DRAFT

San Antonio Creek Valley Basin Groundwater Sustainability Plan

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Prepared for:

San Antonio Basin Groundwater Sustainability Agency
Established 2017

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Abbreviations and Acronyms

2070DEW	Drier/Extreme Warming
2070WMW	Wetter/Moderate Warming
AFY	acre-feet per year
Basin	San Antonio Creek Valley Basin
BCM	Basin Characterization Model
CCWA	Central Coast Water Authority
DWR	California Department of Water Resources
ET	evapotranspiration
EVT	Landfire Existing Vegetation Type spatial data set
ft	foot or feet
GAMA	Groundwater Ambient Monitoring and Assessment
GAMA	Groundwater Ambient Monitoring and Assessment Program
GIS	geographic information system
GSA	San Antonio Basin Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HUC	Hydrologic Unit Code
LACSD	Los Alamos Community Services District
LAFD	Los Alamos Fire Department
m	meter
M&I	municipal and industrial
NWIS	National Water Information System
OWTS	on-site wastewater treatment systems
SGMA	Sustainable Groundwater Management Act
SWP	California State Water Project
SYRVWCD	Santa Ynez River Valley Water Conservation District.
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VAFB	Vandenberg Air Force Base
VIC	variable infiltration capacity
WWTP	Waste water treatment plant

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SECTION 3: **Basin Setting [Article 5, Subarticle 2]**

§354.12 Introduction to Basin Setting. This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.

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 San Antonio Creek Valley Basin (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 budgets 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.

This section includes three major water budget subsections: Section 3.3.3, Historical Water Budget Results; Section 3.3.4, Current Water Budget; Section 3.3.5, Projected Water Budget. Within each subsection, a surface water budget and groundwater budget are presented. Water budgets were developed using estimated inflow and outflow terms and a spreadsheet tool. Before presenting the water budgets, a brief overview of the inflow and outflow terms and spreadsheet tool is presented. 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 the 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 <u>without causing an</u>

undesirable result." 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 Aquifer and Careaga Sand Formation Aquifer. 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. Barka Slough contains important aquatic and terrestrial plant and animal species.

Figure 3-46 presents a general schematic diagram of the hydrologic cycle. The water budgets include the components of the hydrologic cycle.

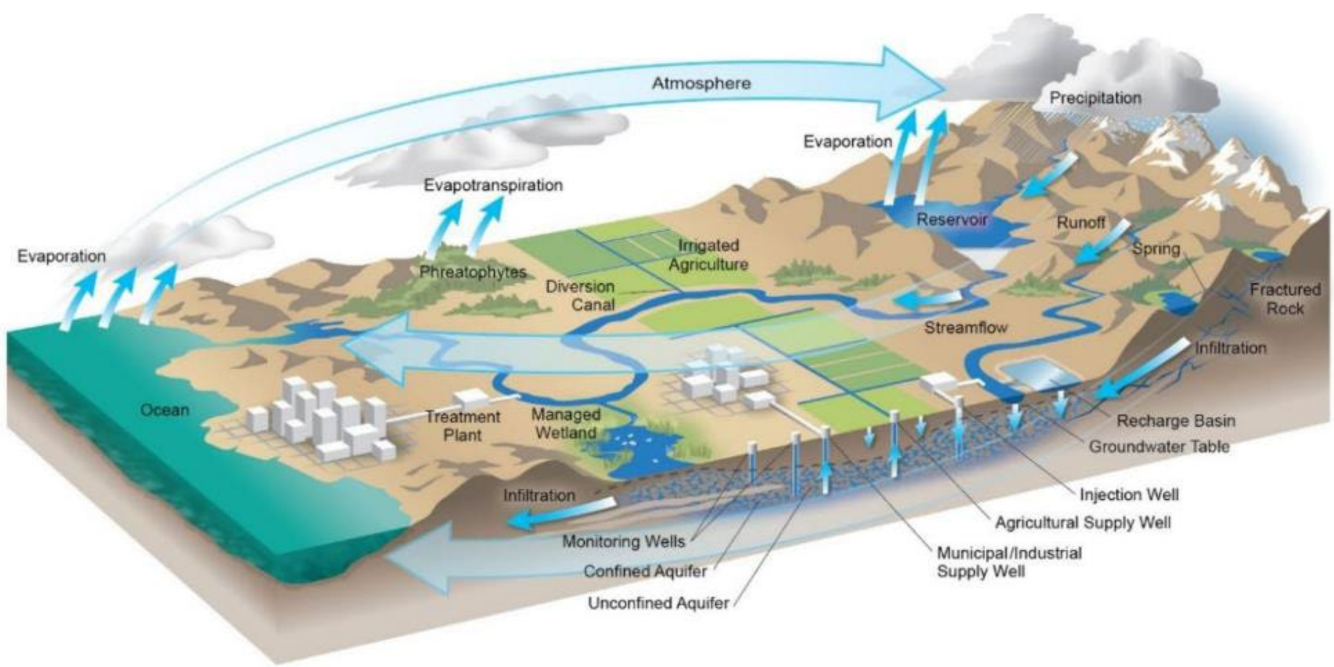

Figure 3-46. The Hydrologic Cycle

(DWR, 2016)

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. The best available science has been used to estimate water budget components that cannot be measured. 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
- Evaporation

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 Los Alamos Community Services District (LACSD) Wastewater Treatment Plant (WWTP) spray irrigation

Groundwater Outflows:

- Evapotranspiration (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 (Figure 3-47).

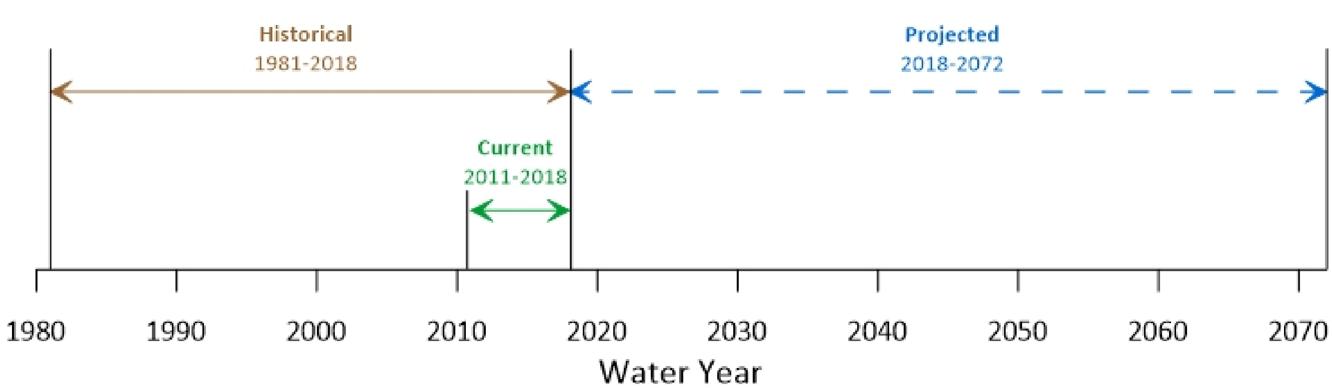

Figure 3-47. Historical, Current, and Projected Water Budget Periods

As is true for the entire GSP, this historical period discussion refers to water years, which run between October 1 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 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 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 3-9.

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

A graph showing the cumulative departure from mean precipitation for the precipitation station was created (Figure 3-17). The climatic trends (which exhibit wet, normal, and dry periods) determined from the station are also presented on the graph.

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. 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 just 77 percent of the historical period. The current water budget is presented in Section 3.3.4.

The projected water budget between 2018 and 2072 extends 50 years past the 2022 submittal of this GSP, for a total of 55 years. 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 U.S. Geological Survey (USGS) is currently being calibrated as part of a multi-year groundwater basin study. As of this writing in early 2021, the groundwater model and related information has yet 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. It is GSI's opinion that the spreadsheet tool is adequate for developing the water budgets and assessing projects and management actions in this Basin because the tool relies on the best available information—local and regional Basin water users, sources/tools identified in the DWR Draft Handbook for Water Budget Development, With or Without Models (DWR, 2020), and published technical reports—and best available science—published hydrogeologic properties and principles, use of developed forecasting and interpolation tools, and multiple calculation methodologies to determine validity of data and calculations—to quantify the water budget for the Basin to provide 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.

Water budget components for the Basin were developed using various publicly available data sets organized in a tabular accounting fashion by water year. Table 3-9 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.

Table 3-9. Primary Information and Data Sources for 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	BCM calibrated to gage data	Calibrated Model – Medium	BCM calibrated to DWR VIC hydrology model for 2030 and 2070 climate data
Groundwater Inflow Components				
Mountain Front Recharge	USGS-BCM Recharge	BCM calibrated to local and regional met station data	Calibrated Model – Medium	BCM calibrated to DWR VIC hydrology model for 2030 and 2070 climate data
Streamflow Percolation	USGS-BCM Recharge	BCM calibrated to local and regional met station data	Calibrated Model – Medium	
Deep Percolation of Direct Precipitation	USGS-BCM Recharge	BCM calibrated to local and regional met station data	Calibrated 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 text	Estimated Medium/Low	Linear projection based on historical data set and estimated population growth
Irrigation Return Flow	Various Land Use Surveys, Crop Water Duty Factors from the SYRWCD, Aerial Survey	Methods described in text	Estimated Medium/Low	Agricultural – 20% of Agricultural Pumping Rural Domestic – 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
Surface Water Outflow Components				
San Antonio Creek/Barka Slough Outflow	USGS-BCM Runoff, Stream Gage Data	BCM calibrated to gage data	Calibrated Model – Medium	BCM calibrated to DWR VIC hydrology model for 2030 and 2070 climate data
Groundwater Discharge to Surface Water	Darcian Flux Calculation, Historical Reports	Methods described in text	Estimated – Low	
Groundwater Outflow Components				
LACSD Pumping	LACSD	Data provided by LACSD	Metered – High	Linear projection based on historical data set and estimated population growth
VAFB Pumping	VAFB	Data provided by VAFB	Metered – High	
Agricultural Irrigation Pumping	Various Land Use Surveys and Crop Water Use Factors from the SYRWCD	Methods described in text	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 text	Estimated – Medium/Low	Linear projection based on historical data set and estimated population growth
Riparian ET	LandFire	Methods described in text	Estimated – Medium	Linear projection of historical data set multiplied by the respective DWR VIC hydrology model ET
Discharge to Surface Water	Darcian Flux Calculation, Historical Reports	Methods described in text	Estimated – Low	BCM calibrated 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

