Title: Model Documentation Report for the Owens Lake Groundwater Model Update (FINAL)

Project: Task Order 030 – Specialized Hydrologic Study to Support the Owens Lake Master Project Environmental Impact Report – Owens Lake Model Update Implementation

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Model Documentation Report for the Owens Lake Groundwater Model Update

Report

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Specialized Hydrologic Study to Support the Owens Lake Master Project Environmental Impact Report – Owens Lake Model Update Implementation

Owens Lake, California

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LIST OF ACRONYMS AND ABBREVIATIONS

AF/yr	Acre-Feet per Year
BAS	Basic Package
CEQA	California Environmental Quality Act
CLN	Connected Linear Network Package
DIS	Discretization Package
DRN	Drain Package
EIR	Environmental Impact Report
ES	Executive Summary
ET	Evapotranspiration
EVT	Evapotranspiration Package
fbgs	Feet Below Ground Surface
fmsl	Feet Above Mean Sea Level
GHB	General-Head Boundary Package
GMS	Groundwater Modeling System
gpm	Gallons per Minute
GWG	Groundwater Working Group
HCM	Hydrologic Conceptual Model
HFB	Horizontal Flow Barrier Package
HMMMP	Hydrologic Monitoring, Management, and Mitigation Plan
Kh	Horizontal Hydraulic Conductivity
LAA	Los Angeles Aqueduct
LADWP	Los Angeles Department of Water and Power
LPF	Layer Property Flow Package
MODFLOW	U.S. Geological Survey Modular Finite-Difference Flow Model
NHD	North Haiwee Dam
NWT	Newton-Raphson Formulation
OC	Output Control Package
OLGDP	Owens Lake Groundwater Development Program
OLGEP	Owens Lake Groundwater Evaluation Project
OLGM	Owens Lake Groundwater Model
RCH	Recharge Package
RIV	River Package

RMSE	Root Mean Square Error
RPP	Resource Protection Protocol
SFIP	South Flood Irrigation Project
SMS	Sparse Matrix Solver Package
Ss	Specific Storage
Sy	Specific Yield
TM	Technical Memorandum
TW	Testing Well
UPW	Upstream-Weighting
USG	Unstructured Grid
USGS	United States Geological Survey
WEL	Well Package
VDA	Vegetated Dune Area

EXECUTIVE SUMMARY

Under Agreement No. 47446E Task No. 30 between Stantec Consulting Services Inc. (Stantec) and the Los Angeles Department of Water and Power (LADWP), Stantec conducted the Task Order entitled *"Specialized Hydrologic Study to Support the Owens Lake Master Project Environmental Impact Project – Owens Lake Model Update Implementation"*. This document is the Owens Lake Groundwater Model (OLGM) Update Documentation Report.

As part of the dust mitigation efforts at Owens Lake, LADWP is developing the Owens Lake Master Project (Master Project) designed to implement more water-efficient dust control measures while maintaining environmental habitat value. The Master Project includes development of groundwater from the sediments beneath Owens Lake to be used for seasonal dust control, with the goal of conserving potable water supplies from the Los Angeles Aqueduct (LAA) that would otherwise be used for dust mitigation. This portion of the Master Project is called the Owens Lake Groundwater Development Project (OLGDP). The Owens Lake study area is shown on **Figure ES-1**.

Background

Between 2009 and 2012 MWH (now Stantec) and LADWP conducted the Owens Lake Groundwater Evaluation Project (OLGEP). The OLGEP culminated in the construction of a numerical groundwater model for the Owens Lake area. This model was used to simulate potential groundwater pumping alternatives to provide groundwater for a portion of the dust mitigation areas.

Since 2012, a suite of new data has been collected. Lithologic data, pumping test data and water quality sampling results have been analyzed and incorporated in the improvement of both the conceptual and numerical models.

Since the creation of the original 2012 model, several significant new tools and modules have been developed for MODFLOW (the U.S. Geological Survey modular finite-difference flow model) that greatly enhance the -OLGM. In addition, simulation of evapotranspiration (ET) has been improved in the model using methods that have recently proved successful in modeling of the Bishop/Laws area. Finally, the model domain has been extended to include thin alluvial deposits to the east and northwest of Owens Lake, the upper layer of the 2012 model has been divided. This should allow integration of Resource Protection Protocols (RPPs) as part of review under the California Environmental Quality Act (CEQA) for the Owens Lake Master Project.

- Pumping Well
- Calibration Wells
- Production Wells
- Flowing Well
- RPP Groundwater Level Monitoring Wells
- RPP Gradient Monitoring Wells
- Non-LADWP Monitoring Key Well
- Model Domain 2019
- Model Domain 2012
- Brine Pool
- Regulatory Shoreline
- Spring/Seep
- LA Aqueduct
- Highways
- Towns
- Fault
- Fault Concealed
- Fault Approximately Located

N

0 1 2 Miles

Figure ES-1
Owens Lake Study Area Map

LA DWP Los Angeles Department of Water & Power | GSI Environmental | H Water Resources | M2 Resource Consulting | Stantec

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C:\Users\ikegley\Desktop\Figure 1-1 20200131.mxd Revised: 2020-02-03 By: ikegley

Purpose

The newly collected data have been used to improve both the conceptual and numerical models. The purpose of updating the hydrologic conceptual model (HCM) is to incorporate the new data and update the understanding of the hydrogeologic system. The overarching objective of updating the OLGM is to improve the estimates of the potential effects of groundwater pumping with the goal to minimize impacts on sensitive resources in the vicinity of Owens Lake.

Specifically, the purpose of this OLGM update is to:

1) Update both the conceptual and numerical models based on new data collected since the original model was built in 2012.
2) Integrate and utilize new tools and modules available for the groundwater modeling software, MODFLOW.
3) Extend the model domain and reduce the thickness of the current upper layer of the OLGM to support monitoring and evaluation of RPPs for the Owens Lake Master Project. A key goal of the model updates and improvements is the ability to simulate changes in head or groundwater levels at selected RPP locations under varying pumping scenarios, identified in the draft RPP document and Hydrologic Monitoring, Management, and Mitigation Plan (HMMMP). Some of these locations involve monitoring head differences between 4-foot and 30-foot deep piezometers surrounding the lake. Given the very large scale (depth and areal extent) of the model, accurately simulating head changes in these piezometers at such a small scale may not be possible but was an initial goal of the modeling.
4) Utilize the updated groundwater model to evaluate the effects of the Owens Valley Fault Zone and other faults or fault zones on groundwater flow and parameter assumptions in the model, as well as simulation of pumping alternatives.

The updated and improved model is expected to be utilized for CEQA documentation and simulation of alternatives for the Master Project.

Approach to Model Conversion and Improvement

A stepwise approach was utilized in the conversion and updating of the existing - OLGM:

- Conversion of the model to MODFLOW-USG (unstructured grid)
- Conversion of the WEL (Well) package to the CLN (connected linear network) package in MODFLOW-USG

- Extend the model domain to the east and northwest of Owens Lake
- Vertical and horizontal grid refinement
- Incorporation of new ET inputs
- Integration of new deep drilling data and pumping test results

Incorporation of Pumping Test Results into the 2019 OLGM Update

Calibration statistics indicate good performance of the model in representing the physical system. Results of the updated model simulating the recent pumping tests are described below.

Flow rate and observed groundwater level at each observation location from the testing wells TW-E and TW-W pumping tests were input in the model. Results of the 24-hour pumping test at TW-E and TW-W were simulated to recalibrate the model. The model was successful in replicating the drawdown observed in the pumping well and the few observation wells that showed influence of the testing. Unfortunately, a response to testing was not observed in the majority of observation wells because of the relatively low pumping rate and duration. Although the model replicates this behavior, opportunities to improve the model based on the testing observations at a variety of locations are limited because drawdown was not observed at most monitoring locations.

The primary reasons for constructing the testing wells is to observe the effects of pumping and to further develop RPPs for pumping, and to improve the groundwater model of the lake. Another key goal of testing of TW-E and TW-W is to observe drawdown in either side of the major fault zones (Owens Valley and Owens River Fault Zones). Again, testing was not conducted at a high enough rate or for a long enough duration to observe differential drawdown across fault zones except for drawdown observed in MW-5 (deep) and lack of drawdown observed in MW-4 (deep) when TW-W was flowing for 24 hours. The degree to which these fault zones act as groundwater barriers is a significant data gap that is most accurately resolved by long-term aquifer testing.

It is therefore recommended in the Pumping Test Technical Memorandum (TM) (Stantec, 2020) that longer-term testing be performed on one or both wells. As a conservative measure, it is recommended that longer term pumping initially involve only one of the wells. Testing of TW-E is recommended to observe the effects of local fault zones, and because the relatively low production at this location is more conservative. A duration of 6 months during or slightly before the dust season is recommended to mimic conditions under which the well might eventually be used.

Therefore, following calibration and in order to predict the impacts of testing, the improved groundwater model was utilized to simulate four (4) long-term (6-month) pumping test alternatives at TW-E at continuous rates of 899, 1,200, 1,600, and 3,600 gallons per minute (gpm).

Summary of Key 2019 OLGM Update Improvements

The following is a summary of key improvements to the transient groundwater flow model:

- Expanded the model domain to the east and northwest to accommodate the evaluation of RPPs and the role of faulting on groundwater flow with planned locations for additional monitoring wells.
- Converted the model to the relatively new USG version of MODFLOW (MODFLOW-USG), thereby increasing the stability of the model and allowing the use of the CLN feature of the unstructured grid version.
- Subdivided the 2012 -OLGM layer 1 into two model layers to more precisely model surficial aquifer groundwater and its influence on vegetation.
- Modified methods to simulate ET using the Evapotranspiration Package (EVT) of MODFLOW.
- Reduced stress period length from 6 months to 2 months to achieve a more precise simulation of seasonal water level fluctuation in surficial aquifers.
- Refined the model grid in areas of concern, such as pumping wells and sensitive spring locations.

During development and calibration of the updated OLGM, several unique characteristics of the model became apparent. The most notable of these characteristics are summarized below.

- ET is the primary mechanism for outflow of groundwater from the Owens Lake Basin. By converting the 2012 -OLGM into MODFLOW-USG model along with incorporation of the Upstream-Weighting (UPW) package and Newton-Raphson Formulation (NWT) solver without change to input data files, the ET package has been applied successfully throughout the model domain. In the area to the north of the lake that overlaps with the Southern Model domain, the Ecological Dynamics Simulation multi-year average model results were used as the maximum ET rate at land surface and an extinction depth of 15 feet was set (Stantec, 2019). To the south of the Southern Model domain, the current maximum ET rate and zonation as documented in Stantec (2019) was used. Initially the extinction depth was set to 30 feet throughout this area. The ET rate, zonation, and extinction depth were refined through the calibration process that resulted in agreement between simulated and observed seasonal groundwater elevation variations in the surficial aquifer.

- Observed hydrographs at shallow piezometers P1 through P8 and groundwater level monitoring wells at or near the Vegetated Dune Area (VDA) and Salt Crust Area (SCA) exhibit sinusoidal characteristics. The transient ET rate estimated by Duell (1990) mirrors the water level hydrographs, where a high ET rate from April to September results in lower groundwater level, while the groundwater level is higher from October to March when the ET rate is low. During model calibration, it was found that if a 6-month stress period was used, then the simulation results failed to capture the short period of water level variation, where the water level fluctuation was averaged out. Thus, a shorter stress period is required. Note that a shorter stress period results in a larger number of stress periods and this in turn, leads to longer model run time. To balance the longer model run time and improved simulation results, the stress period is set to 2 months. Simulation results indicate that the simulated groundwater levels mimic the observed water level both in amplitude and period.
- Transient calibration results indicate that simulated head values at T-918, Dearborn Spring, P1-A, and the monitoring wells on the alluvial fan to the west of the Owens Valley Fault are higher than observed. Two new monitoring wells, MW-2 and MW-3, were drilled in this area to fill data gaps and help characterize the depth to bedrock and hydraulic characteristics of the sediments above bedrock, as well as provide insight on potential groundwater recharge characteristics from the area southwest of the Alabama Hills. Groundwater elevation observations show MW-3 over 100 ft greater in groundwater elevation than MW-2, suggesting an Owens Valley Fault splay in this area may be a barrier to groundwater flow, along with formation change, and/or the contribution of recharge from the west side of Alabama Hills. Elevated bedrock at MW-3 may also be a contributing factor.
- The 24-hour pumping test at TW-E and TW-W was neither at a high enough rate nor long enough to result in any observable groundwater level drawdown at monitoring wells to the west of the Owens Valley Fault. No data exist to confirm the extent to which the faulting acts as a hydraulic barrier. Model simulations support the HCM incorporating estimated fault effects on groundwater flow but additional data will be required to definitively address fault effects on groundwater flow.
- A longer-term testing and monitoring plan has been prepared that will improve estimates of fault effects as well as effects from longer-term pump testing; this plan is pending permitting from the California State Lands Commission.

Summary of Supplemental Model Improvements

Additional model improvements were made after submission and review of the Draft Model Documentation Report for the OLGM Update to incorporate additional data, revise CLN Package application, and address inconsistencies in the model water budget from the previous model version (MHW, 2012). The following improvements were made:

- To reduce inflow from North Haiwee Reservoir, geotechnical test hole data from beneath the dam crest were used to reduce the model depth to bedrock in this area to approximately 200 ft below ground surface (bgs). In addition, updated hydraulic conductivity data from a recent study (Black & Veach, 2018) were used to refine the hydraulic conductivity and storage values in this area. The boundary condition along North Haiwee Reservoir was also changed from a Constant Head (CHD) boundary condition to a General Head (GHB) boundary condition to further calibrate inflow from the reservoir. Resulting inflow from Haiwee Reservoir simulated at steady state, is 4,575 acre-feet per year (AF/yr), within an acceptable estimated range of inflow from previous studies.
- Groundwater production between Owens Lake and Haiwee Reservoir was incorporated in the model using obtained data for wells V404, V405, and partial production information for Butterworth Ranch and Hunter property. Actual ET (ETa) estimates were obtained for irrigated leases RLI-427 and RLI-428, associated with wells V404 and V405, respectively, as well as for the Butterworth Ranch and Hunter property. These data were compared to pumping estimates where combined ETa for RLI-427 and RLI-428 were within 250 AF of average recorded pumping of V404 and V405. Production from these wells from April 2010 through April 2019 were incorporated into the model. Two addition wells were included in the model, one each on Butterworth Ranch and the Hunter property. Pumping rates for these wells were estimated to be 2,000 AF/yr and 1,300 AF/yr from mid-March to mid-November. Additional average total simulated groundwater production between Owens Lake and Haiwee Reservoir is 4,823 AF/yr.
- Information from six (6) monitoring wells: MW-2, MW-3, MW-6_Upper, MW-6_Middle, MW-6_Lower, and T902a installed in four (4) boreholes in late 2019 were used to correlate and refine the model lithology. These wells were also used to refine the depth of alluvium; alluvium was encountered to a depth of 300, 450 and 450 ft at MW-2, MW-3, and MW-6, respectively. A clay layer from 266 to 334 ft was encountered at MW-3 while multiple clay layers were found at MW-6. These data were used to update the master well table and well construction details for these wells. Groundwater elevation observations show MW-3 over 100 ft greater in groundwater elevation than MW-2, suggesting an Owens Valley

Fault splay in this area may be a barrier to groundwater flow, along with formation change, and/or the contribution of recharge from the west side of Alabama Hills. Elevated bedrock at MW-3 may also be a contributing factor. Difference in water levels in the nested MW-6 wells continue to show an upward gradient and the presence of clay confining layers. These data were interpolated in the model and hydraulic conductivity and storage values were adjusted to reflect updated formation depths.

- The model was recalibrated using the same 143 calibration well locations, over a total of 54 stress periods (2-month stress periods from April 2010 to April 2019), for a total of 3,308 residuals evaluated. Calibration statistics remain improved compared to the 2012 OLGM although some accuracy has been lost with incorporation of recent updates and data. The calculated mean error of -1.94 ft indicates that, overall, the model continues to underpredict groundwater elevations. Similarly, both the absolute mean and root mean square error increased with the model update but remain less than the 2012 OLGM.

Recommendations

The OLGM, originally completed in 2012, has been the subject of numerous improvements and updating with recently acquired hydrologic data. Comparison of model simulations to field observations indicates that the model replicates the groundwater regime in the vicinity of Owens Lake very well. As with any model, it is an approximation of the real conditions surrounding Owens Lake, yet represents a powerful tool for adaptive management and simulation of future events. It is recommended that the model continue to be utilized for understanding the potential effects of pumping for dust mitigation and other groundwater management options, while continuously being improved as new data become available. Specifically, the following uses and improvements to the model are recommended:

- Utilize the model to evaluate the impact of a variety of potential **climate change** scenarios, including reduced recharge from snowmelt, and variable runoff from the Eastern Sierra. Evaluate how this may affect RPPs in the future.
- Perform additional **sensitivity analysis** on a wide variety of boundary conditions to evaluate uncertainties in the model, identify data gaps, and focus future data gathering efforts. A focused sensitivity analysis on fault conductance, orientation, and splay discontinuity will be investigated to improve groundwater levels on either side of the fault and overall model calibration statistics. This effort will also seek to confirm general or overall conclusions of the model, even if individual model parameters may be uncertain. This will also involve revision/review of land surface elevation, potentially variable brine pool elevation and its incorporation in associated boundary conditions, as well as bedrock elevation coverage review and revision.

- Re-evaluate use of the **CLN package** for wells, including artesian wells to determine if the CLN package can accurately simulate artesian flow with variable aquifer discharge depending on piezometric heads, hydraulic and storage parameters. The inter-aquifer pressure equilibration and associated groundwater flow for wells screened across multiple aquifers using the CLN package should be investigated and updated or modified where required.
- Utilize the model to evaluate the **feasibility of groundwater management** techniques such as managed recharge on the western and northern margins of the lake in order to minimize loss of water and to augment supplies to sensitive resources which depend on groundwater. Potential **groundwater banking** activities along the mainline should also be modeled to incorporate injection, resulting flow and groundwater elevations, and production. Ancillary to modeling groundwater banking operations are resulting groundwater flow transport characteristics of banked water not withdrawn at the location of infiltration or injection.
- A **6-month pumping test** is planned on TW-E. When available, these data will provide information to improve the calibration of the model and simulation of the effects of the Owens Valley and Owens River Fault Zones on groundwater flow.
- Utilize recently acquired **ETa** data to improve the location and depth of simulation of evapotranspiration within the model boundaries, and particularly near sensitive springs and seeps.
- Recognizing that evapotranspiration is one of the largest outflows in the model domain, utilize time-series ETa data to improve and confirm the overall **water budget** simulated in the model. The model **stress period length** should potentially be reduced from the current 2 months to 1 month to further refine simulation of ET.
- Perform model simulations in which deeper aquifers in the northern portion of the lake are **pumped at increasingly higher rates** to identify where impacts are most likely to occur in order to focus and improve monitoring efforts.
- Utilize the model to evaluate a variety of **water conservation efforts**, including capturing surface flows before they reach the brine pool.
- Working with stakeholders, identify **future simulations of interest** that will be utilized for environmental review of groundwater pumping for dust mitigation.
- The OLGM model was completed in 2012 using hydrogeologic data available at that time. Since 2012, there has been a large amount of data collected, including new drilling data, time-series groundwater elevation measurements, remote sensing, and surface flow data. Although these data have been

incorporated in the model in several update events (including those described in this document), there is a need to re-evaluate and synthesize historical and recent data regarding the **HCM** for the lake, including synthesis of information regarding hydrostratigraphy, structural geology, water budget, and aquifer properties. This will ensure that available hydrogeologic data are utilized to the fullest extent.

- Add information from the recently installed multi-completion monitoring wells MW-7, and MW-8, the proposed monitoring wells associated with VDAs, as well as additional monitoring wells planned for the northern Owens Lake.

1.0 INTRODUCTION

Under Agreement No. 47446E Task No. 30 between Stantec and the Los Angeles Department of Water and Power (LADWP), Stantec conducted the Task Order entitled *"Specialized Hydrologic Study to Support the Owens Lake Master Project Environmental Impact Project – Owens Lake Model Update Implementation"*. This document is the Owens Lake Groundwater Model (OLGM) Update Documentation Report.

As part of the dust mitigation efforts at Owens Lake, LADWP is developing the Owens Lake Master Project (Master Project) designed to implement more water-efficient dust control measures while maintaining environmental habitat value. The Master Project includes development of groundwater from the sediments beneath Owens Lake to be used for seasonal dust control, with the goal of conserving potable water supplies from the Los Angeles Aqueduct (LAA) that would otherwise be used for dust mitigation. This portion of the Master Project is called the Owens Lake Groundwater Development Project (OLGDP). The Owens Lake study area is shown on **Figure 1-1**.

1.1 Background

This section provides background information on the project.

1.1.1 Overview of Existing Model

Between 2009 and 2012 MWH (now Stantec) and LADWP conducted the Owens Lake Groundwater Evaluation Project (OLGEP). The OLGEP culminated in the construction of a numerical groundwater model for the Owens Lake area. This Owens Lake Groundwater Model (OLGM) was used to simulate potential groundwater pumping alternatives to provide groundwater for a portion of the dust mitigation areas.

The -OLGM model was designed using the modular three-dimensional finite-difference groundwater flow model (MODFLOW) groundwater modeling code. LADWP selected the commercial graphical user interface Groundwater Modeling System (GMS) marketed by AQUAVEO to develop the model. In 2012, Stantec simulated a "*no new groundwater pumping*" comparative baseline simulation using the -OLGM numerical groundwater model. Following the baseline simulation, Stantec completed over 90 groundwater simulations, whereby iterative simulations were conducted to optimize groundwater pumping while satisfying environmental constraints (i.e., drawdown at non-LADWP wells, drawdown in confining layers, and reduction in the percent of discharge at groundwater discharge zones).

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Pumping Well
Calibration Wells
Production Wells
Flowing Well
RPP Groundwater Level Monitoring Wells
RPP Gradient Monitoring Wells
Non-LADWP Monitoring Key Well

Model Domain 2019
Model Domain 2012
Brine Pool
Regulatory Shoreline
Spring/Seep
LA Aqueduct
Highways
Towns

Fault
Fault Concealed
Fault Approximately Located

N
0 1 2 Miles

Figure 1-1
Owens Lake Study Area Map

LA DWP Los Angeles Department of Water & Power | GSI Environmental | H Water Resources | M2 Resource Consulting | Stantec

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Field data suggest that the Owens Valley Fault Zone (shown on **Figure 1-1**) acts as a barrier to flow and may reduce effects of groundwater pumping east of the fault on sensitive groundwater-dependent vegetation areas on the west side of the fault (MWH, 2012). A fault study of the northwest Owens Lake area (MWH, 2016) resulted in several key findings regarding implications for groundwater flow and recommended the installation of testing wells.

The 2012 OLGM suggested that approximately 10,000 acre-feet per year (AF/yr) or more of groundwater development at Owens Lake may be environmentally sustainable, but could result in decreased flow to groundwater-dependent vegetation (i.e., at seeps and springs) at the margin of the lake (MWH, 2012). The amount and timing of decreases in spring flow is dependent on the location and amount of pumping near and on the lakebed, as well as the effectiveness of local fault zones (including the Owens Valley and Owens River Fault Zones) (**Figure 1-1**) in acting as barriers to groundwater flow.

1.1.2 Summary of New Work Conducted

In order to further understand fault effects on groundwater flow, two testing wells (TW-E and TW-W) were installed, with locations shown on **Figure 1-1**. Similarly, to document the barrier effect of the Owens Valley Fault Zone and increase confidence in aquifer parameter assumptions and associated shallow groundwater conditions, additional lithologic data, pumping test, and groundwater level monitoring data in the northwest area of the Owens Lake have been collected.

The following work has been completed since 2012:

- Development of Resource Protection Protocols (RPPs) in coordination with the Master Project's Groundwater Working Group (GWG) that provide monitoring locations to address potential effects on groundwater-dependent vegetation from groundwater pumping. Groundwater-related RPPs are described in the Hydrologic Monitoring Management, and Mitigation Plan (HMMMP) prepared for the Owens Lake Master Project Advisory Committee (Stantec, 2018). The RPPs identify the following four groups of sensitive resources: groundwater-dependent vegetation, non-LADWP groundwater wells (production and water quality), land subsidence (potential effects to infrastructure), and potential dust emission areas. The RPP monitoring locations for groundwater-dependent vegetation involve observing head difference between 4- and 30 ft-deep piezometers in the surficial alluvium surrounding the lake, as well as gradients towards the vegetation areas from alluvial fan areas.
- Installation of ten triple nested shallow piezometers (P1, P2, P3, P4, P5, P5A, P6, P7, P8 and P9) surrounding the lake that provide groundwater elevation and vertical

hydraulic gradient monitoring points (Hushmand, 2015). Piezometer locations are shown on **Figure 1-1**.

- Installation of 14, 4-inch diameter monitoring wells ranging in depth from 75 to 268 feet below ground surface (fbgs) (Kleinfelder, 2014). These wells are shown as T918 through T931 on **Figure 1-1** and were installed as part LADWP's groundwater monitoring program to study the potential effects of using groundwater for dust mitigation at Owens Lake.
- Implementation of a baseline water quality and groundwater level sampling program to establish "*baseline*" pre-pumping conditions. Both LADWP and non-LADWP wells were sampled as part of this program in Fall 2017 and Summer 2019.
- Performance of isotope sampling in August 2017 utilizing new sampling points. This sampling built upon the original OLGEP isotope study (MWH, 2012) in order to further characterize the deep aquifer, effects of faulting, and origin of groundwater.
- Detailed mapping of geomorphic features in the northeast portion of Owens Lake.
- Ongoing collection of groundwater level measurements, water quality, and flow measurements from existing locations for the period after the model was completed by LADWP and others (2012 - 2019).
- Installation of TW-E and TW-W shown on **Figure 1-1**.
- Installation of five new monitoring wells shown on **Figure 1-1**. MW-2 through MW-5 were drilled in 2019, and installation of MW-1 has been on-hold pending the results of data collected from MW-2 and MW-3.
- Pumping test of the testing wells with observations at associated monitoring wells for a period of 24 hours at both wells.

The recent lithologic data, pumping test data and water quality sampling results have been analyzed and incorporated in the improvement of both the conceptual and numerical model. An updated Master Well Table is included in Appendix A of the Owens Lake Conceptual Model Update (Stantec, 2019). A compilation of new well logs is provided in Appendix B of the Model Strategy Report (Stantec, 2019).

Since the creation of the OLGM in 2012, several significant new tools and modules have been developed for MODFLOW that greatly enhance the -OLGM model. Simulation of evapotranspiration (ET) has been improved in the model, by applying the evapotranspiration (EVT) package that has recently proved successful in modeling of the Bishop/Laws area. Additionally, the model domain has been extended to include thin alluvial deposits to the east and northwest of Owens Lake, dividing the upper layer of the 2012 model to support integration of RPPs as part California Environmental Quality Act (CEQA) review for the Owens Lake Master Project.

1.2 Purpose

The newly collected data have been used to improve both the conceptual and numerical models. The purpose of updating the HCM is to incorporate the new data and update the understanding of the hydrogeologic system. The overarching objective of updating the OLGM is to improve the estimates of the potential effects of groundwater pumping with the goal to minimize impacts on sensitive resources in the vicinity of Owens Lake.

Specifically, the purpose of this OLGM update is to:

1) Update both the conceptual and numerical models based on new data collected since the original model was built in 2012.
2) Integrate and utilize new tools and modules available for the groundwater modeling software, MODFLOW (modular finite-difference flow model).
3) Extend the model domain and reduce the thickness of the current upper layer of the OLGM to support monitoring and evaluation of RPPs for the Owens Lake Master Project. A key goal of the model updates and improvements is the ability to simulate changes in head or groundwater levels at selected RPP locations under varying pumping scenarios, identified in the draft RPP document and HMMMP. Some of these locations involve monitoring head differences between 4-foot and 30-foot deep piezometers surrounding the lake. Given the very large scale (depth and areal extent) of the model, accurately simulating head changes in these piezometers at such a small scale may not be possible but was an initial goal of the modeling.
4) Utilize the updated groundwater model to evaluate the effect of the Owens Valley Fault Zone and other faults or fault zones on groundwater flow and parameter assumptions in the model, as well as simulation of pumping alternatives.

The updated and improved model is expected to be utilized for California Environmental Quality Act (CEQA) review and simulation of alternatives for the Master Project.

1.3 Organization of Report

This Report is organized as follows:

Section 1 – Introduction: Provides background information, including an overview of the existing groundwater model and summary of new work conducted, and states the purpose of the work.

Section 2 – Model Conversion and Improvement: Discusses model conversion and improvement, including use of new model packages, layering and grid refinement, incorporation of new evapotranspiration input, and integration of pumping test data from new testing wells.

Section 3 – Model Improvement Results and Calibration: Documents model improvement results, including model recalibration, zonation, transient calibration results, simulation of pump testing, and sensitivity analysis.

Section 4 – Summary of Key Model Improvements: Summarizes key improvements to the - OLGM model.

Section 5 – Summary of Supplemental Model Improvements and Calibration: Summarizes additional model refinement.

Section 6 –Recommendations: Provides recommendations for next steps.

Section 7 – References: Includes a listing of references used in the Report.

2.0 MODEL CONVERSION AND IMPROVEMENT

As summarized below, a stepwise approach was used in the conversion and updating of the existing -OLGM Model (MWH, 2012):

- Conversion of the model to MODFLOW-USG (unstructured grid)
- Conversion of the WEL (Well) package to the CLN (connected linear network) package in MODFLOW-USG
- Vertical and horizontal grid refinement
- Incorporation of new ET inputs
- Integration of new deep drilling data and pumping test results

2.1 Conversion of Model to MODFLOW-USG

An unstructured grid (USG) version of the U.S. Geological Survey (USGS) MODFLOW (MODFLOW-USG) provides flexibility in gridding for MODFLOW solutions (Panday et al., 2013). Unstructured grids allow for inclusion of various cell geometries and grid-nesting methodologies to discretize the model domain, as well as inclusion of various other flow processes and domains, such as flow through interconnected one-dimensional features (i.e., fractures, karst, wells, or channels) and through two-dimensional features (i.e., faults or overland flow and their interactions) in a fully implicit formulation. The code is in the public domain and is freely available from the USGS website (https://www.usgs.gov/software/modflow-usg-unstructured-grid-version-modflow-simulating-groundwater-flow-and-tightly).

The existing MODFLOW 2000-based OLGM was converted to MODFLOW-USG using the Upstream-Weighting (UPW) with NWT solution option. For this purpose, the MODFLOW version was changed to MODFLOW-USG, the solver changed to sparse matrix solver (SMS), and all layer options converted to convertible upstream weighting, such that simulation can continue even when simulated head is lower than the aquifer bottom (dry cells). The SMS was modified as shown in **Table 2-1**. Simulation results of the MODFLOW-USG model were then compared to the original model.

Table 2-1: MODFLOW Sparse Matrix Solver Input Parameters

Solver Options	Value Assigned
Maximum head change between outer iterations (L) (HCLOSE)	0.01
Maximum head change between inner iterations (L) (HCLOSE)	0.1
Maximum number of outer nonlinear iterations for problem (MXITER)	100
Maximum number of inner linear iterations for problem (ITER1)	500
Print additional info to listing file (IPRSMS)	(1) print summary
Nonlinear solution method (NONLINMETH)	(1) Newton with Delta-Bar-Delta
Linear matrix solver (LINMETH)	(1)xMD
Options (OPTIONS)	SPECIFIED
Delta-bar-delta learning rate reduction factor (THETA)	0.7
Delta-bar-delta learning rate increment (AKAPPA)	0.07
Delta-bar-delta memory term factor (GAMA)	0.1
Nonlinear fraction history added (AMOMENTUM)	0.0
Maximum residual backtracking iterations (NUMTRACK)	200
Residual change tolerance (BTOL)	1.1
Residual change reduction size (BREDUC)	0.2
Residual reduction limit (RESLIM)	10.0
Acceleration method (IACL)	(1) ORTHOMIN
Ordering scheme (NORDER)	(0) original ordering
ILU decomposition level of fill (LEVEL)	3
Number of orthogonanalizations for ORTHOMIN accel. (NORTH)	5
Reduced system (IREDSYS)	(0) do not apply
Residual tolerance criterion (RRCTOL)	0.0
Perform drop tolerance (IDROPTOL)	(0) do not perform
Drop tolerance value (EPSRN)	0.001

Results of the MODFLOW-USG simulation compared favorably with the original model, where a transient simulation starts on April 1, 1998 and ends on April 1, 2018. This time span of 20 years is discretized into 40 stress periods (6-month each). In turn, each stress period is discretized into 10 time steps. Except for transient pumping in the Lone Pine Wellfield, all other boundary conditions are in steady state. A comparison of water budget from all 40stress periods to the end of stress period 40 is shown in **Table 2-2** and **Table 2-3**. In comparing the total volume and flow rate in **Table 2-2** to those in **Table 2-3**, except storage, the water budget components are generally within 0.5 percent from the original simulation value for the cumulative water budget over the entire simulation period, as well as for rates at the last time-step. Cumulative discrepancy between total inflow less total outflow has been reduced from 94,679,040 cubic feet (ft^3) from the original 2012 model to 138,884 ft^3 for the updated model signifying substantial model improvement. Similarly, the last stress period discrepancy was reduced from 11,405 ft^3/day to 18 ft^3/day in the original and updated model, respectively.

Table 2-2: Water Budget for Original 2012 Model Simulation

Fluxes	Cumulative for all 40 Stress Periods		The End of Stress Period 40	
	Component	Total Volume (ft^3)	Component	Flow Rate (ft^3/d)
Inflow	STORAGE	31,794,022	STORAGE	1,056
	CONSTANT HEAD	6,321,924,608	CONSTANT HEAD	865,425
	WELLS	15,875,940,352	WELLS	2,173,300
	RIVER LEAKAGE	15,850,442,752	RIVER LEAKAGE	2,169,373
	HEAD DEP BOUNDS	9,393,892,352	HEAD DEP BOUNDS	1,285,810
	RECHARGE	2,148,052,992	RECHARGE	294,053
	TOTAL IN	49,622,048,768	TOTAL IN	6,789,017
Outflow	STORAGE	26,593,310	STORAGE	1,384
	CONSTANT HEAD	3,598,335,232	CONSTANT HEAD	492,584
	WELLS	1,755,282,944	WELLS	240,285
	DRAINS	22,071,027,712	DRAINS	3,020,695
	RIVER LEAKAGE	21,020,450,816	RIVER LEAKAGE	2,878,094
	ET	501,015,712	ET	68,585
	HEAD DEP BOUNDS	554,664,896	HEAD DEP BOUNDS	75,984
	TOTAL OUT	49,527,369,728	TOTAL OUT	6,777,611
Discrepancy	IN - OUT	94,679,040	IN - OUT	11,405
Percent Discrepancy		0.19%		0.17%

Note: cubic feet (ft^3), cubic feet per day (ft^3/d)

When comparing the values in the last column in **Table 2-2** to those in **Table 2-3,** the values for all components are slightly different, except "WELLS," "RECHARGE," and "ET." It is posited that the small amount of difference is because all layer options were converted to convertible UPW in the MODFLOW-USG simulation. This conversion solves the dry cell and model stability issues encountered in the 2012 model simulation. The total water budget outflow from the model, from the end of stress period 40 shown in **Table 2-2** and **Table 2-3**, ranged from 6,777,611 ft3/day (56,791 AF/yr) in the 2012 model to 6,784,053 ft3/day (56,845 AF/yr) in the updated model, respectively, which is well within the water budget range of 44,000 to 67,000 AF/yr documented in MWH (2012).

Table 2-3: Water Budget for Updated MODFLOW-USG Simulation

Fluxes	Cumulative for all 40 Stress Periods		The End of Stress Period 40	
	Component	Total Volume (ft^3)	Component	Flow Rate (ft^3/d)
Inflow	STORAGE	57,208	STORAGE	7
	CONSTANT HEAD	6,320,831,921	CONSTANT HEAD	865,275
	WELLS	15,875,958,339	WELLS	2,173,300
	RIVER LEAKAGE	15,829,949,623	RIVER LEAKAGE	2,167,002
	HEAD DEP BOUNDS	9,382,797,683	HEAD DEP BOUNDS	1,284,435
	RECHARGE	2,148,054,884	RECHARGE	294,053
	TOTAL IN	49,557,649,658	TOTAL IN	6,784,072
Outflow	STORAGE	156,741	STORAGE	21
	CONSTANT HEAD	3,600,492,761	CONSTANT HEAD	492,881
	WELLS	1,755,284,665	WELLS	240,285
	DRAINS	22,080,061,188	DRAINS	3,022,596
	RIVER LEAKAGE	21,063,709,841	RIVER LEAKAGE	2,883,465
	ET	501,029,405	ET	68,587
	HEAD DEP BOUNDS	556,776,173	HEAD DEP BOUNDS	76,218
	TOTAL OUT	49,557,510,774	TOTAL OUT	6,784,053
Discrepancy	IN - OUT	138,884	IN - OUT	18
Percent Discrepancy		0.00028%		0.00027%

Note: cubic feet (ft^3), cubic feet per day (ft^3/d)

2.2 Conversion of WEL Package to CLN Package

In MODFLOW, the WEL package allows the user to specify a volumetric rate of fluid withdrawal or injection. Positive pumping rates represent injection; negative rates represent withdrawals. Conversion of the 2012 Model WEL Package to the CLN

Package of MODFLOW-USG is summarized below. There are two significant benefits to using the CLN package.

1) A disadvantage of using the WEL package directly on a groundwater grid-block is that the flux needs to be apportioned appropriately among the multiple layers of a multi-aquifer well a priori, thus introducing possible errors and not accounting for transient system dynamics that drive flow within the well. The CLN package includes vertical conduits representing wellbores in the model, which are then pumped at the bottom of the conduit. This allows for correct apportionment of well pumping among the layers of a multi-aquifer well, which adjusts according to the system flow dynamics and aquifer parameters.
2) A disadvantage of using the WEL package directly on a groundwater grid-block is that the drawdown represents an average condition for the entire cell requiring further refinement of grid-blocks in well locations in an attempt at better solutions around and within the wellbore. The conduits of the CLN package interact with the groundwater flow cell via use of an analytical solution (the Thiem Equation). Thus, the well drawdown is computed as the groundwater level at the radius of the well and does not depend on the groundwater grid-block size. Furthermore, the solution accounts for well efficiency considerations (expressed as skin effects [hydraulic conductivity] of the well-screen and packing).

The Drain (DRN) package is used to simulate the flowing wells (**Table 2-4**). For pumping wells (**Table 2-5**), key groundwater level monitoring wells (**Table 2-6**), and gradient monitoring wells (**Table 2-7**) (locations shown on **Figure 1-1**), the CLN package was used to modify previous use of the WEL package.

Table 2-4: Flowing Wells Represented as DRAIN in 2019 OLGM Update

Well ID	UTM Meters East	UTM Meters North	Ground Surface Elevation (fmsl)	Note
PPG Well	407,820.9	4,037,042	3,580	Uncontrolled Flowing Well
Sulfate Well	419,383.5	4,034,159	3,568	Uncontrolled flowing well
Dirty Socks Well	414,790.9	4,020,909	3,595	Uncontrolled Flowing Well
Horse Pasture	419,970.9	4,039,287	3,595	Uncontrolled Flowing Well
Bartlett Well	408,049.1	4,037,918	3,587	Uncontrolled Flowing Well

Note: feet mean sea level (fmsl).

Table 2-5: Pumping Wells Simulated in 2019 OLGM Update

Well ID	UTM Meters East	UTM Meters North	Ground Surface Elevation (fmsl)	Top of Perforation (fbgs)	Bottom of Perforation (fbgs)
W416	404,022.9	4,051,340.7	3,797	100 200	150 490
W346A	404,427.9	4,051,416.9			
W344	404,254.8	4,051,570.7	3,771	70 235	144 390
W390	405,756.8	4,051,345.6	3,705	120	500
W346	404,346.8	4,051,611.7	3,761	60	410
Shallow River Production	412,708.4	4,044,628.3	3,588	155	225
Deep River Production	412,708.4	4,044,628.3	3,588	485	555
SFIP PW	417,624.3	4,029,651.3	3,562	700	810
FTS_Production_Deep_T5	417,771.5	4,041,952.8	3,588	255	405
DVF Shallow Production	409,331.9	4,049,440.3	3,667	208 303 378	282 321 454
DVF Lower Production	409,330.7	4,049,458.0	3,667	518	590
TW-W	409,511.2	4,038,469.6	3,559	440	880
TW-E	412,675.9	4,040,565.7	3,565	620	1490
SWANSEA WELL	419,035.6	4,042,475.3			
Dunn Production Well	421,137.3	4,040,784.3	3,881	255	430
Keeler CSD	421,329.3	4,039,400.8	3,651	51	109
Duck 1	411,506.4	4,019,852.0	3,592	43	92
Duck 2	410,933.1	4,018,619.3	3,593	40	198
AGRPW1	417,995.2	4,042,694.1	3,606	100	140
AGRPW2	418,138.20	4,042,586.3	3,605	100	140
AGRC50	418,011.6	4,043,232.2	3,624	180	220
OLSAC-PW-1	408,945.9	4,032,088.6	3,594	200	430
Sulfate facility	423,270.9	4,036,187.1	3,619	100	390

Note: feet mean sea level (fmsl), feet below ground surface (fbgs).

Table 2-6: Key Monitoring Wells Simulated in 2019 OLGM Update

Cluster Number	Cluster Name	Key Wells to Monitor	
		Non-LADWP	LADWP
1	Lone Pine	Mt. View Trailer Park	T858
2	Dolomite	FW Aggregates Well 2	T929
3	Swansea	Fault Test Well	---
4	Keeler	Keeler CSD	---
5	Olancha	---	T925
6	Cartago	Cartago Mutual[2]	T924
7	Rio Tinto	Rio Tinto	---
8	OLSAC	---	T922
9	Mortensen	Mortensen	T920
10	Lubken Creek	Boulder Creek RV Park	T348

Table 2-7: Gradient Monitoring Wells Simulated in 2019 OLGM Update

Gradient Type	Upgradient Location	Downgradient Location	General Location on the Margins of Owens Lake
Vertical	P1L	P1U	Northwest (Northwest Spring)
	P2L	P2U	West-Central (Cottonwood)
	P3L	P3U	Southwest/Central (Ash Creek)
	P4L	P4U	South (Olancha)
	P5L	P5U	Southeast/Central (Tubman)
	P5aL	P5aU	East (Trucksticker)
	P6L	P6U	East (Swedes Pasture)
	P7L	P7U	East (Mill Site)
	P8L	P8U	Northeast (Horse Pasture)
Horizontal	MW-3	T918	Northwest
	MW-2	P1U	Northwest
	T920	T919	Northwest
	T922	P2U	West-Central
	T923	P3U	Southwest/Central
	T927	P5aL	Southeast/Central
	T928	P6U	East

Note: The piezometers are triple nested, where "L" indicates lower screen interval and "U" for upper. Due to confining layer, the lower the screen interval, the higher the water level (upgradient).

Well loss was assumed to be accounted for by the Thiem equation including skin effects of the well screen. A skin factor of 1 ft/day and an anisotropy factor of 1 were used for evaluating flow from the groundwater cell to the CLN cell representing the well. A conduit hydraulic conductivity factor of 1 x 10^5 ft/d was used for flow within the wellbore, which was simulated using a laminar flow equation. Well radii and pumping rates used in the existing 2012 model were maintained. The factor and the formulation are detailed in the MODFLOW-USG document (Panday et al., 2013).

2.3 Vertical and Horizontal Grid Refinement

As recommended in the Owens Lake Conceptual Model Update TM (Stantec, 2019), the model domain was extended horizontally to accommodate simulation of shallower alluvial deposits both on the eastern margin and the northwestern portion of the study area, as shown in **Figure 2-1**. A summary of the OLGM layer assignments and corresponding Owens Lake aquifer units is provided in **Table 2-8**.

2.3.1 Grid Refinement

Figure 2-1 shows that the model domain was extended to include the eastern margin and the northwestern portion of the study area. During gridding of the entire model domain, lack of data in certain areas, such as high on the alluvial fans to the northwestern and eastern areas of the lake were noted. As a result, interpolation and extrapolation were made in order to make contouring reasonable in these areas. Such areas are less critical to realistic modeling because these areas generally do not have groundwater-dependent vegetation or shallow non-LADWP wells. In addition, a few local modifications were made to smooth layer boundaries.

Table 2-8: Summary of OLGM Layer Assignments and Owens Lake Aquifers

Aquifer Unit*	Model Layer	
	OLGM 2012	OLGM 2019
Aquifer 1	Layer 3	Layer 4
Aquifer 2	Layer 5	Layer 6
Aquifer 3	Layer 7	Layer 8
Aquifer 4	Layer 9	Layer 10
Aquifer 5	Layer 11	Layer 12
	Layer 12	Layer 13

Note: The surficial aquifer is assigned to OLGM layers 1 and 2 for the OLGM 2012 Model and layers 1 through 3 for the OLGM 2019 Model.

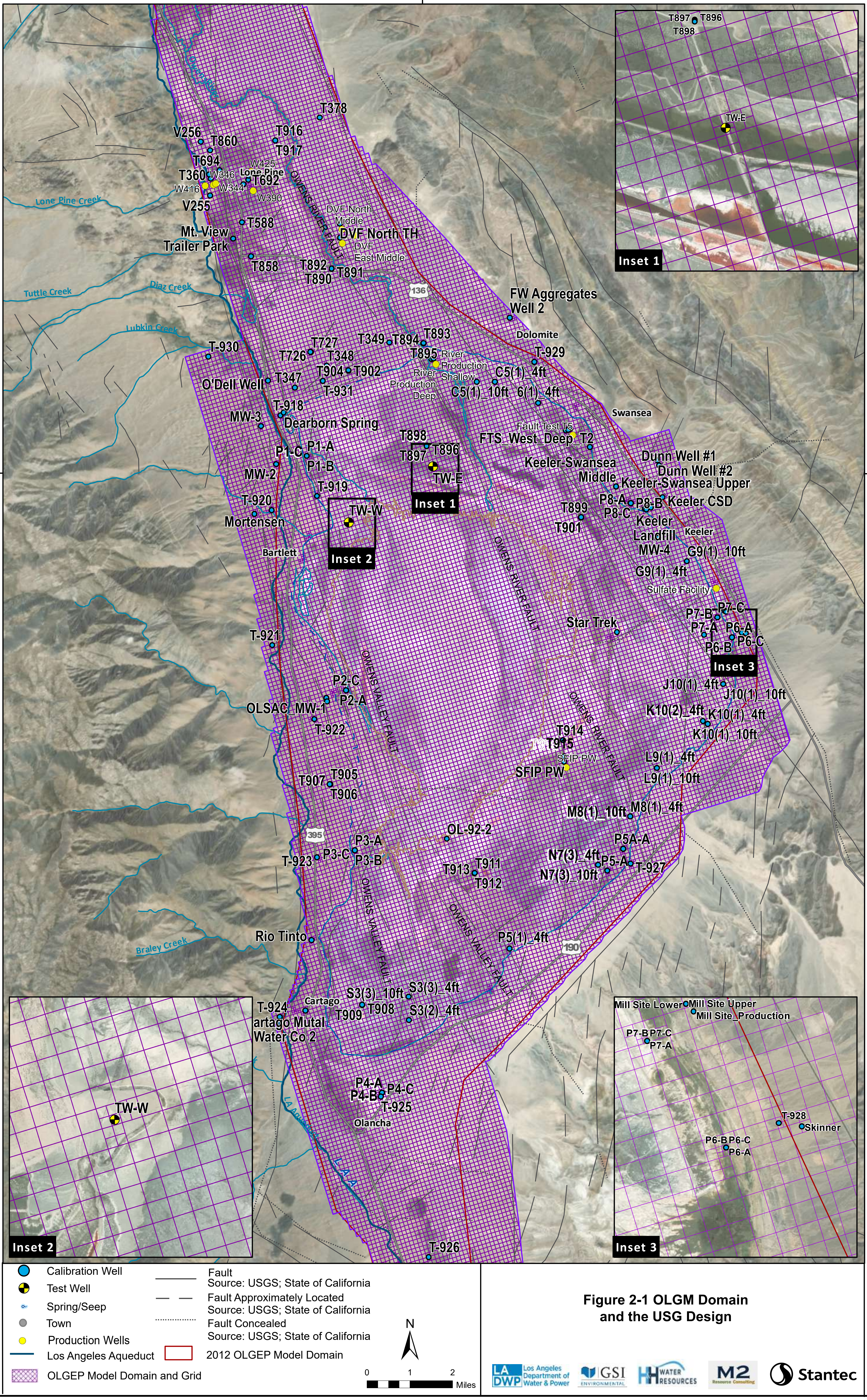


Figure 2-1 OLGM Domain and the USG Design

2.3.2 Layering

To avoid dry cells and model instability, most cells in layer 1 of the 2012 model have a thickness of more than 30 feet. One objective of the model update is to better simulate shallower systems (less than 30 feet). Utilizing MODFLOW-USG, in combination with the MODFLOW-NWT solver, dry cell issues are not a significant impediment. The USG platform also provides numerical stability.

Furthermore, the 2012 OLGM layer 1 was subdivided into two layers to simulate groundwater gradient observed in shallow piezometers. A general depth of 15 fbgs was discretized in areas such as the center of the lakebed and the northwestern area, where there are no clear stratigraphic delineations. The subdivision of the 2012 model layer 1 into two model layers results in a total of 13 model layers (**Table 2-8**).

The vertical discretization into these stratigraphic sequences allows significant flexibility for simulation of pumping from any one of the five discrete aquifer units identified in the delta area (MWH, 2012).

New lithologic data from well logs are discussed in three groups: (1) shallow piezometers (P1 through P8) to a maximum depth of 34 fbgs on each side of the lake, (2) intermediate alluvial monitoring wells (T918 to T931) with depths ranging from 57 to 258 fbgs, and (3) deep testing (TW-E and TW-W) and monitoring wells (MW-4 and MW-5) to a maximum depth of 1,520 fbgs (Stantec, 2019). Lithology, electrical resistivity, and layering of the existing model grid are shown on seven (7) cross sections from A-A' to G-G' in Stantec (2019). Review of these data along with existing grid data were summarized and integrated in a spreadsheet. Utilizing graphic software (Surfer®), the layer top and bottom elevation data were contoured to create a new 3D grid.

2.3.3 Quadtree Refinement

A two-level quadtree refinement was performed in areas around key groundwater features, including flowing wells, pumping wells, key groundwater level monitoring wells and gradient monitoring wells (**Table 2-4** through **Table 2-7**). Grid cells associated with each of these wells (**Table 2-4 through 2-7**) were refined as well as surrounding cells depending upon location of wells along cell boundaries. Only wells were quadtree refined because they have the greatest effect on model calibration and extend through multiple model layers and aquifers. The following describes quadtree refinement in detail.

The 2012 OLGM has a grid size of 500 by 500 feet. The first step in quadtree refinement (**Figure 2-2**) is to refine the 500-foot cells down to 250-foot (A - one-level refinement) then to 125-foot cells (B – two-level refinement). The same refinement was maintained through all model layers. The refined MODFLOW grid is shown in **Figure 2-1**.

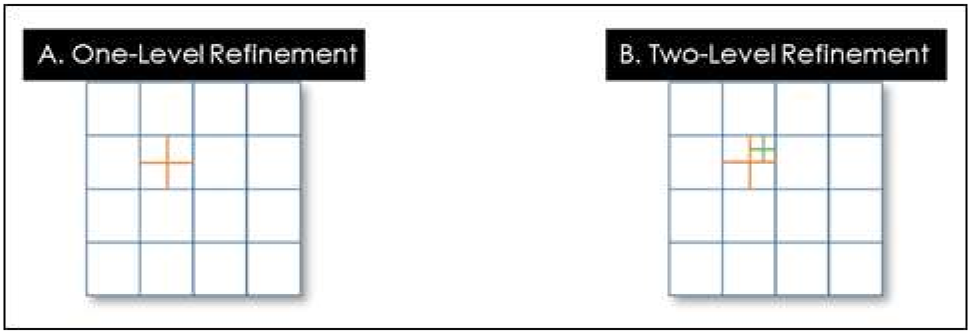


Figure 2-2: Quadtree Refinement of the MODFLOW Model Grid

2.4 Incorporation of New ET Inputs

In MODFLOW (Harbaugh et al., 2000), simulation of ET is handled by the evapotranspiration (EVT) package, which requires three parameters to determine ET: (1) ET surface elevation, (2) maximum ET rate, and (3) extinction depth. When the head in a cell is at or above the ET surface, then ET occurs at the maximum ET rate. When the head is below the extinction depth, then ET is zero. In between these two end points, the ET varies linearly.

Similar to other wellfield models in the Owens Valley, a half year (6-months) stress period was initially set for the transient simulation from 2010 through 2018 to capture seasonal variations specifically near the surface due to ET, where October to March is the wet period and April to September is the dry period (Stantec, 2019).

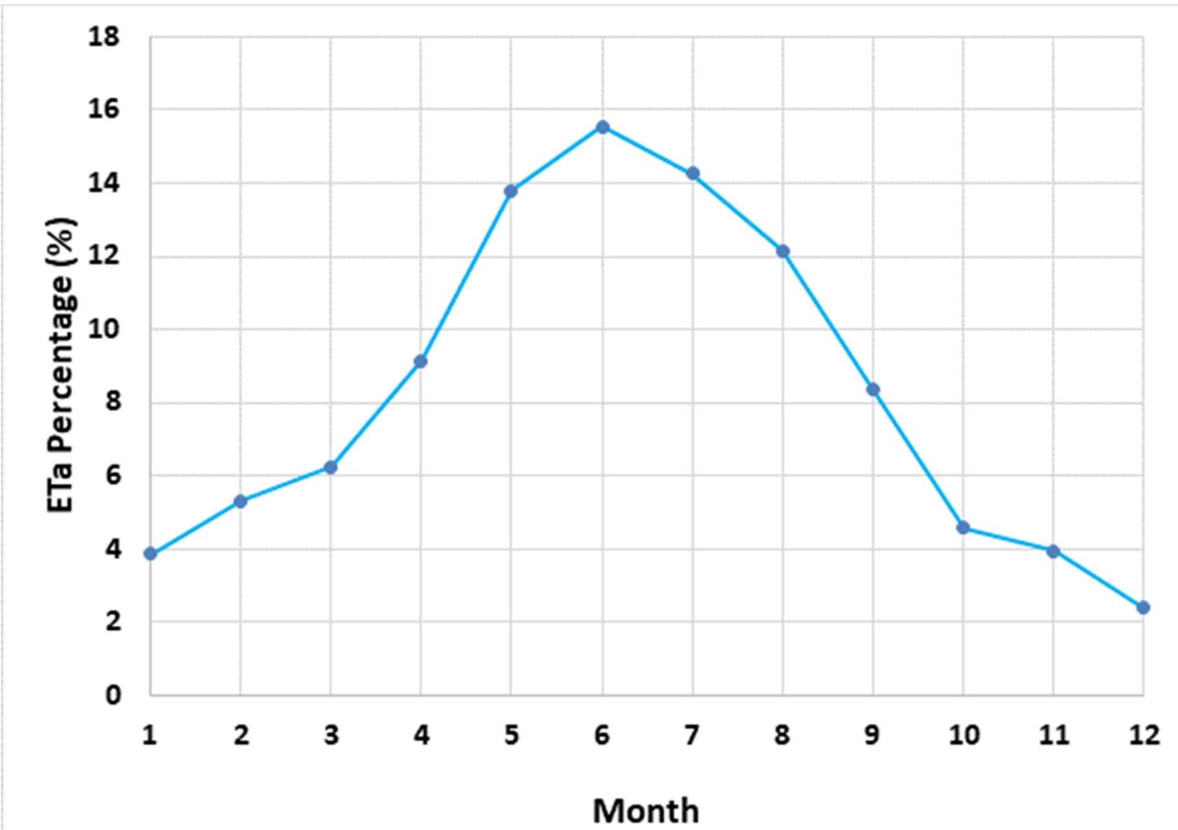
During model calibration, it was determined that if the stress periods were set to 6 months and the simulation results failed to capture short periods of groundwater level variation, the groundwater level fluctuation was averaged out. Thus, a shorter stress period is required. Note that a shorter stress period results in a larger number of stress periods, which in turn leads to a longer model run time. To better simulate observed groundwater levels, the stress period was reduced to 2 months. The aerial distribution was kept consistent with existing model ET zonation.

Duell (1990) estimated ET for December 1983 through October 1985 for seven representative locations in the Owens Valley, which were selected based on hydrogeology and the characteristics of phreatophytic alkaline scrub and meadow communities. He reported that the monthly percentage of annual ET was similar for all sites studied, as summarized on **Table 2-9** and on **Figure 2-3**, and recommended that these monthly percentages along with annual ET may be used throughout the Owens Valley.

Table 2-9: Monthly Percentage of Average Annual ET for 1984-1985

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Percent (%)	3.85	5.3	6.24	9.15	13.8	15.56	14.27	12.14	8.38	4.57	3.93	2.39

Source: Modified after Duell, 1990.



Source: Modified after Duell, 1990.

Figure 2-3: Monthly Percentage of Average Annual ET for 1984-1985 for Owens Valley

Among various sites in the Owens Valley, annual ET was estimated to range from 11.85 to 44.76 inches (Duell, 1990). Based on Duell (1990), a monthly percentage was summed for every 2 consecutive months. A maximum ET rate ranging from 0.009315 to 0.12329 inch/day is documented in MWH (2011). Stantec (2019) recommended to use the same range for the maximum ET rate and the same aerial distribution as documented in MWH (2011). Throughout the model domain, the maximum ET assigned in the present model improvement is 36.99 inches annually. Bi-monthly maximum ET rates used in the current transient model are summarized in **Table 2-10**.

Table 2-10: Summary of Bimonthly Maximum ET Rate

Month		Percentage of Annual ET (%)	MAX_ET Rate (ft/day)	Bimonthly MAX_ET (inch)
From	To			
Apr	May	16	0.008093	5.92
Jun	Jul	48	0.024279	17.77
Aug	Sep	16	0.008093	5.92
Oct	Nov	8	0.0040465	2.96
Dec	Jan	4	0.00202325	1.51
Feb	Mar	8	0.0040465	2.96
Annual Total		100	NA	36.99

A hydrograph showing simulated and observed groundwater levels for P4-C, which is an RPP monitoring well, is shown in **Figure 2-4** to illustrate the sinusoidal pattern, primarily due to fluctuations in ET. At P4-C, the maximum assigned ET rate varies from 0.004 ft/day during the December-January period to 0.024 ft/day during the June-July period. An example of a simulated and observed groundwater level hydrograph at a vegetated dune area (VDA) site is shown for C5(2)-4ft in **Figure 2-5**. At C5(2)-4ft, the maximum assigned ET rate varies from 0.00024 ft/day during the December-January period to 0.0012 ft/day during the June-July period. Simulated and observed hydrographs for all monitoring wells are included in **Appendix A**.

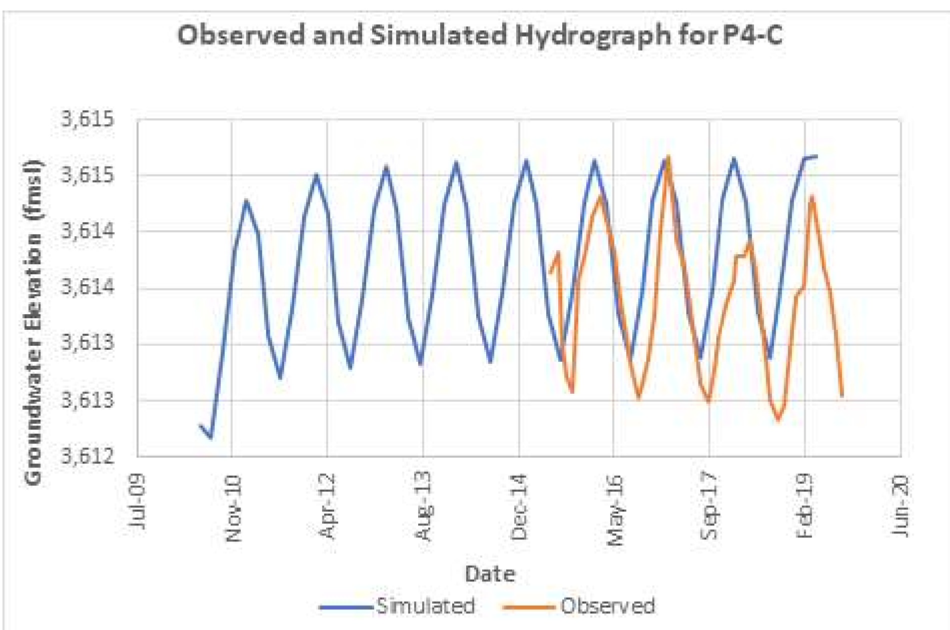


Figure 2-4: Observed and 2019 Updated OLGM Hydrograph for P4-C

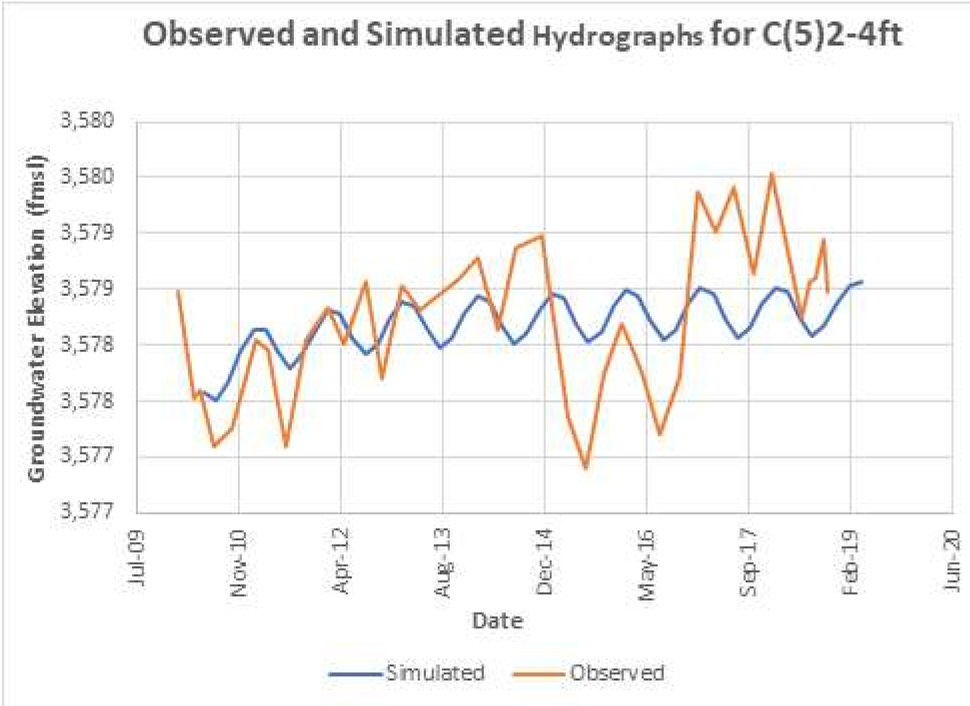


Figure 2-5: Observed and 2019 Updated OLGM Hydrograph for C5(2)-4ft

2.5 Integration of New Deep Drilling Data and Pumping Test Results

This section describes the integration of new deep drilling data into the model as well as pumping test results from the new test wells.

