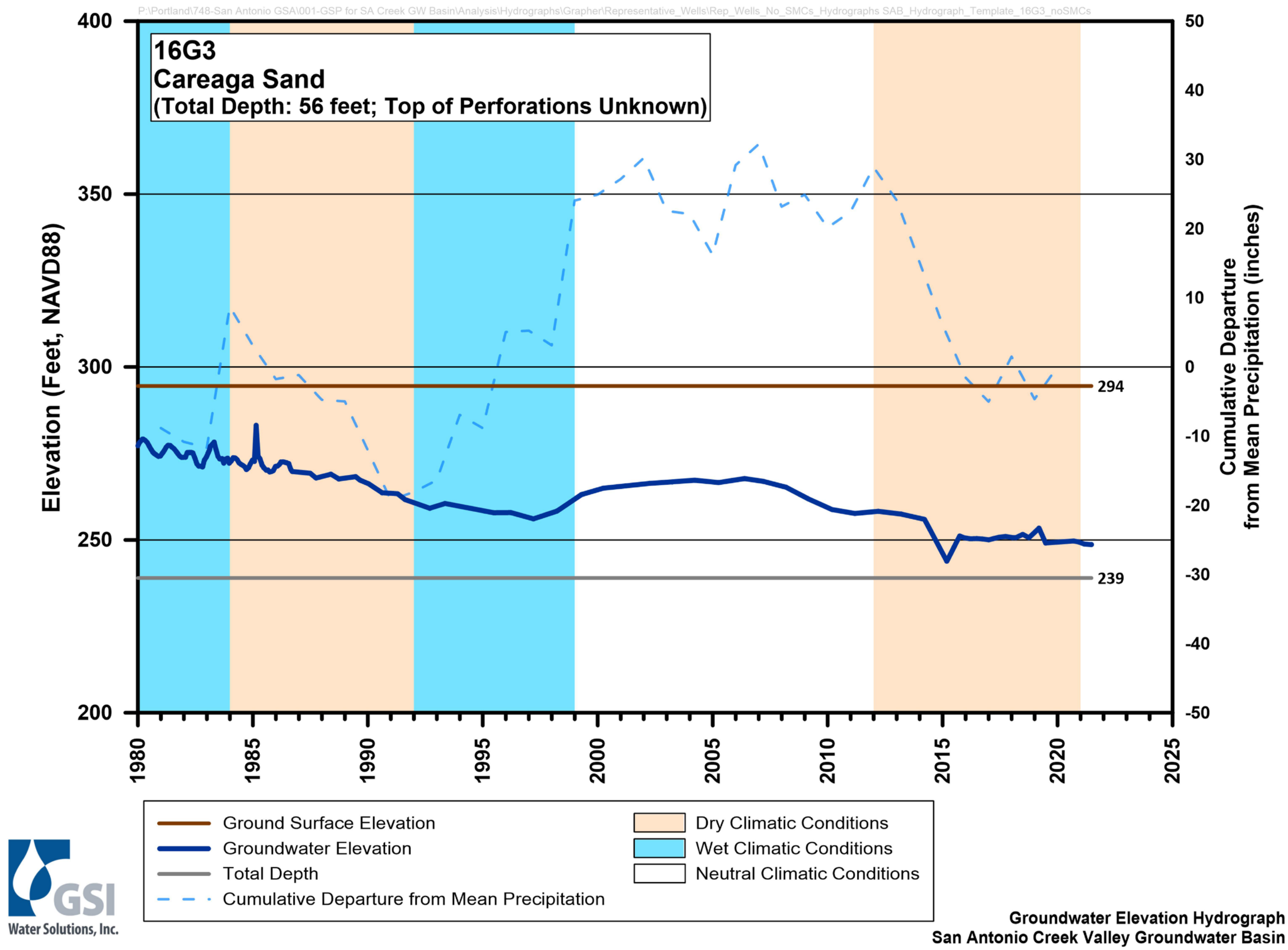

Figure 3-22. Hydrograph of Well 16G3, Careaga Sand

The locations of wells 25D1, 14L1, and 16G3 are shown on Figure 3-11. Well 25D1 is northwest of the town of Los Alamos. Well 14L1 is near the intersection of State Highway 135 and San Antonio Road. Well 16G3 is adjacent to the Barka Slough. The locations of the three wells provide a spatially representative picture of groundwater levels in the Basin from approximately 1980 to present day. Changes in rainfall are generally reflected in the water level hydrographs. Groundwater levels in all three hydrographs have indicated a downward trend until 2017, when above-average precipitation occurred. A plot of the cumulative departure from mean annual precipitation indicates a period of above-average rainfall beginning prior to 1980 and lasting until 1983. That period was followed by below-average rainfall until 1990. A period of above-average rainfall continued until 2011. Although some recovery has occurred in groundwater levels during periods of above-average rainfall, the overall trend shows sharply declining water levels. Since 2017, when the Basin received above-average precipitation, the observed water levels in wells 25D1 and 16G3 show stabilization. Water levels measured in well 14L1 continue to show a steep decline in water levels.

Table 3-3 lists the groundwater elevation high, low, and total change over the period of record for wells 25D1, 14L1, and 16G3. The historical groundwater elevation low for all three wells has occurred in the past 6 years.

Table 3-3. Change in Groundwater Elevations – Careaga Sand

Well Name	Aquifer	Groundwater Elevation High (ft amsl)	Year	Groundwater Elevation Low (ft amsl)	Year	Total Change (ft)	Period of Record (Years)
25D1	Careaga Sand	721.05	1977	646.28	2016	(60.38)	42
14L1	Careaga Sand	311.13	1981	259.49	2021	(48.41)	41
16G3	Careaga Sand	280.44	1976	243.85	2015	(35.04)	43

Notes

Parentheses around a value, such as (60.38), indicate a negative value

ft amsl = feet above mean sea level ft = feet yrs = years

3.2.1.3 Well Impact Analysis

A well impact analysis was performed to aid in selecting minimum thresholds for the chronic lowering of groundwater levels sustainability indicator (see Section 4). Fall 2018 groundwater elevations were compared with top of well screen elevations for agricultural, municipal, and domestic wells screened in principal aquifers within the Basin. The percentage of wells with water levels below top of screen was calculated in 5-foot increments, starting with fall 2018 water levels.

The well impact analysis included 61 agricultural, municipal, and domestic wells in the Basin that have documented well construction and location information. The analysis was performed to help identify conditions that could result in a significant and unreasonable depletion of supply if static groundwater elevations fall below the top of well screen elevations.[18] Groundwater levels that consistently fall below the

[18] Well construction and location information were obtained from the California Department of Water Resources (DWR) Online System for Well Completion Reports, resulting in a total of 423 wells. Filtering the data set to only include wells with well construction and location information (location information required a latitude/longitude measurement with an accuracy more precise than Centroid of Section) resulted in a total of 43 wells. Agricultural wells included in the Groundwater Level Monitoring Network with known well construction information, LACSD municipal wells, and VSFB municipal wells were also included in the analysis.

top of the well screen are likely to result in increased well clogging from biological growth and mineral precipitation, cascading water, sand pumping, and reduced well yield. These conditions are considered by the SABGSA to be undesirable. The magnitude of this impact on well production differs depending on well type: agricultural, municipal, or domestic. For example, agricultural wells often are deeper and have longer well screens that can tolerate the loss of efficiency and greater drawdown that can result from water levels falling below top of screen. Municipal wells serve drinking water to citizens living in the Basin and therefore supply reduction cannot be easily addressed. Likewise, domestic wells tend to be shallower and may be more sensitive to water levels falling within the screen interval. For perspective, the average well depths for municipal, agricultural, and domestic wells included in the well impact analysis were approximately 587 ft, 684 ft, and 565 ft below ground surface, respectively.

Fall 2018 groundwater elevations measured in basin monitoring wells were used to assess how many wells have static water levels that are below the top of screen elevation as of that date and how many would be below top of screen if groundwater levels were lower.[19] The results of the analysis presented on Figure 3-23 indicate that groundwater water elevations in fall 2018 were below top of screen in 20 percent of domestic wells and 12 percent of agricultural wells in the Basin. No municipal wells had static groundwater elevations below the top of well screen. The well impact analysis was used to determine the number and type of wells in the Basin that may further be impacted (i.e., groundwater elevations below well top of screen elevation) if groundwater elevations decline further compared to fall 2018 groundwater elevations (see Figures 3-24 through 3-26).

[19] Fall 2018 groundwater elevations were selected based on recent available data with the greatest number of monitoring locations.

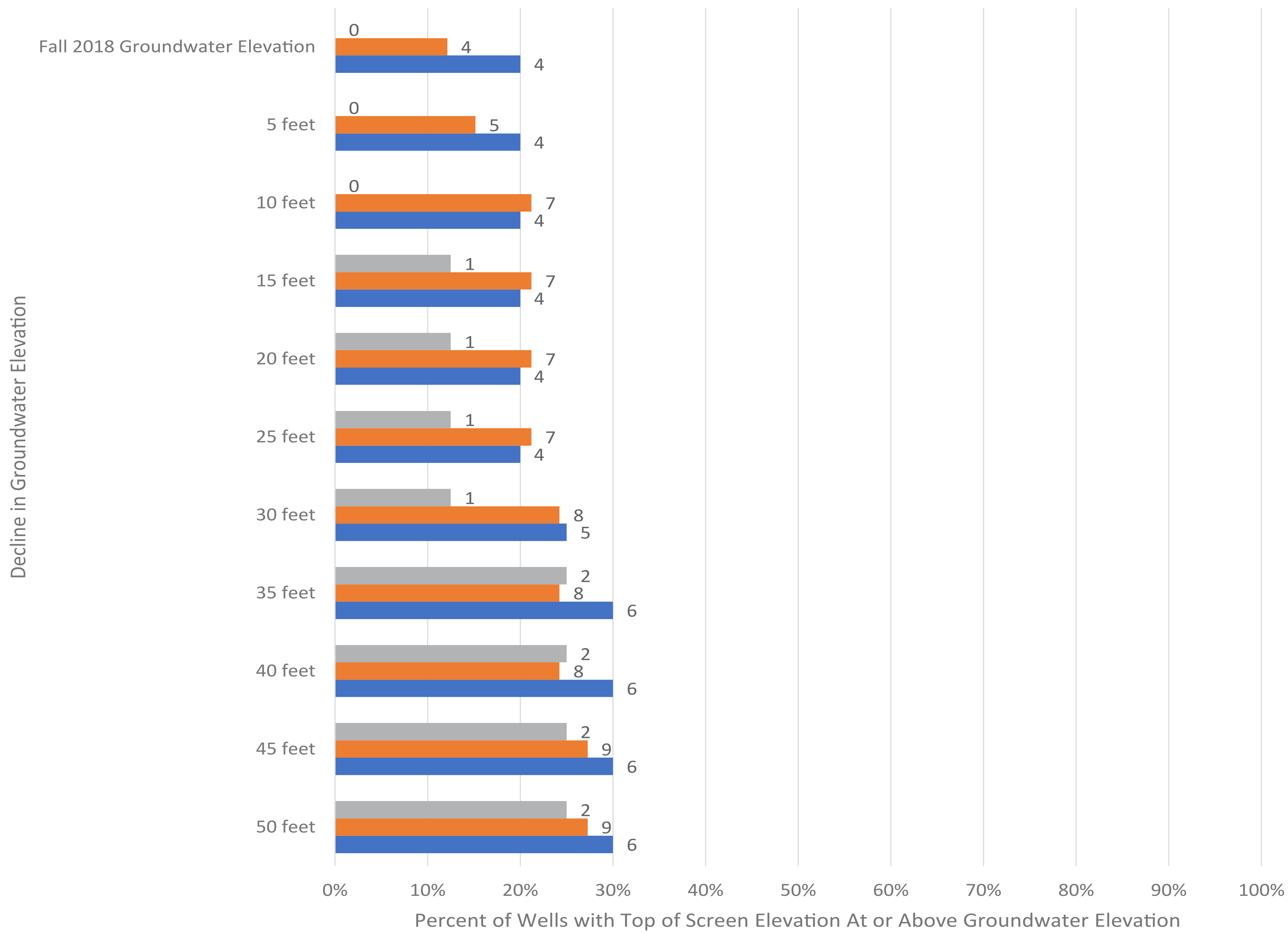

FIGURE 3-23

Well Impact Analysis, Paso Robles Formation and Careaga Sand, Fall 2018

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

- Municipal Wells (8)
- Agricultural Wells (33)
- Domestic Wells (20)

Date: September 16, 2021
Data Sources: DWR (n.d.)

GSI Water Solutions, Inc.

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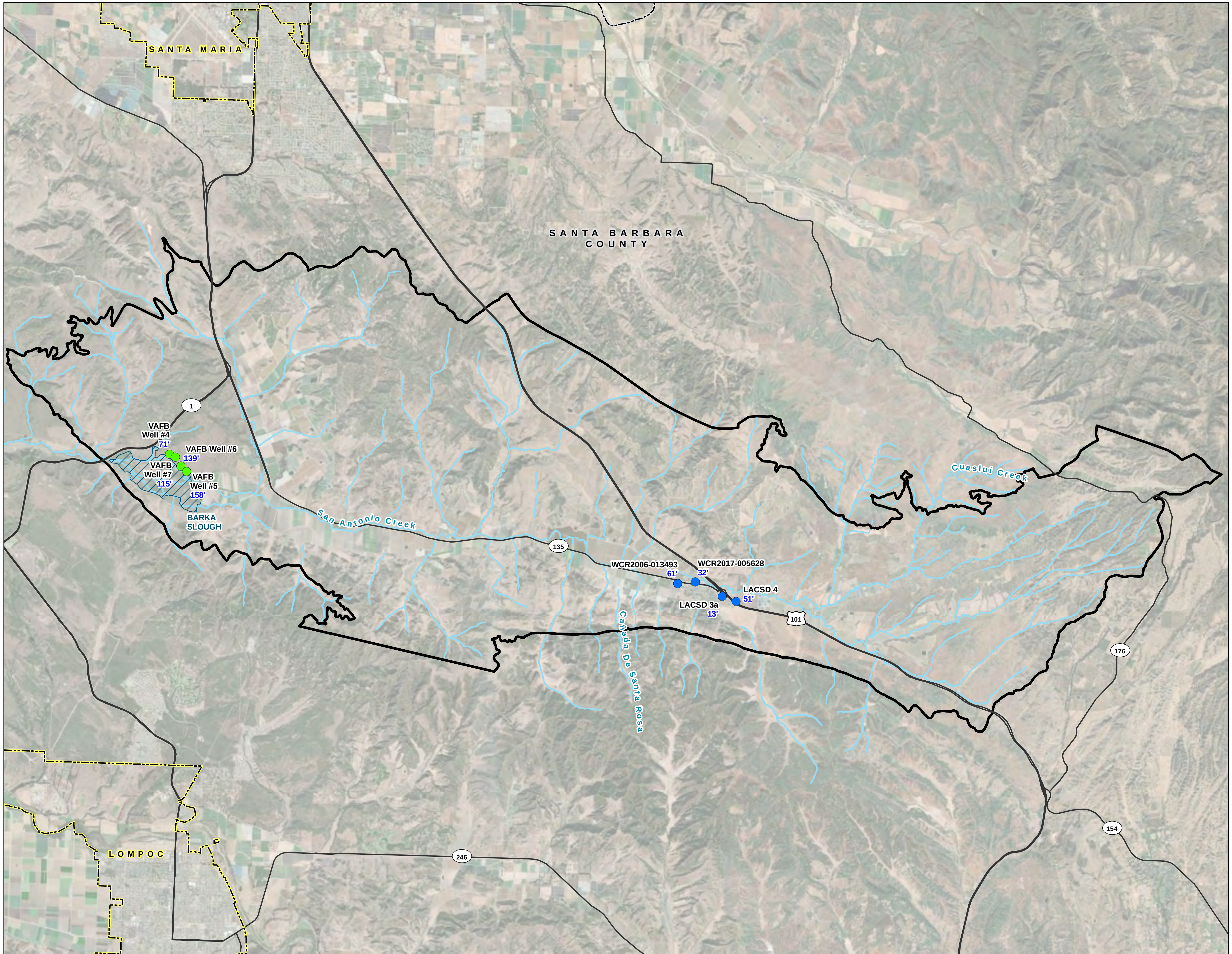

FIGURE 3-24

Well Impact Analysis for Municipal Wells Fall 2018

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Municipal Wells (by screened aquifer)

- Paso Robles Formation
- Careaga Sand Formation
- **80'** Approximate number of feet of groundwater above the reported well top of screen elevation compared to the Fall 2018 groundwater elevations in the Paso Robles Formation or Careaga Sand.

All Other Features

- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road
- San Antonio Creek or Adjacent Tributary

NOTE

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020)

GSI Water Solutions, Inc.

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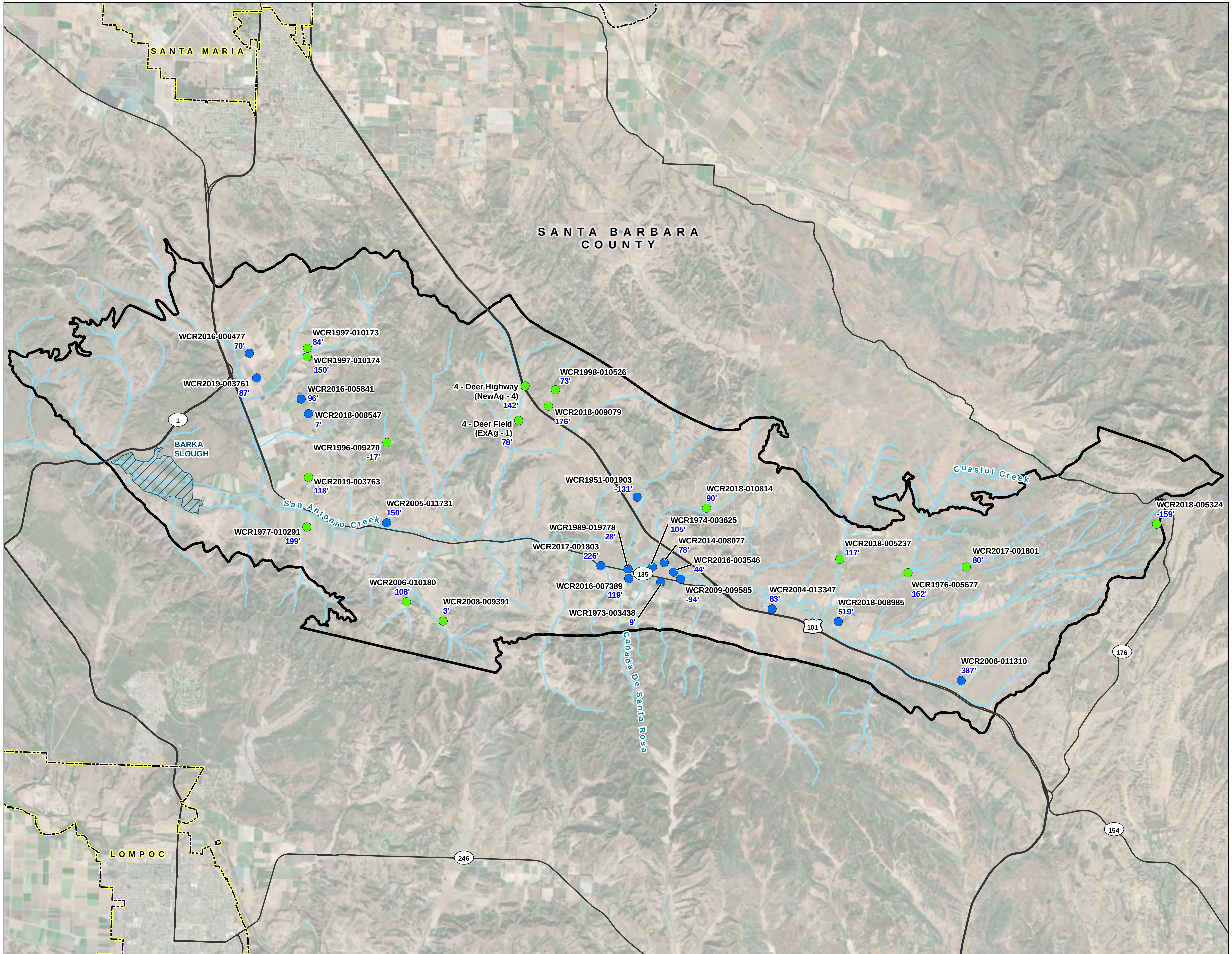
FIGURE 3-25

Well Impact Analysis for Agricultural Wells Fall 2018

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin



LEGEND

Agricultural Wells (by screened aquifer)

- Paso Robles Formation
- Careaga Sand Formation
- 80' Approximate number of feet of groundwater above the reported well top of screen elevation compared to the Fall 2018 groundwater elevations in the Paso Robles Formation or Careaga Sand.

All Other Features

- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road
- San Antonio Creek or Adjacent Tributary

NOTE

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

N

0 5,000 10,000 15,000
Feet

GSI Water Solutions, Inc.

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020)

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_25_Agricultural_Well_Impact_Analysis_top.mxd, abarry

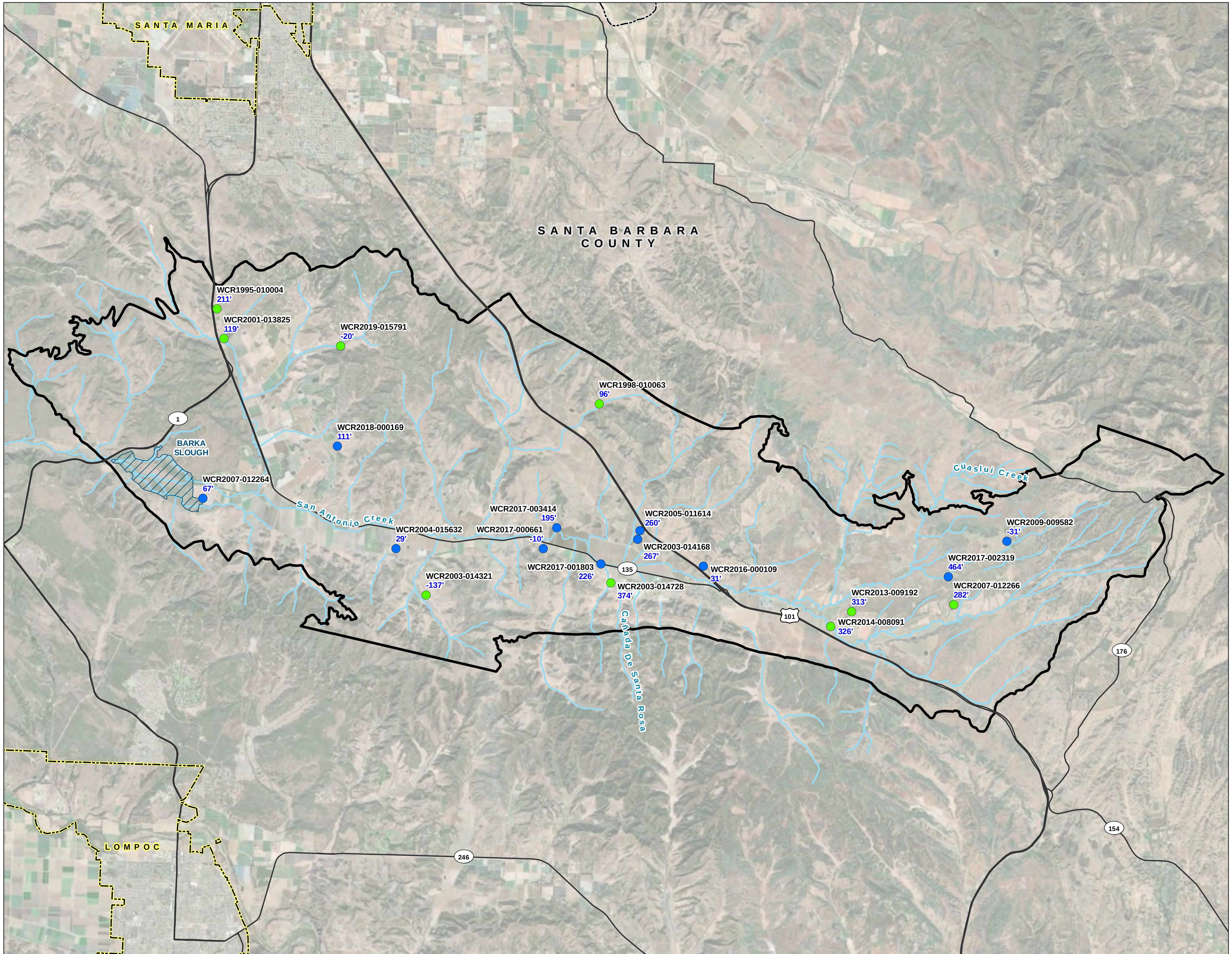


FIGURE 3-26

Well Impact Analysis for Domestic Wells Fall 2018

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Domestic Wells (by screened aquifer)

- Paso Robles Formation
- Careaga Sand Formation

80' Approximate number of feet of groundwater above the reported well top of screen elevation compared to the Fall 2018 groundwater elevations in the Paso Robles Formation or Careaga Sand.

All Other Features

- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road
- San Antonio Creek or Adjacent Tributary

NOTE

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

N

0 5,000 10,000 15,000
Feet

GSI Water Solutions, Inc.

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020)

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_26_Domestic_Well_Impact_Analysis_top.mxd, abarry

3.2.1.4 Vertical Groundwater Gradients

SGMA regulations require assessment of vertical gradients to evaluate the vertical direction of groundwater movement between and within aquifers. Vertical groundwater gradients can be estimated from nested or clustered wells. Currently, there four sets of nested wells in the Basin monitoring network: wells SACR 1 through SACR 5, wells SAGR and 14L1, wells 16C2 and 16C4, and wells SACC 1 through SACC 5 (see Figure 3-1 for their locations). Table 3-4 describes construction details and calculated vertical groundwater gradients for the nested wells. The wells and vertical groundwater gradient within each nested well set is ordered from deepest to shallowest. Based on the data from the four sets of nested wells, the vertical gradient of groundwater is generally downward in the eastern portion of the Basin and gradually becomes upward moving toward Barka Slough.

Table 3-4. Vertical Groundwater Gradient in Nested Wells

Well Name (From)	Aquifer	Surface Elevation (ft amsl)	Groundwater Elevation (ft amsl)	Well Depth (ft bgs)	Well Depth (ft amsl)	Well Name (To)	Vertical Gradient
SACR 1	Careaga Sand	362.45	314.78	690	(327.55)	SACR 2	0.16
SACR 2	Paso Robles Formation	362.45	291.22	540	(177.55)	SACR 3	0.21
SACR 3	Paso Robles Formation	362.45	251.54	350	12.45	SACR 4	(0.12)
SACR 4	Paso Robles Formation	362.45	267.70	220	142.45	SACR 5	0.04
SACR 5	Paso Robles Formation	362.45	262.75	110	252.45	—	—
14L1	Careaga Sand	328.72	237.92	593	(264.28)	SAGR	(0.06)
SAGR	Paso Robles Formation	329.64	266.94	90	239.64	—	—
SACC 1	Paso Robles Formation	586.08	369.53	940	(353.92)	SACC 2	(0.02)
SACC 2	Paso Robles Formation	586.08	373.08	720	(133.92)	SACC 3	0.01
SACC 3	Paso Robles Formation	586.08	371.25	530	56.08	SACC 4	(0.23)
SACC 4	Paso Robles Formation	586.08	418.00	325	261.08	SACC 5	(0.30)
SACC 5	Paso Robles Formation	586.08	478.99	120	466.08	—	—
16C4	Careaga Sand	328.59	262.14	560	(231.41)	16C2	0.02
16C2	Careaga Sand	328.59	253.99	169	159.59	—	—

Notes

Parentheses around a value, such as (327.55), indicate a negative value.

Groundwater elevation data are from the third quarter of 2020.

— = not applicable

ft amsl = feet above mean sea level

ft bgs = feet below ground surface

Wells SACR 1 through SACR 5 include wells screened in both the Paso Robles Formation (SACR 2 through SACR 5) and the Careaga Sand (SACR 1). Ordered from shallowest to deepest they are SACR 5 through SACR 1. Hydrographs for these wells are shown on Figure 3-27. Groundwater data for the set of nested wells indicate that the highest groundwater levels were recorded in SACR 1. It is apparent that there is an upward gradient within the nested wells except for the interval between SACR 3 and SACR 4, which is an approximate downward gradient of -0.12 ft/ft at this location.

SAGR and 14L1, are located adjacent to one another on the west end of the Basin and screened in the Paso Robles Formation and Careaga Sand, respectively. Hydrographs for these wells are shown on Figure 3-28. Groundwater gaging data for wells SAGR and 14L1 indicate that, prior to May 2017, groundwater levels in the Careaga Sand were higher than in the Paso Robles Formation at this location, indicating an upward vertical gradient. Declining water levels in the Careaga Sand since May of 2017 have resulted in a reversal in the direction of groundwater flow and an approximate downward gradient of -0.06 ft/ft at this location, as evident in the hydrograph for 14L1.

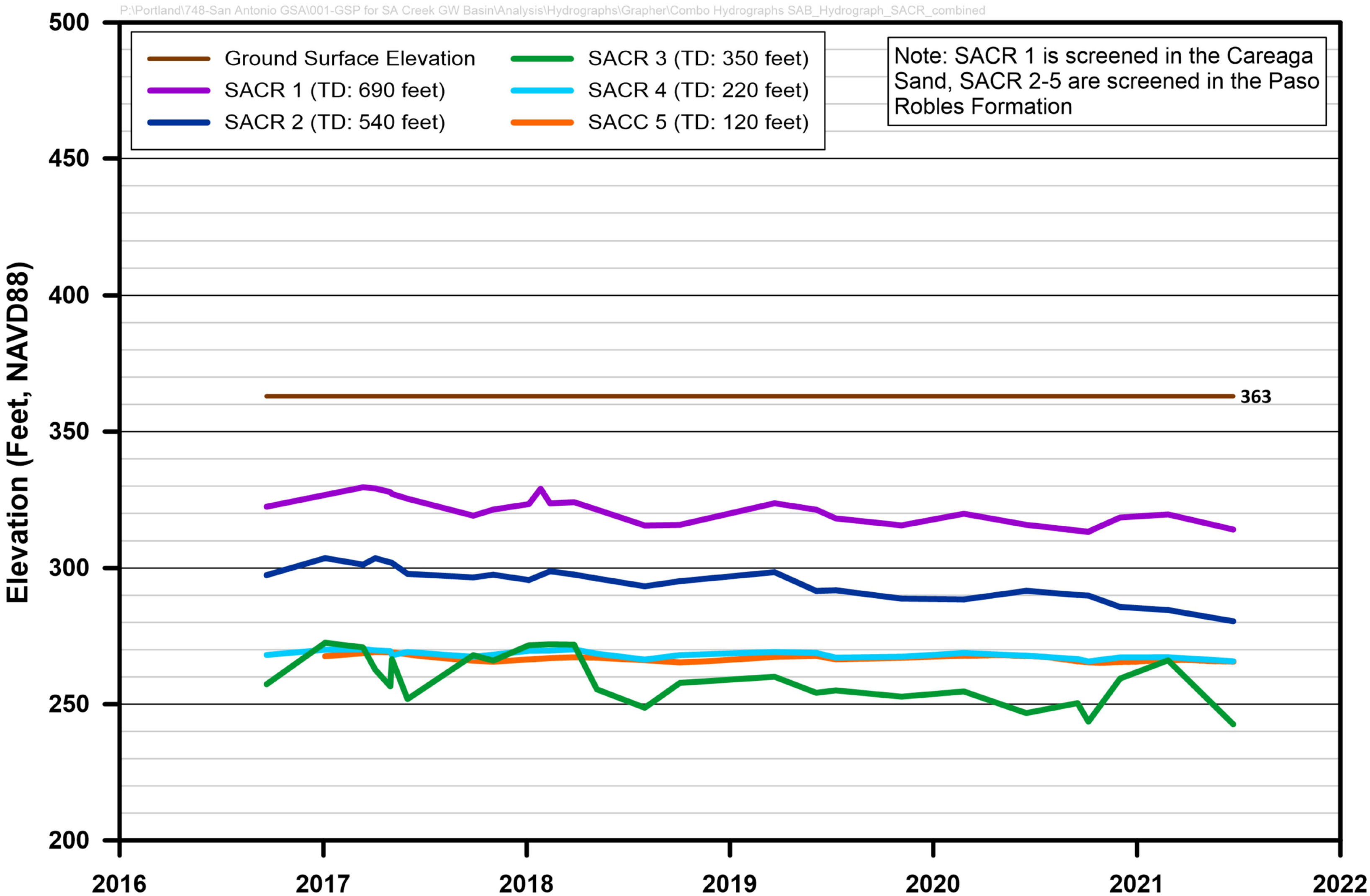


Figure 3-27. Hydrographs for SACR 1 through SACR 5

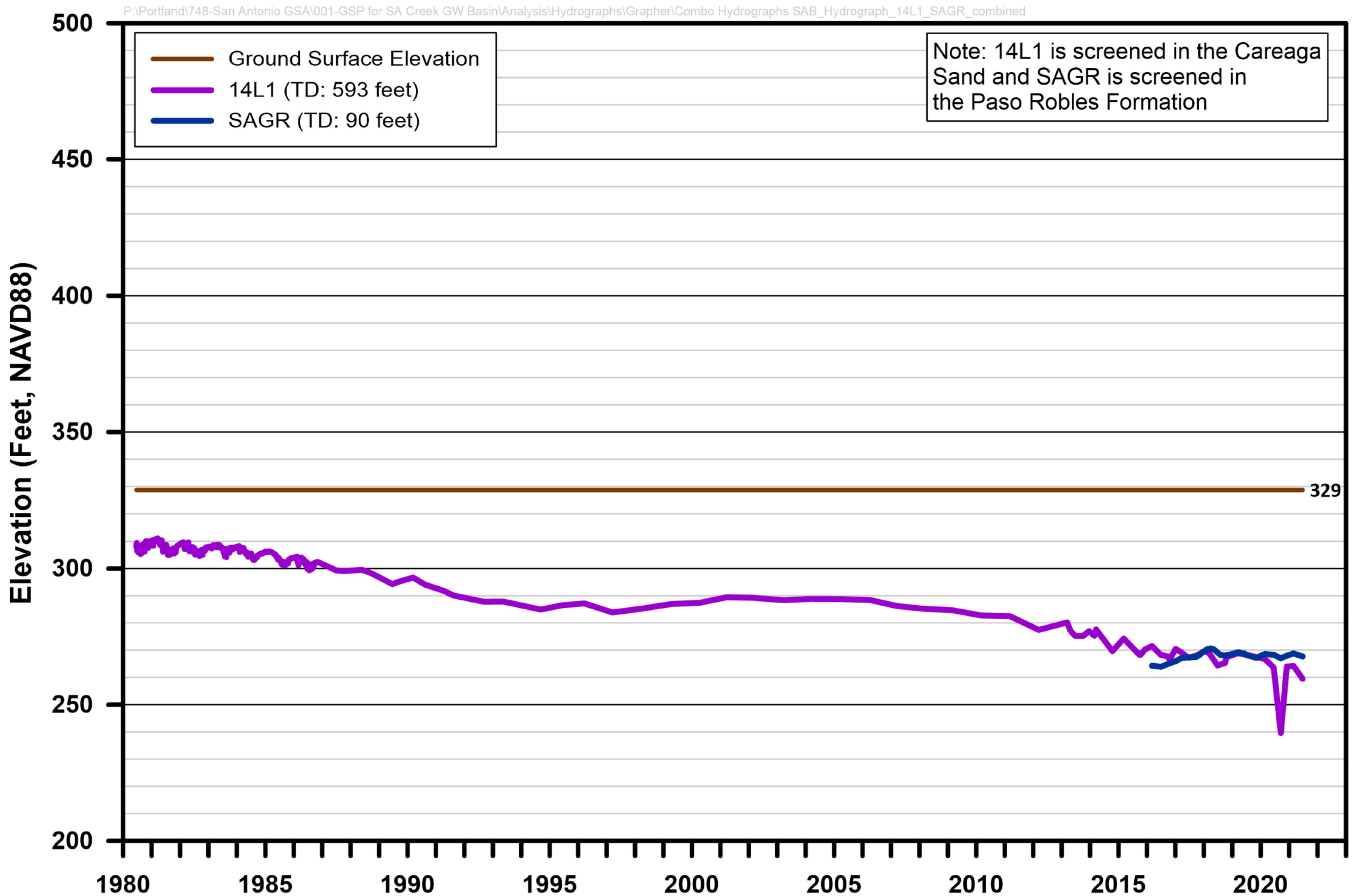


Figure 3-28. Hydrographs for 14L1 and SAGR

Nested wells, SACC 1 through SACC 5, are located near the town of Los Alamos and are all screened in the Paso Robles Formation. Ordered from shallowest to deepest they are SACC 5 through SACC 1. Hydrographs for these wells are shown on Figure 3-29. Groundwater data for the set of nested wells indicate that the highest groundwater levels were recorded in SACC 5. It is apparent that there is an overall downward gradient within the nested wells except for the interval between SACC 2 and SACC 3, which as an approximate upward gradient of 0.01 ft/ft at this location.

A pair of nested wells, 16C2 and 16C4, are located in the Barka Slough area and are both screened in the Careaga Sand. Hydrographs for these wells are shown on Figure 3-30. Well 16C4 is the deeper of the two wells and has a historically higher groundwater elevation, indicating an upward groundwater gradient. The upward flux of groundwater in this area of the Basin is suspected to be a result of the bedrock ridge underlying the western edge of the Barka Slough. The bedrock ridge forces virtually all groundwater to the surface as base flow in the Santa Ynez River or as vertical flux into the Barka Slough. Refer to Figure 3-31 The vertical gradient at this location is approximately 0.02 ft/ft.

The formation and continued existence of Barka Slough is largely due to surface water inflow and the upward flow of groundwater from the underlying Careaga Sand through Barka Slough sediments, becoming surface water or groundwater available to phreatophytes. The Careaga Sand is likely confined in this area of the Basin and therefore generates a hydraulic head that is at a higher elevation than the average ground surface elevation of Barka Slough. Wells 16C2 and 16C4 provide a long record of groundwater elevations in the Careaga Sand in the area of Barka Slough. The ground surface elevation at wells 16C2 and 16C4 is approximately 328.59 ft amsl and the approximate elevation of the average ground surface elevation of Barka Slough is 261 ft amsl. Hydrographs for wells 16C2 and 16C4 indicate artesian conditions have existed in both wells over much of the period of record (1970 through 2020). However, the hydraulic heads of 16C2 and 16C4 over the period of record have decreased by approximately 40 and 45 ft, respectively. Currently, groundwater levels in well 16C4 are equal to the elevation of the average ground surface elevation of Barka Slough. Artesian conditions have not existed at well 16C2 since 2013. A continued decrease in groundwater elevations in the Careaga Sand could result in less groundwater discharging to the Slough and may have an impact on the health of Barka Slough. Surface water is also flowing into Barka Slough. Continued periods of below-average rainfall will also have an effect on Barka Slough habitat.

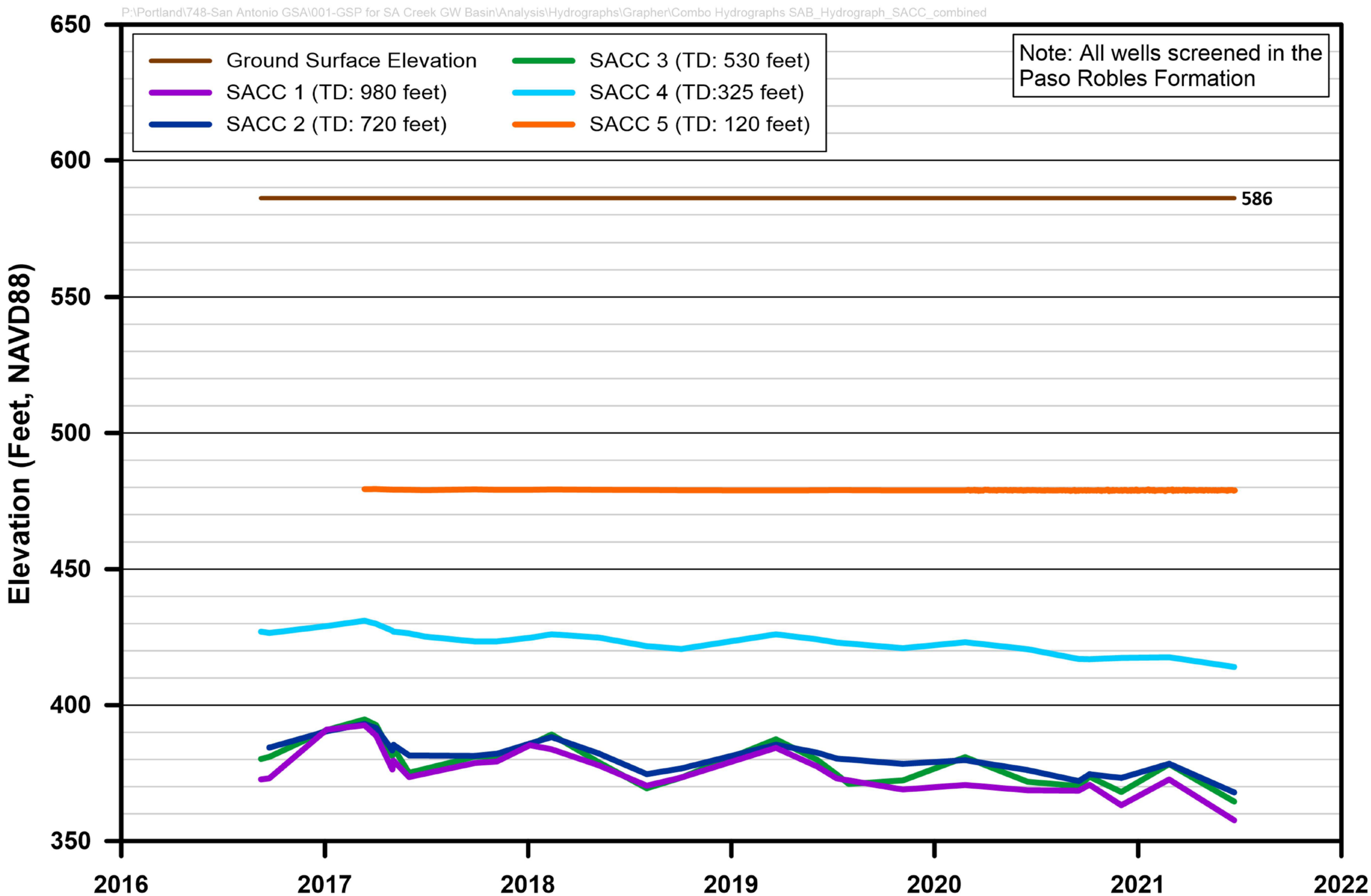


Figure 3-29. Hydrographs for SACC 1 through SACC 5

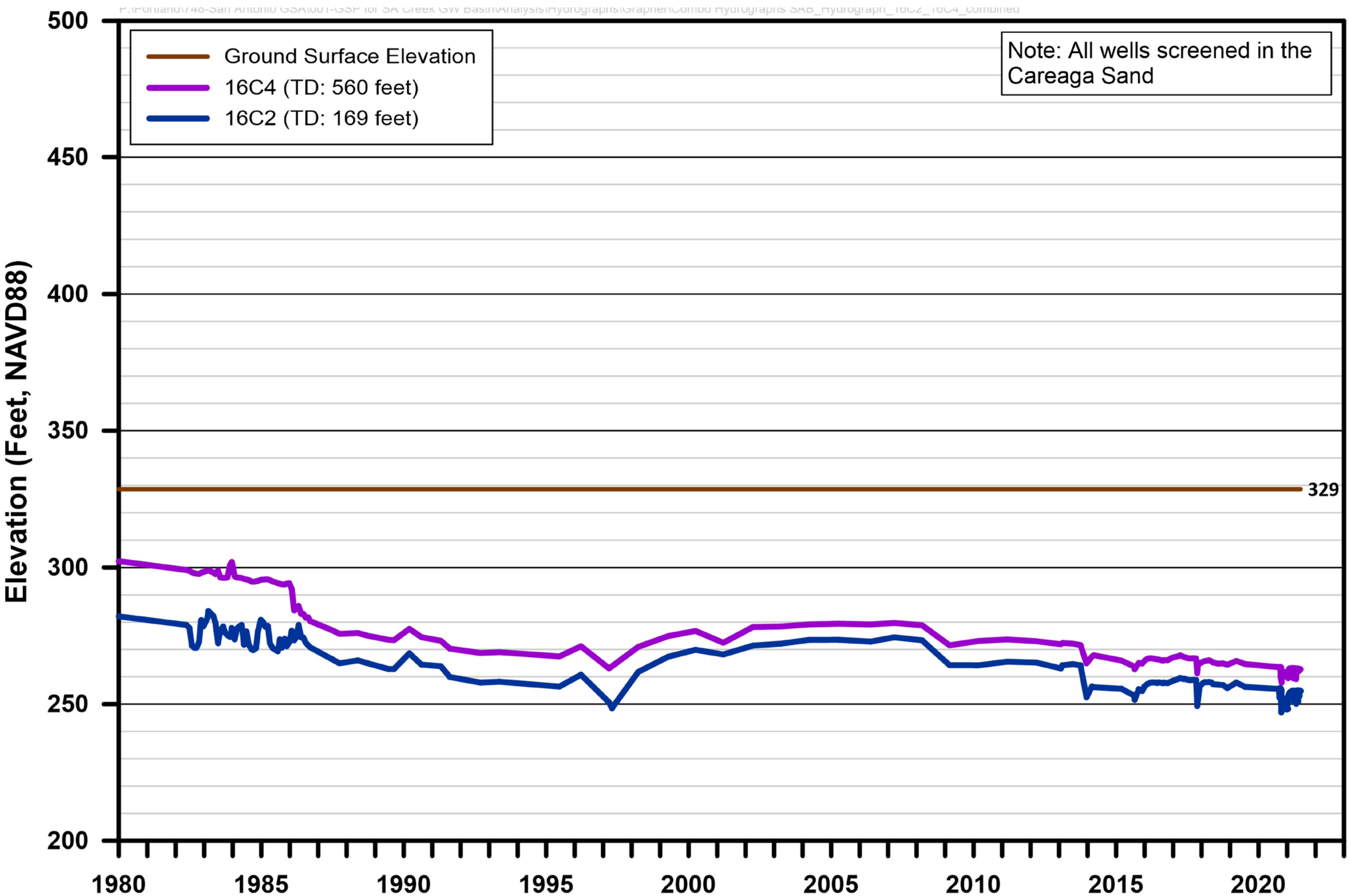


Figure 3-30. Hydrographs for 16C2 and 16C4

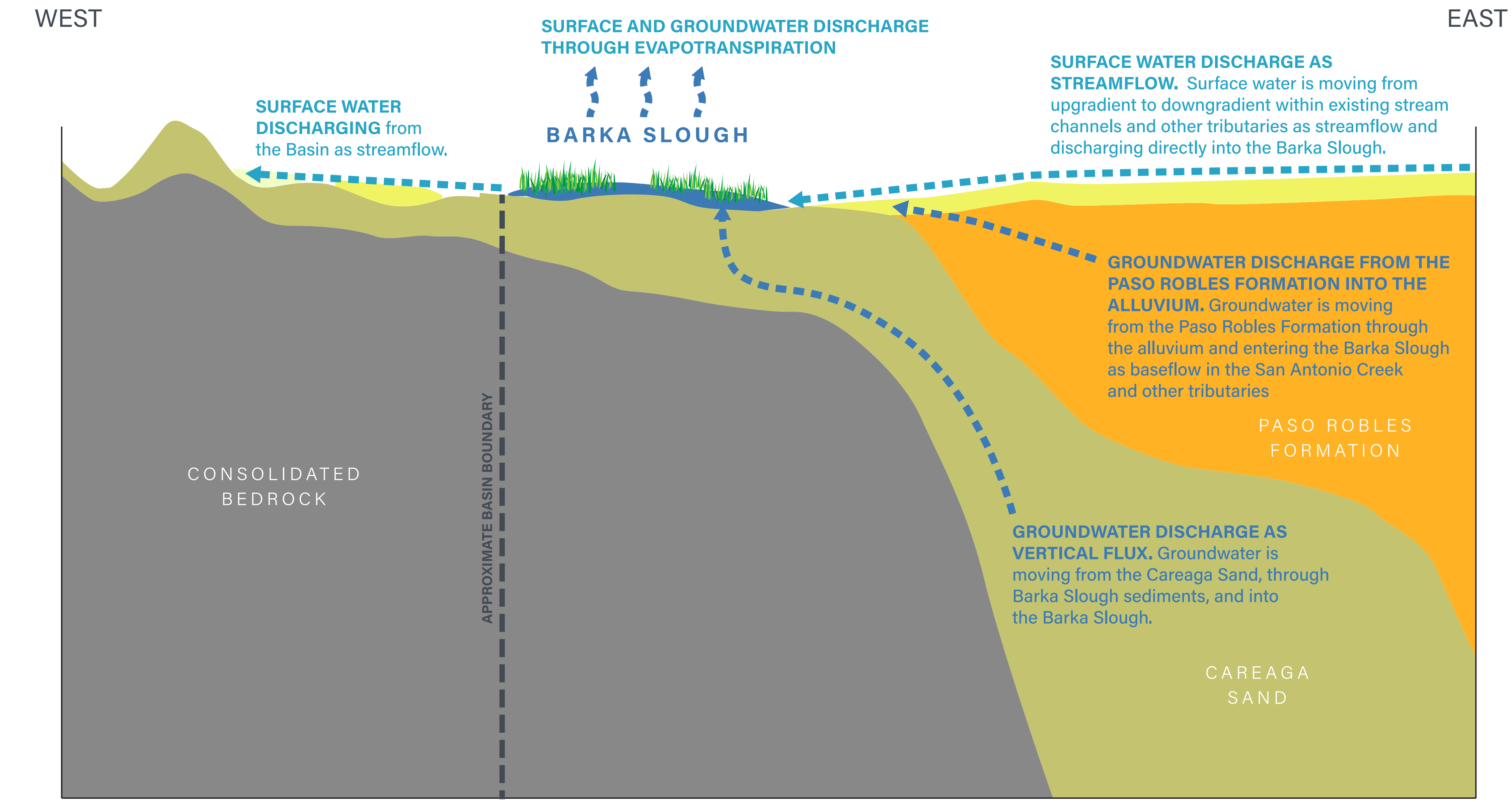


FIGURE 3-31

Conceptualized Surface Water and Groundwater Discharge into the Barka Slough

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

- Channel Alluvium
- Paso Robles Formation
- Careaga Sand
- Consolidated Bedrock

NOTE

View looking north

Date: September 16, 2021
Data Sources: USGS (2020c)

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3.2.2 Change of Groundwater in Storage [§ 354.16(b)]

§ 354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(b) A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.

Changes in groundwater storage for the Paso Robles Formation and the Careaga Sand are addressed in Section 3.3, Water Budget.

3.2.3 Groundwater Quality Distribution and Trends [§ 354.16(d)]

§ 354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes

This section provides a summary of the groundwater quality distribution and trends in the Basin. Water quality is presented in terms of various beneficial uses (drinking water and agricultural), point sources of groundwater contamination, and naturally occurring constituents in groundwater. Groundwater quality samples have been collected and analyzed throughout the Basin for various studies and programs. A broad survey of groundwater quality has been conducted by USGS as part of its GAMA Program. Historical groundwater quality data from NWIS and the SWRCB GeoTracker GAMA database were compiled. Water quality data were also obtained for the LACSD wells as part of the SWRCB Division of Drinking Water (DDW) public supply well water quality program.

This GSP focuses on constituents that relate to beneficial uses of groundwater that might be impacted by groundwater management activities. The constituents of concern are chosen for either or both of the following reasons:

- The constituent has a drinking water standard (MCL or SMCL).
- The constituent has a basin WQO.

3.2.3.1 Groundwater Quality Suitability for Drinking Water

Groundwater in the Basin is generally suitable for drinking water purposes. Water quality data from drinking water supply wells were analyzed to identify exceedances of drinking water standards. The data reviewed include 279 sampling events from the 13 wells in the Basin that are included in the DDW program, collected between March 1984 and November 2019. Drinking water standards are established by federal and state agencies by setting concentration thresholds for certain groundwater constituents using MCLs and SMCLs. MCLs are regulatory thresholds and SMCLs are guidelines established for nonhazardous aesthetic considerations such as taste, odor, and color. WQOs are set by the RWQCB to protect beneficial uses of groundwater.

Table 3-5 summarizes constituents with reported concentrations at or above their respective MCL, SMCL, or WQO. Concentrations of nitrate were measured above the water quality standards in one well. Concentrations of arsenic were measured above the water quality standards in another well. Concentrations of di(2-ethylhexyl)phthalate (DEHP) were detected at or above the MCL in two wells. None of the samples from LACSD wells exceed MCLs.

Iron and manganese were most frequently detected at concentrations at or above their respective SMCL. Samples analyzed for concentrations of iron from 5 of 10 wells exceeded the SMCL (0.3 milligrams per liter [mg/L]) in 83 out of 232 samples. Samples analyzed for concentrations of manganese from 6 of 10 wells exceeded the SMCL (0.05 mg/L) in 150 of 230 samples. Concentrations exceeding SMCLs may affect aesthetic qualities (taste and odor) of the water.

Table 3-5. Summary of Drinking Water and Agricultural Irrigation Water Quality Results

Constituent	MCL (mg/L)	SMCL (mg/L)	WQO (mg/L)	Number of			
				Samples at or Above WQ Standard	Samples Analyzed	Wells with Constituent Concentrations at or Above the WQ Standard	Wells Sampled
Drinking Water Quality							
Nitrate[1]	10[2]	—	5	1	67	1	11
Arsenic	0.01[2]	—	—	1	86	1	10
DEHP[3]	.004	—	—	2	32	2	5
TDS	—	1000[2]	600	0	119	0	11
Iron	—	0.3[2]	—	83	232	5	10
Manganese	—	0.05[2]	—	150	230	6	10
Agricultural Irrigation Water Quality							
Boron	—	—	0.2[2]	21	63	13	33
Chloride	—	500	150[2]	14	118	9	36
Sodium	—	—	100[2]	20	61	12	33
TDS	—	1,000	600[2]	26	116	19	35

Notes

[1] Nitrate concentration measured as nitrogen (EPA MCL)
[2] Water quality standard used to determine exceedances
[3.] State of California Division of Drinking Water MCL

— = No value
DEHP = di(2-ethylhexyl)phthalate
mg/L = milligram per liter
MCL = maximum contaminant level
SMCL = secondary maximum contaminant level
TDS = total dissolved solids
EPA = U.S. Environmental Protection Agency
WQO = water quality objective
WQ = water quality

References

California State Water Resources Control Board. (2019). California Code of Regulations, Title 22. April 16.
Central Coast Regional Water Quality Control Board. (2019). Water Quality Control Plan for the Central Coastal Basin, June 2019 Edition. California Environmental Protection Agency.

Historical MCL and SMCL exceedances of arsenic, iron, and manganese were detected in the VSFB wellfield in the vicinity of Barka Slough. The single exceedance of the MCL for arsenic occurred in 1990. Detected exceedances of the MCL for DEHP occurred in samples from two wells in the VSFB wellfield in 1989 and 1990. Available data indicate that these are isolated concentrations of DEHP that are not laterally continuous.

The single exceedance of the MCL for nitrate occurred in a well in Harris Canyon in 2011. Total dissolved solids (TDS), chloride, sulfate, and nitrate concentrations indicate an increasing trend in well LACSD 4 located east of Los Alamos; however, concentrations of these constituents remain below MCLs, SMCLs, and WQOs.

3.2.3.2 Groundwater Quality Suitability for Agricultural Irrigation

Groundwater in the Basin is generally suitable for agricultural purposes. The agricultural suitability of groundwater was evaluated using two metrics:

1. Salinity as indicated by concentrations of TDS
2. Specific ion toxicity as indicated by concentrations of sodium, chloride, and boron

Groundwater quality data were evaluated from the NWIS and GeoTracker GAMA data sets. The reviewed data consists of 108 sampling events from 37 wells in the Basin with known well completion records, collected between December 1969 and July 2019. Table 3-5 summarizes constituents with reported concentrations at or above their respective MCL, SMCL, or basin WQO.

