Santa Maria River Valley Groundwater Basin

Basin Boundary Modification Request Technical Report

July 20, 2018

Prepared for

San Luis Obispo County Flood Control and Water Conservation District

Prepared by

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CERTIFICATION OF TECHNICAL REPORTS AND MAPS
TECHNICAL REPORT
SANTA MARIA RIVER VALLEY GROUNDWATER BASIN
BASIN BOUNDARY MODIFICATION APPLICATION

on behalf of
San Luis Obispo County Flood Control and Water Conservation District Groundwater Sustainability Agency

Pursuant to the following basin boundary modifications:

Basin: Santa Maria River Valley Groundwater Basin, Basin 3-12
Requesting Agency: Santa Maria Basin Fringe Areas – County of San Luis Obispo Groundwater Sustainability Agency
Types of Modifications: Scientific External, Scientific Internal
Short Descriptions:

1. Scientific External Boundary Modification - Exclude the Pismo Creek Valley Fringe Area from the Santa Maria River Valley Basin and modify the basin boundary to be coincident with the Adjudicated Area boundary of the basin.
2. Scientific External Boundary Modification – Amend the boundary of the Arroyo Grande Creek Valley Fringe Area northeast of the Adjudicated Area boundary of the Santa Maria River Valley Basin from the current published Bulletin 118 boundary line to coincide with the mapped extent of the Recent Alluvium, and amend the Bulletin 118 boundary approximately 1 mile south of the Fringe Area so that it is coincident with the Adjudicated Area boundary, and forms a continuous boundary with the eastern edge of the Arroyo Grande Creek Fringe Area.
3. Scientific Internal Boundary Modification –Create a new “Santa Maria River Valley – Arroyo Grande” subbasin defined by the extent of mapped Recent Alluvium north of the Adjudicated Area boundary of the Santa Maria River Valley Basin.
4. Scientific External Boundary Modification – Exclude the Nipomo Valley Fringe Area from the Santa Maria River Valley Basin, and modify the basin boundary to be coincident with the Adjudicated Area boundary of the basin.
5. Scientific External Boundary Modification – Exclude the Southern Bluffs Fringe Area from the Santa Maria River Valley Basin, and modify the basin boundary to be coincident with the Adjudicated Area boundary of the basin.
6. Scientific External Boundary Modification –Exclude the Ziegler Canyon Fringe Area from the Santa Maria River Valley Basin, to modify the basin boundary to be coincident with the Adjudicated Area boundary of the basin.

This report was prepared by the staff of GSI Water Solutions, Inc. under the direct supervision of professionals whose signatures appear on the following page. We are familiar with the information submitted and believe that the information is true, accurate, and complete. We are further aware that, under California Code of Regulations, Title 25, Section 22-66015.5, “Certification” means a statement of professional opinion based upon knowledge and belief. The findings or professional opinion were prepared in accordance with generally accepted professional engineering and geologic practice.

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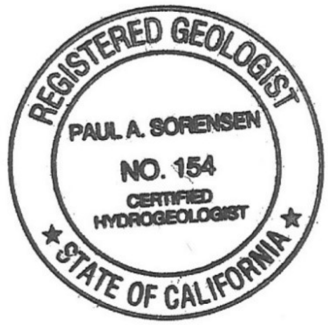

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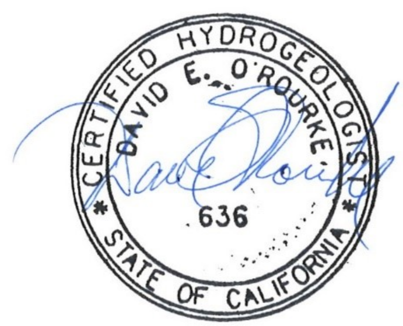

Contents

Tables

Figures

Appendices

List of Acronyms

AFY – Acre-feet per year
AGOF – Arroyo Grande Oil Field
BBMR – Basin Boundary Modification Request
DOGGR – Department of Oil, Gas, and Geothermal Resources
DWR – California Department of Water Resources
EPA – Environmental Protection Agency
GSA – Groundwater Sustainability Agency
GSP – Groundwater Sustainability Plan
MGD – Million gallons per day
NCMA – Northern Cities Management Area
NMMA – Nipomo Mesa Management Area
SMRVGB – Santa Maria River Valley Groundwater Basin
SMVMA – Santa Maria Valley Management Area
SGMA – Sustainable Groundwater Management Act
SWRCB – State Water Resources Control Board
TDEM – Time Domain Electro Magnetic
WWTP – Wastewater Treatment Plant

Executive Summary

This technical report (Report) documents the hydrogeologic data that supports the Santa Maria River Valley Groundwater Basin (SMRVGB or Basin) basin boundary modification requests (BBMR) being proposed by the County of San Luis Obispo acting as the Santa Maria Basin Fringe Areas - County of San Luis Obispo Groundwater Sustainability Agency (County GSA). The proposed basin boundary modifications presented in this report are prepared in accordance with the California Department of Water Resources (DWR) requirements for boundary modifications described in the California Code of Regulations, Title 23 (Waters), Division 2 (Department of Water Resources), Charter 1.5 (Groundwater Management), Subchapter 1 (Groundwater Basin Boundaries), Article 5 (Supporting Information).

The main part of the SMRVGB has been the subject of a lengthy and costly process of litigation and ultimate adjudication, beginning in 1997 and reaching adjudication in 2008. During the technical analysis provided by hydrogeologic experts for each of the litigating parties, it was specifically determined, and agreed to by all of the contestant parties, that the tributary alluvial valleys to the SMRVGB did not have significant enough groundwater resources to affect the management of the Basin, and the Adjudicated Area boundary was specifically drawn to exclude the tributary valleys.

The Sustainable Groundwater Management Act (SGMA) requires certain actions be taken in groundwater basins designated as either high or medium priority by DWR. DWR identified the SMRVGB as a high priority basin; however, SGMA requirements mandating Groundwater Sustainability Plans (GSP) do not apply to a majority of the Basin that is at issue in *Santa Maria Valley Water Conservation District v. City of Santa Maria*, et al. [1] (Adjudicated Area), provided that existing management activities are maintained. The boundaries of the Adjudicated Area do not coincide with the Basin boundaries as documented in DWR's Interim Update to Bulletin 118 (2016). Because the Fringe Areas are not within the Adjudicated Area boundary, they are subject to the requirements of SGMA, and are currently classified as parts of a high priority basin. In order to comply with SGMA, the County of San Luis Obispo (County) formed a Groundwater Sustainability Agency (GSA) over these Fringe Areas. The City of Arroyo Grande formed a GSA over a portion of the Fringe Area known as the Arroyo Grande Creek Valley, and the County of Santa Barbara formed a GSA over a portion of the Fringe Area known as Ziegler Canyon.

In coordination with these other two GSAs, the County GSA is submitting these requests to DWR to revise the boundaries of the SMRVGB as follows:

Modification Request Number 1 – Scientific External Boundary Modification - Exclude the Pismo Creek Valley Fringe Area from the SMRVGB and modify the Basin boundary to be coincident with the Adjudicated Area boundary. Analysis of the hydrogeologic setting and other technical data of the alluvium presented in this analysis indicates that the alluvium in this Fringe Area is not considered to be an aquifer, defined in Article 2 §341 (Definitions) as "… a three-dimensional body of porous and permeable sediment or sedimentary rock that contains sufficient material to yield significant quantities of

[1] Pursuant to Water Code 10720.8(a)(18), some requirements of SGMA do not apply to the Adjudicated Areas of the Santa Maria Valley Groundwater Basin.

groundwater to wells and springs, as further defined or characterized in Bulletin 118." Supporting data presented in this analysis indicate the following:

a) Previous studies and analyses of the alluvium in the Pismo Creek Valley Fringe Area have concluded that that the alluvium in the valley is not sufficiently viable to support a proposed project with an estimated demand of 300 AFY. This demonstrates that the alluvium in the Pismo Creek Valley is not a viable aquifer, and is unable to sustain even modest development.
b) There is presently almost no use of groundwater from the alluvium. Only a single alluvial well is in current use, providing minimal supply to a local landowner for occasional supply of stock tanks. This again demonstrates that the alluvium is not a viable aquifer, as it has not been able to produce any significant supply in recent decades.
c) The CASGEM Basin Prioritization Process report (DWR, 2014) and the 2018 draft basin prioritization states that basins with less than 2,000 AFY of pumping "were automatically ranked as CASGEM Very Low Priority groundwater basins, meaning the Overall Basin Ranking Score is overridden with a zero." Estimated groundwater use in Pismo Creek Valley is less than 2,000 AFY, and no undesirable results as defined in SGMA have been observed. If the CASGEM basin prioritization criteria for groundwater use may be viewed as a proxy to define significant production from a basin, then the Pismo Creek Valley Fringe Area does not utilize significant production of groundwater.
d) The relatively thin veneer of recent alluvium in the Pismo Creek Valley Fringe Area sits directly atop bedrock throughout the entire extent of the valley. The Wilmar Avenue Fault Zone forms an effective barrier to groundwater flow by juxtaposing the impermeable bedrock formations northeast of the fault against the stacked permeable aquifers of the SMRVGB, with more than 500 feet of accumulated Basin sediments, demonstrating that there is no geologic continuity or significant hydraulic connection between the Pismo Creek Fringe Area and the Adjudicated Area, except through the thin veneer of alluvium.
e) Available water level data indicate that there are no declining water level trends in the alluvium, showing that the groundwater in the Fringe Area has demonstrated sustainability over the past twenty years, prior to the implementation of SGMA.
f) Cross Sections indicate that in the part of the Fringe Area north of the Adjudicated Area along the coast, the Quaternary Terrace deposits in this area lie directly atop the bedrock of the Obispo Formation. No viable aquifer capable of producing groundwater exists in this area.
g) Underflow from the Pismo Creek Valley Fringe Area to the Adjudicated Area is only about 0.2% of the recharge to the Adjudicated Area of the Basin in San Luis Obispo County. This demonstrates that the Pismo Creek Valley Fringe Area does not contribute significant recharge to the Adjudicated Area of the Basin, and that hydrogeologic conditions in the Fringe Area will not affect the ability to sustainably manage the Adjudicated Area.
h) The technical experts and the Court for the Basin adjudication also concluded that the alluvial valleys that are tributary to the Adjudicated Area do not contain significant groundwater resources to affect the management of the Adjudicated Area, and specifically excluded it from the Adjudicated Area on that basis.

If DWR finds that the hydrogeologic evidence presented herein does not sufficiently support the request for exclusion of the Pismo Creek Valley Fringe Area, the County GSA proposes the following optional BBMR alternative for DWR's consideration, based on items d through h, above: Adjust the boundary of the Pismo Creek Valley Fringe Area north of the adjudicated boundary of the SMRVGB from the current published Bulletin 118 boundary line to coincide with the mapped extent of the Recent Alluvium, as mapped by Hall (1973), from the adjudicated Basin boundary to the northern extent of the Fringe Area, and establish a new "Santa Maria River Valley – Pismo Creek Valley" subbasin from the SMRVGB defined by the extent of mapped Quaternary Alluvium between the current Adjudicated Area boundary and the northern extent of the current Fringe Area.

Modification Request Number 2 – Scientific External Boundary Modification – Amend the boundary of the Arroyo Grande Creek Valley Fringe Area northeast of the Adjudicated Area boundary of the SMRVGB from the current published Bulletin 118 boundary line, to coincide with the mapped extent of the Recent Alluvium, as mapped by Dibblee (2006b, c, d, e), and adjust the Bulletin 118 boundary immediately south of the Arroyo Grande Creek Valley in the Adjudicated Area so that it is coincides with the adjudicated boundary in that area . Current Bulletin 118 boundaries extend up the mountain slopes west of the valley, and cross through the middle of the valley floor, an apparent artifact of mapping at a larger scale in the past. The requested amendment of the boundaries reflects the original intent of the boundary delineation, relying on most recent and smaller scale geologic mapping to accurately represent the lateral boundaries of the Recent Alluvium, and maintains a continuous boundary from the Arroyo Creek Valley to the Adjudicated Area.

Modification Request Number 3 – Scientific Internal Boundary Modification –Create a new "Santa Maria River Valley – Arroyo Grande" subbasin defined by the extent of mapped Recent Alluvium (Dibblee) north of the Adjudicated Area boundary. Analysis of the hydrogeologic setting of the Arroyo Grande Creek Valley Fringe Area and other technical data presented in this report that supports creation of a separate subbasin includes the following:

a) The primary productive aquifers in the Adjudicated Area are the Paso Robles Formation and the Careaga Formation. The relatively thin veneer of recent alluvium in the Arroyo Grande Creek Valley Fringe Area sits directly atop the bedrock of the Pismo, Monterey, and Obispo Formations. No SMRVGB aquifer materials (except for Recent Alluvium) are present in the surface or subsurface of the Arroyo Grande Creek Valley Fringe Area.
b) The Wilmar Avenue Fault Zone forms an effective barrier to groundwater flow by juxtaposing the impermeable bedrock formations underlying the Alluvium northeast of the fault against the stacked permeable aquifers of the SMRVGB, with over 500 feet of accumulated Basin sediments southwest of the fault, demonstrating that there is no significant hydraulic connection between the Arroyo Grande Creek Fringe Area and the Adjudicated Area, except through the Recent Alluvium.
c) Groundwater level gradients across the Wilmar Avenue Fault Zone display a discontinuity in elevations across the fault. Groundwater elevations in alluvium in the downstream extent of the valley are approximately 60 feet higher than groundwater elevations in the shallow zone of the

Adjudicated Area. This demonstrates that any changes in hydrogeologic conditions in the Adjudicated Area will not propagate upgradient to have any effect on the sustainable management of groundwater in the Arroyo Grande Creek Valley Fringe Area, and vice versa.

d) Groundwater elevation hydrographs in the Arroyo Grande Creek Fringe Area have remained stable over the past decades, in part due to the regular recharge of the aquifer from downstream releases from Lopez Lake. By contrast, the main part of the Basin has been designated a high priority basin, in part due to documented water level declines. This demonstrates that the two areas are separate and distinct hydrogeologic regimes, and that a designation as a distinct subbasin is appropriate.

Modification Request Number 4 – Scientific External Boundary Modification – Exclude the Nipomo Valley Fringe Area from the SMRVGB, and modify the Basin boundary to be coincident with the Adjudicated Area boundary. Analysis of the hydrogeologic setting of the Nipomo Valley presented in this analysis indicates the following data supporting exclusion of the Nipomo Valley Fringe Area from the SMRVGB:

a) None of the primary aquifers of the SMRVGB (Recent Alluvium, Paso Robles Formation, Careaga Formation) are present as hydrogeologic units in the Nipomo Valley Fringe Area. This demonstrates that the Nipomo Valley Fringe Area is comprised of different geologic materials than the SMRVGB, and should not be considered part of the Basin.

b) The primary hydrogeologic unit in the Nipomo Valley Fringe Area is the bedrock of the Monterey and Obispo Formations, which are not part of the SMRVGB materials.

c) Throw along the Wilmar Avenue Fault and Santa Maria River Faults forms an effective barrier to groundwater flow by juxtaposing the impermeable bedrock northeast of the fault in Nipomo Valley with hundreds of feet of permeable Basin and aquifer materials southwest of the fault. This geologic relationship clearly demonstrates that there is no geologic continuity or significant hydraulic connection between Basin aquifer materials southwest of the fault and Nipomo Valley Fringe Area.

d) Because water is drawn from the Monterey Formation in the Nipomo Valley Fringe Area, which is not part of the Basin sediments, hydrogeologic conditions in the Fringe Area will have no effect on the sustainable management of the sedimentary aquifers of the SMRVGB. Similarly, management actions in the Adjudicated Area will have no impact on the conditions in the Nipomo Valley.

e) Historical water quality data indicate distinctly different water quality for wells that draw from the Monterey Formation in the Nipomo Valley Fringe Area and wells that draw from the Paso Robles/Careaga Formations in the Adjudicated Area. This corroborates the interpretation that the Nipomo Valley and the Adjudicated Area have distinctly different hydrogeologic environments, and that excluding the Nipomo Valley from the SMRVGB will have no effect on the ability of the Adjudicated Area to sustainably manage their groundwater resources.

f) The technical experts and the Court for the Basin adjudication also concluded that the Nipomo Valley Fringe Area is not part of the Basin, and specifically excluded it from the Adjudicated Area.

Modification Request Number 5 – Scientific External Boundary Modification – Exclude the Southern Bluffs Fringe Area from the SMRVGB, and modify the Basin boundary to be coincident with the Adjudicated Area boundary. Analysis of the hydrogeologic setting of the Southern Bluffs Fringe Area presented in this analysis indicates the following technical data supporting exclusion of the Southern Bluffs Fringe Area from the SMRVGB:

a) None of the primary aquifers of the SMRVGB (Recent Alluvium, Paso Robles Formation, Careaga Formation) are present as hydrogeologic units in the Southern Bluffs. This demonstrates that the Southern Bluffs Fringe Area is comprised of different geologic materials than the SMRVGB, and should not be considered part of the Basin.
b) The primary hydrogeologic unit in the Southern Bluffs Fringe Area is the bedrock of the Monterey and Obispo Formations, and the Franciscan Group, which are not part of the SMRVGB materials.
c) Throw along the Santa Maria River Fault in the Southern Bluffs forms an effective barrier to groundwater flow by juxtaposing the impermeable bedrock northeast of the fault with hundreds of feet of permeable Basin and aquifer materials southwest of the fault . This geologic relationship demonstrates that there is no geologic continuity or significant hydraulic connection between Basin aquifer materials southwest of the fault and Southern Bluffs Fringe Area.
d) The bedrock formations in the Fringe Area are not viable aquifers capable of supporting the existing agriculture without bringing water from nearby alluvial wells located outside the Fringe Area.
e) All groundwater produced in the Southern Bluffs Fringe Area is from bedrock formations. Therefore, hydrogeologic conditions in the Fringe Area will have no effect on the sustainability of the SMRVGB or the groundwater conditions in the SMRVGB, and vice versa.
f) The technical experts and the Court for the Basin adjudication also concluded that the Southern Bluffs Fringe Area is not part of the Basin, and specifically excluded it from the Adjudicated Area.
g) The technical experts and the Court for the Basin adjudication also concluded that the Nipomo Valley Fringe Area is not part of the Basin, and specifically excluded it from the Adjudicated Area.

Modification Request Number 6 – Scientific External Boundary Modification –Exclude the Ziegler Canyon Fringe Area from the SMRVGB, to modify the Basin boundary to be coincident with the Adjudicated Area boundary. San Luis Obispo County has coordinated with Santa Barbara County staff and local landowners in the preparation of this BBMR. Analysis of the hydrogeologic setting of the Ziegler Canyon Fringe Area presented in this report indicates the following technical data supporting exclusion of the Ziegler Canyon Fringe Area from the SMRVGB:

a) All participants in the adjudication proceedings agreed to specifically omit the Ziegler Canyon area from the Adjudicated Area, based on the judgment that groundwater was not present in significant amounts to affect management actions in the main body of the Basin.

b) The CASGEM Basin Prioritization Process report (DWR, 2014) and the 2018 draft basin prioritization results states that basins with less than 2,000 AFY of pumping "were automatically ranked as CASGEM Very Low Priority groundwater basins, meaning the Overall Basin Ranking Score is overridden with a zero." Estimated groundwater use in Ziegler Canyon is less than 2,000 AFY, and no undesirable results as defined in SGMA have been observed. If the CASGEM basin prioritization criteria for groundwater use may be viewed as a proxy to define significant production from a basin, then the Ziegler Canyon Fringe Area does not utilize significant production of groundwater.
c) No SMRVGB aquifer materials (except for Recent Alluvium) are present in the surface or subsurface of the Ziegler Canyon Fringe Area. The relatively thin veneer of recent alluvium in the Ziegler Canyon Fringe Area sits directly atop the bedrock of the Monterey and Obispo Formations.
d) The Santa Maria River Fault Zone forms an effective barrier to groundwater flow by juxtaposing the impermeable bedrock northeast of the fault against the stacked permeable aquifers of the SMRVGB, with over 800 feet of accumulated Basin aquifer sediments southwest of the fault. This geologic relationship clearly shows that there is no geologic continuity or significant hydraulic connection between Basin aquifer materials southwest of the fault and the Ziegler Canyon Fringe Area, except for the presence of the thin alluvial sediments which are present in the valley, across the fault zone, and in the Adjudicated Area.
e) Groundwater levels display a significant discontinuity across the Santa Maria River Fault Zone between Ziegler Canyon and the Adjudicated Area. Groundwater elevations in the downgradient extent of the Ziegler Canyon Fringe Area are approximately 100 feet higher than groundwater elevations in the nearby Adjudicated Area. This demonstrates that hydrogeologic regimes of the SMRVGB and the Ziegler Canyon Fringe Area are distinct, and that conditions in the Fringe Area will not impact the ability to sustainably manage the SMRVGB.
f) Water levels in Ziegler Canyon alluvial wells have not shown any long term water level declines over the past twenty years, demonstrating that groundwater has been utilized in a sustainable fashion over this tie period.
g) Long-term groundwater sustainability in Ziegler Canyon is ensured due to the regular recharge of the alluvial aquifer accomplished as a result of downstream releases from Twitchell Dam, which are codified in the adjudication judgment.
h) The three landowners who own the entirety of the Fringe Area have managed the groundwater in the valley sustainably over the past decades without State oversight, as demonstrated by the stable water level trends in groundwater elevation hydrographs over the past twenty years.

If DWR finds that the evidence presented herein does not sufficiently support the request for exclusion of the Ziegler Canyon Fringe Area, the County GSA proposes the following optional BBMR alternative for DWR's consideration, based on items c through h, above: Adjust the boundary of the Ziegler Canyon Fringe Area northeast of the adjudicated boundary of the SMRVGB from the current published Bulletin 118 boundary line, to coincide with the mapped extent of the Recent Alluvium, from the adjudicated Basin boundary to the base of Twitchell Dam, and establish a new "Santa Maria River Valley - Ziegler

Canyon" subbasin from the SMRVGB defined by the extent of mapped Quaternary Alluvium and Older Alluvium (Dibblee) between the current Adjudicated Area boundary and the base of Twitchell Dam.

1. Introduction

This Technical Report (Report) documents the hydrogeologic data that supports the basin boundary modification requests (BBMRs) by the County of San Luis Obispo acting as the Santa Maria Basin Fringe Area - San Luis Obispo County Groundwater Sustainability Agency (County GSA) This report also presents the proposed BBMRs and is prepared in accordance with the California Department of Water Resources (DWR) requirements for boundary modifications described in the California Code of Regulations, Title 23 (Waters), Division 2 (Department of Water Resources), Charter 1.5 (Groundwater Management), Subchapter 1 (Groundwater Basin Boundaries), Article 5 (Supporting Information). It is the objective of this report to provide physical, geologic, and hydrogeologic evidence to support the proposed scientific basin boundary modifications being applied for by the County GSA, as detailed in Table 1.

The Sustainable Groundwater Management Act (SGMA) took effect on January 1, 2015, and requires certain actions be taken in groundwater basins designated as either high or medium priority by the DWR. DWR identified the Santa Maria River Valley Groundwater Basin (SMRVGB, or Basin) (Bulletin 118, Basin 3-12) as a high priority basin; however, SGMA requirements mandating Groundwater Sustainability Plans (GSP) do not apply to that portion of the Basin that is at issue in *Santa Maria Valley Water Conservation District v. City of Santa Maria*, et al. [2] (Adjudicated Area), provided that existing management activities are maintained. The Adjudicated Area covers a majority of the Basin. The boundaries of the Adjudicated Area do not coincide with the Basin boundaries as documented in DWR's Interim Update to Bulletin 118 (2016). The Adjudicated Area boundaries encompass an area of 255 square miles (163,300 acres). For the purposes of this Report, the areas between the Bulletin 118 Basin boundaries and the Adjudicated Area boundary in San Luis Obispo County are referred to as "Fringe Areas" (Figure 1). The combined area of the five non-contiguous Fringe Areas that are the subject of this technical report is 25 square miles (15,950 acres). Because the Fringe Areas are not within the Adjudicated Area boundary, they are subject to the requirements of SGMA, and are currently classified as parts of a high priority basin. In order to comply with SGMA, the County of San Luis Obispo (County) formed a Groundwater Sustainability Agencies (GSA) over these Fringe Areas. The City of Arroyo Grande formed a GSA over a portion of the Fringe Area known as the Arroyo Grande Creek Valley, and the County of Santa Barbara formed a GSA over a portion of the Fringe Area known as Ziegler Canyon.

SGMA is groundwater management legislation, but does not change any existing groundwater rights. It is important to note that any potential change in the Basin will not impact the existing jurisdiction of any land use authority, police powers, or other authorities of the existing cities, counties, or state/federal

[2] Pursuant to Water Code 10720.8(a)(18), some requirements of SGMA do not apply to the Adjudicated Areas of the Santa Maria Valley Groundwater Basin.

agencies. Similarly, any potential change in basin boundaries does nothing to affect or reduce the jurisdiction of existing County, State, or Federal agencies, such as the State Water Resources Control Board or the Environmental Protection Agency, from their current mandate and mission to protect groundwater quality.

Table 1. DWR Requirements for a Scientific BBMR and Report Section References

Requirement	Report Section (Figures, Tables, Appendices)					Basin Boundary Emergency Regulation
	Pismo Creek	Arroyo Grande	Nipomo Valley	Southern Bluffs	Ziegler Canyon	
General Information (§344.10)						
Define Basin Boundaries						
Lateral Boundaries	2.2, 2.4 (Fig 5)	3.2, 3.4 (Fig 13)	4.2, 4.4 (Fig 24)	5.2, 5.4 (Fig 30)	6.2, 6.4 (Fig 37)	§344.10(a)
Definable bottom of the basin or subbasin	2.2, 2.4 (Figs 6, 7)	3.2, 3.4 (Figs 14, 15)	4.2, 4.4	5.2, 5.4	6.2, 6.4 (Fig 38, 39)	§344.10(a)
Graphical Map						
Proposed Basin or Subbasin boundary	2.5 (Fig 10)	3.5 (Fig 21)	4.5 (Fig 27)	5.5 (Fig 34)	6.5 (Fig 46)	§344.10(b)
Existing DWR basin or Subbasin boundary	2.5 (Fig 10)	3.5 (Fig 21)	4.5 (Fig 27)	5.5 (Fig 34)	6.5 (Fig 46)	§344.10(b)
Local Agencies within or bordering proposed basin.	2.5 (Fig 10)	3.5 (Fig 21)	4.5 (Fig 27)	5.5 (Fig 34)	6.5 (Fig 46)	§344.10(b)
Hydrogeologic Conceptual Model (§344.12)						
Principal Aquifer Units	1.2, 2.4	1.2, 3.4	1.2, 4.4	1.2, 5.4	1.2, 6.5	§344.12(a)(1)
Lateral Boundaries, including:	2.4 (Fig 5)	3.4 (Fig 13)	4.4 (Fig 24)	5.4 (Fig 30)	6.4 (Fig 37)	§344.12(a)(2)
Geologic Features that significantly impede or impact groundwater flow	2.2	3.2	4.2	5.2	6.2	§344.12(a)(2)(A)
Aquifer characteristics that significantly impede or impact groundwater flow	2.3	3.3	4.3	5.3	6.3	§344.12(a)(2)(B)
Signfiicant features and conditions of the principal aquifers, including:	2.3	3.3	4.3	5.3	6.3	§344.12(a)(2)(C)
Confined or unconfined nature of the aquifer	2.3	3.3	4.3	5.3	6.3	§344.12(a)(2)(C)
Faults and folds	2.2 (Figs 6, 7)	3.4 (Figs 14, 15)	4.4 (Figs 25, 26)	5.4 (Figs 31, 32)	6.4 (Fig 38, 39)	§344.12(a)(2)(C)
Key surface water bodies and significant recharge sources	2.1.4	3.1.4	--	--	6.1.4	§344.12(a)(2)(D)
Recharge and discharge areas	2.3.3, 2.4	3.3.3, 3.4	4.4	5.4	6.3.2, 6.3.3, 6.4	§344.12(a)(3)
Definable bottom of the basin	2.4 (Figs 6, 7)	3.4 (Figs 14, 15)	4.4	5.4	6.4 (Fig 38, 39)	§344.12(a)(4)
Technical Information for Scientific Modifications (§344.14)						
Qualified map depicting lateral boundaries	2.4 (Fig 5)	3.4 (Fig 13)	4.4 (Fig 24)	5.4 (Fig 30)	6.4 (Fig 37)	§344.14(a)(1)
Technical study with subsurface data	All Sections	All Sections	All Sections	All Sections	All Sections	§344.14(a)(2)
Qualified map depicting geologic structures or features impeding flow	2.4 (Fig 5)	3.4 (Fig 13)	4.4 (Fig 24)	5.4 (Fig 30)	6.4 (Fig 37)	§344.14(b)(1)
Technical study providing geologic or hydrogeologic evidence of groundwater conditions, as appropriate						
Historical potentiometric surface maps	--	3.3.2 (Fig 16)	--	--	6.3.2 (Fig 42)	§344.14(b)(2)(A)
Current potentiometric surface map	--	3.3.2 (Fig 17)	--	--	6.3.2 (Fig 39)	§344.14(b)(2)(A)
Groundwater levels	2.3.2 (Fig 9)	3.3.2 (Figs 18-20)	--	--	6.3.2 (Figs 40-44)	§344.14(b)(2)(A)
Recharge and discharge areas	2.3.3, 2.4	3.3.3, 3.4	4.4	5.4	6.4	§344.14(b)(2)(A)
Aquifer testing results	2.3.1 (Table 3)	3.3.1 (Table 6)	--	--	6.3.1 (Tables 7, 8)	§344.14(b)(2)(B)
Water quality information	--	--	4.3.2	--	--	§344.14(b)(2)(C)
Geophysical investigations and supporting data	--	--	--	--	6.3.4 (App C)	§344.14(b)(2)(D)
Other relevant technical information	--	--	--	--	6.1.5	§344.14(b)(2)(E)

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1.1 Fringe Areas

There are five Fringe Areas within San Luis Obispo County that are addressed in this supporting technical report (Figure 1). The following is a list of Fringe Areas from north to south:

- Pismo Creek Valley Fringe Area
- Arroyo Grande Creek Valley Fringe Area
- Nipomo Valley Fringe Area
- Southern Bluffs Fringe Area
- Ziegler Canyon Fringe Area (previously referred to as Cuyama River Valley Fringe Area; this Fringe Area is located in both San Luis Obispo and Santa Barbara Counties.)

A comprehensive analysis and characterization of the Fringe Areas is key to understanding their geology and hydrogeology, and providing foundational information necessary to aid in the management of this critical resource.

1.2 Approach

In the body of this report, technical details for each Fringe Area are discussed separately, but each area is evaluated using the same categories of data and analytical approach. This report presents a summary of the physical setting (including available information on topography, land use, water use, and hydrology), geologic setting, and hydrogeologic setting. All available published reports, private well reports, well completion reports, geologic logs, water level data, and other data were reviewed to generate a compilation of the current understanding of the hydrogeologic setting of the Fringe Areas.

A series of field work activities were performed as described in the following. Constant rate aquifer tests were performed on existing wells in Arroyo Grande Valley and Ziegler Canyon. Pumping test data existed for the known alluvial wells in Pismo Creek Valley, and no additional appropriate wells in this Fringe Area were identified for testing. Nipomo Valley and Southern Bluffs have no wells in the Basin materials. New water level data were collected from several existing wells in key locations. A surface geophysical study was also performed by Ramboll/Environ in Ziegler Canyon.

Crop water demand for irrigation is estimated by applying the crop demand factors in Table 2 to acreage planted in each crop type (based on DWR GIS crop acreage data from 2014).

This report is organized to present the background information, supporting data, and specific BBMRs for each Fringe Area in separate chapters. Of particular importance to each fringe area is its relationship to the Adjudicated Area of the Basin. Therefore, a brief introduction to the hydrogeology of the Adjudicated Area will be discussed.

Table 2 – Crop Demand Factors

Crop Type	Applied Water (acre-feet/acre/year)
Rotational Vegetables	2.27
Strawberries	1.38
Vines	1.08
Alfalfa	3.46
Grain	0.3
Nursery	2.02
Deciduous	2.64
Avocado/Citrus	2.86
Reference: Crop demand factors from GEI, 2013	

1.3 Santa Maria River Valley Basin Hydrogeologic Setting

Of particular significance to the boundary modification requests presented herein is the geologic and hydrogeologic relationships of the Fringe Areas to the Adjudicated Area. A detailed basin characterization report of the Adjudicated Area of the SMRVGB in San Luis Obispo County has been prepared previously (Fugro, 2015). However, this report did not include discussion of the Fringe Areas. A detailed description of the SMRVGB can be found in that document; however, a brief summary of the more significant features of the Basin as they relate to the Fringe Areas is presented here.

The Adjudicated Area of the Basin is a collection of water-bearing sediments of various geologic formations that collectively represent an essential component of the water supply for southern San Luis Obispo County. Figure 2 presents a stratigraphic column displaying the formations that are most relevant to the local hydrogeology of both the Adjudicated Area and the Fringe Areas. For the purpose of discussion in this section of the report, the rocks in the Adjudicated Area and the Fringe Areas will be considered as two basic groups: sedimentary formations of the Basin and bedrock formations outside of the Basin. The bedrock formations range in age and composition from Jurassic-aged serpentine and marine sediments to Tertiary-aged volcanic and marine formations. Although bedding plane and/or structural fractures in these rocks may yield small amounts of water to wells, they do not represent a significant portion of the pumping in the area.

The most significant geologic structure in the Basin is the Wilmar Avenue Fault Zone and the Santa Maria River Fault Zone, and their various extensions and splays (Figure 1). These fault zones run approximately parallel to Highway 101 and along the base of the San Luis Range. The mapped extent of these faults approximates the northeastern boundary of the SMRVGB Adjudicated Area. To the northeast of this fault, older formations are upthrown and exposed at the surface. To the southwest of this fault lie the sediments that comprise the Adjudicated Area.

The water-bearing sedimentary formations present in the Adjudicated Area of the SMRVGB are briefly described below.

Recent Alluvium

The Recent Alluvium is the mapped geologic unit composed of unconsolidated sediments of gravel, sand, silt, and clay, deposited by fluvial processes along the courses of Pismo Creek, Arroyo Grande Creek, and the Cuyama River in Ziegler Canyon. Lenses of sand and gravel are the productive strata within the Recent Alluvium. These strata have no significant lateral continuity across large areas of subsurface. Thickness of Recent Alluvium in the Report area may range from just a few feet to nearly 100 feet. The alluvium constitutes the only non-bedrock aquifer in the Fringe Areas.

Dune Sand

The Dune Sands are only present in the Adjudicated Area, and are not present in the Fringe Areas. Dune Sands include established dune deposits with developed soil and vegetation, and younger dune sand which is actively drifting due to the effect of coastal winds. Dune sands are usually located above the main aquifer, but may have locally perched groundwater caused by interbedded clay layers.

Paso Robles Formation

The Paso Robles Formation underlies the Recent Alluvium throughout most of the Adjudicated Area. It is composed of poorly sorted, unconsolidated to mildly consolidated sandstone, siltstone, and claystone. The Paso Robles Formation was deposited in a terrestrial setting on a mildly sloping floodplain that has been faulted, uplifted, and eroded since deposition. It is extensive below recent dune sands in the Adjudicated Area, but is largely eroded away in the upthrown fault blocks northeast of the Wilmar Avenue Fault, present only as a few small isolated pods near the downstream extent of the Pismo Creek Valley. The Paso Robles Formation is a significant water source in the Adjudicated Area, but provides no water in the Fringe Areas.

Careaga Formation

The marine sandstone that underlies the Paso Robles Formation in the Adjudicated Area is referred to as the Careaga Formation. The Careaga Formation is a marine sandstone similar to the Pismo Formation. It occurs only at depth in the Adjudicated Area, below the Paso Robles Formation. It is not mapped northeast of the Wilmar Avenue Fault, in either the Fringe Areas or the mountainous areas in between. Wells that screen the Careaga Formation inside the Adjudicated Area boundaries are considered to be drawing from the Basin.

The depth of the saturated sediments ranges from 600 to 2,500 feet. The bedrock formations are briefly described below.

Pismo Formation

The Pismo Formation is a Pliocene-aged marine sedimentary unit composed of claystone, siltstone, sandstone, and conglomerate. The Pismo Formation is exposed at the surface in the Santa Lucia Mountains northeast of the adjudicated boundary, and underlies the Paso Robles Formation, where present. There are five recognized members of the Pismo Formation (Figure 2). While all are part of the Pismo Formation, the distinct members reflect different depositional environments, and the variations in geology may affect the hydrogeologic characteristics of the strata. From the top (youngest) down, these are:

- **The Squire Member**, generally described as a medium- to coarse-grained fossiliferous sandstone of white to grey sands.
- **The Belleview Member**, composed of interbedded fine grained sandstones and claystones.
- **The Gragg Member**, usually described as a medium-grained sandstone.
- **The Miguelito Member**, primarily composed of thinly bedded grey or brown siltstones and claystones.
- **The Edna Member**, which lies unconformably atop the Monterey Formation, and is locally bituminous (hydrocarbon-bearing) sandstone.

It is noteworthy that municipal wells in Arroyo Grande that draw from the Pismo Formation outside of the Adjudicated Area are not considered to be pumping from the Basin. The Pismo Formation outside of the Adjudicated Area boundary is not considered to be Basin material.

Monterey Formation

The Monterey Formation is a thinly bedded siliceous shale, with layers of chert in some locations. In numerous areas of San Luis Obispo County, the Monterey Formation is the source of significant oil production. An active oil field is present adjacent to and partially within the Pismo Creek Valley Fringe Area west of Price Canyon. While fractures in consolidated rock may yield small quantities of water to wells, the Monterey Formation is not considered to be water-bearing Basin materials by the DWR.

Obispo Formation

The Obispo Formation and associated Tertiary volcanic rocks are composed of materials associated with volcanic activity along tectonic plate margins approximately 20 to 25 million years ago. The Obispo Formation is composed of ash and other material expelled during volcanic eruptions. The Obispo Formation crops out in small exposures along the northeast side of the Wilmar Avenue Fault and its extensions. Although fractures in consolidated volcanic rock may yield small quantities of water to wells, the Obispo Formation is not considered to be water-bearing Basin materials by the DWR.

Franciscan Assemblage

The Franciscan Assemblage contains the oldest rocks in the Basin area, ranging in age from late Jurassic through Cretaceous (150 to 66 million years ago). The rocks include a heterogeneous collection of basalts, which have been altered through high-pressure metamorphosis associated with subduction of the oceanic crust beneath the North American Plate before the creation of the San Andreas Fault. Although fractures may yield small quantities of water to wells, the Franciscan Assemblage is not considered to be water-bearing Basin materials by the DWR.

1.4 Groundwater Litigation and Adjudication

This section provides a brief history of groundwater litigation and eventual adjudication in the SMRVGB.

The area of the SMRVGB is an area of intensive agricultural development. Conflicts arose involving competing uses of groundwater as far back as the 1970s and litigation regarding rights to pump groundwater from the SMRVGB commenced in 1997 (*Santa Maria Valley Water Conservation District v. City of Santa Maria et al.*, Lead Case No. CV 770214, consolidated with related actions) (Adjudication).

On June 30, 2005, a number of the parties to the Adjudication entered a stipulated judgment (Stipulation), which was approved by the Court on August 3, 2005. The Stipulation establishes three separate management areas, namely the Northern Cities Management Area (NCMA), the Nipomo Mesa Management Area (NMMA), and the Santa Maria Valley Management Area (SMVMA) (Figure 1), and requires each management area to establish a monitoring program to collect and analyze data regarding water supply and demand conditions within its relevant management area and to prepare and file with the court an Annual Report summarizing the results of the monitoring program, changes in groundwater supplies and any threats to groundwater supplies.

Given that a number of the parties to the Adjudication elected not to join (and challenged) the Stipulation, the Adjudication continued. On January 25, 2008, the trial court issued an order (Judgment) that, among other things, ordered the stipulating parties to comply with all of the terms of the Stipulation and independently adopted and imposed on the non-stipulating parties the groundwater monitoring provisions of the Stipulation. In *City of Santa Maria et al. v. Adam* (2012) 211 Cal.App.4th 266, the Sixth District Court of Appeal upheld the trial court's independent adoption and imposition of the monitoring provisions of the Stipulation and on February 13, 2013, the California Supreme Court denied review.

In accordance with the Judgment and the groundwater monitoring programs established pursuant thereto, the agencies collect and analyze data pertinent to water supply and demand, including:

- Land and water uses in the basin
- Sources of supply to meet those uses
- Groundwater conditions (including water levels and water quality)
- Amount and disposition of other sources of water supply in the management areas

The data is then used to prepare the required annual reports and is provided to other public agencies for groundwater monitoring and management purposes.

1.5 Adjudicated Area Boundary

Although it is understood that the adjudicated boundary and DWR boundary were promulgated under different circumstances, it is instructive to review some of the text included in the exhibits for the adjudication agreement describing the selection of the boundary (Santa Clara County Superior Court, 2001). To wit:

> "…the Land Owner Group's concession that the adoption of the "Foreman Line" is appropriate, as well as the concession offered by Mr. Slade that he does not disagree on the "outermost" basin boundary, the Court finds that there is no triable issue of material fact as to the "outermost" basin boundary…"
>
> This excerpt indicates that all technical experts involved in the adjudication were in agreement as to the disposition of the northeastern boundary of the basin.

Additionally:

> "The Court finds that the outermost lateral boundary of the Santa Maria Valley Groundwater Basin ("the Basin") lies along a type of material that does not readily transmit water…(including) the Foxen Formation or older, including the Franciscan Formation, the Knoxville Formation, the Monterey Formation, the Obispo Formation, and the Sisquoc Formation…*Where the Basin boundary crosses tributary streams, the boundary is located across the mouth of each stream to directly connect the closest bedrock contacts on each side of that stream…*" (italics added)
>
> This excerpt indicates that the technical experts involved in the adjudication were in agreement in actively excluding the tributary alluvial streams from the basin.

And finally:

> "…The Court finds on the basis of evidence presented that the Boundary Line demarcates the boundary of the Basin, and that the Basin constitutes the area beneath which groundwater exists in sufficient quantities to be meaningfully included in this lawsuit. The Court also finds that area previously included in the 'outermost basin boundary", but excluded by the Boundary Line, contains potentially water-bearing materials, but *nevertheless lacks actual groundwater in amounts sufficient to justify including in that area…*" (italics added)
>
> This excerpt indicates that the adjudication technical experts and the Court agreed that the quantities of groundwater included in the tributary stream valleys that feed the Basin are insignificant compared to the quantities involved in the main portion of the SMRVGB.

The County understands the legal distinction between the historical adjudication proceedings and the current SGMA-related regulatory activity. However, it appears that to a significant degree, this BBMR application is duplicating a process that was previously contested and resolved among the interested parties in the Basin after the expense of a great deal of time, money and technical analysis.

2. Pismo Creek Valley Fringe Area

This section of the report discusses the data used to characterize the Pismo Creek Valley Fringe Area, and to support the following BBMR being requested by the County GSA for this Fringe Area.

Modification Request Number 1 – Scientific Boundary Modification - Exclude the Pismo Creek Valley Fringe Area from the SMRVGB and modify the Basin boundary to be coincident with the Adjudicated Area boundary.

2.1 Physical Setting

2.1.1 Topography.

The Pismo Creek Valley Fringe Area is just over three miles long, oriented in a northeast-southwest direction, located adjacent to the northernmost extent of the Adjudicated Area boundary (Figures 3 and 4). Land surface elevation ranges from approximately 270 feet above mean sea level (MSL) at the upper extent of the valley to sea level at the bottom of the Fringe Area. Mountain ridges on either side of the valley rise steeply to elevations of over 400 feet on both sides.

Approximately 1.5 miles up from the mouth of valley, Price Canyon constricts to a narrow pass only about 150 feet wide.

2.1.2 Land Use.

Land use at the southern extent of this Fringe Area is municipal/residential, encompassing part of the area of the City of Pismo Beach. North of the City of Pismo Beach boundary, 23 parcels intersect the Alluvium in the Fringe Area.

The northern extent of the area is adjacent to and partially encompassed by the area of an active oil production field, the Arroyo Grande Oil Field (AGOF), presently owned and operated by Sentinel Peak Resources. The AGOF has been in production for over 100 years, extracting oil from the Edna member of the Pismo Formation. Sentinel Peak Resources is currently in the process of applying for an aquifer exemption permit to continue expanded operations at the facility. Public comment has been received by the County GSA inquiring about detailed fate and transport analysis of potential point source groundwater impacts from AGOF operations; this type of analysis is beyond the scope of this Report, and would be addressed under existing regulations and oversight by the Federal Environmental Protection Agency (EPA), State Water Resources Control Board (SWRCB), and California Division of Oil, Gas, and Geothermal Resources (DOGGR). SGMA has no regulatory provisions regarding oil field operations. To date, there has been no documented impact to the water quality of domestic wells in the area from the AGOF operations (Keeling, 2018). Additionally, the SWQCB has recommended the installation of sentry wells near the boundary of the exemption area during the exemption permit review and approval process.

Between the City of Pismo Beach and the AGOF, the valley floor includes portions of 23 rural domestic parcels. In 2014, there were approximately 95 acres of vineyard planted on the slopes on the northwest side of the alluvial valley in the vicinity of Spanish Springs Road (DWR, 2017). However, none of this vineyard area extends on to the alluvium of the valley floor. There is no irrigated agriculture overlying the alluvium in Pismo Creek Valley.

2.1.3 Water Use.

The municipal area including and adjacent to the City of Pismo Beach receives its water supply from the City of Pismo Beach's Utilities Department, which has no supply wells in the Pismo Creek Valley Fringe Area. Sentinel Peak Resources maintains a shallow bedrock well for fire protection and non-potable use that is not located in the Fringe Area; bottled water is used for potable supply. During oil extraction, produced water is recovered from the Edna member of the Pismo Formation; some of this water is treated and discharged under existing permits, and some is re-injected to assist with oil recovery. None of this water comes from the alluvium. Available information indicates only a single active supply well that draws from the alluvium located in the northern half of the valley (Alluvial Well #1 in Figures 3, 4, and 5); this well is currently used to supply cattle stock tanks, and annual use is minimal. In the southern half of the valley, there are no known water wells that extract groundwater from the alluvial aquifer.

Various studies have been undertaken over the past 20 years to assess the viability of using the alluvial aquifer as a water supply source for various proposed projects. Fugro (2009) determined that a proposed project potable water demand of 314 acre-feet per year could not be met using combined groundwater from the alluvial sediments along Pismo Creek and water from the nearby Pismo Formation without some type of recharge augmentation project. Cleath (2008) issued a report about the same proposed project that reached a similar conclusion. It documented a connection between groundwater pumpage and surface water in Pismo Creek, and noted that groundwater pumping could be seasonally constrained to maintain environmental flows in the creek. These studies indicate that the Recent Alluvium in the Pismo Creek Valley Fringe Area is not a viable, productive aquifer to supply even a modest development project.

2.1.4 Hydrology.

Pismo Creek drains a watershed of approximately 47 square miles (DWR, 2002). The uppermost reaches originate in the mountains north of Edna Valley. The Corral de Piedras and West Corral de Piedras tributary branches join to form Pismo Creek near northern extent of Price Canyon, and Pismo Creek flows to the ocean in the City of Pismo Beach. The Canada Verde tributary joins Pismo Creek approximately ½ mile south of the confluence of the Corral de Piedras tributaries.

Pismo Creek has no permanently established stream gage with a long term historical period of record. There is rarely year-round flow in Pismo Creek; the channel is frequently dry during the summer months (Balance Hydrologics, 2008). Sentinel Peak Resources discharges treated water into the upper reach of Pismo Creek under an existing discharge permit at an average rate of 0.5 million gallons per day (MGD), or 0.77 cfs.

Annual Pismo Creek surface flow measurements at the City of Pismo Beach wastewater treatment plant (WWTP), which is just upstream of the Adjudicated Area boundary and near the creek's outlet to the ocean, totaled 80 acre-feet in water year 1990, 2,040 acre-feet in water year 1991, and 4,640 acre-feet in water year 1992. The peak flow recorded during this period was 3,300 cubic feet per second (cfs) on February 15, 1992. The estimated mean discharge for Pismo Creek at the WWTP for this limited period of record was 5.3 cfs (or about 3,800 acre-feet per year).

Entrix (2006a) estimated Pismo Creek mean annual flow at 5,800 AFY, based on assuming a ratio of flows between Pismo Creek and Toto Creek equivalent to the ratio of the size of their respective watersheds.

Balance Hydrologics (2008) performed hydrologic and hydraulic modeling to estimate low flow and high flow events on Pismo Creek, based on a correlation developed while comparing data from the Pismo

Creek watershed and the Upper Lopez Creek watershed. Using this methodology, a median annual flow of 5,300 AFY was estimated.

2.2 Geologic Setting

Figure 5 displays a geologic map (Hall, 1973) in the vicinity of Price Canyon and the Pismo Creek Valley Fringe Area. In the northern half of the valley, various members of the Pismo Formation (i.e., Squire, Miguelito, and Edna) crop out at the surface on both sides of the valley and underlie the Recent Alluvium. In the southern half of the valley, the Pismo Formation members crop out on the eastern flank of the valley, but Monterey and Obispo Formation outcrops are exposed along the western flank of the valley.

The Wilmar Avenue Fault Zone, which is the basis of the definition of the Adjudicated Area boundary, is located at the southern extent of the valley (Figures 3, 4, and 5).

Although the current DWR Bulletin 118 basin boundaries are drawn such that they go up the slopes on either side of Price Canyon, it is apparent that the boundaries are intended to represent the Recent Alluvium in Price Canyon (Figure 5). The Pismo Formation bedrock is not considered to be Basin materials. The alluvium is constricted to a width of only about 150 feet midway up the canyon, about a half mile south of Spanish Springs Road off of Price Canyon Road. Various reports (Cleath 2009, Fugro 2009, Balance 2008) indicate that the stream channel is exposed bedrock in this area, effectively separating the alluvium in the upper canyon from the alluvium in the lower canyon.

A past study evaluated the presence of alluvium in the Arroyo Grande Oil Field and the potential of the alluvium as an aquifer (WZI, 2007). The findings of this investigation challenged the extent of alluvium displayed on the published geologic maps. The report indicated that alluvium was not extensive or continuous in the portions of Pismo Creek through the Arroyo Grande Oil Field, and that Pismo Creek was incised into bedrock of the Edna Member of the Pismo formation. WZI concluded that the alluvium is not as extensive as previously mapped, that there was geologic and hydrogeologic separation between alluvium mapped in the north to Edna Valley and to the south in the Pismo Valley, and "no alluvial aquifer appears to be present within the Pismo Creek drainage in the area of (the company's) property." The WZI report is included as Appendix A.

Figure 6 displays geologic cross section A-A' down the longitudinal axis of the valley. Bedrock of the Pismo, Obispo, and Monterey Formations underlie the Alluvium throughout the valley. The section line includes shallow alluvial wells that are drilled in the alluvium in the upper half of the valley that were installed as part of a past water supply study; perforated intervals of these wells are displayed in the cross section. Only one of these wells is presently used occasionally to fill cattle stock tanks. All other wells in the valley are drilled into and extract groundwater from the underlying bedrock.

The geologic cross section of Figure 6 illustrates an important geologic relationship between the Adjudicated Area and the Pismo Creek Valley Fringe Area. Throw along the Wilmar Avenue Fault, which is defined by the Court as the boundary of the Adjudicated Area, juxtaposes Basin and aquifer materials southwest of the fault against bedrock in Pismo Creek Valley. The geologic relationship illustrated by Figure 6 clearly shows that there is no geologic continuity or hydraulic connection between

Basin aquifer materials southwest of the fault and Pismo Creek Valley, except for the presence of the thin alluvial sediments which are present in the valley, across the fault zone, and in the Adjudicated Area.

Figure 7 displays geologic cross section B-B' oriented perpendicular to the valley axis, upstream of the Wilmar Avenue Fault. This section illustrates that alluvium in the valley reaches a thickness of approximately 35 feet in the lower reaches of Pismo Creek Valley.

Figure 8 displays geologic cross section C-C' to characterize the small portion of the Fringe Area immediately north of the Adjudicated Area boundary that is located along the coast instead of within Price Canyon (Figures 3, 4, 5). This section displays the Obispo Formation cropping out at the surface north of the Wilmar Avenue Fault, and a thin layer of uplifted coastal Quaternary Terrace deposits lying directly atop the Obispo bedrock south of the fault. There is no viable aquifer in this area, and no identified use of groundwater.

2.3 Hydrogeologic Setting

This section of the report describes the hydrogeologic setting of the Pismo Creek Valley Fringe Area, including characterization of hydraulic parameters, field work performed for this project, available water level data, and estimates of underflow from the Pismo Creek Valley Fringe Area to the Adjudicated Area of the SMRVGB.

2.3.1. Hydraulic Parameters

Specific yield is a measurement of the storage capacity of unconfined aquifers, expressed as a dimensionless fraction representing the ratio of the volume of water draining from an unconfined aquifer to the total volume of aquifer. DWR presents summary data of five alluvium wells in the Pismo Creek Valley Fringe Area with specific yields from 0.06 to 0.17, with a median value of 0.12 (DWR, 2002).

In 1999, six alluvial wells were installed in the northern portion of the Pismo Creek Valley as part of water supply study for a local landowner (Fugro 2009, Cleath 2009). Summary information and data from pumping tests on these wells are included in Table 3, below. Reported transmissivity values range from 127 to 1,101 square feet/day (ft^2/day), or 950 to 8,235 gallons per day per foot (gpd/ft). Associated estimates of hydraulic conductivity range from 18 to 120 feet/day.

Table 3 –Pismo Creek Valley Alluvium Hydraulic Parameters

Parameter	Well #1	Well #4	Well #7	Well #9	Well #10	Well #11	Average
Transmissivity [1] (ft2/day)	590	1,101	127	230	154	218	403
Hydraulic Conductivity [1] (ft/day)	75	120	18	38	26	20	50
Well Depth (ft)	59	43	36	39	39	75	48
Drought Pumping Rate [1] (gpm)	28	44	8	9	5	14	18

1) Fugro, 2009.

Fugro estimated the total amount of groundwater in storage in the Pismo Creek Alluvium at 500 to 600 acre-feet (Fugro, 2009).

Table 3 also presents total depth and estimates of expected pumping rate during times of drought (which would be the constraining condition for a long-term supply project) for the Pismo Creek Alluvium wells. The well depths range from 36 feet to 75 feet. (Note that well 11 is located up a hill on an alluvial fan at a higher elevation than the other wells, which are closer to the creek.) The expected drought pumping rates range from 5 gallons per minute (gpm) to 44 gpm.

By contrast, production wells located within the Adjudicated Area of the Basin immediately southwest of the Wilmar Avenue Fault have well depths ranging from 180 feet to 530 feet, and reported pumping rates ranging from 320 gpm to 2,100 gpm, based on available data from NCMA. These data indicate the vast difference in well capacity between the main part of the SMRVGB and the Pismo Creek Valley Fringe Area. Reported data for municipal wells located in the Adjudicated Area of the SMRVGB in the vicinity of Pismo Creek Valley are presented in Table 4.

Table 4 –SMRVGB Municipal Production Well Information

City	Well Number	Well Depth (ft)	Pumping Rate (gpm)
Pismo Beach	5	454	540
	23	372	900
Arroyo Grande	1	220	320
	3	220	400
	4	233	400
	5	200	970
	7A	230	670
	8	250	480
Grover Beach	1	178	178
	2	186	186
	3	180	180
	4	530	530
Note: Data from NCMA.			

2.3.2 Water Levels

The depth to water was measured in the six Pismo Creek Valley alluvial monitoring wells on January 4, 2018. In addition, water level data for the wells were recorded on the 1999 Well Completion Reports, and in a privately commissioned consultant report (Cleath, 2009). The measured depths to water are presented in Table 5. Although only three data points are available for most wells, they span nearly 20 years. Hydrographs of the water levels are presented on Figure 9. These hydrographs indicate that water levels have remained in relative equilibrium over the past 20 years, with no apparent trends of declining water levels over this time period.

One of the consultant reports (Cleath, 2009) presents a groundwater elevation map that displays a groundwater surface gradient of approximately 0.008, which is approximately equal to the land surface gradient of the stream channel in this area. This indicates that the channel bottom gradient may be used as a reasonable approximation of the groundwater flow gradient.

Table 5 –Pismo Creek Valley Alluvium Depth to Water

Date	Well #1	Well #4	Well #7	Well #9	Well #10	Well #11
July 1999	30	10	17	14	--	37
August 2009	32.92	15.15	11.26	15	16	37.74
January 4, 2018	31.29	13.00	11.40	16.21	14.72	36.95
1/4/18 Saturated Thickness (ft)	27.71	30.00	24.60	22.79	24.28	38.05

2.3.3 Outflow to the Adjudicated Area of the SMRVGB

As previously discussed in Section 2.1.4, mean annual surface flow in Pismo Creek has been estimated by various investigators ranging from 3,800 to 5,800 AFY. Surface flow in Pismo Creek exits Price Canyon and enters the Adjudicated Area, where it flows to the coast while water infiltrates from the alluvial stream bed and recharges the aquifers in the SMRVGB.

This section of the report calculates the volume of subsurface underflow from the Pismo Creek Valley Fringe Area to the Adjudicated Area of the SMRVGB through the alluvial sediments, which is separate and distinct from surface flow. It should be noted that this calculation only applies to the underflow of groundwater as it applies to the recharge of the northern part of the SMRVGB. This calculation is separate and distinct from any estimation of surface water flow that leaves Pismo Creek and enters the Basin.

Underflow is calculated, as follows:

$Q = K*i*A$, where

Q = Groundwater Underflow (L^3)

K = Hydraulic conductivity (L/T)

i = Hydraulic Gradient (ft/ft, dimensionless)

A = Area of flow (L^2)

For hydraulic conductivity, a value of 50 ft/day is used. This is the average of the values from the aquifer tests performed on the alluvial wells presented in Table 3.

Hydraulic gradient was estimated by measuring the gradient of the land surface of the stream channel at the bottom of the valley from the USGS topographic map, under the assumption that the gradient of the groundwater surface is comparable to the gradient of the thalweg of the stream. This value is 0.003.

The cross-sectional area of flow was estimated at the bottom of the alluvial valley, where map distance across the valley neck is approximately 1,000 feet. Little data exists to estimate the saturated thickness in the alluvium, but cross section A-A’ (Figure 6) suggests that the total thickness of alluvium across the neck of the valley is about 50 feet. During times when Pismo Creek is flowing, it can be assumed that the full thickness of alluvium is saturated. There are no data to indicate alluvium water levels in this area when the creek is not flowing. However, a conservative assumption is that the full thickness is saturated year round. Thus, with saturated thickness estimated at 50 feet and a length of 1,000 feet, the cross-sectional area of flow is estimated at 50,000 square feet. Therefore,

Q = (50 feet/day)*(0.0031)*(50,000 square feet)

Q = 63 AFY

The calculated flux volume of 63 AFY is comparable to the DWR estimates of underflow from the Pismo Creek Alluvium that ranged from 30 to 320 AFY, with an average of 100 AFY (DWR, 2002). DWR estimated total annual recharge (including percolation of precipitation, stream infiltration, agricultural and urban return flow, and subsurface inflows) to the portion of SMRVGB in San Luis Obispo County ranging from 10,000 to 82,400 AFY, with a long-term average of 29,200 AFY (DWR, 2002). With a long-term calculated recharge estimate of 29,200 AFY to the Adjudicated Area in the County, the relatively insignificant contribution of the Pismo Creek Valley underflow is about 0.2% of the total recharge for the aquifers in the Adjudicated Area.

2.4 Hydrogeologic Conceptual Model of Pismo Creek Valley

A Hydrogeologic Conceptual Model (HCM) is an interpretive collection of the available information describing the hydrogeologic system being investigated. It includes evaluation of significant geologic units, aquifer geometry (delineation of lateral and vertical boundaries), physical characteristics, and identification of components of recharge to and discharge from the hydrogeologic system. Much of this information has been discussed in previous sections, but is presented in summary fashion in this Report section.

The most significant geologic formation of the HCM is the Quaternary Alluvium. This unconsolidated collection of alluvial materials contains groundwater in the interstitial pore spaces between the sedimentary particles. It is defined laterally by the contact of the alluvium with the bedrock of the Pismo, Monterey, and Obispo Formations cropping out in the mountains on the east and west side of Price Canyon, and the Wilmar Avenue Fault Zone to the south (Figure 5). It is defined vertically by the contact between the alluvium and the underlying bedrock (Figures 6 and 7). The total thickness of alluvium in the Fringe Area is about 30 to 50 feet through the valley.

The hydraulic characteristics of the alluvium do not reflect those of a significant and viable aquifer. Transmissivity estimates of alluvial wells range from 130 to 1,100 ft2/day. Estimated long term pumping rates range from less than 10 gpm to approximately 45 gpm. By contrast, pumping rates for supply wells in the Adjudicated Area may be 1,000 gpm.

The primary source of recharge for the Fringe Area is stream infiltration. Pismo Creek, which flows through Price Canyon, flows seasonally during periods of typical winter rainfall. It often ceases to flow during the summer dry season. During times that it flows, stream flow infiltrates into and recharges the alluvium in the valley. Additionally, based on the observation that the potentiometric surface of groundwater in wells screened in the underlying bedrock rises to elevations within the alluvium, there is likely a component of recharge from the underlying bedrock into the overlying alluvium. Other sources of recharge include direct percolation of rainfall on the alluvium surface, and mountain front recharge from runoff along the steep slopes on both sides of the valley.

Sources of discharge for the Fringe Area include evapotranspiration from the root zone of plants along the stream channel, and underflow of groundwater out of the Fringe Area, discussed previously. Also, as discussed previously, occasional pumping from alluvial wells comprises a small component of the total discharge.

Water levels in the valley have remained essentially stable over the past 20 years (Figure 9), indicating that recharge and discharge in the valley are in approximate equilibrium, and the alluvium has demonstrated sustainability over this time period.

2.5 Basin Boundary Modification Request

The County GSA, in which has jurisdiction over Pismo Creek Valley, is submitting this request to DWR to revise the boundaries of the SMRVGB as follows:

Modification Request Number 1 – Scientific External Boundary Modification - Exclude the Pismo Creek Valley Fringe Area from the SMRVGB, and modify the Basin boundary to be coincident with the Adjudicated Area boundary. (Figure 10) Analysis of the hydrogeologic setting of the alluvium presented in this analysis indicates that the alluvium in the Pismo Creek Valley Fringe Area is not considered to be an aquifer, defined in Article 2 §341 (Definitions) as "… a three-dimensional body of porous and permeable sediment or sedimentary rock that contains sufficient material to yield significant quantities of groundwater to wells and springs, as further defined or characterized in Bulletin 118." Supporting data presented in this analysis indicate the following:

a) Previous studies and analyses of the alluvium in the Fringe Area have concluded that that the alluvium in the valley is not sufficiently viable to support a proposed project with an estimated demand of 300 AFY. This demonstrates that the Pismo Creek alluvium is not a significant or viable aquifer as defined in Article 2 §341.
b) There is presently almost no use of groundwater from the alluvium. Only a single well is in current use, providing minimal supply to a local landowner for occasional supply of stock tanks. This corroborates the fact that the alluvium is not a viable aquifer.
c) The CASGEM Basin Prioritization Process report (DWR, 2014) states that basins with less than 2,000 AFY of pumping "were automatically ranked as CASGEM Very Low Priority groundwater basins, meaning the Overall Basin Ranking Score is overridden with a zero." Estimated groundwater use in Pismo Creek Valley is less than 2,000 AFY, and no undesirable results as defined in SGMA have been observed. If the CASGEM basin prioritization criteria for groundwater use may be viewed as a proxy to define significant production from a basin, then the Pismo Creek Valley Fringe Area does not utilize significant production of groundwater.

d) The relatively thin veneer of recent alluvium in the Pismo Creek Valley Fringe Area sits directly atop bedrock throughout the entire extent of the valley. The Wilmar Avenue Fault Zone forms an effective barrier to groundwater flow by juxtaposing the impermeable bedrock formations northeast of the fault against the stacked permeable aquifers of the SMRVGB, with more than 500 feet of accumulated Basin sediments (Figure 5). The northern boundary of the Adjudicated Area essentially follows the Wilmar Avenue Fault Zone. This demonstrates that there is no geologic continuity or significant hydrogeologic connection between the Adjudicated Area southwest of the fault and the Pismo Creek Valley Fringe Area northeast of the fault, except through the thin alluvial deposits.
e) Available water level data indicate that there is no declining water level trends in the Alluvium (Figure 9). This indicates that the alluvium has been demonstrated sustainability over the past decades without State intervention.
f) Cross Sections indicate that in the part of the Fringe Area north of NCMA along the coast, the Quaternary Terrace deposits in this area lie directly atop the bedrock of the Obispo Formation (Figure 8). This demonstrates that no viable aquifer capable of producing groundwater exists in this area.
g) The amount of groundwater underflow from the Pismo Creek Valley Fringe Area to the Adjudicated Area is 0.2% of the total amount of recharge to the SMRVGB in San Luis Obispo County. This demonstrates that hydrogeologic conditions in the Pismo Creek alluvium have no significant effect on the conditions in the Adjudicated Area, or on the ability to sustainably manage the Adjudicated Area of the Basin.
h) The technical experts and the Court for the basin adjudication concluded that the quantities of groundwater in the alluvial valleys that are tributary to the basin are insignificant in comparison to the Adjudicated Area; Pismo Creek Valley was specifically excluded from the Adjudicated Area for this reason.

If DWR finds that the hydrogeologic evidence presented herein does not sufficiently support the request for exclusion of the Pismo Creek Valley Fringe Area, the County GSA proposes the following BBMR alternative for DWR's consideration based on items d through h, above: Adjust the boundary of the Pismo Creek Valley Fringe Area north of the Adjudicated Area boundary from the current published Bulletin 118 boundary line to coincide with the mapped extent of the Recent Alluvium, as mapped by Hall (1973), from the adjudicated Basin boundary to the northern extent of the Fringe Area, and establish a new "Santa Maria River Valley – Pismo Creek Valley" subbasin from the SMRVGB defined by the extent of mapped Quaternary Alluvium between the current Adjudicated Area boundary and the northern extent of the current Fringe Area.

3 Arroyo Grande Creek Valley Fringe Area

This section of the report discusses the data used to characterize the Arroyo Grande Creek Valley Fringe Area, and the following proposed BBMRs being requested by the County GSA for the Arroyo Grande Creek Fringe Area.

Modification Request Number 2 – Scientific External Boundary Modification – Amend the boundary of the Arroyo Grande Creek Valley Fringe Area northeast of the Adjudicated Area boundary of the SMRVGB from the current published Bulletin 118 boundary line, to coincide with the mapped extent of the Recent Alluvium, as mapped by Dibblee (2006b, c, d, e).

Modification Request Number 3 – Scientific Internal Boundary Modification –Create a new "Santa Maria River Valley – Arroyo Grande" subbasin defined by the extent of mapped Recent Alluvium (Dibblee) north of the Adjudicated Area boundary.

3.1. Physical Setting

3.1.1 Topography

The Arroyo Grande Creek Valley Fringe Area is approximately seven miles long, oriented in a northeast-southwest direction, extending from Lopez Dam to the Adjudicated Area boundary (approximately coincident with the Wilmar Avenue Fault and Highway 101). The tributary valley of Tar Springs Creek is about three miles long, oriented east-west, and joins Arroyo Grande Creek about three miles upstream of Highway 101 (Figures 11 and 12). Land surface of Arroyo Grande Creek valley extends from an altitude of about 380 feet MSL at the base of Lopez Dam to about 100 ft MSL at the bottom of the valley. Tar Springs Creek Valley extends from an altitude of about 360 ft MSL to 160 ft MSL at the confluence with Arroyo Grande Creek. Mountain ridges on the north side of the valley rise steeply to elevations of over 1500 feet MSL near Lopez Dam (Figure 12).

The Arroyo Grande Creek Valley Fringe Area is adjacent to the southeastern extent of the San Luis Obispo Groundwater Basin (DWR Basin 3-09) in the northern extent of the Fringe Area (Figure 11). However, there is a groundwater divide between the two basins. Groundwater flow direction in the San Luis Obispo Basin is to the northwest, away from Arroyo Grande Creek Valley (GSI, 2018), so the two basins are distinct and there is minimal hydraulic communication between the basins.

3.1.2 Land Use

The predominant land use throughout most of the valley is irrigated agriculture (Figure 11). In 2014, approximately 1,800 acres (DWR, 2017) in or adjacent to the 3,030 acres of alluvium is planted in various crops. The southern extent of the valley is within the boundaries of the City of Arroyo Grande; land use is primarily municipal/residential within the city limits.

3.1.3 Water Use

The municipal area including and adjacent to the City of Arroyo Grande receives its water supply from the City's Utilities Department; the City's supply portfolio includes surface water from Lopez Lake and groundwater. The irrigated areas upstream of the City are supplied by surface water diversions from Lopez Dam downstream releases and by groundwater from wells tapping both the alluvial aquifer and the underlying Pismo Formation bedrock, where present. Estimated crop demand for the irrigated area is approximately 3,800 acre-feet per year. Part of this is supplied by surface water diversions as indicated by the numerous surface water rights along the Arroyo Grande Creek. As noted previously, the Pismo

Formation outside of the Adjudicated Area boundary is not considered to be part of the SMRVGB sediments.