2.5.1 Drilling Data

Lithology and resistivity logs for MW-4, MW-5, TW-E, and TW-W (see **Figure 1-1** for locations) (Stantec, not yet published Well Completion Report) were used to create profiles and surfaces. Overall, five (5) aquifers and five (5) aquitards are clearly identifiable at TW-E in the Owens River Delta area to the east. At TW-W, alluvial and lacustrine deposits are interspersed. Poor correlation is observed between TW-E and TW-W. To the west at MW-5, fine-grained deposits dominate the shallow strata, while the deep formation is mainly comprised of coarse-grained sandy and gravelly materials. Further to the west, MW-4 encountered sand to sandy gravel throughout its completion depth of 950 fbgs. This lithology is significantly different with more coarse material and absence of clay compared to MW-5 on the east side of the Owens Valley Fault.

Lithologic and geophysical data were summarized and integrated in a spreadsheet for use with the graphic software Surfer®. These data and resultant surfaces were used to discretize the model layer top and bottom elevations to create a new 3D grid.

2.5.2 Pumping Tests

As summarized in **Table 2-11**, step-drawdown and constant rate pumping tests were conducted at TW-E on April 2-3, 2019 and TW-W on April 16-17, 2019. The TM documenting the pumping test is provided as **Appendix B**.

TW-E. Flow rates were measured using a flow meter totalizer. Each step had a duration of 1.5 hours, and the flow rates were 402, 599, and 824 gpm. A 24-hour constant rate pumping test followed, with an average flow rate was 860 gpm.

TW-W. Steps 1 and 2 each lasted 1.5 hours; step 3 had a duration of 1.25 hours. A flow meter was used to measure flow during step tests, and a totalizer was used during the constant flow test. Averaged flow rates for the three steps were 392, 596, and 798 gpm, respectively. The 24-hour constant flow test had an average flow rate of 720 gpm.

Before the pumping test started, transducers were installed in the pumping well and selected nearby monitoring locations to measure groundwater levels before, during and after the pumping tests. **Table 2-12** lists the groundwater level observation wells for the TW-E test and corresponding model layer. Due to artesian water conditions, a flowing test was performed at TW-W. Groundwater level observation wells and corresponding model layers for the flowing test at TW-W are summarized in **Table 2-13**. LADWP staff collected and provided groundwater level observations along with flow records and field notes to Stantec for analysis. These data were reviewed and used to further calibrate the model.

Table 2-12 and **Table 2-13** show that most of the monitoring wells were screened in a single model layer. TW-E is perforated from 620 to 1,490 fbgs, which spans model layers 6 to 12. TW-W is screened from 440 to 880 fbgs and spans model layers 4 to 7. Due to the difference in hydraulic conductivity in each model layer, the simulated groundwater level variation is different from one discrete model layer to another. Simulation results are discussed in **Appendix B**.

Table 2-11: Summary of Pumping Test at TW-E and Flowing Test at TW-W

Test Well	Test Type	Start	End	Flow Rate (gpm)
TW-E	Step 1	4/2/2019 17:00	4/2/2019 18:30	402
	Step 2	4/2/2019 18:30	4/2/2019 20:00	599
	Step 3	4/2/2019 20:00	4/2/2019 21:30	824
	Constant Flow	4/3/2019 7:12	4/4/2019 7:12	860
TW-W	Step 1	4/16/2019 11:01	4/16/2019 12:30	391
	Step 2	4/16/2019 12:55	4/16/2019 14:25	596
	Step 3	4/16/2019 14:30	4/16/2019 15:45	798
	Constant Flow	4/17/2019 8:00	4/18/2019 7:30	720

Note: gallons per minute (gpm)

Table 2-12: Monitoring Wells for Pumping Test at TW-E

ID	Elevation (fmsl)	Top of Screen (ft)	Bottom of Screen (ft)	Model Layer
TW-E	3,565.00	620	1490	4 to 7
TW-W	3,559.30	440	880	4 to 7
T896	3,572.10	1280	1360	12
T897	3,572.39	780	860	8
T898	3,572.22	240	320	4
T893	3,599.49	1430	1510	12 to 13
T894	3,599.72	1170	1250	6 to 12
T895	3,600.07	860	940	10
T931	3,616.91	27	57	2
DeltaW(3)_4ft	3,567.19	3	4	1
DeltaW(3)_10ft	3,567.26	9	10	1
T348	3,643.31			
River_PW_Shallow	3,588	155	225	
T902	3,631.19	1290	1350	12
T903	3,631.30	720	780	8
T904	3,631.46	300	360	4
MW-4(S)	3,643.50	140	160	3
MW-4(D)	3,643.50	530	590	5
MW-5(S)	3,558.90	200	240	3
MW-5(I)	3,558.90	400	460	4
P1_A	3,571.80	29.5	31.5	3
P1_B	3,571.80	10.5	12	1
P1_C	3,571.80	5	6	1
P2_B	3,566.01	10.5	12	1
P2_C	3,566.01	5	6	1

Note: feet (ft), feet mean sea level (fmsl).

Table 2-13: Groundwater Level Observation Wells for Flowing Test at TW-W

ID	Elevation (ft amsl)	Top of Screen (ft)	Bottom of Screen (ft)	Model Layer
TW-W	3559.3	440	880	4 to 7
MW-5(S)	3558.9	200	240	3
MW-5(D)	3558.9	600	660	5
MW-5(I)	3558.9	400	460	4
PPG	3577			
Bartlett	3578			
TW-E	3565	620	1490	6 to 12
T348	3643.31			
T896	3572.1	1280	1360	12
T897	3572.39	780	860	8
T898	3572.22	240	320	4
T902	3631.19	1290	1350	12
T903	3631.3	720	780	8
T904	3631.46	300	360	4
DeltaW(3)_4ft	3567.19	3	4	1
DeltaW(3)_10ft	3567.26	9	10	1
T918	3604.9	33	63	2
T919	3599.73	38	68	2
T931	3616.91	27	57	2

Note: feet (ft), feet mean sea level (fmsl).

Drawdown data from the testing wells were utilized to evaluate aquifer properties using the specialized software AQTESOLV authored by HydroSOLVE, Inc. of Reston, Virginia. Results of these analysis are given in **Appendix B**. The AQTESOLV evaluation indicates an aquifer transmissivity of 515 ft^2/day at TW-E and 4,994 ft^2/day at TW-W. Calculated storage coefficients for TW-E and TW-W are 0.037 and 0.002, respectively.

The results of the testing and calculated aquifer properties at TW-E and TW-W were utilized to improve the model by adjusting aquifer parameters such that the model replicates the drawdown observed in the pumping well and the few observation wells that showed influence from testing. Updated values for hydraulic conductivity, estimated from the pumping test, are averaged over the pumped or flowing well screened lengths because they are screened across multiple aquifers. To incorporate these data, the model was run iteratively to refine hydraulic conductivity and storage values for discrete model layers utilizing the CLN package and through the calibration process described in detail in the following section. Moreover, results showing differences in lithology as well as aquifer response to pumping tests across the Owens Valley Fault were used to assist in model calibration procedures (i.e., varying fault conductances).

3.0 MODEL IMPROVEMENT RESULTS AND CALIBRATION

This section presents results of model improvement, including final model design and the calibration process.

Flow rate and observed groundwater levels at each observation location from the TW-E and TW-W pumping tests were input in the model. Pumping test results of the 24-hour pumping test at TW-E and TW-W were simulated to recalibrate the model. The model was successful in replicating the drawdown observed in the pumping well and the few observation wells that showed influence of the testing. Unfortunately, a response to testing was not observed in the majority of observation wells because of the relatively low pumping rate and duration. Although the model replicates this behavior, opportunities to improve the model based on the testing observations at a variety of locations are limited because drawdown was not observed at most monitoring locations.

One of the primary reasons for constructing the testing wells is to observe the effects of pumping and to further develop RPPs for pumping and improve the groundwater model of the lake. Another key goal of testing of TW-E and TW-W is to observe drawdown in either side of the major fault zones (Owens Valley and Owens River Fault Zones). Again, testing was not conducted at a high enough rate or for a long enough duration to observe differential drawdown across fault zones except for drawdown observed in MW-5 (deep) and lack of drawdown observed in MW-4 (deep) when TW-W was flowing for 24 hours. The degree to which these fault zones act as groundwater barriers is a significant data gap that is most accurately resolved by long-term aquifer testing.

It is therefore recommended in the Pumping Test TM (**Appendix B**) that longer-term testing be performed on one or both wells. As a conservative measure, it is recommended that longer term pumping initially involve only one of the wells. Testing of TW-E is recommended in order to observe the effects of local fault zones, and because the relatively low production at this location is more conservative. A duration of 6 months during or slightly before the dust season is recommended in order to mimic conditions under which the well might eventually be used.

Therefore, following calibration and in order to predict the impacts of testing, the improved groundwater model was utilized to simulate four (4) long-term (6-month) pumping test alternatives at TW-E at continuous rates of 899, 1,200, 1,600, and 3,600 gpm.

3.1 Model Recalibration and Test Simulation

The -OLGM model attributes are described in MWH (2012), where the model code used at the time was MODFLOW 2000 (Harbaugh et al., 2000). The unstructured grid version of the USGS modular finite-difference flow model, MODFLOW-USG (Panday et al., 2017), was selected as the hydrogeologic modeling code for the present model improvement project. Consistent with the 2010 Model, GMS (Aquaveo, 2017), was used as the pre- and post-processor for the transient model. Packages utilized in the present/updated MODFLOW-USG model include:

- BAS – Basic Package
- CLN – Connected Linear Network Package
- DIS – Discretization Package
- DRN – Drain Package
- EVT – Evapotranspiration Package
- GHB – General-Head Boundary Package
- HFB – Horizontal Flow Barrier Package
- LPF – Layer Property Flow Package
- OC – Output Control Package
- RCH – Recharge Package
- RIV – River Package
- SMS – Sparse Matrix Solver Package
- WEL – Well Package

The BAS package provides basic simulation control details. The DIS package includes details of model discretization including the top and bottom elevations of model layers and other geometric and topologic properties of the model cells. The LPF package includes hydraulic conductivity and storage parameters for the groundwater cells. The OC package includes simulation control for output of results. In addition to the above packages, **Table 3-1** contains a summary of regular MODFLOW packages used to simulate boundary conditions in both the original model (MWH, 2012) and the current revised model. In addition to the packages used in the 2012 model, two more packages unique to MODFLOW-USG, including the CLN Package and SMS Package, were also used in the present modeling effort.

3.2 Model Zonation within Layers

The hydraulic properties used in the model include horizontal hydraulic conductivity, vertical hydraulic conductivity, the specific yield for an unconfined aquifer, vertical anisotropy, and the specific storage for confined aquifers.

Table 3-1: Model Boundary Locations and Representation in OLGM

Boundary Location	MODFLOW Module Utilized
Playa	Head Dependent Flux: Drain Package (DRN)
Northern Boundary of Unconsolidated Deposits of Owens Valley	Head Dependent Flux: General Head (GHB)
Southern Boundary at North Haiwee	Constant Head (CHD)
Southern Boundary west of North Haiwee	Head Dependent Flux: General Head (GHB)
Eastern Perimeter of Domain	No Flow and Fixed Flux
Western Perimeter of Domain	No Flow and Fixed Flux
Owens River	Head Dependent Flux: River Package (RIV)
Brine Pool	Constant Head (CHD)
Shallow Flood Dust Control Mitigation	Constant Head (CHD)
Springs and Seeps	Head Dependent Flux: Drain Package (DRN)
Pumping wells	Well Package (WEL) (2012 Model) Connected Linear Networks (CLN) (Revised Model)
Flowing Wells	Head Dependent Flux: Drain Package (DRN)
Evapotranspiration	Head Dependent Flux: EVT Package

For each layer, the model domain is subdivided into a number of zones of assumed similar parameter values. The calibrated parameter values and zone shapefiles from the 2012 -OLGM model were used as a starting point for the model update. These initial data were revised by changing parameter values, spatial extents, and number (added or removed) during the calibration process until the final zonation was achieved following calibration of the transient model. **Table C-1** in **Appendix C** lists the zone properties by layer and parameter that were exported from GMS for the revised model. **Appendix C** presents the model parameter zonation maps for layers 1 through 13, where parameter values are listed in **Table C-1**.

Parameter values fall within the normal range for modeling applications (Anderson and Woessner, 1992), and were determined during the calibration process. Key results include:

- The calibrated parameter values listed in **Table C-1** fall within the range of published hydraulic conductivity and storage coefficients (Freeze and Cherry, 1979).
- The horizontal hydraulic conductivity (Kh) values range from a high of 280 feet/day (representing clean sands and gravels), to a low of 1×10^{-6} feet/day (representing low-conductivity clays).
- The specific yield (Sy) values in layer 1 range from a high of 0.3 to a low of 0.01. Specific storage (Ss) values in layers 2 through 13 range from high of 0.007 to a low of 1×10^{-10}.

3.3 Transient Calibration Results

Transient calibration was completed for the OLGM model improvement in an iterative process. The preliminary calibrated model was recalibrated using the pumping test data at TW-W and TW-E, supplemented by pumping data from W425. Well W425 replaced W390 and is in Lone Pine. During model calibration it was found that the observed groundwater levels at T916 and T917 showed the results of pumping. Pumping from W425 was then incorporated into the model to improve calibrated results.

Previous pumping tests at the River Wells and the South Flood Irrigation Project (SFIP), similar to testing at TW-E and TW-W, showed only localized drawdown where widespread effects could not be documented. The usefulness of these pumping test results is limited in that many of the current monitoring sites for resource protection were not in place yet. However, these data were previously incorporated into the model.

The River (deep) well was pumped at an average rate of 1,335 gpm for a period of approximately 1 month in December of 2011 - January of 2012. During this test, wells that existed at that time were monitored for drawdown. Declines in groundwater levels during this test were only observed (other than the pumping well) in wells T348, T903, Down Valley (deep and intermediate), and the River monitoring well adjacent to the test well. While the adjacent River monitoring well showed a drawdown of approximately 38 feet, the only other monitoring wells that showed observable drawdown were wells T348 and T903 (both having approximately 1.25 feet of drawdown) and the Down Valley deep and intermediate wells (both approximately 2.5 feet of drawdown). No other wells showed drawdown due to the testing.

The River (shallow) well was also pumped for a period of approximately 1 month in February and March of 2012 at an average rate of 2,156 gpm. During this test, declines in groundwater levels were documented in wells T898 (approximately 6.5 feet), T892 (approximately 3.1 feet), Down Valley South and North (both approximately 1.5 feet), T904 (7.5 feet), and the shallow River Monitoring Well (approximately 38 feet). No other wells showed drawdown due to testing.

The SFIP Well was pumped for a period of approximately 2 weeks in June and July 2012 at an average pumping rate of 1,000 gpm. During this test, drawdown was observed in the adjacent SFIP monitoring well (approximately 42.5 feet), T915 (approximately 21 feet), and a barely observable 0.25 feet in Well OL-92. No other wells showed drawdown due to testing.

Both of these tests, while valuable for localized model calibration of both deep and shallow aquifers, did not show widespread drawdown desired for understanding of long-term pumping. Drawdown in these cases was localized in the vicinity of the pumping wells.

3.3.1 Groundwater Level Data

From April 2010 to June 2011, a total of 28 monitoring wells were installed to multiple depths throughout the OLGEP study area (MWH, 2012). Installation of 14, 4-inch monitoring wells ranging in depth from 75 to 268 were completed in 2014 (Kleinfelder, 2014). In addition, ten (10) triple nested shallow piezometers (P1, P2, P3, P4, P5, P5A, P6, P7, P8 and P9) surrounding the lake were developed in 2015 (Hushmand, 2015). Continuous groundwater level observations have been conducted since the completion of these monitoring wells. Analyzing the Owens Valley annual runoff data, 2010 is identified as a normal water year. Accordingly, a transient calibration for the period of 2010 to 2019 runoff years was performed, where a “steady-state” calibration was set at the beginning of this transient calibration.

At the completion of the OLGEP project, groundwater level observations at wells within the updated model domain (**Figure 2-1**) from April 1, 2010 to April 1, 2019 were used for the model calibration. Specific locations and depth intervals of these groundwater level observations are listed in **Appendix D**, where calibration statistics at each of these calibration wells are shown. **Appendix D** includes a total of 143 calibration wells. Transient hydrographs for the 2010-2019 transient simulation are shown in **Appendix A**.

Calibration head residual is the difference between the observed head value at a point in time and the simulated head value at the same time. Note that the simulated head values are output at fixed time points, either at the end of time steps or the end of stress periods. Therefore, groundwater level observations were not necessarily taken at the same time as the model output. In order to calculate the head residual, observed values were linearly interpolated. Among the 143 calibration well locations and for a total of 54 stress periods (2-month stress period from April 2010 to April 2019), a total of 3,308 residuals were evaluated. **Table 3-2** is a statistical residual summary for the improved OLGM, where:

- The mean residual is the average difference between observed and simulated head in feet. If this value is close to zero, then it indicates the residual is normally distributed around zero. The mean residual for the updated model is -1.38 feet. The negative value indicates that, overall, the model tends to underpredict groundwater levels.
- The mean absolute error is the mean error after taking the absolute value of the errors. The mean absolute residual for the model is 2.90 feet, which means that

the average simulated head is about ± 3 feet from an observed head. This value indicates the average elevation residual of the calibrated model.

- The root mean square error (RMSE) is a measure of precision, or the repeatability of the model results. This statistic is calculated by summing the square of the residuals, dividing by the number of observations (3,308), and taking the square root. The lower the RMSE the better the model fit; this model has a RMSE of 3.72 feet.

Table 3-2: Calibration Statistics for the 2019 OLGM Update

Calibration Statistic	2012 OLGM	2019 OLGM Update
Mean Error (ft)	-3.1	-1.38
Absolute Mean Error (ft)	6.6	2.90
Root Mean Squared Error (ft)	9.5	3.72

Figure 3-1 is a plot of all data from December of 2016, representing 105 observation well measurements versus corresponding model simulated heads. Similar patterns and trends are observed for all stress periods. Each symbol type and color represent a calibration point in a different layer. At a few calibration well locations, the screen interval spans over multiple model layers. For example, River Site Deep production well is perforated in model layer 6 and 7. A perfect simulation would result in a straight line, whereby the simulated head would equal the observed head. However, all the points are distributed closely around the 1:1 diagonal line, thereby indicating good performance of the model in representing the physical system. The points that do deviate from the diagonal line are randomly distributed, indicating no significant trend in spatially distributed error in the model domain. Overall, the model reasonably simulates observed water levels throughout the model domain with no one specific area more problematic than others.

Figure 3-2 is a histogram of the model residuals. The residuals are calculated as the difference between the measured value and the simulated one. A histogram is a frequency plot prepared by placing the residuals for all stress periods and for all calibration wells in regularly spaced intervals, or bins, and plotting each bin frequency. This figure illustrates an approximately normal distribution of residuals produced by the Owens Lake model. Based on the residual distribution, 80 percent of simulated values are within 5 feet of the observed values (columns filled with slant lines), and 98 percent of the simulated values are within 10 feet of the observed (combination of columns filled with slant and horizontal lines).

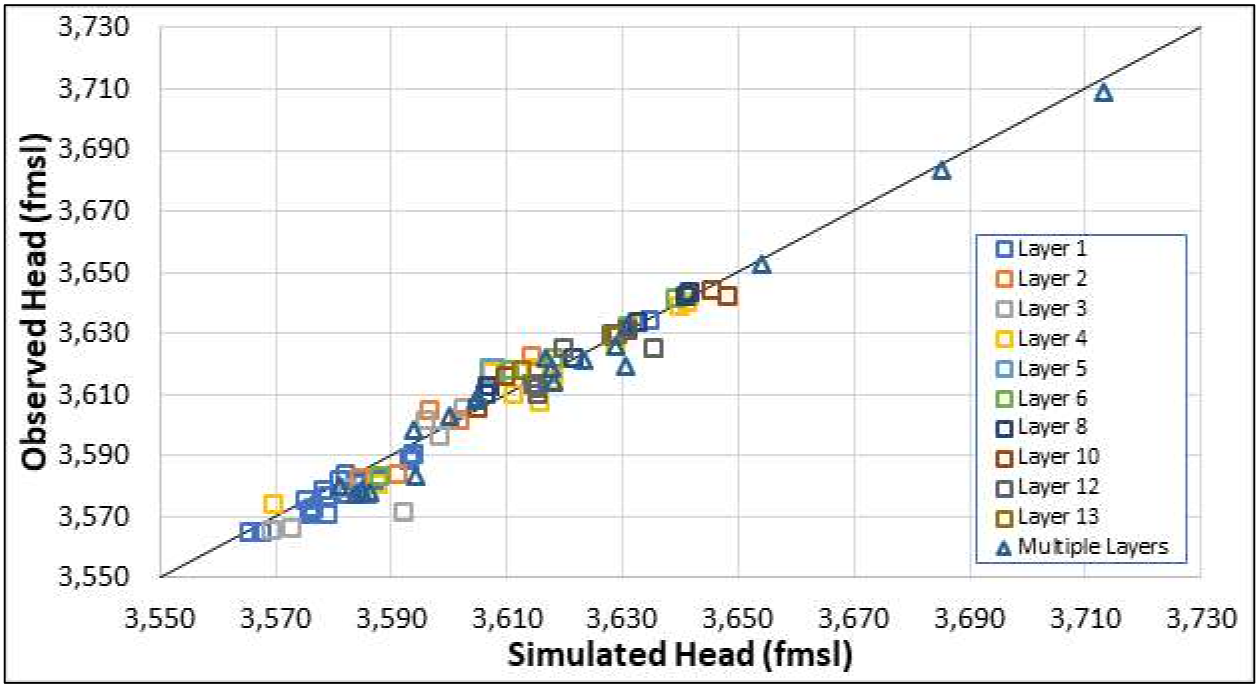


Figure 3-1: Comparison of Observed and Simulated Groundwater Levels in December 2016

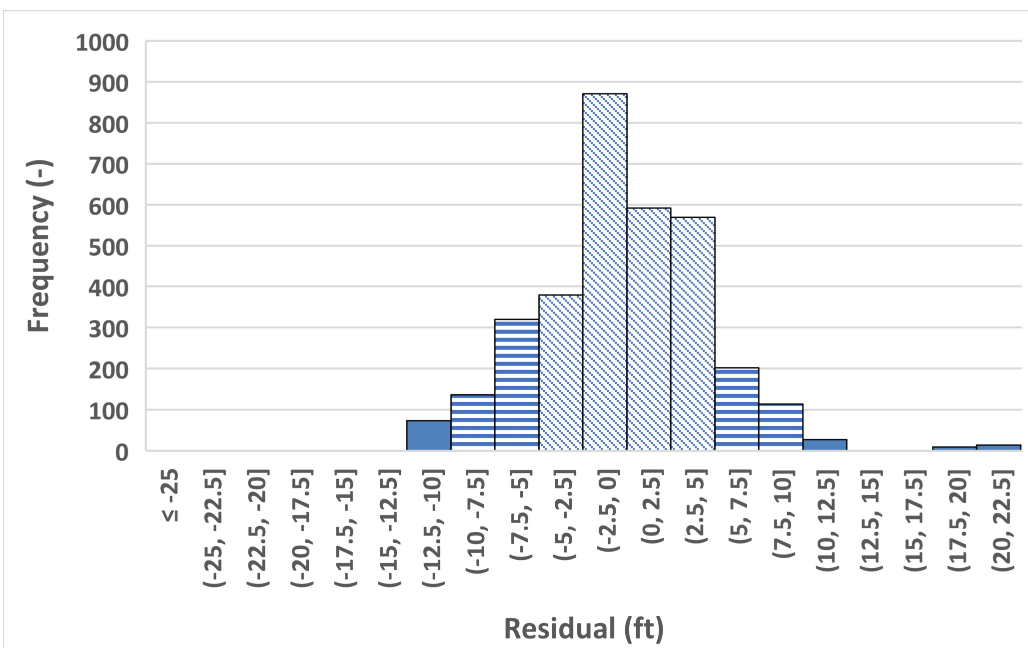


Figure 3-2: Histogram of Model Residuals

Residual ranges at each specific calibration well location are shown in **Figure 3-3**. At each calibration well location and for all stress periods, the maximum residual value (if positive the maximum value is taken; if negative the least value is used in the analysis) is signified by colored circles, whereby blue is for maximum positive residuals and orange for least negative residual values. The larger the size of the circle, the larger the absolute values. Large orange circles indicate simulated heads are lower than observed measurements, thus under-predicts. On the other hand, large blue circles show that the simulated values are higher than observed. At nested calibration well sites, multiple circles overlap and may have different sizes and colors.

It appears that the 2019 OLGM update underpredicts head value in the north and northeastern areas, where long term pumping at Shallow River (2/23/2012 to 3/26/2012) Deep River (12/14/2011 to 1/7/2012), SFIP (6/18/2012 to 7/2/2012) and Fault Test Deep Production Well (FTS_T5 from 10/24/2011 to 11/22/2011) and groundwater level observation at pumping wells (Shallow River and Deep River production wells, SFIP production wells and Fault Test production well T5) were included in the calibration process.

In general, causes of residuals include the following:

- **Known Non-Contemporaneous Data Points.** Groundwater level measurements were linearly interpolated to the fixed stress periods or time step.
- **Partially Penetrating Piezometers within a Layer with a Known Gradient.** There are a few calibration wells that have a screen interval of 2 feet, compared to tens or even hundreds of feet of model layer thickness. At P1-A, groundwater level observation started on June 12, 2015. The simulated value at P1-A is about 20 feet higher than observed. In addition, the Owens Valley Fault in this area plays a significant role in groundwater flow. The model may not accurately represent the fault and groundwater levels in this area.
- **Penetrating Multiple Model Layers.** At a few calibration well locations, the screen interval spans over multiple model layers (i.e., River Site Deep production well was perforated in model layer 6 and 7).
- **Unaccounted for Heterogeneity.** The Owens Lake model domain covers a considerably large area. Estimates of aquifer parameters have been made between known lithologic data points (wells with a lithologic log) and geophysical cross sections, but there is a significant area between these data points. A particular area of uncertainty is below the Brine Pool portion of Owens Lake, because no data exist for this area.

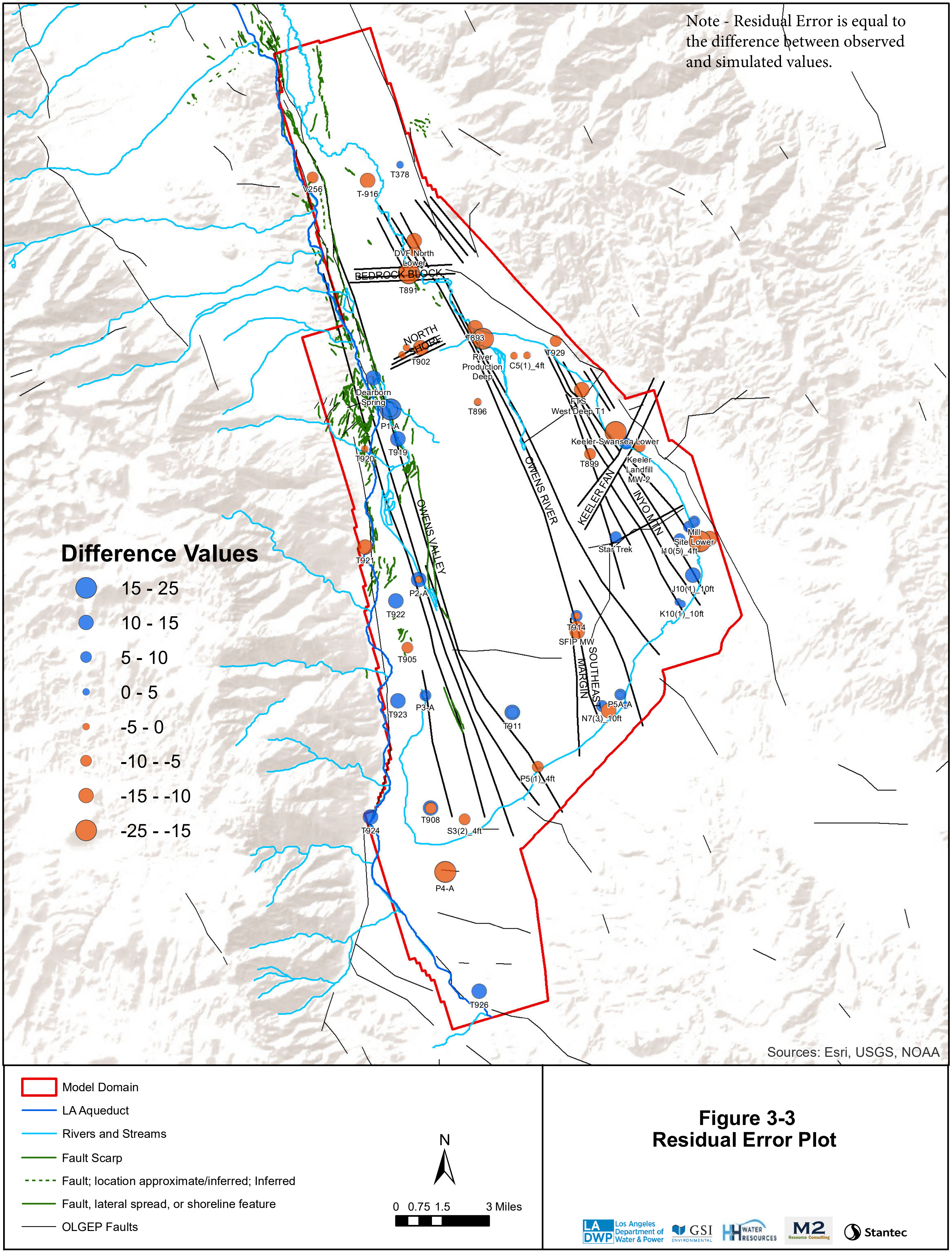


Figure 3-3
Residual Error Plot

- **Numerical Model Cell Size.** At calibration wells, the model computes groundwater levels over a 125 by 125-foot area. This generalized or averaged groundwater level may not be representative of groundwater levels measured in the field at a particular point, particularly in an area of high groundwater gradients (i.e., in a pumping well when the well is pumping). At River Site Deep production well, Shallow production well, SFIP production well, and Fault Test production wells FTS-T5 and FTS-T6, the difference between simulated and observed groundwater levels were outside the 20 feet range when these production wells were pumping in 2011 and 2012.

3.3.2 Groundwater Flow Pattern

Another method of evaluating the model fit is to review model-wide head results for general groundwater flow relationships. **Figure 3-4** illustrates observed and simulated groundwater level contours in Aquifer 1 (model layer 4) for December 2016. Observed groundwater contours are dependent on the distribution of observation well data. Due to the scarcity of data as well as the large distances between observation locations, interpretation of groundwater flow should be made with caution. In general, however, groundwater flows towards the brine pool, similar to prior observations (MWH, 2012). **Appendix E** includes five (5) maps that show the simulated head at calibration points for Aquifers 1 through 5 (model layer 4, 6, 8, 10, 12 and 13). Note that aquifer 5 was discretized into model layers 12 and 13. Due to the significant distance between data points, contours were not prepared for these aquifers.

3.3.3 Water Budget

The extended OLGEP study area is delineated by hydrologic boundaries (either bedrock boundaries or a groundwater divide) except for the northern boundary. To the north, the study area is bounded by the Alabama Hills north and west of Lone Pine, which has caused a narrowing of the Owens Valley. Significant groundwater flow crosses the northern boundary. The southern boundary is defined by the northern end of Haiwee Reservoir, wherein a constant head boundary condition is assigned in three cells in both model Layer 1 and 2, which corresponds to the 2012 OLGM layer 1. East and west boundaries are delineated based on the bedrock contact, with the Sierra Nevada, Inyo, and Coso mountain ranges.

For the extended OLGEP study area, the water budget is an accounting of groundwater inflows into the OLGEP study area and outflows (both groundwater and surface water). **Figure 3-5** shows that water year 2010 represents an average water condition in the Owens Valley. The water budget was developed for this average runoff year condition from April 1, 2010 to March 31, 2011.

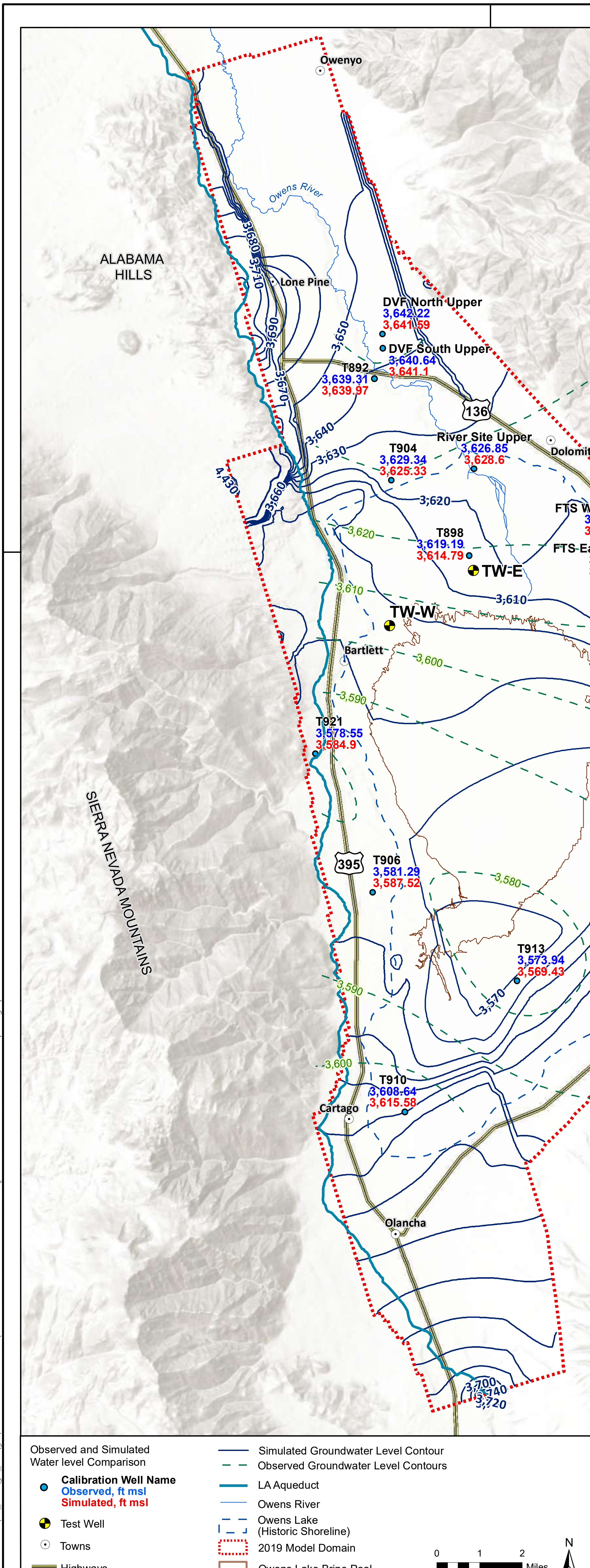


Figure 3-4
Observed and Simulated Grounwater Level Contours for Aquifer 1

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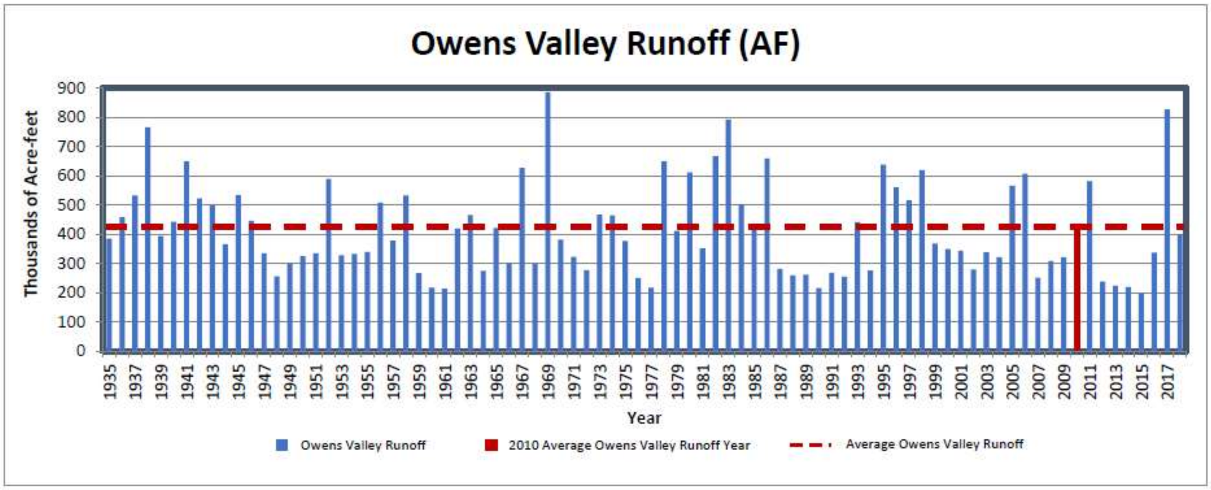


Figure 3-5: Owens Valley Runoff, Showing that 2010 was an Average Runoff Year

Table 3-3 summarizes the simulated inflow and outflow for the Owens Lake Basin. When total inflow is equal to total outflow, there is little change in groundwater storage, indicating that the aquifer system is at or near equilibrium. The difference between the inflow and outflow is negligible. Inflows total 68,844 AF; outflows total 68,847 AF, indicating no change in storage and near equilibrium conditions.

Table 3-3: Steady-State Water Budget Summary for 2019 OLGM Update

Inflow Component	Calibration (AF/yr)	Outflow Component	Calibration (AF/yr)
Down-Valley Flow	6,919	Constant Heads (Brine Pool)	9,037
Stream Channel Recharge	26,824	Drain (Playa)	14,612
Haiwee Reservoir Subsurface Inflow	17,047	River Leakage	19,996
Centennial Flats Subsurface Inflow		Well Pumping	1,338
Mountain Front Recharge	15,586	Evapotranspiration	21,924
Wastewater Return	2,467	General Head Boundary	1,940
Total	**68,844**	**Total**	**68,847**

In the case of Owens Lake Basin, detailed data on outflow from the groundwater system are not available. For example, private groundwater pumping from most wells is not gauged, and the amount of pumped water from those wells that returns to the aquifer through deep percolation is unknown. Additionally, although flow is monitored at several springs and artesian wells, they represent only a small fraction of cumulative flow from springs and seeps near the lake. Therefore, system outflow is a model derived variable.

3.4 Simulation of Long-Term Pumping at TW-E and TW-W

The results of the testing at TW-E and TW-W have also been utilized to improve the model by adjusting aquifer parameters such that the model replicates the drawdown observed in the pumping and the few observation wells that showed influence of the testing. Unfortunately, a response to testing was not observed in the majority of observation wells because of the relatively low pumping rate and duration. Although the model replicates this behavior, opportunities to improve the model based on the testing observations are limited because drawdown was not observed at most monitoring locations.

After recalibration of the model based on the testing of TW-W and TW-E, the model was modified to simulate longer-term pumping from TW-W and TW-E. As summarized in **Table 3-4**, a total of eight (8) alternatives were simulated, where "NO PUMPING" is simulated as the baseline alternative and a constant flow rate ranging from 800 to 3,600 gpm for 6-month is simulated in other seven (7) alternatives. Drawdown impacts to the RPP wells are discussed in detail in the pumping test TM. Discussions of drawdown impacts to the monitoring well locations (the same as the 24-hour constant rate pumping test at TW-E in April 2019) are included herein.

Table 3-4: Summary of Simulated Long-Term Pumping Alternatives

Alternative	Pumping Well	Flow Rate (gpm)	Duration
1	NO PUMPING	0	6-month
2	TW-E	800	6-month
3	TW-E	1,200	6-month
4	TW-E	1,600	6-month
5	TW-E	3,600	6-month
6	TW-W	800	6-month
7	TW-W	1,200	6-month
8	TW-W	1,600	6-month

Note: gallons per minute (gpm)

As summarized in **Appendix B**, TW-E is screened over multiple model layers from model layer 7 to 12. Simulated model layer drawdown hydrographs for TW-E when TW-E is pumped at a flow rate of 1,200 gpm for 6 months are shown on **Figure 3-6**. Due to the hydraulic difference in each model layer, simulated drawdown is different from one discrete model layer to another. The majority of simulated drawdown occurs from layer 6 and below, with the greatest simulated drawdown observed in layer 7 (**Figure 3-6**).

Simulated drawdown is shown for all calibration targets and RPP monitoring locations on **Figure 3-7**, including gradient monitoring wells after 6 months of pumping TW-E at 1,200 gpm. Simulated drawdown, across all model layers shown on **Figure 3-7** are mostly observed and greatest at monitoring wells/calibration targets nearest TW-E. Negligable drawdown (less than 0.1 ft) and change in vertical gradients (less than 1 percent) are observed throughout the remaining model domain.

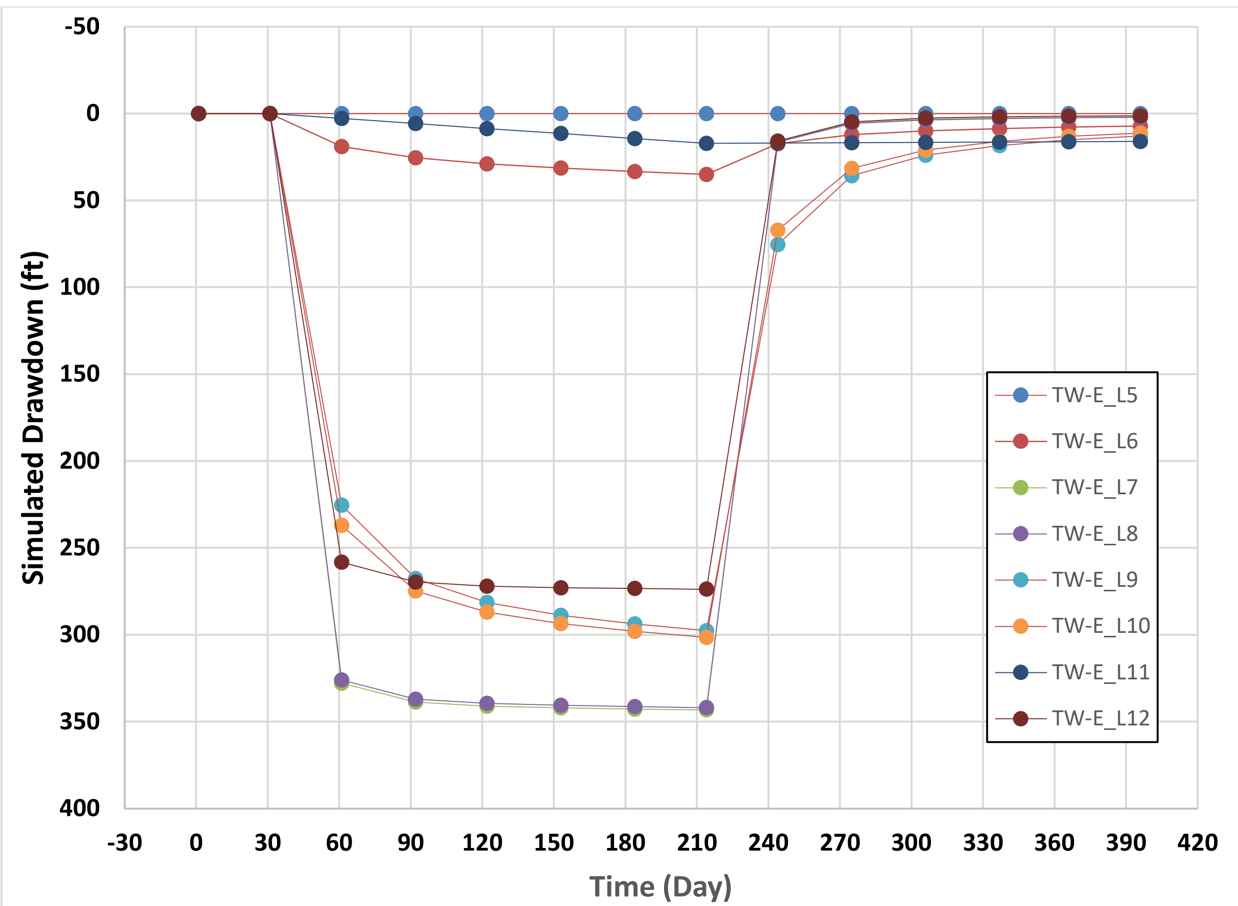
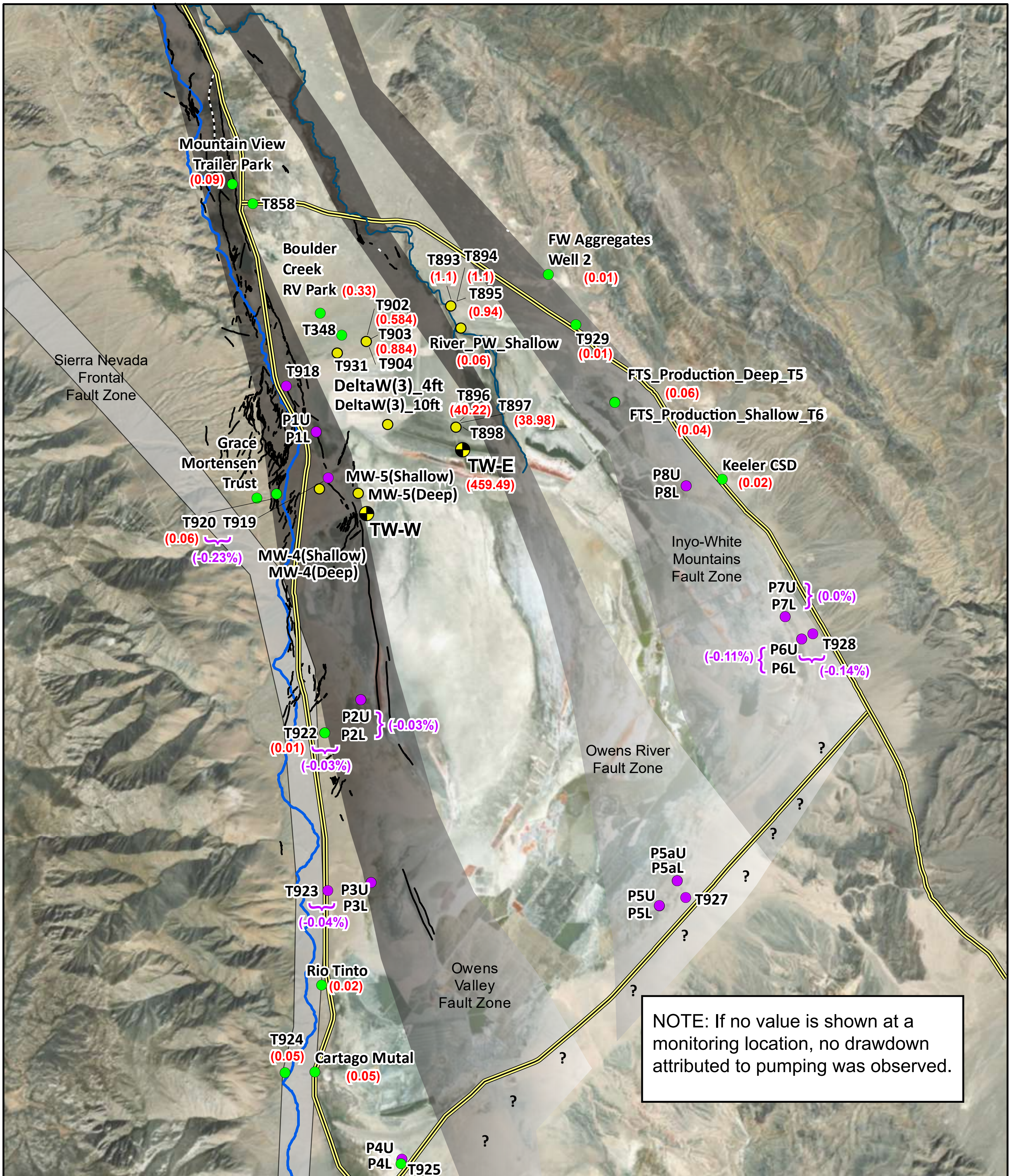


Figure 3-6: Simulated Drawdown when TW-E is Pumping at 1,200 gpm for 6 Months, using 2019 OLGM Update



Observation Well
RPP Groundwater Level Monitoring Wells
RPP Gradient Monitoring Wells
Owens River
LA Aqueduct
Highways
Pumping Well

Mapped Faults at Surface
Fault
Fault Concealed
Fault Approximately Located
Sierra Nevada Fault Zone
Owens Valley Fault Zone
Owens River Fault Zone
Inyo Mountain Fault Zone

(0.07) Drawdown in Feet
(-0.23%) Gradient Change
? Fault Location Uncertain

N

0 0.5 1 2 Miles

TITLE:
Figure 3-7
Simulated Drawdown/Gradient Change when TW-E is Pumping at 1,200 gpm for 6 months

PROJECT: Task Order 003 – Owens Lake Groundwater Development Program Assistance 3

REFERENCE(S):
Coordinate System: NAD 1927 UTM Zone 11N

Stantec

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3.5 Sensitivity Analysis of Hydraulic Conductance along Faults

The updated -OLGM utilizes the horizontal flow barrier (HFB) package to simulate fault effects on groundwater flow. Fault locations are shown on **Figure 3-8**. During model calibration, the hydraulic conductance value was adjusted so that the simulated head on both sides of the barrier matches the observed values. Hydraulic conductance describes the ability of the fault barrier to transmit groundwater.

At the completion of the model calibration, a sensitivity analysis was conducted by varying the calibrated fault conductance values to determine how these values affected simulation results. Model sensitivity here is described in terms of the Mean Error, Absolute Mean Error, and Root Mean Squared Error between observed and simulated groundwater elevations as a result of varying fault conductance (**Table 3-5**). The calibrated conductance values for segments along the Owens Valley Fault were multiplied by 0.1 to 10 times the calibrated estimates.

Table 3-5: Summary of Sensitivity Analysis

Parameter	Calibrated Conductance (X0.1)	Calibrated Conductance (X1)	Calibrated Conductance (X10)
Mean Error (ft)	-1.46	-1.45	-1.46
Absolute Mean Error (ft)	3.07	2.90	3.03
Root Mean Squared Error (ft)	4.22	3.72	4.2

These data suggest that the calibrated value used for fault conductance results in the best fit in terms of the Root Mean Squared Error of 3.72 ft. However, the mean error indicates minor overprediction of groundwater elevations, with minor variation between conductance multipliers. The almost identical mean error between sensitivity conductance ranges suggests the model is not significantly sensitive to small changes in fault conductance overall. This may also indicate a lack of observation data from monitoring wells located cross fault barriers that are used for error calculations. The Absolute Mean Error was also the lowest for the calibrated conductance value. Overall, the model simulated groundwater elevations within approximately 3 ft of observed values on average albeit with slight negative bias (denoting overprediction of groundwater elevations). Focused sensitivity analyses in problematic areas within the model, such as in the north west and south, would improve overall calibration statistics of the model.

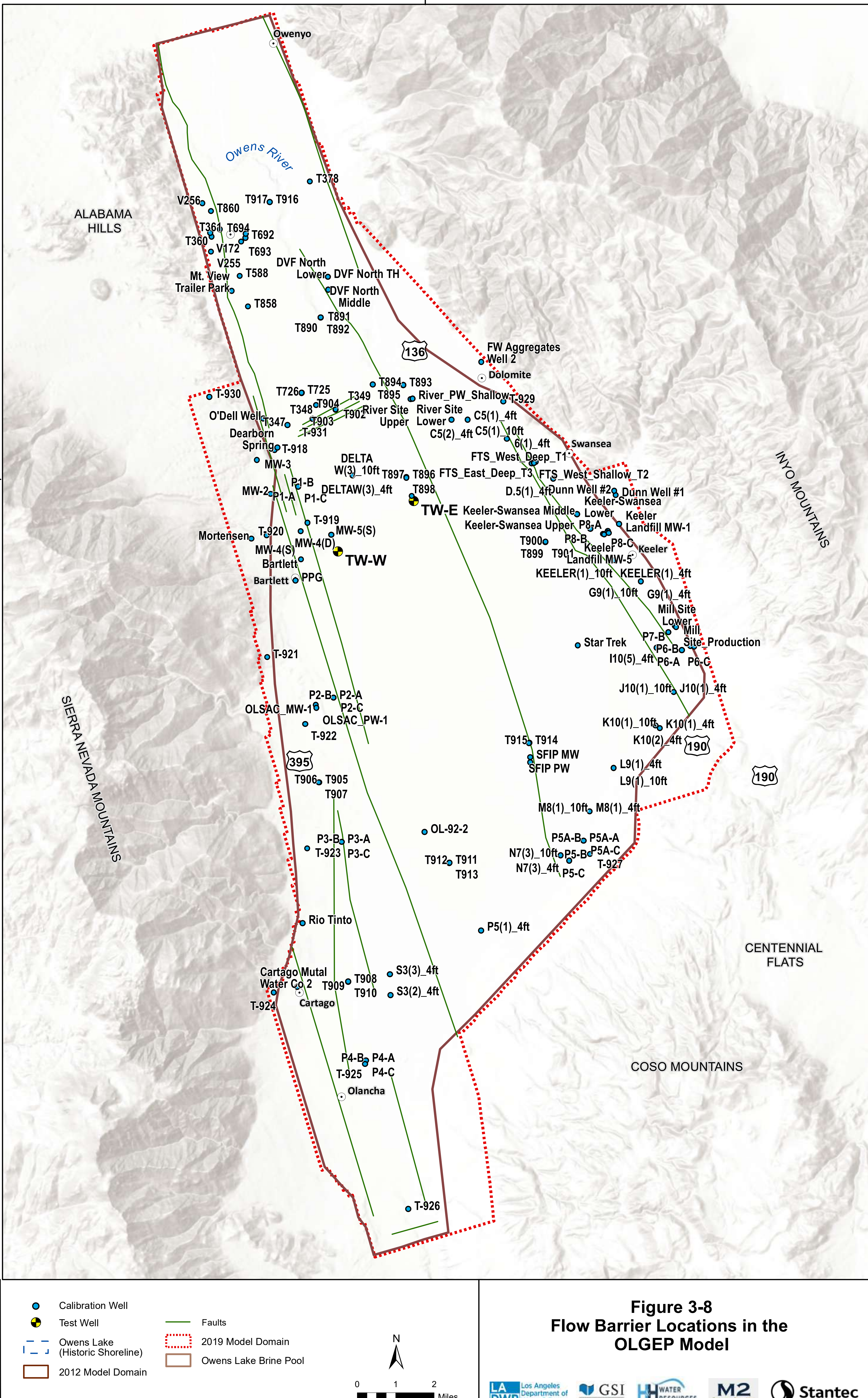

Figure 3-8
Flow Barrier Locations in the OLGEP Model

LA DWP Los Angeles Department of Water & Power | GSI Environmental | HH Water Resources | M2 Resource Consulting | Stantec

C:\Users\ikegley\Desktop\Figure 3-27.mxd Revised: 2020-02-06 By: ikegley

This color map has been designed to print size 11'' by 17''.

4.0 SUMMARY OF KEY MODEL IMPROVEMENTS

The following is a summary of key improvements to the transient groundwater flow model:

- The model domain was expanded to the east and northwest to accommodate thinner alluvial areas and to assist in evaluation of the role of faulting on groundwater flow with planned locations for additional monitoring wells.
- The model was converted to the relatively new USG version of MODFLOW (MODFLOW-USG), thereby increasing the stability of the model and allowing the use of the CLN feature of the unstructured grid version.
- The upper layer of the 2012 -OLGM layer 1 was subdivided into two model layers to more precisely model surficial aquifer groundwater and its influence on vegetation.
- The methods used to simulate ET were modified using the EVT package of MODFLOW. The stress period was reduced in length from 6 months to 2 months to achieve a more precise simulation of seasonal water level fluctuation in surficial aquifers.
- The model grid was refined in areas of concern, such as pumping wells and sensitive spring locations.

During development and calibration of the -OLGM, several unique characteristics of the model became apparent. The most notable of these characteristics are summarized below.

- ET is the primary mechanism for outflow of groundwater from the Owens Lake Basin. By converting the 2012 -OLGM into MODFLOW-USG model along with incorporation of the UPW package and NWT solver without change to input data files, the ET package has been applied successfully throughout the model domain. In the area to the north of the lake that overlaps the Southern Model domain, multi-year average of the Ecological Dynamics Simulation model results were used as the maximum ET rate at land surface and an extinction depth of 15 feet was set (Stantec, 2019). To the south of the Southern model domain, the current maximum ET rate and zonation as documented in Stantec (2019) was used. Initially the extinction depth was set to 30 feet throughout this area. The ET rate, zonation, and extinction depth were refined through the calibration process procedures that resulted in agreement between simulated and observed seasonal groundwater elevation variations in the surficial aquifer.
- Observed hydrographs at shallow piezometers P1 through P8 and groundwater level monitoring wells at or near the Vegetated Dune Area (VDA) and Salt Crust Area (SCA) exhibit sinusoidal characteristics. The transient ET rate estimated by

Duell (1990) mirrors the water level hydrographs, where a high ET rate from April to September results in lower groundwater level, while the groundwater level is higher from October to March when the ET rate is low. During model calibration, it was found that if a 6-month stress period was used, then the simulation results failed to capture the short period of water level variation, where the water level fluctuation was averaged out. Thus, a shorter stress period is required. Note that a shorter stress period results in a larger number of stress periods and this in turn, leads to a longer model run time. To balance the longer model run time and improved simulation results, the stress period is set to 2 months. Simulation results indicate that the simulated groundwater levels mimic the observed water level both in amplitude and period.

- Transient calibration results indicate that simulated head values at T-918, Dearborn Spring, P1-A, and the monitoring wells on the alluvial fan to the west of the Owens Valley Fault are higher than observed. Two new monitoring wells, MW-2 and MW-3, were drilled in this area to fill data gaps and help characterize the depth to bedrock and hydraulic characteristics of the sediments above bedrock, as well as provide insight on potential groundwater recharge characteristics from the area southwest of the Alabama Hills. Groundwater elevation observations show MW-3 over 100 ft greater in groundwater elevation than MW-2, suggesting an Owens Valley Fault splay in this area may be a barrier to groundwater flow, along with formation change, and/or the contribution of recharge from the west side of Alabama Hills. Elevated bedrock at MW-3 may also be a contributing factor.
- The 24-hour pumping test at TW-E and TW-W was neither at a high enough rate nor long enough to result in any observable groundwater level drawdown at monitoring wells to the west of the Owens Valley Fault. No data exist to confirm the extent to which the faulting acts as a hydraulic barrier. Model simulations support the HCM incorporating estimated fault effects on groundwater flow but will require additional data to definitively address fault effects on groundwater flow.
- A longer-term testing and monitoring plan has been prepared that will improve estimates of fault effects as well as effects from longer-term pump testing; this plan is pending permitting from the California State Lands Commission.

5.0 SUMMARY OF SUPPLEMENTAL MODEL IMPROVEMENTS AND CALIBRATION

Additional model improvements were made after submission and review of the Draft Technical Memorandum Model Documentation Report for the Owens Lake Groundwater Model Update to incorporate additional data, revise CLN Package application, and address inconsistencies in the model water budget from the previous model version (MHW, 2012). The updated model was then calibrated and used to simulate 6 months of pumping at TW-E with a flow rate of 1,350 gpm (LADWP, 2020). The following subsections describe modifications made to both the HCM and the groundwater flow model.

5.1 North Haiwee Reservoir Boundary Condition Modification

MWH (2011 and 2012) specified a constant head boundary (CHD) condition at the Haiwee Reservoir and estimated an inflow ranging from 2,000 to 11,000 AF/yr. In the draft model, a CHD boundary condition was again used to simulate inflow of water to the model domain from Haiwee Reservoir. However, simulation results indicated that subsurface inflow from the Haiwee Reservoir was over 17,000 AF/yr (**Table 3-3**). This inflow far exceeded the original estimated range and those from a recent study that estimated 2,070 AF from the North Haiwee Reservoir (Black & Veatch, 2018).

To better understand both inflow at the boundary with North Haiwee Reservoir and hydrogeology at the boundary, geotechnical data were reviewed, including data from three test holes (NH-101-P, NH-102-P and NH-103-P) drilled to a total depth of 225.3, 205 and 130.7 feet below North Haiwee Dam (NHD) crest, respectively (LADWP, 1973). These test holes were subsequently converted into monitoring wells (T.H. N72A, N. Haiwee Dam T.H.#72A; T.H. N72B, N. Haiwee Dam T.H.#72B; and T.H. N72C, N. Haiwee Dam T.H.#72C). Drill cuttings encountered included fill material (embankment), alluvium (foundation) and the underlying bedrock. Depths to bedrock in these three test holes are 178, 192 and 116.5 feet, respectively. Lithology logs are included in LADWP (1973) and laboratory test results are in LADWP (1974).

