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TECHNICAL MEMORANDUM

DATE: March 20, 2025 **PROJECT #:** 9100.68

TO: Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA)

FROM: Victoria Hermosilla, P.G., Tiffani Cáñez

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PROJECT: Salinas Valley Hydrogeological Conceptual Model (HCM) Updates

SUBJECT: Eastside Aquifer Subbasin HCM Update: Data, Methods, and Findings

INTRODUCTION

Since submittal of the Eastside Aquifer Subbasin (Eastside Subbasin or Subbasin) Groundwater Sustainability Plan (GSP) in 2022, SVBGSA and partner agencies have analyzed new information and filled data gaps identified in the GSP. With this information, Montgomery & Associates (M&A) updated the Hydrogeologic Conceptual Model (HCM) for the Subbasin to better inform management decisions and prepare for the upcoming 5-year Periodic Evaluation. M&A worked with key partners to acquire data and review analyses, including Monterey County Water Resources Agency (MCWRA). The updated HCM strengthens the historical understanding of the Subbasin presented in the GSP to guide SGMA implementation with greater accuracy. Concurrently, the updated HCM refines the geologic model that forms the basis for the groundwater flow modeling.

The HCM update focused on key areas where new data indicated an updated understanding was needed. The primary updates to the HCM included:

- Updating the bedrock surface that delineates the bottom of the groundwater basin
- Refining the extents and character of the alluvial fans
- Incorporating the 400/Deep Aquitard that separates the 400-Foot Aquifer from the Deep Aquifers in relation to the alluvial fans
- Exploring potential recharge pathways for future implementation projects

This memo summarizes the data used, the analyses and methods employed, and the findings for the updated Eastside Subbasin HCM.

DATA

The data used to update the HCM are detailed in the following subsections.

Published Cross Sections and Reports

The 2022 GSP summarized published cross sections and reports. For this HCM update, the following reports and cross sections were re-reviewed, compared with new data and information, and incorporated into the revised HCM.

- *State of the Salinas River Groundwater Basin* (Brown and Caldwell, 2015)
- *Final Report, Hydrostratigraphic Analysis of the Northern Salinas Valley* (Kennedy/Jenks, 2004)
- *Hydrogeologic Report on the Deep Aquifer, Salinas Valley, Monterey County, California* (Thorup, 1976; Thorup, 1983)
- *Deep Aquifers Study* (Montgomery & Associates, 2024)

Well Completion Reports

Well Completion Reports (WCRs) helped refine geologic interpretations, and included important information such as driller-observed lithology, screen intervals, and date of well installation. Some WCRs were more detailed than others with more frequent lithologic descriptions, electric logs (e-logs), and other construction or water level details.

M&A obtained WCRs through the California Department of Water Resources (DWR) Online System for Well Completion Reports (OSWCR) database, the County of Monterey Health Department, Monterey County Water Resources Agency, other collaborating partner agencies, and private entities. In particular, MCWRA provided hundreds of WCRs that were mostly supplementary to other geophysical data, but in some regions, they were the only data available.

Numerical Groundwater Flow Model Layers

Previous and current groundwater flow models reflect various conceptual understandings of the Subbasin. Models reviewed for the HCM update included:

- The Salinas Valley Geologic Model (Sweetkind, 2023) that defines the spatial extent, depth, and distribution of geologic material textures for the provisional Salinas Valley Integrated Hydrologic Model (SVIHM). This model was developed by the U.S. Geological Survey (USGS) to cover the entire Salinas Valley and includes a geological framework with key documentation.

- The Salinas Valley Seawater Intrusion Model (SWI Model) (Montgomery & Associates, in production). This model was developed by M&A for SVBGSA and County of Monterey, and covers the coastal area of the Salinas Valley north of Chualar.

These models were primarily used to compare and refine the depths and thicknesses of the hydrostratigraphic layers for the Salinas Valley Groundwater Basin HCM update.

Geophysical Data

The primary types of geophysical data used in this HCM update were:

- Airborne Electromagnetic (AEM) resistivity data. These data were collected by the California Department of Water Resources (DWR), and SVBGSA between 2020 and 2023. These data provide a broad coverage of general lithologic trends.
- Borehole resistivity data. These geophysical data are collected in boreholes prior to well installation, and provided detailed interpretation of localized lithology.

These 2 types of data are both electrical resistivity data, which are collected by sending electrical pulses into the subsurface and receiving signals back.

AEM Data

AEM surveys measure the resistivity of materials, both solid and liquid, in the subsurface over large areas. Lower resistivity materials include clays, silts, and groundwater with high total dissolved solids (TDS) concentrations. Higher resistivity materials include sands and gravels, some types of bedrock, and groundwater with lower TDS concentrations. AEM data are useful for filling gaps between known data points such as wells. This effort focused on reviewing and analyzing the lower resistivities at various target depths where aquitards or clay intervals are expected.

Three sets of AEM surveys were used to fill data gaps, confirm other data, and refine the delineations of primary aquifers and aquitards. These data came from the following surveys:

- DWR Survey Area 1, 2020 (DWR, 2020)
- DWR Survey Area 8, 2022 (DWR, 2022)
- Deep Aquifers Survey, 2023 (M&A, 2024)

E-logs/Borehole geophysical logs

Borehole geophysical logs measure the resistivity of materials in the subsurface adjacent to a borehole. Like AEM data, borehole geophysics can help qualitatively differentiate between clays, silts, sands and gravels, high TDS water, and low TDS water. Borehole geophysics data show much more detail than AEM data, but only reflect conditions immediately adjacent to a borehole. Several borehole geophysical logs used were sourced from other studies or included with WCRs.

Geologic Maps

Geologic maps provide a visual representation of the rocks, formations, and structures encountered at land surface. The 2 primary maps used for this HCM update were the Wagner *et al.*, 2002 surface geology map and the Digital Geologic Map of Monterey County, California, 1934-2001 (Rosenberg, 2001). These geologic maps supplemented other data during the HCM update by verifying surface expressions of the various lithologic units.

METHODS

Geologic modeling and visualization software was used to update the Subbasin hydrostratigraphy through the following steps, starting with the data with the most confidence:

1. Integrating and reviewing the data using Leapfrog Geo software.
2. Prioritizing data based on reliability and availability.
3. Selecting the best data to define the new hydrostratigraphic layers.
4. Contouring the data to create new hydrostratigraphic layers within Leapfrog Geo software.

Geologic Modeling Software

Leapfrog Geo software, developed by Seequent, was the primary 3D modeling and visualization software used to relate and analyze the different types of data described above. All data were imported into the software and methodically reviewed and compared to each other.

Data Prioritization

Various data have differing levels of confidence. The list below demonstrates the general hierarchy of confidence in the various data types used in this analysis.

1. Geologic Maps
2. Published Cross Sections and Reports
3. Borehole Logs (Well Completion Reports and e-logs)
4. AEM data
5. Groundwater Flow Models

Concurrently using multiple data sources can improve confidence in geologic interpretations. For example, confidence in AEM data can be significantly improved when it is combined and coordinated with geologic maps.

