) CHANNEL & 160 ACRES				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN			5631					5534												
FEB			976					845												
MAR	167		2663					2218												
APR	3485		2797					1922			1438									
MAY	3066		1519					1501			125									
JUN	8663															686				
JUL																				
AUG																				
SEP																				
OCT																				
NOV																				
DEC																				
AF	15381		13586					12020			1563					686				

DAY	KWB CANAL (BV) EAST & WEST POOL LOSSES IN CANAL					DIVERTED TO CALIFORNIA AQUEDUCT BV					CANAL HEAD ES INTAKE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN			7					90							
FEB			7					124							
MAR	30		74			137		371							
APR	220		35			1827		840							
MAY	486					2455		17							
JUN	300					7677									
JUL															
AUG															
SEP															
OCT															
NOV															
DEC															
AF	1036		123			12096		1442							

Note : April-May 2010 - 1,563 AF went into Aqueduct for HMWD

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7B) / EAST TO WEST

WD7B

5/1/2014

2010

Units in Acre Feet

DAY	TOTAL SUPPLY					BUENA VISTA WSD DIVERSIONS													OTHER DIVERSIONS																
						BVWSD - WK - BV PONDS / RIVER					BV- OTHER PONDS (M1 & M7)					BV- LOSSES (KWB CANAL)			WEST KERN - WK - BV PONDS & LOSSES							KWB - PONDS									
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	EAST POOL	WEST POOL	BV TOTAL	KR & X	FK	WELL	Del STATE	Loss-KWB STATE	RECL	TOTAL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																																			
FEB																																			
MAR																																			
APR																																			
MAY			885					885										885																	
JUN																																			
JUL	609										399					119	91	609																	
AUG	2739										2553					184	2	2739																	
SEP																																			
OCT																																			
NOV																																			
DEC																																			
AF	3348		885					885			2952					303	93	4233																	

NOTE: BVWSD took 885 AF of Westside Mutual water into East Main Intake down into the BV/WK Ponds when the River Canal concrete panels broke. BVWSD gave them credit back in the State Aqueduct in May 2010.

DATA SHEET - DISTRIBUTION - HMWD IRRIGATION USE

WD8

2010

Units in Acre Feet

5/1/2014

DAY	USE											TOTAL					
	DIRECT		VIA					VIA				USE					
	BV 4&5		BV LAKE					BVARA									TOTAL
	KR & X	STATE	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	RECL	ALL
JAN										1712				1712			1712
FEB		512								841				841	512		1353
MAR										510				510			510
APR																	
MAY								1277		615		1277		615			1892
JUN		4591						3215			1908	3215			6499		9714
JUL		2789						1906			4507	1906			7296		9202
AUG		3783						1964			2838	1964			6621		8585
SEP		234									425				659		659
OCT											54				54		54
NOV		820									1545				2365		2365
DEC		3243								369	2349			369	5592		5961
AF		15972						8362		4047	13626	8362		4047	29598		42007

DISTRIBUTION INPUTS SUPPLIES

Inputs **2011** 5/1/2014

SECOND POINT SUPPLY (Including Deliveries Via Buena Vista Canal) **Units in Acre Feet**

Via To DAY	1st Pt KR	1st Pt 2nd Pt (KD) KR	1st Pt FK CANAL FK-X	1st Pt 2800 KR-X	1st Pt 2800 WELL	1st Pt Spill KR	KCWA Spill FK	KCWA Spill S-X	Via RTO 1 Others @2nd. Pt. S-X	HWD DUE @2ndPt KR	HWD @2nd Pt KR	HWD FK	HWD WELLS	BVWSD DUE @2ndPt KR	BVWSD @2ndPt KR	BVWSD FK CANAL @2ndPt FK-X	BVWSD 2800 @2ndPt WELLS	TOTAL SUPPLY At 2nd Point KR	FK	WELL	STATE	TOTAL SUPPLY
JAN						591			220					5631	5631			6222			220	6442
FEB														17613	17613			17613				17613
MAR			101			317	216	492						11589	11589			11906	317		492	12715
APR			50				107	90		946	946			27130	27130			28076	157		90	28323
MAY	16619					1456				16397	16397			37446	37446			71918				71918
JUN	6949									2623	2623			49369	49369			58941				58941
JUL	1216													18035	18035			19251				19251
AUG														9478	9478			9478				9478
SEP														151	151			151				151
OCT																						
NOV																						
DEC																						
AF	24784		151			2364	323	582	220	19966	19966			176442	176442			223556	474		802	224832

Note: March 2011 KCWA spilled FK & State Water and BVWSD used it for spreading.

Note: Lower Kern River Water Sale in July 2011 (HMWD 393 Af & BVWSD 1,547 AF) &(WKWD also purchased 1,216 AF that was used for spreading)

DISTRIBUTION INPUTS (MISC SUPPIES)

2011

MISC WATER - WELLS & RECLAMATION PUMPS Below 2nd Pt.

Units in Acre Feet

DAY	IIMWD			DISTRICT						TOTAL SUPPLY				
Via	BVARA	BV LAKE AREA		GROWER		BVWSD	BVWSD	GROWER	GROWER	Below 2nd Pt				
				Maples	Maples	BW	BW	BW	BW					
DAY	WELLS	WELLS	RECL	WELLS	RECL	WELLS	RECL	WELLS	RECL	KR	WELL	STATE	RECL	TOTAL
JAN														
FEB						73	1224	50	540		123		1764	1887
MAR							715	8	135		8		850	858
APR							831						831	831
MAY							3290		22				3312	3312
JUN							2411		538				2949	2949
JUL							3327	16	853		16		4180	4196
AUG							1724	113	865		113		2589	2702
SEP						60	153		175		60		328	388
OCT						32					32			32
NOV						30					30			30
DEC						24	39		6		24		45	69
AF						219	13714	187	3134		406		16848	17254

DISTRIBUTION INPUTS (STO)

