TECHNICAL MEMORANDUM 2

DATE: November 13, 2024 **PROJECT #:** 9100

TO: Salinas Valley Basin Groundwater Sustainability Agency

CC: Monterey County Water Resources Agency

FROM: Hanni Haynes

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

PROJECT: Salinas Valley Seawater Intrusion Model

SUBJECT: 2024 Seawater Intrusion Model Updates (Addendum 2 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 plan actions that address seawater intrusion. Working closely with Marina Coast Water District Groundwater Sustainability Agency's (MCWDGSA) consultant, EKI Environment & Water, Inc. (EKI), M&A updated the model in 2024 to incorporate updates to the hydrogeological conceptual model (HCM) and ensure consistency between the SWI Model and adjacent and overlapping groundwater flow models. Revisions were funded through a Round 2 Sustainable Groundwater Management (SGM) Implementation Grant to MCWDGSA and SVBGSA.

Model revisions focused on updating the stratigraphy based on new data and analyses. Model layer adjustments were followed by recalibration of the groundwater elevations and extent of seawater intrusion to prepare the model for the 180/400-Foot Aquifer Subbasin feasibility studies. This technical memorandum documents the model updates and is provided as an addendum to the Seawater Intrusion Model Report, noting the sections and figures of the Report that are affected by this update.

MODEL UPDATES

SWI Model updates focused on the following areas of improvement identified by SVBGSA and MCWDGSA.

- Updating the model layers with new data such as the geophysical data collected for the Deep Aquifers Study
- Adjusting how boundary conditions are simulated
- Adjusting recharge assumptions
- Comparing the SWI model with adjacent and overlapping models to promote consistency across model boundaries
- Updating well and pumping data and updating how wells are simulated
- Updating the model calibration dataset

These update areas are discussed in more detail below.

Updated Model Layers

M&A modified model layer elevations and hydrogeologic parameterization in the SWI model to be generally consistent with recent HCM updates documented in subbasin-specific technical memoranda (M&A, 2024a; 2024b; 2024c; and 2024d). These HCM updates used new information to refine the depth and extents of the aquifers, aquitards, and bedrock, prioritizing data and analyses that should significantly improve the hydrogeologic understanding of the Subbasins.

As documented in the various memoranda, key updates included the following:

- Updating model layering offshore with recent mapping of offshore outcrops, recent seafloor data, and onshore borehole data from oil exploration wells.
- Revising the top of the bedrock and model layer thicknesses, based on AEM geophysical data, seismic data, lithologic logs, and surface geology maps. A contour map of the revised top of bedrock elevation as well as maps showing the updated model layer thicknesses are included in Attachment 1.
- Adjusting the layering and hydrogeologic parameterization to reflect the findings from the Deep Aquifers Study. 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.
- Refining coastal aquitard extents and incorporating aquitard thin spots and gaps through layering adjustments and hydrogeologic parameterization. Maps of the coastal aquitard extents and potential gaps or thin spots simulated with parameters are shown on Figure 2, Figure 6, and Figure 8. Pumping wells with reported screen intervals entirely within the

updated aquitard extents were assigned separate hydrogeologic parameter zones called Aquitard Pumping Areas, as shown on Figure 6 and Figure 8.

- Reducing the El Toro Primary Aquifer System connectivity to the aquifer systems in the 180/400-Foot Aquifer Subbasin.

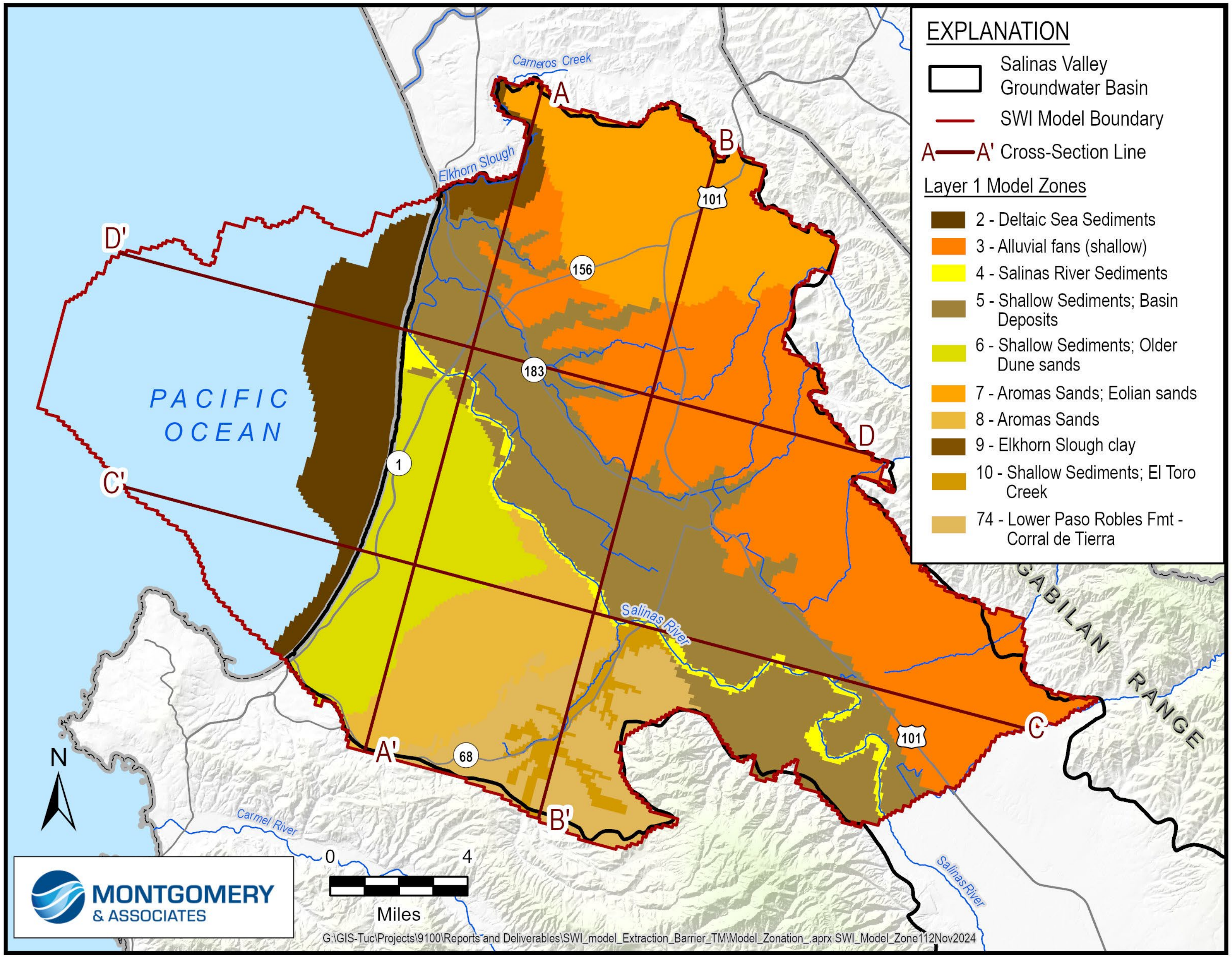

Figure 1. Model Hydrogeologic Zonation in Layer 1

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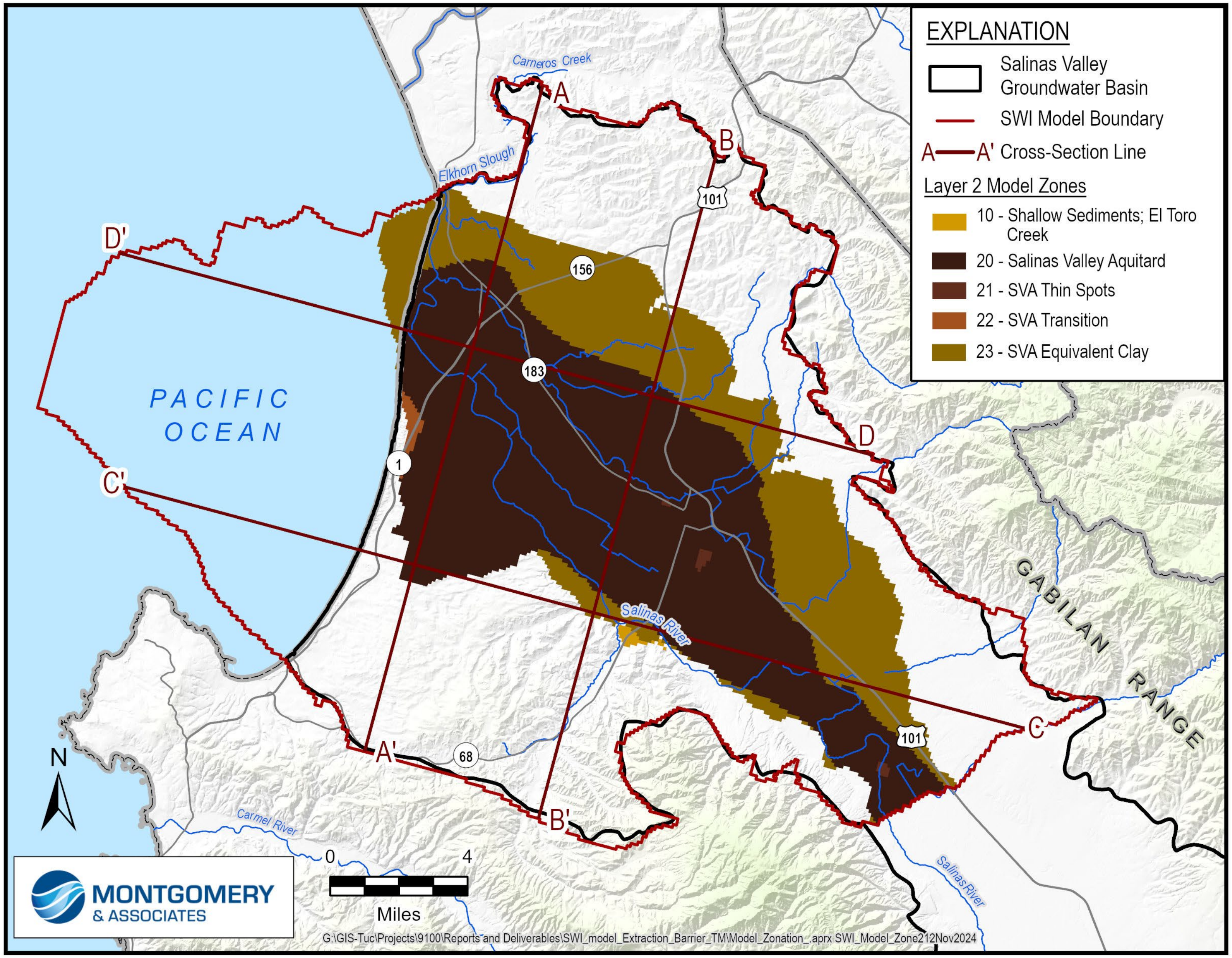

Figure 2. Model Hydrogeologic Zonation in Layer 2

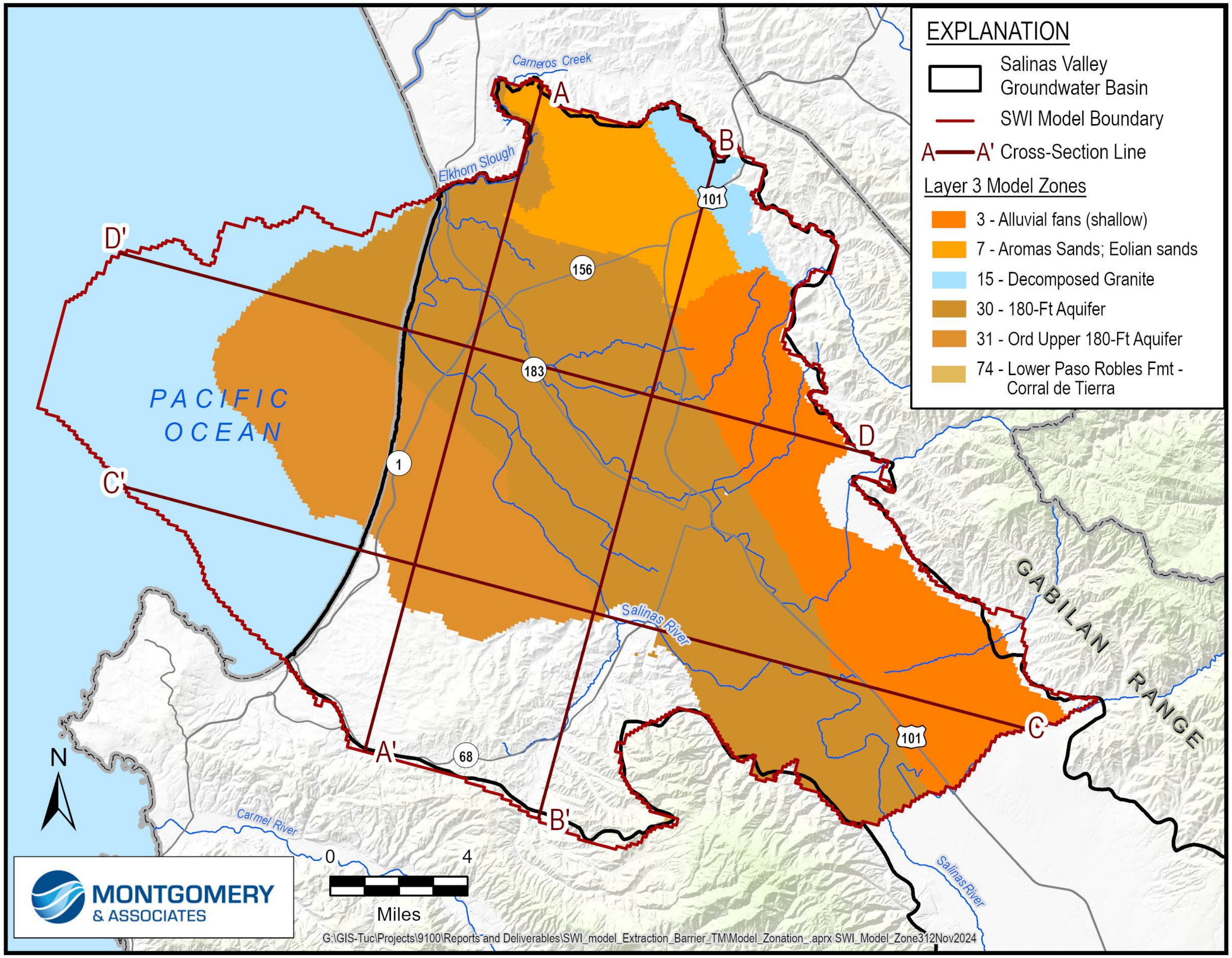

Figure 3. Model Hydrogeologic Zonation in Layer 3

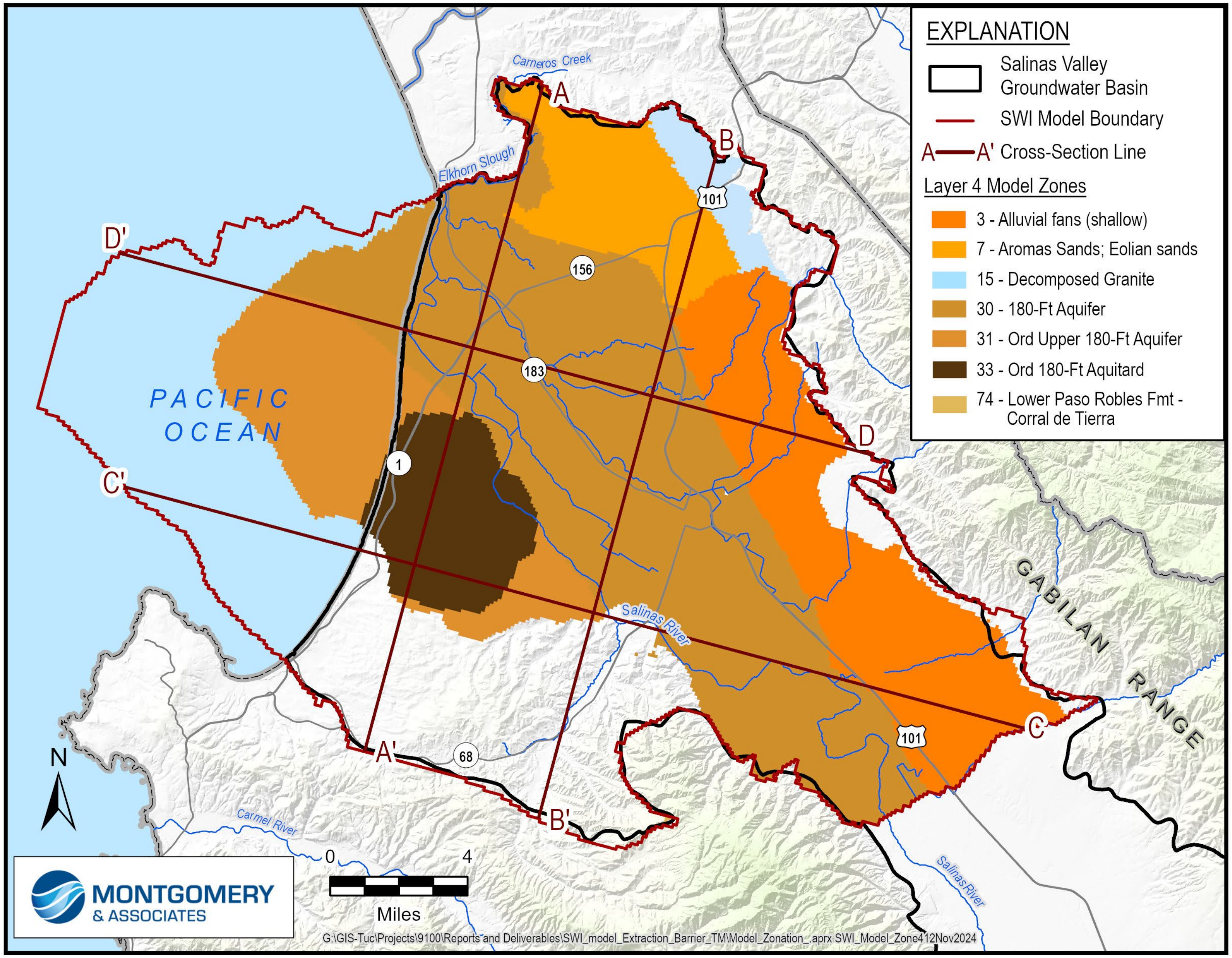

Figure 4. Model Hydrogeologic Zonation in Layer 4

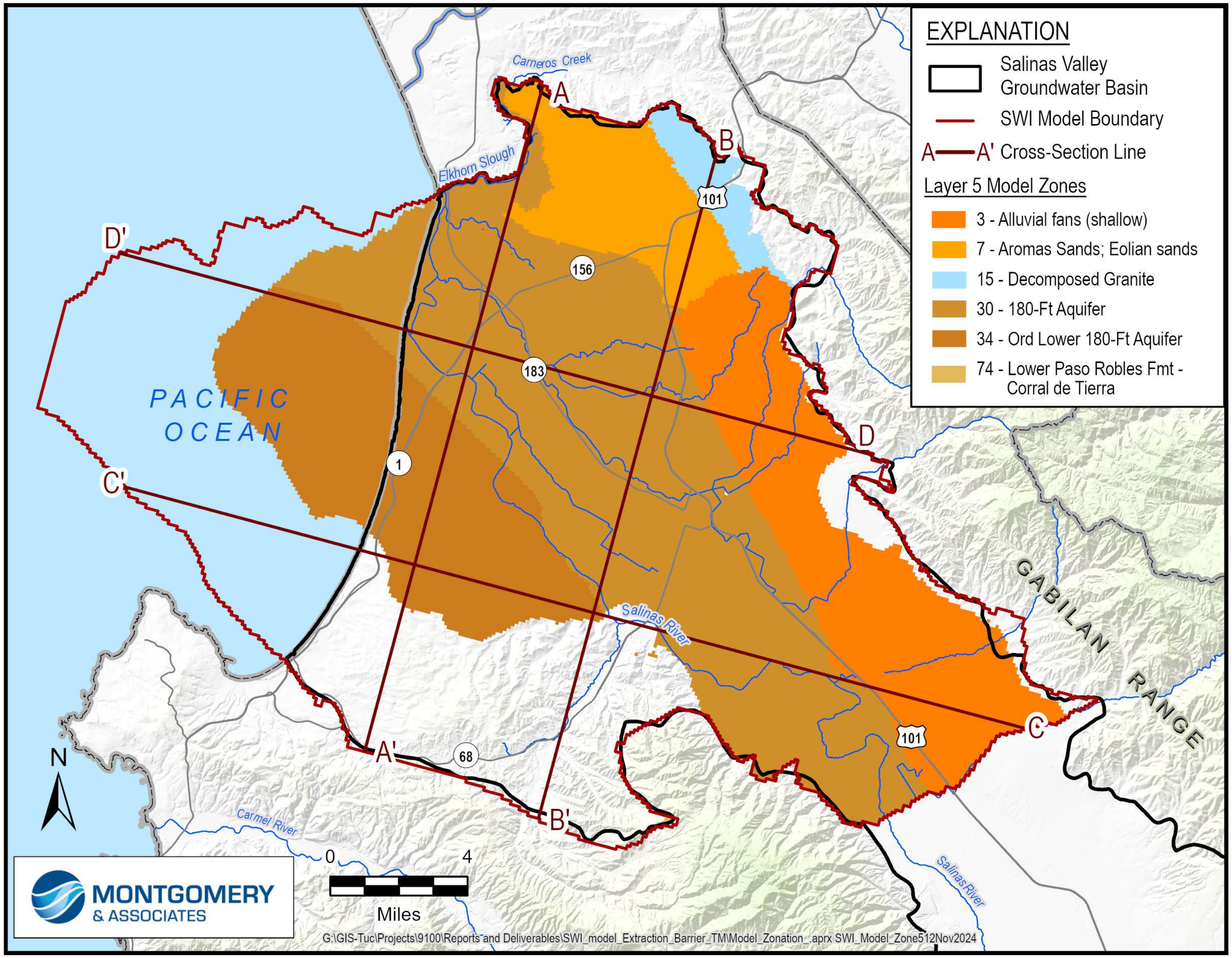

Figure 5. Model Hydrogeologic Zonation in Layer 5

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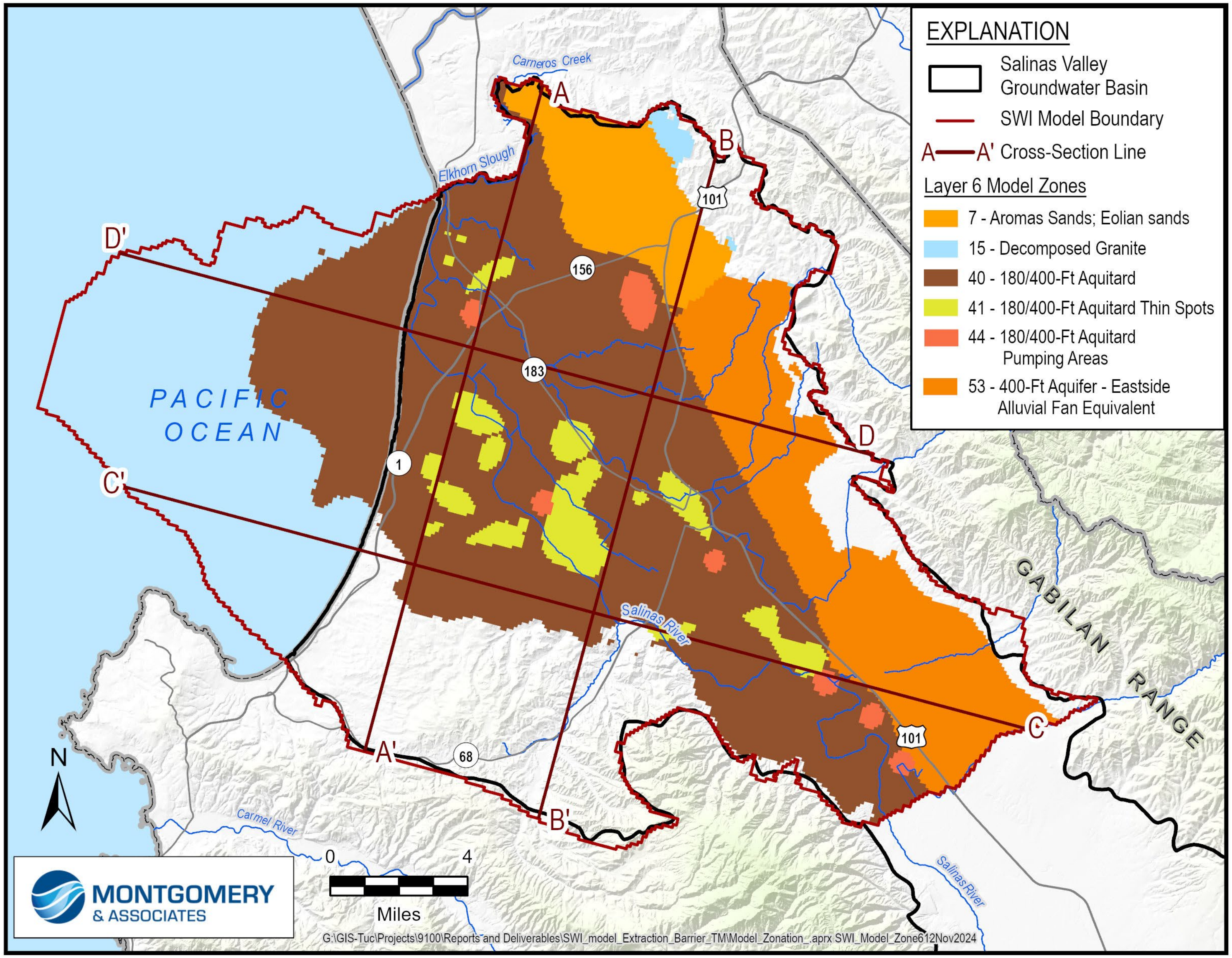