Data are not uniformly distributed throughout the Subbasin. Wells and associated WCRs are more concentrated in areas with more infrastructure, whereas AEM flightlines generally cover areas with less or no infrastructure. Therefore, hydrogeologic interpretations are more strongly influenced by the availability of data in different areas.

Hydrogeologic interpretations initially focused on areas with a higher density of multiple data types to cross validate data. Developing confidence in any data type allowed analyses using those data to expand horizontally and vertically and revise the HCM as needed.

The decision-making procedures for updating the HCM generally used the following guidelines. These guidelines do not represent a decision-making hierarchy, rather they are a group of guidelines that interact in various ways based on circumstances in each particular area.

- Newer geologic maps were prioritized over older geologic maps.
- Newer published cross sections were prioritized over older published cross sections, unless there was higher confidence in older cross sections based on the author and how the sections correlated with other data.
- Geologic maps provided anchor locations for the geologic surface contacts, including bedrock outcrops, where available.
- The hydrostratigraphy was refined by jointly using AEM data, WCRs, and published cross sections in places where the various data types overlapped. This strengthened confidence in AEM data interpretation.
- Where AEM data and cross sections did not align, well logs used to develop the cross section were reviewed and used in conjunction with the AEM data.
- AEM data were the primary data source for hydrostratigraphic interpretation in areas with limited borehole data.
- E-logs and published cross sections were used where AEM data were not available, and correlated with the nearest AEM data.
- WCRs were used as verification and interpolation points for key priority areas.
- Areas with no other nearby data relied on the SVIHM geologic model or SWI Model layers to interpolate the hydrostratigraphic layers.

Figure 1 shows a prime example of an analysis that encompasses many types of data and shows how they are correlated to provide a more cohesive understanding of the hydrostratigraphy of the Salinas Valley Groundwater Basin (Basin). The cross section on Figure 1 was exported from the Leapfrog software, and spans the 180/400-Foot Aquifer Subbasin, the Monterey Subbasin, and the Seaside Subbasin. Hydrostratigraphy in the north (left on Figure 1) is based on well completion reports with finer sediments highlighted in blue. Hydrostratigraphy in the center of Figure 1 is based on AEM data, with finer sediments highlighted in blue also. A previously published map of the Monterey Formation (HydroMetrics, 2009) provided structural data in the south, as well as locations of surface outcrops of Monterey Formation highlighted with yellow disks. Published cross sections, e-logs, and surface geology maps are not shown on the figure; however, in this location they were also reviewed for confirmation of other data. Through careful analysis and integration of all data types, a new bedrock surface was developed, shown in pink mesh and green contour lines in Figure 1. This figure best illustrates the data synthesis methodology applied to each subbasin in the Salinas Valley Basin, and should be viewed as a conceptual depiction of the types of data and decision processes used to update the Eastside Subbasin HCM.

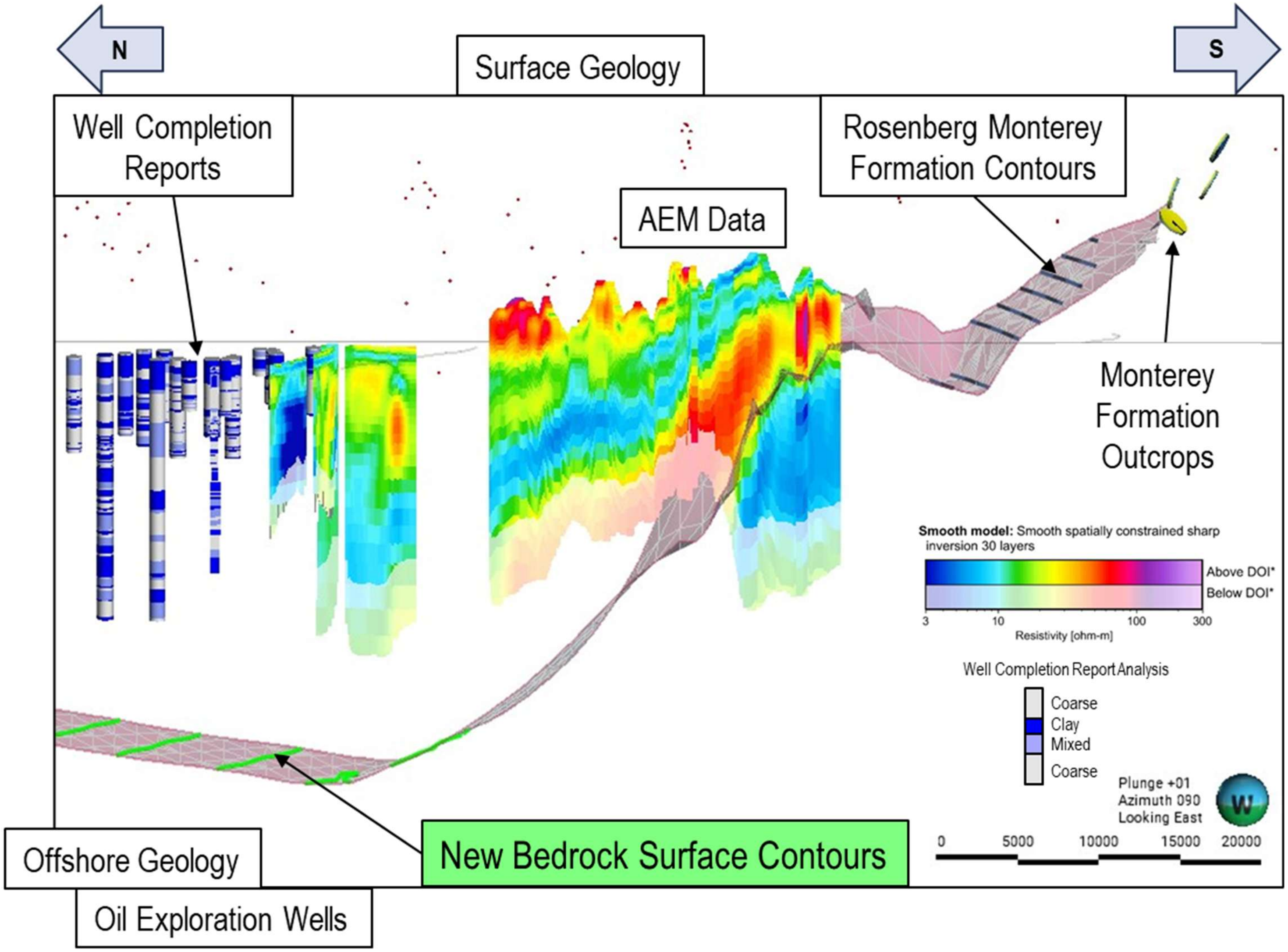

Figure 1. Example of Different Types of Data Juxtaposted in Leapfrog Geo Software

Across the Subbasin, hydrostratigraphic decision-making was prioritized from deepest layers to shallowest layers. Starting with the bedrock, aquitard, and aquifer elevations in the Salinas Valley Geologic Framework (Sweetkind, 2023), the bedrock surface was the first priority, and was modified using AEM data and WCRs. After revising the bedrock surface, the HCM was revised focusing on the alluvial fans. Following that, to assess its relation to the alluvial fans, the location and depth of the aquitard between the 400-Foot Aquifer and Deep Aquifers was revised based on the Deep Aquifers Study (M&A, 2024).

