



TECHNICAL MEMORANDUM 3

DATE: October 16, 2025 **PROJECT #:** 9100

TO: Salinas Valley Basin Groundwater Sustainability Agency

CC: Monterey County Water Resources Agency

FROM: Hanni Blair

REVIEWER: Derrik Williams, P.G., C.Hg.

PROJECT: Salinas Valley Seawater Intrusion Model

SUBJECT: 2025 Seawater Intrusion Model Updates (Addendum 3 to the Salinas Valley Seawater Intrusion Model Report)

INTRODUCTION

In 2023, Montgomery & Associates (M&A) developed the Salinas Valley Seawater Intrusion Model (SWI Model) for the Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA). The model was developed as a tool to assess the effectiveness of projects and management actions that address seawater intrusion in the coastal portions of the Salinas Valley. M&A updated the model in 2024 to incorporate improvements to the hydrogeological conceptual model (HCM) and ensure consistency between the SWI Model and existing adjacent and overlapping groundwater flow models (M&A, 2023, 2024). The 2024 version of the SWI Model is referred to as SWI Model v2 and the updated version of the SWI Model in this technical memorandum is referred to as SWI Model v3.

The United States Geological Survey (USGS) published the Salinas Valley-wide groundwater model—the Salinas Valley Integrated Hydrologic Model (SVIHM)—for the County of Monterey and Monterey County Water Resources Agency (MCWRA) in April 2025. M&A updated the SVIHM to improve the model for compliance with the Sustainable Groundwater Management Act (SGMA) (M&A, 2025). M&A updated the SWI Model to be consistent with the revised SVIHM. This technical memorandum documents the SWI Model updates based on the updated SVIHM.

M&A worked with Marina Coast Water District Groundwater Sustainability Agency's (MCWDGSA) consultant, EKI Environment & Water, Inc. (EKI), and the Seaside Watermaster's modeler to update the SWI Model. Revisions were funded through a Round 2

Sustainable Groundwater Management (SGM) Implementation Grant to MCWDGSA and SVBGSA.

Model revisions focused on updating boundary conditions, hydraulic conductivity, and storage model parameters to match the SVIHM. Both the SVIHM and SWI Model were updated simultaneously as information was passed between the models during calibration.

AGENCY COLLABORATION

M&A coordinated regularly with the MCWD and Seaside Watermaster modeling teams during the model updates. The Seaside Watermaster and MCWD modeling teams reviewed the SWI Model's well locations, screen intervals, and pumping rates. They provided estimates of pumping in the Seaside and Marina Coast areas during the pre-Groundwater Extraction Management System (GEMS) period (before 1995). EKI updated the SVIHM recharge assumptions within the Monterey Dune Sands and City of Marina areas, which directly influenced recharge in the SWI Model. These revisions are documented within the SVIHM Model Report (M&A, 2025). Also, EKI provided suggestions for hydraulic conductivity in coastal Monterey Subbasin to improve water level calibration in that area.

MODEL UPDATES

SWI Model updates focused on reconciling the following with the SVIHM:

- Updating the model hydrogeologic parameter zonation and active extent
- Adjusting recharge assumptions
- Updating well locations, screen intervals, and pumping data to most recent information available as reflected in the SVIHM and GEMS
- Adding flow barriers to represent faults in Monterey and Seaside subbasins
- Implementing hydraulic conductivity and storage parameters consistent with the SVIHM
- Extending the simulation period to October 2022

The prior model simulated groundwater conditions through September 2020. The model was extended through September 2022 to match the simulation period of the SVIHM, and 24 monthly stress periods were added to the model to extend the simulation 2 years.

These update areas are discussed in more detail below.

Updated Model Hydrogeologic Parameter Zonation

Minor modifications were made to the hydrogeologic parameterization and active extent of the SWI Model to be consistent with the SVIHM. Examples include:

- A zone of high vertical conductivity was added to model layer 2 to represent a thin spot in the Salinas Valley Aquitard near Somavia Road.
- The active extent of Layer 11 (Monterey Formation) was reduced so that this layer is only active within the Monterey and Seaside Subbasins. The Monterey Formation is not expected to be water bearing in the other Salinas Valley subbasins.
- Limited model layer elevations and thicknesses were adjusted in the Langley Subbasin to assist the numerical solver.
- The model active extent was adjusted to match the SVIHM near the model boundaries, eliminating very thin model cells.

Figure 1 through Figure 11 show the updated model hydrogeologic zonation for various layers. Figure 12 and Figure 13 show cross sections through the updated layering and zones.