LACSD = Los Alamos Community Services District
VAFB = Vandenberg Air Force Base
USGS = United States Geological Survey
BCM = Basin Characterization Model developed by the USGS, (Flint & Flint, 2014). Monthly data on a uniform 885 feet (ft) × 885 ft grid across the Basin .
SYRVWCD = Santa Ynez River Water Conservation District
NWIS = National Water Information System
GAMA = Groundwater Ambient Monitoring and Assessment Program
VIC = Variable Infiltration Capacity model developed by (Hamman et al, 2018) and (Liang et al, 1994)
ET = evapotranspiration

3.3.2.1 Surface Water Inflow Components

Surface water inflows include only water native to the Basin (runoff of precipitation). The Basin does not receive imported water from the California State Water Project (SWP) nor does it receive reservoir releases into streams and rivers that enter the Basin from the surrounding watershed. The individual component of the surface water budgets is described here.

3.3.2.1.1. Native Streamflow

Native streamflow in the tributary creeks to Santa Antonio Creek were estimated using a combination of USGS Basin Characterization Model (BCM) for California (Flint and Flint, 2017) 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 weather 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, weather 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 weather 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 tributary streamflow gage data, where available, and calibrated to fit the gage data.[1]

3.3.2.2 Surface Water Outflow Components

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

3.3.2.2.1. San Antonio Creek/Barka Slough Outflow

San Antonio Creek/Barka Slough surface water outflows were calculated as the sum of contributing flows from tributary channels, San Antonio Creek (Section 3.3.2.1.1), and groundwater discharging to surface water at Barka Slough (Section 3.3.2.4.6), minus the calculated ET of Barka Slough (Section 3.3.2.4.5).

3.3.2.2.2. Streamflow Percolation

Streamflow percolation, or the deep percolation of surface water to groundwater through the streambed, was calculated using the calibrated USGS BCM for percolation in San Antonio Creek and its tributary channels. Portions of the adjusted BCM runoff data set 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 3.3.2.1.1.

3.3.2.3 Groundwater Inflow Components

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

3.3.2.3.1. 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

[1] The adjusted BCM runoff data were calibrated to match stream gage data (where available) by routing excess or deficit volumes to/from recharge (discussed further below as streamflow percolation, mountain front recharge, and/or deep percolation of direct precipitation).

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 and calibrated BCM model as described above in Section 3.3.2.1.1. Mountain front recharge was calculated as the sum of the adjusted and calibrated BCM recharge data set over the contributing watershed areas outside the Basin minus the portion routed to native streamflow.

3.3.2.3.2. Streamflow Percolation

The calculation of streamflow percolation to groundwater is detailed above in Section3.3.2.2.2

3.3.2.3.3. 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 the 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 3.3.2.1.1, the BCM recharge data set has been adjusted based on comparison to monthly precipitation records at weather stations located within and adjacent to the Basin.

3.3.2.3.4. Percolation of Treated Wastewater (Effluent Spray Irrigation)

LACSD WWTP discharges treated wastewater to the land surface via spray irrigation. The LACSD WWTP was constructed prior to 1981 and so 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). Based on the volume of reported annual discharge, the irrigated acreage, and the crop water duty factors, discharges from the spray irrigation system do not percolate to groundwater and therefore do not contribute to the Basin water budget.

3.3.2.3.5. 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 to not contribute to the Basin water budget. 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 conducting an aerial survey of the Basin and counting residences suspected to have an OWTS unit located in the Basin in 2018 multiplied by an assumed return flow rate of 0.11 acre-feet per year (AFY) per unit (Tetra Tech, 2010). This was then scaled through time using a compilation of census data for nearby communities.

3.3.2.3.6. 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 the irrigated agriculture in the study area, an irrigation efficiency of 80 percent is assumed for all crops except vineyards, which are assumed to be irrigated using drip at an efficiency of 95 percent. The urban landscape irrigation efficiency is assumed to be 70 percent. 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, assumed crop-specific water duty factors, and self-reported irrigation pumping data. These applied water volumes are discussed further in Section 3.3.2.4.

3.3.2.4 Groundwater Outflow Components

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

3.3.2.4.1. 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 multiplying the LACSD pumping for a given year by the percent of rural domestic pumping of the same year in comparison to the rural domestic pumping in the subsequent year (example: 1992 LACSD pumping = 1993 LACSD pumping x [1992 Rural Domestic Pumping / 1993 Rural Domestic Pumping]). This approach considers change in historical population.

3.3.2.4.2. VAFB Pumping

Vandenberg Air Force Base (VAFB) pumping was calculated using production data provided by VAFB. The entire historical water budget period is included in the VAFB pumping data set provided.

3.3.2.4.3. 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 of 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) provided by the USGS (USGS, 2020) 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 Los Alamos 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 agricultural land use type in the land survey data provided by USGS and Santa Barbara County for the Basin. Land use surveys were not available for every year, so spatial-temporal interpolations were made between the land use surveys for the intervening years.

3.3.2.4.4. Rural Domestic Pumping

Rural domestic pumping is considered to be 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 LACSD 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 3-10). The calculated 2018 rural domestic demand was then scaled through time using a compilation of census data for nearby communities.

Table 3-10. 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)

3.3.2.4.5. Riparian Evapotranspiration

Riparian ET was calculated using the LandFire Existing Vegetation Type (EVT) spatial data set[2] 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. The riparian acreage included the riparian vegetation present within Barka Slough, San Antonio Creek, and tributaries.

3.3.2.4.6. 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[3] with hydrogeologic properties according to (Muir, 1964), (Hutchinson, 1980), and (Martin, 1985), or determined using monitoring well data and surficial topography. See Appendix D-4 for calculation details. To determine groundwater discharge to surface water flow values for each year of the historical water budget period, the calculated discharge values from Table 3-8 were multiplied by the percent of average VAFB pumping for a specific year, minus the calculated ET for Barka Slough for the same year.

[2] LandFire is a shared program between the wildland fire management programs of the U.S. Department of Agriculture Forest Service and U.S. Department of the Interior, providing landscape scale geo-spatial products to support cross-boundary planning, management, and operations (https://landfire.gov).

[3] 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.

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

3.3.3.1.1. Historical Surface Water Inflows

Local surface water supplies include surface water flows that enter the Basin from precipitation runoff within the watershed. Table 3-11 summarizes the annual average, minimum, and maximum values for these inflows.

Table 3-11. Annual Surface Water Inflows, Historical Period

Surface Water Inflow Component	Average	Minimum	Maximum
Inflow to Basin including San Antonio Creek and Tributaries	5,000	300	35,200

Note

All values in acre-feet.

The estimated average annual total inflow from these sources over the historical period is 5,000 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.

3.3.3.1.2. Historical Surface Water Outflows

The estimated annual average total surface water outflow leaving the Basin as flow in the San Antonio Creek west of Barka Slough and percolation into the groundwater system over the historical period is summarized in Table 3-12.

Table 3-12. Annual Surface Water Outflows, Historical Period

Surface Water Outflow Component	Average	Minimum	Maximum
San Antonio Creek West of Barka Slough Outflow from Basin	2,300	0	23,200
Streamflow Percolation	3,100	300	12,000
Total[1]	5,400	—	—

Notes

All values in acre-feet.

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

The estimated average annual total outflow from these sources over the historical period is 2,300 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.

3.3.3.1.3. Historical Surface Water Budget Summary

Figure 3-48 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 an orange background, surface water inflows and outflows are small.