3.1.4 Hydrology

Arroyo Grande Creek and its tributaries drain an area of approximately 190 square miles. Lopez Reservoir, which impounds about 70 square miles of the upper watershed, was completed in 1969 with a capacity of 52,500 acre-feet. Its annual dependable yield is 8,730 acre-feet, of which, 4,530 acre-feet are allocated for municipal deliveries and use and 4,200 acre-feet are reserved for downstream releases. The municipal allocations provide drinking water for Arroyo Grande, Grover Beach, Pismo Beach, Oceano, and Avila Beach. Downstream releases from the reservoir include instream flow requirements for the Arroyo Grande Creek, provide an important component of recharge to the underlying alluvial aquifer in both the Fringe Area and the Adjudicated Area of the Basin, as well as providing surface water diversions for irrigation. Annual average precipitation in the valley ranges from 16 inches at the valley mouth to 20 inches near Lake Lopez (DWR, 2002).

3.2. Geologic Setting

Figure 13 displays the geologic maps (Dibblee, 2006b, c, d, e) in the vicinity of the Arroyo Grande Creek Valley. The Pismo Formation bedrock is exposed at the surface in the mountains west of the valley, and in much of the area between Arroyo Grande Valley and Tar Springs Creek Valley. To the southeast of the Arroyo Grande/Tar Creek Springs Valley, the Monterey Formation crops out at the surface. The Edna Fault Zone and the Huasna Fault Zone cross the northern extent of the Arroyo Grande Valley; as a result, faulted and folded rocks of the Monterey Formation and Franciscan Assemblage crop out in the area northeast of the valley.

The Wilmar Avenue Fault Zone is located at the southern extent of the valley. The location of the Wilmar Avenue Fault is presented on Figure 13.

Although the current DWR basin boundaries are drawn such that they extend up the slopes on the north side of the Arroyo Grande Creek Valley and transect the main part of the valley, it is apparent that the boundaries are intended to represent the Recent Alluvium in the valley (Figure 13). As discussed previously, the Pismo Formation bedrock does not constitute Basin aquifer materials and is not part of the Basin.

Figure 14 displays geologic cross section D-D' down the longitudinal axis of Arroyo Grande Creek Valley. Recent Alluvium is present at the surface along the entire section line. The Wilmar Avenue Fault Zone lies at the southwest end of the valley and juxtaposes over 500 feet of stacked Basin sediments of the SMRVGB southwest of the fault against the non-Basin Obispo and Monterey Formations northeast of the fault. The bedrock of the Pismo Formation underlies the Recent Alluvium in the central area of the section line. The geologic map indicates a synclinal structure in the Pismo. Where present, the Pismo Formation provides groundwater to wells, in addition to the Alluvium. The Edna Fault Zone trends across the northern part of the valley and cuts off the Pismo sediments; it appears that Pismo sediments that were previously deposited on the upthrown block were eroded away prior to deposition of the Recent Alluvium.

Figure 15 displays geologic cross section E-E', oriented perpendicularly across the valley axis, about ½ mile upstream of the Wilmar Avenue Fault Zone. This section displays a maximum of 90 feet of Recent Alluvium directly on top of the bedrock of the Monterey Formation. The Pismo Formation crops out in the hills on the west side of the valley, and provides water to wells in that area. The Monterey Formation crops out in the hills east of the valley. A small pod of Paso Robles Formation is exposed at the surface on the eastern extent of this section.

3.3. Hydrogeologic Setting

This section of the report briefly describes the hydrogeologic setting of the Arroyo Grande Creek Valley Fringe Area, including a discussion of hydraulic parameters, field work performed for this project, hydrographs, water level maps, and estimates of underflow from the Arroyo Grande Valley to the adjudicated portion of the SMRVGB.

3.3.1 Hydraulic Parameters

Specific yield is a parameter that describes the volume of water that will drain by gravity from a given soil mass to the volume of that soil, expressed as a dimensionless fraction. DWR reported specific yield values for eight Alluvium wells in the Arroyo Grande Valley ranging from 0.09 to 0.21, with a median value of 0.12 (DWR, 2002). These values are typical of unconfined alluvial sediments.

Hydraulic conductivity of the alluvial aquifer in Arroyo Grande is highly variable. DWR reported a single hydraulic conductivity estimate of 270 ft/day for Arroyo Grande Valley subbasin Alluvium based on aquifer test data, a range of 1.2 to 12 ft/day based on pump efficiency tests, and a range of 22 to 775 ft/day based on lithologic correlation (DWR, 2002).

Two constant rate aquifer tests were performed on alluvial wells in Arroyo Grande Valley for this Report. The locations of the tests are presented on Figure 11. Results indicate that one well had a transmissivity of 90,000 gpd/ft, and a corresponding hydraulic conductivity of 252 ft/day (Table 4). The other well test yielded a transmissivity estimate of 15,000 gpd/ft with a corresponding hydraulic conductivity value of 19 ft/day (Table 6). Time-drawdown graphs from these aquifer tests are included in Appendix B.

DWR estimated that the total amount of groundwater in storage in the Arroyo Grande Valley ranged from 8,000 to 10,000 acre-feet between the years 1975 and 1995 (DWR, 2002).

Table 6 – Arroyo Grande Valley Aquifer Test Data Summary

Well ID	Area	Date	Saturated Thickness (ft)	Transmissivity (gpd/ft)	Hydraulic Conductivity (ft/day)
Huasna Rd Well	Arroyo Grande	12/5/17	48	90,000	252
Biddle Domestic	Arroyo Grande	11/1/17	104	15,000	19
Notes: Aquifer tests performed by GSI Water Solutions, Inc.					

3.3.2 Potentiometric Surface and Hydrographs

DWR presented groundwater elevation contours for the Arroyo Grande Valley for Spring 1975, 1985, and 1995 (DWR, 2002). All three maps are very similar. The Spring 1995 map is re-created on Figure 16. Water level elevations are greater than 300 feet MSL in the upper reach of the valley, and decline to less than 100 feet at the mouth of the valley, under a gradient of approximately 0.009 throughout the valley.

Figure 17 presents groundwater elevation contours for the alluvium in the Arroyo Grande Valley for Spring 2016 based on San Luis Obispo county monitoring data, along with Spring 2016 groundwater elevation contours for the shallow groundwater zone based on NCMA data. The Spring 2016 water elevation contour map is quite similar to the contours displayed in the Spring 1995 contour map. A localized cone of depression, apparently caused by nearby pumping, is evident near the confluence of Arroyo Grande Creek and Tar Springs Creek. The groundwater elevations southwest of the Wilmar Avenue Fault, in the adjudicated portion of the Basin, are at a significantly lower elevation than those in the Arroyo Grande Creek Valley Fringe Area. The data show a significant drop in groundwater elevations of approximately 60 feet across the Wilmar Avenue Fault Zone.

Figure 18 presents a graphical profile of water level elevations down the length of Arroyo Grande Creek Valley Fringe Area, across the Wilmar Avenue Fault Zone, and into the adjudicated portion of the Basin. There is a noticeable discontinuity in the profile across the fault zone, and groundwater conditions in the NCMA are unlikely to propagate upgradient across the fault to affect conditions in the Fringe Area.

Figure 19 presents hydrographs for seven wells throughout the Fringe Area. Seasonal variations on the order of 30 feet are apparent in some of the hydrographs, although some of that may be due to nearby wells pumping while the data was collected. The most important feature of these hydrographs is that they show no trends of long-term water level declines with time. All of the wells display similar groundwater elevations in the present day as they did back in the 1960s and 1970s. This indicates that the aquifer is in approximate equilibrium, and that, despite occasional and intermittent drought periods, the alluvial aquifer in Arroyo Grande Creek Valley is not and does not reach a state of overdraft because of the nature of the alluvial aquifer and because of managed releases out of Lopez Reservoir.

Figure 20 presents hydrographs of two wells in the Arroyo Grande Creek Valley Fringe Area, along with a time series of annual downstream releases from Lake Lopez. Again, water levels in these wells do not display any significant variability other than would be expected due to seasonal climatic and pumping variations. These hydrographs clearly display the stabilizing effect that the downstream releases from Lopez Reservoir have on groundwater elevations in the Arroyo Grande Valley.

3.3.3 Outflow to the Adjudicated Area of the SMRVGB

The quantity of groundwater underflow leaving the alluvial aquifer of the Arroyo Grande Creek Valley is calculated, using the methodology previously described. The outflow calculation is an estimate of the volume of groundwater that flows through the alluvial aquifer across the Wilmar Avenue Fault Zone and into the adjudicated portion of the Basin, thereby becoming a component of recharge to the adjudicated portion of the Basin. This calculated volume is not a measure of surface flow in Arroyo Grande Creek that flows into the adjudicated portion of the Basin.

To calculate the outflow, a hydraulic conductivity estimate of 136 ft/day is used, based on the average of the results of the aquifer tests performed on the alluvial wells for this report.

The hydraulic gradient of 0.009 was estimated by measuring the gradient of the groundwater elevation contours presented in Figure 17.

The cross-sectional area of flow was estimated at 195,000 square feet, based on a measured width of the alluvium of 3,000 feet and a saturated thickness of 65 feet. Therefore,

$$Q = (136 \text{ ft/day})*(0.009)*(195{,}000 \text{ square feet})$$

$$Q = 2{,}000 \text{ AFY}$$

DWR reported estimated subsurface outflows from the Arroyo Grande Valley subbasin ranging from 420 to 4,200 AFY between 1975 and 1995, with a geometric mean of 1,300 AFY (DWR, 2002). DWR's estimates are comparable to the estimate calculated herein. With an average total recharge to the SMRVGB in San Luis Obispo County of 29,200 AFY (DWR, 2002), the Arroyo Grande Creek Valley underflow estimate presented herein accounts for 6.8% of the recharge to the SMRVGB in the County.

3.4 Hydrogeologic Conceptual Model of Arroyo Grande Creek Valley

The most significant geologic formation of the HCM of the Arroyo Grande Creek Valley is the Quaternary Alluvium. This unconsolidated collection of alluvial materials contains groundwater in the interstitial pore spaces between the sedimentary particles. It is defined laterally by the contact of the alluvium with the bedrock of the Pismo, Monterey, Obispo, and Franciscan Formations cropping out in the mountains on the east and west side of Arroyo Grande Creek Valley and the Tar Springs Creek Valley, and the Wilmar Avenue Fault Zone to the south (Figure 13). It is defined vertically by the contact between the alluvium and the underlying bedrock (Figures 14 and 15). The total thickness of alluvium in the Fringe Area ranges from less than 20 feet in some areas to over 150 feet (Figure 14).

The hydraulic characteristics of the alluvium reflect those of a viable aquifer. Transmissivity estimates of alluvial wells based on pump testing range from 15,000 to 90,000 gpd/ft. Corresponding pumping rates ranged from 65 to 450 gpm.

The primary source of recharge for the Arroyo Grande Creek Valley is stream infiltration. Arroyo Grande Creek, which flows through the valley, flows year round due to regular releases of surface water from Lake Lopez. This stream flow infiltrates into and recharges the alluvium in the valley. Additionally, based on the observation that the potentiometric surface of groundwater in wells screened in the underlying bedrock rises to elevations within the alluvium, there is likely a component of recharge from the underlying bedrock into the overlying alluvium. Other sources of recharge include direct percolation of rainfall on the alluvium surface, irrigation return flow, and mountain front recharge from runoff along the steep slopes on both sides of the valley.

The primary source of discharge for the Fringe Area is pumping of irrigation wells screened in the alluvium. As discussed previously, much of the valley is cultivated in various crops. Other sources of discharge include evapotranspiration from the root zone of plants along the stream channel, and underflow of groundwater out of the Fringe Area, discussed previously.

Water levels in the valley have remained essentially stable over the past 50 years (Figure 19), indicating that recharge and discharge in the valley are in approximate equilibrium, and the alluvium has demonstrated sustainability over this time period. The regular recharge of the alluvial aquifer from the Lake Lopez releases is a significant factor in this observed stability of groundwater levels.

3.5 Basin Boundary Modification Request

The County GSA is submitting this request to DWR to revise the boundaries of the SMRVGB as follows:

Modification Request Number 2 – Scientific External Boundary Modification – Amend the boundary of the Arroyo Grande Creek Valley Fringe Area north of the Adjudicated Area boundary of the SMRVGB from the current published Bulletin 118 boundary line to coincide with the mapped extent of the Recent Alluvium, as mapped by Dibblee (Figure 21), and adjust the Bulletin 118 boundary immediately south of the Arroyo Grande Creek Valley in the Adjudicated Area so that it is coincides with the adjudicated boundary in that area. Current Bulletin 118 boundaries extend up the mountain slopes west of the valley, and cross through the middle of the valley floor, an apparent artifact of previous mapping performed a larger scale. The requested amendment of the boundaries reflects the original intent of the boundary delineation, relying on most recent and smaller scale geologic mapping to accurately represent the lateral boundaries of the Recent Alluvium and maintains a continuous boundary from the Arroyo Creek Valley to the Adjudicated Area.

Modification Request Number 3 – Scientific Internal Boundary Modification –Establish a new "Santa Maria River Valley – Arroyo Grande" subbasin defined by the extent of mapped Recent Alluvium (Dibblee) north of the current Adjudicated Area boundary. Analysis of the hydrogeologic setting of the Arroyo Grande Creek Valley Fringe Area and other technical data presented in this report indicates the following:

a) The relatively thin veneer of recent alluvium in the Arroyo Grande Creek Valley Fringe Area sits directly atop the bedrock of the Pismo, Monterey, and Obispo Formations. No SMRVGB aquifer materials (except for Recent Alluvium) are present in the surface or subsurface of the Arroyo Grande Creek Valley Fringe Area (Figure 14).
b) The Wilmar Avenue Fault Zone forms an effective barrier to groundwater flow by juxtaposing the impermeable bedrock northeast of the fault against the stacked permeable aquifers of the SMRVGB, with over 500 feet of accumulated Basin sediments southwest of the fault. This geologic relationship demonstrates that there is no geologic continuity or significant hydrogeologic connection between the Adjudicated Area southwest of the fault and the Arroyo Grande Creek Valley Fringe Area northeast of the fault, except through the relatively thin alluvial deposits (Figure 14).
c) Water levels in alluvial wells in the Arroyo Grande Creek Valley do not indicate any long term declining trends (Figure 19). This demonstrates that the Fringe Area groundwater resources have been utilized sustainably over the past several decades. Stable water levels and replenished groundwater storage are ensured due to the regular downstream releases from Lake Lopez, codified in the adjudication, which regularly recharge the alluvial aquifer (Figure 20).
d) The groundwater level profile across the Wilmar Avenue Fault Zone displays a discontinuity in elevations across the fault (Figure 18). Groundwater elevations in the downstream extent of the Fringe Area are approximately 60 feet higher than groundwater elevations in the Adjudicated Area. This indicates that the Adjudicated Area and the Arroyo Grande Creek Fringe Area have distinct hydrogeologic regimes, and that any changes in hydraulic conditions in the Adjudicated Area will not propagate upgradient to have any effect in the Fringe Area.
e) The technical experts and the Court for the basin adjudication concluded that the quantities of groundwater in the alluvial valleys that are tributary to the basin are not significant to management activities in the Adjudicated Area; Pismo Creek Valley was specifically excluded from the Adjudicated Area for this reason.

4 Nipomo Valley Fringe Area

This section of the report discusses the data used to support the County GSA’s BBMR with respect to the Nipomo Valley Fringe Area.

Modification Request Number 4 – Scientific External Boundary Modification – Exclude the Nipomo Valley Fringe Area from the SMRVGB, and modify the Basin boundary to be coincident with the Adjudicated Area boundary.

4.1. Physical Setting

4.1.1 Topography

The Nipomo Valley is approximately seven miles long, oriented in a northwest-southeast direction, adjacent to the Adjudicated Area boundary northeast of Highway 101 (Figures 22 and 23). The Nipomo Mesa Management Area (NMMA) lies in the Adjudicated Area adjacent to this Fringe Area; the NMMA produces annual reports describing groundwater conditions in their area (NMMA, 2017). Nipomo Creek, a tributary of the Santa Maria River, is approximately coincident with the adjudicated boundary. The area of the Nipomo Valley Fringe Area is 5,450 acres (8.5 square miles) based on the DWR Bulletin 118 Basin boundary. Land surface of Nipomo Valley extends from an altitude of about 600 feet MSL along the northeastern extent to about 300-350 ft MSL along the course of Nipomo Creek. Temettate Ridge, which is located less than a mile to the northeast of the area, has an elevation of approximately 1500-1600 feet MSL (Figure 23).

4.1.2 Land Use

The town of Nipomo is located in the southern portion of the area, but the predominant land use throughout most of the valley is irrigated agriculture of various crops (Figure 22). Approximately 2,370 acres in or adjacent to the Nipomo Mesa Fringe Area is irrigated.

4.1.3 Water Use

The town of Nipomo is served by Nipomo Community Services District. Irrigation water for most of the area is supplied from wells located within the Nipomo Valley Fringe Area that draw from the bedrock of the Monterey Formation. Based on the factors presented in Table 2, estimated crop demand is approximately 4,100 AFY.

4.1.4 Hydrology

A series of small seasonal creeks tributary to Nipomo Creek that originate along the slopes southwest of Temettate Ridge flow through the valley. There are no significant engineered water infrastructure such as reservoirs or canals in the valley. Long term average annual precipitation in the valley is about 16 inches (DWR, 2002).

4.2. Geologic Setting

The significant geologic formations that crop out in the Nipomo Valley Fringe Area (Older Alluvium, Monterey, and Obispo Formation) are not part of the SMRVGB. Figure 24 displays the geologic maps (Dibblee, 2006b, 2006c) in the vicinity of the Nipomo Valley Fringe Area. The most significant geologic formation of note is the Older Alluvium. The basin boundary, as defined in DWR Bulletin 118, appears to have been drawn to include the outcrops of the uplifted Older Alluvium. The Older Alluvium is distinct from the Recent Alluvium. It is comprised of alluvial sediments consisting of sands, silts, clays, and gravels that have been uplifted on the upthrown fault block northeast of the Wilmar Avenue Fault Zone and Santa Maria River Fault Zone. Because they are elevated above the Recent Alluvium, they are largely hydraulically disconnected from the aquifers in the Adjudicated Area, and the formation has little to no saturated thickness. The bedrock of the Obispo and Monterey Formations crop out to the northeast of the valley, and underlie the Older Alluvium throughout the area.

Nearly all wells in the Nipomo Valley Fringe Area draw from the bedrock of the Monterey and Obispo Formations, which are not part of the SMRVGB materials. Figure 25 displays geologic cross section F-F' oriented down the long axis of the Nipomo Valley, parallel to Nipomo Creek and the Wilmar Avenue/Santa Maria River Fault Zones. The cross section displays the depth and perforated interval of the wells in the section line. It is evident from Figure 25 that almost none of the wells that supply water to the irrigated fields draw from the Older Alluvium. (A single exception is a shallow well evident at the extreme southeast extent of the section line, which apparently draws from the local alluvium associated with a small creek.) Because no significant Fringe Area wells draw from Basin materials, hydrogeologic conditions in the Basin will have no effect on the conditions in the Fringe Area. Similarly, conditions in the Fringe Area will have no effect on those of the Basin.

Figure 26 displays geologic cross section G-G' that cuts across the Wilmar Avenue Fault Zone. This section again displays the fact that the wells in the Nipomo Valley draw from the bedrock of the Monterey/Obispo Formations; therefore hydrogeologic conditions in Fringe Area will not affect conditions in the Adjudicated Area, and vice versa. This section also displays the fact that the fault displacement along the Wilmar Avenue and Santa Maria River Faults places the bedrock of the Monterey Formation against the accumulated sediments of the Adjudicated Area. The Wilmar Avenue Fault Zone lies at the southwest end of the valley, and juxtaposes the stacked Basin sediments of the SMRVGB southwest of the fault against the non-Basin Older Alluvium, Obispo Formation, and Monterey Formations northeast of the fault. Due to the significantly less productive water-bearing properties of the bedrock compared to the Basin sediments, there is no significant outflow from the Monterey Formation bedrock to the Basin sediments.

The geologic cross section of Figure 26 illustrates an important geologic relationship between the Adjudicated Area and the Nipomo Valley Fringe Area. Throw along the Wilmar Avenue and Santa Maria River Fault Zones (which are defined by the Court as the boundary of the Adjudicated Area) juxtaposes hundreds of feet of Basin and aquifer materials southwest of the fault against bedrock in Nipomo Valley. The geologic relationship illustrated by Figure 26 clearly demonstrates that there is no geologic continuity or significant hydraulic connection between Basin aquifer materials southwest of the fault and Nipomo Valley Fringe Area northeast of the fault.

4.3. Hydrogeologic Setting

This section of the report briefly describes the hydrogeologic setting of the Nipomo Valley Fringe Area, including characterization of the description of water-bearing sediments and non-water-bearing bedrock, water level maps, and hydrographs.

4.3.1 Hydrogeologic Units

Although it is the formation that covers most of the Fringe Area (Figure 24), the Older Alluvium is insignificant to the hydrogeology of the Nipomo Valley Fringe Area. The cross sections in Figures 25 and 26 indicate that the Older Alluvium unit in the Nipomo Valley is not a viable aquifer. It is not saturated and is not capable of producing significant water to wells. This is demonstrated by the fact that nearly all wells in the Fringe Area are screened in the deeper bedrock of the Monterey and Obispo Formations.

The Monterey Formation, a bedrock formation that is not part of the SMRVGB, is the most significant hydrogeologic unit in the Fringe Area. As discussed previously, nearly all wells in the Nipomo Valley Fringe Area draw from the Monterey Formation.

None of the significant hydrogeologic units present in the SMRVGB (Careaga Formation, Paso Robles Formation, or Recent Alluvium) are present as hydrogeologic units in the Nipomo Valley Fringe Area.

4.3.2 Water Quality

DWR presented an areal representation of water quality from wells on Plate 15 of their report "Water Resources of the Arroyo Grande-Nipomo Mesa Area" (DWR, 2002). DWR presents stiff diagrams of chemical analyses of groundwater samples collected between 1992 and 2000. Four wells in the Nipomo Valley Fringe Area are presented (36R, 8G01, 17A02, 17B05); these results may be compared to the four nearest wells in the Nipomo Mesa (11J03, 13F01, 24A01, 19L03). The wells in Nipomo Valley Fringe Area are significantly higher in Total Dissolved Solids (TDS) than the wells in the Adjudicated Area. TDS concentrations presented for samples from the Nipomo Valley wells range from 860 to 1,300 mg/L, while concentrations for samples from the Adjudicated Area range from 390 to 582 mg/L. The groundwater in Nipomo Valley wells is significantly more highly mineralized than the groundwater in the Adjudicated Area wells. This is consistent with the fact that the Nipomo Valley wells draw from the bedrock of the Monterey Formation, while the Adjudicated Area wells draw from the Paso Robles/Careaga Formations. These water quality data support the interpretation that the Nipomo Valley and the Adjudicated Area have distinctly different hydrogeologic environments, and that excluding the Nipomo Valley from the SMRVGB will have no effect on the ability of the Adjudicated Area to sustainably manage their groundwater resources.

4.4 Hydrogeologic Conceptual Model of Nipomo Valley

The two most significant formations of the HCM in the Nipomo Valley are the Older Alluvium, and the underlying bedrock of the Monterey and Obispo Formations. None of these units are present in the aquifers of the Adjudicated Area.

The Older Alluvium crops out at the surface through most of the Fringe Area (indeed, it appears that the Fringe Area boundaries were originally drawn in DWR Bulletin 118 to include these outcrops). It consists of an unconsolidated collection of alluvial materials which has been uplifted due to its location on the upthrown fault block northeast of the Wilmar Avenue/Santa Maria River Fault Zone. It is not saturated, and is not considered to be an aquifer. The Older Alluvium is underlain by the bedrock of the Obispo and the Monterey Formations. Nearly all wells located in the Nipomo Valley Fringe Area draw from the bedrock of the Monterey and Obispo Formations.

The primary source of recharge for the Nipomo Valley is likely inflow from upgradient in the Monterey Formation. The Monterey Formation crops out at the surface in the area between the Fringe Area and Temetatte Ridge to the northeast. Direct percolation of precipitation which falls on these outcrops recharges the groundwater in the Monterey Formation, and this groundwater flows downgradient to the Fringe Area (DWR, 2002). Precipitation on the outcrop of the Older Alluvium also percolates into the subsurface to recharge the underlying Monterey Formation. However, there is no evidence suggesting that the Older Alluvium retains a saturated interval, and it is not considered to be an aquifer. Another source of recharge is irrigation return flow from cultivated areas in the Fringe Area.

The primary source of discharge for the Fringe Area is pumping of irrigation wells screened in the Monterey Formation. Other minor sources of discharge include evapotranspiration from the root zone of plants along the small stream channels in the area, and underflow of groundwater out of the Fringe Area. Underflow form the Monterey Formation across the fault zone to the Adjudicated Area is not quantified, but is assumed to be insignificant due to the large difference in productivity and associated hydraulic characteristics between Monterey Formation bedrock and the sedimentary aquifers of the Adjudicated Area.

4.5 Basin Boundary Modification Request

The County GSA is submitting this request to DWR to revise the boundaries of the SMRVGB as follows:

Modification Request Number 4 – Scientific External Boundary Modification – Exclude the Nipomo Valley Fringe Area from the SMRVGB, and modify the Basin boundary to be coincident with the Adjudicated Area boundary (Figure 27). Analysis of the hydrogeologic setting of the Nipomo Valley and other technical information presented in this analysis indicates the following:

a) None of the primary aquifers of the SMRVGB (Recent Alluvium, Paso Robles Formation, Careaga Formation) are present as hydrogeologic units in the Nipomo Valley Fringe Area (Figures 25, 26). This demonstrates that the Nipomo Valley Fringe Area is hydrogeologically distinct from the Adjudicated Area.
b) The primary hydrogeologic unit in the Nipomo Valley Fringe Area is the bedrock of the Monterey and Obispo Formations (Figures 25, 26), which are not considered part of the Basin as defined in Bulletin 118, since they do not have well-defined boundaries and are not part of the SMRVGB materials.
c) Because water is drawn from the Monterey Formation in the Fringe Area, hydrogeologic conditions in the Fringe Area have no impact on the sustainable management of the Adjudicated Area and vice versa.
d) Throw along the Wilmar Avenue and Santa Maria River Fault Zones forms an effective barrier to groundwater flow by juxtaposing the impermeable bedrock northeast of the fault against hundreds of feet of permeable Basin and aquifer materials southwest of the fault against bedrock in Nipomo Valley (Figure 25). This geologic relationship clearly shows that there is no geologic continuity or significant hydraulic connection between Basin aquifer materials southwest of the fault and Nipomo Valley Fringe Area.
e) Historical water quality data indicate distinctly different water quality for wells that draw from the Monterey Formation in the Nipomo Valley Fringe Area and wells that draw from the Paso Robles/Careaga Formations in the Adjudicated Area. This corroborates the interpretation that the Nipomo Valley and the Adjudicated Area have distinctly different hydrogeologic environments, and that excluding the Nipomo Valley from the SMRVGB will have no effect on the ability of the Adjudicated Area to sustainably manage their groundwater resources.
f) The technical experts and the Court for the basin adjudication concluded that the quantities of groundwater in the Nipomo Valley Fringe Area are not significant to groundwater management in

the Adjudicated Area; Nipomo Valley was specifically excluded from the Adjudicated Area for this reason.

5 Southern Bluffs Fringe Area

This section of the report discusses the data used to support the County GSA's BBMR with respect to the Southern Bluffs Fringe Area.

Modification Request Number 5 – Scientific External Boundary Modification – Exclude the Southern Bluffs Fringe Area from the SMRVGB, and modify the Basin boundary to be coincident with the Adjudicated Area boundary.

5.1. Physical Setting

5.1.1 Topography

The Southern Bluffs Fringe Area is located immediately southeast of the Nipomo Valley, adjacent to the Santa Maria River, northeast of the Adjudicated Area boundary. It is approximately seven miles long, about 1.5 miles wide at its widest point, oriented in a northwest-southeast direction, and is adjacent to the Adjudicated Area boundary northeast of Santa Maria River. Figure 28 presents an aerial photograph, and Figure 29 presents a topographic map of the area. Land surface of the Southern Bluffs Fringe Area ranges from an altitude of about 400 to 750 feet MSL at along the northeastern extent to about 230-350 ft MSL along the course of Santa Maria River. The area of the Southern Bluffs Fringe Area is about 4,060 acres (6.3 square miles).

5.1.2 Land Use

The area encompassed by the northern third of the Southern Bluffs Fringe Area is largely vacant; small areas are currently used for agriculture as shown in Figure 28. Much of the southern area is used for irrigated agriculture, primarily avocados and citrus. In 2014, approximately 2,100 acres (DWR, 2017) in or adjacent to the Fringe Area were used for agriculture.

5.1.3 Water Use

Because of the marginal productivity of geologic formations in the Southern Bluffs Fringe Area, there are very few wells in the Southern Bluffs. Some of the irrigation water needs in the area are supplied from local wells that draw from the bedrock of the Monterey Formation or Franciscan Group, but much of the irrigation demand is supplied from alluvial wells located outside of the Southern Bluffs Fringe Area. The formations beneath the Southern Bluffs Fringe Area are not viable aquifers capable of supplying the irrigation in the Southern Bluffs. The local landowner who farms most of the irrigated acreage in the Southern Bluffs (Figure 28) supplies much of his operations with groundwater collected from alluvial wells along Twitchell reservoir located upstream of the dam. This groundwater production and use is codified in an executed contract with the Federal Government, U.S. Bureau of Reclamation, dated October 10, 1956. This standing contract pre-dates the completion of Twitchell Dam, and authorizes the landowner to extract up to a maximum of 3,100 AFY in any given year. However, without the addition of significant water brought from outside the Southern Bluffs Fringe Area, this agricultural development could not be supplied from wells within the Fringe Area, because a viable aquifer does not exist that can meet this demand.

5.1.4 Hydrology

There is no significant engineered water infrastructure such as reservoirs or canals in the Southern Bluffs Fringe Area. A privately engineered and maintained pipeline delivers water from wells behind Twitchell Dam to the irrigated area in the Southern Bluffs, as previously described. Long term average annual precipitation in the valley is about 14 inches (DWR, 2002).

5.2. Geologic Setting

Figure 30 displays the geologic map (Dibblee, 1994, 2006a, 2006b) in the vicinity of the Southern Bluffs Fringe Area. The most significant geologic formation to note is the Orcutt Formation. The Bulletin 118 basin boundary was drawn to approximate the outcrops of the Orcutt Formation. The Orcutt Formation is not saturated and is not an aquifer. The Orcutt Formation is very similar to the Older Alluvium unit in the Nipomo Valley. It consists of alluvial sediments consisting of sands, silts, clays, and gravels that have been uplifted on the upthrown fault block northeast of the Santa Maria River Fault Zone. Because these sediments are elevated above the land surface of the main part of the Basin, they are hydraulically disconnected from the aquifers in the Adjudicated Area of the SMRVGB. The Franciscan Assemblage is exposed at the surface to the northeast of most of the Southern Bluffs Fringe Area, and underlies the Orcutt Formation in much of the area.

Figure 31 displays cross section H-H’ oriented down the long axis of the Southern Bluffs, parallel to the Santa Maria River. There are relatively few wells to use as data points in the Southern Bluffs. This cross section displays a geologic setting similar to the Nipomo Valley. There is a relatively thin veneer of highly dissected Orcutt Formation on top of the bedrock of the Franciscan Formation. The cross section displays the total depth and perorated interval of wells in the section line, and shows that none of the wells that supply water to the irrigated fields draw from the Orcutt. (One well visible in the small valley of Suey Creek likely draws from the alluvium associated with that creek.) Nearly all draw from the bedrock of the Monterey Formation or Franciscan Group, which is not part of the SMRVGB.

Figure 32 displays geologic cross section I-I’ oriented northeast-southwest that crosses the Santa Maria River Fault Zone. Like Figure 31, this section also displays the fact that the wells in the Southern Bluffs draw from the bedrock formations and not from the Orcutt Formation. This cross section displays a geologic setting similar to the Nipomo Valley, and similarly illustrates an important geologic relationship between the Adjudicated Area and the Southern Bluffs. Throw along the Santa Maria River Faults juxtaposes hundreds of feet of accumulated Basin aquifer materials (primarily Paso Robles Formation and Careaga Formation) southwest of the fault against Franciscan bedrock in the Southern Bluffs. The geologic relationship clearly shows that there is no geologic continuity or significant hydraulic connection between Basin aquifer materials southwest of the fault and the Southern Bluffs Fringe Area. Due to the significantly less productive water-bearing properties of the bedrock compared to the Basin sediments, it appears that there is limited outflow from the Franciscan Group in the Fringe Area to the sediments in the Adjudicated Area of the Basin.

Figure 33 presents a conceptual cross section J-J' across the Santa Maria River Fault Zone. This section displays many of the same geologic relationships as section H-H', but more clearly displays the prominent bluffs visible from Highway 101.

5.3. Hydrogeologic Setting

The cross sections in Figures 31, 32, and 33 indicate that none of the aquifers of the SMRVGB are present in the Southern Bluffs. This demonstrates that the Adjudicated Area and the Southern Bluffs Fringe Area are distinct and separate hydrogeologic environments.

The Orcutt Formation unit in the Southern Bluffs Fringe Area is not an aquifer; it is an unsaturated unit that is hydraulically disconnected from the Adjudicated Area, sitting atop the bedrock of the Franciscan Group. No wells draw from this unit. The few other existing wells in the Southern Bluffs Fringe Area draw from bedrock formations, either Monterey or Franciscan.

Although the potentiometric surface of groundwater in the wells drawing from the bedrock Formations may rise under pressure into the lowest portion of the Orcutt Formation, the Orcutt Formation itself is not saturated, and is not a viable aquifer capable of transmitting significant quantities of water to wells. The Orcutt Formation is insignificant to the hydrogeology of the Fringe Area.

The Monterey Formation and the Franciscan, the most significant hydrogeologic units in the Fringe Area, are bedrock formations and are not part of the SMRVGB. As discussed previously, nearly all wells in the Southern Bluffs Fringe Area draw from these formations.

None of the significant hydrogeologic units present in the SMRVGB (Careaga Formation, Paso Robles Formation, or Recent Alluvium) are present as hydrogeologic units in the Fringe Area.

5.4 Hydrogeologic Conceptual Model of Southern Bluffs

The two most significant formations of the HCM in the Nipomo Valley are the Orcutt Formation, and the underlying bedrock of the Monterey/Obispo Formations and the Franciscan Group. None of these units are present in the aquifers of the Adjudicated Area.

The Orcutt Formation crops out at the surface throughout most of the Southern Bluffs Fringe Area (indeed, it appears that the Fringe Area boundaries were originally drawn in DWR Bulletin 118 to include these outcrops, Figure 30). The Orcutt Formation is similar to the Older Alluvium in the Nipomo Valley. It consists of an unconsolidated collection of alluvial materials which has been uplifted due to its location on the upthrown fault block northeast of the Santa Maria River Fault Zone. It is not saturated, and is not considered to be an aquifer. The Orcutt Formation is underlain by the bedrock of the Monterey/Obispo Formations and the Franciscan Group. Nearly all wells located in the Southern Bluffs Fringe Area draw from the bedrock of these units.

The primary source of recharge for the Nipomo Valley is likely inflow from upgradient in the bedrock formations. The bedrock formations crop out at the surface upslope from the Fringe Area to the northeast. Direct percolation of precipitation which falls on these outcrops recharges the groundwater in the bedrock, and this groundwater flows downgradient to the Fringe Area via structural joints and fracture systems. Direct precipitation on the outcrop of the Orcutt Formation also percolates into the subsurface to recharge the underlying bedrock formations. However, there is no evidence suggesting that the Older Alluvium retains a saturated interval, and it is not considered to be an aquifer. Another source of recharge is irrigation return flow from cultivated areas in the Fringe Area.

The primary source of discharge for the Fringe Area is pumping of irrigation wells screened in the Monterey Formation. Other minor sources of discharge include evapotranspiration from the root zone of plants along the small stream channels in the area, and underflow of groundwater out of the Fringe Area. Underflow form the Monterey, Obispo, and Franciscan across the fault zone to the Adjudicated Area is not quantified, but is assumed to be insignificant due to the large difference in productivity and associated hydraulic characteristics between the bedrock and the sedimentary aquifers of the Adjudicated Area.

5.5 Basin Boundary Modification Request

Modification Request Number 5 – Scientific External Boundary Modification – Exclude the Southern Bluffs Fringe Area from the SMRVGB and modify the Basin boundary to be coincident with the Adjudicated Area boundary. Analysis of the hydrogeologic setting of the Nipomo Valley and other technical information presented in this analysis indicates the following:

a) None of the primary aquifers of the SMRVGB (Recent Alluvium, Paso Robles Formation, Careaga Formation) are present as hydrogeologic units in the Southern Bluffs (Figures 31, 32, 33). This demonstrates that the Adjudicated Area and the Southern Bluffs Fringe Area are hydrogeologically separate and distinct.
b) The primary hydrogeologic unit in the Southern Bluffs Fringe Area is the bedrock of the Monterey and Obispo Formations, which are not considered a basin as per Bulletin 118, and are also not part of the SMRVGB materials.
c) Throw along the Santa Maria River Faults in the Southern Bluffs forms an effective barrier to groundwater flow by juxtaposing the impermeable bedrock northeast of the fault against hundreds of feet of permeable Basin and aquifer materials southwest of the fault (Figure 31). This geologic relationship clearly shows that there is no geologic continuity or significant hydraulic connection between Basin aquifer materials southwest of the fault and Southern Bluffs Fringe Area.
d) Additionally, the wells drawing from bedrock formations are not capable of supporting the existing agriculture without bringing water from nearby alluvial wells located outside the Fringe Area. This demonstrates that the bedrock formations in the Southern Bluffs Fringe Area are not viable aquifers capable of supplying significant quantities of groundwater.
e) Because water is drawn from the bedrock formations in the Southern Bluffs Fringe Area, hydrogeologic conditions in the Fringe Area will have no impact on the sustainable management of the Adjudicated Area of the SMRVGB, and vice versa.
f) The technical experts and the Court for the basin adjudication concluded that the quantities of groundwater in the Southern Bluffs Fringe Area are not significant to groundwater management in the Adjudicated Area; Southern Bluffs was specifically excluded from the Adjudicated Area for this reason.

6 Ziegler Canyon Fringe Area

This section of the report discusses the data used to support the County GSA's BBMR with respect to the Ziegler Canyon Fringe Area. (This area was originally referred to as the Cuyama River Valley Fringe Area; the local name of Ziegler Canyon was adopted to avoid confusion with the Cuyama River Valley Groundwater Basin.)

Modification Request Number 6 – Scientific External Boundary Modification –Exclude the Ziegler Canyon Fringe Area from the SMRVGB, and modify the Basin boundary to be coincident with the Adjudicated Area boundary (Figure 34).

6.1 Physical Setting

6.1.1 Topography

The Ziegler Canyon Fringe Area straddles the border between San Luis Obispo and Santa Barbara Counties (Figures 35 and 36). It is a north-south oriented narrow alluvial valley of the Cuyama River that extends approximately 6 miles from Twitchell Dam at the upstream end to the Adjudicated Area boundary at the downstream end. It is less than a mile wide at its widest point. Land surface ranges from an altitude of about 500 feet MSL at the base of Twitchell Dam to about 370 ft MSL at the base of the valley (Figure 36). Slopes rise steeply on both sides of the canyon to elevations of over 1,000 ft MSL on both sides. The area of the Ziegler Canyon Fringe Area based on the Bulletin 118 boundary is 1,570 acres (2.5 square miles).

6.1.2 Land Use

Three landowners own the entire portion of Ziegler Canyon within the Bulletin 118 boundary. Land use in Ziegler Canyon is exclusively irrigated agriculture, with nearly all available acreage planted in wine grapes. In 2014 approximately 1,430 acres (DWR, 2017) in or adjacent to Ziegler Canyon were used for agriculture, of which approximately 470 acres are in San Luis Obispo County and 960 acres are in Santa Barbara County.

Because Ziegler Canyon has established fields of high value crops, the current land use is unlikely to change in the foreseeable future. A number of factors would likely preclude the transition of land use to other categories (such as residential/commercial), including current contractual designation as an agricultural preserve under the Williamson Act, the existence of an active river flood plain, the zoning and construction challenges inherent in building on the steep slopes along the canyon walls, and the location immediately downstream from a dam. If land use were to change in the future, DWR has the authority to reconsider any groundwater-related regulatory actions promulgated under the assumption of current use and conditions, and the Counties would retain regulatory control over proposed zoning and land use changes.

Approximately one mile upstream from the downstream end of the valley there is a wetland area with standing water at the surface that is too saturated to plant.

6.1.3 Water Use

All water supply comes from alluvial wells within the valley. Based on the factors presented in Table 2, estimated crop demand is approximately 1,700 AFY. (Crop demand is not equivalent to groundwater production. A portion of this demand is met through precipitation during the growing season.)

The three landowners have overlying water rights to the groundwater in the valley, and cannot use more water than can be put to beneficial use. They have cooperated in sustainable management of the groundwater in the Ziegler Canyon Fringe Area to date.

Figure 35 shows that there is no additional acreage available on the valley floor of Ziegler Canyon to increase irrigated farming operations. This fact demonstrates that the current level of groundwater use, which has been shown to be sustainable (discussion to follow), will not increase under the current ownership and land use.

6.1.4 Hydrology

Hydrology in the valley is dominated by releases from Twitchell Reservoir. Twitchell Dam was completed in 1958, and captures runoff from a drainage area of 1,135 square miles. Twitchell Reservoir has a storage capacity of 197,756 acre-feet, and is used for flood control and water conservation (releases intended for recharge of SMRVGB). Downstream releases from the reservoir are an important component of recharge to the alluvial aquifer in the Ziegler Canyon Fringe Area. It is important to note that in the 2005 Stipulated Judgement for the Santa Maria Basin adjudication, an agreement was described in the Stipulations that 80% of the 32,000 acre-feet of Twitchell Yield from the reservoir storage shall be allocated as follows: City of Santa Maria – 14,300 acre-feet; City of Guadalupe – 1,300 acre-feet; and Southern California Water Company - 10,000 acre-feet. The remaining 20% shall be allocated to the other stipulated groundwater overlying owners – 6,400 acre-feet. However, releases are not guaranteed; during drought cycles, there may be consecutive years during which no water is released. However, releases resume when the drought cycle ends and rains return. Since 1966, the average annual amount of downstream releases through the dam is 46,800 AFY.

Long term average annual precipitation in the valley is about 14 inches (DWR, 2002).

6.1.5 Sustainability Factors

Since the primary goal of SGMA is the establishment of sustainable groundwater management, it is appropriate to discuss factors that have affected the sustainability of the area in the past, and how they are likely to remain consistent in the future.

Population: There is almost no resident population living in Ziegler Canyon. Only three residential structures exist on the valley floor, and only one is permanently occupied (by two people). The other two structures are used to house temporary employees. Additionally, there is no prospect of population growth because current agricultural operations occupy all available land in the Fringe Area, and no available residential structures exist. This demonstrates that population is not a factor that will impact sustainability in the future under current ownership and land use.

Public Supply and Irrigation Wells: There are no public supply wells located in Ziegler Canyon. There are 15 active irrigation wells in the 2.5 square mile Fringe Area.

As previously discussed, irrigation is widespread in the Fringe Area. However, only areas identified on the geologic map as Quaternary Alluvium or Older Alluvium (Figure 37) have suitable soils for agricultural production, and these areas are entirely planted. Therefore, there will be no increase in irrigation demand in the future, and the existing landowners have conducted their operations sustainably over the past decades, even during extended drought periods (as demonstrated in water level hydrographs, discussion to follow).

One hundred percent of supply in Ziegler Canyon is provided by groundwater. However, as previously discussed, there is no availability of land to increase planting, so the current level of groundwater production, which the three landowners have maintained for the past decades, will not increase under existing land use.

Under the sustainable groundwater management practiced by the landowners, there have been no undesired groundwater conditions as discussed in SGMA, such as declining water levels, groundwater quality impacts, subsidence, reduction of storage, surface water depletion, or seawater intrusion.

6.2 Geologic Setting

Figure 37 displays a geologic map (Dibblee, 1994) in the vicinity of the Ziegler Canyon. The Bulletin 118 basin boundary appears to have been drawn to approximate the mapped outcrops of the Recent Alluvium and Older Alluvium associated with the Cuyama River downstream of Twitchell Dam. The Recent Alluvium consists of unconsolidated sands, silts, clays, and gravels that have been deposited by fluvial processes. Some areas of alluvium associated with feeder creeks on the east side of the valley are also included in the Bulletin 118 area. The Obispo Formation crops out along almost the entire west side of the valley. The Monterey Formation crops out along most of the east side of the valley, with some Obispo Formation cropping out at lower elevations of the eastern slopes.

Figure 38 displays geologic cross section K-K’ oriented down the long axis of Ziegler Canyon. There is no other water–bearing formation beneath the Recent Alluvium. Wells along the section line are displayed along with their perforated intervals. All wells in the valley draw from the Recent Alluvium. The Santa Maria River Fault Zone juxtaposes hundreds of feet of SMRVGB aquifer sediments against the bedrock that underlies the Recent Alluvium in the Fringe Area.

The geologic cross section of Figure 38 illustrates an important geologic relationship between the Adjudicated Area and the Ziegler Fringe Area. Throw along the Santa Maria River Fault Zone juxtaposes nearly 800 feet of accumulated Basin aquifer materials (primarily Paso Robles Formation and Careaga Formation) southwest of the fault against bedrock in Ziegler Canyon. The geologic relationship illustrated by Figure 38 clearly shows that there is no geologic continuity or significant hydraulic connection between Basin aquifer materials southwest of the fault and Ziegler Canyon Fringe Area.

Figure 39 displays cross section L-L’ oriented perpendicularly across the valley. This section displays a total thickness of alluvium of about 70 feet. The section includes representation of wells along the section line, with perforated intervals displayed. Because the primary hydrogeologic units of the Adjudicated Area (Paso Robles and Careaga Formations) are not present here, all wells draw from the thin alluvial deposits in the valley. No wells draw from the bedrock formations in this area.

6.3 Hydrogeologic Setting

This section presents the hydrogeologic setting of Ziegler Canyon, including discussion of hydraulic parameters, hydrographs, recharge, and geophysical field work performed by Ramboll/Environ as part of this project.

6.3.1 Hydraulic Parameters

No reports were identified that documented specific aquifer tests using wells in Ziegler Canyon. Cleath (1997) posits a typical hydraulic conductivity of 200 ft/day for alluvial gravels in the valley, corresponding to a transmissivity of about 133,000 gpd/ft for the deeper wells in the area.

Well records from the landowners in Ziegler Canyon were reviewed and included several wells with specific capacity information. Specific capacity is a field-measured parameter frequently measured by pump service companies during routine well maintenance. In a specific capacity test, the well is pumped for a brief time, while flow rate and drawdown are measured. Specific capacity is defined as the flow rate in gpm divided by the drawdown in feet. This test is not as robust as a constant rate aquifer test, but it gives an estimate of aquifer productivity. A hydrogeologic rule of thumb correlates specific capacity (gpm/ft) to transmissivity (gpd/ft) by multiplying the specific capacity value by a factor of 1,500 for unconfined aquifers. This calculation was performed for all wells that had specific capacity data. Hydraulic conductivity was then calculated by dividing transmissivity by saturated thickness. The results are presented in Table 7. (Well identification numbers are arbitrarily assigned to maintain the confidentiality of private well owners' data.)

Three pumping tests were performed in Ziegler Canyon for the purposes of this Report. The locations of these wells are presented on Figure 35. Transmissivity estimates based on these tests ranged from 18,000 gpd/ft to 33,000 gpd/ft, and averaged 25,000 gpd/ft, while associated hydraulic conductivity estimates range from 31 to 82 ft/day, and average 56 ft/day (Table 8). These values are all in the range of the estimated values derived from specific capacities measured in the field as shown in Table 7.

Table 7 – Ziegler Canyon Specific Capacity Data Summary

Well No.	Specific Capacity (gpm/ft)	T (gpd/ft)	K ft/d
1	20.6	30,900	58
2	16.1	24,150	41
3	24.9	37,350	47
4	42.3	63,450	123
5	19.2	28,800	43
6	34.8	52,200	66
7	36.7	55,050	66
8	27.3	40,950	61
9	21.7	32,550	80
10	81.4	122,100	146
11	19.1	28,650	64
12	7.6	11,400	20
Average	29.3	43,963	68
Note: Well numbers presented in this table are arbitrary identifiers assigned to maintain the confidentiality of the data locations for private well owners.			

Table 8 – Ziegler Canyon Constant Rate Pumping Test Data Summary

Well ID	Area	Date	Saturated Thickness (ft)	Transmissivity (gpd/ft)	Hydraulic Conductivity (ft/day)
Well #1 Propane	Ziegler Canyon	10/13/17	54	33,000	82
Well #3 Propane	Ziegler Canyon	10/20/17	77	18,000	31
Tantara Well	Ziegler Canyon	1/15/17	60	24,000	54
Notes: Aquifer tests performed by GSI Water Solutions, Inc.					

6.3.2 Hydrographs and Recharge

Figure 40 displays long-term water level hydrographs for four United States Geological Survey (USGS) monitoring wells in the Ziegler Canyon Fringe Area. This graph also displays the annual downstream releases from Twitchell Dam since its construction. Three of these wells had data collection discontinued around the year 2000, while a fourth well was monitored after this period. Figure 41 displays individual groundwater elevation hydrographs at locations throughout the valley.

The three wells that were being monitored in the late 1980s show a decline of approximately 7-8 feet during the drought period of the late 1980s. However, as soon as releases from Twitchell Dam resumed in 1990, the groundwater elevations quickly recover to their previous levels. Well 74101 (USGS identifier), which has been monitored since 2000, shows a decline of about 18 feet associated with the 2011-2016 drought. Releases from Twitchell Reservoir resumed in August 2017. The most recent water level measurement displayed for this well indicates that by March of 2018, the groundwater elevation in this well had recovered to approximately pre-drought levels. (The most current Twitchell release data was unavailable at the time of this report.)

Figure 40 demonstrates that the groundwater hydrology in Ziegler Canyon is dominated by the surface water releases from the dam. During drought cycles, when there are no releases, groundwater elevations decline. When the releases resume, the local alluvial aquifer is recharged, and groundwater elevations recover. There is no long term trend of declining water levels that would indicate that groundwater in the Ziegler Canyon alluvium is stressed or in need of additional management under current conditions.

The USGS performed a synoptic water level data collection effort in Spring of 1974. A groundwater elevation contour map of this data is presented in Figure 42. Water levels range from 397 ft MSL at the upgradient extent of the data to 342 ft MSL at the mouth of the valley. These contours represent a groundwater flow gradient of 0.004 ft/ft. As previously discussed, groundwater elevations in Ziegler Canyon alluvial wells are in approximate long-term equilibrium, largely due to the regular recharge provided by the downstream releases from Twitchell reservoir.

Figure 42 presents shallow zone groundwater elevation contours in the Santa Maria Valley Management Area's portion of the SMRVGB (Luhdorff-Scalmanini, 2017). In the area immediately downgradient of Ziegler Canyon, the groundwater gradient is approximately 0.007 ft/ft. However, the most significant detail apparent when comparing the two water level maps is that the groundwater elevation in the Adjudicated Area of the Basin is nearly 100 feet lower than the groundwater elevation at the mouth of Ziegler Canyon. The County understands that two different data sets are being compared. However, it has previously been demonstrated that water levels in Ziegler Canyon are in approximate equilibrium due to the releases from Twitchell Reservoir. Therefore, these 1974 water levels are not significantly different from current conditions, and it is appropriate to compare these water level data with recent water level data from the Santa Maria Valley Management Agency. Figure 44 presents a graphical representation of the groundwater elevation profile in Ziegler Canyon, across the fault zone, and down the Santa Maria Valley. There is a significant discontinuity in the groundwater surface profile across the fault zone. Because of this, groundwater conditions in the Adjudicated Area will not propagate upgradient across the fault to affect conditions in the Fringe Area, and vice versa.

6.3.3 Outflow to the Adjudicated Area of the SMRVGB

The quantity of groundwater underflow leaving the alluvial aquifer of Ziegler Canyon is calculated as previously described. This estimate is limited to flow in the Recent Alluvium.

For hydraulic conductivity, an average of the values from the aquifer tests performed on the alluvial wells is applied. The average of these values is 56 ft/day.

Hydraulic gradient was estimated by measuring the gradient of the land surface elevation contours of the river channel thalweg displayed in Figure 36. This value is 0.003.

The cross-sectional area of flow was estimated as a rectangle across the bottom of the alluvial valley. The map distance across the neck at the bottom of the valley is approximately 1,100 feet. Saturated thickness in the alluvium is estimated at 95 feet based on information in well completion reports. Thus, the cross-sectional area of flow is estimated at 104,500 square feet. Therefore,

Q = (56 ft/day)*(0.003)*(104,500 square feet)

Q = 147 AFY

Luhdorff-Scalmanini estimated the average total inflow (including stream infiltration, precipitation-based recharge, irrigation return flows, and wastewater return flows) to the Santa Maria Valley Management Area's portion of the SMRVGB as 114,000 AFY (Luhdorff-Scalmanini, 2000). The Ziegler Canyon underflow estimate presented herein accounts for 0.1% of total inflow to this portion of the Basin. This demonstrates that underflow from Ziegler Canyon is not a significant component of recharge to the Adjudicated Area.

6.3.4 Geophysical Study

As part of this project, staff from Ramboll/Environ performed a surface geophysical field investigation of suitable areas in lower Ziegler Canyon using Time Domain Electro Magnetic (TDEM) methods. A three-day investigation was undertaken on September 25-27, 2017. The Ramboll/Environ report documenting this work is included as Appendix C. Figures 35 and 45 display the locations of 36 sounding stations that were used in the investigation.

Figure 41 displays interpreted conductivity data and associated inferred low permeability strata in the subsurface beneath the sounding stations. Along the primary north-south section line investigation, it appears that low permeability beds beneath the alluvium are dipping northward in the upper part of the section, and southward in the lower part of the section, defining an anticlinal structure of low permeability in the bedrock beneath the alluvium. Inspection of the geologic map on both sides of Ziegler Canyon (Figure 37) indicates that the axis of this interpreted anticlinal structure approximately corresponds to anticlines mapped in the Monterey Formation east of the valley and the Obispo Formation west of the valley.

This interpretation of bedrock structure is significant in the characterization of Ziegler Canyon hydrogeology. As was mentioned previously, and is displayed on Figure 35, a wetland area is present just over a mile upstream from the bottom of the valley where it joins the SMRVGB. The presence of these wetlands may be associated with the low permeability anticline inferred from the geophysical survey. This structure may be forcing groundwater flow to daylight in the wetland area due to the impermeable bedrock strata rising to near the ground surface. This geologic interpretation explains the presence of a perennial wetland at this location. There are no other wetland areas in Ziegler Canyon.

While the presence of the wetland area may be explained by the bedrock structure, the dimensions of the wetland area at land surface are significant to the hydrogeology of the Ziegler Canyon Fringe Area. As indicated on Figure 35 and 45, the wetland area spans nearly the entire width of alluvial valley. In other words, groundwater daylights at the surface across nearly the entire width of the valley at this location, creating a hydrogeologic boundary between approximately the lower fifth and the upper four fifths of the valley. The presence of this hydrogeologic boundary remained unchanged through the recent drought, and is visible in historical air photos available on Google Earth. This boundary separates the valley into two groundwater sub-areas that are essentially hydraulically disconnected. Where the wetland area is present, conditions upgradient of the boundary have no apparent effect on conditions downgradient of the boundary, and vice versa. So while the groundwater in the lower mile of the Ziegler Canyon flows into the Adjudicated Area of SMRVGB, groundwater in the upper four to five miles of the valley has no connection with the Adjudicated Area.

6.4 Hydrogeologic Conceptual Model of Ziegler Canyon

The most significant geologic formation of the HCM of Ziegler Canyon is the Recent Alluvium. This unconsolidated collection of alluvial materials contains groundwater in the interstitial pore spaces between the sedimentary particles. It is defined laterally by the contact of the alluvium with the bedrock of the Monterey and Obispo Formations cropping out in the mountains on the east and west side of the valley, and the Santa Maria River Fault Zone to the south (Figure 37). It is defined vertically by the contact between the alluvium and the underlying bedrock (Figures 38 and 39). The total thickness of alluvium in the Fringe Area is less than 100 feet through most of the valley (Figure 38).

Transmissivity estimates of alluvial wells based on specific capacity tests and constant rate pump testing range average approximately 40,000 gpd/ft. Corresponding pumping rates ranged from approximately 175 to 900 gpm.

The primary source of recharge for Ziegler Canyon is stream infiltration. The streamflow of the Cuyama River, which flows through the valley, are largely regulated through releases of surface water from Twitchell Reservoir. This streamflow infiltrates into and recharges the alluvium in the valley. There is likely a component of recharge from the underlying bedrock into the overlying alluvium. Other sources of recharge include direct percolation of rainfall on the alluvium surface, irrigation return flow, and mountain front recharge from runoff along the steep slopes on both sides of the valley.

The primary source of discharge for the Fringe Area is pumping of irrigation wells screened in the alluvium. As discussed previously, much of the valley is cultivated in various crops. Other sources of discharge include evapotranspiration from the root zone of plants along the stream channel, and underflow of groundwater out of the Fringe Area, discussed previously.

Water levels in the valley have remained essentially stable over the past 20 years (Figures 40, 41), indicating that recharge and discharge in the valley are in approximate equilibrium, and the alluvium has demonstrated sustainability over this time period. The regular recharge of the alluvial aquifer from the Twitchell Reservoir releases is a significant factor in this observed stability of groundwater levels.

6.5 Basin Boundary Modification Request

Modification Request Number 6 – Scientific External Boundary Modification –Exclude the Ziegler Canyon Fringe Area from the SMRVGB and modify the Basin boundary to be coincident with the Adjudicated Area boundary (Figure 46). San Luis Obispo County has coordinated with Santa Barbara County staff and local landowners in the preparation of this BBMR. Analysis of the hydrogeologic setting of the Ziegler Canyon Fringe Area presented in this report indicates the following.

a) All participants in the adjudication proceedings agreed to specifically omit the Ziegler Canyon area from the Adjudicated Area, based on the judgment that groundwater was not present in significant amounts to affect management actions in the main body of the Basin.
b) The CASGEM Basin Prioritization Process report (DWR, 2014) states that basins with less than 2,000 AFY of pumping "were automatically ranked as CASGEM Very Low Priority groundwater basins, meaning the Overall Basin Ranking Score is overridden with a zero." Estimated groundwater use in Ziegler Canyon is less than 2,000 AFY, and no undesirable results as defined in SGMA have been observed. If the CASGEM basin prioritization criteria for groundwater use may be viewed as a proxy to define significant production from a basin, then the Ziegler Canyon Fringe Area does not utilize significant production of groundwater.
c) No SMRVGB aquifer materials (except for Recent Alluvium) are present in the surface or subsurface of the Ziegler Canyon Fringe Area. The relatively thin veneer of recent alluvium in the Ziegler Canyon Fringe Area sits directly atop the bedrock of the Monterey and Obispo Formations.
d) The Santa Maria River Fault Zone forms an effective barrier to groundwater flow by juxtaposing the impermeable bedrock northeast of the fault against the stacked aquifers of the SMRVGB, with over 800 feet of accumulated Basin aquifer sediments southwest of the fault. This geologic relationship clearly shows that there is no geologic continuity or significant hydraulic connection between Basin aquifer materials southwest of the fault and the Ziegler Canyon Fringe Area, except for the presence of the thin alluvial sediments which are present in the valley, across the fault zone, and in the Adjudicated Area.
e) Groundwater levels display a significant discontinuity across the Santa Maria River Fault Zone between Ziegler Canyon and the Adjudicated Area. Groundwater elevations in the downgradient extent of the Ziegler Canyon Fringe Area are approximately 100 feet higher than groundwater elevations in the nearby Adjudicated Area. This demonstrates that hydrogeologic regimes of the SMRVGB and the Ziegler Canyon Fringe Area are distinct, and that conditions in the Fringe Area will not impact the ability to sustainably manage the SMRVGB. Similarly, conditions in the Adjudicated Area will not propagate upgradient to affect the sustainability of the Fringe Area.
f) Water levels in Ziegler Canyon alluvial wells have not shown any long term water level declines over the past twenty years, demonstrating that groundwater has been utilized in a sustainable fashion over this time period.
g) Long-term groundwater sustainability in Ziegler Canyon is ensured due to the regular recharge of the alluvial aquifer accomplished as a result of downstream releases from Twitchell Dam, which are codified in the adjudication judgment.

h) The three landowners who own the entirety of the Fringe Area have managed the groundwater in the valley sustainably over the past decades without State oversight, as demonstrated by the stable water level trends in groundwater elevation hydrographs over the past twenty years.

If DWR finds that the hydrogeologic evidence presented herein does not sufficiently support the request for exclusion of the Ziegler Canyon Fringe Area, the County GSA proposes the following optional BBMR alternative for DWR's consideration, based on items c through h, above: Adjust the boundary of the Ziegler Canyon Fringe Area northeast of the adjudicated boundary of the SMRVGB from the current published Bulletin 118 boundary line, to coincide with the mapped extent of the Recent Alluvium, as mapped by Dibblee (1994), from the adjudicated Basin boundary to the base of Twitchell Dam, and establish a new "Santa Maria River Valley - Ziegler Canyon " subbasin from the SMRVGB defined by the extent of mapped Quaternary Alluvium and Older Alluvium (Dibblee) between the current Adjudicated Area boundary and the base of Twitchell Dam.

7 Summary

This Basin Boundary Modification Report presents a summary of all available data characterizing the hydrogeology of the five Fringe Areas (within San Luis Obispo County) adjacent to the Adjudicated Area of the SMRVGB in support of the proposed BBMRs to the State. The proposed boundary modifications do not limit the opportunity or likelihood of sustainable groundwater management or groundwater storage/recharge in the proposed or adjacent basin or subbasins. In the adjacent Adjudicated Areas the Judgment requires each management area to establish a monitoring program to track any changes in groundwater supplies and any threats to groundwater supplies. The goals of the monitoring programs are to support the sustainable use of groundwater and surface water within the management areas. The monitoring programs accomplish this through regular collection of water level data and regular groundwater quality sampling in order to identify conditions of potential significant water shortages, to identify potential conditions of sea water intrusion, and to minimize the reduction of groundwater in storage in the management areas. The data is then used to prepare the required annual reports and is provided to other public agencies for groundwater monitoring and management purposes. The operation of the Lopez Dam under the Urban Water Management Plan and future Habitat Conservation Plan as described below will continue to play an important role in the management of water supplies in the fringe area and the adjudicated area in light of future SGMA implementation. Additionally, the proposed boundary modifications do not limit the likelihood of coordination of management activities and the sharing of data across basin or subbasin boundaries, as indicated by resolutions of support from bordering local agencies and adjudicated area. The proposed modifications do not result in the isolation of areas with known groundwater management problems, or the isolation of areas that may lack the institutional infrastructure or economic resources to form an effective GSA. No objections to the proposed modifications have been raised by any local groundwater management agencies, adjudicated management areas, or staff from San Luis Obispo and Santa Barbara Counties.

Pertinent physical data includes geographic setting, land use, water use, and hydrology for each of the five Fringe Areas. Pertinent data describing the geologic setting of each Fringe Area includes geologic maps and cross sections. The Report also presents available data describing the hydrogeologic setting, including information on hydraulic parameters, recharge, groundwater elevation hydrographs, and subsurface outflow to the SMRVGB.

In addition to reviewing available published data, the County GSA sponsored collection of new data for the purposes of this Report from several field investigation tasks. Current water levels were collected from alluvial wells in the upper Pismo Creek Valley Fringe Area. Five constant rate aquifer tests were performed on privately-owned wells in the Arroyo Grande Valley Fringe Area and Ziegler Canyon Fringe Area. A TDEM geophysical study was performed in the Ziegler Canyon Fringe Area. The data collected for this Report was used in discussion of the hydrogeologic setting of each area.

The County GSA is requesting that the Pismo Creek Valley be excluded from the SMRVGB, and that the Basin boundaries be adjusted to be coincident with the Adjudicated Area boundary. The Pismo Creek Valley Fringe Area is a small alluvial valley adjacent to the northern extent of the Adjudicated Area. Data presented support the fact that the alluvium in Pismo Creek is not a viable aquifer. Previous studies have concluded it cannot support even modest development. Outflow to SMRVGB is an insignificant percentage of the total recharge to the Adjudicated Area. The throw across the Wilmar Avenue Fault at the bottom of Pismo Creek Valley juxtaposes the bedrock of the Monterey and Obispo formations against the aquifers of the SMRVGB.

The County GSA, in cooperation with the City of Arroyo Grande GSA and local stakeholders, has requested that the boundaries of the Arroyo Grande Creek Valley Fringe be updated to reflect current geologic mapping of Recent Alluvium, and that the area thus defined will be modified to be determined a subbasin of the SMRVGB. The Arroyo Grande Creek Valley Fringe Area is an alluvial valley that extends from the Wilmar Avenue Fault in the South to Lake Lopez reservoir in the north. Most of the area is used for irrigated agriculture. The Flood Control District's Flood Control Zone 3 operates and maintains the Lopez Project under an Urban Water Management Plan (UWMP) to provide a reliable and sustainable water supply for agricultural and municipal needs for the coastal communities of Arroyo Grande, Grover Beach, Pismo Beach, Oceano, and Avila Beach. The Lopez Project also provides instream flow requirements and groundwater recharge to the underlying alluvial aquifer in both the fringe area and the adjudicated area of the Santa Maria Basin. The UWMP is a planning tool to effectively manage water supplies in a sustainable manner, which is becoming increasingly more critical as it adjusts to deal with more extreme weather patterns. The District is also currently developing a Habitat Conservation Plan (HCP) to manage the downstream releases from Lopez Dam in partnership with SWRCB to ensure adequate flows for groundwater recharge, water rights, and for the endangered species in the Arroyo Grande Creek. As a result, water levels in the alluvial wells are stable, and do not display fluctuations associated with multi-year drought cycles. The throw across the Wilmar Avenue Fault at the southern end of the Arroyo Grande Valley juxtaposes the bedrock of the Monterey and Obispo Formations against the aquifers of the SMRVGB. A discontinuity in groundwater surface elevations across the fault zone shows separate hydrogeologic settings. Groundwater conditions in the Adjudicated Area will have no effect on conditions in the Fringe Area, and vice versa.

The County GSA is requesting that the Nipomo Valley Fringe Area be excluded from the SMRVGB, and that the Basin boundaries be adjusted to be coincident with the Adjudicated Area boundary. The Nipomo Valley Fringe Area lies adjacent to northeast of the Adjudicated Area boundary. It has a relatively thin veneer of unsaturated uplifted alluvial sediments (Older Alluvium) on top of the bedrock formation of the Obispo and Monterey Formations and the Franciscan Assemblage. Supply wells in these areas draw from the deeper bedrock formations, which are not part of the SMRVGB. The throw across the Santa Maria River Fault at the southwest extent of these areas juxtaposes the bedrock of the Monterey and Obispo Formations against the aquifers of the SMRVGB, demonstrating a lack of geologic continuity and no significant hydraulic connectivity across the fault. The County GSA is requesting that the Southern Bluffs Fringe Area be excluded from the SMRVGB, and that the Basin boundaries be adjusted to be coincident with the Adjudicated Area boundary. The Southern Bluffs Fringe Areas lies adjacent to and to the northeast of the Adjudicated Area boundary. It has a relatively thin veneer of unsaturated uplifted alluvial sediments (Orcutt Formation) on top of the bedrock formation of the Obispo and Monterey Formations and the Franciscan Assemblage. Supply wells in these areas draw from the deeper bedrock formations, which are not part of the SMRVGB. Water quality data from Monterey Formation wells in the Fringe Area are distinctly different from nearby wells in the Adjudicated Area, indicating significantly greater mineralization of groundwater from the bedrock wells. The throw across the Santa Maria River Fault at the southwest extent of these areas juxtaposes the bedrock of the Monterey and Obispo Formations and the Franciscan Assemblage against the aquifers of the SMRVGB, demonstrating a lack of geologic continuity and no significant hydraulic connectivity across the fault. The Southern Bluffs bedrock formations are not viable aquifers, as they cannot provide sufficient supply for local irrigation without supply from alluvial wells outside of the Fringe Area.

The County GSA is requesting that the Ziegler Canyon Fringe Area be excluded from the SMRVGB, and that the Basin boundaries be adjusted to be coincident with the Adjudicated Area boundary. The Ziegler Canyon Fringe Area is an alluvial valley that extends from Twitchell Dam in the north to the junction with the SMRVGB in the south. Wells in this area draw exclusively from the alluvium; no wells draw from the underlying Monterey or Obispo Formations. Similar to the Arroyo Grande Creek Valley Fringe Area, the alluvial groundwater aquifer is recharged via stream seepage resulting from downstream releases from Twitchell Dam. Water level hydrographs indicate that while water levels may decline during times of drought when dam releases are halted, the water levels recover to pre-drought conditions after dam releases resume. The groundwater elevation profile indicates that groundwater elevations at the outlet of the canyon are nearly 100 feet higher than the elevations in the Adjudicated Area. The TDEM geophysical Report indicates an anticlinal structure of low permeability materials in the area of a perennial wetland located in the valley. This wetland represents a hydrogeologic barrier that isolates the upper part of the Ziegler Canyon Fringe Area basin from the lower part, and from the SMRVGB. Three landowners own the entirety of this Fringe Area; they have been managing this area sustainably over the past decades without State oversight, and they support the request to exclude the Fringe Area from the Basin. All technical experts to the original parties involved in the adjudication agreed to specifically exclude Ziegler Canyon from the Adjudicated Area.