2011

Units in Acre Feet

STATE TURNOUTS

DAY	SUPPLY BV 1B STATE	WELL	KR-X	BR REC	BV 6 STATE	BR REC	KR-X	BV 2 STATE	BR REC	KR-X	BV 7 STATE	KR-X	BV 3 STATE	KR-X	BV 5 STATE	KR-X	BV 4 STATE	KR-X	BV 5 TO BV LAKE STATE	KR-X	SEMITROPIC STATE	KR-X	BR REC	TOTAL STATE	WELL	KR-X	BR REC
JAN			30	957				620		1773			502		1046		124							2292		1803	957
FEB				549	2796		1762	4053		2688			3045				152							10046		4450	549
MAR			40	534				777																777		40	534
APR				734						643				858												1501	734
MAY				1485																							1485
JUN			575	637			274								335		1395							1730		849	637
JUL			980	460			6143			5490		11515	1985		951		1002							3938		24128	460
AUG				2714		1622	4531			5190		17520	4975		611		1262							6848		27241	4336
SEP			121	3884		505		721	178	387		1969	1391		261		155				110		320	2638		2477	4887
OCT			232	4455						3307											141		493	141		3539	4948
NOV			451	4046						2860			2894				347							3241		3311	4046
DEC	123			2288	141		2000	1861		3014			5350		1319		815							9609		5014	2288
AF	123		2429	22743	2937	2127	14710	8032	178	25352		31004	20142	858	4523		5252				251		813	41260		74353	25861

DATA SHEET - DISTRIBUTION - SECOND POINT(WD1)

WD1

5/1/2014

2011

Units in Acre Feet

DAY	SUPPLY SECOND POINT				TOTAL FLOW	DIVERSIONS ALEJ CANAL				KR OUTLET WEIR				KWB - MAIN CANAL (KWB HEAD GATE & KR-PIPELINE)			
	KR	FK	WELL	S-X		KR	FK	S-X	WELL	KR	FK	S-X	WELL	KR	FK	S-X	WELL
JAN	6222			220	6442	541		14		260		131		815			
FEB	17613				17613	12287								1208			
MAR	11906	317		492	12715	5332								1944	101	8	
APR	28076	157		90	28323	19966				1353				2239	50	46	
MAY	71918				71918	22712				7505				37014			
JUN	58941				58941	32692				9667				11865			
JUL	19251				19251	14862				536							
AUG	9478				9478	4403								910			
SEP	151				151	151											
OCT																	
NOV																	
DEC																	
AF	223556	474		802	224832	112946		14		19321		131		55995	151	54	

DAY	INLET WEIR			INTERTIE			KWBA SPREADING MAIN.BYPASS & RIVER			BVWSD SPREADING MAIN.BYPASS & RIVER				LOSSES TRANSPORTATION LOSSES			
	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	S-X	WELL	KR	FK	S-X	WELL
JAN										4606		75					
FEB										4118							
MAR										4630	216	484					
APR										4518	107	44					
MAY										4687							
JUN										4717							
JUL							1216			2637							
AUG										4165							
SEP																	
OCT																	
NOV																	
DEC																	
AF							1216			34078	323	603					

NOTE:

DATA SHEET - DISTRIBUTION - BVARA (WD2A) WD2A 5/1/2014

2011

Units in Acre Feet

DAY	SUPPLY					DIVERSIONS																						
	ALEJ CANAL, BV #3, OTHER				HMWD IRR.	MAPLES CANAL				LCM METER				CELL 2R METER				NORTH RIM METER				DIVERTED TO BV LAKE VIA NR & 2R			DIVERTED CO KERN SALE/CREDIT			
	KR & X	FK	WELL	STATE	WELL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	STATE	KR & X	FK	WELL	STATE
JAN	541			516					482	502			34				109											
FEB	12287			3045		607			89	14368							26				248							
MAR	5332									4330							589				446							
APR	20824					113				18490							1137											
MAY	22712					883				18910				1129			121	692			108							
JUN	32692					2057				21544				5617				1497							1000			
JUL	14862			1985		2073				11147				2805			1767	522			97							
AUG	4403			4975		1716				2221							4258	357			1273							
SEP	151			1391		60											676				305							
OCT																	478											
NOV				2894													1714											
DEC				5350													4185				962							
AF	113804			20156		7509			571	91512			34	9551			15060	3068			3439				1000			

DATA SHEET - DISTRIBUTION - BVARA (WD2B)

WD2B **2011** 5/1/2014

Units in Acre Feet

DAY					RESERVIOUR LOSSES				STORAGE					NET CHANGE				
					DISTRICT ASSUMED				BVARA									
									KR & X	FK	WELL	STATE	TOTAL	BVARA				
	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	2100			-171	1929	KR & X	FK	WELL	STATE	TOTAL
JAN									2139			-280	1859	-39			109	70
FEB									-549			2402	1853	2688			-2682	6
MAR									453			1367	1820	-1002			1035	33
APR									2674			230	2904	-2221			1137	-1084
MAY									3773				3773	-1099			230	-869
JUN									4750				4750	-977				-977
JUL									3065			121	3186	1685			-121	1564
AUG									3174			-435	2739	-109			556	447
SEP									3265			-25	3240	-91			-410	-501
OCT									3265			-503	2762				478	478
NOV									3265			677	3942				-1180	-1180
DEC									3267			877	4144				-202	-202
AF									3267			877	4144	-1165			-1050	-2215

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3A) WD3A **2011** 5/1/2014

Units in Acre Feet

DAY	TOTAL SUPPLY						DIVERSIONS															
	BVARA-BV LAKE WD1-WD2-WD4-WD6-STOS						WASTE WEIR SPILLS OR DELIVERY IN FLOOD CHANNEL					WASTE WEIR SPREADING IN CHANNEL					BV LAKE OUTLET GATES REVERSE FLOWS TO BUENA VISTA LAKE					
	KR & X	FK	WELL	DW#1	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	
JAN	762				165																	
FEB	14368																					
MAR	4330																					
APR	19843											2212										
MAY	26415						1456					2648										
JUN	31211											2235										
JUL	23198											375										
AUG	19741																					
SEP	1969																					
OCT																						
NOV																						
DEC																						
AF	141837				165		1456					7470										

Note: 1,456 AF of 1st Pt. water making 2nd. Pt. got spilled in the Flood Channel over the New Concrete Weir in May 2011.