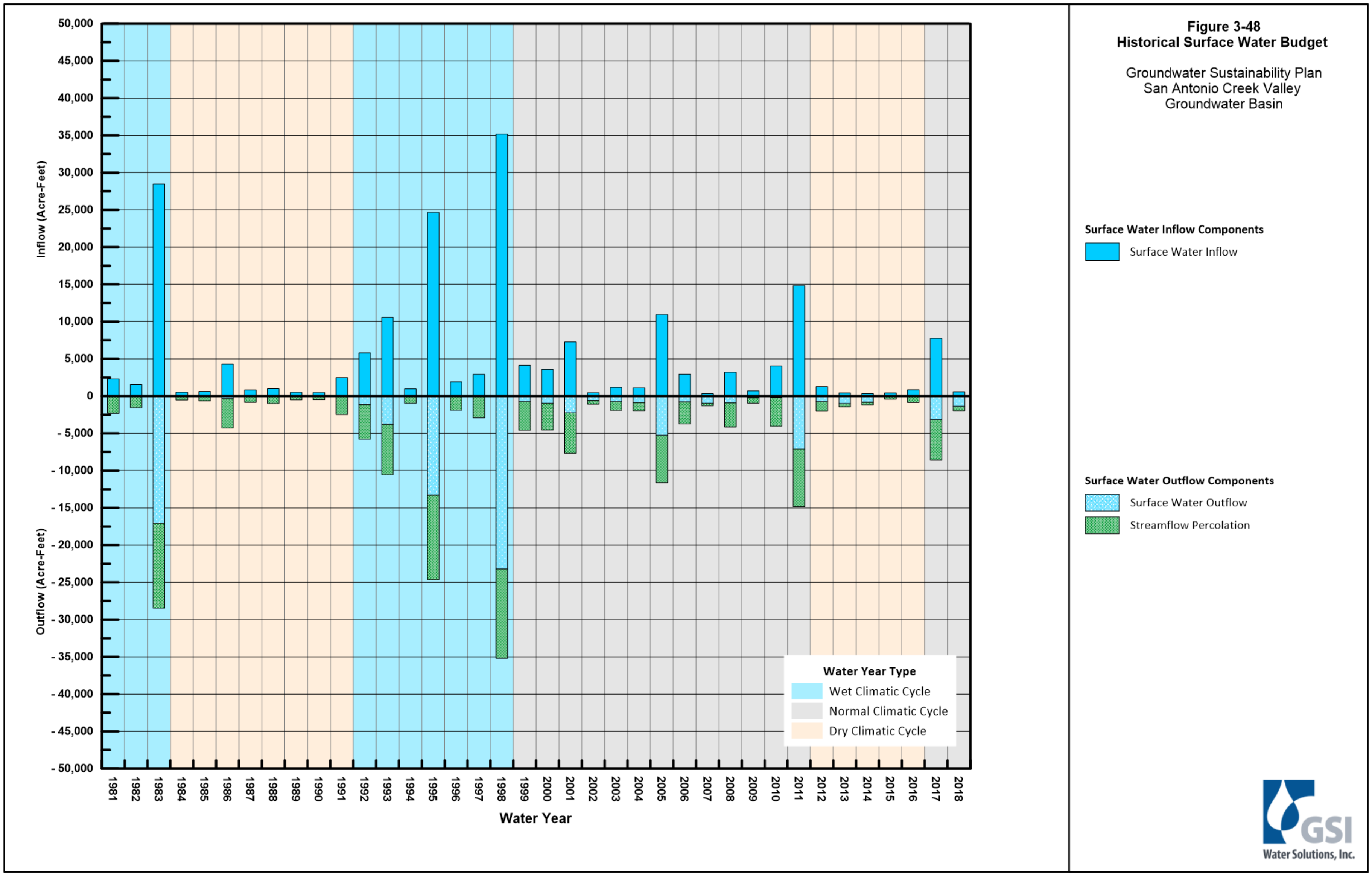

Figure 3-48. Historical Surface Water Budget

3.3.3.1.4. 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 Aquifer and the Careaga Sand Formation Aquifer, supplied virtually 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.

3.3.3.2.1. 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 3-13. Values reported in the table were estimated or derived from the data sources reported in Table 3-9.

Table 3-13. Annual Groundwater Inflow, Historical Period

Groundwater Inflow Component	Average	Minimum	Maximum
Mountain Front Recharge	2,400	10	13,600
Streamflow Percolation[1]	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[2]	17,500	—	—

Notes

All values in acre-feet.

[1] Streamflow Percolation includes San Antonio Creek percolation and tributary channel percolation.

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

During the historical period, estimated total average 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.

3.3.3.2.2. 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 3-14.

Table 3-14. Annual Groundwater Outflow, Historical Period

Groundwater Outflow Component	Average	Minimum	Maximum
Total Groundwater Pumping	19,500	13,800	24,200
Riparian Evapotranspiration	6,500	6,300	6,700
Groundwater Discharge to Surface Water	350	0	1,400
Total[1]	26,400	—	—

Notes

All values in acre-feet.

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

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 3-15.

Table 3-15. Annual Groundwater Pumping by Water Use Sector, Historical Period

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

Notes

All values in acre-feet.

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

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. VAFB, 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.

3.3.3.2.3. Historical Groundwater Budget and Changes in Groundwater in Storage

Average groundwater inflows and outflows for the historical period are presented on Figure 3-49. The average total inflow of approximately 17,500 AFY is less than the average total outflow of 26,400 AFY. A summary of annual groundwater inflows and outflows for the entire historical period are presented on Figure 3-50 (also tabulated in Table 3-16 and Appendix E). Figure 3-50 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 (Table 3-15). The red line shows the cumulative change in groundwater storage over the historical period. The results of the water budget during the historical period show that the Basin is in overdraft.

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 overdraft.

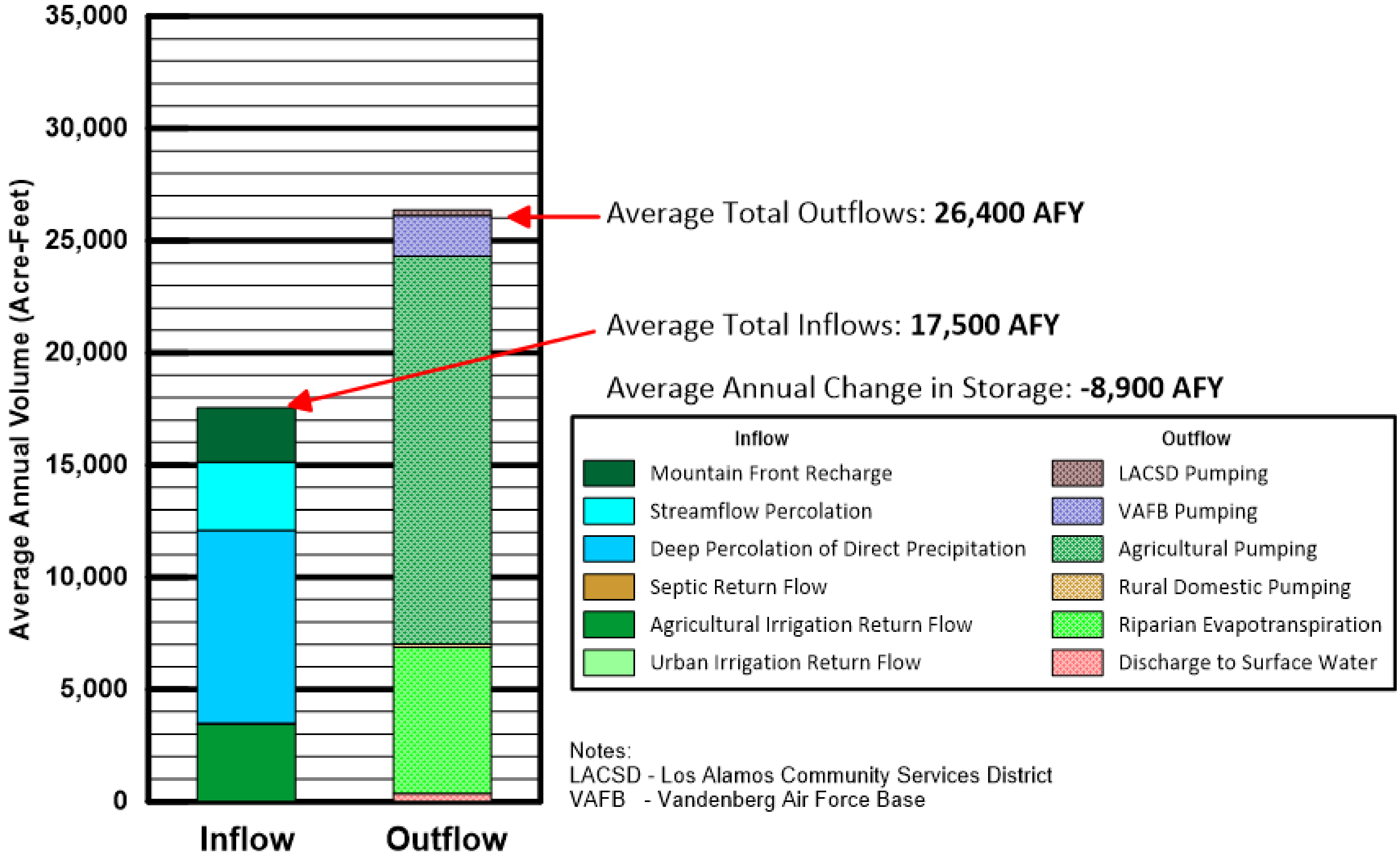

Figure 3-49. Average Groundwater Budget Volumes, Historical Period

Table 3-16. San Antonio Creek Valley Groundwater Basin Historical, Current, and Projected Water Budget Summaries