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Figures

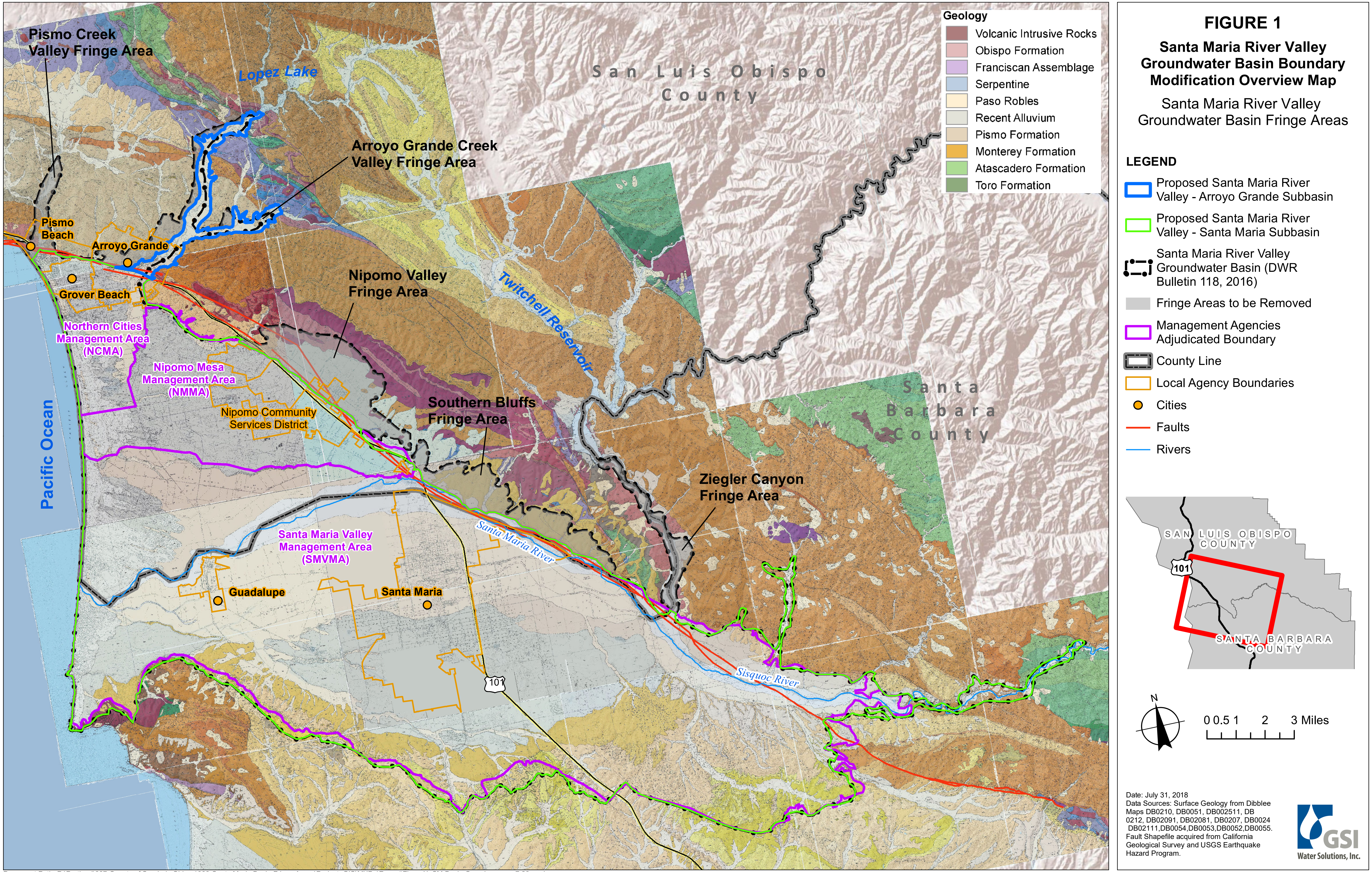

FIGURE 1

Santa Maria River Valley Groundwater Basin Boundary Modification Overview Map

Santa Maria River Valley Groundwater Basin Fringe Areas

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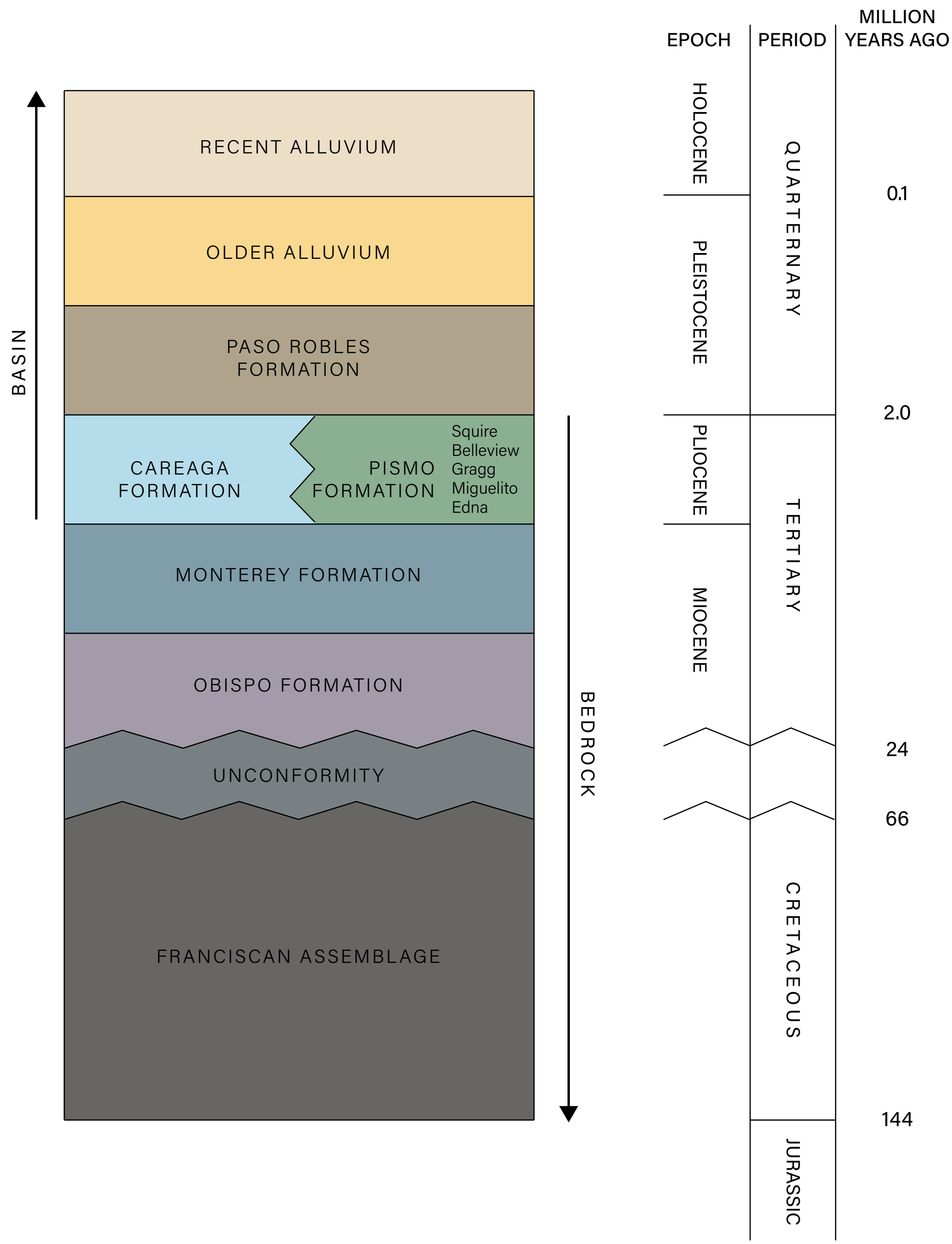


NOTE:
Adapted from Chipping, 1987, with modifications.

FIGURE 2

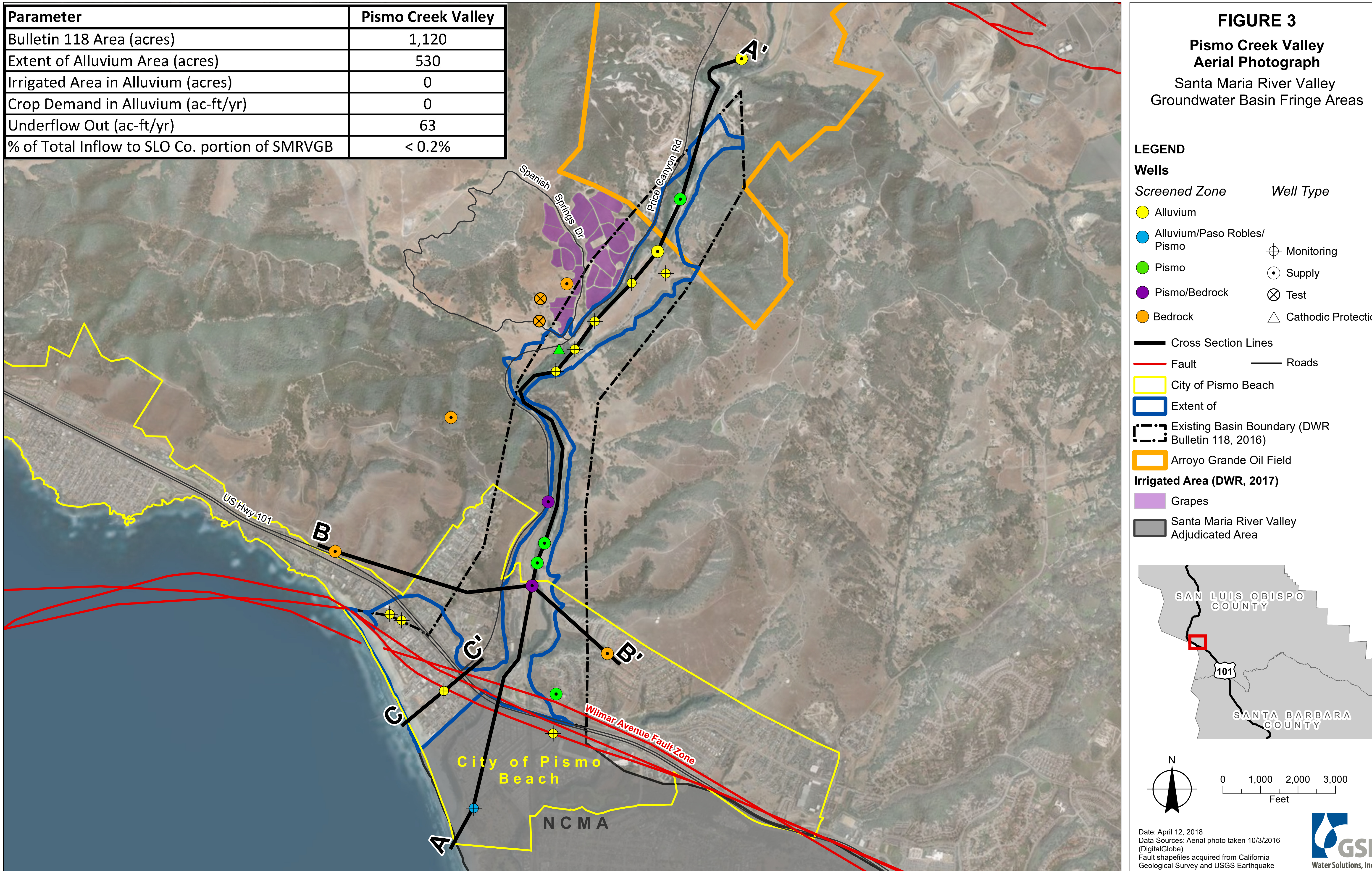
Local Stratigraphic Column

San Luis Obispo Valley Basin Characterization

GSI Water Solutions, Inc.

P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Figures\X Sections

Parameter	Pismo Creek Valley
Bulletin 118 Area (acres)	1,120
Extent of Alluvium Area (acres)	530
Irrigated Area in Alluvium (acres)	0
Crop Demand in Alluvium (ac-ft/yr)	0
Underflow Out (ac-ft/yr)	63
% of Total Inflow to SLO Co. portion of SMRVGB	< 0.2%



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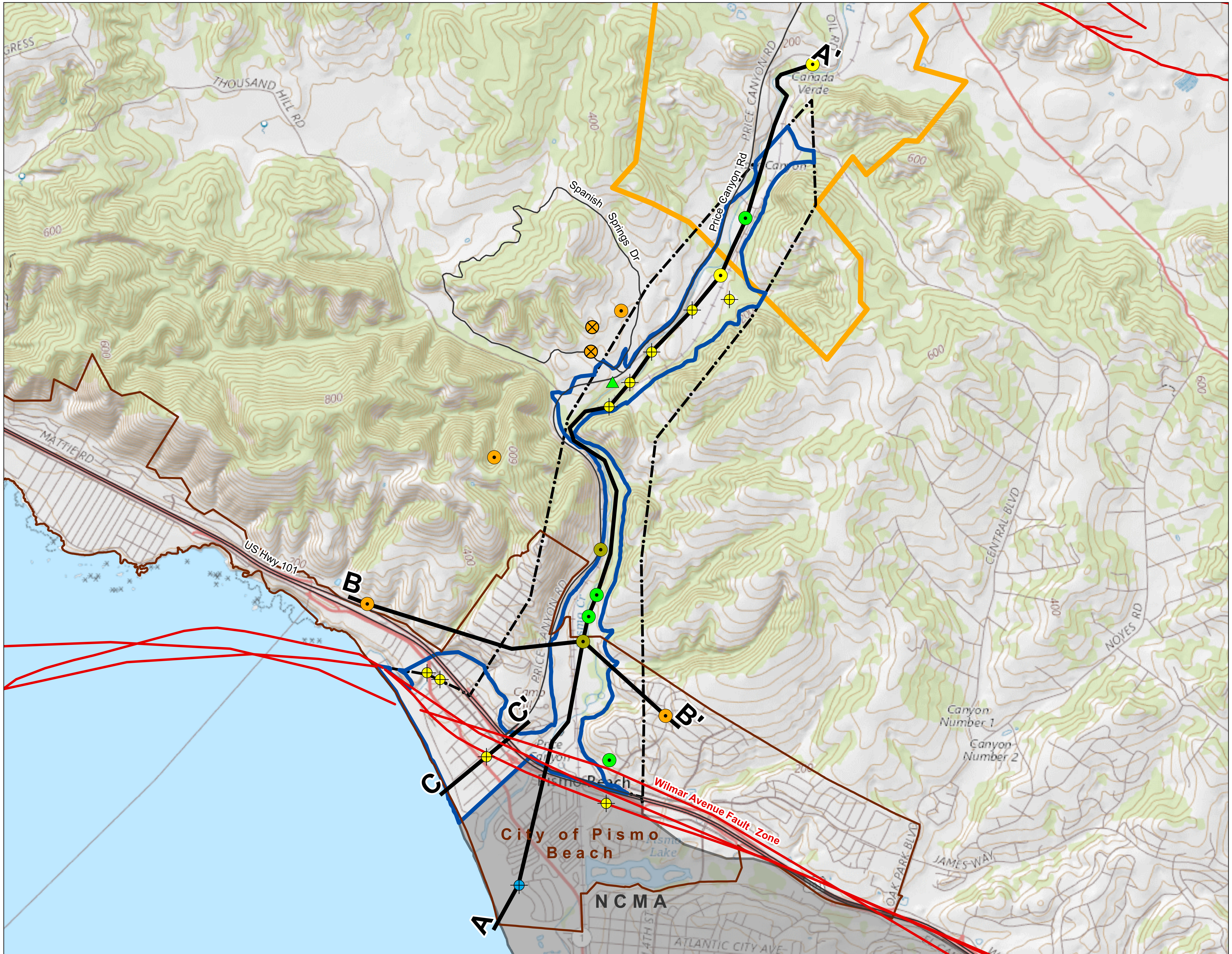

FIGURE 4

Pismo Creek Valley Topographic Map

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

Wells

Screened Zone	*Well Type*
Alluvium	
Alluvium/Paso Robles/ Pismo	Monitoring
Pismo	Supply
Pismo/Bedrock	Test
Bedrock	Cathodic Protection

- Fault
- Roads
- Cross Section Lines
- City of Pismo Beach
- Extent of Alluvium
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Arroyo Grande Oil Field
- Santa Maria River Valley Adjudicated Area

N

0 1,000 2,000 3,000 Feet

Date: April 12, 2018
Data Sources:
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

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FIGURE 5

Pismo Creek Valley Geologic Map

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

Wells

Screened Zone
- Alluvium
- Alluvium/Paso Robles/Pismo
- Pismo
- Pismo/Bedrock
- Bedrock

Well Type
- Monitoring
- Supply
- Test
- Cathodic Protection

Geology
- Pismo (Gregg)
- Pismo (Miguelito)
- Pismo (Edna)
- Pismo (Squire)
- Monterey
- Obispo
- Paso Robles
- Terrace
- Alluvium
- Fault

All Other Features
- Cross Section Lines
- Extent of Alluvium
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- City of Pismo Beach
- Santa Maria River Valley Adjudicated Area

N

0 1,000 2,000 3,000
Feet

Date: March 30, 2018
Data Sources:
Surface Geology from Hall (1973)
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

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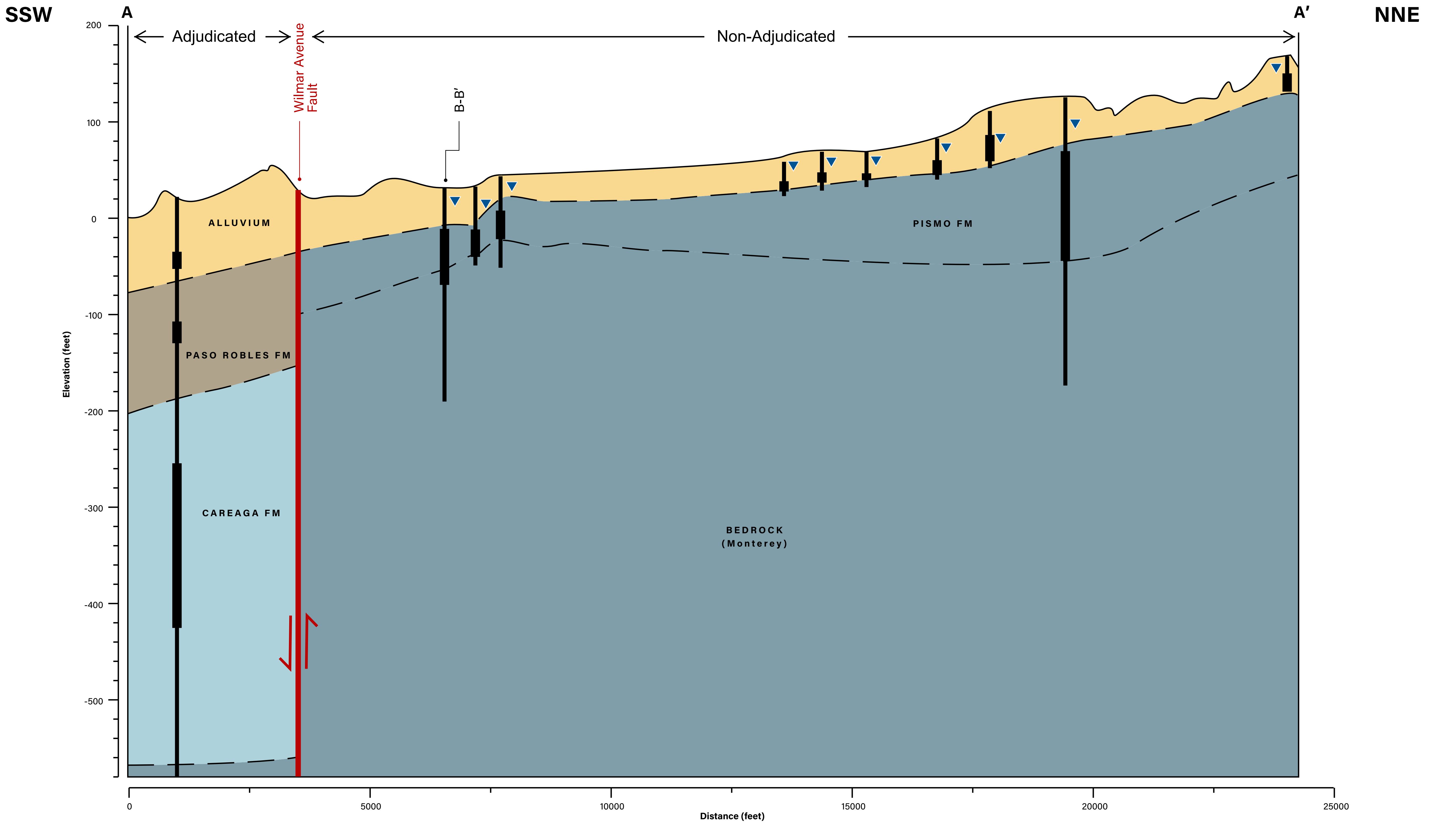


LEGEND

- Alluvium
- Paso Robles Fm
- Pismo Fm
- Careaga Fm
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

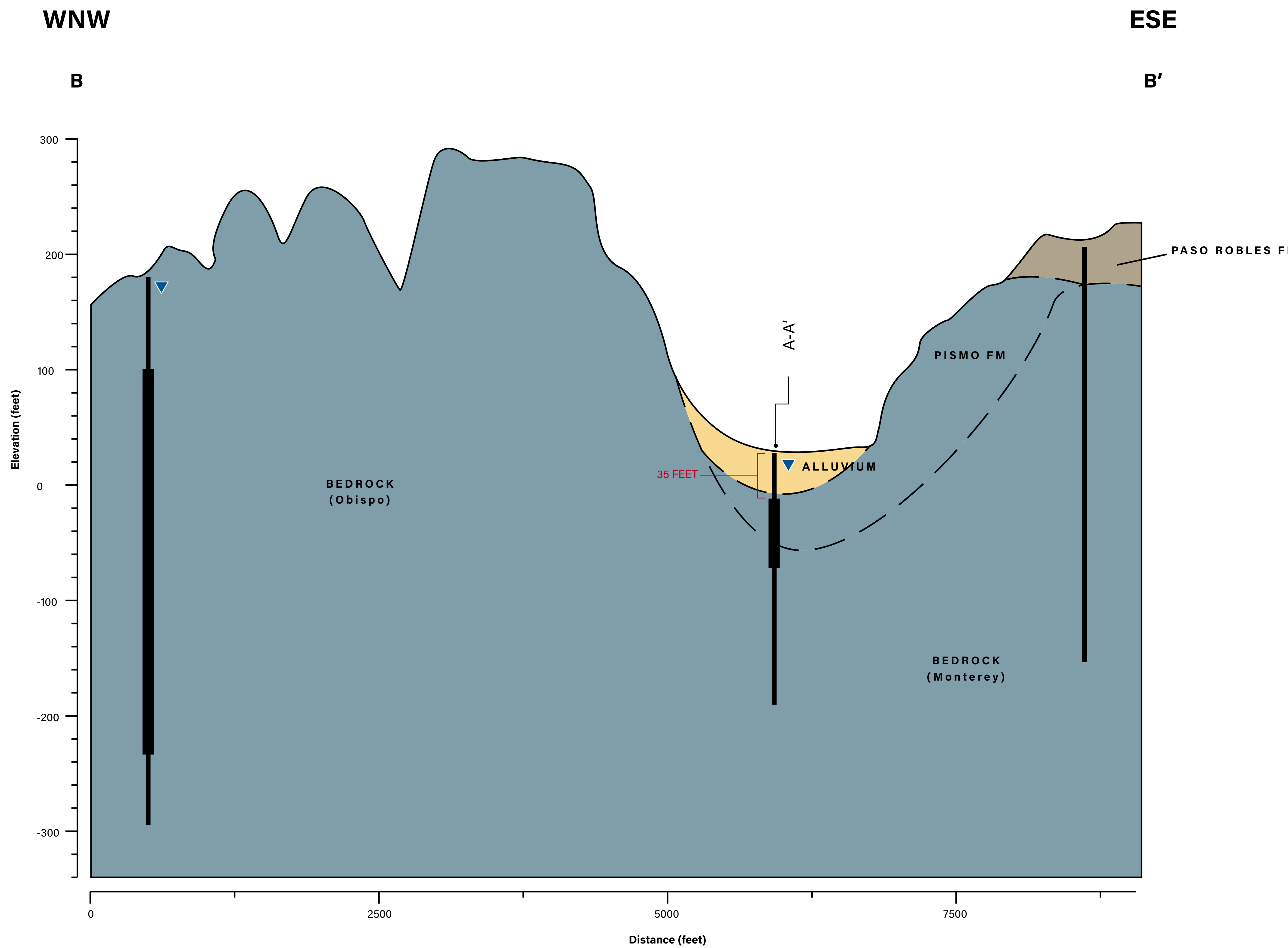
VERTICAL EXAGGERATION:
20X

FIGURE 6

Pismo Creek Valley Cross Section A-A′

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.



LEGEND

- Alluvium
- Paso Robles Fm
- Pismo Fm
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

VERTICAL EXAGGERATION:
10X

FIGURE 7

Pismo Creek Valley Cross Section B-B′

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

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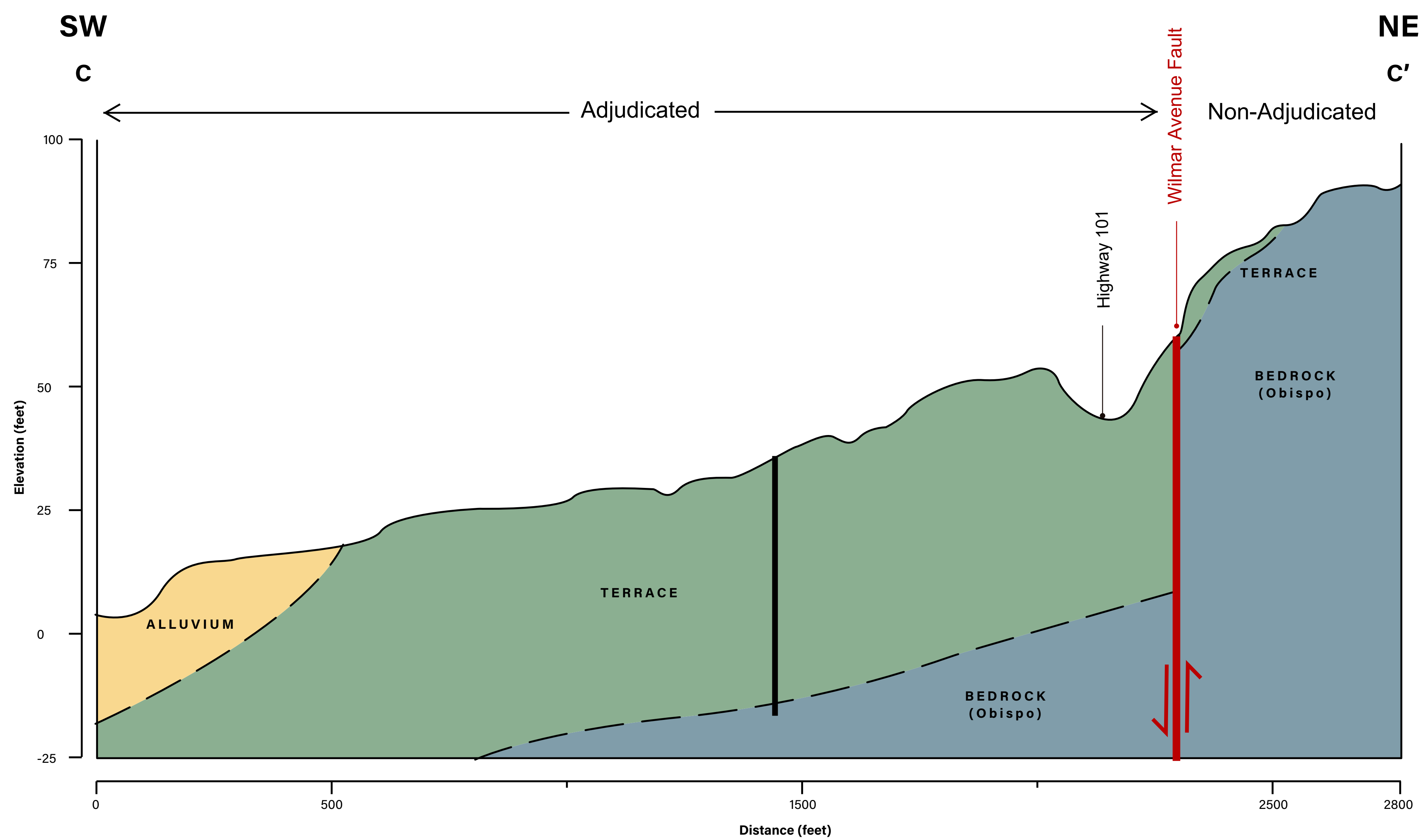

LEGEND

- Alluvium
- Terrace
- Bedrock
- Static Water Level (WCR)
- Borehole

VERTICAL EXAGGERATION:
10X

FIGURE 8

Pismo Creek Valley Cross Section C-C′

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

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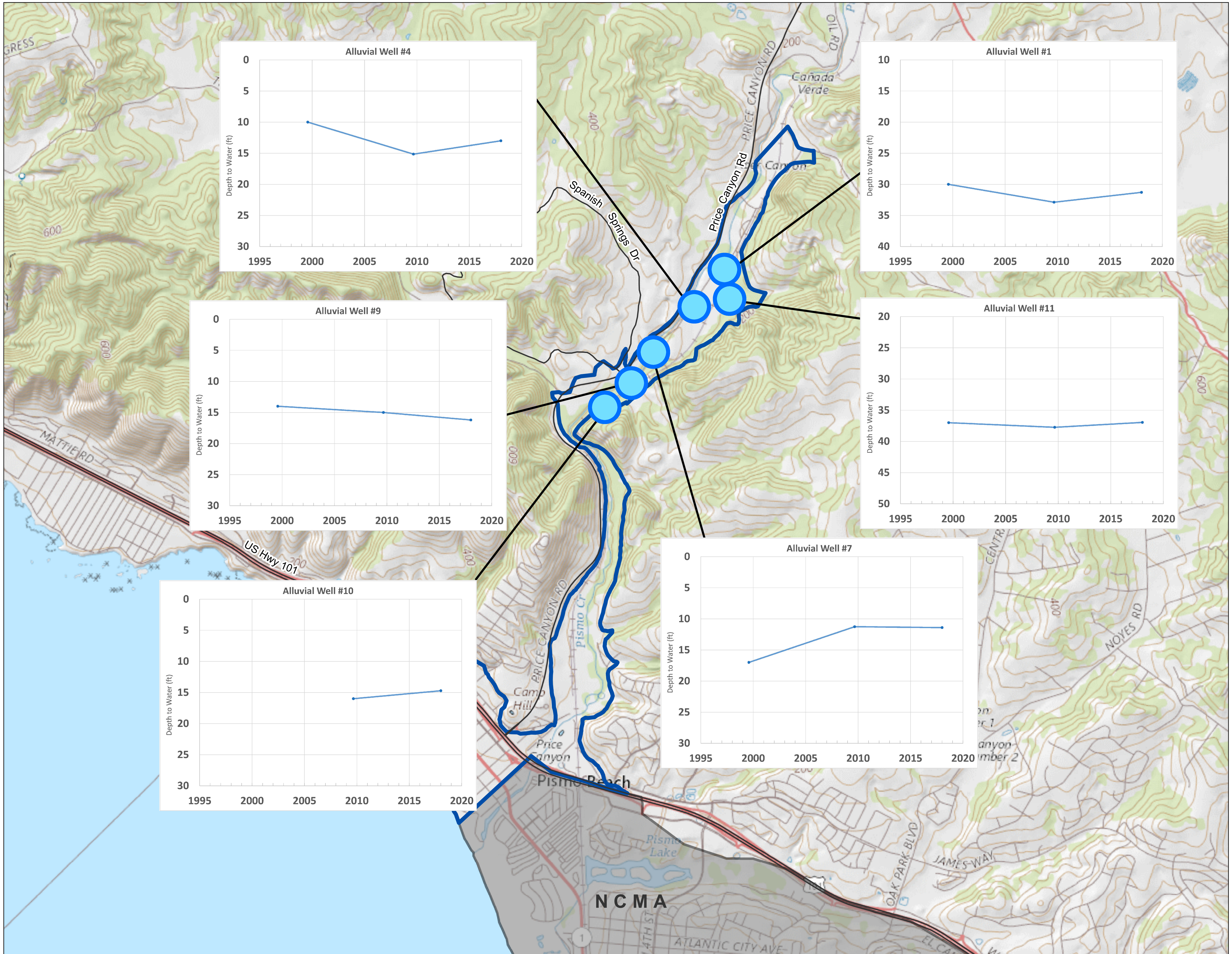
FIGURE 9

Pismo Creek Valley Alluvium Water Level Hydrographs

Santa Maria River Valley Groundwater Basin Fringe Areas



LEGEND

- Extent of
- Santa Maria River Valley Adjudicated Groundwater Basin
- Monitoring Area Associated with Hydrographs

N

0 1,000 2,000 3,000
Feet

Date: April 11, 2018

GSI Water Solutions, Inc.

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FIGURE 10

SMRVGB Modification Request Number 1

Santa Maria River Valley Groundwater Basin Fringe Areas

Legend

- Proposed Boundary
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- City of Pismo Beach
- Santa Maria River Valley Adjudicated Area
- Roads

N

0 1,000 2,000 3,000
Feet

Date: April 12, 2018
Data Sources: Aerial photo taken 10/3/2016 (DigitalGlobe)

GSI Water Solutions, Inc.

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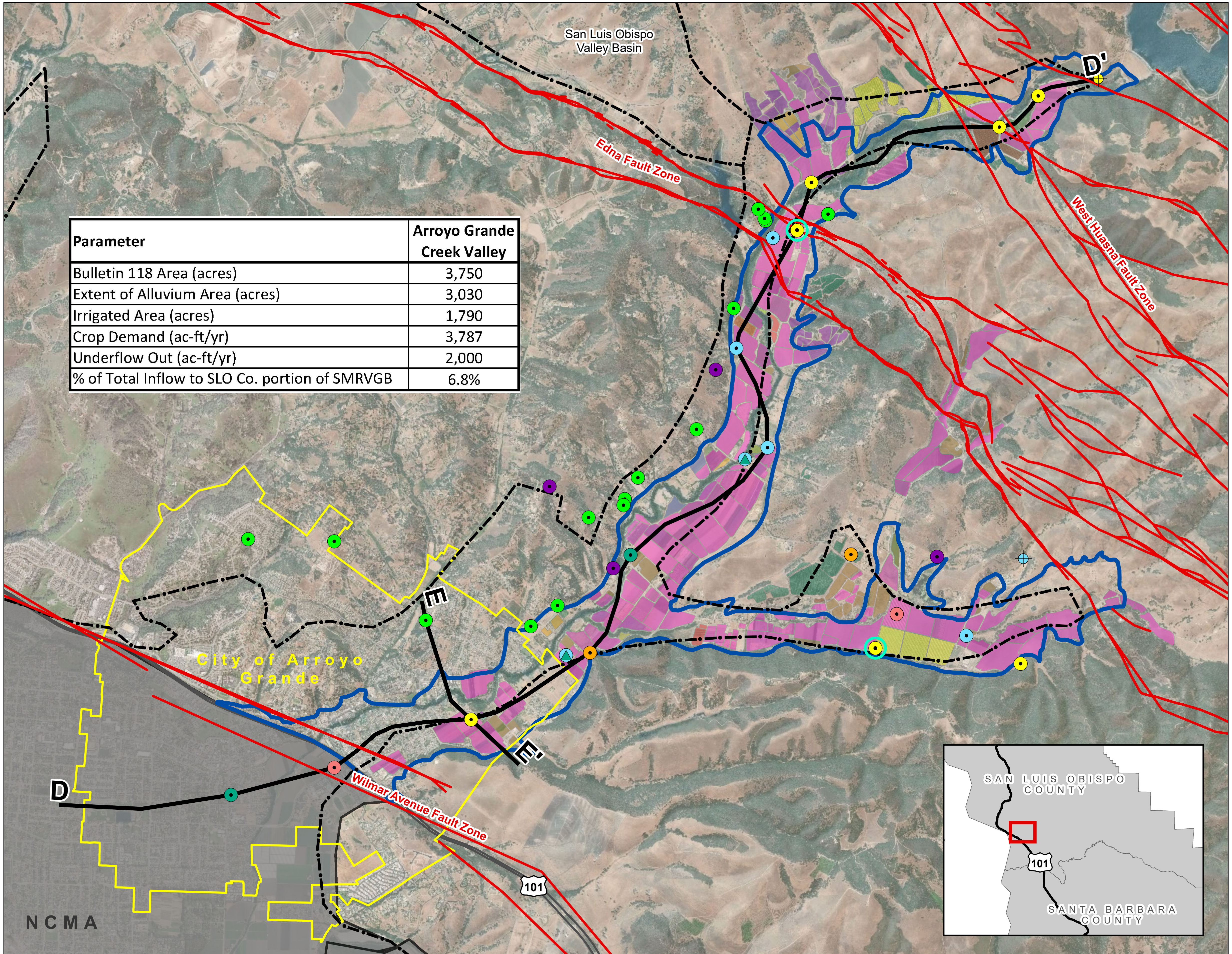
FIGURE 11

Arroyo Grande Creek Valley Aerial Photograph

Santa Maria River Valley Groundwater Basin Fringe Areas



Parameter	Arroyo Grande Creek Valley
Bulletin 118 Area (acres)	3,750
Extent of Alluvium Area (acres)	3,030
Irrigated Area (acres)	1,790
Crop Demand (ac-ft/yr)	3,787
Underflow Out (ac-ft/yr)	2,000
% of Total Inflow to SLO Co. portion of SMRVGB	6.8%

LEGEND

Wells

Screened Zone
- Alluvium
- Alluvium/Pismo
- Alluvium/Bedrock
- Paso Robles/Pismo
- Pismo
- Pismo/Bedrock
- Bedrock

Well Type
- Monitoring
- Supply
- Pumping Test
- Hydrograph

- Fault
- Cross Section Lines
- Extent of Alluvium
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- City of Arroyo Grande
- Santa Maria River Valley Adjudicated Area

Irrigated Area (DWR, 2017)
- Avocados
- Bush Berries
- Citrus
- Cole Crops
- Grapes
- Idle
- Miscellaneous Deciduous
- Miscellaneous Grain and Hay
- Miscellaneous Grasses
- Miscellaneous Subtropical Fruits
- Miscellaneous Truck Crops
- Mixed Pasture
- Walnuts
- Young Perennials

0 0.5 1
Miles

Date: July 13, 2018
Data Sources: Aerial photo taken 7/14/2016 (DigitalGlobe)
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

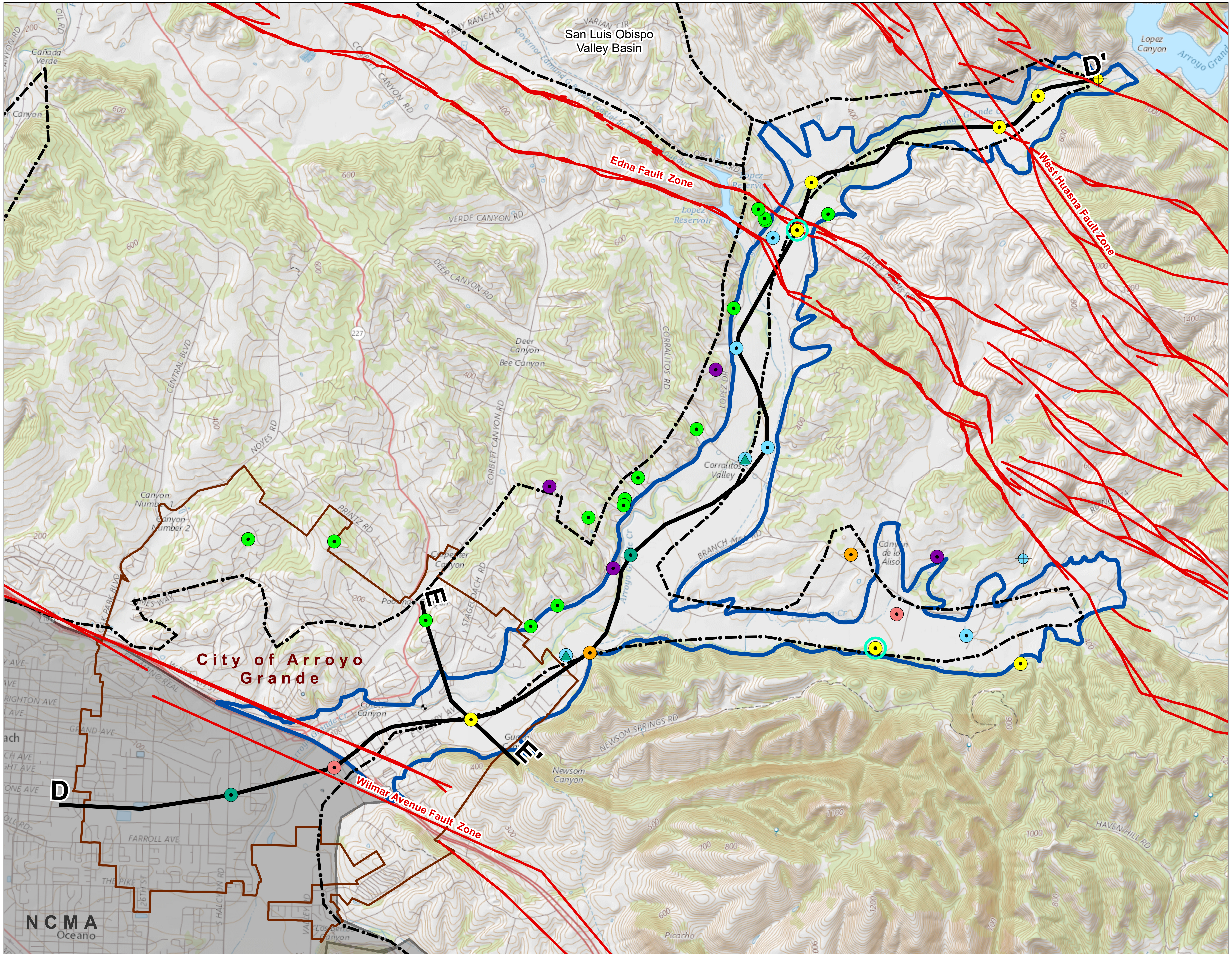
GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure08_AG Creek aerial.mxd

FIGURE 12

Arroyo Grande Creek Valley Topographic Map

Santa Maria River Valley Groundwater Basin Fringe Areas

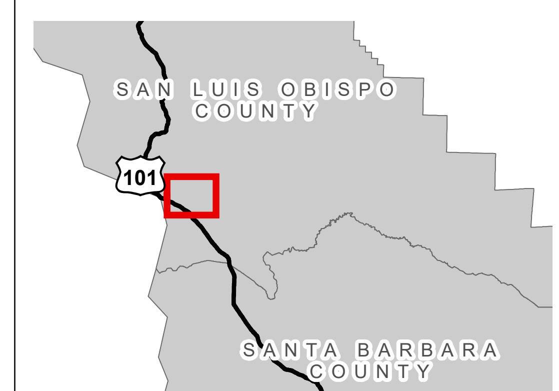


LEGEND

Wells

Screened Zone	*Well Type*
Alluvium	Monitoring
Alluvium/Pismo	Supply
Alluvium/Bedrock	Pumping Test
Paso Robles/Pismo	Hydrograph
Pismo	
Pismo/Bedrock	
Bedrock	

- Cross Section Lines
- Fault
- Extent of Alluvium
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- City of Arroyo Grande
- Santa Maria River Valley Adjudicated Area



N

0 0.5 1
Miles

Date: July 13, 2018
Data Sources:
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure09_AG Creek topo.mxd

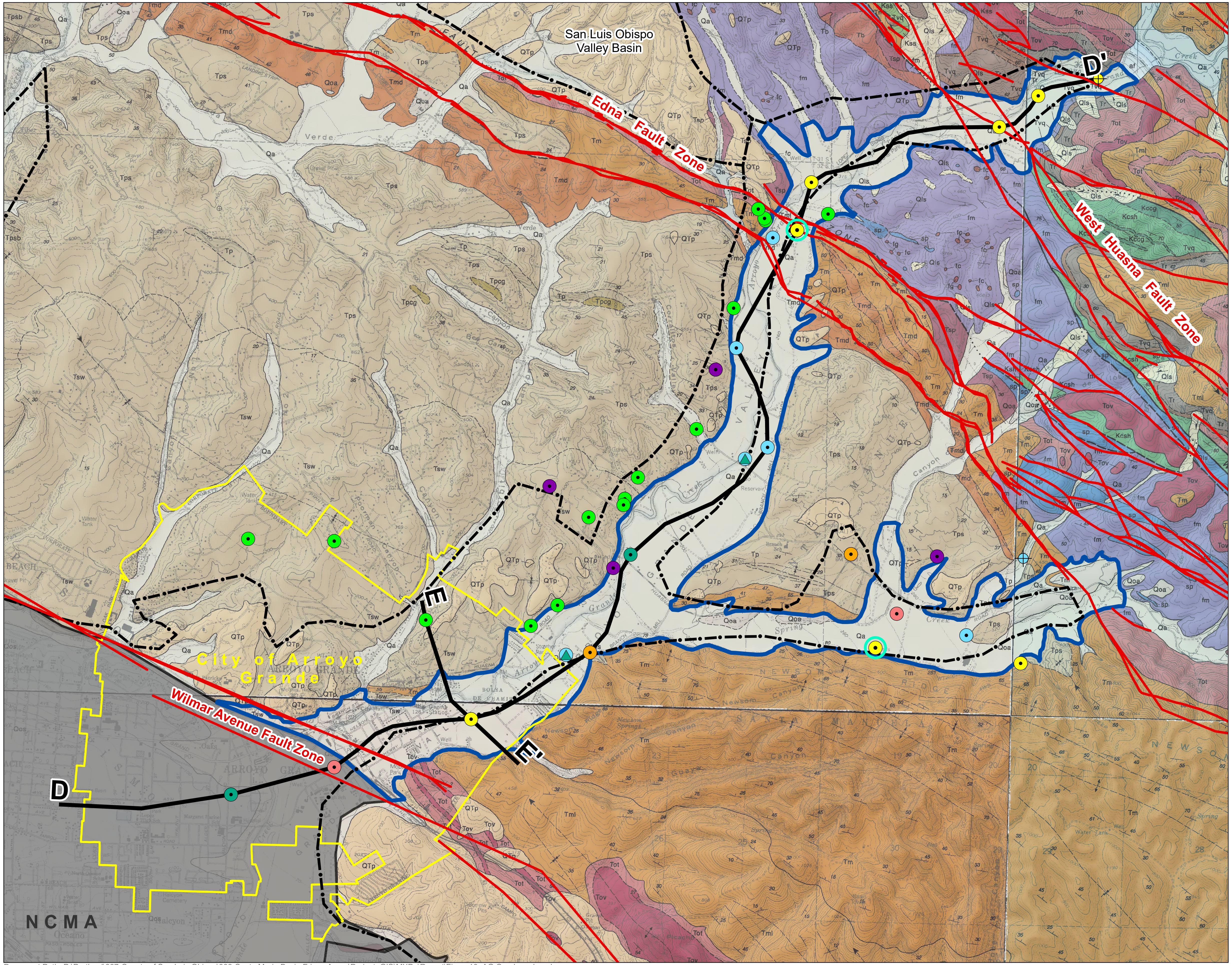


FIGURE 13

Arroyo Grande Creek Valley Geologic Map

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

Wells

Screened Zone
- Alluvium
- Alluvium/Pismo
- Alluvium/Bedrock
- Paso Robles/Pismo
- Pismo
- Pismo/Bedrock
- Bedrock

Well Type
- Monitoring
- Supply
- Pumping Test
- Hydrograph

Geology
- Volcanic Intrusive Rocks
- Obispo Formation
- Franciscan Assemblage
- Serpentine
- Paso Robles
- Recent Alluvium
- Pismo Formation
- Monterey Formation
- Atascadero Formation
- Toro Formation

All Other Features
- Cross Section Lines
- Fault
- Extent of Alluvium
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- City of Arroyo Grande
- Santa Maria River Valley Adjudicated

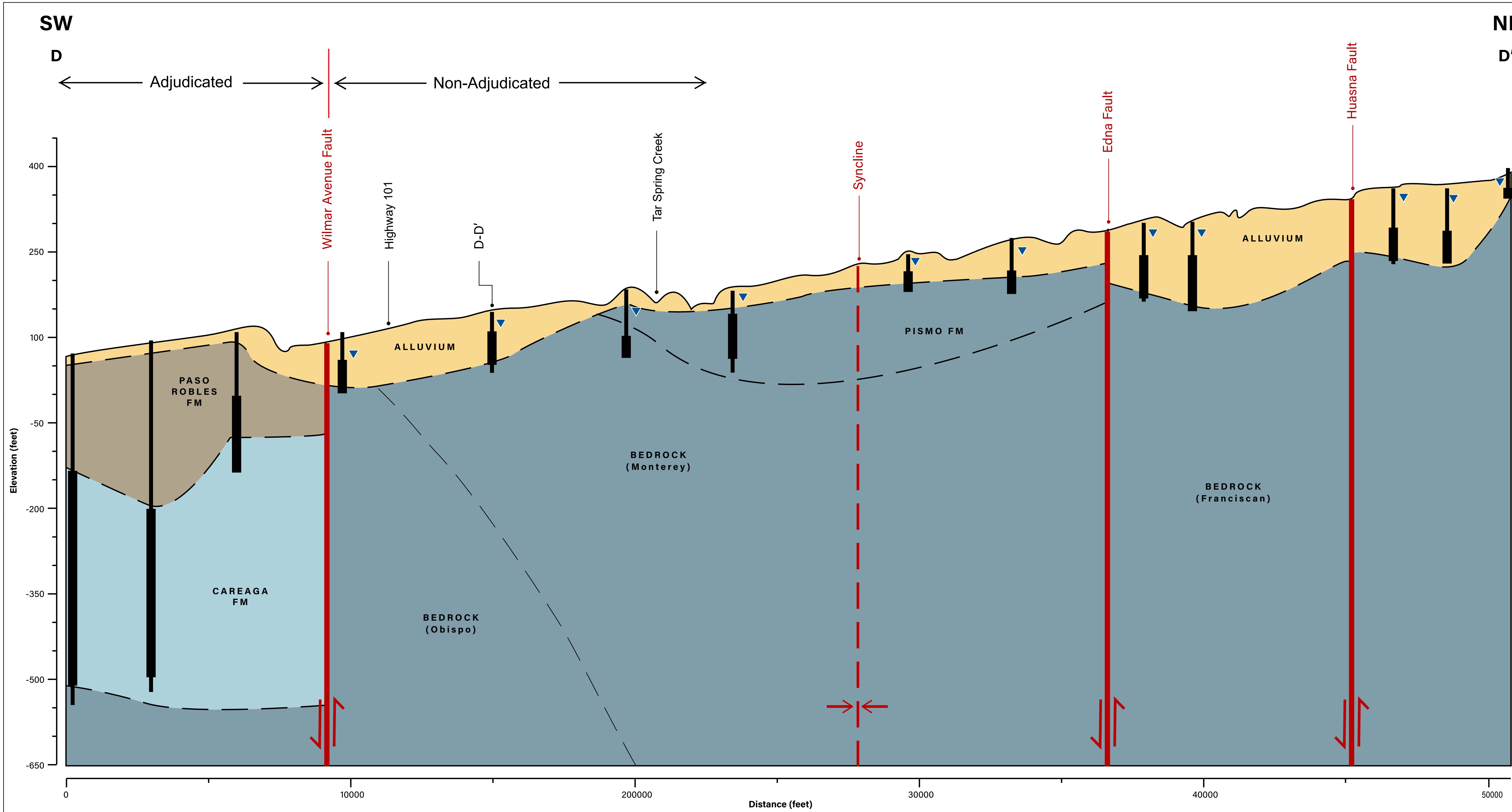
N

0 0.5 1
Miles

Date: July 13, 2018
Data Sources: Surface Geology from Dibblee (2006b, 2006c, 2006d, and 2006e)
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure10_AG Creek geol.mxd



LEGEND

- Alluvium
- Paso Robles Fm
- Pismo Fm
- Careaga Fm
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

VERTICAL EXAGGERATION:
20X

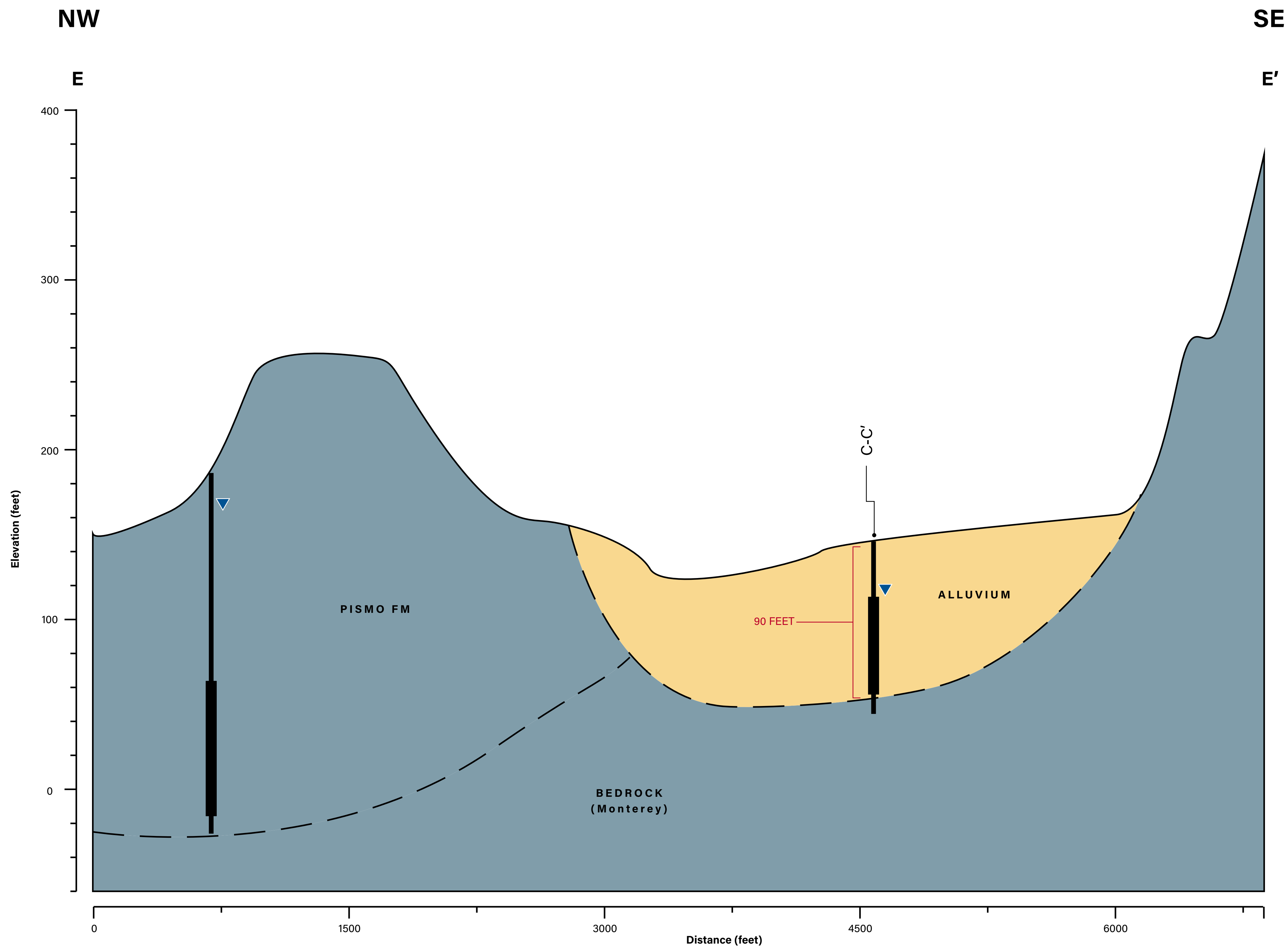
FIGURE 14

Arroyo Grande Creek Valley Cross Section D-D'

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Figures



LEGEND

- Alluvium
- Pismo Fm
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

VERTICAL EXAGGERATION:
10X

P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Figures

FIGURE 15

Arroyo Grande Creek Valley Cross Section E-E'

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

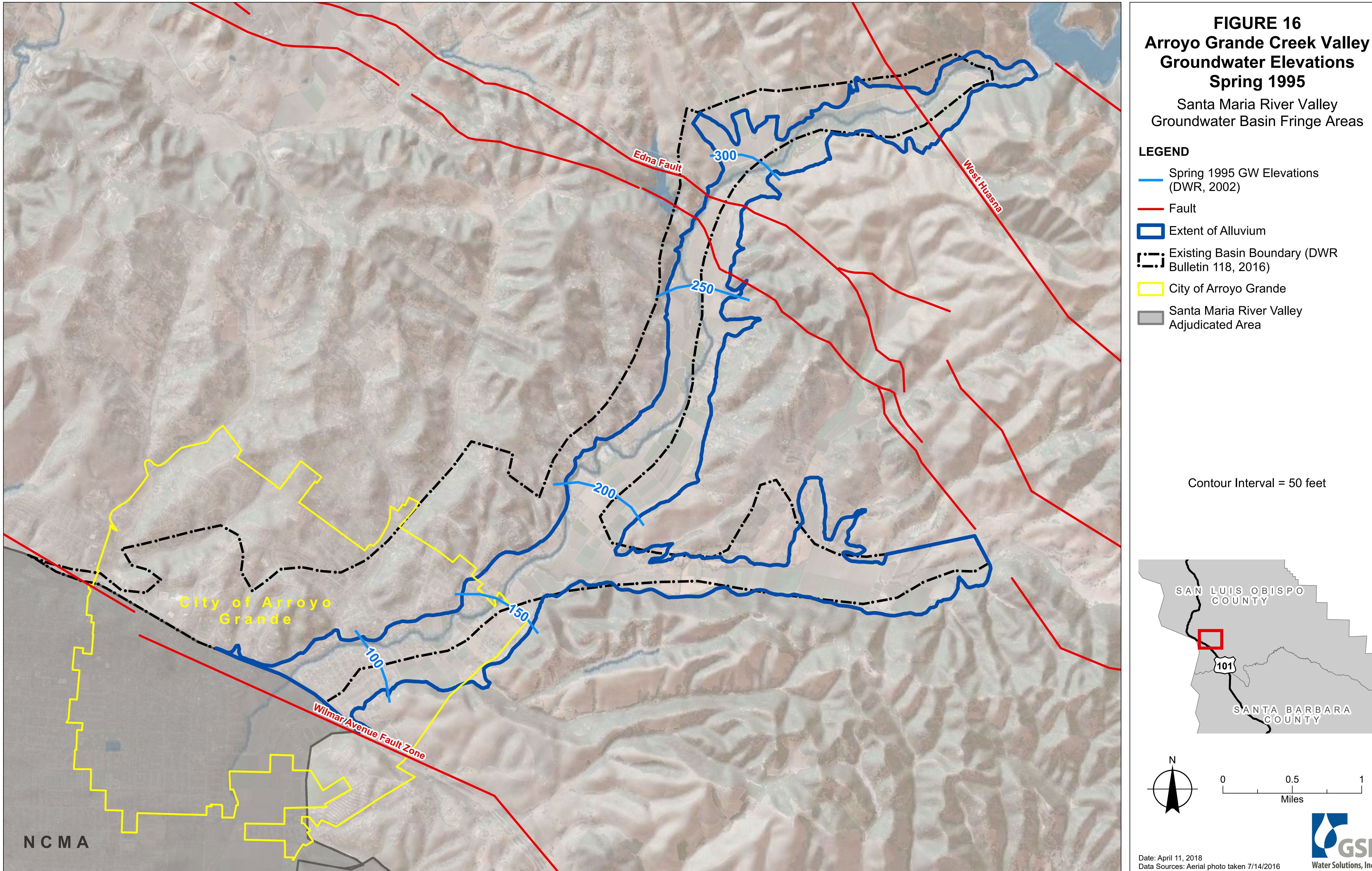


FIGURE 16
Arroyo Grande Creek Valley Groundwater Elevations Spring 1995

Santa Maria River Valley Groundwater Basin Fringe Areas

Date: April 11, 2018
Data Sources: Aerial photo taken 7/14/2016 (DigitalGlobe)

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure13_AG Creek 1995 WLE contour map.mxd

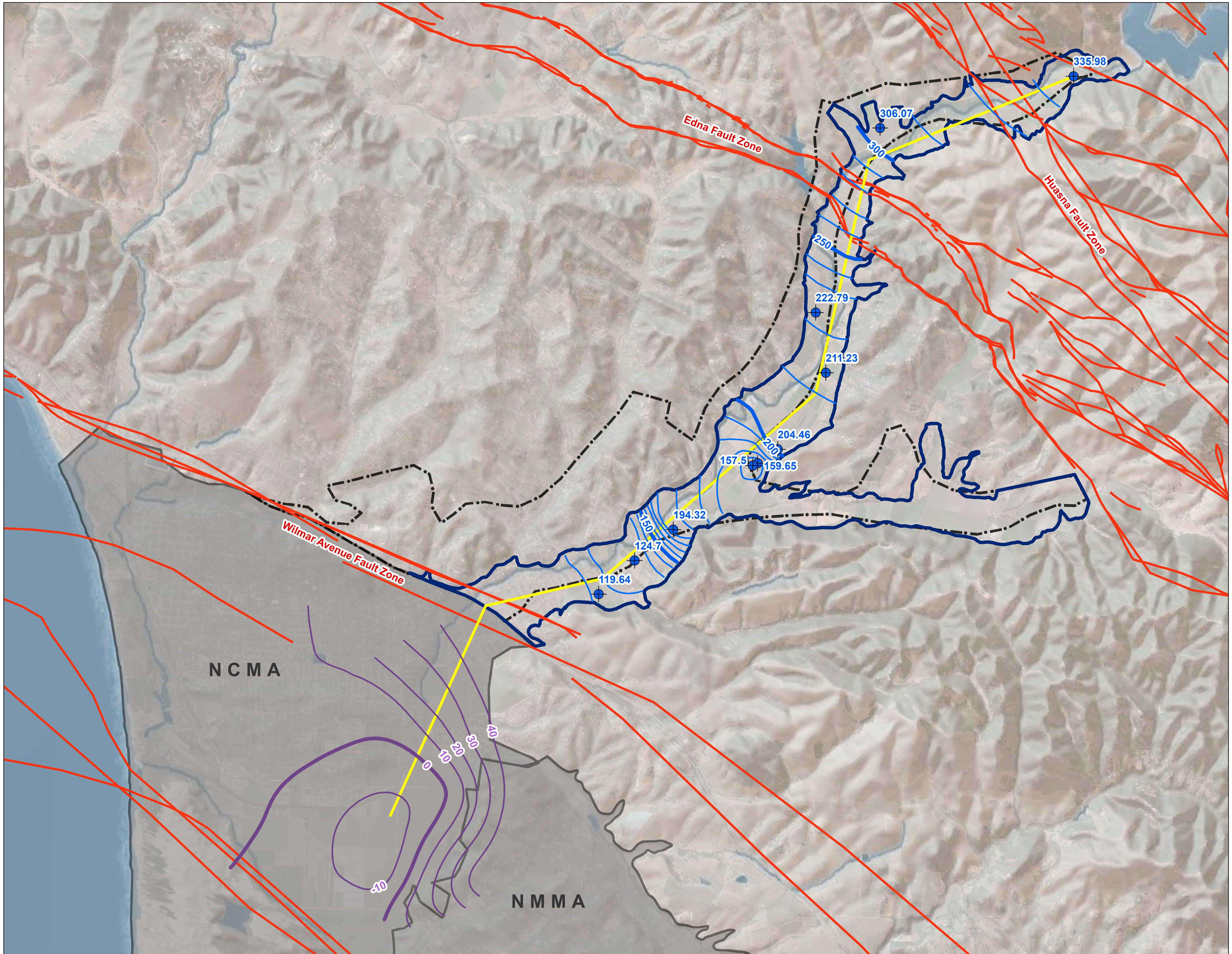


FIGURE 17

Arroyo Grande Creek Valley/NCMA Groundwater Elevation Contours Spring 2016

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

- Wells with Water Level Data
- 397 Spring 2016 Water Elevation
- Water Elevation Contour (SLO Co.)
- Water Elevation Contour (NCMA)
- Groundwater Elevation Profile Line
- Faults
- Extent of Alluvium
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area

Date: April 11, 2018
Data Sources:
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Fig_16_AG_WLE_contours.mxd

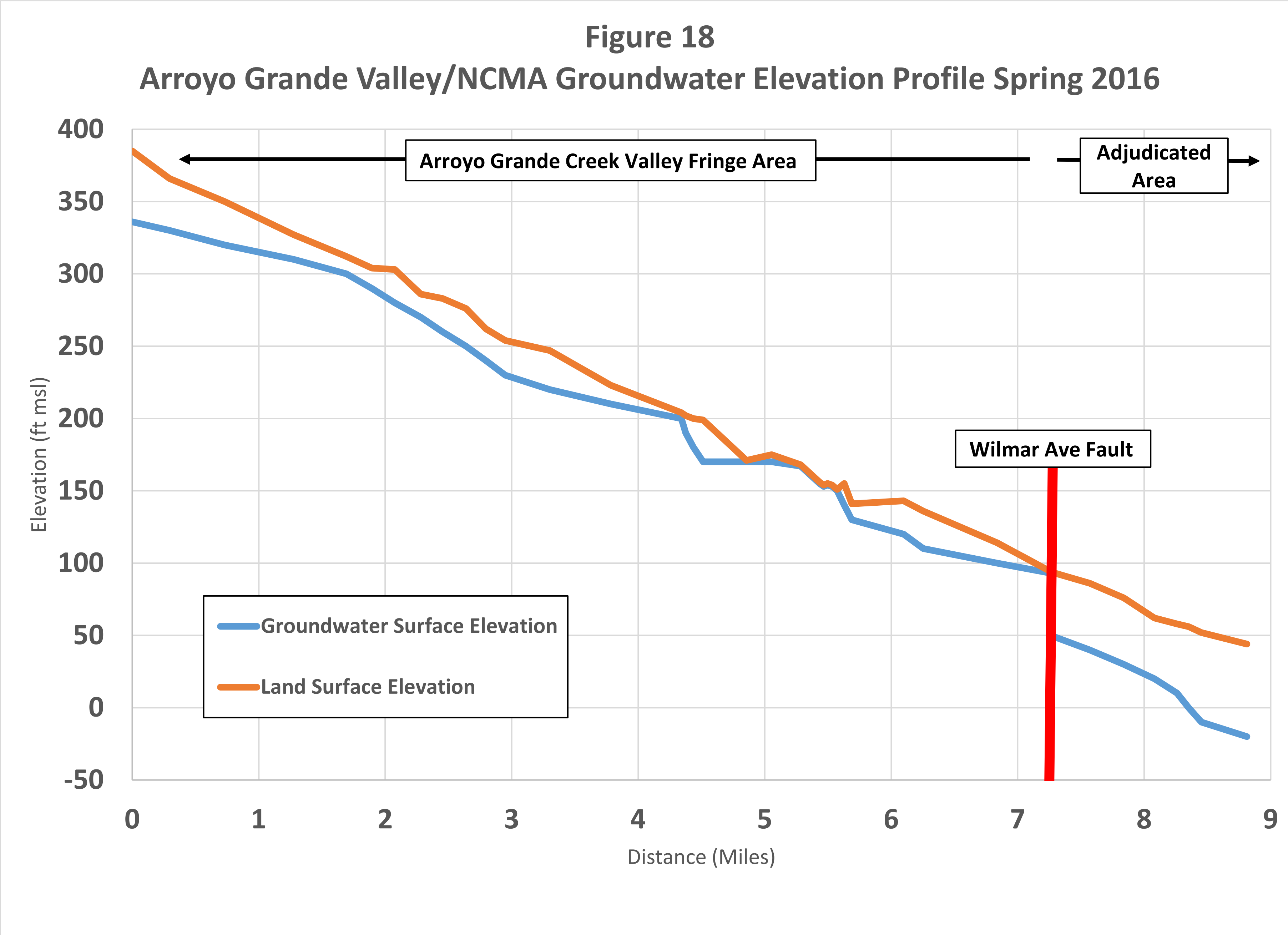


Figure 18
Arroyo Grande Valley/NCMA Groundwater Elevation Profile Spring 2016
Arroyo Grande Creek Valley Fringe Area
Adjudicated Area
Wilmar Ave Fault
Groundwater Surface Elevation
Land Surface Elevation
Elevation (ft msl)
Distance (Miles)
400
350
300
250
200
150
100
50
0
-50
0
1
2
3
4
5
6
7
8
9