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3B)

WD3B

2011 5/1/2014

Units in Acre Feet

DAY	SPREADING CHANNEL OR ELK PEN					OUTLET CANAL SPREADING					OUTLET CANAL LOSSES					OUTLET TOTAL LOSSES	PB-BV#7 TO AQUEDUCT					EAST SIDE INTAKE CANAL HEAD				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN	367			14							395			151		546										
FEB	1781										2430					2430						10157				
MAR											940					940						3390				
APR	2866										3086					3086						11679				
MAY	3606										2753					2753						15952				
JUN	3201										2579					2579						23196				
JUL	3160										1940					1940						17723				
AUG	3195										1690					1690						14856				
SEP	468										38					38						1463				
OCT																										
NOV																										
DEC																										
AF	18644			14							15851			151		16002						98416				

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4A)

WD4A **2011** 5/1/2014

Units in Acre Feet

DAY	SUPPLY										DIVERSIONS															
	OUTLET-MAIN-STOS STO, WD3 & WD7						INTERNAL				OUTSIDE DELIVERIES WK - ST - RRB - KNWR						SPILL TO OUTLET WD 3					SPILL TO MAIN CANAL WD 7				
	KR & X	FK	WELL	STATE	RECL	BR RECL	DIST. WELLS	DIST. RECL	GROWER WELLS	GROWER RECL	KR & X	FK	WELL	STATE	RECL	BR REC	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN	1803			620		957					1803			620		957										
FEB	14607			6849		549	73	1224	50	540				3176	286	549										
MAR	3430			777		534		715	8	135	22			722	166	534										
APR	12322					734		831			1137				585	734										
MAY	15952					1485		3290		22	1101				3290	1486										
JUN	24045					637		2411		538	649				1261	637										
JUL	30336					460		3327	16	853	867				2395	460										
AUG	24577					4336		1724	113	865	856					4336										
SEP	1971			831		4887	60	153		175	152			831		4887										
OCT	3539			141		4948	32				3209			141		4948										
NOV	3311					4046	30				3037					4046										
DEC	5014			2125		2288	24	39		6	3015			50		2288										
AF	140907			11343		25861	219	13714	187	3134	15848			5540	7983	25862										

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4B)

WD4B

5/1/2014

2011

Units in Acre Feet

DAY	SPILL AT HWY 46 KR & X	FK	WELL	STATE	RECL	WKWD Spreading STATE	FIELD DELIVERIES BUTTONWILLOW KR & X	FK	WELL	STATE	RECL	Total FD	CANAL LOSSES INTERNAL SYSTEM KR & X	FK	WELL	STATE	RECL	Total Losses
JAN																		
FEB							11064		123	3673	540	15400	3543				938	4481
MAR							3539		8		307	3854	-131			55	377	301
APR							5593					5593	5592				246	5838
MAY							6317				22	6339	8534					8534
JUN							19285				538	19823	4111				1150	5261
JUL							25063		16		861	25940	4406				924	5330
AUG							21834		113		879	22826	1887				1710	3597
SEP							2237		60		175	2472	-418				153	-265
OCT							330		32			362						
NOV							274		30			304						
DEC							482		24	1793	6	2305	1517			282	39	1838
AF							96018		406	5466	3328	105218	29041			337	5537	34915

DATA SHEET - DISTRIBUTION - MAPLES (WD5)

WD5

2011

5/1/2014

Units in Acre Feet

DAY	SUPPLY								USE																				
	BVARA-BV LAKE WD2 & WD6					BV CANAL	GROWER		KDWD DELIVERIES				SPILL OR DELIVERIES BV LAKE					BVWSD FIELD DELIVERIES					Total FD	SYSTEM CANAL LOSS					Total Losses
	KR & X	FK	WELL	STATE	RECL	KR	WELLS	RECL	KR & X	FK	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	
JAN				482																	325		325				157		157
FEB	607			89														591					591	16			89		105
MAR																													
APR	113																	34					34	79					79
MAY	883																	601					601	282					282
JUN	2057																	1724					1724	333					333
JUL	2073																	1805					1805	268					268
AUG	1716																	1444					1444	272					272
SEP	60																	46					46	14					14
OCT																													
NOV																													
DEC																													
AF	7509			571														6245			325		6570	1264			246		1510

DATA SHEET - DISTRIBUTION - BV LAKE (WD6A) **2011**

Units in Acre Feet

DAY	SUPPLY					USE														
	BVARA-OUTLET-STOS WD1, WD2,WD3,MISC & STO					MAPLES CANAL					OUTLET GATES					HMWD IRRIGATION				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																				
FEB																				
MAR																				
APR																				
MAY																				
JUN																				
JUL																				
AUG																				
SEP																				
OCT																				
NOV																				
DEC																				
AF																				

DATA SHEET - DISTRIBUTION - BV LAKE (WD6B) **2011**

Units in Acre Feet

DAY	RESERVIOUR LOSSES					STORAGE					NET CHANGE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN															
FEB															
MAR															
APR															
MAY															
JUN															
JUL															
AUG															
SEP															
OCT															
NOV															
DEC															
AF															

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7)

WD7A

5/1/2014

2011

Units in Acre Feet

DAY	SUPPLY																																		
	WD1-WD4-Misc					Used By KERN WATER BANK					Used By COUNTY OF KERN & HM					SPREADING KWB & (M1&M7) CHANNEL & 160 ACRES (BVWSD)					KWB CANAL (BVWSD) EAST & WEST POOL LOSSES IN CANAL					DIVERTED TO CALIFORNIA AQUEDUCT BV					CANAL HEAD ES INTAKE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																																			
FEB																																			
MAR																																			
APR																																			
MAY	37014					35796										69					783					366									
JUN	11865					10451										476					603					335									
JUL																																			
AUG																																			
SEP																																			
OCT																																			
NOV																																			
DEC																																			
AF	48879					46247										545					1386					701									

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7B) / EAST TO WEST

WD7B

5/1/2014

2011

Units in Acre Feet

DAY	TOTAL SUPPLY					BUENA VISTA WSD DIVERSIONS												
						BVWSD - WK - BV PONDS / RIVER					BV- OTHER PONDS (M1 & M7)					BV- LOSSES (KWB CANAL)		
																EAST	WEST	BV
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	POOL	POOL	TOTAL
JAN	815										406					409		815
FEB	1208										1168					40		1208
MAR	1944	101		8							1851					93		1944
APR	2240	50		46		1187										107		1294
MAY																		
JUN																		
JUL	1837										922					491	424	1837
AUG	1049										706					343		1049
SEP																		
OCT																		
NOV																		
DEC																		
AF	9093	151		54		1187					5053					1483	424	8147

DAY	OTHER DIVERSIONS																
	WEST KERN - WK - BV PONDS & LOSSES							KWB - PONDS					KCWA (others)				
				Del	Loss-KWB												
	KR & X	FK	WELL	STATE	STATE	RECL	TOTAL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																	
FEB																	
MAR														101		8	
APR													946	50		46	
MAY																	
JUN																	
JUL																	
AUG																	
SEP																	
OCT																	
NOV																	
DEC																	
AF													946	151		54	