Additional studies (LADWP, 1973, 1974, 2007; Black & Veatch, 2013, 2014, 2018) indicate that the lithology near the Haiwee reservoir consists of older alluvium on the east and west sides of the valley and younger fluvial and lacustrine deposits beneath the central portion of the valley. Consisting of argillaceous sandstone with beds of claystone and siltstone, the Coso Formation lies underneath the alluvium and fluvial and lacustrine deposits. Hydraulic properties near the NHD recently used in a seepage analysis (Black & Veatch,2018) are summarized in **Table 5-1**.

Table 5-1: Hydraulic Properties at NHD (Black & Veatch, 2018)

Formation	Horizontal Hydraulic Conductivity K_h (foot/day)		Vertical Hydraulic Conductivity K_v (foot/day)		Specific Storage ($foot^{-1}$)	Storativity/Specific Yield	
	Range	NHD2 Model	Range	NHD2 Model	NHD2 Model	Range	NHD2 Model
Alluvium	120 to 175	150	<0.1XKh	0.1XKh	0.00085	0.05~0.2	0.1
Coso Formation	0.25 to 4.65	1	0.002 to 0.06	0.01		0.001	

Source: Black and Veach, 2018.

These values were then used to update hydraulic conductivity and storage parameters along the southern model boundary. Moreover, water bearing formations at the North Haiwee Dam were previously set to a depth of more than 2,700 ft, comprising each of the 13 model layers. Depth to bedrock was reduced in the model to approximately 200 ft. This was accomplished by setting the bedrock beneath the dam to approximately 200 ft, down-sloping northwards to more than 2,700 ft near the center of the valley along the line from V405 to T-925. Very low hydraulic conductivity values (as low as 0.002 ft/day) were assigned to the lower model layers near the dam, progressively increasing both upwards and northwards. The assigned specific storage value ranged from 1E-5 to 1E-6 (1/ft).

To adequately simulate and provide preliminary control of flow from Haiwee Reservoir to groundwater, the CHD boundary conditions along the North Haiwee Reservoir were replaced by General Head (GHB) boundary conditions. These maintained the stage in the reservoir and allowed for local modification of conductance, where in this instance, hydrogeologic conditions were reviewed and hydraulic conductivity values were modified based on geologic and hydrogeologic studies in this area (**Table 5-1**).

5.2 Evapotranspiration and Groundwater Production South of Owens Lake

New information and data have been obtained for the area south of Owens Lake to North Haiwee Reservoir. These include recent ETa data and groundwater production data. Annual ETa rates for the Butterworth Ranch nearest North Haiwee Reservoir, Hunter property, an unknown property (Other) north of that, and irrigated leases RLI-427 and RLI-428 shown on **Figure 5-1** total 3,164 AFY (**Table 5-2**). Annual ETa ranged from 1,058 AFY at Butterworth Ranch to 210 AFY at the Other area (**Table 5-2**). Mean annual rates ranged from 45.65 inches at Butterworth Ranch to 65.24 inches at Hunter property. ETa totals were used to compare well production estimates for the Butterworth Ranch, the Hunter property, and the two irrigated leases.

Table 5-2: Estimated Annual Actual Evapotranspiration (ETa)

Area ID	Area (acres)	Mean ETa (in)	Volume ETa (AF)
Hunter	113	65.24	614
Butterworth	278	45.65	1,058
Other	53	47.65	210
RLI-427	56	57.73	269
RLI-428	209	58.11	1,012
Total			3,163

Note: inches (in), acre-feet (AF)

It is assumed that groundwater production north of North Haiwee Reservoir is used for irrigation supply at the Butterworth Ranch, Hunter property and at the irrigated leases. Combined annual ETa for range lands RLI-427 and RLI-428 is 1,281 AFY which is within 242 AFY of combined pumping data from wells V404 and V405. Production wells V404 and V405 are assumed to irrigate the RLI-427 and RLI-428 leases, respectively (**Figure 5-1**). Production data for wells V404 and V405, shown in **Table 5-3** and **Table 5-4**, respectively, were added to the model for the entire model simulation period from April 2010 to April 2019.

Groundwater production for the Butterworth Ranch and the Hunter property has been estimated to range from 3,000 to 4,000 AF/yr while total annual ETa is 1,672 AFY (**Table 5-2**). Partial well records for a well located near or on Butterworth Ranch indicate an average annual groundwater production of 1,290 AF from mid-March to mid-November. Assuming a total of 3,300 AF/yr of combined production, approximately twice the ETa estimate, 1,300 AF/yr and 2,000 AF/yr of groundwater production was assigned to the Butterworth Ranch and Hunter property from mid-March to mid-November, respectively. Higher irrigation amounts are attributed to the location of the parcels within higher wind areas.

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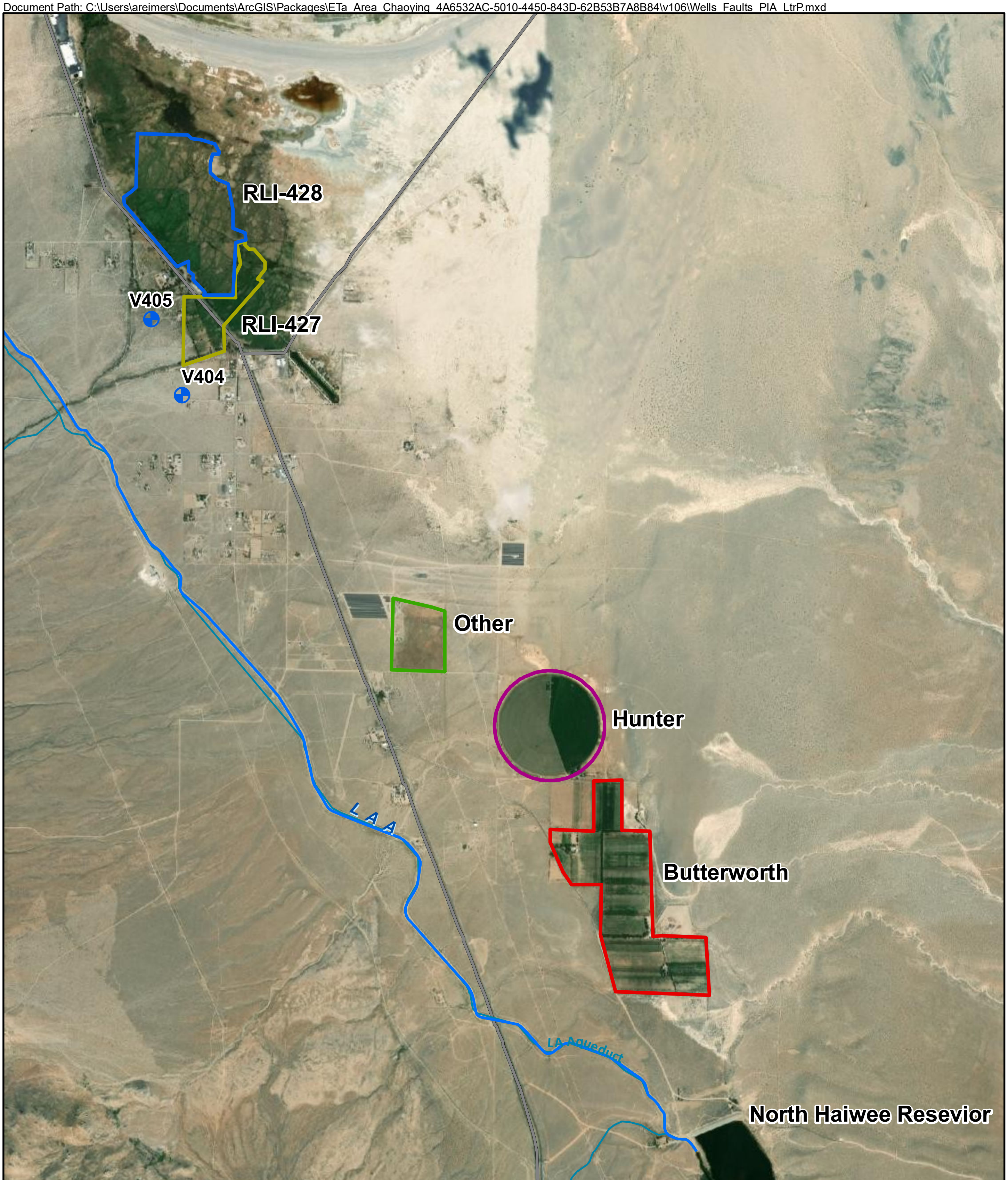

RLI-428
RLI-427
Other Ranch
Butterworth Ranch
Hunter Ranch
Los Angeles Aqueduct

Figure 5-1: ETa Areas and Groundwater Production South of Owens Lake

N

0 0.5 Miles

TITLE:

PROJECT: Owens Lake Groundwater Management Plan

REFERENCE(S): Coordinate System: NAD 1983 UTM Zone 11N

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Table 5-3: Well V404 Total Annual Production (AF)

Year	AF	Year	AF	Year	AF	Year	AF
1992	831	**2000**	1,058	**2008**	916	**2016**	1,254
1993	704	**2001**	1,186	**2009**	1,080	**2017**	856
1994	1,063	**2002**	1,033	**2010**	898	**2018**	1,255
1995	105	**2003**	745	**2011**	615	**2019**	576
1996	401	**2004**	927	**2012**	1,205		
1997	415	**2005**	441	**2013**	1,144	**MAX**	1,255
1998	228	**2006**	759	**2014**	1,129	**MIN**	105
1999	740	**2007**	1,040	**2015**	1,112	**AVG**	847

Table 5-4: Well V405 Total Annual Production (AF)

Year	AF	Year	AF	Year	AF	Year	AF
1992	676	**2000**	925	**2008**	1,108	**2016**	445
1993	181	**2001**	650	**2009**	1,090	**2017**	515
1994	638	**2002**	1,000	**2010**	822	**2018**	748
1995	105	**2003**	761	**2011**	536	**2019**	218
1996	291	**2004**	821	**2012**	1,100		
1997	538	**2005**	202	**2013**	1,078	**MAX**	1,213
1998	284	**2006**	570	**2014**	1,047	**MIN**	105
1999	627	**2007**	1,213	**2015**	747	**AVG**	676

5.3 Additional Monitoring Well Data

Recently completed monitoring well data from late 2019 were reviewed in the north western portion of the model to correlate new information to current understanding of aquifer properties in this area. Six (6) monitoring wells: MW-2, MW-3, MW-6_Upper, MW-6_Middle, MW-6_Lower, and T902a were installed in four (4) boreholes in late 2019. Alluvium was encountered to a depth of 300, 450 and 450 ft at MW-2, MW-3 and MW-6, respectively. A clay layer from 266 to 334 ft was encountered at MW-3 while multiple clay layers were found at MW-6. Well T902a was completed shallow at 50 ft bgs and does not provide new lithologic information. Lithology logs for these boreholes are included in **Appendix F**.

These data were used to update the master well table and well construction details for these wells and are shown in **Table 5-5**. Groundwater elevations and depth to water for these wells are shown in **Table 5-6**. Groundwater elevation observations show MW-3 over 100 ft greater in groundwater elevation than MW-2, suggesting an Owens Valley Fault splay in this area may be a barrier to groundwater flow, along with formation change, and/or the contribution of recharge from the west side of Alabama Hills. Elevated bedrock at MW-3 may also be a contributing factor. Differences in water levels in the nested MW-6 wells continue to show an upward gradient and the presence of clay confining layers. These data were interpolated in the model and hydraulic conductivity and storage values were adjusted to reflect updated formation depths.

Table 5-5: New Well Construction Details

Site	ID	NAD83_Z11_UTM (m)		RP (fmsl)	TD (ft)	Screen Interval (ft)	
		X	Y			Top	Bottom
MW-2	T975	406,783.837	4,040,644.914	3,894.77	300	250	290
MW-3	T976	406,210.448	4,042,110.161	3,949.30	450	220	260
MW-6	MW-6_U	40,9338.797	4,045,779.270	3,668.38	450	50	70
	MW-6_M	409,338.797	4,045,779.270	3,668.39		340	360
	MW-6_L	409,338.797	4,045,779.270	3,668.79		420	440
T902a	T902a	409,420.120	4,044,342.722	3,668.79	60	40	50

Note: feet (ft), feet mean sea level (fmsl).

Table 5-6: New Monitoring Well Water Levels

Site	ID	Water level Data		
		Date	Elevation (fmsl)	DTW (ft)
MW-2	T975	3/2/2020	3652.65	242.12
MW-3	T976	3/2/2020	3758.45	190.85
MW-6	MW-6_U	3/9/2020	3617.69	50.69
	MW-6_M	3/9/2020	3630.61	37.78
	MW-6_L	3/9/2020	3636.50	32.29
T902a	T902a	ND	ND	ND

Note: feet (ft), feet mean sea level (fmsl).

5.4 Re-Calibration

After incorporating boundary condition changes and revised depths to bedrock in the southern portion of the model and at the North Haiwee dam, and newly obtained groundwater production data, the model was recalibrated. The same 143 calibration well locations, over a total of 54 stress periods (2-month stress periods from April 2010 to April 2019), for a total of 3,308 residuals were evaluated. Calibration statistics are shown in **Table 5-7** where the updated model statistics remain improved compared to the 2012 OLGM although some accuracy has been lost with incorporation of recent updates and data. The calculated mean error of -1.94 ft indicates that, overall, the model continues to underpredict groundwater elevations. Similarly, both the absolute mean and root mean square error increased with the model update but remain less than the 2012 OLGM (**Table 5-7**).

Table 5-7: Calibration Statistics for the 2020 OLGM Update

Calibration Statistic	2012 OLGM	2019 OLGM	2020 OLGM Update
Mean Error (ft)	-3.1	-1.38	-1.97
Absolute Mean Error (ft)	6.6	2.90	4.94
Root Mean Squared Error (ft)	9.5	3.72	7.55

Observed versus simulated groundwater elevation is shown in **Figure 5-2** where all data is from December of 2016, representing 105 observation well measurements versus corresponding model simulated heads. Similar patterns and trends are observed for all stress periods. Each symbol type and color represent a calibration point in a different layer. A perfect simulation would result in a straight line, whereby the simulated head would equal the observed head. However, all the points are distributed closely around the 1:1 diagonal line, thereby indicating good performance of the model in representing the physical system. The points that do deviate from the diagonal line are randomly distributed, indicating no significant trend in spatially distributed error in the model domain. Overall, the model continues to reasonably simulate observed water levels throughout the model domain with no one specific area more problematic than others.

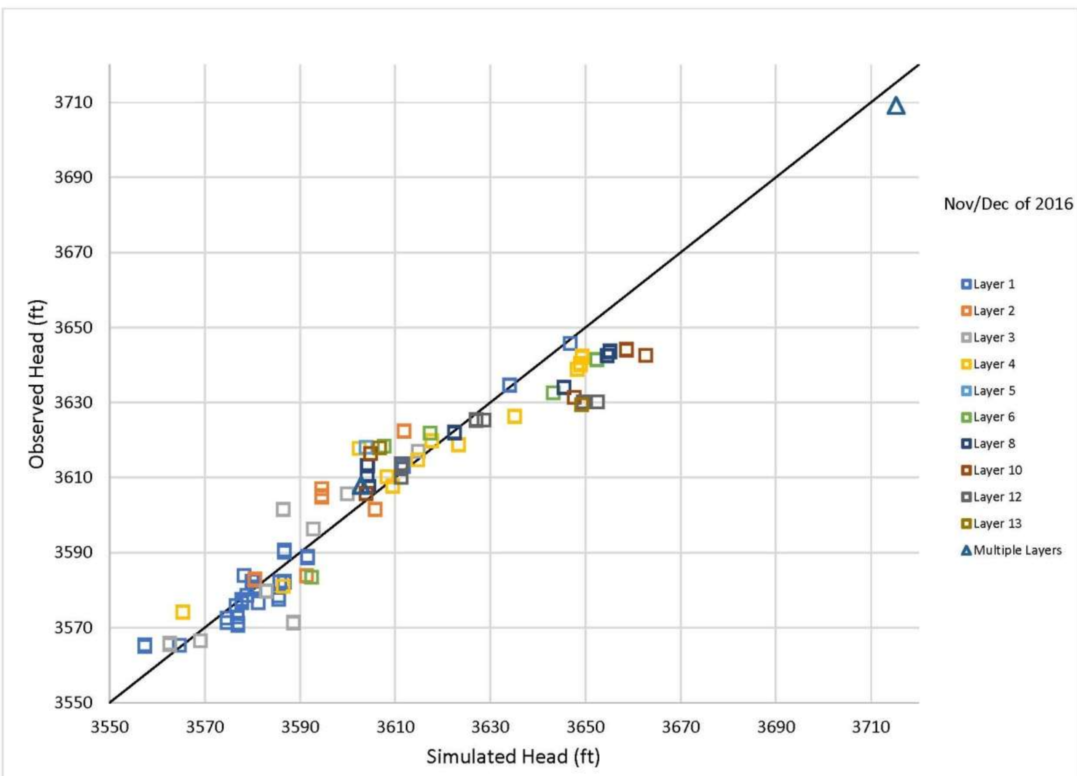

Figure 5-2: Re-Comparison of Observed and Simulated Groundwater Levels in December 2016

The simulated steady-state water budget summary, shown in **Table 5-8**, is close to balanced where total inflow is only 146 AF/yr greater than outflow (a difference of less than 1 percent). The new water budget is approximately 13,000 AF/yr less than the previous budget shown in Table 3-3. The flow from Haiwee Reservoir dam using the GHB boundary condition resulted in 4,576 AF/yr of inflow, which is now within the acceptable range previously identified. The most significant difference is less overall water comprising the budget than before, with less simulated outflow from the brine pool. This is an area of the model, along with further refinement of the southern boundary condition along North Haiwee Dam that requires further calibration.

Table 5-8: Steady-State Water Budget Summary for 2020 OLGM Update

Inflow Component	Calibration (AF/yr)	Outflow Component	Calibration (AF/yr)
River Leakage (RIV)	26,988	River Leakage (RIV)	22,016
Mountain Front Recharge (WEL)	16,437	Evapotranspiration (EVT)	19,059
Lone Pine (GHB)	4,744	LADWP (Town Water System and E/M Project) & Private Well (CLN)	6,733
Haiwee Reservoir Dam (GHB)	4,576	Playa ET (DRN)	5,889
Wastewater Return (RCH)	2,467	Lone Pine (GHB)	1,604
Brine Pool (CHD)	688	Brine Pool (CHB	453
Total	**55,900**	**Total**	**55,754**

Note: acre-feet per year (AF/yr).

6.0 RECOMMENDATIONS

The OLGM, originally completed in 2012, has been the subject of numerous improvements and updating with recently acquired hydrologic data. Comparison of model simulations to field observations indicates that the model replicates the groundwater regime in the vicinity of Owens Lake very well. As with any model, it is an approximation of the real conditions surrounding Owens Lake, yet represents a powerful tool for adaptive management and simulation of future events. It is recommended that the model continue to be utilized for understanding the potential effects of pumping for dust mitigation and other groundwater management options, while continuously being improved as new data become available. Specifically, the following uses and improvements to the model are recommended:

- Utilize the model to evaluate the impact of a variety of potential **climate change** scenarios, including reduced recharge from snowmelt, and variable runoff from the Eastern Sierra. Evaluate how this may affect RPPs in the future.
- Perform additional **sensitivity analysis** on a wide variety of boundary conditions to evaluate uncertainties in the model, identify data gaps, and focus future data gathering efforts. A focused sensitivity analysis on fault conductance, orientation, and splay discontinuity will be investigated to improve groundwater levels on either side of the fault and overall model calibration statistics. This effort will also seek to confirm general or overall conclusions of the model, even if individual model parameters may be uncertain. This will also involve revision/review of land surface elevation, potentially variable brine pool elevation and its incorporation in associated boundary condition, as well as bedrock elevation coverage review and revision.
- Re-evaluate use of the **CLN package** for wells, including artesian wells, to determine if the CLN package can accurately simulate artesian flow with variable aquifer discharge depending on piezometric heads, hydraulic and storage parameters. The inter-aquifer pressure equilibration and associated groundwater flow for wells screened across multiple aquifers using the CLN package should be investigated and updated or modified where required.
- Utilize the model to evaluate the **feasibility of groundwater management** techniques such as managed recharge on the western and northern margins of the lake in order to minimize loss of water and to augment supplies to sensitive resources which depend on groundwater. Potential **groundwater banking** activities along the mainline should also be modeled to incorporate injection, resulting flow and groundwater elevations, and production. Ancillary to modeling groundwater banking operations are resulting groundwater flow and fate of banked water not withdrawn at the location of infiltration or injection.

- A **6-month pumping test** is planned on testing well TW-E. When available, these data will provide information to improve the calibration of the model and simulation of the effects of the Owens Valley and Owens River Fault Zones on groundwater flow.
- Utilize recently acquired actual **ETa** data to improve the location and depth of simulation of evapotranspiration within the model boundaries, and particularly near sensitive springs and seeps.
- Recognizing the ET is one of the largest outflows in the model domain, utilize time-series ETa data to improve and confirm the overall **water budget** simulated in the model. The model **stress period length** should potentially be reduced from the current 2 months to 1 month to further refine simulation of ET.
- Perform model simulations in which deeper aquifers in the northern portion of the lake are **pumped at increasingly higher rates** to identify where impacts are most likely to occur in order to focus and improve monitoring efforts as necessary.
- Utilize the model to evaluate a variety of **water conservation efforts**, including capturing surface flows of water before they reach the brine pool.
- Working with stakeholders, identify **future simulations of interest** that will be utilized in environmental reviews of utilizing groundwater for dust mitigation efforts.
- The OLGM model was completed in 2012 using the hydrogeologic data available at that time. Since 2012, there has been a large amount of data collected, including new drilling data, time-series groundwater elevation measurement, remote sensing, and surface flow data. Although these data have been incorporated in the model in several update events (including those described in this document), there is a need to re-evaluate and synthesize historical and recent data regarding the **HCM** for the lake, including synthesis of information regarding hydrostratigraphy, structural geology, water budget, and aquifer properties. This will ensure that available hydrogeologic data are utilized to the fullest extent.
- Add information from the recently installed multi-completion monitoring wells MW-7, and MW-8, the proposed monitoring wells associated with VDAs, as well as additional monitoring wells planned for the northern Owens Lake.

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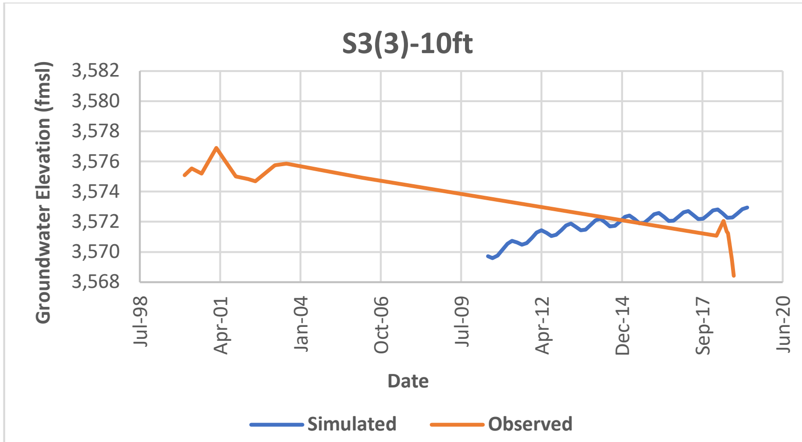
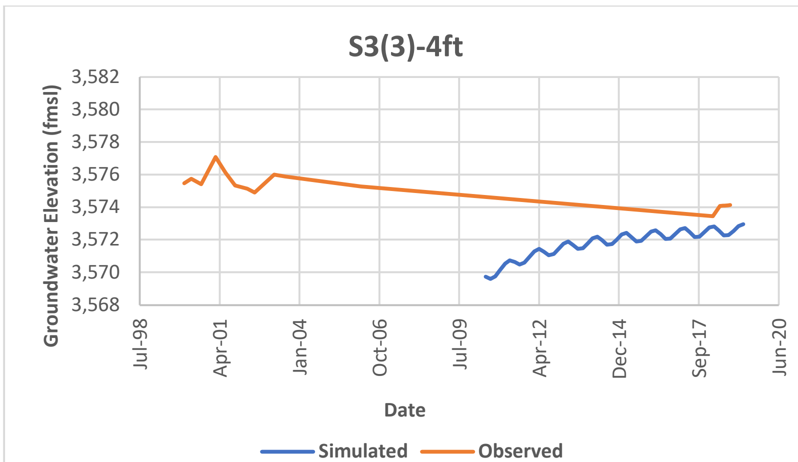
Appendix A

Hydrographs

Note – Hydrographs to be formatted & updated during future model revisions.


S3(3)-10ft
Groundwater Elevation (fmsl)
3,582
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed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Groundwater Elevation (fmsl)
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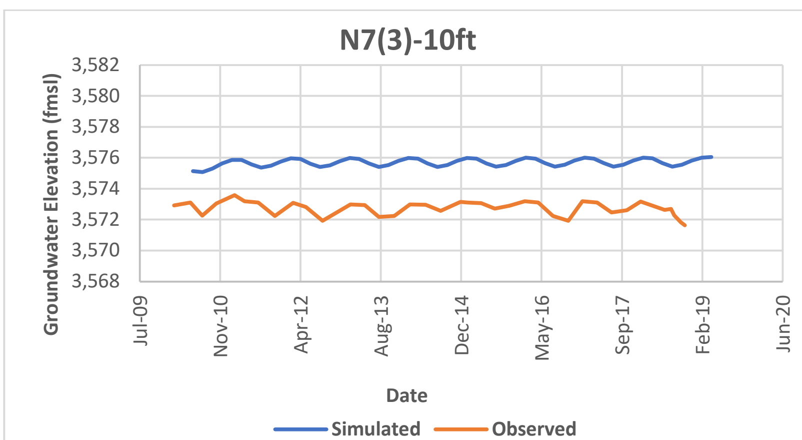
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed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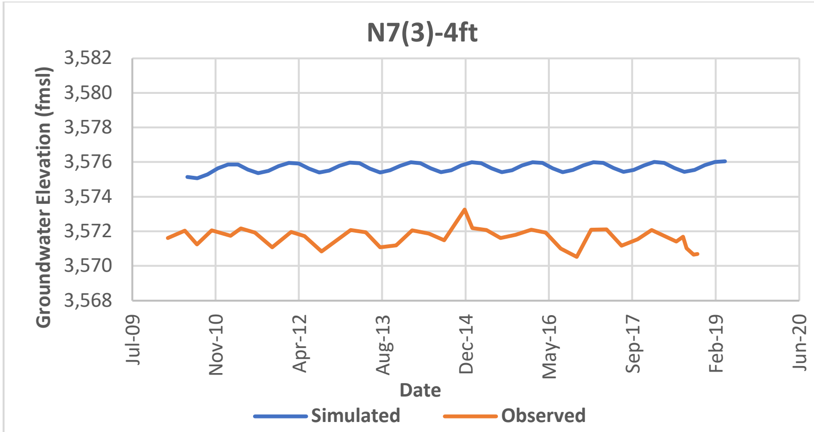
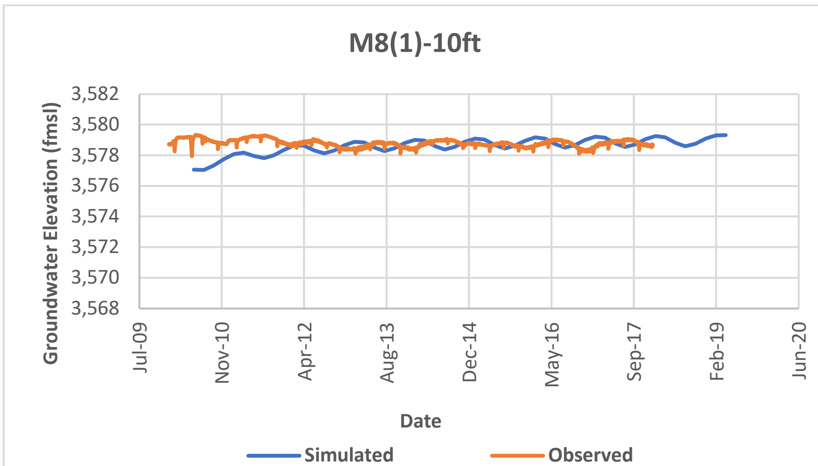
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


N7(3)-4ft
Groundwater Elevation (fmsl)
3,582
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed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Groundwater Elevation (fmsl)
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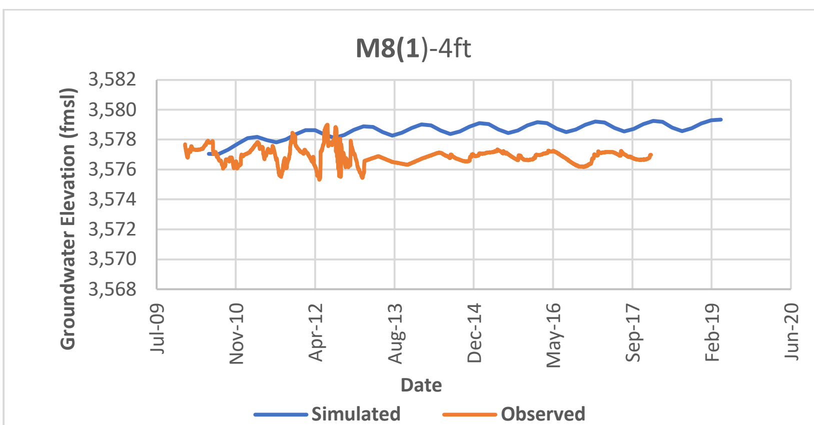
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed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Groundwater Elevation (fmsl)
3,582
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-09
Nov-10
Apr-12
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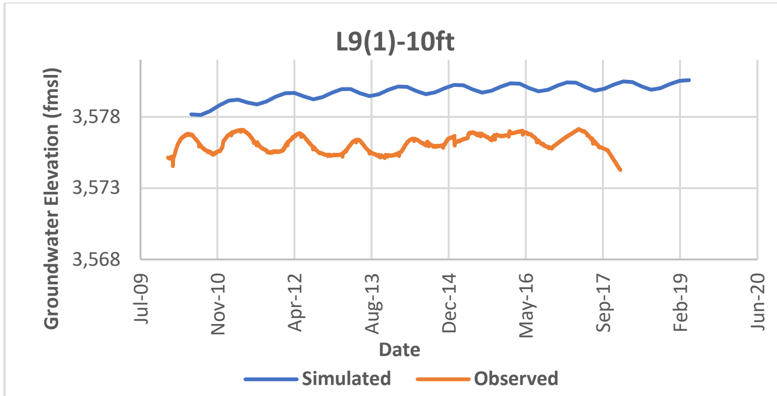
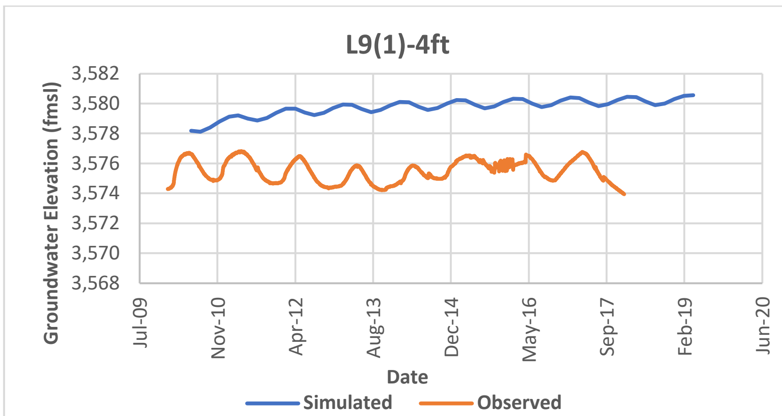
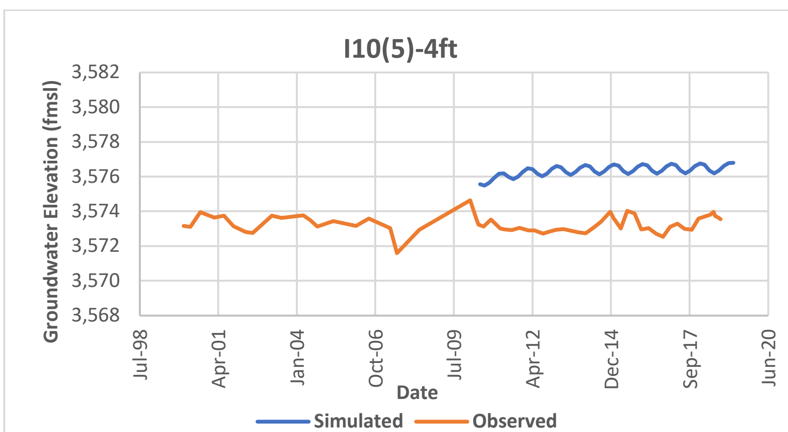
Jun-20
Date
Simulated
Observed


L9(1)-10ft
Groundwater Elevation (fmsl)
3,578
3,573
3,568
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


L9(1)-4ft
Groundwater Elevation (fmsl)
3,582
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed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Groundwater Elevation (fmsl)
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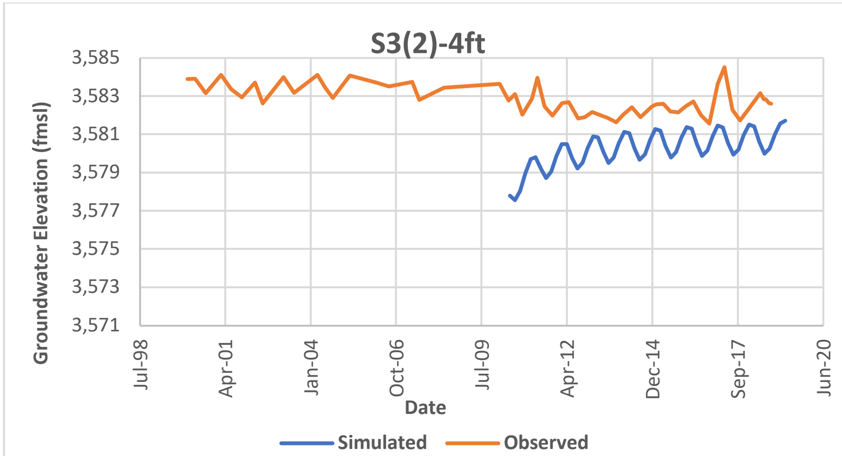
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed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Groundwater Elevation (fmsl)
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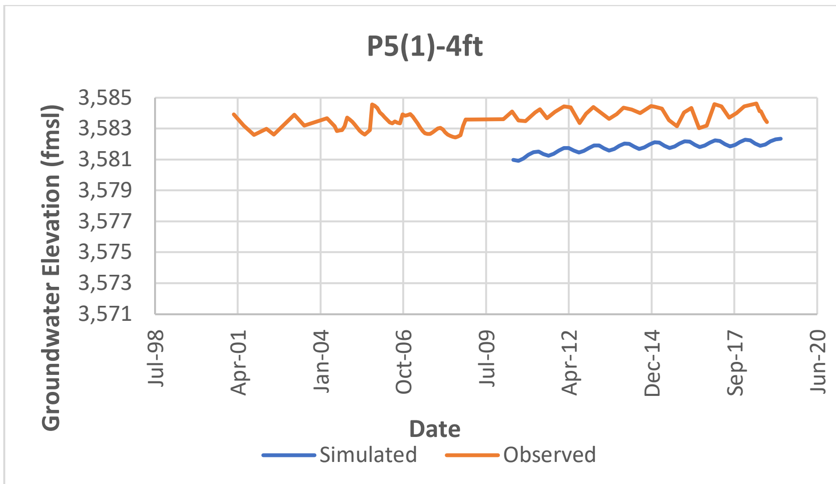
3,583
3,581
3,579
3,577
3,575
3,573
3,571
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed


P5(1)-4ft
Groundwater Elevation (fmsl)
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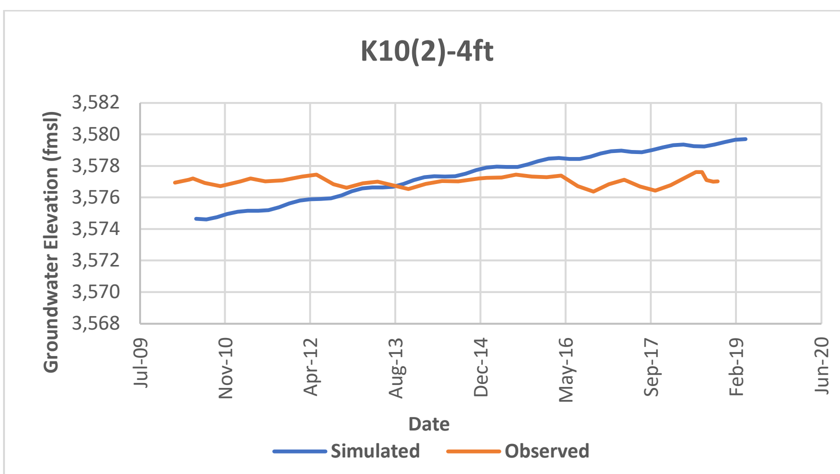
3,583
3,581
3,579
3,577
3,575
3,573
3,571
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed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Groundwater Elevation (fmsl)
3,582
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
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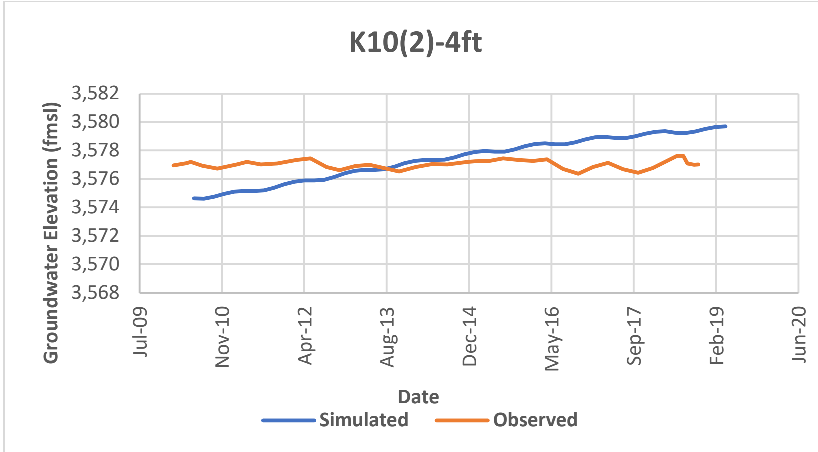
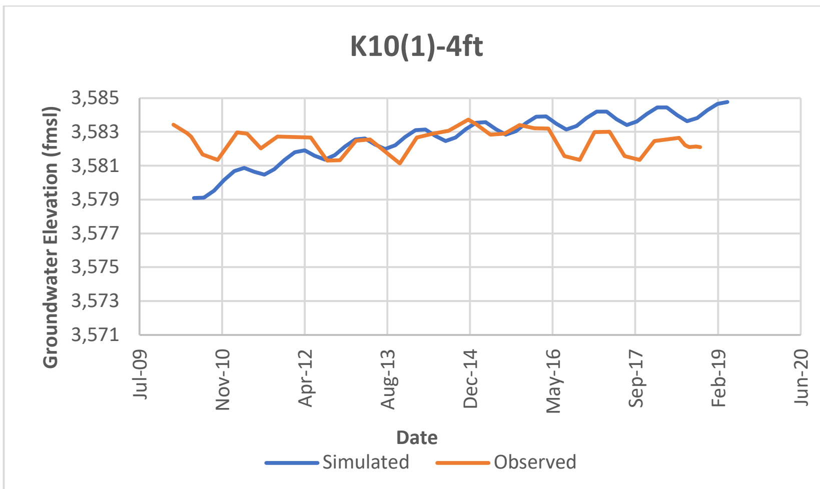
Feb-19
Jun-20
Date
Simulated
Observed


K10(2)-4ft
Groundwater Elevation (fmsl)
3,582
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


K10(1)-4ft
Groundwater Elevation (fmsl)
3,585
3,583
3,581
3,579
3,577
3,575
3,573
3,571
Jul-09
Nov-10
Apr-12
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Dec-14
May-16
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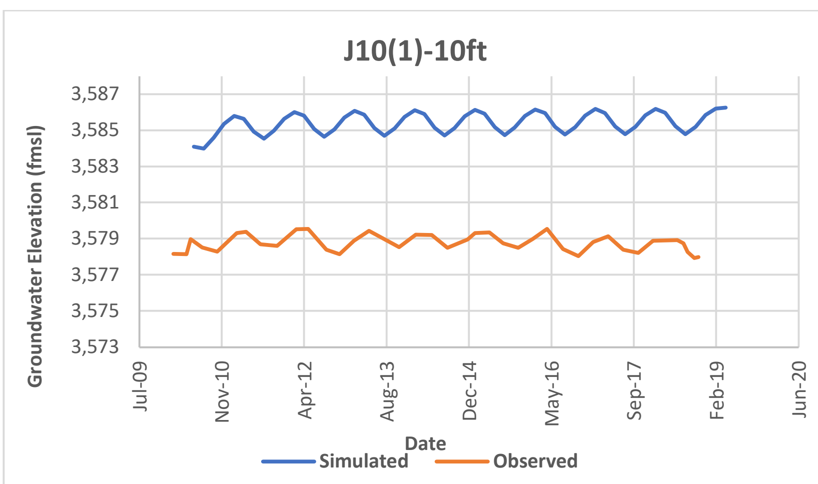
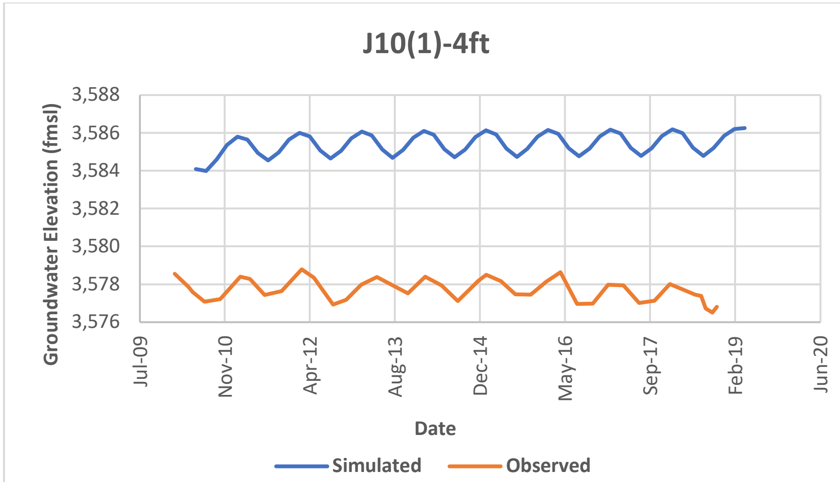
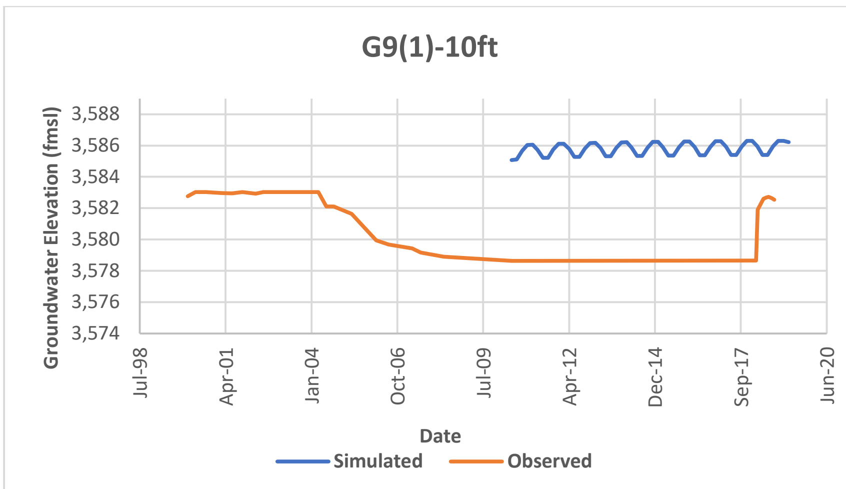
Feb-19
Jun-20
Date
Simulated
Observed


J10(1)-10ft
Groundwater Elevation (fmsl)
3,587
3,585
3,583
3,581
3,579
3,577
3,575
3,573
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


J10(1)-4ft
Groundwater Elevation (fmsl)
3,588
3,586
3,584
3,582
3,580
3,578
3,576
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


G9(1)-10ft
Groundwater Elevation (fmsl)
3,588
3,586
3,584
3,582
3,580
3,578
3,576
3,574
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
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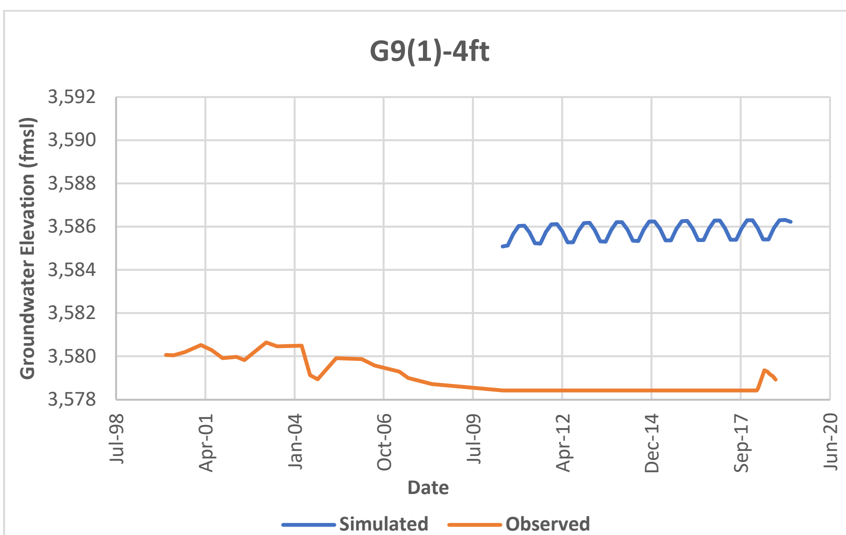
Date
Simulated
Observed


G9(1)-4ft
Groundwater Elevation (fmsl)
3,592
3,590
3,588
3,586
3,584
3,582
3,580
3,578
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
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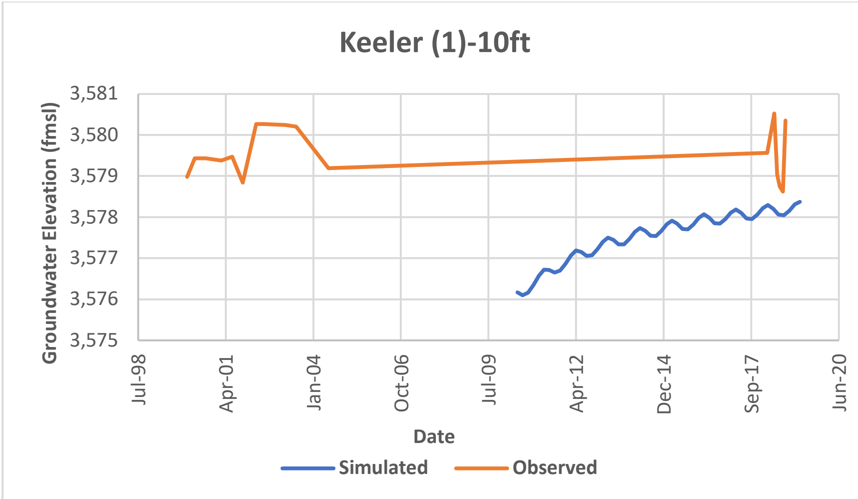
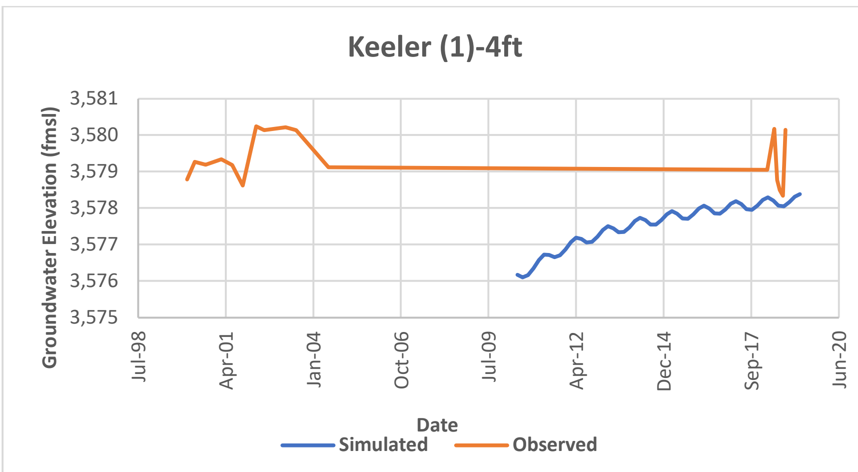
Sep-17
Jun-20
Date
Simulated
Observed


Keeler (1)-10ft
Groundwater Elevation (fmsl)
3,581
3,580
3,579
3,578
3,577
3,576
3,575
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed


Keeler (1)-4ft
Groundwater Elevation (fmsl)
3,581
3,580
3,579
3,578
3,577
3,576
3,575
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
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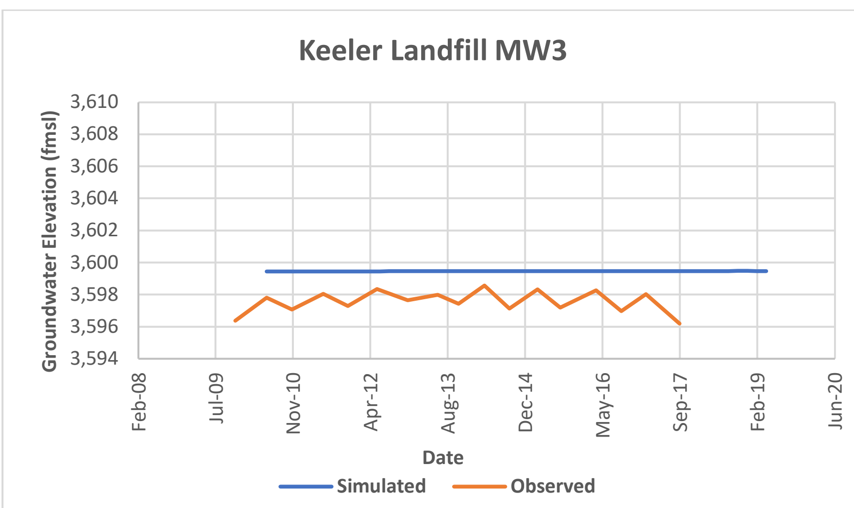
Date
Simulated
Observed


Keeler Landfill MW3
Groundwater Elevation (fmsl)
3,610
3,608
3,606
3,604
3,602
3,600
3,598
3,596
3,594
Feb-08
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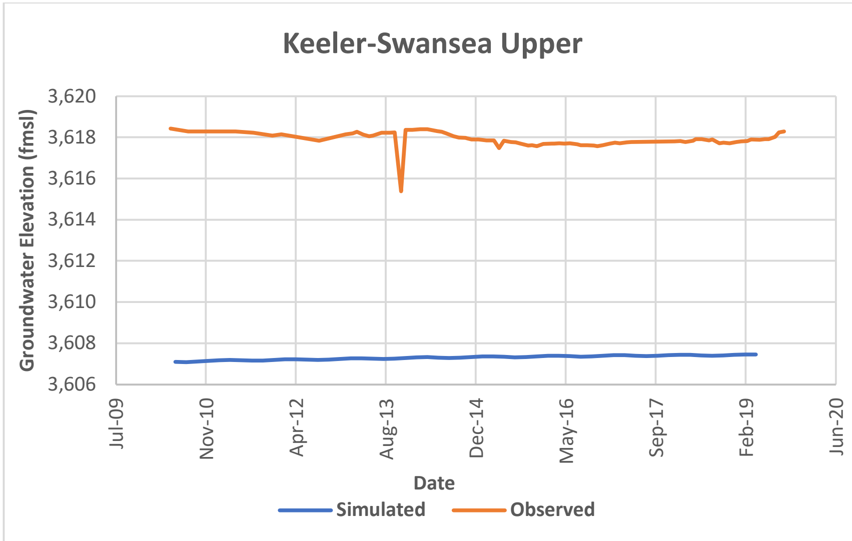
Date
Simulated
Observed


Keeler-Swansea Upper
Groundwater Elevation (fmsl)
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3,618
3,616
3,614
3,612
3,610
3,608
3,606
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
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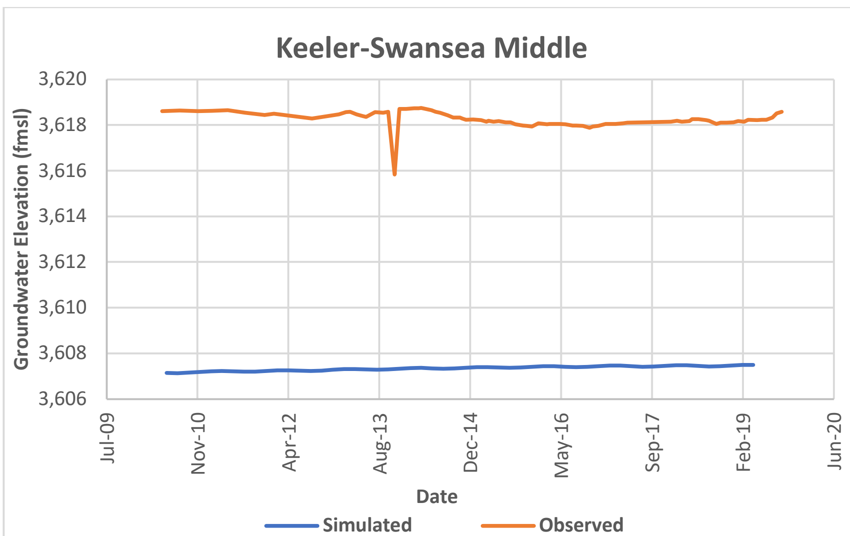
Feb-19
Jun-20
Date
Simulated
Observed


Keeler-Swansea Middle
Groundwater Elevation (fmsl)
3,620
3,618
3,616
3,614
3,612
3,610
3,608
3,606
Jul-09
Nov-10
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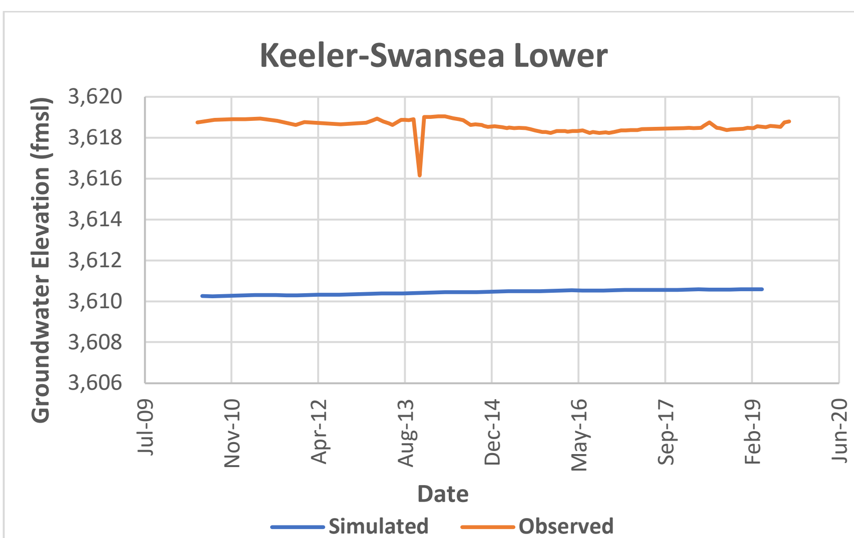
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


Keeler-Swansea Lower
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3,614
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3,610
3,608
3,606
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Aug-13
Dec-14
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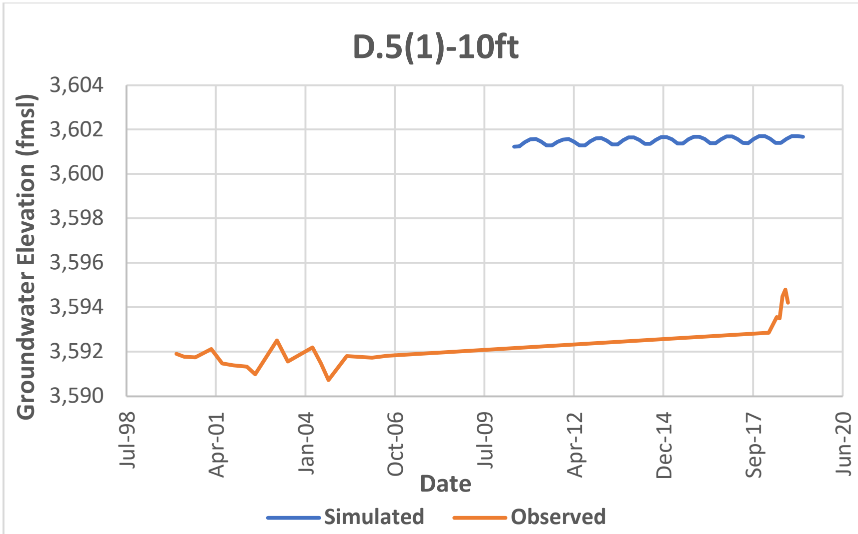
Date
Simulated
Observed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3,602
3,600
3,598
3,596
3,594
3,592
3,590
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
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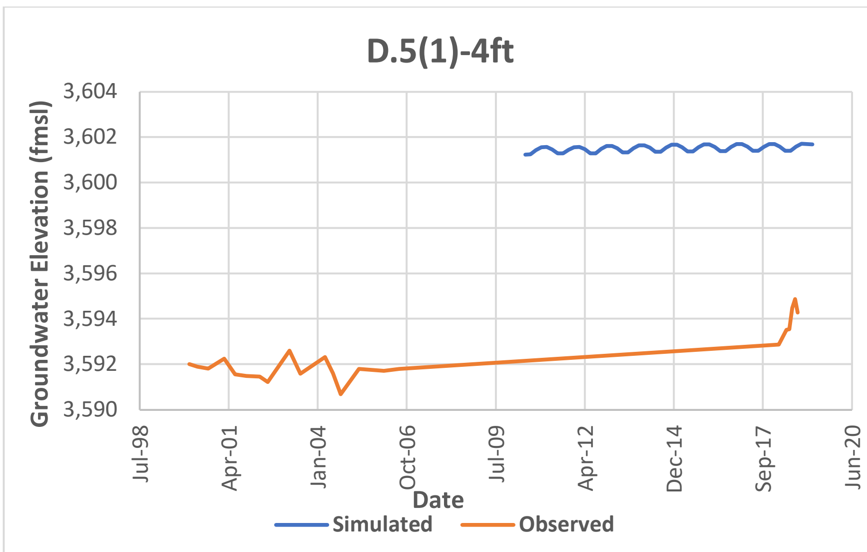
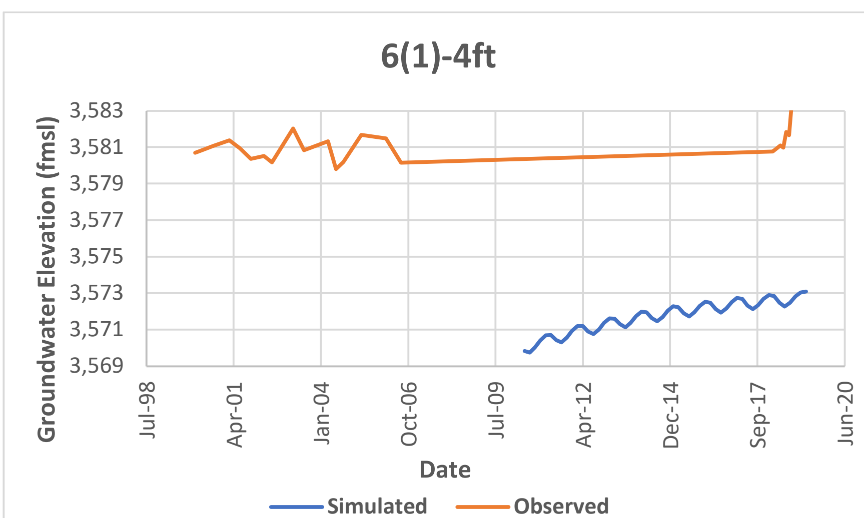
Jun-20
Date
Simulated
Observed


D.5(1)-4ft
Groundwater Elevation (fmsl)
3,604
3,602
3,600
3,598
3,596
3,594
3,592
3,590
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed


6(1)-4ft
Groundwater Elevation (fmsl)
3,583
3,581
3,579
3,577
3,575
3,573
3,571
3,569
Jul-98
Apr-01
Jan-04
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Apr-12
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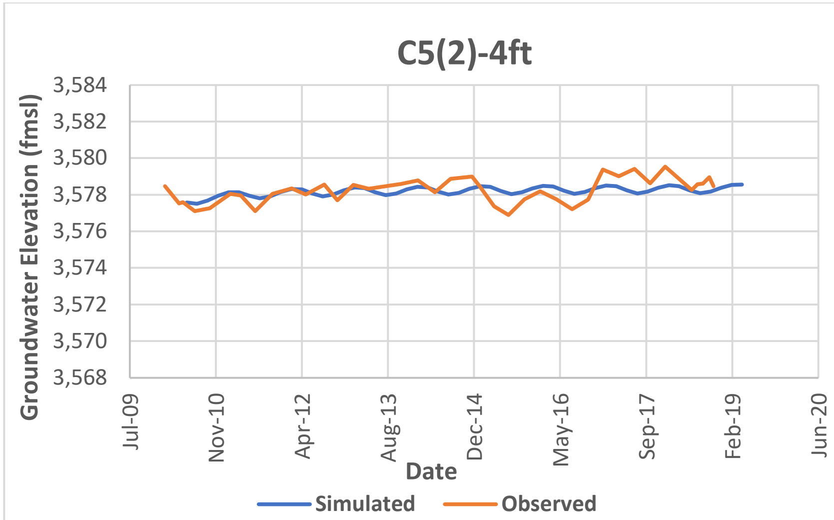
Date
Simulated
Observed