San Antonio Creek Valley Groundwater Basin Water Budget

Values in acre-feet

= Component of Inflow

= Component of Outflow

Water Budget	Water Year	Rainfall		Components of Inflow								Total Inflow	Components of Outflow								Total Outflow	Change in Storage	Cumulative Change in Storage
				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					Riparian Evapotranspiration	Groundwater Discharge to Surface Water	Subsurface Outflow			
		Inches	% of Average										LACSD Pumping	VAFB Pumping	Ag Irrigation Pumping	Rural Domestic Pumping	Total Pumping						
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	0	0	20,400	-9,700	-9,700
	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	0	0	20,600	-10,900	-20,600
	1983	35.7	232%	0	13,600	11,400	42,400	0	10	2,200	1	69,600	180	3,080	11,200	110	14,500	6,500	0	0	21,000	48,600	28,000
	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	0	0	21,700	-18,100	9,900
	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	0	0	22,200	-17,400	-7,600
	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	0	0	22,300	-4,700	-12,200
	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	0	0	22,700	-16,600	-28,700
	1988	15.1	98%	0	1,100	1,000	3,200	0	10	2,600	1	7,900	210	3,250	13,000	120	16,500	6,500	0	0	23,000	-15,100	-43,600
	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	0	0	23,100	-19,800	-63,600
	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	0	0	23,700	-20,300	-83,900
	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	0	0	23,600	-13,600	-97,500
	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	0	0	24,100	1,100	-96,400
	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	0	0	23,900	13,800	-82,600
	1994	13.4	87%	0	600	1,000	1,900	0	10	2,900	1	6,400	230	2,860	14,300	140	17,600	6,500	0	0	24,100	-17,700	-100,300
	1995	29.2	190%	0	7,500	11,300	32,400	0	10	2,900	1	54,100	240	2,690	14,600	140	17,600	6,500	0	0	24,100	30,000	-70,300
	1996	15.5	101%	0	1,300	1,900	5,100	0	10	3,000	1	[illegible]	[illegible]	[illegible]	14,800	140	18,300	6,600	0	0	24,900	-13,600	-83,900
	1997	13.2	85%	0	2,500	2,900	6,900	0	20	[illegible]	1	[illegible]	[illegible]	[illegible]	15,500	140	19,300	6,600	0	0	25,900	-10,600	-94,400
	1998	36.2	235%	0	7,400	12,000	38,300	0	20	3,300	1	60,900	260	1,130	16,200	140	17,800	6,400	400	0	24,600	36,300	-58,100
	1999	16.2	105%	0	2,800	3,900	8,900	0	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16,900	140	17,800	6,300	1,000	0	25,100	-6,100	-64,200
	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	400	0	26,000	-5,100	-69,300
	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	600	0	26,600	-600	-69,900
	2002	7.7	50%	0	20	500	400	0	20	3,800	1	4,700	340	460	19,100	150	20,000	6,500	700	0	27,200	-22,500	-92,400
	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	900	0	28,100	-18,400	-110,800
	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	700	0	28,800	-20,400	-131,200
	2005	28.3	184%	0	7,800	6,400	22,700	0	20	4,200	1	41,100	350	430	21,200	150	22,200	6,500	800	0	29,500	11,600	-119,600
	2006	18.3	119%	0	3,100	3,000	8,100	0	20	4,400	1	18,600	350	340	21,900	150	22,800	6,500	1,000	0	30,300	-11,700	-131,300
	2007	6.3	41%	0	10	300	100	0	20	4,400	1	4,800	360	340	21,900	150	22,800	6,500	900	0	30,200	-25,400	-156,700
	2008	17.0	111%	0	2,200	3,200	8,600	0	20	4,400	1	18,400	360	1,140	22,000	160	23,600	6,500	200	0	30,300	-11,900	-168,600
	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	0	0	30,400	-24,300	-192,900
	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	0	0	30,300	-7,600	-200,600
	2011	21.7	141%	0	7,500	7,700	27,300	0	20	4,400	1	46,900	300	590	22,000	160	23,000	6,400	700	0	30,100	16,800	-183,700
	2012	10.6	69%	0	50	1,300	1,200	0	20	4,400	1	7,000	310	300	22,000	160	22,700	6,500	1,000	0	30,200	-23,200	-206,900
	2013	6.3	41%	0	100	400	300	0	20	4,400	1	5,200	320	430	22,000	160	22,900	6,600	800	0	30,300	-25,100	-232,000
	2014	6.2	41%	0	10	400	200	0	20	4,400	1	5,000	320	1,800	22,000	160	24,200	6,600	0	0	30,800	-25,800	-257,800
	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	0	0	30,800	-25,800	-283,600
	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	800	0	30,200	-23,700	-307,300
	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	1,400	0	30,500	-3,600	-310,900
	2018	9.1	59%	0	100	600	500	0	20	4,400	1	5,800	280	150	22,200	170	22,800	6,600	1,000	0	30,400	-24,800	-335,700
	Minimum	6.2	41%	0	10	300	100	0	10	2,100	1	3,300	170	0	10,300	100	13,800	6,300	0	0	20,400	-25,800	
	Maximum	36.2	235%	0	13,600	12,000	42,400	0	20	4,400	1	69,600	370	3,430	22,200	170	24,200	6,700	1,400	0	30,800	48,600	**Basin Yield**
	Average	**16.4**	**100%**	**0**	**2,400**	**3,100**	**8,600**	**0**	**20**	**3,600**	**1**	**17,500**	**270**	**1,800**	**17,300**	**140**	**18,500**	**6,500**	**360**	**0**	**26,400**	**-8,900**	10,600
			% of Total:	0%	14%	18%	49%	0%	0%	20%	0%		1%	7%	66%	1%		25%	1%	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	23,000	6,400	700	0	30,100	16,800	16,800
	2012	10.6	69%	0	50	1,300	1,200	0	20	4,400	1	7,000	310	300	22,000	160	22,700	6,500	1,000	0	30,200	-23,200	-6,400
	2013	6.3	41%	0	100	400	300	0	20	4,400	1	5,200	320	430	22,000	160	22,900	6,600	800	0	30,300	-25,100	-31,500
	2014	6.2	41%	0	10	400	200	0	20	4,400	1	5,000	320	1,800	22,000	160	24,200	6,600	0	0	30,800	-25,800	-57,300
	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	0	0	30,800	-25,800	-83,100
	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	800	0	30,200	-23,700	-106,800
	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	1,400	0	30,500	-3,600	-110,400
	2018	9.1	59%	0	100	600	500	0	20	4,400	1	5,800	280	150	22,200	170	22,800	6,600	1,000	0	30,400	-24,800	-135,200
	Minimum	6.2	41%	0	10	400	200	0	20	4,400	1	5,000	250	0	22,000	160	22,500	6,400	0	0	30,100	-25,800	
	Maximum	21.8	142%	0	7,500	7,700	27,300	0	20	4,400	1	46,900	320	1,800	22,200	170	24,200	6,700	1,400	0	30,800	16,800	**Basin Yield**
	Average	**11.8**	**77%**	**0**	**1,300**	**2,100**	**6,700**	**0**	**20**	**4,400**	**1**	**13,500**	**290**	**670**	**22,000**	**160**	**23,100**	**6,600**	**700**	**0**	**30,400**	**-16,900**	6,200
			% of Total:	0.0%	10%	16%	42%	0%	0%	33%	0.0%		1%	2%	72%	1%		22%	2%	0%			
																							Basin Yield
Projected Water Budget	2042	15.8	101%	0	2,400	4,400	8,300	0	20	4,900	1	20,000	340	510	24,700	220	25,800	6,800	300	0	32,900	-12,900	12,900
	2072	15.4	100%	0	2,300	4,200	8,000	0	20	5,400	1	19,900	340	510	26,800	220	27,800	7,000	100	0	34,900	-15,000	12,800
	Minimum	15.4	100%	0	2,300	4,200	8,000	0	20	4,900	1	19,900	340	510	24,700	220	25,800	6,800	100	0	32,900	-15,000	
	Maximum	15.8	101%	0	2,400	4,400	8,300	0	20	5,400	1	20,000	340	510	26,800	220	27,800	7,000	300	0	34,900	-12,900	
	Average	**15.6**	**101%**	**0**	**2,400**	**4,300**	**8,200**	**0**	**20**	**5,200**	**1**	**20,000**	**340**	**510**	**25,800**	**220**	**26,800**	**6,900**	**200**	**0**	**33,900**	**-13,900**	12,900
			% of Total:	0.0%	12%	22%	41%	0%	0%	26%	0.0%		1%	2%	76%	1%		20%	1%	0%			

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As shown on Figure 3-50, there was an accumulated reduction of groundwater in storage of 335,700 AF over the entire 38-year period, which is equal to an average deficit of 8,900 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 -200,500 AF during the 30-year period between 1981 and 2010. During the record drought that occurred between 2012 and 2016, an additional cumulative change in groundwater storage deficit of approximately 123,600 AF occurred; which is approximately 37 percent of the total cumulative change in storage during the historical period.

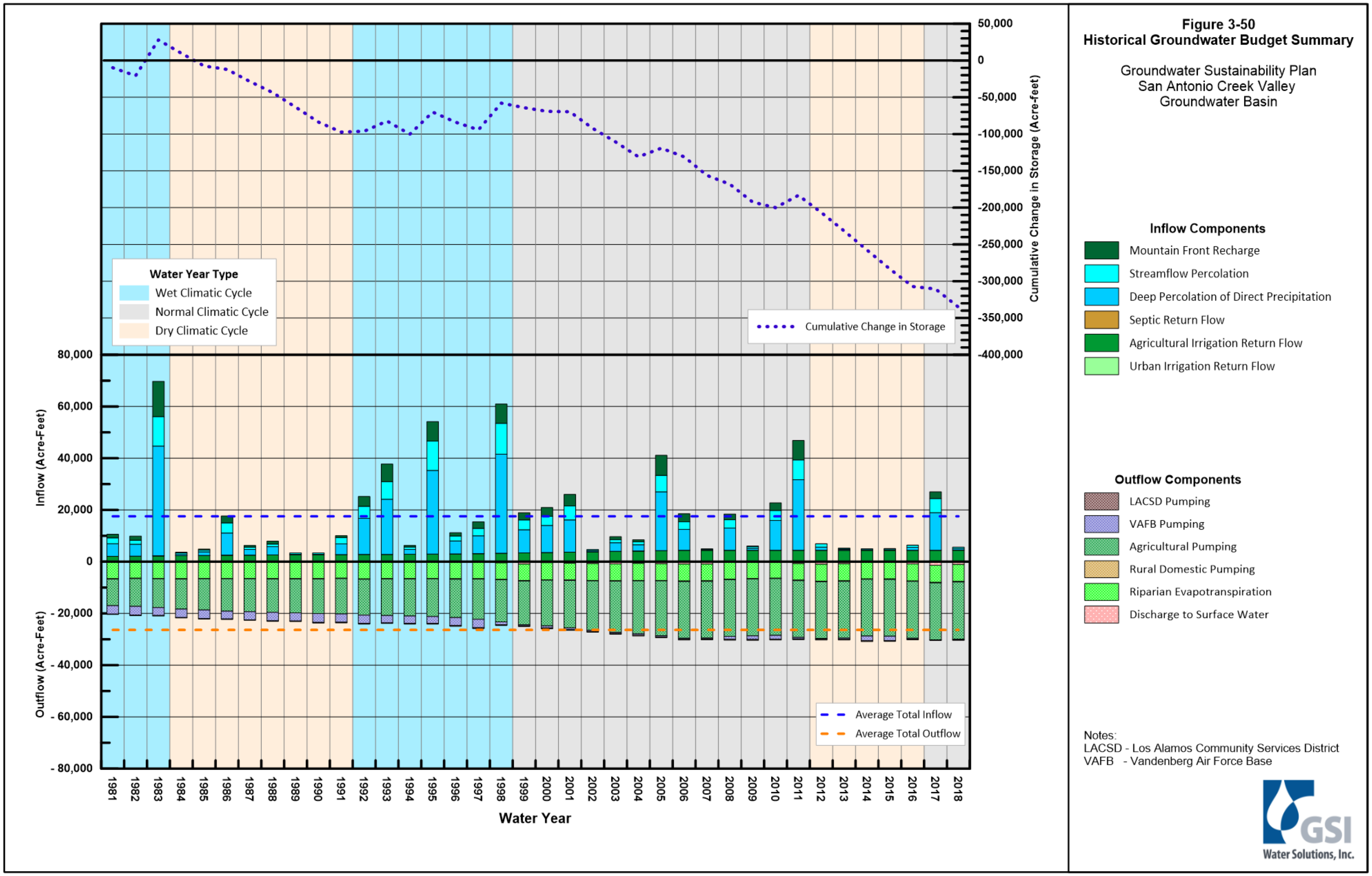


Figure 3-50. Historical Groundwater Budget Summary

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 2016, as depicted by the orange areas on Figure 3-50. 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 3-50. 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 periods from 1999 through 2011 and 2017 through 2018 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 agricultural land use. Table 3-17 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 335,700 AF occurred. The average annual groundwater storage loss was approximately 8,900 AFY.