Groundwater in the Basin is of widely varying quality and generally decreases in quality from east to west coincident with the groundwater flow direction. Concentrations of TDS generally increase from east to west along San Antonio Creek; and are greatest near the Barka Slough, along western San Antonio Creek, and in Harris Canyon. Measured TDS concentrations from 26 water samples collected from wells located throughout the Basin indicate that some caution should be used if irrigating salt-sensitive crops (SWRCB, 2019). Samples collected from 19 of 35 wells indicated TDS concentrations exceeding the WQO in 26 of 116 samples. A total of 16 of the 19 wells with concentrations of TDS exceeding the WQO are located in the western portion of the Basin along San Antonio Creek, near Barka Slough, or in Harris Canyon.

Concentrations of boron, sodium, and chloride are also elevated in the Barka Slough area, along western San Antonio Creek and in Harris Canyon. Analytical results for 20 samples indicate some caution should be used if irrigating with this water, due to potential sodium ion toxicity (SWRCB, 2019). Samples analyzed for concentrations of sodium from 12 of 33 wells exceeded the WQO (100 mg/L) in 20 of 61 samples. All the analytical results that exceeded the WQO were collected from wells located in the western portion of the Basin along San Antonio Creek, near Barka Slough, or in Harris Canyon.

Analytical results for 14 samples indicate some caution should be used if irrigating, due to potential chloride ion toxicity. Samples analyzed for concentrations of chloride from 9 of 36 wells exceeded the WQO (150 mg/L) in 14 of 118 samples. All but one of the samples with detected chloride concentrations exceeding the WQO were collected from wells located in the western portion of the Basin along San Antonio Creek, near Barka Slough, or in Harris Canyon.

Analytical results for 21 water samples indicate some caution should be used if irrigating specifically fruit (including grapes) (Hanson, Grattan, & Fulton, 2006), due to potential boron ion toxicity (SWRCB, 2019). Samples analyzed for concentrations of boron from 13 of 33 wells exceeded the WQO (0.2 mg/L) in 21 of 63 samples. All of the samples with detected boron concentrations exceeding the WQO were collected from wells located in the western portion of the Basin along San Antonio Creek, near Barka Slough, or in Harris Canyon.

Based on available information, the east-to-west trend of increasing TDS and salts concentrations is consistent between the Paso Robles Formation and the Careaga Sand. Analytical results from samples collected from nested monitoring wells (SACC and SACR), located near Los Alamos and along San Antonio Creek in the western portion of the Basin, indicate that concentrations of TDS decreased with depth.

3.2.3.3 Distribution and Concentrations of Point Sources of Groundwater Constituents

Potential point sources of groundwater quality degradation were identified from the SWRCB GeoTracker data management system. Waste Discharge Requirement permits from the SWRCB GeoTracker data management system were also reviewed. Table 3-6 summarizes information from these websites for open/active contaminated sites, permitted land disposal sites, and produced water facilities and underground injection control sites associated with oil and gas production. Figure 3-32 shows the locations of these potential groundwater contaminant point sources, the locations of completed/case-closed sites, the locations of permitted land disposal sites, and the locations of the produced water facilities and underground injection control sites associated with oil and gas production. Based on available information, there are no known impacts to principal aquifers associated with these cases.

Table 3-6. Potential Point Sources of Groundwater Contamination

Site ID/Site Name	Site Type	Constituent(s) of Concern (COCs)	Potential Media of Concern	Status
Escolle Lease (T10000005135)	*Cleanup Program Site*	Benzene, Ethylbenzene, Naphthalene, Polycyclic Aromatic Hydrocarbons (PAHs), Toluene, Total Petroleum Hydrocarbons (TPH), Xylene	Soil, Soil Vapor	Open - Site Assessment as of 7/5/2005
So Cal Gas PSEP SI36-1032 (T10000014573)	*Cleanup Program Site*	Crude Oil, Diesel	Soil	Open - Site Assessment as of 5/13/2020
Chevron Texaco Fugler Lease (T10000005738)	*Cleanup Program Site*	None Specified	Soil	Open - Inactive as of 3/11/2014
Chevron Texaco GWP Lease (T10000005737)	*Cleanup Program Site*	None Specified	Soil	Open - Inactive as of 3/11/2014
Chevron Texaco Los Alamos Fee Lease (T10000005735)	*Cleanup Program Site*	None Specified	Soil	Open - Inactive as of 3/11/2014
Greka Cat Canyon Williams B TB (T10000005749)	*Cleanup Program Site*	None Specified	Soil	Open - Inactive as of 3/12/2014
Texaco Cat Canyon Williams Holding (T10000005739)	*Cleanup Program Site*	None Specified	Soil	Open - Inactive as of 3/11/2014

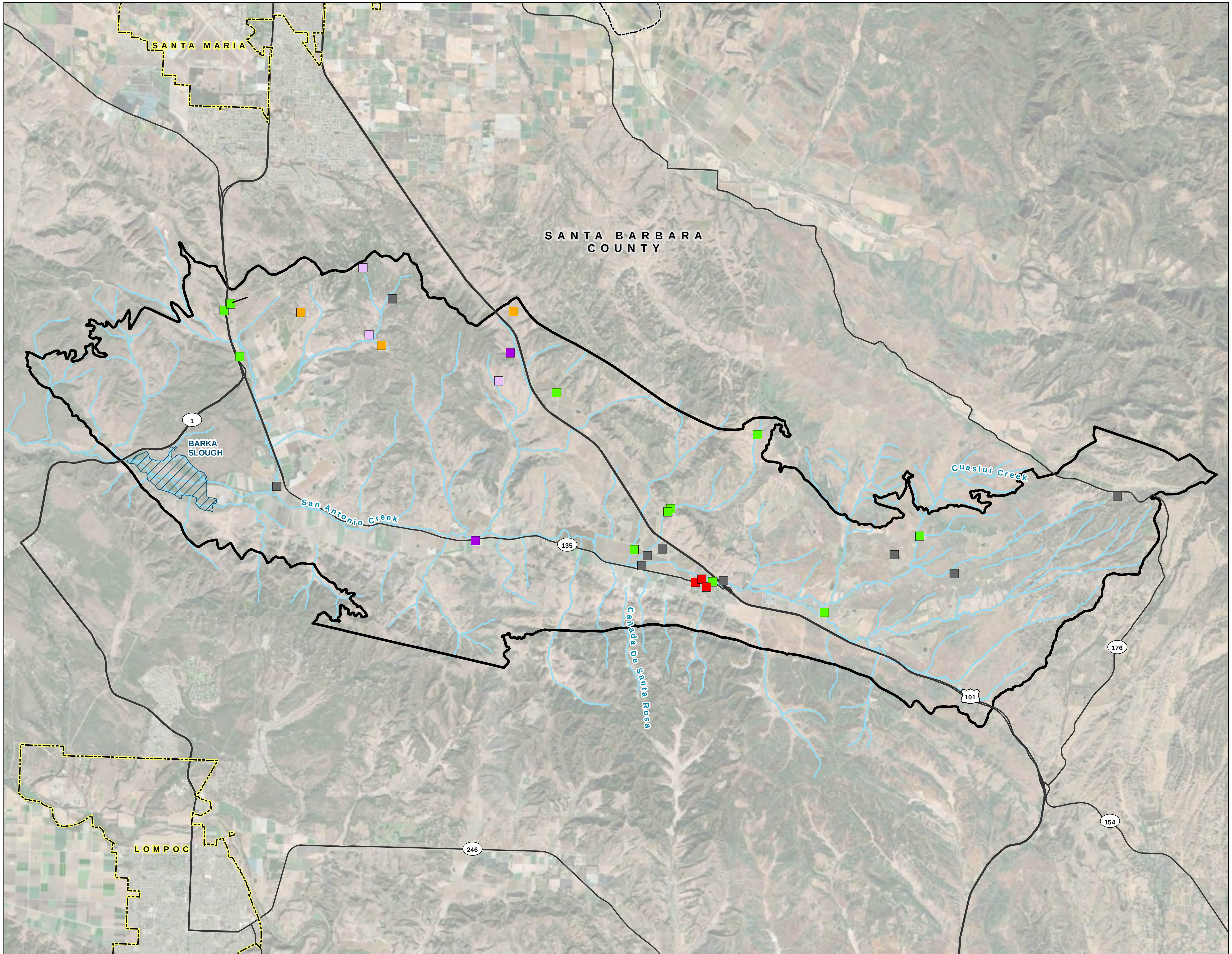
Site ID/Site Name	Site Type	Constituent(s) of Concern (COCs)	Potential Media of Concern	Status
PACIFIC COAST ENERGY CO. LP WASTE PILE FACILITY (SL0608375179)	Land Disposal Site	Crude Oil	Other groundwater (uses other than drinking water), Soil, Surface Water	Open – Operating as of 5/11/2009
Santa Maria Energy Waste Pile Management Facility (T10000006350)	Land Disposal Site	Total Petroleum Hydrocarbons (TPH)	None Specified	Open – Operating as of 11/21/2014
Santa Maria Integrated Waste Management Facility (T10000003494)	Land Disposal Site	None Specified	None Specified	Open – Proposed as of 9/28/2012
CAREAGA CANYON OIL FIELD - PRODUCED WATER FACILITIES (T10000011257)	Other Oil and Gas Projects	Total Petroleum Hydrocarbons (TPH)	Aquifer used for drinking water supply, surface water	Open – Site Assessment as of 1/26/2018
FOUR DEER OIL FIELD - PRODUCED WATER FACILITIES (T10000011703)	Other Oil and Gas Projects	None Specified	Aquifer used for drinking water supply	Open – Inactive as of 6/6/2018
PACIFIC COAST ENERGY CO - CYCLIC STEAM - SISQUOC DIATOMITE (T10000011075)	Underground Injection Control	None Specified	None Specified	Review Complete as of 12/21/2017
PROJECT PROPOSAL FOR VAQUERO ENERGY FOUR DEER OILFIELD MONTEREY FORMATION WATER DISPOSAL (T10000010711)	Underground Injection Control	None Specified	None Specified	Review Complete as of 9/17/2018
SANTA MARIA ENERGY - ORCUTT FIELD (T10000008459)	Underground Injection Control	None Specified	None Specified	Project Complete as of 3/16/2016

Source: State Water Resources Control Board Geotracker. Retrieved from California State Water Resources Control Board website: https://geotracker.waterboards.ca.gov/. (Accessed August 5, 2021.)

FIGURE 3-32

Locations of Potential Point Sources of Groundwater Contamination

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin



LEGEND

Potential Point Source Contamination

- Water Discharge Requirements (WDR) Site
- Underground Injection Control
- Land Disposal Site
- Other Oil and Gas Projects
- LUST Cleanup Site
- Cleanup Program Site

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

LUST: Leaking Underground Storage Tank

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_32_Potential_Pt_Source_Contamination.mxd, abarry

3.2.3.4 Distribution and Concentrations of Diffuse or Natural Groundwater Constituents

The distribution and concentration of naturally occurring groundwater constituents are discussed in the following subsections. Groundwater quality data from the NWIS and GeoTracker GAMA data sets were evaluated. The data reviewed consists of 108 sampling events from 37 wells in the Basin with known well completion records, collected between December 1969 and July 2019. These wells are also included in the basin groundwater level monitoring network. Each constituent is compared with its MCL, SMCL, and WQO. The following subsections focus on constituents that have the potential to be affected by any groundwater management activities.

Total Dissolved Solids

TDS is defined as the total amount of mobile charged ions—including minerals, salts or metals—dissolved in a given volume of water. TDS concentrations in groundwater have been detected above the WQO of 600 mg/L in the Basin. The SMCL for TDS has been established for color, odor and taste, rather than for human health effects. This SMCL includes a recommended standard of 500 mg/L, an upper limit of 1,000 mg/L and a short-term limit of 1,500 mg/L (SWRCB, 2020b).

Salts enter groundwater through dissolution of soil, rock, and organic material. Salinity will increase with time, as more minerals in contact with groundwater dissolve. The concentration of salts in surface and groundwater can increase in several ways. Evaporative enrichment is the process of increasing salinity levels in surface or groundwater by removing water via evaporation. For example, irrigation water is often applied to crops during the summer when evaporation rates are highest. As water molecules evaporate into the atmosphere, salts remain in the irrigation water. This irrigation water can percolate into the underlying groundwater. If the groundwater is later pumped and used for additional irrigation, the evaporation cycle is repeated, and salinity levels can increase. Water uptake by plants can also increase soil salinity. Water percolating through the ground has salts dissolved in it. Plant roots take in water while excluding salts and other non-nutrients. The excluded salts will gradually build up around the roots and must be periodically "flushed" from the root zone to maintain plant health. In natural systems, the types of plants found in a specific environment are adapted for naturally occurring soil salinities. In many agricultural areas, salts are flushed from the soil by applying irrigation water. The salts that are flushed from the soil either enter groundwater or are discharged to surficial drains. Human activities can also affect salinity levels in ground and surface water. The application of synthetic fertilizers, manures, and wastewater treatment facilities can all contribute salt to surface and groundwater. Nitrogen is a necessary nutrient for plant growth and nitrogen fertilizers are typically in the form of the salt nitrate. If excess nitrate fertilizer is applied to a field, the nitrate not used by plants can dissolve and move to groundwater. Manure from confined animal facilities is enriched in nutrients and other salts and can also increase salinity levels in receiving waters. Domestic wastewater is typically enriched in salts, including sodium and chloride, due to household activities such as washing and water softening. Most water treatment facilities cannot remove salt. As a result, discharges from these facilities can increase surface and groundwater salinity (SWRCB, 2017a).

Sample analytical results of TDS concentrations in the Paso Robles Formation and the Careaga Sand for 2017 are shown on Figures 3-33 and 3-34, respectively. TDS concentrations range from 40 mg/L to 1,410 mg/L with a mean of 465 mg/L in the Paso Robles Formation and range from 188 mg/L to 3,900 mg/L with a mean of 827 mg/L in the Careaga Sand. Removing the three highest concentrations from the analysis of the Careaga Sand data set, the mean TDS concentration is 550 mg/L.

Based on the available data, TDS concentrations increase from east to west along San Antonio Creek and are greatest near Barka Slough, along western San Antonio Creek, and in Harris Canyon. The east-to-west trend of increasing TDS concentrations is consistent between the Paso Robles Formation and the Careaga Sand. Analytical results from samples collected from nested monitoring wells (SACC and SACR) located near

Los Alamos and along San Antonio Creek, in the western portion of the Basin, indicate TDS concentrations generally decrease with depth. Increasing TDS concentrations have been detected in a public supply well (LACSD 4) east of Los Alamos. However, TDS concentrations have not exceeded the MCL or WQO in this well.

Based on analytical results from 20 sampling events between May 1978 and February 2017, TDS concentrations in surface water samples collected from San Antonio Creek near Los Alamos (Station 11135800) during flow events do not indicate any long-term trends. TDS concentrations in surface water range from 138 mg/L to 1,280 mg/L with a mean of 433 mg/L. There is no clear correlation between streamflow rates and measured TDS concentrations.

While there are some wells that have concentrations of TDS that exceed regulatory standards, it is possible that these exceedances are a result of natural conditions and not caused by land use activities. Elevated TDS concentrations are often associated with the rocks of marine origin that are present in the Basin.

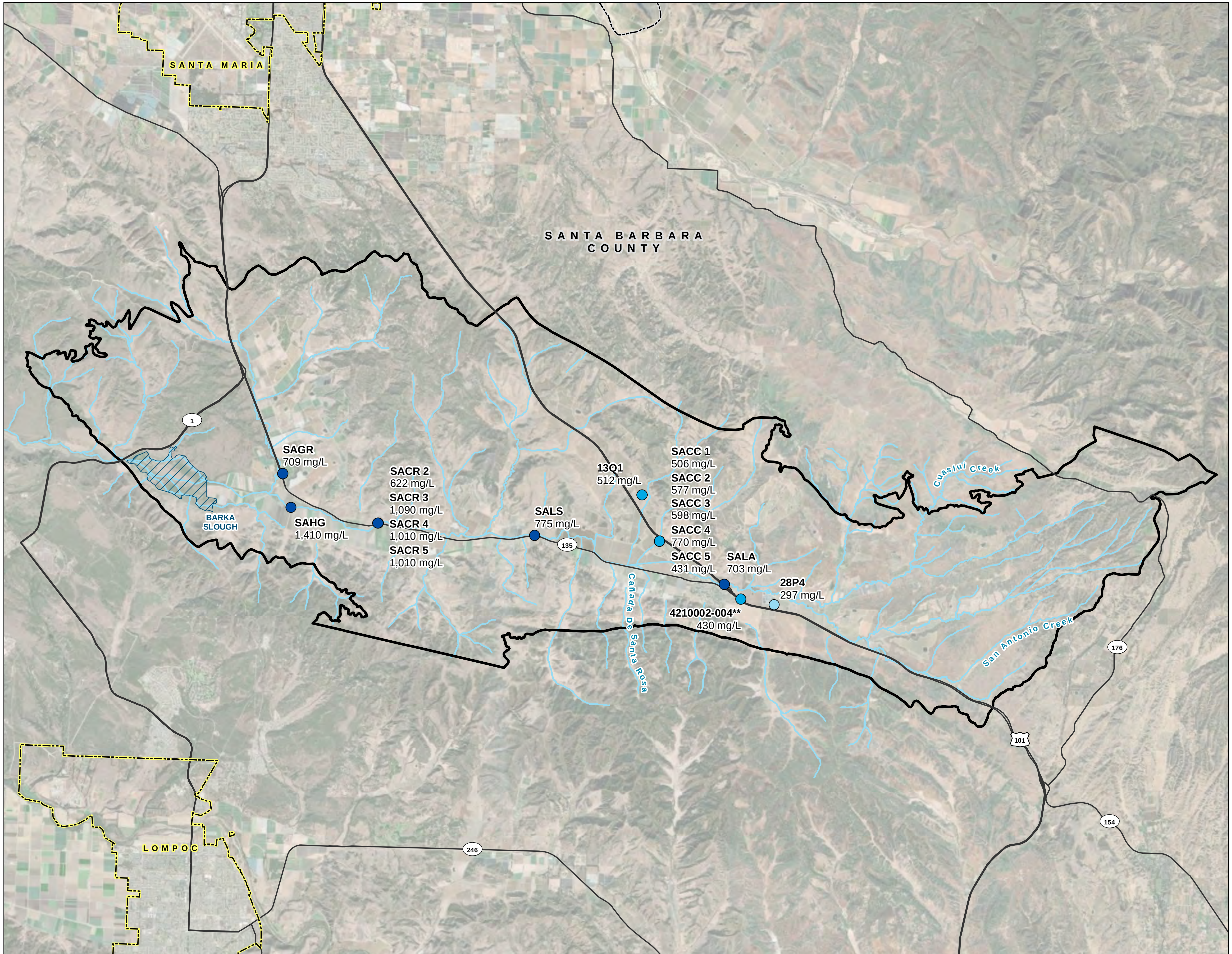


FIGURE 3-33

Total Dissolved Solids, 2017
Paso Robles Formation

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Well Concentrations

Total Dissolved Solids

- < 300 mg/L
- 300 - 600 mg/L
- > 600 mg/L*

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*The Water Quality Objective for Total Dissolved Solids is 600 mg/L.
**4210002-004 is the well identification name for LACSD 4 in the U.S. Geological Survey Groundwater Ambient Monitoring and Assessment Program.

1. The recommended Secondary Maximum Contamination Level is 500 mg/L.
2. San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

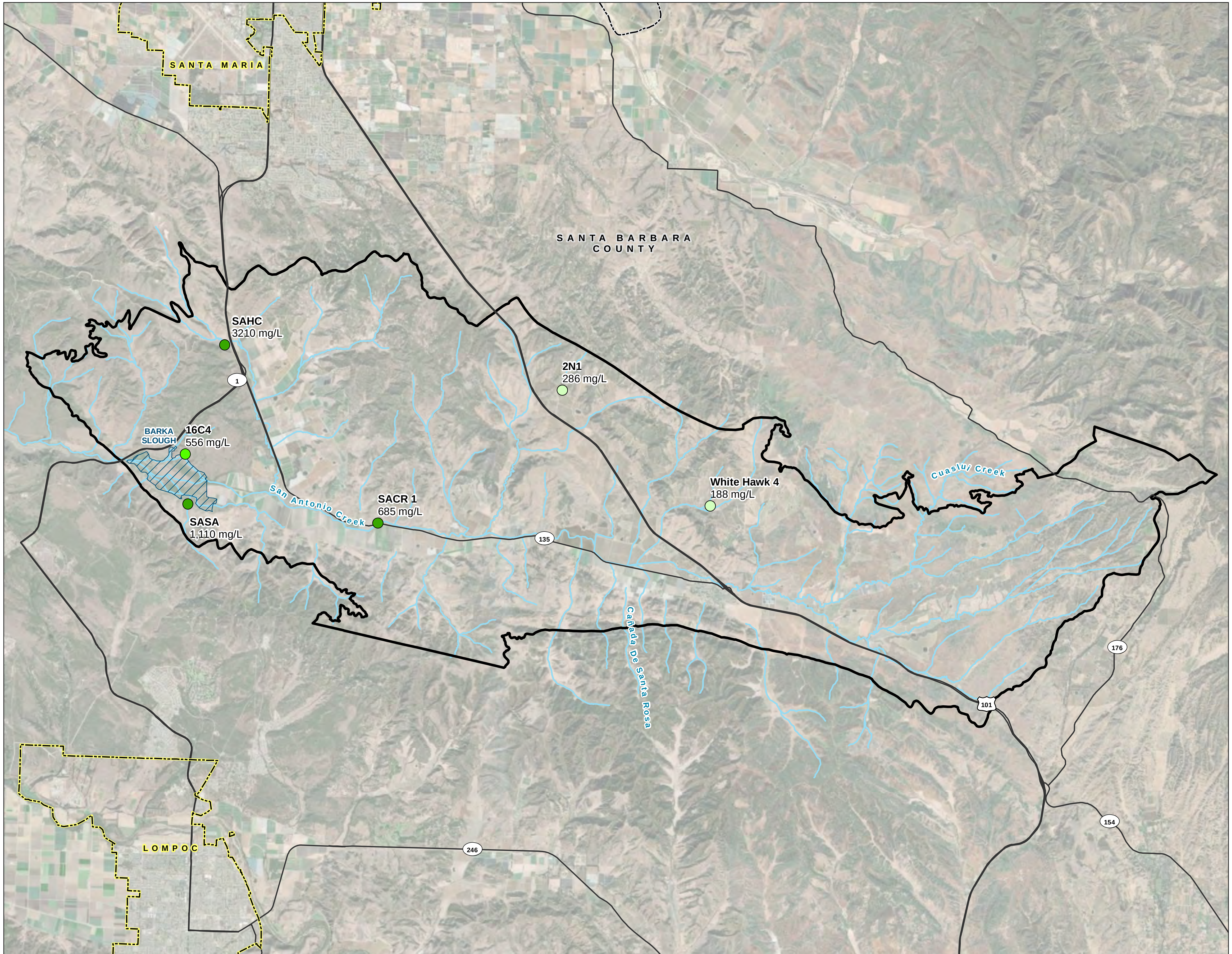
GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_33_Total_Dissolved_Solids_Paso_Robles_Aquifer.mxd, abarry

FIGURE 3-34

Total Dissolved Solids, 2017
Careaga Sand

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin



LEGEND

Well Concentrations

Total Dissolved Solids

- < 300 mg/L
- 300 - 600 mg/L
- > 600 mg/L*

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*The Water Quality Objective for Total Dissolved Solids is 600 mg/L.

1. The recommended Secondary Maximum Contamination Level is 500 mg/L.
2. San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_34_Total_Dissolved_Solids_Careaga_Aquifer.mxd, abarry

Sodium

Sodium is an unregulated constituent and therefore does not have an established federal or state regulatory threshold. However, elevated sodium concentrations in water can damage crops and affect plant growth (SWRCB, 2019).

Sample analytical results of sodium concentrations in the Paso Robles Formation and the Careaga Sand for 2017 are shown on Figures 3-35 and 3-36.

Sodium has been detected at concentrations exceeding the WQO of 100 mg/L in the Basin. Sodium concentrations ranged from 38 mg/L to 180 mg/L with a mean of 93 mg/L in the Paso Robles Formation and ranged from 30 mg/L to 1,300 mg/L with a mean of 133 mg/L in the Careaga Sand. The two highest reported concentrations of sodium were detected in samples collected in 1976 from wells located in the Barka Slough area. The third-highest concentration measured is from a sample collected in 2017 from a well in Harris Canyon. Removing these samples from the available data set, sodium concentrations in the Careaga Sand range from 30 mg/L to 132 mg/L with a mean of 75 mg/L.

Based on available information, sodium concentrations in the Paso Robles Formation and the Careaga Sand have remained relatively stable throughout the period of record. Sodium concentrations increase from east to west along San Antonio Creek and are greatest near Barka Slough, along western San Antonio Creek, and in Harris Canyon. The east-to-west trend of increasing sodium concentrations is consistent between the Paso Robles Formation and the Careaga Sand. Analytical results from samples collected from nested monitoring wells (SACC and SACR) located near Los Alamos and along San Antonio Creek, in the western portion of the Basin, indicate sodium concentrations generally decrease with depth.

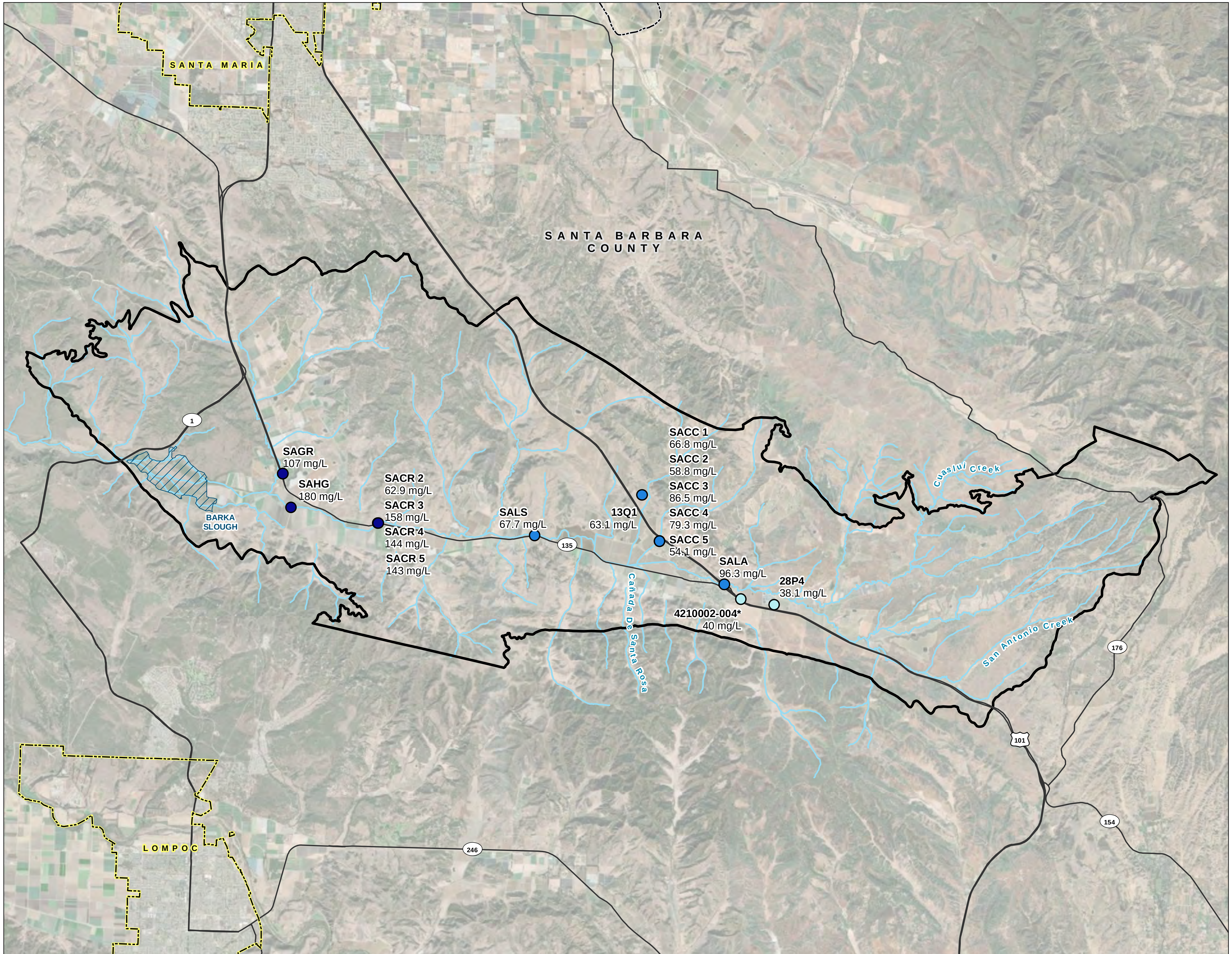
Based on analytical results from seven sampling events between May 1978 and February 2017, sodium concentrations in surface water samples collected from San Antonio Creek near Los Alamos (Station 11135800) during flow events, do not indicate any long-term trends. Analytical results for the water samples indicated sodium concentrations ranging from 16.7 mg/L to 71 mg/L with a mean of 39.4 mg/L.

While there are some wells that have concentrations of sodium that exceed regulatory standards, it is possible that these exceedances are a result of natural conditions and not caused by land use activities. Elevated sodium concentrations are often associated with rocks of marine origin that are present in the Basin.

FIGURE 3-35

Sodium, 2017
Paso Robles Formation

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin



LEGEND

Well Concentrations

Sodium

- < 50 mg/L
- 50 - 100 mg/L
- > 100 mg/L

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*4210002-004 is the well identification name for LACSD 4 in the U.S. Geological Survey Groundwater Ambient Monitoring and Assessment Program.

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

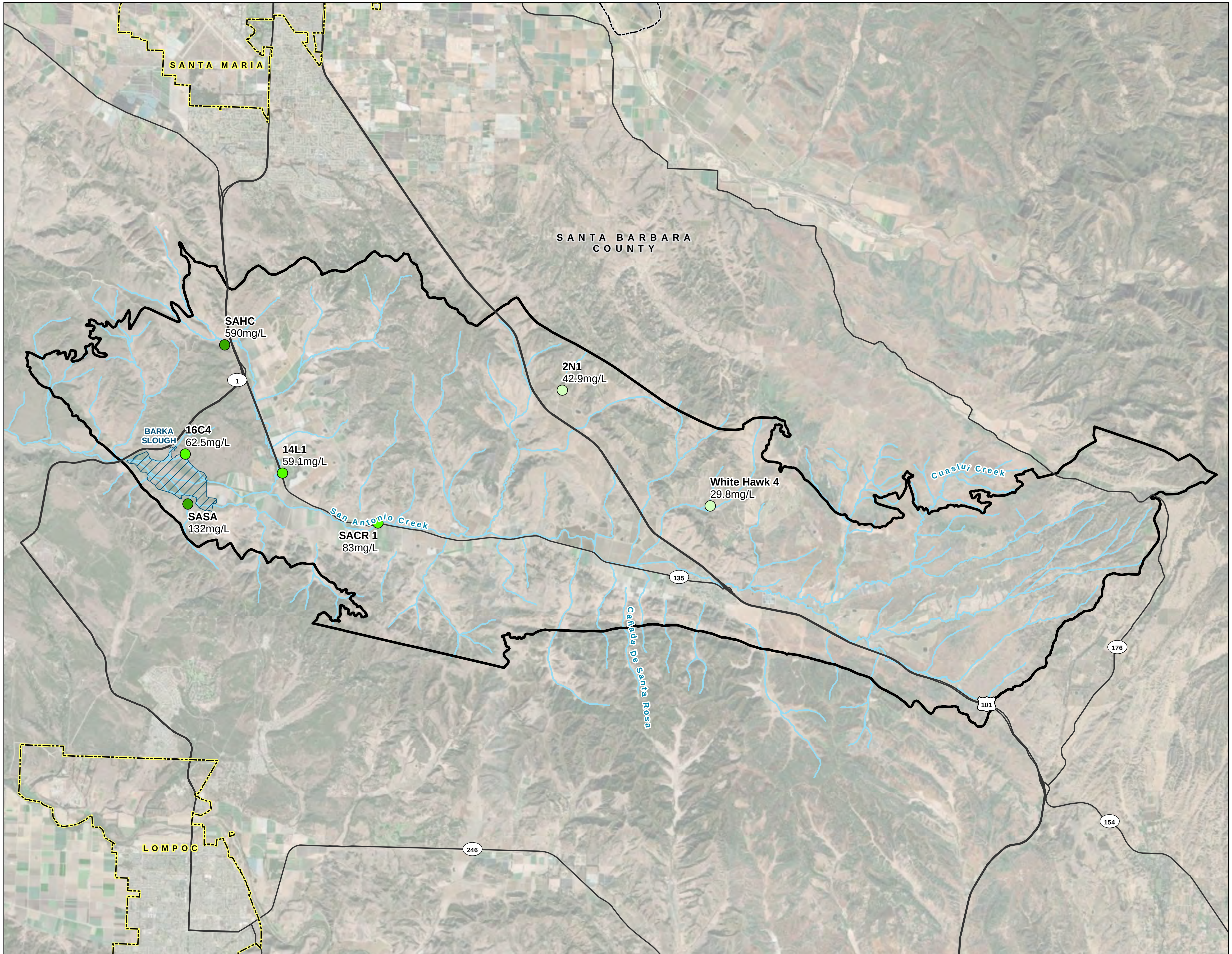


FIGURE 3-36

Sodium, 2017
Careaga Sand

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Well Concentrations

Sodium

- < 50 mg/L
- 50 - 100 mg/L
- > 100 mg/L

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

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Chloride

Chloride concentrations in groundwater have been detected at concentrations greater than the WQO of 150 mg/L in the Basin. The SMCL for chloride has been established for taste, rather than for human health effects. The SMCL includes a recommended standard of 250 mg/L, an upper limit of 500 mg/L and a short-term limit of 600 mg/L (SWRCB, 2018). Chloride concentrations in the Paso Robles Formation and the Careaga Sand for 2017 are shown on Figures 3-37 and 3-38, respectively.

Analytical results indicate chloride concentrations range from 51 mg/L to 618 mg/L, with a mean of 88 mg/L, in the Paso Robles Formation and from 28 mg/L to 1,400 mg/L, with a mean of 191 mg/L, in the Careaga Sand. The two highest reported concentrations of chloride were detected in samples collected in 1976 from wells located in the Barka Slough area. The third highest concentration measured is from a sample collected in 2017 from a well in Harris Canyon. Removing these samples from the available data set, chloride concentrations in the Careaga Sand range from 28 mg/L to 276 mg/L with a mean of 95 mg/L.

Based on the available data, chloride concentrations increase from east to west along San Antonio Creek and are greatest near Barka Slough, along western San Antonio Creek, and in Harris Canyon. The east-to-west trend of increasing chloride concentrations is consistent between the Paso Robles Formation and the Careaga Sand. Analytical results from samples collected from a nested monitoring well (SACR) along San Antonio Creek, in the western portion of the Basin, indicate chloride concentrations generally decrease with depth. Increasing chloride concentrations have been detected in a public supply well (LACSD 4 [sample location 4210002-004]) east of Los Alamos. However, chloride concentrations have not exceeded the WQO in this well.

Based on analytical results from seven sampling events between May 1978 and February 2017, chloride concentrations in surface water samples collected from San Antonio Creek near Los Alamos (Station 11135800) during flow events, do not indicate any long-term trends. Analytical results for the water samples indicated chloride concentrations ranging from 16 mg/L to 58 mg/L with a mean of 37.6 mg/L.

While there are some wells that have concentrations of chloride that exceed regulatory standards, it is possible that these exceedances are a result of natural conditions and not caused by land use activities. Elevated chloride concentrations are often associated with rocks of marine origin that are present in the Basin.

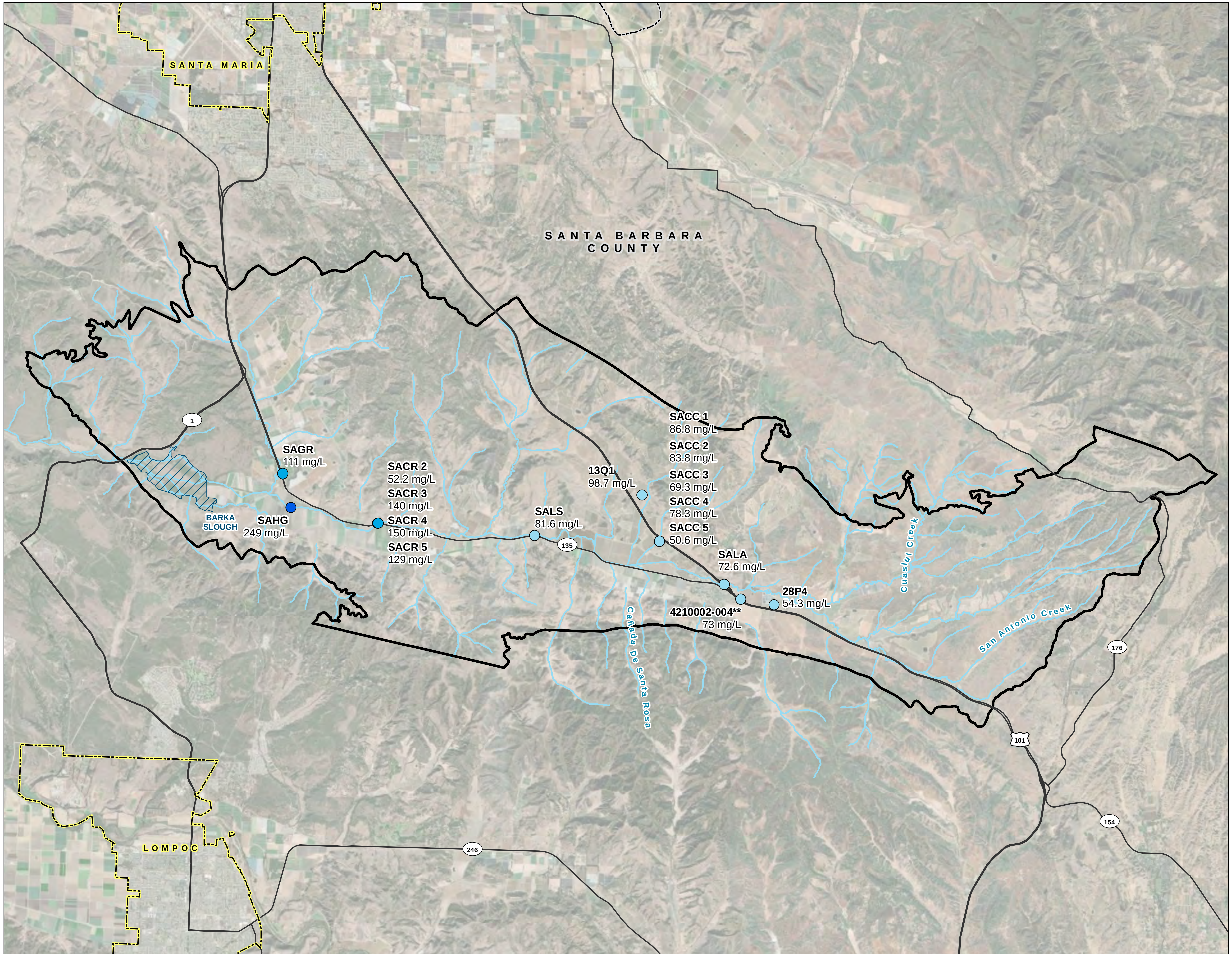

FIGURE 3-37

Chloride, 2017
Paso Robles Formation

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Well Concentrations

Chloride

- < 100 mg/L
- 100 - 150 mg/L
- > 150 mg/L*

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*The Water Quality Objective for Chloride is 150 mg/L.
**4210002-004 is the well identification name for LACSD 4 in the U.S. Geological Survey Groundwater Ambient Monitoring and Assessment Program.

1. The recommended Secondary Maximum Contamination Level is 250 mg/L.
2. San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

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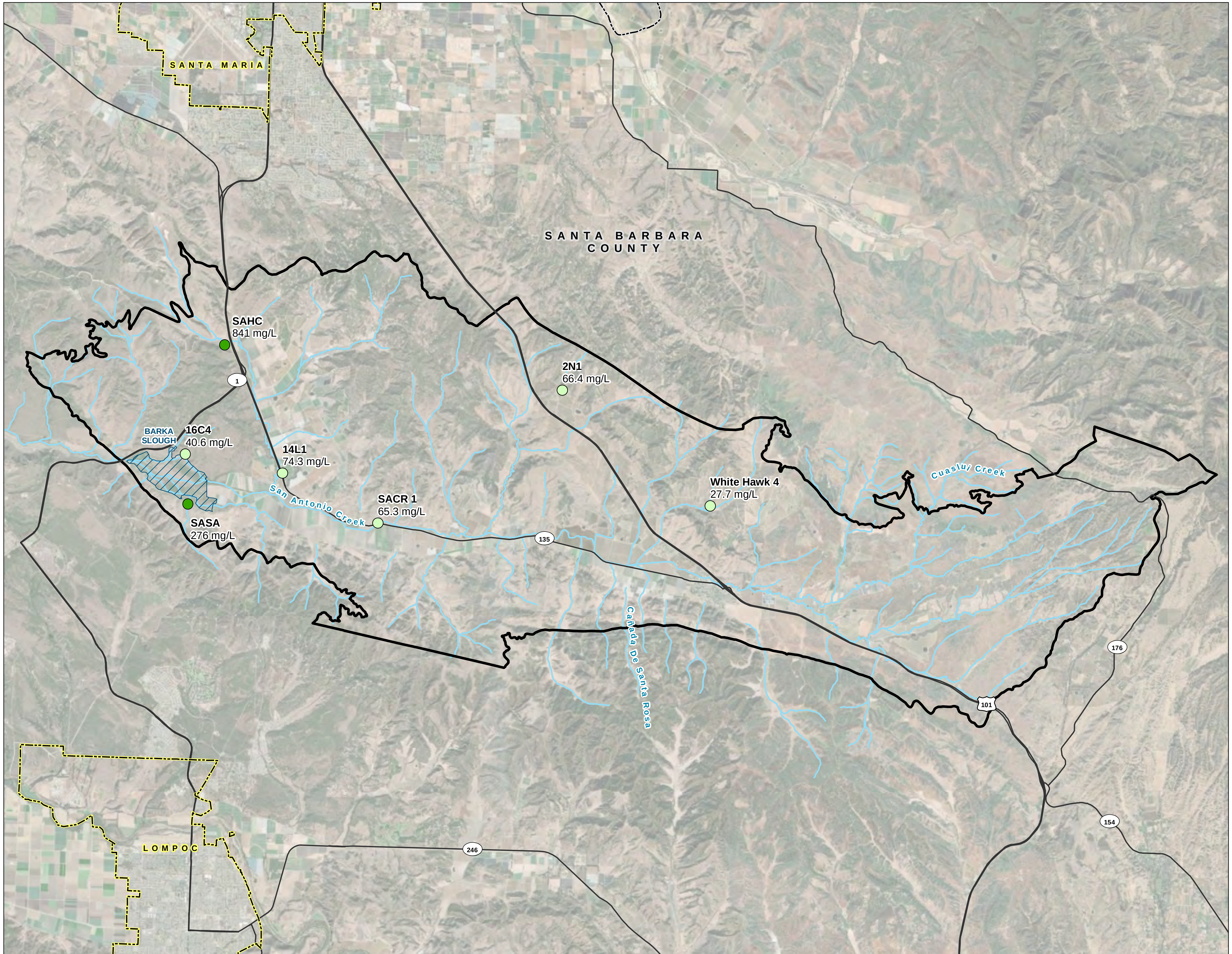

FIGURE 3-38

Chloride, 2017
Careaga Sand

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Well Concentrations

Chloride

- < 100 mg/L
- 100 - 150 mg/L
- > 150 mg/L*

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*The Water Quality Objective for Chloride is 150 mg/L.

1. The recommended Secondary Maximum Contamination Level is 250 mg/L.
2. San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

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Sulfate

Sulfate concentrations in groundwater have been detected at concentrations greater than the WQO of 150 mg/L in the Basin. The SMCL for sulfate was established to avoid causing digestive problems in humans. The SMCL includes a recommended standard of 250 mg/L, an upper limit of 500 mg/L and a short-term limit of 600 mg/L (SWRCB, 2018). Sulfate concentrations in the Paso Robles Formation and the Careaga Sand for 2017 are shown on Figures 3-39 and 3-40, respectively.

Analytical results indicate sulfate concentrations range from 25 mg/L to 362 mg/L, with a mean of 121 mg/L, in the Paso Robles Formation, and from 7.1 mg/L to 1050 mg/L, with a mean of 133 mg/L, in the Careaga Sand. The highest concentration measured is from a sample collected in 2017 from a well in Harris Canyon. Removing this sample from the available data set, sulfate concentrations in the Careaga Sand range from 7 mg/L to 400 mg/L with a mean of 107 mg/L.

Based on the available data, sulfate concentrations increase from east to west along San Antonio Creek and are greatest near Barka Slough, along western San Antonio Creek, and in Harris Canyon. The east-to-west trend of increasing sulfate concentrations is consistent between the Paso Robles Formation and the Careaga Sand.

Increasing sulfate concentrations have been detected in a public supply well (LACSD 4 [sample location 4210002-004]) east of Los Alamos. However, sulfate concentrations have not exceeded the WQO in this well.

Based on analytical results from seven sampling events between May 1978 and February 2017, sulfate concentrations in surface water samples collected from San Antonio Creek near Los Alamos (Station 11135800) during flow events, do not indicate any long-term trends. Analytical results for the water samples indicated sulfate concentrations ranging from 30.4 mg/L to 210 mg/L with a mean of 30.4 mg/L.

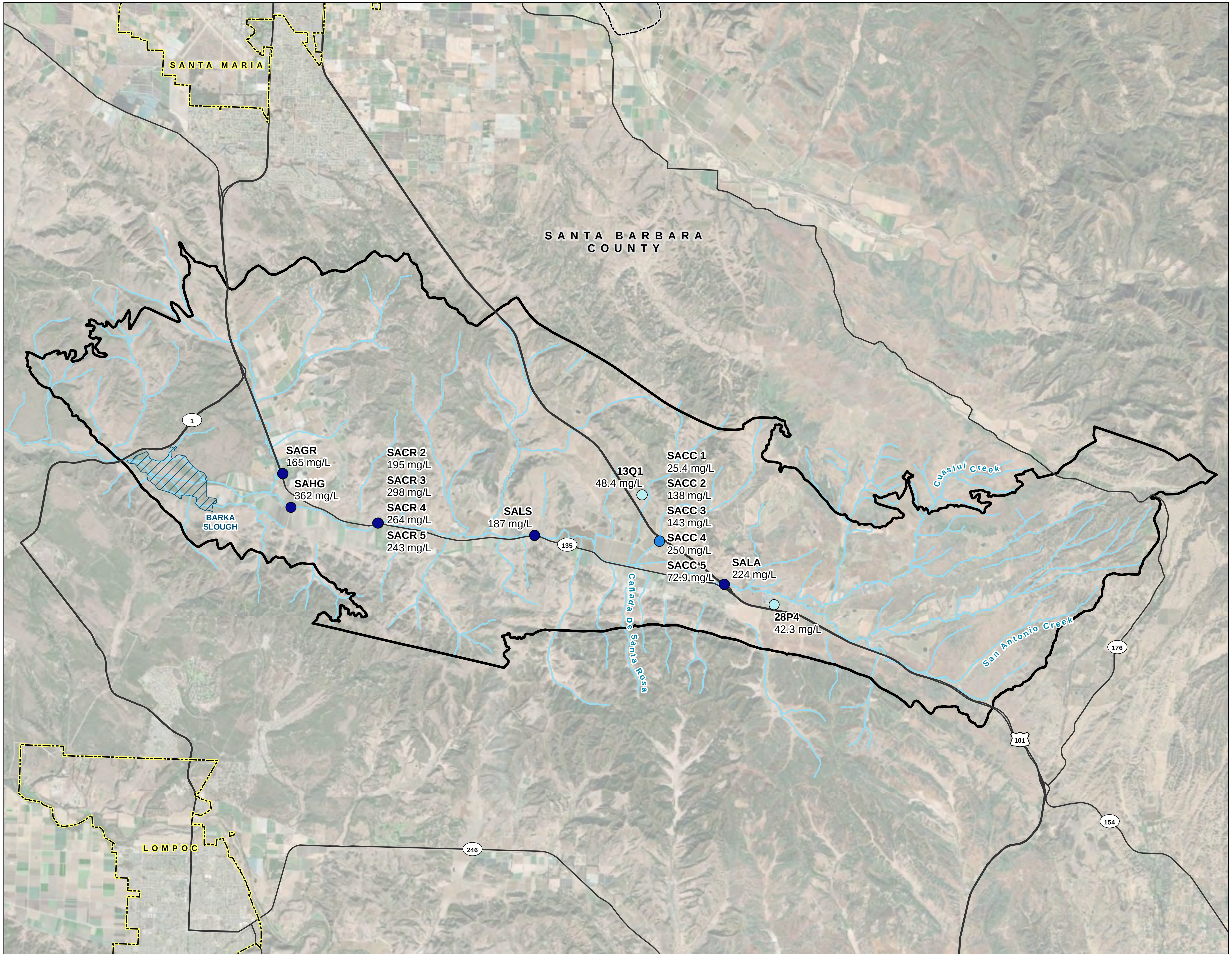


FIGURE 3-39

Sulfate, 2017
Paso Robles Formation

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Well Concentration

Sulfate

- < 50 mg/L
- 50 - 150 mg/L
- > 150 mg/L*

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*The Water Quality Objective for Sulfate is 150 mg/L.

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

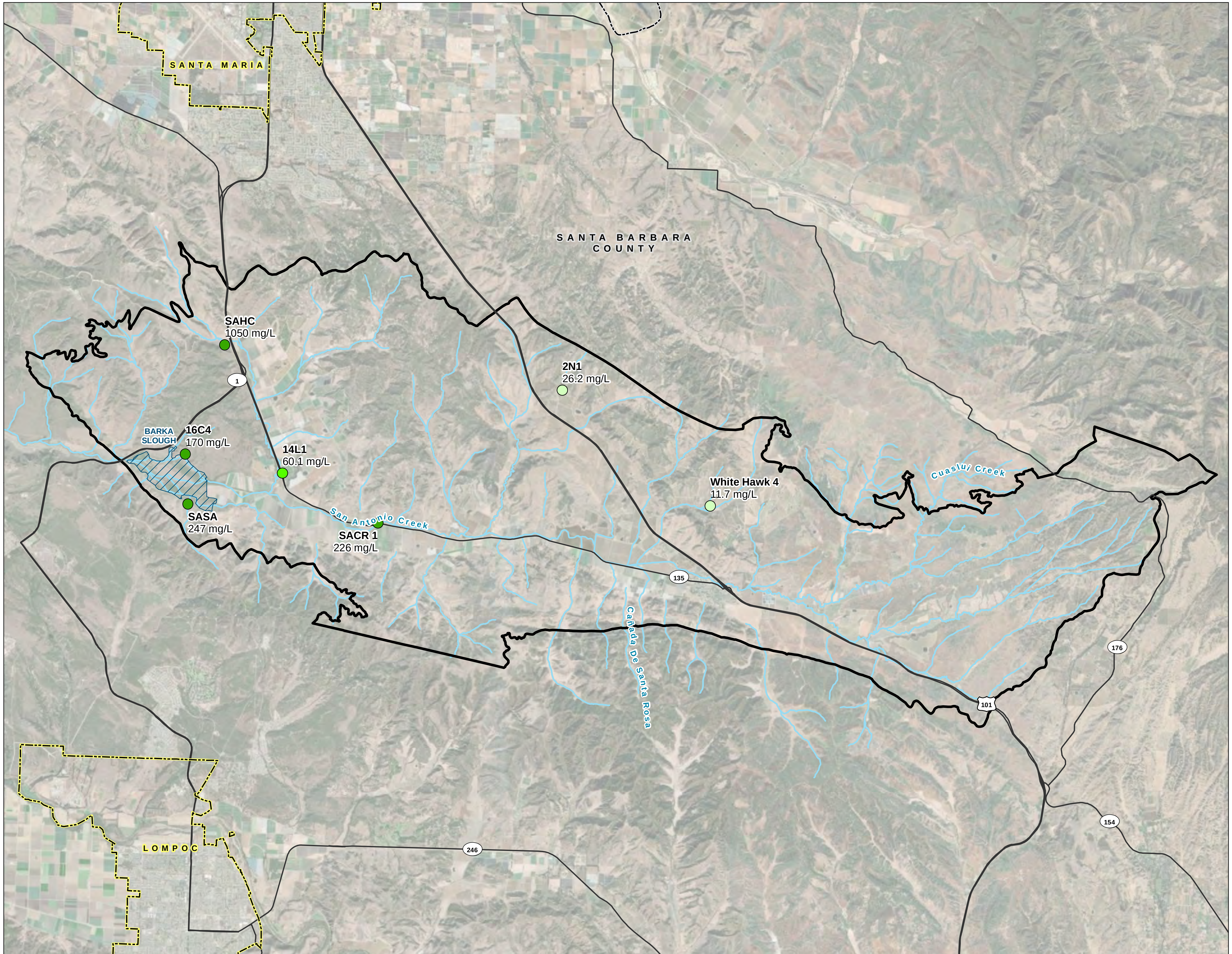
GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_39_Sulfate_Paso_Robles_Aquifer.mxd, abarry

FIGURE 3-40

Sulfate, 2017
Careaga Sand

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin



LEGEND

Well Concentration

Sulfate

- < 50 mg/L
- 50 - 150 mg/L
- > 150 mg/L*

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*The Water Quality Objective for Sulfate is 150 mg/L.

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_40_Sulfate_Careaga_Aquifer.mxd, abarry

Arsenic

Arsenic is a regulated trace element with an MCL in drinking water of 10 microgram per liter (µg/L). Arsenic is a semi-metal element that occurs naturally in the environment but can also be released to the environment by human activities. The primary source of arsenic in the environment is from the weathering of arsenic-containing rocks. Arsenic mobility in groundwater is dependent on the physical and chemical properties of the aquifer, although two types of processes generally control its movement: adsorption/desorption reactions and precipitation/dissolution reactions. During adsorption reactions, dissolved arsenic adheres to the surface of solid aquifer materials. Desorption removes the arsenic from aquifer materials and releases it into the surrounding groundwater. The mobility of arsenate is low in acidic soils that have a high content of oxides and clays (SWRCB, 2017b).

Arsenic concentrations in the Paso Robles Formation and the Careaga Sand for 2017 are shown on Figures 3-41 and 3-42, respectively. Analytical results indicate arsenic concentrations range from 0.2 µg/L to 36.4 µg/L, with a mean of 6.3 µg/L, in the Paso Robles Formation, and from less than 0.05 to 17 µg/L, with a mean of 7.6 µg/L, in the Careaga Sand. Based on the available data, arsenic concentrations increase from east to west along San Antonio Creek and are greatest along western San Antonio Creek. The east-to-west trend of increasing arsenic concentrations is primarily observed in the Paso Robles Formation.

Arsenic concentrations were measured at 9.3 µg/L for the single surface water sample available, collected in February 2017 from San Antonio Creek near Los Alamos (Station 11135800).