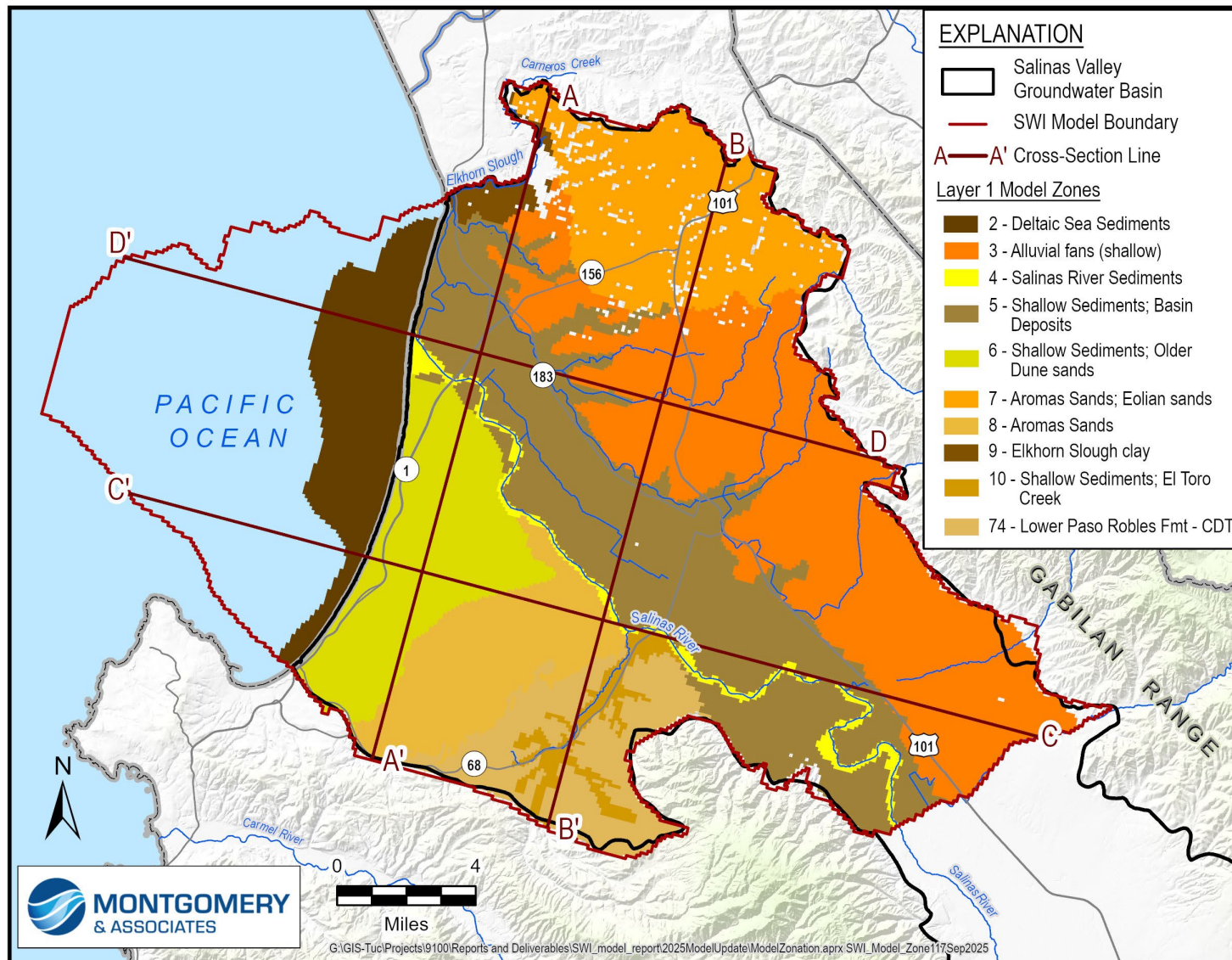


Figure 1. Model Hydrogeologic Zonation in Layer 1

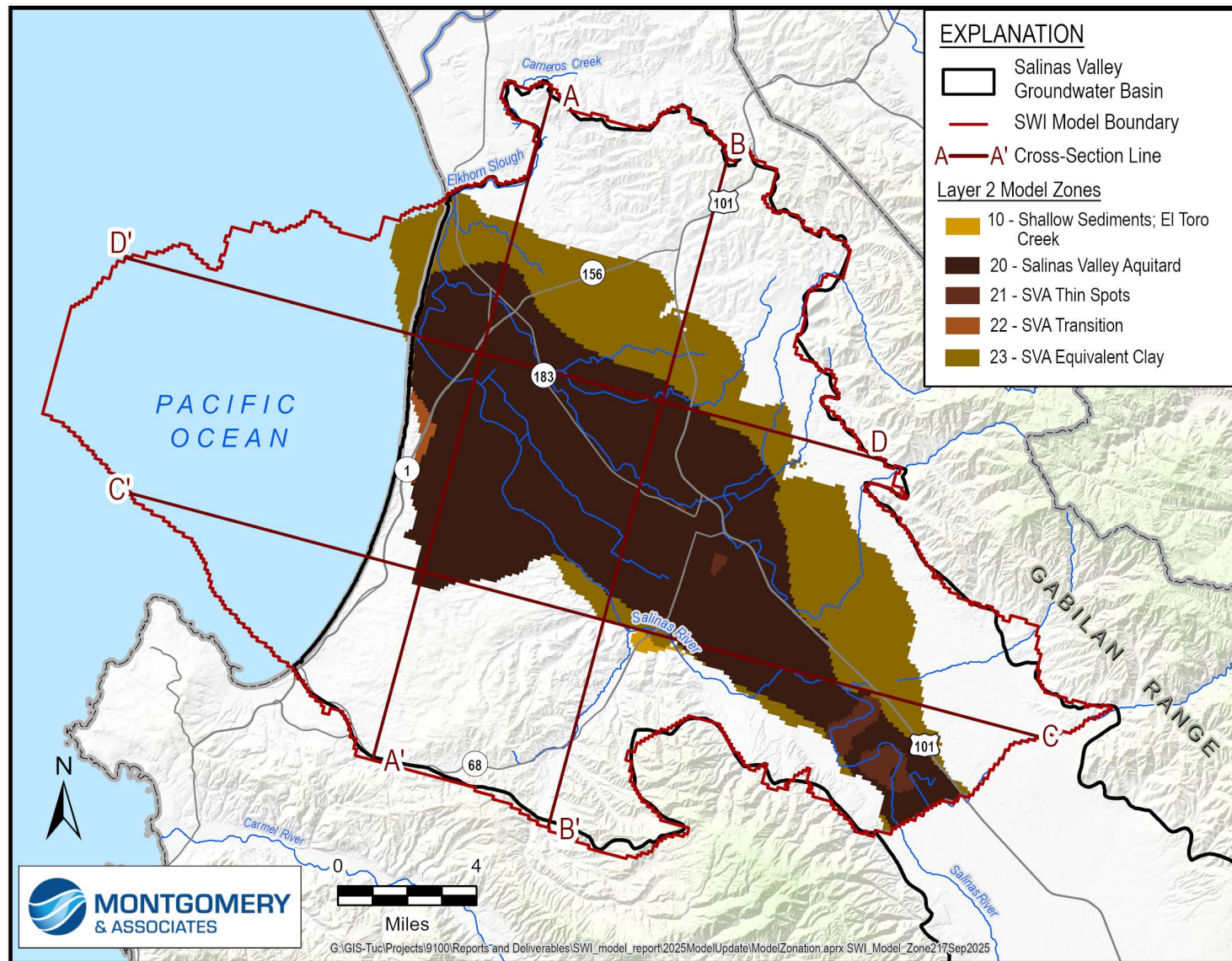


Figure 2. Model Hydrogeologic Zonation in Layer 2

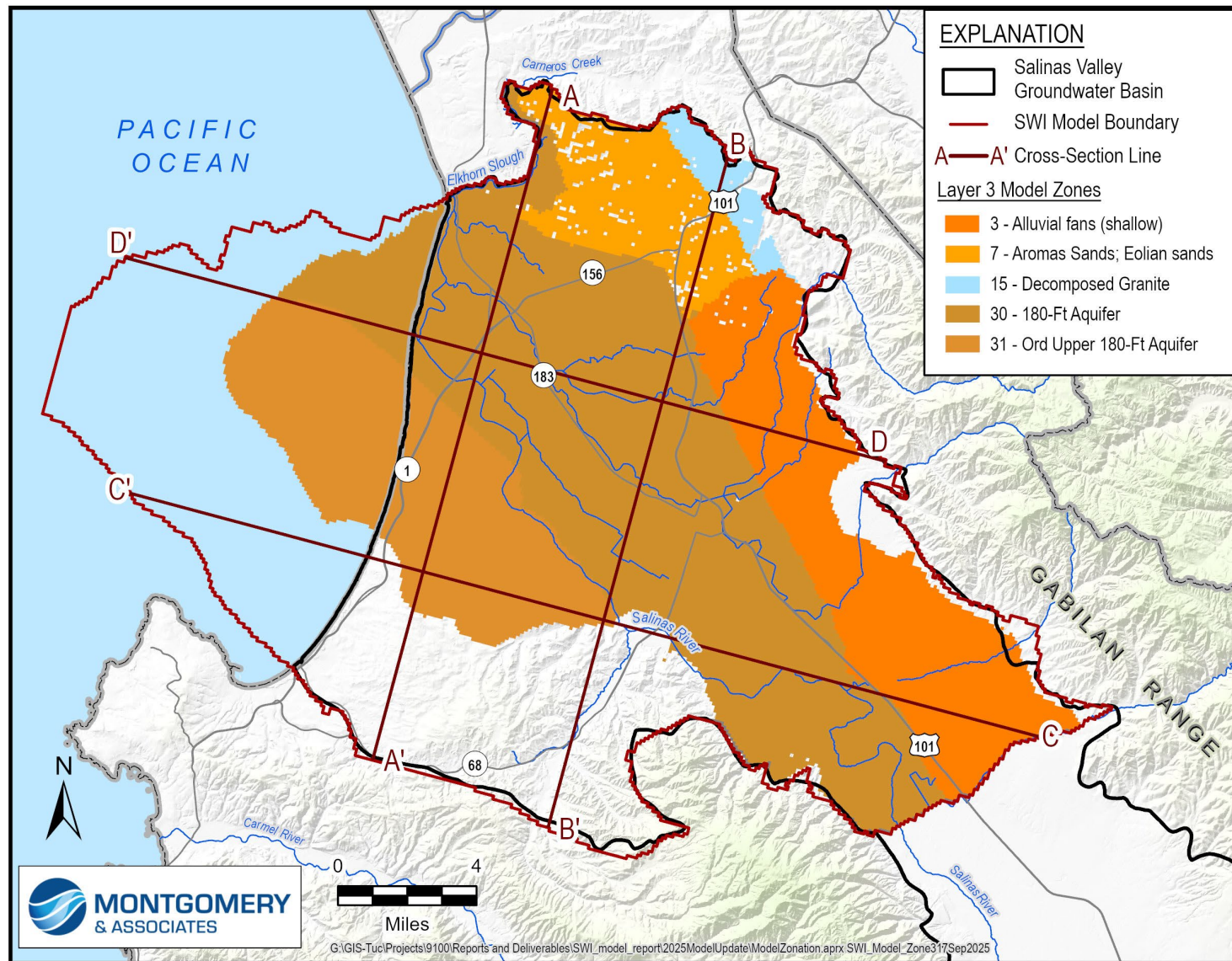


Figure 3. Model Hydrogeologic Zonation in Layer 3

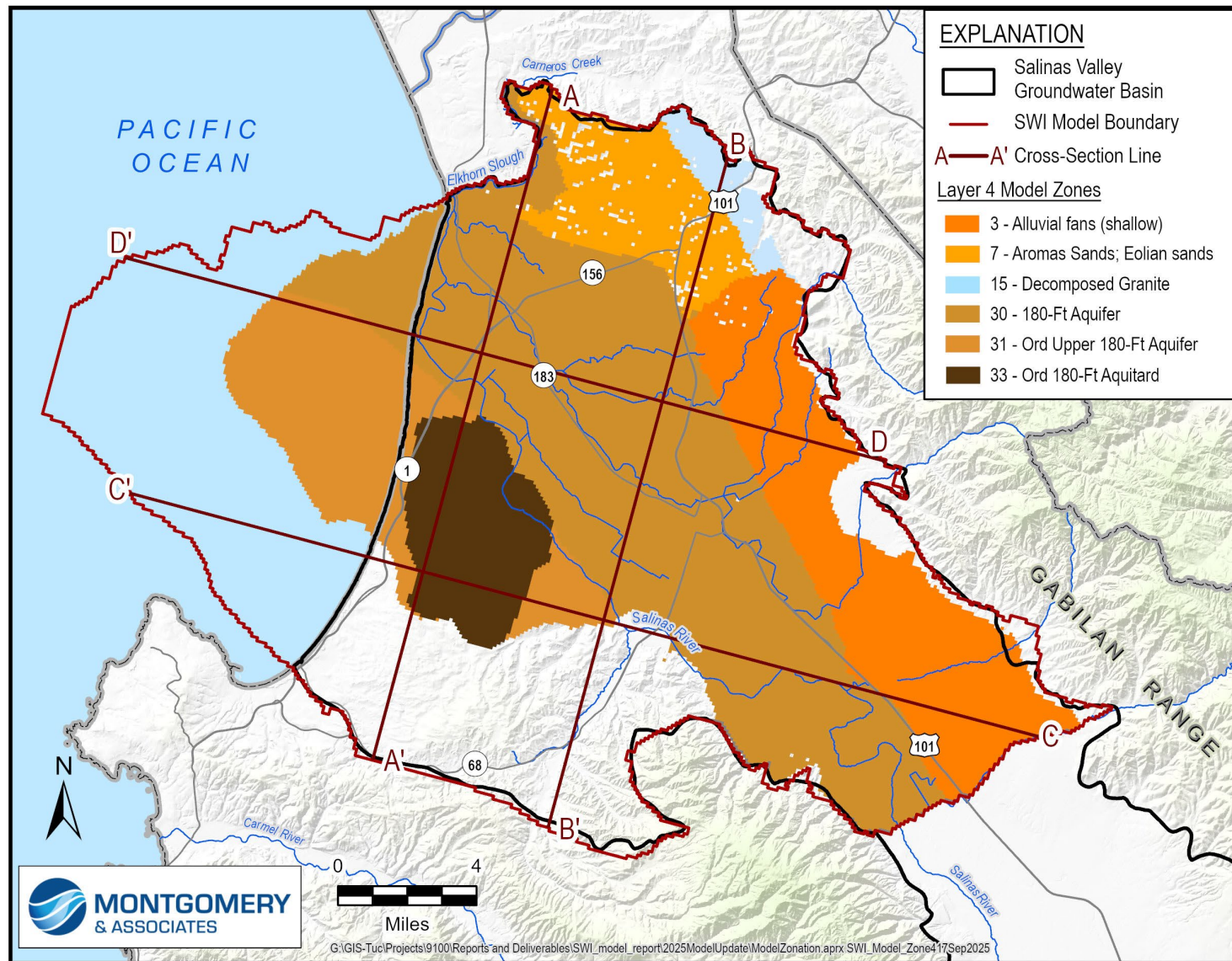


Figure 4. Model Hydrogeologic Zonation in Layer 4

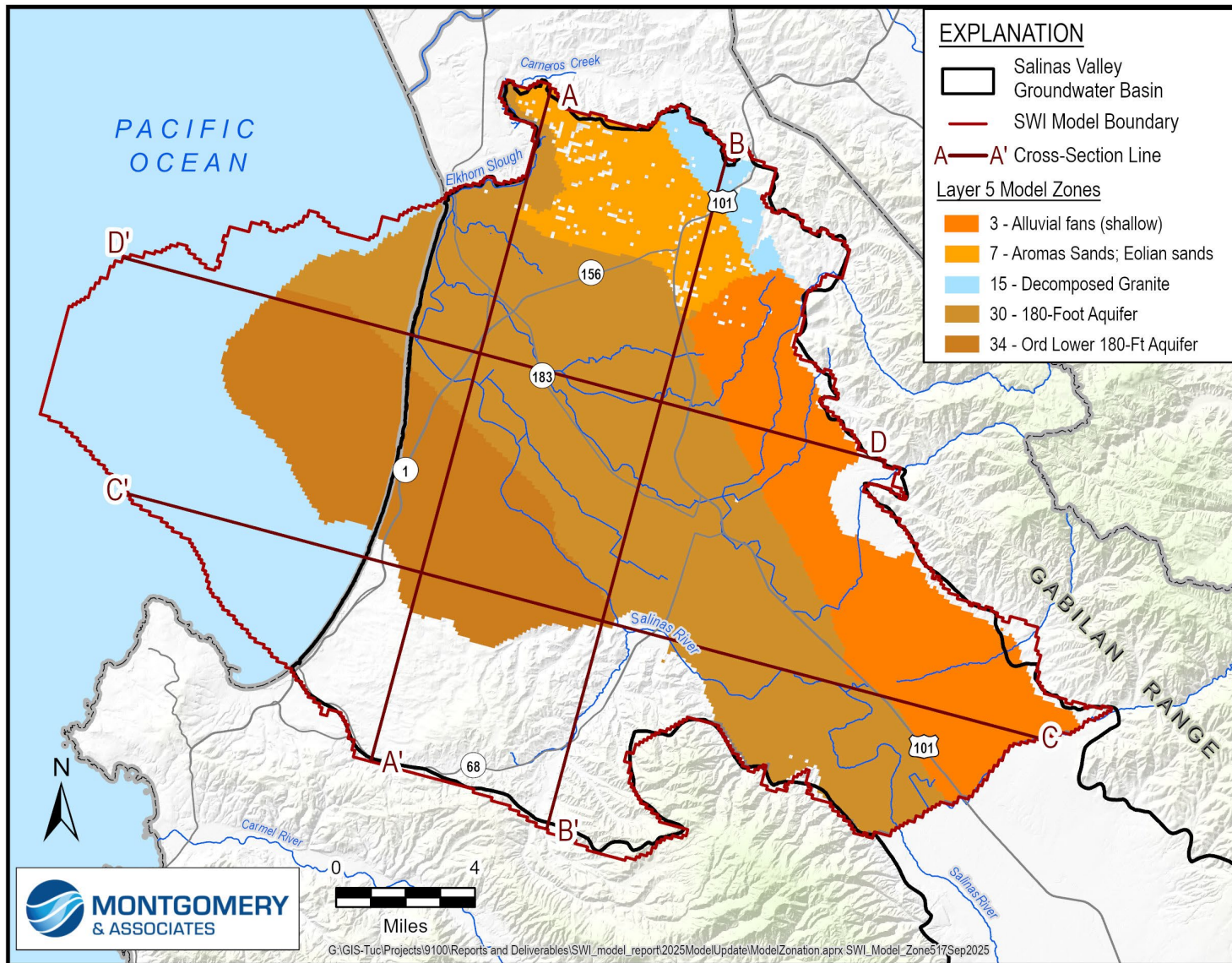


Figure 5. Model Hydrogeologic Zonation in Layer 5

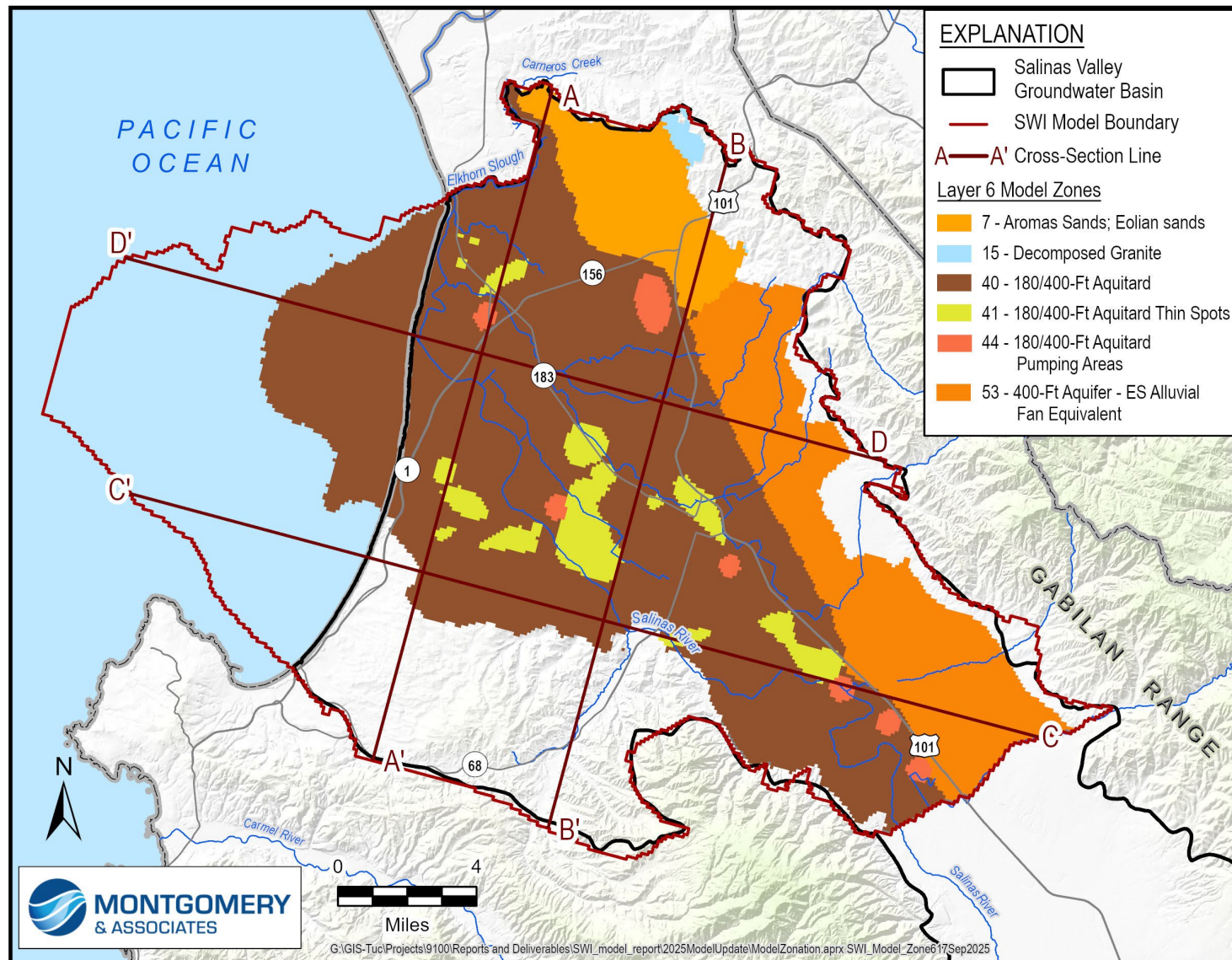


Figure 6. Model Hydrogeologic Zonation in Layer 6

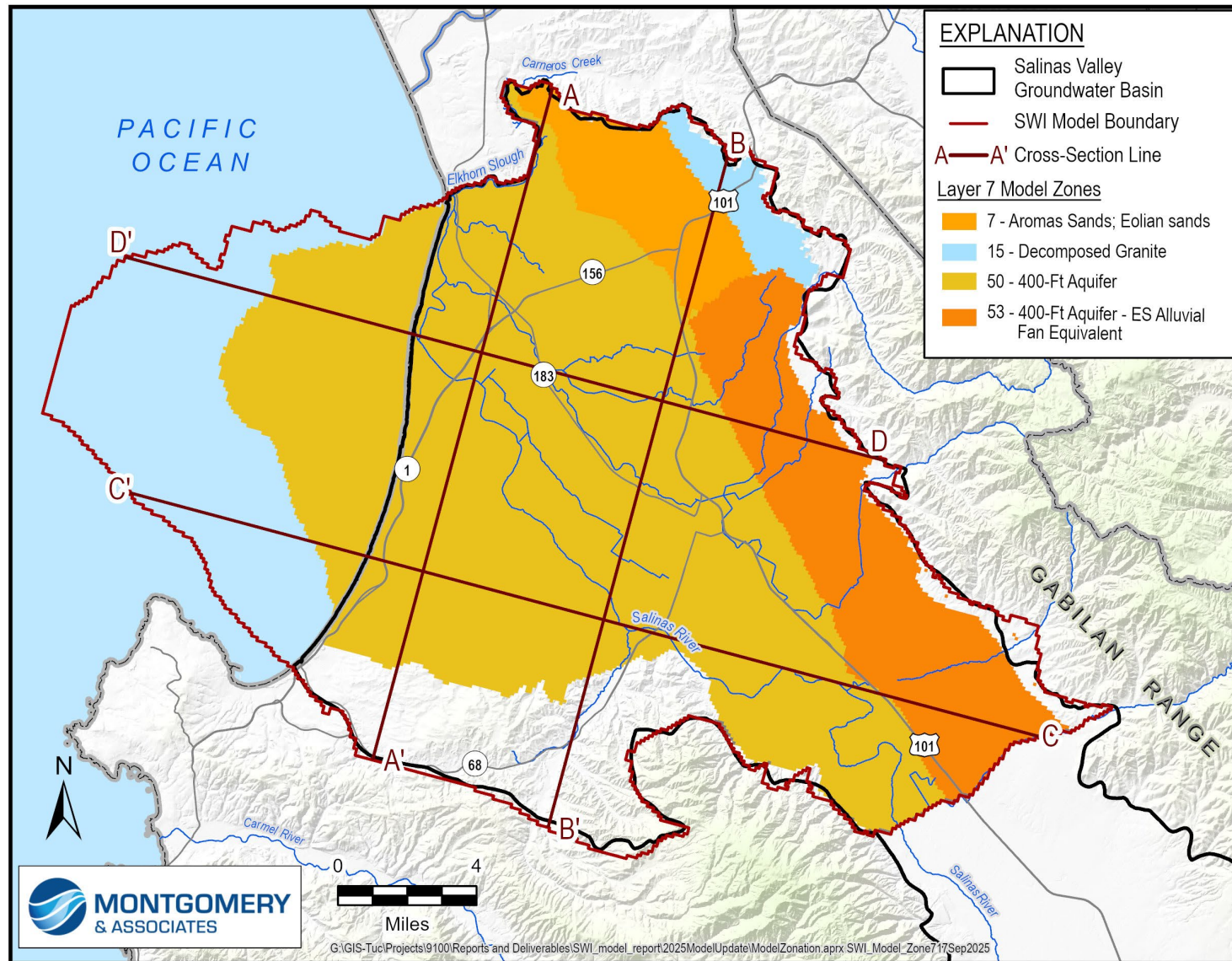


Figure 7. Model Hydrogeologic Zonation in Layer 7

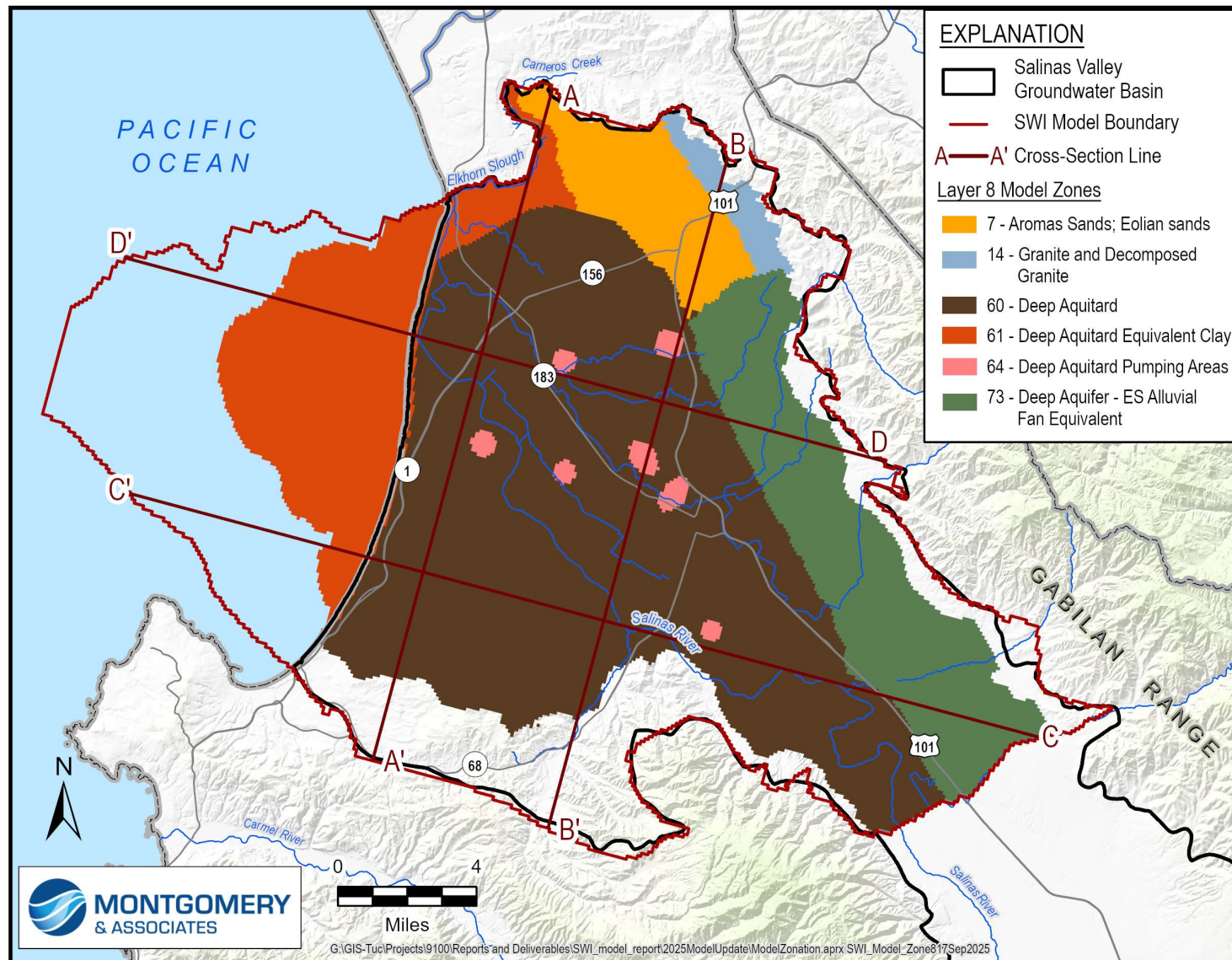


Figure 8. Model Hydrogeologic Zonation in Layer 8

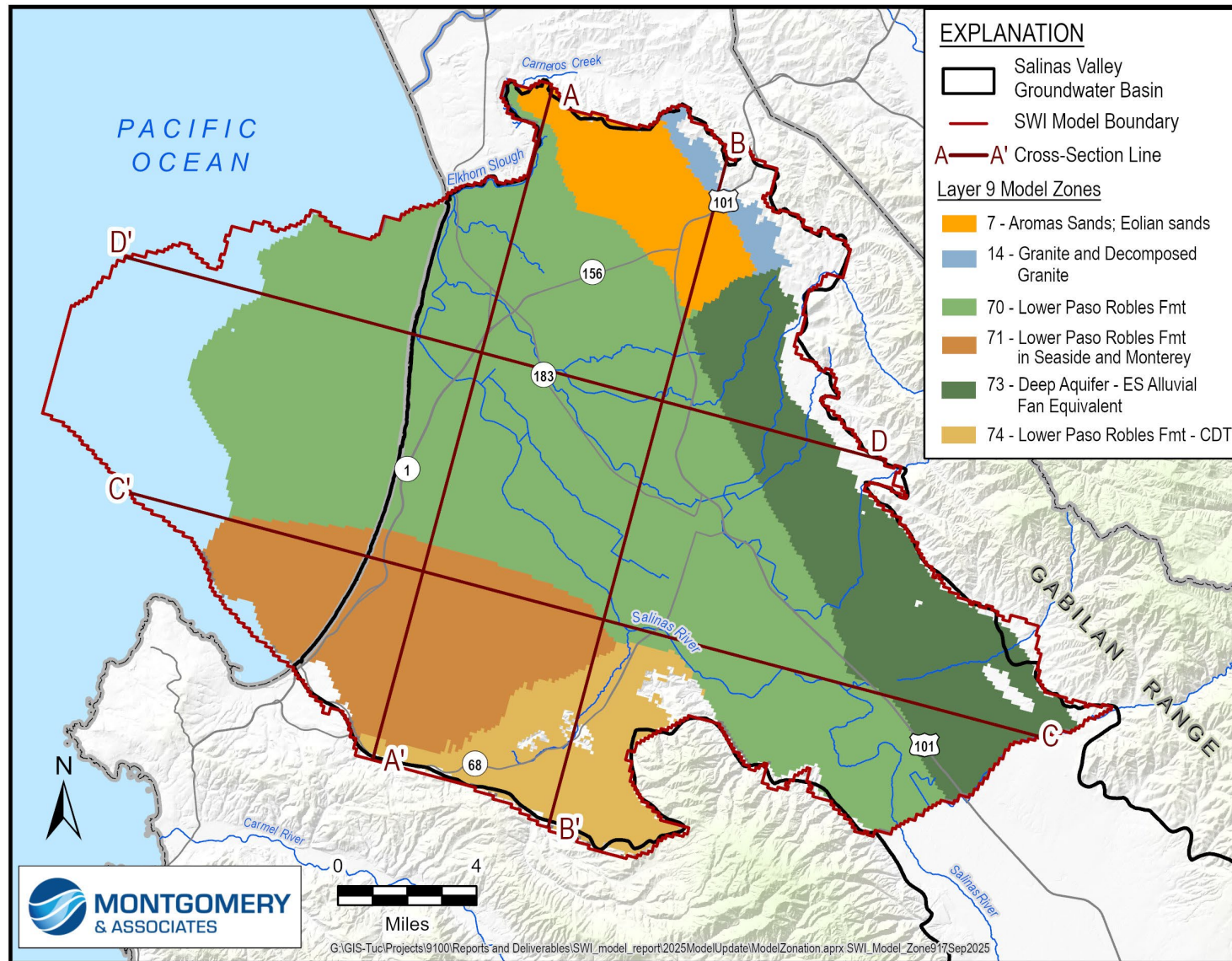


Figure 9. Model Hydrogeologic Zonation in Layer 9

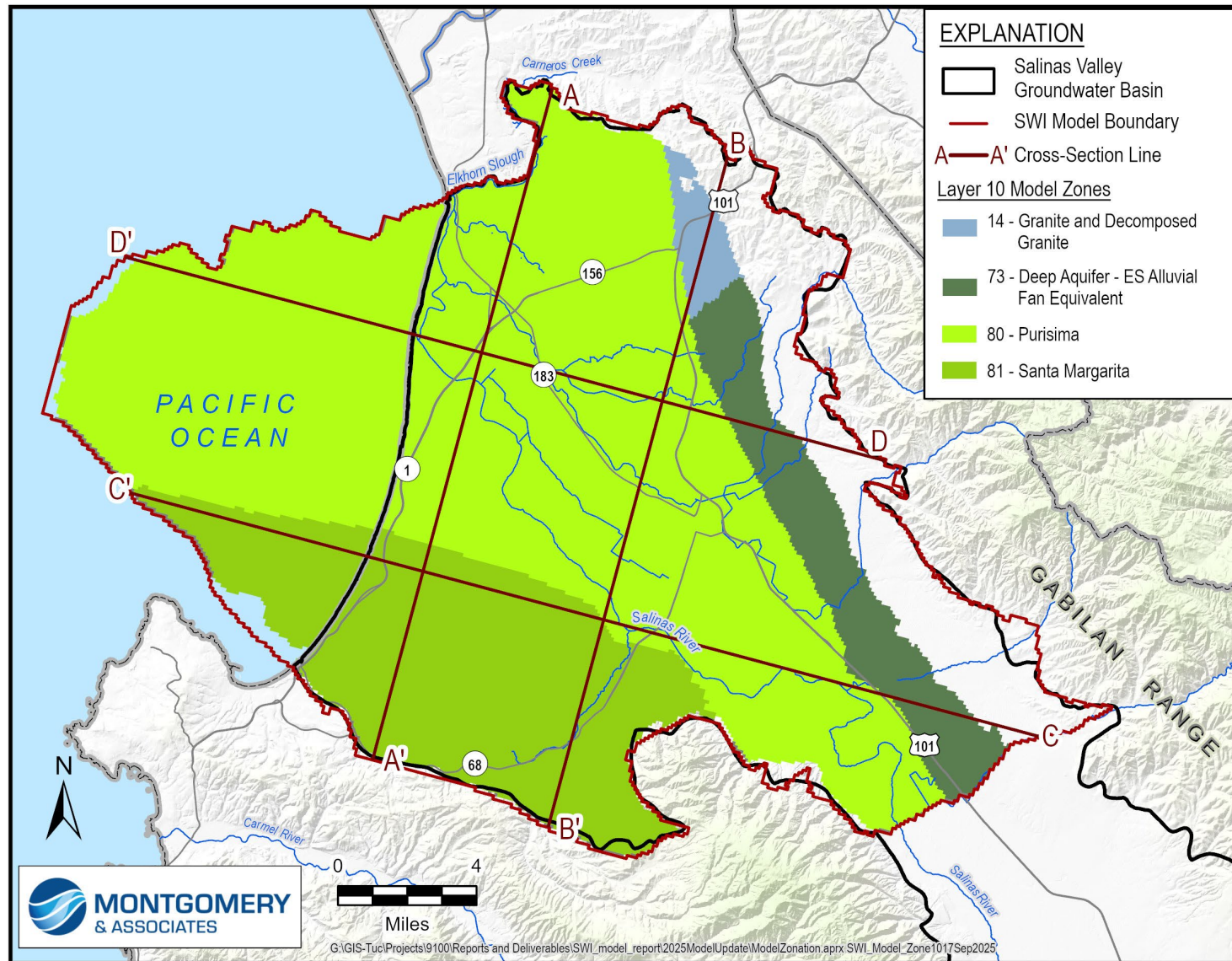


Figure 10. Model Hydrogeologic Zonation in Layer 10

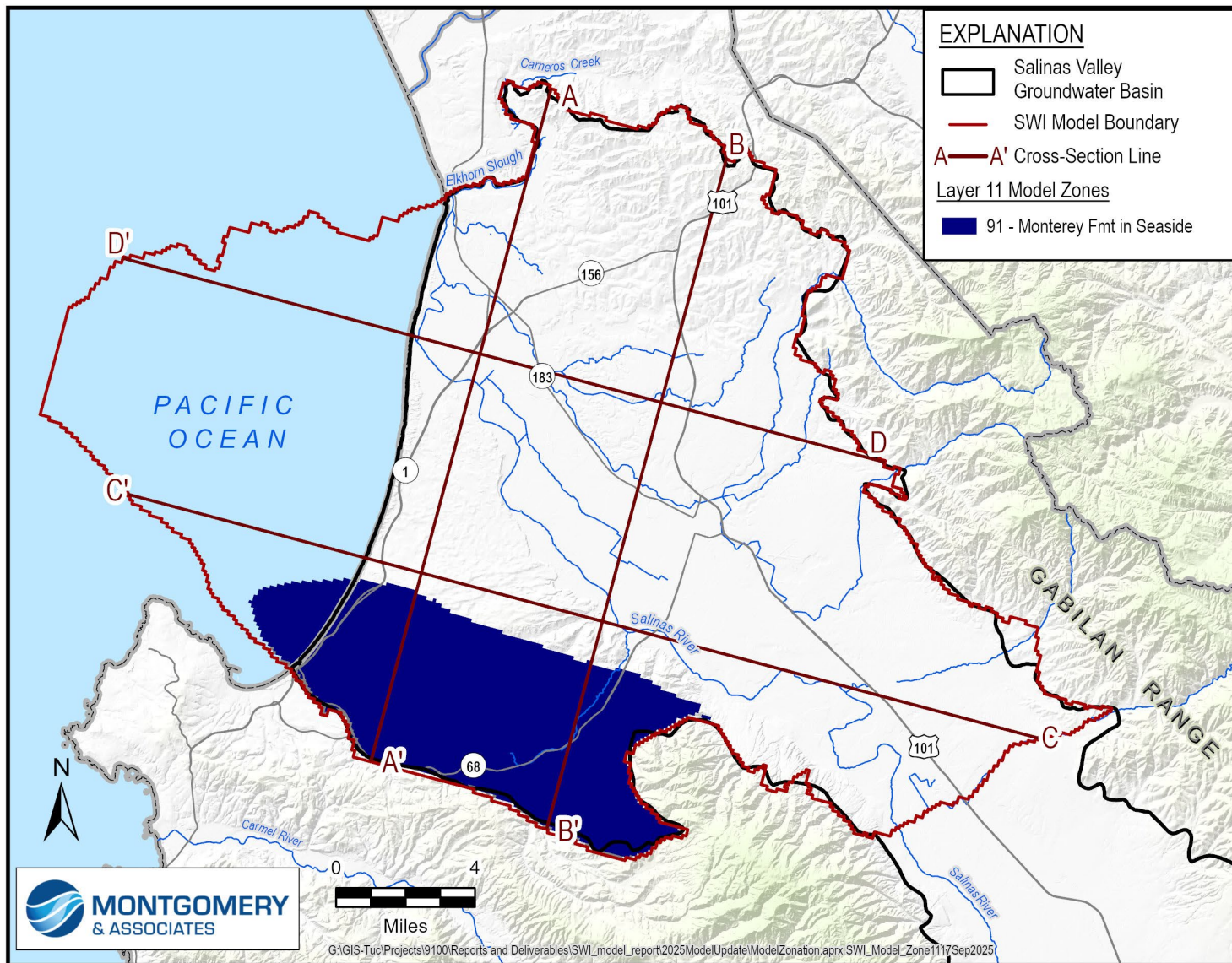


Figure 11. Model Hydrogeologic Zonation in Layer 11

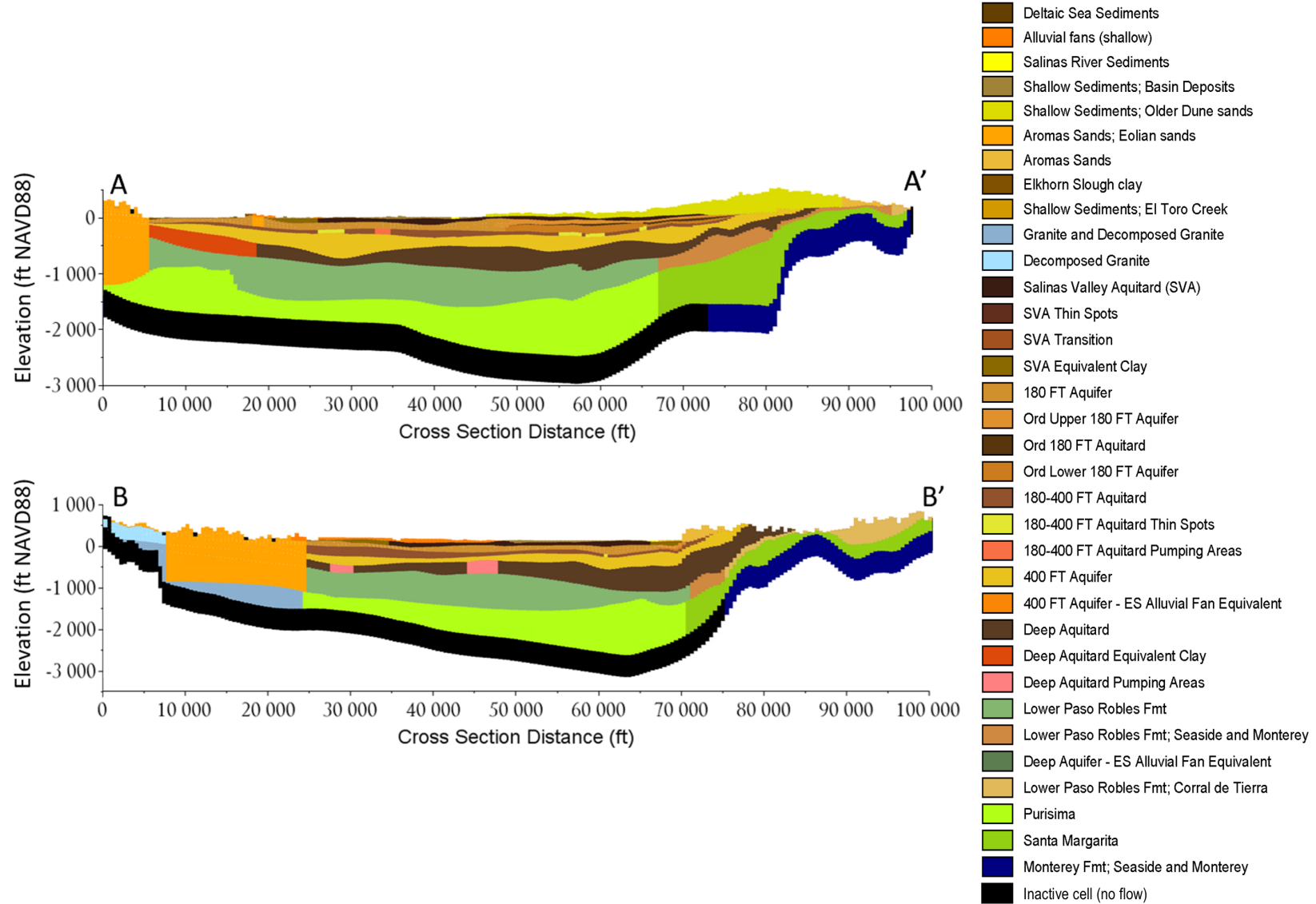


Figure 12. Model Hydrogeologic Zonation in Cross Section A-A' and B-B'

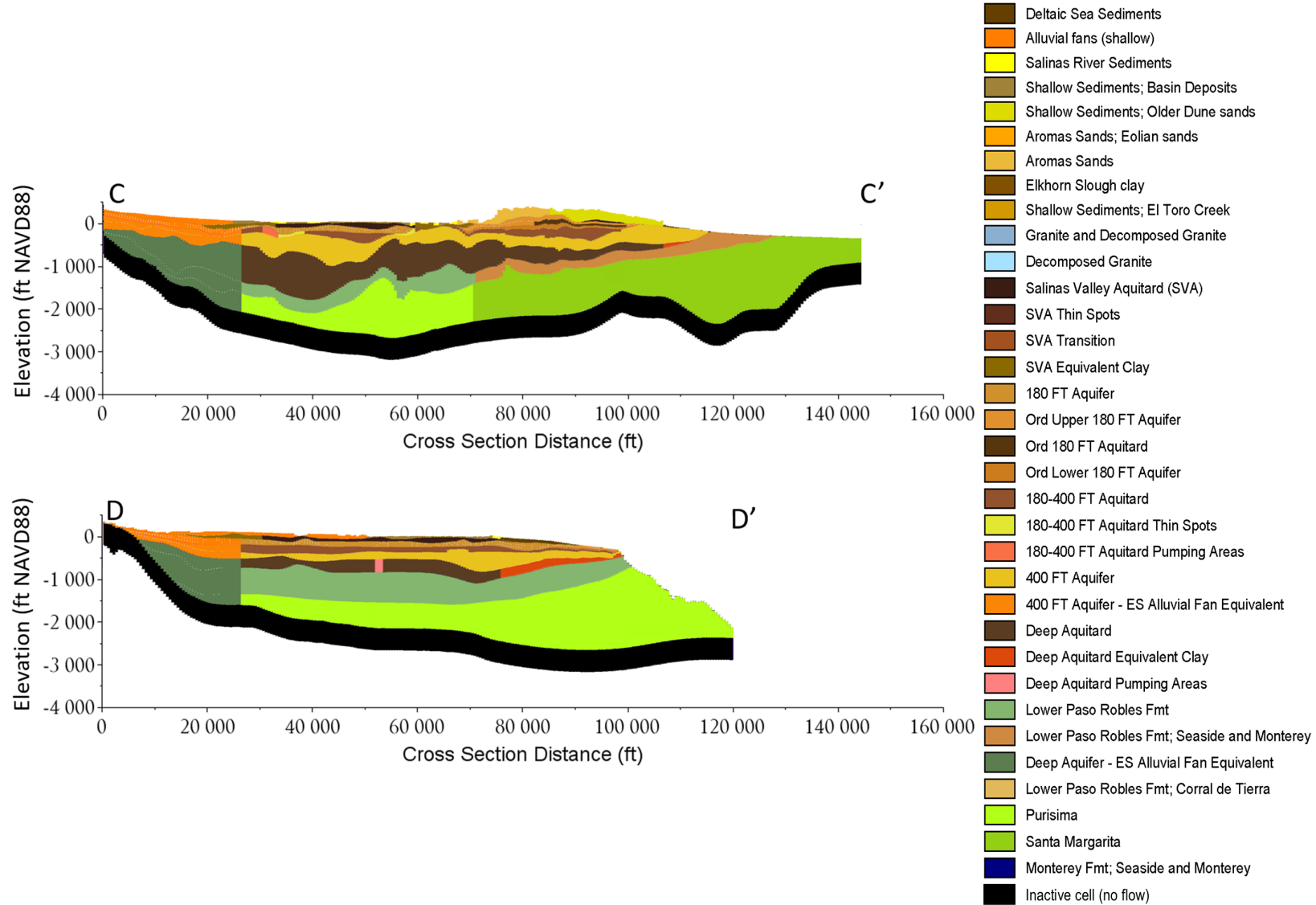


Figure 13. Model Hydrogeologic Zonation in Cross Section C-C' and D-D'

Updated Lateral Boundary Conditions

The sections below describe the methods used to update transient boundary conditions.

Ocean Boundary Conditions

The ocean is modeled with a General Head Boundary (GHB). The ocean GHB cells were not modified as part of the model update. The conductance parameter of the ocean GHB was updated according to the SVIHM values.

The transient heads used for the ocean GHB were extended to match the heads used in the SVIHM ocean boundary condition through September 2022. The heads in the ocean GHB represent transient sea level elevation.

Pajaro Valley Boundary Condition

The northern boundary of the model shared with Pajaro Valley near Elkhorn Slough is modeled with a GHB. The GHB parameters were changed during the previous model update to better match the SVIHM, and were not changed further in this model update. The GHB cells were shifted slightly to accommodate the model's new active extent. The transient heads used for the Pajaro GHB were extended to match the heads used in the SVIHM through September 2022. The heads are based on observations from 4 nearby wells.

Southeastern Up-Gradient Boundary Condition

The southeastern boundary of the model, near the confluence of Chualar Creek and the Salinas River, is modeled with a time dependent constant head (CHD) boundary. Assumptions regarding this boundary condition were not changed in this model update. Transient heads are based on observed water levels from wells near the model boundary. Heads in the Pressure area layers 2-7 are based on the average groundwater levels of wells 16S04E08J01, 16S04E04C01, 16S04E02Q03, 16S04E10R02, 16S04E15D01, 16S04E05M02, 16S04E08B01, 16S04E15R02, 15S04E24N03, 16S04E16E01, and 15S04E14N01. Heads in model layers 2-6 in the Eastside Subbasin are based on groundwater levels observed at well 15S04E24N0, which is screened in the Eastside Shallow Zone. The Eastside Shallow Zone is present in equivalent model layers as the 180-Foot Aquifer in the 180/400 Subbasin. Heads in model layer 7 in the Eastside Subbasin are based on groundwater levels observed at well 16S04E02Q03, which is screened in the Eastside Deep Zone. The Eastside Deep Zone is present in the equivalent model layer as the 400-Foot Aquifer in the 180/400 Subbasin. The transient heads were extended from September 2020 through September 2022 based on groundwater level observations during that period.