RESULTS/FINDINGS

Results of the 4 primary HCM updates listed in the introduction are detailed below.

Bedrock Surface

Principal Data Used: AEM data, WCRs, Salinas Valley Geological Framework, surface geology maps

Understanding the depth and geometry of the bedrock helps determine the available aquifer space for groundwater storage in the Eastside Subbasin. According to Durbin (1978), the bedrock was previously conceptualized to dip steeply from the surface outcrops in the Gabilan Range before leveling out below the main corridor of the Salinas Valley Basin. This geometry was thought to follow a bathtub shape, where the bedrock is concave up.

The AEM data show a higher resistivity material much shallower in the subsurface than the layer that represents the bedrock in the SVIHM, which is based in part on the Durbin (1978) bedrock surface. WCRs were then evaluated to determine if bedrock was identified in the lithology logs. The lithology descriptions that may denote bedrock include: decomposed granite, DG, rock, large granite cobbles, and granite. Drilling operations are commonly stopped when bedrock is encountered in the Salinas Valley, and therefore, lithologic log intervals with bedrock notation are frequently short and at the bottom of the boreholes. Notably, there are only 45 wells drilled deeper than 600 feet near the northeastern boundary of the Eastside Subbasin along the Gabilan Range. Of these 45 deeper wells, 22 included bedrock notations in their lithology logs which aligned with higher resistivity AEM data (60-80 ohm-meter) in the area. This overlap of bedrock notation in WCRs and higher resistivity AEM data prompted the revision of the bedrock surface in the Eastside Subbasin to a shallower bedrock surface. The bedrock surface is now conceptualized as dipping downward more gradually from the surficial contacts at the Gabilan Range before diving more steeply down towards the axis of the Basin, as shown on

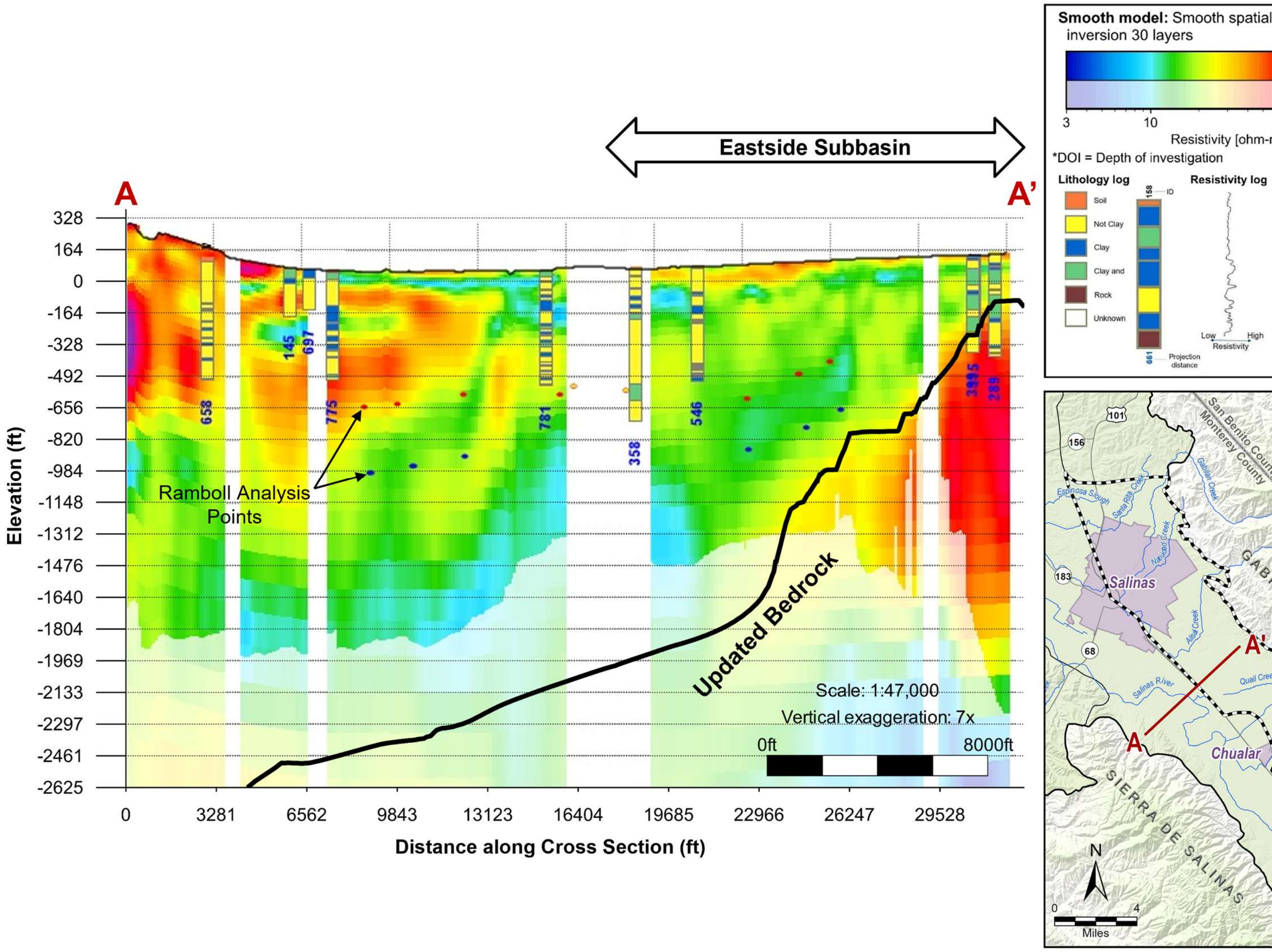
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Figure 2.