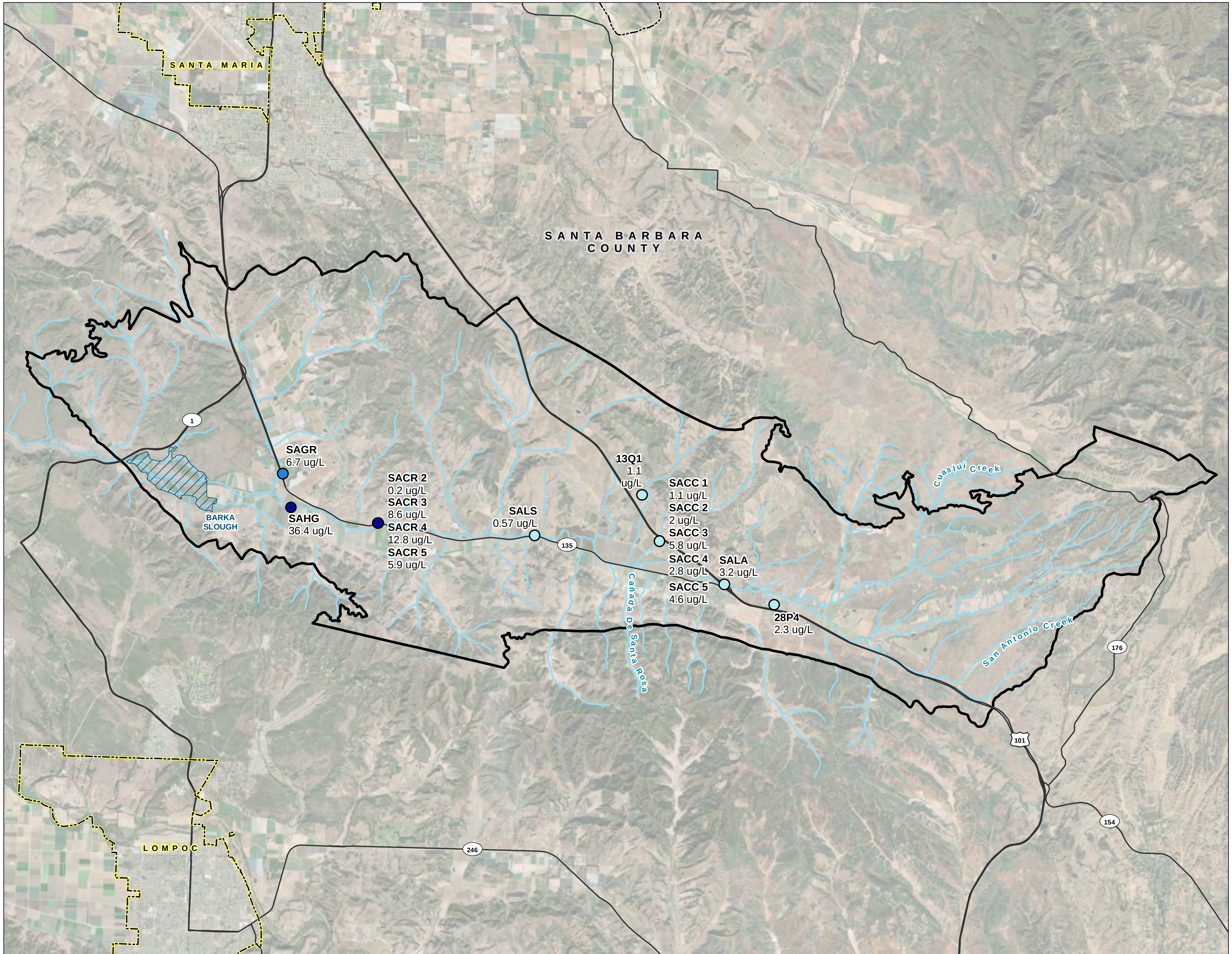


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FIGURE 3-41

Arsenic, 2017
Paso Robles Formation

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Well Concentration

Arsenic

- < 5 µg/L
- 5 - 10 µg/L
- > 10 µg/L

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

1. The recommended Secondary Maximum Contamination Level is 10 µg/L.
2. San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

µg/L: micrograms per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

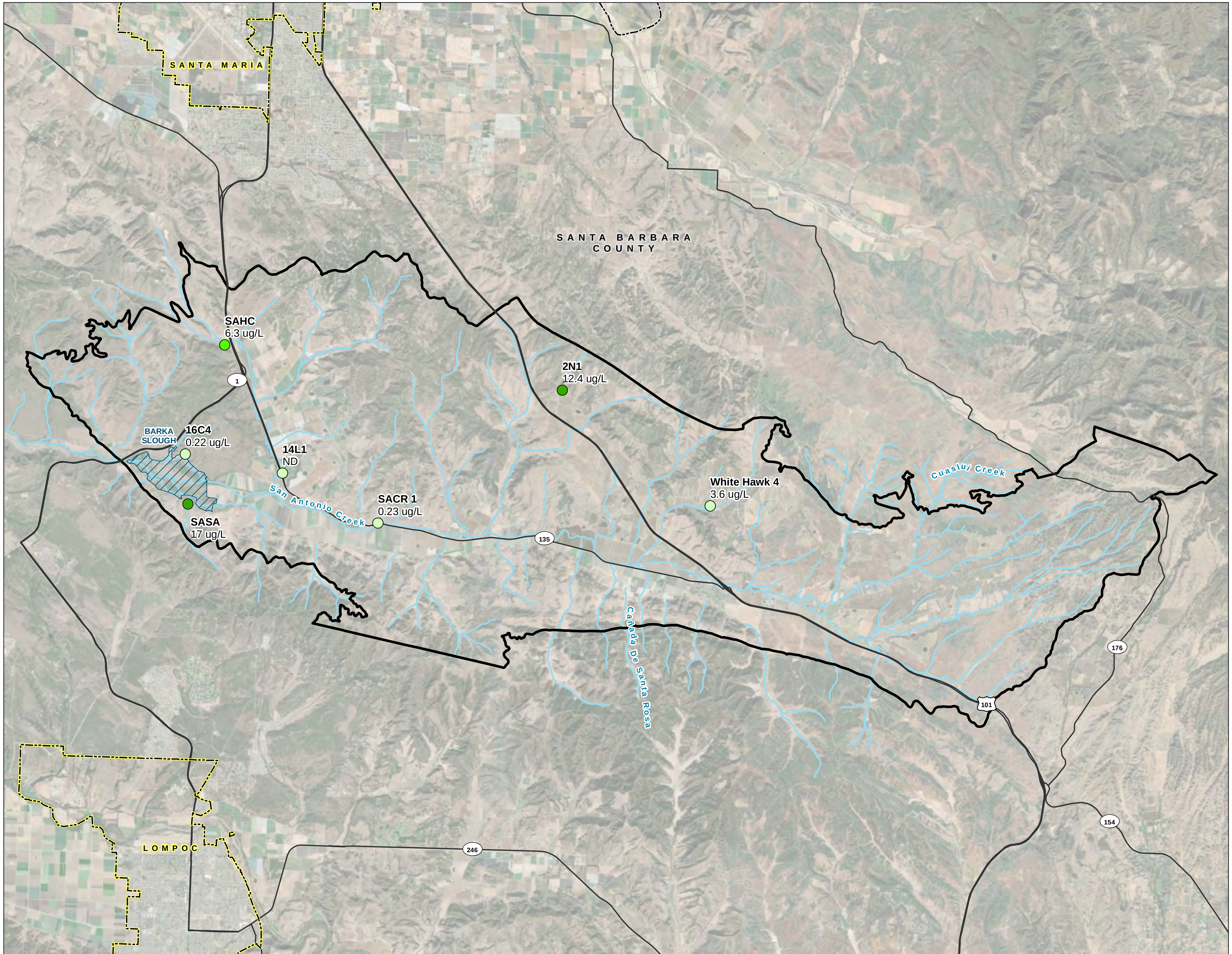


FIGURE 3-42

Arsenic, 2017
Careaga Sand

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Well Concentration

Arsenic

- < 5 µg/L
- 5 - 10 µg/L
- > 10 µg/L

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

1. The recommended Secondary Maximum Contamination Level is 10 µg/L.
2. San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

µg/L: micrograms per liter
ND: non-detect

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

Nitrate

Nitrate is a widespread constituent in California groundwater (California Department of Public Health, 2014). Elevated concentrations of nitrate in groundwater can be associated with agricultural activities, septic systems, confined animal facilities, landscape fertilizers, and wastewater treatment facilities. Nitrate is the primary form of nitrogen detected in groundwater. It is soluble in water and can easily pass through soil to the groundwater table. Nitrate can persist in groundwater for decades and accumulate to increased concentrations as more nitrogen is applied to the land surface each year (California Department of Public Health, 2014).

Sample analytical results of nitrate concentrations in the Paso Robles Formation and the Careaga Sand for 2017 are shown on Figures 3-43 and 3-44, respectively. Nitrate concentrations in groundwater have been detected above the WQO of 5 mg/L in the Basin. The MCL for nitrate has been established at 10 mg/L (SWRCB, 2020b). Nitrate concentrations ranged from less than 0.04 to 36.5 mg/L (with a mean of 3 mg/L) in the Paso Robles Formation and ranged from less than 0.04 to 6.02 mg/L (with a mean of 1.7 mg/L) in the Careaga Sand.

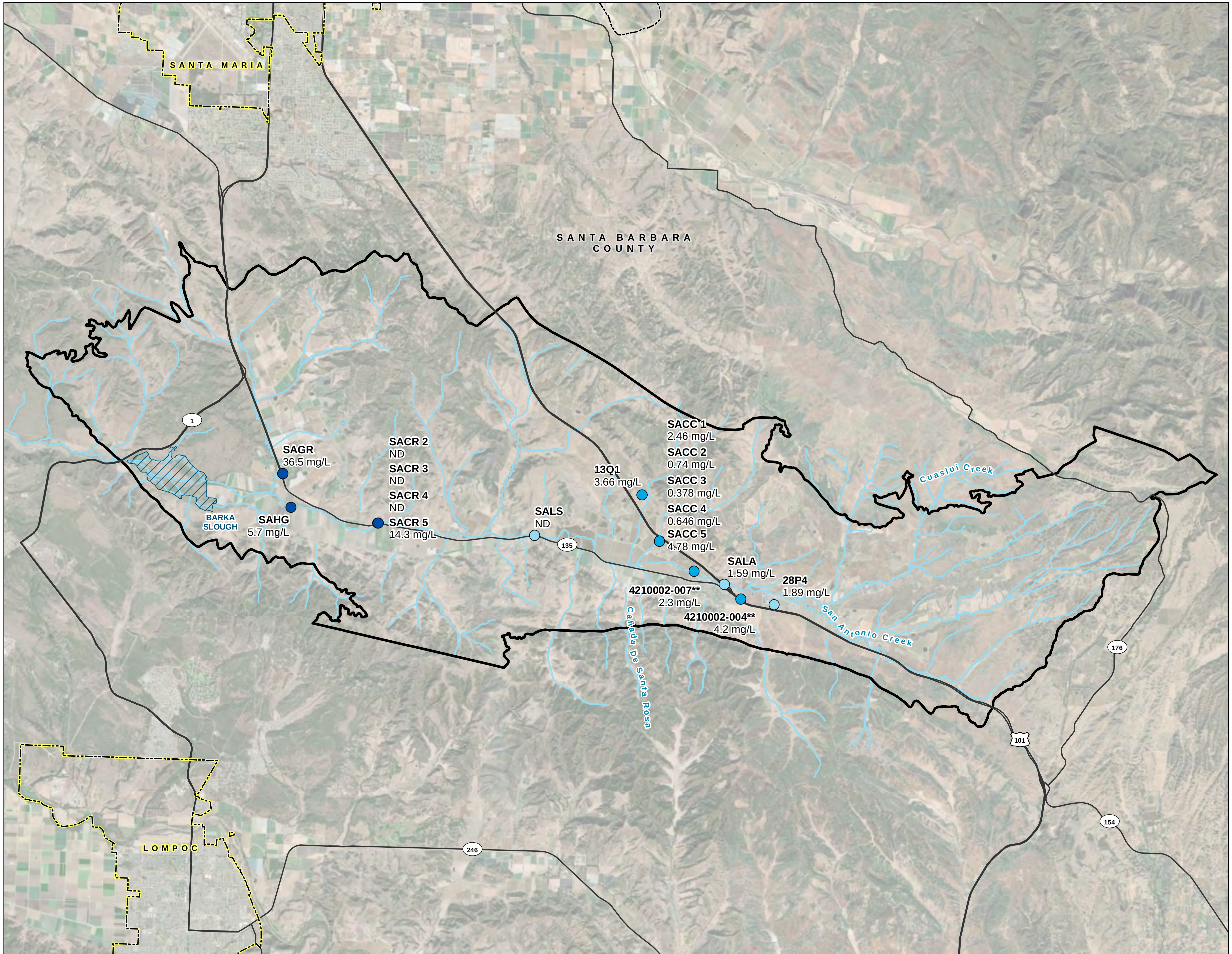
Based on available data, nitrate concentrations increase from east to west along San Antonio Creek and are greatest near Barka Slough, along western San Antonio Creek, and in western Harris Canyon. The east-to-west trend of increasing nitrate concentrations is primarily observed in the Paso Robles Formation. Increasing nitrate concentrations were detected in a public supply well (LACSD 4) east of Los Alamos. However, nitrate concentrations have not exceeded the WQO or MCL in this well.

Based on analytical results from six sampling events between April 2006 and February 2017, nitrate concentrations in surface water samples collected from San Antonio Creek near Los Alamos (Station 11135800) during flow events, do not indicate any long-term trends. Analytical results for the water samples indicate nitrate concentrations ranging from 0.8 mg/L to 13.8 mg/L, with a mean of 4.3 mg/L.

FIGURE 3-43

Nitrate, 2017
Paso Robles Formation

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin



LEGEND

Well Concentrations

Nitrate

- < 2 mg/L
- 2 - 5 mg/L
- > 5 mg/L*

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*The Water Quality Objective for Nirate is 5 mg/L measured as Nitrogen.
**4210002-004 and 4210002-007 are the well identification names for LACSD 4 in the U.S. Geological Survey Groundwater Ambient Monitoring and Assessment Program.

1. The Maximum Contamination Level is 10 mg/L measured as Nitrogen.
2. San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter
ND: non-detect

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

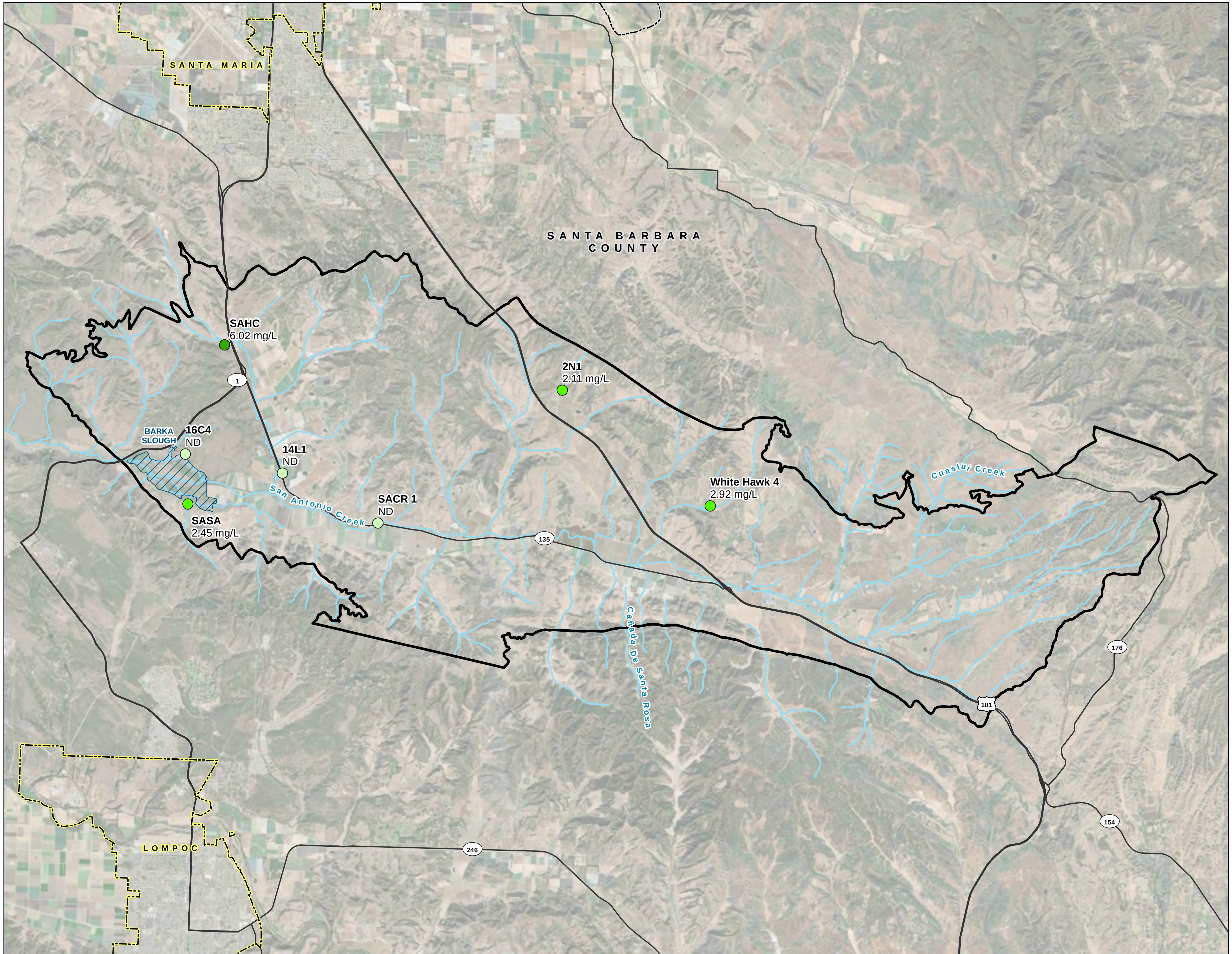


FIGURE 3-44

Nitrate, 2017
Careaga Sand

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Well Concentrations

Nitrate

- < 2 mg/L
- 2 - 5 mg/L
- > 5 mg/L

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*The Water Quality Objective for Nitrate is 5 mg/L measured as Nitrogen.

1. The Maximum Contamination Level is 10 mg/L measured as Nitrogen.
2. San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter
ND: non-detect

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_44_Nitrate_Careaga_Aquifer.mxd, abarry

Boron

Boron is an unregulated constituent and therefore does not have an MCL or SMCL but does have a WQO. Elevated boron concentrations in water can damage crops and affect plant growth (SWRCB, 2019). Sample analytical results of boron concentrations in the Paso Robles Formation and the Careaga Sand for 2017 are shown on Figures 3-45 and 3-46, respectively. Boron has been detected at concentrations exceeding the WQO of 0.2 mg/L in 13 of 33 wells sampled. Boron concentrations ranged from 0.078 mg/L to 0.379 mg/L with a mean of 0.191 mg/L in the Paso Robles Formation and ranged from 0.041 mg/L to 14 mg/L with a mean of 0.785 mg/L in the Careaga Sand. The two highest reported concentrations of boron were detected in samples collected in 1976 from wells located in the Barka Slough area. The third-highest concentration measured is from a sample collected in 2017 from a well in Harris Canyon. Removing these samples from the available data set, boron concentrations in the Careaga Sand range from 0.041 mg/L to 0.55 mg/L with a mean of 0.161 mg/L.

Based on available data, boron concentrations increase from east to west along San Antonio Creek and are greatest near Barka Slough, along western San Antonio Creek, and in western Harris Canyon. The east to west trend of increasing nitrate concentrations is consistent between in the Paso Robles Formation and the Careaga Sand.

Based on analytical results from seven sampling events between May 1978 and February 2017, boron concentrations in surface water samples collected from San Antonio Creek near Los Alamos (Station 11135800) during flow events, do not indicate any long-term trends. Analytical results for the water samples indicate boron concentrations ranging from 0.058 mg/L to 0.200 mg/L, with a mean of 0.101 mg/L.

While there are some wells that have concentrations of boron that exceed regulatory standards, it is possible that these exceedances are a result of natural conditions and not caused by land use activities. Elevated boron concentrations are naturally occurring in many central coast basins.

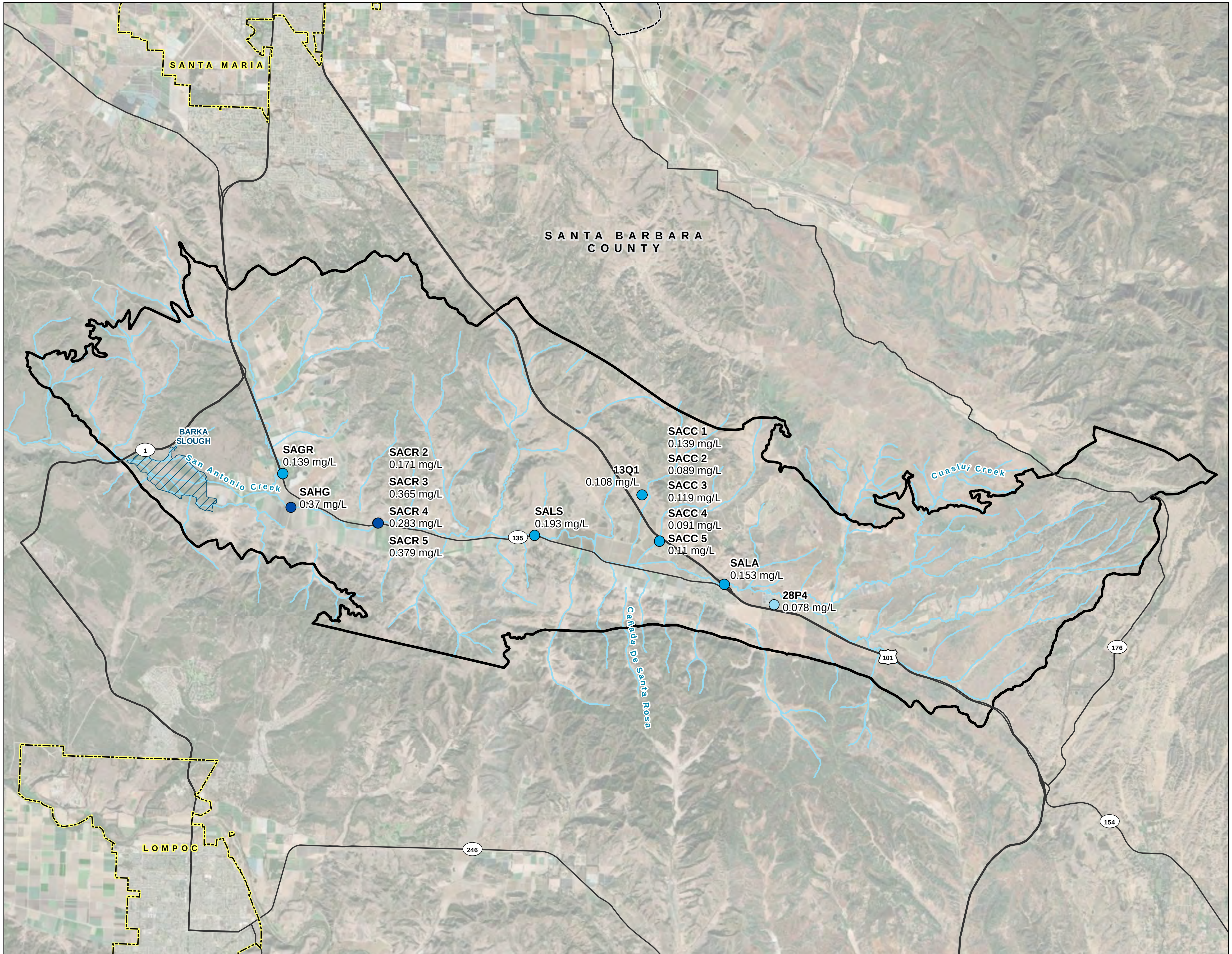


FIGURE 3-45

Boron, 2017
Paso Robles Formation

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Well Concentrations

Boron

- < 0.1 mg/L
- 0.1 - 0.2 mg/L
- > 0.2 mg/L*

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*The Water Quality Objective for Boron is 0.2 mg/L.

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

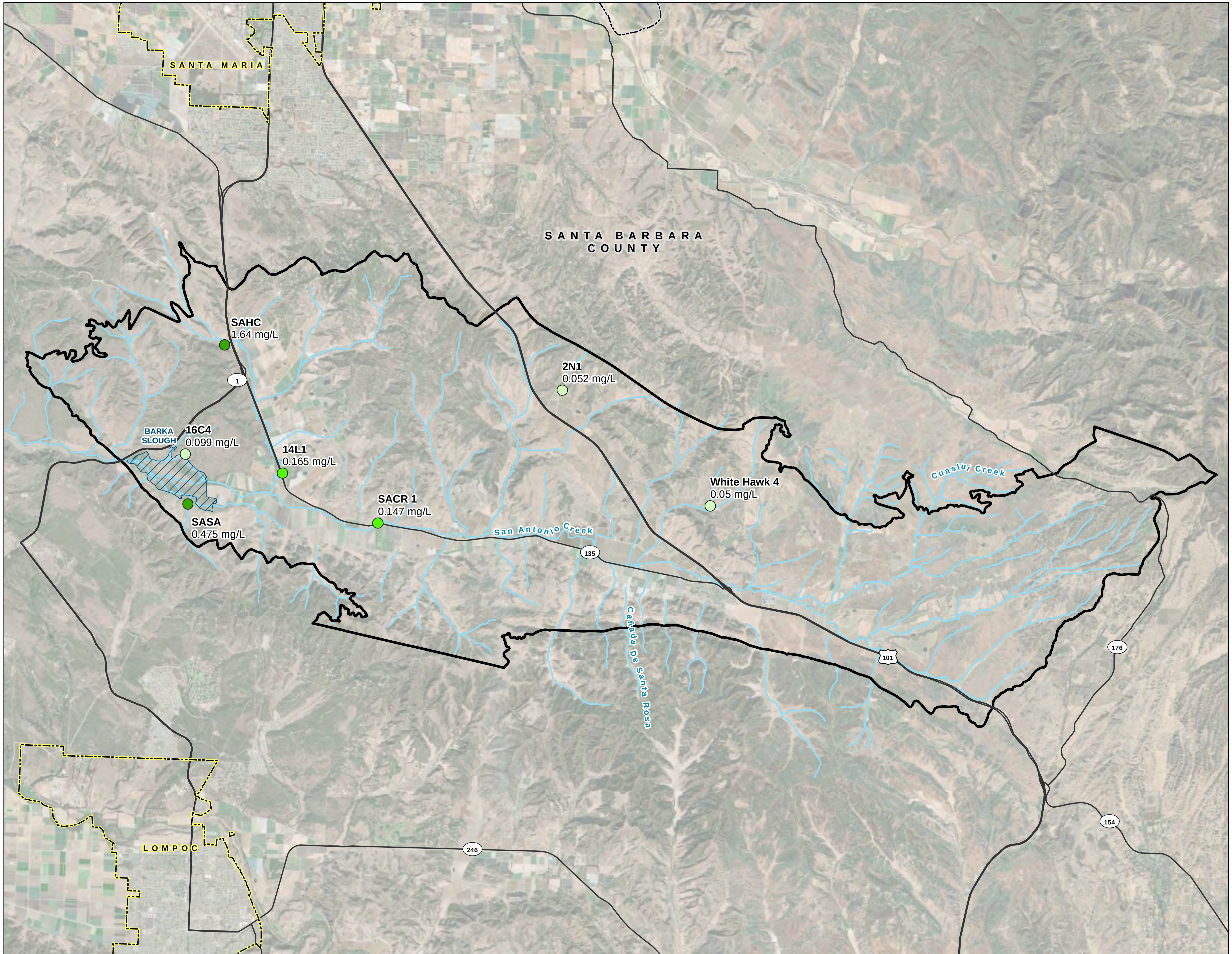
GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_45_Boron_Paso_Robles_Aquifer.mxd, abarry

FIGURE 3-46

Boron, 2017
Careaga Sand

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin



LEGEND

Well Concentrations

Boron

- < 0.1 mg/L
- 0.1 - 0.2 mg/L
- > 0.2 mg/L*

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTES

*The Water Quality Objective for Boron is 0.2 mg/L.

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

mg/L: milligrams per liter

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020).
Water Quality data: GAMA (2021), USGS (2020g)

GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_46_Boron_Careaga_Aquifer.mxd, abarry

Other Constituents

Other constituents detected at concentrations at or above their respective thresholds include iron, manganese, and molybdenum. SMCL exceedances of manganese and iron have been detected throughout the Basin; concentrations for these constituents appear stable. Exceedances of the Federal Health Advisory Level (EPA, 2018) for molybdenum have also been detected throughout the Basin.

Detected exceedances of the action level for lead (EPA, 1991) occurred in samples from two wells in the VSFB wellfield in 2007. Available data indicate that these are isolated concentrations that are not laterally continuous.

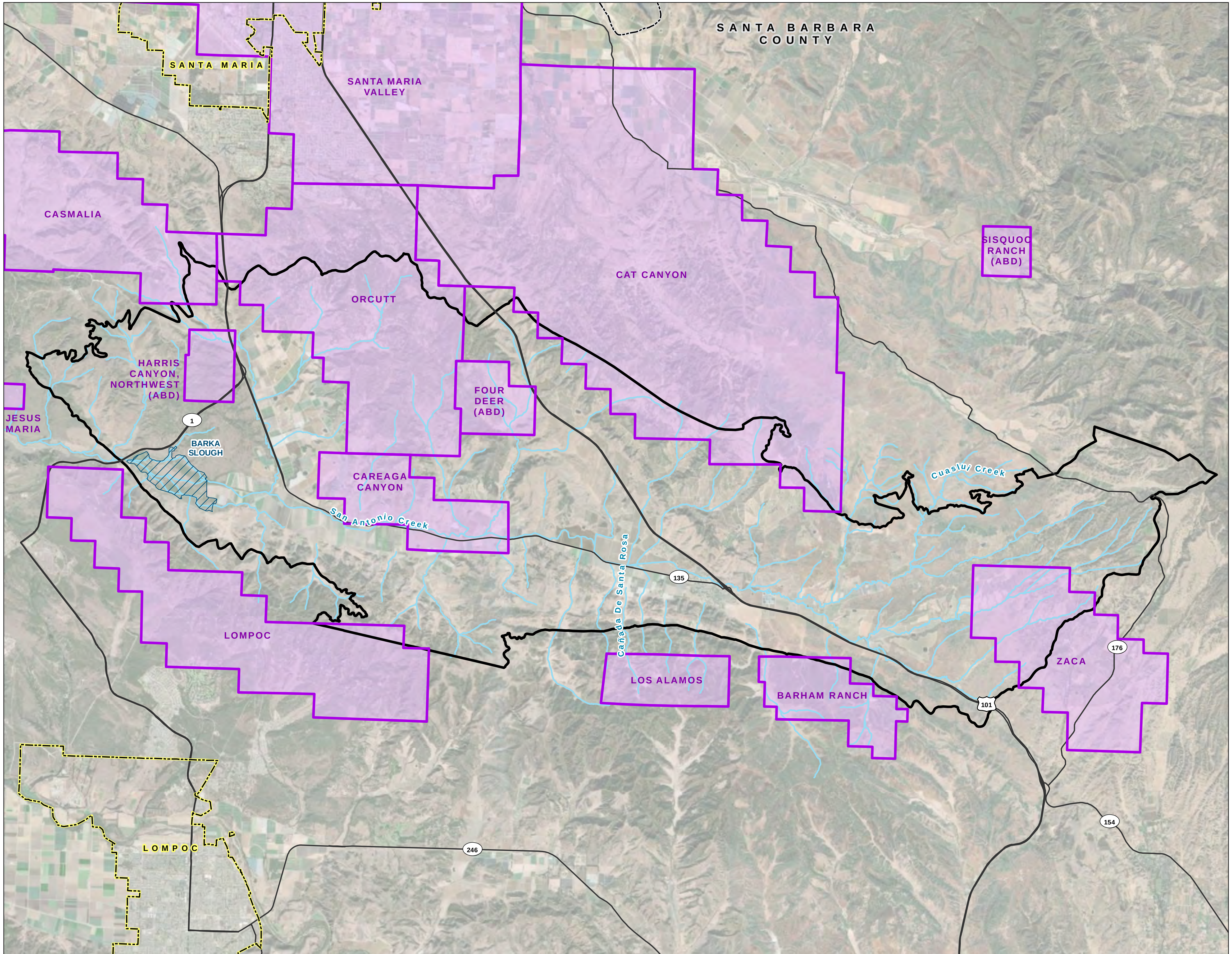
3.2.3.5 Impacts to Groundwater Quality from Oil and Gas Development Activities

According to the California Department of Conservation, Geologic Energy Management Division online Well Finder, or WellSTAR, tool, nine named oil and gas fields are located within or adjacent to the Basin: Cat Canyon, Zaca, Barham Ranch, Los Alamos, Lompoc, Harris Canyon (abandoned), Careaga Canyon, Orcutt, and Four Deer (abandoned) (see Figure 3-47).

FIGURE 3-47

Regional Oil and Gas Fields

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin



LEGEND

- Oil and Gas Field
- San Antonio Creek or Adjacent Tributary
- Barka Slough
- San Antonio Creek Valley Groundwater Basin

All Other Features

- County Boundary
- City Boundary
- Major Road

NOTE

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020), Department of Conservation (2020)

GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_47_Oil_and_Gas_Fields.mxd, abarry

The USGS, in cooperation with the SWRCB, initiated the California Oil, Gas, and Groundwater (COGG) Program in 2015. The objective of the COGG Program is to determine where and to what extent groundwater quality may be adversely impacted by proximal oil and gas development activities (Davis, et al., 2018).

The 487 onshore oil and gas fields in California were prioritized based on potential risk to groundwater from oil and gas development. The USGS developed a criteria-based approach to prioritize the oil and gas fields, the criteria include petroleum-well density, volume of water injected in oil fields, vertical proximity of groundwater resources to oil and gas resource development, and water-well density (Davis et al., 2018).

The priority classifications for the oil and gas fields previously mentioned are shown on Figure 3-48, in Table 3-7, and are summarized below.

- High Priority – Cat Canyon, Zaca, Lompoc, and Orcutt
- Moderate Priority – Careaga Canyon
- Low Priority – Barham Ranch, Los Alamos, Harris Canyon, and Four Deer

Results and interpretations from the COGG Program are not yet available for review. If results and interpretations become available during the implementation period of this GSP, the SABGSA will consider these findings during GSP review periods.

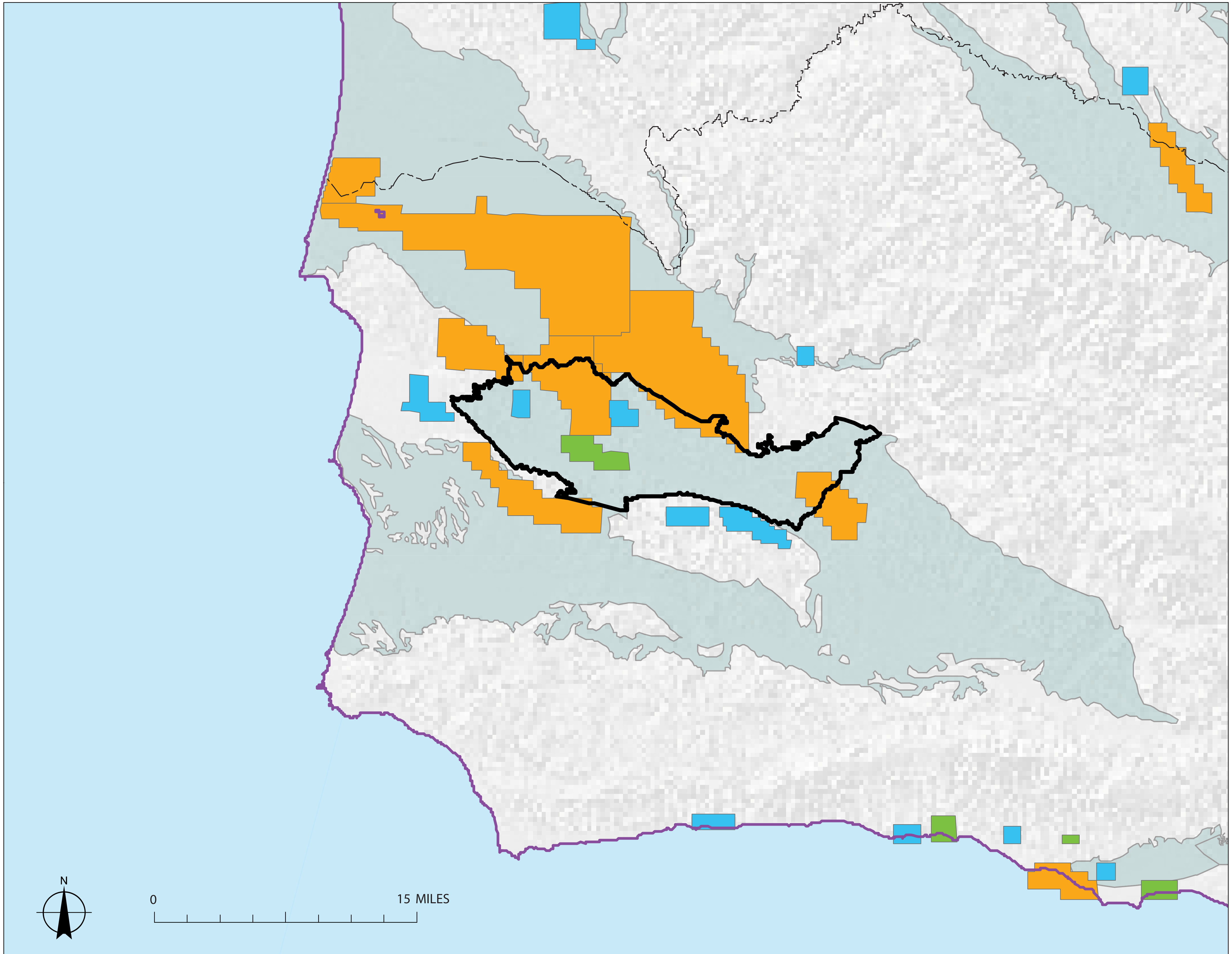


FIGURE 3-48

Prioritization of Oil and Gas Field Regional Groundwater Monitoring

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Priority classifications
- High
- Moderate
- Low

- SAC Basin
- DWR groundwater basins
- DOGGR district boundary
- County

NOTE
DOGGR: California Division of Oil, Gas, and Geothermal Resources

Date: September 16, 2021
Data Sources: Davis et al. (2018), DWR (2018a)

GSI Water Solutions, Inc.

Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3

Table 3-7. Calculated Priority Classification for Oil and Gas Fields

Oil and Gas Field	Field Code	DOGGR District	Field Area (mi²)	Petroleum Well Density: Factor Ranking	Density of all Petroleum Wells (wells/mi²)	Density of Injection Wells (wells/mi²)	Density of Waste-Disposal Wells (wells/mi²)	Volume of Water Injection 1977–2015: Factor Ranking	Total Volume of Water or Steam Injection (MMB)	Total Volume of Water Injection for Waste-Disposal (MMB)	Vertical Proximity: Factor Ranking	Vertical Separation Distance (ft)	Water-Well Density: Factor Ranking	Density of Overlying Water Wells (wells/mi²)	Density of Adjacent Water Wells (wells/mi²)
High/Close Range					>70	>6	>2		>140	>25		<1,000		>8	>4
Moderate Range					10–70	0.02–6	0.02–2		10–140	2.5–25		1,000–3,000		1–8	2–4
Low/Far Range					<10	<0.02	<0.02		<10	<2.5		>3,000		<1	<2
District 3—Central Coast															
High Priority															
Cat Canyon	128	3	41.3	High	55.10	6.32	2.49	High	578.76	334.18	Moderate	1,742	Moderate	1.50	1.51
Lompoc	410	3	13.4	Moderate	16.25	1.04	0.97	High	762.62	762.62	Moderate	2,637	Low	0.82	0.48
Orcutt	524	3	17.2	Moderate	41.11	5.93	0.52	High	1015.61	59.19	Moderate	2,191	Low	0.35	1.77
Zaca	860	3	8.8	Moderate	9.38	1.47	1.47	High	287.57	287.56	Far	3,519	Moderate	1.58	0.75
Moderate Priority															
Careaga Canyon	116	3	4.6	Moderate	3.26	0.43	0.43	Low	1.79	1.79	—	—	Moderate	2.60	0.93
Low Priority															
Four Deer	250	3	2.0	Moderate	14.83	0.99	0.00	Low	0.35	0.00	—	—	Low	0.00	1.12
Harris Canyon, NW	295	3	1.4	Low	3.62	0.00	0.00	Low	0.00	0.00	—	—	Low	0.00	0.53
Los Alamos	420	3	2.5	Low	5.25	0.00	0.00	Low	0.00	0.00	—	—	Low	0.81	0.97

Notes

Fields are listed alphabetically by California Division of Oil, Gas, and Geothermal Resources (DOGGR) district. Fields were ranked by each variable into high, moderate, or low categories using the range of values listed in this table; fields were ranked as close, moderate, and far for vertical proximity. The ranking for petroleum-well density was determined by the highest ranking of the three well density calculations: density of all petroleum wells, density of injection wells, or density of waste-disposal wells. The ranking for volume of injection was the higher ranking of total water injection or water injection for waste disposal. Fields that had high water-well density overlying the field or moderate water-well density overlying field and high water-well density adjacent to field were ranked high for water-well density; fields that had low overlying and adjacent water-well density were ranked low; all other fields were ranked moderate. Petroleum-well density, volume of injection, vertical proximity, and water-well density were combined for each field into an overall priority classification. This table includes only fields that were classified as high priority.

— = not available
mi² = square mile
NW = northwest
DOGGR = California Division of Oil, Gas, and Geothermal Resources
MMB = million barrel (about 42 gallons per barrel)
wells/mi² = wells per square mile
ft = foot

Reference

Davis, T.A., Landon, M.K., and Bennett, G.L. 2018. *Prioritization of Oil and Gas Fields for Regional Groundwater Monitoring Based on a Preliminary Assessment of Petroleum Resource Development and Proximity to California's Groundwater Resources: U.S. Geological Survey Scientific Investigations Report 2018–5065*. Available at https://doi.org/10.3133/sir20185065. (Accessed November 6, 2020.)

3.2.4 Land Subsidence [§ 354.16(e)]

§ 354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(e) The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

Land subsidence can be caused by a number of factors, including (1) lowering of groundwater levels due to pumping if the subsurface geology is prone to subsidence (that is, contains substantial clay beds), (2) oil and gas production, and (3) tectonic activity. For subsidence to occur as a result of groundwater extraction, water levels would need to drop below historical levels for extended periods of time. The DWR data sets reviewed during preparation of the GSP are presented below.

3.2.4.1 NASA-JPL InSAR Data Set, TRE ALTAMIRA Data Set, and UNAVCO CGPS Data Set

The web-based DWR SGMA Data Viewer geographic information system (GIS) (DWR, 2020a) records land surface elevation data for the Basin. Reviewed data include the following:

- Estimated land surface elevation data using Interferometric Synthetic Aperture Radar (InSAR) data that are collected by the European Space Agency Sentinel-1A satellite and processed by TRE ALTAMIRA Inc. (TRE) for the period from June 13, 2015, to September 19, 2019 (TRE ALTAMIRA, Inc., 2020).
- Estimated land surface elevation data using InSAR data collected by the European Space Agency Sentinel-1A satellite and processed by the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory (JPL) for the period between spring of 2015 and summer of 2017 (NASA JPL, 2018).
- Measured land surface elevation data collected by a network of Continuous Global Positioning System (CGPS) stations operated by University NAVSTAR Consortium (UNAVCO). Measured land surface elevation data collected by CGPSs located in Los Alamos were reviewed for the Basin (UNAVCO, 2020a).

Figure 3-49 shows the InSAR measured land surface elevation changes in the Basin. The dark blue areas are areas with measured ground surface rise of between 0 and 0.25 ft. The lighter teal areas are areas with measured ground surface drop of 0 to 0.25 ft. Random sampling of the 100-meter by 100-meter (328-ft by 328-ft) calculation grid cells indicates the greatest decrease in land surface elevation has occurred near the town of Los Alamos. Total measured elevation decrease in the Los Alamos area is approximately 0.1 ft, or 0.025 ft per year between the years 2015 and 2019. (Figure 3-50). This is a minor rate of land surface elevation change that is relatively insignificant and not a major concern for the Basin. However, ongoing subsidence over many years could add up to a more significant ground surface drop.

The data accuracy report for the InSAR data (Towill, Inc., 2020) states that "InSAR data accurately models change in ground elevation to an accuracy tested to be 16 mm at 95% confidence." Based on this, the InSAR-based annual subsidence rate of 4.6 mm (0.18 inches) is below the accuracy range of 16 mm (0.63 inches). Thus, the reported subsidence is within the range of uncertainty of the InSAR data, indicating that no significant subsidence within the Basin has been recorded.

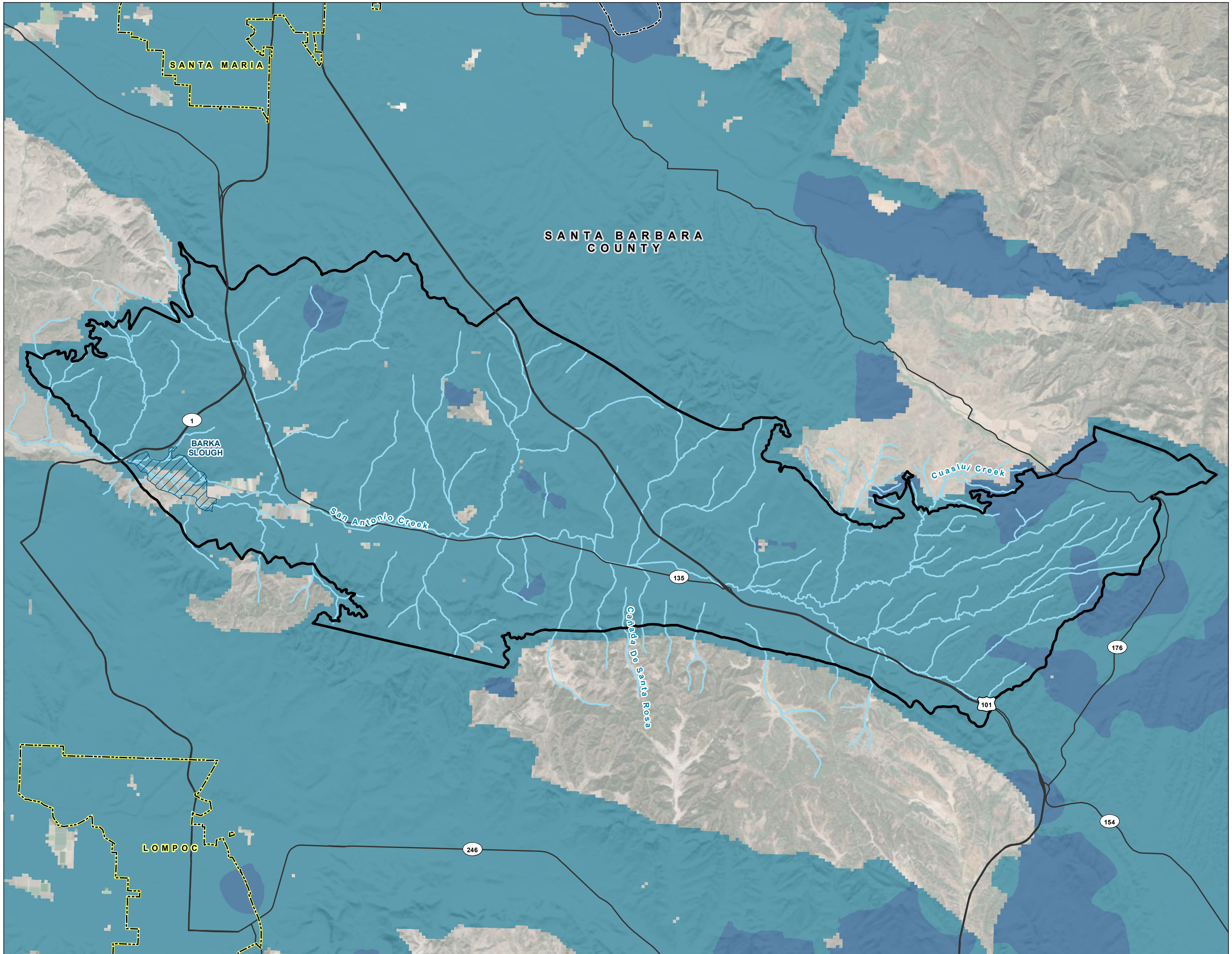


FIGURE 3-49

Total Land Surface Elevation Change (2015-2019), InSAR Data Map

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Land Subsidence

Vertical Displacement

- -0.25 to 0 ft
- 0 to 0.25 ft

All Other Features

- San Antonio Creek or Adjacent Tributary
- Barka Slough
- B118 San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a, 2020a), Maxar imagery (2020)

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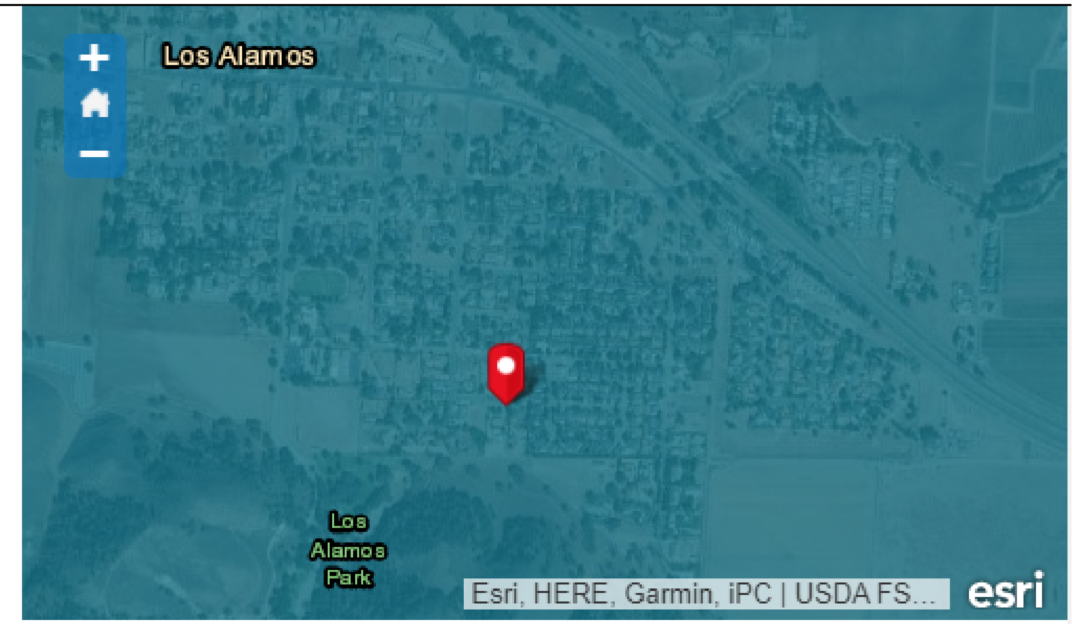
Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_49_Total_Subsidence_2015_2019_InSAR.mxd, abarry

TRE ALTAMIRA Vertical Displacement at Latitude: 34.73869 **Longitude:** -120.27521

Interpolated Displacement (ft): -0.181
Latitude: 34.73869
Longitude: -120.27521



Vertical Displacement

Date: (hover to see values)
TRE Altamira Interpolated Vertical Displacement

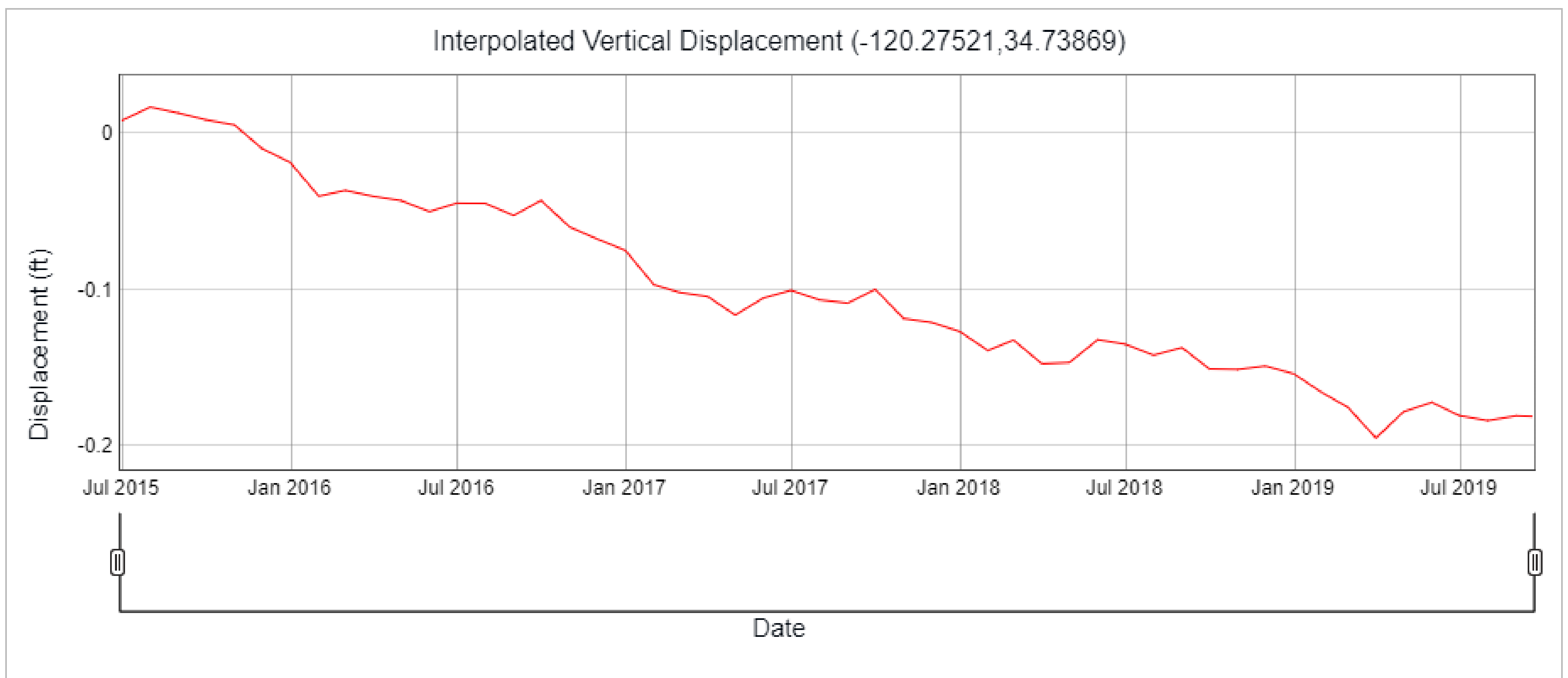


FIGURE 3-50

Land Surface Elevation Change, TRE Point Source, Los Alamos

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

Date: September 16, 2021
Data Sources: DWR (2020a)

GSI Water Solutions, Inc.

3.2.4.2 UNAVCO Continuous Global Positioning System Sites

Figure 3-51 is a time-series plot of land surface elevation change generated from data recorded from the UNAVCO CGPS Station ORES, located in the town of Los Alamos, near Los Alamos Park. Total land surface change recorded by the station during the 20-year period of record (2000 to 2020) is approximately 250 millimeters, or 0.82 ft. Based on these data, the decrease in land surface elevation is occurring at a rate of approximately 0.49 inch per year. The plot indicates an accelerated subsidence rate beginning in 2014–2015. This is a minor rate of subsidence and is relatively insignificant and not a major concern for the Basin. However, ongoing subsidence over many years could add up to a more significant ground surface drop. The SABGSA will continue to monitor annual subsidence as part of its GSP monitoring program.

The Basin is located near the intersection of the Coastal Ranges and Transverse Ranges California Geomorphic Provinces. Consequently, the Basin is in a very tectonically active region. The 0.82 ft of vertical displacement measured at the UNAVCO station could be due to tectonic activity, groundwater extraction, oil and gas extraction, or a combination of the three. In addition, InSAR data provided by DWR show that significant land subsidence did not occur during the period between June 2015 and June 2019 (available InSAR data period of record) in the Basin.

3.2.4.3 Preliminary Subsidence Evaluation

To supplement the InSAR and UNAVCO data and assess the general susceptibility of the Basin to experience subsidence as a result of lowering groundwater levels below historical levels, a preliminary subsidence evaluation was completed. The preliminary evaluation was based on review of subsurface geologic information and groundwater level data for key wells and included estimating ranges of possible long-term subsidence that might be expected in the future. The evaluation, which is included in Appendix D, included the following key conclusions:

- There have been no reports from landowners or public agencies of impacts resulting from subsidence.
- The analysis was completed at two representative well locations and showed an estimated total potential subsidence on the order of 1 to 2 ft over the historical period resulting from the changes in groundwater elevation reported in the hydrographs.
- Historical subsidence on the order of 1 to 2 ft appears relatively consistent with the estimated subsidence rate of 0.5 inches per year reported for the UNAVCO CGPS Station ORES (see Section 3.2.4.2).