C5(2)-4ft
Groundwater Elevation (fmsl)
3,584
3,582
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-09
Nov-10
Apr-12
Aug-13
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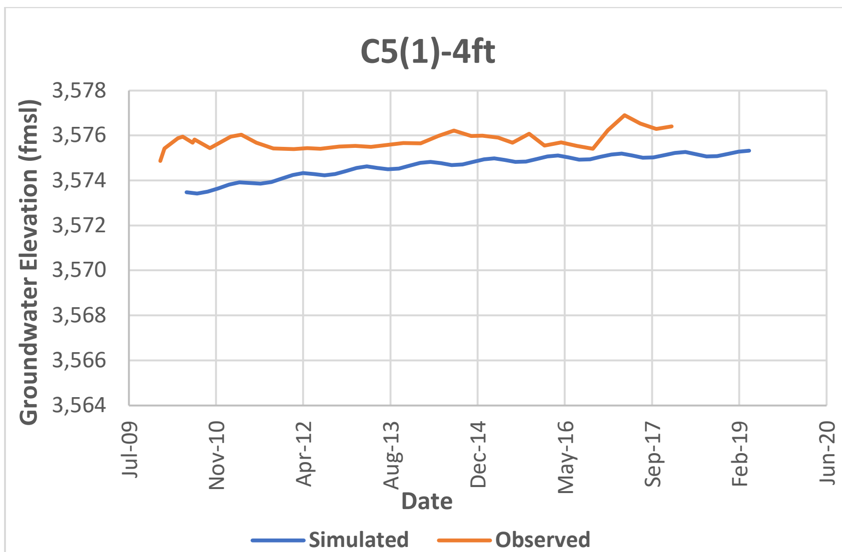
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed



C5(1)-4ft
Groundwater Elevation (fmsl)
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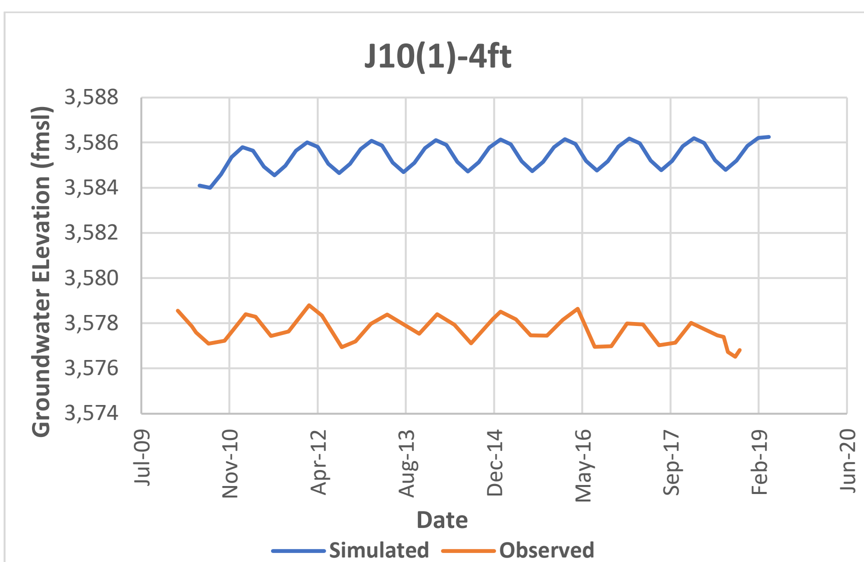
3,576
3,574
3,572
3,570
3,568
3,566
3,564
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed



J10(1)-4ft
Groundwater ELevation (fmsl)
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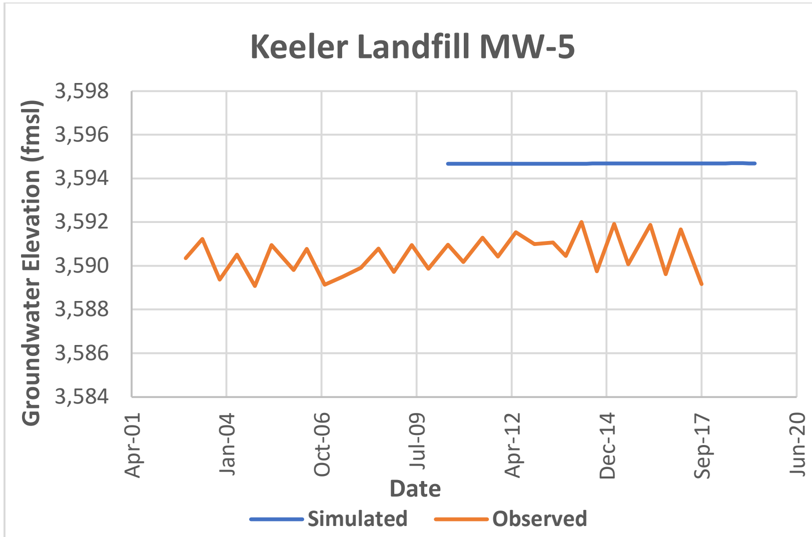
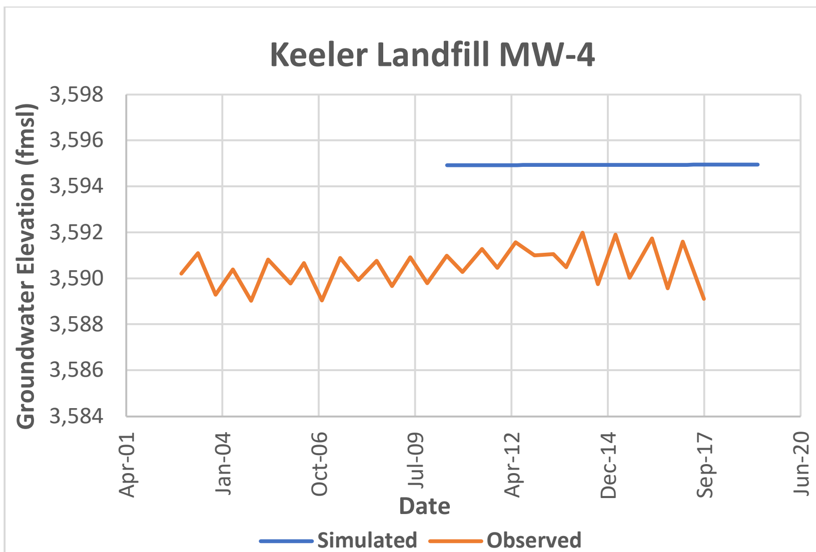
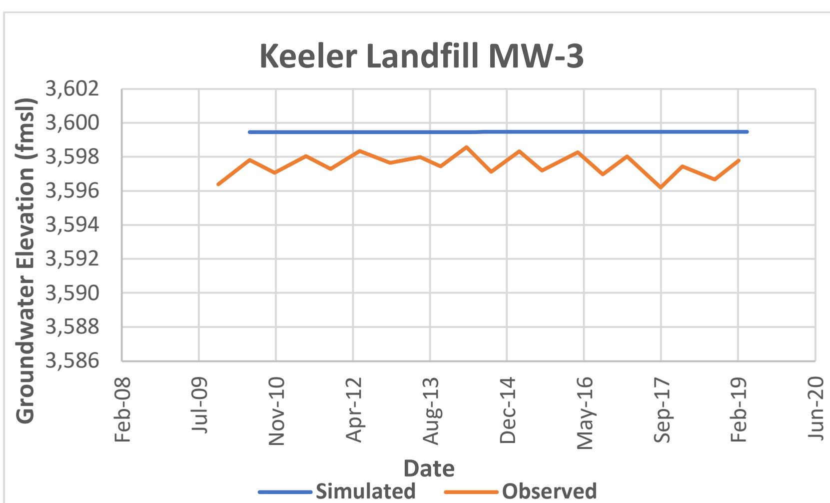
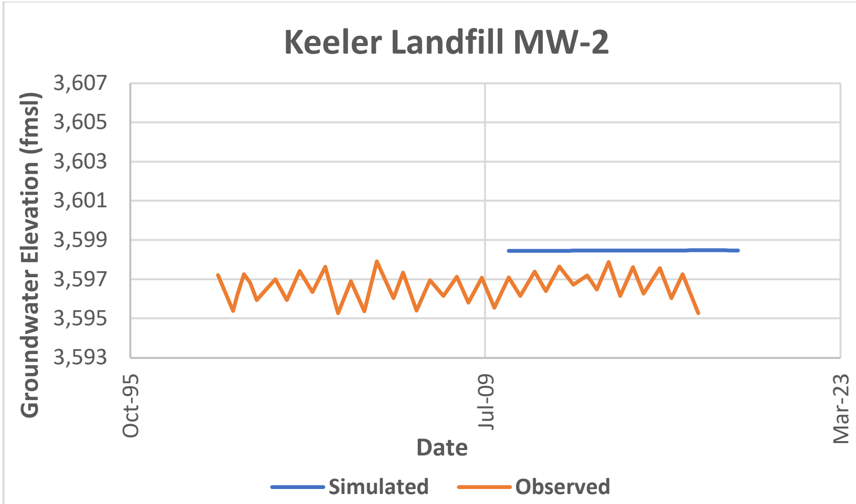
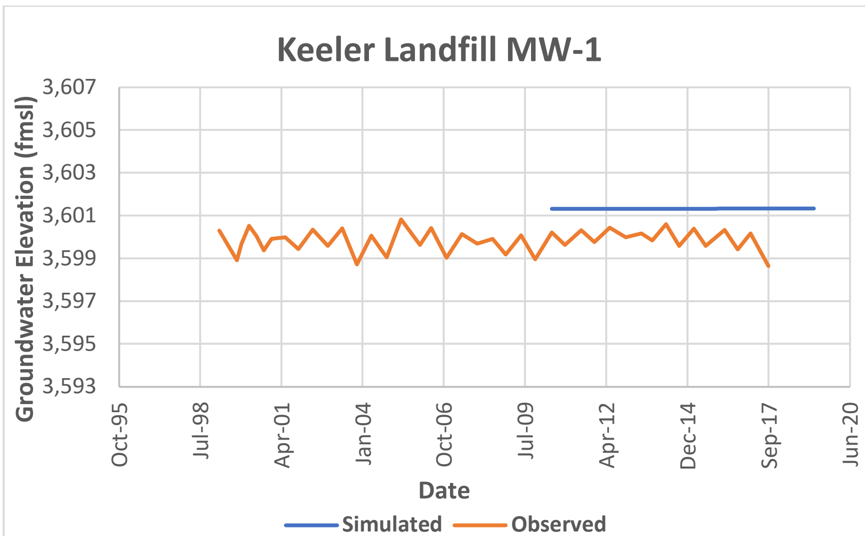
3,586
3,584
3,582
3,580
3,578
3,576
3,574
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

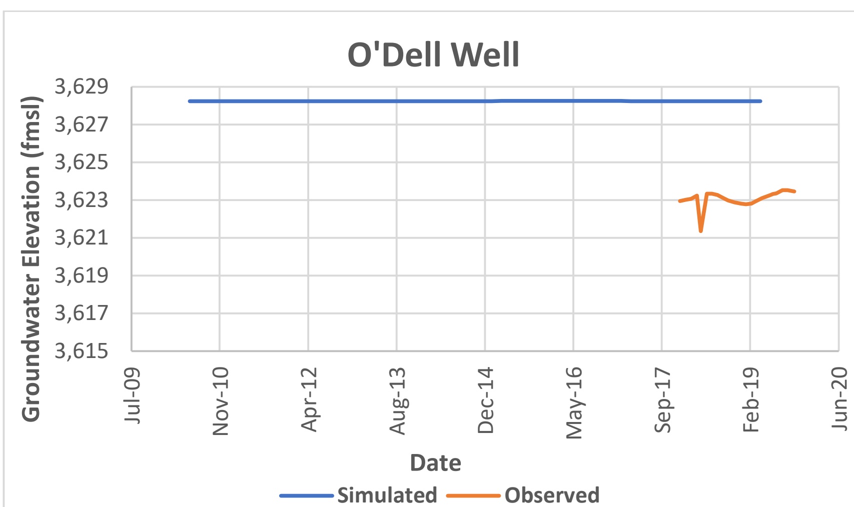

Keeler Landfill MW-5
Groundwater Elevation (fmsl)
3,598
3,596
3,594
3,592
3,590
3,588
3,586
3,584
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed

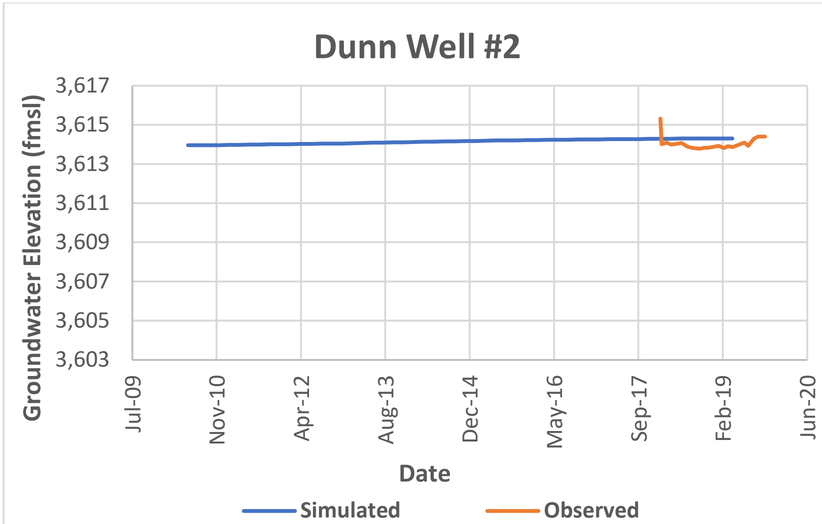

Keeler Landfill MW-4
Groundwater Elevation (fmsl)
3,598
3,596
3,594
3,592
3,590
3,588
3,586
3,584
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed

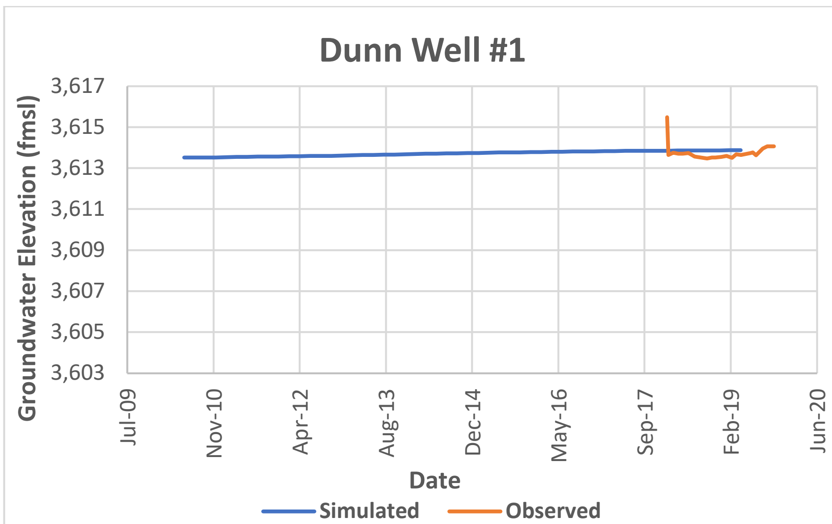

Keeler Landfill MW-3
Groundwater Elevation (fmsl)
3,602
3,600
3,598
3,596
3,594
3,592
3,590
3,588
3,586
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

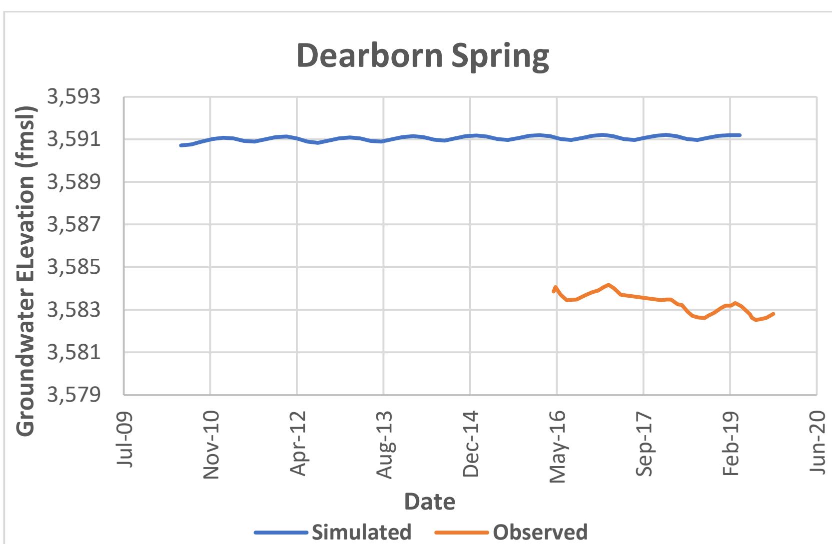

Keeler Landfill MW-2
3,607
3,605
3,603
3,601
3,599
3,597
3,595
3,593
Groundwater Elevation (fmsl)
Oct-95
Jul-09
Mar-23
Date
Simulated
Observed

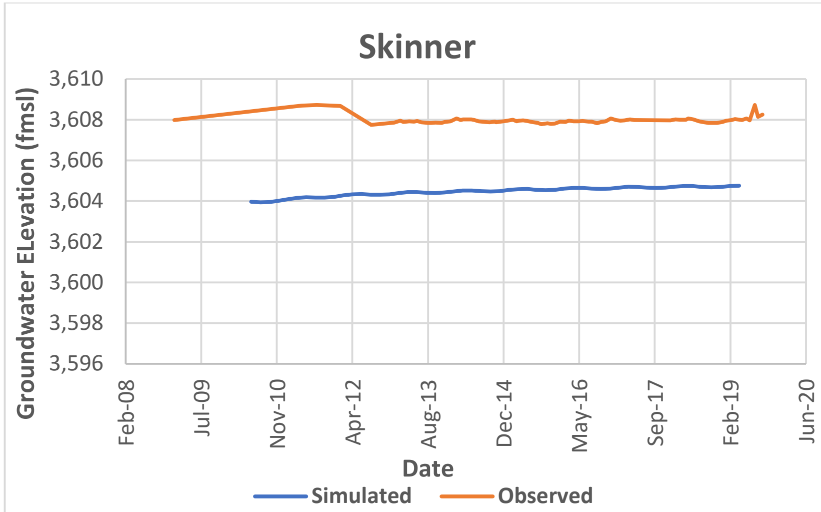

Keeler Landfill MW-1
3,607
3,605
3,603
3,601
3,599
3,597
3,595
3,593
Groundwater Elevation (fmsl)
Oct-95
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed

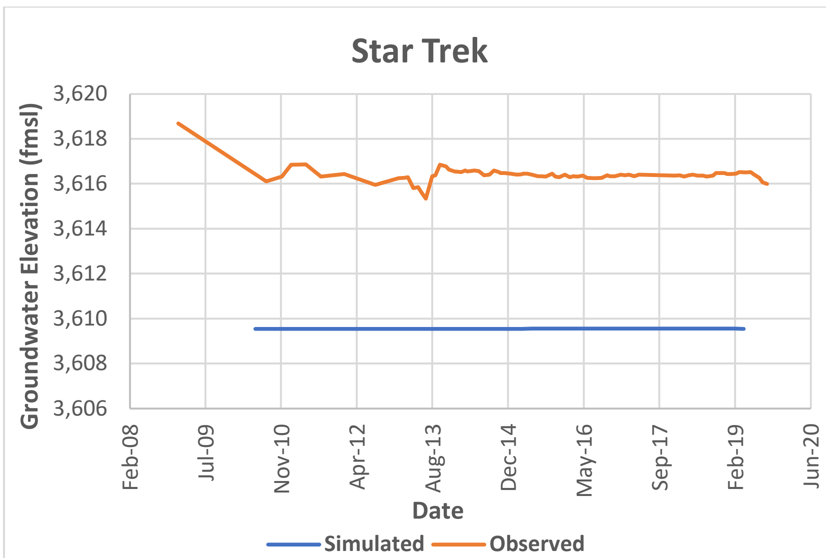

O'Dell Well
3,629
3,627
3,625
3,623
3,621
3,619
3,617
3,615
Groundwater Elevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

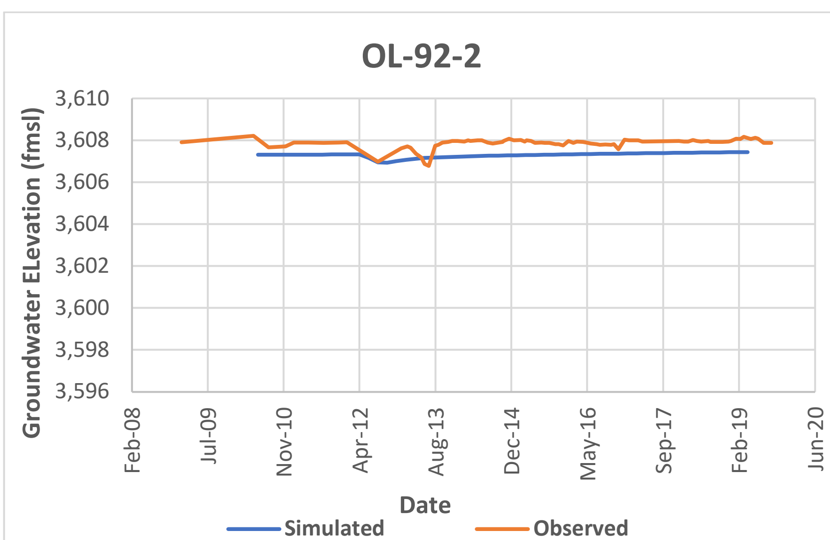

Dunn Well #2
Groundwater Elevation (fmsl)
3,617
3,615
3,613
3,611
3,609
3,607
3,605
3,603
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

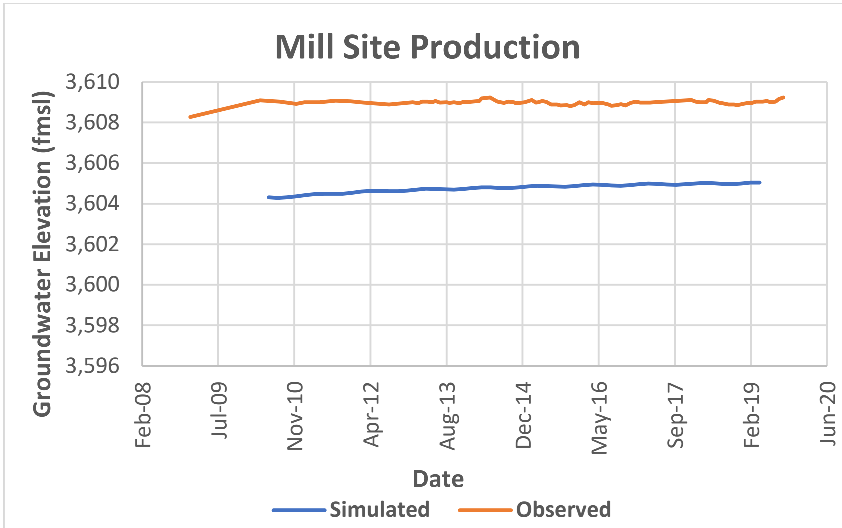

Dunn Well #1
Groundwater Elevation (fmsl)
3,617
3,615
3,613
3,611
3,609
3,607
3,605
3,603
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

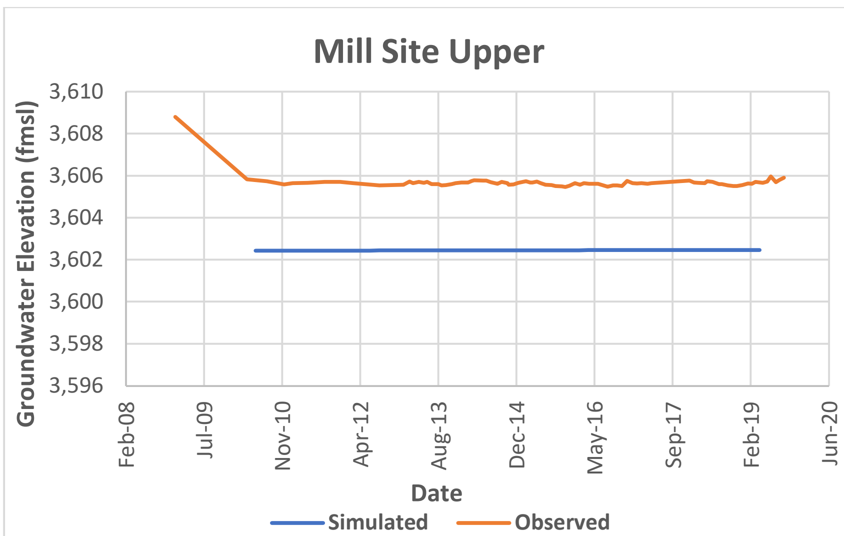

Dearborn Spring
Groundwater ELevation (fmsl)
3,593
3,591
3,589
3,587
3,585
3,583
3,581
3,579
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

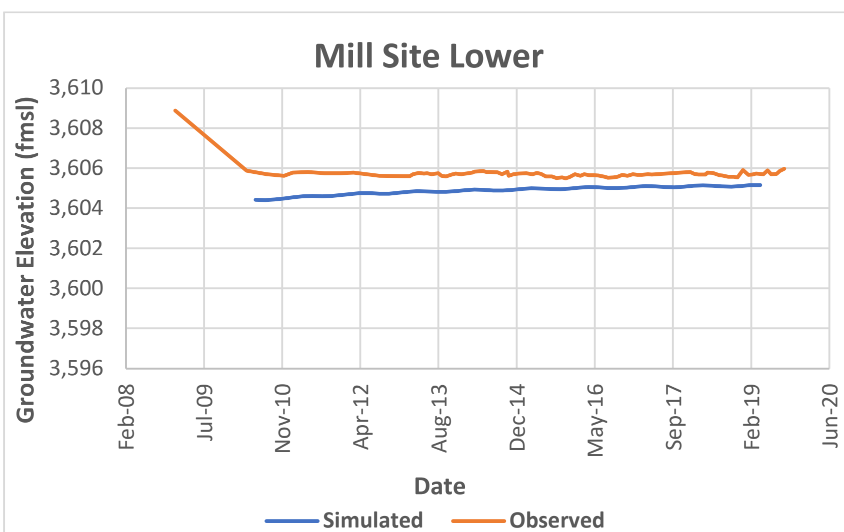

Skinner
Groundwater ELevation (fmsl)
3,610
3,608
3,606
3,604
3,602
3,600
3,598
3,596
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

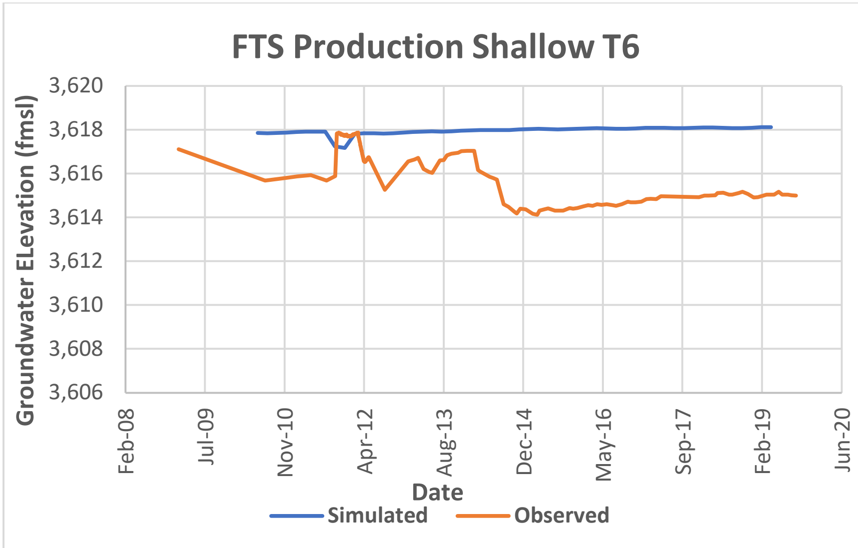

Star Trek
Groundwater Elevation (fmsl)
3,620
3,618
3,616
3,614
3,612
3,610
3,608
3,606
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

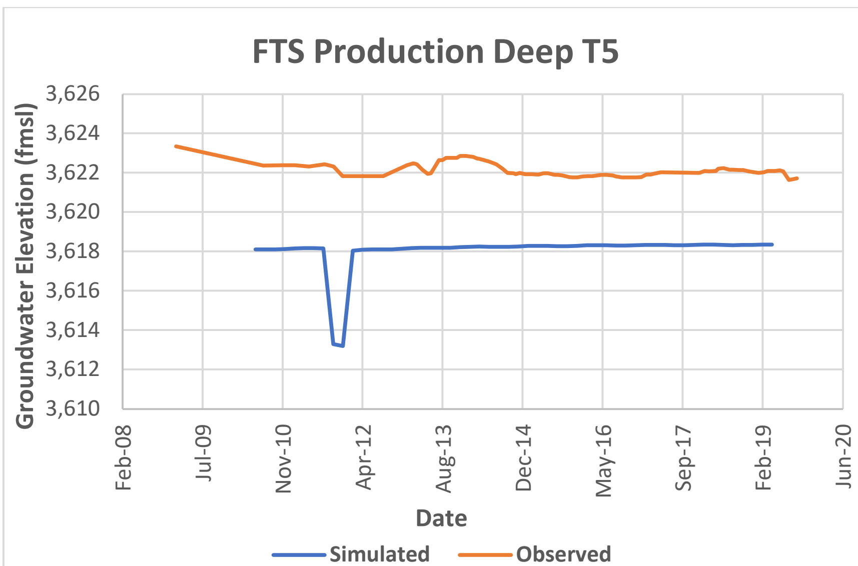

OL-92-2
Groundwater ELevation (fmsl)
3,610
3,608
3,606
3,604
3,602
3,600
3,598
3,596
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

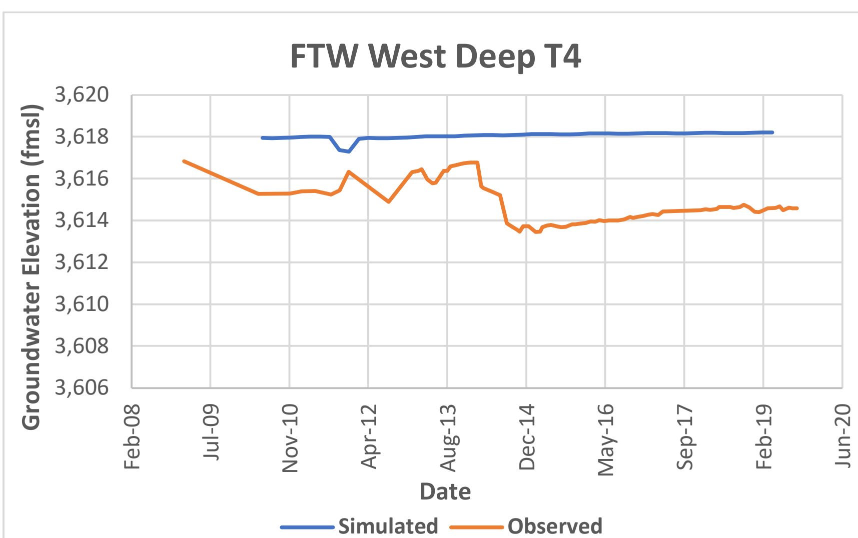

Mill Site Production
Groundwater Elevation (fmsl)
3,610
3,608
3,606
3,604
3,602
3,600
3,598
3,596
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

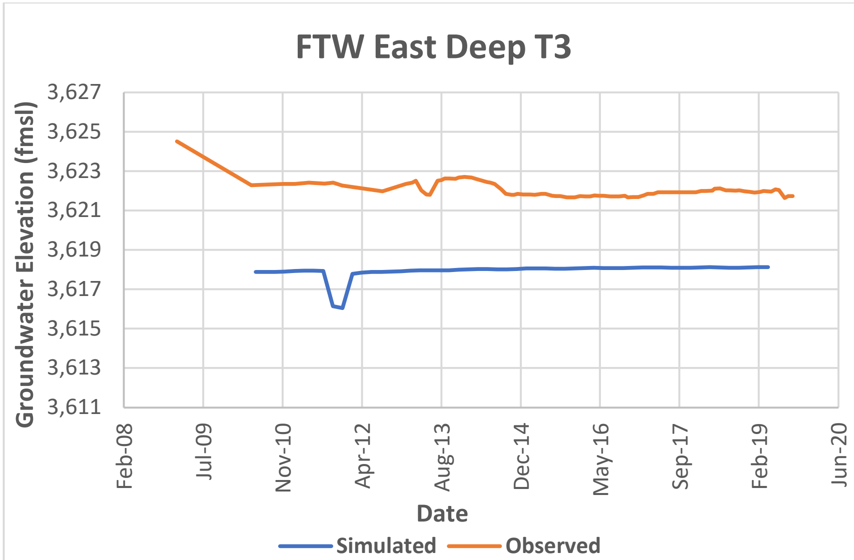

Mill Site Upper
Groundwater Elevation (fmsl)
3,610
3,608
3,606
3,604
3,602
3,600
3,598
3,596
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

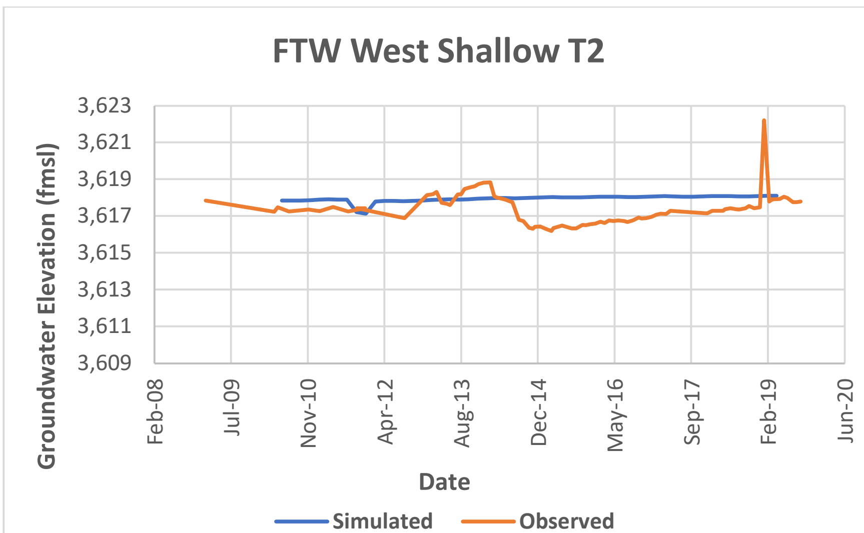

Mill Site Lower
Groundwater Elevation (fmsl)
3,610
3,608
3,606
3,604
3,602
3,600
3,598
3,596
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

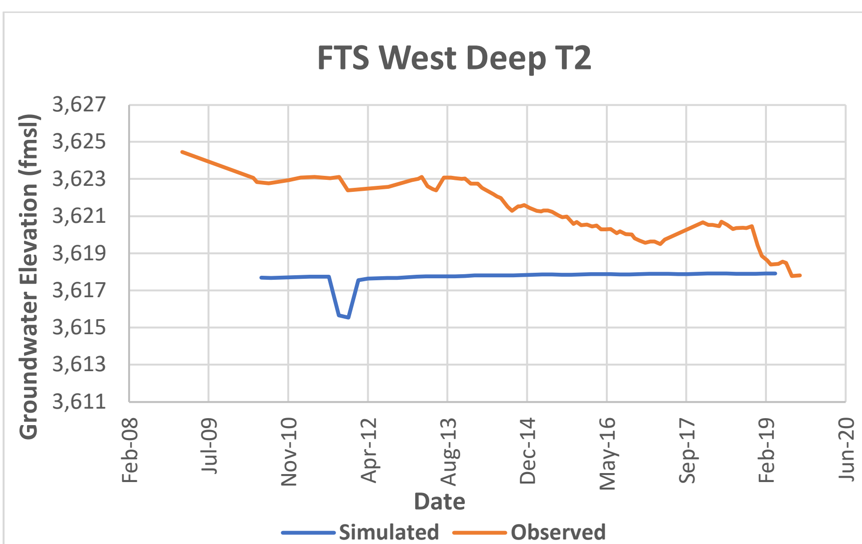

FTS Production Shallow T6
Groundwater ELevation (fmsl)
3,620
3,618
3,616
3,614
3,612
3,610
3,608
3,606
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

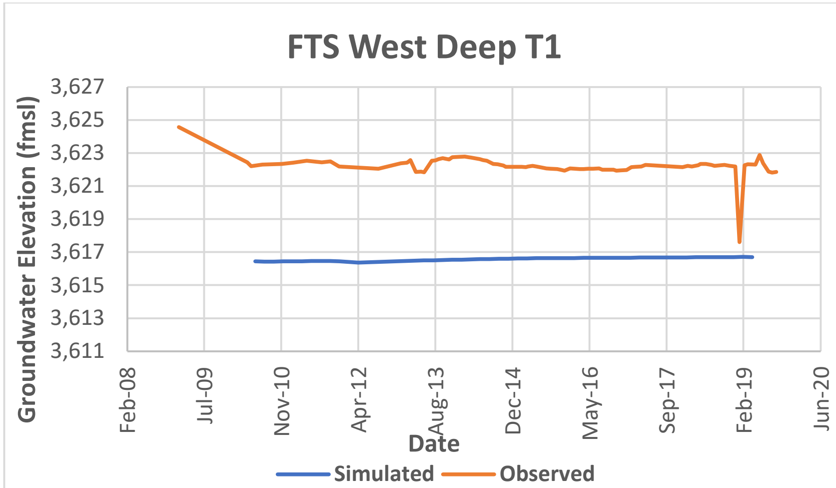

FTS Production Deep T5
Groundwater Elevation (fmsl)
3,626
3,624
3,622
3,620
3,618
3,616
3,614
3,612
3,610
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

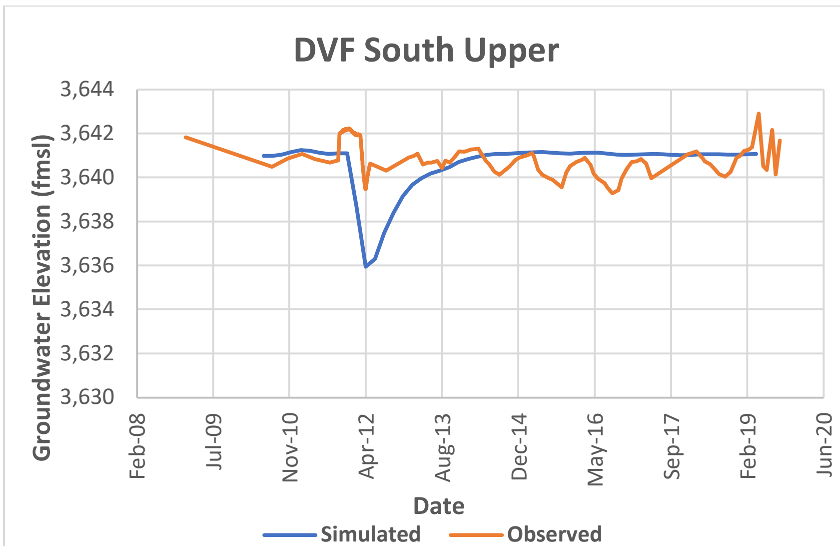

FTW West Deep T4
Groundwater Elevation (fmsl)
3,620
3,618
3,616
3,614
3,612
3,610
3,608
3,606
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

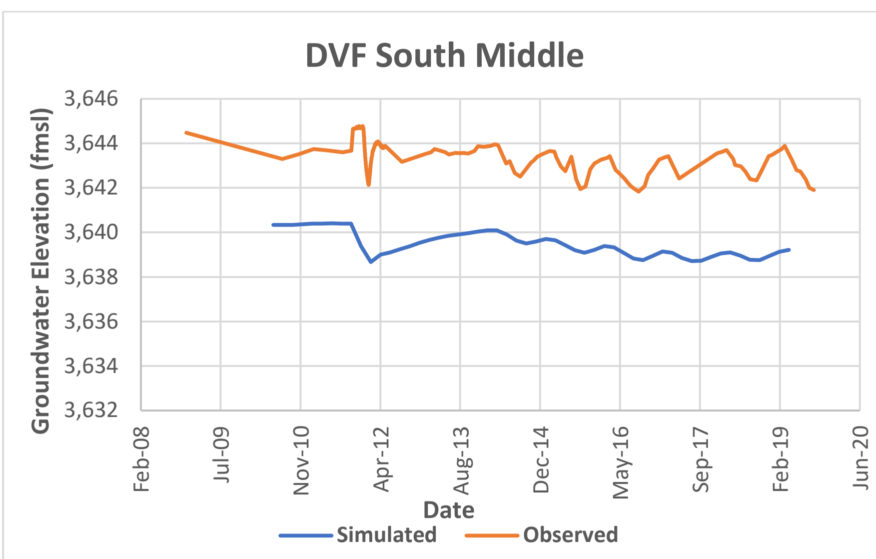

FTW East Deep T3
Groundwater Elevation (fmsl)
3,627
3,625
3,623
3,621
3,619
3,617
3,615
3,613
3,611
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

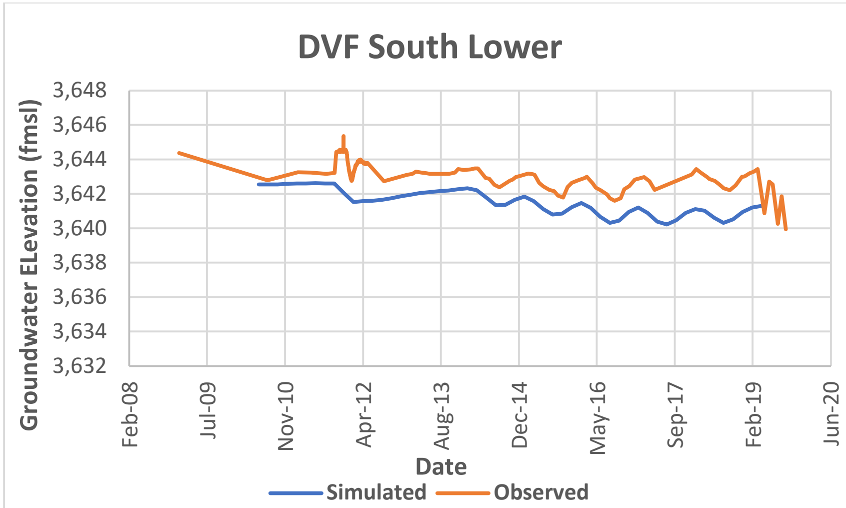

FTW West Shallow T2
Groundwater Elevation (fmsl)
3,623
3,621
3,619
3,617
3,615
3,613
3,611
3,609
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

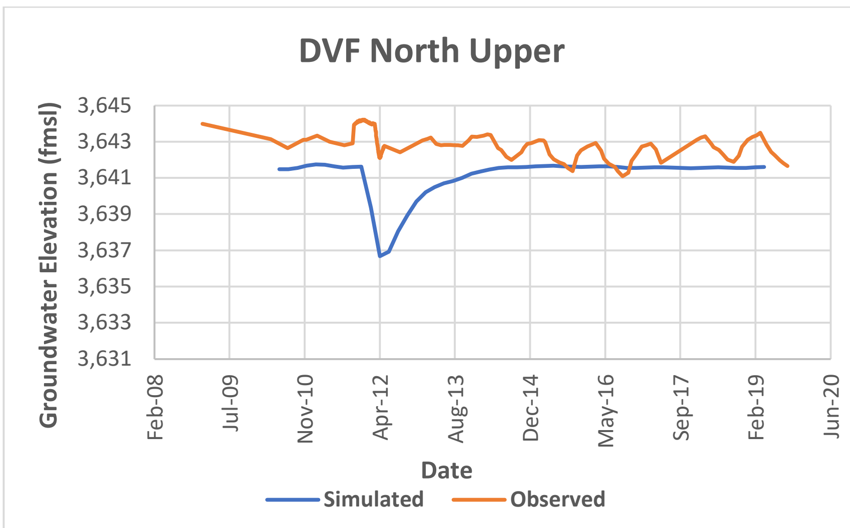

FTS West Deep T2
Groundwater Elevation (fmsl)
3,627
3,625
3,623
3,621
3,619
3,617
3,615
3,613
3,611
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

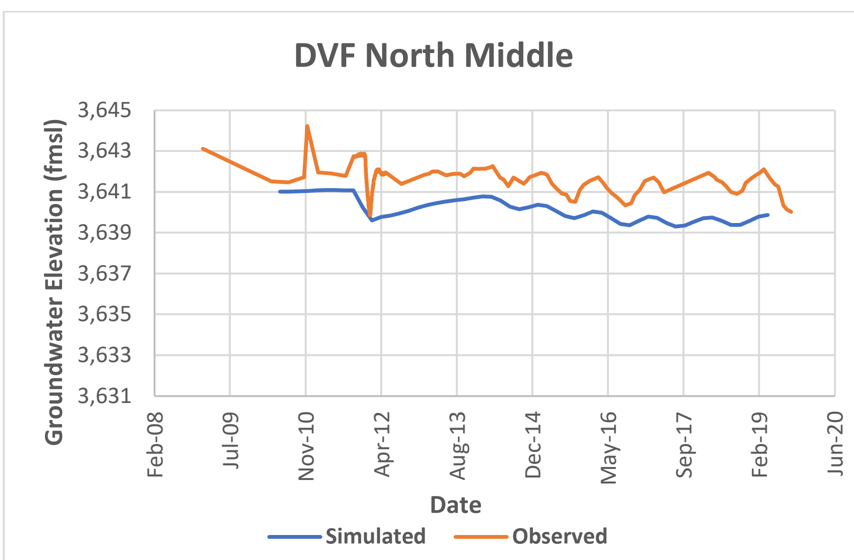

FTS West Deep T1
3,627
3,625
3,623
3,621
3,619
3,617
3,615
3,613
3,611
Groundwater Elevation (fmsl)
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

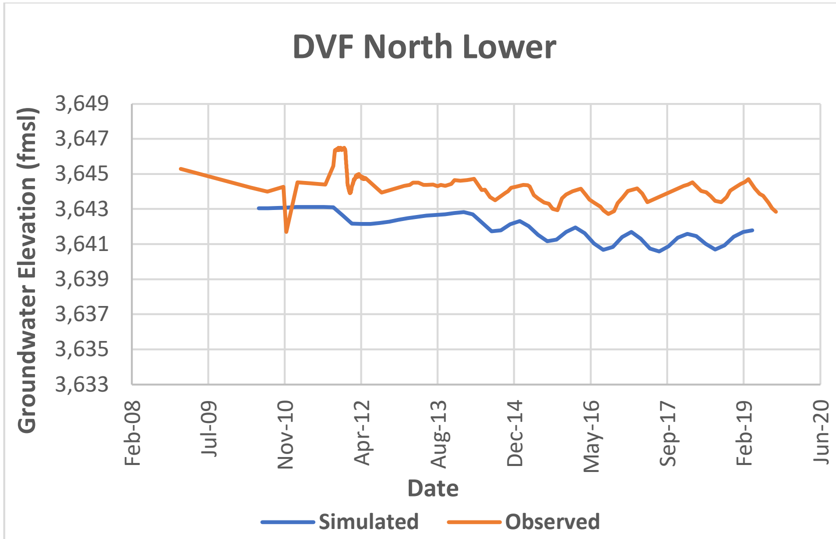

DVF South Upper
3,644
3,642
3,640
3,638
3,636
3,634
3,632
3,630
Groundwater Elevation (fmsl)
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

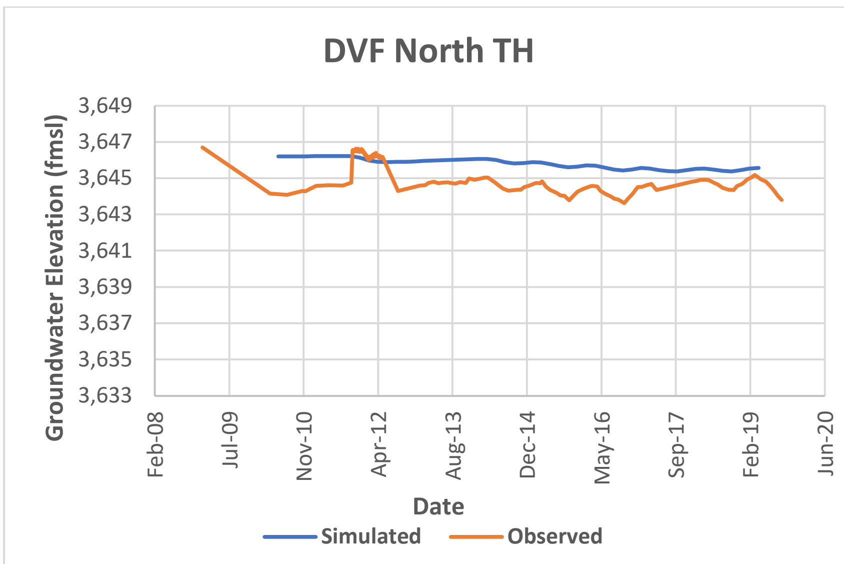

DVF South Middle
3,646
3,644
3,642
3,640
3,638
3,636
3,634
3,632
Groundwater Elevation (fmsl)
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

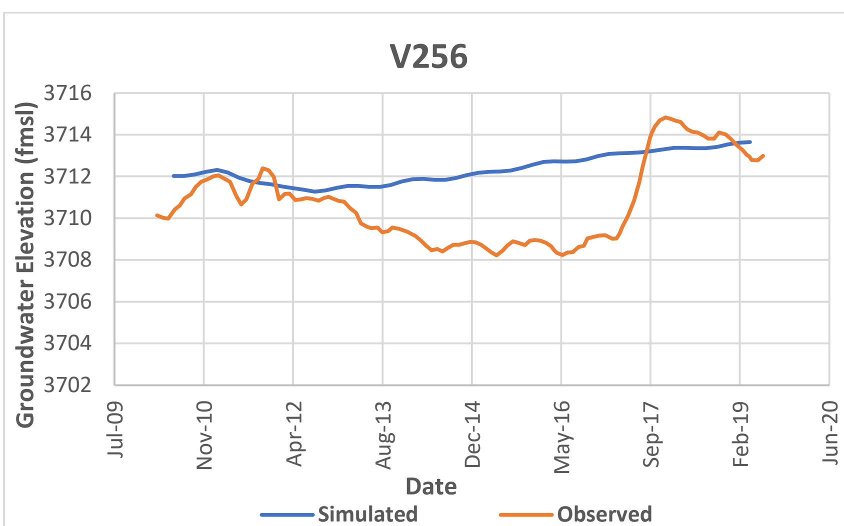

DVF South Lower
Groundwater ELevation (fmsl)
3,648
3,646
3,644
3,642
3,640
3,638
3,636
3,634
3,632
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

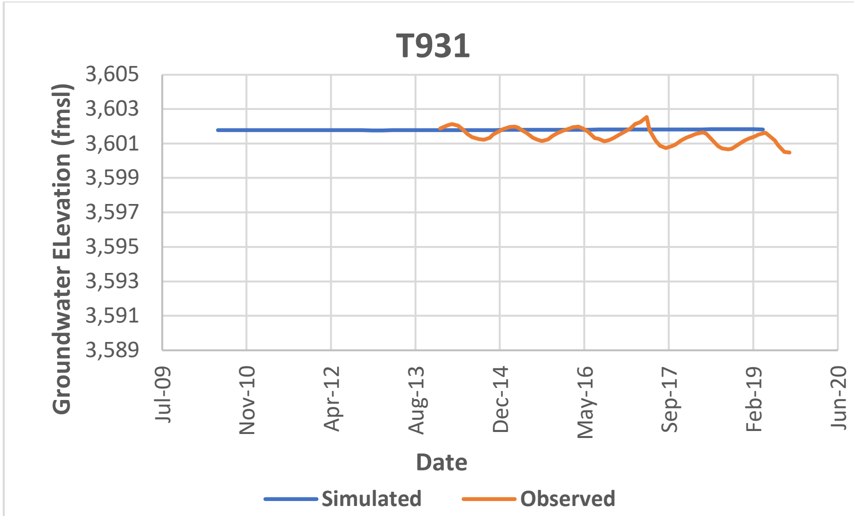

DVF North Upper
Groundwater Elevation (fmsl)
3,645
3,643
3,641
3,639
3,637
3,635
3,633
3,631
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

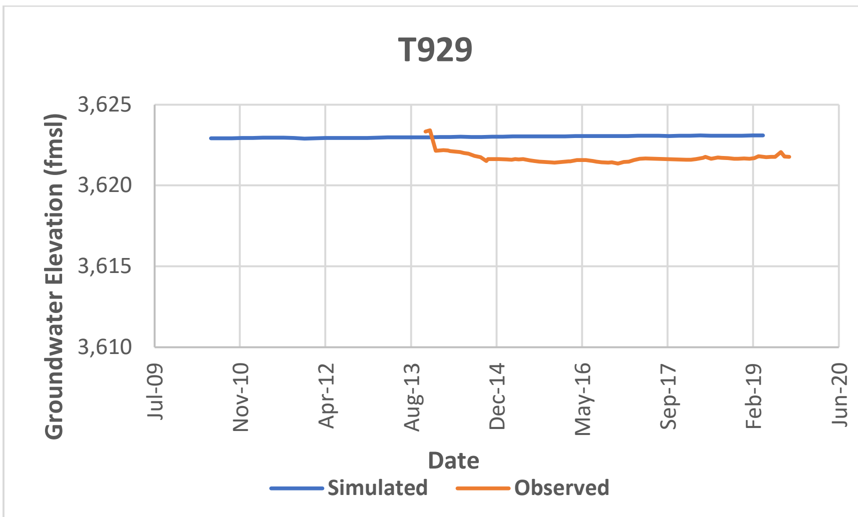

DVF North Middle
Groundwater Elevation (fmsl)
3,645
3,643
3,641
3,639
3,637
3,635
3,633
3,631
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

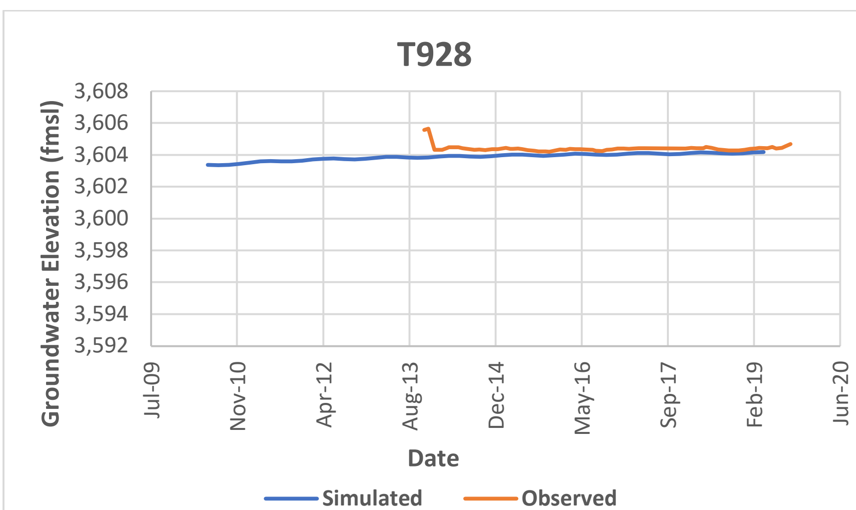

DVF North Lower
Groundwater Elevation (fmsl)
3,649
3,647
3,645
3,643
3,641
3,639
3,637
3,635
3,633
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

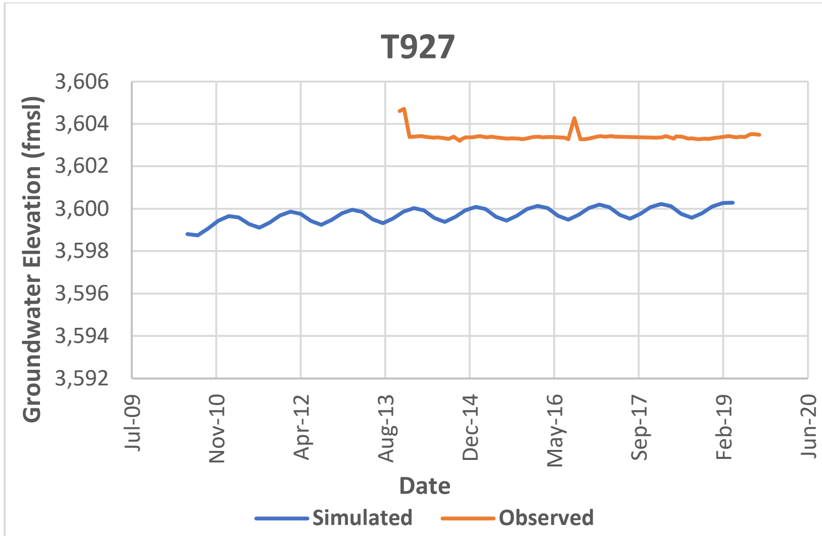

DVF North TH
Groundwater Elevation (fmsl)
3,649
3,647
3,645
3,643
3,641
3,639
3,637
3,635
3,633
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

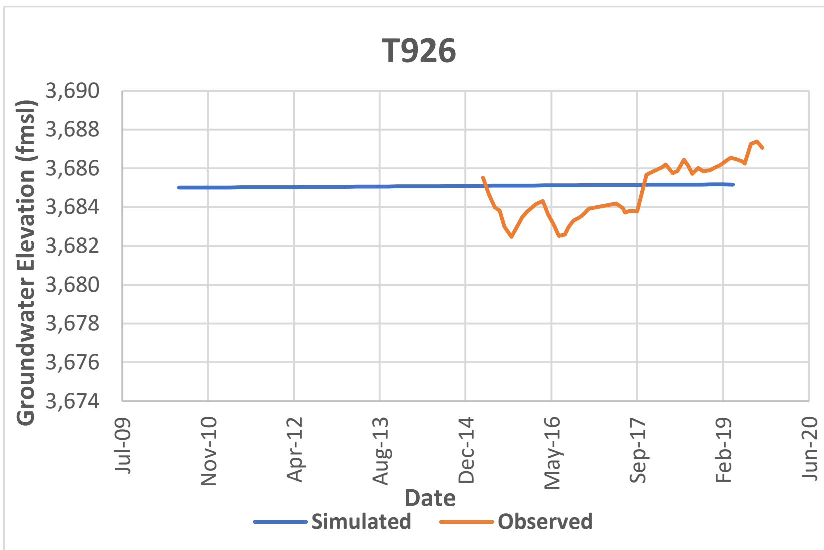

V256
Groundwater Elevation (fmsl)
3716
3714
3712
3710
3708
3706
3704
3702
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

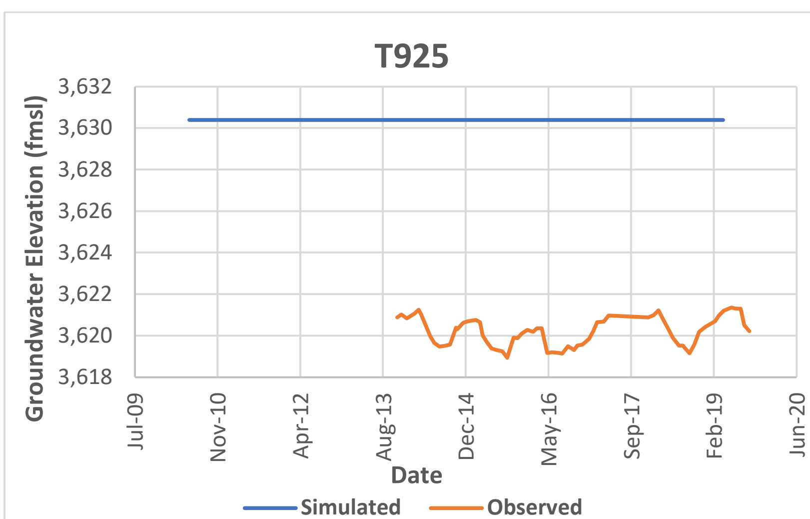

T931
Groundwater ELevation (fmsl)
3,605
3,603
3,601
3,599
3,597
3,595
3,593
3,591
3,589
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

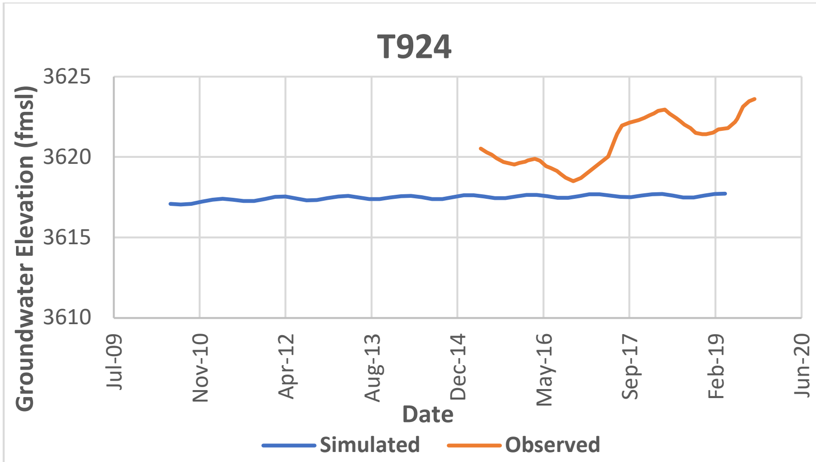

T929
Groundwater Elevation (fmsl)
3,625
3,620
3,615
3,610
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

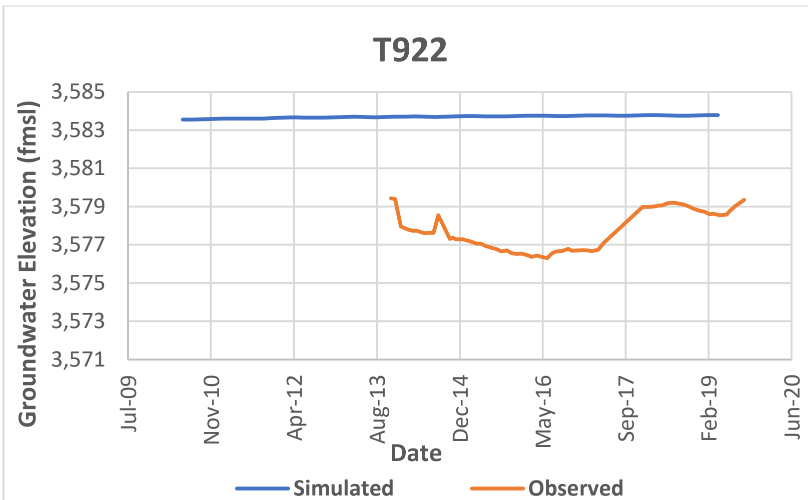

T928
Groundwater Elevation (fmsl)
3,608
3,606
3,604
3,602
3,600
3,598
3,596
3,594
3,592
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