The heads model layers 8-10 are based on an assumed groundwater level difference between the Deep Aquifers and overlying aquifers. This assumption was not changed in this model update.

The groundwater level difference is assumed to change linearly from 10 feet up in Water Year (WY) 1995 (when pumping in the Deep Aquifers was estimated to have started near this boundary) to 28 feet down in WY 2024 (based on groundwater level observations at the new DA-2 monitoring well near Gonzales). With the extended simulation period, the resulting downward groundwater level difference at the end of the simulation in September 2022 is approximately 18 feet. Figure 14 shows a plot of the simulated southeastern boundary elevations extended through 2022.

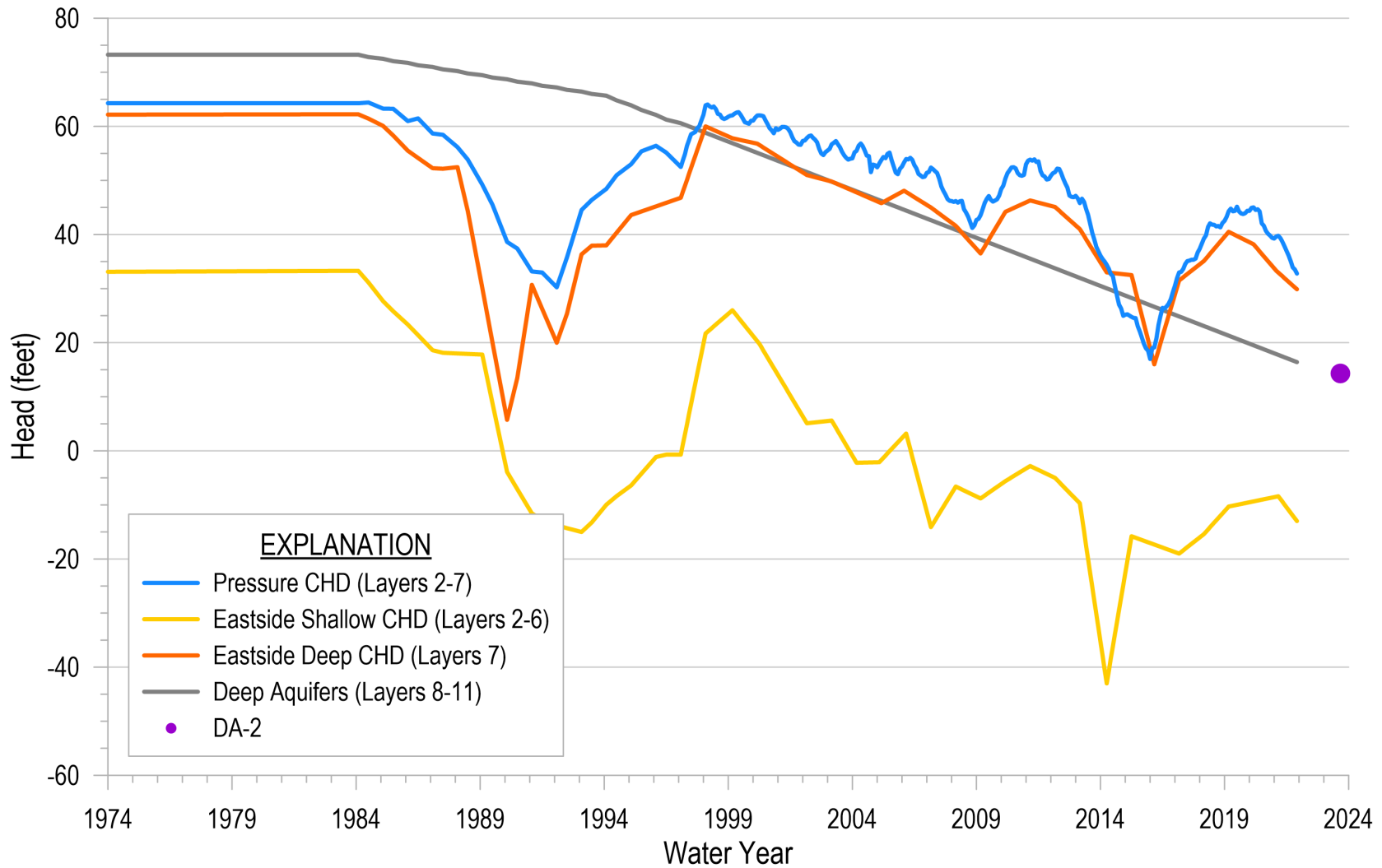


Figure 14. Specified Heads in CHD Along Southeastern Model Boundary Near Chualar

Updated Areal Recharge

Recharge in prior versions of the SWI Model was based on an earlier version of the SVIHM, and the recharge rates were calibrated in the prior SWI Model using multiplier parameters. Recharge rates were extracted from the updated SVIHM for WY 1968 through 2022 for the updated SWI Model. The recharge rates were spatially averaged by SVIHM Water Balance Subregion. The updated SWI Model v3 total annual recharge is compared to the previous SWI Model v2 annual recharge on Figure 15.

Adjustments to the SVIHM recharge were made to accommodate the different stress period lengths and the simulation period of the SWI Model. The SVIHM has monthly stress periods while the SWI Model stress periods are more than 1 month in duration prior to WY 1998. Monthly recharge rates from the SVIHM were averaged across the length of the SWI Model stress periods. The SVIHM starts with WY 1968, which falls within the 60-year-long stress period 2 of the SWI Model. Stress period 2 of the SWI Model simulates WY 1924 through 1984. The recharge for SWI Model stress period 2 was based on the average recharge simulated in the SVIHM from WY 1968 through 1984. Recharge for stress period 1 of the SWI Model was assumed to be the same as stress period 2.

As part of prior updates for SWI Model v2, recharge was modified to incorporate recharge rates estimated for the Dune Sands area using a daily soil water balance model for WY 1998-2021 based on the USGS Soil Water Balance Model Version 2.0 (SWB2.0) (EKI, 2023). The recharge rates were updated for the period WY 1998-2020 in SWI Model v2 based on simulated rates from the soil water balance model. In collaboration with EKI, the assumptions controlling recharge and runoff of precipitation in the Dune Sands area, including the City of Marina, were updated in the SVIHM so simulated recharge in the SVIHM is closer to recharge in the soil water balance model. Recharge in the SVIHM is not directly specified – it is the result of multiple landscape water balance calculations in the Farm Process; therefore, the resulting recharge in the SVIHM and SWI Model do not precisely match the soil water balance model. The modified recharge rates are presented on Figure 16 and Figure 17.

Using recharge estimates from the revised SVIHM, M&A updated the recharge for the Dune Sands Area for the entire simulation period. Average annual recharge rates in the Dune Sands area increased from 5.3 inches per year (in/yr) to 7.9 in/yr during the period WY 1985 through 2020. As shown on Figure 16, the updated recharge rates are close to the rates simulated by SWI Model v2 for the period WY 1998 through 2020. The greatest increases occur prior to WY 1998. Figure 17 shows that the revised monthly recharge rates are similar to SWI Model v2, although the late spring recharge is generally higher than SWI Model v2.