The well logs used in the evaluations include relatively thick sections of clayey materials (which would be where compaction and inelastic subsidence may occur), which are not necessarily representative of the entire Basin. The Paso Robles Formation contains relatively thin, often discontinuous sand and gravel layers interbedded with thicker layers of silt and clay; however, the fine-grained materials that may be subject to subsidence are not laterally continuous. The lack of lateral continuity tends to reduce the likelihood for significant subsidence. The Careaga Sand consists of fine-grained to medium-grained, uniform, massive, marine sand with some gravel and limestone; therefore, lacking laterally continuous fine-grained material susceptible to significant subsidence. Based on the result of this analysis, it is unlikely that the full measure of estimated subsidence (of 1 to 2 ft) would be observed unless groundwater elevations declined significantly below what has been observed historically and did not recover for an extended period.

There has been no reported historical or anecdotal information regarding land subsidence in the Basin as a result of groundwater extractions. There may be, and likely has been, some subsidence as a result of groundwater extraction, but the effects, to date, have not been documented to affect surface features. With groundwater declines of as much as 70 to 143 ft in the Basin (see Section 3.2.1.2), some subsidence may have occurred prior to the initiation of SGMA (January 2015), but there is no readily available information to document that. Due to the limited data available and the fact that factors other than groundwater extraction (e.g., tectonic activity and oil and gas extraction) must be considered, it is unknown how much subsidence has occurred, or how it relates to the maximum amount that may occur in the future. For these reasons, the SABGSA intends to continue to monitor for subsidence.

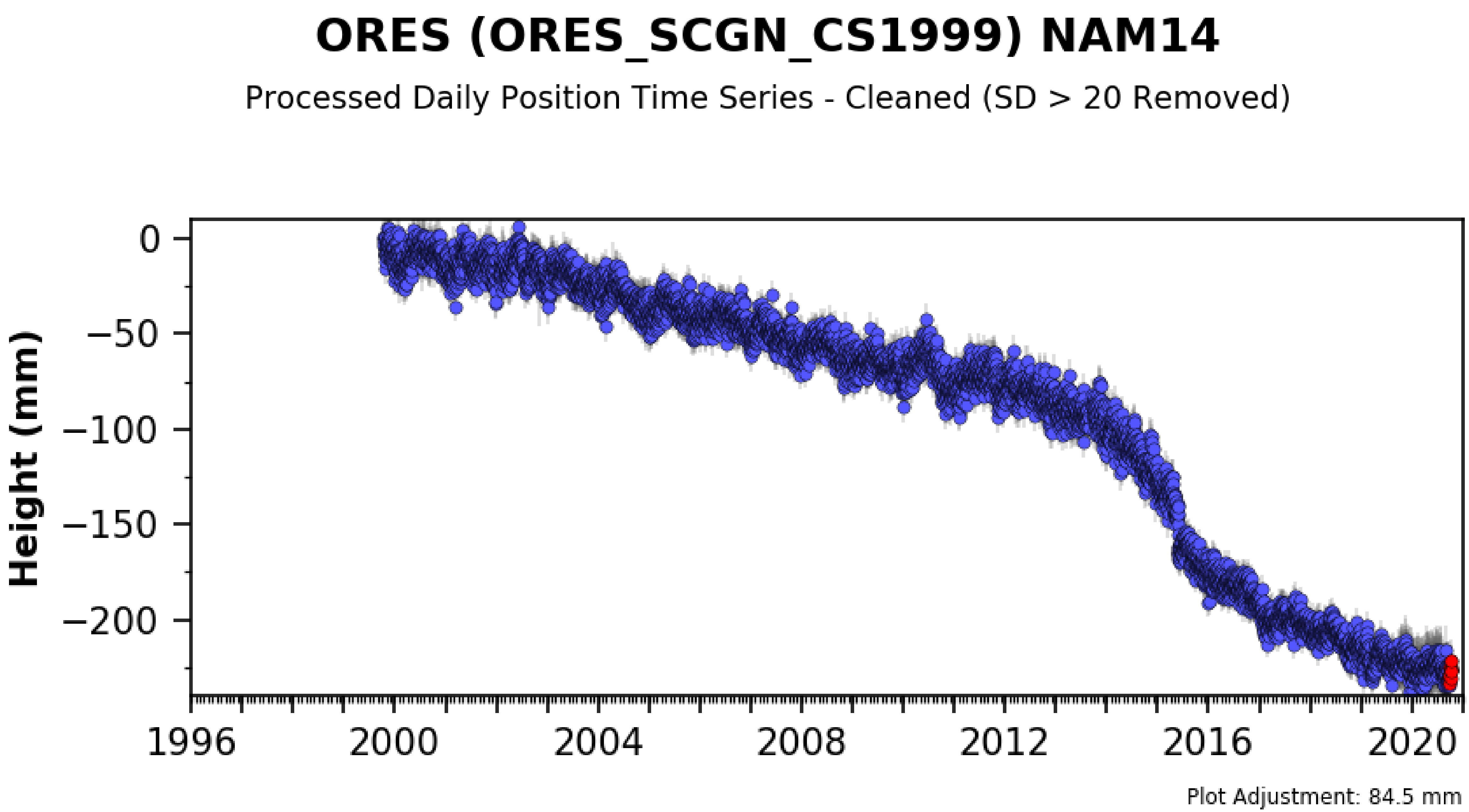


FIGURE 3-51

Time Series Plot of Land Surface Elevation Change from UNAVCO CGPS Station ORES

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Final Solution

Rapid Solution

Standard Deviation

Date: September 16, 2021
Data Sources: UNAVCO (2020b)

GSI Water Solutions, Inc.

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3.2.5 Interconnected Surface Water Systems [§ 354.16(f)]

§ 354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(f) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

Surface water systems interact with groundwater in three basic ways, as follows:

- Surface water systems gain water from inflow of groundwater through the stream bed.
  - Requires the elevation of the water table in the vicinity of the surface water body to be higher than the elevation of the surface water body surface
- Surface water systems lose water to groundwater by outflow through the stream bed.
  - Requires the elevation of the water table in the vicinity of the surface water body to be lower than the elevation of the surface water body surface
- Surface water systems gain water in some reaches of the surface water body and lose water in others.

Figure 3-52 is a drawing of gaining and losing stream conditions.

The connection of surface and groundwater systems can be affected by natural processes such as heavy rain events and periods of drought, as well as anthropogenic processes, such as land development, stream alteration, and pumping of surface water and groundwater. In addition to affecting the direction of water movement and volume of water exchanged between surface and groundwater systems, these processes can also affect water quality.

Figure 3-53 is a stream classification map of the Basin as defined by the USGS NHD (USGS, 2020b). Based on the USGS NHD, all the streams in the Basin are classified as intermittent and likely to be losing streams. The stream channels located in Barka Slough are classified as perennial and likely to be gaining streams.

Ephemeral surface water flows in the Basin make it difficult to assess the interconnectivity of surface water and groundwater and to quantify the degree to which surface water depletion has occurred. According to the USGS NHD, three springs or seeps were identified in the Basin (see Figure 3-9). Based on the location of three springs or seeps, they appear to be overlying the Paso Robles Formation. Two additional springs or seeps were identified by basin stakeholders and are located northeast of Los Alamos on Price Ranch within a tributary to San Antonio Creek and in the Las Flores watershed, a tributary to San Antonio Creek, in the low-lying grassland areas immediately west of U.S. Highway 101 (CRCD, 2003) (see Figure 3-9). Based on location, the spring or seep in the Las Flores watershed overlies the Paso Robles Formation and the Price Ranch spring or seep is located near the contact between the Paso Robles Formation and the Careaga Sand. Without additional analysis, it is unknown whether the groundwater source of these springs or seeps is from the underlying principal aquifer or from perched water within the channel alluvium. As discussed in Section 3.1.3.1, artesian conditions exist in the Basin and are due to localized confining layers created by the synclinal structure of the Basin, the presence of overlying fine-grained deposits, and or faults present within the Basin (Carlson, 2019) (USGS, 2021a). Planned additional analysis of these areas are described in Section 6.

Interconnected surface water and groundwater within the Paso Robles Formation and Careaga Sand is indicated by the Barka Slough and perennial classification of streams in that area. Figure 3-31 is a conceptual model of groundwater flow as it reaches Barka Slough. The results for volume calculations of groundwater discharged annually to Barka Slough are presented in Table 3-8. Refer to Section 3.3 and Appendix D for groundwater discharge calculations.

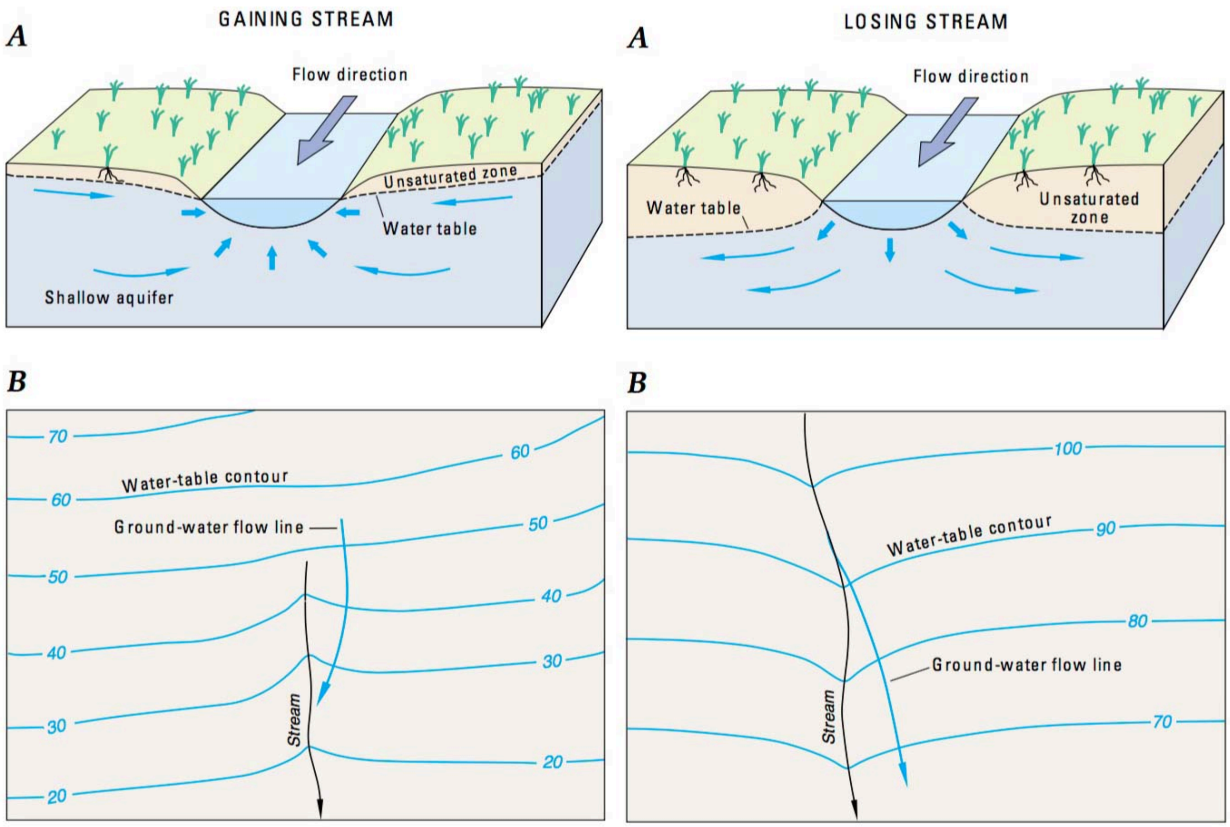

Figure 3-52. Gaining and Losing Streams (USGS, 2020d)

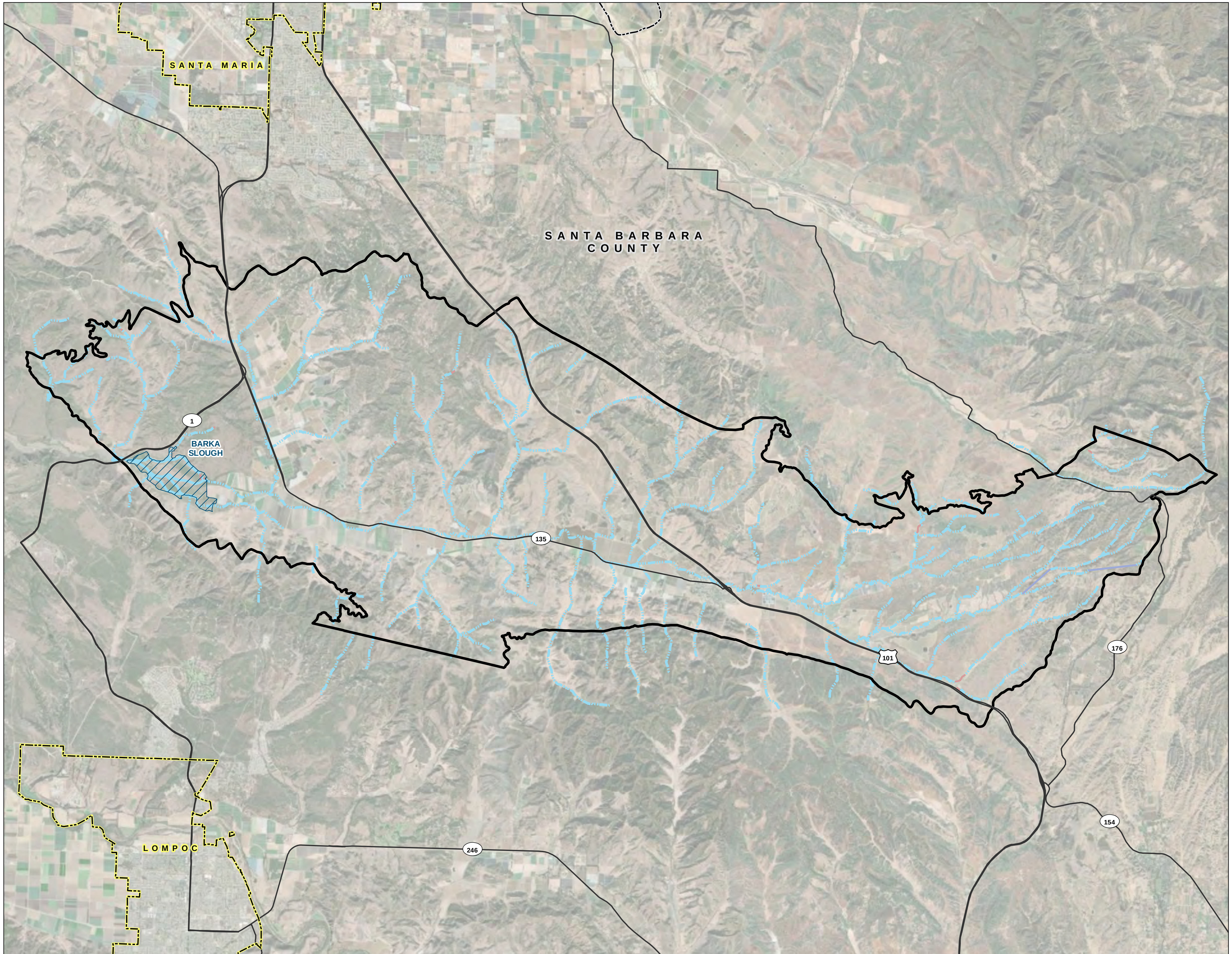

FIGURE 3-53

USGS National Hydrography Dataset (NHD) Stream Classification

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

USGS NHD Stream Classification

- Intermittent
- Perennial
- Connector
- Artificial Path

All Other Features

- Barka Slough
- San Antonio Creek Valley Groundwater Basin
- County Boundary
- City Boundary
- Major Road

NOTE

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

N

0 5,000 10,000 15,000
Feet

GSI Water Solutions, Inc.

Date: November 18, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a), Maxar imagery (2020)

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_53_USGS_NHD_Stream_Classification.mxd, abarry

Table 3-8. Average Annual Surface and Groundwater Discharge to Barka Slough[1]

Water Type	Discharge Type	Discharge Volume (AFY)
Surface Water	Streamflow	2,100
Groundwater	Vertical Flux[2]	4,900
Total		**7,000**

Notes

[1] See Section 3.3 and Appendix D for explanation of calculations.

[2] Vertical flux includes discharge of groundwater into the alluvium from the Paso Robles Formation and through Barka Slough sediments from the Careaga Sand (see Figure 3-31 for conceptual model of surface and groundwater flow as it reaches Barka Slough).

AFY = acre-feet per year

Figure 3-54 shows the locations of active and inactive stream gages along San Antonio Creek and its tributaries. The gages are as follows:

- Stream gage 11135800 is active, located along San Antonio Creek near Los Alamos, and has a period of record of water years 1971 through 2018.
- Stream gage 11136000 is inactive, was located along San Antonio Creek at Harris Canyon and had a period of record of water years 1948 through 1954.
- Stream gage 11136050 is inactive, was located along San Antonio Creek above Barka Slough, and had a period of record of water year 1985.
- Stream gage 11136040 is inactive, was located along Harris Canyon Creek upgradient of the confluence with San Antonio Creek and had a period of record of water year 2018.
- Stream gage 11136100 (referred to as the Casmalia gage) is active, located west of the Basin along San Antonio Creek and has a period of record of water years 1956 through 2018.

Due to the placement of the gages and limited period of record, the recorded flow data cannot be used to accurately quantify stream gains or losses. However, seasonal flow data shown on Figure 3-45 are consistent with the stream classifications on Figure 3-53.

Overview Map

San Antonio Creek Daily Stream Gage Data

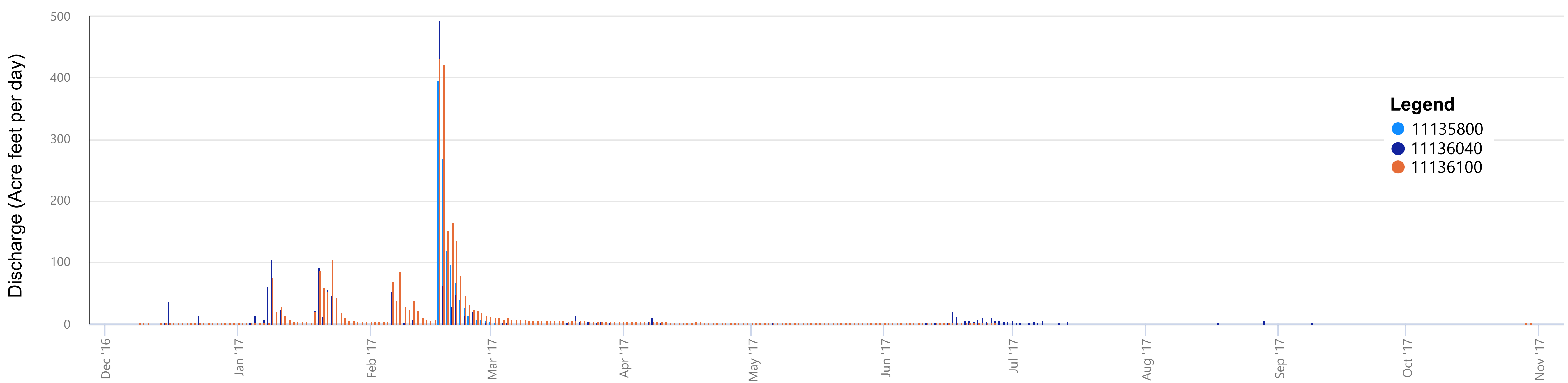

FIGURE 3-54

Daily Stream Gage Data

Groundwater Sustainability Plan
San Antonio Creek Valley Groundwater Basin

GSI Water Solutions, Inc.

Date: September 16, 2021
Data Sources: USGS (2020f), PowerBI

Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3

3.2.6 Groundwater-Dependent Ecosystems [§ 354.16(g)]

§ 354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(g) Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

SGMA and DWR's GSP regulations establish requirements for the identification of GDEs, and if present, identification of impacts on GDEs from management actions in the Basin. GDEs are defined in the SGMA regulations as "ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface." Determination of whether an area within a groundwater basin includes GDEs is the responsibility of the GSA. DWR created the NCCAG data set to assist GSAs with identification of potential GDEs. NCCAG data are presented on Figure 3-10.

The NCCAG data set is a compilation of 48 publicly available state and federal agency data sets that map vegetation, wetlands, springs, and seeps in California. A working group that includes DWR, California Department of Fish and Wildlife (CDFW), and The Nature Conservancy (TNC) reviewed the compiled data set and conducted a screening process to exclude vegetation and wetland types less likely to be associated with groundwater and to retain types commonly associated with groundwater as described in Klausmeyer et al. (2018). Two habitat classes are included in the NCCAG data set statewide:

- Wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions
- Vegetation types commonly associated with the subsurface presence of groundwater (phreatophytes)

The data included in the NCCAG data set do not represent the determination of a GDE by DWR, only the potential existence of a GDE. However, the NCCAG data set can be used by GSAs as a starting point when approaching the task of identifying GDEs within a groundwater basin that are both classified as potential GDEs and connected to groundwater (DWR, 2020b).

3.2.6.1 Identification of Potential GDEs

TNC developed a guidance document based on best available science to assist agencies, consultants, and stakeholders to efficiently incorporate GDEs analysis into GSPs. In the guidance, five steps were outlined to inform the GSP process (Rohde et al., 2018):

Step 1 – Identify potential GDEs

  Step 1.1 – Map GDEs

  Step 1.2 – Characterize GDE Condition

Step 2 – Determine Potential Effects of Groundwater Management on GDEs

Step 3 – Consider GDEs when Establishing Sustainable Management Criteria

Step 4 – Incorporate GDEs into the Monitoring Network

Step 5 – Identify Projects and Management Actions to Maintain or Improve GDEs

The two objectives within Step 1, to map (Step 1a) and characterize (Step 1b) GDEs in the Basin, are the focus of this section. The remaining steps are considered in later sections of the GSP, specifically in

Sustainable Management Criteria (Section 4), Monitoring Network (Section 5), and Projects and Management Actions (Section 6).

Based on review of the NCCAG data set, several wetland features, three mapped springs, and four types of vegetation communities are present in the Basin. The four Natural Communities vegetation types are:

- Coast Live Oak
- Valley Oak
- Riparian Mixed Harwood
- Willow

Wetland classifications recorded in the Natural Communities data set (DWR, 2020b) for the Basin include the following:

- Palustrine, Emergent, Persistent, Seasonally Flooded
- Palustrine, Emergent, Persistent, Semipermanently Flooded
- Palustrine, Forested, Seasonally Flooded
- Palustrine, Scrub-Shrub, Seasonally Flooded
- Palustrine, Unconsolidated Bottom, Permanently Flooded
- Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded
- Riverine, Unknown Perennial, Unconsolidated Bottom, Semipermanently Flooded

Generally, wetlands were recorded along the San Antonio Creek tributary channels as well as Barka Slough. There are a few small areas outside of these locations that may be associated with springs.

The four Natural Communities vegetation classifications are presented as polygons on Figure 3-10 as they occur throughout the Basin. Each of the vegetation classifications are described in detail below. The Natural Communities wetland classifications are also presented on Figure 3-10 (aggregated as one "wetland area" category). The three mapped springs are also shown on Figure 3-10.

Potential GDE Vegetation Classifications

The Natural Communities vegetation classes mapped within the Basin include Coast Live Oak, Valley Oak, Riparian Mixed Hardwood, Riversidean Alluvial Scrub, and Willow. These NCCAG vegetation classifications are a collection of multiple vegetation species. The classifications named after a specific species (e.g., Willow) are generally the predominant species in the classification (Klausmeyer et al, 2018). A summary of each of the classifications is provided below.

The **Coast Live Oak** Natural Communities classification occurs throughout the Basin, covering an area of 2,686 acres, as shown in orange on Figure 3-10. Coast live oak (*Quercus agrifolia*) dominates this type that occurs primarily on protected north-facing ravines within the river channel. Coast live oak is considered the most fire-resistant California tree oak and does not tolerate extended flooding (USDA, 2009). It has evergreen leaves, thick bark, and an ability to sprout from the trunk and roots, given its food reserves stored in an extensive root system (USDA, 2009). Associated species include toyon (*Heteromeles arbutifolia*) and elderberry (*Sambucus mexicana*) (SWRCB, 2011). Reported maximum rooting depths for the coast live oak range from 24 to 35 ft (TNC, 2020).

The **Valley Oak** Natural Communities classification occurs primarily in the eastern portion of the Basin, covering an area of 495 acres as shown in red on Figure 3-10. Valley oak (*Q. lobata*) savanna and woodlands normally occur at elevations below 2,000 ft in valley bottoms on deep, well-drained soils

(Meridian Consultants, 2012). Understory vegetation in relatively undisturbed areas may be constituted of native perennial bunchgrasses. This community may also contain scattered coast live oaks and blue oaks. Reported maximum rooting depth for valley oak is 80 ft (Lewis and Burgy, 1964).

The **Riparian Mixed Hardwoods** Natural Communities classification occurs in several isolated stands within the Basin, covering an area of 171 acres as shown in purple on Figure 3-10. Riparian Mixed Hardwood is found along perennial and intermittent streams in areas that are less frequently and less intensely disturbed by flood events than areas dominated by riparian scrub. The dominant tree species include Fremont or black cottonwood (*Populus fremontii*, *P. balsamifera ssp. trichocarpa*), California sycamore (*Platanus racemosa*), willow (either arroyo, red, or yellow), California walnut (*Juglans californica*), white alder (*Alnus rhombifolia*), and coast live oak (*Q. agrifolia*) (Meridian Consultants, 2012). Understory species, when present, include California mugwort (*Artemisia douglasiana*), California wild rose (*Rosa californica*), poison oak (*Toxicodendron diversilobum*), Pacific blackberry (*Rubus ursinus*), wild cucumber (*Marah macrocarpa*), and non-native plants such as periwinkle (*Vinca minor*) and nasturtium (*Tropaeolum majus*) (Meridian Consultants, 2012). Apart from coast live oak, only a few of this category's primary plant species (willow, Fremont cottonwood, and black cottonwood) have rooting depth information in the GDE Database (TNC, 2020), with ranges from 1 to 7 ft.

The **Willow** Natural Communities classification occurs within Barka Slough, totaling 268 acres as shown in green on Figure 3-10. The Willow CALVEG alliance is defined by the dominance of a single or a combination of deciduous willow tree species including black (*Salix gooddingii*), red (*S. laevigata*), arroyo (*S. lasiolepis*), and/or shining (*S. lucida*) willows (USDA, 2009). A biological assessment prepared for the Vandenberg Dunes Golf Courses Project indicates the presence of arroyo willow in the area (AECOM, 2019). Willows are found on the edge of active channels and floodplain terraces where they have access to shallow groundwater. Other riparian species found within this CALVEG alliance include the Fremont cottonwood (*P. fremontii*) and California sycamore (*P. racemosa*) and a variety of perennial and annual forbs. No information about rooting depths of the specific willow species listed above is provided in the GDE Rooting Depths Database. However, other willow species in the same genus have reported maximum rooting depths ranging up to 8 ft (TNC, 2020).

A complete biological survey of Barka Slough has not been completed nor made available for review. Table 3-9 lists plant species that likely occur in Barka Slough based on the plant species identified during surveys completed as part of the biological assessment for the Vandenberg Dunes Golf Courses Project (AECOM, 2019) and plant species identified during an unpublished survey that was completed after the Harris Fire (2000) (ManTech, 2010). Due to a redirection in funding, the post-fire assessment habitat study was not completed.

Table 3-9. Rooting Depths of Plant Species Likely Present in Barka Slough[1]

Common Name	Species Name	Maximum Rooting Depth (feet)[2]
Arroyo Willow	*Salix lasiolepis*	3 (*S.* spp.)
Black Elderberry	*Sambucus nigra*	3 (*S. Mexicana*)
Basket Rush	*Juncus textilis*	1 (*J. arcticus*)
Deerweed	*Lotus scoparius*	4
California Bulrush	*Schoenoplectus californicus*	2 (*S. americanus*)
Cattail	*Typha* spp.	1 (*T. domingensis*)
Spiny Rush	*Juncus acutus*	1 (*J. arcticus*)
California Sawgrass	*Cladium californicum*	—
Bur-reed	*Sparganium eurycarpum*	0.4

Notes

[1] Plant species listed were identified during surveys completed as part of the biological assessment for the Vandenberg Dunes Golf Courses Project (AECOM, 2019) and post-Harris Fire assessment habitat study completed in 2004 and 2005 (ManTech, 2010).
[2] Rooting depths as described in the California Plant Rooting Depth Database compiled by The Nature Conservancy in California and published on April 19, 2018. A species name in parentheses following the maximum rooting depth indicates no maximum rooting depth was indicated in the database for the specific species listed in the preceding column and the parenthesized species maximum rooting depth is listed.

— = data are unavailable

Screening of Potential GDEs

To confirm whether the Natural Community vegetation and wetland polygons are connected to groundwater, local hydrologic information may be used to confirm a groundwater connection to the potential GDE. TNC guidance (Rohde et al., 2018) provides a list of questions to assess whether Natural Community polygons (potential GDEs) are connected to groundwater. These questions include the following from Worksheet 1 of the guidance:

1. Is the Natural Community polygon underlain by a shallow unconfined or perched aquifer that has been delineated as being part of a Bulletin 118 principal aquifer in the basin?
2. Is the depth to groundwater under the Natural Community polygon less than 30 feet?
3. Is the Natural Community polygon located in an area known to discharge groundwater (e.g., springs/seeps)?

If the answer is yes to any of these three questions, per TNC guidance, it is likely a GDE. As a part of the process, some Natural Community polygons are removed and other GDE polygons may be added, where appropriate. TNC recommends that Natural Community polygons with insufficient hydrologic data also be considered GDEs but be flagged for further investigation.

Contoured groundwater elevation data for spring 2015 were used to determine areas where the Natural Communities polygons were within 30 ft depth to groundwater. Spring 2015 groundwater elevations were chosen for this analysis because this marked a period of the greatest recent data availability.[20] These data are considered representative of average spring-summer conditions within the last 5 years.[21] Areas with

[20] The spatial distribution and density of spring 2015 groundwater elevation data satisfies the TNC recommendation for using wells that are located within 5 kilometers (3.1 miles) of the Natural Communities polygons (TNC, 2019).
[21] Groundwater elevations are generally the highest in the spring, following recharge from winter rains. Spring-time groundwater elevations in 2015, a relatively dry year, are considered representative of average modern conditions as measured throughout the spring-summer months, during the period of maximum annual evapotranspiration.

spring 2015 depth to groundwater of 30 ft or less are shown in purple on Figure 3-55 and the Natural Communities polygons associated with these areas are shown on Figure 3-56. Other than two small areas located just west of the community of Los Alamos, the area of 30 feet or less depth to groundwater is concentrated entirely around the Barka Slough area.

As discussed in Sections 3.2.1.3 and 3.2.5, Barka Slough is located in an area where there is a groundwater flow barrier and where groundwater is known to discharge from underlying aquifers into the Slough area. As a result of this, plus the results of the depth to groundwater analysis, the Barka Slough area and all intersecting Natural Communities polygons are considered GDEs. An area that is known to discharge groundwater to surface water in seeps is located northeast of Los Alamos on Price Ranch (Figure 3-56). The Price Ranch seep area is designated as a 27-acre wetland and is associated with 33-acre stand of coast live oak, according to the Natural Communities data set (DWR, 2020b). These areas are considered GDEs based on observations by a local landowner.[22] Another area known to discharge groundwater in seeps supporting La Graciosa thistle (*Cirsium loncholepis*; a special-status species; see Section 3.2.6.2) is located in the Las Flores watershed, a tributary to San Antonio Creek, in the low-lying grassland areas immediately west of U.S. Highway 101 (CRCD, 2003). This seep area is designated as a 3-acre wetland and is considered a GDE[22] (Figure 3-56).

[22] Although the Price Ranch and Las Flores watershed seeps are not indicated as potential GDEs in the depth-to-groundwater analysis (i.e., having depth to groundwater of less than 30 ft) they are considered GDEs because they are known to discharge groundwater based on field observation (CRCD, 2003 and local landowner Chris Wrather).

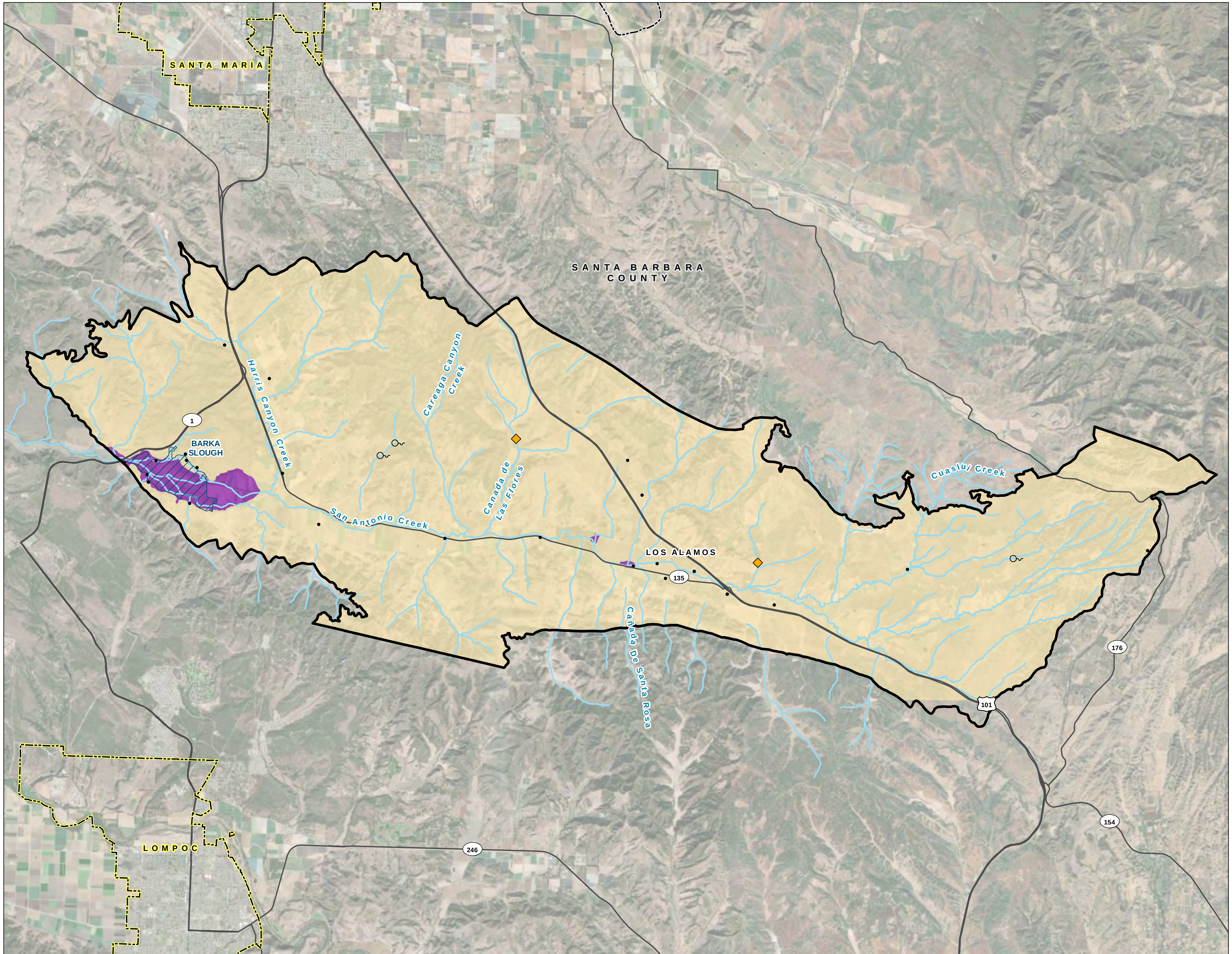

FIGURE 3-55

Groundwater-Dependent Ecosystems 30-Foot Depth to Groundwater Screening

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

- Spring 2015 Measured Groundwater Elevation

Spring 2015 Depth to Groundwater

- <= 30 ft Depth To Water
- > 30 ft Depth To Water

All Other Features

- San Antonio Creek Valley Groundwater Basin
- Barka Slough
- Major Road
- City Boundary
- USGS Spring
- Reported Seep

NOTE

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b), ESRI, DWR (2018a, 2020b), Maxar imagery (2020)

GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_55_GDEs_30ft_Depth_to_GW_Screening.mxd, abarry

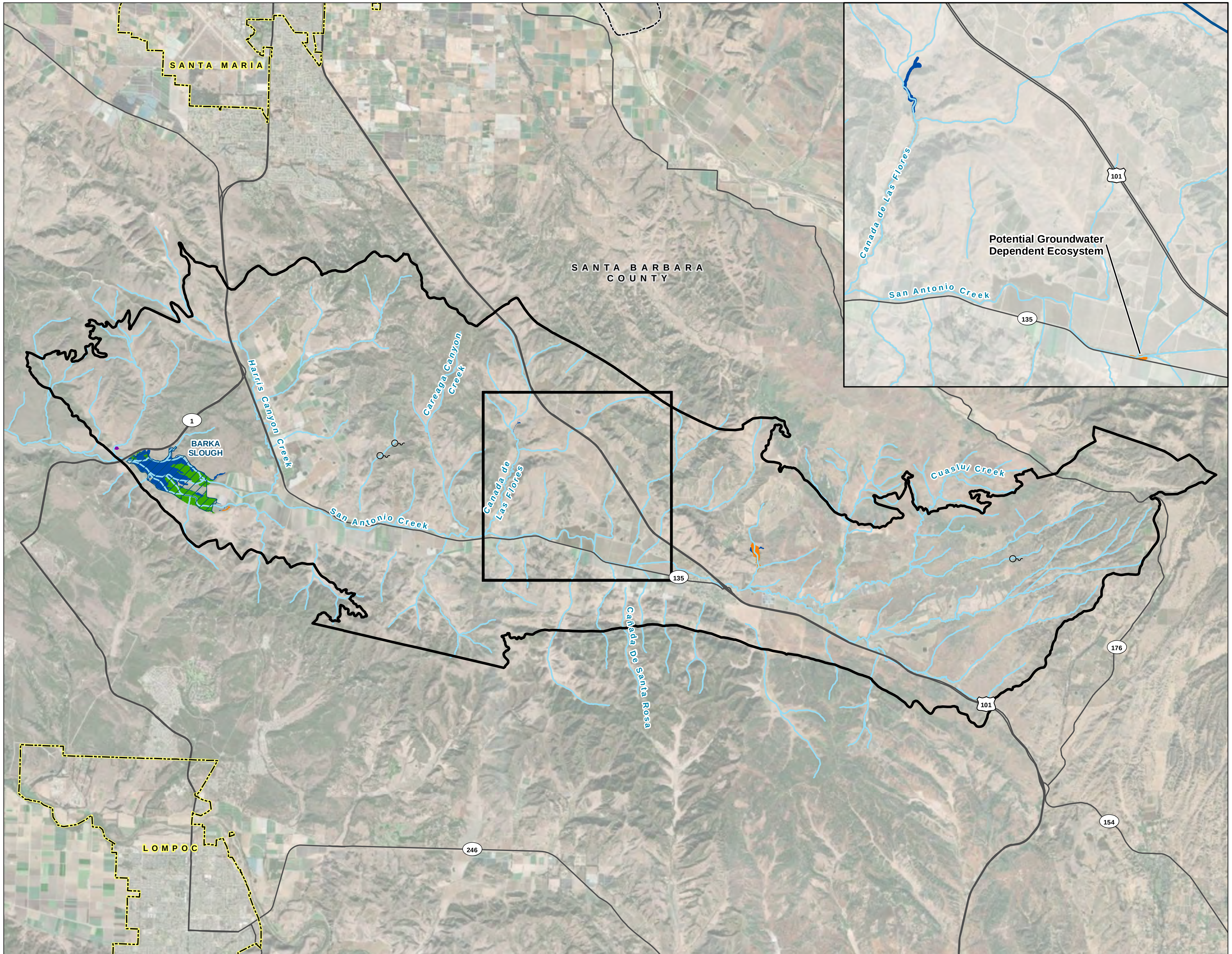

FIGURE 3-56

Groundwater-Dependent Ecosystems

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Natural Communities Commonly Associated with Groundwater (NCCAG)

- Wetland Area

VEGETATION

- Coast Live Oak
- Riparian Mixed Hardwood
- Willow

All Other Features

- San Antonio Creek Valley Groundwater Basin
- Barka Slough
- Major Road
- City Boundary
- USGS Spring

NOTE

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b, 2020h), ESRI, DWR (2018a, 2020b), Maxar imagery (2020)

GSI Water Solutions, Inc.

Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_56_GDEs.mxd, abarry

One small stand of coast live oak (1 acre) located just west of Los Alamos is considered a potential GDE, based on the depth-to-groundwater analysis (see Figure 3-56). The presence of a GDE in this area will be verified during GSP implementation. The vegetation and wetland GDEs (and potential GDE) identified within the Basin are summarized in Tables 3-10 and 3-11.

Table 3-10. Vegetation GDEs (and Potential GDEs)

Natural Communities Vegetation Classification	GDE Acres[1]	Potential GDE acres[2]
Coast Live Oak	36	1
Riparian Mixed Hardwood	3	
Willow	268	
Total	**307**	**1**

Notes

[1] GDE acreage associated with Barka Slough and Price Ranch seeps (33 acres of coast live oak)

[2] Potential GDE acreage located just west of Los Alamos

Table 3-11. Wetland GDEs

Natural Communities Wetland Classification	Acres
Palustrine, Emergent, Persistent, Seasonally Flooded	53
Palustrine, Emergent, Persistent, Semipermanently Flooded	3
Palustrine, Forested, Seasonally Flooded	504
Palustrine, Scrub-Shrub, Seasonally Flooded	15
Palustrine, Unconsolidated Bottom, Permanently Flooded	5
Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded	1
Riverine, Unknown Perennial, Unconsolidated Bottom, Semipermanently Flooded	1
Total	**582**[1]

Note

[1] The potential wetland GDE acres overlap in many areas with potential vegetation type GDEs. Therefore, the total potential GDE acreage in the EMA is less than the sum of the potential wetland GDE and the potential vegetation type GDE acres.

Three USGS mapped springs are located within the Basin as shown on Figure 3-10. Coast Live Oak Natural Communities polygons intersect with two of these mapped springs; however, a brief aerial imagery review reveals little evidence to support or refute the continued presence of springs at these locations. The presence of these springs and any associated GDEs will be verified during GSP implementation.

3.2.6.2 Terrestrial and Aquatic Special-Status Species Occurrence

A literature review was completed to determine the terrestrial and aquatic special-status species that may be associated with GDEs in the Basin. The documents reviewed include the biological assessment that evaluated the potential environmental effects from development of the Vandenberg Dunes Golf Courses Project (AECOM, 2019) and the San Antonio Creek Coordinated Resource Management Plan (CRCD, 2003).

The U.S. Fish and Wildlife Service Critical Habitat Mapper[23] was also consulted. No original work was done for the special status species review of the Basin.

For the purposes of this GSP, special-status species are defined as those meeting the following criteria:

- Listed, proposed, or under review as endangered or threatened under the federal Endangered Species Act or the California Endangered Species Act
- Designated by CDFW as a Species of Special Concern
- Designated by CDFW as Fully Protected under the California Fish and Game Code (§§ 3511, 4700, 5050, and 5515)

[23] Available at https://ecos.fws.gov/ecp/report/table/critical-habitat.html.

Table 3-12 lists the special-status species that are documented to occur within the Basin or are supported by resources originating in the Basin (i.e., groundwater discharge to surface water in the Barka Slough) based on review of the documents listed above. Wildlife species were evaluated for potential groundwater dependence using the Critical Species Lookbook (Rohde et al., 2019). This potential groundwater dependence rating is indicative of the species' general documented reliance on groundwater and should not be considered a statement of specific groundwater reliance occurring within the Basin.

Table 3-12. Special-Status Species that May be Located within the Basin or are Supported by Resources Originating from within the Basin

Common Name	Scientific Name	Status	Potential Dependence on GW[1]
California Red-Legged Frog	*Rana draytonii*	Federally listed (Threatened)	Direct
Tidewater Goby[2]	*Eucyclogobius newberryi*	Federally listed (Endangered)	Direct
Unarmored Threespine Stickleback	*Gasterosteus aculeatus williamsoni*	Federally and State listed (Endangered)	Direct
La Graciosa Thistle	*Cirsium scariosum var. loncholepis*	Federally listed (Endangered) and State listed (Threatened)	Direct
California Tiger Salamander	*Ambystoma californiense*	Federally and State listed (Threatened)	Unknown
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Federally and State listed (Endangered)	Indirect
Least Bell's Vireo	*Vireo bellii pusillus*	Federally and State listed (Endangered)	Indirect
Tricolored Blackbird	*Agelaius tricolor*	Federally not listed (Bird of Conservation Concern) and State Listed (Threatened)	Direct
Arroyo Chub	*Gila orcuttii*	Not Listed (Species of Special Concern)	Unknown
Southern California Steelhead	*Oncorhynchus mykiss*	Federally listed (Endangered)	Direct

Notes

[1] General reliance on groundwater is determined from the Critical Species Lookbook (Rohde et al., 2019) and is not an indication of specific groundwater reliance within the Basin

[2] Tidewater goby do not occur within the Basin; however, potential reductions in San Antonio Creek streamflow leaving the Basin could adversely affect critical habitat downstream (AECOM, 2019).

GW = groundwater

California Red-Legged Frog

Barka Slough provides optimal habitat for California red-legged frogs (AECOM, 2019). However, California red-legged frogs have the potential to occur in a variety of wetland and upland habitats, including ephemeral ponds, intermittent streams, springs, seeps, seasonal wetlands, permanent ponds, perennial streams, marshes, riparian corridors, annual grassland, and oak savannas (CRCD, 2003). Dense, shrubby, or emergent vegetation closely associated with deep-water pools with fringes of cattails and dense stands of overhanging vegetation, such as willows, are considered optimal breeding habitat (AECOM, 2019).

Tidewater Goby

Although usually associated with lagoons, the tidewater goby has been documented in ponded freshwater habitats as far as 4.6 miles upstream from the ocean in San Antonio Creek (Swift et al. 1997). Although tidewater goby do not occur within the Basin, potential reductions of San Antonio Creek streamflow leaving the Basin could adversely affect critical habitat downstream (AECOM, 2019).

Unarmored Threespine Stickleback

Constituent elements of essential habitat for unarmored threespine stickleback (UTS) include permanent streamflow, slow currents, low turbidity, and lack of pollution (AECOM, 2019). Habitat for UTS occurs in the lower 8.4 miles of San Antonio Creek, from the mouth of the creek at the Pacific Ocean upstream to Barka Slough (AECOM, 2019) (Figure 3-57). UTS were not detected in Barka Slough during surveys conducted in 2004–2005 according to unpublished data (ManTech, 2010). However, UTS occurring both within and downstream of Barka Slough are highly reliant on surface water flows originating in Barka Slough (CRCD, 2003).

La Graciosa Thistle

La Graciosa thistle has only been found near the coast of southern San Luis Obispo and northern Santa Barbara counties, growing in riparian habitat, often around seeps or in marshes (CDFW, 2013). Occurrences of La Graciosa thistle were mapped in the Las Flores watershed, tributary to San Antonio Creek, in the low-lying grassland areas immediately west of Highway 101 (CRCD, 2003) (Figure 3-57). This is the most interior site for the species that is primarily found in the dune areas near the ocean. The habitat areas identified are primarily around gently sloping hillside seeps within a grassland plant community (CRCD, 2003). U.S. Fish and Wildlife Service has designated critical habitat for the La Graciosa thistle in the Las Flores watershed and in the eastern end of Barka Slough (Figure 3-57). The primary threat to La Graciosa thistle is reduced access to water, with groundwater decline as the likely major cause, along with hydrological alteration, drought, and climate change (Kofron et al., 2019).

California Tiger Salamander

California tiger salamander habitat includes vernal pools and seasonal ponds associated with coastal scrub, grassland, and oak savanna (CRCD, 2003). Known and potential California tiger salamander habitat within the Basin is shown on Figure 3-57 (CRCD, 2003). California tiger salamanders spend much of their lives in rodent burrows, leaving only to feed and breed during periods of high relative humidity and during rains (CRCD, 2003). California tiger salamanders have no known direct reliance on groundwater, unless groundwater depletion reduces the spatial and temporal availability of seasonal ponds, which could prevent larvae from completing their metamorphoses (Rohde et al., 2019).

Southwestern Willow Flycatcher

The southwestern willow flycatcher is a species in danger of extinction throughout all or a significant portion of its range. Its historical range includes much of central and southern coastal regions of California (USFWS, 2021a). Southwestern willow flycatchers breed along watercourses and canyon bottoms, as well as interior river bottoms, throughout Southern California. This species is found in bushes, willow thickets, brushy fields, and upland copses. It breeds in thickets of deciduous trees and shrubs, especially willows, or along woodland edges. Nest sites are typically located near slow-moving streams, or side channels and marshes with standing water and/or wet soils (Rohde et al., 2019).

Least Bell's Vireo

The least Bell's vireo is a species in danger of extinction throughout all or a significant portion of its range. Its historical range includes much of central and southern coastal regions of California (USFWS, 2021b). These birds require low-elevation riparian areas near water with a dense shrub understory and canopy layer. Such habitats are generated by alluvial river systems. Active river meandering and flooding are highly beneficial to this species because they support riparian vegetation succession, which creates the habitat the birds depend upon. Least Bell's vireo associate with willow (*Salix* spp.) and dense areas of riparian shrubs, trees, and vines for nesting (Rohde et al., 2019).

Tricolored Blackbird

The tricolored blackbird is a Bird of Conservation Concern through its range in the continental United States and Alaska and a State Listed Threatened species. The tricolored blackbird is nearly endemic to California and is found in remaining wetlands, including those in Southern California and along the Central Coast. This species uses semipermanent and permanent wetlands with dense tracts of tall emergent vegetation for nesting, and upland habitat for both nesting and foraging. Upland nesting habitat includes groundwater-dependent grain crops (primarily silage associated with dairies). Foraging habitat includes groundwater-dependent crops and irrigated pasture. Tricolored blackbirds are associated with cattails (*Typha latifolia*), tules (*Scirpus acutus*), bulrush (*Schoenoplectus californicus*), sandbar willow (*Salix exigua*), and mugwort (*Artemisia douglasiana*), as well as grasslands and agricultural crops for foraging (Rohde et al., 2019). The migratory bird's probability of presence in the Basin is highest in March through the first half of August (USFWS, 2021c).

Arroyo Chub

The arroyo chub is a species of special concern. The chub is found only in the streams of Southern California and generally in relatively flat stretches. It is a good indicator of a healthy riparian or stream habitat and a good indicator for other species like steelhead and the threespine stickleback, which rely on the arroyo chub as food (Arroyo Seco Foundation, 2021). Based on the USGS Nonindigenous Aquatic Species online mapping tool, the Arroyo Chub was last documented in the Basin in 1987 (USGS, 2021b). Arroyo chub have the potential to occur within the Basin would likely be adversely impacted by declining surface water levels as a result of over pumping of groundwater.

Southern California Steelhead

Steelhead trout require cold water and complex instream habitat during their freshwater juvenile residency, which generally lasts at least one year, including at least one dry season. Estuaries can provide important rearing habitat for steelhead, with opportunities for rapid growth prior to entering the marine environment. For spawning, all adult salmonids require sufficient flow and suitably cool water temperature for upstream migration to spawning grounds, and streambeds with clean gravel, free of excessive fine sediment deposition to spawn in. Some adult steelhead will survive to spawn a second or third time; thus, adequate streamflows are required for post-spawn adult steelhead to migrate downstream during spring (Rohde et al., 2019). The species historical range included California, Idaho, Oregon, Washington (USFWS, 2021d). Steelhead trout have the potential to occur in the Basin and would be adversely impacted by declining surface water levels as a result of over pumping of groundwater.

3.2.6.3 Ecological Condition of GDEs and Potential GDEs

Once GDEs and potential GDEs are mapped, they are then characterized in Step 1.2 (see list above in Section 3.2.6.1) by their hydrologic and ecological conditions. Although mapping GDEs and potential GDEs has been the primary focus of this GSP, the hydrologic and ecological importance of the Barka Slough is well documented (e.g., CRCD, 2003; AECOM, 2019). An Enhanced Vegetation Index (EVI) analysis was completed using Landsat data processed in Climate Engine[24] as a first step towards analyzing the historical and current ecological condition of the Barka Slough. EVI data provide an indicator of healthy, well-watered vegetation. EVI is calculated from the proportions of visible and near-infrared sunlight reflected by vegetation. EVI values typically range from zero to more than 0.7. Healthy, or well-watered, vegetation absorbs most of the visible light that hits it and reflects a large portion of near-infrared light, resulting in a high EVI value. Unhealthy, dry, or dormant vegetation reflects more visible light and less near-infrared light, leading to a lower EVI value. The results of EVI analyses for the Barka Slough and a subset area, referred to as West Barka Slough, are shown on Figure 3-58. Notable observations from the EVI analysis include the following:

- EVI values fluctuate throughout each year, demonstrating seasonal fluctuations in vegetative health.
- Long-term fluctuations in overall Barka Slough EVI appear to generally track with the cumulative departure from the average precipitation curve, indicating a strong relationship between annual precipitation and overall Barka Slough vegetative health.
- West Barka Slough EVI values appear less influenced by annual precipitation, suggesting a larger component of vegetative water demand satisfied by upwelling groundwater in the western portion of the Slough. The disparity between overall Barka Slough EVI and West Barka Slough EVI is most pronounced during dry years and drought periods.
- Groundwater elevations in well 16G3 declined through the early to mid-1990s during years of consistent ~3,000 acre-feet per year VSFB groundwater production in the vicinity of Barka Slough until 1997, when pumping was substantially decreased as the VSFB obtained State Water Project (SWP) water.
- 1997 marked the beginning of SWP water availability for VSFB and a subsequent decrease in VSFB groundwater production.
- Precipitation totals in water years 1998 through 2001 were all above average (especially 1998), likely contributing to increasing groundwater elevations in well 16G3 and relatively high seasonal EVI values.
- The Harris Fire burned a large portion of Barka Slough, including igniting the underlying peat, in September of 2000. The resultant decrease in vegetation or vegetative health is notable in the EVI data. The vegetative health evidently took several years to recover.
- Groundwater elevations in well 16G3 reached a high point in 2006 and then began to decline through the current drought. The groundwater elevation in 16G3 reached a low point in 2015, coincident with increased VSFB pumping due to limited availability of SWP water. Since 2015, groundwater elevations in 16G3 have remained approximately stable at 250 ft amsl.
- The EVI analysis indicates no discernible long-term trend in Barka Slough vegetative health. The EVI data suggest that vegetative health in the western Slough area continues to be supported primarily by upwelling groundwater, whereas the vegetative health in eastern portions of the Slough may be more closely related to annual precipitation and surface water inflow.

The TNC guidance recommends that the condition of each GDE unit be inventoried and documented by describing the species composition, habitat condition, and other relevant information reflected in Worksheet 2 of the guidance (Rohde et al., 2018). Then the ecological condition of the GDE unit should be characterized as having a high, moderate, or low ecological value based on criteria provided in the TNC guidance. These tasks would likely rely heavily on field surveys. This additional characterization was not conducted but may be undertaken during GSP implementation. Until the additional characterization has been conducted, Barka Slough will be characterized as having high ecological value.