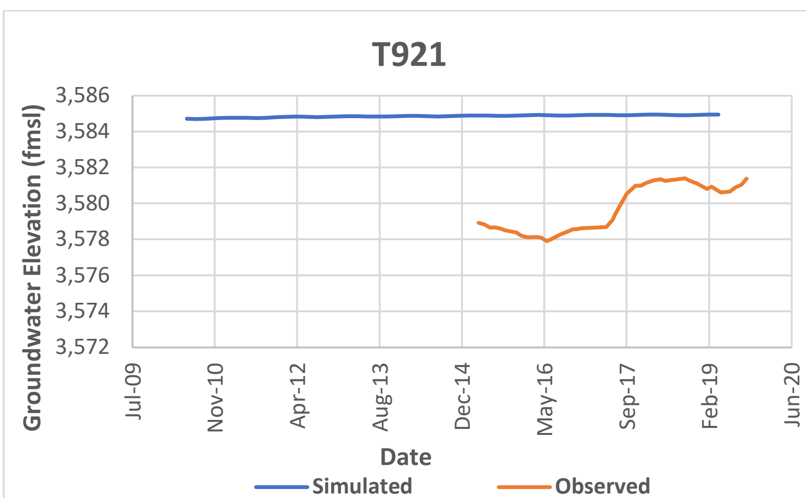

T927
3,606
3,604
3,602
3,600
3,598
3,596
3,594
3,592
Groundwater Elevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

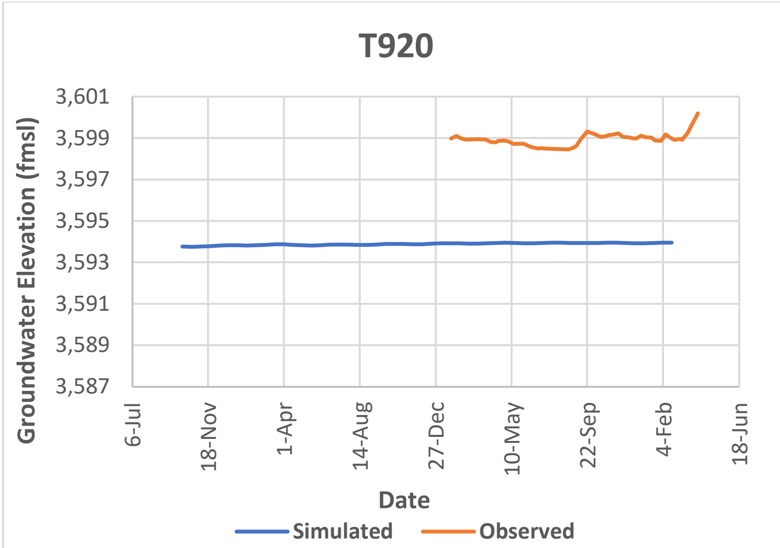

T926
3,690
3,688
3,686
3,684
3,682
3,680
3,678
3,676
3,674
Groundwater Elevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

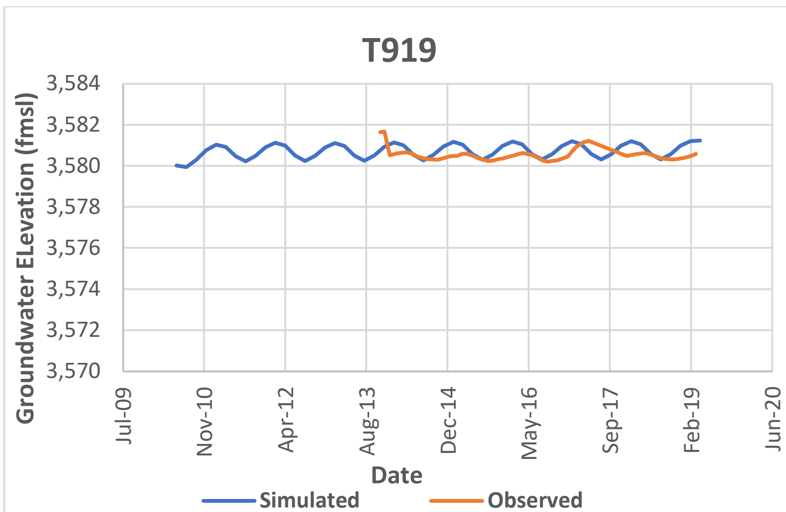

T925
3,632
3,630
3,628
3,626
3,624
3,622
3,620
3,618
Groundwater Elevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

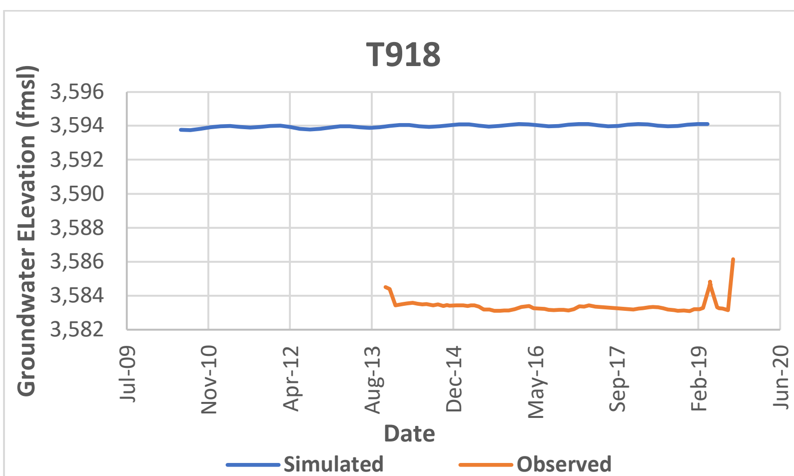

T924
Groundwater Elevation (fmsl)
3625
3620
3615
3610
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

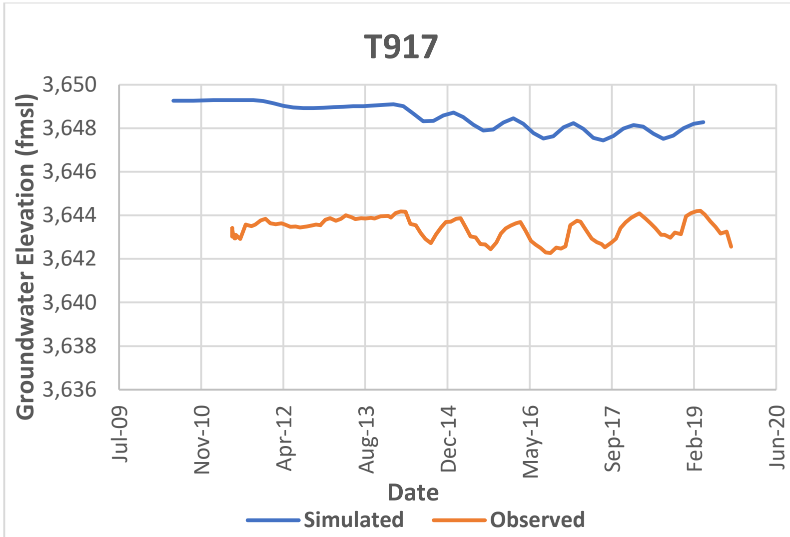

T922
Groundwater Elevation (fmsl)
3,585
3,583
3,581
3,579
3,577
3,575
3,573
3,571
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

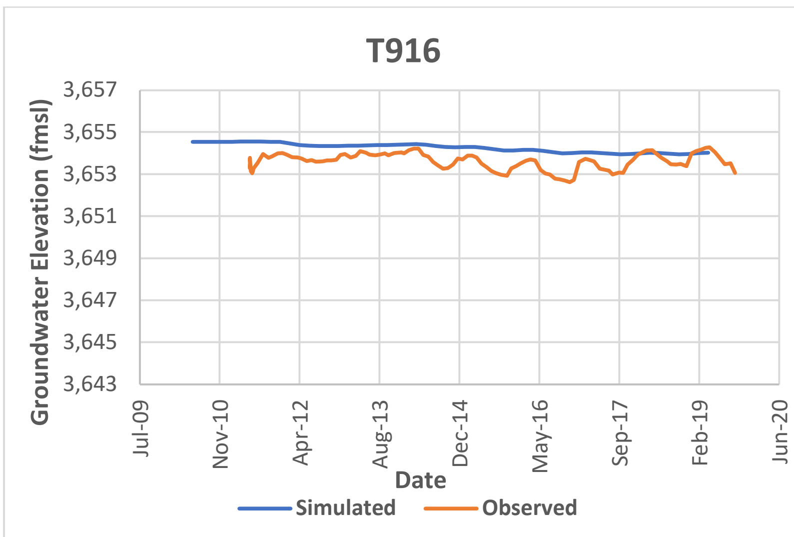

T921
Groundwater Elevation (fmsl)
3,586
3,584
3,582
3,580
3,578
3,576
3,574
3,572
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

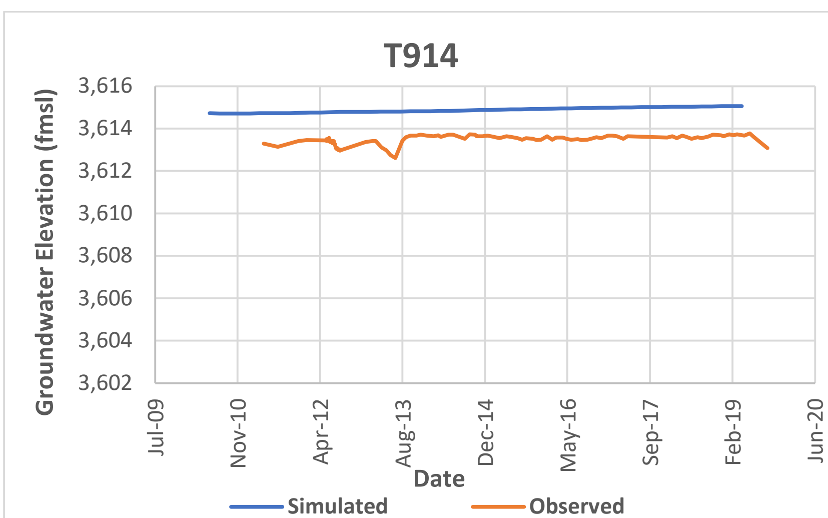

T920
Groundwater Elevation (fmsl)
3,601
3,599
3,597
3,595
3,593
3,591
3,589
3,587
6-Jul
18-Nov
1-Apr
14-Aug
27-Dec
10-May
22-Sep
4-Feb
18-Jun
Date
Simulated
Observed

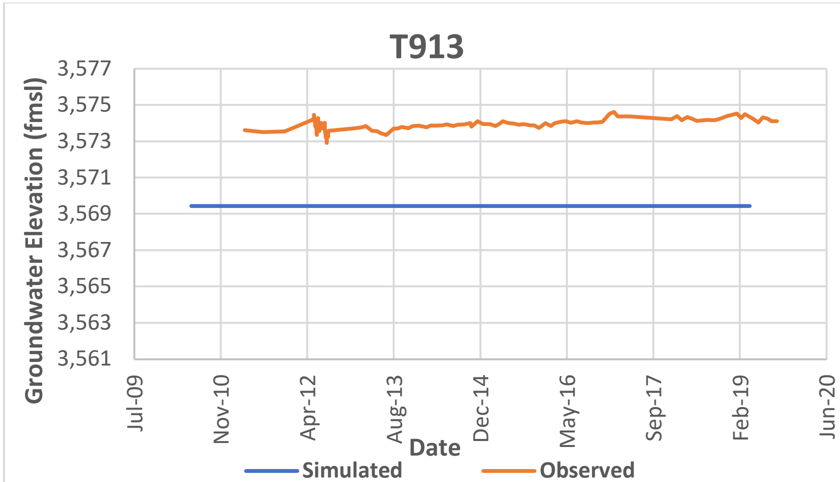

T919
Groundwater ELevation (fmsl)
3,584
3,582
3,580
3,578
3,576
3,574
3,572
3,570
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

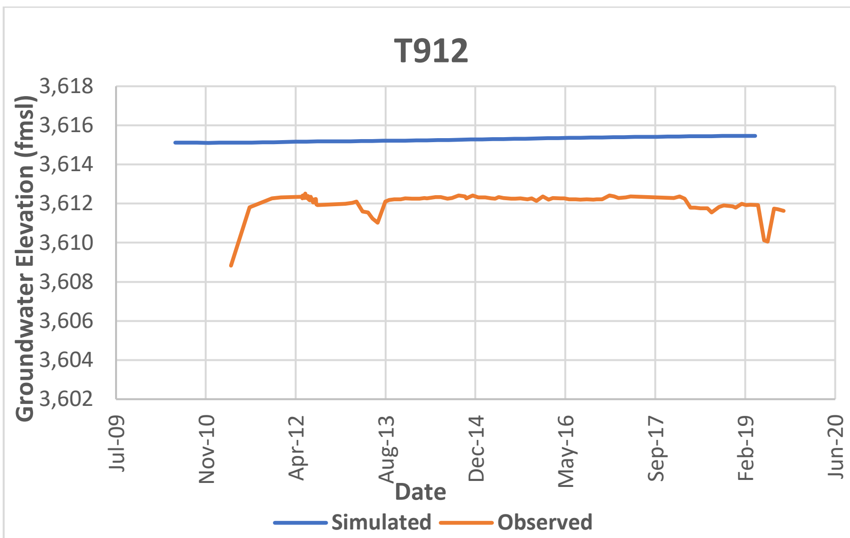

T918
Groundwater ELevation (fmsl)
3,596
3,594
3,592
3,590
3,588
3,586
3,584
3,582
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

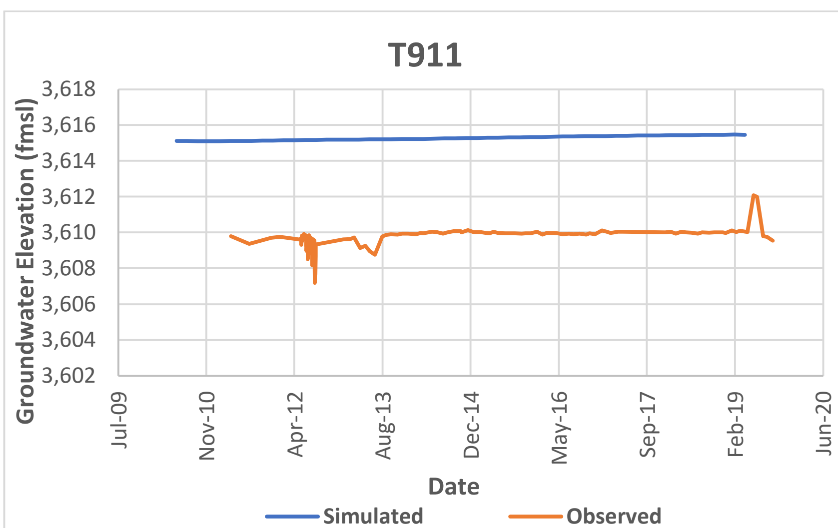

T917
Groundwater Elevation (fmsl)
3,650
3,648
3,646
3,644
3,642
3,640
3,638
3,636
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

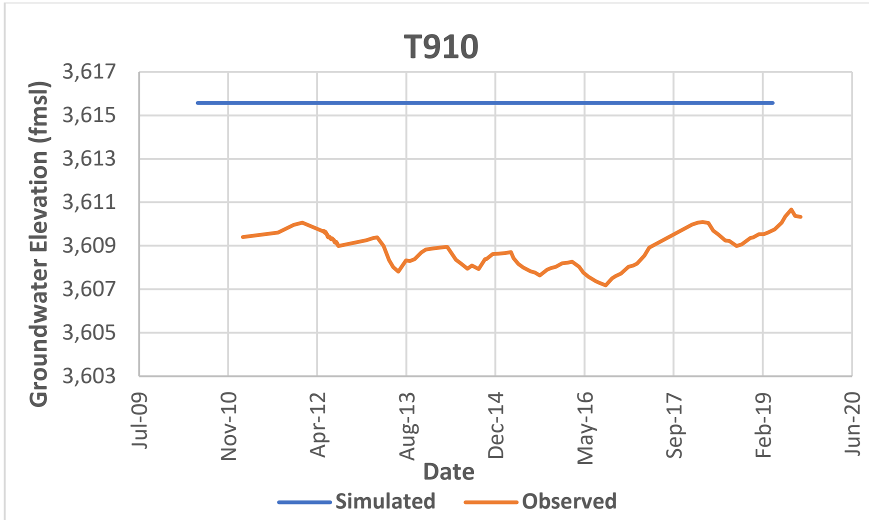

T916
Groundwater Elevation (fmsl)
3,657
3,655
3,653
3,651
3,649
3,647
3,645
3,643
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

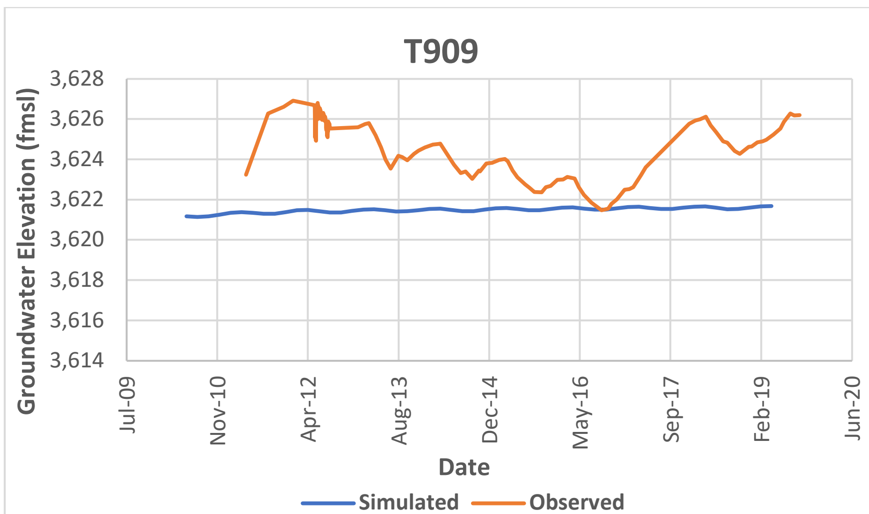

T914
Groundwater Elevation (fmsl)
3,616
3,614
3,612
3,610
3,608
3,606
3,604
3,602
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

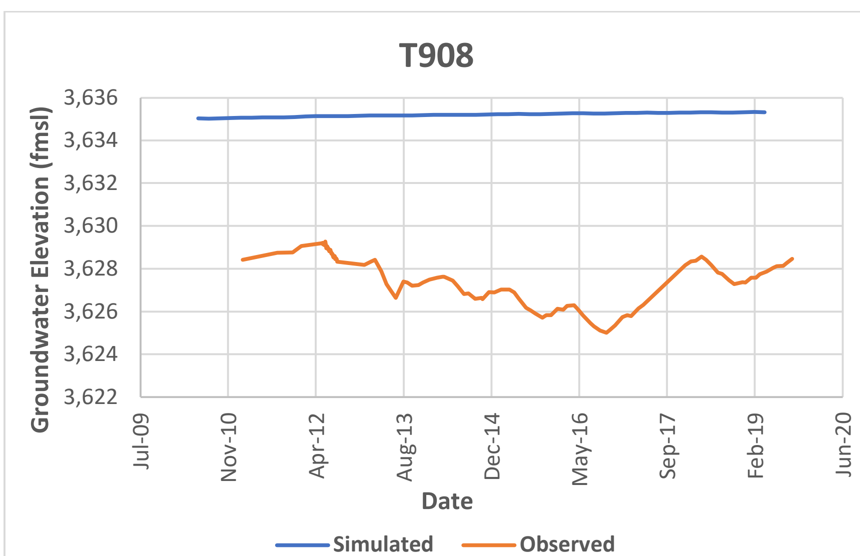

T913
Groundwater Elevation (fmsl)
3,577
3,575
3,573
3,571
3,569
3,567
3,565
3,563
3,561
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

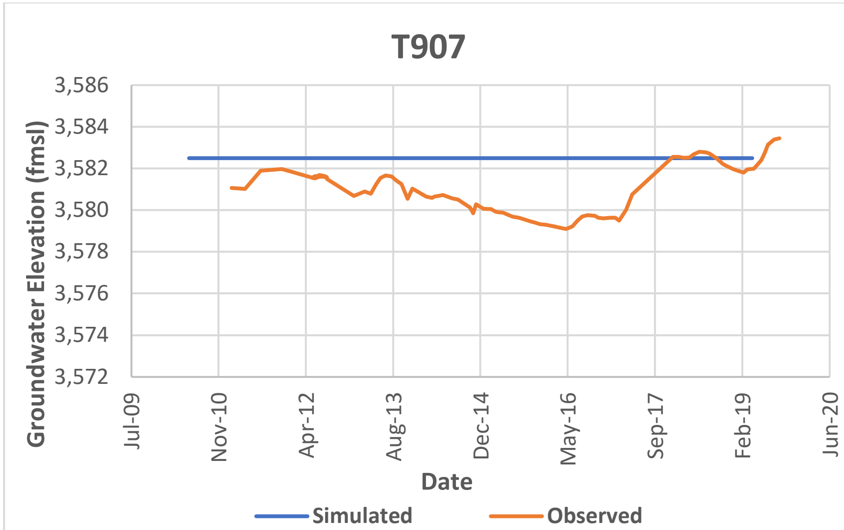

T912
Groundwater Elevation (fmsl)
3,618
3,616
3,614
3,612
3,610
3,608
3,606
3,604
3,602
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

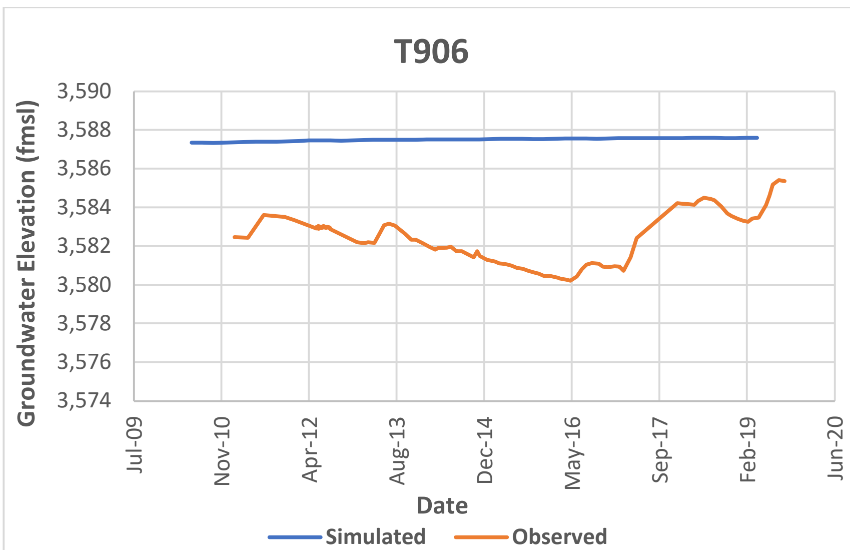

T911
Groundwater Elevation (fmsl)
3,618
3,616
3,614
3,612
3,610
3,608
3,606
3,604
3,602
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

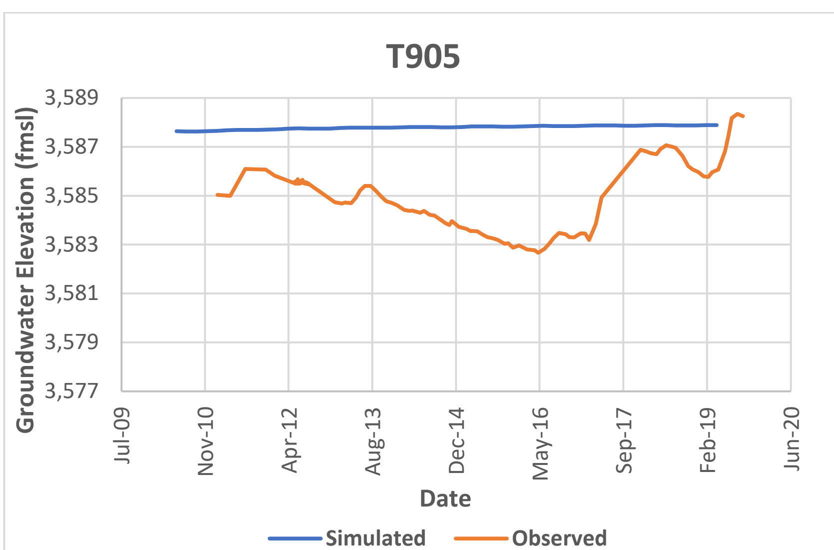

T910
Groundwater Elevation (fmsl)
3,617
3,615
3,613
3,611
3,609
3,607
3,605
3,603
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

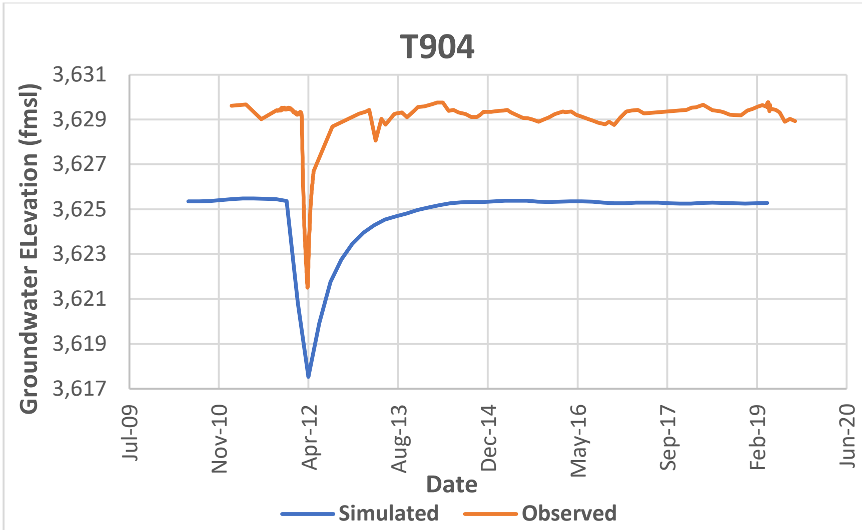

T909
Groundwater Elevation (fmsl)
3,628
3,626
3,624
3,622
3,620
3,618
3,616
3,614
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

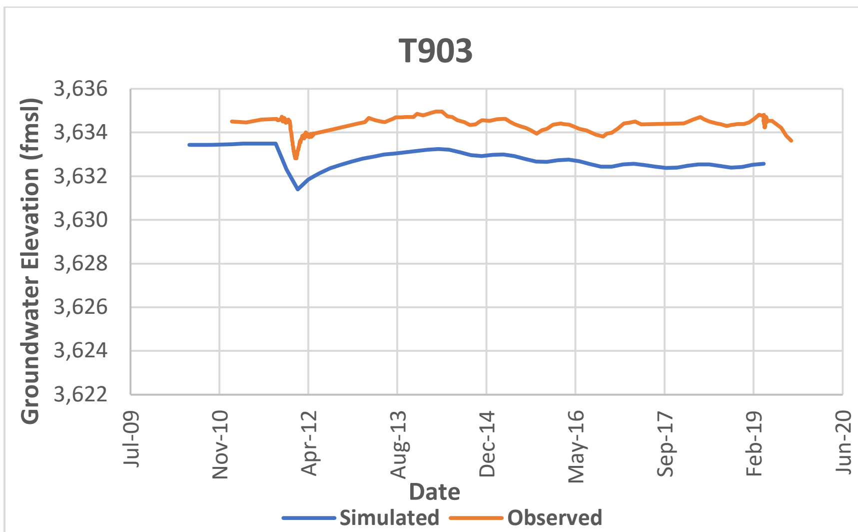

T908
Groundwater Elevation (fmsl)
3,636
3,634
3,632
3,630
3,628
3,626
3,624
3,622
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

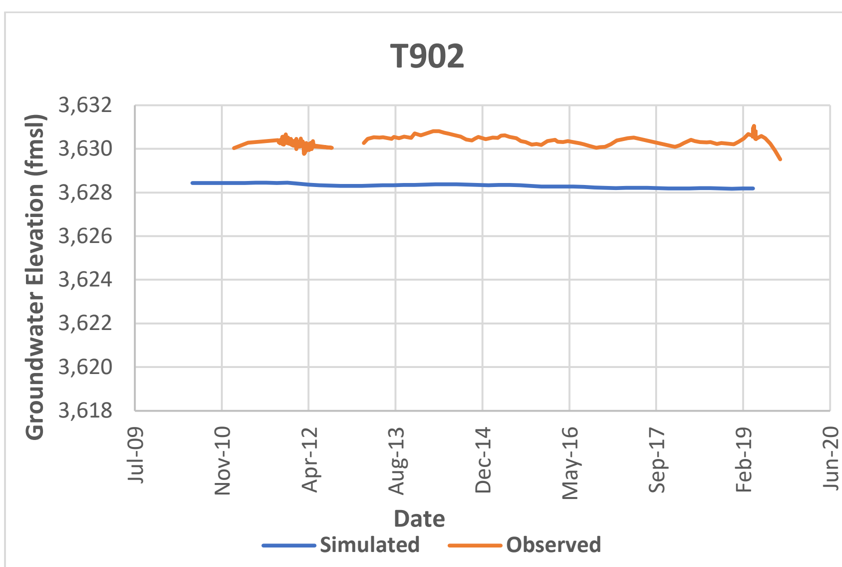

T907
Groundwater Elevation (fmsl)
3,586
3,584
3,582
3,580
3,578
3,576
3,574
3,572
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

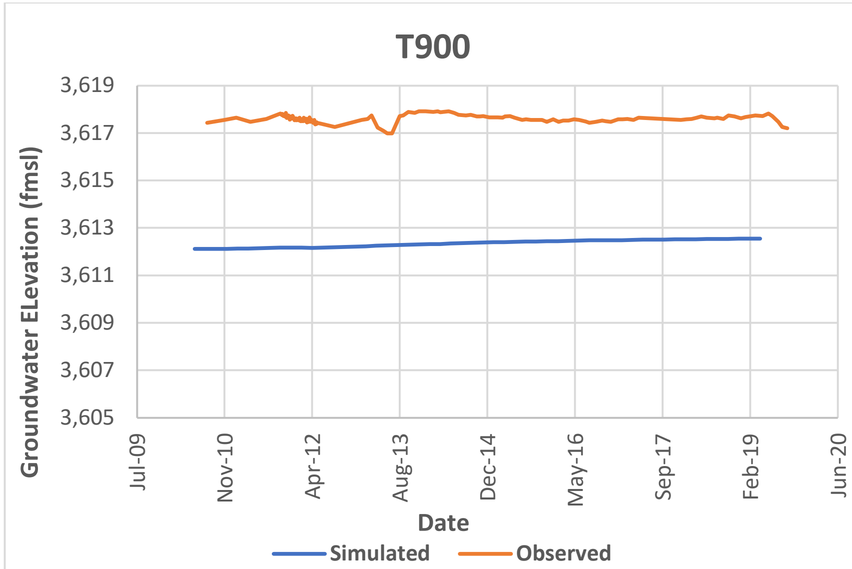

T906
Groundwater Elevation (fmsl)
3,590
3,588
3,586
3,584
3,582
3,580
3,578
3,576
3,574
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

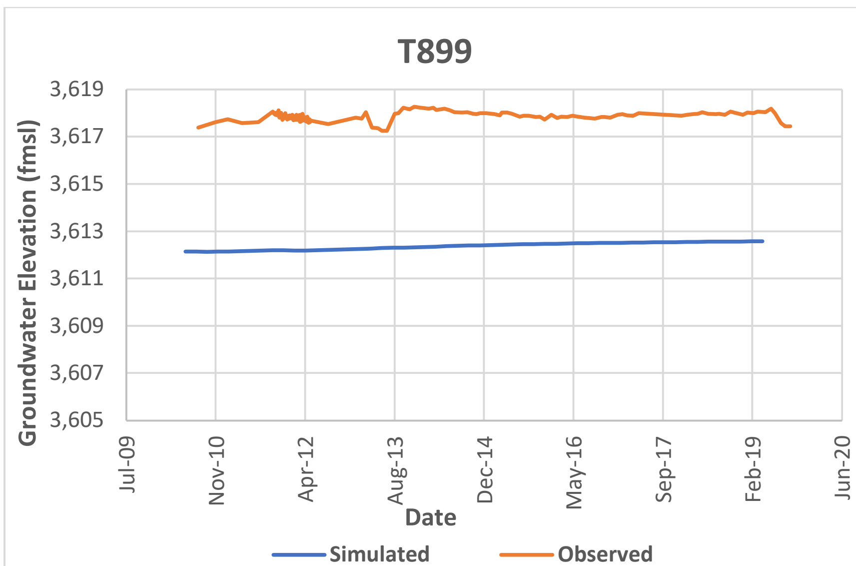

T905
Groundwater Elevation (fmsl)
3,589
3,587
3,585
3,583
3,581
3,579
3,577
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

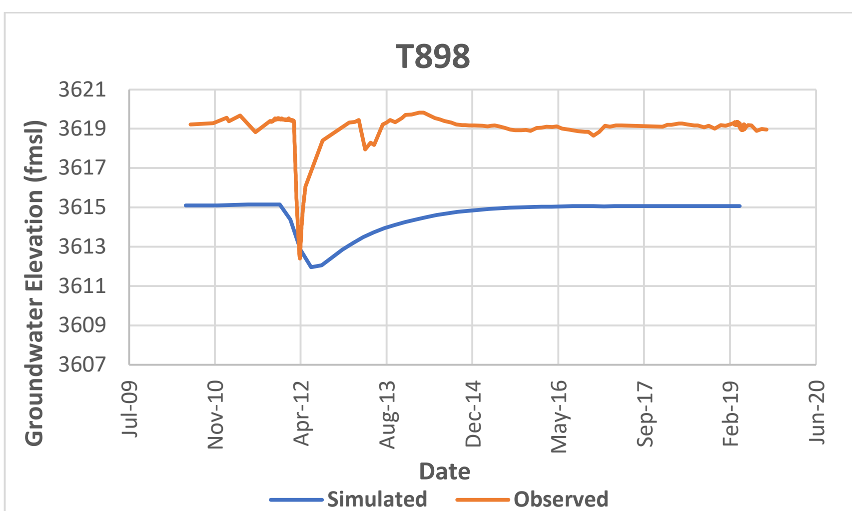

T904
Groundwater ELevation (fmsl)
3,631
3,629
3,627
3,625
3,623
3,621
3,619
3,617
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

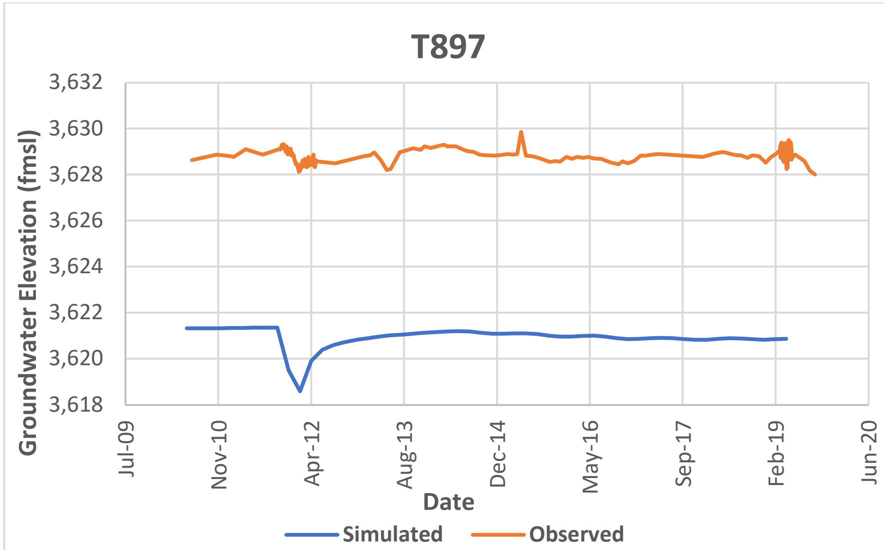

T903
Groundwater Elevation (fmsl)
3,636
3,634
3,632
3,630
3,628
3,626
3,624
3,622
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

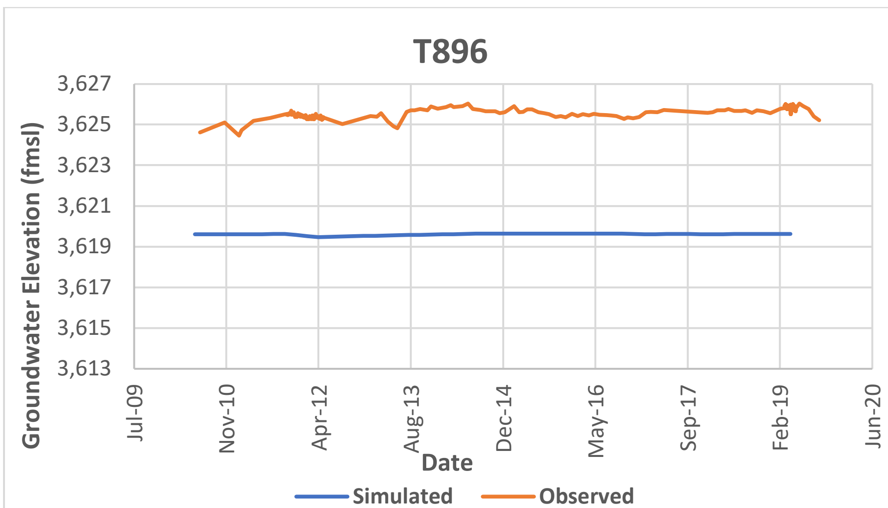

T902
Groundwater Elevation (fmsl)
3,632
3,630
3,628
3,626
3,624
3,622
3,620
3,618
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

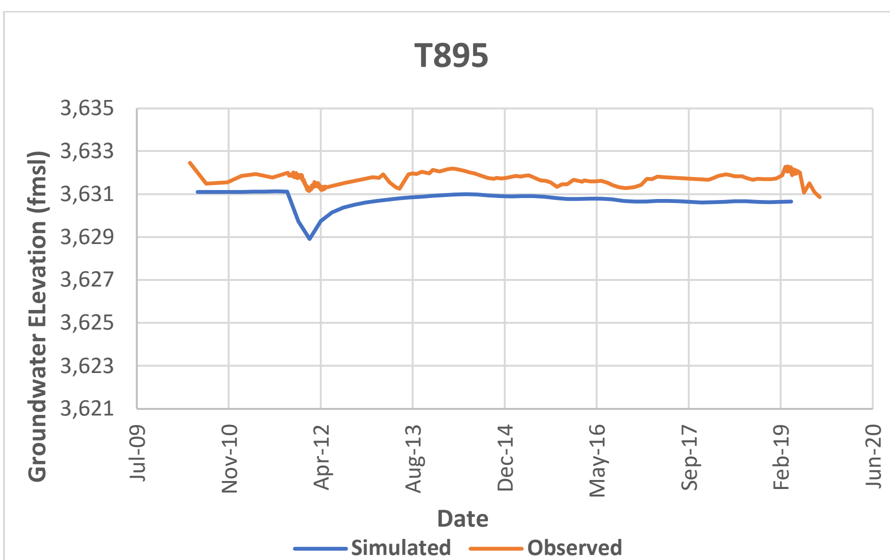

T900
Groundwater ELevation (fmsl)
3,619
3,617
3,615
3,613
3,611
3,609
3,607
3,605
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

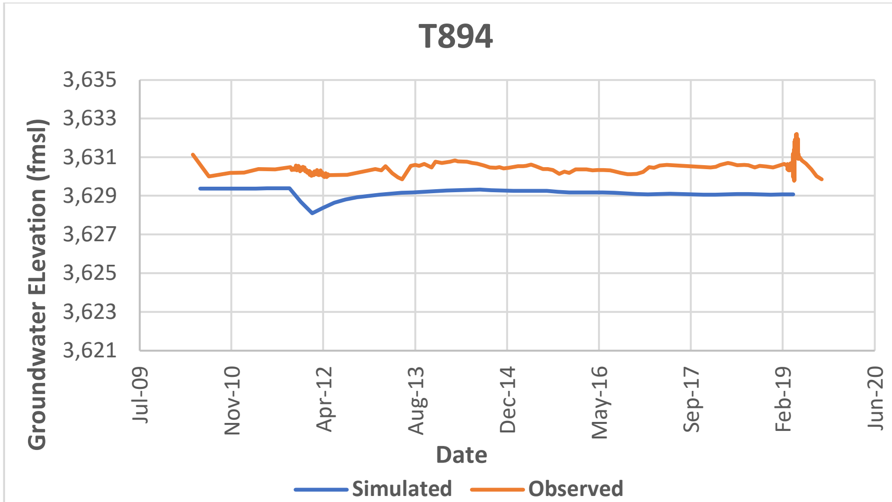

T899
Groundwater Elevation (fmsl)
3,619
3,617
3,615
3,613
3,611
3,609
3,607
3,605
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

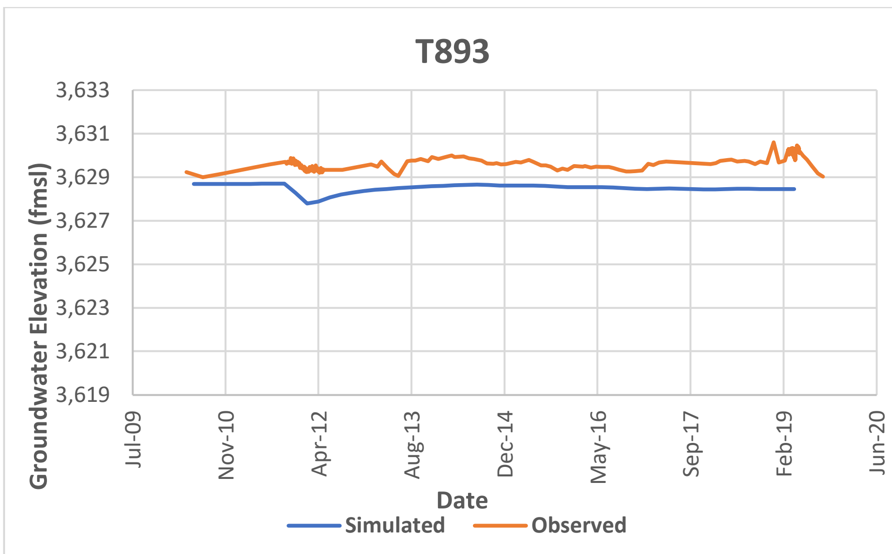

T898
Groundwater Elevation (fmsl)
3621
3619
3617
3615
3613
3611
3609
3607
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

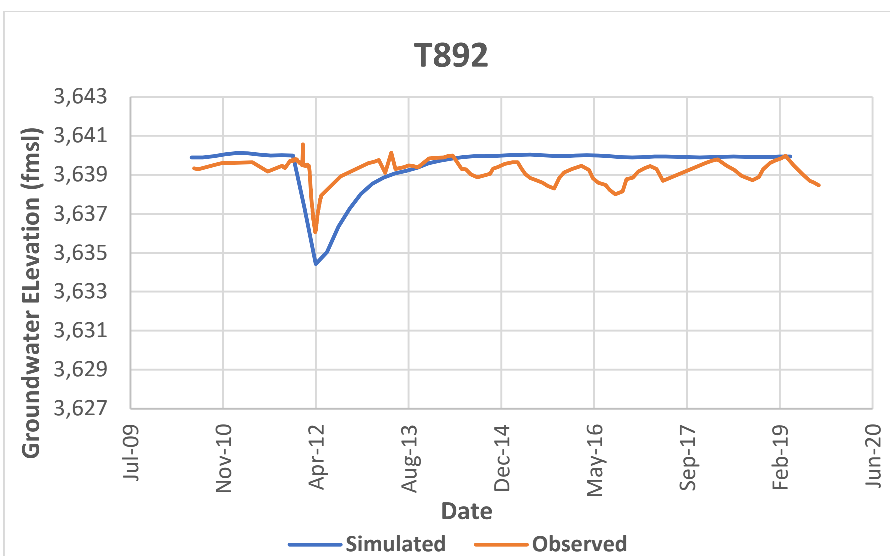

T897
3,632
3,630
3,628
3,626
3,624
3,622
3,620
3,618
Groundwater Elevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

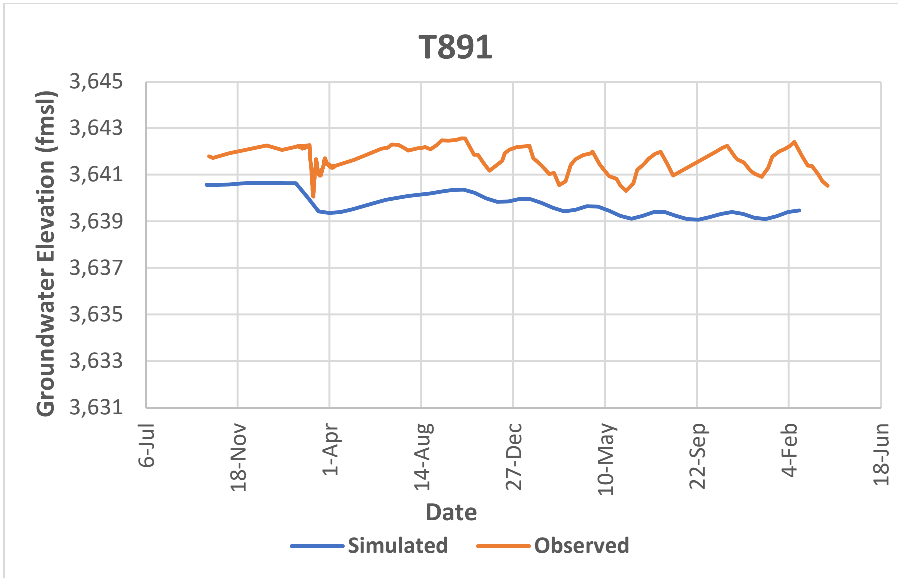

T896
3,627
3,625
3,623
3,621
3,619
3,617
3,615
3,613
Groundwater Elevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

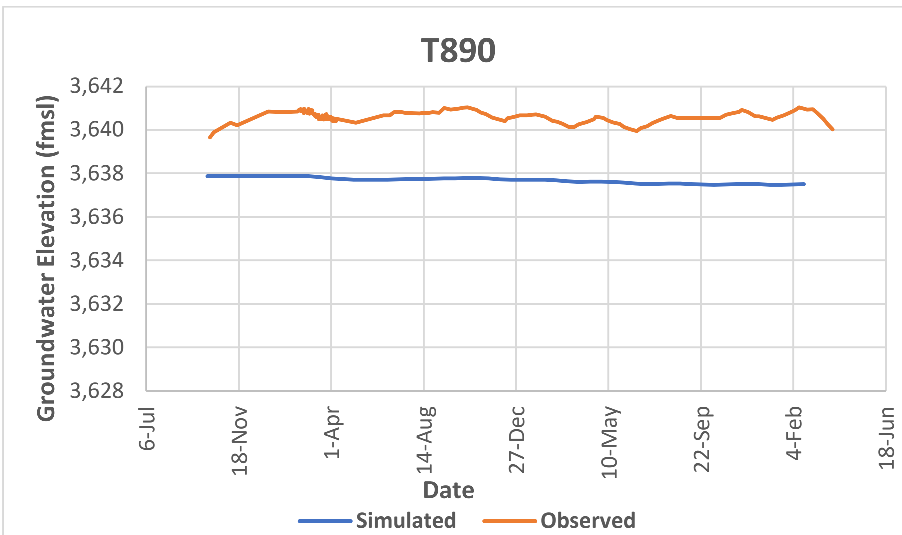

T895
3,635
3,633
3,631
3,629
3,627
3,625
3,623
3,621
Groundwater ELevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

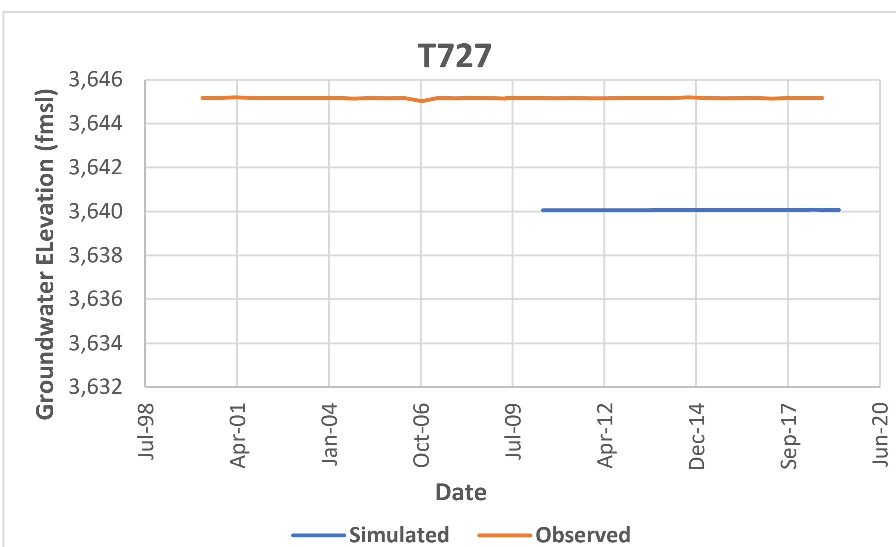

T894
3,635
3,633
3,631
3,629
3,627
3,625
3,623
3,621
Groundwater ELevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

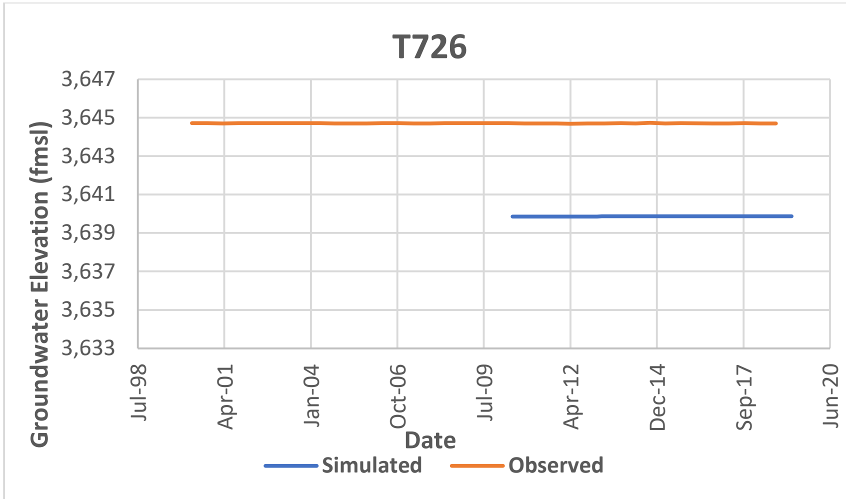

T893
3,633
3,631
3,629
3,627
3,625
3,623
3,621
3,619
Groundwater Elevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

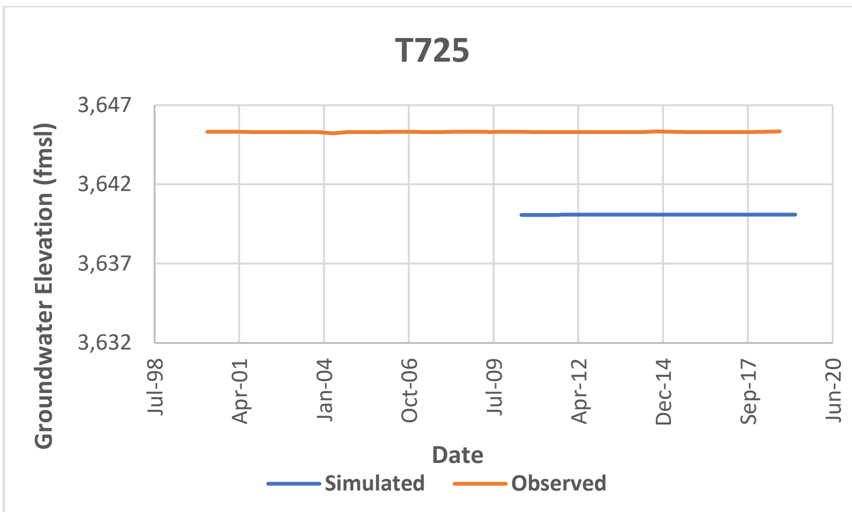

T892
3,643
3,641
3,639
3,637
3,635
3,633
3,631
3,629
3,627
Groundwater ELevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

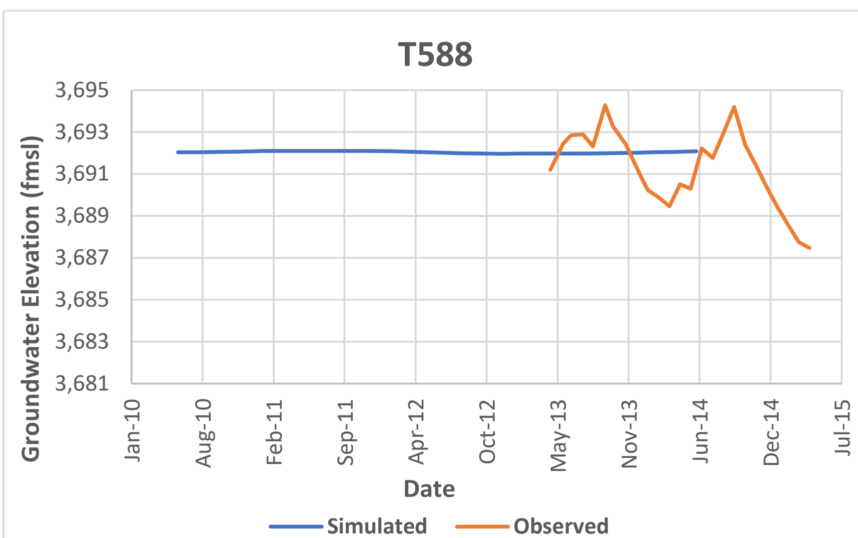

T891
Groundwater Elevation (fmsl)
3,645
3,643
3,641
3,639
3,637
3,635
3,633
3,631
6-Jul
18-Nov
1-Apr
14-Aug
27-Dec
10-May
22-Sep
4-Feb
18-Jun
Date
Simulated
Observed

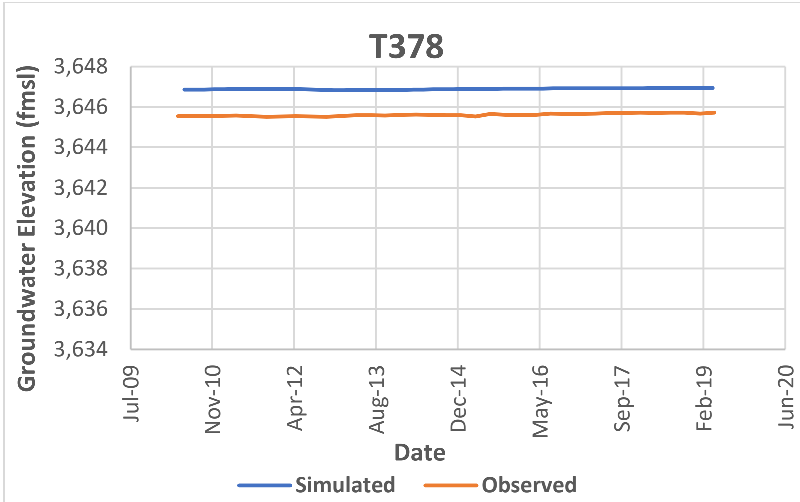

T890
Groundwater Elevation (fmsl)
3,642
3,640
3,638
3,636
3,634
3,632
3,630
3,628
6-Jul
18-Nov
1-Apr
14-Aug
27-Dec
10-May
22-Sep
4-Feb
18-Jun
Date
Simulated
Observed

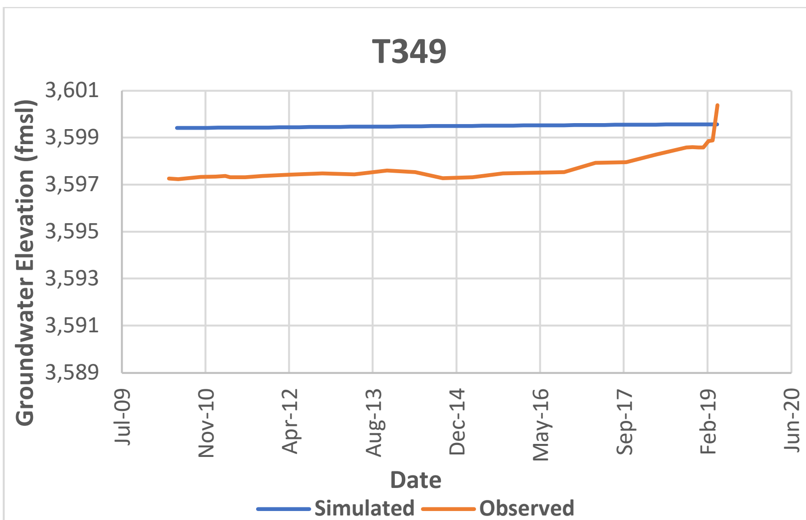

T727
Groundwater ELevation (fmsl)
3,646
3,644
3,642
3,640
3,638
3,636
3,634
3,632
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed

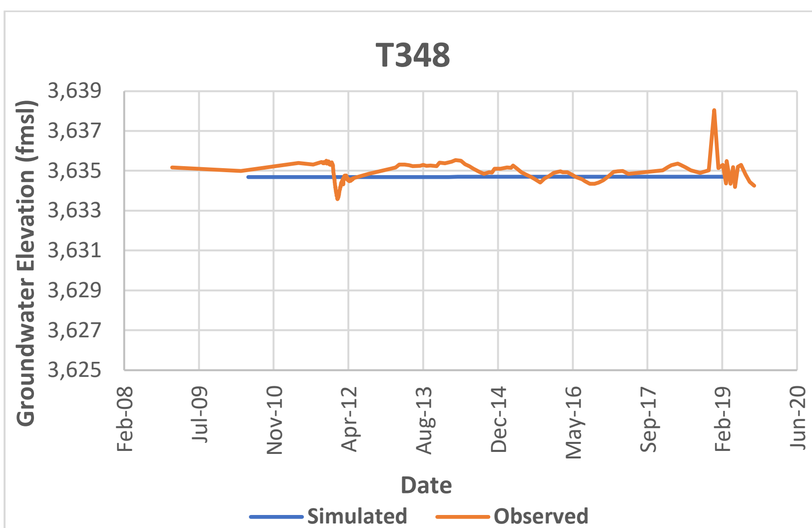

T726
3,647
3,645
3,643
3,641
3,639
3,637
3,635
3,633
Groundwater Elevation (fmsl)
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed

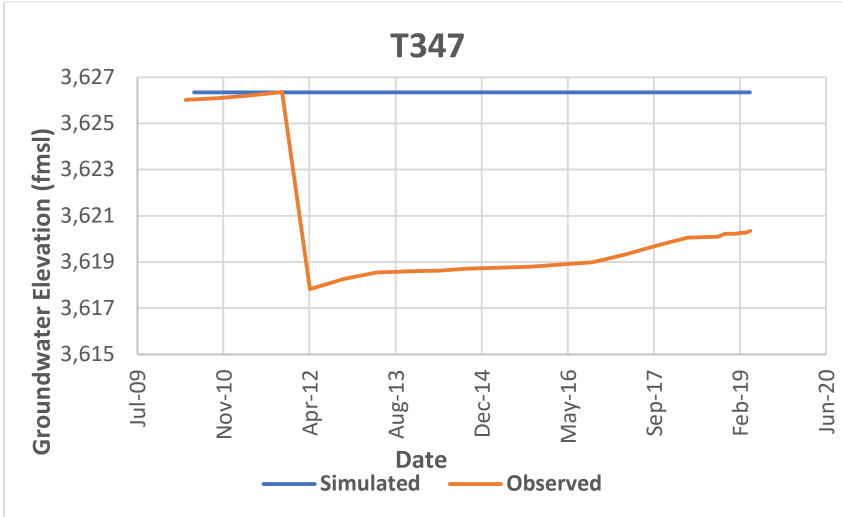

T725
3,647
3,642
3,637
3,632
Groundwater Elevation (fmsl)
Jul-98
Apr-01
Jan-04
Oct-06
Jul-09
Apr-12
Dec-14
Sep-17
Jun-20
Date
Simulated
Observed

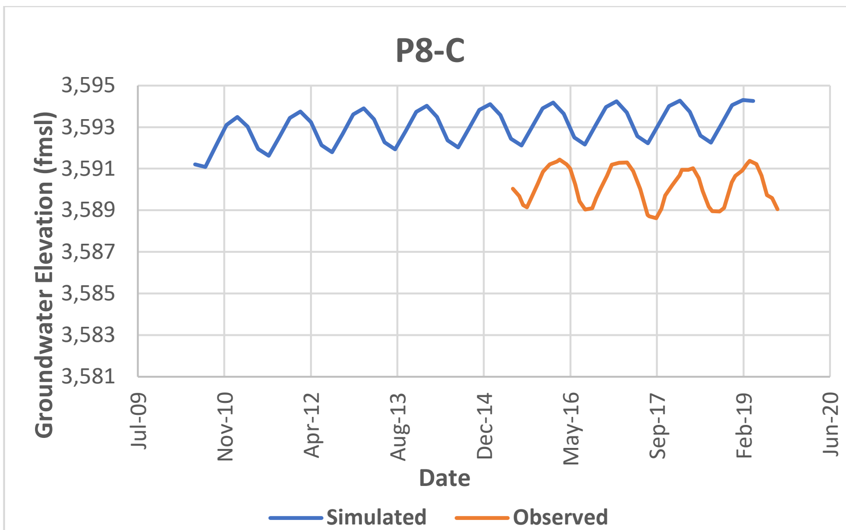

T588
3,695
3,693
3,691
3,689
3,687
3,685
3,683
3,681
Groundwater Elevation (fmsl)
Jan-10
Aug-10
Feb-11
Sep-11
Apr-12
Oct-12
May-13
Nov-13
Jun-14
Dec-14
Jul-15
Date
Simulated
Observed