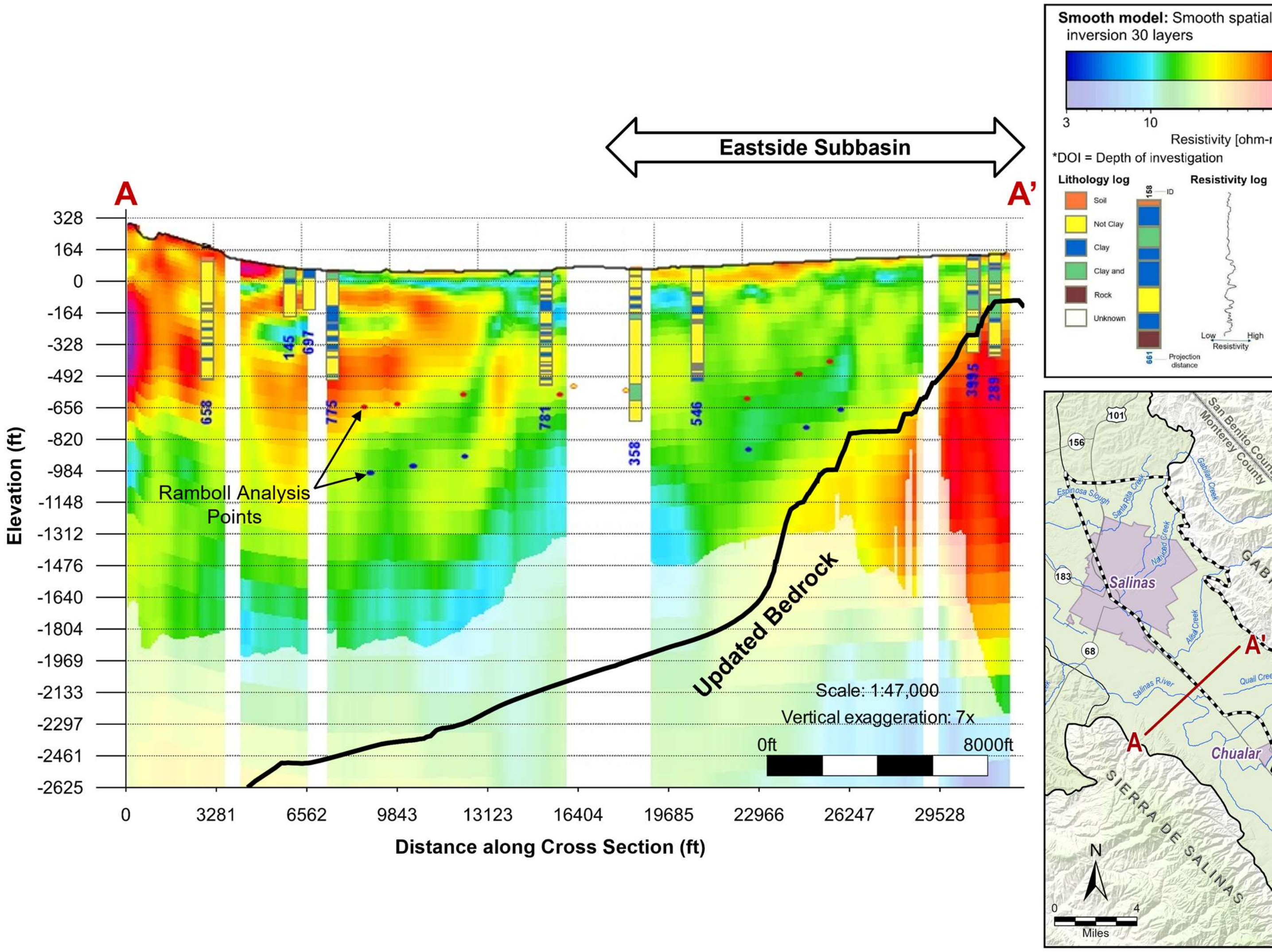

Figure 2 illustrates the updated depth and geometry of the regional bedrock surface in the Eastside Subbasin. However, there may be exceptions within the Subbasin that do not conform to the general bedrock depth and geometry. One exception is hypothesized to be under the City of Salinas where some data indicate there may be a spur in the bedrock surface. There are 4 wells that terminate below the bedrock according to their WCRs. Although there were no AEM surveys conducted within the City of Salinas, due to interference from infrastructure, nearby AEM transects suggest higher resistivity at depths that are consistent with the bedrock notations in the WCRs for the 4 wells that terminate below bedrock.

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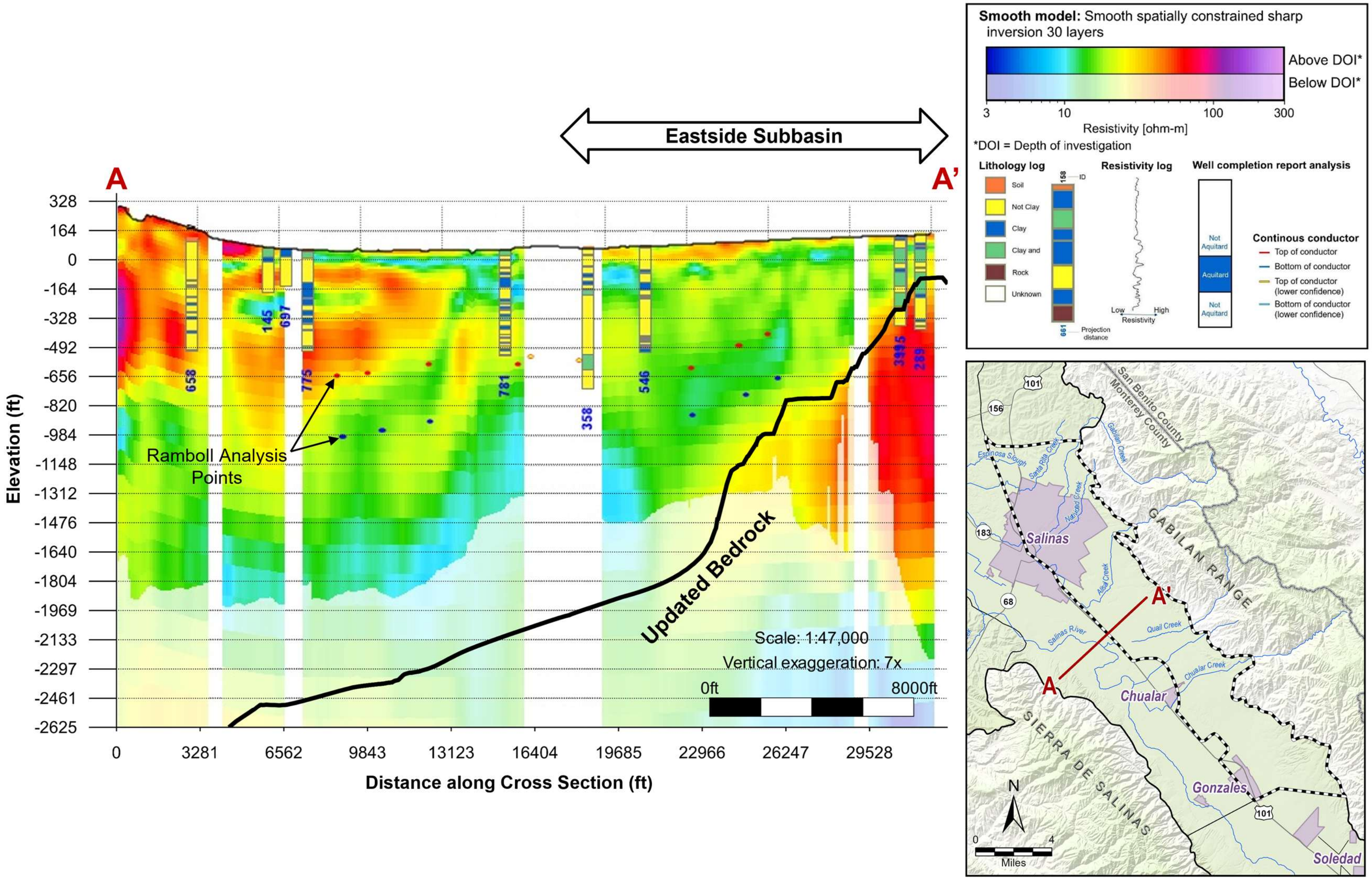