Note : JULY 2011 : Have to get all information from the KCWA Records. As part of an operational exchange, Semitropic WSD and Dudley Ridge WD delivered SWP supplies to BVWSD on the KWB Canal for a like amount of BVWSD Kern River supplies through the Trestle Turnout off the Kern River Channel. (Total 1,837 AF : SWSD 1,470 AF & DRWD 367 AF)

Note : AUGUST 2011 : Have to get all information from the KCWA Records. As part of an operational exchange, Semitropic WSD,Belridge WSD and Wheeler-Ridge Maricopa WSD delivered SWP supplies to BVWSD on the KWB Canal for a like amount of BVWSD Kern River supplies through the Trestle Turnout off the Kern River Channel. (Total 139 AF : SWSD 53 AF, BWSD 58 AF, WRMWSD 28)

DATA SHEET - DISTRIBUTION - HMWD IRRIGATION USE

WD8

5/1/2014

2011

Units in Acre Feet

DAY	USE											TOTAL					
	DIRECT		VIA					VIA				USE					
	BV 4&5		BV LAKE					BVARA									TOTAL
	KR & X	STATE	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	RECL	ALL
JAN		1170									109				1279		1279
FEB		152									274				426		426
MAR											1035				1035		1035
APR											1137				1137		1137
MAY								1821			229	1821			229		2050
JUN		1730						7114				7114			1730		8844
JUL		1953						3327			1864	3327			3817		7144
AUG		1873						357			5531	357			7404		7761
SEP		416									981				1397		1397
OCT											478				478		478
NOV		347									1714				2061		2061
DEC		2134									5147				7281		7281
AF		9775						12619			18499	12619			28274		40893

DISTRIBUTION INPUTS SUPPLIES

Inputs **2012**

SECOND POINT SUPPLY (Including Deliveries Via Buena Vista Canal) **Units in Acre Feet**

Via / To / DAY	1st Pt KR	1st Pt 2nd Pt (KD) KR	1st Pt FK CANAL FK-X	1st Pt 2800 KR-X	1st Pt WELL	1st Pt Spill KR	KCWA Spill FK	KCWA Spill S-X	Via RTO 1 Others @2nd. Pt. S-X	HWD DUE @2ndPt KR	HWD @2nd Pt KR	HWD FK	HWD WELLS	BVWSD DUE @2ndPt KR	BVWSD @2ndPt KR	BVWSD FK CANAL @2ndPt FK-X	BVWSD 2800 @2ndPt WELLS	TOTAL SUPPLY At 2nd Point KR	FK	WELL	STATE	TOTAL SUPPLY
JAN																						
FEB																						
MAR					4931									2844	2844			2844		4931		7775
APR					6061									4856	4856		1711	4856		7772		12628
MAY					2350									1208	1208		1714	1208		4064		5272
JUN					2196									5968	5968		1632	5968		3828		9796
JUL														5986	5986			5986				5986
AUG																						
SEP																						
OCT					1000															1000		1000
NOV																						
DEC																						
AF					16538									20862	20862		5057	20862		21595		42457

DISTRIBUTION INPUTS (MISC SUPPIES)

Misc

2012

MISC WATER - WELLS & RECLAMATION PUMPS Below 2nd Pt. **Units in Acre Feet**

DAY	HMWD			DISTRICT						TOTAL SUPPLY				
Via	BVARA	BV LAKE AREA		GROWER		BVWSD	BVWSD	GROWER	GROWER	Below 2nd Pt				
				Maples	Maples	BW	BW	BW	BW					
DAY	WELLS	WELLS	RECL	WELLS	RECL	WELLS	RECL	WELLS	RECL	KR	WELL	STATE	RECL	TOTAL
JAN						129	97		456		129		553	682
FEB						188	331		597		188		928	1116
MAR						18			190		18		190	208
APR						173			152		173		152	325
MAY	152					311			371		463		371	834
JUN	1051					89	1706	238	742		1378		2448	3826
JUL	343					103	3124	264	1000		710		4124	4834
AUG						55	3112	58	819		113		3931	4044
SEP						125			151		125		151	276
OCT						30			18		30		18	48
NOV	1071					40					1111			1111
DEC	1293					20					1313			1313
AF	3910					1281	8370	560	4496		5751		12866	18617

DISTRIBUTION INPUTS (STO)

STO

2012

Units in Acre Feet

STATE TURNOUTS

DAY	SUPPLY BV 1B STATE	WELL	KR-X	BR REC	BV 6 STATE	BR REC	KR-X	BV 2 STATE	BR REC	KR-X	BV 7 STATE	KR-X	BV 3 STATE	KR-X	BV 5 STATE	KR-X	BV 4 STATE	KR-X	BV 5 TO BV LAKE STATE	KR-X	SEMITROPIC STATE	KR-X	BR REC	TOTAL STATE	WELL	KR-X	BR REC
JAN			16	1585	518			3858					1187				579							6142		16	1585
FEB	1252			1609				600									810							2662			1609
MAR															286		259							545			
APR	54														105		501							660			
MAY	311			400	581			680							1334		157							3063			400
JUN			1194				4513	276		3482	8200	4096	3653		2964		1756							16849		13285	
JUL	1032				125		5500	629		5185	1000	12166	4745		1992		2402							11925		22851	
AUG	1420						3838	424		3966		13468	3029		3255		2556							10684		21272	
SEP	214			3575									448				220							882			3575
OCT			153	5128						2649											114			114		2802	5128
NOV	73		625	3337											1513		928				179			2693		625	3337
DEC	35		693	3112											514		711				149			1409		693	3112
AF	4391		2681	18746	1224		13851	6467		15282	9200	29730	13062		11963		10879				442			57628		61544	18746

DATA SHEET - DISTRIBUTION - SECOND POINT(WD1)

WD1

2012

Units in Acre Feet

DAY	SUPPLY SECOND POINT				TOTAL FLOW	DIVERSIONS ALEJ CANAL				KR OUTLET WEIR				KWB - MAIN CANAL (KWB HEAD GATE & KR-PIPELINE)			
	KR	FK	WELL	S-X		KR	FK	S-X	WELL	KR	FK	S-X	WELL	KR	FK	S-X	WELL
JAN																	
FEB																	
MAR	2844		4931		7775	109								2735			4931
APR	4856		7772		12628									4856			7772
MAY	1208		4064		5272	587			343					621			3721
JUN	5968		3828		9796	5968			1541								2287
JUL	5986				5986	5986											
AUG																	
SEP																	
OCT			1000		1000				1000								
NOV																	
DEC																	
AF	20862		21595		42457	12650			2884					8212			18711

