Laboratory Completeness is achieved via an exhaustive examination of the results of both, field samples and the quality control indicators for each of the laboratory analyses. The laboratory completeness assessment is based on the characteristics of laboratory data listed above: sensitivity, contamination, accuracy, recovery and precision.

Completeness for the Laboratory activities will be determined based on the number of sample results that are not materially impacted by data quality issues. The calculation is the number of unaffected sample results versus the total number of data points generated for the sampling event.

An example of the spreadsheet used in the determination of Laboratory Completeness is included in Appendix A.3.

Table 4: Data Quality Objectives –

Measurement or Analysis Type	Sensitivity	Contamination	Accuracy	Recovery	Precision	Completeness
Physical Parameters (EC, pH, DO, temp)	X		X		X	X
Toxicity	X	X	X	NA	X	X
Pathogens	X	X			X	X
Nutrients/Anions	X	X	X	X	X	X
Carbonate/Bicarbonate Alkalinity	X	X	X		X	X
TDS	X	X	X		X	X
TSS	X	X			X	X
Metals	X	X	X	X	X	X
Carbamates	X	X	X	X	X	X
Organochlorines	X	X	X	X	X	X
Organophosphates	X	X	X	X	X	X
Pyrethroids	X	X	X	X	X	X
Herbicides	X	X	X	X	X	X

ELEMENT 8: SPECIAL TRAINING NEEDS / CERTIFICATIONS

As of this time, there are no Coalition staff members with specialized training in chemistry or laboratory procedures, outside of the coursework taken as part of their general educational curriculum. BSK personnel involved in the project have been performing sample collection procedures for many years and are familiar with the maintenance and calibration of the equipment used and the sampling techniques involved. Technical questions are fielded by the contracted labs and their sampling crew.

BSK's Quality Assurance Manager is responsible for the oversight of training. The QA Manager will ensure that adequate training is provided to the laboratory personnel on the requirements of this Program. The training will consist of both written review and hands-on training, all documented and contained within the Laboratory's record keeping system. The training files are maintained by the Laboratory's Quality Assurance Department.

BSK's field technicians undergo initial training and annual refresher training thereafter on proper sample collection techniques for both water and sediment. Initial training consists of a review and acknowledgement of understanding of the laboratory's standard operating procedure on sample collection. This is followed by hands on sample collection working in conjunction with one of BSK's experienced samplers. This hands-on training will continue until the trainer witnesses and documents the satisfactory understanding demonstration of proper technique. Once the Field Technician has demonstrated sufficient knowledge and understanding of the project, the training will be documented and included in the laboratory's training records. The field technicians are trained according to the following SOPs: Field Sampling from Streams, Rivers and Canals (SR-SP-0015), and Safety for Stream and Canal Sampling (SF-SP-0010).

Coalition field technicians undergo an initial training on proper sample collection techniques for groundwater wells. Initial training consists of a review and acknowledgement of understanding of standard operation procedures on groundwater sample collection. This followed by a hands-on sample collection working in conjunction with one of BSK's experienced samplers. This hands-on training will continue until the trainer witnesses and documents the satisfactory understanding demonstration of proper techniques.

BSK's Project Manager will undergo initial training on the details of the QAPP and other project requirements. The training will be conducted by the Laboratory Program Manager or his designee. The training will consist of a reading of the QAPP and a follow up review with the Project Manager. Following this training, the first work order will be reviewed by the Project Manager as well, both on the initial receipt of samples and also at the time of reporting. This final stage of training will include a review of the final work product, the case narrative, the field logs and any other program requirements associated with the QAPP. Once the BSK Project Manager has demonstrated sufficient knowledge and understanding of the project, the training will be documented and included in the laboratory's training records.

ELEMENT 9: DOCUMENTS AND RECORDS

Record keeping is a critical component to any research project. The data collected by the Coalition is maintained in multiple locations. Each lab is required to maintain a copy of the data for a specified period of time according to each laboratory's standard record retention requirements.

Record Handling

Copies of the data submitted by the labs to the Coalition are kept at the Coalition office in electronic and, where necessary, hardcopy format. Additional copies of the data are submitted to the Regional Board along with the quarterly and annual reports. Copies of this data are kept at the local Board office in Fresno, the Regional Board office in Rancho Cordova (and at the Coalition's office).

Data is submitted to the Coalition by the BSK Laboratory in PDF format, and stored electronically. This is more efficient than paper copies of the reports, given the voluminous amounts of data generated. CD's containing the data are routinely made and stored in a secure manner.

Data submission is to be in a CEDEN and GeoTracker ESI compatible excel spreadsheet, for SWAMP and GQTMP respectively, prepared by the individual laboratories (in addition to the additional data formats submitted), which will be combined into a single spreadsheet for submission to the Regional Board. Staff at the Regional Board will be responsible for the upload of data into the CEDEN database. Coalition staff will be responsible for the upload of data into the GeotTracker ESI database,

Data collected and held by the Coalition will be stored for a minimum of seven years at the Coalition office. How long the data submitted to the Regional Board is held is unknown. The Laboratories will store the raw data in both hardcopy and electronic format in accordance with their respective record retention requirements. For CA ELAP certified laboratories – a required credential for this program – laboratories are required to maintain all records for a minimum of five years. Sufficient records must be maintained to allow complete reconstruction of the data.

Documents retained by the Coalition may include: paper copies of the field data sheets, executed Chains of Custody, purchase orders for lab services, and printed copies of the Chemistry, Microbiology and Water Column Toxicity results. All of which are also backed up electronically.

Each data submission to the Regional Board will be a standalone file stored electronically with the Coalition. Once SWAMP analysis results are submitted and accepted by the Regional Board, the data will be integrated into the CEDEN database as maintained by the Central Valley Regional Data Center (CV RDC). GQTMP analyses results with be submitted to the Regional Board through the GeoTracker ESI system.

The QAPP, will be submitted to the Regional Board in the form of a CD. Two versions will be submitted, one containing proprietary information regarding chemical testing and the other for public viewing. They will be clearly labeled. A paper copy of each version will be provided to the Regional Board for review on request.

Once the QAPP is approved by the Regional Board and signed by all required parties, an official copy will be maintained and controlled by the Coalition Quality Assurance Manager. The QA Manager will be responsible for distributing the official copy to the recipient list specified in Element 3. Due to its size, the official copy will be distributed via CD, sent either through mail (or similar delivery) or hand delivered to each recipient's location. In the event of a change in the QAPP, the QA Manager will be responsible for ensuring the timely delivery of the latest revision.

Report Format

Reports for the Chemistry, Microbiology and Water Column Toxicity will be provided in a manner consistent with this QAPP required content.

Documentation of the field activities will include copies of field logs with anomalies noted, results for field measurements, executed chains of custody, and any additional forms, records, or logs that contain information critical to the quality of the data obtained from the sampling event.

Analytical Reports or Certificates of Analysis will contain the following information:

a. Project Name
b. Sample Description
c. Sample Date and Time of Collection
d. Collection Technique (e.g. grab, composite)
e. Sample Type (e.g. field sample, field blank, field duplicate)
f. Preparation and Test Method
g. Parameter
h. Result
i. Dilution Factor
j. Reporting and Detection Limit
k. Units
l. Date / Time Prepared and Analyzed
m. Data Qualifies
n. Quality Control Data including Blanks, Spikes, Duplicates, Surrogates
o. Case Narrative explaining all data anomalies or deficiencies
p. Chain of Custody
q. Sample Conditions on Receipt Summary
r. Subcontract Reports

Record Distribution

The Project QA Manager will have the responsibility of ensuring that the stakeholders have the current version of all relevant documentation including the QAPP. The QA Manager will issue control copies of the current QAPP to each QAPP recipient listed in Element 3 of this QAPP. On a change or revision, the QA Manager will retract the old version of the document and replace with the most current version. The same process will be used for all other documents required by this Plan.

Element 10: Sampling Process Design

Sampling will be conducted according to the schedule mandated within the MRP, with visits of all surface water monitoring sites on a monthly basis and groundwater monitoring of wells on an annual basis. The date for the surface water sampling event is held open with Coalition as the presence of water at each sampling location is uncertain. This allows the contracted lab to work with the Coalition staff to determine the appropriate date for surface water sampling collection to maximize the collection of a sample at a time of water flow. The groundwater sample collection will be conducted during the summer months of each year.

Surface Water Sampling Process Design

The sampling design is to test for the specified chemistries at each of the identified surface water monitoring sites, thus creating defined areas that can be easily addressed should detection occur. Modifications to the list of tested chemistries are planned once cropping patterns and pesticide usages are analyzed.

The SWMP study design is a simple one because of the nature of the waterways involved. Nearly all of the river and creek systems within the Tulare Lake Basin have been optimized for irrigation deliveries. The flow in the Tule River below Success Dam is controlled by the Army Corps of Engineers, while Deer Creek and White River are smaller watersheds and uncontrolled streams. The Plan is designed to detect any occurrence of chemical contamination of these waterways, and then to trace the source. The method for the connection of any chemical contamination to its source and, ultimately, the management practices or runoff related events are outlined in the SWMP.

All surface water monitoring sites listed within the MRP will be visited during each month. It is anticipated that several of the sampling sites will only require photo documentation for the majority of the sample dates. This is due to infrequent flow in the waterway. Specific sampling points at each location have been identified and the rationale for each point is detailed in the SWMP.

Should a site become inaccessible due to field conditions that prevent a Coalition or Laboratory representative to safely access the site, the condition of the site will be documented and the sampling site revisited as soon as conditions allow. This documentation will be included with the report submitted for the follow up (or make up) sampling event. Resampling due to accessibility problems will be addressed on a case by case basis and coordinated between the contract Laboratory and the Coalition. However, as noted in the SWMP, part of the rationale for the selection of the sampling points was the reliability of each to be accessible at all but the most extreme conditions.

However, in some cases, resampling may not be an option due to inclement weather or some other water management constraint. In the event that it is determined a surface water sample must be collected, the specific sampling point may need to be modified. The Coalition Program Manager and Technical Lead will make the determination if this modification is required. If so, the Program Manager will have the responsibility of informing the Board of the modified sampling point and the rationale for doing so.

The occurrence of an exceedance at any of the surface water monitoring sites will trigger a review of the possible sites where the detected chemical could have been used. Also, a physical survey may be undertaken to determine where the chemical could have entered into the waterway. The exact course of action will depend upon the chemistry detected, and the conditions that were present when the sample was collected.

One or more of the surface water sampling sites may be wet during the full course of the year. For these samples, a full set of chemical tests (as specified by the MRP) will be analyzed during the first year of the program. Samples will be grab samples of ambient water.

A duplicate sample will be randomly collected from those sites with water present. However, given that some sites are more likely to be dry a portion of the year, those sites having water most of the year will likely be disproportionately chosen during most sampling events for the field duplicate. One duplicate will be collected for each event.

The only sources of natural variation within the testing program are the EC values. These sources of variation are natural, and as such, uncontrollable.

No known sources of bias exist within the testing program. Field instruments, which could be considered a source of bias, are constantly checked for calibration against known standards and rechecked at the field during the course of the day. The laboratories constantly recalibrate their instrumentation as per method, so that source of variation is minimized as well, the resultant data having no more variation than that inherently contained within the test methods employed.

Surface water sampling points for the coalition are identified in Table 5.

Table 5: Coalition Surface Water Sampling Point Coordinates

Site name	CEDEN Code	Latitude	Longitude
Deer Creek at Road 120	558DCR120	35.912400	-119.303729
Deer Creek at Road 176	558DCR176	35.946256	-119.181017
Deer Creek at Road 248	558DCR248	35.9929	-119.017900
Porter Slough near Road 192	558SPR192	36.116285	-119.134132
Tule River at Plano Street Bridge	TBD	36.055865	-119.133987
Tule River at North Fork Road 144	558TRA144	36.129178	-119.246882
Tule River at Road 92	558TRAR92	36.092952	-119.366727
White River ar Road 208	TBD	35.858597	-119.107887

All data collected as part of the sampling (pH, EC, temperature, turbidity, flow) will be considered critical to the program. All data will be used in the assessment of ambient conditions of the overall water quality. Field observations such as outside temperature, wind directions, time of the day, etc. will be considered informational and not critical to the Plan. However, such observations should be documented as they may help explain any possible anomalies in the analytical data such as unexpected detections for parameters that are historically low or absent in the watershed.

The sampling schedule for each location is included in the SWMP.

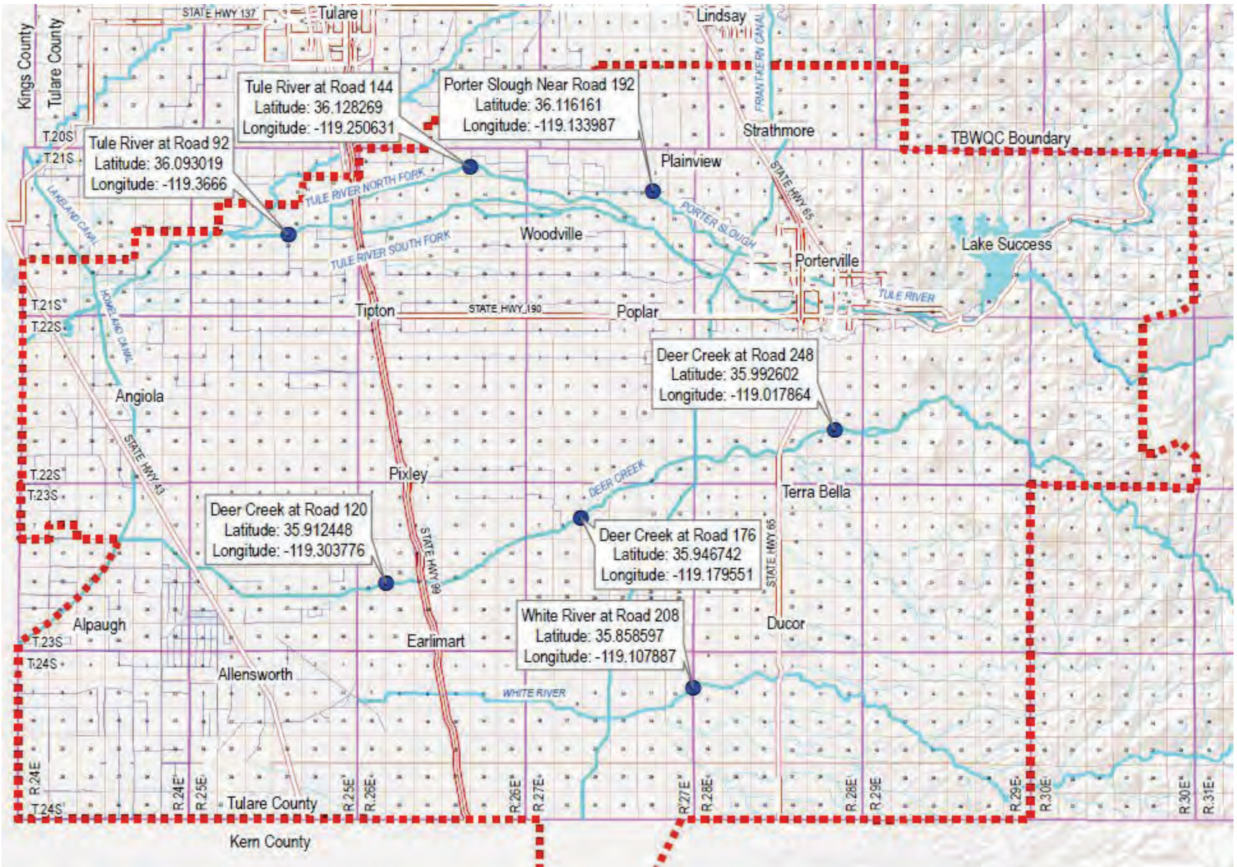


Figure 2: Tule Basin Water Quality Coalition Surface Water Monitoring Sites

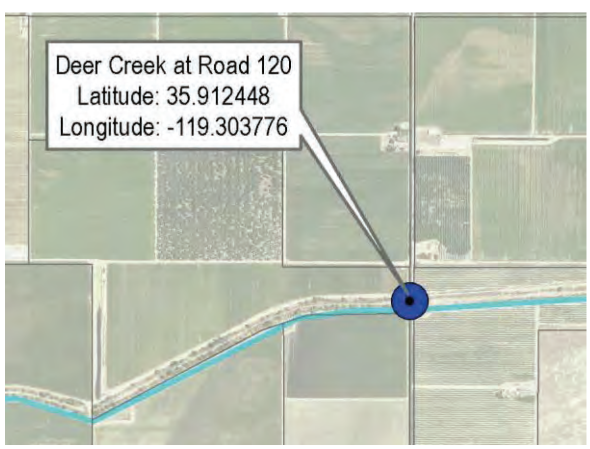


Figure 3: Deer Creek at Road 120 Site Map

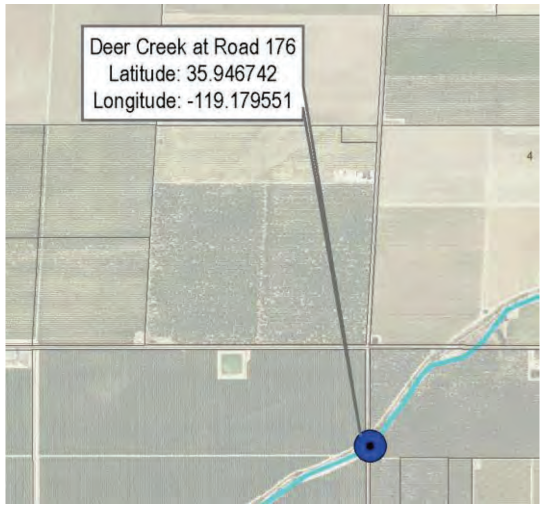


Figure 4: Deer Creek at Road 176 Site Map

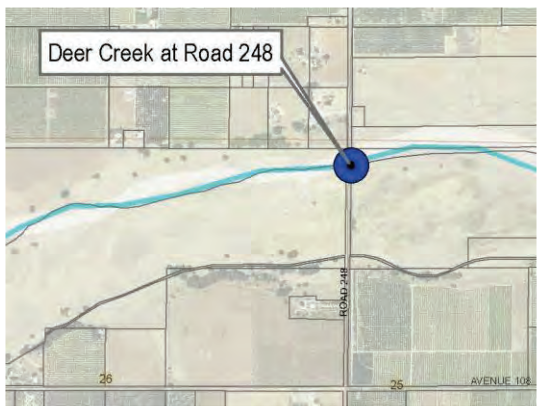


Figure 5: Deer Creek at Road 248 Site Map

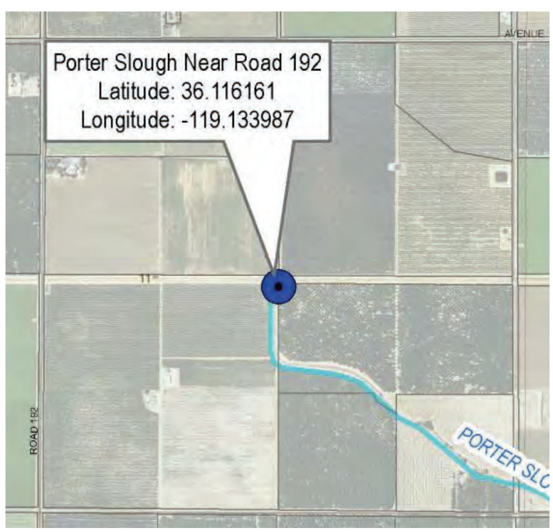


Figure 6: Porter Slough near Road 192Site Map

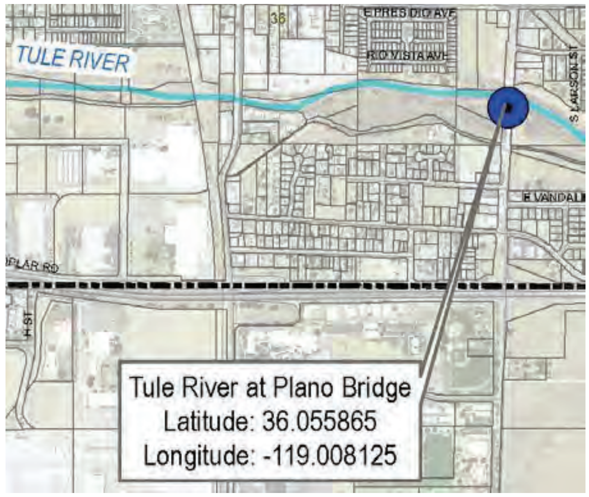


Figure 7: Tule River at Plano Street Bridge Aerial Site Map

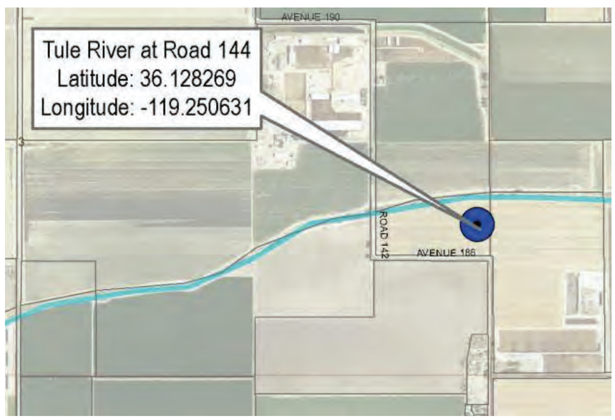


Figure 8: Tule River at North Fork Road 144 Site Map

Figure 9: Tule River at Road 92 Site Map

Figure 10: White River at Road 208 Site Map

Groundwater Sampling Process Design

The groundwater monitoring network as outlined in the GQTMW consists of sampling four wells per township, within both the High and Low Vulnerability areas within the TBWQC, provided, adequate existing wells are available. Domestic and shallow irrigation wells considered for the network are required to have permission from owners, be constructed in the upper most aquifer, with construction details, typically in the form of well completion reports.

Before wells are included in the monitoring program they must be reviewed and approved by the RWQCB to meet the requirements outlined in the MRP. Wells are presented to the RWQCB accompanied with GPS coordinates, well completion reports and construction details including: well depth, perforation intervals, seal information, and casing material.

The GQTMW for the TBWQC was designed in a two phased approach, see Figure 10. Phase 1 encompasses the township and ranges associated with disadvantaged communities (DACs) in the Coalition, with selection and monitoring of well beginning during the first year of the program (2018). Phase 2 makes up the remaining township and ranges within the Coalition and selection and monitoring of wells commencing in the second year (2019) of the program. In the third year of the program all wells will be sampled on the same schedule.

Wells in the GQTMP monitoring network will be sampled on an annual interval for a select group of water quality parameters and sampled every five years for a more extensive set of parameters. Monitoring includes field tested water quality parameters and laboratory analysis of nitrate as nitrogen and general minerals. Constituents and their frequency for analysis are outlined in the MRP.

Water samples shall be obtained from the wellhead, or as near the wellhead as possible, not from any point after the pressure tank. Samples shall not be collected from a faucet inside the home. Wells without these physical capabilities for field sampling were not considered for the trend monitoring well, unless a spigot is installed at or near the wellhead.

If the well goes dry (Drought conditions), or if a well is not selected due to field conditions or access limitations, another well will be identified to replace the well that cannot or can no longer be used. The identification of the secondary well, should the selected well be abandoned, in the nine square mile areas of each township will allow time for identification of a replacement without a gap in data within the township. The Coalition Program Manager and Technical Lead will make the determination if a replacement is required. If so, the Program Manager will have the responsibility of informing the RWQCB of the replacement sampling well location and the rationale for doing so.

Wells used for the monitoring network are included in the GQTMW and periodic updates to network development will be provided to the RWQCB.

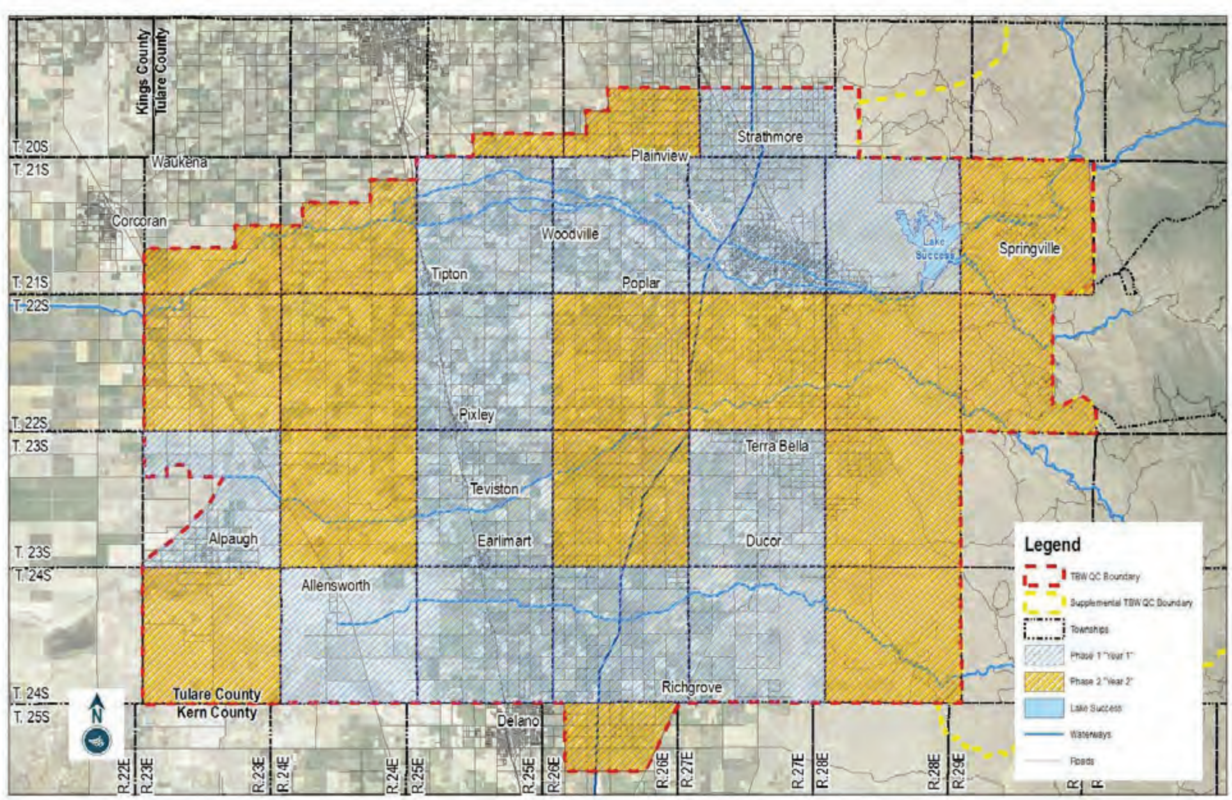


Figure 11: GQTMP Well Network

ELEMENT 11: SAMPLING METHODS

A more detailed description of the sample collection procedures are listed in the SOP in Appendix B.1. As part of the sample collection, photo documentation of the monitoring site will occur. Field technicians will photo log the location, both upstream and downstream of the sampling point as well as the actual point of collection. GPS coordinates will be confirmed and if the point of collection changes, new GPS coordinates will be recorded. A change in the location will only occur on notification and approval of the Project Coordinator.

In the case that the sampling crew is responding to a stormwater event and cannot sample at the exact coordinates indicated in this QAPP, samples will be collected upstream and the Project Coordinator will be notified as soon as possible. Sample analysis will not begin until the location has been approved by the Project Coordinator or his designee. If there is a material difference in the location of actual collection versus the targeted location (>75 yds), the Coalition Project Coordinator will be responsible for notifying the RWQCB.

Safety precautions and procedures in the SOPs for *Field Sampling* must be followed by the sampling crew. Sampling cannot be conducted if the water conditions at the site are deemed hazardous or unsafe. The Project Coordinator will be notified as soon as possible when samplings cannot be performed.

General Sampling Requirements

For the **surface water** sample to be deemed acceptable, the following criteria must be met:

1. Water must be present at the sampling location.
2. The sampler must remain downstream of the sample bottle while the sample is being collected.
3. A delay between samples must occur to allow any disturbed sediment to clear the area of sample collection.
4. The Water Column Toxicity sample bottles should be rinsed with sample water before the final sample is collected.
5. The samples must be kept chilled prior to packing with ice for transport.

Unacceptable surface water samples would include samples from waters that are too shallow to completely submerge the sample container without excessive disturbance of the sediment.

For the **water supply well** sample to be deemed acceptable, the following criteria must be met:

1. Prior to collecting a water sample from a supply well, the water well shall be allowed to run for a period of time that is sufficient for water quality parameter readings for temperature, pH, EC, dissolved oxygen, and turbidity to stabilize to within 10 percent.
2. If the well is currently pumping, the sample may be taken without purging the well.
3. Water samples shall be collected from the discharge point nearest the well head.
4. Samples shall be collected directly into laboratory-prepared bottles. and shall not be taken from a location after treatment of the water for domestic use.
5. The samples must be kept chilled prior to packing with ice for transport.

Surface Water Sediment Sample Collection Requirements

Sediment samples are considered acceptable if the depth of the sediment collected does not exceed 1 inch or 2.5 cm (per method). The sediment must be collected within a reasonable distance of the water collection site, and in sufficient volume to perform an adequate analysis.

Unacceptable sediment samples are those collected from depths in excess of 1 inch or 2.5 cm, from distances too far away from the monitoring site (potentially representing different conditions than those present when water samples are collected), and samples of insufficient volume. Failure to transport the sample at controlled temperatures would also constitute an unacceptable sample.

As a safety precaution, sediment collection should only be performed in a shallow, slow flowing stream or canal waterway, where the water is between a minimal surface flow of a few inches to a maximum depth that is below the height of the sampler's knee. The stream or canal flow must be slow flowing of less than one foot per second. Sampling attempted in conditions exceeding these limitations must be conducted with special safety harness, retrieval gear or rescue apparatus.

Sample Collection Volumes

The volume of collected samples are designated by the contracted laboratory to allow for sufficient volume to test, plus additional volume for retesting in the event of laboratory errors (spillage, instrument failure, operator error). Breakage, unfortunately, cannot be anticipated once the sample is delivered to the lab, so no contingency plan is available for such an occurrence. The only recourse is to fully duplicate all samples, which is impractical for all concerned.

Sample Collection Procedures

Pre-Collection

The sequence of events for a sampling event is as follows:

1. Several days before the event, all bottles are collected and labeled for the event. They are then packed into labeled ice chests for transport.
2. The day before the event, the calibration of the field instruments is performed according to manufacturer specifications. Adequate supplies of standard solutions are placed within the field equipment box for instrumentation checks while at the monitoring sites. Battery issues with field instruments are addressed at this time.
3. The day of the sample, chests are loaded into the vehicle along with a chest filled with frozen "blue ice" sample temperature maintaining blocks.

During Collection

Once at a site, the sequence is as follows:

1. One team member begins the filling out of the sample sheet for the site (field sheet and chain of custody), and takes a photo of the site. The monitoring site where the sample is collected does not change from event to event so the GPS coordinates remain the same from event to event. The names of the sampling crew are recorded on the sample sheet.
2. Ice chests to be used at the site are carried from the vehicle to the sample site.
3. Date, sampler, and time of sample are recorded on the bottles within the chests.
4. Field instruments are checked against the standard solutions (pH and EC) where appropriate, and the data recorded.
5. Field sampling technician will don powder free, nitrile gloves to guard against contamination.
6. If entry into the water is required, field technician approaches the sampling point from downstream to minimize the chance of sediment in the collection field. If sediment is materially disturbed, the zone must be allowed to clear before collecting a sample. ***(surface water sampling)***
7. Samples will be taken with a large carboy to minimize the number of bottles carried into the water body. Once filled, the contents of the carboy will be transferred into the actual preserved sample containers.
8. After all bottles have been filled, a fresh sample is analyzed for field parameters: pH, EC, temperature and dissolved oxygen. The stream velocity is also measured and recorded on the field log for surface water sampling.
9. Water samples are collected until all bottles are filled. Care is exercised to repack the bottles to prevent breakage.
10. If a duplicate sample is to be collected at the site, steps 5 – 9 are repeated.
11. Site photos are taken, with photos of the sampling point, upstream and downstream. ***(surface water sampling)***
12. "Blue" or gel ice is placed in the chests once they are carried back to the vehicle.

Following Collection

After the samples are returned to the office, and offloaded from the vehicle, cubed ice is packed into the chests (blue ice is removed). Chemical test samples are then transported to the lab. Water Column Toxicity samples are stored within the office for transport the next morning if the sampling crew returns too late in the day to package and ship to the aquatic toxicity laboratory.

The Laboratory will provide additional sample containers for the Field Duplicate and Site Specific QC (MS/MSDs). The laboratory will identify the bottles by location and by sample type (Dup, MS/MSD). It is critical that the sampling crew fill ALL bottles provided in the manner specified by the laboratory. Failure to fill all containers may result in insufficient quality control data to meet the project data quality objectives.

There is limited sampling equipment required for the collection of both aqueous and sediment samples. For the aqueous samples, a large 3-L carboy is the only container that may be reused between sampling location. To that end, the carboy will be triple rinsed between sampling locations using 300mL of laboratory grade deionized water. The use of any detergent as a cleansing agent could be problematic given the low reporting limit requirements of the program. Once triple rinsed, the carboy will be sealed and remain closed until the next sampling location. Prior to collection at the next site, the carboy shall be rinsed under the above matrix prior to collecting any samples.

Alternatively, the Laboratory may elect to use virgin bottleware for the collection of samples. If so, no decontamination procedures are required. Additional carboys and any other sampling devices will be carried in the event that there is a problem with the carboy or other device that might be shared between locations.

For the sediment samples, the trowel or large scoop is the only device that may be in contact with each sample. Therefore, after use it will be first rinsed with water from the stream where the sample was collected. This is done to remove any remaining solids. It will then be triple rinsed with deionized water, stored in a clean Zip-lock bag and kept sealed till the next sampling site. Once at the next location, it will be rinsed in the river or stream prior to the collection of the next sample.

Post Collection Handling

Transport represents the greatest risk to the sample once collected, and every effort shall be made to package the samples in protective materials. Glass containers are wrapped in “bubble-wrap” both before and after sample collection. Care is exercised when placing the “blue-ice” temperature control materials within the ice chests after the sample is collected, to prevent breakage. Travel speeds on unimproved roads are also limited.

Water Column Toxicity samples are collected in 1-gallon cubitainer jugs, with 6 gallons of sample per site. Each jug is rinsed using sample water prior to filling with the final sample. Headspace is left at top of bottle to reduce risk of bottle breakage at lab.

As stated in the SOP section (Appendix B.1), the field instruments are rinsed in distilled water after the second (duplicate) reading, and stored within the instrument case. The pH meter is returned to a container containing pH 7 solution for transport.

Problems are always unforeseen. Barring a technical failure in the field instrumentation or an accident during or between the sampling events, most anticipated issues can be dealt with in a manner that will not substantially affect data usability. However, technical failures will result in the loss of all data generated by the field instrument from the point of failure on due to the need to return the instrument to the manufacturer for repairs. Battery issues are eliminated by inspecting the instrument during calibration and by maintaining backup supplies for field activities.

Automobile accidents or the dropping of a sample container are by nature unpredictable.

Access restrictions to the monitoring site are likely to be rare, and corrected (if practical) by hiking to the site.

Sufficient staff exists to cover a sampling event in the event of scheduling conflict or illness.

The only samples that require homogenization are the sediment samples, which are collected across the entire main waterway. Individual containers of approximately 1L will be collected with a sufficient number filled to cover all the testing required including the Toxic Identification Evaluation (TIE) if required. Once transported back to the Laboratory, all individual containers will be emptied and combined into a single sample. The sample will be homogenized in a large stainless steel container and once thoroughly mixed, returned to the original containers. These individual containers will then be distributed to the primary contract Laboratory as well as any subcontract laboratories.

ELEMENT 12: SAMPLE HANDLING AND CUSTODY

Samples are to be collected only in containers provided by the laboratory. Substitute containers are strictly forbidden as the integrity of such containers would be unknown. Any alternative containers provided to the laboratory will be rejected unless otherwise authorized in writing by the Project Coordinator and Program QA Manager.

Using the correct container is critical as each test method has specific preservation requirements. Samples are preserved to ensure that the condition of the sample at the time of analysis is consistent with the conditions as it existed in the field. The laboratory uses a variety of conditions to inhibit bacterial growth that would degrade target analytes, to prevent certain constituents from precipitating and falling out of solution, to prevent oxidation/reduction of the various constituents, and to prevent parameters from evolving off as a gas. The preservation technique and storage requirements for each test method are listed in Table 6.

Once collected, each sample and analysis has a finite amount of time before it must be prepared or analyzed. If the time period (known as the holding time) expires, the results may be considered invalid and would normally be a cause for rejection of the subsequent data. The holding times for each test method are listed in the following Table 6.

Table 6: Method Preservation, Storage and Holding Time Requirements

Parameter	Preservative	Container	Storage	Hold Time to Prepare	Hold Time to Analyze
Ammonia/Ammonium	H_2SO_4	Plastic	<6°C	28 Days	-
Carbamates	None	Clear Glass	<6°C	7 Days	40 Days
Carbonate/Bicarbonate	None	Plastic	<6°C	-	14 Days
Glyphosate	$Na_2S_2O_3$	Amber Glass	<6°C	14 Days	-
Hardness (Calc)	HNO_3	Plastic	Ambient	-	180 Days
Herbicides	None	Amber Glass	<6°C	7 Days	40 Days
Metals	HNO_3	Plastic	Ambient	-	180 Days
Metals (Dissolved)	None	Plastic	Ambient	-	180 Days
Nitrate, Nitrite	None	Plastic	<6°C	-	48 Hours
OCl Pesticides	None	Amber Glass	<6°C	7 Days	40 Days
OP Pesticides	None	Amber Glass	<6°C	7 Days	40 Days
o-Phosphate	None	Plastic	<6°C	-	48 Hours
Paraquat	$Na_2S_2O_3$	Amber Plastic	<6°C	7 Days	21 Days
Pathogens	$Na_2S_2O_3$	Acrylic	<6°C	8 Hours	-
Pyrethroids (Sediment)	None	Clear Glass	<6°C	14 Days	40 Days
Solids (TDS and TSS)	None	Plastic	<6°C	-	7 Days
TOC	H_3PO_4	Clear Glass	<6°C	-	28 Days
Toxicity	Chilled to <6°C/wet ice	Plastic	<6°C	-	36 Hours
Triazine Pesticides	None	Amber Glass	<6°C	7 Days	40 Days
Turbidity	None	Plastic	<6°C	-	48 Hours

Samples are transported within ice chests that contain “blue ice” blocks to maintain low temperatures until the samples can be packed with wet ice. Glass bottles are wrapped in bubble wrap to prevent breakage (it also insulates the samples before they are packed in ice). Toxicity samples are repacked in ice (or have the levels checked) the next morning prior to transport.

Chains of custody forms are provided by the contracted lab and include all of the required information for the proper handling of the samples collected. As the sample passes from the control of one entity to another, the form is signed off by the responsible parties. Copies of the completed custody forms are provided with the final lab reports.

The Quality Assurance Manager and Laboratory Coordinators are responsible for the review and filing of the chains of custody forms.

Once at the lab, the condition of the samples is logged, with copies of the log appended to the lab report. Barcodes are attached to the samples and logged in a computerized tracking system.

Storage of the samples, once they are released to the lab, will be at the condition specified above. Any exceptions to the holding times listed above are noted in the laboratory report and are addressed on a case by case basis. Sample preservation is effectively handled by the chemistry lab as the bottles supplied are pre-treated with the proper preservation (if required, see above Table 6). Samples with pH preservation will be checked on receipt to verify that the sample has reached the proper pH. Any deviations from the method preservation requirements will be brought to the attention of the Project Lead. The laboratory will not proceed with the analysis of any improperly preserved samples without the approval of the Project Lead. Any samples analyzed that were not received under proper preservation will be noted in the report case narrative.

Records are maintained within the contracted lab that includes the checking in and out of samples during the analytical process as well as the disposal of samples following completion of the analytical process and archival. Samples are held under proper storage conditions until all analyses are conducted. Once complete, samples will be moved to a temporary archive where they await disposal. Samples are held by the laboratory for 60 days prior to being disposed.

ELEMENT 13: ANALYTICAL METHODS AND FIELD MEASUREMENTS

Standard Operating Procedures

The contract laboratory utilizes a number of EPA or Standard Methods preparation and determinative methods. The laboratory has SOPs for each method employed as well as SOPs for the procedural activities in the laboratory. The following Table 7 lists the method specific SOPs for this project with the current revisions at the time of submittal of this QAPP. Laboratory SOPs are periodically reviewed and may be updated as necessary.

Table 7: Standard Operating Procedures

Parameter	Method Description	Doc ID	Rev. Date
Ammonia	Ammonia by Gas Diffusion and Automated Phenate	IO-SP-0036-01	1/16/15
Anions	Anions by Ion Chromatography	IO-SP-0085-03	12/18/17
Alkalinity	Alkalinity by PC-Titrate	IO-SP-0061-09	8/17/16
Glyphosate	Glyphosate by HPLC, Post Column Derivatization	OR-SP-0009-06	7/28/17
Hardness	Hardness by Calculation	IO-SP-0044-02	2/17/17
Metals	Metals by ICP-MS	MT-SP-0008-01	11/2/17
	Metals by ICP-AES	MT-SP-0007-01	11/6/17
	Total Recoverable Metals Preparation	MT-SP-0001-01	10/31/18
Ortho-Phosphate and Phosphorus	o-Phosphate and Phosphorus by Ascorbic Acid Reduction	IO-SP-0072-04	6/20/16
Paraquat	Paraquat by SPE, HPLC-UV	OR-SP-0011-06	5/25/17
Pathogens	Multi-Tube Fermentation for Total and Fecal Coliform, and E. Coli	WM-SP-0002-04	11/14/17
Pesticides – N,P, Pyrethroids	Nitrogen, Organophosphorous Pesticides Pyrethroid Pesticides by GC/MS	OR-SP-0034-02	2/17/17
Pesticides – OCl	Organochlorine Pesticides by GC-ECD	OR-SP-0019-04	3/28/17
Solids (TDS and TSS)	Solids by Gravimetric Determination	IO-SP-0020-05	3/29/16
Total Organic Carbon	TOC by TOC analyzer (SM 5310C)	IO-SP-0067-07	12/18/17
Toxicity – Algae	Chronic toxicity	EPA-821-R-02-013	2002
Toxicity – Flea	Acute toxicity	EPA-821-R-02-012	2002
Toxicity - Minnow	Acute toxicity	EPA-821-R-02-012	2002
Toxicity - Hyalella	10 Day Sediment Survival and Growth Test – Hyalella azteca	EPA-600-R-99-064	2000
Turbidity	Turbidity by Nephelometry	IO-SP-0029-04	4/20/15
Sample Collection	Field Sampling from Streams, Rivers and Canals	SR-SP-0015-01	6/8/16
Sample Collection	Safety for Stream and Canal Sampling	SF-SP-0010-00	6/6/16

Copies of these SOPs can be found in Attachment B. These SOPs are considered proprietary information by the laboratory and will be redacted for the purpose of the public version of this QAPP.

Instrumentation

The contract laboratory will utilize a wide range of equipment in the performance of the analytical testing. While not exhaustive in content, the following list of equipment represents the minimal amount of instrumentation required to perform the testing under this Plan. The list does not indicate each individual piece of equipment as the laboratory maintains redundant equipment in many cases.

See Tables 11, 12 and 13 for a listing of field and laboratory instrumentation.

Field Monitoring

All field measurements will be performed at the time of sampling. There will be no *in situ* or continuous monitoring of field conditions at the specific monitoring sites. Any information about the conditions at the sampling points between sampling events would need to be inferred from other indirect sources such as water flows at points upstream or downstream or measurements made or samples collected and analyzed for other purposes. Otherwise, there are no other requirements for the deployment, maintenance, calibration or storage of related data for field equipment.

Method and Instrument Performance Criteria

The contract laboratory performs testing for several watersheds in support of their ILRP monitoring requirements. The test methods employed have been tailored to meet the requirements of this Plan to ensure compliance with the General Order, WDR and QAPP guidelines. All methods utilized are based on approved, standardized methods. There are no other “in-house” or non-standardized methods used for this Plan.

The contract laboratory will observe the following list of performance criteria for the testing done in support of this Plan.

Quantitation and Detection Limits

Table 8: Methods, Reporting Limits and Detection Limits

		BSK Reporting Information			
Constituent	**ILRP PQL**	**RL**	**MDL[1]**	**Units**	**Method**
Physical Parameters					
Flow	1	-	-	cfs	Field
pH	0.1	0.1	-	pH Units	Field
EC	100	5	-	umhos/cm	Field
DO	0.1	0.1	-	mg/L	Field
Temp	0.1	-	-	°C	Field
Turbidity	1	0.1	-	NTU	SM 2130B
TDS	-	10	-	mg/L	SM 2540C
TSS	10	10	-	mg/L	SM 2540D
Hardness as CaCO3	10	0.41	-	mg/L	SM 2340B
TOC	-	0.5	0.086	mg/L	SM 5310C
Percent Solids / Moisture	-	0.1	-	%	SM 2540B
Pathogens					
Fecal Coliform	2	1.8	-	MPN/100mL	SM 9221E
E. coli	2	1.8	-	MPN/100mL	SM 9221F
Water Column Toxicity					
Algae	NA	NA	NA	Cell/mL, % Growth	EPA 821-R-02-013
Water Flea	NA	NA	NA	% Survival	EPA 821-R-02-012
Fathead Minnow	NA	NA	NA	% Survival	EPA 821-R-02-012
Sediment Toxicity					
Hyalella azteca	NA	NA	NA	% Survival	EPA 600-R-99-064
Carbamates					
Aldicarb	0.5	0.4	0.017	ug/L	EPA 8321A
Carbaryl	0.5	0.1	0.022	ug/L	EPA 8321A
Carbofuran	0.5	0.1	0.021	ug/L	EPA 8321A
Methiocarb	0.5	0.4	0.014	ug/L	EPA 8321A
Methomyl	0.5	0.1	0.018	ug/L	EPA 8321A
Thiobencarb	-	0.5	0.0065	ug/L	EPA 8270C
Oxamyl	0.5	0.4	0.021	ug/L	EPA 8321A
Organochlorines					
DDD	0.02	0.01	0.00072	ug/L	EPA 8081A
DDE	0.01	0.01	0.00061	ug/L	EPA 8081A
DDT	0.01	0.01	0.0007	ug/L	EPA 8081A
Dicofol	0.1	0.1	0.015	ug/L	EPA 8270C
Dieldrin	0.01	0.01	0.00097	ug/L	EPA 8081A

		BSK Reporting Information			
Constituent	**ILRP PQL**	**RL**	**MDL[1]**	**Units**	**Method**
Endrin	0.01	0.01	0.00081	ug/L	EPA 8081A
Methoxychlor	0.05	0.01	0.00091	ug/L	EPA 8081A
Toxaphene	-	0.5	0.035	ug/L	EPA 8081A
Organophosphates					
Azinphos-methyl (Guthion)	0.1	0.1	0.032	ug/L	EPA 8270C
Chlorpyrifos	0.015	0.015	0.0029	ug/L	EPA 8270C
Diazinon	0.02	0.02	0.0036	ug/L	EPA 8270C
Dichlorvos	0.1	0.1	0.0048	ug/L	EPA 8270C
Dimethoate	0.1	0.1	0.0075	ug/L	EPA 8270C
Demeton-S (Demeton [O,S])	0.1	0.1	0.025	ug/L	EPA 8270C or EPA 8321A
Disulfoton	0.05	0.05	0.025	ug/L	EPA 8270C or EPA 8321A
Malathion	0.1	0.1	0.0046	ug/L	EPA 8270C
Methamidophos	0.2	0.2	0.022	ug/L	EPA 8270C or EPA 8321A
Methidathion	0.1	0.1	0.011	ug/L	EPA 8270C
methyl Parathion	0.1	0.1	0.003	ug/L	EPA 8270C
Phorate	0.2	0.1	0.0033	ug/L	EPA 8270C
Phosmet	0.2	0.2	0.03	ug/L	EPA 8270C
Herbicides					
Atrazine	0.5	0.5	0.029	ug/L	EPA 8270C
Simazine	0.5	0.5	0.024	ug/L	EPA 8270C
Cyanazine	0.5	0.5	0.036	ug/L	EPA 8270C
Diuron	0.5	0.4	0.022	ug/L	EPA 8321A
Molinate	-	0.5	0.0043	ug/L	EPA 8270C
Glyphosate	5	5	2.1	ug/L	EPA 547
Paraquat	0.5	0.4	0.21	ug/L	EPA 549.2
Linuron	0.5	0.4	0.014	ug/L	EPA 8321A
Trifluralin	0.05	0.05	0.0056	ug/L	EPA 8270C
Metals (Total /Dissolved)					
Arsenic	1	0.2	0.059	ug/L	EPA 200.8
Boron	10	10	4.6	ug/L	EPA 200.8
Cadmium	0.1	0.1	0.075	ug/L	EPA 200.8
Calcium	-	0.1	0.046	mg/L	EPA 200.7
Copper	0.5	1.1	0.49	ug/L	EPA 200.8
Lead	0.5	0.2	0.041	ug/L	EPA 200.8
Magnesium	-	0.1	0.046	mg/L	EPA 200.7
Molybdenum	1	0.5	0.32	ug/L	EPA 200.8
Nickel	1	1	0.20	ug/L	EPA 200.8

		BSK Reporting Information			
Constituent	**ILRP PQL**	**RL**	**MDL[1]**	**Units**	**Method**
Potassium	-	2	0.91	mg/L	EPA 200.7
Selenium	1	1	0.76	ug/L	EPA 200.8
Sodium	-	1	0.46	mg/L	EPA 200.7
Zinc	1	1	0.68	ug/L	EPA 200.8
Nutrients					
Nitrate-N	0.05	0.06	0.028	mg/L	EPA 300.0
Nitrite-N	0.05	0.05	0.020	mg/L	EPA 300.0
Ammonia	0.1	0.1	0.038	mg/L	EPA 350.1
Orthophosphate (as P)	0.01	0.01	0.0049	mg/L	SM 4500-P E
Phosphorus-P	-	0.01	0.0015	mg/L	SM 4500-P E
General Mineral					
Carbonate as CaCO3	-	3	-	mg/L	SM 2320B
Bicarbonate as CaCO3	-	3	-	mg/L	SM 2320B
Chloride	-	1	0.51	mg/L	EPA 300.0
Sulfate	-	1	0.40	mg/L	EPA 300.0
Pyrethroids / Chlorpyrifos					
Chlorpyrifos	-	10	0.36	ug/Kg	EPA 8270C
Bifenthrin	1.0	1.0	0.12	ug/Kg	EPA 8270C
Cyfluthrin	1.0	2.0	0.39	ug/Kg	EPA 8270C
Cypermethrin	1.0	2.0	0.54	ug/Kg	EPA 8270C
Deltamethrin	-	2.0	0.47	ug/Kg	EPA 8270C
Esfenvalerate (+Fenvalerate)	1.0	1.0	0.45	ug/Kg	EPA 8270C
Fenpropathrin	1.0	1.0	0.077	ug/Kg	EPA 8270C
Permethrin (cis-Permethrin)	1.0	1.0	0.11	ug/Kg	EPA 8270C
Lambda Cyhalothrin	1.0	1.0	0.062	ug/Kg	EPA 8270C
Piperonyl Butoxide	-	0.5	0.19	ug/Kg	EPA 8270C

1. The MDLs listed are those in existence at the time this QAPP was written. MDLs may change over time as the laboratory conducts ongoing studies due to changes in the method or equipment or is required to do so as per the SWAMP requirements.

Method Performance

The laboratory will observe the following method and instrument criteria for this project.

Table 9: Laboratory Method QC Criteria

Parameter	Calibration	Calibration Verification	Method Blank	Laboratory Control Spike (LCS)	LCS Duplicate	Matrix Spike (MS)	Matrix Spike Duplicate (MSD), Lab Duplicate	Field Duplicate	Surrogate Recovery
Ammonia	*5 Pts Min. (Linear Fit, R≥0.995) 6 Pts Min. (Non-linear fit. R^2≥0.99)*	*2^{nd} Source verification following calibration, %Diff ≤ 10%, Continuing Verification every 10 field samples, %Diff ≤ 10%*	*<RL*	*1 per batch of 20 samples, 90-110%*	*1 per batch of 20 samples, 20% RPD*	*1 per batch of 20 samples, 90-110%*	*1 per batch of 20 samples, 20% RPD*	*≤25% RPD*	*N/A*
Carbamates	*5 Pts Min. (Linear Fit, R≥0.995) 6 Pts Min. (Non-linear fit. R^2≥0.99)*	*2nd Source verification following calibration, %Diff ≤ 10%, Continuing Verification every 10 field samples, %Diff ≤ 10%*	*<MDL*	*1 per Batch of 20 Samples, 50-150%*	*1 per Batch of 20 Samples, 30% RPD*	*1 per Batch of 20 Samples, 50-150%*	*1 per Batch of 20 Samples, 30% RPD*	*≤30% RPD*	*Applied to all samples and QC, 50-150%*
Glyphosate	*5 Pts Min. (Linear Fit, R≥0.995) 6 Pts Min. (Non-linear fit. R^2≥0.99)*	*2nd Source verification following calibration, %Diff ≤ 20%, Continuing Verification every 10 field samples, %Diff ≤ 20%*	*<MDL*	*1 per batch of 20 samples, 70-130%*	*1 per Batch of 20 Samples, 30% RPD*	*1 per batch of 20 samples, 70-130%*	*1 per Batch of 20 Samples, 30% RPD*	*≤30% RPD*	*Applied to all samples and QC, 70-130% Rec*

Parameter	Calibration	Calibration Verification	Method Blank	Laboratory Control Spike (LCS)	LCS Duplicate	Matrix Spike (MS)	Matrix Spike Duplicate (MSD), Lab Duplicate	Field Duplicate	Surrogate Recovery
Hardness (Calc)	*Performed by Calculation. See Metals QC Criteria.*	*Performed by Calculation. See Metals QC Criteria.*	*<RL*	*Performed by Calculation. See Metals QC Criteria.*	*Performed by Calculation. See Metals QC Criteria.*	*Performed by Calculation. See Metals QC Criteria.*	*Performed by Calculation. See Metals QC Criteria.*	*≤25% RPD*	*N/A*
Herbicides	*5 Pts Min. (Linear Fit, R≥0.995 6 Pts Min. (Non-linear fit. R^2≥0.99)*	*2nd Source verification following calibration, %Diff ≤ 30%, Continuing Verification every 20 field samples, %Diff ≤ 15%*	*<MDL*	*1 per Batch of 20 Samples, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*	*1 per Batch of 20 Samples, 30% RPD*	*1 per Batch of 10 Samples, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*	*1 per Batch of 20 Samples, 30% RPD*	*≤30% RPD*	*Applied to all samples and QC, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*
Metals	*Single Point calibration plus Calibration Blank, multi-point curves must be fit using Linear Regression, R≥0.995*	*2nd Source Verification following calibration, %Diff ≤ 10%, Reporting Limit Verification following calibration, %Diff ≤ 10%, Continuing Verification every 10 field samples, %Diff ≤ 10%*	*<2.2x MDL*	*1 per batch of 20 samples, 85-115%*	*1 per batch of 20 samples, 20% RPD*	*1 per batch of 20 samples, 70-130%*	*1 per batch of 20 samples, 20% RPD*	*≤25% RPD*	*N/A*

Parameter	Calibration	Calibration Verification	Method Blank	Laboratory Control Spike (LCS)	LCS Duplicate	Matrix Spike (MS)	Matrix Spike Duplicate (MSD), Lab Duplicate	Field Duplicate	Surrogate Recovery
Anions – Nitrate, Nitrite, Chloride, Sulfate	*5 Pts Min. (Linear Fit, R≥0.995) 6 Pts Min. (Non-linear fit. R^2≥0.99)*	*2nd Source verification following calibration, %Diff ≤ 10%, Continuing Verification every 10 field samples, %Diff ≤ 10%*	*<RL*	*1 per batch of 20 samples, 90-110%*	*1 per batch of 20 samples, 20% RPD*	*1 per batch of 10 samples, 80-120%*	*1 per batch of 10 samples, 20% RPD*	*≤25% RPD*	*N/A*
OCl Pesticides	*5 Pts Min. (Linear Fit, R≥0.995) 6 Pts Min. (Non-linear fit. R^2≥0.99)*	*2nd Source verification following calibration, %Diff ≤ 30%, Continuing Verification every 20 field samples, %Diff ≤ 15%*	*<MDL*	*1 per Batch of 20 Samples, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*	*1 per Batch of 20 Samples, 30% RPD*	*1 per Batch of 20 Samples, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*	*1 per Batch of 20 Samples, 30% RPD*	*≤30% RPD*	*Applied to all samples and QC, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*
OP Pesticides	*5 Pts Min. (Linear Fit, R≥0.995) 6 Pts Min. (Non-linear fit. R^2≥0.99)*	*2nd Source verification following calibration, %Diff ≤ 30%, Continuing Verification every 20 field samples or 12 hours , %Diff ≤ 20%*	*<MDL*	*1 per Batch of 20 Samples, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*	*1 per Batch of 20 Samples, 30% RPD*	*1 per Batch of 20 Samples, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*	*1 per Batch of 20 Samples, 30% RPD*	*≤30% RPD*	*Applied to all samples and QC, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*

Parameter	Calibration	Calibration Verification	Method Blank	Laboratory Control Spike (LCS)	LCS Duplicate	Matrix Spike (MS)	Matrix Spike Duplicate (MSD), Lab Duplicate	Field Duplicate	Surrogate Recovery
o-Phosphate	*5 Pts Min. (Linear Fit, R≥0.995)*	*2nd Source verification following calibration, %Diff ≤ 15%, Continuing Verification every 10 field samples, %Diff ≤ 10%*	*<RL*	*1 per batch of 20 samples, 90-110%*	*1 per Batch of 20 Samples, 20% RPD*	*1 per batch of 20 samples, 80-120%*	*1 per Batch of 20 Samples, 20% RPD*	*≤25% RPD*	*N/A*
Phosphorus	*5 Pts Min. (Linear Fit, R≥0.995)*	*2nd Source verification following calibration, %Diff ≤ 15%, Continuing Verification every 10 field samples, %Diff ≤ 10%*	*<RL*	*1 per batch of 20 samples, 90-110%*	*1 per Batch of 20 Samples, 20% RPD*	*1 per batch of 20 samples, 80-120%*	*1 per Batch of 20 Samples, 20% RPD*	*≤25% RPD*	*N/A*
Paraquat	*5 Pts Min. (Linear Fit, R≥0.995) 6 Pts Min. (Non-linear fit. R^2≥0.99)*	*2nd Source verification following calibration, %Diff ≤ 20%, Continuing Verification at the beginning of the run, every 8 hours or 20 samples minimally*	*<MDL*	*1 per batch of 20 samples, 70-130%*	*1 per Batch of 20 Samples, 30% RPD*	*1 per batch of 20 samples, 70-130%*	*1 per Batch of 20 Samples, 30% RPD*	*≤30% RPD*	*N/A*

Parameter	Calibration	Calibration Verification	Method Blank	Laboratory Control Spike (LCS)	LCS Duplicate	Matrix Spike (MS)	Matrix Spike Duplicate (MSD), Lab Duplicate	Field Duplicate	Surrogate Recovery
		thereafter, %Diff ≤ 20%							
Pathogens	*N/A*	*N/A*	*<RL[1]*	*N/A[1]*	*N/A*	*N/A*	*N/A*	*≤25% RPD*	*N/A*
Pyrethroids	*5 Pts Min. (Linear Fit, R≥0.995) 6 Pts Min. (Non-linear fit. R^2≥0.99)*	*2nd Source verification following calibration, %Diff ≤ 30%, Continuing Verification every 20 field samples or 12 hours , %Diff ≤ 20%*	*<MDL*	*1 per Batch of 20 Samples, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*	*1 per Batch of 20 Samples, 30% RPD*	*1 per Batch of 20 Samples, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*	*1 per Batch of 20 Samples, 30% RPD*	*≤30% RPD*	*Applied to all samples and QC, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*
Solids (TDS, TSS)	*N/A*	*N/A*	*<RL*	***(TDS Only)*** *1 per Batch of 20 Samples, 70-130%*	*N/A*	*N/A*	*<20% RPD (Lab Dup)*	*≤25% RPD*	*N/A*
Toxicity	*N/A*	*N/A*	*0%*	*0%*	*NA*	*NA*	*NA*	*NA*	*NA*
Triazine Pesticides	*5 Pts Min. (Linear Fit, R≥0.995) 6 Pts Min. (Non-linear fit. R^2≥0.99)*	*2nd Source verification following calibration, %Diff ≤ 30%, Continuing Verification every 20 field samples or*	*<MDL*	*1 per Batch of 20 Samples, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*	*1 per Batch of 20 Samples, 30% RPD*	*1 per Batch of 20 Samples, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*	*1 per Batch of 20 Samples, 30% RPD*	*≤30% RPD*	*Applied to all samples and QC, Rec Range Varies, Avg. Rec ± 3SD, See attached specification sheet*

Parameter	Calibration	Calibration Verification	Method Blank	Laboratory Control Spike (LCS)	LCS Duplicate	Matrix Spike (MS)	Matrix Spike Duplicate (MSD), Lab Duplicate	Field Duplicate	Surrogate Recovery
		12 hours , %Diff ≤ 20%							
Turbidity	*Single Point calibration plus Calibration Blank, dependent on expected range of use*	*2nd Source Verification following calibration, %Diff ≤ 10%, Reporting Limit Verification following calibration, %Diff ≤ 10%, Continuing Verification every 10 field samples, %Diff ≤ 10%*	*<RL*	*N/A*	*N/A*	*N/A*	*<20% RPD (Lab Dup)*	*≤25% RPD*	*N/A*
Alkalinity - Carbonate, Bicarbonate	*N/A*	*N/A*	*<RL*	*1 per Batch of 20 Samples, 80-120%*	*1 per Batch of 20 samples, 20% RPD*	*N/A*	*<20% RPD (Lab Dup)*	*≤25% RPD*	*N/A*

1. Pathogen analysis requires a daily positive control and negative control. BSK also performs a daily sterility check on prepared media.

Disposal Procedures

Most of the sample collected for any given monitoring event will be consumed as part of the analyses. However, as noted above, the contract laboratory will retain the remaining sample volume for a period of 60 days from receipt of the samples, approximately 45 days from the completion based on the standard turnaround time of 10 business days.

Once identified for disposal, samples are segregated into groups according to their waste classification. Any samples identified as hazardous based on the outcome of their testing will be put into the laboratory's waste streams and handled in accordance with EPA and DTSC regulations. Samples that are not determined to be hazardous based on the results of their testing will be disposed of according to their preservation type. Acidic and caustic samples will be neutralized and discarded down the sanitary sewer according to the local and Federal pre-treatment guidelines. Samples that are neutral are poured directly into the drain and flushed. Sample containers are rinsed and then recycled according to their material classification.

The laboratory maintains disposal records to indicate when each set of samples has been disposed.

Corrective Action Measures

The laboratory will take a variety of corrective actions for material failures related to sample conditions, holding time failures, preservation problems and quality control failures. All failures and corrective actions will be documented in the form of a data qualifier and / or addressed in detail in the Case Narrative at the beginning of the laboratory report. The details of these responses are included in the various method SOPs and other related supporting documentation. However, the general corrective actions related to a number of common QC failures are listed below:

<u>Calibration Linearity</u> failures are often caused by instrumentation that is in need of maintenance. If a calibration curve fails to meet linearity criteria, the instrument will be repaired and likely a new set of calibration standards prepared. Once complete, the instrument will be recalibrated.

<u>Initial (ICV) and Continuing Calibration (CCV)</u> failures occur periodically on the laboratory instrumentation. Often times these failures are associated with running large numbers of dirty samples which deteriorate the performance of the equipment. ICV failures will generally be handled by the preparation of a new set of calibration standards and ICV standard, and reanalysis of the ICV and CCV. This is often done in conjunction with maintenance performed consistent with that tied to calibration linearity problems.

<u>Method Blank Contamination</u> failures indicate that the ambient laboratory background may be contributing to sample contamination. The response to specific methods will vary but in general, any detection over a Reporting Limit (RL) will result in the re-

preparation and reanalysis of the associated samples unless the sample results are greater than 10x that found in the blank. Certain methods have corrective action requirements for detections above the MDL or at a multiple of the MDL. Those will be addressed on a case by case basis. All detections in the Method Blanks having a material impact on the data as defined by the ILRP QAPP guidelines will be addressed in the report case narrative.

Laboratory Control Spike Recovery and Precision failures are indicative of a problem in the analytical procedure. Recovery failures are generally addressed by a re-preparation and reanalysis of all samples and QC indicators. Several exceptions may be made where recoveries exceed the upper control limit and samples are non-detected for the failed compound. Precision failures will generally follow the same corrective action plan unless the RPD limit is narrower than the acceptance range for Recovery performance. Under those circumstances, the laboratory will not reject the results but will qualify the data to note the failure.

Matrix Spike Recovery and Precision failures indicate that the sample matrix itself may have some adverse effect on the method performance. However, if the LCS/LCSD recoveries meet control criteria, no corrective action will be needed. The problem at that point is assumed to be associated with the sample matrix itself and beyond the reasonable control of the laboratory. Sample results will be qualified and a note will be made in the case narrative. However, repeated failures for the same analyte will trigger an investigation as the ongoing failure may indicate that the method is poorly suited for a particular sample type and should be modified to address the performance issue.

Laboratory Duplicate failure may indicate a problem with sample homogeneity. On a Lab Duplicate failure, the sample itself will be examined for obvious matrix homogeneity issues. If there are no obvious reasons for the nature of the failure, the samples will be re-prepared and reanalyzed. If an obvious cause is determined, the sample results will be qualified and a note made in the case narrative. However, laboratory duplicate failures that occur when sample results are less than 10x the RL will be ignored as the magnitude of the RPD can be disproportionately affected by low sample results.

Field Duplicate failures indicate homogeneity or sampling issues that occur in the field. No corrective action is taken with such failures with the exception of qualifying the data and making a notation in the case narrative.

Surrogate Recovery failures will be addressed on a case by case basis. Samples with failing surrogate recoveries may be biased either high or low. Surrogate failures on clean matrices with no obvious sample interferences will be re-extracted if possible. Repeated failures will be assumed to be caused by matrix interference. If no re-extraction is possible, the data will be qualified. High surrogate failures on non-detected samples will be treated as immaterial to data usability and qualified only to call attention to the failure.

ELEMENT 14: QUALITY CONTROL

The laboratory will perform the following QC measures listed in Table 10 under this Plan.

Table 10: Required Quality Control by Method

	Samples per Batch	Method Blank	LCS / LCSD	MS / MSD	Lab Dup	Surr. Spike	Field Dup
Ammonia	20	X	X	X		N/A	X
Bicarbonate/ Carbonate Alkalinity	20	X	X		X	N/A	X
Carbamates	20	X	X	X		X	X
Glyphosate	20	X	X	X		X	X
Hardness (Calc)	20	X[3]	X[3]	X[3]		N/A	X
Herbicides	20	X	X	X		X	X
Metals	20	X	X	X		N/A	X
Anions	20	X	X	X		N/A	X
OCl Pesticides	20	X	X	X		X	X
OP Pesticides	20	X	X	X		X	X
o-Phosphate	20	X	X	X		N/A	X
Phosphorus	20	X	X	X		N/A	X
Paraquat	20	X	X	X			X
Pathogens	-	X[1]	X[1]	N/A		N/A	X
Pyrethroids	20	X	X	X		X	X
TOC	20	X	X	X		N/A	X
TDS	20	X	X[2]		X	N/A	X
TSS	20	X			X	N/A	X
Triazine Pesticides	20	X	X	X		X	X
Turbidity	20	X	N/A	N/A	X	N/A	X
Toxicity	NA	X[4]	X[4]	N/A	NA	N/A	X

1. Laboratory performs a sterility check, positive and negative control per day
2. Laboratory analyzes a certified standard reference material for TDS
3. QC for Hardness performed in analysis of Calcium and Magnesium which are used to determine Hardness by calculation
4. Laboratory performs a 0% control per test batch and reference toxicant per test batch or monthly depending on the species.

QC Definitions and Specifications - Chemistry

Method Blank

The method blank is a simulated sample comprised of a clean, interference-free matrix (typically deionized water) that is carried through the sample preparation and analysis procedure. It is used to determine if the ambient laboratory background is free from contaminants that may influence sample results. The results of the Method Blank are assessed against the MDL and RL, depending on the method. Contamination in a method blank may require corrective action as described in Element 13.

Laboratory Control Spike / Duplicate (Blank Spike / Duplicate)

The Laboratory Control Spike – sometimes referred to as Blank Spike – is an interference-free matrix that is fortified with the target analyte at a level reasonably expected to be found in the field sample. Alternatively, laboratories typically fortify at a level that is roughly the midpoint of the calibration range. The result obtained for this "spike" is compared to the level of fortification that results in a recovery value. The recovery is compared to a set of control limits to determine if the method is performing as expected.

LCS or BS recovery is determined according to the following calculation:

$$\%\ \text{Recovery} = \frac{Result\ Observed}{Fortification\ Level} \times 100$$

LCS or BS Duplicate results are evaluated not only for recovery but also for Relative Percent Difference (RPD), a measure of precision. RPD is determined by the following calculation:

$$Relative\ Percent\ Difference = \frac{|LCS\ Res - LCSD\ Res|}{Avg\ (LCS,\ LCSD)} \times 100$$

Matrix Spike / Duplicate

The Matrix Spike (MS) is a sample that has been fortified in the same manner as the LCS or BS. The MS result demonstrates the impact of the sample matrix on the method performance. MS performance is also based on recovery that is calculated as follows:

$$\%\ \text{Recovery} = \frac{(MS\ Result - MS\ Parent\ Sample\ Result)}{Fortification\ Level} \times 100$$

The Matrix Spike is also performed in duplicate to provide the data user with an indication of the impact of the sample matrix on the precision or reproducibility of the method. The MS Duplicate is assessed by RPD which is calculated as follows:

$$Relative\ Percent\ Difference = \frac{|MS\ Res -\ MSD\ Res|}{Avg\ (MS,\ MSD)} \times 100$$

Laboratory and Field Duplicates

A Laboratory Duplicate is a second aliquot of a sample taken from the same container as the original sample that is run in parallel with the original parent sample. The duplicate performance will indicate if the method and / or sample has some inherent variability that is atypical for the method. Like the LCSD or MSD, the Laboratory Duplicate is assessed based on RPD that is calculated in the same manner, comparing the result of the parent sample to that of the duplicate and dividing by the average of the two observations.

$$Relative\ Percent\ Difference = \frac{|Parent\ Res - Duplicate\ Res|}{Avg\ (Parent, Duplicate)}\ X\ 100$$

A Field Duplicate is a second collection of a sample, captured in its own unique container. The Field Duplicate is treated in the same manner as all other samples and is likewise assessed based on the same RPD calculation shown for the laboratory duplicate.

A failure of either the Laboratory or Field Duplicate indicates a potential lack of homogeneity in the sample collection or subsampling procedures.

- On failure of a Field Duplicate, the laboratory will inspect the sample containers for any observable differences between the primary and duplicate samples. If a material difference is observed (e.g. significant suspended or settled matter, differences in color or other physical characteristics), the laboratory will review both the field logs and the sampling procedure for any potential sources of variation. If there is an indication that a sampling error occurred, then the Coalition will be notified to make a determination regarding the usability and representativeness of the sample. If no problems are identified, the data will be qualified to indicate the discrepancy between results and reported to the Coalition.

- On failure of a Laboratory Duplicate, the laboratory will inspect the individual sample container used for the duplicate to ensure a correct subsampling occurred. If there is no obvious source of error, the laboratory will reanalyze the sample in duplicate to assess the situation. If a repeated error occurs, then the original data will be qualified and reported to the Coalition. If the error is no longer observed, then the original results will be discarded and the reanalysis will be reported. If there is an observable homogeneity issue that the laboratory cannot overcome, the results will be qualified as estimated values and reported to the Coalition.

QC Definitions and Specifications – Microbiology

Method Blank (Sterility Check)

The “method blank” for microbiology is a sterility check conducted on all the materials used in the analysis of all field samples, if the sterility check confirms there to be no ambient microbial background which could contribute to the presence of bacteria in the field samples. Positive growth in a sterility check would indicate that the materials used in the analysis of the samples may be contaminated and therefore all associated results should be rejected as suspect.

Negative Control

A Negative Control is used to ensure that the media used in the analysis of samples does not support growth for any pathogen other than that specifically targeted by the method. Should a Negative Control exhibit growth, it would indicate that the media in use is not specific enough for the pathogen and that growth observed for the samples may be attributable to species other than that of interest for the project.

Positive Control

The Positive Control sample ensures that the media used in the analyses of a pathogen is suitable for growing the species of interest. If a positive control exhibits no growth, then sample results are suspect as potential false negatives. The positive control must exhibit some growth to prove that the media can support the culturing of the target species.

QC Definitions and Specifications – Toxicology

0% Control

The 0% Control is used to assess the cleanliness of the laboratory environment and the quality of the laboratory grade water used for sample dilution. The control should not experience any mortality, as this would be indicative of a toxic substance in the dilution water which is adding to any toxicity attributable to the sample.

Reference Toxicant

The Reference Toxicant is a known toxicant that is tested with the organisms to evaluate their response. This demonstrates that the method performance is within plus or minus two standard deviations from the mean of past tests conducted with a particular organism.