Table 3-17. Groundwater Pumping and Agricultural Land Uses

Year	Crop Type	Acres	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

Crop type and acreage according to (USGS, 2020)
Crop water use factors according to (SYRWCD, 2010).

3.3.3.2.4. 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 3-14, 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 8,900 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 10,600 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. Sustainable management criteria and sustainable yield are included as Section 4 under separate cover.

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 the 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 82 percent of the historical average and percolation of direct precipitation averaged about 75 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.

3.3.4.1.1. Current Surface Water Inflow

Current local surface water supplies include surface water flows that enter the Basin from precipitation runoff within the watershed. Table 3-18 summarizes the annual average, minimum, and maximum values for these inflows.

Table 3-18. 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
Total[1]	3,300	—	—

Notes:

All values in acre-feet.

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

The estimated average total inflow from precipitation runoff over the current water budget period was approximately 3,300 AFY, or about 66 percent of the average annual 5,000 AFY of inflow during the historical period. The reduction in surface water inflows reflects the drought conditions that prevailed during the current water budget period.

3.3.4.1.2. 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 3-19. Reductions in surface water outflow for the current water budget period were similar to those reported for the surface water inflows.

Table 3-19. 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	0	7,100
Streamflow Percolation	2,100	400	7,700
Total[1]	3,900	—	—

Notes

All values in acre-feet.

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

3.3.4.1.3. Current Surface Water Budget

Figure 3-51 summarizes the current surface water budget for the Basin. Figure 3-51 shows the effects of the drought conditions that prevailed during the period 2011 through 2018. During this period, precipitation was below average, which resulted in reduced surface water flow.

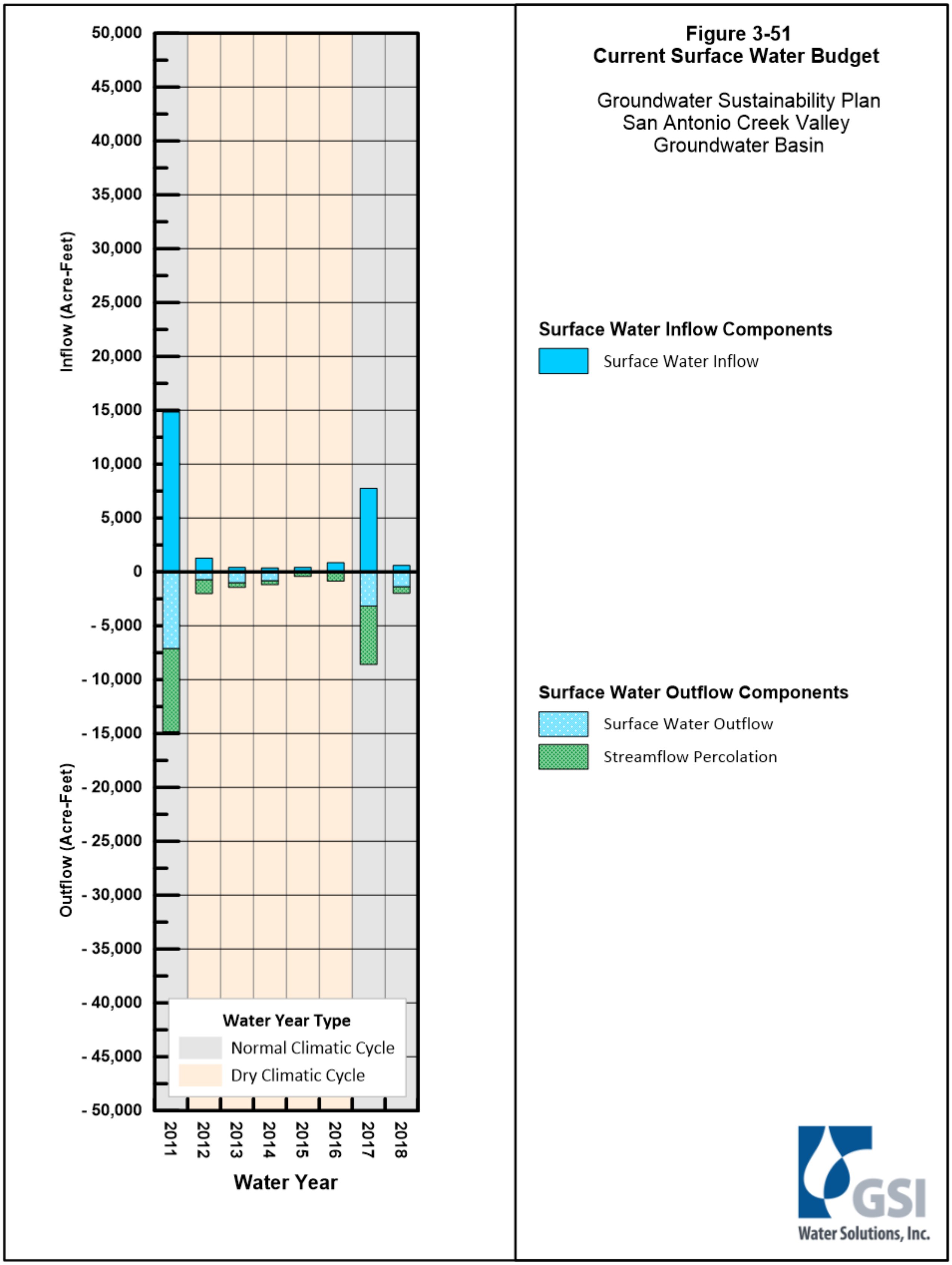


Figure 3-51. Current Surface Water Budget

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.

3.3.4.2.1. 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 3-20.

Table 3-20. Annual Groundwater Inflow, Current Period

Groundwater Inflow Component	Average	Minimum	Maximum
Mountain Front Recharge	1,300	10	7,500
Streamflow Percolation[1]	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[2]	13,500	—	—

Notes

All values in acre-feet.

[1] Streamflow Percolation includes San Antonio Creek percolation and tributary channel percolation.

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

For the current water budget period, 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 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.

3.3.4.2.2. 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 a 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 3-21.

Table 3-21. Annual Groundwater Outflow, Current Period

Groundwater Outflow Component	Average	Minimum	Maximum
Total Groundwater Pumping	23,100	22,500	24,200
Riparian Evapotranspiration	6,600	6,400	6,700
Groundwater Discharge to Surface Water[1]	700	0	1,400
Total[2]	30,400	—	—

Notes

All values in 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.

For the current water budget period, estimated total average groundwater outflows ranged from 30,100 AFY to 30,800 AFY, with an average annual outflow of 30,400 AF. This is a 15 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 3-22.

Table 3-22. Annual Groundwater Pumping by Water Use Sector, Current Period

Water Use Sector	Average	Minimum	Maximum
LACSD	290	250	320
VAFB	670	0	1,800
Agricultural	22,000	22,000	22,200
Rural Domestic	160	160	170
Total[1]	23,100	—	—

Notes

All values in acre-feet.

[1] 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

VAFB = Vandenberg Air Force Base

For the current water budget period, estimated total average groundwater pumping ranged from 22,500 AFY to 24,200 AFY, with an average pumping of 23,100 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. VAFB, 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.

3.3.4.2.3. Current Groundwater Budget and Change in Groundwater Storage

Average groundwater inflows and outflows for the current water budget period are presented on Figure 3-52 and a summary of annual groundwater inflows and outflows are presented on Figure 3-53. Inflow components are graphed above the zero line and outflow components are graphed below the zero line. Figure 3-53 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 red line shows the cumulative change in groundwater storage over the historical period.