[24] Climate Engine (Huntington et al., 2017) is an online tool for cloud computing of climate and remote sensing data powered by Google Earth Engine (Gorelick et al., 2017) (https://app.climateengine.org/climateEngine)

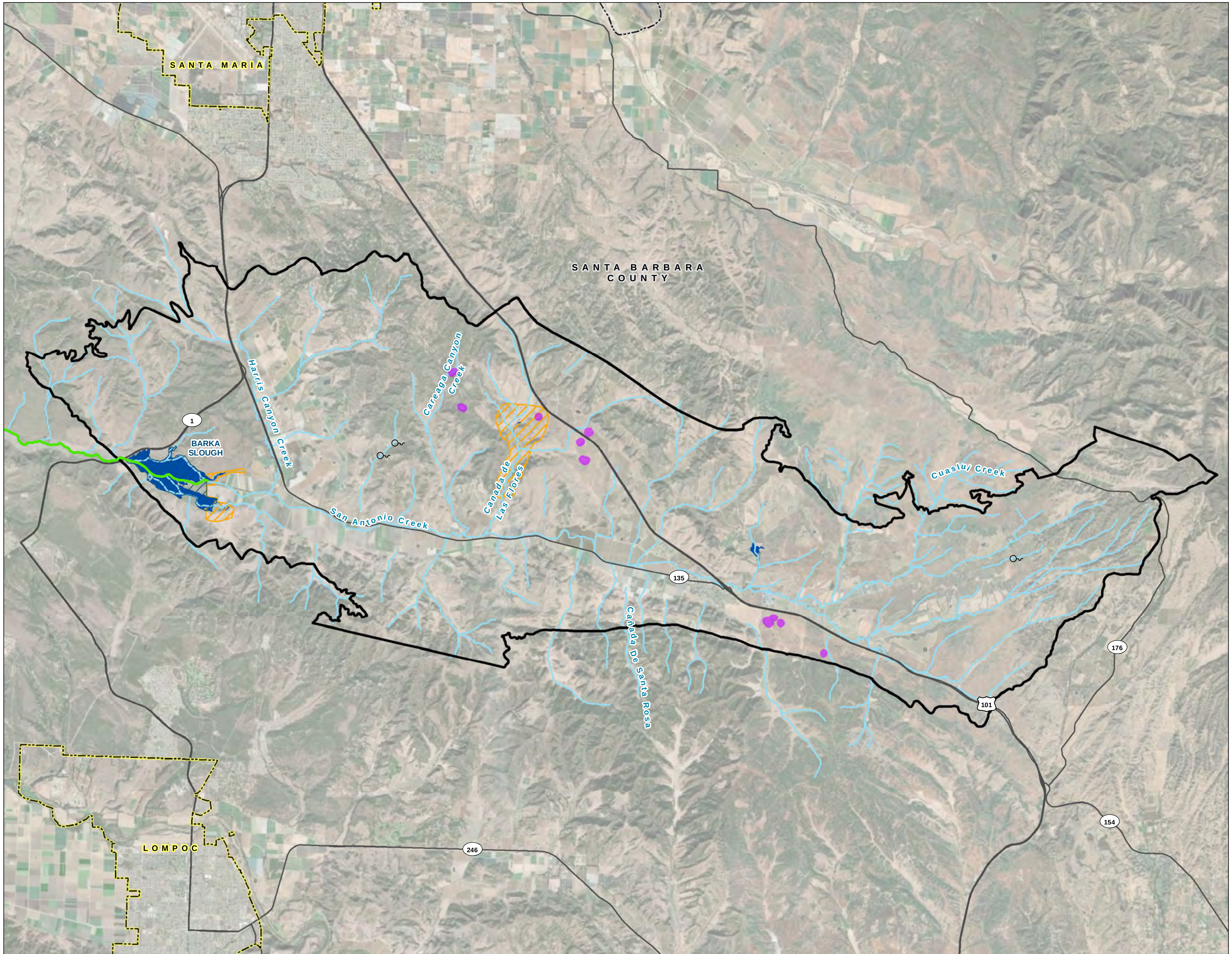

FIGURE 3-57

Special-Status Species Critical Habitat

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Unarmored Threespine Stickleback Habitat
California Tiger Salamander Habitat
La Gracious Thistle Habitat

Natural Communities Commonly Associated with Groundwater (NCCAG)

Wetland Area

All Other Features

San Antonio Creek Valley Groundwater Basin
Barka Slough
Major Road
City Boundary
USGS Spring

NOTE

San Antonio Creek Valley Groundwater Basin Boundary as defined in the California Department of Water Resources Bulletin 118.

N

0 5,000 10,000 15,000
Feet

Date: September 16, 2021
Data Sources: USGS (2020b, 2020h), ESRI, DWR (2018a, 2020b), Maxar imagery (2020)

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Document Path: Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Section3\Figure3_57_Special_Status_Species_Critical_Habitat.mxd, abarry

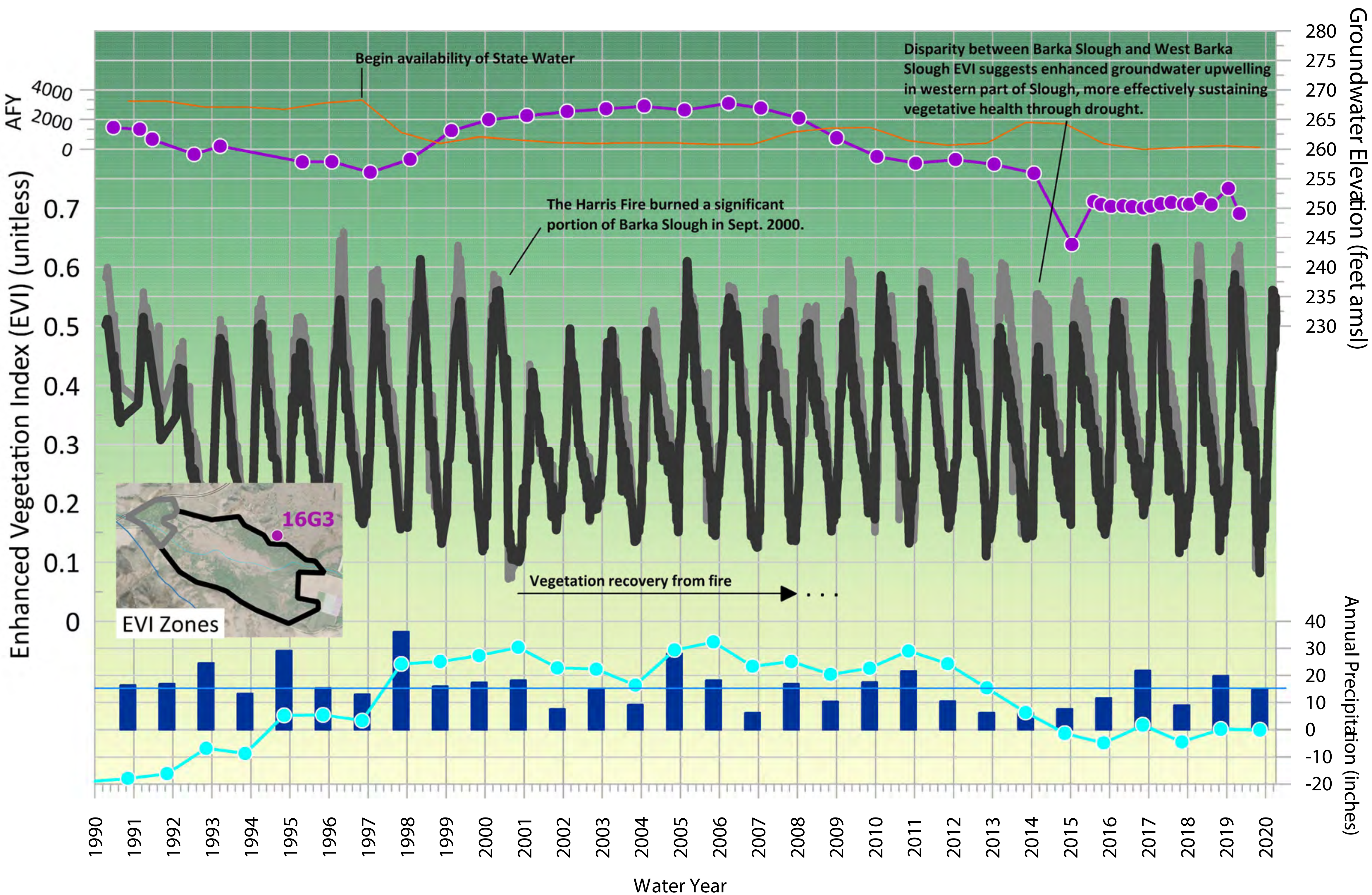

FIGURE 3-58

Enhanced Vegetation Index (EVI) of Barka Slough

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

- Annual Precipitation at Los Alamos Fire Dept.
- Average Annual Precipitation (15.3 in.)
- Cumulative Departure from Average Precipitation
- Barka Slough Mean EVI
- West Barka Slough Mean EVI
- Well 16G3 Groundwater Elevation (ft. amsl)
- VSFB Groundwater Production (AFY)

NOTES

AFY: acre-feet per year
ft amsl: feet above mean sea level
VSFB: Vandenberg Space Force Base

Date: September 16, 2021
Data Sources: County of Santa Barbara (n.d.), Huntington et al. (2017), VSFB (2020)

GSI Water Solutions, Inc.

3.3 Water Budget [§ 354.18]

§ 354.18 Water Budget.

(a) Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

(b)The water budget shall quantify the following, either through direct measurements or estimates based on data:

(1) Total surface water entering and leaving a basin by water source type.

(2) Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.

(3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.

(4) The change in the annual volume of groundwater in storage between seasonal high conditions.

(5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.

(6) The water year type associated with the annual supply, demand, and change in groundwater stored.

This section summarizes the estimated historical, current, and future projected water budgets for the Basin, including information required by the SGMA regulations and information that is important for developing an effective GSP to achieve sustainability. In accordance with the SGMA regulations § 354.18, the GSP should include a water budget for the Basin that provides an accounting and assessment of the total annual volume of surface water and groundwater entering and leaving the Basin—including historical, current, and projected water budget conditions—and the change in the volume of groundwater in storage. The regulations require that the water budget be reported in graphical and tabular formats, where applicable.

3.3.1 Overview of Water Budget Development

§ 354.18 Water Budget.

(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:

(1) Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.

(2) Current water budget information for temperature, water year type, evapotranspiration, and land use.

(3) Projected water budget information for population, population growth, climate change, and sea level rise.

(e) Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.

(f) The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.

The water budgets for the Basin were developed using estimated inflow and outflow terms and a spreadsheet tool. Three types of water budgets are presented here: historical water budget results (Section 3.3.3), a current water budget (Section 3.3.4), and a projected water budget (Section 3.3.5). Within each subsection, a surface water budget and groundwater budget are presented. This section includes a brief overview of the inflow and outflow terms and spreadsheet tool. Appendix E provides additional information about the inflow and outflow terms and spreadsheet tool and compares previously reported water budgets to the water budgets developed for this GSP.

Basin yield of a groundwater basin is the volume of pumping that can be extracted from the basin on a long-term basis without creating a chronic and continued lowering of groundwater levels and the volume of groundwater in storage. Basin yield is not a fixed constant value but a dynamic value that fluctuates over time as the balance of the groundwater inputs and outputs change; thus, the calculated basin yield of the Basin will be estimated and likely modified with each future update of this GSP.

Basin yield is not the same as sustainable yield. Sustainable yield is defined in SGMA as “the maximum quantity of water, calculated over a period representative of long-term conditions in the basin and including any temporary surplus that can be withdrawn annually from a groundwater supply *without causing an undesirable result*” (emphasis added). An undesirable result is one or more of the following adverse effects on the six sustainability indicators:

- Chronic lowering of groundwater levels in the aquifer(s)
- Significant and unreasonable reduction of groundwater in storage
- Significant and unreasonable degradation of water quality
- Seawater intrusion
- Significant and unreasonable land subsidence that interferes with surface land uses
- Depletion of interconnected surface water that has significant and unreasonable adverse impacts on beneficial uses of surface water

Defining the basin yield provides a starting point for later establishing sustainable yield by considering each of the six sustainability indicators listed above.

Section 354.18 of the SGMA regulations requires development of water budgets for both groundwater and surface water that provide an accounting of the total volume of water entering and leaving a basin. To satisfy the requirements of the regulations, a surface water budget was prepared for the Basin and an integrated groundwater budget was developed for each water budget period for the combined inflows and outflows for the two principal aquifers—Paso Robles Formation and Careaga Sand. Groundwater is pumped from both aquifers for beneficial use. Groundwater and surface water also discharge to Barka Slough at the west end of the Basin. The Slough contains important aquatic and terrestrial plant and animal species.

Figure 3-59 presents a general schematic diagram of the hydrologic cycle. The water budgets include the components of the hydrologic cycle.

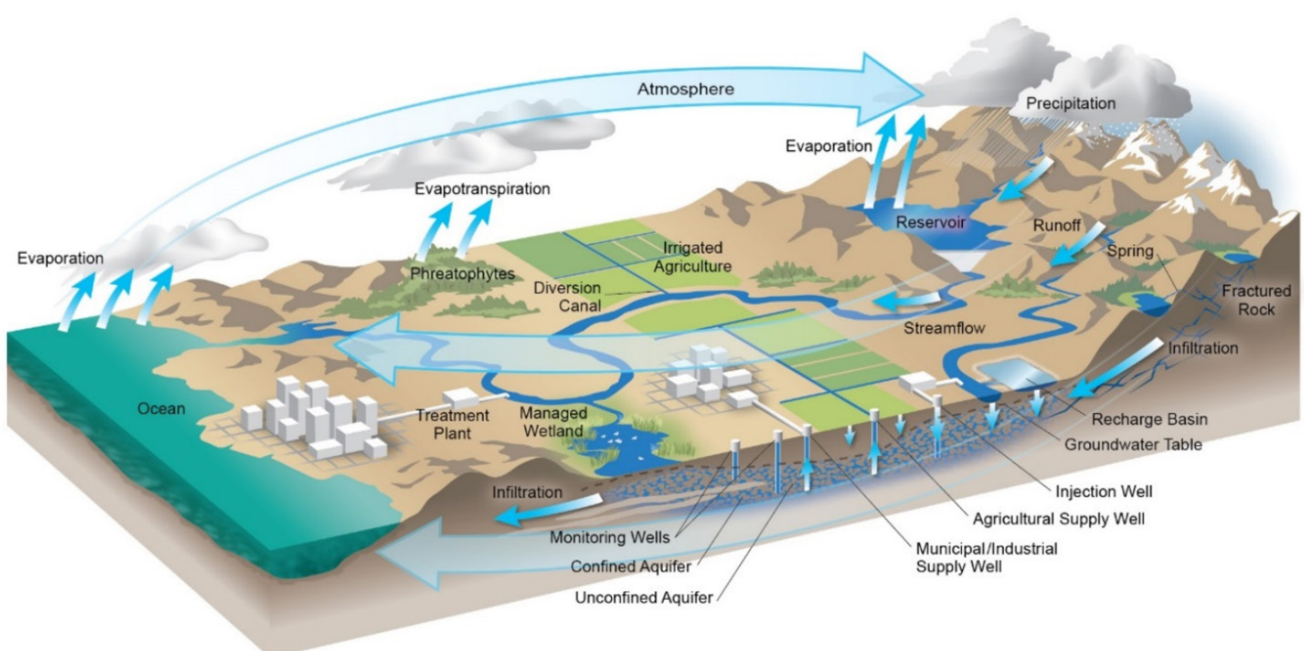

Figure 3-59. The Hydrologic Cycle

Source: DWR, 2016c

A few components of the water budget can be measured, such as streamflow at a gaging station or groundwater pumping from a metered well. Other components of the water budget are estimated, such as recharge from precipitation or unmetered groundwater pumping. For the components that cannot be measured, the best available science has been used to estimate the water budget. The water budget is an inventory and accounting of total surface water and groundwater inflows (recharge) and outflows (discharge) from the Basin, including the following:

Surface Water Inflows:

- Runoff of precipitation into streams and rivers within the watershed

Surface Water Outflows:

- Streamflow exiting the Basin from Barka Slough
- Percolation of streamflow to the groundwater system

Groundwater Inflows:

- Recharge from precipitation, including mountain front recharge
- Irrigation return flow (water not consumed by crops/landscaping)
- Percolation of streamflow to groundwater
- Percolation of treated wastewater from septic systems and LACSD Wastewater Treatment Plant (WWTP) spray irrigation

Groundwater Outflows:

- ET from crops, unirrigated land, and riparian areas
- Groundwater pumping
- Groundwater discharge to surface water

The difference between inflows and outflows is equal to the change of groundwater in storage.

The historical water budget period was selected to be between water years 1981 and 2018. The current water budget period is between water years 2011 and 2018. The projected future water budget extends to 2072 (see Figure 3-60).

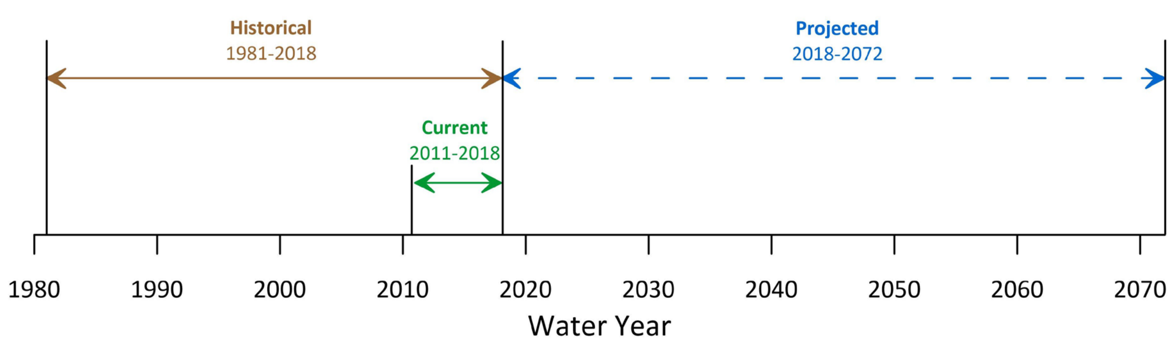

Figure 3-60. Historical, Current, and Projected Water Budget Periods

This historical period discussion refers to water years, which are defined in this GSP as between October 1 of the starting year and September 30 of the following year. For example, the period between October 1, 2017, and September 30, 2018, constitutes water year 2018.

The 38-year period between water years 1981 and 2018 (inclusive) has been selected for the historical water budget to comply with the California Department of Water Resources' (DWR's) regulatory requirement as follows:

> "a quantitative assessment of the historical water budget (be prepared) starting with the most recently available information and extending a minimum of 10 years, or as sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon."

The historical period selected also includes the most recently available information. The 38-year period selected for the historical water budget includes two wet-dry hydrologic cycles and the changes to water demand associated with irrigated land.

The historical water budget was used to define a specific period over which elements of recharge and discharge to the groundwater basin may be compared to the long-term average. This period allows for the identification of long-term trends in groundwater basin supply and demand, as well as water level trends; changes of groundwater in storage; estimates of the annual components of inflow and outflow to the zone of saturation; and basin yield estimates.

Further, SGMA regulations require that the historical water budget provide a "quantitative evaluation of the availability or reliability of historical surface water supply deliveries" and are to start "with the most recently available information ... extending back a minimum of 10 years" (§ 354.18 (c)(2).

A representative base, or baseline, period (referred to as the "historical period" by SGMA) should do the following:

- Be representative of long-term hydrologic conditions (precipitation and streamflow).
- Include wet, dry, and average years of precipitation.
- Span a 20-to-30-year period (Mann, 1968).
- Have its start and end years preceded by comparatively similar rainfall quantities (DWR, 2002).
- Preferably start and end in a dry period (Mann, 1968), which minimizes water draining (in transit) through the vadose zone.
- Include recent cultural conditions (DWR, 2002).

This historical period selection also helps inform the projected water budget. The historical period selection should "utilize 50 years of historical precipitation, ET, and streamflow information as the baseline condition for estimating future hydrology" (§ 354.18 (c)(3)). Notably, the selection of both the historical water budget and current water budget are based on this requirement. The historical water budget period closely approximates the long-term hydrologic conditions based on precipitation. While historical period selection may include consideration of streamflow within this Basin, San Antonio Creek is classified as a losing stream and the flow is intermittent. Because of this, the consideration of streamflow is not as meaningful or useful for the selection of the historical period. Therefore, precipitation data are used as the principal recharge component for the selection of the historical period.

In addition to the consideration of precipitation and streamflow variability, the historical period must include high-quality, reliable data with regard to all of the principal components of the water budget. The historical period selected generally includes reliable data for most, but not all, of the water budget components. Primary information and data sources for the water budget are included as Table 3-14.

The historical period was determined based on a review of long-term precipitation records from the precipitation station located in the Basin at the Los Alamos Fire Station.[25] The period of record for the Los Alamos Fire Station precipitation station dates back to 1910.

The precipitation data for the Los Alamos Fire Station gage is presented as Figure 3-16. The average precipitation within the Basin measured at the Los Alamos Fire Station, which occurs mainly as rainfall, is 15.3 inches for the period of record (1910–2019). The upper portion of the chart shows the annual precipitation. Climatic trends (historical wet-dry cycles) were identified using DWR guidance for defining "water year type." These wet, variable, and dry periods determined from the precipitation data are presented on all hydrographs and water budget graphs in this GSP. The lower portion of the chart shows the climatic variability by showing the cumulative departure from the mean precipitation; upward trending portions (blue areas) represent wet periods of above-average rainfall, and downward trending portions (tan areas) represent drought periods of below-average rainfall.

Highly variable precipitation patterns with multi-year cycles are common to the area; multi-year cycles of drought are punctuated by shorter, intense wet periods. The climate variability within the Basin is evident on Figure 3-16, as well as on Table 3-13.

Table 3-13. Historical Hydrologic Conditions – Water Year Type

Period (Water Years)	Hydrologic Condition	Duration (No. of Years)	Precipitation Deviation (inches)	Deviation Rate (inches per year)
1910 to 1918	Wet	9	+ 26	+ 2.9
1919 to 1934	Drought	16	- 48	- 3
1935 to 1944	Wet	10	+ 35	+ 3.5
1945 to 1977	Drought	33	- 44	- 1.3
1978 to 1983	Wet	7	+ 38	+ 5.4
1984 to 1990	Drought	7	- 30	- 4.2
1991 to 1998	Wet	8	+43	+ 5.4
1999 to 2011	Variable	13	+ 4	+ 0.3
2012 to 2019	Drought	7	- 29	- 4.1

[25] Precipitation records from additional gages were considered for the determination of the historical period; however, some gages were excluded from the analysis due to being located too far from the Basin or having limited available data. Data from previously unconsidered gages will be periodically evaluated to characterize variability of precipitation in different parts of the basin in the future.

Notable aspects of the variable periods include the following:

- A wet period occurred between the beginning of the period of record in water years 1910 through 1918. During this 9-year period, the annual precipitation deviated above the long-term average by 2.9 inches per year.
- A longer drought period occurred from water years 1919 through 1934. During this 16-year drought, the annual precipitation deviated below the long-term average by 3 inches per year.
- Between 1935 and 1944, a wet period occurred during which the average precipitation was 3.5 inches above the long-term average.
- A long drought occurred from water year 1945 through 1977. During the 33-year drought, the annual precipitation deviated below the long-term average by 1.3 inches per year.
- Similar duration wet (1978 to 1983 and 1991 to 1998) and drought periods (1984 to 1990) followed this period.
- The current drought started in water year 2012. Two wet years (2017 and 2019) have occurred during the current drought; however, it remains a severe drought with an average rainfall deficit of 4.1 inches per year compared to the long-term average. The current drought has continued into water year 2021, extending the drought to 10 years (2012 through 2021 inclusive).

Based on review of precipitation data from this station, the initial year for a suitable historical period could be 1976, 1978, 1981, or 1982, all of which start in a dry year preceded by at least one dry year. The ending year of 2018 is a dry year in an overall dry period. The period between 1981 and 2018 is the most balanced period from a precipitation point of view. In consideration of the availability of high-quality data, this period will be used for the Basin historical water budget. The historical water budget is presented in Section 3.3.3.

The current water budget period was selected to be between 2011 and 2018. This period represents a very dry period overall, which—although not as hydrologically balanced as the historical period—is considered representative of the current drought conditions. Precipitation at the Los Alamos Fire Station during this period averaged 11.9 inches, which is 77 percent of the historical period. The current water budget is presented in Section 3.3.4.

The projected water budget, for the 55-year period between 2018 and 2072, extends 50 years past the 2022 submittal of this GSP. The projected water budget is presented in Section 3.3.5.

3.3.2 Water Budget Data Sources and Spreadsheet Tool

A groundwater model developed by the USGS is currently being calibrated as part of a multi-year groundwater basin study. As of this writing in 2021, the groundwater model and related information have not been made available; therefore, it is necessary to use a spreadsheet tool to develop the water budgets for the Basin and to assess projects and management actions needed to bring the Basin into sustainability. While a groundwater model would be preferred, the spreadsheet tool can be used for this purpose in accordance with § 354.18 of the SGMA regulations. The spreadsheet tool is adequate for developing the water budgets and assessing projects and management actions in this Basin. The tool relies on the best available information and the best available science to quantify the water budget for the Basin. This provides an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, groundwater and surface water interaction, and subsurface groundwater flow.

The sources used for the tool include the following:

- Information from local and regional Basin water users
- Sources/tools identified in the DWR *Draft Handbook for Water Budget Development, With or Without Models* (DWR, 2020c)
- Published technical reports
- Published hydrogeologic properties and principles
- Use of developed forecasting and interpolation tools
- Multiple calculation methodologies to determine validity of data and calculations

Water budget components for the Basin were developed using various publicly available data sets organized by water year. Table 3-14 presents a summary of the data sources used for developing the water budgets and a description of each data set's qualitative data rating. Each of these data sets are described in further detail in the following sections.

A qualitative discussion of the estimated level of uncertainty associated with each data source is described in the table below and for each water budget term. This discussion focuses on the level of uncertainty and the authors' confidence in the data, as well as the assumptions and interpretations of the information used to develop the water budgets. The level of uncertainty can significantly affect the SABGSA's ability to sustainably manage the Basin. The data associated with the Basin is adequate to estimate the surface and groundwater inflow and outflow components of the water budget. The qualitative data rankings presented in Table 3-14 acknowledge that the directly measured data—which include gaged streamflow (surface water), metered groundwater pumpage, precipitation, and groundwater levels (groundwater)—is of the highest quality and lowest uncertainty.

The calculated and modeled values are generally of medium quality. Data derived from other sources—including water duty factors for irrigated crops for the estimation of agricultural pumping and related irrigation return flow—are less certain and therefore of medium/low quality (with the highest uncertainty).

These are the best-available data available for the Basin and are similar to the quality and sources of data available in similar groundwater basins throughout the state. Importantly, these data and the resulting water budgets summarized in this section support the sustainable management of the groundwater resource. As discussed in this section and later in Section 6, the quality of many of these data will improve during GSP implementation, which will enable adaptive and sustainable groundwater management. Moreover, the sustainable management criteria (see Section 4) are based largely on groundwater elevation measurements, which are data of high quality and low uncertainty.

Any significant uncertainty in the data could limit the SABGSA's ability to effectively develop sustainable management criteria, select appropriate projects and management actions, and determine whether the Basin is being sustainably managed. These uncertainties are discussed within each water budget data source section and later within the subsequent sections. Data with significant uncertainty that may have an impact on management of the Basin are identified and will be addressed as part of the management actions associated with this GSP.

Table 3-14. Primary Information and Data Sources for the Water Budget

Water Budget Component	Data Source(s)	Comment(s)	Qualitative Data Rating	Projected Data Set Methodology
Surface Water Inflow Components				
Native Streamflow	USGS-BCM Runoff, Stream Gage Data	USGS-BCM adjusted to local and regional meteorological station data	Adjusted Model – Medium	USGS-BCM adjusted to DWR VIC hydrology model for 2030 and 2070 climate data
Groundwater Discharge to Surface Water	USGS-BCM Runoff, Stream Gage Data, Darcian Flux Calculation, Historical Reports	Methods described in Section 3.3.2.1	Estimated – Low	
Groundwater Inflow Components				
Mountain Front Recharge	USGS-BCM Recharge	USGS-BCM adjusted to local and regional meteorological station data	Adjusted Model – Medium	USGS-BCM adjusted to DWR VIC hydrology model for 2030 and 2070 climate data
Streamflow Percolation	USGS-BCM Recharge	USGS-BCM adjusted to local and regional meteorological station data	Adjusted Model – Medium	
Deep Percolation of Direct Precipitation	USGS-BCM Recharge	USGS-BCM adjusted to local and regional meteorological station data	Adjusted Model – Medium	
Percolation of Treated Wastewater (Effluent Spray Irrigation)	LACSD, Crop water use factors	Data provided by LACSD. Published water duty factors for irrigated crop/groundcover	Metered – High Published – High	Linear projection of historical data set
Percolation from Septic Systems	Aerial Survey	Methods described in Section 3.3.2.3	Estimated Medium/Low	Linear projection based on historical data set and estimated population growth

Water Budget Component	Data Source(s)	Comment(s)	Qualitative Data Rating	Projected Data Set Methodology
Irrigation Return Flow	Various Land Use Surveys, Crop Water Duty Factors from the SYRWCD, Aerial Survey	Methods described in Section 3.3.2.3	Estimated Medium/Low	Agricultural – 20% of Agricultural Pumping Rural Domestic – Linear projection based on historical data set and estimated population growth
Surface Water Outflow Components				
San Antonio Creek/ Barka Slough Outflow	USGS-BCM Runoff, Stream Gage Data	USGS-BCM adjusted to gage data	Adjusted Model – Medium	USGS-BCM adjusted to DWR VIC hydrology model for 2030 and 2070 climate data
Groundwater Outflow Components				
LACSD Pumping	LACSD	Data provided by LACSD	Metered – High	Linear projection based on historical data set and estimated population growth
VSFB Pumping	VSFB	Data provided by VSFB	Metered – High	
Agricultural Irrigation Pumping	Various Land Use Surveys and Crop Water Use Factors from the SYRWCD	Methods described in Section 3.3.2.4	Estimated – Medium/Low	Irrigated acreage and water demand based on 2020 land use survey. Crop water duty factors multiplied by the respective DWR VIC hydrology model ET
Rural Domestic Pumping	Aerial Survey	Methods described in Section 3.3.2.4	Estimated – Medium/Low	Linear projection based on historical data set and estimated population growth
Riparian ET	LandFire	Methods described in Section 3.3.2.4	Estimated – Medium	Linear projection of historical data set multiplied by the respective DWR VIC hydrology model ET
Discharge to Surface Water	USGS-BCM Runoff, Stream Gage Data, Darcian Flux Calculation, Historical Reports	Methods described in Section 3.3.2.4	Estimated – Low	USGS-BCM adjusted to DWR VIC hydrology model for 2030 and 2070 climate data

Water Budget Component	Data Source(s)	Comment(s)	Qualitative Data Rating	Projected Data Set Methodology
General Basin and Hydrogeologic Properties				
—	(Muir, 1964; Hutchinson, 1980; Mallory, 1980; and Martin, 1985)	Published scientific reports	High/Medium	—

Notes

— = not applicable
BCM = Basin Characterization Model developed by the USGS, (Flint and Flint, 2014). Monthly data on a uniform 885 feet (ft) × 885 ft grid across the Basin.
ET = evapotranspiration
LACSD = Los Alamos Community Services District
SYRWCD = Santa Ynez River Water Conservation District
USGS = United States Geological Survey
VSFB = Vandenberg Space Force Base
VIC = Variable Infiltration Capacity model developed by (Hamman et al., 2018) and (Liang et al., 1994)

3.3.2.1 Surface Water Inflow Components

The Basin's watershed is the headwaters for San Antonio Creek. Consequently, surface water inflows include only water native to the Basin (runoff of precipitation). The Basin does not receive imported water from the California SWP, nor does it receive reservoir releases into streams and rivers that enter the Basin from the surrounding watershed. The individual components of the surface water budgets are described below.

Native Streamflow

Native streamflow in the tributaries to San Antonio Creek were estimated using a combination of USGS Basin Characterization Model (BCM) for California (Flint and Flint, 2017) local and regional meteorological station data, and stream gage data (if available). The BCM data are provided statewide on a 270 meter (m) × 270 m grid. As a quality assurance check on the BCM data, the gridded BCM monthly precipitation data were compared to the monthly precipitation reported at meteorological stations located within and adjacent to the Basin. On average, over the 110-year period of record from 1910 through 2020, the BCM precipitation across all these stations was 1.4 percent higher than the weather station reported values. For month-to-month comparisons, however, meteorological stations reported more discrepancies between the BCM values for individual locations. As detailed in Appendix E, a correction was applied to the BCM values for each monthly timestep such that the adjusted BCM data exactly matched all recorded meteorological station monthly precipitation values. These monthly adjustments were also applied to the BCM generated runoff and recharge data sets. These adjusted BCM runoff and recharge data sets were then compared to San Antonio Creek streamflow gage data, where available, and adjusted to fit the gage data.[26]

Multiple USGS-operated stream gages exist or formerly existed in the Basin along San Antonio Creek. Therefore, the level of uncertainty of these data is low. The flow from the tributary creeks, however, is ungaged and estimated based on the USGS BCM. The uncertainty of these data is considered moderate, because the USGS BCM is adjusted to measured stream flow and precipitation data within the Basin. Most native streamflow percolates to the groundwater system (see Section 3.3.2.2). The uncertainty associated with estimated tributary flow will not limit the SABGSA's ability to manage the Basin's groundwater system because these estimated water budget terms for tributary inflow are adjusted to measured data.

Groundwater Discharge to Surface Water

Groundwater discharge to surface water flows occur at the downstream end of the Basin into Barka Slough. Average annual groundwater discharge to surface water flow values were calculated using Darcy's law[27] with hydrogeologic properties according to Muir (1964), Hutchinson (1980), and Martin (1985), or determined using groundwater levels from nested monitoring wells near the Slough to calculate vertical gradient, and surficial topography of San Antonio Creek to calculate the hydraulic gradient of the alluvium located immediately east of Barka Slough. See Appendix D for calculation details. To determine groundwater

[26] The BCM precipitation data was adjusted to regional precipitation station data (by adjusting the BCM precipitation data to honor the regional precipitation station data for the pixels where the precipitation gages are located). Initial adjustments to BCM recharge and runoff terms were based on the adjusted precipitation ratio (adjusted precipitation ÷ raw precipitation). Subsequent adjustments were made between recharge and runoff terms to match surface water flow gage data or to match general understanding of runoff to recharge relationships in the area. This was based on a simple hydrologic conceptual model (rejected recharge and streambed percolation of runoff) and related mathematical models were calibrated to the surface water gage flow data. All the BCM-generated recharge and runoff in the Basin was always accounted for, no mass was lost or removed. Rejected recharge was accounted for as surface water and all runoff generated during drier years percolated as streambed percolation.
[27] Darcy's law is an equation that describes the flow of fluid, such as groundwater, through a porous medium, such as beds of sand or gravel in the subsurface. The flow rate predicted by the law depends on several key variables, including the permeability of the medium, the cross-sectional area of the medium through which the fluid flows, the viscosity of the fluid, and gradient (change in elevation) that is present over a given distance.

discharge to surface water flow values for each year of the historical water budget period, the surface water flow data from the Casmalia stream gage, located on San Antonio Creek downstream (west) of the Slough, were used to calculate surface water outflow from the Slough.

The USGS BCM runoff model (adjusted to local regional meteorological station data) was used to estimate the annual surface water inflow to Barka Slough (SswIN). The annual surface water flow discharging from the Slough (SswOUT) was estimated by subtracting the USGS BCM runoff model flows for the watershed areas contributing flow to San Antonio Creek downstream of the Slough and upstream of the Casmalia gage (BCMds) and adding the estimated annual agricultural ET (AgET) for the crops located adjacent to San Antonio Creek between the Slough and the Casmalia gage to the annual surface water flow measured at the Casmalia gage (Cas), as shown here:

$$\boldsymbol{SswOUT = Cas - BCMds + AgET}$$

The AgET was estimated using a fixed annual water duty factor of 2.1 AF per acre per year and an assumed 20 percent irrigation return flow rate.[28] The AgET estimate is based on the assumption that crop irrigation water is derived from shallow alluvial wells in direct communication with San Antonio Creek and that irrigation return flows wind up back in direct communication with San Antonio Creek.[29]

The estimated total annual volume of groundwater discharge to surface water in the Slough (GWdis) was estimated as follows:

$$\boldsymbol{GWdis = SswOUT - SswIN + SET}$$

where, SswIN is the surface water inflows to the Slough and SET is the estimated annual Slough riparian evapotranspiration.

The uncertainty of these data is considered moderate because the USGS BCM is being used to estimate this water budget term. The authors do not have other reliable methods for estimating this term and are applying best available science. However, the authors have attempted to constrain this term by adjusting the USGS BCM to measured streamflow and precipitation data within and downgradient of the Basin. The authors do not believe that the uncertainty associated with estimates of groundwater discharge to surface water limits the SABGSA's ability to manage the Basin's groundwater system because the estimated water component was calculated using measured data from the USGS-operated Casmalia stream gage.

3.3.2.2 Surface Water Outflow Components

The data sources used for the surface water budget outflow terms are described below.

San Antonio Creek/Barka Slough Outflow

San Antonio Creek/Barka Slough surface water outflows calculations and level of uncertainty are discussed in Section 3.3.2.1.

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[28] Crop-specific water duty factors and agricultural irrigation return flow are discussed further in Sections 3.3.2.4 and 3.3.2.3, respectively. Crop type for the area located between Barka Slough and the Casmalia gage was determined based on the 2018 LandIQ data set available on SGMA Data Viewer (https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#waterbudget)

[29] This assumption is supported by geologic mapping showing that San Antonio Creek is contained within a narrow package of recent alluvium underlain by relatively impermeable bedrock between Barka Slough and the Casmalia gage (Dibblee and Ehrenspeck, 1989).

Streamflow Percolation

Streamflow percolation, or the deep percolation of surface water to groundwater through the streambed, was calculated using the adjusted USGS BCM. Portions of the adjusted BCM runoff and recharge data sets routed to San Antonio Creek and tributary streamflow percolation were determined in conjunction with comparisons to San Antonio Creek streamflow gage data as described in Section 3.3.2.1.

The uncertainty of these data is considered moderate because the USGS BCM, adjusted to measured precipitation and streamflow in the Basin, was used to estimate this water budget term and is discussed in Section 3.3.2.1.

3.3.2.3 Groundwater Inflow Components

The data sources used for the groundwater budget inflow terms are described below.

Mountain Front Recharge

As shown in Figure 3-1, the Basin is rimmed by the Casmalia and Solomon Hills to the north, the San Rafael Mountains to the east, and the Purisima Hills to the south. Groundwater enters the Basin where the Basin deposits abut underlying bedrock on the mountain slopes. This component of inflow is termed mountain front recharge.

Mountain front recharge was calculated using the adjusted BCM model as described above in Section 3.3.2.1. Mountain front recharge was calculated as the sum of the adjusted BCM recharge data set over the contributing watershed areas outside the Basin minus the portion routed to native streamflow.

The uncertainty of these data is considered moderate because the USGS BCM, adjusted to measured precipitation and streamflow in the Basin, was used to estimate this water budget term and is discussed in Section 3.3.2.1.

Streamflow Percolation

The calculation of streamflow percolation to groundwater is detailed above in Section 3.3.2.2.

Deep Percolation of Direct Precipitation

Precipitation falling on the land surface of the Basin represents the principal source of inflows. The precipitation varies spatially and seasonally. The precipitation that falls on the ground surface within the contributing watershed to the Basin either runs off into stream channels that eventually discharge to San Antonio Creek and ultimately to Barka Slough, or it infiltrates into the soil zone.

Recharge to groundwater from deep percolation of precipitation was determined using the USGS BCM gridded recharge data set. As described above in Section 3.3.2.1, the BCM recharge data set has been adjusted based on comparison to monthly precipitation records at meteorological stations located within and adjacent to the Basin.

The level of uncertainty of these data is considered moderate because the USGS BCM, adjusted to measured precipitation and streamflow in the Basin, was used to estimate this water budget term and is discussed in Section 3.3.2.1. These data are also within the range of values commonly applied to similar geologic settings.

Percolation of Treated Wastewater (Effluent Spray Irrigation)

LACSD WWTP discharges treated wastewater to the land surface through spray irrigation. Because the LACSD WWTP was constructed prior to 1981, it was evaluated for the historical water budget. The spray irrigation discharge volume and location of irrigated land was provided by LACSD, and details of plant operation were specified in the LACSD Sewer System Management Plan (LACSD, 2011). From 1994 through 2005, 38 acres were irrigated by the LACSD WWTP spray irrigation, which accounted for an average of 63 percent of the irrigated crop reference ET (ETo).[30] LACSD WWTP irrigated acres increased to 64 in 2006. From 2006 through 2018, the spray irrigation accounted for an average of 45 percent of the irrigated crop ETo. Based on the volume of reported annual discharge, the irrigated acreage, and the crop ETo, it is unlikely that effluent from the LACSD WWTP spray irrigation system percolate in any significant volume to groundwater; therefore, it does not contribute to the Basin water budget.

The uncertainty of these data is considered low because the LACSD meters and reports the effluent volume and irrigated acreage. The irrigated crop reference ETo is based on published data.

Percolation from Septic Systems

The residences and businesses in Los Alamos are connected to sewer service. Wastewater flows from these properties are transmitted to the LACSD WWTP and subsequently discharged as spray irrigation. These WWTP discharges do not contribute to the Basin water budget, as discussed in Section 3.3.2.3. Outside of the sewer-serviced areas within the Basin, domestic wastewater is discharged to on-site wastewater treatment systems (OWTS, formerly referred to as septic tank – leach field systems). Return flows from these OWTS provide recharge to the groundwater system. Septic tank return flow was calculated by using a 2018 aerial survey of the Basin to count residences suspected to have an OWTS unit in the Basin, then multiplying that value by an assumed return flow rate of 0.11 acre-feet per year (AFY) per unit (an amount provided in Tetra Tech, 2010). This was then scaled through time using a compilation of census data for nearby communities.

These groundwater recharge components were estimated based on an aerial survey and published OWTS return flow rates. Consequently, the uncertainty of this groundwater budget component is considered moderate. The annual estimated volumes for this groundwater budget component are relatively small compared to other groundwater budget component terms and, therefore, have little impact on the overall water budget.

Irrigation Return Flow

Irrigation return flow is defined as the amount of water applied to the crop in excess of the crop ET demand. The portion of applied water that is used to satisfy crop ET demand is equivalent to the irrigation efficiency, expressed as a percentage. The remaining percentage is equivalent to the irrigation return flow. Return flows can reenter the hydrologic system either as deep drainage and recharge to groundwater, or water that leaves the cropped field as surface flow "tail water" and discharges to a nearby stream. It is assumed that most of the irrigation return flow percolates to groundwater within the Basin. For irrigated agriculture in the Basin, an irrigation efficiency of 80 percent is assumed for all crops except vineyards, which are generally irrigated using a drip system at an efficiency of 90 percent.[31] The urban landscape irrigation efficiency is assumed to be 70 percent. These irrigation return flow proportions were based on feedback from the SABGSA's Special Advisory Committee and conversations between GSI staff and representatives from the

[30] Crop ETo used was for grass in Irrigation Training & Research Center ET Zone 6 during a typical year (http://www.itrc.org/etdata/).

[31] Irrigation efficiencies within vineyards have increased from 70 percent in the 1970s to 80 percent in the 1980s, and to 90 percent more recently, based on verbal conversations with regional irrigators.

Santa Ynez River Valley Groundwater Basin – EMA, Central Management Area, and Western Management Area GSAs. These irrigation return flows were used throughout the Basin. Irrigation return flow volumes have been calculated using these efficiencies multiplied by the calculated annual volumes of irrigation water applied to each crop type (based on land use surveys within the Basin in 1959, 1968, 1977, 1986, 1996, 2006, 2016, and 2020 [see Appendix E]) and assigned crop-specific water duty factors. These applied water volumes are discussed further in Section 3.3.2.4.

These groundwater recharge components were estimated based on published values for irrigation efficiency, which were used throughout both the entire Basin and adjacent basins. Therefore, the level of uncertainty of these data is relatively low.

3.3.2.4 Groundwater Outflow Components

The data sources used for the groundwater budget outflow terms are described below.

LACSD Pumping

LACSD pumping was calculated using production data provided by LACSD from water years 1994 through 2020. LACSD pumping volumes prior to 1994 were calculated by scaling the 1994 demand using a compilation of census data for nearby communities.

Pumping volumes provided by the LACSD are from metered pumping and are considered highly reliable with low uncertainty.

VSFB Pumping

VSFB pumping was calculated using production data provided by VSFB. The entire historical water budget period is included in the VSFB pumping data set provided.

Pumping volumes provided by VSFB are from metered pumping and are considered highly reliable with low uncertainty.

Agricultural Irrigation Pumping

ET by crops results in a loss, or depletion, of water from the system. To meet the crop ET demand, irrigation water is diverted from the surface or groundwater source and applied to the cropped land. All water used to irrigate crops in the Basin is sourced by pumping groundwater. In the absence of metered pumping records, agricultural irrigation pumping was estimated using periodic land use survey data (from 1959, 1968, 1977, 1986, 1996, 2006, 2016, and 2020 [see Appendix E]) provided by the USGS (USGS, 2020e) and the Santa Barbara County Agricultural Commissioner, Weights and Measures Department (Santa Barbara County, 2020) to determine crop types and acreages. Crop-specific water duty factors for the Basin were derived in part from the Groundwater Production Information and Instructions pamphlet prepared by Santa Ynez River Valley Water Conservation District (SYRWCD) (SYRWCD, 2010). Some crop duty factors were adjusted based on feedback from some growers in the Basin. These crop-specific water duty factors were applied to the acreage associated with the agricultural land use types in the land survey data provided by USGS and Santa Barbara County for the Basin. Because land use surveys were not available for every year, spatial-temporal interpolations were made between the land use surveys for the intervening years.

This groundwater budget component is estimated by utilizing crop-specific water duty factors provided by SYRWCD for use in its water use estimates and annual reports. Basin stakeholders reviewed and modified the SYRWCD crop-specific water duty factors to be more accurate for the Basin. Irrigated acreage by crop type was determined using land use surveys provided by the USGS and available from Santa Barbara County (see Appendix E). While the accuracy of the land use mapping of irrigated crops for the recent years is high, uncertainty remains in the estimates of water use from these irrigated lands and hence the assumed amount of pumping needed to meet the crop water requirement. The uncertainty of this groundwater budget component is considered moderate.

Rural Domestic Pumping

Rural domestic pumping is all domestic pumping that occurs outside of LACSD. Rural domestic pumping was calculated by conducting an aerial survey to identify land parcels with home sites in the area outside the LACSD service area in 2018. The 2018 domestic demand for each of these land parcels was calculated using variable demand factors based on parcel acreage, as specified in Tetra Tech (2010) (see Table 3-15). The calculated 2018 rural domestic demand was then scaled through time using a compilation of census data for nearby communities.

Table 3-15. Rural Domestic Demand Factors Based on Lot Size

Lot Size (acres)	Annual Water Use (AFY per lot)
0.16	0.14
0.5	0.52
1	0.82
5	0.98
10	1.15

Source: Tetra Tech, 2010

These groundwater recharge components were estimated based on an aerial survey and published estimated water demand based on parcel size. Consequently, the uncertainty of this groundwater budget component is considered moderate. The annual estimated volumes for this groundwater budget component are relatively small compared to other groundwater budget component terms and, therefore, have little impact on the overall water budget.

Riparian Evapotranspiration

Riparian ET was calculated using the LandFire Existing Vegetation Type (EVT) spatial data set[32] to determine acreages of riparian vegetation types occurring within the Basin. It is assumed that the riparian acreage in the Basin did not change significantly during the historical period. The riparian acreage determined from the LandFire EVT analysis was then multiplied by a variable riparian water duty factor, varied based on water year type. The riparian water duty factor used is 4.5 acre-feet (AF) per acre per year, on average.[33] The riparian acreage included the riparian vegetation present within Barka Slough, San Antonio Creek, and tributaries.

The acreage and water use factors used to estimate riparian ET are based on authoritative sources. The acreage, however, has been collected by remote-sensing methods and has not been field-verified to confirm the presence of the indicated plants. In addition, there is considerable uncertainty associated with the

[32] LandFire is a shared program between the U.S. Department of Agriculture, Forest Service, and the U.S. Department of the Interior's wildland fire management programs. LandFire provides landscape-scale geo-spatial products to assist cross-boundary planning, management, and operations (https://landfire.gov).
[33] The 4.5 AF per acre per year water duty factor used for calculation of riparian evapotranspiration was derived from Muir, 1964 (4.7 AF and 3.0 AF per acre per year for Barka Slough and along San Antonio Creek, respectively) and professional judgement.

phreatophyte ET because the inputs to this water budget term are not directly measured and there is likely to be considerable variability. Therefore, the uncertainty associated with this data source is considered to be high.

Discharge to Surface Water

Refer to Section 3.3.2.1.

3.3.3 Historical Water Budget Results [§ 354.18(c)(2)(B)]

§ 354.18 Water Budget.

(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:

(B) A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.

3.3.3.1 Historical Surface Water Budget

Historical Surface Water Inflows

Local surface water supplies include surface water flows that enter the Basin from precipitation runoff within the watershed and groundwater in the Basin discharging to surface water in the Basin. Table 3-16 summarizes the annual average, minimum, and maximum values for these inflows.

Table 3-16. Annual Surface Water Inflows, Historical Period

Surface Water Inflow Component	Average	Minimum	Maximum
Inflow to Basin including San Antonio Creek and Tributaries	5,100	300	35,200
Groundwater Discharge to Surface Water	2,000	400	5,400
Total[1]	7,100	—	—

Notes

All values are in units of acre-feet.
[1] Minimum and maximum values are not totaled because the values for each component may have occurred in different years.
— = not applicable

The estimated average annual total inflow from these sources over the historical period is 7,100 AF. The largest component of this average inflow is flow in San Antonio Creek. The large difference between the minimum and maximum inflows reflects the difference between dry and wet years in the Basin.

Historical Surface Water Outflows

The estimated annual average total surface water outflow leaving the Basin as flow in San Antonio Creek west of Barka Slough and percolation into the groundwater system over the historical period is summarized in Table 3-17.

Table 3-17. Annual Surface Water Outflows, Historical Period

Surface Water Outflow Component	Average	Minimum	Maximum
San Antonio Creek West of Barka Slough Outflow from Basin	4,200	400	27,500
Streamflow Percolation	3,100	300	12,000
Total[1]	7,300	—	—

Notes

All values are in units of acre-feet.

[1] Minimum and maximum values are not totaled because the values for each component may have occurred in different years.

— = not applicable

The estimated average annual total outflow from these sources over the historical period is 7,300 AF. All surface water outflow from the Basin occurs in San Antonio Creek west of Barka Slough. The large difference between the minimum and maximum outflows reflects the difference between dry and wet years in the Basin.

Historical Surface Water Budget Summary

Figure 3-61 summarizes the historical surface water budget for the Basin. This figure illustrates the strong correlation between precipitation and streamflow in the Basin. In wet periods, shown with a blue background, surface water inflows and outflows are generally large. In contrast, in dry periods, shown with a tan background, surface water inflows and outflows are small.

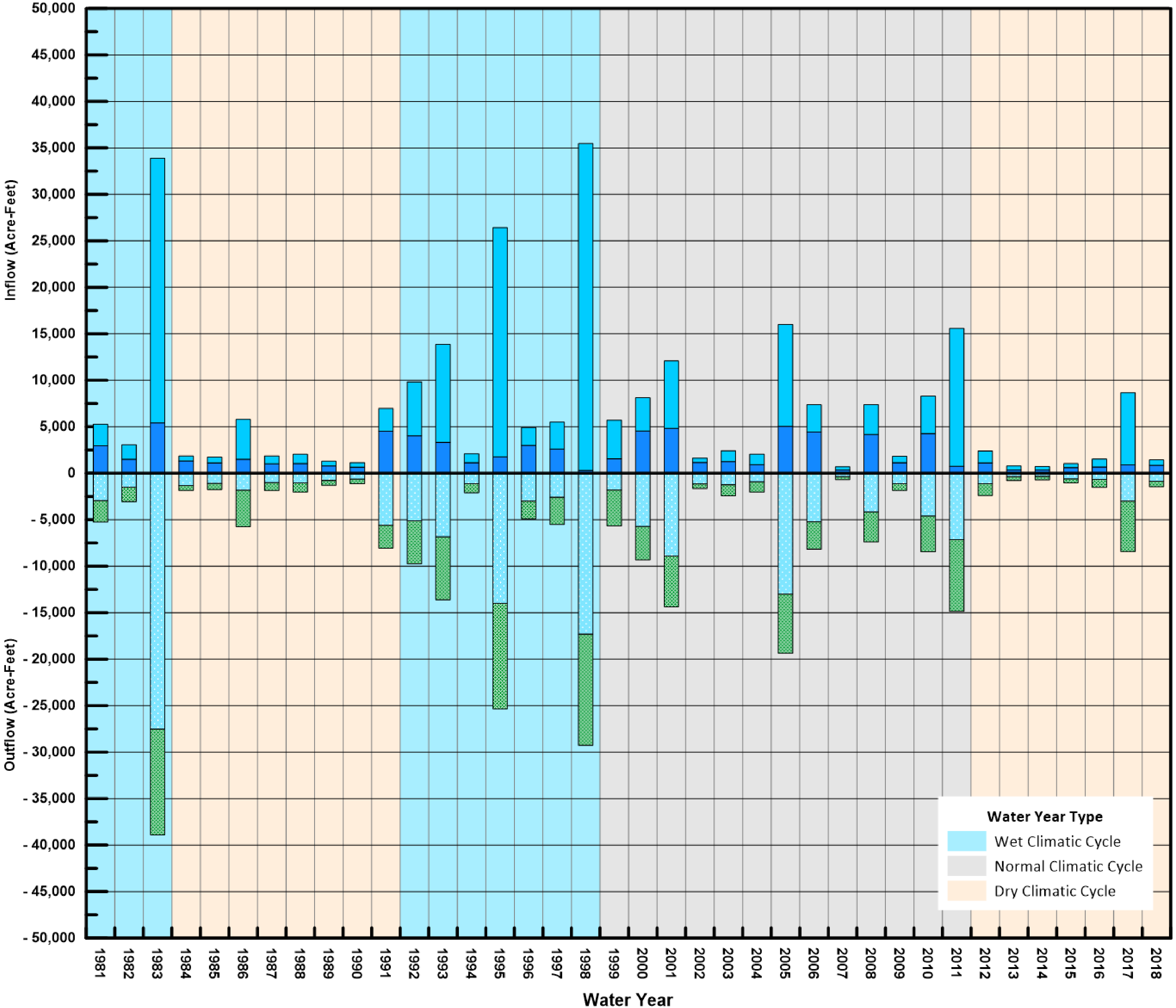


Figure 3-61
Historical Surface Water Budget

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

GSI Water Solutions, Inc.

Reliability of Historical Surface Water Supplies [§ 354.18(c)(2)(A)]

> **§ 354.18 Water Budget.**
>
> **(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:**
>
> **(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:**
>
> **(A) A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.**

Historically, no water surface water deliveries or instances of imported water have occurred in the Basin. Similarly, surface water in the Basin has not been used as a direct resource. Therefore § 354.18(c)(2)(A) of the SGMA regulations is not applicable to the Basin and this GSP.

3.3.3.2 Historical Groundwater Budget

Groundwater, including production from both the Paso Robles Formation and the Careaga Sand, supplied all the water pumped and used in the Basin over the historical period. The historical groundwater budget includes a summary of the estimated groundwater inflows, groundwater outflows, and change in groundwater in storage.

Historical Groundwater Inflows

Groundwater inflow components include streamflow percolation, agricultural irrigation return flow, deep percolation of direct precipitation, mountain front recharge, septic system return flow, and urban irrigation return flow. Estimated annual groundwater inflows for the historical period are summarized in Table 3-18. Values reported in the table were estimated or derived from the data sources reported in Table 3-14.