Figure 6. Model Hydrogeologic Zonation in Layer 6

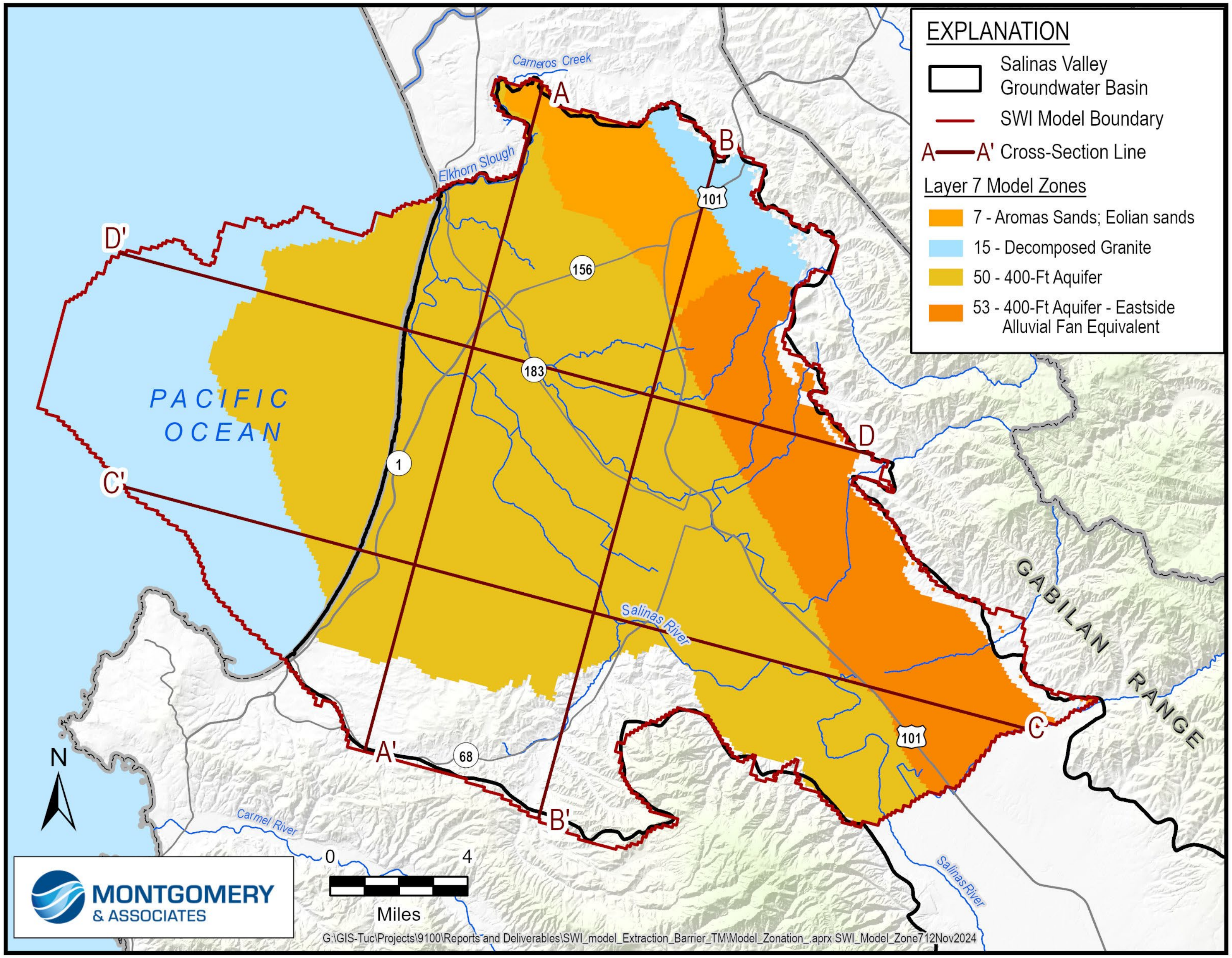

Figure 7. Model Hydrogeologic Zonation in Layer 7

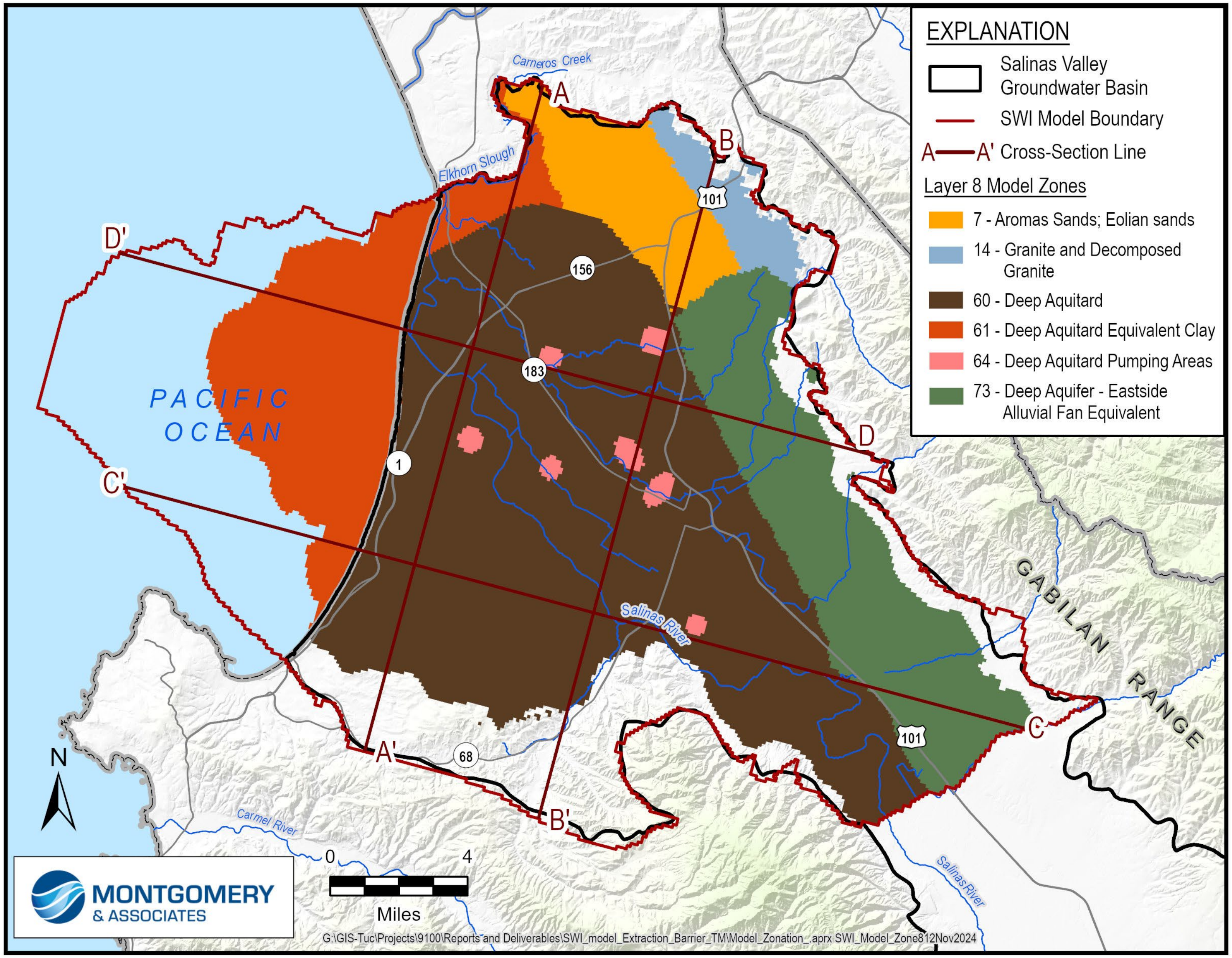

Figure 8. Model Hydrogeologic Zonation in Layer 8

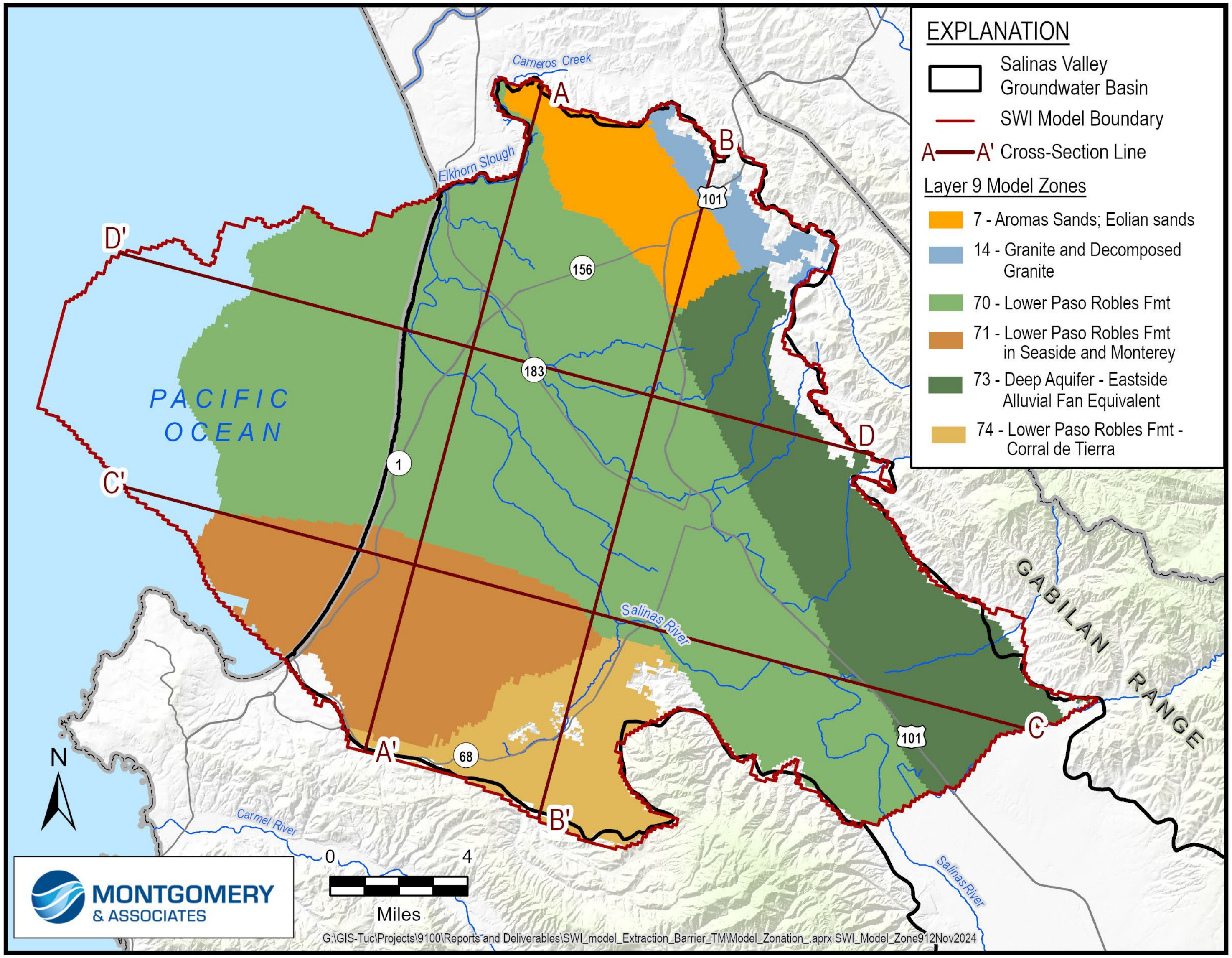

Figure 9. Model Hydrogeologic Zonation in Layer 9

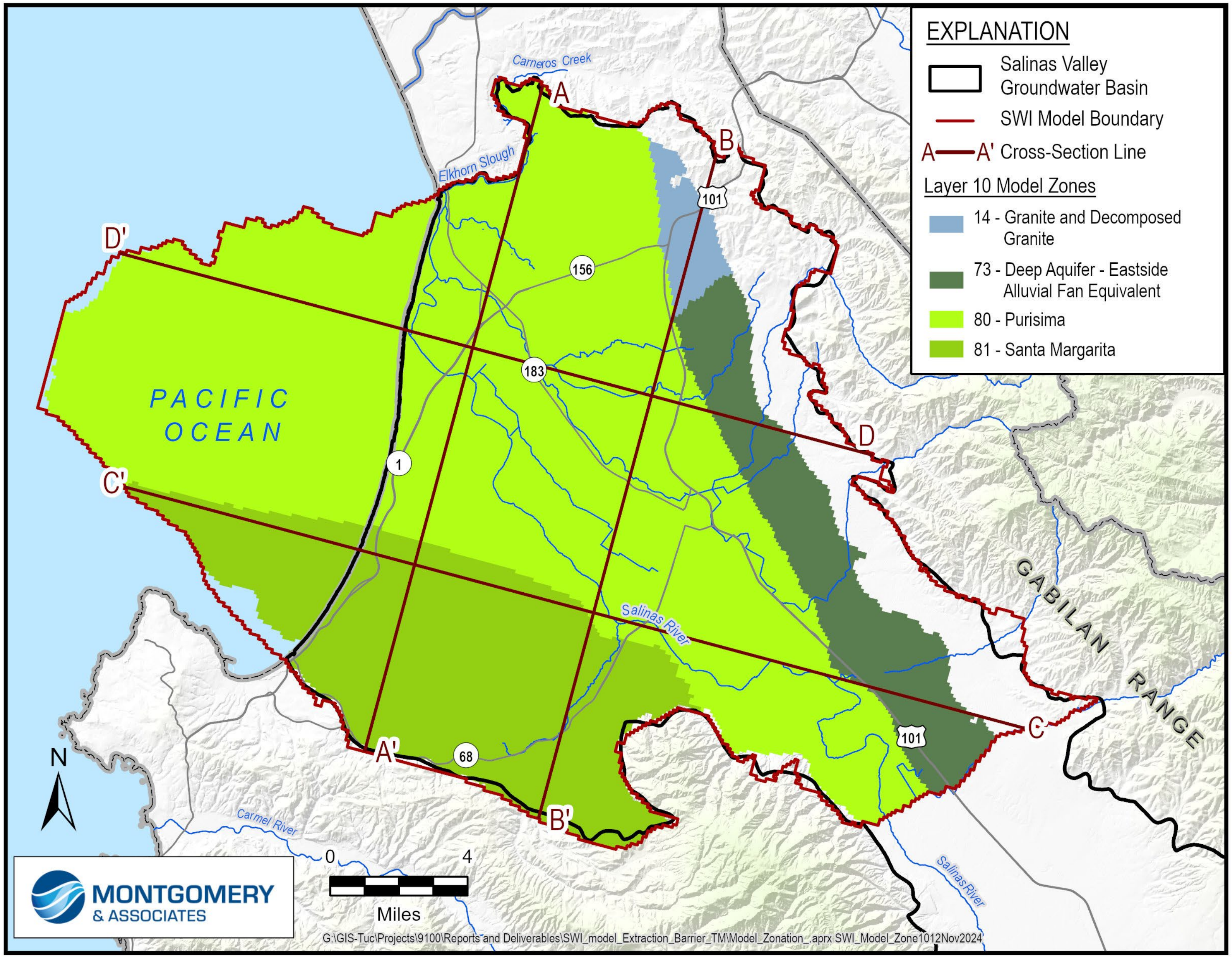

Figure 10. Model Hydrogeologic Zonation in Layer 10

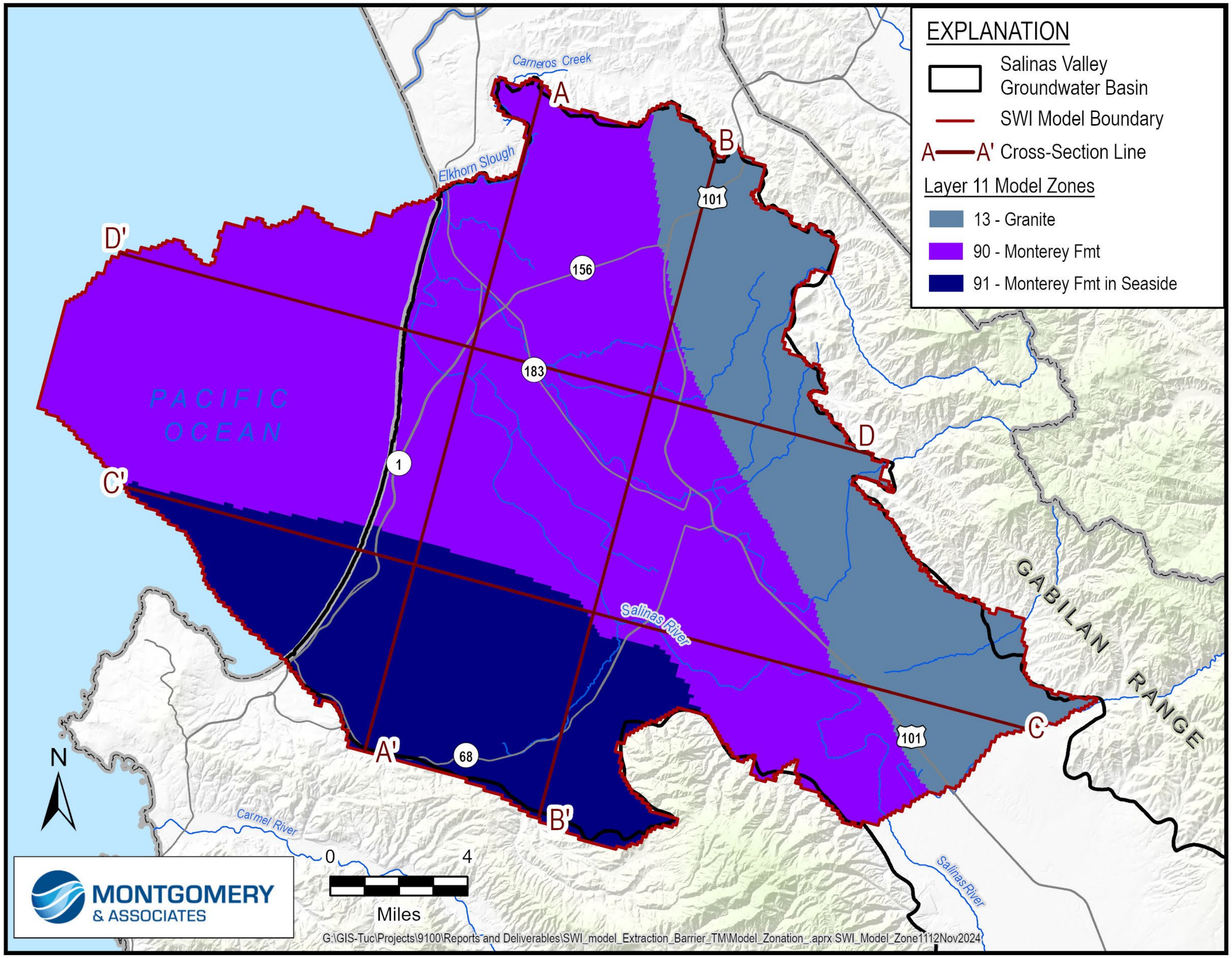

Figure 11. Model Hydrogeologic Zonation in Layer 11

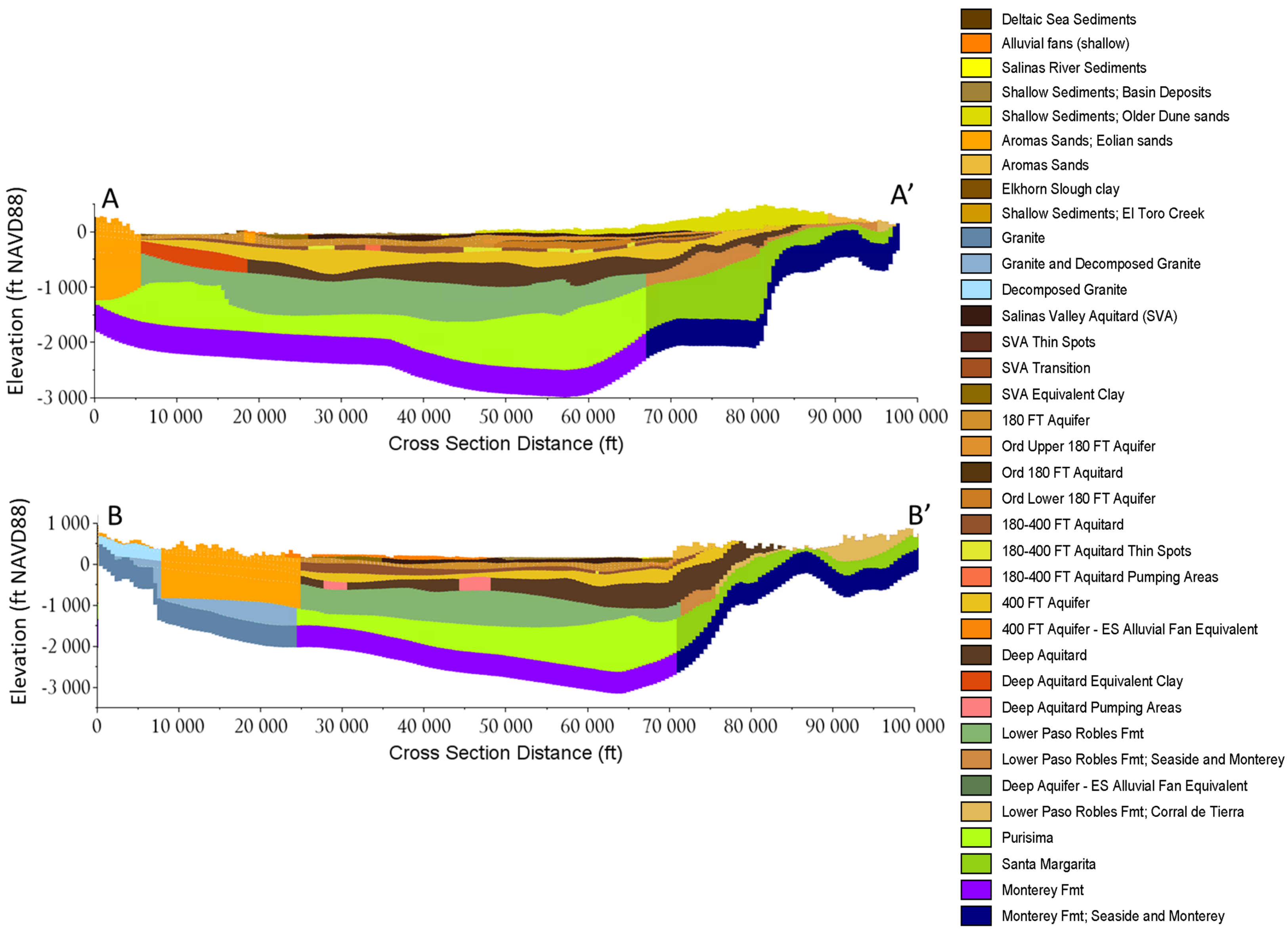

Figure 12. Model Hydrogeologic Zonation in Cross Section A-A' and B-B'

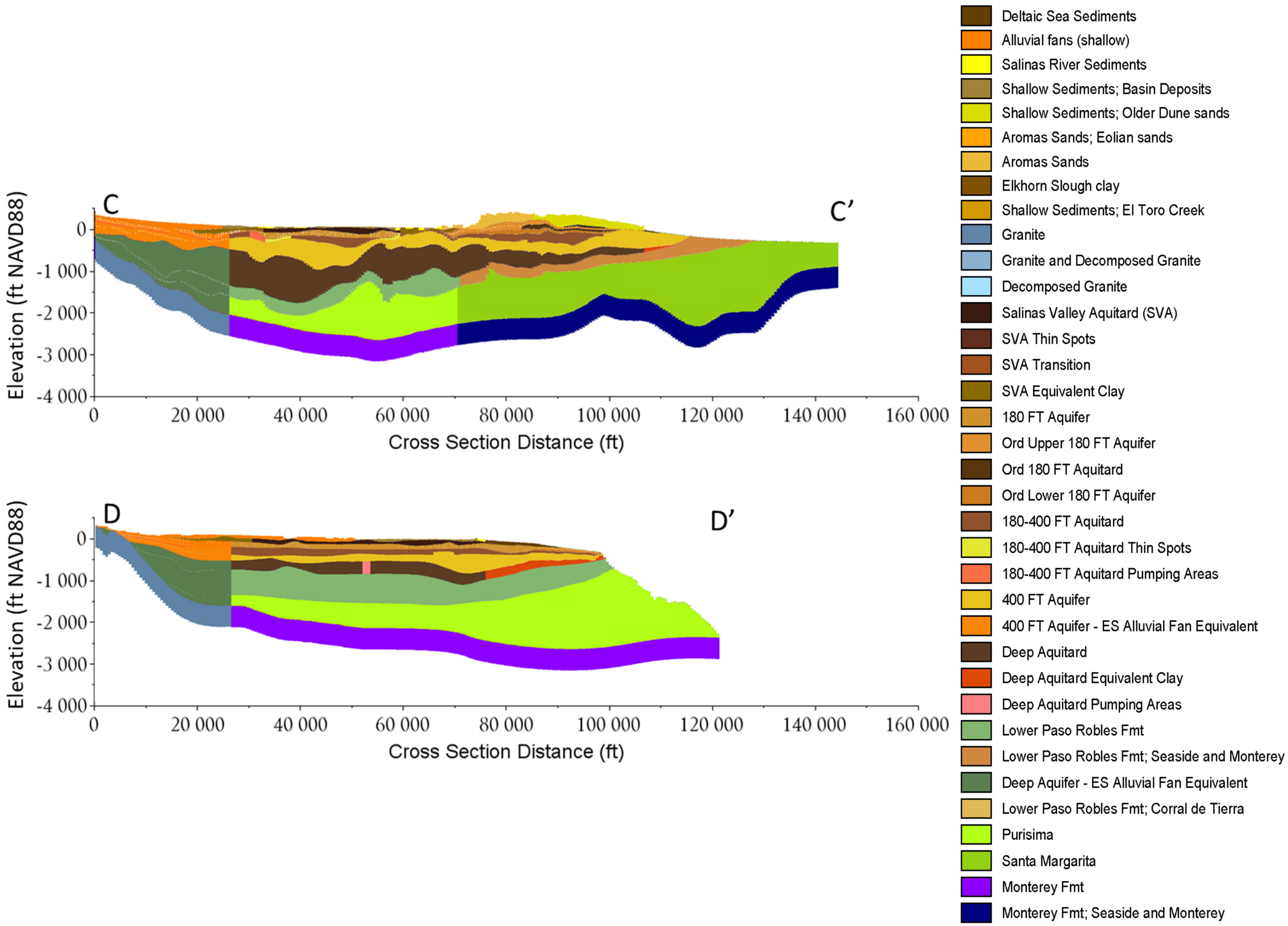

Figure 13. Model Hydrogeologic Zonation in Cross Section C-C' and D-D'

Adjusted Boundary Conditions

Modified Ocean Boundary Conditions

The ocean was previously modeled as a Constant Head Boundary (CHB), present only in layer 1. This boundary condition was changed to a General Head Boundary (GHB). The new GHB is present in the highest active portion of layers 1 through 7. In layers 8 through 11 the GHB is present in the highest active layers adjoining the Monterey Canyon. The GHB allows more flexibility in calibration through the conductance parameter and avoids setting the salinity of the layer 1 ocean sediments to full strength seawater. The conductance parameter was based on the value in the USGS Salinas Valley Integrated Hydrologic Model (SVIHM) ocean GHB.

Modified Pajaro Valley Boundary Condition

The northern boundary of the model shared with Pajaro Valley near Elkhorn Slough is modeled as a GHB. During the model update, the GHB was split into 4 reaches that better match the USGS' Pajaro Valley Hydrologic Model (PVHM) and SVIHM. The layering in the SWI model was updated to match the USGS geologic model along this boundary.

Updated Southeastern Boundary Conditions

The southeastern boundary of the model near the confluence of Chualar Creek and the Salinas River is modeled as a CHD. The portion of the CHD representing the Deep Aquifers was updated based on information in the Deep Aquifer Study and data from the new Deep Aquifers monitoring well near Gonzales (well DA-2). Previously the portion of the CHD representing the Deep Aquifers was assigned the same groundwater level as the 400-Foot Aquifer and 400-Foot Aquifer equivalent layers in Eastside, due to the lack of groundwater elevation data for the Deep Aquifers near the boundary.

Recent groundwater elevation data shows a downward gradient from the 400-Foot Aquifer to the Deep Aquifers in most areas. The difference in groundwater elevations between the Deep and 400-Foot aquifers near the coast ranges from 10 to 50 feet. At the new DA-2 monitoring well near Gonzales, the difference in groundwater elevations between the Deep and 400-Foot aquifers is approximately 30 feet. Historical groundwater elevation data show there used to be an upward gradient from the Deep Aquifers to the 400-Foot Aquifer. Although historical data are not available for the Deep Aquifers near Chualar, it is likely that an upward gradient also existed in this area considering the limited pumping from the Deep Aquifers. Historical groundwater elevation data from the coastal area suggests groundwater levels in the Deep Aquifers were approximately 10 feet higher than the 400-Foot Aquifer.

The CHD in the layers representing the Deep Aquifers were updated to reflect the historical switch from upward to downward gradient between the 400-Foot Aquifer and Deep Aquifers. M&A estimated that groundwater extraction in the Deep Aquifers near this boundary started around WY 1995. Prior to WY 1995 the groundwater levels in the Deep Aquifers and underlying bedrock (layers 8 through 11) were set 10 feet above the groundwater levels in the 400-Foot Aquifer. The difference in groundwater levels was assumed to trend linearly from 10 feet upward to 28 feet downward between WY 1995 and 2024, resulting in a downward groundwater level difference of 24.6 feet at the end of the simulation in September 2020. Figure 14 shows a plot of the simulated southeastern boundary elevations. This figure shows that the groundwater elevations in the Deep Aquifers, shown with the gray line, are initially higher than the groundwater elevations in the 400-Foot Aquifer, shown with the blue and red lines. Beginning in WY 1995, the deep aquifers groundwater elevation begins a linear trend toward the well DA-2 measured water level, shown with the purple dot on the right side of Figure 14.

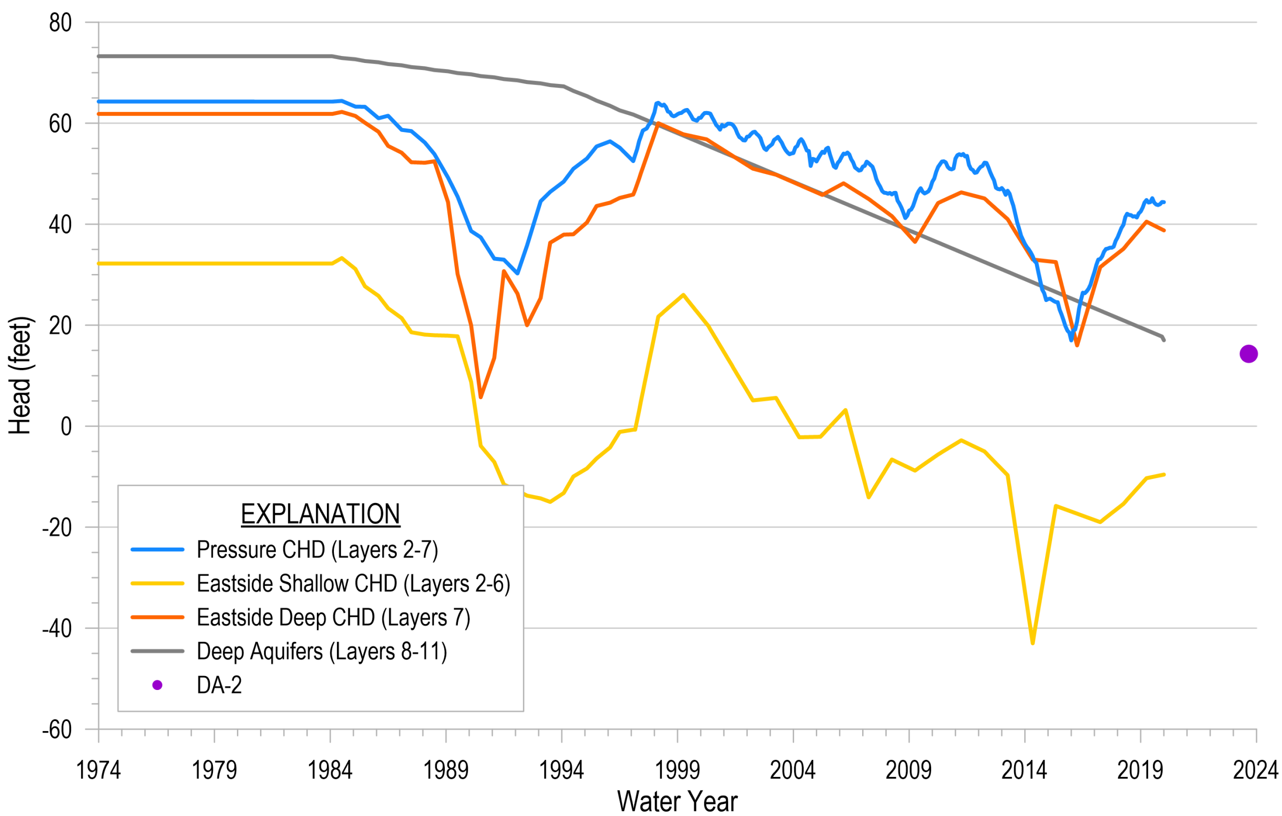

Figure 14. Specified Heads in CHD Along Southeastern Model Boundary Near Chualar

Updated Stream Boundary Parameters Along El Toro Creek

The previous version of the SWI Model systematically underpredicts groundwater levels in Corral de Tierra by roughly 50 to 100 feet, and the simulated stream leakage in the previous version of the SWI Model is most likely unrealistically low. Stream parameters that influence the amount of surface water to groundwater exchange were modified during the model update. A combination of increasing the streambed leakage and slowing the streamflow to increase the stage were used to increase the amount of surface water infiltration and raise the groundwater levels.

Updated Recharge Assumptions in Monterey Subbasin

Comparison between recharge rates in the Dune Sands area of the previous version of the SWI Model and the Monterey Subbasin Groundwater Flow Model (MBGWFM) led to a re-evaluation of the recharge assumptions for the Monterey Subbasin. The following differences were noted in *Review and Comments on Salinas Valley Seawater Intrusion Model* (EKI, 2023a).

1. SWI Model recharge rates in the Dune Sands are lower than those in the MBGWFM.
2. The MBGWFM recharge uses a soil water balance model with a finer spatial resolution than the SWI Model, which uses the USGS Basin Characterization Model (BCM) (Flint, 2014).
3. Neither the SWI Model nor the MBGWFM account for the City of Marina runoff capture and re-infiltration program.

In collaboration with EKI, the SWI Model recharge in the Dune Sands area was updated according to estimates from daily soil water balance model developed by EKI using the USGS' Soil Water Balance Model Version 2.04 (SWB2.0) (EKI, 2023b). The natural recharge portion of the total recharge in the Dune Sands was replaced with the SWB2.0 estimated groundwater recharge. Other portions of the total recharge include runoff recapture, which is calculated by the SWB2.0 model, and urban recharge with is a percentage of urban pumping. Recharge from agriculture was excluded in the updated Dune Sands area recharge due to the minor presence of agriculture in this area.

Based on these updates, the monthly recharge between WY 1998 and WY 2020 were modified in the SWI Model update. The modified recharge rates are presented on Figure 15 and Figure 16. The modifications double the average recharge in the Dune Sands area, which has increased from an average of 3.1 to 6.5 inches per year (in/yr) during the adjusted period. This is equivalent to an increase in recharge of approximately 4,600 AF/yr, most of which is in the Monterey Subbasin, with some in the Seaside Subbasin and the 180/400 Subbasin. As shown on Figure 15, the updated recharge rates are very close to the rates simulated by the SWB2.0 model (EKI, 2023b). The difference between the updated recharge and the SWB2.0 results shown on Figure 15 is the addition of urban recharge in the SWI Model, and averaging over different geographic areas. Figure 16 shows the average monthly recharge rates in the Dune Sands area. The modified winter recharge rates are higher than in the previous model, and the modified summer recharge rates are lower than in the previous model.