Figure 2. Updated Conceptual Understanding of Bedrock Surface and Key Data Used

Extent and Character of the Alluvial Fans

Principal Data Used: WCRs, published cross sections, AEM data, Salinas Valley Geological Framework

The Eastside Subbasin is distinguished by the presence of the alluvial fans emanating from the Gabilan Range. The previous conceptual understanding of the alluvial fans in the Eastside Subbasin focused primarily on their relationship to the principal aquifers and aquitards in the 180/400-Foot Aquifer Subbasin, and was not explored or defined much beyond that. The Subbasin has been long recognized as being more heterogenous and noted to have a higher presence of clay than the adjacent 180/400-Foot Aquifer Subbasin. Yet, it lacks a distinct, continuous aquitard, which resulted in dividing the principal aquifer into the Shallow and Deep Zones instead of 2 separate aquifers. These Zones are generally considered to be contemporaneous with and hydraulically connected to the respective neighboring 180-Foot and 400-Foot Aquifers. The Deep Aquifers Study (M&A, 2024) also showed that the Eastside Deep Zone is likely hydraulically connected to the Deep Aquifers in some locations.

The updated conceptualization focuses on defining the alluvial fans throughout the Eastside Subbasin independent of their relation to the adjacent 180/400-Foot Aquifer Subbasin's aquifers and aquitards. The Eastside alluvial fans are characterized by the presence of very low-resistivity values in the AEM data, which indicates very high clay content, following the sloping shape of the redefined bedrock, as shown within the dashed lines on

Figure 3. The extent of the alluvial fans is generally confirmed by the presence of clay in WCR lithology logs of coinciding wells (shown as blue layers in boreholes in

Figure 3). The strong clay presence in this traditionally coarse-grained depositional environment likely represents chemical decomposition of the granitic materials eroded from the Gabilan Range. This clay content defines alluvial fan shape observed in the low resistivity value AEM data. The slope of the alluvial fans follow the slope of the revised bedrock surface.

The AEM flightlines that transect the Eastside Subbasin from east to west were used to delineate the extent of the alluvial fans. Figure 4 shows how far the alluvial fans extend from the Gabilan Range into the Salinas Valley. The AEM data reinforce earlier understandings regarding the absence of an extensive aquitard, the prevalence of higher clay content throughout the Subbasin, and confirms an historical inability to trace individual sediment layers at specific depths across significant distances. This is more clearly demonstrated in the lower resistivity values above the specific outlined alluvial fans as seen on

Figure 3, which represent increased clay content. Although the alluvial fans are clay-dominated, WCRs show that coarser-grained materials are interspersed throughout the subsurface. Consequently, many wells in the Eastside Subbasin have been constructed with long screen intervals to capture as many of these discrete coarser-grained layers as possible. The coarser-grained intervals encountered by these wells are not necessarily indicative of a laterally extensive aquifer in the same way that the clays are not indicative of a laterally extensive aquitard.

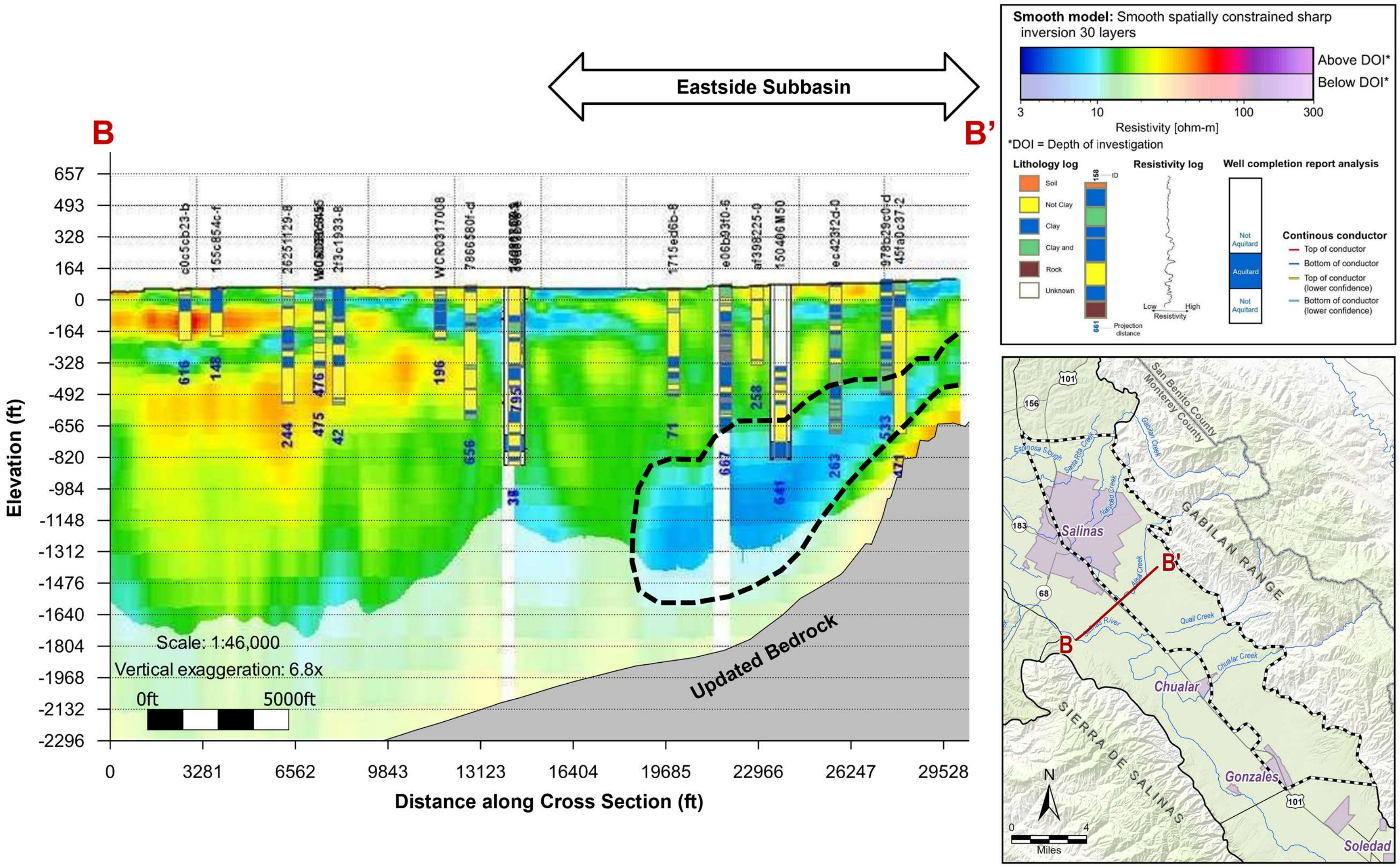

Figure 3. Updated Conceptual Understanding of Alluvial Fans in the Eastside Subbasin with Key Data Used