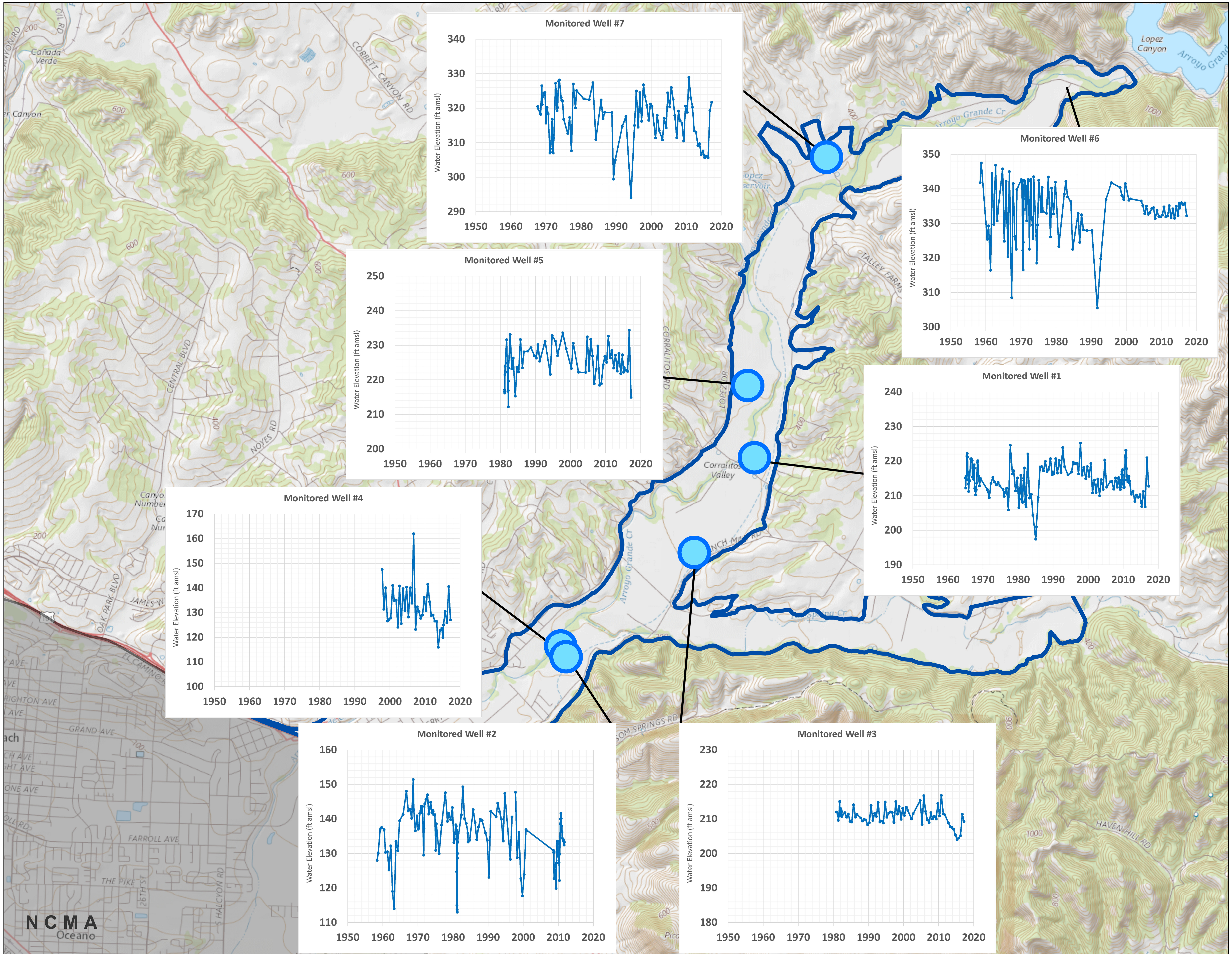


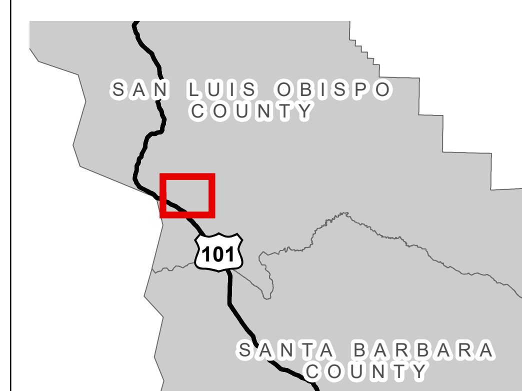
FIGURE 19

Arroyo Grande Creek Valley Groundwater Elevation Hydrographs

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

- Extent of Alluvium
- Santa Maria River Valley Adjudicated Area
- Monitoring Area Associated with Hydrographs



N

0 0.5 1
Miles

Date: April 11, 2018

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\FigureX_AG_hydrographs.mxd

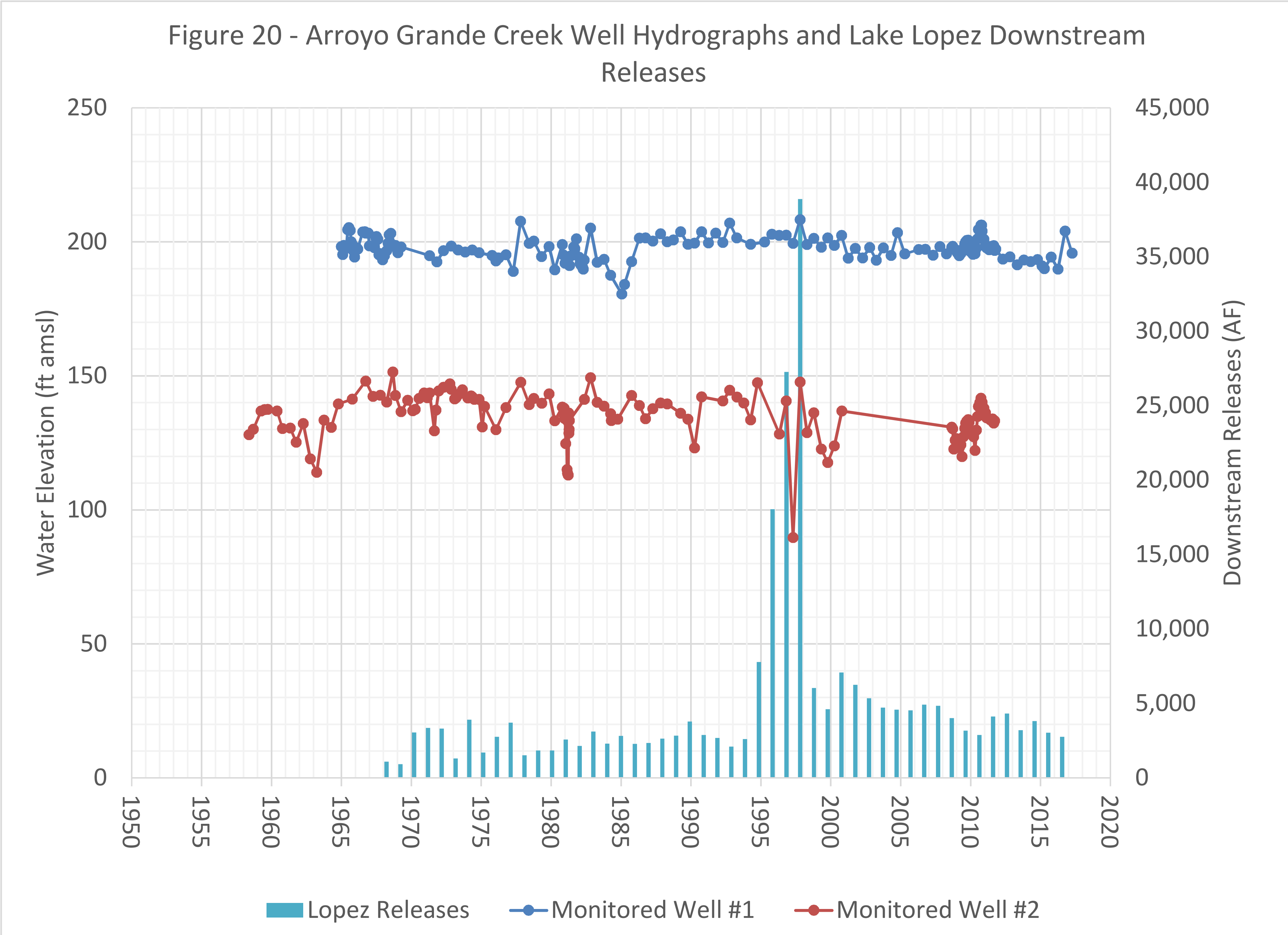
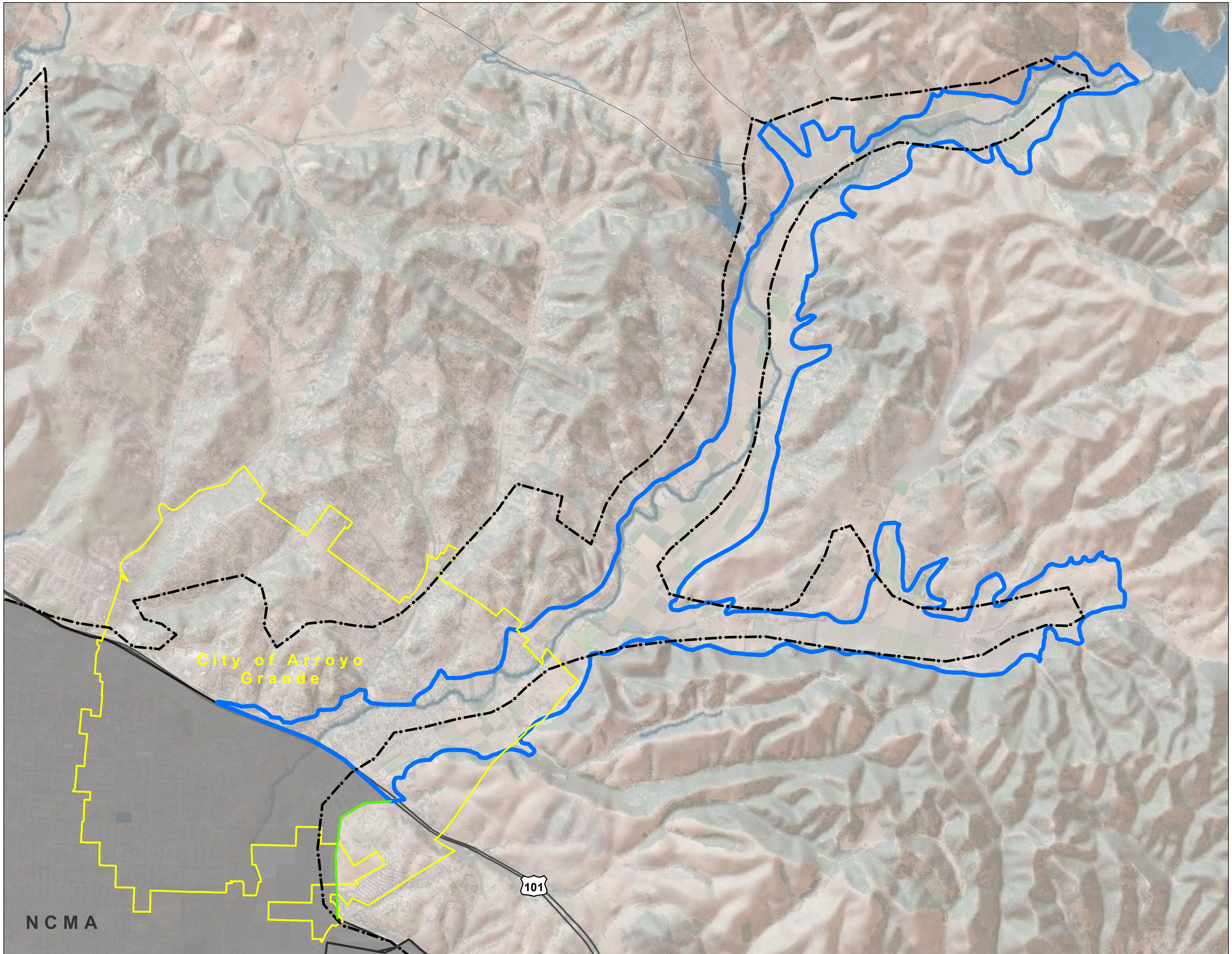


Figure 20 - Arroyo Grande Creek Well Hydrographs and Lake Lopez Downstream Releases
Water Elevation (ft amsl)
Downstream Releases (AF)
250
200
150
100
50
0
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
Lopez Releases
Monitored Well #1
Monitored Well #2

FIGURE 21

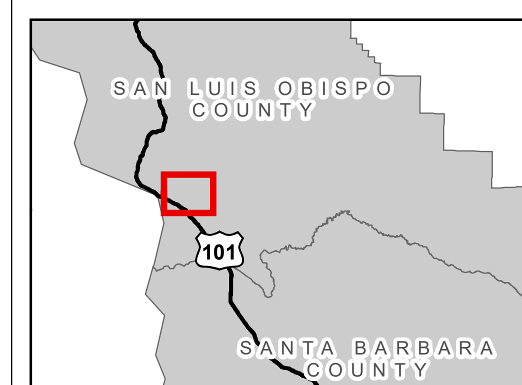
SMRVGB Modification Request Numbers 2 and 3

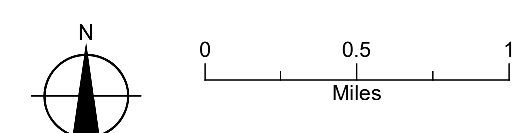
Santa Maria River Valley Groundwater Basin Fringe Areas



LEGEND

- Proposed Subbasin Boundary
- Proposed Bulletin 118 Boundary Modification in Adjudicated Area
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- City of Arroyo Grande
- Santa Maria River Valley Adjudicated Area





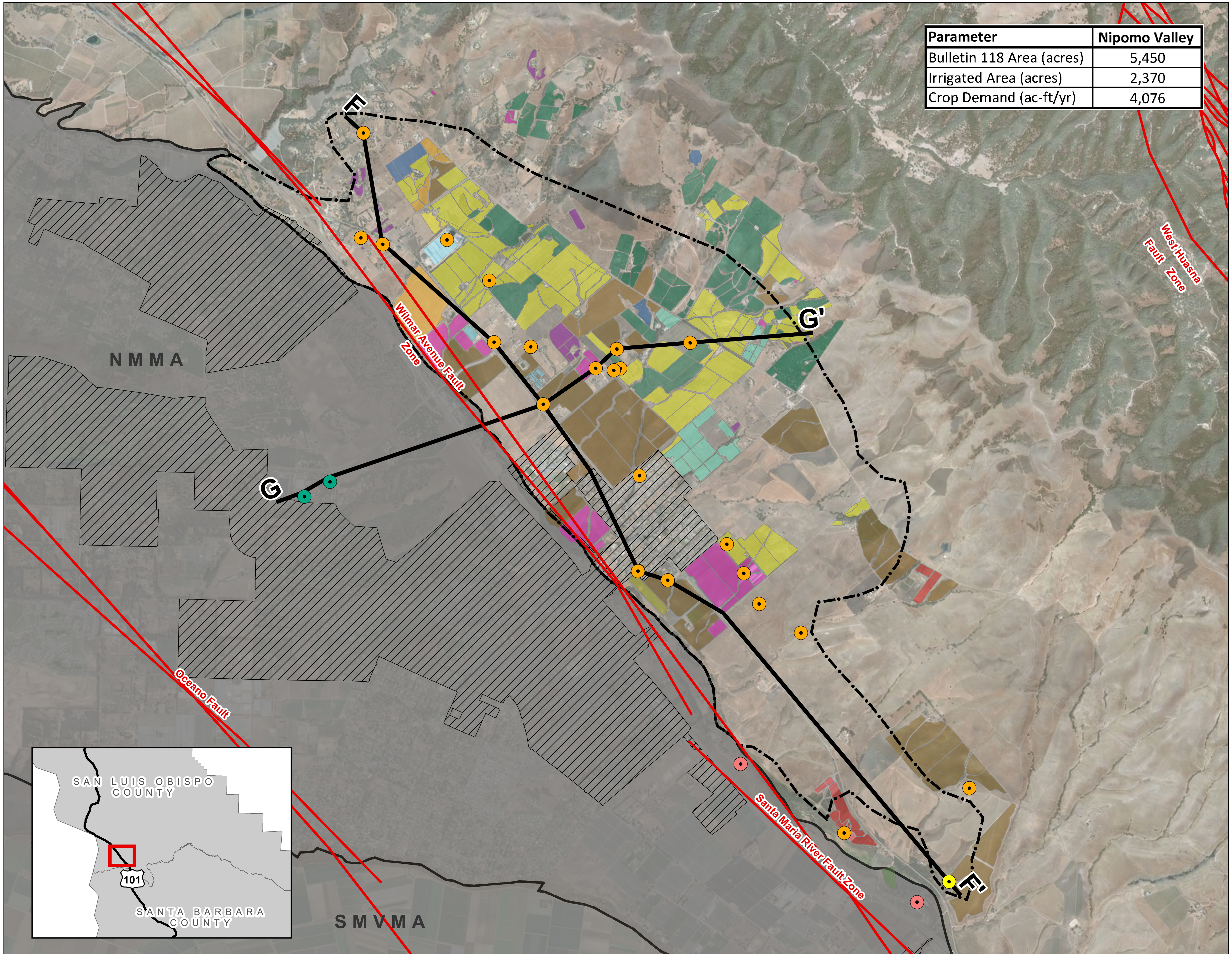
Date: July 20, 2018
Data Sources: Aerial photo taken 7/14/2016 (DigitalGlobe)

Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure21_BBMR Req2.mxd

FIGURE 22

Nipomo Valley
Aerial Photograph
Santa Maria River Valley
Groundwater Basin Fringe Areas



Parameter	Nipomo Valley
Bulletin 118 Area (acres)	5,450
Irrigated Area (acres)	2,370
Crop Demand (ac-ft/yr)	4,076

LEGEND

Wells

Screened Zone
- Alluvium
- Alluvium/Bedrock
- Paso Robles/Pismo
- Bedrock

Well Type
- Supply

- Cross Section Lines
- Fault
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area
- Nipomo Community Services District

Irrigated Area (DWR,
- Avocados
- Bush Berries
- Citrus
- Flowers, Nursery and Tree Farms
- Grapes
- Idle
- Miscellaneous Grain and Hay
- Miscellaneous Grasses
- Miscellaneous Subtropical Fruits
- Miscellaneous Truck Crops
- Mixed Pasture
- Young Perennials

N
0 0.5 1
Miles

Date: April 12, 2018
Data Sources: Aerial photo taken 10/3/2016 (DigitalGlobe)
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

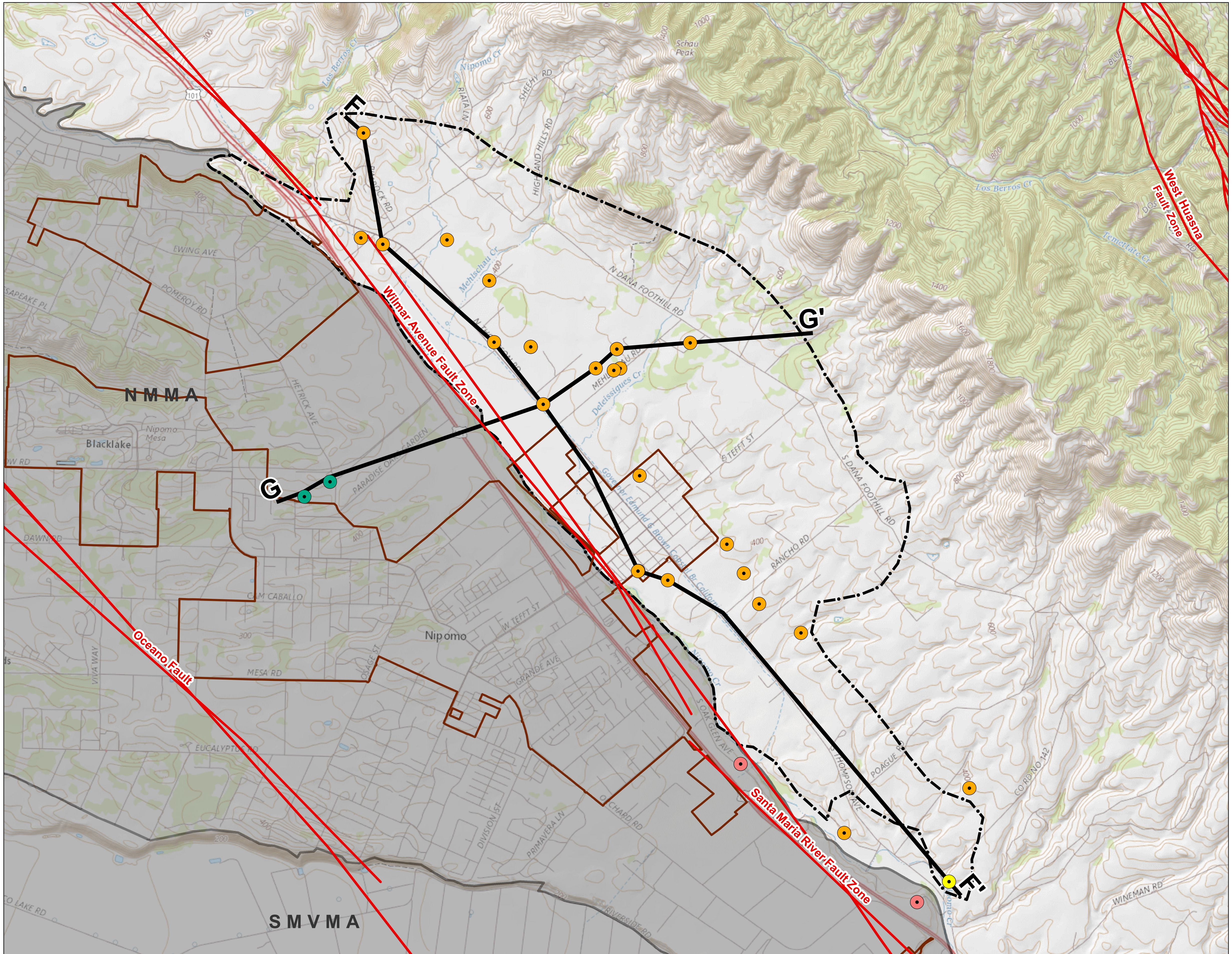
GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure15_Nipomo aerial.mxd

FIGURE 23

Nipomo Valley Topographic Map

Santa Maria River Valley Groundwater Basin Fringe Areas

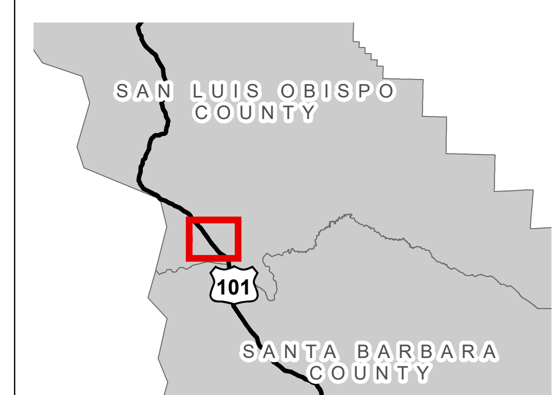


LEGEND

Wells

Screened Zone	*Well Type*
Alluvium	Supply
Alluvium/Bedrock	
Paso Robles/Pismo	
Bedrock	

- Fault
- Cross Section Lines
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Nipomo Community Services District
- Santa Maria River Valley Adjudicated Area



N

0 0.5 1

Miles

Date: April 11, 2018
Data Sources:
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure16_Nipomo_topo.mxd

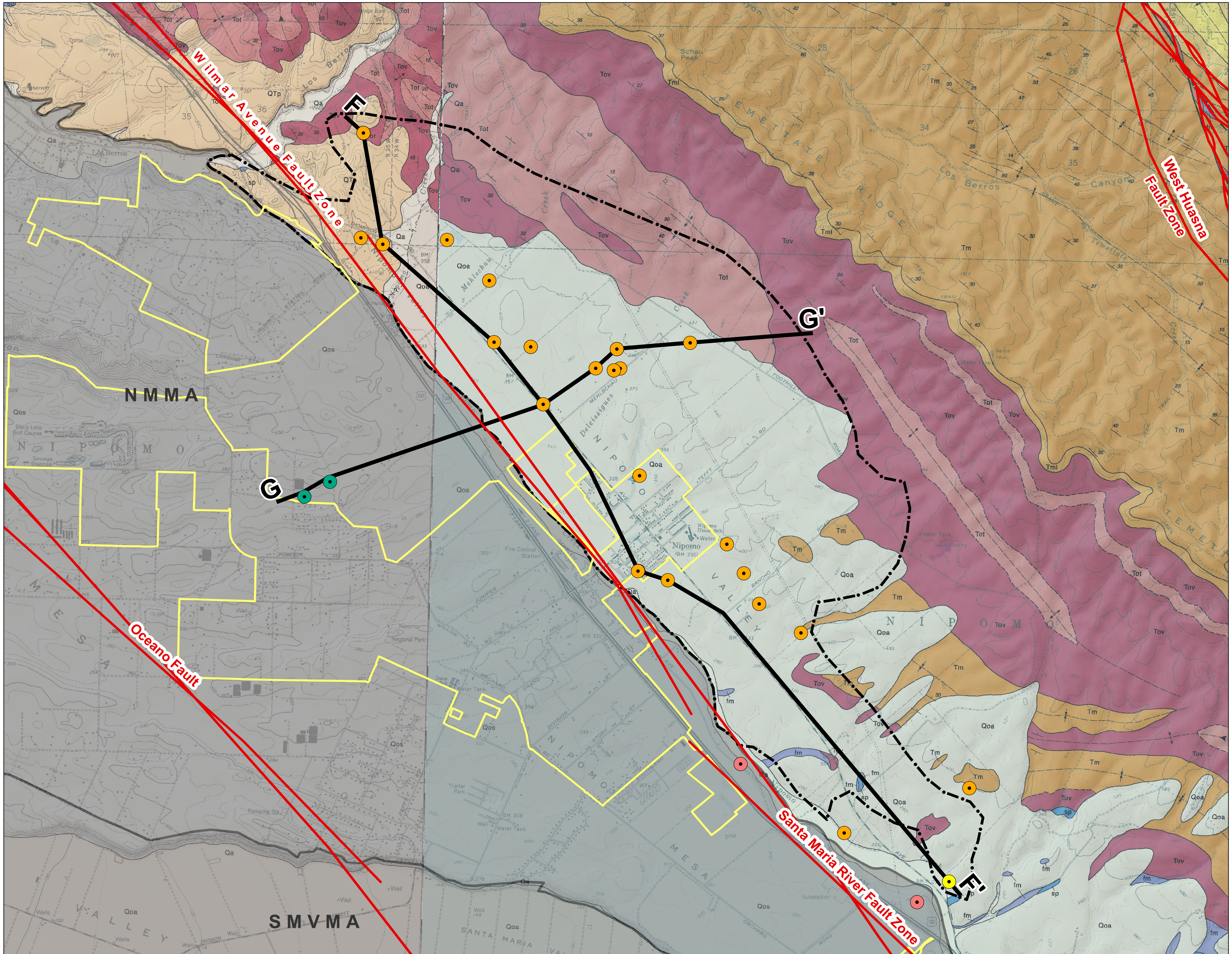


FIGURE 24
Nipomo Valley Geologic Map
Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

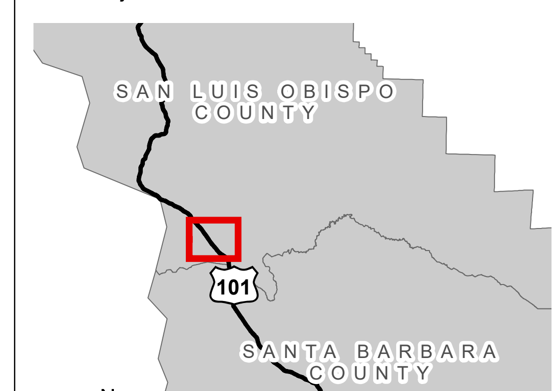
Wells

Screened Zone
- Alluvium
- Alluvium/Bedrock
- Paso Robles/Pismo
- Bedrock

Well Type
- Supply

Geology
- Volcanic Intrusive Rocks
- Obispo Formation
- Franciscan Assemblage
- Serpentine
- Paso Robles
- Recent Alluvium
- Pismo Formation
- Monterey Formation
- Atascadero Formation
- Toro Formation

All Other Features
- Cross Section Lines
- Fault
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Nipomo Community Services District
- Santa Maria River Valley Adjudicated Area



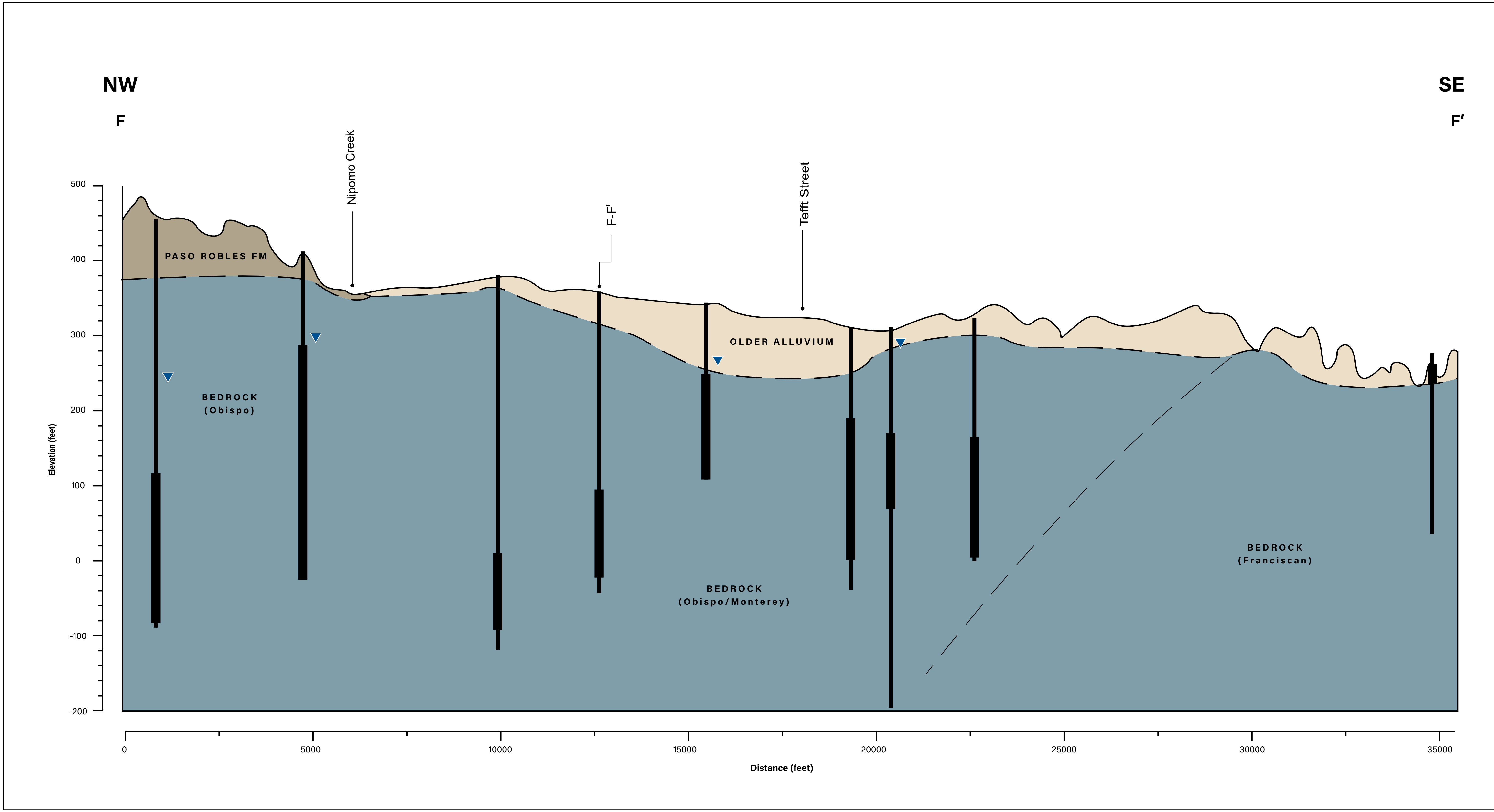
N

0 0.5 1
Miles

Date: April 11, 2018
Data Sources: Surface Geology from Dibblee (2006b and 2006c).
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure17_Nipomo_geo.mxd



LEGEND

- Older Alluvium
- Paso Robles Fm
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

VERTICAL EXAGGERATION:
20X

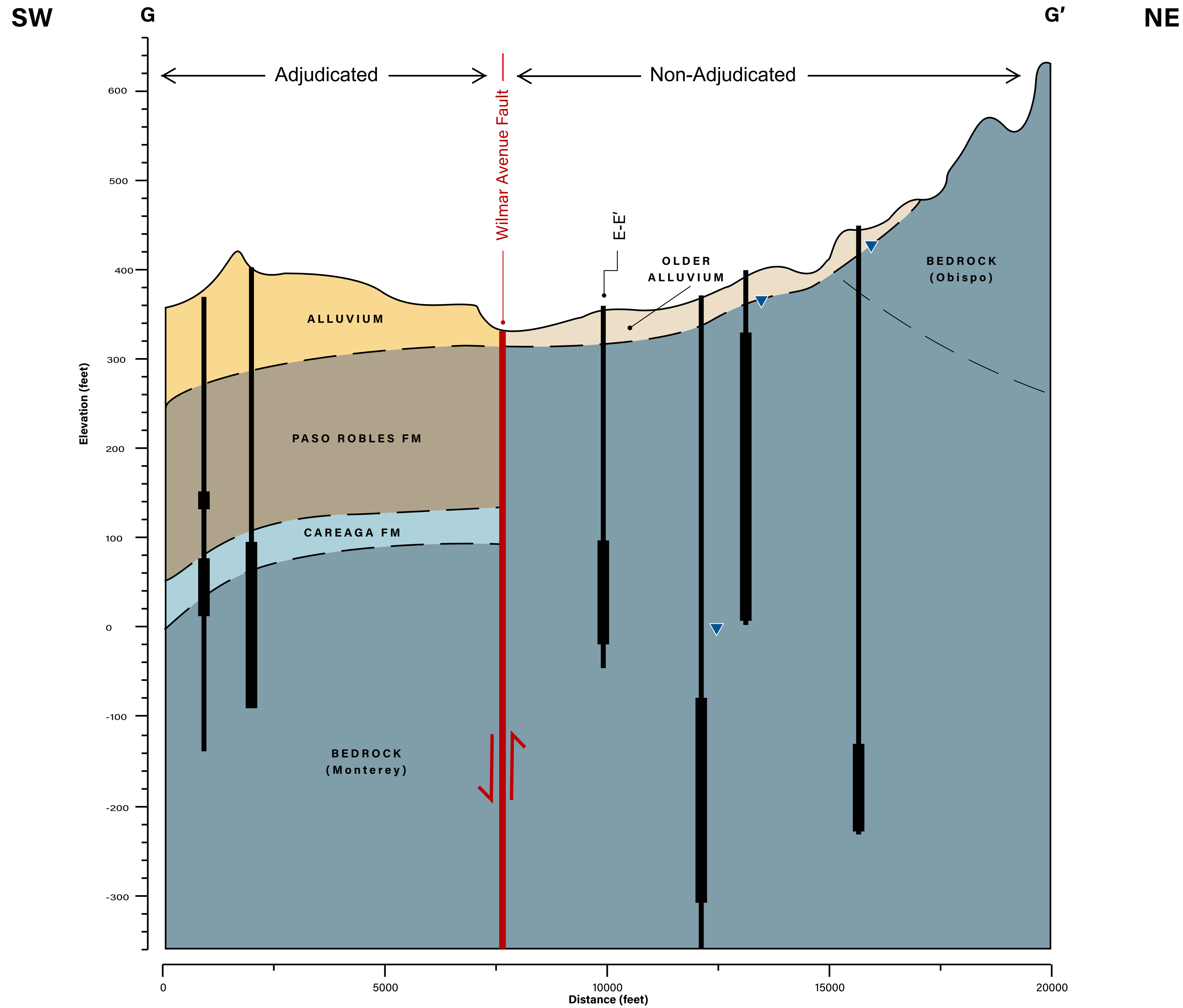
FIGURE 25

Nipomo Valley Cross Section F-F’

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Figures



LEGEND

- Alluvium
- Older Alluvium
- Paso Robles Fm
- Careaga Fm
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

VERTICAL EXAGGERATION:
20X

P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Figures

FIGURE 26

Nipomo Valley Cross Section G-G'

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

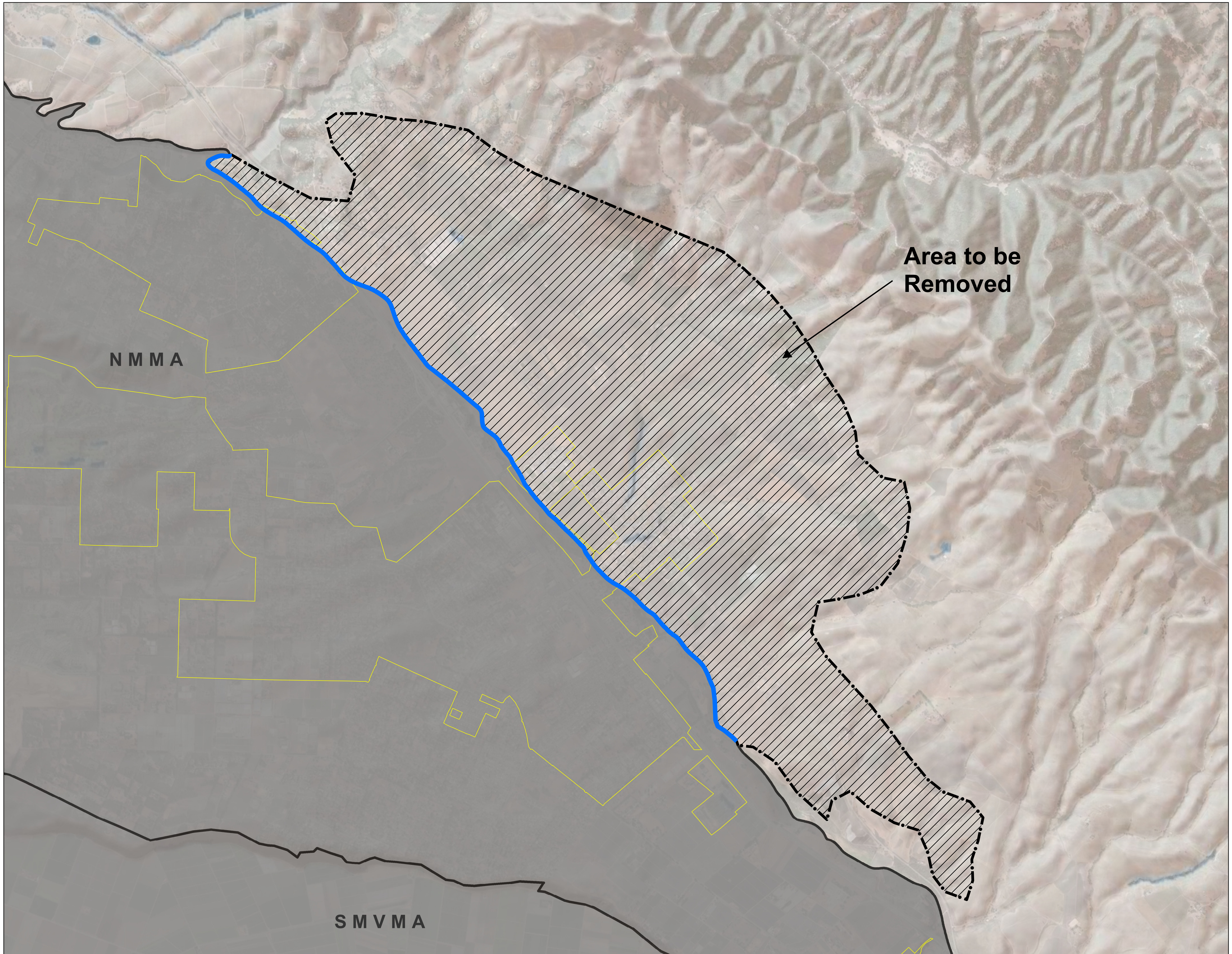
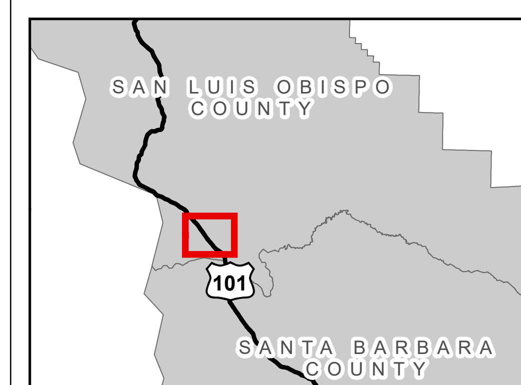


FIGURE 27

SMRVGB Modification Request Number 4
Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

- Proposed Boundary
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area
- Nipomo Community Services District



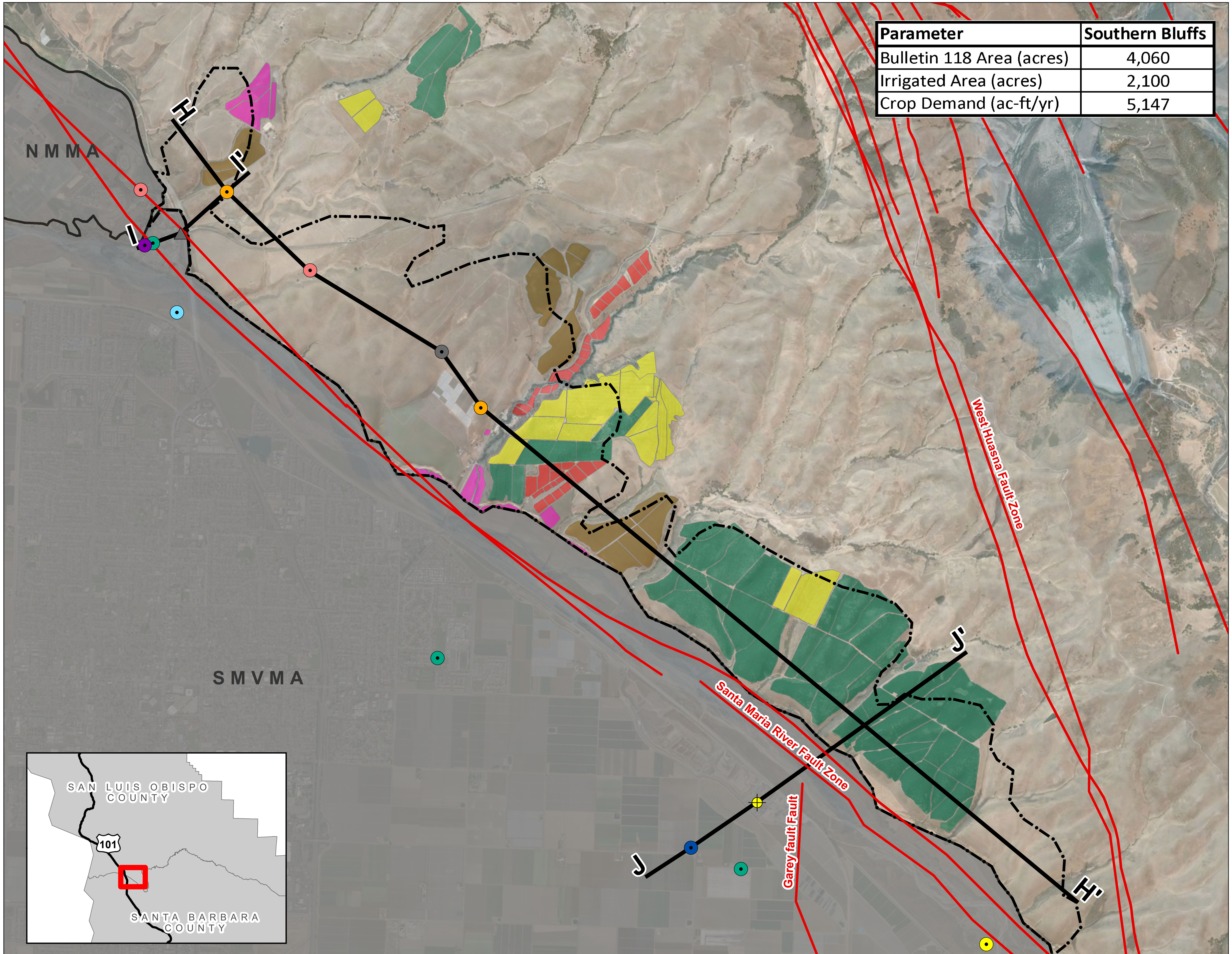
N

0 0.5 1
Miles

Date: April 12, 2018
Data Sources: Aerial photo taken 10/3/2016 (DigitalGlobe)

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure27_BBMR Req3.mxd



Parameter	Southern Bluffs
Bulletin 118 Area (acres)	4,060
Irrigated Area (acres)	2,100
Crop Demand (ac-ft/yr)	5,147

FIGURE 28

Southern Bluffs Aerial Photograph

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

Wells

Screened Zone
- Alluvium
- Alluvium/Paso Robles/ Careaga
- Alluvium/Careaga
- Alluvium/Bedrock
- Paso Robles/Careaga
- Paso Robles/Careaga/Bedrock
- Bedrock
- Unknown

Well Type
- Monitoring
- Supply
- Cathodic Protection

- Cross Section Lines
- Fault
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area

Irrigated Area (DWR, 2017)
- Avocados
- Bush Berries
- Citrus
- Idle
- Miscellaneous Truck Crops

Date: April 12, 2018
Data Sources: Aerial photo taken 10/3/2016 (DigitalGlobe)
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

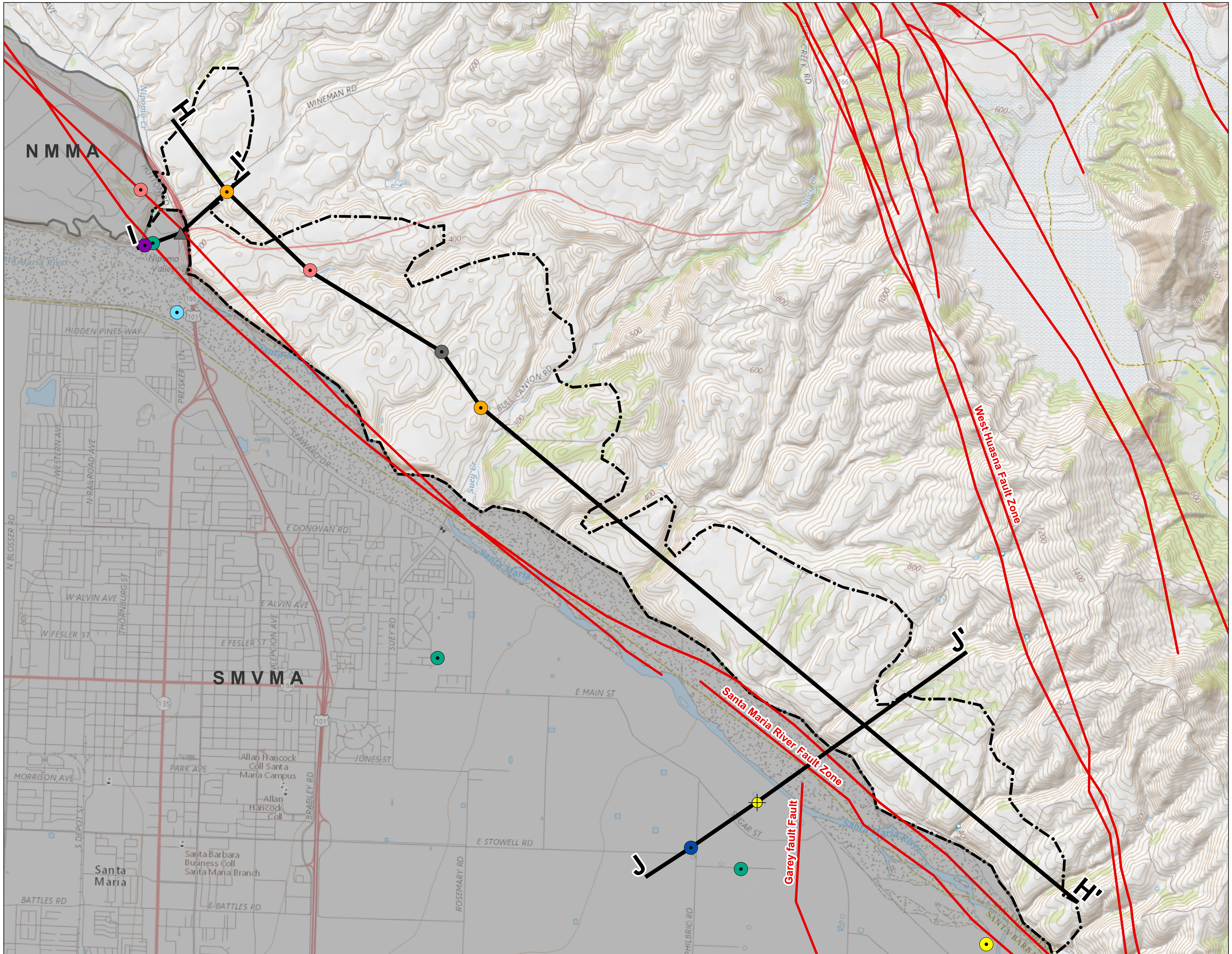
GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure22_Southern Bluffs aerial.mxd

FIGURE 29

Southern Bluffs Topographic Map

Santa Maria River Valley Groundwater Basin Fringe Areas

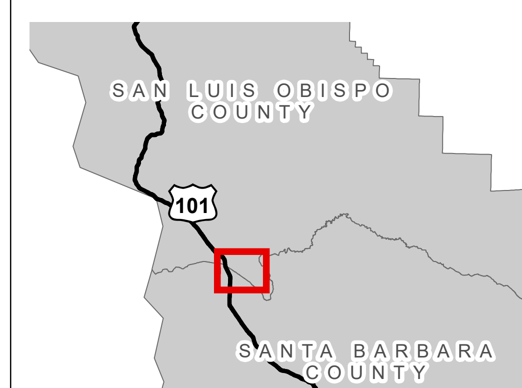


LEGEND

Wells

Screened Zone	*Well Type*
Alluvium	
Alluvium/Paso Robles/ Careaga	
Alluvium/Careaga	Monitoring
Alluvium/Bedrock	Supply
Paso Robles/Careaga	Cathodic Protection
Paso Robles/Careaga/Bedrock	
Bedrock	
Unknown	

- Cross Section Lines
- Fault
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area



N

0 0.5 1

Miles

Date: April 11, 2018
Data Sources:
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure23_Southern Bluffs topo.mxd

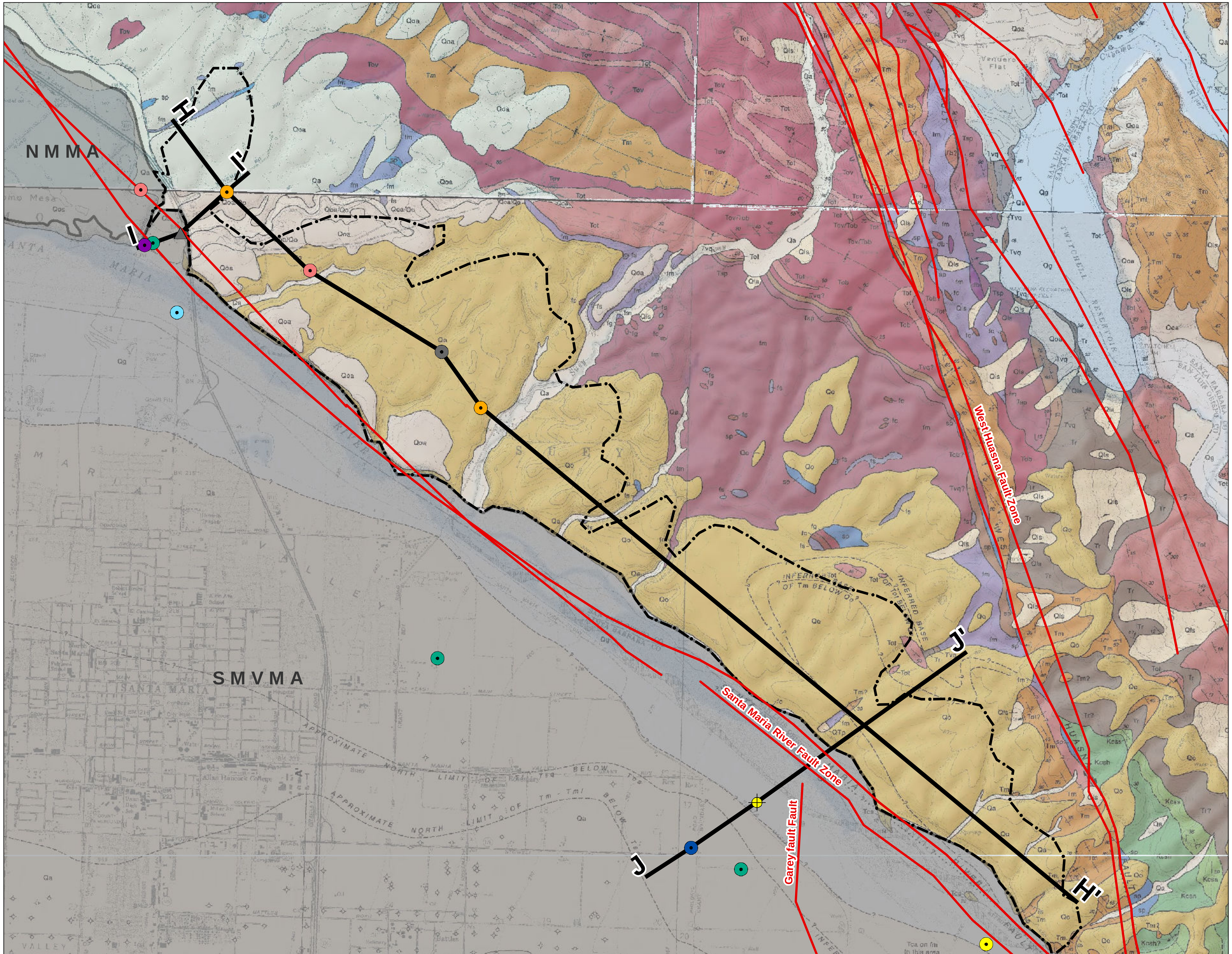


FIGURE 30

Southern Bluffs Geologic Map

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

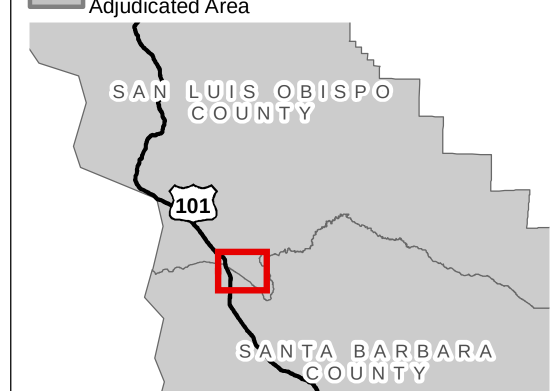
Wells

Screened Zone
- Alluvium
- Alluvium/Paso Robles/Careaga
- Alluvium/Careaga
- Alluvium/Bedrock
- Paso Robles/Careaga
- Paso Robles/Careaga/Bedrock
- Bedrock
- Unknown

Well Type
- Monitoring
- Supply
- Cathodic Protection

Geology
- Volcanic Intrusive Rocks
- Obispo Formation
- Franciscan Assemblage
- Serpentine
- Paso Robles
- Recent Alluvium
- Pismo Formation
- Monterey Formation
- Orcutt
- Atascadero Formation
- Toro Formation

All Other Features
- Cross Section Lines
- Fault
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area



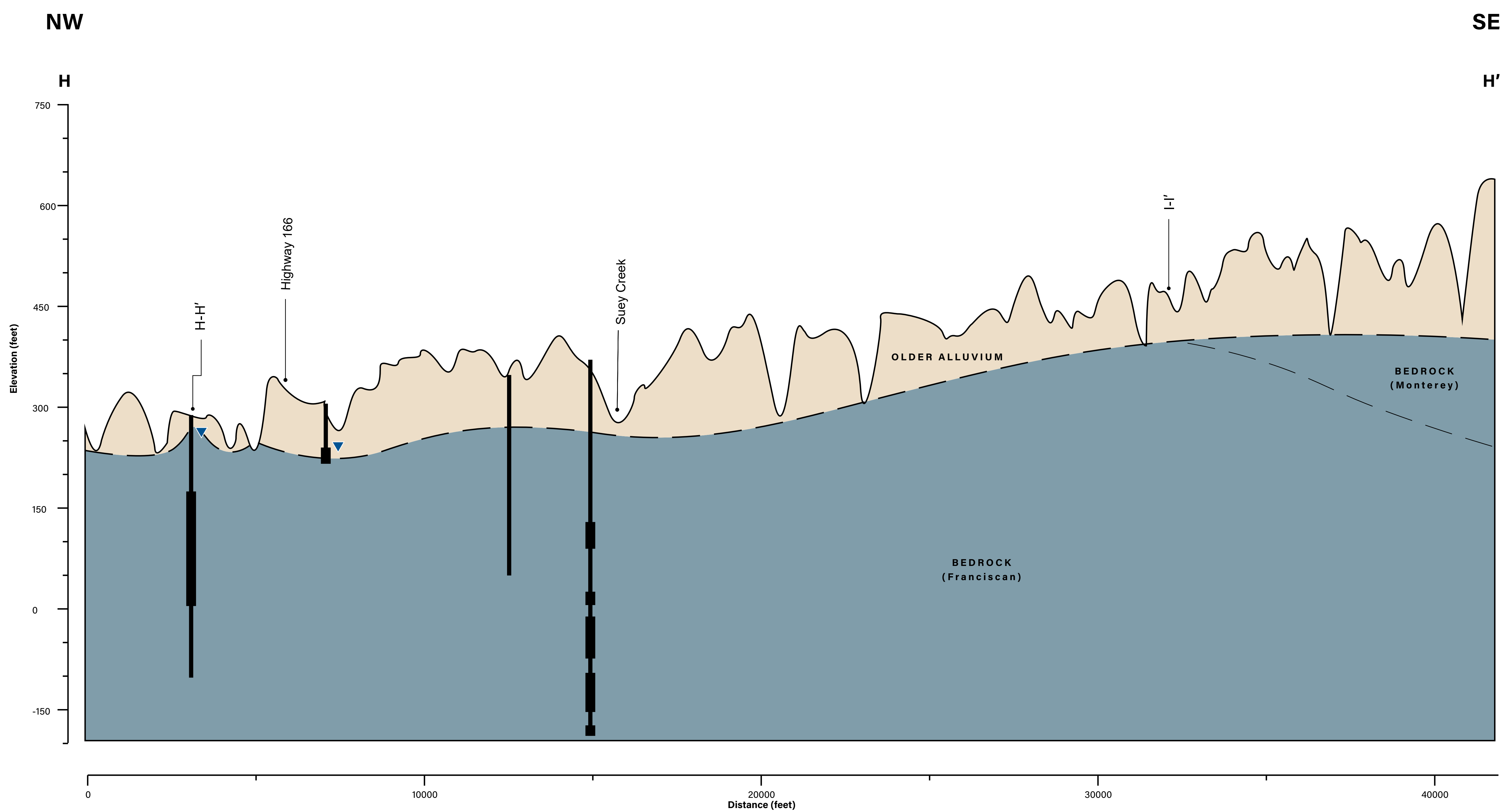
N

0 0.5 1
Miles

Date: April 12, 2018
Data Sources: Surface Geology from Dibblee (1994, 2006a, and 2006b).
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure24_Southern Bluffs geo.mxd



LEGEND

- Older Alluvium
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

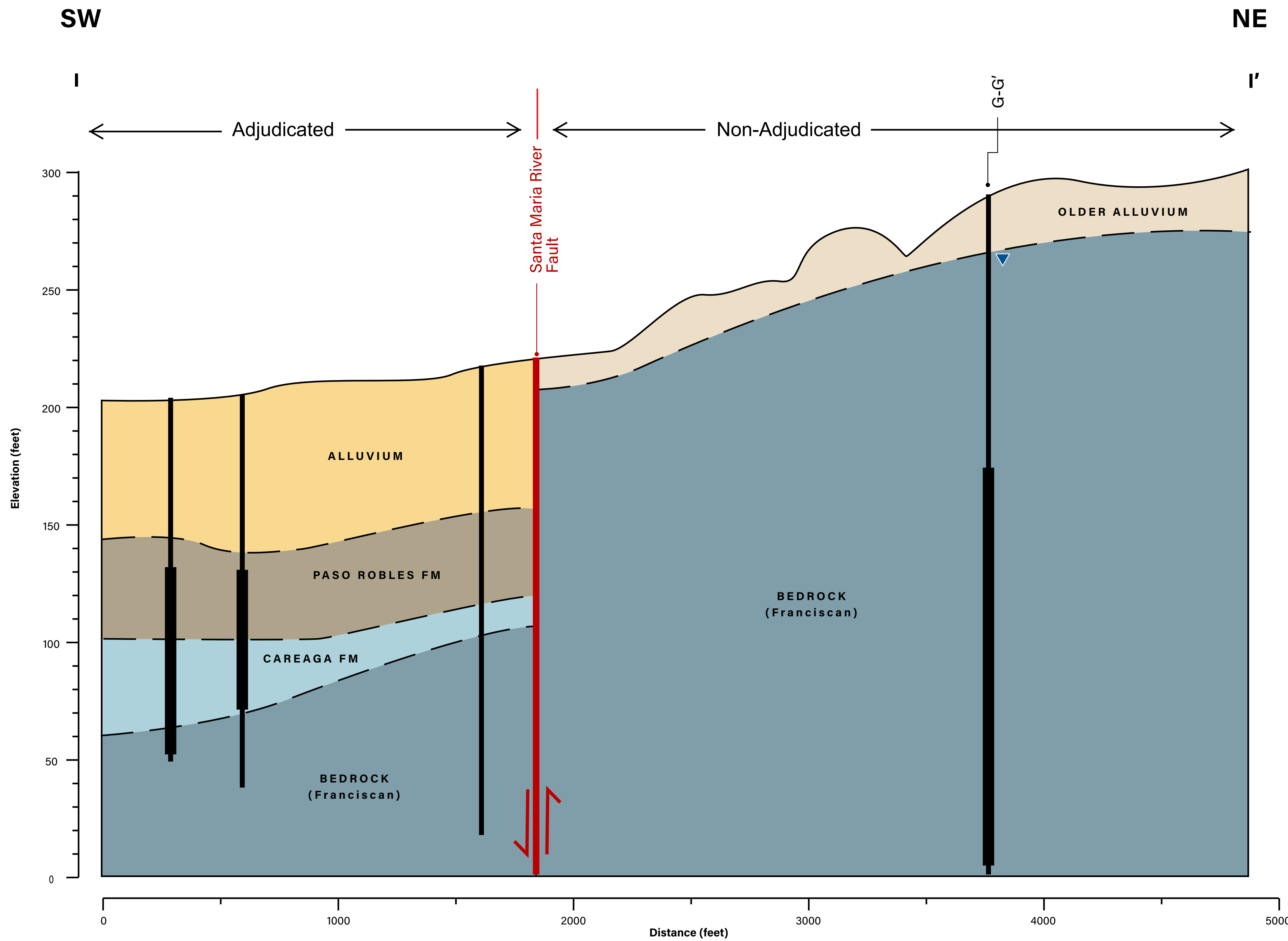
VERTICAL EXAGGERATION:
20X

FIGURE 31

Southern Bluffs Cross Section H-H'

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.



LEGEND

- Alluvium
- Older Alluvium
- Paso Robles Fm
- Careaga Fm
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

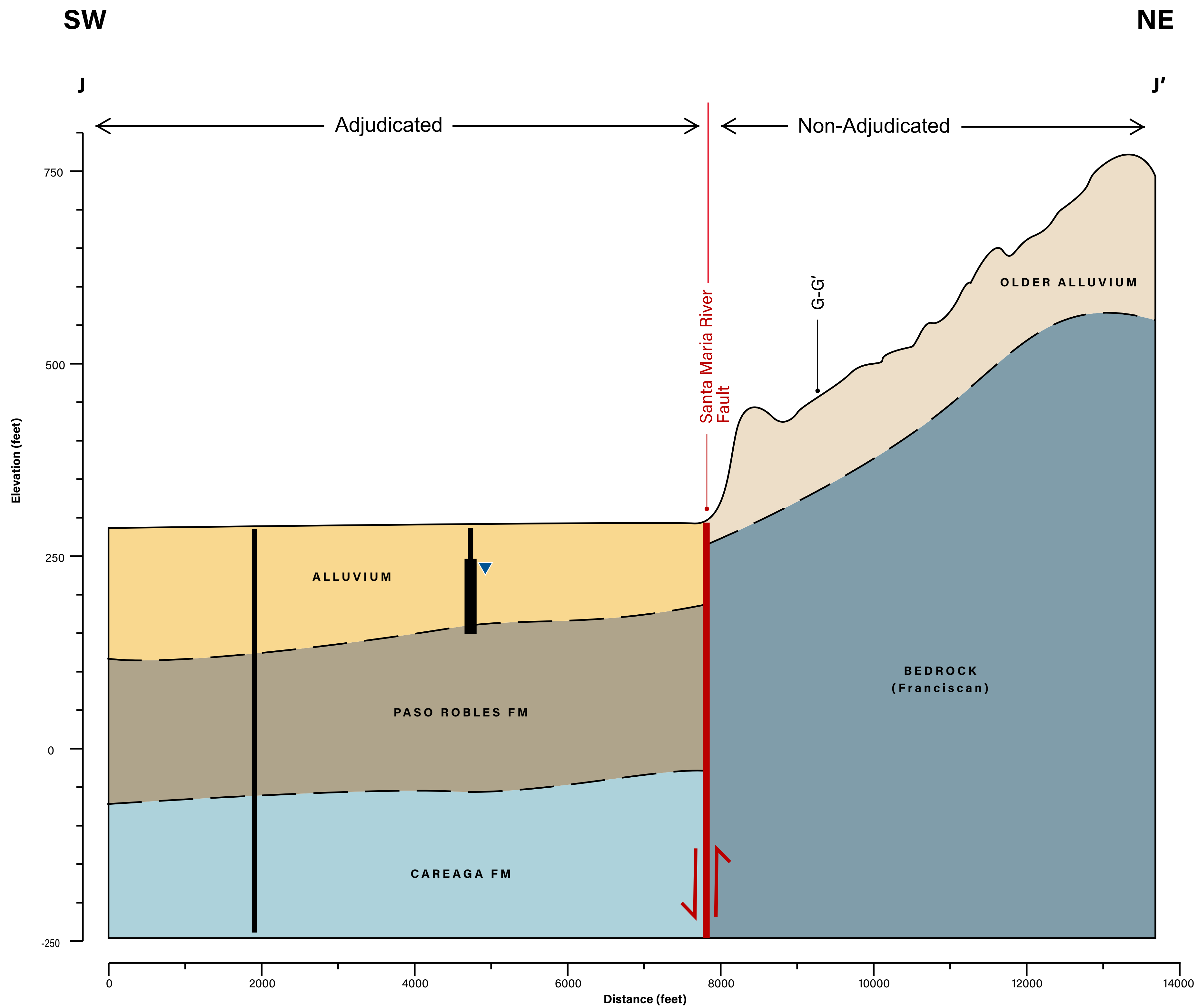
VERTICAL EXAGGERATION:
10X

FIGURE 32

Southern Bluffs Cross Section I-I'

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.