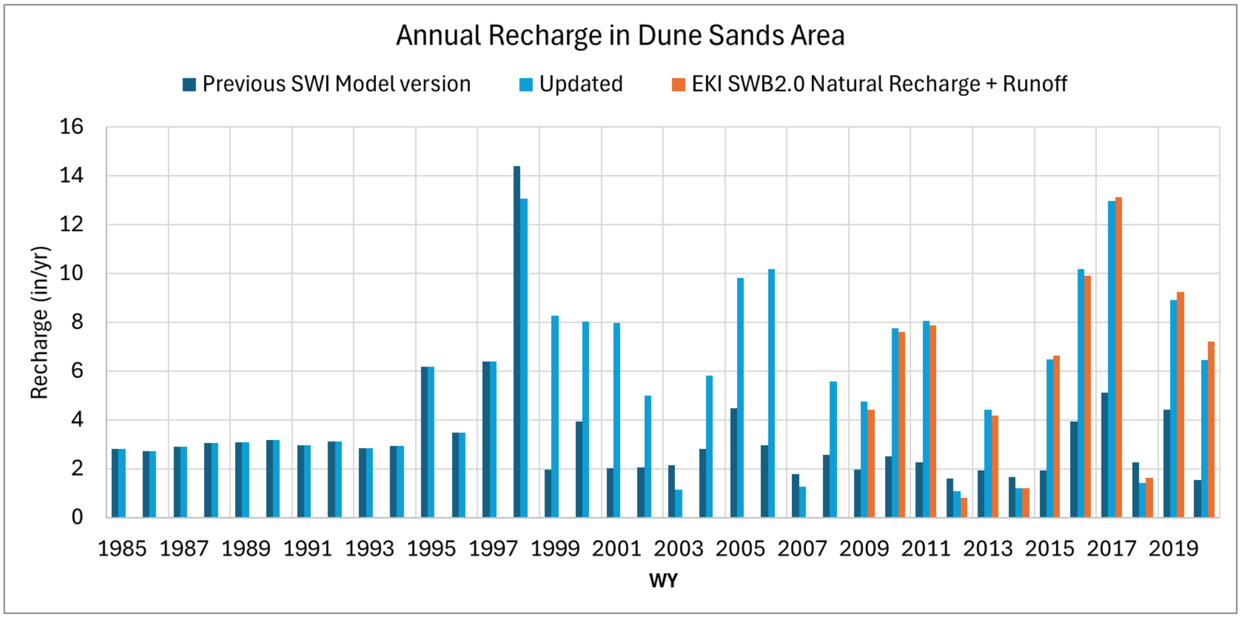

Figure 15. Updated Annual Recharge in Dune Sands Area

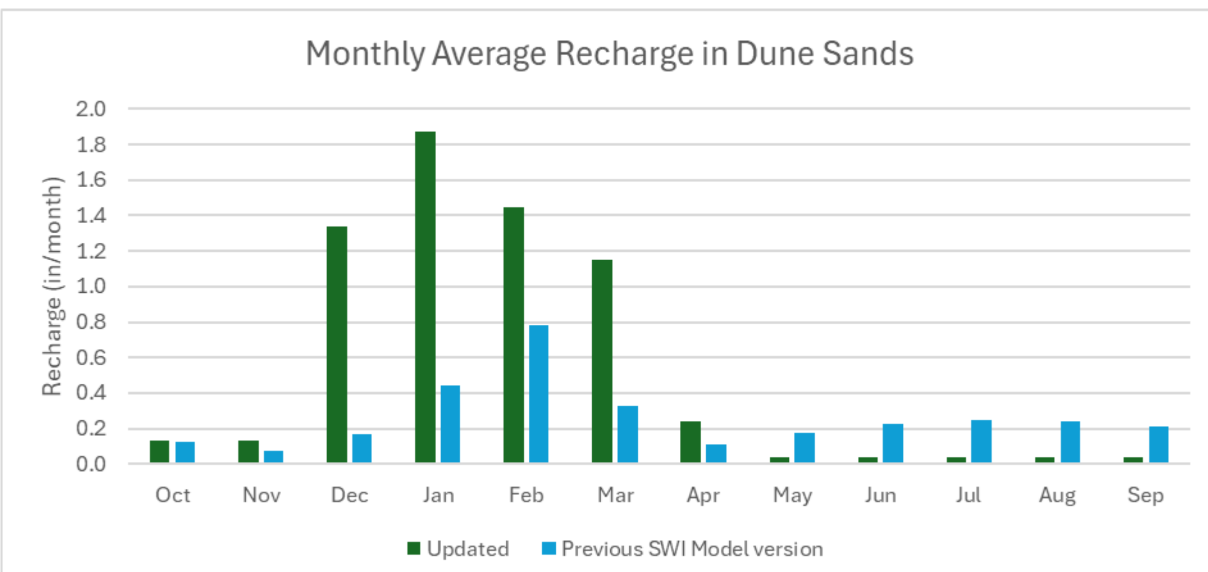

Figure 16. Updated Monthly Recharge in Dune Sands Area

Compared the SWI Model with Adjacent and Overlapping Models

During this round of model updates, M&A reviewed adjacent and overlapping groundwater models including the Seaside Watermaster Groundwater Model, the MBGWFM, and the PVHM. M&A is currently updating the SVIHM to reflect the HCM updates and align the SVIHM with this revised SWI model. Additionally, M&A coordinated with the Seaside Subbasin and Monterey Subbasin modeling teams during the model update.

The Seaside Subbasin Watermaster modeling team was consulted during the HCM updates regarding changes to layering in the Seaside Subbasin. The Seaside Subbasin Watermaster modeler reviewed and agreed that the layering updates are reasonable and reflect available data. It is likely that future updates to the Seaside Subbasin Watermaster Model will draw upon the HCM updates that underpin this SWI model. Comparison of the previous SWI Model to this model indicates that groundwater conditions simulated by the models were generally consistent; however, it will be important to coordinate predictive assumptions in future modeling efforts.

M&A worked closely with EKI during the layering updates in the Monterey Subbasin to come to consensus on aquitard elevations and thicknesses. Additionally, M&A worked with EKI to update the recharge assumptions in the Dune Sands area, as noted in the previous section.

During the HCM update, the layer elevations along the PVHM boundary were confirmed to match the SVIHM as reflected in the Salinas Valley Geologic Framework (Sweetkind, 2023). This area was not a focus of the HCM update and there was no additional information gathered to support modifying the layering in this portion of the model. The GHB boundary conditions were modified during the model update to better reflect the PVHM and SVIHM GHB in this area.

Updated Well and Pumping Data, and Updated How Wells are Simulated

Well completion reports were reviewed during the HCM updates, and well screen interval information gathered during this process were incorporated into the SWI Model. The well screen intervals in the SWI Model were updated according to the following procedure:

1. Reported screen intervals were used for the modeled well screen interval if available.
2. If well screen interval data were not available, the well screen bottom was set to the reported well depth. The well screen top was assumed to be at the top of the aquifer that the reported well depth is located in. If the reported well depth is in an aquitard, then the top of the overlying aquifer is used.

3. If a well depth is not reported, the MCWRA aquifer designation was used to assign the well screen interval. The well screen top was set to the top elevation of the respective aquifer. The well screen bottom was set to the bottom elevation of the respective aquifer.
4. If an aquifer designation was not available, the well screen interval from the prior version of the SWI Model was used. These are based on nearby reported well screen information and well screen intervals in the SVIHM.

Wells were previously simulated using the WEL package. The updated SWI model simulates wells using the connected linear network (CLN) package. The CLN package is able to reassign pumping to lower layers as groundwater levels decrease, reducing the risk of simulating automatic pumping reductions due to low groundwater levels. The CLN package additionally allows wells screened across multiple aquifers to act like conduits between model layers, potentially acting as a flow pathway through an aquitard. Wells with reported screen intervals were not generally screened in multiple aquifers. However, several wells without screen interval information were conservatively assigned a well screen bridging both the 180-Foot Aquifer and 400-Foot Aquifer. 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 the 400-Foot Aquifer.

The SWI Model was refined with monthly extraction data collected by MCWRA through their Groundwater Extraction Management System (GEMS). Prior to this update, annual GEMS data were split into monthly rates based on the pumping distribution in the SVIHM farm process. With the model update, the GEMS monthly pumping rates are directly input into the SWI Model. Review of the monthly GEMS pumping data revealed some isolated data points with questionably high pumping rates. Likely outliers were substituted with more realistic pumping rates.

Other updates include the addition of new wells and verification of some well locations. Eleven new wells, most of which became active at the end of 2019, were added to the model. The locations of the Marina Coast Water District’s public supply wells were verified and updated if necessary.

Updated Water Level Calibration Target Data

Additional groundwater level data from the Deep Aquifer Study were added to the calibration target data set. Groundwater elevations collected between 1983 and 2020 from 48 Deep Aquifers wells were added to the SWI Model water level calibration data. Additionally, the updated model layering was compared to the screen intervals of the water level target wells. Where appropriate, the target’s representative layer was updated based on new model layering. This impacted about one third of the water level targets throughout the SWI model area. Updates to the water level target data set should be considered when comparing water level calibration statistics between the updated SWI Model and the previous version.

MODEL RECALIBRATION

The SWI model was recalibrated by manually varying simulated hydraulic conductivities, storage parameters, and simulated effective porosities. The hydraulic conductivity was manually adjusted by adjusting individual pilot point values (Doherty *et al.*, 2010). The results of the model recalibration are detailed below.

Hydrogeologic Parameters

Table 1 notes the final hydrogeologic parameters in the updated SWI Model following recalibration. The HGU Zone numbers referenced in Table 1 are shown on Figure 1 through Figure 13.

Table 1. Updated Summary of Calibrated Hydraulic Conductivity (K) and Storage Propertiesof the HGUs 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 (Sy) Effective Porosity	Specific Storage (S_s) (ft^{-1})
			Minimum	Maximum	Geometric Mean	Minimum	Maximum	Geometric Mean		
2	Deltaic Sea Sediments	2,2	5.00	398	59.8	0.477	38.0	5.71	0.0821	0.00427
3	Alluvial fans (shallow)	12,12	6.48	33.1	22.1	0.242	1.24	0.825	0.195	0.0000200
4	Salinas River Sediments	1,1	176	176	176	20.7	20.7	20.7	0.232	0.00150
5	Shallow Sediments; Basin Deposits	6,6	5.00	32.8	22.8	0.778	1.48	1.30	0.185	0.00100
6	Shallow Sediments; Older Dune sands	14,14	6.15	75.9	30.4	0.413	7.80	3.09	0.263	0.00100
7	Aromas Sands; Eolian sands	4,4	2.21	7.00	3.92	0.253	0.253	0.253	0.220	0.0006176
8	Aromas Sands	3,3	49.5	50.2	49.7	4.53	14.5	6.75	0.165	0.0000618
9	Elkhorn Slough clay	1,1	0.0100	0.0100	0.0100	0.00100	0.00100	0.00100	0.102	0.0000900
10	Shallow Sediments; El Toro Creek	1,1	79.3	79.3	79.3	10.2	10.2	10.2	0.168	0.00144
13	Granite	1,1	0.00000100	0.00000100	0.00000100	0.00000100	0.00000100	0.00000100	0.208	0.00000505
14	Granite and Decomposed Granite	1,1	0.00680	0.00680	0.00680	0.000634	0.000634	0.000634	0.208	0.00000505
15	Decomposed Granite	1,1	0.680	0.680	0.680	0.178	0.178	0.178	0.208	0.00000505
20	Salinas Valley Aquitard (SVA)	6,11	0.0125	0.0125	0.0125	0.000100	0.005	0.00150	0.120	0.0000100
21	SVA Thin Spots	1,1	5.00	5.00	5.00	0.500	0.500	0.500	0.120	0.0000100
22	SVA Transition	1,1	0.0125	0.0125	0.0125	0.00170	0.00170	0.00170	0.120	0.0000100
23	SVA Equivalent Clay	3,3	0.0125	0.0125	0.0125	0.000787	0.00135	0.00119	0.120	0.0000100
30	180-Foot Aquifer	18,17	30.0	258	141.5	1.00	14.2	6.20	0.100	0.0000363
31	Ord Upper 180-Foot Aquifer	13,13	30.0	230	94.3	0.143	5.58	0.642	0.120	0.0000363
33	Ord 180-Foot Aquitard	3,6	0.00560	0.00560	0.00560	0.000500	0.000500	0.000500	0.128	0.0000363
34	Ord Lower 180-Foot Aquifer	12,9	15.0	230	75.6	0.474	3.92	1.68	0.120	0.0000363
40	180/400-Foot Aquitard	8,13	0.00100	0.00810	0.00670	0.000100	0.0100	0.000217	0.117	0.0000100
41	180/400-Foot Aquitard Thin Spots	1,3	1.00	1.00	1.00	0.00100	0.00500	0.00172	0.100	0.0000100
44	180/400-Foot Aquitard Pumping Areas	1,1	5.00	5.00	5.00	0.00500	0.00500	0.00500	0.100	0.0000100
50	400-Foot Aquifer	30,23	0.700	120	56.1	0.0100	2.74	0.776	0.100	0.0000100

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		
53	400-Foot Aquifer - Eastside Alluvial Fan Equivalent	6,6	13.9	26.5	18.1	0.0995	0.289	0.141	0.195	0.0000200
60	Deep Aquitard	1,1	0.00810	0.00810	0.00810	0.000100	0.0100	0.00224	0.120	0.0000100
61	Deep Aquitard Equivalent Clay	1,1	0.00810	0.00810	0.00810	0.00100	0.00100	0.00100	0.120	0.0000100
64	Deep Aquitard Pumping Areas	10,10	2.00	2.00	2.00	0.200	0.200	0.200	0.168	0.0001438
70	Lower Paso Robles Formation	7,7	0.760	22.9	6.92	0.0415	0.600	0.695	0.168	0.0001438
71	Lower Paso Robles Formation in Seaside and Monterey	2,2	2.18	23.0	13.7	1.80	1.80	1.80	0.168	0.0001438
73	Deep Aquifer - Eastside Alluvial Fan Equivalent	4,4	3.02	10.7	5.96	0.159	0.563	3.33	0.195	0.000200
74	Lower Paso Robles Formation – Corral de Tierra	6,6	1.85	1.85	1.85	0.184	0.184	0.184	0.168	0.0001438
80	Purisima	10,10	6.34	13.9	10.7	0.493	0.493	0.493	0.150	0.0000100
81	Santa Margarita	1,1	3.00	47.0	4.58	0.300	1.37	0.378	0.150	0.0000749
90	Monterey Formation	1,1	0.0000100	0.0000100	0.0000100	0.00000100	0.00000100	0.00000100	0.150	0.0000100
91	Monterey Formation in Seaside and Monterey	2,2	0.00680	0.00680	0.00680	0.000634	0.000634	0.000634	0.120	0.0000100

Groundwater Level Calibration

Table 2 summarizes the groundwater level calibration statistics across the model for each aquifer and for the entire model. The updated water level data are somewhat different than the previous water level data, which complicates direct comparison of water level statistics between the prior model version and the updated model, Table 2 indicates the water level calibration of the updated model is similar to or slightly better than the previous model version. The mean residuals indicate that the model continues to underpredict water levels in the surficial sediments, 180-Foot Aquifer, and 400-Foot Aquifer by a similar magnitude of 5 to 10 feet. The model overpredicts water levels in the Deep Aquifers group by approximately 10 feet. The Deep Aquifers group includes targets in the Lower Paso Robles and Santa Margarita in Corral de Tierra where the increase in stream leakage raised water levels. The scaled root mean square error (RMSE) decreased in each group except the 180-Foot Aquifer, where it increased slightly. The range of observations included in the 180-Foot Aquifer was much smaller following the model update, which makes the scaled RMSE seem larger while the unscaled RMSE decreased. Overall, the scaled RMSE is lower in the 2024 model update, indicating that less of the simulated water level variation is due to errors.

Table 2. Updated Water Level Calibration Statistics

2024 Model Update					
	Surficial Sediments	180-Foot Aquifer	400-Foot Aquifer	Deep Aquifers	All Data
Mean Residual (ft)	5.27	5.44	7.75	-10.44	-1.28
RMS Error (ft)	26.23	13.83	20.63	30.31	25.25
Number of Observations	7,893	11,069	12,113	26,106	58,294
Range in Observations (ft)	537	158	329	833	833
Scaled RMS Error	4.88%	8.73%	6.28%	3.64%	3.03%
Scaled Residual Mean	0.98%	3.45%	2.36%	-1.25%	-0.15%
2023 Model Update					
	Surficial Sediments	180-Foot Aquifer	400-Foot Aquifer	Deep Aquifers	All Data
Mean Residual (ft)	10.56	4.11	2.27	9.48	6.98
RMS Error (ft)	51.31	25.32	19.76	46.66	41.26
Number of Observations	14,709	12,781	9,751	7,251	45,599
Range in Observations (ft)	833	464	252	498	833
Scaled RMS Error	6.16%	5.46%	7.83%	9.38%	4.96%
Scaled Residual Mean	1.27%	0.89%	0.90%	1.91%	0.84%

The simulated and observed water level cross plot (Figure 17) is similar to the previous model version in the 180-Foot and 400-Foot Aquifers. This figure shows there is no clear evidence of systematic bias in the model results.

Some of the groundwater level targets in Corral de Tierra were originally included in the Surficial Sediments group but were moved to the Deep Aquifers group in the model update. These include most of the Deep Aquifers data with simulated and observed water levels above 100 feet. The new Deep Aquifers targets added within the main portion of the Salinas Valley have simulated and observed water levels below 100 feet. The points in the Deep Aquifers and 400-Foot Aquifer that plot above the 1-to-1 line with observed water levels less than -100 feet are in the Eastside alluvial fan equivalent units. These targets in the Eastside alluvial fans were previously included in the Surficial Sediments group but in the model update were impacted by the layering changes and were split out based on the depth of the equivalent aquifer. The updated model continues to overpredict overestimate water levels in the Eastside alluvial fans, especially along the margin of the Gabilan Range where there is an observed groundwater depression. The updated model simulates a groundwater depression in Eastside, but at a lesser magnitude.

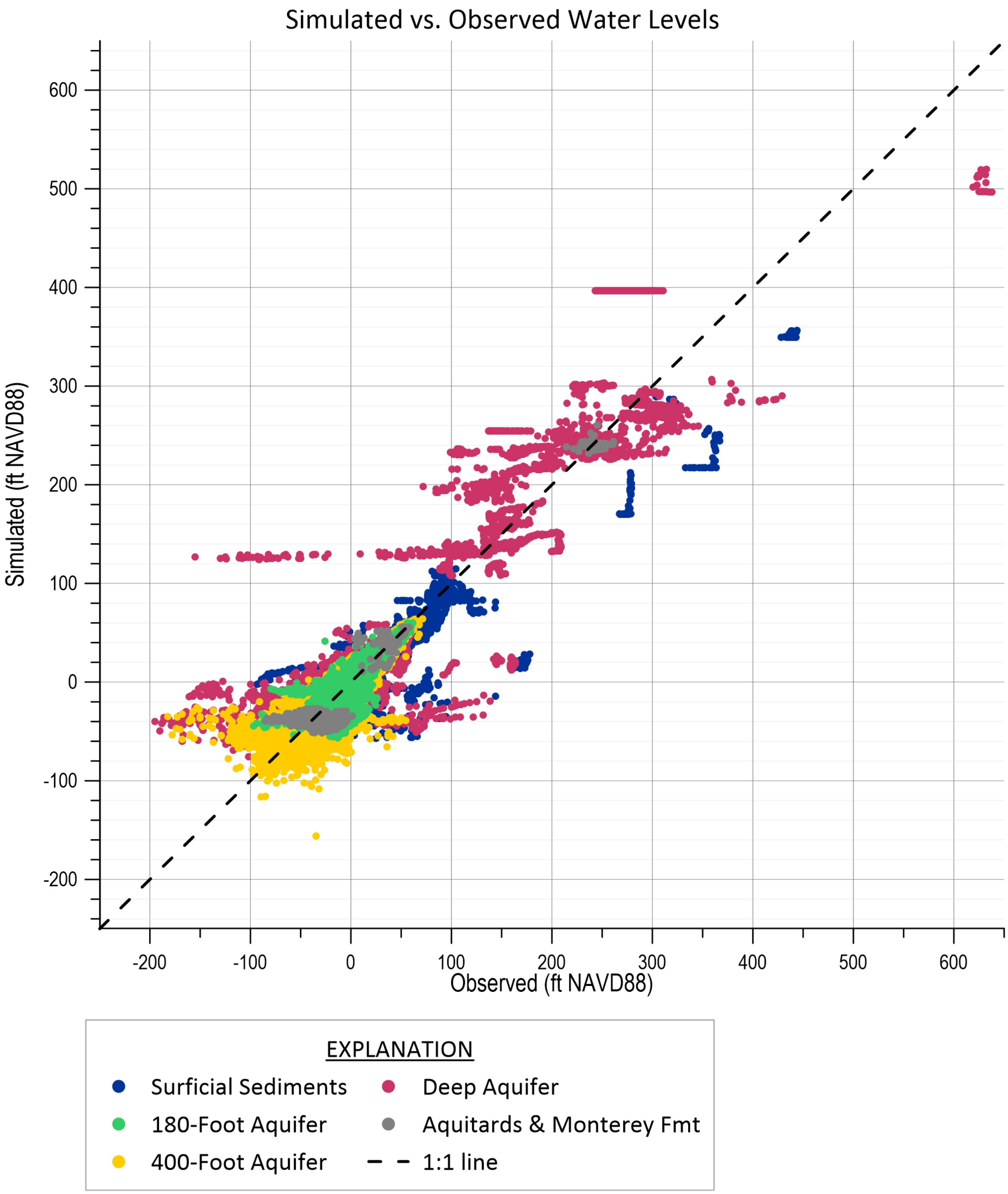

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Figure 17. Simulated and Observed Water Level Cross Plot

Figure 18 through Figure 21 show the spatial distribution of mean residuals in the Surficial Sediments, 180-Foot Aquifer, 400-Foot Aquifer, and Deep Aquifers, respectively. Green bubbles indicate the mean residual for that location is positive and simulated water levels underestimate measured water levels. Orange bubbles indicate the mean residual for that location is negative and simulated water levels overestimate measured water levels.

The water level calibration in the Dune Sands has improved. The mean residuals in the Dune Sands shown on Figure 18 are smaller than in the previous model, and the model overpredicts heads in the underlying portions of the 180-Foot Aquifer to a lesser extent, as shown on Figure 19. Outside of the Dune Sands, Figure 19 shows the updated model has a similar water level calibration to the previous model in the 180-Foot Aquifer.

Water levels in the 400-Foot Aquifer are slightly lower than in the previous model, as shown on Figure 20. The trend of overprediction near Castroville in the prior version of the model has improved. Groundwater levels are slightly lower near Nashua Road in the 400-Foot Aquifer.

The model continues to overpredict groundwater levels in the Deep Aquifers near the coast by approximately 25 feet to 50 feet, as shown on Figure 21. Increasing stream leakage in the Corral de Tierra area resulted in higher water levels and in some cases, now groundwater levels are too high as seen on Figure 21.

Targets in the deeper portion of the Eastside alluvial fans were moved from the Surficial Sediments group in the prior model version to the Deep Aquifer group in the updated model, and are shown on Figure 21. The magnitude of the mean residual in this area east of the City of Salinas is smaller, representing an improvement in the model fit in this area. However, the model still tends to underpredict the observed groundwater level depression along the Gabilan Range in the Eastside Subbasin.

Figure 22, 23, and 24 show updates to representative hydrographs in the 180-Foot Aquifer, 400-Foot Aquifer, and Deep Aquifers.

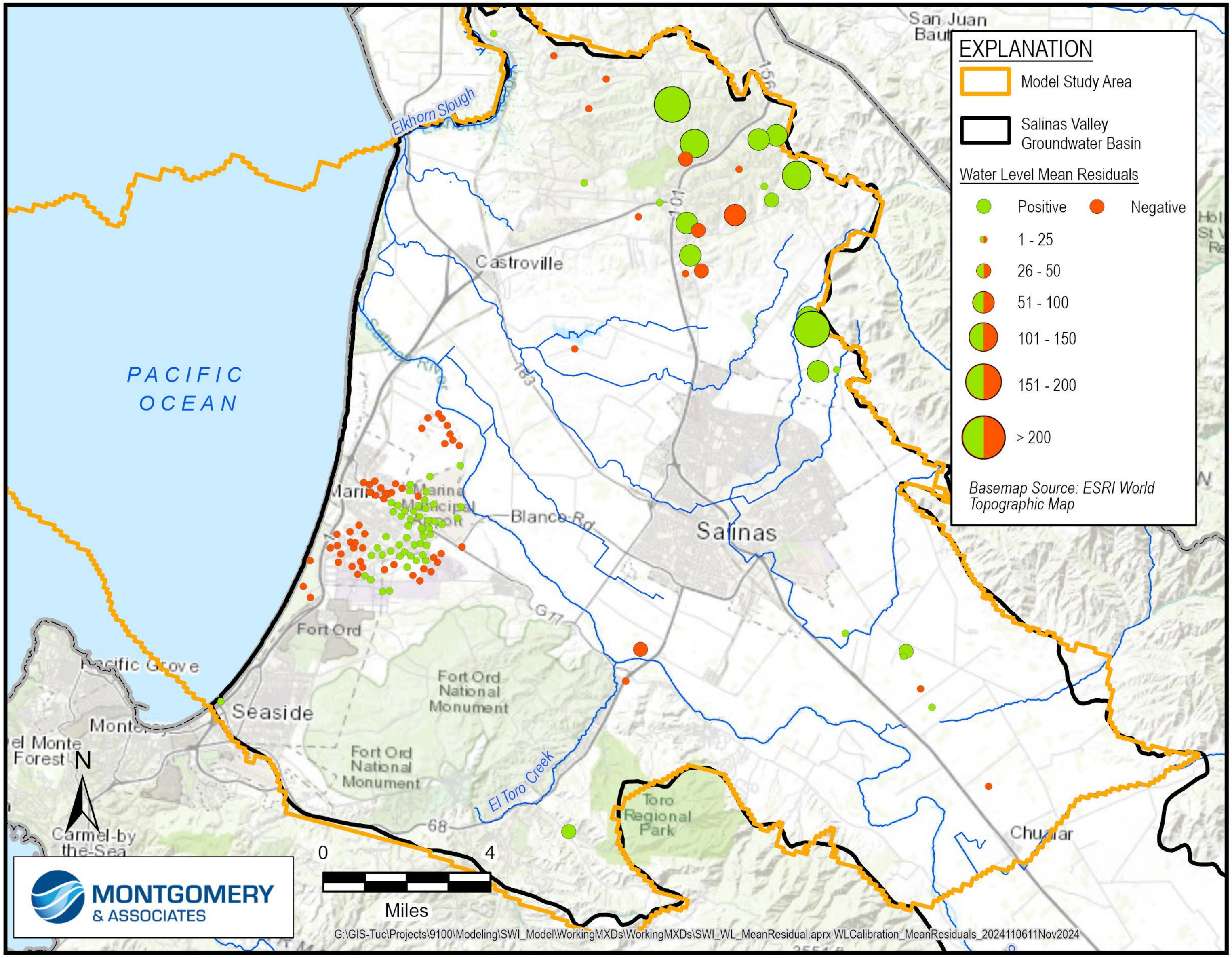

Figure 18. Mean Residual Water Level Bubble Plot within the Surficial Sediments and Equivalent Areas

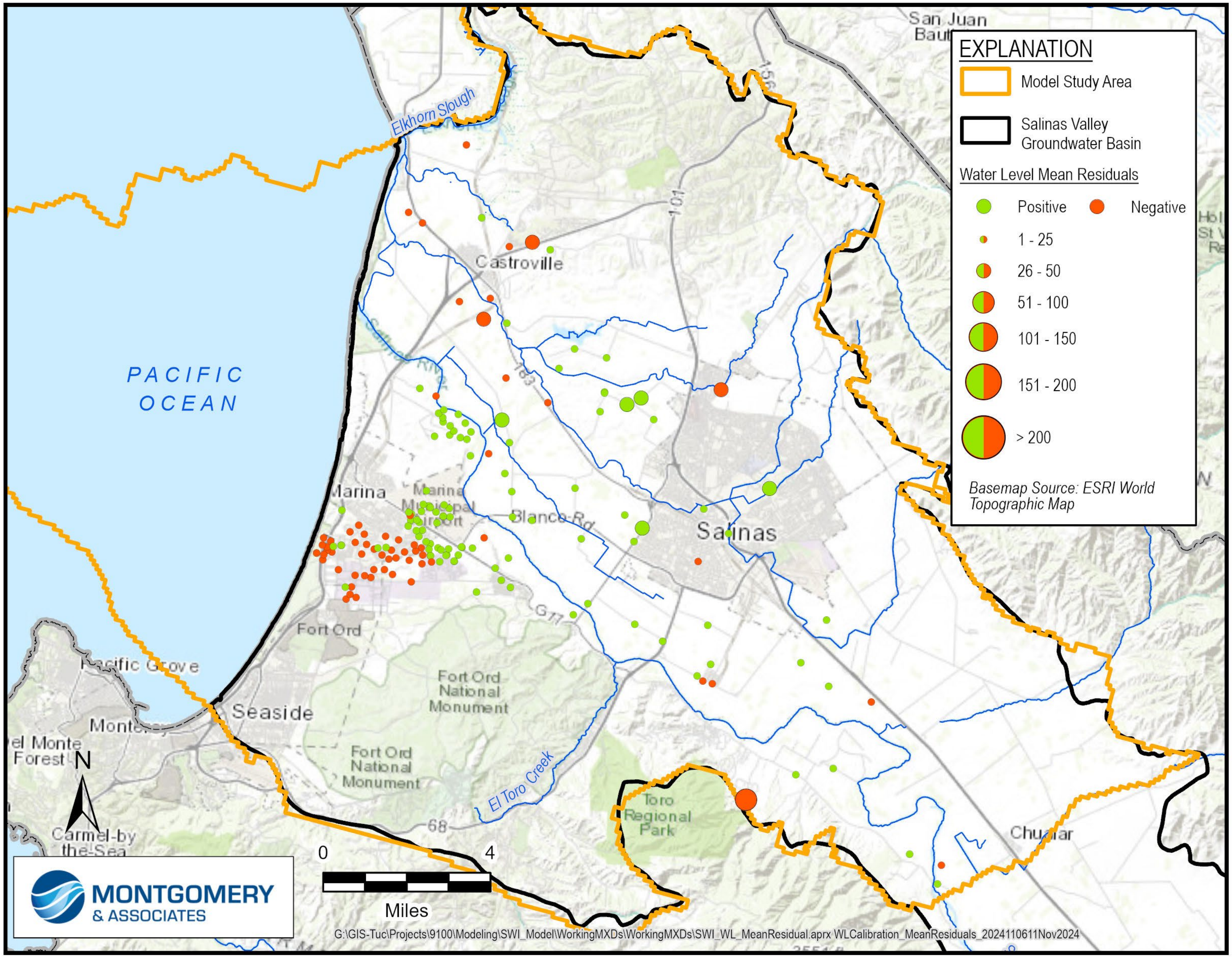

Figure 19. Mean Residual Water Level Bubble Plot within the 180-Foot Aquifer and Equivalent Areas