Table 3-18. Annual Groundwater Inflow, Historical Period

Groundwater Inflow Component	Average[1]	Minimum	Maximum
Mountain Front Recharge	2,400	10	13,600
Streamflow Percolation[2]	3,100	300	12,000
Deep Percolation of Direct Precipitation	8,600	100	42,400
Septic System Return Flow	20	10	20
Agricultural Irrigation Return Flow	3,500	2,100	4,400
Urban Irrigation Return Flow	1	1	1
Total[3]	17,500	—	—

Notes

All values are in units of acre-feet.
[1] Due to rounding, total does not correspond to the sum of all figures shown.
[2] Streamflow Percolation includes San Antonio Creek percolation and tributary channel percolation.
[3] Minimum and maximum values are not totaled because the values for each component may have occurred in different years.
— = not applicable

During the historical period, estimated total groundwater inflow ranged from 3,300 AFY to 69,600 AFY, with an average annual inflow of 17,500 AF. The largest groundwater inflow component is percolation of direct precipitation, which accounts for approximately 49 percent of the total annual average inflow. The large difference between the minimum and maximum inflows from streamflow percolation and direct precipitation reflects the variations in precipitation over the historical period.

Historical Groundwater Outflows

Groundwater outflow components include total groundwater pumping from all water use sectors, groundwater discharge to surface water, and riparian ET. No areas of subsurface flow out of the Basin have been identified. Estimated annual groundwater outflows for the historical period are summarized in Table 3-19.

Table 3-19. Annual Groundwater Outflow, Historical Period

Groundwater Outflow Component	Average	Minimum	Maximum
Total Groundwater Pumping	19,500	13,800	24,300
Riparian Evapotranspiration	6,500	6,300	6,700
Groundwater Discharge to Surface Water	2,000	300	5,400
Total[1]	28,000	—	—

Notes

All values are in units of acre-feet.
[1] Minimum and maximum values are not totaled because the values for each component may have occurred in different years.
— = not applicable

The largest groundwater outflow component from the Basin is groundwater pumping. Estimated annual groundwater pumping by water use sector for the historical period is summarized in Table 3-20.

Table 3-20. Annual Groundwater Pumping by Water Use Sector, Historical Period

Water Use Sector	Average[1]	Minimum	Maximum
LACSD	270	170	370
VSFB	1,800	0	3,430
Agricultural	17,300	10,300	22,200
Rural Domestic	140	100	170
Total[2]	19,500	—	—

Notes

All values are in units of acre-feet.
[1] Due to rounding, total does not correspond to the sum of all figures shown.
[2] Minimum and maximum values are not totaled because the values for each component may have occurred in different years.
— = not applicable
VSFB = Vandenberg Space Force Base

Agricultural pumping is the largest component of total groundwater pumping, accounting for approximately 89 percent of total pumping for the historical period. In general, agricultural pumping increased during the historical period; however, planted acreage did not increase significantly between 2006 and 2020. VSFB, LACSD, and rural domestic pumping account for approximately 9 percent, 1 percent, and 1 percent, respectively, of total average annual pumping over the historical period.

Historical Groundwater Budget and Changes in Groundwater in Storage

Average groundwater inflows and outflows for the historical period are presented on Figure 3-62. The average total inflow of approximately 17,500 AFY is less than the average total outflow of 28,100 AFY. A summary of annual groundwater inflows and outflows for the entire historical period is presented on Figure 3-63 (also tabulated in Table 3-21 and Appendix E). Figure 3-63 shows groundwater inflow and outflow components for every year of the historical period. Inflow components are graphed above the zero line and outflow components are graphed below the zero line. Groundwater outflow by pumping (green bars) includes pumping from all water use sectors (see Table 3-20). The blue line shows the cumulative change in groundwater storage over the historical period. The results of the water budget indicate that average pumping in the Basin has exceeded average recharge throughout the historical period.

Annual variations in the volume of groundwater in storage were calculated for each year of the historical period. The changes in storage for the 38-year period were used to evaluate conditions of water supply surplus and deficiency and in identifying conditions of long-term groundwater storage deficit.

As shown on Figure 3-63, there was an accumulated reduction of groundwater in storage of 400,100 AF over the entire 38-year period, which is equal to an average deficit of approximately 10,600 AFY.

Prior to the beginning of the current water budget period of 2011 through 2018, which is discussed below, the cumulative change in groundwater storage was -264,600 AF during the 30-year period between 1981 and 2010. During the current drought that began in 2012, an additional cumulative change in groundwater storage deficit of approximately 135,500 AF occurred, which is approximately 34 percent of the total cumulative change in storage during the historical period.

Table 3-21. San Antonio Creek Valley Groundwater Basin Historical, Current, and Projected Water Budget Summaries

= Component of Inflow

= Component of Outflow

Values in acre-feet

Water Budget	Water Year	Rainfall		Components of Inflow								Total Inflow	Components of Outflow								Total Outflow	Change in Storage	Cumulative Change in Storage
		Inches	% of Average	Subsurface Inflow	Mountain Front Recharge	Streamflow Percolation	Percolation of Direct Precipitation	LACSD WWTP Effluent	Septic Return Flows	Ag Irrigation Return Flows	Urban Irrigation Return Flows		Groundwater Pumping: LACSD Pumping	Groundwater Pumping: VAFB Pumping	Groundwater Pumping: Ag Irrigation Pumping	Groundwater Pumping: Rural Domestic Pumping	Groundwater Pumping: Total Pumping	Riparian Evapotranspiration	Groundwater Discharge to Surface Water	Subsurface Outflow			
Historical Water Budget	1981	13.3	86%	0	1,400	2,300	4,900	0	10	2,100	1	10,700	170	3,270	10,300	100	13,800	6,600	3,000	0	23,400	-12,700	-12,700
	1982	14.4	94%	0	1,600	1,600	4,600	0	10	2,100	1	9,900	170	3,430	10,700	100	14,400	6,400	1,500	0	22,300	-12,400	-25,100
	1983	35.7	232%	0	13,600	11,400	42,400	0	10	2,200	1	69,600	180	3,080	11,200	110	14,600	6,500	5,400	0	26,500	43,100	18,000
	1984	9.7	63%	0	200	500	600	0	10	2,300	1	3,600	190	3,230	11,600	110	15,100	6,600	1,300	0	23,000	-19,400	-1,400
	1985	10.4	68%	0	400	600	1,400	0	10	2,400	1	4,800	190	3,370	12,000	110	15,700	6,500	1,100	0	23,300	-18,500	-19,900
	1986	15.9	103%	0	2,700	3,900	8,500	0	10	2,500	1	17,600	200	3,000	12,500	120	15,800	6,500	1,500	0	23,800	-6,200	-26,100
	1987	11.7	76%	0	700	800	2,200	0	10	2,500	1	6,200	210	3,140	12,700	120	16,200	6,500	1,000	0	23,700	-17,500	-43,600
	1988	15.1	98%	0	1,100	1,000	3,200	0	10	2,600	1	7,900	210	3,250	13,000	120	16,600	6,500	1,000	0	24,100	-16,200	-59,800
	1989	8.2	54%	0	10	500	200	0	10	2,600	1	3,300	220	3,080	13,200	130	16,600	6,500	800	0	23,900	-20,600	-80,400
	1990	8.1	52%	0	20	500	200	0	10	2,700	1	3,400	220	3,410	13,400	130	17,200	6,500	600	0	24,300	-20,900	-101,300
	1991	16.5	107%	0	700	2,500	4,100	0	10	2,700	1	10,000	230	3,240	13,600	130	17,200	6,400	4,500	0	28,100	-18,100	-119,400
	1992	17.0	110%	0	3,800	4,600	14,000	0	10	2,800	1	25,200	230	3,240	13,900	130	17,500	6,600	4,000	0	28,100	-2,900	-122,300
	1993	24.7	160%	0	6,800	6,800	21,300	0	10	2,800	1	37,700	230	2,840	14,100	140	17,300	6,600	3,300	0	27,200	10,500	-111,800
	1994	13.4	87%	0	600	1,000	1,900	0	10	2,900	1	6,400	230	2,860	14,300	140	17,500	6,500	1,100	0	25,100	-18,700	-130,500
	1995	29.2	190%	0	7,500	11,300	32,400	0	10	2,900	1	54,100	240	2,690	14,600	140	17,700	6,500	1,800	0	26,000	28,100	-102,400
	1996	15.5	101%	0	1,300	1,900	5,100	0	10	3,000	1	11,300	290	3,120	14,800	140	18,400	6,600	3,000	0	28,000	-16,700	-119,100
	1997	13.2	85%	0	2,500	2,900	6,900	0	20	3,100	1	15,400	290	3,320	15,500	140	19,300	6,600	2,600	0	28,500	-13,100	-132,200
	1998	36.2	235%	0	7,400	12,000	38,300	0	20	3,200	1	60,900	260	1,130	16,200	140	17,700	6,400	300	0	24,400	36,500	-95,700
	1999	16.2	105%	0	2,800	3,900	8,900	0	20	3,400	1	19,000	300	410	16,900	140	17,800	6,300	1,600	0	25,700	-6,700	-102,400
	2000	17.5	114%	0	3,400	3,600	10,400	0	20	3,500	1	20,900	320	840	17,700	150	19,000	6,600	4,500	0	30,100	-9,200	-111,600
	2001	18.3	119%	0	4,400	5,500	12,400	0	20	3,700	1	26,000	310	640	18,400	150	19,500	6,500	4,800	0	30,800	-4,800	-116,400
	2002	7.7	50%	0	20	500	400	0	20	3,800	1	4,700	340	460	19,100	150	20,100	6,500	1,200	0	27,800	-23,100	-139,500
	2003	14.8	96%	0	1,100	1,200	3,400	0	20	4,000	1	9,700	320	410	19,800	150	20,700	6,500	1,200	0	28,400	-18,700	-158,200
	2004	9.4	61%	0	800	1,100	2,400	0	20	4,100	1	8,400	370	460	20,500	150	21,500	6,600	900	0	29,000	-20,600	-178,800
	2005	28.3	184%	0	7,800	6,400	22,700	0	20	4,200	1	41,100	350	430	21,200	150	22,100	6,500	5,100	0	33,700	7,400	-171,400
	2006	18.3	119%	0	3,100	3,000	8,100	0	20	4,400	1	18,600	350	340	21,900	150	22,700	6,500	4,400	0	33,600	-15,000	-186,400
	2007	6.3	41%	0	10	300	100	0	20	4,400	1	4,800	360	340	21,900	150	22,800	6,500	400	0	29,700	-24,900	-211,300
	2008	17.0	111%	0	2,200	3,200	8,600	0	20	4,400	1	18,400	360	1,140	22,000	160	23,700	6,500	4,200	0	34,400	-16,000	-227,300
	2009	10.5	68%	0	200	700	800	0	20	4,400	1	6,100	350	1,420	22,000	160	23,900	6,500	1,100	0	31,500	-25,400	-252,700
	2010	17.6	114%	0	2,900	3,800	11,600	0	20	4,400	1	22,700	300	1,470	22,000	160	23,900	6,400	4,300	0	34,600	-11,900	-264,600
	2011	21.7	141%	0	7,500	7,700	27,300	0	20	4,400	1	46,900	300	590	22,000	160	23,100	6,400	700	0	30,200	16,700	-247,900
	2012	10.6	69%	0	50	1,300	1,200	0	20	4,400	1	7,000	310	300	22,000	160	22,800	6,500	1,100	0	30,400	-23,400	-271,300
	2013	6.3	41%	0	100	400	300	0	20	4,400	1	5,200	320	430	22,000	160	22,900	6,600	400	0	29,900	-24,700	-296,000
	2014	6.2	41%	0	10	400	200	0	20	4,400	1	5,000	320	1,800	22,000	160	24,300	6,600	400	0	31,300	-26,300	-322,300
	2015	7.6	50%	0	10	400	200	0	20	4,400	1	5,000	250	1,720	22,000	160	24,100	6,700	600	0	31,400	-26,400	-348,700
	2016	11.8	77%	0	30	900	1,100	0	20	4,400	1	6,500	250	390	22,000	160	22,800	6,600	700	0	30,100	-23,600	-372,300
	2017	21.8	142%	0	2,600	5,400	14,500	0	20	4,400	1	26,900	250	0	22,100	170	22,500	6,600	900	0	30,000	-3,100	-375,400
	2018	9.1	59%	0	100	600	500	0	20	4,400	1	5,600	280	150	22,200	170	22,800	6,600	900	0	30,300	-24,700	-400,100
	Minimum	6.2	41%	0	10	300	100	0	10	2,100	1	3,300	170	0	10,300	100	13,800	6,300	300	0	22,300	-26,400	
	Maximum	36.2	235%	0	13,600	12,000	42,400	0	20	4,400	1	69,600	370	3,430	22,200	170	24,300	6,700	5,400	0	34,600	43,100	**Basin Yield**
	Average	**15.4**	**100%**	**0**	**2,400**	**3,100**	**8,600**	**0**	**20**	**3,500**	**1**	**17,500**	**270**	**1,800**	**17,300**	**140**	**19,500**	**6,500**	**2,000**	**0**	**28,100**	**-10,600**	**8,900**
			% of Total:	0%	14%	18%	49%	0%	0%	20%	0%		1%	6%	62%	0%		23%	7%	0%			
Current Water Budget	2011	21.7	141%	0	7,500	7,700	27,300	0	20	4,400	1	46,900	300	590	22,000	160	23,100	6,400	700	0	30,200	16,700	16,700
	2012	10.6	69%	0	50	1,300	1,200	0	20	4,400	1	7,000	310	300	22,000	160	22,800	6,500	1,100	0	30,400	-23,400	-6,700
	2013	6.3	41%	0	100	400	300	0	20	4,400	1	5,200	320	430	22,000	160	22,900	6,600	400	0	29,900	-24,700	-31,400
	2014	6.2	41%	0	10	400	200	0	20	4,400	1	5,000	320	1,800	22,000	160	24,300	6,600	400	0	31,300	-26,300	-57,700
	2015	7.6	50%	0	10	400	200	0	20	4,400	1	5,000	250	1,720	22,000	160	24,100	6,700	600	0	31,400	-26,400	-84,100
	2016	11.8	77%	0	30	900	1,100	0	20	4,400	1	6,500	250	390	22,000	160	22,800	6,600	700	0	30,100	-23,600	-107,700
	2017	21.8	142%	0	2,600	5,400	14,500	0	20	4,400	1	26,900	250	0	22,100	170	22,500	6,600	900	0	30,000	-3,100	-110,800
	2018	9.1	59%	0	100	600	500	0	20	4,400	1	5,600	280	150	22,200	170	22,800	6,600	900	0	30,300	-24,700	-135,500
	Minimum	6.2	41%	0	10	400	200	0	20	4,400	1	5,000	250	0	22,000	160	22,500	6,400	400	0	29,900	-26,400	
	Maximum	21.8	142%	0	7,500	7,700	27,300	0	20	4,400	1	46,900	320	1,800	22,200	170	24,300	6,700	1,100	0	31,400	16,700	**Basin Yield**
	Average	**11.9**	**77%**	**0**	**1,300**	**2,100**	**5,700**	**0**	**20**	**4,400**	**1**	**13,500**	**290**	**670**	**22,000**	**160**	**23,200**	**6,600**	**700**	**0**	**30,500**	**-17,000**	**6,200**
			% of Total:	0.0%	10%	16%	42%	0%	0%	33%	0%		1%	2%	72%	1%		22%	2%	0%			
																							Basin Yield
Projected Water Budget	2042	15.8	101%	0	2,300	4,200	8,200	0	20	5,000	1	19,700	340	510	24,900	220	26,000	6,900	2,100	0	35,000	-15,300	10,700
	2072	15.4	100%	0	2,200	4,200	8,000	0	20	5,100	1	19,500	340	510	25,500	220	26,600	7,000	2,100	0	35,700	-16,200	10,400
	Minimum	15.4	100%	0	2,200	4,200	8,000	0	20	5,000	1	19,500	340	510	24,900	220	26,000	6,900	2,100	0	35,000	-16,200	
	Maximum	15.8	101%	0	2,300	4,200	8,200	0	20	5,100	1	19,700	340	510	25,500	220	26,600	7,000	2,100	0	35,700	-15,300	**Basin Yield**
	Average	**15.6**	**101%**	**0**	**2,300**	**4,200**	**8,100**	**0**	**20**	**5,100**	**1**	**19,600**	**340**	**510**	**25,200**	**220**	**26,300**	**7,000**	**2,100**	**0**	**35,400**	**-15,800**	**10,500**
			% of Total:	0.0%	12%	21%	41%	0%	0%	26%	0%		1%	1%	71%	1%		20%	6%	0%			

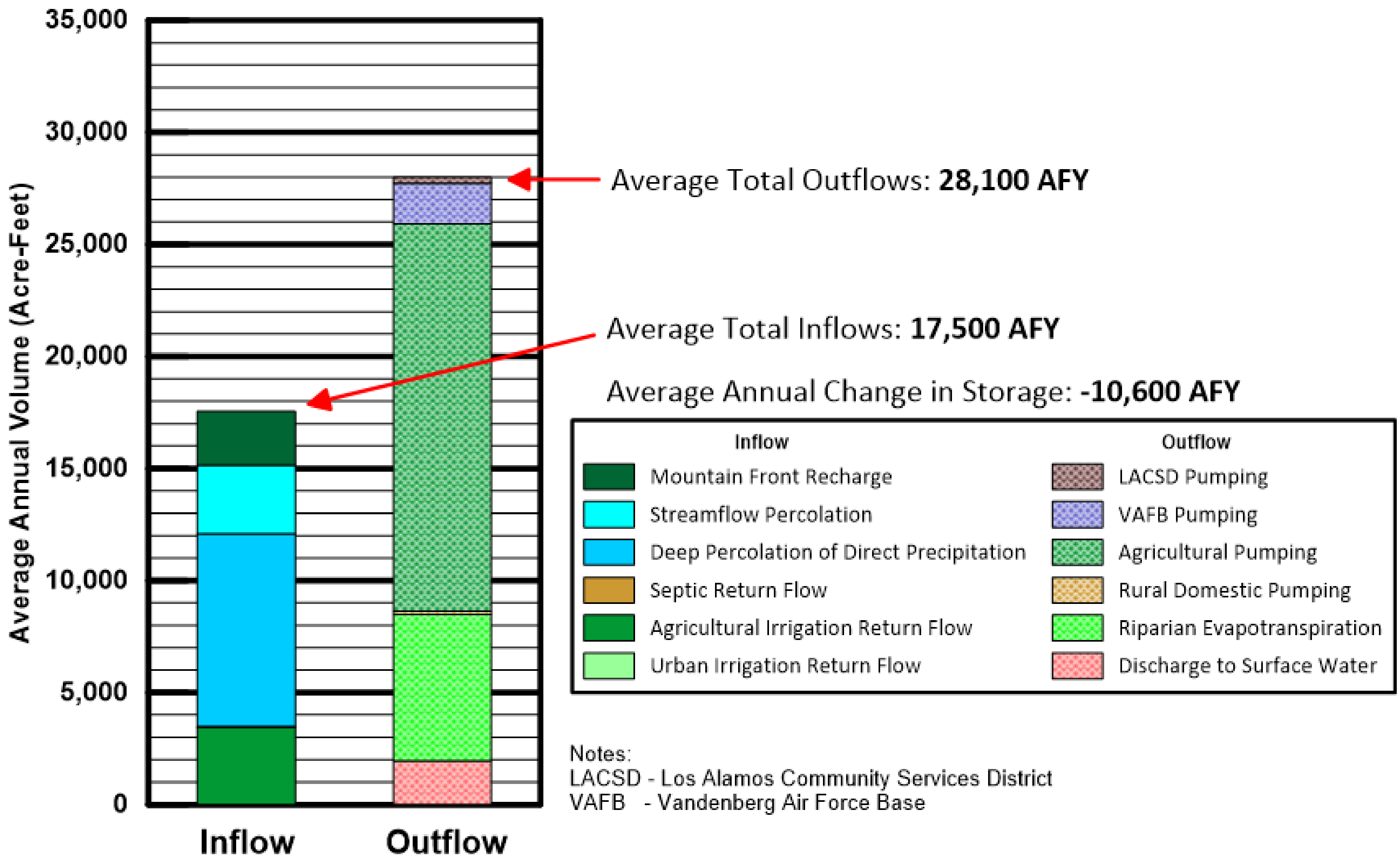


Figure 3-62. Average Groundwater Budget Volumes, Historical Period

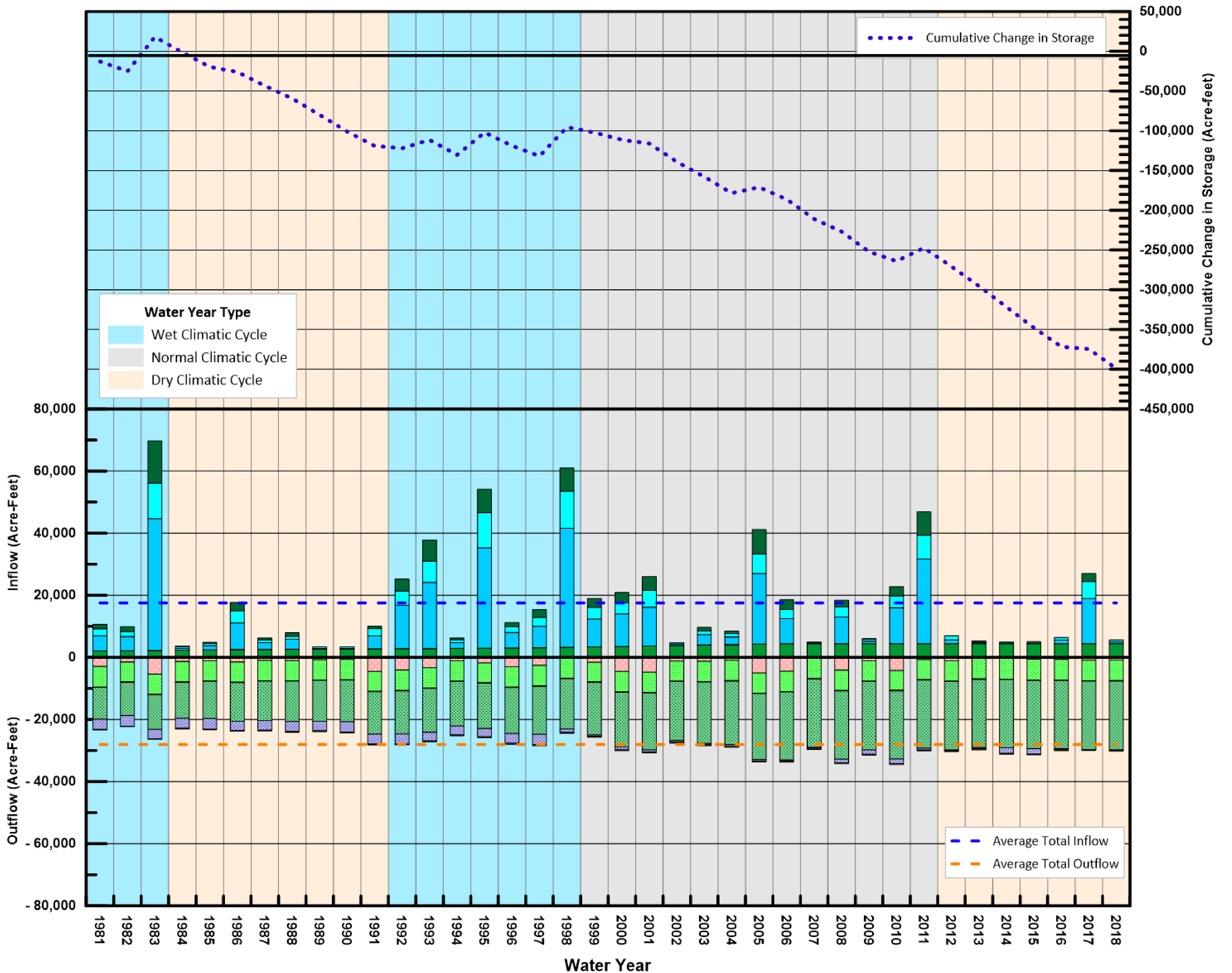


Figure 3-63
Historical Groundwater Budget Summary

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

Notes:
LACSD - Los Alamos Community Services District
VAFB - Vandenberg Air Force Base

GSI Water Solutions, Inc.

The historical groundwater budget is substantially influenced by the amount of precipitation falling on the Basin. During the historical period, dry conditions prevailed from 1984 through 1991 and 2012 through 2018, as depicted by the tan areas on Figure 3-63. During these dry periods, the amount of deep percolation of direct precipitation, mountain front recharge, and streamflow percolation was generally orders of magnitude lower than in normal or wet periods. The net result was a loss of groundwater from storage.

In contrast, wet conditions prevailed in the early 1980s and 1992 through 1998, as shown by blue areas on Figure 3-63. During these wet periods, the amount of deep percolation of direct precipitation, mountain front recharge, and streamflow percolation was generally 10,000 AFY or more. The net result was a gain of groundwater in storage. The period from 1999 through 2011 had generally alternating years of average precipitation. During this period, the amount of deep percolation of direct precipitation, mountain front recharge, and streamflow percolation was average; however, due to the amount of groundwater pumping occurring in the Basin, the net result was a loss of groundwater from storage.

Groundwater pumping is the largest component of outflow in the historical water budget. Over the historical period, the total amount of groundwater pumping increased from 1981 to 2009 and remained at that amount of pumping through 2018. Based on the USGS land use survey data, the increase in pumping corresponds with an increase in irrigated agricultural land use. Table 3-22 lists the total acreage of agricultural land use and approximate associated groundwater pumping for years when land use survey data were available. Agricultural land use area more than doubled in acreage from 1977 to 2020. An increase in irrigation efficiencies is indicated by the change in crop types (e.g., conversion to vineyard or hemp) as well as the reduction in groundwater pumping per acre of agricultural land use.

Over the 38-year historical period, a net loss of groundwater storage of about 400,100 AF occurred. The average annual groundwater storage loss was approximately 10,600 AFY.

Table 3-22. Groundwater Pumping and Agricultural Land Uses

Year	Crop Type[1]	Acres[1]	Total (acres)	Agricultural Irrigation Groundwater Pumping (acre-feet)
1977	Tree Crops	5	4,983	8,700
	Field Crops	1,929		
	Pasture	916		
	Truck and Berry Crops	1,402		
	Vineyards	731		
1986	Tree Crops	7	7,918	12,500
	Field Crops	1,110		
	Truck and Berry Crops	3,059		
	Vineyards	3,742		
1996	Tree Crops	3	9,032	14,800
	Field Crops	636		
	Truck and Berry Crops	3,186		
	Pasture	467		
	Vineyards	4,740		
2006	Field Crops	86	13,094	21,900
	Tree Crops	33		
	Truck and Berry Crops	4,668		
	Vineyards	8,306		
2016	Tree Crops	449	13,137	22,000
	Truck and Berry Crops	5,289		
	Vineyards	7,190		
2020	Field Crops	432	13,459	23,600
	Tree Crops	882		
	Truck and Berry Crops	4,687		
	Pasture	654		
	Vineyards	6,796		
	Cannabis/Hemp	9		

Notes

[1] Crop types and acreages are according to USGS, 2020e and Santa Barbara County, 2020 (see Appendix E).

The crop water use factors are shown below in acre-feet per year by evapotranspiration zones 6 and 3, respectively, and are according to SYRWCD, 2010 and the basin stakeholders (except for the cannabis/hemp totals, which are from Battany, 2019):

Tree Crops: 2.06 / 1.65 Field Crops: 1.23 / 0.99 Truck and Berry Crops: 2.62 / 2.10
Pasture: 3.75 / 3.00 Vineyards: 1.60 / 1.28 Cannabis/Hemp: 1.5 / 1.2

Historical Water Balance of the Basin

The computed long-term decrease of groundwater in storage indicates that total groundwater outflow exceeded the total inflow in the Basin from 1981 through 2018. As summarized in Table 3-19, total groundwater pumping averaged approximately 19,500 AFY during the historical period.

The historical basin yield was estimated by summing the estimated average groundwater storage decrease of 10,600 AFY with the estimated total average amount of groundwater pumping, of 19,500 AFY, for the historical period. This results in a historical basin yield for the Basin of about 8,900 AFY. This estimated value reflects historical climate, hydrologic, and pumping conditions and provides insight into the amount of groundwater pumping that could be sustained in the Basin to maintain a balance between groundwater inflows and outflows. It is anticipated that this value may fluctuate in the future as conditions change or as more data are obtained.

Section 354.18(b)(7) of the SGMA regulations requires a quantification of sustainable yield for the Basin for the historical period. Sustainable yield is the maximum quantity of groundwater, calculated over a period representative of long-term conditions in the Basin and including any temporary surplus that can be withdrawn annually from a groundwater supply without causing an undesirable result. Sustainable yield differs from the basin yield because sustainable yield incorporates consideration of the sustainable management criteria developed for the Basin. Based on the Basin's sustainable management criteria described in Section 4, the basin yield is equal to the sustainable yield for the Basin calculated for the historical period.

3.3.3.3 Impact of Historical Conditions on Basin Operations [§ 354.18(c)(2)(C)]

§ 354.18 Water Budget.

(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:

(C) A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.

The data sources used to generate the historical water budget, as summarized in Section 3.3.2, are considered of high enough quality and consist of a sufficiently long period of record to adequately estimate and project future water budget information and future aquifer response to proposed groundwater management practices over the planning and implementation horizon. Data gaps identified in the data sources, if any, are discussed in Section 3.3.2.

3.3.4 Current Water Budget [§ 354.18(c)(1)]

> **§ 354.18 Water Budget.**
>
> **(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:**
>
> **(1) Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information.**

SGMA regulations require that the current surface water and groundwater budget be based on the most recent hydrology, water supply, water demand, and land use information. For this GSP, 2011 through 2018 was selected as the period for the current water budget. This period is a subset of the historical period described in Section 3.3.3.2.

The current water budget period corresponds to a drought period when annual precipitation averaged about 77 percent of the historical average and percolation of direct precipitation averaged about 66 percent of the historical average. As a result, the current water budget period represents drought conditions and is not representative of the long-term hydrological conditions needed for sustainability planning purposes.

Estimates of the surface water and groundwater inflow and outflow and changes in storage for the current water budget period are provided below.

3.3.4.1 Current Surface Water Budget

The current surface water budget quantifies important sources of surface water. Similar to the historical surface water budget, the current surface water budget includes one surface water source type: local supplies.

Current Surface Water Inflow

Current local surface water supplies include surface water flows that enter the Basin from precipitation runoff within the watershed and groundwater in the Basin discharging to surface water in the Basin. Table 3-23 summarizes the annual average, minimum, and maximum values for these inflows.

Table 3-23. Annual Surface Water Inflow, Current Period

Surface Water Inflow Component	Average	Minimum	Maximum
Inflow to Basin, including San Antonio Creek and Tributaries	3,300	400	14,800
Groundwater Discharge to Surface Water	700	400	1,100
Total[1]	4,000	—	—

Notes

All values are in units of acre-feet.

[1] Minimum and maximum values are not totaled because the values for each component may have occurred in different years.

— = not applicable

The estimated average inflow from precipitation runoff over the current water budget period was approximately 3,300 AFY, or about 65 percent of the average annual 5,100 AFY of inflow during the historical period. The estimated average groundwater discharge to surface water over the current water budget period was approximately 700 AFY, or about 35 percent of the average annual 2,000 AFY of groundwater discharge to surface water during the historical period. The reduction in surface water inflows reflects the drought conditions that prevailed during the current water budget period.

Current Surface Water Outflows

The estimated annual average, minimum, and maximum surface water outflow leaving the Basin as flow in San Antonio Creek west into Barka Slough and the percolation into the groundwater system over the current period is summarized in Table 3-24. Reductions in surface water outflow for the current water budget period were similar to those reported for the surface water inflows.

Table 3-24. Annual Surface Water Outflow, Current Period

Surface Water Outflow Component	Average	Minimum	Maximum
San Antonio Creek West of Barka Slough Outflow from Basin	1,800	400	7,100
Streamflow Percolation	2,100	400	7,700
Total[1]	3,900	—	—

Notes

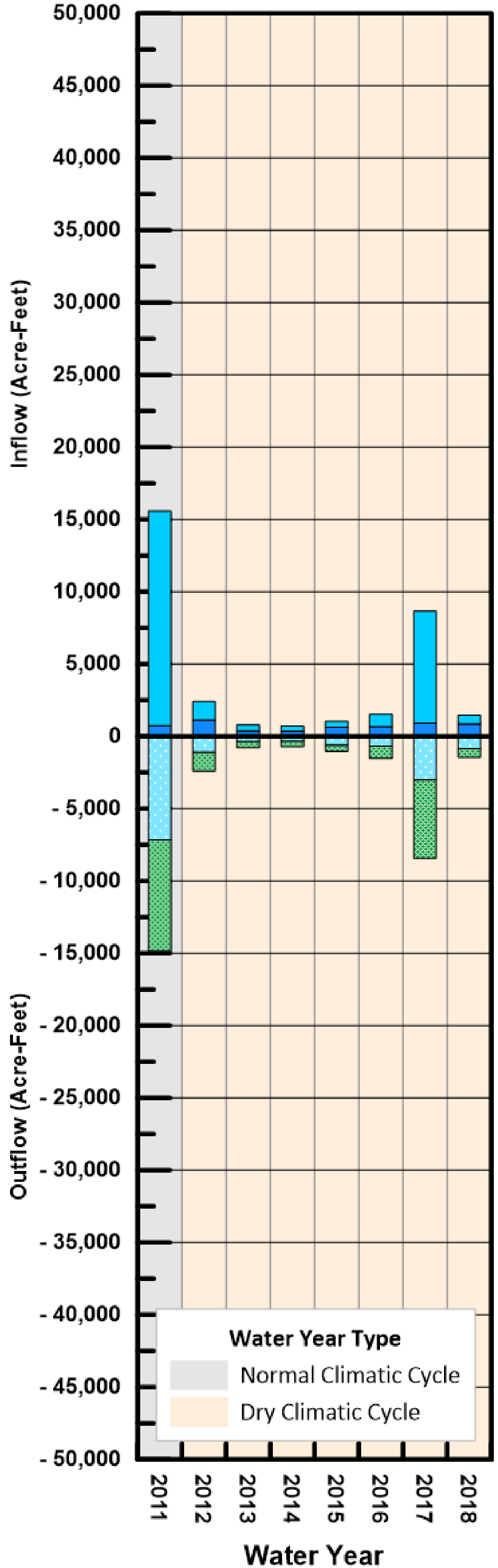
All values are in units of acre-feet.
[1] Minimum and maximum values are not totaled because the values for each component may have occurred in different years.
— = not applicable

Current Surface Water Budget

Figure 3-64 summarizes the current surface water budget for the Basin and shows the effects of the drought conditions that prevailed during the period of 2011 through 2018. During this period, precipitation was below average and average annual groundwater discharge to surface water decreased compared to the historical period, which resulted in reduced surface water flow.

Figure 3-64
Current Surface Water Budget

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin



Surface Water Inflow Components

- Surface Water Inflow
- Groundwater Discharge to Surface Water

Surface Water Outflow Components

- Surface Water Outflow
- Streamflow Percolation

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3.3.4.2 Current Groundwater Budget

Groundwater supplied all the beneficial uses in the Basin during the current water budget period. The current water budget includes a summary of the estimated groundwater inflows, groundwater outflows, and change in groundwater in storage.

Current Groundwater Inflows

Groundwater inflow components include streamflow percolation, agricultural irrigation return flow, deep percolation of direct precipitation and mountain front recharge, septic system return flow, wastewater treatment plant spray irrigation, and urban irrigation return flow. Estimated annual groundwater inflows for the current water budget period are summarized in Table 3-25.

Table 3-25. Annual Groundwater Inflow, Current Period

Groundwater Inflow Component	Average[1]	Minimum	Maximum
Mountain Front Recharge	1,300	10	7,500
Streamflow Percolation[2]	2,100	400	7,700
Deep Percolation of Direct Precipitation	5,700	200	27,300
Septic System Return Flow	20	20	20
Agricultural Irrigation Return Flow	4,400	4,400	4,400
Urban Irrigation Return Flow	1	1	1
Total[3]	13,500	—	—

Notes

All values are in units of acre-feet.
[1] Due to rounding, total does not correspond to the sum of all figures shown.
[2] Streamflow Percolation includes San Antonio Creek percolation and tributary channel percolation.
[3] Minimum and maximum values are not totaled because the values for each component may have occurred in different years.
— = not applicable

For the current water budget period, the estimated total average groundwater inflow ranged from 5,000 AFY to 46,900 AFY, with an average inflow of 13,500 AFY. Notable observations from the summary of groundwater inflows for the current water budget period include the following:

- Average total inflow during the current water budget period was about 77 percent of the historical period.
- Total annual average recharge from percolation of direct precipitation for the current water budget period was about 66 percent of the recharge from direct precipitation for the historical period.
- Total annual average streamflow percolation in the current water budget period was approximately 68 percent of the recharge from streamflow percolation for the historical period.
- Total annual average recharge from mountain front recharge for the current water budget period was about 54 percent of the recharge from mountain front recharge for the historical period.

Current Groundwater Outflows

Groundwater outflow components include total groundwater pumping from all water use sectors, groundwater discharge to surface water, and riparian ET. No areas of subsurface flow out of the Basin have been identified because there is low-permeability bedrock high located on the west end of the Basin at Barka Slough. Estimated annual groundwater outflows for the current water budget period are summarized in Table 3-26.

Table 3-26. Annual Groundwater Outflow, Current Period

Groundwater Outflow Component	Average	Minimum	Maximum
Total Groundwater Pumping	23,200	22,500	24,300
Riparian Evapotranspiration	6,600	6,400	6,700
Groundwater Discharge to Surface Water[1]	700	400	1,100
Total[2]	30,500	—	—

Notes

All values are in units of acre-feet.
[1] Volume of groundwater discharge to surface water in Barka Slough in excess of evapotranspiration.
[2] Minimum and maximum values are not totaled because the values for each component may have occurred in different years.
—= not applicable

For the current water budget period, estimated total average groundwater outflows ranged from 29,900 AFY to 31,400 AFY, with an average annual outflow of 30,500 AF; equating to a 9 percent increase in the total average groundwater outflows that were estimated for the historical period.

The largest groundwater outflow component from the Basin in the current water budget period is pumping. Estimated annual groundwater pumping by water use sector for the current water budget period is summarized in Table 3-27.

Table 3-27. Annual Groundwater Pumping by Water Use Sector, Current Period

Water Use Sector	Average[1]	Minimum	Maximum
LACSD	290	250	320
VSFB	670	0	1,800
Agricultural	22,000	22,000	22,200
Rural Domestic	160	160	170
Total[2]	23,200	—	—

Notes

All values are in units of acre-feet.
[1] Due to rounding, total does not correspond to the sum of all figures shown.
[2] Minimum and maximum values are not totaled because the values for each component may have occurred in different years.
LACSD = Los Alamos Community Services District
— = not applicable
VSFB = Vandenberg Space Force Base

For the current water budget period, estimated total average groundwater pumping ranged from 22,500 AFY to 24,300 AFY, with an average pumping of 23,200 AFY. Agricultural pumping is the largest component of total groundwater pumping, accounting for approximately 95 percent of total pumping over the current water budget period. Agricultural pumping increased by approximately 27 percent during the current water budget period compared to the historical period due to an increase in irrigated acres (see Table 3-22). VSFB, LACSD, and rural domestic pumping account for approximately 3 percent, 1 percent, and 1 percent, respectively, of total average annual pumping during the current water budget period.

Current Groundwater Budget and Change in Groundwater Storage

Average groundwater inflows and outflows for the current water budget period are presented on Figure 3-65 and a summary of annual groundwater inflows and outflows are presented on Figure 3-66. Inflow components are graphed above the zero line and outflow components are graphed below the zero line. Figure 3-66 also shows annual and cumulative change in groundwater storage during the current water budget period. Annual decreases in groundwater in storage are graphed below the zero line. The dotted blue line shows the cumulative change in groundwater storage over the current period

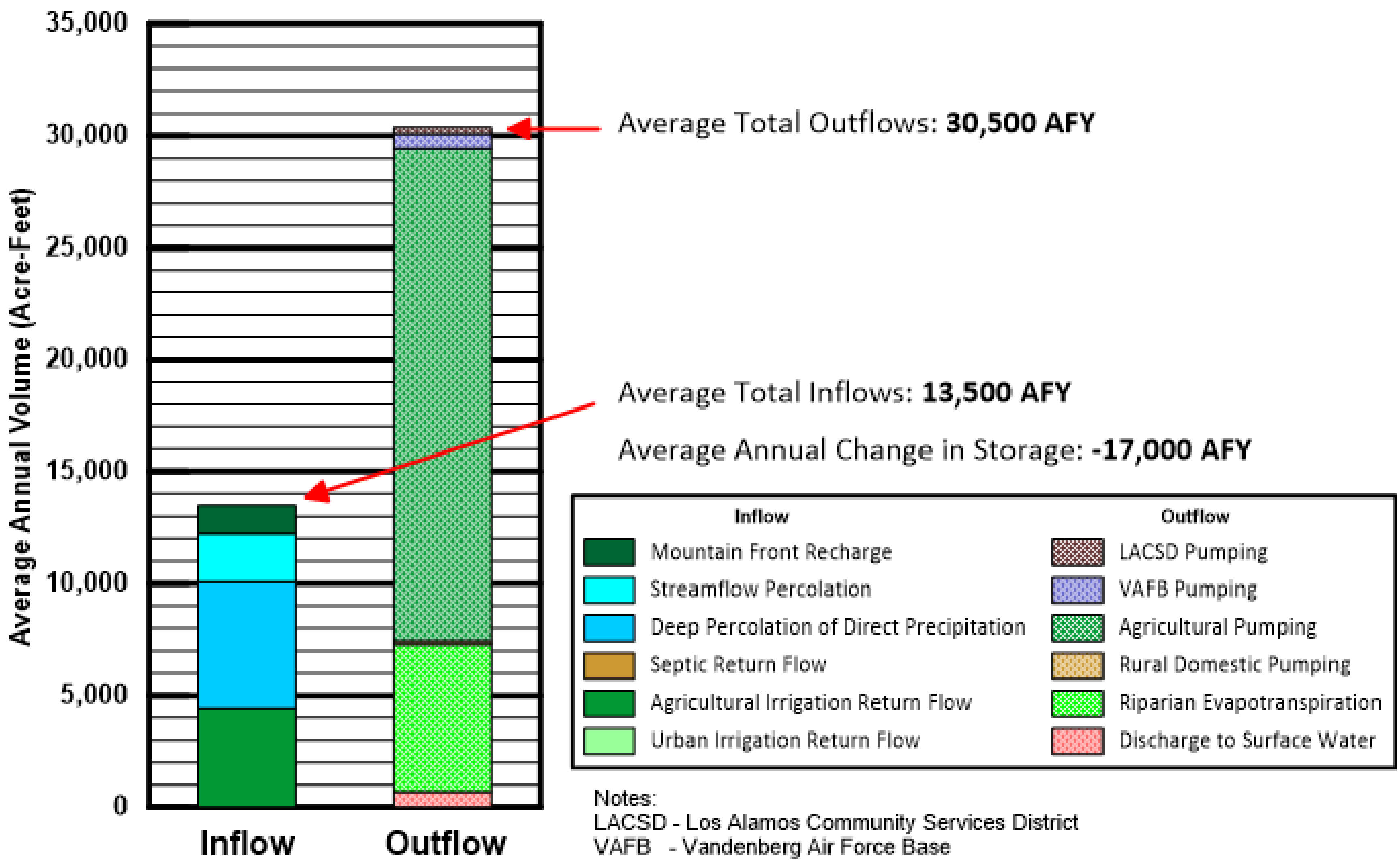
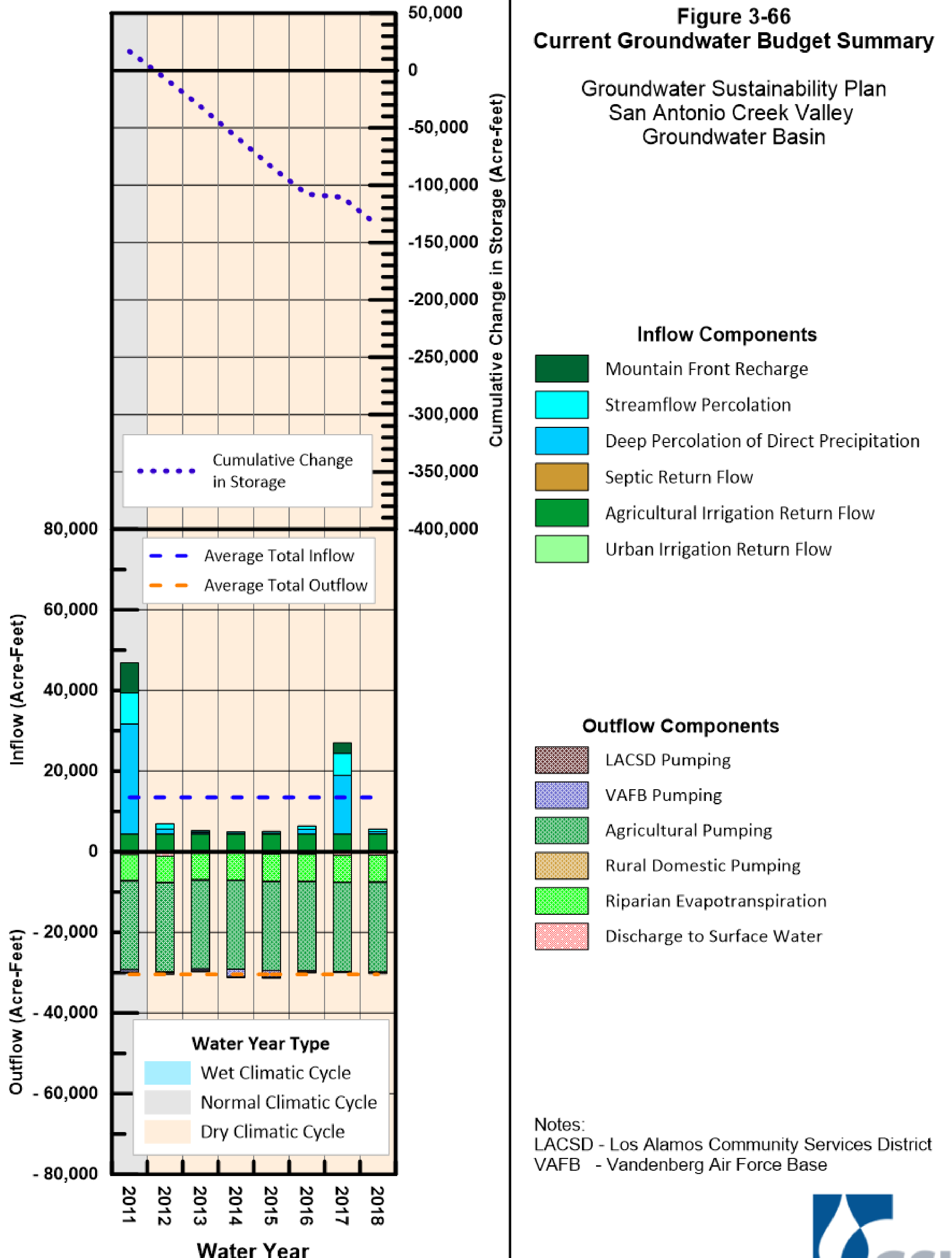


Figure 3-65. Current Groundwater Budget Average Volumes

Figure 3-66
Current Groundwater Budget Summary

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin



Notes:
LACSD - Los Alamos Community Services District
VAFB - Vandenberg Air Force Base

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The current groundwater budget is strongly influenced by the current drought, beginning in 2012, and groundwater pumping associated with agricultural irrigation. During the current water budget period, the amounts of streamflow percolation, mountain front recharge, and percolation of direct precipitation were approximately 68 percent, 54 percent, and 66 percent, respectively, compared to what occurred during the historical period. The average amount of total pumping was 19 percent higher during the current water budget period than during the historical period. Over the 8-year current water budget period, an estimated net loss of groundwater in storage of about 135,500 AF occurred (see Figure 3-66). The annual average groundwater in storage loss, or the difference between outflow and inflow to the Basin, was approximately 17,000 AFY.

Current Water Balance

The short-term depletion of groundwater in storage indicates that total groundwater outflows exceeded the total inflows over the current water budget period. As summarized in Figure 3-65, total groundwater pumping averaged approximately 23,200 AFY during the current water budget period. A quantification of the basin yield for the Basin during the current water budget period is estimated by subtracting the average groundwater storage deficit (17,000 AFY) from the total average amount of groundwater pumping (23,200 AFY) to yield about 6,200 AFY. Based on the Basin's sustainable management criteria described in Section 4, the basin yield is equal to the sustainable yield for the Basin calculated for the historical period. Due to the drought conditions, the current water budget period is not appropriate for long-term sustainability planning.

3.3.5 Projected Water Budget [§ 354.18(c)(3)(A)(B)(C)]

§ 354.18 Water Budget.

(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:

(A) Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.

(B) Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.

(C) Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.

3.3.5.1 Projected Water Budget Calculation Methods [§ 354.18(d)(1),(d)(2),(d)(3),(e), and (f)]

The surface water and groundwater inflow and outflow components of the projected water budget in the Basin were estimated using estimated future land uses and related pumping volumes and repeating factors associated with the observed historical climatic conditions forward in time through 2042 and 2072. The effects of climate change were also evaluated using DWR-provided climate change factors. The USGS BCM, as discussed in Section 3.3.2.1, was adjusted to the DWR Variable Infiltration Capacity (VIC) hydrology model (see Section 3.3.5.1) for 2030 and 2070 climate data to estimate surface and groundwater flow components for the projected water budget. Table 3-14 lists the methodologies used to project volumes for each water budget component. This section briefly describes the estimated components of the projected water budget that include the effects of changing land use and water demand and effects caused by climate change.

Projected Climate

The 2030 and 2070 precipitation, ET, and streamflow climate change factors are available on 6-kilometer resolution grids from DWR. The climate data sets were processed by a soil moisture accounting model known as the VIC hydrology model developed by Hamman et al. (2018) and Liang et al. (1994) and routed to the outlet of basins or subbasins contributing water to the Basin. The resulting downscaled hydrologic time series are available on the SGMA Data Viewer hosted by DWR.[34] Climate grid cells for precipitation and ET data are defined by the DWR Bulletin 118 groundwater basin boundaries (DWR, 2018a) and streamflow climate grid cells are defined by the 8-digit Hydrologic Unit Codes (HUCs). Precipitation and ET data used in this analysis were downloaded from the SGMA Data Viewer for climate grid cells within San Antonio Creek Valley Groundwater Basin (3-014). Streamflow data used in this analysis were downloaded from the SGMA Data Viewer for climate grid cells within HUC 8-18060009. Monthly time series change factors were then developed for the Basin. Mean monthly and annual values were computed from the basin time series to show projected patterns of change under 2030 and 2070 conditions.

Projected Groundwater and Surface Water Inflow and Non-Pumping Outflow Components

Projected groundwater and surface water inflow components, including mountain front recharge, streamflow percolation, percolation of direct precipitation, and groundwater discharge to surface water, were calculated with methodologies and historical data sets consistent with those used to develop the historical and current water budgets (see Section 3.3.2.1). Additionally, projected changes in climatic factors, including ET and precipitation (see Section 3.3.5.1), were used to adjust the USGS BCM, as outlined in Table 3-14.

Projected Agricultural, Municipal, and Industrial Pumping

Calculation methodologies for projected agricultural pumping and municipal and industrial (M&I) pumping are discussed in Section 3.3.5.3.

[34] Available at https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels. (Accessed February 4, 2021.)

Projected Hydrology [§ 354.18(c)(3)(A)]

§ 354.18 Water Budget.

(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:

(A) Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.

DWR's Water Budget and Modeling BMPs (DWR, 2016d, 2016e, and 2020c) describe the use of climate change data to estimate projected hydrology. DWR has also provided SGMA Climate Change Data[35] and published a *Guidance for Climate Change Data Use for Groundwater Sustainability Plan Development* (DWR, 2018b), which is the primary source of technical guidance used in this analysis.

The DWR-provided climate change data are based on the California Water Commission's Water Storage Investment Program (WSIP) climate change analysis results, which used the global climate models and radiative forcing scenarios recommended for hydrologic studies in California by the Climate Change Technical Advisory Group. Climate data from the recommended General Circulation Model models and scenarios have also been downscaled and aggregated to generate an ensemble time series of change factors that describe the projected change in precipitation, ET, and streamflow values for climate conditions that are expected to prevail at mid-century and late century, centered around 2030 and 2070, respectively. The DWR data set also includes two additional simulation results for extreme climate scenarios under 2070 conditions. Use of the extreme scenarios, which represent Drier/Extreme Warming (2070DEW) and Wetter/Moderate Warming (2070WMW) conditions in GSPs, is optional.

This section describes the retrieval, processing, and analysis of DWR-provided climate change data to project the impact of climate change on precipitation, ET, and streamflow under 2030 and 2070 conditions. The precipitation and ET change projections are computed relative to a baseline period of 1981 to 2011 (due to the availability of the data for DWR-provided climate change factors and the USGS BCM data set). The baseline period was selected based on the historical period (which includes water years from 1981 to 2018), the availability of concurrent climate projections from the DWR VIC hydrology model (calendar years 1915 to 2011) and derived hydrologic simulations from the USGS BCM (water years 1981 to 2018). The projected 50-year based period included the following sequence of historical water years: 1981–2011, 1984–1992, and 1998–2001 (see Figure 3-67).

[35] Available at https://data.cnra.ca.gov/dataset/sgma-climate-change-resources. (Accessed February 4, 2021.)

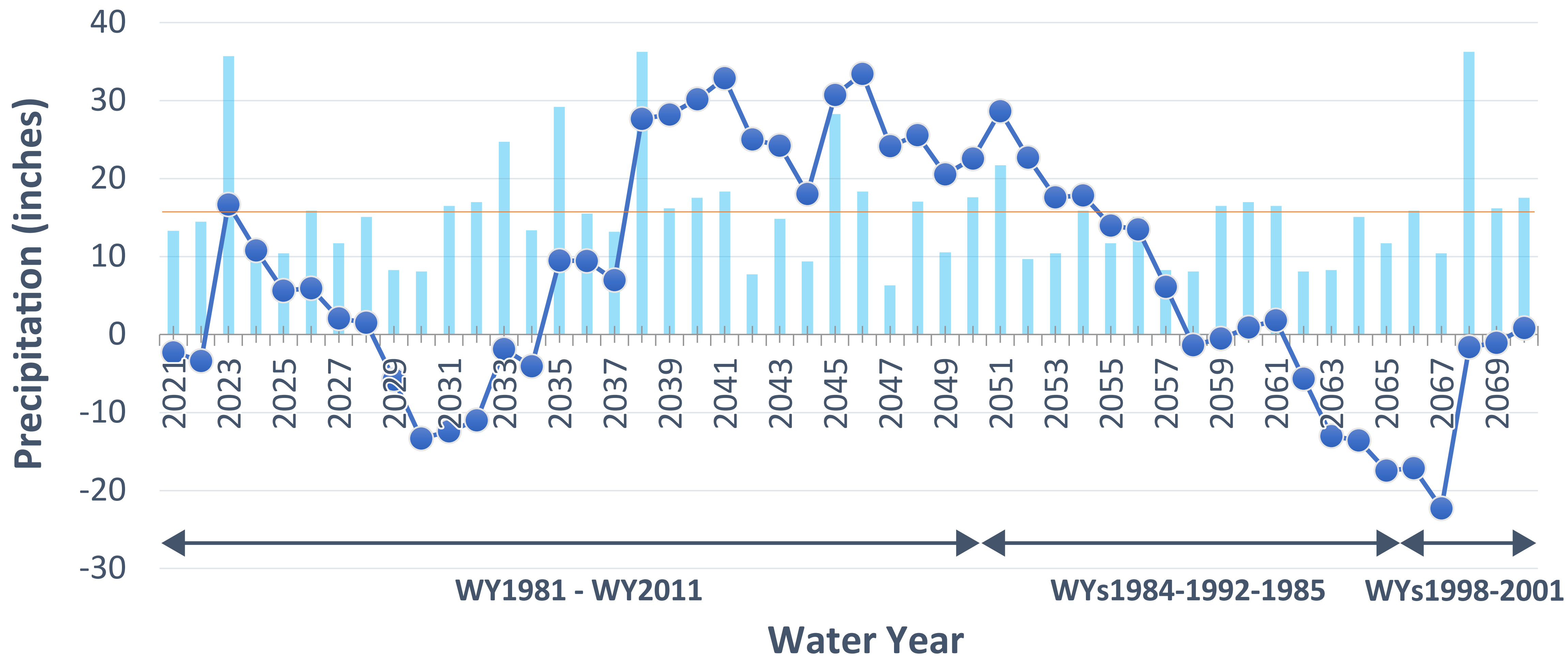

FIGURE 3-67

Projected Future Precipitation at the Los Alamos Fire Station Projected Water Budget 50-Year Future Baseline

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Precipitation (inches)

Cumulative Departure from Mean Precipitation

Date: September 16, 2021
Data Sources: County of Santa Barbara (n.d.)