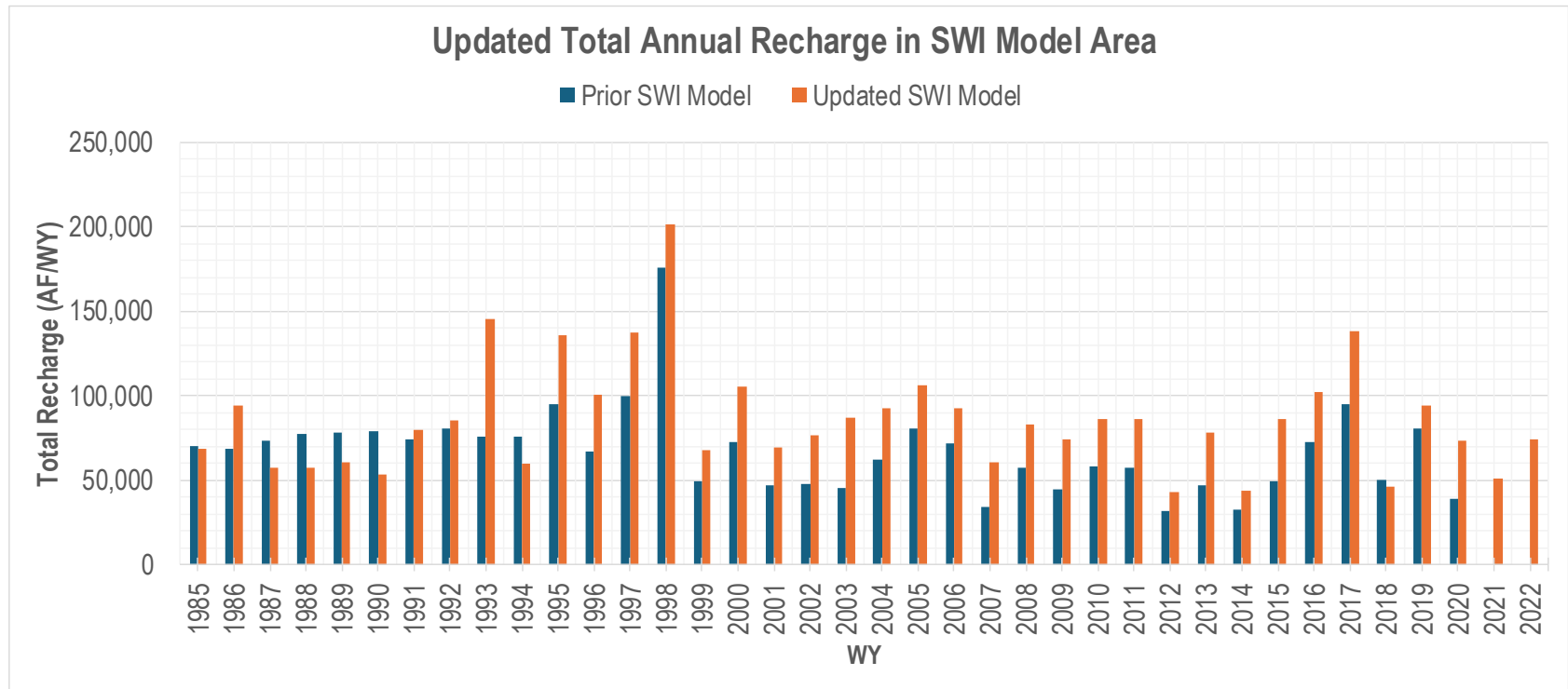


Figure 15. Updated Total Annual Recharge in SWI Model Area

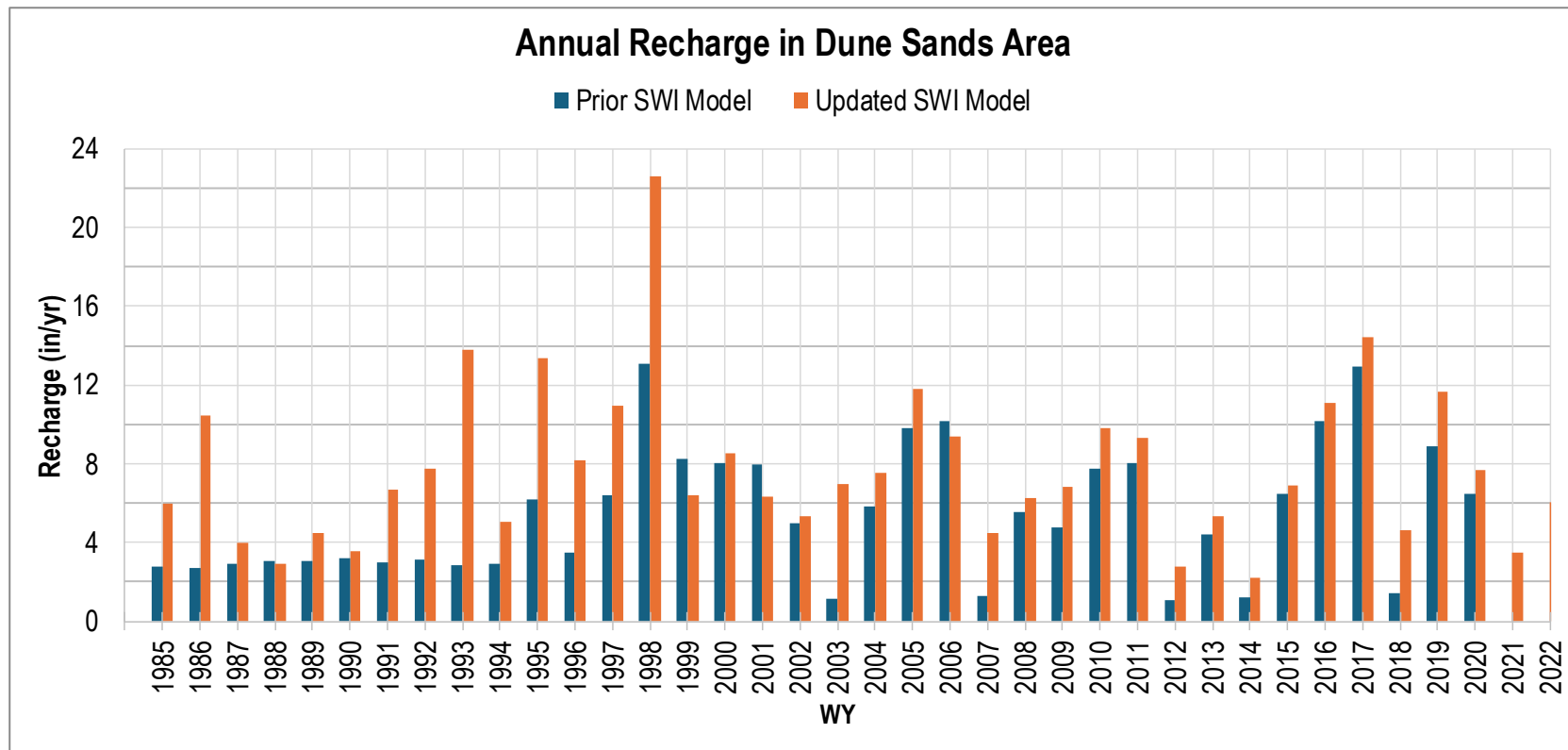


Figure 16. Updated Annual Recharge in Dune Sands Area

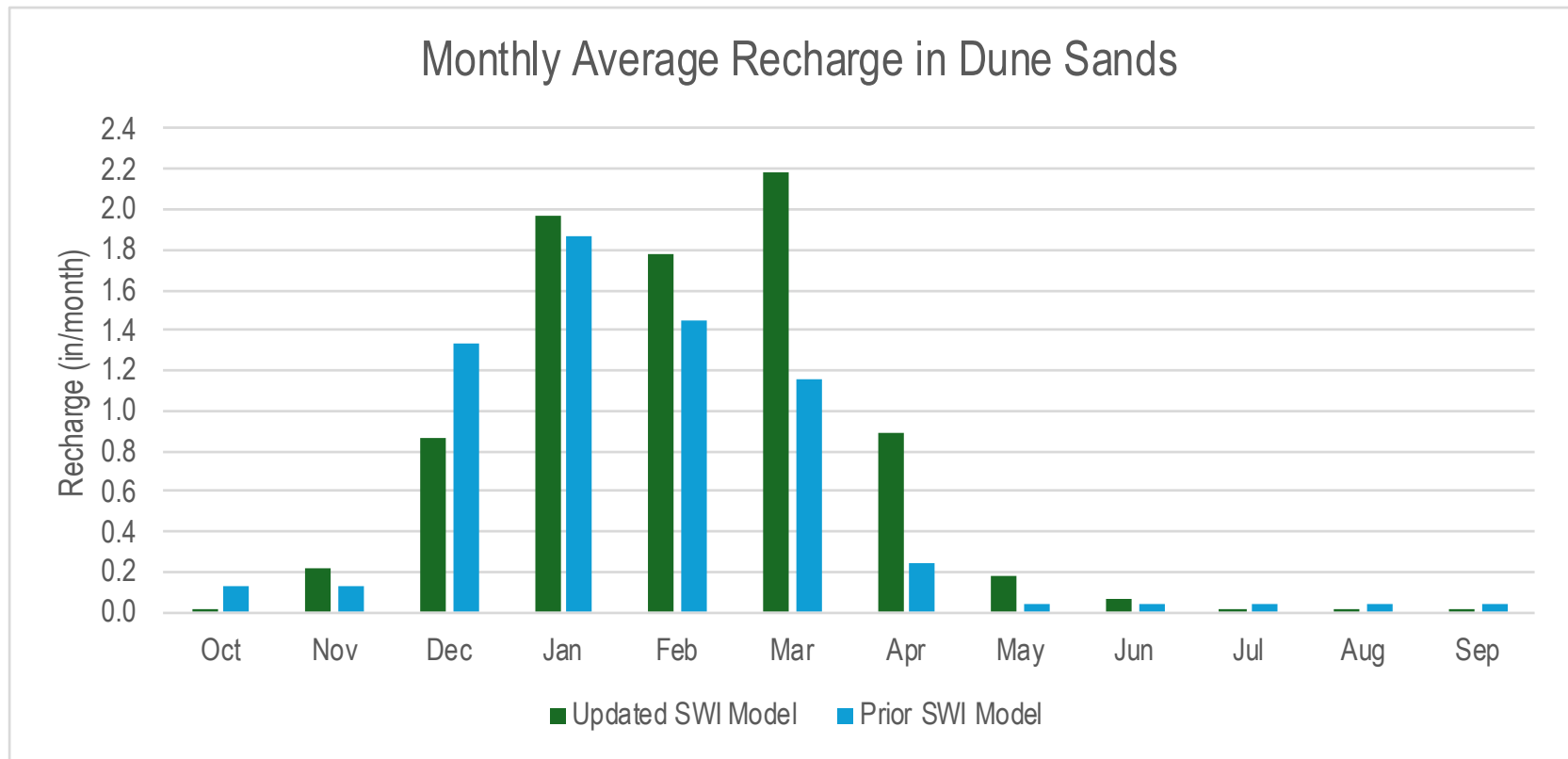


Figure 17. Updated Monthly Average Recharge in Dune Sands Area for WY 1998-2020

Updated Riparian Evapotranspiration

Evapotranspiration (ET) in riparian areas is simulated using the evapotranspiration MODFLOW package (EVT). Actual ET is calculated from potential ET rates that diminish with lower groundwater levels until the ET is zero when groundwater levels drop below a predetermined extinction depth. Generally, only a fraction of the potential ET becomes actual ET; approximately 10% of potential ET becomes actual ET in the SWI Model annually. The potential ET rates in riparian areas of the SWI Model were calculated from the USGS Basin Characterization Model (BCM) (Flint, 2014) during the original SWI model development. These original ET estimates were not changed in the current model update. Because actual ET is typically much less than potential ET, the WY 2020 monthly riparian potential ET rates were used as inputs for WY 2021 and 2022.

Updated Streams

Streambed bottom elevation and channel widths represented in the SWI Model were originally developed from SVIHM inputs. These were recalculated in the updated SVIHM to better match digital elevation model surveys of Salinas Valley. In many cases, this resulted in a significant decrease in the streambed elevation. The SWI Model update focused on modifying streambed leakance parameters to match SVIHM simulated leakage. The leakance was generally increased in streams in the Eastside Subbasin and decreased in Corral de Tierra area to better match SVIHM simulated leakage. Streambed elevations were updated in the SWI Model for streams in the Langley, Eastside, and Corral de Tierra areas.

The transient stream inflows were updated through 2022 based on the inflows in the SVIHM, which originate from the Salinas Valley Watershed Model (Hevesi *et al.*, 2025). Due to uncertainty in stress period 1 and 2 inflows, the prior model version inflows were maintained.

Updated Well and Pumping Data

The SWI Model well locations and screen intervals were updated based on information included in the revised SVIHM. The updated urban and agricultural pumping rates are shown on Figure 18 and Figure 19. The pumping rates were revised in the SWI Model to match those in the SVIHM Model for pre-GEMS period (before 1995) for both urban and agricultural pumping. Changes to agricultural pumping pre-1995 result from updates to the SVIHM Farm Package. Changes to urban pumping pre-1995 result from a review and revision of estimated urban pumping rates by M&A as well as EKI and the Seaside Watermaster's modelers.

Pumping rates in the SWI Model from 1995 through 2022 are based on GEMS pumping data for both municipal and agricultural pumping. The pumping rates from 1995 to 2022 are similar to

the prior SWI Model rates; differences are due to subsequent review and corrections to the GEMS pumping data.

A test slant well for the California American Water (Cal-Am) Monterey Peninsula Water Supply Project was added to the model as a well in the connected linear network (CLN) package. The test slant well was assumed to pump at rates reported by the Monterey Peninsula Water Supply Project Hydrogeology Working Group (2016). The test slant well is screened in the Dune Sands and upper 180-Foot Aquifer near the coast (Geoscience Support Services, Inc., 2019).

As in the prior model update, there are several wells without screen interval information where the well screen was conservatively assumed to bridge both the 180-Foot and 400-Foot Aquifers. When this resulted in migration of seawater from the 180-Foot Aquifer to the 400-Foot Aquifer through the CLN well in an area where this has not previously been observed, the well screens were reassigned to either the 180-Foot or 400-Foot Aquifer.

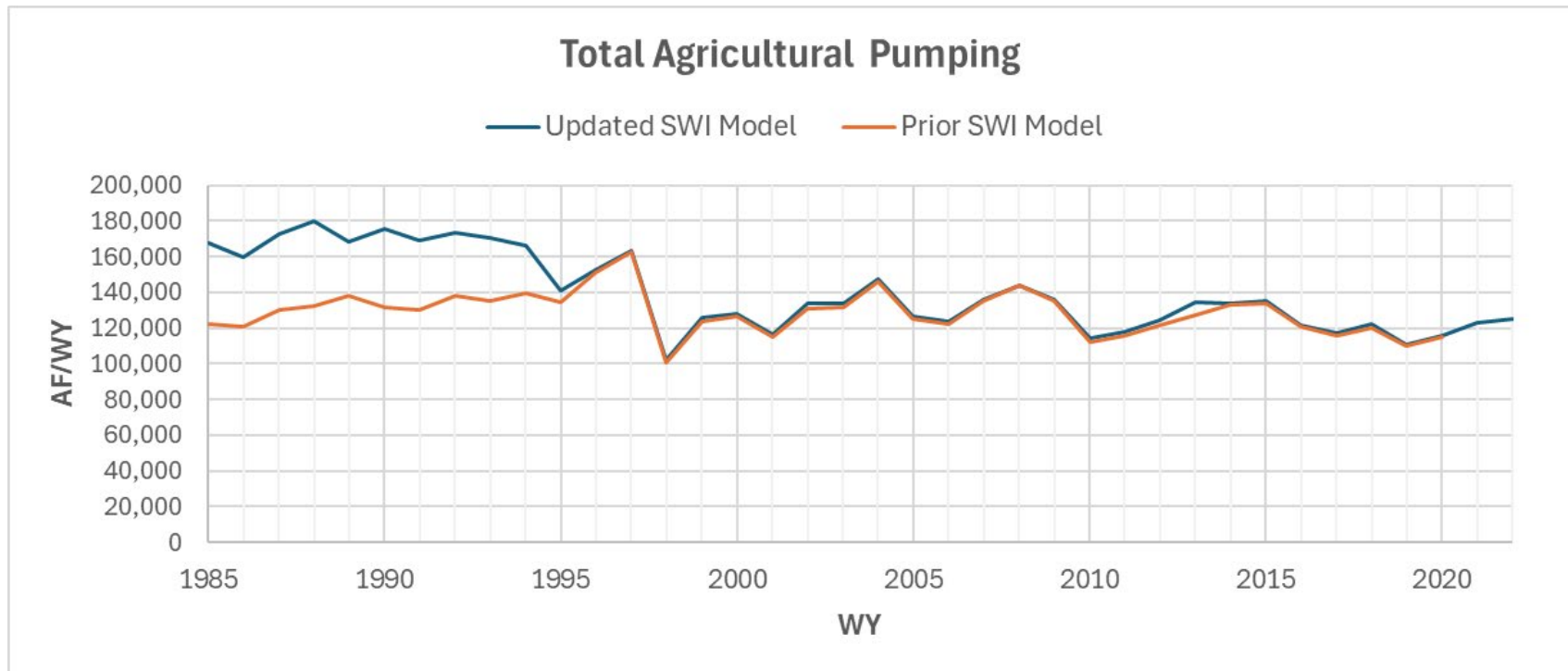


Figure 18. Updated Total Annual Agricultural Pumping

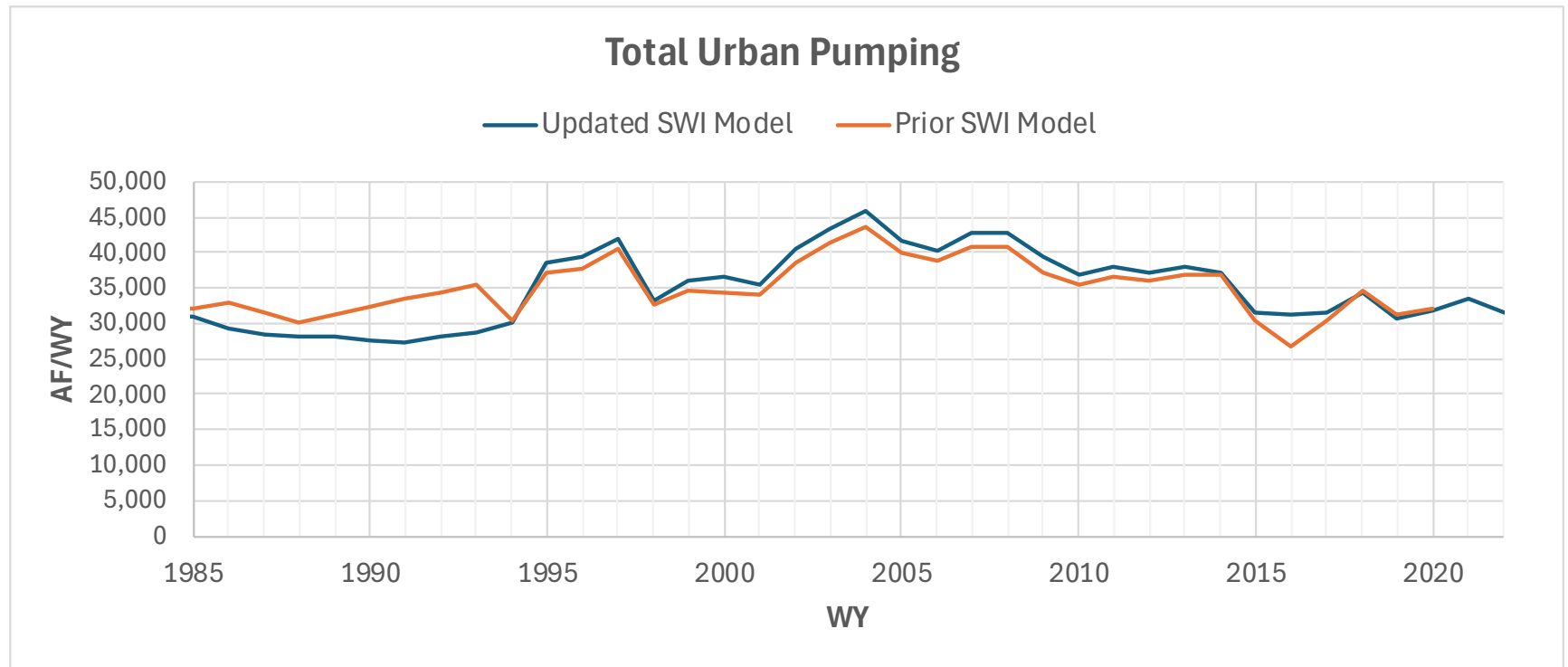


Figure 19. Updated Total Annual Urban Pumping

New Faults

Faults were simulated with the Horizontal Flow Barrier package (HFB). These faults were not in SWI Model v2, but were added to SWI Model v3 to mirror the faults in the Seaside Watermaster model (SSWM) and the updated SVIHM. The Seaside, Ord Terrace, and Reliz faults were added to the SWI model. The faults were placed in the SWI Model layers equivalent to the hydrogeologic units in which the fault is found in the SSWM. A 1-foot thickness was assumed and the conductance values used were the calibrated conductance values from the SSWM. Table 1 displays properties of the simulated faults. Figure 20 shows the location of the faults.