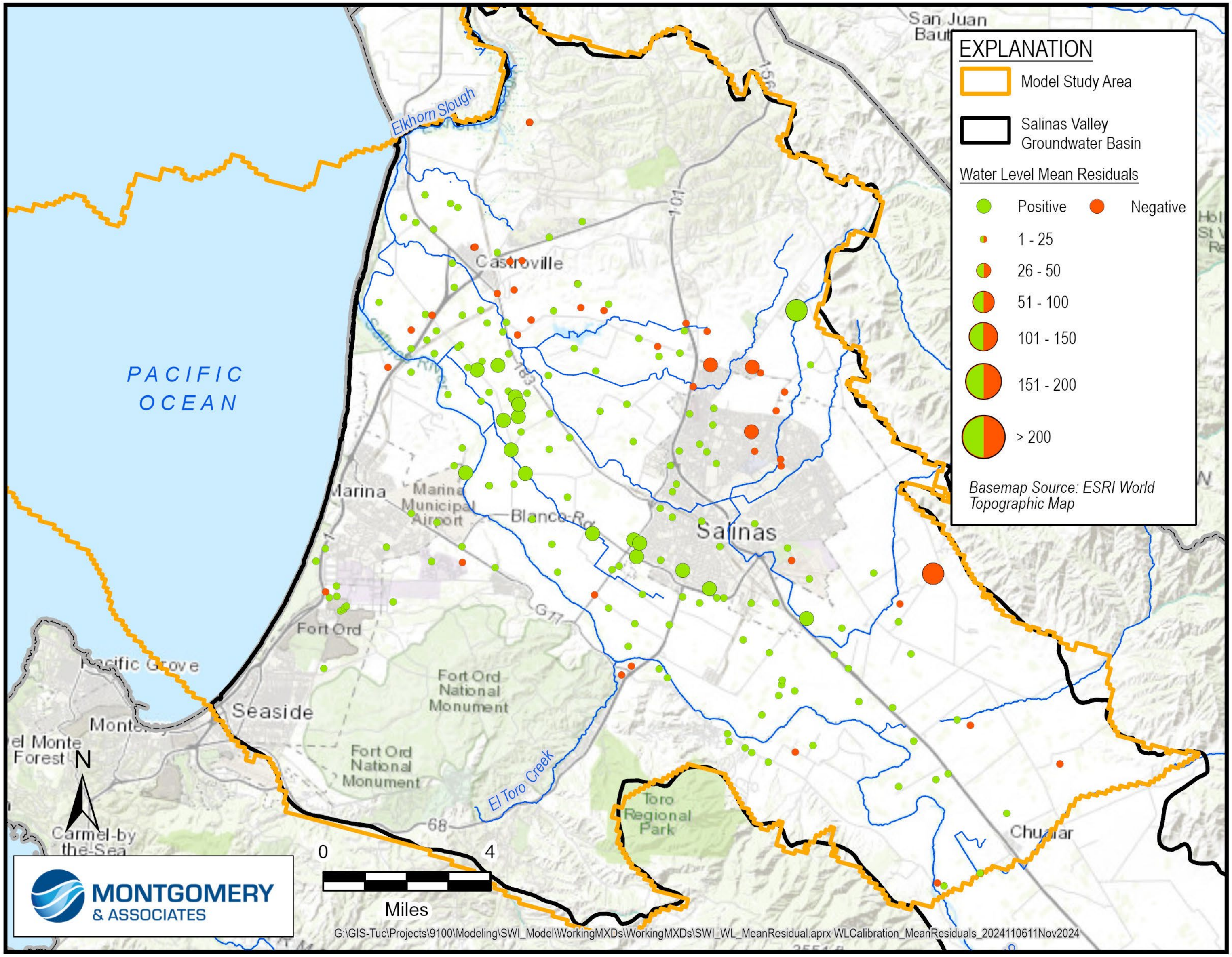

Figure 20. Mean Residual Water Level Bubble Plot within the 400-Foot Aquifer and Equivalent Areas

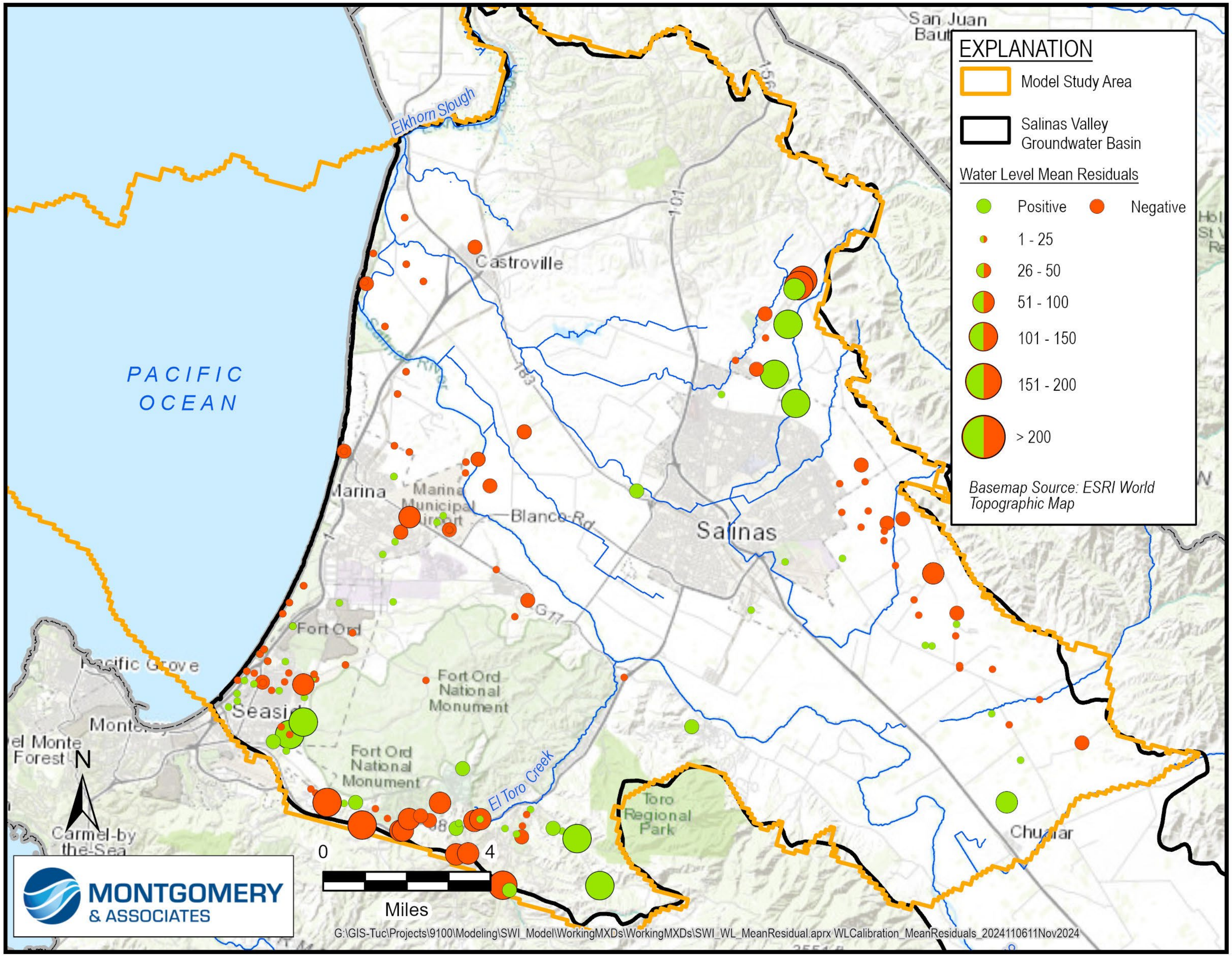

Figure 21. Mean Residual Water Level Bubble Plot within the Deep Aquifer and Equivalent Areas

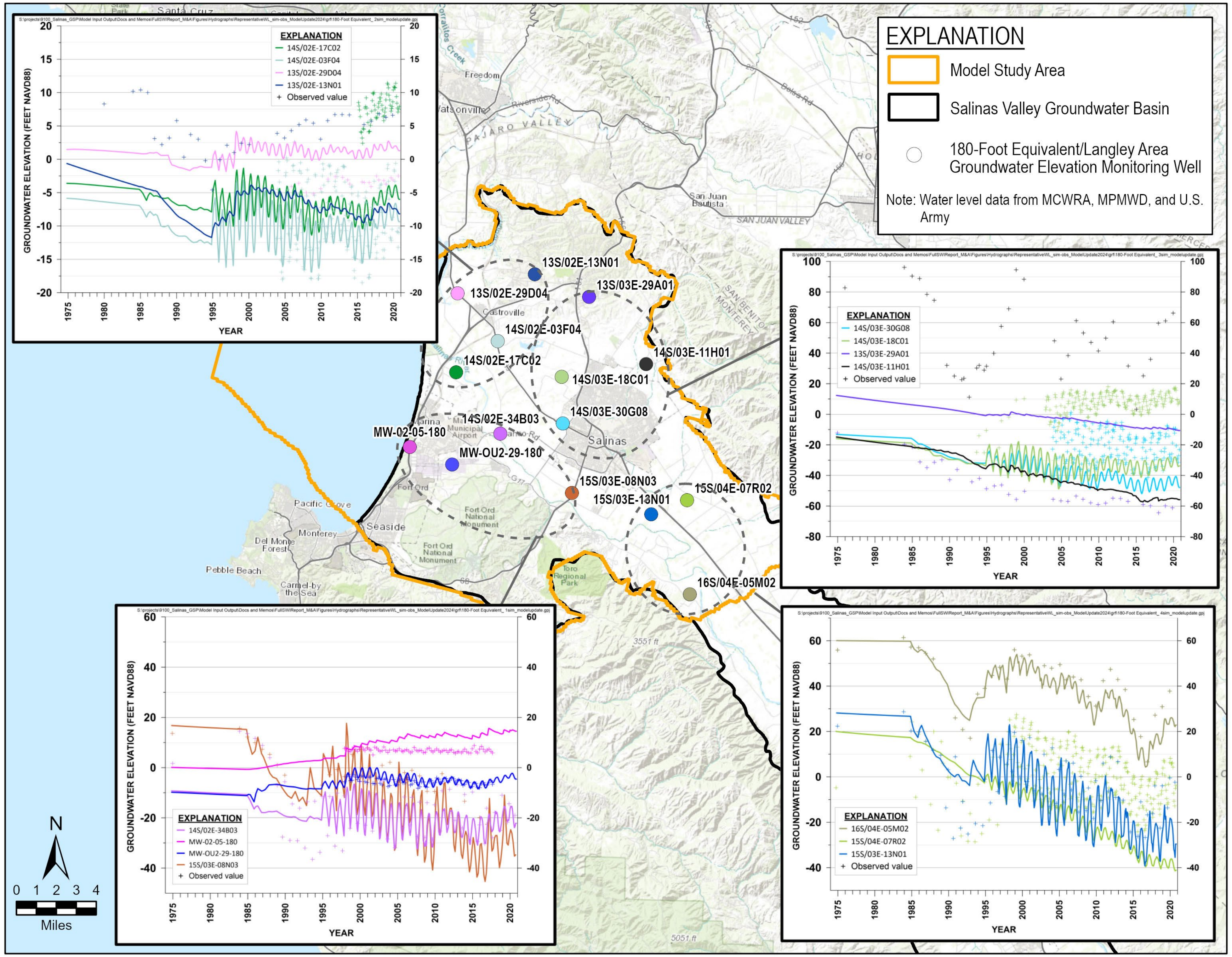

Figure 22. Observed and Simulated Representative Hydrographs within the 180-Foot Aquifer

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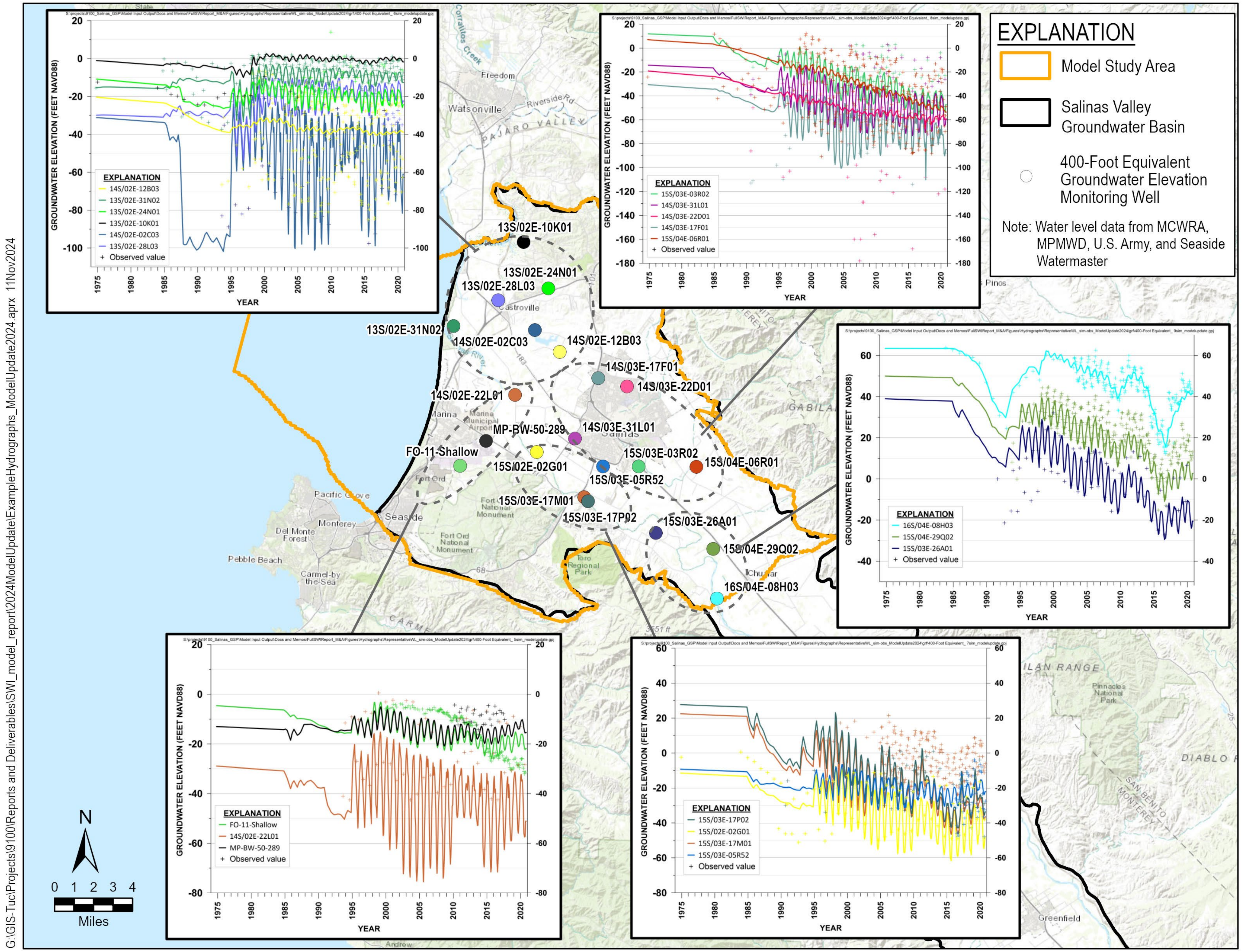

Figure 23. Observed and Simulated Representative Hydrographs within the 400-Foot Aquifer

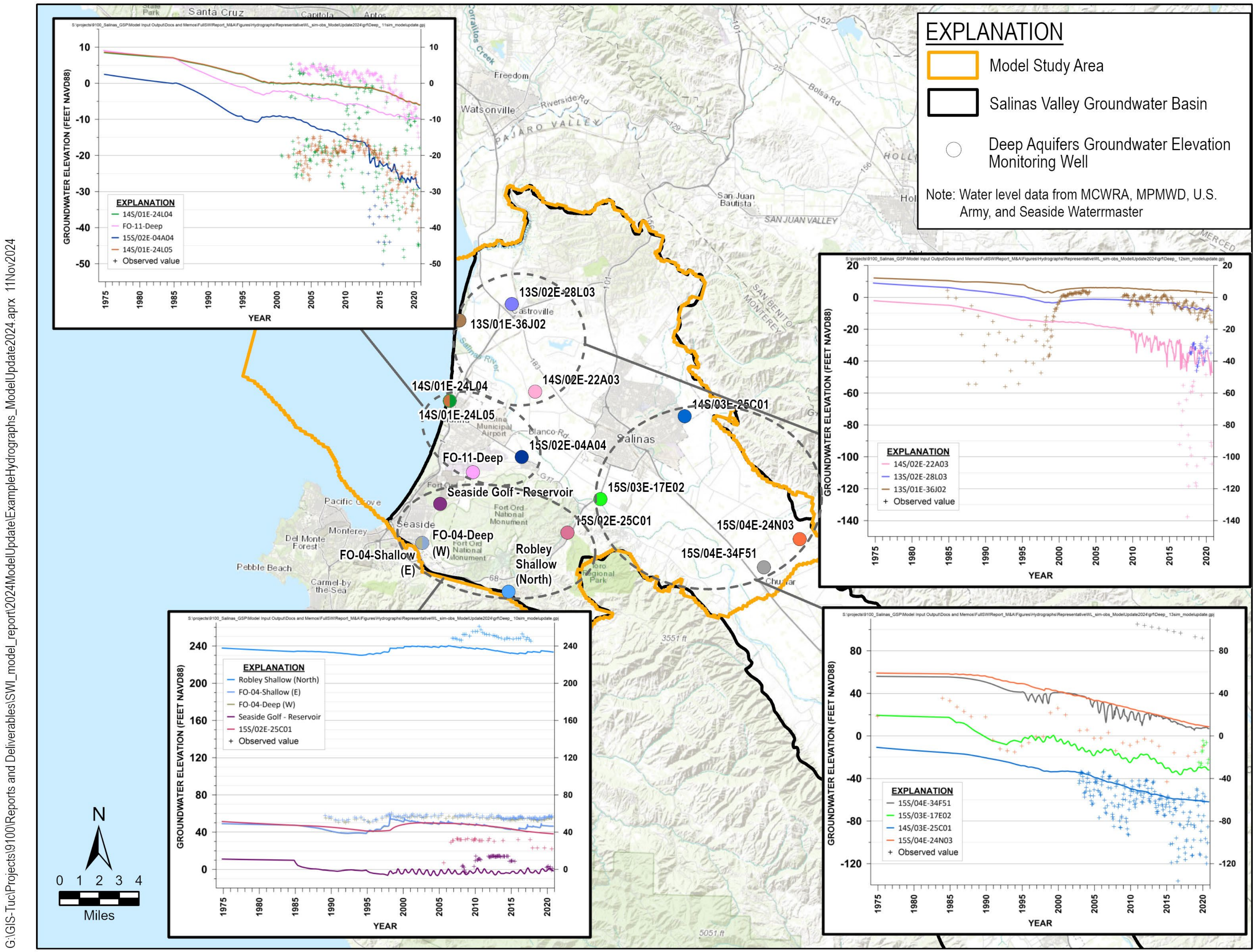

Figure 24. Observed and Simulated Representative Hydrographs within the Deep Aquifer

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 MCWRA contours. The inland progression of the simulated 500 mg/L contours are compared to the contours as reported by MCWRA on Figure 25 and Figure 26 below. The simulated distribution of chloride concentrations in the 180-Foot Aquifer and 400-Foot Aquifer at the end of the simulation in 2020 is shown on Figure 27 and Figure 28, respectively.

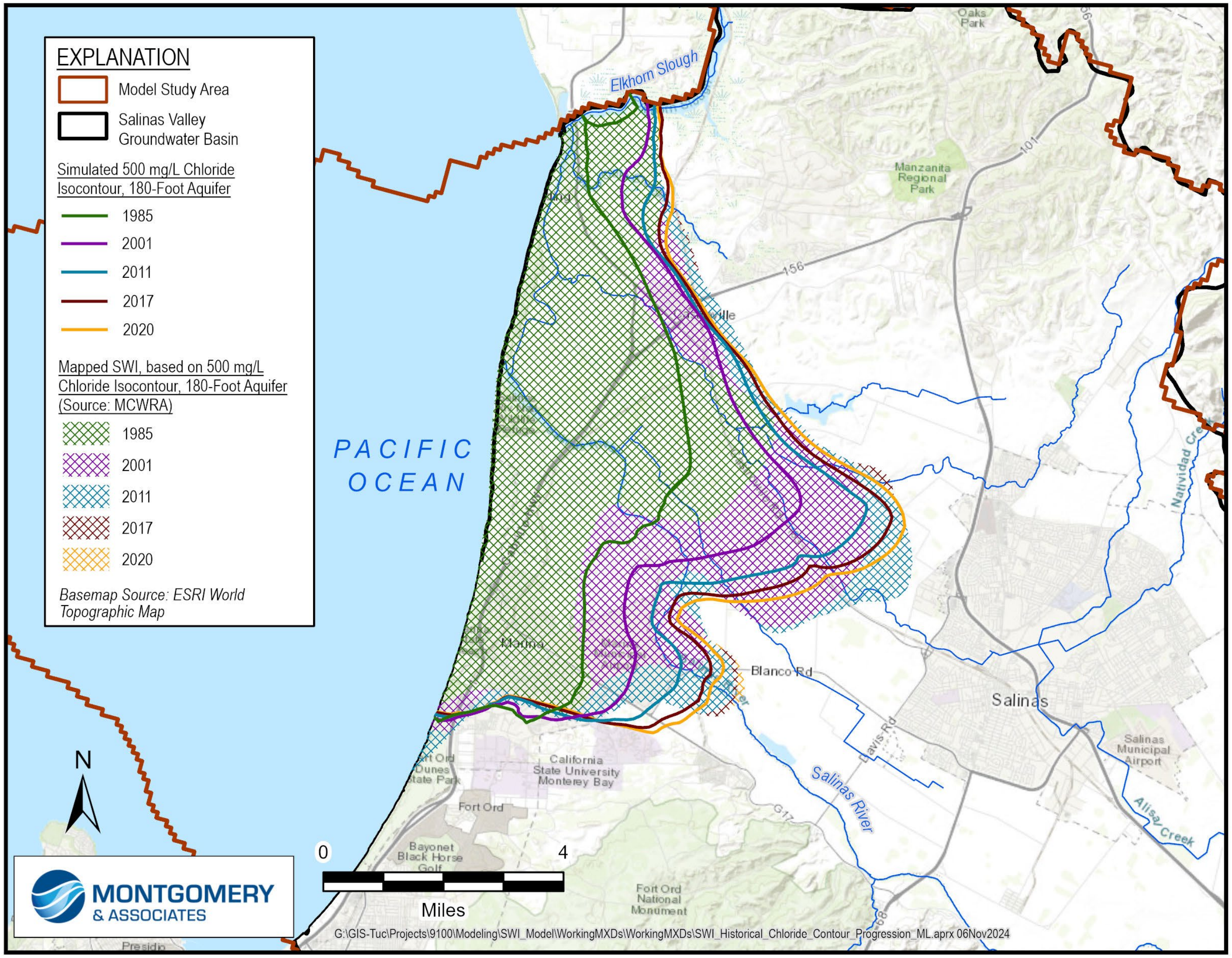

Figure 25. 180-Foot Aquifer Simulated and Observed 500 mg/L Chloride Concentration Contours in 1985, 2001, 2011, 2017, and 2020

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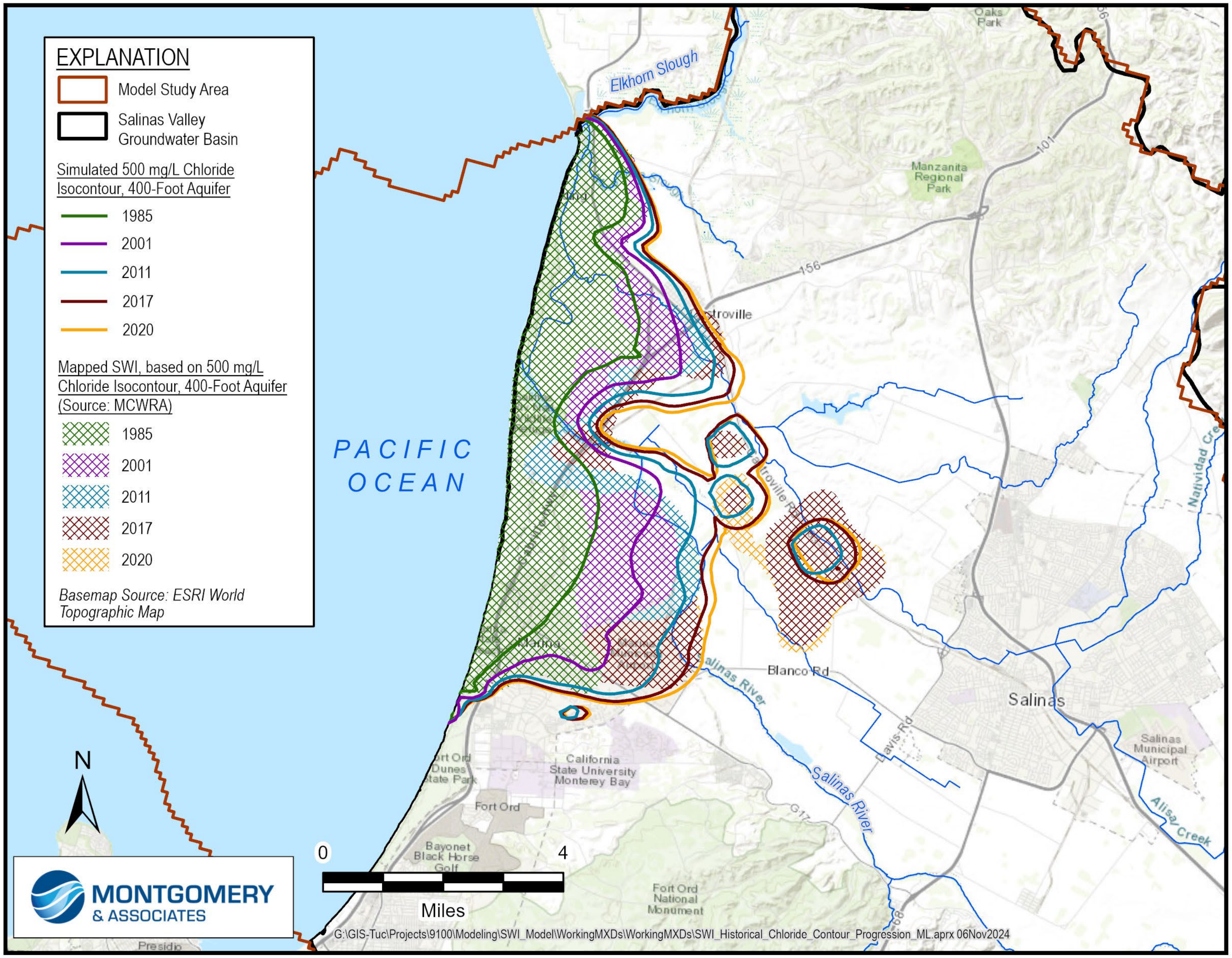

Figure 26. 400-Foot Aquifer Simulated and Observed 500 mg/L Chloride Concentration Contours in 1985, 2001, 2011, 2017, and 2020

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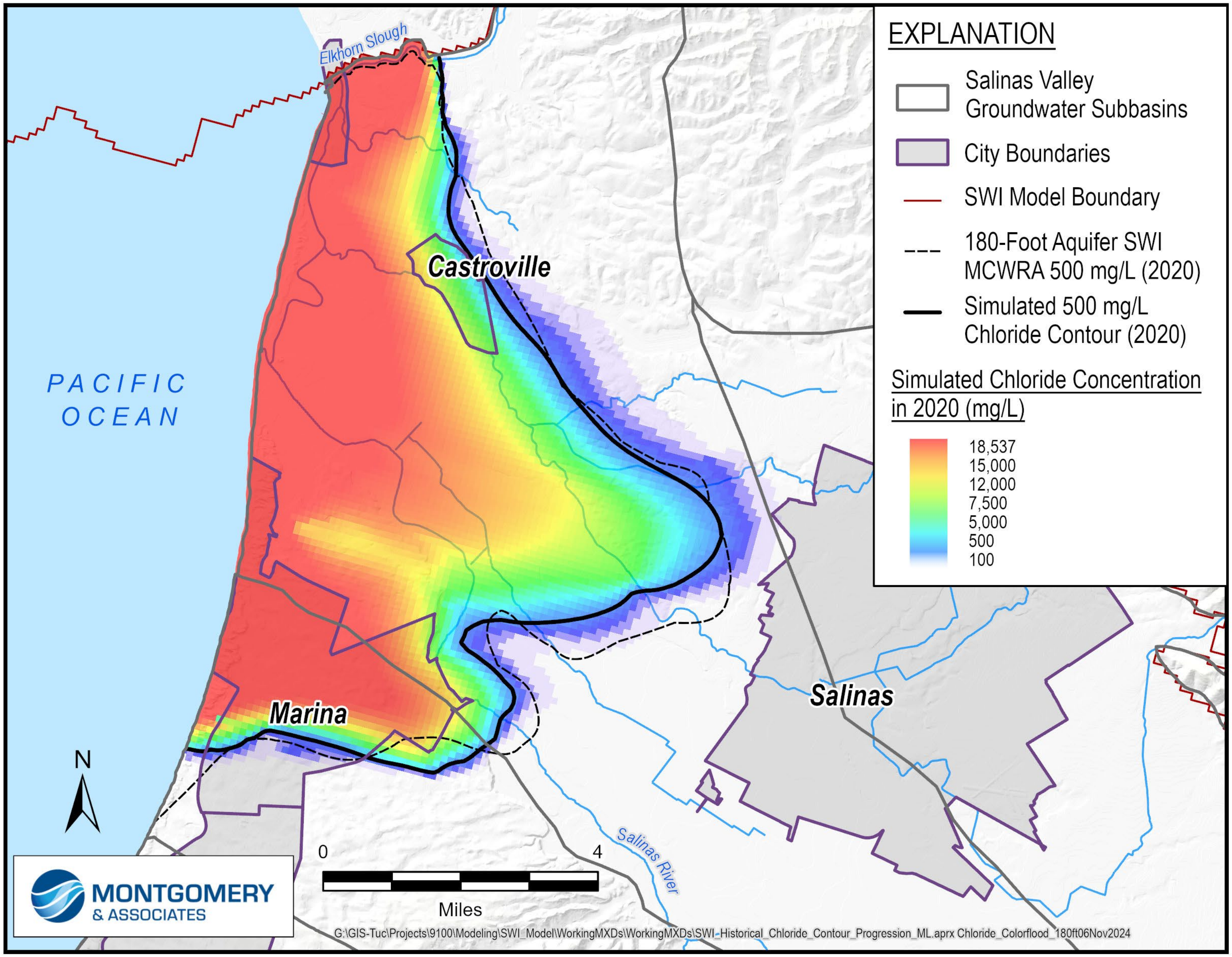

Figure 27. 180-Foot Aquifer Simulated Chloride Concentration in 2020

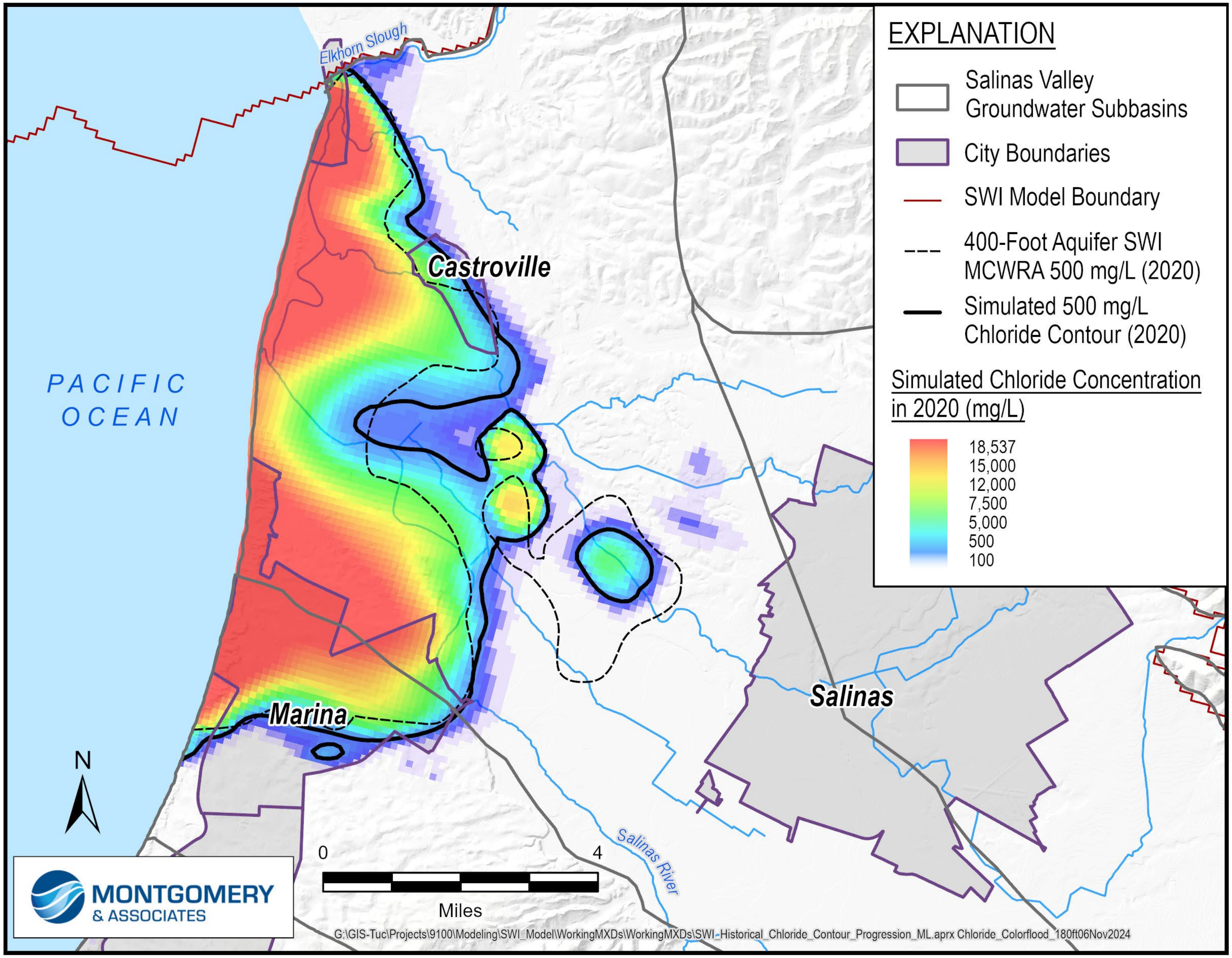

Figure 28. 400-Foot Aquifer Simulated Chloride Concentration in 2020

The overall calibration of the seawater intrusion in the updated model is similar to the previous model version in extent and rate, with some small differences. The MCWRA observed contours suggest rapid seawater intrusion from 1985 through 2011 and then slower seawater intrusion from 2011 through 2020. The model continues to simulate seawater intrusion at a steadier rate than suggested by the MCWRA contours. However, the rate of seawater intrusion in the 400-Foot Aquifer better matches the MCWRA observed contours in the updated model. The extent of seawater intrusion in the 400-Foot Aquifer has also improved, particularly near Castroville. The seawater intrusion in the 180-Foot Aquifer is slightly less in the updated model. The furthest inland extent of seawater intrusion in the 180-Foot Aquifer in 2020 covers a slightly smaller area on the southern side of the main lobe. An improvement is that the southern extent of the seawater intrusion in the City of Marina better matches the observed extent near the coast in both the 180-Foot and 400-Foot Aquifers, although in the 180-Foot Aquifer, the model still overpredicts seawater intrusion to the east of Marina near Reservation Road.