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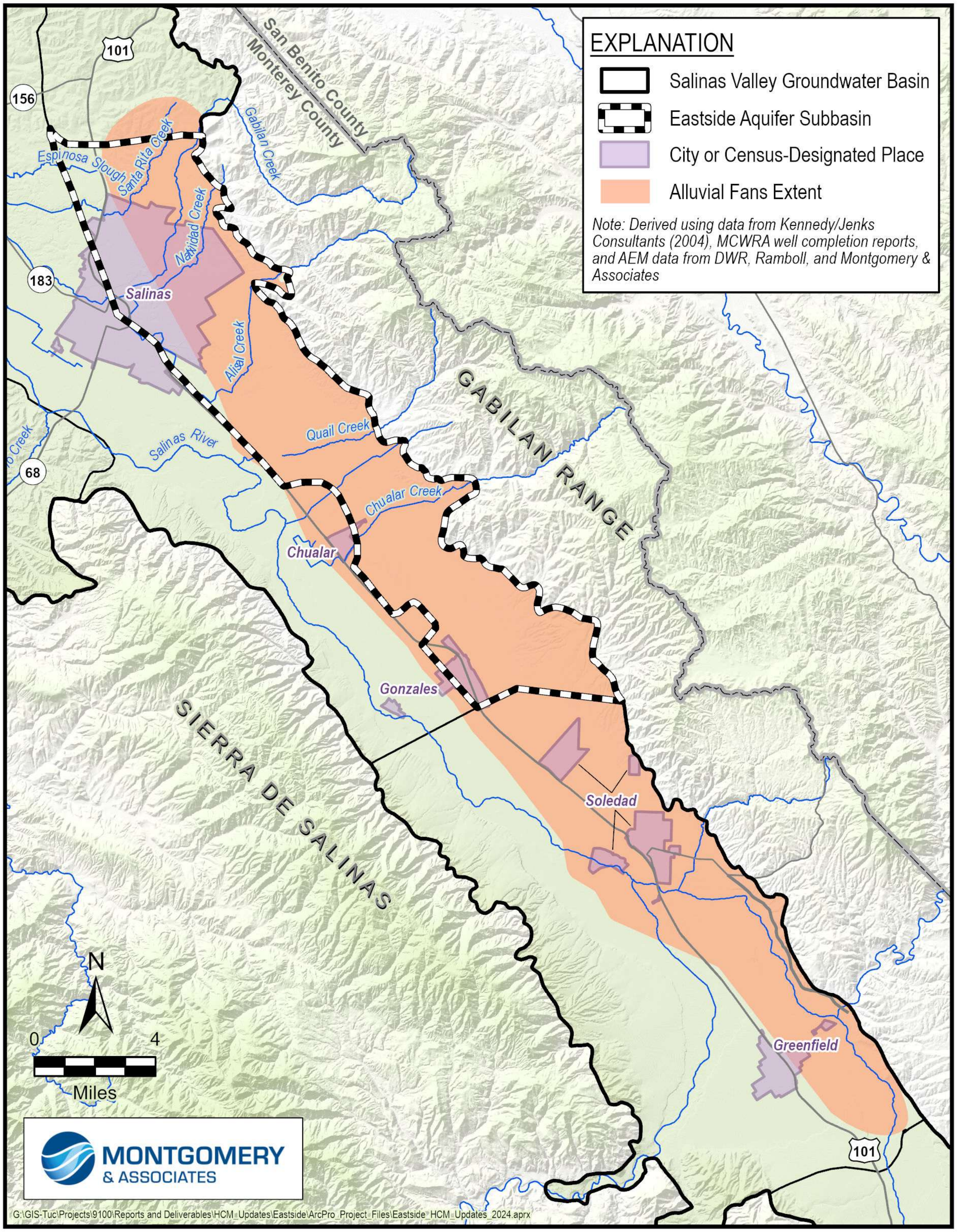

Figure 4. Extent of the Alluvial Fans along the Gabilan Range

Deep Aquifers' Extent

Principal Data Used: Previously published studies, AEM data, WCRs

The Deep Aquifers' extent was revised by incorporating results and data from the *Deep Aquifers Study* (Study) (Montgomery & Associates, 2024). Attachment A to the Study details the data, methods, and extent findings, which are summarized here.

No cohesive description of the Deep Aquifers' depth and extent existed prior to the Study. The previous understanding of the Deep Aquifers focused on the coastal areas of the 180/400-Foot Aquifer and Monterey Subbasins, where the majority of the deep wells were installed. The *Deep Aquifer Investigation - Hydrogeologic Data Inventory, Review, Interpretation and Implications* (Feeney and Rosenberg, 2003) detailed the geology that constitutes the Deep Aquifers, and summarized the known Deep Aquifers wells' screened intervals, extraction, and locations.

The *Hydrogeologic Report on the Deep Aquifer, Salinas Valley, Monterey County, California* (Thorup, 1976) defined the Deep Aquifers as the entirety of the Paso Robles Formation within the Salinas Valley Basin and developed recharge and storage estimates assuming the whole Formation was the Deep Aquifers. Other subsequent studies and analyses generally defined the Deep Aquifers based on the presence of the overlying 400-Foot Aquifer or MCWRA-designated Deep Aquifers wells, but notably there was no defined extent.

The updated understanding of the Deep Aquifers presented in the Study focused on the presence of the 400/Deep Aquitard to delineate the Deep Aquifers from the shallower principal aquifers. Accordingly, the Deep Aquifers incorporate all the productive zones below the 400/Deep Aquitard, including the previously named 800-Foot, 900-Foot, 1,100-Foot, and 1,500-Foot Aquifers; and comprise portions of the Paso Robles Formation, Purisima Formation, and Santa Margarita Sandstone. Insufficient data exist to subdivide the Deep Aquifers into component horizons.

The Study delineated the lateral extent of the Deep Aquifers through a portion of the northern part of the Eastside Subbasin as shown on Figure 5. The Deep Aquifers are of a different depositional environment than the alluvial fans that characterize the Eastside Subbasin; therefore, the Deep Aquifers do not extend into the southern portion of the Subbasin where the alluvial fans dominate. Additionally, AEM data presented in the Deep Aquifers Study suggest that the Deep Aquifers are also hydraulically connected to the Deep Zone of the principal aquifer in the Eastside Subbasin. Figure 5 includes areas marked as the uncertain extent, which are areas that the Deep Aquifers may be present, but where current data are not sufficient to conclusively determine its presence or absence.