Table 1. Simulated Faults

Fault	Present in Model Layers	Simulated Conductance (ft/d)	Simulated Thickness (ft)
Ord Terrace Fault	7-11	2.65	1
Seaside Fault	9	0.11	1
Reliz Fault	10	1	1

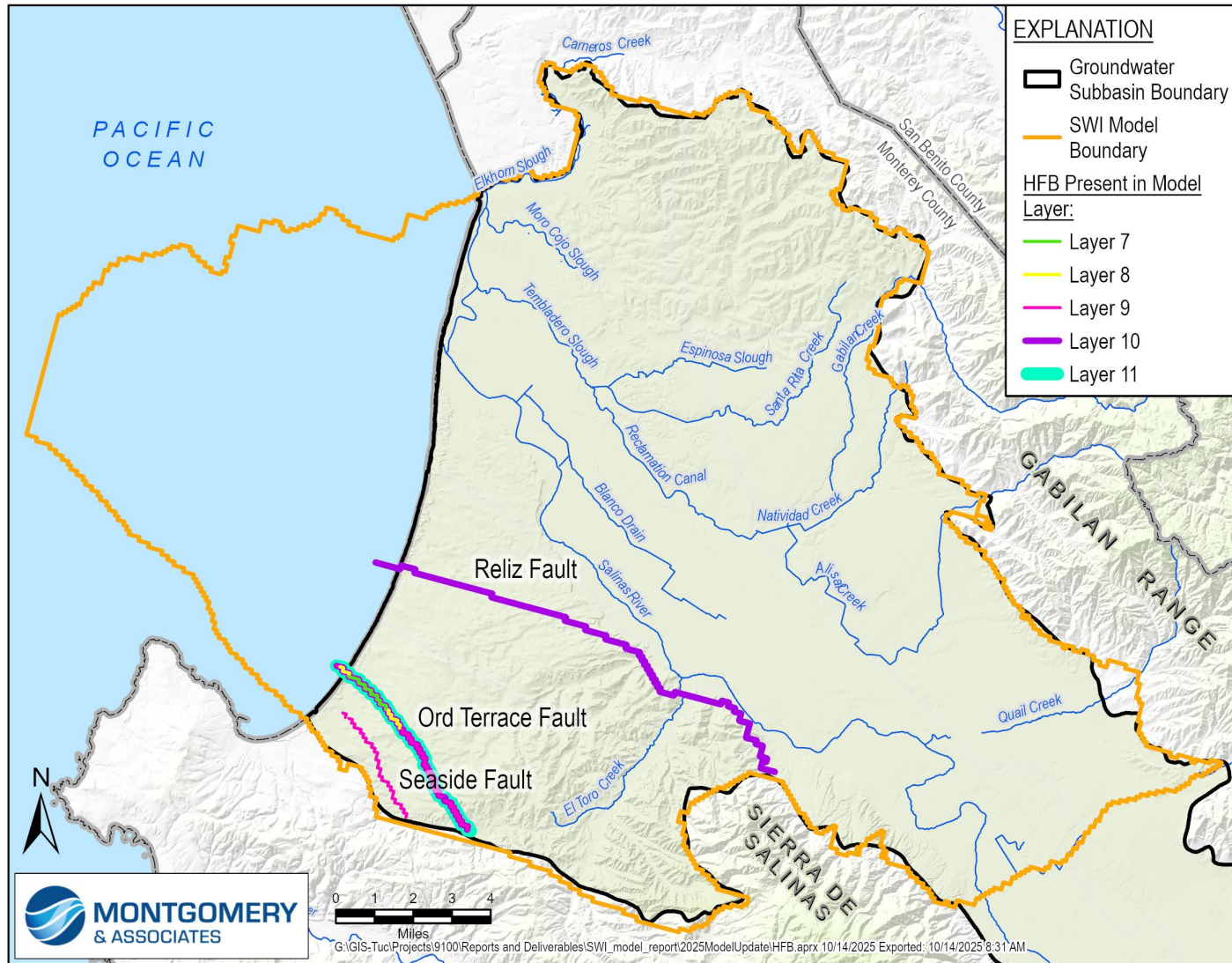


Figure 20. Map of Simulated Faults

Updated Water Level Calibration Target Data

The water level target database was updated to match the water level targets used for the SVIHM. The head observations package (HOB) was used for calibration of water levels in the SVIHM. The HOB package can calculate simulated water levels in wells that screen multiple model layers, but this package is not available with the MODFLOW-USG code used for the SWI Model. A single representative layer was selected for each well in the SVIHM water level observations database based on the model layer in which the majority of the well is screened. The water level observations span 1967 through 2022.

MODEL RECALIBRATION

SWI Model v3 recalibration focused on maintaining consistency with the revised SVIHM while maintaining an acceptable chloride concentration calibration. The revised SVIHM was recalibrated using the pilot points and other parameter estimation techniques included in PEST (Doherty *et al.*, 2010). The calibration parameters included horizontal hydraulic conductivity and vertical anisotropy, specific storage, streambed conductance, and upland recharge/runoff.

The resulting calibrated SVIHM hydraulic conductivity and anisotropy pilot points and specific storage values were imported directly into the SWI Model. The pilot point values were subsequently modified manually to achieve an acceptable chloride concentration calibration. Most of the manually modified pilot points were in seawater intruded parts of Marina and the coastal 180/400 Subbasin. The final hydraulic conductivity pilot point values from the SWI Model were passed back to the SVIHM for model consistency.

The results of the model recalibration are detailed below.

Hydrogeologic Parameters

Table 1 lists the final hydrogeologic parameter values in SWI Model v3 following recalibration. The HGU Zone numbers referenced in Table 1 are shown on Figure 1 through Figure 13. The specific yield and effective porosity values were not adjusted during the model update.

Table 2. Updated Summary of Calibrated Hydraulic Conductivity (K) and Storage Properties of the HGU's within the Model

HGU Zone No.	HGU Description	K _h , K _v Number of Pilot Points	K _h Pilot Point (ft/day)			K _v Pilot Point (ft/day)			Specific Yield (S _y) Effective Porosity	Specific Storage (S _s) (ft ⁻¹)
			Minimum	Maximum	Geometric Mean	Minimum	Maximum	Geometric Mean		
2	Deltaic Sea Sediments	3,3	2.00	56.0	20.7	16.0	48.6	30.2	0.0821	0.0236
3	Alluvial fans (shallow)	16,16	0.340	181	13.2	0.0629	17.5	1.17	0.195	0.0000263
4	Salinas River Sediments	1,1	201	201	201	10.5	10.5	10.5	0.232	0.00100
5	Shallow Sediments; Basin Deposits	6,6	0.805	174	17.1	0.0188	19.7	1.05	0.185	0.00127
6	Shallow Sediments; Older Dune sands	14,14	10.0	219	51.8	0.413	7.80	3.10	0.263	0.000500
7	Aromas Sands; Eolian sands	4,4	0.200	2.00	0.639	0.00775	0.0625	0.0165	0.220	0.000312
8	Aromas Sands	3,3	9.20	43.6	18.2	3.14	15.6	8.73	0.165	0.000194
9	Elkhorn Slough clay	1,1	0.00646	0.00646	0.00646	0.000162	0.000162	0.000162	0.102	0.0000294
10	Shallow Sediments; El Toro Creek	1,1	40.2	40.2	40.2	7.06	7.06	7.06	0.168	0.000137
14	Granite and Decomposed Granite	1,1	0.00703	0.00703	0.00703	0.0000921	0.0000921	0.0000921	0.208	0.0000928
15	Decomposed Granite	1,1	0.131	0.131	0.131	0.0305	0.0305	0.0305	0.208	0.00131
20	Salinas Valley Aquitard (SVA)	11,11	0.00260	0.0229	0.00797	0.0000889	0.0168	0.000792	0.120	0.0000585
21	SVA Thin Spots	1,1	33.6	33.6	33.6	2.74	2.74	2.74	0.120	0.00000200
22	SVA Transition	1,1	0.00542	0.00542	0.00542	0.000223	0.000223	0.000223	0.120	0.0000341
23	SVA Equivalent Clay	3,3	0.00113	0.0622	0.0213	0.000037	0.0256	0.00324	0.120	0.0000324
30	180-Foot Aquifer	19,19	38.7	250	142	1.31	25.0	11.0	0.100	0.0000295
31	Ord Upper 180-Foot Aquifer	13,13	30.0	230	92.4	0.0143	5.58	0.413	0.120	0.00000930
33	Ord 180-Foot Aquitard	6,6	0.560	0.560	0.560	0.00500	0.00500	0.00500	0.128	0.00000757
34	Ord Lower 180-Foot Aquifer	12,12	15.0	230	83.9	0.474	3.92	1.51	0.120	0.0000665
40	180/400-Foot Aquitard	13,13	0.000765	0.00623	0.00802	0.0000163	0.0100	0.000126	0.117	0.0000121
41	180/400-Foot Aquitard Thin Spots	3,3	0.691	0.691	0.691	0.000837	0.00391	0.00137	0.100	0.0000104
44	180/400-Foot Aquitard Pumping Areas	1,1	7.85	7.85	7.85	0.00783	0.00783	0.00783	0.100	0.0000361
50	400-Foot Aquifer	31,31	3.36	200	56.7	0.0100	8.51	0.738	0.100	0.00000768
53	400-Foot Aquifer - Eastside Alluvial Fan Equivalent	16,16	0.230	206	5.76	0.00294	2.83	0.0697	0.195	0.00000438

HGU Zone No.	HGU Description	K _h , K _v Number of Pilot Points	K _h Pilot Point (ft/day)			K _v Pilot Point (ft/day)			Specific Yield (Sy) Effective Porosity	Specific Storage (S _s) (ft ⁻¹)
			Minimum	Maximum	Geometric Mean	Minimum	Maximum	Geometric Mean		
60	Deep Aquitard	8,8	0.000727	0.0864	0.00538	0.00000890	0.0853	0.00265	0.120	0.0000536
61	Deep Aquitard Equivalent Clay	1,1	0.00001	0.00001	0.00001	0.0000100	0.0000100	0.0000100	0.120	0.00000858
64	Deep Aquitard Pumping Areas	1,1	1.14	1.14	1.14	0.139	0.139	0.139	0.168	0.000535
70	Lower Paso Robles Formation	10,10	0.559	67.5	7.60	0.0582	25.1	0.811	0.168	0.000000820
71	Lower Paso Robles Formation in Seaside and Monterey	8,8	1.00	193	13.5	0.0844	7.97	0.663	0.168	0.00146
73	Deep Aquifer - Eastside Alluvial Fan Equivalent	13,13	0.950	39.2	9.12	0.0145	2.86	0.257	0.195	0.00000327
74	Lower Paso Robles Formation – Corral de Tierra	4,4	1.50	20.0	7.38	0.0895	1.00	0.194	0.168	0.00337
80	Purisima	6,6	1.84	77.0	7.41	0.0310	39.3	0.767	0.150	0.000000739
81	Santa Margarita	11,11	0.472	35.0	5.11	0.0485	5.47	0.725	0.150	0.0000404
91	Monterey Formation in Seaside and Monterey	2,2	0.0169	0.700	0.108	0.00297	0.00297	0.00297	0.120	0.0000913

Groundwater Level Calibration

Groundwater levels were recalibrated after implementing all the structural and boundary condition refinements. The groundwater level calibration of SWI Model v3 is generally as accurate as SWI Model v2 across the model domain. Figure 21 shows the cross plot of observed and simulated groundwater levels for SWI Model v3, and Table 3 summarizes the groundwater level calibration statistics across the model for each aquifer and for the entire model. Table 3 shows that the scaled Root Mean Squared (RMS) statistic is similar between SWI Model v2 and SWI Model v3.

As mentioned earlier, the water level calibration dataset was updated to match the calibration dataset used to evaluate the SVIHM. The statistics shown in Table 3 use the updated water level calibration data set for both SWI Model v2 and SWI Model v3. However, the SWI Model v2 was only evaluated through WY 2020, while the SWI Model v3 was evaluated through WY 2022.

Improvements to the surficial sediments calibration statistics are mostly due to improvements to the calibration in the Dune Sands. Water levels in the Aromas Sands portion of Langley Subbasin were included in the surficial sediments group, but the water levels in the granite uplands portion of the Langley Subbasin were evaluated separately and are not included in the Table 3 statistics. The granite upland water levels are shown on the cross plot. The model tends to overpredict the water levels in the granite uplands, whereas the previous model version tended to underpredict water levels in the granite uplands.

The water level calibration in the 180-Foot Aquifer and Eastside equivalent aquifer is similar to the previous model version. The mean residual shows that simulated water levels tend to be slightly low. The water level calibration in the 400-Foot Aquifer and Eastside equivalent aquifer is almost the same as the previous model version.

The water level calibration in the Deep Aquifers has improved. The mean residual indicates that average water levels in the Deep Aquifers within the 180/400-Foot and Monterey Subbasins are shifted slightly lower than the previous model version. On average, the simulated water levels are approximately 5 feet too high in the Deep Aquifers, which is an improvement over 17 feet too high in the previous model version.

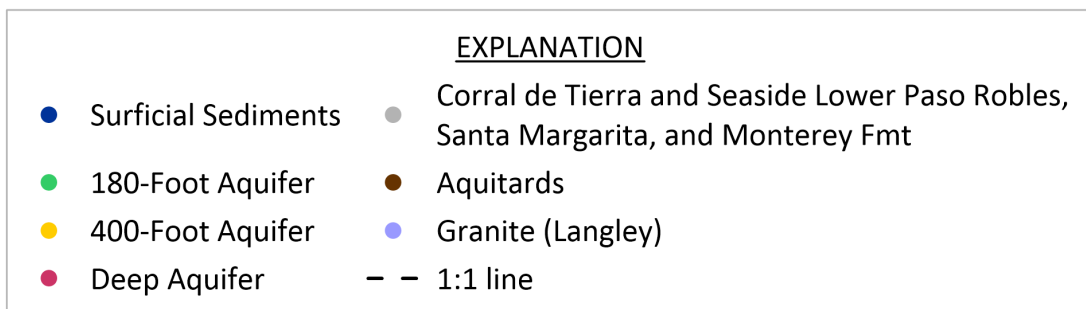
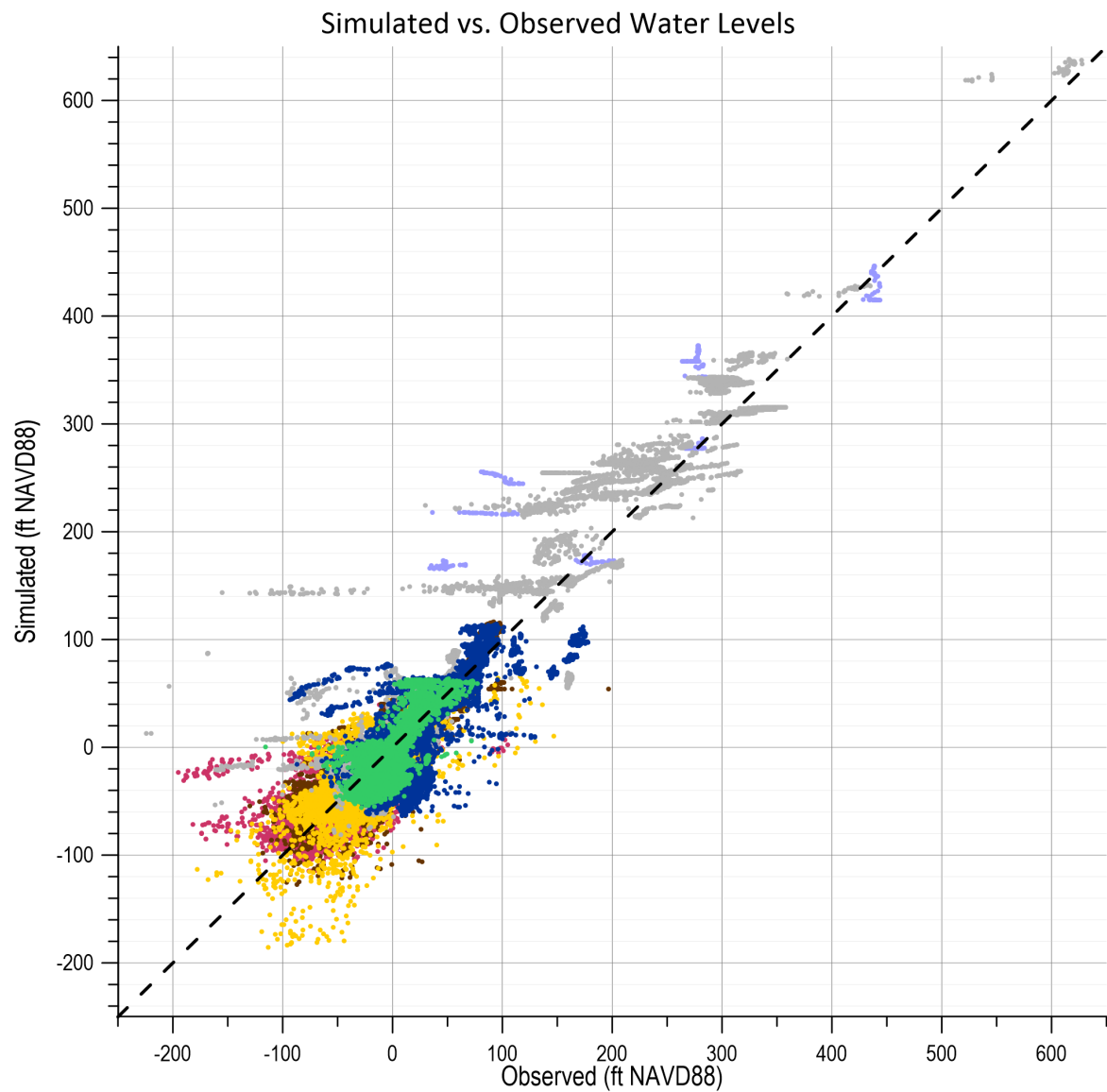
Average simulated groundwater levels in the Seaside Subbasin and Corral de Tierra area increased compared SWI Model v2, as indicated by the increase in the mean residual from 1 foot too high to 20 feet too high. However, the scaled RMS statistic for the Seaside Subbasin and Corral de Tierra area is approximately the same between both models. Review of hydrographs from this area suggests that simulated water levels tend to decline more gradually than observed trends, particularly in the Santa Margarita Formation.

Table 3. Updated Water Level Calibration Statistics

SWI Model v3 (Updated Water Level Calibration Dataset)						
	Surficial Sediments	180-Foot Aquifer	400-Foot Aquifer	Deep Aquifers	Corral de Tierra and Seaside ¹	All Data
Mean Residual (feet)	0.85	4.55	4.77	-5.30	-20.02	-1.41
RMS Error (feet)	20.36	13.09	19.27	27.42	38.79	23.91
Number of Observations	18,276	16,428	15,946	8,350	12,135	83,904
Range in Observations (feet)	272	193	325	300	852	852
Scaled RMS Error	7.50%	6.78%	5.94%	9.14%	4.56%	2.81%
Scaled Residual Mean	0.31%	2.36%	1.47%	-1.77%	-2.35%	-0.17%
SWI Model v2 (Updated Water Level Calibration Dataset ²)						
	Surficial Sediments	180-Foot Aquifer	400-Foot Aquifer	Deep Aquifers	Corral de Tierra and Seaside	All Data
Mean Residual (feet)	3.53	2.35	4.51	-17.31	-1.06	1.24
RMS Error (feet)	23.26	12.43	19.25	28.29	24.66	24.29
Number of Observations	17,790	15,897	15,213	7,601	11,131	79,802
Range in Observations (feet)	272	193	325	300	852	852
Scaled RMS Error	8.57%	6.44%	5.93%	9.43%	4.42%	2.85%
Scaled Residual Mean	1.30%	1.22%	1.39%	-5.77%	-0.13%	0.15%

¹ Corral de Tierra and Seaside Lower Paso Robles, Santa Margarita, and Monterey Formation.

² Due to differences in simulation period, evaluated through WY 2020 for SWI Model v2 and through WY 2022 for SWI Model v3.



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Figure 21. Simulated and Observed Water Level Cross Plot

Figure 22 through Figure 25 show the spatial distribution of mean residuals in the Surficial Sediments, 180-Foot Aquifer, 400-Foot Aquifer, and Deep Aquifers, respectively. Green bubbles indicate that simulated water levels underestimate measured water levels. Orange bubbles indicate that simulated water levels overestimate measured water levels.

The mean residuals in the Dune Sands shown on Figure 22 show a mixture of overprediction and underprediction. The spatial trend in overprediction (lower Dune Sand elevations) and underprediction (higher Dune Sand elevations) is similar to SWI Model v2, except the mean residuals are generally smaller. Figure 22 also shows that the mean residuals in Langley Area Subbasin are a mixture of overprediction and underprediction, as in SWI Model v2. More detailed review, however, suggests that in the Langley Area Subbasin, groundwater levels in the shallower zones are generally underpredicted and groundwater levels in the deeper zones are generally overpredicted.

Figure 23 and Figure 24 show the mean residuals in the 180-Foot Aquifer and 400-Foot Aquifer, respectively. Each of these figures additionally include the residuals in the equivalent Eastside Subbasin aquifers. These 2 figures show that groundwater levels are slightly underestimated in the 180/400-Foot Subbasin, but the underestimation is small; simulated heads are on average less than 10 feet too low in most of the 180-Foot and 400-Foot Aquifers. SWI Model v3 better simulates the regional groundwater depression along the Gabilan Range in the Eastside Subbasin.

The model generally overpredicts groundwater levels in the Deep Aquifers as shown on Figure 25. The water levels are lower than before and the mean residuals are generally between 10 and 25 feet, as opposed to 25 feet and 50 feet in the previous model version. Some of the largest mean residuals are observed along Highway 68, with simulated groundwater levels 25 to 100 feet too high, which is consistent with SWI Model v2.

Figure 26, Figure 27, and Figure 28 show updates to selected hydrographs in the 180-Foot Aquifer, 400-Foot Aquifer, and Deep Aquifers.