ELEMENT 15: INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE

The ready availability of equipment shall be maintained by the contract laboratory and the TBWQC as they are responsible for both the field and in-house laboratory analyses

Field Instrumentation / Equipment

Field units are maintained constantly as they are subject to use on applications other than under this Plan. The instruments are used for non ILRP activities, and any indication of failure can quickly be addressed as the need arises. Batteries are replaced on a regular schedule to insure against failure in the field. Backup batteries and other parts subject to failure will be maintained in supply to ensure no material downtime. The instruments are regularly checked for calibration against known standards. Calibration will be documented as required below.

The field sampling crew will be responsible for ensuring that all support equipment is maintained and in good working order. Equipment that is damaged in a way that will adversely affect usage will be replaced. The equipment will be cleaned according to standard operating procedures in place for environmental field sampling prior to the sampling event and between sample monitoring sites.

The field instrumentation requiring Inspection, Maintenance and Calibration includes:

Table 11: BSK Field Instrumentation

Instrument	Make	Model
DO Meter	Oakton	DO 300
EC, pH Meter, Temperature	Oakton	PC 10
Flow Meter	Global Water	FP 211

Table 12: TBWQC Field Instrumentation

Instrument	Make	Model
DO, EC, pH, Temperature Meter	YSI	Pro

Laboratory Instrumentation

The contract laboratories have sufficient redundancy in their instrumentation to recover from the failure of any particular instrument. Calibrations are ongoing, as are MDL studies and other indicators of method performance. The laboratory maintains service contracts for key pieces of equipment where redundant equipment is not feasible due to the substantial cost of replacement.

Compliance with method procedures is a must. Instrument failures or anomalous data are documented in the laboratory report either in the form of a data qualifier or in the case narrative at the beginning of the laboratory report.

Table 13: Laboratory Instrumentation

Instrument	Make	Model
pH, EC, Alkalinity Titrator	Mansci	PC-Titrate
Nutrient Analyzer	Westco	SmartChem 200
Continuous Flow Analyzer	Skalar	3000
Ion Chromatograph	Metrohm	930 Compact IC Flex
HPLC-UV/Vis, Fluor, PDA	Thermo Separations	AS 3000
HPLC-MS/MS	AB Sciex	4000
GC-ECD	Agilent	7890
GC-MS	Agilent	6890/5975, 6890/5973
TOC Analyzer	Tekmar	Phoenix 8000
Turbidimeter	HF Scientific	DRT-15CE
ICP	Perkin Elmer	Optima 8300 RL
ICP-MS	Perkin Elmer	ELAN DRC IIe
Oven	VWR	1380FM

ELEMENT 16: INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Field Instrumentation

Laboratory field technicians and the TBWQC are responsible for ensuring the inspection, maintenance, and when appropriate, the calibration of field instruments and equipment.

Field instruments are calibrated (or verified as being in calibration) prior to the beginning of the sampling event, and rechecked in the field using known standards. Instruments that require calibration checks include the EC, pH, and DO meters listed above. Calibration procedures will be conducted according to the contract laboratory SOPs and consistent with manufacturer recommendations.

See Element 15 for a listing of equipment requiring calibration.

Laboratory Instrumentation

Laboratory analysts and technicians are responsible for the inspection, maintenance, operation and, where appropriate, calibration of their assigned laboratory instrumentation.

Calibration at the laboratory is conducted according to method requirements. Specific schedules are outlined in the laboratory specific SOPs provided in Appendix B (Proprietary copy only). Checks include initial and continuing calibration verifications to demonstrate the instrumentation remains in calibration and operating normally. The laboratory will run a calibration point or a calibration verification check at or below the equivalent of the project reporting limit. This ensures that the instrumentation has adequate sensitivity to achieve the levels needed for the project.

All calibration runs are documented and maintained by the laboratory in a manner consistent with its standard record retention requirements. Any deficiencies will be addressed according to the laboratory standard operating procedures. Corrective actions and additional details will be maintained in the laboratory's log books and raw data. Where applicable, these deficiencies will also be documented in the report Case Narrative should they have any material impact on data usability.

See Element 15 for a listing of the equipment requiring calibration.

ELEMENT 17: INSPECTION / ACCEPTANCE OF SUPPLIES AND CONSUMABLES

The contract laboratory will be solely responsible for the procurement, inspection and acceptance of supplies and consumables. Given the substantial volume of samples processed and the requirements of the ISO-17025 based quality system, the laboratory has policies and procedures in place to qualify and determine the suitability of each material for use. Suppliers of reagents, standards, consumables, parts and other supplies are limited by the laboratory purchasing system to ensure that the laboratory always receives supplies it has determined are suitable for use. A single person within the contract laboratory is responsible for the ordering and receiving of supplies.

Standards and reagents are tracked within the laboratory using a system of identification numbers. This system allows the laboratory to be able to trace the source of all measurements to a specific lot for any given critical supply. This is especially true of all standard and reference materials that serve as the basis for all laboratory calibrations. Certificates of Analysis for analytical standards and reagents are collected and retained by the Laboratory Quality Assurance Manager according to the Laboratory's record retention requirements.

Bottles and sampling supplies are included in this tracking system. Reagents used for preservatives are tracked and each bottle includes a lot number that can be traced to the day it was produced, the person who added the preservative where applicable, and the identity of the preservative used on that day. This allows the lab to trace any potential problems with a sample container back to the production source, permitting a retraction of sample container by lot number if required.

ELEMENT 18: NON-DIRECT MEASUREMENTS

The are no non-direct measurements used in this program. All flow rates within the system are obtained from the hydrologists or watermaster that supervises the delivery of irrigation water and monitors waterway flows. These values are derived based on the known discharges into the designated waterways and validated using flow measurements at key points within defined flow channels along the flow path. The flow rates are accurate to within 10% of the actual flows and deemed sufficiently accurate for the purposes of the program. Flow rates in the form of velocity measurements are one of the field parameters to be determined at the time of sample collection and will be the primary point of comparison when evaluating water flows at the time of collection.

ELEMENT 19: DATA MANAGEMENT

Presently, there are no *In Situ* or continuous measurements being made related to this Plan. Data production begins with field measurements and sample collection. All notes will be recorded on bound logbooks. Copies of the field documentation will be provided to the analytical laboratory for inclusion into the laboratory reports. The office where the sample crew originates will maintain the original records for a period of no less than five years, the same as the record retention policy of the laboratory.

The data generated by the laboratory will exist in both electronic and hardcopy records, each held for a minimum of five years from the date of generation. This includes the Laboratory Information Management System database that houses all the results and supporting data associated with the samples. The contracted laboratory scans all hardcopy records into an electronic archival which is also maintained consistent with the record retention policy.

Hardcopy data is held in a secure location controlled by the laboratory. Access is limited and records are disposed based on standard operating procedure. Electronic data – raw data files, scanned images, Adobe PDF reports, etc., – are held on secure company servers that are backed up daily. Backup media is rotated off site on a scheduled basis, a responsibility of the IT Department.

Data will be provided to the Coalition in electronic format. The analytical report will be an Adobe PDF that includes all results, QC, case narrative, chain of custody and sample receipt documentation. Laboratory raw data, other than the raw data for the toxicity testing, will not be included in the analytical report. However, all laboratory raw data such as chromatograms, spectra, summaries of initial and continuing calibrations, sample injection or sequence logs, prep sheets, etc., will be retained by the laboratory for a minimum of five years and will be provided if specifically requested by the Coalition.

In addition, the laboratory will create a CEDEN and GeaoTracker ESI compliant electronic data deliverable (EDD) for the SWAMP and GQTMP, respectively, that includes all required data for the programs. The EDD will be verified against the CEDEN data checker (http://ceden.org/CEDEN_checker/Checker/CEDENUpload.php) or Geotracker ESI data checker (https://geotracker.waterboards.ca.gov/esi) for content and structure. A copy of the error report will be provided to the Coalition in conjunction with the file for monthly, quarterly and annual reporting. Data from both the primary laboratory and the subcontract lab (toxicity data) will be produced in separate files and sent via email to the Coalition once evaluated.

Data received by the Coalition will be given a cursory review for correct format and completeness. All data, electronic or paper copy, will be filed according to sample date and monitoring site. Electronic format data will be filed in a manner that allows for historical trends and summaries to be analyzed along with quick retrieval for quarterly and annual submittals. The Coalition will work with the contracted laboratory if any issues regarding data are encountered.

ELEMENT 20: ASSESSMENT AND RESPONSE ACTIONS

The Quality Assurance Manager, in cooperation with the Laboratory Coordinators, will review both sampling procedures and laboratory performance annually. Changes in the SOPs used by any of the contracted labs will be communicated between the QA Manager and the Laboratory Coordinators as they occur. Both the QA Manager and the Laboratory Coordinator have “stop work” authority should a situation arise that necessitates an immediate corrective action.

The Laboratory Coordinator will have the responsibility of managing the contracted laboratory. Any issues encountered during the analysis of the samples are to be resolved by the Laboratory Coordinator and then communicated to the QA Manager. Any reported issues at the laboratories will be communicated to the Regional Board as needed and discussed in detail within the Annual Report.

The Laboratory Coordinator will work directly with the Laboratory Project Manager to resolve issues as they occur on any given monitoring event. For ongoing performance issues or to address matters related to the adherence to the QAPP, the Laboratory Coordinator will work directly with the Laboratory Program Manager. These two will meet at least on an annual basis to review the contract lab performance and to address any procedural changes required to ensure ongoing success of the program.

The laboratory QAPPs contained within the attached appendices all address the issue of analyst training and performance, as well as procedures for failed tests. These procedures closely match the Regional Board guidelines for standard laboratory practices and corrective actions.

A copy of the most recent MDL study is to be obtained on at least an annual basis along with a listing of the current SOPs. Material changes in any of the quality control practices, SOPs or other significant procedures may require a revision to this QAPP.

ELEMENT 21: REPORTS TO MANAGEMENT

Activities of the sampling staff are documented and reviewed as part of the submission to the laboratory for the monthly and annual monitoring events. The Laboratory Program Manager will have the responsibility to address any performance issues with the branch office where the sample crew for surface water sampling originated. The TBWQC Technical lead shall address performance issues of groundwater sampling staff. Anomalies or other failures will trigger a Non-Conformance Report ultimately leading to a Corrective Action/Preventative Action (CAPA) event. This will include a root cause determination and a remedial corrective action where necessary. These corrective action reports will be made available to the Laboratory Coordinator on request.

As a result of the meetings between the Laboratory Coordinator and the Laboratory Program Manager, the Coordinator will prepare a summary report of the outcomes of the meeting. The report will contain details on the performance of the contract laboratory, improvements or enhancements to be made that will improve the overall success of the Plan, and any remedial measures taken to address potential performance issue leading to deficiencies in data deliverables.

Quarterly reports (CEDEN formatted data) and annual reports (GeoTracker ESI) are prepared by the Laboratory Coordinators and submitted to the QA Manager for final review. Once the review is completed, the Project Coordinator will prepare a cover letter to accompany the data for the Regional Board. The Project Coordinator is responsible for the drafting of the yearly report for submission to the Regional Board.

Reports submitted to the Regional Board will be sent to the liaison within the Fresno, CA office. Additional copies of the integrated report are kept at the Coalition office.

ELEMENT 22: DATA REVIEW, VERIFICATION AND VALIDATION

Data submitted to the Coalition has undergone a thorough review process at the contracted labs. A statement that the data has been reviewed and is acceptable is provided with the lab report linked to each chain of custody.

The laboratories follow a three tier review process. The primary analyst conducting the analysis is responsible for the generation of results. This analyst performs a double check of their work as part of the reporting process. Upon completion, the data package is then handed off to a peer review, most often the immediate supervisor or another qualified peer reviewer. The peer review consists of a check against all method requirements with documentation applied to any deficiencies. Once all results have undergone a peer or secondary review, the Laboratory Project Manager will review the report in its entirety, looking for agreement within the results and consistency with project requirements. Partial results may be provided to the Coalition on a preliminary basis, if the results have been reviewed through the three-tier review process.

For this QAPP, the report will undergo a final review by the Laboratory Program Manager or his designee. This person checks reports against the requirements of the QAPP and prepares the case narrative. This person generates the CEDEN electronic deliverable and evaluates the content using the CV RDC electronic data checker. Once complete, the report is finalized and sent to the Coalition.

Once received by the Coalition, the data is further reviewed by the QA Manager for exceedances, and the appropriate communication reports are prepared, if necessary, to the Regional Board.

ELEMENT 23: VERIFICATION AND VALIDATION METHODS

The Coalition QA Manager is responsible for the final review and determination of the validity and usability of the data. The determination of completeness is performed at both the level of the field activities and the in-house laboratory activities. Any questions or anomalies resulting from this review will be addressed directly with the laboratory prior to making the final determination. The overall completeness goal for the project is 90%.

ELEMENT 24: RECONCILIATION WITH USER REQUIREMENTS

The purpose of the sampling program is to determine if any constituents of concern exceed water quality standards in the water samples. If such detections are made, the Coalition will then open an inquiry as to the persistence of the detection (is it in more than one site, is it still present in the next sample period), review the conditions prior to the sampling event that produced the detection, and begin to research the potential sources of the detection.

The data, as reported by the lab, is considered valid if no problems are identified within the laboratory report and case narrative. In the event that the laboratory data quality indicators do not meet the criteria listed in Table 8 (or exceed other requirements listed in the cited analytical method), then the data will be annotated with data qualifiers that identify the deficiency. Laboratory reports containing notations that indicate QC failures or other issues that do not meet QAPP requirements will need to be assessed for impact. Not all failures result in the rejection of data but scrutiny will be applied to all failures or QAPP deviations. It is the responsibility of the QA Manager to make the final determination of data usability and its suitability for intended use. All QC failures or other known deficiencies will be indicated on the laboratory Certificate of Analysis, either in the form of a data qualifier and/or noted in the detailed Case Narrative provided therein. These deficiencies represent the possible limitations on the use of the data but will nonetheless be reported in order for the Coalition and Board to determine their suitability for use.

All data will be uploaded into the SWAMP Information Management System or GeoTracker ESI. At this point the Board may use the data in the overall evaluation of the surface water and groundwater quality in the Tule Basin watershed. Future decisions for water regulations will be made, in part, on the information provided under this Plan.

Questions will always arise when a toxicity level shows an exceedance, but the chemistry data taken at the same time fails to show a toxic substance that might cause the problem. Given the relatively limited list of monitoring parameters versus the number of both known and unknown potential contaminants, it is not inconceivable that a constituent could contribute to toxicity but fail to be identified from the chemistry testing. Continuing discrepancies between the outcome of the toxicity testing and the chemistry testing should be further evaluated in an attempt to determine the possible presence of a persistent, harmful parameter.

Any concerns or unanswered questions that arise from the data will be addressed as comments or footnotes within the written reports submitted to the Regional Board.

ELEMENT 25: DEFINITIONS

Term	Definition
BPO	Basin Plan Objective
BS/BSD	Blank Spike / Blank Spike Duplicate
CAPA	Corrective Action / Preventative Action
CEDEN	California Environmental Data Exchange Network
CA ELAP	California Environmental Laboratory Accreditation Program
CV RDC	Central Valley Regional Data Center
EDD	Electronic Data Deliverable
ESI	Electronic Submittal of Information
General Order (Order)	CA Central Valley Regional Board Order #R5-2013-0120 (Amended by R5-2014-0143 and R5-2015-0115)
GQTMP	Groundwater Quality Trend Monitoring Program
GQTMW	Groundwater Quality Trend Monitoring Workplan
ISO	International Organization for Standardization
IT	Information Technology
LCS/LCSD	Laboratory Control Spike / Laboratory Control Spike Duplicate. Often used interchangeably with BS/BSD.
ILRP	Irrigated Lands Regulatory Program
MDL	Method Detection Limit
MRP	Monitoring and Reporting Program
MS/MSD	Matrix Spike / Matrix Spike Duplicate
NTC	
PQL	Practical Quantitation Limit
QA	Quality Assurance
QAPP	Quality Assurance Program Plan
QC	Quality Control
RDC	Regional Data Center
RL	Reporting Limit
RPD	Relative Percent Difference
SOP	Standard Operating Procedure
SSJVWQC	Southern San Joaquin Valley Water Quality Coalition
SWAMP	Surface Water Ambient Monitoring Program
SWMP (Plan)	Surface Water Monitoring Plan (Tule Basin SWMP)
TBWQC	Tule Basin Water Quality Coalition
TIE	Toxicity Identification Evaluation

APPENDIX A.1

Chain of Custody

BSK ASSOCIATES

1414 Stanislaus St., Fresno, CA 93706
(559) 497-2888 · Fax (559) 497-2893
www.bskassociates.com

Turnaround Time Request
☐ Standard - 10 business days
☐ Rush (Surcharge may apply)
Date needed:

ANALYTICAL CHAIN OF CUSTODY

*Required Fields

Temp:

Company/Client Name*:

Report Attention*:

Additional cc's:

Invoice To*:

PO#:

Phone*:

Fax:

E-mail*:

Address*: **City*:** **State*:** **Zip*:**

Project: Project #:

How would you like to receive your completed results?* ☐ E-Mail ☐ Fax ☐ Mail

Reporting Options: ☐ Trace (J-Flag) ☐ Swamp ☐ EDD Type: ____________

Sampler Name (Printed/Signature)*:

Regulatory Carbon Copies
☐ SWRCB (Drinking Water)
☐ Merced Co ☐ Fresno Co
☐ Madera Co ☐ Tulare Co
☐ Other:

Regulatory Compliance
☐ EDT to California SWRCB (Drinking Water)
System Number*: ____________
☐ Geotracker #: ____________

Matrix Types: SW=Surface Water BW=Bottled Water GW=Ground Water WW=Waste Water STW=Storm Water DW=Drinking Water SO=Solid

#	Sample Description*	Sampled* Date	Sampled* Time	Matrix*	Comments / Station Code / WTRAX

Relinquished by: (Signature and Printed Name)	Company	Date	Time	Received by: (Signature and Printed Name)	Company
Relinquished by: (Signature and Printed Name)	Company	Date	Time	Received by: (Signature and Printed Name)	Company
Received for Lab by: (Signature and Printed Name)		Date	Time	Payment Received at Delivery: Check / Cash Date: Amount: PIA#: Init.	

Shipping Method: ONTRAC UPS GSO WALK-IN FED EX Courier: ____________ Custody Seal: Y / N

Cooling Method: Wet Blue None Chilling Process Begun: Y / N

Payment for services rendered as noted herein are due in full within 30 days from the date invoiced. If not so paid, account balances are deemed delinquent. Delinquent balances are subject to monthly service charges and interest specified in BSK's current Standard Terms and Conditions for Laboratory Services. The person signing for the Client/Company acknowledges that they are either the Client or an authorized agent to the Client, that the Client agrees to be responsible for payment for the services on this Chain of Custody, and agrees to BSK's terms and conditions for laboratory services unless contractually bound otherwise. BSK's current terms and conditions can be found at www.bskassociates.com/BSKLabTermsConditions.pdf

SR-FL-0012-07

APPENDIX A.2

Field Sample Collection Logs

ILRP/SWAMP 2.5 Field Data Sheet - Water Sample Collection Pg of Pgs

Coalition Name:			DATE (mm/dd/yyyy):
StationID & Name:			FIRST SAMPLE TIME:
ProjectID:	Arrival Time:	Departure Time:	Target Lat. & Long.:
Sampling Crew (and Agency):			Actual Lat & Long:
			Datum: / Accuracy (ft / m):

OBSERVATIONS	WADEABLE: YES / NO	PICTURE NAME/S:
DOMINANT SUBSTRATE: Concrete, Cobble, Gravel, Sand, Mud, Unk., Other		
SITE ODOR: None, Sulfides, Sewage, Petroleum, Mixed, Other	SKY CODE:	clear, partly cloudy, overcast, fog, hazy
OTHER PRESENCE: Vascular, Nonvascular, OilySheen, Foam, Trash, None, Other	PRECIPITATION:	None, Foggy, Drizzle, Rain, Snow
WATER ODOR: None, Sulfides, Sewage, Petroleum, Mixed, Other	PRECIPITATION (last 24 hrs):	Unknown, <1", >1", None
WATER CLARITY: Clear (see bottom), Cloudy (>4" vis), Murky (<4" vis)	WATERCOLOR:	colorless, green, yellow, brown, other
OBSERVED FLOW: NA, Dry Waterbody Bed, No Observed Flow, Isolated Pool, 0.1 - 1cfs, 1 - 5 cfs, 5 - 20 cfs, 20 - 50 cfs, 50 - 200 cfs, >200cfs		

Comments:

PHYSICAL PARAMETERS	SAMPLE COLLECTION	Sample Depth (circle one): 0.1 m (subsurface grab) -88 (integrated)
Water Temp (Celsius):	STARTING BANK:	LB / RB/ NA
Air Temp (Celsius):	OCCUPATION METHOD:	Walk-in, Bridge, Other
*pH>8.5 or <6.5 pH:	SAMPLING EQUIPMENT:	Indiv bottle by hand, By pole, Other
*EC>700 EC (uS/cm):	SAMPLE LOCATION:	Bank, Near Bank, Thalweg, Midchannel, Open Water
*DO<7.0 DO (mg/L)	HYDRO-MODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert, Other
TDS:	HYDROMODLOC:	US / DS / NA

CALCULATED SITE DISCHARGE (cfs): Transfer Calculated Value From Discharge Worksheet		Wet Channel Width (m): / Midchannel depth (m):	Wet Channel Width (m): / Stage:

√	Sample ID	Analyte	Container	Number	Notes

APPENDIX A.2

Field Sample Collection Logs

ILRP/SWAMP 2.5 Discharge Worksheet

Coalition Name:		DATE (mm/dd/yyyy):
StationID & Name :		FIRST SAMPLE TIME:
ProjectID:	Method: USGS (bridge), USGS (wading), culvert, other:	
Left Edge Water (LEW):	Start Time (24 hr):	Discharge (cfs):
Right Edge Water (REW):	End Time (24 hr):	Discharge calculated by:

#	Angle (if from bridge)	Interval Midpoint (meters or feet)	Interval Depth (meters or feet)	% Depth (from surface)*	Revolutions/Velocity (m/s or f/s)	Notes
1				0.2 / 0.8 or 0.6		
2				0.2 / 0.8 or 0.6		
3				0.2 / 0.8 or 0.6		
4				0.2 / 0.8 or 0.6		
5				0.2 / 0.8 or 0.6		
6				0.2 / 0.8 or 0.6		
7				0.2 / 0.8 or 0.6		
8				0.2 / 0.8 or 0.6		
9				0.2 / 0.8 or 0.6		
10				0.2 / 0.8 or 0.6		
11				0.2 / 0.8 or 0.6		
12				0.2 / 0.8 or 0.6		
13				0.2 / 0.8 or 0.6		
14				0.2 / 0.8 or 0.6		
15				0.2 / 0.8 or 0.6		
16				0.2 / 0.8 or 0.6		
17				0.2 / 0.8 or 0.6		
18				0.2 / 0.8 or 0.6		
19				0.2 / 0.8 or 0.6		
20				0.2 / 0.8 or 0.6		
21				0.2 / 0.8 or 0.6		
22				0.2 / 0.8 or 0.6		
23				0.2 / 0.8 or 0.6		
24				0.2 / 0.8 or 0.6		
25				0.2 / 0.8 or 0.6		
26				0.2 / 0.8 or 0.6		
27				0.2 / 0.8 or 0.6		
28				0.2 / 0.8 or 0.6		
29				0.2 / 0.8 or 0.6		

*two measurement should be taken (0.2 and 0.8 from the surface of the water) if the depth is greater than 0.76m (2.5ft).

APPENDIX A.2

Field Sample Collection Logs

ILRP/SWAMP 2.5 Field Data Sheet - Sediment Sample Collection			Pg of Pgs
Coalition Name:			DATE (mm/dd/yyyy):
StationID & Name :			FIRST SAMPLE TIME:
ProjectID:	Arrival Time:	Departure Time:	Target Lat. & Long.:
Sampling Crew (and Agency):			Actual Lat & Long:
			Datum: / Accuracy (ft / m):

OBSERVATIONS		WADEABLE: YES / NO	PICTURE NAME/S:
DOMINANT SUBSTRATE:	Concrete, Cobble, Gravel, Sand, Mud, Unk., Other		
SITE ODOR:	None, Sulfides, Sewage, Petroleum, Mixed, Other	SKY CODE:	clear, partly cloudy, overcast, fog, hazy
OTHER PRESENCE:	Vascular, Nonvascular, OilySheen, Foam, Trash, None, Other	PRECIPITATION:	None, Foggy, Drizzle, Rain, Snow
WATER ODOR:	None, Sulfides, Sewage, Petroleum, Mixed, Other	PRECIPITATION (last 24 hrs):	Unknown, <1", >1", None
WATER CLARITY:	Clear (see bottom), Cloudy (>4" vis), Murky (<4" vis)	WATERCOLOR:	colorless, green, yellow, brown, other
OBSERVED FLOW:	NA, Dry Waterbody Bed, No Observed Flow, Isolated Pool, 0.1 - 1cfs, 1 - 5 cfs, 5 - 20 cfs, 20 - 50 cfs, 50 - 200 cfs, >200cfs		
DOMINANTSUBSTRATE:	Bedrock, Concrete, Cobble, Gravel, Sand, Mud, Unk, Other ________		
SEDODOR:	None, Sulfides, Sewage, Petroleum, Mixed, Other ________		
SEDCOLOR:	Colorless, Green, Yellow, Brown		
SEDCOMPOSITION:	Silt/Clay, Fine Sand, Coarse Sand, Gravel, Cobble, Mixed, Hard Pan Clay		

Comments:

PHYSICAL PARAMETERS			SAMPLE COLLECTION	Sample Depth (circle one): 1 cm, 2 cm, -88 (integrated depth or core)
	Water Temp (Celsius):		STARTING BANK:	LB / RB/ NA
	Air Temp (Celsius):		OCCUPATION METHOD:	Walk-in, Bridge, Other
*pH>8.5 or <6.5	pH:		SAMPLING EQUIPMENT:	Hand trowel, Eckman Sampler, Other
*EC>700	EC (uS/cm):		SAMPLE LOCATION:	Bank, Near Bank, Midchannel Bed
*DO<7.0	DO (mg/L):		HYDRO-MODIFICATION:	None, Bridge, Pipes, Concrete Channel, Grade Control, Culvert, Other
	TDS:		HYDROMODLOC:	US / DS / NA

√	Sample ID	Analyte	Container	Number	Notes

APPENDIX A.3

Example Laboratory Data Completeness Worksheet

Lab Data Completeness Worksheet															
Sampling Event	Month, Year	Sample Results		Acceptable Data Quality Indicators								Total DQIs			
Method	Analyte	Total	Adversely Impacted	Sensitivity	Contamination	Accruacy (LCS)	Precision (LCS)	Recovery (MS)	Precision (MS)	Precision (Lab Dup)	Hold Time	# Acceptable	# Performed	Percent Sample Completeness	DQI Success Rate
ASTM D422	Grain size											0			
EPA 200.7, Calc	Hardness (as CaCO3)											0			
EPA 200.8	Arsenic (Total)											0			
EPA 200.8	Boron (Total)											0			
EPA 200.8	Cadmium (Dissolved)											0			
EPA 200.8	Cadmium (Total)											0			
EPA 200.8	Copper (Dissolved)											0			
EPA 200.8	Copper (Total)											0			
EPA 200.8	Lead (Dissolved)											0			
EPA 200.8	Lead (Total)											0			
SM 2540C	Total Dissolved Solids (TDS)											0			
SM 2540D	Total Suspended Solids (TSS)											0			
SM 4500-NH3 G	Ammonia											0			
SM 4500-P E	Orthophosphate											0			
SM 5310C	Total Organic Carbon (TOC)											0			
SM 8010F	Unionized Ammonia (calculated value)											0			
SM 9221 B,F	E. Coli											0			
SM 9221 E	Fecal Coliform											0			
Walkley Black	Total Organic Carbon (TOC)											0			
	Totals	0	0	0	0	0	0	0	0	0	0	0	0		

APPENDIX A.4

Example Field and Transport Completeness Worksheet

Field Data Completeness Worksheet				
Date Sampled				
	Sampling Locations			
Activity	**Sample Point 1**	**Sample Point 2**	**Sample Point 3**	**Sample Point 4**
Field Sampling				
Water Present at Location?				
Photo documentation captured?				
Field Equipment Rinsed?				
All containers for all samples filled?				
Sample Labels Verified to COC?				
Lat. / Long. Recorded?				
Field Conditions Recorded?				
Field Measurements Collected				
Flow				
Temp				
pH				
EC				
Dissolved Oxygen				
Sample Transport				
Were samples packed on ice?				
COC signed by sampler?				
Was COC included in cooler?				
Sample Receipt				
Samples received within temperature?				
If no, received on ice on date collected?				
All bottles unbroken and intact?				
Bottle labels agree with COC?				
Were bottles correct for tests requested?				
Sufficient sample received for all tests?				
Arrived at lab within hold times?				
Passing Criteria	0	0	0	0
Total Assessments	0	0	0	0
% Complete				
% Completeness - Field Activities				

Appendix F

Groundwater Sampling Form

Groundwater Sampling

Job Name:___________________________________ Well No./ I.D.___________________________________
Job Number:_________________________________ Well Type: Monitor Extraction Other:
Recorded By:________________________________ Well Material: PVC St. Steel Other:
(Signature) Date: Time:
Sampled By:___________________________________

WELL PURGING

PURGE VOLUME	PURGE METHOD
Casing Diameter (**D** inches): 2 4 6 Other:____	Bailer - Type:______________________________
Total Depth of Casing (**TD** in feet BTOC):	Submersible ☐Centrifugal Bladder; Pump No.:
Water Level Depth (**WL** in feet BTOC):	Other Type:
Number of well volumes to be purged (**# Vols**):	**PUMP INTAKE SETTING**
3 4 5 10 Other:	Near Bottom Near Top Other:
	Depth in ft (BTOC): Screen Interval in ft (BTOC):
	From____________ To____________

PURGE VOLUME CALCULATION:

(________) - (__________) • ________ 2 • ________ • .0408 = ______________________gallons

TD (feet) **GW** (feet) **D** (Inches) **# Vols** *Calculated Purge Volume*

PURGE TIME	PURGE RATE	ACTUAL PURGE VOLUME
Start:____________ Stop:____________	Initial:____________ gpm	__________ • ____________=___________ gallons
Elapsed:	Final: ____________gpm	

FIELD PARAMATER MEASURMENTS:

Minutes Since Pumping Began:	pH	Cond. (μ Mhos/cm)	T C° F°	Other:	OBSERVATIONS DURRING PURGING (Well Condition, Turbidity, Color, Odor):
					DISCHARGE WATER DISPOSAL:
					Sanitary Sewer Storm Sewer
Meter Nos.:					Other:______________________________

WELL SAMPLING

SAMPLING METHOD

Same As Above
☐Bailer - Type:______________________________
Submersible ☐Centrifugal Bladder; Pump No.:____________________
Grab - Type:______________________________
Other - Type:______________________________

SAMPLE DISTRIBUTION Sample Series:______________________

Sample No.	Volume/ Cont.	Analysis Requested	Preservatives	Lab	Comments

QUALITY CONTROL SAMPLES

Duplicate Samples		Blank Samples		Other Samples	
Original Sample No.	Duplicate Sample No.	Type	Sample No.	Type	Sample No.

Thomas Harder & Co.
Groundwater Consulting

TULE SUBBASIN SETTING

TULE SUBBASIN COORDINATION AGREEMENT ATTACHMENT 2

Tule Subbasin Setting

January 2020

Prepared for

Tule Subbasin Technical Advisory Committee

Prepared by

Thomas Harder, P.G., CH.G.
Principal Hydrogeologist

CERTIFIED HYDROGEOLOGIST
THOMAS E. HARDER
No: 588
STATE OF CALIFORNIA

Benjamin Lewis, P.G., CH.G.
Senior Hydrogeologist

CERTIFIED HYDROGEOLOGIST
BENJAMIN TRENT LEWIS
No: 1047
STATE OF CALIFORNIA

Thomas Harder & Co.
Groundwater Consulting

Table of Contents

Tables

Figures

Appendices

A. Lower Tule River Irrigation District GSA Water Budgets and Hydrographs

B. Eastern Tule GSA Water Budgets and Hydrographs

C. Delano-Earlimart Irrigation District GSA Water Budgets and Hydrographs

D. Pixley Irrigation District GSA Water Budgets and Hydrographs

E. Tri-County Water Authority GSA Water Budgets and Hydrographs

F. Alpaugh Irrigation District GSA Water Budgets and Hydrographs

CHAPTER 2: TULE SUBBASIN SETTING §354.12

§ 354.12. Introduction to Basin Setting

This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.

The Tule Subbasin is located in the southern portion of the San Joaquin Valley Groundwater Basin in the Central Valley of California (see Figure 2-1). The area of the Tule Subbasin is defined by the latest version of CDWR Bulletin 118 (CDWR, 2016) and is shown on Figures 2-1 and 2-2. The Tule Subbasin area is approximately 744 square miles (475,895 acres) and includes the jurisdictional areas of multiple water management and service entities. The subbasin has been divided into seven individual Groundwater Sustainability Agencies (GSAs): Eastern Tule GSA, Lower Tule River GSA, Pixley GSA, Delano-Earlimart GSA, Alpaugh GSA, Tri-County Water Authority GSA, and Tulare County GSA (see Figure 2-3).

Communities within the subbasin include Porterville, Tipton, Pixley, Earlimart, Richgrove, Ducor and Terra Bella (see Figure 2-2). Neighboring CDWR Bulletin 118 subbasins include the Kern County Subbasin to the south, the Tulare Lake Subbasin to the west, and the Kaweah Subbasin to the north.

2.1 Hydrogeologic Conceptual Model §354.14

§ 354.14. Hydrogeologic Conceptual Model

(a) Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.

The hydrogeologic conceptual model is a description of the groundwater flow system of the Tule Subbasin and how it interacts with surface water and land use of the area. The conceptual model includes a description of the geologic setting, geologic structure, and boundary conditions including the principal aquifers and aquitards. The hydrogeologic conceptual model of the Tule Subbasin, as described herein, has been developed in accordance with the requirements of California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2, Article 5, Subarticle 2 (§354.14) and in consideration of California Department of Water Resources' (CDWR) Best Management Practices (BMP) for the preparation of hydrogeologic conceptual models. The hydrogeologic conceptual model forms the basis for the numerical groundwater flow model of the subbasin.

2.1.1. Sources of Data

Compilation, review and analysis of multiple types of data were necessary to develop the hydrogeologic conceptual model and water budget of the Tule Subbasin. The various types of data included geology, soils/lithology, hydrogeology, surface water hydrology, climate, crop types/land use, topography, remote sensing, and groundwater recharge and recovery. Data were obtained from multiple sources:

Geological Data including geologic maps and cross sections were obtained from the United States Geological Survey (USGS), the California Geological Survey (CGS), and Kenneth D. Schmidt & Associates (KDSA) (Schmidt, 2018). Geophysical logs were obtained from the California Division of Oil, Gas and Geothermal Resources (DOGGR), Angiola Water District, Alpaugh Irrigation District, Kern-Tulare Water District (KTWD), KDSA, and private well owners.

Soils/Lithological Data were obtained from drillers' logs and reports from the CDWR, the City of Porterville, the USGS and the United States Department of Agriculture (USDA).

Hydrogeological Data including groundwater levels and pumping tests were obtained from the California Statewide Groundwater Elevation Monitoring (CASGEM) website, the Deer Creek and Tule River Authority (DCTRA), Angiola Water District, Alpaugh Irrigation District, KTWD, Delano-Earlimart Irrigation District (DEID), the City of Porterville, Kern County Water Agency, 4Creeks Inc., Schmidt (2011) and Schmidt (2018). Additional hydrogeological information was obtained from USGS reports, Semitropic Water Storage District Groundwater Banking Project Biennial Reports, and the Tulare Lake Bed Groundwater Management Plan.

Groundwater Quality Data including nitrate and electrical conductivity (EC) data from the Tule Basin Water Quality Coalition, multiple reports and studies associated with the Tulare Lakebed Municipal Delisting program, and contaminants identified in the California State Water Resources Control Board Geotracker website (Geotracker, 2018).

Groundwater Recharge and Recovery Data including spreading basin locations and dimensions, artificial recharge, water well construction, well locations, groundwater production, surface water diversions, canal losses, and river losses were obtained from Lower Tule River Irrigation District (LTRID), CDWR, Tule River Association (TRA) annual reports, and DCTRA annual reports.

Hydrological (i.e. Surface Water) Data consisting of stream gage data along the Tule River, Deer Creek, and White River were obtained from the USGS, DCTRA reports and TRA annual reports. Imported water deliveries were obtained from the United States Bureau of Reclamation (USBR) and the individual agencies within the subbasin.

Climate Data was acquired from CDWR's California Irrigation Management Information System (CIMIS) and the Western Regional Climate Center website.

Land Use Data was obtained from the CDWR, LTRID, the Kern County Department of Agriculture and Measurement Stands, and the USGS Earth Resources Observation and Science Center. Political boundaries were obtained from the California Cal-Atlas Geospatial Clearinghouse, Kern-Tulare Water District, and the LTRID.

In addition to the various types of data, numerous historical reports on the geology, hydrogeology and groundwater management of the Tule Subbasin were reviewed and analyzed. These reports included USGS publications, CDWR reports and bulletins, consultant reports, and academic publications. Publications relied on for the hydrogeological conceptual model and water budget are summarized in the References Section (Section 2.5).

2.1.2. Geologic Setting §354.14 (b)(1)

§ 354.14. (b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:

> (1) The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.
>
> (2) Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.

The Tule Subbasin is located in the Tulare Lake Hydrologic Region of the Central Valley of California (see Figure 2-1). The Central Valley is a geographically significant structural depression that extends from the Cascade Range on the north to the Tehachapi Mountains on the south (Faunt, 2009). The Central Valley groundwater basin has been subdivided on a regional scale into the Sacramento Valley Groundwater Basin north of the Sacramento River Delta, and the San Joaquin Valley Groundwater Basin south of the Sacramento River Delta. The Tulare Lake Hydrologic Region is located in the southern portion of the San Joaquin Valley Groundwater Basin. The Tulare Lake Hydrologic Region is defined by a surface water drainage watershed that includes the Sierra Nevada Mountains to the east, the Tehachapi Mountains to the south and southeast, and the Coast Ranges to the west. The northern boundary of this hydrologic region is defined by the drainage divide between the San Joaquin River to the north and the Kings River to the south.

The portion of the Central Valley structural depression that is beneath the Tulare Lake Hydrologic Region is filled with marine and nonmarine sediments, which extend to depths of more than 32,000 feet in places (Planert and Williams, 1995). The deepest sediments were deposited within a marine environment associated with an inland sea that inundated the valley between 200 million years ago (Jurassic Period) and 2 million years ago (end of the Tertiary Period) (Croft, 1972). The deeper marine sediments are overlain by as much as 9,000 ft of nonmarine continental deposits associated with Quaternary (2 million years to present) lacustrine and alluvial deposition (Planert and Williams, 1995). The current depositional environment consists of multiple coalescing alluvial fans along the basin margins with localized lacustrine deposits at the terminus of the fans in the central portion of the basin.

The Tule Subbasin is located on a series of coalescing alluvial fans that extend toward the center of the valley from the Sierra Nevada Mountains (see Figure 2-4). The alluvial fans merge with lacustrine deposits of the Tulare Lake bed in the western portion of the subbasin. Land surface elevations within the Tule Subbasin range from approximately 850 ft above mean sea level (amsl) along the eastern margins of the subbasin to approximately 180 ft amsl at the western boundary (see Figure 2-4).

Geologic formations observed at the land surface and in the subsurface beneath the Tule Subbasin can be grouped into five generalized geologic units, described below in order of increasing age:

Unconsolidated Continental Deposits – These sediments consist of fluvial (i.e. streambed deposits), alluvial, flood plain, and lacustrine (i.e. lake bed) deposits (labeled "surficial deposits" on Figure 2-4). The unconsolidated continental deposits range in thickness from 0 ft at the eastern contact with the Sierra Nevada Mountains to more than 3,000 ft near the margins of Tulare Lake in the western part of the subbasin (see Figure 2-5; Lofgren and Klausing, 1969). Subsurface alluvial sediments consist of highly stratified layers of more permeable sand and gravel interbedded with lower permeability silt and clay. Clear correlation of individual sand or clay layers laterally across the Tule Subbasin is difficult due to the interbedded nature of the sediments. However, it is noted that the thickness of clay sediments in the upper 1,000 ft below ground surface (bgs) generally increases in the vicinity of Tulare Lake. The unconsolidated continental deposits form the primary groundwater reservoir in the Tule Subbasin.

The unconsolidated continental deposits range in age from recent in near-surface stream channels to Upper Pliocene (approximately 2.6 million years before present) at depth. In the eastern portion of the Tule Subbasin, Pleistocene sediments (2.6 million to 11,700 years before present) crop out at the land surface along the base of the Sierra Nevada Mountains, forming what is referred to as the dissected uplands (Lofgren and Klausing, 1969). These older continental deposits are semi-consolidated and contain a high percentage of clay. As such, they generally do not yield significant water to wells.

The lowermost portion of unconsolidated continental deposits is generally correlated with the Tulare Formation. The Tulare Formation is notable in that it includes the Corcoran Clay, a regionally extensive confining layer that has also been referred to as the "E-Clay" (see Figure 2-5) (Frink and Kues, 1954). The Corcoran Clay consists of a Pleistocene diatomaceous fine-grained lacustrine deposit (primarily clay; Faunt, 2009). In the Tule Subbasin, the Corcoran Clay is as much as 150 ft thick beneath the Tulare Lake bed but becomes progressively thinner to the east, eventually pinching out immediately east of Highway 99 (Lofgren and Klausing, 1969).

Pliocene Marine Deposits – These sediments underlie the continental deposits and consist of consolidated to loosely consolidated marine siltstone with minor interbedded sandstone beds. The marine siltstone unit thickens to the west, ranging from approximately 500 ft thick near State Highway 65 to more than 1,600 ft beneath State Highway 99 (Lofgren and Klausing, 1969; see Figures 2-5 and 2-6). The marine siltstone beds dip sharply from the base of the Sierra Nevada Mountains on the east to the central portion of the valley in the west. The Pliocene marine strata have relatively low permeability and do not yield significant water to wells.

Santa Margarita Formation – This formation occurs beneath the Pliocene marine strata and consists of Miocene (approximately 5.3 to 23 million years before present) sand and gravel that is relatively permeable and yields water to wells. The formation is approximately 150 to 520 feet thick and occurs at depths ranging from 1,200 feet near State Highway 65 to greater than 3,000 feet beneath State Highway 99. This formation is a significant source of groundwater to wells in the southeastern portion of the Tule Subbasin near the community of Richgrove.

Tertiary Sedimentary Deposits – Beneath the Santa Margarita Formation exists an interbedded assemblage of semi-consolidated to consolidated sandstone, siltstone and claystone of Tertiary age (approximately 2.6 to 66 million years before present). Some irrigation wells in the southeastern part of the Tule Subbasin are known to produce fresh water from the Olcese Sand Formation, which is in the uppermost portion of the unit (Ken Schmidt, 2019. Personal Communication). The water quality of the groundwater in the Tertiary sedimentary deposits becomes increasingly saline to the southwest and most of the groundwater in the unit is not useable for crop irrigation or municipal supply except near Highway 65.

Granitic Crystalline Basement – Sedimentary deposits beneath the Tule Subbasin are underlain by a basement consisting of Mesozoic granitic rocks that compose the Sierra Nevada batholith (Faunt, 2009). At depth, the basement rocks are assumed to be relatively impermeable.

There are no significant faults mapped in the Tule Subbasin that would form a groundwater flow barrier or affect groundwater flow.

2.1.3. Lateral Basin Boundaries §354.14 (b)(2)

The lateral boundaries of the Tule Subbasin are defined in CDWR Bulletin 118 and include both natural and political boundaries. The eastern boundary of the Tule Subbasin is defined by the surface contact between crystalline rocks of the Sierra Nevada and surficial alluvial sediments that make up the groundwater basin (see Figure 2-4). The northern boundary is defined by the LTRID and Porterville Irrigation District (PID) boundaries. The western boundary is defined by the Tulare

County/Kings County boundary, except for a portion of the Tulare Lake Basin Water Storage District that extends east across the county boundary and is excluded from the subbasin. The southern boundary is defined by the Tulare County/Kern County boundary except for the portion of the Delano-Earlimart Irrigation District (DEID) that extends south of the county boundary and is included in the subbasin. The total area of the Tule Subbasin is approximately 744 square miles (475,895 acres).

2.1.4. Bottom of Basin §354.14 (b)(3)

> § 354.14. (b) (3) The definable bottom of the basin.

The physical bottom of the Tule Subbasin is defined by the interface between the Tertiary sedimentary deposits and the relatively impermeable granitic bedrock below them. This depth ranges from zero at the eastern margins of the subbasin where the continental deposits meet the granitic bedrock to approximately 5,000 feet below ground surface in the western portion of the subbasin (Planert and Williams, 1995).

The physical bottom of the subbasin is deeper than the bottom of the fresh water aquifer. The total dissolved solids (TDS) concentration of the groundwater generally increases with increasing depth such that below a certain level, the groundwater is not suitable for municipal, irrigation or other beneficial uses. Accordingly, a better measure of the bottom of the basin is the fresh water/brackish water interface, as defined in Page (1973) by an electrical conductivity of 3,000 micromhos per centimeter (μmohs/cm), which is approximately correlative to a total dissolved solids (TDS) concentration of 2,000 milligrams per liter (mg/L).

In the Tule Subbasin, the fresh water/brackish water interface varies across the subbasin but is generally 1,500 to 3,000 feet below land surface (Page, 1973; Planert and Williams, 1995). The deepest fresh water occurs in the western portion of the Tule Subbasin. Agricultural irrigation wells in the western Tule Subbasin are as deep as 1,500 feet and some agricultural wells west of the Tulare/Kings County boundary are as deep as 2,200 feet. The bottom of the effective groundwater basin, based on the fresh water/brackish water interface, is shown on Figures 2-5 and 2-6.

2.1.5. Surface Water Features §354.14 (d)(5)

§ 354.14. (d) (5) Surface water bodies that are significant to the management of the basin.

2.1.5.1. Tulare Lake

Although now largely a dry lake bed, prior to the mid-1800s Tulare Lake was the largest fresh water lake, by area, west of the Mississippi River. The original area of the lake was approximately 570 square miles and was fed from surface water discharges at the terminus of the Kern River, Tule River, Kaweah River, and Kings River. Beginning in the mid-1800s, surface water from the rivers feeding the lake was diverted for agricultural irrigation and municipal supply. By 1900, the lake was dry except for residual marshes and wetlands and occasional flooding. This condition continues to the present.

2.1.5.2. Lake Success

Lake Success is a manmade reservoir created by the construction of Success Dam that was completed in 1961 and serves as a flood control and water conservation project for the Tule River. Success dam and reservoir are managed by the United States Army Corps of Engineers (ACOE). Water storage in Lake Success is subject to the ACOE's flood control diagram and released as directed by the ACOE and downstream water rights holders as administered by the Tule River Association (TRA), in accordance with the Tule River Water Diversion Schedule and Storage Agreement (TRA, 1966).

2.1.5.3. Tule River

The Tule River is the largest natural drainage feature in the Tule Subbasin. From its headwaters in the Sierra Nevada Mountains, the Tule River flows first into Lake Success and then, through controlled releases at the dam, flows through the City of Porterville where it is diverted at various points before flowing into the LTRID. A significant diversion point is the Porter Slough, which flows to the north and semi-parallel to the main river channel and is used to convey surface water to various recharge facilities and canals. Downstream of Porterville, the Tule River ultimately discharges onto the Tulare Lakebed during periods of above-normal precipitation. Stream flow is measured via gages located below Success Dam, at Rockford Station downstream of Porterville, and at Turnbull Weir (see Figure 2-7). From water years 1986/87 to 2016/17, releases from Lake Success to the Tule River, quantified in TRA annual reports as the sum of Pioneer Water Company diversion and stream flow at the Below Success Dam gage, has ranged from 8,820 acre-ft in water year 2014/15 to 439,125 acre-ft in water year 1997/98 with an annual average during this time period of approximately 118,300 acre-ft.

Releases of water below Lake Success dam are diverted from the Tule River channel at various locations in accordance with TRA (1966). Diversion points along the river are located at the Porter Slough headgate, Campbell and Moreland Ditch Company, Vandalia Water District, Poplar Irrigation Company, Hubbs and Miner Ditch Company, and Woods-Central Ditch Company. The lower portion of the Tule River channel is also used as a conveyance mechanism to convey imported water from the Friant-Kern Canal to the PID and LTRID. Within the PID and LTRID, a combination of natural stream flow and imported water are further diverted into unlined canals for distribution to artificial recharge basins and farmers. Any residual stream flow left in the Tule River after diversions is measured at the Turnbull Weir, located at the west end of the LTRID (see Figure 2-7).

2.1.5.4. Deer Creek

Deer Creek is a natural drainage that originates in the Sierra Nevada Mountains, flowing in a westerly direction north of Terra Bella and into Pixley (see Figure 2-7). Although the Deer Creek channel extends past Pixley, discharges rarely reach the historical Tulare Lakebed. Stream flow in Deer Creek has been measured at the USGS gaging station at Fountain Springs from 1968 to present time. Average annual flow at this gage between water year 1986/87 and 2016/17 was approximately 17,800 acre-ft/yr with a low of approximately 2,000 acre-ft in water year 2014/15 and a high of approximately 88,000 acre-ft in water year 1997/98. Stream flow has also been measured at a second USGS gaging station on Deer Creek at Terra Bella although the period of record (1971 through 1987) is not as complete as the station at Fountain Springs. Friant-Kern Canal water is also diverted and monitored into Deer Creek and again measured at Trenton Weir before being delivered to riparian lands via unlined canals (see Figure 2-7). During wet years, water that reaches the terminus of Deer Creek is discharged into the Homeland Canal.

2.1.5.5. White River

The White River drains out of the Sierra Nevada Mountains east of the community of Richgrove in the southern portion of the Tule Subbasin (see Figure 2-7). Stream flow in the White River has been measured at the USGS gaging station near Ducor from 1972 to 2005. Data after 2005 has been interpolated. Average annual flow between water year 1986/87 and 2016/17 was approximately 5,800 acre-ft/yr with a low of approximately 250 acre-ft in water year 2014/15 and a high of approximately 37,000 acre-ft in 1997/98. The White River channel extends as far as State Highway 99 but does not reach the historical Tulare Lakebed.

2.1.5.6. Imported Water §354.14 (d)(6)

> § 354.14. (d) (6) The source and point of delivery for imported water supplies.

Most of the water imported into the Tule Subbasin is from the Central Valley Project (CVP) and delivered via the Friant-Kern Canal (see Figure 2-7). Angiola Water District also imports water from other various sources including the King's River and State Water Project. The water is delivered to farmers and recharge basins via the Tule River and Deer Creek channels, unlined canals, and pipeline distribution systems of PID, LTRID, Terra Bella Irrigation District, Teapot Dome Water District, DEID, and Saucelito Irrigation District.

Distribution of stream flow diversions and imported water occur via a system of manmade canals and pipeline distribution systems that extend throughout the Tule Subbasin. The largest of these is the Friant-Kern Canal, which supplies imported water through the Federal Central Valley Project (CVP). The Friant-Kern Canal is concrete lined and trends approximately north-south through the eastern part of the Tule Subbasin (see Figure 2-7). Numerous other canals and pipeline distribution systems are located within the Tule Subbasin to convey surface water from the Friant-Kern Canal, Tule River and Deer Creek to various recharge facilities and agricultural areas. The canals are unlined and occur primarily in the LTRID, Pixley Irrigation District, PID, Alpaugh Irrigation District, and Atwell Island Water District. The Angiola Water District receives deliveries from the Tule River and Kings River via the Homeland Canal and distributes that water via an internal system of unlined canals.

Many of the irrigation districts and water districts in the Tule Subbasin that receive imported water from the Friant-Kern Canal distribute the water exclusively via pipeline distribution systems. These districts include the Delano-Earlimart Irrigation District, Kern-Tulare Water District, Terra Bella Irrigation District, Saucelito Irrigation District, and Tea Pot Dome Water District.

2.1.6. Areas of Groundwater Recharge and Discharge §354.14 (d)(4)

> § 354.14. (d) (4) Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.

Groundwater recharge in the Tule Subbasin occurs within stream channels, unlined canals, in managed recharge basins, and in areas of the subbasin with irrigated agriculture. Favorable areas for deep percolation of surface water are characterized by relatively permeable surface soils (see Figure 2-8), and lack of subsurface impediments to groundwater recharge.

The University of California at Davis has developed a Soil Agricultural Groundwater Banking Index (SAGBI) that identifies favorable areas of recharge based on deep percolation potential, root zone residence time, topography, chemical limitations, and soil surface condition. The SAGBI zones for the Tule Subbasin are shown on Figure 2-9. In general, the most favorable areas for recharge are within the stream channels of the Tule River, Deer Creek and White River, in the Porterville area, and in a north-south zone in the west-central portion of the subbasin. Areas that are not favorable for deep percolation of surface water and recharge of groundwater are in the furthest east portion of the subbasin along the base of the Sierra Nevada Mountains and in the furthest west portion of the subbasin coincident with Tulare Lake lacustrine deposits. It is noted that the SAGBI zones shown on Figure 2-9 are limited to the surface deposits and any areas to be considered for additional recharge basins should be further investigated with boreholes and recharge tests to confirm the recharge potential of the location.

There are no areas of groundwater discharging at the land surface in the Tule Subbasin due to the depth of the groundwater. The primary source of groundwater discharge is pumping from wells (see Section 2.3.1.1.4), which occurs across most of the subbasin.

2.1.7. Principal Aquifers and Aquitards §354.14 (b)(4)

§ 354.14. (b) (4) Principal aquifers and aquitards, including the following information:

(A) Formation names, if defined.

(B) Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.

(C) Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.

(D) General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.

(E) Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.

2.1.7.1 Aquifer Formations §354.14 (b)(4)(A)

In general, there are five general aquifer/aquitard units in the subsurface beneath the Tule Subbasin (see Figures 2-5 and 2-6):

1. Upper Aquifer
2. The Corcoran Clay Confining Unit
3. Lower Aquifer
4. Pliocene Marine Deposits (generally considered an aquitard)
5. Santa Margarita Formation and Olcese Formation of the Southeastern Subbasin

The upper aquifer occurs across the entire Tule Subbasin area. This aquifer is generally unconfined to semi-confined. The upper aquifer occurs in the upper 450 ft of sediments on the western side of the subbasin and shallows to the east to less than approximately 100 ft of sediments in the Porterville area. In the southeastern portion of the basin, the upper aquifer is generally considered unsaturated although there may be local areas of groundwater.

The Corcoran Clay confining unit occurs beneath the upper aquifer in the western half of the Tule Subbasin (see Figures 2-4, 2-5 and 2-6). This unit consists primarily of blue or green diatomaceous clay although in places it is interbedded with sandy sediments. The Corcoran Clay is thickest in the western part of the subbasin and thins to the east, pinching out approximately two to three miles east of State Highway 99 (see Figure 2-4). It is noted that, in places, the Corcoran Clay, as formally defined in Frink and Kues (1954) and later Davis et al. (1959), is bounded above and below by fine-grained clay not specifically associated with the Corcoran Clay. As such, the thickness of the Corcoran Clay unit, as shown on Figures 2-5 and 2-6 has been defined to include these adjacent clays.

The lower aquifer extends across the entire western portion of the Tule Subbasin and beneath the northeastern portion of the subbasin. The total depth of this aquifer ranges from approximately 400 bgs in the eastern Tule Subbasin to more than 2,000 feet in the western portion of the subbasin. This aquifer is confined beneath the Corcoran Clay where this confining layer exists, and beneath other clay lenses in other parts of the subbasin. The lower aquifer system is conceptualized to be semi-confined in the northeastern portion of the subbasin east of the Corcoran Clay.

In the southeastern portion of the Tule Subbasin, the lower aquifer is separated from the underlying Santa Margarita Formation aquifer by a relatively thick (500 to 1,600 feet) layer of Pliocene marine deposits. These deposits consist primarily of siltstone with minor interbedded sandstone and are conceptualized as a confining unit that separates the deep alluvial aquifer from the Santa Margarita Formation aquifer. Some wells in the southeastern portion of the Tule Subbasin are perforated partially within this unit but the contribution of groundwater from the formation is low (Lofgren and Klausing, 1969).

The Santa Margarita Formation and Olcese Formation underlie the Pliocene marine deposits and forms a localized aquifer in the southeastern portion of the Tule Subbasin. This aquifer is a primary source of groundwater for agricultural irrigation in the southeastern portion of the subbasin. The aquifer is relatively permeable and well yields greater than 1,500 gallons per minute have been reported (Kern-Tulare Water District, 2018). Until additional data are collected, this localized aquifer is conceptualized as hydrologically separate from the deep aquifer in the rest of the subbasin.

2.1.7.2 Aquifer Physical Properties §354.14 (b)(4)(B)

Where saturated in the subsurface, the permeable sand and gravel layers form the principal aquifers in the Tule Subbasin and adjacent areas to the north, south and west. Individual aquifer layers consist of lenticular sand and gravel deposits of varying thickness and lateral extent. The aquifer layers are interbedded with low permeability silt and clay lenses. In general, shallow saturated sediments in the Tule Subbasin are unconfined to semi-confined. The aquifer beneath the Corcoran Clay unit in the western portion of the basin is confined. The hydrologic characteristics of the deeper aquifer system in the western portion of the subbasin are unknown but are expected to change with depth.

The ability of aquifer sediments to transmit and store water is described in terms of the aquifer parameters transmissivity, hydraulic conductivity, and storativity. The most reliable estimates of these parameters are obtained from long-term (e.g. 24-hr or more constant rate) controlled pumping tests in wells. In the absence of this type of test, estimates can be obtained through short-term pumping tests and/or assignment of literature values based on the soil types observed in driller's logs. Long-term pumping test data was obtained from KDSA and DEID for wells located in the southern part of the subbasin. Short-term pumping test data was obtained from driller's logs, KDSA for Angiola Water District and City of Porterville wells, and KTWD for selected wells. Where pumping test data were not available, aquifer parameters were assigned from literature values in published in Faunt (2009).

Transmissivity is a measure of the ability of groundwater to flow within an aquifer and is defined as the rate of groundwater flow through a unit width of aquifer under a unit hydraulic gradient (Fetter, 1994). Transmissivity was estimated from short-term pumping test data based on Theis et al., 1963 and the following relationship:

$$T = \frac{S_c \, x \, 2{,}000}{E}$$

Where:

T	=	Transmissivity (gpd/ft);
S_c	=	Specific Capacity (gpm/ft);
E	=	Well Efficiency (assumed to be 0.7)

Transmissivity values at individual wells were converted into hydraulic conductivity (i.e. aquifer permeability) by dividing by the aquifer thickness (in this case the perforation interval of the well). Horizontal hydraulic conductivity values for the upper aquifer are shown on Figure 2-10 and range from less than 5 ft/day to greater than 160 ft/day, the higher values indicating more permeable sediments. Hydraulic conductivity values for the lower aquifer are shown on Figure 2-11 and range from less than 5 ft/day to greater than 80 ft/day.

Storage properties of the upper aquifer are expressed in terms of specific yield since the majority of this aquifer is conceptualized as unconfined. Specific yield is the ratio of the volume of water sediment will yield by gravity drainage to the volume of the sediment. Specific yield values for the upper aquifer were assigned based on a USGS texture analysis published in Faunt (2009). Textural descriptions describe the percent coarse-grained sediment as inferred from drillers' logs from boreholes or wells drilled within or immediately outside the Tule Subbasin. Higher percent coarse-grained sediment descriptions are correlated with higher specific yield (see Figure 2-12). As shown, higher percent coarse-grained sediments are observed in the upper aquifer through most of the Tule Subbasin with the exception of the southwestern portion. Values of specific yield for the upper aquifer range from 0.05 to greater than 0.2.

The lower aquifer in the Tule Subbasin is confined to semi-confined and, as such, storage properties for this aquifer are expressed in terms of storativity. Storativity is a measure of the volume of water an aquifer can release from, or take into, storage per unit of aquifer surface area per unit change in hydraulic head. Storativity is derived from long-term pumping tests where pumping interference is measured in a monitoring well located a known distance from the pumping well. As no pumping interference data are available for the Tule Subbasin, storativity values for the lower alluvial aquifer were originally based on values published in Faunt (2009) and modified during calibration of the numerical model for the Tule Subbasin. Values for storativity in the deep aquifer range from 0.00015 to 0.001 (see Figure 2-13). These values indicate confined to semi-confined aquifer conditions.

2.1.7.3 Geologic Structures that Affect Groundwater Flow §354.14 (b)(4)(C)

There are no significant faults mapped in the Tule Subbasin that affect groundwater flow.

The Corcoran Clay unit is the most significant geologic feature that affects vertical groundwater flow in the Tule Subbasin. In general, the aquifer system above the clay unit is unconfined to semi-confined and the aquifer system below it is confined. The hydraulic head in the upper aquifer is higher than that of the lower aquifer, such that there is vertical downward hydraulic gradient between the two. Despite the low vertical hydraulic conductivity of the Corcoran Clay, the area for downward flow is large (hundreds of thousands of acres), and the vertical gradients are relatively steep (commonly 20 to 40 feet per 100 feet). This allows for significant downward flow of water through the clay on a regional basis. In addition, many wells in the subbasin are perforated across both the upper and lower aquifers (composite wells) creating communication between the two. As such, these wells facilitate some recharge of the lower aquifer from the upper aquifer. East of the Corcoran Clay, other localized confining beds are present that separate the upper aquifer from the lower aquifer.

2.1.7.4 Aquifer Water Quality §354.14 (b)(4)(D)

Groundwater quality in the Tule Subbasin varies across the subbasin and with depth in the aquifer system. Overall, the native groundwater quality is generally very good, with historical EC measurements generally less than approximately 600 μmohs/cm (Tule Basin Water Quality Coalition, 2017) (see Figure 2-14). Groundwater quality issues in the subbasin include both regional non-point sources of groundwater quality degradation and point-source contaminant issues.

On a regional level, non-point source constituents of concern for groundwater quality include nitrate, pesticides, 1,2-dibromo-3-chloropropane (DBCP), and 1,2,3, tricholoropropane (TCP) in the upper aquifer and arsenic, manganese, and, hydrogen sulfide for the lower aquifer. In the western part of the subbasin, color and methane gas are also non-point constituents of concern.

Nitrate is the primary non-point constituent of concern (Tule Basin Water Quality Coalition, 2017). Historical nitrate concentrations (reported as nitrate) in the subbasin range from non-detect to greater than 300 mg/L (see Figure 2-15). The highest nitrate concentrations have been detected in shallow groundwater in the northwest portion of the subbasin and are likely correlated with overlying land use.

Wells from which elevated EC values have been detected above the subbasin average occur in shallow groundwater in the northwest and southwest portions of the subbasin (see Figure 2-14). High EC values measured in groundwater in the northwest part of the subbasin are likely associated with overlying land use. High EC has also been detected in shallow and locally perched groundwater in the southwestern part of the subbasin. This area of the subbasin is on the historical Tulare Lakebed where the Regional Water Quality Control Board – Central Valley Region and California State Water Resources Control Board (SWRCB) has removed the municipal and agricultural beneficial use designation (SWRCB, 2017).

For point-source contaminants, there are 26 active cleanup sites in the Tule Subbasin identified on the California Geotracker website (see Figure 2-16; Table 2-1). Twelve of the point source contamination sites are associated with leaking underground storage tanks (LUSTs) for which the primary contaminant is petroleum hydrocarbons (gasoline, diesel and kerosene). There are 14 Regional Water Quality Control Board Cleanup Program or Department of Toxic Substance Control (DTSC) sites within the subbasin (see Figure 2-16). Contaminants associated with these sites include metals, volatile organic compounds (VOCs), pesticides, herbicides, cyanide, and polyaromatic hydrocarbons (PAHs). Groundwater contaminant plumes associated with these sites are highly localized.

2.1.7.5 Aquifer Primary Uses §354.14 (b)(4)(E)

The predominant beneficial use of groundwater in the Tule Subbasin is agricultural irrigation. Other beneficial uses include municipal water supply, private domestic water supply, and livestock washing and watering.

2.1.8. Uncertainty in the Hydrogeologic Conceptual Model §354.14 (b)(5)

> § 354.14. (b) (5) Identification of data gaps and uncertainty within the hydrogeologic conceptual model

The primary sources of uncertainty in the hydrogeologic conceptual model include:

- Knowledge of the hydraulic interaction between the shallow and deep aquifer
- Lack of aquifer-specific groundwater levels with adequate spatial distribution to enable preparation of representative groundwater level maps of each aquifer in parts of the subbasin
- Characteristics of the Santa Margarita Formation aquifer
- Groundwater underflow into the alluvial aquifer system from the Sierra Nevada mountain block
- Aquifer characteristics of hydraulic conductivity, transmissivity and storativity
- Agricultural groundwater pumping
- Well construction and pumping distribution between the shallow and deep aquifers
- Canal seepage
- Travel time for recharge from the land surface through the unsaturated zone to the groundwater

Uncertainty in the hydrogeologic conceptual model is being addressed through a sensitivity and uncertainty analysis of the numerical model results from the Tule Subbasin model (TH&Co, 2019) (see Section 2.3.2.7).

2.2 Groundwater Conditions §354.16

> § 354.16. Groundwater Conditions
>
> Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

2.2.1 Groundwater Occurrence and Flow §354.16 (a)

§ 354.16. (a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:

> (1) Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.
>
> (2) Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.

In general, groundwater in the Tule Subbasin flows from areas of natural recharge along major streams at the base of the Sierra Nevada Mountains on the eastern boundary towards a groundwater pumping depression in the west-central portion of the subbasin (see Figures 2-17 and 2-18). The pumping depression has reversed the natural groundwater flow direction in the western portion of the subbasin, inducing subsurface inflow along the southern and western boundaries.

In the upper aquifer, the pumping depression is most pronounced between the Tule River and Deer Creek west of Highway 99 and east of Highway 43. The pumping depression has persisted in this area since at least 1987, even during periods of above-normal precipitation when groundwater levels temporarily recovered. Recharge from the Tule River results in a groundwater flow divide in the upper aquifer along the northern boundary of the Tule Subbasin. As such, upper aquifer groundwater on the north side of the river flows to the north and out of the subbasin. Groundwater flow patterns in the upper aquifer have generally not changed significantly since 1990.

In the lower aquifer, groundwater flows to the southwest toward a pumping depression in the western portion of the subbasin (see Figure 2-19). This pumping depression extends from west of Corcoran in the northwest to the Alpaugh area in the southwestern Tule Subbasin west of Highway 43. There is inadequate data to prepare groundwater contour maps specific to the lower aquifer for spring and fall of 2017. The groundwater contour map provided on Figure 2-19 for 2010 is the most recent year for which data were available to prepare a contour map.

Groundwater level changes over time can be observed from hydrographs developed from wells monitored in the Tule Subbasin. Despite a relatively wet hydrologic period between 1995 and 1999 and periodic wet years (2005 and 2011), groundwater levels in upper aquifer wells show a persistent downward trend between approximately 1987 and 2017 (see Figure 2-20). Groundwater level trends in wells perforated exclusively in the lower aquifer vary depending on location in the subbasin. In the northwestern part of the subbasin, lower aquifer groundwater levels have shown a persistent downward trend from 1987 to 2017. In the southern part of the subbasin, groundwater levels were relatively stable between 1987 and 2007 but began declining after 2007 (see Figure 2-21).

Comparisons of hydrographs from wells perforated in the upper aquifer with wells perforated predominantly in the lower aquifer and in close proximity show that groundwater levels in the upper aquifer are higher than groundwater levels in the lower aquifer (see Figure 2-22). This indicates a downward hydraulic gradient and indicates that the upper aquifer is recharging the lower aquifer of the Tule Subbasin. This is corroborated by depth-specific isolated aquifer zone testing conducted by the City of Porterville in three wells in which the equilibrated groundwater level (i.e. hydraulic head) in the deepest isolated zones, which also correspond to the lower aquifer, were as much as 180 ft lower than the groundwater level in the shallowest isolated zones (Schmidt, 2009). Faunt (2009) has suggested that the recharge of the lower aquifer via wells that are perforated across both aquifers has increased with the number of deep wells constructed in the San Joaquin Valley.

2.2.2 Groundwater Storage §354.16 (b)

§ 354.16. (b) A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.

Changes in groundwater storage within the Tule Subbasin have been estimated through analysis of the water budget for the subbasin. Annual change in groundwater storage in the subbasin between 1986/87 and 2016/17 is shown in Table 2-3 and is graphically presented on Figure 2-23. Comparison of the groundwater inflow elements of the water budget with the outflow elements shows a cumulative change in groundwater storage over the 31-year period between 1986/87 and 2016/17 of approximately -4,948,000 acre-ft. The average annual change in storage resulting from the groundwater budget is approximately -160,000 acre-ft/yr over this time period.

2.2.3 Seawater Intrusion §354.16 (c)

§ 354.16. (c) Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.

Seawater intrusion cannot occur in the Tule Subbasin due to its location with respect to the Pacific Ocean. The Tule Subbasin is approximately 110 miles inland of the Pacific Ocean (see Figure 2-1) and is separated from the ocean by approximately 90 miles of sedimentary rocks that make up the Coast Ranges. These sedimentary rocks effectively separate the Pacific Ocean hydraulically from the aquifer system in the San Joaquin Valley. Further, the Coast Ranges are dissected by multiple northwest trending faults, the largest of which is the San Andreas Fault. These faults form groundwater flow barriers, which further act to separate the San Joaquin Valley aquifers from the Pacific Ocean. Accordingly, groundwater pumping in the Tule Subbasin cannot induce seawater intrusion.

2.2.4 Groundwater Quality Issues §354.16 (d)

§ 354.16. (d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.

The primary groundwater quality issues that could affect the beneficial uses of groundwater in the Tule Subbasin are nitrate and pesticides. Nitrate concentrations in excess of the Maximum Contaminant Level (MCL) of 45 mg/L have been detected in some wells, particularly in the northwest portion of the subbasin (see Figure 2-15). While nitrate is not an issue for agricultural irrigation or dairy supply, elevated nitrate in groundwater from small domestic supply wells could limit the beneficial use of water where these wells are impacted.

There are 26 active cleanup sites in the Tule Subbasin identified on the California Geotracker website (see Figure 2-16; Table 2-1). Twelve of the point source contamination sites are associated with LUSTs for which the primary contaminant is petroleum hydrocarbons (gasoline, diesel and kerosene). There are 14 Regional Water Quality Control Board Cleanup Program or Department of Toxic Substance Control (DTSC) sites within the subbasin (see Figure 2-16). Contaminants associated with these sites include metals, VOCs, pesticides, herbicides, cyanide, and PAHs.

2.2.5 Land Subsidence §354.16 (e)

§ 354.16. (e) The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

Land surface subsidence in the Tule Subbasin as a result of lowering the groundwater level from groundwater production has been well documented (Ireland et al., 1984; Faunt, 2009; Luhdorff and Scalmanini, 2014). Prior to 1970, as much as 12 ft of land surface subsidence was documented for the area immediately south of Pixley (Ireland et al., 1984). As groundwater levels rose in the area throughout the 1970s and early 1980s, land subsidence was largely arrested. During this time, monitoring for land subsidence that had previously been conducted along the portion of the Friant-Kern Canal that is within the Tule Subbasin was discontinued.

From the late 1980s into the 2000s, it is suspected that land subsidence in the Tule Subbasin was reactivated as groundwater levels declined. Groundwater flow model simulations of land subsidence in the Central Valley by Faunt et al. (2009), which were calibrated to historical land subsidence that occurred in the 1960s, simulated an additional two to four feet of land subsidence between 1986 and 2003.

The reactivation of land subsidence was confirmed in the late 2000s based on data from Interferometric Synthetic Aperture Radar (InSAR) satellites and one Global Positioning System (GPS) station located in Porterville, California. InSAR data showed as much as four feet of additional land subsidence occurring in the northwestern portion of the Tule Subbasin between 2007 and 2011 (see Figure 2-24) (Luhdorff and Scalmanini, 2014). Approximately 0.4 ft of land subsidence occurred in the Porterville area between 2007 and 2011. From 2015 through 2018, land subsidence in the Tule Subbasin, as observed from InSAR data, continued with as much as 2.75 ft of additional land subsidence in the northwest portion of the subbasin and as much as 0.75 ft of additional land subsidence at the Porterville GPS station (see Figure 2-25). Based on benchmarks located along the Friant-Kern Canal and monitored by the Friant Water Authority, cumulative land subsidence along the canal between 1959 and 2017 has ranged from approximately 1.7 ft in the Porterville area to 9 feet in the vicinity of Deer Creek (see Figure 2-24).

For the time period between 1987 and 2018, cumulative subsidence across the Tule Subbasin was estimated (in feet) based on model simulation results of land subsidence using a groundwater flow model equipped with a subsidence simulation package calibrated to observed land subsidence from InSAR and GPS data. The highest cumulative land subsidence for the time period was estimated for the northwestern portion of the subbasin where approximately 12 feet was simulated. The lowest rates of land subsidence were observed in the southeast portion of the subbasin between Delano and Richgrove where less than one foot of cumulative land subsidence was simulated.

The rate of land subsidence in the Tule Subbasin varies both spatially, according the geology of the subsurface sediments, and temporally with changes in groundwater levels. The average rate of change in land surface elevation between 1987 and 2018 for the area of maximum subsidence was estimated to be approximately 12 feet over the 32-year period for a rate of 0.4 ft/yr. At the Porterville GPS station, the annual rate of subsidence between 2006 and 2013 was approximately 0.09 ft/yr but increased to approximately 0.29 ft/yr between 2013 and 2019 (see Figure 2-25).