DAY	INLET WEIR			INTERTIE			KWBA SPREADING MAIN.BYPASS & RIVER			BVWSD SPREADING MAIN.BYPASS & RIVER				LOSSES TRANSPORTATION LOSSES (BVWSD only)			
	KR	FK	WELL	KR	FK	WELL	KR	FK	WELL	KR	FK	S-X	WELL	KR	FK	S-X	WELL
JAN																	
FEB																	
MAR																	
APR																	
MAY																	
JUN																	
JUL																	
AUG																	
SEP																	
OCT																	
NOV																	
DEC																	
AF																	

NOTE:

DATA SHEET - DISTRIBUTION - BVARA (WD2A)

WD2A

2012

Units in Acre Feet

DAY	SUPPLY					DIVERSIONS																						
	ALEJ CANAL, BV #3, OTHER				HMWD IRR.	MAPLES CANAL				LCM METER				CELL 2R METER				NORTH RIM METER				DIVERTED TO BV LAKE VIA NR & 2R			DIVERTED CO KERN SALE/CREDIT			
	KR & X	FK	WELL	STATE	WELL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	KR & X	FK	STATE	KR & X	FK	WELL	STATE
JAN				1187													651				137							
FEB																	980											
MAR	109																				44							
APR																												
MAY	587		343		152	111				399		343				152	366											
JUN	5968		1541	3653	1051	468		1541		5578						694	2848			357	403							
JUL	5986			4745	343	2471				5849						343	4090				242							
AUG				3029		946			962	4							1065				859							
SEP				448					430								103				44							
OCT			1000														187				248						1000	
NOV					1071											857	266			65								
DEC					1293											1236				217								
AF	12650		2884	13062	3910	3996		1541	1392	11830		343				3282	10556			639	1977						1000	

DATA SHEET - DISTRIBUTION - BVARA (WD2B)

WD2B

2012

Units in Acre Feet

DAY					RESERVIOUR LOSSES				STORAGE					NET CHANGE				
					DISTRICT ASSUMED				BVARA									
									KR & X	FK	WELL	STATE	TOTAL	BVARA				
	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	3267			877	4144	KR & X	FK	WELL	STATE	TOTAL
JAN									3267			1277	4544				-400	-400
FEB									3267			298	3565				979	979
MAR									3376			254	3630	-109			44	-65
APR									3376			254	3630					
MAY									3453			-111	3342	-77			365	288
JUN									3376			292	3668	77			-403	-326
JUL									1041			704	1745	2335			-412	1923
AUG									91			847	938	950			-143	807
SEP									91			718	809				129	129
OCT									91			283	374				435	435
NOV									91		149	18	258			-149	265	116
DEC									91		-12	18	97			161		161
AF									91		-12	18	97	3176		12	859	4047

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3A)

WD3A

2012

Units in Acre Feet

DAY	TOTAL SUPPLY BVARA-BV LAKE WD1-WD2-WD4-WD6-STOS						DIVERSIONS WASTE WEIR SPILLS OR DELIVERY IN FLOOD CHANNEL					WASTE WEIR SPREADING IN CHANNEL (WKWD)					BV LAKE OUTLET GATES REVERSE FLOWS TO BUENA VISTA LAKE				
	KR & X	FK	WELL	DW#1	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN					3021										305						
FEB					600										62						
MAR																					
APR																					
MAY	399		343																		
JUN	9674		8		8200																
JUL	18015		10		1000																
AUG	13472																				
SEP																					
OCT																					
NOV																					
DEC																					
AF	41560		361		12821										367						

DATA SHEET - DISTRIBUTION - OUTLET CANAL (WD3B)

WD3B

2012

Units in Acre Feet

DAY	SPREADING CHANNEL OR ELK PEN (WKWD)					OUTLET CANAL SPREADING (WKWD)					OUTLET CANAL LOSSES					OUTLET TOTAL LOSSES	PB-BV#7 TO AQUEDUCT					EAST SIDE INTAKE CANAL HEAD				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN				2353					363																	
FEB				465					73																	
MAR																										
APR																										
MAY											399		343			742										
JUN											2102					2102						7572		8	8200	
JUL											2100					2100						15915		10	1000	
AUG											1004					1004						12468				
SEP																										
OCT																										
NOV																										
DEC																										
AF				2818					436		5605		343			5948						35955		18	9200	

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4A)

WD4A

2012

Units in Acre Feet

DAY	SUPPLY										DIVERSIONS															
	OUTLET-MAIN-STOS STO, WD3 & WD7						INTERNAL				OUTSIDE DELIVERIES WK - ST - RRB - KNWR						SPILL TO OUTLET WD 3 (WKWD)					SPILL TO MAIN CANAL WD 7				
	KR & X	FK	WELL	STATE	RECL	BR RECL	DIST. WELLS	DIST. RECL	GROWER WELLS	GROWER RECL	KR & X	FK	WELL	STATE	RECL	BR REC	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN	16			4376		1585	129	97		456	16					1585				3021						
FEB				1852		1609	188	331		597						1609				600						
MAR							18			190																
APR				54			173			152																
MAY				1572		400	311			371						400										
JUN	16761		8	8476			81	1706	238	742				276	654											
JUL	26600		10	2786			93	3124	264	1000				629	1506											
AUG	20272			1844			55	3112	58	819				286	1512											
SEP				214		3575	125			151				4		3575										
OCT	2802			114		5128	30			18	2506			114		5128										
NOV	625			252		3337	40							252		3337										
DEC	693			184		3112	20							184		3112										
AF	67769		18	21724		18746	1263	8370	560	4496	2522			1745	3672	18746				3621						

DATA SHEET - DISTRIBUTION - CANAL HEAD TO FIELD (WD4B)

WD4B

2012

Units in Acre Feet

DAY	SPILL AT HWY 46					FIELD DELIVERIES BUTTONWILLOW					Total FD	CANAL LOSSES INTERNAL SYSTEM					Total Losses
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	
JAN								129	1140	456	1725				215	97	312
FEB								188	1252	597	2037					331	331
MAR								18		190	208						
APR								173	46	152	371				8		8
MAY								311	182	371	864				1390		1390
JUN						8680		327	8200	742	17949	8081				1052	9133
JUL						18208		367	2157	1000	21732	8392				1618	10010
AUG						15385		113	1558	952	18008	4887				1467	6354
SEP								125	147	151	423				63		63
OCT						296		30		18	344						
NOV						625		40			665						
DEC						593		20			613	100					100
AF						43787		1841	14682	4629	64939	21460			1676	4565	27701

DATA SHEET - DISTRIBUTION - MAPLES (WD5)