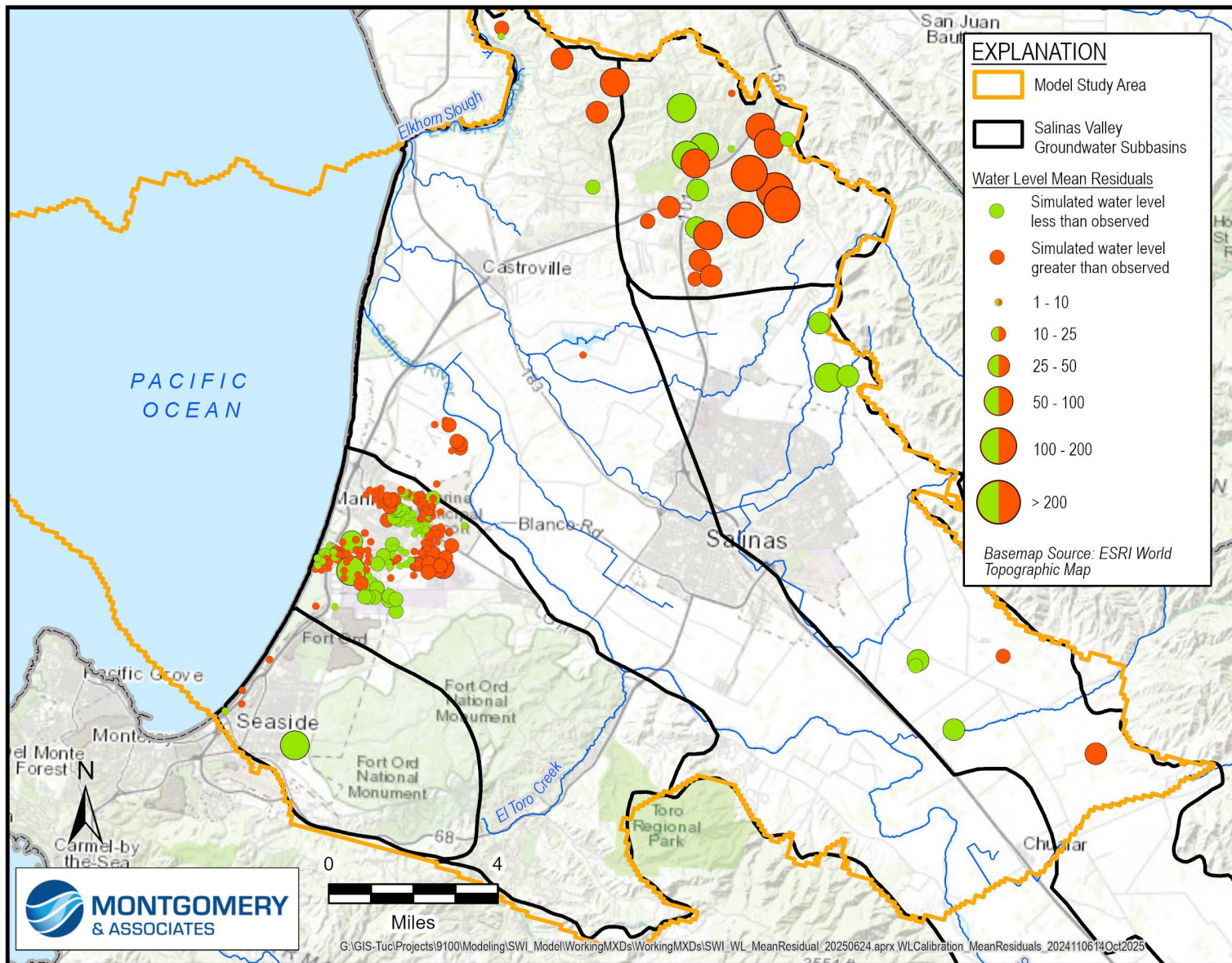


Figure 22. Mean Residual Water Level Bubble Plot within the Surficial Sediments and Langley Granite

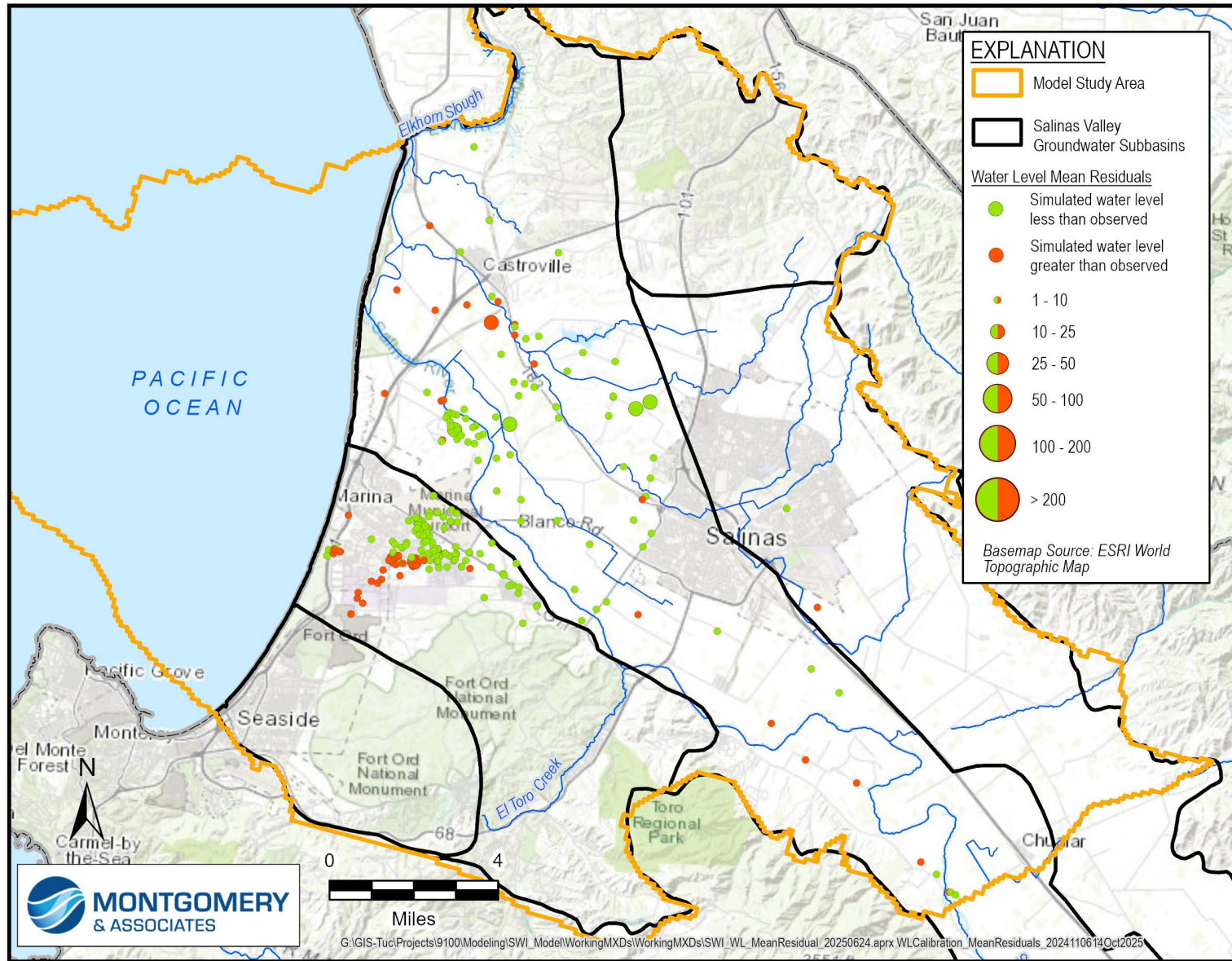


Figure 23. Mean Residual Water Level Bubble Plot within the 180-Foot Aquifer and Equivalent Areas

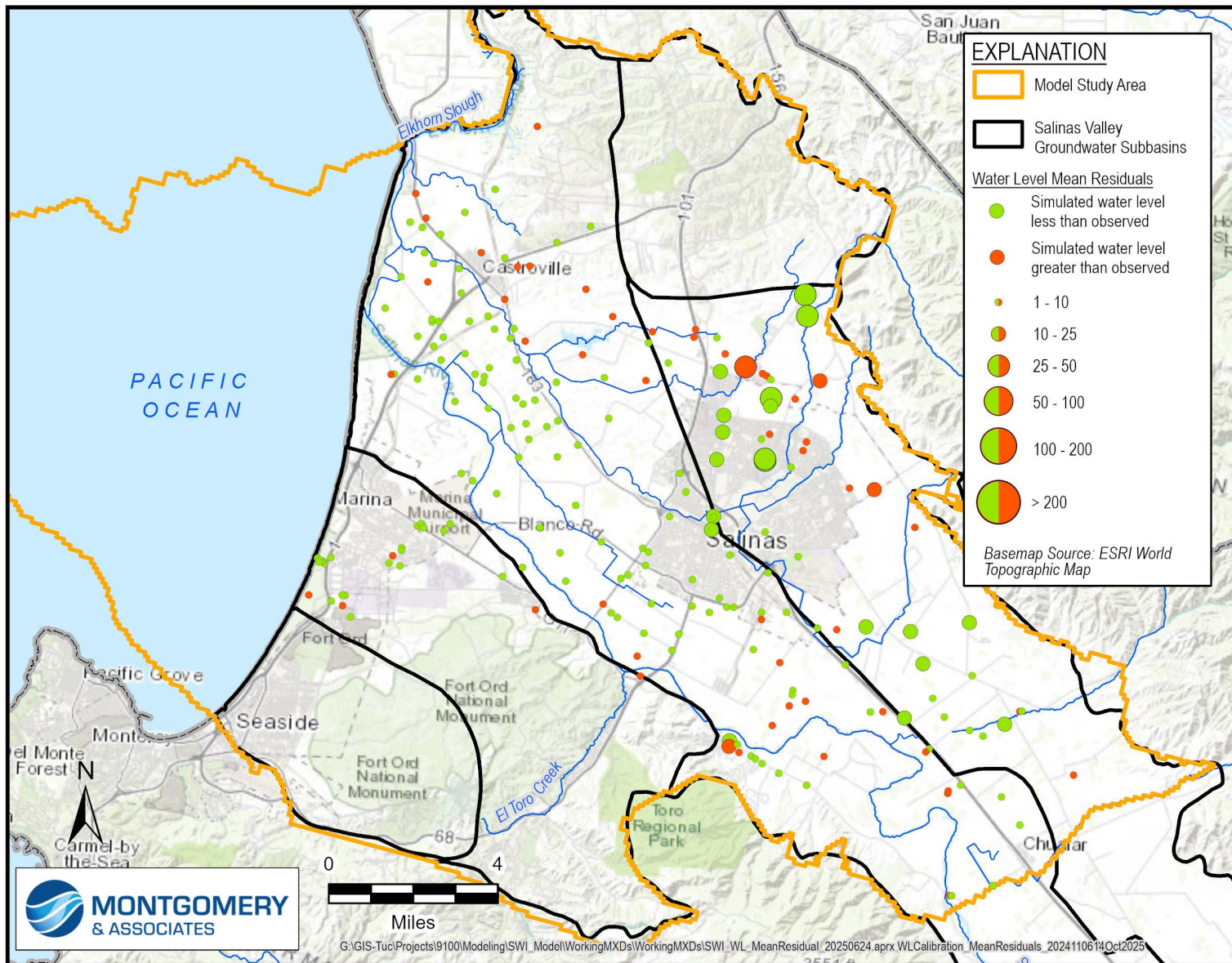


Figure 24. Mean Residual Water Level Bubble Plot within the 400-Foot Aquifer and Equivalent Areas

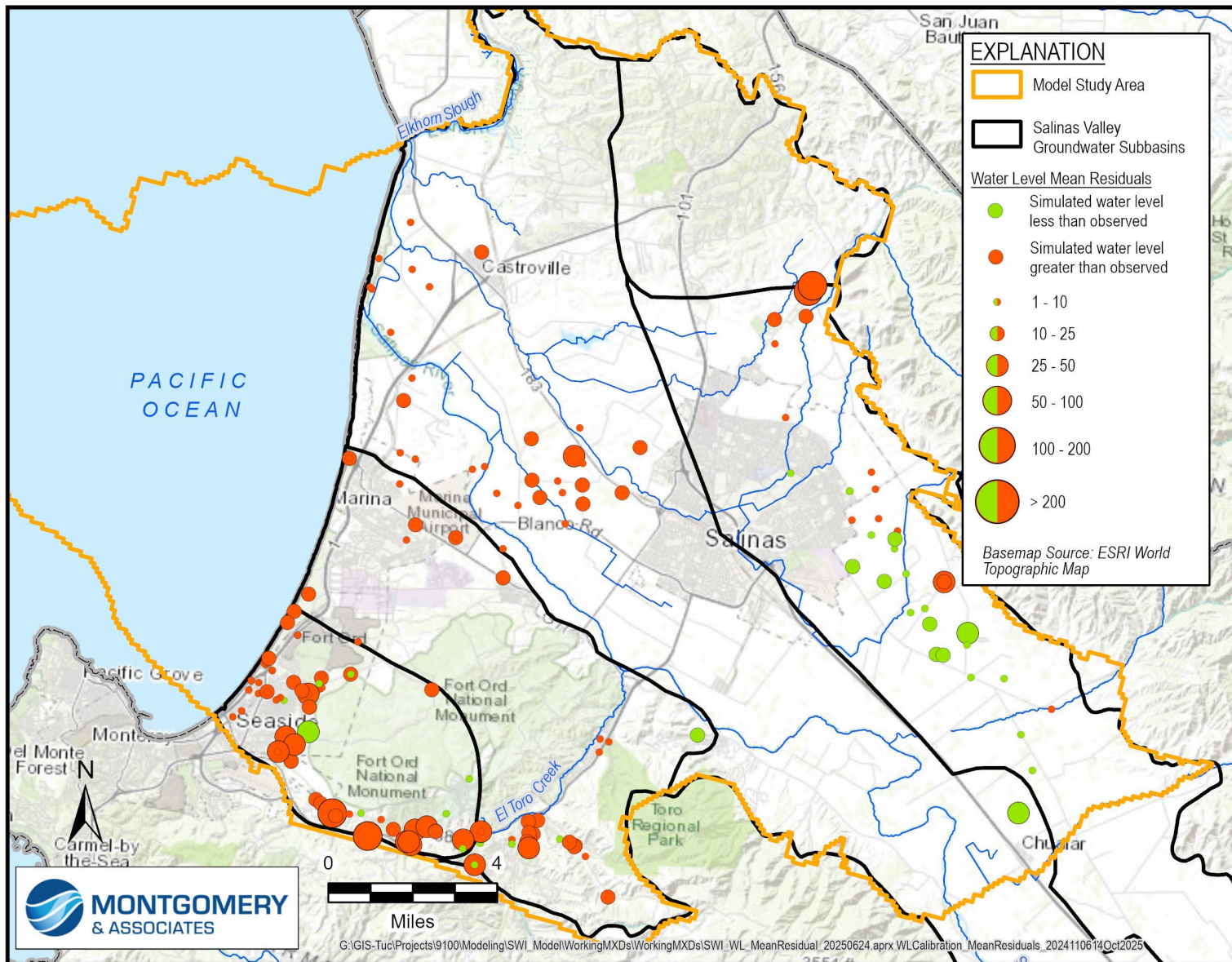


Figure 25. Mean Residual Water Level Bubble Plot within the Deep Aquifer and Equivalent Areas



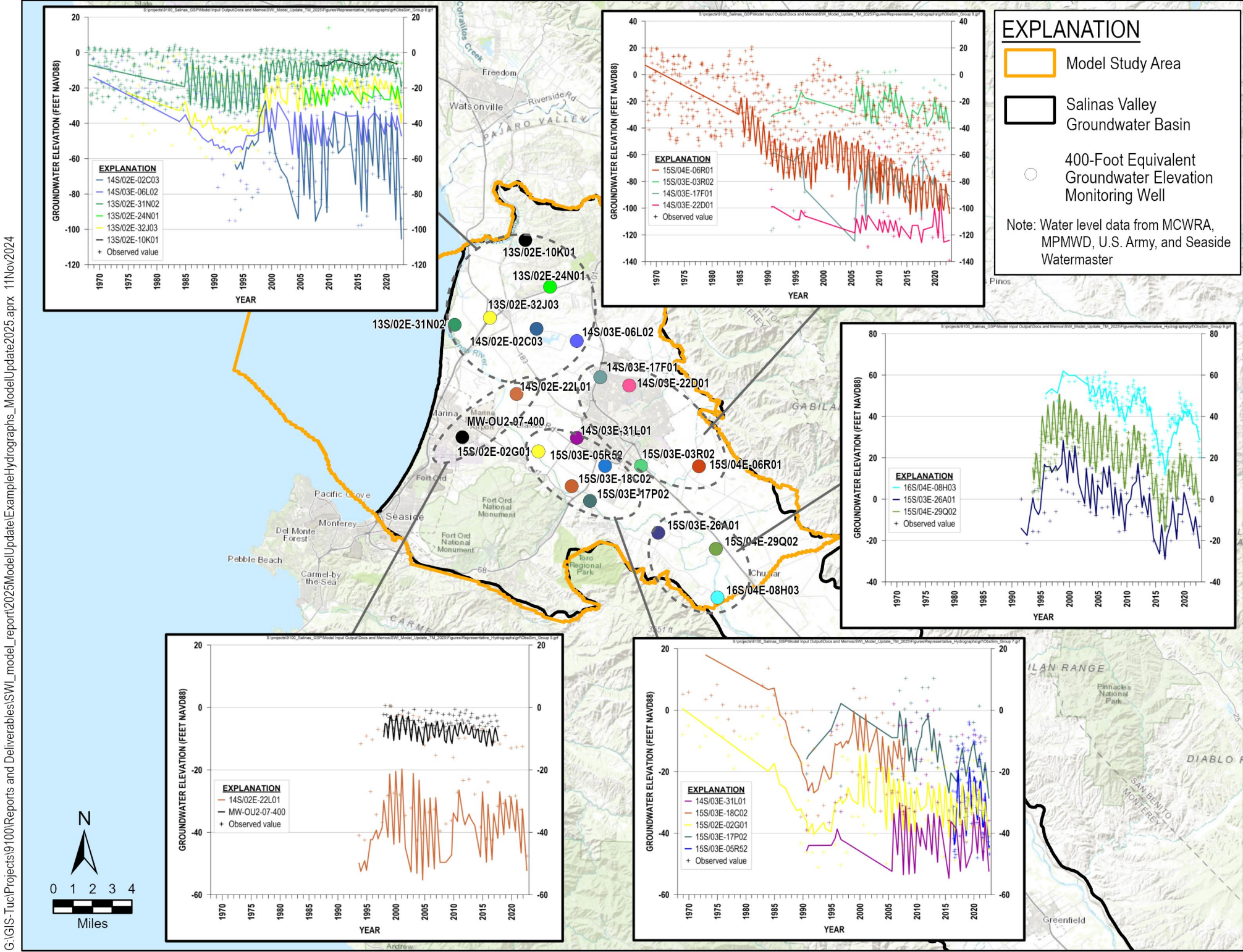


Figure 27. Observed and Simulated Selected Hydrographs within the 400-Foot Aquifer

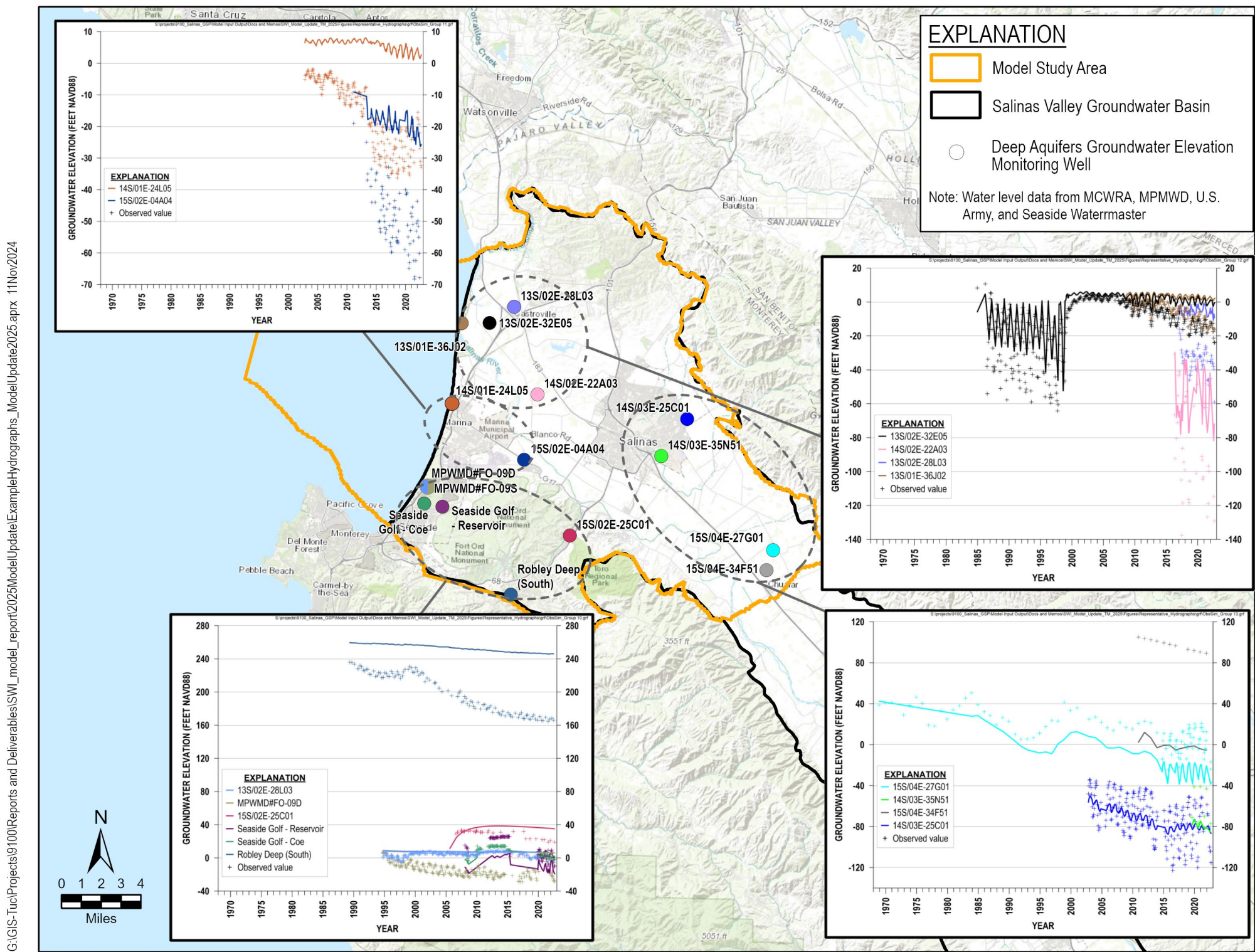


Figure 28. Observed and Simulated Selected Hydrographs within the Deep Aquifer

Chloride Concentration Calibration

The primary metric of the chloride calibration is the simulated extent of the 500 mg/L chloride contour line within the 180-Foot and 400-Foot Aquifers. The extent of the simulated 500 mg/L chloride contour was compared to the 500 mg/L chloride contours produced by MCWRA. The inland progression of the simulated 500 mg/L contours are compared to the MCWRA contours on Figure 29 and Figure 30. The crosshatched areas on these 2 figures represent the area of intrusion estimated by MCWRA. The contour lines on these 2 figures represent the simulated 500 mg/L chloride concentration fronts. The simulated chloride concentration fronts are color-coded to match the equivalent MCWRA crosshatched area. The simulated distribution of chloride concentrations in the 180-Foot Aquifer and 400-Foot Aquifer at the end of the simulation in 2022 is shown on Figure 31 and Figure 32, respectively.

