CITY OF ARROYO GRANDE CALIFORNIA 1911

COUNTY of SAN LUIS OBISPO

Arroyo Grande Subbasin Groundwater Sustainability Plan

Final

OCTOBER 2022

Arroyo Grande Subbasin Groundwater Sustainability Agencies

ARROYO GRANDE SUBBASIN

GROUNDWATER SUSTAINABILITY AGENCIES

Arroyo Grande Subbasin Groundwater Sustainability Plan

OCTOBER 2022

Prepared by Water Systems Consulting, Inc

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ACROYNMS & ABBREVIATIONS

AB	Assembly Bill
ADD	Average Day Demand
AF	Acre Feet
AFY	Acre Feet per Year
AMSL	Above Mean Sea Level
AG SUBBASIN	Arroyo Grande Groundwater Subbasin
BASIN PLAN	Water Quality Control Plan for the Central Coast AG Subbasin
BMP	Best Management Practices (DWR)
CAL POLY	California Polytechnic State University
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CASGEM	California State Groundwater Elevation Monitoring program
CCR	California Code of Regulations
CCRWQCB	Central Coast Regional Water Quality Control Board
CCGC	Central Coast Groundwater Coalition
CDFM	Cumulative departure from the mean
CDPH	California Department of Public Health
CIMIS	California Irrigation Management Information System
CITY	City of Arroyo Grande
COUNTY	County of San Luis Obispo
CPUC	California Public Utilities Commission
CPWS-52	Cal Poly Weather Station 52
CRWQCB	California Regional Water Quality Control Board
CWC	California Water Code
DDW	Division of Drinking Water
DU/AC	Dwelling Units per Acre
DWR	Department of Water Resources

EPA	Environmental Protection Agency
ET0	Evapotranspiration
°F	Degrees Fahrenheit
FAR	Floor Area Ratio
FY	Fiscal Year
GAMA	Groundwater Ambient Monitoring and Assessment program
GDE	Groundwater Dependent Ecosystem
GHG	Greenhouse Gas
GMP	Groundwater Management Plan
GPM	Gallons per Minute
GSA	Groundwater Sustainability Agency
GSC	Groundwater Sustainability Commission
GSP	Groundwater Sustainability Plan
GSWC	Golden State Water Company
HCM	Hydrogeologic Conceptual Model
HCP	Habitat Conservation Plan
IRWMP	San Luis Obispo County Integrated Regional Water Management Plan
ILRP	Irrigated Lands Regulatory Program
KWH	Kilowatt-Hour
LUCE	Land Use and Circulation Element
LUFTS	Leaky Underground Fuel Tanks
MAF	Million Acre Feet
MCL	Maximum Contaminant Level
MG	Million Gallons
MGD	Million Gallons per Day
MG/L	Milligrams per Liter
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MWR	Master Water Report

NCCAG	Natural Communities Commonly Associated with Groundwater
NCDC	National Climate Data Center
NCMA	Northern Cities Management Area
NOAA	National Oceanic and Atmospheric Administration
NWIS	National Water Information System
RW	Recycled Water
RWQCB	Regional Water Quality Control Board
SAGBI	Soil Agricultural Groundwater Banking Index
SB	Senate Bill
SGMA	Sustainable Groundwater Management Act
SGMP	Sustainable Groundwater Management Planning
SGWP	Sustainable Groundwater Planning
SLO BASIN	San Luis Obispo Valley Groundwater Basin
SLOFCWCD	San Luis Obispo Flood Control and Water Conservation District
SMCL	Secondary Maximum Contaminant Level
SMRVGB	Santa Maria River Valley Groundwater Basin
SOI	Sphere of Influence
SNMP	Salt and Nutrient Management Plan
SSURGO	Soil Survey Geographic Database
SWRCB	California State Water Resources Control Board
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
USDA-NRCS	United States Department of Agriculture – Natural Resources Conservation Service
USGS	United States Geological Survey
USFW	United States Fish and Wildlife Service
USTS	Underground Storage Tanks
UWMP	Urban Water Management Plan
UWMP ACT	Urban Water Management Planning Act

UWMP GUIDEBOOK	Department of Water Resources 2015 Urban Water Management Plan Guidebook
WCR	Well Completion Report
WCS	Water Code Section
WMP	Water Master Plan
WPA	Water Planning Areas
WRF	Water Reclamation Facility
WRCC	Western Regional Climate Center
WRRF	Water Resource Recovery Facility
WSA	Water Supply Assessment
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

ARROYO GRANDE GROUNDWATER SUSTAINABILITY PLAN DISCLAIMER / LIMITATIONS

The Arroyo Grande Subbasin (3-12.02) (Basin) is currently designated as a very low priority basin by the California Department of Water Resources Bulletin 118. Thus, the Basin is not required to be managed under a Groundwater Sustainability Plan or coordinated Groundwater Sustainability Plan pursuant to the Sustainable Groundwater Management Act (SGMA) (see e.g. Water Code Section 10720.7 and Water Code Section 10727) and Chapter 11. State Intervention of SGMA (Water Code Section 10735 et seq.) does not apply to the Basin. Nonetheless, and as authorized by subsection (b) of Water Code Section 10720.7, the County of San Luis Obispo (County) and the City of Arroyo Grande (City) have chosen to prepare the Arroyo Grande Subbasin Groundwater Sustainability Plan (GSP) for the limited purposes of better understanding Basin conditions and supporting future Habitat Conservation Plan efforts with the Arroyo Grande Creek Watershed Model. As such, an Implementation period start date has not been defined, but the County and City may choose to revisit GSP implementation should a change in subbasin conditions arise.

GROUNDWATER SUSTAINABILITY PLAN

Executive Summary

The Sustainable Groundwater Management Act (SGMA), Section 10720, et. seq., of the State Water Code, requires sustainable groundwater management in all high and medium priority basins. The Santa Maria River Valley - Arroyo Grande groundwater subbasin (DWR No. 3-012.02) (AG Subbasin) was designated as a high priority basin (DWR, 2016), and was reprioritized in 2019 to a very low priority basin (DWR, 2019).

The Santa Maria River Valley - Arroyo Grande groundwater subbasin (AG Subbasin) was originally part of the non-adjudicated “fringe” areas of the adjudicated Santa Maria River Valley Groundwater Basin (DWR No. 3-012), which was designated as a high priority basin (DWR, California's Groundwater: Bulletin 118 - Interim Update 2016, Working Towards Sustainability, 2016), but due to the final results of the DWR’s groundwater basin boundary modifications in 2019, the AG Subbasin and Santa Maria River Valley – Santa Maria (No. 3-012.01) groundwater subbasin (Santa Maria Subbasin) were established as separate subbasins within the previously designated Santa Maria River Valley Basin (No. 3-012). The AG Subbasin was then reprioritized as very low priority (DWR, 2019).

IN THIS SECTION

Introduction

San Luis Obispo County (County) and the City of Arroyo Grande (City), entered into a Memorandum of Agreement (MOA) regarding preparation of a GSP for the AG Subbasin effective as of October 6, 2020. The MOA's purpose is for the City and County to coordinate preparation of a single GSP for the entire AG Subbasin pursuant to SGMA and other applicable provisions of law.

Because of the AG Subbasin's very low prioritization, SGMA does not require the development of a GSP for the AG Subbasin. However, the AG Subbasin GSAs are proceeding with the development of a GSP to assure continued sustainable conjunctive management of groundwater and surface water supplies. Work efforts included in the GSP development are important for informing the future water resource management of the AG Subbasin and interconnected surface waters of the Arroyo Grande Creek watershed that overlie the subbasin. In the AG Subbasin, there are several federally listed endangered species that are impacted by the Lopez Project which includes the Lopez Lake (i.e., Lopez Reservoir) and the Lopez Terminal Reservoir. Due to the requirements of the Endangered Species Act, the San Luis County Flood Control and Water Conservation District (District) Zone 3 (FC Zone 3) that operates the Lopez Project is currently developing a Habitat Conservation Plan (HCP). The HCP will characterize the impacts the Lopez Project operations on the endangered species within the Arroyo Grande Creek watershed. The HCP will also likely include an adaptive downstream release strategy that will satisfy and sustainably manage competing demands of the water supply contracts, the appropriate downstream releases for groundwater recharge, and in-stream flow requirements all within the safe yield of the reservoir. Through the development of this GSP, a set of computer modeling management tools will be developed to support the HCP to evaluate the relationship between flow in AG Creek due to reservoir releases and groundwater uses in the subbasin through pumping.

Plan Area

The AG Subbasin lies in the southern portion of San Luis Obispo County. The AG Subbasin is approximately seven miles long, oriented in a northeast-southwest direction, extending from Lopez Dam to the boundary of the Adjudicated Area of the Santa Maria Subbasin (approximately coincident with the Wilmar Avenue Fault and Highway 101). The tributary valley of Tar Spring Creek is about three miles long, oriented east-west, and joins Arroyo Grande Creek about three miles upstream of Highway 101. Below Lopez Lake where the AG Subbasin lies, the valleys of gentle flatlands and rolling hills ranging in elevation from approximately 100 to 500 feet above mean sea level are prominent. Average annual precipitation ranges from approximately 16.1 inches near Highway 101 to about 19.1 inches in higher elevation areas near Lopez Lake. The AG Subbasin is composed of two distinct valleys, with the Arroyo Grande Creek Valley in the north and the Tar Spring Creek Valley in the southeast.

The County, City and State have land use authority in the AG Subbasin within their respective jurisdictions. Land use information for the AG Subbasin was based on DWR's land use database (DWR, California's Groundwater: Bulletin 118 - Interim Update 2016, Working Towards Sustainability, 2016). The 2016 land use in the AG Subbasin is shown on Table 3-1 and is summarized by group in Figure 3-2. All land use categories except native vegetation listed in Table 3-1 are provided by DWR (DWR, California's Groundwater: Bulletin 118 - Interim Update 2016, Working Towards Sustainability, 2016). The areas of the basin that did not have a land use designation were assumed to be native vegetation.

Water users in the AG Subbasin utilize two types of water sources to meet the demands: groundwater and surface water. Lopez Dam impounds 70 square miles of the upper Arroyo Grande Creek watershed forming Lopez Lake (i.e., Lopez Reservoir). The Lopez Dam was built to provide an additional water supply to reduce the reliance on groundwater, as well as provide recreation opportunities, which was a requirement of the State grant. Lopez Reservoir has a storage capacity of 49,388 acre-feet and an approximate dependable yield of 8,730 acre-feet that is distributed as municipal diversions (4,530 acre-feet) and downstream releases (4,200 acre-feet).

The municipal diversions are transported from Lopez Reservoir to the Lopez Terminal Reservoir through a pipeline. Water stored at the Lopez Terminal Reservoir is held for DDW regulation residence time requirements and subsequently treated onsite at the Lopez Water Treatment Plant before being delivered to Zone 3 municipal agencies. The Lopez Water Treatment Plant has the capacity to treat up to 6 MGD. These municipal agencies include the City, City of Grover Beach, City of Pismo Beach, Ocean Community Services District, and County Service Area 12 (Avila). Table 32 summarizes the contract entitlements for each Zone 3 municipal agency. The downstream releases are discharged from the base of the dam into Arroyo Grande Creek. These downstream releases are used to maintain environmental flows within Arroyo Grande Creek throughout the year to maintain natural seasonal variability in Arroyo Grande Creek for habitat and wildlife purposes and provide groundwater recharge for irrigated crop production.

The Arroyo Grande Creek Valley includes part of the City of Arroyo Grande jurisdictional boundaries, while the remainder of the Arroyo Grande Creek Valley is unincorporated land. Land use in the City boundary is primarily single- and multi-family residential with some agricultural. The majority of the AG Subbasin along Arroyo Grande Creek has significant areas of irrigated agriculture, primarily truck, nursery, and berry crops.

The predominant groundwater use in the AG Subbasin is pumping for agricultural supply. Approximately 50% of land in the Subbasin is used for agriculture. Agricultural pumping accounts for over 90% of pumping in the subbasin. A variety of crops are grown in the AG Subbasin. Most agricultural production in the AG Subbasin relies on groundwater for irrigation supply, although some have riparian water rights along Arroyo Grande Creek. The City of Arroyo Grande does not have any active supply wells located in the AG Subbasin. Most of the City's productive supply wells are located in the NCMA portion of the Santa Maria Subbasin

(GSI, 2021). Private domestic residential wells in the AG Subbasin are used for local potable supply. These entities are discussed in more detail in Chapter 3.0 of this report.

Basin Setting

The physical definition of the AG Subbasin boundary is the contact between the unconsolidated or loosely consolidated sediments of Recent alluvium with the Pismo Formation, Monterey Formation, and Franciscan Assemblage. The alluvial sediments of the Arroyo Grande Creek Valley range up to 120-140 feet thick atop bedrock, while along Tar Springs Creek Valley the alluvial sediments range up to 80-100 feet thick.

For the purpose of this GSP, the geologic units in the AG Subbasin and vicinity may be considered as two basic groups; the AG Subbasin alluvial sediments and the consolidated bedrock formations surrounding and underlying the AG Subbasin. The consolidated bedrock formations range in age and composition from (1) Jurassic-aged serpentine and marine sediments to (2) Tertiary-aged marine and volcanic depositions. Compared to the saturated sediments that comprise the AG Subbasin aquifer, the consolidated bedrock formations are not considered to be significantly water-bearing. Although bedding plane and/or structural fractures in these rocks may yield economically usable amounts of water to wells, they do not represent a significant portion of the pumping in the area.

Groundwater levels and quality are currently measured in the AG Subbasin by the SLOFCWCD and a variety of other agencies as described in the body of this GSP. The Water Resources Division of the SLO County Public Works maintains eight (8) real-time data monitoring stream gages within the Arroyo Grande Creek watershed. Three out of the eight stream gages are located within the Arroyo Grande Subbasin that include Rodriguez, Cecchetti, and Arroyo Grande Creek.

Cross Sections are presented in Chapter 4 along the Arroyo Grande Creek Valley axis and along the Tar Spring Creek Valley axis. In the Arroyo Grande Creek Valley, land surface elevations range from about 350 ft MSL to about 100 ft MSL, and the thickness of alluvium is relatively constant at about 100 to 150 feet thick. It is observed that a significant contiguous strata comprised predominantly of clay is present and interpreted to extend from the vicinity of the Wilmar Avenue Fault to the northwest to about two miles downstream from Lopez Dam, ranging in thickness from about 10 to 50 feet. The presence of this clay layer may have implications regarding the understanding of direct percolation of streamflow throughout the AG Subbasin. The contiguous clay strata that are observed appears to pinch out about two miles downstream of Lopez Dam. Southwest of the Wilmar Avenue Fault, the alluvial sediments are directly underlain by the Paso Robles Formation, which overlies Franciscan Assemblage bedrock. Northeast of the Wilmar Avenue Fault, the Alluvium is underlain by bedrock of the Obispo Formation, Monterey Formation, and Pismo Formation, successively. The Wilmar Avenue Fault is not interpreted to displace the Alluvium, nor to create a significant hydrogeologic barrier to groundwater flow in the Alluvium.

The cross section along the Tar Spring Creek Valley axis from its confluence with Arroyo Grande Creek to the upgradient extent of the AG Subbasin indicates land surface elevation ranging from approximately 150 feet AMSL at Arroyo Grande Creek to about 350 feet AMSL at the eastern edge of the section. Thickness of the Alluvium ranges from about 50 to 100 feet along Tar Spring Creek. A 10- to 20-foot-thick layer of alluvial strata comprised primarily of clay is observed near land surface in the lithologic data used to generate this section and is interpreted to extend contiguously along the length of Tar Spring Creek. The Edna Fault is mapped in bedrock beneath the alluvium at the eastern extent of the section, emplacing Monterey Formation bedrock west of the fault against Franciscan Group bedrock east of the Fault. These faults displace the bedrock formations but is not interpreted to displace the Recent Alluvium.

Groundwater Conditions

Data describing transmissivity, specific capacity, and air lift tests from water wells throughout the AG Subbasin are compiled and presented in Chapter 5 of this GSP. The data was obtained from previous regional studies or reports, well completion reports, previous pumping tests, and well service information provided by local stakeholders. All available reports and documents that were made available through data requests, report reviews, etc., were reviewed for technical information, and included in this summary if the data were judged to be sufficient.

Well yields reported in the various data sources reviewed for this GSP range from 10 gpm to 500 gpm. In general, well yields in the Subbasin are sufficient to supply domestic and agricultural requirements in the Subbasin.

Surface water/groundwater interactions represent a significant portion of the water budget of the AG Subbasin aquifer system. In the AG Subbasin, these interactions occur primarily as a function of releases from Lopez Dam to Arroyo Grande Creek, and to a lesser degree in the course of natural flows in Tar Spring Creek. The watersheds support important habitat for native fish and wildlife, including the federally threatened South-Central California Coast steelhead (*Oncorhynchus mykiss).*

Groundwater interaction with streams in the AG Subbasin is not well quantified, but it is recognized as an important component of aquifer recharge in the water budget. Where the water table is above the streambed and slopes toward the stream, the stream receives groundwater flow from the aquifer; this is known as a gaining reach (i.e., the stream gains flow as it moves through the reach). Because there is always some amount of flow released to Arroyo Grande Creek to support fish populations in the stream, it is thought that the streamflow in Arroyo Grande Creek is in hydraulic communication with the groundwater in the surrounding aquifer, maintaining groundwater levels in the vicinity of the creek at levels approximately equivalent to the surface water levels in the creek. Some areas may receive inflow from the aquifer, and some reaches may discharge to the aquifer, but along Arroyo Grande Creek they are always in communication. Along Tar Spring Creek, by contrast, where the water table is beneath the streambed and slopes away from the stream, the stream loses water to the aquifer; this is known as a losing reach. During seasonal dry flow conditions, groundwater elevations are deeper than the streambed since no base flow is present in the creek. Therefore, it is generally understood that the streams in the AG Subbasin discharge to the underlying aquifer, at least in the first part of the wet-weather flow season. If there is constant seasonal surface water flow, it is possible that groundwater elevations may rise to the point that they are higher than the stream elevation, and the creek may become a seasonally gaining stream in some reaches.

In general, the primary direction of groundwater flow in the Subbasin is from the areas of highest groundwater elevations (Lopez Dam on the northern Subbasin boundary and Tar Spring Creek at the eastern boundary) to where the flow leaves the Subbasin near Highway 101. Groundwater in the Arroyo Grande Creek Valley flows south-southwest and parallel to the valley axis, while groundwater in the Tar Spring Creek valley flows west along the tributary valley and into the Arroyo Grande Creek valley. Groundwater Elevation maps for years 1954, 1975, 1985, 1995, 1996, 2015, and 2020 are presented in Chapter 5. Changes is groundwater elevation ranging from about 20 feet of decline to 20 feet of rise are observed between periods of significant drought and periods of greater than average precipitation.

Groundwater elevation hydrographs are presented for 6 wells in the Subbasin, with periods of record ranging from about 22 years to about 65 years. These hydrographs indicate fluctuating groundwater elevations that reflect periods of drought and periods of greater rainfall. However, the hydrographs do not indicate any persistent trends of declining water levels over the periods of record. The hydrographs illustrate that seasonal water level fluctuations dominate the water level trends, with seasonal fluctuations up to +/- 20 feet (although some of this fluctuation may be due to nearby pumping).

Potential Groundwater Dependent Ecosystems (GDEs) are identified by performing a desktop GIS analysis wherein the Natural Communities Commonly Associated with Groundwater (NCCAG) is overlain with groundwater elevation data from spring 2015. Areas in which the NCCAG dataset intersect with areas in which depth to groundwater is less than 30 are identified as potential GDEs, and these results are presented in Chapter 5 of this GSP. No field work was performed to confirm this desktop analysis.

Water quality of groundwater in the Subbasin was evaluated using existing state and federal databases. The primary water quality constituents of concern identified in the subbasin are Total Dissolved Solids (TDS) and nitrates. TDS is a constituent of concern in groundwater because it has been detected at concentrations greater than its RWQCB Subbasin Objective of 800 mg/l in the Subbasin, and greater than the published federal Secondary Drinking Water maximum Contaminant Level (MCL). Secondary MCLs been established for color, odor, and taste, rather than human health effects. This Secondary MCL includes a recommended standard of 500 mg/L, an upper limit of 1,000 mg/L and a short-term limit of 1,500 mg/l. TDS water quality results ranged from 170 to 2,360 mg/l with an average of 1,003 mg/l and a median of 810 mg/l.TDS concentrations are lowest in the first few miles of the subbasin below Lopez Dam, with concentrations ranging up to 750 mg/L. Further south in the subbasin, near the Wilmar Avenue

Fault, TDS concentration greater than 1,500 mg/L are observed. No time series data indicate any trends of rising TDS concentrations in the subbasin.

Nitrate is a widespread contaminant in California groundwater. Although it does occur naturally at low concentrations, high levels of nitrate in groundwater are commonly associated with agricultural activities, septic systems, confined animal facilities, landscape fertilizers and wastewater treatment facilities. Nitrate is the primary form of nitrogen detected in groundwater. It is soluble in water and can easily pass-through soil to the groundwater table. Nitrate can persist in groundwater for decades and accumulate to high levels as more nitrogen is applied to the land surface each year. It is a Primary Drinking Water Standard constituent with an MCL of 10 mg/l of nitrate as nitrogen (as N). Nitrate is a constituent of concern in groundwater because it has been detected at concentrations greater than its RWQCB Subbasin Objectives of 10 mg/l (as N) in the Subbasin. The Nitrate (as N) MCL has been established at 10 mg/l. Overall, nitrate water quality results ranged from below the detection limit to 67 mg/l (as N) with an average of 2.5 mg/l (as N) and a median value of 0.4 mg/l (as N). Although time series data for nitrate concentrations in groundwater within the Subbasin are sparse, the available data indicate occasional spikes in nitrate concentrations, but no persistent trends of increasing nitrate concentrations with time.

Water Budget

Detailed annual groundwater and surface water budgets for the Subbasin are presented in Chapter 6 of this GSP. These water budgets include all significant components of groundwater inflow in the Subbasin, including precipitation, streamflow, agricultural and domestic groundwater pumping, inflow from contributing watershed area, evapotranspiration, urban and agricultural return flows, septic return flows, stream percolation, mountain front recharge, and subsurface outflow. Estimates of total groundwater in storage in the Subbasin were calculated for nine specific years during the historical base period, and ranged from 10,400 acre-feet to 15,200 acre-feet. The average change of groundwater in storage in the alluvial aquifer within the Subbasin from WY 1988 to 2020 is -10 acre-feet per year. This indicates that there have been no significant cumulative or persistent storage declines over the historical base period. Therefore, the Arroyo Grande Subbasin is not in overdraft. A preliminary sustainable yield estimate of 2,500 acre-feet per year is presented for the Subbasin.

Monitoring Network

Monitoring is a fundamental component of the GSP necessary to identify impacts to beneficial uses or Basin users, and to measure progress toward the achievement of any management goal. The monitoring networks must be capable of capturing data on a sufficient temporal and spatial distribution to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface water conditions, and to yield representative information about groundwater conditions for GSP implementation.

The monitoring network must provide adequate spatial resolution to properly monitor changes to groundwater and surface water conditions relative to measurable objectives and minimum thresholds within the Basin. The network must also provide data with sufficient temporal resolution to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface water conditions.

A proposed monitoring network of 13 wells distributed throughout the Subbasin is presented in Chapter 7 of this GSP. This monitoring network is intended to document general conditions throughout the Subbasin for the purposes of developing groundwater elevation maps and hydrographs. Four of these wells are identified as Representative Monitoring Sites (RMSs) for the Sustainable Management Criteria (SMCs) of Chronic Water Level Decline and Decline of Groundwater in Storage. Three of these wells are identified as RMSs for the SMC of Interconnected Surface Water Depletion. Seven wells are identified as RMSs for the SMC of Water Quality Degradation. In addition, three existing stream gage sites in the Subbasin are included as monitoring network for surface water flow conditions in the Subbasin.

Sustainable Management Criteria

Defining Sustainable Management Criteria (SMC) requires technical analysis of historical data, and input from the affected stakeholders in the Basin. Data and methods used to develop the SMC are presented, and discussion is included describing how they influence beneficial uses and users. The SMCs presented in this GSP are based on currently available data and application of the best available science. Data gaps exist in the hydrogeologic conceptual model, and uncertainty caused by these data gaps was considered when developing the SMC. Due to uncertainty in the hydrogeologic conceptual model, these SMCs are considered initial criteria and will be reevaluated and potentially modified in the future as new data become available.

The SMCs include definition of Measurable Objectives (MOs), Minimum Thresholds (MTs), and undesirable results. These criteria define the future sustainable conditions in the Basin and guide the GSAs in development of policies, implementation of projects, and promulgation of management actions that will achieve these future conditions.

SMCs are developed for the following Sustainability Indicators, which are applicable in the Basin:

1. Chronic lowering of groundwater elevations
2. Reduction in groundwater storage
3. Degraded water quality
4. Land subsidence
5. Depletion of interconnected surface water

The sixth Sustainability Indicator, sea water intrusion, only applies to coastal basins, and is not applicable in the Basin.

Figures displaying the locations of the RMSs at which SMCs will be evaluated are presented in Chapter 7.

MTs for the first two Sustainability Indicators, chronic lowering of groundwater elevations and reduction of groundwater in storage, are defined as minimum groundwater elevations as measured in the four wells established as Representative Monitoring Sites in the Basin. MOs are defined as goals considered to be achievable after evaluation of historical data in the period of record for each RMS, and Interim Milestones (IMs) are interim goals to be assessed every 5 years when the GSPs are revised. These SMCs are presented in Table ES-1. All SMCs were developed after stakeholder input during public meetings, and public comment to published draft chapters of the GSP. Due to the recent historical drought conditions being experienced in the Subbasin, the most recent water level data collected was the lowest water level observed in the period of record for three of the four RMS wells. Since drought conditions may continue, the decision was made to define the MTs at a level five feet lower than the lowest observed water level in the period of record; this would avoid the possibility of immediately being in exceedance of the MTs at the next monitoring event should the drought continue. It is the opinion of the GSAs that this nominal decrease in water levels should the drought continue will not result in significant or unreasonable conditions that are detrimental to the Subbasin, and water levels will rebound above the MTs when the drought ends.

SMCs for these two Sustainability Indicators are summarized in Table ES-1.

Table ES-1. Summary of MTs, Mos, and IMs for Arroyo Grande Subbasin RMSs

RMS	MT	MO	2021 WL	2027 IM	2032 IM	2037 IM	Sustainability Indicator
Arroyo Grande Creek Valley							
AGV-01	326	335	331	332	334	335	Water Levels/Storage/ISW
AGV-03	284	315	306	309	312	315	Water Levels/Storage
AGV-06	190	208	195	199	204	208	Water Levels/Storage/ISW
AGV-12	114	127	119	122	124	127	Water Levels/Storage/ISW

Note: All water level and interim milestone measurements refer to fall measurements.

MTs for the third Sustainability Indicator, degradation of water quality, are based on existing water quality regulatory criteria as measured in the nine wells established as water quality Representative Monitoring Sites (RMSs) in the Basin. (For water quality SMCs, MTs are equal to MOs). Identified potential contaminants of concern are TDS and nitrates. TDS has no primary MCL, but a water quality goal of 800 ppm is promulgated in the RWQCB Basin Plan; the MT for the constituent TDS was set at this level, unless historical data indicate that TDS has never been measured below this criteria; in that case, the SMC was set to 900 ppm. These SMCs are presented in Table ES-2. All SMCs were developed after considerable stakeholder input during public meetings, and public comment to published draft chapters of the GSP. SMCs for these two Sustainability Indicators are summarized in Table ES-2 below.

Table ES-2. Arroyo Grande Subbasin Water Quality Minimum Thresholds

ID	TDS MT (ppm)	NO3 MT (ppm)
WQ-1	800	10
WQ-2	800	10
WQ-3	800	10
WQ-4	800	10
WQ-5	800	10
WQ-6	900	10
WQ-7	900	10

MTs for the fourth Sustainability Indicator, land subsidence, are based on data collected under the California state program of InSAR data, which measures land subsidence from space using satellite technology. There is no current measurable subsidence in the Basin. The MT is defined as no more than 0.1 feet of subsidence due to groundwater extraction in any given year, and a cumulative measured subsidence of 0.5 feet in any 5-year period.

MTs for the fifth Sustainability Indicator, depletion of interconnected surface water (ISW), were defined based on the language in SGMA that allows groundwater levels to be used as a proxy in place of the actual measurement of groundwater/surface water (GW/SW) flux, which is difficult to accurately quantify. A Darcy's Law analysis is presented to support the use of groundwater elevations as a proxy measurement for this SMC, recognizing that the difference in elevation between the surface water and the groundwater largely defines flux between the two. Three RMS wells identified in the Basin are located immediately adjacent to Arroyo Grande Creek and were selected as appropriate RMS wells for ISW. These three wells have groundwater elevation data for a substantial period of record which indicate that there have been no trends of significantly declining water levels in these areas. However, due to the current historical drought conditions being experienced in the Subbasin, the most recent depth to water measurements in these wells is the lowest observed in the period of record. For this reason, MTs were defined water levels were set to a level 5 feet below the recent lowest water levels in the period of record; this is intended to avoid having undesirable conditions in the first monitoring event after submission of the GSP, should drought conditions continue. The management goal of the GSP for these wells is to prevent significant and undesirable conditions due to groundwater management activities. It is the opinion of the GSAs that this nominal decrease in water levels allowed by this MT, should the drought continue, will not result in significant or unreasonable conditions that are detrimental to the Subbasin, and water levels will rebound above the MTs when the drought ends. Measurable Objectives, which define the goal to which management activities will strive to attain, were defined as equal to the average Spring water level from 2015 through 2021.

Projects and Management Actions

Because the Arroyo Grande Subbasin is not judged to be in overdraft, there are no significant civil engineering projects required to help water levels recover, or reduce demand. However, some projects and management actions are recommended to maintain Subbasin data collection, address data gaps, and to better understand conditions within the riparian corridor.

Habitat Conservation Plan. The District is in the process of updating the water rights permit for the Lopez Water Project. In support of that effort the District will be applying for an Incidental Take Permit and completing a Habitat Conservation Plan (HCP) to address potential adverse effects of the Lopez Water Project on steelhead and California red-legged frog, for example. The HCP will draw from the information in this GSP as well as other survey and technical data, including a recently completed in-stream habitat assessment to identify management actions and projects that would benefit these species. It is anticipated that once the HCP is completed the GSP may need to be subsequently updated to reflect performance criteria/indicators in the HCP.

Integrated Flow Model. As part of the development of this GSP, the GSAs incorporated the development of an integrated groundwater-surface water model of the Arroyo Grande Creek Watershed. Detailed documentation of the model is included in Appendix G, Surface Water/Groundwater Modeling Documentation. The integrated model was developed using GSFLOW, a modeling code developed and maintained by the United States Geological Survey (USGS). GSFLOW incorporates two existing USGS modeling codes under a single structure. The first is the Precipitation Runoff Modeling System (PRMS), which models rainfall, plant uptake, evapotranspiration, and runoff to streams, using a water budget approach applied to a gridded domain of the model area. The second is MODFLOW, which simulates groundwater flow and surface water/groundwater interaction in the aquifers of the model area.

GSFLOW operates by first running PRMS, using climatological input and daily time steps to calculate the movement of rainfall that falls onto the Basin area through plant canopy, root zone, runoff to streams, and deep percolation to the groundwater environment. GSFLOW then transmits necessary data to MODFLOW (e.g., streamflow, deep percolation, etc.) at times and locations significant to the simulation of groundwater flow for the completion of the GSFLOW run. The integrated model was also dynamically linked to a reservoir operations model (MODSIM) to simulate operations of Lopez Dam and Reservoir in the Subbasin. The linked models will be used to support future analyses in the Subbasin as part of the Habitat Conservation Plan (HCP).

Expansion of Monitoring Network. This management action expands the monitoring network from the current SLOCFCWCD monitoring network of 9 wells to the new network of 13 monitoring wells as presented in Chapter 7 (Monitoring Network) within the first two years of the GSP implementation. Chapter 7 describes a proposed monitoring network that has adequate spatial resolution to properly monitor changes to groundwater and surface water conditions relative to SMCs within the Subbasin. The network will provide data with sufficient temporal resolution to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions. Also included in Chapter 7 are recommendations to revise the rating curves at the stream gages periodically as they can shift due to changes in channel geometry and affect the accuracy of the stream flow data.

GROUNDWATER SUSTAINABILITY PLAN

1.0 Introduction to the AG Subbasin GSP

The Sustainable Groundwater Management Act (SGMA), Section 10720, et. al., of the State Water Code, requires sustainable groundwater management in all high and medium priority basins. The Santa Maria River Valley - Arroyo Grande groundwater subbasin (DWR No. 3-012.02) (AG Subbasin) was designated as a high priority basin (DWR, 2016), and was reprioritized in 2019 to a low priority basin (DWR, 2019).

IN THIS SECTION

- Purpose of the Plan
- Basin Overview

1.1 Purpose of the Groundwater Sustainability Plan

The Santa Maria River Valley - Arroyo Grande groundwater subbasin (AG Subbasin) was originally part of the non-adjudicated “fringe” areas of the adjudicated Santa Maria River Valley Groundwater Basin (DWR No. 3-012), which was designated as a high priority basin (DWR, California's Groundwater: Bulletin 118 - Interim Update 2016, Working Towards Sustainability, 2016), but due to the final results of the DWR’s groundwater basin boundary modifications in 2019, the AG Subbasin and Santa Maria River Valley – Santa Maria (No. 3-012.01) groundwater subbasin (Santa Maria Subbasin) were established as separate subbasins within the previously designated Santa Maria River Valley Basin (No. 3-012). The AG Subbasin was then reprioritized as very low priority (DWR, 2019). Additional information regarding the sequence of events that led to designation of the AG Subbasin and prioritization as a very low priority basin is included in Figure 1-1.

The AG Subbasin’s very low prioritization does not require the development of a GSP for the AG Subbasin, but the AG Subbasin GSAs are proceeding with the development of a GSP to assure continued sustainable conjunctive management of groundwater and surface water supplies. Work efforts included in the GSP development are important for advancing water resource management of the AG Subbasin and interconnected surface waters of the Arroyo Grande Creek watershed that overlie the subbasin. In the AG Subbasin, there are several federally listed endangered species that are impacted by the Lopez Project which includes the Lopez Lake (i.e., Lopez Reservoir) and the Lopez Terminal Reservoir. Due to the requirements of the Endangered Species Act, the San Luis County Flood Control and Water Conservation District (District) Zone 3 (FC Zone 3) that operates the Lopez Project is currently developing a Habitat Conservation Plan (HCP). The HCP will characterize the impacts the Lopez Project operations on the endangered species within the Arroyo Grande Creek watershed. The HCP will also most likely include an adaptive downstream release strategy that will satisfy and sustainably manage competing demands of the water supply contracts, the appropriate downstream releases for groundwater recharge, and in-stream flow requirements all within the safe yield of the reservoir. Through the development of this GSP, a set of computer modeling management tools will be developed to support the HCP to evaluate the relationship between flow in AG Creek due to reservoir releases and groundwater uses in the subbasin through pumping.

This document fulfills the GSP development requirements. This GSP describes and assesses the groundwater condition of the AG Subbasin, develops quantifiable management objectives that account for the interests of the AG Subbasin’s beneficial groundwater uses and users, and identifies a group of projects and management actions that will allow the AG Subbasin to achieve and maintain sustainability in the future. Appendix A (DWR Element of the Plan Guide) identifies the location in this GSP where the statutory requirements of SGMA are addressed.

1.2 Description of AG Subbasin

This GSP covers the entire AG Subbasin identified as Basin No. 3-012.02 in the DWR's Bulletin 118 (DWR, 2019). The AG Subbasin lies in the southern portion of San Luis Obispo County. The AG Subbasin lies to the north of Highway 101 and just south of Lopez Lake. This area is known as the non-adjudicated "fringe" area of the adjudicated Santa Maria River Valley Groundwater Basin. Below Lopez Lake where the AG Subbasin lies, the valleys of gentle flatlands and rolling hills ranging in elevation from approximately 100 to 500 feet above mean sea level are prominent. A terrain map displaying the AG Subbasin boundaries is presented in Figure 1-1, which also displays the watershed areas of the Arroyo Grande Creek, Lopez Canyon, Tar Spring Creek, and Los Berros Creek drainages, faults, and nearby groundwater basins, as symbolized by the Final Bulletin 118 Basin Prioritization update (DWR, 2019). Average annual precipitation ranges from approximately 16.14 inches near Highway 101 to about 19.11 inches in relatively higher elevation areas of similar elevation to Lopez Lake. The AG Subbasin is within the watershed areas of the Arroyo Grande Creek and Tar Spring Creek drainages. The AG Subbasin is commonly referenced as being composed of two distinct valleys, with the Arroyo Grande Creek Valley in the north and the Tar Spring Creek Valley in the southeast.

Arroyo Grande Creek and Tar Spring Creek and their respective tributaries are the primary surface water features within the AG Subbasin. Significant tributaries to the Arroyo Grande Creek within Basin that discharge into Lopez Lake include Lopez Canyon Creek, Vasquez Creek, Wittenberg Creek, Dry Creek, Potrero Creek, and Phoenix Creek. Tar Spring Creek and Los Berros Creek merge with Arroyo Grande Creek south of Lopez Lake. There are no significant tributaries within the Basin to Tar Spring Creek. Urban areas within the AG Subbasin include the City of Arroyo Grande. Highway 101 is the most significant north-south highway in the Basin.

1.3 Basin Prioritization

The DWR prioritized California's groundwater basins through the California Statewide Groundwater Elevation Monitoring (CASGEM) program and released the results in 2014. With the passage of SGMA, DWR redefined 54 groundwater basins based on requests for basin boundary modifications and classified the basins into four categories: high, medium, low, or very low priority. The AG Subbasin was classified as a very low priority basin as described in §1.1.

The DWR reassessed the priority of the groundwater basins following the 2016 basin boundary modification, as required by the Water Code and documented the results in the SGMA 2019 Basin Prioritization (DWR, 2019). DWR followed the process and methods developed for the CASGEM 2014 Basin Prioritization and incorporated new data, to the extent data was available, and amended the language of Water Code Section 10933(b)(8) (component 8) to include an analysis of adverse impacts on local habitat and local streamflow. Therefore, DWR prioritized the basins based on the following components specified in Water Code Section 10933(b):

1. The population overlying the basin or sub-basin.
2. The rate of current and projected growth of the population overlying the basin or sub-basin.
3. The number of public supply wells that draw from the basin or sub-basin.
4. The total number of wells that draw from the basin or sub-basin.
5. The irrigated acreage overlying the basin or sub-basin.
6. The degree to which persons overlying the basin or sub-basin rely on groundwater as their primary source of water.
7. Any documented impacts on the groundwater within the basin or sub-basin, including overdraft, subsidence, saline intrusion, and other water quality degradation.
8. Any other information determined to be relevant by the department, including adverse impacts on local habitat and local streamflow.

With the addition of component 8, the AG Subbasin was classified as a very low priority basin not in critical overdraft and is not required to submit a GSP to DWR by January 31, 2022. However, the City of Arroyo Grande and County of San Luis Obispo (GSAs) decided to proceed with preparing a GSP for the AG Subbasin as a proactive measure to support the development of the HCP and maintains groundwater sustainability in the AG Subbasin into the future.

Additional information about how each of these components were analyzed can be found in the 2019 SGMA Basin Prioritization Process and Results Document (DWR, 2019). DWR is required to provide updates on basin boundaries, basin priority, and critically overdrafted basins every 5 years beginning in 2020 as part of the Bulletin 118 updates.

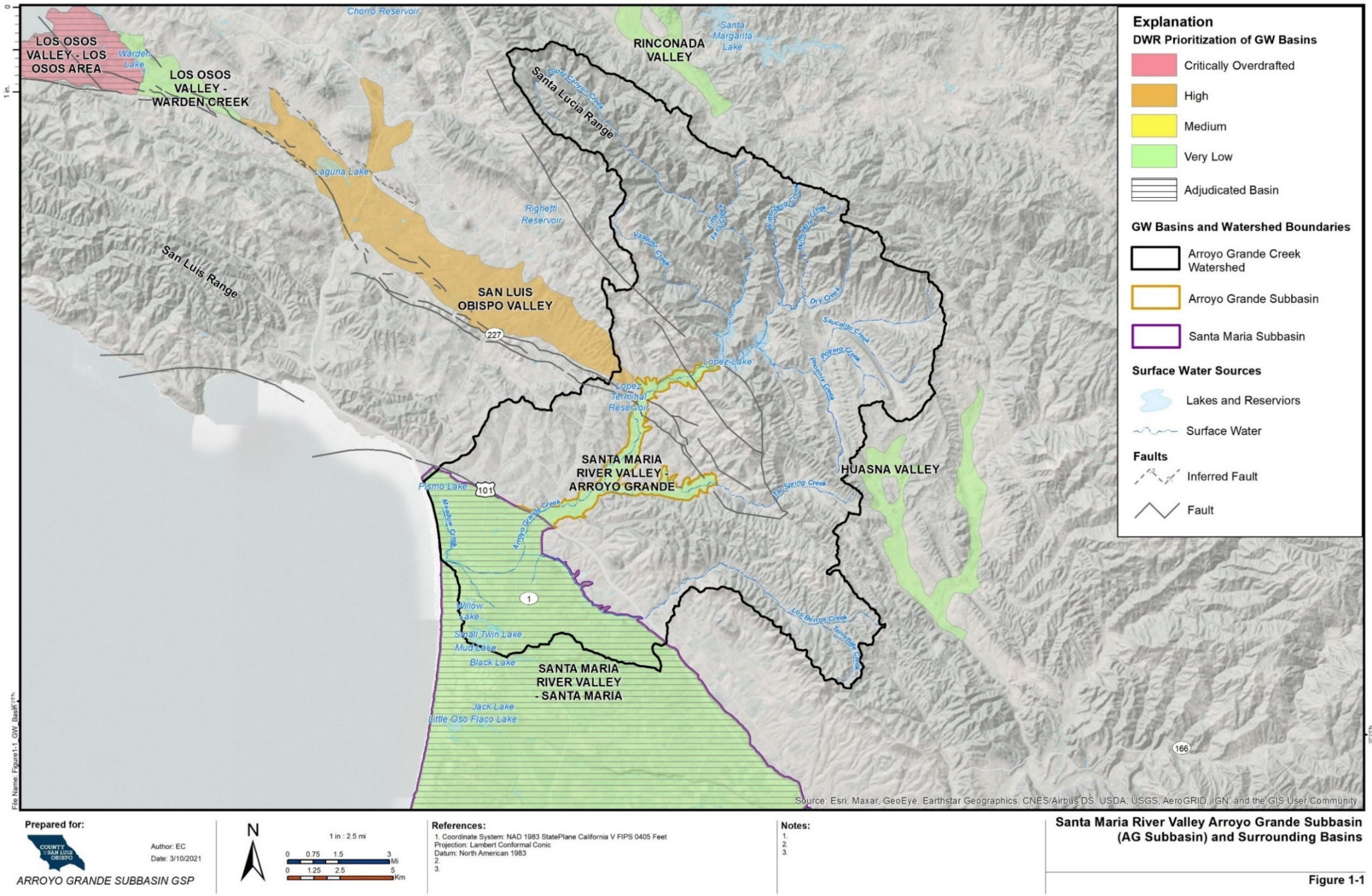


Figure 1-1. Santa Maria River Valley Arroyo Grande Subbasin (AG Subbasin) and Surrounding Basins

GROUNDWATER SUSTAINABILITY PLAN

2.0 Agency Information (§ 354.6)

On March 28, 2017, the City of Arroyo Grande formed the City of Arroyo Grande Groundwater Sustainability Agency (City GSA) for the portion of the AG Subbasin that lies within its city boundary. On May 16, 2017, the County of San Luis Obispo formed the Santa Maria Basin Fringe Areas – County of San Luis Obispo Groundwater Sustainability Agency (County GSA) to cover all otherwise unrepresented areas within the AG Subbasin.

IN THIS SECTION

2.1 Agency Information (§ 354.6)

The County and City (each referred to individually as a " Party" and collectively as the "Parties") entered into a Memorandum of Agreement Regarding Preparation of a GSP for the AG Subbasin (MOA) effective as of October 6, 2020. The MOA's purpose is for the City and County to coordinate preparation of a single GSP for the entire AG Subbasin pursuant to SGMA and other applicable provisions of law. Figure 2-1shows the service area boundaries of each of the MOA Parties and the GSA areas.

On January 29, 2019, the County GSA gave notice to DWR (Appendix B) that it intends to develop a GSP in collaboration with the City GSA for the non-adjudicated "fringe areas" of the Santa Maria Valley River Groundwater Basin wholly within San Luis Obispo County, which includes the AG Subbasin in accordance with California Water Code (CWC) Section 10727.8 and the Title 23, Section 353.6 of the California Code of Regulations (CCR).The letter to DWR was drafted before the basin boundary modification request was finalized. However, it included all fringe areas of the Santa Maria River Valley, which includes AG Subbasin.

2.2 Agencies Names and Mailing Addresses

The following contact information is provided for each groundwater sustainability agency for the AG Subbasin pursuant to California Water Code §10723.8.

County of San Luis Obispo

County Government Center, Room 206

San Luis Obispo, CA 93408

Attention: John Diodati, Public Works Director

City of Arroyo Grande

Public Works Department

1375 Ash Street

Arroyo Grande, CA 93420

Attention: Bill Robeson, Director

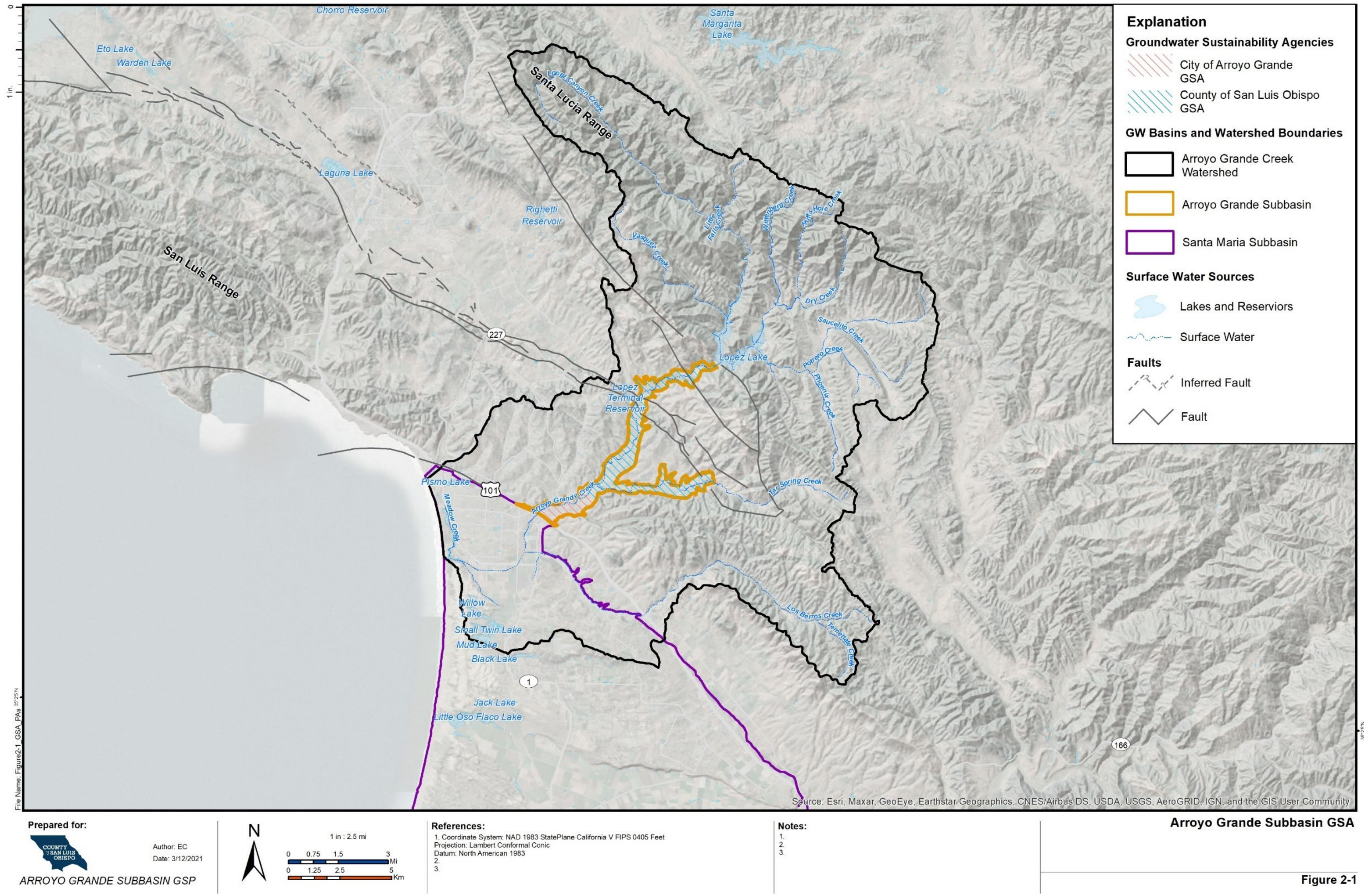


Figure 2-1. Arroyo Grande Subbasin GSA

2.3 Agencies Organization and Management Structures

The MOA establishes the terms under which the City GSA and County GSA will jointly develop a single GSP. No other participating parties will be involved explicitly in the develop of the GSP. City and County staff will collaboratively participate in developing a GSP through, among other things, providing guidance to consultant and engaging AG Subbasin users and stakeholders. Once the GSP is developed, it will be considered for adoption by the GSAs (i.e., City Council and County Board of Supervisors) and subsequently submitted to DWR for approval. The organization and management structures of each of the Parties are described in the following sections. The MOA does not specify the appointment of officer positions. However, Figure 2-2 shows the names of the appointed GSA staff representatives and depicts the relationship of the GSAs and the overall governance structure for developing the GSP:

Figure 2-2. GSA Staff Representatives

2.3.1 County of San Luis Obispo

The County is a GSA and Party of the MOA. The County is governed by a five-member Board of Supervisors representing five districts in the County. Board of Supervisor members are elected to staggered four-year terms.

2.3.2 City of Arroyo Grande

The City is a GSA and Party of the MOA. The City is an incorporated city and operates under the "Council-Mayor-City Manager" form of municipal government. The five-member City Council consists of the directly elected Mayor and four City Council Members. The Mayor is elected to a two-year term and Council Members are elected to four-year terms.

2.3.3 Groundwater Sustainability Agencies

“Local agency” is defined pursuant to CWC§ 10721 as a local public agency that has water supply, water management, or land use responsibilities within a groundwater basin. The GSAs developing this coordinated GSP were formed in accordance with the requirements of California Water Code §10723 et seq. The resolutions of formation for the GSAs and the Memorandum of Understanding (MOA) are included in Appendices A-C.

2.3.3.1 County of San Luis Obispo

The County was created as described in Government Code Section 460 which states that the state is divided into counties, the names, boundaries, and territorial subdivisions of which are declared in Title 3 of the Government Code. The County has land use authority over the unincorporated areas of the county, including areas overlying the AG Subbasin. The County is therefore a local agency under CWC§ 10721(n) with the authority to establish itself as a GSA. Upon establishing itself as a GSA, the County retains all the rights and authorities provided to GSAs under CWC§ 10725 et seq. The City and the County shall each be responsible for adopting the GSP and implementing the GSP within their respective service areas.

2.3.3.2 City of Arroyo Grande

The City is incorporated under the laws of the State of California. The City provides water supply and land use planning services to its residents. The City is therefore a local agency under CWC§ 10721(n) with the authority to establish itself as a GSA. Upon establishing itself as a party of the GSA, Arroyo Grande retains all the rights and authorities provided to GSAs under CWC§ 10725 et seq. The City and the County shall each be responsible for adopting the GSP and implementing the GSP within their respective service areas.

2.3.4 Memorandum of Agreement

The MOA Parties entered into the MOA effective as of October 6, 2020. The MOA establishes terms under which the City GSA and County GSA will jointly develop a single GSP. City and County staff will collaboratively participate in developing a GSP through, among other things, providing guidance to the consultant and engaging AG Subbasin users and stakeholders. The County Board of Supervisors and the City Council may approve or reject adopting the GSP independently from one another’s decision. The MOA may be terminated by either Party upon thirty days written notice to the other Party’s designated address. A copy of the MOA is included in Appendix E.

2.3.5 Coordination Agreements

Only a single GSP is developed by the City and County GSAs to cover the entire AG Subbasin. Therefore, no coordination agreements with other GSAs are necessary because there is not multiple GSPs.

2.4 Contact information for Plan Manager

Name: Blaine Reely, Groundwater Sustainability Director, County of San Luis Obispo
Phone Number: 805-781-5000 (main County directory)
Mailing address: County Government Center, 1055 Monterey Street, San Luis Obispo, CA

93408
Electronic mail address: breely@co.slo.ca.us

2.5 Notices and Communications (§ 354.10)

The outreach activities conducted to support GSP development are documented in Appendix F. A Communication and Engagement Plan (C&E Plan) was executed and includes the planned activities for engaging interested parties in SGMA implementation efforts in the AG Subbasin (Appendix F). Appendix F includes a Communications and Engagement Implementation Workplan for AG Sub Basin GSP. The workplan details the target stakeholder categories, developed outreach goals and evaluation metrics, identified communication priorities schedule, and describes the outreach tools and materials that were used throughout the GSP development.

The goals of the C&E Plan are as follows:

- Create an inclusive and transparent participation experience that builds public trust in the GSP and optimizes participation among all stakeholders.
- Employ outreach methods that facilitate shared understanding of the importance of sustainable groundwater conditions and impacts on stakeholders.
- Communicate "early and often," and actively identify and eliminate barriers to participation.
- Develop a cost-effective, stakeholder-informed GSP supported by best-in-class technical data.

Outreach and communication throughout GSP development included regular presentations at public meetings, meetings with community groups, meetings with individual stakeholders, and community workshops. Comments and responses to the comments from stakeholders were collected and posted on the County of San Luis Obispo's website and considered in the development of the GSP. Table 2-1 lists the public meetings and events that were held throughout the development of the GSP where elements of the Plan were discussed or considered by the GSAs.

Table 2-1. List of Public Meetings and Workshops

EVENT	LOCATION	DATE	TIME
Stakeholder Workshop	Zoom	12/15/2020	03:30PM
Stakeholder Workshop	Zoom	12/15/2021	03:30PM
Stakeholder Workshop	Zoom	7/25/2022	03:00PM

GROUNDWATER SUSTAINABILITY PLAN

3.0 Description of Plan Area (§ 354.8)

The AG Subbasin is oriented in a northeast-southwest direction and composed of unconsolidated or loosely consolidated sedimentary deposits. It is approximately 7.1 miles long, 4.5 miles wide between Arroyo Grande Creek and Tar Springs Creek at the northeast end of the basin, and less than 1 mile wide at its narrowest point near the southwest end of the basin. It covers a surface area of about 2,899 acres (4.53 square miles).

IN THIS SECTION

- AG Subbasin Information
- Jurisdictional Areas
- Land Use
- Existing Plans

3.1 AG Subbasin Introduction

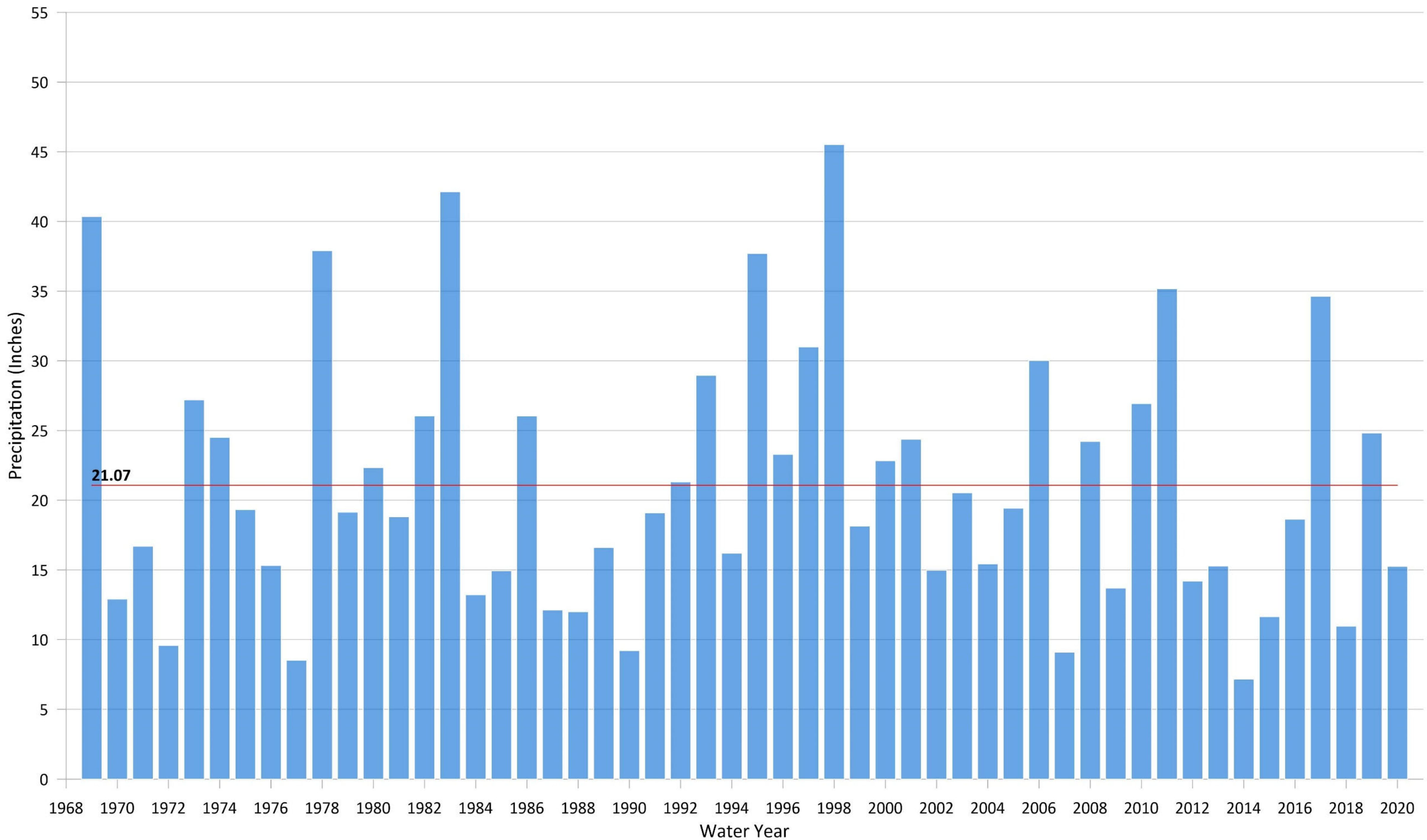
The AG Subbasin is bounded on the northeast by the relatively impermeable bedrock formations of the Santa Lucia Range where the Edna Valley and West Huasna Fault Zones reside, and on the southwest by the formations of the San Luis Range and the Wilmar Avenue Fault Zone that parallels Highway 101. The bottom of the AG Subbasin is defined by the contact of permeable sediments with the impermeable bedrock Miocene-aged and Franciscan Assemblage rocks (DWR, California's Groundwater: Bulletin 118 - Update 2003, Groundwater Basin Descriptions., 2003). The AG Subbasin is commonly referenced as being composed of two distinct valleys that come together, with the Arroyo Grande Creek Valley in the northeast and the Tar Springs Creek Valley in the southeast.

The Arroyo Grande Creek Valley comprises the northeastern portion of the AG Subbasin. It is the area of the AG Subbasin drained by Arroyo Grande Creek and its tributaries (Lopez Canyon Creek, Vasquez Creek, Wittenberg Creek, Dry Creek, Potrero Creek, Phoenix Creek, Tar Spring Creek, and Los Berros Creek). Surface drainage in Arroyo Grande Creek Valley drains out of the AG Subbasin adjacent to Highway 101, flowing to the southwest along the course of Arroyo Grande Creek that is located within the Santa Maria Subbasin, toward the coast. The Arroyo Grande Creek Valley includes part of the City of Arroyo Grande jurisdictional boundaries, while the remainder of the Arroyo Grande Creek Valley is unincorporated land. Land use in the City boundary is primarily single- and multi-family residential with some agricultural. The majority of the AG Subbasin along Arroyo Grande Creek has significant areas of irrigated agriculture, primarily truck, nursery, and berry crops.

The Tar Springs Creek Valley comprises approximately the southeastern portion of the AG Subbasin. The Tar Springs Creek has mostly smaller unnamed tributaries. The primary land use in the Tar Springs Creek Valley is agriculture. During the past two decades truck, nursery, and berry crops have been the dominant crops grown in the AG Subbasin along Tar Springs Creek.

The physical definition of the AG Subbasin boundary is the contact between the unconsolidated or loosely consolidated sediments of Recent alluvium with the Pismo Formation, Monterey Formation, and Franciscan Assemblage. The alluvial sediments of the Arroyo Grande Creek Valley range up to 120-140 feet thick atop bedrock, while along Tar Springs Creek Valley the alluvial sediments range up to 80-100 feet thick. Precipitation that falls northeast in the tributary areas of Arroyo Grande Creek and Tar Springs Creek confluences into Arroyo Grande Creek in the southwest part of the AG Subbasin.

The primary weather patterns for the AG Subbasin derive from seasonal patterns of atmospheric conditions that originate over the Pacific Ocean and move inland. As storm fronts move in from the coast, rainfall in the area falls more heavily in the mountains, and the AG Subbasin itself receives less rainfall because of a muted rain shadow effect. Average annual precipitation ranges from approximately 16 inches throughout most of the AG Subbasin to about 21 inches in relatively higher elevation areas near the Lopez Reservoir. Figure 3-1 presents the time series of annual precipitation for the period of record from 1968 to 2019 at the Lopez Dam Weather Station. The average historical rainfall at this location to date is 21.18 inches, with a standard deviation of 9.28 inches. The historical maximum is 45.52 inches, which occurred in 1998. The historical minimum is 7.16 inches, which occurred in 2014.



Prepared for:

Author: EC

03/01/2021

ARROYO GRANDE BASIN GSP

Legend

Precipitation (Annual)

Historical Average Precipitation

Notes:

1. Data Source: Lopez Dam Weather Station

Arroyo Grande Historical Annual Precipitation

Figure 3-1

Figure 3-1. Arroyo Grande Historical Annual Precipitation

3.2 Adjudicated Areas

The AG Subbasin is not an adjudicated basin.

3.3 Jurisdictional Areas

In addition to MOA Parties, there are several entities that have some degree of water management authority in the AG Subbasin. Each entity is discussed below.

3.3.1 Federal Jurisdictions

There are no federal agencies with land holdings in the AG Subbasin.

3.3.2 Tribal Jurisdiction

The two prominent Native American tribes in the County are the Obispeño Chumash and Salinan Indian Tribes. The Chumash occupied the coast between San Luis Obispo and northwestern Los Angeles County, inland to the San Joaquin Valley. They were divided into two broad groups, of which the Obispeño were the northern group. The Salinan were northern neighbors of the Chumash, and although the presence of a firm boundary between the Chumash and the Salinan is uncertain, ethnographic accounts have placed Salinan territories in the northern portion of the County. However, these two tribes do not have any recognized tribal land in the AG Subbasin.

3.3.3 State Jurisdictions

The State of California Division of Water Resources owns and operates 40-acres of land along Arroyo Grande Creek in the AG Subbasin. In addition, State of California Parks owns and operates less than 1-acre of land within the AG Subbasin.

3.3.4 County Jurisdictions

The County of San Luis Obispo and the associated San Luis Obispo County Flood Control and Water Conservation District (SLOFCWCD) (see section under Special Districts below) have jurisdiction over the entire County including the AG Subbasin. The County owns approximately 800 acres of land in the AG Subbasin and is primarily located in the vicinity of the spillways of Lopez Lake (i.e., Lopez Reservoir) dam and Lopez Terminal Reservoir and portions along Arroyo Grande Creek.

3.3.5 City and Local Jurisdictions

The City is located in the southern portion of the AG Subbasin and has land and water management authority over its incorporated area. The City's primary water supply sources include surface water from Lopez Reservoir and groundwater from wells located in the NCMA adjudicated basin area adjacent to the AG Subbasin. One major mutual water company, Varian Ranch Mutual Water Company, has one operational agricultural well that provides water to agriculture customers in the AG Subbasin.

3.3.6 Special Districts

The San Luis Obispo County Flood Control and Water Conservation District (SLOFCWCD) is an independent Special District governed by the County Board of Supervisors. It has jurisdiction over all of the County including the AG Subbasin and was established as a resource to help individuals and communities in San Luis Obispo County identify and address flooding problems with the purpose "to provide for control, disposition and distribution of the flood and storm waters of the district and of streams flowing into the district...".

3.3.6.1 Zone 3

The San Luis Obispo County Flood Control and Water Conservation District Flood Control Zone 3 (Zone 3) was established to fund and operate the Lopez water supply system and is a wholesale supplier. The contractors in Zone 3 include the communities of Oceano, Grover Beach, Pismo Beach, Arroyo Grande, and CSA 12 (including the Avila Beach area). Zone 3 operates Lopez Reservoir, in the Arroyo Grande Creek watershed for municipal and agricultural water supplies and recreation, and consists of Lopez Reservoir, Lopez Dam, Lopez Terminal Reservoir, Lopez Water Treatment Plant and Lopez Pipeline.

3.3.6.2 Zone 1/1A

Zone 1/1A was established for the maintenance and operations of the Arroyo Grande and Los Berros Channels to provide flood protection near the City of Arroyo Grande and the community of Oceano.

3.4 Land Use

The County, City and State have land use authority in the AG Subbasin within their respective jurisdictions. Land use information for the AG Subbasin was based on DWR's land use database (DWR, California's Groundwater: Bulletin 118 - Interim Update 2016, Working Towards Sustainability, 2016). The 2016 land use in the AG Subbasin is shown on Table 3-1 and is summarized by group in Figure 3-2. All land use categories except native vegetation listed in Table 3-1 are provided by DWR (DWR, California's Groundwater: Bulletin 118 - Interim Update 2016, Working Towards Sustainability, 2016). The areas of the basin that did not have a land use designation were assumed to be native vegetation.

Table 3-1. Agricultural Land use categories defined for the AG Subbasin by DWR (2016)

Land Use Category	Acres
Citrus and subtropical	141
Deciduous fruits and nuts	7
Grain and hay crops	56
Idle	16
Pasture	9
Truck nursery and berry crops	1,177
Urban	322
Vineyard	38
Young perennial	<1
Native vegetation	1137
Total	**2901**

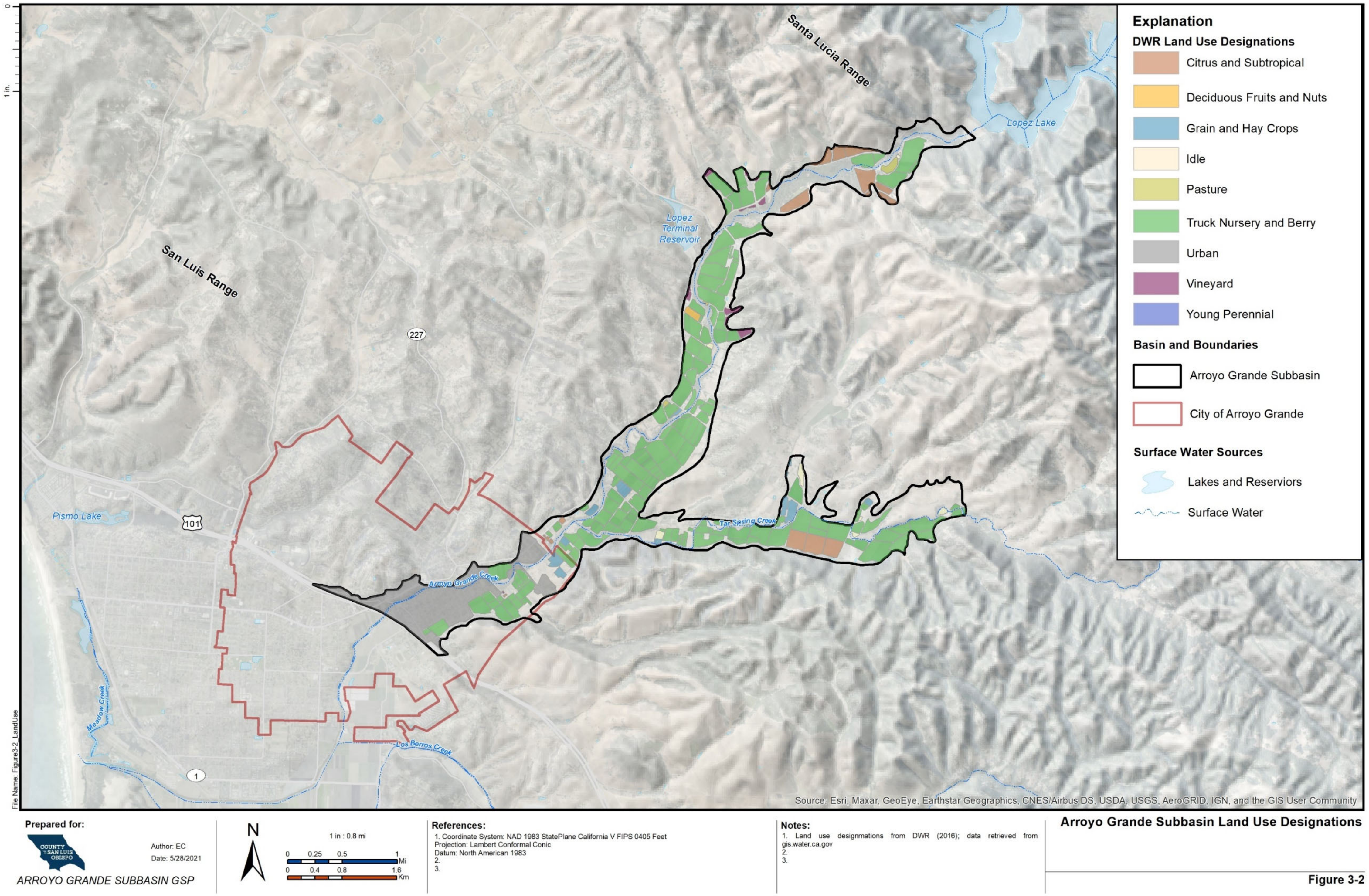


Figure 3-2. AG Subbasin Existing Land Use Designations

3.4.1 Water Source Types

Entities in the AG Subbasin utilize two types of water sources to meet the demands: groundwater and surface water. Lopez Dam which impounds 70 square miles of the upper Arroyo Grande Creek watershed forming Lopez Lake (i.e., Lopez Reservoir). The Lopez Dam was built to provide an additional water supply to reduce the reliance on groundwater, as well as provide recreation opportunities, which was a requirement of the State grant. Lopez Reservoir has a storage capacity of 49,388 acre-feet and an approximate dependable yield of 8,730 acre-feet that is distributed as municipal diversions (4,530 acre-feet) and downstream releases (4,200 acre-feet).

The municipal diversions are transported from Lopez Reservoir to the Lopez Terminal Reservoir through a pipeline. Water stored at the Lopez Terminal Reservoir is held for DDW regulation residence time requirements and subsequently treated onsite at the Lopez Water Treatment Plant before being delivered to Zone 3 municipal agencies. The Lopez Water Treatment Plant has the capacity to treat up to 6 MGD. These municipal agencies include the City, City of Grover Beach, City of Pismo Beach, Ocean Community Services District, and County Service Area 12 (Avila). Table 3-2 summarizes the contract entitlements for each Zone 3 municipal agency.

Table 3-2. Summary of Zone 3 Contract Entitlements for Treated Distributed Water

Contract Agency	Contract Volume (AFY)
City of Pismo Beach	892
Oceano CSD	303
City of Grover Beach	800
City of Arroyo Grande	2,290
CSA 12	245
Total	**4,530**

The downstream releases are discharged from the base of the dam into Arroyo Grande Creek. These downstream releases are used to maintain environmental flows within Arroyo Grande Creek throughout the year to maintain natural seasonal variability in Arroyo Grande Creek for habitat and wildlife purposes and provide groundwater recharge for irrigated crop production. Arroyo Grande Creek provides habitat for fish and wildlife species including anadromous steelhead (Oncorhynchus mykiss), tidewater gobies (Eucyclogobius newberryi), and California red-legged frogs (Rana aurora draytonii). All are listed for protection under the Federal Endangered Species Act (ESA). Downstream agricultural users pump groundwater from wells in the underlying aquifer or divert surface water from the creek. The releases are adjusted (increased or decreased) as necessary in response to changing agricultural demands, changes in weather conditions and/or other factors that may influence surface flows within the creek system. The adaptive management of downstream releases has generally resulted in annual releases less than 4,200 AF. The current guidance document for managing downstream releases from Lopez Reservoir is the Zone 3 Interim Downstream Release Schedule (IDRS). The IDRS looks to optimized storage and stream/reservoir management, to meet the needs of municipal, agricultural, and environmental demands in the interim.

Any unused safe yield (unused agency water plus un-released water for downstream beneficial uses) is offered to the Contract Agencies each year as surplus water and can be purchased in the following water year. Table 3-3 summarizes the historical monthly average of downstream releases. Table 3-4 summarizes the available surface water supply from Lopez Reservoir and Figure 3-3 shows the locations of surface water supply source within the AG Subbasin Basin.

Table 3-3. Summary of monthly average downstream releases and pipeline diversions from Lopez Dam

Month	Average of Downstream Releases (AFY)	Average of Pipeline Diversion (AFY)
January	282	316
February	361	259
March	484	302
April	507	354
May	452	422
June	509	449
July	502	466
August	450	449
September	402	416
October	327	405
November	289	361
December	302	301

Data Sources:

1 Lopez Dam Operations Data provided by County of SLO. Monthly averages calculated from 1968 – 2019.

Table 3-4. Summary of surface water supply sources available to the AG Subbasin

Supply Sources	Amount Available (AFY)
Lopez Reservoir – Municipal Diversions	4,530
Lopez Reservoir – Downstream Releases	4,200
Total	**8,730**

Data Sources:

1 Santa Maria River Valley Groundwater Basin Fringe Area Characterization Study, 2018.

2 UWMP 2015 Update, Zone 3, SLOFCWCD, 2016.

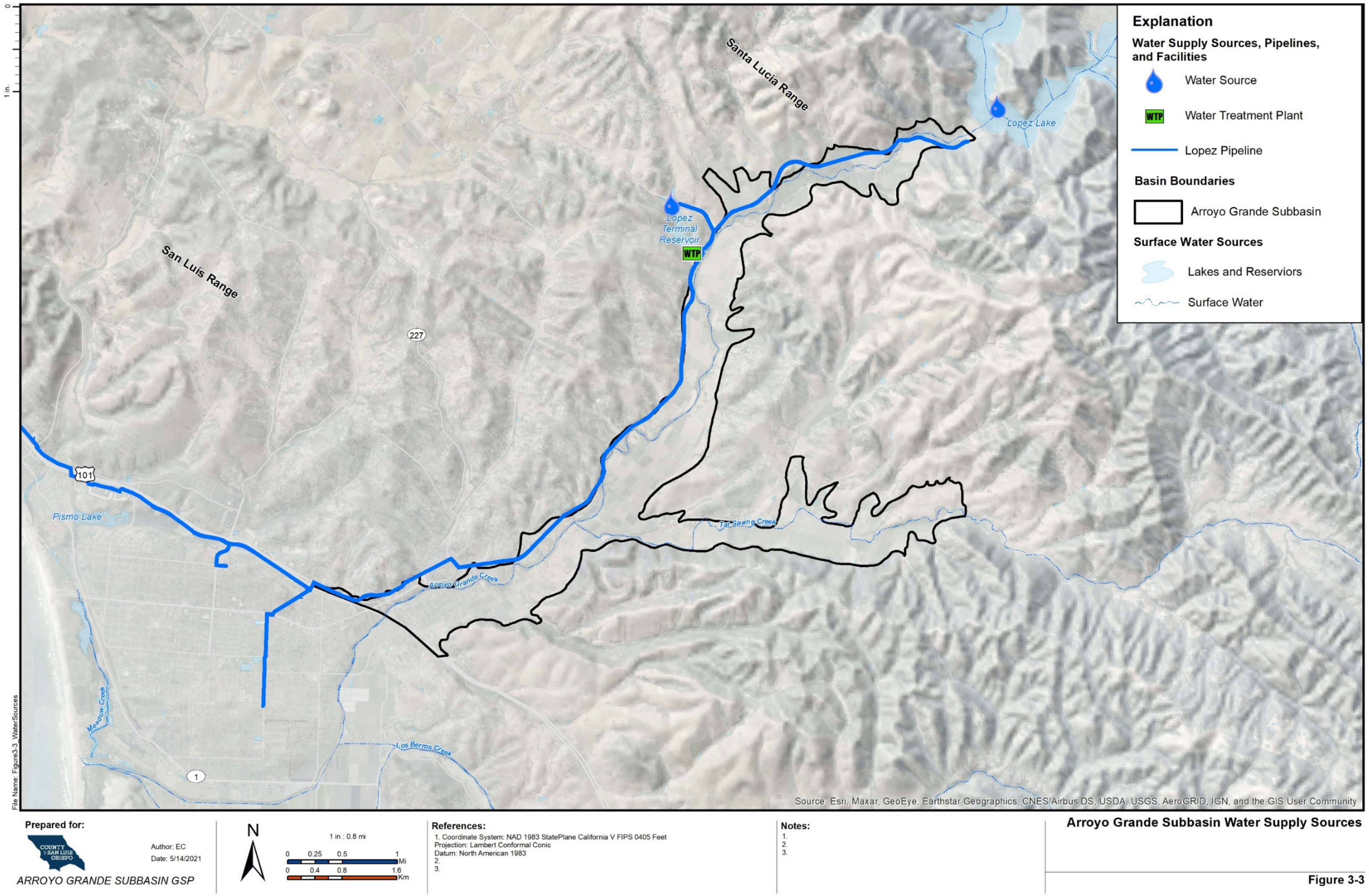


Figure 3-3. AG Subbasin Water Supply Sources

3.4.2 Water Use Sectors

Water demand in the AG Subbasin is organized into the six water use sectors identified in the GSP Emergency Regulations. These include:

- **Urban-** Urban water use is assigned to non-agricultural water uses in the City and census-designated places. Domestic use outside of census-designated places is not considered urban use.
- **Industrial-** There is limited industrial use in the AG Subbasin. The DWR land use designations in the AG Subbasin does not include industrial uses.
- **Agricultural-** This is the largest groundwater use sector in the AG Subbasin by water demand.
- **Managed wetlands-** There are several managed wetlands in the AG Subbasin that are managed by federal, state, and local agencies. In general, wetlands in the area are managed by either of the following agencies: (1) City of Arroyo Grande, (2) California Department of Fish and Wildlife, (3) California State Water Resources Control Board, (4) U.S. Fish and Wildlife Service, and (5) U.S. Army Corps of Engineers. The wetlands and natural vegetation areas (Figure 3-4) that are potentially groundwater dependent ecosystems include reaches of Arroyo Grande Creek and Tar Springs Creek. Water use for these ecologically sensitive areas will be addressed in the water budget and modeling scope of this GSP in order to implement appropriate management actions and proposed projects to provide adequate water supply for these areas.
- **Managed recharge-** There is no managed recharge in the AG Subbasin.
- **Native vegetation-** This is the second largest water use sector in the AG Subbasin by land area. This sector includes rural residential areas.

Figure 3-4 shows the distribution of the water use sectors and potential groundwater dependent ecosystems in the AG Subbasin.

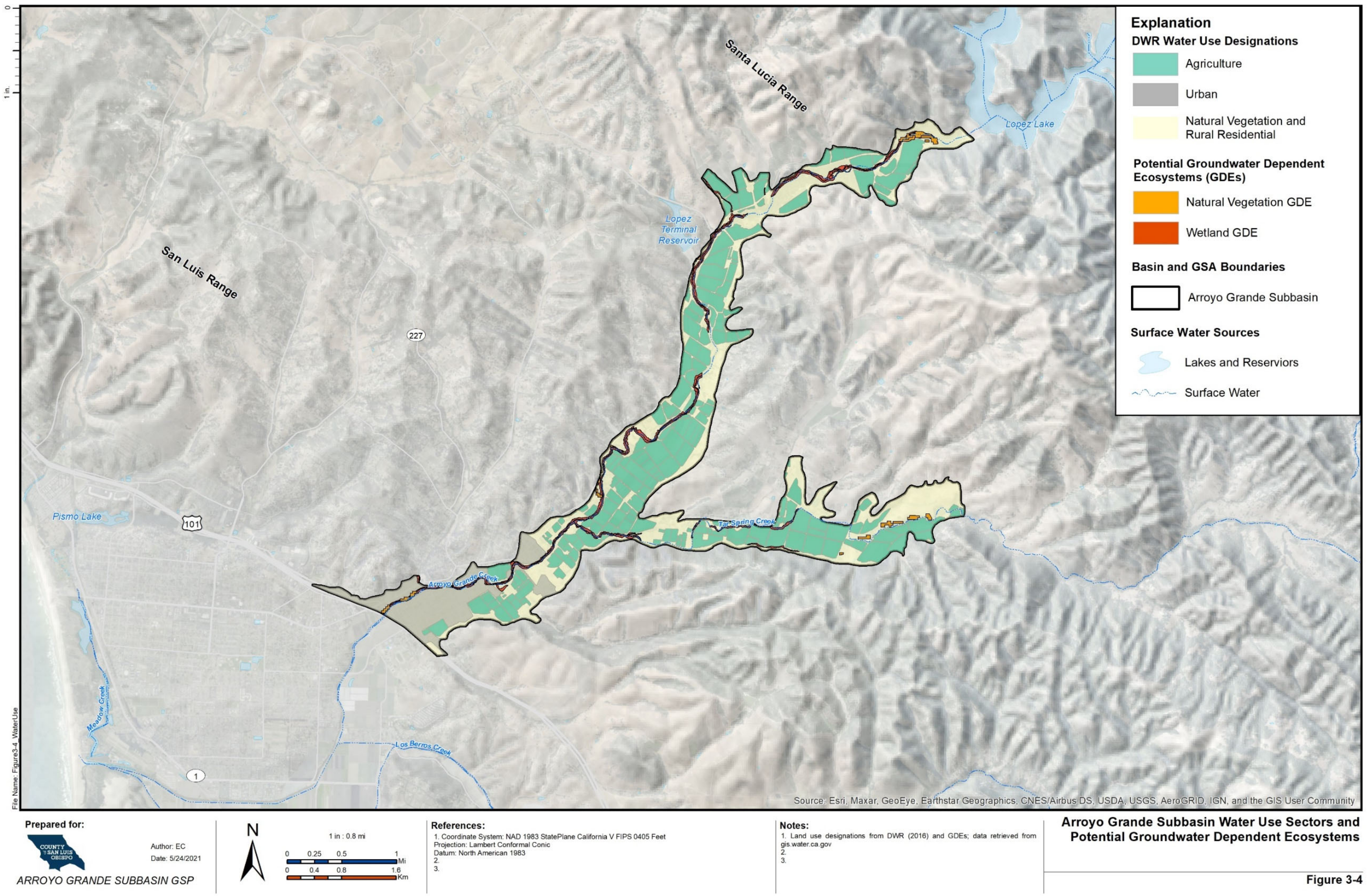


Figure 3-4. AG Subbasin Water Use Sectors

3.5 Density of Wells

Well types, well depth data, and well distribution data were downloaded from DWR's well completion report map application (DWR, 2019). DWR categorizes wells in this mapping application as either domestic, production (agricultural and industrial wells), or public supply. These categories are based on the well use information submitted with the well logs to DWR. Well information was also collected from County of San Luis Obispo Environmental Health Services (EHS). The EHS dataset was compiled from information gained from the well construction permit application process. Table 3-5 summarizes the types of wells by use for all well logs submitted to DWR and EHS.

Table 3-5. DWR and County Wells

Well Data Source	Type of Well	Total No. of Wells
Lopez Reservoir	Domestic	32
	Production	12
	Public Supply	0
	Total	*44*
County EHS	Domestic Private	117
	Domestic Public	5
	Irrigation	48
	Total	*170*

Figure 3-5 and Figure 3-6 show the density of wells in the AG Subbasin by their types of use based on DWR's classification. No map is shown for Public Wells since there are no Public Wells within the subbasin as classified by DWR. The DWR data used to develop these maps is not necessarily the same set of well data from EHS as shown in Figure 3-7. DWR data was used to develop maps of well densities because they are organized for easy mapping of well density per square mile. These maps should be considered representative of well distributions but are not definitive. It is also important to note that both the DWR and EHS well databases are not updated with information regarding well status and the well locations are not verified in the field. Therefore, it is uncertain whether the wells in these databases are currently active or have been abandoned or destroyed.

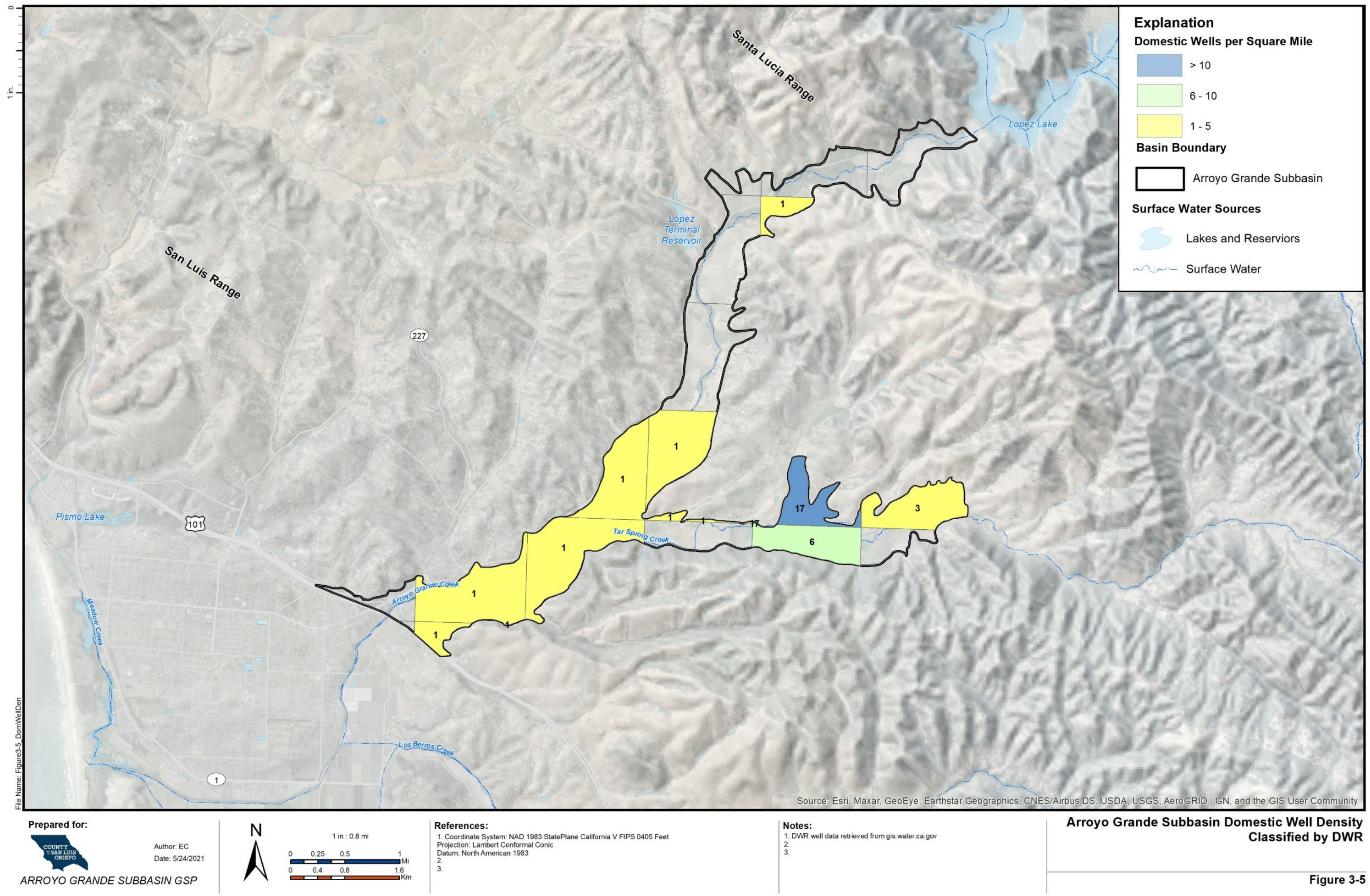


Figure 3-5. AG Subbasin Domestic Well Density

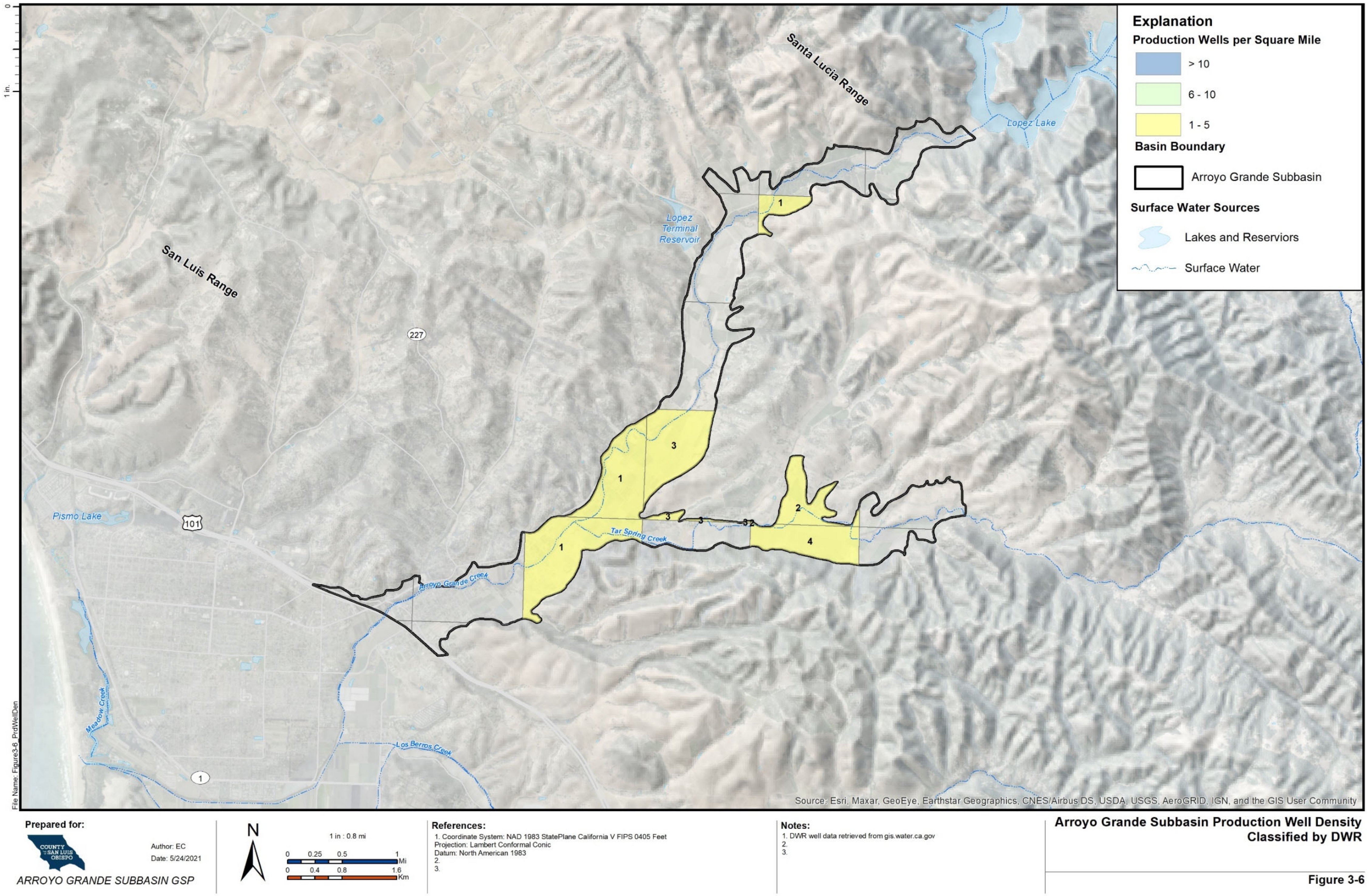


Figure 3-6. AG Subbasin Production Well Density

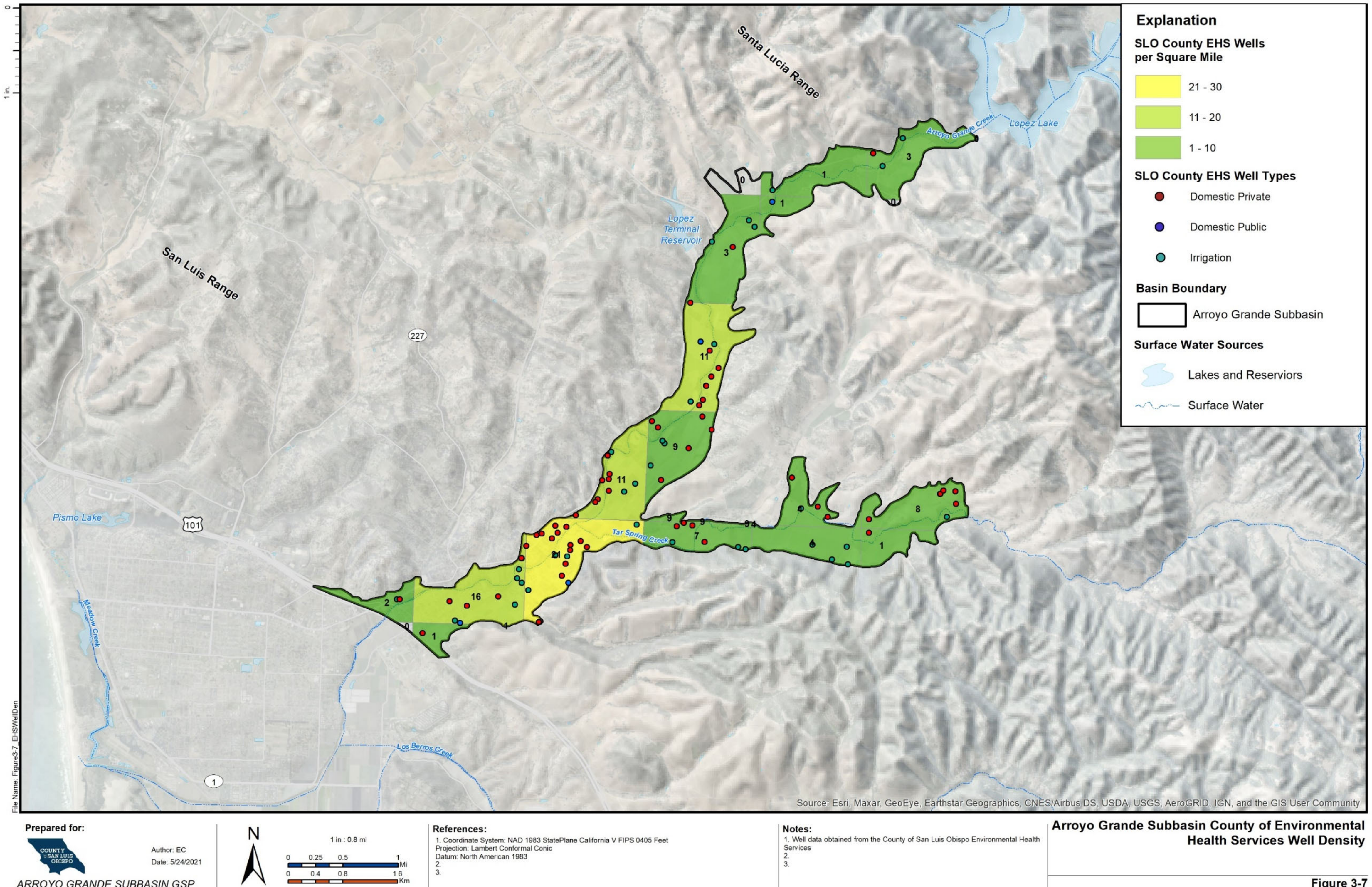


Figure 3-7. AG Subbasin Public Supply Well Density

3.6 Existing Monitoring and Management Programs

3.6.1 Groundwater Monitoring

Groundwater levels and quality are currently measured in the AG Subbasin by the SLOFCWCD and a variety of other agencies as described below. Figure 3-8 shows the locations of monitored wells identified in the Groundwater Ambient Monitoring and Assessment (GAMA) program (i.e., publicly available data) that are monitored by several public agencies, the SLOFCWCD, and the Central Coast Regional Water Quality Control Board (CCRWQCB) Irrigated Lands Program. The monitoring network also includes other wells in the area designated as private that are not shown on this map (Figure 3-8). Additional evaluation of the current monitoring program will be conducted for the GSP to establish a representative monitoring network of public and private wells that will be used during plan implementation to track groundwater elevations and quality to ensure that minimum thresholds have not been exceeded.