2.2.6 Interconnected Surface Water Systems §354.16 (f)

§ 354.16. (f) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

Interconnected surface water is surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted. As of January 2015, there are no areas within the Tule Subbasin where the depth to groundwater is within 25 ft of the land surface (see Figure 2-26). Based on the depth to groundwater, it is assumed that an unsaturated zone exists between surface water features and the aquifer system during average and dry periods. It is noted that there may be periods of time when the groundwater level temporarily rises to within 25 feet of the land surface in only a few relatively small areas of the Tule Subbasin, namely along the Tule River in and upstream of Porterville, and in the upper reaches of Deer Creek and White River. However, this condition, if it occurs, would be temporary and is not the normal hydrologic relationship between surface water and groundwater in these areas.

2.2.7 Groundwater Dependent Ecosystems §354.16 (g)

> § 354.16. (g) Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

Groundwater dependent ecosystems require shallow groundwater or groundwater that discharges at the land surface. Throughout the Tule Subbasin, the depth to groundwater is well below the level required to support riparian vegetation (vegetation that draws water directly from groundwater) or near surface ecosystems, except some areas along the Tule River east of Porterville. Based on the CDWR Groundwater Dependent Ecosystems database (www.groundwaterresourcehub.org), the deepest root zones for groundwater dependent plants in the Tule Subbasin are for Valley Oak, which can reach a depth of approximately 25 feet. Figure 2-26 is a depth to groundwater map based on groundwater levels in January 2015. As shown, there were no areas of the subbasin where the groundwater was within 25 feet of the land surface at that time. It is noted that there may be periods of time when the groundwater level is within 25 feet of the land surface in some areas of the subbasin. The areas most likely to support groundwater dependent ecosystems are along the Tule River in and upstream of Porterville, and in the upper reaches of Deer Creek and White River.

2.3 Water Budget §354.18

> § 354.18. Water Budget
>
> (a) Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

2.3.1. Surface Water Budget

The surface water budget for the Tule Subbasin was developed for the 31-year period from 1986/87 to 2016/17 (see Table 2-2a for Inflow Terms and Table 2-2b for Outflow Terms). Inflow terms for the surface water budget include precipitation, stream inflow, imported water, and discharge to the land surface from wells. Outflow terms include infiltration of precipitation, evapotranspiration of precipitation from areas of native vegetation and crops, stream infiltration, canal loss, recharge in basins, return flow, and consumptive use.

Ideally, the total surface water inflow to the subbasin would equal the total surface water outflow, indicating a complete and accurate accounting of water at the surface. In reality, there is uncertainty in many of the surface water budget terms for the Tule Subbasin that does not allow for a perfect surface water accounting. These include estimates for agricultural groundwater production, crop consumptive use, precipitation recharge, surface water outflow to Homeland Canal from Deer Creek, and others. For the Tule Subbasin surface water budget, the percent difference between the average annual surface water inflow (1,477,000 acre-ft; Table 2-2a) and average annual outflow (1,474,000 acre-ft; Table 2-2b) is approximately 0.2 percent. This represents a very good match between surface water inflows and outflows and indicates that the water budget is a good representation of actual conditions. As additional data become available, it is anticipated that the surface water budget will become more accurate with time.

It is noted that many of the surface water outflow terms are also groundwater inflow (i.e. groundwater recharge) terms. Of the surface water outflow terms that become groundwater recharge, many are associated with water diverted in accordance with pre-existing water rights or purchased imported water. Sources of surface water outflow that become groundwater recharge and are associated with existing rights and/or imported water deliveries are excluded from the Sustainable Yield estimate and are indicated with magenta-colored columns in Table 2-2b. Surface water losses that become groundwater recharge and are used to estimate Sustainable Yield are indicated with blue-colored columns in Table 2-2b. Surface water losses that do not become groundwater recharge, such as through evapotranspiration, crop consumptive use, or surface water outflow are indicated with yellow-colored columns in Table 2-2b (page 2).

Details of the individual surface water budget terms are provided in the following sections.

2.3.1.1 Surface Water Inflow §354.18 (b)(1)

> § 354.18. (b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
>
> (1) Total surface water entering and leaving a basin by water source type.

2.3.1.1.1. Precipitation

The annual volume of water entering the Tule Subbasin as precipitation was estimated for the surface water budget based on the long-term average annual isohyetal map shown on Figure 2-27 and the annual precipitation data reported for the Porterville precipitation station. As annual precipitation values are not available throughout the entire Tule Subbasin, it was assumed that the relative precipitation distribution for each year was the same as that shown on the isohyetal map. The magnitude of annual precipitation within each isohyetal zone was varied from year to year based on the ratio of annual precipitation at the Porterville Station (see Figure 2-28) to annual average precipitation at the Porterville isohyetal zone multiplied by the isohyetal zone average annual precipitation. Using this method, total annual precipitation in the Tule Subbasin between water years 1986/87 and 2016/17 ranged from approximately 99,000 to 728,000 acre-ft/yr with an average of 306,000 acre-ft/yr (see Column A of Table 2-2a).

2.3.1.1.2. Stream Inflow

Surface water inflow to the Tule Subbasin occurs primarily via three native streams: Tule River, Deer Creek, and the White River (see Columns B through D of Table 2-2a). Flow in the Tule River is controlled through releases from Lake Success, which are documented in TRA annual reports. For water years 1986/87 to 2016/17, annual surface water inflow to the Tule Subbasin via the Tule River, measured as releases from Lake Success, ranged from 8,820 to 439,125 acre-ft/yr with an average of 118,300 acre-ft/yr. The long-term 114-year average (1904 to 2017) inflow to Lake Success via the Tule River channels is 139,187 acre-ft/year.

Annual inflow from Deer Creek is measured at Fountain Springs by the USGS and has varied from approximately 2,000 to 88,000 acre-ft/yr with an average of 17,800 acre-ft/yr over water years 1986/87 to 2016/17. The long-term average inflow via Deer Creek for the period of record from 1920 to 2017 is 22,035 acre-ft/year. It is noted that although the Fountain Springs gage is located approximately five miles upstream of the Tule Subbasin, the creek flows over granitic bedrock between the gage and the alluvial basin boundary and losses along this reach are assumed to be limited to evapotranspiration.

Surface water inflow from the White River is based on USGS stream gage data from the White River station near Ducor. The measured data from this station is only available from 1971 to 2005. In order to estimate annual streamflow from 1986/87 to2016/17, it was assumed that the magnitude of flow in the White River is proportional to the magnitude of flow in Deer Creek. TH&Co plotted monthly White River streamflow against monthly Deer Creek streamflow for the period 1971 to 2005. A linear regression through the data resulted in a correlation coefficient of 0.91, suggesting that the relationship is applicable (see Figure 2-29). White River streamflow between 2006 and 2017 was based on the linear interpolation of measured data. Based on the measured and interpolated data, annual inflows from the White River ranged from approximately 250 to 37,000 acre-ft/yr and averaged 5,800 acre-ft/yr from water years 1986/87 to 2016/17.

2.3.1.1.3. Imported Water

Imported water is delivered to eleven water agencies within the Tule Subbasin from the Friant-Kern Canal (see Columns E through O of Table 2-2a). Data from PID, Saucelito Irrigation District, Tea Pot Dome Water District, Alpaugh Irrigation District, Atwell Island Irrigation District, and Terra Bella Irrigation District was obtained from USBR Central Valley Operation Annual Reports. Imported water data for the other agencies was provided by the respective agencies. Based on these data, an average of 345,600 acre-ft/yr was imported into the Tule Subbasin for the period from 1986/87 to 2016/17.

2.3.1.1.4. Discharge to Crops from Wells

Water applied to crops from wells is assumed to be the total applied water minus surface water deliveries from imported water and diverted streamflow (see Figure 2-30). The total crop demand was estimated based on consumptive use estimates and an assumed irrigation efficiency of 79 percent. The estimated average annual discharge to crops from wells for water years 1986/87 to 2016/17was approximately 664,000 acre-ft/yr (see Column P of Table 2-2a).

2.3.1.1.5. Municipal Deliveries from Wells

Groundwater pumping for municipal supply is conducted by the City of Porterville and small municipalities for the local communities in the Tule Subbasin. From water years 1986/87 to 2016/17, municipal pumping from wells was estimated to average approximately 20,000 acre-ft/yr (see Column Q of Table 2-2a).

It is noted that there are some households in the rural portions of the Tule Subbasin that rely on private wells to meet their domestic water supply needs. However, given the low population density of these areas, the volume of pumping from private domestic wells is considered negligible compared to the other pumping sources.

2.3.1.2 Surface Water Outflow

2.3.1.2.1 Areal Recharge from Precipitation

Areal recharge from precipitation falling on the valley floor in the Tule Subbasin was estimated based on Williamson et al., (1989). As part of a regional hydrogeological study of the California Central Valley, Williamson et al., (1989) developed a monthly soil-moisture budget for the Sacramento Valley and San Joaquin Valley areas. The soil moisture budget was based on precipitation records for the 50-yr period from 1922 to 1971. The analysis considered potential evapotranspiration, assumed plant root depth, soil moisture-holding capacity, and precipitation. Monthly precipitation that exceeded monthly potential evapotranspiration and soil-moisture storage was computed as net infiltration to the groundwater system. The results were simplified with a linear regression model that estimates net infiltration (i.e. groundwater recharge) from annual precipitation (herby referred to as the Williamson Method). The resulting relationship for the San Joaquin Valley region was:

$$PPT_{ex} = (0.64)PPT - 6.2$$

Where:

PPT_{ex} = Excess Annual Precipitation (ft/yr);
PPT = Annual Precipitation (ft/yr)

It is noted that the Williamson Method applied to the San Joaquin Valley results in no groundwater recharge if average annual precipitation is less than 9.69 inches per year. Results of the net infiltration analysis from Williamson et al., (1989) were used in the development of the Central Valley Groundwater Model developed by the USGS and documented in Faunt (2009).

For each year, annual groundwater recharge from precipitation (i.e. PPT_{ex}) was estimated for each isohyetal zone (see Section 2.3.1.1.1 and Figure 2-27) using the above equation from the Williamson Method. The resulting annual groundwater recharge from areal precipitation for the period 1986/87 to 2016/17ranged from 0 acre-ft/yr to 219,000 acre-ft/yr with an average of approximately 21,000 acre-ft/yr (see Column A of Table 2-2b) or approximately 7 percent of total precipitation.

2.3.1.2.2 Streambed Infiltration (Channel Loss)

Tule River

The Tule River is a losing stream such that infiltration of surface water within the stream channel recharges the groundwater system beneath it. Total channel loss (i.e. streambed infiltration) in the Tule River between Lake Success and Oettle Bridge is based on TRA annual reports. Streambed infiltration in the Tule River between Oettle Bridge and Turnbull Weir was estimated based on LTRID monthly water use summaries and TRA annual reports. Measured channel loss includes infiltration as well as evapotranspiration. Therefore, infiltration is equal to channel loss, as reported in TRA reports, minus evapotranspiration (described in Section 2.3.1.2.6).

It is noted that there are two sources of water in the Tule River channel: 1) native flow associated with releases from Lake Success and 2) imported water from the Friant-Kern Canal. Surface water in the Tule River channel from Lake Success to Oettle Bridge is exclusively native water (Column B of Table 2-2b). Surface water in the Tule River channel from Oettle Bridge to Turnbull Weir is primarily native flow but periodically includes imported water released to the channel from the Friant-Kern Canal.

As there is no current accounting of Tule River channel loss from Oettle Bridge to Turnbull Weir, it was necessary to estimate it based on available data and an assumed loss factor. The loss factor was based on the assumption that the ratio of streamflow to channel losses upstream of Oettle Bridge is the same as the ratio downstream. Thus, the ratio of streamflow to channel losses observed upstream of Oettle Bridge (the “loss factor”) was applied to measured flow Below Oettle Bridge. The loss factor was applied separately to native Tule River water and imported water releases to develop streambed infiltration estimates specific to both. From water years 1986/87 to 2016/17, average annual streambed infiltration from Success to Oettle Bridge was approximately 16,500 acre-ft/yr (Column B of Table 2-2b). During the same time period, average annual streambed infiltration between Oettle Bridge and Turnbull Weir was approximately 3,200 acre-ft/yr (see Column C of Table 2-2b).

Deer Creek

Deer Creek is a losing stream such that infiltration of surface water within the stream channel recharges the groundwater system beneath it. Streambed infiltration (channel loss) is estimated for the stream reaches between the Fountain Springs gaging station and Trenton Weir and between Trenton Weir and Homeland Canal. The difference in streamflow between Fountain Springs station and Trenton Weir is assumed to be total channel loss along this section. Streambed and canal infiltration in the Deer Creek channel between Trenton Weir and Homeland Canal were estimated based on Pixley Irrigation District monthly water use summaries. Measured channel loss includes infiltration as well as evapotranspiration. Therefore, infiltration is channel loss minus evapotranspiration (described in Section 2.3.1.2.6).

It is noted that there are two sources of water in the Deer Creek channel: 1) native flow and 2) imported water from the Friant-Kern Canal. Imported water is introduced into the Deer Creek channel by the Friant Water Authority via controlled and measured releases from the Friant-Kern Canal upstream of Trenton Weir. Thus, until a stream gage is established upstream of the Friant-Kern Canal/Deer Creek intersection, the separate accounting of losses associated with imported water and native Deer Creek surface flow will have to be approximated.

Deer Creek channel loss from Fountain Springs to Trenton Weir was estimated based on the difference in measured flows between the two stations. The surface flow between these two stations is assumed to be, for this water budget, native Deer Creek water. Average annual infiltration from Fountain Springs to Trenton Weir was approximately 12,100 acre-ft/yr between water years 1986/87 to 2016/17 (see Column D of Table 2-2b).

Flow in the Deer Creek channel from Trenton Weir to Homeland Canal is a combination of native Deer Creek water and imported water purchased by the Pixley Irrigation District for distribution in their service area. For this water balance, it is assumed that all of the water that flows through Trenton Weir is either delivered to riparians and farmers or becomes channel or canal loss (i.e. there is no data available to document surface flow from the Deer Creek channel to Homeland Canal although it is known that this occurs during periods of above normal precipitation). The infiltration of native Deer Creek water in the Deer Creek channel downstream of Trenton Weir is estimated for each month based on Pixley Irrigation District's annual water use summaries in the following way:

1. Imported water deliveries discharged from the Friant-Kern Canal to the Deer Creek channel were subtracted from the total flow measured at Trenton Weir to estimate the volume entering Pixley Irrigation District that is attributed to native Deer Creek flow.

2. Pixley Irrigation District sales and deliveries to basins were subtracted from the total flow through Trenton Weir to determine the volume of water presumably lost as infiltration in the Deer Creek channel and canals.
3. The total loss in No. 2 was multiplied by the ratio of Deer Creek water to total water measured at Trenton Weir to estimate the total losses attributed to native Deer Creek water.
4. A ratio was developed for the length of Deer Creek channel versus the length of canals downstream of the Trenton Weir (0.21).
5. The total loss attributed to native Deer Creek flow, as estimated from No. 3, was multiplied by the ratio of Deer Creek channel length to canal length from No. 4 to estimate the volume of native Deer Creek flow loss estimated to occur in the Deer Creek channel.
6. The volume of native Deer Creek flow lost in canals was estimated as the total loss (No. 3) minus the loss estimated to occur in the Deer Creek channel (No. 5).

Using the methodologies described above, average annual native Deer Creek infiltration from Fountain Springs to Trenton Weir for water years 1986/87 to 2016/17 was 12,100 acre-ft/yr (see Column D of Table 2-2b). The average annual native Deer Creek infiltration in the Deer Creek channel between Trenton Weir and Homeland Canal was approximately 700 acre-ft/yr (see Column E of Table 2-2b).

White River

All of the surface water flow measured or interpolated at the White River stream gage, after accounting for ET losses, is assumed to become streambed infiltration. Average annual infiltration from White River flow for water year 1986/87 to 2016/17was estimated to be approximately 5,600 acre-ft/yr (see Column F of Table 2-2b).

2.3.1.2.3 Canal Losses

Canal Losses from Tule River Diversions

A portion of the native Tule River water that is diverted into unlined canals is lost through infiltration into the subsurface groundwater subbasin. For PID, Vandalia Water District, and Woods-Central Ditch Co., delivery losses in unlined canals are accounted for in the portion of the water budget that address deep percolation of applied water.

In the LTRID, canal losses attributed to Tule River diversions are estimated from the District's annual water use summaries reports. Total canal losses within the LTRID (which include both native river water and imported water) are estimated by subtracting streambed infiltration and ET from the total losses reported in the annual water use summaries. Canal losses attributed to native Tule River water are based on the ratio of native Tule River water to imported water (Table 2-2b, Column G). The average annual Tule River canal loss from water years 1986/87 to 2016/17 was approximately 22,300 acre-ft/yr.

Canal Losses from Deer Creek Diversions

It is assumed that canal losses from delivery of native Deer Creek water to riparians and farmers occur only within the Pixley Irrigation District. To estimate canal losses within the Pixley Irrigation District, the estimated infiltration and ET within the Deer Creek channel (see Section 2.3.1.2.6) was subtracted from total losses. The average annual Deer Creek canal loss for water years 1986/87 to 2016/17was approximately 2,600 acre-ft/yr (see Column H of Table 2-2b).

Canal Losses from Imported Water Deliveries

With the exception of canal losses within the Angiola Water District and PID, imported water that infiltrates into the subsurface groundwater subbasin from the Tule River channel, Deer Creek channel, and unlined canals is grouped together. Within the Angiola Water District and PID, canal losses are accounted for in the portion of the water budget that addresses deep percolation of applied water.

For the LTRID GSA and Pixley Irrigation District GSA areas, imported water losses in channels and canals are estimated by subtracting infiltration losses attributed to native Tule River and Deer Creek water from the total losses estimated to occur in the LTRID and Pixley Irrigation District service areas as documented in their respective annual water use summary reports. The resulting estimate of average annual imported water canal loss for water years 1986/87 to 2016/17 was approximately 50,600 acre-ft (see Column I of Table 2-2b).

2.3.1.2.4 Managed Recharge in Basins

Managed Recharge of Tule River Diversions

Managed recharge (i.e. recharge in basins) of diverted streamflow, imported water, and recycled water is accomplished within the Tule Subbasin via multiple recharge facilities (see Figure 2-7). Native Tule River water is diverted to basins for recharge by Pioneer Water Company, Campbell and Moreland Ditch Company, Vandalia Water District, PID, and LTRID. All of the water diverted to basins by Campbell and Moreland Ditch Company and Vandalia Water District is native Tule River flow. To estimate the portion of basin recharge attributable to native Tule River water in LTRID basins downstream of Oettle Bridge, TH&Co multiplied the ratio of Tule River gaged flow below Oettle Bridge to the total water delivered to the LTRID by the total recharge in basins reported in the LTRID annual water use summaries. Using this methodology, the average annual Tule River recharge in basins from water years 1986/87 to 2016/17 was approximately 11,600 acre-ft (see Column J of Table 2-2b).

Managed Recharge of Deer Creek Diversions

Managed recharge (i.e. recharge in basins) of diverted Deer Creek streamflow is accomplished via multiple recharge facilities (see Figure 2-7). Native Deer Creek water is diverted to basins for recharge by Pixley Irrigation District and DCTRA. Artificial recharge attributed to native Deer Creek water is estimated by multiplying the total recharge in basins reported in Pixley Irrigation District annual water use summaries by the ratio of native Deer Creek water to total water flowing through the Trenton Weir. The average annual Deer Creek recharge in basins for water years 1986/87 to 2016/17was estimated to be approximately 800 acre-ft/yr (see Column K of Table 2-2b).

Managed Recharge of Imported Water

Managed recharge of imported water is accomplished via multiple recharge facilities within the LTRID, Pixley Irrigation District, PID, Teapot Dome Water District and DEID. Managed recharge attributed to imported water in the LTRID is estimated by multiplying the total recharge in basins reported in annual water use summaries by the ratio of imported water to total surface water flow available. Managed recharge attributed to imported water in the Pixley Irrigation District is estimated by multiplying the total recharge in basins reported in annual water use summaries by the ratio of imported water to total water flowing through the Trenton Weir. Volumes of imported water delivered to recharge in basins for PID, Teapot Dome Water District, and DEID were provided by the respective agencies. The resulting estimated average annual imported water recharge in basins for water years 1986/87 to 2016/17 was approximately 11,100 acre-ft (see Column L of Table 2-2b).

Recharge of Recycled Water in Basins

A portion of recycled water from the City of Porterville is discharged to basins where it infiltrates into the subsurface. Artificial recharge of recycled water was estimated as 75 percent of all available recycled water from 1990/91 to 2003/04 based on California Regional Water Quality Control Board Order No. R5-2008-0034. Artificial recharge was assumed to be 2,000 acre-ft/yr from 2004/05 to 2009/10 based on Schmidt (2009). The average annual recycled water recharge for water years 1986/87 to 2016/17was estimated to be approximately 3,200 acre-ft/yr (see Table 2-2b, Column M).

2.3.1.2.5 Deep Percolation of Applied Water

Deep Percolation of Applied Tule River Diversions

A portion of native Tule River water that is delivered and applied for agricultural irrigation is assumed to infiltrate below the root zones of plants and become deep percolation to the groundwater. Deep percolation from irrigated agriculture was applied to the various land uses in the Tule Subbasin according to the irrigation method (e.g. drip irrigation, flood irrigation, micro sprinkler, etc.) for each land use type reported in CDWR on-line land use maps. Irrigation efficiencies were applied to the different irrigation methods based on tables reported in California Energy Commission (2006).

Tule River water is diverted for agricultural irrigation by the Pioneer Water Company, Porter Slough Headgate, Porter Slough Ditch Company, Campbell and Moreland Ditch Company, Poplar Irrigation Company, Woods-Central Ditch Company, Hubbs and Miner Ditch Company, and LTRID. In the LTRID, applied water attributed to native Tule River water is based on the ratio of total native Tule River water entering the LTRID to the total water available to the district (including imports) multiplied by the volume of water delivered for irrigation. Using this methodology, the average annual deep percolation of native Tule River water for water years 1986/87 to 2016/17was approximately 14,200 acre-ft/yr (see Column N of Table 2-2b).

Deep Percolation of Applied Deer Creek Diversions

The portion of native Deer Creek water delivered for agricultural use within the Pixley Irrigation District is estimated by multiplying the total deliveries reported in Pixley Irrigation District annual water use summaries by the ratio of native Deer Creek water to total water flowing through the Trenton Weir. Deep percolation of applied Deer Creek diversions is estimated based on the irrigation method (e.g. drip irrigation, flood irrigation, micro sprinkler, etc.) for each land use type reported in DWR on-line land use maps. Irrigation efficiencies were applied to the different irrigation methods based on tables reported in California Energy Commission (2006). From water years 1986/87 to 2016/17, average annual deep percolation of native Deer Creek water was estimated to be approximately 300 acre-ft/yr (see Column O of Table 2-2b).

Deep Percolation of Applied Imported Water

The estimate of imported water delivered and applied to crops within the agencies that receive imported water is based on the total imported water delivery minus losses and recharge in basins. Deep percolation of applied imported water is estimated based on the irrigation method (e.g. drip irrigation, flood irrigation, micro sprinkler, etc.) for each land use type reported in DWR on-line land use maps. Irrigation efficiencies were applied to the different irrigation methods based on tables reported in California Energy Commission (2006). For water years 1986/87 to 2016/17, the estimated average annual deep percolation from imported water was approximately 64,300 acre-ft/yr (see Column P of Table 2-2b).

Deep Percolation of Applied Recycled Water

The estimate of recycled water delivered and applied to crops was provided by the City of Porterville. Deep percolation of applied recycled water is estimated based on the irrigation method (e.g. drip irrigation, flood irrigation, micro sprinkler, etc.) for each land use type reported in DWR on-line land use maps. Irrigation efficiencies were applied to the different irrigation methods based on tables reported in California Energy Commission (2006). For water years 1986/87 to 2016/17, the estimated average annual deep percolation from recycled water was approximately 400 acre-ft/yr (see Column Q of Table 2-2b).

Deep Percolation of Applied Native Groundwater for Agricultural Irrigation

The balance of agricultural irrigation demand not met by imported water or stream diversions is assumed to be met by groundwater pumping. Deep percolation of applied native groundwater is estimated based on the irrigation method (e.g. drip irrigation, flood irrigation, micro sprinkler, etc.) for each land use type reported in DWR on-line land use maps. Irrigation efficiencies were applied to the different irrigation methods based on tables reported in California Energy Commission (2006). For water years 1986/87 to 2016/17, average annual deep percolation from applied agricultural pumping was approximately 145,400 acre-ft/yr (see Column R of Table 2-2b).

Deep Percolation of Applied Native Groundwater for Municipal Irrigation

Deep percolation from applied landscape irrigation was estimated for the urbanized portions of the Tule Subbasin. Because the cities within the Tule Subbasin do not have surface water rights on the Tule River or Deer Creek and do not purchase imported water, 100 percent of their water demand is met from groundwater pumping. For the City of Porterville, landscape irrigation was estimated to be 47 percent of the total water delivered to each home based on an analysis of the total groundwater production and influent flows to the wastewater treatment plant (City of Porterville draft Urban Water Management Plan 2010 Update, 2014). Of the water used for irrigation, 25 percent was assumed to become return flow.

For the other smaller communities in the Tule Subbasin, wastewater discharge was assumed to be through individual septic systems. For water discharged to septic systems, it was assumed that 100 percent of the discharge became return flow. As with the City of Porterville, 47 percent of total water use was assumed to be for landscape irrigation and 25 percent of the landscape irrigation is assumed to become return flow.

For water years 1986/87 to 2016/17, average annual return flow from municipal production was estimated to be approximately 6,700 acre-f/yr (see Column S of Table 2-2b).

2.3.1.2.6 Evapotranspiration

Evapotranspiration of Precipitation from Crops and Native Vegetation

Evapotranspiration (ET) is the loss of water to the atmosphere from free-water evaporation, soil-moisture evaporation, and transpiration by plants (Fetter, 1994). Evapotranspiration of precipitation is assumed to be the balance between total precipitation and areal recharge. This value includes evapotranspiration of precipitation from crops as well as native vegetation. From water years 1986/87 to 2016/17, evapotranspiration of precipitation was estimated to average approximately 286,000 acre-ft/yr (see Column T of Table 2-2b, Page 2).

Evapotranspiration of Surface Water within the Tule River Channel

Evapotranspiration of surface water within the Tule River channel is a function of the ET rate and wetted channel surface area. The ET rate was based on published data for riparian vegetation in an intermittent stream (Leenhouts et al., 2005). As the channel width of the Tule River varies, TH&Co identified reaches with similar average channel width using aerial photographs (Google Earth). The ET rate was applied to the surface area of each reach to obtain an estimate of ET. The sum of reach by reach ET estimates between Lake Success and the western Tule Subbasin boundary represents the total Tule River ET shown in Table 2-2b, Page 2, Column U. The resulting average annual ET is approximately 700 acre-ft/yr for water years 1986/87 to 2016/17 (see Table 2-2b, Page 2, Column V).

Evapotranspiration of Surface Water within the Deer Creek Channel

Evapotranspiration within the Deer Creek channel was estimated using the same methodology as for the Tule River. Average annual ET within the Deer Creek channel was estimated to be approximately 300 acre-ft/yr for water years 1986/87 to 2016/17 (see Table 2-2b, Page 2, Column X).

Evapotranspiration of Surface Water within the White River Channel

Evapotranspiration in the White River channel was estimated using the same methodology as for the Tule River. For water year 1986/87 to 2016/17, the average annual evapotranspiration was estimated to be approximately 100 acre-ft/yr (see Column Y of Table 2-2b, Page 2).

Evapotranspiration of Recycled Water in Basins

Evapotranspiration of recycled water delivered to recharge basins was estimated to be 50 acre-ft/yr (see Column AB of Table 2-2b, Page 2) based on Schmidt (2009).

Agricultural Consumptive Use

Columns U, W, Z, AA and AC of Table 2-2b includes agricultural consumptive use of applied water, not including the portion of the consumptive use met by precipitation, which is included in Column T. Historical agricultural crop water demand (i.e. applied water demand) was estimated based on records of the types and areas of crops grown, estimates of consumptive use for each crop, and estimates of the irrigation efficiency. Information on the types and areas of crops for the LTRID and Pixley Irrigation District were obtained from annual crop surveys from each respective district. The types and areas of crops in other parts of the Tule Groundwater Subbasin within Tulare County were estimated from land use maps and associated data published by the CDWR for 1993, 1999, and 2007 (see Figure 2-31). For the portion of the Subbasin in Kern County (DEID), land use maps were obtained from CDWR (1990) and Kern County Department of Agriculture and Measurement Standards (1999 and 2007). Consumptive use estimates for the various crop types were based on crop coefficients published in ITRC (2003). In order to estimate a total agricultural irrigation water demand, the consumptive use estimates for each crop were multiplied by the area of the crop, which in turn was multiplied by a return flow factor reflecting the irrigation efficiency (see Section 2.3.1.2.5).

The estimated average annual agricultural consumptive use for the period of the groundwater budget was approximately 773,900 acre-ft/yr (sum of Columns U, W, Z, AA and AC of Table 2-2b).

Municipal Consumptive Use

Consumptive use of landscaping associated with applied municipal groundwater pumping was estimated based on an assumed applied water to landscaping and return flow factor. As presented in Section 2.3.1.2.5, it is assumed 47 percent of municipal water use is applied to landscaping. It is assumed that 75 percent of applied water to landscaping is consumptively used by the plants and 25 percent becomes return flow. For water years 1986/87 to 2016/17, estimated average annual municipal consumptive use was approximately 6,800 acre-ft/yr (see Column AD of Table 2-2b).

2.3.1.2.7 Surface Water Outflow

Tule River

Any residual stream flow in the Tule River that reaches the Turnbull Weir, located at the west (downstream) end of the Tule Subbasin, is assumed to flow out of the subbasin (see Figure 2-7). From water years 1986/87 to 2016/17, surface water outflow ranged from 0 to 121,000 acre-ft/yr and averaged 14,000 acre-ft/yr (see Table 2-2b, Page 2, Column AE).

It is noted that additional outflow may occur at smaller canal outlets at the west end of the Tule Subbasin. The data for these outflows was unavailable for this report.

Deer Creek

During periods of above-normal precipitation, residual stream flow left in the Deer Creek after diversions has historically flowed into Homeland Canal, located at the west end of the Tule Subbasin (see Figure 2-7). The data for this outflow was unavailable for this report (see Column AF of Table 2-2b, Page 2). As this data becomes available, it will be incorporated into the surface water budget.

2.3.2. Groundwater Budget §354.18 (b)(2)

The groundwater budget describes the sources and estimates the volumes of groundwater inflow and outflow within the Tule Subbasin (see Table 2-3). A fundamental premise of the groundwater budget is the following relationship:

$$\text{Inflow} - \text{Outflow} = +/- \Delta S$$

Inflow terms include groundwater recharge to the subbasin including areal recharge from precipitation, recharge in stream/river channels, artificial recharge, canal losses, return flow, release of water from compression of aquitards, and subsurface inflow. It is noted that many of the groundwater inflow terms are surface water outflow terms from Table 2-2b. Outflow terms include groundwater pumping, evapotranspiration, and subsurface outflow. The difference between the sum of inflow terms and the sum of outflow terms is the change in groundwater storage (ΔS) (see Table 2-3).

As with the surface water budget tables, the individual columns in the groundwater budget table are color coded to reflect their role in the Sustainable Yield estimate. Sources of groundwater recharge (i.e. inflow) that are associated with pre-existing water rights and/or imported water deliveries are indicated with magenta-colored columns in Table 2-3 and are not used to estimate the Sustainable Yield. Groundwater recharge elements that are used to estimate Sustainable Yield are indicated with blue-colored columns. Groundwater pumping is not used in the equation to estimate Sustainable Yield and is shown as yellow-colored columns in Table 2-3.

2.3.2.1 Sources of Groundwater Recharge §354.18 (b)(2)

> § 354.18. (b) (2) Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.

2.3.2.1.1 Areal Recharge

Groundwater recharge from precipitation falling on the valley floor in the Tule Subbasin was estimated based on Williamson et al., (1989) (see Section 2.3.1.1.1). The resulting annual groundwater recharge from areal precipitation using this method ranged from 0 acre-ft/yr to 219,000 acre-ft/yr with a 31-yr average of approximately 21,000 acre-ft/yr (see Column A, Table 2-3).

2.3.2.1.2 Groundwater Recharge from the Tule River

Groundwater recharge of native Tule River water occurs as streambed infiltration, infiltration of water in unlined canals, recharge in basins, and deep percolation of applied water. Tule River water that becomes groundwater recharge is described in Section 2.3.1.2 and summarized in Columns B through F of Table 2-3. Average annual groundwater recharge of native Tule River water was estimated to be approximately 67,800 acre-ft/yr for water years 1986/87 to 2016/17.

2.3.2.1.3 Groundwater Recharge from Deer Creek

Groundwater recharge of native Deer Creek water occurs as streambed infiltration, canal loss, recharge in basins, and deep percolation of applied water. Deer Creek water that becomes groundwater recharge is described in Section 2.3.1.2 and summarized in Columns G through K of Table 2-3. For water years 1986/87 to 2016/17 average annual groundwater recharge of native Deer Creek water was estimated to be approximately 16,500 acre-ft/yr.

2.3.2.1.4 Streambed Infiltration in the White River

Groundwater recharge of White River water occurs as streambed infiltration as described in Section 2.3.1.2 and summarized in Column L of Table 2-3. Estimated average annual groundwater recharge from White River water was approximately 5,600 acre-ft/yr for water years 1986/87 to 2016/17.

2.3.2.1.5 Groundwater Recharge from Imported Water Deliveries

Groundwater recharge of imported water occurs as canal loss, recharge in basins, and deep percolation of applied water as described in Section 2.3.1.2 and summarized in Columns M through O of Table 2-3. For water years 1986/87 to 2016/17 average annual groundwater recharge from imported water was estimated to be approximately 126,000 acre-ft/yr.

2.3.2.1.6 Recycled Water

Groundwater recharge of recycled water occurs as artificial recharge and return flow of applied water as described in Section 2.3.1.2 and summarized in Columns R and S of Table 2-3. For water years 1986/87 to 2016/17 average annual groundwater recharge from recycled water was estimated to be approximately 3,600 acre-ft/yr.

2.3.2.1.7 Deep Percolation of Applied Water from Groundwater Pumping

A portion of irrigated agriculture and municipal applied water from groundwater pumping becomes deep percolation and groundwater recharge as described in Section 2.3.1.2.5 and summarized in Columns P and Q of Table 2-3. For water years 1986/87 to 2016/17 average annual groundwater recharge associated with return flow from groundwater pumping was estimated to be approximately 152,100 acre-ft/yr.

2.3.2.1.8 Release of Water from Compression of Aquitards

Prolonged lowering of groundwater levels in the Tule Subbasin results in the drainage of water from low permeability subsurface aquitards that occur beneath the potentiometric groundwater surface. Aquitards are low permeability layers with relatively high silt and clay content. As the aquitards are compressible, the release of pore pressure caused by the lowering of groundwater levels also results in compression of the low permeability layers. Within a limited range of groundwater level fluctuation, the compressed aquitard can accept water back into its structure when groundwater levels rise resulting in elastic rebound. However, if groundwater levels are maintained at low elevations for long enough periods of time as a result of groundwater pumping, the compression of aquitards becomes permanent. This permanent compression of subsurface layers results in land surface subsidence, which has been observed in the Tule Subbasin prior to 1970 (Ireland et al., 1984) and between 2007 and 2011 (Luhdorff and Scalmanini, 2014). The slow release of water from the permanent compaction of subsurface aquitards also results in a one-time contribution of water to the aquifer system. However, it is noted that this is not a renewable source of water to the aquifer.

The estimate of the volume of water contributed to the aquifer through compression of aquitards between 1986 and 2017 was based on groundwater flow model analysis and output using the subsidence package in MODFLOW. The total volume of water contributed to the aquifer from aquitard compression during this time period is estimated to be approximately 2,400,000 acre-ft with an annual average of approximately 77,000 acre-ft/yr (see Column T of Table 2-3).

2.3.2.1.9 Subsurface Inflow

The Tule Subbasin is not a closed basin and the aquifer is in hydrologic connection with adjacent subbasins to the north, west and south. Groundwater flow into and out of the Tule Subbasin along these boundaries varies over time in accordance with the groundwater level conditions and flow patterns within and outside the subbasin. The only source of subsurface inflow to the Tule Subbasin along the eastern boundary is mountain-front inflow resulting from infiltration of precipitation in the secondary porosity features (joints and fractures) of the bedrock east of the basin and along the mountain front. This recharge enters the alluvial groundwater basin where the alluvium is in hydrologic connection with the fractures in the bedrock in the subsurface.

A summary of subsurface inflow values estimated for 1986/87 to 2016/17 is provided in Table 2-3 (Column U). As shown, inflow through the southern and western boundary across both the shallow and deep aquifers ranges from 83,000 acre-ft in 2009/10 to 144,000 acre-ft in 1990/91 with an average over the years of interest of 118,000 acre-ft/yr. The average net inflow into the

Tule Subbasin along the south and west boundaries for the time period is approximately 53,000 acre-ft/yr after accounting for outflow (see Section 2.3.2.3.4).

2.3.2.1.10 Mountain Front Recharge

Mountain front recharge represents the infiltration of precipitation into the fractures in the bedrock east of the Tule Subbasin, which eventually flows into the alluvial aquifer system of the Tule Subbasin in the subsurface where the fractured rock aquifer system in in hydrologic communication with the alluvial aquifer system. Subsurface inflow along the eastern Tule Subbasin boundary was estimated through a parameter estimation calibration process of the groundwater flow model of the subbasin. In this calibration method, the model was given a wide range of potential recharge along the eastern Tule Subbasin. The model automatically varied aquifer parameters and mountain-front recharge through an iteration process until it arrived at an optimum fit of measured and model-generated groundwater levels. Tule Subbasin mountain-front recharge that resulted in the best model calibration was approximately 29,000 acre-ft/yr (see Column V of Table 2-3 and Column J of Table 2-4).

2.3.2.2 Sources of Groundwater Discharge §354.18 (b)(3)

> § 354.18. (b) (3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.

2.3.2.2.1 Municipal Groundwater Pumping

Groundwater pumping for municipal supply is conducted by the City of Porterville and small municipalities for the local communities in the Tule Subbasin as described in Section 2.3.1.1.5. For water years 1986/87 to 2016/17, municipal groundwater production was estimated to average approximately 19,400 acre-ft/yr (see Column W of Table 2-3, Page 2).

2.3.2.2.2 Agricultural Groundwater Pumping

Agricultural groundwater production is estimated as the total applied water demand for crops minus surface deliveries. The estimated average annual discharge to crops from wells for water years 1986/87 to 2016/17 is approximately 664,000 acre-ft/yr (see Column X of Table 2-3, Page 2).

2.3.2.2.3 Groundwater Pumping for Export Out of the Tule Subbasin

Some of the groundwater pumping that occurs on the west side of the Tule Subbasin is exported out of the subbasin for use elsewhere. Angiola Water District and the Boswell/Creighton Ranch have historically exported pumped groundwater out of the Tule Subbasin. Annual groundwater exports have ranged from 0 between 1995 and 1999 to 63,640 acre-ft in the 2012/13 water year (see Column Y of Table 2-3, Page 2) with the average for water years 1986/87 to 2016/17 of 28,200 acre-ft/yr. This water is accounted for separately because the water is not applied within the subbasin and there is no associated return flow.

2.3.2.2.4 Subsurface Outflow

Outflow estimates (Table 2-3; Column AA) range from 51,000 acre-ft in 1988/89 to 92,000 acre-ft in 2009/10, with an average of 65,000 acre-ft/yr.

2.3.2.3 Changes in Groundwater Storage §354.18 (b)(4)

> § 354.18. (b) (4) The change in the annual volume of groundwater in storage between seasonal high conditions.

Comparison of the groundwater inflow elements of the water budget with the outflow elements shows a cumulative change in groundwater storage over the period between 1986/87 to 2016/17 of approximately -4,948,000 acre-ft (see Table 2-3). The average annual change in storage resulting from the groundwater budget is approximately -160,000 acre-ft/yr. It is noted that this time period was used as it matches the calibration period for the Tule Subbasin groundwater flow model used to evaluate future projects and management actions for the subbasin. However, the average hydrology over the time period is relatively dry (see Figure 2-28) and the resulting change in storage is not representative of long-term average conditions. A groundwater change in storage value representative of average hydrological conditions is provided in Section 2.3.2.5 for the period 1990/91 to 2009/10.

2.3.2.4 Overdraft §354.18 (b)(5)

> § 354.18. (b) (5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.

The average annual change in groundwater storage over the period from 1990/91 to 2009/10, which represents average hydrologic conditions within the Tule Subbasin, was approximately -115,300 acre-ft/yr. This value represents the average annual historical overdraft of the subbasin.

2.3.2.5 Water Year Type §354.18 (b)(6)

> § 354.18. (b) (6) The water year type associated with the annual supply, demand, and change in groundwater stored.

All water budget elements and change in groundwater storage presented herein are based on a water year, which begins October 1 and ends September 30. Water year types with respect to hydrologic conditions (i.e. above average, average or below average precipitation conditions based on Figure 2-28) are shown in the historical water budget tables (Tables 2-2a, 2-2b, and 2-3).

2.3.2.6 Sustainable Yield §354.18 (b)(7)

§ 354.18. (b) (7) An estimate of sustainable yield for the basin.

Sustainable yield is defined in the Sustainable Groundwater Management Act (SGMA) Chapter 2, §10721 (v) 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 result.

The Sustainable Yield of the Tule Subbasin is a function of the overall water balance of the area. Changes in surface water/groundwater inflow to the basin and surface water/groundwater outflow from the basin impact the Sustainable Yield. As groundwater management and land use changes impact the water balance, they also impact the Sustainable Yield. A generalized expression of the water balance is as follows:

$$\text{Inflow} - \text{Outflow} = +/- \text{ Change in Storage} \qquad (1)$$

The water balance equation for pre-developed conditions (prior to human occupation) can be further expressed as:

$$(I_{pr} + I_{str} + I_{ss} + I_{mb}) - (O_{ss} + O_{et}) = \Delta S \qquad (2)$$

Where:

I_{pr} = Inflow from Areal Recharge of Precipitation

I_{str} = Inflow from Infiltration of Runoff in Stream Beds

I_{ss} = Inflow from Subsurface Underflow

I_{mb} = Inflow from Mountain-Block Recharge

O_{ss} = Subsurface Outflow

O_{et} = Evapotranspiration

ΔS = Change in Groundwater Storage

Under pre-developed conditions, the groundwater basin would be in a state of equilibrium such that the inflow and outflow would balance and there would be no significant long-term change in storage assuming a static climatic condition. Under this condition, groundwater levels would be relatively stable.

Under developed land use conditions, the water balance changes as groundwater is pumped from the basin for irrigation and municipal supply. Lowering of the groundwater table resulting from pumping reduces the amount of groundwater that would otherwise leave the basin and reduces evapotranspiration losses in areas of shallow groundwater (e.g. Tulare Lake). Some of the pumped groundwater used for irrigation infiltrates past the roots of the plants and returns to the groundwater as return flow. Water imported into the area is applied to crops but some is lost as infiltration in unlined canals and as return flow. Groundwater return flow also occurs as a result of discharges from individual septic systems. Other sources of recharge to the groundwater under developed land use include wastewater treatment plant discharges and artificial recharge in spreading basins.

The water balance equation for developed land use conditions can be modified as follows:

$$(I_{pr} + I_{str} + \mathbf{I_{can}} + \mathbf{I_{ar}} + \mathbf{I_{rfgw}} + \mathbf{I_{rfimp}} + \mathbf{I_{com}} + I_{ss} + I_{mb}) - (O_{ss} + O_{et} + \mathbf{O_p}) = \Delta S \qquad (3)$$

Where:

I_{can} = Inflow from Canal Losses

I_{ar} = Inflow from Artificial Recharge

I_{rfgw} = Inflow from Return Flow of Applied Water from Groundwater Pumping

I_{rfimp} = Inflow from Return Flow of Applied Water from Imported Water

I_{com} = Inflow of Water Released from Compression of Aquitards

O_p = Outflow from Groundwater Pumping

If the inflow terms exceed the outflow terms, then the groundwater in storage increases (become positive) and groundwater levels rise. If the outflow terms exceed the inflow, then the groundwater in storage decreases (become negative) and groundwater levels drop. It is assumed that the Sustainable Yield of the Tule Subbasin is the long-term average groundwater pumping rate, under projected land use conditions, that results in no significant long-term net negative change in groundwater storage in the basin. Based on this premise, the water balance equation can be rearranged and simplified to estimate Sustainable Yield:

$$\text{Sustainable Yield} = \Delta S + O_p - \mathbf{I_{can}} - \mathbf{I_{ar}} - \mathbf{I_{rfimp}} - \mathbf{I_{com}} \qquad (4)$$

Thus, if the change in groundwater storage over the planning period is zero and there is no imported water or release of water from compression of aquitards, then the Sustainable Yield is equal to the pumping. This relationship is valid if the following conditions are met:

1. The Sustainable Yield incorporates a hydrology that is representative of a relatively long period of record that includes multiple wet and dry hydrologic cycles.
2. The land use conditions are representative of the time period.

The Sustainable Yield can also be expressed as all of the components of the water balance not explicitly expressed in Equation 4:

$$\text{Sustainable Yield} = I_{pr} + I_{str} + I_{rfgw} + I_{ss} + I_{mb} - O_{ss} \quad (5)$$

It is noted that the Tule Subbasin Technical Advisory Committee has determined that recharge to the Tule Subbasin associated with the delivery of imported water and the diversion of water from the Tule River and Deer Creek associated with Pre-1914 water rights will not be included in the Sustainable Yield of the subbasin. This includes canal losses from delivery of imported water and diverted stream flow, deep percolation of applied imported water and diverted stream flow, and managed recharge in basins.

Applying Equations 4 and 5 to the historical water budget of the Tule Subbasin does not result in a representative Sustainable Yield because the subbasin was in overdraft during the historical water budget period. Groundwater pumping depressions that have developed in the western portion of the subbasin have historically captured groundwater that would have otherwise left the subbasin. This increase in groundwater inflow and subsequent decrease in groundwater outflow increased the apparent Sustainable Yield, which was reported to be approximately 257,725 acre-ft/yr based on the water budget from water year 1990/91 to 2009/10 (TH&Co, 2017). However, since the downward groundwater trends that resulted in this condition are not sustainable, the associated Sustainable Yield from this water budget is not representative.

The Sustainable Yield of the Tule Subbasin will change in the future as a result of changes in groundwater levels and flow associated with planned projects and management actions and changes in deep percolation of applied water (i.e. return flow) from reduced groundwater pumping. Most of the GSAs in the subbasin plan management actions that include a reduction in irrigated acreage to address the need to reduce groundwater production. This necessary action will change the water budget by not only decreasing outflow from groundwater pumping but also reducing deep percolation of applied water (return flow) and changing the dynamics of inflow and outflow at the subbasin boundaries. This new water budget regime will result in a Sustainable Yield that is different from what was realized historically. Thus, the Sustainable Yield of the Tule Subbasin presented herein was estimated based on the projected future water budget (see Section 2.3.5), which is more representative than the Sustainable Yield from the historical water budget.

The projected water budget that was the basis for the Sustainable Yield estimate was developed using a calibrated groundwater flow model of the Tule Subbasin (TH&Co, 2019). The projected water budgets incorporated all planned projects and management actions of the Tule Subbasin GSAs as well as adjustments to hydrology and water deliveries from climate change guidelines provided by the CDWR (see Section 2.3.5). In order to address uncertainty in the model results, the projected water budget was initially analyzed with 240 realizations of the groundwater flow model. In each realization, aquifer parameters, consumptive use, and mountain front recharge were varied within acceptable ranges that produced acceptable overall model calibrations. The resulting water budgets were processed, based on Equation 5 above, to produce Sustainable Yield estimates for each year of the 50-yr implementation and planning horizon (2020 to 2070). Of the original 240 model realizations, 175 resulted in a projected average annual change in groundwater storage greater than -5,000 acre-ft/yr. The average Sustainable Yield for the time period from 2040 to 2050 was used as the Sustainable Yield for the 175 model realizations resulting in greater than -5,000 acre-ft/yr of annual storage change. The 175 estimates of Sustainable Yield formed a normal distribution when plotted (see Figure 2-32). The time period from 2040 to 2050 was selected because it occurs after all planned projects and management actions have been implemented but before the time when long-term climate change adjustments to hydrology and water deliveries are applied to the projected water budget (2050). The long-term climate change adjustments were not considered as reliable as the near-term adjustments.

The projected future Sustainable Yield of the Tule Subbasin, which is the 50th percentile of the distribution of estimates derived from the uncertainty analysis, is estimated to be approximately 130,000 acre-ft/yr (see Table 2-4). The plausible range of Sustainable Yield was selected as the values between the 20th and 80th percentile, resulting in a range of approximately 108,000 to 162,000 acre-ft/yr (see Figure 2-32). The projected Sustainable Yield does not include:

- Water released to the aquifer system from the compression of aquitards,
- Diverted Tule River water canal losses, recharge in basins, and deep percolation of applied water,
- Diverted Deer Creek water canal losses, recharge in basins, and deep percolation of applied water,
- Imported water canal losses, recharge in basins, and deep percolation of applied water, and
- Deep percolation of applied recycled water and recycled water recharge in basins.

Each GSA will determine their allowable groundwater pumping by multiplying that GSA's proportionate areal coverage of the Tule Subbasin times the total Sustainable Yield of the subbasin (130,000 acre-ft/yr), as described in the Coordination Agreement. The estimated consumptive use rate that can be sustained under the Subbasin-wide Sustainable Yield is 65,000 acre-ft/yr. When applied across the entire 475,895 acres of the subbasin, this consumptive use rate is approximately 0.14 acre-ft/acre. This consumptive use rate incorporates consumptive use from both agriculture and municipal demand. This "sustainable" consumptive use rate does not equal the Sustainable Yield on an acre-ft/acre basis because it does not account for irrigation return flow and changes to subbasin inflow and outflow caused by changes in pumping stress within the subbasin. It is noted that the consumptive use rate of 0.14 acre-ft/acre is for irrigation water only (i.e. does not include consumptive use of precipitation) and is the baseline sustainable consumptive use as applied across the entire subbasin. Each GSA will individually estimate their total allowable consumptive use as the sum of the baseline sustainable consumptive use, available precipitation, and surface water supplies.

As additional data become available and as projects and management plans are implemented, the groundwater flow model used to estimate the Sustainable Yield of the Tule Subbasin will be updated and the Sustainable Yield may be adjusted to reflect the new data.

2.3.3. Current Water Budget §354.18 (c)(1)

> § 354.18. (c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
>
> (1) Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information.

The surface water and groundwater budget for the Tule Subbasin in 2017 is shown in Tables 2-2a, 2-2b, and 2-3. Total groundwater inflow to the subbasin for water year 2016/17 was approximately 855,000 acre-ft. Total groundwater outflow from the subbasin for water year 2016/17 was approximately 550,000 acre-ft. The net change in storage during the water year was approximately 305,000 acre-ft.

2.3.4. Historical Water Budget §354.18 (c)(2)

> § 354.18. (c) (2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:
>
> (A) A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.
>
> (B) A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.
>
> (C) A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.

The historical surface water and groundwater budgets for the Tule Subbasin are shown in Tables 2-2a, 2-2b, and 2-3 and described in Sections 2.3.1 and 2.3.2. Historical surface water and groundwater budgets for each of the six GSAs in the subbasin are provided in:

- Appendix A - LTRID GSA.
- Appendix B – ETGSA
- Appendix C – DEID GSA
- Appendix D – Pixley GSA
- Appendix E – Tri-County Water Authority GSA
- Appendix F – Alpaugh GSA

Sources of surface water supply to agriculture in the Tule Subbasin include diverted stream flow from the Tule River and Deer Creek and imported supplies delivered via the Friant-Kern Canal, State Water Project, and other diverted streamflow from streams located outside the subbasin (i.e. King's River). A comparison of water rights and annual water deliveries for the 10-yr period from 2007/08 to 2016/17 is provided for the Tule River and Friant-Kern Canal in Table 2-5. As shown, total Tule River water diversions during the 10-yr period are approximately 90 percent of the sum of diversion rights over that period. The primary reason for this is that the 10-yr period from 2007/08 to 2016/17 was relatively dry with precipitation approximately 69 percent of long-term average (see Figure 2-28). Friant-Kern Canal deliveries to agencies with contracts within the Tule Subbasin have also been below the sum of Class I and Class II contract amounts for most of the 10-yr period. However, many contractors sell a portion of their available supply from the canal to other agencies. Likewise, some contractors (e.g. Kern-Tulare Water District) purchase additional supplies from the canal from other contractors. Thus, while precipitation trends do effect the volume of water available to Friant-Kern Canal contractors (the precipitation amounts during the 10-yr period from 2007/08 to 2016/17 are below average), it is difficult to compare planned versus actual deliveries based on these data.

The primary surface water supply issue affecting the ability of agencies to operate within the Sustainable Yield of the subbasin is reduced delivery capacity in the Friant-Kern Canal due to land subsidence. Land subsidence has lowered the canal elevation in certain areas resulting in a reduction in downstream canal delivery capacity. Reduced deliveries due to land subsidence can result in greater groundwater pumping to meet agricultural water demand. While the reduced supply capacity of the Friant-Kern Canal is not the primary reason for the overdraft observed in the Tule Subbasin from 1986/87 to 2016/17, it is a contributing factor.

2.3.5. Projected Water Budget §354.18 (c)(3)

A projected water budget for the Tule Subbasin has been developed to incorporate the planned projects and management actions of each of the six GSAs for achieving sustainability (see Tables

2-6 and 2-7). The projects and management actions were incorporated into the groundwater flow model of the Tule Subbasin for the projected time period from 2020 to 2070 in order to assess the sustainability of the planned actions, assess the interaction of the planned actions on groundwater levels between the GSAs, and estimate the Sustainable Yield of the subbasin. The model projection also incorporated adjustments to the hydrology and water deliveries to account for potential climate change. The final projected water budget is the one that produced the 50th percentile Sustainable Yield estimate (see Section 2.3.2.7 herein). The projected surface water and groundwater budgets are shown in Tables 2-8a, 2-8b, and 2-9. Projected water budgets for each of the six GSAs are provided in Appendices A through F.

Baseline Tule River flows, Friant-Kern Canal deliveries, and the State Water Project's California Aqueduct deliveries used in the future projection for the model were adjusted to account for projections of future climate change. Adjustments were applied based on output from the DWR's CalSim-II model, which provided adjusted historical hydrology for major drainages and imported supplies based on scenarios recommended by the DWR Climate Change Technical Advisory Group.[1] Climate change adjustments to hydrology and surface water deliveries were applied over two time periods within the SGMA planning horizon, as defined by California Water Commission (2016)[2]:

1. A 2030 central tendency time period, which provides near-term projections of potential climate change impacts on hydrology, centered on the year 2030, and
2. A 2070 central tendency time period, which provides long-term projections of potential climate change impacts on hydrology, centered on the year 2070.

For imported water supplies from the Friant-Kern Canal, TH&Co utilized projected delivery schedules from the Friant Water Authority (Friant Water Authority, 2018). The projected water deliveries include adjustments to supplies associated with the planned San Joaquin River Restoration Project (SJRRP). Adjustments to Friant-Kern Canal supplies to account for climate change and SJRRP were applied beginning in 2025. The adjustments were applied incrementally between 2025 and 2030 such that the full adjustments were in effect in 2030. TH&Co applied the 2070 central tendency time period climate-related adjustments to imported water deliveries in the Tule Subbasin model projection for the period from 2050 to 2070.

[1] DWR Climate Change Technical Advisory Group, 2015. Perspectives and Guidance for Climate Change Analysis. DWR Technical Information Record.

[2] California Water Commission, 2016. Technical Reference – Water Storage Investment Program. Dated November 2016.

2.4 Management Areas §354.20

> § 354.20. Management Areas
>
> (a) Each Agency may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin.

Of the six GSAs within the Tule Subbasin, four have identified separate management areas within their boundaries (see Figure 2-33). The management areas are as follows:

LTRID GSA

Tipton Management Area
Woodville Management Area
Poplar Management Area
Lower Tule Southwest Management Area

ETGSA

Porterville Community Management Area
Terra Bella Community Management Area
Ducor Community Management Area
Kern-Tulare Management Area
Greater Eastern Tule Management Area

DEID GSA

Annex Management Area

Pixley GSA

Pixley Management Area
Teviston Management Area

In addition to the management areas identified for each GSA, a separate land subsidence monitoring area has been identified for the eastern portion of the subbasin in the vicinity of the Friant-Kern Canal (see Figure 2-36). This monitoring area was developed based on the extent of historical land subsidence observed along the Friant-Kern Canal, including model results of cumulative land subsidence calibrated to historical land subsidence rates measured from InSAR satellite data. The recommended monitoring zone is approximately centered on the Friant-Kern Canal and extends from approximately two miles north of the Tule River on the north to approximately four miles south of the White River on the south. The eastern extent was based on the 1-ft subsidence contour of cumulative subsidence between 1986 and 2017 from the calibrated groundwater flow model. The western boundary of the monitoring zone is four miles from, and parallel to, the Friant-Kern Canal. Land subsidence monitoring features in this monitoring area are detailed in the Tule Subbasin Monitoring Plan, which is Attachment 1 to the Tule Subbasin Coordination Agreement.

2.4.1 Criteria for Management Areas §354.20 (b)(1)

> § 354.20. (b) A basin that includes one or more management areas shall describe the following in the Plan:
>
> (1) The reason for the creation of each management area.

The majority of the management areas are associated with communities that provide municipal water supply. These communities have been delineated separately because the beneficial use of the groundwater produced within the management areas (municipal supply) is different than the beneficial use of groundwater across the majority of the subbasin (agriculture). Other management areas were identified for portions of the subbasin with unique hydrogeology and areas where access to imported water is different than other portions of the GSA in which they are located.

Management Areas categorized under the Community Management Area Type have been created to specifically address the needs of the Tule Subbasin's population centers and communities. Future projects and management actions focused in these areas will seek to achieve the Tule Subbasin sustainability goal and improve access to safe, reliable drinking water supplies. The boundaries for each Community Management Area consider existing County and/or City adopted Urban Development Boundaries, as well as the service area boundaries of the public water suppliers providing services to residents within these areas.

In addition to community management areas, LTRID GSA has delineated a management area associated with lands outside and to the southwest of the LTRID service area that were annexed to the LTRID GSA (see Figure 2-33). The Lower Tule Southwest Management Area was formed because it does not have the same access to surface water deliveries from the Friant-Kern Canal as the LTRID service area and, therefore, will require separate management actions than the rest of the GSA.

ETGSA has delineated a separate management area for the Kern-Tulare Water District (Kern-Tulare Management Area). Wells from this area produce groundwater primarily from a deeper and separate aquifer system (i.e. Pliocene Marine and Santa Margarita Formation) than other parts of the ETGSA. Groundwater level conditions in wells in this area are different than other areas of the ETGSA. Additionally, the service area of Kern-Tulare Water District is divided between the Tule and Kern County Subbasins. Future projects and management actions in this Management Area will focus on enabling Kern-Tulare Water District to achieve the sustainability goals of both the Tule and Kern County Subbasins while minimizing the need to alter its operations. As such, Kern-Tulare Water District has developed their own monitoring plan for their service area.

DEID GSA has delineated a management area associated with lands outside and to the west of the DEID service area. These lands were annexed (Annex Management Area) to the DEID GSA. The Annex Management Area was formed because it does not have the same access to surface water deliveries from the Friant-Kern Canal as the DEID service area and, therefore, will require separate management actions than the rest of the GSA.

2.4.2 Minimum Thresholds and Measurable Objectives §354.20 (b)(2)

> § 354.20. (b) (2) The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.

Minimum thresholds and measurable objectives are provided in the individual Groundwater Sustainability Plans (GSPs) for each GSA. Model projection hydrographs for each representative monitoring site in each GSA are provided in Appendices A through F.

2.4.3 Monitoring Plan §354.20 (b)(3)

> § 354.20. (b) (3) The level of monitoring and analysis appropriate for each management area.

The Tule Subbasin Technical Advisory Committee has developed a subbasin-wide monitoring plan, which describes the monitoring network and monitoring methodologies to be used to collect the data to be included in Tule Subbasin GSPs and annual reports. The subbasin-wide monitoring plan is included as Attachment 1 to the Coordination Agreement. Separate monitoring networks have been established for groundwater levels (see Figure 2-34), groundwater quality (see Figure 2-35), land subsidence (see Figure 2-36) and surface water (see Figure 2-7). For each monitoring network, the monitoring plan describes the monitoring features included in the plan, the monitoring procedure to be followed to collect the data, and the monitoring frequency. The monitoring plan also includes an assessment of data gaps and a data management plan.

A subset of groundwater level monitoring features in the monitoring plan have been identified as representative monitoring sites to be relied on for the purpose of assessing progress with respect to groundwater level sustainability in the subbasin. The representative groundwater level monitoring sites are shown on Figure 2-34. At least one representative groundwater level monitoring site has been identified within each management area. Where possible based on available wells, representative monitoring sites have been chosen with perforations exclusively in either the Upper or Lower Aquifer. To provide adequate spatial coverage of the subbasin, some representative monitoring sites include perforations across multiple aquifers until new monitoring features can be constructed. Representative groundwater level monitoring wells will be equipped with pressure transducers to measure groundwater levels on a daily basis.

Representative land subsidence monitoring sites are shown on Figure 2-36. All of these monitoring sites consist of GPS stations along the Friant-Kern Canal for the purpose of assessing progress with respect to arresting land subsidence along the canal. Land surface elevation measurements at the GPS stations will be monitored quarterly (every four months).

2.4.4 Coordination with Adjacent Areas §354.20 (b)(4)

> § 354.20. (b) (4) An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.

The minimum thresholds described in each GSA's GSP have been informed through an analysis of potential future groundwater levels in the subbasin using a numerical groundwater flow model that incorporates future planned projects and management actions of each of the GSAs. The minimum thresholds have been developed such that maintenance of groundwater levels above those levels should preserve beneficial uses of the groundwater and prevent undesirable results with respect to groundwater levels, groundwater storage, and land subsidence within the management area, GSA and adjacent areas. Management of the Tule Subbasin is adaptive. As management actions and projects are implemented throughout the subbasin and as additional data are collected through the Tule Subbasin Monitoring Plan, minimum threshold values and measurable objectives may change. Changes to basin management to address undesirable results will be conducted through the Tule Subbasin TAC in accordance with the Tule Subbasin Coordination Agreement.

2.5 References

California Department of Water Resources, 2016. Final 2016 Bulletin 118 Groundwater Basin Boundaries shapefile. http://www.water.ca.gov/groundwater/sgm/basin_boundaries.cfm

California Energy Commission, 2006. PIER Project Report: Estimating Irrigation Water Use for California Agriculture: 1950s to Present. May 2006.

California Regional Water Quality Control Board, 2008. Order No. R5-2008-0034 Waste Discharge Requirements for City of Porterville Wastewater Treatment Facility Tulare County. Dated March 2008.

California State Water Resources Control Board, 2017. Resolution 2017-0048 Approving an Amendment to the Water Quality Control Plan for the Tulare Lake Basin to Remove the Municipal and Domestic Supply (MUN) and Agricultural Supply (AGR) Beneficial Uses from Groundwater within a Designated Horizontal and Vertical Portion of the Tulare Lake Bed. Adopted September 6, 2017.

City of Porterville, 2014. Draft Urban Water Management Plan. Dated August 2014.

Croft, M.G., 1972. Subsurface Geology of the Late Tertiary and Quaternary Water-Bearing Deposits of the Southern Part of the San Joaquin Valley, California. USGS Water-Supply Paper 1999-H.

Davis, G.H., Green, J.H, Olmsted, F.H., and Brown, D.W., 1959. Ground-Water Conditions and Storage Capacity of the San Joaquin Valley, California. USGS Water-Supply Paper 1469, 287 p.

Faunt, C.C., 2009. *Groundwater Availability of the Central Valley Aquifer, California*. USGS Professional Paper 1766.

Fetter, C. W., 1994. Applied Hydrogeology. 3rd Edition. Macmillan College Publishing, New York.

Friant Water Authority, 2018. Technical Memorandum: Estimate of Future Friant Division Supplies for Use in Groundwater Sustainability Plans.

Frink, J.W., and Kues, H.A., 1954. *Corcoran Clay – A Pleistocene Lacustrine Deposit in San Joaquin Valley, California*. American Association of Petroleum Geologists Bulletin Vol. 38, No. 11, pgs. 2357 – 2371.

Ireland, R.L., Poland, J.F., and Riley, F.S., 1984. Land Subsidence in the San Joaquin Valley, California, as of 1980. U.S. Geological Survey Professional Paper 437-I.

ITRC, 2003. California Crop and Soil Evapotranspiration for Water Balances and Irrigation Scheduling/Design. ITRC No. 03-001, dated January 2003.

Kern-Tulare Water District, 2018. 2018 Groundwater Monitoring Report.

Leenhouts, J.M., Stromberg, J.C., and Scott R.L., 2005. *Hydrologic Requirements of and Consumptive Ground-Water Use by Riparian Vegetation along the San Pedro River, Arizona*. USGS Scientific Investigations Report 2005-5163.

Lofgren, B.E., and Klausing, R.L., 1969. Land Subsidence Due to Ground-Water Withdrawal Tulare-Wasco Area California. USGS Professional Paper 437-B.

Luhdorff and Scalmanini, 2014. Land Subsidence from Groundwater Use in California. Prepared in Cooperation with the California Water Foundation.

Page, R.W., 1973. Base of Fresh Ground Water in the San Joaquin Valley, California. USGS Hydrologic Investigations Atlas HA-489.

Planert, M. and Williams, J.S., 1995. Ground Water Atlas of the United States, Segment 1 – California and Nevada. USGS Hydrologic Investigations Atlas 730-B.

Schmidt, K., 2009. *Groundwater Conditions within the City of Porterville Urban Area Boundary*. Prepared for the City of Porterville, dated October 2009.

Schmidt, K., 2011. Groundwater Conditions in the Angiola Area. Prepared for the Angiola Water District, dated July 2011.

Schmidt, K., 2018. Hydrogeologic Conceptual Model and Groundwater Conditions for the Tri-County WA GSP. Prepared for Tri-County Water Authority. Dated September 2018.

Theis, C.V., Brown, R.H., Myer, R.R., 1963. Estimating the Transmissivity of a Water-table Aquifer from the Specific Capacity of a Well. USGS Water Supply Paper 1536-1, p 331-336.

Thomas Harder & Co., 2017. Hydrogeological Conceptual Model and Water Budget of the Tule Subbasin. Prepared for the Tule Subbasin MOU Group.

Thomas Harder & Co., 2019. Groundwater Flow Model of the Tule Subbasin (DRAFT in Progress).

Tule Basin Water Quality Coalition, 2017. Groundwater Quality Trend Monitoring Work Plan. Dated January 6, 2017.

Tule River Association, 1966. Tule River Water Diversion Schedule and Storage Agreement. Dated February 1, 1966; revised June 16, 1966.

Williamson, A.K., Prudic, D.E., and Swain, L.A., 1989. Ground-Water Flow in the Central Valley, California. USGS Professional Paper 1401-D.