Potential pathways for seawater migration from the 180-Foot to the 400-Foot Aquifers were noted during calibration. The potential pathways included wells with simulated screens across the both 180-Foot Aquifer and 400-Foot Aquifer, and areas where there is a simulated gap or thin spot in the 180/400 Aquitard. Areas with suspected thin spots or gaps in aquitards were included as zones of high vertical hydraulic conductivity in the updated model. The light blue area in the 400-Foot Aquifer on Figure 28 represents seawater migrating from the 180-Foot Aquifer to the 400-Foot Aquifer through wells screened across both aquifers at a concentration between 100 and 500 mg/L chloride. 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 29 through Figure 32 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. The streamflow hydrographs for the Salinas River at Chualar, the Salinas River at Spreckels, and Gabilan Creek are similar to the previous model version. There were no changes to the stream parameters in these areas so those hydrographs were expected to be similar to the previous model. The streamflow hydrograph on Figure 32 shows lower simulated flow rates at the El Toro Creek gage compared to the previous model because changes to modeled stream parameters resulted in more stream leakage from El Toro Creek into groundwater. It is likely the stream leakage in the updated model is now slightly too high, whereas in the previous model version it was too low. This is supported by the lower flow rates in El Toro Creek compared to the observed flow rates and the positive mean water level residuals nearby.

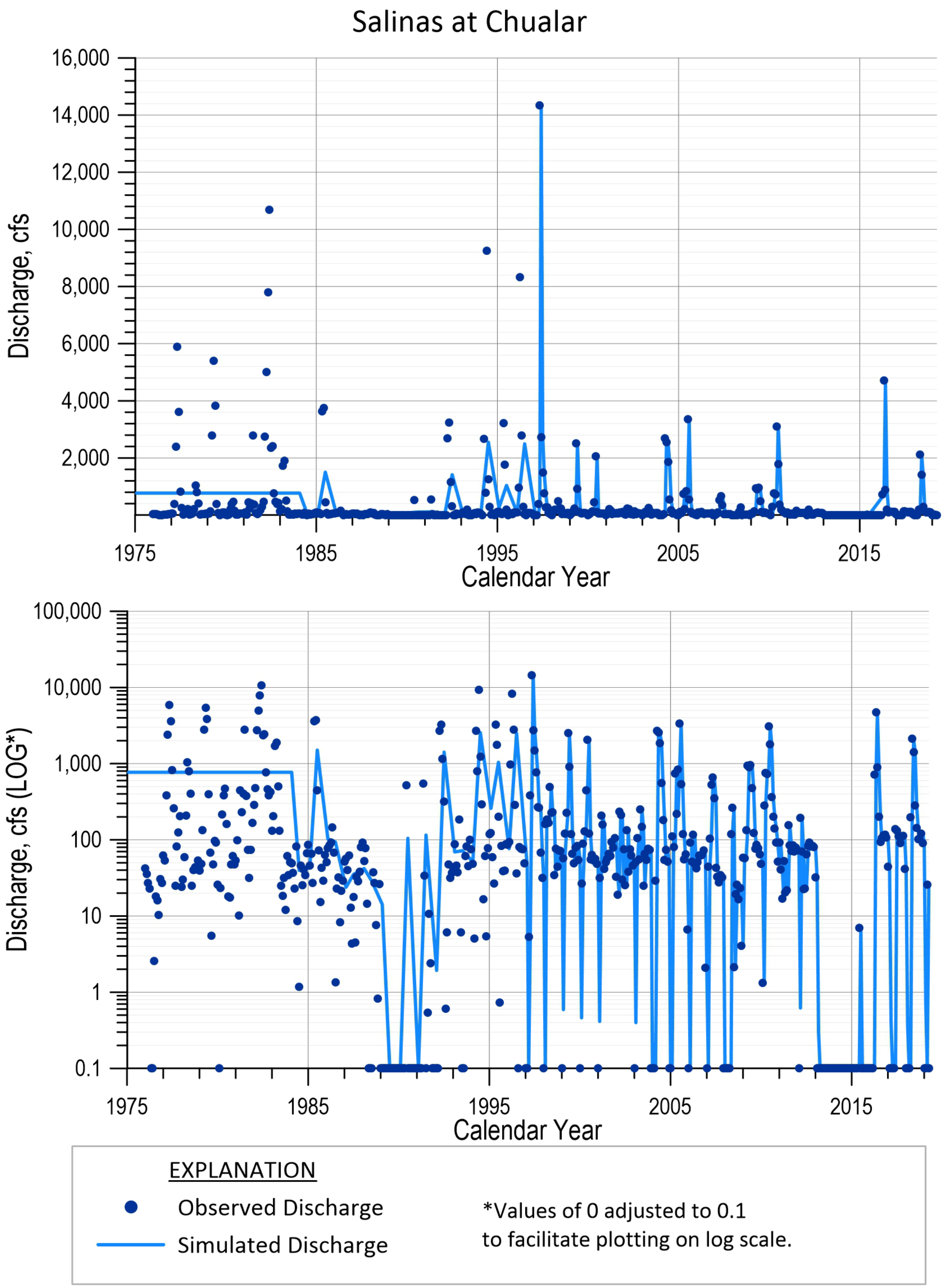

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Figure 29. Simulated and Measured Stream Flow in the Salinas River at the Gage near Chualar

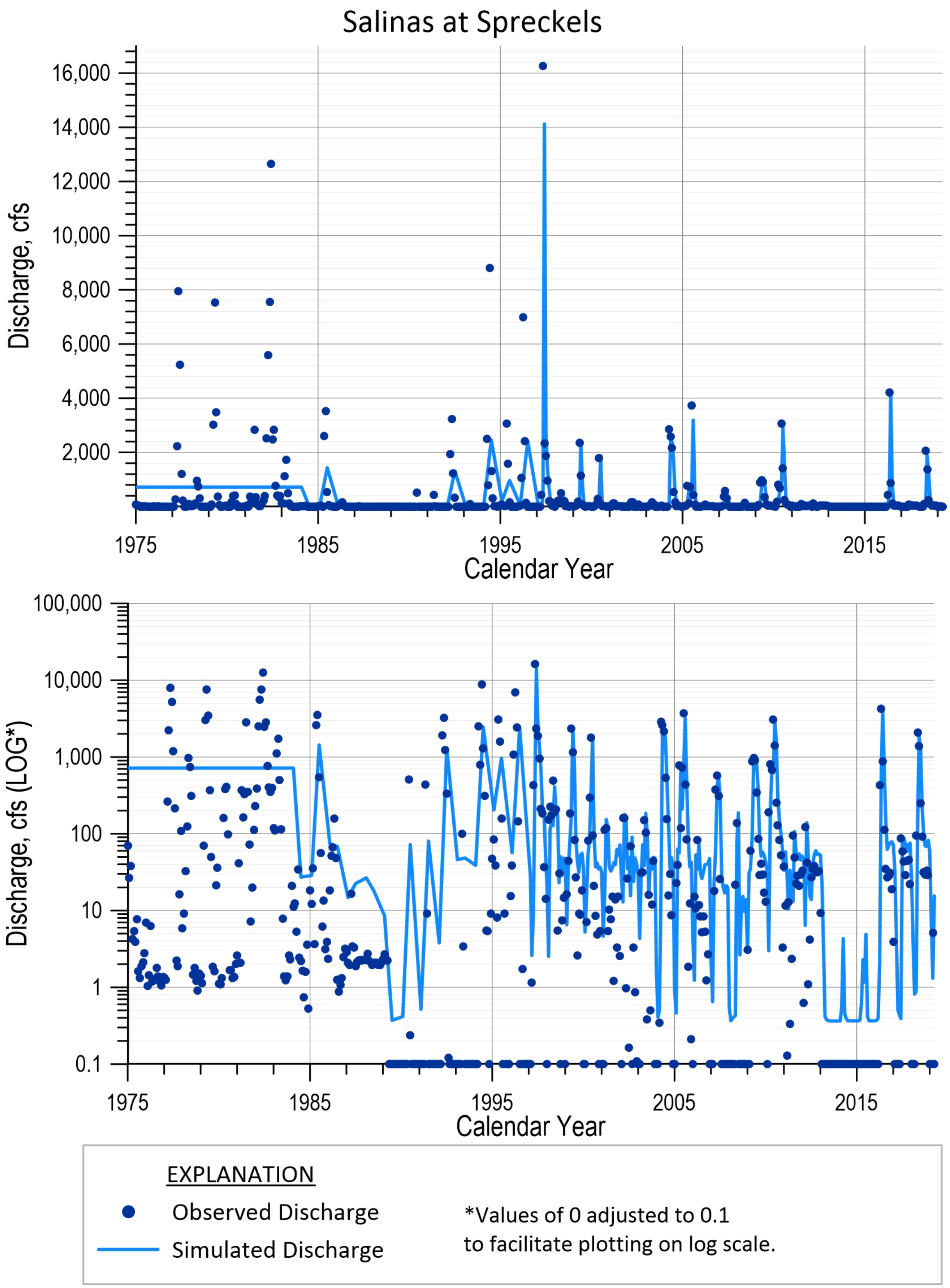

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Figure 30. Simulated and Measured Stream Flow in the Salinas River at the Gage near Spreckels

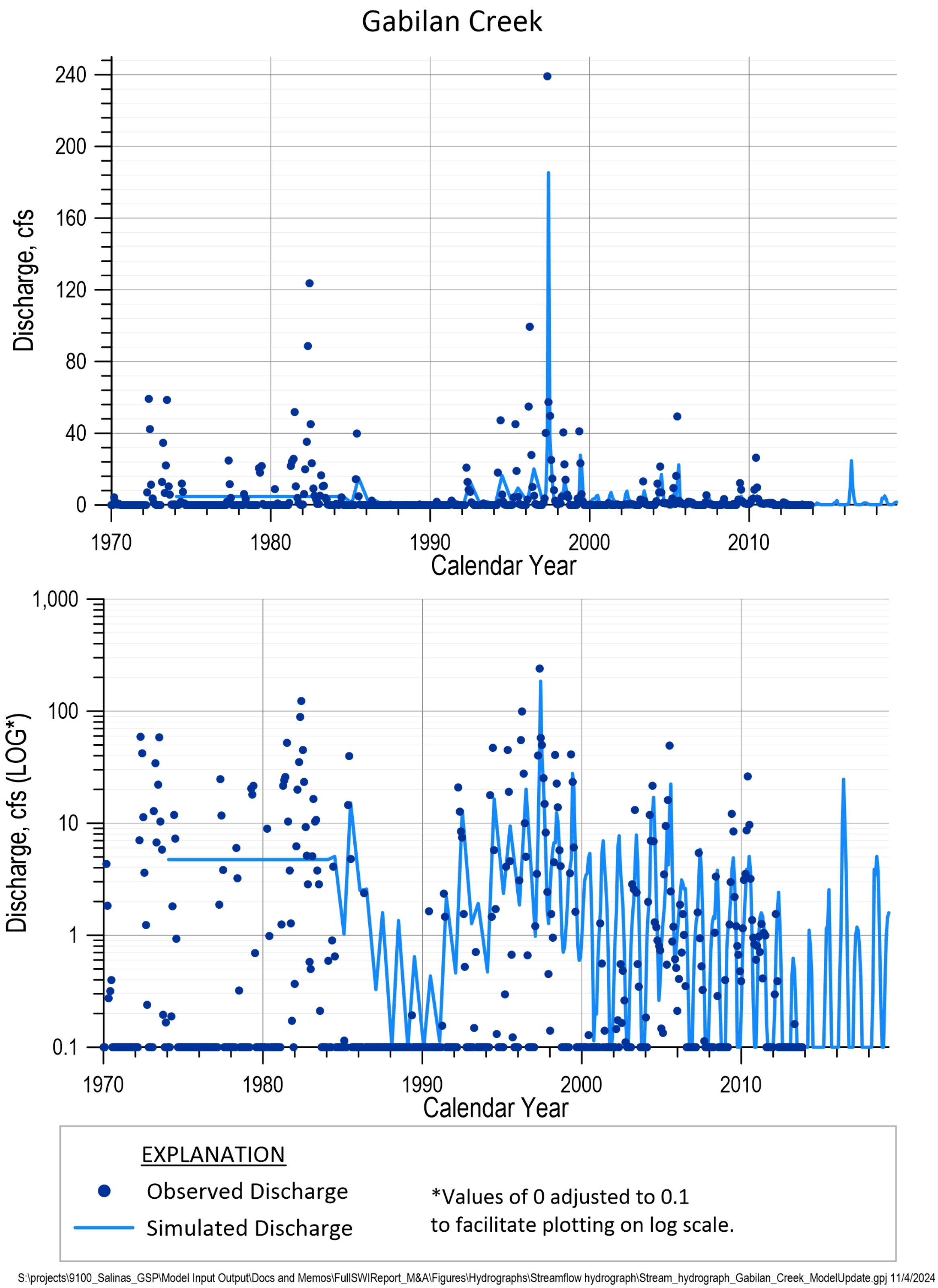

Figure 31. Simulated and Measured Stream Flow in Gabilan Creek

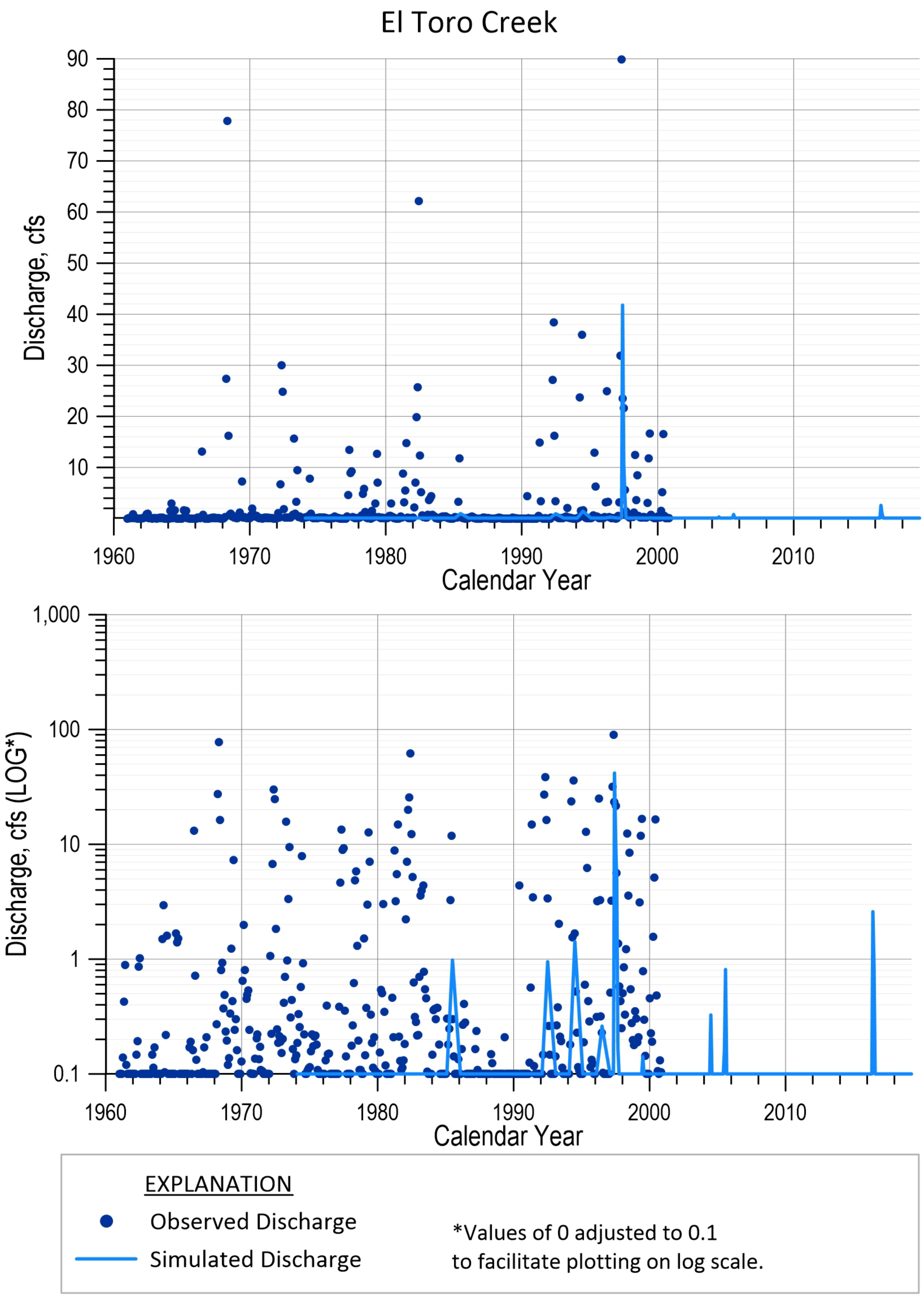

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Figure 32. Simulated and Measured Stream Flow in El Toro Creek

Updated Water Budget

The average annual water budget for the updated model between Water Years (WY) 1985-2020 is summarized in Table 3.

Table 3. Updated Water Budget Summary

Inflows		2023 Model Update WY 1985-2020 Average AF/yr	2024 Model Update WY 1985-2020 Average AF/yr
Recharge		64,100	67,200
Subsurface Inflow	Valley Upgradient Inflow near Chualar	10,400	21,800
	Seawater Intrusion	15,000	16,000
Injection	ASR - Seaside	300	300
Outflows			
Pumping		156,500	163,100
Groundwater Evapotranspiration	Riparian	11,700	16,900
Subsurface Outflow	Valley Outflow to Ocean + Pajaro	1,100	1,100
Net Stream Exchange		29,000	35,500

The updates to the WY 1998 to WY 2020 recharge assumptions in the Dune Sands area resulted in an increase of 3,100 AF/yr in total model recharge over the historical model period. The updated layering is responsible for the increase in valley upgradient inflow near Chualar from approximately 10,000 AF/yr to 22,000 AF/yr. The total thickness of model layers corresponding to the 180-Foot Aquifer and 400-Foot Aquifer is much greater than in the previous model version, particularly in the 180/400 Subbasin. These units have the highest hydraulic conductivity and the increased thickness results in greater inflows. It is unclear if lower hydraulic conductivities in the 180-Foot and 400-Foot aquifers near the southeastern model boundary, resulting in less inflow along that boundary, would significantly impact calibration. This is a sensitivity analysis that should be conducted in the future. In addition, the hydraulic conductivity of the Deep Aquifers was slightly increased during calibration, which results in greater inflows through the Deep Aquifers portion of the boundary.

The increase in pumping is due to adjustments made to the representation of the wells in the model that limits automatic flow reduction. Most of the increase in net stream exchange with groundwater is due to updates to stream parameters in Corral de Tierra. The resulting WY 1985-2020 average net stream exchange in Corral de Tierra increased from 10 to 4,400 AF/yr.

The subsurface flow from the SWI Model area to Pajaro Valley remained the same despite the alterations to the GHB boundary. The flow direction is consistent with the values reported for the PVHM and the net flows are of a similar magnitude (Hanson *et al.,* 2014).

CONCLUSION

M&A updated the SWI Model to incorporate new data and analyses gathered during the HCM updates and Deep Aquifer Study. The SWI Model was then recalibrated using manual calibration methods to adjust hydrogeologic parameters, with particular attention paid to updating model layering, aquitard extents, and simulation of boundary conditions. These improvements result in a more accurate and reliable groundwater model for simulating historical and future seawater intrusion. Tasks involved in the SWI Model update included the following:

- Updating the model layers with new data such as the geophysical data collected for the Deep Aquifers Study
- Adjusting how boundary conditions are simulated
- Adjusting recharge assumptions
- Comparing the SWI model with adjacent and overlapping models to promote consistency across model boundaries
- Updating well and pumping data and updating how wells are simulated
- Updating the model calibration data set

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 updated to reflect the layering changes. The chloride calibration was verified by comparing the simulated 500 mg/L chloride contours to the MCWRA observations between 1985 and 2020. The model updates improved the calibration of the seawater intrusion—particularly in the 400-Foot Aquifer near Castroville—and in both the 180-Foot Aquifer and 400-Foot Aquifer near the coast in the City of Marina.

NEXT STEPS

This model update focused on the 180-Foot and 400-Foot Aquifers to prepare the model for use in the feasibility studies being conducted for the 180/400-Foot Aquifer Subbasin. While the HCM updates were incorporated across the entire model domain, calibration in some areas was limited by lack of adequate data. As more data are collected, future model updates could focus on improving the calibration in areas with limited data including:

- The Deep Aquifers
- The El Toro Primary Aquifer System
- The Fort Ord Monument in the central portion of the Monterey Subbasin
- The Eastside Subbasin.

Simulations using the existing model should acknowledge that while these areas are calibrated on best available data, some uncertainty exists.

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ATTACHMENT 1

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

Table Number	Table Caption
4-1	Water Level Calibration Statistics
4-2	Summary of Calibrated Hydraulic Conductivity (K) and Storage Properties of the HGUs within the Model
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.
3-2	Model Boundary Conditions
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
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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 Crossplot
4-8	Observed and Simulated Representative Hydrographs within the 180-Foot Aquifer
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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

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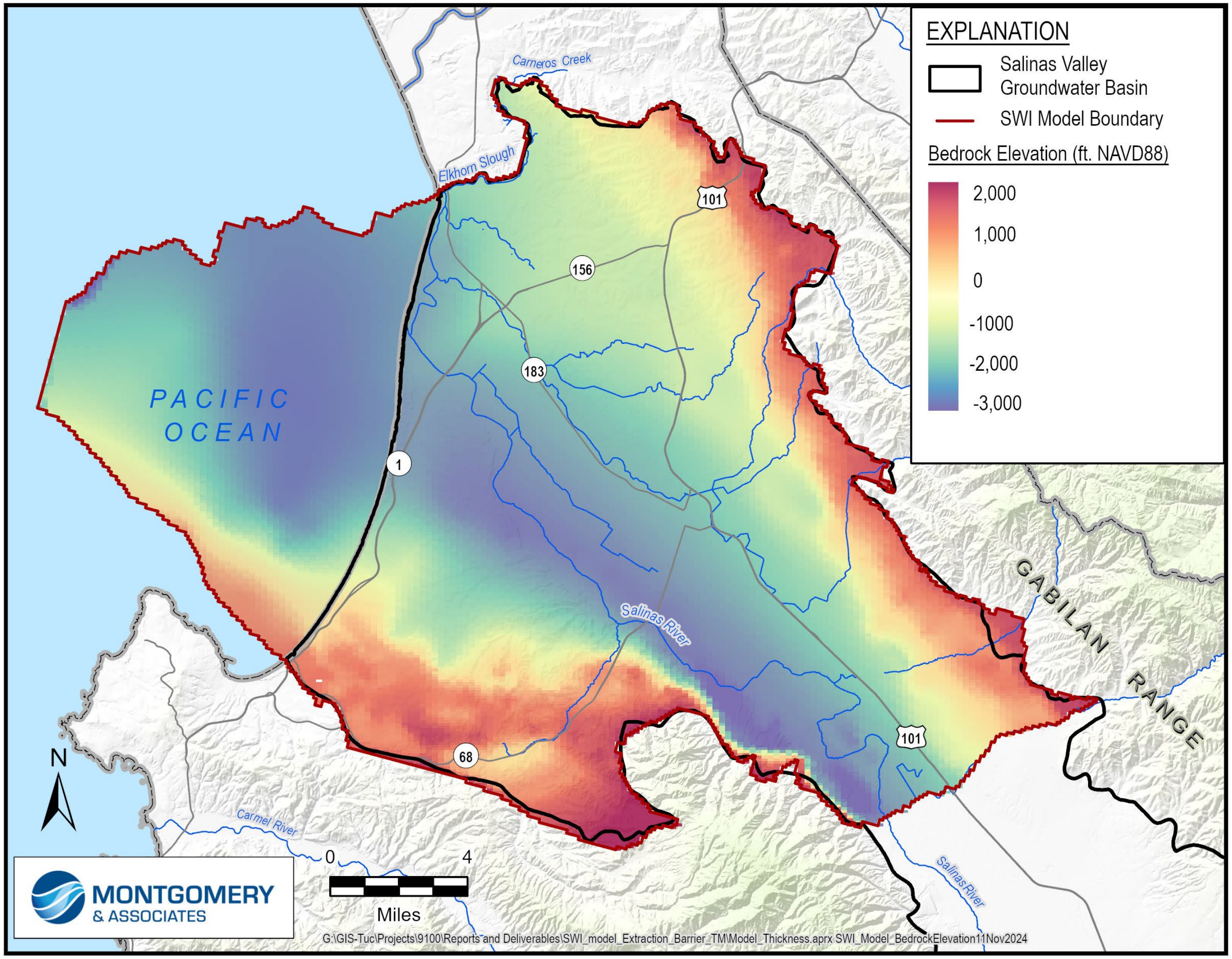

Figure 1. SWI Model Top of Bedrock Elevation (Top of Layer 11)

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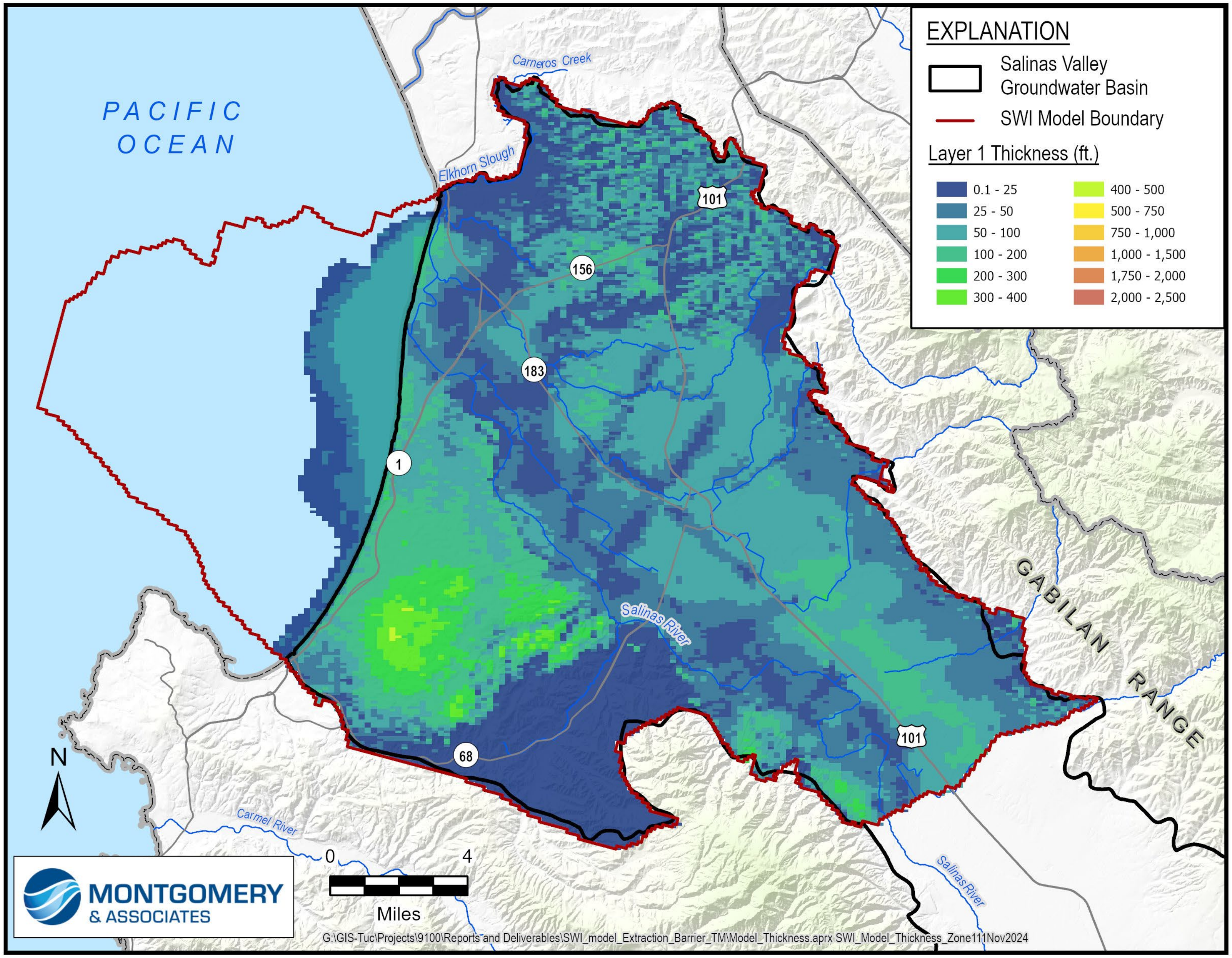