3.1.1.1 Groundwater Level Monitoring

The SLOFCWCD has been monitoring groundwater levels county-wide on a semi-annual basis for more than 50 years to support general planning and for engineering purposes. Groundwater level measurements are taken once in the spring and once in the fall. The monitoring takes place from a voluntary network of wells. In the AG Subbasin, there are 18 active wells in this program (Figure 3-8), but only three are visible due to confidentiality reasons. The voluntary monitoring network has changed over time as access to wells has been lost or new wells have been added to the network.

3.1.1.2 Groundwater Quality Monitoring

Groundwater quality is monitored/reported under several different programs and by different agencies including:

- Municipal and community water purveyors must collect water quality samples on a routine basis for compliance monitoring and reporting to the California State Water Resources Control Board (SWRCB) Division of Drinking Water (DDW).
- The USGS collects water quality data on a routine basis under the GAMA program. These data are stored in the State's GeoTracker GAMA system.
- There are multiple sites that are monitoring groundwater quality as part of investigation or compliance monitoring programs through the CCRWQCB. See Figure 3-8 for CCRWQCB well monitoring locations through the GeoTracker GAMA system.
- The CCRWQCB under Agricultural Order No. R3-2017-0002, a Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands, requires all growers to implement groundwater monitoring, either individually or as part of a cooperative regional monitoring program. Growers electing to implement individual monitoring (i.e., not participating in the regional monitoring program implemented by the Central Coast Groundwater Coalition [CCGC] within the AG Subbasin) are required to test all on-farm domestic wells and the primary irrigation supply wells for nitrate or nitrate plus nitrite, and general minerals (including, but not limited to, TDS, sodium, chloride, and sulfate).

- California Water Data Library contains groundwater level and water quality monitoring stations. The data contains wells that are also captured in GAMA and other State reporting databases.

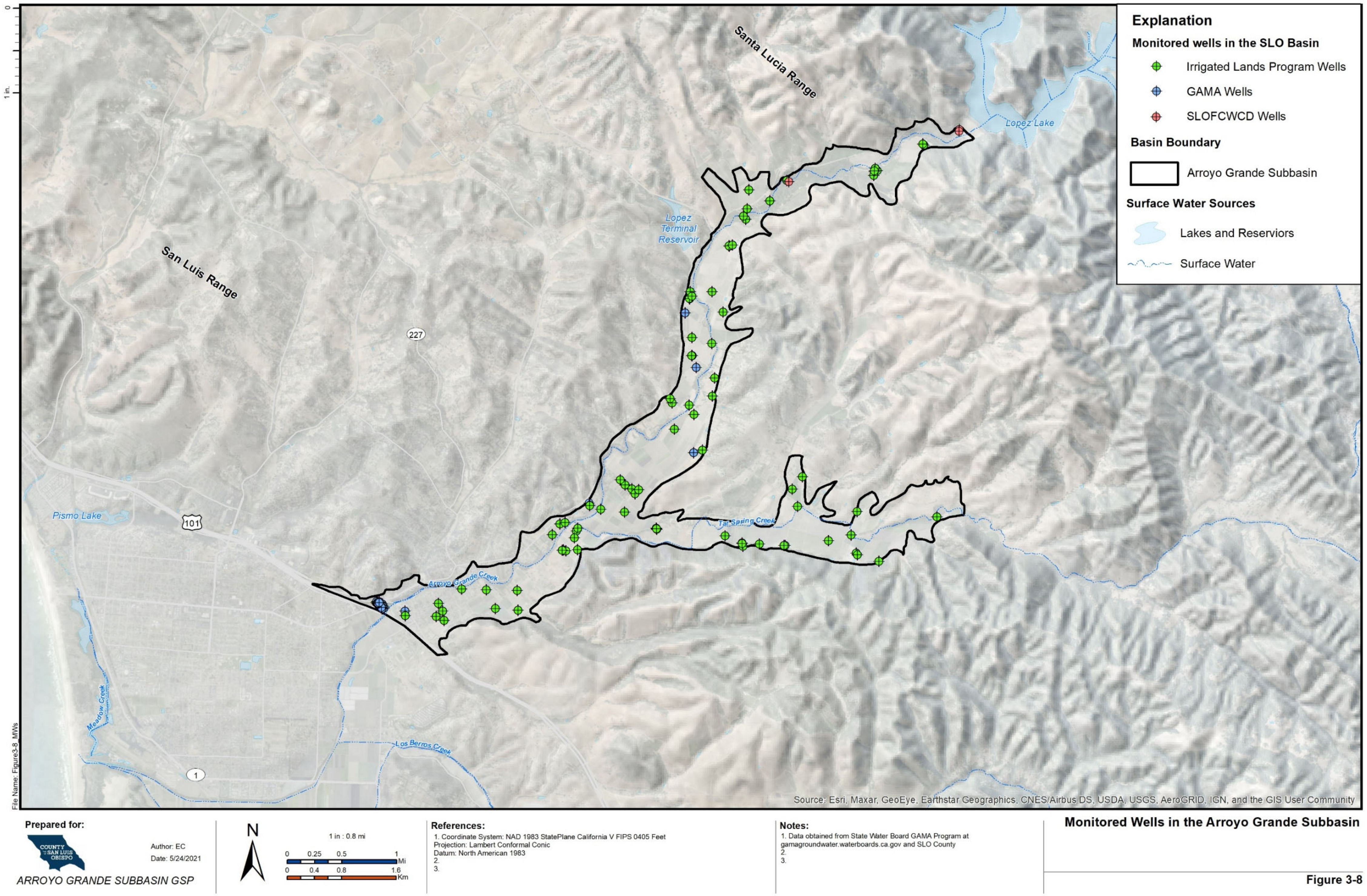


Figure 3-8. Monitored Wells in the AG Subbasin

3.1.1.3 Surface Water Monitoring

The Water Resources Division of the SLO County Public Works maintains eight (8) real-time data monitoring stream gages within the Arroyo Grande Creek watershed. Three out of the eight stream gages are located within the Arroyo Grande Subbasin that include Rodriguez, Cecchetti, and Arroyo Grande Creek. As summarized in Table 3-6, each stream gage measures stage at 15-minute intervals. Stage-discharge relationships, or rating curves, were developed by Western Hydrologics for the County and streamflow data in cubic feet per second (CFS) and were calculated for each gage. In addition, the USGS has one stream gage located in the upper watershed of Lopez Canyon. The location of the eight County gages and USGS gage are presented in Table 3-6.

Table 3-6. Stream gages and summary of records available within the Arroyo Grande Creek Watershed

Stream Gage	Source	Data Recorded	Data Interval	Year Data Begins	Datum[1]
Lopez Canyon (USGS 11141280)	USGS	Stage	15 Minutes	1967	NGVD29
Arroyo Grande at Rodriguez (733)	SLO County	Stage	15 Minutes	2007	NAVD 88
Arroyo Grande at Cecchetti (735)	SLO County	Stage	15 Minutes	2006	NAVD 88
Arroyo Grande at Arroyo Grande (736)	SLO County	Stage	15 Minutes	1967	NAVD 88
Los Berros Creek (757)	SLO County	Stage	15 Minutes	1968	NAVD 88
Valley Road (731)	SLO County	Stage	15 Minutes	2005	NAVD 88
Arroyo Grande at 22nd Street Bridge (730)	SLO County	Stage	15 Minutes	2008	NAVD 88
Arroyo Grande Creek Lagoon (769)	SLO County	Stage	15 Minutes	2005	NAVD 88
Meadow Creek Lagoon (770)	SLO County	Stage	15 Minutes	2005	NAVD 88

[1]Prior to 5/23/2017 County data was recorded on NGVD 29 datum. Conversion is 2.86 feet.

3.1.1.4 Climate Monitoring

Climate monitoring in the AG Subbasin includes stations that primarily only collect precipitation data with limited or incomplete records. One station resides just outside of the AG Subbasin boundary located at the Lopez Reservoir where precipitation, evapotranspiration, and temperature data has been collected. Daily data at the Lopez Reservoir records begin in December of 1993 and monthly data records begin in May of 1968. The location of the Lopez Reservoir weather station is shown on Figure 3-9. Table 3-7 lists the climate stations and summary of records available.

The long-term precipitation and cumulative departure from the mean (CDFM) measurements at Lopez Reservoir are shown in Figure 3-10 from 1968 - 2020. CDFM is a relative measure of how a given year of annual precipitation diverged from the historical mean and is used to qualitatively identify wet, normal, and dry precipitation intervals. Average annual precipitation at this station varies from approximately 7 to 45 inches with a mean annual average precipitation of 21.07 inches. The longest dry period on record occurred from 1968 – 1977 and the longest wet period on record occurred from 1991 – 2001. Table 3-8 provides a summary of average monthly rainfall, temperature, and reference evapotranspiration (ET_0) for the AG Subbasin from the Lopez Reservoir weather station.

Table 3-7. Weather station Information and summary of records available within the Arroyo Grande Creek Watershed.

Station	Source	Data Recorded	Data Interval	Year Data Begins
Lopez Reservoir	SLO County	Precipitation, Temperature*, Evapotranspiration	Daily	1993
Arroyo Grande Creek	SLO County	Precipitation	Daily	2006
Lopez Rec Area	SLO County	Precipitation	Daily	2005
Los Berros	SLO County	Precipitation	Daily	2014
Lopez WTP	SLO County	Precipitation	Daily	2019
Oceano	SLO County	Precipitation	Daily	2005
Upper Lopez	SLO County	Precipitation	Daily	2020

* Temperature daily data records start January 2000

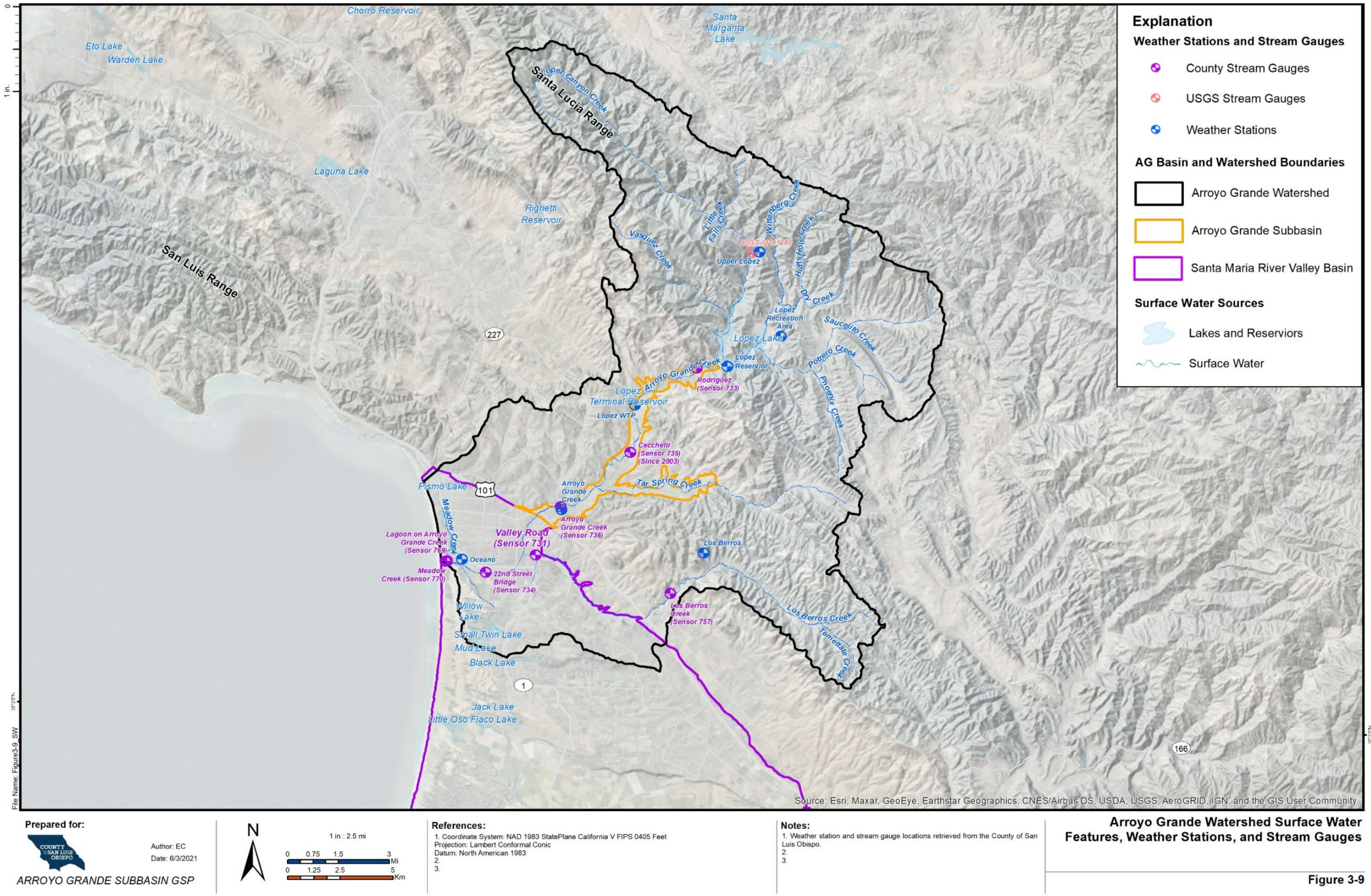


Figure 3-9. AG Subbasin Surface Water Features, Weather Stations, and Stream Gages

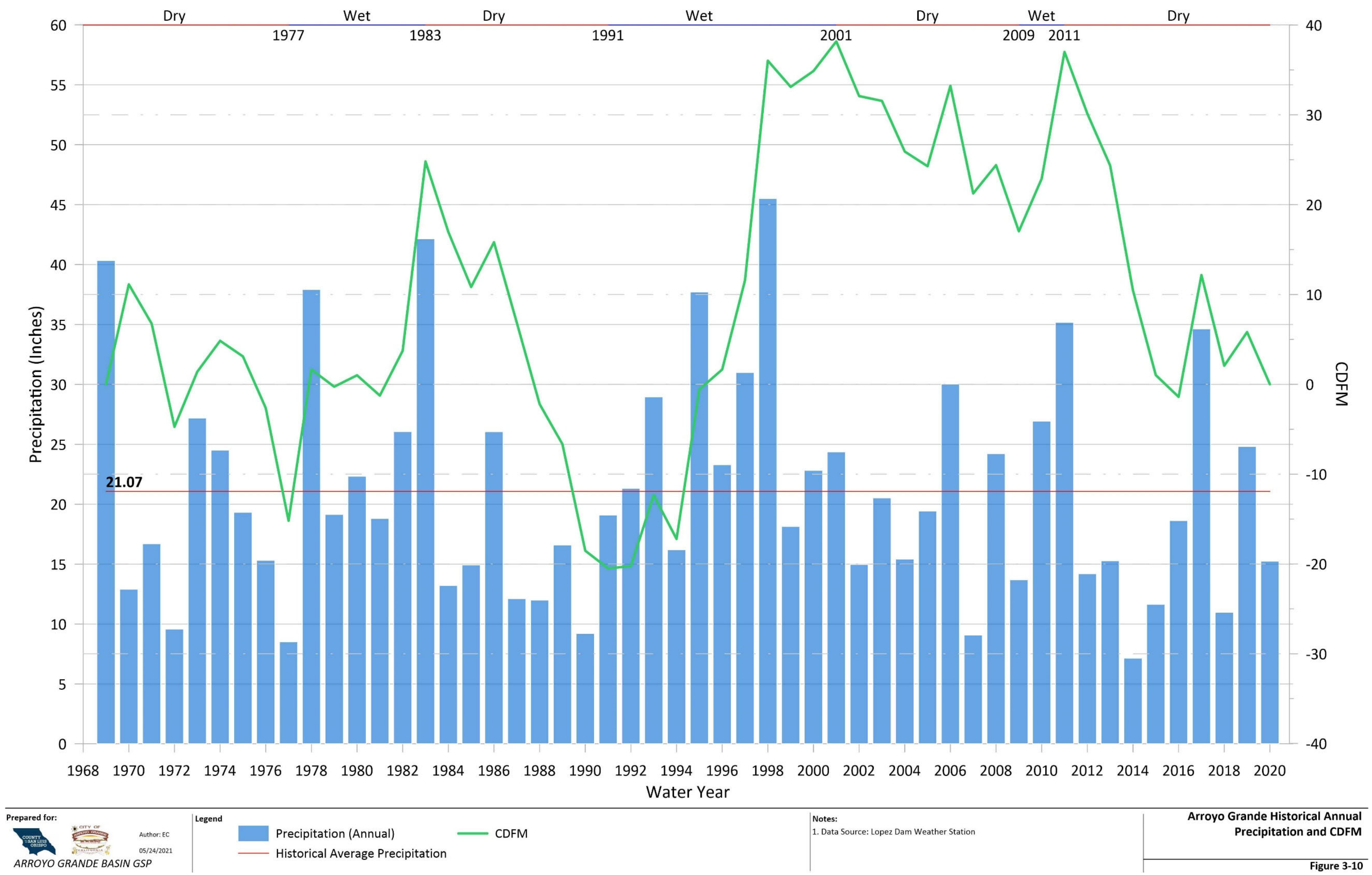


Figure 3-10. AG Subbasin Historical Annual Precipitation and CDFM

Table 3-8. Average Monthly Climate Summary 1993 – 2020 at Lopez Reservoir Weather Station

Month	Average Precipitation (inches)[a]	Average ET_0 (inches)[a]	Average Temperature (°F)*
January	5.21	0.82	59.3
February	4.45	0.92	57.9
March	3.31	1.71	57.1
April	1.5	2.93	58.4
May	0.63	4.31	57.2
June	0.08	5.31	59
July	0.04	5.53	60
August	0	5.23	58
September	0.06	3.78	57.8
October	0.9	2.5	56.8
November	1.95	1.46	55.7
December	3.5	1.09	54.6
Monthly Average	1.8	2.97	56

*Average of monthly data at Lopez Reservoir Weather Station 1993 – 2020.

3.6.2 Existing Management Plans

There are numerous groundwater and water management plans and study reports that cover either the whole or portion of the AG Subbasin. These plans and reports are described in the following subsections, along with brief descriptions of how they relate to the management of current water supply, projected water supplies, and land use.

3.6.2.1 Santa Maria River Valley Groundwater Basin Fringe Area Characterization Study

The Santa Maria River Valley Groundwater Basin Fringe Area Characterization Study (GSI Water Solutions, 2018) provides a summary of the geologic setting and hydrology of the fringe areas of the Santa Maria River Valley Groundwater Basin including the AG Subbasin. This information is intended to provide characterization of the subbasin and justification for the basin boundary modification of the AG Subbasin. This study has limited information on the AG Subbasin.

3.6.2.2 San Luis Obispo County Master Water Report (2012)

The County's Master Water Report (MWR) (Carollo, 2012) is a compilation of the current and future water resource management activities being undertaken by various entities within the County and is organized by Water Planning Areas (WPA). The MWR explores how these activities interrelate, analyzes current and future supplies and demands, identifies future water management strategies and ways to optimize existing strategies, and documents the role of the MWR in supporting other water resource planning efforts. The MWR evaluates and compares the available water supplies to the water demands for the different water planning areas. This was accomplished by reviewing or developing the following:

- Current water supplies and demands based on available information
- Forecast water demands and water supplies available in the future under current land use policies and designations
- Criteria under which there is a shortfall when looking at supplies versus demands
- Criteria for analyzing potential water resource management strategies, projects, programs, or policies
- Potential water resource management strategies, projects, programs, or policies to resolve potential supply deficiencies

3.6.2.3 San Luis Obispo County Integrated Regional Water Management Plan (2014)

The San Luis Obispo County Integrated Regional Water Management Plan (IRWMP) was initially developed by GEI Consultants and adopted by the SLOFCWCD in 2005 and has been updated several times. The SLOFCWCD, in cooperation with the SLOFCWCD's Water Resources Advisory Committee (WRAC), prepared the 2014 IRWMP (SLO-FCWCD, 2014) to align the region's water resources management planning efforts with the State's planning efforts. The IRWMP is used to support the region's water resource management planning and submittal of grant applications to fund these efforts.

The IRWMP includes goals and objectives that provide the basis for decision-making and are used to evaluate project benefits. The goals and objectives reflect input from interested stakeholders on the region's major water resources issues. These goals and objectives help secure and enhance the water supply reliability, water quality, ecosystems, groundwater, flood management and water-related communication efforts across the entire region. In addition, the IRWMP identifies resource management strategies, recognizes other funding opportunities and includes a list of action items (projects, programs, and studies) that agencies around the region including the Arroyo Grande Creek watershed are undertaking to achieve and further these goals and objectives.

The latest IRWMP update was finalized in May 2020 and submitted to DWR and adopted by local agencies in September of 2020.

3.6.2.4 City of Arroyo Grande 2015 Urban Water Management Plan (2015)

The City's Urban Water Management Plan (UWMP) (City of Arroyo Grande, 2015) describes the City's current and future water demands, identifies current water supply sources, and assesses supply reliability for the City. The UWMP describes the City's use of groundwater and its support for efforts to avoid overdraft by developing additional sources. The UWMP provides a forecast of future growth, water demand, and water sources for the City through 2035. These sources include water conservation, extension of the Nacimiento Pipeline, desalination, recycled water, and State Water Project water. The UWMP identifies beneficial impacts to groundwater quality through the use of these sources.

3.6.2.5 San Luis Obispo County Stormwater Resources Control Plan (2015)

The Stormwater Resources Control Plan identifies and prioritizes stormwater and dry weather runoff capture projects in the County that may provide multiple benefits. These benefits range from improving watershed conditions, surface water flows, habitat conservation, and groundwater conditions. Nine (9) areas were outlines within the County, named "Watershed Groups", that are separated by surface-water drainage divides.

The Arroyo Grande/Pismo Watershed Group was assessed. Water quality conditions in Arroyo Grande Creek were found to be of good quality and suitable for steelhead, red-legged frogs, and other aquatic resources. However, below Lopez Reservoir water quality degrades downstream due to agricultural and urban pollutants. Flows in the creek are strongly dependent on downstream releases from Lopez Reservoir.

Stormwater capture projects were identified, ranked, and scored for all Watershed Groups. For the Arroyo Grande/Pismo Watershed Group, five projects were ranked: (1) stormwater infiltration basins, (2) Pismo Preserve Rd improvement, (3) Corbett Ck floodplain and stream restoration, (4) Oceano Drainage improvement, and (5) South Halycon Green Street. Of the five, the stormwater infiltration basins received the highest score, but adequate cost estimates are unknown.

3.6.2.6 San Luis Obispo County General Plan – Resource Summary Report (2018)

The Resources Summary Report describes the state of available resources and infrastructure, capabilities, limitations, and forecasts with regards to water supply, water systems, and wastewater. Levels of severity were assigned to coastal and inland area throughout the County for water supplies based on criteria that quantify projected level of demand relative to estimated available supply over certain time frames. Levels of severity were also assigned to water and wastewater systems based on criteria that quantify the projected level of demand relative to the estimated capacities. However, the level of severity for the Lopez Reservoir system was not evaluated.

3.6.2.7 Arroyo Grande Creek Habitat Conservation Plan (HCP) for Lopez Reservoir (2004 - present)

In 2004, Zone 3 prepared a draft HCP for the Lopez Dam project for the purpose of complying with the ESA and providing incidental take authorization for steelhead, tidewater goby, and red-legged frog for covered operations and maintenance activities affecting the Arroyo Grande Creek. The draft was submitted to resource agencies for review and comment which resulted in the need to develop a new draft HCP. This work is still underway and current efforts include the development of an integrated surface/groundwater model for the Arroyo Grande Creek Watershed which is a part of this GSP. The model will be a key tool to allow Zone 3 and the Contract Agencies to better understand the relationship between downstream release and groundwater pumping and their impacts on the availability of habitat in lower Arroyo Grande Creek. It is envisioned that the model will allow for the development of a new downstream release program that will be proposed to the environmental regulatory agencies. The updated downstream release program and the HCP are intended to provide a plan for the operation of Lopez Reservoir that fulfills the contractual water supply obligations to the Zone 3 contractors and provides releases for downstream agricultural users, and habitat enhancement for steelhead, tidewater goby, red-legged frog, and other environmentally sensitive biota in lower Arroyo Grande Creek.

In addition, Zone 3 is considering addressing its water rights permit issues by filing a time extension on the permit with the SWRCB. This will allow Zone 3 to then file a change petition to pursue needed changes to the permit that will reflect actual operations of the Dam in terms of direct diversions, diversions to storage and re-diversions.

While the HCP and the updated downstream release program are still being developed, Zone 3 has prepared an Interim Downstream Release Schedule (IDRS), that optimizes storage and stream/reservoir management, to meet the demands of municipal, agricultural, and environmental users in the interim. The IDRS was followed by the development of the Low Reservoir Response Plan (LRRP) consisting of a set of actions that Zone 3 will implement during drought conditions when the amount of water storage in the reservoir drops below 20,000 AF. The purpose of the LRRP is to limit both municipal levels and downstream releases to preserve or extend water supplies in the reservoir above the minimum pool for 3 to 4 years under continuing drought conditions. The IDRS and LRRP are not employed to increase municipal supplies beyond current contractual entitlements.

3.6.3 Existing Groundwater Regulatory Programs

3.6.3.1 Groundwater Export Ordinance (2015)

In 2015, County of San Luis Obispo adopted an Exportation of Groundwater ordinance (County Code Chapter 8.95) that requires a permit for the export of groundwater out of a groundwater basin or out of the County. An export permit is only approved if the Department of Public Works Director or his/her designee finds that moving the water would not have any adverse impacts to groundwater resources, such as causing aquifer levels to drop, disrupting the flow of neighboring wells, or resulting in seawater intrusion. Export permits are only valid for one year.

3.6.3.2 Countywide Water Conservation Program Resolution 2015-288 (2015)

The ordinance also identified areas of severe decline in groundwater elevation and properties overlying these areas would be further restricted from planting new or expanding irrigated agriculture except for those converting irrigated agriculture on the same property into a different crop type. This resolution applies only to the Nipomo Mesa Water Conservation Area, which is part of the Santa Maria Subbasin, the Los Osos Groundwater Basin, and the Paso Robles Groundwater Basin. Therefore, it is not applicable to the AG Subbasin.

3.6.3.3 Agricultural Order R3-2017-002 (2017)

In 2017 the CCRWQCB issued Agricultural Order No. R3-2017-0002, a Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands. The permit requires that growers implement practices to reduce nitrate leaching into groundwater and improve surface water quality. Specific requirements for individual growers are structured into three tiers based on the relative risk their operations pose to water quality.

Growers must enroll, pay fees, and meet various monitoring and reporting requirements according to the tier to which they are assigned. All growers are required to implement groundwater monitoring, either individually or as part of a cooperative regional monitoring program. Growers electing to implement individual monitoring (i.e., not participating in the regional monitoring program implanted by the Central Coast Groundwater Coalition [CCGC]) are required to test all on-farm domestic wells and the primary irrigation supply wells for nitrate or nitrate plus nitrite, and general minerals (including, but not limited to, TDS, sodium, chloride, and sulfate).

3.6.3.4 Water Quality Control Plan for the Central Coast Basins (2017)

The Water Quality Control Plan for the Central Coastal Basin (Basin Plan) was recently updated in September 2017 by the SWRCB. The objective of the Basin Plan is to outline how the quality of the surface water and groundwater in the Central Coast Region should be managed to provide the highest water quality reasonably possible.

The Basin Plan lists beneficial users, describes the water quality that must be maintained to allow those uses, provides an implementation plan, details SWRCB and CCRWQCB plans and policies to protect water quality, and a statewide surveillance and monitoring program as well as regional surveillance and monitoring programs.

Present and potential future beneficial uses for inland waters in the AG Subbasin are surface water and groundwater as municipal supply (water for community, military or individual water supplies); agricultural; groundwater recharge; recreational water contact and non-contact; sport fishing; warm freshwater habitat; wildlife habitat; rare threatened or endangered species; and spawning, reproduction, and/or early development of fish.

Water Quality Objectives for both groundwater (drinking water and irrigation) and surface water are provided in the Basin Plan and are used to set the sustainability management criteria for the groundwater quality indicator for the GSP.

3.6.3.5 California DWR Well Standards (1991)

Under the CWC Sections 13700 to 13806, DWR has the responsibility for developing well standards. DWR maintains these standards to protect groundwater quality. California Well Standards, published as DWR Bulletin 74, represent minimum standards for well construction, alteration, and destruction to protect groundwater. Cities, counties, and water agencies in California have regulatory authority over wells and can adopt local well ordinances that meet or exceed the statewide Well Standards. When a well is constructed, modified or destroyed a well completion report is required to be submitted to DWR.

3.6.3.6 Requirements for New Wells (2017)

Senate Bill 252 effective on January 1, 2018. SB 252 requires well permit applicants in critically over-drafted basins to include information about the proposed well, such as location, depth, and pumping capacity. The bill also requires the permitting agency to make the information easily accessible to the public and the GSA. As of 2019, these requirements are under review by DWR. This bill is not applicable because the AG Subbasin is not a critically overdrafted basin.

In addition to State permitting requirements for critically over-drafted basins, the County of San Luis Obispo has its own well permitting processes to review and approve wells that will be constructed within the County. All new prospective water wells and monitoring wells must be permitted through the County Environmental Health Services.

3.6.3.7 Title 22 Drinking Water Program (2018)

The 2018 SWRCB DDW regulates public water systems in the State to ensure the delivery of safe drinking water to the public. A public water system is defined as a system for the provision of water for human consumption through pipes or other constructed conveyances that has 15 or more service connections or regularly serves at least 25 individuals daily at least 60 days out of the year. Private domestic wells, wells associated with drinking water systems with less than 15 residential service connections, and industrial and irrigation wells are not regulated by the DDW. There are six (6) public water systems located within the AG Subbasin [1].

The SWRCB DDW enforces the monitoring requirements established in Title 22 of CCR for public water system wells, and all the data collected must be reported to the DDW. Title 22 also designates the regulatory limits (e.g., maximum contaminant levels [MCLs]) for various waterborne contaminants, including volatile organic compounds, non-volatile synthetic organic compounds, inorganic chemicals, radionuclides, disinfection byproducts, general physical constituents, and other parameters.

3.6.3.8 Arroyo Grande Creek Watershed Management Plan (2009)

The Arroyo Grande Creek Watershed Management Plan (Central Coast Salmon Enhancement, 2009) was developed by Central Coast Salmon Enhancement in association with private landowners and public agencies to assess the long-term steelhead habitat restoration on public and private lands in the watershed by performing comprehensive watershed-wide planning activities. The plan provides the California Department of Fish and Game and landowners (Central Coast Salmon Enhancement, 2009) below Lopez Reservoir with recommendations and implementation concepts that will address problems affecting steelhead habitat in the watershed. The recommended actions are intended to improve steelhead fish habitat by reducing soil erosion and sedimentation through bank stabilization and assessing and removing fish passage barriers, improving water quality and riparian habitat, and addressing flood control and in-channel vegetation management. With respect to groundwater, this plan provides planning information that relates to groundwater dependent ecosystems (GDE) which play an important role in current and future management of groundwater within the AG Subbasin.

3.6.3.9 Incorporation Into GSP

Information in these various plans mentioned above has been incorporated into this GSP for consideration in the development of Sustainability Goals, when setting Minimum Thresholds and Measurable Objectives, and was considered during development of Projects and Management Actions to provide consistency among the above listed plans to achieve groundwater sustainability in the AG Subbasin.

3.6.3.10 Limits to Operational Flexibility

Some of the existing management plans and ordinances will limit operational flexibility. These limits to operational flexibility have already been incorporated into the sustainability projects and programs included in this GSP. Examples of limits on operational flexibility include:

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[1] https://sdwis.waterboards.ca.gov/PDWW/JSP/WaterSystems.jsp?PointOfContactType=none&number=&name=&county=San%20Luis%20Obispo

- The Groundwater Export Ordinance requires County approval to export of water out of the AG Subbasin. This is likely not a significant limitation because exporting water out of the AG Subbasin hinders sustainability.
- Title 22 Drinking Water Program regulates the quality of water that can be recharged into the AG Subbasin.

3.7 Conjunctive Use Programs

Though there are no active formal conjunctive use programs currently operating within AG Subbasin, the City of Arroyo Grande and other subbasin pumpers do manage their surface and groundwater supplies conjunctively.

3.8 Land Use Plans

The County and City have land use authority in the AG Subbasin. However, SGMA requires the GSAs to consider land use documents by the overlying governing agencies when making decisions. Government Code Section 65350.5 and 65352 require review and consideration of groundwater requirements before the adoption or any substantial amendment of a City's or County's general plan. The planning agency shall review and consider GSPs and any proposed action should refer to the GSA and GSP. Land use is an important factor in water management as described below. The following sections provide a general description of these land use plans and how implementation may affect groundwater supply.

3.8.1 City of Arroyo Grande General Plan

The General Plan (City of Arroyo Grande, 2018) is the principal tool the City uses when evaluating municipal service improvements and land use proposals. Every service the City provides to its citizens can trace its roots back to goals and policies found in the General Plan. General Plan goals, policies, and implementation measures are based on an assessment of current and future needs and available resources. The land use element designates the general distribution and intensity of land uses, including the location and type of housing, businesses, industry, open space, and education, public buildings, and parks. Figure 3-11 shows the City's Land Use Map.

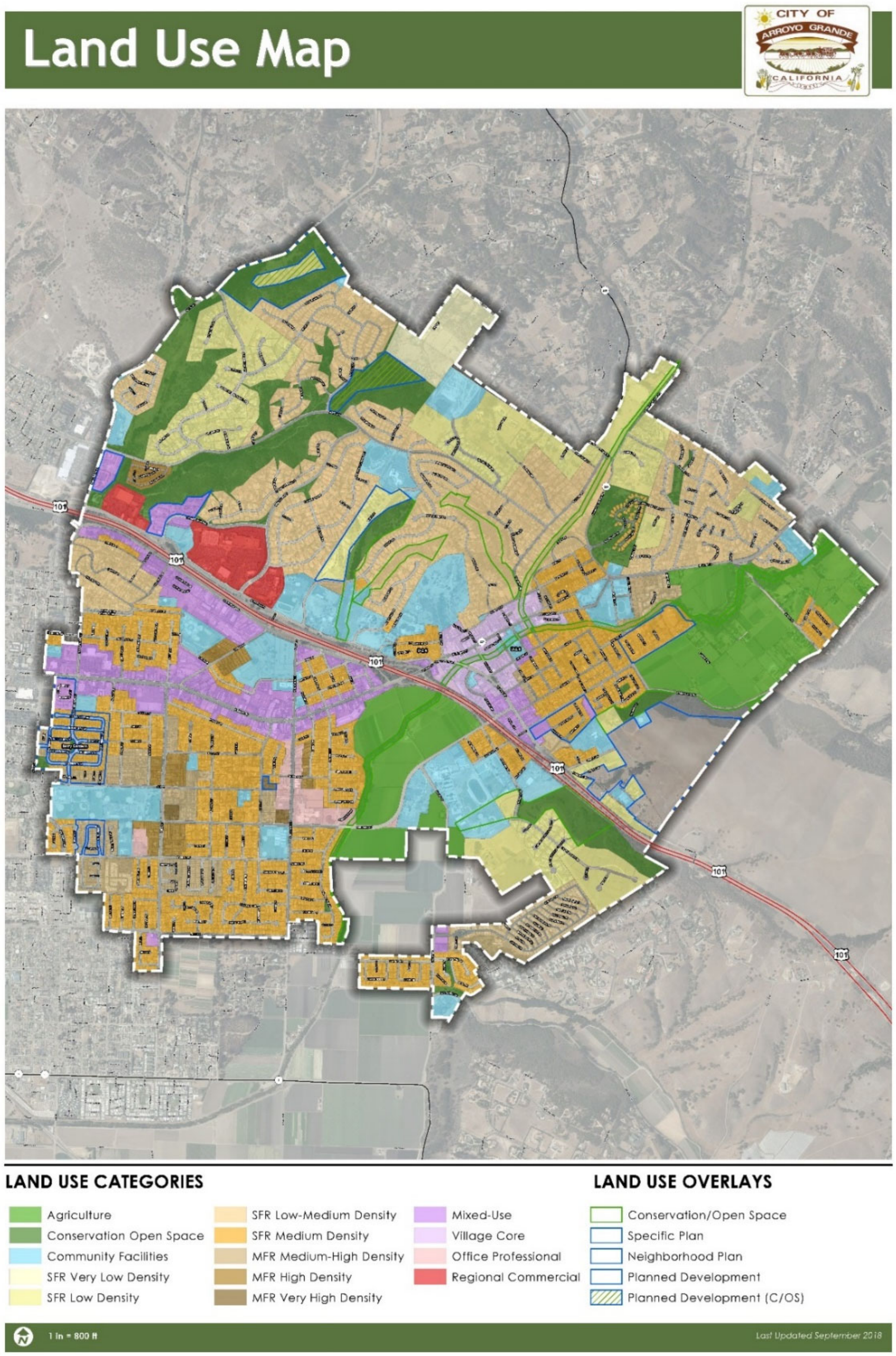

Figure 3-11. City Land Use Map

The City manages its housing supply growth based on density and other factors. The City decided to adopt numerous Land Use Elements addressing water resources, wastewater services, and environmental impacts because of the vital role of these resources and the far-reaching impacts of water policies on community growth and character. These elements translate the Land Use Element's capacity for development into potential demand for water supply and wastewater services. This element outlines how the City plans to provide adequate water and wastewater services for its citizens and not exceed maximum density thresholds that are consistent with the goals and policies of other General Plan elements. As stated in the General Plan, land use development projects must show adequate groundwater supplies and wastewater services exist before a new land division is approved and further restrictions are imposed in the Arroyo Grande Fringe Planning Area which makes up a portion of the AG Subbasin. The City envisions groundwater playing an important role in ensuring continued resiliency in its water supply portfolio.

3.8.2 County of San Luis Obispo General Plan

The 2014 County General Plan contains three pertinent elements that are related to land use and water supply. Pertinent sections include the Land Use, Agricultural, and Inland Area Plans elements.

The County's General Plan also contains programs that are specific, non-mandatory actions or policies recommended by the Land Use and Circulation Element (LUCE) to achieve community or area wide objectives. Implementing each LUCE program is the responsibility of the County or other public agency that is identified in the program. Programs are recommended actions rather than mandatory requirements. Implementation of any program by the County should be based on consideration of community needs and substantial community support for the program and its related cost.

The AG Subbasin is within the South County Planning Area. The planning areas do not conform to the AG Subbasin boundaries but do provide a general representation of the land use in the areas. Figure 3-12 shows the planning areas and land uses

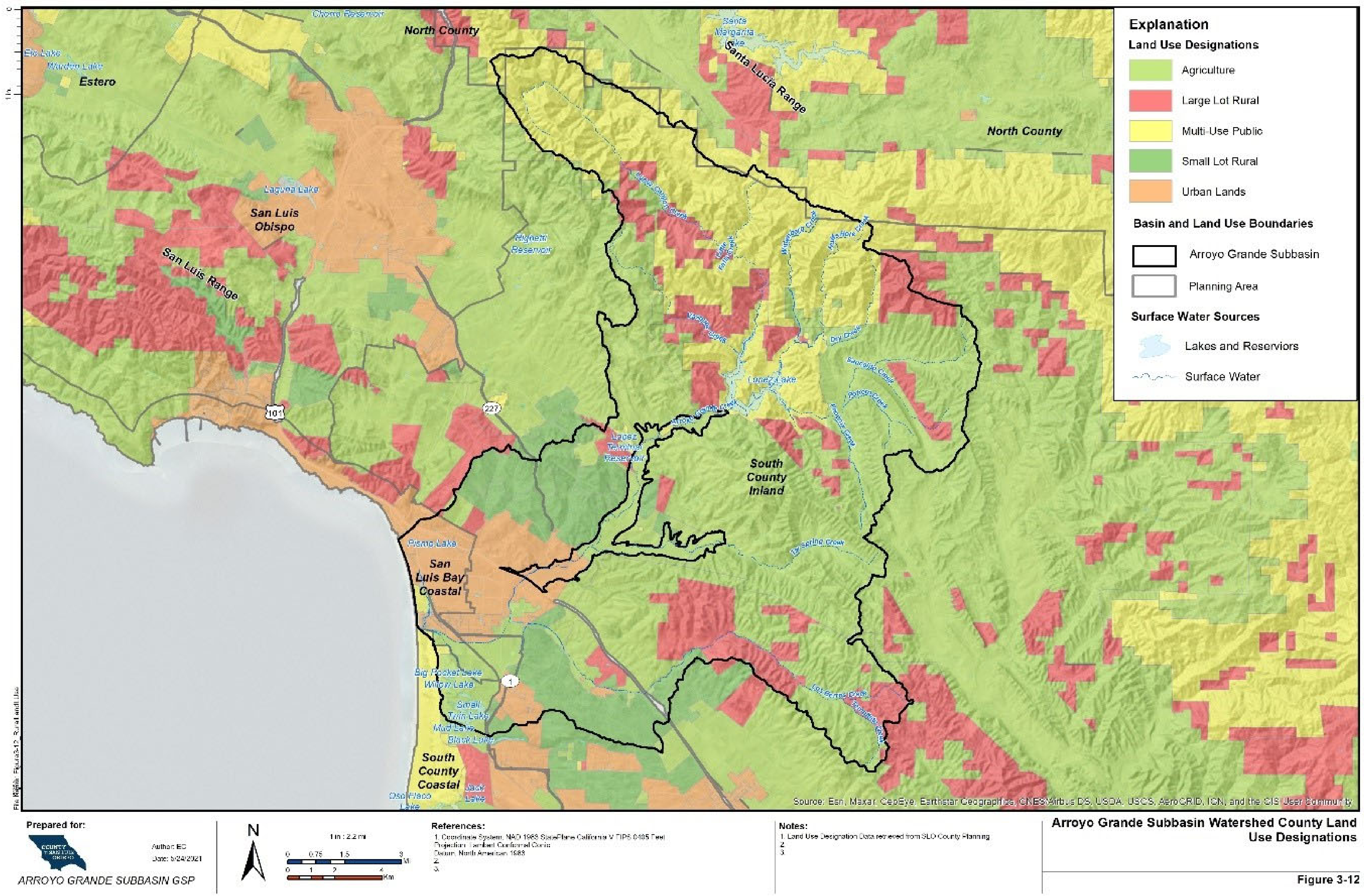

Figure 3-12. Arroyo Grande Subbasin Watershed County Land Use Designation

The General Plan Framework for Planning does not provide tabular assessment of land use types and acres, or population projection estimates within the South County Planning Area. Therefore, projected demands and supplies based on land use aren't identified for the AG Subbasin in the Land Use element.

3.8.3 Land Use Plans Outside of Basin

The Parties submitting this GSP have not included information regarding the implementation of land use plans outside of the AG Subbasin as adjacent basins are also required to implement SGMA and their GSPs will require them to achieve sustainable groundwater management.

3.8.4 Reason for Creation

The City manages its housing supply growth based on density and other factors. The City decided to adopt numerous Land Use Elements addressing water resources, wastewater services, and environmental impacts because of the vital role of these resources and the far-reaching impacts of water policies on community growth and character. These elements translate the Land Use Element's capacity for development into potential demand for water supply and wastewater services. This element outlines how the City plans to provide adequate water and wastewater services for its citizens and not exceed maximum density thresholds that are consistent with the goals and policies of other General Plan elements. As stated in the General Plan, land use development projects must show adequate groundwater supplies and wastewater services exist before a new land division is approved and further restrictions are imposed in the Arroyo Grande Fringe Planning Area which makes up a portion of the AG Subbasin. The City envisions groundwater playing an important role in ensuring continued resiliency in its water supply portfolio.

3.8.5 County of San Luis Obispo General Plan

The 2014 County General Plan contains three pertinent elements that are related to land use and water supply. Pertinent sections include the Land Use, Agricultural, and Inland Area Plans elements.

The County's General Plan also contains programs that are specific, non-mandatory actions or policies recommended by the Land Use and Circulation Element (LUCE) to achieve community or area wide objectives. Implementing each LUCE program is the responsibility of the County or other public agency that is identified in the program. Programs are recommended actions rather than mandatory requirements. Implementation of any program by the County should be based on consideration of community needs and substantial community support for the program and its related cost.

The AG Subbasin is within the South County Planning Area. The planning areas do not conform to the AG Subbasin boundaries but do provide a general representation of the land use in the areas. **Error! Reference source not found.** shows the planning areas and land uses. The General Plan Framework for Planning does not provide tabular assessment of land use types and acres, or population projection estimates within the South County Planning Area. Therefore, projected demands and supplies based on land use aren’t identified for the AG Subbasin in the Land Use element.

GROUNDWATER SUSTAINABILITY PLAN

4.0 Subbasin Setting

This section describes the geologic setting of the AG Subbasin, including the AG Subbasin boundaries, geologic formations and structures, principal aquifer units, geologic cross sections, and hydraulic parameter data.

IN THIS SECTION

4.1 Basin Setting (§ 354.14)

The information presented in this chapter, when considered with the information presented in Chapter 5.0 (Groundwater Conditions) and Chapter 6.0 (Water Budget), comprises the basis of the Hydrogeologic Conceptual Model (HCM) of the AG Subbasin. This section draws upon previously published studies. The data and information presented in this section is not intended to be exhaustive but is a summary of the relevant and important aspects of the AG Subbasin hydrogeology that influence groundwater sustainability. More detailed information can be found in the original reports listed in the references section of these chapters. This chapter presents the framework for subsequent sections on groundwater conditions and water budgets.

As part of the GSP process, a numerical groundwater model is being developed for the AG Subbasin and downstream areas in the adjudicated portion of the Santa Maria Subbasin to use as a tool in the GSP and the Habitat Conservation Plan (HCP) development processes (Appendix G). Much of the information comprising the HCM presented in Chapters 4.0, 5.0, and 6.0 of the GSP is applied directly to the development of the groundwater model. Physical data on the geology and hydrogeologic parameters of the AG Subbasin presented in Chapter 4.0 are used to develop the model structure and parameterization. Data on groundwater conditions and water budget presented in Chapters 5.0 and 6.0 are used in model calibration.

Multiple sources and types of data are presented in Chapters 4.0, 5.0, and 6.0. Some of this data, such as rainfall amounts, depth to groundwater, and depth to bedrock, is directly measurable and involves a low degree of uncertainty. Other data, such as aquifer transmissivity, is based on calculations and interpretations of observed data, but is not directly measurable, and so involves a greater amount of uncertainty than direct measurements. And finally, values presented in the water budget are primarily derived from analysis of related data since most groundwater related water budget components are not directly measurable, and so involve more uncertainty than the previously discussed data types.

4.2 Basin Topography and Boundaries

The AG Subbasin is approximately seven miles long, oriented in a northeast-southwest direction, extending from Lopez Dam to the boundary of the Adjudicated Area of the Santa Maria Subbasin (approximately coincident with the Wilmar Avenue Fault and Highway 101). The tributary valley of Tar Spring Creek is about three miles long, oriented east-west, and joins Arroyo Grande Creek about three miles upstream of Highway 101 (Figure 4-1 and Figure 4-2). Land surface of AG Subbasin extends from an altitude of about 380 feet AMSL at the base of Lopez Dam to about 100 ft AMSL at the bottom of the AG Subbasin. Tar Spring Creek Valley extends from an altitude of about 360 ft AMSL to 160 ft AMSL at the confluence with Arroyo Grande Creek. Mountain ridges on the north side of the AG Subbasin rise steeply to elevations of over 1500 feet AMSL near Lopez Dam (Figure 4-1).

The primary weather patterns for the AG Subbasin are derived from seasonal patterns of atmospheric conditions that originate over the Pacific Ocean and move inland. As storm fronts move in from the coast, rainfall in the area falls more heavily in the mountains, and the AG Subbasin itself receives less rainfall because of a muted rain shadow effect. Average annual precipitation ranges from under 16 inches at the lower elevations of the AG Subbasin near Highway 101 to about 21 inches in relatively higher elevation areas near Lopez Dam (Figure 4-3). The time series of annual precipitation for the period of record from 1969 to 2020 at the Lopez Dam weather station was presented in Chapter 3.0, (Figure 3-1). The average rainfall at this location is 21.07 inches. The historical maximum is 45.52 inches, which occurred in 1998. The historical minimum is 7.16 inches, which occurred in 2014.

The AG Subbasin (DWR No. 3-012.02) is a DWR-recognized groundwater subbasin of the adjudicated Santa Maria River Valley Groundwater Basin (previously classified as DWR No. 3-012). The main part of the Santa Maria Subbasin that is adjudicated and managed is now known as the Santa Maria Subbasin and has been reclassified by DWR (DWR No. 3-12.01). The southwestern extent of the AG Subbasin borders the northernmost of these management areas, the Northern Cities Management Area (NCMA), at the Wilmar Avenue Fault, approximately coincident with Highway 101. The AG Subbasin is adjacent to the southeastern extent of the San Luis Obispo Valley Groundwater Basin (DWR Basin 3-09) in the northern extent of the AG Subbasin Santa Maria AG Subbasin AG Subbasin. However, there is a groundwater divide between the two adjacent basins. Groundwater flow direction in the San Luis Obispo Valley Basin is to the northwest, away from AG Subbasin (GSI, 2018), so the two basins are distinct and there is minimal hydraulic communication between the basins.

The physical definition of the AG Subbasin boundary is the contact of unconsolidated alluvial sediments with the bedrock of the Miocene-aged formations and Franciscan Assemblage. (The geologic units will be described in greater detail Section 4.4.) Figure 4-4 displays a surface defining the bottom boundary of the AG Subbasin, based on the elevation of bedrock surface below the AG Subbasin sediments. The elevations range from about 400 feet AMSL near Lopez Dam to about 40 ft AMSL near the southern boundary of the AG Subbasin. Figure 4-5 displays contours of the thickness of the AG Subbasin sediments and indicates that a maximum thickness of over 120 feet is present north of the confluence with Tar Spring Creek.

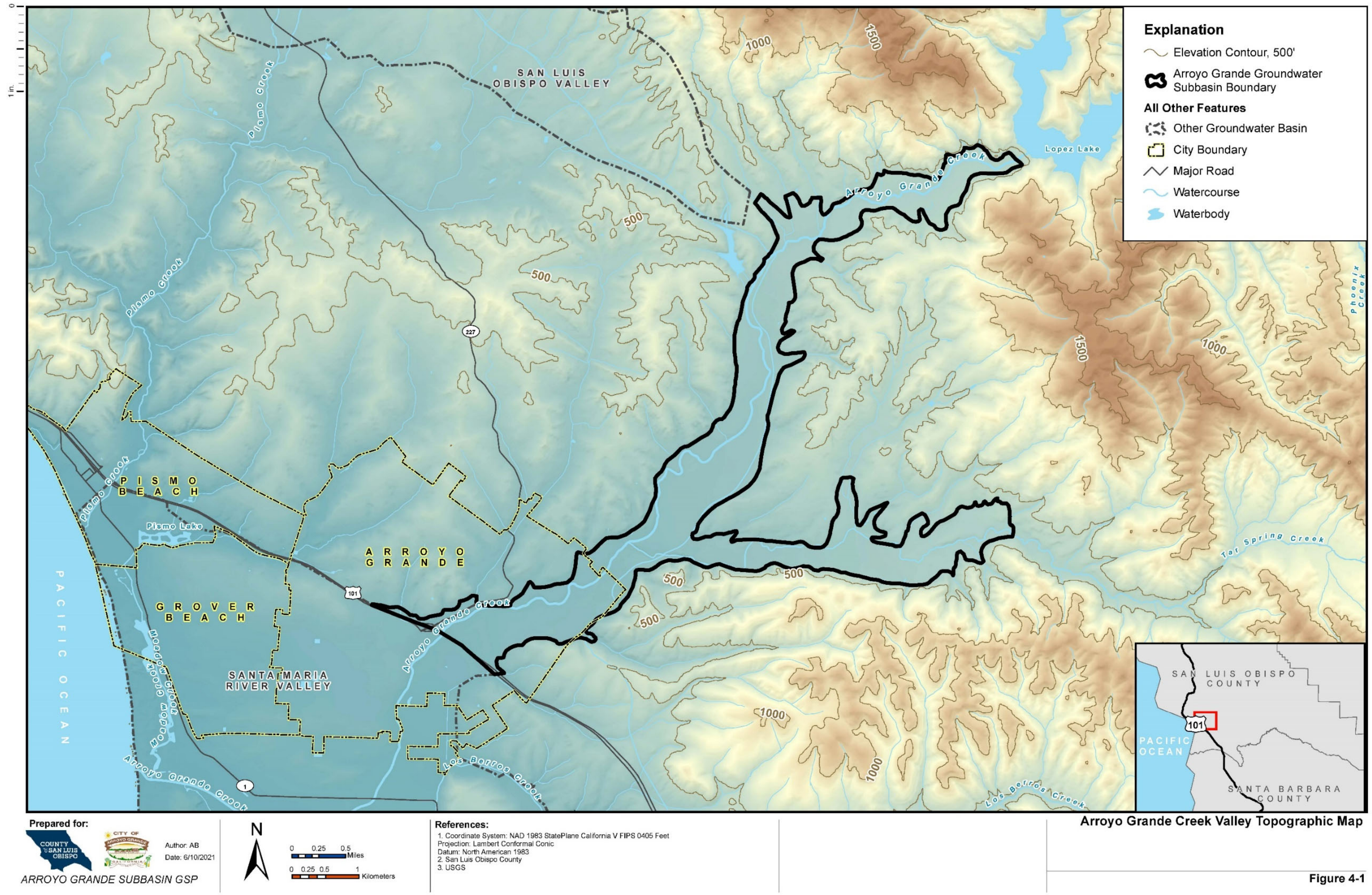

Figure 4-1. Arroyo Grande Creek Valley Topographic Map

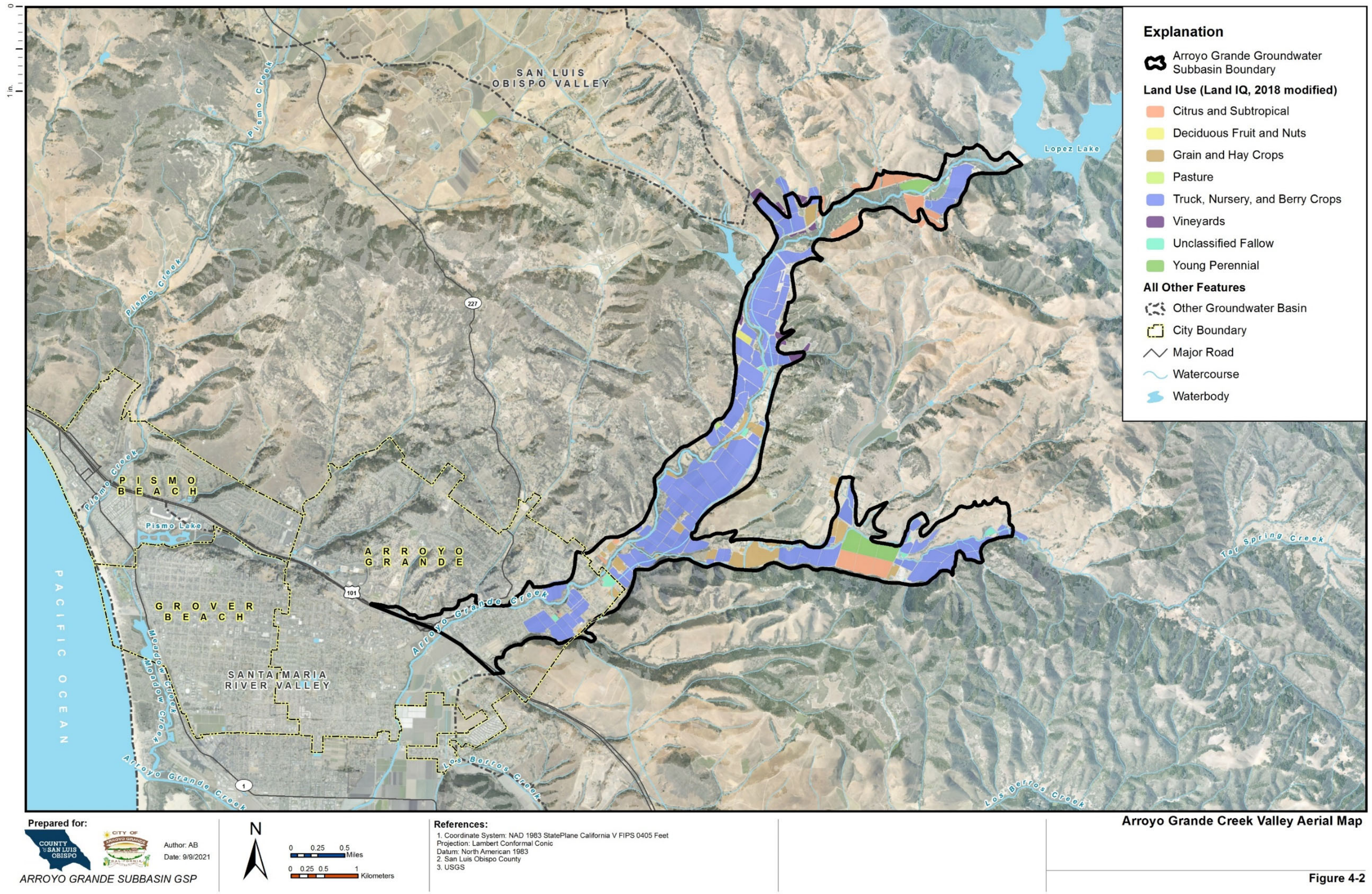

Figure 4-2. Arroyo Grande Creek Valley Aerial Map

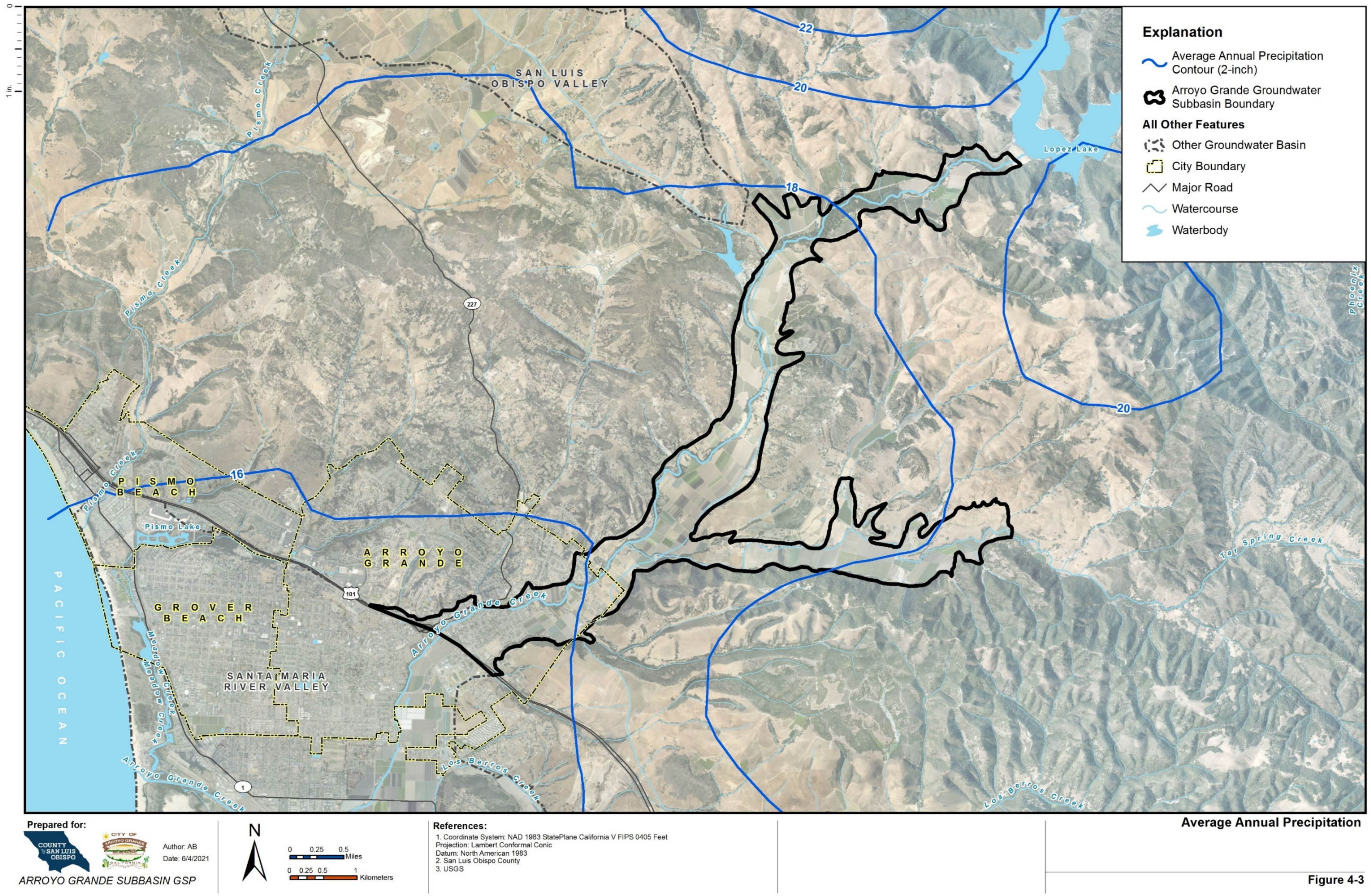

Figure 4-3. AG Subbasin Average Annual Precipitation

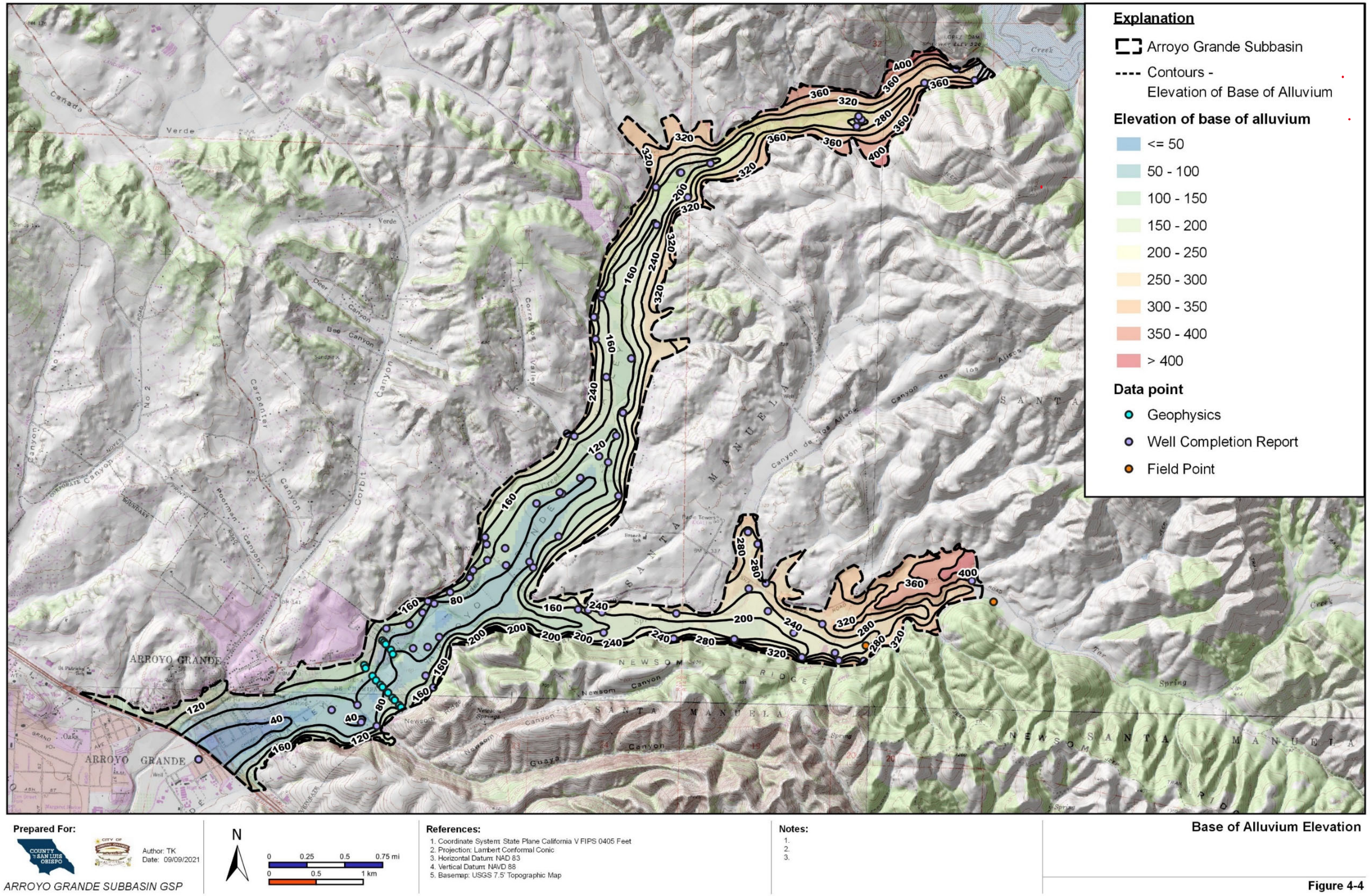

Figure 4-4. AG Subbasin Base of Alluvium Elevation

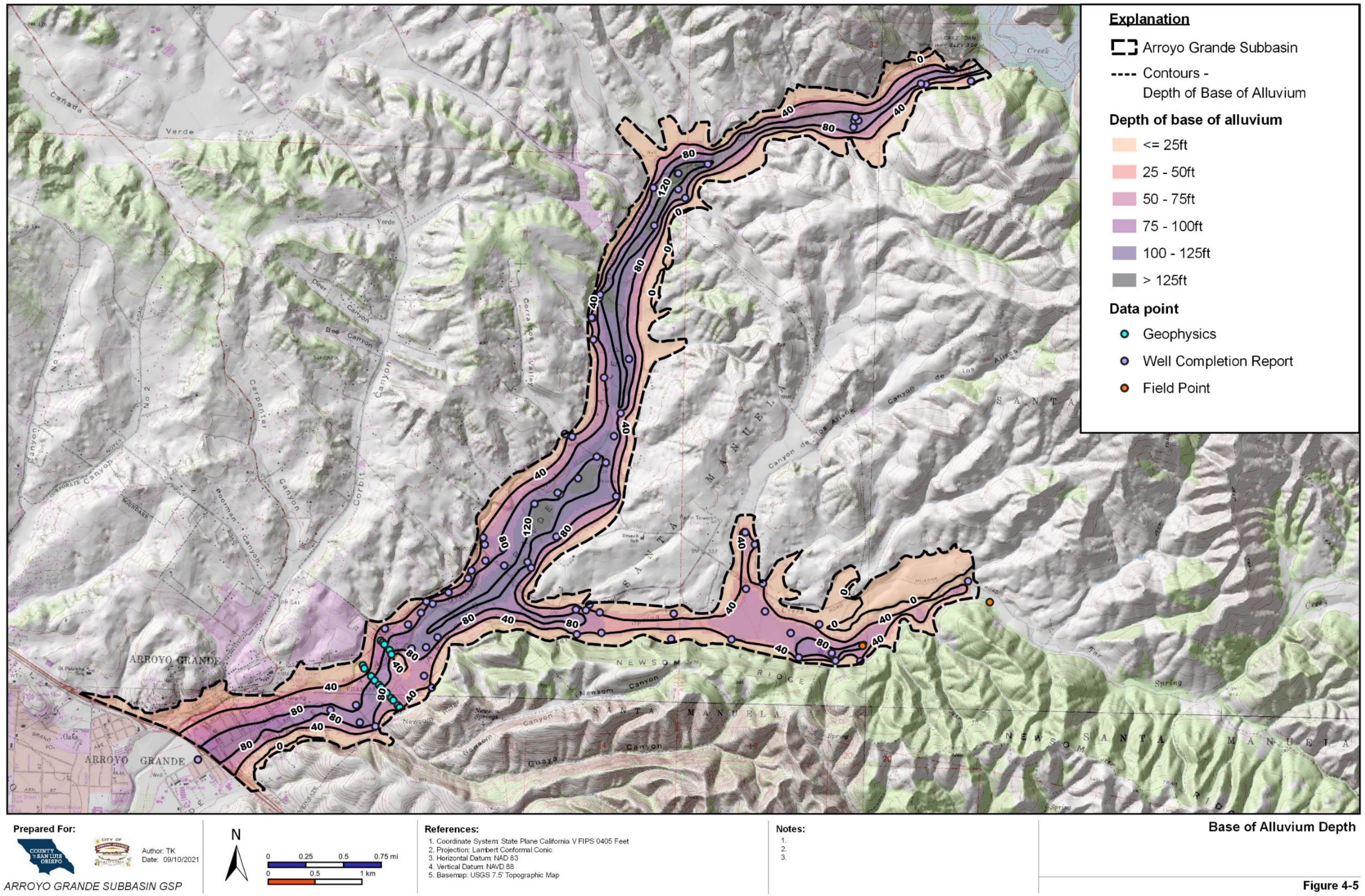

Figure 4-5. AG Subbasin Thickness of Alluvium

4.3 Primary Uses of Groundwater

The predominant groundwater use in the AG Subbasin is pumping for agricultural supply. Approximately 50% of land in the Subbasin is used for agriculture (Figure 4-2). Annual estimates of groundwater extraction are presented in greater detail in Chapter 6.0 (Water Budget), but agricultural pumping accounts for over 90% of pumping in the subbasin. A variety of crops are grown in the AG Subbasin, as displayed previously in Figure 3-2. Most agricultural production in the AG Subbasin relies on groundwater for irrigation supply, although some have riparian water rights along Arroyo Grande Creek. The City of Arroyo Grande does not have any supply wells located in the AG Subbasin. Most of the City's productive supply wells are located in the NCMA portion of the Santa Maria Subbasin (GSI, 2021). Private domestic residential wells in the AG Subbasin are used for local potable supply. These entities are discussed in more detail in Chapter 3.0 of this report.

The AG Subbasin is dominated by agricultural land use (Figure 4-2), with historical estimates of agricultural acreage ranging from 1,620 acres in 1975 to 1,920 acres in 1995 (DWR, 2002), although in 2002 the DWR AG Subbasin encompassed 3,860 acres, compared to the currently defined AG Subbasin area of 2,899 acres. Other historical estimates for agricultural acreage in the Arroyo Grande valley range from 1,770 acres in 2009 to 1,867 acres in 2013 (Cleath-Harris Geologists, 2015), but also include acreages outside of the currently defined AG Subbasin. A 2016 estimate of agricultural land use of 1,440 acres within the formal AG Subbasin boundary is provided in Table 3-1 (Chapter 3.0; total acreage minus native vegetation and urban land use). The main crop type for all years is vegetable crops.

4.4 Soils Infiltration Potential

Saturated hydraulic conductivity of surficial soils is a good indicator of the soil's infiltration potential. Soil data from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) (USDA-NRCS, 2007) is shown by the four hydrologic groups on Figure 4-6. The soil hydrologic group is an assessment of soil infiltration rates that is determined by the water transmitting properties of the soil, which includes hydraulic conductivity and percentage of clays in the soil relative to sands and gravels. The groups are defined as:

- Group A – High Infiltration Rate: water is transmitted freely through the soil; soils typically less than 10 percent clay and more than 90 percent sand or gravel.
- Group B – Moderate Infiltration Rate: water transmission through the soil is unimpeded; soils typically have between 10 and 20 percent clay and 50 to 90 percent sand.
- Group C – Slow Infiltration Rate: water transmission through the soil is somewhat restricted; soils typically have between 20 and 40 percent clay and less than 50 percent sand.
- Group D – Very Slow Infiltration Rate: water movement through the soil is restricted or very restricted; soils typically have greater than 40 percent clay, less than 50 percent sand.
- A higher soil infiltration capacity does not necessarily correlate to higher transmissivity in the underlying aquifer, but it may correlate to greater recharge potential in localized areas. This will be discussed in more detail in Chapter 5.0.

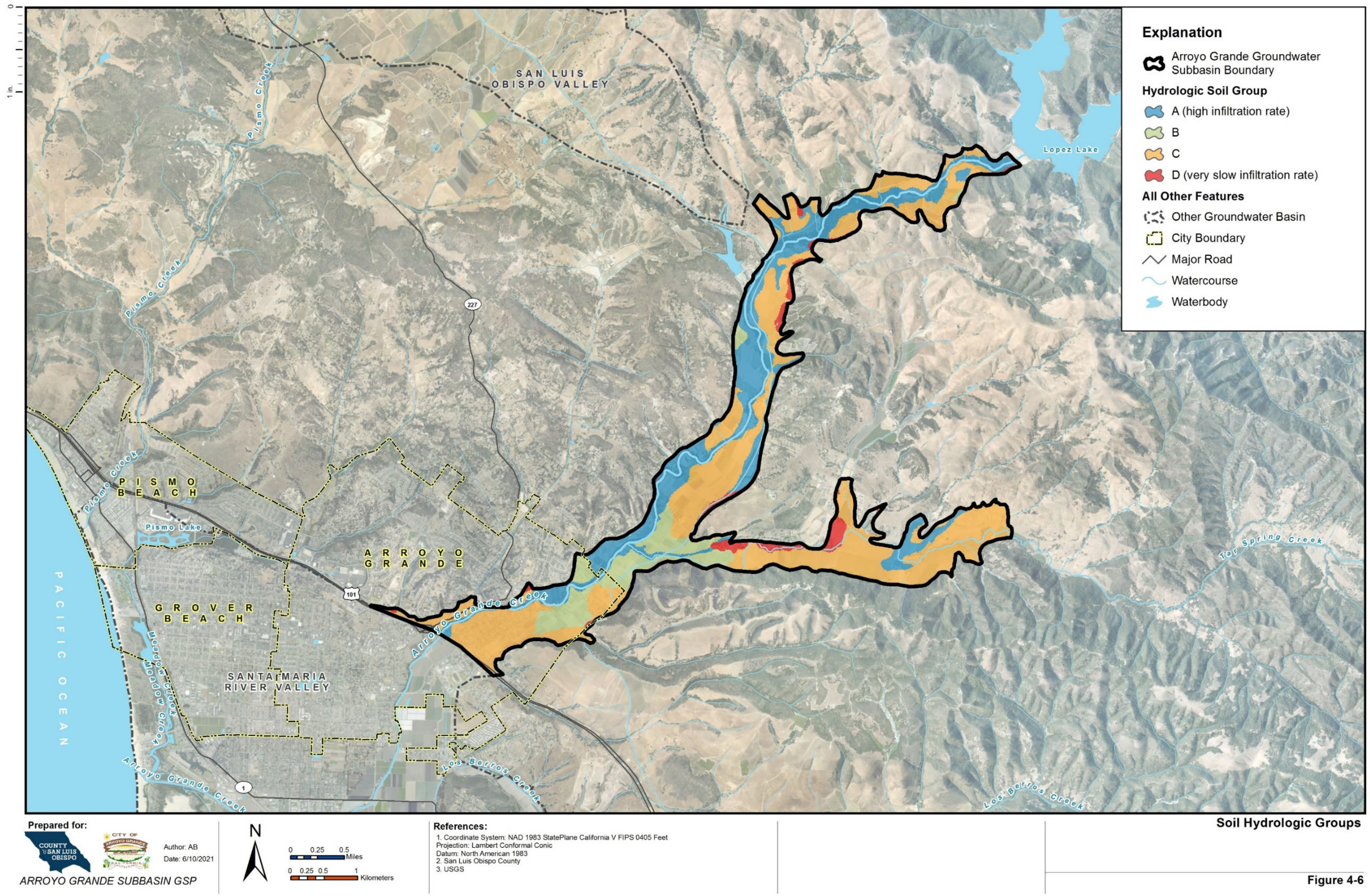

Figure 4-6. AG Subbasin Soil Hydrologic Groups

4.5 Regional Geology

This section provides a description of the geologic formations and structures in the AG Subbasin. These descriptions are summarized from previously published reports. Figure 4-7 displays a stratigraphic column presenting the significant geologic formations within the AG Subbasin (Chipping, 1987). Figure 4-8 presents a surficial geologic map of the AG Subbasin [(Dibble, Geologic Map of Nipomo Quadrangle, San Luis Obispo County, CA, 2006a), (Dibble, Geologic Map of the Oceano Quadrangle, San Luis Obispo County, CA, 2006b), (Dibble, Geologic Map of the Tar Springs Ridge Quadrangle, San Luis Obispo County, CA, 2006c), (Dibble, Geologic Map of the Arroyo Grande NE Quadrangle, San Luis Obispo County, CA, 2006d)] and surrounding area and displays the locations of lithologic data used for this plan, and the section lines corresponding to cross sections in the following figures. Geologic cross sections are presented in Figure 4-9, Figure 4-10, and Figure 4-11. The geologic cross sections illustrate the relationship of the geologic formations that comprise the AG Subbasin and the geologic formations that underlie and bound the AG Subbasin.

4.5.1 Regional Geologic Structures

The AG Subbasin is crosscut by three regional fault systems; the Wilmar Avenue Fault, the Edna Fault, and the Huasna Fault. The most significant fault from a hydrogeologic standpoint is the Wilmar Avenue Fault. This fault defines the downgradient extent of the AG Subbasin and its boundary with the greater Santa Maria Subbasin. The Wilmar Fault has been interpreted in the past to provide a partial hydrogeologic barrier to groundwater flow from the AG Subbasin to the Santa Maria Subbasin (GSI, 2018). The Edna Fault extends to the northwest where it defines the southern boundary of the San Luis Obispo Groundwater Basin. All the faults are classified as normal faults, where primary displacement motion is vertical rather than lateral.

Fault data displayed in Figure 4-8 were acquired via the USGS Earthquake Hazards Program. The Quaternary fault and fold database from which the shapefiles are derived was published in 2006 and cites a wide variety of published sources. Fault traces within the shapefile represent surficial deformation caused by earthquakes during the Quaternary Period (the last 1.6 million years). The water-bearing sedimentary formations and the non-water-bearing bedrock formations are briefly described below.

4.5.2 Geologic Formations within the AG Subbasin

For the purpose of this plan, the geologic units in the AG Subbasin and vicinity may be considered as two basic groups; the AG Subbasin sediments and the consolidated bedrock formations surrounding and underlying the AG Subbasin. The consolidated bedrock formations range in age and composition from (1) Jurassic-aged serpentine and marine sediments to (2) Tertiary-aged marine and volcanic depositions. Compared to the saturated sediments that comprise the AG Subbasin aquifer, the consolidated bedrock formations are not considered to be significantly water-bearing. Although bedding plane and/or structural fractures in these rocks may yield economically usable amounts of water to wells, they do not represent a significant portion of the pumping in the area.

The delineation of the AG Subbasin boundaries is defined both laterally and vertically by the contacts of the AG Subbasin alluvial sedimentary formations with the consolidated bedrock formations. From a hydrogeologic standpoint, the most important strata in the AG Subbasin are the alluvial deposits associated with Arroyo Grande Creek and Tar Spring Creek that define the vertical and lateral extents of the AG Subbasin. Figure 4-7 presents a stratigraphic column of the significant local geologic units. Figure 4-8 presents a geologic map of the AG Subbasin vicinity (assembled from a mosaic of the Dibblee maps from the Tar Spring Ridge, Oceano, Nipomo, and Arroyo Grande NE quadrangles) showing where the various formations crop out at the surface.

4.5.2.1 Alluvium

The Recent Alluvium is the mapped geologic unit composed of unconsolidated sediments of gravel, sand, silt, and clay, deposited by fluvial processes along the courses of Arroyo Grande Creek, and Tar Spring Creek, and their tributaries. Lenses of sand and gravel are the productive strata within the Recent Alluvium. The Recent Alluvium sediments have no significant lateral continuity across large areas of subsurface within the AG Subbasin and may range from just a few feet to more than 120 feet. Well pumping rates may range from less than 10 gallons per minute (gpm) to more than 500gpm. If adequate thickness of alluvium is not available at a given well location, that well may be screened through the alluvium into the underlying bedrock to increase well yield.

4.5.3 Geologic Formations Surrounding the AG Subbasin

Older geologic formations that underlie the AG Subbasin sediments typically have lower permeability and/or porosity and are generally considered non-water-bearing. In some cases, these older beds may occasionally yield flow adequate for local or domestic needs, but wells drilled into these units are also often dry or produce only small rates of groundwater yield. Generally, the water quality from the bedrock units is poor in comparison to the AG Subbasin sediments. In general, the geologic units underlying the AG Subbasin include Tertiary-age consolidated sedimentary and volcanic beds (Pismo, Monterey, and Obispo Formations), and Cretaceous-age sedimentary and metamorphic rocks (Franciscan Assemblage).

The Pismo Formation bedrock is exposed at the surface in the mountains west of the valley, and in much of the area between Arroyo Grande Valley and Tar Spring Creek Valley. To the southeast of the Arroyo Grande/Tar Creek Spring Valley, the Monterey Formation crops out at the surface. The Edna Fault Zone and the Huasna Fault Zone cross the northern extent of the Arroyo Grande Valley; as a result, faulted and folded rocks of the Monterey Formation and Franciscan Assemblage crop out in the area northeast of the valley.

4.5.3.1 Pismo Formation

The youngest geologic unit that crops out around the AG Subbasin is the Pismo Formation. The Pismo Formation is a Pliocene-aged sequence of unconsolidated to loosely consolidated marine deposited sedimentary units composed of claystone, siltstone, sandstone, and conglomerate. There are five recognized members of the Pismo Formation, reflecting different depositional environments, and the variations in geology may affect the hydrogeologic characteristics of the strata. From the bottom (oldest) up, these are 1) the Edna Member, which lies unconformably atop the Monterey Formation, and is locally bituminous (hydrocarbon-bearing), 2) the Miguelito Member, primarily composed of thinly bedded grey or brown siltstones and claystones, 3) the Gragg Member, usually described as a medium-grained sandstone, 4) the Bellview Member, composed of interbedded fine-grained sandstones and claystones, and 5) the Squire Member, generally described as a medium- to coarse-grained fossiliferous sandstone of white to grey sands.

4.5.3.2 Monterey Formation

The Monterey Formation is a thinly bedded siliceous shale, with layers of chert in some locations. In other areas of the County outside of the AG Subbasin, the Monterey Formation is the source of significant oil production. While fractures in consolidated rock may yield usable quantities of water to wells, the Monterey Formation is not considered to be an aquifer for the purposes of this GSP. Regionally, the unit thickness is as great as 2,000 feet, and the unit is often highly deformed. Water wells completed in the Monterey Formation are occasionally productive if a sufficient thickness of highly deformed and fractured shale is encountered. More often, however, the Monterey shale produces groundwater to wells in low quantities. Groundwater produced from the Monterey Formation often has high concentrations of Total Dissolved Solids (TDS), hydrogen sulfide, total organic carbon, and manganese.

4.5.3.3 Obispo Formation

The Obispo Formation and associated Tertiary volcanics are composed of materials associated with volcanic activity along tectonic plate margins approximately 20 to 25 million years ago. The Obispo Formation is composed of ash and other material expelled during volcanic eruptions. Although fractures in consolidated volcanic rock may yield small quantities of water to wells, the Obispo Formation is not considered to be an aquifer for the purposes of this GSP.

4.5.3.4 Franciscan Assemblage

The Franciscan Assemblage contains the oldest rocks in the AG Subbasin area, ranging in age from late Jurassic through Cretaceous (150 to 66 million years ago). The rocks include a heterogeneous collection of basalts, which have been altered through high-pressure metamorphosis associated with subduction of the oceanic crust beneath the North American Plate before the creation of the San Andreas Fault. The current assemblage includes ophiolites, which weather to serpentinites and are common in the San Luis and Santa Lucia Ranges. Although fractures may yield small quantities of water to wells, the Franciscan Assemblage is not considered to be an aquifer for the purposes of this GSP.

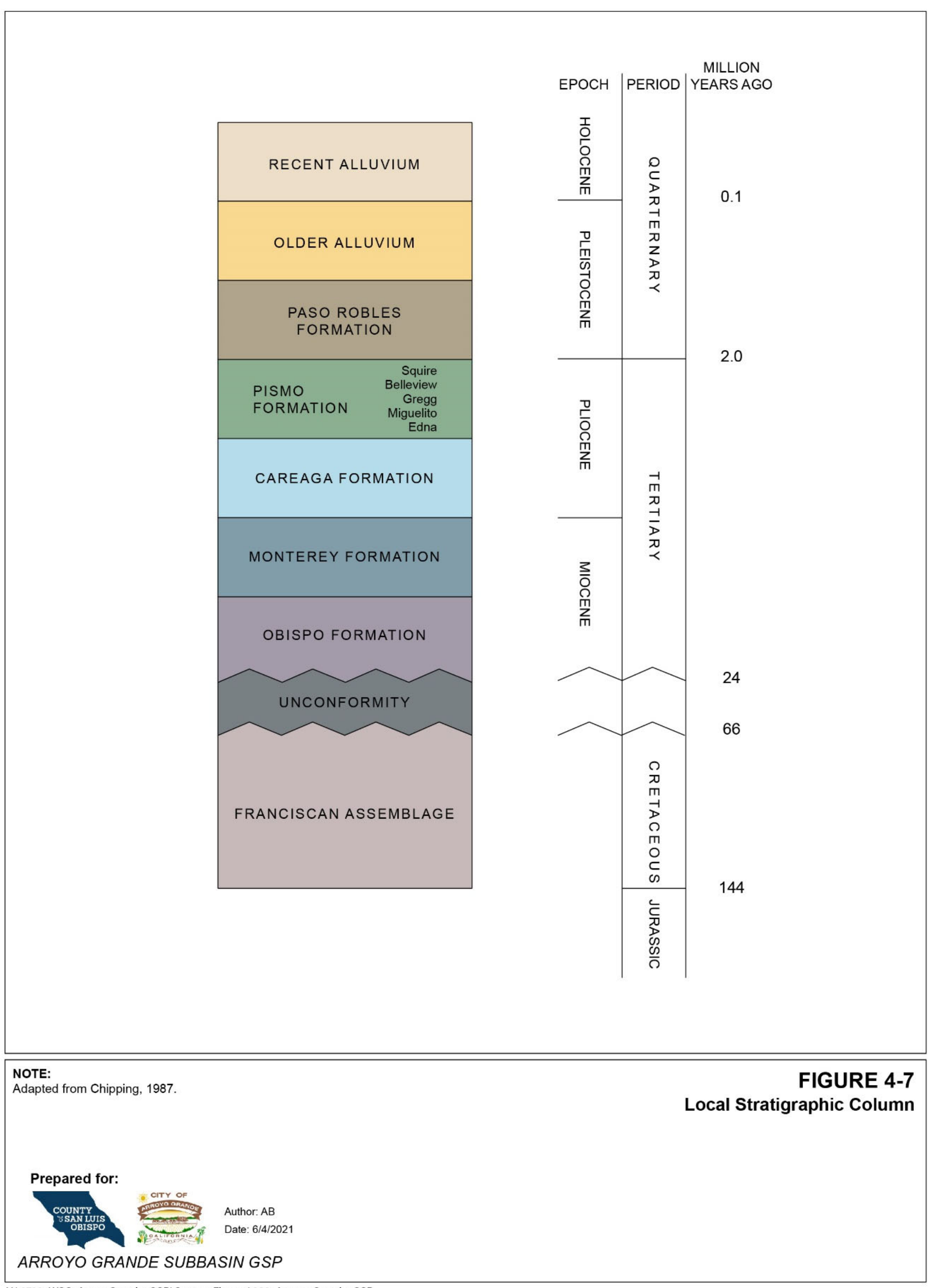

Figure 4-7. AG Subbasin Local Stratigraphic Column

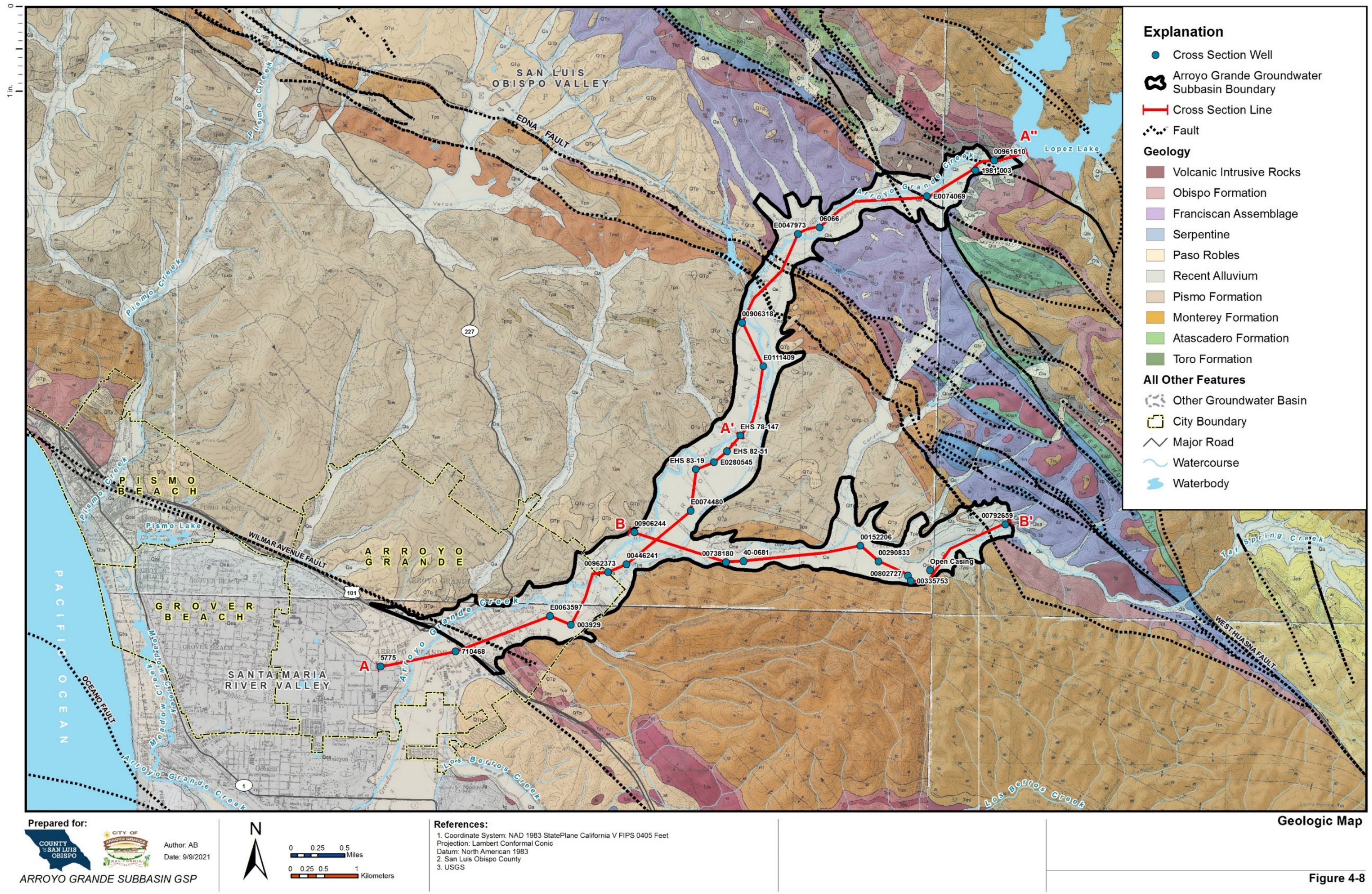

Figure 4-8. AG Subbasin Geologic Map

4.6 Principal Aquifers and Aquitards

Water-bearing sand and gravel beds that may be laterally and vertically discontinuous are generally grouped together into zones that are referred to as aquifers. The aquifers can be vertically separated by fine-grained zones that can impede movement of groundwater between aquifers, referred to as aquitards. The Alluvial Aquifer is the only aquifer formation present in the AG Subbasin. It is a relatively continuous aquifer comprising alluvial sediments that define the extent of the AG Subbasin.