LEGEND

- Alluvium
- Older Alluvium
- Paso Robles Fm
- Careaga Fm
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

VERTICAL EXAGGERATION:
10X

FIGURE 33

Southern Bluffs Cross Section J-J'

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Figures

FIGURE 34

SMRVGB Modification Request Number 5

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

- Proposed Boundary
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area

Date: April 12, 2018
Data Sources: Aerial photo taken 10/3/2016 (DigitalGlobe)

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure34_BBMR Req4.mxd

Parameter	SLO County	Santa Barbara County	Total
Bulletin 118 Area (acres)	830	740	1,570
Extent of Alluvium Area (acres)	720	1,090	1,810
Irrigated Area (acres)	470	960	1,430
Crop Demand (ac-ft/yr)	610	1,059	1,669
Underflow Out (ac-ft/yr)	147		
% of Total Inflow to SLO Co. portion of SMRVGB	0.5%		

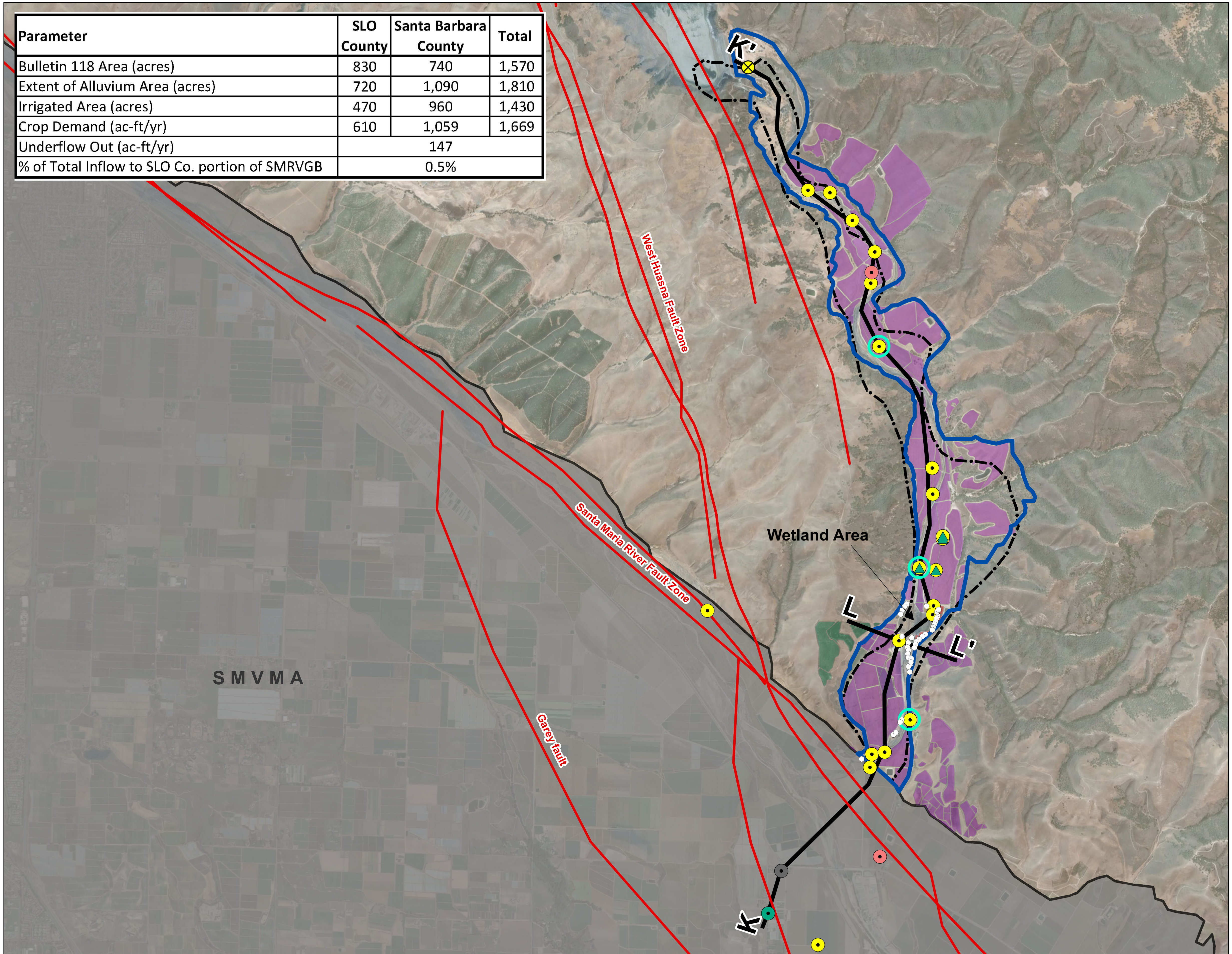


FIGURE 35

Ziegler Canyon Aerial Photograph

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

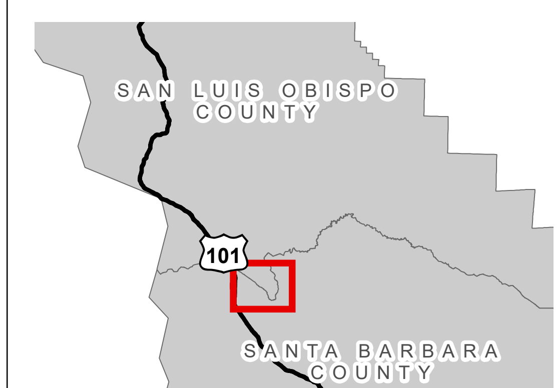
Wells

Screened Zone
- Alluvium
- Alluvium/Bedrock
- Paso Robles/Careaga
- Unknown
- TDEM Survey Point

Well Type
- Supply
- Test
- Pumping Test
- Hydrograph

- Cross Section Lines
- Fault
- Extent of Alluvium
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area

Irrigated Area (DWR, 2017)
- Avocados
- Bush Berries
- Grapes
- Idle
- Miscellaneous Truck Crops



N

0 0.5 1
Miles

Date: April 11, 2018
Data Sources: Aerial photo taken 10/3/2016 (DigitalGlobe)
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure28_Ziegler aerial.mxd

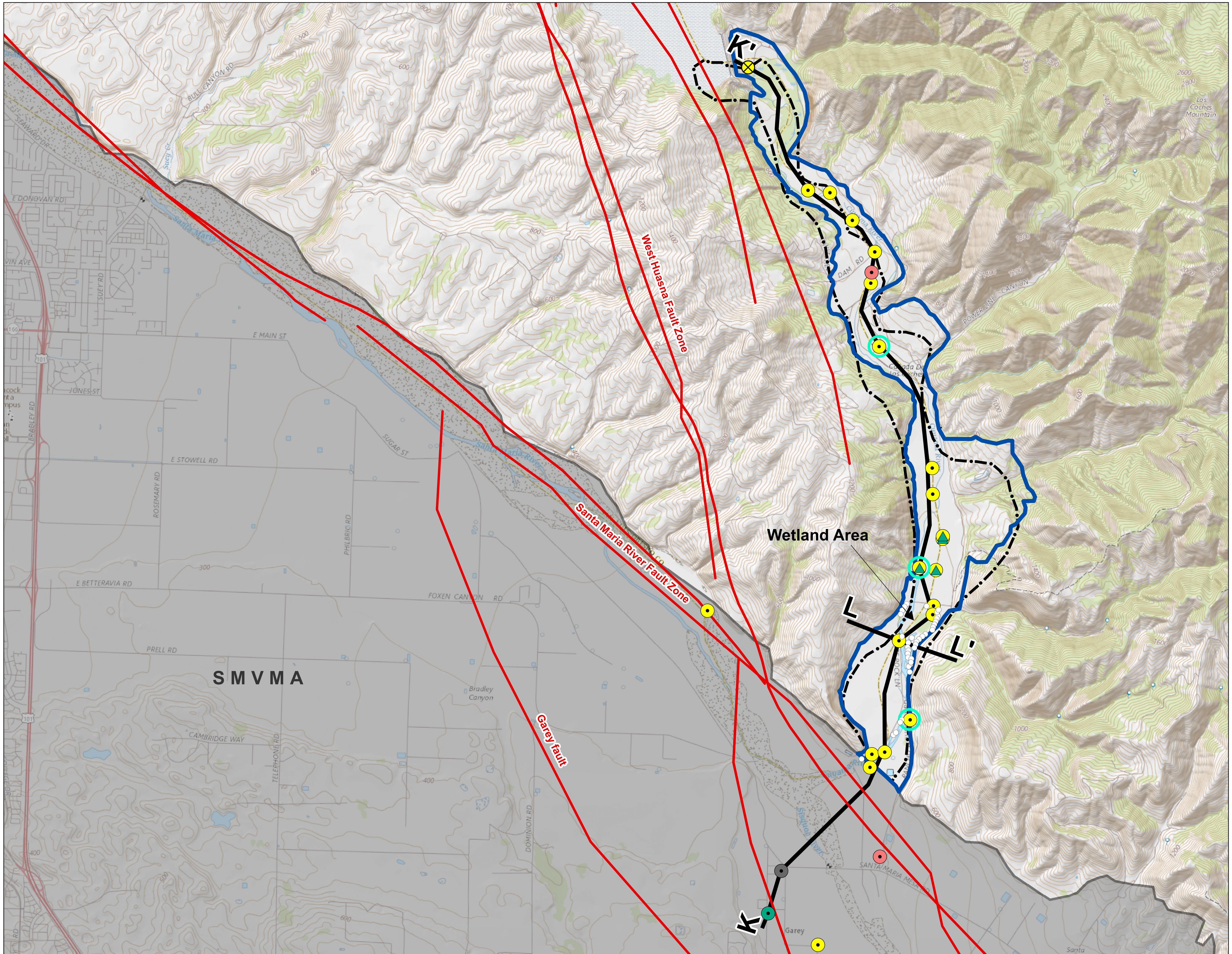


FIGURE 36

Ziegler Canyon Topographic Map

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

Wells

Screened Zone
- Alluvium
- Alluvium/Bedrock
- Paso Robles/Careaga
- Unknown
- TDEM Survey Point

Well Type
- Supply
- Test
- Pumping Test
- Hydrograph

- Fault
- Extent of Alluvium
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area

Date: April 12, 2018
Data Sources:
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure29_Ziegler topo.mxd

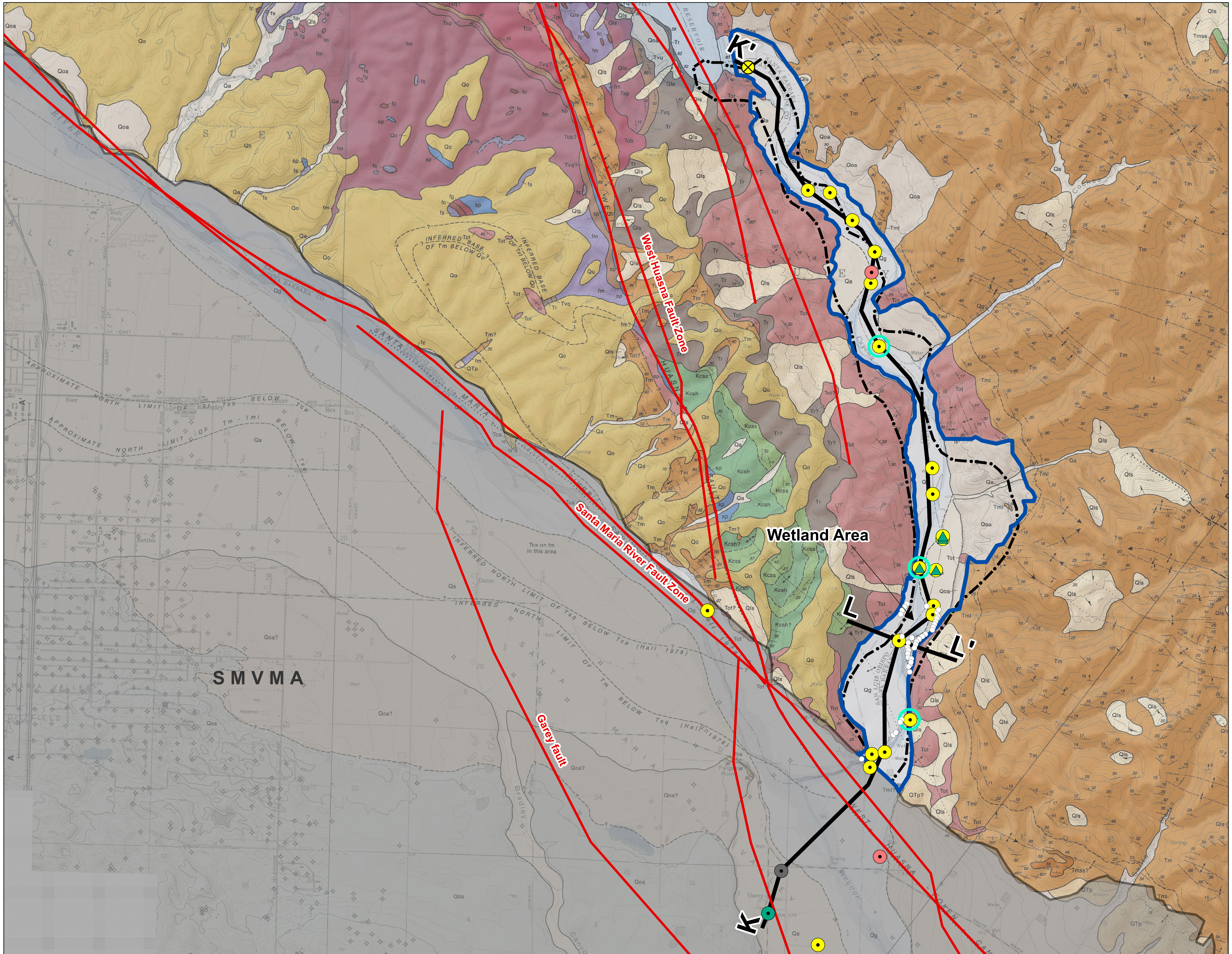


FIGURE 37

Ziegler Canyon Geologic Map

Santa Maria River Valley
Groundwater Basin Fringe Areas

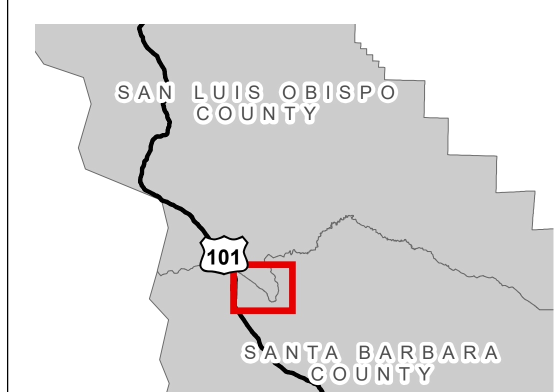
LEGEND

Wells

Screened Zone	*Well Type*
Alluvium	Supply
Alluvium/Bedrock	Test
Paso Robles/Careaga	Pumping Test
Unknown	Hydrograph
TDEM Survey Point	

Geology

- Volcanic Intrusive Rocks
- Obispo Formation
- Franciscan
- Serpentine
- Paso Robles
- Recent
- Pismo Formation
- Monterey Formation
- Atascadero Formation
- Toro Formation
- Fault
- Extent of
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area



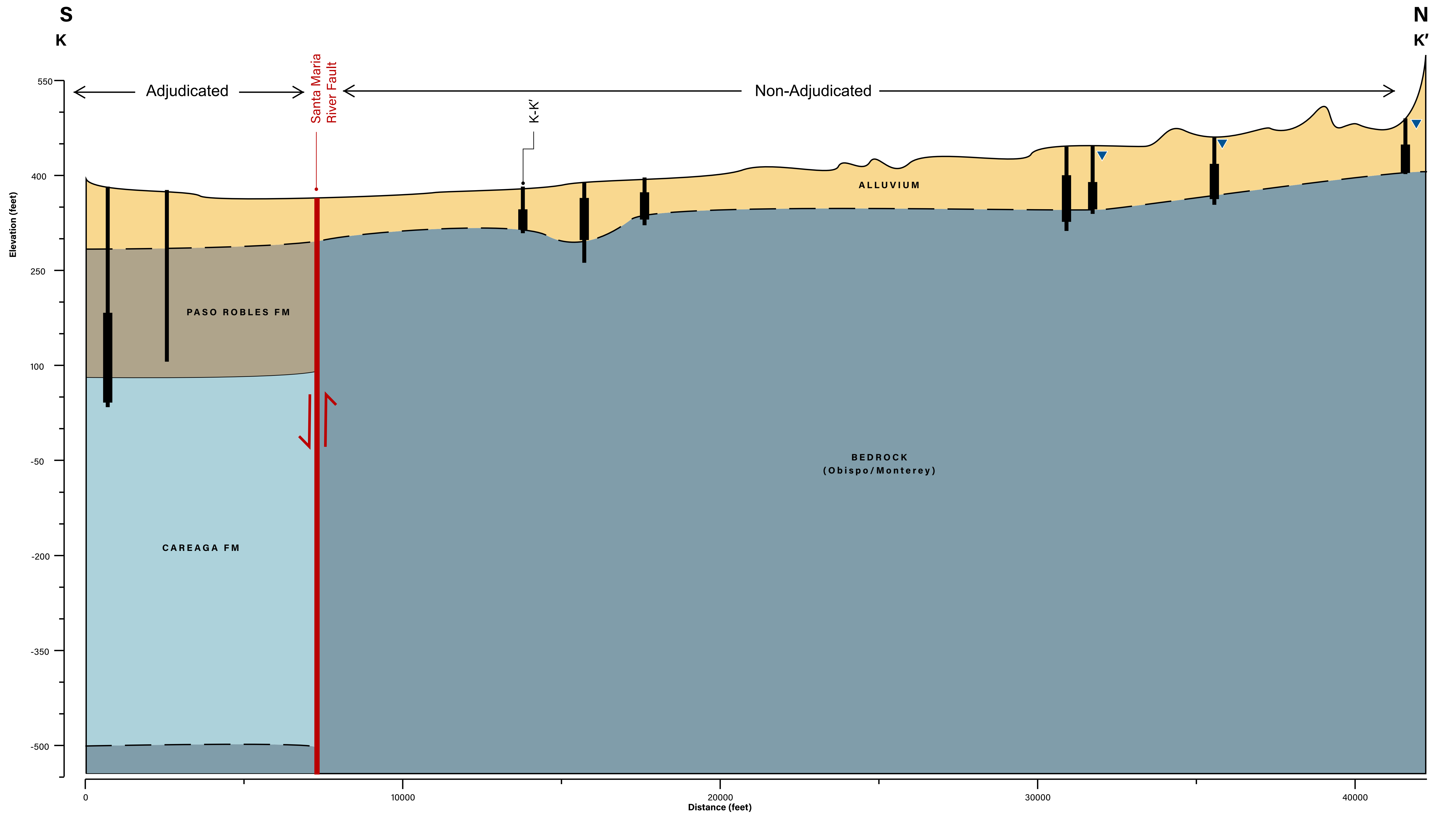
N

0 0.5 1
Miles

Date: April 11, 2018
Data Sources: Surface Geology from Dibblee (1994).
Fault shapefiles acquired from California Geological Survey and USGS Earthquake Hazards Program

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure30_Ziegler geo.mxd



LEGEND

- Alluvium
- Paso Robles Fm
- Careaga Fm
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

VERTICAL EXAGGERATION:
20X

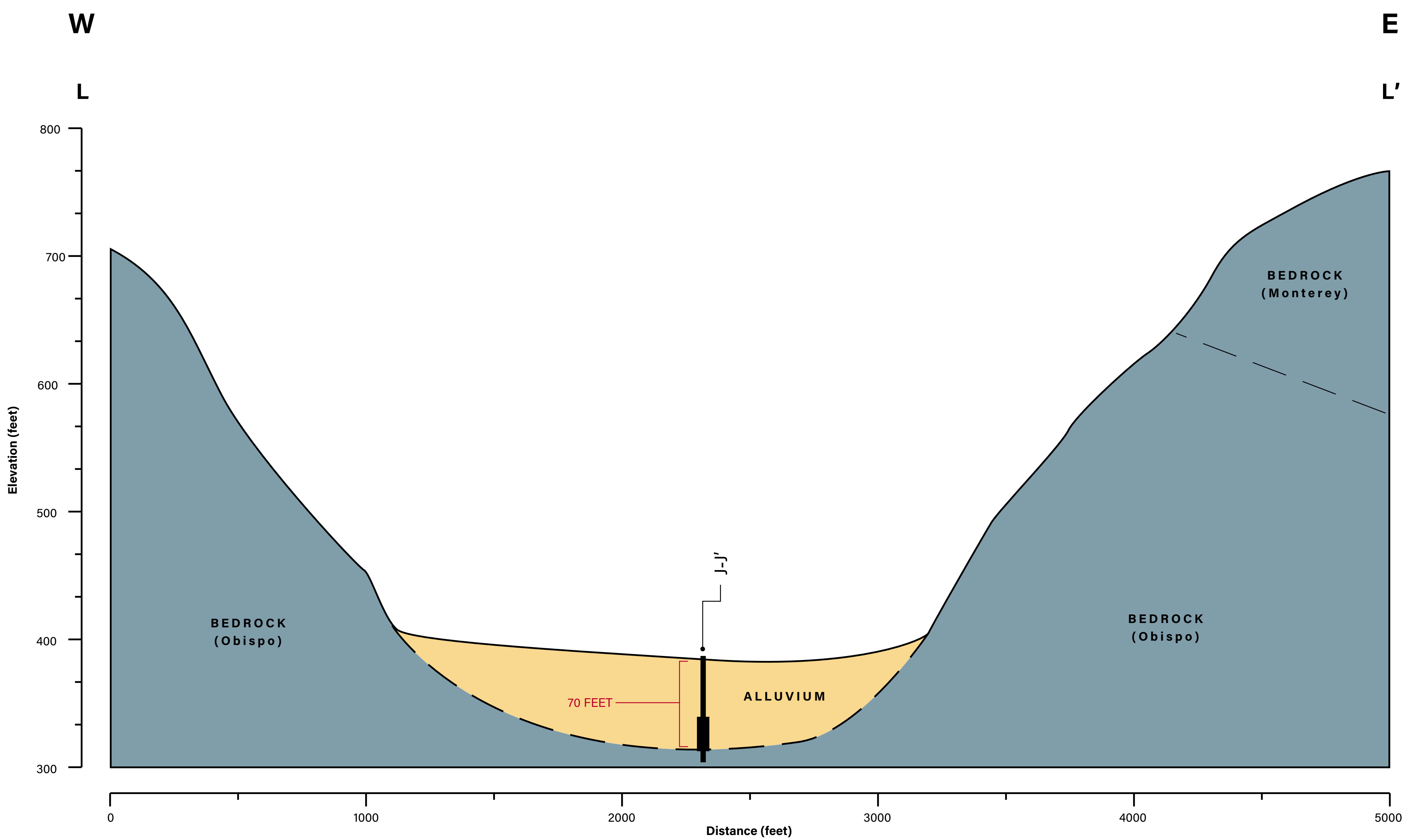
FIGURE 38

Ziegler Canyon Cross Section K-K'

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Figures



LEGEND

- Alluvium
- Bedrock
- Static Water Level (WCR)
- Borehole
- Perforated

VERTICAL EXAGGERATION:
5X

FIGURE 39

Ziegler Canyon Cross Section L-L'

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Figures

Figure 40
Ziegler Canyon Hydrographs with Twitchell Reservoir Downstream Releases

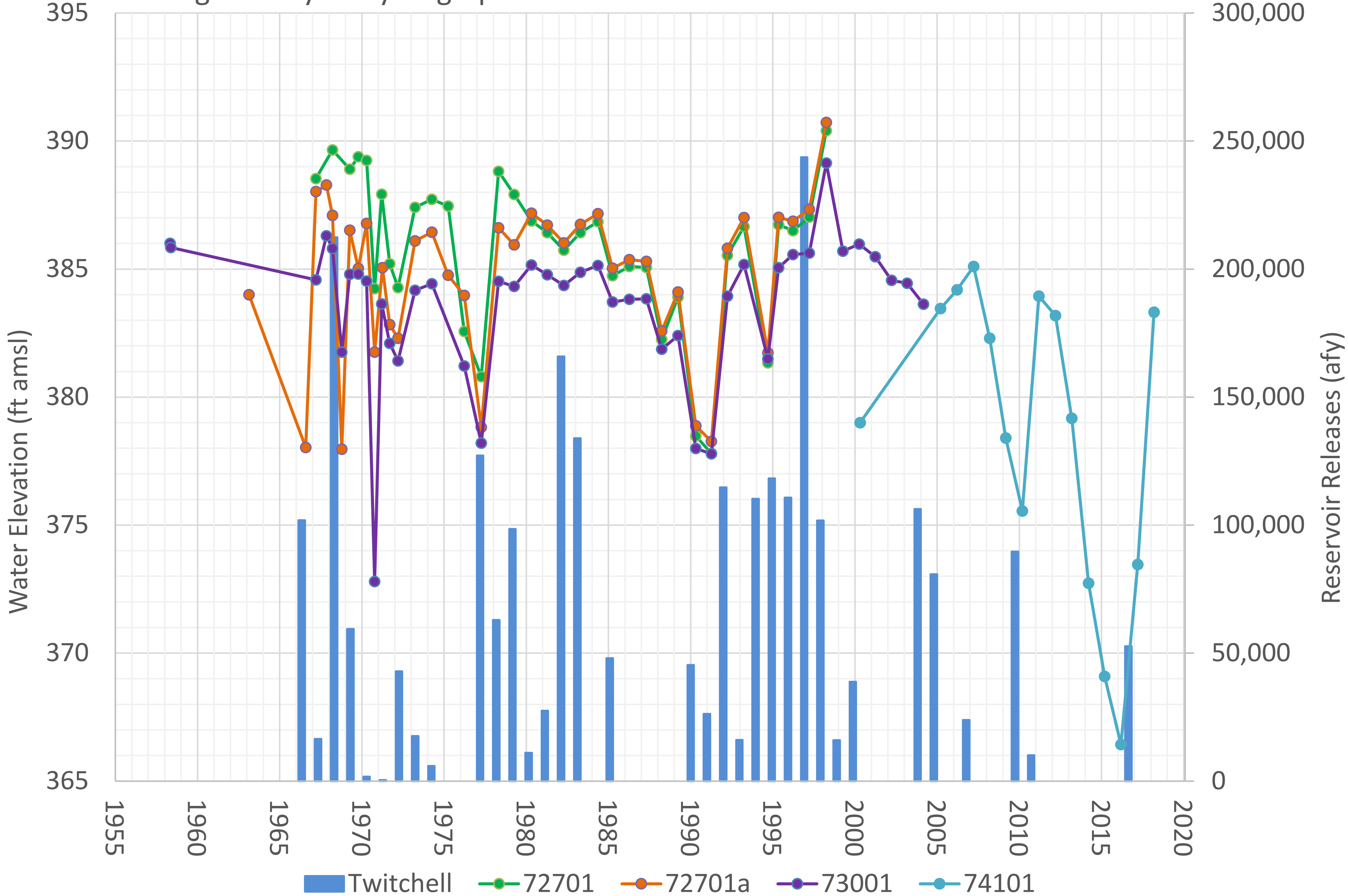
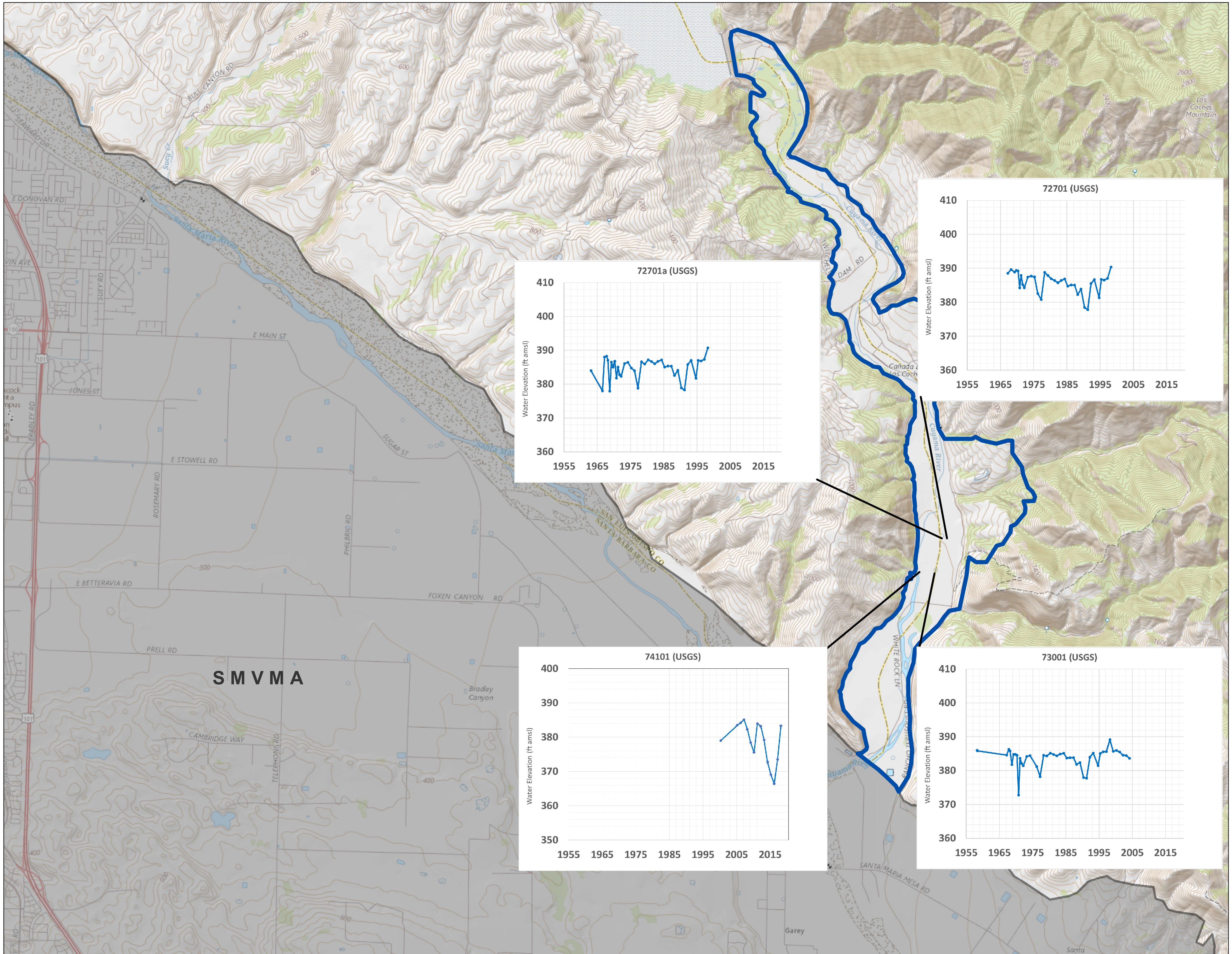


FIGURE 41

Ziegler Canyon Groundwater Elevation Hydrographs

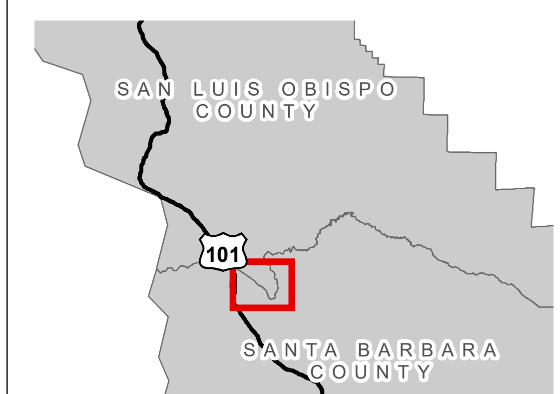
Santa Maria River Valley Groundwater Basin Fringe Areas



LEGEND

Extent of Alluvium

Santa Maria River Valley Adjudicated Area



N

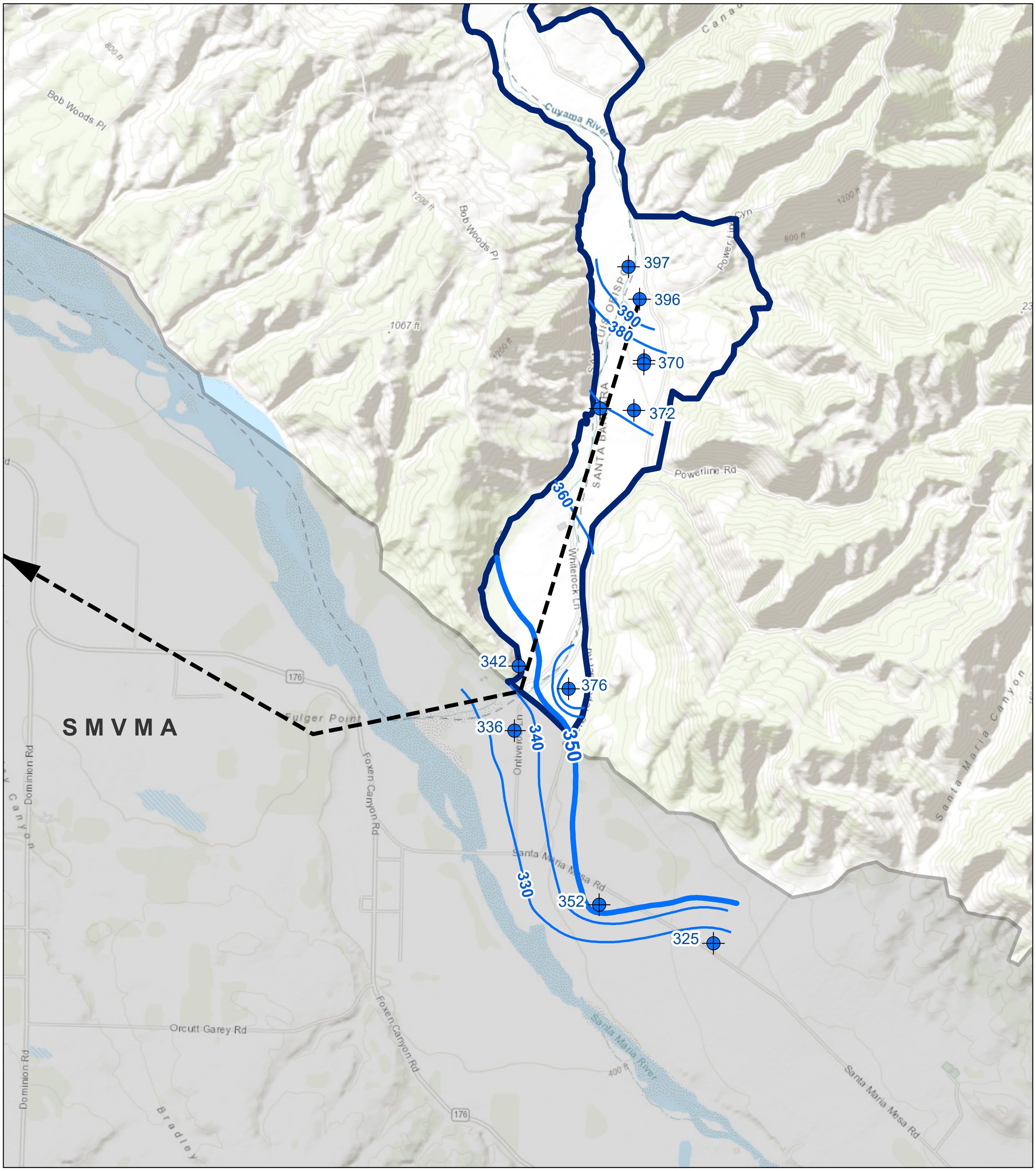
0 0.5 1

Miles

GSI Water Solutions, Inc.

Date: May 4, 2018

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\FigureX_Ziegler hydrographs.mxd



LEGEND

- Wells with Water Level Data
- 397 1974 Water Elevation
- Water Elevation Contour
- Extent of Alluvium
- Santa Maria River Valley Adjudicated Area
- Groundwater Profile Line (Fig 44)

0 2,000 4,000
Feet

FIGURE 42

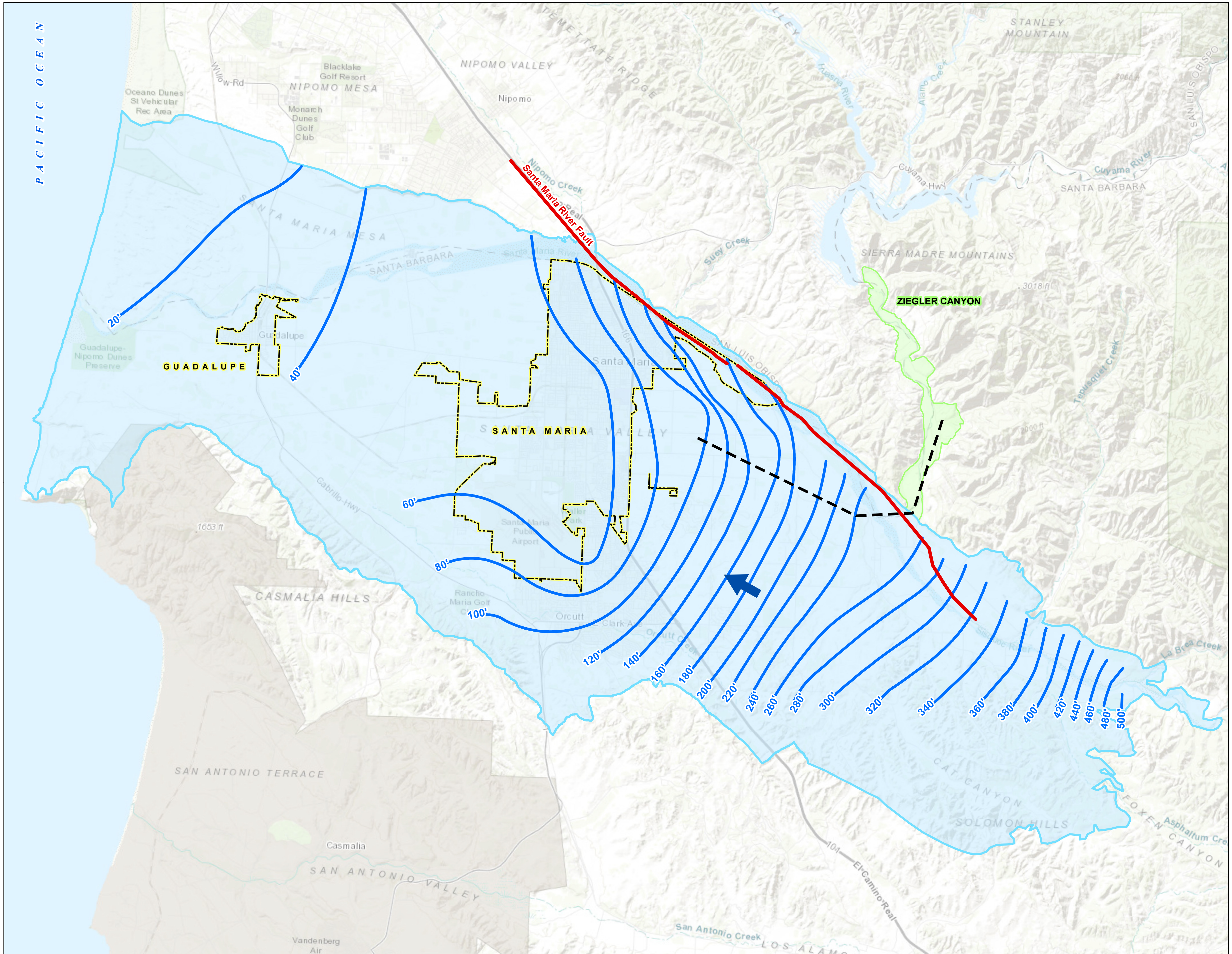
Ziegler Canyon Groundwater Elevation Contours, 1974

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

Date: April 12, 2018

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure37_ZieglerCyn_Contours.mxd



Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure39_SMVMA_GW_Contours_Spring2016.mxd

FIGURE 43

Santa Maria Valley Management Area Shallow Groundwater Elevation Contours, Spring 2016

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

- Shallow Groundwater Elevation Contour
- Groundwater Flow Direction
- Groundwater Profile Section Line (Fig 44)
- Santa Maria Valley Management Area
- Fringe Area Boundary
- City Boundary

NOTE:
Contours based on SMVMA 2016 Annual Report, Figure 2.1-3a

N

0 6,000 12,000 18,000
Feet

Date: April 12, 2018
Data Sources: USGS

GSI Water Solutions, Inc.

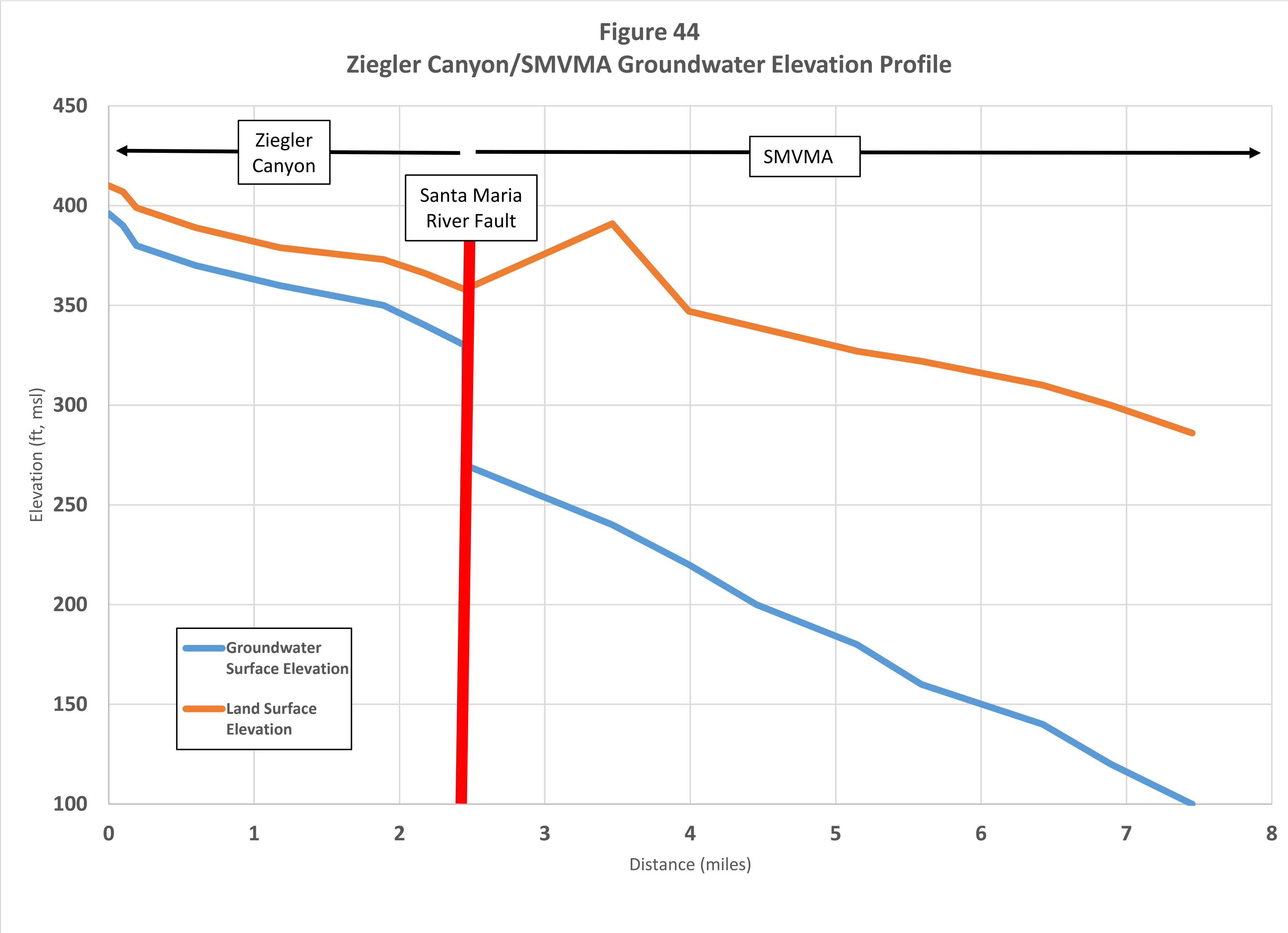


Figure 44
Ziegler Canyon/SMVMA Groundwater Elevation Profile
450
400
350
300
250
200
150
100
Elevation (ft, msl)
0
1
2
3
4
5
6
7
8
Distance (miles)
Ziegler Canyon
SMVMA
Santa Maria River Fault
Groundwater Surface Elevation
Land Surface Elevation

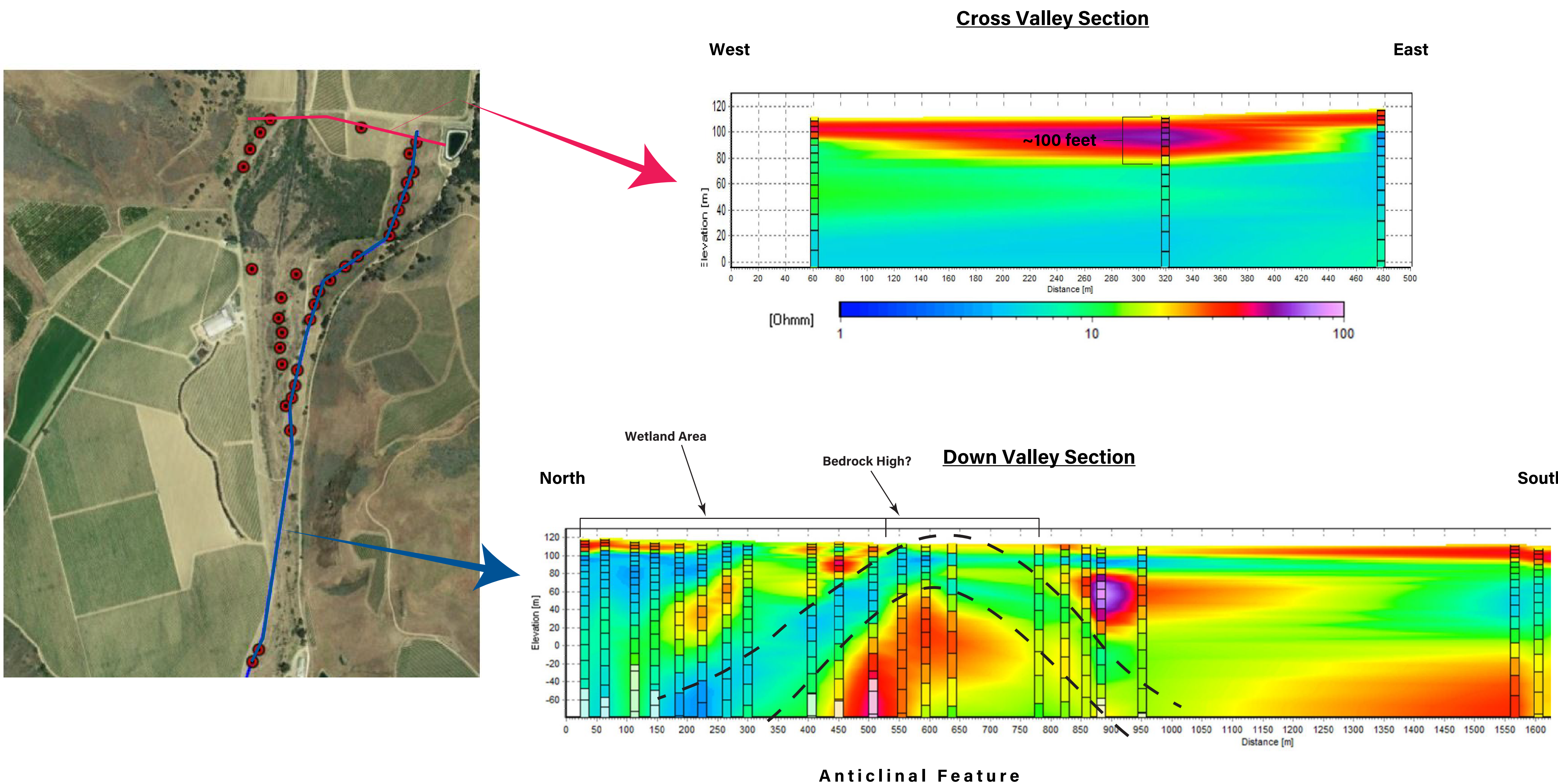


FIGURE 45

Ziegler Canyon TDEM Survey

Santa Maria River Valley Groundwater Basin Fringe Areas

GSI Water Solutions, Inc.

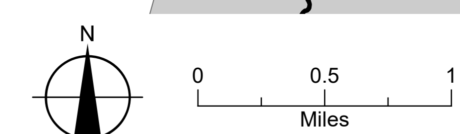
FIGURE 46

SMRVGB Modification Request Number 6

Santa Maria River Valley Groundwater Basin Fringe Areas

LEGEND

- Proposed Boundary
- Existing Basin Boundary (DWR Bulletin 118, 2016)
- Santa Maria River Valley Adjudicated Area



Date: April 12, 2018
Data Sources: Aerial photo taken 10/3/2016 (DigitalGlobe)

GSI Water Solutions, Inc.

Document Path: P:\Portland\667-County of San Luis Obispo\003-Santa Maria Basin Fringe Areas\Project_GIS\MXDs\Report\Figure46_BBMR Req5.mxd

Appendix A

WIZ Pismo Alluvium Report

WZI INC.

Plains Exploration & Production Company

Pismo Creek Alluvial Evaluation
Arroyo Grande Oil Field
San Luis Obispo County, California

February 2007

Submitted to:
Plains Exploration & Production Company
1200 Discovery Drive, Suite 500
Bakersfield, California 93309

Prepared by:
WZI Inc.
1717 28th Street
Bakersfield, California 93301

TABLE OF CONTENTS

EXHIBITS

APPENDICES

Introduction

Plains Exploration & Production Company (PXP) recently received a conditional use permit (CUP) from San Luis Obispo County for their Phase IV drilling project at the Arroyo Grande (AG) Oil Field located along Price Canyon Road in San Luis Obispo County, California (Location Map, **Exhibit 1**). An additional CUP is currently being sought for a water treatment plant to support the Phase IV operations.

As a result of the Phase IV permitting process, several issues concerning the potential impact of the project on surface and groundwater resources in the area were identified. Previous geologic mapping of the area (Hall, 1973) indicated the presence of a fresh water alluvial aquifer that extends along Pismo Creek.

As a requirement of San Luis Obispo County for approval of the Phase IV drilling project, four sentry monitoring wells were installed along Pismo Creek in October 2005 to monitor shallow groundwater within the alluvium. Based on the results of the sentry well installations, it was determined that the actual extent of the alluvium in the area was not as depicted on the published geologic map of the area. Consequently, field mapping of the contact between the alluvium and underlying Pismo Formation were conducted to better define the actual extent of the alluvium in the area of the PXP's property. The following presents the methodology utilized to evaluate the extent of alluvium along Pismo Creek and the results of the field investigation.

Geologic Setting

A geologic map of the area was published by the California Division of Mines and Geology in 1973 on the Arroyo Grande 15' Quadrangle (Hall, 1973). According to the 1973 map, surface geology in the area of the Arroyo Grande Oil Field consists primarily of hard sandstones, pebbly sands, and conglomerates of the Edna Member of the Pismo Formation. The Edna member grades to the southwest of the Arroyo Grande Oil Field into brown clays and silts of the Meguelito Member of the Pismo Formation.

An area containing Quaternary age alluvium was mapped along the drainage of Pismo Creek and adjacent tributaries. It was interpreted that the veneer of alluvium provided a fresh water aquifer in the area which could potentially be impacted by the Phase IV oil and gas operations. The published extent of the alluvium was later utilized in a report on the geologic separation of the Price Canyon oil development from the fresh water aquifer (Pacific Geotechnical Associates, Inc., 2005). A cross section depicting the interpretation of the distribution of alluvium along Pismo Creek from the 2005 Pacific Geotechnical Associates, Inc. report presented as **Exhibit 2.**

Investigation Methodology

In order to evaluate the extent of alluvium along Pismo Creek a total of three days were spent conducting a field mapping program. The area along Pismo Creek was initially observed by vehicle and on foot. The field mapping program was then conducted which consisted of making a series of eight transects across the Pismo Creek drainage, recording lithologies at 54 outcrop locations, recording field observations, and photographing the Pismo Creek drainage. The

California State Plane coordinates for each outcrop location were recorded using a Magelan Meridian Series GPS unit. The coordinates were then plotted on a geo-referenced air photo. An air photo map depicting the transects and the individual outcrop locations observed is included as **Exhibit 3**.

Investigation Results and Conclusions

During the field investigation, the Pismo Creek drainage was observed to be incised directly into the Edna Member of the Pismo Formation bedrock. A soil profile of decomposed Pismo Formation is present in the vegetated areas adjacent to the creek but no extensive or continuous alluvial deposits are present along the Pismo Creek drainage through the PXP property.

The Edna Member of the Pismo Formation is characterized by gray sandstone containing natural crude oil stain and seepage at many of the outcrop locations observed along Pismo Creek. The observed outcrop lithologies and crude oil seepage appear to be consistent with formation conditions encountered in the 4 sentry wells located along Pismo Creek. **Appendix 1** contains a series of representative photographs that show the Pismo Creek drainage incised directly into the Edna Member of the Pismo Formation.

Based on the results of the field investigation, it was determined that the previously mapped distribution of alluvium within the Pismo Creek drainage and tributaries was incorrect. Consequently, no alluvial aquifer appears to be present within the Pismo Creek drainage in the area of PXP's property.

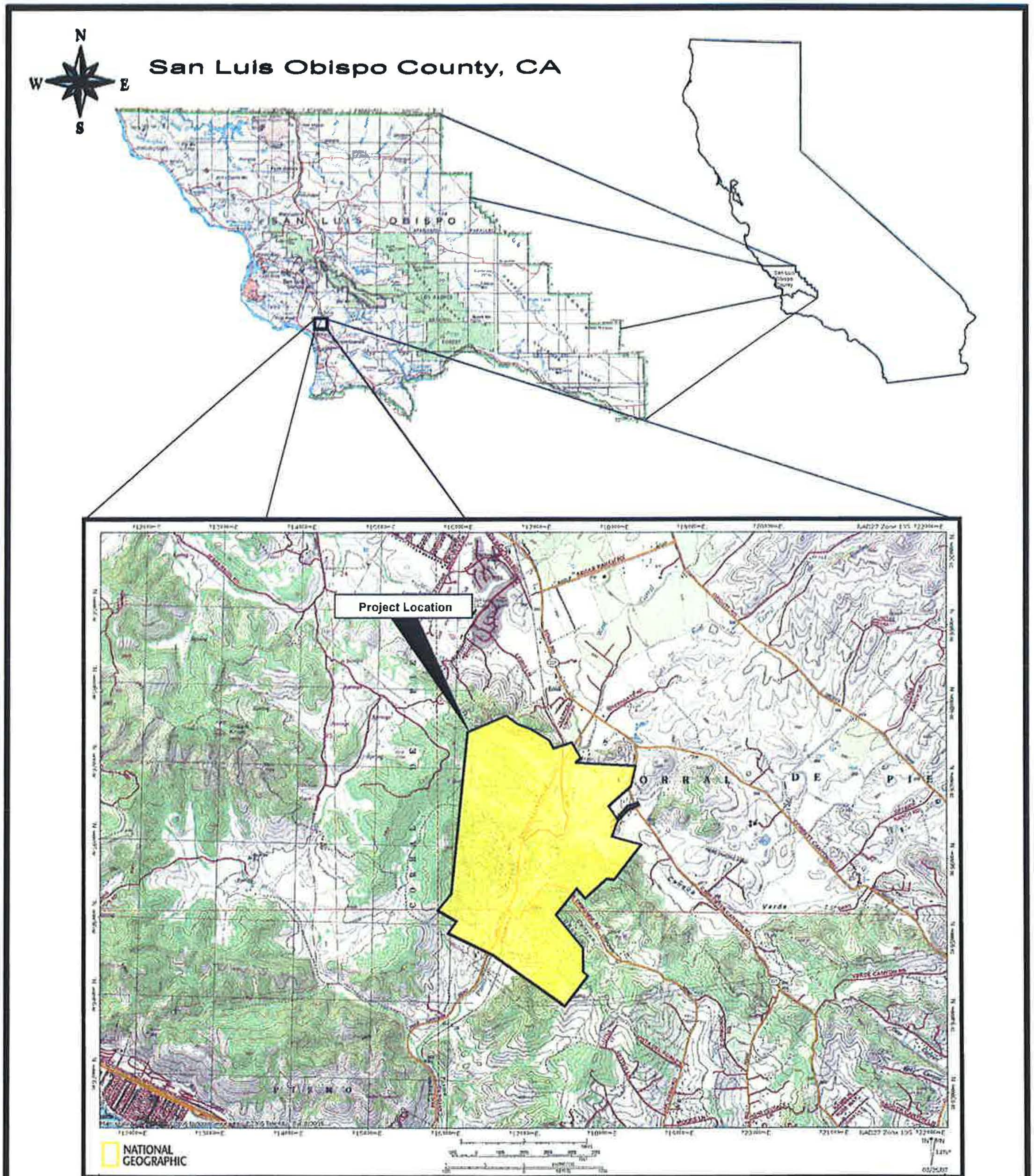
References

Entrix, Inc., 2006, *Sentry Well Groundwater Monitoring Installation and Initial Sampling, Arroyo Grande Oil Field 1821 Price Canyon Road, San Luis Obispo, California*, consulting report prepared by Entrix, Inc. for Plains Exploration & Production Company.

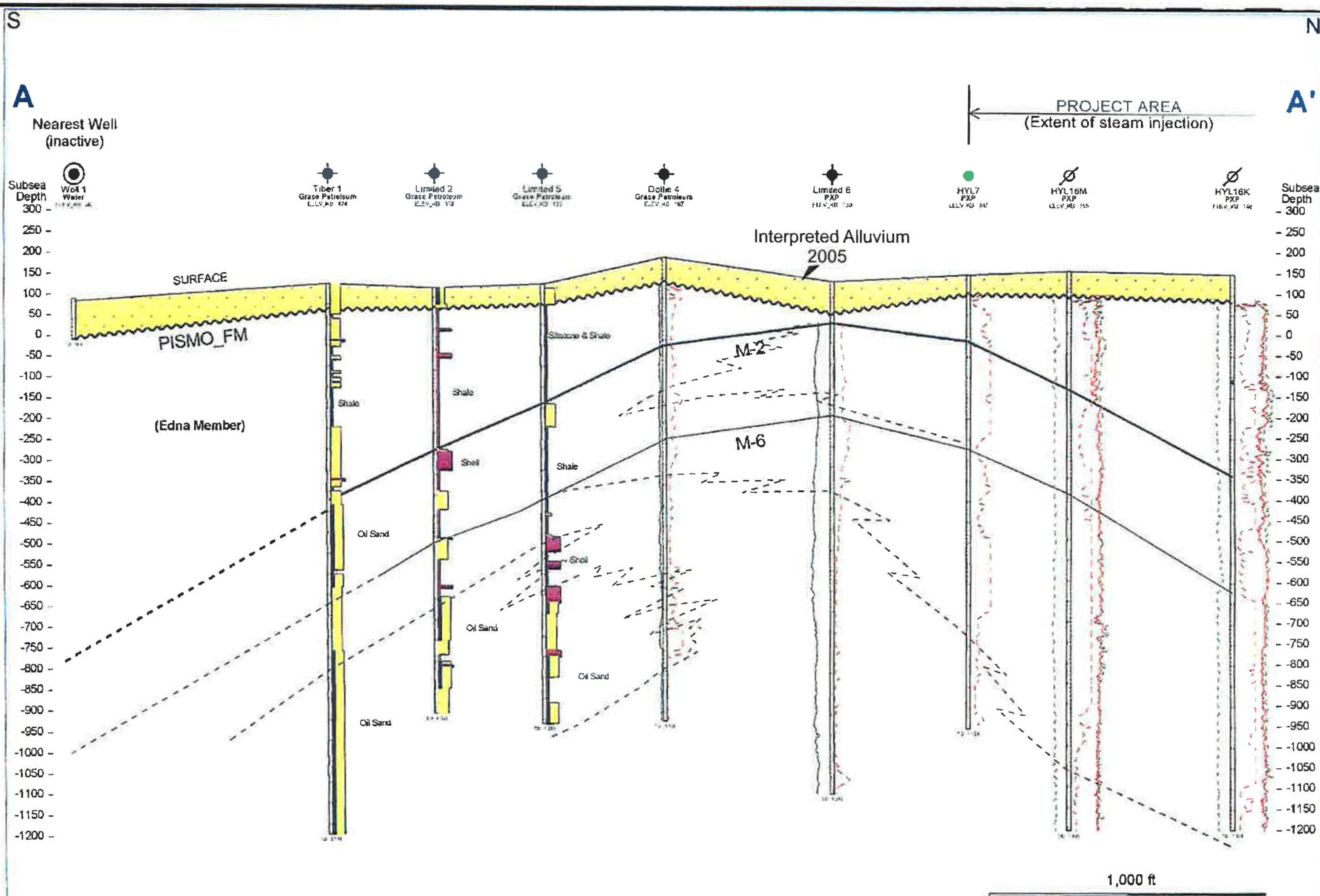
Hall, C.A., 1973, *Geology of the Arroyo Grande 15' Quadrangle, San Luis Obispo County, California*, California Division of Mines and Geology Arroyo Grande 15' Quadrangle map sheet 24.

Pacific Geotechnical Associates, Inc., 2005, *Analysis of Geological Separation of Price canyon Oil Development From the Fresh Water Aquifer, Price canyon, Arroyo Grande, San Luis Obispo County,* consulting report prepared for Plains Exploration & Production Company.

EXHIBITS



WZI INC. BAKERSFIELD, CALIFORNIA	
Plains Exploration & Production Co.	
Location Map	
DATE 2/07	1601000010	EXHIBIT 1

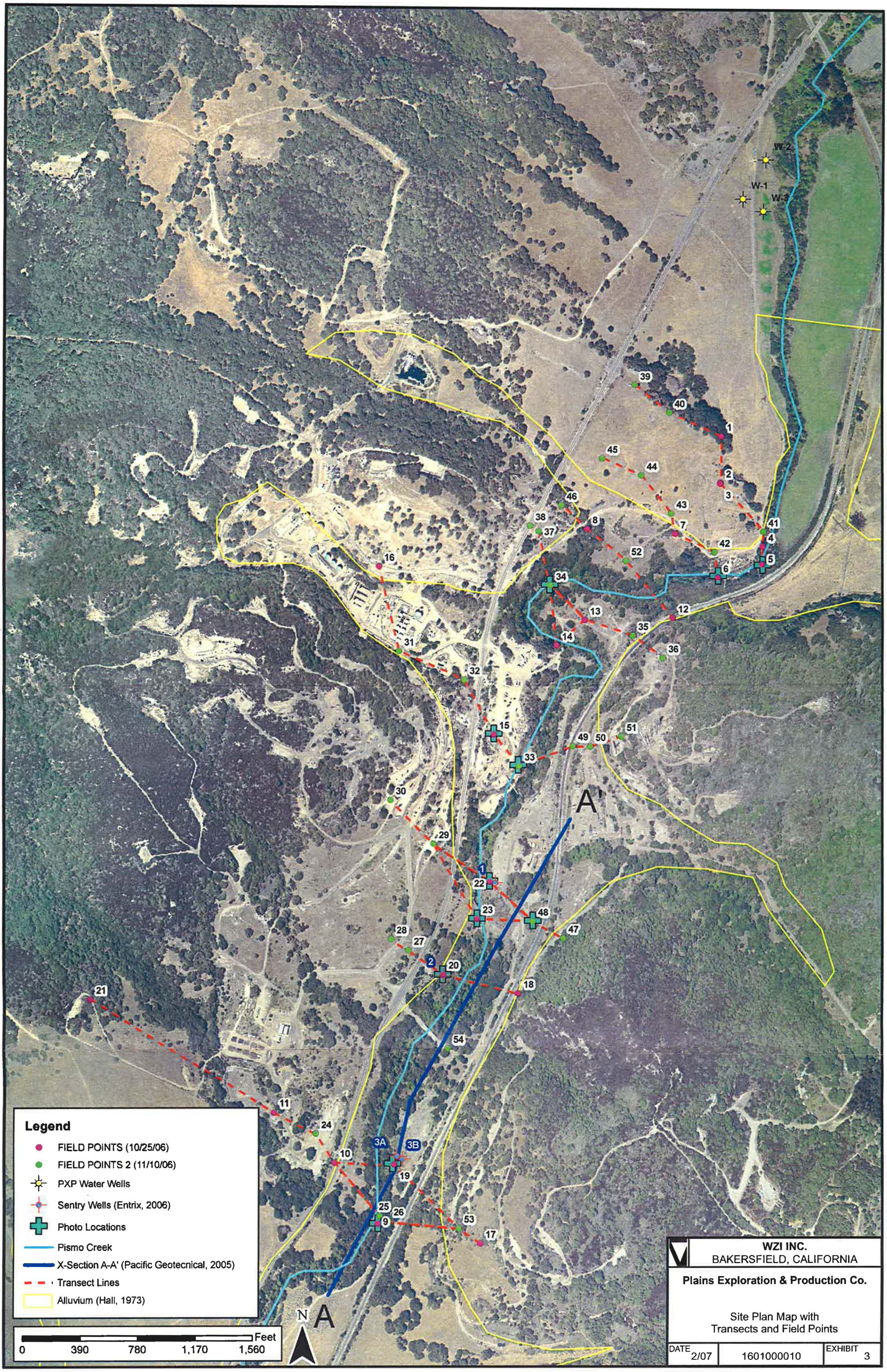


WZI INC.
BAKERSFIELD, CALIFORNIA

Plains Exploration & Production Co.

Cross Section A-A'
Pismo Creek Alluvium Interpretation
Pacific Geotechnical Associates 2005

DATE 2/07	1601000010	EXHIBIT 2


W-2
W-1
W-3
A'
A
N
Legend
FIELD POINTS (10/25/06)
FIELD POINTS 2 (11/10/06)
PXP Water Wells
Sentry Wells (Entrix, 2006)
Photo Locations
Pismo Creek
X-Section A-A' (Pacific Geotecnical, 2005)
Transect Lines
Alluvium (Hall, 1973)
Feet
0 390 780 1,170 1,560
WZI INC.
BAKERSFIELD, CALIFORNIA
Plains Exploration & Production Co.
Site Plan Map with
Transects and Field Points
DATE 2/07
1601000010
EXHIBIT 3

APPENDIX

Pismo Creek Photo Location #5

Appendix 1

Pismo Creek Photo Location #9

Appendix 1

Pismo Creek Photo Location #15

Poso Creek Photo Location #20

Appendix 1

Pismo Creek Photo Location #22

Appendix 1

Pismo Creek Photo Location #23

Pismo Creek Photo Location #33

Appendix 1

Pismo Creek Photo Location #34

Appendix 1

Pismo Creek Photo Location #48

Appendix 1

Pismo Creek Photo Location #6

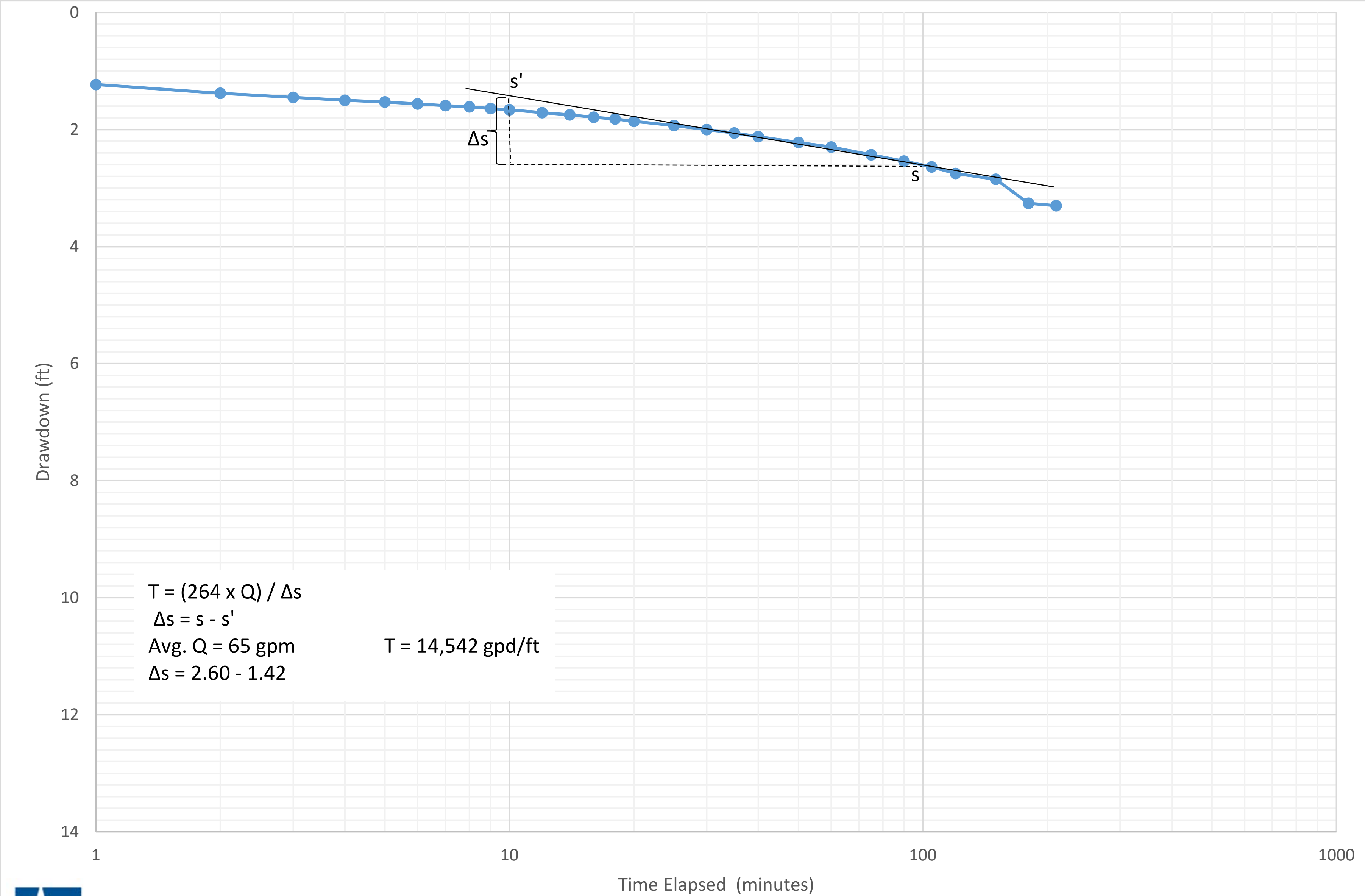
Appendix 1

Poso Creek Photo Location #19

Appendix 1

Appendix B

Aquifer Test Graphs



GSI Water Solutions, Inc.