GSI Water Solutions, Inc.

Y:\0748_San_Antonio_GSP\Source_Figures\001_SanAntonio_Basin_GSA\GW_Sustainability_Plan\Water_Budget

Projected Changes in Evapotranspiration. In a warmer climate such as that of the Basin, crops require more water to sustain growth, and this increased water requirement is characterized in climate models using the rate of ET. Under 2030 conditions, the Basin is projected to experience average annual ET increases of approximately 3.6 percent relative to the baseline period. The largest monthly changes would occur in late fall, with projected average increases of approximately 4.9 percent and 5.6 percent in October and November, respectively. Under 2070 conditions, annual ET is projected to increase by approximately 8 percent relative to the baseline period. The largest monthly changes would occur in late fall to early winter, with projected average increases of 11.5 percent and 11 percent in November and December, respectively. Summer increases peak at approximately 8 percent in May.

Projected Changes in Precipitation. The seasonal timing and amount of precipitation in the Basin is projected to change. Decreases are projected in the summer, mid-fall, and late winter. Increases are projected in mid-winter, early spring, and late summer to early fall. Under 2030 conditions, the largest monthly changes would occur in October with projected decreases of 12 percent, while increases of approximately 8 percent would occur in January and August and 12 percent in May. Under 2070 conditions, decreases of up to 23 percent are projected in May and the largest increases are projected to occur in January (17 percent) and September (22 percent). The Basin is projected to experience minimal changes in total annual precipitation. Annual precipitation increases by approximately 1 percent projected under 2030 conditions relative to the baseline period. Under 2070 conditions, small decreases in annual precipitation, of approximately 2 percent, are projected. The DWR-provided climate change data do not include descriptions regarding precipitation intensity.

Projected Changes in Streamflow. The DWR-provided time series of climate change factors for streamflow was compiled as annual factors. Consequently, changes in projected streamflow cannot be determined on a seasonal basis without additional analysis. The Basin is projected to experience average annual increases in streamflow of approximately 2 percent and 6 percent under 2030 and 2070 conditions, respectively,

3.3.5.2 Projected Surface Water Budget

The projected surface water budget inflow includes surface water flows that enter the Basin from precipitation runoff within the watershed and groundwater in the Basin discharging to surface water in the Basin. Table 3-28 summarizes the annual averages for the historical and projected water budgets.

Table 3-28. Annual Surface Water Inflows, Historical and Projected Periods

Surface Water Inflow Component	Annual Average		
	Historical Period	2042[1]	2072[1]
Inflow to Basin including San Antonio Creek and Tributaries	5,100	5,100	5,000
Groundwater Discharge to Surface Water	2,000	2,100	2,100
Total	7,100	7,200	7,100

Notes

All values are in units of acre-feet.

[1] 2042 and 2072 volumes are annual averages calculated using the 50-year base period described in Section 3.3.5.1.

Surface water inflows are projected to increase in the 2042 projected water budget by approximately 1 percent compared to the historical period. Future surface water inflow for the 2072 projected period is equal to the historical period average. The DWR climatic factors discussed in Section 3.3.5.1 are forecasted for 2030 and 2070. To generate a 50-year period to develop projected water budgets for 2042 and 2072, the two data sets were combined for calculating water years 2031 through 2042. Consequently, the forecasted increase of precipitation as part of the 2030 DWR climatic factors (and decrease as part of the 2070 climatic factors) are moderated, due to the combining of the data sets for water years 2031 through 2042.

Projected surface water budget outflows include surface water leaving the Basin as flow in San Antonio Creek west of Barka Slough and streamflow percolation into the groundwater system. These annual average surface water outflows are summarized in Table 3-29.

Future streamflow percolation is projected to increase by 35 percent for the 2042 and 2072 projected future water budget periods. The increase in streamflow percolation could be a result of declining groundwater water levels (discussed further in Section 3.3.5.3), resulting in an increased recharge capacity. The projected increase in surface water outflow is a result of projected increases in streamflow-based DWR climate factors.

Table 3-29. Annual Surface Water Outflows, Historical and Projected Periods

Surface Water Outflow Component	Annual Average		
	Historical Period	2042[1]	2072[1]
San Antonio Creek West of Barka Slough, Outflow from Basin	4,200	4,400	4,600
Streamflow Percolation	3,100	4,200	4,200
Total	7,300	8,600	8,800

Notes

All values are in units of acre-feet.

[1] 2042 and 2072 volumes are annual averages calculated using the 50-year base period described in Section 3.3.5.1.

3.3.5.3 Projected Groundwater Budget

Groundwater inflow components for the projected water budget include mountain front recharge, streamflow percolation, deep percolation of direct precipitation, septic system return flow, agricultural irrigation return flow, and urban irrigation return flow. Estimated annual groundwater inflows for the historical and projected periods are summarized in Table 3-30. Values reported in the table were estimated or derived from the data sources reported in Table 3-14.

Table 3-30. Annual Groundwater Inflows, Historical and Projected Periods

Groundwater Inflow Component	Annual Average		
	Historical Period[1]	2042[1]	2072[2]
Mountain Front Recharge	2,400	2,300	2,200
Streamflow Percolation[3]	3,100	4,200	4,200
Deep Percolation of Direct Precipitation	8,600	8,200	8,000
Septic System Return Flow	20	20	20
Agricultural Irrigation Return Flow	3,500	5,000	5,100
Urban Irrigation Return Flow	1	1	1
Total	17,500	19,700	19,500

Notes
All values are in units of acre-feet.
[1] Due to rounding, total does not correspond to the sum of all figures shown.
[2] 2042 and 2072 volumes are annual averages calculated using the 50-year base period described in Section 3.3.5.1.
[3] Streamflow percolation includes San Antonio Creek and tributary channel percolation.

The total average annual groundwater inflow is 2,200 AF greater than the historical period average during the 2042 projected period, and 2,000 AF greater during the 2072 projected period. As discussed in Section 3.1, the Basin is a closed basin; therefore, the only source of recharge from outside of the Basin boundaries is precipitation. Groundwater inflow components directly correlated to precipitation, such as mountain front recharge and deep percolation of direct precipitation, indicate a slight decrease in the projected water budget. Groundwater inflow components indicating a notable increase include agricultural return flow and streamflow percolation. The increase in agricultural return flow is due to the projected increased water demand for agricultural irrigation.

Table 3-31 summarizes the historical and projected annual average groundwater outflows.

Table 3-31. Annual Groundwater Outflows, Historical and Projected Periods

Groundwater Outflow Component	Annual Average		
	Historical Period	2042[1]	2072[1]
Total Groundwater Pumping	19,500	26,000	26,600
Riparian Evapotranspiration	6,500	6,900	7,000
Groundwater Discharge to Surface Water	2,000	2,100	2,100
Total	28,000	35,000	35,700

Notes
All values are in units of acre-feet.
[1] 2042 and 2072 volumes are annual averages calculated using the 50-year base period described in Section 3.3.5.1.

The total average annual groundwater outflow is estimated to be 7,000 AF greater during the 2042 projected period than the historical period average, and 7,700 AF greater during the 2072 projected period. Projected groundwater pumping is estimated to increase by 6,500 AF and 7,100 AF for the 2042 and 2072 projected periods, respectively. Riparian ET is also estimated to increase by 400 AF and 500 AF for the 2042 and 2072 projected periods, respectively. The projected increase in groundwater demand from pumping and riparian ET results in a decrease of groundwater discharging to surface water at Barka Slough.

Projected Water Demand [§ 354.18(c)(3)(B)]

§ 354.18 Water Budget.

(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:

(B) Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.

Total water demand within the Basin was estimated for the 2042 and 2072 projected water budget periods based on the historical and current water budgets. To estimate total demand for projected periods, two components of demand were considered: agriculture pumping and M&I pumping. This section describes the methods used to estimate these components through 2042 and 2072, and the respective results.

Between water years 1981 and 2018, irrigated agriculture demand ranged between 10,300 AFY and 22,200 AFY. Available crop survey data indicate that this demand is from a variety of crops, of which the acreages vary from year to year. The crop types are grouped into five categories: deciduous fruits and nuts (trees); field crops; pasture; vineyards; and truck and berry crops. Crop ET was derived for each of these crops for each year during the historical period of 1981 to 2018, based on trends in water use for each crop.

Crop acreages for each of the five categories were extrapolated with linear extrapolation techniques, based on crop distribution trends to determine projected water demand. The slope generated by the extrapolated planted acreage indicates an inflection point and decreased gradient beginning in 2006. The rate of growth of planted acreage in the Basin has slowed in the last two decades to approximately 0.2 percent annually. According to the United States Department of Agriculture (USDA) online Web Soil Survey tool,[36] there are approximately 13,436 acres of prime farmland within the Basin. The USDA tool considers factors such as soil type, slope, and drainage. Based on 2020 County of Santa Barbara spatial pesticide use permit data, there were approximately 13,459 planted acres in the Basin. Consequently, the 2020 planted acreage according to the County of Santa Barbara was used as the cap for irrigated acres in the Basin for the purposes of the projected water budget. Additionally, the percentages of planted crop types according to the

[36] Available at https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. (Accessed February 4, 2021.)

2020 pesticide use permit data remained constant during the projected water budget. Using the planted acreage, crop types, and crop water duty factors, a water demand of 1.75 AF/acre was calculated for 2020. The future agricultural water demand for the 2042 and 2072 projected water budget periods was calculated using the 50-year base period described in Section 3.3.5.1, DWR future climate factors for ET, and the calculated 2020 agricultural water demand. Future agricultural water demand was calculated at 24,900 AF (1.85 AF/acre) and 25,500 AF (1.9 AF/acre) for 2042 and 2072, respectively.

Future M&I demands were estimated for the VSFB, LACSD, and rural domestic users. To estimate future M&I demands, GSI reviewed the following:

- Historical demand records from VSFB and LACSD
- Estimated rural domestic pumping for the historical period
- Santa Barbara County Association of Governments Regional (population) Growth Forecasts (SBCAG, 2007)
- California Department of Finance Population and Housing Estimates (California Department of Finance, 2020)

These sources were used to project demand through time relative to estimated population increases and water demand trends. The estimated future agricultural and M&I water demand within the Basin during historical water budget period (1981–2018) and projected values for 2042 and 2072 are presented on Table 3-32.

Table 3-32. Projected Water Demand Summary

Average Demand		Historical Period	2042	2072
Agricultural Demand				
Irrigation Demand		17,300	24,900	25,500
Municipal and Industrial Demand				
VSFB[1]		1,800	510	510
LACSD[2]		270	340	340
Rural Domestic[2]		140	220	220
Total M&I		2,210	1,070	1,070
	Total	19,510	25,970	26,570
	Change	—	6,460	7,060

Notes

All values are in units of acre-feet per year.

[1] VSFB projected pumping assumes continued delivery of SWP water and no development of the proposed Vandenberg Dunes Golf Courses Project.

[2] LACSD and Rural Domestic projected pumping is based on a calculated 3-percent annual population increase from 2020 through 2072.

— = not applicable

DWR = California Department of Water Resources

LACSD = Los Alamos Community Services District

M&I = municipal and industrial

SWP = California State Water Project

VSFB = Vandenberg Space Force Base

Estimated M&I demands in the Basin were 2,210 AFY during the historical period, which was met with groundwater pumping. Imported SWP water became available to the VSFB in 1997 (during the historical water budget period [1981–2018]) through a water supply agreement with the Central Coast Water Authority (CCWA), which caused groundwater pumping in the Basin to decrease compared to previous years. The M&I demand calculated for the projected water budget assumes VSFB will continue to receive SWP deliveries and the proposed Vandenberg Dunes Golf Course Project will not be developed.

The delivery of imported SWP water to VSFB reduces VSFB's groundwater demand from the Basin; therefore M&I demand is projected to decrease in comparison to M&I demand during the historical period. By 2042, at the end of the GSP implementation period, total demand in the Basin may increase by 33 percent relative to the historical period, and further by a total of 36 percent by 2072 in response to an increase in agricultural demand to meet future climatic factors from DWR for ET. The increase in demand is assumed to be a linear projection from current conditions as presented graphically on Figure 3-68.

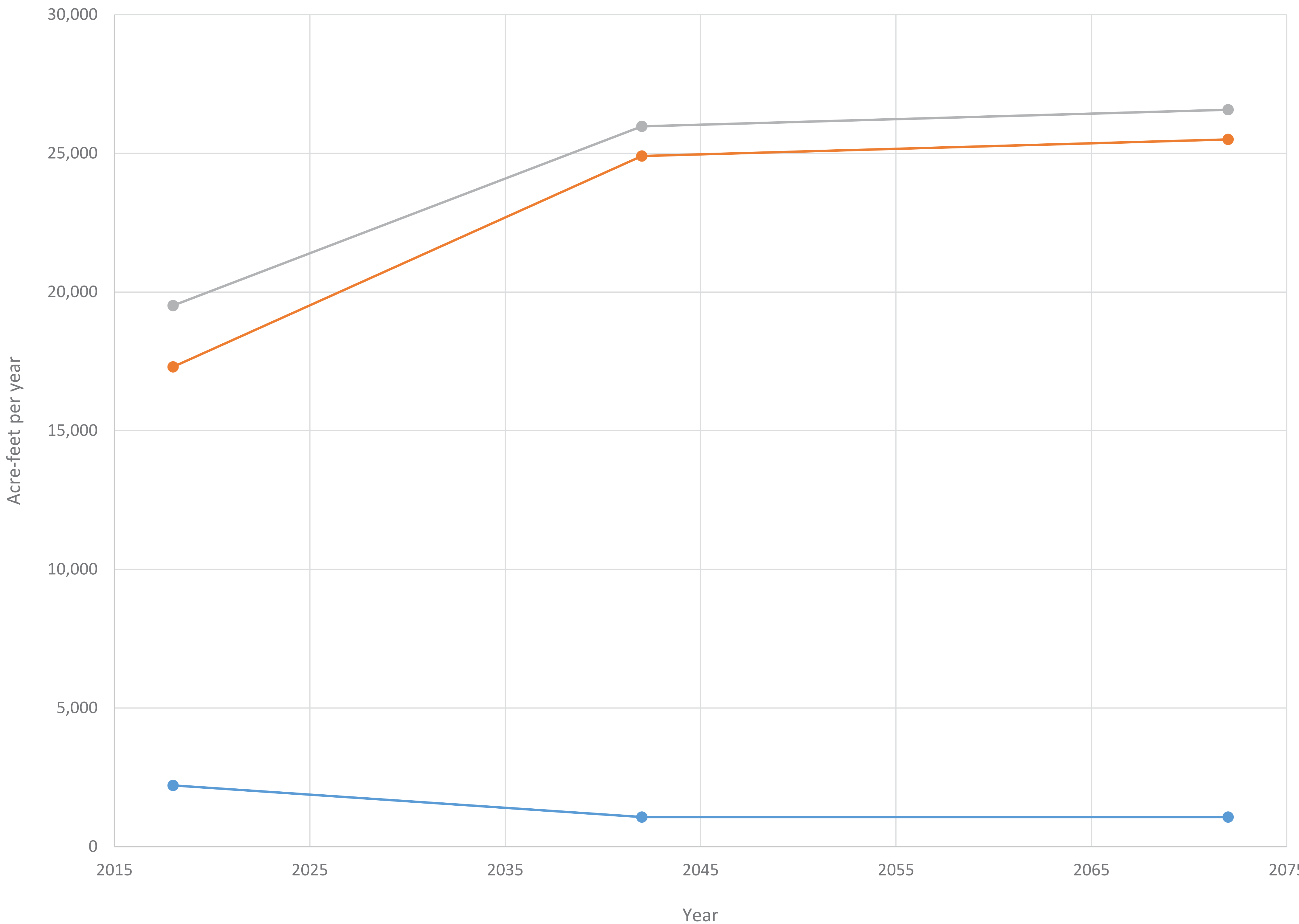

FIGURE 3-68

Projected Demand – Historical Period, 2042, and 2072

Groundwater Sustainability Plan
San Antonio Creek Valley
Groundwater Basin

LEGEND

Total Demand

Agricultural Demand

M&I Demand

NOTE

M&I: Municipal and Industrial

Date: September 16, 2021

GSI Water Solutions, Inc.

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Approximately 921 AFY is the estimated water consumption for the Vandenberg Dunes Golf Courses Project (AECOM, 2019). Including this additional volume in the 2042 and 2072 projected water budgets equates to an additional 970 AFY and 1,000 AFY, respectively, of groundwater outflow from the Basin after applying the forecasted DWR climate factors for ET. The location of the proposed Vandenberg Dunes Golf Courses Project is west of the Basin and therefore the Basin would not receive any irrigation return flow or septic return flow from golf course operations. It should be noted that, in 1997, CCWA approved a portion of the SWP water the VSFB had requested. VSFB is currently working to secure the outstanding portion of the originally requested allotment as well as exploring options outside of the Basin such as desalination. Due to the annual fluctuations in percentage of SWP water allocations available, the formerly estimated additional groundwater outflow volumes of 970 AFY and 1,000 AFY did not include SWP water.

Projected Water Budget and Change in Groundwater Storage

Average groundwater inflows and outflows for the 2042 and 2072 projected periods are presented on Figure 3-69 and Figure 3-70, respectively. A summary of annual groundwater inflows and outflows are tabulated in Table 3-21 and Appendix E.

As discussed in Section 3.3.5.2, and consistent with the historical period, the projected water budget is dominated by groundwater pumping for agricultural irrigation. Consequently, on the inflow side of the water budget, there is an increase in agricultural irrigation return flow due to the increase in the volume of groundwater used for irrigation. The other inflow component, streamflow percolation, shows a notable increase even though a decrease in mountain front recharge and deep percolation of direct precipitation is projected from the BCM and VIC models. The increase in streamflow percolation likely results from a lowering of groundwater levels that creates an increased capacity for recharge in the aquifers.

Riparian ET is the second largest outflow component. This is consistent with the historical period and increases when applying future climatic factors from DWR for ET. Average annual precipitation for the projected period (using the 50-year base period described in Section 3.3.5.1 and DWR future climate factors) was calculated to be 3 percent greater than the historical period average annual precipitation for the 2042 projected period and equal to the historical period average for the 2072 projected period. As stated previously, the distribution of the precipitation throughout the year is projected to change.

The average annual groundwater inflow for the Basin is projected to increase by approximately 13 percent and 11 percent during the 2042 and 2072 projected periods, respectively, compared to the historical period. The average annual groundwater outflow is projected to increase by approximately 25 percent and 27 percent during the 2042 and 2072 projected periods, respectively, compared to the historical period. The average annual change in storage for the Basin is projected to decrease by approximately 44 percent and 53 percent during the 2042 and 2072 project periods, respectively, compared to the historical period.

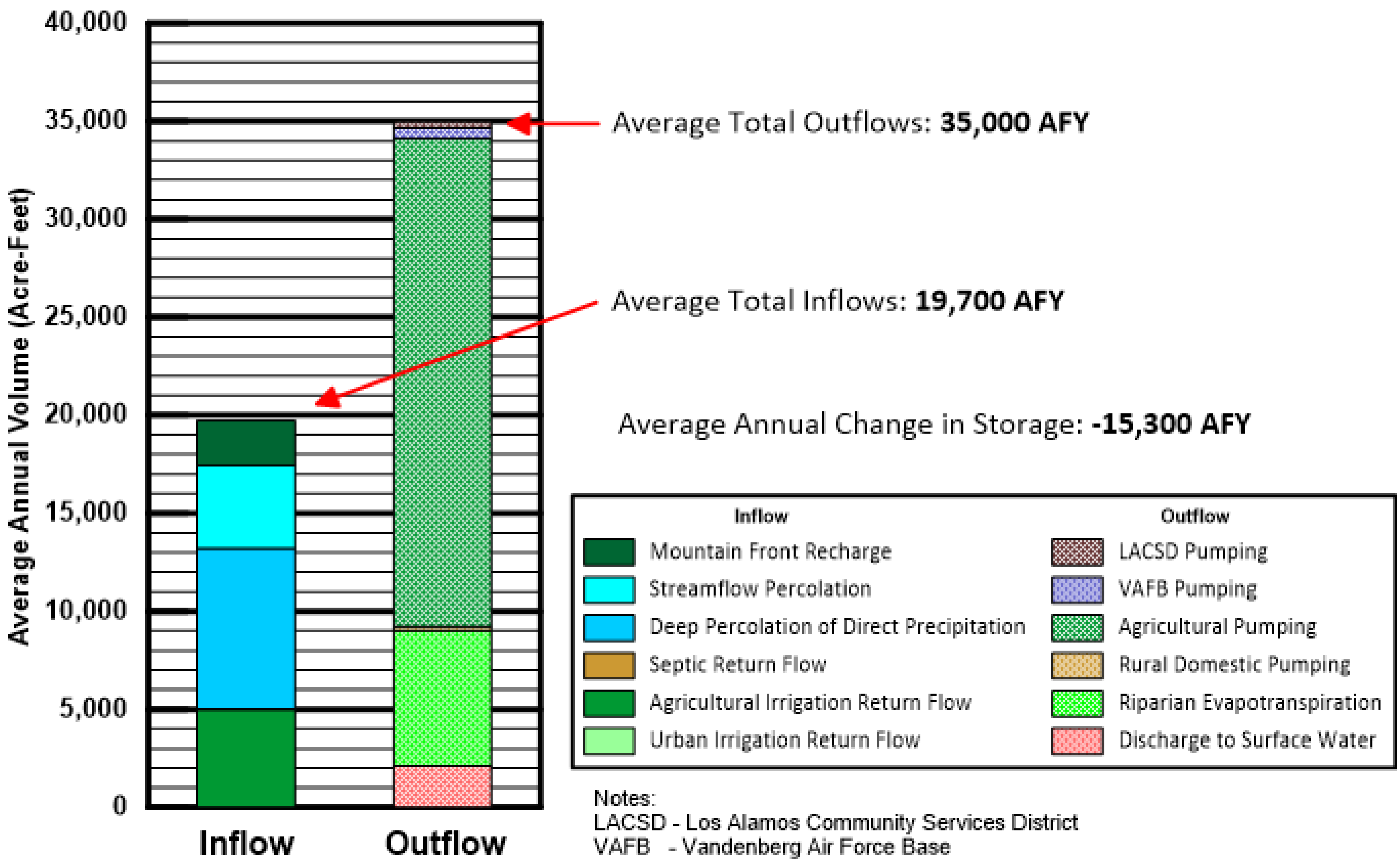


Figure 3-69. 2042 Projected Water Budget Average Volumes

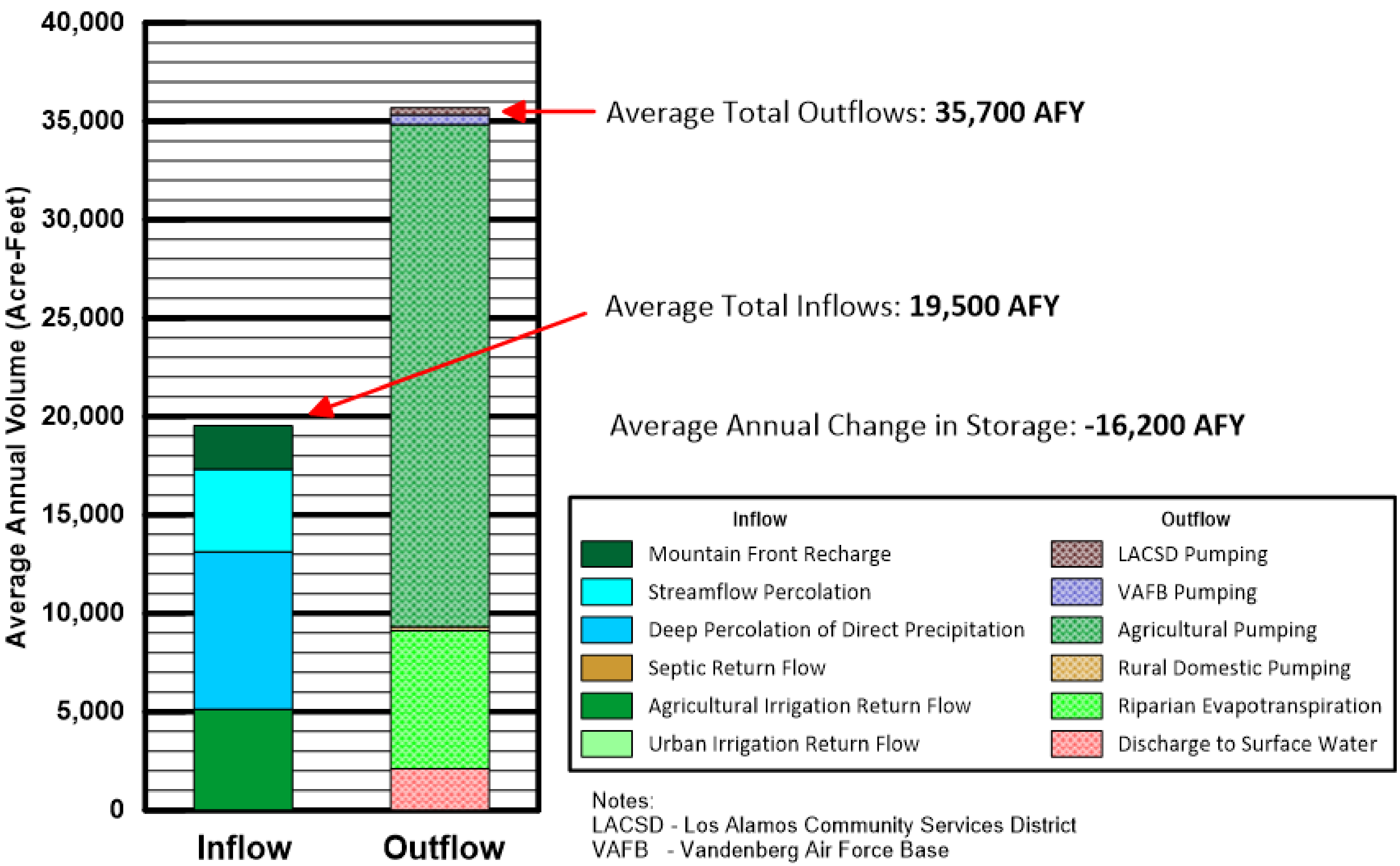
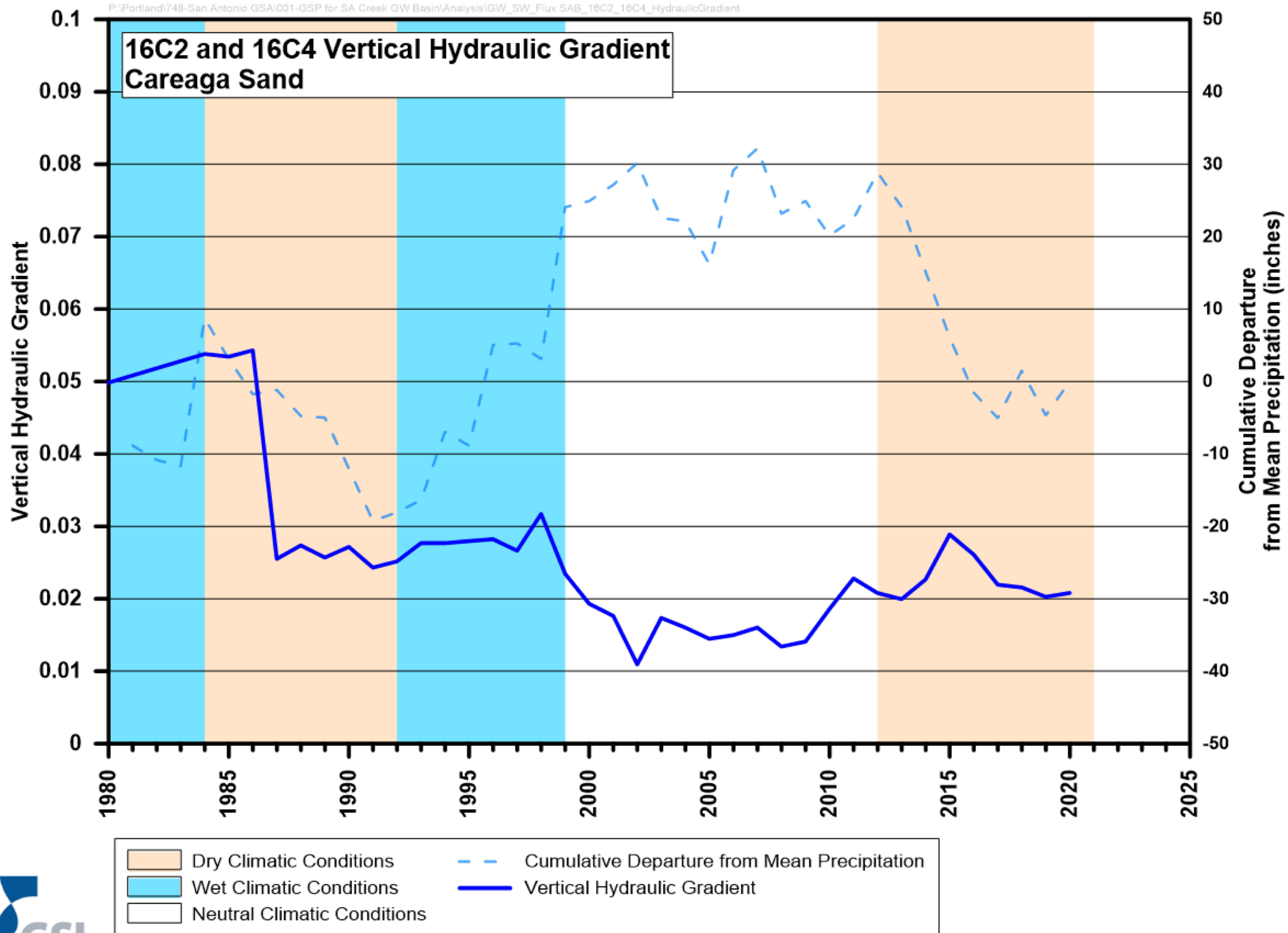


Figure 3-70. 2072 Projected Water Budget Average Volumes

Projected Water Levels in Barka Slough

As discussed in Section 3.2.1.3, the formation and continued existence of Barka Slough is largely due to surface water inflow and the upward flow (vertical hydraulic gradient) of groundwater from the underlying Careaga Sand through the Barka Slough sediments and becoming surface water or available to phreatophytes. Groundwater levels in wells near Barka Slough have decreased significantly over the period of record (40 ft in well 16C2 and 45 ft in well 16C4 from 1970 through 2019). This results in a decrease in the magnitude of the upward vertical groundwater gradient into the Slough, which equates to less upward flow of groundwater into the Slough. Figure 3-71 shows the reduction in vertical hydraulic gradient from nested groundwater wells 16C2 and 16C4 from 1970 through 2019. The cumulative departure from mean annual precipitation for the period from 1960 through 2019 is also shown on the figure.



GSI Water Solutions, Inc.

Figure 3-71. Vertical Hydraulic Gradient for Nested Groundwater Wells 16C2 and 16C4

The historical high vertical groundwater gradient of 0.07 was measured in 1982. The current vertical groundwater gradient is approximately 0.02. The vertical gradient has remained relatively stable after a sharp decline in the middle 1980s. Due to the depth of the wells and the location within the Basin, the vertical gradient response to periods of above-average rainfall is delayed. Without the use of a groundwater model and based on the available information, it is difficult to determine at what groundwater elevation the vertical hydraulic gradient in Barka Slough could reverse, causing groundwater to no longer discharge into Barka Slough. As discussed in Section 3.3.5.3, in response to climate change effects, the projected water budget indicates an annual average 5 percent increase in groundwater discharge to surface water at Barka Slough for the 2042 and 2072 projected water budgets and an 8 percent and 18 percent average annual increase in surface water discharge to Barka Slough for the 2042 and 2072 projected water budgets, respectively.

Basin Yield Estimate [§ 354.18(b)(7)]

§ 354.18 Water Budget.

(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:

(7) An estimate of sustainable yield for the basin.

The projected groundwater budget indicates that total outflows relative to total inflows in the Basin increase over time and contribute to a chronic decrease of groundwater in storage. The projected average annual amount of groundwater in storage is estimated to decrease by approximately 44 percent and 53 percent during the 2042 and 2072 projected periods, respectively, compared to the historical period (as discussed in Section 3.3.5.3). A calculated annual volume for the projected basin yield of the Basin was estimated by adding the average groundwater storage deficit to the projected average annual volume of groundwater pumping for the 2042 and 2072 projected periods. The projected basin yield for the 2042 projected period is estimated to be 10,700 AFY, and 10,400 AFY for the 2072 projected period.

The estimated projected basin yield of 10,700 AFY and 10,400 AFY for the 2042 and 2072 projected periods, respectively, is 1,800 AFY and 1,500 AFY greater than the estimated basin yield for the historical period. This comparison of basin yield values between the historical and projected periods indicates that projected future climate change is expected to have an impact on the basin yield.

The primary reason that the average basin yield increases during the projected periods compared to the historical period—even coupled with the assumed climate change modifiers and increased projected groundwater pumping—is the increase in agricultural irrigation return flow and streamflow percolation.

3.3.6 Spreadsheet Tool Assumptions and Uncertainty

The GSP spreadsheet tool is based on available hydrogeologic and land use data from the past several decades, former studies of Basin hydrogeologic conditions, and the adjusted USGS BCM for the Basin. The GSP spreadsheet gives insight into how the complex hydrologic processes are operating in the Basin. Limited data sets and methodologies used by USGS for its Groundwater Study, and made available to the SABGSA, were incorporated into the spreadsheet tool to the extent practical. The spreadsheet tool is unable to model various scenarios of surface and groundwater processes and other time-variant processes that are occurring in the Basin.

Estimates of changes in groundwater in storage and sustainable yield made with the spreadsheet tool have uncertainty due to limitations in available data and assumptions made to develop the tool including, but not limited to, accuracy of publicly available spatial data, water use factors based on parcel size, thicknesses of geologic units to calculate hydraulic properties, irrigation return flow factors, and crop water duty factors. Uncertainty inherent in the spreadsheet tool has been considered in the development of management actions and projects discussed in Section 6. The results of the water budget analysis using the spreadsheet tool are sufficient to establish the magnitude of the annual and cumulative change in groundwater in storage. As a check on the validity of the change in groundwater in storage calculations using the water budget tool, GSI computed the change in storage by comparing water level elevation contour maps prepared for the years 2015 and 2018. The difference between the volume of groundwater represented by these two groundwater level surfaces multiplied by a basin storage coefficient (0.15 for the Paso Robles Formation and 0.001 for the confined portion [Barka Slough area] of the Careaga Sand) (Martin, 1985) results in a volume of groundwater removed from storage for the years between 2015 and 2018 equal to a deficit of approximately 83,800 AF. This results in approximately a 7 percent difference with the estimated change in storage using the spreadsheet water budget tool.

New data will be collected and/or refined throughout the early implementation of this GSP (after adoption by the SABGSA). The information will be used to recalculate volumes generated from the spreadsheet tool or as inputs into the model currently being calibrated for the Basin by USGS. New hydrologic data and an updated spreadsheet tool or calibrated model will be used in the future to evaluate the effectiveness of proposed or new management actions, and to monitor that progress toward the sustainability goal is being achieved.

3.4 References and Technical Studies [§ 354.4(b)]

§ 354.4 General Information.

(b) Each Plan shall include the following general information: A list of references and technical studies relied upon by the Agency in developing the Plan. Each Agency shall provide to the Department electronic copies of reports and other documents and materials cited as references that are not generally available to the public.

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SECTION 4: **Sustainable Management Criteria [Article 5, Subarticle 3]**

§ 354.22 Introduction to Sustainable Management Criteria. This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.

This section defines the conditions that constitute sustainable groundwater management and discusses the process by which the San Antonio Basin Groundwater Sustainability Agency (SABGSA) will characterize undesirable results and establish minimum thresholds and measurable objectives for each sustainability indicator in the San Antonio Creek Valley Groundwater Basin (Basin).

Section 4 presents the data and methods used to develop sustainable management criteria (SMCs) and demonstrate how these criteria influence beneficial uses and users. The SMCs presented in this section are based on currently available data and application of the best available science. As noted in this Groundwater Sustainability Plan (GSP), data gaps exist in the hydrogeologic conceptual model. Uncertainty caused by these data gaps was considered when developing the SMCs. These SMCs are considered initial criteria and will be reevaluated, at a minimum of once every 5 years during GSP interim periods, and potentially modified as new data become available.

The SMCs are grouped by sustainability indicator. The following five sustainability indicators are applicable in the Basin:

- Chronic lowering of groundwater levels
- Reduction of groundwater in storage
- Degraded groundwater quality
- Land subsidence
- Depletion of interconnected surface water

The sixth SMC, seawater intrusion, is not applicable in the Basin.

To retain a consistent and organized approach, this section follows the same format for each sustainability indicator. The description of each SMC includes all the information required by § 354.22 et seq. of the Sustainable Groundwater Management Act (SGMA) regulations and outlined in the California Department of Water Resources (DWR) SMC best management practice (BMP) guidance (DWR, 2017), including the following:

- How the definition of what might constitute significant and unreasonable conditions was developed
- How minimum thresholds were developed, including the following:
  - The information and methodology used to develop minimum thresholds (§ 354.28 (b)(1))
  - The relationship between minimum thresholds and each sustainability indicator (§ 354.28 (b)(2))
  - The effect of minimum thresholds on neighboring basins (§ 354.28 (b)(3))
  - The effect of minimum thresholds on beneficial uses and users (§ 354.28 (b)(4))
  - How minimum thresholds relate to relevant federal, state, or local standards (§ 354.28 (b)(5))

    - The method for quantitatively measuring minimum thresholds (§ 354.28 (b)(6))
- How measurable objectives and interim milestones were developed, including the following:
    - The methodology for setting measurable objectives (§ 354.30)
    - The methodology for setting interim milestones (§§ 354.30 (a), 354.30 €, and 354.34 (g)(3))
- How undesirable results were developed, including:
    - The criteria defining when and where the undesirable effects (potential effects on beneficial uses and users of groundwater as described by the sustainability indicators) cause undesirable results (when the effects are significant and unreasonable), based on a quantitative description of the combination of minimum threshold exceedances (§ 354.26 (b)(2))
    - The potential causes of undesirable results (§ 354.26 (b)(1))
    - The effects of these undesirable results on the beneficial users and uses (§ 354.26 (b)(3))

4.1 Definitions

The SGMA legislation and regulations include a number of new terms relevant to the SMCs. These terms below use the definitions in the SGMA regulations (§ 351, Article 2). Where appropriate, additional explanatory text is added in italics. This explanatory text is not part of the official definitions of these terms. To the extent possible, plain language, with only a limited use of highly technical terms and acronyms, was used to assist as broad an audience as possible in understanding the development process and implications of the SMCs.

Groundwater-dependent ecosystem (GDE) refers to habitat, plant communities, and aquatic and terrestrial species that rely on surface or near surface water that is supported by groundwater.

Interconnected surface water refers to surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer. Interconnected surface waters are parts of streams, lakes, or wetlands where the groundwater table is close enough to the ground surface to influence water in the lakes, streams, or wetlands or vice versa.

Interim milestone refers to a target value representing measurable groundwater conditions, in increments of 5 years, set by a Groundwater Sustainability Agency (GSA or Agency) as part of a Groundwater Sustainability Plan (Plan or GSP). Interim milestones are targets such as groundwater levels that will be achieved every 5 years to demonstrate progress towards sustainability.

Management area (MA) refers to an area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors.

Measurable objectives (MOs) refer to specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin. Measurable objectives are goals that the Plan is designed to achieve.

Minimum thresholds (MTs) refer to numeric values for each sustainability indicator that are used to define undesirable results. Minimum thresholds are established at representative monitoring sites. Minimum thresholds are defined when an unreasonable condition might occur. For example, a particular groundwater level might be a minimum threshold if lower groundwater levels would result in a significant and unreasonable reduction of groundwater in storage.

Representative monitoring site (RMS) refers to a monitoring site within a broader network of sites that typifies one or more conditions within the basin or an area of the basin.

Sustainability indicator refers to the set of six conditions defined by the DWR that may be present in a basin that may result in effects, when significant and unreasonable, that cause undesirable results (defined below), and impact sustainability of the basin as described in California Water Code § 10721(x).

Uncertainty refers to a lack of understanding of the basin setting that significantly affects the Agency's[37] ability to develop SMCs and appropriate projects and management actions in the Plan,[38] or to evaluate the efficacy of Plan implementation, and therefore may limit the ability to assess whether a basin is being sustainably managed.

Undesirable result refers to the definition provided in § 10721 of SGMA, which states that:

> "*Undesirable result means one or more of the following effects caused by groundwater conditions occurring throughout the basin:*
>
> *(1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.*
>
> *(2) Significant and unreasonable reduction of groundwater storage.*
>
> *(3) Significant and unreasonable seawater intrusion.*
>
> *(4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.*
>
> *(5) Significant and unreasonable land subsidence that substantially interferes with surface land uses.*
>
> *(6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water."*

Section 354.26 of the SGMA regulations states that "The criteria used to define when and where the effects of the groundwater conditions cause undesirable results shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin."

[37] The SABGSA is the Agency referred to in this definition.
[38] The San Antonio Creek Valley Groundwater Basin GSP is the Plan referred to in this definition.

4.2 Sustainability Goal [§ 354.24]

§ 354.24 Sustainability Goal. Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.

Per § 354.24 of the SGMA regulations, the sustainability goal for the Basin has three parts:

- A description of the sustainability goal
- A discussion of the measures that will be implemented to ensure the Basin will be operated within sustainable yield
- An explanation of how the sustainability goal is likely to be achieved

Sustainability Goal: The goal of this GSP is to sustainably manage the groundwater resources of the Basin for current and future beneficial uses of groundwater, including Barka Slough (Slough), through an adaptive management approach that builds on best available science and monitoring and considers economic, social, and other objectives of Basin stakeholders. This goal was developed with input from Basin stakeholders. It takes into consideration the need to maintain a vibrant agricultural community while ensuring that domestic and environmental water uses are protected. As discussed in Section 3 of the GSP, the GSA recognizes that the observed water level declines and chronic storage deficit are undesirable. The GSA is committed to implementing a number of projects and management actions, including a pumping allocation program, after the GSP is adopted (see Section 6) that will result in basin pumping within the sustainable yield and avoidance of undesirable results within the next 20 years. The GSP includes plans to fill critical data gaps and an extensive monitoring program (see Section 5) that addresses each of the applicable sustainability indicators. Minimum thresholds, measurable objectives, and interim milestones have been established to measure sustainability and to assess progress toward meeting the sustainability goal over the next 20 years. This GSP is intended to be an adaptive plan that allows for consideration of observed basin conditions and adaptive management actions through the planning horizon.

4.2.1 Qualitative Objectives for Meeting Sustainability Goals

Qualitative objectives are designed to help stakeholders understand the overall purpose for sustainably managing groundwater resources (e.g., Avoid Chronic Lowering of Groundwater Levels) and reflect the local economic, social, and environmental values within the Basin. A qualitative objective is often compared to a mission statement. The qualitative objectives for the Basin are the following:

- **Avoid Chronic Lowering of Groundwater Levels**
  - Maintain groundwater levels that continue to support current and future groundwater uses and sustain the health of Barka Slough in the Basin.
- **Avoid Chronic Reduction of Groundwater in Storage**
  - Maintain sufficient groundwater volumes in storage to sustain current and planned groundwater use in prolonged drought conditions while avoiding impacts to Barka Slough resulting from groundwater pumping.

- **Avoid Degraded Groundwater Quality**
  - Maintain access to drinking water supplies.
  - Maintain access to agricultural water supplies.
  - Maintain quality consistent with current ecosystem uses.
- **Avoid Land Subsidence**
  - Prevent land subsidence that causes significant and unreasonable effects to groundwater supply, land uses, infrastructure, and property interests.
- **Avoid Depletion of Interconnected Surface Water**
  - Avoid significant and unreasonable effects to beneficial uses, including GDEs, caused by groundwater extraction.
  - Maintain sufficient groundwater levels to maintain areas of interconnected surface water as of January 2015 when SGMA was enacted.
- **Avoid Seawater Intrusion**
  - Not applicable due to the inland location of the Basin.

4.3 Process for Establishing Sustainable Management Criteria [§ 354.26(a)]

§ 354.26 Undesirable Results.

(a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

This section presents the process that was used to develop the SMCs for the Basin, including input obtained from Basin stakeholders, the criteria used to define undesirable results, and the information used to establish minimum thresholds and measurable objectives.

4.3.1 Public Input

The public input process was developed in conjunction with the SABGSA member agency's continued engagement of local stakeholders and interested parties on water issues. This included the formation of the Stakeholder Advisory Committee (SAC), whose members were selected by the SABGSA Board because members have an interest in maintaining a healthy agricultural and business community, good water quality, and a healthy environment. The SMCs and beneficial uses presented in this section were developed using a combination of information from public input, public meetings, comment forms, hydrogeologic analysis, and meetings with SAC members.

The general process for establishing SMCs included the following:

- Holding a series of SAC meetings and workshops that outlined the GSP development process and introduced stakeholders to SMCs.

- Conducting public meetings to present initial conceptual minimum thresholds and measurable objectives and receive additional public input. Three virtual meetings on SMCs were held.[39]

4.3.2 Criteria for Defining Undesirable Results [§ 354.26(b)(2) and (d), (b)(3)]

§ 354.26 Undesirable Results.

(b) The description of undesirable results shall include the following:

(2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.

(3) Description of potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

Section 4.2.1 discusses the qualitative objectives for meeting sustainability goals. These goals were discussed in terms of avoiding undesirable results for each of the sustainability indicators. The general criteria used (conjunctively) to define undesirable results in the Basin are as follows:

- There must be significant and unreasonable effects caused by pumping
- A minimum threshold is exceeded in a specified number of representative monitoring sites over a prescribed period
- Significant and unreasonable impacts to beneficial uses occur, including to GDEs and/or threatened or endangered species

These criteria may be refined during the 20-year GSP implementation period based on monitoring data and analysis.

[39] See https://sanantoniobasingsa.org/meeting-agendas/ for details on the meetings and workshops.

4.3.3 Information and Methodology Used to Establish Minimum Thresholds and Measurable Objectives [§ 354.28(b)(1),(c)(1)(A)(B), a€(e)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by the uncertainty in the understanding of the basin setting.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(1) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:

(A) The rate of groundwater elevation decline based on historical trend, water year type, and projected water use in the basin.

(B) Potential effects on other sustainability indicators.

(e) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.

The following information and data were used to establish minimum thresholds and measurable objectives for each of the sustainability indicators.

4.3.3.1 Avoid Chronic Lowering of Groundwater Levels

The information used for establishing the minimum thresholds and measurable objectives that pertain to chronic lowering of groundwater levels includes the following:

- Information gathered from the public meetings about the public's perspective of significant and unreasonable conditions and preferred current and future groundwater levels
- Historical groundwater level data plotted versus time from wells monitored by the U.S. Geological Survey (USGS), Los Alamos Community Services District (LACSD), Vandenberg Space Force Base (VSFB), and other agencies
- Depths and locations of existing wells
- Maps of current and historical groundwater level data
- Mapping of the location and types of GDEs
- Analysis of the potential for lowered groundwater levels to impact municipal, domestic, and agricultural wells (see Section 3.2)

- An historical and projected future water budget for the Basin (see Section 3.3), including determination of water year types, used to estimate the magnitude of annual storage reduction that has already occurred and may occur in the future, and to estimate the amount of pumping that can be sustained annually.

The monitoring network and protocols that will be used to measure groundwater levels at the RMSs are presented in Section 5. The data will be used to monitor groundwater levels and assess changes of groundwater in storage as discussed below.

4.3.3.2 Avoid Chronic Reduction of Groundwater in Storage

Groundwater levels can be used as a surrogate for assessing changes in groundwater in storage and evaluating whether basin-wide total groundwater withdrawals could lead to undesirable results. Therefore, the information that is used to establish minimum thresholds and measurable objectives for the chronic groundwater level decline sustainability indicator can also be used to avoid chronic reduction of groundwater in storage.

4.3.3.3 Avoid Degraded Groundwater Quality

The information used for assessing degraded groundwater quality thresholds includes the following:

- Historical groundwater quality data from wells in the Basin
- Municipal drinking water supply wells (LACSD and VSFB wells) via the State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW) compliance monitoring program
- Domestic and irrigation wells via the SWRCB Irrigated Lands Regulatory Program (ILRP) and USGS National Water Information System (NWIS)
- Observation wells via the USGS Groundwater Ambient Monitoring and Assessment (GAMA) Program and SWRCB GeoTracker database
- Federal and state drinking water quality standards (SWRCB, 2019) and Basin water quality objectives (WQOs) presented in the Water Quality Control Plan for the Central Coastal Basin (Basin Plan) (RWQCB, 2019)
- Feedback about significant and unreasonable conditions from the SABGSA members and the public

The historical groundwater quality data used to establish thresholds are presented in Section 3.2.3.

Thresholds for contaminants (e.g., volatile organic compounds) are not proposed because assessment, source identification, and cleanup of these constituents of concern are regulated under the authority of state agencies, including the Central Coast Regional Water Quality Control Board (RWQCB). The SABGSA does not have the responsibility nor the authority to manage contaminants. It is, however, the responsibility of the SABGSA to ensure concentrations, if any, of these constituents present in groundwater prior to the enactment of SGMA in January 2015 are not increased as a result of pumping or actions taken by the SABGSA. Elevated concentrations of salts and nutrients (e.g., total dissolved solids [TDS], sulfate, chloride, and nitrate) can impact beneficial uses, including drinking water and agricultural uses. Thus, minimum thresholds and measurable objectives are proposed for these constituents in accordance with the Basin Plan.

4.3.3.4 Avoid Land Subsidence

Minimum thresholds for subsidence were established to protect groundwater supply, land uses, infrastructure, and property interests from substantial subsidence that may lead to undesirable results. Changes in ground surface elevation are presently measured using Interferometric Synthetic Aperture Radar (InSAR) data available from DWR and the University NAVSTAR Consortium (UNAVCO) Continuous Global Positioning System (CGPS) ORES, located in the town of Los Alamos, near Los Alamos Park. The general minimum threshold is the absence of long-term land subsidence arising from groundwater pumping in the Basin. Section 3.2.4 includes a detailed discussion of the InSAR data provided by DWR and the measured land subsidence data collected by the UNAVCO CGPS.

As described in Section 3.1 of the GSP, the principal aquifers in the Basin include the Paso Robles Formation and the Careaga Sand. The Paso Robles Formation contains stream-deposited lenticular beds of sand, gravel, silt and clay; however, the fine-grained material that would be subject to subsidence are not laterally continuous, which tends to reduce the likelihood for significant subsidence. Total subsidence recorded by the UNAVCO station located in Los Alamos during the 20-year period of record (2000 to 2020) indicates a land subsidence rate of approximately 0.49 inches per year. There have been no reports from landowners of impacts resulting from subsidence.

To supplement the InSAR and UNAVCO data, an analysis of the potential for land subsidence was conducted by GEI Consultants and is summarized in Section 3.2.4 and presented in Appendix D. The analysis includes an assessment of the soils and geology in this Basin and the degree to which they would be subject to subsidence and an assessment of the potential for significant and unreasonable subsidence to occur as a result of projected changes in future groundwater levels.

4.3.3.5 Avoid Depletion of Interconnected Surface Water

The information used for establishing minimum thresholds and measurable objectives for depletion of interconnected surface water includes the following:

- Available stream gage data for Harris Canyon Creek and San Antonio Creek
- Groundwater levels measured in shallow wells near Barka Slough, including multi-level completion wells, that indicate changes in vertical gradients that affect groundwater flow into the Slough
- Water budget computations used to estimate exchanges between surface water and groundwater at the Slough during historical and projected future time frames
- Studies and analysis that identify the extent and distribution of GDEs
- Public input

4.3.4 Relationship between Individual Minimum Thresholds and Other Sustainability Indicators [§ 354.28(b)(2)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(2) The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

Section 354.28 of the SGMA regulations requires that the description of all minimum thresholds include a discussion about the relationship between the minimum thresholds for each sustainability indicator. In its BMP guidance for SMCs (DWR, 2017), DWR has clarified this requirement. First, the GSP must describe the relationship between each sustainability indicator's minimum threshold; in other words, describe why or how a groundwater level minimum threshold established at a particular RMS is similar to or different from groundwater level thresholds in nearby RMSs. Second, the GSP must describe the relationship between the selected minimum threshold and minimum thresholds for other sustainability indicators. For example, the GSP must describe how a groundwater level minimum threshold for chronic lowering of groundwater levels, if reached, would not trigger an undesirable result for land subsidence (because it had a more conservative threshold).

4.4 Representative Monitoring Sites

Minimum thresholds and measurable objectives are established at RMSs (also referred to as representative wells) that are deemed to be representative of local and basin-wide groundwater conditions in each principal aquifer. Representative wells were selected from a subset of the wells that have been monitored over time in the Basin and have the following characteristics:

- They have known well completion information and are screened exclusively within either the Paso Robles Formation or the Careaga Sand.
- They are spatially distributed to provide information across most of the Basin.
- They have a reasonably long record of data (period of record) so that trends can be determined.
- They have signatures (groundwater levels or water quality trends) that are representative of wells in the surrounding area.

See Section 5 for a detailed discussion of the rationale for selecting RMSs and Figure 3-11 for a map of their locations. In summary, the RMS network for groundwater level consists of 15 wells (8 wells in the Paso Robles Formation and 7 wells in the Careaga Sand) that will be used to help identify chronic reductions in groundwater levels and storage. One representative well is an observation well located adjacent to Barka Slough in the vicinity of the VSFB wellfield near the west end of the Basin. One well is a municipal drinking water supply well operated by the LACSD. Five are production wells used for agricultural irrigation. While not ideal for use as a monitoring well, these five production wells are currently included as RMSs because of their location in the Basin, available well construction data, and a long period of record. These five wells have been matched individually with nearby observation wells (non-pumping wells) that provide comparable spatial coverage of the Basin and have known well construction and aquifer completion data, but do not have a long period of record. Therefore, the five sets of paired wells will continue to be monitored until the period of record for the observation wells is adequate to identify trends in groundwater elevations and confirm the observation wells are representative of the pumping well to be eventually replaced in the monitoring program.

Minimum thresholds and measurable objectives have been established at these RMSs using measured groundwater elevation data and water quality data where available. Barka Slough is a GDE that receives both surface water and groundwater discharging from the underlying Careaga Sand. It is apparent that there is a connection between Basin groundwater levels and the Slough; however, there is considerable uncertainty about how much lower groundwater levels can go in the Basin without causing significant and unreasonable impacts to the Slough. Additional characterization of the nature, type, and extent of the GDEs in the Slough, installation of surface water gages in the east and west end of the Slough, and evaluation of the Slough water budget and effects of the water level minimum thresholds on surface water depletion using the USGS groundwater model, when it is available, would significantly improve understanding of this dynamic. These actions are described in Section 6. For the interim, a minimum threshold for surface water depletion will be established based on measured flow leaving the Slough (measured at the Casmalia stream gage).

Two additional areas with interconnected surface water and associated GDEs were identified in the Basin based on observations from a local landowner, the Natural Communities data set (DWR, 2020), and the Cachuma Resource Conservation District (CRCD, 2003) (see Section 3.2.6). The Price Ranch seep is located northeast of Los Alamos on Price Ranch. Another area is located in the Las Flores watershed, a tributary to San Antonio Creek, in the low-lying grassland areas immediately west of U.S. Highway 101 (CRCD, 2003) (see Figure 3-56). Without additional analysis, it is unknown whether the groundwater source of these springs or seeps is from the underlying principal aquifer or perched water within the channel alluvium. Therefore, until flow of groundwater is better understood in these areas, meaningful SMCs related to interconnected surface water and supporting associated GDEs cannot be developed. If analysis of these areas indicates interconnected surface water with the Paso Robles Formation or the Careaga Sand, SMCs will be developed pursuant to avoid undesirable results as described Section 4.10. Planned additional analysis of these areas are described in Section 6.