4.6.1 Cross Sections

Three cross sections were prepared for this GSP; two (A-A', A'-A'') are oriented along the longitudinal axis of the Arroyo Grande Creek Valley of the AG Subbasin and one (B-B') is oriented along the longitudinal axis of the Tar Spring Creek Valley (a part of the AG Subbasin) approximately perpendicular to Arroyo Grande Creek (Figure 4-8). All available lithologic data was reviewed during the selection of the section line locations. The cross sections display lithology, interpretations of geologic contacts based on available data, well screen intervals, and interpreted and mapped faults. If the geologic interpretation was not clear from the points on the cross-section lines, nearby data from other locations was reviewed to provide broader geologic context. Each geologic cross section is discussed in the following paragraphs. Additionally, previous geophysical data analysis performed by CHG (Cleath-Harris Geologists, 2019) in the AG Subbasin was referenced and incorporated into the cross sections.

- Cross Section A-A' (Figure 4-9) extends approximately 4.5 miles along the Arroyo Grande Creek Valley axis, from just beyond the southwest boundary of the AG Subbasin (coincident with the Wilmar Avenue Fault) at its boundary with the Santa Maria Subbasin to a point about halfway up the Arroyo Grande Creek Valley, approximately coincident with a mapped synclinal axis in the underlying bedrock. Land surface elevation is about 100 feet AMSL at the southwest end of the section line, and slopes gently upward to about 225 feet AMSL at the northeast extent. Recent Alluvium is exposed at the surface for the entire length of this cross section, ranging in thickness from less than 50 feet in the Santa Maria Subbasin portion of the cross section to about 125 feet in most of the AG Subbasin portion of the section. A significant contiguous strata comprised predominantly of clay is present and interpreted to extend from the vicinity of the Wilmar Avenue Fault to the northwest through the entire cross section, ranging in thickness from about 10 to 50 feet. The presence of this clay layer may have implications regarding the understanding of direct percolation of streamflow throughout the AG Subbasin. (Field work is currently under way with the objective of enhancing the understanding of this process in the AG Subbasin.) Southwest of the Wilmar Avenue Fault, the alluvial sediments are directly underlain by the Paso Robles Formation, which overlies Franciscan Assemblage bedrock. Northeast of the Wilmar Avenue Fault, the Alluvium is underlain by bedrock of the Obispo Formation, Monterey Formation, and Pismo Formation, successively. The Wilmar Avenue Fault is not interpreted to displace the Alluvium, nor to create any hydrogeologic barrier to groundwater flow in the Alluvium.
- Cross Section A'-A" (Figure 4-10) extends approximately 4.5 miles along the Arroyo Grande Creek Valley axis, starting at the match line with Cross Section A-A' and extending northwest to Lopez Dam. Land surface elevation ranges from approximately 225 feet AMSL at the southwest extent of the section to about 375 feet AMSL at the base of Lopez Dam. Thickness of the Alluvium is relatively constant in the section, with a maximum thickness of about 150 feet. The contiguous clay strata that are observed in Section A-A' appears to pinch out about two miles downstream of Lopez Dam. The Edna Fault and the Huasna Fault systems are mapped in the area of this section; these faults displace the bedrock formation of the mountains surrounding the AG Subbasin but are not interpreted to displace the Recent Alluvium. The Alluvium is underlain by the Pismo Formation southwest of the Edna Fault, and by the Franciscan Formation northeast of the Fault.
- Cross section B-B' (Figure 4-11) is oriented approximately east-west and extends approximately 4.5 miles along the Tar Spring Creek Valley axis from its confluence with Arroyo Grande Creek to the upgradient extent of the AG Subbasin. Land surface elevation ranges from approximately 150 feet AMSL at Arroyo Grande Creek to about 350 feet AMSL at the eastern edge of the section. Thickness of the Alluvium ranges from about 50 to 100 feet along Tar Spring Creek. A 10- to 20-foot-thick layer of alluvial strata comprised primarily of clay is observed near land surface in the lithologic data used to generate this section and is interpreted to extend contiguously along the length of Tar Spring Creek. The Edna Fault is mapped in bedrock beneath the alluvium at the eastern extent of the section, emplacing Monterey Formation bedrock west of the fault against Franciscan Group bedrock east of the Fault. These faults displace the bedrock formations but is not interpreted to displace the Recent Alluvium.

4.6.2 Aquifer Characteristics

The relative productivity of an aquifer can be expressed in terms of transmissivity, hydraulic conductivity, or specific capacity. The most robust method is measuring transmissivity using a long-term constant-rate pumping test (frequently 24 hours or more). Water level drawdown data collected during this test can be analyzed and used to calculate aquifer transmissivity. Aquifer transmissivity is the rate of flow under a unit hydraulic gradient through a unit width of aquifer of a saturated thickness and the transmissivity of an aquifer is related to its hydraulic conductivity. Hydraulic conductivity is a measure of a material's capacity to transmit water. Specific capacity is a simple measure of flow rate (gpm) divided by drawdown (feet), routinely measured by well service contractors during well maintenance and reported in units of gpm per foot of drawdown (gpm/ft). A common practice for well drillers in San Luis Obispo County is to conduct air lift tests, wherein compressed air is pumped into the bottom of the well, which displaces groundwater out the top of the well at a rate estimated by the driller. This method provides no drawdown measurement and is dependent on subjective flow estimates made by the driller, but it does provide general information on the comparative productivity of the aquifer in different parts of the AG Subbasin. Information on specific capacity measurements may be affected by poor well construction or degraded well materials, and, therefore, are not necessarily uniquely correlated to aquifer transmissivity. Nevertheless, the following commonly employed empirical relationship allows transmissivity to be estimated from specific capacity measurements.

T (gpd/ft) = SC (gpm/ft) * (1,500 to 2,000)

Where T = Transmissivity (gpd/ft),

SC = Specific Capacity (gpm/ft),

1,500 – 2,000 = Empirical factor (1,500 used for unconfined, 2,000 for confined aquifer)

Data describing transmissivity, specific capacity, and air lift tests from water wells throughout the AG Subbasin were compiled. The data was obtained from previous regional studies or reports, well completion reports, previous pumping tests, and well service information provided by local stakeholders. All available reports and documents that were made available through data requests, report reviews, etc., were reviewed for technical information, and included in this summary if the data were judged to be sufficient. Figure 4-12 displays the spatial distribution of the available data locations for well tests in the AG Subbasin listed on Table 4-1. Inspection of Figure 4-12 indicates a good spatial coverage of locations, with reasonable data density throughout the AG Subbasin.

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

Hydraulic conductivity of the alluvial aquifer in Arroyo Grande is variable. DWR reported a single hydraulic conductivity estimate of 270 ft/day for Arroyo Grande Valley subbasin Alluvium based on aquifer test data, a range of 1.2 to 12 ft/day based on pump efficiency tests, and a range of 22 to 775 ft/day based on lithologic correlation (DWR, 2002). Data reviewed for this GSP and summarized in Table 4-1 indicate a range of hydraulic conductivity values from 8 ft/day to 46 ft/day.

Three constant rate aquifer tests were performed on wells in Arroyo Grande Valley during the preparation of the Basin Boundary Modification Request (GSI, 2018). The locations of the tests are presented as large blue dots on Figure 4-12. Results indicate that one well had a transmissivity of 90,000 gpd/ft, and a corresponding hydraulic conductivity of 252 ft/day; however, it was subsequently determined that this well is partially screened in the underlying Monterey Formation, and the transmissivity apportioned to the alluvial aquifer is estimated to be about 18,000 gpd/ft. The other well test yielded a transmissivity estimate of 15,000 gpd/ft with a corresponding hydraulic conductivity value of 19 ft/day (Table 4-1).

Table 4-1 presents a compilation of all well test data compiled during the preparation of this GSP. This information is used to inform the groundwater model development, and in the technical work supporting preparation of the GSP for the AG Subbasin.

Table 4-1. Well Test Data for Wells within AG Subbasin

WCR/ID	GPM	Duration (hrs)	SWL (ft)	DD (ft)	SC (gpm/ft)	T (gpd/ft)	K (ft/d)
Aquifer tests (pumping tests with drawdown curves)							
906318	115	24	32	4.5	25.6	24,300	46
Biddle Dom.	65	4		3.3	19.7	15,000	19
Huasna Rd.	440	4		11.2	39.3	18,000	38
Specific capacity tests (pumping tests with final drawdown only)							
802727	201	6	28	32	6.3	6700	15
385342	50	4	30	25	2	1800	8
962373	75	12	38.5	16	4.7	5500	14
Air-lift tests							
156766	30	2		-	-	-	-
337436	300 @ 100ft		33	-	-	-	-
395065	100	4	35	-	-	-	-
448657	10 @ 70ft		30	-	-	-	-
505757	45@35ft / 50@55ft		17	-	-	-	-
738175	50+		39	-	-	-	-
738180	60-100		10	-	-	-	-
739489	500		30	-	-	-	-
906244	20+		34	-	-	-	-
1084102	500+		25	-	-	-	-
1097967	200+		26	-	-	-	-
1979-618	30		15	-	-	-	-
E0063592	30	1	34	-	-	-	-
E0063597	40-50	1	27	-	-	-	-
E0074480	30@80ft/150@130ft		61	-	-	-	-
E0075996	15@28ft/30@100ft		26	-	-	-	-
E0101996	300+@110ft		10	-	-	-	-

WCR/ID	GPM	Duration (hrs)	SWL (ft)	DD (ft)	SC (gpm/ft)	T (gpd/ft)	K (ft/d)
E0111409	300@60ft/500@125ft		22	-	-	-	-
E0180027	20	1.5	18	-	-	-	-
E0211771	200+@60ft/300+@140ft		28	-	-	-	-
E0277953	100	1.5	39	-	-	-	-
E0280545	150	4	73	-	-	-	-
2017-003929	400	6	48	-	-	-	-
2018-06066	200	2	27	-	-	-	-
2019-016947	300	4	63	-	-	-	-
961610	500+		30	-	-	-	-
539759	200-300		40	-	-	-	-
539798	30		15	-	-	-	-
580609	25		30	-	-	-	-

4.6.3 Aquitards

An aquitard is a layer of low permeability, usually comprised of fine-grained materials such as clay or silt, which vertically separates adjacent layers of higher permeability formations that may serve as aquifers. As displayed in the cross sections in Figure 4-9, Figure 4-10, and Figure 4-11, there is a contiguous clay layer present in the lower 6 miles of the Arroyo Grande Valley, and a contiguous clay layer present near the surface through most of Tar Spring Creek Valley. These clay layers are part of the Alluvial aquifer but may function as local aquitards impacting the relative ability of the alluvial aquifer to percolate streamflow or direct percolation of precipitation. The presence of these clay layers is considered in the development of the integrated model.

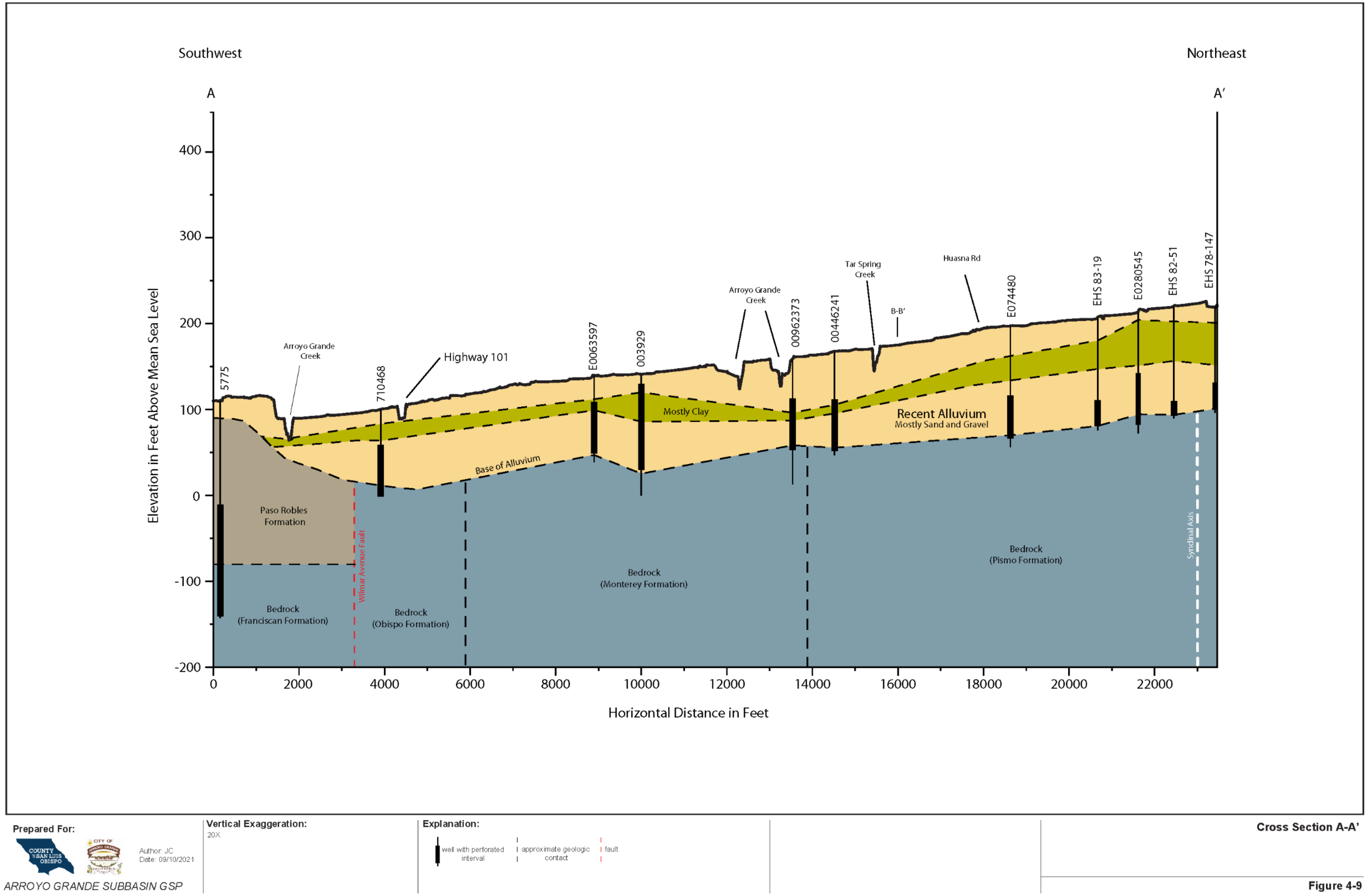

Figure 4-9. AG Subbasin Cross Section A – A'

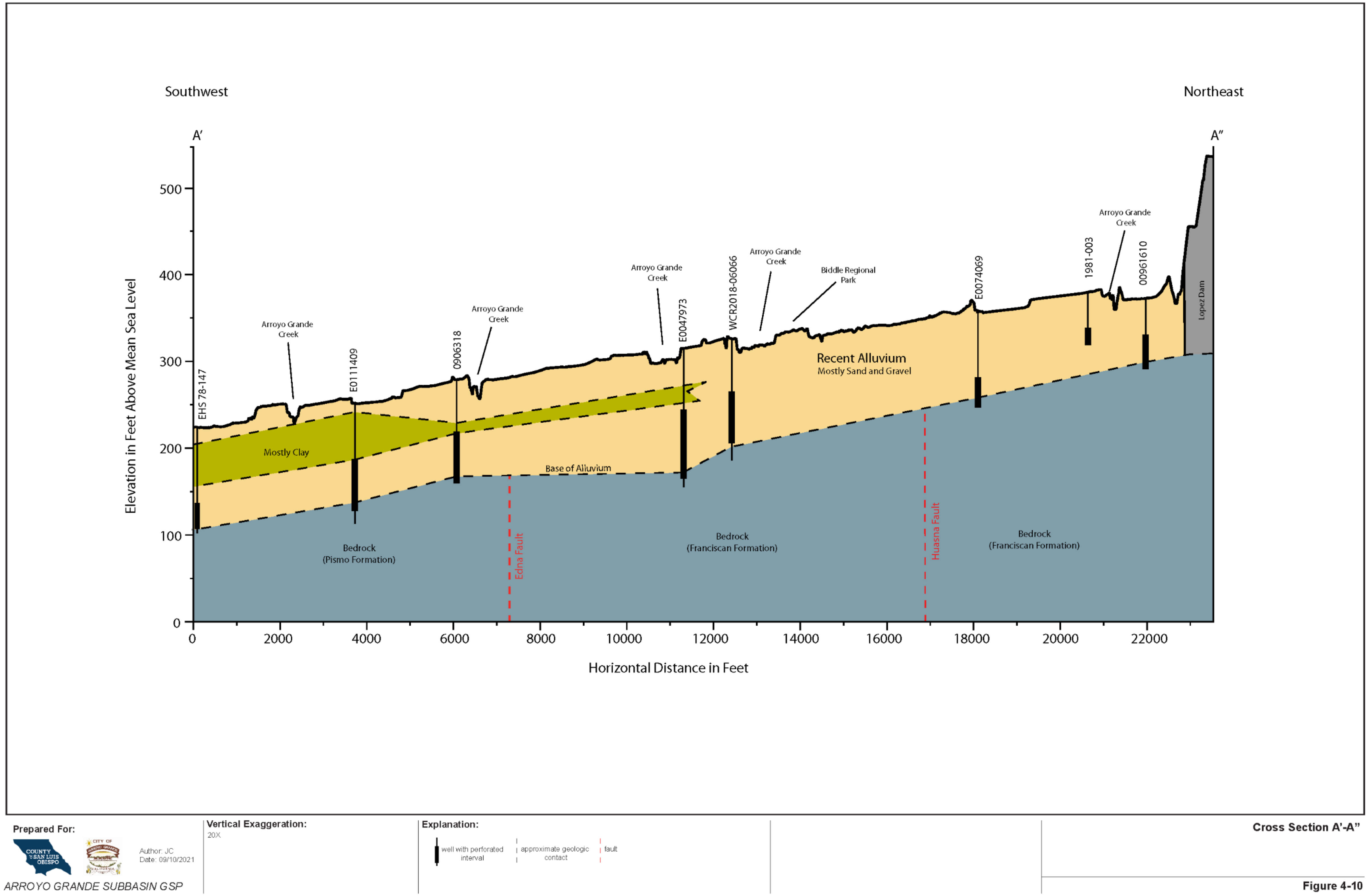

Figure 4-10. AG Subbasin Cross Section A' – A"

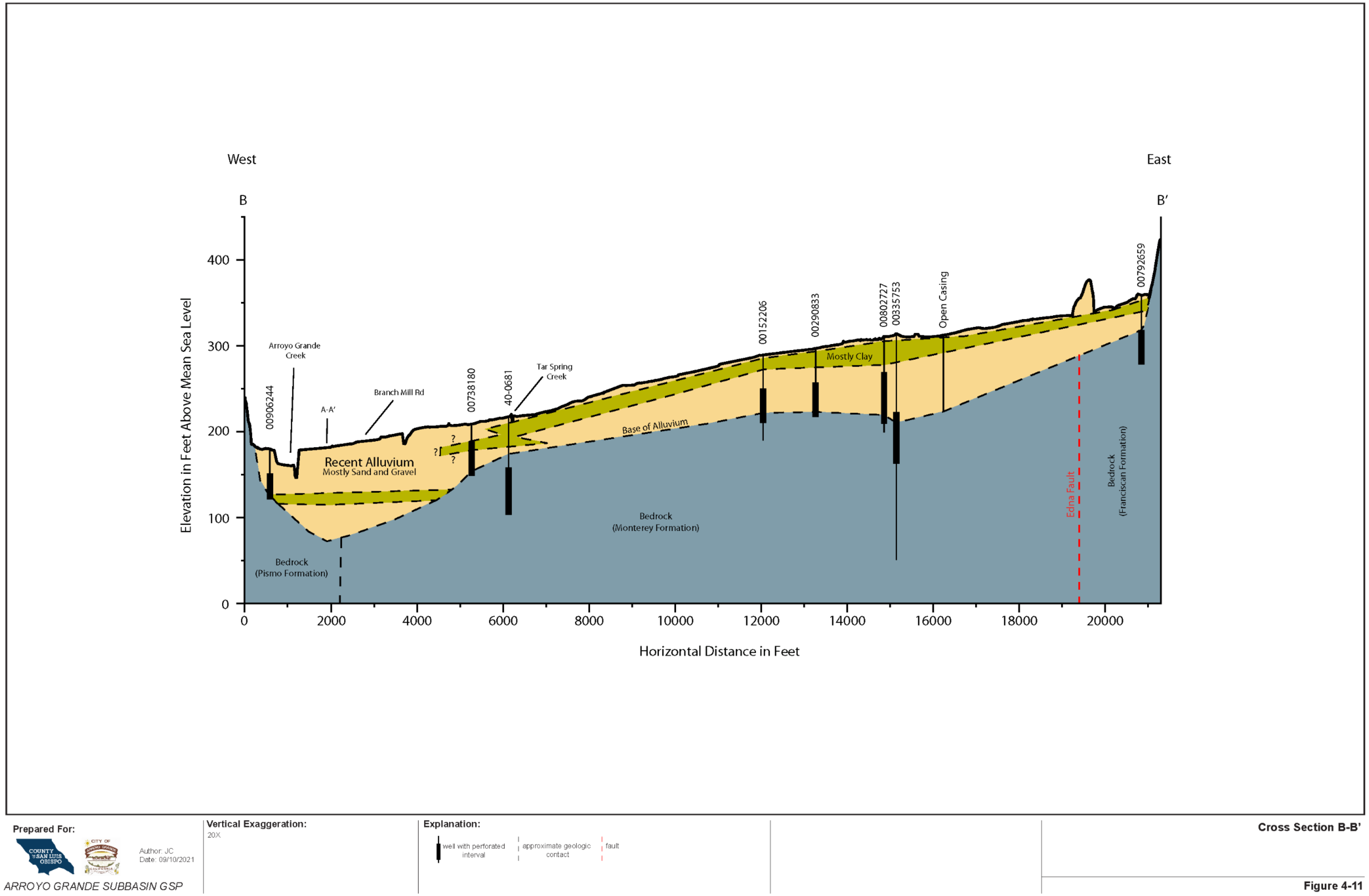

Figure 4-11. AG Subbasin Cross Section B – B'

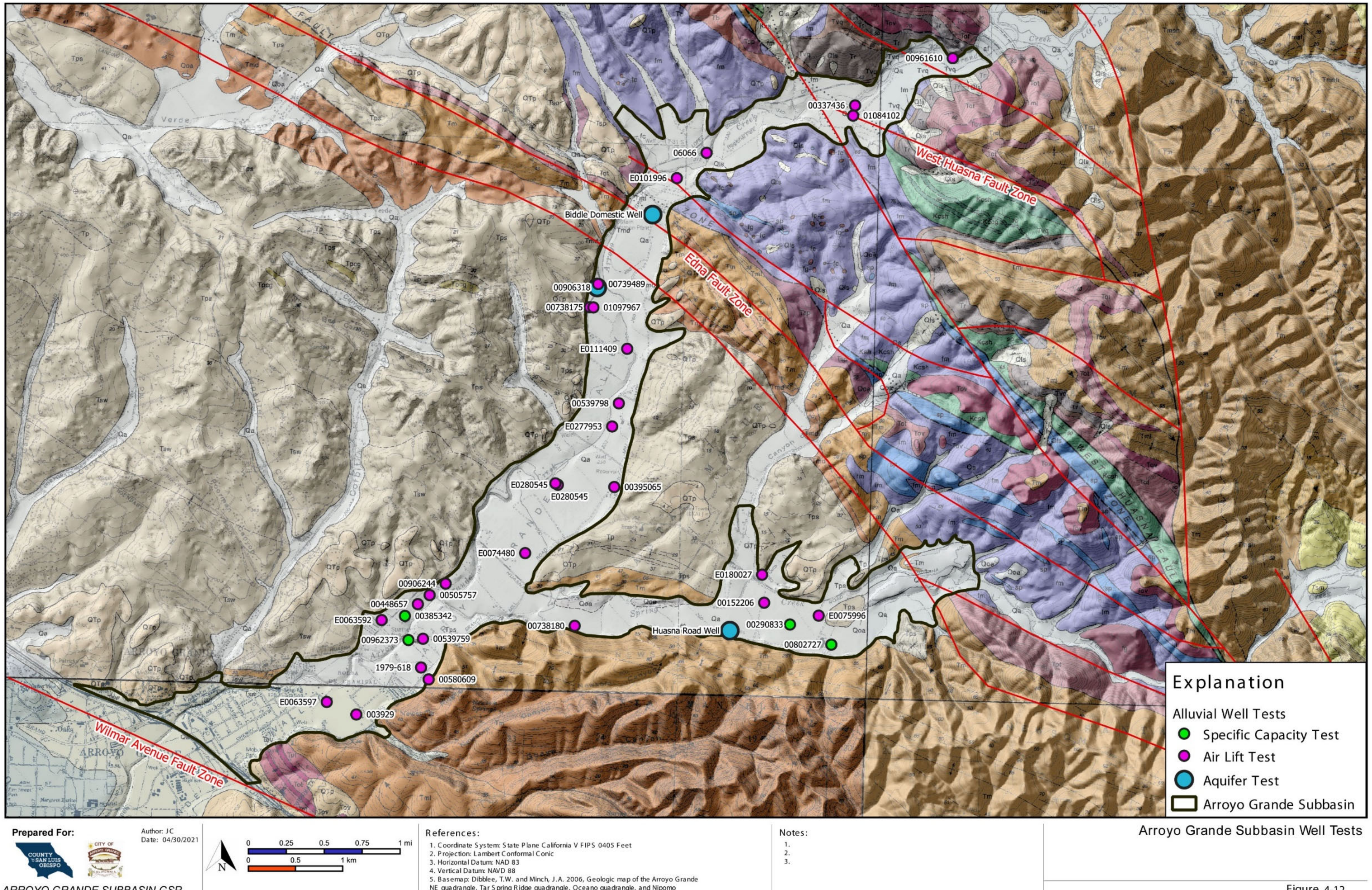

Figure 4-12. AG Subbasin Well Tests

4.7 Surface Water Bodies

Surface water/groundwater interactions represent a significant portion of the water budget of the AG Subbasin aquifer system. In the AG Subbasin, these interactions occur primarily as a function of releases from Lopez Dam to Arroyo Grande Creek, and to a lesser degree in the course of natural flows in Tar Spring Creek.

The watersheds support important habitat for native fish and wildlife, including the federally threatened South-Central California Coast steelhead (*Oncorhynchus mykiss)* (Stillwater, 2014).

Groundwater interaction with streams in the AG Subbasin is not well quantified, but it is recognized as an important component of aquifer recharge in the water budget. Where the water table is above the streambed and slopes toward the stream, the stream receives groundwater flow from the aquifer; this is known as a gaining reach (i.e., the stream gains flow as it moves through the reach). Because there is always some amount of flow released to Arroyo Grande Creek to support fish populations in the stream, it is thought that the streamflow in Arroyo Grande Creek is in hydraulic communication with the groundwater in the surrounding aquifer, maintaining groundwater levels in the vicinity of the creek at levels approximately equivalent to the surface water levels in the creek. Some areas may receive inflow from the aquifer, and some reaches may discharge to the aquifer, but along Arroyo Grande Creek they are always in communication. Along Tar Spring Creek, by contrast, where the water table is beneath the streambed and slopes away from the stream, the stream loses water to the aquifer; this is known as a losing reach. During seasonal dry flow conditions, groundwater elevations are deeper than the streambed since no base flow is present in the creek. Therefore, it is generally understood that the streams in the AG Subbasin discharge to the underlying aquifer, at least in the first part of the wet-weather flow season. If there is constant seasonal surface water flow, it is possible that groundwater elevations may rise to the point that they are higher than the stream elevation, and the creek may become a seasonally gaining stream in some reaches. Field work is being conducted to further investigate the surface water/groundwater interaction along Arroyo Grande Creek, and groundwater modeling can help evaluate surface water/groundwater interaction.

The SLO County Flood Control and Water Conservation District (SLOFC&WCD) maintains eight (8) real-time data monitoring stream gages within the Arroyo Grande Creek watershed. Three out of the eight stream gages are located within the Arroyo Grande AG Subbasin that include Rodriguez, Cecchetti, and Arroyo Grande Creek Gages. As summarized in Table 3-6, each stream gage measures stage at 15-minute intervals. Stage-discharge relationships, or rating curves, were developed by Western Hydrologics for the SLOFC&WCD and streamflow data in cubic feet per second (CFS) were calculated for each gage. In addition, the USGS has one stream gage located in the upper watershed of Lopez Canyon. The location of the eight SLOFC&WCD gages and USGS gage are presented in Figure 3-9.

4.8 Subsidence Potential

Subsidence is the gradual settling or sinking of the earth's surface due to material movement at depth at a given location. It may be associated with lowered groundwater levels caused by groundwater pumping and is one of the undesired results identified in SGMA. For clarity, this Sustainable Management Criterion references two related concepts:

1. Land Subsidence is a gradual settling of the land surface caused by, among other processes, compaction of subsurface materials due to lowering of groundwater elevations from groundwater pumping. Land subsidence from dewatering subsurface clay layers can be an inelastic process, and the potential decline in land surface could be permanent.
2. Land Surface Fluctuation is the periodic or annual measurement of the ground surface elevation. Land surface may rise or fall in any one year. Declining land surface fluctuation may or may not indicate long-term permanent subsidence.

Reduced groundwater levels may allow the dewatering of shallow clay or peat layers if present, causing them to lose the hydrostatic pressure of the groundwater in the pore space, allowing the sediments to compress under the weight of overlying sediments. Subsidence can cause damage to buildings and infrastructure at the surface, resulting in significant economic impacts. If subsidence occurs in agricultural areas without significant buildings or infrastructure present, a small amount of subsidence may have no negative impact. There have been no historical long-term declines of groundwater levels in the AG Subbasin, and no subsidence has been documented in the Arroyo Grande Creek AG Subbasin.

DWR has implemented a satellite-based data collection program referred to as Interferometric Synthetic Aperture Radar (InSAR) capable of measuring small changes in land surface altitude in the state over time. DWR identifies the AG Subbasin as having a low subsidence potential. Inspection of data online in DWR's SGMA data web portal indicates Interpolated Displacement Values clustered around zero, indicating no measurable subsidence in recent years 2015 to 2020. DWR has stated that, on a statewide level, for the total vertical displacement measurements between June 2015 and September 2019, the errors are as follows (NASA-JPL, 2018):

1. The error between InSAR data and continuous GPS data is 16 mm (0.052 feet) with a 95% confidence level.
2. The measurement accuracy when converting from the raw InSAR data to the maps provided by DWR is 0.048 feet with 95% confidence level.

For the purposes of this GSP, the error for InSAR data is considered the sum of errors 1 and 2, combined total error of 0.1 foot. Figure 4-13 presents InSAR total vertical displacement (TVD) data in the AG Subbasin for the period from 2015 to 2019. This figure indicates TVD values ranging from –0.04 to +0.04 over this time period. These values are within the 0.1-foot error range discussed above and corroborate anecdotal information that there have been no negative impacts associated with subsidence in the AG Subbasin.

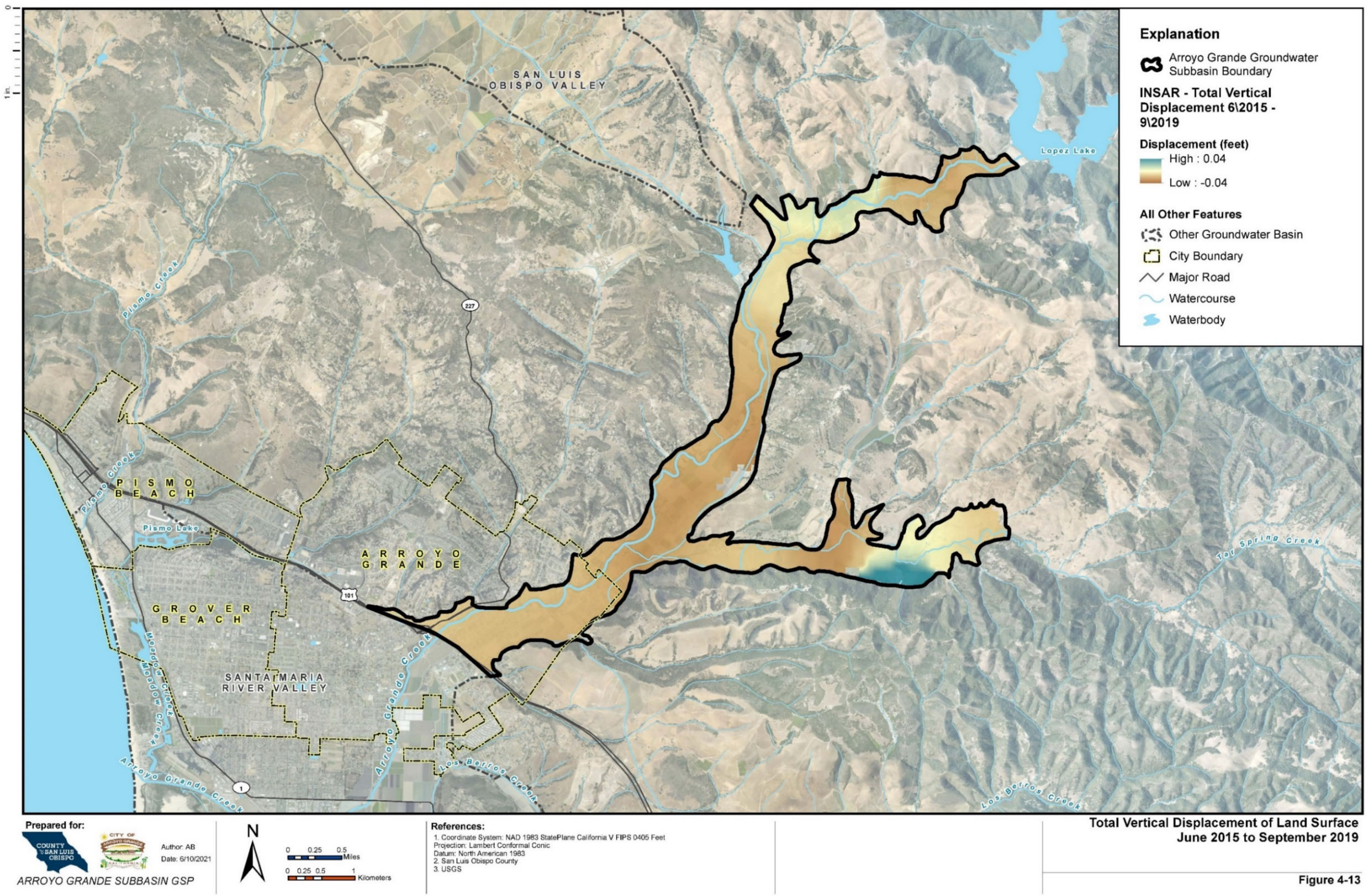

Figure 4-13. Total Arroyo Grande Creek Vertical Displacement of Land Surface from June 2015 to September 2019

GROUNDWATER SUSTAINABILITY PLAN

5.0 Groundwater Conditions (§ 354.16)

This section describes the current and historical groundwater conditions in the Alluvial Aquifer in the Arroyo Grande Subbasin of the SMRVGB.

IN THIS SECTION

- Groundwater Elevations
- Groundwater Recharge and Discharge
- Interconnected Surface Water
- Groundwater Dependent Ecosystems

In accordance with the SGMA Emergency Regulations §354.16, current conditions are any conditions occurring after January 1, 2015. By implication, historical conditions are any conditions occurring prior to January 1, 2015. This chapter focuses on information required by the GSP regulations and information that is important for developing an effective understanding of current and historical groundwater conditions in the Subbasin, and ultimately to develop a plan to achieve sustainability. The six sustainability indicators specified in the GSP regulations are as follows:

1. Chronic lowering of groundwater elevations;
2. Groundwater storage reductions;
3. Seawater intrusion;
4. Land subsidence;
5. Depletion of interconnected surface waters, and;
6. Degradation of groundwater quality.

The Arroyo Grande Subbasin is hydraulically connected to the Santa Maria Subbasin and, by association, the Pacific Ocean. However, the base of alluvial sediments in the Arroyo Grande Subbasin is above sea level (Figure 4-4), therefore seawater intrusion is not an issue and will not be discussed further in this GSP.

5.1 Groundwater Elevations and Interpretation

As discussed in Chapter 4.0, the Subbasin is comprised of a single alluvial aquifer. The groundwater elevation data is combined and presented as a single groundwater elevation map for each time period presented. As discussed in Chapter 3.0, Lopez Reservoir is a major public works project operating at the upstream boundary of the Subbasin. The reservoir has a storage capacity of 49,388 acre-feet and a safe yield of 8,730 acre-feet that is distributed as municipal diversions (4,530 acre-feet) and downstream releases (4,200 acre-feet). (Water Systems Consulting, Inc., 2021)

In general, the primary direction of groundwater flow in the Subbasin is from the areas of highest groundwater elevations (Lopez Dam on the northern Subbasin boundary and Tar Spring Creek at the eastern boundary) to where the flow leaves the Subbasin near Highway 101. Groundwater in the Arroyo Grande Creek Valley flows south-southwest and parallel to the valley axis, while groundwater in the Tar Spring Creek valley flows west along the tributary valley and into the Arroyo Grande Creek valley. Groundwater Elevation maps for various recent and historical time periods are presented and discussed in the following sections.

5.1.1 Fall 1954 Groundwater Elevations

DWR published a series of maps (DWR, 1958) depicting groundwater elevations for various basins in the County, including groundwater elevations in the Arroyo Grande Subbasin for fall 1954 (Figure 5-1). Groundwater flow direction arrows were added to Figure 5-1 for this GSP to illustrate the primary direction of flow in the Basin. This is the oldest Subbasin-wide groundwater elevation map available, and pre-dates construction of Lopez Reservoir. The hydraulic gradient (the ratio of horizontal distance along the groundwater flow path to the change in elevation) in the main valley in fall 1954, based on the elevation contours, was approximately 0.007 feet/foot (ft/ft). In the Tar Spring Creek valley portion of the Subbasin, the dominant groundwater flow direction is westward from the higher groundwater elevations at the east Subbasin boundary to lower elevations at the confluence with the Arroyo Grande Creek Valley. The gradient in lower Tar Spring Creek valley was estimated to be double that in the Arroyo Grande Creek Valley, approximately 0.015 ft/ft. The discharge point for both surface water and groundwater are coincident with the area where Arroyo Grande Creek leaves the Subbasin.

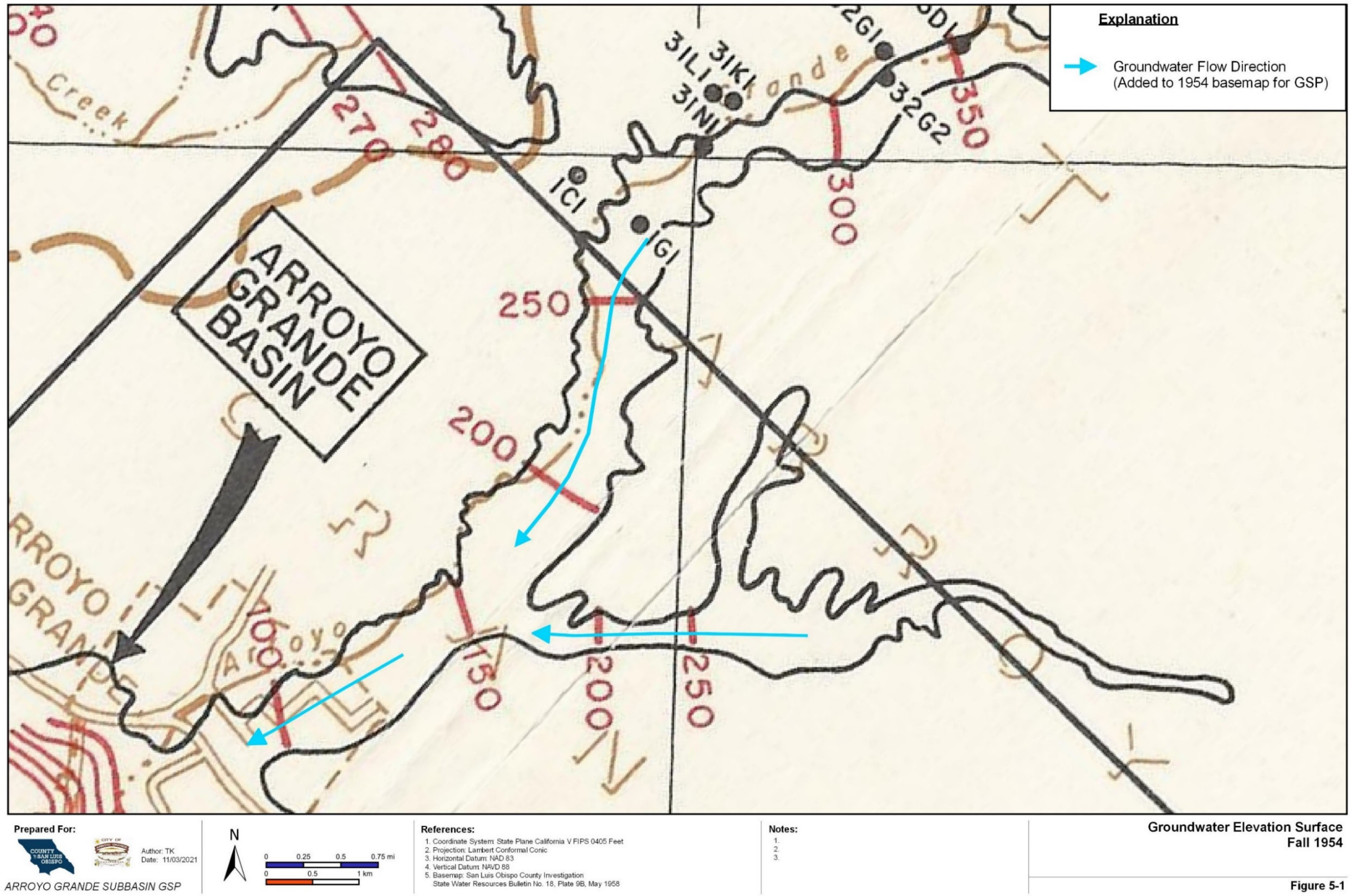

Figure 5-1. Groundwater Elevation Surface Fall 1954.

5.1.2 Spring 1975, 1985, and 1995 Groundwater Elevations

As part of their 2002 Report of *Water Resources of the Arroyo Grande - Nipomo Mesa Area* (DWR, 2002), DWR mapped water level elevations in the Arroyo Grande Creek Valley Subbasin in Spring of 1975, 1985 and 1995. A digitized recreation of the DWR groundwater elevation contours for these three years is presented in Figure 5-2. and displays patterns of groundwater flow direction in the Basin similar to those exhibited in the DWR 1954 map. Groundwater elevation data was compiled from San Luis Obispo County, Santa Barbara County, USGS and DWR records as well as from drillers and local well owners. These years represented average (19.38 inches of rainfall), dry (14.87 inches of rainfall) and wet (38.34 inches of rainfall) years, respectively. Average rainfall at the Lopez Dam rain gage from 1969-2020 is 21.07 inches (Figure 3-1; Chapter 3.0).

In 1975 and 1985, groundwater elevations were similar through the main Arroyo Grande Creek valley, with a hydraulic gradient of approximately 0.007 ft/ft. In 1995, water levels appear up to 30-35 feet higher in the middle of the Subbasin, where the Tar Spring Creek valley enters the main valley, although the overall hydraulic gradient from the dam to the Highway 101 remains approximately 0.007 ft/ft (Figure 5-2). Although 1995 was a wet year, releases through the dam into the Subbasin from Lopez Reservoir between April 1994 through March 1995 (2,600 acre-feet) were only 200 acre-feet more than 1985, and 60 acre-feet less than 1975. Therefore, the higher groundwater elevations through the middle of the Subbasin in 1995 are interpreted to be due to greater inflow from the Tar Spring Creek valley.

The Arroyo Grande Creek valley was recognized in the 2002 DWR report (DWR, 2002) as a subbasin bounded on the south by the Wilmar Avenue fault, which is consistent with the current southern boundary interpretation. The hydraulic gradient for outflow into the main SMRVGB across the southern Subbasin boundary was estimated from water levels contours to range from approximately 0.008 to 0.010 ft/ft, with the higher gradient in spring 1995 (a wet year).

The DWR only shows water level elevation contours in the lower Tar Spring Creek valley for 1975, with a hydraulic gradient of 0.014 ft/ft. Overall, the water level elevations and hydraulic gradients are similar to the pre-dam 1954 values.

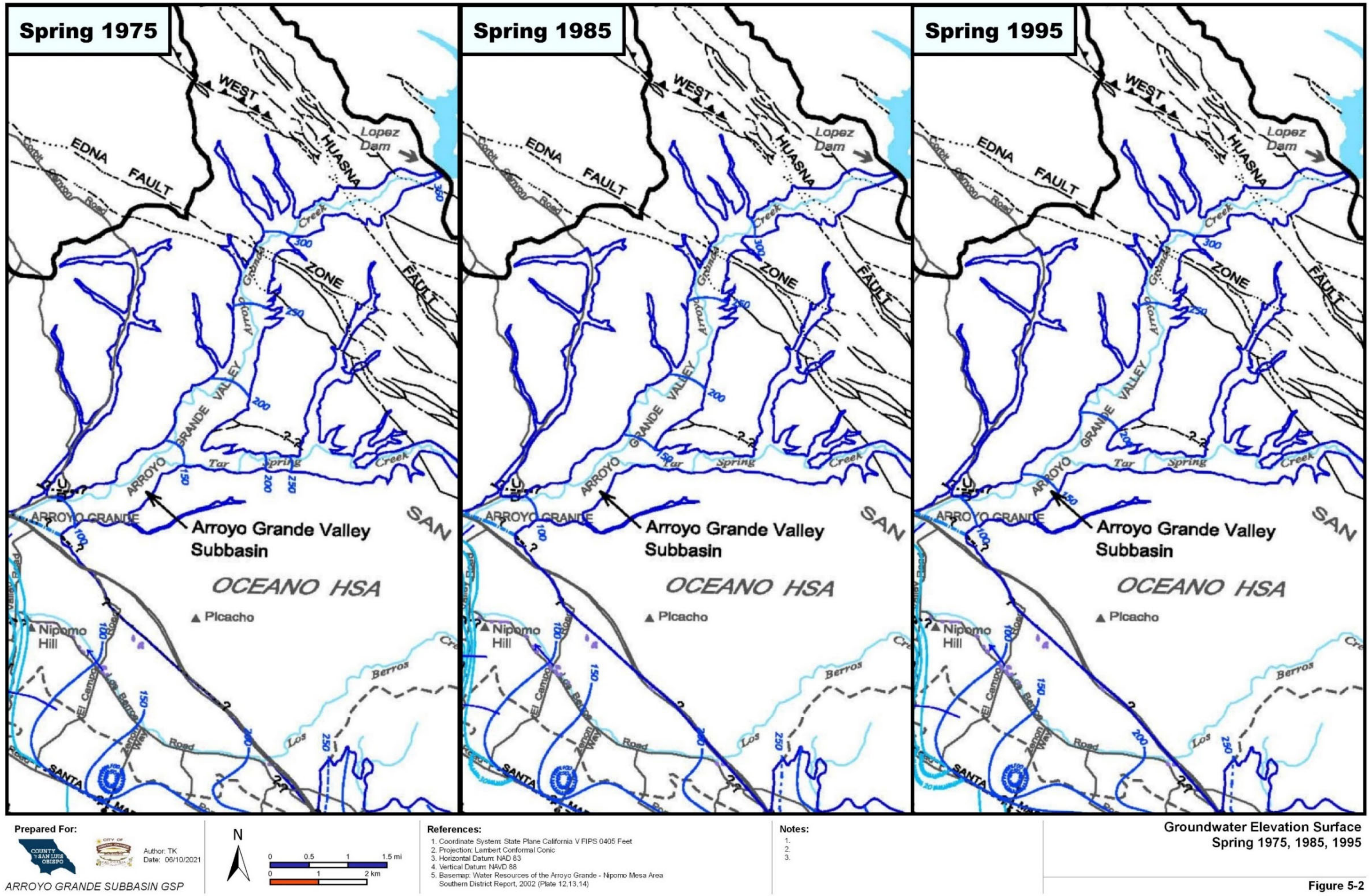

Figure 5-2. Groundwater Elevation Surface for Spring 1975, 1985, and 1995

5.1.3 Groundwater Elevation Contouring Methodology

More recent groundwater level data were obtained and used to generate groundwater elevation maps to evaluate more recent and current conditions. The following assessment of groundwater elevation conditions is based primarily on data from the San Luis Obispo County Flood Control and Water Conservation District's (SLOFCWCD) groundwater monitoring program, supplemented by field data collected for this GSP by consultant team staff in Tar Spring Creek valley in spring 2021. No water level records were available for Tar Spring Creek valley since 1989, therefore, water level monitoring was conducted in April 2021 to assist in representing both current and historical water levels.

Groundwater levels are measured by SLOFCWCD through a network of private wells in the Subbasin. Figure 5-3, Figure 5-4, Figure 5-5, Figure 5-6, and Figure 5-7 presents the contours generated from the data for the Spring 1996, Spring 2015, and Spring 2020 monitoring events. Control points are not displayed to maintain confidentiality agreements negotiated with well owners. Water year 1996 recorded above average rainfall during an overall wet period (23.29 inches of rainfall at Lopez Dam), 2015 was a dry year during extended drought (10.76 inches or rainfall), and 2020 was below average (15.25 of rainfall) and represents current conditions.

Historical water level monitoring data are available for approximately 60 wells in the Subbasin. The set of wells and data points used in the groundwater elevation assessment were selected based on the following criteria:

- The wells have groundwater elevation data for the periods of record of interest;
- Groundwater elevation data were deemed representative of static conditions.
- In areas where a data gap exists, water levels were estimated from a combination of (a) water level data from Well Completion Reports for the general period of interest; (b) correlation with general water level trends; (c) correlation with general hydraulic gradients.

Based on available data and above criteria, approximately 20 wells were used for contouring groundwater elevations in the main alluvial valley for selected years. Water level data collected for the GSP from an additional 11 wells were used for contouring Spring 2021 groundwater elevations in the Tar Spring Creek tributary valley and adjusted to represent prior years based on water level trend and hydraulic gradient correlations. The following information is presented in subsequent subsections.

- Groundwater elevation contour maps for spring 1996, 2015, and 2020;
- A map depicting the change in groundwater elevation between 1996 and 2015;
- A map depicting the change in groundwater elevation between 2015 and 2020;
- A map depicting the change in groundwater elevation between 1996 and 2020;
- Hydrographs for select representative wells.

Spring 1996 Groundwater Elevations (Figure 5-3) presents a groundwater surface map for Spring 1996 based primarily on field data collected by the SLOFCWCD. As mentioned above, the 1996 water year was above average for precipitation. The 1996 water year also included elevated surface water releases to Arroyo Grande Creek from Lopez Reservoir, totaling 11,462 acre-feet through March 1996. Spring 1996 represents a full Subbasin condition, although not the maximum storage condition.

As mentioned above, the Tar Spring Creek valley had a data gap with respect to water level records after 1989, with no wells monitored in 1996. Elevation contours in the tributary valley were estimated based on applying the spring 2021 hydraulic gradient to the 1996 water levels at the confluence with the main valley. No adjustments to the spring 2021 water levels were needed in order to achieve a reasonable transition between the tributary valley and spring 1996 water levels in the main Arroyo Grande Creek Valley.

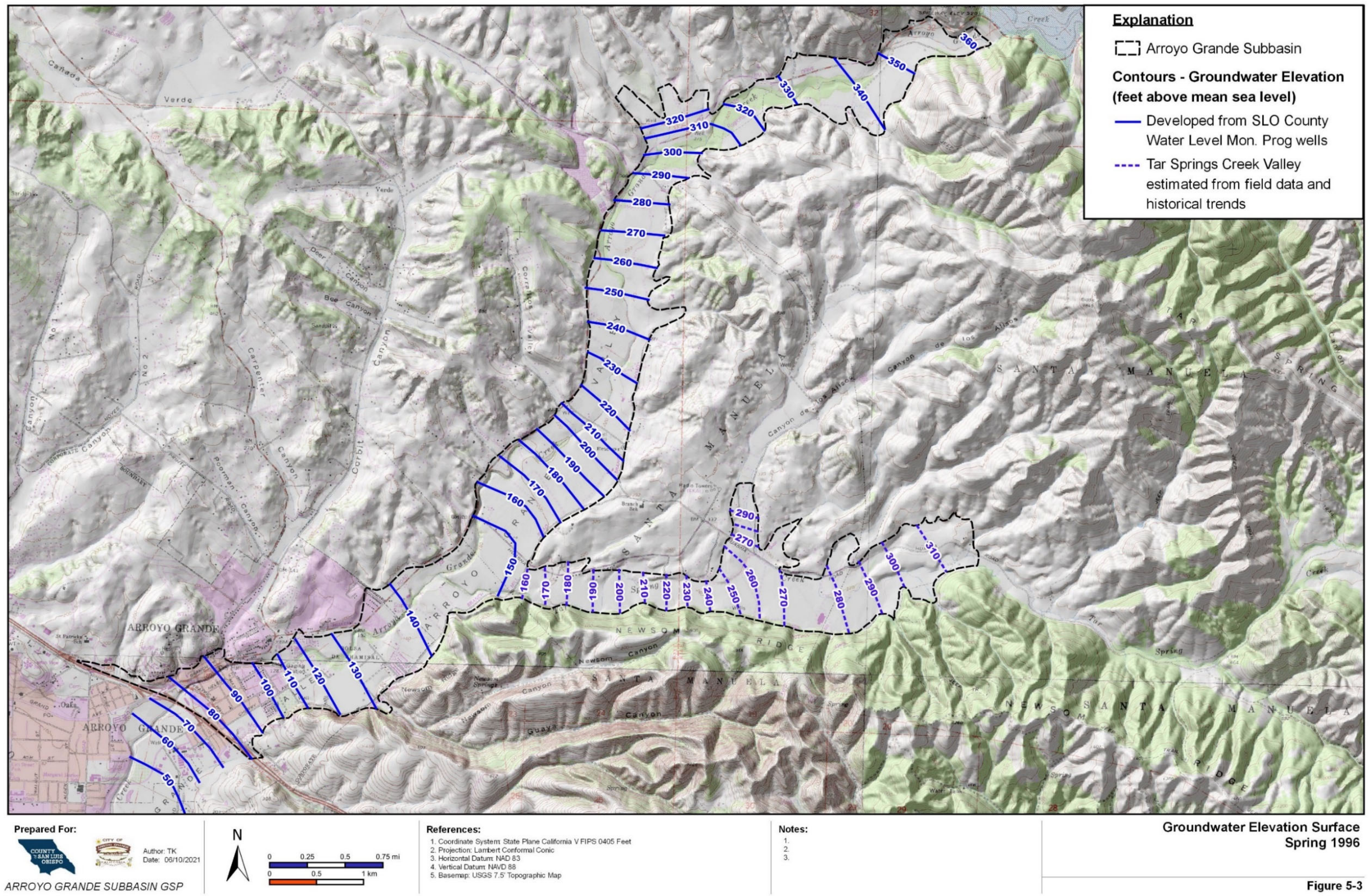

Figure 5-3: Groundwater Elevation Surface for Spring 1996

There are a few features of interest in Figure 5-3. The hydraulic gradient is uniform across the southern Subbasin boundary into the main SMRVGB, indicating the Wilmar Avenue Fault does not appear to significantly restrict alluvial water levels or underflow out of the Subbasin. The overall hydraulic gradient from below the dam to the highway is estimated at 0.007 ft/ft, which has remained relatively constant since before dam construction.

There is also a distinct flattening of the hydraulic gradient in the middle of the Subbasin, where Tar Spring Creek valley enters the Arroyo Grande Creek Valley. This flattening is interpreted to be due primarily to the contribution of flow from the tributary valley, which results in a greater volume of water in storage at the confluence. The added storage raises local water levels, which flattens the hydraulic gradient. Once sufficient saturated thickness has been reached within the alluvial aquifer to accommodate the storage increase, the hydraulic gradient returns to the steeper profile, albeit at a higher elevation than it would have been without the tributary valley groundwater contributions.

5.1.4 Spring 2015 Groundwater Elevations

Spring 2015 represents a critical drought year, with only 10.76 inches of rainfall at Lopez Reservoir, and was the fourth drought year in the 2012-2016 extreme drought period. Lopez Reservoir releases to Arroyo Grande Creek were maintained at an average of 3,690 AFY through the drought.

Figure 5-4 displays groundwater elevation contours for Spring 2015. The overall hydraulic gradient from the dam to the southern Subbasin boundary was estimated to be 0.008 ft/ft, which is similar to prior year estimates.

As with spring 1996, water levels in Tar Spring Creek valley are not available for spring 2015. In order to estimate the 2015 groundwater elevations, water levels for Tar Spring Creek valley wells from drought years 1977 and 1989 were reviewed. Available water levels for three wells averaged approximately 20 feet lower during prior drought years as compared to spring 2021 conditions, therefore, the water levels for spring 2015 are also estimated to be 20 feet lower than recently measured in Tar Spring Creek wells.

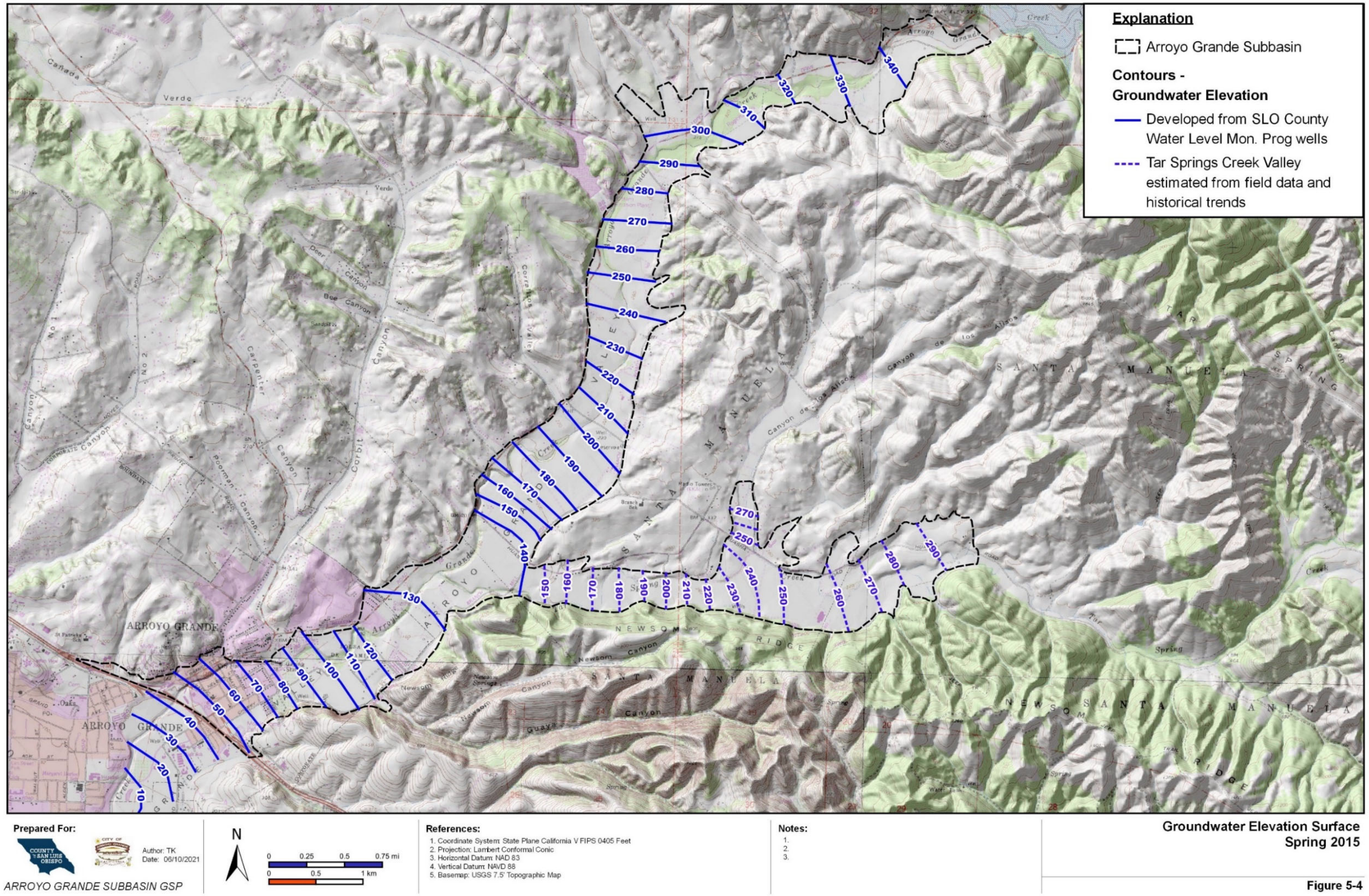

Figure 5-4. Groundwater Elevation Surface Spring 2015

5.1.5 Spring 2020 Groundwater Elevations

Figure 5-5 presents a groundwater surface elevation map for Spring 2020 and represents the current condition. The 2020 water year (October 2019 to September 2020) had below average rainfall, with 15.25 inches recorded at the Lopez Dam gage. Releases from Lopez Reservoir into Arroyo Grande Creek were 2,672 acre-feet.

The overall hydraulic gradient between Lopez Dam and the southern Subbasin boundary for Spring 2020 is estimated to be 0.007 ft/ft, which is consistent with the historical gradient for all years reviewed except for 2015 (estimated at 0.008 ft/ft), which was during extreme drought. As with prior years, the hydraulic gradient is uniform across the southern Subbasin boundary into the Santa Maria Area Subbasin, indicating the Wilmar Avenue Fault does not appear to significantly restrict alluvial water levels or underflow out of the Subbasin. The hydraulic gradient also flattens at the confluence with Tar Spring Creek, with is attributed to the tributary inflow.

As previously mentioned, a water level survey was conducted in the Tar Spring Creek valley (tributary to Arroyo Grande Creek valley) in April 2021 to address the historical data gap in groundwater monitoring records. A total of 11 wells were sounded and the resulting static water levels used to develop the water level contours in Figure 5-4. Although Figure 5-5 is for spring 2020, there was no basis for making significant adjustments to the 2021 water levels, and the spring 2021 groundwater elevations are used for spring 2020. The overall hydraulic gradient in the tributary valley from the eastern Subbasin boundary to the confluence with Arroyo Grande Creek valley is approximately 0.010 ft/ft.

The direction of groundwater flow is westerly from Tar Spring Creek valley into the Arroyo Grande Creek Valley. This is a normal condition for a tributary valley (flow from the tributary into the main valley) and precludes the operation of Lopez Reservoir and associated releases to Arroyo Grande creek from having a significant influence on groundwater conditions in the Tar Spring Creek valley.

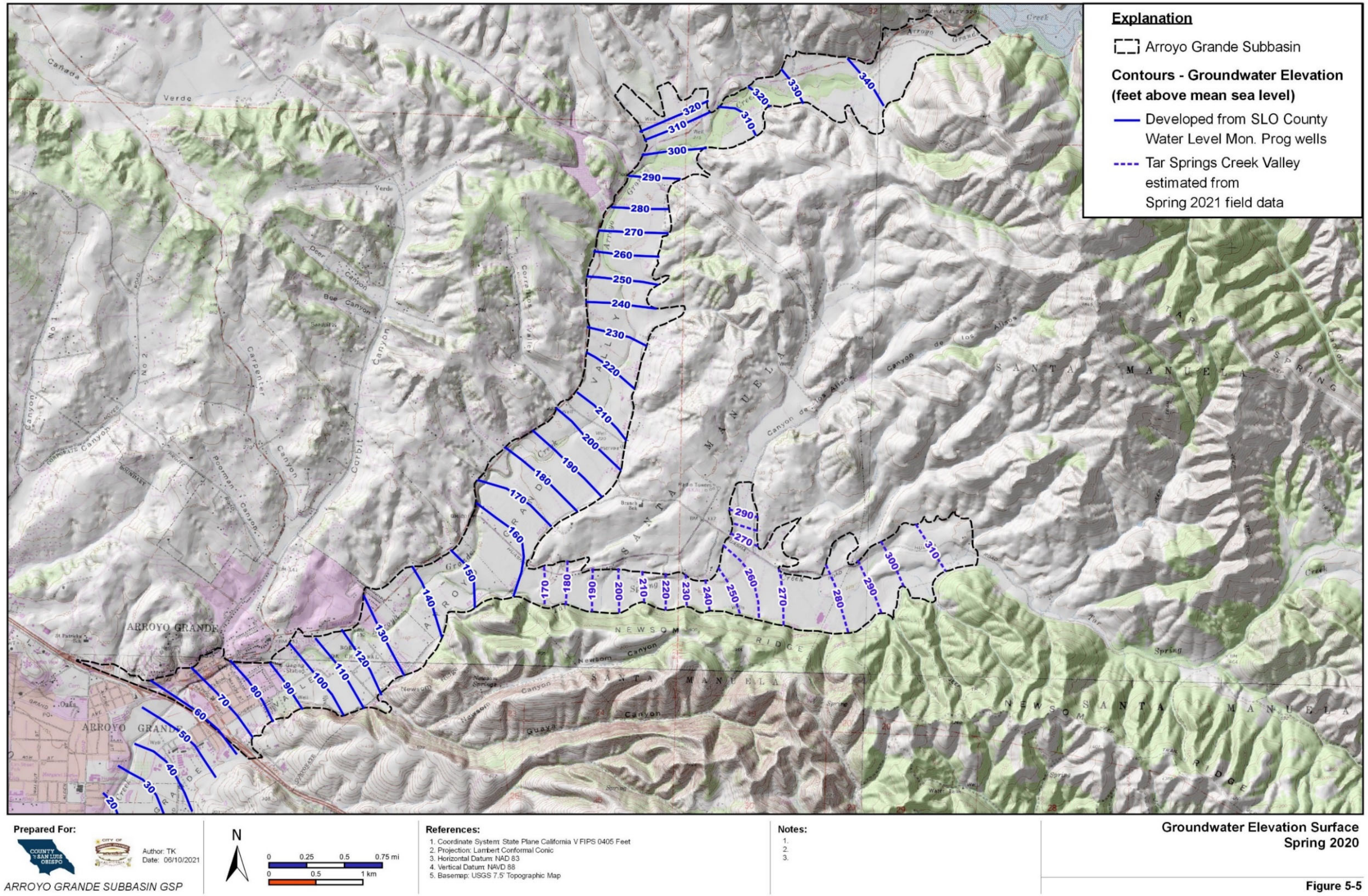

Figure 5-5. Groundwater Elevation Surface Spring 2020

5.1.6 Changes in Groundwater Elevation

Changes in groundwater elevations are a proxy for changes in groundwater storage. Both chronic lowering of groundwater elevations and reductions in Subbasin storage are used as sustainability indicators in this GSP. A quantification of groundwater in storage and changes over time will be presented in Chapter 6.0 (Water Budget).

In order to demonstrate how groundwater elevations have varied over the recent history of the Subbasin, three maps were generated that display changes in groundwater elevation. These maps were developed by comparing contoured groundwater elevation surfaces from one year to the next and calculating the differences in elevation between the surfaces over the specified time period. It should be noted that the results of this analysis are largely dependent on the density of data points and should be viewed as indicative of general trends.

The first time period compares changes in groundwater elevation from spring 1996 to spring 2015, which depicts changes from a relatively full basin condition to a drought condition. Calculated changes in groundwater elevation over this 19-year period are presented in Figure 5-6. This figure indicates a groundwater decline of 5 to 10 feet over most of the Subbasin, with maximum declines in groundwater elevation of 30 feet approaching the southern Subbasin boundary, and a decline of 20 feet in the Tar Spring Creek valley. No significant increases in groundwater elevation are noted, although there is a relatively small area of the Subbasin, above the tributary valley confluence, which does not show a decline in water levels.

The next time period selected compares changes in groundwater elevation from spring 2015 to spring 2020. This time period was selected to capture the potential recovery of the Subbasin between extreme drought and current conditions, which between 2016 and 2020 were average (discussed in Chapter 6.0). Water years 2020 and 2021 have been dry overall but followed a wet year (2017) and an above average rainfall year (2019) that marked the end of the prior extreme drought. Calculated changes in groundwater elevation over the 5-year period from 2015 to 2020 are presented in Figure 5-7. This figure indicates groundwater elevations have rebounded across the Subbasin, with maximum increases in groundwater elevation of 20 feet in the Tar Spring Creek valley, and most areas recording a 5- to 15-foot gain in groundwater elevation.

The third time period compares changes in groundwater elevation from spring 1996 to spring 2020. This time period is the summation of the prior two periods and was selected to compare the overall change in groundwater elevation from a relatively full condition in 1996 to current conditions (average). Calculated changes in groundwater elevation over this 24-year period are presented in Figure 5-8. Groundwater elevations have generally declined by 5 feet or less, with a maximum decline of up to 20 feet near the southern Subbasin boundary and a maximum increase of approximately 5 feet near the confluence of Tar Spring Creek valley with the Subbasin.

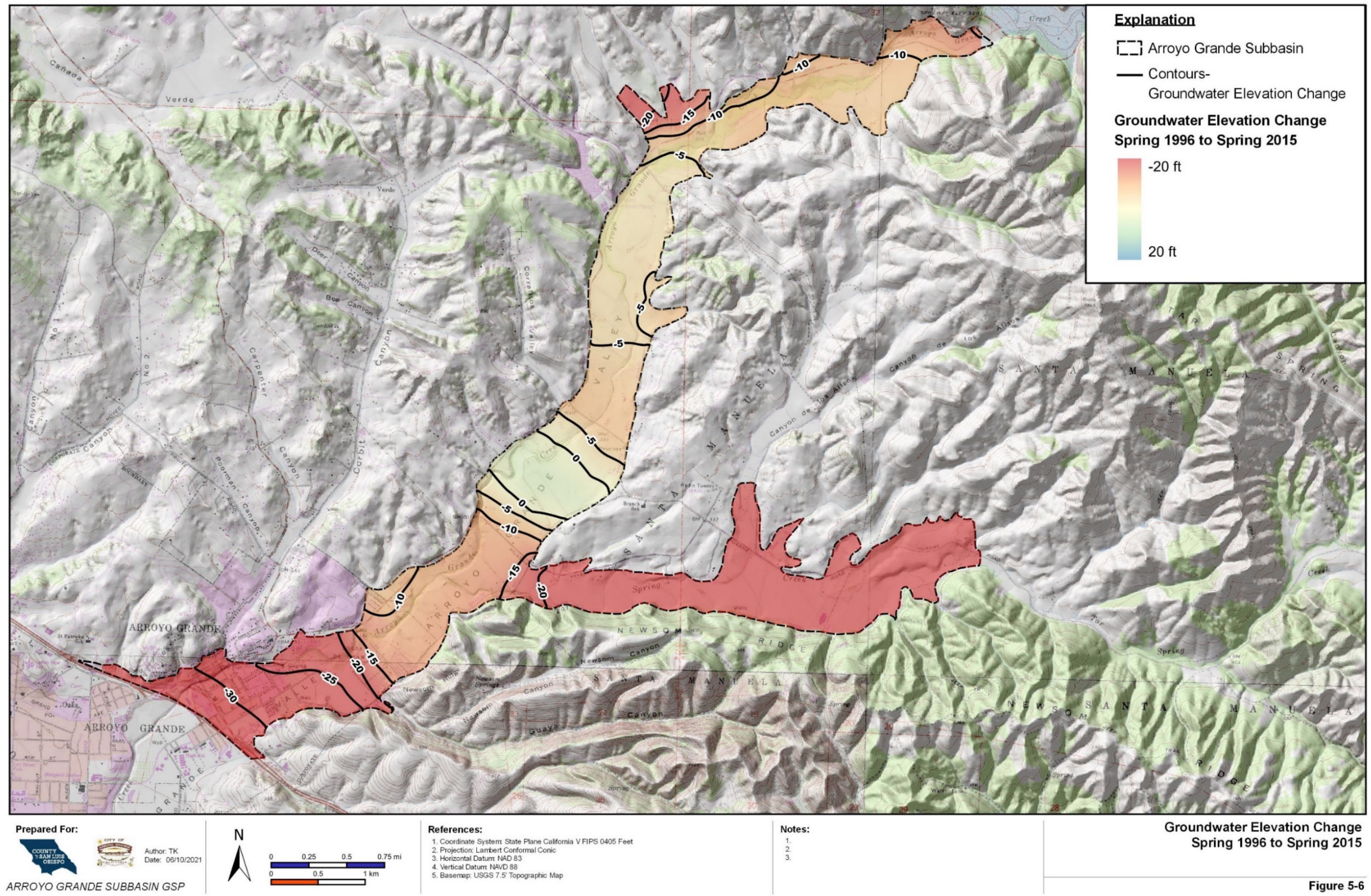

Figure 5-6. Groundwater Elevation Change for Spring 1996 to Spring 2015

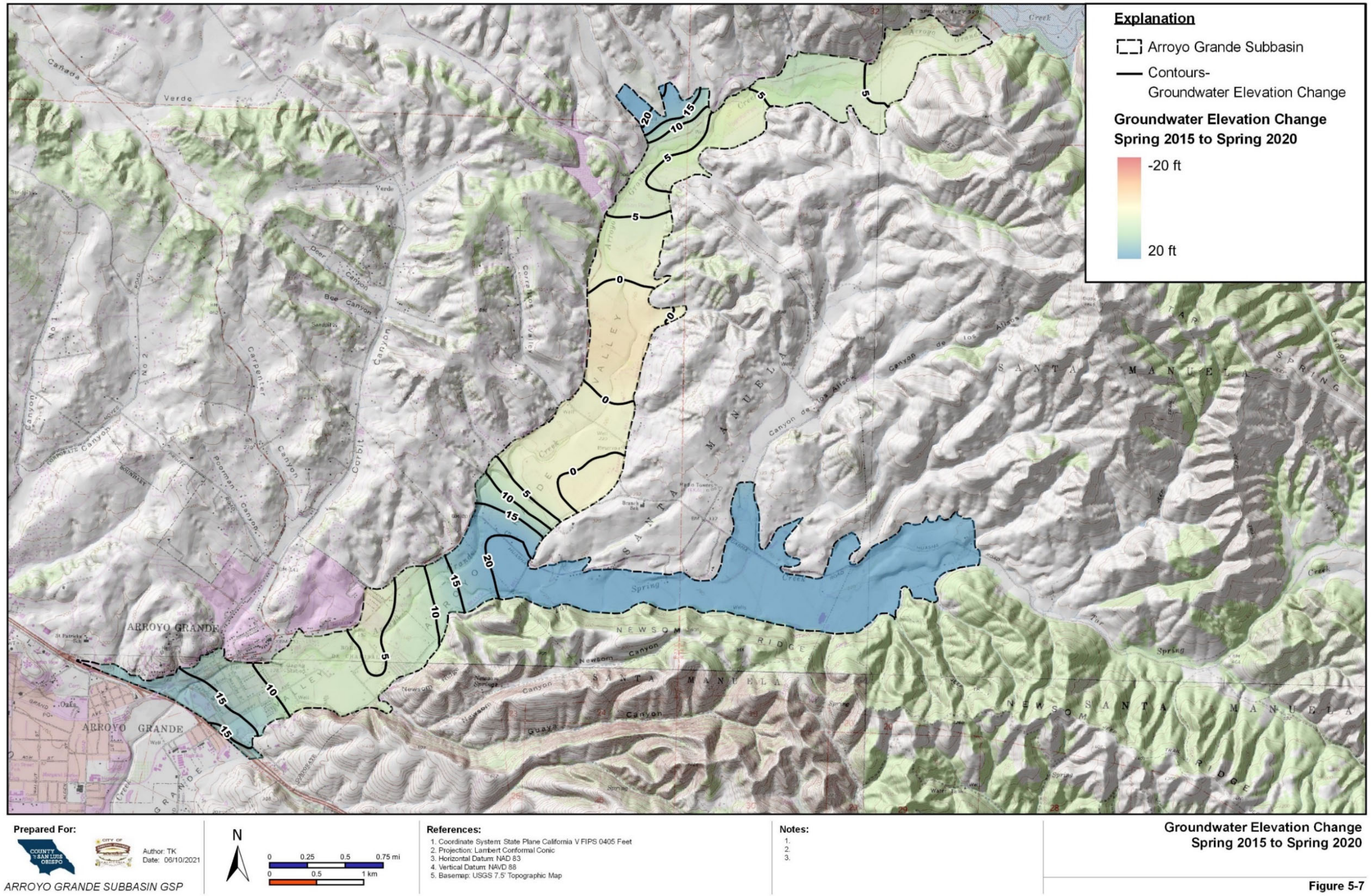

Figure 5-7. Groundwater Elevation Change for Spring 2015 to Spring 2020

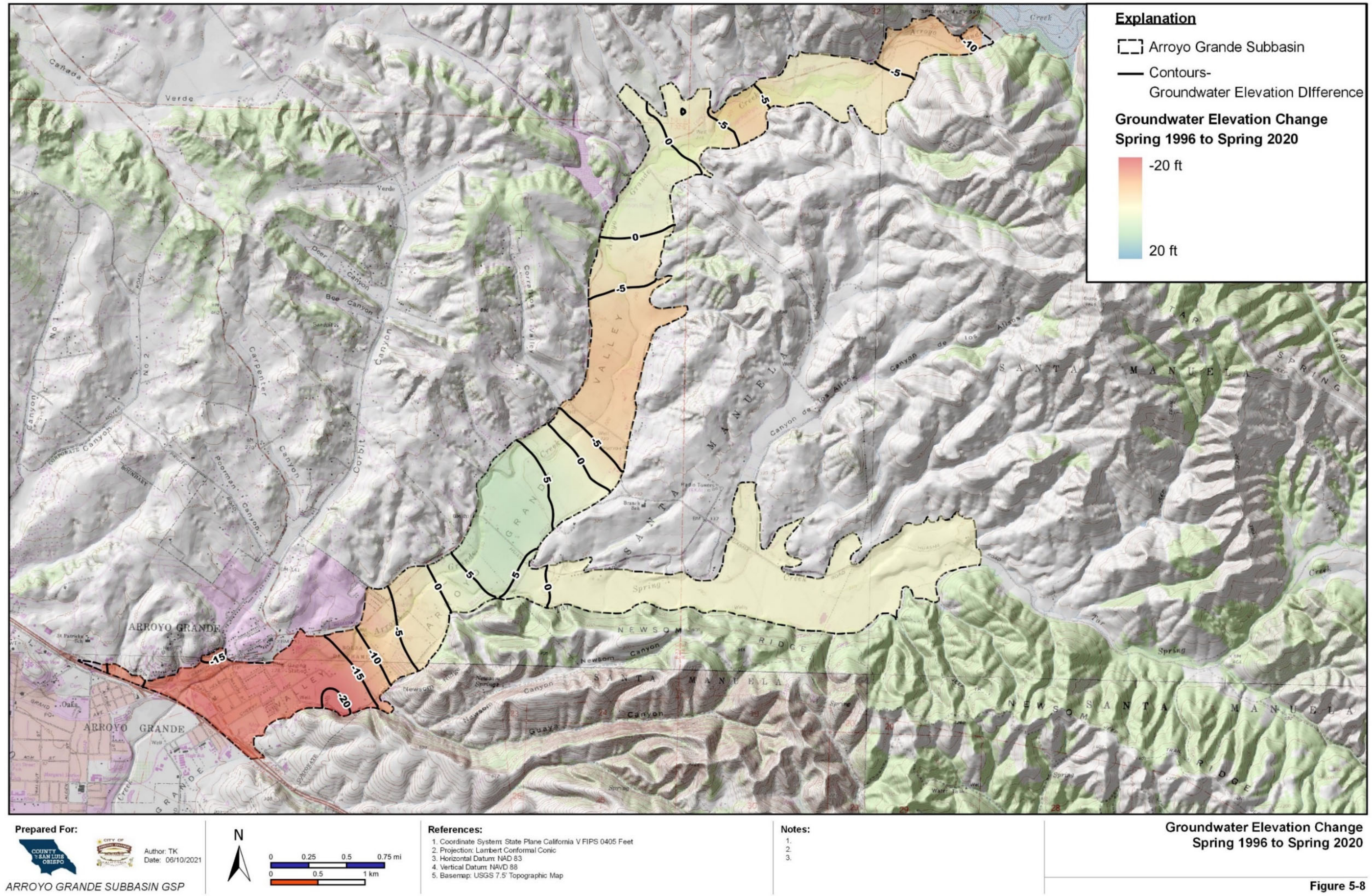

Figure 5-8. Groundwater Elevation Change Spring 1996 to Spring 2020

5.1.7 Vertical Groundwater Gradients

Vertical hydraulic gradients are calculated by measuring the difference in groundwater elevation at a single location between specific and distinct strata or aquifers. The characterization of vertical gradients may have implications with respect to characterization of flow between aquifers, migration of contaminant plumes, and other technical details describing groundwater flow in specific areas. In order to accurately characterize vertical groundwater gradient, it is necessary to have two (or more) piezometers sited at the same location, with each piezometer screened across a unique interval that does not overlap with the screened interval of the other piezometers(s). If groundwater elevations at one such piezometer are higher than the other(s), the vertical flow direction can be established since groundwater flows from areas of higher pressure to areas of lower pressure. However, because such a “well cluster” must be specifically designed and installed as part of a broader investigation, limited data exists to assess vertical groundwater gradients.

The Arroyo Grande Subbasin is effectively composed of a single, unconfined, alluvial aquifer, but vertical hydraulic gradients may exist both within the alluvium and between the alluvium and bedrock formations. Alluvial groundwater supply wells are typically screened through the base of the alluvial deposits, and may also continue into underlying bedrock, where other water-bearing strata may occur, but which are not part of the Subbasin. Vertical hydraulic gradients between the alluvial aquifer and any underlying bedrock aquifers that may be present would generally be expected to be upward, since the bedrock formations extend laterally to form hills surrounding the alluvial valley where groundwater elevations are above the valley floor.

Relatively extensive clay aquitards occur within the alluvium (Figure 4-9, Figure 4-10, and Figure 4-11) that result in local vertical gradients between alluvial deposits above and below these clays. Given that the basal alluvial gravels are the main water supply aquifer in the Subbasin, groundwater pumping would generally result in downward vertical gradients. In the vicinity of Arroyo Grande Creek and Tar Spring Creek, return flows from irrigation that perch on these shallow clays may result in gaining reaches of stream flow, even though downward vertical hydraulic gradients are present within the alluvium.

There are no paired wells that provide specific data comparing water levels in wells screening the bedrock and the Subbasin sediments, or between shallow saturated strata and the underlying alluvial supply aquifer. However, from a conceptual standpoint, the Pismo, Monterey, and Obispo Formations are assumed to receive rainfall recharge in the surrounding mountains at higher elevations than the Basin sediments. As indicated above, it is assumed that an upward vertical flow gradient exists between the bedrock and the overlying Basin sediments. The rate of this flux will be considered in Chapter 6.0 (Water Budget). The lack of nested or clustered piezometers to assess vertical gradients in the Basin is a data gap that will be discussed further in Chapter 8.0.

5.2 Groundwater Elevation Hydrographs

The Arroyo Grande Subbasin is primarily agricultural land use (Figure 3-2; Chapter 3.0), with historical estimates of agricultural acreage ranging from 1,620 acres in 1975 to 1,920 acres in 1995 (DWR, 2002), although in 2002 the DWR Subbasin encompassed 3,860 acres, compared to the currently defined Subbasin area of 2,899 acres (per the 2019 basin boundary modification). Other historical estimates for agricultural acreage in the Arroyo Grande Creek valley range from 1,770 acres in 2009 to 1,867 acres in 2013 (Cleath-Harris Geologists, 2015), but also include acreages outside of the currently defined Subbasin. A 2016 estimate of agricultural land use of 1,440 acres within the formal Subbasin boundary is provided in Table 3-1 (Chapter 3.0; total acreage minus native vegetation and urban land use). The main crop type for all years is vegetable crops.

Available water level data was reviewed to evaluate historical trends at individual wells and throughout the Subbasin. Data from selected wells are presented in Figure 5-9 and discussed in this section. All of the data was obtained from the County's groundwater monitoring network database.

Figure 5-9 presents groundwater elevation hydrographs for six wells throughout the Subbasin and one well located within the Subbasin along Tar Springs Creek. Seasonal variations on the order of 30 feet are apparent in some of the hydrographs, although some of that may be due to the influence of nearby pumping wells when the data was collected. The most important feature of these hydrographs is that they show no long-term trends of chronic lowering of water levels over time, although differences between wet and dry periods are evident. All the wells display elevations under current conditions that are within the historical range of water levels in the 1960's and 1970's. State well identification numbers are not displayed for reasons of owner confidentiality.

The well below the dam (Monitored Well #6) displays seasonal fluctuations within a range of 20-30 feet over from the late 1950s to the mid-1990s, followed by a shift to seasonal fluctuations of approximately 5 feet through 2020. This change in fluctuation is interpreted to be associated with a change in well use (such as discontinued pumping). The spring static elevations at Monitored Well #6 have declined by close to 10 feet overall since the late 1950's, with a few feet of decline appearing to coincide with dam construction in the late 1960's, and the remaining several feet of decline following the last reservoir spill event in 1999. Water levels have been stable for the last 15 years.

Another well with a long and continuous history of record is Monitored Well #1, located near the center of the main valley (Figure 5-9). Seasonal fluctuations at this well are generally close to 5 feet, with occasional greater fluctuations due to high spring peaks. There has been a decline of several feet in the average water level since the wet period during the mid to late-1990's, but levels are similar to earlier records from the 1907's and 1980's, and the last high spring peak in 2017 was also similar to prior high spring peaks.

In the lower Subbasin, below the confluence with the Tar Spring Creek valley, are two adjacent wells, Monitored Well #2 and Monitored Well #4 (Figure 5-9). Monitored Well #2 has a period of record beginning in 1958 and ending in 2012, while Monitored Well #2 begins in 1998 and is actively monitored. The general pattern of fluctuations in Monitored Well #2 is variable and may be affected by pumping. When the records are combined, there appears to have been a decline of close 10 feet in water levels since the mid to late-1990's wet period, although the last high spring peak in 2017 was similar to spring high water levels recorded in the early 1960's. In addition, the overlapping higher peaks in spring 1998 And 2011 are approximately 5 feet higher in Monitored Well #2, compared to Monitored Well #4, suggesting there may be an elevation adjustment needed when merging the datasets for trend analysis.

Monitored Well #3 is one of the wells in Tar Spring Creek valley where historical data was available ending in 1989. A recent spring 2021 water level has been added to update the record. The water levels show close to 10 feet of decline since 1986, although there is only one recent measurement for comparison. The two other wells for which updated water levels are available show little to no decline.

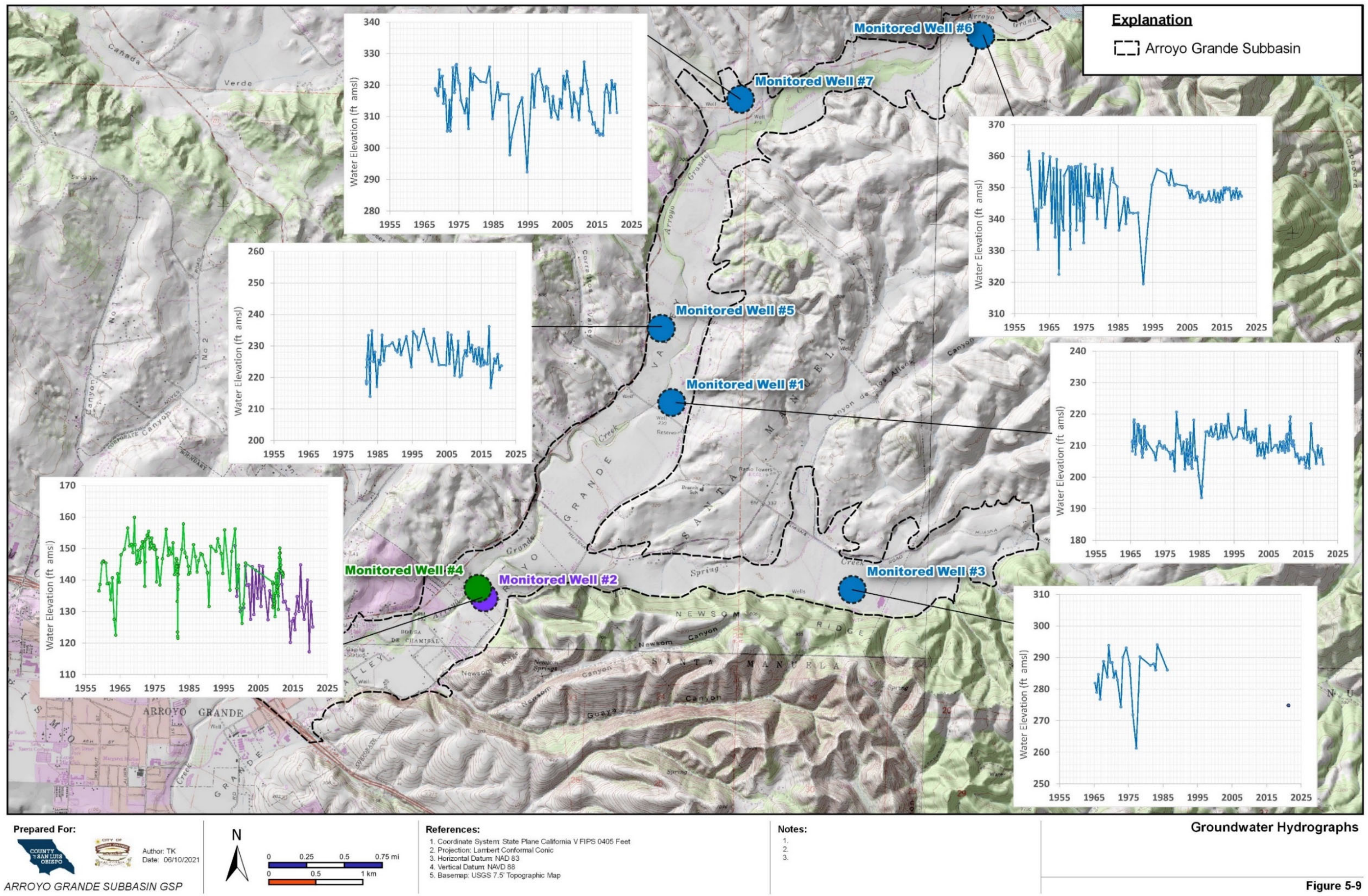

Figure 5-9. Groundwater Hydrographs at Select Monitoring Wells

Figure 5-10 shows groundwater elevation hydrographs for selected monitoring wells along with a time series of Lopez Reservoir releases and spills into Arroyo Grande Creek. Spill years occur when the reservoir fills beyond its storage capacity. As shown in the figure, there have been releases into Arroyo Grande Creek every year since 1969, with multiple spill years between 1970 and 1987, after which there have been only three other spill years (1997, 1998, and 1999).

The hydrographs shown in Figure 5-10 illustrate that seasonal water level fluctuations dominate the water level trends. In Monitored Well #1, seasonal fluctuations are typically 5-10 feet, both prior to and during Lopez Reservoir operation, and the long-term trend in water levels is flat. At Monitored Well #2 seasonal water level fluctuations are more variable, possibly associated with pumping, both prior to and during Lopez Reservoir operations. The long-term trend is flat for Monitored Well #2 but appears to show a slightly declining water level trend after the last reservoir spill in 1999, when combined with adjacent Monitored Well #4 data as shown in the figure. As previously mentioned, there may be an elevation adjustment needed when merging the datasets for trend analysis, but even without the adjustment, spring water level recovery outside of drought are comparable to levels recorded in the 1960's.