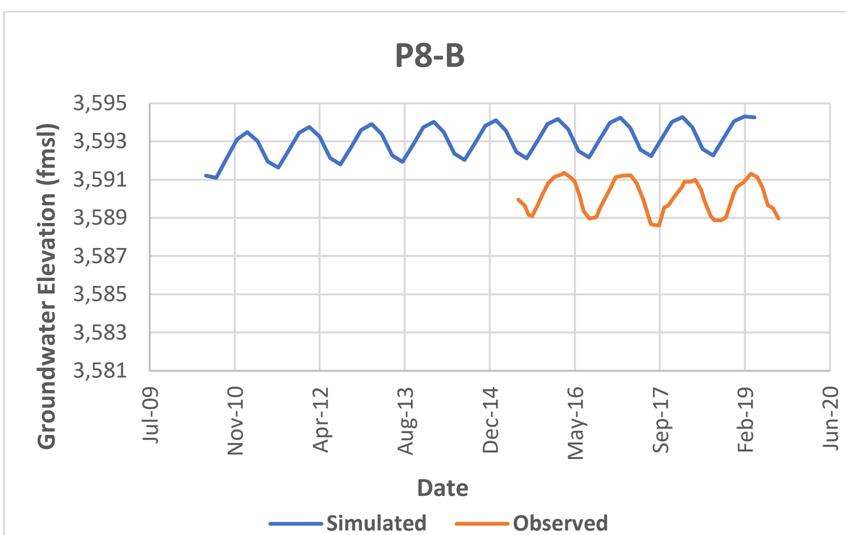

T378
Groundwater Elevation (fmsl)
3,648
3,646
3,644
3,642
3,640
3,638
3,636
3,634
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

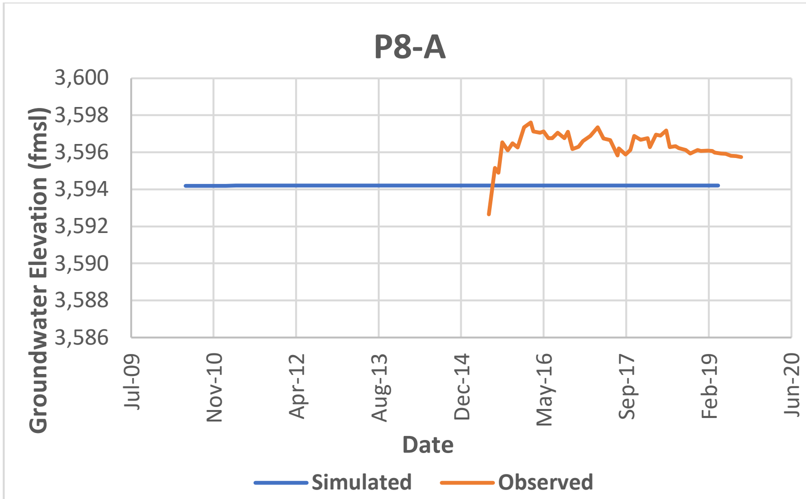

T349
Groundwater Elevation (fmsl)
3,601
3,599
3,597
3,595
3,593
3,591
3,589
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


T348
Groundwater Elevation (fmsl)
3,639
3,637
3,635
3,633
3,631
3,629
3,627
3,625
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

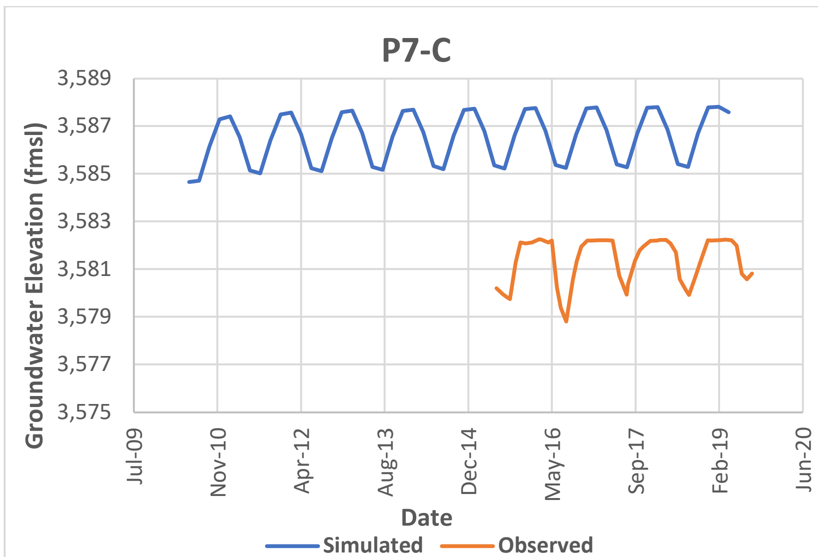

T347
Groundwater Elevation (fmsl)
3,627
3,625
3,623
3,621
3,619
3,617
3,615
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


P8-C
Groundwater Elevation (fmsl)
3,595
3,593
3,591
3,589
3,587
3,585
3,583
3,581
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

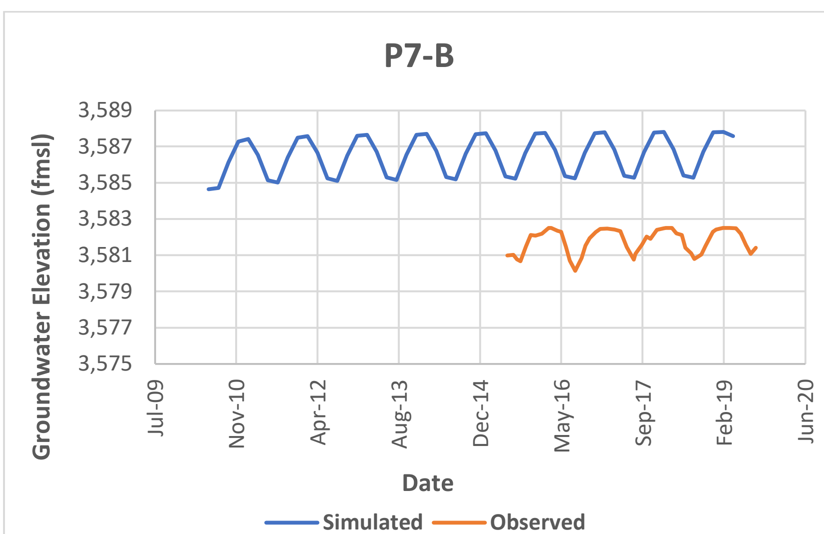

P8-B
Groundwater Elevation (fmsl)
3,595
3,593
3,591
3,589
3,587
3,585
3,583
3,581
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed



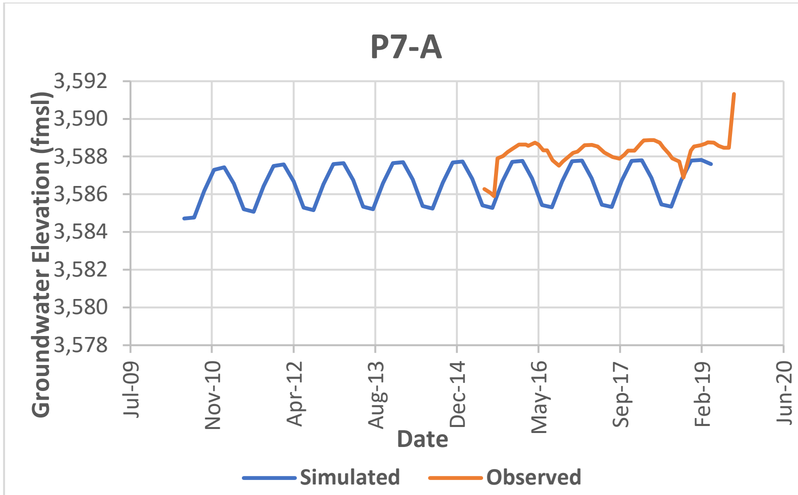
P8-A
Groundwater Elevation (fmsl)
3,600
3,598
3,596
3,594
3,592
3,590
3,588
3,586
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

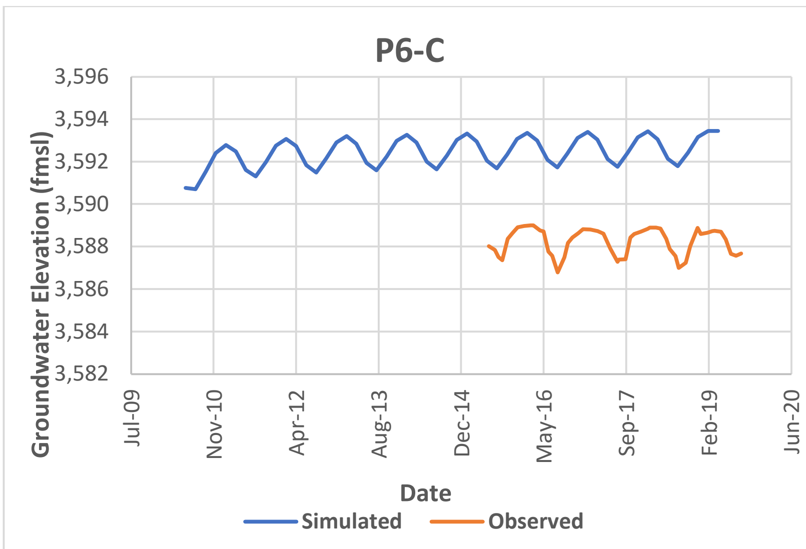


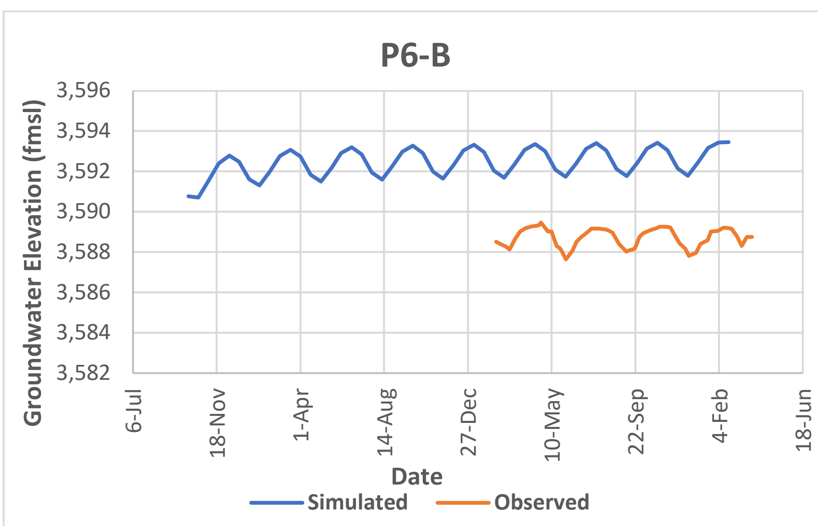
P7-C
Groundwater Elevation (fmsl)
3,589
3,587
3,585
3,583
3,581
3,579
3,577
3,575
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

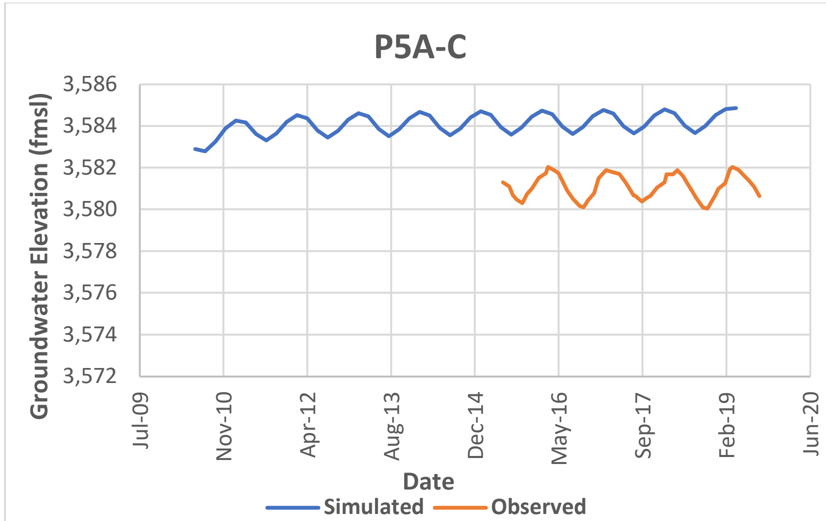


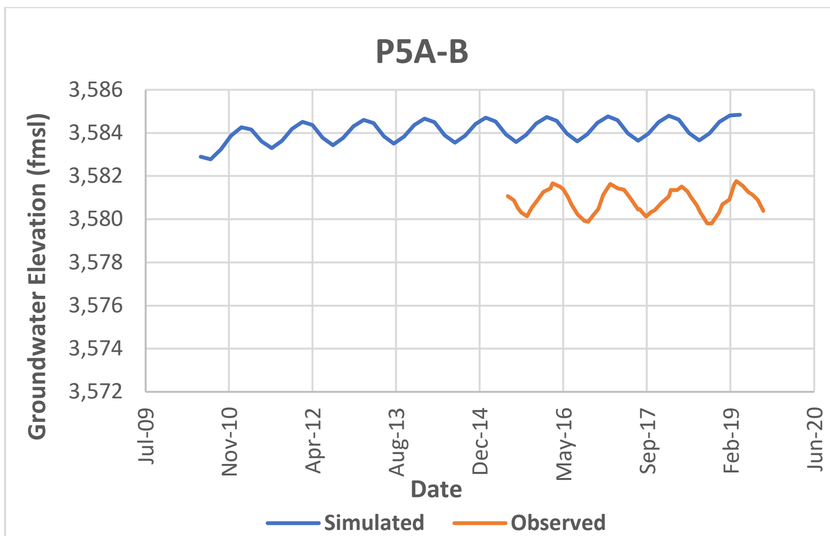
P7-B
Groundwater Elevation (fmsl)
3,589
3,587
3,585
3,583
3,581
3,579
3,577
3,575
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

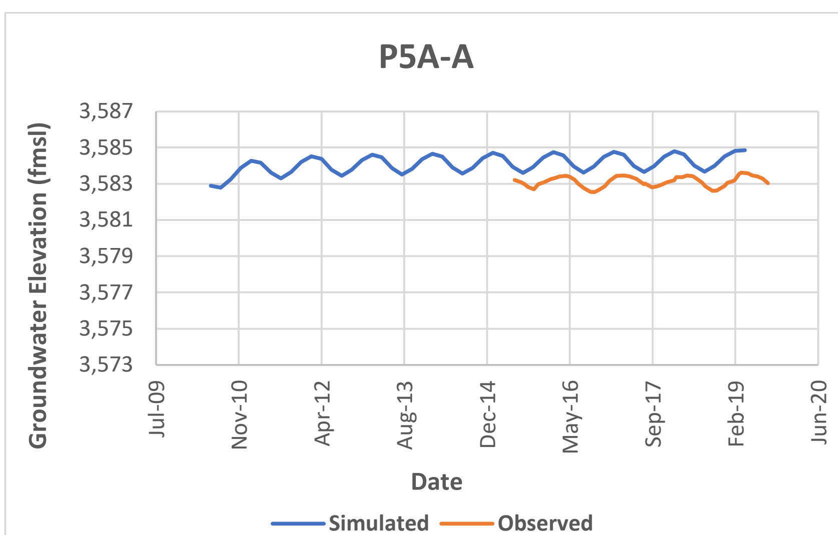

P7-A
Groundwater Elevation (fmsl)
3,592
3,590
3,588
3,586
3,584
3,582
3,580
3,578
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

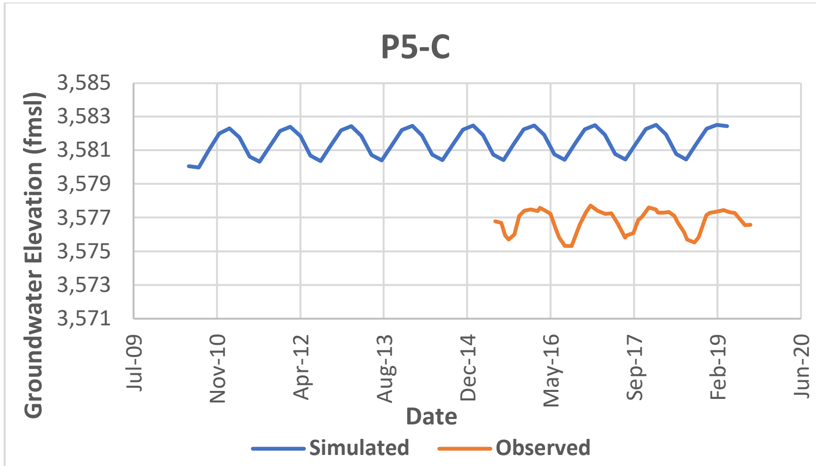

P6-C
Groundwater Elevation (fmsl)
3,596
3,594
3,592
3,590
3,588
3,586
3,584
3,582
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

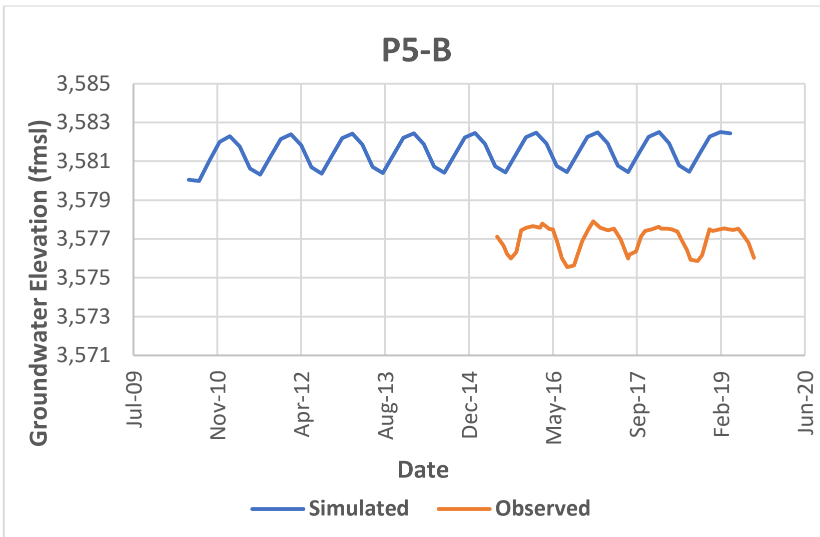

P6-B
Groundwater Elevation (fmsl)
3,596
3,594
3,592
3,590
3,588
3,586
3,584
3,582
6-Jul
18-Nov
1-Apr
14-Aug
27-Dec
10-May
22-Sep
4-Feb
18-Jun
Date
Simulated
Observed

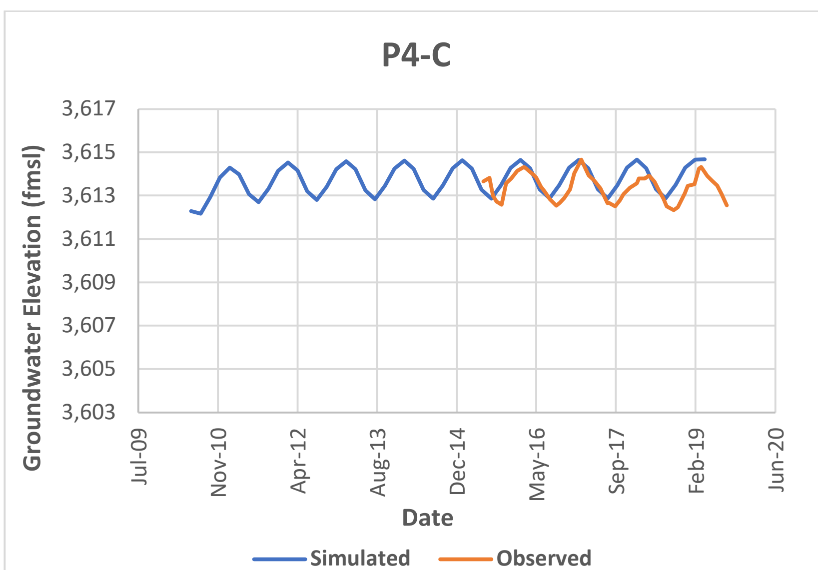

P5A-C
Groundwater Elevation (fmsl)
3,586
3,584
3,582
3,580
3,578
3,576
3,574
3,572
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

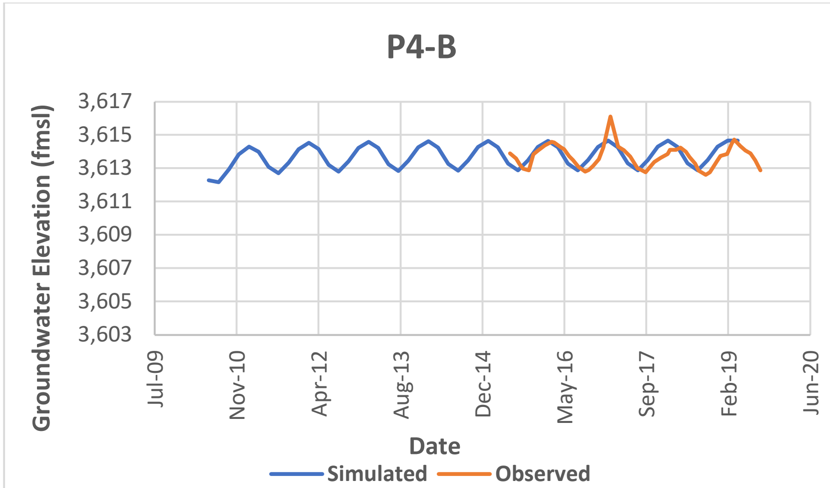

P5A-B
Groundwater Elevation (fmsl)
3,586
3,584
3,582
3,580
3,578
3,576
3,574
3,572
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

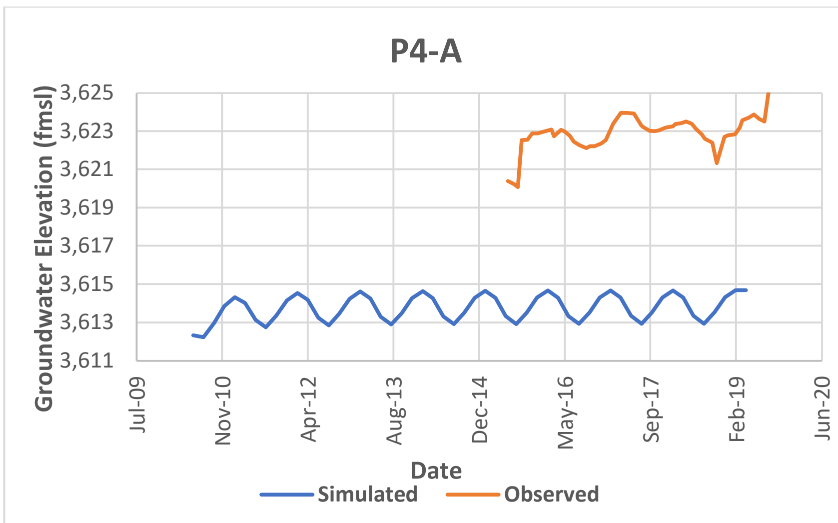

P5A-A
Groundwater Elevation (fmsl)
3,587
3,585
3,583
3,581
3,579
3,577
3,575
3,573
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

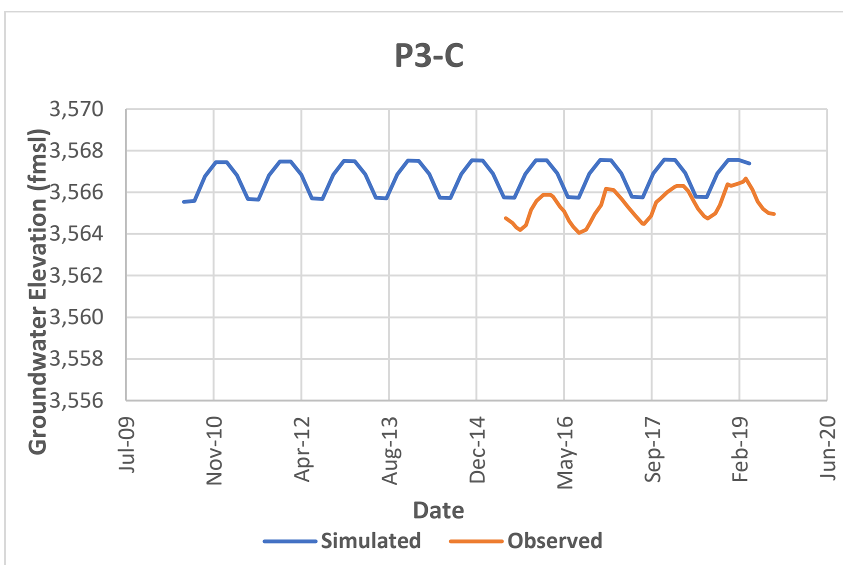

P5-C
Groundwater Elevation (fmsl)
3,585
3,583
3,581
3,579
3,577
3,575
3,573
3,571
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

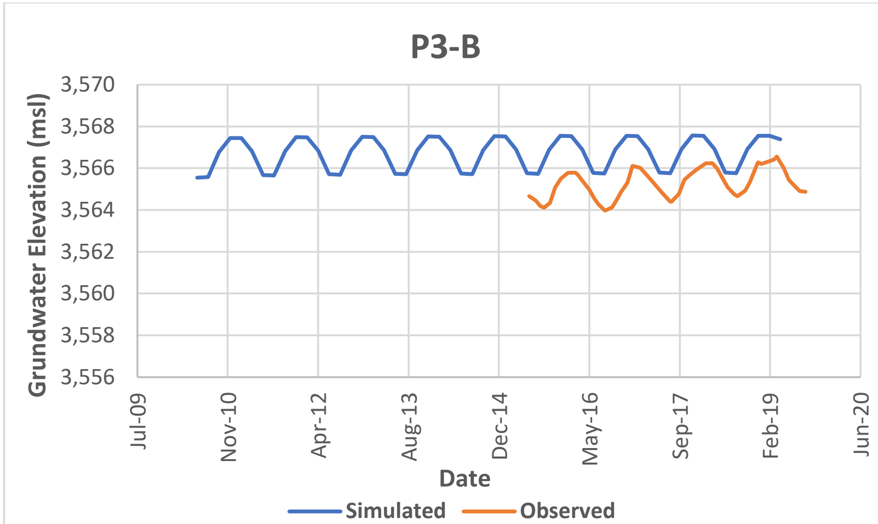

P5-B
Groundwater Elevation (fmsl)
3,585
3,583
3,581
3,579
3,577
3,575
3,573
3,571
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

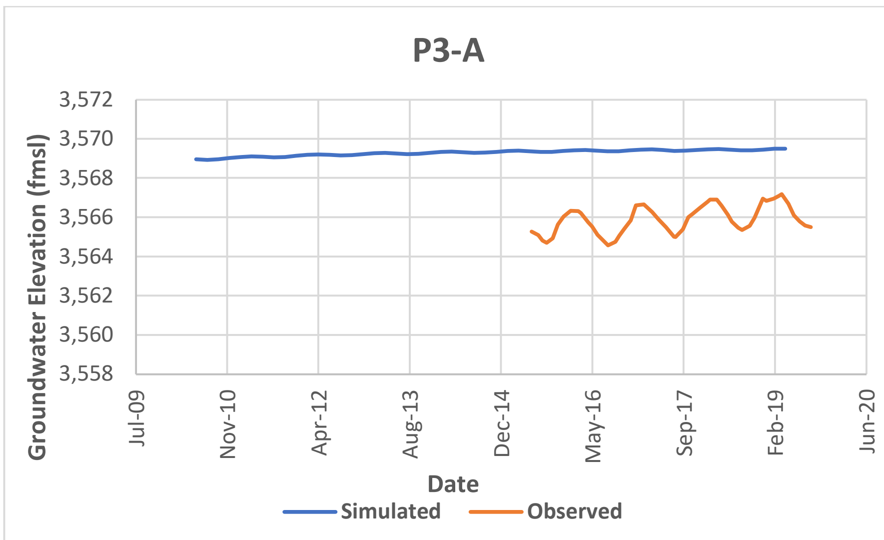

P4-C
Groundwater Elevation (fmsl)
3,617
3,615
3,613
3,611
3,609
3,607
3,605
3,603
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

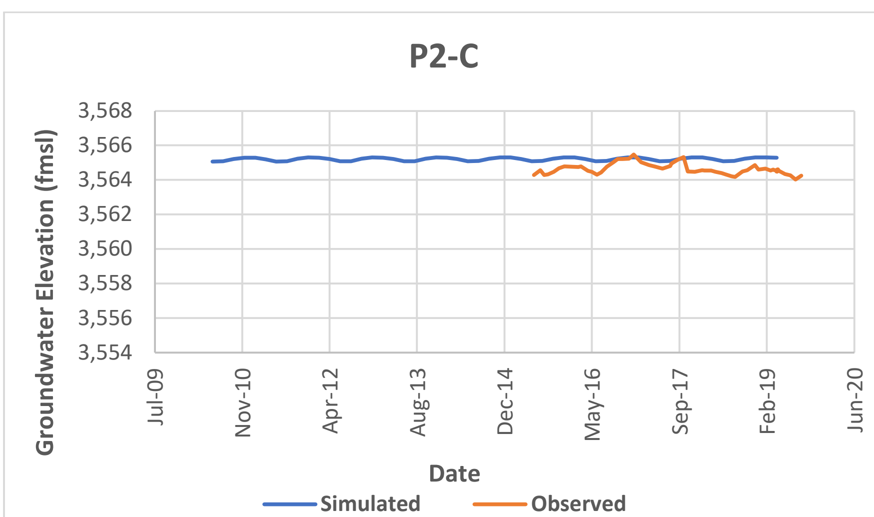

P4-B
Groundwater Elevation (fmsl)
3,617
3,615
3,613
3,611
3,609
3,607
3,605
3,603
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

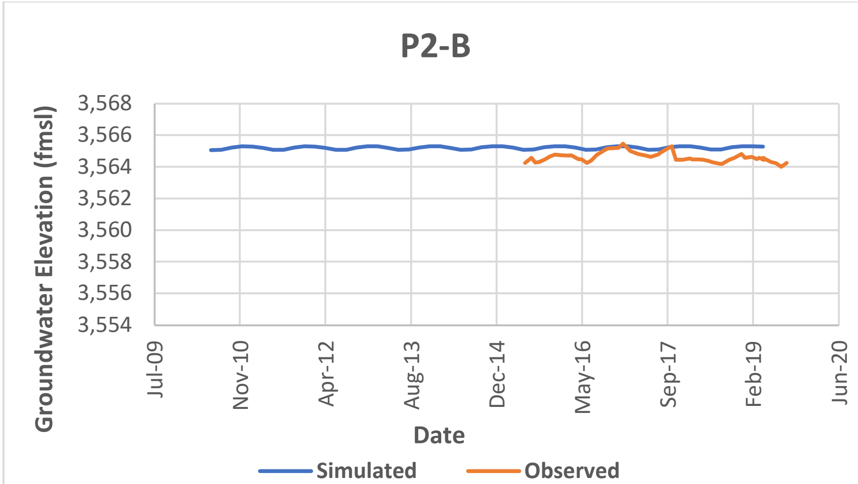

P4-A
Groundwater Elevation (fmsl)
3,625
3,623
3,621
3,619
3,617
3,615
3,613
3,611
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


P3-C
Groundwater Elevation (fmsl)
3,570
3,568
3,566
3,564
3,562
3,560
3,558
3,556
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

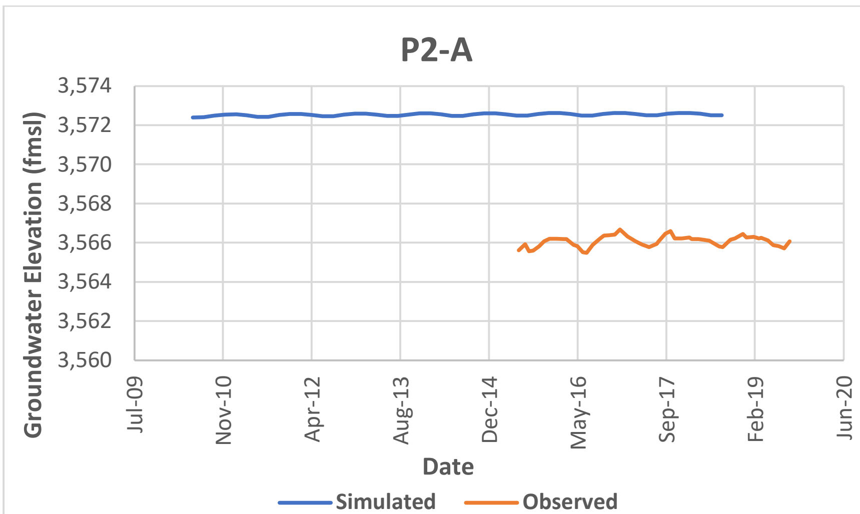

P3-B
3,570
3,568
3,566
3,564
3,562
3,560
3,558
3,556
Groundwater Elevation (msl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


P3-A
3,572
3,570
3,568
3,566
3,564
3,562
3,560
3,558
Groundwater Elevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

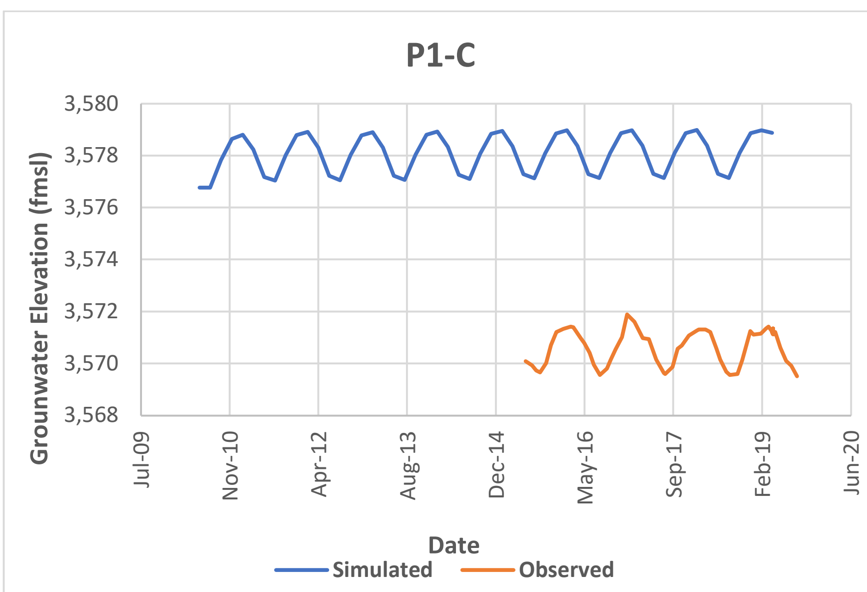

P2-C
3,568
3,566
3,564
3,562
3,560
3,558
3,556
3,554
Groundwater Elevation (fmsl)
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed



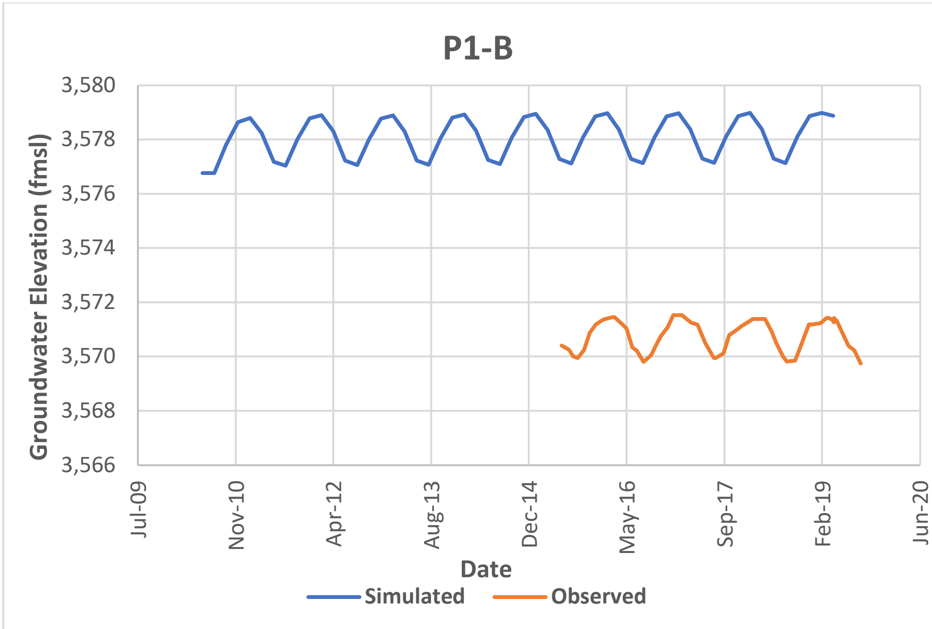
P2-B
Groundwater Elevation (fmsl)
3,568
3,566
3,564
3,562
3,560
3,558
3,556
3,554
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed



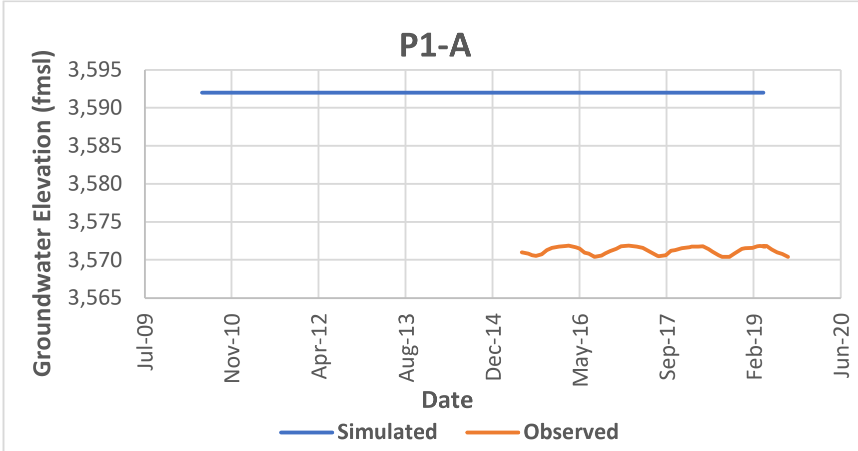
P2-A
Groundwater Elevation (fmsl)
3,574
3,572
3,570
3,568
3,566
3,564
3,562
3,560
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

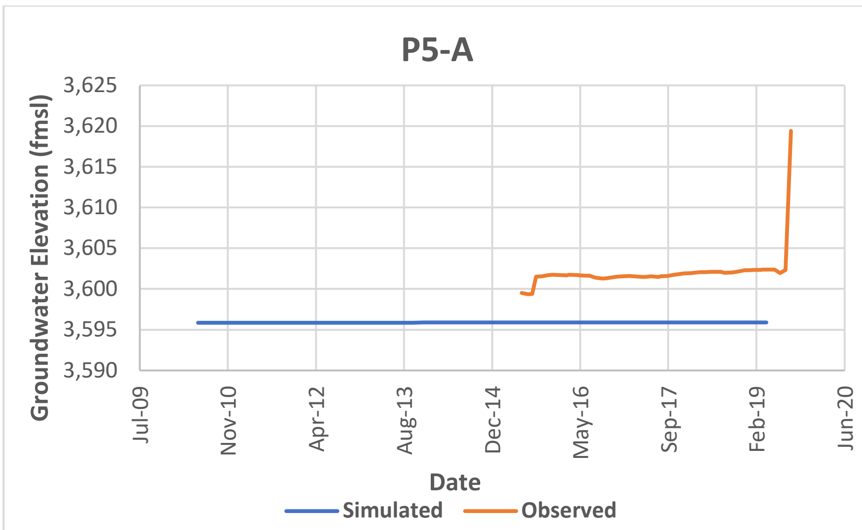


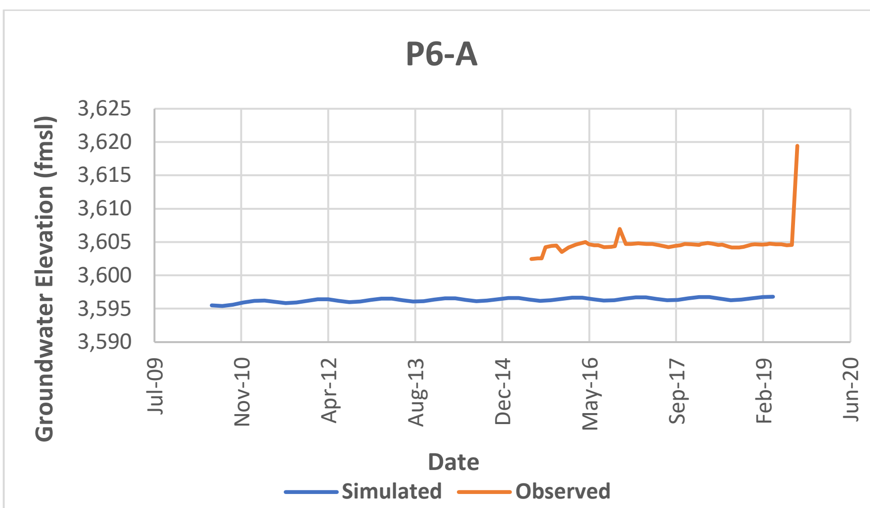
P1-C
Grounwater Elevation (fmsl)
3,580
3,578
3,576
3,574
3,572
3,570
3,568
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

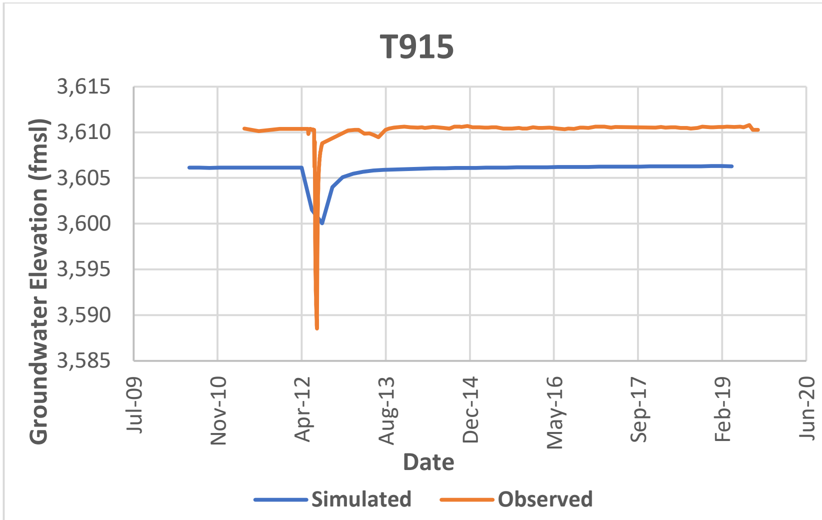

P1-B
Groundwater Elevation (fmsl)
3,580
3,578
3,576
3,574
3,572
3,570
3,568
3,566
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

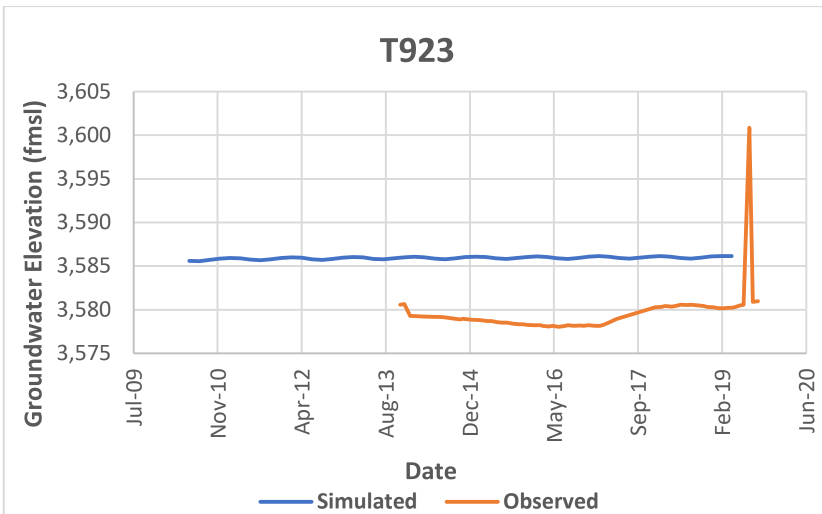
Graphs that have outliers/are not within 14 fmsl of groundwater elevation:

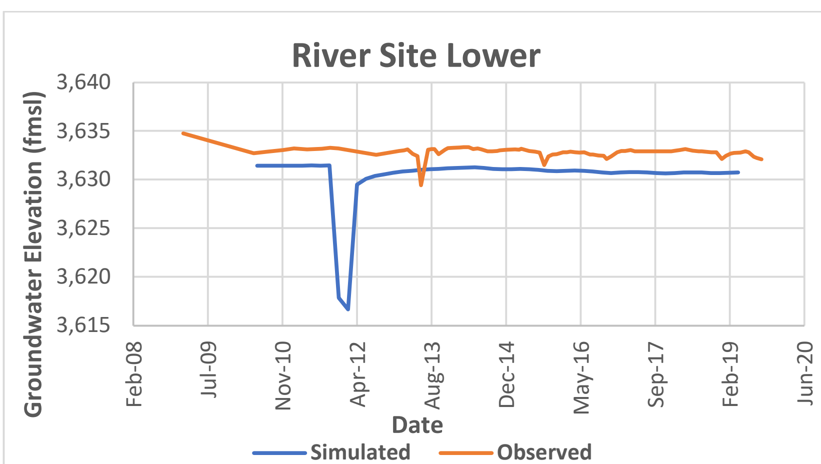


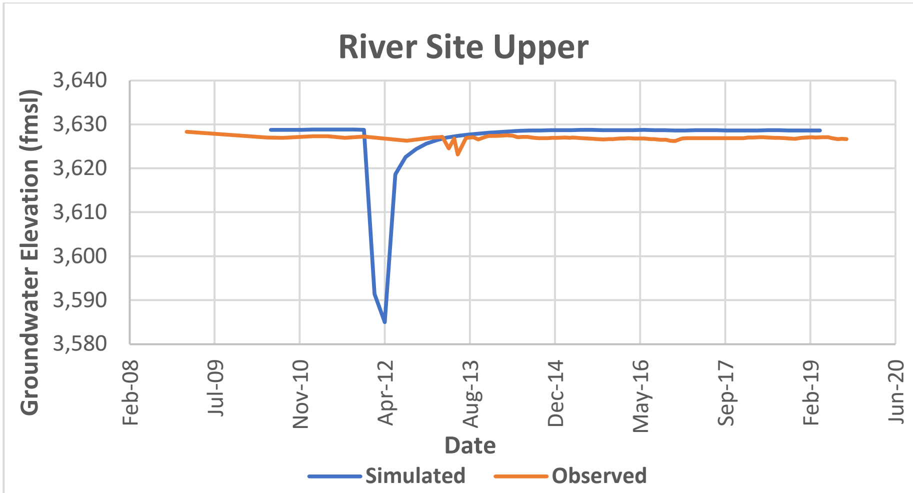


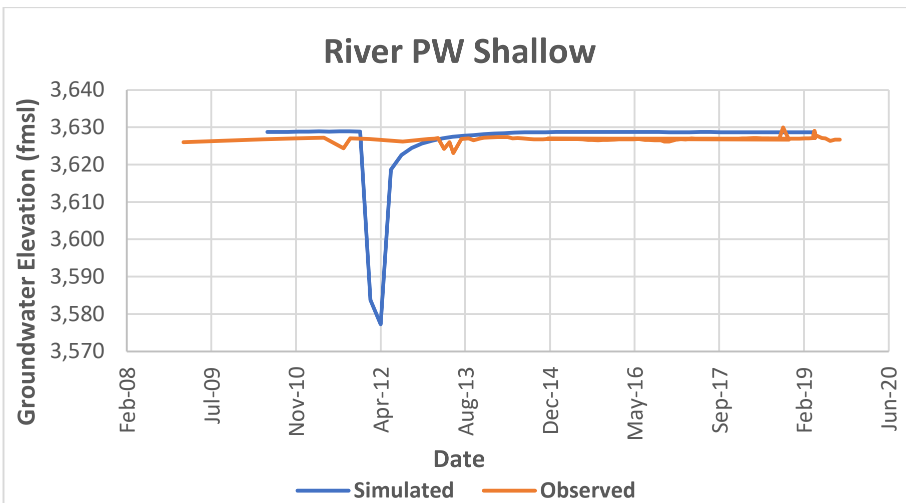


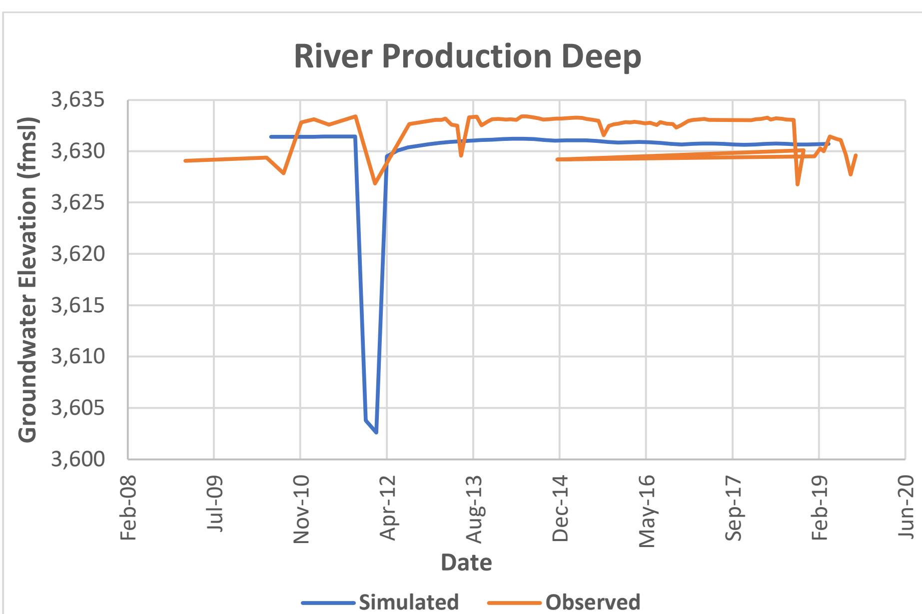

T915
Groundwater Elevation (fmsl)
3,615
3,610
3,605
3,600
3,595
3,590
3,585
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

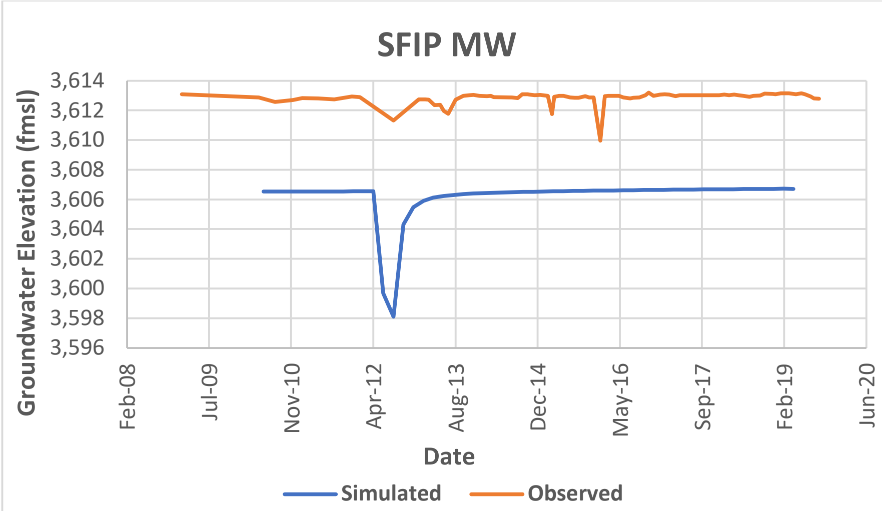

T923
Groundwater Elevation (fmsl)
3,605
3,600
3,595
3,590
3,585
3,580
3,575
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

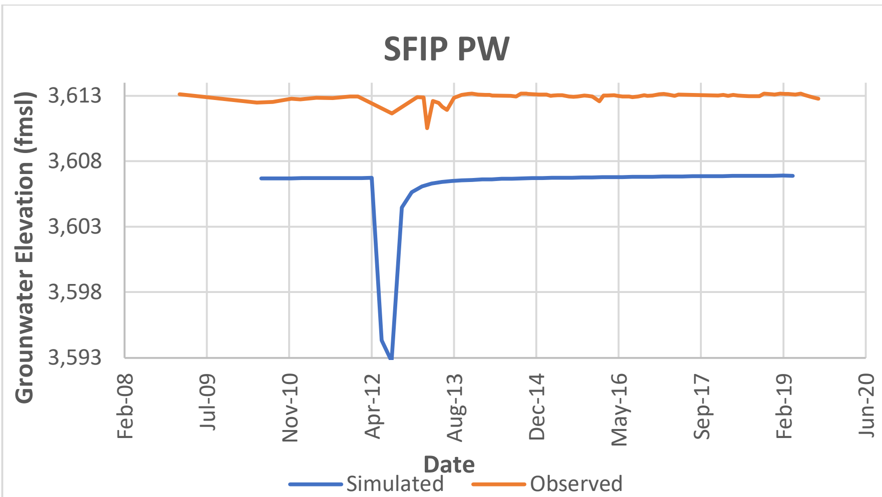

River Site Lower
Groundwater Elevation (fmsl)
3,640
3,635
3,630
3,625
3,620
3,615
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


River Site Upper
3,640
3,630
3,620
3,610
3,600
3,590
3,580
Groundwater Elevation (fmsl)
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


River PW Shallow
3,640
3,630
3,620
3,610
3,600
3,590
3,580
3,570
Groundwater Elevation (fmsl)
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


River Production Deep
3,635
3,630
3,625
3,620
3,615
3,610
3,605
3,600
Groundwater Elevation (fmsl)
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


SFIP MW
Groundwater Elevation (fmsl)
3,614
3,612
3,610
3,608
3,606
3,604
3,602
3,600
3,598
3,596
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed


SFIP PW
Grounwater Elevation (fmsl)
3,613
3,608
3,603
3,598
3,593
Feb-08
Jul-09
Nov-10
Apr-12
Aug-13
Dec-14
May-16
Sep-17
Feb-19
Jun-20
Date
Simulated
Observed

Appendix B

TM: Pumping Tests of Test Wells East and West, Owens Lake, California – Results and Recommendations

Note –Revised Testing Plan for Pumping Test of Testing Wells TW-E at Owens Lake is out for Public Review

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Appendix C

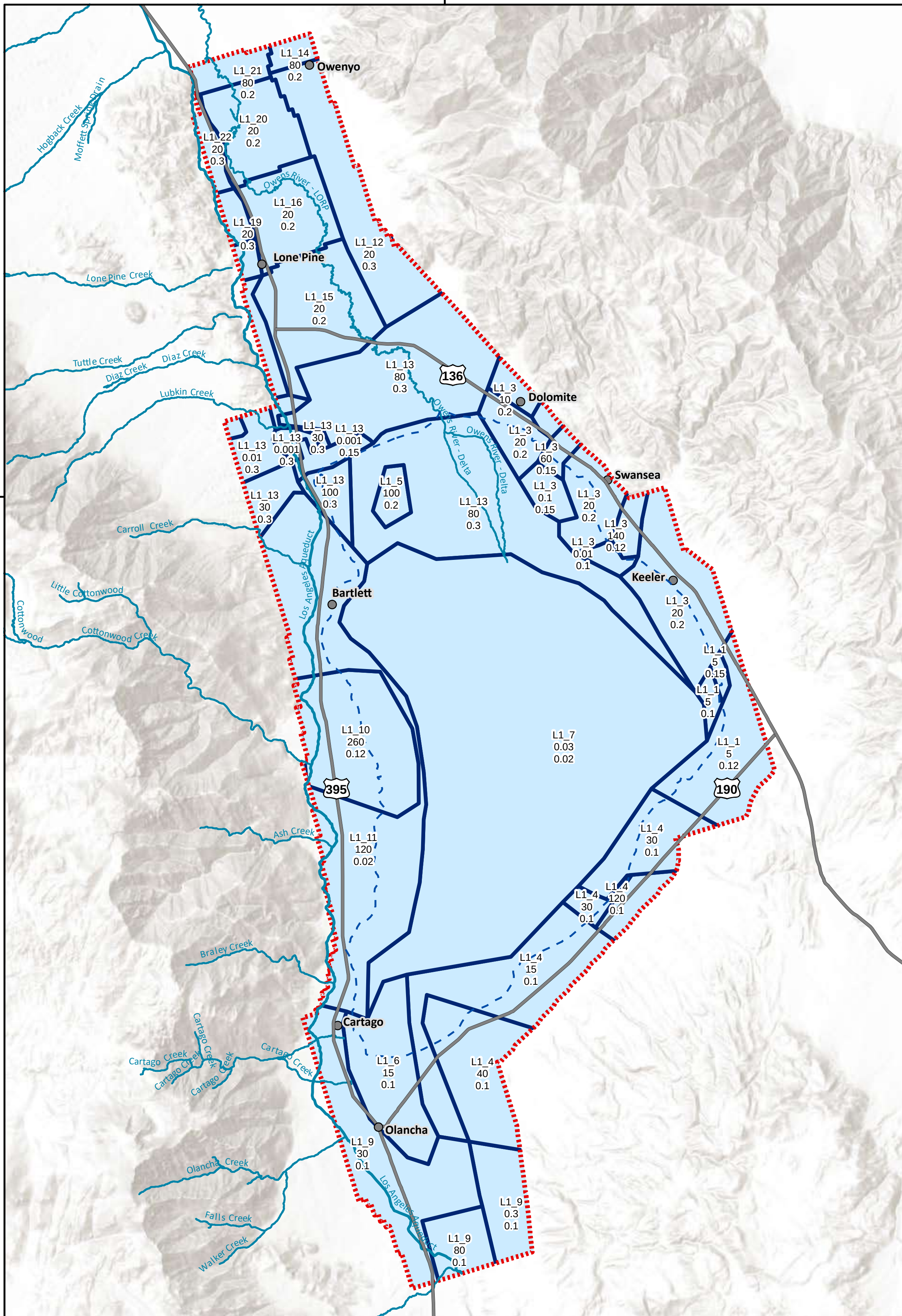
Table of Calibrated Model Layer Zone Properties and Model Parameter Zonation Maps (by Layer 1-13)

Table C-1: Calibrated Model Layer Zone Properties

Name	Kh (ft/d)	Ss (1/ft)	Sy (-)	Name	Kh (ft/d)	Ss (1/ft)	Sy (-)	Name	Kh (ft/d)	Ss (1/ft)	Sy (-)	Name	Kh (ft/d)	Ss (1/ft)	Sy (-)
L1_1	5	0.007	0.25	L2_27	100	0.0001	0.3	L4_26	60	1.00E-06	0.2	L8_12	2	1.00E-06	0.02
L1_2	5	0.0001	0.25	L2_28	0.001	0.0001	0.15	L4_27	8	1.00E-06	0.2	L8_13	0.1	2.50E-06	0.02
L1_3	5	0.0001	0.25	L2_29	80	0.0001	0.3	L5_1	30	0.00001	0.1	L8_14	250	0.0001	0.15
L1_4	20	0.0001	0.2	L2_30	0.1	0.0001	0.3	L5_2	2	0.00001	0.1	L8_15	0.02	1.00E-07	0.1
L1_5	140	0.00001	0.05	L2_31	20	0.0001	0.3	L5_3	2	0.00001	0.1	L8_16	0.001	1.00E-06	0.02
L1_6	120	0.0001	0.1	L2_32	30	0.0001	0.3	L5_4	7	0.0003	0.15	L8_17	3	0.0001	0.15
L1_7	30	0.0001	0.15	L2_33	80	0.0001	0.2	L5_5	0.0002	0.0001	0.01	L8_18	80	1.00E-07	0.12
L1_8	0.01	0.0001	0.1	L2_34	20	0.0001	0.2	L5_6	0.01	0.00001	0.1	L8_19	1	0.00001	0.12
L1_9	30	0.0001	0.1	L2_35	120	0.0001	0.02	L5_7	30	0.0001	0.15	L8_20	8	1.00E-06	0.02
L1_10	20	0.0001	0.2	L2_36	20	0.0001	0.2	L5_8	30	0.00001	0.1	L9_1	30	0.00001	0.1
L1_11	60	0.0001	0.15	L2_37	10	0.0001	0.3	L5_9	30	0.00001	0.15	L9_2	2	0.00001	0.1
L1_12	0.01	0.0001	0.2	L2_38	30	0.0001	0.3	L5_10	1	0.00001	0.15	L9_3	0.07	0.0001	0.01
L1_13	0.1	0.0001	0.15	L2_39	10	0.0001	0.3	L5_11	12	2.50E-06	0.1	L9_4	1.E-06	0.0001	0.01
L1_14	10	0.0001	0.2	L2_40	0.01	0.0001	0.3	L5_12	0.001	1.00E-06	0.02	L9_5	0.001	1.00E-06	0.1
L1_15	20	0.0001	0.2	L2_41	20	0.0001	0.3	L5_13	0.5	1.00E-06	0.1	L9_6	30	0.0001	0.15
L1_16	0.3	0.0001	0.1	L2_42	3	0.0001	0.3	L5_14	8	1.00E-06	0.02	L9_7	30	0.00001	0.1
L1_17	40	0.0001	0.1	L2_43	20	0.0001	0.2	L5_15	100	0.0001	0.15	L9_8	0.00005	1.00E-06	0.15
L1_18	80	0.0001	0.1	L2_44	80	0.0001	0.2	L5_16	2	1.00E-06	0.02	L9_9	0.00005	1.00E-07	0.03
L1_19	15	0.0001	0.1	L2_45	20	0.0001	0.3	L6_1	50	0.0001	0.12	L9_10	0.0001	1.00E-08	0.12
L1_20	100	0.0001	0.2	L3_1	10	0.0001	0.12	L6_2	5	0.0001	0.12	L9_11	1	0.00001	0.12
L1_21	80	0.0001	0.3	L3_2	0.01	0.0001	0.12	L6_3	50	0.0001	0.12	L9_12	0.00005	0.00001	0.12
L1_22	15	0.0001	0.05	L3_3	1	0.0001	0.1	L6_4	5	0.00001	0.1	L9_13	100	0.0001	0.15
L1_23	0.03	0.0001	0.02	L3_4	0.05	0.0001	0.12	L6_5	0.01	0.00001	0.12	L10_1	50	0.0001	0.12
L1_24	30	0.0001	0.1	L3_5	0.001	0.0005	0.02	L6_6	35	0.00008	0.12	L10_2	30	0.0001	0.1
L1_25	260	0.0001	0.05	L3_6	2	9.2E-06	0.02	L6_7	0.02	0.00002	0.15	L10_3	0.05	0.00005	0.15
L1_26	100	0.0001	0.3	L3_7	0.5	0.0005	0.05	L6_8	0.01	0.0001	0.15	L10_4	5	0.00001	0.15
L1_27	0.001	0.0001	0.15	L3_8	0.001	0.0005	0.02	L6_9	30	0.00001	0.12	L10_5	25	0.00001	0.12
L1_28	80	0.0001	0.3	L3_9	20	0.0005	0.02	L6_10	50	0.0001	0.15	L10_6	50	0.0001	0.15
L1_29	0.001	0.0001	0.3	L3_10	150	0.0001	0.12	L6_11	50	0.0001	0.1	L10_7	50	0.0001	0.1
L1_30	20	0.0001	0.3	L3_11	20	0.0001	0.1	L6_12	80	1.00E-06	0.12	L10_8	30	0.00001	0.15
L1_31	30	0.0001	0.3	L3_12	80	0.0001	0.12	L6_13	100	1.00E-07	0.12	L10_9	50	0.00001	0.12
L1_32	80	0.0001	0.2	L3_13	0.001	0.0005	0.02	L6_14	5	1.00E-06	0.12	L10_10	150	0.00001	0.12
L1_33	20	0.0001	0.2	L3_14	2	0.00001	0.1	L6_15	5	1.00E-07	0.12	L10_11	0.02	0.00001	0.12
L1_34	120	0.0001	0.02	L3_15	50	0.00001	0.2	L6_16	2	1.00E-06	0.02	L10_12	2	1.00E-09	0.02
L1_35	20	0.0001	0.2	L3_16	0.005	0.00001	0.2	L6_17	20	0.00001	0.12	L10_13	0.001	0.00001	0.12