Tables

Table 2-1

Summary of Active Cleanup Sites Within the Tule Subbasin

Geotracker Global ID	Site Type	Status	Constituent of Concern
60001606	School	Active	Metals, Pesticides, Petroleum
54360008	State Response or NPL	Active	Freon 113, Lead, VOCs
54070051	State Response or NPL	Active	Herbicides, Pesticides, Lead, VOCs
60002076	State Response or NPL	Active	Cyanide, PAHS, SVOCs
54070296	Voluntary Cleanup	Active	Pesticides
60001216	Evaluation	Active	PCE
54070288	Evaluation	Inactive - Needs Evaluation	Zinc
54280106	Evaluation	Inactive - Needs Evaluation	Pesticides/Herbicides
T10000010424	Cleanup Program Site	Open - Active	NA
T0610740454	LUST Cleanup Site	Open - Assessment & Interim Remedial Action	Gasoline
T0610700023	Cleanup Program Site	Open - Assessment & Interim Remedial Action	Gasoline, Benzene
T0610700454	LUST Cleanup Site	Open - Eligible for Closure	Gasoline
T10000010850	LUST Cleanup Site	Open - Eligible for Closure	Gasoline, MTBE, TBA, other fuel oxygenates
T0610700430	LUST Cleanup Site	Open - Eligible for Closure	Gasoline
T0610700127	LUST Cleanup Site	Open - Eligible for Closure	Gasoline
SLT5FS354453	Cleanup Program Site	Open - Inactive	Nitrate, other Petroleum
SL375384617	Cleanup Program Site	Open - Remediation	Gasoline, Diesel, other Petroleum
SL205734285	Cleanup Program Site	Open - Remediation	VOCs
T0610700216	LUST Cleanup Site	Open - Remediation	Gasoline
T0610700256	LUST Cleanup Site	Open - Site Assessment	Kerosene
T0610700058	LUST Cleanup Site	Open - Site Assessment	Gasoline
SLT5FU104564	Cleanup Program Site	Open - Site Assessment	Pesticides/Herbicides
T0610793749	LUST Cleanup Site	Open - Site Assessment	Gasoline

Table 2-1

Summary of Active Cleanup Sites Within the Tule Subbasin

Geotracker Global ID	Site Type	Status	Constituent of Concern
T0610700064	LUST Cleanup Site	Open - Site Assessment	Gasoline
T0610700099	LUST Cleanup Site	Open - Site Assessment	Gasoline
T0610700469	LUST Cleanup Site	Open - Verification Monitoring	Gasoline

Notes:

LUST = Leaky underground storage tank
NPL = National Priorities List
VOCs = Volatile Organic Compounds
PAHS = Polynuclear aromatic hydrocarbons
SVOCs = Semi-Volatile Organics
PCE = Perchloroethylene
MTBE = Methyl tert-butyl ether
TBA = Tertiary Butyl Alcohol
Source = https://geotracker.waterboards.ca.gov
NA = Not available

Table 2-2a

Tule Subbasin Historical Surface Water Budget

Water Year	Water Year Type	Surface Water Inflow (acre-ft)																	Total In
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	
			Stream Inflow			Imported Water											Discharge from Wells		
		Precipitation	Tule River	Deer Creek	White River	Saucelito ID	Terra Bella ID	Kern-Tulare WD	Porterville ID	Tea Pot Dome WD	LTRID	Pixley ID	Delano-Earlimart ID	Angiola WD	Alpaugh ID	Atwell Island WD	Agriculture Pumping	Municipal Pumping	
1986 - 1987	Below Average	219,000	70,029	8,389	2,496	23,879	13,136	10,899	15,337	5,490	89,541	9,356	114,782	7,278	794	1,109	724,000	13,500	1,329,000
1987 - 1988	Average	315,000	39,842	6,095	1,420	19,666	21,961	12,210	13,067	5,493	64,654	0	110,345	3,530	0	0	768,000	15,100	1,396,000
1988 - 1989	Below Average	254,000	49,667	7,795	1,942	22,426	22,561	11,991	13,106	6,226	63,922	5,289	105,980	6,026	0	0	728,000	15,700	1,315,000
1989 - 1990	Below Average	245,000	29,342	4,706	778	16,166	23,159	11,371	11,520	6,193	24,325	0	83,837	3,847	0	0	838,000	16,300	1,315,000
1990 - 1991	Average	331,000	51,275	7,247	1,362	19,848	18,725	9,762	11,322	5,636	71,430	0	106,877	925	0	0	799,000	16,700	1,451,000
1991 - 1992	Below Average	285,000	34,325	4,080	739	21,336	20,743	11,700	15,569	6,607	51,949	0	92,567	1,611	0	0	817,000	17,000	1,380,000
1992 - 1993	Above Average	462,000	115,640	15,422	3,623	41,261	18,180	12,357	12,310	6,968	321,973	96,890	133,359	3,420	12,219	6,423	496,000	17,200	1,775,000
1993 - 1994	Below Average	293,000	61,313	6,908	1,148	22,064	18,740	14,255	12,895	6,526	71,784	7,793	92,394	3,640	3,605	2,000	791,000	17,600	1,427,000
1994 - 1995	Above Average	610,000	218,480	32,053	10,596	37,477	16,186	11,681	9,455	6,562	229,683	55,365	124,388	8,918	8,263	5,395	574,000	17,600	1,976,000
1995 - 1996	Average	321,000	174,473	23,095	5,957	48,924	21,617	15,415	13,808	7,993	236,845	60,931	144,069	12,551	11,130	5,267	508,000	17,800	1,629,000
1996 - 1997	Above Average	450,000	353,968	58,781	12,920	40,908	20,158	15,736	13,379	7,298	192,934	37,048	153,967	12,383	0	0	567,000	18,700	1,955,000
1997 - 1998	Above Average	728,000	439,125	88,360	36,764	28,221	13,165	11,745	10,159	4,913	101,180	41,823	119,815	7,460	0	0	630,000	17,900	2,279,000
1998 - 1999	Above Average	373,000	108,466	18,410	7,469	37,062	17,567	14,527	16,107	9,218	183,971	34,736	124,051	9,778	0	0	620,000	18,000	1,592,000
1999 - 2000	Average	354,000	102,354	15,230	4,878	39,734	19,200	16,476	15,545	7,191	177,192	40,076	134,272	8,118	0	253	651,000	18,900	1,604,000
2000 - 2001	Below Average	265,000	55,249	7,016	4,695	25,252	19,194	17,550	15,436	6,456	83,405	9,098	117,746	3,824	0	0	719,000	19,100	1,368,000
2001 - 2002	Below Average	252,000	73,206	10,370	6,176	26,131	20,234	15,088	13,628	6,388	78,511	13,588	126,747	2,932	0	0	713,000	20,900	1,379,000
2002 - 2003	Below Average	247,000	125,004	15,678	5,875	33,692	18,356	14,591	14,646	5,844	131,470	32,195	121,277	4,728	104	0	610,000	20,600	1,401,000
2003 - 2004	Below Average	207,000	51,738	6,882	2,350	26,988	20,352	15,755	14,698	6,913	71,472	9,839	127,364	3,434	0	0	656,000	21,700	1,242,000
2004 - 2005	Above Average	395,000	172,558	22,758	6,502	42,840	15,266	13,495	14,748	5,217	247,595	59,211	119,847	11,741	14,490	0	479,000	20,600	1,641,000
2005 - 2006	Above Average	401,000	195,667	23,868	7,588	45,106	21,763	14,507	13,251	6,436	194,019	60,634	121,005	10,909	16,112	0	490,000	21,600	1,643,000
2006 - 2007	Below Average	170,000	38,587	6,901	1,815	16,280	20,797	15,133	9,775	5,489	33,174	7,200	79,111	6,641	0	0	746,000	22,700	1,180,000
2007 - 2008	Below Average	189,000	74,030	8,411	2,355	24,083	18,192	17,689	12,988	6,894	71,872	12,243	106,470	2,165	0	0	637,000	23,000	1,206,000
2008 - 2009	Below Average	203,000	54,737	6,620	1,751	31,282	19,701	15,524	18,000	6,165	113,189	23,620	111,556	191	2,131	0	660,000	22,500	1,290,000
2009 - 2010	Average	325,000	144,778	16,470	5,080	42,855	17,574	14,027	14,335	5,845	200,064	32,972	118,671	3,243	2,671	0	483,000	21,800	1,448,000
2010 - 2011	Above Average	479,000	266,473	44,873	14,997	46,733	16,381	13,405	9,387	6,105	229,763	48,391	127,447	6,476	10,951	0	514,000	21,800	1,856,000
2011 - 2012	Below Average	302,000	87,533	11,311	3,334	19,189	19,757	14,309	9,318	4,680	67,684	5,914	114,108	3,156	943	0	730,000	22,500	1,416,000
2012 - 2013	Below Average	139,000	30,283	4,777	1,145	14,102	20,628	14,955	10,298	4,354	37,073	5,012	87,302	1,492	0	0	790,000	22,700	1,183,000
2013 - 2014	Below Average	99,000	13,171	2,957	535	5,724	12,390	9,986	178	1,030	0	0	38,106	1,048	0	0	900,000	21,900	1,106,000
2014 - 2015	Below Average	142,000	8,820	1,994	253	1,503	12,012	5,438	114	260	0	0	18,591	575	0	0	890,000	19,700	1,101,000
2015 - 2016	Below Average	217,000	74,330	14,559	4,547	20,049	14,357	11,805	13,271	4,627	73,382	3,442	93,806	587	0	0	614,000	19,700	1,179,000
2016 - 2017	Below Average	227,000	352,963	51,145	17,241	51,137	16,089	14,203	21,651	6,694	273,151	82,363	137,773	12,146	2,367	0	429,000	20,100	1,715,000
86/87-16/17 Avg		306,000	118,300	17,800	5,800	28,800	18,300	13,500	12,600	5,900	122,200	25,600	109,900	5,300	2,800	700	664,000	19,400	1,477,000

Table 2-2b

Tule Subbasin Historical Surface Water Budget

		Surface Water Outflow (acre-ft)																		
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
			Streambed Infiltration					Canal Loss			Recharge in Basins				Deep Percolation of Applied Water					
			Tule River		Native Deer Creek															
Water Year	Water Year Type	Areal Recharge of Precipitation	Success to Oettle Bridge	Oettle Bridge to Turnbull Weir	Before Trenton Weir	Trenton Weir to Homeland Canal	White River	Tule River	Deer Creek	Imported Water	Tule River	Deer Creek	Imported Water	Recycled Water	Tule River	Deer Creek	Imported Water	Recycled Water	Agricultural Pumping	Municipal Pumping
1986 - 1987	Below Average	0	11,600	1,100	8,100	0	2,400	20,700	0	52,500	5,400	0	0	2,600	8,500	0	56,100	200	169,900	5,200
1987 - 1988	Average	4,000	8,000	900	5,800	0	1,300	8,800	0	32,700	5,000	0	0	3,200	5,500	0	48,100	200	183,200	5,400
1988 - 1989	Below Average	0	8,700	0	7,500	0	1,800	7,400	0	20,500	6,200	0	0	3,400	6,100	0	51,800	200	172,100	5,600
1989 - 1990	Below Average	0	5,000	0	4,400	0	700	2,900	0	7,400	3,700	0	0	3,600	2,700	0	36,200	200	199,700	5,700
1990 - 1991	Average	7,000	6,400	300	6,900	0	1,300	6,800	0	24,300	5,200	0	0	3,700	5,900	0	46,900	200	190,300	5,800
1991 - 1992	Below Average	1,000	4,300	0	3,800	0	700	3,100	0	16,100	3,700	0	0	3,800	3,500	0	44,700	200	194,900	5,900
1992 - 1993	Above Average	57,000	18,500	3,000	15,100	0	3,500	27,800	0	184,400	8,200	0	5,600	3,900	16,800	0	118,000	200	111,300	6,000
1993 - 1994	Below Average	2,000	6,100	200	6,600	0	1,100	14,200	0	35,600	5,000	0	700	4,000	8,700	0	51,800	200	187,400	6,100
1994 - 1995	Above Average	144,000	36,400	10,400	21,200	1,000	10,500	39,500	3,800	128,500	7,800	1,800	10,400	3,900	34,600	1,000	88,900	200	130,900	6,100
1995 - 1996	Average	5,000	20,700	4,000	13,700	700	5,800	26,200	2,800	87,600	21,200	700	39,500	3,900	31,800	1,200	119,000	200	115,700	6,200
1996 - 1997	Above Average	50,000	34,600	9,700	45,100	1,800	12,800	47,300	6,900	64,200	25,300	1,900	14,100	4,300	31,400	700	117,300	200	130,700	6,300
1997 - 1998	Above Average	219,000	41,100	9,000	14,900	12,700	36,600	79,100	48,800	54,100	32,000	900	16,200	3,900	41,100	3,100	65,200	200	143,800	6,300
1998 - 1999	Above Average	18,000	14,300	2,800	13,300	600	7,300	19,500	2,500	58,200	17,600	400	19,800	3,900	14,100	300	88,700	200	143,200	6,400
1999 - 2000	Average	12,000	16,900	2,900	10,100	600	4,800	11,100	2,400	64,400	8,900	500	13,000	4,200	15,200	300	93,200	200	152,400	6,500
2000 - 2001	Below Average	0	12,300	0	6,700	0	4,600	7,000	0	28,500	5,000	0	2,700	4,300	7,800	0	61,700	200	169,600	6,600
2001 - 2002	Below Average	0	14,800	700	10,100	0	6,100	13,400	0	24,800	5,800	0	100	4,900	9,000	0	65,200	300	169,100	6,900
2002 - 2003	Below Average	0	19,700	3,700	13,600	100	5,800	22,800	400	53,600	12,200	300	5,000	4,800	11,500	200	65,700	200	123,200	6,900
2003 - 2004	Below Average	0	9,900	300	6,600	0	2,300	7,700	0	19,600	3,900	0	0	5,100	6,200	0	57,800	200	134,000	7,100
2004 - 2005	Above Average	26,000	24,200	4,700	14,400	400	6,400	22,900	1,500	91,200	19,000	2,900	32,000	2,400	15,300	700	89,700	500	92,600	7,100
2005 - 2006	Above Average	28,000	28,100	7,200	14,400	900	7,500	40,500	3,400	78,000	23,300	3,200	26,600	2,000	29,300	400	91,000	700	95,700	7,300
2006 - 2007	Below Average	0	6,200	1,500	6,600	0	1,700	5,100	0	15,500	4,300	0	100	2,000	4,800	0	36,000	700	151,600	7,500
2007 - 2008	Below Average	0	11,700	1,100	8,100	0	2,300	15,900	0	22,100	6,900	0	1,600	2,000	7,800	0	45,500	800	129,700	7,600
2008 - 2009	Below Average	0	9,500	1,400	6,300	0	1,600	7,100	0	43,800	5,200	0	8,100	2,000	7,600	0	57,400	700	135,300	7,600
2009 - 2010	Average	6,000	25,600	4,500	16,100	0	5,000	34,600	0	72,700	14,300	0	29,900	2,000	19,200	0	77,700	600	93,900	7,500
2010 - 2011	Above Average	65,000	37,100	7,500	24,400	1,300	14,800	82,400	5,000	89,500	39,000	9,700	45,700	2,000	30,300	1,400	84,700	600	101,900	7,600
2011 - 2012	Below Average	3,000	13,600	300	11,000	0	3,200	17,800	0	23,100	8,100	0	7,000	2,000	11,900	0	46,200	700	151,300	7,700
2012 - 2013	Below Average	0	4,900	0	4,500	0	1,000	4,400	0	13,000	5,300	0	100	2,000	3,400	0	35,000	700	165,100	7,800
2013 - 2014	Below Average	0	2,300	0	2,700	0	400	0	0	0	3,800	0	0	2,000	1,000	0	13,000	600	183,400	7,700
2014 - 2015	Below Average	0	1,000	0	1,800	0	200	0	0	0	3,600	0	0	2,000	1,100	0	5,600	500	178,800	7,500
2015 - 2016	Below Average	0	16,000	5,500	14,300	0	4,400	11,400	0	28,600	6,600	0	3,700	2,000	5,900	0	35,300	400	123,500	7,600
2016 - 2017	Below Average	0	42,100	15,900	37,000	800	17,100	82,600	3,100	133,700	37,300	3,700	61,000	2,000	41,400	1,400	99,000	500	83,300	7,700
86/87-16/17 Avg		21,000	16,500	3,200	12,100	700	5,600	22,300	2,600	50,600	11,600	800	11,100	3,200	14,200	300	64,300	400	145,400	6,700

Groundwater Inflows to be Included in Sustainable Yield Estimates
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Tule Subbasin Surface Water Budget

		Surface Water Outflow (acre-ft)													
		T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	
		Evapotranspiration											Surface Outflow		
			Tule River		Deer Creek		White River	Imported Water		Recycled Water					
Water Year	Water Year Type	Precipitation Crops/Native	Agricultural Cons. Use	Stream Channel	Agricultural Cons. Use	Stream Channel	Stream Channel	Agricultural Cons. Use	Ag. Cons. Use from Pumping	Recharge in Basins	Agricultural Cons. Use	Municipal (Landscape ET)	Tule River	Deer Creek	Total Out
1986 - 1987	Below Average	219,000	24,700	800	0	300	100	183,000	553,900	50	700	4,800	0	0	1,332,000
1987 - 1988	Average	311,000	13,800	400	0	300	100	170,100	584,700	50	900	5,300	0	0	1,399,000
1988 - 1989	Below Average	254,000	17,600	400	0	300	100	185,200	556,200	50	1,000	5,500	0	0	1,312,000
1989 - 1990	Below Average	245,000	8,800	400	0	300	100	136,700	638,100	50	1,000	5,700	0	0	1,308,000
1990 - 1991	Average	324,000	16,800	500	0	300	100	173,300	608,700	50	1,000	5,900	0	0	1,442,000
1991 - 1992	Below Average	284,000	10,800	400	0	300	100	161,300	622,000	50	1,100	6,000	0	0	1,372,000
1992 - 1993	Above Average	406,000	34,900	800	0	400	100	357,500	385,000	50	1,100	6,100	0	0	1,771,000
1993 - 1994	Below Average	291,000	21,100	500	0	300	100	167,600	603,800	50	1,100	6,200	0	0	1,421,000
1994 - 1995	Above Average	466,000	71,600	900	2,900	400	100	285,600	442,700	50	1,100	6,200	25,000	0	1,983,000
1995 - 1996	Average	316,000	62,600	1,000	3,600	400	100	332,300	392,200	50	1,100	6,300	7,000	0	1,629,000
1996 - 1997	Above Average	399,000	57,100	1,000	2,000	400	100	298,200	436,100	50	1,200	6,600	121,000	0	1,927,000
1997 - 1998	Above Average	509,000	98,000	1,000	9,100	400	200	203,000	485,800	50	1,100	6,300	132,000	0	2,274,000
1998 - 1999	Above Average	354,000	37,700	1,000	1,000	400	200	280,600	477,200	50	1,100	6,300	0	0	1,591,000
1999 - 2000	Average	342,000	39,200	700	900	400	100	286,800	498,600	50	1,200	6,600	5,000	0	1,601,000
2000 - 2001	Below Average	264,000	21,900	700	0	300	100	205,000	548,900	50	1,200	6,700	0	0	1,366,000
2001 - 2002	Below Average	252,000	22,600	700	0	300	100	213,200	543,800	50	1,400	7,400	0	0	1,373,000
2002 - 2003	Below Average	247,000	37,500	700	700	400	100	252,500	487,300	50	1,400	7,300	5,000	0	1,390,000
2003 - 2004	Below Average	207,000	18,200	600	0	300	100	219,400	522,200	50	1,500	7,700	1,000	0	1,239,000
2004 - 2005	Above Average	369,000	43,800	800	2,500	400	100	322,200	386,800	50	3,300	7,300	22,000	0	1,612,000
2005 - 2006	Above Average	373,000	58,800	800	1,300	400	100	308,200	394,100	50	4,000	7,600	11,000	0	1,647,000
2006 - 2007	Below Average	170,000	14,200	400	0	300	100	142,000	594,200	50	4,400	8,000	0	0	1,177,000
2007 - 2008	Below Average	189,000	24,300	600	0	300	100	203,400	507,600	50	4,500	8,100	1,000	0	1,202,000
2008 - 2009	Below Average	203,000	22,300	500	0	300	100	233,000	524,600	50	4,200	7,900	0	0	1,290,000
2009 - 2010	Average	320,000	45,400	800	0	400	100	275,700	388,600	50	3,900	7,700	0	0	1,452,000
2010 - 2011	Above Average	414,000	65,300	800	4,700	400	200	295,900	412,300	50	3,800	7,700	8,000	0	1,863,000
2011 - 2012	Below Average	299,000	33,800	600	0	300	100	182,700	578,500	50	4,100	7,900	10,000	0	1,424,000
2012 - 2013	Below Average	139,000	10,300	500	0	300	100	147,100	625,000	50	4,200	8,000	0	0	1,182,000
2013 - 2014	Below Average	99,000	2,400	300	0	300	100	55,500	716,500	50	3,800	7,700	0	0	1,103,000
2014 - 2015	Below Average	142,000	2,300	300	0	200	100	32,900	711,500	50	2,700	7,000	0	0	1,101,000
2015 - 2016	Below Average	217,000	19,400	500	0	300	100	167,700	490,200	50	2,700	7,000	0	0	1,170,000
2016 - 2017	Below Average	227,000	67,100	900	4,800	400	200	323,800	345,900	50	2,800	7,100	71,000	0	1,721,000
86/87-16/17 Avg		286,000	33,000	700	1,100	300	100	219,400	518,200	50	2,200	6,800	14,000	0	1,474,000

Groundwater Inflows to be Included in Sustainable Yield Estimates
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Tule Subbasin Historical Groundwater Budget

Water Year	Water Year Type	Groundwater Inflows (acre-ft)																						Total In
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	
			Tule River Infiltration					Deer Creek Infiltration						Imported Water Deliveries				Municipal Pumping						
																			Recycled Water					
		Areal Recharge from Precipitation	Success to Oettle Bridge Infiltration	Oettle Bridge to Turnbull Weir Infiltration	Canal Loss	Recharge in Basins	Return Flow	Before Trenton Weir Infiltration	Trenton Weir to Homeland Canal Infiltration	Canal Loss	Recharge in Basins	Return Flow	White River Infiltration	Canal Loss	Recharge in Basins	Return Flow	Agricultural Pumping Return Flow	Return Flow	Agricultural Return Flow	Artificial Recharge	Release of Water from Compression of Aquitards	Sub-surface Inflow	Mountain-Block Recharge	
1986 - 1987	Below Average	0	11,600	1,100	20,700	5,400	8,500	8,100	0	0	0	0	2,400	52,500	0	56,100	169,900	5,200	200	2,600	120,000	113,000	28,000	605,000
1987 - 1988	Average	4,000	8,000	900	8,800	5,000	5,500	5,800	0	0	0	0	1,300	32,700	0	48,100	183,200	5,400	200	3,200	88,000	131,000	29,000	560,000
1988 - 1989	Below Average	0	8,700	0	7,400	6,200	6,100	7,500	0	0	0	0	1,800	20,500	0	51,800	172,100	5,600	200	3,400	71,000	131,000	29,000	522,000
1989 - 1990	Below Average	0	5,000	0	2,900	3,700	2,700	4,400	0	0	0	0	700	7,400	0	36,200	199,700	5,700	200	3,600	132,000	133,000	29,000	566,000
1990 - 1991	Average	7,000	6,400	300	6,800	5,200	5,900	6,900	0	0	0	0	1,300	24,300	0	46,900	190,300	5,800	200	3,700	126,000	144,000	29,000	610,000
1991 - 1992	Below Average	1,000	4,300	0	3,100	3,700	3,500	3,800	0	0	0	0	700	16,100	0	44,700	194,900	5,900	200	3,800	143,000	140,000	30,000	599,000
1992 - 1993	Above Average	57,000	18,500	3,000	27,800	8,200	16,800	15,100	0	0	0	0	3,500	184,400	5,600	118,000	111,300	6,000	200	3,900	44,000	93,000	30,000	746,000
1993 - 1994	Below Average	2,000	6,100	200	14,200	5,000	8,700	6,600	0	0	0	0	1,100	35,600	700	51,800	187,400	6,100	200	4,000	85,000	123,000	30,000	568,000
1994 - 1995	Above Average	144,000	36,400	10,400	39,500	7,800	34,600	21,200	1,000	3,800	1,800	1,000	10,500	128,500	10,400	88,900	130,900	6,100	200	3,900	33,000	101,000	30,000	845,000
1995 - 1996	Average	5,000	20,700	4,000	26,200	21,200	31,800	13,700	700	2,800	700	1,200	5,800	87,600	39,500	119,000	115,700	6,200	200	3,900	19,000	95,000	27,000	647,000
1996 - 1997	Above Average	50,000	34,600	9,700	47,300	25,300	31,400	45,100	1,800	6,900	1,900	700	12,800	64,200	14,100	117,300	130,700	6,300	200	4,300	19,000	111,000	28,000	763,000
1997 - 1998	Above Average	219,000	41,100	9,000	79,100	32,000	41,100	14,900	12,700	48,800	900	3,100	36,600	54,100	16,200	65,200	143,800	6,300	200	3,900	17,000	126,000	30,000	1,001,000
1998 - 1999	Above Average	18,000	14,300	2,800	19,500	17,600	14,100	13,300	600	2,500	400	300	7,300	58,200	19,800	88,700	143,200	6,400	200	3,900	18,000	122,000	30,000	601,000
1999 - 2000	Average	12,000	16,900	2,900	11,100	8,900	15,200	10,100	600	2,400	500	300	4,800	64,400	13,000	93,200	152,400	6,500	200	4,200	20,000	131,000	30,000	601,000
2000 - 2001	Below Average	0	12,300	0	7,000	5,000	7,800	6,700	0	0	0	0	4,600	28,500	2,700	61,700	169,600	6,600	200	4,300	42,000	142,000	30,000	531,000
2001 - 2002	Below Average	0	14,800	700	13,400	5,800	9,000	10,100	0	0	0	0	6,100	24,800	100	65,200	169,100	6,900	300	4,900	59,000	135,000	30,000	555,000
2002 - 2003	Below Average	0	19,700	3,700	22,800	12,200	11,500	13,600	100	400	300	200	5,800	53,600	5,000	65,700	123,200	6,900	200	4,800	42,000	123,000	29,000	544,000
2003 - 2004	Below Average	0	9,900	300	7,700	3,900	6,200	6,600	0	0	0	0	2,300	19,600	0	57,800	134,000	7,100	200	5,100	70,000	127,000	29,000	487,000
2004 - 2005	Above Average	26,000	24,200	4,700	22,900	19,000	15,300	14,400	400	1,500	2,900	700	6,400	91,200	32,000	89,700	92,600	7,100	500	2,400	26,000	96,000	29,000	605,000
2005 - 2006	Above Average	28,000	28,100	7,200	40,500	23,300	29,300	14,400	900	3,400	3,200	400	7,500	78,000	26,600	91,000	95,700	7,300	700	2,000	16,000	97,000	29,000	630,000
2006 - 2007	Below Average	0	6,200	1,500	5,100	4,300	4,800	6,600	0	0	0	0	1,700	15,500	100	36,000	151,600	7,500	700	2,000	78,000	125,000	29,000	476,000
2007 - 2008	Below Average	0	11,700	1,100	15,900	6,900	7,800	8,100	0	0	0	0	2,300	22,100	1,600	45,500	129,700	7,600	800	2,000	96,000	113,000	30,000	502,000
2008 - 2009	Below Average	0	9,500	1,400	7,100	5,200	7,600	6,300	0	0	0	0	1,600	43,800	8,100	57,400	135,300	7,600	700	2,000	125,000	108,000	30,000	557,000
2009 - 2010	Average	6,000	25,600	4,500	34,600	14,300	19,200	16,100	0	0	0	0	5,000	72,700	29,900	77,700	93,900	7,500	600	2,000	70,000	83,000	29,000	592,000
2010 - 2011	Above Average	65,000	37,100	7,500	82,400	39,000	30,300	24,400	1,300	5,000	9,700	1,400	14,800	89,500	45,700	84,700	101,900	7,600	600	2,000	34,000	93,000	29,000	806,000
2011 - 2012	Below Average	3,000	13,600	300	17,800	8,100	11,900	11,000	0	0	0	0	3,200	23,100	7,000	46,200	151,300	7,700	700	2,000	86,000	123,000	29,000	545,000
2012 - 2013	Below Average	0	4,900	0	4,400	5,300	3,400	4,500	0	0	0	0	1,000	13,000	100	35,000	165,100	7,800	700	2,000	145,000	130,000	29,000	551,000
2013 - 2014	Below Average	0	2,300	0	0	3,800	1,000	2,700	0	0	0	0	400	0	0	13,000	183,400	7,700	600	2,000	186,000	132,000	30,000	565,000
2014 - 2015	Below Average	0	1,000	0	0	3,600	1,100	1,800	0	0	0	0	200	0	0	5,600	178,800	7,500	500	2,000	189,000	124,000	30,000	545,000
2015 - 2016	Below Average	0	16,000	5,500	11,400	6,600	5,900	14,300	0	0	0	0	4,400	28,600	3,700	35,300	123,500	7,600	400	2,000	140,000	112,000	30,000	547,000
2016 - 2017	Below Average	0	42,100	15,900	82,600	37,300	41,400	37,000	800	3,100	3,700	1,400	17,100	133,700	61,000	99,000	83,300	7,700	500	2,000	61,000	95,000	29,000	855,000
86/87-16/17 Avg		21,000	16,500	3,200	22,300	11,600	14,200	12,100	700	2,600	800	300	5,600	50,600	11,100	64,300	145,400	6,700	400	3,200	77,000	118,000	29,000	617,000

Groundwater Inflows to be Included in Sustainable Yield Estimates
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Tule Subbasin Groundwater Budget

		Groundwater Outflows (acre-ft)						
		W	X	Y	Z	AA		
		Groundwater Pumping						
Water Year	Water Year Type	Municipal	Irrigated Agriculture	Exports	Groundwater Banking Extraction	Sub-surface Outflow	Total Out	Change in Storage (acre-ft)
1986 - 1987	Below Average	13,500	724,000	6,550	0	61,000	805,000	-200,000
1987 - 1988	Average	15,100	768,000	34,180	0	53,000	870,000	-310,000
1988 - 1989	Below Average	15,700	728,000	38,290	0	51,000	833,000	-311,000
1989 - 1990	Below Average	16,300	838,000	50,430	0	53,000	958,000	-392,000
1990 - 1991	Average	16,700	799,000	46,300	0	61,000	923,000	-313,000
1991 - 1992	Below Average	17,000	817,000	41,250	0	52,000	927,000	-328,000
1992 - 1993	Above Average	17,200	496,000	14,550	0	73,000	601,000	145,000
1993 - 1994	Below Average	17,600	791,000	11,220	0	59,000	879,000	-311,000
1994 - 1995	Above Average	17,600	574,000	1,320	0	61,000	654,000	191,000
1995 - 1996	Average	17,800	508,000	0	0	65,000	591,000	56,000
1996 - 1997	Above Average	18,700	567,000	0	0	65,000	651,000	112,000
1997 - 1998	Above Average	17,900	630,000	0	0	62,000	710,000	291,000
1998 - 1999	Above Average	18,000	620,000	0	0	62,000	700,000	-99,000
1999 - 2000	Average	18,900	651,000	7,720	0	60,000	738,000	-137,000
2000 - 2001	Below Average	19,100	719,000	30,600	0	60,000	829,000	-298,000
2001 - 2002	Below Average	20,900	713,000	44,520	0	58,000	836,000	-281,000
2002 - 2003	Below Average	20,600	610,000	33,660	0	55,000	719,000	-175,000
2003 - 2004	Below Average	21,700	656,000	37,790	0	55,000	770,000	-283,000
2004 - 2005	Above Average	20,600	479,000	11,720	0	66,000	577,000	28,000
2005 - 2006	Above Average	21,600	490,000	150	0	64,000	576,000	54,000
2006 - 2007	Below Average	22,700	746,000	49,500	0	54,000	872,000	-396,000
2007 - 2008	Below Average	23,000	637,000	50,090	0	68,000	778,000	-276,000
2008 - 2009	Below Average	22,500	660,000	48,860	550	78,000	810,000	-253,000
2009 - 2010	Average	21,800	483,000	28,530	70	92,000	625,000	-33,000
2010 - 2011	Above Average	21,800	514,000	8,060	0	86,000	630,000	176,000
2011 - 2012	Below Average	22,500	730,000	43,570	3,860	76,000	876,000	-331,000
2012 - 2013	Below Average	22,700	790,000	63,640	5,990	68,000	950,000	-399,000
2013 - 2014	Below Average	21,900	900,000	58,030	5,590	69,000	1,055,000	-490,000
2014 - 2015	Below Average	19,700	890,000	53,270	1,150	64,000	1,028,000	-483,000
2015 - 2016	Below Average	19,700	614,000	50,000	70	70,000	754,000	-207,000
2016 - 2017	Below Average	20,100	429,000	11,330	0	90,000	550,000	305,000
		19,400	664,000	28,200	600	65,000	777,000	-160,000
							Cummulative Change in Storage	-4,948,000

Light blue	Groundwater Inflows to be Included in Sustainable Yield Estimates
Pink	Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Yellow	Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Table 2-4

Projected Future Tule Subbasin Sustainable Yield

	Groundwater Inflows (acre-ft)										Groundwater Outflow (acre-ft)	
	A	B	C	D	E	F	G	H	I	J	K	
		Streambed Infiltration					Return Flow					
		Tule River		Deer Creek								
Water Year	Areal Recharge from Precipitation	Success to Oettle Bridge	Oettle Bridge to Turnbull Weir	Before Trenton Weir Infiltration	Trenton Weir to Homeland Canal Infiltration	White River	Irrigated Agriculture	Municipal	Sub-surface Inflow	Mountain-Block Recharge	Sub-surface Outflow	Sustainable Yield
2040 - 2041	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	51,000	32,000	90,000	127,700
2041 - 2042	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	52,000	32,000	90,000	128,700
2042 - 2043	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	52,000	32,000	90,000	128,700
2043 - 2044	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	52,000	32,000	90,000	128,700
2044 - 2045	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	52,000	32,000	90,000	128,700
2045 - 2046	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	53,000	32,000	89,000	130,700
2046 - 2047	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	53,000	32,000	89,000	130,700
2047 - 2048	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	53,000	32,000	89,000	130,700
2048 - 2049	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	53,000	32,000	89,000	130,700
2049 - 2050	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	53,000	32,000	88,000	131,700
40/41-49/50 Avg	21,000	17,900	3,900	11,600	600	6,200	64,100	9,400	52,000	32,000	89,000	129,700

Table 2-5

Historical Planned versus Actual Water Deliveries
2007/08 - 2016/17

Water Year	Water Year Type	Tule River			Friant-Kern Canal								
					Saucelito ID			Terra Bella ID			Kern-Tulare WD		
		Total Diversion Right	Total Delivered	Percent of Diversion Right (%)	Contract Amount[1]	Total Delivered[2]	Percent of Contract (%)	Contract Amount[1]	Total Delivered[2]	Percent of Contract (%)	Contract Amount[1]	Total Delivered[2]	Percent of Contract (%)
2007 - 2008	Below Average	57,100	41,974	74%	54,300	24,083	44%	29,000	18,192	63%	5,000	17,689	354%
2008 - 2009	Below Average	57,100	32,290	57%	54,300	31,282	58%	29,000	19,701	68%	5,000	15,524	310%
2009 - 2010	Average	57,100	60,570	106%	54,300	42,855	79%	29,000	17,574	61%	5,000	14,027	281%
2010 - 2011	Above Average	57,100	106,619	187%	54,300	46,733	86%	29,000	16,381	56%	5,000	13,405	268%
2011 - 2012	Below Average	57,100	66,992	117%	54,300	19,189	35%	29,000	19,757	68%	5,000	14,309	286%
2012 - 2013	Below Average	57,100	23,406	41%	54,300	14,102	26%	29,000	20,628	71%	5,000	14,955	299%
2013 - 2014	Below Average	57,100	9,747	17%	54,300	5,724	11%	29,000	12,390	43%	5,000	9,986	200%
2014 - 2015	Below Average	57,100	6,417	11%	54,300	1,503	3%	29,000	12,012	41%	5,000	5,438	109%
2015 - 2016	Below Average	57,100	36,752	64%	54,300	20,049	37%	29,000	14,357	50%	5,000	11,805	236%
2016 - 2017	Below Average	57,100	128,361	225%	54,300	51,137	94%	29,000	16,089	55%	5,000	14,203	284%
	Total:	571,000	513,128	90%	543,000	256,657	47%	290,000	167,081	58%	50,000	131,341	263%

Water Year	Water Year Type	Friant-Kern Canal											
		LTRID			Delano-Earlimart ID			Porterville ID			Tea Pot Dome WD		
		Contract Amount[1]	Total Delivered[2]	Percent of Contract (%)	Contract Amount[1]	Total Delivered[2]	Percent of Contract (%)	Contract Amount[1]	Total Delivered[2]	Percent of Contract (%)	Contract Amount[1]	Total Delivered[2]	Percent of Contract (%)
2007 - 2008	Below Average	299,200	71,872	24%	183,300	106,470	58%	45,000	12,988	29%	7,200	6,894	96%
2008 - 2009	Below Average	299,200	113,189	38%	183,300	111,556	61%	45,000	18,000	40%	7,200	6,165	86%
2009 - 2010	Average	299,200	200,064	67%	183,300	118,671	65%	45,000	14,335	32%	7,200	5,845	81%
2010 - 2011	Above Average	299,200	229,763	77%	183,300	127,447	70%	45,000	9,387	21%	7,200	6,105	85%
2011 - 2012	Below Average	299,200	67,684	23%	183,300	114,108	62%	45,000	9,318	21%	7,200	4,680	65%
2012 - 2013	Below Average	299,200	37,073	12%	183,300	87,302	48%	45,000	10,298	23%	7,200	4,354	60%
2013 - 2014	Below Average	299,200	0	0%	183,300	38,106	21%	45,000	178	0%	7,200	1,030	14%
2014 - 2015	Below Average	299,200	0	0%	183,300	18,591	10%	45,000	114	0%	7,200	260	4%
2015 - 2016	Below Average	299,200	73,382	25%	183,300	93,806	51%	45,000	13,271	29%	7,200	4,627	64%
2016 - 2017	Below Average	299,200	273,151	91%	183,300	137,773	75%	45,000	21,651	48%	7,200	6,694	93%
	Total:	2,992,000	1,066,178	36%	1,833,000	953,830	52%	450,000	109,540	24%	72,000	46,654	65%

Notes: [1]Sum of Class 1 and Class 2 Fraint-Kern Canal Contract Amount
[2]Total delivered water may include 16B water and water purchased from other Friant-Kern Canal contractors.
Likewise, delivered water may not reflect available supplies as contractors periodically sell water under their contract.

Summary of Projects Exclusive of Transitional Pumping

Eastern Tule GSA

No.	Lead Entity	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
1	City of Porterville	Population Increase	Increase GW Production	2.5%/yr 2020-2040	9,500 af/yr by 2040	N/A	High
2	City of Porterville	Recycling Increase	Increase RW Applied to Ag	2.5%/yr 2020-2040	1,900 af/yr by 2040	Recycled Water	High
3	City of Porterville	Recycling Increase	Increase RW Recharge	2.5%/yr 2020-2040	1,600 af/yr by 2040	Recycled Water	High
4	City of Porterville	Tule River Recharge	Recharge Project	Starting 2019/20	900 af/yr	Tule River	High
5	City of Porterville	FKC Recharge	Recharge Project	Starting 2020/21	1,100 af/yr	FKC via Porterville ID	High
6	Porterville ID	SA 1 & 2	Expand distribution system	Starting 2018/19	3,200 af/yr	Tule River and FKC	High
7	Porterville ID	Falconer Bank	Develop water bank	Starting 2020/21	3,300 af/yr of leave-behind	FKC and others	High
8	Porterville ID	Recharge Policy	On-Farm recharge	Starting 2019/20	3,000 af/yr	Tule River and FKC	High
9	Saucelito ID	Conway Bank	Develop water bank	Starting 2020/21	1,100 af/yr of leave-behind	FKC and others	High
10	Saucelito ID	Recharge Policy	On-Farm recharge	Starting 2019/20	2,000 af/yr	FKC	High
11	Kern-Tulare WD	In-District Pricing	Pricing change	Starting 2020/21	2,600 af/yr	N/A	High
12	Kern-Tulare WD	Reservoir Storage	Surface water storage	Starting 2029/30	500 af/yr	FKC and others	Medium
13	Kern-Tulare WD	CRC Pipeline	Deliver produced water	Starting 2024/25	680 af/yr	CRC Produced water	High
14	Terra Bella ID	Deer Creek Recharge	Divert and recharge DC	Starting 2017/18	800 af/yr	Deer Creek	High
15	PWC, VWD, & CMDC	SREP	Success Dam Enlargement	Starting 2024/25	400 af/yr	Tule River	High
16	Hope WD	In-District Recharge	Recharge Project	Starting 2022/23	5,000 af/yr every 3 years	FKC and others / unknown	Medium
17	Ducor ID	In-District Recharge	Pipeline and Recharge Project	Starting 2023/24	4,000 af/yr	FKC and others / unknown	High

LTRID GSA

No.	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
1	Creighton Ranch	Groundwater exports	Unknown	Unknown	Not applicable	N/A
2	LTRID - Pixley ID FKC	Continue FKC transfers to Pixley ID	Ongoing	13,670 af/yr	FKC	N/A
3	SREP	Success Dam Enlargement	Starting 2024/25	2,600 af/yr	Tule River	N/A

Pixley GSA

No.	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
1	LTRID - Pixley ID FKC	Continue FKC transfers from LTRID	Ongoing	13,670 af/yr	FKC	N/A

DEID GSA

No.	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
N/A	No planned projects	N/A	N/A	N/A	N/A	N/A

Tri-County GSA

No.	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
1	Deep Pumping Reduction	Replace deep pumping with 24 new shallow wells	Start in 2019/20, completed in 2023/24	24,000 af/yr	Not applicable	High
2	Duck Club Project	Duck Club water transferred to farms	2019/20	5,400 af every 7 years	Unknown	High
3	Liberty Project	Participation in the Liberty Project surface water storage	Start in 2019/20, completed in 2022/23	5,000 af/yr	FID, FKC, KR, TR, KW, SWP	High
4	Recharge Scenario	Confidential. Capture and recharge flood water	Unknown	1,200 to 1,800 af/yr	Unknown	N/A

Alpaugh GSA

No.	Project Name	Description	Timeframe	Annual Volume	Water Source	Confidence
1	Water Capture	Deer Creek flood capture	Starting in 2022/23	1,100 af 2.5x per yr every 2 yrs	Deer Creek	N/A
2	Cropping Changes	Install drip irrigation on 1,900 acres	Starting 2019/20	Not applicable	Not applicable	N/A

Summary of Projects Exclusive of Transitional Pumping

Notes:

N/A= Not Available
af/yr = acre-foot per year
ID = Irrigation District
GW = Groundwater
RW = Recycled water
Ag = Agricultural
DC = Deer Creek
FKC = Friant-Kern Canal
SA = Service Area
CRC = California Resources Corporation
PWC = Pioneer Water Company
VMD = Vandalia Water District
CMDC = Campbell Moreland Ditch Company
SREP = Success Reservoir Enlargement Project
WD = Water District
MA = Management Area
FID = Fresno Irrigation District (Fresno Slough)
KR = Kaweah River
TR = Tule River
KW = Kaweah River
SWP = State Water Project

Planned Transitional Pumping by GSA

<table>
<tr><th></th><th>Eastern Tule GSA</th><th>LTRID GSA</th><th>Pixley ID GSA</th><th>DEID-District Area</th><th>DEID White Lands Area</th><th>Tri-Co GSA</th><th>Alpaugh GSA</th></tr>
<tr><td>2020-2025</td><td>90% of over-pumping[1]</td><td>2.0 af/ac Over Cons. Use Target</td><td>Fallow 5,000 acres; Remaining no change</td><td rowspan="5">No Change/ Sustainable</td><td>100% of over-pumping</td><td>100% of over-pumping</td><td rowspan="2">Reduce cropped area by 880 acres; 80% of overpumping</td></tr>
<tr><td>2025-2030</td><td>80% of over-pumping</td><td>1.5 af/ac Over Cons. Use Target</td><td>Fallow 5,000 acres; Remaining 1.5 af/ac Over Cons. Use Target[2]</td><td rowspan="2">Linear Transitional Pumping</td><td rowspan="2">Reduce pumping 10,000 af/yr</td></tr>
<tr><td>2030-2035</td><td>30% of over-pumping</td><td>1.0 af/ac Over Cons. Use Target</td><td>Fallow 5,000 acres; Remaining 1.0 af/ac Over Cons. Use Target</td><td>50% of overpumping</td></tr>
<tr><td>2035-2040</td><td rowspan="2">Sustainable</td><td>0.5 af/ac Over Cons. Use Target</td><td>Fallow 5,000 acres; Remaining 0.5 af/ac Over Cons. Use Target</td><td rowspan="2">Sustainable</td><td rowspan="2">Sustainable</td><td>20% of overpumping</td></tr>
<tr><td>2040+</td><td>Sustainable</td><td>Sustainable</td><td>Sustainable</td></tr>
</table>

Notes:

[1]Over-pumping means pumping in excess of the consumptive use target

[2]Over consumptive use target means over pumping

Table 2-8a

Projected Future Tule Subbasin Surface Water Budget

	Surface Water Inflow (acre-ft)																					
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	
		Stream Inflow			Imported Water															Discharge from Wells		
Water Year	Precipitation	Tule River	Deer Creek	White River	Saucelito ID	Terra Bella ID	Kern-Tulare WD	Porterville ID	Tea Pot Dome WD	City of Porterville	Hope WD	Ducor ID	LTRID	Pixley ID	Delano-Earlimart ID	Angiola WD	Alpaugh ID	Atwell Island WD	Private	Agriculture Pumping	Municipal Pumping	Total In
2017 - 2018	306,000	131,258	19,410	6,347	34,567	18,786	15,335	19,803	6,528	0	0	0	143,186	31,763	116,902	5,911	3,680	0	0	549,000	21,700	1,430,000
2018 - 2019	306,000	131,258	19,410	6,347	34,567	18,786	15,335	19,803	6,528	0	0	0	143,186	31,763	116,902	5,911	3,680	0	0	548,000	23,400	1,431,000
2019 - 2020	306,000	131,258	19,410	6,347	34,567	18,786	15,335	23,103	6,528	0	0	0	143,186	31,763	116,902	7,961	3,680	0	0	529,000	25,000	1,419,000
2020 - 2021	306,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	0	0	143,186	31,763	116,902	9,211	3,680	0	0	526,000	25,400	1,422,000
2021 - 2022	306,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	0	0	143,186	31,763	116,902	10,461	3,680	0	0	524,000	25,700	1,422,000
2022 - 2023	306,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	1,667	0	143,186	31,763	116,902	13,590	3,680	0	0	523,000	26,100	1,426,000
2023 - 2024	306,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	1,667	4,000	143,186	31,763	116,902	18,926	3,680	0	0	522,000	26,500	1,435,000
2024 - 2025	306,000	134,258	19,410	6,347	34,893	20,304	18,229	24,339	6,594	1,100	1,667	4,000	135,513	31,763	117,661	24,261	3,680	0	1,500	494,000	26,900	1,412,000
2025 - 2026	306,000	134,258	19,410	6,347	34,118	21,823	17,843	25,575	6,661	1,100	1,667	4,000	127,841	31,763	118,420	29,597	4,813	0	1,500	487,000	27,400	1,407,000
2026 - 2027	306,000	134,258	19,410	6,347	33,343	23,341	17,458	26,812	6,727	1,100	1,667	4,000	120,168	31,763	119,180	34,933	4,751	0	1,500	481,000	27,800	1,402,000
2027 - 2028	306,000	134,258	19,410	6,347	32,568	24,860	17,072	28,048	6,793	1,100	1,667	4,000	112,496	31,763	119,939	40,268	4,689	0	1,500	474,000	28,200	1,395,000
2028 - 2029	306,000	134,258	19,410	6,347	31,794	26,378	16,687	29,285	6,860	1,100	1,667	4,000	104,823	31,763	120,698	43,725	4,627	0	1,500	468,000	28,700	1,388,000
2029 - 2030	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	4,565	0	1,500	412,000	29,200	1,328,000
2030 - 2031	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	5,737	0	1,500	413,000	29,600	1,331,000
2031 - 2032	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	5,737	0	1,500	410,000	30,100	1,328,000
2032 - 2033	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	5,737	0	1,500	407,000	30,600	1,326,000
2033 - 2034	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	5,737	0	1,500	405,000	31,100	1,324,000
2034 - 2035	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	5,737	0	1,500	345,000	31,700	1,265,000
2035 - 2036	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	6,970	0	1,500	344,000	32,200	1,266,000
2036 - 2037	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	6,970	0	1,500	344,000	32,800	1,266,000
2037 - 2038	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	6,970	0	1,500	344,000	33,300	1,267,000
2038 - 2039	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	6,970	0	1,500	344,000	33,900	1,267,000
2039 - 2040	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	6,970	0	1,500	303,000	34,500	1,227,000
2040 - 2041	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2041 - 2042	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2042 - 2043	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2043 - 2044	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2044 - 2045	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2045 - 2046	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2046 - 2047	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2047 - 2048	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2048 - 2049	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2049 - 2050	306,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,151	31,763	121,457	43,430	7,793	0	1,500	302,000	34,500	1,227,000
2050 - 2051	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2051 - 2052	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2052 - 2053	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2053 - 2054	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2054 - 2055	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2055 - 2056	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2056 - 2057	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2057 - 2058	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2058 - 2059	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2059 - 2060	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2060 - 2061	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2061 - 2062	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2062 - 2063	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2063 - 2064	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2064 - 2065	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2065 - 2066	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2066 - 2067	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2067 - 2068	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	43,209	7,793	0	1,500	297,000	34,500	1,189,000
2068 - 2069	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	45,214	7,793	0	1,500	297,000	34,500	1,191,000
2069 - 2070	306,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	84,084	31,763	112,046	24,476	7,793	0	1,500	297,000	34,500	1,170,000
17/18-69/70 Avg	306,000	132,500	19,200	6,300	31,200	25,700	17,800	28,300	6,700	1,000	1,500	3,500	100,500	31,800	117,100	37,800	6,600	0	1,300	361,000	32,000	1,268,000

Projected Future Tule Subbasin Surface Water Budget

Water Year	Surface Water Outflow (acre-ft)																		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
	Areal Recharge of Precipitation	Streambed Infiltration					Canal Loss			Recharge in Basins				Deep Percolation of Applied Water					
		Tule River		Native Deer Creek		White River	Tule River	Deer Creek	Imported Water	Tule River	Deer Creek	Imported Water	Recycled Water	Tule River	Deer Creek	Imported Water	Recycled Water	Agricultural Pumping	Municipal Pumping
		Success to Oettle Bridge	Oettle Bridge to Turnbull Weir	Before Trenton Weir	Trenton Weir to Homeland Canal														
2017 - 2018	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	12,200	1,300	15,900	2,000	15,500	800	66,900	600	110,400	7,900
2018 - 2019	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	12,200	1,300	15,900	2,000	15,500	800	66,900	700	110,300	8,100
2019 - 2020	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	13,100	1,300	19,200	2,500	15,500	800	68,100	400	106,600	8,300
2020 - 2021	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	13,100	1,300	21,400	2,600	15,500	800	68,700	400	106,000	8,300
2021 - 2022	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	13,100	1,300	21,400	2,600	15,500	800	68,900	400	105,700	8,400
2022 - 2023	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	13,100	1,300	23,000	2,700	15,500	800	69,100	500	105,400	8,400
2023 - 2024	21,000	17,900	3,900	11,600	600	6,200	17,000	2,100	65,200	13,100	1,300	27,000	2,800	15,500	800	69,100	500	105,300	8,500
2024 - 2025	21,000	17,900	3,900	11,600	600	6,200	18,200	2,100	62,400	13,700	1,300	27,900	2,800	15,800	800	69,600	500	100,200	8,500
2025 - 2026	21,000	17,900	3,900	11,600	600	6,200	18,400	2,100	59,600	13,700	1,300	27,300	2,900	15,800	1,100	70,200	500	98,900	8,600
2026 - 2027	21,000	17,900	3,900	11,600	600	6,200	18,700	2,100	56,800	13,700	1,300	26,700	3,000	15,800	1,100	70,500	500	98,000	8,600
2027 - 2028	21,000	17,900	3,900	11,600	600	6,200	19,000	2,100	53,900	13,700	1,300	26,100	3,100	15,800	1,100	70,900	500	97,000	8,700
2028 - 2029	21,000	17,900	3,900	11,600	600	6,200	19,300	2,100	51,100	13,700	1,300	25,500	3,100	15,800	1,100	71,300	500	96,000	8,700
2029 - 2030	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,200	15,500	1,100	71,800	500	86,900	8,800
2030 - 2031	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,300	15,500	1,100	72,100	600	86,900	8,800
2031 - 2032	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,400	15,500	1,100	72,100	600	86,400	8,900
2032 - 2033	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,500	15,500	1,100	72,100	600	85,900	8,900
2033 - 2034	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,500	15,500	1,100	72,100	600	85,400	9,000
2034 - 2035	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,600	15,500	1,100	72,100	600	74,000	9,100
2035 - 2036	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,700	15,500	1,100	72,400	600	73,700	9,100
2036 - 2037	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,800	15,500	1,100	72,400	700	73,700	9,200
2037 - 2038	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	3,900	15,500	1,100	72,400	700	73,700	9,300
2038 - 2039	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,000	15,500	1,100	72,400	700	73,700	9,300
2039 - 2040	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,400	700	64,300	9,400
2040 - 2041	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2041 - 2042	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2042 - 2043	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2043 - 2044	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2044 - 2045	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2045 - 2046	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2046 - 2047	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2047 - 2048	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2048 - 2049	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2049 - 2050	21,000	17,900	3,900	11,600	600	6,200	19,400	2,100	48,300	13,600	1,300	24,900	4,100	15,500	1,100	72,600	700	64,100	9,400
2050 - 2051	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2051 - 2052	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2052 - 2053	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2053 - 2054	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2054 - 2055	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2055 - 2056	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2056 - 2057	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2057 - 2058	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2058 - 2059	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2059 - 2060	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2060 - 2061	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2061 - 2062	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2062 - 2063	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2063 - 2064	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2064 - 2065	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2065 - 2066	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2066 - 2067	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2067 - 2068	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2068 - 2069	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
2069 - 2070	21,000	17,400	3,800	11,300	500	6,000	19,300	2,100	43,500	12,900	1,300	23,800	4,100	15,400	1,100	68,400	700	62,400	9,400
17/18-69/70 Avg	21,000	17,700	3,900	11,500	600	6,100	19,000	2,100	49,500	13,200	1,300	24,100	3,700	15,500	1,100	70,200	600	75,300	9,100

Table 2-8b

Projected Future Tule Subbasin Surface Water Budget

Water Year	Surface Water Outflow (acre-ft)													Total Out
	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	
	Evapotranspiration											Surface Outflow		
	Precipitation Crops/Native	Tule River Agricultural Cons. Use	Tule River Stream Channel	Deer Creek Agricultural Cons. Use	Deer Creek Stream Channel	White River Stream Channel	Imported Water Agricultural Cons. Use	Ag. Cons. Use from Pumping	Recycled Water Recharge in Basins	Recycled Water Agricultural Cons. Use	Municipal (Landscape ET)	Tule River	Deer Creek	
2017 - 2018	285,000	47,400	700	2,900	300	100	250,700	438,600	50	3,500	7,700	15,000	0	1,431,000
2018 - 2019	285,000	47,400	700	2,900	300	100	250,700	437,800	50	4,300	8,200	8,000	0	1,425,000
2019 - 2020	285,000	47,400	700	2,900	300	100	254,400	420,400	50	2,600	11,200	8,000	0	1,414,000
2020 - 2021	285,000	47,400	700	2,900	300	100	257,400	417,300	50	2,600	11,400	8,000	0	1,417,000
2021 - 2022	285,000	47,400	700	2,900	300	100	258,200	416,100	50	2,700	11,600	8,000	0	1,417,000
2022 - 2023	285,000	47,400	700	2,900	300	100	259,000	414,900	50	2,800	11,800	8,000	0	1,418,000
2023 - 2024	285,000	47,400	700	2,900	300	100	259,000	414,500	50	2,800	12,000	8,000	0	1,422,000
2024 - 2025	285,000	48,500	700	2,900	300	100	262,700	392,000	50	2,900	12,200	8,000	0	1,400,000
2025 - 2026	285,000	48,500	700	3,800	300	100	266,800	385,800	50	3,000	12,400	8,000	0	1,396,000
2026 - 2027	285,000	48,500	700	3,800	300	100	269,800	380,300	50	3,000	12,600	8,000	0	1,390,000
2027 - 2028	285,000	48,500	700	3,800	300	100	272,900	374,800	50	3,100	12,800	7,000	0	1,383,000
2028 - 2029	285,000	48,600	700	3,800	300	100	276,000	369,300	50	3,200	13,100	7,000	0	1,378,000
2029 - 2030	285,000	47,400	700	3,800	300	100	280,300	322,400	50	3,300	13,300	7,000	0	1,322,000
2030 - 2031	285,000	47,400	700	3,800	300	100	281,200	323,200	50	3,400	13,600	7,000	0	1,325,000
2031 - 2032	285,000	47,400	700	3,800	300	100	281,200	321,100	50	3,400	13,800	7,000	0	1,323,000
2032 - 2033	285,000	47,400	700	3,800	300	100	281,200	319,000	50	3,500	14,100	7,000	0	1,321,000
2033 - 2034	285,000	47,400	700	3,800	300	100	281,200	316,900	50	3,600	14,300	7,000	0	1,318,000
2034 - 2035	285,000	47,400	700	3,800	300	100	281,200	268,900	50	3,700	14,600	7,000	0	1,260,000
2035 - 2036	285,000	47,400	700	3,800	300	100	282,200	267,800	50	3,800	14,900	7,000	0	1,260,000
2036 - 2037	285,000	47,400	700	3,800	300	100	282,200	267,700	50	3,900	15,200	7,000	0	1,261,000
2037 - 2038	285,000	47,400	700	3,800	300	100	282,200	267,600	50	4,000	15,500	7,000	0	1,261,000
2038 - 2039	285,000	47,400	700	3,800	300	100	282,200	267,500	50	4,100	15,800	7,000	0	1,261,000
2039 - 2040	285,000	47,400	700	3,800	300	100	282,200	236,000	50	4,200	16,100	7,000	0	1,221,000
2040 - 2041	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2041 - 2042	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2042 - 2043	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2043 - 2044	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2044 - 2045	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2045 - 2046	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2046 - 2047	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2047 - 2048	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2048 - 2049	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2049 - 2050	285,000	47,400	700	3,800	300	100	282,800	235,400	50	4,200	16,100	7,000	0	1,221,000
2050 - 2051	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2051 - 2052	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2052 - 2053	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2053 - 2054	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2054 - 2055	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2055 - 2056	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2056 - 2057	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2057 - 2058	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2058 - 2059	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2059 - 2060	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2060 - 2061	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2061 - 2062	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2062 - 2063	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2063 - 2064	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2064 - 2065	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2065 - 2066	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2066 - 2067	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2067 - 2068	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2068 - 2069	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
2069 - 2070	285,000	45,800	700	3,700	300	100	264,400	232,300	50	4,200	16,100	6,000	0	1,183,000
86/87-16/17 Avg	285,000	46,900	700	3,600	300	100	270,800	283,800	50	3,800	14,700	7,000	0	1,262,000

Table 2-9

Projected Future Tule Subbasin Groundwater Budget

Water Year	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	Total In
	Groundwater Inflows (acre-ft)																						
		Tule River Infiltration					Deer Creek Infiltration						Imported Water Deliveries				Municipal Pumping						
																		Recycled Water					
	Areal Recharge from Precipitation	Success to Oettle Bridge Infiltration	Oettle Bridge to Turnbull Weir Infiltration	Canal Loss	Recharge in Basins	Return Flow	Before Trenton Weir Infiltration	Trenton Weir to Homeland Canal Infiltration	Canal Loss	Recharge in Basins	Return Flow	White River Infiltration	Canal Loss	Recharge in Basins	Return Flow	Agricultural Pumping Return Flow	Return Flow	Agricultural Return Flow	Artificial Recharge	Release of Water from Compression of Aquitards	Sub-surface Inflow	Mountain-Block Recharge	
2017 - 2018	21,000	17,900	3,900	17,000	12,200	15,500	11,600	600	2,100	1,300	800	6,200	65,200	15,900	66,900	110,400	7,900	600	2,000	52,000	73,000	33,000	537,000
2018 - 2019	21,000	17,900	3,900	17,000	12,200	15,500	11,600	600	2,100	1,300	800	6,200	65,200	15,900	66,900	110,300	8,100	700	2,000	56,000	71,000	33,000	539,000
2019 - 2020	21,000	17,900	3,900	17,000	13,100	15,500	11,600	600	2,100	1,300	800	6,200	65,200	19,200	68,100	106,600	8,300	400	2,500	58,000	68,000	33,000	540,000
2020 - 2021	21,000	17,900	3,900	17,000	13,100	15,500	11,600	600	2,100	1,300	800	6,200	65,200	21,400	68,700	106,000	8,300	400	2,600	60,000	64,000	33,000	541,000
2021 - 2022	21,000	17,900	3,900	17,000	13,100	15,500	11,600	600	2,100	1,300	800	6,200	65,200	21,400	68,900	105,700	8,400	400	2,600	62,000	60,000	33,000	539,000
2022 - 2023	21,000	17,900	3,900	17,000	13,100	15,500	11,600	600	2,100	1,300	800	6,200	65,200	23,000	69,100	105,400	8,400	500	2,700	64,000	57,000	33,000	539,000
2023 - 2024	21,000	17,900	3,900	17,000	13,100	15,500	11,600	600	2,100	1,300	800	6,200	65,200	27,000	69,100	105,300	8,500	500	2,800	66,000	55,000	33,000	543,000
2024 - 2025	21,000	17,900	3,900	18,200	13,700	15,800	11,600	600	2,100	1,300	800	6,200	62,400	27,900	69,600	100,200	8,500	500	2,800	61,000	51,000	33,000	530,000
2025 - 2026	21,000	17,900	3,900	18,400	13,700	15,800	11,600	600	2,100	1,300	1,100	6,200	59,600	27,300	70,200	98,900	8,600	500	2,900	59,000	50,000	33,000	524,000
2026 - 2027	21,000	17,900	3,900	18,700	13,700	15,800	11,600	600	2,100	1,300	1,100	6,200	56,800	26,700	70,500	98,000	8,600	500	3,000	59,000	50,000	33,000	520,000
2027 - 2028	21,000	17,900	3,900	19,000	13,700	15,800	11,600	600	2,100	1,300	1,100	6,200	53,900	26,100	70,900	97,000	8,700	500	3,100	59,000	50,000	33,000	516,000
2028 - 2029	21,000	17,900	3,900	19,300	13,700	15,800	11,600	600	2,100	1,300	1,100	6,200	51,100	25,500	71,300	96,000	8,700	500	3,100	59,000	51,000	33,000	514,000
2029 - 2030	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	71,800	86,900	8,800	500	3,200	52,000	51,000	33,000	495,000
2030 - 2031	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,100	86,900	8,800	600	3,300	50,000	50,000	33,000	492,000
2031 - 2032	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,100	86,400	8,900	600	3,400	49,000	51,000	33,000	492,000
2032 - 2033	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,100	85,900	8,900	600	3,500	48,000	51,000	33,000	490,000
2033 - 2034	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,100	85,400	9,000	600	3,500	47,000	51,000	33,000	489,000
2034 - 2035	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,100	74,000	9,100	600	3,600	38,000	50,000	33,000	468,000
2035 - 2036	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,400	73,700	9,100	600	3,700	35,000	50,000	33,000	465,000
2036 - 2037	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,400	73,700	9,200	700	3,800	34,000	50,000	32,000	463,000
2037 - 2038	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,400	73,700	9,300	700	3,900	33,000	51,000	32,000	463,000
2038 - 2039	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,400	73,700	9,300	700	4,000	32,000	53,000	32,000	465,000
2039 - 2040	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,400	64,300	9,400	700	4,100	23,000	51,000	32,000	444,000
2040 - 2041	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	21,000	51,000	32,000	442,000
2041 - 2042	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	20,000	52,000	32,000	442,000
2042 - 2043	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	19,000	52,000	32,000	441,000
2043 - 2044	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	19,000	52,000	32,000	441,000
2044 - 2045	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	18,000	52,000	32,000	440,000
2045 - 2046	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	17,000	53,000	32,000	440,000
2046 - 2047	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	17,000	53,000	32,000	440,000
2047 - 2048	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	16,000	53,000	32,000	439,000
2048 - 2049	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	16,000	53,000	32,000	439,000
2049 - 2050	21,000	17,900	3,900	19,400	13,600	15,500	11,600	600	2,100	1,300	1,100	6,200	48,300	24,900	72,600	64,100	9,400	700	4,100	16,000	53,000	32,000	439,000
2050 - 2051	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	16,000	52,000	31,000	423,000
2051 - 2052	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	16,000	52,000	32,000	424,000
2052 - 2053	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	16,000	53,000	31,000	424,000
2053 - 2054	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	15,000	53,000	31,000	423,000
2054 - 2055	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	15,000	53,000	31,000	423,000
2055 - 2056	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	15,000	53,000	32,000	424,000
2056 - 2057	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	14,000	53,000	31,000	422,000
2057 - 2058	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	14,000	53,000	31,000	422,000
2058 - 2059	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	14,000	53,000	31,000	422,000
2059 - 2060	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	14,000	54,000	31,000	423,000
2060 - 2061	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	13,000	54,000	31,000	422,000
2061 - 2062	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	13,000	54,000	31,000	422,000
2062 - 2063	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	13,000	54,000	31,000	422,000
2063 - 2064	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	13,000	54,000	31,000	422,000
2064 - 2065	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	12,000	54,000	31,000	421,000
2065 - 2066	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	12,000	54,000	31,000	421,000
2066 - 2067	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	12,000	54,000	31,000	421,000
2067 - 2068	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	12,000	55,000	31,000	422,000
2068 - 2069	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	11,000	55,000	31,000	421,000
2069 - 2070	21,000	17,400	3,800	19,300	12,900	15,400	11,300	500	2,100	1,300	1,100	6,000	43,500	23,800	68,400	62,400	9,400	700	4,100	11,000	55,000	31,000	421,000
17/18-69/70 Avg	21,000	17,700	3,900	19,000	13,200	15,500	11,500	600	2,100	1,300	1,100	6,100	49,500	24,100	70,200	75,300	9,100	600	3,700	30,000	54,000	32,000	462,000

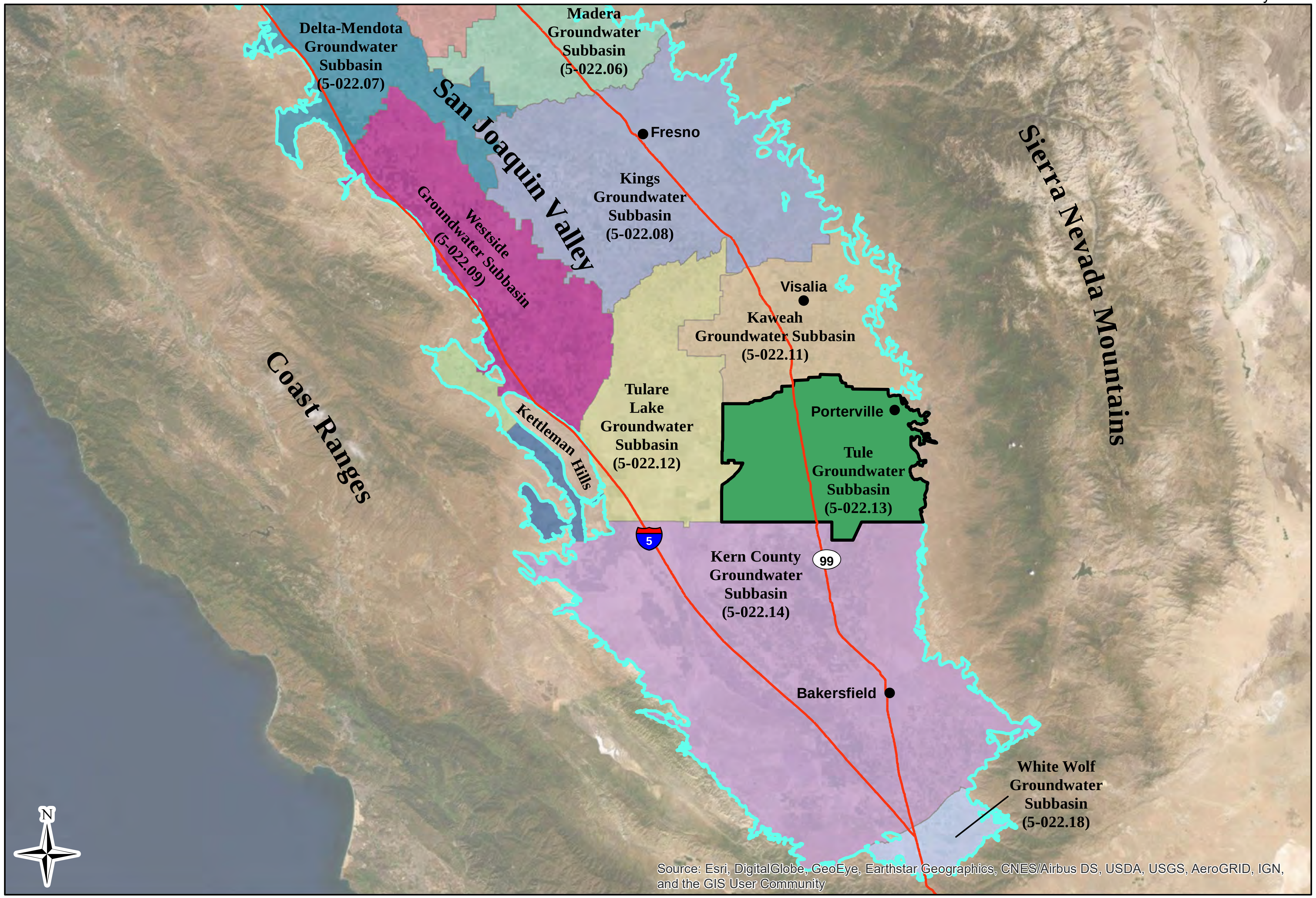
Projected Future Tule Subbasin Groundwater Budget

	Groundwater Outflows (acre-ft)						
	W	X	Y	Z	AA		
	Groundwater Pumping						
Water Year	Municipal	Irrigated Agriculture	Exports	Groundwater Banking Extraction	Sub-surface Outflow	Total Out	Change in Storage (acre-ft)
2017 - 2018	21,700	549,000	22,920	2,200	83,000	679,000	-142,000
2018 - 2019	23,400	548,000	22,920	2,200	82,000	679,000	-140,000
2019 - 2020	25,000	529,000	22,920	2,200	83,000	662,000	-122,000
2020 - 2021	25,400	526,000	22,920	2,200	83,000	660,000	-119,000
2021 - 2022	25,700	524,000	22,920	2,200	84,000	659,000	-120,000
2022 - 2023	26,100	523,000	22,920	2,200	85,000	659,000	-120,000
2023 - 2024	26,500	522,000	22,920	2,200	85,000	659,000	-116,000
2024 - 2025	26,900	494,000	22,920	2,200	86,000	632,000	-102,000
2025 - 2026	27,400	487,000	20,010	2,200	90,000	627,000	-103,000
2026 - 2027	27,800	481,000	20,010	2,200	92,000	623,000	-103,000
2027 - 2028	28,200	474,000	20,010	2,200	94,000	618,000	-102,000
2028 - 2029	28,700	468,000	20,010	2,200	96,000	615,000	-101,000
2029 - 2030	29,200	412,000	20,010	2,200	94,000	557,000	-62,000
2030 - 2031	29,600	413,000	17,100	2,200	95,000	557,000	-65,000
2031 - 2032	30,100	410,000	17,100	2,200	94,000	553,000	-61,000
2032 - 2033	30,600	407,000	17,100	2,200	93,000	550,000	-60,000
2033 - 2034	31,100	405,000	17,100	2,200	92,000	547,000	-58,000
2034 - 2035	31,700	345,000	17,100	2,200	93,000	489,000	-21,000
2035 - 2036	32,200	344,000	14,190	2,200	93,000	486,000	-21,000
2036 - 2037	32,800	344,000	14,190	2,200	91,000	484,000	-21,000
2037 - 2038	33,300	344,000	14,190	2,200	89,000	483,000	-20,000
2038 - 2039	33,900	344,000	14,190	2,200	88,000	482,000	-17,000
2039 - 2040	34,500	303,000	11,280	2,200	90,000	441,000	3,000
2040 - 2041	34,500	302,000	11,280	2,200	90,000	440,000	2,000
2041 - 2042	34,500	302,000	11,280	2,200	90,000	440,000	2,000
2042 - 2043	34,500	302,000	11,280	2,200	90,000	440,000	1,000
2043 - 2044	34,500	302,000	11,280	2,200	90,000	440,000	1,000
2044 - 2045	34,500	302,000	11,280	2,200	90,000	440,000	0
2045 - 2046	34,500	302,000	11,280	2,200	89,000	439,000	1,000
2046 - 2047	34,500	302,000	11,280	2,200	89,000	439,000	1,000
2047 - 2048	34,500	302,000	11,280	2,200	89,000	439,000	0
2048 - 2049	34,500	302,000	11,280	2,200	89,000	439,000	0
2049 - 2050	34,500	302,000	11,280	2,200	88,000	438,000	1,000
2050 - 2051	34,500	297,000	11,280	2,200	88,000	433,000	-10,000
2051 - 2052	34,500	297,000	11,280	2,200	88,000	433,000	-9,000
2052 - 2053	34,500	297,000	11,280	2,200	87,000	432,000	-8,000
2053 - 2054	34,500	297,000	11,280	2,200	87,000	432,000	-9,000
2054 - 2055	34,500	297,000	11,280	2,200	87,000	432,000	-9,000
2055 - 2056	34,500	297,000	11,280	2,200	87,000	432,000	-8,000
2056 - 2057	34,500	297,000	11,280	2,200	86,000	431,000	-9,000
2057 - 2058	34,500	297,000	11,280	2,200	86,000	431,000	-9,000
2058 - 2059	34,500	297,000	11,280	2,200	86,000	431,000	-9,000
2059 - 2060	34,500	297,000	11,280	2,200	86,000	431,000	-8,000
2060 - 2061	34,500	297,000	11,280	2,200	85,000	430,000	-8,000
2061 - 2062	34,500	297,000	11,280	2,200	85,000	430,000	-8,000
2062 - 2063	34,500	297,000	11,280	2,200	85,000	430,000	-8,000
2063 - 2064	34,500	297,000	11,280	2,200	85,000	430,000	-8,000
2064 - 2065	34,500	297,000	11,280	2,200	85,000	430,000	-9,000
2065 - 2066	34,500	297,000	11,280	2,200	84,000	429,000	-8,000
2066 - 2067	34,500	297,000	11,280	2,200	84,000	429,000	-8,000
2067 - 2068	34,500	297,000	11,280	2,200	84,000	429,000	-7,000
2068 - 2069	34,500	297,000	11,280	2,200	84,000	429,000	-8,000
2069 - 2070	34,500	297,000	11,280	2,200	84,000	429,000	-8,000
17/18-69/70 Avg	32,000	361,000	14,600	2,200	88,000	498,000	-36,000

Figures

Tule Subbasin

January 2020



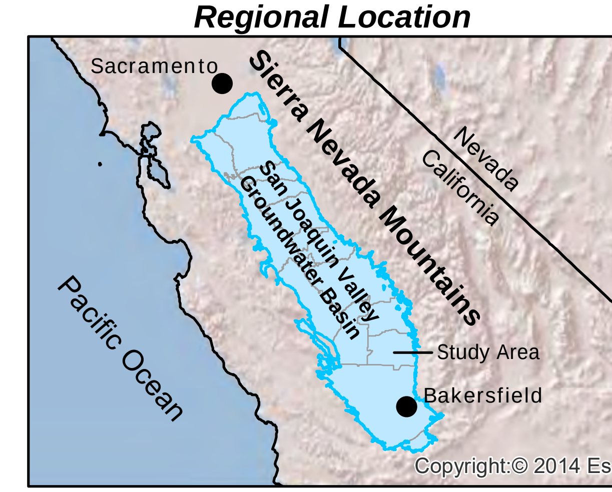
NAD 83 State Plane Zone 4

Map Features

- San Joaquin Groundwater Basin
- Major City
- Freeway/State Highway

Note: Groundwater basins from Bulletin 118, California Department of Water Resources Rev. 2016

Regional Location



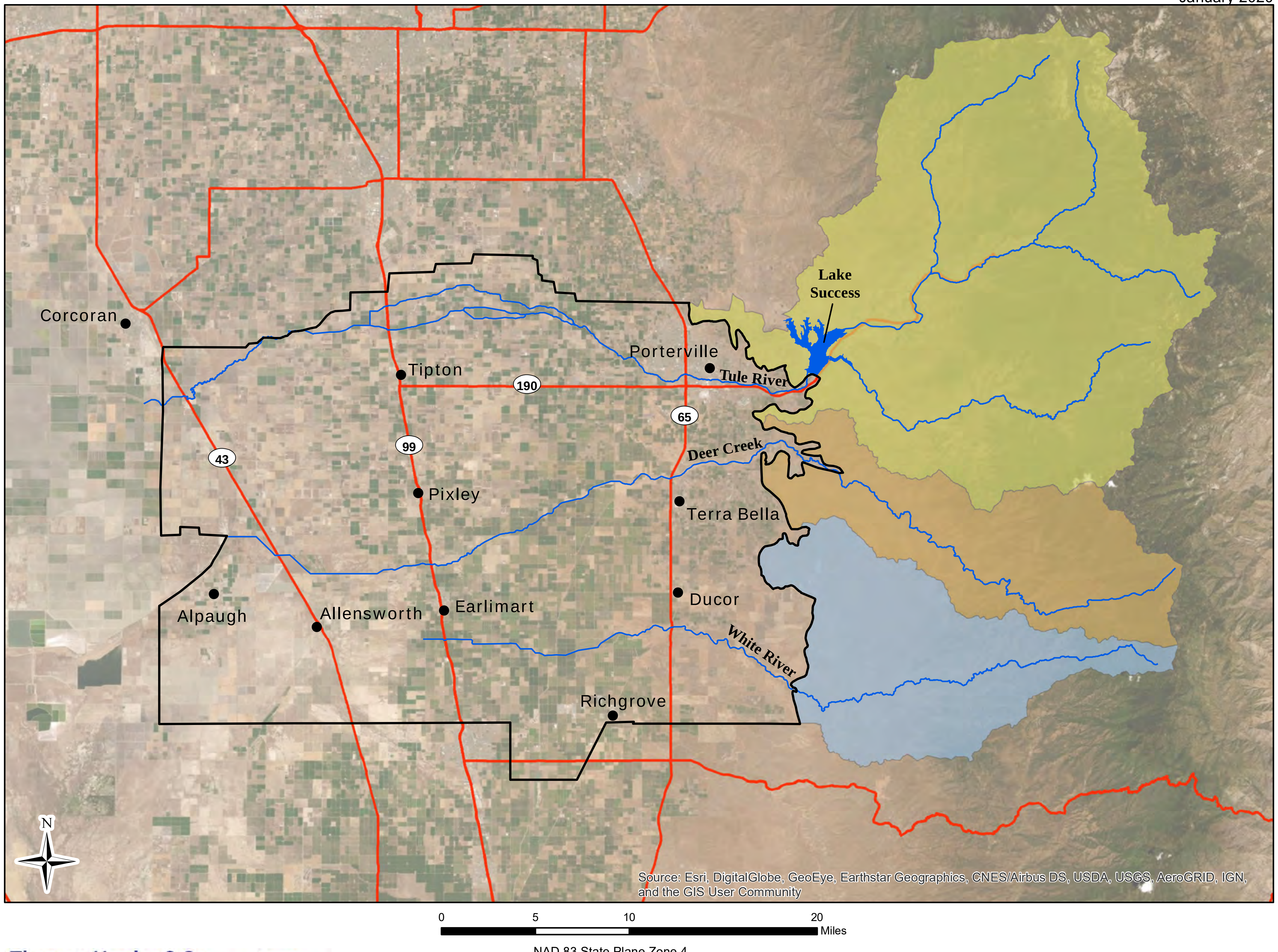
Thomas Harder & Co.
Groundwater Consulting

Regional Map

Figure 2-1

Tule Subbasin

January 2020



Map Features

- Tule Subbasin
- Tule River Drainage Basin
- California Hot Springs Drainage Basin
- White River Drainage Basin
- City or Community
- Major Hydrologic Feature
- State Highway/Major Road

Notes: Drainage basins from California Interagency Watershed Map of 1999, California Department of Water Resources.