WD5

2012

Units in Acre Feet

DAY	SUPPLY								USE																				
	BVARA-BV LAKE WD2 & WD6					BV CANAL	GROWER		KDWD DELIVERIES				SPILL OR DELIVERIES BV LAKE					BVWSD FIELD DELIVERIES					Total FD	SYSTEM CANAL LOSS					Total Losses
	KR & X	FK	WELL	STATE	RECL	KR	WELLS	RECL	KR & X	FK	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL		KR & X	FK	WELL	STATE	RECL	
JAN																													
FEB																													
MAR																													
APR																													
MAY	111																							111					111
JUN	468		1541															268		1313			1581	200		228			428
JUL	2471																	2071					2071	400					400
AUG	946			962														639			863		1502	307			99		406
SEP				430																	323		323				107		107
OCT																													
NOV																													
DEC																													
AF	3996		1541	1392														2978		1313	1186		5477	1018		228	206		1452

DATA SHEET - DISTRIBUTION - BV LAKE (WD6A)

WD6 **2012**

Units in Acre Feet

DAY	SUPPLY					USE														
	BVARA-OUTLET-STOS WD1, WD2,WD3,MISC & STO					MAPLES CANAL					OUTLET GATES					HMWD IRRIGATION				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																				
FEB																				
MAR																				
APR																				
MAY																				
JUN																				
JUL																				
AUG																				
SEP																				
OCT																				
NOV																				
DEC																				
AF																				

DATA SHEET - DISTRIBUTION - BV LAKE (WD6B)

2012

Units in Acre Feet

DAY	RESERVIOUR LOSSES					STORAGE					NET CHANGE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN															
FEB															
MAR															
APR															
MAY															
JUN															
JUL															
AUG															
SEP															
OCT															
NOV															
DEC															
AF															

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7)

WD7A

2012

Units in Acre Feet

DAY	SUPPLY WD1-WD4-Misc					Used By KERN WATER BANK					Used By COUNTY OF KERN & HM					SPREADING KWB & (M1&M7) CHANNEL & 160 ACRES (BVWSD)					KWB CANAL (BVWSD) EAST & WEST POOL LOSSES IN CANAL					DIVERTED TO CALIFORNIA AQUEDUCT BV					CANAL HEAD ES INTAKE				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																																			
FEB																																			
MAR	2735		4931					4931													80					2655									
APR	4856		7772					6061													127		38			4729		1673							
MAY	621		3721					2350													14		14			607		1357							
JUN			2287					2196																				91							
JUL																																			
AUG																																			
SEP																																			
OCT																																			
NOV																																			
DEC																																			
AF	8212		18711					15538													221		52			7991		3121							

DATA SHEET - DISTRIBUTION - MAIN CANAL (WD7B) / EAST TO WEST

WD7B

2012

Units in Acre Feet

DAY	TOTAL SUPPLY					BUENA VISTA WSD DIVERSIONS																						OTHER DIVERSIONS									
						BVWSD - WK - BV PONDS / RIVER					BV- OTHER PONDS (M1 & M7)					BV- LOSSES (KWB CANAL)			WEST KERN - WK - BV PONDS & LOSSES							KWB - PONDS					KCWA (others)				
	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL	EAST POOL	WEST POOL	BV TOTAL	KR & X	FK	WELL	Del STATE	Loss-KWB STATE	RECL	TOTAL	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	RECL
JAN																																			
FEB																																			
MAR																																			
APR																																			
MAY																																			
JUN																																			
JUL																																			
AUG																																			
SEP																																			
OCT																																			
NOV																																			
DEC																																			
AF																																			