Figure 2. SWI Model Layer 1 Thickness

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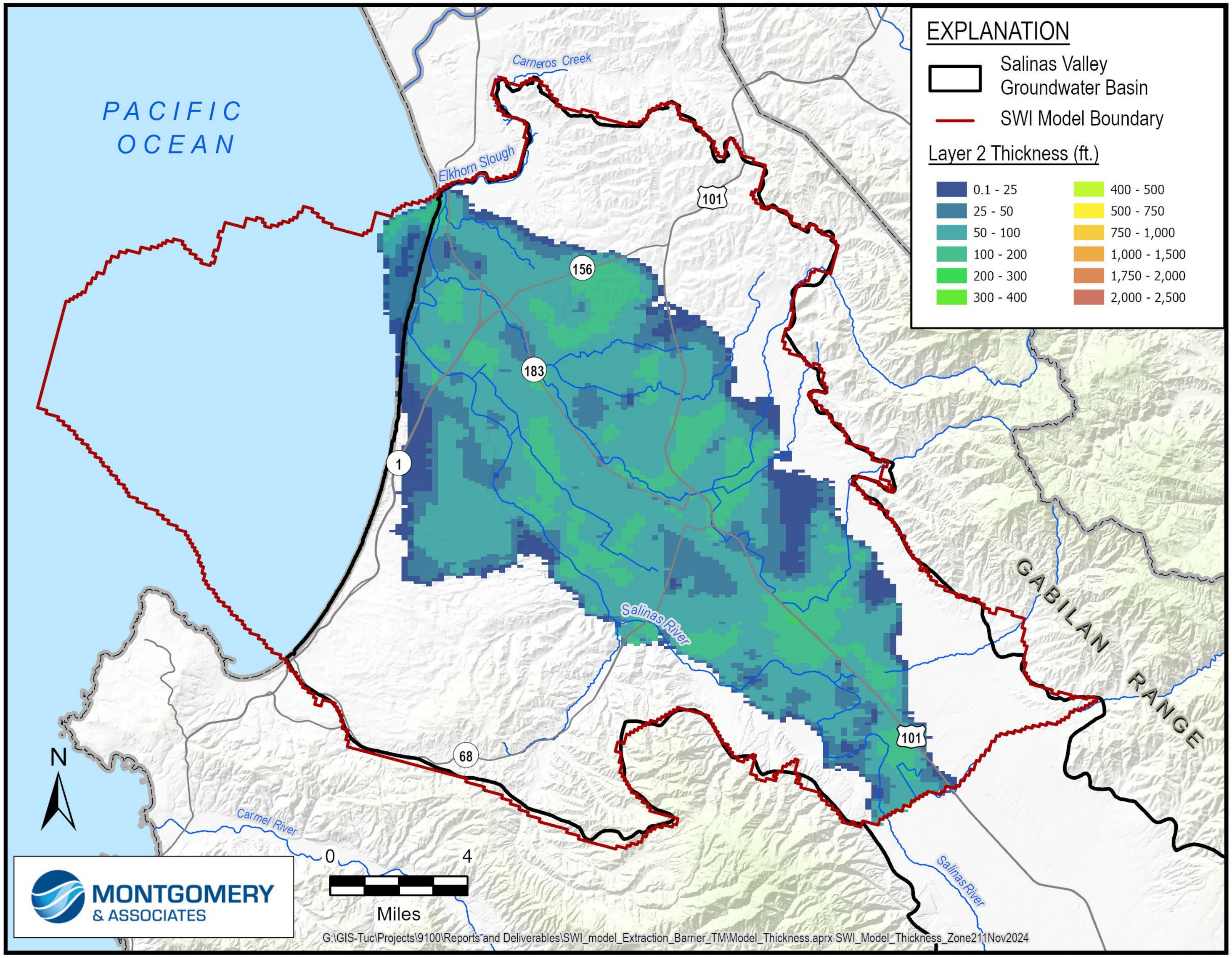

Figure 3. SWI Model Layer 2 Thickness

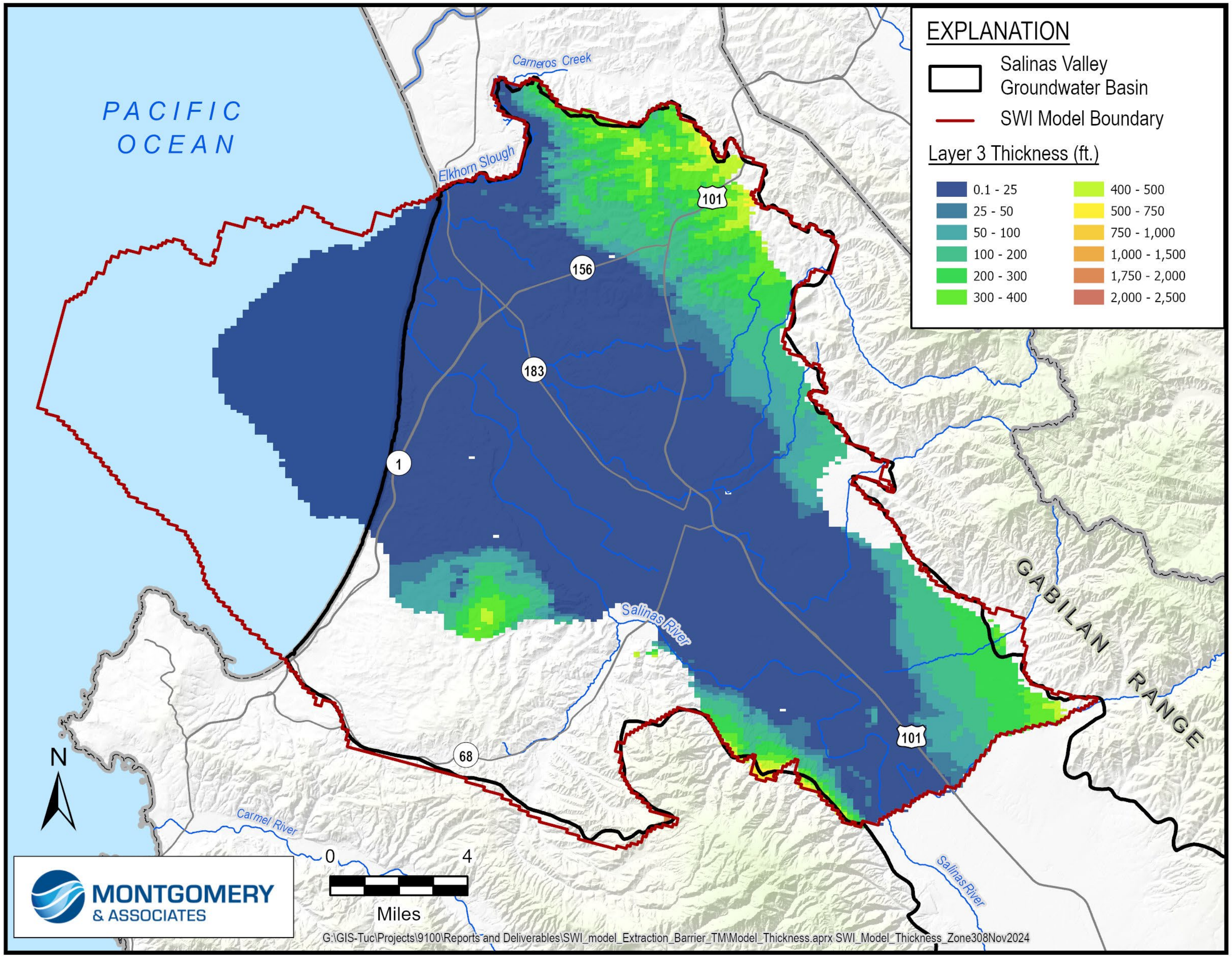

Figure 4. SWI Model Layer 3 Thickness

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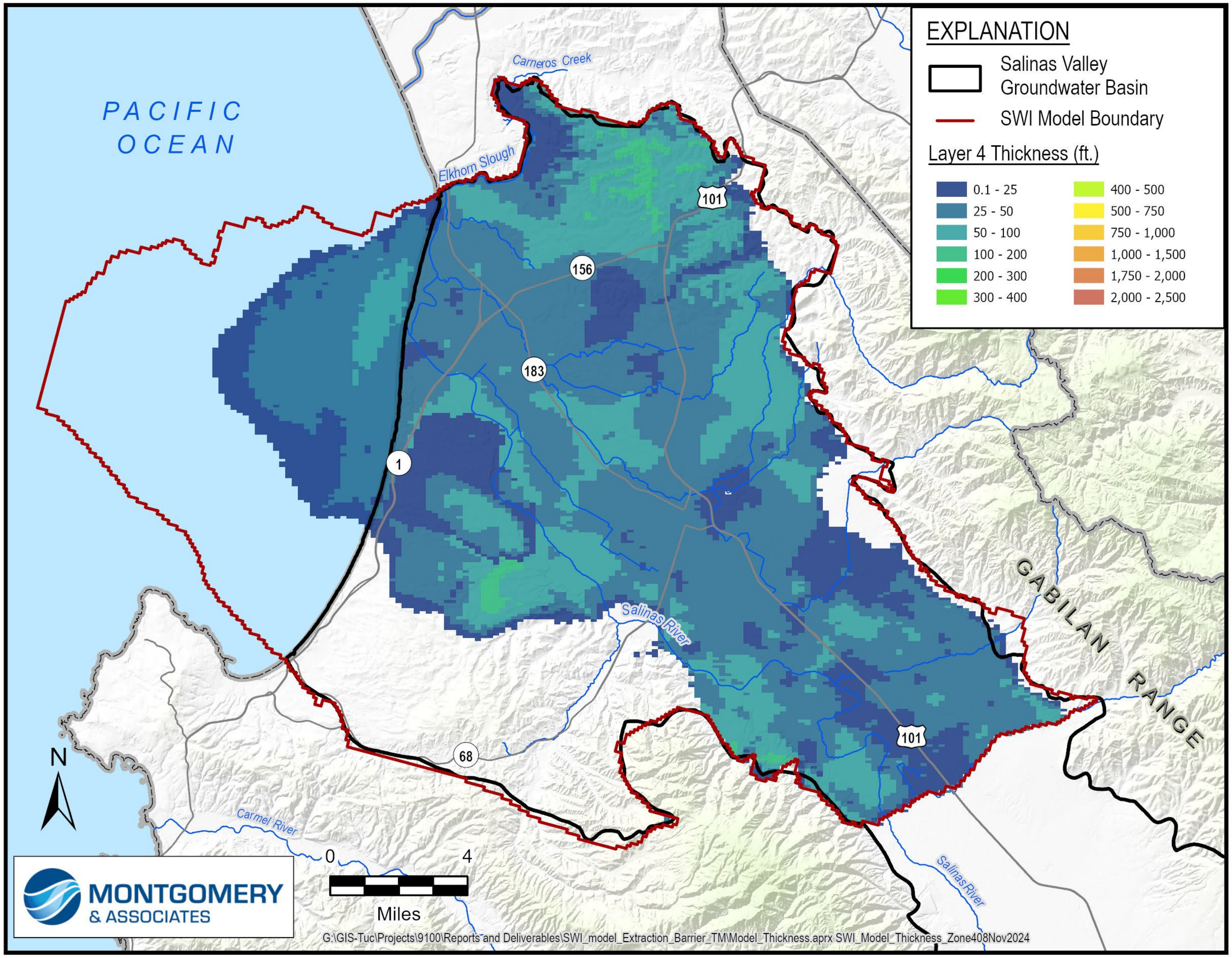