Overall, the hydrographs indicate the Subbasin is in approximate equilibrium, and that, despite occasional and intermittent drought periods, the alluvial aquifer in the Subbasin has not reached a state of overdraft because of the managed releases from Lopez Reservoir. Further discussion of sustainable yield indicators related to changes to groundwater in storage will be covered in Chapter 6.0 (Water Budget).

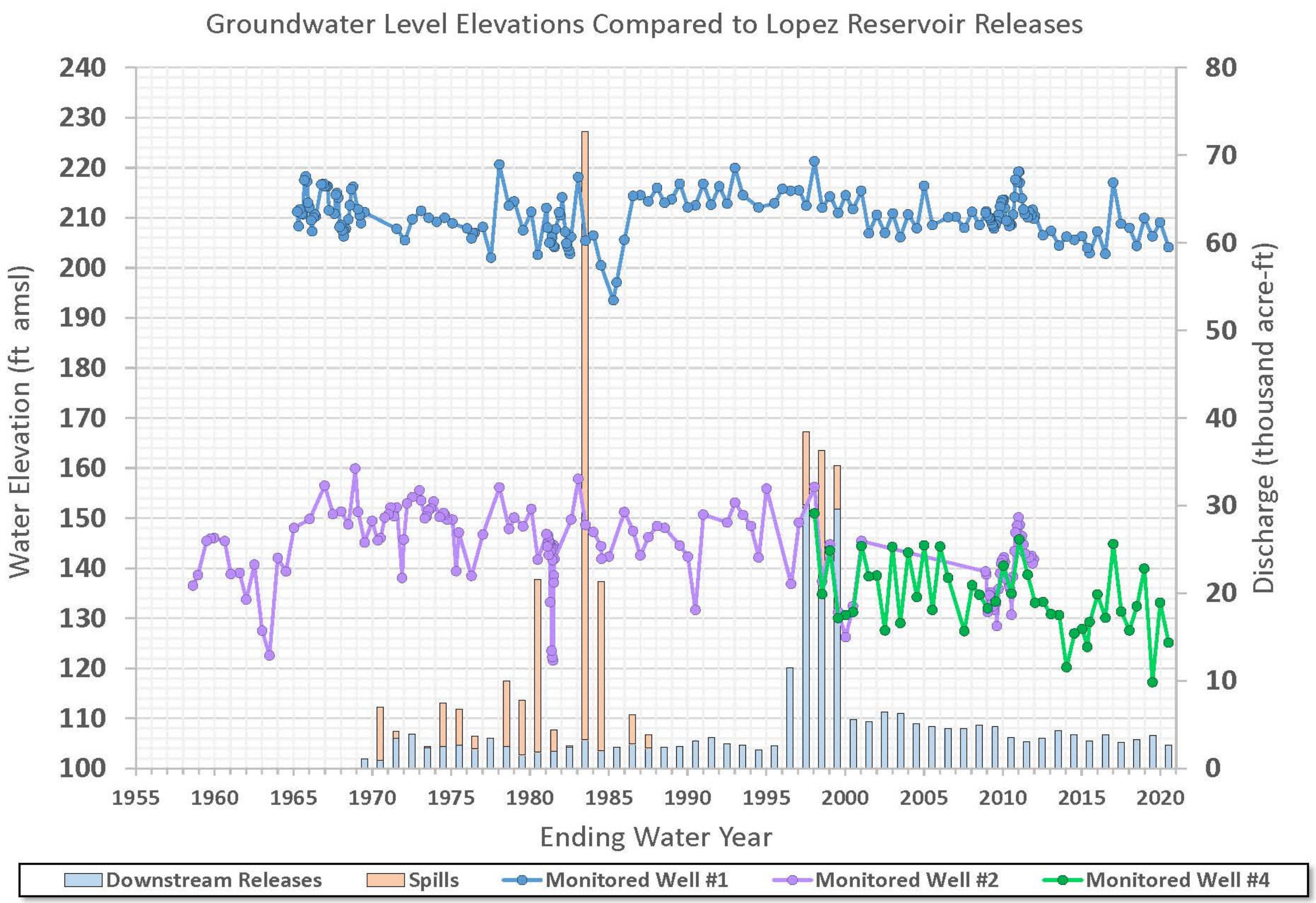

Figure 5-10. Groundwater Level Elevations Compared to Lopez Reservoir Releases

5.3 Groundwater Recharge and Discharge Areas

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

Areas of significant areal recharge and discharge within the Subbasin are discussed below. Quantitative information about all natural and anthropogenic recharge and discharge components is provided in Chapter 6.0 (Water Budget).

5.3.1 Groundwater Recharge Areas

In general, natural areal recharge occurs via the following processes:

1. Distributed areal infiltration of precipitation,
2. Subsurface inflow from adjacent “non-water bearing bedrock”, and
3. Percolation of surface water from streams and creeks.
4. Anthropogenic recharge

The following sections discuss each of these components.

5.3.1.1 Percolation of Precipitation

Areal infiltration of precipitation is a significant component of recharge in the Subbasin. Water that does not run off to stream or get taken up via evapotranspiration migrates vertically downward through the unsaturated zone until it reaches the water table. By leveraging available GIS data that defines key factors such as topography and soil type, locations with higher likelihood of recharge from precipitation have been identified. These examinations are desktop studies and therefore are conceptual in nature. Still, the results of these studies provide an initial effort at identifying areas that may have the intrinsic physical characteristics to allow greater amounts of precipitation-based recharge in the Subbasin.

The University of California (UC) at Davis and the UC Cooperative Extension published a study in 2015 that uses existing GIS data to identify areas potentially favorable for enhanced groundwater recharge projects (UC Davis Extension, 2015). The UC study is statewide in scope includes more than 17.5 million acres, is scientifically peer reviewed, and focuses on the possibilities of using fallow agricultural land as temporary percolation basins during periods when excess surface water is available. The UC study developed a methodology to determine a Soil Agricultural Groundwater Banking Index (SAGBI) to assign an index value to agricultural lands through the state. The SAGBI analysis incorporates deep percolation, root zone residence time, topography, chemical limitations (salinity), and soil surface conditions into its analysis. The results of the SAGBI analysis in the Subbasin are presented in Figure 5-11. Areas with excellent recharge properties are shown in green. Areas with poor recharge properties are shown in red. Not all land is classified, this map provides guidance on where natural recharge likely occurs.

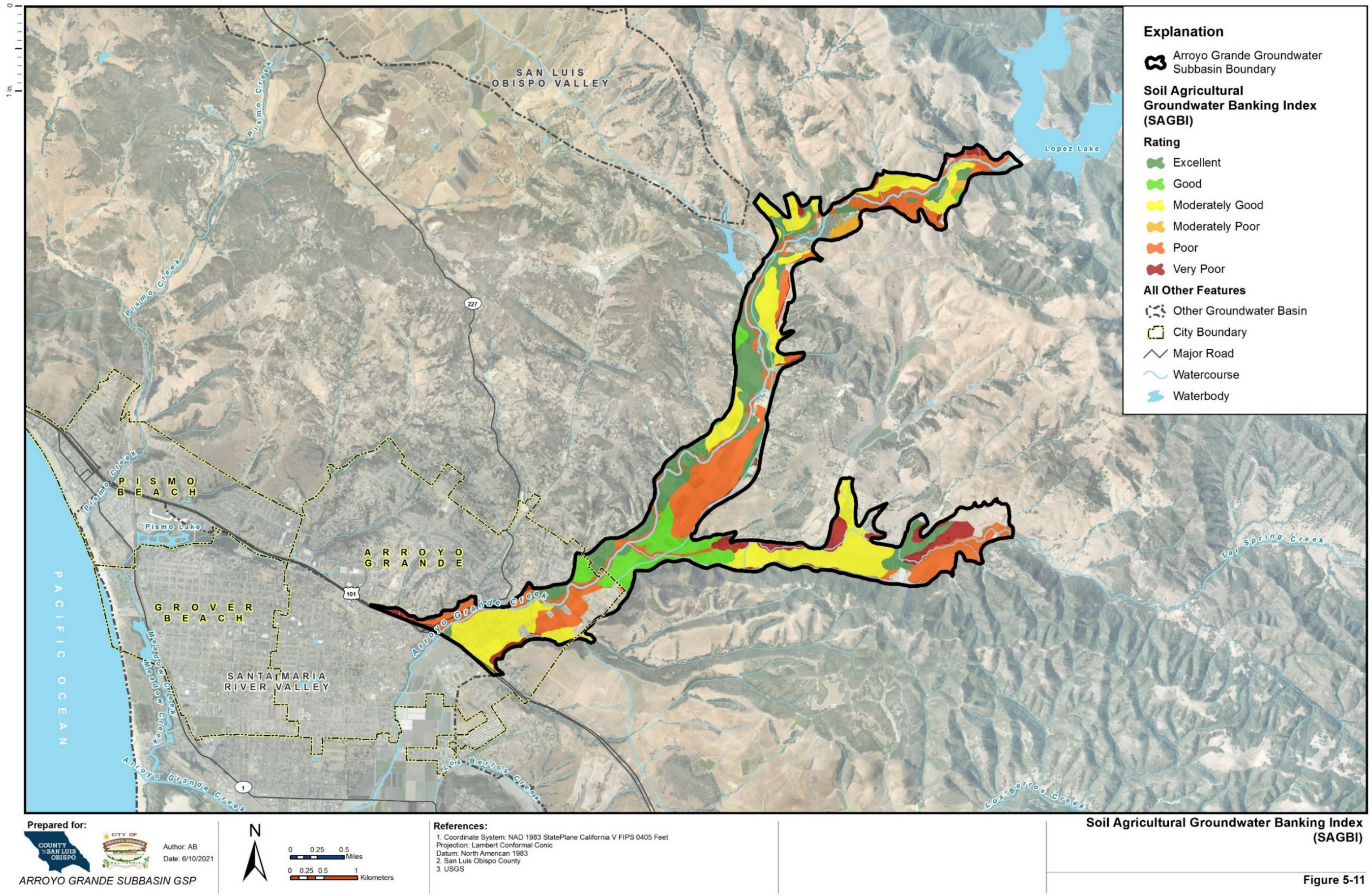

Figure 5-11. Soil Agricultural Groundwater Banking Index (SAGBI)

5.3.1.2 Subsurface Inflow

Subsurface inflow is the flow of groundwater from the surrounding bedrock into the Subbasin sediments. This process is sometimes referred to as mountain front recharge. Groundwater flows from areas of high head to areas of lower head, and water levels in the mountains are at a higher elevation than the Subbasin. Flow across the Subbasin boundary is predominantly via highly conductive, but random and discontinuous fracture systems. The rate of subsurface inflow to the Subbasin from the surrounding hill and mountain area varies considerably from year to year depending upon precipitation (intensity, frequency and duration, seasonal totals, etc.) and groundwater level gradients. There are no available published or unpublished inflow data for the hill and mountain areas surrounding the Subbasin. An estimate of this component of recharge is presented in Chapter 6.0 (Water Budget).

5.3.1.3 Percolation of Streamflow

Percolation of streamflow is a significant source of recharge in the Subbasin. Groundwater recharge from percolation of streamflow is thought to occur in the Arroyo Grande Creek Valley. Because releases from Lopez Dam maintain flow in the creek year-round, water levels are assumed to be maintained at elevations at or near the creek bed elevation. In Tar Spring Creek, the natural streamflow regime is unaffected by Lopez operations, and during the dry season, water levels decrease to below land surface. Therefore, the periodic streamflow appears to recharge the underlying Alluvium in this area. Specific isolated monitoring of alluvial wells compared to the underlying aquifers' water levels could clarify this recharge component.

5.3.1.4 Anthropogenic Recharge

Significant anthropogenic recharge occurs via the two processes discussed below:

1. Percolation of return flow from agricultural irrigation, and
2. Percolation of return flow from domestic septic fields.

Irrigated agriculture is prevalent in the Subbasin. Return flows from irrigated agriculture occur when water is supplied to the irrigated crops in excess of the crop's water demand. This is done to avoid excess build-up of salts in the soil and overcome non-uniformity in the irrigation distribution system. These are all standard practices. In addition, there are a small number of residences in the Subbasin that rely on septic fields for their wastewater disposal, and these systems regularly have an element of return flow to the underlying aquifer. An estimate of this component of recharge is presented in Chapter 6.0 (Water Budget).

5.3.2 Groundwater Discharge Areas

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

Groundwater elevation hydrographs of wells in the Subbasin indicate that water levels in the valley have remained essentially stable over the past 50 years (Figure 5-9), indicating that recharge and discharge in the valley are in approximate equilibrium, and the alluvium has demonstrated sustainability over this time period. The regular recharge of the alluvial aquifer from the Lake Lopez releases is a significant factor in this observed stability of groundwater levels.

Natural groundwater discharge occurs as discharge to springs, seeps and wetlands, subsurface outflows, and evapotranspiration (ET) by phreatophytes. There are no significant mapped springs or seeps located within the Subbasin boundaries; most springs in the vicinity are located at higher elevations in the surrounding mountain areas.

Natural groundwater discharge can also occur as discharge from the aquifer directly to streams. Groundwater discharge to streams and potential groundwater dependent ecosystems (GDEs) are discussed in Section 5.5. In contrast to mapped springs and seeps, whose source water generally comes from bedrock formations in the mountains, groundwater discharge to streams is derived from the alluvium. Discharge to springs or streams can vary seasonally as precipitation and stream conditions change throughout the year. Subsurface outflow and ET by phreatophytes are discussed in Chapter 6.0 (Water Budget).

5.4 Interconnected Surface Water

Surface water/groundwater interactions may represent a significant portion of the water budget of an aquifer system. Where the water table is at a higher elevation than the streambed and slopes toward the stream, the stream receives groundwater from the aquifer; that is called a gaining reach (i.e., it gains flow as it moves through the reach). Where the water table is beneath the streambed and slopes away from the stream, the stream loses water to the aquifer; that is called a losing reach. In addition, a stream may be disconnected from the regional aquifer system if the elevation of streamflow and alluvium is significantly higher than the elevation of the water table in the underlying aquifer.

5.4.1 Depletion of Interconnected Surface Water

Groundwater withdrawals are balanced by a combination of reductions in groundwater storage and changes in the rate of exchange across hydrologic boundaries. In the case of surface water depletion, this rate change could be due to reductions in rates of groundwater discharge to surface water, and increased rates of surface water percolation to groundwater. High-capacity wells located immediately adjacent to a stream could locally affect aquifer discharge to the stream. Seasonal variation in rates of groundwater discharge to surface water or surface water percolation to groundwater occur naturally throughout any given year, as driven by the natural hydrologic cycle. However, they can also be affected by anthropogenic actions. Since, as presented in the discussion of hydrographs in the Subbasin in Section 5.2, there has been no long-term water level declines in this area, there is no evidence of long-term depletion of interconnected surface water in the subbasin.

5.5 Potential Groundwater Dependent Ecosystems

The SGMA Regulations §354.8(a)(5) require identification of groundwater dependent ecosystems within the Subbasin. Several datasets were utilized to identify the spatial extent of potential groundwater dependent ecosystems (GDEs) in the Subbasin, as discussed in the following sections. As defined in SGMA Regulations §351 (m), "groundwater dependent ecosystems refer to ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface". In areas where the water table is sufficiently high, groundwater discharge may occur as evapotranspiration (ET) from phreatophyte vegetation within these GDEs.

The overall distribution of potential GDEs within the Subbasin has been initially estimated in the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset (DWR, 2018). The Natural Communities data set is a compilation of 48 publicly available state and federal agency data sets that map vegetation, wetlands, Spring, and seeps in California. A working group that includes DWR, CDFW, and The Nature Conservancy (TNC) reviewed the compiled data set and conducted a screening process to exclude vegetation and wetland types less likely to be associated with groundwater and to retain types commonly associated with groundwater as described in (Klausmeyer, 2018). Two habitat classes are included in the Natural Communities data set statewide:

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

This dataset was reviewed and the resulting distribution of potential GDEs is shown in

Figure 5-12. The data included in the Natural Communities data set do not represent the determination of a GDE by DWR, but only the potential existence of a GDE. However, the Natural Communities data set can be used by GSAs as a starting point when approaching the task of identifying GDEs within a groundwater basin that are both classified as potential GDEs and are connected to groundwater (The Nature Conservancy, 2020).

There has been no field verification that the locations shown on this map constitute GDEs. Additional field reconnaissance is necessary to verify the existence and extent of these potential GDEs and may be considered as part of the monitoring network for future planning efforts.

In support of the State Water Resources Control Board licensing/permitting process for the Lopez Project, the District is currently preparing an HCP Studies in support of the HCP are underway.

It is anticipated that the integrated surface/groundwater model for the Arroyo Grande Creek Watershed currently being developed as part of the GSP process will inform the HCP. Specifically, the model may be a key tool allowing the District to better understand the relationship between downstream releases from the reservoir and groundwater pumping on the availability of surface water and GDEs in lower Arroyo Grande Creek. The updated downstream release program and the HCP would provide an approach for the operation of Lopez Reservoir that fulfills the contractual water supply obligations to the Zone 3 contractors and provides releases for downstream agricultural users, while also maintaining and enhancing habitat steelhead, red-legged frog, and other environmentally sensitive biota in lower Arroyo Grande Creek.

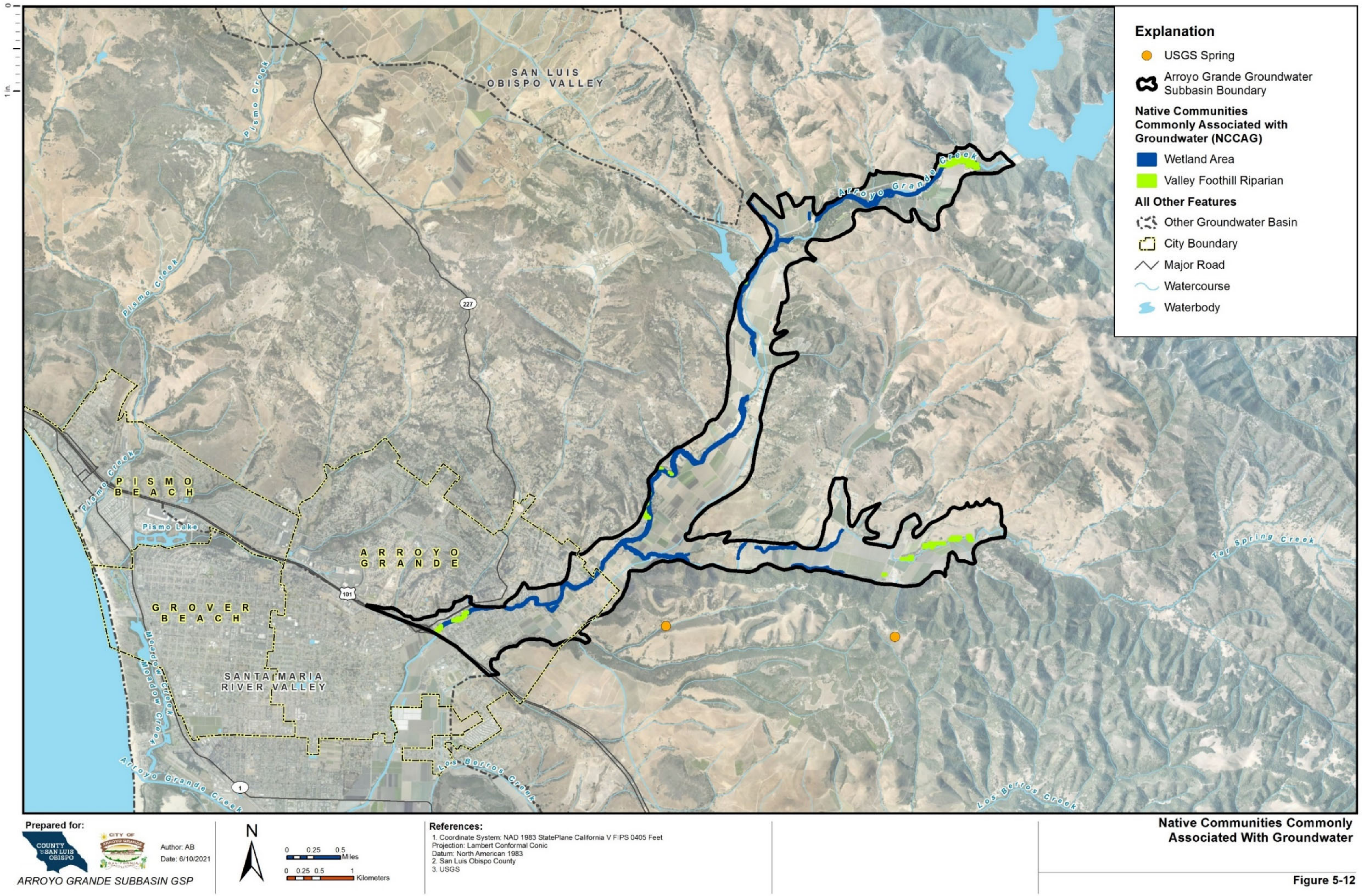

Figure 5-12. Native Communities Commonly Associated with Groundwater

5.5.1 Identification of Potential GDEs

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

1. Step 1 – Identify potential GDEs;
    a. Step 1.1 - Map GDEs
    b. Step 1.2 - Characterize GDE Condition
2. Step 2 – Determine Potential Effects of Groundwater Management on GDEs;
3. Step 3 – Consider GDEs when Establishing Sustainable Management Criteria
4. Step 4 – Incorporate GDEs into the Monitoring Network; and
5. Step 5 – Identify Projects and Management Actions to Maintain or Improve GDEs.

There are two objectives within Step 1 which are to map (Step 1.1) and characterize (Step 1.2) GDEs in the Subbasin. Steps 1.1 and 1.2 are the focus of this section. The remaining steps are considered in later sections of the GSP.

Based on review of the Natural Communities data set, several wetland features and one type of vegetation community are present within the basin. The Natural Communities vegetation type is Valley Foothill Riparian.

Wetland classifications recorded in the Natural Communities data set for the Basin are: palustrine, emergent, persistent, seasonally flooded; palustrine, forested, broad-leaved- evergreen, seasonally flooded; palustrine, forested, seasonally flooded; palustrine, scrub-shrub, seasonally flooded; riverine, unknown perennial, unconsolidated bottom, semi-permanently flooded; and riverine, upper perennial, unconsolidated bottom, permanently flooded (The Nature Conservancy, 2019). Generally, wetlands were recorded along Arroyo Grande Creek and portions of Tar Spring Creek.

The Natural Communities vegetation classifications are presented as polygons on

Figure 5-12 as they occur throughout the basin. The Valley Foothill Riparian vegetation classification is described in detail below. The Natural Communities wetland classifications are also presented on

Figure 5-12 (lumped as one ‘wetland area’ category).

5.5.1.1 Potential GDE Vegetation Classification

The Natural Communities vegetation class mapped within the Subbasin is Valley Foothill Riparian. In general, NCAAG vegetation classifications are a collection of multiple vegetation species dominated by a few key species, as described below.

The Valley Foothill Riparian Natural Communities classification occurs in a few scattered stands within the Subbasin, including areas along Arroyo Grande Creek and the upper reaches of Tar Spring Creek. The Valley Foothill Riparian classification covers an area of 28 acres within the Subbasin, as shown of

Figure 5-12. Valley Foothill Riparian habitats are found in valleys bordered by sloping alluvial fans, slightly dissected terraces, lower foothills, and coastal plains. They are generally associated with low velocity flows, flood plains, and gentle topography (Mayer, 1988). The dominant species within this classification are cottonwood, California sycamore, and valley oak, with a subcanopy of white alder, boxelder, and Oregon ash. Typical understory shrub layer plants include wild grape, wild rose, California blackberry, blue elderberry, poison oak, button brush, and willows. The herbaceous layer consists of sedges, rushes, grasses, miner's lettuce, Douglas sagewort, poison-hemlock, and hoary nettle (Mayer, 1988). Rooting depths for Valley Foothill Riparian species vary from 1 foot for willow (TNC, 2020), up to a reported maximum rooting depth of 80 feet for valley oak (Lewis, 1964).

5.5.1.2 Screening of Potential GDEs

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

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

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

Contoured groundwater elevation data for spring 2015 was used to determine areas where the Natural Communities polygons were within 30 feet depth to groundwater. Spring 2015 groundwater elevations were chosen for this analysis because this marked a period of the greatest recent data availability[2]. These data are considered representative of average spring-summer conditions within the last 5 years[3]. Areas with spring 2015 depth to groundwater of 30 feet or less are shown in purple on Figure 5-13 and the Natural Communities polygons associated with these areas are shown on Figure 5-13. Other than one small area in the Tar Spring Creek drainage, the areas with

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[2] The spatial distribution and density of spring 2015 groundwater elevation data satisfies the TNC recommendation for using wells that are located within 5 kilometers (3.1 miles) of the Natural Communities polygons (TNC, 2019).

[3] Groundwater elevations are generally the highest in the spring, following recharge from winter rains. Spring-time groundwater elevations in 2015, being a relatively dry year, are considered representative of average modern conditions as measured throughout the spring-summer months, during the period of maximum annual evapotranspiration.

30 feet or less depth to groundwater are concentrated along the main stem of Arroyo Grande Creek and especially within the upper reaches of the creek.

The Natural Communities polygons associated with spring 2015 depth to groundwater of 30 feet or less shown on Figure 5-14 are considered potential GDEs within the Subbasin. A brief aerial photo review indicates the potential GDEs identified in this step generally match areas of visible vegetation within the 30 foot or less depth to groundwater areas. An on-site biological survey is recommended by (The Nature Conservancy, 2019) as a final GDE verification step. Biological surveys have not been completed in preparation of the GSP. However, the presence of these potential GDEs shall be verified during GSP implementation. The vegetation and wetland GDEs (and potential GDE) within the basin are summarized in Table 5-1 and Table 5-2.

Table 5-1: Potential Vegetation GDEs.

Natural Communities Vegetation Classification	Acres
Valley Foothill Riparian	19

Table 5-2: Potential Wetland GDEs.

Natural Communities Wetland Classification	Acres
Palustrine, Emergent, Persistent, Seasonally Flooded	1
Palustrine, Forested, Broad-Leaved- Evergreen, Seasonally Flooded	21
Palustrine, Forested, Seasonally Flooded	64
Palustrine, Scrub-Shrub, Seasonally Flooded	7
Riverine, Unknown Perennial, Unconsolidated Bottom, Semi permanently Flooded	1
Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded	15
Total	**109**

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

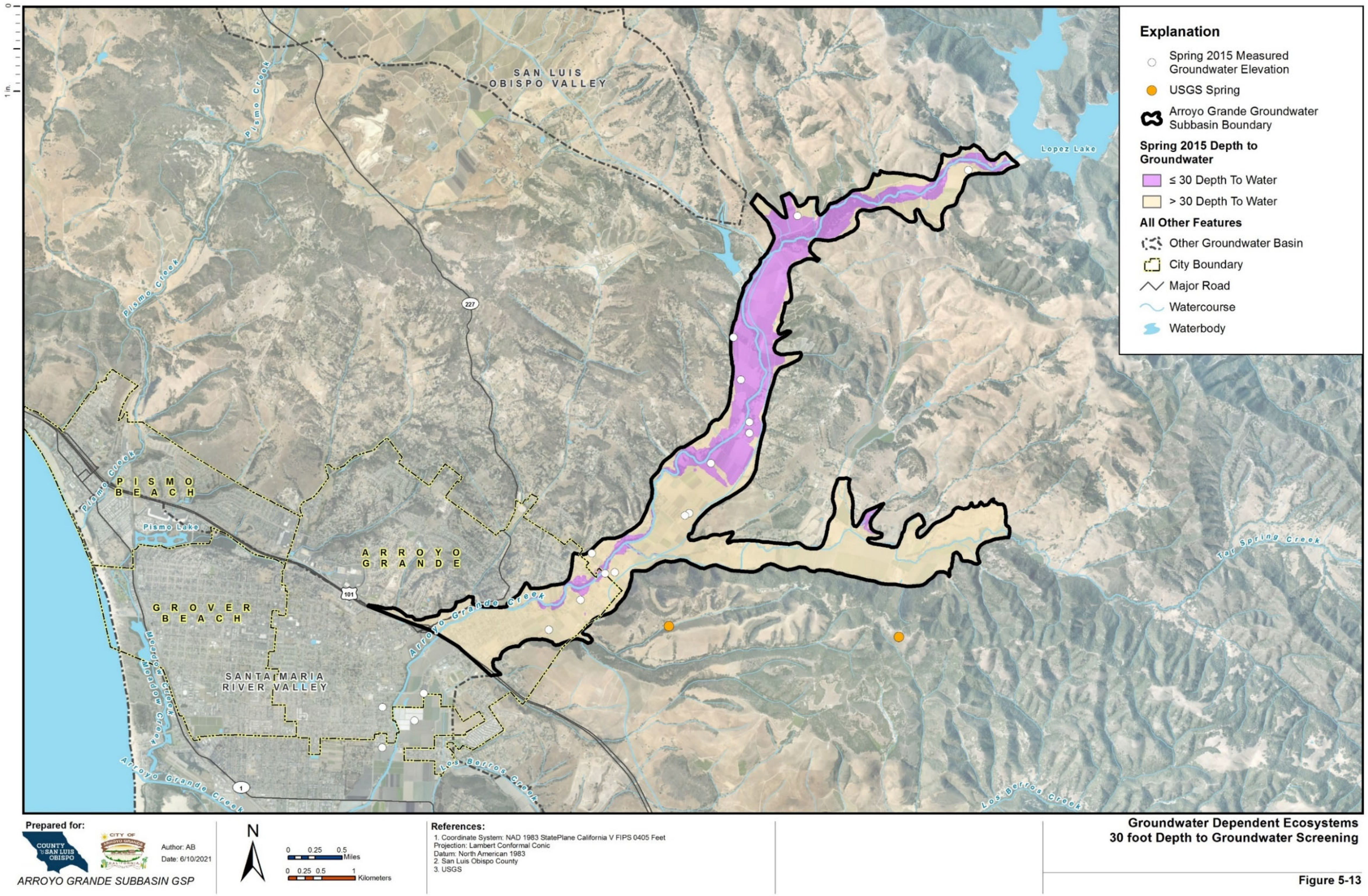

Figure 5-13. Groundwater Dependent Ecosystems 30-foot Depth to Groundwater Screening Criteria

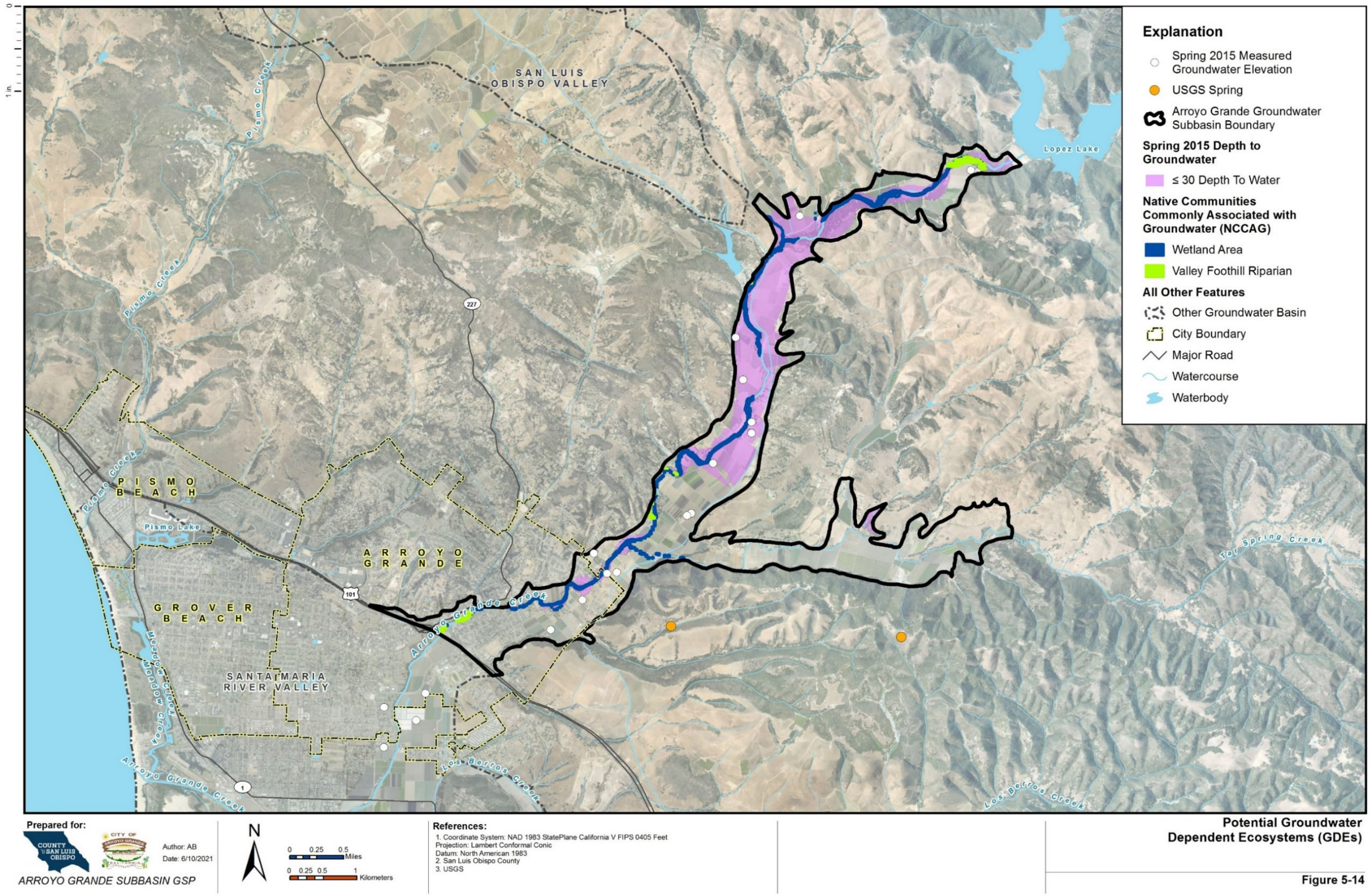

Figure 5-14. Potential Groundwater Dependent Ecosystems (GDEs)

5.5.2 Special Status Species Occurrence

The draft Arroyo Grande Creek Habitat Conservation Plan (HCP) (H.T. Harvey & Associates, 2015) was reviewed to determine the terrestrial and aquatic special-status species that may utilize potential GDE units overlying the basin. The US Fish and Wildlife Service (USFWS) Critical Habitat Mapper was also consulted (https://ecos.fws.gov/ecp/report/table/critical-habitat.html). No original work was done for the special status species review of the basin.

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

- listed, proposed, or under review as endangered or threatened under the federal Endangered Species Act (ESA) or the California Endangered Species Act (CESA);
- designated by California Department of Fish and Wildlife (CDFW) as a Species of Special Concern;
- designated by CDFW as Fully Protected under the California Fish and Game Code (Sections 3511, 4700, 5050, and 5515);

Table 5-3 lists the special-status species that are documented to occur within the basin or are supported by resources originating in the basin based on review of the HCP and the USFWS Critical Habitat Mapper. Wildlife species were evaluated for potential groundwater dependence using the Critical Species Lookbook (Rodhe, 2019). This potential groundwater dependence rating is indicative of the species' general documented reliance on groundwater and should not be considered a statement of specific groundwater reliance occurring within the Subbasin.

Table 5-3: Special Status Species within the Subbasin.

Common Name	Scientific Name	Status	Potential Dependence on GW[1]
California Red-legged Frog	*Rana draytonii*	Federally listed (Threatened)	Direct
Least Bell's Vireo	*Vireo bellii pusillus*	State and Federally listed (Endangered)	Indirect
South-Central California Coast Steelhead DPS	*Oncorhynchus mykiss*	Federally listed (Threatened)	Direct
Tidewater Goby[2]	*Eucyclogobius newberryi*	Federally listed (Endangered)	Direct

Notes:

DPS - distinct population segment

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

[2] – Tidewater goby do not occur within the subbasin, however, potential reductions in streamflow of Arroyo Grande Creek leaving the subbasin could adversely affect critical habitat downstream.

5.5.3 Ecological Condition of Potential GDEs

Once potential GDEs are mapped, they are then characterized in Step 1.2 by their hydrologic and ecological conditions. Mapping of potential GDEs has been the focus of this GSP. Additional characterization of potential GDEs will be undertaken during finalization of the HCP, or during GSP implementation.

The TNC guidance recommends that the condition of each GDE unit be inventoried and documented by describing the species composition, habitat condition, and other relevant information reflected in Worksheet 2 of the guidance (Rohde, 2018). Then the ecological condition of the GDE unit should be characterized as having a high, moderate, or low ecological value based on criteria provided in the TNC guidance. This additional characterization can be undertaken during Final HCP development or GSP implementation.

5.6 Groundwater Quality Distribution and Trends

Groundwater quality samples have been collected and analyzed throughout the Subbasin for various studies and are collected on a regular basis for compliance with regulatory programs. Water quality data surveyed for this GSP were collected from:

- The California State Water Resources Control Board (SWRCB) GeoTracker GAMA database,
- The California Safe Drinking Water Information System (SDWIS), a repository for public water system water quality data,
- The National Water Quality Monitoring Council water quality portal (this includes data from the recently decommissioned EPA STORET database, the USGS, and other federal and state entities [Note: in the Subbasin the agencies include USGS, California Environmental Data Exchange Network (CEDEN), and Central Coast Ambient Monitoring Program {CCAMP}].

In general, the quality of groundwater in the Subbasin is good. There is relatively little time series data on water quality. Water quality trends in the Subbasin are stable, with no significant trends of ongoing deterioration of water quality based on the Regional Water Quality Control Board's Subbasin Objectives, outlined in the Water Quality Control Plan for the Central Coast Subbasin (Basin Plan, June 2019). The Subbasin Plan takes all beneficial uses into account and establishes measurable goals to ensure healthy aquatic habitat, sustainable land management, and clean groundwater. The distribution, concentrations, and trends of some of the most commonly cited major water quality constituents are presented in the following sections.

Groundwater in the Subbasin is generally suitable for drinking water purposes. Groundwater quality data was evaluated from the SDWIS and GeoTracker GAMA datasets. The data reviewed includes 352 sampling events from 129 supply wells and monitoring wells in the Subbasin, collected between November 1950 and April 2020. Primary drinking water standards referred to as Maximum Contaminant Levels (MCLs) and Secondary MCLs (SMCLs) are established by Federal and State agencies. MCLs are legally enforceable standards, while SMCLs are guidelines established for nonhazardous aesthetic considerations such as taste, odor, and color.

5.6.1 Distribution and Concentrations of Point Sources of Groundwater Constituents

Potential point sources of groundwater quality degradation due to release of anthropogenic contaminants were identified using the State Water Resources Control Board (SWRCB) GeoTracker website. Waste Discharge permits were also reviewed from on-line regional SWRCB websites. Figure 5-15 shows the locations of these documented groundwater contaminant point source cases; all of the cases displayed are completed/case closed sites. Based on available information there are no mapped ground-water contamination plumes at these sites, or in the Subbasin as a whole.

5.6.2 Distribution and Concentrations of Diffuse or Natural Groundwater Constituents

The distribution and concentration of several constituents of concern are discussed in the following subsections. Groundwater quality data was evaluated from the SDWIS and GeoTracker GAMA datasets. Each of the constituents are compared to their drinking water standard, if applicable, or their Subbasin Plan Median Groundwater Quality Objective (RWQCB Objective) (RWQCB-CCR, 2017). This GSP focuses only on constituents that might be impacted by groundwater management activities. The constituents discussed below are chosen because they have either a drinking water standard, a known effect on crops, or concentrations have been observed above either the drinking water standard or the level that affects crops.

5.6.2.1 Total Dissolved Solids

TDS is defined as the total amount of mobile charged ions, including minerals, salts, or metals, dissolved in a given volume of water and is commonly expressed in terms of milligrams per liter (mg/L). Specific ions of salts such as chloride, sulfate, and sodium may be evaluated independently, but all are included in the TDS analysis, so TDS concentrations are correlated to concentrations of these specific ions. Therefore, TDS is selected as a general indicator of groundwater quality in the Subbasin. TDS is a constituent of concern in groundwater because it has been detected at concentrations greater than its RWQCB Subbasin Objective of 800 mg/l in the Subbasin. The TDS Secondary MCL has been established for color, odor, and taste, rather than human health effects. This Secondary MCL includes a recommended standard of 500 mg/L, an upper limit of 1,000 mg/L and a short-term limit of 1,500 mg/l. TDS water quality results ranged from 170 to 2,360 mg/l with an average of 1,003 mg/l and a median of 810 mg/l.

The distribution and trends of TDS concentrations in the Subbasin groundwater are presented on Figure 5-16. TDS concentrations are color coded and represent the maximum result if multiple samples are documented since 2015. It is noteworthy that TDS concentrations are higher in the lower part of the Subbasin. The reason for this is not apparent. It may be related to the presence of the shallow clay layer discussed in the cross sections in Chapter 4.0. Where the clay layer is not present, there may be a greater degree of percolation of fresh water released from the dam, while this mechanism may not be as significant where the clay layer is present. There is not a great amount of time series data in the Subbasin, but some graphs displaying TDS concentration with time are included on Figure 5-16. These graphs do not indicate any upward trend in TDS concentrations over the past twenty years. Potential management actions implemented as part of this GSP are not anticipated to increase groundwater TDS concentrations in wells that are currently below the SMCL.

5.6.2.2 Nitrate

Nitrate is a widespread contaminant in California groundwater. Although it does occur naturally at low concentrations, high levels of nitrate in groundwater are commonly associated with agricultural activities, septic systems, confined animal facilities, landscape fertilizers and wastewater treatment facilities. Nitrate is the primary form of nitrogen detected in groundwater. It is soluble in water and can easily pass-through soil to the groundwater table. Nitrate can persist in groundwater for decades and accumulate to high levels as more nitrogen is applied to the land surface each year. It is a Primary Drinking Water Standard constituent with an MCL of 10 mg/l of nitrate as nitrogen (as N).

Nitrate is a constituent of concern in groundwater because it has been detected at concentrations greater than its RWQCB Subbasin Objectives of 10 mg/l (as N) in the Subbasin. The Nitrate (as N) MCL has been established at 10 mg/l. Overall, nitrate water quality results ranged from below the detection limit to 67 mg/l (as N) with an average of 2.5 mg/l (as N) and a median value of 0.4 mg/l (as N).

Figure 5-17 presents occurrences and trends for nitrate in the Subbasin groundwater. Wells with the most sampling data over time were selected for presentation. The color-coded symbols represent the maximum result if multiple samples are documented. The vast majority of results are below the MCL of 10 mg/l. There is not a great amount of time series data in the Subbasin, but some graphs displaying TDS concentration with time are included on Figure 5-17. One of the chemographs displayed on Figure 5-17 in the northern Arroyo Grande Creek valley indicates stable concentrations of nitrate below the MCL, and do not indicate trends of increasing concentrations with time. A second chemograph located in Tar Spring Creek valley indicates temporary spikes of nitrate in the 30 to 40 mg/l range in 2012 and 2018, with other occasional results above the MCL of 10 mg/l, and most of the results lower than the MCL. Potential sustainability projects and management actions implemented as part of this GSP are not anticipated to increase nitrate concentrations in groundwater in a well that would otherwise remain below the MCL to increase above the MCL.

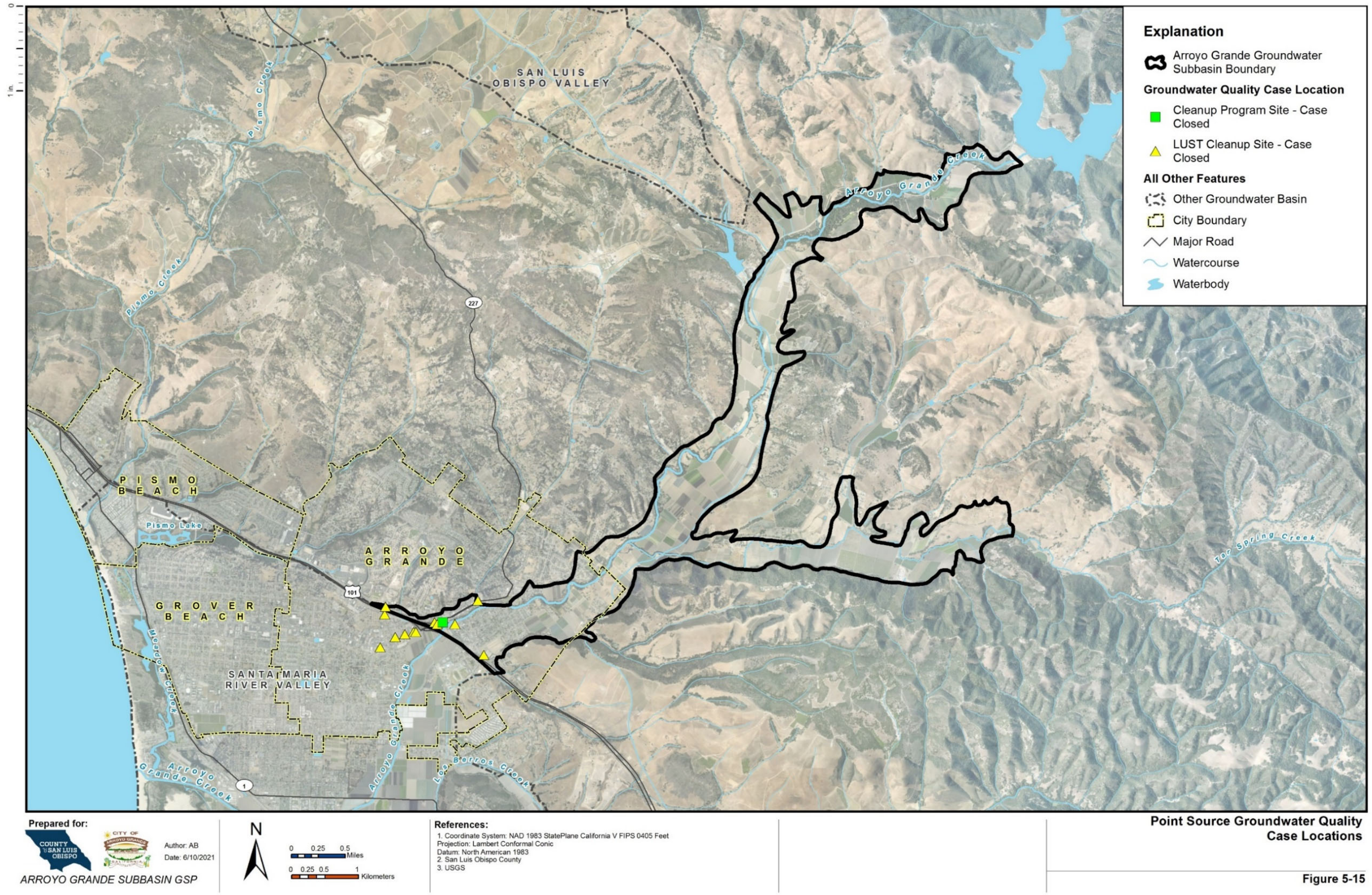

Figure 5-15. Point Source Groundwater Quality Case Locations

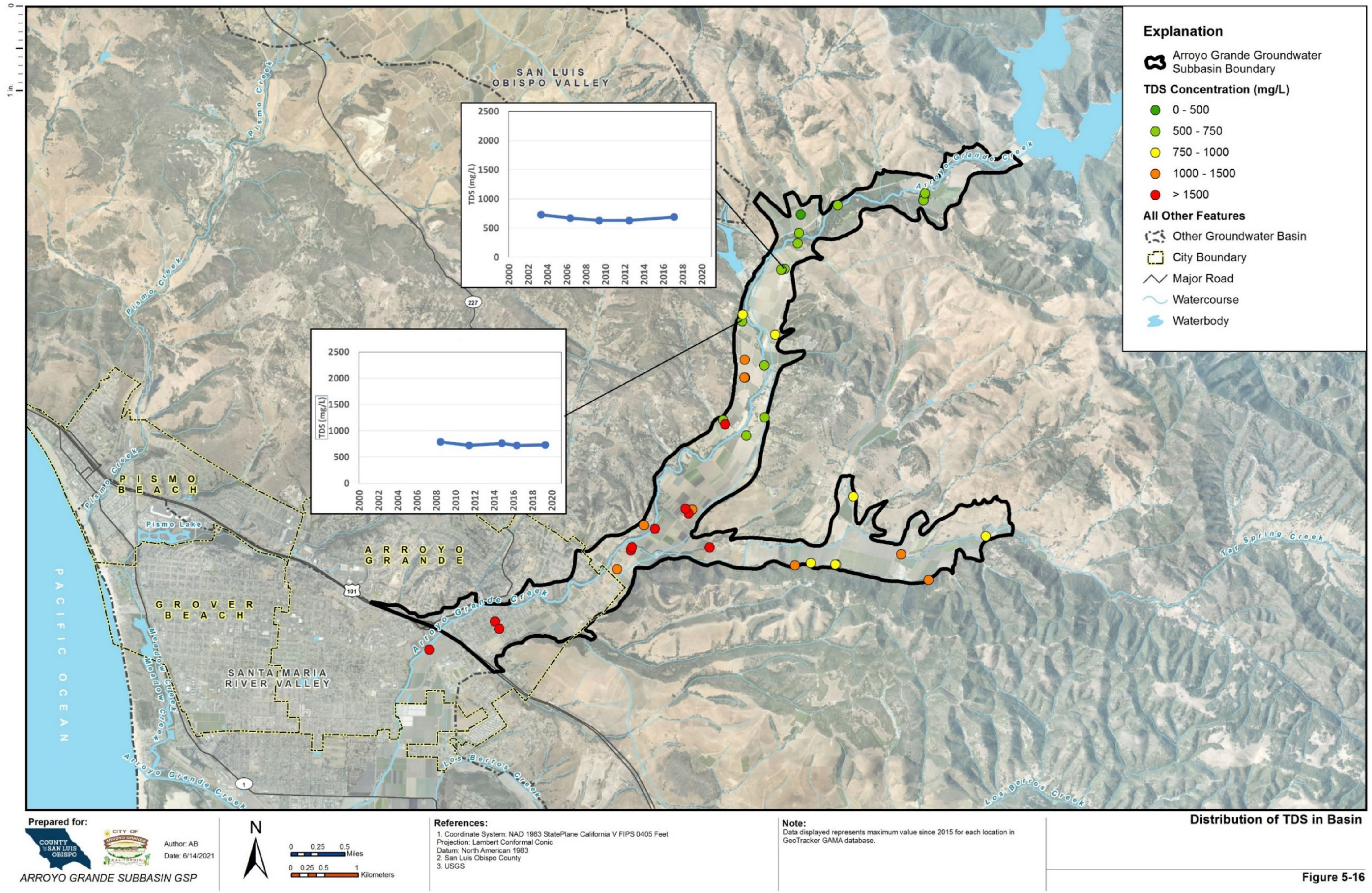

Figure 5-16. Distribution of TDS in Basin

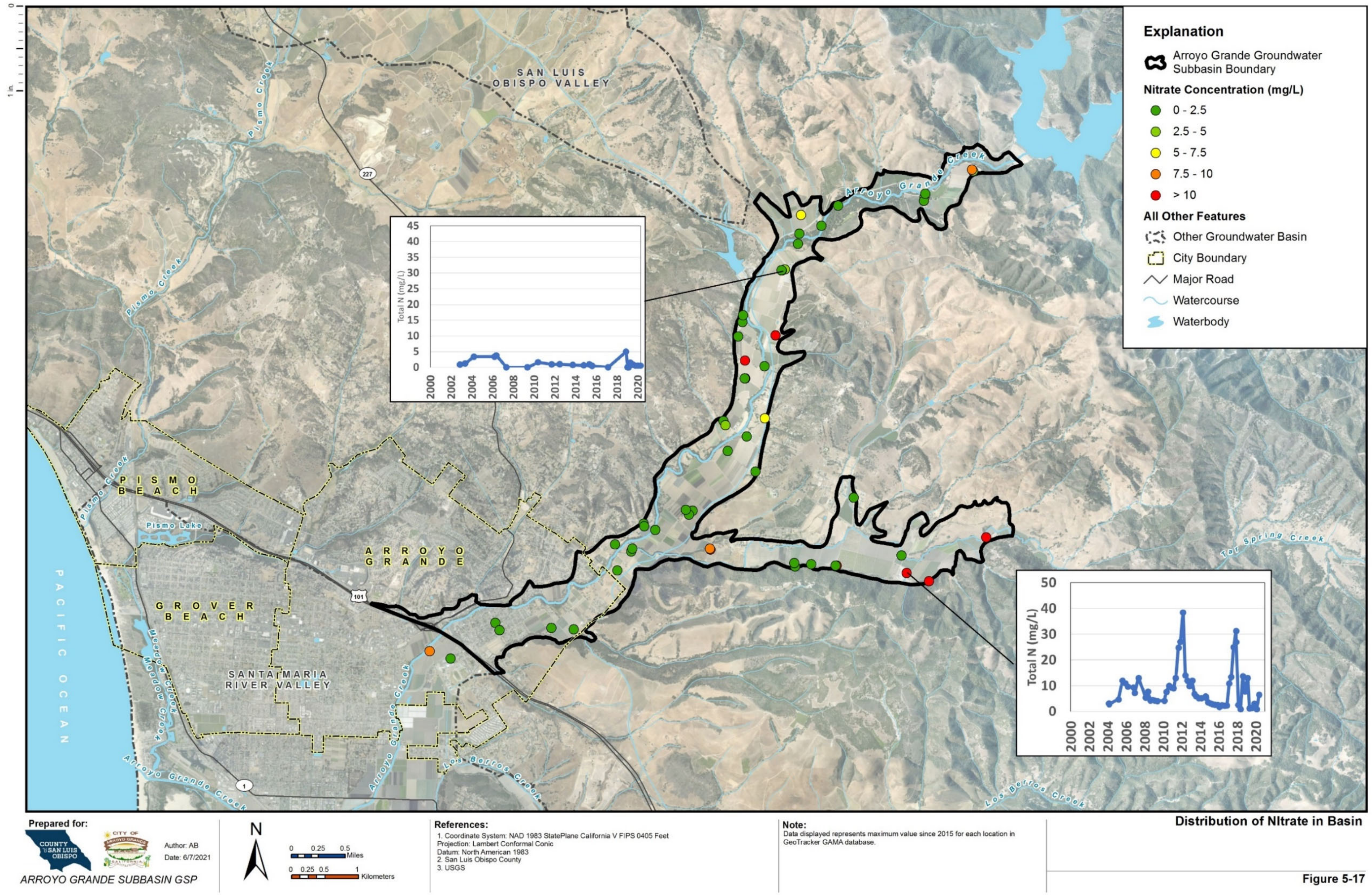

Figure 5-17. Distribution of Nitrate in Basin

GROUNDWATER SUSTAINABILITY PLAN

6.0 Water Budget (§ 354.18)

The purpose of a water budget is to provide an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the Subbasin, including historical, current, and projected water budget conditions, and the change in volume stored. Both numerical and analytical methods have been used during water budget preparations for the GSP.

IN THIS SECTION

The analytical method as used in this document refers to application of the water budget equation and the inventory method using spreadsheets, with groundwater flow estimates based on Darcy's Law and change in storage calculations based on the specific yield method.

Numerical methods refer to surface water and groundwater flow modeling, which provide a dynamic and more rigorous analysis of both surface-groundwater interactions and the impacts from pumping on groundwater in storage. The historical and current analytical groundwater budget will be used as part of the Subbasin Hydrogeologic Conceptual Model (HCM) to prepare input estimates and provide a check for the numerical model, from which the projected water budget will be produced. This chapter presents the analytical water budget for the historical and current periods and the numerical model water budget for the projected future period. Once the numerical model water budget is calibrated, the results will be presented as comparisons to the analytical water budget.

A water budget identifies and quantifies various components of the hydrologic cycle within a user-defined area, in this case the Arroyo Grande Valley groundwater Subbasin. Water circulates between the atmospheric system, land surface system, surface water bodies, and the groundwater system, as shown in Figure 6-1 (DWR, 2016). The water budget equation used for the analytical method is as follows:

INFLOW – OUTFLOW = CHANGE IN STORAGE

Inflow is the sum of all surface water and groundwater entering the Subbasin and outflow is the sum of all surface water and groundwater leaving the Subbasin. The difference between total inflow and total outflow over a selected time period is equal to the change in total storage (surface water and groundwater) within the Subbasin over the same period. Components of inflow and outflow represented in the water budget are shown in Figure 6-2. Not all of the components shown are needed for the Subbasin GSP. A key using letters to represent components in this water budget has been added to Figure 6-2 for reference with the main water budget tables. Some components have been modified and renamed from the original DWR figure to better represent this specific water budget.

The water budget equation given above is simple in concept, but it is challenging to measure and account for all the components of inflow and outflow within a Basin. Some of these components can be measured or estimated independently, while others are calculated using the water budget equation.

The water budget for this GSP has been prepared for the Subbasin as a whole.

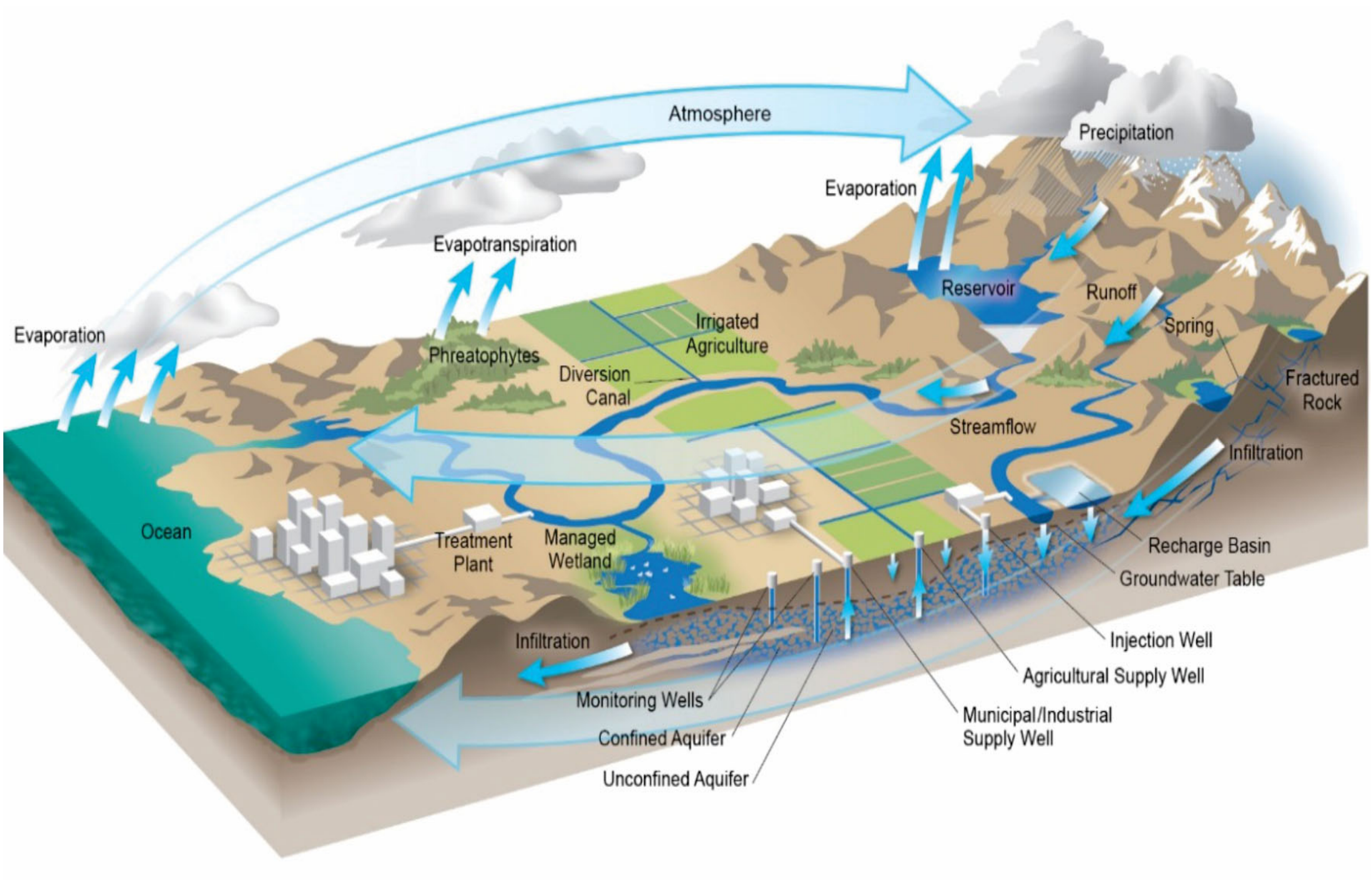

Figure 6-1. The Hydrologic Cycle

Source: Department of Water Resources (Water Budget BMP, 2016)

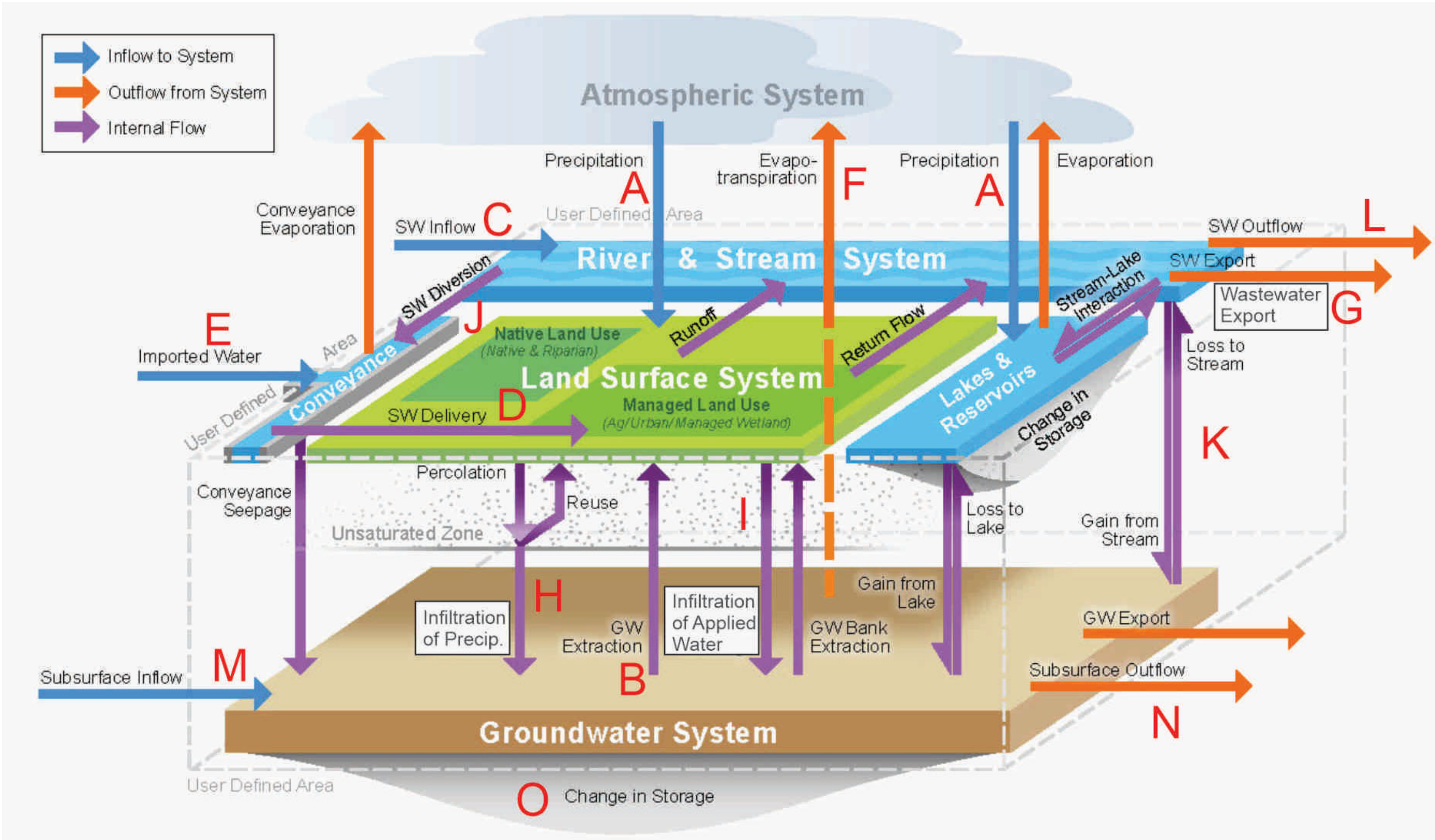

Figure 6-2. Components of the Water Budget

Source: Modified from Department of Water Resources (Water Budget BMP, 2016)

The Subbasin is approximately 2,900 acres (4.5 square miles) and receives surface inflow from a watershed of approximately 65,800 acres (102.8 square miles) of which approximately 44,000 acres (68.8 square miles; 67%) are upstream of Lopez Dam. The largest tributary to Arroyo Grande Creek entering the Subbasin downstream of the dam is Tar Spring Creek (Figure 3-3, Chapter 3.0).

Table 6-1 presents the historical surface water and groundwater budgets for the Subbasin. Bar graphs for the surface water and groundwater budgets are included in Figure 6-3 and Figure 6-4. A letter key has been added to provide a visual reference between Table 6-1 and Figure 6-2.

Note that Figure 6-2 separates the water budget into four components (atmospheric system, land surface system, river & stream system, and groundwater system). The atmospheric system transfers evaporation to precipitation and overlies the other systems. The land surface system is the portion of the water budget that includes land surface and the unsaturated zone extending to the top of the groundwater system. The rivers & streams system is the portion of the water budget that includes rivers, streams, conveyance facilities and diversion ditches, and lakes and reservoirs. The atmospheric, land surface, and river & streams water budgets for this Subbasin have been combined into a single surface water budget. As a result, not all the components in Table 6-1 have corresponding budget items listed for the Subbasin. For example, the runoff and return flow components of the land surface system into the river & stream system in Figure 6-2 are part of the surface water outflow component (Labeled “L”).

The bar graphs are graphical representations of the water budget that allow quick comparisons of the various budget quantities. Figure 6-3 illustrates the surface water budget portions of Table 6-1, while Figure 6-4 illustrates the groundwater budget portions of the table. Water budget climate, historical time period, methodology, sustainable yield, and overdraft interpretation are also presented in this chapter.

Table 6-1. Historical Water Budget – Arroyo Grande Subbasin

Historical Water Budget - Arroyo Grande Subbasin																														
	SURFACE WATER INFLOW (AF)							SURFACE WATER OUTFLOW (AF)												GROUNDWATER INFLOW (AF)						GROUNDWATER OUTFLOW (AF)				
Water Year	Precipitation	GW extractions (Urban)	GW extractions (Ag)	Stream Inflow	Surface Water Delivery	Local Imported Supplies	TOTAL IN	ET of Precipitation	ET of Applied Water (Urban)	ET of Applied Water (Ag)	Riparian ET	Wastewater export	Infiltration of Precipitation	Infilt. of Applied Water (Urban)	Infilt. of Applied Water (Ag)	Surface Water Diversion	GW-SW interaction	Stream outflow	TOTAL OUT	Infiltration of Precipitation	Infilt. of Applied Water (Urban)	Infilt. of Applied Water (Ag)	GW-SW interaction	Subsurface Inflow	TOTAL IN	GW Extractions (Urban)	GW Extractions (Ag)	Subsurface Outflow	TOTAL OUT	Change in GW Storage (AF)
KEY	A	B	B	C	D	E		F	F	F	F	G	H	I	I	J	K	L		H	I	I	K	M		B	B	N		O
1988	2,380	120	2,810	3,950	450	440	10,150	2,260	480	2,170	230	180	100	70	640	450	1,350	2,220	10,150	100	70	640	1,350	170	2,330	120	2,810	480	3,410	-1,080
1989	3,050	110	2,410	4,310	450	410	10,740	2,710	450	1,850	230	160	280	70	560	450	1,470	2,510	10,740	280	70	560	1,470	170	2,550	110	2,410	480	3,000	-450
1990	1,920	110	2,810	4,150	450	390	9,830	1,900	430	2,170	230	150	20	70	640	450	1,420	2,360	9,840	20	70	640	1,420	170	2,320	110	2,810	480	3,400	-1,080
1991	3,920	110	2,590	4,110	450	380	11,560	3,020	430	1,990	230	150	740	70	590	450	1,410	2,490	11,570	740	70	590	1,410	170	2,980	110	2,590	480	3,180	-200
1992	4,150	110	2,530	5,040	450	390	12,670	3,080	430	1,940	230	150	880	70	580	450	1,730	3,130	12,670	880	70	580	1,730	170	3,430	110	2,530	480	3,120	310
1993	5,820	110	2,400	7,590	450	380	16,750	3,150	420	1,840	230	150	2,210	70	550	450	820	6,840	16,730	2,210	70	550	820	170	3,820	110	2,400	480	2,990	830
1994	3,080	110	2,150	3,700	450	360	9,850	2,740	400	1,640	230	140	290	60	510	450	1,260	2,120	9,840	290	60	510	1,260	170	2,290	110	2,150	480	2,740	-450
1995	7,600	110	2,340	11,900	450	380	22,780	3,160	420	1,800	230	150	3,400	70	540	450	1,290	11,270	22,780	3,400	70	540	1,290	170	5,470	110	2,340	480	2,930	2,540
1996	4,610	110	2,320	19,490	450	420	27,400	3,170	460	1,780	230	170	1,190	70	540	450	1,110	18,240	27,410	1,190	70	540	1,110	170	3,080	110	2,320	480	2,910	170
1997	6,010	120	2,730	55,830	450	370	65,510	3,180	420	2,110	230	150	2,350	70	620	450	950	54,990	65,520	2,350	70	620	950	170	4,160	120	2,730	480	3,330	830
1998	9,070	110	2,060	80,040	450	420	92,150	3,180	460	1,570	230	170	1,310	70	490	450	1,370	82,860	92,160	1,310	70	490	1,370	170	3,410	110	2,060	480	2,650	760
1999	3,670	120	2,820	17,350	450	450	24,860	2,990	490	2,190	230	180	560	80	640	450	990	16,080	24,880	560	80	640	990	170	2,440	120	2,820	480	3,420	-980
2000	4,520	110	2,020	9,070	450	430	16,600	3,190	470	1,540	230	170	1,080	70	480	450	520	8,400	16,600	1,080	70	480	520	170	2,320	110	2,020	480	2,610	-290
2001	4,830	110	2,100	10,420	450	450	18,360	3,190	490	1,610	230	180	1,340	70	490	450	590	9,710	18,350	1,340	70	490	590	170	2,660	110	2,100	480	2,690	-30
2002	2,970	120	2,400	6,530	450	450	12,920	2,700	490	1,850	230	180	230	80	550	450	1,340	4,830	12,930	230	80	550	1,340	170	2,370	120	2,400	480	3,000	-630
2003	4,070	120	1,960	8,350	450	460	15,410	3,100	490	1,490	230	180	790	80	470	450	900	7,210	15,390	790	80	470	900	170	2,410	120	1,960	480	2,560	-150
2004	3,060	120	2,110	7,200	450	430	13,370	2,740	480	1,610	230	170	260	80	490	450	780	6,080	13,370	260	80	490	780	170	1,780	120	2,110	480	2,710	-930
2005	3,850	120	2,020	11,060	450	420	17,920	3,030	470	1,550	230	170	670	80	480	450	2,270	8,540	17,940	670	80	480	2,270	170	3,670	120	2,020	480	2,620	1,050
2006	5,950	130	2,030	8,990	450	450	18,000	3,190	500	1,550	230	180	2,280	80	480	450	510	8,550	18,000	2,280	80	480	510	170	3,520	130	2,030	480	2,640	880
2007	1,790	160	2,670	5,780	450	430	11,280	1,790	500	2,070	230	170	0	80	600	450	630	4,760	11,280	0	80	600	630	170	1,480	160	2,670	480	3,310	-1,830
2008	4,810	160	2,660	7,500	450	400	15,980	3,190	480	2,060	230	160	1,320	80	600	450	430	6,980	15,980	1,320	80	600	430	170	2,600	160	2,660	480	3,300	-700
2009	2,710	150	2,410	5,450	340	370	11,430	2,550	440	1,880	230	150	140	80	530	340	1,120	3,980	11,440	140	80	530	1,120	170	2,040	150	2,410	480	3,040	-1,000
2010	5,340	150	1,770	6,310	580	360	14,510	3,200	430	1,320	230	150	1,760	80	450	580	1,290	5,020	14,510	1,760	80	450	1,290	170	3,750	150	1,770	480	2,400	1,350
2011	6,950	150	2,020	8,740	490	380	18,730	3,200	450	1,540	230	150	3,110	80	490	490	1,790	7,210	18,740	3,110	80	490	1,790	170	5,640	150	2,020	480	2,650	2,990
2012	2,830	160	2,130	5,160	600	370	11,250	2,630	450	1,600	230	150	170	80	530	600	1,060	3,760	11,260	170	80	530	1,060	170	2,010	160	2,130	480	2,770	-760
2013	3,030	170	2,840	5,380	510	360	12,290	2,730	450	2,190	230	150	250	80	640	510	1,100	3,950	12,280	250	80	640	1,100	170	2,240	170	2,840	480	3,490	-1,250
2014	1,420	170	2,500	4,220	420	360	9,090	1,420	450	1,940	230	140	0	80	560	420	1,440	2,410	9,090	0	80	560	1,440	170	2,250	170	2,500	480	3,150	-900
2015	2,130	170	2,650	3,620	420	350	9,340	2,070	440	2,060	230	140	50	80	590	420	1,240	2,030	9,350	50	80	590	1,240	170	2,130	170	2,650	480	3,300	-1,170
2016	3,870	170	2,100	4,700	420	340	11,600	3,090	430	1,620	230	140	640	80	480	420	1,610	2,870	11,610	640	80	480	1,610	170	2,980	170	2,100	480	2,750	230
2017	6,860	180	2,500	7,990	400	340	18,270	3,260	430	1,940	230	130	3,000	90	560	400	2,730	5,500	18,270	3,000	90	560	2,730	170	6,550	180	2,500	480	3,160	3,390
2018	2,170	190	2,230	4,770	420	330	10,110	2,120	430	1,730	230	130	50	90	500	420	820	3,600	10,120	50	90	500	820	170	1,630	190	2,230	480	2,900	-1,270
2019	4,920	180	1,940	7,560	310	320	15,230	3,320	420	1,520	230	130	1,310	90	420	310	1,290	6,200	15,240	1,310	90	420	1,290	170	3,280	180	1,940	480	2,600	680
2020	3,020	200	2,340	3,890	450	330	10,230	2,760	440	1,810	230	130	210	90	530	450	800	2,780	10,230	210	90	530	800	170	1,800	200	2,340	480	3,020	-1,220

Type Year: Dry / Below Normal / Above Normal / Wet

AF = Acre-Feet; KEY = Reference Components on Figure 6-2

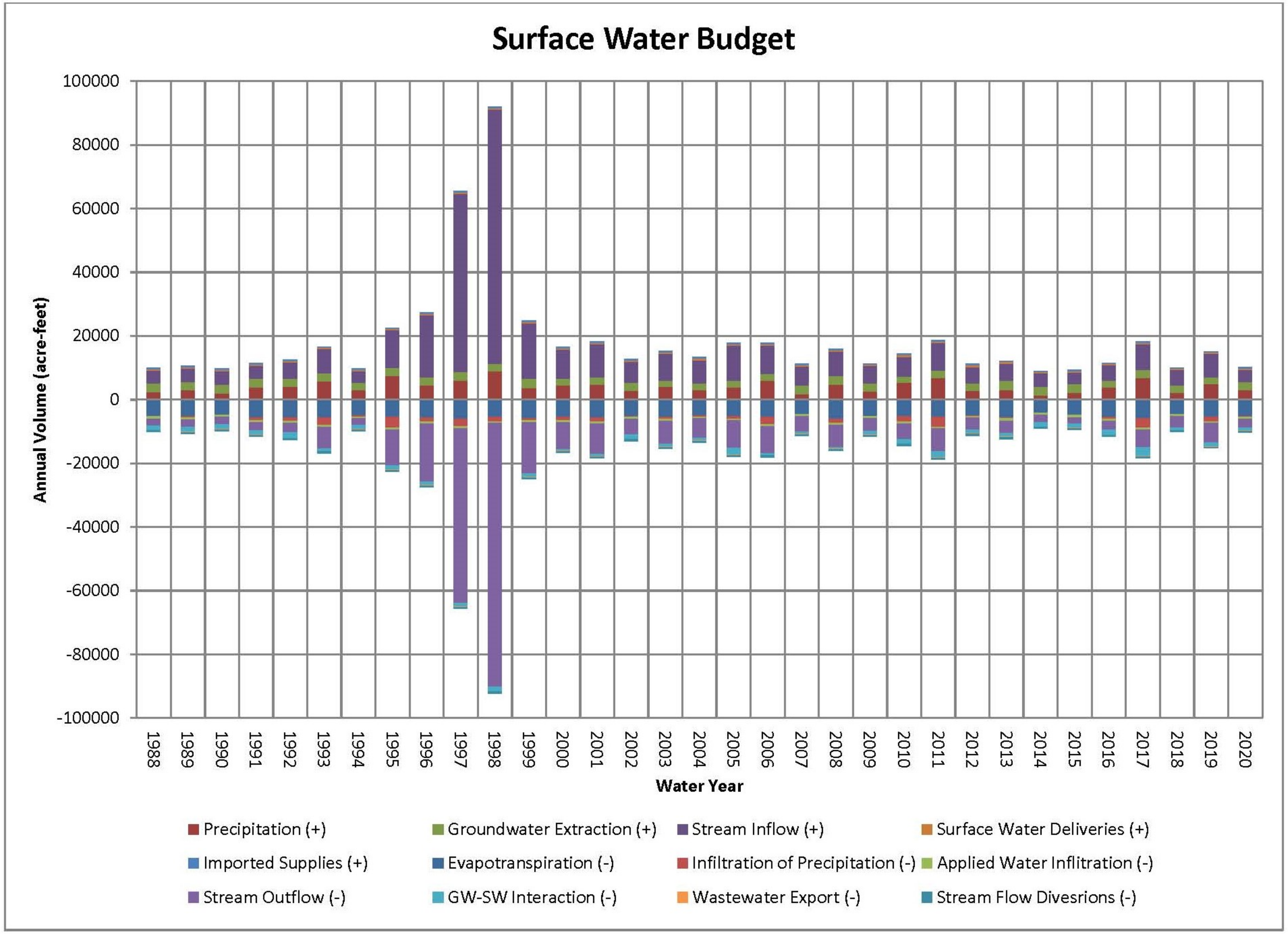

Figure 6-3. Surface Water Budget

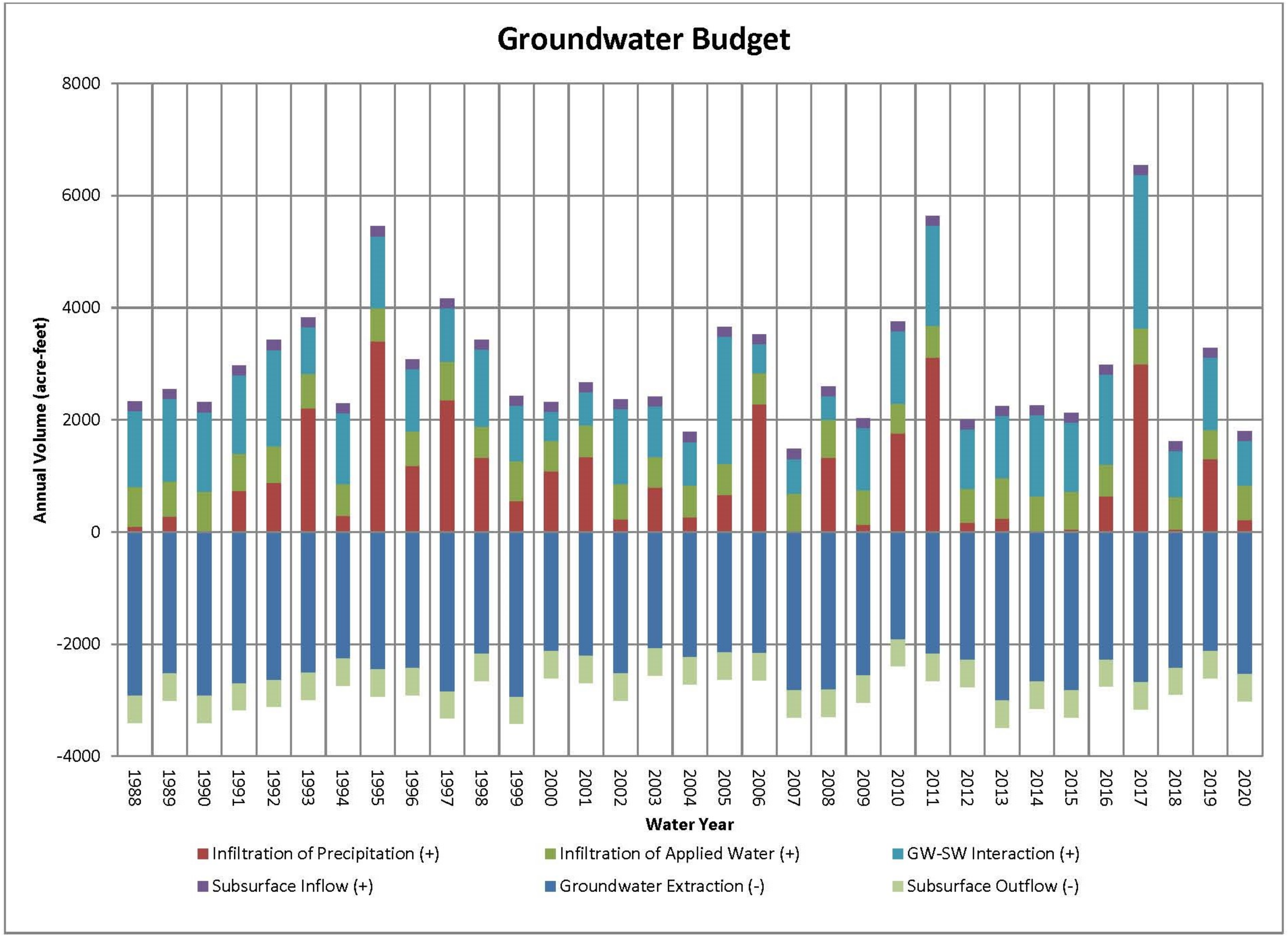

Figure 6-4. Groundwater Budget

6.1 Climate

Climate is one of the principal measures of water supply conditions and is used for hydrologic base period definition and for developing evapotranspiration estimates. The main component of climate monitoring in the Subbasin is rainfall, with records at Lopez Dam (Station 737; formerly Station 178.1) beginning in the 1968-69 rainfall year (July 1st – June 30th). Rainfall is used in the water budget for establishing the hydrologic base period needed for representing long-term water supply conditions.

Another climate parameter used in the water budget is evapotranspiration. Evapotranspiration is calculated from a combination of monitored parameters, such as air temperature, wind speed, solar radiation, vapor pressure, and relative humidity. These parameters, along with precipitation, have been monitored at CIMIS Station #52 (San Luis Obispo – Cal Poly) since 1986. The water budget uses crop evapotranspiration for estimating the applied irrigation requirements for crops (see Section 6.3.4.2). Cal Poly is within DWR reference evapotranspiration Zone 6 (Upland Central Coast), which is one of 18 climate zones in California based on long-term monthly average reference evapotranspiration (CIMIS, 1999). Approximately one third of the Subbasin is within Climate Zone 6, with the remaining two thirds in Climate Zone 3 (Coastal Valleys). CIMIS Station #202 (Nipomo) is within Climate Zone 3, with a record that begins in 2006. A correlation between evapotranspiration at CIMIS Stations #52 and #202 was performed to extend a record representative of Climate Zone 3 to the beginning of the historical base period, as discussed below.

6.1.1 Historical Climate/Base Period

The historical rainfall record at Lopez Dam has been used to define a period of years, referred to as a base period, which represents long-term hydrologic conditions. As described by DWR (2002):

> *The base period should be representative of long-term hydrologic conditions, encompassing dry, wet, and average years of precipitation. It must be contained in the historical record and should include recent cultural conditions to assist in determining projected Basin operations. To minimize the amount of water in transit in the zone of aeration, the beginning and end of the base period should be preceded by comparatively similar rainfall quantities.*

The historical rainfall record for the Lopez Dam Station was presented in Figure 3-10; Chapter 3.0. The SLOCFCWCD reports rainfall data on a water year basis running from July 1 through June 30 (also referred to as rainfall year), while stream flow data is reported from October 1 through September 30 (San Luis Obispo County, 2005). The DWR reports hydrologic data on a water year basis from October 1 through September 30. These conventions are maintained for the water budget, and the DWR water year is used for all water budget components of inflow and outflow. Water years are referenced herein based on the ending year.

The hydrologic base period selected to represent historical climatic conditions for the Subbasin encompasses the years 1988 through 2020 (33 years). Average precipitation at Lopez Dam over this base period was 20.9 inches, compared to the long-term average of 21.07 inches, and included wet, average, and dry periods (Figure 6-5). These periods are visually defined by the movement of the cumulative departure from mean precipitation curve, which declines over dry periods, is flat through average periods, and rises over wet periods.

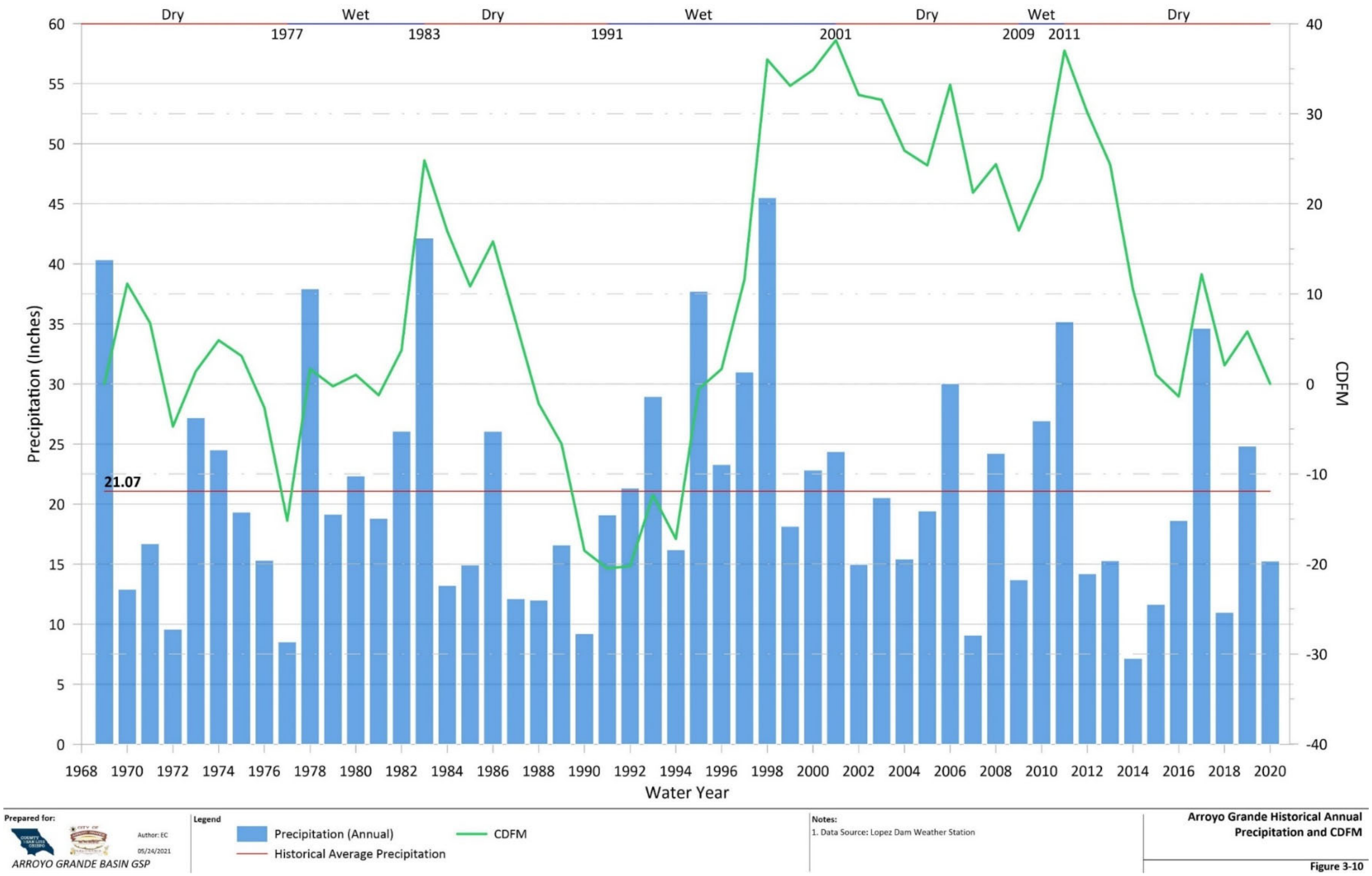

Figure 6-5. Historical Annual Precipitation and CDFM

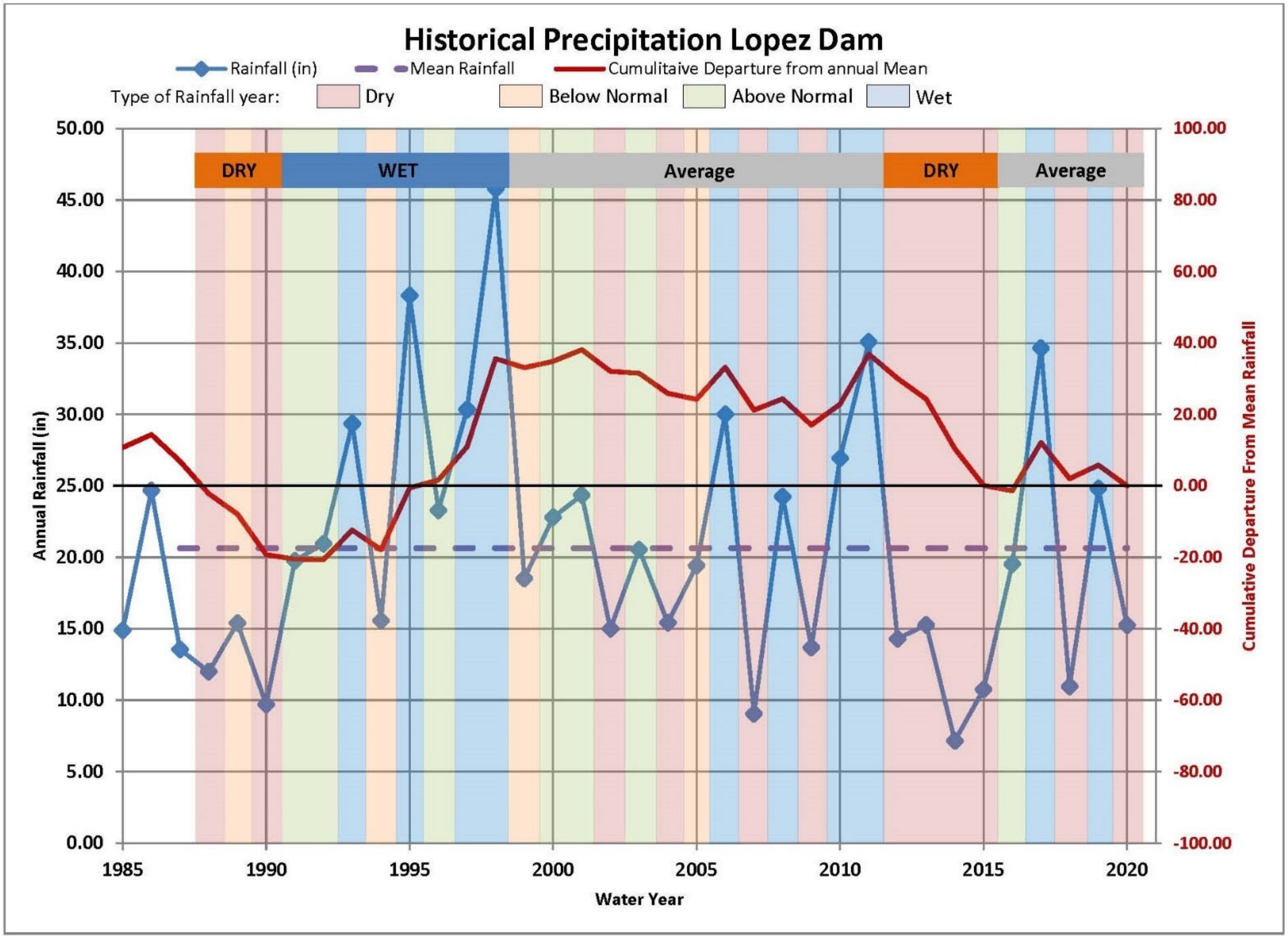

Figure 6-6. 1988-2020 Historical Base Period Climate

Water year types for this water budget have been developed and classified based on annual precipitation as a percentage of the previous 30-year average precipitation. Each July 1 through June 30 rainfall year of the historical base period was given a ranking of 1 (wettest) through 30 (driest) based on a comparison to a 30-year (rolling) data set. The minimum precipitation threshold for wet type years was assigned based on the average for the 10th ranked year (23.75 inches). The maximum precipitation threshold for dry type years was assigned based on the average for the 21st ranked year (15.05 inches). Below normal (from 15.05 to less than 19.66 inches) represents the 16th through 20th ranked years, while above normal (from 19.65 to 23.75 inches) represents the 10th through 15th ranked years. Note that the division between below normal and above normal rainfall (19.66 inches) is less than the average over the base period (20.9 inches) because there are more below average rainfall years than above average years. The water year types were developed from Lopez Dam rainfall records. The rainfall thresholds for water year types are summarized in Table 6-2.