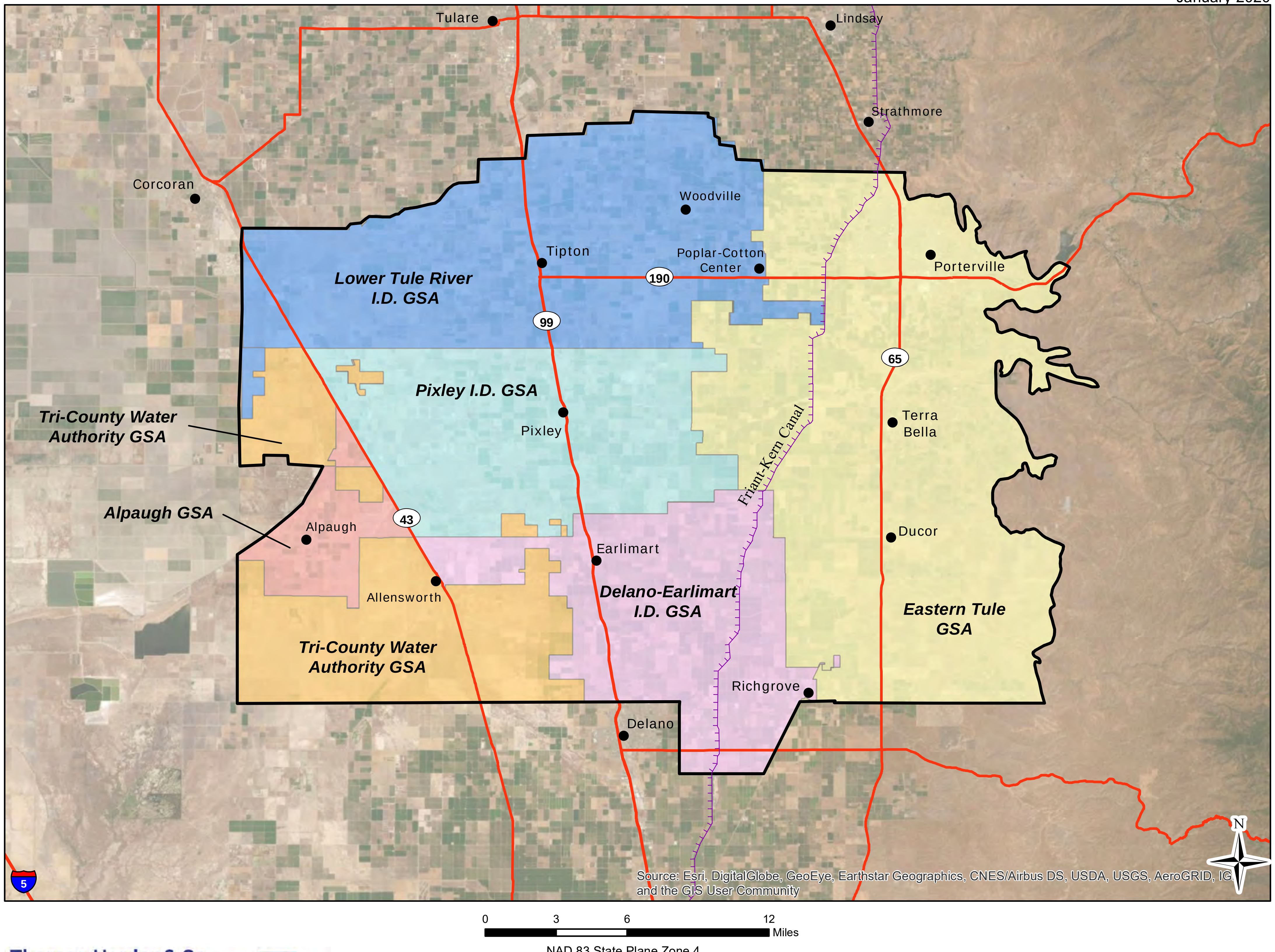
Thomas Harder & Co.
Groundwater Consulting

Tule Subbasin Area

Figure 2-2

Tule Subbasin

January 2020



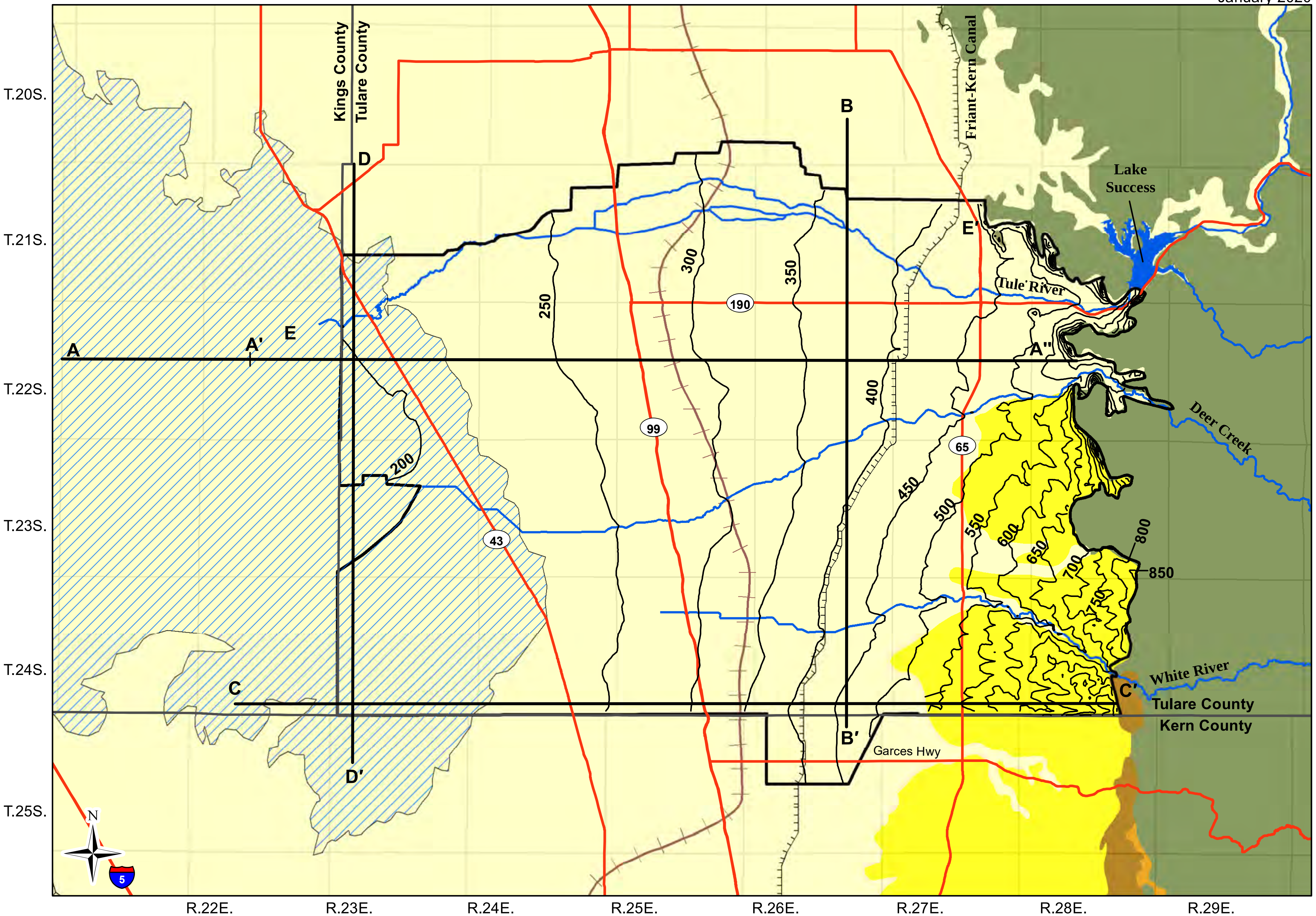
Thomas Harder & Co.
Groundwater Consulting

GSA Boundaries

Figure 2-3

Tule Subbasin

January 2020



Map Features

- Land Surface Elevation Contour (ft amsl)
- Cross Sections
- County Boundary
- Surficial Deposits
- Tertiary Loosely Consolidated Deposits
- Non-Marine Sedimentary Rocks
- Marine Sedimentary Rocks
- Crystalline Basement
- Approximate Eastern Extent of the Corcoran Clay
- Tulare Lake Surface Deposits
- Friant-Kern Canal
- Basin Boundary
- Major Hydrologic Feature
- State Highway/Major Road

Corcoran Clay from USGS Professional Paper 1766,
http://water.usgs.gov/GIS/dsdl/pp1766_CorcoranClay.zip

Geologic units modified from USGS Open-File Report 2005-1305

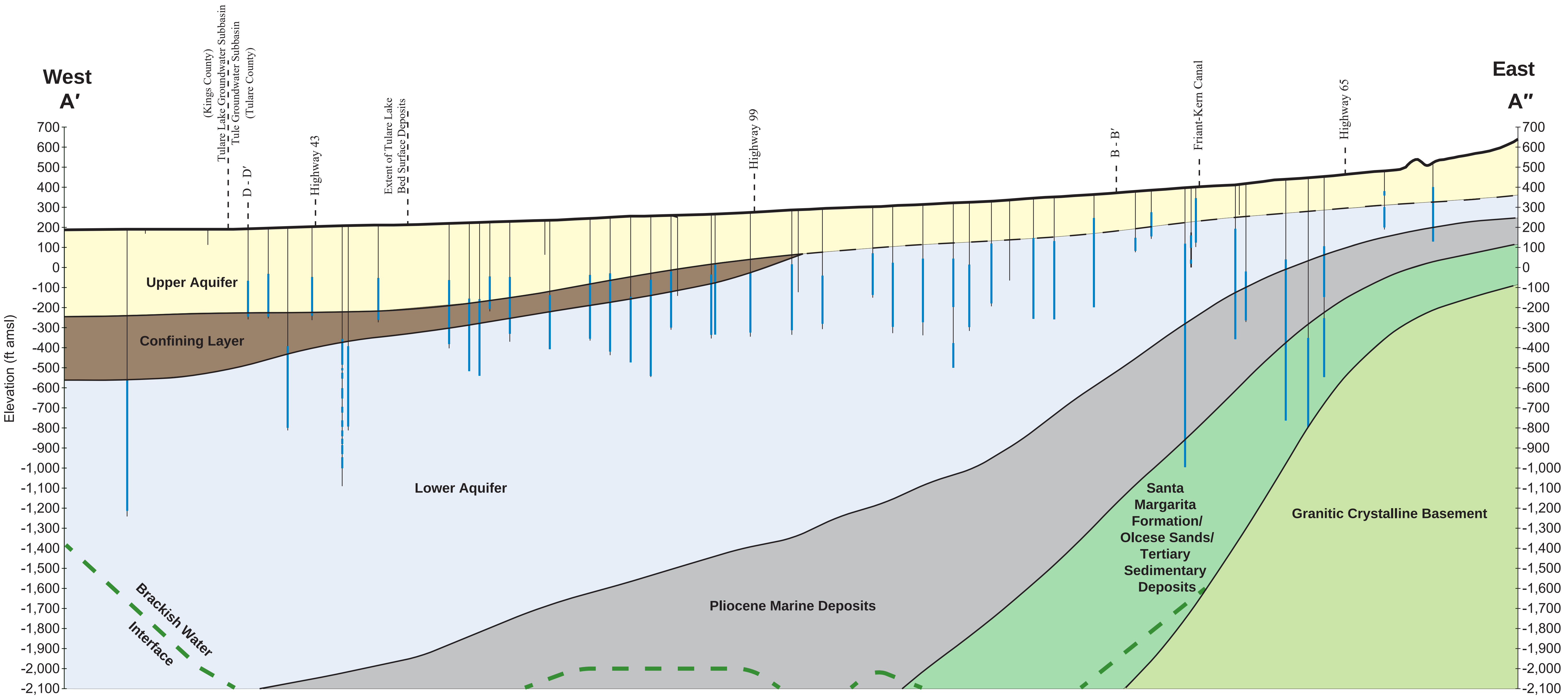
Lake Deposits from California Geological Survey Geologic Atlas of California Map No. 002 1:250,000 scale, Compiled by A.R. Smith, 1964 and Geologic Atlas of California Map No. 005, 1:250,000 scale, Compiled by: R.A. Matthews and J.L. Burnett

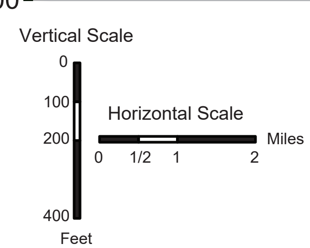
Thomas Harder & Co.
Groundwater Consulting

0 3 6 12 Miles
NAD 83 State Plane Zone 4

Geology and Cross Section Locations

Figure 2-4





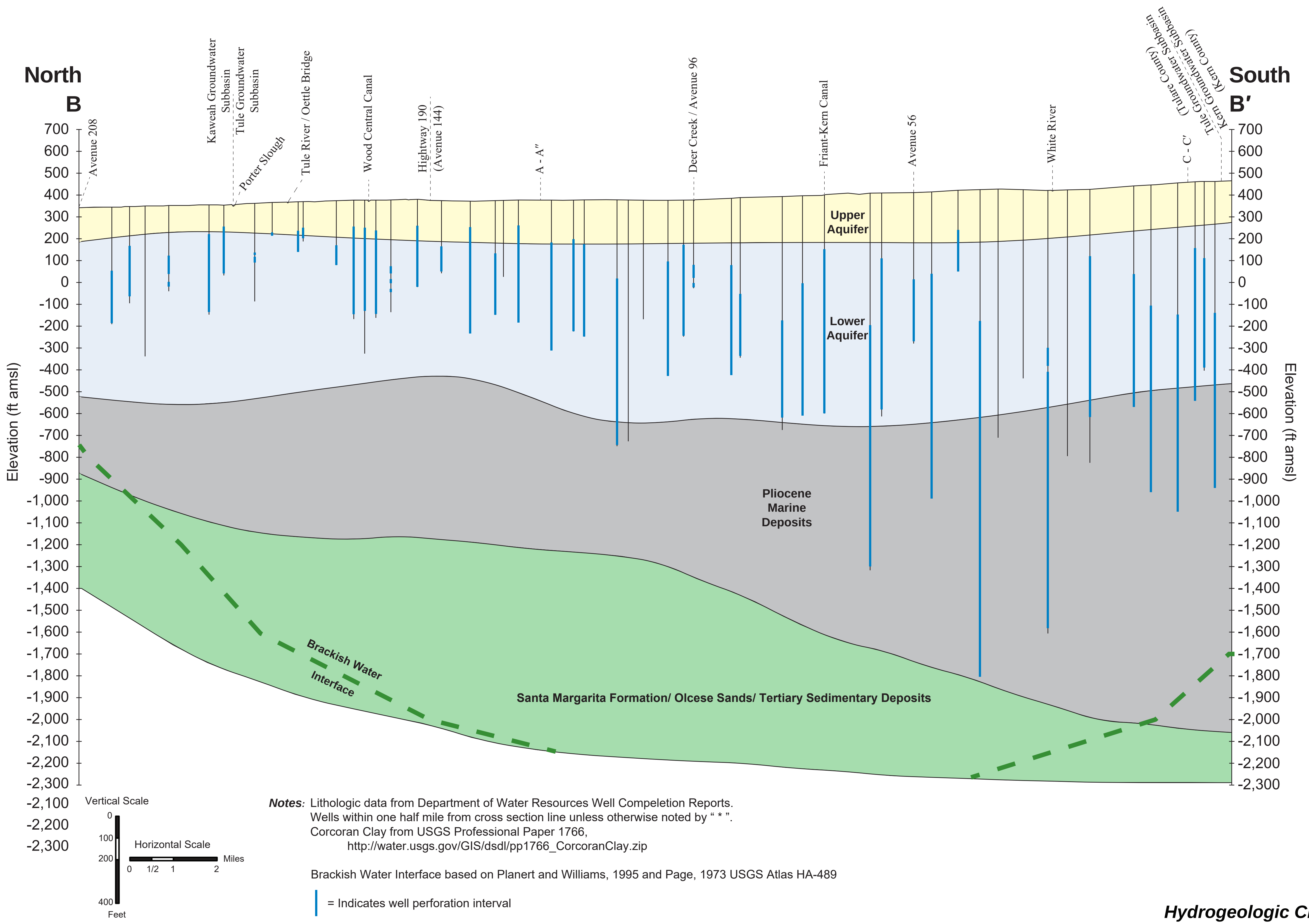
Notes: Lithologic data from Department of Water Resources Well Compeletion Reports.
Wells within one half mile from cross section line unless otherwise noted by " * ".
Corcoran Clay from USGS Professional Paper 1766,
http://water.usgs.gov/GIS/dsdl/pp1766_CorcoranClay.zip

Brackish Water Interface based on Planert and Williams, 1995 and Page, 1973 USGS Atlas HA-489

| = Indicates well perforation interval

Thomas Harder & Co.
Groundwater Consulting

Hydrogeologic Cross Section A'-A"
Tule Groundwater Subbasin
Figure 2-5
January 2020



Notes: Lithologic data from Department of Water Resources Well Compeletion Reports.
Wells within one half mile from cross section line unless otherwise noted by " * ".
Corcoran Clay from USGS Professional Paper 1766,
http://water.usgs.gov/GIS/dsdl/pp1766_CorcoranClay.zip

Brackish Water Interface based on Planert and Williams, 1995 and Page, 1973 USGS Atlas HA-489

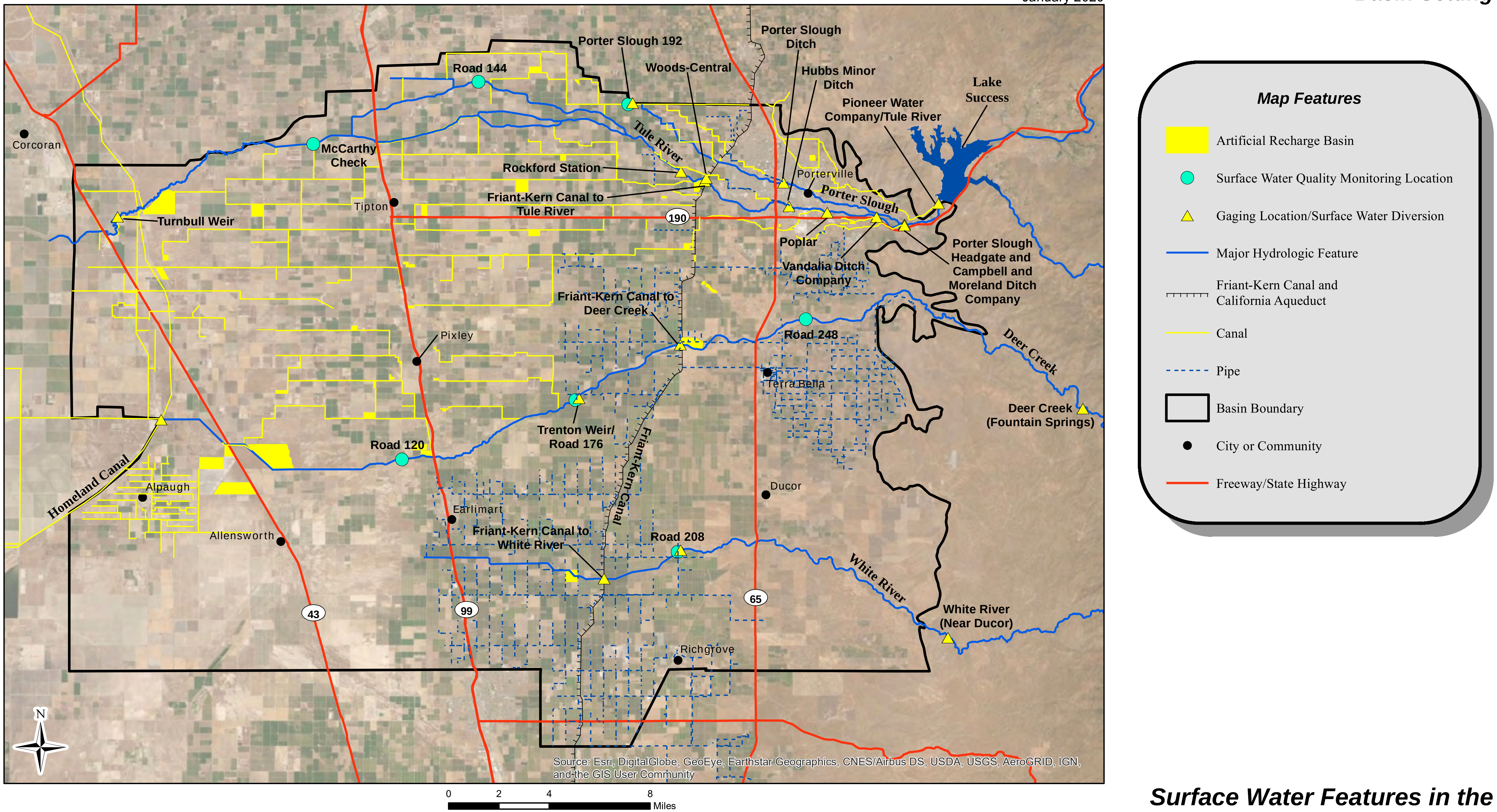
| = Indicates well perforation interval

Thomas Harder & Co.
Groundwater Consulting

Hydrogeologic Cross Section B-B′
Tule Groundwater Subbasin
Figure 2-6
January 2020

Tule Subbasin

January 2020



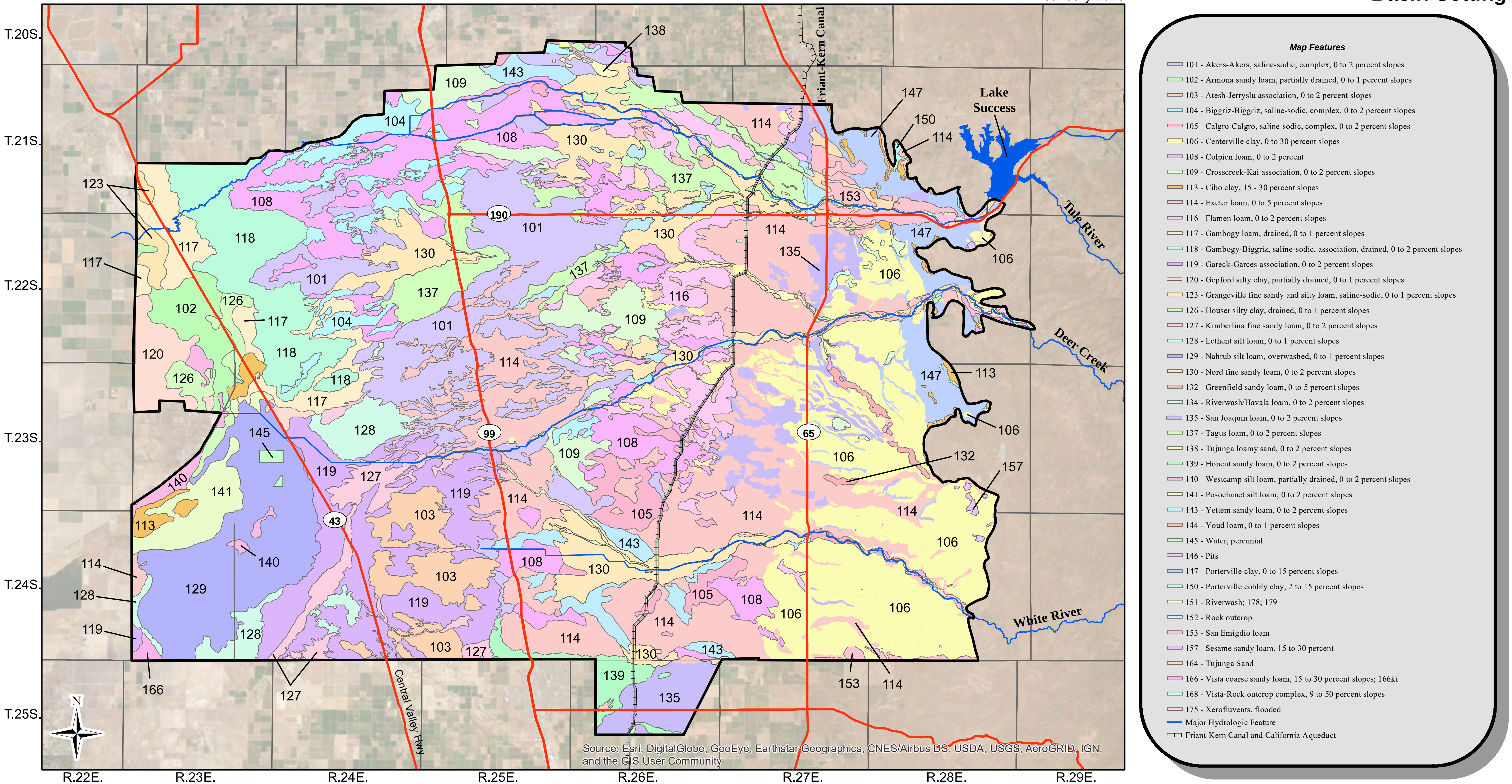
Thomas Harder & Co.
Groundwater Consulting

Surface Water Features in the Tule Subbasin and Vicinity

Figure 2-7

Tule Subbasin

January 2020



0 3 6 12 Miles

NAD 83 State Plane Zone 4

Thomas Harder & Co.
Groundwater Consulting

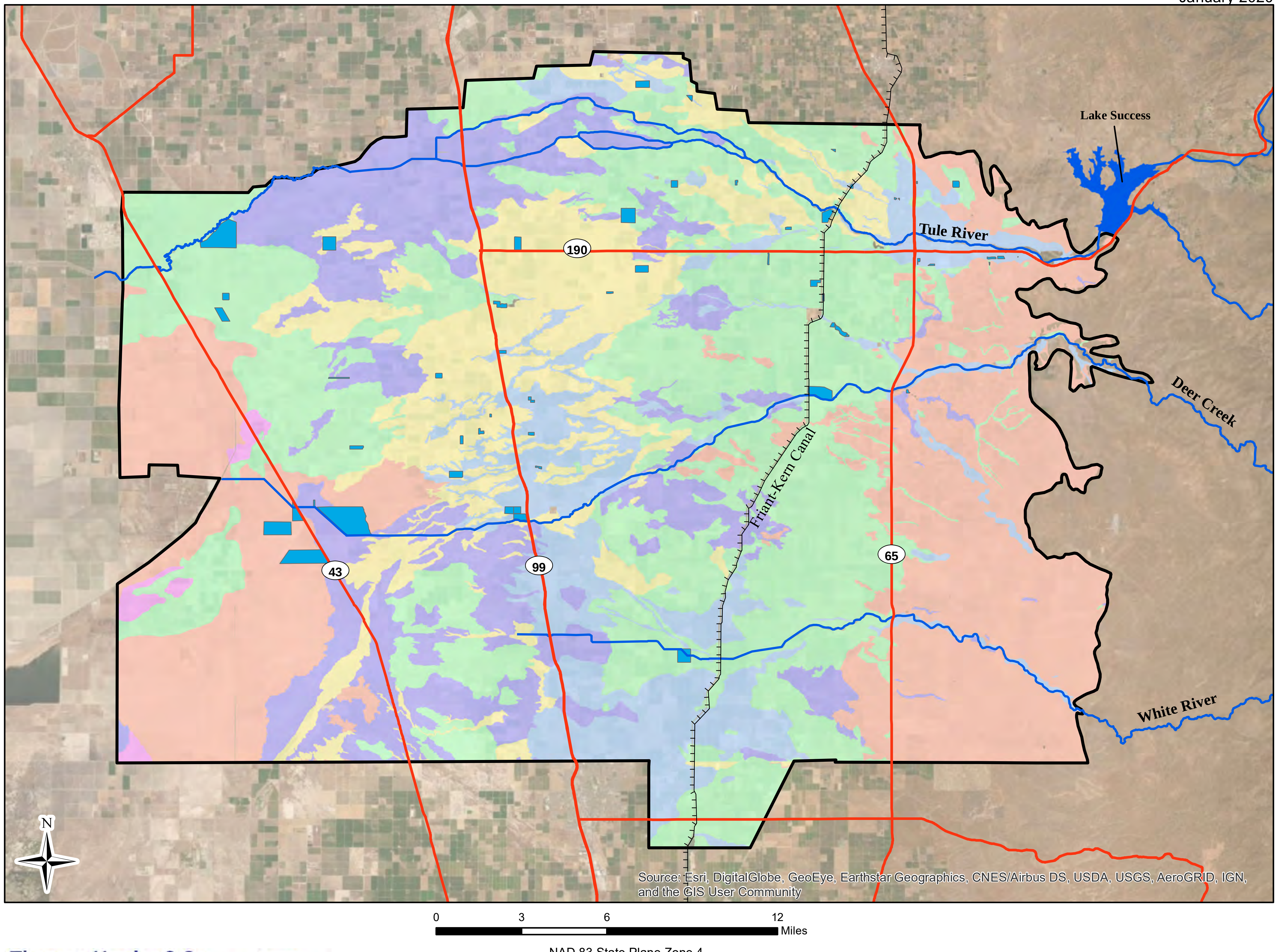
Source: USDA National Resources Conservation Service Soils - Web Soil Survey.
Associated reports inclued: USDA; Soil Survey of Tulare County, California, Western Part.
USDA; Soil Survey of Tulare County, California, Central Part.
and USDA; Soil Survey of Kern County, Northeastern Part, and Southeastern Part of Tulare County, California.

Soil Map

Figure 2-8

Tule Subbasin

January 2020



Map Features

SAGBI Index

- Excellent
- Good
- Moderately Good
- Moderately Poor
- Poor
- Very Poor
- Basin Boundary
- Artificial Recharge Basin
- Friant-Kern Canal
- Major Hydrologic Feature
- State Highway/Major Road

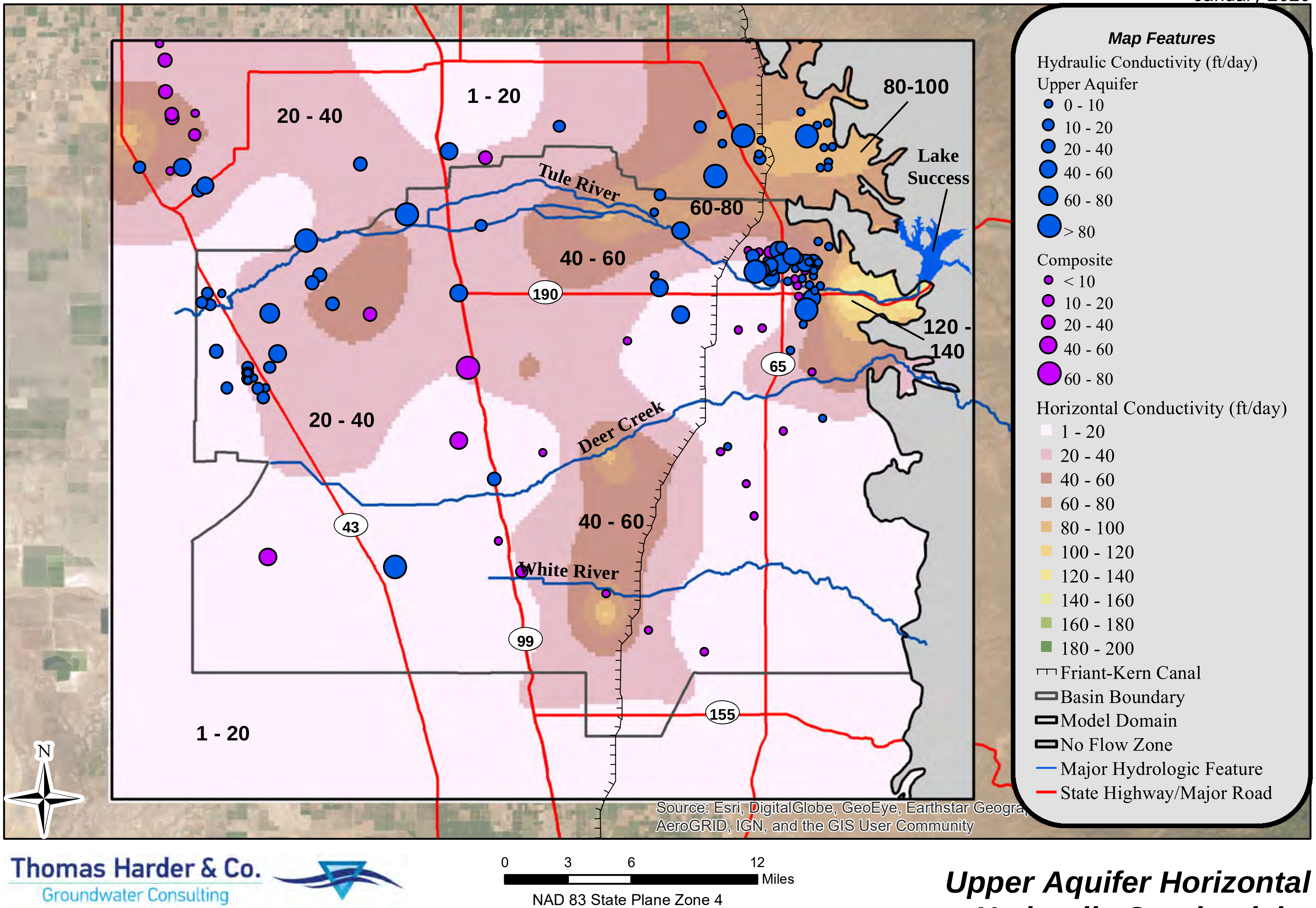
The Soil Agricultural Groundwater Banking Index (SAGBI) is a suitability index for groundwater recharge on agricultural land. It is based on five factors: deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition.

Source: SAGBI | Soil Agricultural Groundwater Banking Index interactive map. https://casoilresource.lawr.ucdavis.edu/sagbi/

Thomas Harder & Co.
Groundwater Consulting

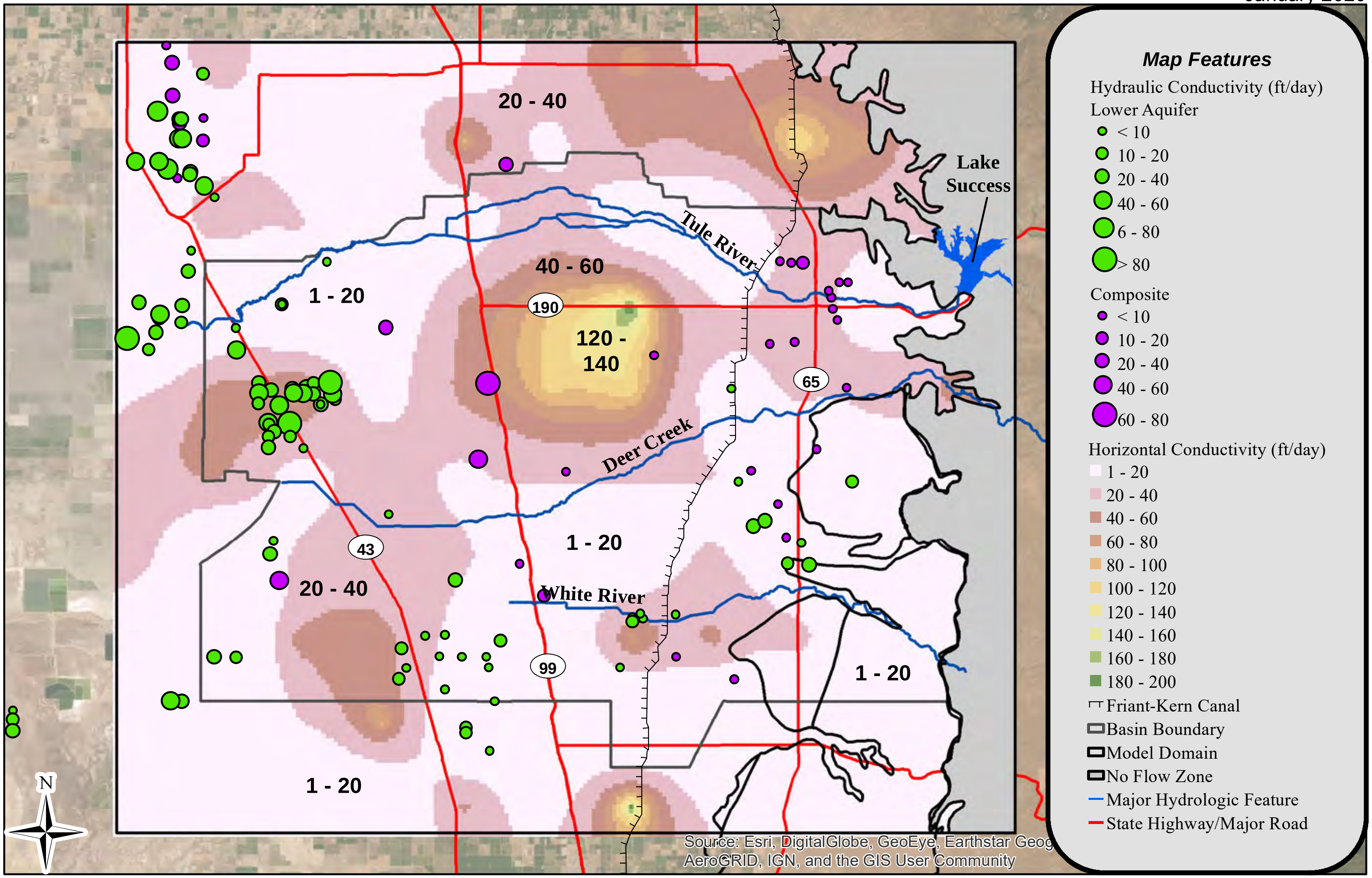
Recharge Basins and Favorable Areas for Recharge

Figure 2-9



Upper Aquifer Horizontal Hydraulic Conductivity

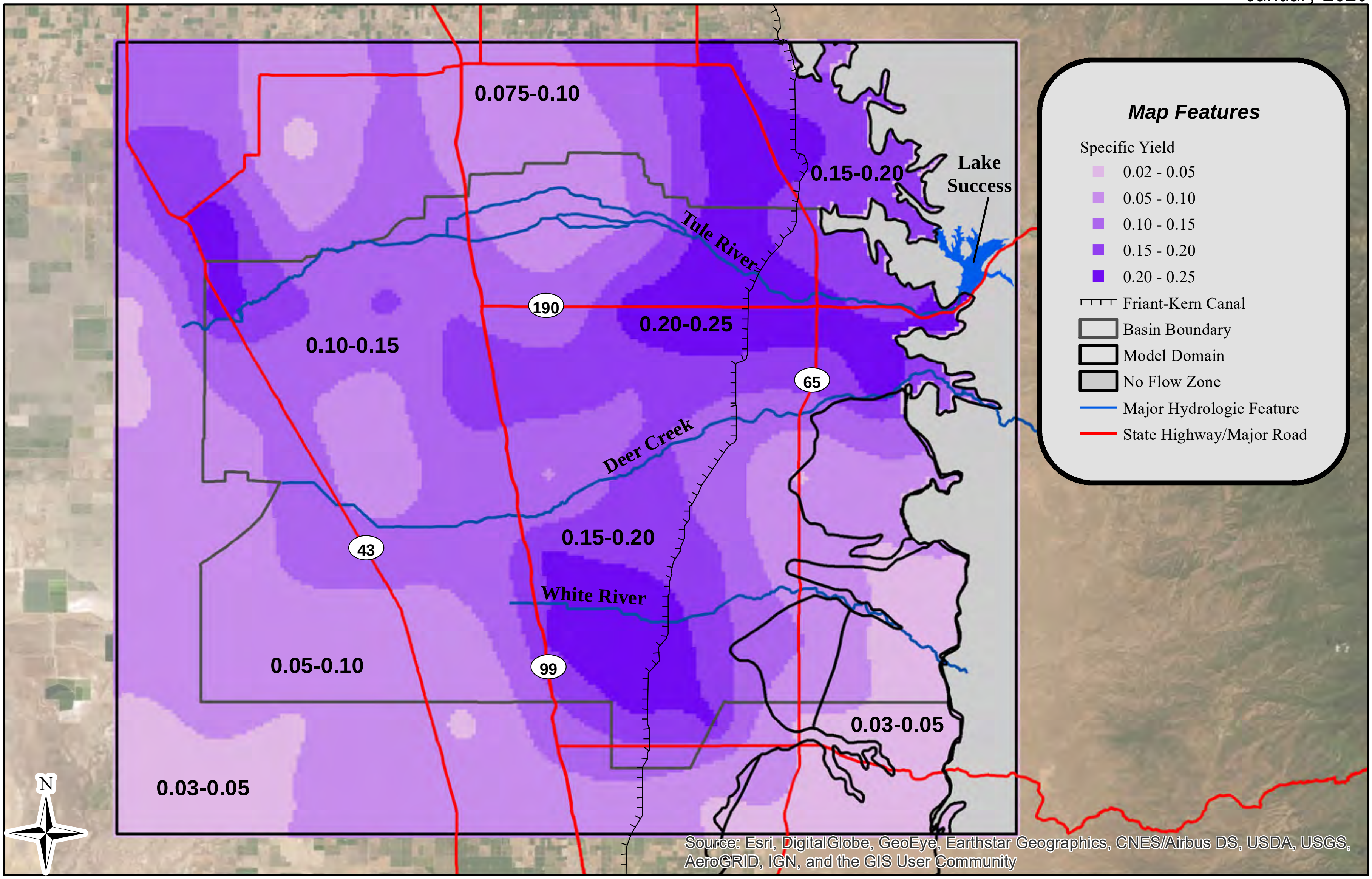
Figure 2-10



Thomas Harder & Co.
Groundwater Consulting

Lower Aquifer Horizontal Hydraulic Conductivity
Figure 2-11

Tule Subbasin

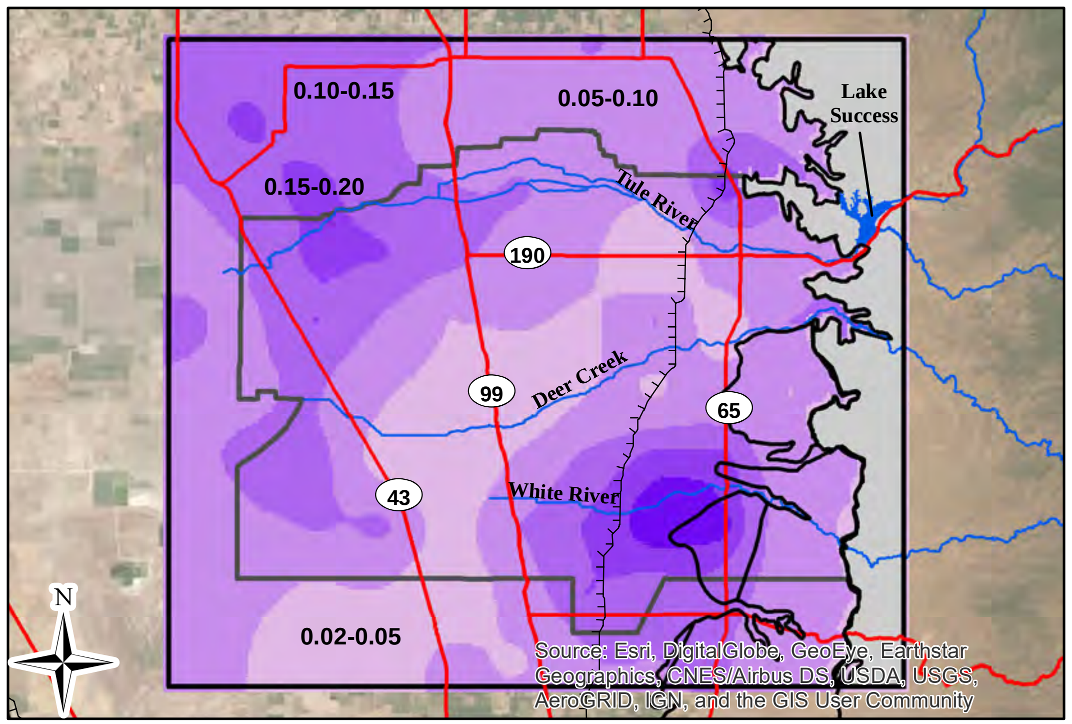


Thomas Harder & Co.
Groundwater Consulting

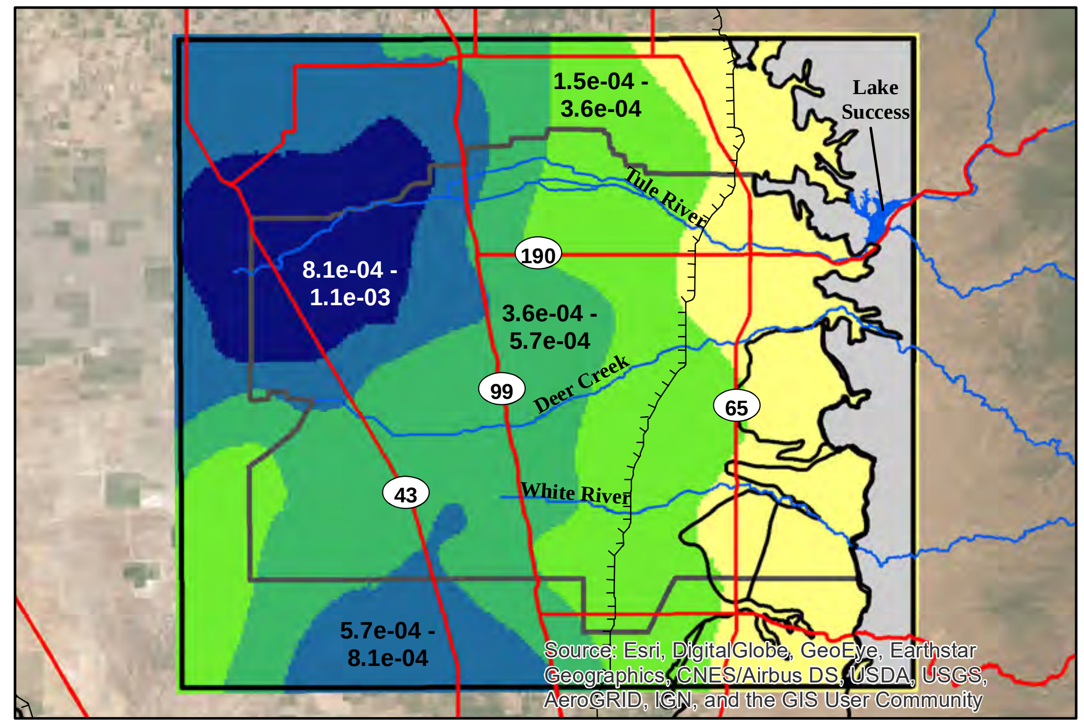
Upper Aquifer Specific Yield

Figure 2-12

Specific Yield



Storativity



Note: Specific Yield values apply to areas of the subbasin where groundwater levels are below the top of the aquifer (primarily the east side of the subbasin).Storativity values apply to areas of the subbasin where groundwater levels are confined beneath the Corcoran clay or other confining beds.

Map Features

Specific Yield (Under Unconfined Conditions)

- 0.02 - 0.05
- 0.05 - 0.10
- 0.10 - 0.15
- 0.15 - 0.20
- 0.20 - 0.25

Storativity (Under Confined Conditions)

- 8.0e-06 - 1.5e-04
- 1.5e-04 - 3.6e-04
- 3.6e-04 - 5.7e-04
- 5.7e-04 - 8.1e-04
- 8.1e-04 - 1.1e-03

- Friant-Kern Canal
- Basin Boundary
- Model Domain
- No Flow Zone
- State Highway/Major Road
- Major Hydrologic Feature

0 5 10 20 Miles

NAD 83 State Plane Zone 4

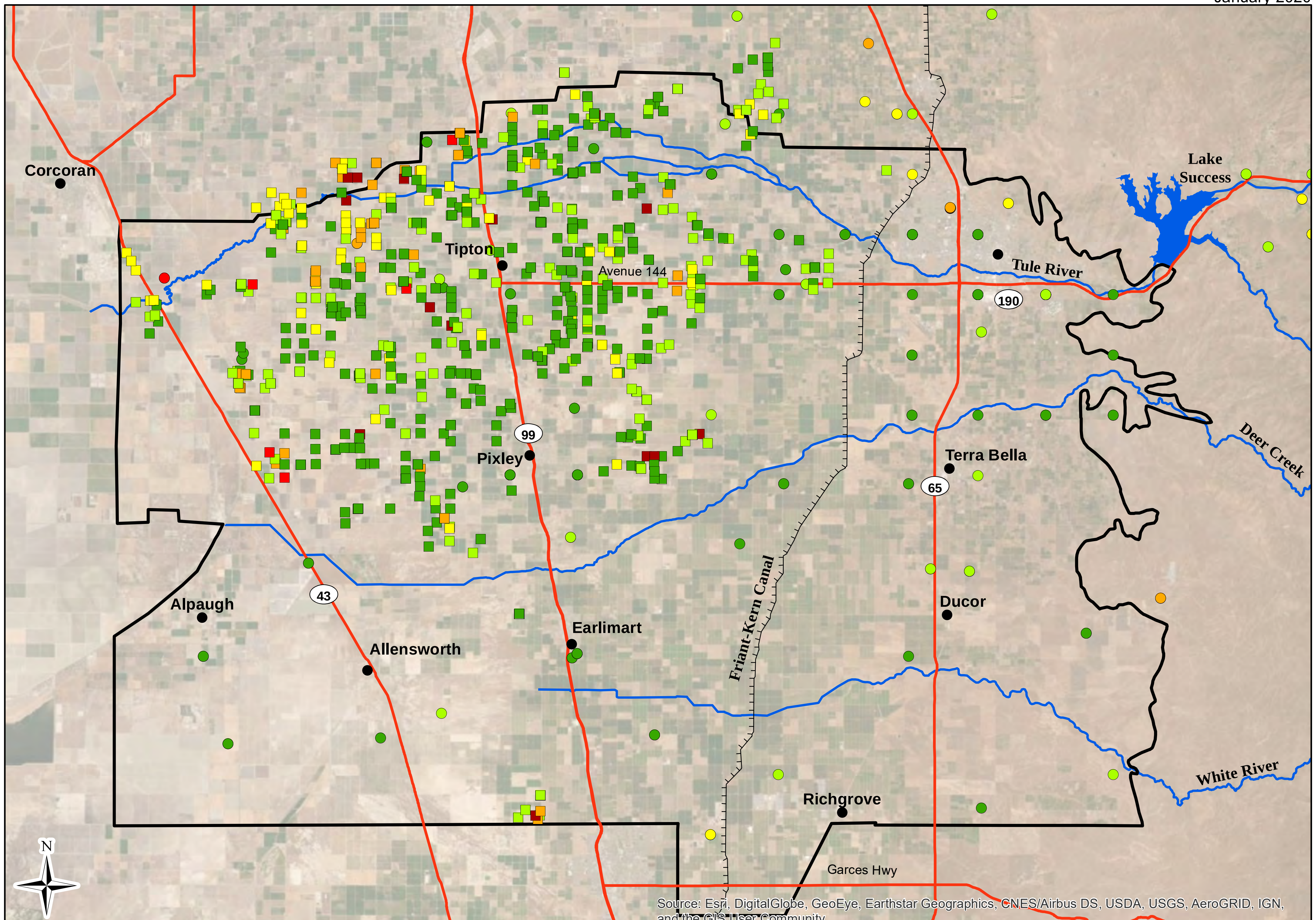
Thomas Harder & Co.
Groundwater Consulting

Lower Aquifer Storage Properties

Figure 2-13

Tule Subbasin

January 2020



Map Features

Dairy Well Electrical Conductivity (umhos/cm)

- 32 - 500
- 501 - 750
- 751 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 9700

Well Electrical Conductivity (umhos/cm)

- 180 - 500
- 501 - 750
- 751 - 1000
- 1001 - 1500
- 1501 - 2000

- City or Community
- Friant-Kern Canal
- Basin Boundary
- Major Hydrologic Feature
- State Highway/Major Road

Well Electrical Conductivity data from:
Tule Basin Water Quality Coalition, 2017

Thomas Harder & Co.
Groundwater Consulting

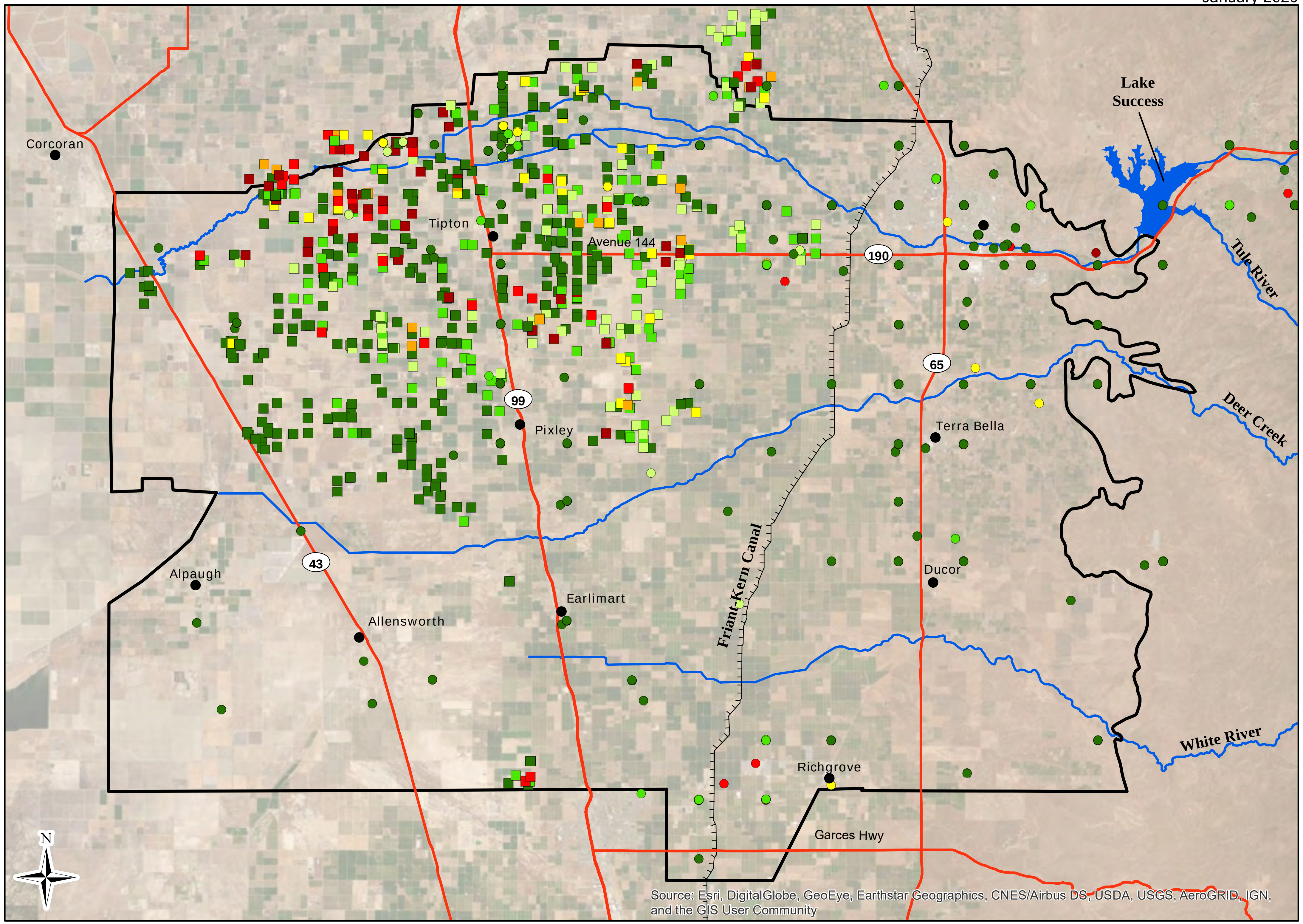
0 2.5 5 10 Miles
NAD 83 State Plane Zone 4

Electrical Conductivity 2010 - 2016

Figure 2-14

Tule Subbasin

January 2020



Map Features

Well Nitrate (mg/L)

- 6 - 15
- 16 - 30
- 31 - 45
- 46 - 60
- 61 - 75
- 76 - 100
- 101 - 190

Dairy Well Nitrate (mg/L)

- 0 - 15
- 16 - 30
- 31 - 45
- 46 - 60
- 61 - 75
- 76 - 100
- 101 - 325
- City or Community
- Friant-Kern Canal
- Basin Boundary
- Major Hydrologic Feature
- State Highway/Major Road

Well Nitrate data from:
Tule Basin Water Quality Coalition, 2017

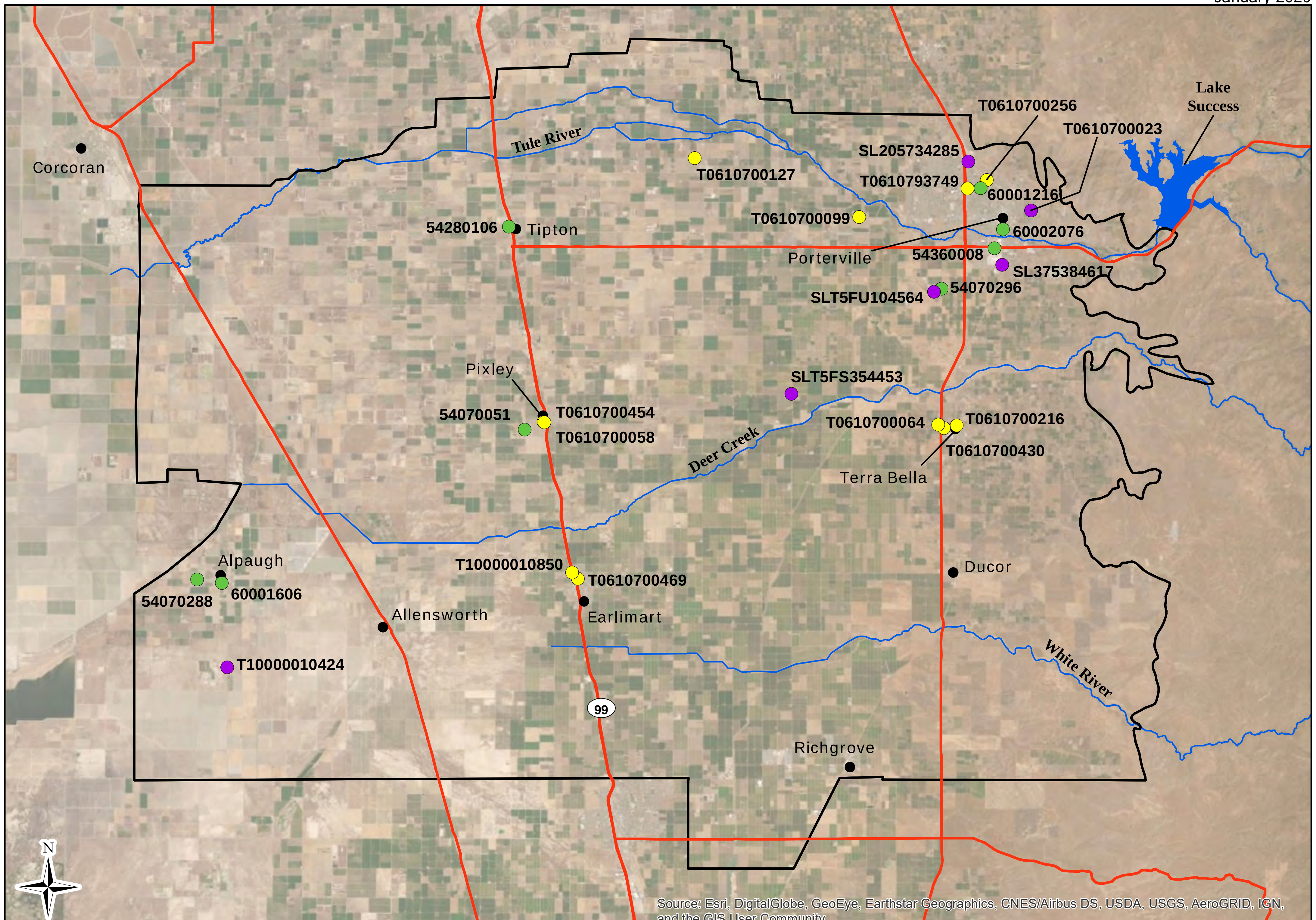
Thomas Harder & Co.
Groundwater Consulting

Nitrate (NO3) Concentration 2010 - 2016

Figure 2-15

Tule Subbasin

January 2020



0 3 6 12 Miles

NAD 83 State Plane Zone 4

Map Features

Active Cleanup Site
- Cleanup Program Site
- DTSC
- LUST Cleanup Site
- Freeway/State Highway
- Tule Subbasin
- City or Community
- Major Hydrologic Feature

Source: https://geotracker.waterboards.ca.gov

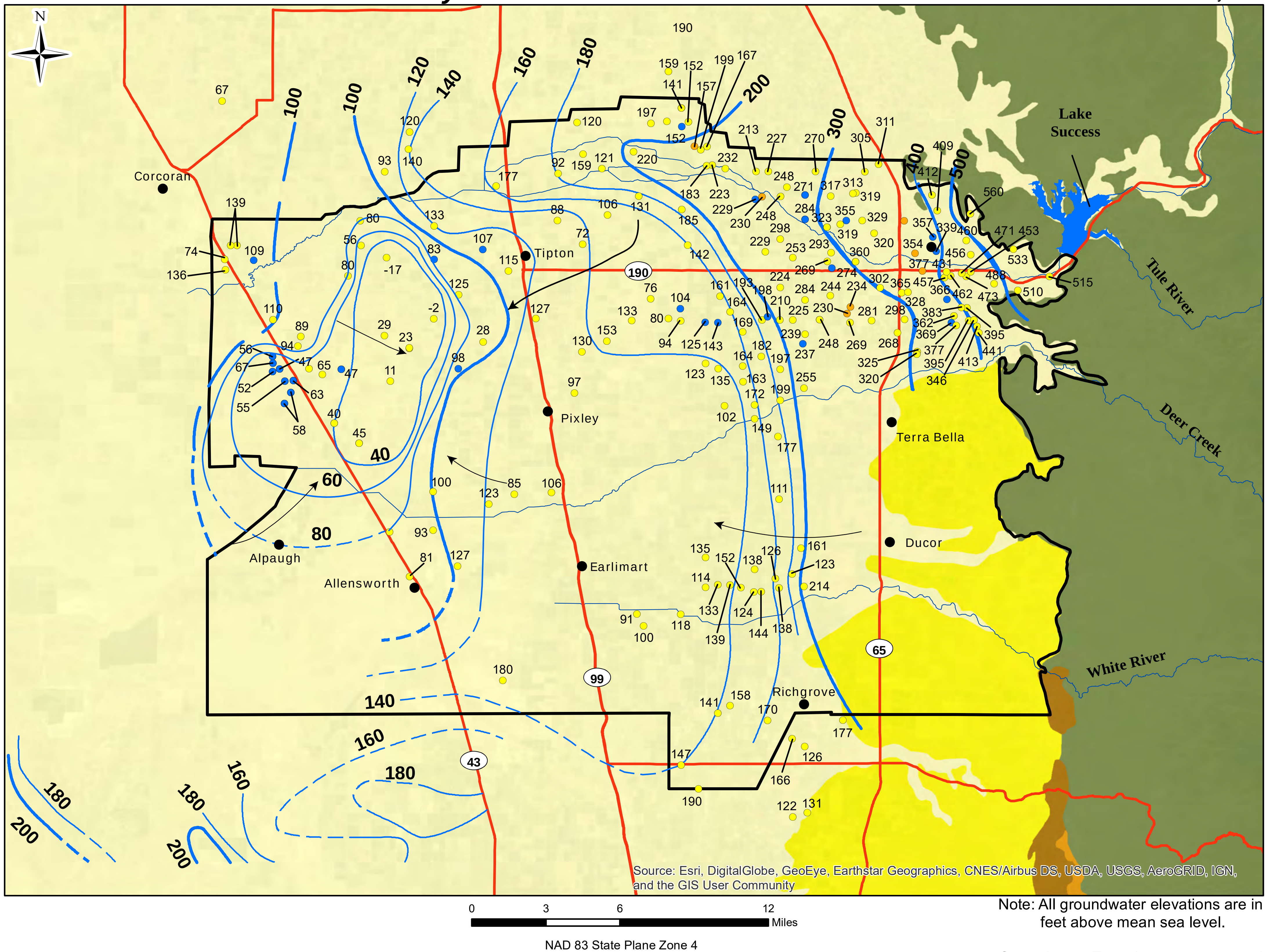
Thomas Harder & Co.
Groundwater Consulting

Active Cleanup Sites within the Tule Subbasin

Figure 2-16

Tule Subbasin Technical Advisory Committee

January 2020



Map Features

- 140 — Groundwater Elevation Contour, dashed where approximate (ft amsl)
- Groundwater Flow Direction
- Groundwater Elevations from Well with Unknown Perforation Interval
- Groundwater Elevations from Well with Perforations in the Upper and Lower Aquifer
- Groundwater Elevations from Well with Perforations in the Upper Aquifer
- Tule Subbasin
- City or Community
- Major Hydrologic Feature
- State Highway/Major Road
- Surficial Deposits
- Tertiary Loosely Consolidated Deposits
- Non-Marine Sedimentary Rocks
- Marine Sedimentary Rocks
- Crystalline Basement

Groundwater contours shown south of the Tule Subbasin and west of Highway 43 are depicted based on Water-Level Elevations And Direction of Groundwater Flow For the Upper Zone (Spring 2017)

Note: All groundwater elevations are in feet above mean sea level.

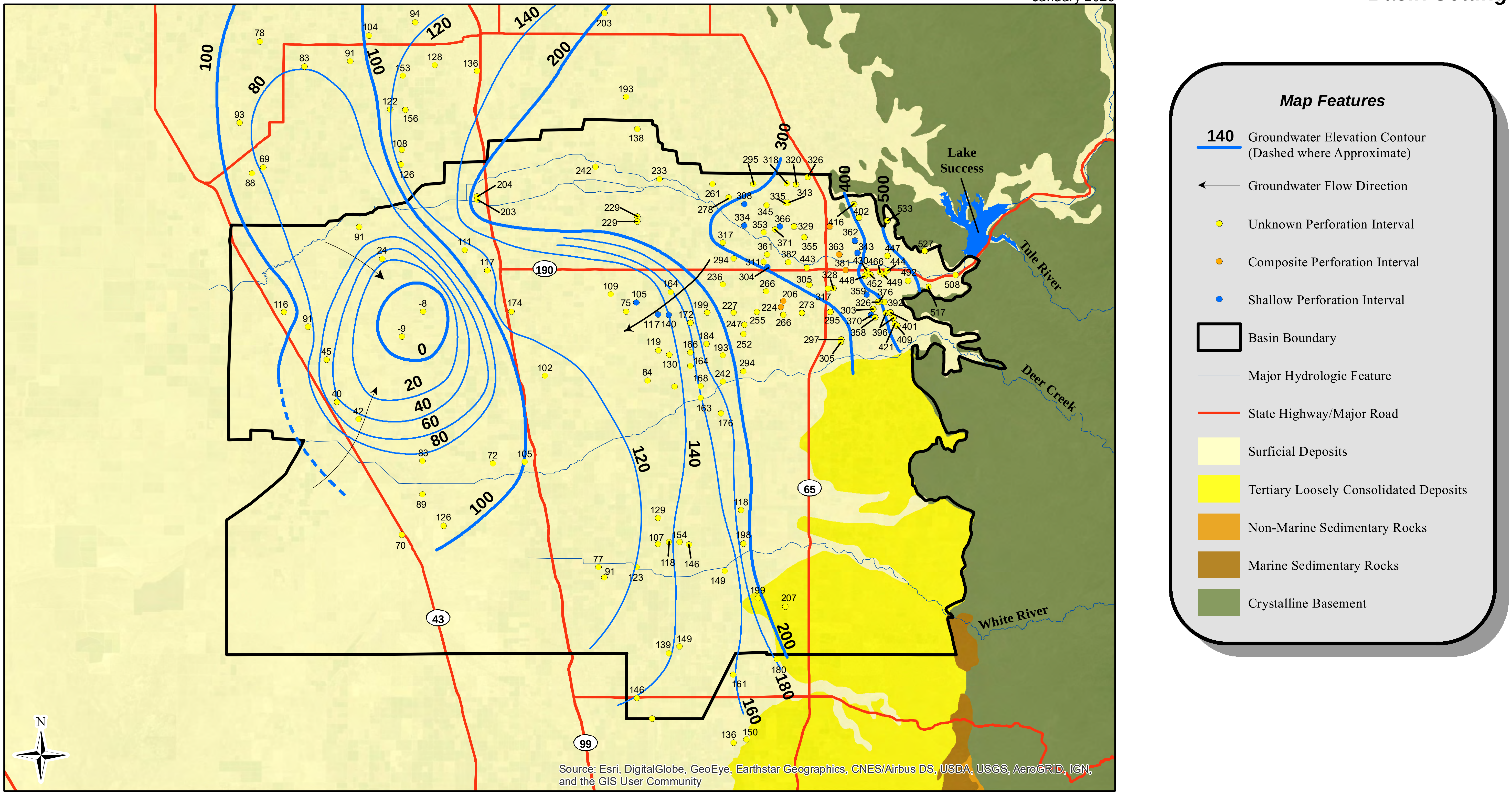
Groundwater Elevations are measured from January to May.

Spring 2017 Upper Aquifer Groundwater Elevation Contours

Figure 2-17

Tule Subbasin

January 2020



0 3 6 12 Miles

NAD 83 State Plane Zone 4

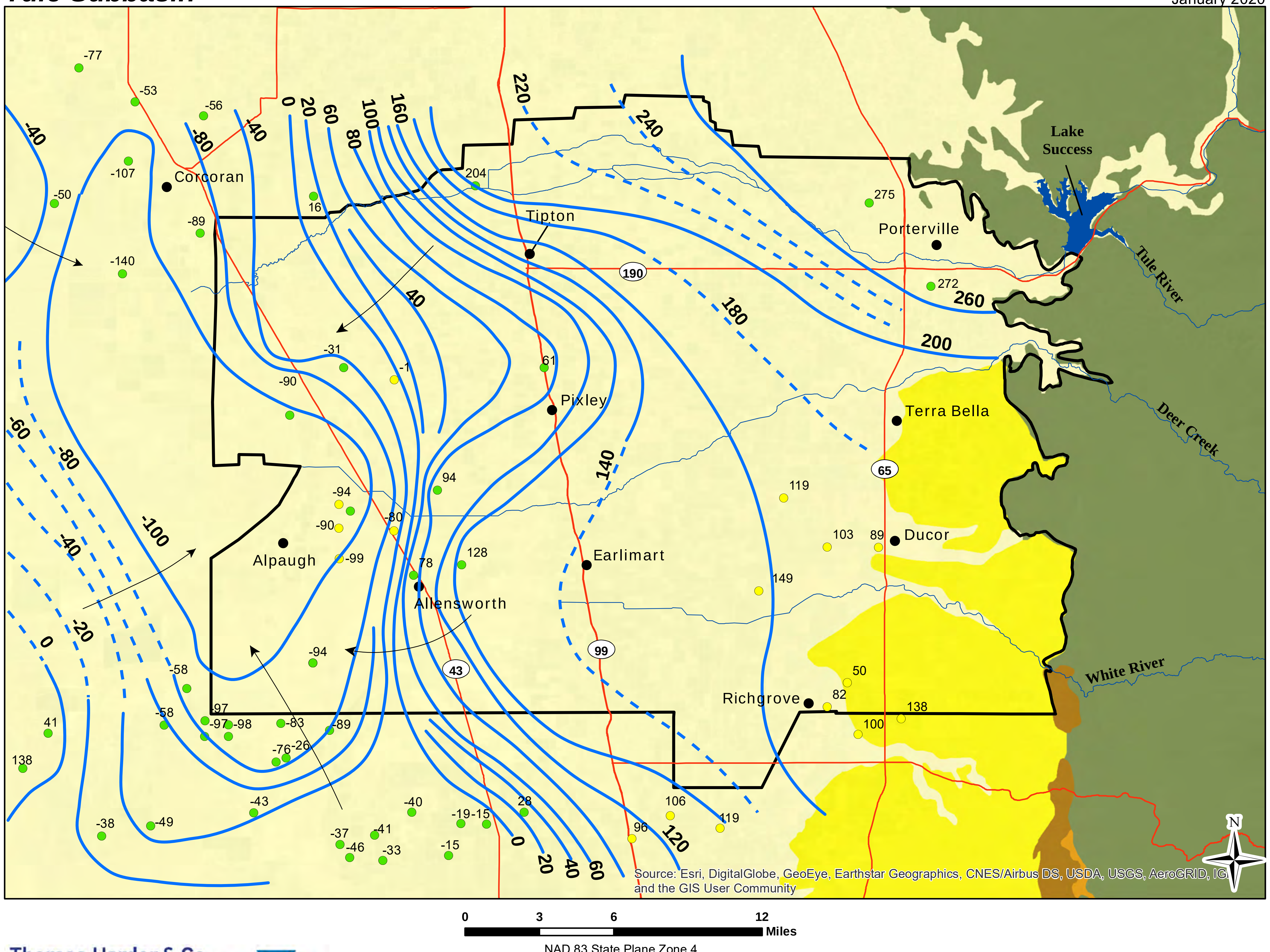
Thomas Harder & Co.
Groundwater Consulting

Fall 2017 Upper Aquifer Groundwater Elevation Contours

Figure 2-18

Tule Subbasin

January 2020



Map Features

- **140** Groundwater Elevation Contour, dashed where approximate (ft amsl)
- Groundwater Flow Direction
- Groundwater Elevations from Well with Perforations in the Deep Aquifer
- Groundwater Elevations from Well with Unknown Perforation Interval
- Basin Boundary
- City or Community
- Major Hydrologic Feature
- State Highway/Major Road
- Surficial Deposits
- Tertiary loosely consolidated deposits
- Non-Marine Sedimentary Rocks
- Marine Sedimentary Rocks
- Crystalline Basement

Note: All groundwater elevations are in feet above mean sea level.