Figure 5. SWI Model Layer 4 Thickness

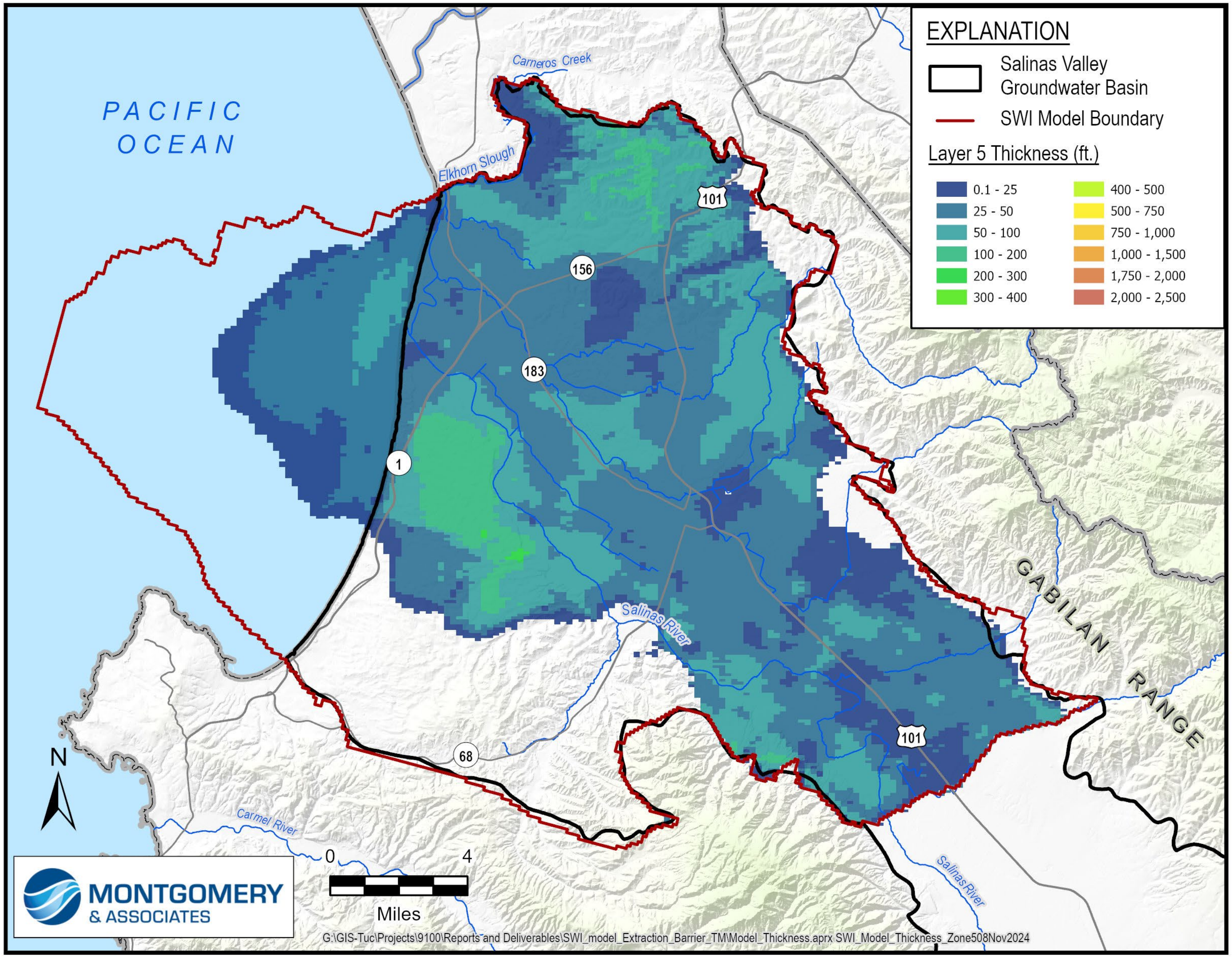

Figure 6. SWI Model Layer 5 Thickness

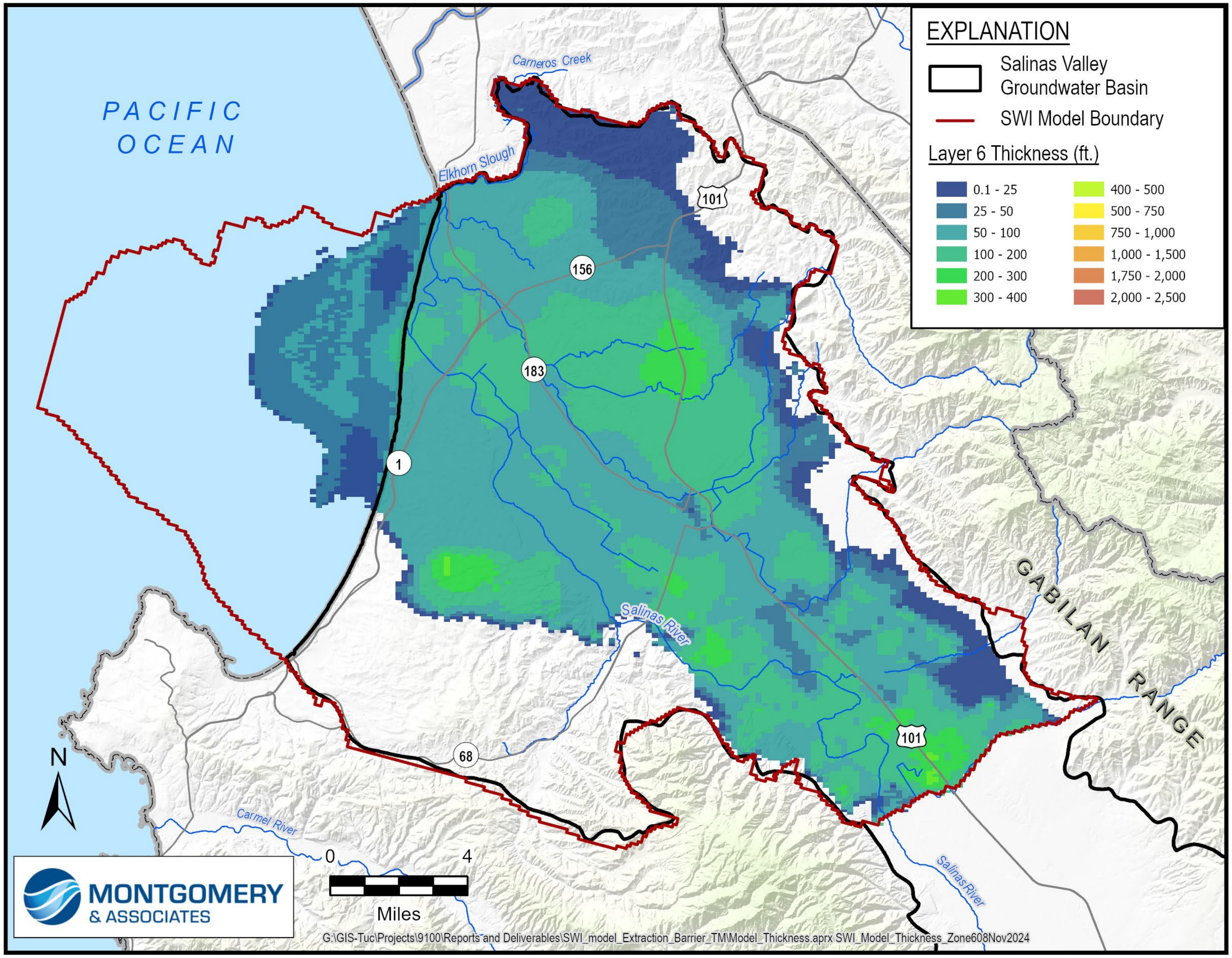

Figure 7. SWI Model Layer 6 Thickness

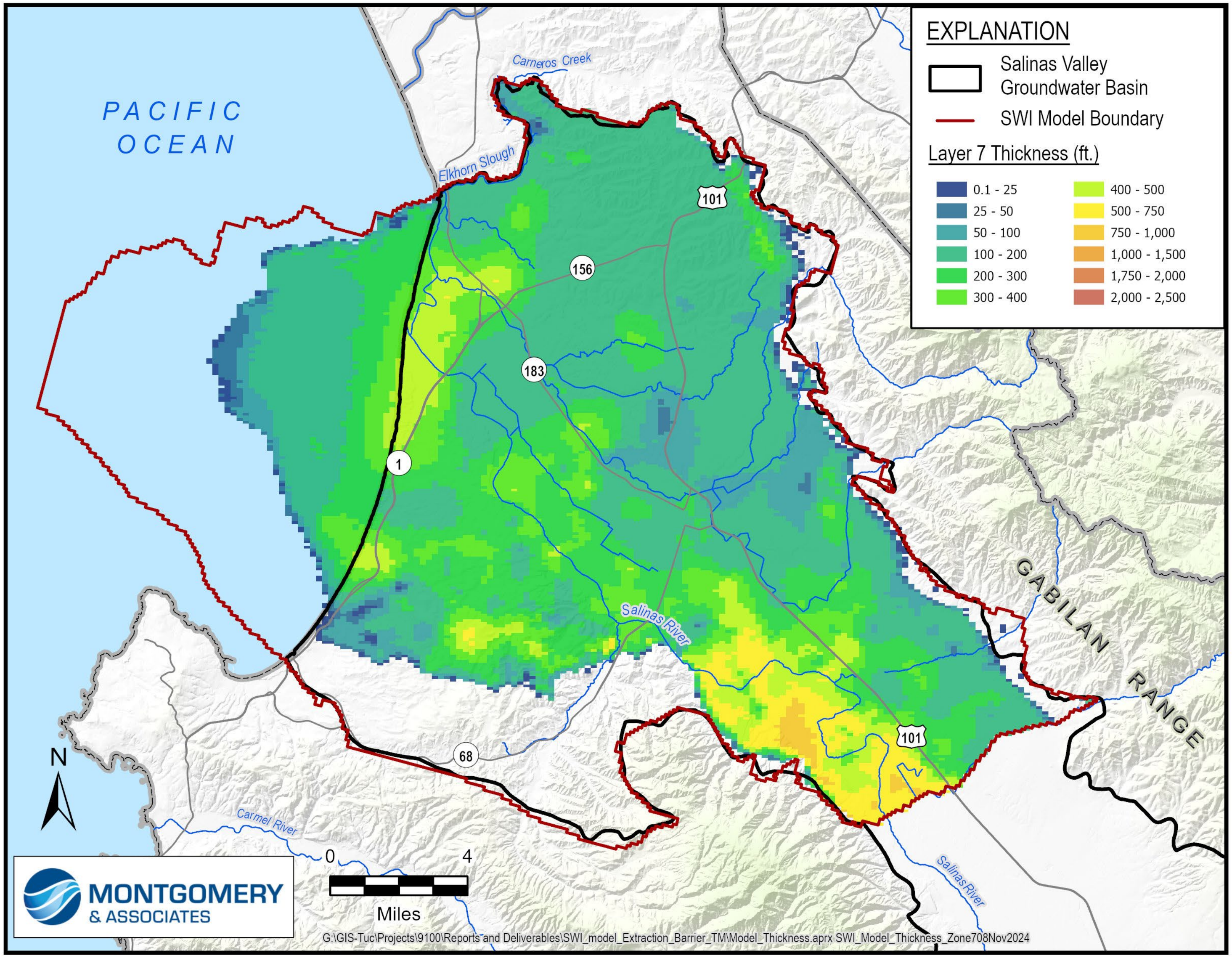

Figure 8. SWI Model Layer 7 Thickness

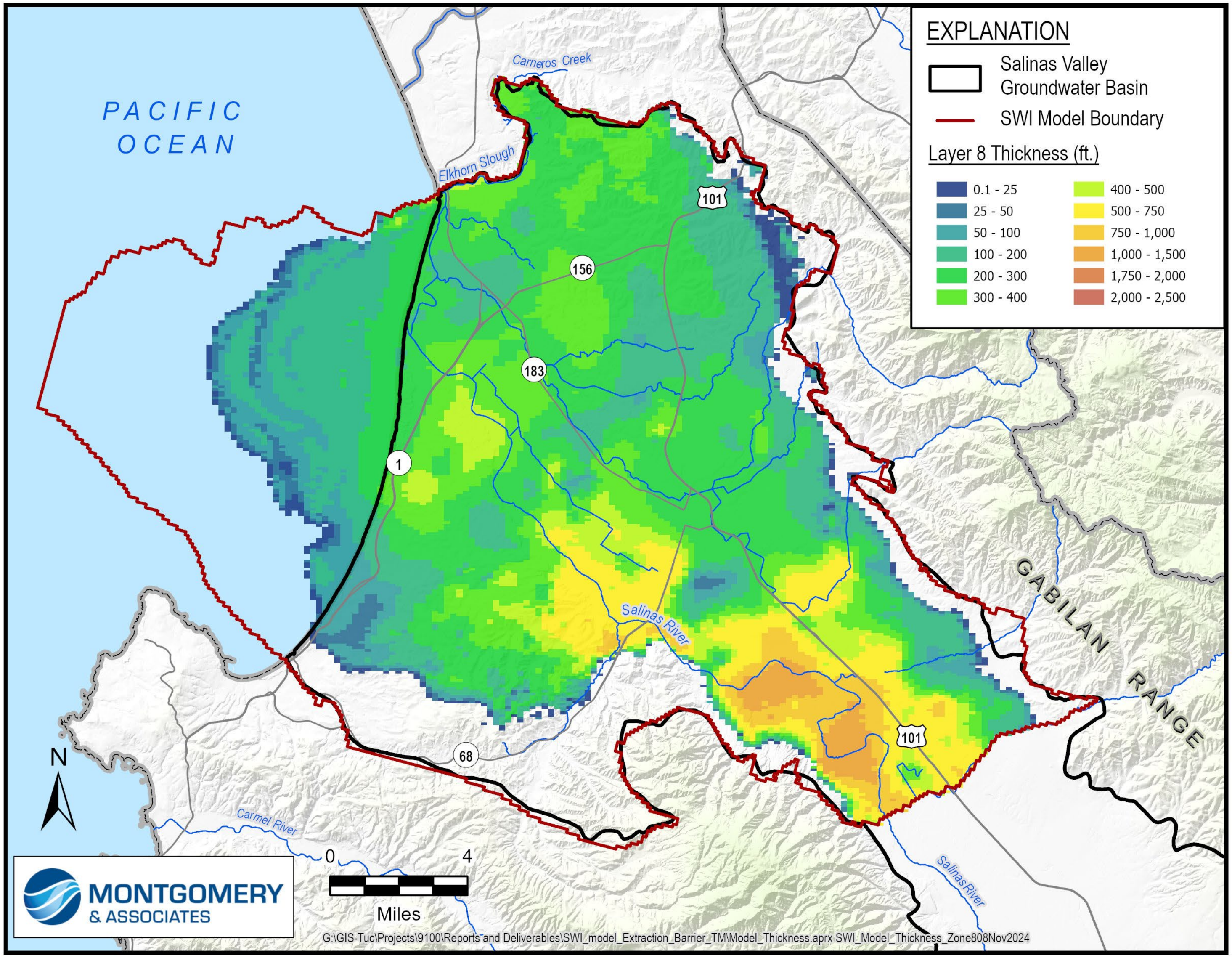

Figure 9. SWI Model Layer 8 Thickness

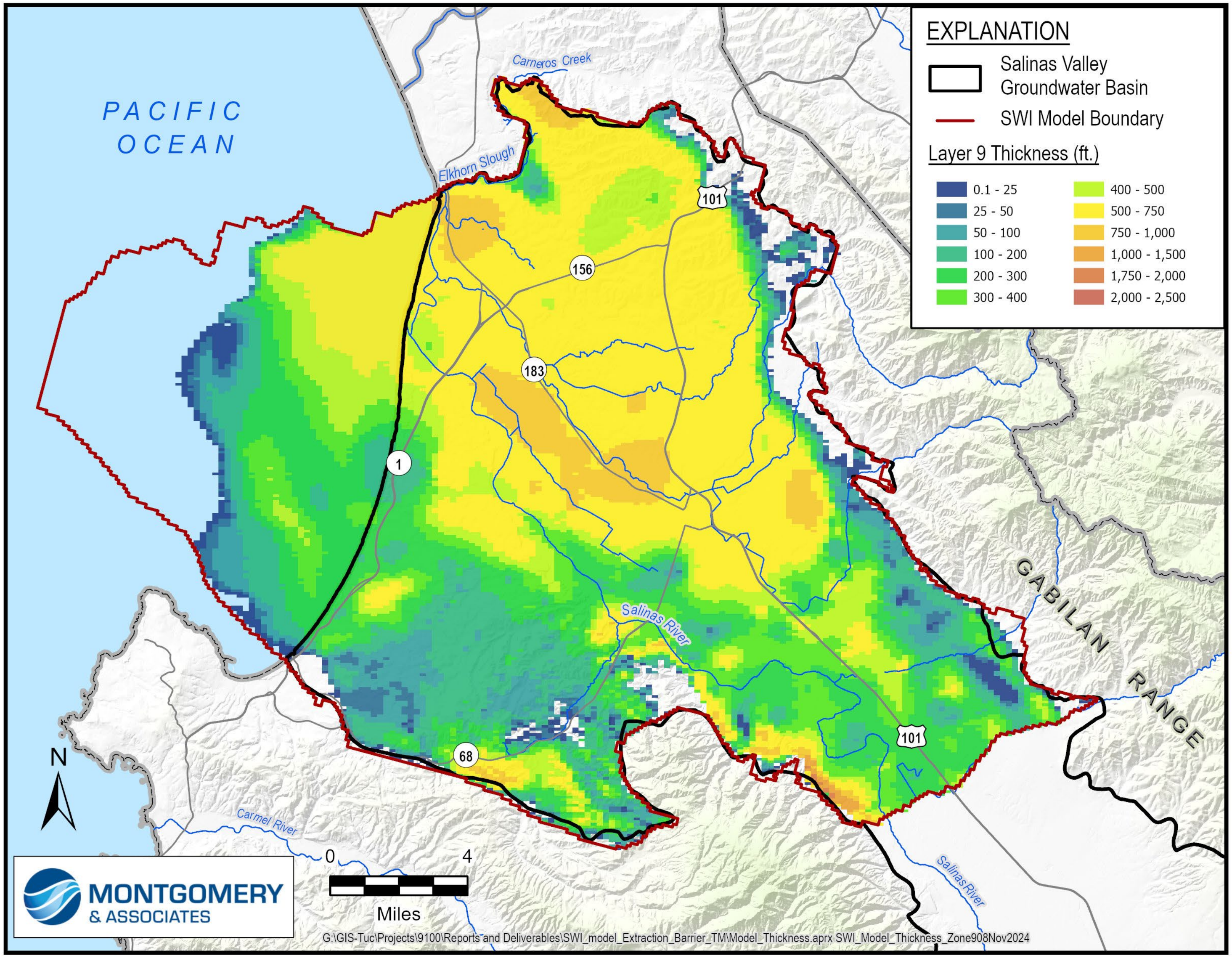

Figure 10. SWI Model Layer 9 Thickness

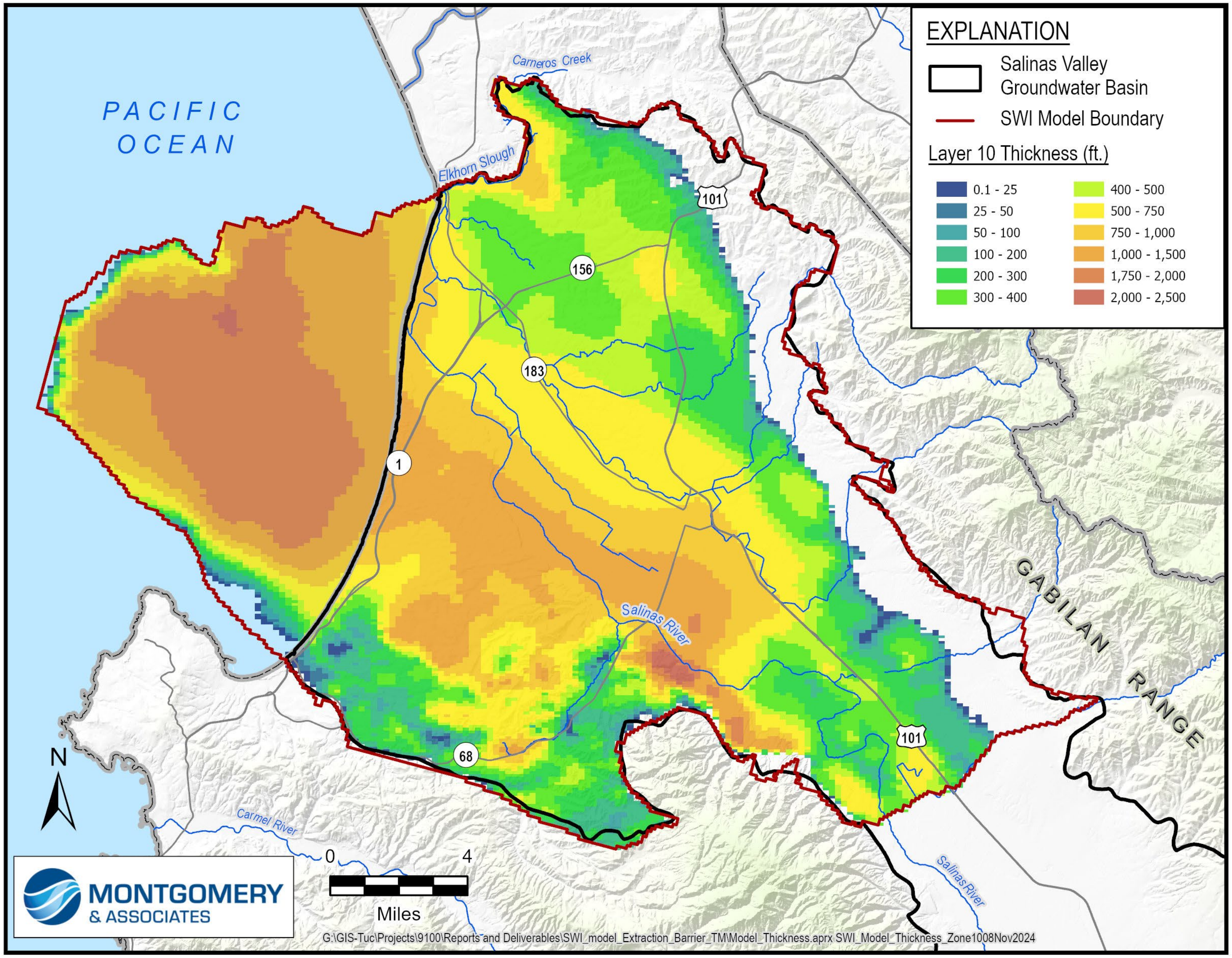

Figure 11. SWI Model Layer 10 Thickness

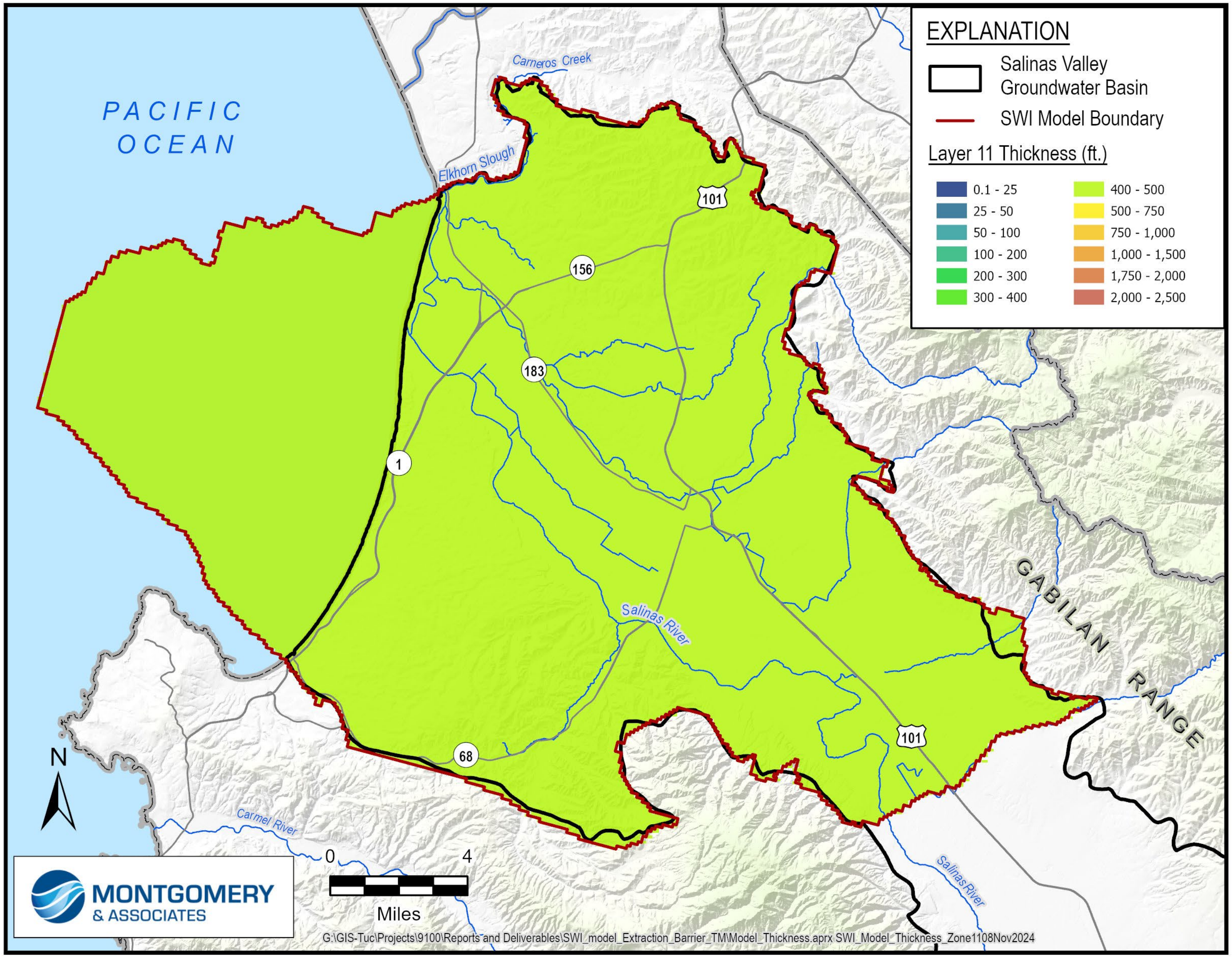

Figure 12. SWI Model Layer 11 Thickness

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Attachment 2

2070 No Project Scenario

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INTRODUCTION

To assist in evaluating and designing projects and management actions that address seawater intrusion, Mongomery & Associates (M&A) has developed a predictive version of the updated Salinas Valley Seawater Intrusion Model (SWI Model) that estimates future groundwater conditions if no projects and management actions are implemented. This simulation is referred to as the No Project Scenario, and it simulates predicted seawater intrusion from Water Year (WY) 2021 through 2070 (a water year runs from October to September). Predicted results from modeling various projects and management actions will be compared to these No Project Scenario model results.

The No Project Scenario model was initially developed in 2023 and is documented in Attachment 2 of *2023 Model Updates to Address Groundwater Technical Advisory Comments* (Montgomery & Associates, 2023). The No Project Scenario has been updated to reflect improvements to the historical SWI Model conducted in 2024, including updates to the Hydrologic Conceptual Model (HCM). This document describes the assumptions used to develop the updated No Project Scenario simulation and summarizes the updated model results. The No Project Scenario simulation will continue to be updated alongside future model improvements.

NO PROJECT SCENARIO MODEL DEVELOPMENT

The No Project Scenario simulation predicts seawater intrusion in the Salinas Valley if there are no changes to the Valley's groundwater management. The following assumptions are included in the scenario:

- Land use remains constant throughout the simulation. Land use is not simulated directly; however, the groundwater demands at the end of the historical SWI Model are carried forward.
- Boundary conditions are a continuation of recent hydrologic conditions in the Salinas Valley through WY 2070.
- Climate change and sea level rise are not simulated in the No Project Scenario. The previous No Project Scenario simulation assumed projected impacts of 2070 climate change and sea level rise. This change was made so that the No Project Scenario results represent the impacts of continued groundwater extraction on groundwater conditions in the SWI Model area independent of potential impacts associated with climate change.

The No Project Scenario simulates 50 years of monthly stress periods. Although this simulation was not intended to predict conditions at any specific future year, the No Project Scenario is assigned WY 2021 through 2070 for convenience in presenting results. Groundwater elevations and chloride concentrations from the last stress period at the end of the historical SWI Model (the end of September 2020) are the initial conditions for the No Project Scenario simulation.

The approach to boundary condition and other assumptions vary based on if future conditions are anticipated to be more reflective of recent (WY 2016 to 2020) pumping or of a longer period that is representative of recent climate conditions with wet and dry periods. Selection of years was bounded by the years within the historical SWI Model and SVOM. Table 1 summarizes the approach and justification for boundary condition and other assumptions. The modification of the historical boundary conditions for the No Project Scenario simulation are summarized in the following section.

Table 1. Summary of No Project Scenario Boundary Conditions Approach

Boundary	Approach	Justification
Groundwater Pumping	Average by month historical model rates from WY 2016 to 2020	Represents most recent pumping conditions
Groundwater Recharge	Average by month historical model rates from WY 1996 to 2018	Representative of recent climate conditions
Riparian ET	Average by month historical model rates from WY 1996 to 2018	Representative of recent climate conditions
Ocean Boundary	Set head to WY 2020 average sea level	Most recent sea level in the historical model
Pajaro Valley Boundary	Set heads to average observed groundwater levels from WY 1996 to 2018	Represents groundwater conditions under recent climate. Data along this boundary is not regular and represents a small amount of groundwater flow.
Southeastern Boundary Groundwater Inflow	Cycle timeseries of WY 1996-2018 heads from historical model for 50 years	Represents groundwater conditions under recent climate.
Surface Water Flow	Cycle timeseries of WY 1996-2018 stream flows from historical model. Salinas River at Chualar inflows and SRDF diversions from SVOM.	Represents stream flow under recent climate conditions. SVOM calculates stream flow and diversions dependent on reservoir operations.

Groundwater Pumping

Monthly average pumping rates for the No Project Scenario were based on average historical SWI Model monthly pumping rates between WY 2016 and 2020, and were repeated for 50 years. The historical SWI Model used well locations and pumping derived from Monterey County's Groundwater Extraction Management System (GEMS). The WY 2016 to 2020 period was selected because it represents recently active well locations and pumping rates, and includes both wet and dry years. All wells pump throughout the No Project Scenario, which does not account for changes in pumping practices in response to continued seawater intrusion. Table 2 shows the average annual pumping rates for the historical period WY 2016-2020 which are inputs to the No Project Scenario model.

Table 2. Input Pumping Rates for the No Project Scenario

	Total Pumping (AF/WY)[1]					
	180 400[2]	Eastside[2]	Langley	Monterey	Seaside[3]	Subbasins Total
Input Pumping Rates based on WY 2016-2020 Average	80,700	57,800	800	5,800	2,700	147,900
Agriculture	70,000	46,200	200	200	0	116,500
Water Systems & Industrial Users	10,700	11,600	100	5,500	2,700	30,600

[1] Values are rounded to the nearest hundred. Actual input numbers are not rounded. AF/WY = acre-feet per water year
[2] Portion of these subbasins within the SWI Model boundaries
[3] Net pumping including ASR injection

Unlike the previous version of the No Project Scenario model, the pumping is not scaled or adjusted for 2070 climate change.

Groundwater Recharge

Monthly groundwater recharge for the No Project Scenario was based on average monthly historical SWI Model recharge between WY 1996 and 2018. These years were considered representative of recent climate conditions in the Salinas Valley. A year of monthly average groundwater recharge rates based on the historical SWI Model from the representative period was used in the No Project Scenario and repeated for 50 years.

To verify the adequacy of the average WY 1996-2018 recharge rates, average recharge rates between several historical periods were compared. The WY 1996-2018 average recharge rate is close to the WY 1985-2020 average, and the difference is distributed across the subbasins. Table 3 shows the No Project Scenario input recharge rates compared to the historical recharge.

Table 3. No Project Scenario Input Recharge Rates

	Total Recharge (AF/WY)[1]					
	180 400[2]	Eastside[2]	Langley	Monterey	Seaside	Subbasins Total
WY 1985-2020 Average	30,900	15,800	5,300	10,400	4,100	66,500
Predictive Model Input based on WY 1996-2018 Average[3]	27,700	12,800	5,900	12,200	4,800	63,500

[1] Values are rounded to the nearest hundred. Actual input numbers are not rounded. AF/WY = acre-feet per water year
[2] Portion of these subbasins within the SWI Model boundaries
[3] Model input is slightly different from the WY 1996-2018 average because the stress periods were evenly weighted and the earliest stress periods were longer

Unlike the previous version of the No Project Scenario, the groundwater recharge is not scaled or adjusted for 2070 climate change.

Riparian Groundwater ET

Monthly Potential ET (PET) of groundwater in riparian areas in the No Project Scenario was based on historical monthly SWI Model PET between WY 1996 and WY 2018. This PET is directly input in the SWI Model and is repeated for 50 years.

Ocean Boundary

The ocean is modeled as a general head boundary (GHB) and is present in cells that represent the seawater interface. The head in the boundary is set to a constant value of 3.16 feet NAVD88, which is the average sea level from the last year of the historical SWI Model (WY 2020). Sea level in the No Project Scenario model is not adjusted for projected sea level rise.

Pajaro Valley Boundary

The model boundary shared with Pajaro Valley to the north is modeled as a GHB. The GHB reference heads are split into reaches based on groundwater level observations from 4 wells near the boundary. Since observed data is limited, the GHB reference heads in the No Project Scenario are set to a constant value equivalent to the average observed heads from WY 1996 to WY 2018.

Southeastern Boundary Groundwater Inflow

Specified heads along the model boundary at Chualar Creek are based on historical observed groundwater elevations between WY 1996 and WY 2018. The timeseries of specified heads used in the historical SWI Model for WY 1996 to 2018 are cycled to fill the 50-year simulation period in the No Project Scenario. The head difference between the 400-Foot Aquifer and Deep Aquifer is assumed to remain approximately the same as at the end of the historical model (25 feet) throughout the simulation period. Figure 1 shows how the boundary heads cycle over a 22-year period along 4 different boundary reaches. One effect of this boundary head cycling is that the head in the Deep Aquifers resets every 22 years, which may be inaccurate. Unlike the previous version of the No Project Scenario model, the specified heads at the southeastern boundary are not adjusted for 2070 climate change.

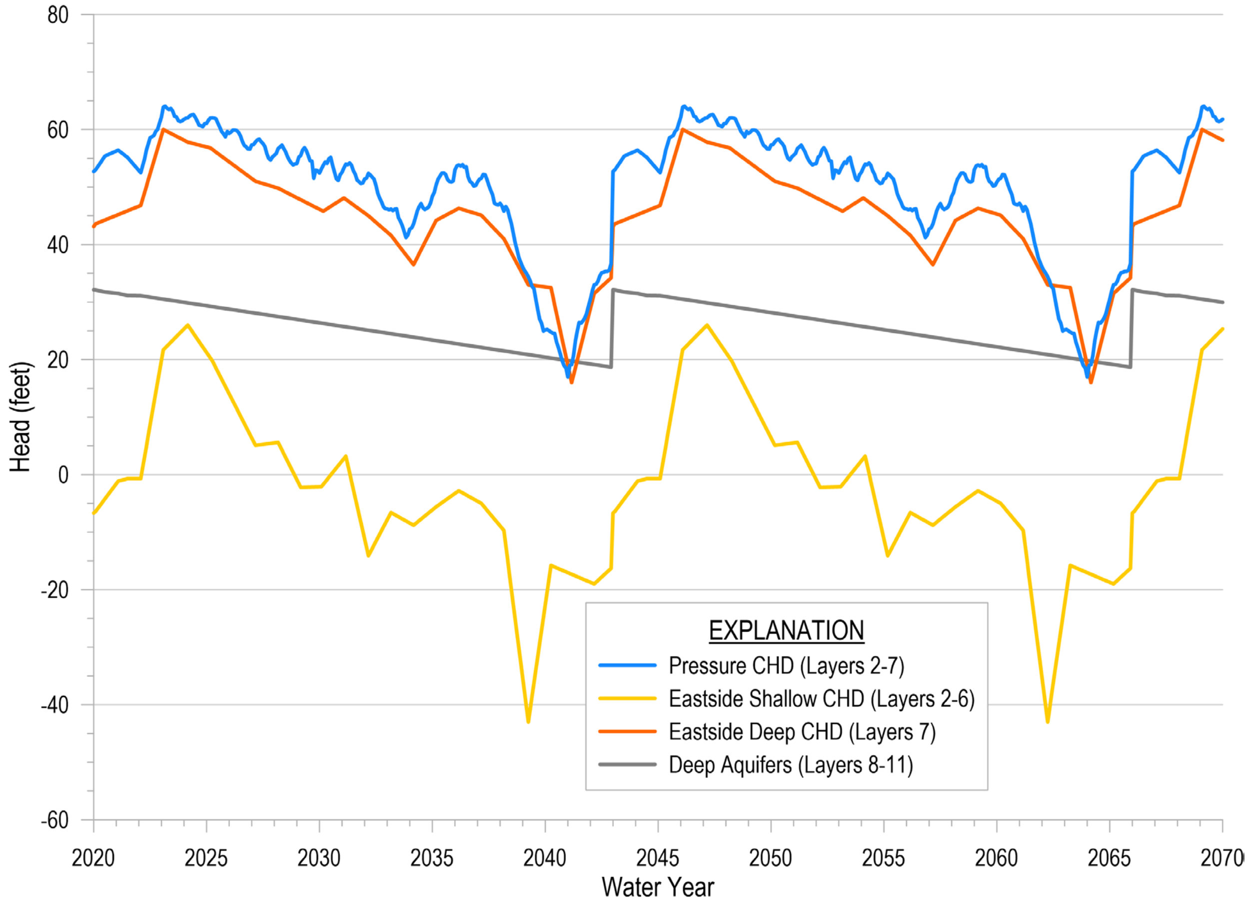

Figure 1. Simulated No Project Scenario Heads at the Southeastern Model Boundary

Surface Water Flows and Diversions

Except for the Salinas River at Chualar and diversions from the SRDF, stream inflows are the monthly flows used in the historical SWI Model for WY 1996 through 2018. The monthly timeseries of stream flows from WY 1996 through 2018 are cycled over 50 years in the No Project Scenario.

Salinas River inflows at the SWI Model boundary near Chualar, as well as the diversions from the Salinas River at the SRDF, are derived from the U.S. Geological Survey's Salinas Valley Operations Model (SVOM). The USGS developed the SVOM as a predictive version of the Salinas Valley Integrated Hydrologic Model (SVIHM). The preliminary version of the SVOM made available in May 2024 was used[1] and updated to reflect the Castroville Seawater Intrusion Project (CSIP) supplemental wells that are active as of 2024, as well as their capacity.

The Salinas River flows at Chualar, as well as the SRDF diversions, are strongly influenced by reservoir operations. The Surface Water Operations package in the SVOM regulates releases from San Antonio and Nacimiento reservoirs based on MCWRA's existing operating policies and simulates when conditions will be met to operate the SRDF. SRDF diversions are made throughout the duration of the SVOM whenever reservoir storage and streamflow conditions allow from April through October, at a rate up to 18 cubic feet per second. The updated No Project Scenario does not include the impacts of climate change.

The SRDF diversions and the Salinas River inflows to the SWI Model at Chualar simulated in the SVOM for WY 1996 through WY 2018 are cycled over the 50-year simulation in the No Project Scenario. Figure 2 shows the simulated river inflows at Chualar for the No Project Scenario.

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[1] These data (model and/or model results) are preliminary or provisional and are subject to revision. This model and model results are being provided to meet the need for timely best science. The model has not received final approval by the U.S. Geological Survey (USGS). No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the model and related material nor shall the fact of release constitute any such warranty. The model is provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the model.

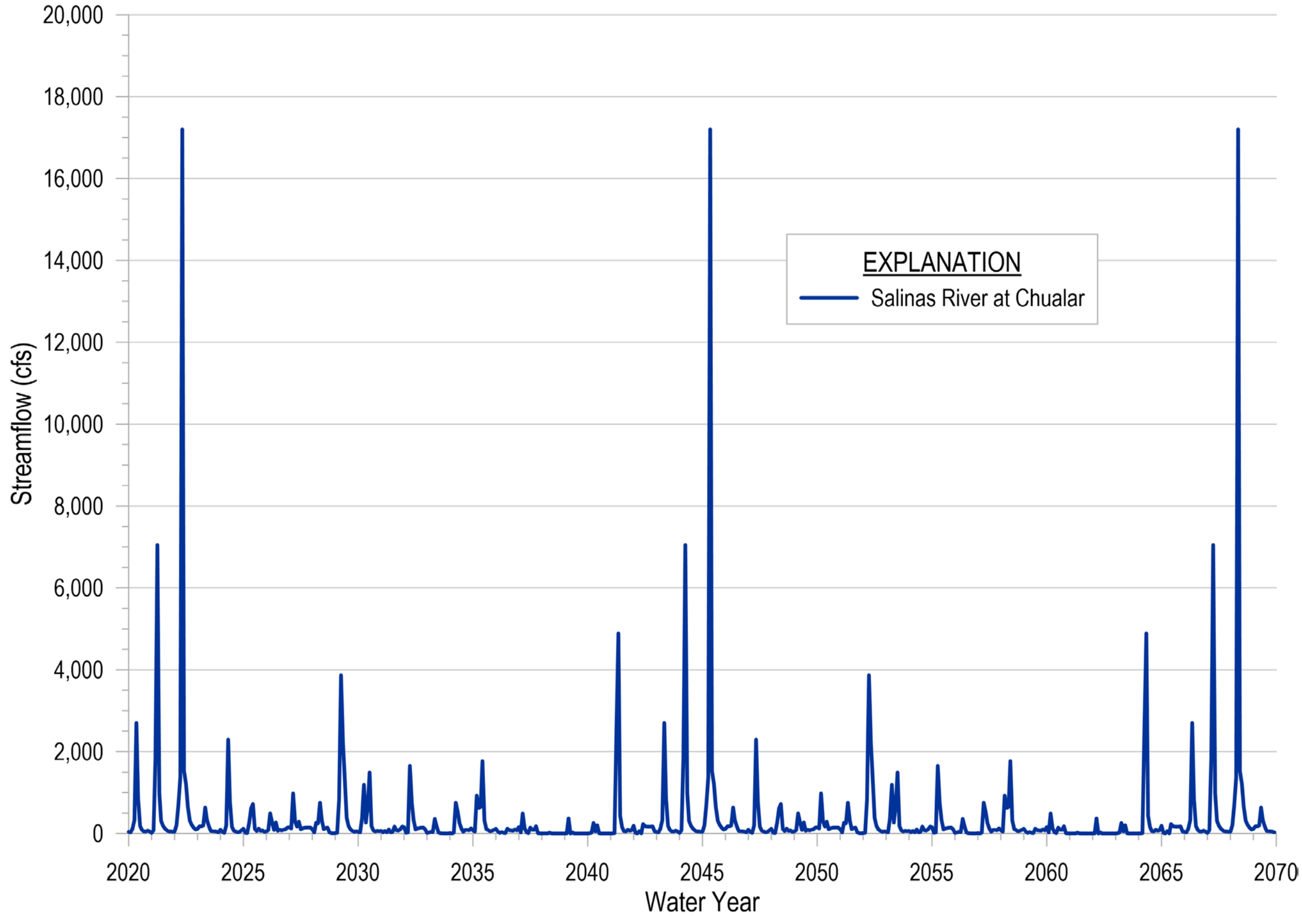

Figure 2. Simulated No Project Scenario Salinas River Inflow at Chualar

MODEL RESULTS

Model results are assessed by comparing projected groundwater conditions from the end of the 50-year No Project Scenario simulation to the conditions at the start of the No Project Scenario simulation. Although this simulation was not intended to predict conditions at any specific future year, the No Project Scenario is assigned WY 2021 through 2070 for convenience in presenting results. Results are summarized by model layer, which include the noted aquifer and its stratigraphic equivalent that is included in the same model layer. The No Project Scenario water budget is compared to the historical SWI Model water budget.

Groundwater Levels

Simulated change in groundwater level is calculated by comparing the groundwater levels at the beginning of the No Project Scenario to the levels at the end of the simulation. To avoid comparing head variations due to seasonal and interannual climate fluctuations, the average heads of the first 10 years of the No Project Scenario are compared to the average heads of the last 10 years of the model. The calculations are performed for the 180-Foot Aquifer (Figure 3) and 400-Foot Aquifer (Figure 4). The 180-Foot Aquifer is represented by the model layer 3 through 5 average head difference. The 400-Foot Aquifer is represented by the head difference in model layer 7.

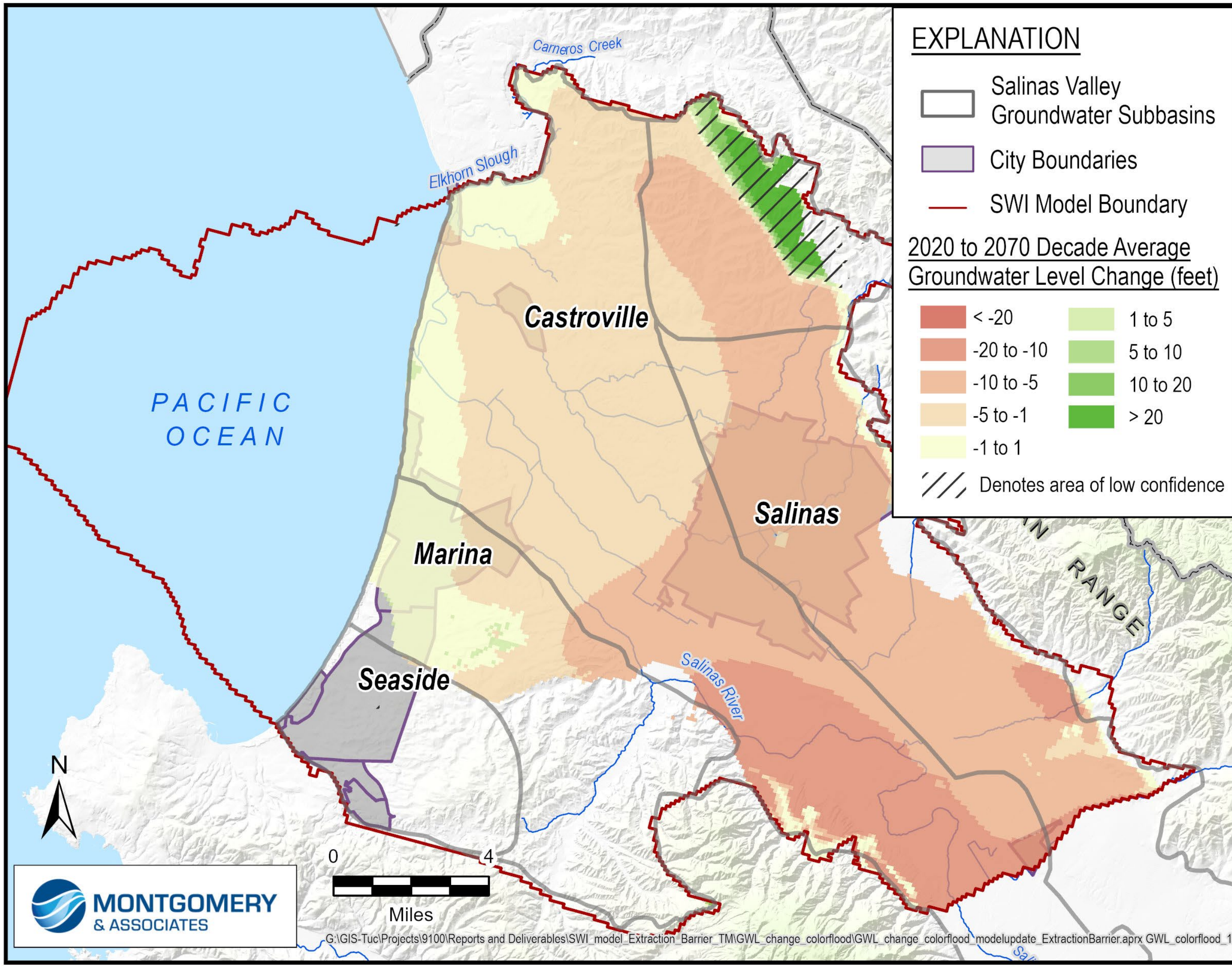

Figure 3. No Project Scenario Simulated 2020 to 2070 Drawdown in the 180-Foot Aquifer (Model Layers 3-5)

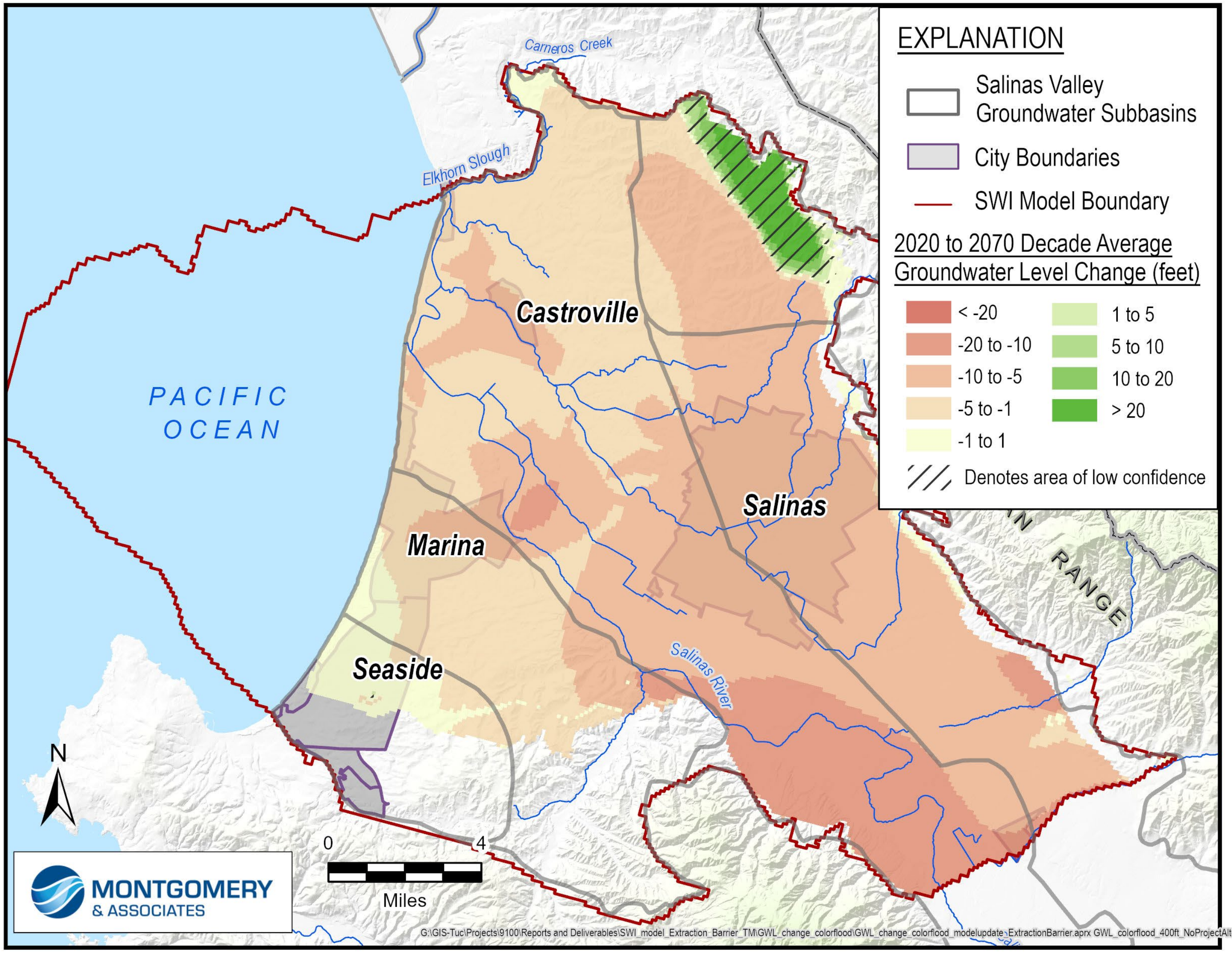

Figure 4. No Project Scenario Simulated 2020 to 2070 Drawdown in the 400-Foot Aquifer (Model Layer 7)

The model projects that by 2070, groundwater levels will generally decrease in the Salinas Valley between 1 and 20 feet in both the 180-Foot and 400-Foot Aquifers under the No Project Scenario. There is an area with increasing groundwater levels predicted in Granite Ridge area in eastern Langley; however, it is poorly calibrated in the model and the predicted results are likely unreliable in this area.