Table 6-2: Rainfall Thresholds for Water Year Types.

Water Year Type	Rainfall Threshold (in.)*
Dry	<15.05
Below Normal	15.05 - <19.66
Above Normal	19.66 – 23.75
Wet	>23.75

*As measured at Lopez Dam

The base period includes recent cultural conditions (i.e., water supply, water demand, and land use) as recommended. Differences between water in transit in the vadose zone (deep percolation of precipitation and stream seepage) are minimal, based on comparing the two rainfall years leading up to the beginning and ending of the base period. The 1986 and 1987 rainfall years leading into the base period have 24.68 inches and 13.56 inches, respectively, compared to 24.82 and 15.25 inches of rainfall at the end of the base period in 2019 and 2020 (Figure 6-5).

An isohyetal map of average annual rainfall is shown in Figure 4-3 (Chapter 4.0). The average annual precipitation across the Subbasin between 1981 and 2010 ranged from 15.5 inches to 20 inches and averaged approximately 17 inches.

The water budget uses the Lopez Dam rain gauge (Station 737) to identify the historical base period and water year types due to the extensive period of record. Annual rainfall used in the surface water budget calculations that involve precipitation volumes, however, are adjusted to account for the difference between rainfall at the dam and average rainfall across the Subbasin.

Table 6-3 presents the annual rainfall at Lopez Dam over the historical base period. Water years are listed as dry, below normal, above normal, and wet in accordance with the thresholds described above. Average annual rainfall over the historical base period at the dam is estimated to be 20.9 inches.

Table 6-3: Historical Base Period Rainfall.

Year	Type	Lopez Dam
		Rainfall (in.)
1988	Dry	12.00
1989	Below Normal	15.40
1990	Dry	9.70
1991	Above Normal	19.77
1992	Above Normal	20.96
1993	Wet	29.36
1994	Below Normal	15.57
1995	Wet	38.34
1996	Above Normal	23.29
1997	Wet	30.34
1998	Wet	45.80
1999	Below Normal	18.53
2000	Above Normal	22.80
2001	Wet	24.36
2002	Dry	15.00
2003	Above Normal	20.55
2004	Below Normal	15.43
2005	Below Normal	19.43

Year	Type	Lopez Dam Rainfall (in.)
2006	Wet	30.02
2007	Dry	9.05
2008	Wet	24.26
2009	Dry	13.70
2010	Wet	26.93
2011	Wet	35.08
2012	Dry	14.30
2013	Below Normal	15.28
2014	Dry	7.16
2015	Dry	10.76
2016	Below Normal	19.53
2017	Wet	34.64
2018	Dry	10.97
2019	Wet	24.82
2020	Below Normal	15.25
Average		20.9

6.2 Water Budget Data Sources

The following sources and types of data have been used for the water budget:

- Hydrogeologic and geologic studies and maps
- County stream flow gages
- County and NOAA precipitation Stations
- PRISM 30-year normal dataset (1981-2010)
- CIMIS weather station data
- Aerial Imagery
- County water level monitoring program
- City of Arroyo Grande, County, and DWR land use data and planning documentation
- County Ag Commissioner's Office data sets
- County Water Master Plan
- Stakeholder supplied information
- Water rights filings

6.3 Historical Water Budget

In accordance with GSP regulations, the historical water budget shall quantify the following, either through direct measurement or estimates based on data (reference to location of data in Chapter 6.0 also listed):

(1) Total surface water entering and leaving a Basin by water source type (Table 6-1).
(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 (Table 6-1).
(3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow (Table 6-1).
(4) The change in annual volume of groundwater in storage between seasonal high conditions (Table 6-1).
(5) If overdraft occurs, 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 (Section 6.3.8).
(6) The water year type associated with the annual supply, demand, and change in groundwater stored (Table 6-1).
(7) An estimate of sustainable yield for the Basin (Section 6.3.7).

6.3.1 Historical Time Period

The time period over which the historical water budget is estimated is the hydrologic base period from 1988-2020 (33 years). Groundwater storage calculations using the specific yield method were performed for Spring 1987, 1990, 1996, 2002, 2009, 2011, 2015, 2017, and 2020. These years include the beginning (Spring 1987) and ending (Spring 2020) storage in the base period, with multiple interspersed years to characterize change in storage trends through the base period.

6.3.2 Historical Land Use

Land use is one of the primary data sets used in developing a water budget. Several types of land use/land cover in the basin have been used to estimate components of the water budget. For example, the acreages of various crops are multiplied by their respective water use factors to estimate agricultural groundwater extractions (Section 6.3.4.2), and acreages of various land covers are multiplied by empirical correlations to estimate their respective evapotranspiration and percolation of precipitation (Section 6.3.4.1). The land uses/land covers including the following:

- Irrigated Agriculture
    - Citrus
    - Deciduous
    - Pasture
    - Vegetable
    - Vineyard
- Native Vegetation
    - Brush, trees, native grasses
    - Wetlands/open water (Riparian)
- Urban/Suburban
    - Developed (City, subdivisions)
    - Open space (parks, empty lots)
    - Turf (play fields)

Irrigated Agriculture

Irrigated crop acreage was estimated from aerial imagery of the Subbasin for the following years: 1989, 1994, 1999, 2003, 2005, 2007, and 2011. San Luis Obispo County land use data was used for crop acreage from 2013 to 2020. The DWR land use survey for 1985 was also used. Figure 6-6 shows an example of the County irrigated crop data set for 2018.

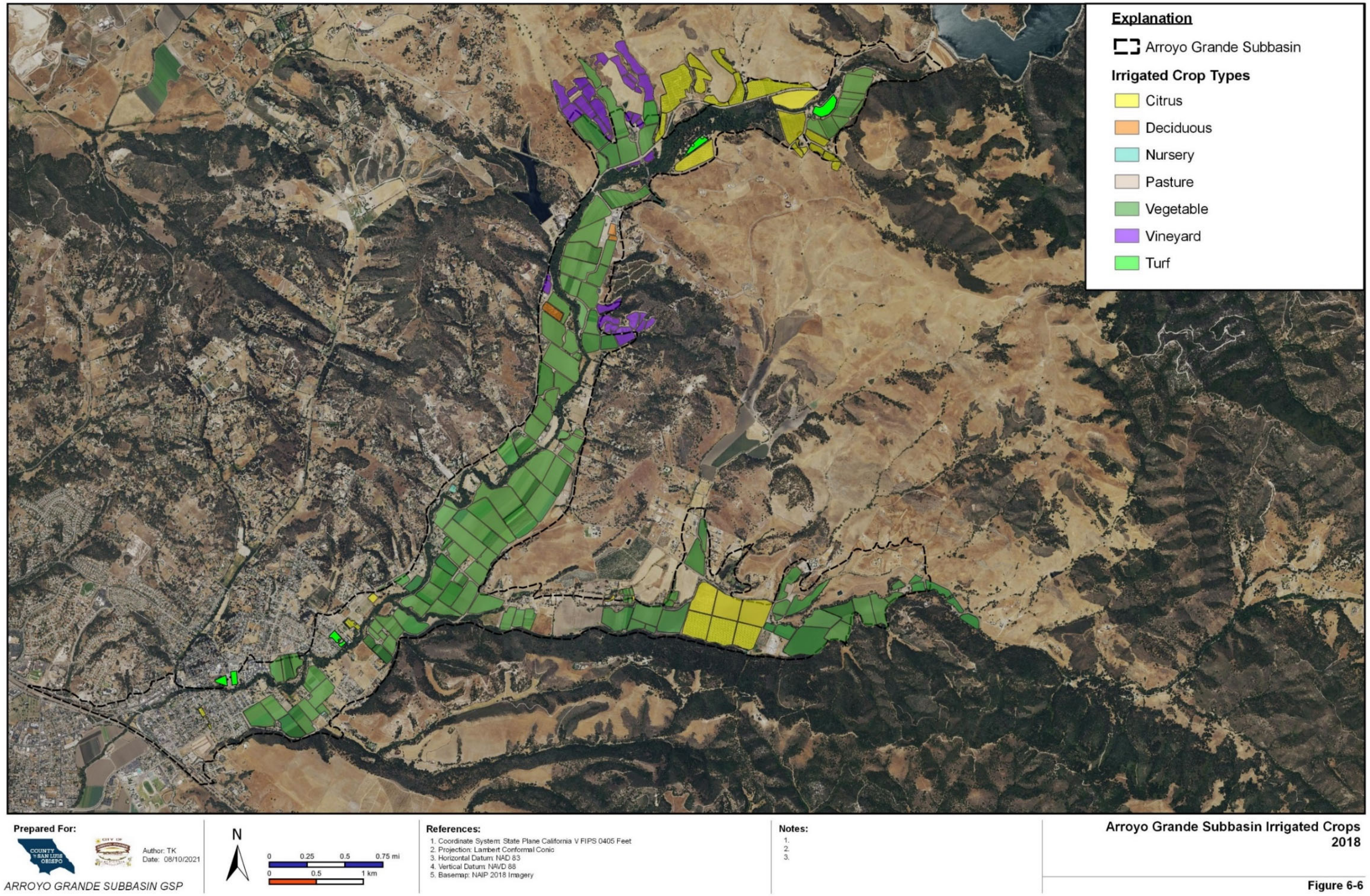

Figure 6-7. San Luis Obispo Valley Basin Irrigated Crops 2016

Irrigated acreage for years in the historical base period without aerial imagery, surveys, or County data were estimated from the nearest available year with data. Acreages for irrigated crops, estimated from aerial imagery and County datasets used to characterize the historical base period are shown in Table 6-4.

Table 6-4: Irrigated Agriculture Acreages.

Crop Type	1985	1989	1994	1999	2003	2005	2007	2011	2013	2014	2015	2016	2017	2018	2019
	San Luis Valley Subarea (acres)														
Citrus	26	99	132	130	152	152	156	156	156	176	176	192	192	245	262
Deciduous	5	5	5	10	10	10	27	27	30	22	22	1	10	8	18
Pasture	36	15	1	3	3	3	3	3	3	3	3	3	2	2	0
Vegetable	1,508	1,462	1,414	1,356	1,312	1,328	1,309	1,294	1,307	1,238	1,275	1,063	1,130	1,099	1,018
Vineyard	80	64	93	96	127	127	133	128	128	121	124	127	135	111	111
Subtotal	1,654	1,645	1,646	1,594	1,603	1,619	1,628	1,609	1,625	1,561	1,601	1,386	1,469	1,465	1,410

Native Vegetation and Urban Areas

Native vegetation acreages were compiled using data sets from the National Land Cover Database (NLCD), which is derived primarily from satellite imagery. The years for which NLCD coverage is available are 2001, 2004, 2006, 2008, 2011, 2013, 2016, and 2019. Adjustments to the acreages in the NLCD data were performed to reconcile with the agricultural acreages and urban turf areas compiled using the aerial imagery and crop survey data set. Where the NLCD data sets showed less agricultural acreage than the aerial imagery, the native vegetation (brush, trees, grassland) acreage and urban open space was reduced or increased so the total basin acreage remained constant. The estimated acreages for native vegetation and urban areas, along with irrigated agriculture interpolated from Table 6-4, are presented in Table 6-5 below.

Table 6-5: Land Cover Acreages.

Land cover	2001	2004	2006	2008	2011	2013	2016	2019
	Arroyo Grande Subbasin (acres)							
Native - brush, trees, grassland	513	517	505	491	493	484	542	582
Native - Riparian*	281	281	281	282	283	282	282	285
Urban - Developed	394	396	399	400	401	404	408	404
Urban - Open Space	102	84	79	86	97	79	134	181
Urban - Turf	10	10	14	17	17	17	17	17
Irrigated Agriculture	1,599	1,611	1,621	1,623	1,609	1,632	1,516	1,429
Subbasin Total	2,899	2,899	2,899	2,899	2,899	2,899	2,899	2,899

*riparian corridors mapped as wetlands/open water in NLCD imagery

6.3.3 Historical Surface Water Budget

The surface water system is represented by water at the land surface within the boundaries of the Subbasin. As previously mentioned, surface water systems for the water budget include the atmospheric system, lakes & streams system, and the land surface system (Figure 6-2).

6.3.3.1 Components of Surface Water Inflow

The surface water budget includes the following sources of inflow:

- Local Supplies
    - Precipitation
    - Groundwater extractions
    - Stream inflow at Basin boundary
    - Surface Water Deliveries
    - Groundwater-Surface Water Interactions
- Local Imported Supplies
    - Lopez Reservoir Water
    - Groundwater from outside the Subbasin

Precipitation

Precipitation occurs as rainfall. The annual volume of rainfall within the Subbasin has been estimated as 80 percent of the rainfall year totals for Lopez Dam, multiplied by the Subbasin area. As previously mentioned, the average rainfall over the subbasin is lower than the average at the

Lopez Dam rain station. Rainfall volumes falling within the subbasin boundary are shown as precipitation in the surface water inflow budget of Table 6-1.

Groundwater Extractions

Groundwater extractions are included in the surface water budget as inflow because after extraction groundwater is distributed and applied at land surface. These extractions are then divided into Urban and Agricultural water use sectors and match the groundwater extraction outflow values from the groundwater budget. Details on data collection and groundwater pumping estimates are provided in the Historical Groundwater Budget section (Section 6.3.3).

Stream Inflow at Basin Boundary

Inflow along stream channels at the Subbasin boundary has been estimated based on paired watershed methodology. The total watershed area drained by the Subbasin was divided into 5 sub-watershed areas, one of which is the subarea drained by Lopez Canyon (sub-watershed 1, Figure 6-7). Annual (water year) flows from 1988 through 2020 at the Lopez Canyon stream gage was then processed using a watershed area factor and an isohyetal factor to estimate annual flows for each of the other subareas. The watershed area factor was the ratio of the watershed area for which flow was being estimated to the Lopez Canyon gage watershed area. The isohyetal factor addressed differences between the average annual rainfall across each of the sub-watersheds being compared and consisted of the ratio of average annual precipitation above 13.5 inches between sub-watersheds.

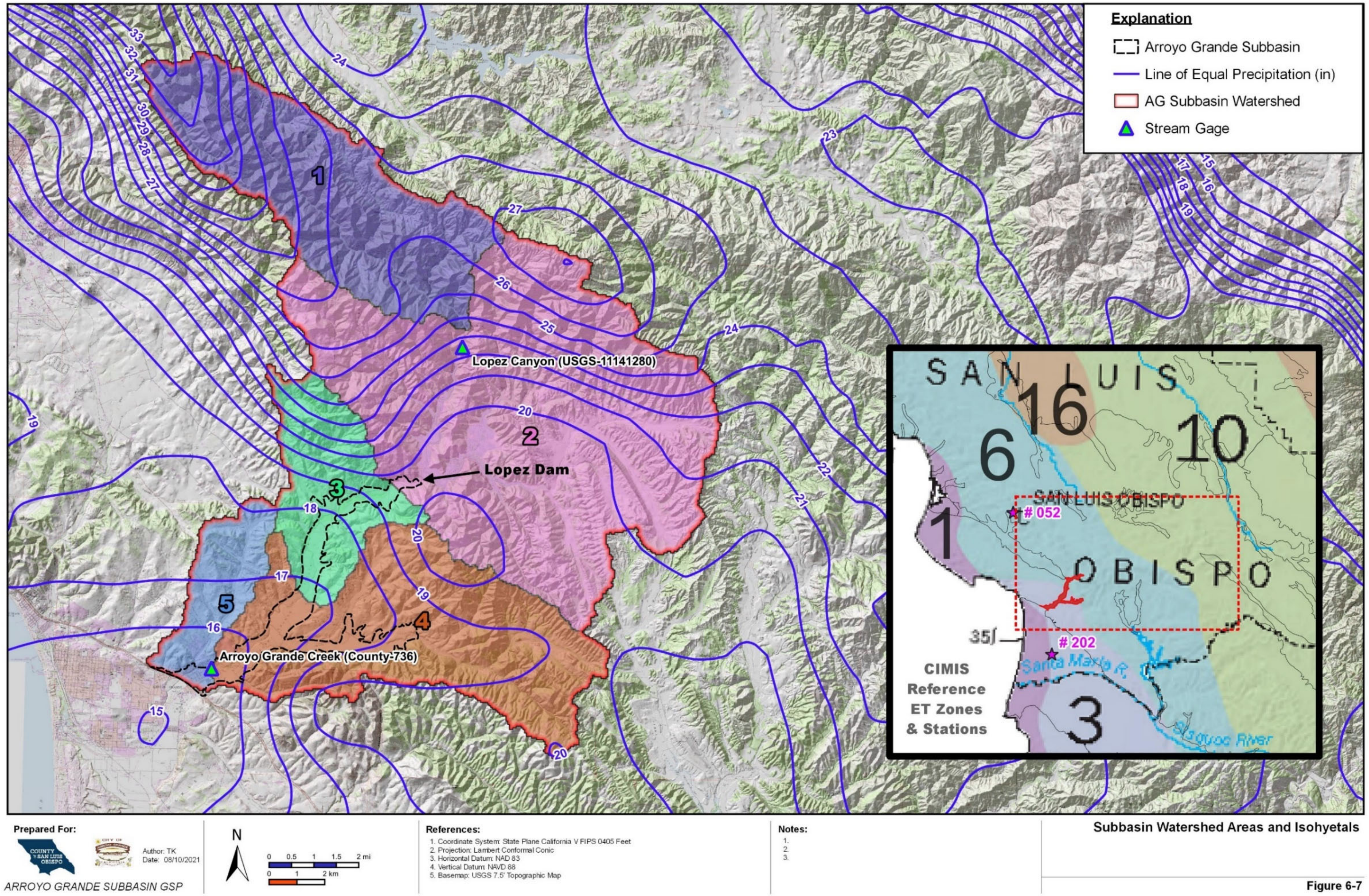

Figure 6-8: Basin Sub-watershed Areas and Isohyetals

Surface Water Deliveries

Surface water deliveries represent the movement of water generated by surface water diversion between the streams & lakes system to the land surface system (Figure 6-2). In the surface water budget, in-stream diversions are represented as outflow, and the delivery of this water for irrigation is inflow. They are offsetting values, and further discussed under surface water diversions (Section 6.3.3.2).

Groundwater-Surface Water Interaction (Net)

Groundwater-surface water interactions take place primarily along stream channels. When groundwater is rising into streams (gaining reaches of a stream), the interaction is a surface water budget inflow and a groundwater budget outflow. Conversely, when stream flow is percolating to groundwater (losing reaches of a stream), the interaction is a surface water budget outflow and groundwater budget inflow. This water budget has combined the gaining and losing stream reaches into single (net) term, the result of which are net losing streams in the Subbasin, which is an outflow component of the surface water budget and inflow component of the groundwater budget. Net groundwater-surface water interaction was estimated by adjusting the percent of stream inflow that recharges groundwater while optimizing the water balance. The optimization consisted of minimizing the sum of squares of the residual error between the calculated change in storage and measured change in storage (Section 6.3.4.1).

Local Imported Supplies

The City of Arroyo Grande imports water from Lopez Reservoir and also uses groundwater from outside the Subbasin. A portion of the local imported supplies are delivered to customers overlying the subbasin. In order to estimate the volumes of local imported supplies delivered to City residents overlying the Subbasin, the acreages of various City land use classifications (such as Village Core, Single Family Residential Medium Density, and Mixed Use) were multiplied by water use factors for each land use type reported in the Arroyo Grande Urban Water Management Plan (2012, Updated 2015). Local imported supplies are presented in the surface water budget of Table 6-1.

6.3.3.2 Components of Surface Water Outflow

The surface water budget includes the following sources of outflow:

- Evapotranspiration of Precipitation
- Evapotranspiration of Applied Water
- Riparian Corridor ET
- Infiltration of Precipitation
- Infiltration of Applied Water
- Wastewater Export
- Surface Water Diversions
- Groundwater-Surface Water Interaction
- Stream outflow (runoff)

Evapotranspiration of Precipitation

The fate of precipitation that falls within the Subbasin boundaries can be divided into three components: evapotranspiration, infiltration, and runoff. Of these three, infiltration has the greatest influence on the groundwater budget and ultimately, Subbasin sustainable yield. Therefore, the approach to estimating the fate of precipitation uses a methodology focused primarily on infiltration, but from which the other two components may also be estimated. This methodology is based on work by Blaney (1933, 1963), and which has been used for other analytical water budgets in major studies of central coast Basins (DWR, 2002; Fugro, 2002).

Evapotranspiration is the evaporation of water from surfaces and the transpiration of water by plants. The first seasonal rains falling on the Subbasin are mostly evaporated directly from surfaces (vegetative canopy, soil, urban area hardscapes) and used to replenish soil moisture deficits that accumulate during the dry season. For the Arroyo Grande – Nipomo Mesa area of the Santa Maria Groundwater Basin, DWR (2002) assumed that precipitation could begin to infiltrate to groundwater (deep percolate) only after 11 inches of annual precipitation had fallen in urban and agricultural irrigation areas, and when 17 inches of rainfall had fallen in areas of native vegetation. In the Paso Robles groundwater Basin, an estimated 12 inches of annual rainfall was needed for infiltration below agricultural lands, while 18 inches of rainfall was needed for infiltration beneath native ground cover and urban/suburban areas (Fugro, 2002).

These threshold values for minimum annual rainfall prior to infiltration are assumed to approximate the annual evapotranspiration of precipitation. Once these thresholds are exceeded, infiltration to groundwater and runoff would become dominant. It is recognized that a portion of the initial annual rainfall may result in runoff, depending on rain intensity, but this is assumed to be offset by the portion of the late season rainfall that is evapotranspired. Since infiltration is the critical component of precipitation with respect to Subbasin sustainable yield, offsetting of early wet season runoff with late wet season evapotranspiration in the water budget is considered a reasonable approach.

The specific thresholds for annual rainfall that are estimated to evapotranspire prior to infiltration and runoff have been developed from Blaney's field studies. Evapotranspiration of precipitation has been estimated by multiplying land use/land cover acreages by the infiltration threshold values. Results of these estimates are shown in the surface water budget of Table 6-1. Additional details of the methodology are provided in Section 6.3.4.1 (Components of Groundwater Inflow).

Evapotranspiration of Applied Water

The evapotranspiration of applied irrigation water has been divided into urban and agricultural sectors. Urban applied water includes residential outdoor irrigation and park/play field irrigation. Most of the urban applied water is from imported local supplies by the City of Arroyo Grande. Other water purveyors within the Subbasin are relatively small (typically less than 30 connections) and are considered rural residential. Estimation of applied water for agricultural irrigation involves a soil-moisture balance approach discussed in section 6.3.4.1 (Components of Groundwater Outflow).

Most water applied for irrigation is taken up by plants and transpired. Some water, however, is lost to evaporation or infiltrates to groundwater as return flow. The evapotranspiration of applied irrigation water has been calculated by subtracting the estimated return flow from the applied water estimates. Both applied water and return flow estimates are presented under the historical groundwater budget section. Results of the calculations of evapotranspiration of applied water are shown in the surface water budget of Table 6-1.

Riparian Corridor Evapotranspiration

Riparian plant communities present along the creeks can access surface flows and creek underflow. An estimated 282 acres of riparian areas are included within the Subbasin (Table 6-5) based on the interpreted NLCD satellite imagery, which maps the riparian corridors as mostly woody wetlands and emergent herbaceous wetlands, with a few acres of open water. Given that the riparian corridor is directly connected to adjacent surface flows, and stream flow is present throughout of the year, water use for the riparian corridor is included in the surface water budget. Riparian vegetation water use is the evapotranspiration of precipitation estimated for the native brush, trees, and grasses land cover, with an additional 0.8 acre-feet per acre of consumptive water use (Fugro, 2002; Robinson, 1958). Riparian evapotranspiration is included in Table 6-1.

Infiltration of Precipitation and Applied Water

Infiltration of precipitation and applied water are both outflow components from the surface water budget and inflow components to the groundwater budget. Discussion of these components is provided in Section 6.3.4.1 (Components of Groundwater Inflow).

Wastewater Export

When imported surface water is brought into the Subbasin from local supplies (Lopez Reservoir), it is counted as surface water inflow. This imported water is then provided to customers through deliveries from the City of Arroyo Grande. After residential and business use, most of the delivered water that was used indoors is conveyed by sewer out of the Subbasin to a wastewater treatment plant (South San Luis County Sanitation District) for treatment and discharge. Since the wastewater does not return to the Subbasin, it is effectively exported. Similar to the estimated for Local Imported Supplies, the acreages of various City land use classifications (such as Village Core, Single Family Residential Medium Density, and Mixed Use) were multiplied by sewer flow factors for each land use type reported in the Arroyo Grande Wastewater Master Plan (City of Arroyo Grande, 2012) and shown in the surface water budget of Table 6-1.

Stream Flow Diversions

Stream flow on Arroyo Grande Creek is subject to permitted diversion by in-stream pumping. Reported annual stream flow diversions were compiled from available records, which were considered representative beginning in 2009 (more complete reporting). The reported creek flow diversions ranged from 340 acre-feet in 2009 to 600 acre-feet in 2012, with an annual average diversion of 450 acre-feet per year between 2009 and 2019. The resulting estimated stream inflow estimates for the historical base period are shown in the surface water budget of Table 6-1.

Groundwater-Surface Water Interaction (Net)

Groundwater-surface water interaction involves both surface water and groundwater budgets. The net interaction is an outflow component for the surface water budget and an inflow component for the groundwater budget (losing streams). Details of the methodology used to develop the groundwater-surface water interaction are presented in the Sections 6.3.4.1 and 6.3.6.

Stream Outflow from Basin

Stream outflow was estimated using the water balance method and compared to available flow records. No significant changes to surface water in storage are assumed in the water budget from year to year. Storm water runoff exits the Subbasin annually, and creek storage fluctuations are considered minor compared to the total surface water budget. Lopez Reservoir and Lopez Terminal Reservoir are outside of the Subbasin boundary.

Using the water budget equation, stream outflow is estimated as the difference between total surface water inflow and all other components of surface water outflow. Results of stream outflow calculations are presented in Table 6-1. The stream gage on Arroyo Grande Creek at the City of Arroyo Grande (Station 736) is the closest gage to the south Subbasin boundary and captures runoff from approximately 95 percent of the watershed drained by the subbasin (roughly 65,500 acres gaged out of 68,700 acres of watershed (including watershed area above Lopez Dam).

A comparison of gaged stream flow at Station 736 with the estimated stream flow leaving the basin from the surface water budget is presented in Figure 6-8. The comparison shows that the surface water budget produces stream outflow estimates that are reasonably close to the measured flows at Station 736.

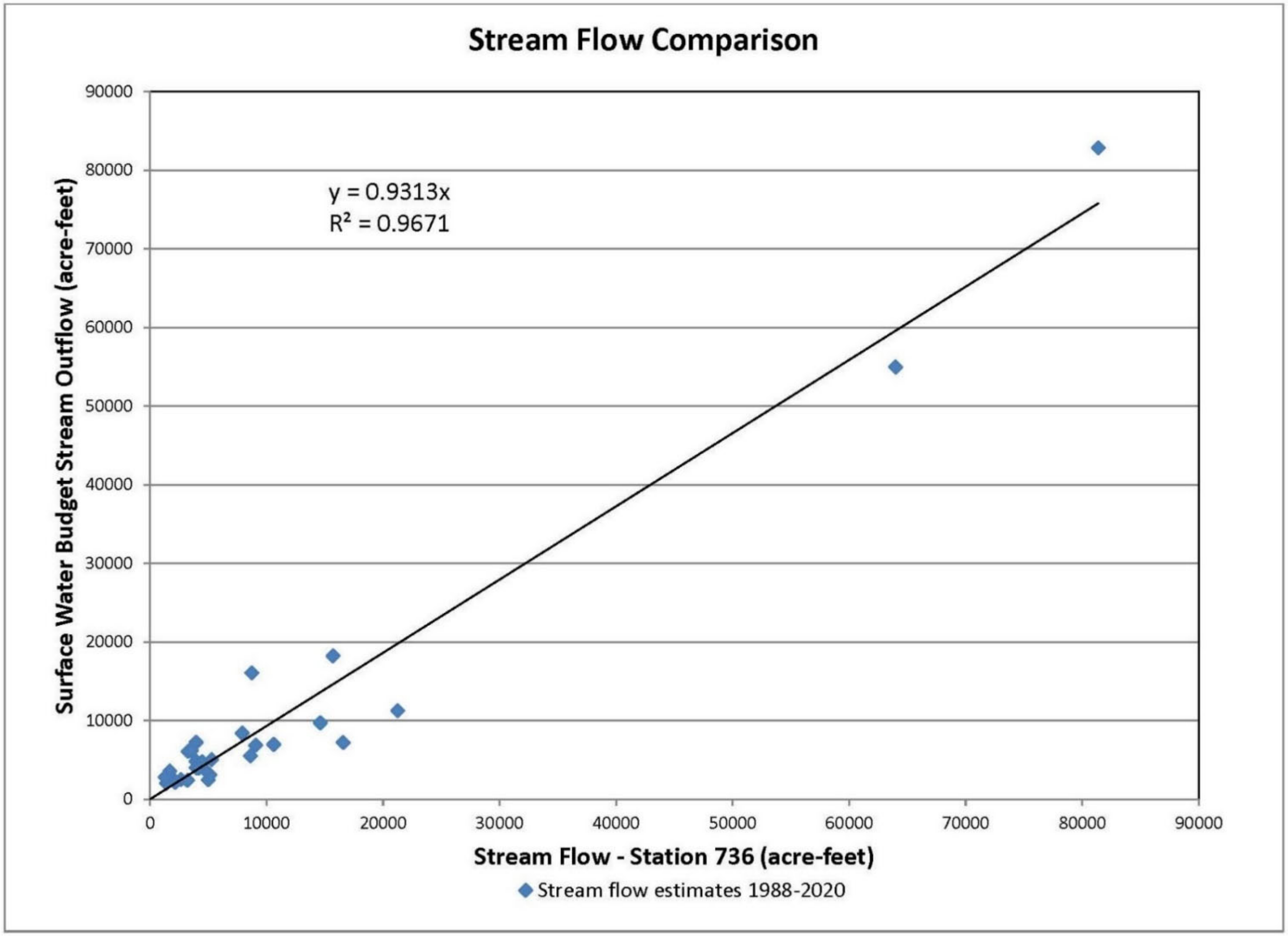

Figure 6-9. 1988-2020 Stream Flow Comparison

6.3.4 Historical Groundwater Budget

The groundwater budget includes the following sources of inflow:

- Infiltration of Precipitation
- Groundwater-Surface Water Interaction
- Subsurface Inflow
- Infiltration of Applied Water (Return Flow)

The groundwater budget includes the following sources of outflow:

- Groundwater Extractions
- Subsurface Outflow
- Groundwater-Surface Water Interaction

6.3.4.1 Components of Groundwater Inflow

Infiltration of Precipitation

Infiltration of precipitation refers to the amount of rainfall that directly recharges groundwater after moving through the soil and unsaturated zone (Figure 6-2). Direct measurement of infiltration has not been performed in the Subbasin, and estimates have been prepared based on prior work by Blaney (1933) in Ventura County basins and Blaney et al. (1963) in the Lompoc Area. These studies involved soil moisture measurements at rainfall penetration test plots with various types of land cover, and the resulting deep percolation versus rainfall correlations have been considered applicable to central coast Basins (DWR, 2002; Fugro, 2002). The work by Blaney is several decades old, however, modeling efforts have shown the generalizations are relatively accurate for semi-arid climates (Rosenberg, 2001). The main advantage of Blaney's approach is that it is based on direct measurements of infiltration of precipitation.

Criteria based on Blaney et al. (1963) were used for analytical water budgets in the Santa Maria Valley and Tri-Cities Mesa areas, where it was assumed that precipitation could infiltrate only in urban and agricultural areas when 11 inches of precipitation had fallen annually, and on areas of native vegetation when 17 inches of precipitation had fallen annually. Any amount of rainfall above 30 inches annually was not considered to contribute to deep percolation of precipitation, regardless of the land use classification (DWR, 2002). Correlations between infiltration and annual rainfall based on Blaney (1933) were also used historically for the 2002 Paso Robles Groundwater Basin analytical water budget (Fugro, 2002).

Estimates for infiltration of precipitation for the Arroyo Grande Subbasin have been developed by applying Blaney correlations that restrict deep percolation to precipitation in agricultural areas that occurs after 11-12 inches of rainfall, and in native vegetation areas after approximately 18 inches of rainfall. Native vegetation was the most restrictive land cover for infiltration when tested by Blaney due to high initial soil moisture deficiencies.

Urban areas were not part of the original studies by Blaney. The low permeability of hardscape (buildings and paving) limits infiltration and increases surface evaporation, compared to other types of land cover, but hardscape also increases runoff, which can lead to greater infiltration in adjacent areas receiving the runoff. Therefore, the infiltration threshold was set higher than irrigated agricultural land, but not as high as native grasslands. The Blaney correlation that produces infiltration between irrigated agriculture and native grassland is the curve for non-irrigated grain, with an infiltration threshold of approximately 14 inches of rainfall. Figure 6-10 plots the data collected by Blaney (1933).

As with prior work by the DWR in northern Santa Barbara and southern San Luis Obispo Counties, rainfall above 30 inches was not considered to contribute to deep percolation in the Basin (DWR, 2002). The rainfall values used for the Blaney Correlations in the Subbasin were 80 percent of the rainfall totals at Lopez Dam. Infiltration of precipitation results are shown in Table 6-1.

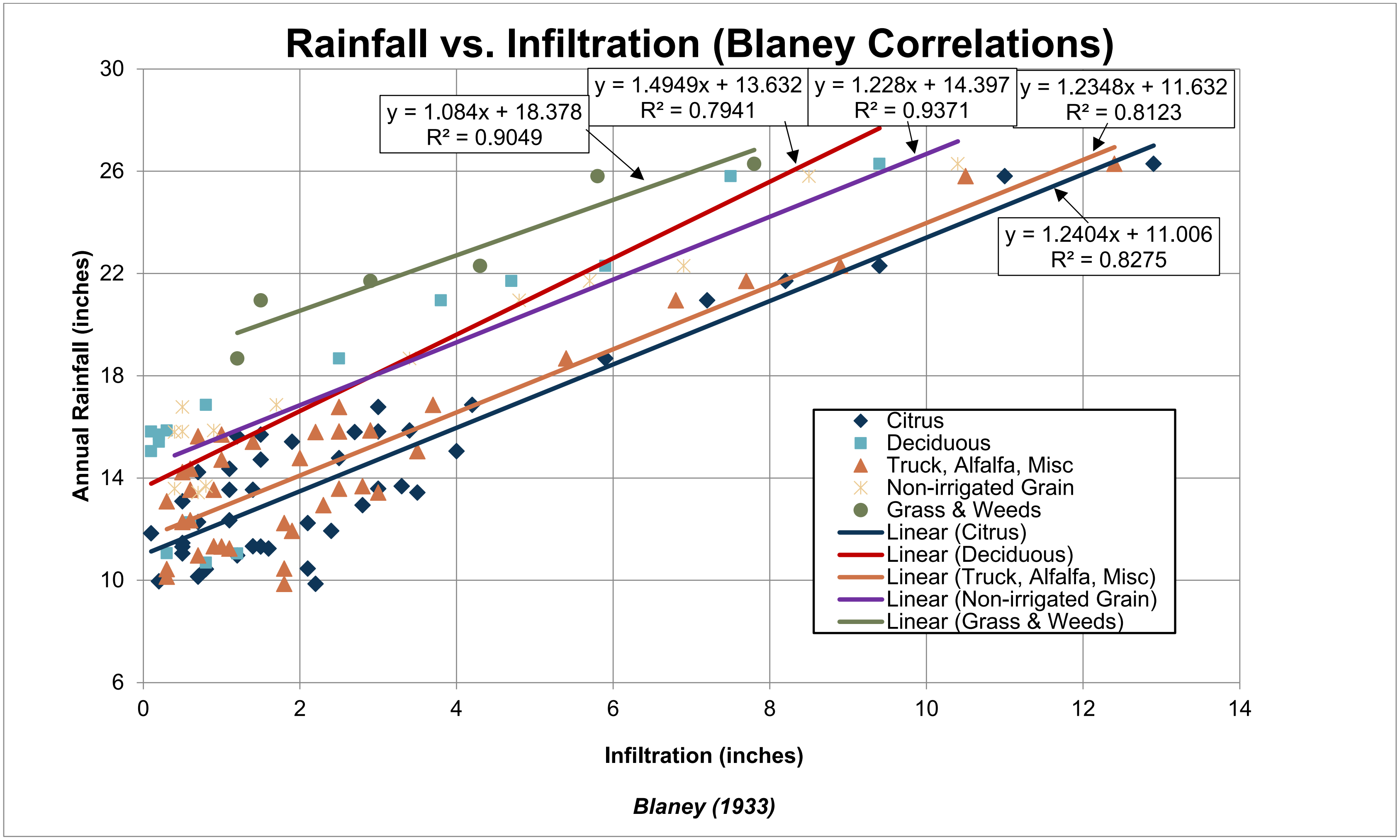

Figure 6-10. Rainfall vs Infiltration

The land use classifications for which infiltration thresholds have been developed for this GSP include citrus, deciduous, pasture, vegetable, vineyard, native brush/grassland (includes riparian corridors), urban developed/open space, and urban turf. The minimum rainfall needed before infiltration of precipitation can occur for various land uses and covers are summarized in Table 6-6.

Table 6-6: Minimum Rainfall for Infiltration.

Land Use/Cover	Infiltration Threshold (in.)
Citrus	11.0
Deciduous	13.6
Pasture	11.6
Vegetable	11.6
Vineyard	13.6
Native brush/grassland	18.4
Urban developed/open space	14.4
Urban turf	11.6

Groundwater-Surface Water Interaction (Net)

As previously mentioned, groundwater-surface water Interaction involves both components of the surface water and groundwater budgets. The net interaction is an outflow component of the surface water budget and inflow component of the groundwater budget (losing streams).

The groundwater-surface water interaction component is estimated using a mass balance approach for the Subbasin by adjusting the percent of stream inflow that percolates to groundwater (as recharge) while minimizing the sum of squares of the residual error between the calculated change in storage and the measured change in storage (specific yield method) for multiple years. It became apparent during water budget calibration that a variable percentage was needed depending on the type of year (a greater percentage of stream flow percolation during drought years) and reservoir operation (lowest percent of stream flow seepage during reservoir spill years).

The maximum amount of groundwater storage in Subbasin is assumed to be 15,200 acre-feet, based on the specific yield method. In 1998, inflow to the groundwater budget exceeded the maximum storage capacity, and some of the inflow (percolation of precipitation) was transferred to the surface water budget as stream outflow for that year. The groundwater-surface water interaction estimates are in Table 6-1. Additional details of the calibration methodology used to minimize the residual error are presented in Change in Storage (Section 6.3.6).

Subsurface inflow

Subsurface inflow from bedrock were estimated using Darcy's Law, which is an empirical formula describing the flow of fluid though a porous material, and expressed as:

$$Q = -K\frac{dh}{dl}A$$

Where:
Q = groundwater discharge rate through a cross-sectional area of the porous material
K = hydraulic conductivity of the material
$\frac{dh}{dl}$ = hydraulic gradient at the cross-section
A = cross-sectional area

The negative sign denotes that flow is in the direction of decreasing pressure. Since groundwater pressures are greater within the bedrock hills surrounding the Subbasin than beneath the alluvial valleys, there is subsurface inflow to the Subbasin from bedrock. The application of Darcy's Law to estimate subsurface inflow from bedrock involves simplification and assumptions of uniformity in the subsurface.

Cross-sectional areas for boundary flows were based on the approximate length of the Subbasin boundary (126,500 feet divided into 12 straight-line segments), multiplied by the estimated saturated thickness of Subbasin sediments adjacent to each segment (the weighted average was 70 feet thick). Hydraulic gradients for each segment were developed by averaging topographic slopes between a line along the Subbasin boundary and a line drawn at a 2,500-foot setback from the boundary, and assuming the average hydraulic gradient was approximately three-quarters of these slopes (0.75 ft/ft). The hydraulic conductivity of bedrock was estimated at a nominal 0.03 feet per day. The resulting average annual subsurface inflow from bedrock is 170 acre-feet per year.

Infiltration of Applied Water (Return Flows)

Estimates for infiltration of applied water include urban return flow and agricultural return flow. Urban return flow comes from water delivered for domestic or commercial/industrial uses that infiltrates to groundwater, mainly through landscape/turf irrigation and septic system discharges (includes suburban/rural residential return flow). Urban return flow does not include City wastewater that is collected and exported from the Subbasin, which is accounted for in the surface water budget. Agricultural return flows come from applied irrigation water to crops, originating from both groundwater wells and in-stream diversions.

The first step in estimating urban return flows was to separate delivered water (from local imported supplies and suburban groundwater) into indoor and outdoor use. An estimated 5 percent of indoor use is assumed to be consumptive use (95 percent return flow; EPA, 2008), while 85 percent of outdoor use is consumed (15 percent return flow) based on the typical range of estimates for other local Basins (DWR, 2002; Fugro, 2002). Almost all Indoor water use drains to septic systems or sewer systems. Outdoor water use is generally for irrigation, most of which evapotranspires into the atmosphere.

The distribution of indoor to outdoor water use will vary based on the user. For example, City customers in single-family homes (medium density) are estimated in the Water and Wastewater Master Plans (2015, 2012) to use approximately 700 gallons per day of water and produce 310 gallons per day of wastewater, for an average 44 percent indoor use and 56 percent outdoor use. The indoor and outdoor water use and associated return flows were estimated from water use by the City, suburban/rural residences, and a few commercial operations. Infiltration of Applied Water estimates for urban and agricultural sectors are presented in the historical water budget Table 6-1.

6.3.4.2 Components of Groundwater Outflow

Urban Groundwater Extractions

Groundwater extraction from wells is the primary component of outflow in the groundwater budget. Estimates for historical pumping were derived primarily from land use data and water duty factors, and from the daily soil-moisture budgets. There are no City groundwater extractions from the Subbasin.

Rural residential groundwater use was estimated based on the number of residences identified on aerial images within the Subbasin but outside of the City water service area. Each rural residence was assigned a water use of 0.8 AFY, consistent with the San Luis Obispo County Master Water Plan (Carollo, 2012) and with stakeholder-provided information. In addition to rural residences overlying the Subbasin, residences in two subdivisions with homes outside of the Subbasin but supplied by alluvial wells in the Subbasin were added to the total count.

Aerial images for multiple years were reviewed for rural residential development. The estimated number of residences outside of the City service area was compiled, and resulting computed rural residential water use for these years is presented in Table 6-7.

Table 6-7: Rural Residential Water Use.

Year	Arroyo Grande Subbasin	
	Estimated Number of Residences[1]	Estimated Water Use (AFY)[2]
1989	91	73
1994	93	74
1999	94	75
2002	98	78
2003	101	81
2007	117	94
2011	127	102
2014	136	109
2019	164	131

Notes:

[1] outside City limits

[2] based on 0.8 AFY per residence

In addition to the above rural residential water use, there are three commercial operations in the Subbasin that were evaluated separately for water use: Talley Vineyard and Talley Farms in the upper Arroyo Grande Valley, and the Mushroom Farm in Tar Spring Canyon. Square footages of the various buildings were estimated from aerial imagery and multiplied by a nominal water duty factor of 0.06 acre-feet per year per 1,000 square feet, which is considered representative of warehouse, commercial service, and manufacturing (City of San Luis Obispo, 2000). The resulting combined water use for the three commercial operations was 10 acre-feet per year.

Agricultural Groundwater Extractions

Groundwater use for agricultural irrigation has been estimated using the DWR Consumptive Use Program Plus (CUP+; DWR, 2015) which is a crop water use estimator that uses a daily soil moisture balance. CUP+ was developed as part of the 2013 California Water Plan Update to help growers and agencies estimate the net irrigation water needed to produce a crop.

Daily climate data from CIMIS Station #52 (San Luis Obispo) from 1988 to 2020 were used in the CUP+ program, along with estimates for various crop and soil parameters. The climate data is used to determine local reference evapotranspiration (ETo) on a daily basis. Crop coefficients are then estimated for up to four growth stages (initial, rapid, mid-season, late-season) which determine the crop evapotranspiration (ET_c) values. Lastly, the CUP+ program uses variables related to the soil and crop type to determine the estimated applied water demand (ET_{aw}), which is equivalent to the net irrigation requirement. Figure 6-10 shows the annual ET_{aw} for various crops during the historical base period, along with ETo and rainfall at CIMIS Station #52.

As noted in Section 6.1, the CIMIS Station at Cal Poly is within DWR reference evapotranspiration Climate Zone 6 (Upland Central Coast; average ETo of 49.7 inches), which is one of 18 climate zones in California based on long-term monthly average reference evapotranspiration (CIMIS, 1999). As shown in the inset in Figure 6-7, most of the Subbasin is within Climate Zone 3 (Coastal Valleys; average ETo of 46.3 inches). Therefore, the reference ETo at Cal Poly would be expected to be greater than in the Subbasin. As previously mentioned in Section 6.1, Nipomo CIMIS Station #202 is within Climate Zone 3, with a historical record going back to 2006 (Figure 6-7 inset). A correlation between the two CIMIS stations shows that the ETo at Station #202 is approximately 83 percent of the ETo at Station #52. Therefore, results of the 1988-2020 soil moisture budget using Station #52 were reduced by 17 percent to better represent the Arroyo Grande Subbasin.

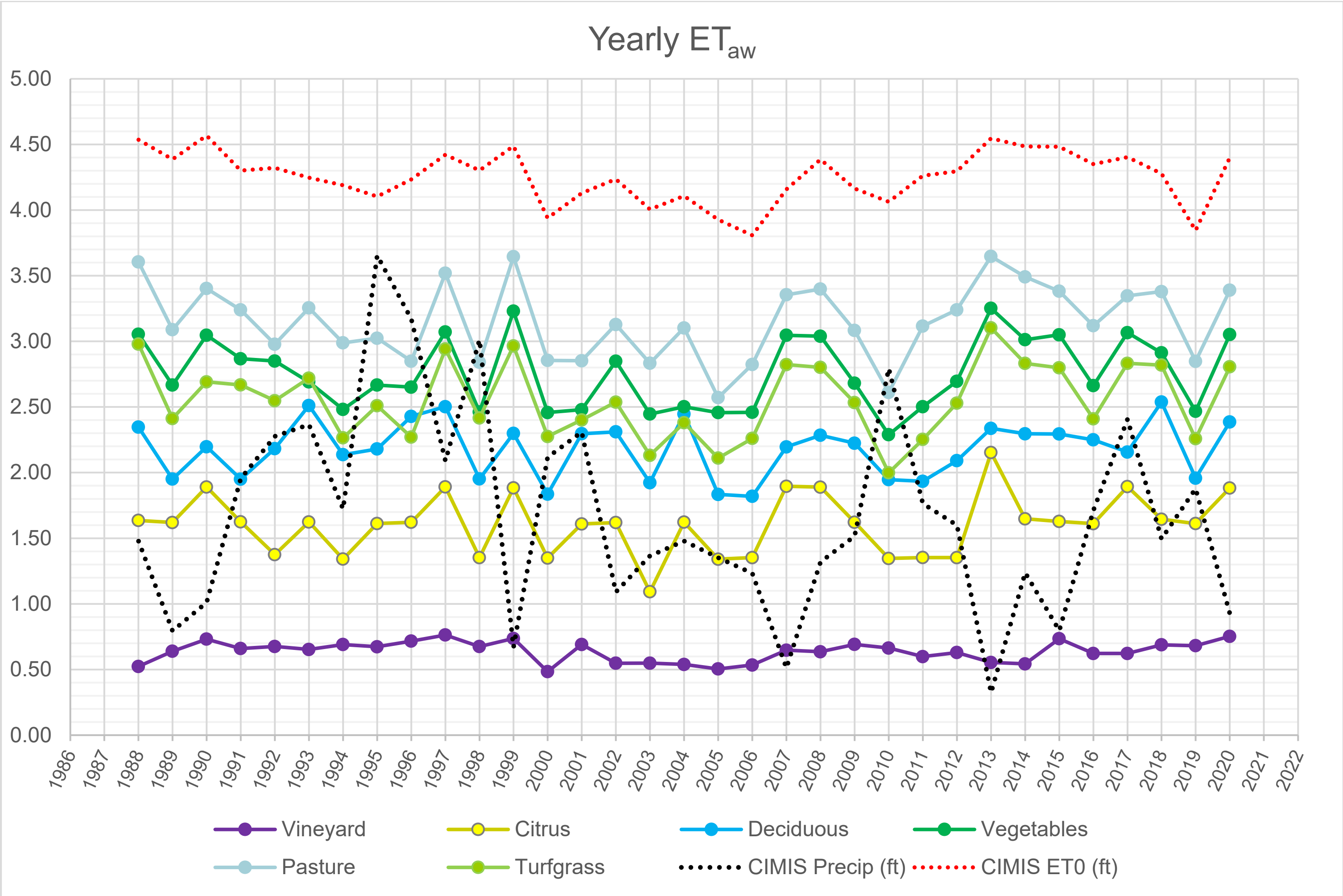

Figure 6-11. Consumptive Use of Applied Water

Crop types were grouped according to the classification used by County Agricultural Commissioner's Office for crops overlying the Basin. These crop types included citrus, deciduous (non-vineyard), pasture, vegetable, and vineyard. A turf grass classification was added for estimating Urban sector water demand served by groundwater. The CUP+ program provides monthly water demand for each crop type during the hydrologic base period (1988-2020). Low, medium, and high consumptive use of applied irrigation water estimates are presented in Table 6-8. Low and high consumptive use are the respective annual minimum and maximum estimates over the base period, while medium consumptive use is the average. The CUP+ applied water requirement for vegetables was reduced by 40 percent to account for fallow acreage, which is not in production at any given time, based historical aerial image review and discussion with a local grower.

Table 6-8. Consumptive Use of Applied Water

Crop Type	Acre-feet per acre per year		
	Low	Med	High
Citrus	0.9	1.3	1.8
Deciduous	1.5	1.8	2.1
Pasture	2.1	2.6	3.0
Vegetables*	1.1	1.4	1.6
Vineyard	0.4	0.5	0.6
Turfgrass	1.7	2.1	2.6

*60 percent of ET_{aw} to account for fallow fields

As previously discussed in Section 6.3.2 (Historical Land Use), the distribution of crop acreage was determined by a review and correlation of DWR and County crop surveys with aerial imagery. Crop acreages were interpolated between the years with data.

Applied water demand volumes were calculated by multiplying the annual acreage for each crop by the average annual applied water demand during each year. The final applied water estimates used for the water budget were adjusted to include efficiency (with system leakage) factors of 80 percent for drip/micro emitter and high-efficiency sprinkler irrigation (citrus, deciduous, vineyard, and turfgrass) and 75 percent for mostly sprinkler with some drip irrigation (pasture and vegetables), based on information from the County Water Master Plan (Carollo, 2012). The estimated groundwater extractions for agricultural water use are shown in the main water budget Table 6-1.

Subsurface Outflow

Subsurface outflow from Subbasin sediments occurs as underflow through the alluvial deposits of Arroyo Grande Creek. Outflow volumes were estimated using Darcy's Law (see Subsurface Inflow in Section 6.3.4.2). Table 6-9 presents the parameters used for subsurface outflow estimates.

Table 6-9. Subsurface Outflow Estimates

Cross-Sectional Area*	Hydraulic Gradient	Hydraulic Conductivity	Outflow
ft^2	ft/ft	ft/day	AFY
170,000	0.01	34	480

Cross sectional areas for outflow were based on the estimated saturated cross-sectional area of alluvial deposits in the vicinity of where the creek exits the groundwater Subbasin. Hydraulic gradients are the approximate grade of the stream channel, and the hydraulic conductivities are based on pumping tests (Chapter 5.0). The outflow estimate is within the range of prior estimates by DWR (2002), but lower than the previous estimate of 2,000 AFY (GSI, 2018), mainly due to a lower hydraulic conductivity based on available pumping tests.

6.3.5 Total Groundwater in Storage

Groundwater is stored within the pore space of Subbasin sediments. The Specific yield is a ratio of the volume of pore water that will drain under the influence of gravity to the total volume of saturated sediments. The specific yield method for estimating groundwater in storage is the product of total saturated Subbasin volume and average specific yield. Calculation of total groundwater in storage for selected years was performed based on the specific yield method.

Estimates of specific yield for Subbasin sediments were obtained based on a review of 19 representative well logs. The lithology for each well log was correlated with specific yield values reported for sediment types in San Luis Obispo County (Johnson, 1967), and were weighted based on the thicknesses of individual sediment types in each log. A summary of the correlations is shown in Table 6-11. Locations of well logs used for the specific yield correlations are shown in the referenced cross-sections from Chapter 4.0. The average specific yield for the alluvial deposits is estimated at 14.7 percent, compared to 12 percent previously estimated by DWR (2002).

Table 6-10. Specific Yield of Alluvial Deposits.

Well ID	Cross-Section	Specific Yield (%)
961610	*A'-A"*	21.0

Well ID	Cross-Section	Specific Yield (%)
1981-003	*A'-A"*	21.2
E0074069	*A'-A"*	18.9
WCR2018-06066	*A'-A"*	17.8
906318	*A'-A"*	15.8
E0047973	*A'-A"*	12.6
E0111409	*A'-A"*	11.8
E0074480	A-A'	15.7
0962373	A-A'	12.6
003929	A-A'	15.4
E0063597	A-A'	11.6
00792659	*B-B'*	9.7
00335753	*B-B'*	15.0
00802727	*B-B'*	16.0
00152206	*B-B'*	13.9
00738180	*B-B'*	11.9
00906244	*B-B'*	14.9
EHS 78-147	A-A' & A'-A"	11.3
EHS 82-51	A-A'	12.9
Average		*14.7*

Notes: Cross-sections in Chapter 4 (Figures 4-9, 4-10, 4-11)

Groundwater in storage calculations were performed for the Spring conditions of 1987, 1990, 1996, 2002, 2009, 2011, 2015, 2017, and 2020 using the specific yield method. Water level contours for each year were prepared based on available water level data from various sources, including the County water level monitoring program, well logs, and Stakeholder provided information. Water level contour maps for Spring 1996, 2015, and 2020 were shown previously in Chapter 5.0. Water level contours for Spring 1987 (the start of the historical base period), along with a change in groundwater elevation map from Spring 1987 to Spring 2020 (the end of the historical base period) is shown in Figure 6-11 and Figure 6-12.

The water level contours for storage calculations extend to the Subbasin boundaries. Groundwater levels in the Subbasin in Spring 1987 show a pattern similar to the other contour maps in Chapter 5.0, including the flattening of the hydraulic gradient in the middle of the Subbasin, where Tar Spring Creek valley enters the Arroyo Grande valley (Figure 6-11). The change in water level elevation map shows relatively minor differences between 1987 and 2020, with fluctuations ranging from five feet of water level decline to 10 feet of water level increase over the base period (Figure 6-12).

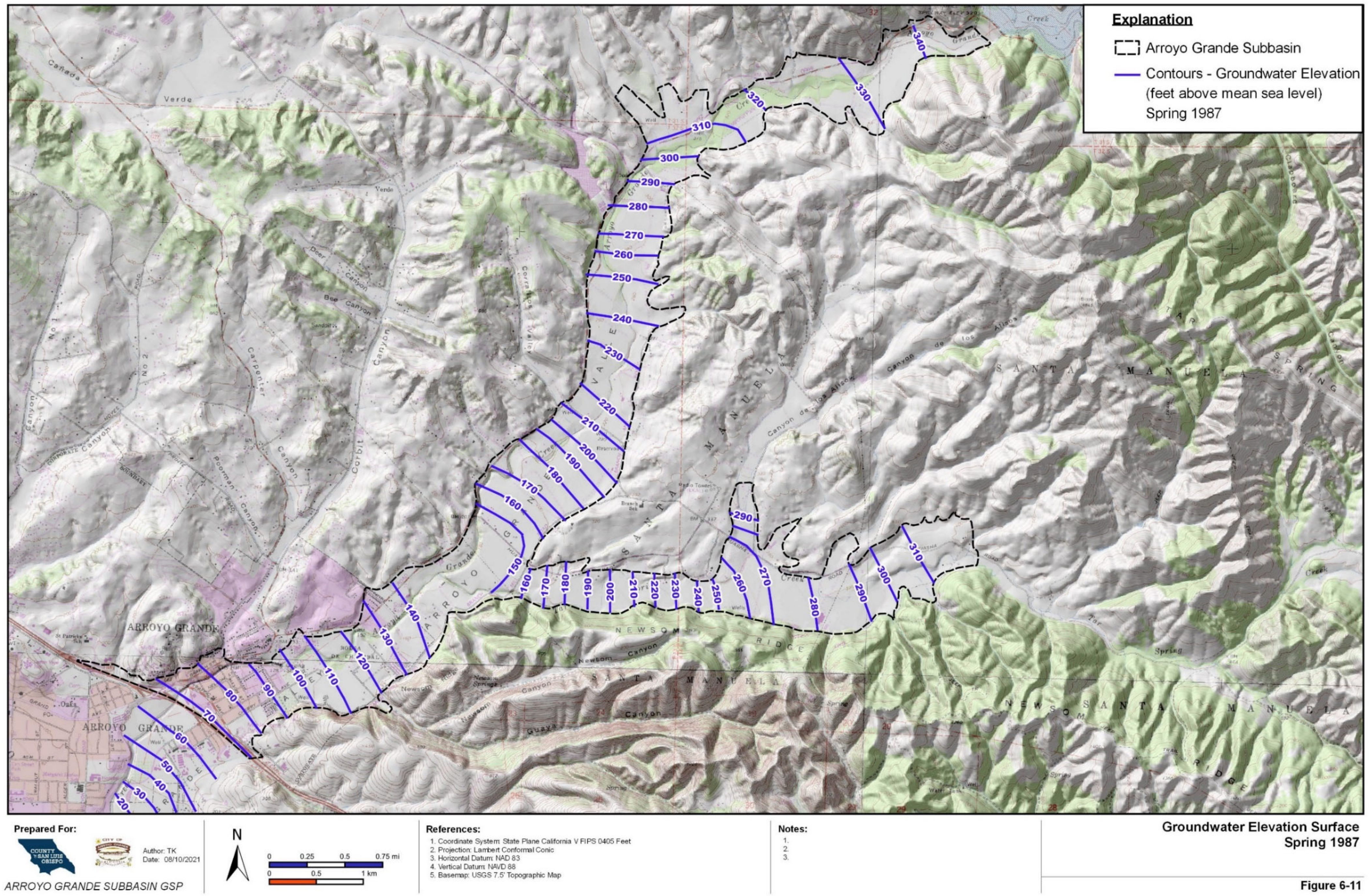

Figure 6-12. Groundwater Elevation Contours Spring 1986

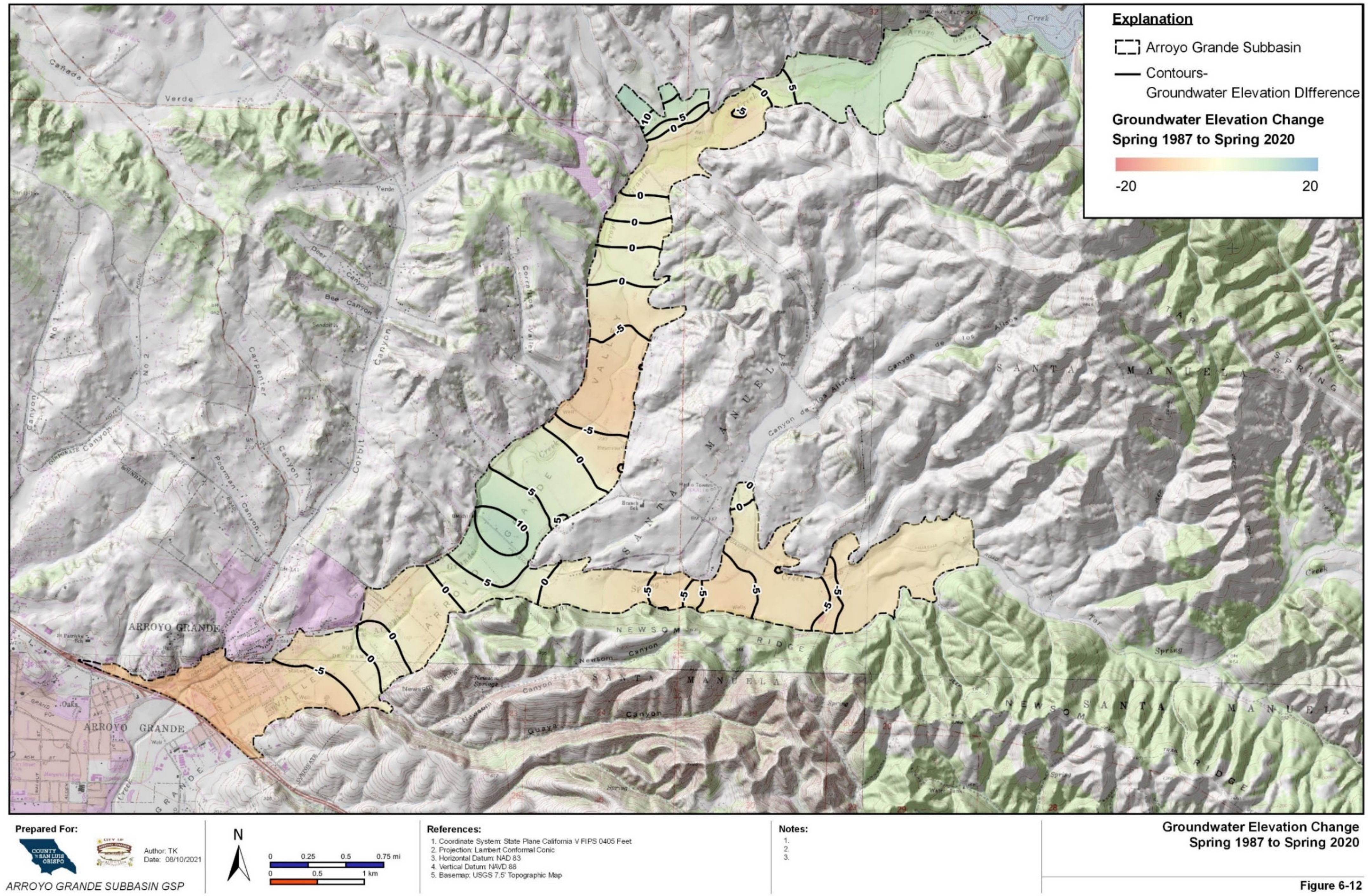

Figure 6-13. Groundwater Elevation Contours Spring 2019

The water level contour maps and the base of permeable sediments were processed for volume calculation using Surfer, a grid-based mapping and graphic program. The methodology consisted of gridding and trimming surfaces to the Basin subarea boundaries, followed by volume calculation between surfaces. The gross volumes obtained were then multiplied by the representative specific yield. An example of the methodology showing gridded surfaces for Spring 2020 water levels and the base of permeable sediments is presented in Figure 6-13. Estimated total storage volumes for selected years using the specific yield method are listed in Table 6-11.

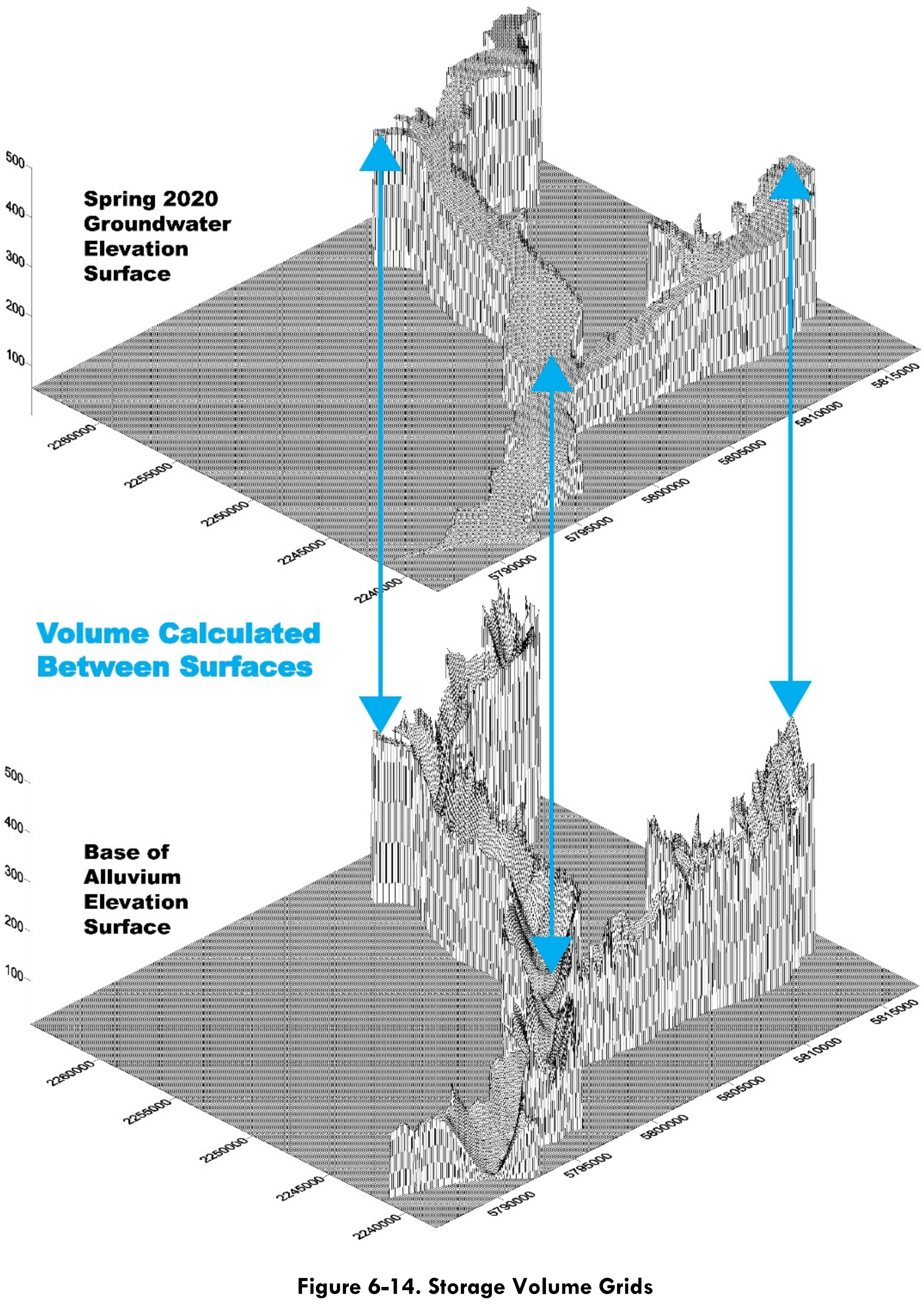

Figure 6-14. Storage Volume Grids

Table 6-11. Spring Groundwater Storage Estimates

Year	Groundwater Storage
	Acre-Feet
1987	13,000
1990	10,300
1996	13,700
2002	13,300
2009	10,400
2011	15,200
2015	10,700
2017	14,700
2020	12,800

The groundwater storage estimates are comparable to previously reported estimate of 14,000 acre-feet total storage capacity for the Arroyo Grande Valley (DWR, 2002). The DWR total storage capacity represented the total volume that could theoretically be held in underground storage. The maximum storage estimated herein by the specific yield method is 15,200 acre-feet (Spring 2011).

6.3.6 Change in Storage

Balancing the water budget final step in water budget development. As previously mentioned, the water budget equation is as follows:

INFLOW – OUTFLOW = CHANGE IN STORAGE

The annual change in storage for the surface water budget is assumed to be zero, as surface flow moves quickly through the basin and any differences in storage are minor compared to the total budget. Therefore, the surface water balance equation can be simplified as INFLOW = OUTFLOW and was used to estimate the stream outflow component of the surface water budget.

For the groundwater budget, groundwater-surface water interaction (as stream flow seepage) was adjusted to approximate the change in storage calculated using the specific yield method discussed above. The difference between the estimated change in storage shown in the water budget and the measured change in storage using the specific yield method is the mass balance error. Change in storage is reported between seasonal high (Spring) conditions per GSP regulations. Change in storage and mass balance error for the groundwater budget is shown in Table 6-12. Figure 6-14 compares storage estimates using the water budget and the specific yield method.

Table 6-12. Change in Storage Comparison – Historical Base Period 1988 – 2020

Groundwater Budget	Specific Yield Method	Mass Balance Error		
Change in Storage (acre-feet)		**acre-feet**	**AFY**	**Percent***
-300	-200	100	3	0

*Percent of total subarea water budget

The difference in change in storage estimates between the water budget and the specific yield method is approximately 100 AFY for the Subbasin over the historical base. The water budget estimates a 300 acre-foot decline in storage, compared to a 200 acre-foot decline in storage using the specific yield method. The difference in change in storage estimates between the water budget and the specific yield method is less than 5 AFY over the historical base period.

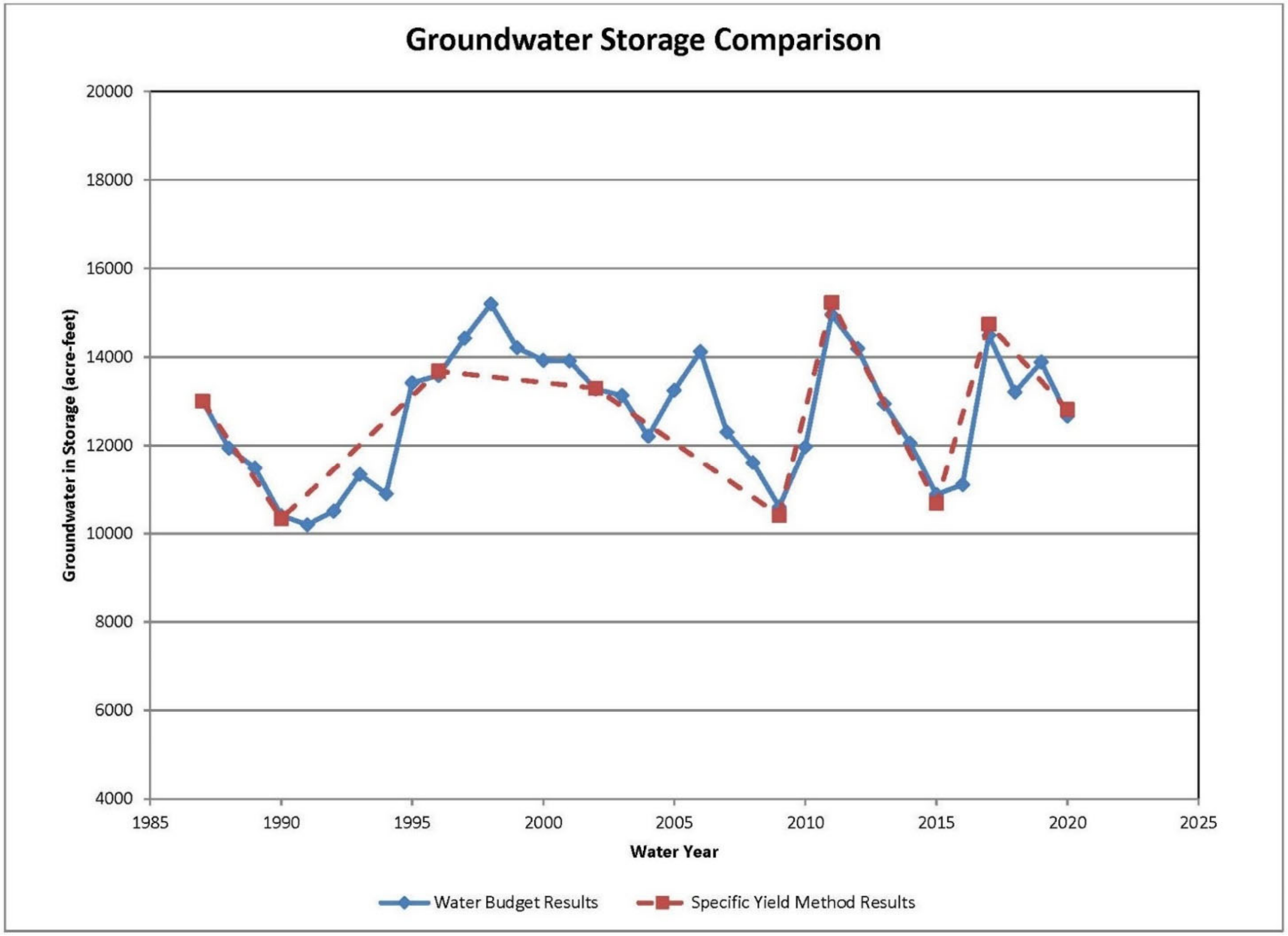

Figure 6-14. Groundwater Storage Estimate Comparison

6.3.7 Preliminary Sustainable Yield Estimate

The sustainable yield is the maximum quantity of water, calculated over a base period representative of long-term conditions in the Subbasin and including any temporary surplus, which can be withdrawn annually from a groundwater supply without causing an undesirable result. Temporary surplus is the amount of water that may be pumped from an aquifer to make room to store future water that would otherwise be unavailable for use. Undesirable results will be defined for six sustainable management criteria in Chapter 8.0. Examples of potential undesirable results are related to long-term declines in water levels and associated loss of groundwater in storage.

Estimating sustainable yield includes evaluating historical, current, and projected water budget conditions. The analytical water budget method utilized in this analysis evaluates historical and current conditions and provides a preliminary estimate for the Subbasin sustainable yield. The projected water budget will be evaluated using the Subbasin numerical model presented later in the projected water budget section of the chapter, at which time the minimum thresholds for the sustainable management criteria can be incorporated and the final sustainable yield will be determined. The preliminary sustainability estimate can be used for planning potential projects and management action scenarios for the Subbasin numerical model.

The Arroyo Grande Subbasin has not experienced cumulative and persistent storage declines. The estimated net decline in groundwater storage of less than 10 acre-feet per year over the 33-year historical base period is less than one percent of the annual groundwater budget.

The preliminary sustainable yield of the Arroyo Grande Subbasin is estimated at 2,500 AFY, based on the long-term average recharge of 3,000 AFY minus 500 AFY subsurface outflow (rounded to nearest 100 acre-feet). This preliminary sustainable yield assumes continued operation of Lopez Reservoir in accordance with historical practices. Table 6-13 summarizes the preliminary sustainable yield estimates.

Table 6-13: Preliminary Sustainable Yield Estimate (AFY).

Long-term recharge	3,000
Subsurface outflow	-500
Sustainable Yield	2,500

There are no prior estimates of the Subbasin sustainable yield for comparison. DWR (2002) estimated sustainable yield for portions of the main (downstream) groundwater basin areas. Absent of cumulative and persistent storage declines or other identified undesirable results, the existing level of groundwater basin development may be considered sustainable. It is not a coincidence that Subbasin pumping over the base period for urban and agricultural uses averaged 2,500 AFY, equal to the preliminary sustainable yield.

6.3.8 Quantification of Overdraft

Overdraft is the condition of a groundwater basin or subbasin where the amount of water withdrawn by pumping exceeds the amount of water that recharges a basin or subbasin over a period of years, during which the water supply conditions approximate average conditions.

The Arroyo Grande Subbasin is not in overdraft. There have been no significant cumulative and persistent storage declines over the 33-year historical base period. As with the preliminary sustainable yield estimate given above, the absence of overdraft assumes continued operation of Lopez Reservoir in accordance with historical practices.

6.4 Current Water Budget

The current water budget quantifies inflows and outflows for the Subbasin based on the last five years of the historical water budget, from 2016 to 2020. These years provide the most recent population, land use, and hydrologic conditions. Recent Subbasin conditions have been characterized by average rainfall (with wet and dry years), along with a slight increase in urban extractions associated with development projects. There has also been a slight decline in total agricultural acreage and associated groundwater extractions over the last 5 years in the Subbasin, compared to the 33-year base period.

Comparisons of the current water budget to the 1988-2020 historical water budget are shown in Table 6-14, and graphs are shown in Figure 6-15 and Figure 6-16. The average annual surface water budget inflows and outflows are lower for current conditions (averaging 13,090 AFY) compared to the historical base period average of 18,360 AFY. The main reason for the lower total surface water budget for the current condition, despite average rainfall, is a decrease in stream inflow, which was due to the extreme drought that preceded the current condition. Lopez Reservoir was only about 24 percent capacity at the start of the 2016 water year (October 2015), with capacity subsequently doubling by the end of water year 2020. Downstream releases from the reservoir over the current condition were half of the historical average.

The average annual groundwater budget outflows are similar for current conditions (averaging 2,890 AFY) compared to the historical base period average of 2,960 AFY. The groundwater budget inflows, however, are slightly greater for the current condition (3,240 AFY), compared to the historical average of 2,950 AFY. The main reason for the increased inflow is also a response to the preceding drought period. Close to 35 inches of rain fell at Lopez Reservoir in 2017, which replenished soil moisture deficits from the drought and resulted in 3,000 acre-feet of deep percolation across the Subbasin, one of the highest estimated values on record (Table 6-1). Overall groundwater in storage increased an estimated 3,390 acre-feet in 2017. Storage has been generally decreasing since 2017, although there was a net gain over the current condition (2016 through 2020).

Table 6-14. Historical, Current, and Future Water Budget Water Budget

SURFACE WATER BUDGET	Historical Average (1988-2020)	Current (2016-2020)	Future Baseline (2021-2045)	Future Climate Change (2021-2045)
Inflow	AFY			
Precipitation	4,130	4,170	4,285	4,421
Groundwater extractions (Urban)	140	180	2,255	2,255
Groundwater extractions (Ag)	2,340	2,220		
Stream Inflow at Basin Boundaries	10,910	5,780	7,093	7,919
Surface Water Deliveries	450	400	0	0
Local Imported Supplies	390	340	0	0
TOTAL IN	18,360	13,090	13,632	14,595
Outflow	AFY			
ET of precipitation	2,820	2,910	4,705	4,640
ET of Applied Water (Urban)	450	430		
ET of Applied Water (Ag)	1,800	1,720		
Riparian ET	230	230		
Wastewater Export	160	130	0	0
Stream Flow Diversions	450	400	0	0
Infiltration of Precipitation	970	1,040	1,141	1,280
Infiltration of Applied Water (Urban)	80	90	598	599
Infiltration of Applied Water (ag)	540	500		
GW-SW interaction (net)	1,200	1,450	1,262	1,081
Stream outflow at basin boundary	9,680	4,190	9,143	10,827
TOTAL OUT	18,360	13,090	16,849	18,427

Table 6-15. Historical, Current, and Future Water Budget Water Budget

GROUNDWATER BUDGET	Historical Average (1988-2020)	Current (2016-2020)	Future Baseline (2021-2045)	Future Climate Change (2021-2045)
Inflow	AFY			
Infiltration of precipitation	970	1,040	1,141	1,280
Urban water return flow	80	90	598	599
Agricultural return flow	540	500		
GW-SW interaction (net)	1,200	1,450	1,262	1,081
Subsurface from bedrock	170	170	82	82
TOTAL IN	2,950	3,240	3,083	3,042
Outflow				
Groundwater extractions (Urban)	140	180	2,255	2,255
Groundwater extractions (Ag)	2,340	2,220		
Subsurface outflow	480	480	122	122
Groundwater ET	0	0	774	741
TOTAL OUT	2,960	2,890	3,151	3,118

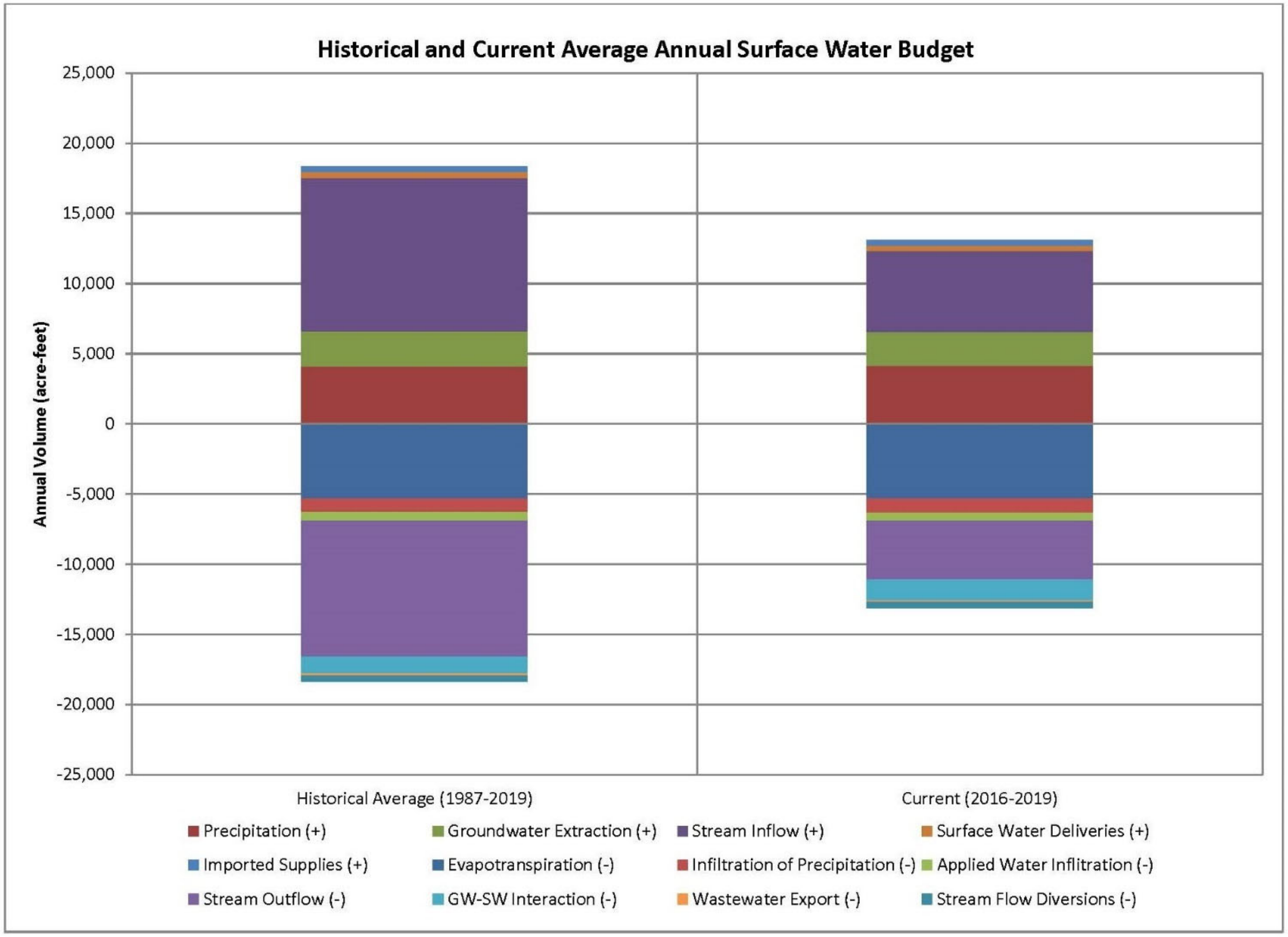

Figure 6-15. Historical and Current Average Annual Surface Water Budget – Arroyo Grande Subbasin

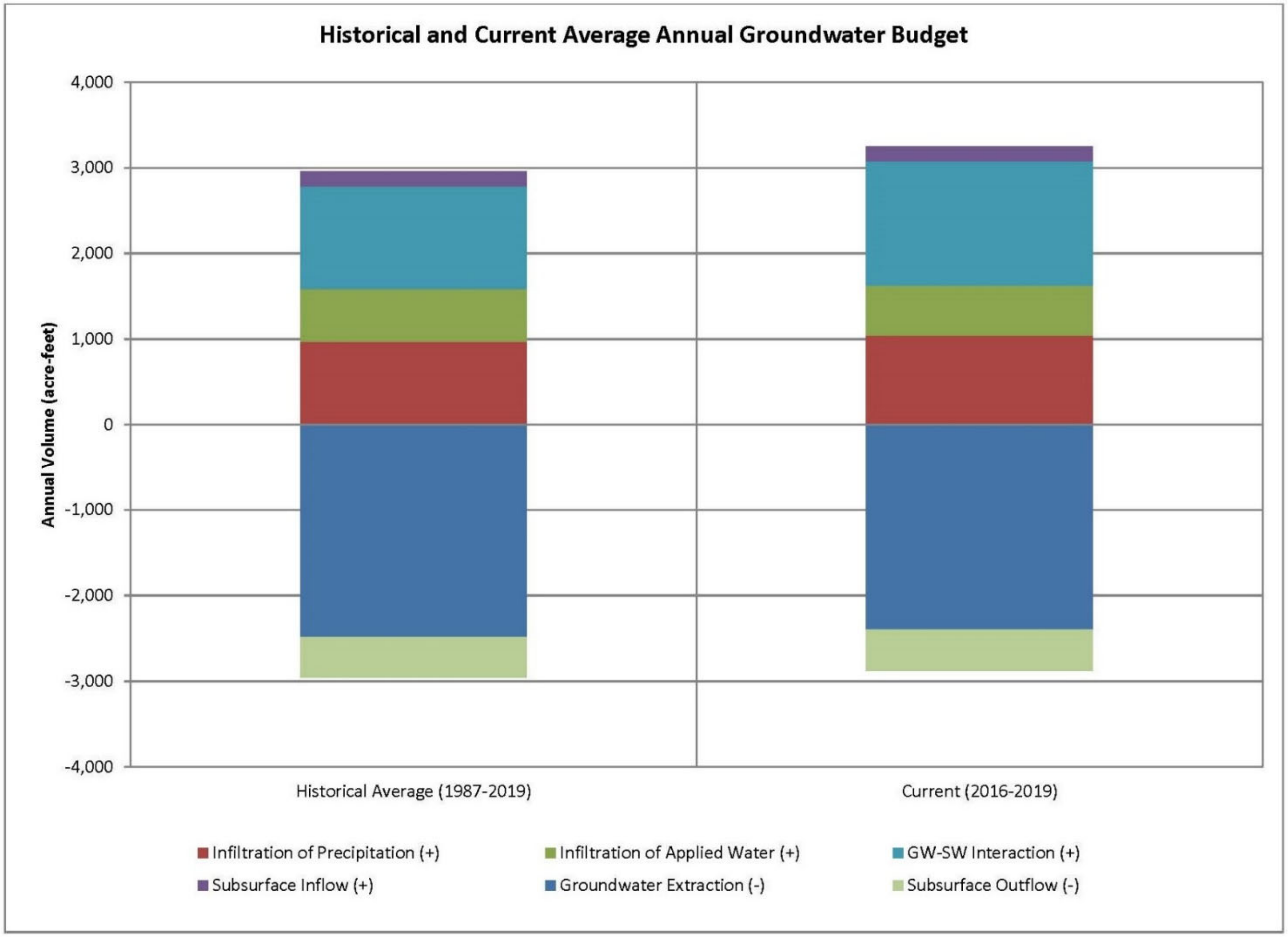

Figure 6-16. Historical and Current Average Annual Groundwater Budget – Arroyo Grande Subbasi

The graphs in Figures 6-16 and 6-17 provide a visual comparison of the magnitude of components of inflow and outflow listed in Table 6-14. The surface water budget (Figure 6-16) is balanced (total inflow equals total outflow), while the groundwater budget (Figure 6-17) depicts a relatively balanced historical period with a net increase of inflow compared to outflow for current conditions

6.5 Future Water Budget

SGMA Regulations require the development of a future surface water and groundwater budget to estimate future baseline conditions of supply, demand, and aquifer response to Basin groundwater use. The future water budget provides a baseline against which management actions will be evaluated over the GSP implementation period from 2022 to 2042. Future water budgets were developed using the GSFLOW model developed for this GSP (Appendix G). Each simulation was run continuously over the predictive simulation period, (water years 2021 through 2045). Assumptions and details of the model simulations are provided in the following sections.

6.5.1 Assumptions Used in Future Water Budget Development

SGMA regulations mandate the development of a future groundwater budget to estimate future baseline conditions of supply, demand, and aquifer response to Basin pumping. The future water budget provides a baseline against which projects and management actions (if any) may be evaluated during the GSP implementation period. Future water budgets were developed using the Basin GSFLOW integrated model.

As per Section 354.18(c)(3)(A) of the SGMA GSP regulations, the future water budget should be based on 50 years of historical climate data. The GSP GSFLOW model and historical water budget analysis is based on 33 years of historical data (water years 1988-2020) rather than 50 years of data. As detailed in Section 6.1.1., this is judged to be a representative historical period spanning a variety of hydrologic year types and is the best available information for groundwater planning purposes. Therefore, the future water budget is based on this time series rather than a 50-year time series of data.

Assumptions about future groundwater supplies and demands are described in the following subsections.

6.5.1.1 Future Water Demand Assumptions

For the purpose of evaluating the effects of climate change and future baseline water budget development, the assumption is made that there will be no increase in irrigated acreage or agricultural pumping over the SGMA planning horizon. The area of the Subbasin is largely planted to the full extent possible; little room is physically available for expansion of agriculture. Agricultural pumping is maintained at Water Year 2020 levels. Representatives of agricultural stakeholders have been involved in the GSP planning process from the beginning, including active involvement in public meetings, and significant contributions through the public comment process. It is understood by the agricultural stakeholders that the path to sustainability likely requires no significant increase in agricultural pumping. In accordance with Section 354.18 (c)(3)(B) of the SGMA GSP Regulations, the most recently available land use (in this case, crop acreage) and crop coefficient information is used as the baseline condition for estimating future agricultural irrigation water demand.

There is currently no municipal pumping within the Subbasin. The assumption is made that the City of Arroyo Grande will maintain their future pumping in the adjudicated NCMA portion of the watershed, downgradient of the Subbasin.

Additionally, rural domestic de minimis pumping is assumed to remain at current levels; there are no significant development plans in County-administered parts of the Basin. Additionally, this is a small portion of the overall water budget (6-7% of total pumping), and minor revisions to this pumping category will not significantly affect model results.

6.5.1.2 Future Climate Assumptions

For the baseline predictive scenario, the historical time series of climatological model input parameters for water years 1989 through 2013 was repeated for the predictive model period of water years 2021 through 2045. The 1995 – 2019 historical period includes several different water year types, including representation of the recent drought.

For the climate change predictive scenario, SGMA GSP Regulations require incorporating future climate estimates into the future water budget. To meet this requirement, DWR developed an approach for incorporating reasonably expected, spatially gridded changes to monthly precipitation and reference ETo (DWR 2018). The approach for addressing future climate change developed by DWR was used in the future water budget modeling for the Basin. The changes are presented as separate monthly change factors for both precipitation and ETo and are intended to be applied to historical time series within the climatological base period through 2011. Specifically, precipitation and ETo change factors were applied to historical climate data for the period 1989-2013 for modeling the future water budget.

DWR provides several sets of change factors representing potential climate conditions in 2030 and 2070. The AG Subbasin used the 2070 climate conditions to develop a future water budget. Consistent with DWR recommendations, datasets of monthly 2070 change factors for the AG Subbasin area were applied to precipitation and ETo data from the historical base period to develop monthly time series of precipitation and ETo, which were then used to simulate future hydrology conditions.

6.5.2 Future Surface Water Budget

The future surface water budget includes average inflows from local supplies, average stream outflows, and average stream percolation to groundwater. Table 6-14 summarizes the average components of the historical, current, and projected surface water budget. Because the timeline of preparing the GSP chapters required text chapter completions prior to the completion of the integrated surface water/groundwater model, the historical average values and the current values presented in Table 6-14 taken from the analytical water budget analysis presented in this chapter. The future water budget values presented are taken from the average 2021-2045 GSFLOW model output for the climate change scenario. These are different methods of analysis, and as a result some of the future water budget results are different in magnitude and, in some cases, water budget component categories, from the analytical water budget results. Differences in values between some of the component categories of the water budget may be attributable to differences in estimation methods between the analytical approach and the modeling approach. In addition, many of the differences relate to the surface water/groundwater component of the water budget, which has a lack of reliable data during the historical period of record. If the model is used to develop historical water budgets during future GSP revisions, past and future estimates will likely be more consistent.

Inspection of values in the future surface water budget and groundwater budgets in Table 6-14 reveal some differences between the model-generated future water budget values and the analytically estimated historical and current water budgets. As mentioned previously, the two approaches to analyzing a water budget are quite different. Still, the differences merit some discussion. First, it is important to remember that the current water budget represents water years 2016-2020, which included both wet and dry conditions. The historical average period includes a 33-year period. The future water budget encompasses a 25-year period using the assumptions previously discussed (I.e., hydrology input time series using water year 1989-2013 data). Since there was no significant overdraft in the historical water budget, there is consequently no overdraft in the future water budget.

6.5.3 Future Groundwater Budget

Projected groundwater budget components are computed using the GSFLOW integrated surface water/groundwater flow model to simulate average conditions over the implementation period. Table 6-14 summarizes the projected average annual groundwater budget for the Arroyo Grande Subbasin. The primary difference between the future groundwater budget calculated using the GSFLOW model and the historical groundwater budget calculated using analytical methods is the magnitude of the groundwater/surface water interaction. This is a poorly constrained component of the water budget, and may be improved in the future with improvements to the surface water monitoring network.