Groundwater Elevations are measured from October to December.

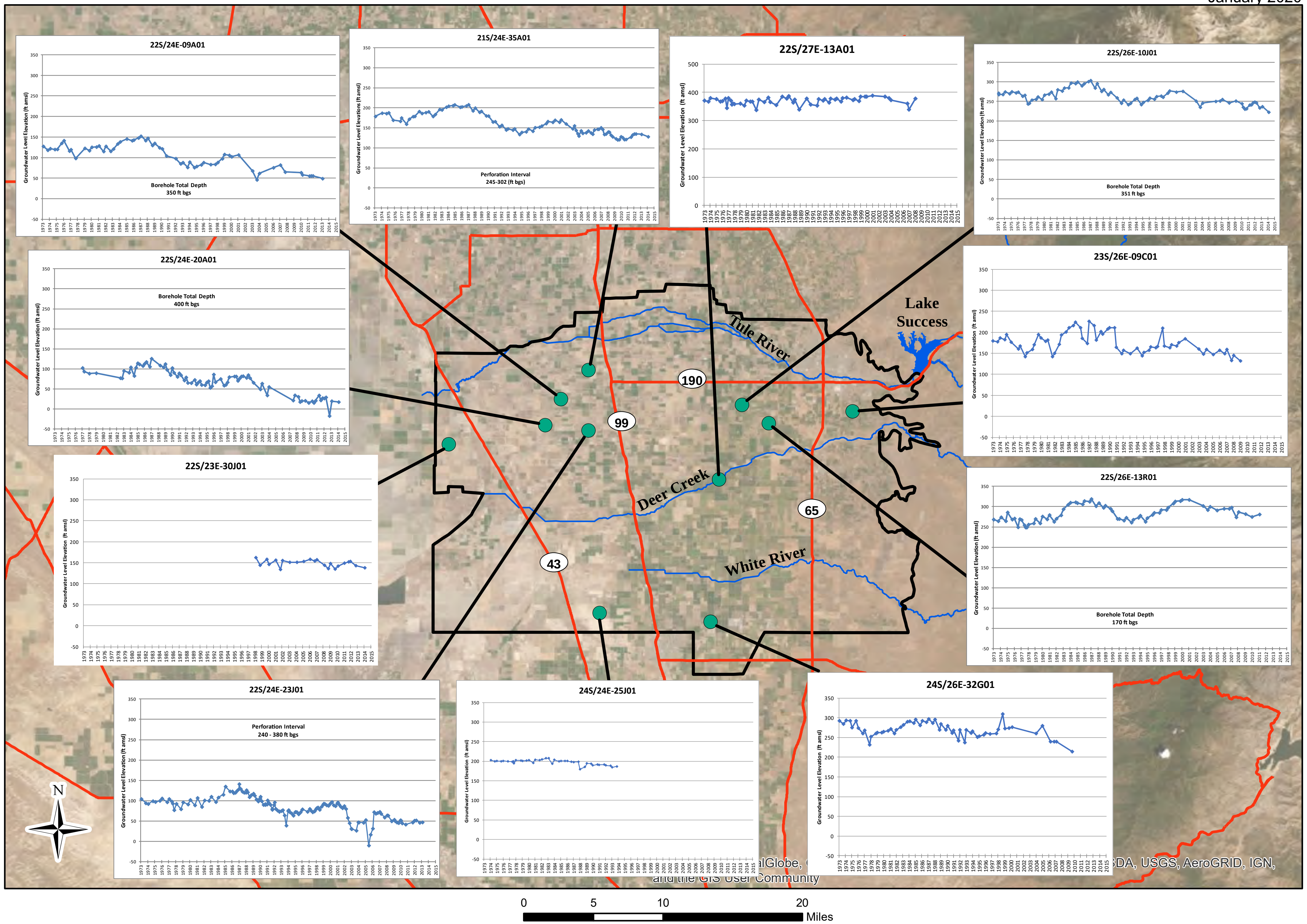
Thomas Harder & Co.
Groundwater Consulting

Fall 2010 Lower Groundwater Elevation Contour Map

Figure 2-19

Tule Subbasin

January 2020



NAD 83 State Plane Zone 4

Map Features

- Hydrograph Well
- Tule Subbasin
- Major Hydrologic Feature
- State Highway/Major Road

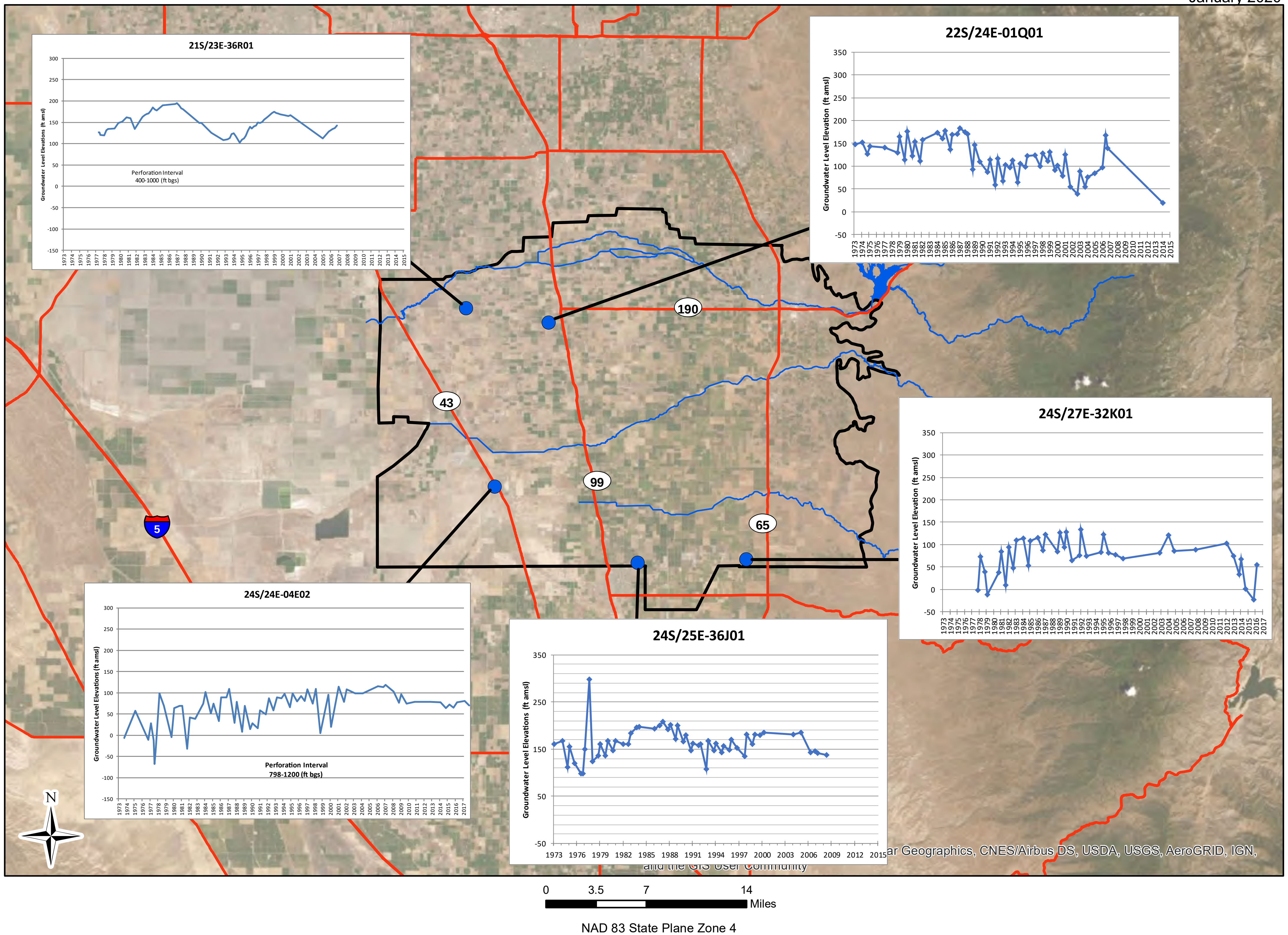
Thomas Harder & Co.
Groundwater Consulting

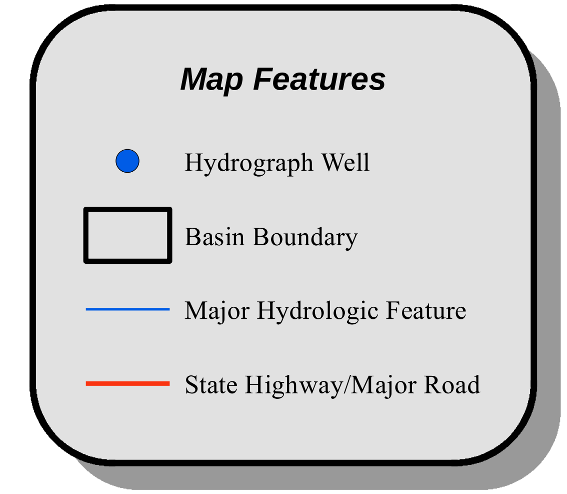
Upper Aquifer Groundwater Level Hydrographs

Figure 2 - 20

Tule Subbasin

January 2020



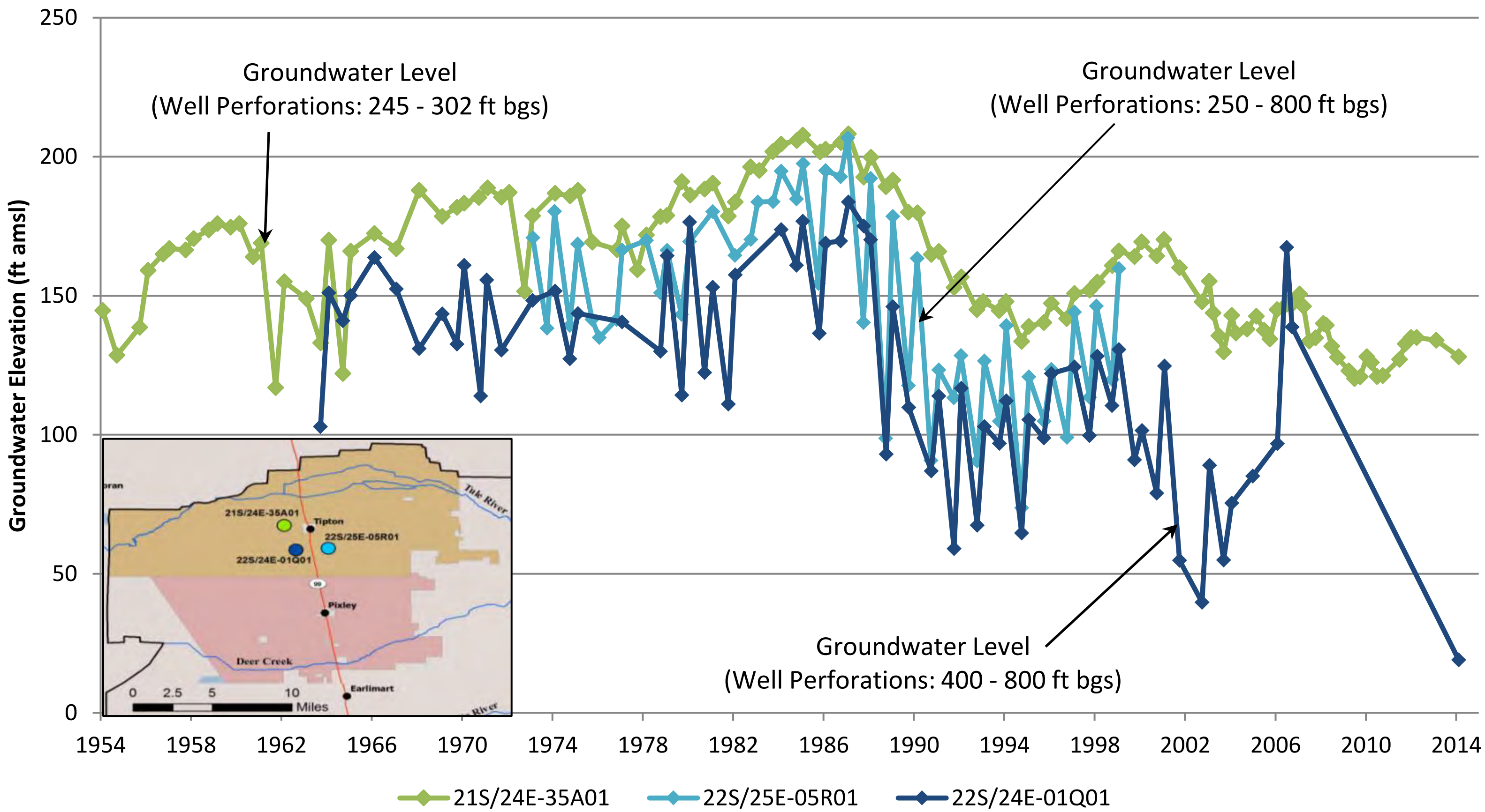


Thomas Harder & Co.
Groundwater Consulting

Lower Aquifer Groundwater Level Hydrographs

Figure 2 - 21

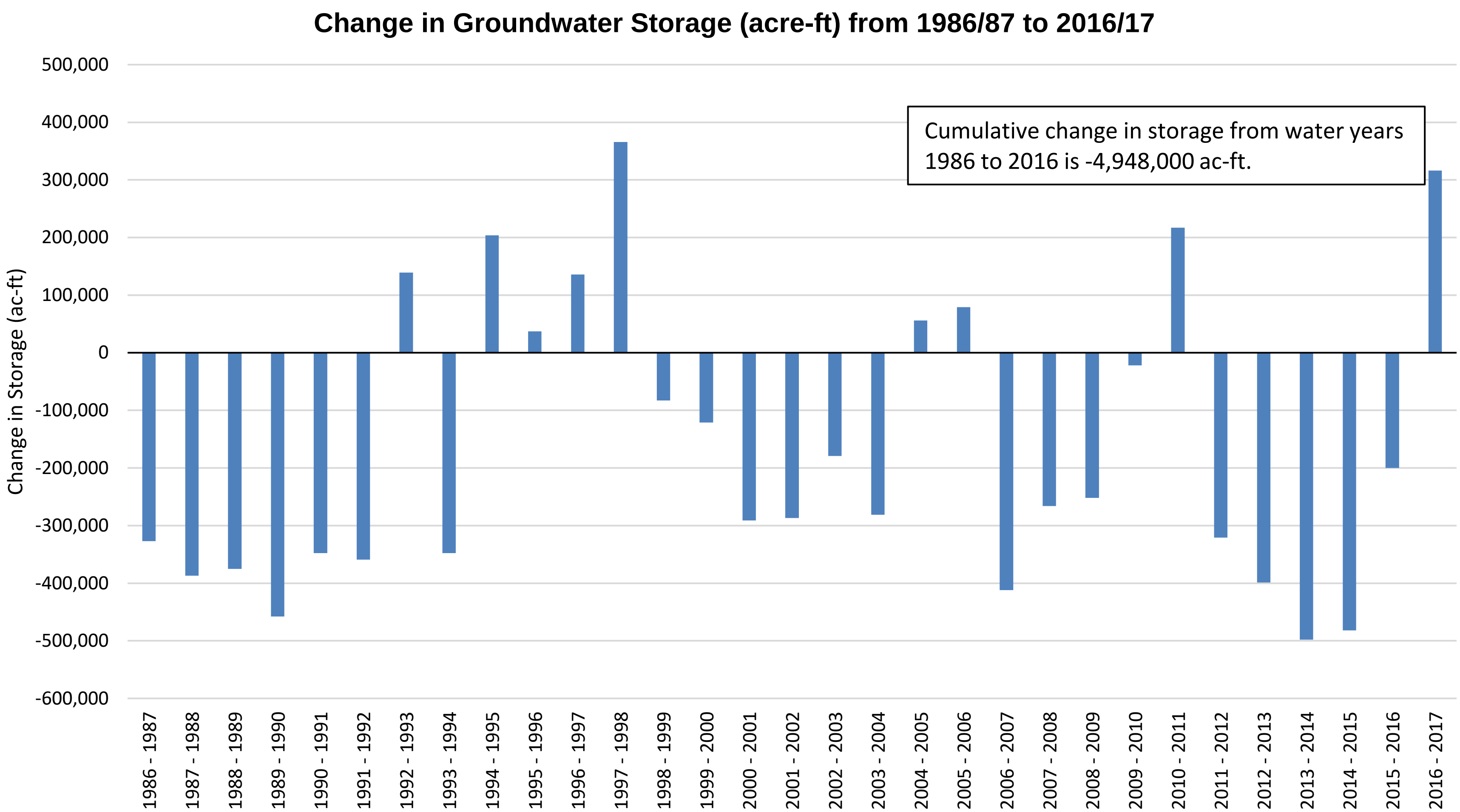
Groundwater Levels Near Tipton



Note:

ft bgs = feet below ground surface.

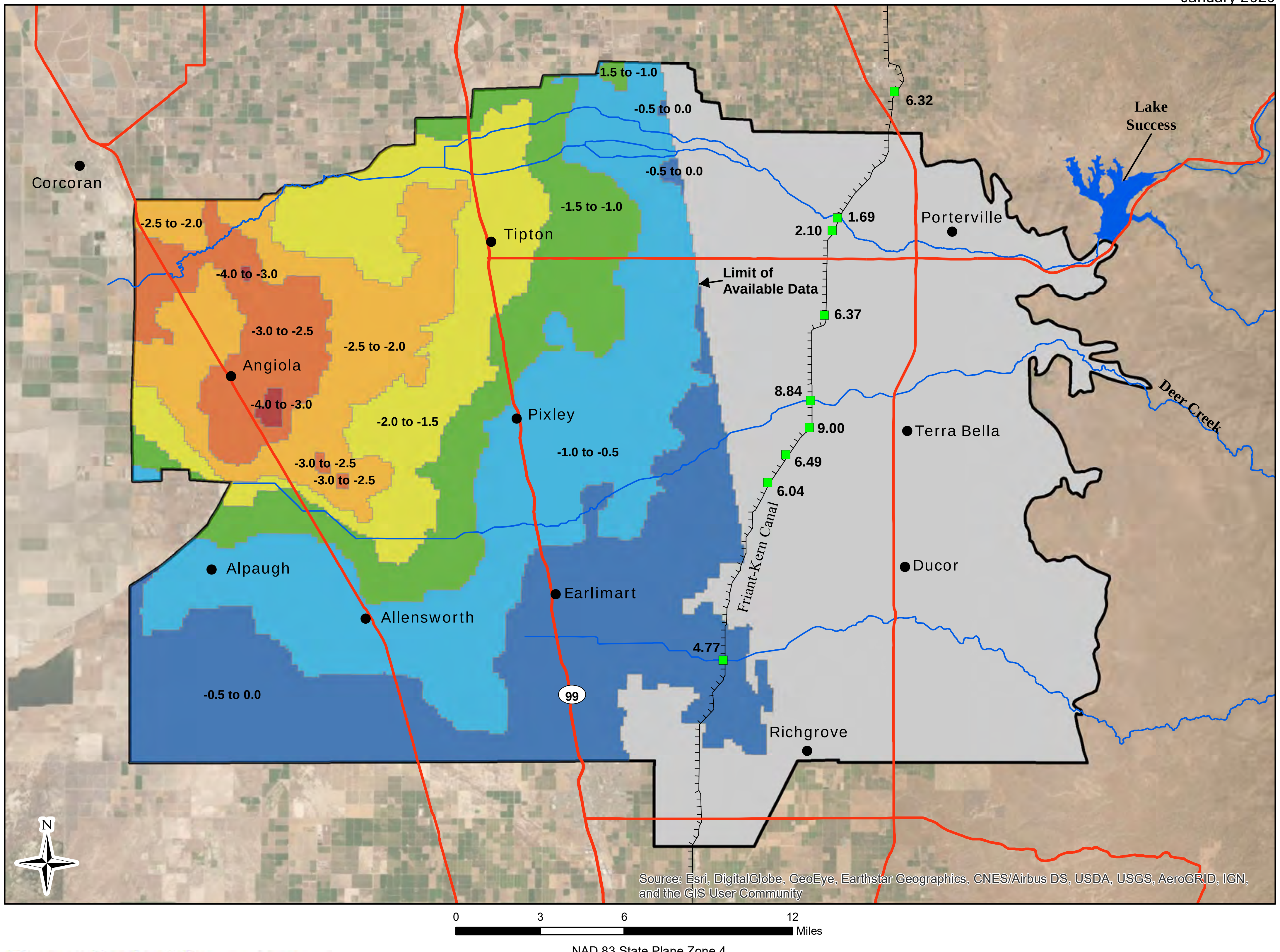
Figure 2-23



Note: Data in water years (October 1 to September 30).

Tule Subbasin

January 2020



Map Features

2007 - 2011 Land Surface Subsidence* (ft)

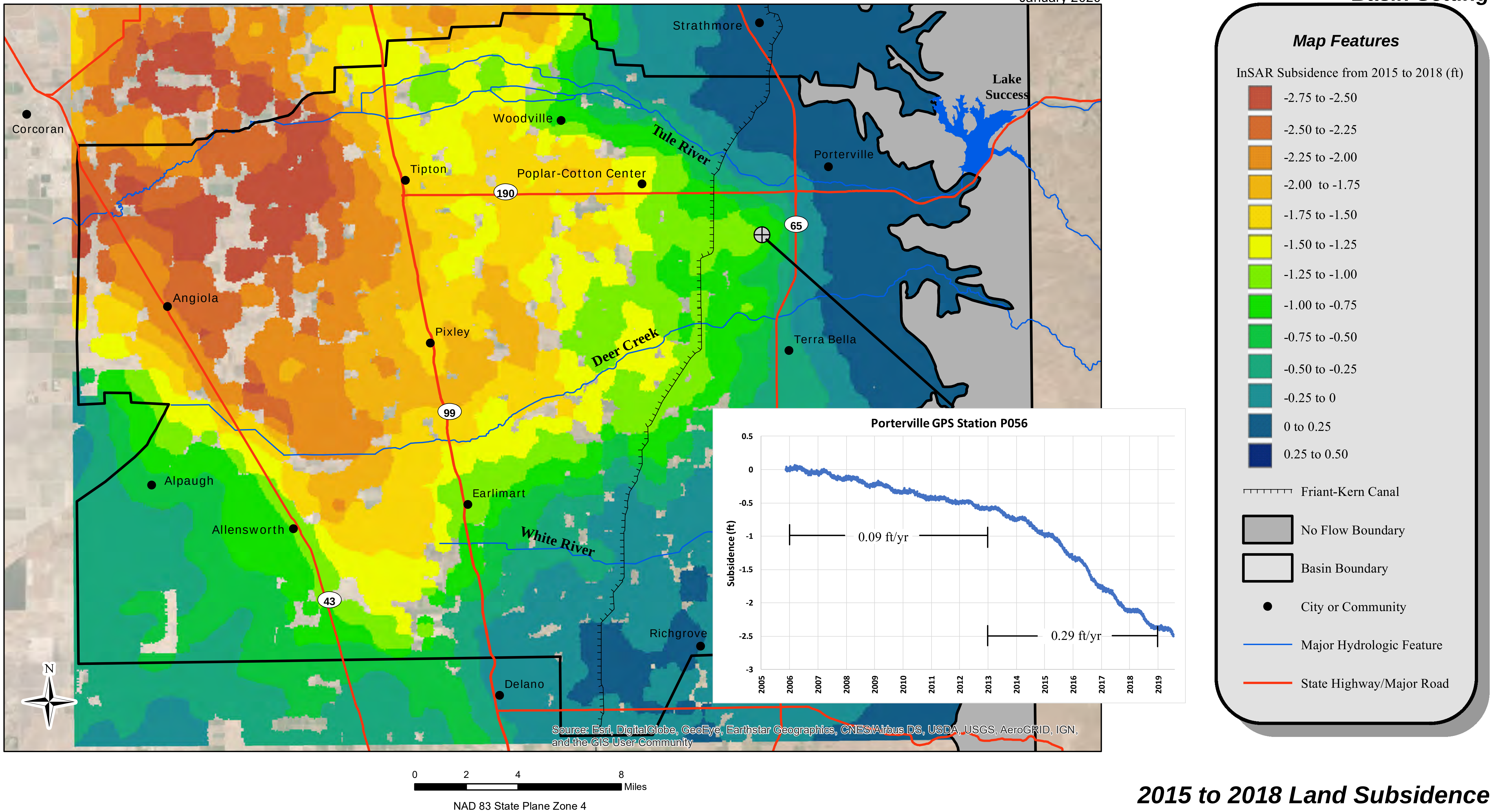
- -4.0 to -3.0
- -3.0 to -2.5
- -2.5 to -2.0
- -2.0 to -1.5
- -1.5 to -1.0
- -1.0 to -0.5
- -0.5 to 0.0
- Measured Subsidence Points along the Friant-Kern Canal (ft) 1959-2017
- Friant-Kern Canal
- Basin Boundary
- City or Community
- Major Hydrologic Feature
- Freeway/State Highway

*From LSCE, 2014

Thomas Harder & Co.
Groundwater Consulting

2007 to 2011 Land Subsidence

Figure 2-24



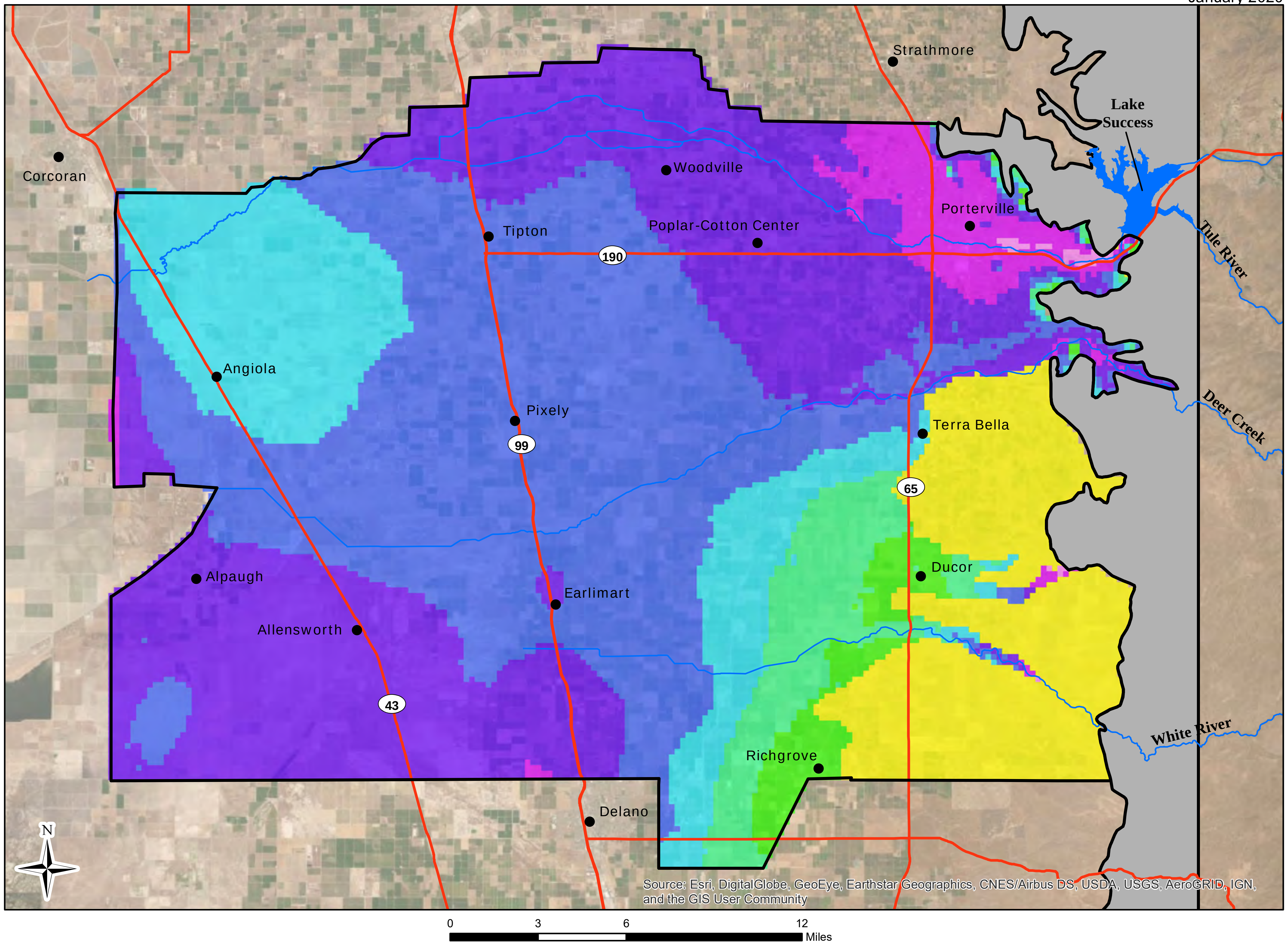
Thomas Harder & Co.
Groundwater Consulting

2015 to 2018 Land Subsidence

Figure 2-25

Tule Subbasin

January 2020



Map Features

Depth to Groundwater (ft bgs)

- 25 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- 200 - 250
- 250 - 300
- 300 - 350
- Areas Where the Upper Aquifer is Dry
- City or Community
- Basin Boundary
- No Flow
- Major Hydrologic Feature
- State Highway/Major Road

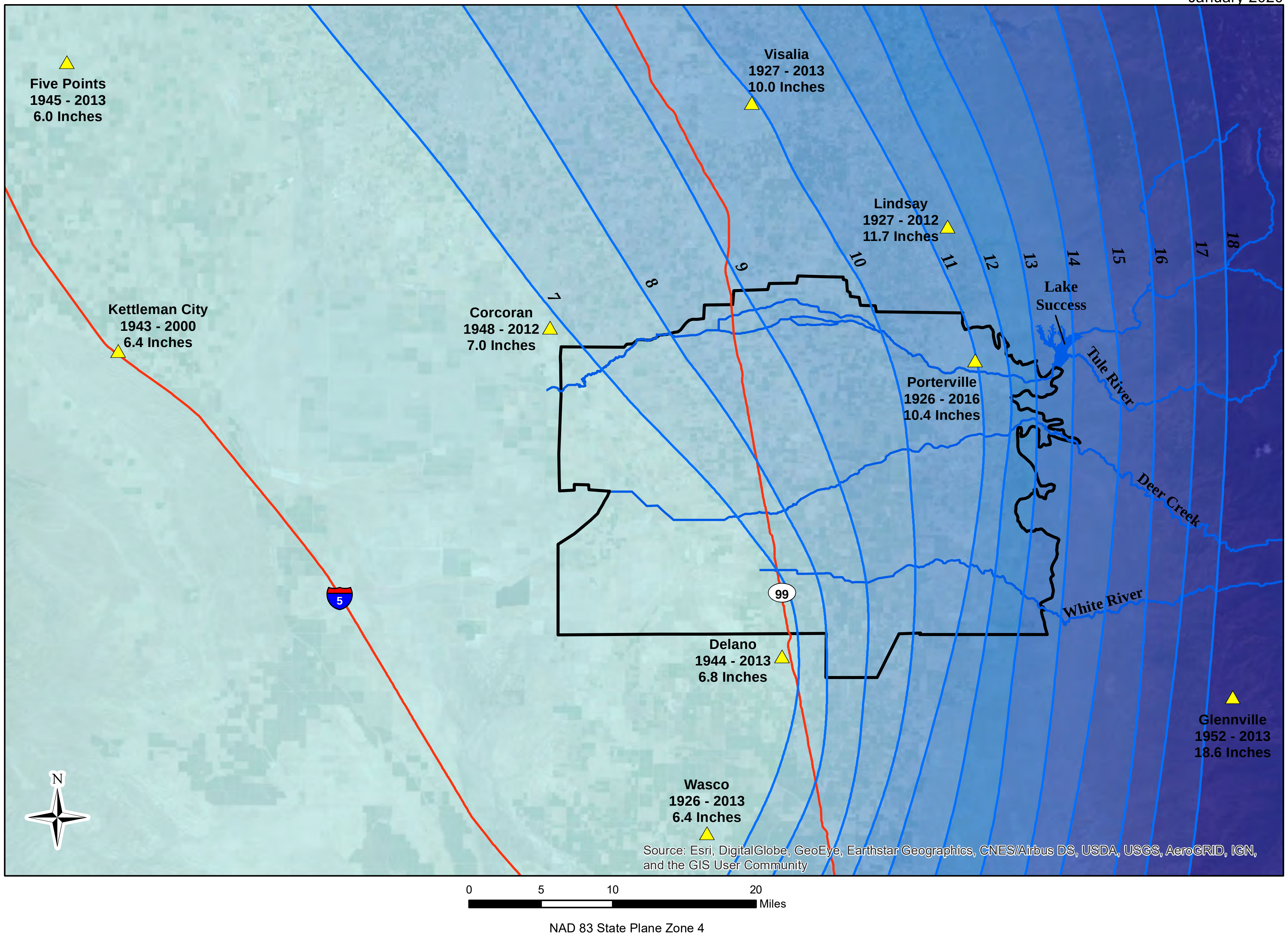
Thomas Harder & Co.
Groundwater Consulting

Depth to Groundwater Upper Aquifer - January 2015

Figure 2-26

Tule Subbasin

January 2020



Map Features

Lindsay
1927 - 2012
11.7 Inches
Precipitation Station, Period of Record, and Average Annual Precipitation

Average Annual Precipitation Inches Per Year

Basin Boundary

Major Hydrologic Feature

Freeway/State Highway

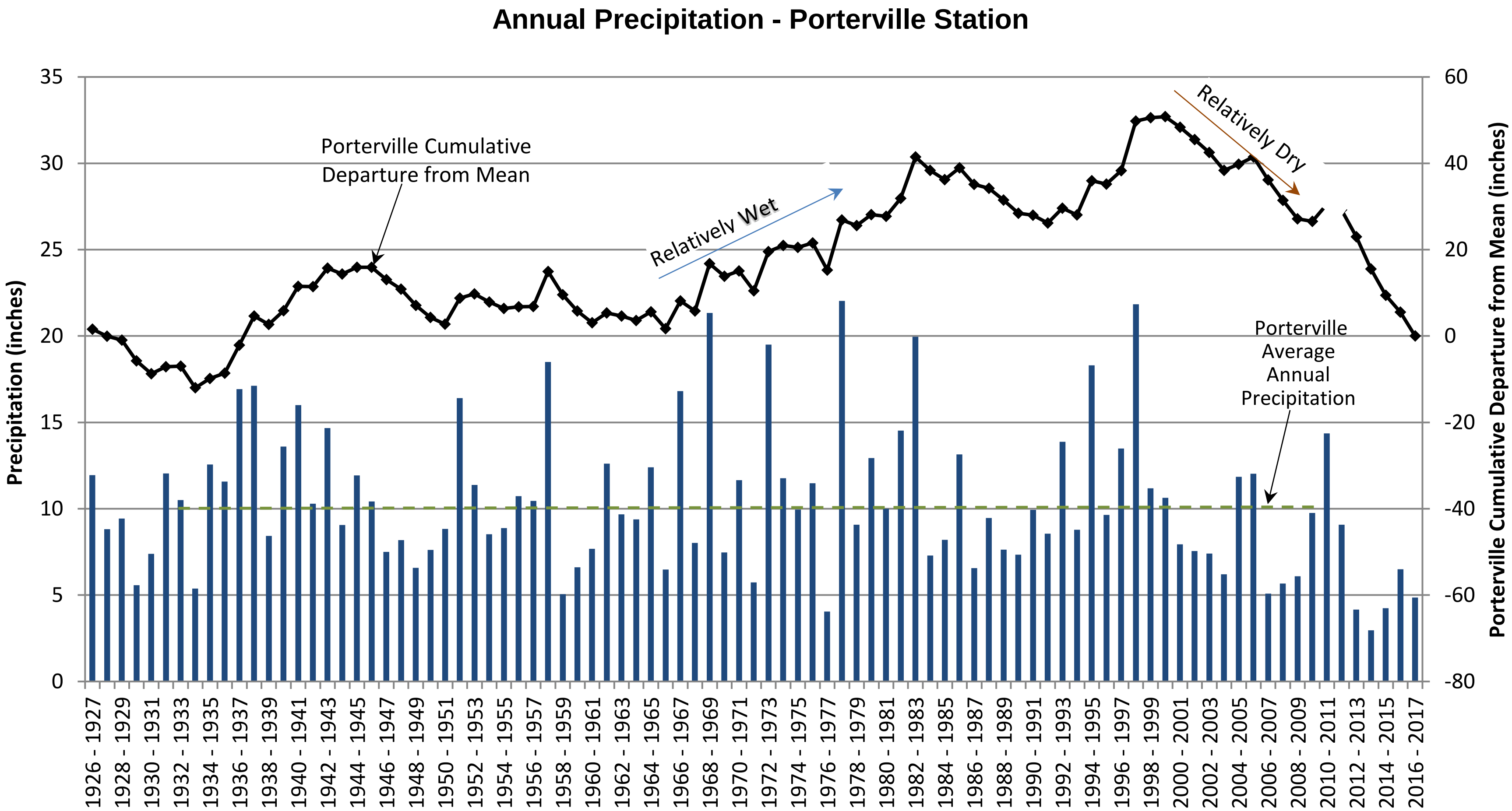
Notes: Precipitation station data from Western Regional Climate Center (www.wrcc.dri.edu) and California Irrigation Management Information System.

Isohyetal data from Average Annual Precipitation Zones from the California Department of Forestry and Fire Protection (1998). Data for 1900 through 1960.

Thomas Harder & Co.
Groundwater Consulting

Isohyetal Map

Figure 2-27



Notes:

Data in water years (October 1 to September 30).
Data from Western Regional Climate Center (1926-2001), California Irrigation Management Information System (2002-2016).

Figure 2-29

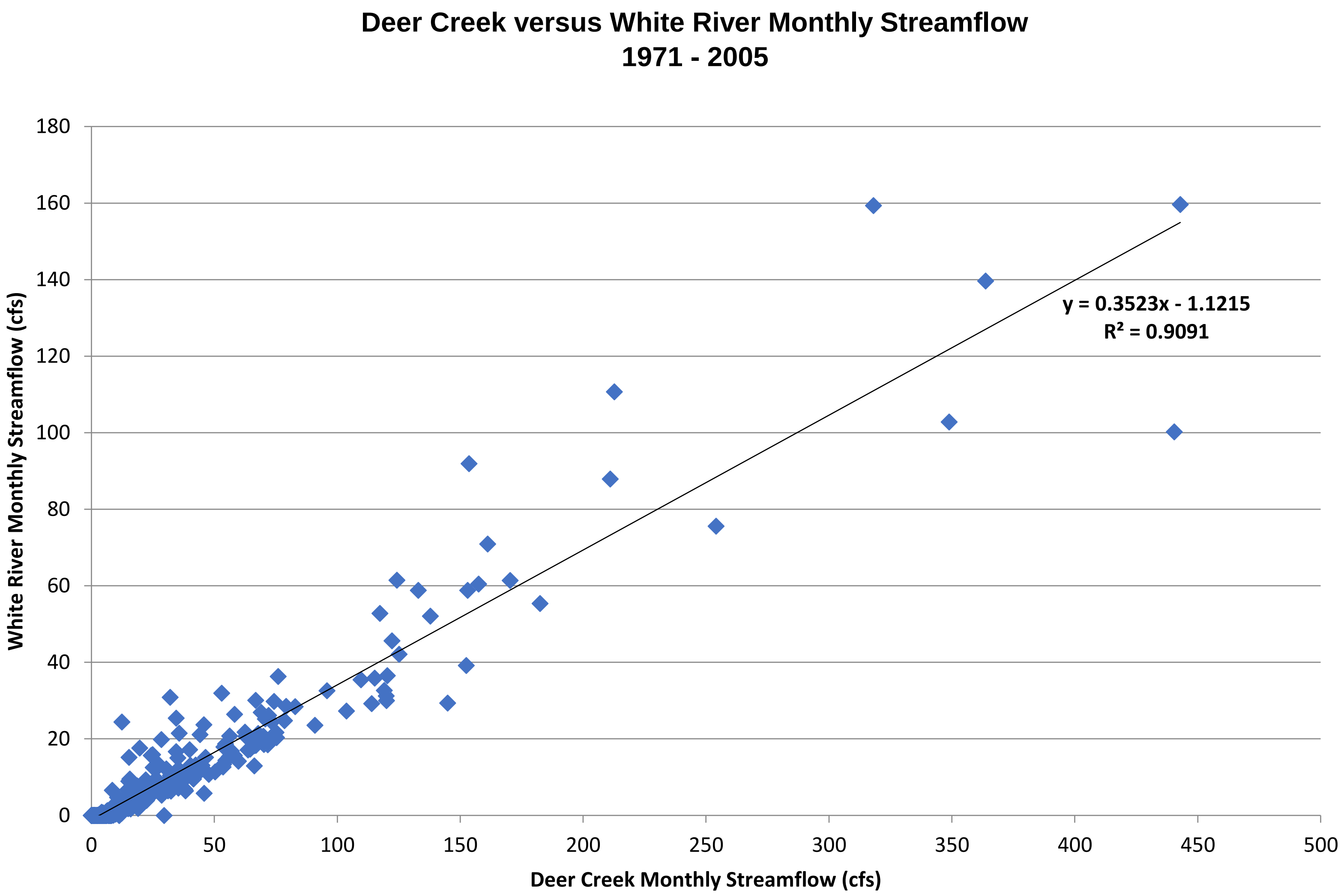
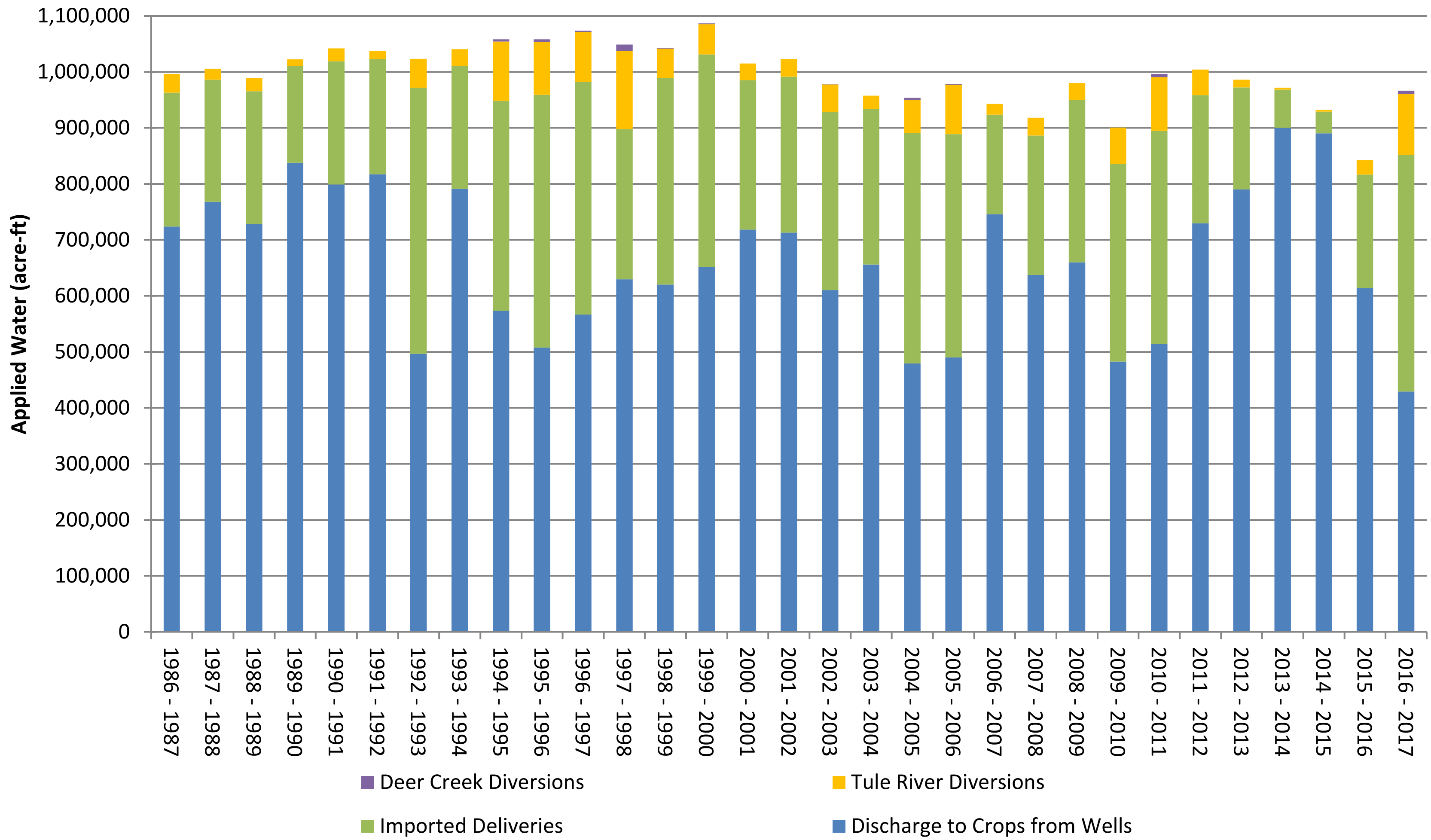

Deer Creek versus White River Monthly Streamflow
1971 - 2005
White River Monthly Streamflow (cfs)
180
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
400
450
500
Deer Creek Monthly Streamflow (cfs)
y = 0.3523x - 1.1215
R² = 0.9091

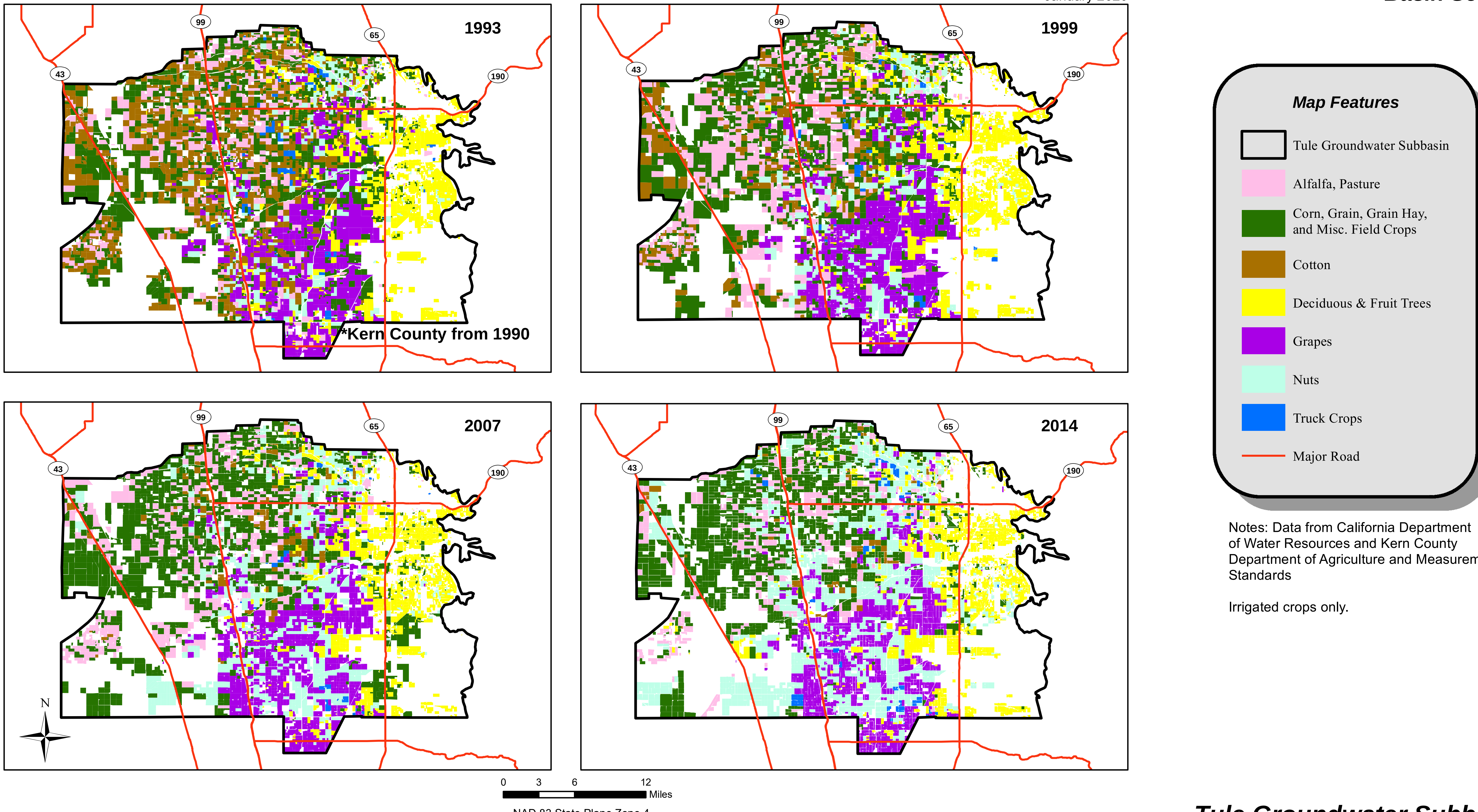
Figure 2-30

Applied Water to Irrigated Agriculture by Source



Tule Subbasin

January 2020



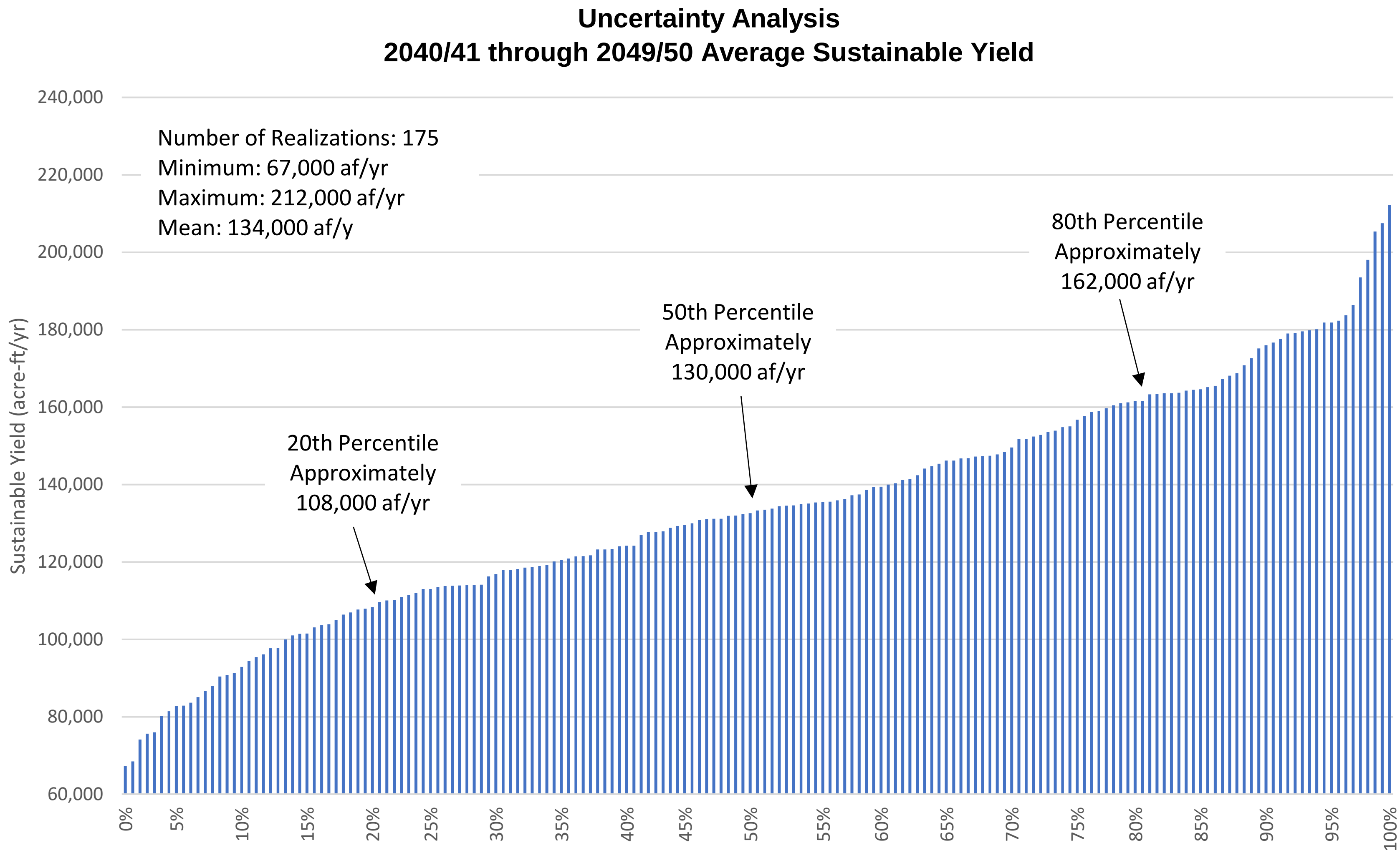
Notes: Data from California Department of Water Resources and Kern County Department of Agriculture and Measurement Standards

Irrigated crops only.

Thomas Harder & Co.
Groundwater Consulting

Tule Groundwater Subbasin
Historical Crop Patterns
Figure 2-31

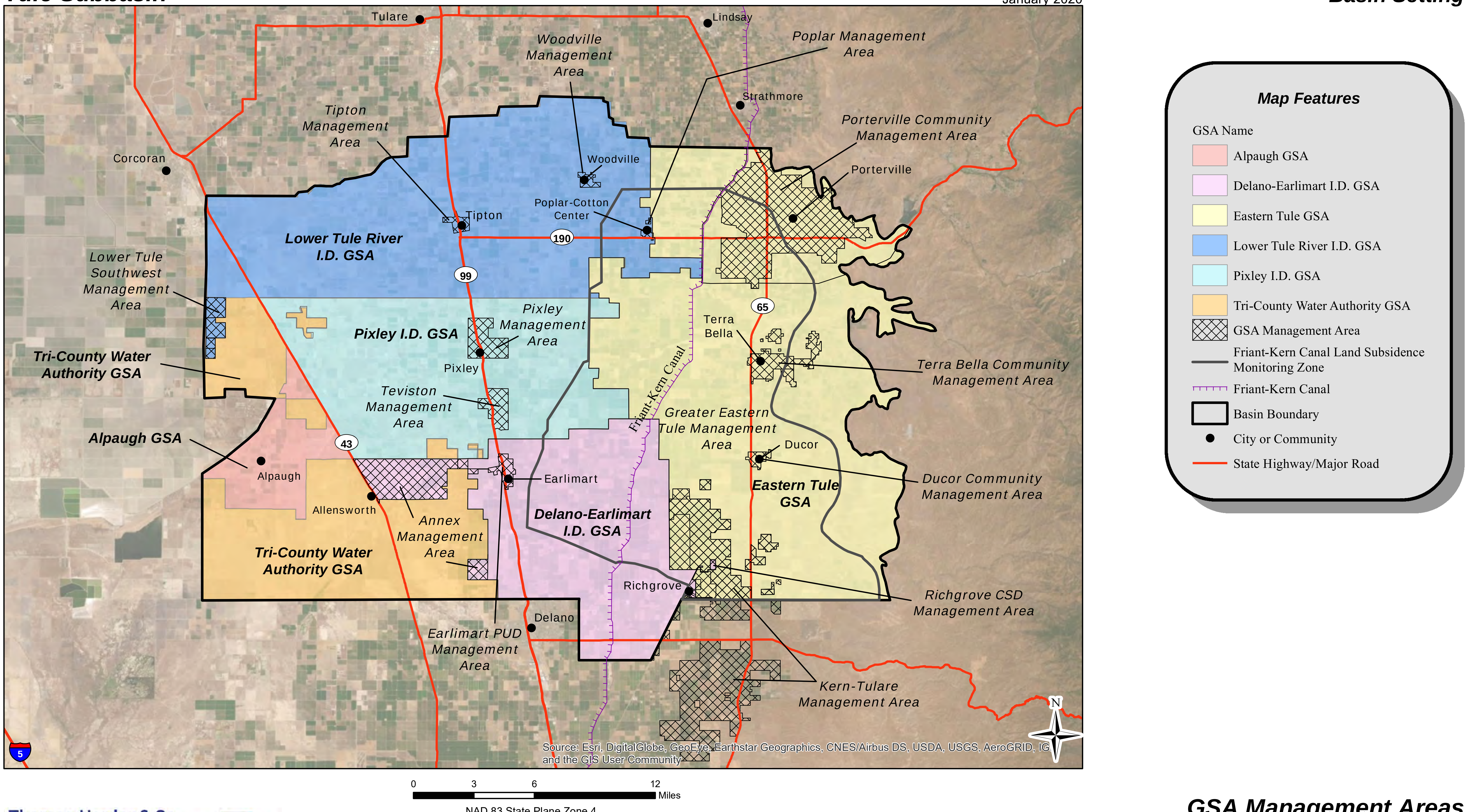
Figure 2-32



*Realizations with a storage change of -5,000 af/yr or greater

Tule Subbasin

January 2020

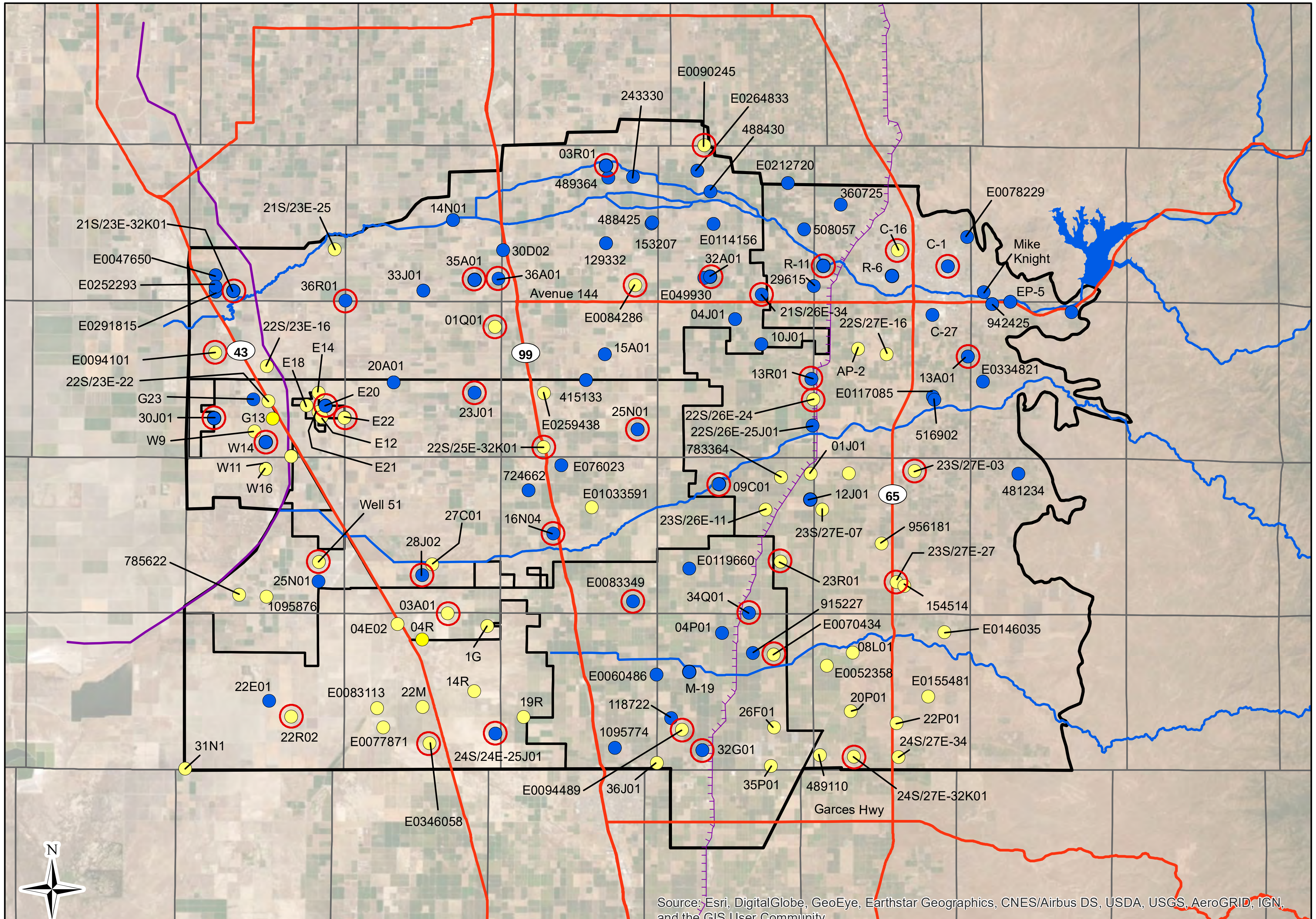


Thomas Harder & Co.
Groundwater Consulting

GSA Management Areas

Figure 2-33

Tule Subbasin January 2020



Map Features

- Upper Aquifer Well
- Lower Aquifer Well
- Representative Upper Aquifer Monitoring Site
- Representative Lower Aquifer Monitoring Site
- Canal
- Friant-Kern Canal
- Basin Boundary
- GSA Boundaries
- State Highway/Major Road

Thomas Harder & Co.
Groundwater Consulting

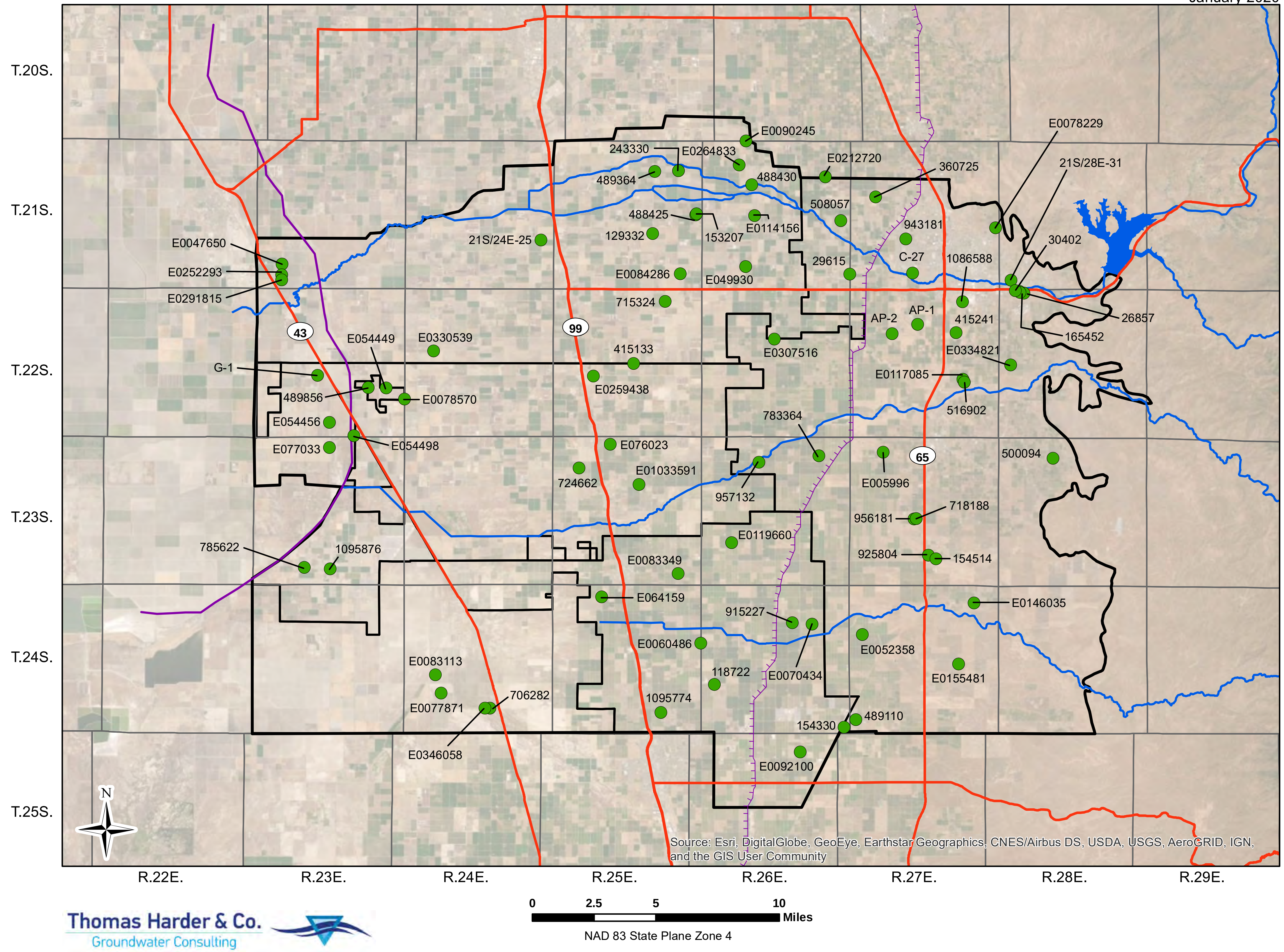
0 2.5 5 10 Miles
NAD 83 State Plane Zone 4

Groundwater Level Monitoring Network

Figure 2-34

Tule Subbasin

January 2020



Map Features

- Groundwater Quality Well Location
- Canal
- Friant-Kern Canal
- Basin Boundary
- GSA Boundaries
- State Highway/Major Road

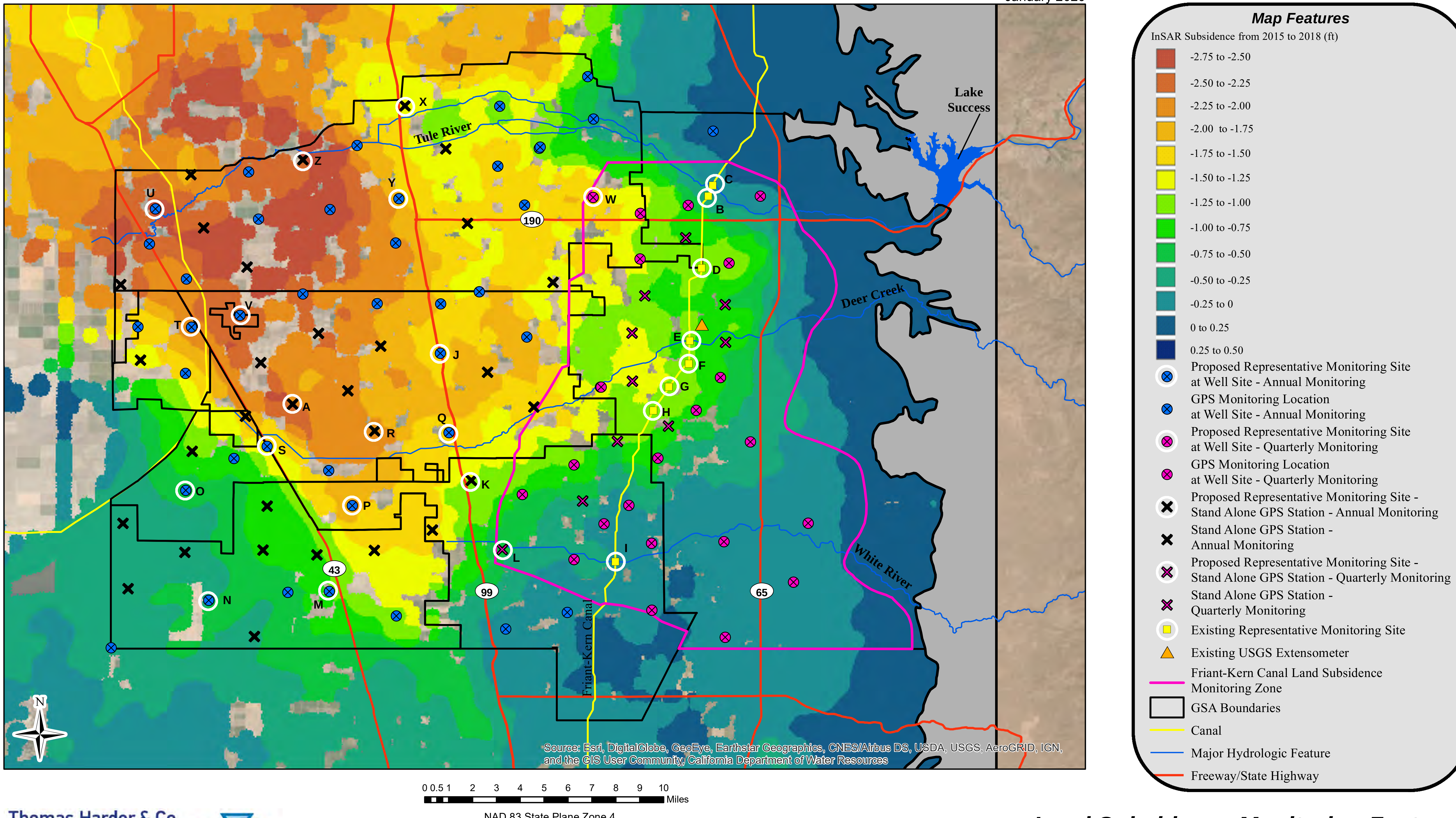
Well Location data from:
Tule Basin Water Quality Coalition, 2017

Groundwater Quality Monitoring Network

Figure 2-35

Tule Subbasin

January 2020



Thomas Harder & Co.
Groundwater Consulting

Land Subsidence Monitoring Features

Figure 2-36

Appendix A

Lower Tule River Irrigation District GSA

Water Budgets and Hydrographs

Appendix A
Table 1a

Lower Tule River Irrigation District GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Inflow (acre-ft)					Total In
	Precipitation	Stream Inflow Tule River	Imported Water LTRID	Discharge from Wells Agricultural	Discharge from Wells Municipal	
1986 - 1987	46,000	40,421	89,541	224,000	1,400	401,000
1987 - 1988	66,000	14,702	64,654	261,000	1,400	408,000
1988 - 1989	53,000	22,873	63,922	224,000	1,400	365,000
1989 - 1990	51,000	7,103	24,325	276,000	1,400	360,000
1990 - 1991	69,000	22,727	71,430	253,000	1,400	418,000
1991 - 1992	60,000	9,869	51,949	277,000	1,400	400,000
1992 - 1993	97,000	57,632	321,973	94,000	1,400	572,000
1993 - 1994	61,000	31,263	71,784	246,000	1,400	411,000
1994 - 1995	128,000	142,879	229,683	129,000	1,400	631,000
1995 - 1996	67,000	105,949	236,845	107,000	1,400	518,000
1996 - 1997	94,000	250,253	192,934	116,000	1,400	655,000
1997 - 1998	152,000	286,694	101,180	135,000	1,400	676,000
1998 - 1999	78,000	70,954	183,971	127,000	1,400	461,000
1999 - 2000	74,000	64,026	177,192	158,000	1,400	475,000
2000 - 2001	55,000	27,525	83,405	196,000	1,400	363,000
2001 - 2002	53,000	32,853	78,511	207,000	1,500	373,000
2002 - 2003	52,000	77,642	131,470	143,000	1,500	406,000
2003 - 2004	43,000	24,494	71,472	204,000	1,600	345,000
2004 - 2005	83,000	91,549	247,595	96,000	1,600	520,000
2005 - 2006	84,000	129,184	194,019	93,000	1,700	502,000
2006 - 2007	35,000	19,981	33,174	231,000	1,800	321,000
2007 - 2008	39,000	42,745	71,872	183,000	1,800	338,000
2008 - 2009	42,000	29,196	113,189	200,000	1,900	386,000
2009 - 2010	68,000	82,489	200,064	74,000	1,800	426,000
2010 - 2011	100,000	191,791	229,763	116,000	1,900	639,000
2011 - 2012	63,000	58,763	67,684	228,000	1,900	419,000
2012 - 2013	29,000	14,374	37,073	255,000	1,800	337,000
2013 - 2014	21,000	0	0	280,000	1,800	303,000
2014 - 2015	30,000	0	0	243,000	1,800	275,000
2015 - 2016	45,000	35,381	73,382	152,000	1,800	308,000
2016 - 2017	47,000	187,807	273,151	82,000	1,900	592,000
86/87-16/17 Avg	64,000	70,100	122,200	181,000	1,600	439,000