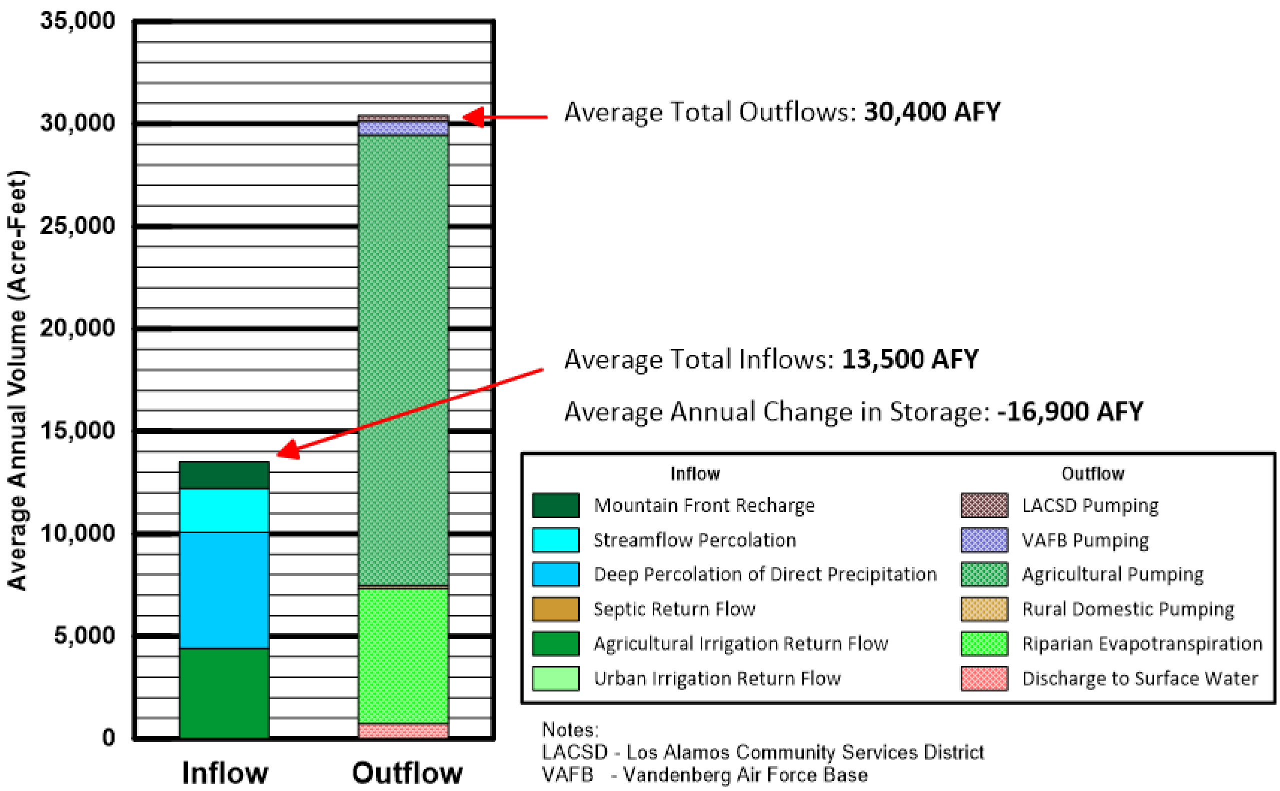


Figure 3-52. Current Groundwater Budget Average Volumes

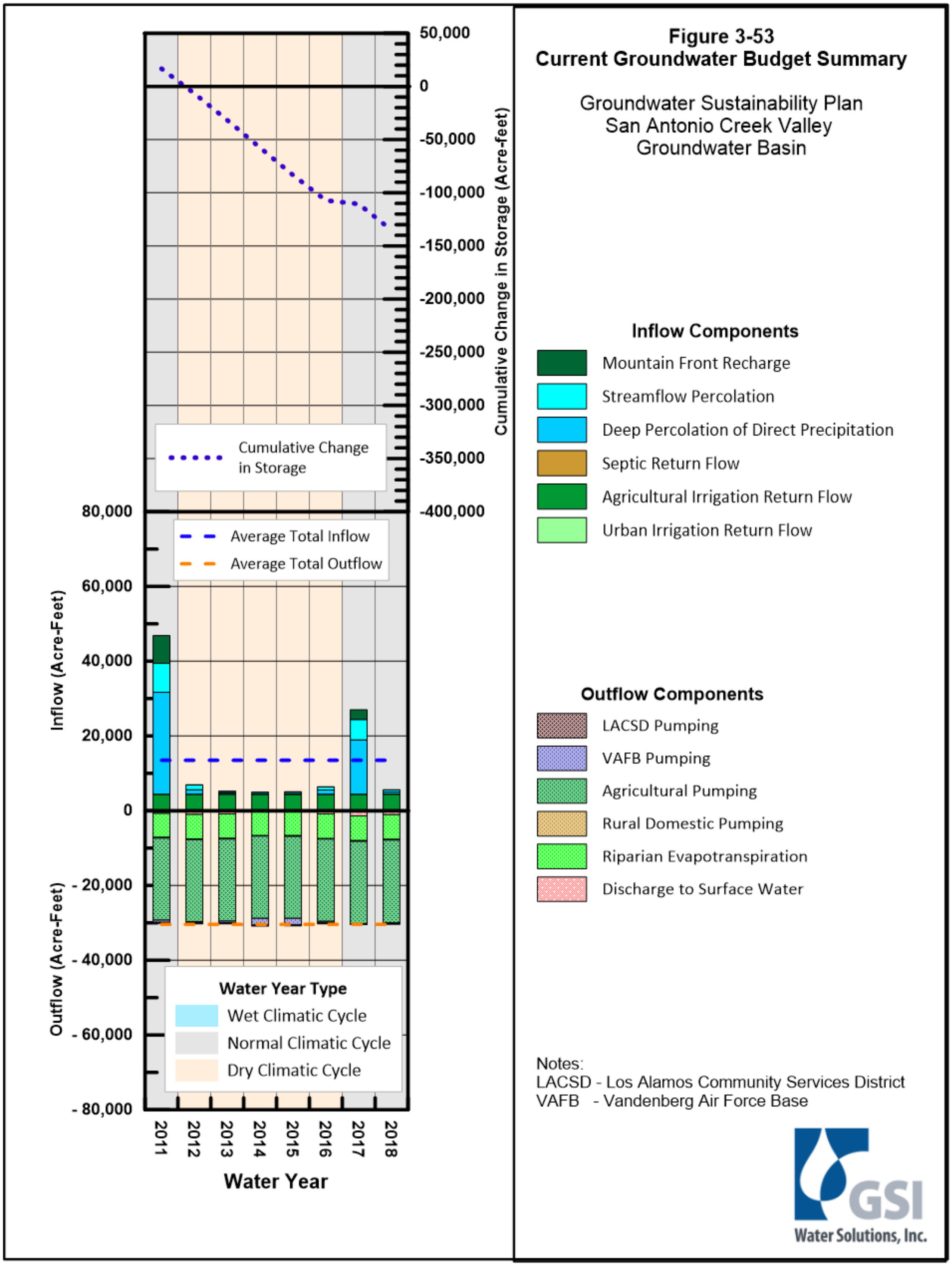


Figure 3-53. Current Groundwater Budget Summary

The current groundwater budget is strongly influenced by the recent drought 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, respectively, approximately 68 percent, 54 percent, and 66 percent lower than during the historical period. The average amount of total pumping was 18 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 135,200 AF occurred (Figure 3-53). The annual average groundwater in storage loss, or the difference between outflow and inflow to the Basin, was approximately 16,900 AFY.

3.3.4.2.4. 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 3-52, total groundwater pumping averaged approximately 23,100 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 (16,900 AFY) from the total average amount of groundwater pumping (23,100 AFY) to yield about 6,200 AFY. 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 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**

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

The SGMA regulations require the following regarding projected water budgets:

> "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."
>
> "Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology…"
>
> "Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand…"
>
> "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."

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 3.3.2.1.1, was calibrated to the DWR Variable Infiltration Capacity (VIC) hydrology model (discussed in Section 3.3.5.1.1 below) for 2030 and 2070 climate data to estimate surface and groundwater flow components for the projected water budget. Table 3-9 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 includes the effects of changing land use and water demand and effects caused by climate change.

3.3.5.1.1. 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.[4] Climate grid cells for precipitation and ET data are defined by 8-digit Hydrologic Unit Codes (HUCs) and streamflow climate grid cells are defined by the DWR Bulletin 118 groundwater basin boundaries (DWR, 2018). Precipitation and ET data used in this analysis were downloaded from the SGMA Data Viewer for climate grid cells within HUC 8-18060009. Streamflow 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). 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.

3.3.5.1.2. 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 (refer to Sections 3.3.2.1 and 3.3.2.2). Additionally, projected changes in climatic factors, including ET and precipitation (refer to Sections 3.3.5.1.1 and 3.3.5.1.4), were used to calibrate the USGS BCM, as outlined in Table 3-9.

3.3.5.1.3. Projected Agricultural, Municipal, and Industrial Pumping

Calculation methodologies for projected agricultural pumping and municipal and industrial (M&I) pumping are discussed in Section 3.3.5.3.1.

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

3.3.5.1.4. 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, 2016) (DWR, 2020) describe the use of climate change data to estimate projected hydrology. DWR has also provided SGMA Climate Change Data[5] and published a Guidance for Climate Change Data Use for Groundwater Sustainability Plan Development (DWR, 2018), 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 and ET 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).

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 5 percent and 5.6 percent in October and November,

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

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 percent and 11.5 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 September (22 percent) and January (17 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.

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. Table 3-23 summarizes the annual averages for the historical and projected water budgets.

Table 3-23. Annual Surface Water Inflows, Historical and Projected Periods

Surface Water Inflow Component	Annual Average		
	Historical Period	2042	2072
Inflow to Basin including San Antonio Creek and Tributaries	5,000	5,200	5,000

Note

All values in acre-feet.

Surface water inflows are projected to increase in the 2042 projected water budget by approximately 4 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 3.3.5.1.4 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 the San Antonio Creek west of Barka Slough and streamflow percolation into the groundwater system over the historical period. These annual average surface water outflows are summarized in Table 3-24.

Table 3-24. Annual Surface Water Outflows, Historical and Projected Periods

Surface Water Outflow Component	Annual Average		
	Historical Period	2042	2072
San Antonio Creek West of Barka Slough, Outflow from Basin	2,300	1,200	900
Streamflow Percolation	3,100	4,400	4,200
Total	5,400	5,600	5,100

Note

All values in acre-feet.

Future streamflow percolation is projected to increase by 42 percent and 35 percent, respectively, 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 decrease in surface water outflow is also the result of projected declining groundwater water levels and increased riparian ET.

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 3-25. Values reported in the table were estimated or derived from the data sources reported in Table 3-9.