6.5.4 Impact Assessment of Climate Change

In order to assess the effect that climate change may have on groundwater elevations in the Basin, the following methodology was used. A baseline predictive scenario was simulated in which no projects or management actions were simulated, Subbasin pumping was maintained at the levels documented for water year 2020, and climate conditions from water years 1989 to 2013 were repeated for the predictive period of water years 2021 through 2045. Then a climate change scenario was incorporated in which a meteorological input into the GSFLOW model was changed as per guidance from DWR. Comparisons of these two scenarios provides an indication of potential impacts on Basin conditions from climate change.

The model was applied to evaluate the possible effects of climate change using the following methodology. Table 6-14 presents total average precipitation in the Subbasin between the baseline and the climate change runs. Precipitation in the climate change run is about 3% *higher* than the baseline run. A brief comparison was made between water level results between the baseline predictive run and the baseline run with climate change factors incorporated into the future predictive model simulation. Water level results in the four RMS well sites in the Basin, discussed further in Chapter 7 (Monitoring Network). The average of final groundwater elevations at the four RMS wells was 0.5 feet lower in the climate change scenario run than in the baseline run. This does not indicate a significant impact on water levels. These results indicate that climate change is not a significant planning factor that needs to be considered in the Basin over the SGMA planning horizon.

6.5.5 Future Sustainable Yield and Overdraft

The sustainable yield of the Basin was estimated at 2,500 AFY based on a review of data for the period from water year 1988 through water year 2020. Absent any significant changes in land use patterns or climatological factors, there is no reason to expect that the sustainable yield estimate developed in this chapter will vary significantly prior to the next scheduled revision and update of this GSP. An update of the water budget and sustainable yield estimate may be recommended at the next update of the GSP, particularly if significant drought conditions are experienced in the coming years; if it becomes arguable that we are entering a new drought of record, that would constitute new climatological conditions that might necessitate a revision of the sustainable yield estimate. However, for the current planning period it is assumed that the future sustainable yield estimate will be approximately equal to that presented previously in this chapter.

GROUNDWATER SUSTAINABILITY PLAN

7.0 Monitoring Networks (§ 354.32 and § 354.34)

This chapter describes the proposed monitoring networks for the GSP in accordance with SGMA regulations in Sub article 4: Monitoring Networks.

IN THIS CHAPTER

- Monitoring Networks
- Sustainability Indicator Monitoring
- Monitoring and Technical Reporting Standards
- Assessment and Improvement of Monitoring Network

Monitoring is a fundamental component of the GSP necessary to identify impacts to beneficial uses or Basin users, and to measure progress toward the achievement of any management goal. The monitoring networks must be capable of capturing data on a sufficient temporal and spatial distribution to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface water conditions, and to yield representative information about groundwater conditions for GSP implementation. There are three proposed monitoring networks for the Subbasin: a groundwater level network, a groundwater quality network, and a surface water flow network.

Chapter 7.0 describes the monitoring objectives, rationale, protocols, and data reporting requirements of the monitoring networks. Monitoring requirements for sustainability indicators are presented, and data gaps are identified, along with steps to be taken to fill the data gaps before the first five-year assessment. The following is a list of applicable SGMA sustainability indicators that will be monitored in the Subbasin:

- Chronic lowering of groundwater levels.
- Reduction in groundwater storage.
- Degradation of groundwater quality.
- Land subsidence.
- Depletion of interconnected surface water (includes GDE sustainability).

Sustainability indicators are discussed in detail in Chapter 8.0. This monitoring networks chapter focuses on the monitoring sites and data collection needed to support the evaluation of each sustainability indicator.

7.1 Monitoring Objectives

The proposed monitoring network must be able to adequately measure changes in groundwater conditions to accomplish the following monitoring objectives:

- Demonstrate progress toward achieving measurable objectives.
- Monitor impacts to the beneficial uses and users of groundwater.
- Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds for sustainability indicators.
- Quantify annual changes in water budget components.

The network must also provide data with sufficient temporal resolution to demonstrate short-term, seasonal and long-term trends in groundwater and related surface conditions.

7.1.1 Management Areas

Separate management areas have not been established for the Subbasin. The monitoring network includes representative wells across the Subbasin for which minimum thresholds and measurable objective have been selected based on local conditions, as described in Chapter 8.0.

7.1.2 Representative Monitoring Sites

Monitoring sites are the individual locations within a monitoring network and consist of groundwater wells and stream gages. While a monitoring network uses a sufficient number of sites to observe the overall groundwater conditions and the effects of Subbasin management projects, a subset of the monitoring sites may be used as representative for meeting the monitoring objectives for specific sustainability criteria.

Representative monitoring sites are the locations at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined. The criteria that were used to determine which wells to utilize are as follows:

- A minimum 10-year period of record of historical measurements spanning wet and dry periods.
- Available well information (well depth, screened interval).
- Access considerations.
- Proximity and frequency of nearby pumping wells.
- Spatial distribution relative to the applicable sustainability indicators.
- Groundwater use.
- Impacts on beneficial uses and Subbasin users.

7.1.3 Scientific Rationale

GSP monitoring program development is based on a combination of SGMA monitoring networks best management practices (BMPs), local hydrogeology, and the monitoring requirements for individual sustainability criteria. Some of the SGMA monitoring network BMPs implemented for this GSP include the following:

- Defining the monitoring objectives.
- Utilizing existing monitoring networks and data sources to the greatest extent possible to meet those objectives.
- Adjusting the temporal/spatial coverage to provide monitoring data consistent with the need.
- Efficient use of representative monitoring sites to provide data for more than one sustainability indicator.

County monitoring programs that existed before SGMA include sites that do not meet SGMA monitoring network BMPs with respect to known construction information, such as wells with no available Well Construction Report (WCR) and active wells that are used for groundwater supply. While not prohibiting the use of these wells as a monitoring site, SGMA regulations require that the GSP identify sites that do not meet BMPs and describe the nature of the divergence. If the monitoring network uses wells that lack construction information, the GSP shall include a schedule for acquiring monitoring wells with the necessary information or shall demonstrate that such information is not necessary to understand or manage groundwater in the Subbasin.

As discussed in Chapters 4.0 (Basin Setting) and 5.0 (Groundwater Conditions), the Alluvial Aquifer is the only aquifer present in the Subbasin. Although there are some deep wells within the Subbasin boundary that are producing from the bedrock formations, wells considered for the monitoring program are all producing from the alluvial aquifer. Obtaining well construction information for all monitoring network wells is not an immediate necessity and will be addressed (see Section 7.6).

7.1.4 Existing Monitoring Programs

Existing monitoring programs are discussed in Chapter 3.0. Figure 3-8 (Chapter 3.0) shows the locations of monitoring wells identified in the GAMA program (publicly available groundwater quality data), the SLOFCWCD semi-annual groundwater level program, and the CCRWQCB Irrigated Lands Regulatory Program (groundwater quality data). There are also groundwater level and quality data collected for various monitoring programs that are publicly available from the SWRCB GeoTracker website.

7.2 Monitoring Networks

This section introduces the proposed GSP monitoring networks and describes the networks in relation to the following SGMA sustainability indicators applicable to the Subbasin:

- Chronic lowering of groundwater levels.
- Reduction of groundwater in storage.
- Groundwater quality degradation.
- Land subsidence.
- Depletion of interconnected surface water (includes GDE sustainability).

The GSP monitoring program consists of three separate networks, one for groundwater levels, one for groundwater quality, and one for surface water flow. Each network is described below.

7.2.1 Groundwater Level Monitoring Network

Groundwater level monitoring is a fundamental tool in characterizing Subbasin hydrology. Groundwater levels (often reported as elevations relative to a reference point) in wells are measures of the hydraulic head in an aquifer. Groundwater moves in the direction of decreasing head (downgradient), and groundwater elevation contours can be used to show the general direction and hydraulic gradient associated with groundwater movement. Changes in the amount of groundwater in storage within an aquifer can also be estimated based on changes in hydraulic head, along with other parameters.

There are 13 monitoring wells in the GSP groundwater level monitoring network for the Subbasin, with 11 wells in the main Arroyo Grande Creek valley and two wells in the Tar Spring Creek tributary valley (Figure 7-1 and Table 7-1). Some construction information is available for 9 of the 13 wells. Eight of the wells are used for irrigation, two are private domestic wells, and three are dedicated monitoring wells.

Groundwater levels may be used as a proxy for monitoring other sustainability indicators (besides chronic lowering of water levels) provided that significant correlation exists between groundwater elevations and the sustainability indicator for which the groundwater elevations serve as a proxy. Four of the 13 groundwater level monitoring network wells are representative monitoring sites used for evaluating sustainability criteria. All four representative monitoring site wells are used for evaluating chronic lowering of groundwater level and reduction of groundwater in storage, which is correlated with groundwater levels (Chapter 6.0, Section

6.3.5). Three of the wells are used to evaluate depletion of interconnected surface water, which is also correlated with groundwater levels (Chapter 5.0, Section 5.7). The sustainability criteria and associated minimum thresholds and measurable objectives are presented in Chapter 9.0.

7.2.1.1 Groundwater Level Monitoring Data Gaps

SGMA regulations do not require a specific density of monitoring wells, other than being sufficient to represent groundwater conditions for GSP Implementation. The monitoring network well density is roughly 30 wells per 10 square miles, which is 15 times greater density than guidelines for the statewide CASGEM program. There are currently sufficient wells in the network to provide information for overall sustainable management of the Subbasin, although some local data gaps have been identified that have been addressed by the monitoring program or that will be addressed during GSP implementation.

A data gap was previously identified in Chapter 5.0 (Section 5.1.3) with respect to water level monitoring in the Tar Spring Creek tributary valley. There were no records for water levels in the tributary valley after 1989, so a water level survey was conducted in Spring 2021. Two wells (AGV-09 and AGV-10; Table 7-1) have been selected from the 2021 survey for the GSP groundwater level monitoring network, which will fill the data gap in future years.

A second data potential data gap was identified in Chapter 5.0 (Section 5.1.7) with respect to vertical gradients between alluvial deposits above and below the relatively extensive clay aquitard. The assumption of a downward vertical gradient between shallow alluvial sediments and the basal alluvial gravels appears to be confirmed in the vicinity of Cecchetti Road (adjacent to Arroyo Grande Creek), based on the Arroyo Grande Creek Integrated Model Field Data Collection and Investigation conducted during the summer of 2021 (CHG, 2021). An inactive, 118-foot-deep irrigation well on Cecchetti Road (AGV-07); Table 7-1) has been included in the GSP groundwater level monitoring network to help interpret vertical gradients.

Table 7-1 presents the GSP groundwater level monitoring network wells. Figure 7-1 shows the location of the groundwater level monitoring program wells.

Table 7-1. Groundwater Level Monitoring Network

GSP ID[1]	TRS / State ID[2]	Well Depth (feet)	Screen Interval (feet)	RP Elev.[3] (feet AMSL)	First Data Year	Last Data Year	Data period (years)	Data Count	Well Criteria[4]	Well Use[5]	GSA
AGV-01	**31S/14E-32F**	40	20-40	364.5	2006	2021	15	79	WL, GWS, ISW	MW	County
<u>AGV-02</u>	31S/14E-31L	20	10-20	332.7	2006	2021	15	80		MW	County
<u>AGV-03</u>	**31S/13E-36R01**			329.7	1968	2021	53	116	WL, GWS	IRR-A	County
AGV-04	32S/13E-12B									DOM-I	County
AGV-05	32S/13E-12F05	63	43 - 63	253.4	1981	2021	40	93		IRR-A	County
AGV-06	**32S/13E-12Q03**			229.1	1965	2021	56	187	WL, GWS, ISW	IRR-A	County
AGV-07	32S/13E-13C	118	88 - 118			2021	1	4		IRR-I	County
AGV-08	32S/13E-14R02	108	83 - 108	194.8	1965	2021	56	157		DOM-A	County
AGV-09	32S/14E-16N	49			2021		1	1		MW	County
AGV-10	32S/14E-19A01	125			1965	2021	56	37		IRR-A	County
AGV-11	32S/13E-23F03	120	80 - 120	153.6	1988	2021	33	47		IRR-A	County
AGV-12	**32S/13E-23M01**			151.1	2008	2021	13	26	WL, GWS, ISW	IRR-A	City
<u>AGV-13</u>	32S/13E-22R03	100	61 - 100	152.1	1972	2021	49	98		IRR-A	City

Notes:

1- Representative Monitoring Sites are in **bold**. Wells with known State Well Completion Reports are <u>underlined.</u>
2- TRS = Township Range Section and ¼-¼ section listed, State Well ID bolded where applicable.
3- Reference Point elevations from various sources with variable accuracy.
4- Representative well criteria include Subsidence (SUB), Interconnected Surface Water Depletion (ISW), Chronic Water Level Decline (WL), and Groundwater Storage Decline (GWS).
5- Well Use includes Monitoring Well (MW), Irrigation Well (IRR), and Domestic Well (DOM). Modifiers are Active (A) or Inactive (I). Information for some wells pending.

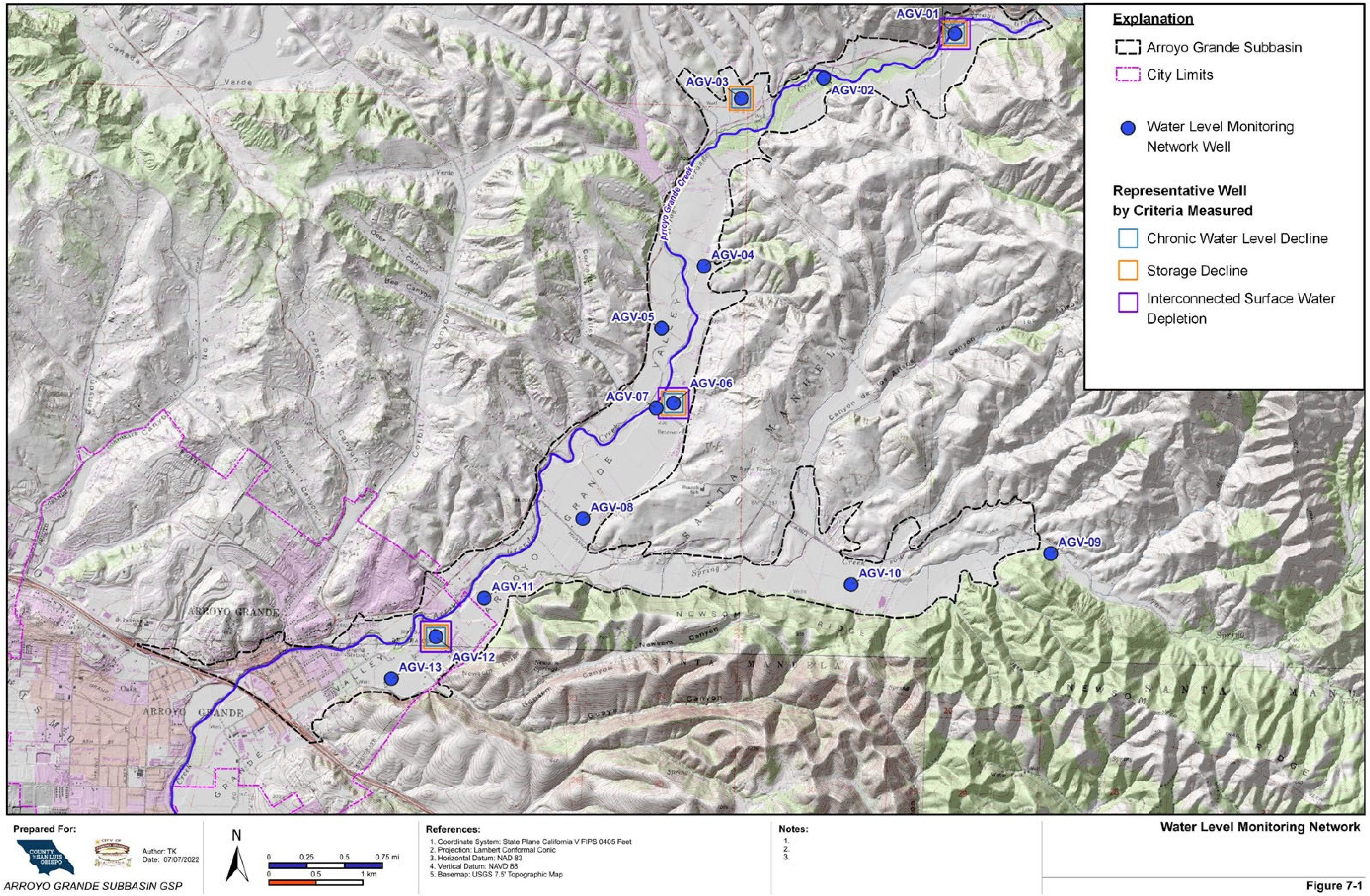

Figure 7-1. Water Level Monitoring Network

7.2.2 Groundwater Quality Monitoring Network

Groundwater quality monitoring refers to the periodic collection and chemical or physical analysis of groundwater from wells. As discussed in Chapter 5.0 (Section 5.6), the quality of groundwater in the Subbasin is generally good, although TDS concentrations are higher in the southwestern part of the subbasin and can exceed drinking water standards. Groundwater quality trends in the Subbasin appear stable, with no significant trends of ongoing deterioration of groundwater quality based on the Central Coast Basin Plan.

Groundwater quality networks should be designed to demonstrate that the degraded groundwater quality sustainability indicator is being observed for the purposes of meeting the sustainability goal (DWR Monitoring Networks BMP, 2016). In other words, the main purpose of the groundwater quality monitoring network is to support the determination of whether the degradation of groundwater quality is occurring at the monitoring sites, based on the sustainability indicator constituents and minimum thresholds selected. This GSP groundwater quality network is also designed to use existing monitoring programs to the greatest degree possible (DWR Monitoring Networks BMP, 2016).

Sustainability indicator constituents selected for groundwater quality are Total Dissolved Solids (TDS) and Nitrate. These constituents were introduced in Chapter 5.0 (Section 5.6.2) as diffuse or naturally occurring in the Subbasin and are further discussed in relation to sustainability indicators in Chapter 8.0.

The groundwater quality network consists of 7 sites (Figure 7-2), which includes five Public Water System supply wells, 1 private domestic well and 1 private irrigation well. Water quality for these wells can be accessed using the GAMA Groundwater Information System. Agricultural Order 4.0 of the Irrigated Lands Regulatory Program was approved in April 2021, which includes the requirement for annual sampling of major constituents including TDS and Nitrate. Selection of specific wells regulated under that program would not be recommended until the program is implemented and monitoring data is available for review. Annual sampling as part of this program will start in 2023. By comparison, the public water system wells have a history of groundwater quality data and specific wells are sampled at regular intervals for the two indicators recommended for groundwater quality monitoring in Chapter 8.0 (Sustainable Management Criteria).

7.2.2.1 Groundwater Quality Monitoring Data Gaps

Current groundwater quality monitoring within the Subbasin is generally sufficient to collect the spatial and historical data needed to determine groundwater quality trends for groundwater quality indicators in the Subbasin. The GAMA database includes 12 wells within the Subbasin boundaries that have been monitored for groundwater quality in the last three years, as well as several to the south of the Subbasin. Several of these wells either have limited data or are considered spatially redundant and have not been included in the monitoring network. The seven wells selected that are shown in Figure 7-2 provide representative Subbasin coverage but can be supplemented with other data if needed to support sustainability indicator evaluation.

The water quality network wells will be used collectively to provide the metric for use with the groundwater quality degradation sustainability indicator (Chapter 8.0). No data gaps in groundwater quality monitoring are currently identified.

Figure 7-3 presents the GSP groundwater quality monitoring network. Figure 7-2 show the locations of the groundwater quality monitoring wells.

Table 7-2. Groundwater Quality Monitoring Network

GSP ID	State ID[1]	First Data Year	Last Data Year	Data period (years)	Data Count (TDS)[2]	Data Count (N)[3]	Well Use	GSA
WQ-1	4000815-001	2010	2021	11	4	14	Public	County
WQ-2	4000733-001	2002	2021	19	1	19	Public	County
WQ-3	4000678-001	1987	2021	34	6	25	Public	County
WQ-4	4000808-002	2006	2021	15	5	15	Public	County
WQ-5	AGL020013087-WELL #1	2014	2020	6	3	2	Private Domestic	County
WQ-6	4000784-007	2014	2020	6	4	65	Public	County
WQ-7	AGL020002547-PUMP18_IRR	2014	2019	5	2	4	Private Irrigation	City

Notes: Data accessed on GAMA Groundwater Information System

1- State ID in GeoTracker Data System
2- TDS = Total Dissolved Solids – typically measured every three years
3- N = Nitrate-Nitrogen – typically measured every year or quarterly

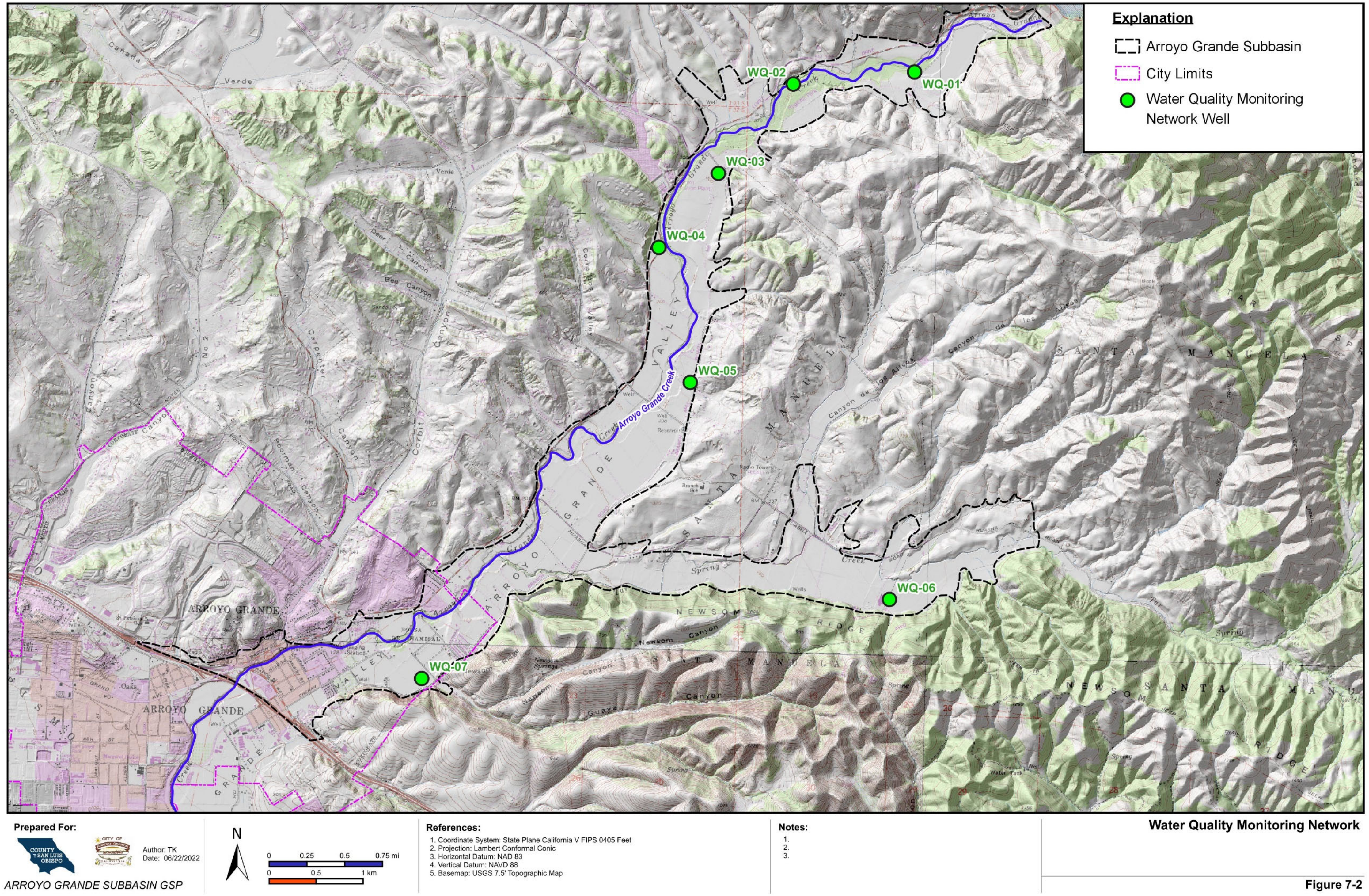

Figure 7-2. Water Quality Monitoring Network

7.2.3 Surface Water Flow Monitoring Network

Surface water flow monitoring can provide valuable information for the Subbasin model and for evaluating potential depletion of interconnected surface water for groundwater dependent ecosystems (GDEs), which is one of the sustainability indicators.

As summarized in Chapter 3.0, there are 3 permanent stream gages located in the Subbasin along Arroyo Grande Creek (Figure 7-3), as well as two additional downstream gages outside of the Subbasin but within the Arroyo Grande Creek watershed. The existing gaging stations only provide stage data, and not actual stream flow data. In addition, there is an active USGS stream gaging station (USGS 11141280) located in the same watershed above Lopez Lake that records discharge, as well as two inactive USGS stream gages that previously recorded discharge data: Tar Spring Creek (USGS 11141400) and AG Creek at AG Creek (USGS 11141500), which was discontinued in 1986 and converted to the current FCWCD-maintained SG-736, which measures stage data. Stream stage is the height of water level in the stream above an arbitrary point, usually at or below the stream bed. Stage data can be useful for identifying flow and no-flow conditions, flood stage alerts, and analyzing the timing of precipitation and runoff in watersheds. Streamflow data is critical for quantifying Subbasin recharge from stream seepage as part of the water budget/model and for addressing sustainability indicators related to GDEs and depletion of interconnected surface water.

Stage data can be converted to streamflow through the use of a rating curve, which incorporates information that is specific to each site, including the cross-sectional area of the channel and the average surface water velocity for a given flow stage. A description of the methodology for monitoring surface water flow in natural channels is presented in Appendix H. There are historical rating curves for the gages, and streamflow in cubic feet per second (CFS) has been estimated for use in modeling and for comparison with the water budget (Figure 6-8; Chapter 6.0).

7.2.3.1 Surface Flow Monitoring Data Gaps

The existing gages in the Arroyo Grande Creek watershed are sufficient to monitor surface flow where the majority of potential GDEs have been identified (Figure 5-15; Chapter 5.0). Table 7-4 presents the GSP surface water flow monitoring network. Figure 7-3 shows the locations of the existing gages.

Table 7-3. Existing Surface Water Flow Monitoring Network

Local ID	Water Course	Location	First Data Year	Data Interval	Data period (years)	GSA
SG-733	Arroyo Grande Creek	Rodriguez Bridge	2006	15-minutes	15	County
SG-735	Arroyo Grande Creek	Cecchetti Road	2003	15-minutes	18	County
SG-736	Arroyo Grande Creek	Stanley Avenue	1939	15-minutes	82	City

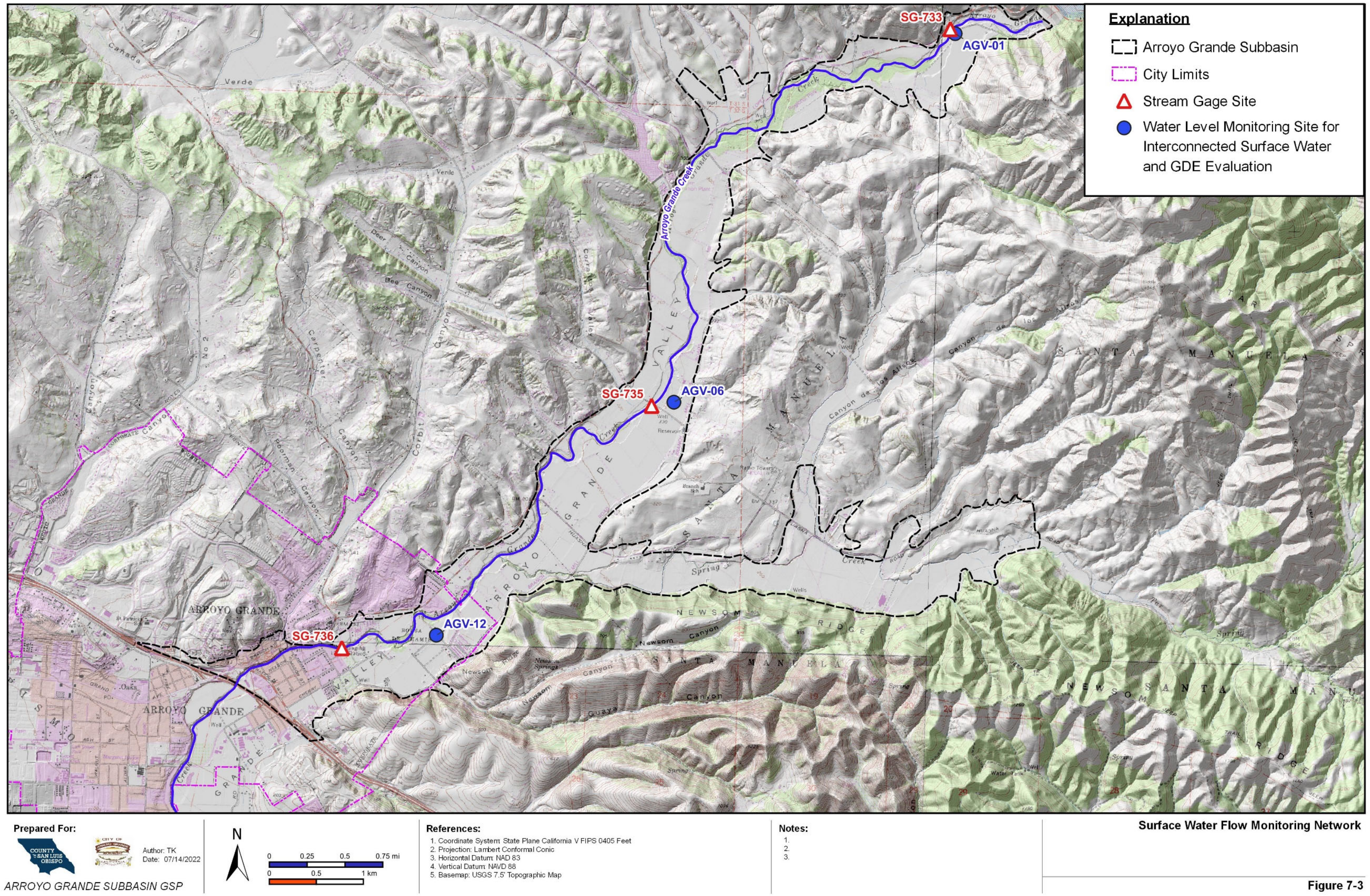

Figure 7-3. Surface Water Flow Monitoring Network

7.3 Sustainability Indicator Monitoring

Sustainability indicators are the effects caused by groundwater conditions occurring throughout the Subbasin that, when significant and unreasonable, become undesirable results. The SGMA sustainability indicators for GSP implementation are as follows:

- Chronic lowering of groundwater levels.
- Reduction in groundwater storage.
- Seawater Intrusion (this indicator is not applicable to Subbasin).
- Degraded groundwater quality.
- Land subsidence.
- Depletion of interconnected surface water (includes GDE sustainability).

7.3.1 Chronic Lowering of Groundwater Levels

Chronic lowering of groundwater levels can lead to a significant and unreasonable depletion of the water supply. All of the groundwater level monitoring network wells can be used for evaluating chronic lowering of groundwater levels, with a selected subset of four representative wells formally assigned to assess Minimum Thresholds and Measurable Objectives (Chapter 8.0). Groundwater monitoring network wells not included in the subset of representative wells are included in the network primarily for preparing groundwater level contour maps, which are used for evaluating hydraulic gradient and groundwater flow direction. Groundwater level contour maps can reveal groundwater pumping depressions that result from lowering of groundwater levels and can also be used to calculate change in groundwater storage. There is currently no indication of chronic lowering of groundwater levels in the Subbasin.

Static groundwater level measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions. Historically, the semi-annual groundwater level program conducted by SLOFCWCD has measured groundwater levels in April and October of each year. This schedule will be maintained for the GSP.

7.3.2 Reduction of Groundwater Storage

Groundwater storage and water levels are directly correlated, and chronic lowering of water levels also leads to a reduction of groundwater storage. Change in groundwater storage will be monitored using the overall monitoring network, while selected representative wells will track reduction of groundwater storage as the sustainability indicator.

The water level monitoring network will be used to contour groundwater elevations for seasonal high conditions, from which annual spring groundwater storage estimates will be estimated and the annual change in storage reported if required for Annual Reports. Groundwater storage will be calculated using the specific yield method, which is the product of total saturated Subbasin volume and average specific yield. The saturated Subbasin volume is the volume between a groundwater elevation contour map for a specific period (such as Spring 2020) and the base of permeable sediments. Representative wells that will be used for monitoring reductions in groundwater storage are listed in Table 7-1 and shown in Figure 7-1. Chapter 8.0 discusses the Minimum Thresholds and Measurable Objectives assigned to the representative wells.

7.3.3 Seawater Intrusion

The Subbasin is not susceptible to seawater intrusion and will not be monitored for that indicator.

7.3.4 Degraded Groundwater Quality

The significant and unreasonable degradation of water quality would be an undesirable result. As discussed in Section 7.2.2, groundwater quality constituents in the Subbasin that have been selected for groundwater quality indicator monitoring include TDS and Nitrate. The selected water quality indicators represent common constituents of concern in relation to groundwater production for domestic, municipal and agricultural use that will be assessed by the monitoring network. TDS is selected as a general indicator of groundwater quality in the Subbasin. Nitrate is a widespread contaminant in California groundwater and selected due to the prevailing land use across the Subbasin associated with agricultural activities, septic systems, and landscape fertilizer. Other constituents of concern may be added to the list during GSP implementation. The sites currently best suited for evaluating trends over time are public supply wells. Sampling intervals vary by well and by constituent, ranging from every three years to monthly, but longer historical records are available, compared to other types of wells.

7.3.5 Land Subsidence

Land subsidence can lead to undesirable results when it interferes with surface land uses. Land subsidence is frequently associated with groundwater pumping. However, within the Arroyo Grande Creek Subbasin, there have been no long-term declines of groundwater levels and no documentation of subsidence (see Chapter 4.0; Section 4.7 and Chapter 6.0; Section 6.7.3). The purpose of land subsidence monitoring is to identify the rate and extent of land subsidence and to provide data for sustainability criteria thresholds. DWR maintains a land subsidence dataset derived from Interferometric Synthetic Aperture Radar (InSAR) data from satellite imagery. InSAR is a remote sensing method used to measure land-surface elevations over large areas, with accuracy on the order of centimeters to millimeters. InSAR uses satellites that emit and measure electromagnetic waves that reflect off of the earth’s surface to produce synthetic aperture radar images with a spatial resolution of about 100 meters by 100 meters. Vertical displacement values associated with land subsidence can be estimated by comparing these images over time.

The DWR land subsidence dataset shows vertical displacement from 2015-2019 in California groundwater basins. The raster GIS dataset covers the entire Subbasin, with no data gaps. The dataset shows minimal vertical displacement of less than an inch from 2015-2019 throughout the Basin (Chapter 4.0). Continued evaluation of Subbasin land subsidence through monitoring the available InSAR data is planned. No additional sites are recommended for monitoring land subsidence. Groundwater level can be a proxy for land subsidence because the process is typically not reversible and maintaining groundwater levels above historic lows in areas susceptible to land subsidence can protect against future undesirable results (see Chapter 8.0).

7.3.6 Depletion of Interconnected Surface Water

Surface water provides beneficial uses, and depletion of interconnected surface water due to groundwater pumping can result in undesirable results by impacting these beneficial uses. The purpose of monitoring for depletion of interconnected surface water is to characterize the following:

- Flow conditions including surface water discharge, surface water head, and baseflow contribution.
- Identifying the approximate date and location where ephemeral or intermittent flowing streams cease to flow.
- Historical change in conditions due to variations in stream discharge and regional groundwater extraction.
- Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.

One of the beneficial uses of surface water is the environmental water demand which supports riverine, riparian, and wetland ecosystems. Locations where surface water is interconnected with groundwater have the potential for creating GDEs, which are ecological communities or species that depend on groundwater emerging from aquifers (rising into streams or lakes) or on groundwater occurring near ground surface where it may be used by riparian vegetation, wetland vegetation, or oak woodlands.

Depending on location and time of year, GDEs that overlie the Subbasin can be supported by a range of water sources including direct precipitation, surface runoff, shallow subsurface flow, and groundwater. Lopez Reservoir releases are regular and continue through the dry season within the Subbasin, which can affect groundwater recharge and support GDEs to a greater extent than would otherwise occur with naturally drained watersheds. No additional GDE monitoring sites are recommended at this time until further GDE investigation is performed in the Subbasin.

There are three existing County stream gages within the Arroyo Grande Subbasin (Table 7-4, Figure 7-3). The existing gages only currently report stage, as discussed in Section 7.2.3. Groundwater level monitoring occurs along Arroyo Grande Creek in the general vicinity of the stream gages sites (Figure 7-3). Table 7-4 shows the pairing between the stream gages and the nearby water level monitoring sites for interconnected surface water and GDE indicator evaluation.

Table 7-4. Interconnected Surface Water and Associated Potential GDE indicator Monitoring Locations

Stream Gage	Monitoring Well	Area
SG-733	AGV-01	AG Creek at Rodriguez Bridge
SG-735	AGV-06	AG Creek at Cecchetti Rd

Stream Gage	Monitoring Well	Area
SG-736	AGV-13	AG Creek at Stanley Ave

The wells in Table 7-4 used for interconnected surface water and potential GDE monitoring should be representative of groundwater levels in the riparian zones. Well AGV-01 is immediately adjacent to the stream gage and taps the shallow alluvial deposits. The other two wells (AGV-06 and AGV-13) are not immediately adjacent to their paired stream gage but appear to have sufficient hydraulic connection to the local riparian corridor to be useful for potential GDE indicator evaluation. Depths to water in these wells are typically less than 30 feet.

Well AGV-08 (Figure 7-1) is an inactive irrigation well immediately adjacent to stream gage SG-735. This well is interpreted to tap the basal alluvial gravel below the clay aquitard and does not appear to be interconnected with surface water or shallow groundwater along the riparian corridor. Water levels in AGV-08 averaged 60 feet depth during the Arroyo Grande Creek Integrated Model Field Data Collection and Investigation (CHG, 2021). Monitoring at this well can be used to evaluate vertical gradients and to demonstrate the local hydraulic separation between surface water and alluvial groundwater below the aquitard.

7.4 Monitoring Technical and Reporting Standards

Monitoring technical and reporting standards include a description of the protocols, standards for monitoring sites, and data collection methods.

7.4.1 Groundwater Levels

Monitoring protocols and data collection methods for groundwater level monitoring and reporting are described in the attached Appendix H, and are based on SGMA monitoring protocols, standards and sites BMPs, USGS data collection methods, and practical experience. Wells used for monitoring program sites have been constructed according to applicable construction standards, although not all the information required under the BMPs is available for every site. Table 7-2 lists the pertinent information available for the monitoring sites.

7.4.2 Groundwater Quality

Monitoring protocols and standards for groundwater quality sampling sites are those required for public water systems from which the groundwater quality data is obtained. Sample collection and field tests shall be performed by appropriately trained personnel as required by California Code of Regulations Title 22, Section 64415. All wells used for public supply are expected to meet applicable construction standards.

7.4.3 Surface Water Flow

As previously discussed, the existing gaging stations currently only provide stage data, and not actual stream flow data. Stage data can be converted to streamflow through the use of a rating curve, which incorporates information that is specific to each site, including the cross-sectional area of the channel and the average surface water velocity for a given flow stage. These rating curves are developed using depth profiles and flow velocity measurements during storm-runoff events (Appendix H). Historical rating curves have been prepared for existing gages within the Subbasin but need to be revised periodically as they can shift due to changes in channel geometry. Protocols and data collection methods will be based on applicable USGS standards and SLOFCWCD standards.

7.4.4 Monitoring Frequency

Monitoring frequency is the time interval between data collection. Seasonal fluctuations relating to groundwater levels or quality are typically on quarterly or semi-annual cycles, correlating with seasonal precipitation, recharge, groundwater levels, and well production. The monitoring schedule for groundwater levels collected under the GSP groundwater level monitoring program will coincide with seasonal groundwater level fluctuations, with higher levels (i.e., elevations) in April (Spring) and lower levels in October (Fall). A semi-annual monitoring frequency provides a measure of seasonal cycles, which can then be distinguishable from the long-term trends.

The monitoring frequency for groundwater quality sampling is variable and based on the schedule determined by the regulating agency (County Environmental Health Services for small public water systems and the State Division of Drinking Water for large public systems). TDS is typically monitored every three years, while nitrate may be monitored annually, quarterly, or even monthly at vulnerable systems. The frequency selected for monitoring individual constituents at each system is sufficient to protect public health, and therefore considered sufficient for Basin management purposes.

Surface monitoring network frequency is a near-continuous record of flow stage, collected at 15-minute intervals. The stage data can then be converted to average daily flow (cubic feet per second) using a rating curve. Automatic gaging equipment (e.g., radar sensors or bubbler gages) at flow monitoring locations maintain the near-continuous monitoring frequency. Updated rating curves are needed at all gage sites, which requires manual flow measurements over a range of stream stages.

7.5 Data Management System

SGMA requires development of a Data Management System (DMS). The DMS stores data relevant to development of a groundwater Basin's GSP as defined by the GSP Regulations (California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2). To comply with SGMA, the Basin DMS was developed in this GSP and will store data that is relevant to development and implementation of the GSP as well as for monitoring and reporting purposes. Appendix H describes the data management plan associated with the DMS.

7.6 Assessment and Improvement of Monitoring Network

The current assessment of the monitoring networks has not identified critical data gaps with respect to sustainable management of the Subbasin.

As previously mentioned, obtaining well construction information for all monitoring network wells is not an immediate necessity or a requirement for Subbasin management purposes, provided the lack of information does not affect the usefulness of the monitoring results toward Subbasin management. Over time, wells for which construction information is not known may be inspected with a video camera to document construction, either within the next five years or at the earliest practical opportunity, such as when the well pump is being serviced. The monitoring networks will be re-evaluated at each five-year assessment.

7.7 Annual Reports and Periodic Evaluation by the GSAS

Reporting requirements for the Annual Report and for periodic evaluation of the GSP are contained in Article 7 of the GSP regulations. Because the Subbasin is a very low priority basin, however, it is not required to submit an Annual Report or five-year updates. Reporting is anticipated to take place as part of future HCP efforts and through the County's Master Water Report process.

GROUNDWATER SUSTAINABILITY PLAN

8.0 Sustainable Management Criteria (§354.22)

This chapter defines the conditions specified at each of the Representative Monitoring Sites (RMSs) that constitute Sustainable Management Criteria (SMCs), discusses the process by which the GSAs in the Subbasin will characterize undesirable results, and establishes minimum thresholds and measurable objectives for each Sustainability Indicator.

IN THIS SECTION

The chapter defines sustainability in the Subbasin for the purposes of managing groundwater in compliance with SGMA, and it addresses the regulatory requirements involved. The Measurable Objectives (MOs), Minimum Thresholds (MTs), and undesirable results presented in this chapter define the future sustainable conditions in the Basin and guide the GSAs in development of policies, implementation of projects, and promulgation of management actions that will achieve these future conditions.

Defining Sustainable Management Criteria (SMC) requires technical analysis of historical data, and input from the affected stakeholders in the Basin. This chapter presents the data and methods used to develop the SMC and demonstrate how they influence beneficial uses and users. The SMCs presented in this chapter are based on currently available data and application of the best available science. As noted in this GSP, data gaps exist in the hydrogeologic conceptual model. Uncertainty caused by these data gaps was considered when developing the SMC. Due to uncertainty in the hydrogeologic conceptual model, these SMCs are considered initial criteria and will be reevaluated and potentially modified during the 20-year implementation period as new data become available.

The discussion of SMC in this chapter is organized by Sustainability Indicators. The following Sustainability Indicators are applicable in the Basin:

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

The sixth Sustainability Indicator, sea water intrusion, only applies to coastal basins, and is not applicable in the Subbasin.

To maintain an organized approach throughout the text, this chapter follows the same structure for each Sustainability Indicator. The description of each SMC contains all the information required by Section 354.22 et. seq of the SGMA regulations and outlined in the Sustainable Management Criteria BMP (DWR, 2017), including:

- How undesirable results were developed, including:
    - The criteria defining when and where the effects of the groundwater conditions that cause undesirable results based on a quantitative description of the combination of minimum threshold exceedances (§354.26 (b)(2))
    - The potential causes of undesirable results (§354.26 (b)(1))
    - The effects of these undesirable results on the beneficial users and uses (§354.26 (b)(3))
- How minimum thresholds were developed, including:
    - The information and methodology used to develop minimum thresholds (§354.28 (b)(1))
    - The relationship between minimum thresholds and the relationship of these minimum thresholds to other Sustainability Indicators (§354.28 (b)(2))
    - The effect of minimum thresholds on neighboring basins (§354.28 (b)(3))
    - The effect of minimum thresholds on beneficial uses and users (§354.28 (b)(4))

    - How minimum thresholds relate to relevant Federal, State, or local standards (§354.28 (b)(5))
    - The method for quantitatively measuring minimum thresholds (§354.28 (b)(6))
- How measurable objectives were developed, including:
    - The methodology for setting measurable objectives (§354.30)
    - Interim milestones (§354.30 (a), §354.30 (e), §354.34 (g)(3))

The SGMA regulations address minimum thresholds before measurable objectives. This order was maintained for the discussion of all applicable Sustainability Indicators.

8.1 Definitions (§ 351)

The SGMA legislation and regulations contain a number of new terms relevant to the SMCs. These terms are defined below using the definitions included in the SGMA regulations (§ 351, Article 2). Where appropriate, additional explanatory text is added in italics. This explanatory text is not part of the official definitions of these terms. To the extent possible, plain language, including limited use of overly technical terms and acronyms, was used so that a broad audience will understand the development process and implications of the SMCs.

1. ***Interconnected surface water (ISW)*** refers to surface water that is hydraulically connected at any point by a continuous saturated zone between the underlying aquifer and the overlying surface water. Interconnected surface waters are parts of streams, lakes, or wetlands where the groundwater table is at or near the ground surface and there is water in the lakes, streams, or wetlands.
2. ***Interim milestone (IM)*** refers to a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan. Interim milestones are targets such as groundwater elevations that will be achieved every five years to demonstrate progress towards sustainability.
3. ***Management area*** refers to an area within a basin for which the Plan may identify different minimum thresholds, measurable objectives, monitoring, or projects and management actions based on differences in water use sector, water source type, geology, aquifer characteristics, or other factors.
4. ***Measurable objectives (MOs)*** refer to specific, quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted Plan to achieve the sustainability goal for the basin. Measurable objectives are goals that the GSP is designed to achieve.
5. ***Minimum thresholds (MTs)*** refer to numeric values for each Sustainability Indicator used to define undesirable results. Minimum thresholds are established at representative monitoring sites. Minimum thresholds are indicators of where an unreasonable condition might occur. For example, a particular groundwater elevation might be a minimum threshold if lower groundwater elevations would result in a significant and unreasonable reduction in groundwater storage.
6. ***Representative monitoring site (RMS)*** refers to a monitoring site within a broader network of sites that typifies one or more conditions within the basin or an area of the basin.
7. ***Sustainability Indicator*** refers to any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results, as described in Water Code Section 10721(x). The five Sustainability Indicators relevant to the Basin are listed in the introductory section of Chapter 8.0.

8. ***Uncertainty*** refers to a lack of understanding of the basin setting that significantly affects an Agency's ability to develop sustainable management criteria and appropriate projects and management actions in a Plan, or to evaluate the efficacy of Plan implementation, and therefore may limit the ability to assess whether a basin is being sustainably managed.
9. ***Undesirable Result*** Section 10721 of the Sustainable Groundwater Management Act states that Undesirable result means one or more of the following effects caused by groundwater conditions occurring throughout the basin:
    a. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
    b. Significant and unreasonable reduction of groundwater storage.
    c. Significant and unreasonable seawater intrusion.
    d. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
    e. Significant and unreasonable land subsidence that substantially interferes with surface land uses.
    f. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

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

8.2 Sustainability Goal (§ 354.24)

The sustainability goal for the Arroyo Grande Subbasin is a comprehensive statement that describes the important factors to be considered during the SGMA planning horizon. The sustainability goal was developed during a series of public workshops, and during ongoing input from the City, County, and affected stakeholders. The SGMA regulations require the sustainability goal to culminate in the absence of undesirable results within 20 years of the applicable statutory deadline. Per Section § 354.24 of the SGMA regulations the Sustainability goal has three parts:

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

8.2.1 Description of Sustainability Goal

The sustainability goal for the Subbasin is to manage the Subbasin to ensure beneficial uses and basin users have access to a safe and reliable groundwater supply that meets current and future demand without causing undesirable results. Guiding principles of this goal are:

- Available groundwater supply supports diverse needs reliably and equitably.
- Stored groundwater equitably supports supply resilience and evolving needs.
- Groundwater levels support the sustained health of groundwater dependent ecosystems.
- Cost of maintaining sustainable groundwater levels is equitably distributed.
- Groundwater quality is maintained to a safe standard to meet diverse basin needs.

8.2.2 Sustainability Strategy

The water budget analysis detailed in Chapter 6.0 indicates that there is currently no overdraft in the Subbasin. This indicates that the Subbasin is sustainable under current conditions and operations. The sustainability strategy will be to maintain an increased effort for data collection in the Subbasin to document conditions on an ongoing basis. Chapter 9.0 Projects and Management Actions and Implementation Plan will provide additional detail on the sustainability strategy for the Subbasin.

8.3 Generalized Process For Establishing Sustainable Management Criteria (§ 354.22-30)

SMCs for the Subbasin were developed after technical analysis of hydrogeologic and geotechnical data by the consulting team, input from the GSAs, stakeholder input received in public meetings, written public comments in response to GSA meeting and workshop presentations, and meetings with GSA staff. Public comments on alternative SMCs discussed during GSC meetings and responses to those comments are included in Appendix I. All presentations made at public meetings are available for review at the Arroyo Grande Subbasin web site created for this GSP, https://slocounty.ca.gov/agbasin

The general process for establishing minimum thresholds and measurable objectives for the SMC and assessing significant and unreasonable conditions constituting undesirable results in the Subbasin was iterative and included the following:

- Evaluating historical data on groundwater elevations from wells monitored by the City and County.
- Evaluating water budget information presented in Chapter 6.0, including sustainable yield estimates and average deficits for Subbasin.
- Holding a series of public meetings that outlined the GSP development process and introduced stakeholders to SMC, MOs, MTs, and other related information.
- Soliciting public comment and input on alternative minimum threshold and measurable options based upon preliminary technical analysis presented at GSC meetings.
- Evaluating public comment to assess what are significant and unreasonable effects relevant to SMC.
- Combining public comment, outreach efforts, hydrogeologic data and considering the interests of beneficial uses and groundwater users, land uses, and property interests in the Basin to describe undesirable results and setting preliminary conceptual MTs and MOs.
- Reviewing and considering public and GSC input on recommended preliminary SMCs with GSA staff.

Various alternative options for both MTs and MOs were considered for each RMS after evaluation of the historical record of groundwater elevations at each well, assessment of trends of groundwater elevation decline (where applicable), and input from stakeholders regarding their desired conditions. Details regarding the specific SMCs for each Sustainability Indicator are included in the following sections of this chapter describing each indicator.

The chronic lowering of groundwater levels sustainability indicator, the reduction of groundwater in storage sustainability indicator, and the depletion of interconnected surface water sustainability indicator all utilize direct measurements of groundwater elevation as a proxy metric to assess the SMC for the respective sustainability indicators. Water levels are measured directly at each RMS. The water quality sustainability indicator will be evaluated by leveraging existing water quality monitoring programs with data available through the GAMA Groundwater Information System. The land subsidence Sustainability Indicator will be monitored based on available InSAR data, published by DWR.

8.4 Chronic Lowering Of Groundwater Levels Sustainability Indicator

This section of the GSP describes the SMC for the Chronic Lowering of Groundwater Levels Sustainability Indicator. The definition of Undesirable Results is presented, and MTs and MOs are presented for each RMS in the monitoring network.

8.4.1 Undesirable Results (§ 354.26)

The definition of undesired conditions for the Chronic Lowering of Groundwater Indicator for the purposes of this GSP is as follows:

> *The Subbasin will be considered to have undesirable results if one or more RMSs for water levels display exceedances of the minimum threshold groundwater elevation values for two consecutive fall measurements. MT exceedances will require investigation to determine if local or basin wide actions are required in response.*

Details addressing specific MTs and MOs are presented in the following sections. A summary of MTs and MOs used in the definition of Undesirable Conditions for the Chronic Lowering of Groundwater Sustainability Indicator are presented along with other indicators in Table 8-1. Figure 8-1 through Figure 8-4 present historical groundwater elevation hydrographs and the MTs selected for the four RMS wells defined in the Subbasin. Figure 8-5 presents all of these hydrographs on a map of the Subbasin to demonstrate the spatial distribution of RMSs in the Subbasin.

Table 8-1. Summary of MTs, MOs, and IMs for Arroyo Grande Subbasin RMSs

RMS	MT	MO	2021 WL	2027 IM	2032 IM	2037 IM	Sustainability Indicator
Arroyo Grande Creek Valley							
AGV-01	326	335	331	332	334	335	Water Levels/Storage/ISW
AGV-03	284	315	306	309	312	315	Water Levels/Storage
AGV-06	190	208	195	199	204	208	Water Levels/Storage/ISW
AGV-12	114	127	119	122	124	127	Water Levels/Storage/ISW

Note: All water level and interim milestone measurements refer to fall measurements.

8.4.1.1 Criteria for Establishing Undesirable Results §354.26(b)(2)

Significant and unreasonable Chronic Lowering of Groundwater Levels in the Subbasin are those that:

- Reduce the ability of existing domestic wells of average depth to produce adequate water for domestic purposes (drought resilience).
- Cause significant financial burden to those who rely on groundwater.
- Interfere with other SGMA Sustainability Indicators.

8.4.1.2 Potential Causes of Undesirable Results §354.26(b)(1)

Conditions that could theoretically lead to an undesirable result include the following:

- Development of additional municipal or agricultural pumping at significantly higher rates than are currently practiced.
- Expansion of de minimis pumping. Adding domestic de minimis pumpers in the areas of the Subbasin administered by the County may result in lower groundwater elevations, and an exceedance of the proxy minimum threshold.
- Extensive, unanticipated drought. Minimum thresholds are established based on reasonable anticipated future climatic conditions. Extensive, unanticipated droughts more severe than those on record may lead to excessively low groundwater recharge and unanticipated high pumping rates that could cause an exceedance of the proxy minimum threshold.

8.4.1.3 Effects of Undesirable Results on Beneficial Users and Land Uses - §354.26 (b)(3)

Beneficial users may experience undesirable results associated with the lowering of groundwater levels following multiple exceedances in succession of the MT at an RMS. Allowing one exceedance in an RMS is reasonable if subsequent monitoring indicates groundwater level have recovered above the respective MT. If an MT at an RMS is exceeded in succession during two or more monitoring events, it indicates that significant and unreasonable effects are likely being experienced by, at a minimum, some beneficial users in the Subbasin. Exceedances of MTs will require investigation to determine the significance and causes of the observed conditions.

8.4.2 Minimum Thresholds - §354.28(c)(1)

Section §354.28(c)(1) of the SGMA regulations states that "The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results".

MTs were developed at each of the four selected RMSs (see Chapter 7.0 for RMS selection rationale) for the chronic lowering of groundwater levels sustainability indicator based on the evaluation of historical groundwater elevations over the available period of record (including consideration of average water levels over various time periods, long term trends, response to the recent drought, etc.), consideration of likely future use of groundwater, well construction data, assessment of remaining available saturated thickness, and public input from stakeholders. The following sections present details on the development of MTs for specific RMSs in the Subbasin.

8.4.2.1 Information and Methods Used for Establishing Chronic Lowering of Groundwater Level Minimum Thresholds - §354.28(b)(1)

The primary source of data that was evaluated for the Sustainability Indicator of chronic lowering of groundwater levels is historical groundwater elevation data collected by the County (SLOFCWCD semi-annual groundwater level program). The information used for establishing the MTs for the chronic lowering of groundwater levels Sustainability Indicator included:

- Historical groundwater elevation data from wells monitored by the County.
- Depths and locations of existing wells.
- Maps of current and historical groundwater elevation data.
- Input from stakeholders regarding significant and unreasonable conditions and desired current and future groundwater elevations communicated during public meetings on December 12, 2021 and July 25, 2022, and solicitation of public comment on various options of MTs presented in the public forum.

Observed hydrograph signatures for wells located in Arroyo Grande Creek valley and Tar Spring Creek tributary valley are similar as they are all alluvial wells dominated by seasonal fluctuations and changes in annual groundwater levels often on the order of tens of feet. Due to current, ongoing, drought conditions (beginning in at least WY 2012), measured water levels in three of the four RMSs were observed to be at historical lows during the Fall 2021 monitoring event. Although only groundwater levels in Arroyo Grande Creek valley wells (I.e., not wells in Tar Spring Valley) are moderated by Lopez Reservoir releases and spills, none of the RMS wells in the Subbasin indicate a chronic lowering of groundwater levels (see Section 5.2), nor have Subbasin stakeholders reported experiencing any undesirable results related to lowering of groundwater levels. Therefore, the minimum threshold for the chronic lowering of groundwater levels sustainability indicator is equal to the historical low groundwater level measured at each RMS plus an additional 5 feet of decline.

Figure 7-1 displays the locations of RMSs in the Subbasin. MTs are presented in Table 8-1. Hydrographs with SMC for the four RMSs are presented on Figure 8-1 through Figure 8-4.

Hydrographs for all four RMSs (AGV-1, AGV-3, AGV-6, and AGV-12) indicate water level declines over the past 5-10 years. This period of decline corresponds with the current drought. Water level decline in AGV-1, AGV-3, and AGV-12 over the last decade has been steady. Conversely, water levels in AGV-6 declined steeply between Spring 2017 and Fall 2018. The flux in water levels during this period is also apparent in the other three RMS hydrographs, however total water level decline over the period was greatest in AGV-6. Although three of the four RMS hydrographs indicate the Fall 2021 measurement as the historical low, taking the current drought conditions into consideration, current water levels in all RMSs are nearly within the historical observed range.

Various alternative approaches were considered to establish MTs including designation of current water levels, water levels higher than current water levels, historical low water levels, and levels lower than the historical low. Per SGMA, groundwater conditions, including groundwater levels, occurring prior to 2015 are not required to be restored. Additionally, per SGMA, current groundwater levels within the Subbasin occur at a sustainable operational range. The decision to establish 5 feet below the historical low groundwater level measured at each RMS as the MT for the chronic lowering of groundwater levels sustainability indicator was based on the following: none of the RMS wells in the Subbasin indicate a groundwater pumping induced chronic lowering of groundwater levels, Subbasin stakeholders have not reported experiencing any undesirable results related to lowering of groundwater levels, the Subbasin water budget (see Chapter 6.0) indicates the Subbasin is in approximate equilibrium, groundwater recharge in the Subbasin is moderated by managed releases from Lopez Reservoir, and recent historical low groundwater levels measured at RMS correspond with the current drought period.

In order to assess the risk on shallow, typically domestic, wells of having groundwater elevations lower than recent drought low levels, a review was completed of data available data through DWR's California Groundwater Live online tool[4]. The online tool displays "California's latest groundwater information and conditions" including current conditions, groundwater levels, well infrastructure, and land subsidence. Within "Well Infrastructure" is a "Dry Domestic Well

[4] Available at https://sgma.water.ca.gov/CalGWLive/.

Susceptibility within Groundwater Basins" tool as well as a "Reported Dry Wells" tool. The Dry Domestic Well Susceptibility within Groundwater Basins tool displays susceptibility per square mile based on analysis by combining the latest information on domestic well locations, depths, and local groundwater level conditions (DWR, 2022). Based on the Dry Domestic Well Susceptibility within Groundwater Basins tool, one square mile, located near the confluence of Arroyo Grande Creek Valley and Tar Spring Creek tributary indicates a dry domestic well susceptibility within the 0 to 10^{th} percentile, or 1 of 2 domestic wells reported being susceptible. Within the most northern reach of the Tar Spring Creek tributary is a square mile categorized in the 30 to 40^{th} percentile, with 4 of 17 domestic wells reported being susceptible. The rest of the Subbasin is categorized as "Domestic wells present, not susceptible". According to the Reported Dry Wells tool, one well, located near the intersection of Branch Mill Road and Via dos Ranchos was reported as dry in Fall 2015. No other wells have been reported dry in the Subbasin.

The objective of this data review is to assess the level of impact to domestic wells associated with water level reduction below historical low groundwater levels. This is not intended to be a definitive analysis, given that depth and location data of the domestic wells are typically incomplete. However, it is intended to provide a general indication of how many additional domestic wells might be impacted if water levels were decreased. The conclusion of this analysis is that lowering water levels 5 feet below the historical low measured at RMSs constitutes an acceptable level of risk for all stakeholders, and the proposed MT for the chronic lowering of groundwater levels does not constitute unreasonable or undesirable conditions.

8.4.2.2 Relationship between Individual Minimum Thresholds and Relationship to Other Sustainability Indicators - §354.28(b)(2)

Section 354.28 of the SGMA regulations requires that the description of all MTs include a discussion of the relationship between the MTs for each Sustainability Indicator. In the SMC Best Management Practices document (DWR, 2017), DWR has clarified this requirement. First, the GSP must describe the relationship between each Sustainability Indicator's MT by describing why or how a water level MT set at a particular RMS is similar to or different to water level thresholds in a nearby RMS. Second, the GSP must describe the relationship between the selected MT and MTs for other Sustainability Indicators; in other words, describe how (for example) a water level minimum threshold would not trigger an undesirable result for land subsidence.

Groundwater elevation MTs are derived from examination of the historical record reflected in hydrographs at the RMS. Because the MTs are largely based on observed historical groundwater conditions, the minimum thresholds derived from these objectives are not expected to conflict with each other. Groundwater elevation MTs can theoretically influence other Sustainability Indicators. Examples are listed below:

1. **Change of groundwater in storage.** Changes in groundwater elevations are directly correlated to changes in the amount of stored groundwater. Pumping at or less than the sustainable yield will maintain or raise average groundwater elevations in the Subbasin.

The groundwater elevation MTs are set to establish a minimum elevation that will not lead to undesirable conditions, and that are acceptable to the stakeholders in the area. Therefore, if the groundwater elevation MTs are met, they will not result in long term significant or unreasonable changes in groundwater storage.

2. **Subsidence.** A significant and unreasonable condition for subsidence is permanent pumping-induced subsidence that substantially interferes with surface land use. One cause for subsidence is dewatering and compaction of clay-or peat-rich sediments in response to lowered groundwater levels. As discussed in Section 4.7, no significant subsidence has been observed in the Subbasin over the period of record of the available DWR InSAR dataset, and historically based on anecdotal information. If groundwater elevations MTs are maintained at or above the historical low groundwater levels observed in the RMS, based on available subsidence data, no significant subsidence or an increase in rate of subsidence is anticipated to occur in the Subbasin.
3. **Degraded water quality.** Protecting groundwater quality is critically important to all groundwater users in the Subbasin, particularly for drinking water and agricultural uses. Maintaining groundwater levels protects against degradation of water quality or exceeding regulatory limits for constituents of concern in supply wells due to actions proposed in the GSP. Water quality in the Subbasin could theoretically be affected through two processes:
    a. Low groundwater elevations in an area could theoretically cause deeper, poorer-quality groundwater to flow upward from bedrock into existing supply wells. Should groundwater quality degrade due to lowered groundwater elevations, the groundwater elevation MTs may be raised to avoid this degradation. However, since MTs are set to avoid significant declines of groundwater elevations below historically observed levels, and the historical low water levels did not result in water quality degradation, this is not expected to occur.
    b. Changes in groundwater elevation due to actions implemented to achieve sustainability could change groundwater gradients, which could cause poor quality groundwater to flow towards supply wells that would not have otherwise been impacted. Based on available groundwater level data, the Subbasin is in approximate equilibrium, despite periods of drought, due to the managed releases from Lopez Reservoir. Therefore, no project or management actions, aside from monitoring, is proposed for the Subbasin. Additionally, MTs are established so as not to change the basin patterns or gradients of groundwater flow, so this is not expected to occur in the Subbasin.
4. **Depletion of Interconnected Surface Water.** Groundwater levels measured at RMSs (AGV-01, AGV-06, and AGV-12) will serve as a proxy for depletion of interconnected surface water. In addition, stream flow gages along Arroyo Grande Creek will continue to measure surface water conditions in Arroyo Grande Creek Valley. Reported releases from Lopez Reservoir and measured stream flow data from the three existing stream gage sites along Arroyo Grande Creek are adequate to allow for generation of information on surface water inflow and outflow in the Subbasin, allowing for direct

measurement of surface water gains and losses to the groundwater systems based on future hydrologic and pumping conditions in the Subbasin. Groundwater level MTs are defined at levels designed to avoid significant water declines, including surface water, with the goal of minimizing any potential significant depletion of interconnected surface water flows. It is important to note that the Lopez Reservoir Dam is currently undergoing a relicensing process which includes the development of a Habitat Conservation Plan. The Habitat Conservation Plan is subject to review and approval which contains elements including managed Lopez Reservoir releases. Any potential modification to planned releases could have an impact on groundwater levels, and consequently interconnected surface water, in the Subbasin.

5. **Seawater intrusion.** This Sustainability Indicator is not applicable to this Groundwater Basin.

8.4.2.3 Effect of Minimum Thresholds on Neighboring Basins - §354.28(b)(3)

Two neighboring groundwater basins share a boundary with the Subbasin; the San Luis Obispo Valley Basin to the northwest near Orcutt Road, and the Santa Maria River Valley – Santa Maria Subbasin to the southwest with U.S. Highway 101 coincident with the boundary. The shared boundary with both of these basins is not extensive. In the Subbasin there have been no trends indicating pumping induced chronic groundwater declines that would affect either neighboring basin. The Hydrogeologic Conceptual Model (HCM) posits that a groundwater divide separates the groundwater between the San Luis Obispo Basin and the Arroyo Grande Subbasin. Also, the elevation of groundwater in the Subbasin is up to 50 feet higher than groundwater elevations in the downgradient Santa Maria Basin, so any hydrogeologic changes in the Subbasin are not expected to significantly impact conditions in the Santa Maria Basin.

Additionally, the Subbasin's GSAs have developed a cooperative working relationship with both the San Luis Obispo Valley Basin GSA and the Northern Cities Management Area. Hydrogeologic conditions near the basin boundaries will be monitored, and any issues potentially affecting those basins will be communicated.

8.4.2.4 Effects of Minimum Thresholds on Beneficial Users and Land Uses - §354.28(b)(4)

Agricultural land uses and users

The agricultural stakeholders in the Subbasin have maintained an active role during the development of this GSP. The groundwater elevation MTs place a practical limit on the acceptable lowering of groundwater levels in the Subbasin, thus conceptually restricting the current level of agriculture in the region without projects to supplement water supply to the Subbasin, or management actions to reduce current pumping. In the absence of other mitigating measures, this has been the practical effect of potentially limiting the amount of groundwater pumping in the Subbasin. Limiting the amount of groundwater pumping could limit the additional amount and type of crops that can be grown in the Subbasin, which could result in a reduction of economic viability for some properties. The groundwater elevation MTs could therefore limit the Subbasin's agricultural economy. This could have various effects on beneficial users and land uses:

- There could be an economic impact to agricultural employees and suppliers of agricultural production products and materials, as well as the tourism industry supported by the wineries and vineyards in the Subbasin. Many parts of the local economy rely on a vibrant agricultural industry, and they too will be hurt proportional to the losses imparted to agricultural businesses.
- Growth of city, county, and state tax rolls could be slowed or reduced due to the limitations imposed on agricultural growth and associated activities.

Urban land uses and users

The groundwater elevation MTs effectively limit the amount of groundwater pumping in the Subbasin. However, the MTs in the Subbasin are established below currently observed groundwater elevations (historical lows at select RMSs) to allow for reasonable future operational range of water levels while avoiding significant and undesirable results associated with lowering of groundwater levels. If groundwater elevations decline in the immediate vicinity of Arroyo Grande Creek, this could potentially result in less groundwater discharge to the creek due to areas of interconnected surface water. Impacts to stream flows will be monitored with the current data collection programs in the Subbasin.

Domestic land uses and users

The groundwater elevation MTs are established to protect as many domestic wells as possible. Therefore, the MTs will likely have an overall beneficial effect on existing domestic land uses by protecting the ability to pump from domestic wells within the Subbasin. Additionally, the groundwater elevation MTs may limit the increase of non-de minimis groundwater use in order to limit future declines in groundwater levels caused by non-de minimis pumping.

Ecological land uses and users

Groundwater elevation MTs protect the groundwater resource and the existing ecological habitats that rely upon it because they are set to avoid long term declines in groundwater levels. As noted above, groundwater level MTs may limit increases in non-de minimis and agricultural groundwater uses. Ecological land uses and users may benefit by this potential reduction in future non-de minimis and agricultural groundwater uses.

8.4.2.5 Relevant Federal, State, or Local Standards - §354.28(b)(5)

No Federal, State, or local standards exist for chronic lowering of groundwater elevations.

8.4.2.6 Method for Quantitative Measurement of Minimum Thresholds - §354.28(b)(6)

Conformance of Subbasin conditions to the established groundwater elevation MTs will be assessed through direct measurement of water levels from existing RMS. Groundwater level monitoring will be conducted in accordance with the monitoring plan outlined in Chapter 7.0 and will comply with the requirements of the technical and reporting standards included in SGMA regulations. As noted in Chapter 7.0, the existing groundwater monitoring network in the Subbasin includes 13 wells.

8.4.3 Measurable Objectives - §354.30(a)-(g)

The MOs for chronic lowering of groundwater levels represent target groundwater elevations that are established to achieve the sustainability goal by 2042. MOs are groundwater levels established at each RMS. MO groundwater levels are higher than MT groundwater levels and provide operational flexibility above MTs to ensure that the Subbasin be sustainably managed over a range of climate and hydrologic variability. MOs are subject to change by the GSAs after GSP adoption as new information and hydrologic data become available.

8.4.3.1 Information and Methods Used for Establishing Chronic Lowering of Groundwater Level Measurable Objectives §354.30(b)

Preliminary MOs were established based on historical groundwater level data, along with input and desired future groundwater levels from domestic groundwater users, agricultural interests, environmental interests, and other Subbasin stakeholders. The input and desired conditions were used to formulate a range of alternative MO options, which were discussed by the GSA. Final MOs were discussed with and approved by the GSA.

Preliminary MOs were established based on evaluation of historical groundwater level data and input regarding desired future groundwater levels from domestic groundwater users, agricultural interests, environmental interests, and other public stakeholders. The input and desired conditions were used to formulate a range of conceptual MO scenarios. These scenarios were evaluated during this GSP preparation to project the effects of future Basin operation and to select measurable objectives for the GSP.

The MOs for the chronic lowering of groundwater levels sustainability indicator is equal to the average Spring water level at each RMS during the period of 2015 through 2021. The MO takes the following into consideration: none of the RMS wells in the Subbasin indicate a groundwater pumping induced chronic lowering of groundwater levels, Subbasin stakeholders have not reported experiencing any undesirable results related to lowering of groundwater levels, the Subbasin water budget (see Chapter 6.0) indicates the Subbasin is in approximate equilibrium, groundwater recharge in the Subbasin is moderated by managed releases from Lopez Reservoir, and recent historical low groundwater levels measured at RMS correspond with the current drought period. In addition to the previously listed factors, the period of Spring 2015 through Spring 2021 was selected to represent recent groundwater level conditions, and not to attempt to restore groundwater conditions, including water levels, to those occurring prior to 2015 (SGMA implementation).

MTs and MOs will be reviewed throughout the twenty-year SGMA planning horizon to assess if the RMSs and the assigned MOs and MTs remain protective of sustainable conditions in the Subbasin. MTs and MOs may be modified in the future as hydrogeologic conditions are monitored through the implementation phase of SGMA.

8.4.3.2 Interim Milestones §354.30(a)(e)

Interim milestones (IMs) are required to be included in the GSP. IMs at 5-year intervals for the MOs established at each RMS are included on Table 8-1.

Preliminary IMs were developed for the 4 RMS wells established for the Subbasin. Although there has been no chronic lowering of groundwater levels in the Subbasin, IMs were generally selected to define a smooth linear increase in water levels between the observed groundwater elevation at the RMS in 2021, and the MO as presented in Table 8-1.

IMs may be adjusted at any time during the SGMA timeline. Failure to meet IMs is not in and of itself an indication of undesired conditions but is meant to provide information determining whether the 20-year goals are on track to being achieved. Alternative projects and management actions may be considered or pursued if the IMs are not being met. Table 8-1 summarizes the interim milestones for the RMS.

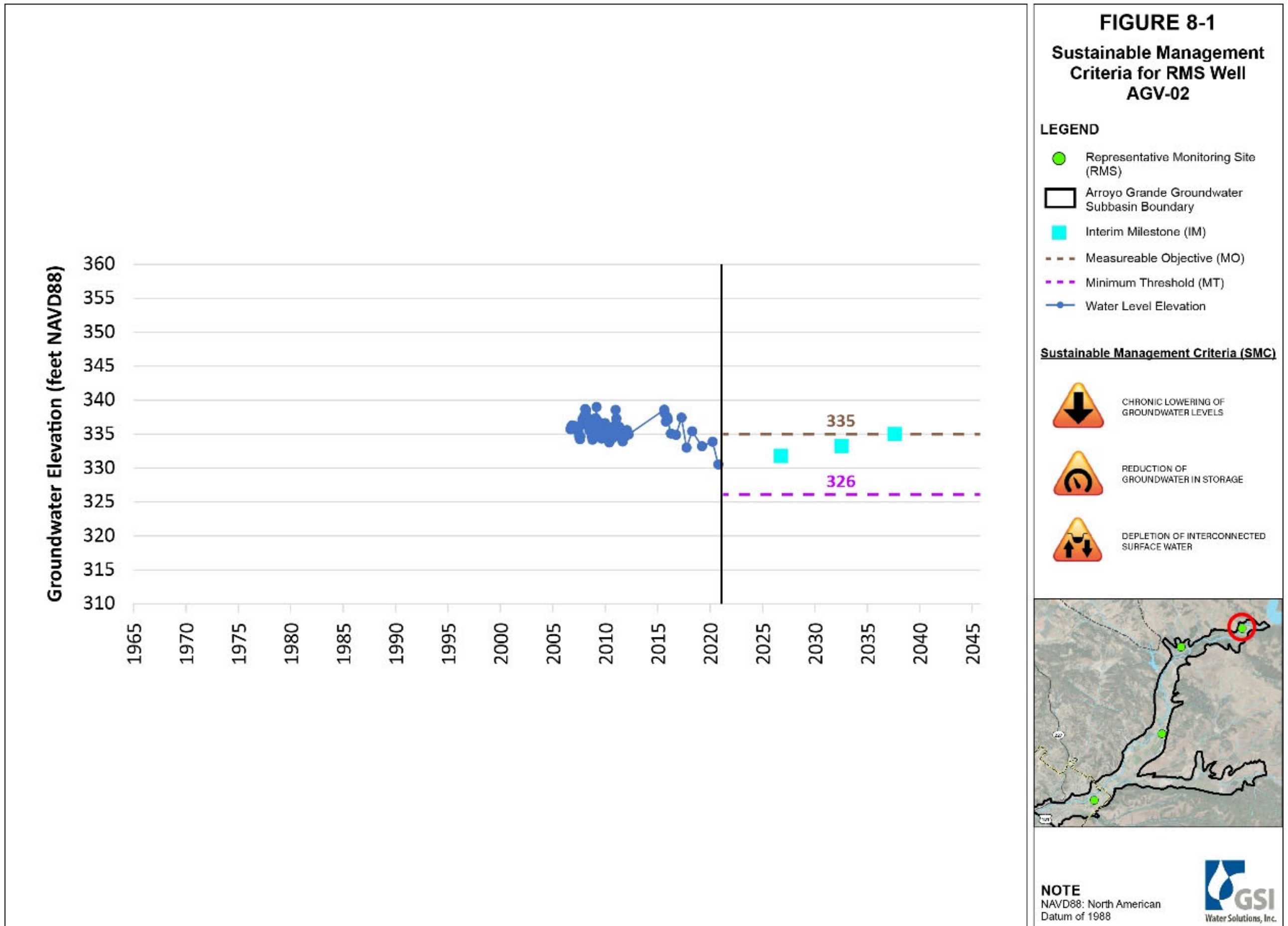

Figure 8-1. Sustainable Management Criteria for RMS Well AGV-01

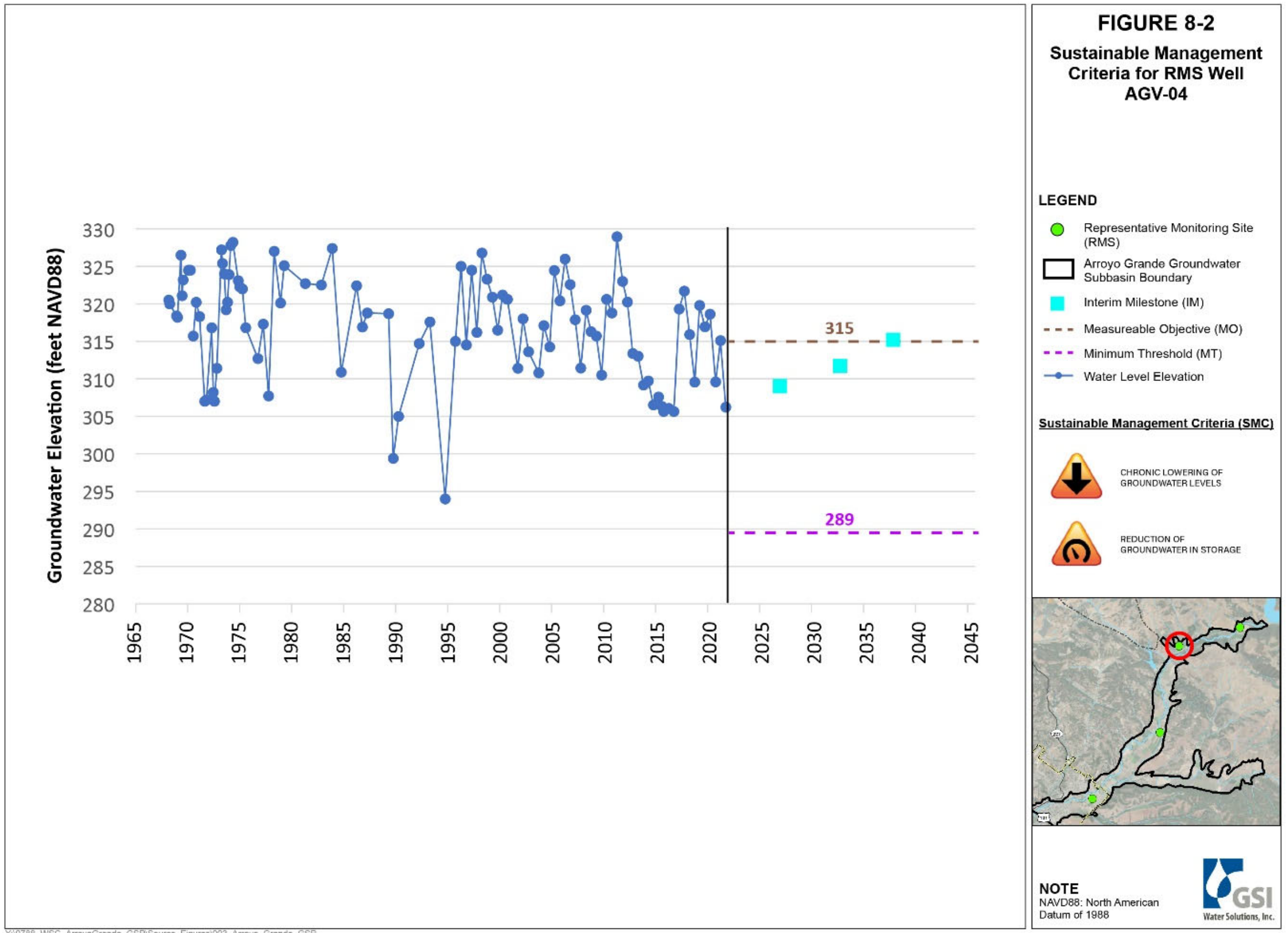

Figure 8-2. Sustainable Management Criteria for RMS Well AGV-03

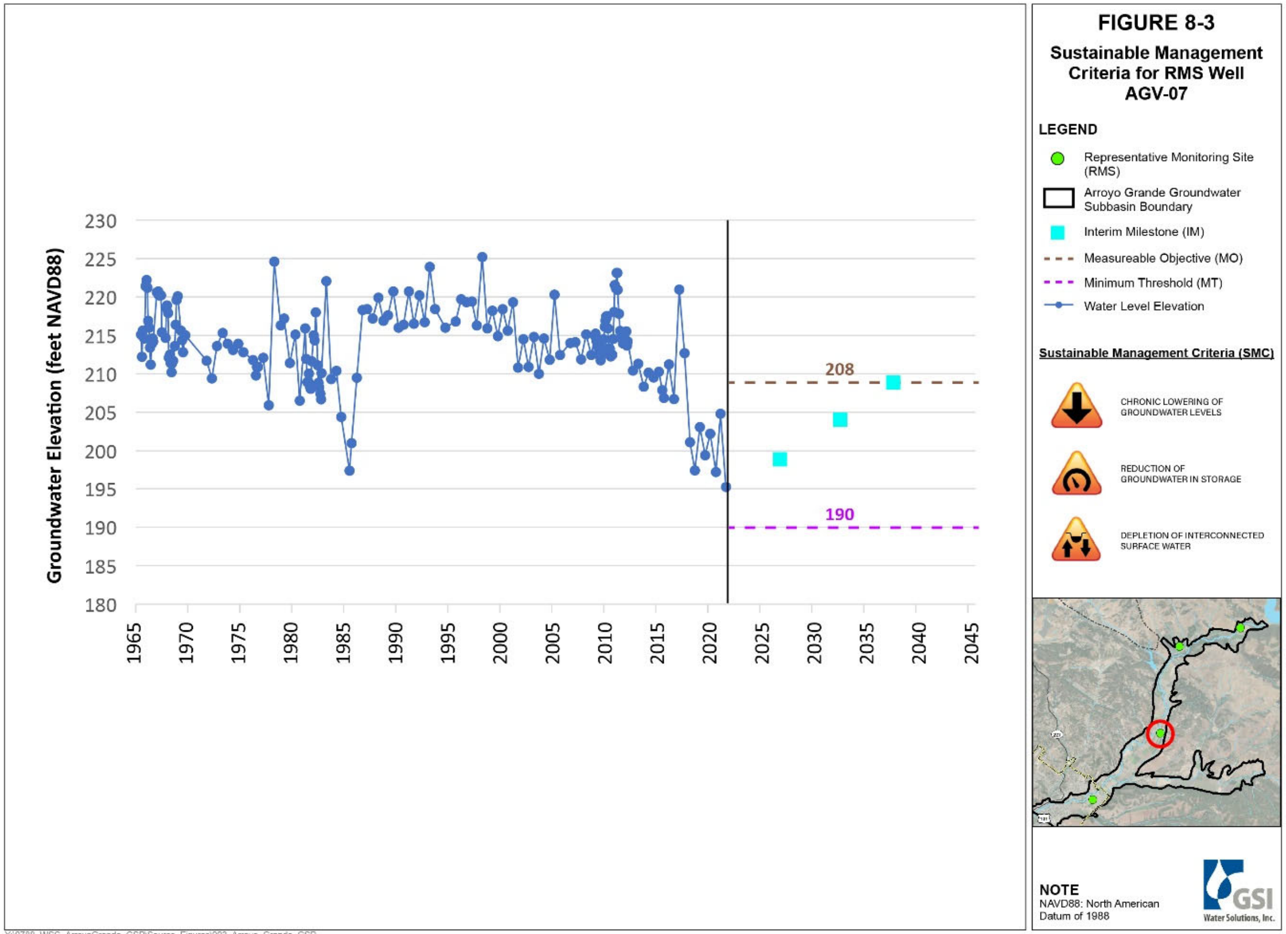

Figure 8-3. Sustainable Management Criteria for RMS Well AGV-06

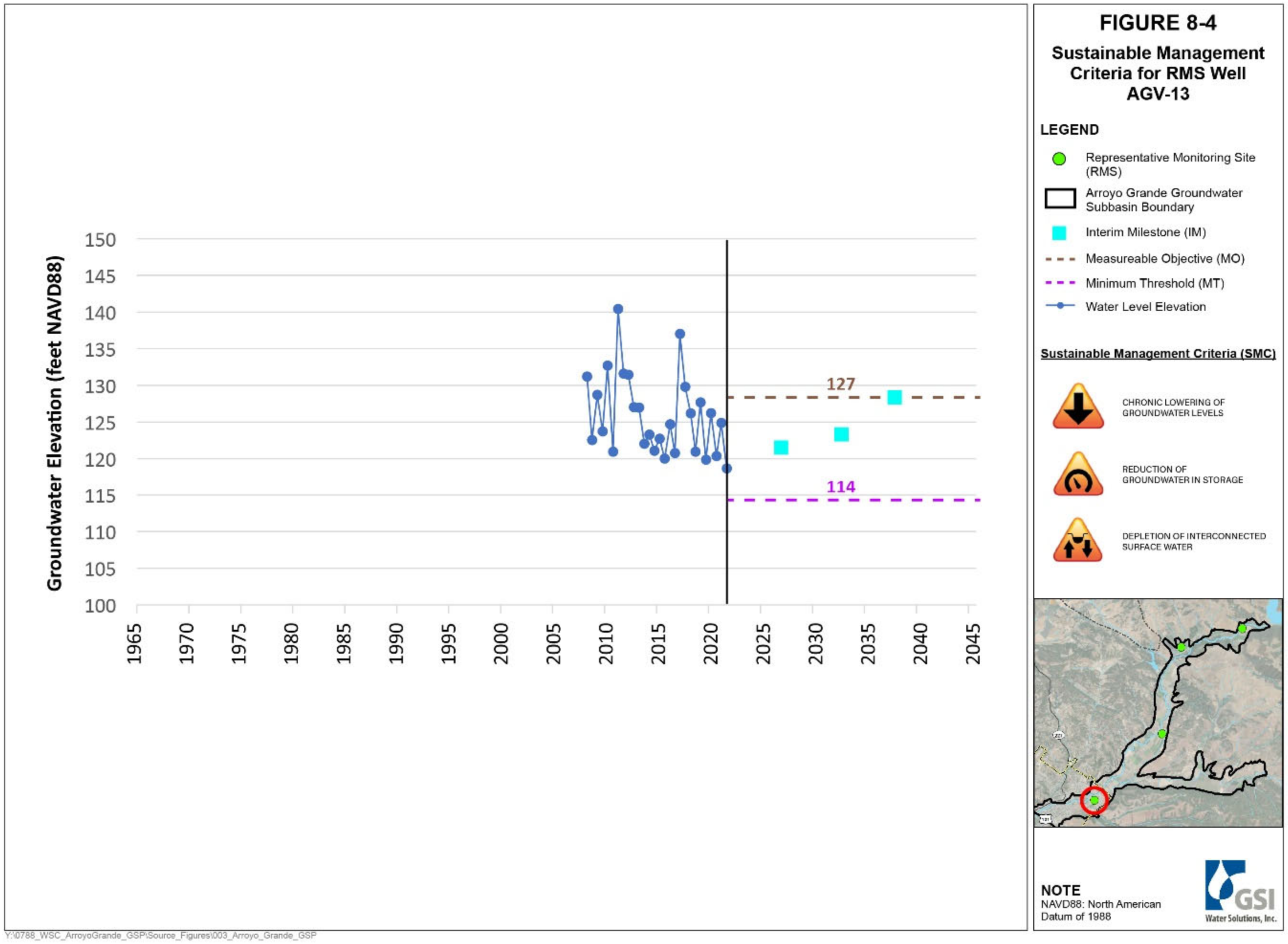

Figure 8-4. Sustainable Management Criteria for RMS Well AGV-12

8.5 Reduction of Groundwater in Storage Sustainability Indicator §354.28(c)(2)

8.5.1 Undesirable Results

As per §354.26 of the SGMA regulations, locally defined significant and unreasonable conditions were assessed based on review of historical groundwater data and stakeholder input during public meetings, analysis of available data, and discussions with GSA staff. It is recognized based on well-established hydrogeologic principles that the Reduction of Groundwater Storage Sustainability Indicator is directly correlated to the lowering of water level Sustainability Indicator. Significant and unreasonable changes in groundwater storage in the Subbasin are those that:

- Lead to long-term reduction in groundwater storage.
- Interfere with other Sustainability Indicators.

Assessment of groundwater in storage will initially be evaluated with the same RMS wells and associated water level MTs and MOs as the chronic lowering of groundwater levels sustainability criteria. As additional data is collected in the monitoring network described in Chapter 7.0, new RMS wells may be established, and revised SMCs may be determined by the GSAs, if they judge it to be appropriate.

For the purposes of this GSP, the definition of undesired conditions for the Reduction of Groundwater Storage Sustainability Indicator is as follows:

> *The Subbasin will be considered to have undesirable results if one or more RMSs for water levels display exceedances of the minimum threshold groundwater elevation values for two consecutive fall measurements. MT exceedances will require investigation to determine if local or basin wide actions are required in response.*

8.5.1.1 Criteria for Establishing Undesirable Results §354.2(b)(2)

Significant and unreasonable Reduction of Groundwater Storage in the Subbasin are those that:

- Reduce the ability of existing domestic wells of average depth to produce adequate water for domestic purposes (drought resilience).
- Cause significant financial burden to those who rely on the groundwater subbasin.
- Interfere with other SGMA Sustainability Indicators.

8.5.1.2 Potential Causes of Undesirable Results §354.2(b)(1)

Conditions that could theoretically lead to an undesirable result include the following:

- Development of additional municipal or agricultural pumping at significantly higher rates than are currently practiced.
- Expansion of de minimis pumping. Adding domestic de minimis pumpers in the areas of the Subbasin administered by the County may result in lower groundwater elevations, and an exceedance of the proxy minimum threshold.

- Extensive, unanticipated drought. Minimum thresholds are established based on reasonable anticipated future climatic conditions. Extensive, unanticipated droughts more severe than those on record may lead to excessively low groundwater recharge and unanticipated high pumping rates that could cause an exceedance of the proxy minimum threshold.

8.5.1.3 Effects of Undesirable Results on Beneficial Users and Land Uses §354.2(b)(3)

The effects of these undesirable results on the beneficial users and uses are the same effects as those discussed for the Chronic Lowering of Groundwater Levels Sustainability Indicator. The primary effects on the beneficial users (§354.26 (b)(3)) occurs from allowing consecutive exceedances of the MT at any RMS. Allowing one exceedance in an RMS is reasonable if subsequent monitoring indicates groundwater level have recovered above the respective MT. If an MT at an RMS is exceeded in succession during two or more monitoring events, it indicates that significant and unreasonable effects are likely being experienced by, at a minimum, some beneficial users in the Subbasin. Exceedances of MTs will require investigation to determine the significance and causes of the observed conditions.

8.5.2 Minimum Thresholds §354.28(c)(2)

Section §354.28(c)(2) of the SGMA regulations states that “The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.”

As allowed in §354.36(b)(1) of the SGMA regulations, groundwater elevation data at the RMS will be reported annually as a proxy to track changes in the amount of groundwater in storage. Based on well-established hydrogeologic principles, stable groundwater elevations maintained above the MTs will limit depletion of groundwater from storage. Therefore, using groundwater elevations as a proxy, the MT is that the groundwater surface elevation averaged across all the wells in the groundwater level monitoring network will remain stable above the MT for chronic lowering of groundwater levels. A summary of MTs and MOs used in the definition of Undesirable Conditions for the Reduction of Groundwater in Storage Sustainability Indicator are presented along with other indicators in Table 8-1. Figure 8-1 through Figure 8-4 present historical groundwater elevation hydrographs and the MTs selected for the four RMS wells defined in the Subbasin. Figure 8-5 presents all of these hydrographs on a map of the Subbasin to demonstrate the spatial distribution of RMSs in the Subbasin.

8.5.2.1 Information and Methods Used for Establishing Reduction of Storage Minimum Thresholds §354.28(b)(1)

As with the chronic reduction of groundwater levels Sustainability Indicator, the primary source of data that was evaluated for the Sustainability Indicator of reduction of groundwater storage is historical groundwater elevation data maintained by the County. The information used for establishing the MOs and MTs for the chronic lowering of groundwater levels Sustainability Indicator included:

- Historical groundwater elevation data from wells monitored by the County of San Luis Obispo.
- Depths and locations of existing wells.
- Maps of current and historical groundwater elevation data.
- Input from stakeholders regarding significant and unreasonable conditions and desired current and future groundwater elevations communicated during public meetings and solicitation of public comment on various options of MTs and MOs presented in the public forum.

Storage MTs will be measured by collecting water level measurements at the RMS sites in the monitoring network. The monitoring network and protocols used to measure groundwater elevations at the RMS are presented in Chapter 7.0. The Water Level Monitoring Network is presented in Figure 7-1. This data will be used to monitor groundwater elevations and assess changes in groundwater storage.