Figure C1
Santa Maria Basin Fringe Areas
Arroyo Grande Biddle Domestic Well Constant Rate Test

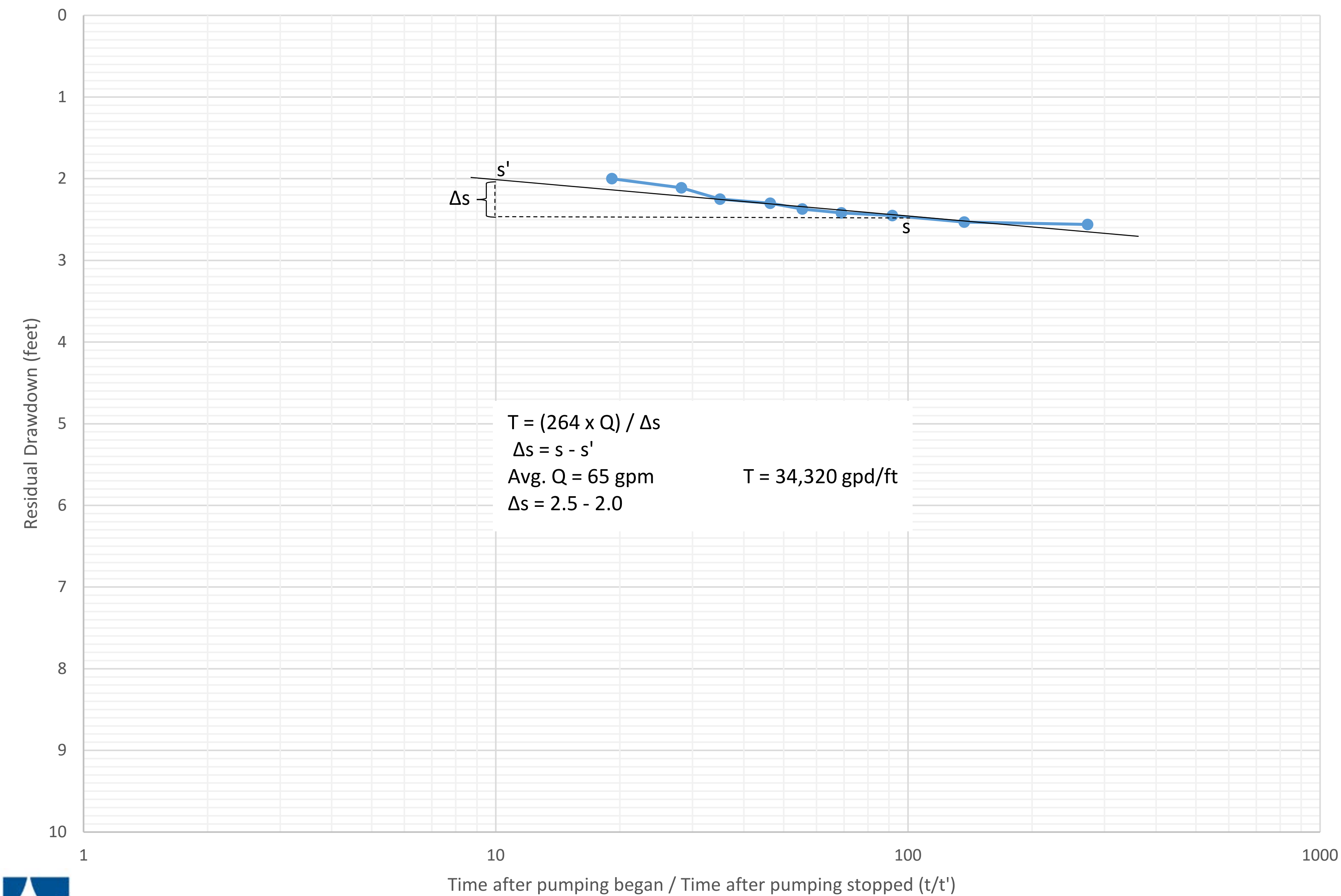


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Figure C2
Santa Maria Basin Fringe Areas
Arroyo Grande Biddle Domestic Well Recovery Test

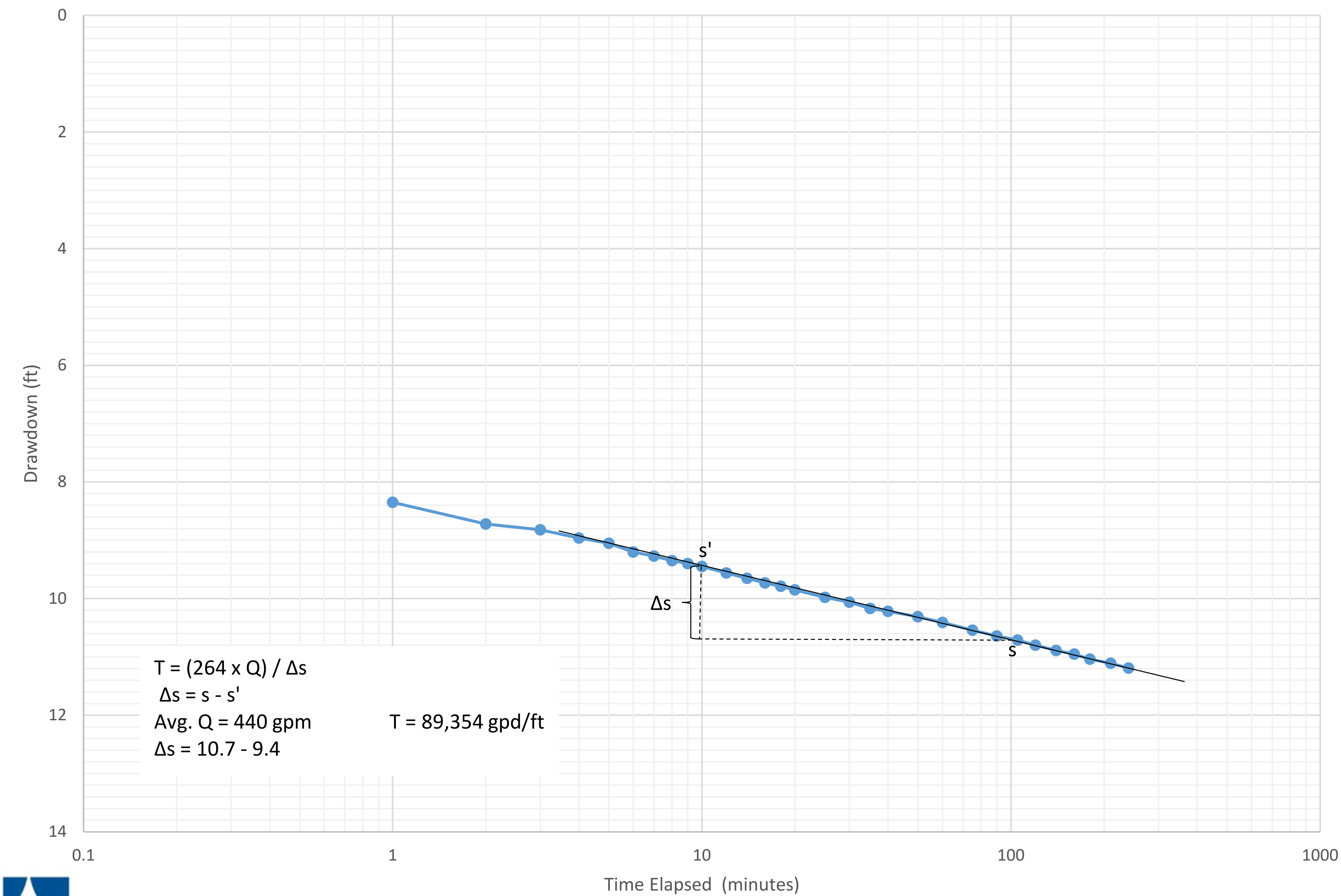

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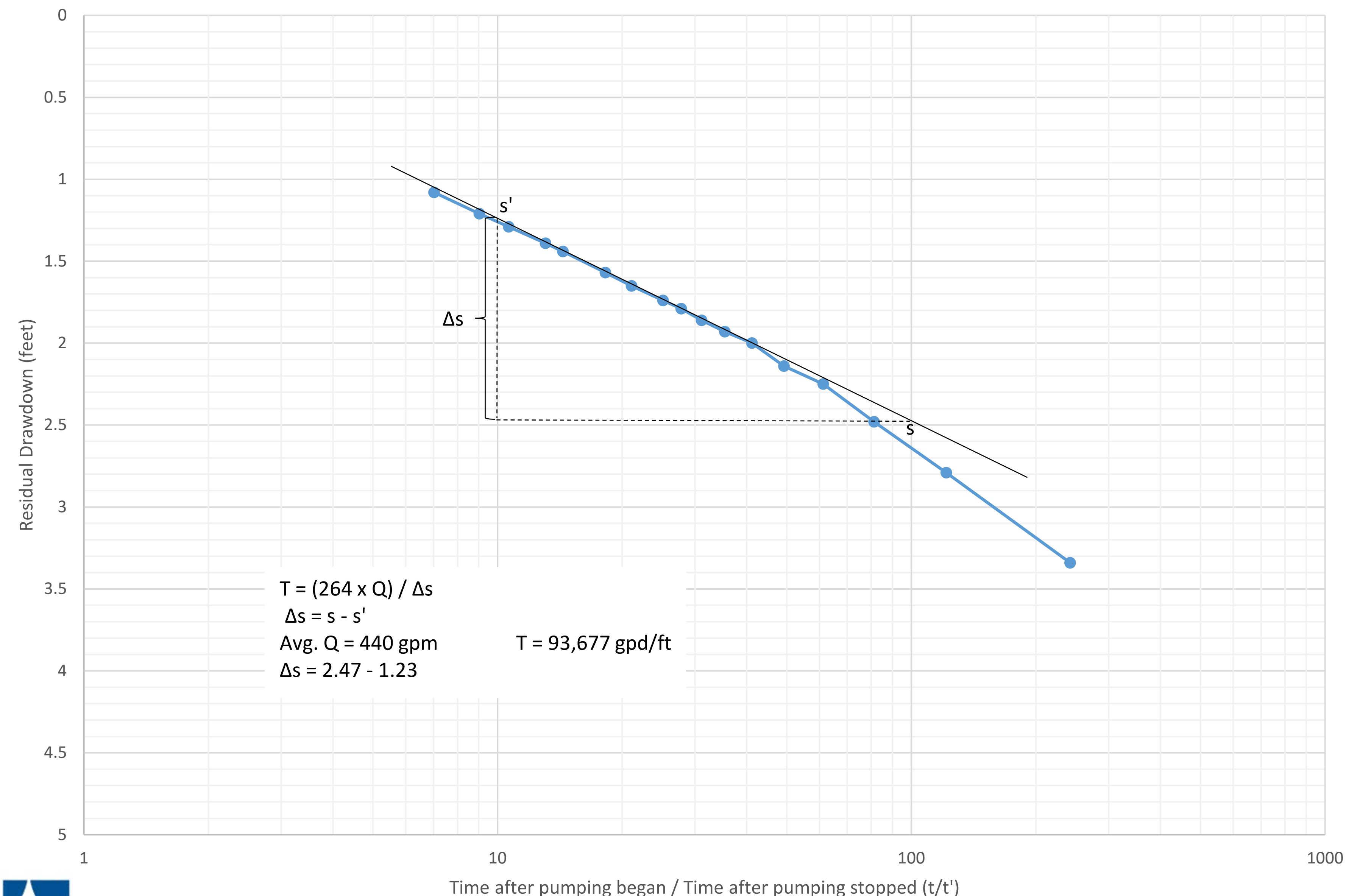
Figure C3
Santa Maria Basin Fringe Areas
Arroyo Grande Huasna Road Well Constant Rate Test



GSI Water Solutions, Inc.

Figure C4
Santa Maria Basin Fringe Areas
Arroyo Grande Huasna Road Well Recovery Test

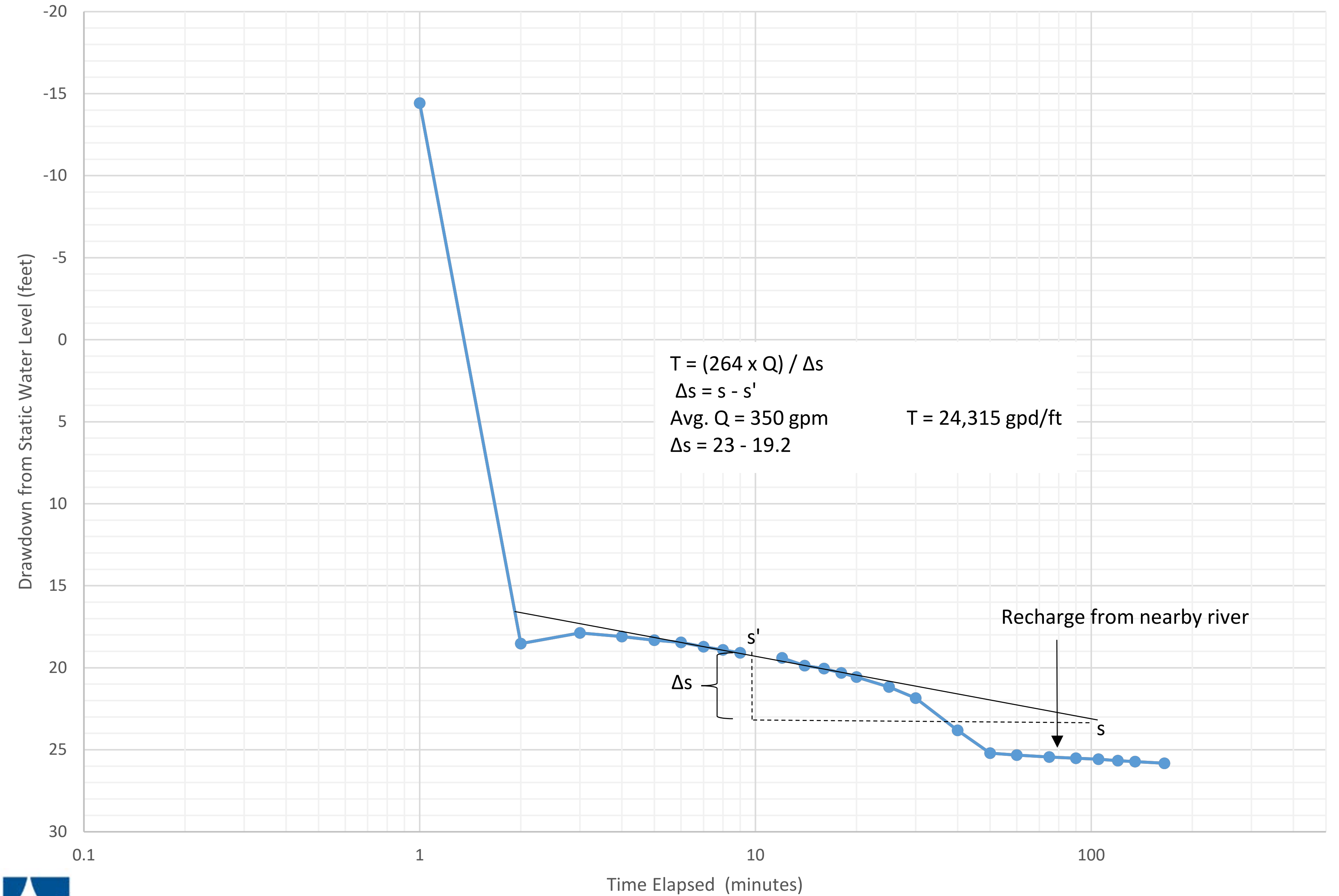
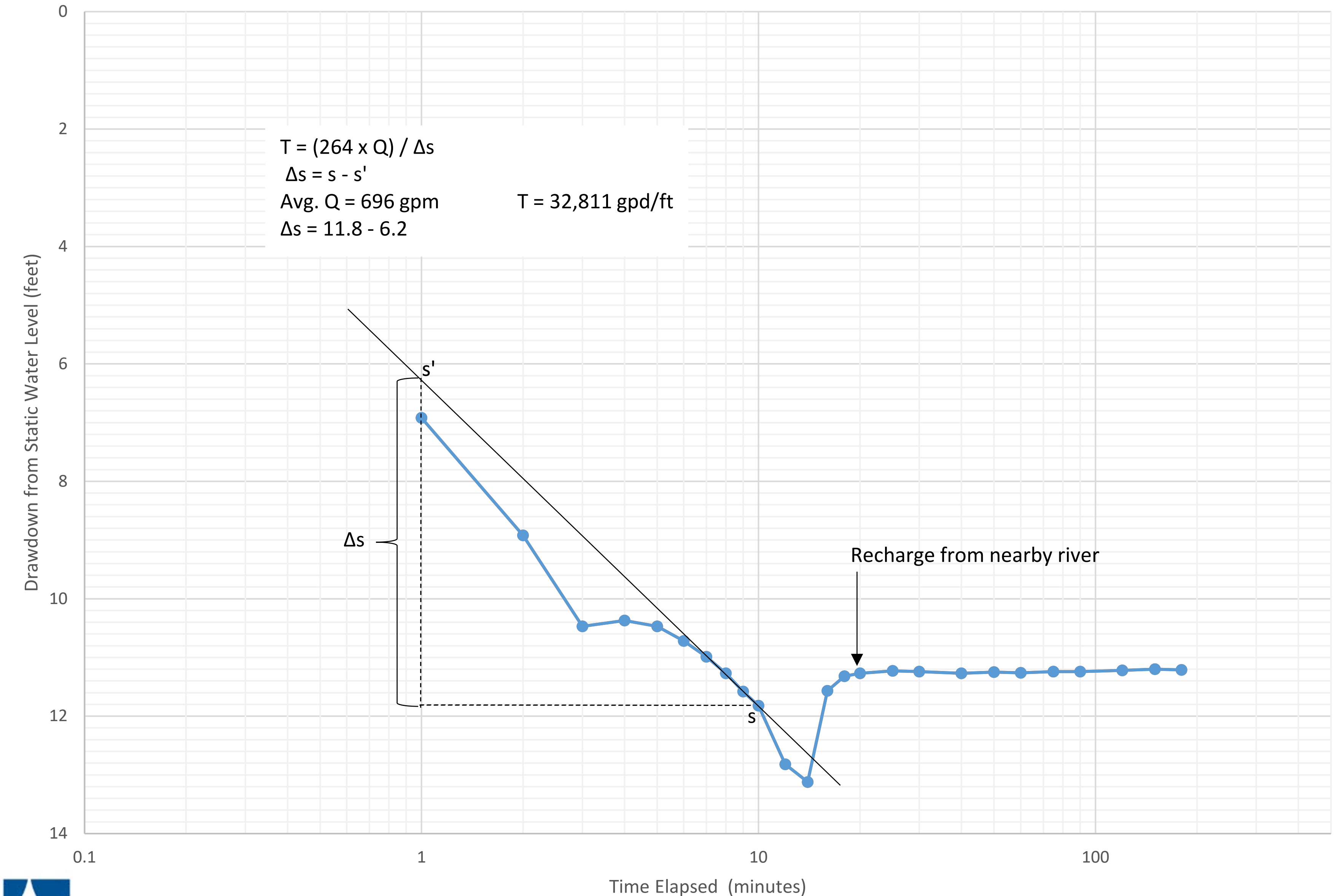


Figure C5
Santa Maria Basin Fringe Areas
Ziegler Canyon Tantara Well Constant Rate Test



GSI Water Solutions, Inc.

Figure C6
Santa Maria Basin Fringe Areas
Ziegler Canyon Well 1P Constant Rate Test

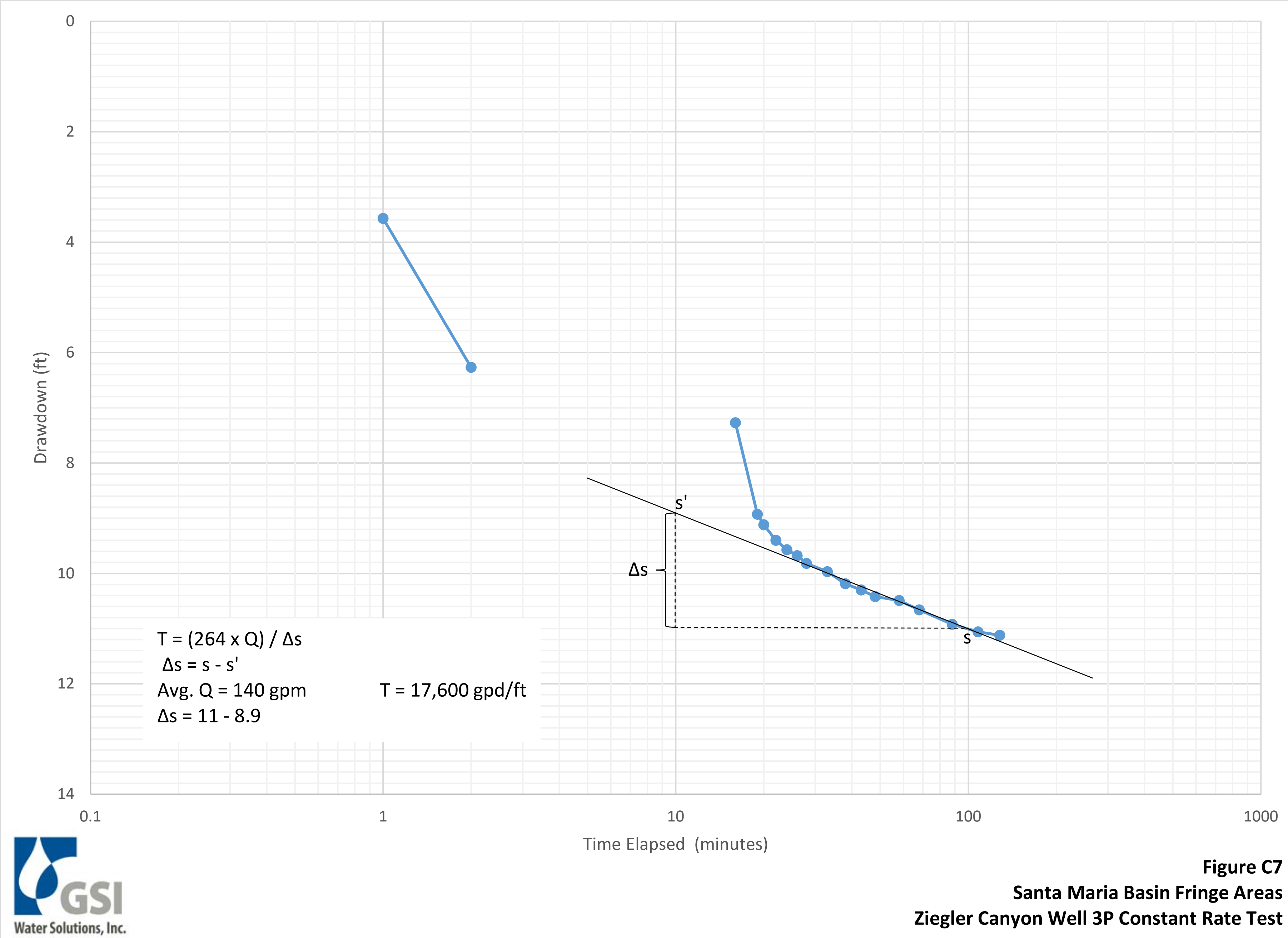
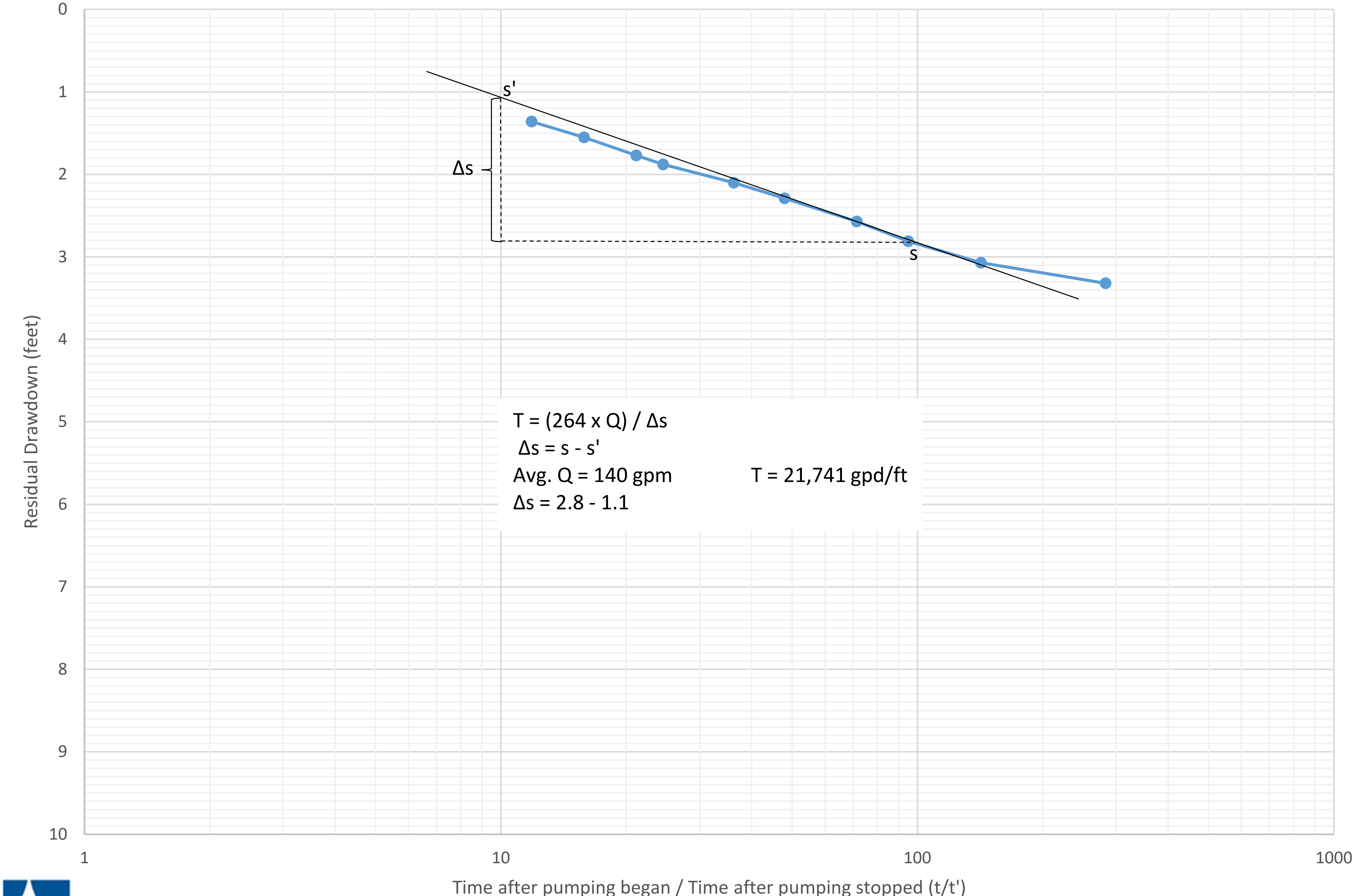


Figure C7
Santa Maria Basin Fringe Areas
Ziegler Canyon Well 3P Constant Rate Test



GSI Water Solutions, Inc.

Figure C8
SLO Basin Characterization
Ziegler Canyon Well 3P Recovery Test

Appendix C

Cuyama River Valley (Ziegler Canyon) Fringe Area Geophysics-
TDEM Technical Report

Intended for

San Luis Obispo County Flood Control and Water Conservation District

Document type

Technical Report

Date

December 2017

CUYAMA RIVER VALLEY FRINGE AREA GEOPHYSICS - TDEM

CUYAMA RIVER VALLEY FRINGE AREA GEOPHYSICS - TDEM

Revision	**1**
Date	**12/12/2017**
Made by	**Max Halkjaer, Peter Thomsen**
Checked by	**Joakim Westergaard**
Approved by	**Max Halkjaer**
Description	**Technical Report**
[Optional 1]	**Cuyama River Valley Fringe Area Geophysics - TDEM**

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https://projects.rambollgrp.com/projects/1100030175/Project Documents/20170926_Report_CuyanaRiver_TDEM.docx

CONTENTS

FIGURES

ANNEX

1. INTRODUCTION

This is a technical report describing a geophysical survey in the lower part of Cuyama River valley where it reaches the Santa Maria Valley groundwater basin.

The scope of work has been to develop insight in the hydrogeological connection between the side valley and the main basin. The geophysical method Time Domain Electromagnetics (TDEM) has been applied. It is a none invasive method, where soundings will show the variations in the resistivity of the geological layers.

The geophysical results will enter into other hydrogeological investigations to create fundamental knowledges about the hydraulic conditions and layer connectivity in the area.

1.1 Survey area

The survey area is located 8 miles southeast of Santa Maria at the lower part of Cuyama River. The area is dominated by vineyards. The location of the survey area is shown at Figure 1.

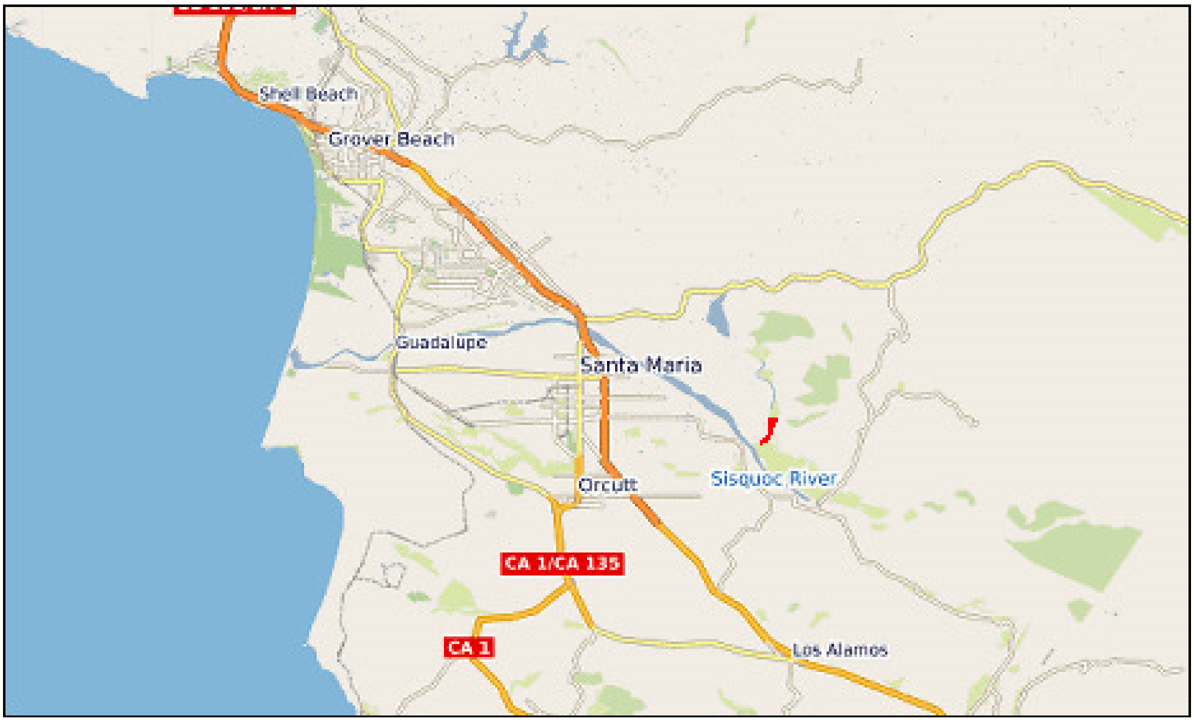


Figure 1 Survey area marked with red

2. METHOD AND INSTRUMENTATION

Time Domain Electromagnetics (TDEM) is a geophysical survey technique used frequently in groundwater exploration.

TDEM soundings yield insight in the resistivity (or the reciprocal, the conductivity) of the survey area. The resistivity can be related to the subsurface conditions, being lithology, saturation and ground water composition (i.e salinity). The measured values are presented in Ohm-m. In general dry and/or unsaturated lithology's (dry sand and gravel) will yield high resistivity values. As sediments becomes saturated the resistivity will decrease, these values will further decrease if the groundwater contains dissolved salts. Less permeable clays results in low resistivity values, silt will yield intermediate values.

When interpreting resistivity data it is important to include 'ground truth' data, because the measured values can reflect different combinations of lithology and groundwater quality. For example a sand layer saturated with brackish groundwater can show the same resistivity values as a clay layer saturated with fresh water.

The technique deployed at Cuyama River is a so-called 1D survey technique. Data is collected per station which can be seen as a single (1D) location; however the measured value will reflect a footprint and hence an average of a volume of soil.

2.1 Principles of TDEM

A direct current (DC) is build up in a transmitter loop. When the current is stable the current is abruptly turned off. The process of abruptly reducing the transmitter current to zero induces a short-duration voltage pulse in the ground, which creates current in the subsurface. The amplitude of the current flow as a function of time is measured by measuring its decaying magnetic field (the secondary magnetic field) using a receiver coil located at the centre of the transmitter loop.

2.2 Instrumentation

The survey at Cuyama River Valley Fringe was executed using a WalkTEM unit manufactured by Guideline Geo, Figure 2.


Figure 2 WalkTEM. The transmitter and the receiver is combined in one instrument that can be hand carried from site to site.

For the specific survey a single loop transmitter with a size of 40x40 m (ø2.5 mm^2) has been applied, Figure 3.

The receiver coil is a two turn wire in a 10x10m loop in the centre of the transmitter loop. The receiver coil has a low pass filter characteristic of 150 kHz.

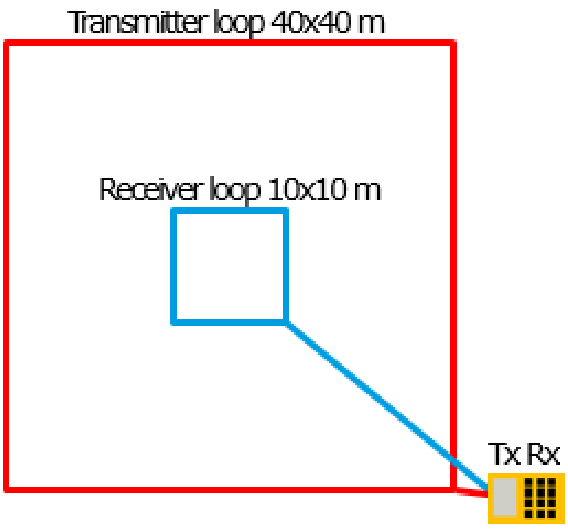


Figure 3 System setup for Cuyama River survey

Transmitter for low moment was approx. 1 Amp, and for high transmitter moment it was 7 Amp.

2.3 GPS positioning

Handheld GARMIN 62S. The G625 has accuracy in the range of +/-5m which is satisfactory when taking the footprint and the uncertainties for the TDEM system into account.

The GPS position is measured in the centre of the receiver/transmitter loop.

3. FIELD WORK

The field operation was carried out from the 25th to the 27th of September 2017. Field crew was Max Halkjær and Peter Thomsen from Ramboll. David O'Rourke from GSI Water Solutions was supervising and there was no problem with instrumentation or access during data acquisition.

Figure 4 Data acquisition

As the TDEM methods require a safe distance to powerlines, metal fence and other metal object it has been a challenge to locate site in the valley, especially due to the presents for vineyards in the area. The location of the 36 soundings are listed in Table 3.1 below (projection: NAD83 / California zone 5 (ftUS), EPSG: 2229). Note that there is no sounding no. 23.

Table 3.1 Position of the 36 TDEM from Cuyama River. NAD83 / California zone 5 (ftUS), EPSG: 2229

Sounding number	UTM - X	UTM - Y
01	5874601	2166039
02	5874570	2166205
03	5874635	2166306
04	5874544	2165940
05	5874508	2165807
06	5874459	2165694
07	5874407	2165572
08	5874373	2165462
09	5874078	2165283
10	5873961	2165191
11	5873818	2165073
12	5873714	2164973
13	5873512	2165134
14	5873672	2164854
15	5873370	2164925
16	5871425	2160087
17	5873629	2164718
18	5873341	2164739
19	5873371	2164606
20	5873348	2164469
21	5873363	2164318
22	5873502	2164261
24	5873478	2164121
25	5873446	2164011
26	5873387	2163936
27	5873425	2163714
28	5874136	2166453
29	5873307	2166547
30	5873212	2166430
31	5873116	2166280
32	5873052	2166119
33	5872749	2161098
34	5872852	2161191
35	5873093	2161727
36	5873031	2161619
37	5873108	2165190

At Figure 5 the location of the 36 TDEM are shown on an aerial photo. Many of the soundings are collected “side by side” with a distance between soundings at 40 meter.

Figure 5 Location of the 36 TDEM in Cuyama River. Note that No. 23 is missing.

4. PROCESSING AND INVERSION

4.1 Data flow

Data are uploaded from the WalkTEM unit to PC. Data are processed using the SPIA version 2.3.1 software packages from University of Aarhus. This software is specially designed for processing and inversion of TDEM-soundings.

Data are merged with GPS position. Data influenced by noise from man-made installations are cruelled. Finally the data are filtered and averaged. For the TDEM at Cuyama River the S/N level is relatively high and data are of general high quality.

Inversion is performed by applying a multilayer approach (smooth), using 30 layers model with fixed layer boundaries. In the inversion scheme, the thickness of each layer is constant and only resistivity can vary within each layer. The result is a smooth transition from layer to layer. This type of inversion is unbiased as the inversion scheme starts out with a homogenous half space. The initial resistivity is 50 ohmmeter for all layers as a starting model.

All data curves and inversion results are attached as Annex1.

5. RESULTS

The inverted models are presented as model sections and as mean resistivity in depth intervals.

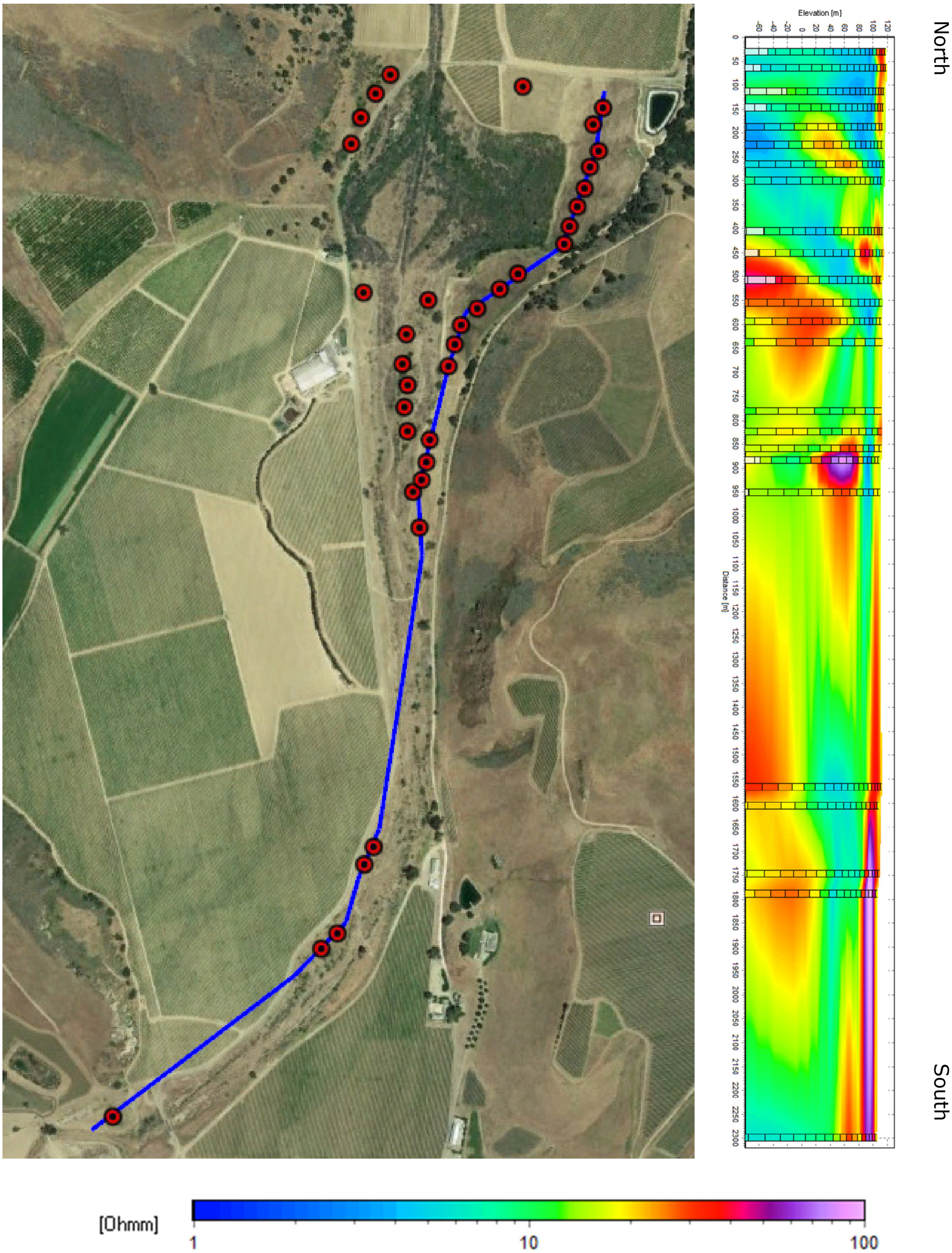


Figure 6 Model section 1

At Figure 6 a cross section from north to south is presented. From north and 600 m south dipping layers with varying resistivity can be identified. Layers are dipping towards north and have alternating low and high resistivity. From around 600 m the resistivity indicates more layered geology and from the sounding at 1550 m a top high resistive layer with a thickness at around 10 m is determined.

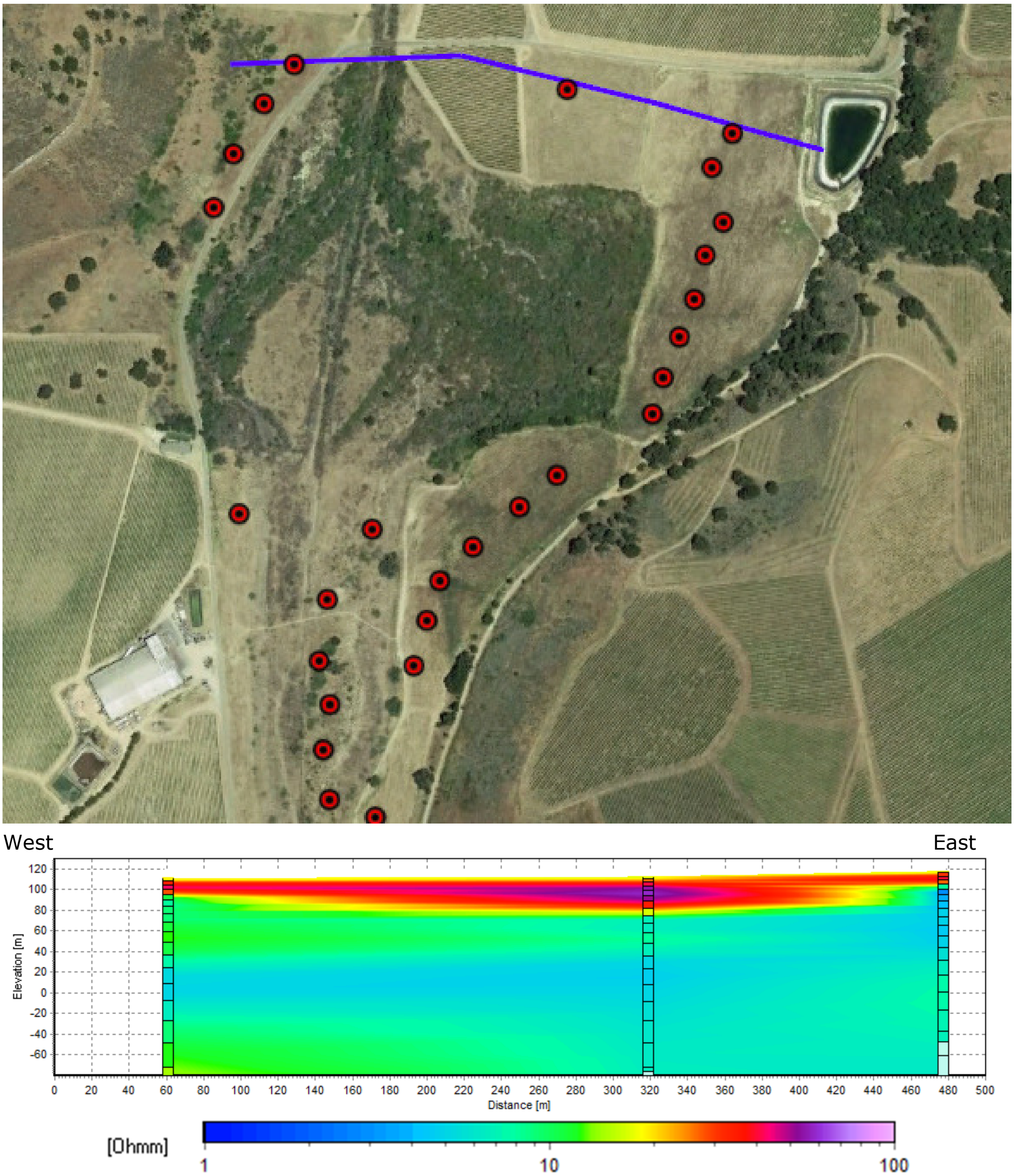


Figure 7 Model section 2

Model section 2, Figure 7 is located in the northern part of the area and is orientated from west to east. There are only three TDEM sounding shown on the section, indicating a top high resistive and high permeable layer, with a thickness at around 10 m to 20 m. Below this layer the resistivity drops to around, or below 10 ohm-m indicating less permeable sediments.

At Figure 8 model section 3 is shown from north to south. As for section 2 a high resistive layer can be seen in the upper 10 m to 20 m. In the lower part it seems like layers are dipping towards north, in accordance to what was mapped along model section 1.

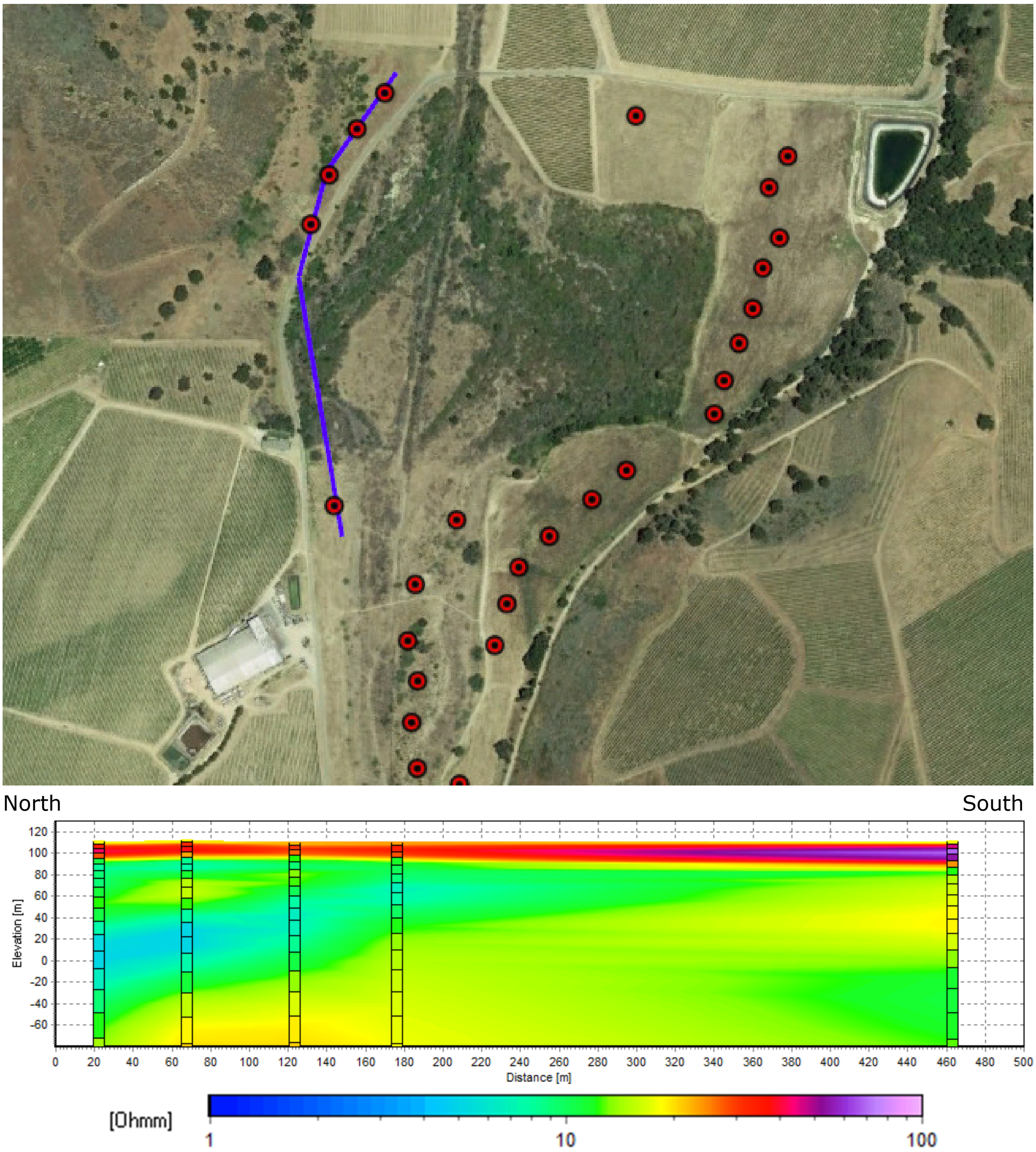


Figure 8 Model section 3

Model section 4, Figure 9, is also presented from north to south. At this section the top resistive layer is less than 10 m thick, decreasing in resistivity towards south. Towards north dipping layers can be seen in the northern half of the section, while the southern half is characterized with more horizontal layers.

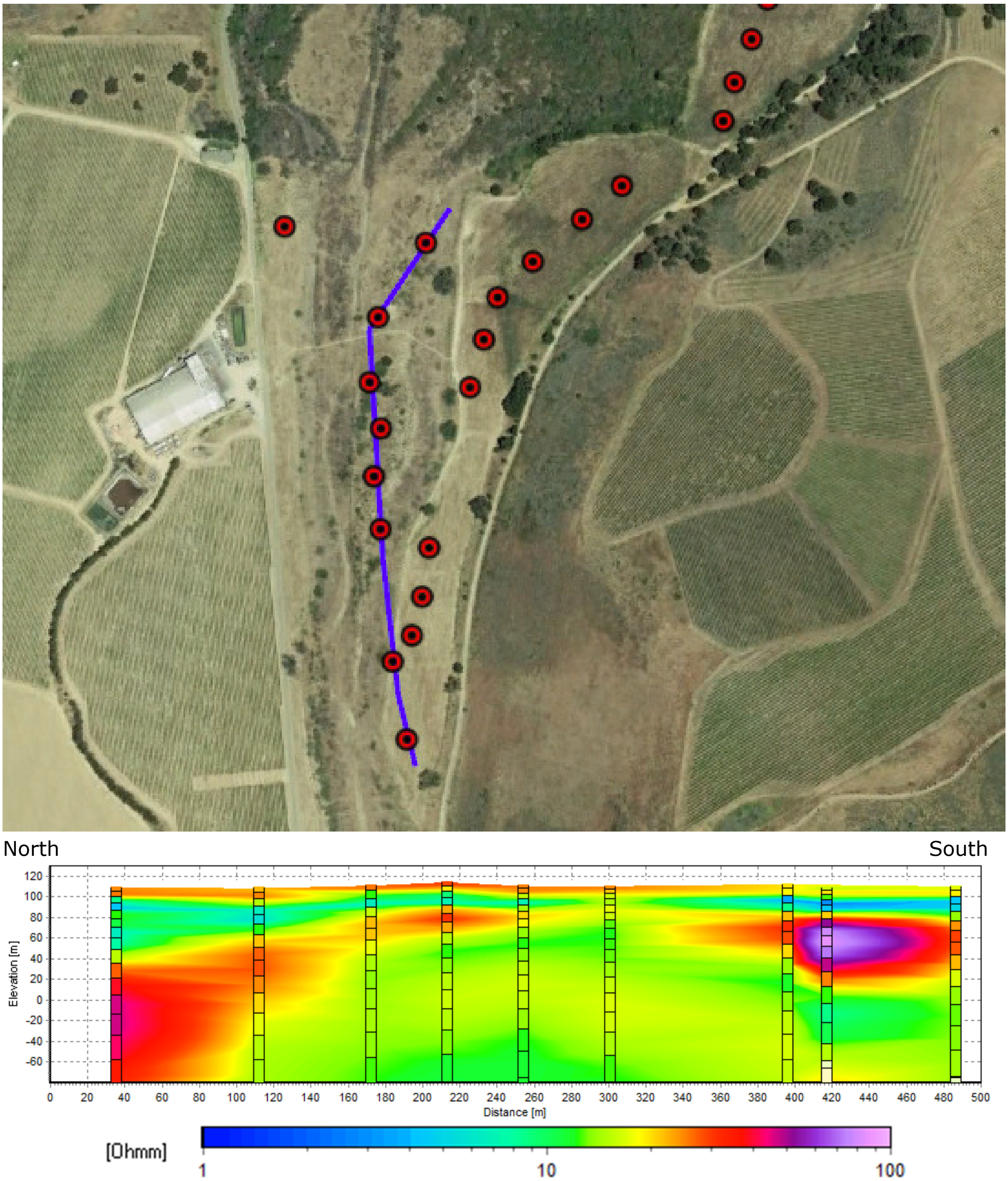


Figure 9 Model section 4

At Figure 10 a short cross section from west to east is shown. At this section the top high resistive layer is interpreted, especially in the western part of the section. In the central and for the most eastern sounding a high resistive layer is identified below a layer with resistivity at around 10 oh-m. This layer is assumed to have a high hydraulic conductivity.

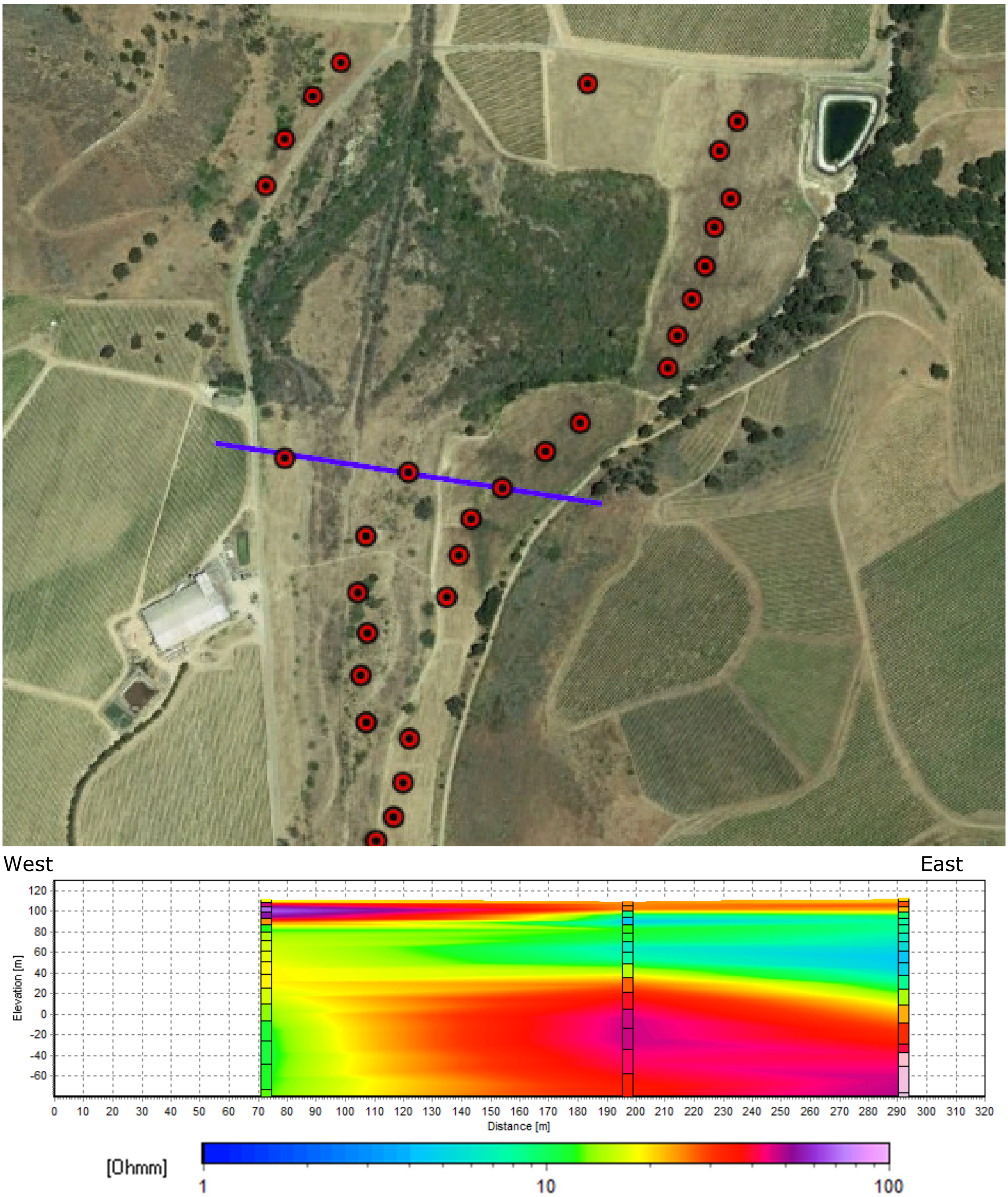


Figure 10 Model section 5

At Annex 2.01 and 2.02 the mean resistivity in depth intervals with a thickness of 10 m is shown. From Annex 1.01 the high resistive top layer is identified as soundings with high resistivity in the depth interval from 0 to 10 m. From depth 10 to 20 m, only a few sounding still have high resistivity especially in the southern part of the area (South part of section 1, Figure 6). From depth 30 m, some of the soundings are interpreted with high resistivity, indicating layers with higher hydraulic conductivity in depth.

The mean resistivity maps generally show large variations within short distances. This clearly indicates that the geology is highly variating from more or less impermeable layers to layers with higher hydraulic conductivity.

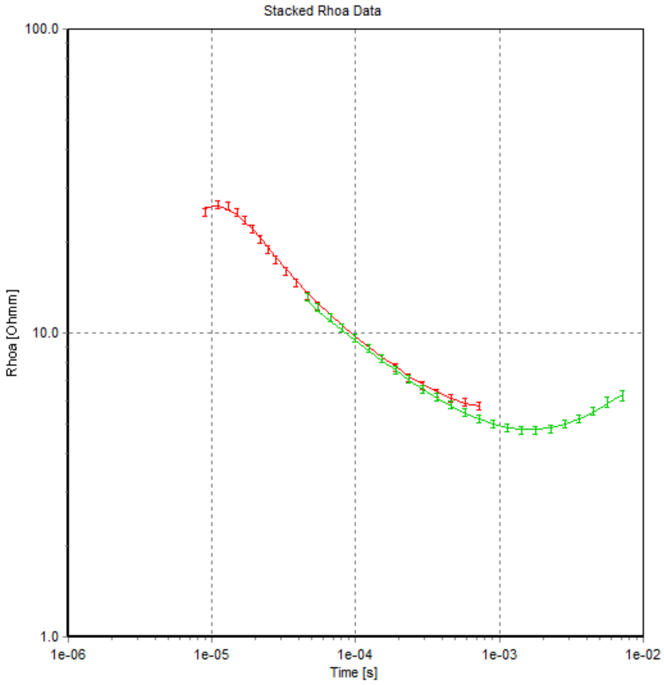
6. CONCLUSION

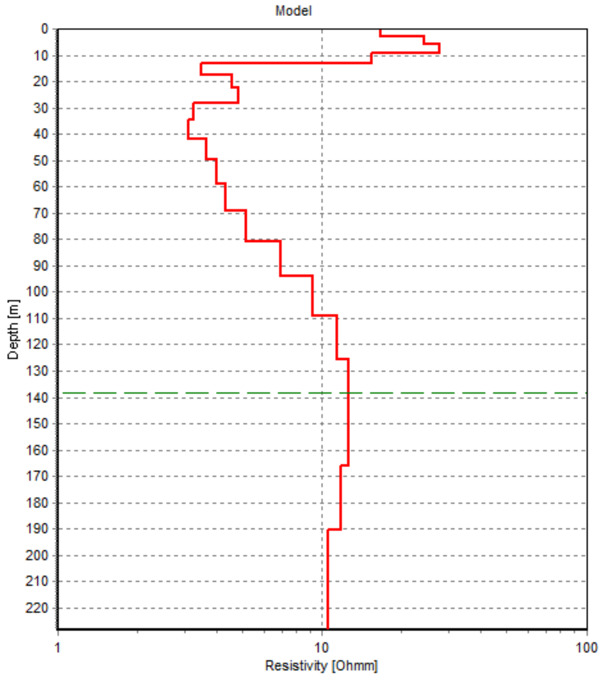
Based on the collected TDEM data a general understanding of a varying geology in the area is obtained. Result may indicate that there is a barrier between the upper part of that Cuyama River Valley Fringe and the Santa Maria Valley groundwater basin. By combining the TDEM results with borehole information it will be possible to obtain a more integrated interpretation of the hydrogeological settings.