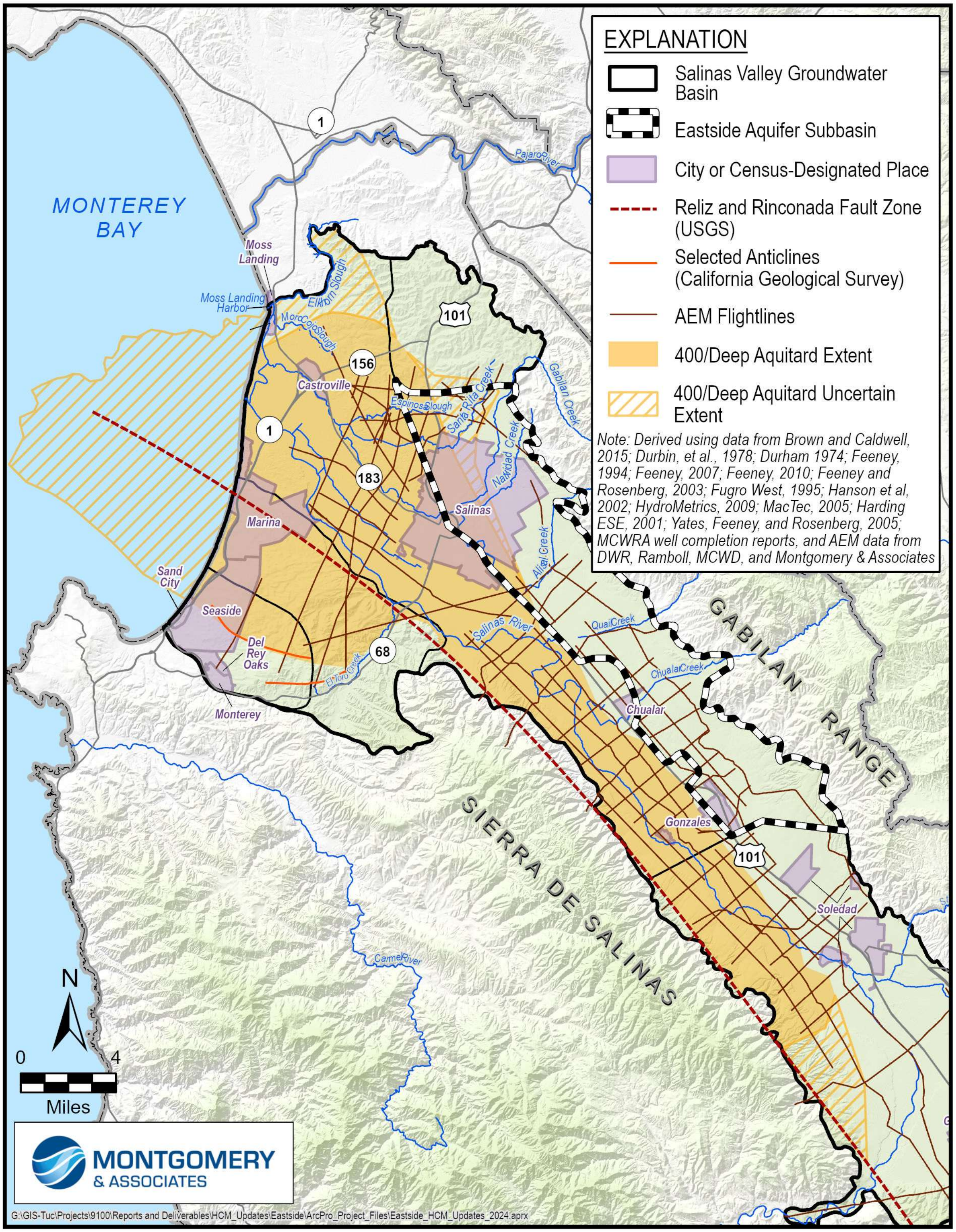

Figure 5. Updated Deep Aquifers' Extent as Determined by the Deep Aquifers Study (M&A, 2024)

Potential Recharge Pathways

Key Data Used: AEM data, tritium data, surface geology maps

The previous understanding of recharge pathways in the Eastside Subbasin was based on surface materials mapping, like that shown on Figure 6, or was presumed to primarily occur along tributaries from the Gabilan Range (County of Monterey, 2025). Figure 6 illustrates the Soil Agricultural Groundwater Banking Index (SAGBI), developed by researchers at the University of California, Davis. This index assesses soil suitability for groundwater recharge based on five major factors: deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition (O'Geen et al., 2015). The index rating ranges from "very poor" to "excellent" recharge suitability. However, actual recharge to the productive zones of the Subbasin could be limited because the discontinuous sediments of the alluvial fans may not provide a continuous path for recharge. Additionally, interfingering clay lenses could slow down or completely prevent recharge of the regional aquifer.

Figure 7 shows the Subbasin from an oblique angle and outlines in gray several AEM transects that show yellow and orange (25-45 ohm-m) resistivity data that correspond to coarser sediments in the subsurface. These areas may be more readily accessible from the surface, and could potentially provide good groundwater storage if perched conditions exist. The areas identified in the AEM data align well with the "good" recharge locations as indicated on the SAGBI map indicating potentially good connectivity with the subsurface (Figure 6).

Figure 7 also shows tritium isotope sample locations within the Subbasin. The youngest water identified, represented by the blue markers, is along Quail Creek. This sample represents groundwater within the coarse sediment areas identified from AEM data and coincides with the "good" recharge locations shown on the SAGBI map (Figure 6). Together, these three key points of data indicate the Quail Creek area as being the most suitable location for a recharge project within the Eastside Subbasin. This area is circled in red in Figure 7.

More data will be necessary to confirm the recharge potential of the other areas outlined in gray on Figure 7. The remainder of the AEM flightlines within the Subbasin generally show shallower, lower resistivity materials such as clays or silts, that likely impede recharge to much of the aquifer. Therefore, no other areas in the Subbasin have been identified as suitable for recharge at this time.