Table 3-25. Annual Groundwater Inflows, Historical and Projected Periods

Groundwater Inflow Component	Annual Average		
	Historical Period	2042	2072
Mountain Front Recharge	2,400	2,400	2,300
Streamflow Percolation[1]	3,100	4,400	4,200
Deep Percolation of Direct Precipitation	8,600	8,300	8,000
Septic System Return Flow	20	20	20
Agricultural Irrigation Return Flow	3,500	4,900	5,400
Urban Irrigation Return Flow	1	1	1
Total	17,600	20,000	19,900

Notes

All values in acre-feet.

[1] Streamflow percolation includes San Antonio Creek and tributary channel percolation.

The total average annual groundwater inflow is 2,400 AF greater than the historical period average during the 2042 projected period, and 2,300 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 3-26 summarizes the historical and projected annual average groundwater outflows.

Table 3-26. Annual Groundwater Outflows, Historical and Projected Periods

Groundwater Outflow Component	Annual Average		
	Historical Period	2042	2072
Total Groundwater Pumping	19,500	25,800	27,800
Riparian Evapotranspiration	6,500	6,800	7,000
Groundwater Discharge to Surface Water	350	300	100
Total	26,400	32,900	34,900

Note

All values in acre-feet.

The total average annual groundwater outflow is estimated to be 6,500 AF greater during the 2042 projected period than the historical period average, and 8,500 AF greater during the 2072 projected period. Projected groundwater pumping is estimated to increase by 6,300 AF and 8,300 AF for the 2042 and 2072 projected periods, respectively. Riparian ET is also estimated to increase by 300 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.

3.3.5.3.1. 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, the two components of demand were considered: agriculture pumping and M&I pumping. This section describes the methods used to estimate these components through 2042, 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 1 percent annually. According to the United States Department of Agriculture (USDA) online Web Soil Survey tool,[6] 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 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. To calculate the future agricultural water demand for the 2042 and 2072 projected water budget periods, the 2020 water demand (AF/acre) was multiplied by the DWR VIC hydrology model climatic factors for the respective years and subsequently multiplied by the 2020 planted acres. Future agricultural water demand was calculated at 24,700 AF and 26,800 AF for 2042 and 2072, respectively.

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

- Historical demand records from the VAFB 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 2018 and projected values for 2042 and 2072 are presented on Table 3-27.

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

Table 3-27. Projected Water Demand Summary

Average Demand	Historical Period	2042	2072
Agricultural Demand			
Irrigation Demand	17,300	24,700	26,800
Municipal and Industrial Demand			
VAFB[1]	1,800	510	510
LACSD	270	340	340
Rural Domestic	140	220	220
Total M&I	2,210	1,070	1,070
Total	19,510	25,770	27,870
Change	--	6,260	8,360

Notes

Values in acre-feet per year

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

DWR = California Department of Water Resources
LACSD = Los Alamos Community Services District
M&I = municipal and industrial
SWP = California State Water Project
VAFB = Vandenberg Air 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 VAFB in 1997 via 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 VAFB will continue to receive SWP deliveries and the proposed Vandenberg Dune Golf Course Project will not be developed.

The delivery of imported SWP water to VAFB reduces VAFB'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 32 percent relative to the historical period, and further by a total of 43 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 3-54.

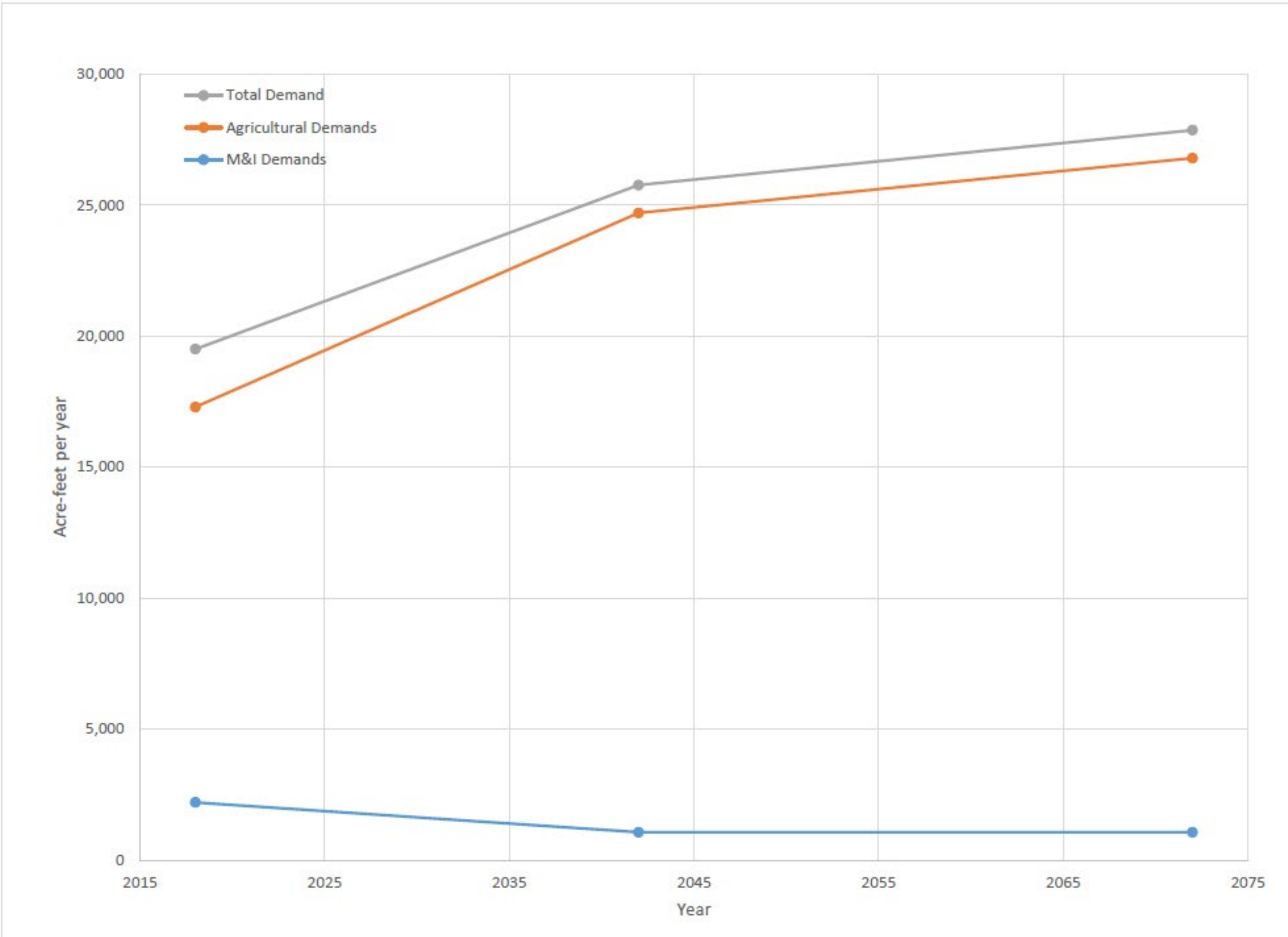


Figure 3-54. Projected Demand – Historical Period, 2042, and 2072

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 VAFB had requested. VAFB 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.

3.3.5.3.2. Projected Water Budget and Change in Groundwater Storage

Average groundwater inflows and outflows for the 2042 and 2072 projected periods are presented on Figure 3-55 and Figure 3-56, respectively. A summary of annual groundwater inflows and outflows are tabulated in Table 3-16 and Appendix E.

As discussed in Sections 3.3.5.2 and 3.3.5.3 above, 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 is equal to the historical period average annual precipitation for the 2042 projected period and—interestingly—2.6 percent greater than 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 14.3 percent and 13.7 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 32 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 45 percent and 69 percent during the 2042 and 2072 project periods, respectively, compared to the historical period.