DATA SHEET - DISTRIBUTION - HMWD IRRIGATION USE

WD8

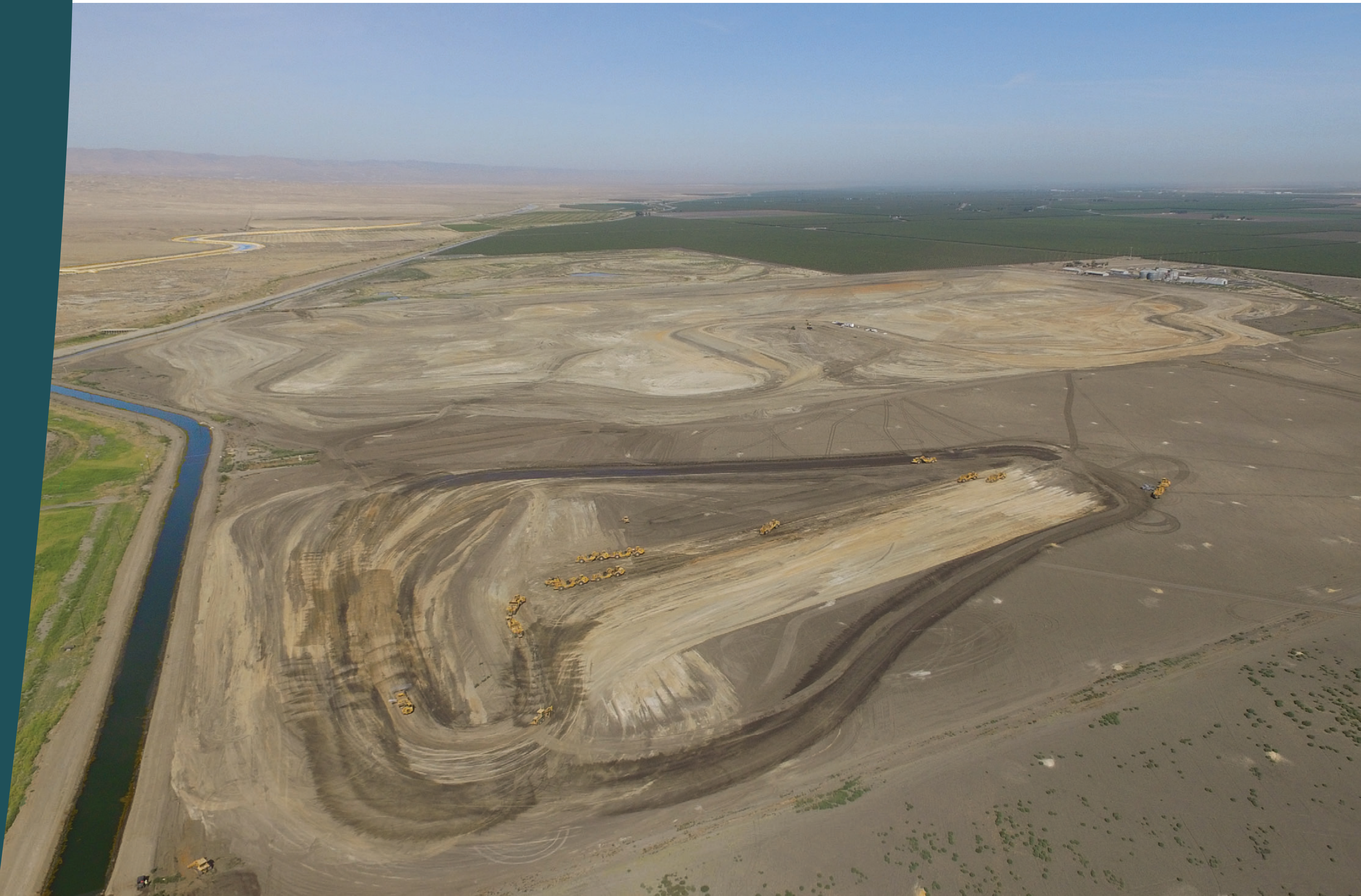
2012

Units in Acre Feet

DAY	USE											TOTAL					
	DIRECT		VIA					VIA				USE					
	BV 4&5		BV LAKE					BVARA									TOTAL
	KR & X	STATE	KR & X	FK	WELL	STATE	RECL	KR & X	FK	WELL	STATE	KR & X	FK	WELL	STATE	RECL	ALL
JAN		579									788				1367		1367
FEB		810									980				1790		1790
MAR		545									44				589		589
APR		606													606		606
MAY		1491								152	366			152	1857		2009
JUN		4720								1051	3251			1051	7971		9022
JUL		4394								343	4332			343	8726		9069
AUG		5811									1924				7735		7735
SEP		220									147				367		367
OCT											435				435		435
NOV		2441								922	266			922	2707		3629
DEC		1225								1453				1453	1225		2678
AF		22842								3921	12533			3921	35375		39296

Appendix J

Buena Vista Land Fallowing Program Information



Description of Fallow Land Program

At its December 6, 2019 Board of Director's Meeting, Buena Vista Water Storage District (BVWSD) enacted a fallow land program for 2020 since it appears the year may be a below average water year. The Board approved payment of $500 per acre for a maximum District-wide of 4,000 acres or total payments of $2,000,000.

This offer was made on a first come first approved basis and is valid through March of 2020, although historically farming/planting decisions are made no later than December. In the accompanying table the 10 growers who have signed up for the program already have an approved participating acreage of 2,055 acres. Land enrolled in the program will be fallowed in 2020 to reduce water consumption in the BVGSA. It is estimated that this will lower demand by approximately 6,000 AF.

BV has implemented fallow land programs before and understands that these programs need to be in place before growers invest time and money in field preparation.