The No Project Scenario predicts that the change in heads will be about the same in both the 180-Foot and 400-Foot Aquifers. Heads closer to the coast generally decline by 1 to 5 feet. Farther inland near the City of Salinas, a greater head decline of 5 to 10 feet is projected. South of the City of Salinas in the 180/400 Subbasin a decline of 10 to 20 feet in heads is projected. The decline in groundwater levels predicted in Eastside Subbasin is about 5 to 10 feet.

Chloride Concentrations

The model projects that seawater intrusion in the 180-Foot and 400-Foot Aquifers will steadily advance inland from 2020 through 2070. Areas resulting in chloride concentrations greater than background (about 100 mg/L) by 2070 are evaluated for seawater intrusion. Seawater intrusion is mapped by the inland progression of the simulated 500 milligrams per liter (mg/L) chloride contour. Projected chloride results are mapped in 2030, 2040, 2050, 2060, and 2070. Though the location of the simulated 500 mg/L chloride contour and rate of movement are approximation of future groundwater conditions, additional seawater intrusion into the Salinas Valley would be expected under the conditions simulated in the No Project Scenario.

The extent of the simulated 500 mg/L chloride contour was evaluated to project the trend of future seawater intrusion in the Salinas Valley. The progression of the 500 mg/L contours in the 180-Foot Aquifer is presented on Figure 5. A map of the chloride concentrations above 100 mg/L in the 180-Foot Aquifer at the end of the No Project Scenario is shown on Figure 6. Chloride concentrations in model layer 5 are selected to represent the 180-Foot Aquifer because the lower portion of the aquifer generally exhibits more advanced seawater intrusion.

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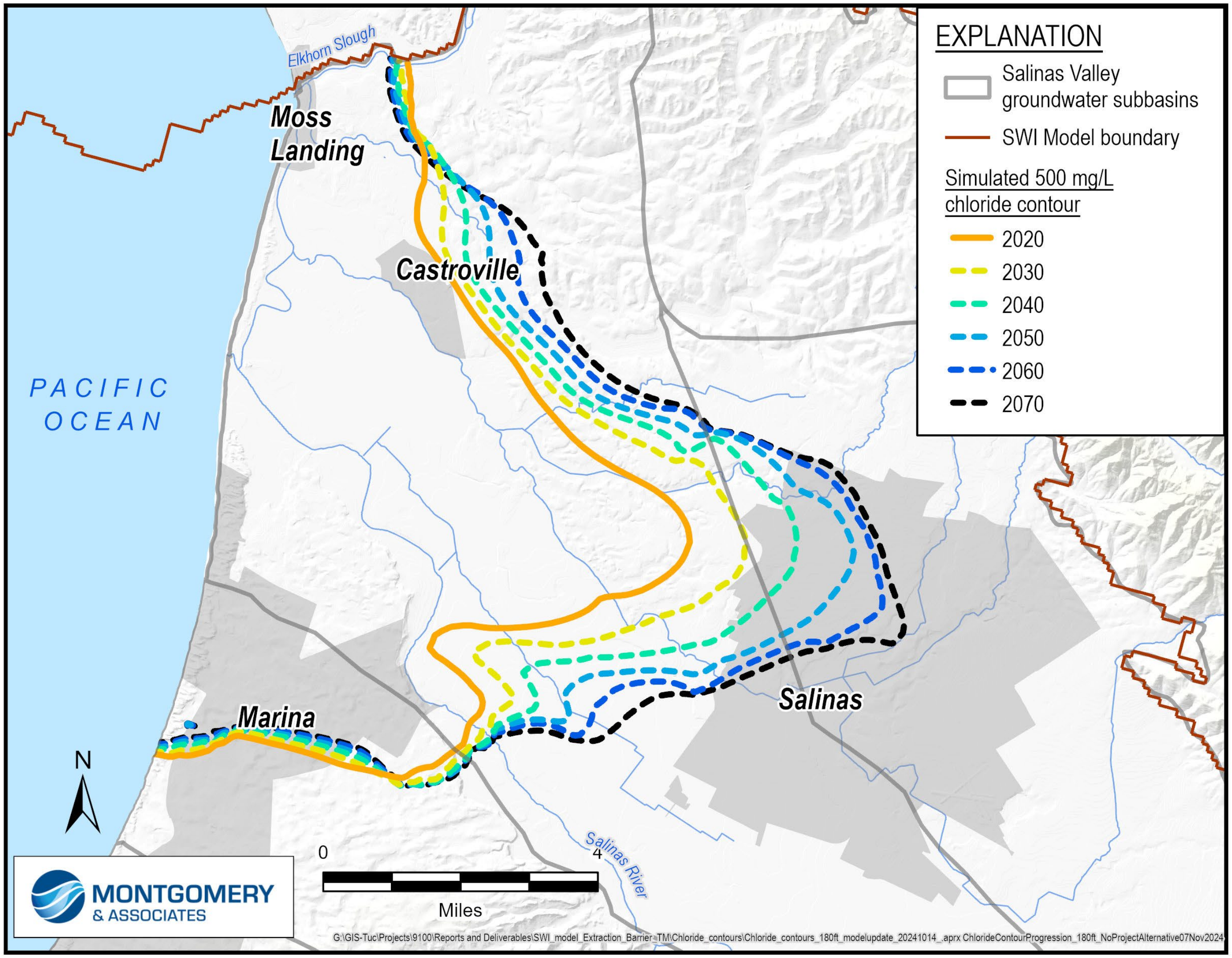

Figure 5. Lower 180-Foot Aquifer (Model Layer 5) No Project Scenario Simulated 500 mg/L Chloride Concentration Contours in 2020, 2030, 2040, 2050, 2060, and 2070

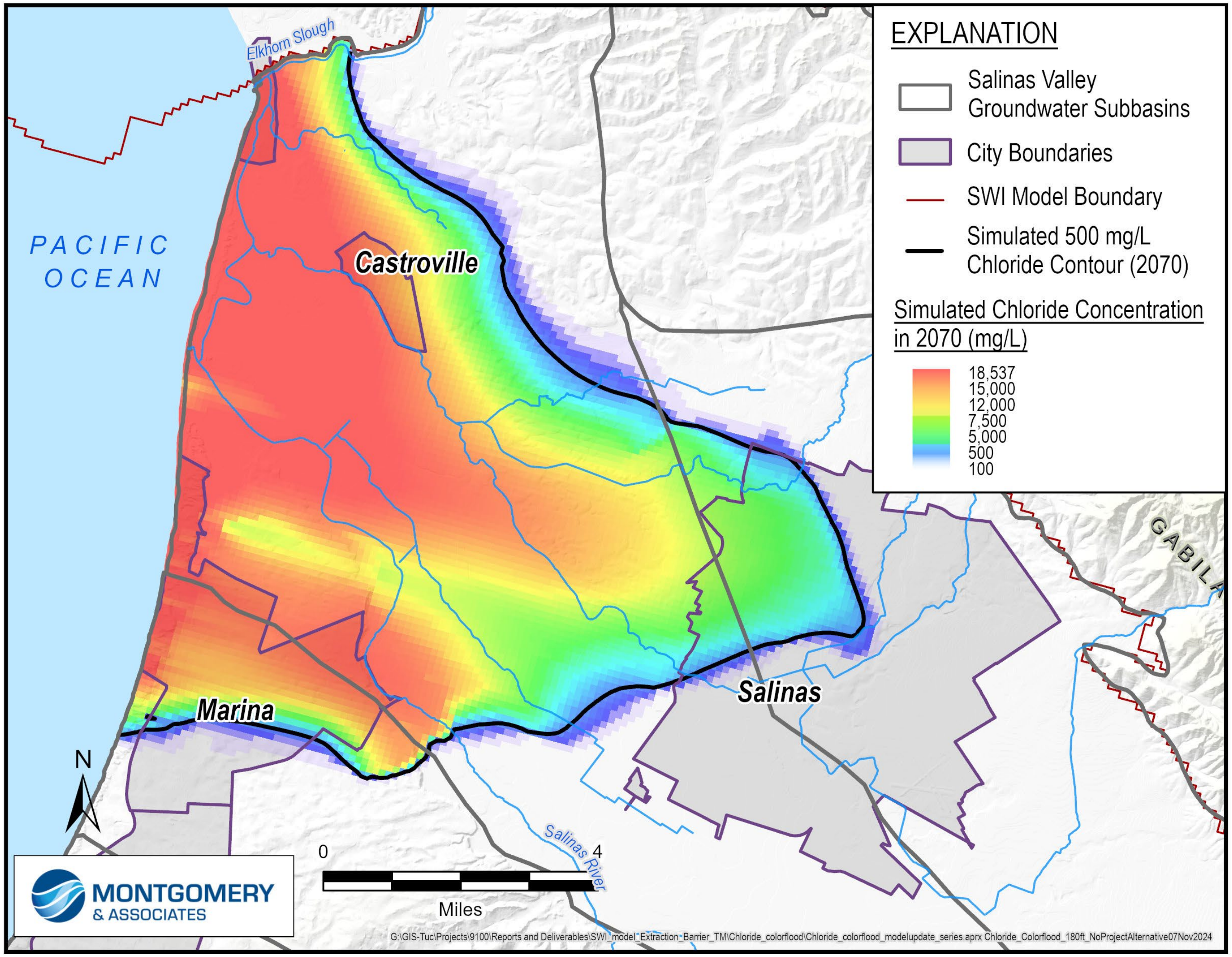

Figure 6. Lower 180-Foot Aquifer (Model Layer 5) No Project Scenario Simulated Chloride Concentrations in 2070

In the 180-Foot Aquifer, the main lobe of seawater reaches the outskirts of Salinas between 2030 and 2040 and continues advancing in the direction of the observed groundwater depression in the northern portion of Salinas. Between 2060 and 2070 seawater reaches the Eastside alluvial fan deposits which have a lower hydraulic conductivity and slows its advance in the western direction. This is observed as a flattening of the 2070 500 mg/L chloride contour on Figure 5.

On the northern side of the 180-Foot Aquifer seawater intrusion front, in the vicinity of Castroville, seawater intrusion is projected to continue at a slower rate than near Salinas. On the southern side of the seawater intrusion front, some additional seawater intrusion is projected east of the City of Marina between 2020 and 2070. Little additional seawater intrusion is projected in the southern direction near the City of Marina. Analysis of cross sections of the updated HCM suggests that the limitation on additional seawater intrusion near the City of Marina in the model is a result of the 180-Foot Aquifer rising in elevation to the south and east.

The progression of the 500 mg/L contours in the 400-Foot Aquifer is presented on Figure 7. A map of the chloride concentrations above 100 mg/L in the 400-Foot Aquifer at the end of the No Project Scenario is presented on Figure 8. Chloride concentrations in model layer 7 are shown to represent seawater intrusion in the 400-Foot Aquifer.

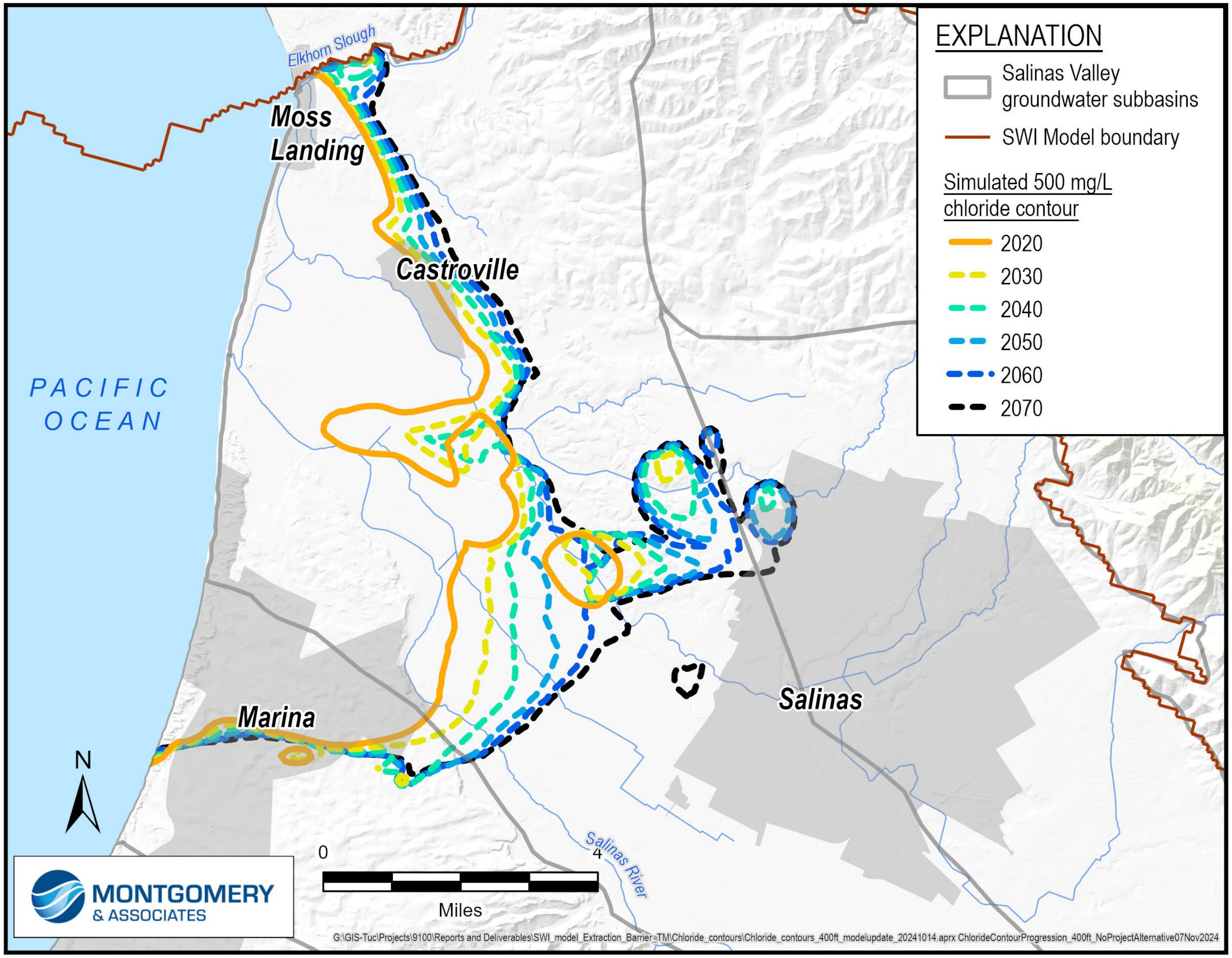

Figure 7. 400-Foot Aquifer (Model Layer 7) No Project Scenario Simulated 500 mg/L Chloride Concentration Contours in 2020, 2030, 2040, 2050, 2060, and 2070

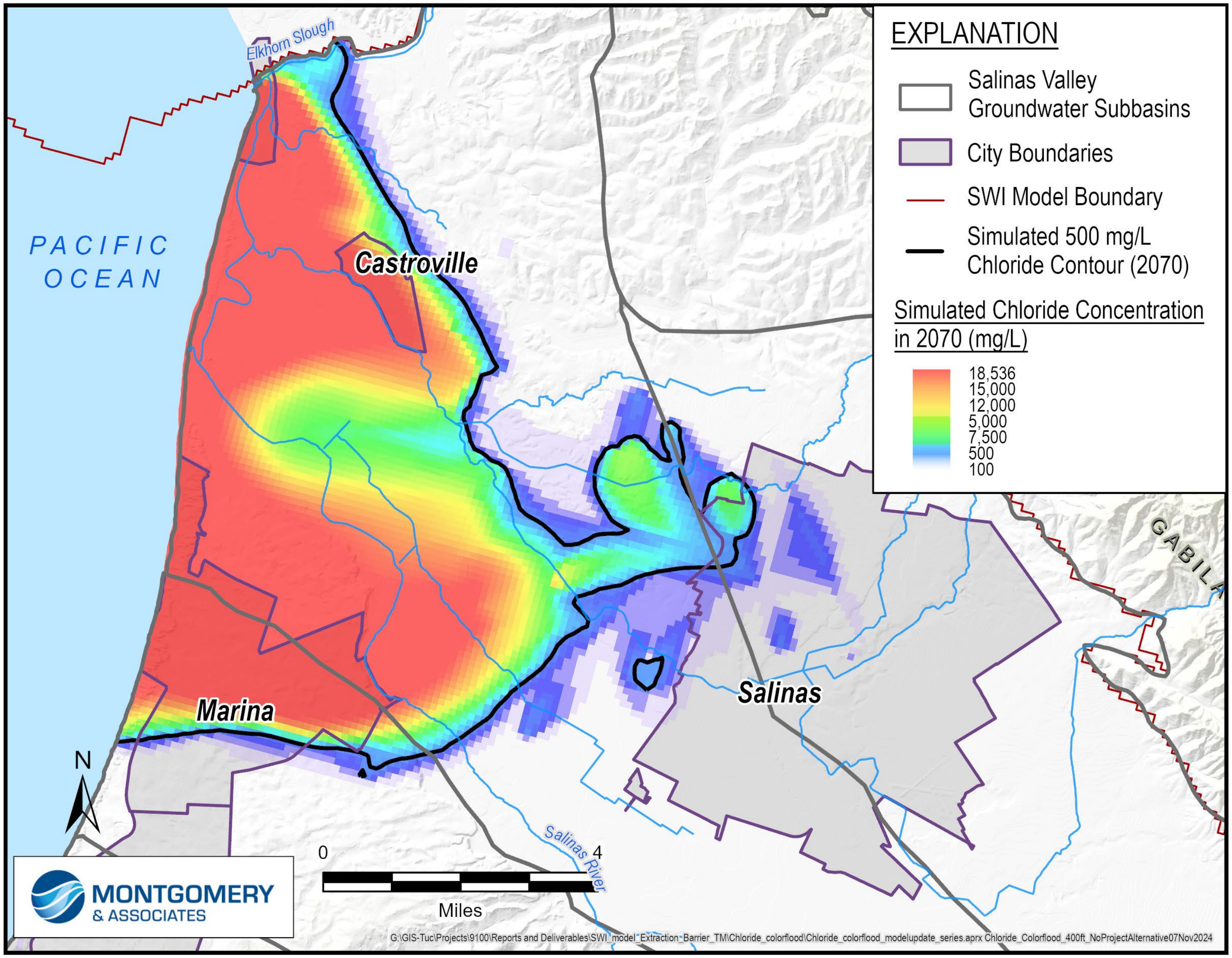

Figure 8. 400-Foot Aquifer (Model Layer 7) No Project Scenario Simulated Chloride Concentrations in 2070

In the 400-Foot Aquifer, seawater intrusion advances toward the northern portion of the City of Salinas. The main lobe of seawater advances as far as where the isolated island of seawater was in 2020. The island of seawater slowly disperses and shrinks in size while continuing to move inland. Starting in 2030 and through 2070, additional seawater islands appear between the advancing front of seawater in the 400-Foot Aquifer and the City of Salinas. The appearance of these seawater islands in the 400-Foot Aquifer is facilitated by downward flow from the 180-Foot Aquifer through groundwater wells screened across both aquifers. These model results demonstrate that seawater could flow from the 180-Foot Aquifer into the 400-Foot Aquifer in the future through cross-screened wells. However, locations of wells screened in multiple aquifers is only estimated in the model. These model results should not be interpreted as an accurate prediction of where new seawater intrusion islands may appear. These results highlight the importance of surveying for wells screened in multiple aquifers to prevent this as a potential migration pathway in the future.

On the northern side of the seawater intrusion front in the 400-Foot Aquifer, in the vicinity of Castroville, seawater intrusion is projected to continue but at a slower rate than near Salinas. On the southern side of the seawater intrusion front, additional seawater intrusion is projected east of the City of Marina between 2020 and 2070. Some additional seawater intrusion is projected in the southern direction near the City of Marina. Seawater intrusion in the southern direction near the City of Marina may be hindered by a slight rise in the elevation of the Deep Aquitard; however, the geometry of the 400-Foot Aquifer suggests that there would be little obstruction for up to an additional 1 mile of seawater intrusion in the 400-Foot Aquifer in the southern direction.

Simulated Pumping from Impacted Wells

The No Project Scenario predicts that by 2070 the seawater intrusion front will advance through an area of mainly agricultural groundwater users and into the City of Salinas. Groundwater extraction from wells within the simulated seawater intruded area are assessed. In the No Project Scenario model, wells impacted by seawater intrusion continue to pump through 2070. No assumptions were made to cease pumping from impacted wells because stopping pumping at these wells would require providing an alternative water supply or changing land use. Future projects simulations could include such scenarios.

Groundwater extracted from the wells was assessed for chloride concentrations exceeding 100 mg/L and 500 mg/L. Figure 9 shows the predicted annual amount of water pumped by wells impacted by seawater intrusion from 2020 to 2070. Figure 10 is a map of wells impacted by chloride concentrations above 500 mg/L by 2070. By 2070, wells representing approximately 17,000 AF/yr of demand are projected to be impacted by chloride concentrations exceeding 500 mg/L and 28,000 AF/yr by concentrations above 100 mg/L in the No Project Scenario. The majority of the impacted wells are in the 400-Foot Aquifer.

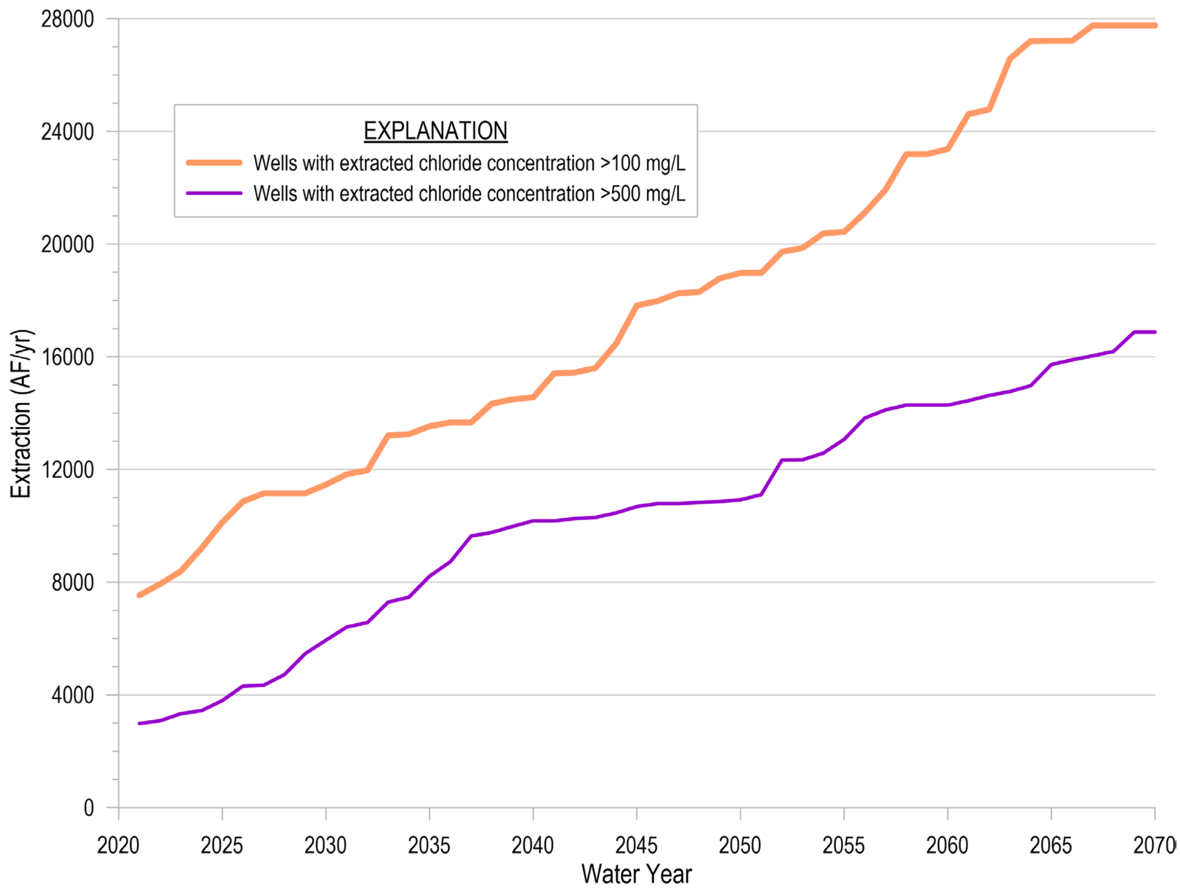

Figure 9. Simulated Groundwater Demand Impacted by Seawater Intruded Wells

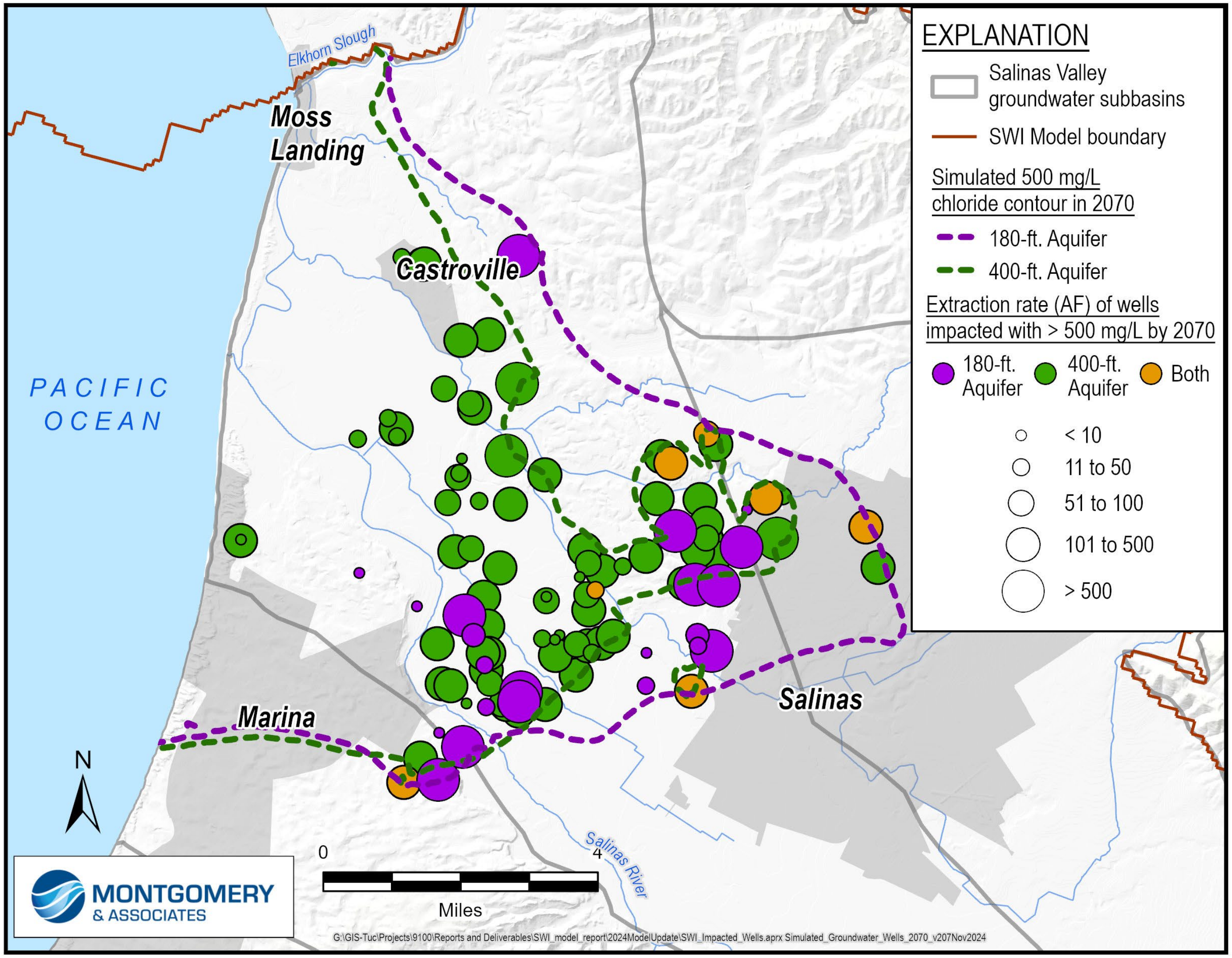

Figure 10. Simulated Groundwater Wells Impacted by Chloride Concentrations Exceeding 500 mg/L by 2070

CONCLUSION

M&A developed a predictive version of the SWI Model that predicts 50 years of groundwater conditions in the coastal portion of the Salinas Valley. Future groundwater conditions were simulated with the No Project Scenario model to serve as a reference of comparison for other simulations of project and management actions.

The No Project Scenario model simulates groundwater conditions that may occur in the Salinas Valley under current groundwater extraction rates and climate conditions. Climate change and sea level rise were not included in this update to the model so that the model results represent the impacts of continued groundwater extraction on groundwater conditions in the SWI Model area independent of potential impacts associated with climate change. Groundwater extraction in the No Project Scenario reflects WY 2016-2020 average pumping rates. Other hydrologic conditions such as recharge and streamflows are represented by average WY 1996-2018 rates, which was selected as a representative recent climate period.

The No Project Scenario model projects that groundwater levels will decrease by up to 10 feet near the coast and the City of Salinas in both the 180-Foot and 400-Foot Aquifers and their stratigraphic equivalents. Groundwater levels are projected to decrease by up to 20 feet south of the City of Salinas. Seawater intrusion in the 180-Foot and 400-Foot Aquifers is projected to continue if current groundwater management practices remain in place. The results indicate the importance of identifying wells in the path of seawater intrusion that may be screened in both the 180-Foot and 400-Foot Aquifers if they do exist.

The No Project Scenario will be updated alongside future model improvements. These results demonstrate a baseline against which potential projects and management actions may be compared. The No Project Scenario may be used for assessing, comparing, and designing projects and management actions that reach groundwater sustainability goals.

REFERENCES

Montgomery & Associates. 2023. 2023 Model Updates to Address Groundwater Technical Advisory Comments. Addendum 1 to the Salinas Valley Seawater Intrusion Model.