Name	Kh (ft/d)	Ss (1/ft)	Sy (-)	Name	Kh (ft/d)	Ss (1/ft)	Sy (-)	Name	Kh (ft/d)	Ss (1/ft)	Sy (-)	Name	Kh (ft/d)	Ss (1/ft)	Sy (-)
L1_36	10	0.0001	0.3	L3_17	125	0.0001	0.12	L6_18	250	0.0001	0.15	L10_14	0.00001	1.00E-09	0.02
L1_37	30	0.0001	0.3	L3_18	20	0.00001	0.2	L6_19	0.2	1.00E-07	0.12	L10_15	250	0.0001	0.15
L1_38	50	0.0001	0.3	L3_19	0.01	1.0E-07	0.12	L6_20	0.001	1.00E-06	0.02	L10_16	0.02	1.00E-09	0.02
L1_39	0.01	0.0001	0.3	L3_20	0.6	0.00001	0.2	L6_21	3	0.0001	0.15	L10_17	2	0.00001	0.18
L1_40	20	0.0001	0.3	L3_21	12	2.5E-06	0.1	L6_22	0.5	1.00E-07	0.12	L11_1	20	0.0001	0.15
L1_41	3	0.0001	0.3	L3_22	3	0.00001	0.15	L6_23	40	1.00E-06	0.12	L11_2	20	0.00001	0.05
L1_42	20	0.0001	0.2	L3_23	0.001	1.0E-06	0.1	L6_24	8	1.00E-06	0.02	L11_3	0.0001	0.0001	0.02
L1_43	80	0.0001	0.2	L3_24	1	0.00001	0.2	L7_1	30	0.00001	0.1	L11_4	25	0.00001	0.12
L1_44	20	0.0001	0.3	L3_25	40	0.00001	0.2	L7_2	2	0.00001	0.1	L11_5	10	0.00001	0.02
L2_1	150	0.0001	0.12	L3_26	20	0.00001	0.2	L7_3	2	1.00E-06	0.1	L11_6	5	0.00001	0.02
L2_2	140	0.007	0.25	L4_1	0.1	0.0001	0.12	L7_4	0.00008	0.0001	0.01	L11_7	0.05	1.00E-07	0.12
L2_3	70	0.007	0.25	L4_2	15	0.0001	0.1	L7_5	5	0.00001	0.15	L11_8	1.E-06	1.00E-09	0.02
L2_4	5	0.007	0.25	L4_3	100	0.0001	0.12	L7_6	1.5	1.00E-06	0.1	L11_9	0.05	1.00E-07	0.02
L2_5	20	0.0001	0.2	L4_4	5	0.00001	0.12	L7_7	2.5	0.00035	0.01	L11_10	0.0002	1.00E-09	0.02
L2_6	140	0.00001	0.05	L4_5	0.2	0.0001	0.15	L7_8	2	1.00E-06	0.1	L11_11	15	0.00001	0.05
L2_7	150	0.0001	0.1	L4_6	90	0.00001	0.2	L7_9	30	0.0001	0.15	L12_1	0.05	0.00001	0.05
L2_8	30	0.007	0.1	L4_7	0.001	0.0001	0.15	L7_10	30	0.00001	0.1	L12_2	1	0.00001	0.05
L2_9	0.01	0.0001	0.1	L4_8	22	0.00001	0.2	L7_11	5	0.00001	0.12	L12_3	10	0.00001	0.05
L2_10	30	0.0001	0.1	L4_9	80	0.00001	0.2	L7_12	12	2.50E-06	0.02	L12_4	0.8	1.00E-06	0.05
L2_11	20	0.0001	0.2	L4_10	0.5	0.0005	0.15	L7_13	0.001	1.00E-06	0.02	L12_5	80	0.00001	0.05
L2_12	60	0.0001	0.15	L4_11	0.5	0.00001	0.12	L7_14	1	0.0001	0.12	L12_6	2	0.00001	0.05
L2_13	0.01	0.0001	0.2	L4_12	0.01	0.0001	0.15	L7_15	8	1.00E-06	0.02	L12_7	20	0.00001	0.05
L2_14	0.1	0.0001	0.15	L4_13	20	1.0E-07	0.12	L7_16	100	0.0001	0.15	L12_8	15	1.00E-10	0.05
L2_15	10	0.0001	0.2	L4_14	120	0.0001	0.15	L7_17	2	1.00E-06	0.02	L12_9	0.01	0.00001	0.02
L2_16	20	0.0001	0.2	L4_15	30	0.0001	0.1	L8_1	50	0.0001	0.12	L12_10	0.002	1.00E-09	0.02
L2_17	0.3	0.0001	0.1	L4_16	2	0.00001	0.2	L8_2	30	0.000032	0.12	L12_11	5	0.00001	0.05
L2_18	40	0.0001	0.1	L4_17	7	0.00005	0.2	L8_3	5	0.0001	0.12	L12_12	25	0.00001	0.05
L2_19	120	0.0001	0.1	L4_18	10	1.0E-07	0.2	L8_4	50	0.0001	0.1	L12_13	5	0.00001	0.05
L2_20	15	0.0001	0.1	L4_19	2	5.0E-06	0.2	L8_5	7	3.00E-06	0.12	L13_1	80	0.00001	0.05
L2_21	100	0.0001	0.2	L4_20	12	2.5E-06	0.1	L8_6	7	0.0001	0.12	L13_2	20	0.00001	0.05
L2_22	80	0.0001	0.3	L4_21	80	0.0001	0.15	L8_7	0.07	1.00E-07	0.12	L13_3	0.02	1.00E-09	0.02
L2_23	5	1.0E-06	0.05	L4_22	0.2	1.0E-07	0.12	L8_8	50	0.0001	0.15	L13_4	25	0.00001	0.05
L2_24	0.03	0.0001	0.02	L4_23	0.001	1.0E-06	0.1	L8_9	50	0.0001	0.1	L13_5	0.0002	1.00E-09	0.02
L2_25	30	0.0001	0.1	L4_24	3	0.0001	0.15	L8_10	40	0.00001	0.12	L13_6	25	1.00E-10	0.05
L2_26	280	0.0001	0.12	L4_25	120	1.0E-06	0.2	L8_11	2	0.00001	0.12	L13_7	3	1.00E-09	0.02

Figure 3-1 to 3-13



Layer # - Zone #

L2-9
80
0.1

Horizontal Hydraulic Conductivity (ft/day)

Specific Yield (-)

Towns

2019 Model Domain

Regulatory Shoreline

N

0 1 2 Miles

Layer 1
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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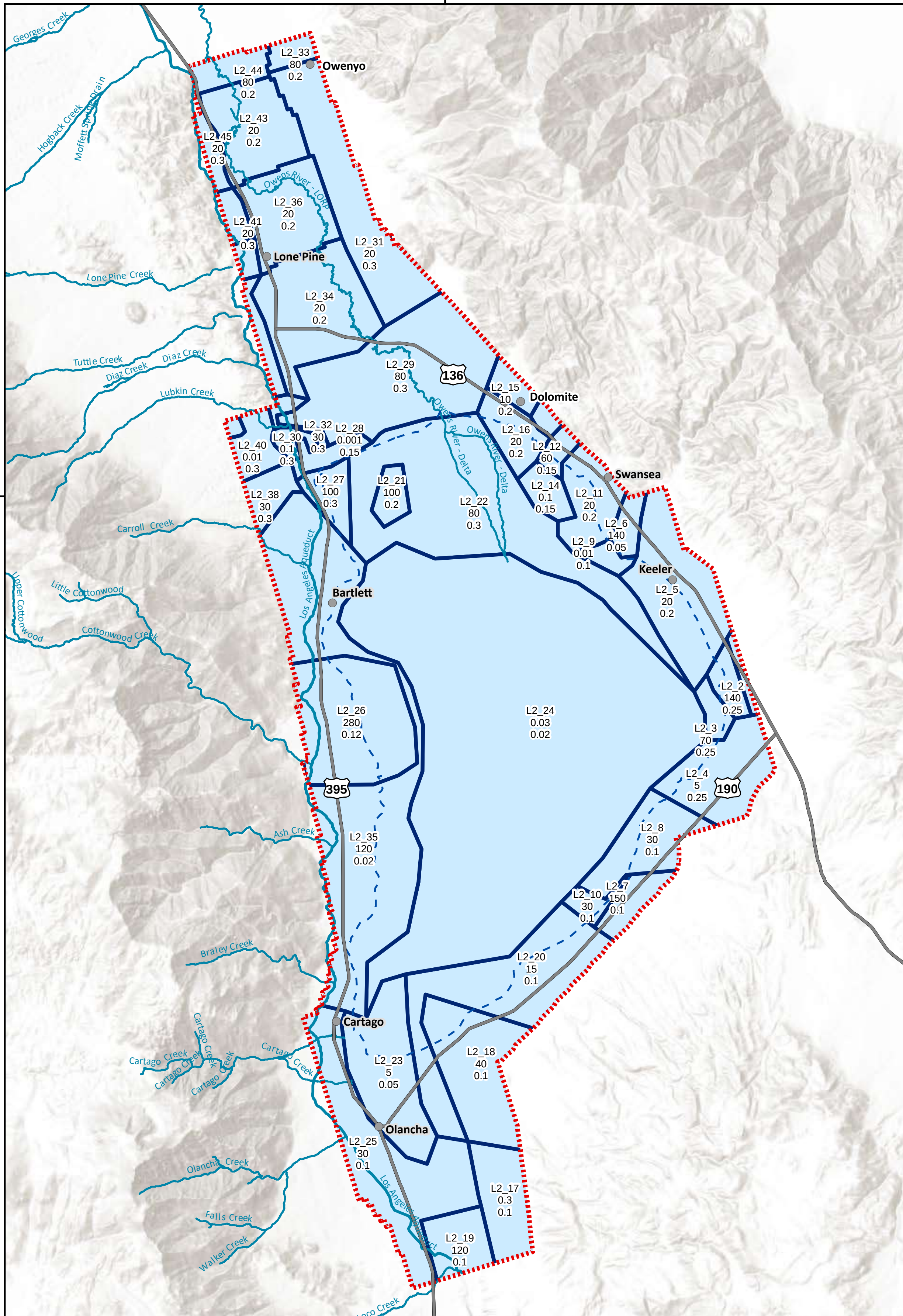

Layer # - Zone #

L2-9
80
0.1

Horizontal Hydraulic Conductivity (ft/day)

Specific Yield (-)

Towns

2019 Model Domain

Regulatory Shoreline

N

0 1 2 Miles

Layer 2
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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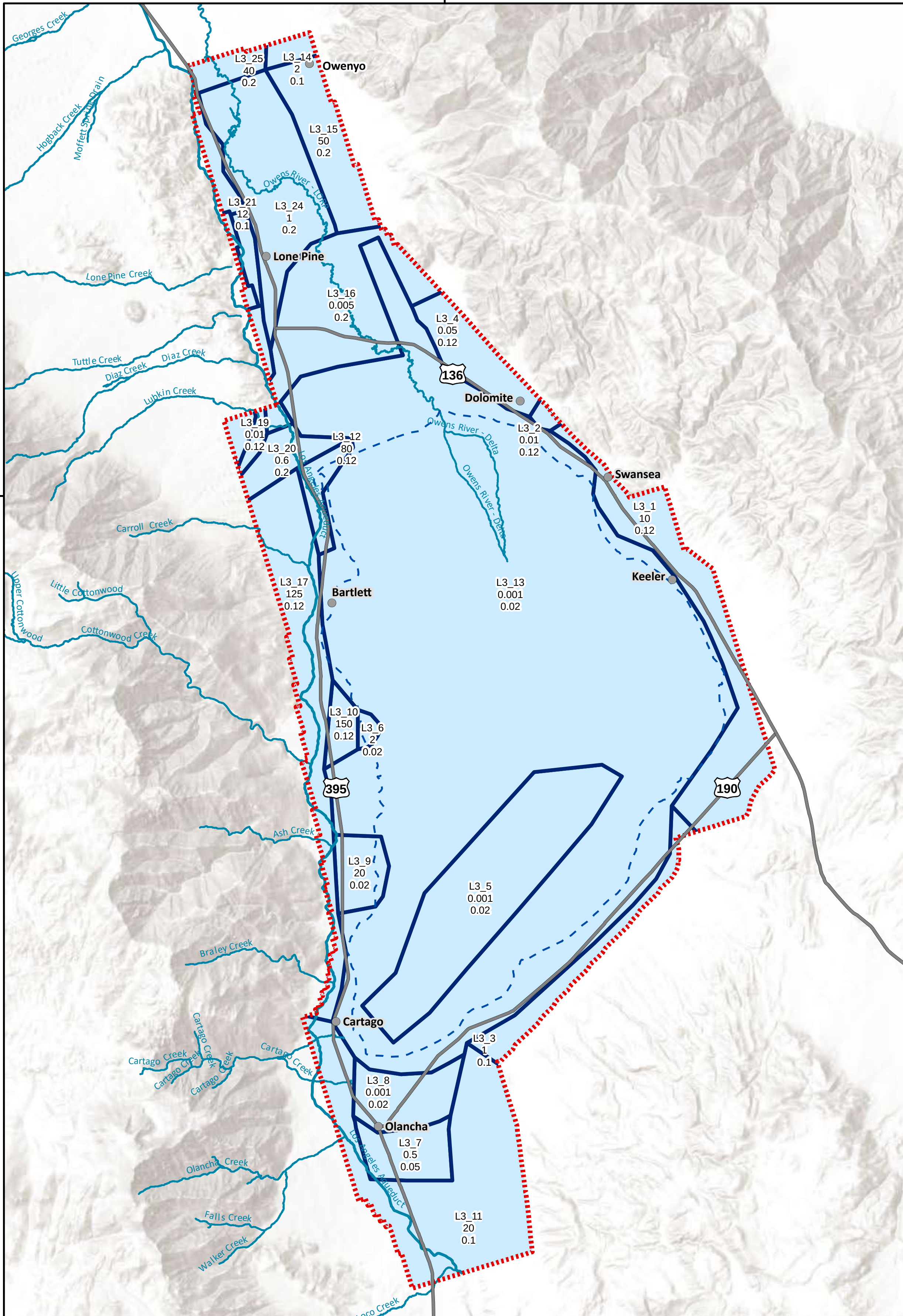

Layer # - Zone #

L2-9 80 0.1	Horizontal Hydraulic Conductivity (ft/day) Specific Yield (-)

- Towns
- 2019 Model Domain
- Regulatory Shoreline

N

0 1 2 Miles

Layer 3
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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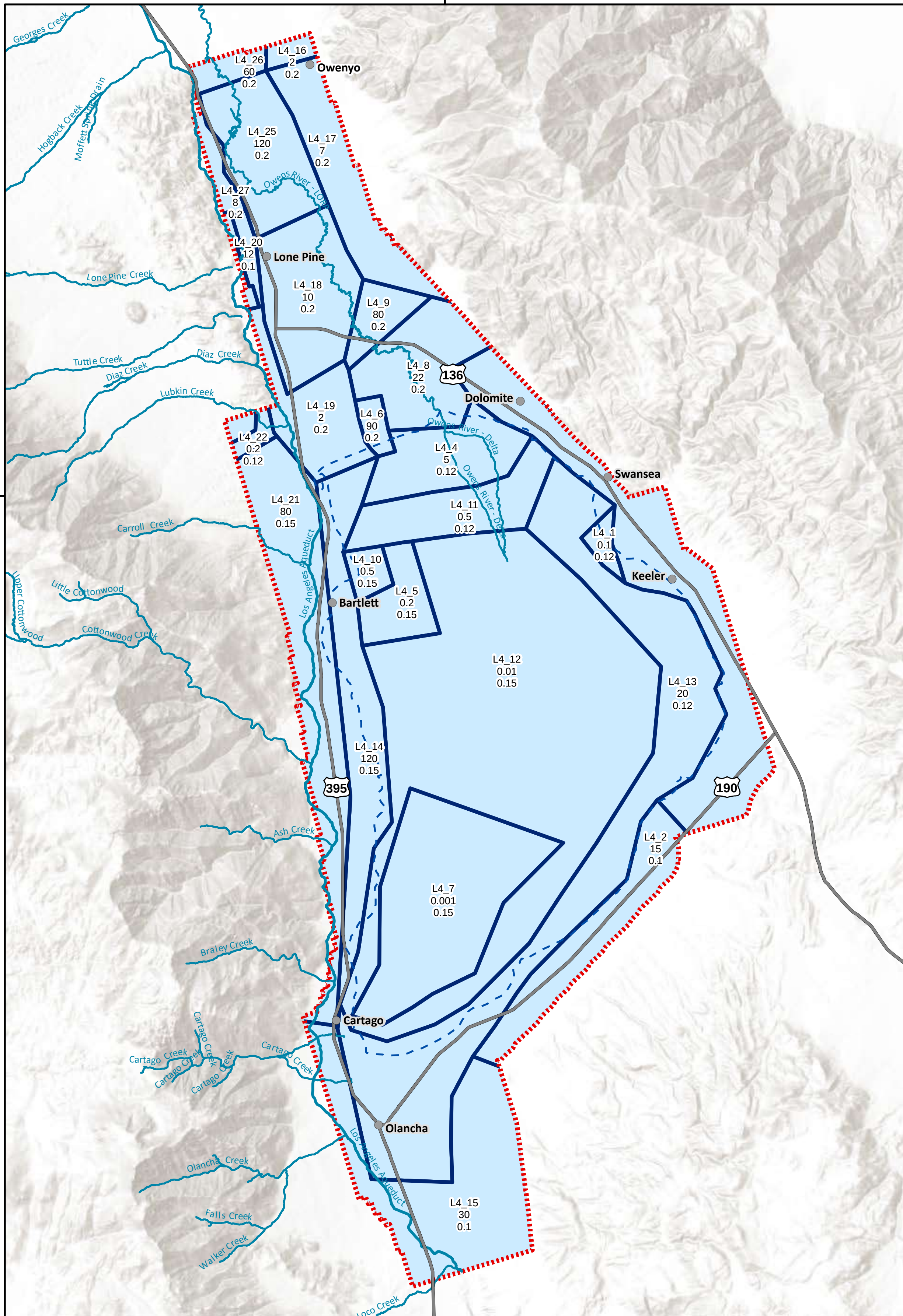

Layer # - Zone #

L2-9
80
0.1

Horizontal Hydraulic Conductivity (ft/day)

Specific Yield (-)

Towns

2019 Model Domain

Regulatory Shoreline

N

0 1 2 Miles

Layer 4
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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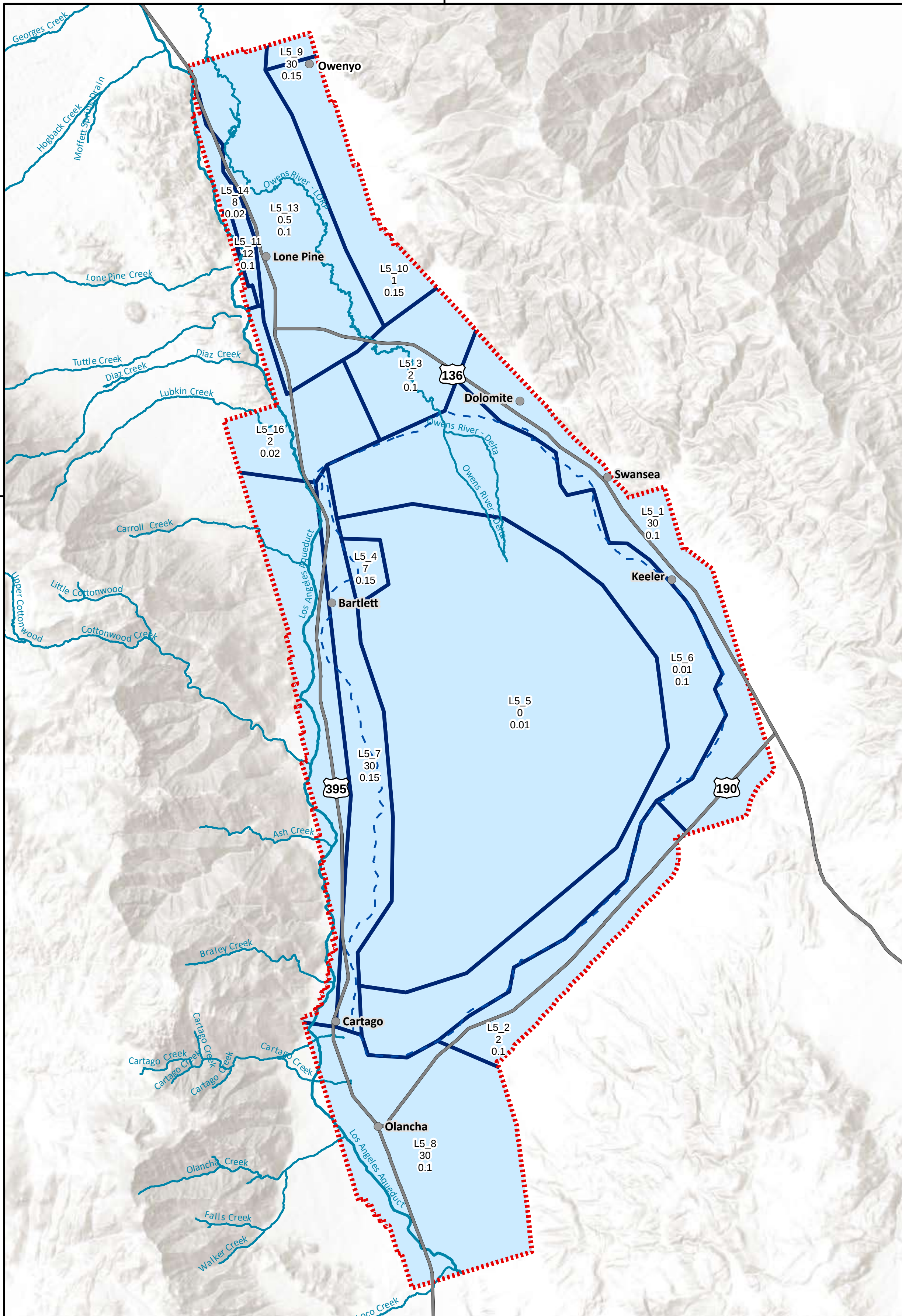

Layer # - Zone #

L2-9	Horizontal Hydraulic Conductivity (ft/day)
80	
0.1	Specific Yield (-)

- Towns
- 2019 Model Domain
- Regulatory Shoreline

N

0 1 2 Miles

Layer 5
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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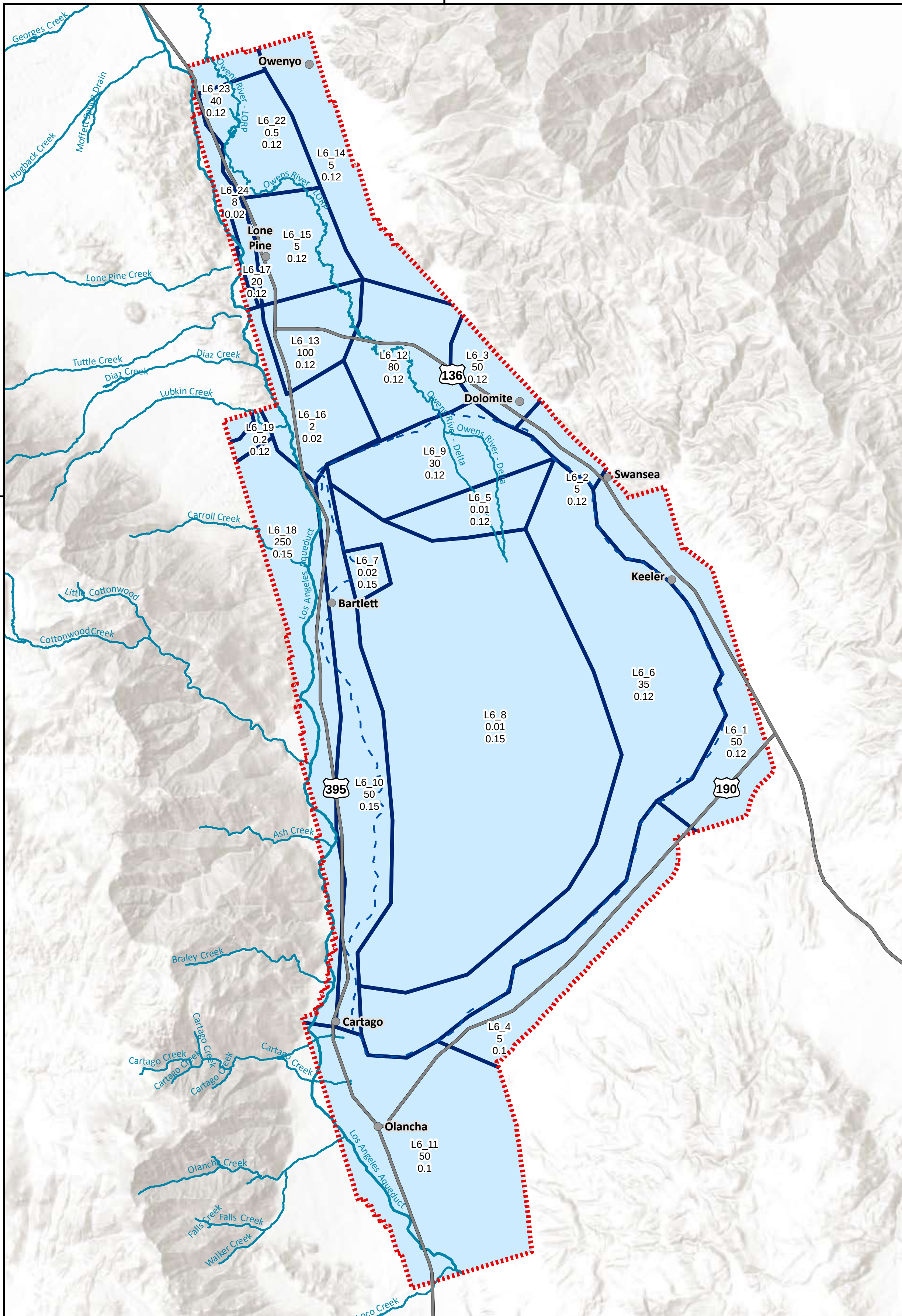

Layer # - Zone #

L2-9
80
0.1

Horizontal Hydraulic Conductivity (ft/day)

Specific Yield (-)

Towns

2019 Model Domain

Regulatory Shoreline

N

0 1 2 Miles

Layer 6
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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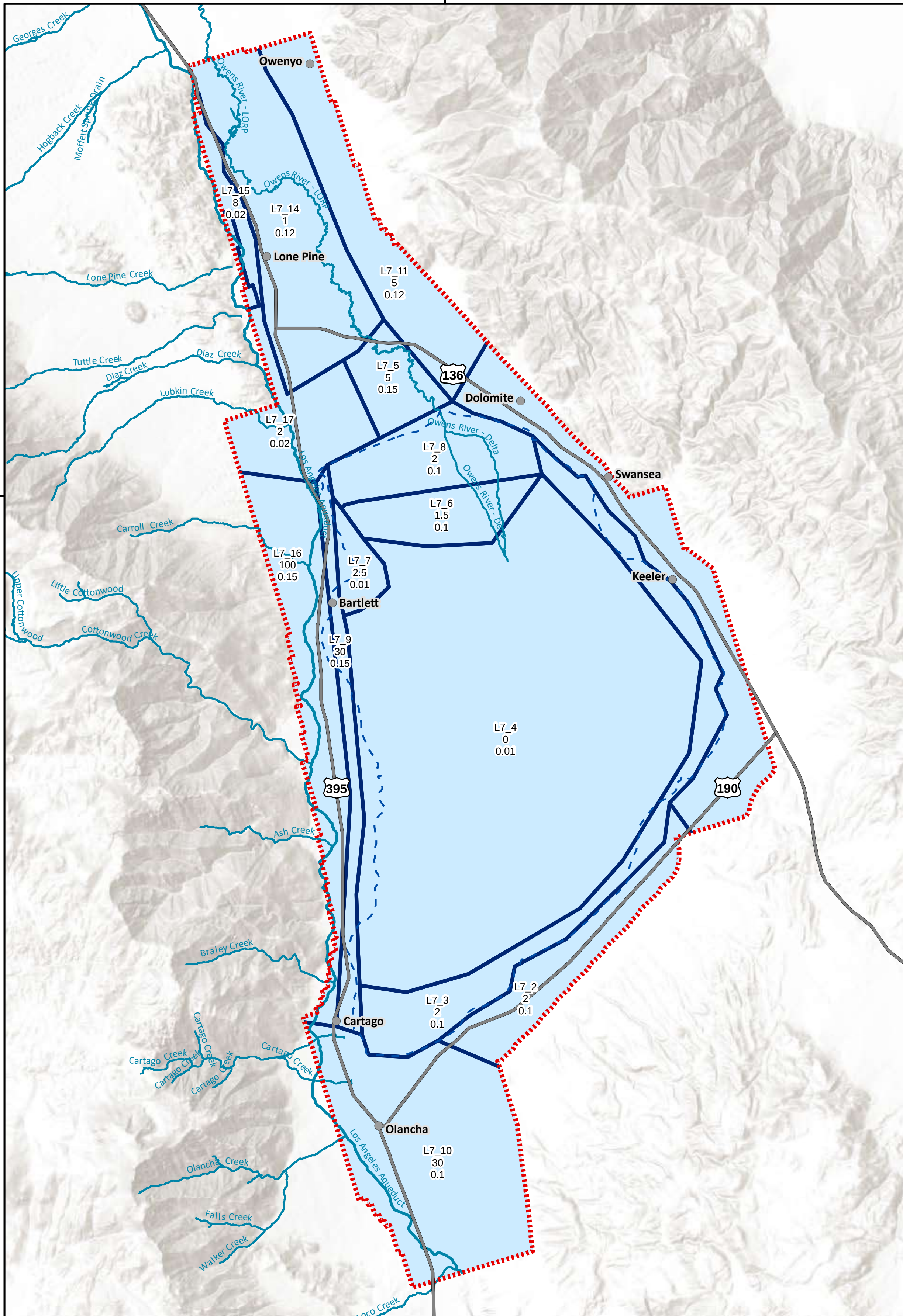

Layer # - Zone #

L2-9
80
0.1

Horizontal Hydraulic Conductivity (ft/day)

Specific Yield (-)

Towns

2019 Model Domain

Regulatory Shoreline

N

0 1 2
Miles

Layer 7
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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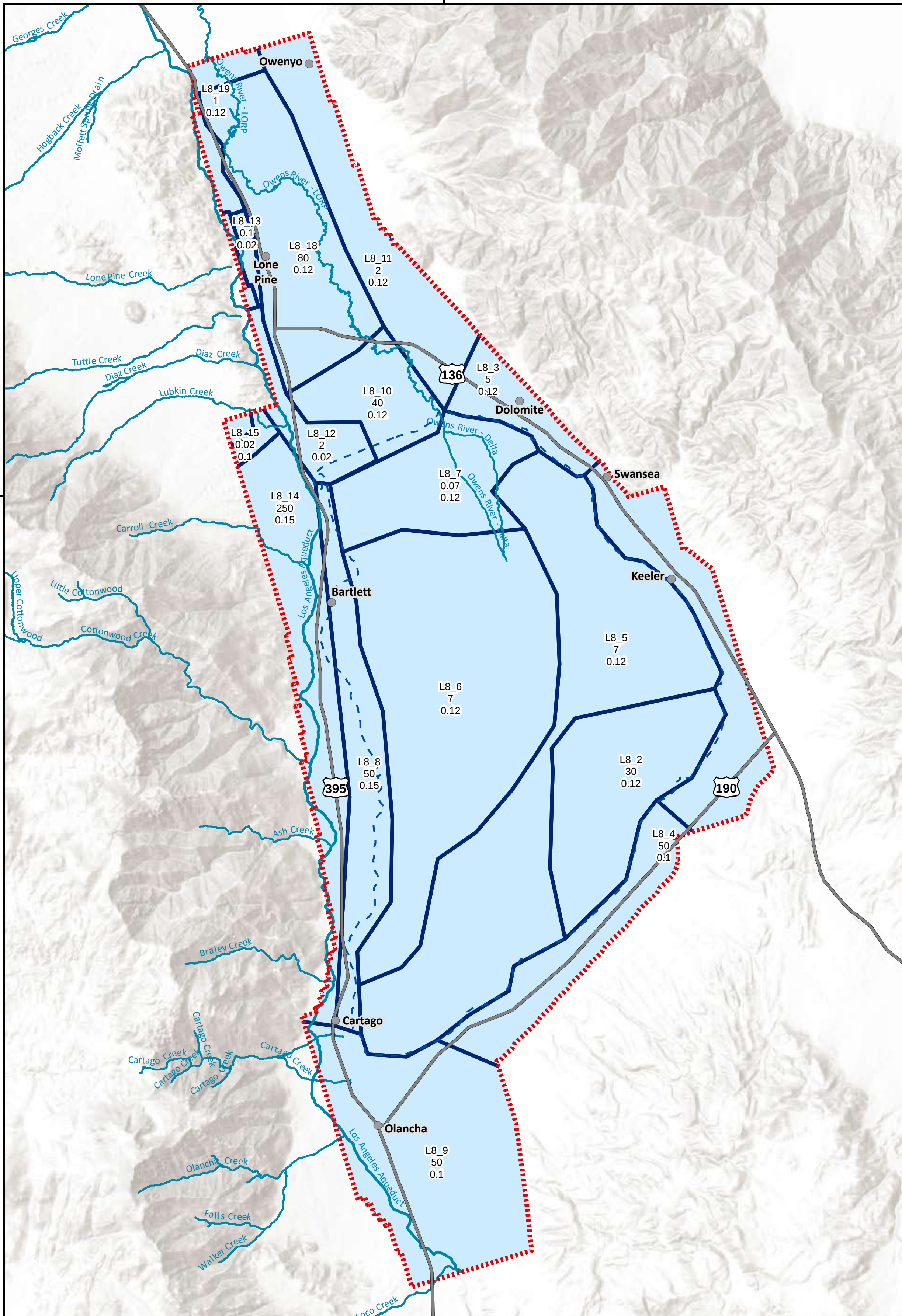

Layer # - Zone #

L2-9	
80	Horizontal Hydraulic Conductivity (ft/day)
0.1	Specific Yield (-)

- Towns
- 2019 Model Domain
- Regulatory Shoreline

N

0 1 2 Miles

Layer 8
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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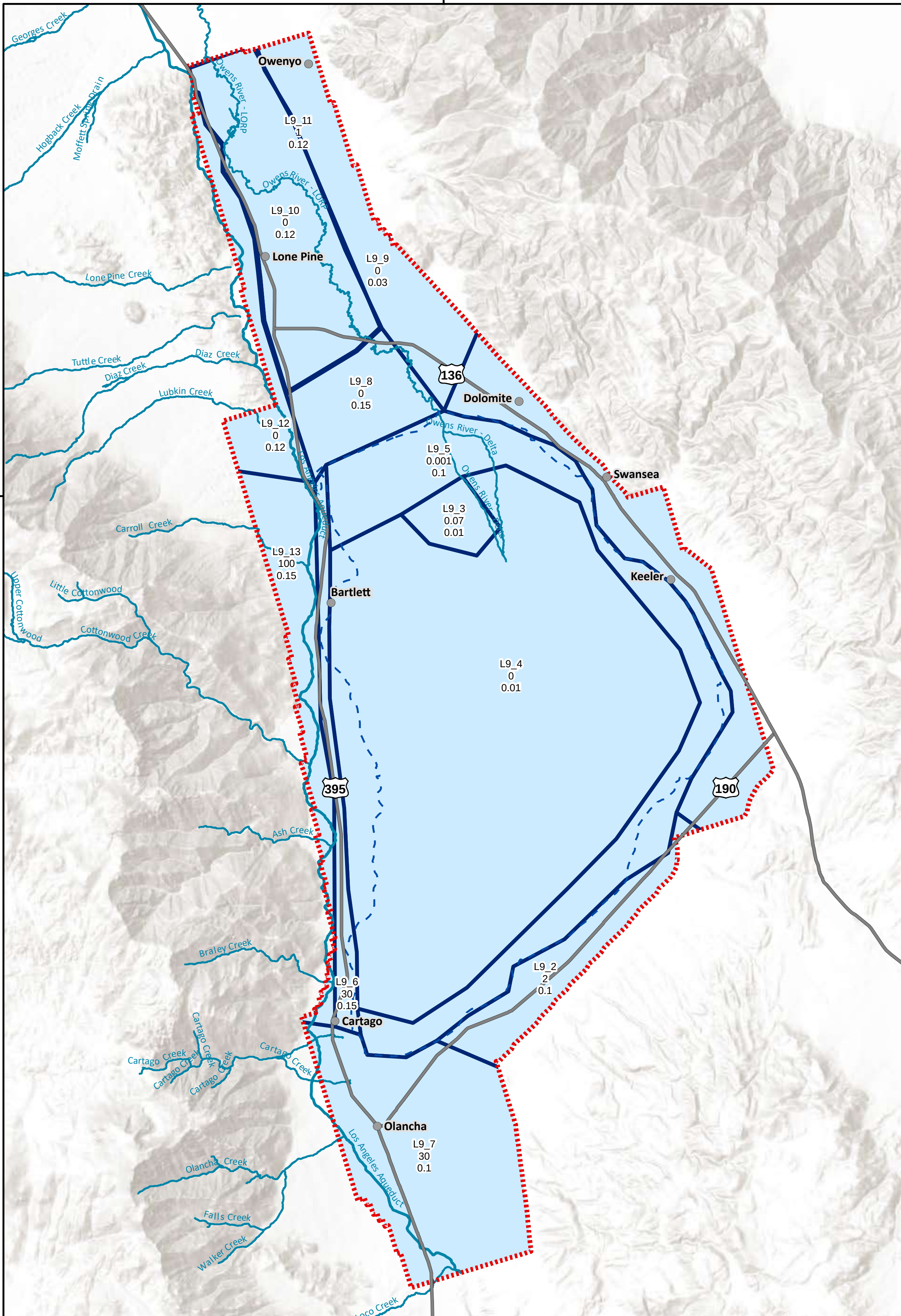

Layer # - Zone #

L2-9	Horizontal Hydraulic Conductivity (ft/day)
80	
0.1	Specific Yield (-)

- Towns
- 2019 Model Domain
- Regulatory Shoreline

N

0 1 2 Miles

Layer 9
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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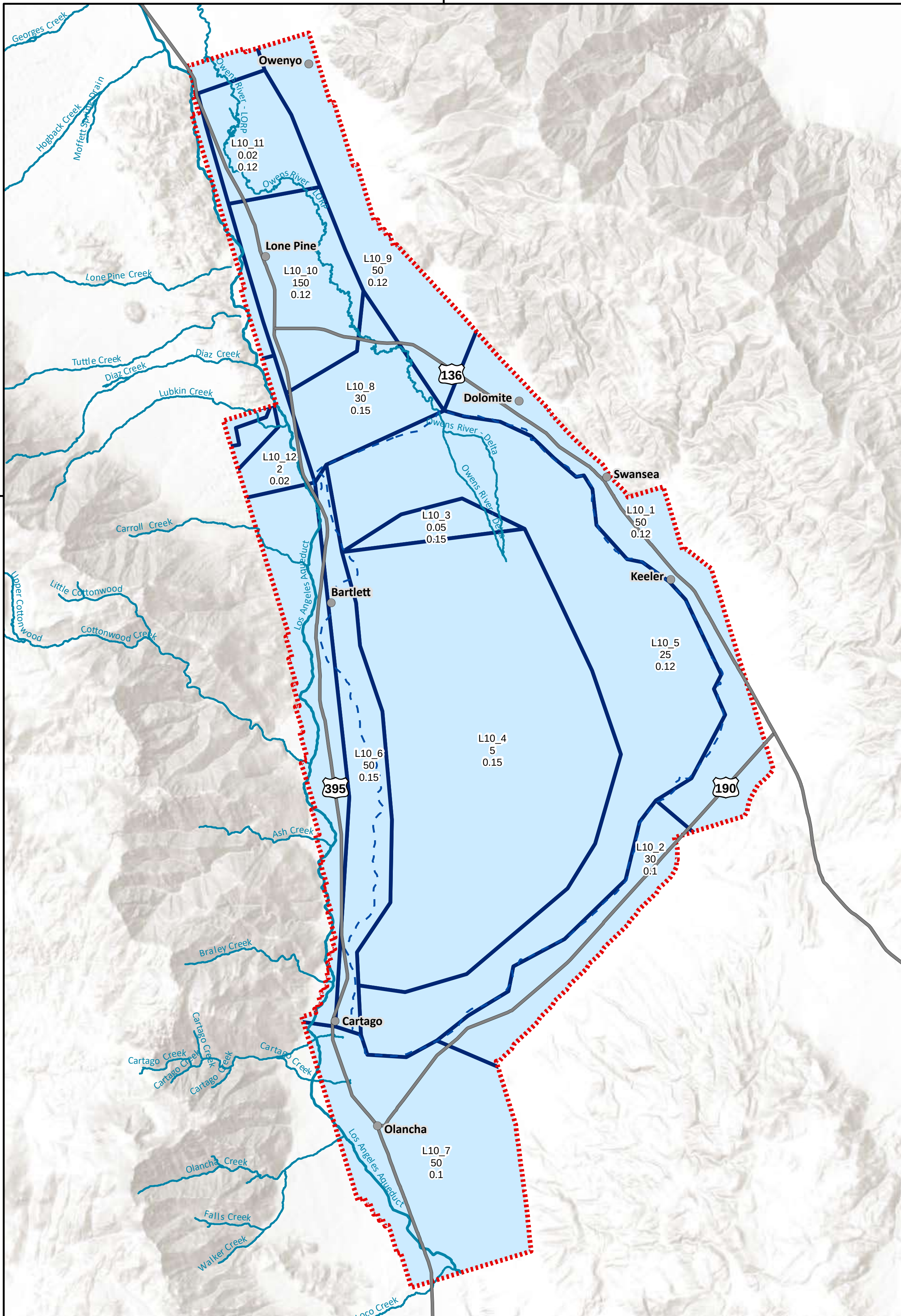

Layer # - Zone #

L2-9	Horizontal Hydraulic Conductivity (ft/day)
80	
0.1	Specific Yield (-)

- Towns
- 2019 Model Domain
- Regulatory Shoreline

Layer 10
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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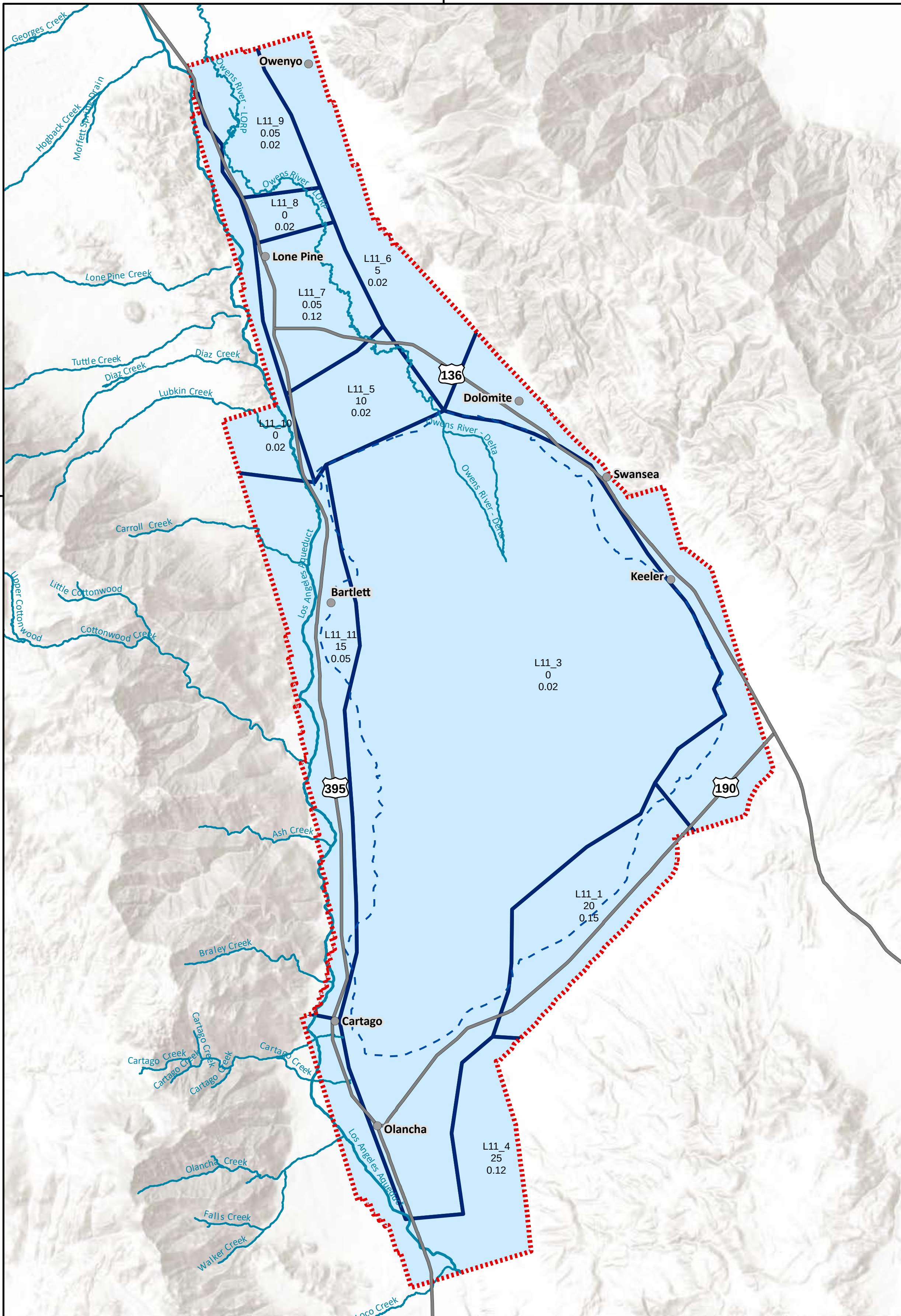

Layer # - Zone #

L2-9
80
0.1

Horizontal Hydraulic Conductivity (ft/day)

Specific Yield (-)

Towns

2019 Model Domain

Regulatory Shoreline

N

0 1 2 Miles

Layer 11
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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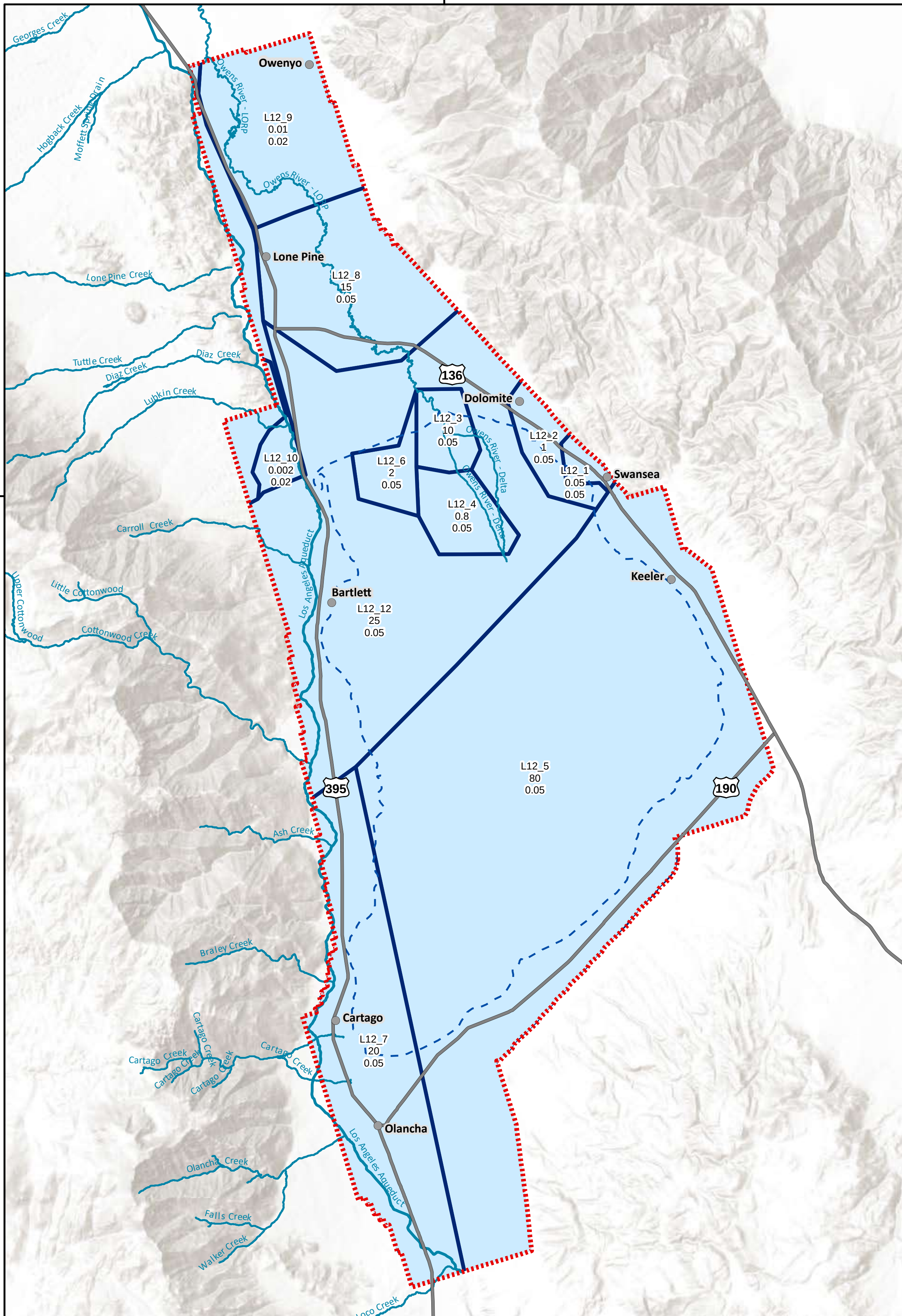

Layer # - Zone #

L2-9
80
0.1

Horizontal Hydraulic Conductivity (ft/day)

Specific Yield (-)

Towns

2019 Model Domain

Regulatory Shoreline

N

0 1 2 Miles

Layer 12
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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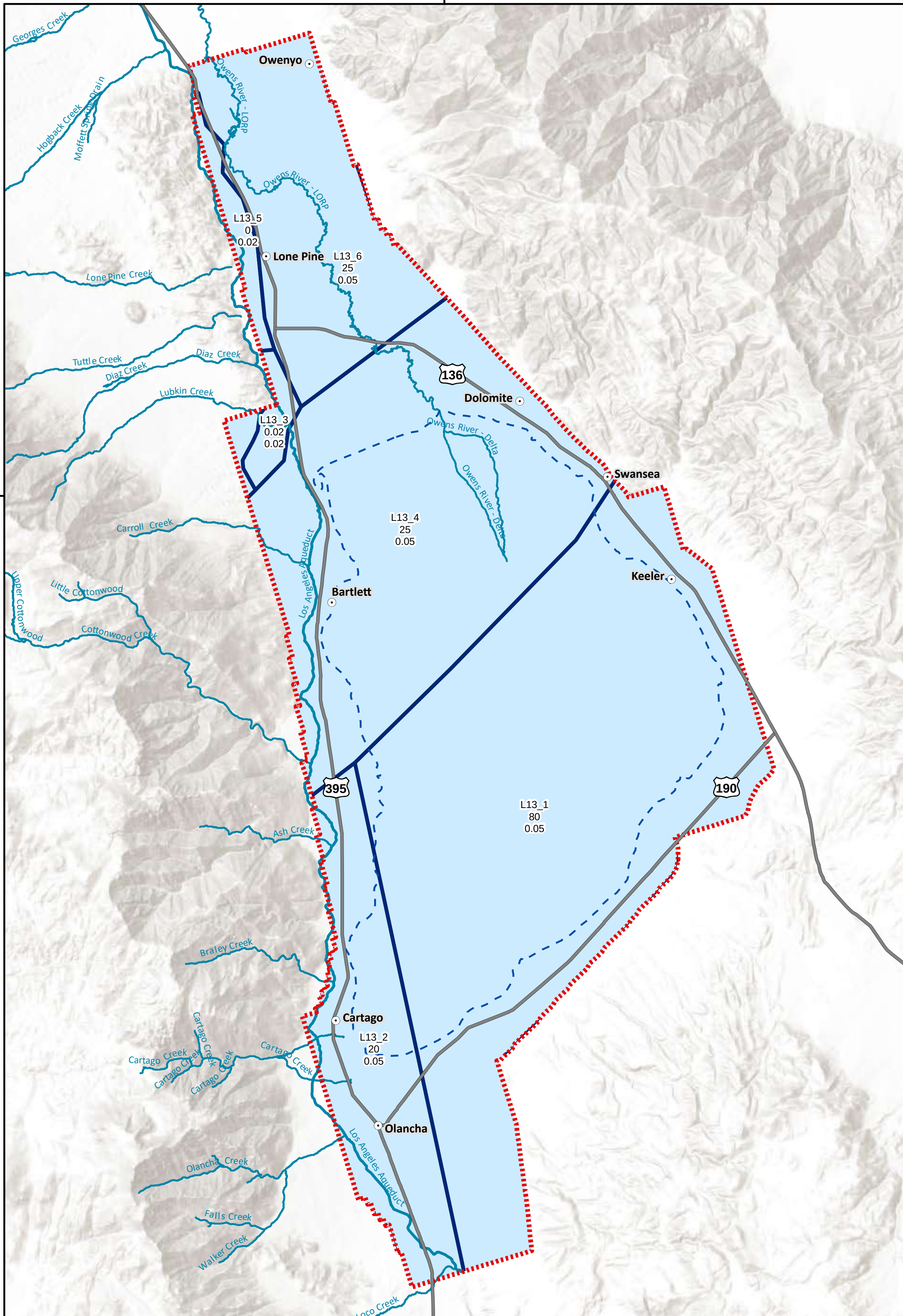

Layer # - Zone #

L2-9
80
0.1

Horizontal Hydraulic Conductivity (ft/day)

Specific Yield (-)

Towns

2019 Model Domain

Regulatory Shoreline

N

0 1 2 Miles

Layer 13
Model Parameter Zonation Map
Hydraulic Conductivity and Storage Coefficient

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Appendix D

Table of Calibration Wells and Summary of Transient Calibration Head Residuals

Well ID	Easting (m)	Northing (m)	Ground Surface Elevation (ft)	Well Depth (ft)	Top of Perforated Interval (ft bgs)	Bottom of Perforated Interval (ft bgs)	Model Layer	Maximum Residual (ft)	Minimum Residual (ft)	Mean Residual (ft)
P1-A	407934.423	4040957.32	3571.8	33	29.5	31.5	3	21.59	20.12	20.75
P1-B	407934.423	4040957.32	3571.8	13.9	10.5	12	1	8.17	6.71	7.40
P1-C	407934.423	4040957.32	3571.8	9.2	5	6	1	8.43	6.69	7.57
P2-A	409408.081	4032138.39	3566.014	33.1	29.5	31.5	3	7.03	5.92	6.48
P2-B	409408.081	4032138.39	3566.014	13.3	10.5	12	1	0.97	-0.21	0.57
P2-C	409408.081	4032138.39	3566.014	8.32	5	6	1	0.97	-0.22	0.54
P3-A	409743.701	4026119.91	3566.435	34.4	30	32	3	4.81	2.32	3.54
P3-B	409743.701	4026119.91	3566.435	13	10.5	12	1	2.50	0.53	1.53
P3-C	409743.701	4026119.91	3566.435	7.95	5	6	1	2.42	0.45	1.44
P4-A	410760.596	4016994.17	3615.71	34	30.5	32.5	2	-6.41	-10.42	-8.90
P4-B	410760.596	4016994.17	3615.71	13.2	10.5	12	1	0.98	-1.17	0.19
P4-C	410760.596	4016994.17	3615.71	8.05	5	6	1	1.26	-0.41	0.48
P5-A	419255.04	4025348.49	3577.869	35.5	31.5	33.5	3	-3.48	-6.49	-5.78
P5-B	419255.04	4025348.49	3577.869	10.4	8.4	10.4	1	5.68	3.80	4.60
P5-C	419255.04	4025348.49	3577.869	4.4	3.4	4.4	1	5.98	4.07	4.83
P5A-A	419842.402	4026174.45	3582.604	36	31.5	33.5	2	1.56	0.72	1.17
P5A-B	419842.402	4026174.45	3582.604	13.6	10.5	12	1	4.31	2.74	3.45
P5A-C	419842.402	4026174.45	3582.604	8.2	5	6	1	4.08	2.37	3.18
P6-A	423944.373	4034134.79	3588.683	34	30	32	2	-6.12	-10.55	-7.93
P6-B	423944.373	4034134.79	3588.683	10.3	2.3	10.3	1	4.64	3.38	3.96
P6-C	423944.373	4034134.79	3588.683	4.9	3.9	4.9	1	5.36	3.76	4.41
P7-A	423395.664	4034878.02	3581.261	34.1	30.5	32.5	2	0.52	-2.74	-1.46
P7-B	423395.664	4034878.02	3581.261	--	--	--	1	5.72	3.89	4.87
P7-C	423395.664	4034878.02	3581.261	--	--	--	1	7.07	4.00	5.28
P8-A	420130.705	4039184.18	3591.824	32.1	30.5	32.5	2	1.54	-3.41	-2.21
P8-B	420130.705	4039184.18	3591.824	13.3	10.5	12	1	4.53	2.13	3.21
P8-C	420130.705	4039184.18	3591.824	7.26	5	6	1	4.50	2.03	3.15

Well ID	Easting (m)	Northing (m)	Ground Surface Elevation (ft)	Well Depth (ft)	Top of Perforated Interval (ft bgs)	Bottom of Perforated Interval (ft bgs)	Model Layer	Maximum Residual (ft)	Minimum Residual (ft)	Mean Residual (ft)
T347	407483	4043533	3634.652	22	12	22	1	0.34	0.33	0.33
T348	408766	4044160	3643.312	810	10	20	1	3634.69	-6.37	136.82
T349	411125	4045031	3636.743	38.26	28	38	1	2.18	2.07	2.10
T378	408430	4053649	3679.697	36.6	27	37	1	1.30	1.22	1.26
T588	405492	4049815	3709.054	39	29	39	1	4.59	-2.29	0.71
T725	408152	4044678	3666.717	20	10	20	1	-5.23	-5.23	-5.23
T726	408167	4044680	3666.958	20	10	20	1	-4.84	-4.85	-4.85
T727	408162	4044663	3666.807	20	10	20	1	-5.09	-5.10	-5.10
T890	408870.3	4048003.8	3666.8	1500	1150	1230	12	-1.79	-3.27	-2.88
T891	408869.6	4048009.6	3667.19	540	480	520	6	-0.66	-3.02	-1.93
T892	408868.2	4048015.5	3667.22	390	290	370	4	1.81	-1.27	0.50
T893	412319	4045191.3	3599.49	1530	1430	1510	13	-0.55	-1.80	-1.09
T894	412325	4045196	3599.72	1270	1170	1250	12	-0.72	-1.55	-1.24
T895	412330.6	4045200.9	3600.07	960	860	940	10	-0.46	-1.62	-0.94
T899	418254.5	4038643.9	3572.98	1003	920	960	13	-4.97	-5.95	-5.49
T900	418259.9	4038647.2	3572.95	720	660	700	12	-4.72	-5.62	-5.23
T901	418265.1	4038651.5	3572.87	190	150	170	4	1.21	-0.09	0.65
T902	409502	4044157.4	3631.19	1500	1290	1350	12	-1.81	-2.44	-2.13
T903	409501.7	4044165.8	3631.3	800	720	780	8	-1.21	-2.22	-1.62
T904	409501.4	4044174.4	3631.46	380	300	360	4	-3.48	-6.18	-4.13
T905	408814.5	4028605.5	3643.6	1500	1200	1260	6	5.18	1.06	3.79
T906	408806.8	4028605.1	3643.6	530	450	510	4	7.35	3.39	5.93
T907	408799.6	4028604.7	3643.48	330	250	310	3	3.40	-0.05	2.21
T908	410017.4	4020292.7	3581.9	1470	1360	1400	12	10.25	6.27	8.49
T909	410017.4	4020298.7	3581.91	800	740	780	8	0.05	-5.29	-2.07
T910	410018.6	4020304.8	3581.5	260	200	240	4	8.39	5.49	7.22
T911	414252	4025254.3	3564.44	1500	1420	1460	12	6.44	5.13	5.41