Appendix A
Table 1b

Lower Tule River Irrigation District GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Outflow (acre-ft)																	Total Out
	Areal Recharge of Precipitation	Streambed Infiltration	Canal Loss		Recharge in Basins		Deep Percolation of Applied Water				Evapotranspiration						Surface Outflow	
		Tule River										Tule River		Imported Water				
		Oettle Bridge to Turnbull Weir Infiltration	Tule River	Imported Water	Tule River	Imported Water	Tule River	Imported Water	Agricultural Pumping	Municipal Pumping	Precipitation Crops/Native	Agricultural Cons. Use	Stream Channel	Agricultural Cons. Use	Ag. Cons. Use from Pumping	Municipal (Landscape ET)	Tule River	
1986 - 1987	0	1,100	20,700	44,200	0	0	5,200	12,700	62,800	900	46,000	13,400	400	32,600	161,000	500	0	402,000
1987 - 1988	0	900	8,800	32,700	0	0	1,400	9,000	73,200	900	66,000	3,600	100	23,000	187,000	500	0	407,000
1988 - 1989	0	0	7,400	18,800	0	0	4,400	12,700	62,900	900	53,000	11,200	100	32,400	161,000	500	0	365,000
1989 - 1990	0	0	2,900	7,400	0	0	1,200	4,700	77,600	900	51,000	3,000	0	12,100	199,000	500	0	360,000
1990 - 1991	0	300	6,800	24,300	0	0	4,400	13,200	71,200	900	69,000	11,200	200	33,900	182,000	500	0	418,000
1991 - 1992	0	0	3,100	16,100	0	0	1,900	10,100	77,800	900	60,000	4,900	100	25,800	199,000	500	0	400,000
1992 - 1993	9,000	3,000	27,800	141,000	0	0	7,900	53,300	26,500	900	88,000	18,900	400	127,600	68,000	500	0	573,000
1993 - 1994	0	200	14,200	27,800	0	0	4,700	12,400	69,200	900	61,000	12,100	200	31,600	177,000	500	0	412,000
1994 - 1995	28,000	10,400	39,500	108,800	0	0	19,300	34,400	36,100	900	100,000	48,500	500	86,500	92,000	500	25,000	630,000
1995 - 1996	0	4,000	26,200	69,600	13,400	33,800	15,800	37,700	30,000	900	67,000	40,000	600	95,600	77,000	500	7,000	519,000
1996 - 1997	7,000	9,700	47,300	51,200	19,900	7,000	16,700	43,000	32,700	900	87,000	35,600	600	91,700	84,000	500	121,000	656,000
1997 - 1998	44,000	9,000	79,100	39,200	28,000	10,800	29,100	14,400	37,900	900	109,000	74,400	600	36,800	97,000	500	95,000	706,000
1998 - 1999	1,000	2,800	19,500	45,800	11,400	15,800	10,500	34,400	35,800	900	77,000	26,800	600	88,100	92,000	500	0	463,000
1999 - 2000	0	2,900	11,100	51,300	3,400	8,000	12,000	32,900	44,400	900	74,000	30,700	300	84,300	113,000	500	5,000	475,000
2000 - 2001	0	0	7,000	25,900	200	2,000	5,700	15,600	55,100	900	55,000	14,600	300	39,900	141,000	500	0	364,000
2001 - 2002	0	700	13,400	20,800	0	0	5,300	16,200	58,100	1,000	53,000	13,500	300	41,500	149,000	500	0	373,000
2002 - 2003	0	3,700	22,800	42,700	5,900	3,300	9,700	20,600	34,500	1,000	52,000	30,500	300	64,800	108,000	500	5,000	405,000
2003 - 2004	0	300	7,700	16,600	0	0	3,800	13,100	48,500	1,000	43,000	12,100	200	41,800	155,000	600	1,000	345,000
2004 - 2005	2,000	4,700	22,900	76,200	11,800	23,500	9,400	33,000	23,000	1,100	80,000	30,000	400	105,500	73,000	600	22,000	519,000
2005 - 2006	3,000	7,200	40,500	62,500	16,500	17,000	13,800	29,500	22,200	1,100	81,000	39,900	400	85,000	71,000	600	11,000	502,000
2006 - 2007	0	1,500	5,100	12,700	0	0	3,200	4,900	55,100	1,100	35,000	10,200	100	15,600	176,000	600	0	321,000
2007 - 2008	0	1,100	15,900	18,200	900	600	5,700	12,600	43,500	1,200	39,000	18,300	300	40,400	139,000	600	1,000	338,000
2008 - 2009	0	1,400	7,100	36,400	400	4,300	4,900	17,500	47,600	1,200	42,000	15,600	100	56,000	152,000	700	0	387,000
2009 - 2010	0	4,500	34,600	61,600	5,800	15,100	10,200	33,500	17,500	1,200	68,000	27,400	400	89,800	56,000	600	0	426,000
2010 - 2011	11,000	7,500	82,400	80,300	31,800	27,700	15,500	30,400	27,500	1,200	89,000	46,600	400	91,300	88,000	700	8,000	639,000
2011 - 2012	0	300	17,800	21,200	1,500	4,200	10,100	10,900	54,300	1,200	63,000	29,100	200	31,400	174,000	700	0	420,000
2012 - 2013	0	0	4,400	11,400	0	0	2,400	6,100	60,800	1,100	29,000	7,600	200	19,600	195,000	600	0	338,000
2013 - 2014	0	0	0	0	0	0	0	0	66,700	1,200	21,000	0	0	0	213,000	600	0	303,000
2014 - 2015	0	0	0	0	0	0	0	0	57,900	1,200	30,000	0	0	0	185,000	600	0	275,000
2015 - 2016	0	5,500	11,400	27,400	800	0	4,200	11,000	36,200	1,200	45,000	13,500	200	35,100	116,000	600	0	308,000
2016 - 2017	0	15,900	82,600	113,100	28,400	34,000	14,500	30,400	19,500	1,200	47,000	46,400	500	95,600	62,000	700	71,000	663,000
86/87-16/17 Avg	3,000	3,200	22,300	42,100	5,800	6,700	8,200	19,700	47,300	1,000	61,000	22,200	300	53,400	134,000	600	12,000	443,000

Groundwater Inflows to be Included in Sustainable Yield Estimates
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Appendix A
Table 2

Lower Tule River Irrigation District GSA
Historical Groundwater Budget 1986/87 to 2016/17

Water Year	Groundwater Inflows (acre-ft)													Total In	Groundwater Outflows (acre-ft)					Total Out	Change in Storage (acre-ft)
	Areal Recharge from Precipitation	Tule River				Imported Water Deliveries			Agricultural Pumping	Municipal Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow			Groundwater Pumping			Sub-surface Outflow			
		Oettle Bridge to Turnbull Weir Infiltration	Canal Loss	Recharge in Basins	Return Flow	Canal Loss	Recharge in Basins	Return Flow	Return Flow	Return Flow		From Outside Subbasin	From Other GSAs		Muni-cipal	Agri-cultural	Exports	To Outside Subbasin	To Other GSAs		
1986 - 1987	0	1,100	20,700	0	5,200	44,200	0	12,700	62,800	900	27,000	76,000	39,000	290,000	1,400	224,000	0	16,000	115,000	356,000	-66,000
1987 - 1988	0	900	8,800	0	1,400	32,700	0	9,000	73,200	900	26,000	90,000	38,000	281,000	1,400	261,000	15,940	16,000	108,000	402,000	-121,000
1988 - 1989	0	0	7,400	0	4,400	18,800	0	12,700	62,900	900	13,000	90,000	37,000	247,000	1,400	224,000	26,160	16,000	107,000	375,000	-128,000
1989 - 1990	0	0	2,900	0	1,200	7,400	0	4,700	77,600	900	38,000	87,000	39,000	259,000	1,400	276,000	26,590	16,000	97,000	417,000	-158,000
1990 - 1991	0	300	6,800	0	4,400	24,300	0	13,200	71,200	900	42,000	95,000	38,000	296,000	1,400	253,000	28,190	17,000	104,000	404,000	-108,000
1991 - 1992	0	0	3,100	0	1,900	16,100	0	10,100	77,800	900	53,000	97,000	38,000	298,000	1,400	277,000	17,420	17,000	101,000	414,000	-116,000
1992 - 1993	9,000	3,000	27,800	0	7,900	141,000	0	53,300	26,500	900	15,000	62,000	30,000	376,000	1,400	94,000	7,940	28,000	127,000	258,000	118,000
1993 - 1994	0	200	14,200	0	4,700	27,800	0	12,400	69,200	900	24,000	79,000	33,000	265,000	1,400	246,000	0	24,000	107,000	378,000	-113,000
1994 - 1995	28,000	10,400	39,500	0	19,300	108,800	0	34,400	36,100	900	9,000	62,000	33,000	381,000	1,400	129,000	0	26,000	123,000	279,000	102,000
1995 - 1996	0	4,000	26,200	13,400	15,800	69,600	33,800	37,700	30,000	900	2,000	53,000	30,000	316,000	1,400	107,000	0	30,000	126,000	264,000	52,000
1996 - 1997	7,000	9,700	47,300	19,900	16,700	51,200	7,000	43,000	32,700	900	1,000	60,000	31,000	327,000	1,400	116,000	0	28,000	132,000	277,000	50,000
1997 - 1998	44,000	9,000	79,100	28,000	29,100	39,200	10,800	14,400	37,900	900	0	72,000	32,000	396,000	1,400	135,000	0	26,000	134,000	296,000	100,000
1998 - 1999	1,000	2,800	19,500	11,400	10,500	45,800	15,800	34,400	35,800	900	2,000	73,000	30,000	283,000	1,400	127,000	0	28,000	139,000	295,000	-12,000
1999 - 2000	0	2,900	11,100	3,400	12,000	51,300	8,000	32,900	44,400	900	2,000	80,000	30,000	279,000	1,400	158,000	2,820	26,000	129,000	317,000	-38,000
2000 - 2001	0	0	7,000	200	5,700	25,900	2,000	15,600	55,100	900	6,000	94,000	31,000	243,000	1,400	196,000	17,290	22,000	119,000	356,000	-113,000
2001 - 2002	0	700	13,400	0	5,300	20,800	0	16,200	58,100	1,000	15,000	89,000	32,000	252,000	1,500	207,000	25,590	20,000	110,000	364,000	-112,000
2002 - 2003	0	3,700	22,800	5,900	9,700	42,700	3,300	20,600	34,500	1,000	10,000	75,000	29,000	258,000	1,500	143,000	20,610	22,000	117,000	304,000	-46,000
2003 - 2004	0	300	7,700	0	3,800	16,600	0	13,100	48,500	1,000	27,000	78,000	31,000	227,000	1,600	204,000	17,440	20,000	95,000	338,000	-111,000
2004 - 2005	2,000	4,700	22,900	11,800	9,400	76,200	23,500	33,000	23,000	1,100	9,000	56,000	27,000	300,000	1,600	96,000	7,720	26,000	107,000	238,000	62,000
2005 - 2006	3,000	7,200	40,500	16,500	13,800	62,500	17,000	29,500	22,200	1,100	2,000	53,000	27,000	295,000	1,700	93,000	0	29,000	115,000	239,000	56,000
2006 - 2007	0	1,500	5,100	0	3,200	12,700	0	4,900	55,100	1,100	24,000	71,000	30,000	209,000	1,800	231,000	27,930	22,000	85,000	368,000	-159,000
2007 - 2008	0	1,100	15,900	900	5,700	18,200	600	12,600	43,500	1,200	36,000	74,000	29,000	239,000	1,800	183,000	26,140	23,000	93,000	327,000	-88,000
2008 - 2009	0	1,400	7,100	400	4,900	36,400	4,300	17,500	47,600	1,200	47,000	74,000	31,000	273,000	1,900	200,000	21,470	24,000	96,000	343,000	-70,000
2009 - 2010	0	4,500	34,600	5,800	10,200	61,600	15,100	33,500	17,500	1,200	18,000	48,000	27,000	277,000	1,800	74,000	10,770	30,000	122,000	239,000	38,000
2010 - 2011	11,000	7,500	82,400	31,800	15,500	80,300	27,700	30,400	27,500	1,200	6,000	55,000	28,000	404,000	1,900	116,000	3,880	31,000	125,000	278,000	126,000
2011 - 2012	0	300	17,800	1,500	10,100	21,200	4,200	10,900	54,300	1,200	22,000	79,000	31,000	254,000	1,900	228,000	21,600	24,000	109,000	385,000	-131,000
2012 - 2013	0	0	4,400	0	2,400	11,400	0	6,100	60,800	1,100	53,000	88,000	33,000	260,000	1,800	255,000	39,910	25,000	88,000	410,000	-150,000
2013 - 2014	0	0	0	0	0	0	0	0	66,700	1,200	71,000	91,000	32,000	262,000	1,800	280,000	37,120	25,000	81,000	425,000	-163,000
2014 - 2015	0	0	0	0	0	0	0	0	57,900	1,200	74,000	83,000	31,000	247,000	1,800	243,000	33,170	24,000	84,000	386,000	-139,000
2015 - 2016	0	5,500	11,400	800	4,200	27,400	0	11,000	36,200	1,200	53,000	70,000	27,000	248,000	1,800	152,000	28,300	27,000	90,000	299,000	-51,000
2016 - 2017	0	15,900	82,600	28,400	14,500	113,100	34,000	30,400	19,500	1,200	16,000	55,000	24,000	435,000	1,900	82,000	6,810	33,000	112,000	236,000	199,000
36/87-16/17 Avg	3,000	3,200	22,300	5,800	8,200	42,100	6,700	19,700	47,300	1,000	24,000	74,000	32,000	289,000	1,600	181,000	15,200	24,000	110,000	332,000	-43,000

Cumulative Change in Storage | -1,290,000

Groundwater Inflows or Outflows to be Included in Sustainable Yield Estimates
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Groundwater Outflows Not Included in Sustainable Yield Estimates

Appendix A
Table 3a

Projected Future Lower Tule River Irrigation District GSA Surface Water Budget

Water Year	Surface Water Inflow (acre-ft)					Total In
	Precipitation	Stream Inflow Tule River	Imported Water LTRID	Discharge from Wells Agricultural	Discharge from Wells Municipal	
2017 - 2018	65,000	79,995	143,186	149,000	1,900	439,000
2018 - 2019	65,000	79,995	143,186	149,000	1,900	439,000
2019 - 2020	65,000	79,995	143,186	149,000	1,900	439,000
2020 - 2021	65,000	79,995	143,186	149,000	1,900	439,000
2021 - 2022	65,000	79,995	143,186	149,000	1,900	439,000
2022 - 2023	65,000	79,995	143,186	149,000	1,900	439,000
2023 - 2024	65,000	79,995	143,186	149,000	1,900	439,000
2024 - 2025	65,000	82,595	135,513	151,000	1,900	436,000
2025 - 2026	65,000	82,595	127,841	155,000	1,900	432,000
2026 - 2027	65,000	82,595	120,168	159,000	1,900	429,000
2027 - 2028	65,000	82,595	112,496	164,000	1,900	426,000
2028 - 2029	65,000	82,595	104,823	168,000	1,900	422,000
2029 - 2030	65,000	81,976	97,151	172,000	1,900	418,000
2030 - 2031	65,000	81,976	97,151	172,000	1,900	418,000
2031 - 2032	65,000	81,976	97,151	172,000	1,900	418,000
2032 - 2033	65,000	81,976	97,151	172,000	1,900	418,000
2033 - 2034	65,000	81,976	97,151	172,000	1,900	418,000
2034 - 2035	65,000	81,976	97,151	171,000	1,900	417,000
2035 - 2036	65,000	81,976	97,151	171,000	1,900	417,000
2036 - 2037	65,000	81,976	97,151	171,000	1,900	417,000
2037 - 2038	65,000	81,976	97,151	171,000	1,900	417,000
2038 - 2039	65,000	81,976	97,151	171,000	1,900	417,000
2039 - 2040	65,000	81,976	97,151	152,000	1,900	398,000
2040 - 2041	65,000	81,976	97,151	152,000	1,900	398,000
2041 - 2042	65,000	81,976	97,151	152,000	1,900	398,000
2042 - 2043	65,000	81,976	97,151	152,000	1,900	398,000
2043 - 2044	65,000	81,976	97,151	152,000	1,900	398,000
2044 - 2045	65,000	81,976	97,151	152,000	1,900	398,000
2045 - 2046	65,000	81,976	97,151	152,000	1,900	398,000
2046 - 2047	65,000	81,976	97,151	152,000	1,900	398,000
2047 - 2048	65,000	81,976	97,151	152,000	1,900	398,000
2048 - 2049	65,000	81,976	97,151	152,000	1,900	398,000
2049 - 2050	65,000	81,976	97,151	152,000	1,900	398,000
2050 - 2051	65,000	79,772	84,084	141,000	1,900	372,000
2051 - 2052	65,000	79,772	84,084	141,000	1,900	372,000
2052 - 2053	65,000	79,772	84,084	141,000	1,900	372,000
2053 - 2054	65,000	79,772	84,084	141,000	1,900	372,000
2054 - 2055	65,000	79,772	84,084	141,000	1,900	372,000
2055 - 2056	65,000	79,772	84,084	141,000	1,900	372,000
2056 - 2057	65,000	79,772	84,084	141,000	1,900	372,000
2057 - 2058	65,000	79,772	84,084	141,000	1,900	372,000
2058 - 2059	65,000	79,772	84,084	141,000	1,900	372,000
2059 - 2060	65,000	79,772	84,084	141,000	1,900	372,000
2060 - 2061	65,000	79,772	84,084	141,000	1,900	372,000
2061 - 2062	65,000	79,772	84,084	141,000	1,900	372,000
2062 - 2063	65,000	79,772	84,084	141,000	1,900	372,000
2063 - 2064	65,000	79,772	84,084	141,000	1,900	372,000
2064 - 2065	65,000	79,772	84,084	141,000	1,900	372,000
2065 - 2066	65,000	79,772	84,084	141,000	1,900	372,000
2066 - 2067	65,000	79,772	84,084	141,000	1,900	372,000
2067 - 2068	65,000	79,772	84,084	141,000	1,900	372,000
2068 - 2069	65,000	79,772	84,084	141,000	1,900	372,000
2069 - 2070	65,000	79,772	84,084	141,000	1,900	372,000
17/18-69/70 Avg	65,000	80,900	100,500	152,000	1,900	400,000

Projected Future Lower Tule River Irrigation District GSA Surface Water Budget

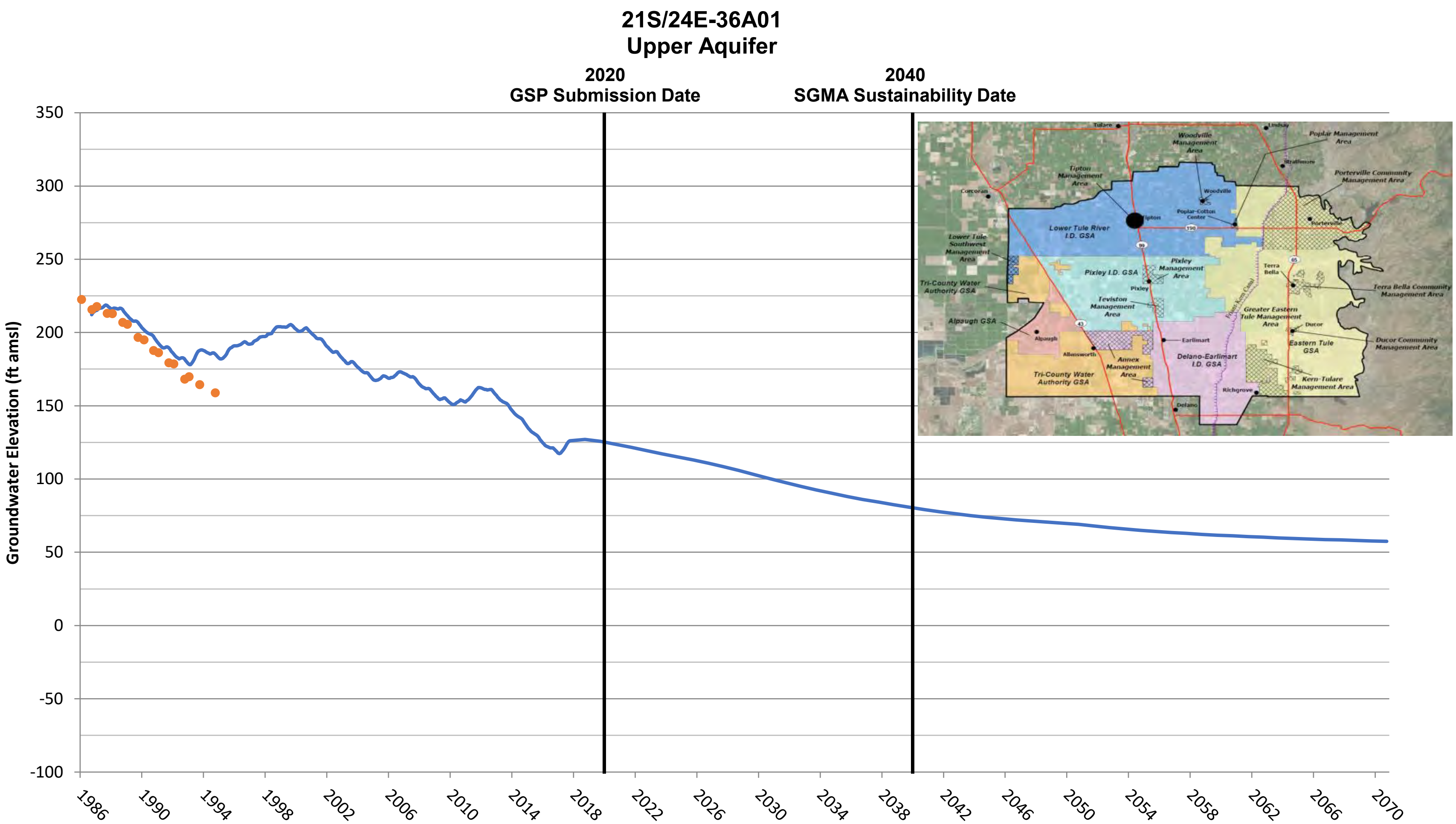
Water Year	Surface Water Outflow (acre-ft): Areal Recharge of Precipitation	Streambed Infiltration: Tule River: Oettle Bridge to Turnbull Weir Infiltration	Canal Loss: Tule River	Canal Loss: Imported Water	Recharge in Basins: Tule River	Recharge in Basins: Imported Water	Deep Percolation of Applied Water: Tule River	Deep Percolation of Applied Water: Imported Water	Deep Percolation of Applied Water: Agricultural Pumping	Deep Percolation of Applied Water: Municipal Pumping	Evapotranspiration: Precipitation Crops/Native	Evapotranspiration: Tule River: Agricultural Cons. Use	Evapotranspiration: Tule River: Stream Channel	Evapotranspiration: Imported Water: Agricultural Cons. Use	Evapotranspiration: Ag. Cons. Use from Pumping	Evapotranspiration: Municipal (Landscape ET)	Surface Outflow: Tule River	Total Out
2017 - 2018	3,000	3,900	17,000	52,400	6,400	11,400	10,800	19,400	35,400	1,200	61,000	33,500	300	59,900	113,000	700	15,000	444,000
2018 - 2019	3,000	3,900	17,000	52,400	6,400	11,400	10,800	19,400	35,400	1,200	61,000	33,500	300	59,900	113,000	700	8,000	437,000
2019 - 2020	3,000	3,900	17,000	52,400	6,400	11,400	10,800	19,400	35,400	1,200	61,000	33,500	300	59,900	113,000	700	8,000	437,000
2020 - 2021	3,000	3,900	17,000	52,400	6,400	11,400	10,800	19,400	35,400	1,200	61,000	33,500	300	59,900	113,000	700	8,000	437,000
2021 - 2022	3,000	3,900	17,000	52,400	6,400	11,400	10,800	19,400	35,400	1,200	61,000	33,500	300	59,900	113,000	700	8,000	437,000
2022 - 2023	3,000	3,900	17,000	52,400	6,400	11,400	10,800	19,400	35,400	1,200	61,000	33,500	300	59,900	113,000	700	8,000	437,000
2023 - 2024	3,000	3,900	17,000	52,400	6,400	11,400	10,800	19,400	35,400	1,200	61,000	33,500	300	59,900	113,000	700	8,000	437,000
2024 - 2025	3,000	3,900	18,200	49,600	6,600	10,800	11,200	18,400	35,900	1,200	61,000	34,600	300	56,700	115,000	700	8,000	435,000
2025 - 2026	3,000	3,900	18,400	46,800	6,600	10,200	11,200	17,300	36,900	1,200	61,000	34,600	300	53,500	118,000	700	8,000	432,000
2026 - 2027	3,000	3,900	18,700	44,000	6,600	9,600	11,200	16,300	37,900	1,200	61,000	34,600	300	50,300	121,000	700	8,000	428,000
2027 - 2028	3,000	3,900	19,000	41,200	6,600	8,900	11,200	15,300	38,900	1,200	61,000	34,500	300	47,000	125,000	700	7,000	425,000
2028 - 2029	3,000	3,900	19,300	38,400	6,600	8,300	11,200	14,300	40,000	1,200	61,000	34,500	300	43,800	128,000	700	7,000	422,000
2029 - 2030	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,200	40,900	1,200	61,000	34,200	300	40,600	131,000	700	7,000	417,000
2030 - 2031	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,200	40,900	1,200	61,000	34,200	300	40,600	131,000	700	7,000	417,000
2031 - 2032	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,200	40,900	1,200	61,000	34,200	300	40,600	131,000	700	7,000	417,000
2032 - 2033	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,200	40,900	1,200	61,000	34,200	300	40,600	131,000	700	7,000	417,000
2033 - 2034	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,200	40,900	1,200	61,000	34,200	300	40,600	131,000	700	7,000	417,000
2034 - 2035	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	40,700	1,200	61,000	34,200	300	40,600	130,000	700	7,000	416,000
2035 - 2036	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	40,700	1,200	61,000	34,200	300	40,600	130,000	700	7,000	416,000
2036 - 2037	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	40,700	1,200	61,000	34,200	300	40,600	130,000	700	7,000	416,000
2037 - 2038	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	40,700	1,200	61,000	34,200	300	40,600	130,000	700	7,000	416,000
2038 - 2039	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	40,700	1,200	61,000	34,200	300	40,600	130,000	700	7,000	416,000
2039 - 2040	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2040 - 2041	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2041 - 2042	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2042 - 2043	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2043 - 2044	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2044 - 2045	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2045 - 2046	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2046 - 2047	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2047 - 2048	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2048 - 2049	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2049 - 2050	3,000	3,900	19,400	35,600	6,500	7,700	11,200	13,300	36,200	1,200	61,000	34,200	300	40,600	116,000	700	7,000	398,000
2050 - 2051	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2051 - 2052	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2052 - 2053	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2053 - 2054	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2054 - 2055	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2055 - 2056	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2056 - 2057	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2057 - 2058	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2058 - 2059	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2059 - 2060	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2060 - 2061	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2061 - 2062	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2062 - 2063	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2063 - 2064	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2064 - 2065	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2065 - 2066	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2066 - 2067	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2067 - 2068	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2068 - 2069	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
2069 - 2070	3,000	3,800	19,300	30,800	6,300	6,700	10,900	11,500	33,600	1,200	61,000	33,300	300	35,100	108,000	700	6,000	372,000
17/18-69/70 Avg	3,000	3,900	19,000	36,800	6,400	8,000	11,000	13,700	36,100	1,200	61,000	33,800	300	42,000	116,000	700	6,900	400,000

Projected Future Lower Tule River Irrigation District GSA Groundwater Budget

Water Year	Groundwater Inflows (acre-ft)														Total In	Groundwater Outflows (acre-ft)					Total Out	Change in Storage (acre-ft)
	Areal Recharge from Precipitation	Tule River				Imported Water Deliveries			Agricultural Pumping	Municipal Pumping	Release of Water from Compression of Aquitards	Sub-surface Inflow				Groundwater Pumping			Sub-surface Outflow			
		Oettle Bridge to Turnbull Weir Infiltration	Canal Loss	Recharge in Basins	Return Flow	Canal Loss	Recharge in Basins	Return Flow	Return Flow	Return Flow		From Outside Subbasin	From Other GSAs		Muni-cipal	Agri-cultural	Exports	To Outside Subbasin	To Other GSAs		
2017 - 2018	3,000	3,900	17,000	6,400	10,800	52,400	11,400	19,400	35,400	1,200	10,000	44,000	42,000	257,000	1,900	149,000	11,640	41,000	98,000	302,000	-45,000
2018 - 2019	3,000	3,900	17,000	6,400	10,800	52,400	11,400	19,400	35,400	1,200	12,000	43,000	43,000	259,000	1,900	149,000	11,640	41,000	96,000	300,000	-41,000
2019 - 2020	3,000	3,900	17,000	6,400	10,800	52,400	11,400	19,400	35,400	1,200	14,000	41,000	44,000	260,000	1,900	149,000	11,640	41,000	93,000	297,000	-37,000
2020 - 2021	3,000	3,900	17,000	6,400	10,800	52,400	11,400	19,400	35,400	1,200	16,000	39,000	44,000	260,000	1,900	149,000	11,640	41,000	92,000	296,000	-36,000
2021 - 2022	3,000	3,900	17,000	6,400	10,800	52,400	11,400	19,400	35,400	1,200	17,000	37,000	45,000	260,000	1,900	149,000	11,640	41,000	91,000	295,000	-35,000
2022 - 2023	3,000	3,900	17,000	6,400	10,800	52,400	11,400	19,400	35,400	1,200	18,000	35,000	45,000	259,000	1,900	149,000	11,640	42,000	90,000	295,000	-36,000
2023 - 2024	3,000	3,900	17,000	6,400	10,800	52,400	11,400	19,400	35,400	1,200	19,000	33,000	46,000	259,000	1,900	149,000	11,640	42,000	89,000	294,000	-35,000
2024 - 2025	3,000	3,900	18,200	6,600	11,200	49,600	10,800	18,400	35,900	1,200	20,000	32,000	46,000	257,000	1,900	151,000	11,640	43,000	85,000	293,000	-36,000
2025 - 2026	3,000	3,900	18,400	6,600	11,200	46,800	10,200	17,300	36,900	1,200	20,000	31,000	47,000	254,000	1,900	155,000	8,730	43,000	83,000	292,000	-38,000
2026 - 2027	3,000	3,900	18,700	6,600	11,200	44,000	9,600	16,300	37,900	1,200	22,000	31,000	48,000	253,000	1,900	159,000	8,730	43,000	80,000	293,000	-40,000
2027 - 2028	3,000	3,900	19,000	6,600	11,200	41,200	8,900	15,300	38,900	1,200	23,000	31,000	48,000	251,000	1,900	164,000	8,730	43,000	78,000	296,000	-45,000
2028 - 2029	3,000	3,900	19,300	6,600	11,200	38,400	8,300	14,300	40,000	1,200	24,000	32,000	49,000	251,000	1,900	168,000	8,730	42,000	75,000	296,000	-45,000
2029 - 2030	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,200	40,900	1,200	24,000	32,000	50,000	249,000	1,900	172,000	8,730	42,000	70,000	295,000	-46,000
2030 - 2031	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,200	40,900	1,200	23,000	31,000	51,000	248,000	1,900	172,000	5,820	42,000	68,000	290,000	-42,000
2031 - 2032	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,200	40,900	1,200	23,000	32,000	51,000	249,000	1,900	172,000	5,820	42,000	67,000	289,000	-40,000
2032 - 2033	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,200	40,900	1,200	22,000	32,000	52,000	249,000	1,900	172,000	5,820	41,000	65,000	286,000	-37,000
2033 - 2034	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,200	40,900	1,200	22,000	32,000	52,000	249,000	1,900	172,000	5,820	41,000	64,000	285,000	-36,000
2034 - 2035	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	40,700	1,200	20,000	31,000	53,000	247,000	1,900	171,000	5,820	42,000	56,000	277,000	-30,000
2035 - 2036	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	40,700	1,200	18,000	31,000	53,000	245,000	1,900	171,000	2,910	42,000	54,000	272,000	-27,000
2036 - 2037	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	40,700	1,200	17,000	31,000	53,000	244,000	1,900	171,000	2,910	41,000	52,000	269,000	-25,000
2037 - 2038	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	40,700	1,200	16,000	31,000	53,000	243,000	1,900	171,000	2,910	41,000	50,000	267,000	-24,000
2038 - 2039	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	40,700	1,200	16,000	31,000	53,000	243,000	1,900	171,000	2,910	41,000	48,000	265,000	-22,000
2039 - 2040	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	12,000	29,000	53,000	232,000	1,900	152,000	0	42,000	47,000	243,000	-11,000
2040 - 2041	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	10,000	30,000	53,000	231,000	1,900	152,000	0	42,000	46,000	242,000	-11,000
2041 - 2042	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	10,000	30,000	53,000	231,000	1,900	152,000	0	42,000	45,000	241,000	-10,000
2042 - 2043	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	9,000	30,000	53,000	230,000	1,900	152,000	0	42,000	44,000	240,000	-10,000
2043 - 2044	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	8,000	30,000	53,000	229,000	1,900	152,000	0	42,000	43,000	239,000	-10,000
2044 - 2045	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	8,000	31,000	53,000	230,000	1,900	152,000	0	42,000	42,000	238,000	-8,000
2045 - 2046	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	7,000	31,000	53,000	229,000	1,900	152,000	0	41,000	42,000	237,000	-8,000
2046 - 2047	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	7,000	31,000	53,000	229,000	1,900	152,000	0	41,000	41,000	236,000	-7,000
2047 - 2048	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	7,000	31,000	54,000	230,000	1,900	152,000	0	41,000	41,000	236,000	-6,000
2048 - 2049	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	6,000	31,000	54,000	229,000	1,900	152,000	0	41,000	41,000	236,000	-7,000
2049 - 2050	3,000	3,900	19,400	6,500	11,200	35,600	7,700	13,300	36,200	1,200	6,000	32,000	54,000	230,000	1,900	152,000	0	41,000	40,000	235,000	-5,000
2050 - 2051	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	6,000	31,000	54,000	218,000	1,900	141,000	0	41,000	41,000	225,000	-7,000
2051 - 2052	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	6,000	31,000	54,000	218,000	1,900	141,000	0	41,000	41,000	225,000	-7,000
2052 - 2053	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	6,000	31,000	54,000	218,000	1,900	141,000	0	41,000	41,000	225,000	-7,000
2053 - 2054	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	6,000	31,000	54,000	218,000	1,900	141,000	0	41,000	40,000	224,000	-6,000
2054 - 2055	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	5,000	31,000	54,000	217,000	1,900	141,000	0	41,000	40,000	224,000	-7,000
2055 - 2056	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	5,000	32,000	54,000	218,000	1,900	141,000	0	41,000	40,000	224,000	-6,000
2056 - 2057	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	5,000	32,000	54,000	218,000	1,900	141,000	0	41,000	39,000	223,000	-5,000
2057 - 2058	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	5,000	32,000	54,000	218,000	1,900	141,000	0	41,000	39,000	223,000	-5,000
2058 - 2059	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	5,000	32,000	54,000	218,000	1,900	141,000	0	41,000	39,000	223,000	-5,000
2059 - 2060	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	5,000	32,000	54,000	218,000	1,900	141,000	0	41,000	39,000	223,000	-5,000
2060 - 2061	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	4,000	32,000	54,000	217,000	1,900	141,000	0	41,000	39,000	223,000	-6,000
2061 - 2062	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	4,000	33,000	54,000	218,000	1,900	141,000	0	41,000	39,000	223,000	-5,000
2062 - 2063	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	4,000	33,000	54,000	218,000	1,900	141,000	0	41,000	39,000	223,000	-5,000
2063 - 2064	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	4,000	33,000	54,000	218,000	1,900	141,000	0	41,000	39,000	223,000	-5,000
2064 - 2065	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	4,000	33,000	54,000	218,000	1,900	141,000	0	41,000	39,000	223,000	-5,000
2065 - 2066	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	4,000	33,000	54,000	218,000	1,900	141,000	0	41,000	38,000	222,000	-4,000
2066 - 2067	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	4,000	33,000	54,000	218,000	1,900	141,000	0	41,000	38,000	222,000	-4,000
2067 - 2068	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	3,000	33,000	54,000	217,000	1,900	141,000	0	41,000	39,000	223,000	-6,000
2068 - 2069	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	3,000	33,000	54,000	217,000	1,900	141,000	0	41,000	38,000	222,000	-5,000
2069 - 2070	3,000	3,800	19,300	6,300	10,900	30,800	6,700	11,500	33,600	1,200	3,000	33,000	54,000	217,000	1,900	141,000	0	41,000	38,000	222,000	-5,000
17/18-69/70 Avg	3,000	3,900	19,000	6,400	11,000	36,800	8,000	13,700	36,100	1,200	11,000	33,000	52,000	235,000	1,900	152,000	3,300	41,000	55,000	253,000	-18,000

Lower Tule River Irrigation District GSA
Representative Monitoring Site

Appendix A
Figure **1**

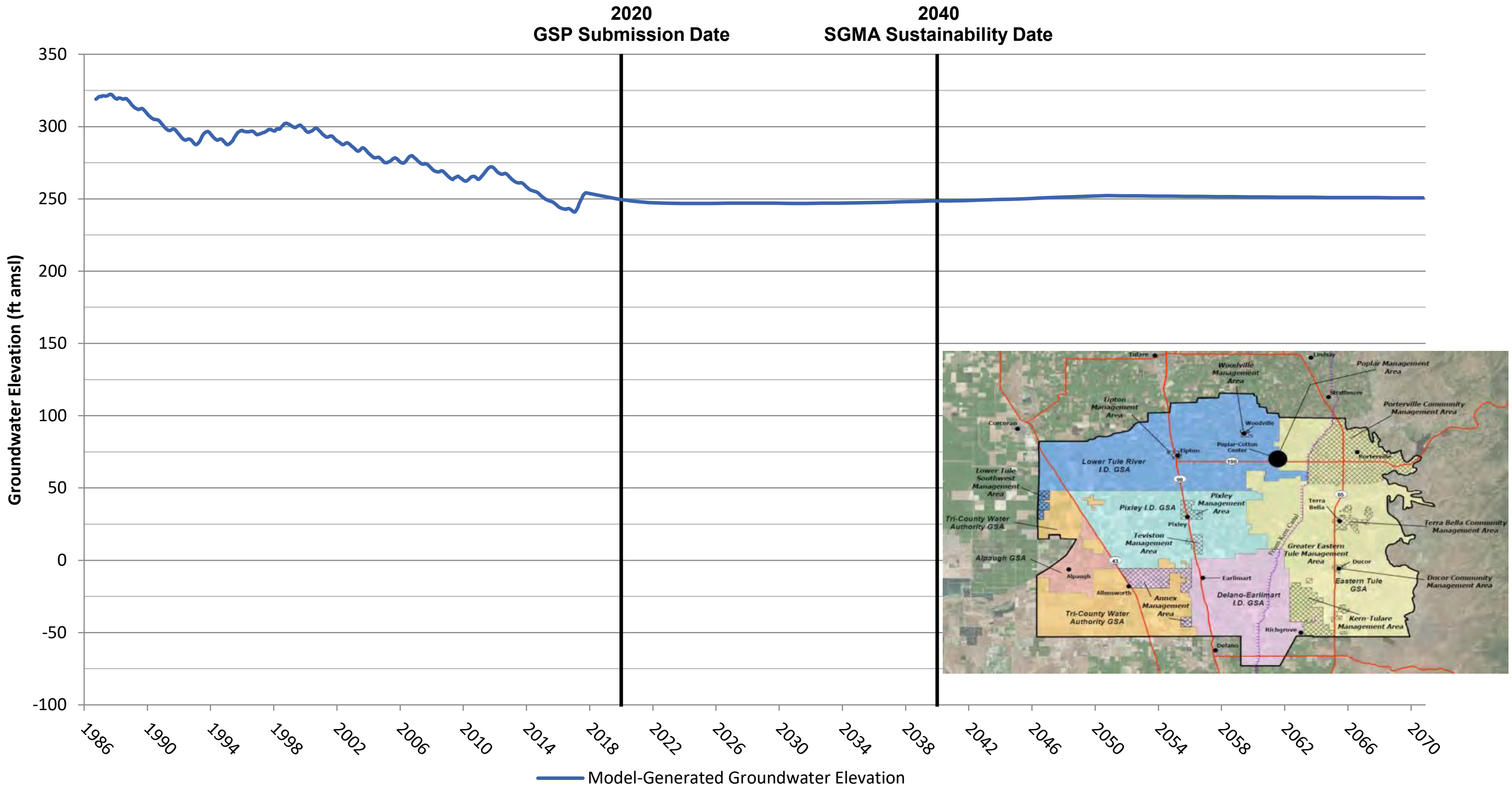


Tule Subbasin
Basin Setting

Lower Tule River Irrigation District GSA
Representative Monitoring Site

Appendix A
Figure 2

21S/26E-34
Upper Aquifer
Perforations: 253 to -27 (ft amsl)

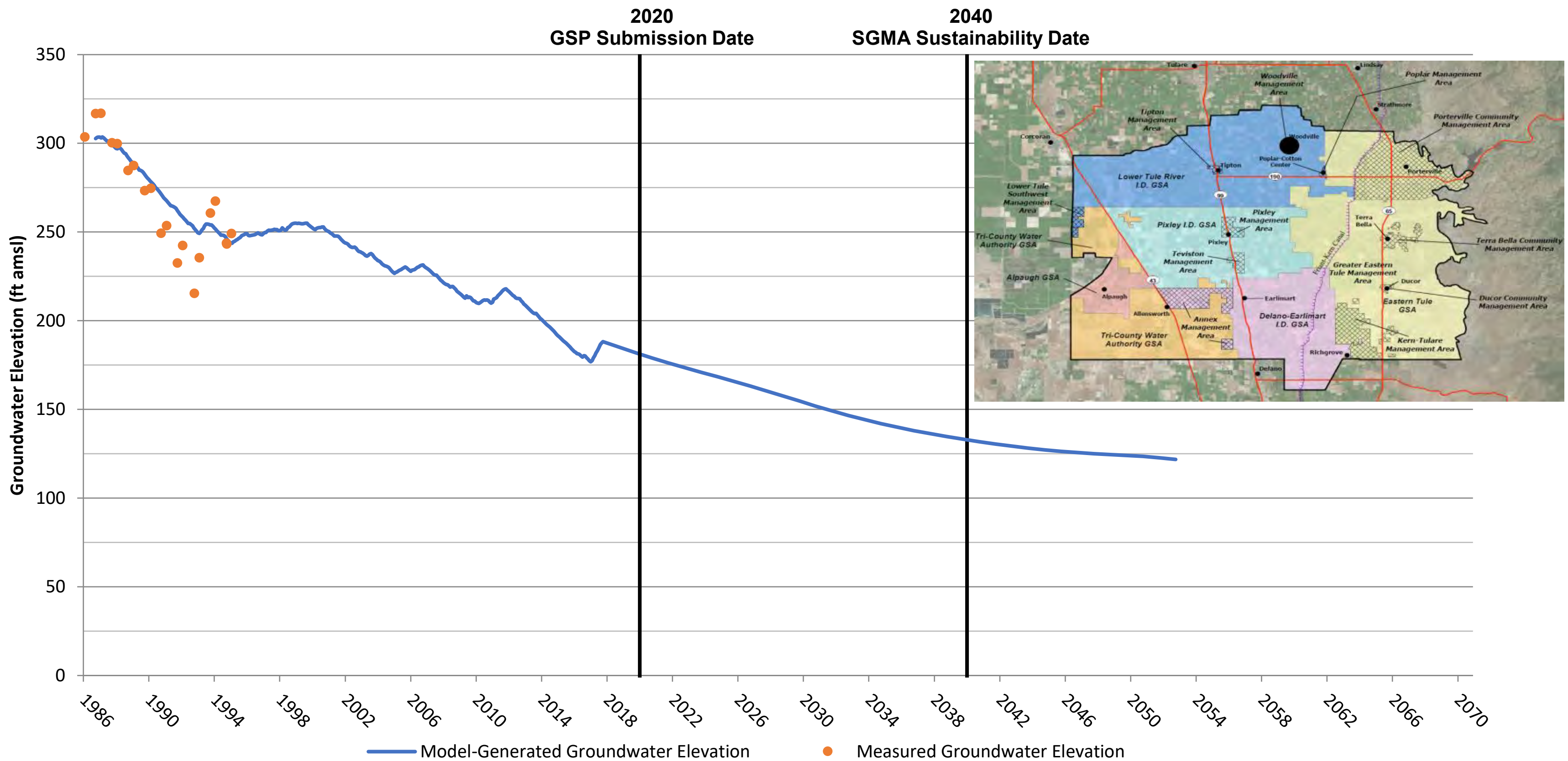


Thomas Harder & Co.
Groundwater Consulting

January 2020

Lower Tule River Irrigation District GSA
Representative Monitoring Site

21S/26E-17N01
Upper Aquifer

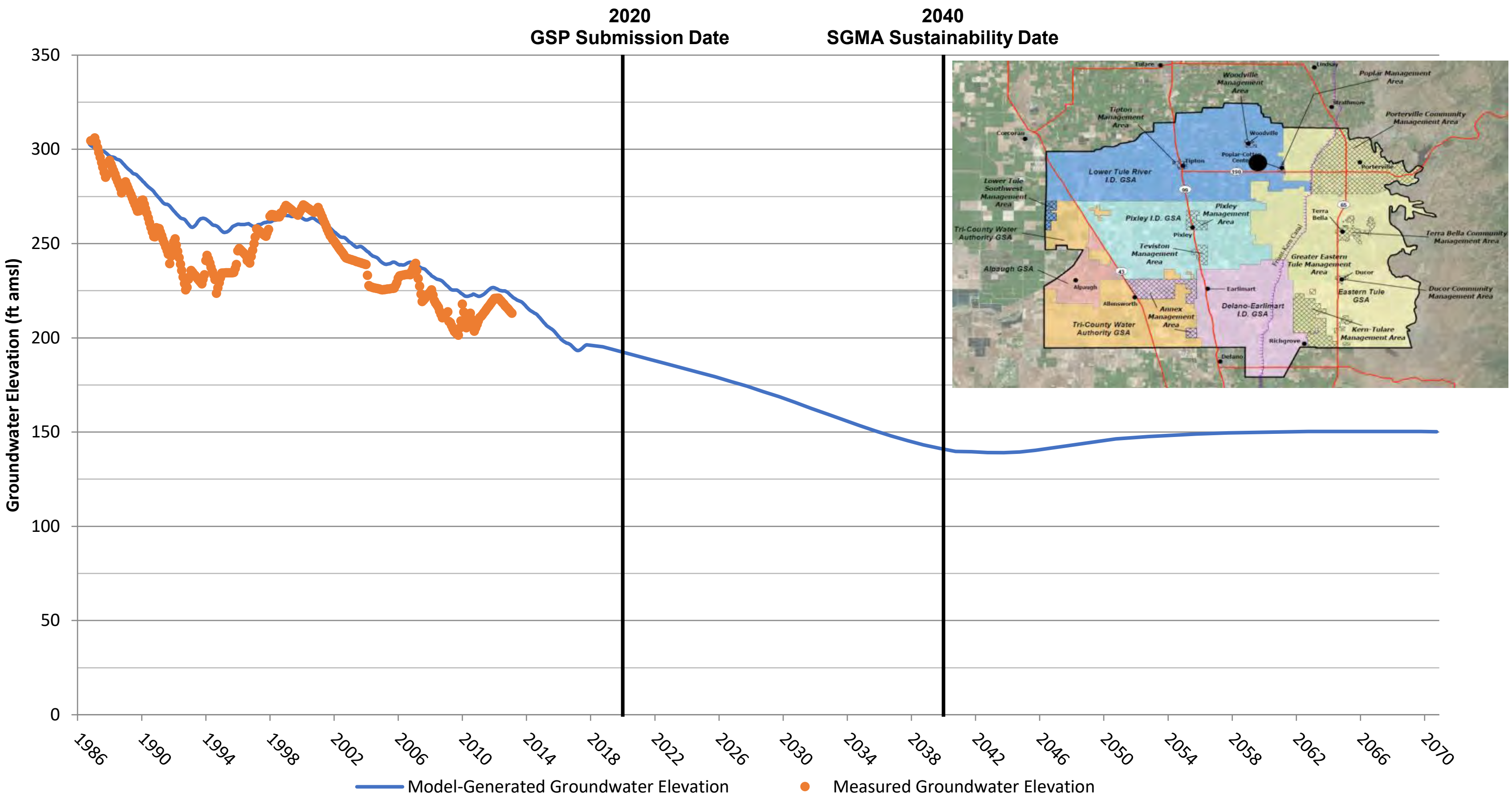


Thomas Harder & Co.
Groundwater Consulting

January 2020

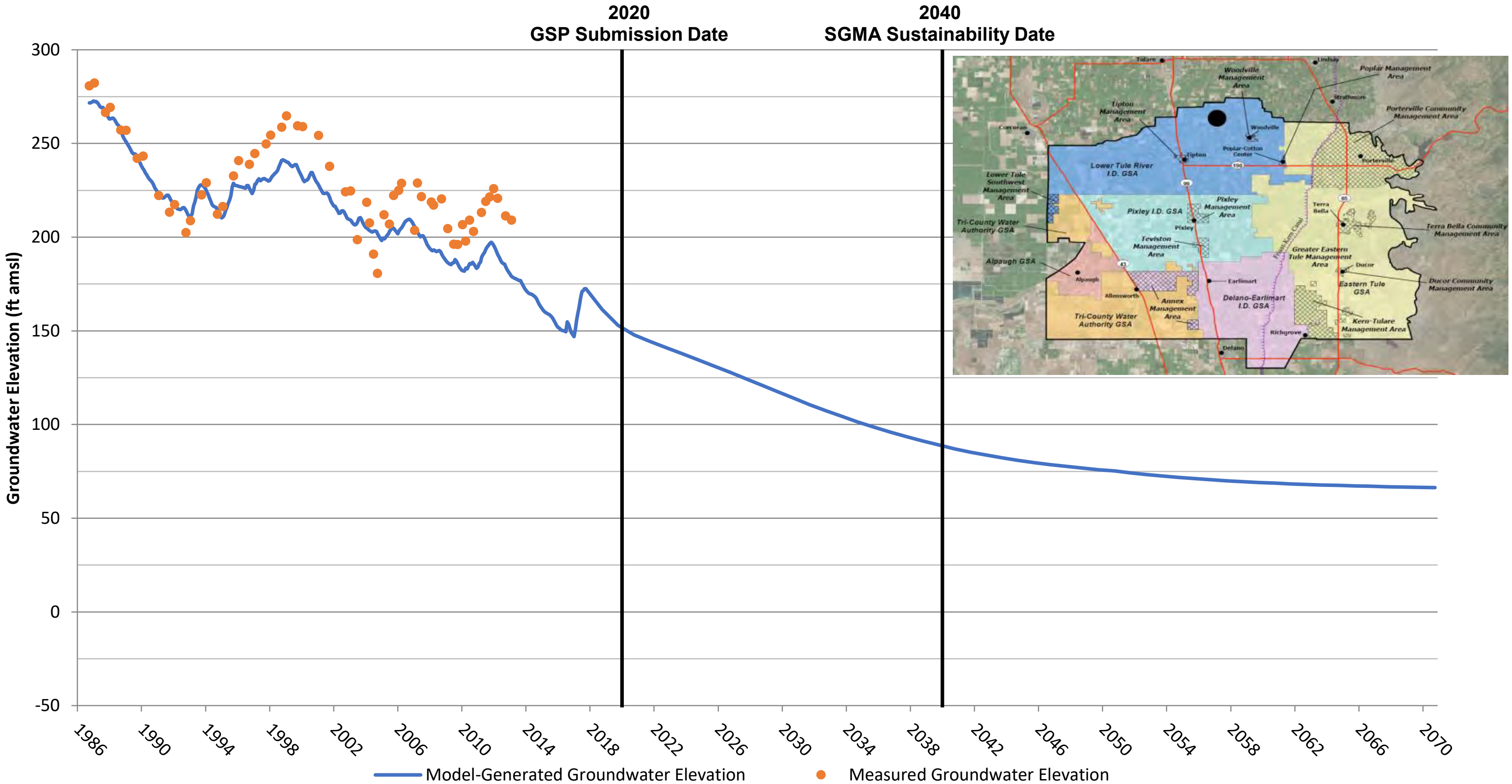
Lower Tule River Irrigation District GSA
Representative Monitoring Site

21S/26E-32A01
Upper Aquifer
Perforations: 194 to 86 (ft amsl)



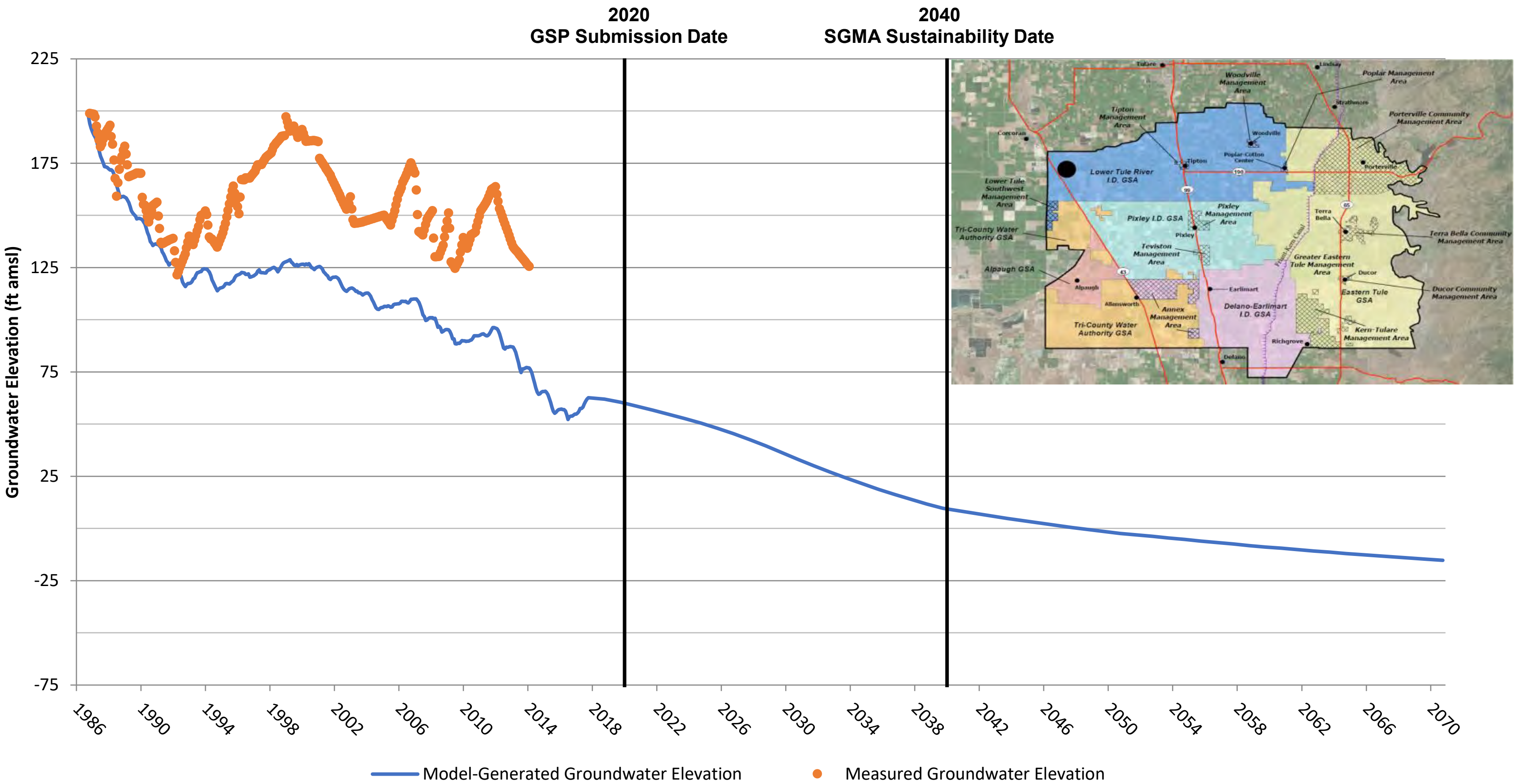
Lower Tule River Irrigation District GSA
Representative Monitoring Site

21S/25E-03R01
Upper Aquifer
Perforations: 153 to 60 (ft amsl)



Lower Tule River Irrigation District GSA
Representative Monitoring Site

21S/23E-32K01
Upper Aquifer
Perforations: 96 to -202 (ft amsl)

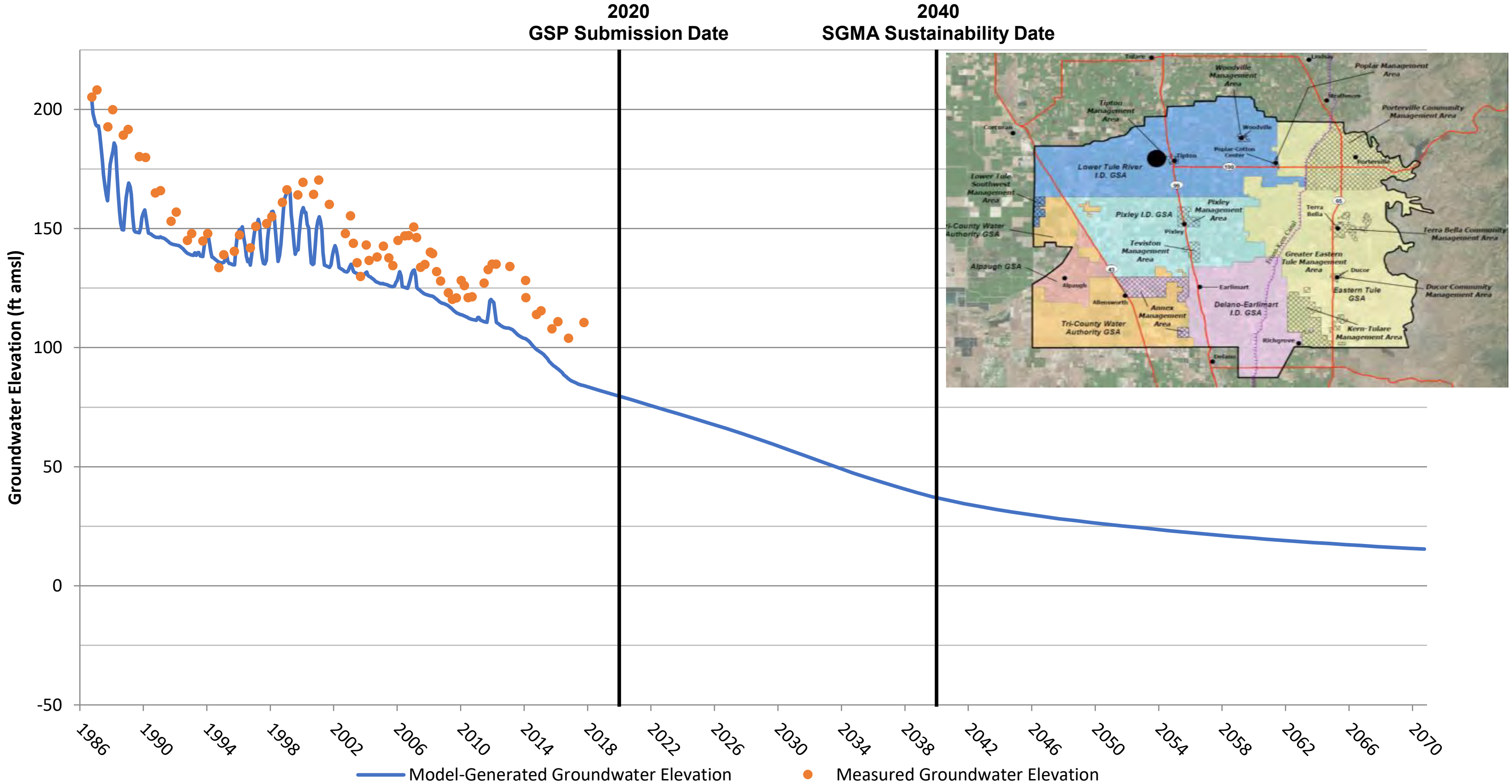


Thomas Harder & Co.
Groundwater Consulting

January 2020

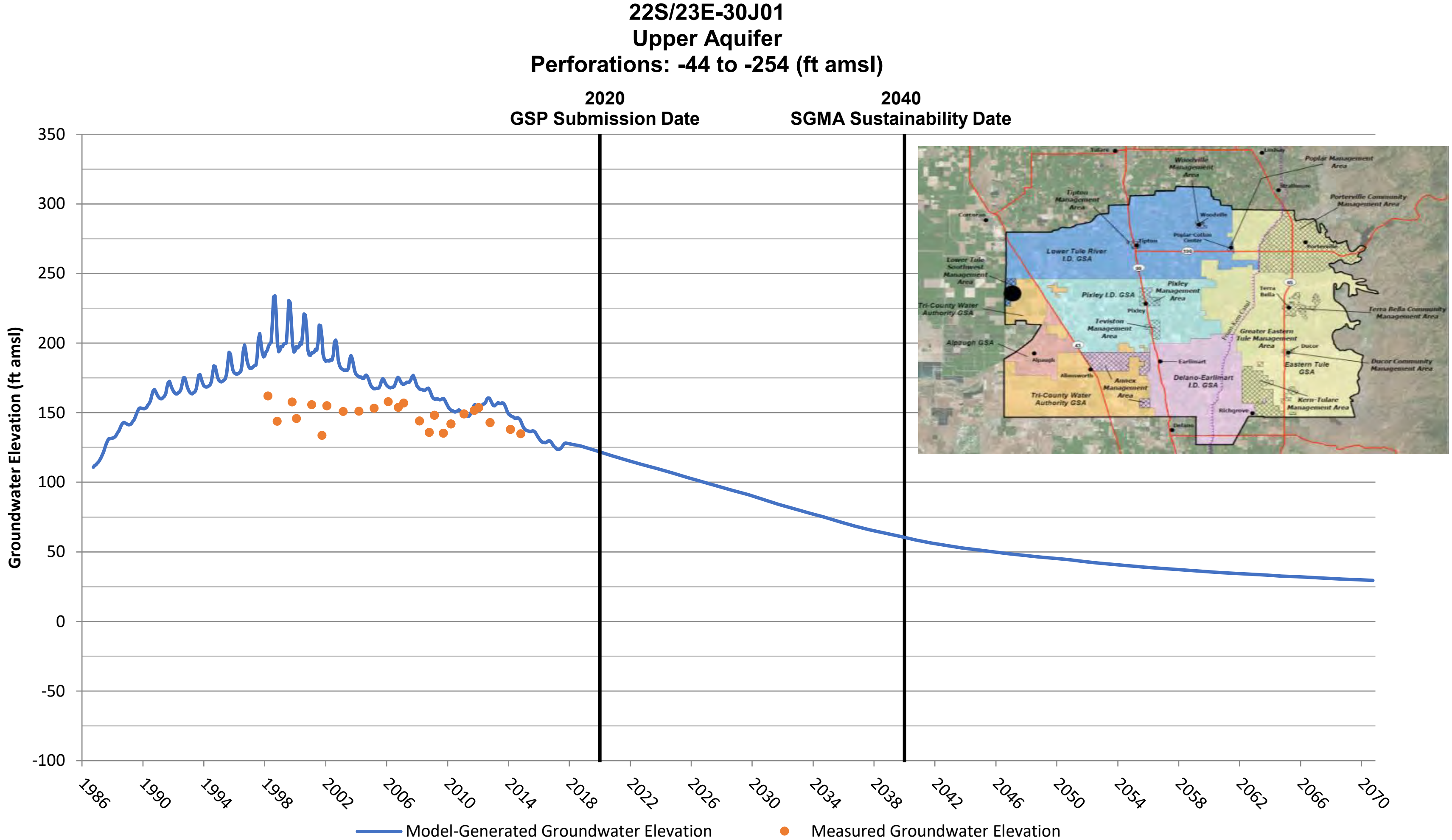
Lower Tule River Irrigation District GSA
Representative Monitoring Site

21S/24E-35A01
Upper Aquifer
Perforations: 4 to -53 (ft amsl)



Lower Tule River Irrigation District GSA
Representative Monitoring Site

Appendix A
Figure **8**



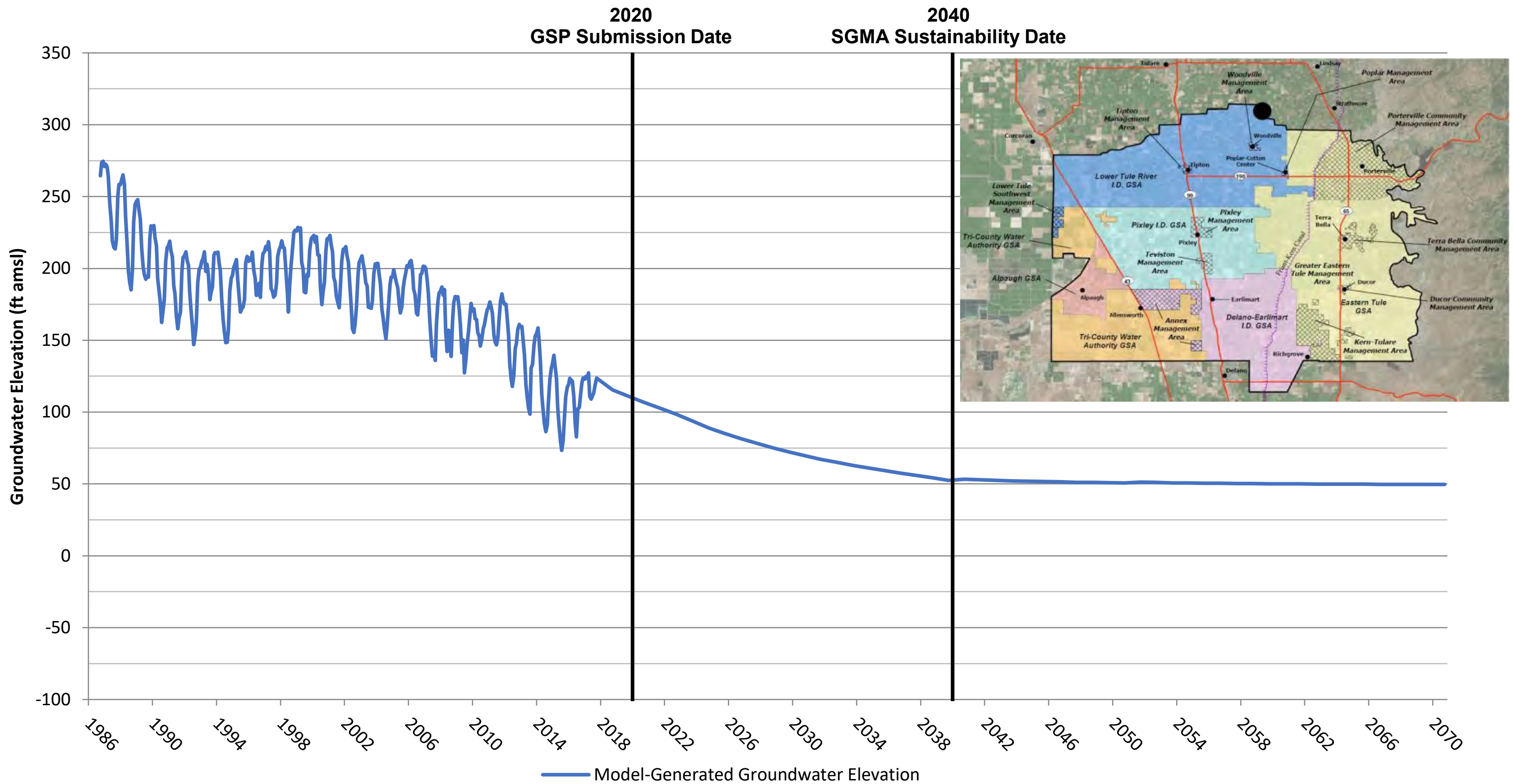
Thomas Harder & Co.
Groundwater Consulting

January 2020

Lower Tule River Irrigation District GSA
Representative Monitoring Site

Appendix A
Figure **9**

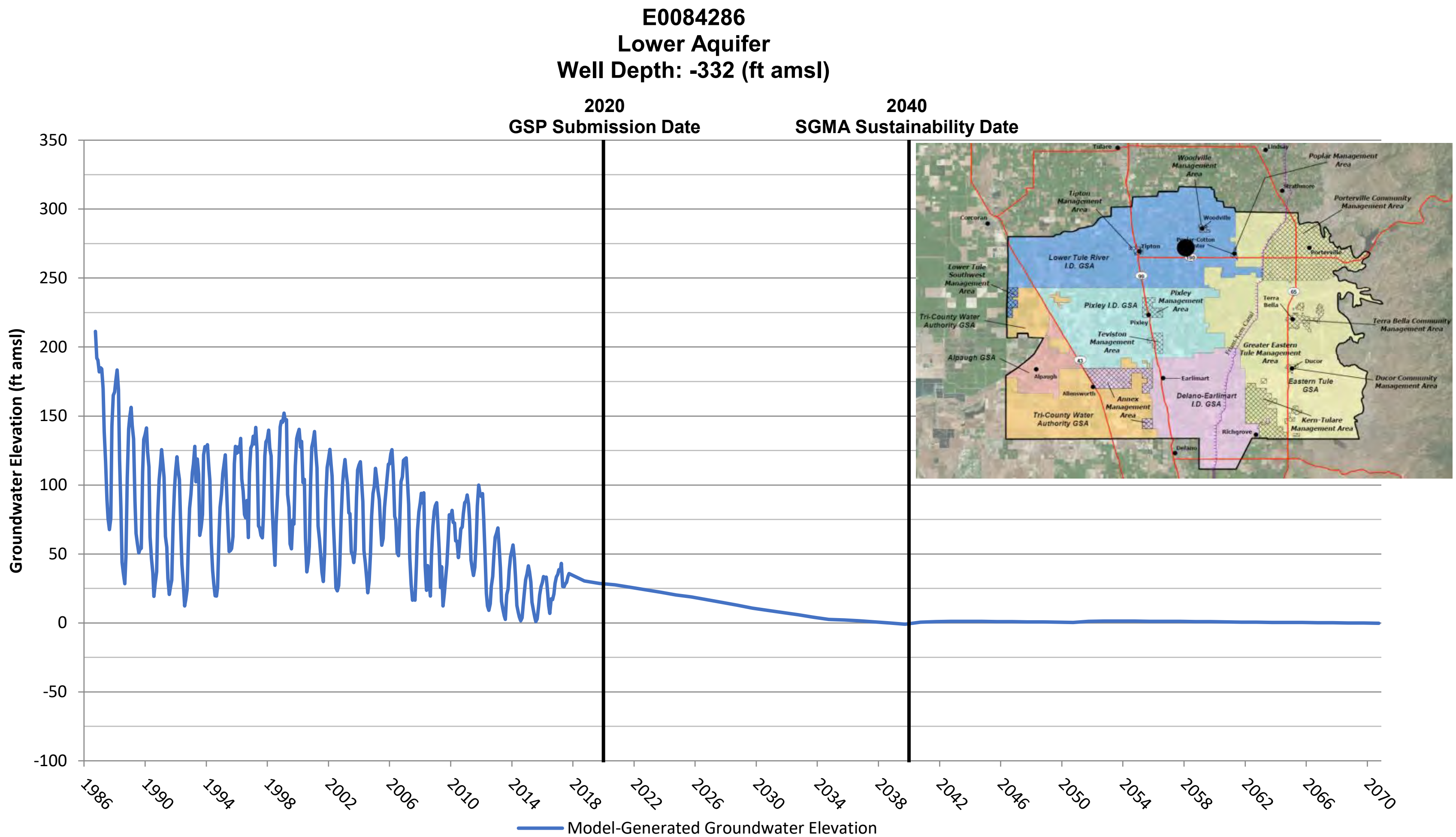
E0090245
Lower Aquifer
Well Depth: -349 (ft amsl)