Although groundwater levels and groundwater in storage have decreased substantially over the period of record, no significant and unreasonable impacts to beneficial uses of groundwater (by agriculture, recreation, businesses, municipal, and domestic users) have been reported and there is no indication that wells have been going dry. It is likely that groundwater and surface water entering Barka Slough has decreased over time, but it is unclear to what extent this has been caused by pumping versus drying conditions in the region. There is no documented impact to the Slough; however, significant and unreasonable impacts to beneficial uses of groundwater including the Slough may occur in the future under assumed climate conditions and if current pumping trends continue (e.g., groundwater levels continue to decline).

The RMS for subsidence utilizes UNAVCO satellite data. Should this satellite-based subsidence monitoring method indicate that subsidence may be occurring or if there is evidence of damage to infrastructure and property interests, benchmarks for monitoring land surface elevations will be established in the Basin. The RMS for monitoring depletion of interconnected surface water and impacts to GDEs will be established at a Casmalia stream gage located west of Barka Slough.

Minimum thresholds and measurable objectives for chronic groundwater level decline are presented in Section 4.5, and minimum thresholds and measurable objectives for reduction of groundwater in storage are presented in Section 4.6. The potential for impacts to GDEs for the chronic lowering of groundwater levels sustainability indicator are discussed in Section 4.5 and for the interconnected surface water sustainability indicator in Section 4.10. Minimum thresholds and measurable objectives for degraded groundwater quality are discussed in Section 4.8 and for land subsidence in Section 4.9.

4.5 Chronic Lowering of Groundwater Levels Sustainable Management Criterion

4.5.1 Undesirable Results for Groundwater Levels [§ 354.26(a),(b)(2),(c) and (d)]

§ 354.26 Undesirable Results.

(a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

(b) The description of undesirable results shall include the following:

(2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.

Conditions that may lead to an undesirable result for groundwater levels in the Basin include the following:

- **Extended drought.** Extensive droughts may lead to excessively low groundwater levels and undesirable results. Short-term impacts due to drought are anticipated in the SGMA regulations with recognition that management actions need sufficient flexibility to accommodate drought periods and ensure short-term impacts can be offset by increases in groundwater levels or storage during normal or wet periods.
- **High rate of pumping in the Paso Robles Formation.** If the amount of pumping in the Paso Robles Formation exceeds the long-term rate of recharge derived from mountain front recharge, stream percolation, percolation of direct precipitation, septic return flow, irrigation return flow, and discharges from the Careaga Formation (in western portion of the Basin), then groundwater levels may decline, which could affect Paso Robles Formation well production, groundwater discharge into Barka Slough, and GDEs.
- **High rate of pumping in the Careaga Sand.** If the amount of pumping in the Careaga Sand exceeds the long-term rate of natural recharge derived from mountain front recharge, stream percolation, percolation of direct precipitation, septic return flow, irrigation return flow, and recharge from the Paso Robles Formation, then groundwater levels may decline, which could affect Careaga Sand well production, reduce groundwater discharge into Barka Slough, and GDEs. Increased pumping by VSFB to irrigate proposed golf courses would exacerbate this problem.

Significant and unreasonable lowering of groundwater levels in the Basin are characterized (disjunctively) as follows:

- Groundwater levels in the Paso Robles Formation or Careaga Sand drop below the minimum threshold (see Section 4.5.2) after periods of average and above-average precipitation[40] in 50 percent[41] of representative wells for 2 consecutive years. By disqualifying periods of below-average precipitation or periods of drought that result in lowering of groundwater levels, this approach focuses on periods when groundwater levels are expected to increase (due to average or above-average precipitation measured at the Los Alamos Fire Station gage) to identify groundwater level decline associated with groundwater pumping.
- An acute or chronic, measurable significant and unreasonable impact to GDEs associated with interconnected surface water (see Section 4.10), specifically Barka Slough, caused by groundwater pumping in the Basin (during periods of average or above-average precipitation measured at the Los Alamos Fire Station gage).
- Lowering of groundwater levels results in an inability to produce estimated annual volume of groundwater equal to the sustainable yield for the Basin determined using the water budget method described in this GSP.

As discussed in Section 3.3.1, groundwater levels have reportedly declined over 140 feet in some areas of the Basin during the period of record. Additionally, from 1981 through 2018, an estimated decrease of 400,100 AF of groundwater in storage occurred in the Basin (see Section 3.3). Based on input from water users in the Basin, consultation with the California Department of Fish and Wildlife, and review of available water level data, no significant and unreasonable results associated with groundwater extraction and groundwater level decline have been observed in the Basin. However, if current rates of pumping continue (see Section 3.3.5), it is likely that undesirable results would occur in the future, particularly if the effects of climate change are observed.

[40] For the purposes of the Chronic Lowering of Groundwater Levels Sustainability Indicator Minimum Threshold, the total recorded precipitation from the preceding 3 water years will be used to determine if periods of average or above precipitation have occurred. Because climate change will likely have an effect on precipitation, a 20-year moving average will be utilized to determine average precipitation.

[41] A percentage of 50 representative wells was selected by basin stakeholders as significant and unreasonable for the Chronic Lowering of Groundwater Levels Sustainability Indicator. This was based on the location and distribution (spatially, completion depth, and aquifer of completion) of the representative wells.

4.5.2 Minimum Thresholds for Groundwater Levels [§ 354.28(a),(b)(1),(c)(1)(A)(B),(e), and (d)]

§ 354.28 Minimum Thresholds.

(a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by the uncertainty in the understanding of the basin setting.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(1) Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:

(A) The rate of groundwater elevation decline based on historical trend, water year type, and projected water use in the basin.

(B) Potential effects on other sustainability indicators.

(e) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Section 354.28(c)(1) of the SGMA regulations states that "The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results." When selecting the minimum thresholds, the SABGSA considered the potential for depletion of supply to domestic, municipal, and agricultural wells if water levels continue to decline (discussed below and in Section 3.2).

As discussed in Section 3.2.1.3, a well impact analysis was performed to aid in identifying undesirable results and selecting minimum thresholds for the chronic lowering of groundwater levels sustainability indicator. In general, water levels that consistently continue to fall below the top of screen are likely to result in increased well clogging from biological growth and mineral precipitation, cascading water, sand pumping, and reduced yield and pump efficiencies and possibly, if continued, well failure. These conditions may cause a depletion of supply, depending on the type of well (domestic, municipal, or agricultural). The magnitude of this impact on well production differs depending on well type; agricultural versus municipal, versus domestic. For example, domestic wells tend to be shallower and may be more sensitive to water levels falling within the screen interval. Likewise, municipal wells serve drinking water to citizens living in the Basin and so supply reduction cannot be easily addressed. Agricultural wells often are deeper and have longer well screens that can tolerate loss of efficiency and more drawdown resulting from water levels falling below top of screen.

To gain some perspective on the significance of water level decline on different types of wells in the Basin, fall 2018 groundwater elevations were compared with top of well screen elevations for a total of 61 agricultural, municipal, and domestic wells screened in principal aquifers within the Basin. These wells were selected from a total of 423 well completion reports that were reviewed because of known location and well construction details. The percentage of wells with water levels below top of screen was calculated in 5-foot increments, starting with fall 2018 water levels (see Figures 3-13 and 3-15). The analysis illustrated the number and type of wells in the Basin that would be further impacted (groundwater elevations below well top of screen elevation) if groundwater elevations decline further compared to fall 2018 groundwater elevations.

The results of the analysis presented in Figure 3-23 indicate that groundwater elevations in fall 2018 were below top of screen in 20 percent of domestic wells, 12 percent of agricultural wells, and no municipal supply wells. As expected, the analysis indicates as water levels decline further, the number of wells and percentages of the different types of wells with water level below top of screen increase, but not significantly. When considering where to set the minimum thresholds, specific consideration was given to domestic wells, which are generally shallower, and municipal wells, which serve larger populations.[42]

The analysis indicates that water levels declining 25 feet below fall 2018 water levels do not result in a substantial increase in the number of wells affected by this condition. If water levels continue to decline, the analysis indicates well owners could observe some depletion of supply. Based on this analysis, stakeholders in the Basin believe that setting the minimum threshold for water levels at 25 feet below fall 2018 water levels will not result in depletion of supply or undesirable results. Setting the minimum threshold at this level allows time for project and management actions to be implemented before minimum thresholds are reached. Projects and management actions will be initiated upon implementation of the GSP. Projects and management actions are detailed in Section 6 and are designed to stabilize current groundwater levels. The well impact analysis presented in Section 3.2 indicates that the majority of the agricultural and domestic wells can tolerate additional groundwater level decline without experiencing undesirable results.

Table 4-1 includes the selected water level elevations for the minimum thresholds established for the Paso Robles Formation and Careaga Sand based on the foregoing analysis. Appendix F of the GSP presents a representative well location map and hydrographs showing the minimum thresholds for each representative well that will be used to monitor for chronic lowering of groundwater levels. Five representative wells are production wells used for agricultural irrigation. While not ideal for use as a monitoring wells, these five production wells are currently included as RMSs because of their location in the Basin, available well construction information, and long period of record. These five wells have been matched individually with nearby observation wells (non-pumping wells) that provide comparable spatial coverage of the Basin, have known well construction and aquifer completion data, but do not have a long period of record. Therefore, the five sets of paired wells will continue to be monitored until the period of record for the observation wells is

[42] Domestic well owners cannot easily respond to a reduction in supply, particularly during extended dry periods, and would have to absorb substantial cost if wells had to be deepened. The SABGSA agreed to provide mitigation (e.g., deepen their well or pump) to domestic well owners who experience depletion of supply as a result of basin pumping.

adequate to identify trends in groundwater elevations and confirm that the observation wells are representative of the pumping well that will be eventually replaced in the monitoring program.

Table 4-1. Chronic Lowering of Groundwater Levels Minimum Thresholds and Measurable Objectives for the Paso Robles Formation and the Careaga Sand

RMS ID[1]	Well Type	Minimum Threshold (feet NAVD 88)	Measurable Objective (feet NAVD 88)
Paso Robles Formation			
LACSD 4	Existing Production Well	407	440
30D1	Existing Production Well[2] (Awaiting Access Agreement)	345	388
SACC 1[3]	Existing Observation Well	348	--
22K3	Existing Production Well[2] (Awaiting Access Agreement)	344	370
SALS[3]	Existing Observation Well	397	--
20Q2	Existing Production Well[2] (Awaiting Access Agreement)	298	335
SACR 3[3]	Existing Observation Well	233	--
2M1	Existing Production Well	244	286
Careaga Sand			
25D1	Existing Production Well (Awaiting Access Agreement)	634	661
13C1	Existing Observation Well	565	597
24E1	Existing Production Well[2] (Awaiting Access Agreement)	220	257
SACR 1[3]	Existing Observation Well	291	--
34P1	Existing Production Well[2]	361	386
SAHC[3]	Existing Observation Well	358	--
16G3	Existing Observation Well	226	251

Notes

[1] Refer to Figure 3-11 and Appendix F for representative well locations.
[2] Production well proposed to be replaced with observation well.
[3] Observation well proposed to replace RMS production well. The well was constructed after spring 2015 (measurable objective water levels) and a measurable objective will be selected during the GSP-implementation period.
-- = Value to be selected during the GSP implementation period.
LACSD = Los Alamos Community Services District
NAVD 88 = North American Vertical Datum of 1988
RMS = representative monitoring site

4.5.2.1 Minimum Thresholds for the Paso Robles Formation and Careaga Sand Aquifers

As discussed previously, the minimum thresholds for the Paso Robles Formation and Careaga Sand aquifers are set at 25 feet below fall 2018 water levels (see Table 4-1). The rationale for setting this minimum threshold was discussed above. This threshold was selected to recognize that the Basin has experienced a lowering of groundwater levels without undesirable results to date and the well impact analysis indicates that a significant number of additional wells will not be affected if water levels decline to 25 feet below fall 2018 levels. This threshold level allows time for project and management actions to be implemented, recognizing that no significant and unreasonable effects have been observed during the historical period.

4.5.2.2 Relationship between Individual Minimum Thresholds and Relationships to Other Sustainability Indicators [§ 354.28(b)(2) and (d)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(2) The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Groundwater level minimum thresholds can potentially influence other sustainability indicators, such as the following:

- **Avoid Chronic Reduction of Groundwater in Storage.** Changes in groundwater levels reflect changes in the amount of groundwater in storage. Pumping at, or less than, the sustainable yield will maintain average groundwater levels in the Basin. Likewise. the groundwater level minimum thresholds will maintain an adequate amount of groundwater in storage over an extended period when pumping is equal to or less than the sustainable yield. Therefore, maintaining groundwater levels above the minimum thresholds will not result in long-term significant or unreasonable change of groundwater in storage.
- **Avoid Degraded Groundwater Quality.** A significant and unreasonable condition for groundwater quality is the increase in concentration of constituents of concern exceeding Basin WQOs or state or federal maximum contaminant levels (MCLs) or secondary maximum contaminant levels (SMCLs) (regulatory thresholds) for drinking water caused by lowering of groundwater levels induced by groundwater pumping. Maintaining groundwater levels above minimum thresholds helps minimize the potential for experiencing degraded groundwater quality (since enactment of SGMA in 2015) or exceeding regulatory thresholds for constituents of concern in drinking water and agricultural wells. Groundwater quality could be affected through two processes:
    1. Low groundwater levels in an area could cause deeper, poor-quality groundwater to flow into existing supply wells. Groundwater level minimum thresholds are set below current groundwater levels, meaning a flow of deep, poor-quality groundwater could occur in the future at or below minimum threshold levels. Although no point-source groundwater contamination has been

identified in the Basin, the Careaga Sand is underlain by marine deposits. Consequently, groundwater within these underlying marine deposits likely contains increased salt concentrations and is of poorer quality than the groundwater within the overlying Careaga Sand. Should groundwater quality degrade due to lower groundwater levels, the groundwater level minimum thresholds will be reviewed.

2. Changes in groundwater levels arising from management actions implemented by the SABGSA to achieve sustainability could change groundwater gradients, which could cause poor-quality groundwater to flow towards supply wells that would not have otherwise been impacted. Examples of these actions may include installation of groundwater recharge facilities (e.g., gravity stormwater recharge or aquifer recharge with recharge wells using treated wastewater). Because these kinds of projects are subject to review under the California Environmental Quality Act, concerns about the potential to introduce or mobilize contaminant plumes would be evaluated before such a project could be implemented.

- **Avoid Land Subsidence.** A significant and unreasonable condition for subsidence is permanent pumping-induced subsidence that substantially interferes with surface land use. Subsidence is caused by dewatering and compaction of clay-rich sediments in response to lowering groundwater levels. Very small amounts of ground surface elevation fluctuations have been reported across the Basin and are within the measurement margin of error. The groundwater level minimum thresholds are set just below existing and historical groundwater levels, which could induce a minor amount of additional subsidence. However, the local soils and geological conditions are less susceptible to compaction and subsidence because there are no known thick clay layers that extend across the full area where the Paso Robles Formation is present (although some clay layers are distinctly present in localized areas). Groundwater levels would likely have to be substantially lower than are predicted to occur in the future to produce significantly more subsidence.
- **Avoid Depletion of Interconnected Surface Water.** A significant and unreasonable condition for depletion of surface water is a significant and unreasonable pumping-induced reduction in groundwater discharge to surface water and resulting impacts to GDEs. There is limited available information about the condition of the Slough during periods of historical low groundwater levels. In addition, the relative degree to which groundwater discharge and surface water discharge into the Slough supports the GDEs is not well understood. Drought conditions that have been prevalent in the area since the early 2000’s is also a significant factor affecting the health of wetlands throughout California, including the Slough according to conversations with California Department of Fish and Wildlife (CDFW).[43] It is apparent that there is connection between basin groundwater levels and the Slough; however, there is considerable uncertainty about how much lower groundwater levels can go in the Basin without causing significant and unreasonable impacts to the Slough. Additional characterization of the nature, type, and extent of the GDEs in the Slough, installation of surface water gages in the east and west end of the Slough, and evaluation of the Slough water budget and effects of the water level minimum thresholds on surface water depletion using the USGS groundwater model, when it is available, would significantly improve understanding of this dynamic. These actions are described in Section 6.
- **Avoid Seawater Intrusion.** This sustainability indicator is not applicable to this Basin.

The minimum thresholds set for chronic groundwater level decline are protective of all beneficial uses and do not result in undesirable effects for the other sustainability indicators.

[43] Jennifer Strotman and Christopher Diel, CDFW, phone conversation, June 2020.

4.5.2.3 Effects of Minimum Thresholds on Neighboring Basins [§ 354.28(b)(3)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

According to DWR Bulletin 118, there is no adjacent downstream groundwater basin; therefore, this section of the SGMA regulations is not applicable to the Basin or this GSP.

4.5.2.4 Effects of Minimum Thresholds on Beneficial Uses and Land Uses [§ 354.28(b)(4)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

The groundwater level minimum thresholds have been selected to protect beneficial uses in the Basin while providing a reliable and sustainable groundwater supply. They assume that mitigation of continued water level decline will prevent undesirable results and impacts to beneficial uses.

As presented in Section 3.2, a comparison of recent groundwater levels (fall 2018) and top of screen elevation for domestic, municipal, and agricultural wells (for wells with reported construction information) located in the Basin indicated significant or unreasonable effects leading to depletion of supply are not expected if groundwater levels were to reach the minimum threshold.

4.5.2.5 Relevant Federal, State, or Local Standards [§ 354.28(b)(5)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

No federal, state, or local standards exist for chronic lowering of groundwater levels unless significant or unreasonable reduction in groundwater levels caused by pumping significantly reduces the flow of water into the Slough where sensitive species may exist. This issue is further discussed in Section 4.1.

4.5.2.6 Methods for Quantitative Measurement of Minimum Thresholds [§ 354.28(a) and (b)(6)]

§ 354.28 Minimum Thresholds.

(a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Groundwater level minimum thresholds will be directly measured from RMSs (see Table 4-1). The groundwater level monitoring program will be conducted in accordance with the monitoring plan outlined in Section 5 and will consist of collecting groundwater level measurements that reflect non-pumping conditions. The groundwater level monitoring program will be designed and conducted to meet the requirements of the technical and reporting standards included in the SGMA regulations. As discussed in Section 4.5.1, the potential exists for undesirable results to occur if minimum thresholds are exceeded in 50 percent of the representative wells for 2 consecutive years.

4.5.3 Measurable Objectives for Groundwater Levels [§ 354.30(a),(b),(c),(d), and (g)]

§ 354.30 Measurable Objectives.

(a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.

(g) An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.

The measurable objectives for chronic lowering of groundwater levels provide a target for stabilizing water levels (not recovering water levels to historical levels) over the 20-year GSP implementation period to ensure reliable access to groundwater without undesirable results. Measurable objectives for chronic lowering of groundwater levels provide operational flexibility above minimum threshold levels to ensure that the Basin can be managed sustainably over a reasonable range of climate and hydrologic variability. Measurable objectives may change after GSP adoption, as new information and hydrologic data become available.

4.5.3.1 Methodology for Setting Measurable Objectives

Measurable objectives were established to meet the sustainability goal and were based on trends in historical groundwater level data, historical precipitation data, and input from the SAC. The measurable objective levels were set so that: (1) declining water level trends caused by pumping do not continue to occur and (2) water levels stabilize with no chronic decline that continues during average and above-average rainfall conditions. With stakeholder input, the measurable objective groundwater elevation at representative wells was set at spring 2015 elevations when SGMA was enacted. Table 4-1 includes the estimated elevations for the measurable objectives established for the Paso Robles Formation and the Careaga Sand. Hydrographs showing the measurable objectives are presented in Appendix F.

4.5.3.2 Measurable Objectives for the Paso Robles Formation and Careaga Sand Aquifer

The measurable objectives for the Paso Robles Formation and Careaga Sand aquifers are the groundwater levels measured at each RMS in spring 2015. These levels were selected using available groundwater elevation monitoring data.

4.5.4 Interim Milestones for Groundwater Levels [§ 354.30(e)]

§ 354.30 Measurable Objective.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin with 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

Interim milestones show how the SABGSA would move from current conditions to meeting the measurable objectives in the 20-year GSP implementation horizon. For this Basin, interim milestones are proposed every 5 years, beginning after the GSP is submitted in 2022 and continuing through 2042 (see Table 4-2). Figure 4-1 presents the general approach for setting interim milestones in the Basin.

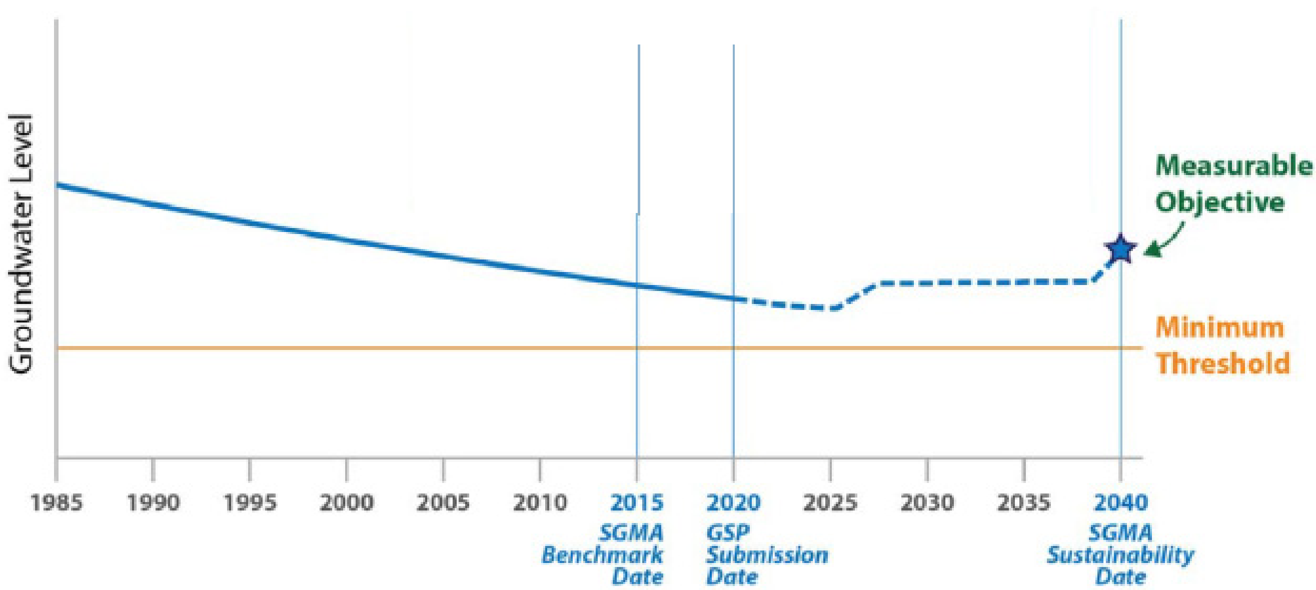

Figure 4-1. Generalized Approach to Setting Interim Milestones

Source: DWR, 2017

A period of 2 years following submittal of this GSP has been allotted to allow time for planning and funding of projects and management actions to be initiated. After the 2-year planning period, interim milestones identify target groundwater levels to be achieved every 5 years so that progress toward reaching the measurable objective target can be evaluated. Achievement of these targets will depend on both the effectiveness of any set of projects and management actions but also climate (precipitation) during that time. If new data identify undesirable results in the future, additional or modifications to existing interim milestones may be proposed as part of a GSP update that is planned for every 5 years.

Table 4-2. Chronic Lowering of Groundwater Levels Interim Milestones for the Paso Robles Formation and the Careaga Sand

	Interim Milestones (feet NAVD 88)				
RMS ID[1]	2022	2027	2032	2037	2042[4]
Paso Robles Formation					
LACSD 4	434	435	437	438	440
30D1[2]	374	377	381	384	388
SACC 1[3]	358	--	--	--	--
22K3[2]	362	364	366	368	370
SALS[3]	420	--	--	--	--
20Q2[2]	322	325	328	332	335
SACR 3[3]	243	--	--	--	--
2M1	268	271	276	281	286
Careaga Sand					
25D1	661	661	661	661	661
13C1	583	586	589	593	597
24E1[2]	252	253	254	255	257
SACR 1[3]	314	--	--	--	--
34P1[2]	386	386	386	386	386
SAHC[3]	382	--	--	--	--
16G3	249	249	250	250	251

Notes

1 Refer to Figure 3-11 and Appendix F for representative well locations.
2 Production well proposed to be replaced with subsequent observation well.
3. Observation well proposed to replace RMS production well. The well was constructed after spring 2015 (measurable objective water levels) and a measurable objective will be selected during the GSP-implementation period.
4. Value is equal to the measurable objective at the RMS for the respective sustainability indicator.
-- = Value to be selected during the GSP-implementation period.
LACSD = Los Alamos Community Services District
NAVD 88 = North American Vertical Datum of 1988
RMS = representative monitoring site

4.6 Reduction of Groundwater in Storage Sustainable Management Criterion

4.6.1 Undesirable Results for Storage Reduction [§ 354.26(a),(b)(2),(c), and (d)]

§ 354.26 Undesirable Results.

(a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

(b) The description of undesirable results shall include the following:

(2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.

Conditions that may lead to an undesirable result for groundwater in storage in the Basin are related to chronic lowering of groundwater levels and include the following:

- **Extended drought.** Extensive droughts may lead to excessively low groundwater levels, a reduced amount of groundwater in storage, and undesirable results. Short-term impacts due to drought are anticipated in the SGMA regulations with recognition that management actions need sufficient flexibility to accommodate drought periods and ensure short-term impacts can be offset by increases in groundwater levels or storage during normal or wet periods.
- **High rate pumping in the Paso Robles Formation.** If the amount of pumping in the Paso Robles Formation exceeds the long-term rate of recharge derived from mountain front recharge, stream percolation, percolation of direct precipitation, septic return flow, irrigation return flow, and discharges from the Careaga Formation (in western portion of the Basin), then groundwater levels may decline, which could affect Paso Robles Formation well production, groundwater discharge into Barka Slough, GDEs, and the volume of groundwater in storage.
- **High rate pumping in the Careaga Sand.** If the amount of pumping in the Careaga Sand exceeds the long-term rate of natural recharge derived from mountain front recharge, stream percolation, percolation of direct precipitation, septic return flow, irrigation return flow, and recharge from the Paso Robles Formation, then groundwater levels may decline, which could affect Careaga Sand well production, reduce groundwater discharge into Barka Slough, GDEs, and the volume of groundwater in storage.

Significant and unreasonable reductions in the quantity of groundwater in storage are characterized as follows:

- Groundwater levels in the Paso Robles Formation or Careaga Sand drop below the minimum threshold (see Section 4.5.2) after periods of average and above-average precipitation in 50 percent of representative wells for 2 consecutive years.[44] By disqualifying periods of below-average precipitation or periods of drought that cause lowering of groundwater levels, this approach focuses on periods when groundwater levels are expected to increase to identify groundwater level decline associated with groundwater pumping.
- Reduction of groundwater in storage results in an inability to produce estimated annual volume of groundwater equal to the sustainable yield for the Basin determined using the water budget method described in this GSP.

The practical effect of this GSP for protecting against undesirable results arising from a reduction of groundwater in storage is that it encourages the maintenance of long-term stability in groundwater levels and storage during average hydrologic conditions over multiple years and decades. Maintaining long-term stability in groundwater levels maintains long-term stability in groundwater storage and prevents chronic declines, thereby providing beneficial uses and users with access to groundwater on a long-term basis and preventing undesirable results associated with groundwater withdrawals. Pumping at the long-term sustainable yield during drought years would likely temporarily lower groundwater levels and reduce the amount of groundwater in storage. Such short-term impacts due to drought are anticipated in the SGMA regulations with recognition that management actions need sufficient flexibility to accommodate drought periods and ensure short-term impacts can be offset by increases in groundwater levels or storage during normal or wet periods. Prolonged reductions in the amount of groundwater in storage could lead to undesirable results affecting beneficial users and uses of groundwater. In particular, groundwater pumpers that rely on water from shallow wells (e.g., domestic wells) in the Los Alamos and Harris Canyon areas of the Basin may be temporarily impacted by temporary reductions in the amount of groundwater in storage and lower groundwater levels in their wells. Domestic wells located in the fringe areas above the valley floor portion of the Basin could be affected by pumping in the lower portion of the Basin. There is a lack of water level data for shallow domestic wells, which is a data gap to be addressed in the Section 6 of this GSP.

[44] For the purposes of the Chronic Lowering of Groundwater Levels Sustainability Indicator Minimum Threshold, the total recorded precipitation from the preceding 3 water years will be used to determine if periods of average or above precipitation have occurred. Because climate change will likely have an effect on precipitation, a 20-year moving average will be utilized to determine average precipitation.

4.6.2 Minimum Thresholds for Storage Reduction [§ 354.28(a),(b)(1),(c)(2),(e), and (d)]

§ 354.28 Minimum Thresholds.

(a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by the uncertainty in the understanding of the basin setting.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(2) Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that my lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.

(e) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Section 354.28(c)(2) of the SGMA regulations states that "The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin."

The minimum threshold for reduction of groundwater in storage is based on achieving the sustainable yield and avoiding conditions that may lead to undesirable results. This pertains to the Basin as a whole, not for individual aquifers. Consequently, any reduction in storage that would cause an undesirable result in only a limited portion of the Basin, as determined through continuation of the groundwater elevation monitoring program, shall be addressed in that area or in areas where declining groundwater levels indicate management actions or projects will be effective.

In accordance with the SGMA regulation cited above, the minimum threshold metric is a volume of pumping per year, or an annual pumping rate. Conceptually, the sustainable yield is the total volume of groundwater that can be pumped annually from the Basin on a long-term (multi-year/multi-decadal) basis without leading to undesirable results. As discussed in Section 3.3.5, absent the addition of supplemental water, the 2042 projected future long-term sustainable yield of the Basin under reasonable climate change assumptions is approximately 10,700 AFY.

This GSP adopts changes in groundwater levels as a proxy for the change of groundwater in storage metric. As allowed in § 354.36(b)(1) of the SGMA regulations, an average of the groundwater elevation data at the RMSs will be reported annually as a proxy to track changes in the amount of groundwater in storage because water levels and storage are closely associated. The rationale for selecting minimum thresholds for water levels, and hence, the rationale for reduction in storage, are presented in Section 4.5.2.

Based on well-established hydrogeologic principles, maintaining long-term stability in groundwater levels above the minimum threshold for chronic lowering of groundwater levels will limit continued depletion of groundwater from storage. Therefore, using groundwater elevation levels as a proxy, the minimum threshold for chronic reduction of groundwater in storage at each RMS is defined by the minimum threshold for chronic lowering of groundwater levels (see Table 4-1).

4.6.2.1 Relationship between Individual Minimum Thresholds and Relationship to Other Sustainability Indicators [§ 354.28(b)(2)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(2) The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

The minimum threshold for reduction of groundwater in storage is based on the groundwater level minimum thresholds established for chronic groundwater level decline at RMSs. Therefore, the concept of potential conflict between minimum thresholds at different locations in the Basin is not applicable.

The minimum threshold for reduction of groundwater in storage could influence other sustainability indicators. The minimum threshold for reduction of groundwater in storage was selected to avoid undesirable results for other sustainability indicators, as outlined below.

- **Avoid Chronic Lowering of Groundwater Levels.** Because groundwater levels will be used as a proxy for estimating groundwater pumping and changes in groundwater storage, the groundwater in storage sustainability criteria would not cause undesirable results for this sustainability indicator.
- **Avoid Degraded Groundwater Quality.** The minimum threshold proxy of long-term stability in groundwater levels helps minimize the potential for experiencing degraded groundwater quality or exceeding regulatory limits for constituents of concern in supply wells.
- **Avoid Land Subsidence.** Future groundwater levels would likely have to be substantially lower than are predicted to occur in the future to produce significant subsidence. Should significant and unreasonable subsidence be observed from future groundwater levels, the groundwater level minimum thresholds for this sustainability indicator will be raised to avoid this subsidence.

- **Avoid Depletion of Interconnected Surface Water.** A significant and unreasonable condition for depletion of surface water is a pumping-induced reduction in groundwater discharge to surface water and resulting impacts to GDEs (Barka Slough). There is little available information about the condition of the Slough during periods of historical low groundwater levels. In addition, the relative degree to which groundwater discharge and surface water discharge into the Slough supports the GDEs is not well understood. Drought conditions that have been prevalent in the area since the early 2000's is also a significant factor affecting the health of wetlands throughout California, including the Slough according to conversations with CDFW.[45] It is apparent that there is connection between basin groundwater levels and the Slough; however, there is considerable uncertainty about how much lower groundwater levels can go in the Basin without causing significant and unreasonable impacts to the Slough. Additional characterization of the nature, type, and extent of the GDEs in the Slough, installation of surface water gages in the east and west end of the Slough, and evaluation of the Slough water budget and effects of the water level minimum thresholds on surface water depletion using the USGS groundwater model, when it is available, would significantly improve understanding of this dynamic. These actions are described in Section 6.
- **Avoid Seawater Intrusion.** This sustainability indicator is not applicable to this Basin.

4.6.2.2 Effects of Minimum Thresholds on Neighboring Basins [§ 354.28(b)(3)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

According to DWR Bulletin 118, there is no adjacent downstream groundwater basin; therefore, this section of the SGMA regulations is not applicable to the Basin or this GSP. However, removing groundwater from storage in the Basin may result in a lowering of groundwater levels thus reducing groundwater flow into Barka Slough and then reducing flow to surface water that exits in the Basin in San Antonio Creek and flows west toward the Pacific Ocean.

4.6.2.3 Effects on Beneficial Uses and Land Uses [§ 354.28(b)(4)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

The minimum thresholds for reduction of groundwater in storage and lowering of groundwater levels have been established to avoid undesirable results. For this reason, groundwater serving beneficial uses (including GDEs) and land uses will not be adversely affected.

[45] Jennifer Strotman and Christopher Diel, CDFW, phone conversation, June 2020.

4.6.2.4 Relevant Federal, State, or Local Standards [§ 354.28(b)(5)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

No federal, state, or local standards exist for reductions in groundwater storage.

4.6.2.5 Methods for Quantitative Measurement of Minimum Thresholds [§ 354.28(b)(6)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

The measurement program for evaluating the minimum thresholds for reductions in groundwater in storage will rely on the groundwater elevation monitoring program described previously for chronic lowering of groundwater levels (see Section 4.5). Groundwater levels (as a surrogate for change of groundwater in storage) that drop below the minimum threshold values for decline in groundwater levels in 50 percent of the same representative wells over 2 consecutive years may lead to undesirable results and long-term reduction of groundwater in storage.

4.6.3 Measurable Objectives for Storage Reduction [§ 354.30(a),(c),(d), and (g)]

§ 354.30 Measurable Objectives.

(a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.

(g) An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.

The measurable objectives for reduction of groundwater in storage are based on the measurable objectives for water levels and are shown in Table 4-1. These levels provide a target for stabilizing water levels (not recovering water levels to historical water levels) and groundwater in storage over the 20-year GSP implementation period to ensure reliable access to groundwater. Measurable objectives for water levels and groundwater in storage provide operational flexibility above minimum threshold levels to ensure that the Basin can be managed sustainably over a reasonable range of climate and hydrologic variability. Measurable objectives may change after GSP adoption, as new information and hydrologic data become available.

4.6.4 Interim Milestones for Storage Reduction [§ 354.30(e)]

§ 354.30 Measurable Objective.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin with 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

Interim milestones show how the SABGSA would move from current conditions to meeting the measurable objectives in the 20-year GSP implementation horizon. For this Basin, interim milestones for groundwater in storage are proposed every 5 years, beginning after the GSP is submitted in 2022 and continuing through 2042 (see Table 4-2). Because chronic reduction in storage indicators rely on groundwater levels as a proxy, interim milestones for storage are the same as those set for chronic water level declines. A period of 2 years following submittal of this GSP has been allotted to allow time for planning and funding of projects and management actions to be initiated. After the 2-year planning period, interim milestones identify target groundwater levels to be achieved every 5 years so that progress toward reaching the measurable objective target can be evaluated. Achievement of these targets will depend on both the effectiveness of any set of projects and management actions but also climate (precipitation) during that time. If new data identify undesirable results in the future, additional or modifications to existing interim milestones may be proposed as part of a GSP update that is planned for every 5 years.

4.7 Seawater Intrusion Sustainable Management Criterion (Not Applicable)

The seawater intrusion sustainability indicator is not applicable to this Basin.

4.8 Degraded Groundwater Quality Sustainable Management Criterion

This sustainability indicator takes into consideration protection of municipal drinking water supplies, domestic uses, and agricultural uses of groundwater in the Basin. Table 3-5 presents a summary of groundwater quality data for the Basin. For municipal wells and drinking water supplied by domestic wells, state and federal regulatory standards (SMCLs and MCLs) established by the SWRCB DDW and U.S. Environmental Protection Agency, respectively, were used to establish thresholds. For agricultural uses, thresholds were established using WQOs presented in the Basin Plan (RWQCB, 2019). The SABGSA has no responsibility to manage groundwater quality unless it can be shown that water quality degradation is caused by pumping in the Basin, or the SABGSA implements a project that degrades water quality. Potential degradation of groundwater quality caused by groundwater pumping will be monitored as part of the Basin's water quality monitoring network (see Section 5). Likewise, potential degradation of water quality due to implementation of projects and management actions (see Section 6) will be evaluated during the planning stage of the respective action and monitored at a minimum as part of the Basin's water quality monitoring network.

4.8.1 Undesirable Results for Groundwater Quality [§ 354.26(a),(b)(1),(b)(2), and (d)]

§ 354.26 Undesirable Results.

(a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

(b) The description of undesirable results shall include the following:

(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.

Conditions that may lead to an undesirable result for groundwater quality in the Basin include the following:

- **Concentrations of regulated contaminants** in untreated groundwater from private domestic wells, agricultural wells. or municipal wells exceed regulatory thresholds as a result of pumping or SABGSA activities.
- **Groundwater pumping or SABGSA activities** cause concentrations of TDS, chloride, sulfate, boron, sodium, and nitrate to increase and exceed WQOs since SGMA was enacted in January 2015.

4.8.2 Minimum Thresholds for Groundwater Quality [§ 354.28(b)(1),(c)(4), and (e)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by the uncertainty in the understanding of the basin setting.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(4) Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.

(e) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.

Section 354.28(c)(2) of the SGMA regulations states that "The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin." The purpose of the minimum thresholds for constituents of concern in this Basin is to avoid increased degradation of groundwater quality from baseline concentrations measured since enactment of SGMA in January 2015. Minimum thresholds established for contaminants and for salts and nutrients are presented in the following subsections.

4.8.2.1 Contaminants

Minimum thresholds that pertain to contaminants measured in groundwater are as follows:

- No minimum thresholds have been established for contaminants because state regulatory agencies, including the RWQCB and the Department of Toxic Substances Control, have the responsibility and authority to regulate and direct actions that address contamination.

As discussed in Section 3.2.3, groundwater quality samples have been collected and analyzed throughout the Basin for various studies and programs. A broad survey of groundwater quality has been conducted by USGS as part of its GAMA Program. Historical groundwater quality data were obtained from USGS NWIS and the SWRCB GeoTracker GAMA database, and the SWRCB ILRP database. Water quality data were also obtained for the LACSD and VSFB wells as part of the SWRCB DDW compliance monitoring program.

Groundwater in the Basin is of widely varying quality and generally decreases in quality from east to west. Concentrations of TDS generally increase from east to west along San Antonio Creek; and are greatest near the Barka Slough, along western San Antonio Creek, and in Harris Canyon. Concentrations of boron, sodium, and chloride are also elevated in the slough area, along western San Antonio Creek, and in Harris Canyon. Detected chloride concentrations exceeding the WQO were collected from wells located in the western portion of the Basin along San Antonio Creek, near Barka Slough, or in Harris Canyon. Boron concentrations exceeding the WQO were collected from wells located in the western portion of the Basin along San Antonio Creek, near Barka Slough, or in Harris Canyon. Based on available information, the east to west trend of increasing TDS and salts concentrations is consistent between the Paso Robles Formation and the Careaga Sand. Analytical results from samples collected from a nested monitoring well (SACR) along San Antonio Creek, in the western portion of the Basin, indicate that concentrations of TDS decreased with depth.

Table 4-3 presents regulatory standards for selected constituents of concern for drinking water listed in the Basin Plan (RWQCB, 2019) and California Code of Regulations, Title 22 drinking water quality standards (SWRCB, 2019), and concentration of select constituents of concern in groundwater around the time SGMA was enacted (January 2015).

Constituent concentrations detected at or above their respective MCL in some public water supply wells include nitrate, arsenic, and di(2-ethylhexyl)phthalate (DEHP). A single exceedance of the MCL for nitrate occurred in a well located in Harris Canyon in 2011. A single exceedance of the MCL for arsenic occurred in a well in the VSFB wellfield in 1990. Exceedances of the MCL for DEHP occurred in samples from two wells in the VSFB wellfield in 1989 and 1990. Available data indicate that these are isolated detections of DEHP. Iron and manganese were most frequently detected at concentrations at or above their respective SMCL in public supply wells. Public supply wells with SMCL exceedances are primarily located in the VSFB wellfield. None of the samples from LACSD wells exceed MCLs. TDS, chloride, and nitrate concentrations indicate an increasing trend in LACSD well 4 located east of Los Alamos; however, concentrations of these constituents remain below MCLs, SMCLs, and WQOs.

Potential point sources of groundwater quality degradation were identified from the SWRCB GeoTracker data management system. Information for open/active contaminated sites and completed/case closed sites were reviewed. Based on available information, there are no known impacts to groundwater associated with these cases. Potential impacts on Basin groundwater quality from oil and gas development in the Basin is being investigated by the California Oil, Gas, and Groundwater program (see Section 3.2.3.5). The results of that study are not yet available.

The SABGSA intends to periodically review available water quality databases, including DDW, SWRCB ILRP, and GeoTracker databases, on an annual basis to identify contaminants that have been detected and reported. If contaminants exceed regulatory standards that affect beneficial uses in the Basin (domestic, agricultural, or municipal) are observed, the SABGSA will communicate with the appropriate state regulatory agency that has responsibility and authority to address the contamination. This information will also be reported in annual reports submitted to DWR and the public by the SABGSA.

Table 4-3. Water Quality Standards for Selected Constituents of Concern

Constituent	MCL (mg/L)	SMCL[2] (mg/L)	WQO (mg/L)
Nitrate[1]	10	--	5
Arsenic	0.01	--	--
DEHP[3]	0.004	--	--
Iron	--	0.3	--
Manganese	--	0.05	--
Boron	--	--	0.2
Chloride	--	500	150
Sodium	--	--	100
Sulfate	--	500	150
Total Dissolved Solids	--	1,000	600

Notes:
[1] Nitrate concentration measured as nitrogen (U.S. Environmental Protection Agency MCL)
[2] Upper consumer acceptance level
[3] State of California DDW MCL
-- = no value
DDW = Division of Drinking Water
mg/L = milligram per liter
MCL = maximum contaminant level (drinking water)
SMCL = secondary maximum contaminant level (drinking water)
WQO = water quality objective (median groundwater objective)
DEHP = di(2-ethylhexyl)phthalate

Sources: SWRCB, 2019 and RWQCB, 2019.

4.8.2.2 Salts and Nutrients [§ 354.28(a) and (d)]

§ 354.28 Minimum Thresholds.

(a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

Minimum thresholds pertaining to salts and nutrients measured in groundwater are as follows:

- The WQOs presented in Table 4-3 are the minimum thresholds for TDS, chloride, sulfate, boron, sodium, and nitrate as measured by SWRCB ILRP and DDW programs in 20 percent of wells monitored. In cases where the ambient (prior to January 2015) water quality exceeds the WQO, the minimum threshold concentration is 110 percent of the ambient water quality in 20 percent of the wells.

4.8.2.3 Relationship between Individual Minimum Thresholds and Other Sustainability Indicators [§ 354.28(b)(2) and (c)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(2) The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.

(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

The groundwater quality minimum thresholds were set based on state and federal drinking water quality standards as well as WQOs included in the Basin Plan.

Because SGMA regulations do not require projects or actions to improve groundwater quality beyond what existed prior to January 1, 2015, or beyond that required by other regulatory agencies with clear jurisdiction over the matter, there will be no direct actions under the GSP associated with the groundwater quality minimum thresholds. Therefore, there are no actions that directly influence other sustainability indicators.

- **Avoid Chronic Lowering of Groundwater Levels.** Groundwater quality minimum thresholds could influence groundwater level minimum thresholds by limiting the types of water that can be used for recharge to raise groundwater levels. Water used for recharge cannot exceed any of the groundwater quality minimum thresholds.
- **Avoid Chronic Reduction of Groundwater in Storage.** Nothing in the groundwater quality minimum thresholds promotes pumping in excess of the sustainable yield. Therefore, the groundwater quality minimum thresholds will not result in an exceedance of the groundwater storage minimum threshold.
- **Avoid Land Subsidence.** Nothing in the groundwater quality minimum thresholds promotes a condition that will lead to additional subsidence; therefore, the groundwater quality minimum thresholds will not result in a significant or unreasonable level of subsidence.
- **Avoid Depletion of Interconnected Surface Waters.** There is no information indicating that the groundwater quality minimum thresholds would have significant and unreasonable effects on interconnected surface waters. Nothing in the groundwater quality minimum thresholds promotes additional pumping or lower groundwater levels in areas where interconnected surface waters may exist. Therefore, the groundwater quality minimum thresholds will not result in a significant or unreasonable depletion of interconnected surface waters.
- **Avoid Seawater Intrusion.** This sustainability indicator is not applicable to this Basin.

4.8.2.4 Effects of Minimum Thresholds on Neighboring Basins [§ 354.28(b)(3)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(3) How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.

According to DWR Bulletin 118, there is no adjacent downstream groundwater basin; therefore, this section of the SGMA regulations is not applicable to the Basin or this GSP.

4.8.2.5 Effects of Minimum Thresholds on Beneficial Uses and Land Uses [§ 354.26(b)(3)]

§ 354.26 Undesirable Results.

(b) The description of undesirable results shall include the following:

(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.

The minimum thresholds for degraded groundwater quality have been established to avoid undesirable results. For this reason, groundwater serving beneficial uses (including GDEs) and land uses will not be adversely affected.

- **Agricultural land uses and users.** The degraded groundwater quality minimum thresholds generally benefit the agricultural water users in the Basin. For example, setting the minimum threshold for salts and nutrients at the WQOs described in the Basin Plan ensures that a supply of usable groundwater will exist for beneficial agricultural use.
- **Municipal uses and users.** The degraded groundwater quality minimum thresholds generally benefit the municipal water users in the Basin because there are existing regulatory programs and agencies that ensure there is an adequate supply of good quality groundwater for drinking water uses.
- **Domestic users.** The degraded groundwater quality minimum thresholds for municipal wells benefit the domestic water users in the Basin because these uses share the aquifer with municipal water supply wells. In addition, water quality standards for contaminants, salts, and nutrients are intended to be protective of drinking water uses.
- **Ecological land uses and users.** Although the degraded groundwater quality minimum thresholds do not directly benefit ecological uses, it can be inferred that the degraded groundwater quality minimum thresholds will benefit ecological water uses in the Basin because these thresholds limit future increases in concentrations of constituents of concern from what they are now, or prior to what they were when SGMA was enacted in January of 2015.

4.8.2.6 Relevant Federal, State, or Local Standards [§ 354.28(b)(5)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(5) How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.

The degraded groundwater quality minimum thresholds specifically incorporate federal and state drinking water standards.

4.8.2.7 Methods for Quantitative Measurement of Minimum Thresholds [§ 354.28(b)(6)]

§ 354.28 Minimum Thresholds.

(b) The description of minimum thresholds shall include the following:

(6) How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.

Degraded groundwater quality minimum thresholds will be directly measured from existing or new municipal (DDW compliance monitoring program), domestic (ILRP) and agricultural supply wells (ILRP). Exceedances of regulatory standards and WQOs will be assessed on an annual basis in accordance with the monitoring program (see Section 5).

4.8.3 Measurable Objectives for Groundwater Quality [§ 354.30(a),(b),(c),(d), and (g)]

§ 354.30 Measurable Objectives.

(a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

(b) Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.

(c) Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.

(d) An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.

(g) An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.

4.8.3.1 Measurable Objectives Pertaining to Contaminants

Improving groundwater quality is not a requirement under SGMA; however, protecting it from degradation is important to the beneficial users and uses of the resource in this Basin so that pumping can be maintained at desired levels. Thus, the measurable objective as it relates to contaminants is to maintain groundwater quality equal to or below regulatory standards or, equal to or below concentrations present in groundwater when SGMA was enacted.

4.8.3.2 Measurable Objectives Pertaining to Salts and Nutrients

The measurable objective as it relates to salts and nutrients (TDS, chloride, sulfate, boron, sodium, and nitrate) is to maintain groundwater quality equal to or below Water Quality Objectives presented in the Basin Plan, or equal to or below concentrations present in groundwater when SGMA was enacted.

4.8.4 Interim Milestones for Groundwater Quality [§ 354.30(e)]

§ 354.30 Measurable Objective.

(e) Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin with 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.

Interim milestones show how the SABGSA anticipates moving from current conditions to meeting the measurable objectives. No significant or unreasonable results that significantly impact beneficial uses have been observed in the Basin in association with degraded groundwater quality. Therefore, no interim milestones are being proposed.

4.9 Land Subsidence Sustainable Management Criterion

4.9.1 Undesirable Results for Land Subsidence [§ 354.26(a),(b)(1),(b)(2), and (d)]

§ 354.26 Undesirable Results.

(a) Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.

(b) The description of undesirable results shall include the following:

(1) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(2) The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.

(d) An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.

Conditions that may lead to an undesirable result in the Basin include a shift in pumping locations or substantial increase in pumping beyond what has been observed, which could lead to a substantial decline in groundwater levels that could result in subsidence. Shifting or increasing a significant amount of pumping that causes groundwater levels to fall in an area that is susceptible to subsidence could trigger subsidence exceeding the minimum thresholds.

Locally defined significant and unreasonable conditions for land subsidence are land subsidence rates exceeding rates observed from 2000 to 2020 at the UNAVCO CGPS Station ORES, located in the town of Los Alamos, near Los Alamos Park; and land subsidence that causes damage to groundwater supply, land uses, infrastructure, and property interests. For clarity, this SMC adopts two related concepts:

- **Land subsidence** is a gradual settling of the land surface caused by, among other processes, compaction of subsurface materials due to lowering of groundwater levels from groundwater pumping. Land subsidence from dewatering subsurface clay layers can be an inelastic process and the potential decline in land surface could be permanent. This can also be caused by exploitation of oil and gas from fields located within or near the Basin.
- **Land surface fluctuation.** Land surface may rise or fall, elastically, in any one year. Land surface fluctuation may or may not indicate long-term permanent subsidence. This can be caused by tectonic activity in the earth.

By regulation, the ground surface subsidence undesirable result is a quantitative combination of subsidence minimum threshold exceedances. For the Basin, no long-term subsidence that impacts groundwater supply, land uses, infrastructure, and property interests is acceptable. Therefore, the ground surface subsidence undesirable results (disjunctively) include the following:[46]

- Groundwater extraction results in subsidence that substantially interferes with surface land uses (including agricultural, residential, rural residential, and town buildings) and property interests.
- Groundwater extraction results in subsidence that causes land surface deformation that impacts the use of critical infrastructure (including LACSD wells, WWTP, and associated infrastructure) and roads.
- Groundwater extraction results in land subsidence greater than minimum thresholds at the UNAVCO CGPS Station ORES.

Currently, ground surface elevation is being monitored at one continuous global positioning system site in the Basin as reported by UNAVCO from its Data Archive Interface.[47] Since the beginning of data collection in 2000, the net vertical displacement is negative (0.82 feet). This means that the land surface elevation has decreased (negative displacement) 0.82 feet in the last 20 years. The Basin is located near the intersection of the Coastal Ranges and Transverse Ranges California Geomorphic Provinces. Consequently, the Basin is in a very tectonically active region. The 0.82 feet of vertical displacement measured at the UNAVCO station could be due to tectonic activity, groundwater extraction, oil and gas extraction, or a combination of the three. In addition, InSAR data provided by DWR shows that meaningful (greater than the range of uncertainty of InSAR data) land subsidence did not occur during the period between June 2015 and June 2019 in the Basin (see Section 3.2.4).

To supplement the InSAR and UNAVCO data and assess the general susceptibility of the Basin to experience subsidence as a result of lowering groundwater levels below historical levels, a preliminary subsidence evaluation was completed. The preliminary evaluation was based on review of subsurface geologic information and groundwater level data for key wells and included estimating ranges of possible long-term subsidence that might be expected in the future. The evaluation, which is included in Appendix D, included the following key conclusions:

- There have been no reports from landowners or public agencies of impacts resulting from subsidence.

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[46] The listed criteria for ground surface subsidence undesirable results only apply if groundwater levels are below historical low groundwater levels during the period of ground surface subsidence in question.
[47] The UNAVCO Data Archive Interface is available at http://www.unavco.org/data/data.html.

- The analysis was completed at two representative well locations and showed an estimated total potential subsidence on the order of 1 to 2 feet over the historical period resulting from the changes in groundwater elevation reported in the hydrographs.
- Historical subsidence on the order of 1 to 2 feet appears relatively consistent with the estimated subsidence rate of 0.5 inches per year reported for the UNAVCO CGPS Station ORES (see Section 3.2.4.2).

Based on the result of this analysis, it is unlikely that the full measure of estimated subsidence (of 1 to 2 feet) would be observed unless groundwater elevations declined significantly below what has been observed historically and did not recover for an extended period.

There has been no reported historical or anecdotal information regarding land subsidence in the Basin as a result of groundwater extractions. There may be, and likely has been, some subsidence as a result of groundwater extraction, but the effects, to date, have not been documented to impact surface features. With groundwater declines of as much as 70 to 143 feet in the Basin (see Section 3.2.1.2), some subsidence may have occurred prior to the initiation of SGMA (January 2015), but there is no readily available information to document that. Due to the limited data available and the fact that factors other than groundwater extraction (e.g., tectonic activity and oil and gas extraction) must be considered, it is unknown how much subsidence has occurred, or how it relates to the maximum amount that may occur in the future. For these reasons, the SABGSA intends to continue to monitor for subsidence.

Staying above the minimum threshold will avoid the subsidence undesirable result and protect the beneficial uses and users from impacts to groundwater supply, land uses, infrastructure, and property interests. Should subsidence in excess of the minimum threshold be observed, the SABGSA will first assess whether the subsidence may be due to (1) groundwater pumping and (2) elastic processes (subsidence that will recover with rising groundwater). If the subsidence is not elastic or is due to pumping, the SABGSA will undertake a program to correlate the observed subsidence with measured groundwater elevations. If subsidence is confirmed to be a result of groundwater extraction and property damage is observed, the SABGSA will implement additional monitoring of the elevation of benchmarks established at key locations in the Basin. The SABGSA will also accelerate implementation of projects and management actions that stabilize groundwater levels so that continued subsidence is mitigated.

4.9.2 Minimum Thresholds for Land Subsidence [§ 354.26(c) and 354.28(a),(b)(1),(c)(5)(A)(B),(d), and (e)]

§ 354.26 Undesirable Results.

(c) The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.

§ 354.28 Minimum Thresholds.

(a) Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.

(b) The description of minimum thresholds shall include the following:

(1) The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by the uncertainty in the understanding of the basin setting.

(c) Minimum thresholds for each sustainability indicator shall be defined as follows:

(5) Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:

(A) Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including an explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those affects.

(B) Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.

(d) An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.

(e) An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.

Section 354.28(c)(5) of the SGMA regulations states that "The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results."

The subsidence minimum threshold is as follows and summarized in Table 4-4:

- The rate of subsidence does not exceed 0.05 feet (0.6 inches) per year for 3 consecutive years measured at the UNAVCO CGPS Station ORES.