Well ID	Easting (m)	Northing (m)	Ground Surface Elevation (ft)	Well Depth (ft)	Top of Perforated Interval (ft bgs)	Bottom of Perforated Interval (ft bgs)	Model Layer	Maximum Residual (ft)	Minimum Residual (ft)	Mean Residual (ft)
T912	414248.3	4025249.3	3564.42	1080	1020	1060	12	4.71	2.85	3.12
T913	414255.5	4025259.6	3564.51	312	260	300	4	-3.91	-5.20	-4.49
T914	417580.6	4030256.9	3566.34	1500	1360	1400	12	2.18	1.10	1.37
T915	417575.6	4030253.2	3566.3	1088	760	800	8	-3.63	-5.18	-4.38
T913	414255.5	4025259.6	3564.51	312	260	300	4	-3.91	-5.20	-4.49
T914	417580.6	4030256.9	3566.34	1500	1360	1400	12	2.18	1.10	1.37
T915	417575.6	4030253.2	3566.3	1088	760	800	8	-3.63	-5.18	-4.38
T916	406753.5	4052838.8	3679.27	1500	1220	1260	12	1.51	0.18	0.74
T917	406748.9	4052842.6	3669.38	990	930	970	10	6.37	4.45	5.30
T918	406949.6617	4042483.24	3604.901	68	33	63	3	10.92	9.49	10.58
T919	408327.347	4039442.61	3599.726	73	38	68	2	0.57	-1.58	0.14
T920	406618.1112	4038917.04	3810.684	253	218	248	9	-4.56	-5.19	-4.88
T921	406640.0979	4033835.61	3811.33	263	228	258	4	6.99	5.95	6.53
T922	408221.2237	4031044.09	3669.468	133	98	128	2	7.13	4.29	6.32
T923	408317.273	4025851.12	3650.283	113	78	108	2	7.94	5.29	7.24
T924	406910.7933	4019843.04	3760.374	183	148	178	3	-0.98	-2.84	-1.94
T925	410723.9723	4016846.21	3618.75	78	43	73	3	11.45	9.15	10.29
T926	412530.6849	4010806.9	3715.439	98	63	93	2	2.63	-0.42	1.55
T927	420117.1656	4025612.52	3635.118	68	33	63	2	-3.32	-4.95	-3.60
T928	424311.6491	4034305.46	3633.461	93	58	88	3	-0.22	-1.79	-0.40
T929	416496.2869	4044499.75	3632.19	93	58	88	3	1.69	-0.43	1.34
T930	404224.1941	4044698.12	4231.589	73	38	68	10	1.91	-2.44	0.31
T931	408540.8534	4043782.92	3616.905	62	27	57	2	0.99	-0.43	0.22
V256	403903.8404	4052988.67	3744	208	?	546	Multiple	4.48	-1.52	1.67
River Site Lower	412624.125	4044605	3588	515	485	505	6	1.56	-6.14	-1.98
River Site Upper	412624.125	4044605	3588	230	170	220	4	4.18	-9.85	1.23
River Production Deep	412708.375	4044628.25	3588	565	485	555	6	2.31	-6.05	-1.84

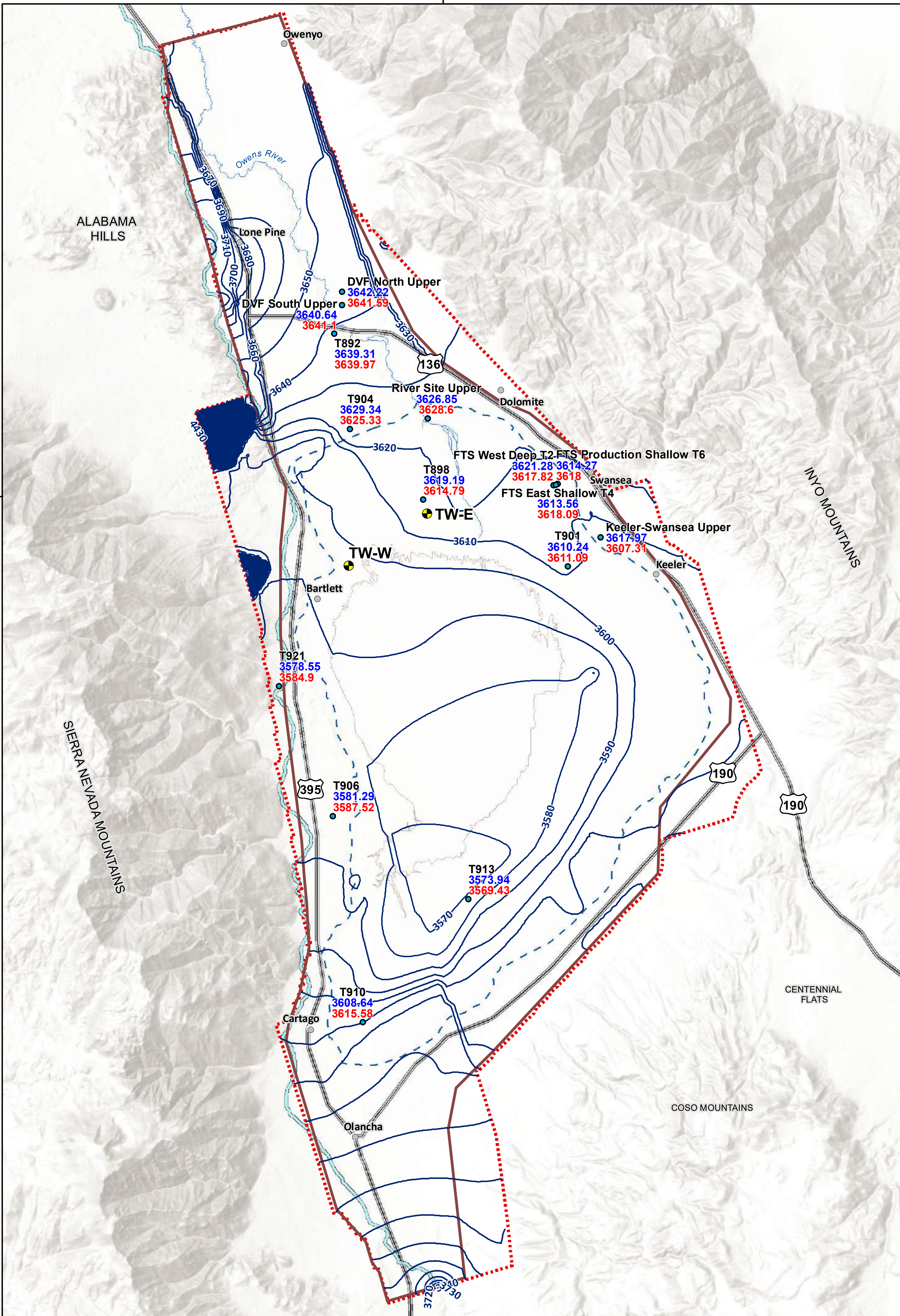
Well ID	Easting (m)	Northing (m)	Ground Surface Elevation (ft)	Well Depth (ft)	Top of Perforated Interval (ft bgs)	Bottom of Perforated Interval (ft bgs)	Model Layer	Maximum Residual (ft)	Minimum Residual (ft)	Mean Residual (ft)
River Production Shallow	412708.375	4044628.25	3588	235	155	225	Multiple	4.27	-11.74	1.44
DVF North TH	409172.2813	4049710.25	3669.017	1038	938	1038	10	2.08	-0.51	1.30
DVF North Lower	409176.3125	4049703.5	3668.873	722	662	722	8	1.39	-3.35	-2.02
DVF North Middle	409176.3125	4049703.5	3668.873	602	512	592	6	-0.43	-3.18	-1.39
DVF North Upper	409176.3125	4049703.5	3668.873	448	212	438	4	0.49	-3.07	-1.22
DVF South Lower	409187.8125	4049175.5	3666.719	719	659	719	8	-0.42	-2.80	-1.35
DVF South Middle	409187.8125	4049175.5	3666.719	608	518	598	6	-2.71	-4.80	-3.68
DVF South Upper	409187.8125	4049175.5	3666.719	450	205	440	4	1.78	-1.42	0.32
FTS_West_Deep_T1	417685.2813	4041922.75	3587	726	551	711	12	-5.28	-8.14	-5.69
FTS_West_Deep_T2	417688.1563	4041915	3586	154	59	144	4	-1.61	-6.73	-3.72
FTS_West_Shallow_T2	417688.1563	4041915	3586	435	255	405	3	1.82	-0.87	0.75
FTS_East_Deep_T3	417855.0938	4041990.75	3592	430	260	410	6	-3.60	-6.64	-4.06
FTS_East_Shallow_T4	417859.5938	4041980	3591	168	63	148	4	4.67	1.09	3.31
FTS_Production_Deep_T5	417771.5313	4041952.75	3590	425	255	405	6	-3.45	-5.75	-3.94
FTS_Production_Shallow_T6	417778.7188	4041934.5	3590	173	67.5	152.5	4	3.90	0.93	2.75
Keeler-Swansea Lower	419577.75	4039812.25	3606	390	220	320	6	-5.75	-8.63	-8.08
Keeler-Swansea Middle	419577.75	4039812.25	3606	190	160	180	5	-8.52	-11.45	-10.88
Keeler-Swansea Upper	419577.75	4039812.25	3606	135	100	120	4	-8.11	-11.17	-10.58
Mill Site Lower	423665.7813	4035136	3620.64	260	220	240	10	-0.50	-4.47	-0.80
Mill Site Upper	423665.7813	4035136	3620.74	150	110	130	3	-3.02	-6.37	-3.25
Mill Site_Production	423665.7813	4035136	3617.599	265	110	255	Multiple	-3.91	-4.79	-4.17
SFIP MW	417606.25	4029623	3562	902	700	820	8	-3.38	-7.74	-6.33

Well ID	Easting (m)	Northing (m)	Ground Surface Elevation (ft)	Well Depth (ft)	Top of Perforated Interval (ft bgs)	Bottom of Perforated Interval (ft bgs)	Model Layer	Maximum Residual (ft)	Minimum Residual (ft)	Mean Residual (ft)
SFIP PW	417625.9	4029449	3561	820	700	810	8	-4.50	-8.55	-6.26
OL-92-2	413205.7188	4026543.75	3558	1059	745	775	8	0.37	-0.91	-0.55
Star Trek	419616.25	4034332	3562.949	784	644	774	10	-5.80	-9.81	-7.03
Skinner	424472.4804	4034283.78	3653.472	75	?	?	Multiple	-3.23	-4.57	-3.42
Dearborn Spring	407066.67	4042589.33	3590.049	?	20?	30?	2	7.63	6.94	7.35
Dunn Well #1	421197	4040597	3858	263	183	263	Multiple	0.21	-1.17	-0.28
Dunn Well #2	421133	4040784	3881	535	255	430	Multiple	0.27	-0.54	-0.03
O'Dell Well	406469.0972	4043793.12	3688.812	?	100?	150?	2	5.23	5.18	5.21
Keeler Landfill MW-1	420860.881	4039101.3	3609.48	?	50?	70?	3	2.36	1.11	1.75
Keeler Landfill MW-2	420829.494	4039036.67	3604.24	?	50?	70?	3	3.20	1.26	1.86
Keeler Landfill MW-3	420897.807	4039016.37	3605.58	?	50?	70?	3	1.66	1.66	1.66
Keeler Landfill MW-4	420665.174	4038975.75	3601.34	?	50?	70?	3	5.13	3.94	4.59
Keeler Landfill MW-5	420713.177	4038951.74	3600.7	?	50?	70?	3	4.81	3.71	4.30
River_PW_Shallow	412708.375	4044628.25	3588	235	155	225	3	4.27	-11.74	1.44
C5(1)_4ft	415018.3947	4043750.88	3580.271	4	3	4	1	-0.61	-2.48	-1.52
C5(1)_10ft	415017.6872	4043750.5	3580.389	10	9	10	1	-0.70	-2.67	-1.67
C5(2)_4ft	414330.519	4043745.13	3580.242	4	3	4	1	1.14	-0.90	-0.14
6(1)_4ft	416643.7071	4042944.13	3584.733	4	3	4	1	-7.65	-16.64	-10.86
D.5(1)_4ft	418589.2698	4041293.13	3596.118	4	3	4	1	9.73	6.42	7.44
D.5(1)_10ft	418589.2872	4041293.2	3595.967	10	9	10	1	9.76	6.41	7.45
KEELER(1)_4ft	421125.5806	4037878.13	3580.747	4	3	4	1	-0.18	-6.79	-2.25
KEELER(1)_10ft	421126.2872	4037877.74	3580.534	10	9	10	1	-0.46	-6.86	-2.44
G9(1)_4ft	422245.3609	4036994.88	3583.001	4	3	4	1	7.27	0.96	5.64
G9(1)_10ft	422245.3872	4036994.98	3583.001	10	9	10	1	6.38	0.81	3.36
J10(1)_4ft	423613.9861	4032372.13	3580.734	4	3	4	1	8.89	5.72	7.53

Well ID	Easting (m)	Northing (m)	Ground Surface Elevation (ft)	Well Depth (ft)	Top of Perforated Interval (ft bgs)	Bottom of Perforated Interval (ft bgs)	Model Layer	Maximum Residual (ft)	Minimum Residual (ft)	Mean Residual (ft)
J10(1)_10ft	423613.987	4032372.16	3580.744	10	9	10	1	7.47	4.92	6.43
K10(1)_4ft	423029.5199	4030866.88	3586.252	4	3	4	1	2.08	-4.33	-0.09
K10(1)_10ft	423029.487	4030867	3586.062	10	9	10	1	3.60	-4.74	0.08
K10(2)_4ft	422847.8926	4030980.38	3580.294	4	3	4	1	2.53	-2.61	0.30
P5(1)_4ft	415570.5185	4022420.38	3586.407	4	3	4	1	-1.52	-3.17	-2.22
S3(2)_4ft	411783.9882	4019724.63	3586.521	4	3	4	1	-1.24	-5.78	-2.54
I10(5)_4ft	422900.8608	4034234.63	3575.531	4	3	4	1	3.65	1.69	2.88
L9(1)_4ft	421112.1115	4029209.38	3578.595	4	3	4	1	6.63	6.49	6.57
L9(1)_10ft	421112.0871	4029209.31	3578.742	10	9	10	1	6.31	6.15	6.24
M8(1)_4ft	420108.7679	4027389.88	3579.97	4	3	4	1	2.40	2.29	2.34
M8(1)_10ft	420108.7871	4027389.93	3579.845	10	9	10	1	0.75	0.59	0.67
N7(3)_4ft	418898.2364	4025567.63	3574.55	4	3	4	1	5.04	3.04	3.94
N7(3)_10ft	418898.2873	4025567.51	3574.553	10	9	10	1	3.87	1.96	2.83
S3(3)_4ft	411766.8615	4020599.38	3578.368	4	3	4	1	-4.27	-6.15	-5.28
S3(3)_10ft	411766.8874	4020599.5	3577.614	10	9	10	1	3.17	-11.86	-1.86

Appendix E

Simulated Groundwater Level Contours by Aquifer (1-5)



Observed and Simulated Water level Comparison

Calibration Well Name
Observed, ft msl
Simulated, ft msl

0 1 2 Miles

N

Simulated Groundwater Level Contour
Test Well
Owens Lake (Historic Shoreline)
2012 Model Domain
2019 Model Domain
Owens Lake Brine Pool

Simulated Groundwater Level Contours for Aquifer 1

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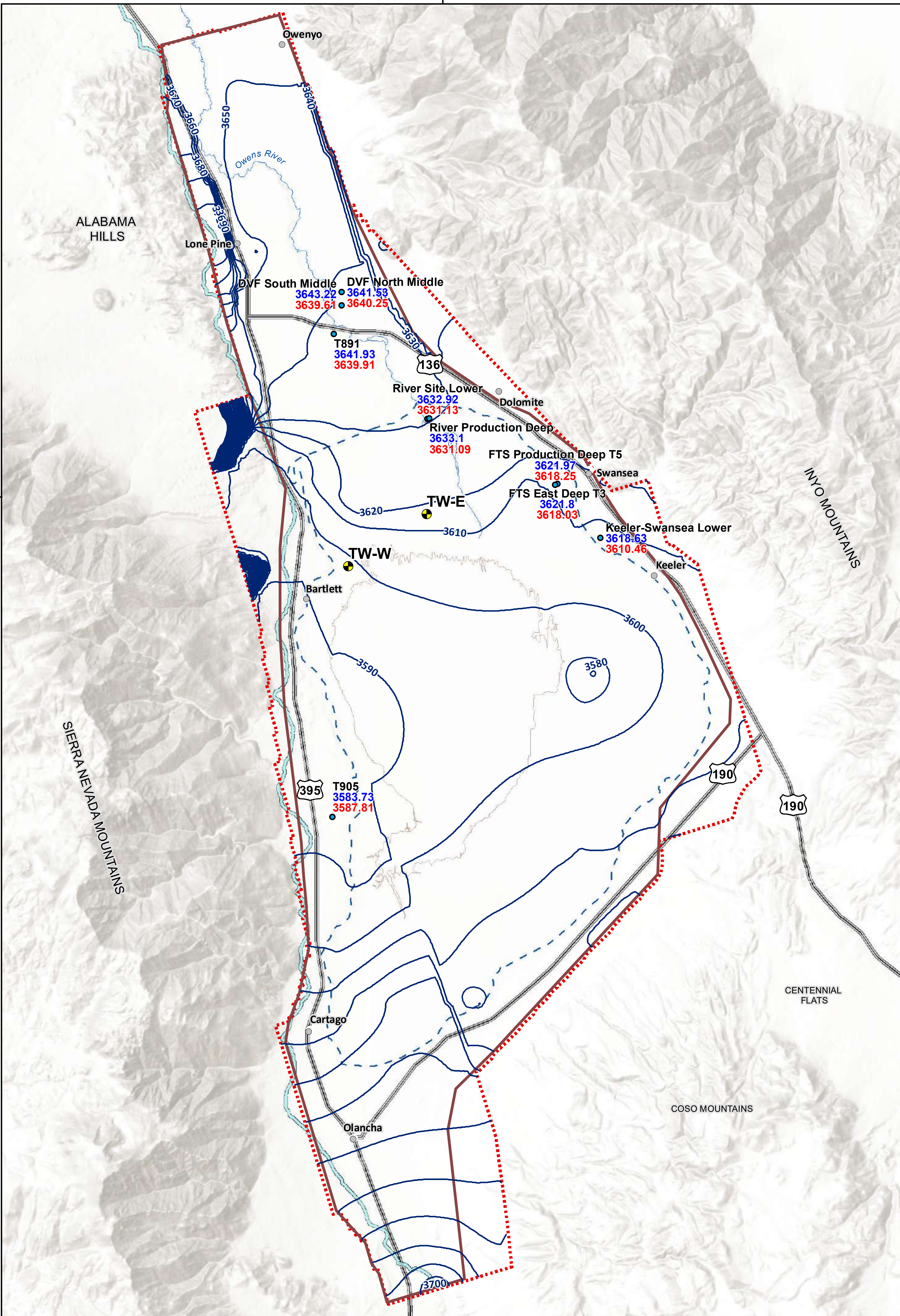
V:\1858\active\185865208\gis_MXDs\OLGEP_ModelUpdate\Pumping_Test_Analysis\MB_SimulatedGWL_Contours_Aquifers_20191111.mxd Revised: 2019-12-13 By: cwhelan

This color map has been designed to print size 11'' by 17''.



Observed and Simulated Water level Comparison

- **Calibration Well Name**
- **Observed, ft msl**
- **Simulated, ft msl**

0 1 2 Miles

N

- Simulated Groundwater Level Contour
- Test Well
- Owens Lake (Historic Shoreline)
- 2012 Model Domain
- 2019 Model Domain
- Owens Lake Brine Pool

Simulated Groundwater Level Contours for Aquifer 2

LA DWP Los Angeles Department of Water & Power

GSI ENVIRONMENTAL

M2 Resource Consulting

HH WATER RESOURCES

Stantec

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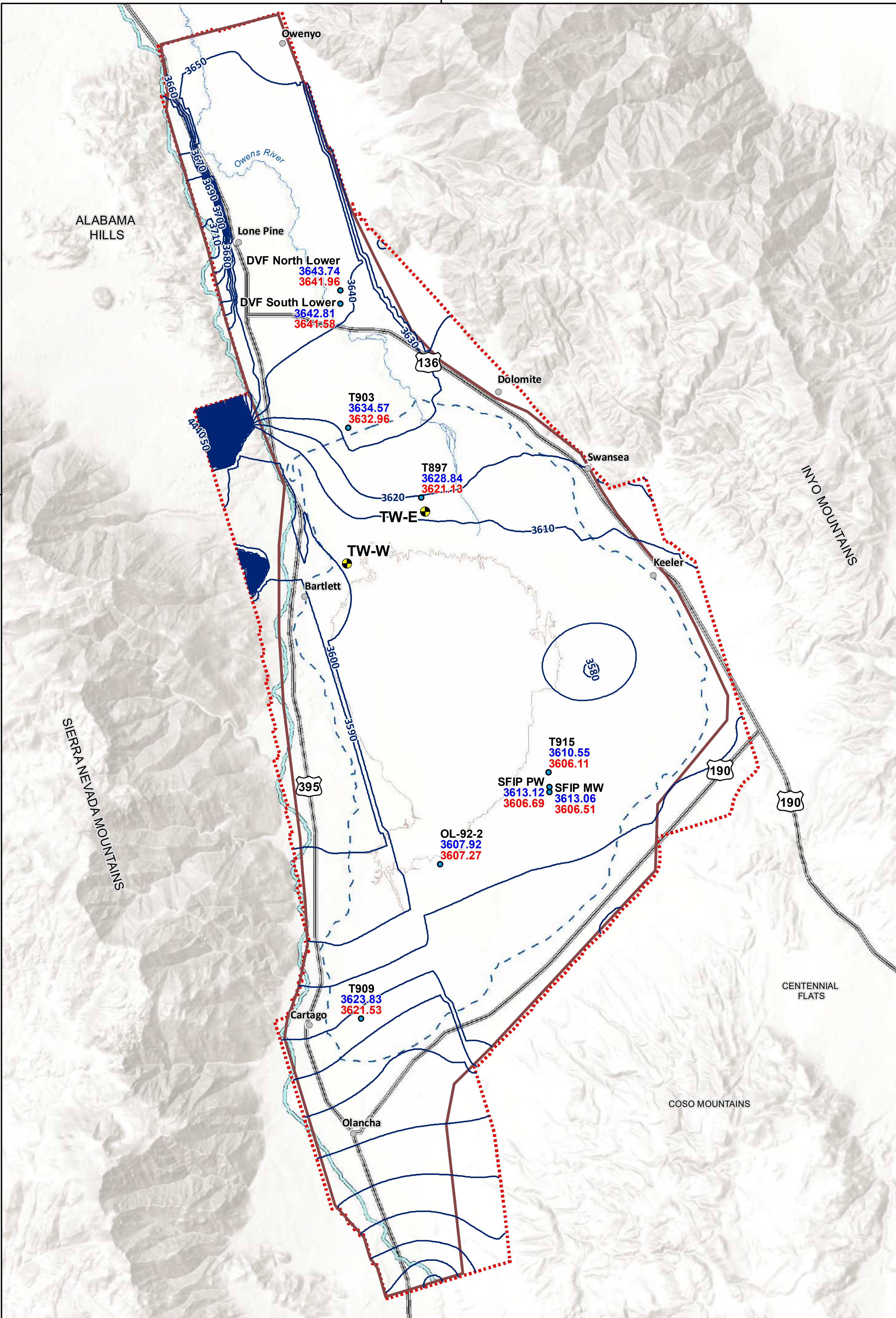
This color map has been designed to print size 11'' by 17''.



Observed and Simulated Water level Comparison

- Calibration Well Name
- Observed, ft msl
- Simulated, ft msl

- Simulated Groundwater Level Contour
- Test Well
- Owens Lake (Historic Shoreline)
- 2012 Model Domain
- 2019 Model Domain
- Owens Lake Brine Pool

0 1 2 Miles

N

Simulated Groundwater Level Contours for Aquifer 3

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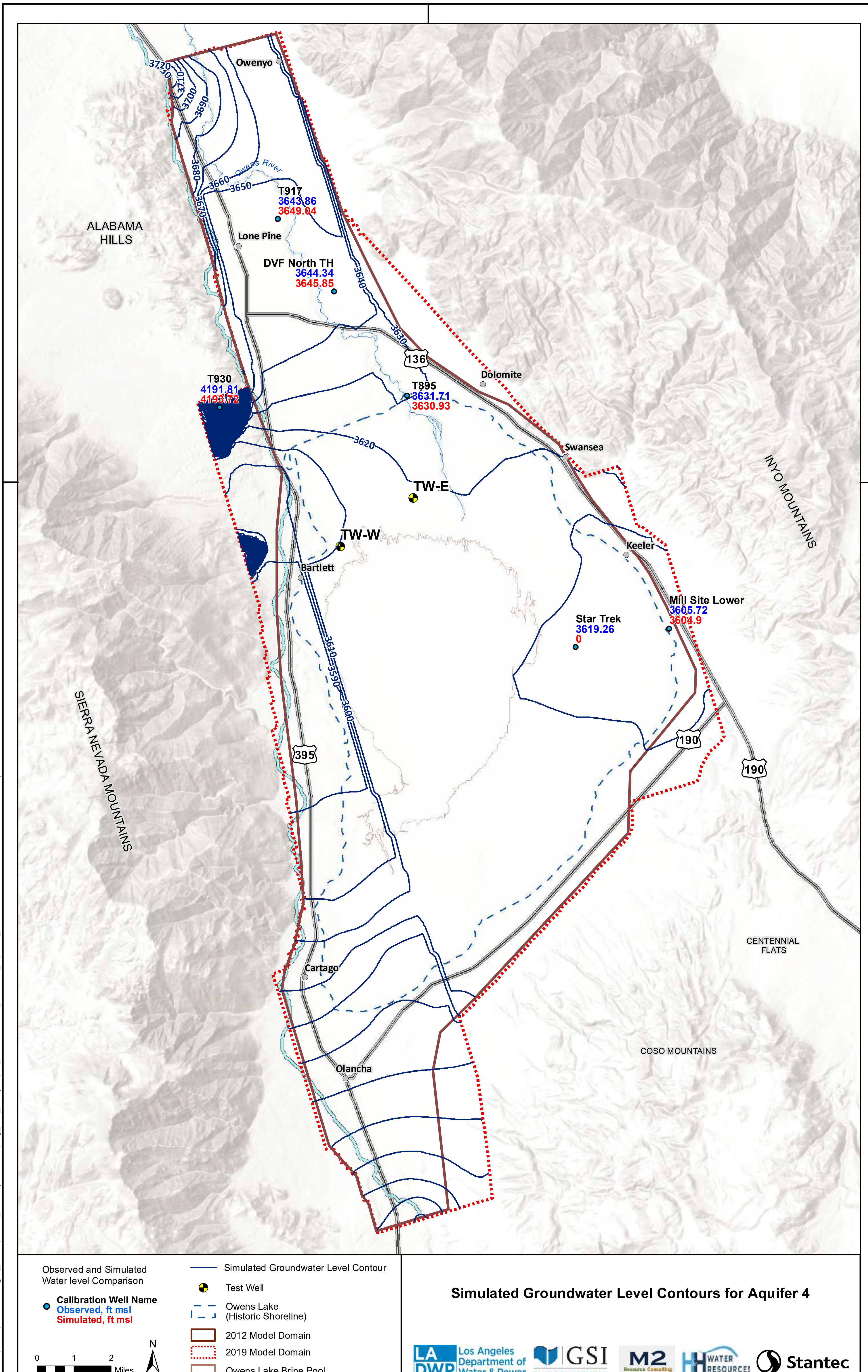
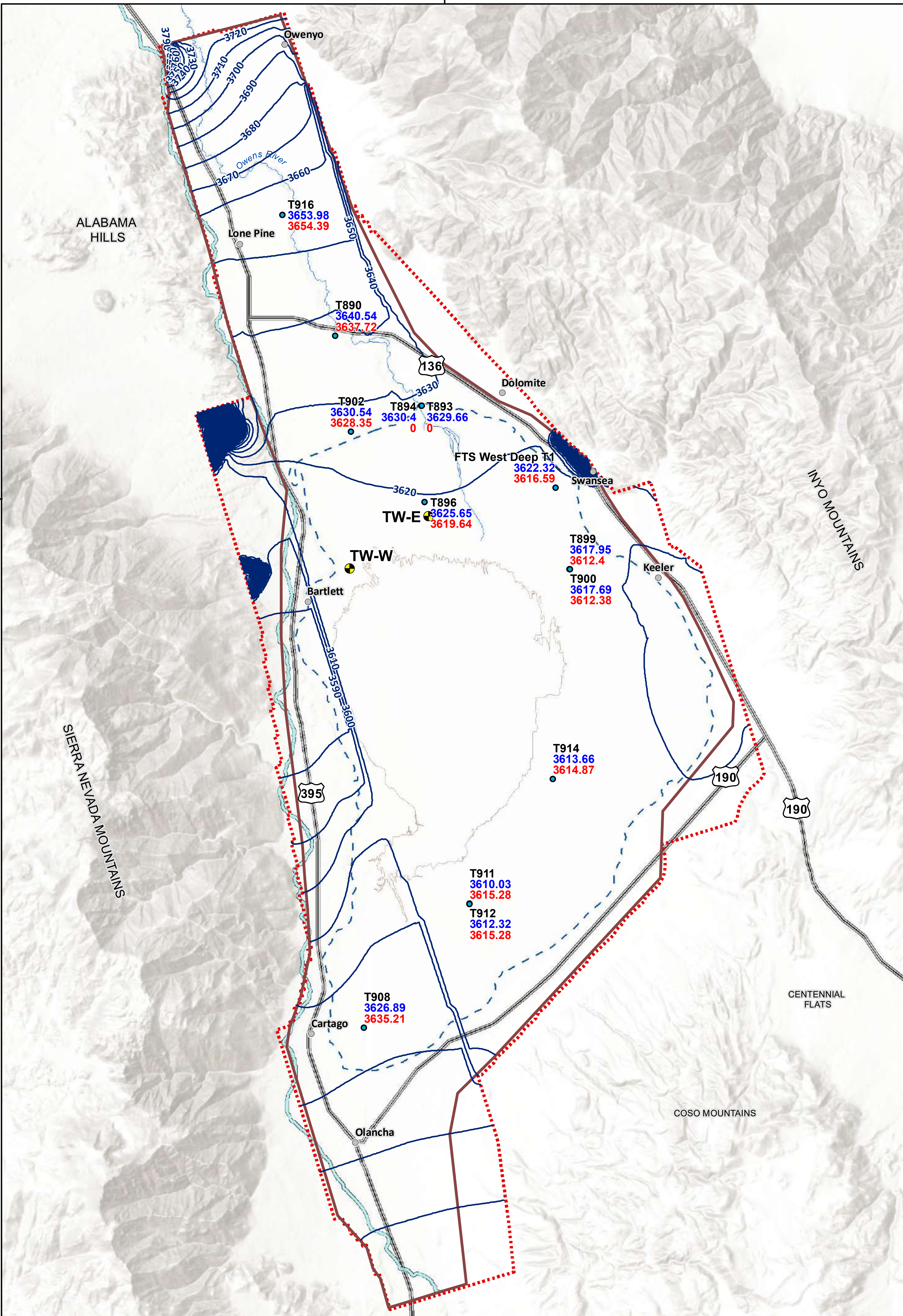
This color map has been designed to print size 11'' by 17''.



Simulated Groundwater Level Contours for Aquifer 4

V:\1858\active\185865208\gis_MXDs\OLGEP_ModelUpdate\Pumping_Test_Analysis\MB_SimulatedGWL_Contours_Aquifers_20191111.mxd Revised: 2019-12-13 By: cwhelan

This color map has been designed to print size 11'' by 17''.



Observed and Simulated Water level Comparison

Calibration Well Name
Observed, ft msl
Simulated, ft msl

0 1 2 Miles

N

Simulated Groundwater Level Contour
Test Well
Owens Lake (Historic Shoreline)
2012 Model Domain
2019 Model Domain
Owens Lake Brine Pool

Simulated Groundwater Level Contours for Aquifer 5

LA DWP Los Angeles Department of Water & Power
GSI ENVIRONMENTAL
M2 Resource Consulting
HH WATER RESOURCES
Stantec

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This color map has been designed to print size 11'' by 17''.

Appendix F

Supplementary Well Logs

LOG OF BOREHOLE MW #2 (T975)

Project:	Owens Valley Well Installation	Surface Elevation:	3,949.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.506703 W 118.041253	Depth to Water:	254.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
1	100				SILTY SAND: medium to coarse grained sand, subangular, dry, Alluvium. Trace fine to coarse gravel. Granitic, very pale brown 10YR 8/4.
2	100				Dry to moist, trace cobble.
		3944.0	5		Rock flour.
3	100				
4	100				Rock core.
		3939.0	10		SILTY SAND: dry.
5	100				
6	100				
7	100	3934.0	15		
					Rock flour.
8	100				SAND: fine to medium grained sand, dry to moist, light olive brown 2.5YR 5/3.
9	100				
		3929.0	20		Rock core.
10	100				CLAYEY SAND: fine to medium grained sand, moist, some rock flour, light brownish gray 2.5Y 6/2.
					Rock core.
11	100				SAND: medium to coarse grained sand, subangular, Trace cobbles, no clay.
12	100	3924.0	25		
13	100				
					Rock flour.
14	100				
		3919.0	30		
15	100				
					SAND: dry.
16	100				Some rock flour.
			35		

continued

Completion Depth:	300.0 ft	Remarks:
Date Borehole Started:	11/18/2019	
Date Borehole Completed:	12/11/2019	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #2 (T975)

Project:	Owens Valley Well Installation	Surface Elevation:	3,949.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.506703 W 118.041253	Depth to Water:	254.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SAND: dry. *(continued)*
17	100				Trace cobble, angular coarse gravel.
18	100				
		3909.0	40		Rock fragments.
19	100				
					SILTY SAND: fine to coarse grained sand, dry to moist, Trace fine gravel, light yellowish brown 10YR 6/4.
20	100				
21	100	3904.0	45		Dry.
22	100				
23	100				
		3899.0	50		
24	100				
25	100				
26	100	3894.0	55		
27	100				
28	100				
		3889.0	60		
29	100				
30	100				Angular fine gravel.
31	100	3884.0	65		Rock flour with cobbles.
32	100				
33	100				
			70		

continued

Completion Depth:	300.0 ft
Date Borehole Started:	11/18/2019
Date Borehole Completed:	12/11/2019
Logged By:	Mark Ching
Drilling Company:	BC2 Environmental

Remarks:

Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #2 (T975)

Project:	Owens Valley Well Installation	Surface Elevation:	3,949.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.506703 W 118.041253	Depth to Water:	254.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
34	100				SILTY SAND: fine to coarse grained sand, dry to moist, Trace fine gravel, light yellowish brown 10YR 6/4. *(continued)*
35	100				
36	100	3874.0	75		
37	100				SAND: medium to coarse grained sand, subangular, dry to moist, light olive gray 5Y 6/2.
38	100				
39	100				SILTY SAND: fine to coarse grained sand, dry to moist, light yellowish brown 10YR 6/4.
		3869.0	80		
40	100				
41	100				
42	100	3864.0	85		
43	100				Pulverized granite.
44	100				SILTY SAND: fine to coarse grained sand, dry to moist, light yellowish brown 10YR 6/4.
		3859.0	90		Pulverized rock.
45	100				
46	100				SILTY SAND: fine to coarse grained sand, dry to moist, light yellowish brown 10YR 6/4.
47	100	3854.0	95		
48	100				
49	100				
		3849.0	100		Trace cobbles.
50	100				
51	100				Olive gray.
			105		

continued

Completion Depth:	300.0 ft	Remarks:
Date Borehole Started:	11/18/2019	
Date Borehole Completed:	12/11/2019	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

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LOG OF BOREHOLE MW #2 (T975)

Project:	Owens Valley Well Installation	Surface Elevation:	3,949.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.506703 W 118.041253	Depth to Water:	254.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
52	100				SILTY SAND: fine to coarse grained sand, dry to moist, light yellowish brown 10YR 6/4. *(continued)*
53	100				Wet, With sand.
54	100				SILTY SAND: fine to coarse grained sand, wet, Trace clay, olive gray.
		3839.0	110		
55	100				
56	100				
		3834.0	115		
57	100				
58	100				Rock flour.
		3829.0	120		SILTY SAND: fine to coarse grained sand, wet, Some cobbles.
59	100				
					No cobbles.
60	100				
		3824.0	125		
					Trace clay.
61	100				
62	100				
		3819.0	130		Rock flour.
63	100				
64	100				
		3814.0	135		
65	100				
66	100				
			140		

continued

Completion Depth:	300.0 ft	Remarks:
Date Borehole Started:	11/18/2019	
Date Borehole Completed:	12/11/2019	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #2 (T975)

Project:	Owens Valley Well Installation	Surface Elevation:	3,949.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.506703 W 118.041253	Depth to Water:	254.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SILTY SAND: fine to coarse grained sand, wet, Some cobbles. *(continued)*
					With fine to coarse gravel and angular cobbles.
67	100				
68	100	3804.0	145		
69	100				
		3799.0	150		DG gravel.
70	100				
71	100	3794.0	155		
72	100				Trace clay.
73	100				
		3789.0	160		SAND: medium to coarse grained sand, wet, Trace fine grain sand, angular to subangular, trace silt.
74	100				
75	100				
76	100	3784.0	165		Trace cobble.
77	100				
78	100	3779.0	170		Moist.
					No gravel or cobbles.
79	100				
			175		

continued

Completion Depth:	300.0 ft	Remarks:
Date Borehole Started:	11/18/2019	
Date Borehole Completed:	12/11/2019	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #2 (T975)

Project:	Owens Valley Well Installation	Surface Elevation:	3,949.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.506703 W 118.041253	Depth to Water:	254.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
80	100				SAND: medium to coarse grained sand, wet, Trace fine grain sand, angular to subangular, trace silt. *(continued)*
					Some silt, DG fragments.
81	100				
		3769.0	180		
82	100				
					Wet, DG core.
83	100				SAND: medium to coarse grained sand, wet, DG sand.
		3764.0	185		Some fines, very weathered.
84	100				
85	100				
		3759.0	190		
86	100				
					Dry, few fines, DG sand, coarse gravel.
87	100				
		3754.0	195		
88	100				
					Wet.
89	100				
		3749.0	200		Cobble.
90	100				
					Moist, trace fine gravel, trace cobbles, light brown.
91	100				
					Trace coarse gravel, brown.
92	100	3744.0	205		
					Friable rock fragments.
93	100				
94	100				
			210		

continued

Completion Depth:	300.0 ft	Remarks:
Date Borehole Started:	11/18/2019	
Date Borehole Completed:	12/11/2019	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

LOG OF BOREHOLE MW #2 (T975)

Project:	Owens Valley Well Installation	Surface Elevation:	3,949.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.506703 W 118.041253	Depth to Water:	254.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SAND: medium to coarse grained sand, wet, DG sand. *(continued)*
95	100				
					Some fine grain sand, gray.
					Fine to coarse grained sand.
96	100				
		3734.0	215		
					Wet, some rock flour.
97	100				
					DG.
98	100				
		3729.0	220		
99	30				
					Moist.
100	100				
					Trace cobble.
		3724.0	225		
101	100				
					No cobbles, with DG.
102	100				
		3719.0	230		
103	0				
104	100				
					Wet, some rock flour.
		3714.0	235		
105	100				
					Trace cobble.
106	100				
		3709.0	240		
					Medium to coarse grained sand, some rock flour, some fine grain sand.
107	100				
108	100				
					Fine to coarse grained sand.
			245		

continued

Completion Depth:	300.0 ft	Remarks:
Date Borehole Started:	11/18/2019	
Date Borehole Completed:	12/11/2019	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #2 (T975)

Project:	Owens Valley Well Installation	Surface Elevation:	3,949.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.506703 W 118.041253	Depth to Water:	254.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
109	100				SAND: medium to coarse grained sand, wet, DG sand. *(continued)*
					Trace fine gravel.
110	100				
		3699.0	250		Fine to medium grained sand, some coarse grain sand.
111	100				
112	100				
113	100		∇	∇	
		3694.0	255		
114	100				
					Trace fine gravel.
115	100				
		3689.0	260		
116	100				
					Trace cobble.
117	100				
118	0				
		3684.0	265		
119	100				
					Trace silt.
120	100				
		3679.0	270		Less silt.
121	100				
122	100				
					Trace cobble.
		3674.0	275		
123	100				
					No cobbles.
124	100				
			280		

continued

Completion Depth:	300.0 ft	Remarks:
Date Borehole Started:	11/18/2019	
Date Borehole Completed:	12/11/2019	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

LOG OF BOREHOLE MW #2 (T975)

Project:	Owens Valley Well Installation	Surface Elevation:	3,949.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.506703 W 118.041253	Depth to Water:	254.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SAND: medium to coarse grained sand, wet, DG sand. *(continued)*
125	100				Trace fines.
126	100				Trace coarse gravel.
					Some cobbles.
127	100	3664.0	285		
128	100				Moist, no cobbles, no fines, some coarse grain sand.
129	100	3659.0	290		Some fine gravel.
130	100				
131	100	3654.0	295		Trace fines.
132	100				
133		3649.0	300		
		3644.0	305		
		3639.0	310		
			315		

Completion Depth:	300.0 ft	Remarks:
Date Borehole Started:	11/18/2019	
Date Borehole Completed:	12/11/2019	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
1	0				
2	100	3895.0	5		SAND: fine to medium grained sand, subangular, dry, Trace fine gravel, light brown.
3	100				Dry to moist.
4	100				Trace coarse sand.
		3890.0	10		Some coarse sand.
5	100				
6	100				
7	100	3885.0	15		Moist, trace coarse sand, brown.
8	100				
9	100				Light brown.
		3880.0	20		Medium to coarse grained sand, wet, trace fines.
10	100				
11	100				Coarse grained sand, some medium grain sand.
12	100	3875.0	25		Angular to subangular.
13	100				Fine to medium grained sand, trace coarse grain sand.
14	100				Trace coarse gravel.
		3870.0	30		Medium to coarse grained sand.
15	100				
16	100				Fine to medium grained sand, trace coarse grain sand.
			35		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
17	100				SAND: fine to medium grained sand, subangular, dry, Trace fine gravel, light brown. *(continued)*
					Few coarse gravel.
18	100				
					Trace cobble, some rock flour.
19	100				
		3860.0	40		
20	100				Subangular, no gravel, no cobble, brown.
					Trace coarse gravel.
21	100				
		3855.0	45		
22	100				Dry, some coarse gravel, rock flour, gray.
					Trace cobble.
23	100				
		3850.0	50		Few cobbles, light brown.
24	100				
					Some cobbles, rock flour, gray.
25	100				
					Coarse grained sand, wet, few cobbles, with gravel, brown.
26	100	3845.0	55		
					Fine to coarse grained sand.
27	100				
					Some cobbles.
28	100				
		3840.0	60		With rock flour, gray.
29	100				
					Few coarse gravel, no cobble.
30	100				
		3835.0	65		
					Medium grained sand, light brown.
31	100				
					Fine grained sand, dry, trace fine gravel.
32	100				
			70		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SAND: fine to medium grained sand, subangular, dry, Trace fine gravel, light brown. *(continued)*
33	100				No gravel, trace coarse grain sand.
34	100				Trace coarse gravel, light reddish brown.
35	100	3825.0	75		Trace cobble, light brown.
36	100				No cobbles.
37	100				Gray.
		3820.0	80		
38	100				Fine to medium grained sand, wet, trace cobble, few coarse gravel, olive brown.
39	100				
40	100	3815.0	85		Trace silt.
41	100				
42	100				
		3810.0	90		Some rock flour.
43	100				
44	100				
		3805.0	95		Medium grained sand, dry, rock flour, some coarse gravel.
45	100				Trace coarse gravel, few fine gravel, some coarse grain sand.
					Dry to moist.
46	100				
47	100	3800.0	100		
48	100				
49	100				Dry, some rock flour, gray.
			105		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SAND: fine to medium grained sand, subangular, dry, Trace fine gravel, light brown. *(continued)*
50	100				Wet, few fines, few cobbles, brown.
51	100				Dry, no cobbles, light brown.
		3790.0	110		
52	100				Wet, no gravel.
53	100				Some fines.
					Rock flour with coarse gravel.
		3785.0	115		
54	20				Rock core.
					SAND: fine grained sand, dry, few fine gravel, few medium grain sand, light brown.
55	100				
		3780.0	120		
56	100				
57	100				
		3775.0	125		Some silt.
58	100				SAND: fine to medium grained sand, dry, With rock flour, few fine gravel, trace cobble, light brown.
					Trace coarse gravel, no cobble.
59	100				
		3770.0	130		Moist, no gravel, no cobble, brown.
60	100				
61	100				
		3765.0	135		
					Fine to coarse grained sand.
62	100				Medium to coarse grained sand, wet, angular to subangular.
					Fine to coarse grained sand, trace fine and coarse gravel.
			140		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
63	100				SAND: fine to medium grained sand, dry, With rock flour, few fine gravel, trace cobble, light brown. *(continued)*
					Fine grained sand, no gravel, trace silt.
64	100				
65	100	3755.0	145		
66	100				
					Some consolidated alluvium, friable, caliche rind.
		3750.0	150		
67	100				
68	100				
					Trace fine gravel.
69	100	3745.0	155		
70	100				
		3740.0	160		
71	100				Medium to coarse grained sand, wet.
72	100				Trace coarse gravel.
73	100	3735.0	165		Coarse grained sand, angular, some rock flour.
					Fine grained sand, some rock flour, trace fine gravel.
74	100				
		3730.0	170 ▽	▽	Fine to coarse grained sand, moist, no rock flour.
75	100				
					Medium to coarse grained sand.
76	100		175		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SAND: fine to medium grained sand, dry, With rock flour, few fine gravel, trace cobble, light brown. *(continued)*
77	100				
78	100				Fine to medium grained sand, some coarse grain sand, trace fine gravel.
		3720.0	180		Granite core.
79	100				
					SAND: fine to coarse grained sand, trace fine gravel.
80	100				
		3715.0	185		
81	100				Fine grained sand, dry, with silt, dark olive.
					Fine to coarse grained sand, trace fine gravel.
82	100				
		3710.0	190		Some consolidated alluvium.
83	100				Fine grained sand, moist, with clay, trace fine gravel, dark brown.
84	100				
		3705.0	195		
85	100				Less clay.
86	100				Wet, no gravel, light brown.
		3700.0	200		
87	100				
					Fine to medium grained sand, brown.
88	100				
		3695.0	205		Trace clay.
89	100				
			210		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
90	100				SAND: fine to coarse grained sand, trace fine gravel. *(continued)*
91	100				
					Rock flour with fine gravel, light gray.
		3685.0	215		
92	0				
					Medium to coarse grained sand, moist, no gravel, no clay, light brown.
93	100				
		3680.0	220		
					Fine grained sand, moist, trace fine gravel, reddish brown.
94	100				
					Brown.
95	100				
96	100	3675.0	225		
					Fine to coarse grained sand.
					Fine to medium grained sand.
97	100				
					Gravel consisting of consolidated alluvium.
		3670.0	230		
98	100				
					Fine to coarse grained sand.
99	100				
		3665.0	235		
					Cobbles of friable consolidated alluvium.
100	100				
					Fine grained sand, trace gravel, brown.
101	100				
		3660.0	240		
					Angular gravel.
102	100				
103	100				
			245		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SAND: fine to coarse grained sand, trace fine gravel. *(continued)*
104	100				Fine grained sand, wet, trace cobble, with clay, yellowish brown.
105	100				Dry, trace fine gravel.
		3650.0	250		
106	100				No clay.
107	100				
					Some clay.
		3645.0	255		
108	100				No clay, friable gravel.
109	100				Trace angular cobble.
		3640.0	260		Trace angular coarse gravel.
110	100				
111	100	3635.0	265		
					CLAY: medium to high toughness, dry, trace fine gravel, few coarse sand, reddish brown.
112	100				
113	100				
		3630.0	270		
114	100				Some sand.
115	100	3625.0	275		
116	100				
117	100				
			280		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					CLAY: medium to high toughness, dry, trace fine gravel, few coarse sand, reddish brown. *(continued)*
118	100				
					Brown.
119	100				
		3615.0	285		Reddish brown.
120	100				
121	100				
		3610.0	290		
122	100				
123	100				
		3605.0	295		
124	100				
		3600.0	300		
125	100				
					Light olive brown.
126	100				
127	100	3595.0	305		
					Reddish brown.
128	100				
		3590.0	310		
129	100				
130	100				
			315		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
131	100				CLAY: medium to high toughness, dry, trace fine gravel, few coarse sand, reddish brown. *(continued)*
132	100				
133	100				
		3580.0	320		
134	100				
					Some sand.
		3575.0	325		
135	100				
136	100				
		3570.0	330		
					Light olive brown.
137	100				
					CLAYEY SAND: fine to coarse grained sand, reddish brown.
138	100	3565.0	335		
139	100				
140	100				
		3560.0	340		
141	100				
142	100				
		3555.0	345		
143	100				
144	100				
			350		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					CLAYEY SAND: fine to coarse grained sand, reddish brown. *(continued)*
145	100				
					Indicative of weathered in place.
146	100				
147	100	3545.0	355		
					Dark brown.
148	100				
					Fine gravel (phenocrysts).
149	100				
		3540.0	360		Less sand.
150	100				
151	100				
		3535.0	365		
152	100				
153	100				
		3530.0	370		Subangular fine gravel, drilling harder.
154	100				
155	100				
		3525.0	375		
156	100				
157	100				
		3520.0	380		
158	100				
					Trace subangular cobble, some coarse gravel.
159	100				
			385		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
160	100				SAND: fine grained sand, dry, some fine to coarse gravel, trace cobble, some rock flour.
161	100	3510.0	390		SANDY CLAY: fine to coarse grained sand, reddish brown.
162	100				
163	100	3505.0	395		Trace rounded gravel.
164	100				Few subangular cobbles.
165	100				CLAY: trace sand, dark brown.
		3500.0	400		
166	100				
167	100	3495.0	405		
168	100				
169	100				CLAYEY SAND.
170	100	3490.0	410		
171	100				
172	100	3485.0	415		
173	100				SANDY CLAY with Gravel: fine to coarse grained sand, dry, some fine gravel, yellowish brown.
			420		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #3 (T976)

Project:	Owens Valley Well Installation	Surface Elevation:	3,900.0 ft
Job Number:	791R1	Top of Casing Elev.:	
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.519462 W 118.047489	Depth to Water:	170.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SANDY CLAY with Gravel: fine to coarse grained sand, dry, some fine gravel, yellowish brown. *(continued)*
174	100				
175	100				
					Trace subangular fine gravel.
		3475.0	425		
176	100				
177	100				
		3470.0	430		
178	100				
					CLAYEY SAND.
179	100				
		3465.0	435		
180	100				
181	100				
		3460.0	440		
182	100				
183	100				
184	100				
		3455.0	445		
185	100				
186	100				
187		3450.0	450		
			455		

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	12/10/2019	
Date Borehole Completed:	1/16/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order: YCA32

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
1	100	3663.0	5		SAND: fine to coarse grained sand, subangular, dry, Alluvium. Some fine gravel., light brown.
2	100				
3	100				Trace fine gravel.
		3658.0	10		Fine to medium grained sand, some silt.
4	100				
5	100				Medium to coarse grained sand, moist, some fine grain sand, few silt, yellowish brown.
6	100	3653.0	15		
7	100				
8	100				Dry.
		3648.0	20		No gravel.
9	100				
10	100				Some silt.
11	100	3643.0	25		
12	100				Medium to coarse grained sand, moist, brown.
13	100				Fine to medium grained sand, trace silt.
		3638.0	30		
14	100				
15	100				Fine to coarse grained sand.
			35		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	2/19/2020	
Date Borehole Completed:		
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE T902a

Project:	Owens Valley Well Installation	Surface Elevation:	3,633.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,636.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.540278 W 118.011944	Depth to Water:	38.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
1	100				SAND: medium grained sand, dry to moist, Alluvium. Some fine grain, few coarse grain sand. Few fine gravel., brown.
2	100				Fine grained sand, dry, few coarse gravel.
3	100	3628.0	5		No gravel, light brownish gray.
4	100				
5	100				
		3623.0	10		
6	100				
					Light brown.
7	100	3618.0	15		
8	100				
					Few fine gravel.
9	100	3613.0	20		
10	100				
11	0	3608.0	25		
12	100				
					SILTY SAND: fine grained sand, dry to moist, brown.
					SILT: moist, few fine grain sand, no odor, dark gray.
13	100	3603.0	30		
					Some fine grain sand.
14	100				
			35		

continued

Completion Depth:	60.0 ft	Remarks: Last 14 feet samples unavailable.
Date Borehole Started:	2/4/2020	
Date Borehole Completed:	2/7/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE T902a

Project:	Owens Valley Well Installation	Surface Elevation:	3,633.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,636.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.540278 W 118.011944	Depth to Water:	38.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
15	100				SILT: moist, few fine grain sand, no odor, dark gray. *(continued)*
16	0		▽	▽	
17	100	3593.0	40		Wet.
18	100				
19	100	3588.0	45		Remaining samples not available.
		3583.0	50		
		3578.0	55		
		3573.0	60		
		3568.0	65		
			70		

Completion Depth:	60.0 ft	Remarks: Last 14 feet samples unavailable.
Date Borehole Started:	2/4/2020	
Date Borehole Completed:	2/7/2020	
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
16	100				SAND: fine to coarse grained sand, subangular, dry, Alluvium. Some fine gravel., light brown. *(continued)* Some silt.
17	100				
18	100				
		3628.0	40		
19	100				Light brown.
20	100				
21	100	3623.0	45		Fine grained sand, dry to moist, gray.
					Platy minerals, dark gray.
22	100				
23	100				Moist.
		3618.0	50	∇	
24	100				
25	100				
26	100	3613.0	55		Wet, trace silt.
27	100				
28	100				
		3608.0	60		Trace fine organics, no odor.
29	100				SANDY SILT: fine grained sand, moist, trace fine organics, dark gray.
30	100				
31	100	3603.0	65		Organic streaks.
32	100				
33	100				
			70		

continued

Completion Depth:	450.0 ft	Remarks:	
Date Borehole Started:	2/19/2020		
Date Borehole Completed:			
Logged By:	Mark Ching		
Drilling Company:	BC2 Environmental	Work Order:	

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
34	100				SANDY SILT: fine grained sand, moist, trace fine organics, dark gray. *(continued)*
35	100				
36	100	3593.0	75		SILTY CLAY: fine grained sand, moist, gray.
37	100				
38	100				CLAY.
		3588.0	80		
39	100				
40	100				
41	100	3583.0	85		
42	100				
43	100				
		3578.0	90		Wet.
44	100				
45	100				
46	100	3573.0	95		
47	100				
48	100				
		3568.0	100		
49	100				
50	100				
			105		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	2/19/2020	
Date Borehole Completed:		
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
51	100				CLAY. *(continued)*
52	100				
53	100				
		3558.0	110		
54	100				
55	100				
		3553.0	115		
56	100				
		3548.0	120		
57	100				
58	100				
59	100	3543.0	125		
60	100				
61	100				
		3538.0	130		
62	100				
63	100				
64	100	3533.0	135		
65	100				
66	100				
			140		

continued

Completion Depth:	450.0 ft	Remarks:	
Date Borehole Started:	2/19/2020		
Date Borehole Completed:			
Logged By:	Mark Ching		
Drilling Company:	BC2 Environmental	Work Order:	

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					CLAY. *(continued)*
67	100				
68	100				
					Few silt.
		3523.0	145		
69	100				
70	100				Dry.
		3518.0	150		
71	100				
					Moist.
72	100				
73	100	3513.0	155		
74	100				
75	100				
		3508.0	160		
76	100				
77	100				
78	100	3503.0	165		
79	100				
80	100				
		3498.0	170		
81	100				
82	100				
					Trace medium grain sand.
			175		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	2/19/2020	
Date Borehole Completed:		
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
83	100				CLAY. *(continued)*
84	100				No sand.
85	100				
		3488.0	180		
86	100				
87	100				Trace fine grain sand.
88	100	3483.0	185		Black spots.
89	100				Olive.
90	100				
		3478.0	190		
91	100				
92	100				
93	100	3473.0	195		
94	100				
95	100				
		3468.0	200		Fine to medium grained sand, wet, dark gray.
96	100				
97	100				
98	100	3463.0	205		CLAY: moist, gray.
99	100				
100	100				
			210		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	2/19/2020	
Date Borehole Completed:		
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SAND: medium to coarse grained sand, wet, some fine grain sand, dark gray.
101	100				
102	100				
103	100	3453.0	215		
104	100				
105	100				
		3448.0	220		
106	100				
					Trace fines.
107	100				
108	100	3443.0	225		
109	100				
110	100				
		3438.0	230		
					Fine to medium grained sand, trace silt.
111	100				
					SANDY CLAY: fine to medium grained sand, wet, trace coarse grain sand, olive.
112	100				
					SAND: medium to coarse grained sand, wet, some silt, dark gray.
		3433.0	235		
113	100				
					Less silt.
114	100				
		3428.0	240		
					Trace fine gravel.
115	100				
116	100				
					SANDY SILT: fine grained sand, wet, olive.
			245		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	2/19/2020	
Date Borehole Completed:		
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
117	100				SANDY SILT: fine grained sand, wet, olive. *(continued)* Some clay. Slight organic odor.
118	100				
		3418.0	250		CLAY: wet, no odor, olive.
119	100				Some silt.
120	100				
		3413.0	255		
121	100				
					SAND: medium to coarse grained sand, wet, few silt, dark gray.
122	100				
		3408.0	260		SILT: with fine grain sand.
123	100				
					SAND: fine grained sand, few silt.
124	100				
		3403.0	265		
125	100				
126	100				
		3398.0	270		
127	100				
		3393.0	275		
128	100				
			280		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	2/19/2020	
Date Borehole Completed:		
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
					SAND: fine grained sand, few silt. *(continued)*
129	100				
130	100				Trace fine gravel.
131	100	3383.0	285		
132	100				
		3378.0	290		
133	100				
134	100				Less silt.
		3373.0	295		SANDY SILT: fine grained sand, moist, trace organics, dark gray.
135	100				
					Olive.
136	100				
		3368.0	300		
137	100				
138	100				
139	100	3363.0	305		
140	100				
		3358.0	310		
141	100				
142	100				
			315		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	2/19/2020	
Date Borehole Completed:		
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
143	100				SANDY SILT: fine grained sand, moist, trace organics, dark gray. *(continued)* Fine to medium grained sand.
144	100				
		3348.0	320		Organic streaks.
145	100				
146	100				Trace clay.
					SILT: olive.
		3343.0	325		
147	100				
148	100				
		3338.0	330		SAND: fine to medium grained sand, few silt.
149	100				
150	100				
					Some coarse grain sand.
151	100	3333.0	335		
					Some subrounded fine gravel.
152	100				
		3328.0	340		Fine grained sand, no gravel, few silt.
153	100				
154	100				Fine to medium grained sand, trace silt.
		3323.0	345		
155	100				
156	100				
			350		

continued

Completion Depth:	450.0 ft	Remarks:	
Date Borehole Started:	2/19/2020		
Date Borehole Completed:			
Logged By:	Mark Ching		
Drilling Company:	BC2 Environmental	Work Order:	

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
157	100				SAND: fine to medium grained sand, few silt. *(continued)*
158	100				
159	100	3313.0	355		
160	100				
		3308.0	360		
161	100				Trace coarse grain sand.
162	100				
163	100	3303.0	365		
164	100				
		3298.0	370		CLAY: wet, olive.
165	0				
166	100				
167	100	3293.0	375		
168	100				
		3288.0	380		
169	100				
170	100				
			385		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	2/19/2020	
Date Borehole Completed:		
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

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LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
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Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
171	100				CLAY: wet, olive. *(continued)*
172	100				
		3278.0	390		
173	100				SAND: medium to coarse grained sand, trace fine grain sand.
174	100				Trace fine gravel.
175	100	3273.0	395		
176	100				
177	100				
		3268.0	400		
178	100				Medium grained sand, few fine grain sand, no gravel.
179	100				
		3263.0	405		Medium to coarse grained sand, trace fine grain sand.
180	100				
					Fine to medium grained sand.
181	100				
		3258.0	410		Medium to coarse grained sand.
182	100				
183	100				
		3253.0	415		
184	100				
185	100				
			420		

continued

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	2/19/2020	
Date Borehole Completed:		
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.

LOG OF BOREHOLE MW #6

Project:	Owens Valley Well Installation	Surface Elevation:	3,668.0 ft
Job Number:	791R1	Top of Casing Elev.:	3,671.0 ft
Location:	Owens Valley, CA	Drilling Method:	Sonic
Coordinates:	N 36.553361 W 118.012633	Depth to Water:	50.0 ft

Sample No.	Recovery %	Elevation, (ft)	Depth, (ft)	Symbol / USCS	MATERIAL DESCRIPTION
186	100				SAND: medium to coarse grained sand, trace fine grain sand. *(continued)* Trace fine gravel.
187	100				No gravel.
		3243.0	425		
188	100				
189	100				
		3238.0	430		
190	100				
191	100				
		3233.0	435		
192	100				
193	100				
		3228.0	440		
194	100				
195	100				
196	100	3223.0	445		
197	100				
198		3218.0	450		
			455		

Completion Depth:	450.0 ft	Remarks:
Date Borehole Started:	2/19/2020	
Date Borehole Completed:		
Logged By:	Mark Ching	
Drilling Company:	BC2 Environmental	Work Order:

The stratification lines represent approximate boundaries. The transition may be gradual.