Tule Subbasin
Basin Setting

Lower Tule River Irrigation District GSA
Representative Monitoring Site

Appendix A
Figure 10



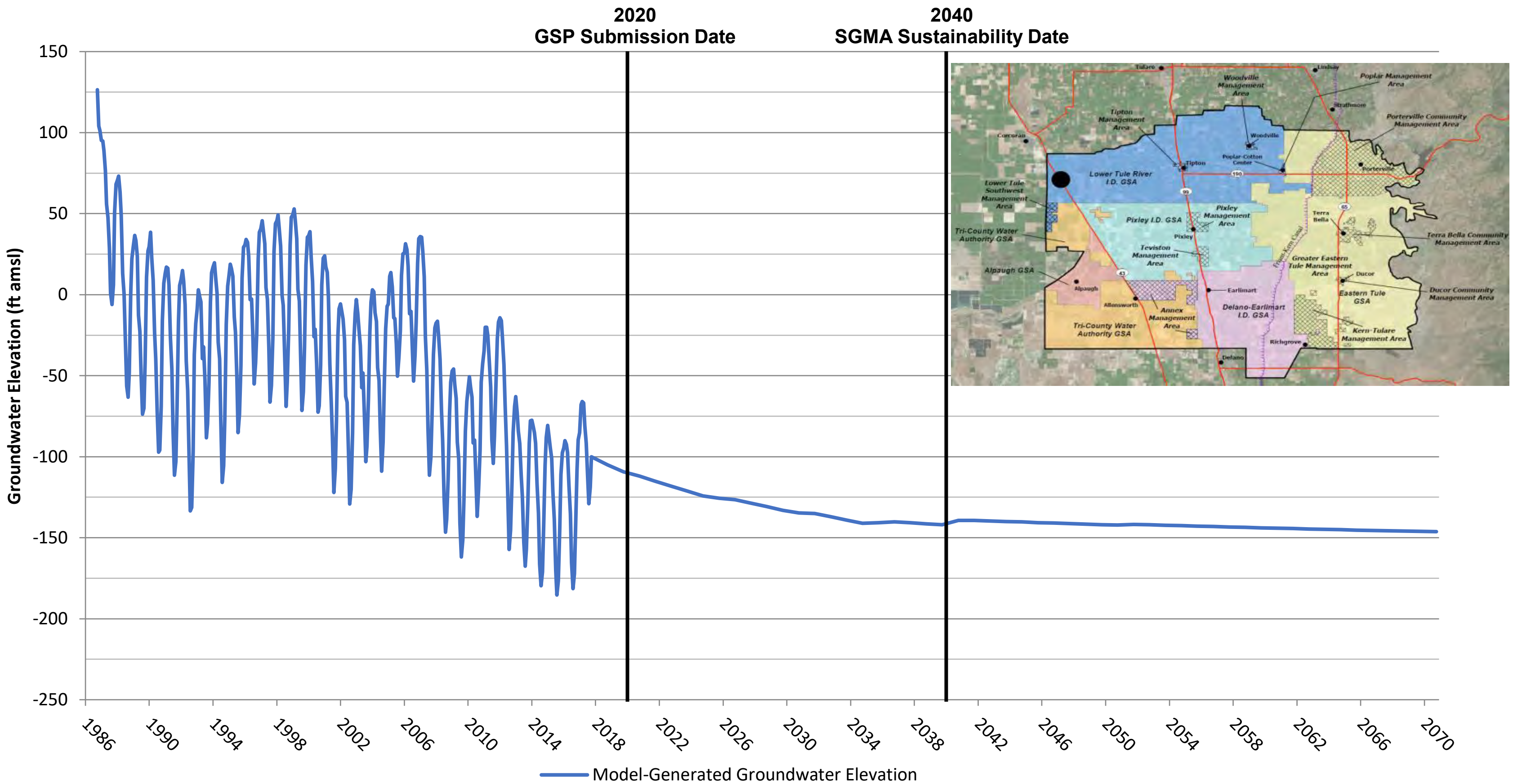
Thomas Harder & Co.
Groundwater Consulting

January 2020

Lower Tule River Irrigation District GSA
Representative Monitoring Site

Appendix A
Figure 11

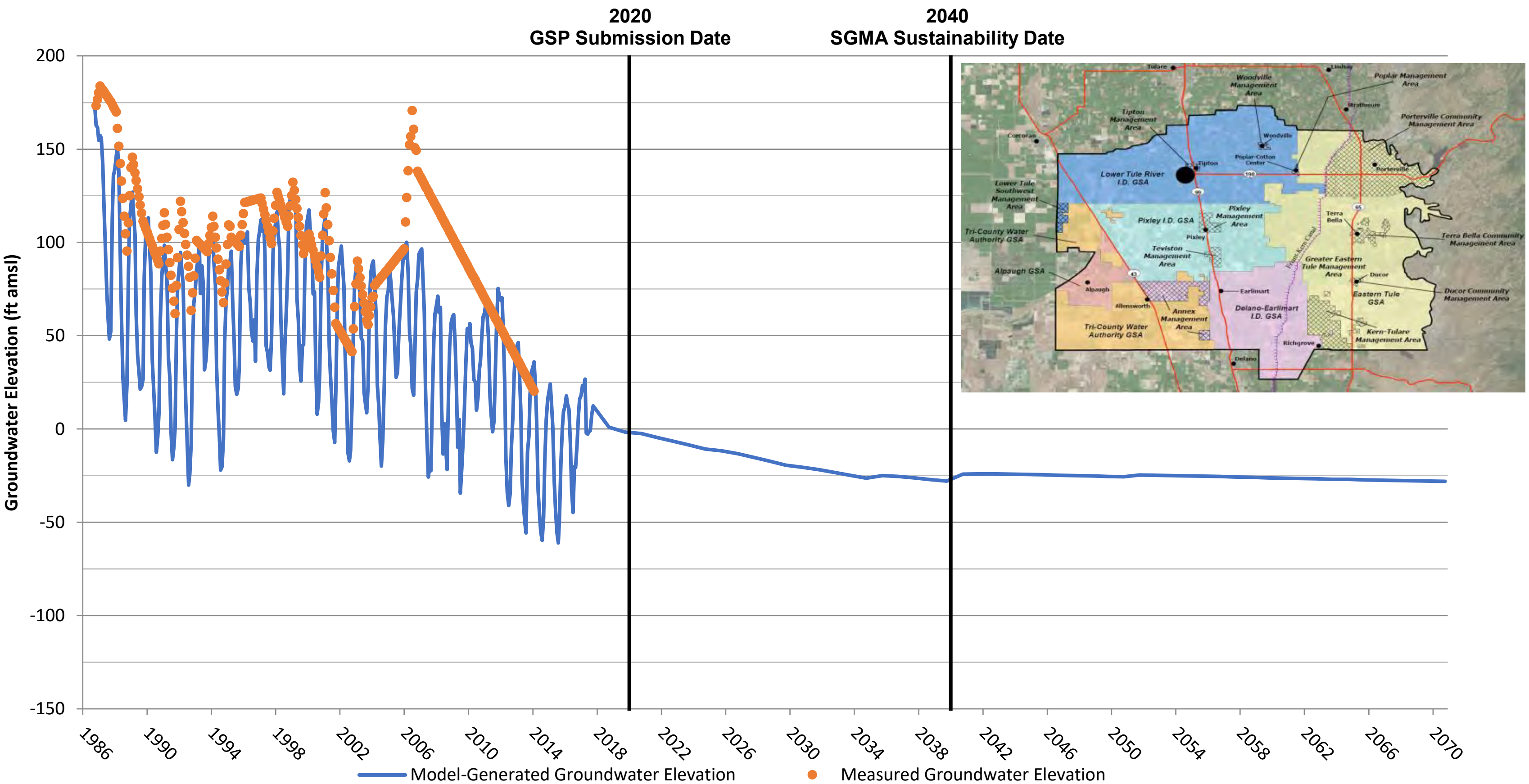
E0094101
Lower Aquifer
Perforations: -380 to -1,030 (ft amsl)



Thomas Harder & Co.
Groundwater Consulting

Lower Tule River Irrigation District GSA
Representative Monitoring Site

22S/24E-01Q01
Lower Aquifer
Perforations: -211 to -431 (ft amsl)



Thomas Harder & Co.
Groundwater Consulting

Appendix B

Eastern Tule GSA

Water Budgets and Hydrographs

Appendix B
Table 1a

Eastern Tule GSA
Historical Surface Water Budget 1986/87 to 2016/17

Water Year	Surface Water Inflow (acre-ft)											Total In
		Stream Inflow			Imported Water					Discharge from Wells		
	Precip-itation	Tule River	Deer Creek	White River	Saucelito ID	Terra Bella ID	Kern-Tulare WD	Porterville ID	Tea Pot Dome WD	Agricultural	Municipal	
1986 - 1987	92,000	70,029	8,389	2,496	23,879	13,136	10,899	15,337	5,490	207,000	9,600	458,000
1987 - 1988	132,000	39,842	6,095	1,420	19,666	21,961	12,210	13,067	5,493	207,000	11,100	470,000
1988 - 1989	107,000	49,667	7,795	1,942	22,426	22,561	11,991	13,106	6,226	206,000	11,700	460,000
1989 - 1990	103,000	29,342	4,706	778	16,166	23,159	11,371	11,520	6,193	215,000	12,200	433,000
1990 - 1991	139,000	51,275	7,247	1,362	19,848	18,725	9,762	11,322	5,636	218,000	12,600	495,000
1991 - 1992	120,000	34,325	4,080	739	21,336	20,743	11,700	15,569	6,607	207,000	12,900	455,000
1992 - 1993	194,000	115,640	15,422	3,623	41,261	18,180	12,357	12,310	6,968	181,000	13,100	614,000
1993 - 1994	123,000	61,313	6,908	1,148	22,064	18,740	14,255	12,895	6,526	206,000	13,500	486,000
1994 - 1995	256,000	218,480	32,053	10,596	37,477	16,186	11,681	9,455	6,562	180,000	13,400	792,000
1995 - 1996	135,000	174,473	23,095	5,957	48,924	21,617	15,415	13,808	7,993	163,000	13,600	623,000
1996 - 1997	189,000	353,968	58,781	12,920	40,908	20,158	15,736	13,379	7,298	172,000	14,500	899,000
1997 - 1998	305,000	439,125	88,360	36,764	28,221	13,165	11,745	10,159	4,913	195,000	13,700	1,146,000
1998 - 1999	156,000	108,466	18,410	7,469	37,062	17,567	14,527	16,107	9,218	185,000	13,700	584,000
1999 - 2000	149,000	102,354	15,230	4,878	39,734	19,200	16,476	15,545	7,191	186,000	14,600	570,000
2000 - 2001	111,000	55,249	7,016	4,695	25,252	19,194	17,550	15,436	6,456	200,000	14,700	477,000
2001 - 2002	106,000	73,206	10,370	6,176	26,131	20,234	15,088	13,628	6,388	201,000	16,400	495,000
2002 - 2003	104,000	125,004	15,678	5,875	33,692	18,356	14,591	14,646	5,844	190,000	16,000	544,000
2003 - 2004	87,000	51,738	6,882	2,350	26,988	20,352	15,755	14,698	6,913	191,000	17,000	441,000
2004 - 2005	166,000	172,558	22,758	6,502	42,840	15,266	13,495	14,748	5,217	172,000	15,800	647,000
2005 - 2006	168,000	195,667	23,868	7,588	45,106	21,763	14,507	13,251	6,436	159,000	16,600	672,000
2006 - 2007	71,000	38,587	6,901	1,815	16,280	20,797	15,133	9,775	5,489	207,000	17,500	410,000
2007 - 2008	79,000	74,030	8,411	2,355	24,083	18,192	17,689	12,988	6,894	192,000	17,700	453,000
2008 - 2009	85,000	54,737	6,620	1,751	31,282	19,701	15,524	18,000	6,165	181,000	17,000	437,000
2009 - 2010	136,000	144,778	16,470	5,080	42,855	17,574	14,027	14,335	5,845	165,000	16,300	578,000
2010 - 2011	201,000	266,473	44,873	14,997	46,733	16,381	13,405	9,387	6,105	154,000	16,200	790,000
2011 - 2012	127,000	87,533	11,311	3,334	19,189	19,757	14,309	9,318	4,680	195,000	16,800	508,000
2012 - 2013	58,000	30,283	4,777	1,145	14,102	20,628	14,955	10,298	4,354	199,000	17,100	375,000
2013 - 2014	41,000	13,171	2,957	535	5,724	12,390	9,986	178	1,030	233,000	16,100	336,000
2014 - 2015	59,000	8,820	1,994	253	1,503	12,012	5,438	114	260	243,000	13,900	346,000
2015 - 2016	91,000	74,330	14,559	4,547	20,049	14,357	11,805	13,271	4,627	194,000	13,700	456,000
2016 - 2017	95,000	352,963	51,145	17,241	51,137	16,089	14,203	21,651	6,694	144,000	14,000	784,000
86/87-16/17 Avg	129,000	118,300	17,800	5,800	28,800	18,300	13,500	12,600	5,900	192,000	14,600	557,000

Eastern Tule GSA
Historical Subbasin Surface Water Budget 1986/87 to 2016/17

Surface Water Outflow (acre-ft)

Water Year	Areal Recharge of Precip-itation	Streambed Infiltration: Tule River – Success to Oettle Bridge Infiltration	Streambed Infiltration: Deer Creek – Before Trenton Weir Infiltration	Streambed Infiltration: White River	Recharge in Basins: Tule River	Recharge in Basins: Recyled Water	Deep Percolation of Applied Water: Tule River	Deep Percolation of Applied Water: Imported Water	Deep Percolation of Applied Water: Recycled Water	Deep Percolation of Applied Water: Agri-cultural Pumping	Deep Percolation of Applied Water: Muni-cipal Pumping	Evapotranspiration: Precipitation Crops/Native	Evapotranspiration: Tule River – Agricultural Cons. Use	Evapotranspiration: Tule River – Stream Channel	Evapotranspiration: Deer Creek – Stream Channel	Evapotranspiration: White River – Stream Channel	Evapotranspiration: Imported Water – Agricultural Cons. Use	Evapotranspiration: Ag. Cons. Use from Pumping	Evapotranspiration: Recycled Water – Agricultural Cons. Use	Evapotranspiration: Recycled Water – Recharge in Basins	Evapotranspiration: Municipal (Landscape ET)	Surface Outflow: Tule River – To LTIRD GSA	Surface Outflow: Tule River – To FKC	Surface Outflow: Deer Creek – To Pixley GSA	Surface Outflow: White River – To DEID GSA	Total Out
1986 - 1987	0	11,600	8,100	2,400	5,400	2,600	3,200	13,400	200	36,000	2,700	92,000	11,300	400	300	100	55,300	171,000	700	50	3,400	40,400	0	0	0	659,000
1987 - 1988	4,000	8,000	5,800	1,300	5,000	3,200	4,100	15,000	200	37,100	2,900	128,000	10,200	300	300	100	57,400	170,000	900	50	3,900	14,700	0	0	0	709,000
1988 - 1989	0	8,700	7,500	1,800	6,200	3,400	1,700	14,300	200	37,000	3,000	107,000	6,500	300	300	100	62,000	169,000	1,000	50	4,100	22,900	0	0	0	673,000
1989 - 1990	0	5,000	4,400	700	3,700	3,600	1,500	12,500	200	39,100	3,100	103,000	5,800	400	300	100	55,900	175,000	1,000	50	4,300	7,100	0	0	0	634,000
1990 - 1991	7,000	6,400	6,900	1,300	5,200	3,700	1,500	12,500	200	39,200	3,200	132,000	5,500	300	300	100	52,800	179,000	1,000	50	4,500	22,700	0	0	0	719,000
1991 - 1992	1,000	4,300	3,800	700	3,700	3,800	1,600	14,300	200	37,100	3,200	118,000	5,900	400	300	100	61,600	170,000	1,100	50	4,500	9,900	0	0	0	672,000
1992 - 1993	41,000	18,500	15,100	3,500	8,200	3,900	8,900	20,000	200	30,600	3,300	153,000	16,000	400	400	100	71,100	150,000	1,100	50	4,600	57,600	0	0	0	882,000
1993 - 1994	2,000	6,100	6,600	1,100	5,000	4,000	4,000	15,700	200	36,900	3,400	121,000	8,900	300	300	100	58,800	169,000	1,100	50	4,800	31,300	0	0	0	710,000
1994 - 1995	81,000	36,400	21,200	6,600	7,800	3,900	15,400	17,600	200	30,200	3,400	175,000	23,100	400	400	100	63,800	150,000	1,100	50	4,700	142,900	0	10,400	3,900	1,096,000
1995 - 1996	5,000	20,700	13,700	4,600	7,800	3,900	16,100	27,100	200	27,000	3,500	130,000	22,600	400	400	100	80,700	136,000	1,100	50	4,800	105,900	0	9,000	1,300	887,000
1996 - 1997	37,000	34,600	45,100	6,100	5,400	4,300	14,700	23,300	200	29,200	3,600	151,000	21,500	400	400	100	74,200	143,000	1,200	50	5,100	250,300	36,400	13,300	6,700	1,188,000
1997 - 1998	112,000	41,100	14,900	9,500	4,100	3,900	12,000	14,400	200	33,000	3,600	193,000	23,600	400	400	200	53,800	162,000	1,100	50	4,800	286,700	0	74,600	27,100	1,384,000
1998 - 1999	17,000	14,300	13,300	7,100	6,200	3,900	3,600	19,700	200	32,000	3,600	139,000	10,900	400	400	200	74,800	153,000	1,100	50	4,800	71,000	0	4,800	200	843,000
1999 - 2000	12,000	16,900	10,100	4,100	5,500	4,200	3,200	21,500	200	32,500	3,700	137,000	8,500	400	400	100	76,700	154,000	1,200	50	5,100	64,000	0	4,800	600	826,000
2000 - 2001	0	12,300	6,700	4,300	4,800	4,300	2,100	16,700	200	35,800	3,800	111,000	7,300	300	300	100	67,100	164,000	1,200	50	5,200	27,500	0	0	300	701,000
2001 - 2002	0	14,800	10,100	5,000	5,800	4,900	3,800	17,300	300	36,000	4,000	106,000	9,100	400	300	100	64,100	165,000	1,400	50	5,800	32,900	0	0	1,100	708,000
2002 - 2003	0	19,700	13,600	5,100	6,300	4,800	1,800	15,800	200	30,000	3,900	104,000	6,900	400	400	100	71,400	160,000	1,400	50	5,600	77,600	0	1,700	600	748,000
2003 - 2004	0	9,900	6,600	2,300	3,900	5,100	2,400	14,600	200	30,100	4,100	87,000	6,100	400	300	100	70,100	160,000	1,500	50	6,000	24,500	0	0	0	633,000
2004 - 2005	23,000	24,200	14,400	5,100	7,300	2,400	5,900	16,900	500	26,200	3,900	143,000	13,900	400	400	100	74,700	146,000	3,300	50	5,600	91,500	0	8,000	1,300	881,000
2005 - 2006	24,000	28,100	14,400	5,100	6,900	2,000	15,500	21,000	700	24,200	4,000	144,000	18,900	400	400	100	80,000	135,000	4,000	50	5,800	129,200	0	9,200	2,400	947,000
2006 - 2007	0	6,200	6,600	1,700	4,300	2,000	1,700	11,600	700	33,300	4,100	71,000	4,000	300	300	100	55,900	174,000	4,400	50	6,200	20,000	0	0	0	577,000
2007 - 2008	0	11,700	8,100	2,300	6,000	2,000	2,100	13,800	800	30,500	4,200	79,000	6,000	300	300	100	66,000	162,000	4,500	50	6,200	42,700	0	0	0	635,000
2008 - 2009	0	9,500	6,300	1,600	4,800	2,000	2,700	16,500	700	28,400	4,100	85,000	6,700	400	300	100	74,200	153,000	4,200	50	6,000	29,200	0	0	0	635,000
2009 - 2010	6,000	25,600	16,100	5,000	8,500	2,000	9,000	18,600	600	24,900	4,000	131,000	18,100	400	400	100	76,100	140,000	3,900	50	5,800	82,500	0	0	0	834,000
2010 - 2011	45,000	37,100	24,400	8,300	7,200	2,000	14,700	18,500	600	23,400	4,000	156,000	18,800	400	400	200	73,500	131,000	3,800	50	5,700	191,800	10,000	20,200	6,500	1,080,000
2011 - 2012	3,000	13,600	11,000	3,200	6,600	2,000	1,800	11,600	700	31,500	4,100	124,000	4,700	400	300	100	55,700	163,000	4,100	50	5,900	58,800	0	0	0	727,000
2012 - 2013	0	4,900	4,500	1,000	5,300	2,000	1,100	10,900	700	32,300	4,100	58,000	2,700	400	300	100	53,400	167,000	4,200	50	6,000	14,400	0	0	0	525,000
2013 - 2014	0	2,300	2,700	400	3,800	2,000	1,000	5,100	600	37,900	4,000	41,000	2,400	300	300	100	24,200	195,000	3,800	50	5,700	0	0	0	0	443,000
2014 - 2015	0	1,000	1,800	200	3,600	2,000	1,100	2,600	500	39,400	3,700	59,000	2,300	300	200	100	16,700	203,000	2,700	50	4,900	0	0	0	0	467,000
2015 - 2016	0	16,000	14,300	4,400	5,800	2,000	1,700	10,600	400	30,700	3,700	91,000	5,900	300	300	100	53,500	163,000	2,700	50	4,800	35,400	0	0	0	632,000
2016 - 2017	0	42,100	37,000	6,900	8,900	2,000	26,900	29,300	500	21,400	3,700	95,000	20,700	400	400	200	80,500	122,000	2,800	50	4,900	187,800	0	13,800	10,200	940,000
86/87-16/17 Avg	14,000	16,500	12,100	3,600	5,800	3,200	6,000	15,900	400	32,000	3,700	115,000	10,800	400	300	100	63,100	160,000	2,200	50	5,100	70,100	1,500	5,500	2,000	775,000

Groundwater Inflows to be Included in Sustainable Yield Estimates
Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Surface Water or ET Outflows Not Included in Groundwater Recharge or Sustainable Yield Estimates

Appendix B
Table 2

Eastern Tule GSA
Historical Groundwater Budget 1986/87 to 2016/17

Water Year	Groundwater Inflows (acre-ft)																Groundwater Outflows (acre-ft)					Change in Storage (acre-ft)
	Areal Recharge from Precip-itation	Tule River			Deer Creek	White River	Imported Water Deliveries	Agricultural Pumping	Municipal Pumping			Release of Water from Compression of Aquitards	Sub-surface Inflow		Mountain-Block Recharge	Total In	Groundwater Pumping		Sub-surface Outflow		Total Out	
										Recycled Water												
		Success to Oettle Bridge Infiltration	Recharge in Basins	Return Flow	Infiltration Before Trenton Weir	Infiltration Before DEID	Return Flow	Irrigated Agriculture	Return Flow	Agricultural Return Flow	Artificial Recharge		From Outside Subbasin	From Other GSAs			Muni-cipal	Agri-culture	To Outside Subbasin	To Other GSAs		
1986 - 1987	0	11,600	5,400	3,200	8,100	2,400	13,400	36,000	2,700	200	2,600	36,000	9,000	37,000	28,000	196,000	9,600	207,000	4,000	74,000	295,000	-99,000
1987 - 1988	4,000	8,000	5,000	4,100	5,800	1,300	15,000	37,100	2,900	200	3,200	15,000	10,000	36,000	29,000	177,000	11,100	207,000	4,000	73,000	295,000	-118,000
1988 - 1989	0	8,700	6,200	1,700	7,500	1,800	14,300	37,000	3,000	200	3,400	12,000	11,000	45,000	29,000	181,000	11,700	206,000	3,000	72,000	293,000	-112,000
1989 - 1990	0	5,000	3,700	1,500	4,400	700	12,500	39,100	3,100	200	3,600	15,000	10,000	39,000	29,000	167,000	12,200	215,000	4,000	79,000	310,000	-143,000
1990 - 1991	7,000	6,400	5,200	1,500	6,900	1,300	12,500	39,200	3,200	200	3,700	16,000	10,000	45,000	29,000	187,000	12,600	218,000	4,000	77,000	312,000	-125,000
1991 - 1992	1,000	4,300	3,700	1,600	3,800	700	14,300	37,100	3,200	200	3,800	15,000	10,000	41,000	30,000	170,000	12,900	207,000	4,000	78,000	302,000	-132,000
1992 - 1993	41,000	18,500	8,200	8,900	15,100	3,500	20,000	30,600	3,300	200	3,900	10,000	9,000	54,000	30,000	256,000	13,100	181,000	4,000	59,000	257,000	-1,000
1993 - 1994	2,000	6,100	5,000	4,000	6,600	1,100	15,700	36,900	3,400	200	4,000	14,000	8,000	36,000	30,000	173,000	13,500	206,000	5,000	70,000	295,000	-122,000
1994 - 1995	81,000	36,400	7,800	15,400	21,200	6,600	17,600	30,200	3,400	200	3,900	8,000	8,000	51,000	30,000	321,000	13,400	180,000	6,000	65,000	264,000	57,000
1995 - 1996	5,000	20,700	7,800	16,100	13,700	4,600	27,100	27,000	3,500	200	3,900	7,000	7,000	49,000	27,000	220,000	13,600	163,000	6,000	56,000	239,000	-19,000
1996 - 1997	37,000	34,600	5,400	14,700	45,100	6,100	23,300	29,200	3,600	200	4,300	5,000	7,000	46,000	28,000	290,000	14,500	172,000	6,000	58,000	251,000	39,000
1997 - 1998	112,000	41,100	4,100	12,000	14,900	9,500	14,400	33,000	3,600	200	3,900	7,000	6,000	49,000	30,000	341,000	13,700	195,000	7,000	58,000	274,000	67,000
1998 - 1999	17,000	14,300	6,200	3,600	13,300	7,100	19,700	32,000	3,600	200	3,900	6,000	6,000	49,000	30,000	212,000	13,700	185,000	6,000	58,000	263,000	-51,000
1999 - 2000	12,000	16,900	5,500	3,200	10,100	4,100	21,500	32,500	3,700	200	4,200	5,000	8,000	45,000	30,000	202,000	14,600	186,000	5,000	58,000	264,000	-62,000
2000 - 2001	0	12,300	4,800	2,100	6,700	4,300	16,700	35,800	3,800	200	4,300	8,000	8,000	42,000	30,000	179,000	14,700	200,000	5,000	61,000	281,000	-102,000
2001 - 2002	0	14,800	5,800	3,800	10,100	5,000	17,300	36,000	4,000	300	4,900	10,000	8,000	43,000	30,000	193,000	16,400	201,000	5,000	63,000	285,000	-92,000
2002 - 2003	0	19,700	6,300	1,800	13,600	5,100	15,800	30,000	3,900	200	4,800	10,000	8,000	48,000	29,000	196,000	16,000	190,000	4,000	56,000	266,000	-70,000
2003 - 2004	0	9,900	3,900	2,400	6,600	2,300	14,600	30,100	4,100	200	5,100	11,000	8,000	40,000	29,000	167,000	17,000	191,000	4,000	57,000	269,000	-102,000
2004 - 2005	23,000	24,200	7,300	5,900	14,400	5,100	16,900	26,200	3,900	500	2,400	9,000	7,000	49,000	29,000	224,000	15,800	172,000	5,000	49,000	242,000	-18,000
2005 - 2006	24,000	28,100	6,900	15,500	14,400	5,100	21,000	24,200	4,000	700	2,000	5,000	7,000	47,000	29,000	234,000	16,600	159,000	6,000	52,000	234,000	0
2006 - 2007	0	6,200	4,300	1,700	6,600	1,700	11,600	33,300	4,100	700	2,000	11,000	7,000	35,000	29,000	154,000	17,500	207,000	6,000	59,000	290,000	-136,000
2007 - 2008	0	11,700	6,000	2,100	8,100	2,300	13,800	30,500	4,200	800	2,000	12,000	7,000	42,000	30,000	173,000	17,700	192,000	5,000	57,000	272,000	-99,000
2008 - 2009	0	9,500	4,800	2,700	6,300	1,600	16,500	28,400	4,100	700	2,000	14,000	7,000	39,000	30,000	167,000	17,000	181,000	5,000	60,000	263,000	-96,000
2009 - 2010	6,000	25,600	8,500	9,000	16,100	5,000	18,600	24,900	4,000	600	2,000	12,000	6,000	47,000	29,000	214,000	16,300	165,000	6,000	52,000	239,000	-25,000
2010 - 2011	45,000	37,100	7,200	14,700	24,400	8,300	18,500	23,400	4,000	600	2,000	5,000	6,000	47,000	29,000	272,000	16,200	154,000	6,000	55,000	231,000	41,000
2011 - 2012	3,000	13,600	6,600	1,800	11,000	3,200	11,600	31,500	4,100	700	2,000	10,000	7,000	39,000	29,000	174,000	16,800	195,000	6,000	63,000	281,000	-107,000
2012 - 2013	0	4,900	5,300	1,100	4,500	1,000	10,900	32,300	4,100	700	2,000	13,000	7,000	37,000	29,000	153,000	17,100	199,000	5,000	64,000	285,000	-132,000
2013 - 2014	0	2,300	3,800	1,000	2,700	400	5,100	37,900	4,000	600	2,000	22,000	7,000	35,000	30,000	154,000	16,100	233,000	6,000	65,000	320,000	-166,000
2014 - 2015	0	1,000	3,600	1,100	1,800	200	2,600	39,400	3,700	500	2,000	24,000	7,000	33,000	30,000	150,000	13,900	243,000	6,000	63,000	326,000	-176,000
2015 - 2016	0	16,000	5,800	1,700	14,300	4,400	10,600	30,700	3,700	400	2,000	18,000	6,000	35,000	30,000	179,000	13,700	194,000	6,000	54,000	268,000	-89,000
2016 - 2017	0	42,100	8,900	26,900	37,000	6,900	29,300	21,400	3,700	500	2,000	13,000	5,000	42,000	29,000	268,000	14,000	144,000	7,000	45,000	210,000	58,000
86/87-16/17 Avg	14,000	16,500	5,800	6,000	12,100	3,600	15,900	32,000	3,700	400	3,200	12,000	8,000	43,000	29,000	205,000	14,600	192,000	5,000	62,000	274,000	-69,000

Cummulative Change in Storage | -2,132,000

Light blue	Groundwater Inflows or Outflows to be Included in Sustainable Yield Estimates
Pink	Groundwater Inflows to be Excluded from the Sustainable Yield Estimates
Yellow	Groundwater Outflows Not Included in Sustainable Yield Estimates

Projected Future Eastern Tule GSA Surface Water Budget

Water Year	Surface Water Inflow (acre-ft)														Total In
	Precip-itation	Stream Inflow			Imported Water								Discharge from Wells		
		Tule River	Deer Creek	White River	Saucelito ID	Terra Bella ID	Kern-Tulare WD	Porterville ID	Tea Pot Dome WD	City of Porterville	Hope WD	Ducor ID	Agricultural	Municipal	
2017 - 2018	128,000	131,258	19,410	6,347	34,567	18,786	15,335	19,803	6,528	0	0	0	158,000	14,700	553,000
2018 - 2019	128,000	131,258	19,410	6,347	34,567	18,786	15,335	19,803	6,528	0	0	0	157,000	16,400	553,000
2019 - 2020	128,000	131,258	19,410	6,347	34,567	18,786	15,335	23,103	6,528	0	0	0	151,000	18,000	552,000
2020 - 2021	128,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	0	0	148,000	18,400	555,000
2021 - 2022	128,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	0	0	148,000	18,800	555,000
2022 - 2023	128,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	1,667	0	148,000	19,100	557,000
2023 - 2024	128,000	131,258	19,410	6,347	35,667	18,786	17,935	23,103	6,528	1,100	1,667	4,000	148,000	19,500	561,000
2024 - 2025	128,000	134,258	19,410	6,347	34,893	20,304	18,229	24,339	6,594	1,100	1,667	4,000	138,000	20,000	557,000
2025 - 2026	128,000	134,258	19,410	6,347	34,118	21,823	17,843	25,575	6,661	1,100	1,667	4,000	138,000	20,400	559,000
2026 - 2027	128,000	134,258	19,410	6,347	33,343	23,341	17,458	26,812	6,727	1,100	1,667	4,000	136,000	20,800	559,000
2027 - 2028	128,000	134,258	19,410	6,347	32,568	24,860	17,072	28,048	6,793	1,100	1,667	4,000	134,000	21,300	559,000
2028 - 2029	128,000	134,258	19,410	6,347	31,794	26,378	16,687	29,285	6,860	1,100	1,667	4,000	132,000	21,700	559,000
2029 - 2030	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	92,000	22,200	523,000
2030 - 2031	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	97,000	22,700	529,000
2031 - 2032	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	96,000	23,100	528,000
2032 - 2033	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	96,000	23,600	529,000
2033 - 2034	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	96,000	24,200	529,000
2034 - 2035	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	70,000	24,700	504,000
2035 - 2036	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	70,000	25,200	504,000
2036 - 2037	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	70,000	25,800	505,000
2037 - 2038	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	26,300	504,000
2038 - 2039	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	26,900	505,000
2039 - 2040	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2040 - 2041	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2041 - 2042	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2042 - 2043	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2043 - 2044	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2044 - 2045	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2045 - 2046	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2046 - 2047	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2047 - 2048	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2048 - 2049	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2049 - 2050	128,000	134,258	19,410	6,347	31,019	27,897	18,039	30,521	6,926	1,100	1,667	4,000	69,000	27,500	506,000
2050 - 2051	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2051 - 2052	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2052 - 2053	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2053 - 2054	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2054 - 2055	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2055 - 2056	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2056 - 2057	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2057 - 2058	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2058 - 2059	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2059 - 2060	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2060 - 2061	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2061 - 2062	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2062 - 2063	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2063 - 2064	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2064 - 2065	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2065 - 2066	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2066 - 2067	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2067 - 2068	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2068 - 2069	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
2069 - 2070	128,000	130,581	18,943	6,143	29,378	26,278	18,039	28,441	6,524	1,100	1,667	4,000	68,000	27,500	495,000
17/18-69/70 Avg	128,000	132,500	19,200	6,300	31,200	25,700	17,800	28,300	6,700	1,000	1,500	3,500	88,000	25,000	515,000

Appendix B
Table 3b

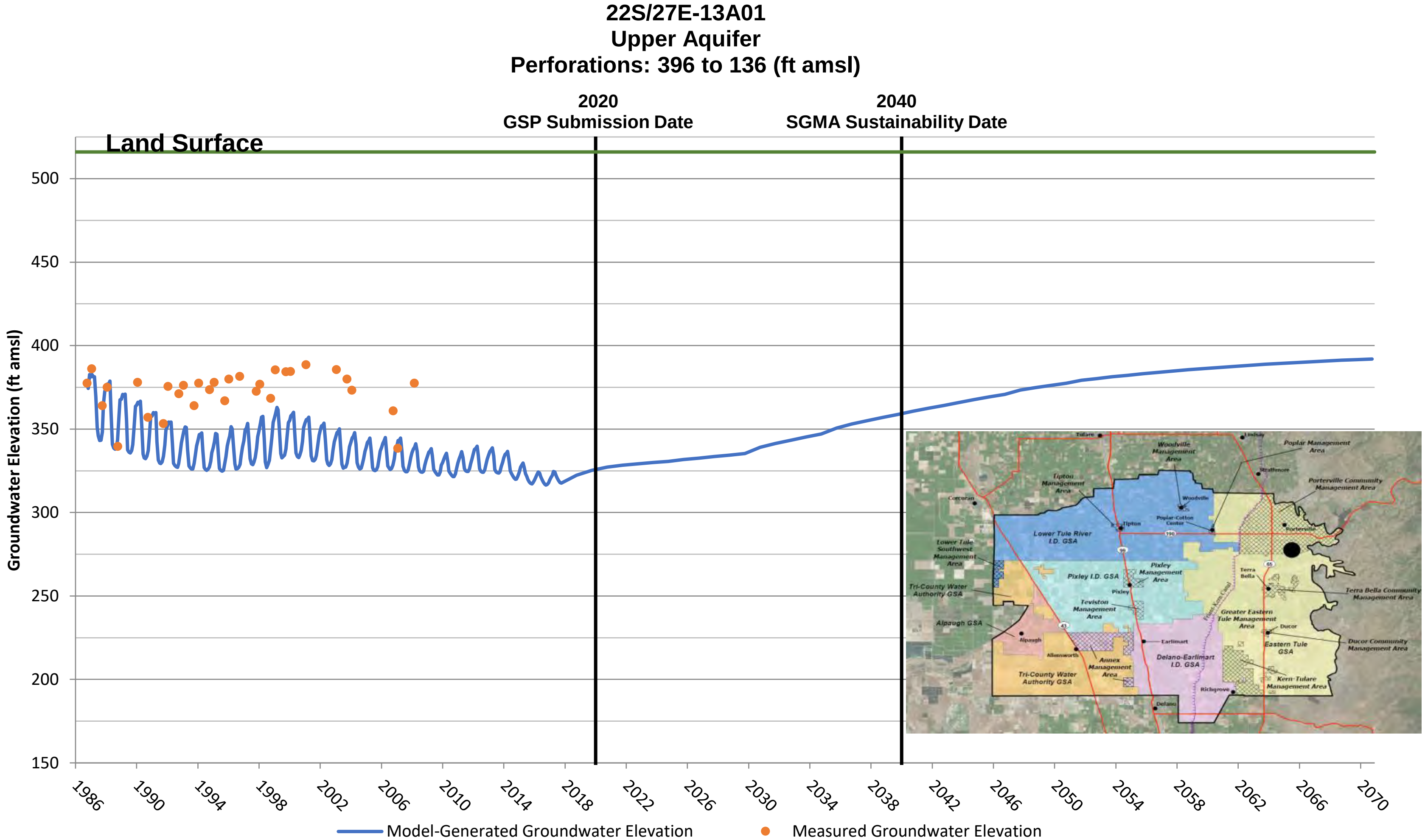
Projected Future Eastern Tule GSA Subbasin Surface Water Budget

Water Year	Surface Water Outflow (acre-ft)																											
		Streambed Infiltration			Recharge in Basins				Deep Percolation of Applied Water					Evapotranspiration										Surface Outflow				
	Areal Recharge of Precip-itation	Tule River Success to Oettle Bridge Infiltration	Deer Creek Before Trenton Weir Infiltration	White River	Tule River	Deer Creek	Imported Water	Recycled Water	Tule River	Imported Water	Recycled Water	Agri-cultural Pumping	Muni-cipal Pumping	Precipitation Crops/Native	Tule River Agricultural Cons. Use	Tule River Stream Channel	Deer Creek Stream Channel	White River Stream Channel	Imported Water Agricultural Cons. Use	Ag. Cons. Use from Pumping	Recycled Water Agricultural Cons. Use	Recycled Water Recharge in Basins	Municipal (Landscape ET)	Tule River To LTIRD GSA	Tule River To FKC	Deer Creek To Pixley GSA	White River To DEID GSA	Total Out
2017 - 2018	14,000	17,900	11,600	4,000	5,800	800	0	2,000	4,600	19,700	600	24,300	3,400	115,000	13,900	300	300	100	75,400	133,000	3,500	50	5,200	80,000	0	6,700	2,200	544,000
2018 - 2019	14,000	17,900	11,600	4,000	5,800	800	0	2,000	4,600	19,700	700	24,200	3,600	115,000	13,900	300	300	100	75,400	133,000	4,300	50	5,800	80,000	0	6,700	2,200	546,000
2019 - 2020	14,000	17,900	11,600	4,000	6,700	800	3,300	2,500	4,600	20,600	400	23,200	3,800	115,000	13,900	300	300	100	77,700	125,000	2,600	50	8,700	80,000	0	6,700	2,200	546,000
2020 - 2021	14,000	17,900	11,600	4,000	6,700	800	5,500	2,600	4,600	21,000	400	22,800	3,800	115,000	13,900	300	300	100	80,000	123,000	2,600	50	8,900	80,000	0	6,700	2,200	549,000
2021 - 2022	14,000	17,900	11,600	4,000	6,700	800	5,500	2,600	4,600	21,000	400	22,800	3,800	115,000	13,900	300	300	100	80,000	123,000	2,700	50	9,100	80,000	0	6,700	2,200	549,000
2022 - 2023	14,000	17,900	11,600	4,000	6,700	800	7,200	2,700	4,600	21,000	500	22,800	3,900	115,000	13,900	300	300	100	80,000	123,000	2,800	50	9,300	80,000	0	6,700	2,200	551,000
2023 - 2024	14,000	17,900	11,600	4,000	6,700	800	11,200	2,800	4,600	21,000	500	22,800	3,900	115,000	13,900	300	300	100	80,000	123,000	2,800	50	9,500	80,000	0	6,700	2,200	556,000
2024 - 2025	14,000	17,900	11,600	4,000	7,100	800	11,200	2,800	4,600	21,400	500	21,300	4,000	115,000	14,000	300	300	100	81,900	114,000	2,900	50	9,700	82,600	0	6,700	2,200	551,000
2025 - 2026	14,000	17,900	11,600	4,000	7,100	800	11,200	2,900	4,600	21,700	500	21,200	4,000	115,000	14,000	300	300	100	83,200	114,000	3,000	50	9,900	82,600	0	6,700	2,200	553,000
2026 - 2027	14,000	17,900	11,600	4,000	7,100	800	11,200	3,000	4,600	22,000	500	20,900	4,100	115,000	14,000	300	300	100	84,600	113,000	3,000	50	10,100	82,600	0	6,700	2,200	554,000
2027 - 2028	14,000	17,900	11,600	4,000	7,100	800	11,200	3,100	4,600	22,300	500	20,600	4,100	115,000	14,000	300	300	100	86,000	111,000	3,100	50	10,400	82,600	0	6,700	2,200	554,000
2028 - 2029	14,000	17,900	11,600	4,000	7,100	800	11,200	3,100	4,500	22,600	500	20,300	4,200	115,000	14,000	300	300	100	87,300	110,000	3,200	50	10,600	82,600	0	6,700	2,200	554,000
2029 - 2030	14,000	17,900	11,600	4,000	7,100	800	11,200	3,200	4,300	23,200	500	14,300	4,200	115,000	13,200	300	300	100	90,100	75,000	3,300	50	10,800	82,000	0	6,700	2,200	515,000
2030 - 2031	14,000	17,900	11,600	4,000	7,100	800	11,200	3,300	4,300	23,200	600	15,100	4,300	115,000	13,200	300	300	100	90,100	79,000	3,400	50	11,100	82,000	0	6,700	2,200	521,000
2031 - 2032	14,000	17,900	11,600	4,000	7,100	800	11,200	3,400	4,300	23,200	600	15,100	4,400	115,000	13,200	300	300	100	90,100	79,000	3,400	50	11,300	82,000	0	6,700	2,200	521,000
2032 - 2033	14,000	17,900	11,600	4,000	7,100	800	11,200	3,500	4,300	23,200	600	15,100	4,400	115,000	13,200	300	300	100	90,100	79,000	3,500	50	11,600	82,000	0	6,700	2,200	522,000
2033 - 2034	14,000	17,900	11,600	4,000	7,100	800	11,200	3,500	4,300	23,200	600	15,100	4,500	115,000	13,200	300	300	100	90,100	79,000	3,600	50	11,900	82,000	0	6,700	2,200	522,000
2034 - 2035	14,000	17,900	11,600	4,000	7,100	800	11,200	3,600	4,300	23,200	600	11,000	4,500	115,000	13,200	300	300	100	90,100	56,000	3,700	50	12,100	82,000	0	6,700	2,200	496,000
2035 - 2036	14,000	17,900	11,600	4,000	7,100	800	11,200	3,700	4,300	23,200	600	11,000	4,600	115,000	13,200	300	300	100	90,100	56,000	3,800	50	12,400	82,000	0	6,700	2,200	496,000
2036 - 2037	14,000	17,900	11,600	4,000	7,100	800	11,200	3,800	4,300	23,200	700	10,900	4,700	115,000	13,200	300	300	100	90,100	56,000	3,900	50	12,700	82,000	0	6,700	2,200	497,000
2037 - 2038	14,000	17,900	11,600	4,000	7,100	800	11,200	3,900	4,300	23,200	700	10,900	4,700	115,000	13,200	300	300	100	90,100	56,000	4,000	50	13,000	82,000	0	6,700	2,200	497,000
2038 - 2039	14,000	17,900	11,600	4,000	7,100	800	11,200	4,000	4,300	23,200	700	10,900	4,800	115,000	13,200	300	300	100	90,100	56,000	4,100	50	13,300	82,000	0	6,700	2,200	498,000
2039 - 2040	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2040 - 2041	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2041 - 2042	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2042 - 2043	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2043 - 2044	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2044 - 2045	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2045 - 2046	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2046 - 2047	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2047 - 2048	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2048 - 2049	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2049 - 2050	14,000	17,900	11,600	4,000	7,100	800	11,200	4,100	4,300	23,200	700	10,900	4,900	115,000	13,200	300	300	100	90,100	56,000	4,200	50	13,600	82,000	0	6,700	2,200	498,000
2050 - 2051	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2051 - 2052	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2052 - 2053	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2053 - 2054	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2054 - 2055	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2055 - 2056	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2056 - 2057	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2057 - 2058	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2058 - 2059	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2059 - 2060	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2060 - 2061	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2061 - 2062	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2062 - 2063	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2063 - 2064	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2064 - 2065	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2065 - 2066	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2066 - 2067	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2067 - 2068	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2068 - 2069	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
2069 - 2070	14,000	17,400	11,300	3,900	6,600	800	11,200	4,100	4,500	22,200	700	10,800	4,900	115,000	12,500	300	300	100	85,400	54,000	4,200	50	13,600	79,800	0	6,500	2,200	486,000
17/18-69/70 Avg	14,000	17,700	11,500	4,000	6,800	800	10,300	3,700	4,400	22,400	600	13,800	4,600	115,000	13,100	300	300	100	86,300	72,000	3,800	50	12,200	81,000	0	6,600	2,200	508,000

Projected Future Eastern Tule GSA Groundwater Budget

Water Year	Groundwater Inflows (acre-ft): Areal Recharge from Precip-itation	Tule River: Success to Oettle Bridge Infiltration	Tule River: Recharge in Basins	Tule River: Return Flow	Deer Creek: Infiltration Before Trenton Weir	Deer Creek: Recharge in Basins	White River: Infiltration Before DEID	Imported Water Deliveries: Return Flow	Imported Water Deliveries: Recharge in Basins	Agricultural Pumping: Irrigated Agriculture	Municipal Pumping: Return Flow	Municipal Pumping, Recycled Water: Agricultural Return Flow	Municipal Pumping, Recycled Water: Artificial Recharge	Release of Water from Compression of Aquitards	Sub-surface Inflow: From Outside Subbasin	Sub-surface Inflow: From Other GSAs	Mountain-Block Recharge	Total In	Groundwater Outflows (acre-ft): Groundwater Pumping: Muni-cipal	Groundwater Pumping: Agri-culture	Sub-surface Outflow: To Outside Subbasin	Sub-surface Outflow: To Other GSAs	Total Out	Change in Storage (acre-ft)
2017 - 2018	14,000	17,900	5,800	4,600	11,600	800	4,000	19,700	0	24,300	3,400	600	2,000	9,000	6,000	36,000	33,000	193,000	14,700	158,000	7,000	51,000	231,000	-38,000
2018 - 2019	14,000	17,900	5,800	4,600	11,600	800	4,000	19,700	0	24,200	3,600	700	2,000	9,000	6,000	36,000	33,000	193,000	16,400	157,000	7,000	51,000	231,000	-38,000
2019 - 2020	14,000	17,900	6,700	4,600	11,600	800	4,000	20,600	3,300	23,200	3,800	400	2,500	9,000	6,000	36,000	33,000	197,000	18,000	151,000	6,000	51,000	226,000	-29,000
2020 - 2021	14,000	17,900	6,700	4,600	11,600	800	4,000	21,000	5,500	22,800	3,800	400	2,600	8,000	5,000	35,000	33,000	197,000	18,400	148,000	7,000	51,000	224,000	-27,000
2021 - 2022	14,000	17,900	6,700	4,600	11,600	800	4,000	21,000	5,500	22,800	3,800	400	2,600	8,000	5,000	35,000	33,000	197,000	18,800	148,000	7,000	50,000	224,000	-27,000
2022 - 2023	14,000	17,900	6,700	4,600	11,600	800	4,000	21,000	7,170	22,800	3,900	500	2,700	8,000	5,000	35,000	33,000	199,000	19,100	148,000	7,000	50,000	224,000	-25,000
2023 - 2024	14,000	17,900	6,700	4,600	11,600	800	4,000	21,000	11,170	22,800	3,900	500	2,800	8,000	5,000	35,000	33,000	203,000	19,500	148,000	7,000	50,000	225,000	-22,000
2024 - 2025	14,000	17,900	7,100	4,600	11,600	800	4,000	21,400	11,170	21,300	4,000	500	2,800	6,000	5,000	34,000	33,000	199,000	20,000	138,000	6,000	49,000	213,000	-14,000
2025 - 2026	14,000	17,900	7,100	4,600	11,600	800	4,000	21,700	11,170	21,200	4,000	500	2,900	6,000	5,000	33,000	33,000	198,000	20,400	138,000	6,000	49,000	213,000	-15,000
2026 - 2027	14,000	17,900	7,100	4,600	11,600	800	4,000	22,000	11,170	20,900	4,100	500	3,000	6,000	5,000	32,000	33,000	198,000	20,800	136,000	6,000	49,000	212,000	-14,000
2027 - 2028	14,000	17,900	7,100	4,600	11,600	800	4,000	22,300	11,170	20,600	4,100	500	3,100	5,000	4,000	32,000	33,000	196,000	21,300	134,000	7,000	49,000	211,000	-15,000
2028 - 2029	14,000	17,900	7,100	4,500	11,600	800	4,000	22,600	11,170	20,300	4,200	500	3,100	5,000	4,000	31,000	33,000	195,000	21,700	132,000	7,000	49,000	210,000	-15,000
2029 - 2030	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	14,300	4,200	500	3,200	2,000	4,000	28,000	33,000	183,000	22,200	92,000	4,000	49,000	167,000	16,000
2030 - 2031	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	15,100	4,300	600	3,300	2,000	4,000	27,000	33,000	183,000	22,700	97,000	4,000	49,000	173,000	10,000
2031 - 2032	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	15,100	4,400	600	3,400	2,000	4,000	26,000	33,000	183,000	23,100	96,000	4,000	49,000	172,000	11,000
2032 - 2033	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	15,100	4,400	600	3,500	2,000	4,000	25,000	33,000	182,000	23,600	96,000	4,000	49,000	173,000	9,000
2033 - 2034	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	15,100	4,500	600	3,500	2,000	4,000	25,000	33,000	182,000	24,200	96,000	3,000	49,000	172,000	10,000
2034 - 2035	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	11,000	4,500	600	3,600	1,000	4,000	22,000	33,000	174,000	24,700	70,000	2,000	49,000	146,000	28,000
2035 - 2036	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	11,000	4,600	600	3,700	1,000	4,000	21,000	33,000	173,000	25,200	70,000	2,000	49,000	146,000	27,000
2036 - 2037	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,700	700	3,800	1,000	4,000	20,000	32,000	171,000	25,800	70,000	2,000	50,000	148,000	23,000
2037 - 2038	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,700	700	3,900	0	4,000	20,000	32,000	170,000	26,300	69,000	2,000	50,000	147,000	23,000
2038 - 2039	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,800	700	4,000	0	4,000	19,000	32,000	169,000	26,900	69,000	2,000	51,000	149,000	20,000
2039 - 2040	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	19,000	32,000	170,000	27,500	69,000	1,000	50,000	148,000	22,000
2040 - 2041	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	18,000	32,000	169,000	27,500	69,000	1,000	50,000	148,000	21,000
2041 - 2042	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	18,000	32,000	169,000	27,500	69,000	1,000	50,000	148,000	21,000
2042 - 2043	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	17,000	32,000	168,000	27,500	69,000	1,000	50,000	148,000	20,000
2043 - 2044	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	17,000	32,000	168,000	27,500	69,000	1,000	51,000	149,000	19,000
2044 - 2045	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	17,000	32,000	168,000	27,500	69,000	1,000	51,000	149,000	19,000
2045 - 2046	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	16,000	32,000	167,000	27,500	69,000	1,000	52,000	150,000	17,000
2046 - 2047	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	16,000	32,000	167,000	27,500	69,000	1,000	52,000	150,000	17,000
2047 - 2048	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	16,000	32,000	167,000	27,500	69,000	1,000	53,000	151,000	16,000
2048 - 2049	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	16,000	32,000	167,000	27,500	69,000	1,000	53,000	151,000	16,000
2049 - 2050	14,000	17,900	7,100	4,300	11,600	800	4,000	23,200	11,170	10,900	4,900	700	4,100	0	4,000	16,000	32,000	167,000	27,500	69,000	1,000	54,000	152,000	15,000
2050 - 2051	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	4,000	16,000	31,000	163,000	27,500	68,000	1,000	55,000	152,000	11,000
2051 - 2052	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	4,000	15,000	32,000	163,000	27,500	68,000	1,000	55,000	152,000	11,000
2052 - 2053	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	4,000	15,000	31,000	162,000	27,500	68,000	1,000	56,000	153,000	9,000
2053 - 2054	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	4,000	15,000	31,000	162,000	27,500	68,000	1,000	56,000	153,000	9,000
2054 - 2055	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	4,000	15,000	31,000	162,000	27,500	68,000	1,000	57,000	154,000	8,000
2055 - 2056	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	4,000	15,000	32,000	163,000	27,500	68,000	1,000	58,000	155,000	8,000
2056 - 2057	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	58,000	155,000	5,000
2057 - 2058	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	58,000	155,000	5,000
2058 - 2059	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	59,000	156,000	4,000
2059 - 2060	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	59,000	156,000	4,000
2060 - 2061	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	59,000	156,000	4,000
2061 - 2062	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	60,000	157,000	3,000
2062 - 2063	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	60,000	157,000	3,000
2063 - 2064	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	60,000	157,000	3,000
2064 - 2065	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	60,000	157,000	3,000
2065 - 2066	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	61,000	158,000	2,000
2066 - 2067	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	61,000	158,000	2,000
2067 - 2068	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	61,000	158,000	2,000
2068 - 2069	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	61,000	158,000	2,000
2069 - 2070	14,000	17,400	6,600	4,500	11,300	800	3,900	22,200	11,170	10,800	4,900	700	4,100	0	3,000	14,000	31,000	160,000	27,500	68,000	1,000	62,000	159,000	1,000
17/18-69/70 Avg	14,000	17,700	6,800	4,400	11,500	800	4,000	22,400	10,300	13,800	4,600	600	3,700	2,000	4,000	21,000	32,000	174,000	25,000	88,000	3,000	53,000	169,000	5,000

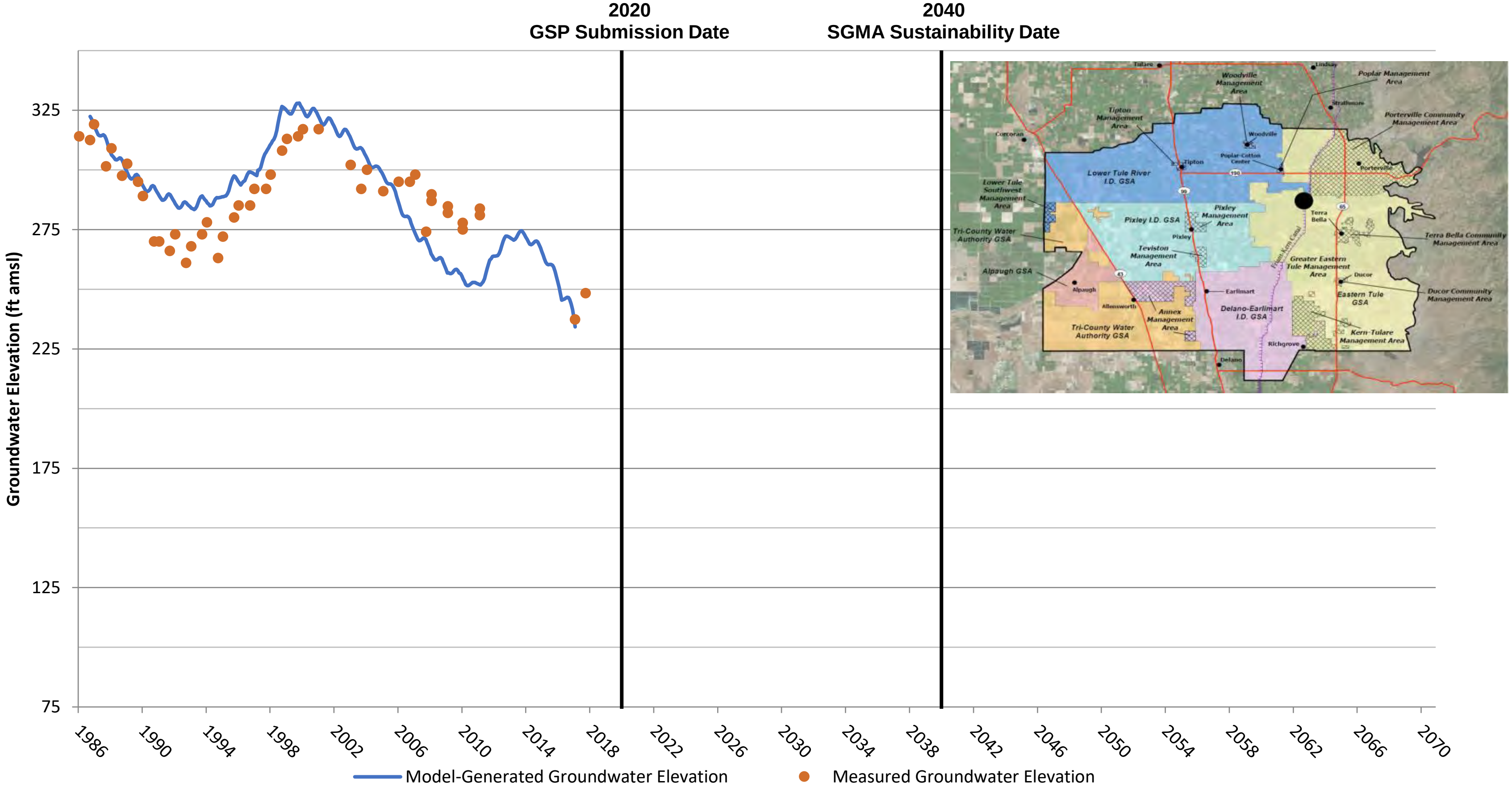
Eastern Tule GSA
Representative Monitoring Site



Eastern Tule GSA
Representative Monitoring Site

Appendix **B**
Figure 2

22S/26E-13R01
Upper Aquifer
Perforations: 158 to 18 (ft amsl)

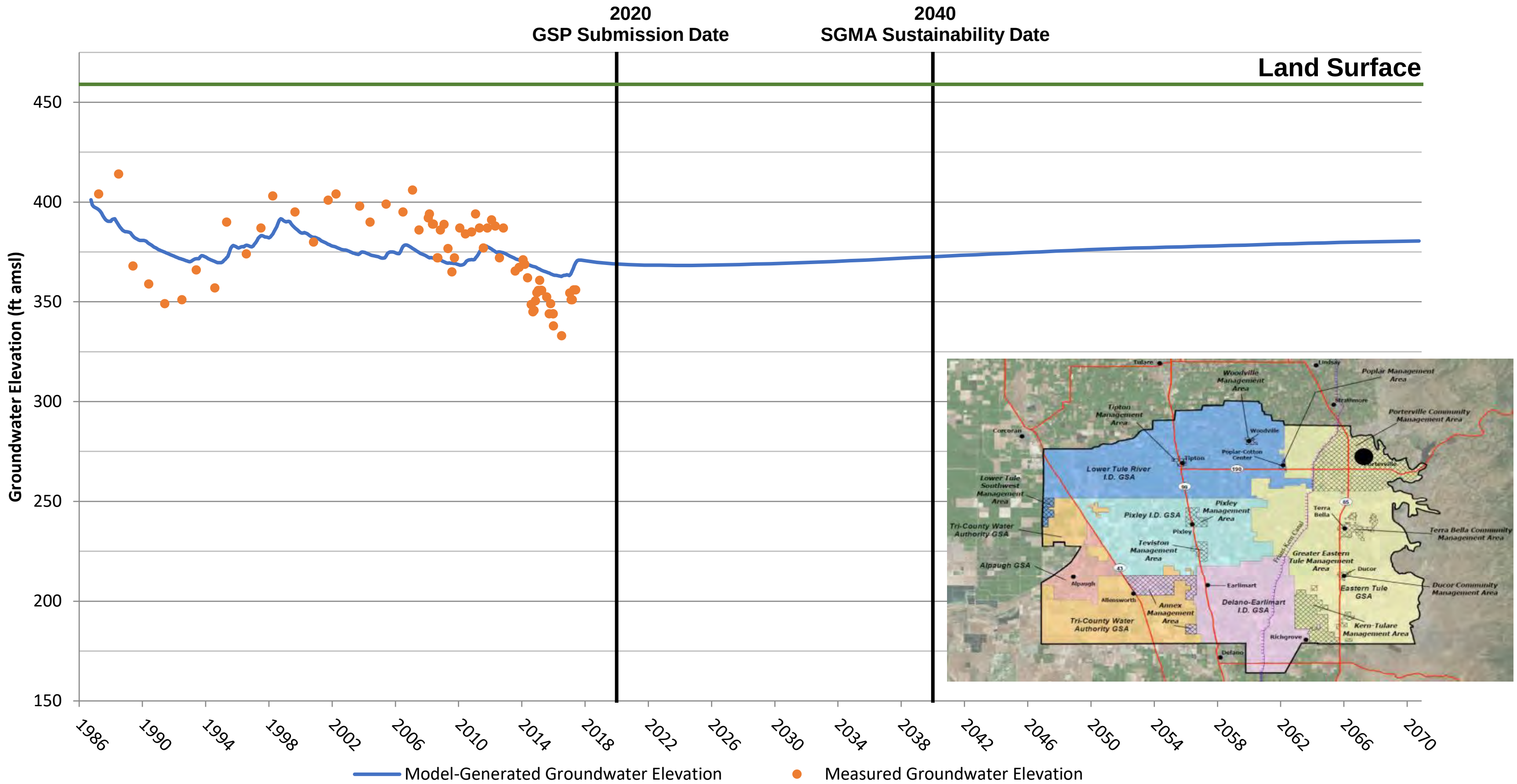


Thomas Harder & Co.
Groundwater Consulting

January 2020

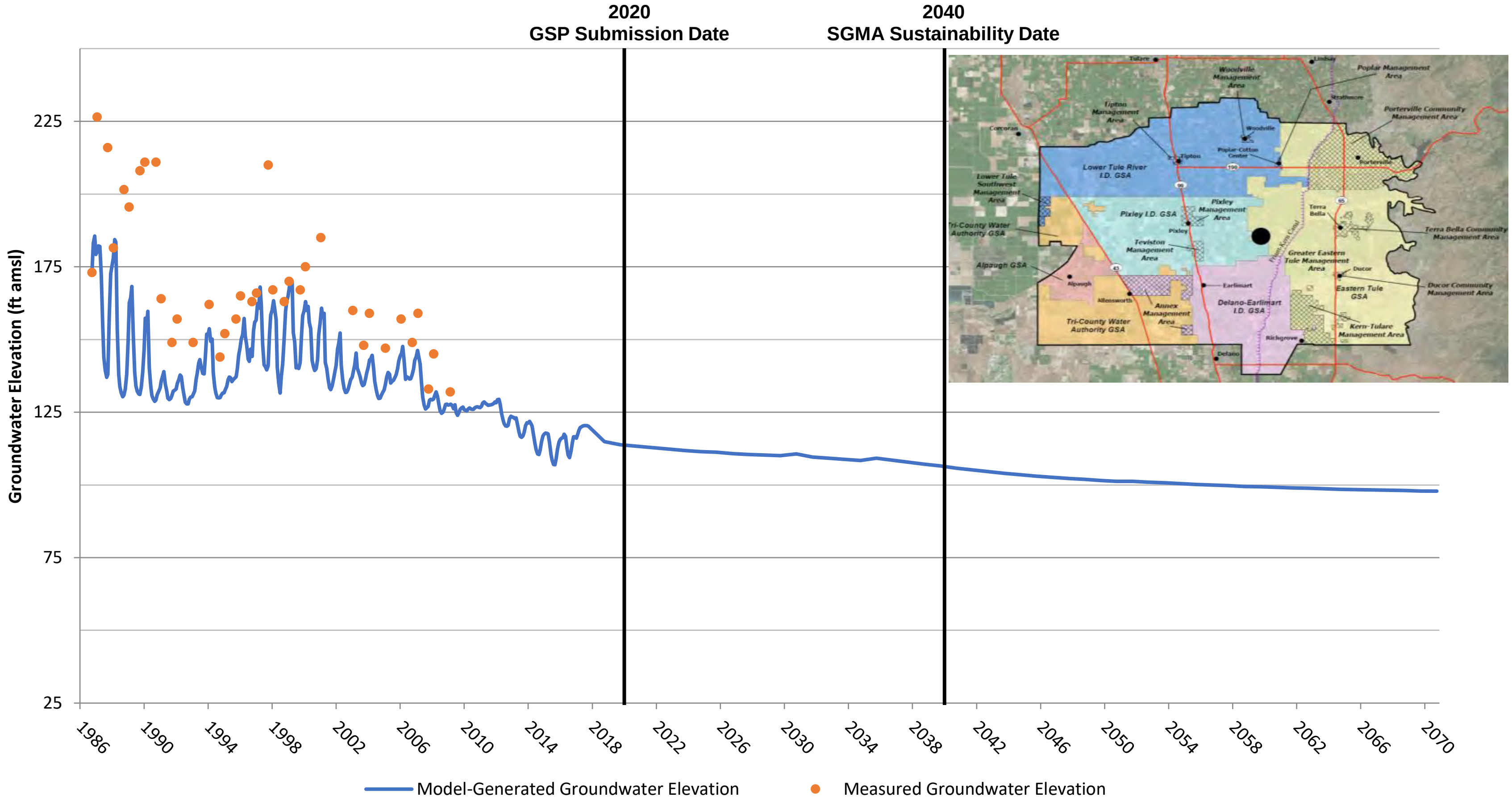
Eastern Tule GSA
Representative Monitoring Site

C-1
Upper Aquifer
Perforations: 337 to 217 (ft amsl)



Eastern Tule GSA
Representative Monitoring Site

23S/26E-09C01
Upper Aquifer
Perforations: 148 to -42 (ft amsl)

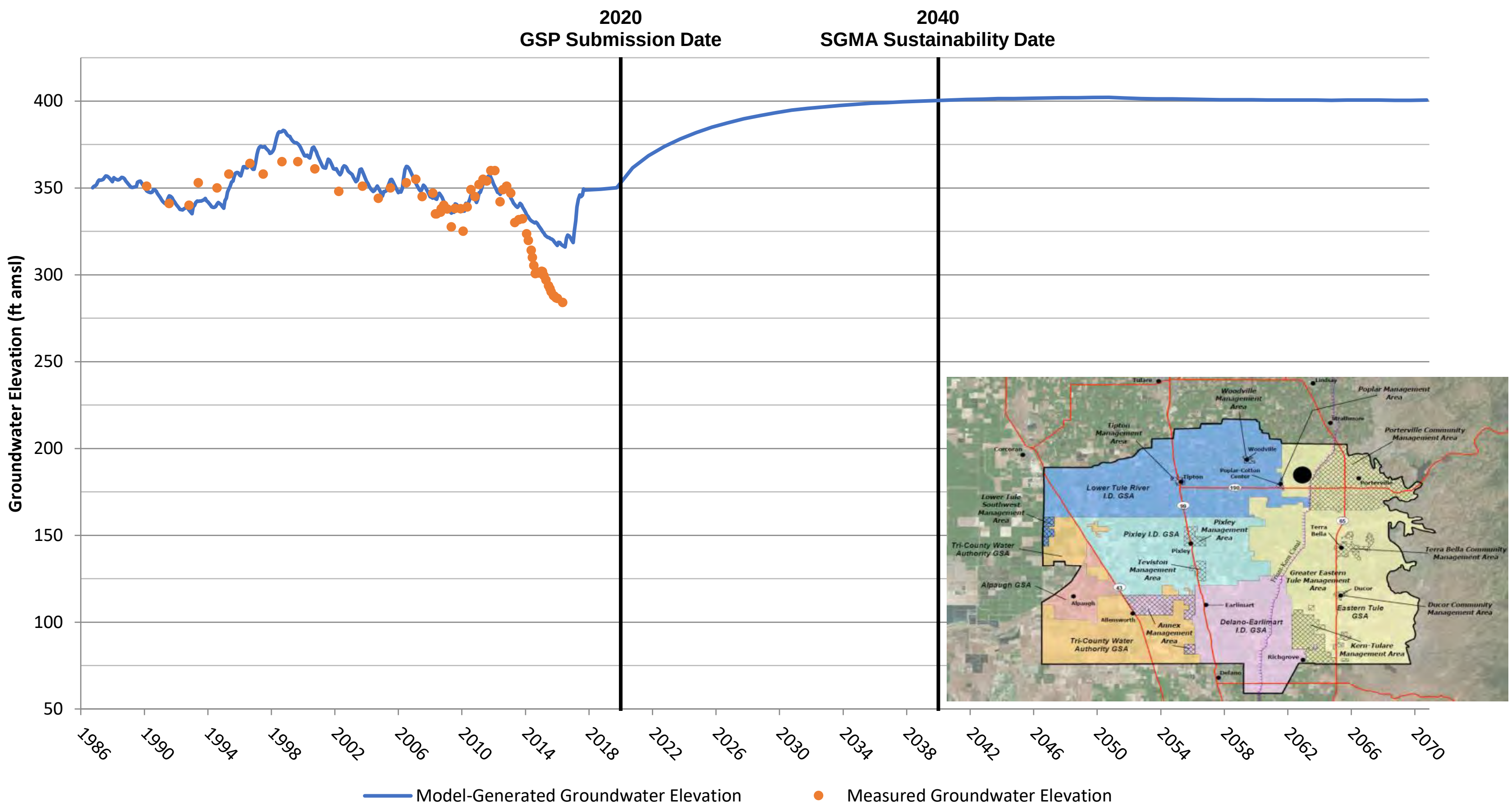


Thomas Harder & Co.
Groundwater Consulting

January 2020

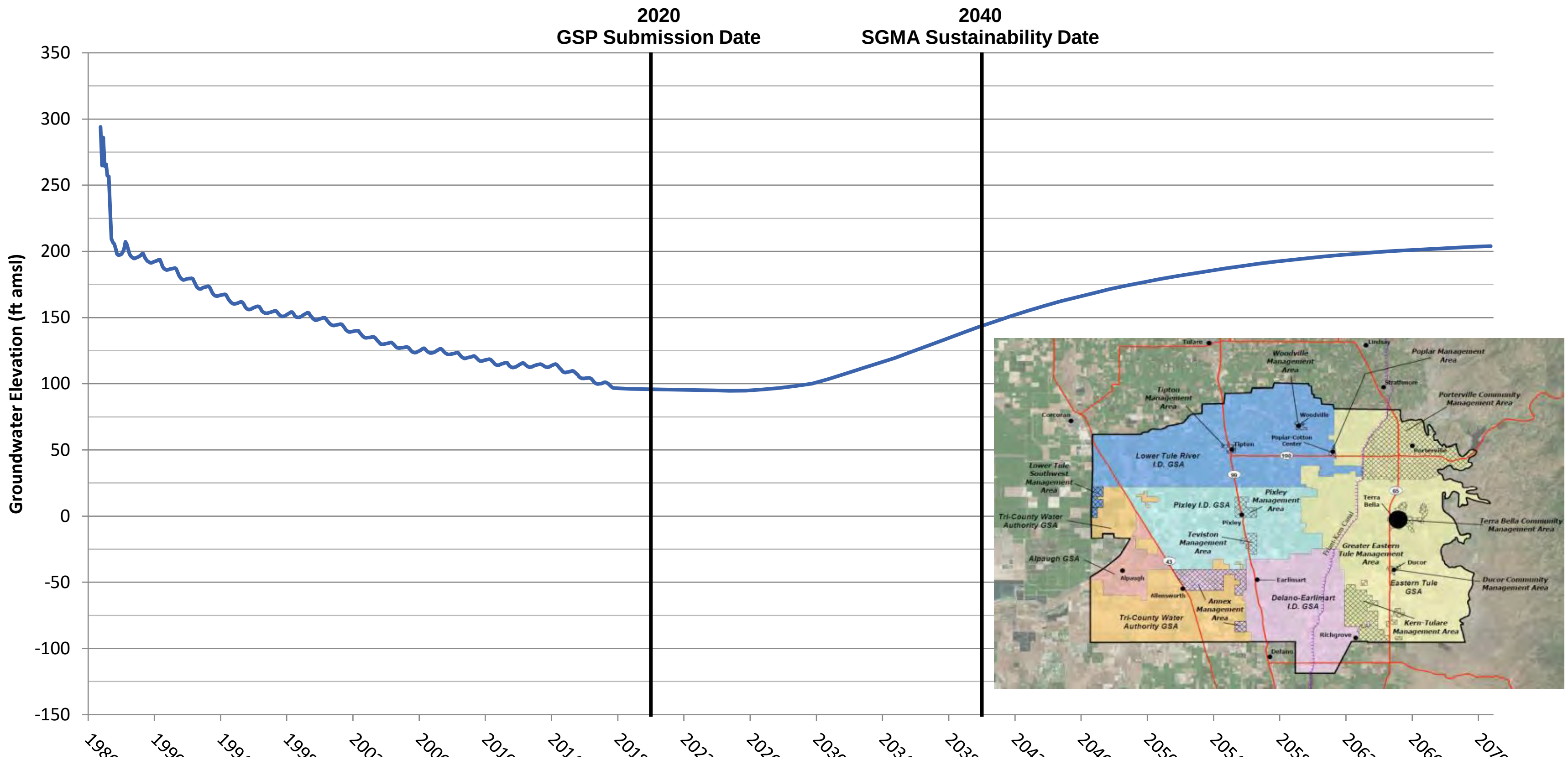
Eastern Tule GSA
Representative Monitoring Site

Port R-11
Upper Aquifer
Well Depth: (184 ft amsl)



Eastern Tule GSA
Representative Monitoring Site

23S/27E-03
Lower Aquifer
Perforations: 298 to -92 (ft amsl)



Thomas Harder & Co.
Groundwater Consulting

January 2020