Station 01

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5874601
UTMY:	2166039
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.5
No. of Layers:	20
DOI:	138m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	16.7	1.30	2.72	1.001	2.72	1.001
2	24.1	1.42	3.07	1.001	5.79	1.001
3	27.7	1.47	3.47	1.001	9.26	1.001
4	15.4	1.37	3.91	1.001	13.2	1.000
5	3.48	1.13	4.42	1.001	17.6	1.000
6	4.57	1.24	4.99	1.001	22.6	1.000
7	4.8	1.32	5.63	1.001	28.2	1.000
8	3.27	1.28	6.36	1.001	34.6	1.000
9	3.12	1.31	7.18	1.001	41.7	1.000
10	3.65	1.38	8.1	1.001	49.8	1.000
11	4	1.42	9.15	1.001	59	1.000
12	4.3	1.44	10.3	1.001	69.3	1.000
13	5.18	1.48	11.7	1.001	81	1.000
14	6.92	1.55	13.2	1.001	94.2	1.000
15	9.24	1.62	14.9	1.001	109	1.000
16	11.4	1.67	16.8	1.001	126	1.000
17	12.6	1.72	19	1.001	145	1.000
18	12.6	1.83	21.4	1.001	166	1.000
19	11.7	2.05	24.1	1.001	190	1.000
20	10.5	2.46				

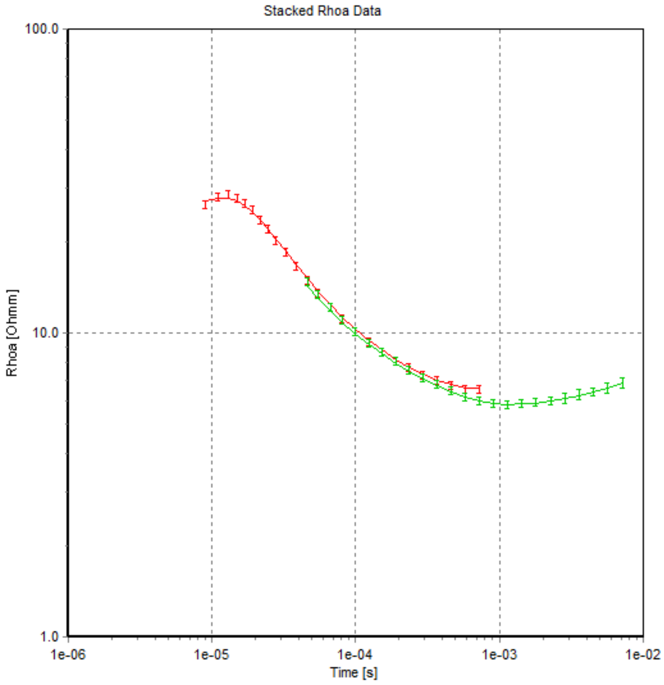


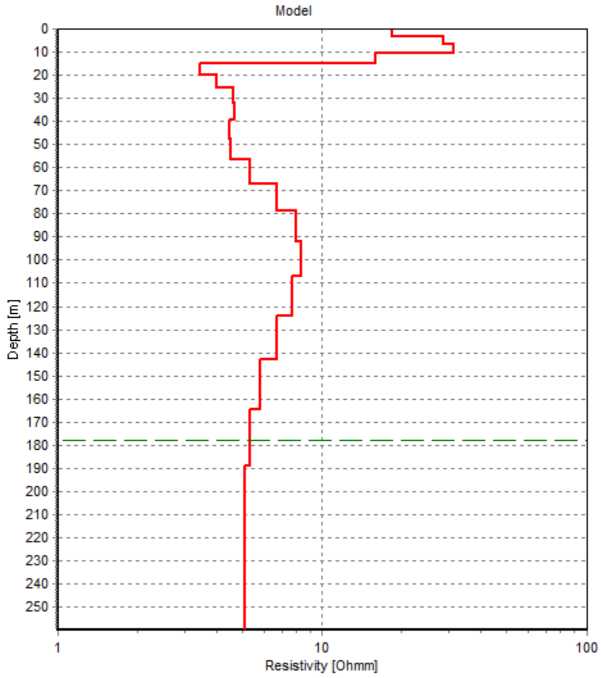


Station 02

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5874570
UTMY: 2166205
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.4
No. of Layers: 20
DOI: 178m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	18.3	1.29	3.1	1.001	3.1	1.001
2	28.5	1.41	3.49	1.001	6.59	1.001
3	31.4	1.44	3.95	1.001	10.5	1.001
4	15.9	1.35	4.45	1.001	15	1.000
5	3.46	1.11	5.03	1.001	20	1.000
6	4	1.20	5.68	1.001	25.7	1.000
7	4.62	1.30	6.41	1.001	32.1	1.000
8	4.65	1.34	7.24	1.001	39.3	1.000
9	4.45	1.36	8.17	1.001	47.5	1.000
10	4.49	1.38	9.23	1.001	56.7	1.000
11	5.34	1.44	10.4	1.001	67.2	1.000
12	6.75	1.51	11.8	1.001	78.9	1.000
13	7.94	1.56	13.3	1.001	92.2	1.000
14	8.28	1.59	15	1.001	107	1.000
15	7.72	1.58	16.9	1.001	124	1.000
16	6.74	1.55	19.1	1.001	143	1.000
17	5.85	1.58	21.6	1.001	165	1.000
18	5.3	1.77	24.4	1.001	189	1.000
19	5.09	2.23	27.5	1.001	217	1.000
20	5.12	2.98				

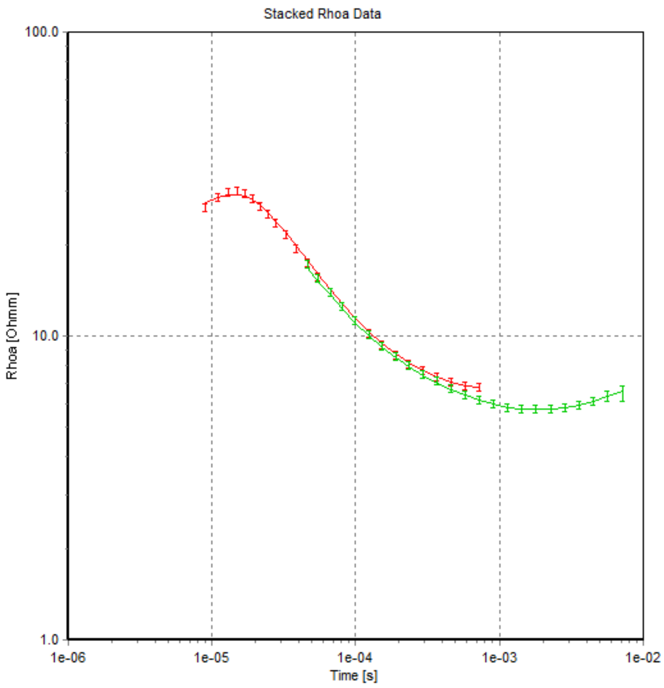


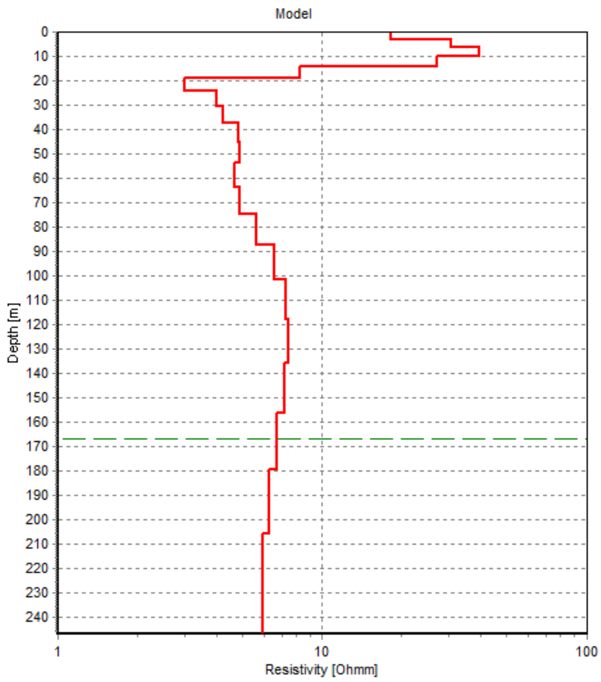


Station 03

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5874635
UTMY: 2166306
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.4
No. of Layers: 20
DOI: 167m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	18.2	1.26	2.94	1.001	2.94	1.001
2	30.8	1.47	3.32	1.001	6.26	1.001
3	39.4	1.54	3.75	1.001	10	1.001
4	27	1.43	4.23	1.001	14.2	1.000
5	8.22	1.24	4.78	1.001	19	1.000
6	3.03	1.12	5.4	1.001	24.4	1.000
7	3.97	1.24	6.09	1.001	30.5	1.000
8	4.2	1.30	6.88	1.001	37.4	1.000
9	4.83	1.36	7.77	1.001	45.2	1.000
10	4.88	1.39	8.77	1.001	53.9	1.000
11	4.64	1.41	9.9	1.001	63.8	1.000
12	4.86	1.44	11.2	1.001	75	1.000
13	5.64	1.48	12.6	1.001	87.6	1.000
14	6.6	1.53	14.3	1.001	102	1.000
15	7.28	1.57	16.1	1.001	118	1.000
16	7.47	1.58	18.2	1.001	136	1.000
17	7.22	1.63	20.5	1.001	157	1.000
18	6.75	1.82	23.1	1.001	180	1.000
19	6.29	2.23	26.1	1.001	206	1.000
20	5.97	2.92				

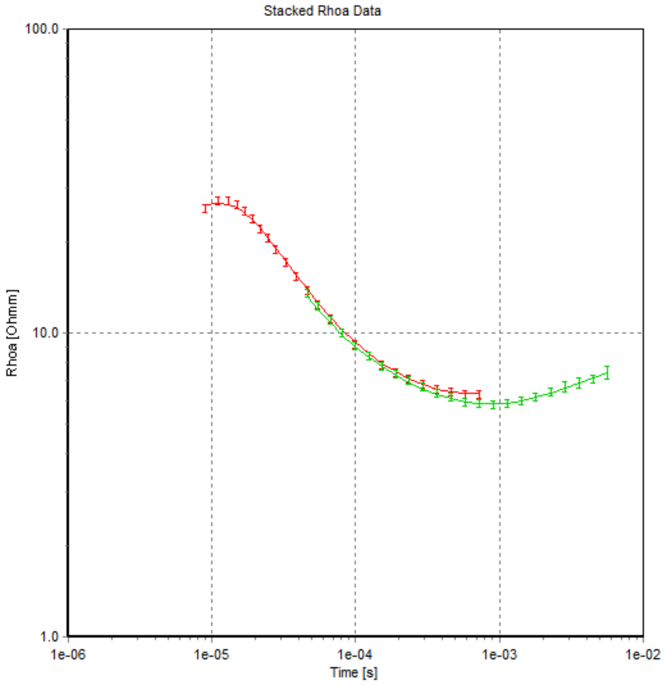


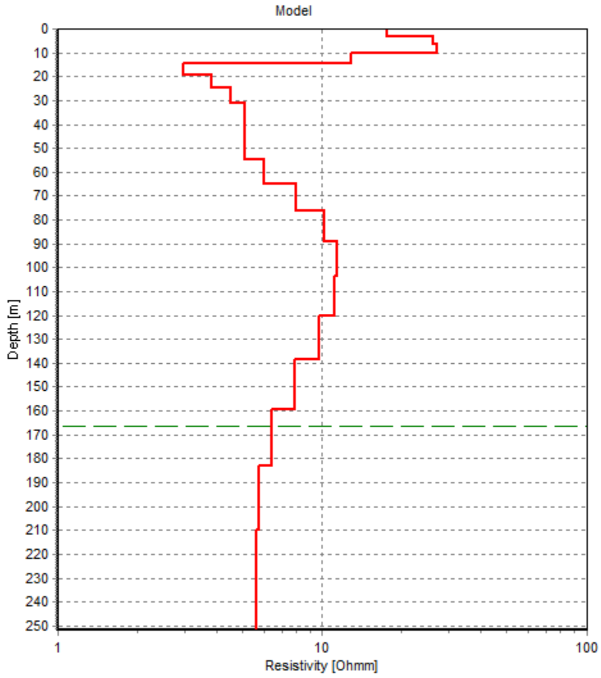


Station 04

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5874544
UTMY: 2165940
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.4
No. of Layers: 20
DOI: 166m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	17.6	1.30	3	1.001	3	1.001
2	26.1	1.40	3.38	1.001	6.38	1.001
3	27.1	1.43	3.82	1.001	10.2	1.001
4	12.8	1.32	4.31	1.001	14.5	1.000
5	2.98	1.11	4.87	1.001	19.4	1.000
6	3.8	1.21	5.5	1.001	24.9	1.000
7	4.51	1.32	6.21	1.001	31.1	1.000
8	5.11	1.37	7.01	1.001	38.1	1.000
9	5.11	1.38	7.91	1.001	46	1.000
10	5.07	1.40	8.93	1.001	55	1.000
11	6.03	1.46	10.1	1.001	65	1.000
12	7.99	1.54	11.4	1.001	76.4	1.000
13	10.1	1.61	12.9	1.001	89.3	1.000
14	11.4	1.64	14.5	1.001	104	1.000
15	11.2	1.64	16.4	1.001	120	1.000
16	9.71	1.61	18.5	1.001	139	1.000
17	7.88	1.62	20.9	1.001	160	1.000
18	6.45	1.80	23.6	1.001	183	1.000
19	5.74	2.26	26.6	1.001	210	1.000
20	5.62	3.01				

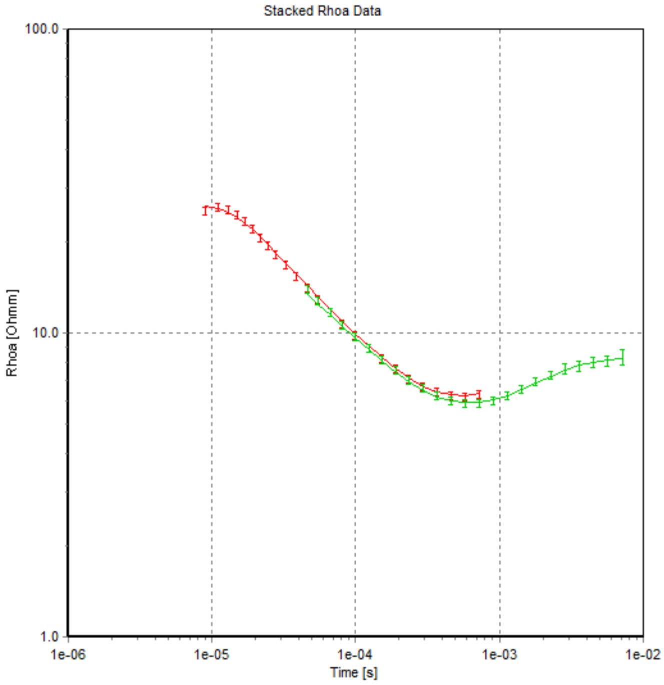


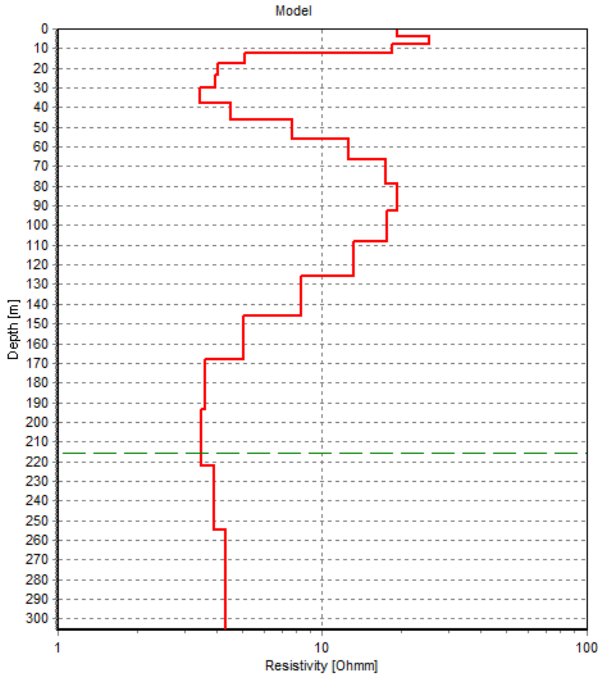


Station 05

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5874508
UTMY: 2165807
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.4
No. of Layers: 20
DOI: 216m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	19.1	1.21	3.64	1.001	3.64	1.001
2	25.3	1.41	4.11	1.001	7.75	1.001
3	18.4	1.35	4.64	1.001	12.4	1.001
4	5.09	1.14	5.24	1.001	17.6	1.000
5	4.04	1.17	5.91	1.001	23.5	1.000
6	3.93	1.24	6.68	1.001	30.2	1.000
7	3.43	1.26	7.54	1.001	37.8	1.000
8	4.5	1.34	8.51	1.001	46.3	1.000
9	7.66	1.46	9.61	1.001	55.9	1.000
10	12.6	1.57	10.9	1.001	66.7	1.000
11	17.3	1.67	12.3	1.001	79	1.000
12	19.3	1.74	13.8	1.001	92.8	1.000
13	17.5	1.76	15.6	1.001	108	1.000
14	13.1	1.73	17.6	1.001	126	1.000
15	8.35	1.67	19.9	1.001	146	1.000
16	5.05	1.61	22.5	1.001	168	1.000
17	3.59	1.68	25.4	1.001	194	1.000
18	3.47	2.05	28.6	1.001	222	1.000
19	3.91	2.78	32.3	1.001	255	1.000
20	4.33	3.78				

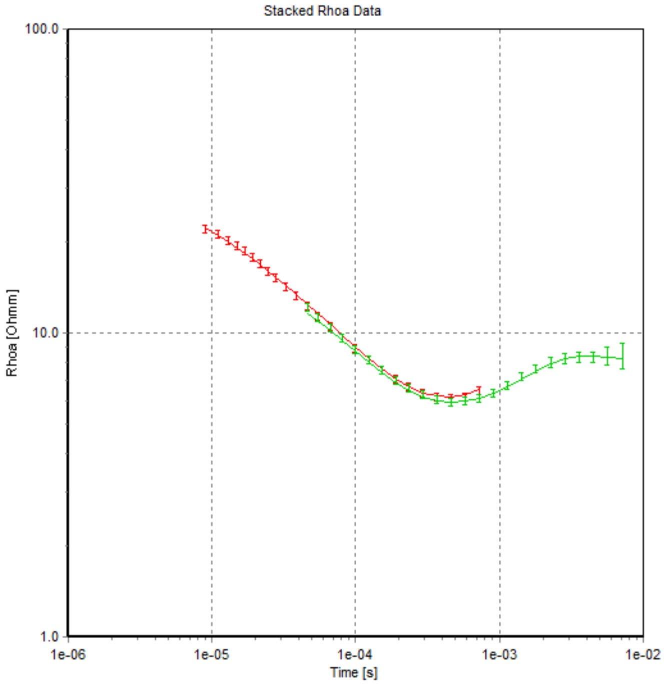


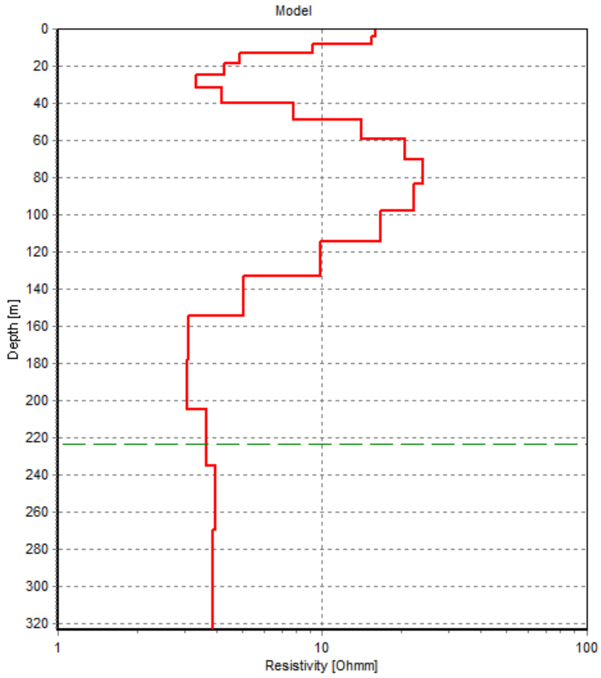


Station 06

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5874459
UTMY:	2165694
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.4
No. of Layers:	20
DOI:	224m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	15.9	1.22	3.85	1.001	3.85	1.001
2	15.4	1.30	4.35	1.001	8.2	1.001
3	9.17	1.25	4.91	1.001	13.1	1.001
4	4.87	1.16	5.54	1.001	18.7	1.000
5	4.26	1.21	6.26	1.001	24.9	1.000
6	3.32	1.24	7.07	1.001	32	1.000
7	4.16	1.30	7.98	1.001	40	1.000
8	7.78	1.43	9.01	1.001	49	1.000
9	14	1.58	10.2	1.001	59.1	1.000
10	20.5	1.71	11.5	1.001	70.6	1.000
11	24	1.79	13	1.001	83.6	1.000
12	22.3	1.82	14.6	1.001	98.2	1.000
13	16.5	1.80	16.5	1.001	115	1.000
14	9.78	1.76	18.6	1.001	133	1.000
15	5.05	1.73	21	1.001	154	1.000
16	3.11	1.82	23.8	1.001	178	1.000
17	3.08	2.23	26.8	1.001	205	1.000
18	3.65	3.09	30.3	1.001	235	1.000
19	3.93	4.27	34.2	1.001	270	1.000
20	3.86	5.44				

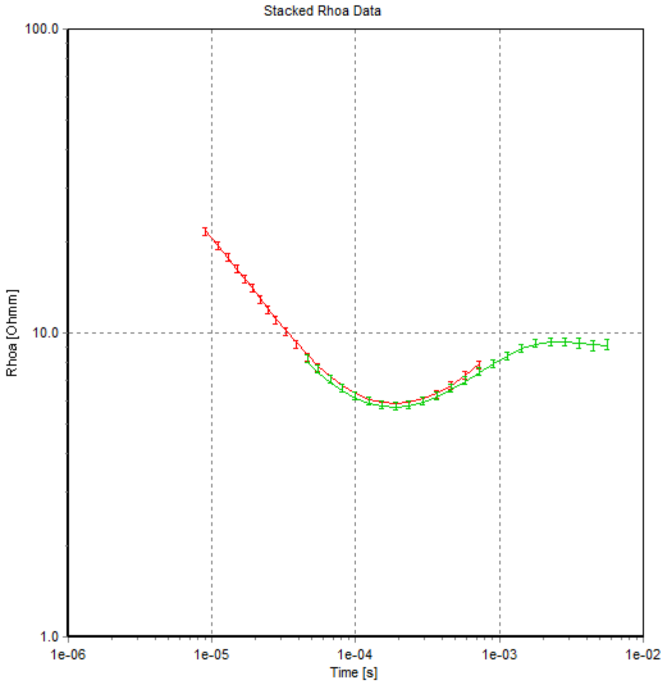


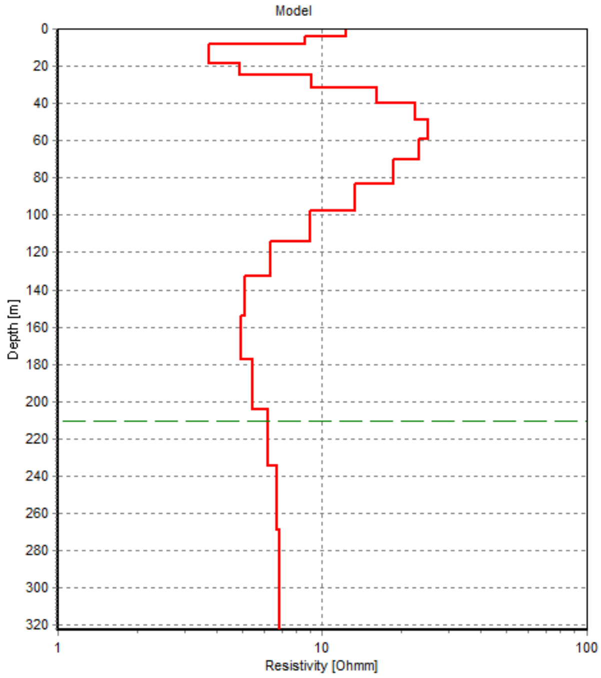


Station 07

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5874407
UTMY: 2165572
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.4
No. of Layers: 20
DOI: 211m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	12.3	1.14	3.84	1.001	3.84	1.001
2	8.57	1.23	4.34	1.001	8.18	1.001
3	3.73	1.13	4.9	1.001	13.1	1.001
4	3.75	1.19	5.53	1.001	18.6	1.000
5	4.87	1.28	6.24	1.001	24.8	1.000
6	9.13	1.42	7.05	1.001	31.9	1.000
7	16	1.54	7.96	1.001	39.9	1.000
8	22.4	1.63	8.98	1.001	48.8	1.000
9	25	1.68	10.1	1.001	59	1.000
10	23.2	1.68	11.4	1.001	70.4	1.000
11	18.5	1.65	12.9	1.001	83.4	1.000
12	13.2	1.60	14.6	1.001	97.9	1.000
13	9.03	1.54	16.5	1.001	114	1.000
14	6.37	1.50	18.6	1.001	133	1.000
15	5.1	1.46	21	1.001	154	1.000
16	4.9	1.48	23.7	1.001	178	1.000
17	5.43	1.65	26.8	1.001	205	1.000
18	6.2	2.12	30.2	1.001	235	1.000
19	6.75	2.88	34.1	1.001	269	1.000
20	6.9	3.84				

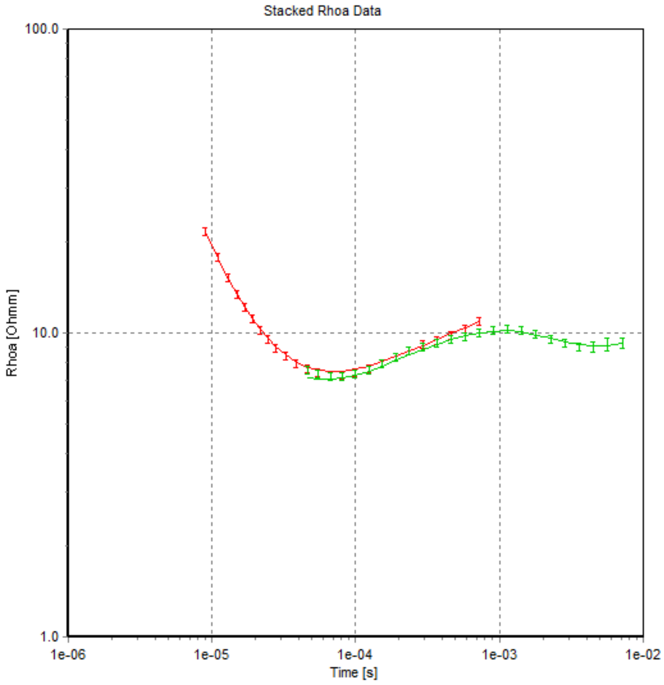


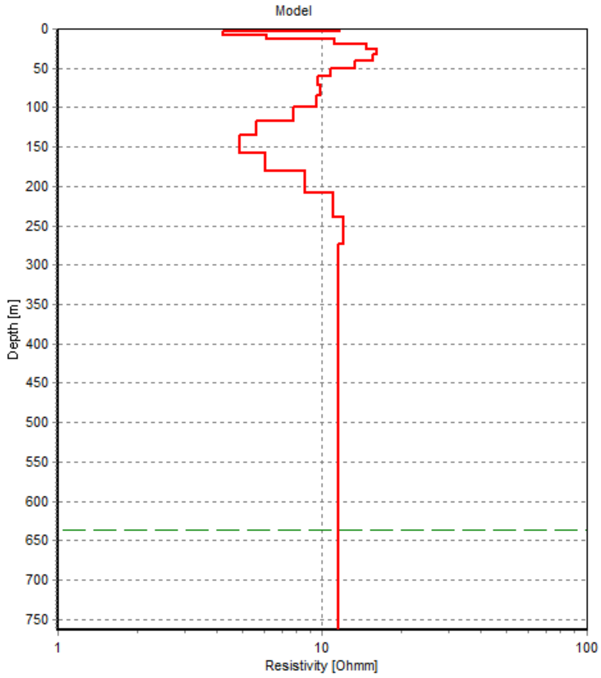


Station 08

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5874373
UTMY: 2165462
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.5
No. of Layers: 20
DOI: 636m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	11.6	1.11	3.92	1.001	3.92	1.001
2	4.23	1.11	4.42	1.001	8.34	1.001
3	6.12	1.22	4.99	1.001	13.3	1.001
4	11.1	1.37	5.64	1.001	19	1.000
5	14.6	1.44	6.37	1.001	25.3	1.000
6	16.1	1.50	7.19	1.001	32.5	1.000
7	15.6	1.52	8.12	1.001	40.6	1.000
8	13.4	1.48	9.16	1.001	49.8	1.000
9	10.8	1.44	10.3	1.001	60.2	1.000
10	9.65	1.46	11.7	1.001	71.8	1.000
11	9.79	1.49	13.2	1.001	85	1.000
12	9.54	1.49	14.9	1.001	99.9	1.000
13	7.79	1.47	16.8	1.001	117	1.000
14	5.61	1.43	19	1.001	136	1.000
15	4.89	1.42	21.4	1.001	157	1.000
16	6.12	1.46	24.2	1.001	181	1.000
17	8.61	1.61	27.3	1.001	209	1.000
18	11	1.99	30.8	1.001	239	1.000
19	12	2.67	34.8	1.001	274	1.000
20	11.5	3.61				

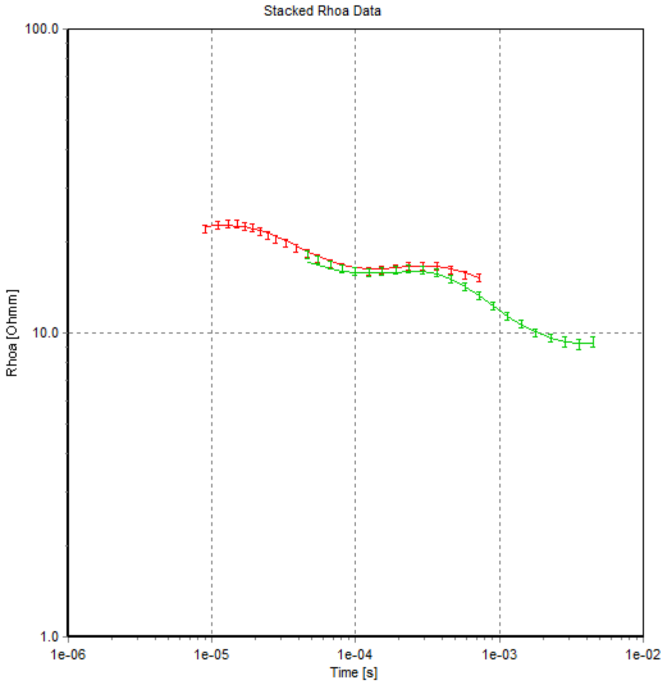


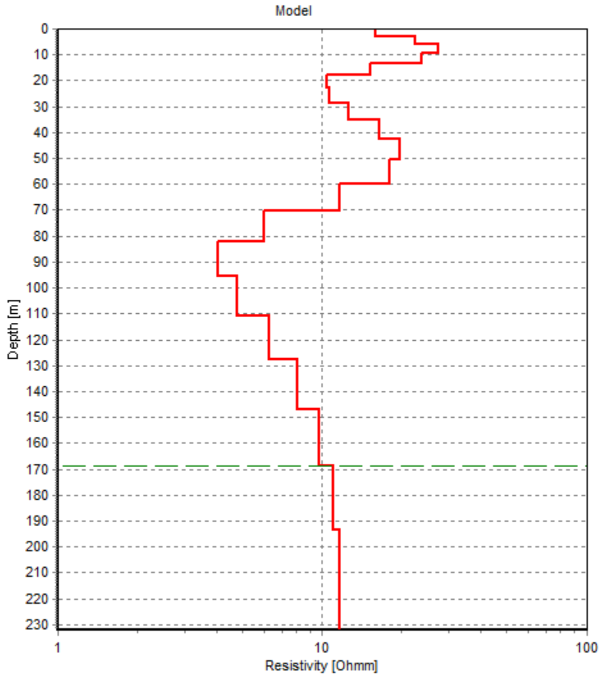


Station 09

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5874078
UTMY: 2165283
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.5
No. of Layers: 20
DOI: 168m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	15.9	1.27	2.76	1.001	2.76	1.001
2	22.3	1.44	3.12	1.001	5.88	1.001
3	27.4	1.48	3.52	1.001	9.4	1.001
4	23.8	1.40	3.98	1.001	13.4	1.000
5	15.2	1.37	4.49	1.001	17.9	1.000
6	10.4	1.29	5.07	1.001	22.9	1.000
7	10.7	1.34	5.72	1.001	28.7	1.000
8	12.6	1.37	6.46	1.001	35.1	1.000
9	16.4	1.44	7.29	1.001	42.4	1.000
10	19.6	1.50	8.23	1.001	50.7	1.000
11	18	1.50	9.3	1.001	59.9	1.000
12	11.7	1.44	10.5	1.001	70.4	1.000
13	6	1.35	11.9	1.001	82.3	1.000
14	4.02	1.31	13.4	1.001	95.7	1.000
15	4.74	1.37	15.1	1.001	111	1.000
16	6.32	1.43	17	1.001	128	1.000
17	8.05	1.48	19.3	1.001	147	1.000
18	9.68	1.57	21.7	1.001	169	1.000
19	11	1.81	24.5	1.001	193	1.000
20	11.7	2.28				

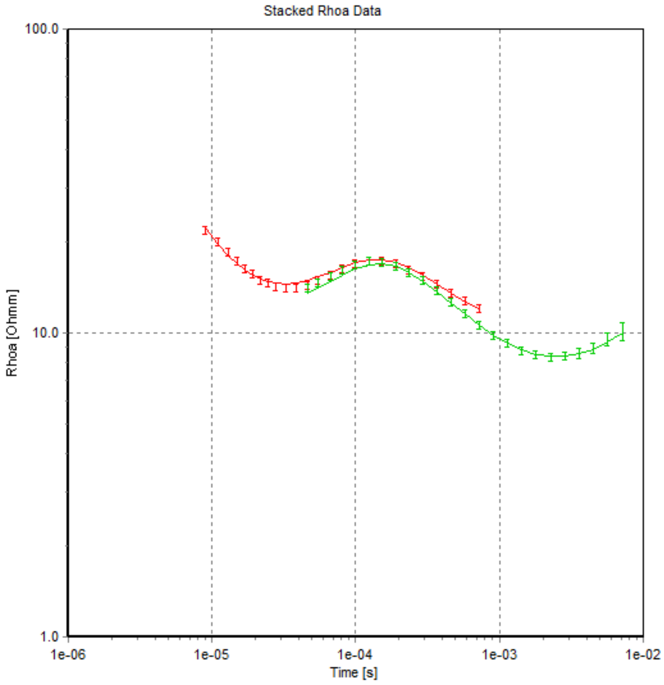


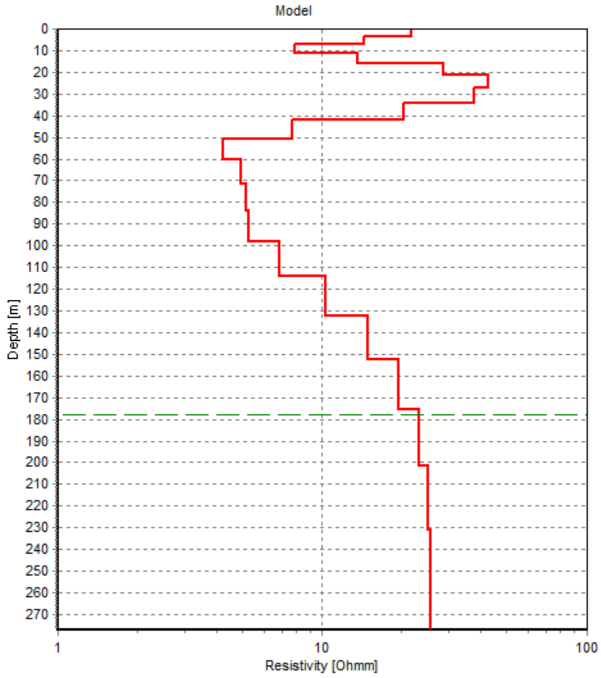


Station 10

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873961
UTMY: 2165191
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.6
No. of Layers: 20
DOI: 178m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	21.7	1.31	3.3	1.001	3.3	1.001
2	14.4	1.35	3.73	1.001	7.03	1.001
3	7.89	1.14	4.21	1.001	11.2	1.001
4	13.6	1.13	4.75	1.001	16	1.000
5	28.8	1.44	5.36	1.001	21.3	1.000
6	42.3	1.51	6.05	1.001	27.4	1.000
7	37.3	1.56	6.84	1.001	34.2	1.000
8	20.2	1.49	7.72	1.001	42	1.000
9	7.68	1.33	8.71	1.001	50.7	1.000
10	4.23	1.26	9.84	1.001	60.5	1.000
11	4.9	1.34	11.1	1.001	71.6	1.000
12	5.13	1.36	12.5	1.001	84.1	1.000
13	5.28	1.38	14.1	1.001	98.3	1.000
14	6.91	1.43	16	1.001	114	1.000
15	10.3	1.53	18	1.001	132	1.000
16	14.9	1.63	20.4	1.001	153	1.000
17	19.5	1.71	23	1.001	176	1.000
18	23.1	1.74	26	1.001	202	1.000
19	25.2	1.68	29.3	1.001	231	1.000
20	25.6	1.57				

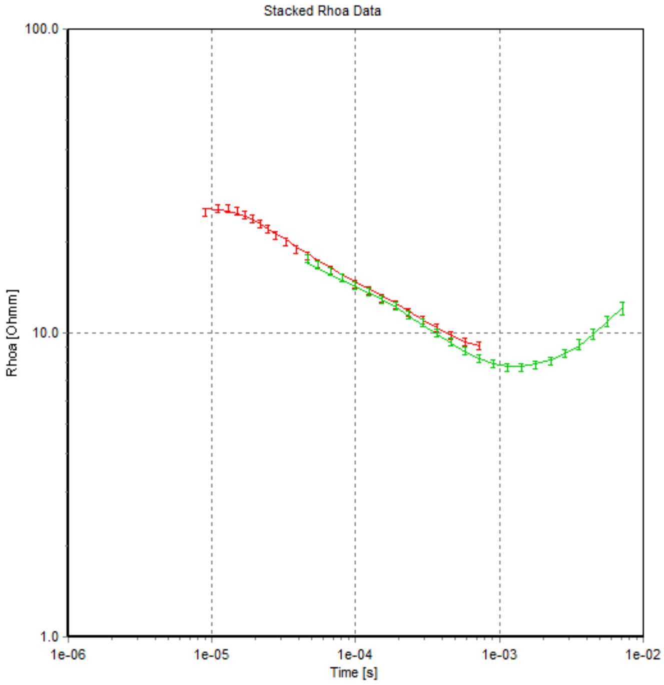


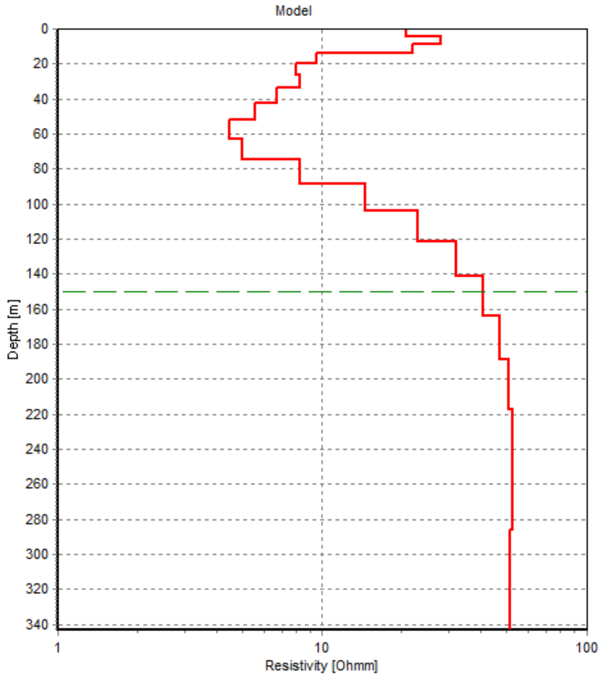


Station 11

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873818
UTMY: 2165073
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.4
No. of Layers: 20
DOI: 150m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	20.7	1.14	4.09	1.001	4.09	1.001
2	28	1.29	4.61	1.001	8.7	1.001
3	22	1.33	5.21	1.001	13.9	1.001
4	9.51	1.20	5.88	1.001	19.8	1.000
5	7.97	1.21	6.64	1.001	26.4	1.000
6	8.22	1.29	7.5	1.001	33.9	1.000
7	6.71	1.29	8.47	1.001	42.4	1.000
8	5.54	1.31	9.56	1.001	52	1.000
9	4.45	1.30	10.8	1.001	62.7	1.000
10	4.96	1.35	12.2	1.001	74.9	1.000
11	8.25	1.45	13.8	1.001	88.7	1.000
12	14.5	1.57	15.5	1.001	104	1.000
13	22.9	1.68	17.5	1.001	122	1.000
14	32.2	1.76	19.8	1.001	142	1.000
15	40.6	1.84	22.3	1.001	164	1.000
16	46.9	1.95	25.2	1.001	189	1.000
17	50.8	2.12	28.5	1.001	218	1.000
18	52.4	2.38	32.2	1.001	250	1.000
19	52.3	2.76	36.3	1.001	286	1.000
20	51.1	3.27				

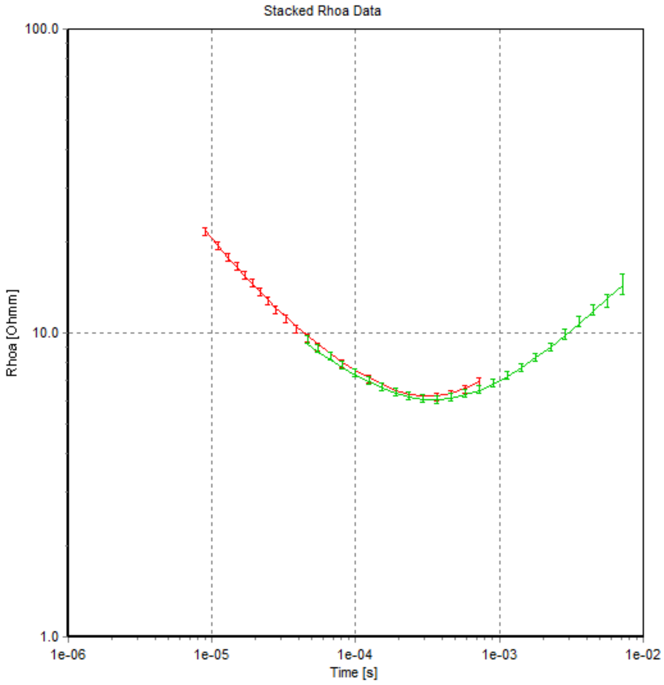


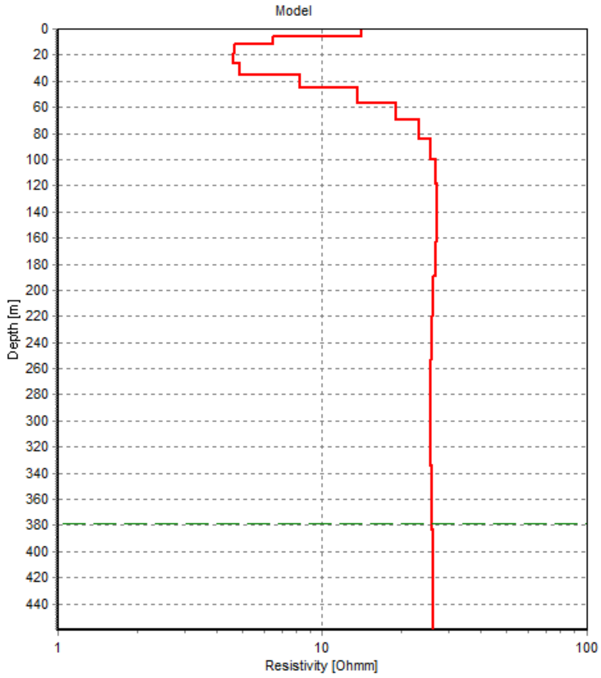


Station 12

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873714
UTMY: 2164973
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.4
No. of Layers: 20
DOI: 379m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	14.1	1.06	5.48	1.001	5.48	1.001
2	6.5	1.08	6.18	1.001	11.7	1.001
3	4.66	1.11	6.98	1.001	18.6	1.001
4	4.61	1.18	7.88	1.001	26.5	1.000
5	4.85	1.26	8.9	1.001	35.4	1.000
6	8.25	1.40	10.1	1.001	45.5	1.000
7	13.5	1.50	11.3	1.001	56.8	1.000
8	19	1.57	12.8	1.001	69.6	1.000
9	23.2	1.61	14.5	1.001	84.1	1.000
10	25.7	1.64	16.3	1.001	100	1.000
11	26.9	1.69	18.4	1.001	119	1.000
12	27.2	1.73	20.8	1.001	140	1.000
13	27.1	1.74	23.5	1.001	163	1.000
14	26.8	1.72	26.5	1.001	190	1.000
15	26.3	1.69	29.9	1.001	220	1.000
16	25.9	1.68	33.8	1.001	253	1.000
17	25.6	1.70	38.2	1.001	292	1.000
18	25.6	1.72	43.1	1.001	335	1.000
19	25.8	1.70	48.7	1.001	383	1.000
20	26.2	1.68				

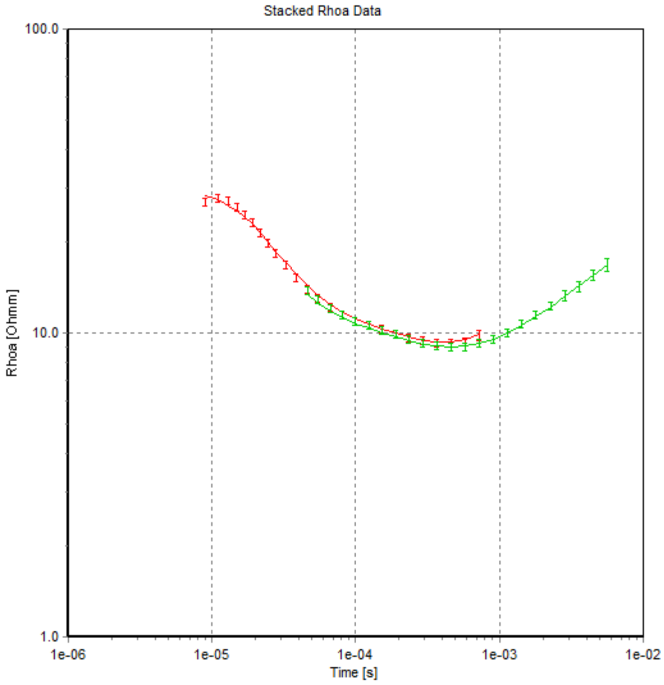


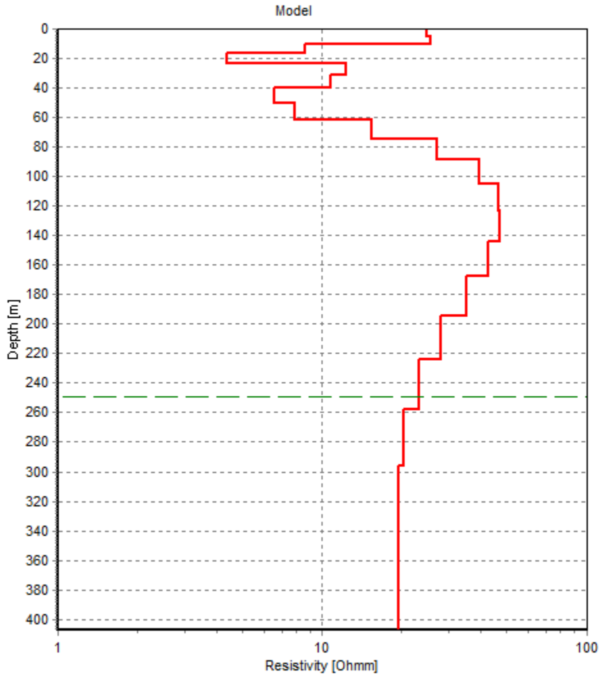


Station 13

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5873512
UTMY:	2165134
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.5
No. of Layers:	20
DOI:	250m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	24.9	1.19	4.85	1.001	4.85	1.001
2	25.7	1.39	5.47	1.001	10.3	1.001
3	8.57	1.12	6.18	1.001	16.5	1.001
4	4.33	1.09	6.98	1.001	23.5	1.000
5	12.3	1.36	7.88	1.001	31.4	1.000
6	10.8	1.37	8.9	1.001	40.3	1.000
7	6.57	1.30	10	1.001	50.3	1.000
8	7.89	1.36	11.3	1.001	61.6	1.000
9	15.4	1.50	12.8	1.001	74.4	1.000
10	27.2	1.63	14.4	1.001	88.9	1.000
11	39	1.72	16.3	1.001	105	1.000
12	46.2	1.78	18.4	1.001	124	1.000
13	46.9	1.79	20.8	1.001	144	1.000
14	42.2	1.76	23.5	1.001	168	1.000
15	35.1	1.71	26.5	1.001	194	1.000
16	28.2	1.67	29.9	1.001	224	1.000
17	23.1	1.66	33.8	1.001	258	1.000
18	20.3	1.65	38.2	1.001	296	1.000
19	19.4	1.56	43.1	1.001	339	1.000
20	19.5	1.33				

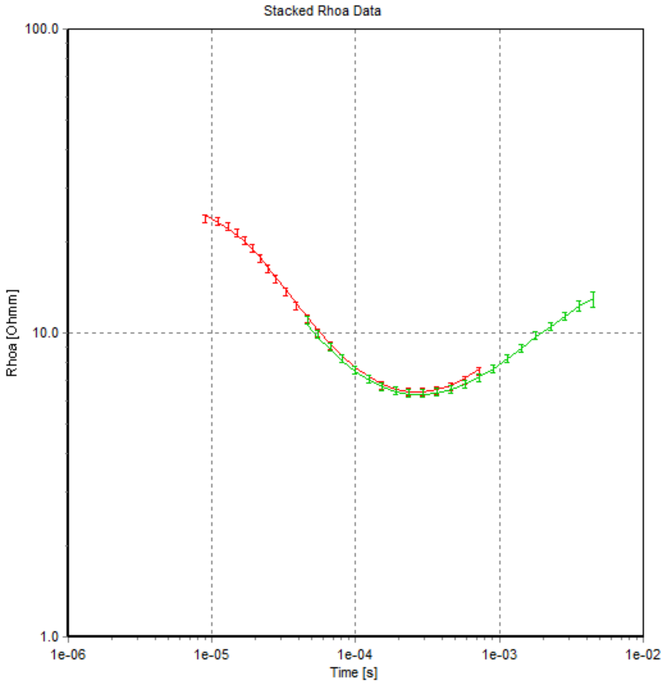


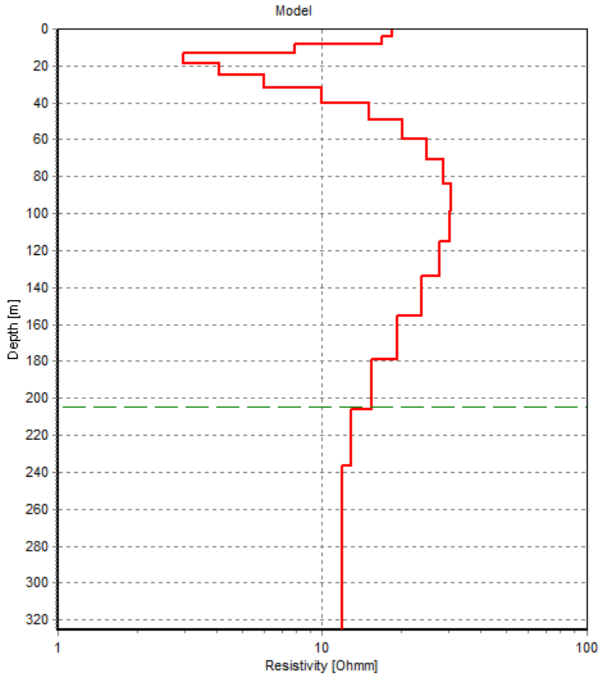


Station 14

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5873672
UTMY:	2164854
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.4
No. of Layers:	20
DOI:	204m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	18.3	1.20	3.88	1.001	3.88	1.001
2	16.7	1.37	4.38	1.001	8.25	1.001
3	7.85	1.17	4.94	1.001	13.2	1.001
4	3	1.09	5.58	1.001	18.8	1.000
5	4.09	1.21	6.3	1.001	25.1	1.000
6	6.03	1.34	7.11	1.001	32.2	1.000
7	9.98	1.43	8.02	1.001	40.2	1.000
8	14.9	1.53	9.06	1.001	49.3	1.000
9	20.1	1.61	10.2	1.001	59.5	1.000
10	24.9	1.67	11.6	1.001	71	1.000
11	28.7	1.71	13	1.001	84.1	1.000
12	30.7	1.74	14.7	1.001	98.8	1.000
13	30.4	1.75	16.6	1.001	115	1.000
14	27.8	1.74	18.8	1.001	134	1.000
15	23.7	1.70	21.2	1.001	155	1.000
16	19.2	1.68	23.9	1.001	179	1.000
17	15.4	1.73	27	1.001	206	1.000
18	12.9	1.99	30.5	1.001	237	1.000
19	11.8	2.56	34.4	1.001	271	1.000
20	11.9	3.43				

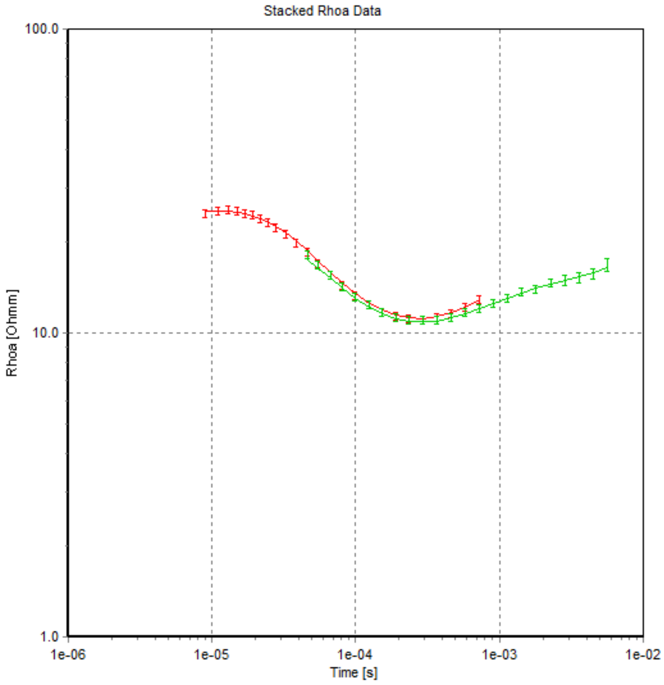


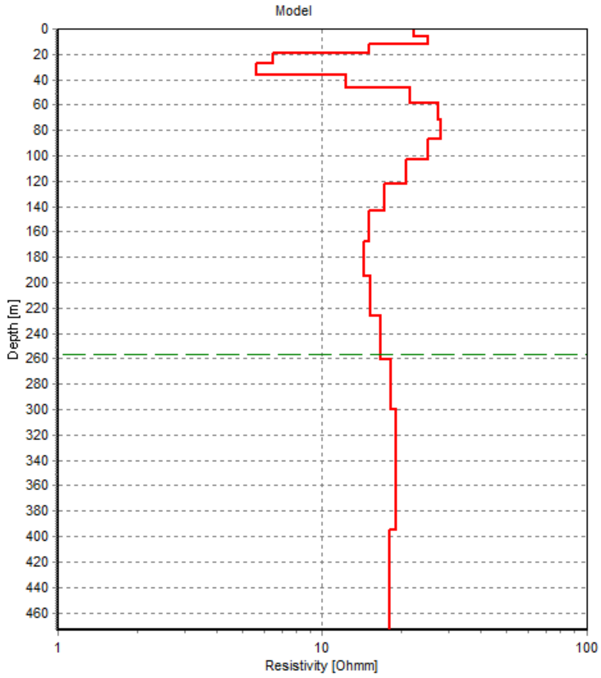


Station 15

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873370
UTMY: 2164925
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.4
No. of Layers: 20
DOI: 256m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	22.1	1.12	5.64	1.001	5.64	1.001
2	25.1	1.31	6.37	1.001	12	1.001
3	15	1.22	7.19	1.001	19.2	1.001
4	6.5	1.12	8.12	1.001	27.3	1.000
5	5.61	1.16	9.16	1.001	36.5	1.000
6	12.3	1.37	10.4	1.001	46.8	1.000
7	21.5	1.47	11.7	1.001	58.5	1.000
8	27.4	1.55	13.2	1.001	71.7	1.000
9	28.2	1.58	14.9	1.001	86.6	1.000
10	25	1.57	16.8	1.001	103	1.000
11	20.7	1.55	19	1.001	122	1.000
12	17.1	1.52	21.4	1.001	144	1.000
13	15	1.51	24.2	1.001	168	1.000
14	14.4	1.51	27.3	1.001	195	1.000
15	15.2	1.54	30.8	1.001	226	1.000
16	16.7	1.66	34.8	1.001	261	1.000
17	18.2	1.90	39.3	1.001	300	1.000
18	19.1	2.24	44.4	1.001	345	1.000
19	18.9	2.62	50.1	1.001	395	1.000
20	18	3.01				

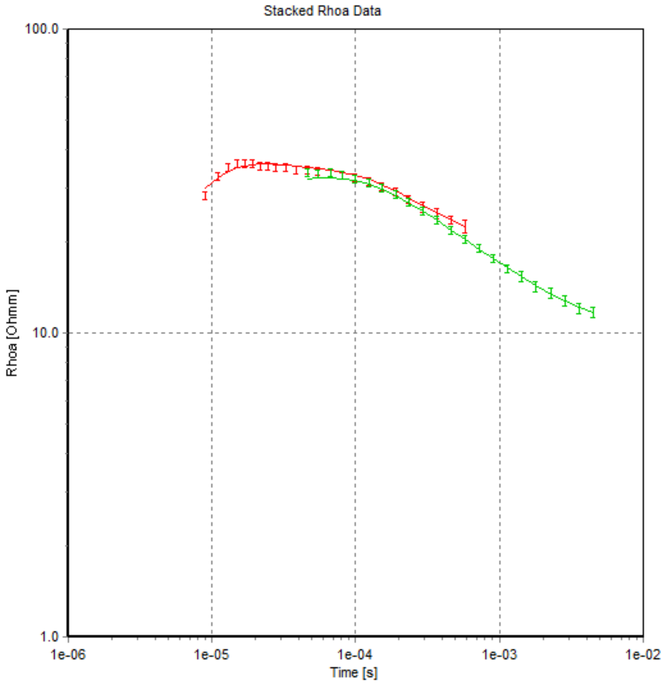


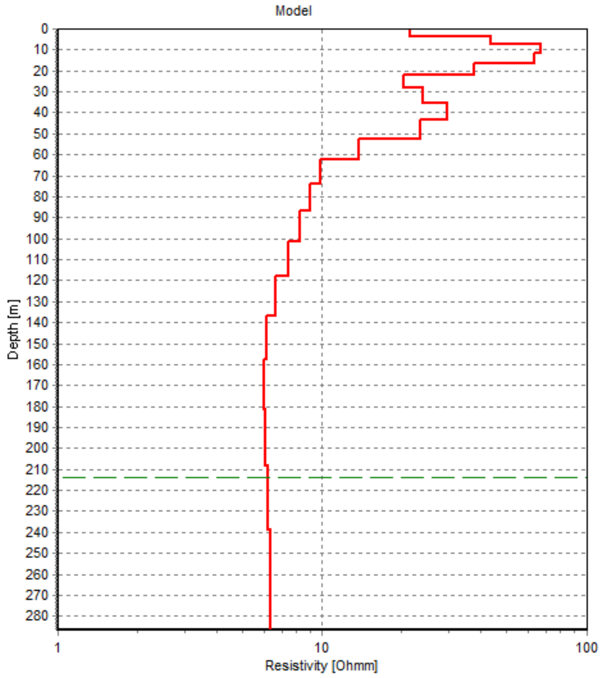


Station 16

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5871425
UTMY: 2160087
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.6
No. of Layers: 20
DOI: 214m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	21.5	1.22	3.41	1.001	3.41	1.001
2	43.1	1.49	3.85	1.001	7.27	1.001
3	66.7	1.56	4.35	1.001	11.6	1.001
4	63	1.49	4.91	1.001	16.5	1.000
5	37.6	1.42	5.54	1.001	22.1	1.000
6	20.2	1.31	6.26	1.001	28.3	1.000
7	24.1	1.36	7.07	1.001	35.4	1.000
8	29.8	1.43	7.98	1.001	43.4	1.000
9	23.4	1.40	9.01	1.001	52.4	1.000
10	13.7	1.34	10.2	1.001	62.6	1.000
11	9.83	1.31	11.5	1.001	74	1.000
12	8.95	1.33	13	1.001	87	1.000
13	8.26	1.36	14.6	1.001	102	1.000
14	7.47	1.39	16.5	1.001	118	1.000
15	6.67	1.42	18.6	1.001	137	1.000
16	6.14	1.44	21.1	1.001	158	1.000
17	6	1.50	23.8	1.001	182	1.000
18	6.09	1.76	26.8	1.001	208	1.000
19	6.24	2.37	30.3	1.001	239	1.000
20	6.37	3.28				

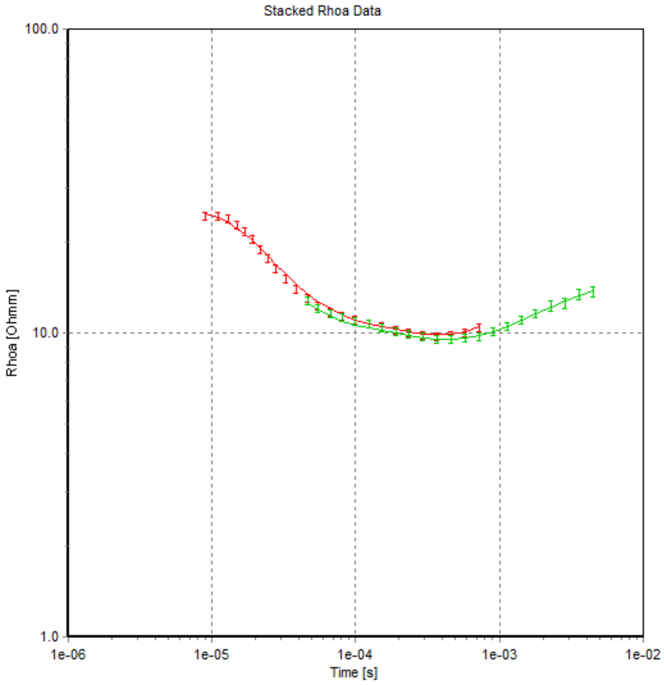


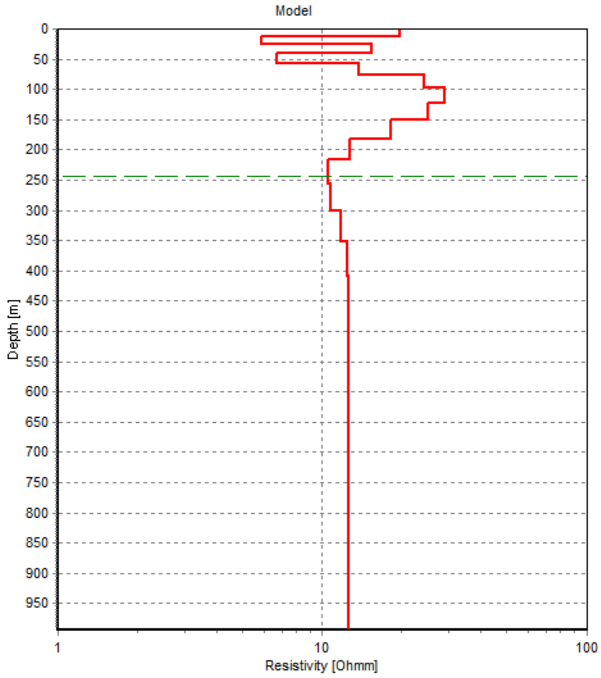


Station 17

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873629
UTMY: 2164718
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.5
No. of Layers: 20
DOI: 244m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	19.5	1.02	11.8	1.001	11.8	1.001
2	5.91	1.03	13.4	1.001	25.2	1.001
3	15.4	1.21	15.1	1.001	40.3	1.001
4	6.77	1.16	17	1.001	57.3	1.000
5	13.7	1.37	19.2	1.001	76.6	1.000
6	24.3	1.49	21.7	1.001	98.3	1.000
7	28.9	1.57	24.5	1.001	123	1.000
8	25.2	1.60	27.7	1.001	150	1.000
9	18.1	1.60	31.2	1.001	182	1.000
10	12.7	1.68	35.3	1.001	217	1.000
11	10.6	2.08	39.8	1.001	257	1.000
12	10.8	2.92	45	1.001	302	1.000
13	11.7	4.01	50.8	1.001	352	1.000
14	12.4	5.05	57.3	1.001	410	1.000
15	12.6	5.95	64.7	1.001	474	1.000
16	12.6	6.79	73	1.001	548	1.000
17	12.6	7.64	82.5	1.001	630	1.000
18	12.6	8.56	93.1	1.001	723	1.000
19	12.6	9.54	105	1.001	828	1.000
20	12.6	10.58				

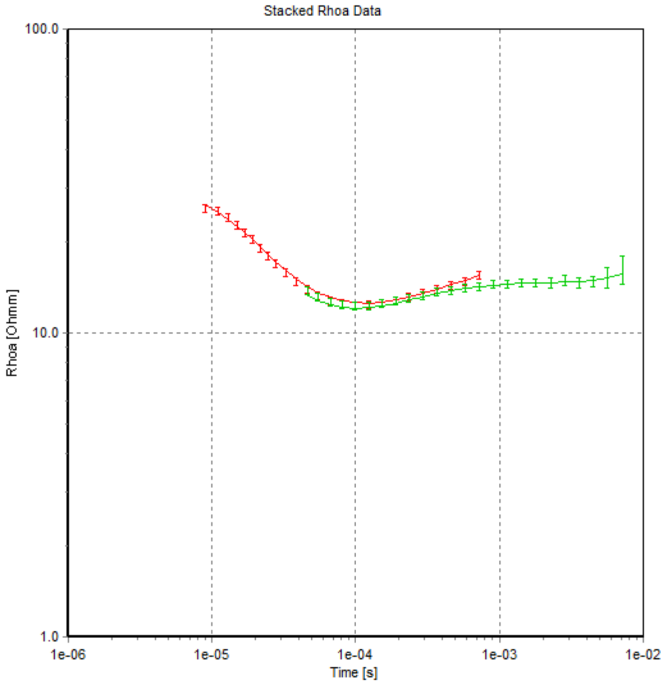


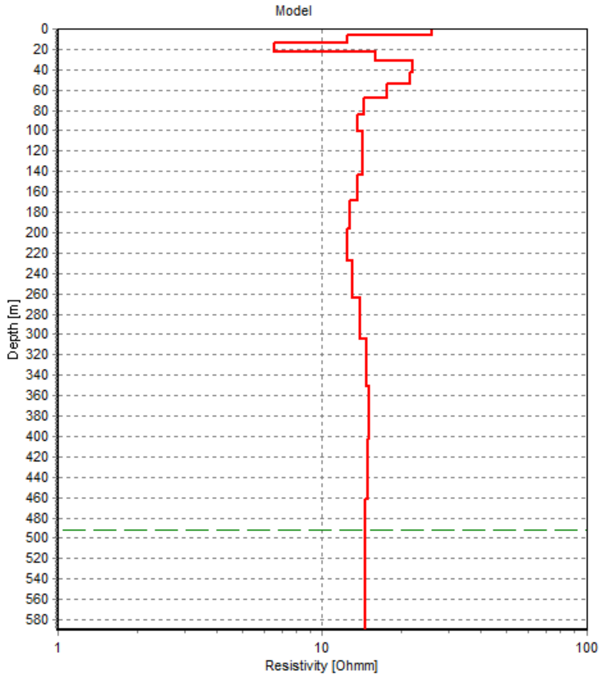


Station 18

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873341
UTMY: 2164739
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.5
No. of Layers: 20
DOI: 492m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	25.9	1.09	6.59	1.001	6.59	1.001
2	12.4	1.10	7.44	1.001	14	1.001
3	6.62	1.08	8.4	1.001	22.4	1.001
4	15.9	1.28	9.48	1.001	31.9	1.000
5	21.9	1.40	10.7	1.001	42.6	1.000
6	21.5	1.43	12.1	1.001	54.7	1.000
7	17.6	1.41	13.6	1.001	68.4	1.000
8	14.4	1.41	15.4	1.001	83.8	1.000
9	13.6	1.43	17.4	1.001	101	1.000
10	14.1	1.46	19.6	1.001	121	1.000
11	14.3	1.47	22.2	1.001	143	1.000
12	13.5	1.47	25	1.001	168	1.000
13	12.6	1.48	28.3	1.001	196	1.000
14	12.4	1.50	31.9	1.001	228	1.000
15	12.9	1.55	36	1.001	264	1.000
16	13.9	1.61	40.7	1.001	305	1.000
17	14.7	1.66	45.9	1.001	351	1.000
18	15.1	1.69	51.8	1.001	403	1.000
19	14.9	1.80	58.5	1.001	461	1.000
20	14.5	2.06				

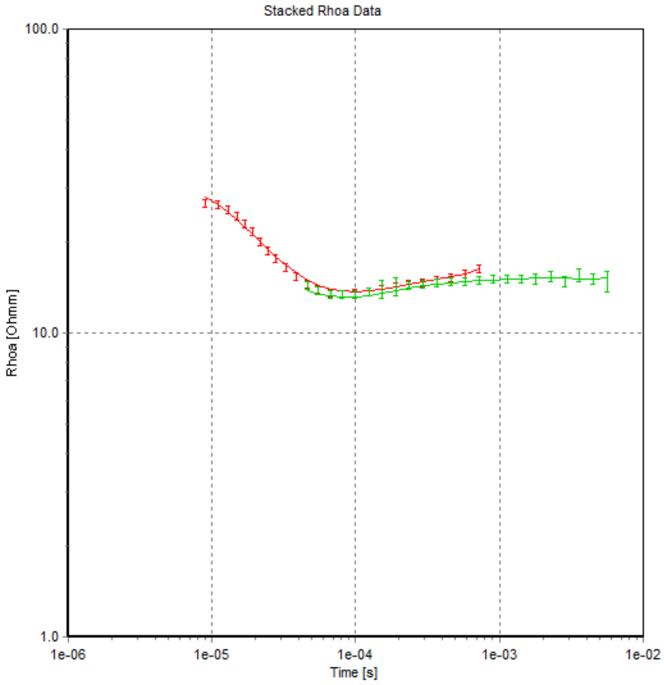


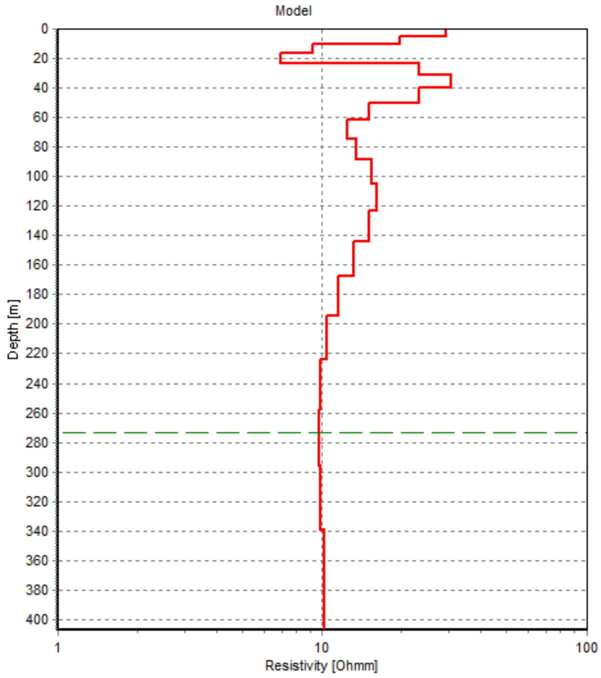


Station 19

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873371
UTMY: 2164606
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.5
No. of Layers: 20
DOI: 274m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	29.2	1.26	4.85	1.001	4.85	1.001
2	19.6	1.33	5.47	1.001	10.3	1.001
3	9.2	1.14	6.18	1.001	16.5	1.001
4	6.99	1.13	6.98	1.001	23.5	1.000
5	23.1	1.45	7.88	1.001	31.4	1.000
6	30.6	1.49	8.89	1.001	40.2	1.000
7	23.1	1.47	10	1.001	50.3	1.000
8	15.1	1.41	11.3	1.001	61.6	1.000
9	12.4	1.40	12.8	1.001	74.4	1.000
10	13.4	1.44	14.4	1.001	88.9	1.000
11	15.3	1.48	16.3	1.001	105	1.000
12	16	1.51	18.4	1.001	124	1.000
13	15	1.52	20.8	1.001	144	1.000
14	13.2	1.52	23.5	1.001	168	1.000
15	11.6	1.53	26.5	1.001	194	1.000
16	10.4	1.58	29.9	1.001	224	1.000
17	9.86	1.81	33.8	1.001	258	1.000
18	9.72	2.36	38.1	1.001	296	1.000
19	9.88	3.21	43	1.001	339	1.000
20	10.2	4.25				





Station 20

Print Date: 13-12-2017

Database Name: TDEM_SLO_EPSG2229.gdb

UTMX: 5873348

UTMY: 2164469

EPSG: NAD83/California zone 5, EPSG:2229

Importer: Not Available

Version: Not Available

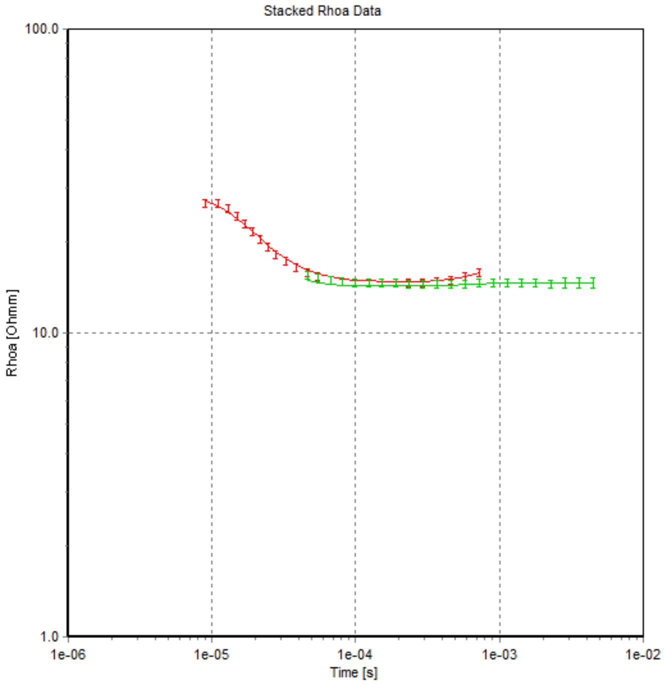
Data Residual: 0.5

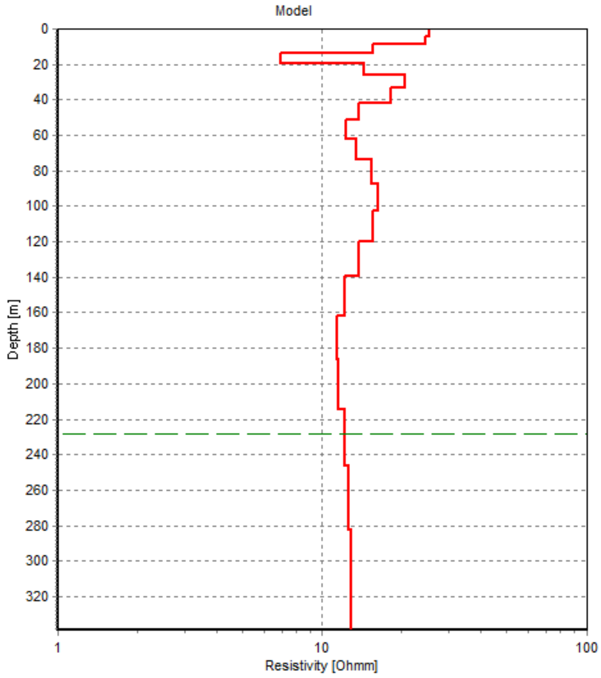
No. of Layers: 20

DOI: 228m

Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	25.3	1.25	4.03	1.001	4.03	1.001
2	24.7	1.38	4.56	1.001	8.59	1.001
3	15.6	1.26	5.14	1.001	13.7	1.001
4	7	1.16	5.81	1.001	19.5	1.000
5	14.4	1.34	6.56	1.001	26.1	1.000
6	20.6	1.42	7.4	1.001	33.5	1.000
7	18.2	1.42	8.36	1.001	41.9	1.000
8	13.8	1.40	9.43	1.001	51.3	1.000
9	12.2	1.40	10.6	1.001	61.9	1.000
10	13.4	1.43	12	1.001	74	1.000
11	15.3	1.48	13.6	1.001	87.5	1.000
12	16.3	1.51	15.3	1.001	103	1.000
13	15.6	1.51	17.3	1.001	120	1.000
14	13.8	1.51	19.5	1.001	140	1.000
15	12.1	1.49	22.1	1.001	162	1.000
16	11.4	1.49	24.9	1.001	187	1.000
17	11.5	1.53	28.1	1.001	215	1.000
18	12.1	1.77	31.7	1.001	247	1.000
19	12.6	2.31	35.8	1.001	282	1.000
20	12.8	3.14				