8.5.2.2 Relationship between Individual Minimum Thresholds and Other Sustainability Indicators §354.28(b)(2)

The reduction in groundwater storage MT could influence other Sustainability Indicators. The reduction in groundwater storage MT was selected to avoid undesirable results for other Sustainability Indicators, as outlined below:

- **Chronic lowering of groundwater levels.** Because groundwater elevations will be used as a proxy for estimating changes in groundwater storage, the potential reduction in groundwater storage would not cause undesirable results for this Sustainability Indicator.
- **Seawater intrusion.** This Sustainability Indicator is not applicable to this Subbasin.
- **Degraded water quality.** The chronic lowering of groundwater levels minimum threshold being used as a proxy for the reduction of groundwater in storage sustainability indicator is not expected to lead to a degradation of groundwater quality because groundwater levels would remain approximately within historical range.
- **Subsidence.** No significant land subsidence has historically occurred in the Subbasin. Therefore, the proposed minimum thresholds for this sustainability indicator will not induce any significant subsidence, because water levels would remain approximately within the historical range.
- **Depletion of interconnected surface waters.** Groundwater levels measured at RMSs (AGV-02, AGV-07, and AGV-13) will serve as a proxy for depletion of interconnected surface water. In addition, stream flow gages along Arroyo Grande Creek will continue to measure surface water conditions in Arroyo Grande Creek Valley. Reported releases from Lopez Reservoir and measured stream flow data from the three existing stream gage sites along Arroyo Grande Creek are adequate to allow for generation of information on surface water inflow and outflow in the Subbasin, allowing for direct measurement of surface water gains and losses to the groundwater systems based on future hydrologic and pumping conditions in the Subbasin. Groundwater level MTs are defined at levels designed to avoid significant water declines, including surface water, with the goal of minimizing any potential significant depletion of interconnected surface

water flows. It is important to note that the Lopez Reservoir Dam is currently undergoing a relicensing process which includes the development of a Habitat Conservation Plan. The Habitat Conservation Plan is subject to review and approval which contains elements including managed Lopez Reservoir releases. Any potential modification to planned releases could have an impact on groundwater levels, and consequently interconnected surface water, in the Subbasin.

8.5.2.3 Effects of Minimum Thresholds on Neighboring Basins §354.28(b)(3)

Two neighboring groundwater basins share a boundary with the Subbasin; the San Luis Obispo Valley Basin to the northwest near Orcutt Road, and the Santa Maria River Valley – Santa Maria Subbasin to the southwest with U.S. Highway 101 coincident with the boundary. The shared boundary with both of these basins is not extensive, and the HCM posits that a groundwater divide separates the groundwater between those basins and the Subbasin. In the Subbasin there have been no trends indicating pumping induced chronic groundwater declines that would affect either neighboring basin. It is not anticipated that actions, if any, associated with the GSP will have any significant impact on either the San Luis Obispo Valley Basin or the Santa Maria River Valley – Santa Maria Subbasin.

Additionally, the Subbasin's GSAs have developed a cooperative working relationship with both the San Luis Obispo Valley Basin GSA and the Northern Cities management Area of the Santa Maria River Valley Groundwater Basin. Hydrogeologic conditions near the basin boundaries will be monitored, and any issues potentially affecting those basins will be communicated.

8.5.2.4 Effects of Minimum Thresholds on Beneficial Uses and Users §354.28(b)(4)

The MT for reduction in groundwater storage will maintain approximately historical groundwater elevations but may require a reduction in the amount of groundwater pumping in the Subbasin, or development of sources of supplemental water if additional pumping is proposed in the Subbasin. Reducing pumping may impact the beneficial uses and users of groundwater in the Subbasin.

The practical effect of this GSP for protecting against the reduction in groundwater storage undesirable result is that it encourages minimal long-term net change in groundwater elevations and storage. Seasonal and drought cycle variations are expected, but during average conditions and over the long-term, beneficial users will have access to adequate volumes of water from the aquifer to service the needs of all water use sectors. The beneficial users of groundwater are protected from undesirable results.

Agricultural Land Uses and Users

The MT for reduction in groundwater storage may limit expansion of non-de minimis production in the Subbasin by reducing the amount of available water. The practical effect of these MTs on agricultural users is that expansion of current agricultural pumping may not be sustainable without development of additional sources of water to the Subbasin. Owners of undeveloped agricultural lands that are currently not irrigated may be particularly impacted because the additional groundwater pumping needed to irrigate these lands could increase the Subbasin pumping beyond the sustainable yield, exceeding the MT. Existing agricultural operations may also be limited in their use of more water-intensive crops, expansion of existing irrigated lands, and by periods of extended drought that decrease the quantity of water naturally returning to the Subbasin.

Urban Land Uses and Users

The MTs effectively limit the amount of groundwater pumping in the Subbasin. However, the MTs in the Subbasin are established below currently observed groundwater elevations (historical lows at select RMSs) to allow for reasonable future operational range of water levels while avoiding significant and undesirable results associated with lowering of groundwater levels. If groundwater elevations decline in the immediate vicinity of Arroyo Grande Creek, this could potentially result in less groundwater discharge to the creek due to areas of interconnected surface water. Impacts to stream flows will be monitored with the current data collection programs in the Subbasin.

Domestic Land Uses and Users

The groundwater elevation MTs are established to protect as many domestic wells as possible. Therefore, the MTs will likely have an overall beneficial effect on existing domestic land uses by protecting the ability to pump from domestic wells within the Subbasin. Additionally, the groundwater elevation MTs may limit the increase of non-de minimis groundwater use in order to limit future declines in groundwater levels caused by non-de minimis pumping.

Ecological Land Uses and Users

Groundwater dependent ecosystems would generally benefit from this MT. Maintaining groundwater levels close to current levels keeps groundwater supplies near present levels, which will continue to support groundwater dependent ecosystems.

8.5.2.5 Relation to State, Federal, or Local Standards §354.28(b)(5)

No federal, state, or local standards exist for reductions in groundwater storage.

8.5.2.6 Methods for Quantitative Measurement of Minimum Threshold §354.28(b)(6)

The quantitative metric for assessing compliance with the reduction in groundwater in storage MT is monitoring groundwater elevations. The approach for quantitatively evaluating compliance with the MT for reduction in groundwater in storage will be based on evaluating groundwater elevations at the RMS wells.

8.5.3 Measurable Objectives §354.30(a)-(g)

The change of groundwater in storage Sustainability Indicator uses groundwater levels as a proxy for direct calculation of groundwater in storage. The same MTs and MOs are used as are defined in the chronic lowering of groundwater level indicator to protect against significant and unreasonable reduction of groundwater in storage.

8.5.3.1 Information and Methods Used for Establishing Reduction of Groundwater Storage Measurable Objectives §354.30(b)

The reduction of groundwater in storage Sustainability Indicator uses the chronic lowering of groundwater levels Sustainability Indicator as a proxy; therefore, the same MOs and information and methods to establish MOs described in Section 8.4.3 apply. MOs for each RMS included on Table 8-1.

8.5.3.2 Interim Milestones §354.30(a)(e)

Interim milestones for groundwater storage are the same as those established for chronic lowering of groundwater elevations. Achieving the groundwater elevation interim milestones will also eliminate long term reductions of groundwater in storage. Interim milestones for each RMS are included on Table 8-1.

8.6 Seawater Intrusion Sustainability Indicator §354.28(c)(3)

This Sustainability Indicator does not apply to the Basin since the Basin is not a coastal basin.

8.7 Degradation of Groundwater Quality Sustainability Indicator §354.28(c)(4)

The purpose of the Degraded Water Quality Indicator in SGMA is to prevent any degradation in groundwater quality as a result of groundwater management under the GSP. SGMA is not intended to serve as impetus to improve water quality within the Subbasin. The Subbasin's current water quality is not considered degraded. For these reasons, the SMC in this section is set to maintain current conditions in the Subbasin, protecting groundwater quality from potential degradation as a result of groundwater management under this GSP.

8.7.1 Undesirable Results §354.26(a)-(d)

Section §354.28(c)(2) of the SGMA regulations states that "The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin."

By SGMA regulations, the Degraded Groundwater Quality undesirable result is a quantitative combination of groundwater quality minimum threshold exceedances. As discussed in Chapter 5.0, the primary constituents of concern in the Subbasin are TDS and Nitrates. Additionally, water quality samples are collected at irregular intervals at these wells under existing regulatory programs but are not collected annually. The undesirable results for the Degraded Water Quality Sustainability Indicator as defined for the purposes of this GSP are as follows:

The Basin will be considered to have Undesirable Results if, during the first five-year implementation period, groundwater quality minimum threshold exceedances are observed at more than two of the representative monitoring sites in the Basin, in relation to 2015 Basin conditions, as a result of groundwater management implemented as part of the GSP.

There are seven wells in the Water Quality Monitoring Network (Figure 7-2). Since the undesirable result is based on a total number of these wells exceeding the MTs, all seven wells displayed in Figure 7-2 are effectively RMS wells (I.e., there is no subset of the Water Quality network defined as RMSs; all seven wells serve as RMSs.) The undesirable conditions for degraded water quality in the Basin are based on the goal of no more than two of the seven of the RMSs for water quality exceedances that can occur as a result of GSP groundwater management activities over each 5-year management period. Based on the current number of wells (seven) in the existing water quality monitoring network described in Chapter 7.0, a maximum of two wells that can exceed the minimum thresholds.

Specifics regarding the definition of the MTs used in defining the Undesirable Results are detailed in the following sections. A summary of the MTs defined for the Degradation of Water Quality Sustainability Indicator are presented in Table 8-2.

Table 8-2. Water Quality Minimum Thresholds

ID	TDS MT (ppm)	NO3 MT (ppm)
WQ-1	800	10
WQ-2	800	10
WQ-3	800	10
WQ-4	800	10
WQ-5	800	10
WQ-6	900	10
WQ-7	900	10

8.7.1.1 Criteria for Establishing Undesirable Results §354.26(b)(2)

Criteria used to establish the Undesirable Results for Degraded Water Quality Sustainability Indicator are observed water quality data and trends that:

- Reduce capacity of public water supply systems or unreasonably increase costs for public or private water supply.
- Reduce crop production.

- Result in constituent concentrations above regulatory primary drinking water standards at supply wells.
- Results in constituent concentrations significantly above the established baseline or mean for secondary standards (TDS)

8.7.1.2 Potential Causes of Undesirable Results §354.26(b)(1)

Conditions that may lead to an undesirable result include the following:

- Changes to Basin Pumping: If the location and rates of groundwater pumping change as a result of projects implemented under the GSP, these changes could cause movement of one of the constituents of concern towards a supply well at concentrations that exceed relevant water quality standards or induce the movement of poorer quality water from underlying bedrock formations into the alluvial aquifer.
- Recharge of Poor-Quality Water: Recharging the Basin with water that exceeds a primary or secondary MCL or concentration that reduces crop production could lead to an undesirable result. However, permitting requirements generally preclude this circumstance.

8.7.1.3 Effects of Undesirable Results on Beneficial Users and Land Uses §354.26(b)(3)

As defined in this GSP, undesirable results are established to prevent degradation of water quality within the Basin prior to the implementation of any actions inherent in the management of groundwater in the Basin. This limits the potential impacts of undesirable water quality on beneficial users in the Basin. However, potential effects of undesirable results include:

- Increased water treatment costs for public or private supply wells
- Reduced agricultural production

8.7.2 Minimum Thresholds § 354.28(c)(4)

8.7.2.1 Information and Methods Used for Establishing Degradation of Water Quality Minimum Thresholds § 354.28 (b)(1)

Locally defined significant and unreasonable conditions were assessed based on federal and state mandated drinking water and groundwater quality regulations, the Sustainable Management Criteria survey, public meetings, and discussions with GSA staff. Significant and unreasonable changes in groundwater quality in the Basin are increases in a chemical constituent that either:

- Result in groundwater concentrations in a public supply well above an established primary MCL, or
- Lead to reduced crop production.

The information used for establishing the degraded groundwater quality minimum thresholds included:

- Historical groundwater quality data from production wells in the Basin
- Federal and state primary drinking water quality standards
- RWQCB Basin objectives for groundwater quality (2019) for TDS

- Feedback about significant and unreasonable conditions from GSA staff members or public stakeholders.

Based on the review of groundwater quality in Chapter 5.0, water quality in the basin is generally adequate for agricultural purposes and domestic use. The primary constituents of concern that exist for both agricultural wells and public supply wells are:

- Total Dissolved Solids (TDS)
- Nitrate

The historical groundwater quality data used to evaluate groundwater quality minimum thresholds are presented in Chapter 5.0 (Figure 5-16 and Figure 5-17).

As stated in Section 8.7.1, the SGMA regulations allow three options to develop an approach for setting degraded water quality minimum thresholds (number of wells, volume of water, or location of concentration isocontour).

In the Subbasin, degraded water quality minimum thresholds for nitrates are based on EPA-published water quality standards (EPA, 2018); the primary MCL for nitrate in drinking water is 10 mg/L.

The published Basin Objective for TDS in the Arroyo Grande Creek Valley is 800 mg/L (RWQCB, 2017). However, it should be noted that the area for which this Basin Objective is applicable is not entirely coincident with the Subbasin; it includes the area downstream of the Subbasin as well. In addition, it is established that groundwater in portions of the Subbasin has TDS concentrations that currently exceed this objective (Figure 5-16). It is not the objective of SGMA to promulgate unreasonable goals for water quality improvement. Therefore, if historical data for the Water Quality RMS wells indicates a time series of values that exceed the Basin Objective, the MTs for TDS are defined as the maximum observed TDS concentration in the period of record for that well.

As noted in Section 354.28 (c)(4) of the SGMA regulations, minimum thresholds are based on a degradation of groundwater quality, not an improvement of groundwater quality. Therefore, this GSP was developed to avoid taking actions that may inadvertently move groundwater constituents that have already been identified in the Basin in such a way that they have a significant and unreasonable impact that would not otherwise occur.

The MTs for the constituents of concern are presented in Table 8-2.

8.7.2.2 Relation of Minimum Thresholds to Other Sustainability Indicators § 354.28(b)(2)

The groundwater quality minimum thresholds were set for each of the constituents previously discussed. These minimum thresholds were derived from existing data measured at individual wells and applicable regulatory criteria. There are no conflicts between the existing groundwater quality data. Because the underlying groundwater quality distribution is reasonable and realistic, there is no conflict that prevents the Basin from simultaneously achieving all minimum thresholds.

No actions regarding the MTs for Water Quality will directly influence other Sustainability Indicators. However, preventing migration of poor groundwater quality (for example, actions required to prevent additional migration of contaminant plumes) could theoretically limit activities needed to achieve minimum thresholds for other Sustainability Indicators, as discussed below:

- **Change in groundwater levels.** Groundwater quality minimum thresholds could influence groundwater level minimum thresholds by limiting the types of water that can be used for recharge to raise groundwater levels or locations where it could be recharged. Water used for recharge cannot exceed any of the groundwater quality minimum thresholds.
- **Change in groundwater storage.** Nothing in the groundwater quality minimum thresholds promotes pumping in excess of the sustainable yield. The groundwater quality minimum thresholds will not result in an exceedance of the groundwater storage minimum threshold.
- **Seawater intrusion.** This Sustainability Indicator is not applicable to this basin.
- **Subsidence.** Nothing in the groundwater quality minimum thresholds promotes a condition that will lead to additional subsidence and therefore, the groundwater quality minimum thresholds will not result in a significant or unreasonable level of subsidence.
- **Depletion of interconnected surface waters.** Nothing in the groundwater quality minimum thresholds promotes additional pumping or lower groundwater elevations in areas where interconnected surface waters may exist. Therefore, the groundwater quality minimum thresholds will not result in a significant or unreasonable depletion of interconnected surface waters.

8.7.2.3 Effect of Minimum Thresholds on Neighboring Basins § 354.28(b)(3)

Because the HCM posits a groundwater divide between the Arroyo Grande Subbasin and the adjacent San Luis Obispo Basin, there is no anticipated effect of the degraded groundwater quality minimum thresholds on the neighboring Basins. The Northern Cities Management Area of the Santa Maria Groundwater Basin is routinely monitored for water quality, and the MTs established herein for the Arroyo Grande Subbasin are not expected impact water quality in the NCMA.

8.7.2.4 Effects of Minimum Thresholds on Beneficial Users and Land Uses § 354.28(b)(4)

The practical effect of the MTs for the Degraded Groundwater Quality Sustainability Indicator is that it deters any significant long-term changes to groundwater quality in the Basin. Therefore, Basin management that prevents the undesirable results from occurring will not constrain the use of groundwater, nor have a negative effect on the beneficial users and uses of groundwater.

Agricultural land uses and users. The degraded groundwater quality minimum thresholds generally benefit the agricultural water users in the Basin by maintaining groundwater quality suitable for use in agriculture. For example, limiting the number of additional agricultural supply wells that may exceed constituent of concern concentrations (for example, TDS) that could reduce crop production ensures that a supply of usable groundwater will exist for beneficial agricultural use.

Urban land uses and users. The degraded groundwater quality minimum thresholds generally benefit the urban water users in the Basin, although the City's wells in the Subbasin are rarely used for municipal supply. Limiting the number of additional wells where constituents of concern could exceed primary or secondary MCLs ensures an adequate supply of quality groundwater for municipal use. Management of the Basin to prevent occurrences of these MTs may also result in lowered costs for water treatment. Existing State, Federal, Public Health or Municipal regulations may require that a well not be used if MCLs are exceeded and may supersede any actions related to SGMA-related MT exceedances. Wells in violation of federal, state, and local water quality regulations will have to comply with the specific regulations.

Domestic land uses and users. The degraded groundwater quality minimum thresholds generally benefit the domestic water users in the Basin by maintaining current and acceptable water quality.

Ecological land uses and users. Although the groundwater quality minimum thresholds do not directly benefit ecological uses, it can be inferred that the degraded groundwater quality minimum thresholds generally benefit the ecological water uses in the Basin. Preventing constituents of concern from migrating will prevent unwanted contaminants from impacting ecological groundwater supply.

8.7.2.5 Relevant Federal, State, or Local Standards § 354.28(b)(5)

The Degraded Groundwater Quality minimum thresholds specifically incorporate federal and state drinking water standards.

8.7.2.6 Method for Quantitative Measurement of Minimum Thresholds § 354.28(b)(6)

The Degraded Groundwater Quality minimum thresholds will be directly measured using analytical laboratory results of sampling conducted at the RMSs of the Water Quality Monitoring Network presented in Chapter 7.0. Groundwater quality will initially be measured using existing monitoring programs.

- Exceedances of primary or secondary MCLs will be monitored by reviewing water quality reports submitted to the California Division of Drinking Water by municipalities and small water systems for the wells that are included in the Water Quality Monitoring Network, and of agricultural wells being monitored under the Irrigated Lands program.

8.7.3 Measurable Objectives § 354.30(a)-(g)

Groundwater quality should not be degraded due to actions taken under this GSP and, therefore, the measurable objectives are defined as zero exceedances as a result of groundwater management, in samples from the Water Quality Monitoring Network wells over the 20-year SGMA planning horizon.

8.7.3.1 Information and Methods Used for Establishing Degradation of Water Quality Measurable Objectives § 354.30(b)

Because protecting groundwater quality is important to the beneficial users and uses of the resource, the measurable objective for the Degradation of Water Quality Sustainability Indicator is defined as zero exceedances of the MTs over the 20-year SGMA planning horizon. Any exceedance will be reviewed by the GSAs to determine its significance and potential responses.

8.7.3.2 Interim Milestones § 354.28(a)(e)

Interim milestones show how the GSAs anticipate moving from current conditions to meeting the measurable objectives. For water quality, measurable objectives are set at the current number of water quality exceedances, which in this case is zero. Interim milestones are set for each five-year interval following GSP adoption. The interim milestones for degraded groundwater quality are defined as zero exceedances of the MT for each constituent of concern for 5, 10 and 15 years after GSP adoption.

8.8 Land Subsidence Sustainability Indicator § 354.28(c)(5)

8.8.1 Undesirable Results § 354.26(a)-(d)

Locally defined significant and unreasonable conditions for the Land Subsidence Sustainability Indicator were assessed based on public meetings and discussions with GSA staff. Significant and unreasonable rates of land subsidence in the Basin are those that lead to a permanent subsidence of land surface elevations that impact infrastructure. For clarity, this Sustainable Management Criterion references two related concepts:

- Land Subsidence is a gradual settling of the land surface caused by, among other processes, compaction of subsurface materials due to lowering of groundwater elevations from groundwater pumping. Land subsidence from dewatering subsurface clay layers can be an inelastic process, and the potential decline in land surface could be permanent.
- Land Surface Fluctuation is the periodic or annual measurement of the ground surface elevation. Land surface may rise or fall in any one year. Declining land surface fluctuation may or may not indicate long-term permanent subsidence.

As discussed in Chapter 4.0 (Basin Setting), no significant subsidence has historically been documented in the Subbasin. Currently, InSAR data provided by DWR shows that no significant land subsidence occurred in the Basin during the period between June 2015 and September 2019 (Figure 4-13).

By regulation, the ground surface Land Subsidence undesirable result is a quantitative combination of subsidence minimum threshold exceedances. For the Basin, no long-term subsidence that impacts infrastructure (including commercial buildings, homes, utility infrastructure, etc.) is acceptable. The Undesirable Results for the land subsidence Sustainability Indicator as defined for the purposes of this GSP are as follows:

The Basin will be considered to have Undesirable Results if measured subsidence using InSAR data, between June of one year and June of the subsequent year is greater than 0.1 foot in any 1-year, or a cumulative 0.5 foot in any 5-year period, as a result of groundwater management under the GSP, or any long-term permanent subsidence is attributable to groundwater management.

Should potential subsidence be observed, the GSAs will first assess whether the subsidence may be due to elastic processes. If the subsidence is not elastic, the GSAs will undertake a study to evaluate potential correlation between the observed subsidence and measured groundwater levels.

8.8.1.1 Criteria for Establishing Undesirable Results § 354.26(b)(2)

Criteria used to establish the Undesirable Results for Land Subsidence Sustainability Indicator are satellite-measured subsidence data (InSAR data) collected by DWR.

8.8.1.2 Potential Causes of Undesirable Results § 354.26(b)(1)

Conditions that may lead to an undesirable result include:

- A shift in pumping locations, which could lead to a substantial decline in groundwater levels.
- Shifting a significant amount of pumping and causing groundwater levels to fall in an area that is susceptible to subsidence, such as certain areas underlaying the City, could trigger subsidence in excess of the minimum threshold.

8.8.1.3 Effects of Undesirable Results on Beneficial Users and Land Uses § 354.26(b)(3)

The effects of these undesirable results on the beneficial users and uses (§354.26 (b)(3)) include the potential damage of critical infrastructure, and the potential damage of private or commercial structures that would adversely affect their uses. Staying above the minimum threshold will avoid the subsidence undesirable conditions.

8.8.2 Minimum Thresholds § 354.28(c)(5)

Section 354.28(c)(5) of the SGMA regulations states that "The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results."

Based on an analysis of potential errors in the InSAR data, as discussed in the following section, the subsidence minimum threshold is: The InSAR measured subsidence between June of one year and June of the subsequent year shall be no more than 0.1 foot in any single year and a cumulative 0.5 foot in any five-year period, resulting in no long-term permanent subsidence.

8.8.2.1 Information and Methods Used for Establishing Land Subsidence Minimum Thresholds § 354.28(b)(1)

Minimum thresholds are established to protect groundwater supply, land uses and property interests from substantial subsidence that may lead to undesirable results. Changes in surface elevation are measured using InSAR data available from DWR. The general minimum threshold is the absence of long-term land subsidence due to pumping in the Basin. The InSAR data provided by DWR, however, are subject to measurement error. DWR has stated that, on a statewide level, for the total vertical displacement measurements between June 2015 and June 2018, the errors are as follows (GSP, Paso Robles Basin, 2020):

1. The error between InSAR data and continuous GPS data is 16 mm (0.052 feet) with a 95% confidence level.
2. The measurement accuracy when converting from the raw InSAR data to the maps provided by DWR is 0.048 feet with 95% confidence level.

For the purposes of this GSP, the errors for InSAR data are considered the sum of errors 1 and 2, combined total error of 0.1 foot. Thus, measured land surface change of greater than 0.1 feet will be assessed as potential subsidence. As discussed previously, land surface elevations can fluctuate naturally. Therefore, subsidence will be monitored at the same time each year to reduce the effect of general fluctuations of elevation on observed data. Additionally, if subsidence is observed, a correlation to lowered groundwater elevations at RMS SLV-09 must exist for the minimum threshold to be exceeded.

Locally defined significant and unreasonable conditions are assessed based on historically observed water levels in areas of known past land subsidence, satellite-based measurements of land subsidence provided by DWR, public meetings, and discussions with GSA staff.

8.8.2.2 Relation of Minimum Thresholds to Other Sustainability Indicators § 354.28(b)(2)

Land Subsidence minimum thresholds have little or no impact on other minimum thresholds, as described below:

- **Chronic lowering of groundwater elevations.** The Land Subsidence minimum thresholds will not result in significant or unreasonable groundwater elevations.
- **Change in groundwater storage.** The Land Subsidence minimum thresholds will not change the amount of pumping and will not result in a significant or unreasonable change in groundwater storage.
- **Seawater intrusion.** This Sustainability Indicator is not applicable in the Basin.
- **Degraded water quality.** The Land Subsidence minimum thresholds will not change the groundwater flow directions or rates, and therefore and will not result in a significant or unreasonable change in groundwater quality.
- **Depletion of interconnected surface waters.** The Land Subsidence minimum thresholds will not change the amount or location of pumping and will not result in a significant or unreasonable depletion of interconnected surface waters.

8.8.2.3 Effect of Minimum Thresholds on Neighboring Basins § 354.28(b)(3)

The ground surface subsidence minimum thresholds are set to prevent any long-term subsidence that could harm infrastructure. Therefore, the subsidence minimum thresholds will not prevent the San Luis Obispo Basin or the Northern Cities Management Area from achieving sustainability.

8.8.2.4 Effects of Minimum Thresholds on Beneficial Users and Land Uses § 354.28(b)(4)

The Land Subsidence minimum thresholds are set to prevent subsidence that could harm infrastructure. Available data indicate that there is currently no subsidence occurring in the Basin that affects infrastructure, and reductions in pumping are already required by the reduction in groundwater storage Sustainability Indicator. Therefore, the Land Subsidence minimum thresholds do not require any additional reductions in pumping. However, in general the amount of pumping in the Los Osos Valley Road area must be kept at levels significantly lower than implemented in the 1990s.

Staying above the minimum threshold will avoid the Land Subsidence undesirable result and protect the beneficial uses and users from impacts to infrastructure and interference with surface land uses.

8.8.2.5 Relevant Federal, State, or Local Standard § 354.28(b)(5)

There are no federal, state, or local regulations related to subsidence.

8.8.2.6 Method for Quantitative Measurement of Minimum Thresholds § 354.28(b)(6)

Minimum thresholds will be assessed using DWR-supplied InSAR data.

8.8.3 Measurable Objectives § 354.30(a)-(g)

The measurable objectives for subsidence represent target subsidence rates in the Basin. Long-term ground surface elevation data do not suggest the occurrence of permanent subsidence in the Basin. Therefore, the measurable objective for subsidence is maintenance of current ground surface elevations.

8.8.3.1 Information and Methods Used for Establishing Land Subsidence Measurable Objectives 0§ 354.3(b)

The measurable objectives are set based on maintaining current conditions and changes are measured by DWR-supplied InSAR data.

8.8.3.2 Interim Milestones § 354.28(a)(e)

Interim milestones show how the GSAs anticipate moving from current conditions to meeting the measurable objectives. Interim milestones are set for each five-year interval following GSP adoption. Land Subsidence measurable objectives are set at current conditions of no long-term subsidence. There is no change between current conditions and sustainable conditions. Therefore, the interim milestones are identical to the minimum thresholds and measurable objectives.

8.9 Depletion of interconnected surface water Sustainability Indicator § 354.28(c)(6)

Natural hydraulic connections can exist between shallow groundwater systems and some surface water bodies. These surface water bodies can be gaining (receiving discharge from the alluvial aquifer) or losing (discharging water to the alluvial aquifer). These relationships may change in magnitude and direction across wet and dry cycles, and in response to changes in surface water operations or groundwater management practices. The total volume or rate of streamflow in a creek is dependent upon many factors other than contributions from groundwater. Precipitation, temperature, evapotranspiration, and influent streamflow from the upper contributing watershed area each individually have a much greater influence on streamflow than groundwater pumping.

Depletions of interconnected surface water occurs when there are decreased gains or increased losses in volumes of streamflow caused by lowered groundwater elevations associated with groundwater use. At certain levels, depletions may have adverse impacts on beneficial uses of the surface water and may lead to undesirable results.

Flux between a stream and the surrounding aquifer may be theoretically calculated using Darcy's Law:

Q = KIA, WHERE

Q = rate of the flux (ft^3/d)

K = Hydraulic conductivity of Aquifer (ft/day)

i = Hydraulic gradient between groundwater elevation and surface water elevations (ft/ft)

A = Cross Sectional Area of Groundwater Flow (ft^2)

Of the variables of Darcy's Law presented above, it is assumed that hydraulic conductivity and area of flow do not change with changing groundwater elevations; only the hydraulic gradient changes based on the groundwater elevation in the aquifer and the surface water elevation. A high groundwater elevation corresponds to a specific quantity of flux, while a lower groundwater elevation corresponds to a lesser flux quantity. So, although it is the quantity of flux that impacts GDEs, for the purposes of this GSP, this flux is defined and expressed in terms of the water level in the nearby alluvial sediments that results in the flux. If the groundwater elevation in the aquifer is greater than the elevation of the water surface in the stream, then the direction of flow is from the aquifer to the stream. If the water surface elevation of the stream is higher than the groundwater elevations, the direction of flow is from the stream to the surrounding aquifer. In order to accurately make this calculation, surveyed elevations of groundwater and surface water are necessary, as well as an estimate of hydraulic conductivity of the alluvial aquifer. If groundwater elevations in the vicinity of a stream are maintained such that the direction and magnitude of hydraulic gradient between the creek and the aquifer are not significantly changed, it follows that there will not be a significant or unreasonable depletion of Interconnected Surface Water flux between stream and aquifer. Therefore, groundwater levels in appropriate wells are judged to be a valid proxy for the quantification of depletion of interconnected surface water, and MTs defined in terms of groundwater elevations are a valid proxy for the corresponding amount of GW/SW flux.

Direct measurement of flux between an aquifer and an interconnected stream is not feasible using currently available data. Options to improve the collection of surface water and interconnected groundwater data are discussed in Chapter 7.0 (Monitoring Networks), and potential details for these tasks are discussed in Chapter 9 (Projects and Management Actions and Implementation). Until such time as this data is available, this GSP uses water level measurements in representative wells located near Arroyo Grande Creek as a proxy for the flux between the creek and the adjacent aquifer, consistent with the Darcy's Law analysis in the preceding paragraph, and as permitted under SGMA regulations.

8.9.1 Undesirable Results § 354.26(a)-(d)

The undesirable result for Depletions of Interconnected Surface Water is a result that causes significant and unreasonable adverse effects on beneficial uses of interconnected surface water within the Basin over the planning and implementation horizon of this GSP. As discussed in Section 8.9, measurement of the fluxes between the aquifer and Basin creeks is not feasible with currently available data. Therefore, water level measurements at the RMSs designated for the Depletion of Interconnected Surface Water Sustainability Indicator will be used as the basis MTs and Undesirable Results until better data becomes available under future monitoring activities.

The statement defining undesirable results for the Depletion of Interconnected Surface Water for this GSP is as follows:

> *The Basin will be considered to have undesirable results if any of the representative wells monitoring groundwater/surface water interaction display exceedances of the minimum threshold values for two consecutive Fall measurements.*

8.9.1.1 Criteria for Establishing Undesirable Results § 354.26(b)(2)

Criteria used to define undesired conditions for this Sustainability Indicator are those that:

- Impact the ability of the stream system to meet instream flow requirements and maintain groundwater dependent ecosystems (GDEs)
- Impact the ability to provide surface water supplies to direct diverters
- Interfere with other SGMA Sustainability Indicators.

The information used for establishing the criteria for undesirable results for the Depletion of Interconnected Surface Water Sustainability Indicator is water levels data collected from three RMS wells (i.e., AGV-1, AGV-6, AGV-12) that are located adjacent to Arroyo Grande Creek. For the present, water levels in these wells will be used as a proxy indicator of undesirable results.

8.9.1.2 Potential Causes of Undesirable Results § 354.26(b)(1)

Potential causes of undesirable results include increases in pumping in the proximity of a Subbasin creeks, or instream projects that could alter the natural flow regimes of the creeks.

8.9.1.3 Effects of Undesirable Results on Beneficial Users and Land Uses § 354.26(b)(3)

If depletions of interconnected surface water were to reach undesirable results, adverse effects could include the reduced ability of the stream flows to meet instream flow requirements for local fisheries and critical habitat, or reduced ability to deliver surface water supplies to direct users of surface water in the Basin.

8.9.2 Minimum Thresholds

Section 354.28(c)(6) of the SGMA regulations states that "The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results."

Current data are insufficient to determine the rate or volume of surface water depletions in the creeks. Therefore, groundwater elevations in the RMSs intended to monitor surface water/groundwater interaction (i.e., AGV-1, AGV-6, AGV-12) are used as a proxy for the Depletion of Interconnected Surface Water Sustainability Indicator. If in the future, data from a more comprehensive monitoring program (as discussed in Chapter 7.0 and Chapter 9.0) succeed in quantifying surface water depletions, those data may be used to re-define minimum thresholds for areas of interconnection. Minimum thresholds for these representative wells are presented in Table 8-1 and Figure 8-1, 8-9, and 8-10.

Arroyo Grande Creek is a significant feature in the Basin. It is a regulated (I.e., dammed) creek, with the dam structure creating the impoundment of Lake Lopez, a significant piece of infrastructure for water resources management in the Subbasin and the Northern Cities Management Area downstream. The dam is operated primarily for municipal water supply, and as such always allows some water to pass through the dam gates. As discussed in Chapter 5.0 (Groundwater Conditions), these operations have the ancillary effect of recharging the alluvial aquifer in the valley on a continual basis. A more extensive description and quantification of the stream/aquifer interaction is included in Chapter 5.0 (Groundwater Conditions) and Chapter 6.0 (Water Budget).

As described in Chapter 4.0 (Hydrogeologic Conceptual Model) and Chapter 5.0 (Groundwater Conditions), there are insufficient data to quantitatively assess the extent of the connection between surface water and groundwater in the Basin. As described in Chapter 7.0 (Monitoring Networks), a more expansive monitoring network may be developed during GSP implementation to improve understanding of interconnection between surface water and groundwater in the Basin. Chapter 9.0 (Projects and Management Actions and Implementation) addresses details of the plan to accumulate better data for this Sustainability Indicator. If in the future, better data are generated to quantify the connection between surface water and groundwater, undesirable results may be revised to reflect this data. However, for this GSP, groundwater elevations in AGV-1, AGV-6, AGV-12 will be used as a proxy for the Depletion of Interconnected Surface Water Sustainability Indicator.

8.9.2.1 Information and Methods Used for Establishing Depletion of Interconnected Surface Water Minimum Thresholds

As with the other Sustainability Indicators, the primary methods for development of SMCs for this Sustainability Indicator are monitoring of groundwater elevations in the three RMSs established for the purpose of monitoring hydrogeologic conditions in the adjacent creeks.

As with the chronic reduction of groundwater levels Sustainability Indicator, the primary source of data that was evaluated for the Depletion of Interconnected Surface Water Sustainability Indicator is historical groundwater elevation data maintained by the GSAs. The information used for establishing the MOs and MTs for the chronic lowering of groundwater levels Sustainability Indicator included:

- Historical groundwater elevation data from wells monitored by the County of San Luis Obispo.
- Construction details of RMS wells
- Long-term trends displayed in hydrographs of the RMS wells identified for this Sustainability Indicator.

The use of groundwater elevation as a proxy metric for the Depletion of Interconnected Surface Water Sustainability Indicator is adopted given the challenges and cost of direct monitoring of depletions of interconnected surface water. The depletion of interconnected surface water is driven by the gradient between water surface elevation in the surface water body and groundwater elevations in the connected, shallow groundwater system. By defining minimum thresholds in terms of groundwater elevations in shallow groundwater wells near surface water, the GSAs will monitor and manage this gradient, and in turn, manage potential changes in depletions of interconnected surface.

The initial concept for defining the MTs for Interconnected Surface Water proposed defining the MT as the lowest observed water level in the RMSs in the observed period of record. However, the Fall 2021 water levels were observed to be the lowest groundwater levels on record for the three proposed ISW RMS wells. Because the current drought could extend beyond the current period, it is possible that next fall's water levels could be lower than Fall 2021. In order to avoid the possibility of an immediate exceedance of the MTs in the first year of the SGMA implementation period, MTs were defined as 5 feet lower than the lowest observed water level for the period of record in each RMS well. The DWR Dry Domestic Well Susceptibility study described in Section 8.4.2.1 indicates domestic wells in the Subbasin are at low risk. Additionally, no domestic wells have been reported as going dry to date during this drought. Therefore, it was considered that defining the MTs to be 5 feet lower than the lowest observed levels imparts a low level of risk for domestic users in the Subbasin.

8.9.2.2 Relationship between Individual Minimum Thresholds and Other Sustainability Indicators

The MTs for the Depletion of Interconnected Surface Water Sustainability Indicator are defined as the lowest water levels observed in the period of record for each of the three RMSs. Therefore, the concept of potential conflict between MTs at different locations in the Basin is not applicable. The Depletion of Interconnected Surface Water Sustainability Indicator could influence other Sustainability Indicators. The Depletion of Interconnected Surface Water Sustainability Indicator MTs was selected to avoid undesirable results for other Sustainability Indicators, as outlined below:

- **Chronic lowering of groundwater levels.** Because groundwater elevations will be used as a proxy for estimating Depletion of Interconnected Surface Water Sustainability Indicator, and the definitions of the MTs are set at historically observed conditions, the MTs will not cause undesirable results for this Sustainability Indicator.
- **Depletion of Groundwater Storage.** Because groundwater elevations will be used as a proxy for estimating Depletion of Interconnected Surface Water Sustainability Indicator, and the definitions of the MTs are set at historically observed conditions, the MTs will not cause undesirable results for this Sustainability Indicator.
- **Seawater intrusion.** This Sustainability Indicator is not applicable to this Basin.
- **Degraded water quality.** The minimum threshold proxy of stable groundwater levels is not expected to lead to a degradation of groundwater quality.
- **Subsidence.** Because future groundwater levels will be above historically observed conditions, they will not induce any additional subsidence.

8.9.2.3 Effects of Minimum Thresholds on Neighboring Basins

Two neighboring groundwater basins share a boundary with the Arroyo Grande Subbasin Basin; the San Luis Obispo Basin to the northwest, and the Northern Cities Management Area of the Santa Maria Valley Groundwater Basin to the southwest. Neither of these shared boundaries are extensive, and the HCM posits that a groundwater divide separates the groundwater between the Subbasin and the SLO Basin. Therefore, conditions in the Subbasin are not expected to impact conditions in the SLO Basin. Arroyo Grande Creek flows into the NCMA Management Area. The synoptic flow study (Appendix H) indicates that when measured flow leaves the Subbasin, it percolates into the subsurface and the creek reaches zero flow before it reaches the ocean. Therefore, conditions in NCMA indicate losing reaches in their area, and conditions in the Subbasin will not impact conditions in NCMA.

The Subbasin GSAs have developed a cooperative working relationship with the SLO Basin Groundwater Sustainability Committee and the Northern Cities Management Area. Groundwater conditions near the borders with these basins will be monitored and shared.

8.9.2.4 Effects of Minimum Thresholds on Beneficial Uses and Users

The practical effect of this GSP for protecting against the Depletion of Interconnected Surface Water MTs is that it encourages minimal long-term net change in groundwater elevations in the vicinity of Arroyo Grande Creek. Seasonal and drought cycle variations are expected, but during average conditions and over the long-term, beneficial users will have access to adequate volumes of water from the aquifer to service the needs of all water use sectors. The beneficial users of groundwater are protected from undesirable results.

Agricultural Land Uses and Users

The water levels set as MTs are approximately within the historical range of data, implying that surface water/groundwater interaction will be within historical norms. Additionally, operation at Lake Lopez maintain flow in the creek year-round. Therefore, existing agricultural operations are not expected to be affected by the Depletion of Interconnected Surface Water MTs.

Urban Land Uses and Users

Development of real estate along streams and creeks is generally constrained by prohibiting development in mapped floodplains in the Basin. Therefore, the Depletion of Interconnected Surface Water MTs are not anticipated to affect urban land users in the Basin.

Domestic Land Uses and Users

Development of real estate along streams and creeks is generally constrained by prohibiting development in mapped floodplains in the Basin. Therefore, the Depletion of Interconnected Surface Water MTs are not anticipated to affect urban land users in the Basin.

Ecological Land Uses and Users.

Groundwater dependent ecosystems would generally benefit from this MT. Maintaining groundwater levels close to within historically observed ranges will continue to support groundwater dependent ecosystems. More detailed mapping of GDEs, and other expected fisheries-related work that will be required during the development of the Habitat Conservation Plan, will clarify the effects of these MTs on ecological uses.

8.9.2.5 Relation to State, Federal, or Local Standards

As previously discussed, current federal licensing activities associated Lopez Dam are being pursued by the county and member agencies supplied by lake Lopez. A Habitat Conservation Plan is being developed that will more specifically address these issues, and will be supported by the Arroyo Grande Creek Watershed Model developed as part of the GSP.

8.9.2.6 Methods for Quantitative Measurement of Minimum Threshold

The quantitative metric for assessing compliance with the Depletion of Interconnected Surface Water MTs is monitoring groundwater elevations at the three RMSs designated for this Sustainability Indicator (AGV-1, AGV-6, AGV-12). The approach for quantitatively evaluating compliance with the MT for reduction in groundwater storage will be based on evaluating groundwater elevations semi-annually. All groundwater elevations collected from the groundwater level monitoring network will be analyzed.

8.9.3 Measurable Objectives

Similar to minimum thresholds, measurable objectives were defined using water level data based on the historical water level data observed in RMSs intended to monitor streamflow conditions. Measurable objectives for these wells are presented in Table 8-1 and Figure 8-1. If future data from a more comprehensive surface water monitoring program documents quantitative estimates of stream flow depletion, those data may be used to re-define the measurable objectives for areas of interconnection.

8.9.3.1 Method for Quantitative Measurement of Measurable Objectives

The measurable objectives are set based on maintaining current conditions of seasonal high water level elevations observed in the RMS wells during rainy periods. The quantitative method for assessing compliance with the MOs is monitoring of groundwater elevations at the selected RMSs.

8.9.3.2 Interim Milestones

Interim milestones show how the GSAs anticipate moving from current conditions to meeting the measurable objectives. Interim milestones are set for each five-year interval following GSP adoption. MOs for the Depletion of Interconnected Surface Water are set at historically observed conditions of high groundwater elevations during wet climatic periods. Therefore, the interim milestones are defined to be identical to the water levels associated with the Mos.

8.10 Management Areas

Management areas are not established in the Basin. The GSAs and GSC members did not find it necessary to sub-divide the Basin into smaller management areas with specific administrative requirements.

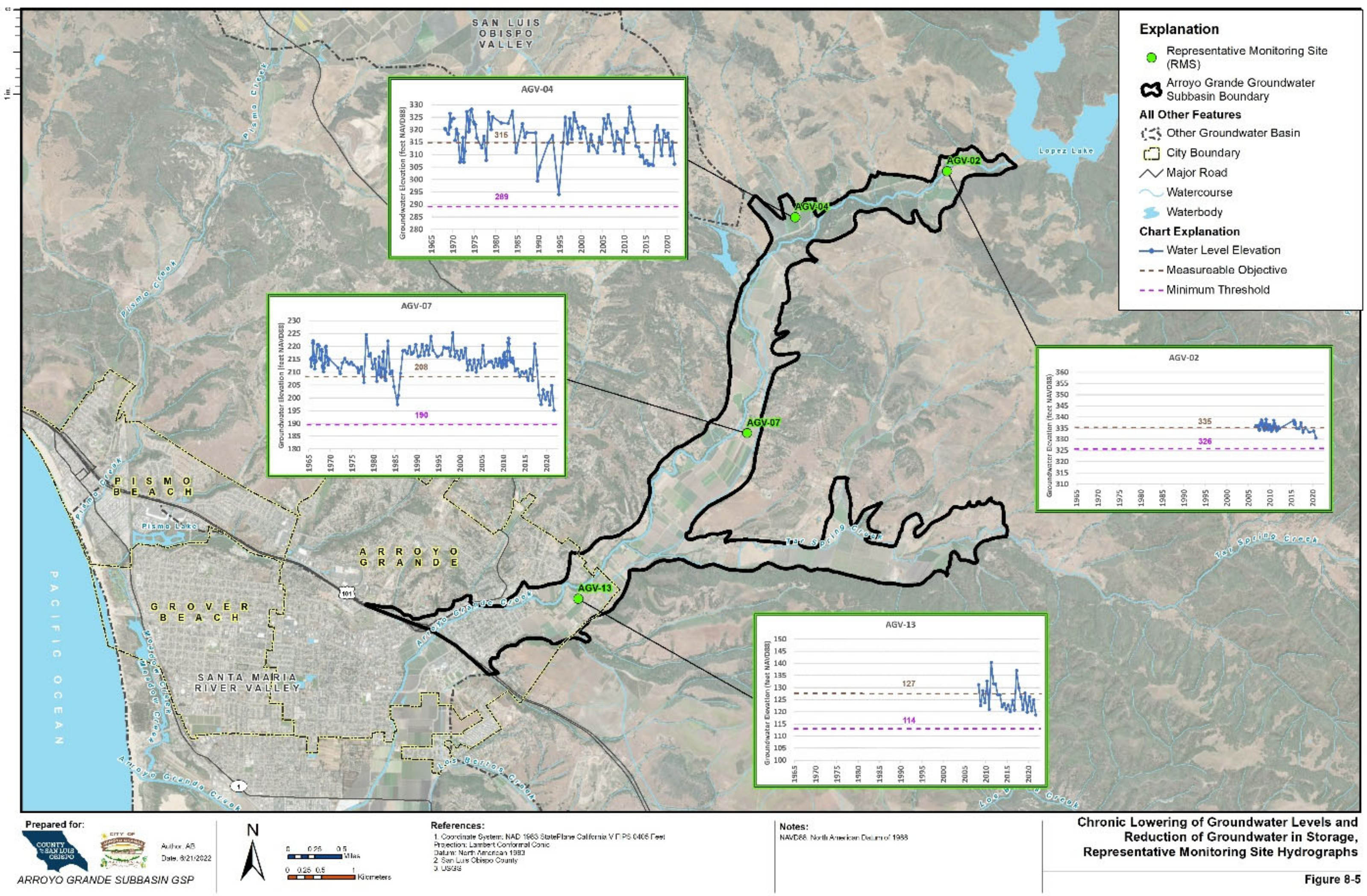

Figure 8-5. Chronic Lowering of Groundwater Levels and Reduction in Groundwater in Storage, Representative Monitoring Site Hydrographs

GROUNDWATER SUSTAINABILITY PLAN

9.0 Projects and Management Actions (§354.44) and Implementation

This chapter describes the Projects, Management Actions, and Implementation Plan of the GSP.

IN THIS SECTION

9.1 Introduction

As described in the Introduction to the GSP the AG Subbasin was originally part of the non-adjudicated "fringe" areas of the adjudicated Santa Maria River Valley Groundwater Basin (DWR No. 3-012), which was designated as a high priority basin (DWR, California's Groundwater: Bulletin 118 - Interim Update 2016, Working Towards Sustainability, 2016), but due to the final results of the DWR's groundwater basin boundary modifications in 2019, the AG Subbasin was then reprioritized as very low priority (DWR, 2019). Basins previously prioritized as high- or medium-priority that are now low- or very low-priority are not subject to the requirements in SGMA to form a GSA and prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention. However, these basins are still encouraged to form GSAs and develop GSPs, update existing groundwater management plans, and coordinate with others to develop a new groundwater management plan in accordance with Water Code Section 10750 et seq (DWR, 2019a):

a) *The Legislature finds and declares that groundwater is a valuable natural resource in California, and should be managed to ensure both its safe production and its quality. It is the intent of the Legislature to encourage local agencies to work cooperatively to manage groundwater resources within their jurisdictions.*

b) *The Legislature also finds and declares that additional study of groundwater resources is necessary to better understand how to manage groundwater effectively to ensure the safe production, quality, and proper storage of groundwater in this state.*

The AG Subbasin's very low prioritization does not require the development of a GSP for the AG Subbasin, but the AG Subbasin GSAs are proceeding with the development of a GSP to assure continued sustainable conjunctive management of groundwater and surface water supplies. Work efforts included in the GSP development are important for advancing water resource management of the AG Subbasin and interconnected surface waters of the Arroyo Grande Creek watershed that overlie the subbasin.

As described in Chapter 6.0 (Water Budget), the preliminary sustainable yield of the AG Subbasin is estimated at 2,500 AFY and is not in overdraft. There have been no significant cumulative and persistent storage declines over the 33-year historical base period. This preliminary sustainable yield and overdraft assumes continued operation of Lopez Reservoir in accordance with historical practices. This chapter describes the projects and management actions and Implementation Plan the GSAs that will allow the AG Subbasin to maintain sustainability into the future.

9.2 Projects and Management Actions

The projects and management actions concepts were developed over a series of working sessions with GSA staff and in a public meeting on July 25, 2022. The project called for in this plan is a series of projects collectively termed Lopez Water Project. The management action called for in this plan is to expand the monitoring network.

9.2.1 Lopez Water Project

The San Luis Obispo County Flood Control and Water Conservation District, Zone 3 (Zone 3) operates the Lopez Reservoir which impounds about 70 square miles of the upper watershed. The Lopez Reservoir was completed in 1969 with a capacity of 52,500 acre-feet. Its annual dependable yield is 8,730 acre-feet, of which, 4,530 acre-feet are allocated for municipal deliveries and use and 4,200 acre-feet are reserved for downstream releases. Downstream releases from the reservoir include instream flow requirements for the Arroyo Grande Creek, provide an important component of recharge to the underlying alluvial aquifer to the AG Subbasin, as well as providing surface water diversions for irrigation.

The Lopez Water Project for the purposes of this GSP includes the Habitat Conservation Plan (HCP) and the development of an integrated surface water-groundwater flow model to support the Habitat Conservation Plan. The model will be a key tool to allow Zone 3 and the Contract Agencies to better understand the relationship between downstream release and groundwater pumping and its impacts on creek habitats in lower Arroyo Grande Creek. It is envisioned that the model may allow for the development of an updated downstream release program that will inform the Habitat Conservation Plan. The updated downstream release program and the HCP are intended to provide a plan for the operation of the Lopez Reservoir that fulfills the contractual water supply obligations to the Zone 3 Contractors, provides releases for downstream agricultural users, and enhances habitat for steelhead trout, California red-legged frogs, and other environmentally sensitive biota in the Arroyo Grande Creek.

9.2.1.1 Habitat Conservation Plan

The District is in the process of updating the water rights permit for the Lopez Water Project. In support of that effort the District will be applying for an Incidental Take Permit and completing a Habitat Conservation Plan (HCP) to address potential adverse effects of the Lopez Water Project on steelhead and California red-legged frog, for example. The HCP will draw from the information in this GSP as well as other survey and technical data, including a recently completed in-stream habitat assessment to identify management actions and projects that would benefit these species. It is anticipated that once the HCP is completed the GSP may need to be subsequently updated to reflect performance criteria/indicators in the HCP.

9.2.2 Integrated Flow Model

As part of the development of this GSP, the GSAs incorporated the development of an integrated groundwater-surface water model of the Arroyo Grande Creek Watershed. A brief overview of the development and application of the model is presented herein. This discussion is not intended to be complete; more detailed documentation of the model is included in Appendix G, Surface Water/Groundwater Modeling Documentation.

The integrated model was developed using GSFLOW, a modeling code developed and maintained by the United States Geological Survey (USGS). GSFLOW incorporates two existing USGS modeling codes under a single structure. The first is the Precipitation Runoff Modeling System (PRMS), which models rainfall, plant uptake, evapotranspiration, and runoff to streams, using a water budget approach applied to a gridded domain of the model area. The second is MODFLOW, which simulates groundwater flow and surface water/groundwater interaction in the aquifers of the model area. GSFLOW operates by first running PRMS, using climatological input and daily time steps to calculate the movement of rainfall that falls onto the Basin area through plant canopy, root zone, runoff to streams, and deep percolation to the groundwater environment. GSFLOW then transmits necessary data to MODFLOW (e.g., streamflow, deep percolation, etc.) at times and locations significant to the simulation of groundwater flow for the completion of the GSFLOW run. The integrated model was also dynamically linked to a reservoir operations model (MODSIM) to simulate operations of Lopez Dam and Reservoir in the Subbasin. The linked models will be used to support future analyses in the Subbasin as part of the Habitat Conservation Plan (HCP).

9.2.2.1.1 Calibration

Modeled surface water flows calculated using PRMS were calibrated at five stream gage locations (one upstream of Lake Lopez, and four along Arroyo Grande Creek). Modeled streamflows were compared with observed data at these locations and compared with daily, monthly, and annual flows. The residuals for average flow at these five locations ranged from -1.2 cfs at the 22nd Street stream gage to to 1.0 cfs at the Arroyo Grande Creek stream gage. The percent error for volume of flow at these locations ranged from -21.5% at the 22nd Street Gage to 10.4% at the Rodriguez Gage. In addition, modeled streamflow results were compared against the results from a synoptic surface water flow study conducted during the summer of 2021 to identify gaining and losing reaches, and the results compared favorably. Statistics describing surface water calibration results are detailed in the model documentation (Appendix G). The surface water model is considered to be calibrated within industry standards, and the model is suitable for planning activities in the Subbasin.

Modeled groundwater elevations calculated by MODFLOW were calibrated using 3,627 water level measurements collected at 90 wells within the model domain. The range of observed groundwater elevations in the model area was 547 feet. The mean residual for all calibration targets in the historical calibration period is -7.6 feet. The relative error of groundwater elevations throughout the historical calibration period was 2.1%; a commonly referenced standard for this calibration measurement is that a calibrated model should be less than 10%. Statistics describing groundwater calibration results are detailed in the model documentation (Appendix G). The groundwater model is considered to be calibrated within industry standards, and the model is suitable for planning activities in the Subbasin.

9.2.3 Expand Monitoring Network

This management action expands the monitoring network from the current SLOCFCWCD monitoring network of 9 wells to the new network of 13 monitoring wells as presented in Chapter 7.0 (Monitoring Network) within the first two years of the GSP implementation. Chapter 7.0 describes a proposed monitoring network that has adequate spatial resolution to properly monitor changes to groundwater and surface water conditions relative to SMCs within the Subbasin. The network will provide data with sufficient temporal resolution to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions. Also included in Chapter 7.0 are recommendations to revise the rating curves at the stream gages periodically as they can shift due to changes in channel geometry and affect the accuracy of the stream flow data.

9.3 Implementation Plan

As described in the introduction to this chapter, the AG Subbasin is not required to complete a GSP and is not subject to the associated SGMA requirements. Thus, an implementation start period has not been defined. Should circumstances change, e.g. DWR reprioritizes the Arroyo Grande Subbasin as a high or medium priority basin, the GSAs will abide by all applicable requirements. Such requirements might include, without limitation, revising the GSP to account for changes in subbasin conditions, submitting the GSP to DWR's SGMA Portal, and initiating implementation efforts.

9.3.1 GSP Administration

The City and County GSAs will continue to operate under the existing MOA, including the existing governance structure, until actions are taken amending, revising, or dissolving the existing MOA by either party. The existing MOA is included in Appendix E. The existing governance structure and GSP could be revisited in the future if conditions and needs in the Subbasin change.

9.3.2 Implementation Costs

Costs associated with monitoring and operations of Lopez Dam and the subbasin are currently funded by the San Luis Obispo County Flood Control and Water Conservation District. Potential funding sources for expanded monitoring efforts and rating curve updates include District funds, grants, and State technical assistance.

9.3.3 Reporting

The County will utilize the upcoming Master Water Report update to publicly report conditions and activities related to the Subbasin. The Zone 3 Advisory Committee meets on a bi-monthly basis to discuss the needs of water contractors, residents, agriculture, and property owners in Zone 3. Future outreach activities related to HCP or GSP implementation efforts may be presented at Zone 3 Advisory Committee meetings.

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A

Appendix A DWR Element of the Plan Guide

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
§ 354.			**Introduction to Plan Contents**					
			This Article describes the required contents of Plans submitted to the Department for evaluation, including administrative information, a description of the basin setting, sustainable management criteria, description of the monitoring network, and projects and management actions.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
SubArticle 1.			**Administrative Information**					
§ 354.2.			**Introduction to Administrative Information**					
			This Subarticle describes information in the Plan relating to administrative and other general information about the Agency that has adopted the Plan and the area covered by the Plan.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.4.			**General Information**					
			Each Plan shall include the following general information:					
(a)			An executive summary written in plain language that provides an overview of the Plan and description of groundwater conditions in the basin.		N/A	1-1		Executive Summary is not included in the GSP. The AG Subbasin is categorized as very low priority and therefore not subject to SGMA requirements or required to prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention.
(b)			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.		REF			References are included after Section 9, Projects and Management Actions, and before Appendix A, DWR Element of the Plan Guide.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10733.2 and 10733.4, Water Code.					
§ 354.6.			**Agency Information**					
			When submitting an adopted Plan to the Department, the Agency shall include a copy of the information provided pursuant to Water Code Section 10723.8, with any updates, if necessary, along with the following information:					
(a)			The name and mailing address of the Agency.		2.2			
(b)			The organization and management structure of the Agency, identifying persons with management authority for implementation of the Plan.		2.3	2-2		
(c)			The name and contact information, including the phone number, mailing address and electronic mail address, of the plan manager.		2.4			
(d)			The legal authority of the Agency, with specific reference to citations setting forth the duties, powers, and responsibilities of the Agency, demonstrating that the Agency has the legal authority to implement the Plan.		2.3			

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(e)			An estimate of the cost of implementing the Plan and a general description of how the Agency plans to meet those costs.		9.3.2			Costs associated with monitoring and operations of Lopez Dam and the subbasin are currently funded by the San Luis Obispo County Flood Control and Water Conservation District. Potential funding sources for expanded monitoring efforts and rating curve updates include District funds, grants, and State technical assistance.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.8, 10727.2, and 10733.2, Water Code.					
§ 354.8.			**Description of Plan Area**					
			Each Plan shall include a description of the geographic areas covered, including the following information:					
(a)			One or more maps of the basin that depict the following, as applicable:					
	(1)		The area covered by the Plan, delineating areas managed by the Agency as an exclusive Agency and any areas for which the Agency is not an exclusive Agency, and the name and location of any adjacent basins.		3.1	1-1, 2-1		
	(2)		Adjudicated areas, other Agencies within the basin, and areas covered by an Alternative.		3.2			The AG Subbasin is not an adjudicated basin.
	(3)		Jurisdictional boundaries of federal or state land (including the identity of the agency with jurisdiction over that land), tribal land, cities, counties, agencies with water management responsibilities, and areas covered by relevant general plans.		3.3			
	(4)		Existing land use designations and the identification of water use sector and water source type.		3.4	3-2:3-4	3-1	
	(5)		The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.		3.5	3-5:3-7		
(b)			A written description of the Plan area, including a summary of the jurisdictional areas and other features depicted on the map.		3.1	2-1		
(c)			Identification of existing water resource monitoring and management programs, and description of any such programs the Agency plans to incorporate in its monitoring network or in development of its Plan. The Agency may coordinate with existing water resource monitoring and management programs to incorporate and adopt that program as part of the Plan.		3.6	3-8:3-9	3-6	
(d)			A description of how existing water resource monitoring or management programs may limit operational flexibility in the basin, and how the Plan has been developed to adapt to those limits.	N/A				No water resource monitoring or management programs will limit the operation flexibility of AG Subbasin.

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(e)			A description of conjunctive use programs in the basin.		3.7			There are no active formal conjunctive use programs currently operating within AG Subbasin, but the City of Arroyo Grande and other subbasin pumpers do manage their surface and groundwater supplies conjunctively.
(f)			A plain language description of the land use elements or topic categories of applicable general plans that includes the following:					
	(1)		A summary of general plans and other land use plans governing the basin.		3.8	3-11:3-13,		
	(2)		A general description of how implementation of existing land use plans may change water demands within the basin or affect the ability of the Agency to achieve sustainable groundwater management over the planning and implementation horizon, and how the Plan addresses those potential effects		N/A			The existing land use plans will not affect the sustainable groundwater management in the AG Subbasin.
	(3)		A general description of how implementation of the Plan may affect the water supply assumptions of relevant land use plans over the planning and implementation horizon.		N/A			Implementation of the Plan is not expected to affect the water supply assumptions of relevant land use plans over the planning and implementation horizon.
	(4)		A summary of the process for permitting new or replacement wells in the basin, including adopted standards in local well ordinances, zoning codes, and policies contained in adopted land use plans.		3.6.3.6			
	(5)		To the extent known, the Agency may include information regarding the implementation of land use plans outside the basin that could affect the ability of the Agency to achieve sustainable groundwater management.		N/A			Land Use Plans outside the AG Subbasin will not affect the ability of the GSAs to achieve sustainable groundwater management.
(g)			A description of any of the additional Plan elements included in Water Code Section 10727.4 that the Agency determines to be appropriate.		N/A			No additional Plan elements included in Water Code Section 10727.4 were determined to be appropriate.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10720.3, 10727.2, 10727.4, 10733, and 10733.2, Water Code.					
§ 354.10.			**Notice and Communication**					
			Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:					
(a)			A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.		4.3, 6.0, 6.3.2, App E	6-3, 6-7,	6-1, 6-4, 6-7:6-8	The Communication and Engagement Plan describes the beneficial uses and users in the basin.
(b)			A list of public meetings at which the Plan was discussed or considered by the Agency.		2.5		2-1	
(c)			Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.		App I			
(d)			A communication section of the Plan that includes the following:					

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(1)		An explanation of the Agency's decision-making process.		2.3.4, App E			
	(2)		Identification of opportunities for public engagement and a discussion of how public input and response will be used.		App F			App F, Communication and Engagement Plan
	(3)		A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.		App F			App F, Communication and Engagement Plan
	(4)		The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.		App F			App F, Communication and Engagement Plan
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.8, 10728.4, and 10733.2, Water Code					
SubArticle 2.			**Basin Setting**					
§ 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.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.14.			**Hydrogeologic Conceptual Model**					
(a)			Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.		4.1:4.8,5.1:5.6	4-1:4-13, 5-1:5-17		
(b)			The hydrogeologic conceptual model shall be summarized in a written description that includes the following:					
	(1)		The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.		4.5:4.6	4-7:4-13		
	(2)		Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.		4.5.1			
	(3)		The definable bottom of the basin.		4.6.3	4-9:4-11		
	(4)		Principal aquifers and aquitards, including the following information:					
		(A)	Formation names, if defined.		4.5.2			
		(B)	Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.		4.6			
		(C)	Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.		4.5.1			

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
		(D)	General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.		5.6			
		(E)	Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.		3.4.2, 4.3			
	(5)		Identification of data gaps and uncertainty within the hydrogeologic conceptual model		7.2.1.1, 7.2.2.1, 7.2.3.1			The HCM for the AG Subbasin is well defined. Data gaps are addressed throughout.
(c)			The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.		4.6.1:4.6.3	4-9:4-11		
(d)			Physical characteristics of the basin shall be represented on one or more maps that depict the following:					
	(1)		Topographic information derived from the U.S. Geological Survey or another reliable source.		4.2	4-1		
	(2)		Surficial geology derived from a qualified map including the locations of cross-sections required by this Section.		4.6.3	4-9:4-11		
	(3)		Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.		4.5.2	4-7:4-8		
	(4)		Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.		5.3	5-11:5-14		
	(5)		Surface water bodies that are significant to the management of the basin.		4.7			
	(6)		The source and point of delivery for imported water supplies.		3.3:3.4	3-3		
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10733, and 10733.2, Water Code.					
§ 354.16.			**Groundwater Conditions**					
			Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:					
(a)			Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:					
	(1)		Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.		5.1.1:5.1.6	5-1:5-8		
	(2)		Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.		5.2	5-9:5-10		
(b)			A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.		5-2	5-9:5-10		

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(c)			Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.		8.6			The AG Subbasin is not adjacent to a coastline.
(d)			Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.		5.6, 8.7	5-15:5-17		
(e)			The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.		4.8	4-13		
(f)			Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.		5.4, 7.3.6	5-13:5-14		
(g)			Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.		5.5, App G	5-14		
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10727.4, and 10733.2, Water Code.					
§ 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.		6.0	6-3:6-4	6-1	Chapter 6 is the Water Budget Chapter.
(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.		6.0	6-3	6-1	
	(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.		6.0	6-4	6-1	
	(3)		Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.		6.0	6-4	6-1	
	(4)		The change in the annual volume of groundwater in storage between seasonal high conditions.		6.3.6	6-12:6-14	6-12	
	(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.		6.3.8			The Arroyo Grand Subbasin is not in overdraft. There have been no significant cumulative and persistent storage declines over the 33-year historical period.
	(6)		The water year type associated with the annual supply, demand, and change in groundwater stored.		6.1.1		6-1	
	(7)		An estimate of sustainable yield for the basin.		6.3.7		6-13	

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(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.		6.4	6-1:6-4	6-1	
	(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.		6.3.3	6-3, 6-9	6-1	
		(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.		6.0	6-3:6-4	6-1	
		(C)	A description of how historical conditions concerning hydrology, water demand, and surface water supply availability or reliability have impacted the ability of the Agency to operate the basin within sustainable yield. Basin hydrology may be characterized and evaluated using water year type.		6-1:6-3	6-2:6-6, 6-8:6-11	6-1:6-13	
	(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.		6.3.3	6-3:6-6, 6-10	6-1:6-3, 6-6	

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
		(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.		N/A			Projected demands and supplies based on land use are not identified for the AG Subbasin in the Land Use element of the County of San Luis Obispo General Plan as indicated in 3.8.2. The AG Subbasin is categorized as very low priority and therefore not subject to SGMA requirements or required to prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention.
		(C)	Projected surface water supply shall utilize the most recent water supply information as the baseline condition for estimating future surface water supply. The projected surface water supply shall also be applied as the baseline condition used to evaluate future scenarios of surface water supply availability and reliability as a function of the historical surface water supply identified in Section 354.18(c)(2)(A), and the projected changes in local land use planning, population growth, and climate.		N/A			Projected supplies are not identified for the AG Subbasin. The AG Subbasin is categorized as very low priority and therefore not subject to SGMA requirements or required to prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention.
(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.		6.3	6-3:6-8	6-1:6-5	
	(2)		Current water budget information for temperature, water year type, evapotranspiration, and land use.		6.4	6-1:6-3, 6-15:6-16	6-14	
	(3)		Projected water budget information for population, population growth, climate change, and sea level rise.		N/A			Projected water budget information for population, population growth, climate change, and sea level rise is not included. The AG Subbasin is categorized as very low priority and therefore not subject to SGMA requirements or required to prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention.

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(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.		6			Chapter 6 relies on the best available information and best available science to quantify the water budget. The AG Subbasin is categorized as very low priority and therefore not subject to SGMA requirements or required to prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention.
(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.		N/A			Documentation for an integrated groundwater and surface water model is in Appendix G.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10723.2, 10727.2, 10727.6, 10729, and 10733.2, Water Code.					
§ 354.20.			**Management Areas**					
(a)			Each Agency may define one or more management areas within a basin if the Agency has determined that creation of management areas will facilitate implementation of the Plan. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin.		7.1.1, 8.10			The AG Subbasin does not have management areas.
(b)			A basin that includes one or more management areas shall describe the following in the Plan:					
	(1)		The reason for the creation of each management area.		7.1.1, 8.10			The AG Subbasin does not have management areas.
	(2)		The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.		8.4.2.3, 8.5.2.3, 8.7.2.3, 8.8.2.3, 8.9.2.3			The AG Subbasin does not have management areas, but has developed a working relationship with both the San Luis Obispo Valley Basin GSA and the Northern Cities management area of the Santa Maria River Valley Groundwater Basin.
	(3)		The level of monitoring and analysis appropriate for each management area.		N/A			The AG Subbasin does not have management areas.
	(4)		An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.		N/A			The AG Subbasin does not have management areas.
(c)			If a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas.		N/A			The AG Subbasin does not have management areas.
			Note: Authority cited: Section 10733.2, Water Code.					

				GSP Document References: Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			Reference: Sections 10733.2 and 10733.4, Water Code.					
SubArticle 3.			**Sustainable Management Criteria**					
§ 354.22.			**Introduction to Sustainable Management Criteria**					
			This Subarticle describes criteria by which an Agency defines conditions in its Plan that constitute sustainable groundwater management for the basin, including the process by which the Agency shall characterize undesirable results, and establish minimum thresholds and measurable objectives for each applicable sustainability indicator.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.24.			**Sustainability Goal**					
			Each Agency shall establish in its Plan a sustainability goal for the basin that culminates in the absence of undesirable results within 20 years of the applicable statutory deadline. The Plan shall include a description of the sustainability goal, including information from the basin setting used to establish the sustainability goal, a discussion of the measures that will be implemented to ensure that the basin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved within 20 years of Plan implementation and is likely to be maintained through the planning and implementation horizon.		8.2			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10727, 10727.2, 10733.2, and 10733.8, Water Code.					
§ 354.26.			**Undesirable Results**					
(a)			Each Agency shall describe in its Plan the processes and criteria relied upon to define undesirable results applicable to the basin. Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin.		8.4.1, 8.5.1, 8.7.1, 8.8.1, 8.9.1			
(b)			The description of undesirable results shall include the following:					
	(1)		The cause of groundwater conditions occurring throughout the basin that would lead to or has led to undesirable results based on information described in the basin setting, and other data or models as appropriate.		8.4.1.2, 8.5.1.2, 8.7.1.2, 8.8.1.2, 8.9.1.2			
	(2)		The criteria used to define when and where the effects of the groundwater conditions cause undesirable results for each applicable sustainability indicator. The criteria shall be based on a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin.		8.4.1.1, 8.5.1.1, 8.7.1.1, 8.8.1.1, 8.9.1.1			
	(3)		Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results.		8.4.1.3, 8.5.1.3, 8.7.1.3, 8.8.1.3, 8.9.1.3			

				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(c)			The Agency may need to evaluate multiple minimum thresholds to determine whether an undesirable result is occurring in the basin. The determination that undesirable results are occurring may depend upon measurements from multiple monitoring sites, rather than a single monitoring site.		8.4.2, 8.5.2, 8.7.2, 8.8.2, 8.9.2			
(d)			An Agency that is able to demonstrate that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin shall not be required to establish criteria for undesirable results related to those sustainability indicators.		8.6			Seawater intrusion does not apply to the AG Subbasin since the Basin is not a coastal basin.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10721, 10723.2, 10727.2, 10733.2, and 10733.8, Water Code.					
§ 354.28.			**Minimum Thresholds**					
(a)			Each Agency in its Plan shall establish minimum thresholds that quantify groundwater conditions for each applicable sustainability indicator at each monitoring site or representative monitoring site established pursuant to Section 354.36. The numeric value used to define minimum thresholds shall represent a point in the basin that, if exceeded, may cause undesirable results as described in Section 354.26.		8.4.2, 8.5.2, 8.7.2, 8.8.2, 8.9.2			
(b)			The description of minimum thresholds shall include the following:					
	(1)		The information and criteria relied upon to establish and justify the minimum thresholds for each sustainability indicator. The justification for the minimum threshold shall be supported by information provided in the basin setting, and other data or models as appropriate, and qualified by uncertainty in the understanding of the basin setting.		8.4.2.1, 8.5.2.1, 8.7.2.1, 8.8.2.1, 8.9.2.1			
	(2)		The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators.		8.4.2.2, 8.5.2.2, 8.7.2.2, 8.8.2.2, 8.9.2.2			
	(3)		How minimum thresholds have been selected to avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.		8.4.2.3, 8.5.2.3, 8.7.2.3, 8.8.2.3, 8.9.2.3			
	(4)		How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.		8.4.2.4, 8.5.2.4, 8.7.2.4, 8.8.2.4, 8.9.2.4			

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(5)		How state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the Agency shall explain the nature of and basis for the difference.		8.4.2.5, 8.5.2.5, 8.7.2.5, 8.8.2.5, 8.9.2.5			
	(6)		How each minimum threshold will be quantitatively measured, consistent with the monitoring network requirements described in Subarticle 4.		8.4.2.6, 8.5.2.6, 8.7.2.6, 8.8.2.6, 8.9.2.6			
(c)			Minimum thresholds for each sustainability indicator shall be defined as follows:					
	(1)		Chronic Lowering of Groundwater Levels. The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results. Minimum thresholds for chronic lowering of groundwater levels shall be supported by the following:					
		(A)	The rate of groundwater elevation decline based on historical trends, water year type, and projected water use in the basin.		8.4.2.1	8-1:8-4		
		(B)	Potential effects on other sustainability indicators.		8.4.2.2, 8.5.2.2, 8.7.2.2, 8.8.2.2, 8.9.2.2			
	(2)		Reduction of Groundwater Storage. The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results. Minimum thresholds for reduction of groundwater storage shall be supported by the sustainable yield of the basin, calculated based on historical trends, water year type, and projected water use in the basin.		8.5			
	(3)		Seawater Intrusion. The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results. Minimum thresholds for seawater intrusion shall be supported by the following:					
		(A)	Maps and cross-sections of the chloride concentration isocontour that defines the minimum threshold and measurable objective for each principal aquifer.		N/A			This Sustainability Indicator does not apply to the Basin since the Basin is not a coastal basin
		(B)	A description of how the seawater intrusion minimum threshold considers the effects of current and projected sea levels.		N/A			This Sustainability Indicator does not apply to the Basin since the Basin is not a coastal basin

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(4)		Degraded Water Quality. The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency that may lead to undesirable results. The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin. In setting minimum thresholds for degraded water quality, the Agency shall consider local, state, and federal water quality standards applicable to the basin.		N/A			This Sustainability Indicator does not apply to the Basin since the Basin is not a coastal basin
	(5)		Land Subsidence. The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results. Minimum thresholds for land subsidence shall be supported by the following:					
		(A)	Identification of land uses and property interests that have been affected or are likely to be affected by land subsidence in the basin, including an explanation of how the Agency has determined and considered those uses and interests, and the Agency's rationale for establishing minimum thresholds in light of those effects.		8.8			
		(B)	Maps and graphs showing the extent and rate of land subsidence in the basin that defines the minimum threshold and measurable objectives.		4.8	4-13		
	(6)		Depletions of Interconnected Surface Water. The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results. The minimum threshold established for depletions of interconnected surface water shall be supported by the following:					
		(A)	The location, quantity, and timing of depletions of interconnected surface water.		8.9			
		(B)	A description of the groundwater and surface water model used to quantify surface water depletion. If a numerical groundwater and surface water model is not used to quantify surface water depletion, the Plan shall identify and describe an equally effective method, tool, or analytical model to accomplish the requirements of this Paragraph.		App G, 8.9			
(d)			An Agency may establish a representative minimum threshold for groundwater elevation to serve as the value for multiple sustainability indicators, where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual minimum thresholds as supported by adequate evidence.		8.9.2			
(e)			An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish minimum thresholds related to those sustainability indicators.		8.9.2.2			
			Note: Authority cited: Section 10733.2, Water Code.					

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			Reference: Sections 10723.2, 10727.2, 10733, 10733.2, and 10733.8, Water Code.					
§ 354.30.			**Measurable Objectives**					
(a)			Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.		8.4.3.2, 8.5.3.2, 8.7.3.2, 8.8.3.2, 8.9.3.2			
(b)			Measurable objectives shall be established for each sustainability indicator, based on quantitative values using the same metrics and monitoring sites as are used to define the minimum thresholds.		8.4.3.1, 8.5.3.1, 8.7.3.1, 8.8.3.1, 8.9.3.1			
(c)			Measurable objectives shall provide a reasonable margin of operational flexibility under adverse conditions which shall take into consideration components such as historical water budgets, seasonal and long-term trends, and periods of drought, and be commensurate with levels of uncertainty.		8.4.3, 8.5.3, 8.7.3, 8.8.3, 8.9.3			
(d)			An Agency may establish a representative measurable objective for groundwater elevation to serve as the value for multiple sustainability indicators where the Agency can demonstrate that the representative value is a reasonable proxy for multiple individual measurable objectives as supported by adequate evidence.		8.4.3	8-1:8-4	8-1	
(e)			Each Plan shall describe a reasonable path to achieve the sustainability goal for the basin within 20 years of Plan implementation, including a description of interim milestones for each relevant sustainability indicator, using the same metric as the measurable objective, in increments of five years. The description shall explain how the Plan is likely to maintain sustainable groundwater management over the planning and implementation horizon.		9.3			9.3 is the Implementation Plan
(f)			Each Plan may include measurable objectives and interim milestones for additional Plan elements described in Water Code Section 10727.4 where the Agency determines such measures are appropriate for sustainable groundwater management in the basin.		8.4.3.2, 8.5.3.2, 8.7.3.2, 8.8.3.2, 8.9.3.2			
(g)			An Agency may establish measurable objectives that exceed the reasonable margin of operational flexibility for the purpose of improving overall conditions in the basin, but failure to achieve those objectives shall not be grounds for a finding of inadequacy of the Plan.		N/A			MOs do not exceed the reasonable margin of operational flexibility for the AG Subbasin.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					
SubArticle 4.			**Monitoring Networks**					
§ 354.32.			**Introduction to Monitoring Networks**					

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			This Subarticle describes the monitoring network that shall be developed for each basin, including monitoring objectives, monitoring protocols, and data reporting requirements. The monitoring network shall promote the collection of data of sufficient quality, frequency, and distribution to characterize groundwater and related surface water conditions in the basin and evaluate changing conditions that occur through implementation of the Plan.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.34.			**Monitoring Network**					
(a)			Each Agency shall develop a monitoring network capable of collecting sufficient data to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions, and yield representative information about groundwater conditions as necessary to evaluate Plan implementation.		7			Chapter 7 is the Monitoring Netork.
(b)			Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:					
	(1)		Demonstrate progress toward achieving measurable objectives described in the Plan.		7.1:7.3			
	(2)		Monitor impacts to the beneficial uses or users of groundwater.		7.1			
	(3)		Monitor changes in groundwater conditions relative to measurable objectives and minimum thresholds.		7.1			
	(4)		Quantify annual changes in water budget components.		7.1			
(c)			Each monitoring network shall be designed to accomplish the following for each sustainability indicator:					
	(1)		Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:					
		(A)	A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.		7.2.1.1			
		(B)	Static groundwater elevation measurements shall be collected at least two times per year, to represent seasonal low and seasonal high groundwater conditions.		7.2.1			
	(2)		Reduction of Groundwater Storage. Provide an estimate of the change in annual groundwater in storage.		7.2.1,7.3.2			
	(3)		Seawater Intrusion. Monitor seawater intrusion using chloride concentrations, or other measurements convertible to chloride concentrations, so that the current and projected rate and extent of seawater intrusion for each applicable principal aquifer may be calculated.		7.3.3			The AG Subbasin is not susceptible to seawater intrusion and will not be monitored for that indicator.

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(4)		Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.		7.3.4			
	(5)		Land Subsidence. Identify the rate and extent of land subsidence, which may be measured by extensometers, surveying, remote sensing technology, or other appropriate method.		7.3.5			
	(6)		Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:					
		(A)	Flow conditions including surface water discharge, surface water head, and baseflow contribution.		7.3.6			
		(B)	Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.		7.3.6, App G			
		(C)	Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.		7.3.6, App G			
		(D)	Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.		7.3.6, App G			
(d)			The monitoring network shall be designed to ensure adequate coverage of sustainability indicators. If management areas are established, the quantity and density of monitoring sites in those areas shall be sufficient to evaluate conditions of the basin setting and sustainable management criteria specific to that area.		7.3.6			
(e)			A Plan may utilize site information and monitoring data from existing sources as part of the monitoring network.		7.1.4			
(f)			The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:					
	(1)		Amount of current and projected groundwater use.		7.1			
	(2)		Aquifer characteristics, including confined or unconfined aquifer conditions, or other physical characteristics that affect groundwater flow.		7.1			Discussed throughout Chapter 7 and Chapter 8.
	(3)		Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.		7.1			Discussed throughout Chapter 7 and Chapter 8.
	(4)		Whether the Agency has adequate long-term existing monitoring results or other technical information to demonstrate an understanding of aquifer response.		7.1			Discussed throughout Chapter 7 and Chapter 8. Specifically in the Interconnected GW/SW components of the plan.
(g)			Each Plan shall describe the following information about the monitoring network:					

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(1)		Scientific rationale for the monitoring site selection process.		7.1.3			
	(2)		Consistency with data and reporting standards described in Section 352.4. If a site is not consistent with those standards, the Plan shall explain the necessity of the site to the monitoring network, and how any variation from the standards will not affect the usefulness of the results obtained.		7.4			
	(3)		For each sustainability indicator, the quantitative values for the minimum threshold, measurable objective, and interim milestones that will be measured at each monitoring site or representative monitoring sites established pursuant to Section 354.36.		7.3			
(h)			The location and type of each monitoring site within the basin displayed on a map, and reported in tabular format, including information regarding the monitoring site type, frequency of measurement, and the purposes for which the monitoring site is being used.		7.1:7.3	7-1:7-3	7-1:7-4	
(i)			The monitoring protocols developed by each Agency shall include a description of technical standards, data collection methods, and other procedures or protocols pursuant to Water Code Section 10727.2(f) for monitoring sites or other data collection facilities to ensure that the monitoring network utilizes comparable data and methodologies.		7.4			
(j)			An Agency that has demonstrated that undesirable results related to one or more sustainability indicators are not present and are not likely to occur in a basin, as described in Section 354.26, shall not be required to establish a monitoring network related to those sustainability indicators.		7.3.3			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10727.4, 10728, 10733, 10733.2, and 10733.8, Water Code					
§ 354.36.			**Representative Monitoring**					
			Each Agency may designate a subset of monitoring sites as representative of conditions in the basin or an area of the basin, as follows:					
(a)			Representative monitoring sites may be designated by the Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined.		7.1.2			
(b)			(b) Groundwater elevations may be used as a proxy for monitoring other sustainability indicators if the Agency demonstrates the following:					
	(1)		Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.		7.2.1			
	(2)		Measurable objectives established for groundwater elevation shall include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.		8.3,8.5,8.9			

				GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
(c)			The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area.		8.3			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2 and 10733.2, Water Code					
§ 354.38.			**Assessment and Improvement of Monitoring Network**					
(a)			Each Agency shall review the monitoring network and include an evaluation in the Plan and each five-year assessment, including a determination of uncertainty and whether there are data gaps that could affect the ability of the Plan to achieve the sustainability goal for the basin.		7.6,7.7			
(b)			Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency.		7.2.1.1,7.2.2.1,7.2.3.1			
(c)			If the monitoring network contains data gaps, the Plan shall include a description of the following:					
	(1)		The location and reason for data gaps in the monitoring network.		7.2.1.1, 5.1.3, 5.1.7			
	(2)		Local issues and circumstances that limit or prevent monitoring.		N/A			No local issues identified that limit or prevent monitoring.
(d)			Each Agency shall describe steps that will be taken to fill data gaps before the next five-year assessment, including the location and purpose of newly added or installed monitoring sites.		7.2.1.1, 5.1.3, 5.1.7			
(e)			Each Agency shall adjust the monitoring frequency and density of monitoring sites to provide an adequate level of detail about site-specific surface water and groundwater conditions and to assess the effectiveness of management actions under circumstances that include the following:					
	(1)		Minimum threshold exceedances.		7.4.4			
	(2)		Highly variable spatial or temporal conditions.		7.4.4			
	(3)		Adverse impacts to beneficial uses and users of groundwater.		7.4.4			
	(4)		The potential to adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of sustainability goals in an adjacent basin.		7.4.4			
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10723.2, 10727.2, 10728.2, 10733, 10733.2, and 10733.8, Water Code					
§ 354.40.			**Reporting Monitoring Data to the Department**					
			Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.					

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10728, 10728.2, 10733.2, and 10733.8, Water Code.					
SubArticle 5.			**Projects and Management Actions**					
§ 354.42.			**Introduction to Projects and Management Actions**					
			This Subarticle describes the criteria for projects and management actions to be included in a Plan to meet the sustainability goal for the basin in a manner that can be maintained over the planning and implementation horizon.					
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Section 10733.2, Water Code.					
§ 354.44.			**Projects and Management Actions**					
(a)			Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.		9			Chapter 9 is the Projects and Management Actions Section
(b)			Each Plan shall include a description of the projects and management actions that include the following:					
	(1)		A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action. The list shall include projects and management actions that may be utilized to meet interim milestones, the exceedance of minimum thresholds, or where undesirable results have occurred or are imminent. The Plan shall include the following:					
		(A)	A description of the circumstances under which projects or management actions shall be implemented, the criteria that would trigger implementation and termination of projects or management actions, and the process by which the Agency shall determine that conditions requiring the implementation of particular projects or management actions have occurred.		9.2:9.3			Sections 9.2 and 9.3 discuss the GSP's Projects and Management Actions and Implementation Plan. The AG Subbasin is categorized as very low priority and therefore not subject to SGMA requirements or required to prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention.
		(B)	The process by which the Agency shall provide notice to the public and other agencies that the implementation of projects or management actions is being considered or has been implemented, including a description of the actions to be taken.		N/A			This item is not included. The AG Subbasin is categorized as very low priority and therefore not subject to SGMA requirements or required to prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention.
	(2)		If overdraft conditions are identified through the analysis required by Section 354.18, the Plan shall describe projects or management actions, including a quantification of demand reduction or other methods, for the mitigation of overdraft.		9.2			

Article 5.			Plan Contents for Arroyo Grande Subbasin Basin	GSP Document References				
				Page Numbers of Plan	Or Section Numbers	Or Figure Numbers	Or Table Numbers	Notes
	(3)		A summary of the permitting and regulatory process required for each project and management action.		9.2.1.1			Not all projects and management actions require permitting or regulatory process.
	(4)		The status of each project and management action, including a time-table for expected initiation and completion, and the accrual of expected benefits.		9.3.3			The County will utilize the upcoming Master Water Report update to publicly report conditions and activities related to the Subbasin.
	(5)		An explanation of the benefits that are expected to be realized from the project or management action, and how those benefits will be evaluated.		9.2.1:9.2.3			
	(6)		An explanation of how the project or management action will be accomplished. If the projects or management actions rely on water from outside the jurisdiction of the Agency, an explanation of the source and reliability of that water shall be included.		9.2.1:9.2.3			
	(7)		A description of the legal authority required for each project and management action, and the basis for that authority within the Agency.		N/A			Legal authorities are not explicitly described for each project and management action. The AG Subbasin is categorized as very low priority and therefore not subject to SGMA requirements or required to prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention.
	(8)		A description of the estimated cost for each project and management action and a description of how the Agency plans to meet those costs.		9.3.2			
	(9)		A description of the management of groundwater extractions and recharge to ensure that chronic lowering of groundwater levels or depletion of supply during periods of drought is offset by increases in groundwater levels or storage during other periods.		N/A			Projects and management actions were not modeled for extraction and recharge of groundwater. The AG Subbasin is categorized as very low priority and therefore not subject to SGMA requirements or required to prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention.
(c)			Projects and management actions shall be supported by best available information and best available science.		9.2.1:9.2.3			
(d)			An Agency shall take into account the level of uncertainty associated with the basin setting when developing projects or management actions.		N/A			Uncertainties were not identified. The AG Subbasin is categorized as very low priority and therefore not subject to SGMA requirements or required to prepare a GSP or an alternative to avoid potential State Water Resources Control Board intervention.
			Note: Authority cited: Section 10733.2, Water Code.					
			Reference: Sections 10727.2, 10727.4, and 10733.2, Water Code.					

B

Appendix B Letter of Intent to Develop GSP to DWR

Attachment 2

January 29, 2019

Trevor Joseph, SGM Section Chief
California Department of Water Resources
P.O. Box 942836
Sacramento, CA 94236-0001

City Council, City of Arroyo Grande
300 E. Branch Street
Arroyo Grande, CA 93420

City Council, City of Pismo Beach
760 Mattie Road
Pismo Beach, CA 93449

SUBJECT: NOTIFICATION OF INTENT TO INITIATE DEVELOPMENT OF GROUNDWATER SUSTAINABILITY PLAN FOR THE SANTA MARIA RIVER VALLEY GROUNDWATER BASIN

To Whom It May Concern:

In accordance with California Water Code Section 10727.8 and the Title 23, Section 353.6 of the California Code of Regulations, the County of San Luis Obispo, acting as the Santa Maria Basin Fringe Areas - County of San Luis Obispo Groundwater Sustainability Agency (County GSA), hereby gives notice that it intends to initiate development of a groundwater sustainability plan (GSP) and anticipates doing so in collaboration with the City of Arroyo Grande Groundwater Sustainability Agency for the "fringe areas" of the Santa Maria Valley River Groundwater Basin wholly within San Luis Obispo County (B118 3-012, Santa Maria Basin).

SGMA does not apply to the adjudicated areas of the Santa Maria Basin (that portion of the Santa Maria Basin at issue in Santa Maria Valley Water Conservation District v. City of Santa Maria, et al.) ("adjudicated area"), provided that certain requirements are met (Water Code Section 10720.8(a)(18)). However, there are multiple "fringe areas" located outside of the adjudicated area in both San Luis Obispo and Santa Barbara Counties, which are subject to SGMA. The Nipomo Community Services District and City of Pismo Beach both adopted resolutions formally authorizing or recommending that the County of San Luis Obispo serve as the groundwater sustainability agency (GSA) for the "fringe areas" within their boundaries. Therefore, two local agencies, the County of San Luis Obispo and the City of Arroyo Grande, formed GSAs, resulting in full coverage of the "fringe areas" of the Santa Maria Basin within the County of San Luis Obispo, and the Santa Barbara County Water Agency formed a GSA to cover the "fringe areas" within the County of Santa Barbara.

The County GSA and Santa Barbara County Water Agency both submitted basin boundary modification requests (BBMRs) to the California Department of Water Resources (DWR) for the Santa Maria Basin "fringe areas." On November 29, 2018, DWR published draft decisions on the BBMRs. However, the subsequent final basin boundary modifications and re-prioritization will not be determined until early 2019. Therefore, the areas which will be covered by the GSP will not be defined until 2019 pending DWR's final basin boundary modification processes. The County GSA will provide updates to DWR and appropriate legislative bodies regarding changes to the area intended to be covered by the GSP as a result of DWR's final determinations consistent with all regulatory requirements. It has also not been determined as of the date of this Notice whether the GSAs within the Santa Maria Basin will all jointly develop and adopt a single GSP or whether there will be multiple coordinated GSPs. It is anticipated that the GSAs within the Santa Maria Basin may enter into a memorandum of agreement (MOA) or a coordination agreement establishing the process by which a single GSP or coordinated GSPs will be developed.

While GSAs were formed by the local public agencies mentioned above, SGMA provides that other entities are eligible to participate in GSA decision making. Various other eligible entities within the Santa Maria Basin, including the City of Pismo Beach, and Nipomo Community Services District have been engaged in SGMA processes and outreach to local stakeholders since 2015.

Interested parties are encouraged to participate in the GSP development. It is anticipated that the GSP consultant, once retained by the County (anticipated in 2019), will develop a stakeholder outreach and engagement plan, likely in coordination with the other GSAs within the Santa Maria Basin. The County GSA or the GSAs jointly may decide to establish one or more advisory committees in order to consider the interests of beneficial uses and users not already represented. These stakeholder engagement decisions will be made during the early stages of the GSP development once the County retains a GSP consultant. The meeting dates and locations will be posted by the County (and other GSAs as applicable) and noticed through the interested stakeholder e-mail list and press releases. In the meantime, interested parties can participate in the GSP development by attending public meetings and/or related public workshops. After the GSP(s) is completed, it will then be considered for adoption by each GSA and subsequently submitted to DWR for approval.

Interested parties can visit the County's SGMA webpage at: www.slocountywater.org/sgma to get additional information, meeting updates, sign up for the interested stakeholder e-mail list, and to see materials for past or upcoming meetings related to the GSP development.

The County GSA looks forward to working with DWR and other Santa Maria Basin stakeholders towards sustainable groundwater management planning and implementation. Please do not hesitate to contact Dick Tzou, Water Resources Engineer, at (805) 781-4473 if you have questions or comments.