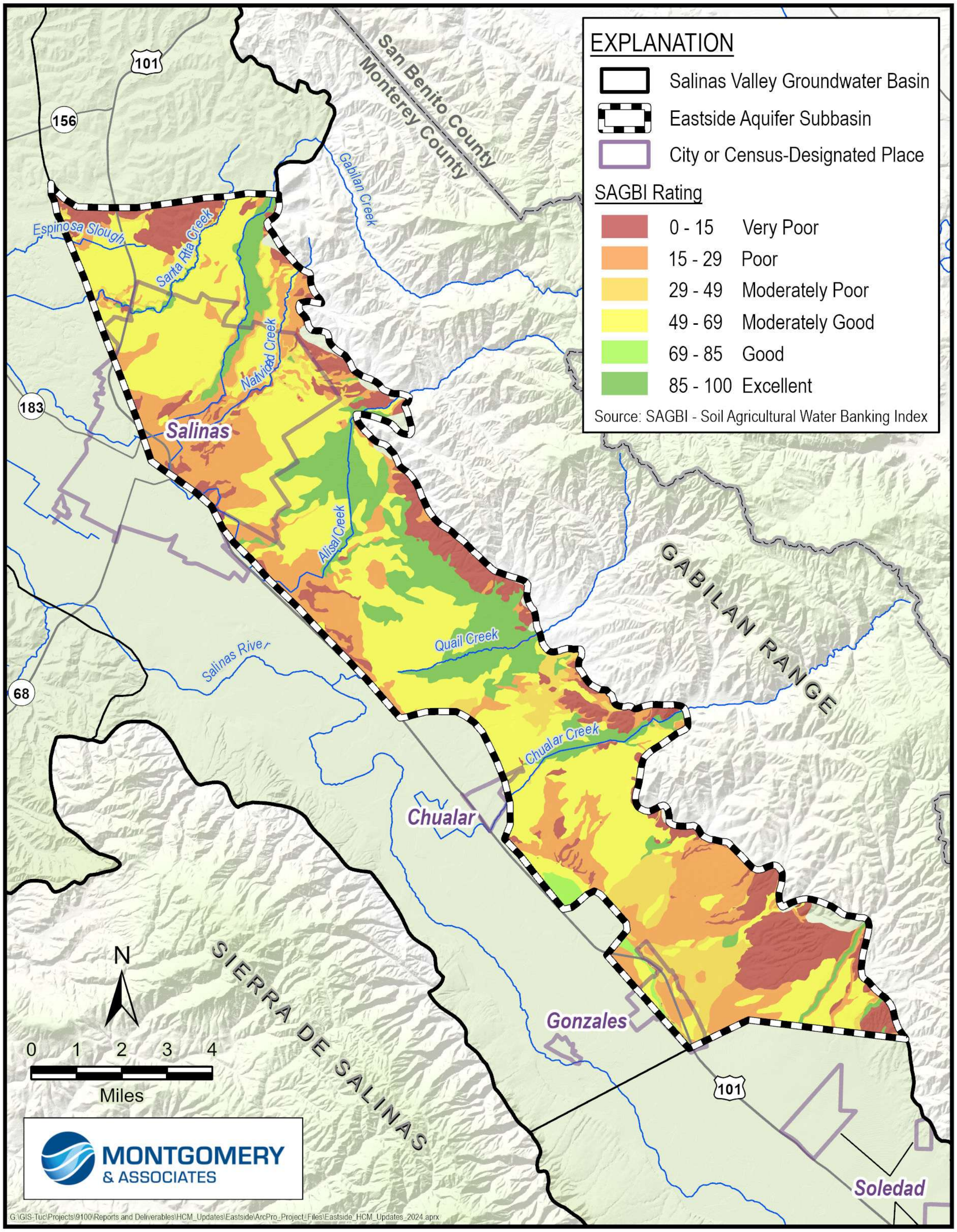

Figure 6. SAGBI Soil Mapping

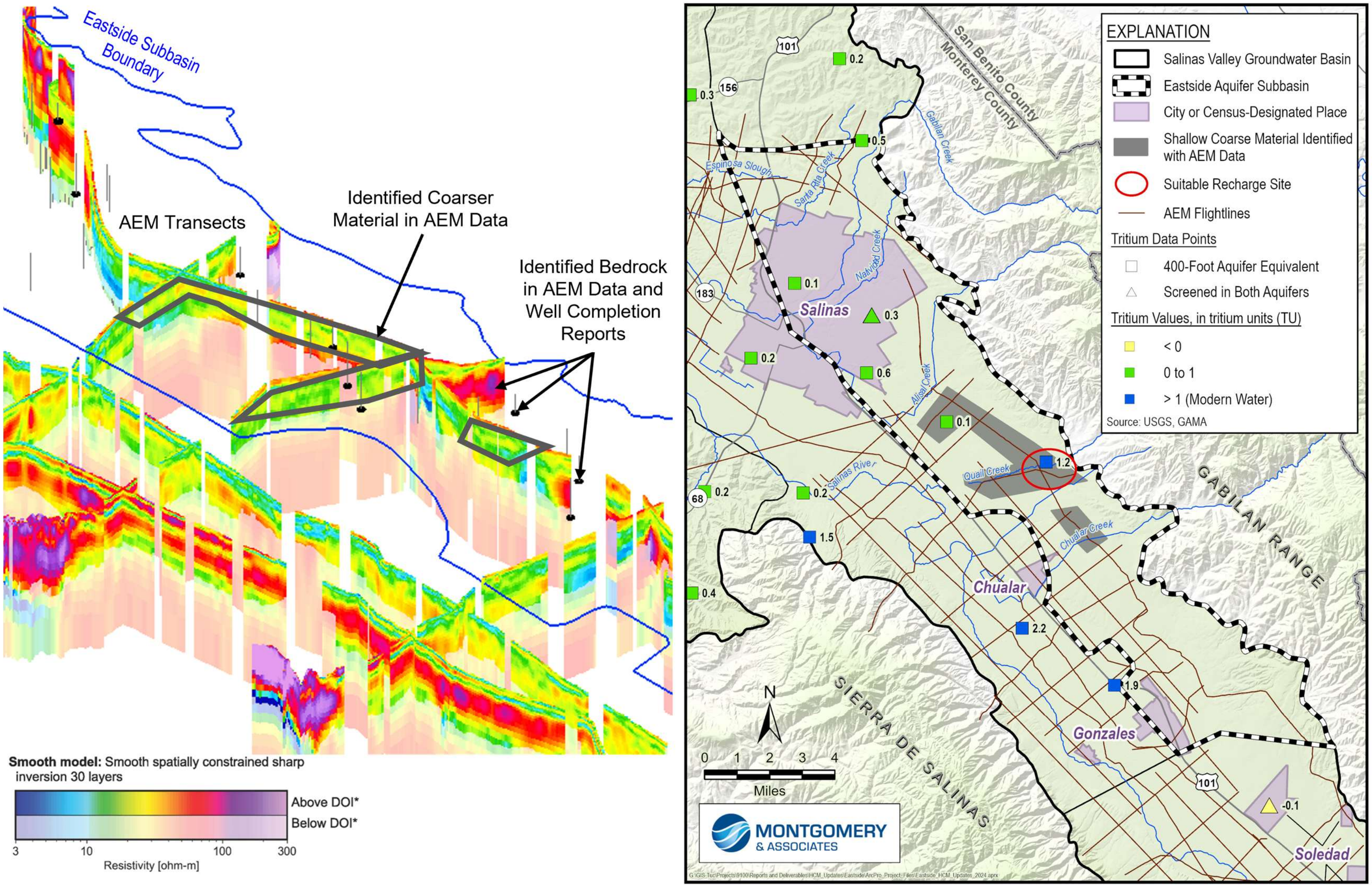

Figure 7. Suitable Location for a Rechage Project with Supporting Data

CONCLUSIONS

The Eastside Subbasin HCM presented in the GSP was developed using the best available data and information at the time. This HCM update uses the best available data and information procured since GSP development and provides clear refinements for the Subbasin overall.

The following are principal updates to the Eastside Subbasin HCM:

- The bedrock surface that delineates the bottom of the Subbasin is both shallower and more gently sloping from the Gabilan Range than previously understood.
- The alluvial fans that characterize the Subbasin are identified by the presence of high clay content, which is likely from chemical decomposition of eroded granitic material from the Gabilan Range, and follow the slope of the redefined bedrock surface.
- The Deep Aquifers are hydraulically connected to the Deep Zone of the Eastside Subbasin's principal aquifer and extend farther into the northern part of the Subbasin than previously mapped, based on the results of the *Deep Aquifer Study* (M&A, 2024).
- One potentially suitable recharge location is identified along Quail Creek, and supported by multiple lines of data. Other recharge locations and pathways are likely to be more limited throughout the Subbasin as a result of sediments with higher content of fine-grained materials close to the surface, and/or due to the discontinuous nature of the alluvial sediments which may not provide a viable mechanism for direct recharge.

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