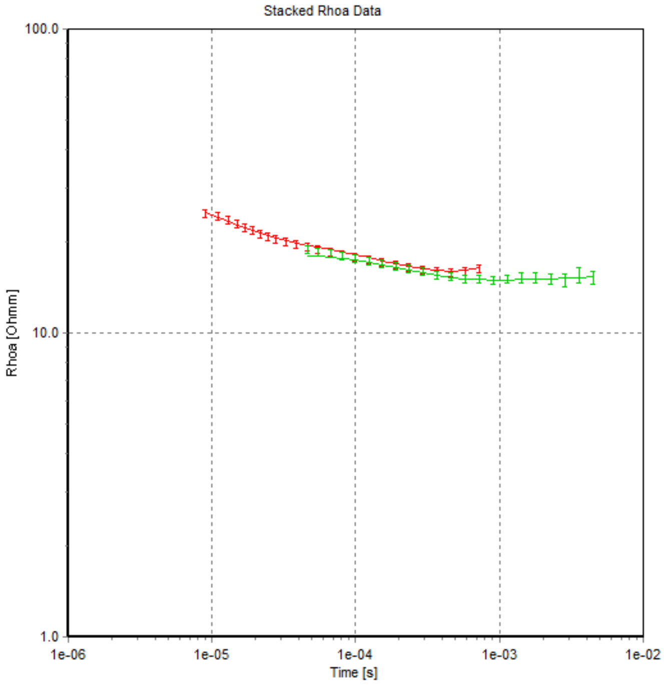


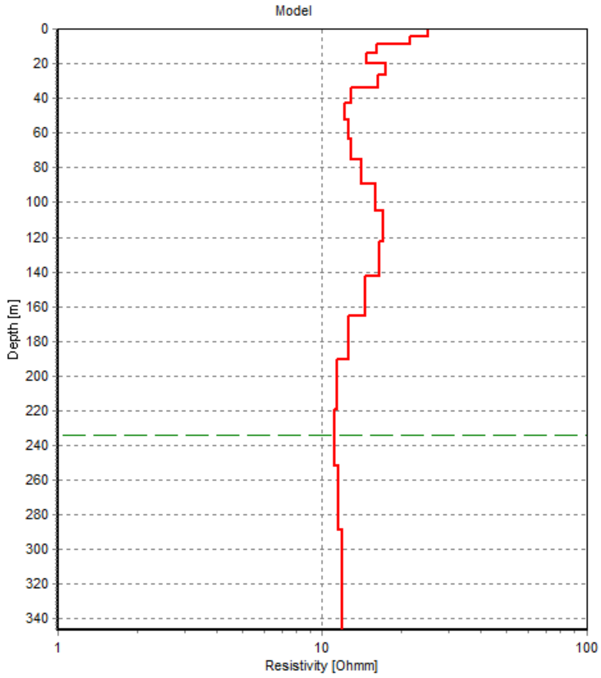


Station 21

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873363
UTMY: 2164318
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.5
No. of Layers: 20
DOI: 234m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	25	1.28	4.12	1.001	4.12	1.001
2	21.5	1.36	4.66	1.001	8.78	1.001
3	16.1	1.25	5.26	1.001	14	1.001
4	14.6	1.29	5.93	1.001	20	1.000
5	17.4	1.33	6.7	1.001	26.7	1.000
6	16.2	1.36	7.56	1.001	34.2	1.000
7	12.9	1.34	8.54	1.001	42.8	1.000
8	12.1	1.36	9.64	1.001	52.4	1.000
9	12.5	1.38	10.9	1.001	63.3	1.000
10	12.9	1.41	12.3	1.001	75.6	1.000
11	14	1.45	13.9	1.001	89.5	1.000
12	15.8	1.49	15.7	1.001	105	1.000
13	17	1.52	17.7	1.001	123	1.000
14	16.4	1.53	20	1.001	143	1.000
15	14.5	1.53	22.5	1.001	165	1.000
16	12.5	1.54	25.5	1.001	191	1.000
17	11.3	1.61	28.7	1.001	220	1.000
18	11.1	1.92	32.4	1.001	252	1.000
19	11.5	2.57	36.6	1.001	289	1.000
20	11.9	3.50				

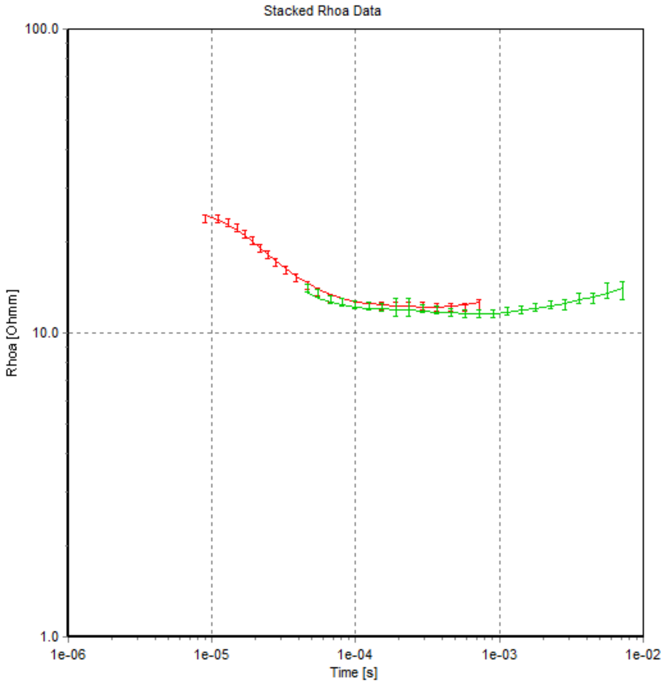


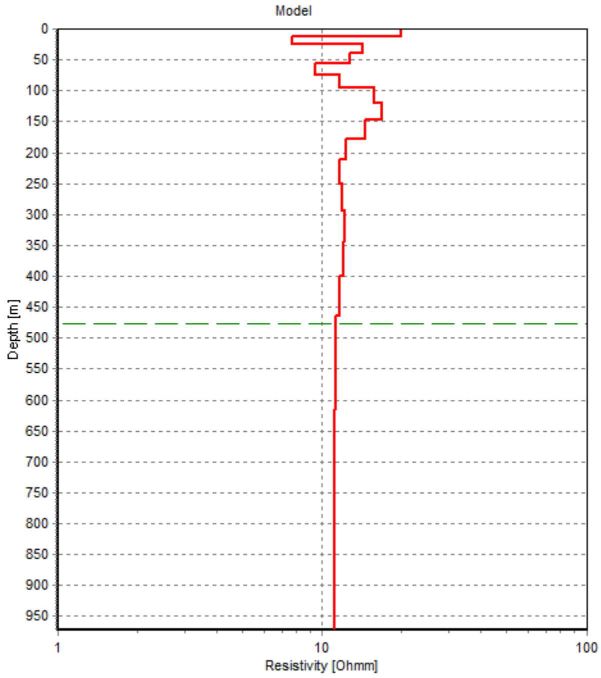


Station 22

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5873502
UTMY:	2164261
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.5
No. of Layers:	20
DOI:	477m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	19.9	1.02	11.6	1.001	11.6	1.001
2	7.73	1.03	13.1	1.001	24.6	1.001
3	14.2	1.16	14.8	1.001	39.4	1.001
4	12.7	1.27	16.7	1.001	56.1	1.000
5	9.37	1.27	18.8	1.001	74.9	1.000
6	11.7	1.37	21.2	1.001	96.1	1.000
7	15.8	1.44	24	1.001	120	1.000
8	16.8	1.47	27.1	1.001	147	1.000
9	14.6	1.47	30.5	1.001	178	1.000
10	12.3	1.46	34.5	1.001	212	1.000
11	11.6	1.52	39	1.001	251	1.000
12	11.9	1.65	44	1.001	295	1.000
13	12.2	1.84	49.6	1.001	345	1.000
14	12	2.08	56	1.001	401	1.000
15	11.6	2.42	63.3	1.001	464	1.000
16	11.3	2.87	71.4	1.001	535	1.000
17	11.2	3.42	80.7	1.001	616	1.000
18	11.2	4.03	91.1	1.001	707	1.000
19	11.2	4.71	103	1.001	810	1.000
20	11.2	5.45				

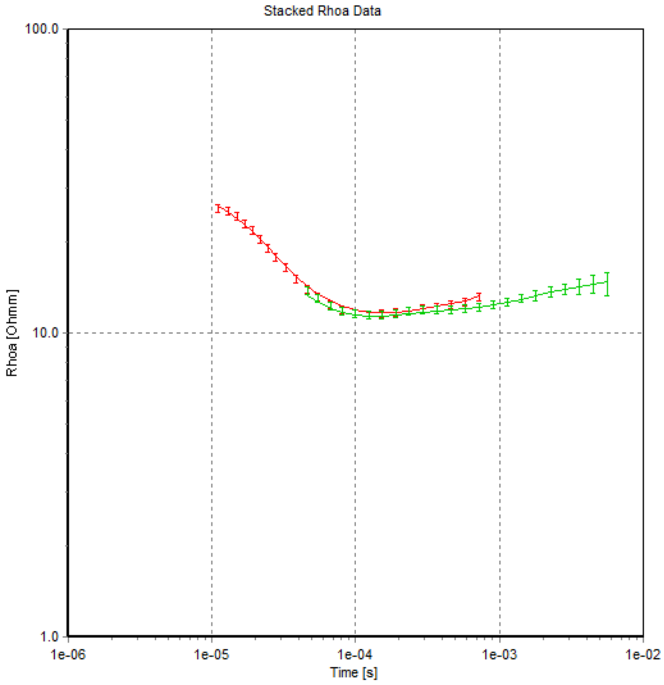


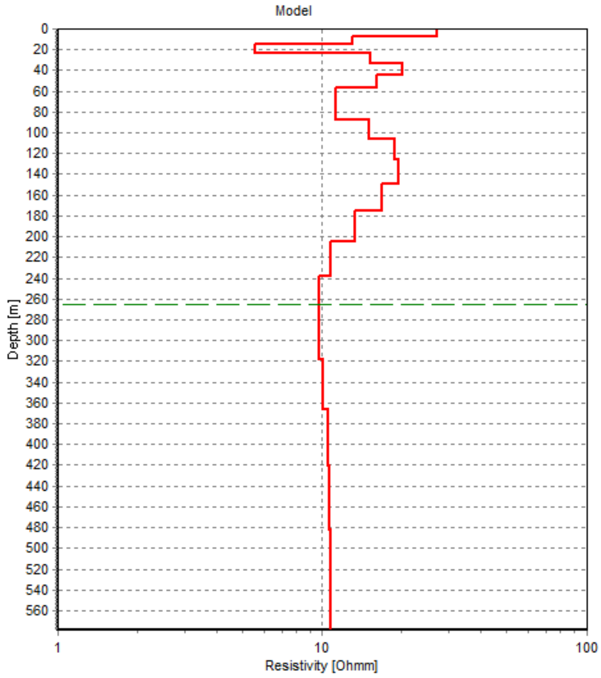


Station 24

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5873446
UTMY:	2164011
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.4
No. of Layers:	20
DOI:	265m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	27	1.14	6.89	1.001	6.89	1.001
2	13	1.15	7.78	1.001	14.7	1.001
3	5.54	1.08	8.78	1.001	23.5	1.001
4	15.2	1.31	9.92	1.001	33.4	1.000
5	20.1	1.40	11.2	1.001	44.6	1.000
6	16.1	1.41	12.6	1.001	57.2	1.000
7	11.3	1.36	14.3	1.001	71.5	1.000
8	11.2	1.39	16.1	1.001	87.6	1.000
9	15.1	1.47	18.2	1.001	106	1.000
10	18.9	1.54	20.5	1.001	126	1.000
11	19.5	1.58	23.2	1.001	149	1.000
12	16.8	1.59	26.2	1.001	176	1.000
13	13.2	1.62	29.5	1.001	205	1.000
14	10.7	1.76	33.4	1.001	239	1.000
15	9.68	2.17	37.7	1.001	276	1.000
16	9.67	2.92	42.5	1.001	319	1.000
17	10.1	3.91	48	1.001	367	1.000
18	10.5	4.95	54.2	1.001	421	1.000
19	10.7	5.91	61.2	1.001	482	1.000
20	10.8	6.80				

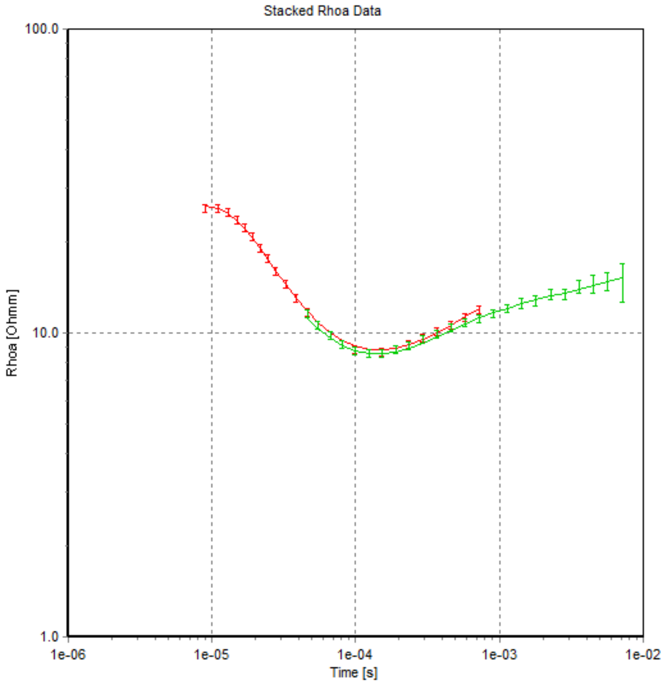


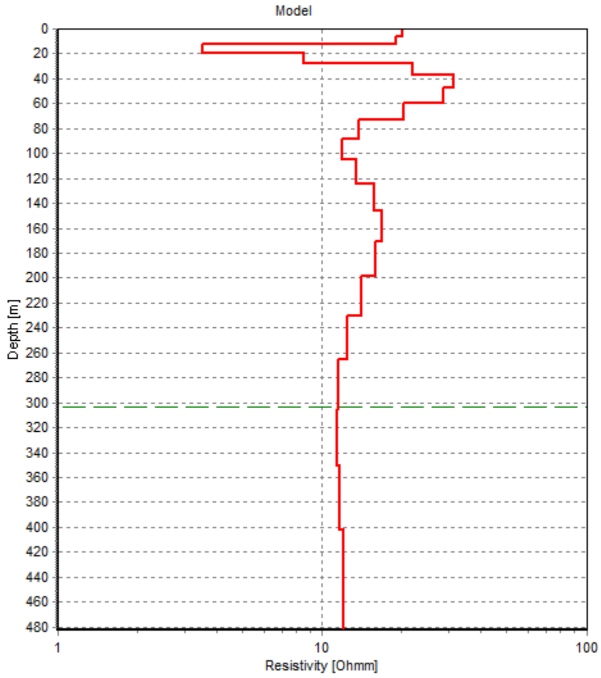


Station 25

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873387
UTMY: 2163936
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.5
No. of Layers: 20
DOI: 304m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	20	1.09	5.74	1.001	5.74	1.001
2	19	1.20	6.49	1.001	12.2	1.001
3	3.53	1.05	7.32	1.001	19.6	1.001
4	8.52	1.21	8.27	1.001	27.8	1.000
5	21.9	1.46	9.34	1.001	37.2	1.000
6	31.3	1.56	10.5	1.001	47.7	1.000
7	28.8	1.57	11.9	1.001	59.6	1.000
8	20.3	1.52	13.4	1.001	73	1.000
9	13.8	1.46	15.2	1.001	88.2	1.000
10	11.9	1.45	17.1	1.001	105	1.000
11	13.4	1.49	19.3	1.001	125	1.000
12	15.7	1.54	21.8	1.001	146	1.000
13	16.7	1.57	24.6	1.001	171	1.000
14	15.8	1.58	27.8	1.001	199	1.000
15	14	1.62	31.4	1.001	230	1.000
16	12.4	1.76	35.5	1.001	266	1.000
17	11.5	2.07	40	1.001	306	1.000
18	11.3	2.46	45.2	1.001	351	1.000
19	11.6	2.80	51	1.001	402	1.000
20	12	3.11				

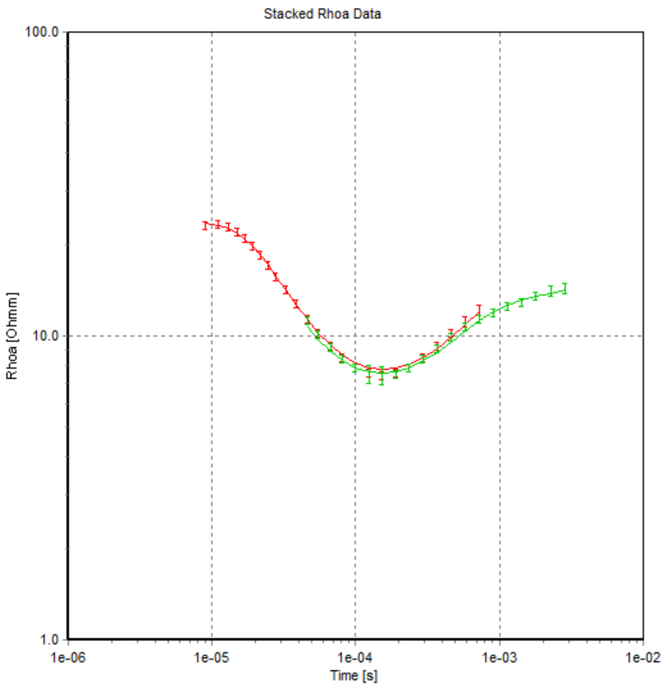


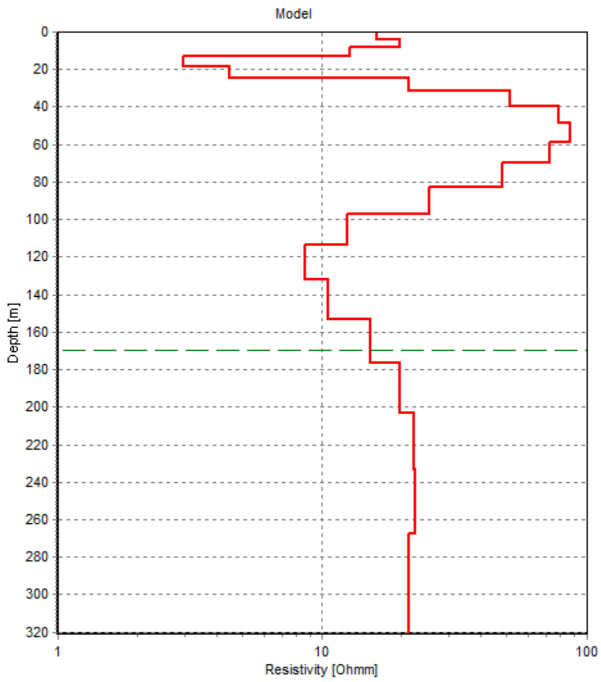


Station 26

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873425
UTMY: 2163714
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.6
No. of Layers: 20
DOI: 169m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	16	1.16	3.82	1.001	3.82	1.001
2	19.7	1.37	4.31	1.001	8.14	1.001
3	12.7	1.25	4.87	1.001	13	1.001
4	2.99	1.08	5.5	1.001	18.5	1.000
5	4.45	1.15	6.21	1.001	24.7	1.000
6	21.1	1.55	7.01	1.001	31.7	1.000
7	51.5	1.77	7.91	1.001	39.6	1.000
8	78.4	1.90	8.93	1.001	48.6	1.000
9	86.2	1.94	10.1	1.001	58.7	1.000
10	72.6	1.90	11.4	1.001	70.1	1.000
11	47.8	1.79	12.9	1.001	82.9	1.000
12	25.3	1.63	14.5	1.001	97.4	1.000
13	12.4	1.48	16.4	1.001	114	1.000
14	8.59	1.43	18.5	1.001	132	1.000
15	10.5	1.49	20.9	1.001	153	1.000
16	15.1	1.63	23.6	1.001	177	1.000
17	19.7	1.91	26.6	1.001	203	1.000
18	22.2	2.39	30.1	1.001	233	1.000
19	22.4	3.06	33.9	1.001	267	1.000
20	21.3	3.88				

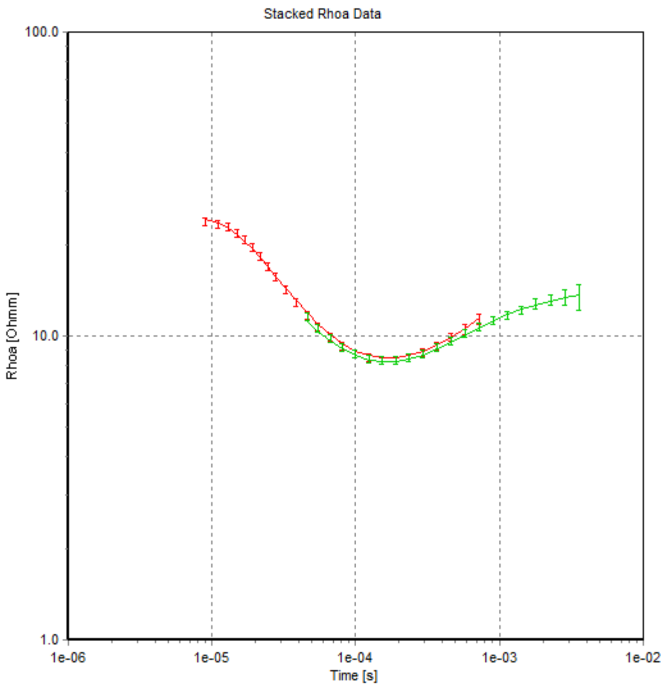


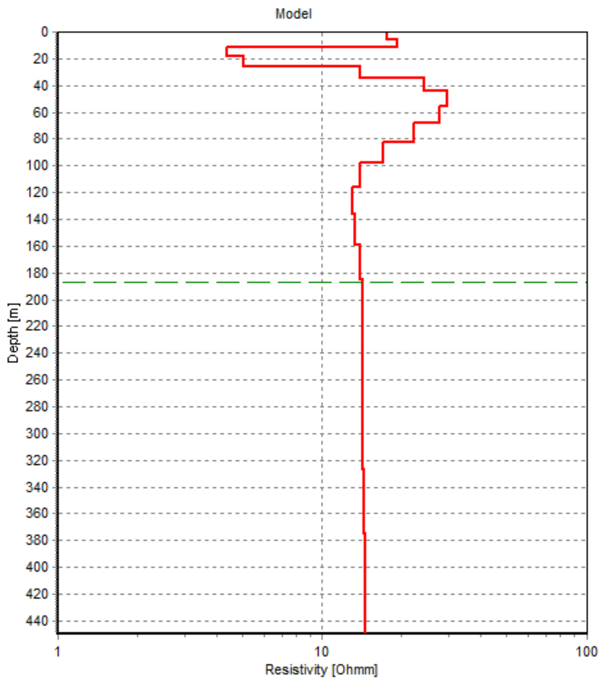


Station 27

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5874136
UTMY:	2166453
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.4
No. of Layers:	20
DOI:	187m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	17.5	1.10	5.36	1.001	5.36	1.001
2	19.2	1.26	6.05	1.001	11.4	1.001
3	4.35	1.08	6.83	1.001	18.2	1.001
4	5.03	1.14	7.71	1.001	25.9	1.000
5	13.9	1.41	8.7	1.001	34.6	1.000
6	24.3	1.51	9.82	1.001	44.5	1.000
7	29.5	1.58	11.1	1.001	55.6	1.000
8	27.7	1.60	12.5	1.001	68.1	1.000
9	22.2	1.58	14.1	1.001	82.2	1.000
10	17	1.53	16	1.001	98.2	1.000
11	13.9	1.50	18	1.001	116	1.000
12	13	1.51	20.3	1.001	137	1.000
13	13.4	1.57	23	1.001	160	1.000
14	13.9	1.73	25.9	1.001	185	1.000
15	14.2	2.09	29.3	1.001	215	1.000
16	14.2	2.69	33	1.001	248	1.000
17	14.1	3.50	37.3	1.001	285	1.000
18	14.2	4.43	42.1	1.001	327	1.000
19	14.4	5.36	47.6	1.001	375	1.000
20	14.6	6.25				

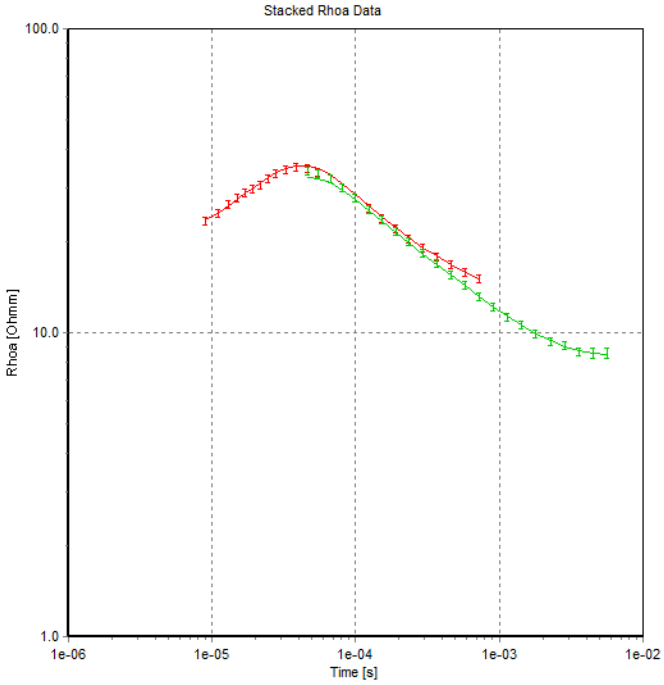


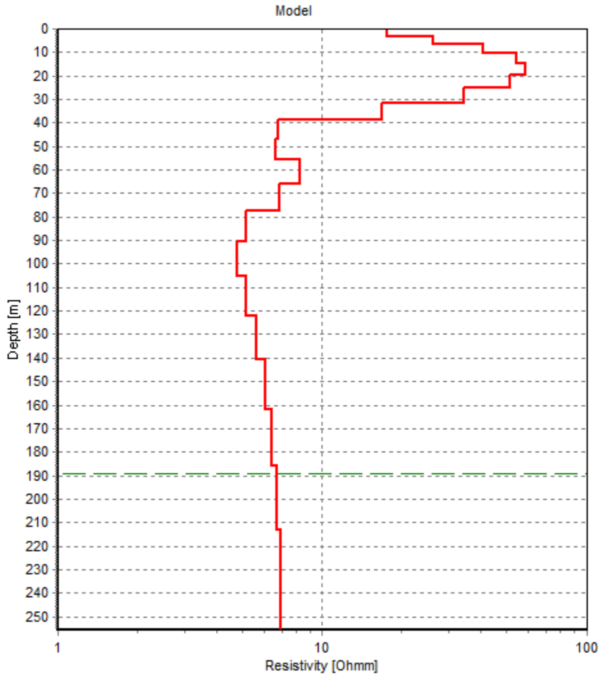


Station 28

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5873307
UTMY:	2166547
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.4
No. of Layers:	20
DOI:	189m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	17.6	1.25	3.05	1.001	3.05	1.001
2	26.4	1.43	3.44	1.001	6.48	1.001
3	40.7	1.49	3.88	1.001	10.4	1.001
4	54.1	1.50	4.38	1.001	14.7	1.000
5	58.8	1.54	4.95	1.001	19.7	1.000
6	51.2	1.53	5.59	1.001	25.3	1.000
7	34.4	1.46	6.3	1.001	31.6	1.000
8	16.8	1.37	7.12	1.001	38.7	1.000
9	6.8	1.22	8.04	1.001	46.7	1.000
10	6.65	1.27	9.07	1.001	55.8	1.000
11	8.2	1.35	10.2	1.001	66	1.000
12	6.88	1.35	11.6	1.001	77.6	1.000
13	5.13	1.33	13.1	1.001	90.7	1.000
14	4.78	1.36	14.7	1.001	105	1.000
15	5.17	1.40	16.6	1.001	122	1.000
16	5.66	1.44	18.8	1.001	141	1.000
17	6.08	1.47	21.2	1.001	162	1.000
18	6.43	1.59	24	1.001	186	1.000
19	6.73	1.96	27	1.001	213	1.000
20	6.95	2.61				

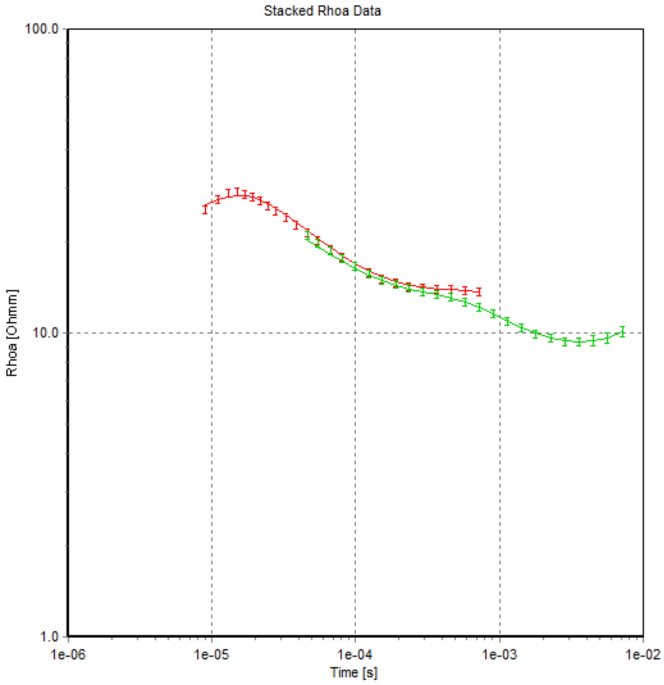


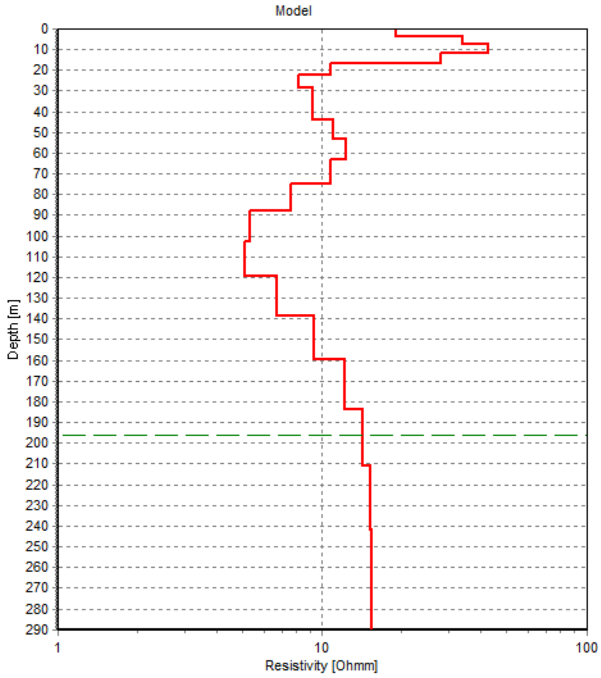


Station 29

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5873212
UTMY:	2166430
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.4
No. of Layers:	20
DOI:	196m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	19	1.21	3.46	1.001	3.46	1.001
2	34	1.46	3.9	1.001	7.36	1.001
3	42.2	1.48	4.41	1.001	11.8	1.001
4	28.1	1.40	4.97	1.001	16.7	1.000
5	10.8	1.25	5.61	1.001	22.4	1.000
6	8.14	1.24	6.34	1.001	28.7	1.000
7	9.16	1.30	7.16	1.001	35.8	1.000
8	9.15	1.33	8.08	1.001	43.9	1.000
9	11	1.39	9.12	1.001	53	1.000
10	12.3	1.44	10.3	1.001	63.3	1.000
11	10.8	1.44	11.6	1.001	75	1.000
12	7.57	1.40	13.1	1.001	88.1	1.000
13	5.32	1.37	14.8	1.001	103	1.000
14	5.12	1.38	16.7	1.001	120	1.000
15	6.7	1.44	18.9	1.001	139	1.000
16	9.34	1.51	21.3	1.001	160	1.000
17	12.1	1.57	24.1	1.001	184	1.000
18	14.2	1.68	27.2	1.001	211	1.000
19	15.2	1.93	30.7	1.001	242	1.000
20	15.3	2.37				





Station 30

Print Date: 13-12-2017

Database Name: TDEM_SLO_EPSG2229.gdb

UTMX: 5873116

UTMY: 2166280

EPSG: NAD83/California zone 5, EPSG:2229

Importer: Not Available

Version: Not Available

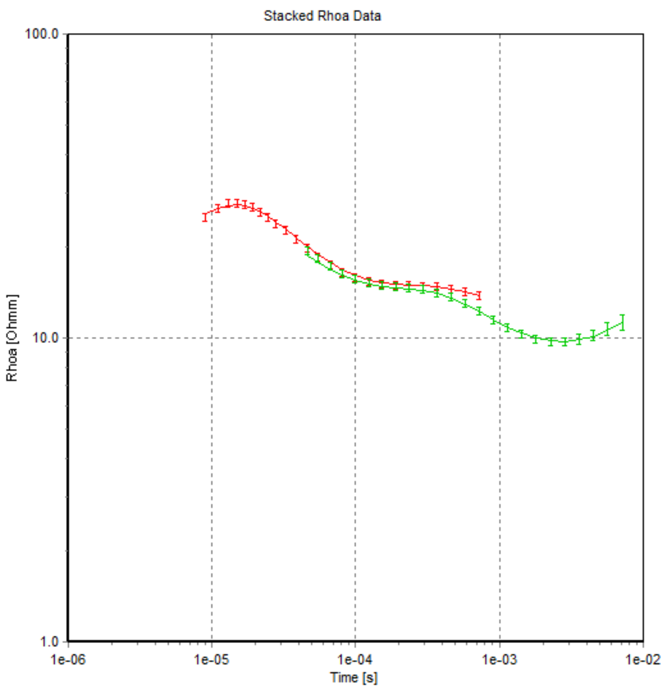
Data Residual: 0.4

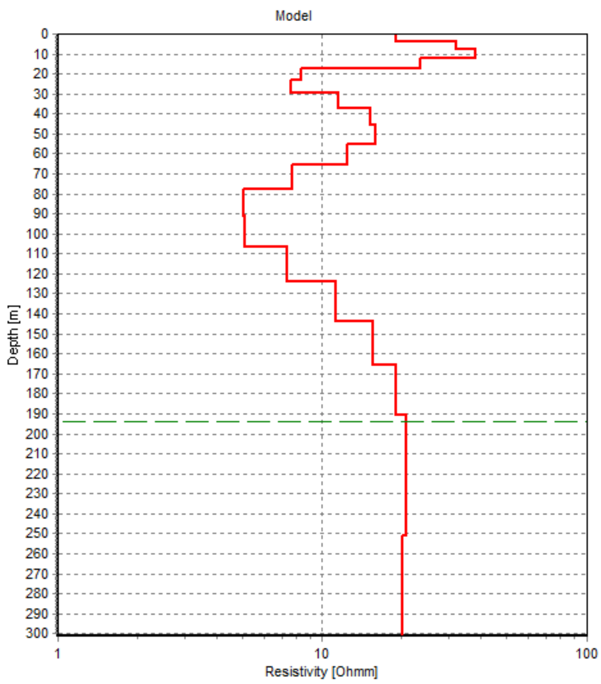
No. of Layers: 20

DOI: 194m

Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	18.9	1.20	3.59	1.001	3.59	1.001
2	32	1.45	4.05	1.001	7.64	1.001
3	37.8	1.44	4.57	1.001	12.2	1.001
4	23.3	1.36	5.16	1.001	17.4	1.000
5	8.35	1.21	5.83	1.001	23.2	1.000
6	7.65	1.23	6.58	1.001	29.8	1.000
7	11.5	1.35	7.43	1.001	37.2	1.000
8	15.2	1.42	8.38	1.001	45.6	1.000
9	15.9	1.46	9.47	1.001	55	1.000
10	12.5	1.43	10.7	1.001	65.7	1.000
11	7.73	1.38	12.1	1.001	77.8	1.000
12	5.03	1.34	13.6	1.001	91.4	1.000
13	5.07	1.35	15.4	1.001	107	1.000
14	7.4	1.44	17.4	1.001	124	1.000
15	11.3	1.53	19.6	1.001	144	1.000
16	15.6	1.60	22.1	1.001	166	1.000
17	19	1.67	25	1.001	191	1.000
18	20.8	1.81	28.2	1.001	219	1.000
19	20.8	2.09	31.9	1.001	251	1.000
20	20	2.55				

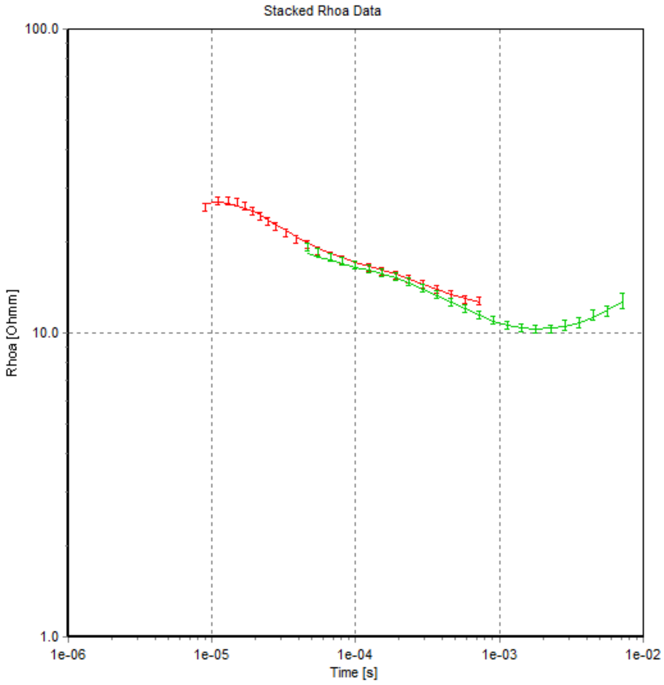


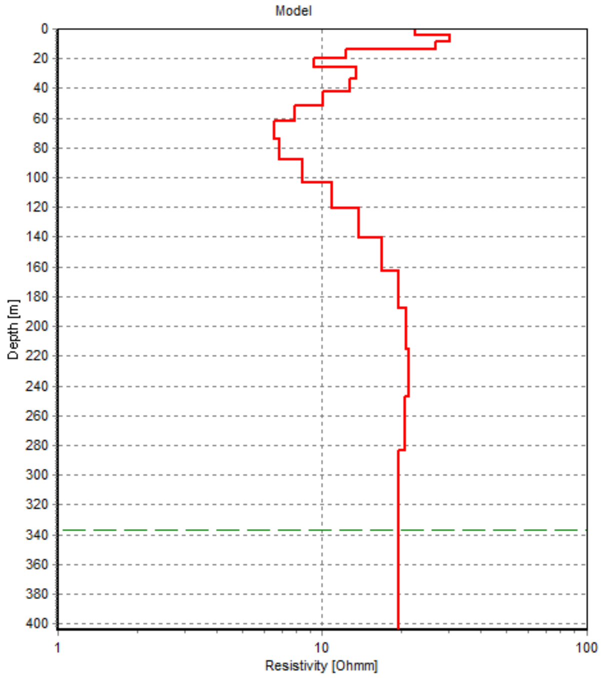


Station 31

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873052
UTMY: 2166119
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.5
No. of Layers: 20
DOI: 337m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	22.3	1.24	4.05	1.001	4.05	1.001
2	30.4	1.40	4.57	1.001	8.63	1.001
3	26.9	1.35	5.17	1.001	13.8	1.001
4	12.3	1.26	5.83	1.001	19.6	1.000
5	9.28	1.21	6.58	1.001	26.2	1.000
6	13.4	1.33	7.43	1.001	33.6	1.000
7	12.6	1.36	8.39	1.001	42	1.000
8	10	1.36	9.48	1.001	51.5	1.000
9	7.82	1.34	10.7	1.001	62.2	1.000
10	6.61	1.34	12.1	1.001	74.3	1.000
11	6.89	1.37	13.6	1.001	87.9	1.000
12	8.43	1.42	15.4	1.001	103	1.000
13	10.8	1.48	17.4	1.001	121	1.000
14	13.8	1.55	19.6	1.001	140	1.000
15	16.8	1.59	22.1	1.001	162	1.000
16	19.3	1.63	25	1.001	187	1.000
17	20.8	1.73	28.2	1.001	216	1.000
18	21.1	2.00	31.9	1.001	248	1.000
19	20.5	2.46	36	1.001	284	1.000
20	19.4	3.08				

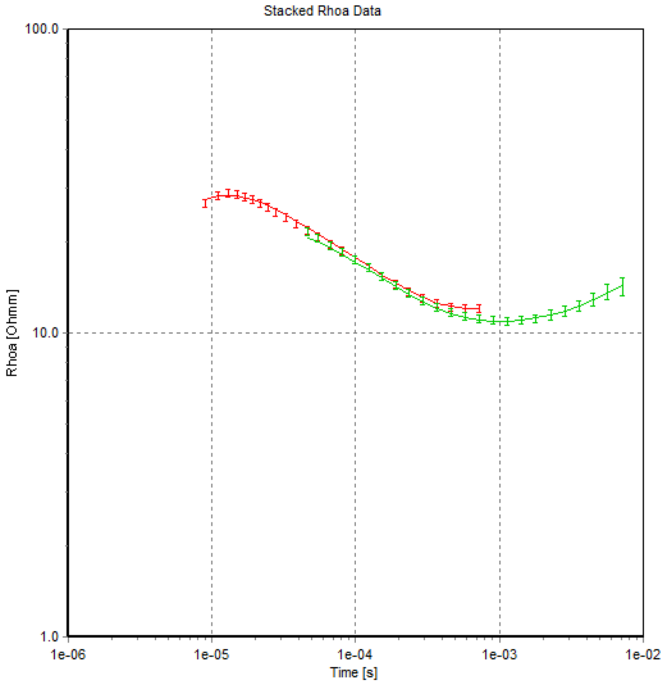


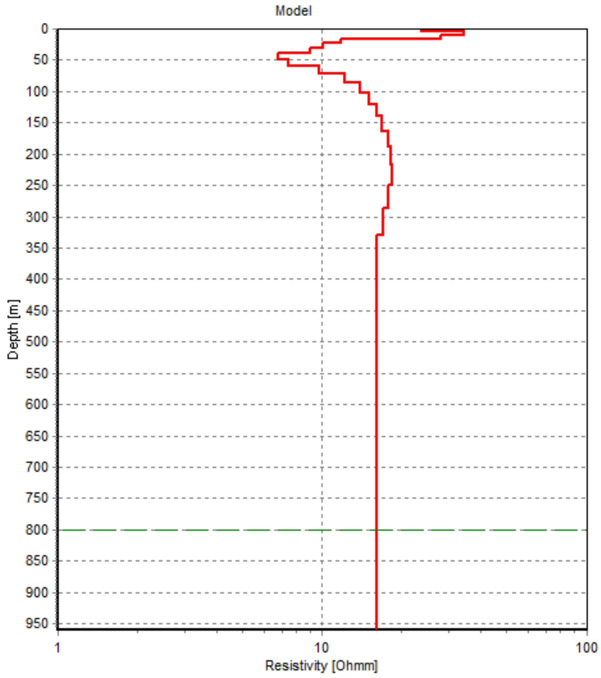


Station 32

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5872749
UTMY:	2161098
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.4
No. of Layers:	20
DOI:	800m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	23.8	1.17	4.7	1.001	4.7	1.001
2	34.2	1.40	5.31	1.001	10	1.001
3	27.9	1.33	5.99	1.001	16	1.001
4	11.7	1.21	6.76	1.001	22.8	1.000
5	10	1.23	7.64	1.001	30.4	1.000
6	8.96	1.27	8.62	1.001	39	1.000
7	6.79	1.26	9.73	1.001	48.8	1.000
8	7.46	1.32	11	1.001	59.8	1.000
9	9.69	1.39	12.4	1.001	72.2	1.000
10	12.1	1.45	14	1.001	86.2	1.000
11	13.9	1.49	15.8	1.001	102	1.000
12	15.1	1.52	17.9	1.001	120	1.000
13	16	1.55	20.2	1.001	140	1.000
14	16.8	1.58	22.8	1.001	163	1.000
15	17.7	1.60	25.7	1.001	188	1.000
16	18.2	1.66	29	1.001	217	1.000
17	18.3	1.75	32.8	1.001	250	1.000
18	17.9	1.80	37	1.001	287	1.000
19	17	1.68	41.8	1.001	329	1.000
20	16	1.14				

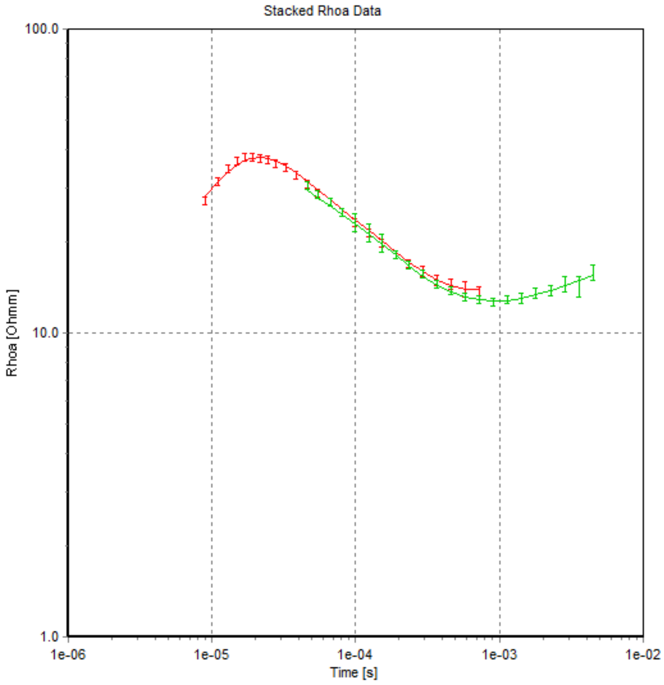


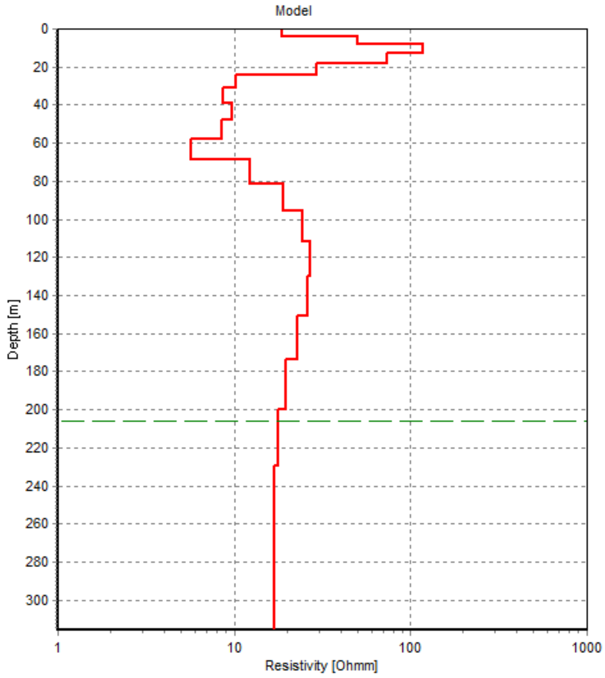


Station 33

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873093
UTMY: 2161727
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.5
No. of Layers: 20
DOI: 206m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	18.6	1.14	3.76	1.001	3.76	1.001
2	50.1	1.51	4.24	1.001	8	1.001
3	118	1.62	4.79	1.001	12.8	1.001
4	73.3	1.51	5.41	1.001	18.2	1.000
5	29.4	1.38	6.11	1.001	24.3	1.000
6	10.3	1.21	6.89	1.001	31.2	1.000
7	8.69	1.24	7.78	1.001	39	1.000
8	9.72	1.31	8.79	1.001	47.8	1.000
9	8.53	1.33	9.92	1.001	57.7	1.000
10	5.67	1.26	11.2	1.001	68.9	1.000
11	12.2	1.45	12.6	1.001	81.5	1.000
12	19.1	1.55	14.3	1.001	95.8	1.000
13	24.5	1.61	16.1	1.001	112	1.000
14	26.9	1.64	18.2	1.001	130	1.000
15	25.9	1.64	20.5	1.001	151	1.000
16	22.9	1.63	23.2	1.001	174	1.000
17	19.7	1.65	26.2	1.001	200	1.000
18	17.6	1.79	29.6	1.001	230	1.000
19	16.8	2.15	33.4	1.001	263	1.000
20	16.9	2.78				

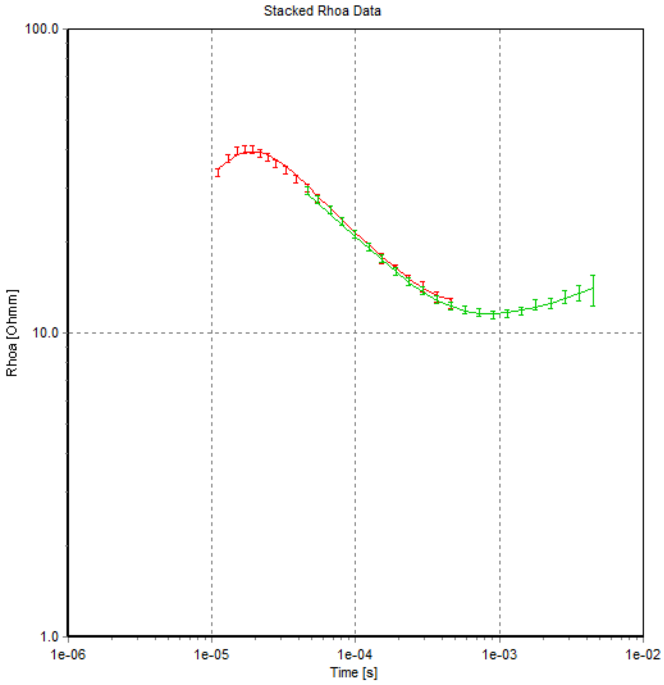


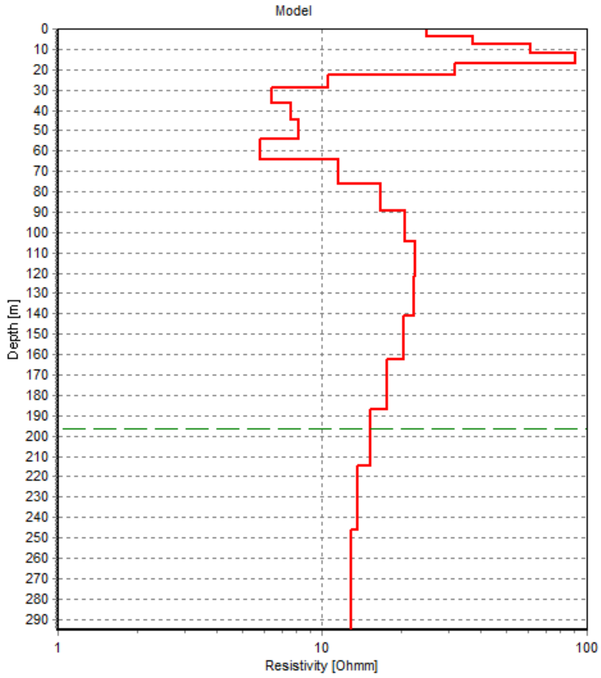


Station 34

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873031
UTMY: 2161619
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.6
No. of Layers: 20
DOI: 197m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	25	1.32	3.52	1.001	3.52	1.001
2	37	1.44	3.97	1.001	7.49	1.001
3	61.1	1.61	4.48	1.001	12	1.001
4	90.7	1.61	5.06	1.001	17	1.000
5	31.8	1.41	5.71	1.001	22.7	1.000
6	10.5	1.24	6.45	1.001	29.2	1.000
7	6.4	1.19	7.28	1.001	36.5	1.000
8	7.57	1.27	8.22	1.001	44.7	1.000
9	8.1	1.34	9.28	1.001	54	1.000
10	5.81	1.28	10.5	1.001	64.5	1.000
11	11.5	1.46	11.8	1.001	76.3	1.000
12	16.7	1.54	13.4	1.001	89.6	1.000
13	20.6	1.59	15.1	1.001	105	1.000
14	22.5	1.63	17	1.001	122	1.000
15	22.2	1.65	19.2	1.001	141	1.000
16	20.2	1.66	21.7	1.001	163	1.000
17	17.5	1.73	24.5	1.001	187	1.000
18	15.2	1.95	27.7	1.001	215	1.000
19	13.6	2.41	31.2	1.001	246	1.000
20	12.9	3.13				

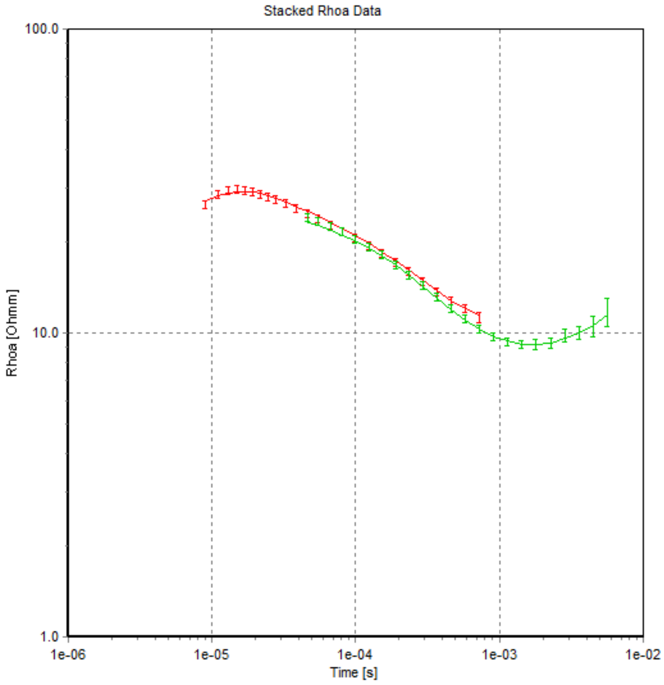


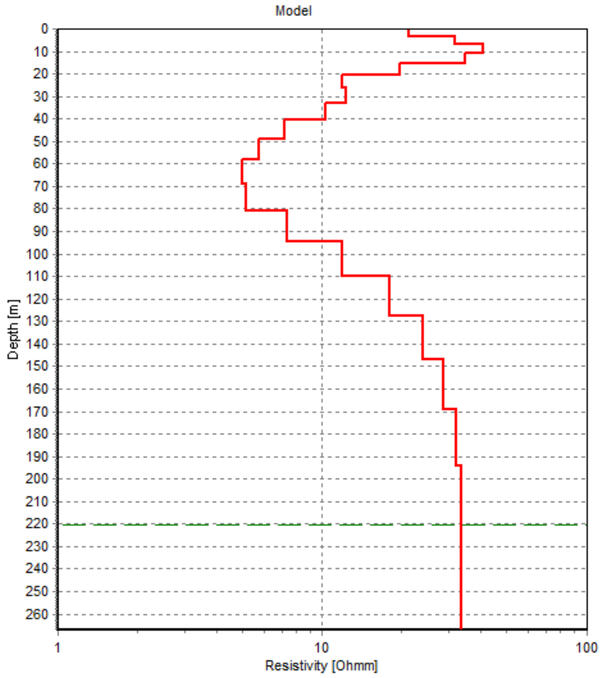


Station 35

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873108
UTMY: 2165190
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.4
No. of Layers: 20
DOI: 220m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	21.2	1.27	3.18	1.001	3.18	1.001
2	31.6	1.45	3.59	1.001	6.77	1.001
3	40.3	1.51	4.05	1.001	10.8	1.001
4	34.5	1.42	4.58	1.001	15.4	1.000
5	19.6	1.36	5.17	1.001	20.6	1.000
6	11.9	1.27	5.83	1.001	26.4	1.000
7	12.2	1.33	6.59	1.001	33	1.000
8	10.3	1.32	7.44	1.001	40.4	1.000
9	7.2	1.30	8.4	1.001	48.8	1.000
10	5.76	1.30	9.48	1.001	58.3	1.000
11	4.95	1.31	10.7	1.001	69	1.000
12	5.13	1.34	12.1	1.001	81.1	1.000
13	7.36	1.42	13.6	1.001	94.7	1.000
14	11.9	1.52	15.4	1.001	110	1.000
15	17.9	1.63	17.4	1.001	128	1.000
16	23.9	1.74	19.6	1.001	147	1.000
17	28.8	1.87	22.2	1.001	169	1.000
18	32	2.04	25	1.001	194	1.000
19	33.4	2.27	28.3	1.001	223	1.000
20	33.6	2.55				

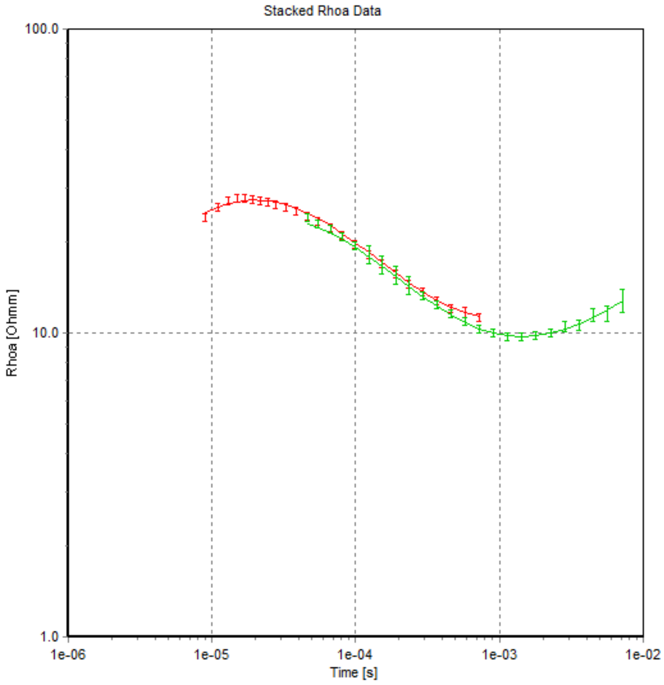


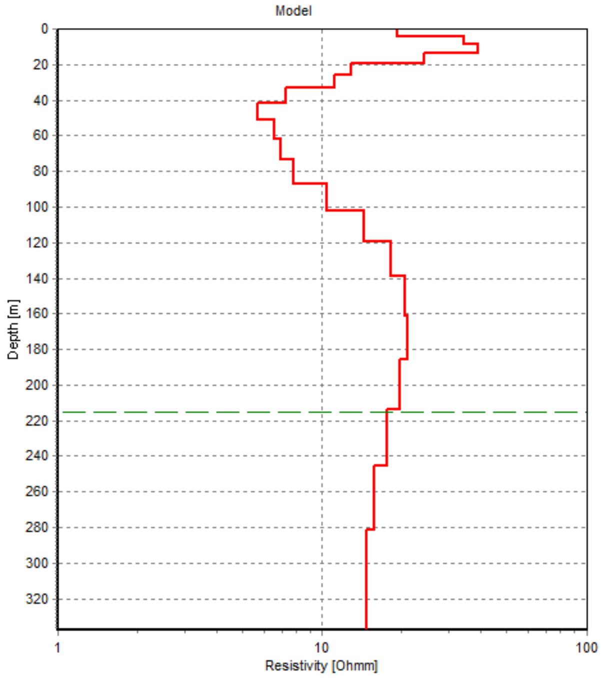


Station 36

Print Date: 13-12-2017
Database Name: TDEM_SLO_EPSG2229.gdb
UTMX: 5873478
UTMY: 2164121
EPSG: NAD83/California zone 5, EPSG:2229
Importer: Not Available
Version: Not Available
Data Residual: 0.5
No. of Layers: 20
DOI: 215m
Program: SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	19.1	1.17	4.02	1.001	4.02	1.001
2	34.2	1.44	4.54	1.001	8.56	1.001
3	38.6	1.41	5.12	1.001	13.7	1.001
4	24.4	1.35	5.79	1.001	19.5	1.000
5	12.9	1.25	6.53	1.001	26	1.000
6	11.1	1.29	7.37	1.001	33.4	1.000
7	7.26	1.25	8.32	1.001	41.7	1.000
8	5.66	1.25	9.4	1.001	51.1	1.000
9	6.57	1.34	10.6	1.001	61.7	1.000
10	6.95	1.37	12	1.001	73.7	1.000
11	7.78	1.40	13.5	1.001	87.2	1.000
12	10.4	1.47	15.3	1.001	102	1.000
13	14.3	1.55	17.2	1.001	120	1.000
14	18.2	1.61	19.5	1.001	139	1.000
15	20.6	1.65	22	1.001	161	1.000
16	20.9	1.68	24.8	1.001	186	1.000
17	19.6	1.76	28	1.001	214	1.000
18	17.6	1.97	31.6	1.001	246	1.000
19	15.8	2.39	35.7	1.001	281	1.000
20	14.7	3.04				

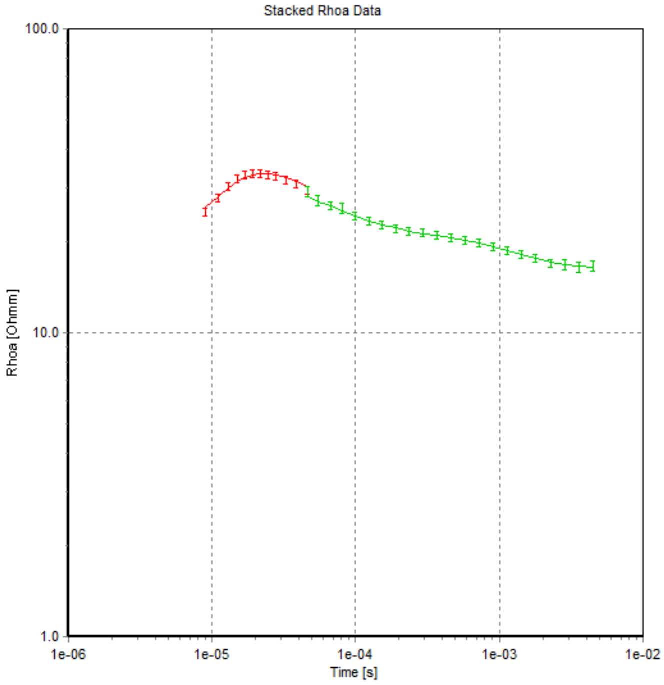


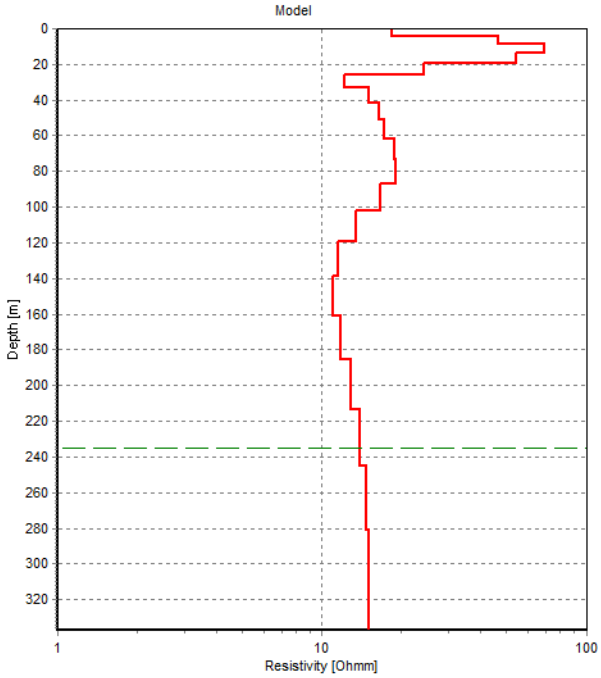


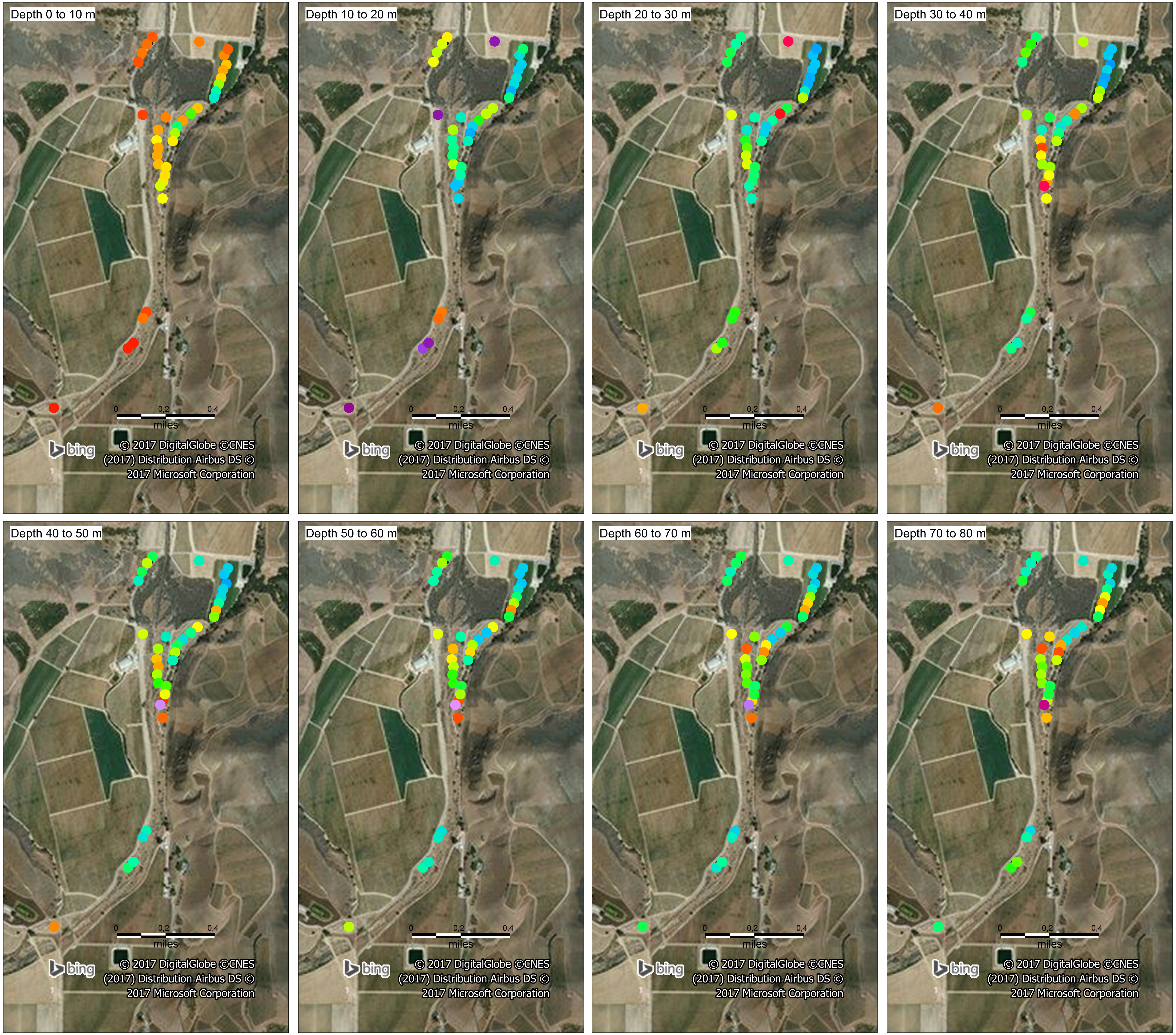
Station 37

Print Date:	13-12-2017
Database Name:	TDEM_SLO_EPSG2229.gdb
UTMX:	5872852
UTMY:	2161191
EPSG:	NAD83/California zone 5, EPSG:2229
Importer:	Not Available
Version:	Not Available
Data Residual:	0.4
No. of Layers:	20
DOI:	235m
Program:	SPIA.exe, version 2.3.1.0

#	Res	ResSTD	Thk	ThkSTD	Dep	DepSTD
1	18.4	1.14	4.01	1.001	4.01	1.001
2	46.4	1.49	4.53	1.001	8.55	1.001
3	69.3	1.50	5.12	1.001	13.7	1.001
4	54.1	1.44	5.78	1.001	19.4	1.000
5	24.3	1.36	6.52	1.001	26	1.000
6	12.2	1.23	7.36	1.001	33.3	1.000
7	15	1.33	8.31	1.001	41.6	1.000
8	16.5	1.37	9.39	1.001	51	1.000
9	17.2	1.40	10.6	1.001	61.6	1.000
10	18.7	1.44	12	1.001	73.6	1.000
11	18.9	1.47	13.5	1.001	87.1	1.000
12	16.6	1.47	15.3	1.001	102	1.000
13	13.5	1.45	17.2	1.001	120	1.000
14	11.5	1.44	19.4	1.001	139	1.000
15	11.1	1.45	21.9	1.001	161	1.000
16	11.7	1.46	24.8	1.001	186	1.000
17	12.9	1.50	28	1.001	214	1.000
18	14	1.66	31.6	1.001	245	1.000
19	14.8	2.08	35.7	1.001	281	1.000
20	15.1	2.79				







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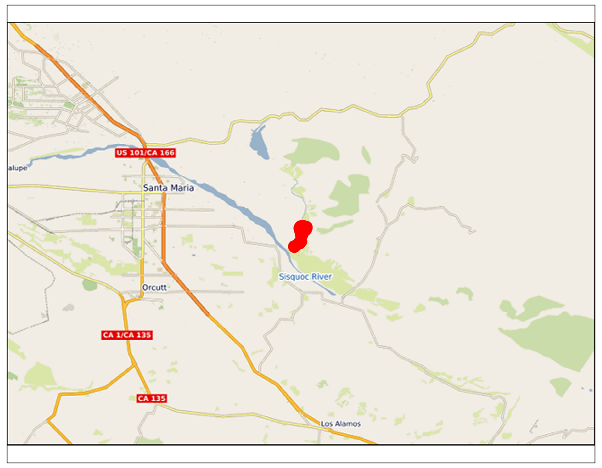

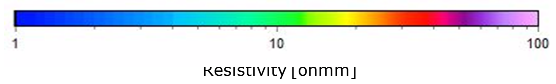

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Annex 2.01

Mean resisitivity 0 to 80 mbsl.

Cuyama River Valley Fringe Area - TDEM

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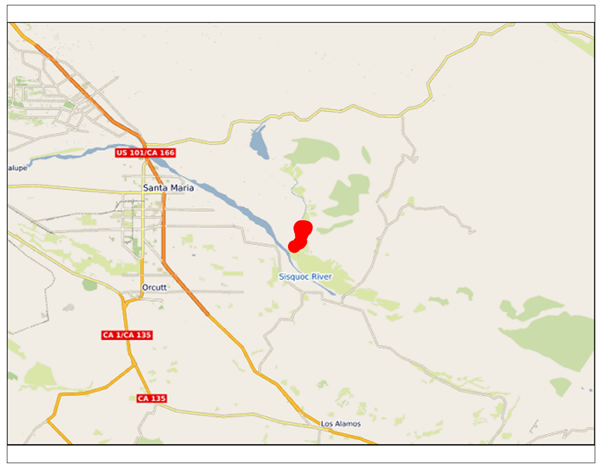

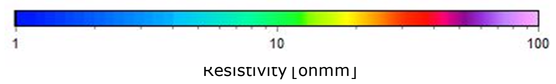

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Annex 2.02

Mean resisitivity 80 to 160 mbsl.

Cuyama River Valley Fringe Area - TDEM

RAMBOLL

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