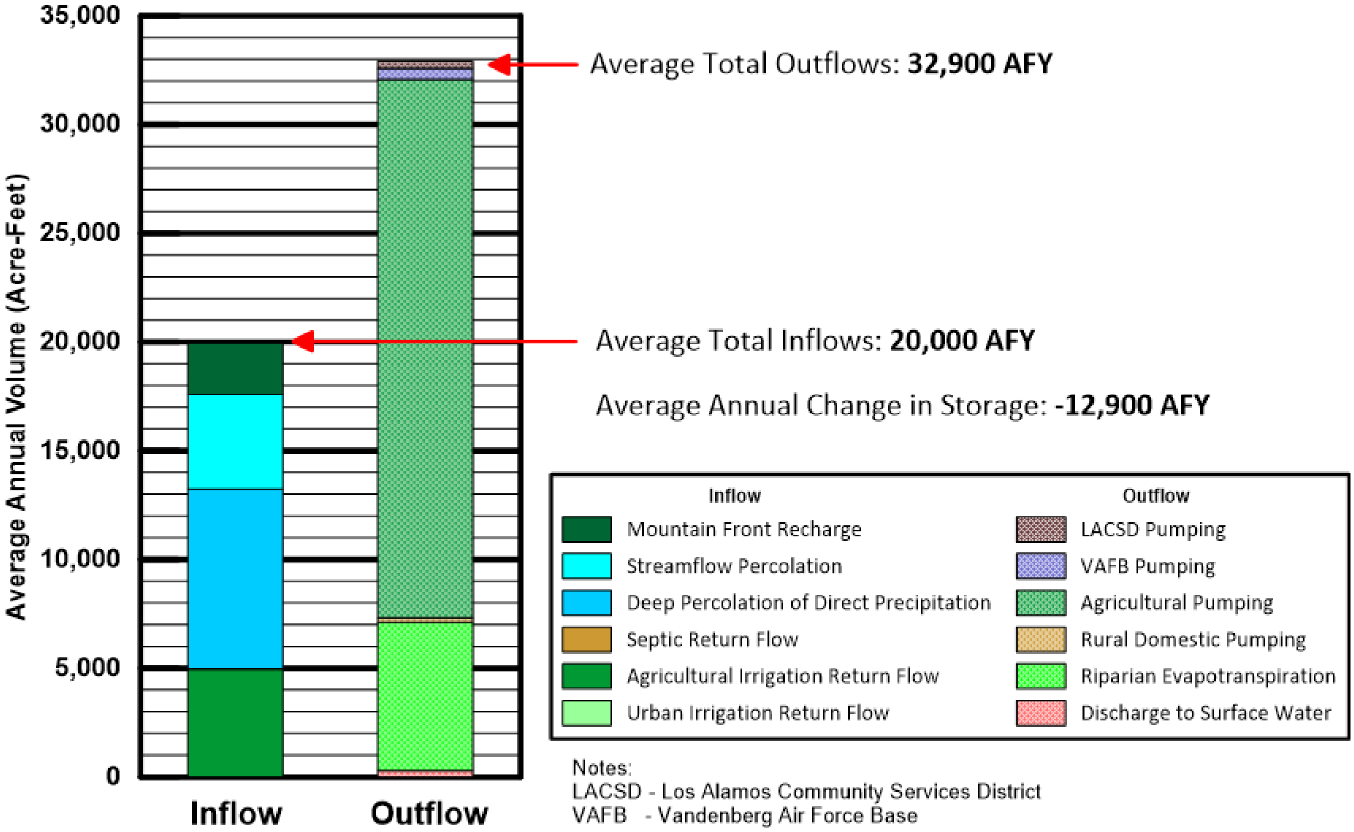


Figure 3-55. 2042 Projected Water Budget Average Volumes

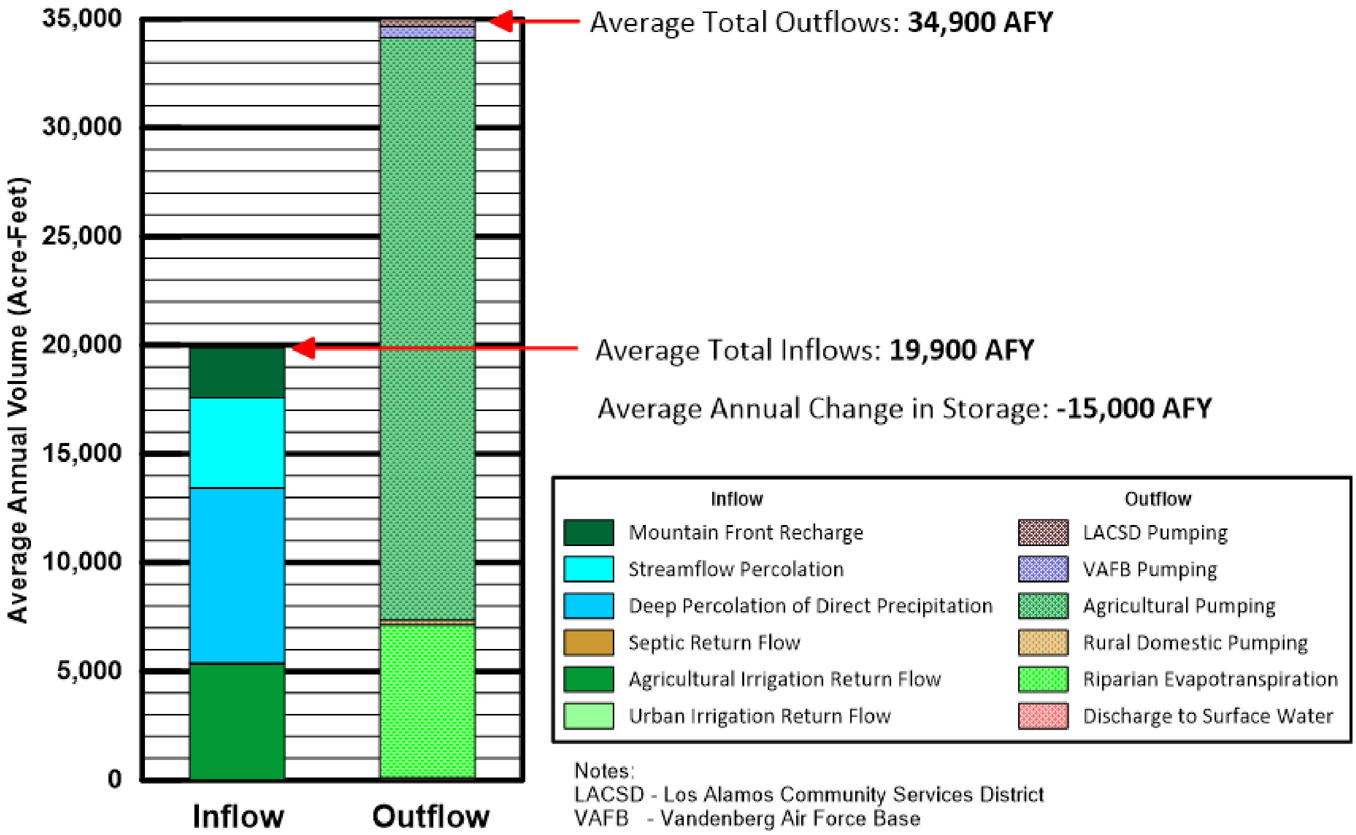


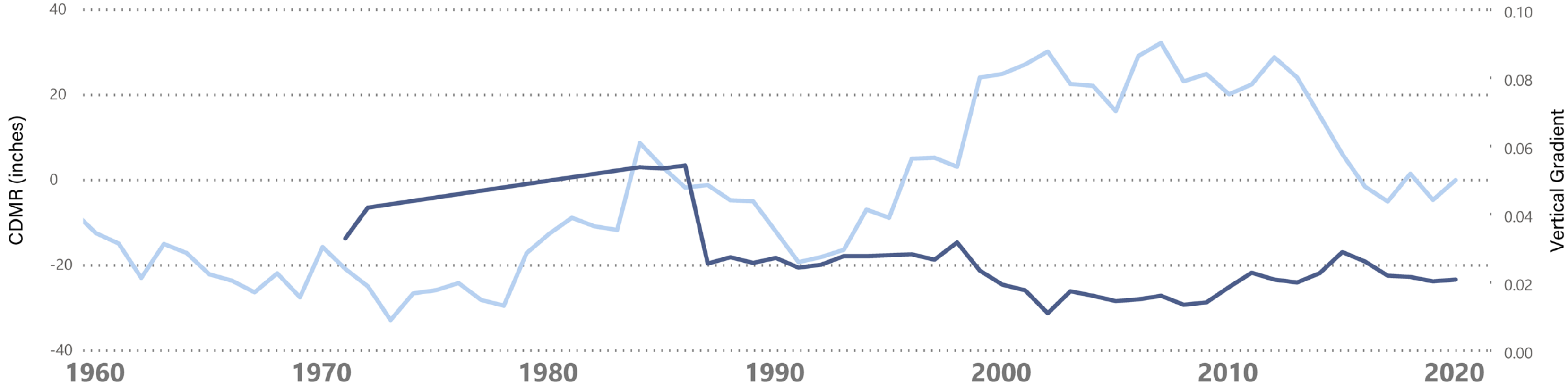
Figure 3-56. 2072 Projected Water Budget Average Volumes

3.3.5.3.3. 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 Formation Aquifer through the Barka Slough sediment and becoming surface water or available to phreatophytes. Groundwater levels in wells located near Barka Slough have decreased significantly over the period of record (40 feet [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 3-57 shows the reduction in vertical hydraulic gradient from nested groundwater wells 16C2 and 16C4 from 1970 through 2019. The cumulative departure from mean annual rainfall for the period from 1960 through 2019 is also shown on the figure.

Overview Map

16C2 and 16C4 Vertical Hydraulic Gradient- Careaga Sand Formation Aquifer



Cumulative Departure from Mean Annual Rainfall (inches)

Vertical Hydraulic Gradient

FIGURE 3-57

Vertical Hydraulic Gradient for Nested Groundwater Wells 16C2 and 16C4

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NOTES
Data Sources: Bing, ESRI, PowerBI
1. 16C2 and 16C4 are are a nested well set screened in the Careaga Sand Formation Aquifer.

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Figure 3-57. 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 increased streamflow percolation, agricultural pumping, and climate change effects, the projected water budget indicates a 14 percent and 71 percent decrease in groundwater discharge and a 57 percent and 58 percent decrease in surface water discharge to Barka Slough in 2042 and 2072, respectively.

3.3.5.3.4. 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.

Projected Basin Yield

The projected groundwater budget indicates that total outflows relative to total inflows in the Basin increase over time and contribute to a chronic overdraft condition. The projected average annual amount of groundwater in storage is estimated to decrease by approximately 45 percent and 69 percent during the 2042 and 2072 projected periods, respectively, compared to the historical period (as discussed in Section 3.3.5.3.2). 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 12,900 AFY, and 12,800 AFY for the 2072 projected period.

The estimated projected basin yield of 12,900 AFY and 12,800 AFY for the 2042 and 2072 projected periods, respectively, is 2,300 AFY and 2,200 AFY greater than the estimated basin yield for the historical period. This close comparison of basin yield values between the historical and projected periods indicates that projected future climate change is not expected to have a substantial 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 as well as the decrease in discharge of groundwater to surface water at Barka Slough.

The calculated basin yield of the Basin is a reasonable estimate of the long-term pumping that can be maintained without a long-term lowering of groundwater levels. The sustainable yield of the Basin will be estimated after an assessment of the sustainable management criteria and identification of potential undesirable results. Sustainable yield looks to the presence or absence of undesirable results, not strictly inflows and outflows. The sustainable yield can be determined only after undesirable results (Section 4.0), as defined by the six sustainability indicators (Section 3.3.1), have been shown to have not occurred. The basin and sustainable yield estimates may be revised in the future as new data become available during GSP implementation.

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 a calibrated 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 the USGS for its Groundwater Study, and made available to the San Antonio Basin Groundwater Sustainability Agency (GSA), 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. It is GSI's opinion that 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 Aquifer and 0.001 for the confined portion [Barka Slough area] of the Careaga Sand Formation Aquifer) (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 result compares very favorably 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 GSA). 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 the 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.

SECTION 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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