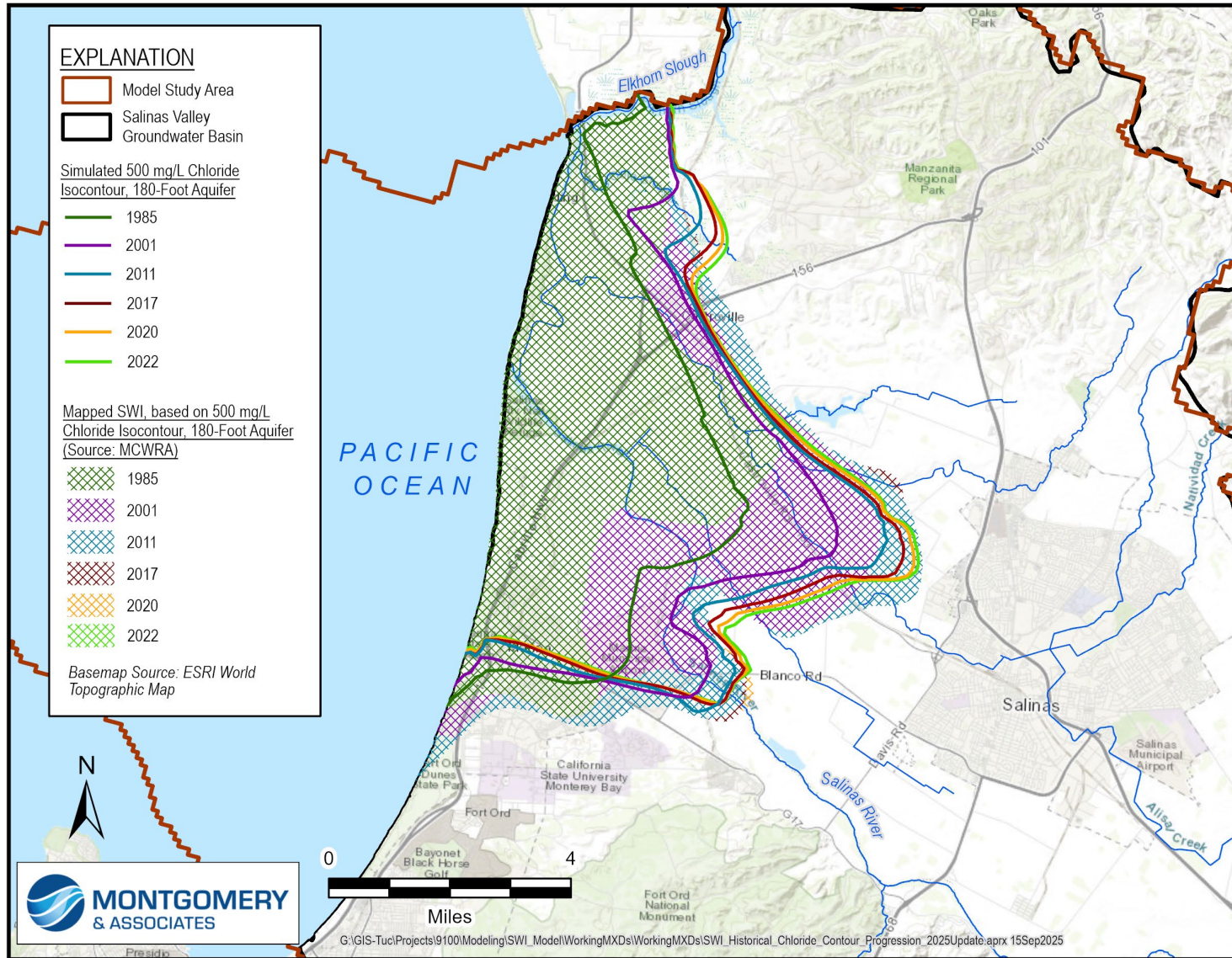


Figure 29. 180-Foot Aquifer Simulated and Observed 500 mg/L Chloride Concentration Contours in 1985, 2001, 2011, 2017, 2020 and 2022

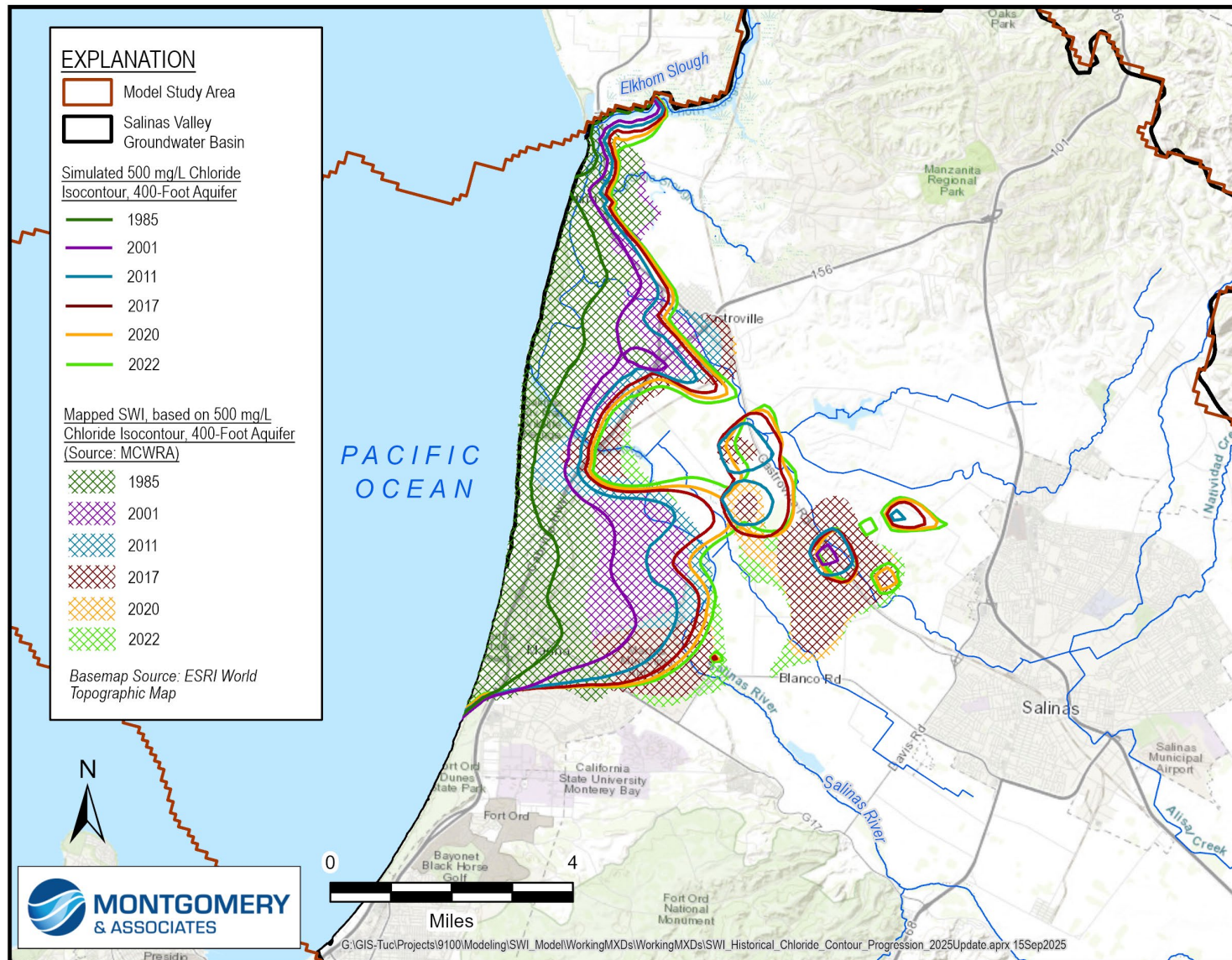


Figure 30. 400-Foot Aquifer Simulated and Observed 500 mg/L Chloride Concentration Contours in 1985, 2001, 2011, 2017, 2020 and 2022

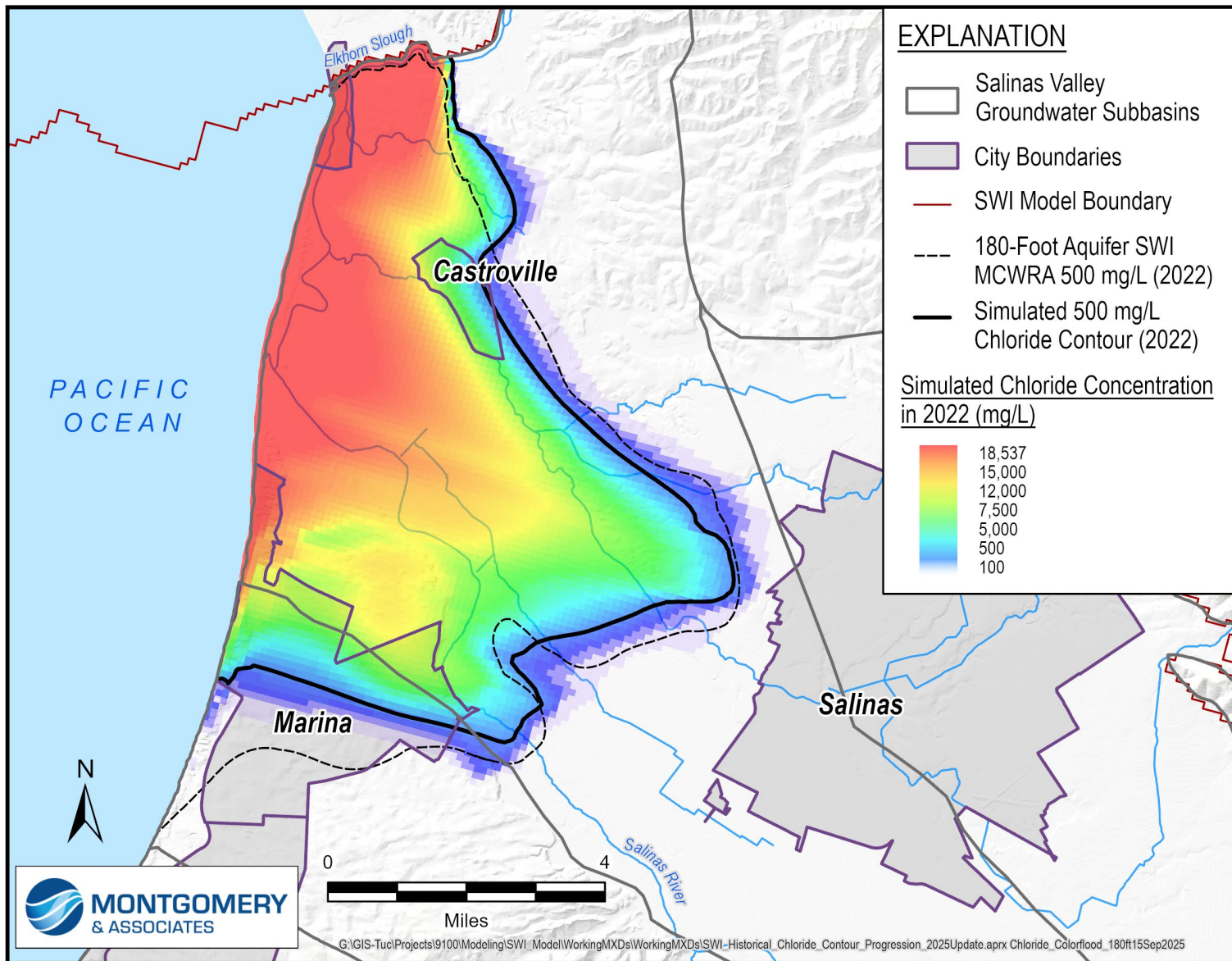


Figure 31. 180-Footer Aquifer Simulated Chloride Concentration at 2022

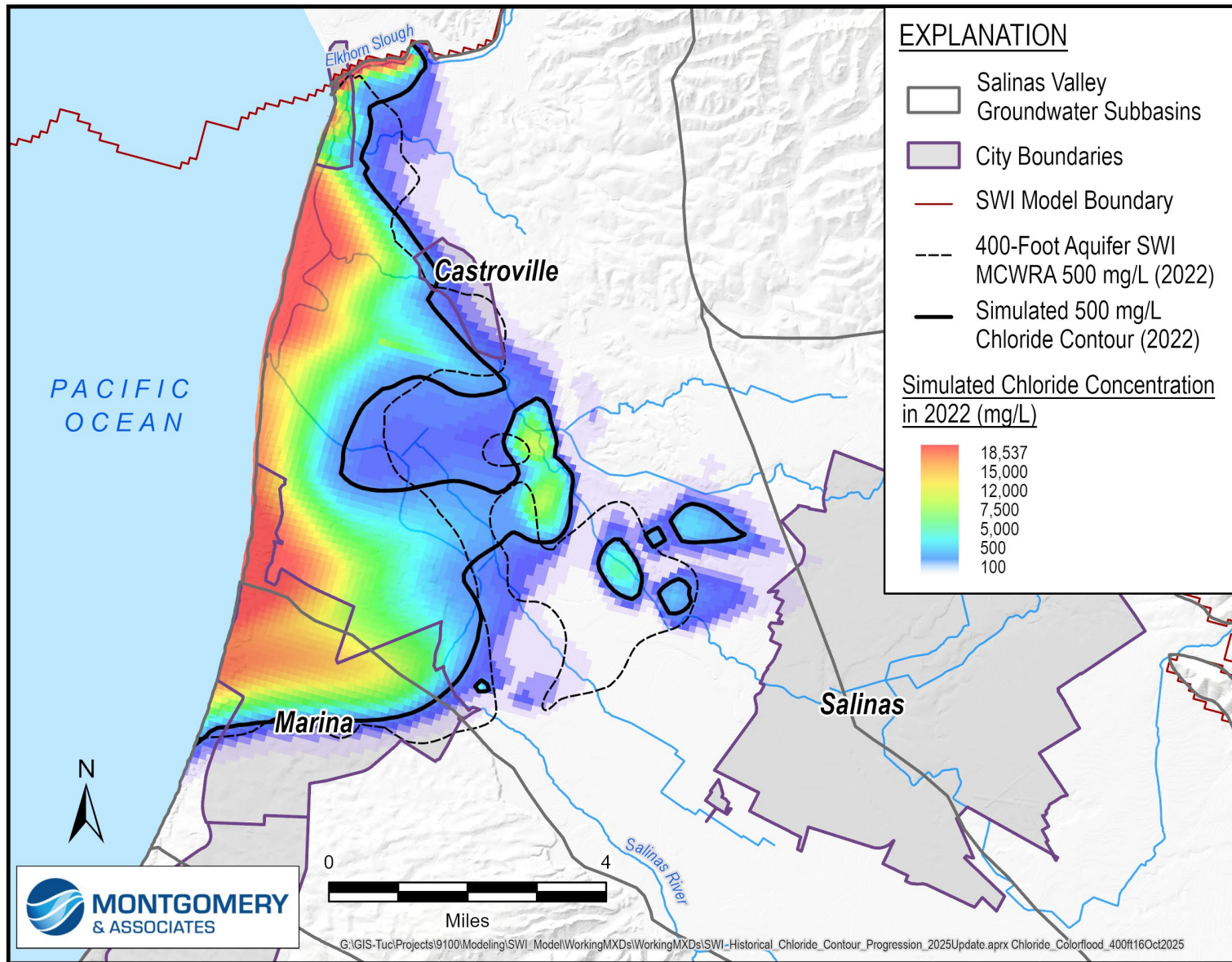


Figure 32. 400-Foot Aquifer Simulated Chloride Concentration at 2022

The calibration of the seawater intrusion front's progression in SWI Model v3 is similar to SWI Model v2 in extent and rate. The MCWRA observed contours in the 180-Foot Aquifer suggest rapid seawater intrusion from 1985 through 2011 and then slower seawater intrusion from 2011 through 2022. Seawater does not advance rapidly enough in the model between 1985 and 2001, but the relative advance of the seawater front between 2001 and 2011 is about the same as the MCWRA contours suggest. There is more simulated seawater intrusion between 2011 and 2020 than shown by the MCWRA contours. However, there is little additional seawater intrusion between 2020 and 2022, which is consistent with the MCWRA contours. The seawater intruded area does not extend as far south in the 180-Foot Aquifer in SWI Model v3 as in SWI Model v2 and was closer to the MCWRA contours in the previous model. This is possibly a result of changes to the recharge applied in the Dune Sands and City of Marina. This is an area for future model improvement.

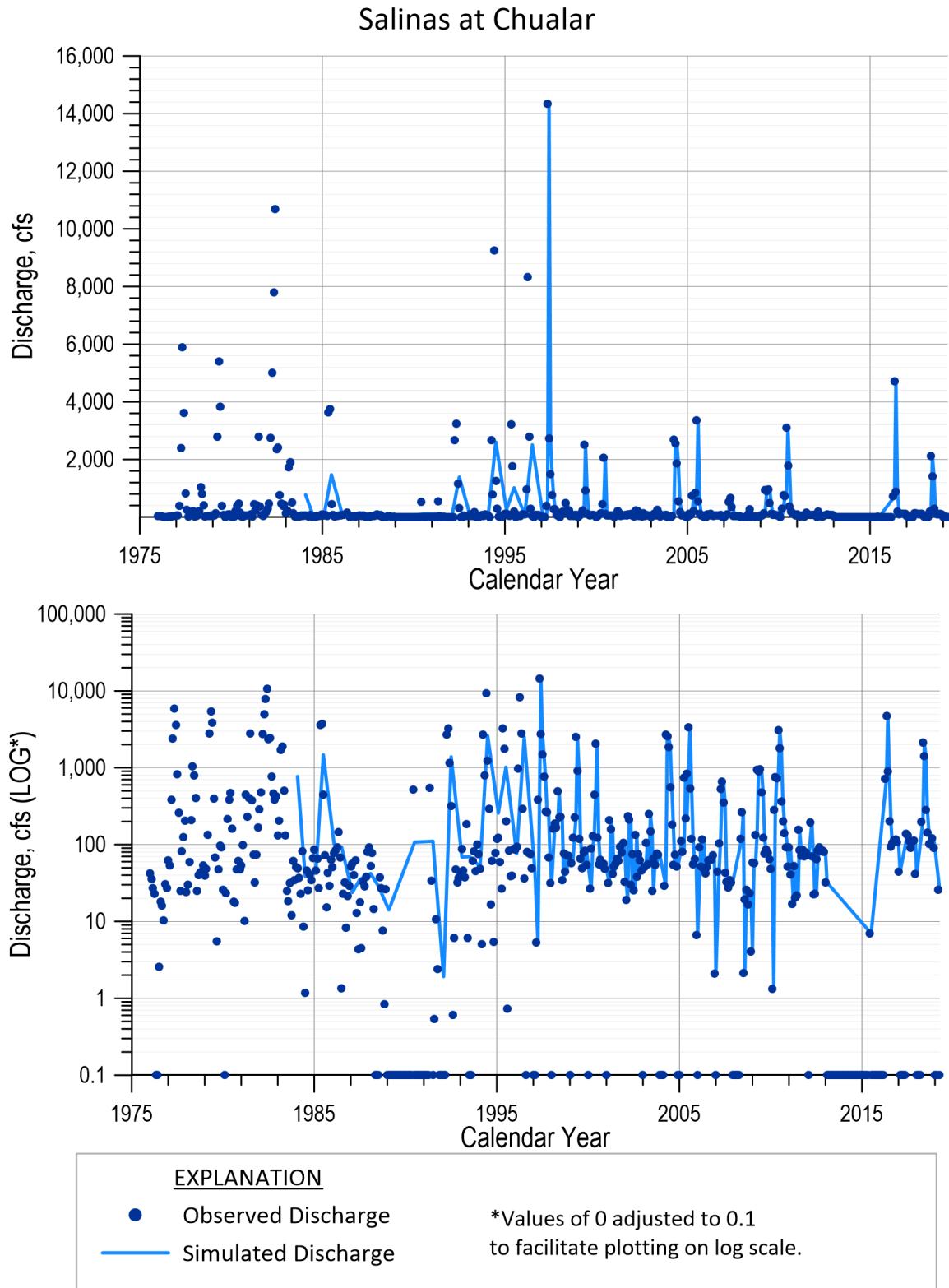
The extent of seawater intrusion in the 400-Foot Aquifer is less than the MCWRA contours in 1985. However, the extent of seawater intrusion by 2020 is about the same as the MCWRA contours with some exceptions. While the extent matches MCWRA in the northern part of Marina, the extent is less to the southeast. The extent of seawater intrusion is also less than observed on the northeast side of Castroville and east of Moss Landing.