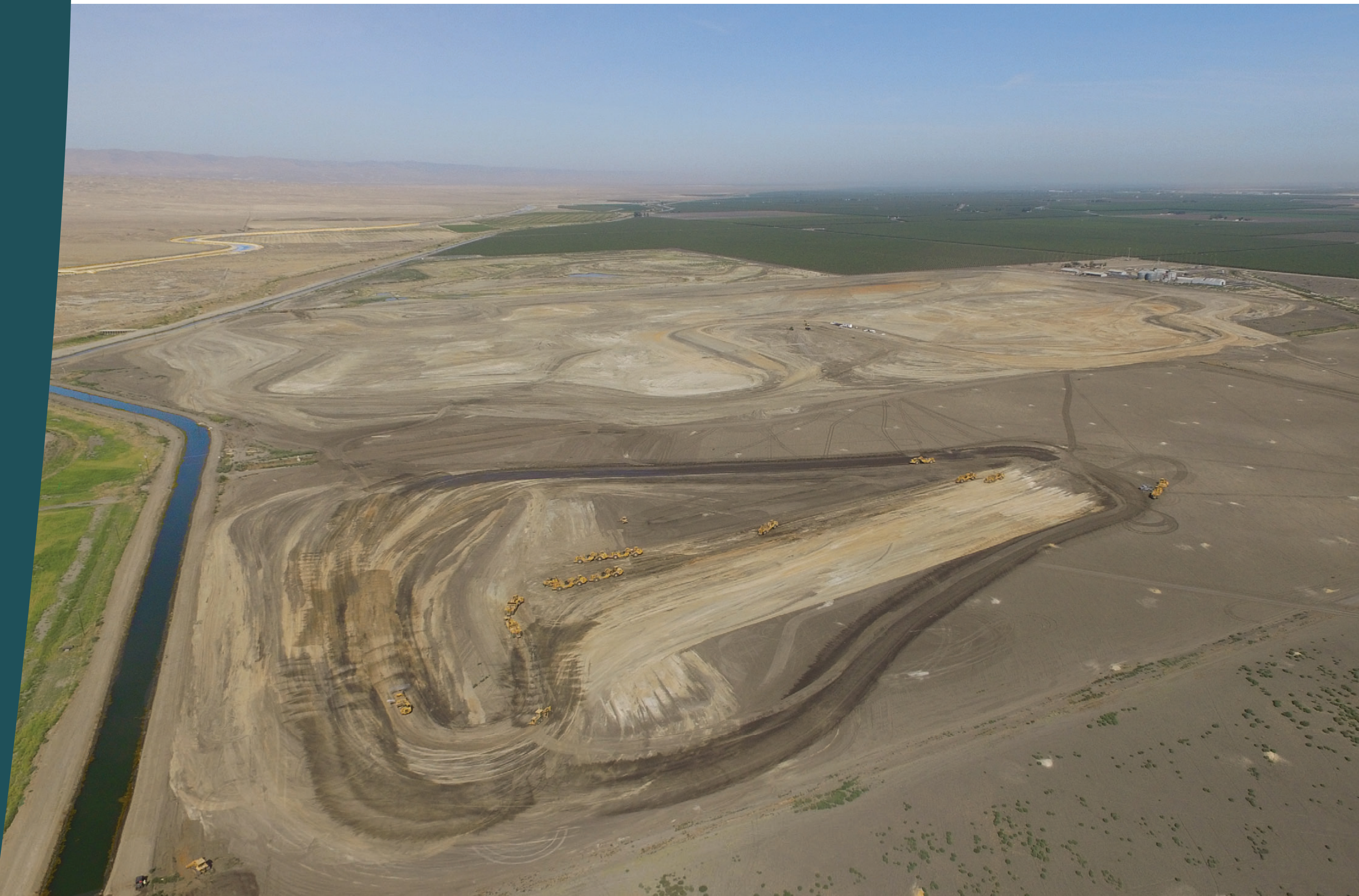
2020 Fallow Land Program

TA 1-10-2020

Landowner	Acres	Acres Recommended	Payment Rate	Payment	Comments
Landowner #1	92.4	92.4	$ 500.00	$ 46,200	
Landowner #2	134.19	134.19	$ 500.00	$ 67,095	
Landowner #3	225	95	$ 500.00	$ 47,500	One Field being planted in Fall
Landowner #4	439.98	439.98	$ 500.00	$ 219,990	
Landowner #5	159.32	159.32	$ 500.00	$ 79,660	
Landowner #6	126.39	40	$ 500.00	$ 20,000	Only partially ready to farm
Landowner #7					
recently farmed	500	500	0	$ -	Not Accepting Payment
not ready to farm	500	0	0	$ -	Not Ready to be Farmed
Landowner #8	7.3	7.3	$ 500.00	$ 3,650	
Landowner #9	34	34	$ 500.00	$ 17,000	
Landowner #10	553.5	553.5	$ 500.00	$ 276,750	
TOTALS	**2772.08**	**2,055.69**		**$ 777,845.00**	

Appendix K

Interested Parties List



Preliminary Interested Parties List

The BVGSA has been engaged routinely with the interested parties listed below. This list now consists largely of other GSAs engaged in SGMA implementation in the Kern County Subbasin. The Buttonwillow County Water District, which lies entirely within the BVGSA, has been an active cooperator.

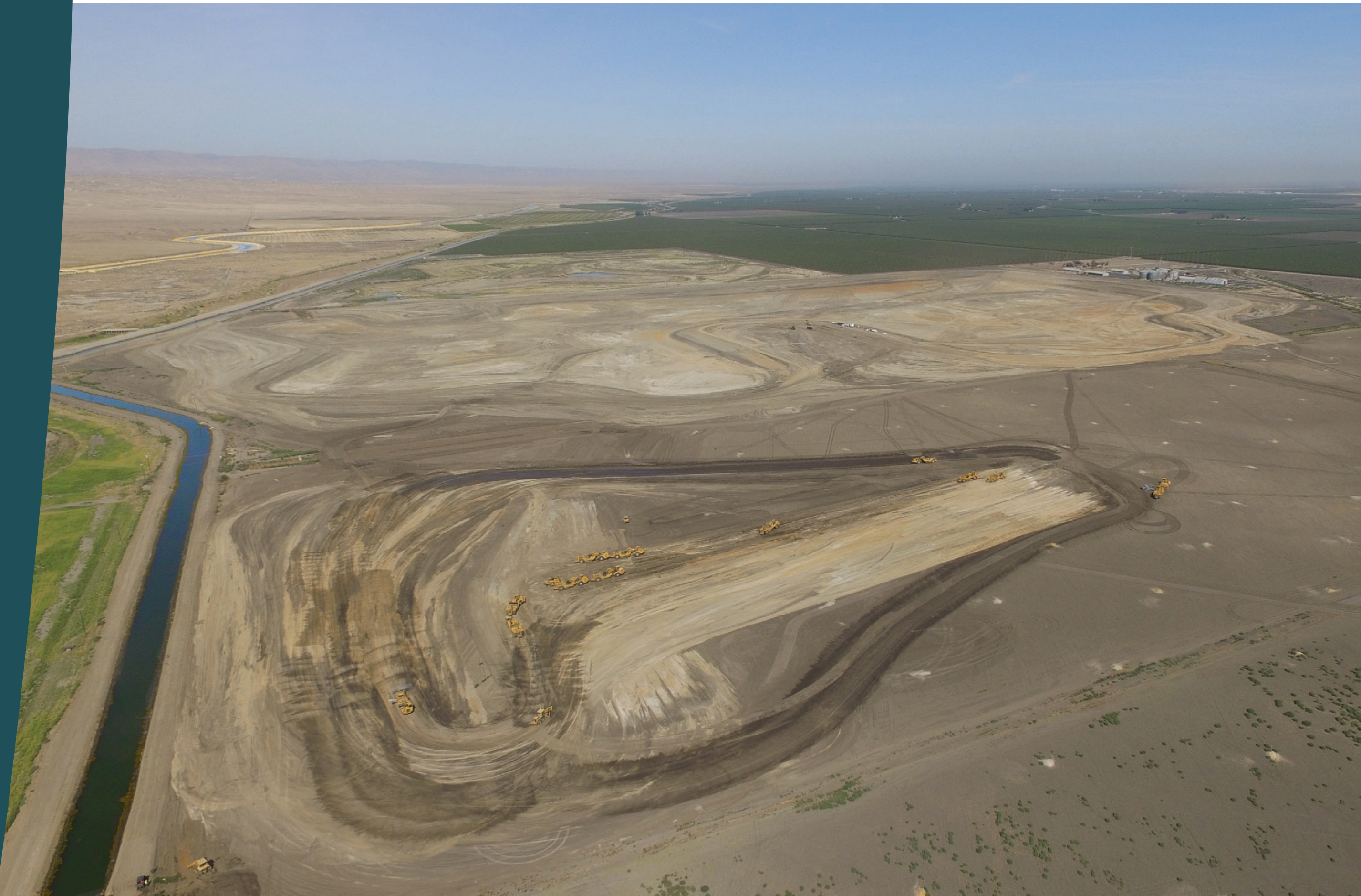
- Buttonwillow County Water District
- Cawelo GSA
- City of Bakersfield
- Greenfield County Water District
- Henry Miller Water District (HMGSA)
- Kern Groundwater Authority GSA (KGAGSA)
- Kern River GSA (KRGSA)
- Kern Water Bank Authority
- McFarland GSA
- Olcese GSA
- Pioneer GSA
- Rosedale-Rio Bravo Water Storage District
- Semitropic Water Storage District
- Todd Groundwater
- West Kern Water District

The BVGSA is also represented on the Basin Coordination Committee consisting of KGAGSA, KRGSA, HMGSA, and the Olcese GSA and on the Basin Technical Committee consisting of KGA, individual members of KGA, and KRGSA, HMGSA, and Olcese GSA and all the consultants serving these GSAs.

The BVWSD regularly updates its webpage with information relevant to development and implementation of the GSP. Information on SGMA-related meetings can also be accessed by interested parties via the website which stores meeting minutes and attendance records and hosts the interested parties list. Entities interested in registering as interested parties can sign up through the website.

Appendix L

References



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