Potential pathways for seawater migration from the 180-Foot to the 400-Foot Aquifers include wells screened across the both 180-Foot Aquifer and 400-Foot Aquifer, and areas where there is a gap or thin spot in the 180/400 Aquitard. Areas with suspected thin spots or gaps in aquitards were included as zones of higher vertical hydraulic conductivity in the updated model (see Figure 6 and Table 2). The light blue islands of seawater in the 400-Foot Aquifer on Figure 32 represent seawater migrating from the 180-Foot Aquifer to the 400-Foot Aquifer through wells screened across both aquifers. The locations of wells screened across multiple aquifers, as well as the locations of possible aquitard gaps, will be updated as more data become available.

Surface Water Flow Calibration

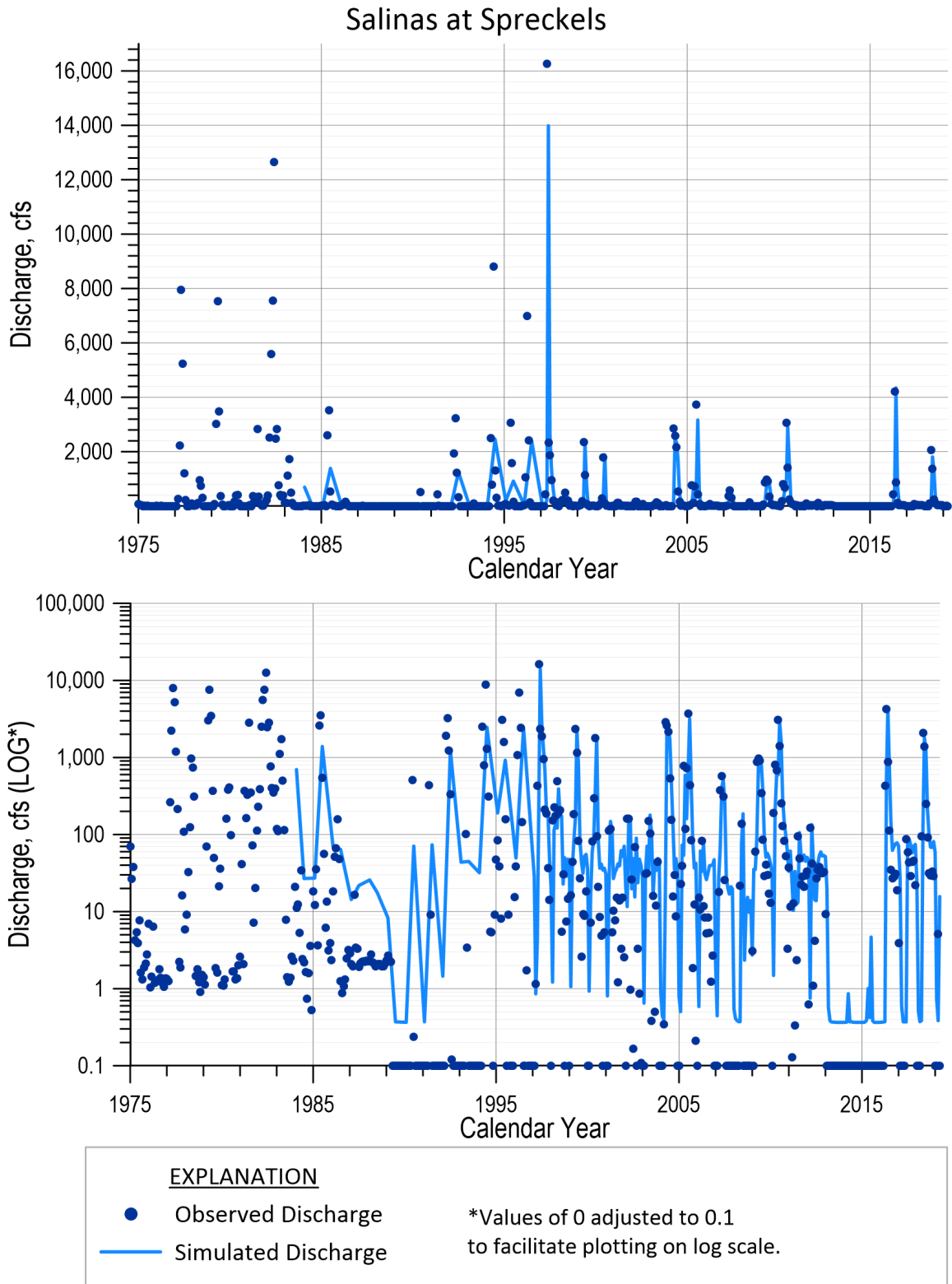
Figure 33 through Figure 36 show the updated simulated streamflow versus observed stream flow measurements at the Salinas River gage near Chualar, the Salinas River gage near Spreckels, the gage in Gabilan Creek, and the gage in El Toro Creek, respectively. The streamflow hydrograph for the Salinas River at Chualar is a model input at the model boundary, and therefore matches the observed data. The hydrographs for the Salinas River at Spreckels are similar to SWI Model v2 because the streamflow leakance and elevations were not modified during this update. The simulated streamflow in Gabilan Creek during low flow periods does not drop below 0.1 cubic feet per second (cfs), whereas the observations sometimes do (Figure 35). The simulated Gabilan Creek low flows are still much less than 1 cfs. The increase in low flows is most likely due to the updated streambed elevation for Gabilan Creek. The simulated

streamflow hydrograph for El Toro Creek indicates extended periods of baseflow at rates of less than 1 cfs, which are not supported by the observed gage data (Figure 36). The simulated baseflow is most likely a result of updates to the streambed elevation which decreased the streambed elevation, combined with simulated water levels that are too high near the creek.



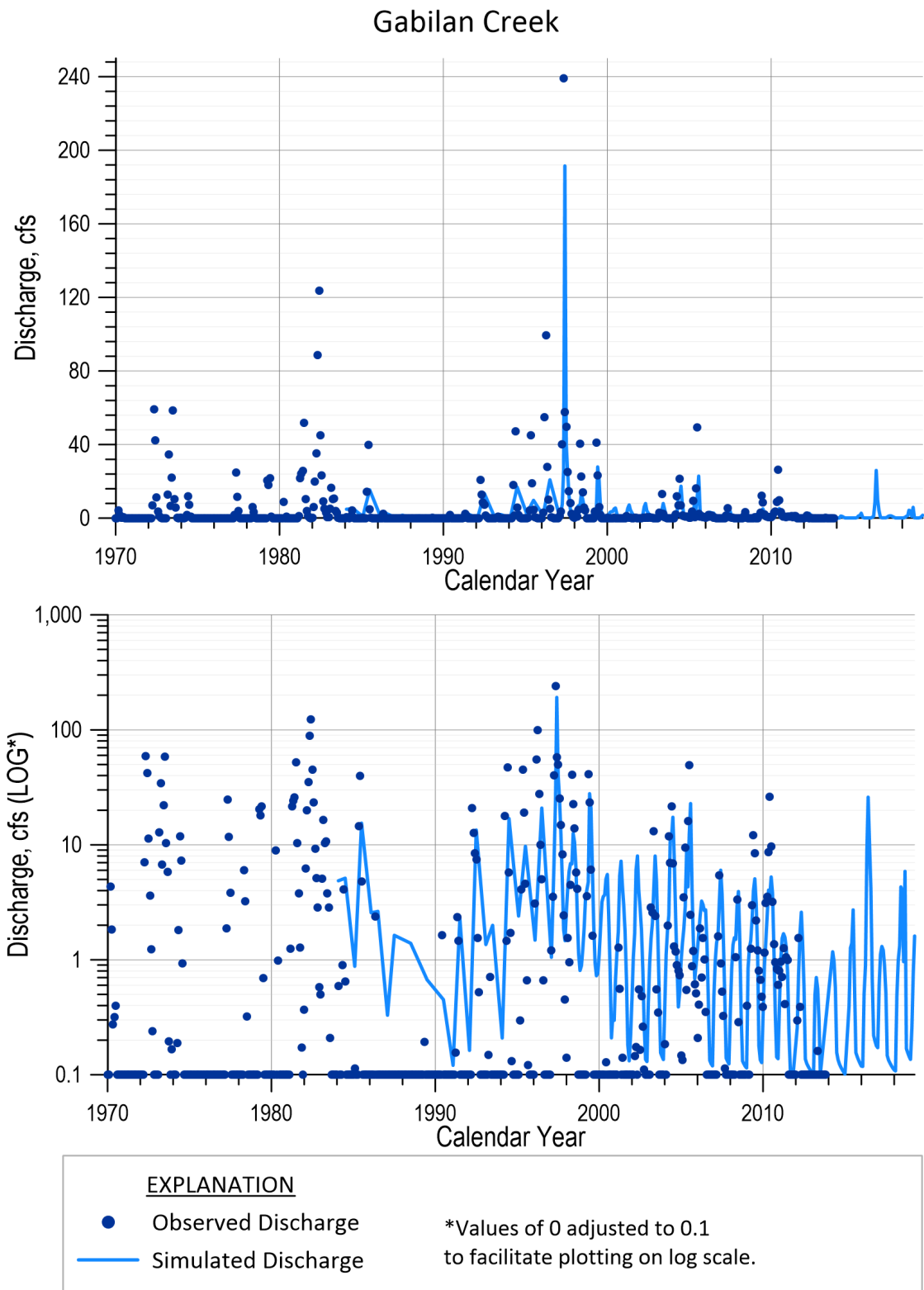
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Figure 33. Simulated and Measured Stream Flow in the Salinas River at the Gage near Chualar



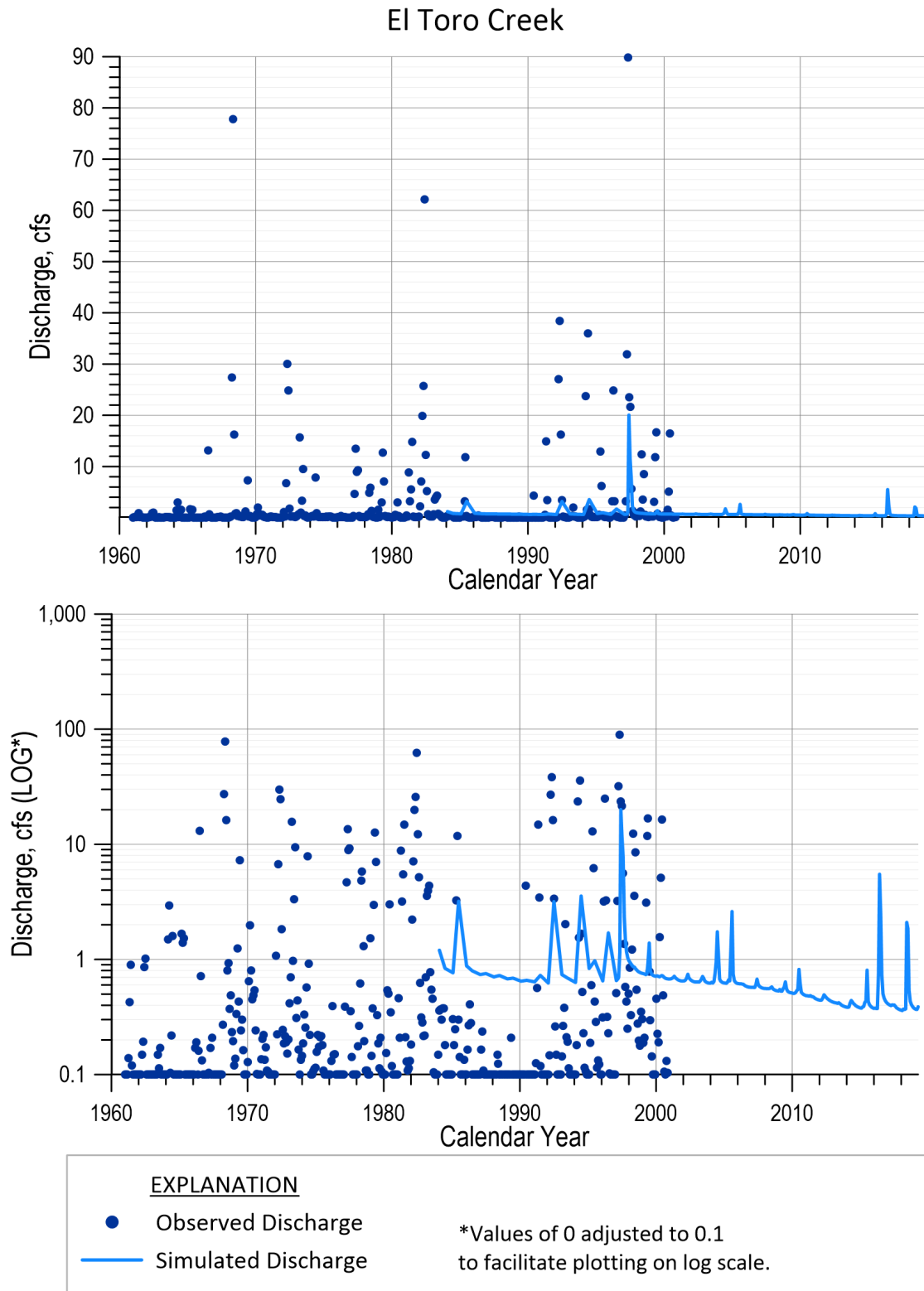
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Figure 34. Simulated and Measured Stream Flow in the Salinas River at the Gage near Spreckels



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Figure 35. Simulated and Measured Stream Flow in Gabilan Creek



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Figure 36. Simulated and Measured Stream Flow in El Toro Creek

Water Budget

The average annual water budget for SWI Model v3 between WY 1985-2020 is summarized in Table 4. This period is shown rather than WY 1985-2022 to facilitate comparison with SWI Model v2.

Table 4. Updated Water Budget Summary

Inflows		SWI Model v2 WY 1985-2020 Average AF/yr	SWI Model v3 WY 1985-2020 Average AF/yr
Recharge		67,200	86,900
Net Stream Leakage to Groundwater		35,500	37,300
Subsurface Inflow	Valley Upgradient Inflow near Chualar	21,800	22,600
	Seawater Intrusion	16,000	14,800
Injection	ASR - Seaside	300	300
Outflows			
Pumping		163,100	169,200
Groundwater Evapotranspiration	Riparian	16,900	16,500
Subsurface Outflow	Valley Outflow to Ocean + Pajaro	1,100	100
Net Change in Groundwater Storage		-40,300	-23,300

The updates to the recharge based on the SVIHM recharge estimates resulted in an approximately 30% increase in average recharge over the historical model period. Recharge increased in each subbasin as a result of updates to the SVIHM and is not just a consequence of updates to the Dune Sands. The upgradient inflow near Chualar is about the same as the previous model version. The ASR injection in Seaside is the same as the previous model, which is specified based on historical records. The net seawater intrusion across the coastline decreased slightly in both the 180/400 and Monterey Subbasins. The net flow of Seaside with the ocean switched from an average of 400 AF/yr net seawater intrusion to 400 AF/yr net groundwater discharge to the ocean.

The total pumping and riparian ET are approximately the same as in SWI Model v2. There is a slight net outflow to Pajaro, though it is less than before. This is most likely because simulated heads are slightly lower in the shared boundary with the 180/400 Subbasin, which resulted in a small net inflow from Pajaro in this subbasin.

The net stream exchange represents slightly more leakage to groundwater than in SWI Model v2. The Salinas River net stream exchange is about the same as before. The net stream exchange in

Eastside increased from about 300 AF/yr to 3,500 AF/yr due to modifications to streambed elevation and leakance. Meanwhile the WY 1985-2020 average net stream leakage in Corral de Tierra decreased from 4,400 AF/yr to 650 AF/yr.

CONCLUSION

M&A updated the SWI Model in coordination with an update to the valley-wide SVIHM to ensure consistency between the models. Particular attention was given to aligning boundary conditions and hydrologic parameters with the SVIHM. These improvements harmonize both the SWI Model v3 and SVIHM with the current HCM, creating tools that can interact seamlessly to better simulate historical and future groundwater conditions and seawater intrusion in Salinas Valley. SWI Model updates focused on reconciling the following key inputs with the SVIHM:

- Updating the model hydrogeologic parameter zonation and active extent
- Adjusting recharge assumptions
- Updating well locations, screen intervals, and pumping data to most recent information available as reflected in the SVIHM and GEMS
- Adding flow barriers to represent faults in Monterey and Seaside subbasins
- Implementing hydraulic conductivity and storage parameters consistent with SVIHM
- Extending the simulation period to October 2022

These model updates were completed without adverse effects to the water level or seawater intrusion calibration. The water level calibration was verified by comparing to the water level target data set, which was updated to reflect the SVIHM calibration data. The chloride calibration was verified by comparing the simulated 500 mg/L chloride contours to the MCWRA observations between 1985 and 2022. The calibration of seawater intrusion in the 180-Foot and 400-Foot Aquifers is about the same in SWI Model v3 as SWI Model v2. The water level calibration in the Deep Aquifers is improved in the 180/400 subbasin compared to SWI Model v2.

NEXT STEPS

No model, regardless of its complexity, can fully replicate the intricacies of real-world systems. The SWI model is a mathematical approximation of real-world processes relying on input data, assumptions, and simplifications. These factors are necessary to make the problem tractable; however, they introduce a degree of uncertainty and limit the model's predictive accuracy.

During the model update, it became clear that achieving a tighter water-level calibration in the Seaside Subbasin and Corral de Tierra area was more challenging than expected. This suggests

that the current model representation may not fully capture system behavior. It was recognized that more in-depth collaboration with the Seaside Watermaster would be necessary to focus on the Santa Margarita Formation. The next step to be undertaken in fall 2025 will involve collaboration with SSWM and MCWD modelers to improve water level calibration within the Santa Margarita Formation and adjacent portions of the Monterey subbasin. This effort is expected to include further refinement of the hydrogeologic zonation and recharge assumptions in these areas.

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ATTACHMENT 1

Table 1. Seawater Intrusion Model Report Model Development Tables and Figures Affected by Updates

Table Number	Table Caption
3-1	Summary of Model Boundary Conditions and Components
3-3	Repeated Water Years for Basin Boundary Surface Water Inflows
4-1	Water Level Calibration Statistics
4-2	Summary of Calibrated Hydraulic Conductivity (K) and Storage Properties of the HGUs within the Model
4-3	Calibrated Recharge Multipliers
Figure Number	Figure Caption
2-2	Extent and Depth to the Salinas Valley Aquitard in Model Study Area
2-3	Extent of Aquitard Layers in the Model Study Area
2-4	Example Cross Section Showing the 9 Model Layers in the Hydrogeologic Model.
2-17	Recharge Component Areas
2-18	Recharge Areas
2-19	Pumping Locations and Data Sources
3-2	Model Boundary Conditions
3-4	Historical Snapshots of Estimated Recharge
3-5	Estimated Monthly Spatial Distribution of Recharge in Water Year 2020
3-8	Model Hydrogeologic Zonation in Layer 1
3-9	Model Hydrogeologic Zonation in Layer 2
3-10	Model Hydrogeologic Zonation in Layer 3
3-11	Model Hydrogeologic Zonation in Layer 4
3-12	Model Hydrogeologic Zonation in Layer 5
3-13	Model Hydrogeologic Zonation in Layer 6
3-14	Model Hydrogeologic Zonation in Layer 7
3-15	Model Hydrogeologic Zonation in Layer 8
3-16	Model Hydrogeologic Zonation in Layer 9
3-17	Model Hydrogeologic Zonation in Layer 10
3-18	Model Hydrogeologic Zonation in Layer 11
3-19	Model Hydrogeologic Zonation in Cross Section A-A'
3-20	Model Hydrogeologic Zonation in Cross Section B-B'
3-21	Model Hydrogeologic Zonation in Cross Section C-C'
3-22	Model Hydrogeologic Zonation in Cross Section D-D'
4-1	Water Level Calibration Target Locations with their Associated Calibration Group
4-3	Simulated and Observed 500 mg/L Chloride Concentration Contours within the 180-Foot Aquifer in 1985, 1997, 2005, 2015, and 2020
4-4	Simulated and Observed 500 mg/L Chloride Concentration Contours within the 400-Foot Aquifer in 1985, 1995, 2005, 2015, and 2020
4-5	Mean Residual Water Level Bubble Plot within the 180-Foot Aquifer and Equivalent Areas
4-6	Mean Residual Water Level Bubble Plot within the 400-Foot Aquifer and Equivalent Areas
4-7	Simulated and Observed Water Level Cross plot
4-8	Observed and Simulated Representative Hydrographs within the 180-Foot Aquifer
4-9	Observed and Simulated Representative Hydrographs within the 400-Foot Aquifer
4-10	Observed and Simulated Representative Hydrographs within the Deep Aquifers
4-11	Simulated and Measured Stream Flow in the Salinas River at the Gage near Chualar
4-12	Simulated and Measured Stream Flow in the Salinas River at the Gage near Spreckels
4-13	Simulated and Measured Stream Flow in Gabilan Creek
4-14	Simulated and Measured Stream Flow in El Toro Creek
4-15	Hydraulic Conductivity Pilot Points Used during Model Calibration