Sincerely,

Debbie Arnold

DEBBIE ARNOLD
Chair, District 5 Supervisor

Attachment: Vicinity Map

c: Dane Mathis, Department of Water Resources
Matthew Owens, Department of Water Resources
Matthew Young, Santa Barbara County Water Agency
Board of Supervisors, County of Santa Barbara
Mario Iglesias, Nipomo Community Services District (miglesias@ncsd.ca.gov)
Daniel Heimel, Northern Cities Management Area (dheimel@wsc-inc.com)
Norm Brown, Nipomo Mesa Management Area (water@normbrown.com)
Randy Sharer, Santa Maria Valley Management Area (oldbeanfarmer@yahoo.com)

File: CF 340.300.01 SGMA

L:\Water Resources\2019\January\BOS\SMB\Santa Maria Basin Notice of Intent ltr.docx.dt.mp

ATTEST:

Tommy Gong, County Clerk-Recorder and
Ex-Officio Clerk of the Board of Supervisors

By, Sandy Currens
Deputy Clerk

C

Appendix C City of Arroyo Grande Resolution to form GSA

RESOLUTION NO. 4784

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF ARROYO GRANDE, COUNTY OF SAN LUIS OBISPO ADOPTING AND DIRECTING THE FORMATION OF A GROUNDWATER SUSTAINABILITY AGENCY (GSA) OVER THE NON-ADJUDICATED PORTION OF THE SANTA MARIA GROUNDWATER BASIN WITHIN THE ARROYO GRANDE CITY LIMITS IN COMPLIANCE WITH THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT OF 2014

WHEREAS, in 2014 the California Legislature and the Governor passed into law the Sustainable Groundwater Management Act (SGMA) for local management of groundwater resources in California through the formation of Groundwater Sustainability Agencies (GSAs) and through preparation and implementation of Groundwater Sustainability Plans (GSPs); and

WHEREAS, the City overlies a portion of the non- adjudicated "fringe area" of the Santa Maria Groundwater Basin, which is subject to SGMA, and thus one or more GSAs must be formed for the Sub-basin by June 30, 2017, or the Sub-basin may be subject to regulation by the State Water Resources Control Board; and

WHEREAS, the City is a "local agency" as that term is defined by SGMA, and as such is authorized to form a GSA to manage groundwater resources in the Sub-basin and within the City's jurisdictional boundaries in accordance with SGMA and other applicable laws and authorities; and

WHEREAS, the City desires to form a GSA to manage groundwater resources in the Santa Maria Groundwater Basin beneath and within the City's jurisdictional boundaries; and

WHEREAS, the City intends that its GSA will work cooperatively with the other GSAs that have formed or will be formed in the non- adjudicated "fringe area" of the Santa Maria Groundwater Basin to prepare one or more GSPs by January 2020, so that groundwater resources in the Sub-basin will be properly managed and sustainable in accordance with the provisions of SGMA; and

WHEREAS, it is essential that the City form this GSA because SGMA grants GSAs substantial additional powers and authorities to ensure sustainable groundwater management. Acting as the GSA within the City's jurisdictional boundaries will, among other things, confirm the City's role as the local groundwater management agency; and.

WHEREAS, pursuant to the requirements of SGMA, the City held a public hearing on this date after publication of notice pursuant to California Government Code section 6066 to consider adoption of this Resolution.

RESOLUTION NO. 4784
PAGE 2

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Arroyo Grande as follows:

1. All of the above recitals are true and correct and incorporated herein by reference.

2. The Mayor is authorized to sign a resolution for the City of Arroyo Grande to become a Groundwater Sustainability Agency in accordance with the Sustainable Groundwater Management Act of 2014 over the portion of the non- adjudicated "fringe area" of the Santa Maria Groundwater Basin which lies under and within the jurisdictional boundaries of the City of Arroyo Grande.

On motion of Council Member Harmon, seconded by Council Member Ray, and on the following roll call vote, to wit:

AYES: Council Members Harmon, Ray, Barneich, Brown, and Mayor Hill
NOES: None
ABSENT: None

the foregoing Resolution was passed and adopted this 28th day of March, 2017.

RESOLUTION NO. 4784
PAGE 3

JIM HILL, MAYOR

ATTEST:

KELLY WETMORE, CITY CLERK

APPROVED AS TO CONTENT:

ROBERT MCFALL, INTERIM CITY MANAGER

APPROVED AS TO FORM:

HEATHER K. WHITHAM, CITY ATTORNEY

OFFICIAL CERTIFICATION

I, **KELLY WETMORE,** City Clerk of the City of Arroyo Grande, County of San Luis Obispo, State of California, do hereby certify under penalty of perjury, that the attached Resolution No. 4784 was passed and adopted at a regular meeting of the City Council of the City of Arroyo Grande on the 28th day of March, 2017.

WITNESS my hand and the Seal of the City of Arroyo Grande affixed this 30th day of March, 2017.

Kelly Wetmore

KELLY WETMORE, CITY CLERK

D

Appendix D County of San Luis Obispo Resolution to form GSA

GSA Formation **Exhibit C - Resolution forming the Santa Maria Basin Fringe Areas - County of SLO GSA**

BEFORE THE BOARD OF SUPERVISORS

of the

COUNTY OF SAN LUIS OBISPO

Tuesday, May 16, 2017

PRESENT: Supervisors Bruce S. Gibson, Adam Hill, Lynn Compton, Debbie Arnold and Chairperson John Peschong

ABSENT: None

RESOLUTION NO. 2017-130

RESOLUTION FORMING THE SANTA MARIA BASIN FRINGE AREAS – COUNTY OF SAN LUIS OBISPO GROUNDWATER SUSTAINABILITY AGENCY AND FINDING THAT THE PROJECT IS EXEMPT FROM SECTION 21000 ET SEQ. OF THE CALIFORNIA PUBLIC RESOURCES CODE (CEQA)

The following Resolution is hereby offered and read:

WHEREAS, in 2014, the California Legislature adopted, and the Governor signed into law, three bills (SB 1168, AB 1739, and SB 1319) collectively referred to as the Sustainable Groundwater Management Act (SGMA) (Water Code §§ 10720 *et seq.*), that became effective on January 1, 2015, and that have been subsequently amended; and

WHEREAS, the intent of SGMA, as set forth in Water Code section 10720.1, is to provide for the sustainable management of groundwater basins at a local level by providing local groundwater agencies with the authority, and technical and financial assistance necessary, to sustainably manage groundwater; and

WHEREAS, SGMA requires the formation of Groundwater Sustainability Agencies (GSAs) for the purpose of achieving groundwater sustainability through the adoption and implementation of Groundwater Sustainability Plans (GSPs) for all medium and high priority basins as designated by the California Department of Water Resources (DWR); and

WHEREAS, SGMA requires that a local agency or collection of local agencies decide to become a GSA for all medium and high priority basins on or before June 30, 2017 and that the GSA or GSAs for basins DWR has not designated as "subject to critical conditions of overdraft" develop a GSP or coordinated GSPs on or before January 31, 2022; and

WHEREAS, the Santa Maria River Valley Groundwater Basin (Basin), located within both the County of San Luis Obispo and the County of Santa Barbara, has been designated by DWR as a high priority basin, but not subject to critical conditions of overdraft; and

WHEREAS, although Water Code Section 10720.8 identifies the adjudicated areas of the Basin as exempt from SGMA provided certain requirements are met, the non-adjudicated areas of the Basin, commonly referred to as the Basin "Fringe Areas," some of which are located within the County of San Luis Obispo and some of which are located within the County of Santa Barbara, are subject to SGMA; and

WHEREAS, it is anticipated that the County of Santa Barbara will form a GSA covering the portions of the Basin "Fringe Areas" located within the County of Santa Barbara; and

WHEREAS, although there are a number of "local agencies" within the portion of the Basin "Fringe Areas" within the County of San Luis Obispo eligible to become a GSA pursuant to Water Code Section 10721, it is anticipated that only the City of Arroyo Grande will form a GSA; and

WHEREAS, both the Nipomo Community Services District (by Resolution No. 2017-1436) and the City of Pismo Beach (by Resolution No. 2017-027) have formally recommended or authorized that the County of San Luis Obispo serve as the GSA for the portions of the Basin "Fringe Areas" within their boundaries; and

WHEREAS, the County of San Luis Obispo intends to form a GSA to cover all areas which will not otherwise be covered by a GSA within the Basin "Fringe Areas" within the County of San Luis Obispo; and

WHEREAS, the County of San Luis Obispo published a notice of public hearing consistent with the requirements contained within Water Code Section 10723(b); and

WHEREAS, the Board of Supervisors conducted such a public hearing on May 16, 2017; and

WHEREAS, the County of San Luis Obispo is committed to the sustainable management of groundwater within the Basin "Fringe Areas" and intends to coordinate with other GSAs and affected parties, and to consider the interests of all beneficial users and uses of groundwater within the Basin "Fringe Areas" through the formation of an advisory committee.

NOW, THEREFORE, BE IT RESOLVED AND ORDERED by the Board of Supervisors of the County of San Luis Obispo, State of California, that:

Section 1: The foregoing recitals are true and correct and are incorporated herein by reference.

Section 2: The County of San Luis Obispo hereby decides to become the GSA for, and undertake sustainable groundwater management within, the Basin "Fringe Areas" with the exception of the portions of the Basin "Fringe Areas" located within the City of Arroyo Grande and within the County of Santa Barbara ("GSA Boundary"). A map of the GSA Boundary is attached hereto as Exhibit A and incorporated herein.

Section 3: The Director of Public Works of the County of San Luis Obispo, or designee, is hereby authorized and directed to submit notice of adoption of this Resolution in addition to all other information required by SGMA, including but not limited to, all information required by Water Code Section 10723.8, to DWR, and to develop and maintain an interested persons list as described in Water Code Section 10723.4 and a list of interested parties as described in Water Code Section 10723.8(a)(4).

Section 4: The Director of Public Works of the County of San Luis Obispo, or designee, is hereby authorized and directed to take such other and further actions as may be necessary or appropriate to implement the intent and purposes of this Resolution.

Section 5: The Board of Supervisors finds that the adoption of this Resolution is exempt from the requirements of the California Environmental Quality Act (Public Resources Code §§ 21000 et seq.) (CEQA) pursuant to Section 15061(b)(3) of the CEQA Guidelines.

Section 6: The Environmental Coordinator of the County of San Luis Obispo is hereby directed to file a Notice of Exemption in accordance with the provisions of CEQA.

Upon motion of Supervisor Compton, seconded by Supervisor Hill, and on the following roll call vote, to wit:

AYES: Supervisors Compton, Hill, Gibson, Arnold and Chairperson Peschong

NOES: None

ABSENT: None

ABSTAINING: None

the foregoing resolution is hereby adopted on the 16th day of May, 2017.

John Peschong
Chairperson of the Board of Supervisors

ATTEST:

Tommy Gong
Clerk of the Board of Supervisors
By: Sandy Currens
Deputy Clerk

[SEAL]

APPROVED AS TO FORM AND LEGAL EFFECT:

RITA L. NEAL
County Counsel

By: */s/Erica Stuckey*
Deputy County Counsel

Dated: April 27, 2017

STATE OF CALIFORNIA, } ss.
County of San Luis Obispo,

I, Tommy Gong, County Clerk and ex-officio Clerk of the Board of Supervisors, in and for the County of San Luis Obispo, State of California, do hereby certify the foregoing to be a full, true and correct copy of an order made by the Board of Supervisors, as the same appears spread upon their minute book.

WITNESS my hand and the seal of said Board of Supervisors, affixed this 30th day of May, 2017.

Tommy Gong
County Clerk and Ex-Officio Clerk of the Board
of Supervisors

(SEAL)

By Sandy Currens
Deputy Clerk.

4 of 5

E

Appendix E Memorandum of Agreement – Preparation of GSP

MEMORANDUM OF AGREEMENT REGARDING PREPARATION OF A GROUNDWATER SUSTAINABILITY PLAN FOR THE SANTA MARIA RIVER VALLEY - ARROYO GRANDE SUBBASIN

This Memorandum of Agreement ("MOA") is entered into by and between the City of Arroyo Grande ("City") and the County of San Luis Obispo ("County") (each referred to individually as a "Party" and collectively as the "Parties") for purposes of coordinating preparation of a single groundwater sustainability plan for the Santa Maria River Valley – Arroyo Grande Subbasin.

Recitals

WHEREAS, on September 16, 2014, Governor Jerry Brown signed into law Senate Bills 1168 and 1319 and Assembly Bill 1739, known collectively as the Sustainable Groundwater Management Act ("SGMA"), which became effective on January 1, 2015 and which have been and may continue to be amended from time to time; and

WHEREAS, SGMA requires the establishment of a groundwater sustainability agency ("GSA") or agencies and the adoption of a groundwater management plan ("GSP") or plans for all basins designated as medium- or high-priority by the California Department of Water Resources ("DWR") but authorizes such activities within all basins defined in DWR Bulletin No. 118 or as modified by DWR subject to certain enumerated exceptions; and

WHEREAS, on February 11, 2019, DWR released the Final 2018 Basin Boundary Modifications, which created two separate subbasins out of the previously identified Santa Maria River Valley Basin (DWR No. 3-012) ("Old Basin") which included both an adjudicated area (over which SGMA does not apply) and certain "fringe" areas, namely the Santa Maria River Valley – Arroyo Grande Subbasin (DWR No. 3-012.02) ("Subbasin") and the Santa Maria River Valley – Santa Maria Subbasin (DWR No. 3-012.01); and

WHEREAS, although the Old Basin had been designated by DWR as a high-priority basin, the Final SGMA 2019 Basin Prioritization Process and Results Document identifies the Subbasin as a very low-priority basin; and

WHEREAS, prior to DWR's creation of the Subbasin, both Parties decided to become the GSA for the portion of the "fringe" areas of the Old Basin (i.e. those areas outside of the adjudicated area) located within their respective service areas and informed DWR on their decision and intent to undertake sustainable groundwater management therein; and

WHEREAS, also prior to DWR's creation of the Subbasin, the County applied for and was awarded a Proposition 1, Sustainable Groundwater Planning Grant ("Grant") for GSP development efforts within the "fringe" areas of the Old Basin and within the San Luis Obispo Groundwater Basin; and

WHEREAS, the Grant Agreement between the County and DWR ("Grant Agreement") allocates $494,975 of the total Grant award to GSP development efforts within the fringe areas of the Old Basin (Component 3) subject to the terms and conditions set forth in the Grant Agreement, including, the condition that the County contribute a local cost share equal to the amount of the Grant allocated to Component 3 ("Local Cost Share"); and

WHEREAS, although SGMA likely no longer requires the adoption of a GSP within said areas, the Parties still desire to develop a GSP for the Subbasin given the existence of the Grant (DWR has confirmed that use of Grant funds to fund the development of a GSP within the newly created and prioritized Subbasin is consistent with the Grant and Grant Agreement) and given that the technical analysis resulting from the development of the GSP will likely provide information necessary for the preparation of the Arroyo Grande Creek Habitat Conservation Plan under development by the San Luis Obispo County Flood Control and Water Conservation District ("District") as well as a better overall understanding of the hydrogeologic processes in the Arroyo Grande Creek Watershed, both of which would assist with effective management of the District's Zone 3.

NOW, THEREFORE, it is mutually understood and agreed as follows:

Section 1
Purpose

This MOA is entered into by the Parties for the purpose of establishing the manner in which the Parties will coordinate in the development of a single GSP for the Subbasin that will be considered for adoption by the City Council and the County Board of Supervisors and that may be subsequently submitted to DWR for approval.

Section 2
Term

This MOA shall become effective on the date that the last Party signs ("Effective Date") and shall remain in effect until terminated in accordance with Section 8.1 below.

Section 3
City and County Roles and Responsibilities

3.1 The Parties shall work jointly to meet the objectives of this MOA.

3.2 The Parties shall retain the services of a consultant(s) to meet the objectives of this MOA, including, but not limited to, preparation of a GSP for the Subbasin in accordance with the provisions set forth in Section 4 and Section 6 below.

3.3 The Parties shall each designate a staff person(s) to participate in the development of the GSP and related technical studies through, without limitation, the provision of guidance and available data, in coordination with the consultant(s).

3.4 The Parties shall each be responsible for adopting the GSP and implementing the GSP within their respective service areas. Notwithstanding the foregoing, nothing contained in this MOA shall be construed as obligating either the City Council or the County Board of Supervisors to adopt the GSP developed pursuant to this MOA or as preventing either the City Council or the County Board of Supervisors from adopting the GSP developed under this MOA in the event that the other elects not to adopt it.

3.5 The Parties may individually or jointly lead certain Subbasin-wide public outreach and stakeholder involvement to improve development of the GSP in a manner consistent with Section 4 below.

Section 4
Public Engagement

4.1 The Parties will collaborate jointly in coordination with the consultant(s) to engage interested and affected stakeholders in the Subbasin regarding the development of the GSP. The public engagement process may entail holding public meetings, workshops, communicating through emails and postal mailings and establishing a web-based communication portal. The City and County staff designated pursuant to Section 3.3 above will provide regular updates to their respective governing bodies on the progress of the GSP development.

4.2 Each draft chapter and/or section of the GSP provided by the consultant(s) will first be internally reviewed by the City and County staff designated pursuant to Section 3.3 above and then subsequently made available for public comment during a specified comment period. Comments received during each such period will be considered prior to compilation and publication of the complete draft GSP which will also be made available for public comment during a specified comment period prior to either Party's adoption of the GSP.

Section 5
Funding

5.1 For each year during the term of this MOA, the City and County staff designated pursuant to Section 3.3 above shall develop an annual budget to implement this MOA.

5.2 Subject to approval of said budget by the County Board of Supervisors, the County agrees to fund all costs included in such approved budget contingent on the prior occurrence of the following: subsequent to recommendation / endorsement by the District Zone 3 Advisory Committee, the District includes in its approved annual budget(s) an amount equal to ten percent (10%) of the Local Cost Share required under the Grant Agreement with respect to Grant funds expended / claimed in connection with Component

3, but not to exceed a total of $50,000, and the District remits said amount to County in accordance with invoices issued by County. Nothing herein shall be construed as requiring the County Board of Supervisors or the District Board of Supervisors to approve any particular budget or budget item in any year.

Section 6
Retention of Consultants

6.1 The County agrees to act as the contracting agent to retain the services of a consultant(s) as described in Section 3.2 above.

6.2 Notwithstanding the foregoing, the County agrees that no request for proposals will be circulated until City staff approves the scope of work included therein and that a City staff representative shall be invited to participate in the various subsequent stages of the selection process, including, but not limited to, review of proposals and participation on interview panels.

6.3 All consultant contracts entered into by the County pursuant to this MOA shall include a provision requiring that the consultant name the City as an additional insured and to indemnify and hold the City harmless from damages and costs caused in whole or in part by any negligent or wrongful act, error or commission of consultant.

Section 7
Notice

7.1 To provide for consistent and effective communication between the Parties, each Party shall designate a representative as its central point of contact on matters relating to this MOA.

7.2 All notices, statements, or payments related to this MOA shall be deemed to have been duly given if in writing and delivered electronically, personally or mailed by first-class, registered or certified mail to the Parties at the addresses set forth in Exhibit A. The Parties may update Exhibit A from time to time without formal amendment to this MOA.

Section 8
Termination

8.1 This MOA may be terminated by either Party upon thirty (30) days written notice to the other Party's designated address as listed in Exhibit A.

Section 9
Miscellaneous

9.1 This MOA may be amended only in a writing signed by both Parties.

9.2 This MOA may be executed in counterparts, each of which shall be deemed to be an original, but all of which, when taken together, shall constitute one and the same agreement. This MOA may be executed and delivered by facsimile or scanned signature by either of the Parties and the receiving Party may rely on the receipt of such document so executed and delivered by facsimile or email as if the original had been received.

9.3 This MOA is made in the State of California, under the Constitution and laws of said State and is to be so construed.

9.4 If any provision of this MOA is determined to be invalid or unenforceable, the remaining provisions shall remain in full force and unaffected to the fullest extent permitted by law and regulation.

9.5 This MOA constitutes the sole, entire, integrated and exclusive agreement between the Parties regarding the contents herein. Any other contracts, agreements, terms, understandings, promises or representations not expressly set forth or referenced in this writing are null and void and of no force and effect.

9.6 The Parties agree and acknowledge that this MOA has been developed through negotiation, and that each Party has had a full and fair opportunity to revise the terms of this MOA. Consequently, the normal rule of construction that any ambiguities are to be resolved against the drafting party shall not apply in construing or interpreting this MOA.

[signatures to follow on next page]

IN WITNESS WHEREOF, the Parties have executed this MOA by authorized officials thereof on the dates indicated below.

CITY OF ARROYO GRANDE	**COUNTY OF SAN LUIS OBISPO**
By: ______________	By: ______________
Its: MAYOR PRO TEM	Its: Chairperson, Board of Supervisors, County of San Luis Obispo, State of California
Date: 6-25-2020	Date: October 6, 2020
APPROVED AS TO FORM AND LEGAL EFFECT:	**APPROVED AS TO FORM AND LEGAL EFFECT:**
By: ______________	By: ______________
Its: CITY ATTORNEY	Its: Deputy County Counsel
Date: 6-25-2020	Date: June 3, 2020

ATTEST:
Wade Horton, County Clerk of the Board and
Ex-Officio Clerk of the Board of Supervisors
By, ______________
Deputy Clerk

Page **6** of **7**

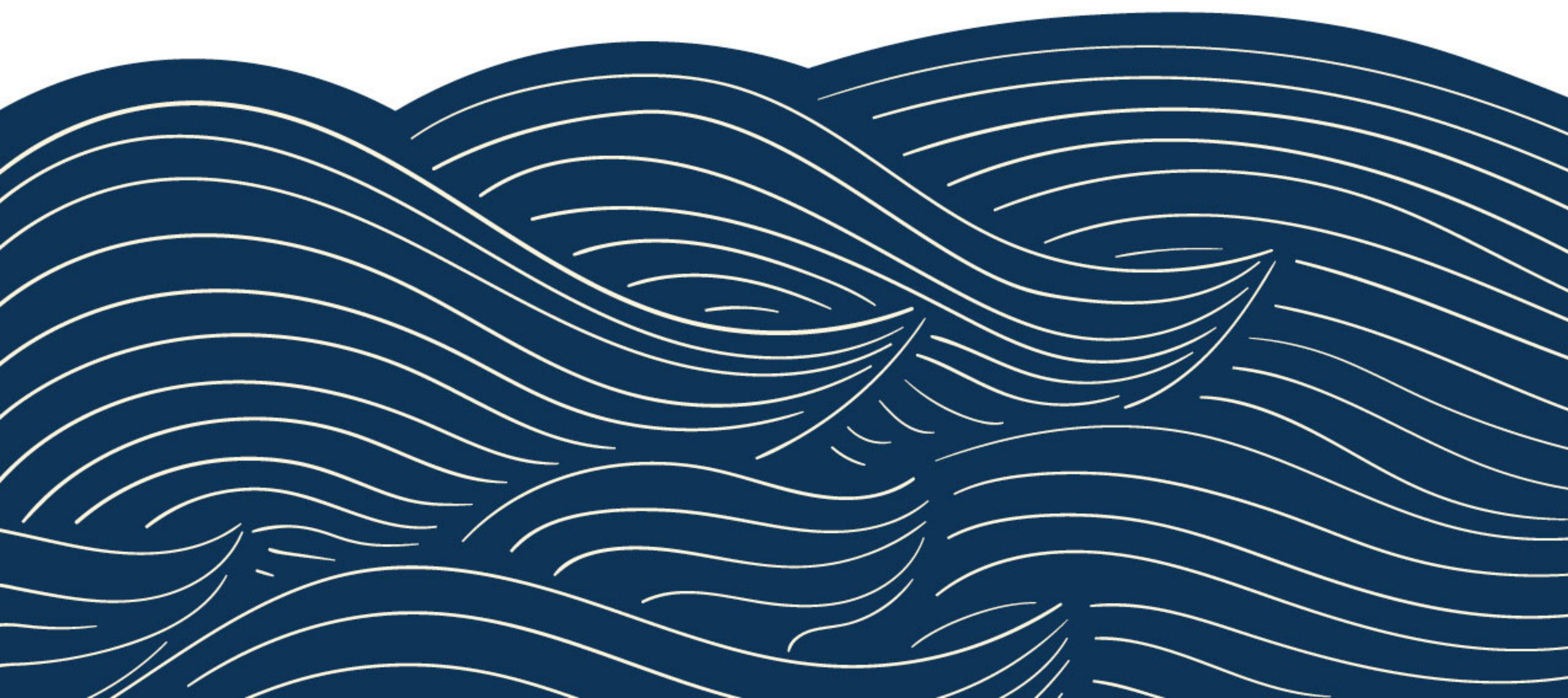
EXHIBIT A
PARTY ADDRESS LIST

County of San Luis Obispo
County Government Center, Room 206
San Luis Obispo, CA 93408
Attention: John Diodati, Interim Public Works Director

City of Arroyo Grande
Public Works Department
1375 Ash Street
Arroyo Grande, CA 93420
Attention: Bill Robeson, Director

F

Appendix F Communication and Engagement Plan



Arroyo Grande Subbasin GSP

Stakeholder Outreach and Engagement Plan

November 2020

WSC
Water Systems Consulting, Inc.

Plan Purpose

This Communication and Engagement Plan (C&E Plan) describes the planned activities for engaging interested parties in the development of a Sustainable Groundwater Management Act (SGMA) compliant Groundwater Sustainability Plan (GSP) for the Arroyo Grande Valley Subbasin. It is designed to meet the stakeholder engagement requirements of SGMA and the GSP regulations.

This plan is structured to relay the following as advised by the California Department of Water Resources' (DWR) stakeholder Communication and Engagement Guidance Document:

- Demonstrate how the Groundwater Sustainability Agency (GSA) aims to communicate with and engage relevant Basin stakeholders
- Identify the methods and tools to support communication and engagement
- Identify how the GSA plans to solicit and utilize stakeholder input in the plan development

Plan Goals

OUTREACH AND ENGAGEMENT GOALS

- Utilize a SGMA-compliant engagement approach
- Educate stakeholders about the project and Basin
- Engage beneficial uses/users of Basin groundwater across three interactive workshops
- Obtain public comment on the GSP in an actionable and timely manner
- Effectively communicate to stakeholders the relationship between this and parallel projects

Plan Roles

PROJECT CONTACTS AND ROLES

GSA MEMBER AGENCIES (Decision Authority)

- County of San Luis Obispo, Dick Tzou
- City of Arroyo Grande, Shane Taylor

CONTRACTOR PM
Dan Heimel, WSC

OUTREACH AND ENGAGEMENT LEAD
Tiffany Meyer, WSC

Recommended Communications Approach

2. COORDINATED STAKEHOLDER OUTREACH

- **WEBSITE CONTENT:** *All project information will be housed on a SGMA web page on the County of San Luis Obispo website. This includes workshop and meeting information as well as documents open for public comment.*
- **EMAIL OUTREACH:** *Periodic informational emails to notify stakeholders of opportunities to get involved, and to report out on workshop recordings and summaries.*

2. INTERACTIVE PUBLIC WORKSHOPS

The GSA members will host three educational and interactive virtual workshops to give stakeholders an opportunity to inform key GSP decisions:

- **DEC. 15, '20:** BASIN SETTING, VISIONING
- **MAR. 3, '21:** SUSTAINABLE GOAL SETTING
- **MAY 12, '21:** PROJECTS AND MANAGEMENT ACTIONS

3. PUBLIC MEETING GSP PROJECT UPDATES

The GSA members will provide periodic project updates of the project to their relevant councils as follows:

- **COUNTY OF SLO:** County Board of Supervisors SGMA Update
- **CITY OF ARROYO GRANDE:** City of AG City Council

4. GSP PUBLIC COMMENT PERIOD

Per SGMA requirements, the GSAs will release chapters in stages for a minimum of a 30-day public comment period as follows:

- **CHAPTERS 1-3:** JAN '20
- **CHAPTERS 4-6:** MAY '21
- **CHAPTERS 7-8:** JUN '21
- **CHAPTERS 9-10:** JUL '21
- **FULL DRAFT GSP:** NOV '21

Project Schedule

Step 1. Establish Governance Structure
CHAPTERS 1-3

NOV '20 – JAN '21

PUBLIC COMMENT PERIOD
JAN 2020

Step 2. Document Basin Setting
CHAPTERS 4-6

NOV '20 – MAY '21

STAKEHOLDER WORKSHOP #1: BASIN SETTING AND VISIONING
DEC 15, 2020

PUBLIC COMMENT PERIOD
MAY 2021

PUBLIC MEETING PROJECT UPDATES — PER DEFINED SCHEDULE
- County Board of Supervisors SGMA Update
- City of AG City Council

Step 3. Set Sustainability Goals
CHAPTERS 7-8

FEB '21 – JUN '21

STAKEHOLDER WORKSHOP #2: SUSTAINABLE GOAL SETTING
MAR 3, 2021

PUBLIC COMMENT PERIOD
JUN 2021

PUBLIC MEETING PROJECT UPDATES — PER DEFINED SCHEDULE
- County Board of Supervisors SGMA Update
- City of AG City Council

Step 4. Develop Plan to Sustainability
CHAPTERS 9-10

JAN '21 – JUL '21

STAKEHOLDER WORKSHOP #3: PROJECTS AND MANAGEMENT ACTIONS
MAY 12, 2021

PUBLIC COMMENT PERIOD
JUL 2021

PUBLIC MEETING PROJECT UPDATES — PER DEFINED SCHEDULE
- County Board of Supervisors SGMA Update
- City of AG City Council

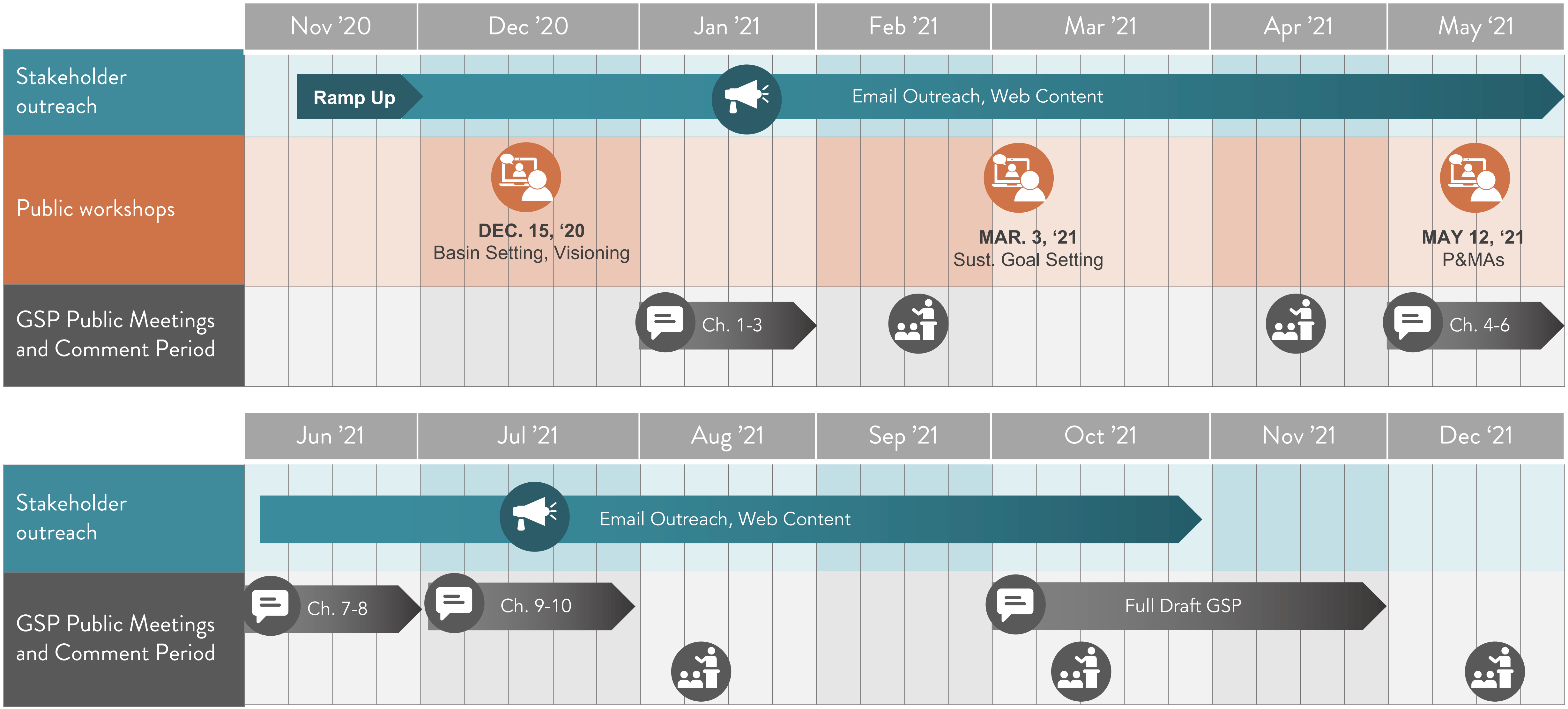
Step 5. Adopt the Plan
FINISHED PLAN

APR '21 – JAN '22

FULL DRAFT GSP / PUBLIC COMMENT PERIOD
NOV 2021

PUBLIC MEETING PROJECT UPDATES — PER DEFINED SCHEDULE
- County Board of Supervisors SGMA Update
- City of AG City Council

Schedule of Outreach and Engagement Activities



Stakeholder Audience Segments

The following stakeholders were identified in the project kick off meeting and align with the segments of beneficial uses and users of groundwater as recommended by DWR.

AGRICULTURAL WATER USERS
Individual agric. landowners, farm bureaus

ECONOMIC DEVELOPMENT
Economic Development Corp; Hourglass Project; wine association; Elected officials

ENVIRO. AND CONSERV. NGOS
Creeklands Conservation, Surfrider Foundation

GENERAL PUBLIC
Unknown, other, water customers

HUMAN RIGHTS TO WATER
Disadvantaged communities; Rural Community Assistance Corp

INTEGRATED WATER MANAGEMENT
SLO County Flood and Water Conservation District, IRWMG Group, Water Resource Advisory Committee, Zone 3 Flood Control District

LAND USE / MUNICIPALITIES
County of SLO, City of Arroyo Grande, Zone 3, NCMA, NMMA, Zone 1/1A

PRIVATE, RURAL GW USERS
Private pumpers, domestic users (townhome and mobile home communities, campgrounds, private home-owners)

REGULATORY AGENCIES
DWR, SWRCB

STATE AND FEDERAL LANDS
State Parks, NMFS, USFWS, CDFW

TRIBES
Chumash People

Communication Forums and Tools

PROJECT WEBSITE

Communication Forums and Tools

EMAIL OUTREACH

Communication Forums and Tools

PUBLIC NOTICES

The stakeholder workshops are for stakeholder engagement purposes only. They are not designed to conduct official business by the GSA members, nor to make public decisions. Therefore, public notices compliant with the requirements of the Brown Act are not required for the stakeholder workshops.

However, the GSA members will maintain accurate workshop and public comment period information on the project website.

DIRECT OUTREACH TO BASIN STAKEHOLDERS

To encourage workshop participation by a diverse representation of basin stakeholders, the GSA members will also manage direct one-on-one outreach via email and follow up phone calls to highest priority stakeholders.

Communication Forums and Tools

VIRTUAL PUBLIC WORKSHOPS (offered via Zoom Meetings)

Dec. 15, 2020 • Virtual
Basin Setting and Visioning

In this virtual workshop, attendees will help create a shared vision for what a "sustainable Arroyo Grande Subbasin" means. To inform the interactive exercise, the project team will give a brief recap of the purpose of the Groundwater Sustainability Plan (GSP) and the requirements of the Sustainable Groundwater Management Act (SGMA) in easy-to-understand terms. Next, they'll summarize key takeaways of the Basin Setting work completed to date, which describes the Basin's unique geological makeup, potential challenges associated with groundwater management, and anticipated future groundwater use. Stakeholder input documented in this workshop will be used to create a set of guiding principles that will inform the remaining GSP decisions.

Mar. 3, 2021• Virtual
Sustainable Goal Setting

In this virtual workshop, attendees will help determine the preliminary set of sustainability goals for the Basin. To inform the interactive exercises, the project team will recap the guiding principles created with stakeholders in the first workshop. Next, they'll describe the relevant requirements of SGMA, including the role of Sustainable Management Criteria, minimum thresholds, and measurable objectives. Stakeholder input documented in this workshop will be used to draft the chapters 7-8 of the GSP.

May 12, 2020 • Virtual
Projects and Management Actions

In this virtual workshop, stakeholders will help inform a preliminary set of projects and management actions that will be used over the next 20 years to reach the sustainability goals set for the basin. To inform the interactive exercises, the project team will recap the guiding principles developed with stakeholders, as well as the sustainability goals developed in workshop #2. Activities will surface considerations for sharing project costs, and an implementation plan that keeps the approach flexible and on track. Stakeholder input documented in this workshop will be used to draft chapters 9-10 of the GSP.

Immediate Workplan

			November				December				
Category	**Actions**	**Resp**	**11/02**	**11/09**	**11/16**	**11/23**	**11/30**	**12/07**	**12/14**	**12/21**	**12/28**
Centralized outreach	Create ready-to-use website content, graphics and instructions for placement / publication by client	WSC / Tiffany									
	Create ready-to-use email bulletin content and distribution schedule (in MS Word) and images	WSC / Tiffany									
	Work with client to create target stakeholder list	WSC / Tiffany									
	Set up Mailchimp email account for ongoing outreach; manage ongoing email bulletins				X		X		X	X	
Public Workshops	**Workshop #1** • Design workshop #1 format, exercises, slides • Set up workshop Zoom registration • Review workshop content with client • Finalize workshop content • Facilitate workshop • Deliver workshop recording/slides to website for client to publish	WSC / Tiffany (Lead), Dan, Michael + GSA Members				Client Content Review	Re-hearsal		Recording & workshop summary published		
	Workshops #2 and #3 • Select dates/times for remaining workshops • Set up workshop Zoom registration • Add workshop details to project website	WSC / Tiffany									

G

Appendix G Integrated Groundwater and Surface Water Model Documentation

Technical Memorandum

Date:	10/14/2022	
To:	Brandon Zuniga, PE Water Resources Engineer County of San Luis Obispo (805) 788-2110	Shane Taylor Utilities Manager City of Arroyo Grande (805) 473-5464
CC:	Angela Ford, PE, Courtney Howard, PE	
Prepared By:	Erik Cadaret, PG, Alico Wolf, PG, CHG, Dave O'Rourke, PG, CHG	
Reviewed By:	Michael Cruikshank, PG, CHG	
Project:	Arroyo Grande Subbasin Groundwater Sustainability Plan	
Subject:	**SURFACE WATER/GROUNDWATER INTEGRATED MODEL DOCUMENTATION**	

1.0 Introduction

This draft Technical Memorandum is prepared by Water Systems Consulting, Inc. (WSC) and GSI Water Solutions, Inc. (GSI), for the San Luis Obispo County (County) Groundwater Sustainability Agency (GSA) and the City of Arroyo Grande GSA. As part of the Groundwater Sustainability Plan (GSP) for the Santa Maria River Valley- Arroyo Grande Subbasin (DWR Basin 3-012.2) (AG Subbasin), the consultant team is developing an integrated surface water-groundwater numerical model for the objective of evaluating the potential impacts of proposed projects and management actions associated with the GSP. The integrated model will also be dynamically linked to a reservoir operations model (MODSIM) to simulate operations of Lopez Dam and Reservoir in the Subbasin. The linked models will be used to support the GSP, as well as to support future analyses in the Subbasin as part of the Habitat Conservation Plan (HCP). The objective of this TM is to document the integrated model creation, calibration, and validation for the Arroyo Grande Subbasin.

The AG Subbasin is approximately seven miles long, oriented in a northeast-southwest direction, extending from Lopez Dam to the Adjudicated Area boundary (approximately coincident with the Wilmar Avenue Fault and Highway 101). The AG Subbasin is adjacent to the southeastern extent of the San Luis Obispo Groundwater Basin (DWR Basin 3-09) where there is a groundwater divide between the two basins (Figure 1). Groundwater flow direction in the San Luis Obispo Basin is to the northwest, away from AG Subbasin (GSI, 2018), so the two basins are distinct and there is assumed to be no significant hydraulic communication between the basins. Below Highway 101 is the Santa Maria River Valley Subbasin (SMRVS; DWR Basin 3-012.1) which is a large adjudicated coastal groundwater basin previously called the Santa Maria River Valley Groundwater Basin. The AG Subbasin was originally considered a part of the SMRVS as one of the “fringe areas” of the SMRVS but was recategorized by the State of California Department of Water Resources (DWR) as a separate groundwater basin from the SMRVS after a Basin Boundary Modification Request was submitted by the County and updated by DWR in their latest basin categorization.

The AG Subbasin has two primary tributaries: Arroyo Grande Creek and Tar Springs Creek. Arroyo Grande Creek valley is approximately seven miles long, oriented northwest-southeast, and is the primary surface water feature in the AG Subbasin. Tar Springs Creek valley is approximately about three miles long, oriented east-west, and joins Arroyo Grande Creek about three miles upstream of Highway 101 (Figure 1). Land surface of Arroyo Grande Creek valley extends from an altitude of about 380 feet MSL at the base of Lopez Dam to about 100 feet MSL at the bottom of the valley. Tar Springs Creek Valley extends from an altitude of about 360 feet MSL to 160 feet MSL at the confluence with Arroyo Grande Creek. Mountain ridges on the north side of the valley rise steeply to elevations of over 1500 feet MSL near Lopez Dam (Figure 1-1).

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

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

To date, neither a groundwater model or integrated surface water/groundwater model has been developed for the Arroyo Grande Creek Valley subbasin. However, several groundwater models have been developed for the southern portion of the proposed model domain in the SMRVS. The most recent model was completed in 2019 and is referred to herein as the Phase 1B model (Geoscience Support Services, 2019). As part of the model development, multiple modeling components were required to be combined into a single integrated model capable of simulating surface water hydrologic processes (i.e., rainfall/runoff) processes, movement of groundwater in the basin aquifers, groundwater/surface water interaction, and reservoir operations at Lopez Dam. The modeling components to be integrated include the following:

1. GSFLOW – This model, developed and maintained by the USGS, integrates Precipitation-Runoff Modeling System (PRMS) watershed model code with the MODFLOW groundwater model code.
2. MODFLOW – The existing Phase 1B model was developed as part of the Central Coast Blue (CCB) project to evaluate future groundwater conditions and preferential pathways for seawater intrusion and design an advanced purified water injection well network to protect the basin from degradation. The calibrated aquifer parameters and hydrostratigraphy documented in the Phase 1B Model were implemented for overlapping portions of the two models.
3. OASIS – This model is currently used to model operations at the Lopez Reservoir and downstream release conditions. This model is not compatible with GSFLOW without the development of custom computer code.
4. MODSIM – This model is a used to simulate water allocation and operations in river basins. This model is compatible with GSFLOW and was integrated with GSFLOW to translate the OASIS model into GSFLOW.

In this TM, we present the model creation and calibration process and results for the surface water model (PRMS) that were initially completed separately before being coupled in the GSFLOW integrated model. We also present the integration of these model components into GSFLOW and the final calibration and validation process and results for the GSFLOW integrated model.

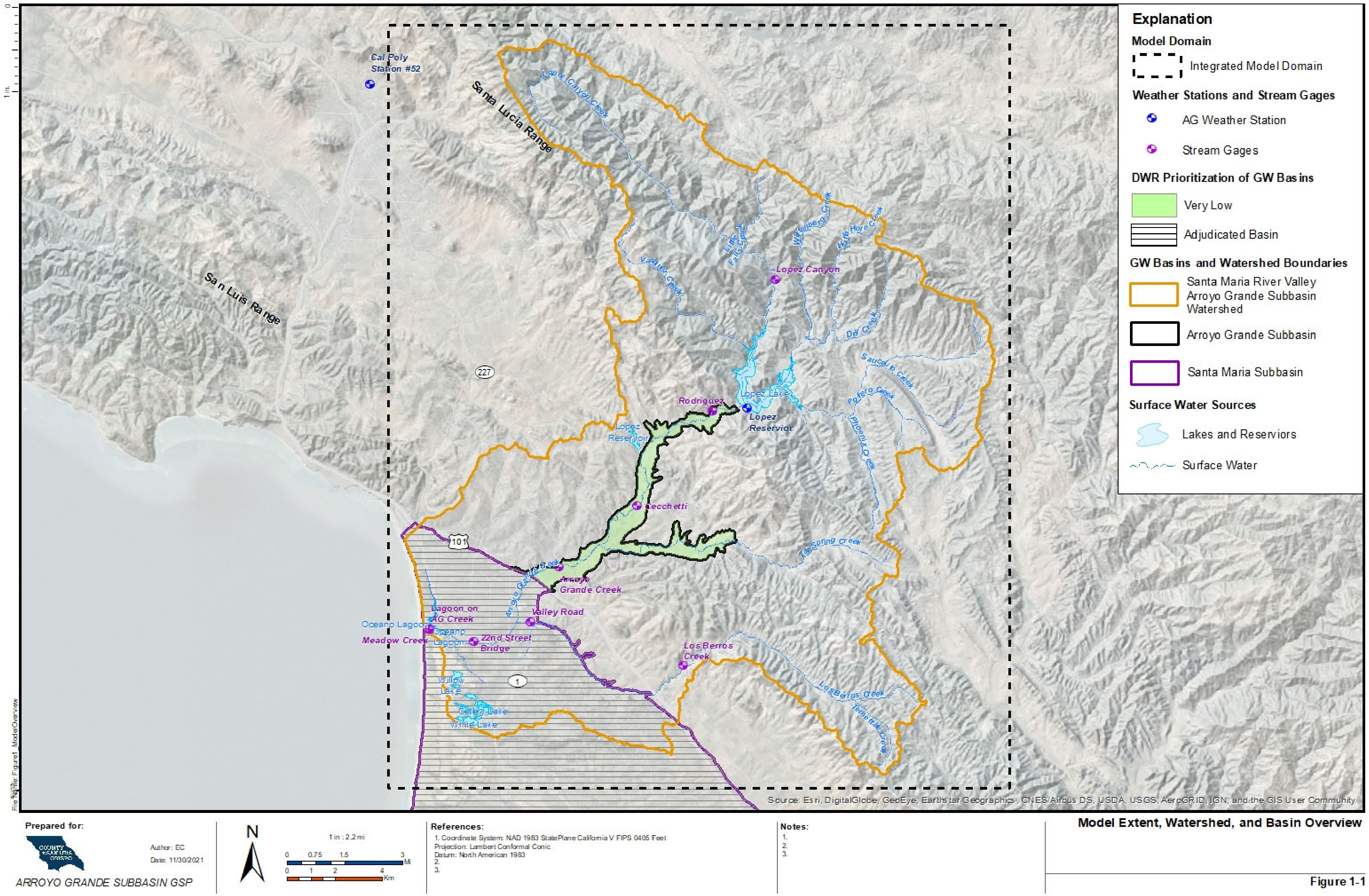


Figure 1--1. Model Extent, Watershed, and Basin Overview

2.0 Surface Water Model Development

The Basin surface water model was developed using the Precipitation-Runoff Modeling System (PRMS) version 5.2.0 which simulates the watershed-scale surface water component of the GSFLOW integrated model. PRMS is a deterministic, distributed-parameter, physical-process hydrologic model used to simulate and evaluate the watershed response of various combinations of climate and land use (Markstrom, et al., PRMS-IV, the Precipitation-Runoff Modeling System, Version 4, 2015).

In the PRMS model, climate data, including precipitation, temperature, and solar radiation, are applied to simulate hydrologic water budgets based on spatially defined watershed-component model parameters such as plant canopy and soil zone properties. Surface and subsurface flow is calculated through the cascading of rain-generated runoff. When run in PRMS-only mode, runoff that infiltrates into the soil zone is distributed to the subsurface reservoir and groundwater reservoir where it can interflow to streams or lakes. When run in a coupled GSFLOW simulation, groundwater flow routing is simulated in MODFLOW rather than PRMS. Initial parameter estimation of the PRMS model was performed in PRMS-only mode prior to integration into GSFLOW and final calibration of the integrated model for water year (WY) 1988 - 2020. The calibration period for the surface water model was WY 1994 – 2018 based on the available surface water data sets based on Lopez Canyon and Arroyo Grande Creek stream gages which had the most comprehensive data available for calibration purposes.

Model Grid

The surface water model was developed to cover the entire Basin watershed. The model grid cell was determined by evaluating the width of riparian zones (as defined by the width of tree canopy along the stream course) which averages approximately 200-feet (Figure 2-1). Therefore, the model grid was designed to utilize 200-foot square grid cells for both PRMS and MODFLOW for the entire watershed area. This approach in evaluating a model grid cell size was taken to reasonably simulate surface water/groundwater interaction of GDEs within the basin that will be relevant to support GSP and HCP objectives.

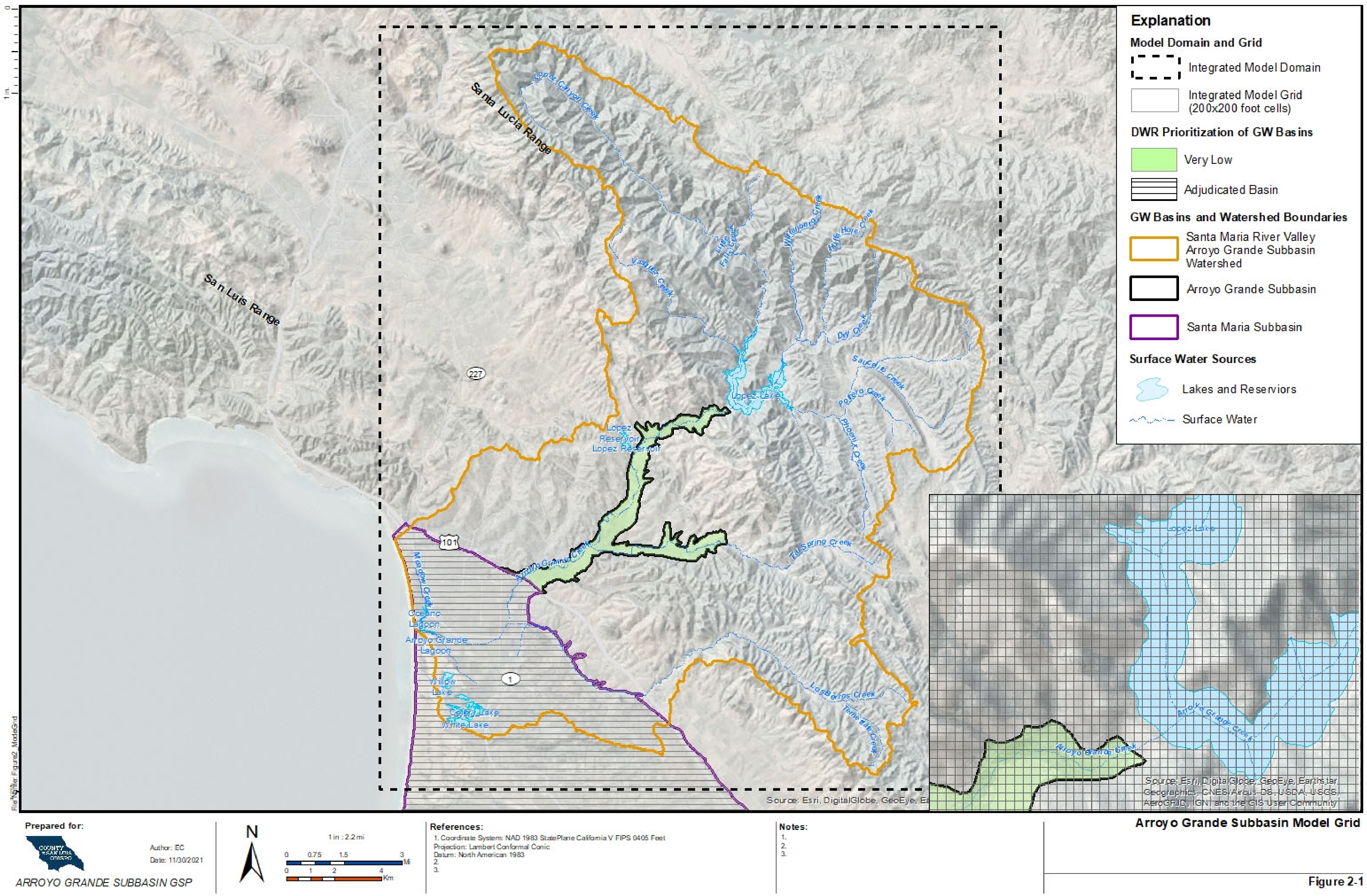


Figure 2--1. Arroyo Grande Subbasin Model Grid

Datasets and Sources

The data used in the surface water model to develop and initially calibrate PRMS are described in the following sections.

Climate Data

The climate data sources within the Basin include two weather stations, Cal Poly #52 and Lopez Reservoir[1](shown in Figure 1-1) and Parameter-Regression on Independent Slopes Model (PRISM) data (Table 2-1) were used in the surface water model calibration.

Table 2--1: Climate data used for surface water model.

Climate Data Source	Date Range	Precipitation (in)	Date Range	Temperature (F)	Date Range	Evapotranspiration (in)	Date Range	Solar Radiation (Ly/day)
Cal Poly #52*	1870 - 2019	YES[A]	1906 - 2019	YES[B]	1986 - 2019	YES[C]	1986 - 2019	YES[C]
Lopez Reservoir (Monthly)	1968 - 2020	YES	2000 - 2020	Yes	1968 - 2020	Yes (Pan Evaporation and Coefficients)	-	-
Lopez Reservoir (Daily)	1994 - 2020	YES	2000 - 2020	Yes	1994 - 2020	Yes (Pan Evaporation and Coefficients)	-	-
PRISM	1981 - 2010	YES	1981 – 2010	YES	-	-	-	-

Notes:

* - Weather station contains sensors from ITRC, CIMIS, and NOAA
A - Daily precipitation record starts 2/1/1893
B - Daily temperature record starts 4/1/1906
C - Daily evaporation and solar radiation record starts 4/2/1986

PRISM data spatially distributes precipitation and temperature to account for orographic effects due to elevation change. The 800m mean monthly precipitation and minimum and maximum temperature values from 1981 to 2010 from the Parameter-Regression on Independent Slopes Model (PRISM) (NACSE, 2019) were used in the surface water model. Monthly precipitation scaling factors and daily minimum and maximum temperature were calculated at each HRU using GSFLOW-ArcPy scripts developed by Gardner et al., 2018. The precip_1sta and temp_sta modules were used to perform precipitation and temperature calculations as described above.

[1]Temperature data at this location was manually measured twice a day manually and records only go back to WY 2000. No solar radiation data is recorded at this location.

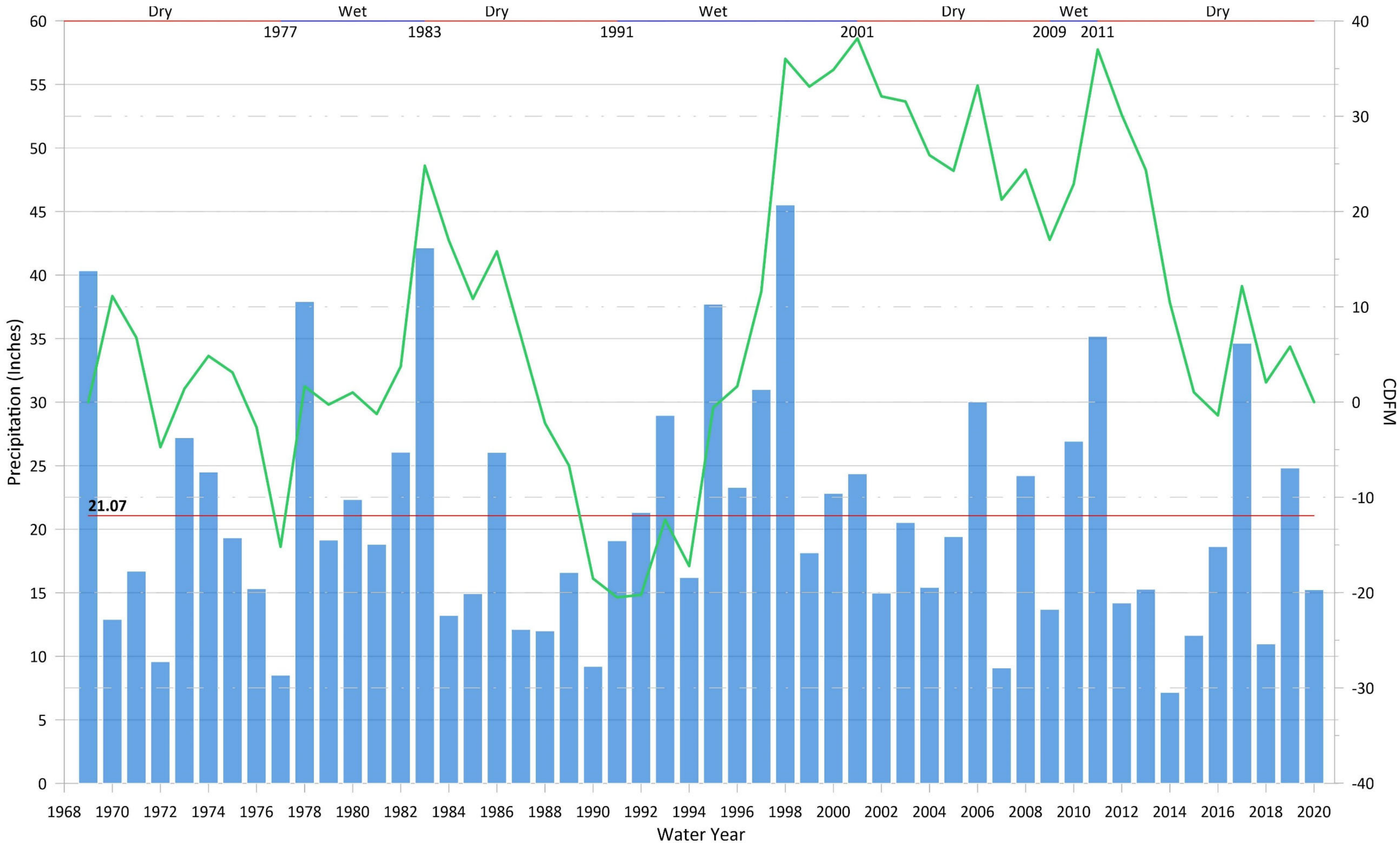
Figure 2-2 shows the measured Lopez Reservoir precipitation data from 1969 to 2020 as well the approximated wet-dry years as interpreted from the calculated cumulative departure from the mean (CDFM) line.

Potential Evapotranspiration Data

Potential evapotranspiration (PET) for natural vegetation and irrigated crops was computed by the PRMS model based on air temperature, solar radiation, and two Jensen-Haise formula coefficients using the Jensen-Haise method (Jensen and Haise, 1963). Annual PET data for reference crops are available from CIMIS and specific evapotranspiration data for different crop types within the Basin are available from DWR. The actual evapotranspiration was calculated in the model from the PET data while also considering land use, vegetation type, soil type, and available soil moisture.

Topography

A 10-m USGS digital elevation model (DEM) was used to determine the slopes, connectivity, and elevations within the watershed area. The DEM was processed using the GSFLOW-ArcPy scripts (Gardner et al., 2018) that utilize the USGS Cascade Routing Tool (Henson et al., 2013) to define the cascading surfaces and subsurface flow paths for the grid-based domain. As part of the CRT calculation, unintentional swales (low-lying areas) are smoothed to provide continuous down-sloping HRUs. After these calculations have been completed, we found not all unintentional swales were adequately smoothed and, in these areas, manual modifications were made to provide continuous down-sloping HRUs. Figure 2-3 presents the 10-m DEM used for the surface water model.



Prepared for:

Author: EC

12/02/2021

ARROYO GRANDE BASIN GSP

Legend

Precipitation (Annual)

CDFM

Historical Average Precipitation

Notes:

1. Data Source: Lopez Dam Weather Station

Arroyo Grande Historical Annual Precipitation and CDFM

Figure 2-2

Figure 2--2. Arroyo Grande Historical Annual Precipitation and CDFM

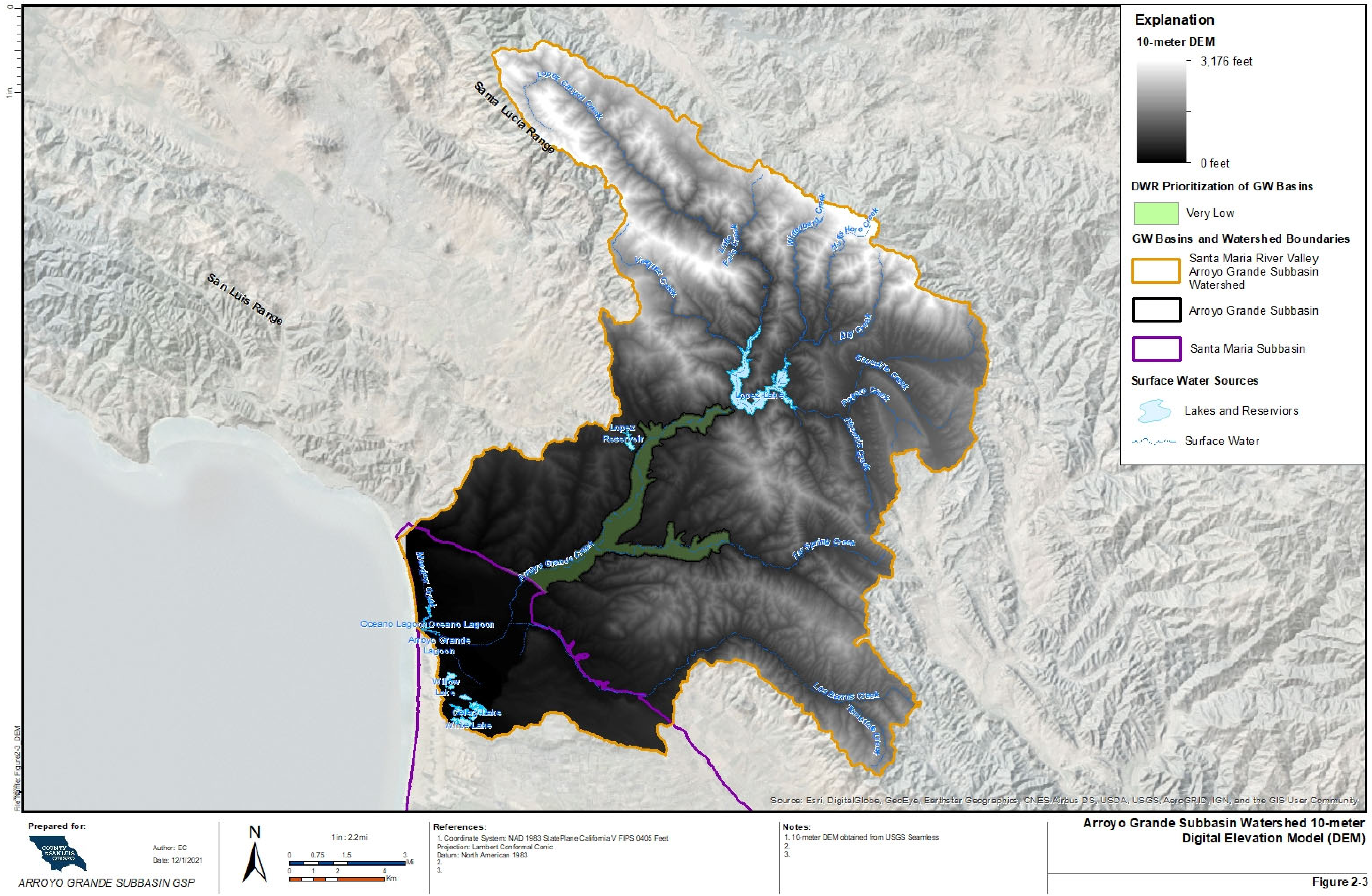


Figure 2--3. Arroyo Grande Subbasin Watershed 10-meter Digital Elevation Model (DEM)

Land Use

Soil attributes based on the National Resources Conservation Service (NRCS) soil survey data (SSURGO and STATSGO) are assigned to HRUs and are used by various soil parameters in PRMS to model fluxes between vegetation and the soil-root zone. SSURGO data didn't fully extend across the entire watershed and STATSGO data was used in the northeast portion of the watershed in the Santa Lucia Mountains to provide full soil data coverage.

Land use was fixed in the PRMS baseline model to provide a starting point for comparison for future model scenarios. The National Land Cover Dataset (Homer, Fry, & Barnes, 2012) is a grid-based representation of land uses in the watershed and was used as a base land use layer. DWR spatial crop data from 2016 and U.S. Forest Service (USFS) Landfire dataset were used in conjunction with the NLCD dataset to provide a more detailed characterization of land cover and use. The land cover percentages are assigned to each HRU and is used to model fluxes between vegetation and the soil root-zone and in the case of impervious land cover areas, no infiltration that would lead to surface runoff. Figure 2-4 through 2-7 presents the NLCD land use, DWR crop, and Landfire vegetation datasets used for the surface water model.

Stream Network

Streamflow routing is handled in MODFLOW using the SFR package once PRMS is coupled in MODFLOW. Before integrating in GSFLOW, PRMS requires streamflow routing to be completed. The PRMS stream network is delineated by assigning mean surface elevations to each HRU grid cell within the watershed using the watershed 10-m DEM as described in *Topography* from the National Elevation Dataset (National Elevation Dataset, 2019).The mean elevations are then used by the GSFLOW-ArcPy scripts to designate the stream segments locations by creating continuously down-sloping HRUs. Generated stream segments were viewed in comparison to USGS National Hydrography Dataset (NHD) streams in ArcMap (National Hydrography Dataset, 2002 - 2016) and recent satellite imagery from Google Earth to evaluate the accuracy of the stream delineation. Stream segment alignments were iteratively adjusted by manually altering the mean elevation of HRUs and rerunning the GSFLOW-ArcPy scripts. The level of detail with regards to stream order was optimized to be representative of the main branches and the primary tributaries. Figure 2-9 presents the stream segments generated for the PRMS model.

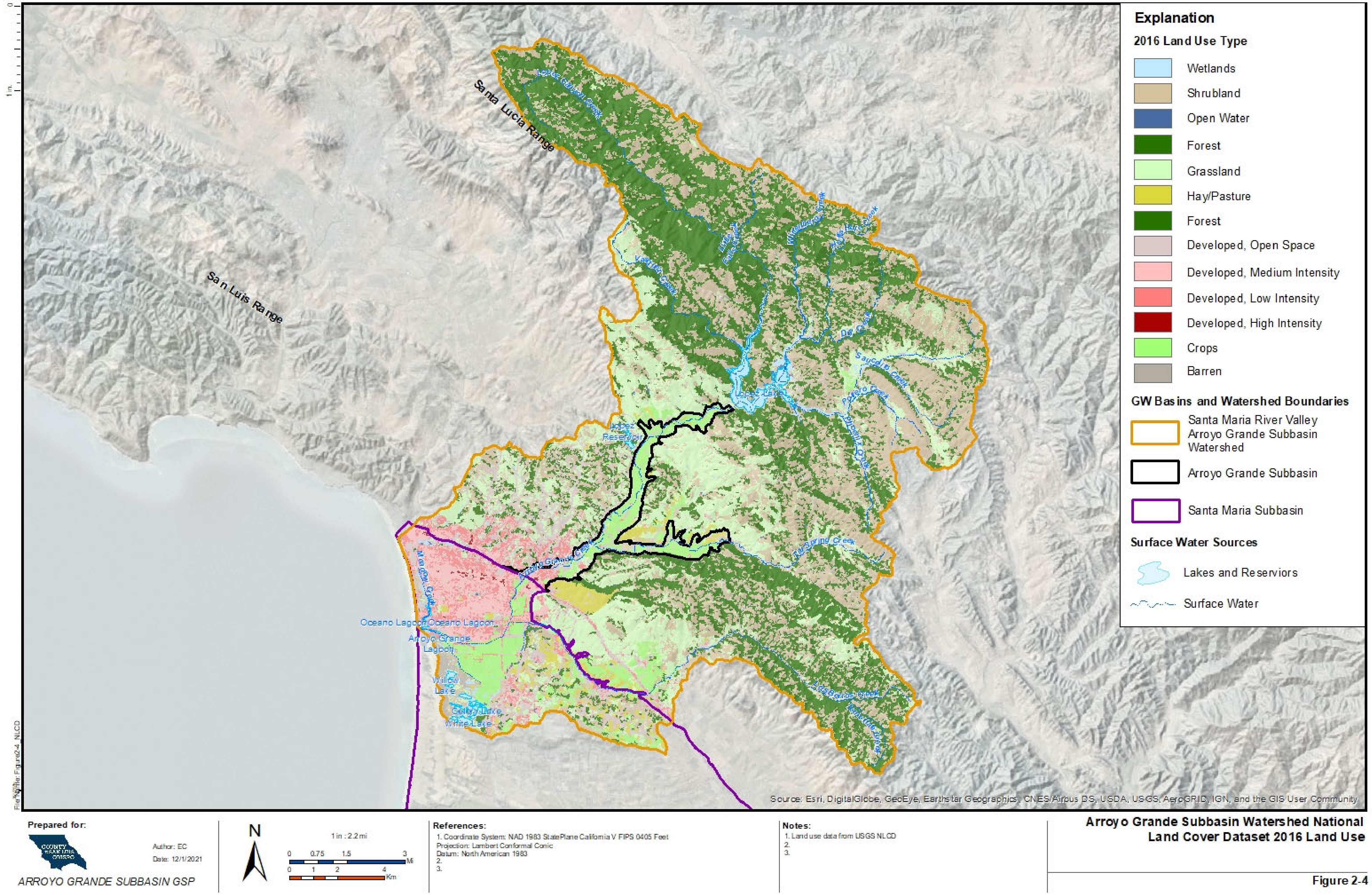


Figure 2--4. Arroyo Grande Subbasin Watershed National Land Cover Dataset 2016 Land Use

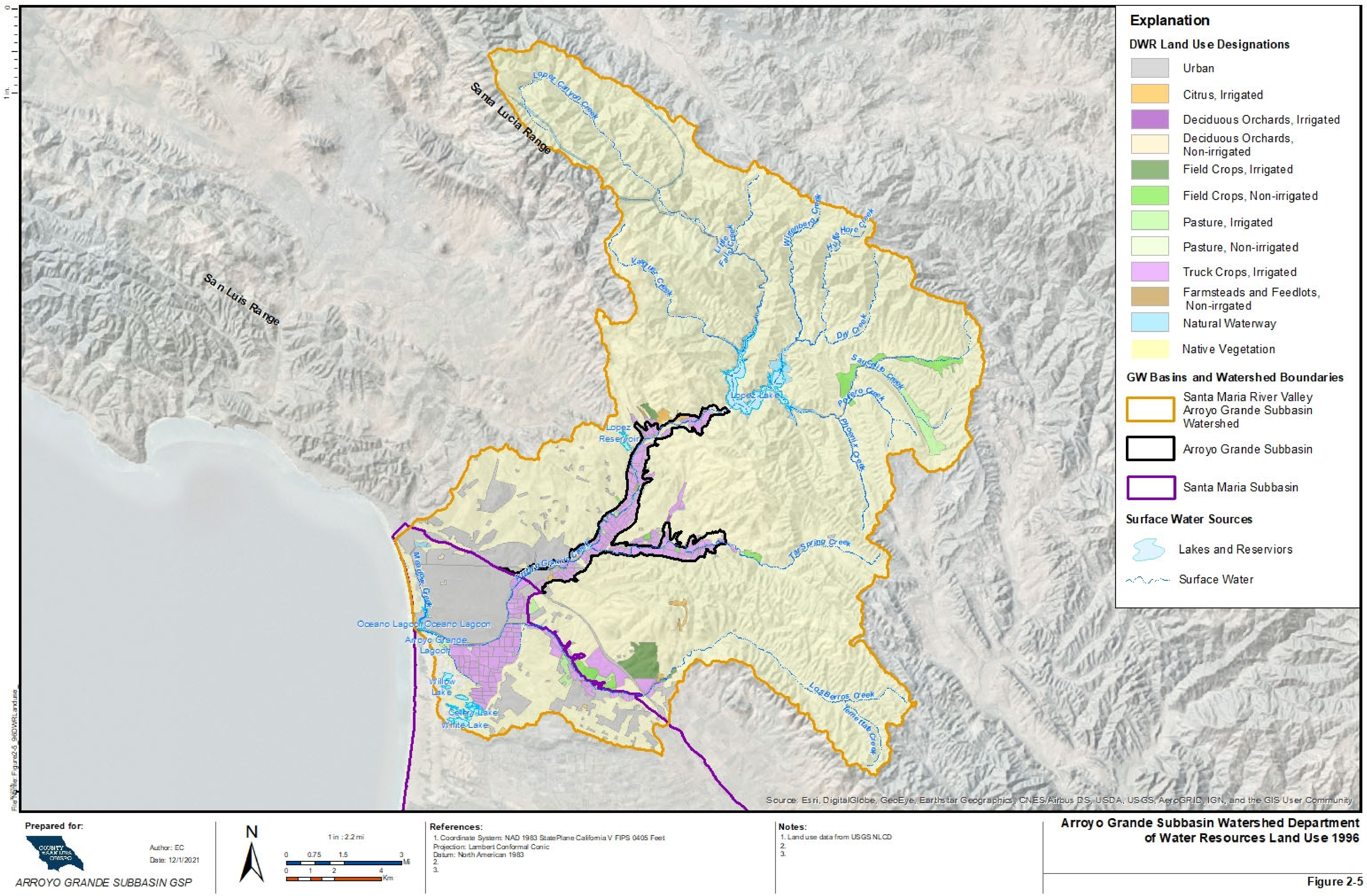


Figure 2--5. Arroyo Grande Subbasin Watershed Department of Water Resources Land Use 1996

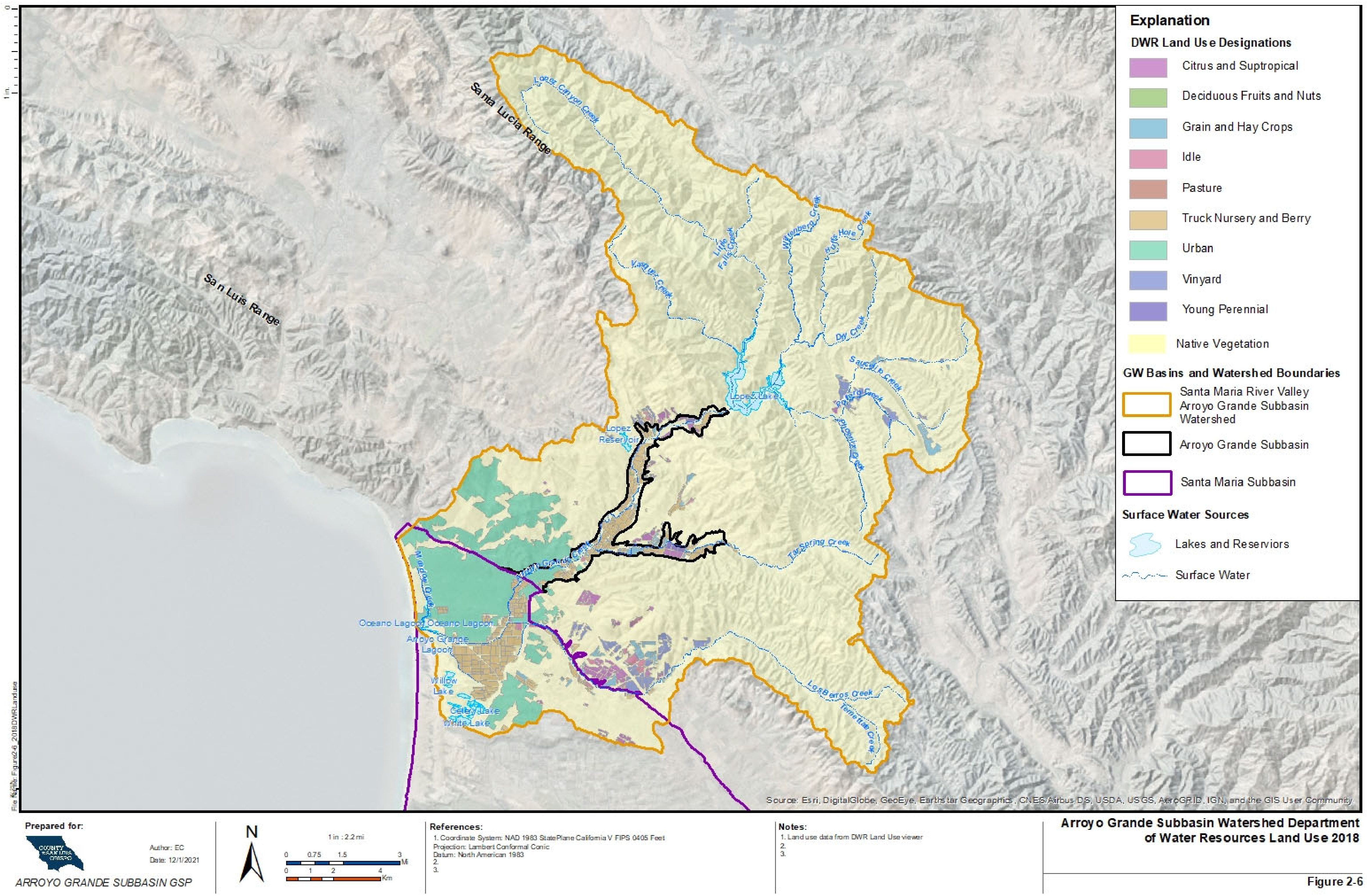


Figure 2--6. Arroyo Grande Subbasin Watershed Department of Water Resources and Land Use 2018

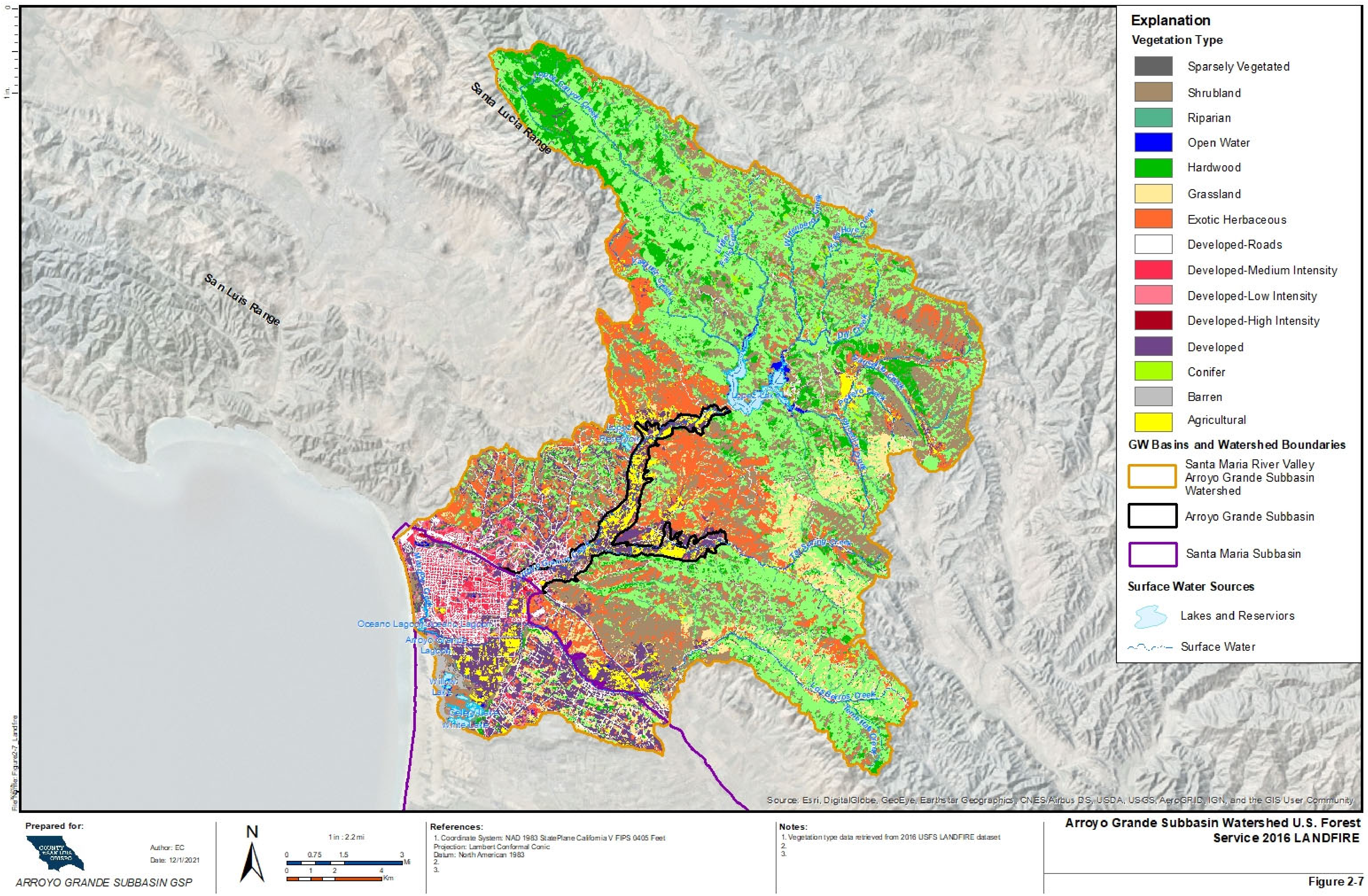


Figure 2--7. Arroyo Grande Subbasin Watershed US Forest Service 2016 LANDFIRE

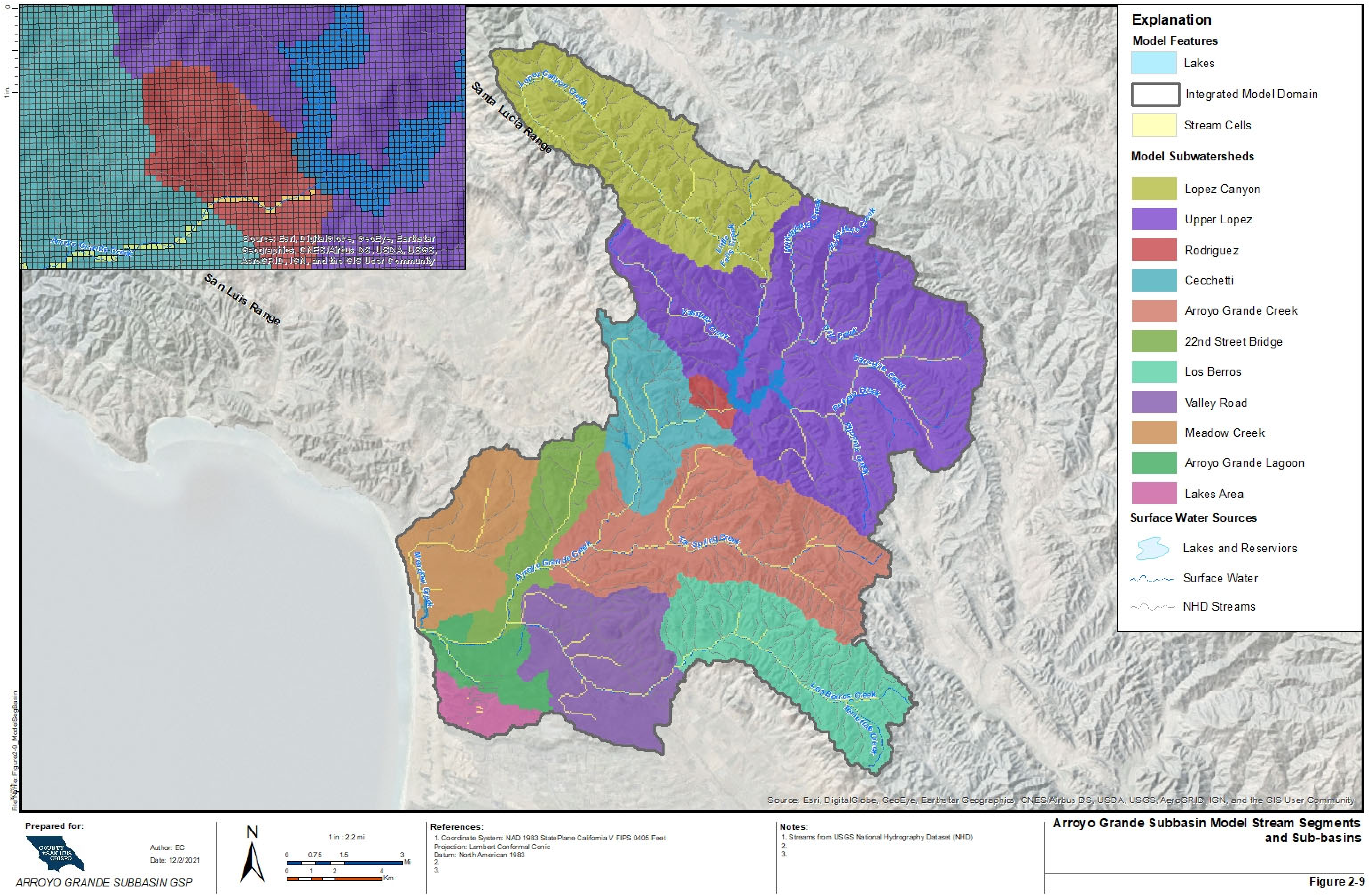


Figure 2--9. Arroyo Grande Subbasin Model Stream Segments and Subbasin

Streamflow Gages

The County of San Luis Obispo operates nine real-time data monitoring stream gages along Arroyo Grande Creek and its tributaries, within the model domain (Figure 2-10). Table 2-2 provides a summary of the streamflow data available for each stream gage. Each gage station records creek stage (depth or elevation) on fifteen-minute intervals. Available stage data at each station dates to back to various years. Only two stream gages have extensive and validated records: Lopez Canyon and Arroyo Grande Creek and are considered the most reliable stream gages within the AG watershed. Three other gages were also used for calibration purposes: Rodriguez, Cecchetti, and 22nd Street Bridge. Gage locations are displayed on Figure 1-1.

In addition to the County operated gages, the County also measures and records all water released from Lopez Reservoir. This dataset provides an additional flow measurement within the model that is used in the MODFLOW Lake Package and MODSIM to simulate operations at the dam that influence the flows in AG Creek downstream of Lopez Reservoir.

Table 2--2. Selected Modules Used in PRMS Model

Stream Gage	Source/Station No.	Data Recorded	Data Interval	Data Range	Datum[1]
Lopez Canyon	USGS 11141280	Stage/CFS	15 Minutes	12/23/1970 - 12/31/2020	NAVD 88
Lopez Reservoir (Monthly)	Lopez Dam	AF	Monthly	3/1/1968 – 12/31/2020	NAVD 88
Lopez Reservoir (Daily)	Lopez Dam	AF	Daily	12/1/1993 – 12/31/2020	NAVD 88
Rodriguez	SLO County (773)	Stage	15 Minutes	1/1/2007 - 12/31/2016	NAVD 88
Cecchetti	SLO County (733)	Stage	15 Minutes	11/6/2006 - 12/31/2014	NAVD 88
Arroyo Grande Creek	SLO County (736)	Stage	15 Minutes	10/1/1967 - 9/30/2018	NAVD 88
Los Berros	SLO County (757)	Stage	15 Minutes	8/1/1968 - 12/31/2018	NAVD 88
Valley Road	SLO County (731)	Stage	15 Minutes	1/4/2008 - 12/31/2014	NAVD 88
22nd Street Bridge	SLO County (734)	Stage	15 Minutes	1/4/2008 - 2/28/2015	NAVD 88
Meadow Creek	SLO County (770)	Stage	15 Minutes	12/31/2017 - 12/31/2020	NAVD 88
Arroyo Grande Creek Lagoon	SLO County (769)	Stage	15 Minutes	12/31/2017 - 12/31/2020	NAVD 88

Notes:

[1]Prior to 5/23/2017 County data was recorded on NGVD 29 datum. Conversion is 2.86 feet.

PRMS Modules

PRMS simulates the hydrologic cycle through various processes, each with one or more modules available for use. Table 2-3 presents the modules that were selected for use in the surface water model.

Table 2--3. Selected Modules Used in PRMS Model

Module Name	Process	Description[1]
basin	Basin Definition	Defines shared watershed wide and HRU physical parameters and variables.
cascade	Cascading Flow	Determines computational order of the HRUs and groundwater reservoirs for routing flow downslope.
soltab	Solar Table	Computes potential solar radiation and sunlight hours for each HRU for each day of the year.
obs	Time Series Data	Reads and stores observed data from all specified measurement stations.
temp_sta	Temperature Distribution	Distributes maximum and minimum temperatures to each HRU by using temperature data measured at one station.
precip_1sta	Precipitation Distribution	Determines the form of precipitation and distributes it from one or more station to each HRU by using monthly correction factors to account for differences in altitude, spatial variation, topography, topography, and measurement gage efficiency.
ddsolrad	Solar Radiation Distribution	Distributes solar radiation to each HRU and estimates missing solar radiation data using a maximum temperature per degree-day relation.
transp_tindex	Transpiration Period	Determines whether the current time step is in a period of active transpiration by the temperature index method.
potent_jh	Potential Evapotranspiration	Computes the potential evapotranspiration by using the Jensen-Haise formulation (Jensen & Haise, 1963)
intcp	Canopy Interception	Computes volume of intercepted precipitation, evaporation from intercepted precipitation, and throughfall that reaches the soil.
srunoff_smidx	Surface Runoff	Computes surface runoff and infiltration for each HRU by using a nonlinear variable-source-area method allowing for cascading flow.
soilzone	Soil-Zone	Computes inflows to and outflows from soil zone of each HRU and includes inflows from infiltration, groundwater, and upslope HRUs, and outflows to gravity drainage, interflow, and surface runoff to down-slope HRUs.
gwflow	Groundwater	Sums inflow to and outflow from PRMS groundwater reservoirs. Used in the PRMS-only model, not the integrated GSFLOW model.
strmflow	Streamflow	Computes flow in the stream network using the Muskingum routing method and flow and storage in on-channel lake using several methods. Used in the PRMS-only model, not the integrated GSFLOW model.

Notes:

[1] (Markstrom, et al., PRMS-IV, the Precipitation -Runoff Modeling System, Version 4: Updated Tables from Version 4.0.3 to Version 5.0.0, 2019; Markstrom, Niswonger, Regan, Prudic, & Barlow, 2008)

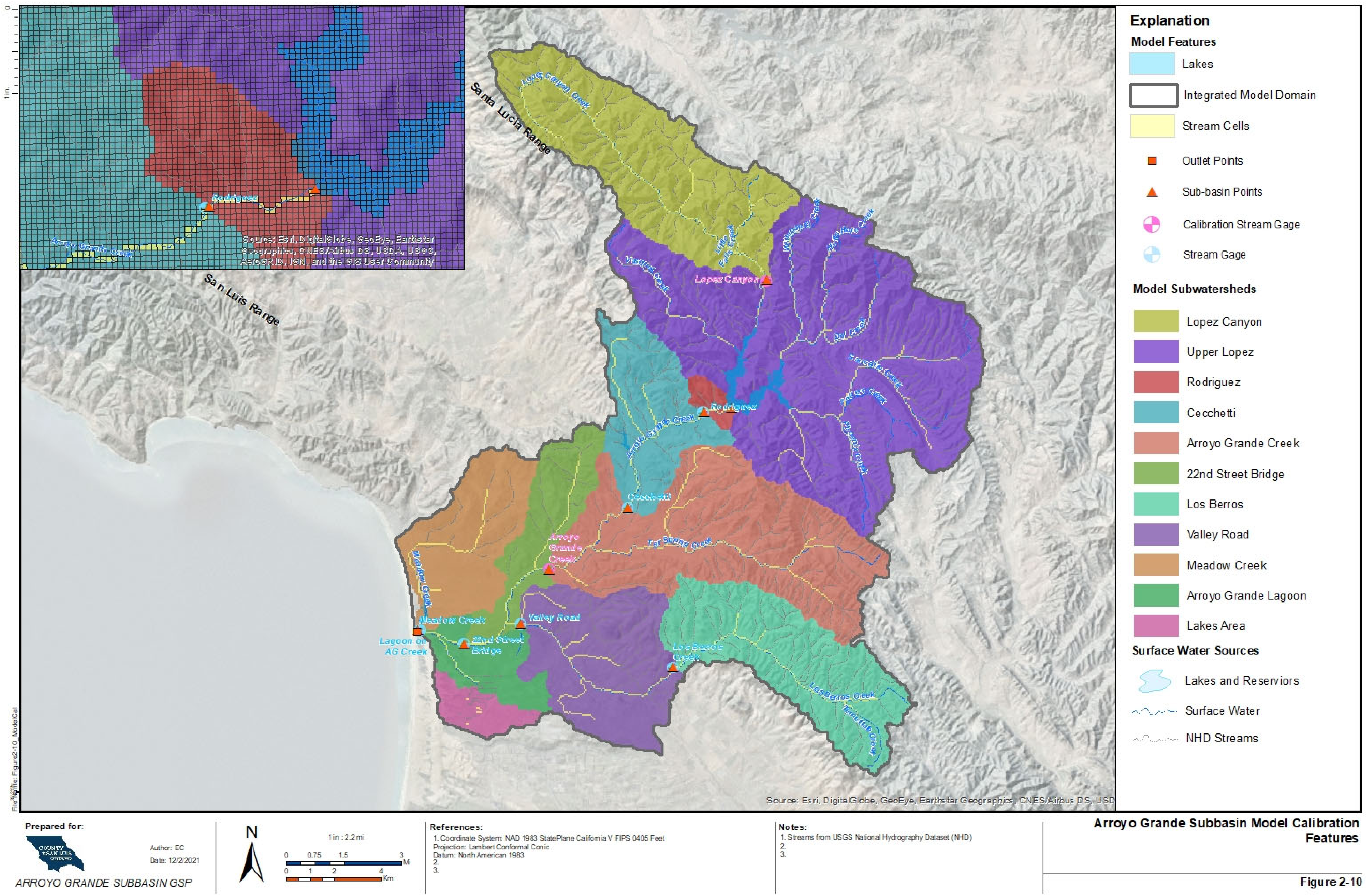


Figure 2--10. Arroyo Grande Subbasin Model Calibration Features

PRMS Calibration Approach and Initial Results

The PRMS model was calibrated using the USGS developed Python library pyGSFLOW

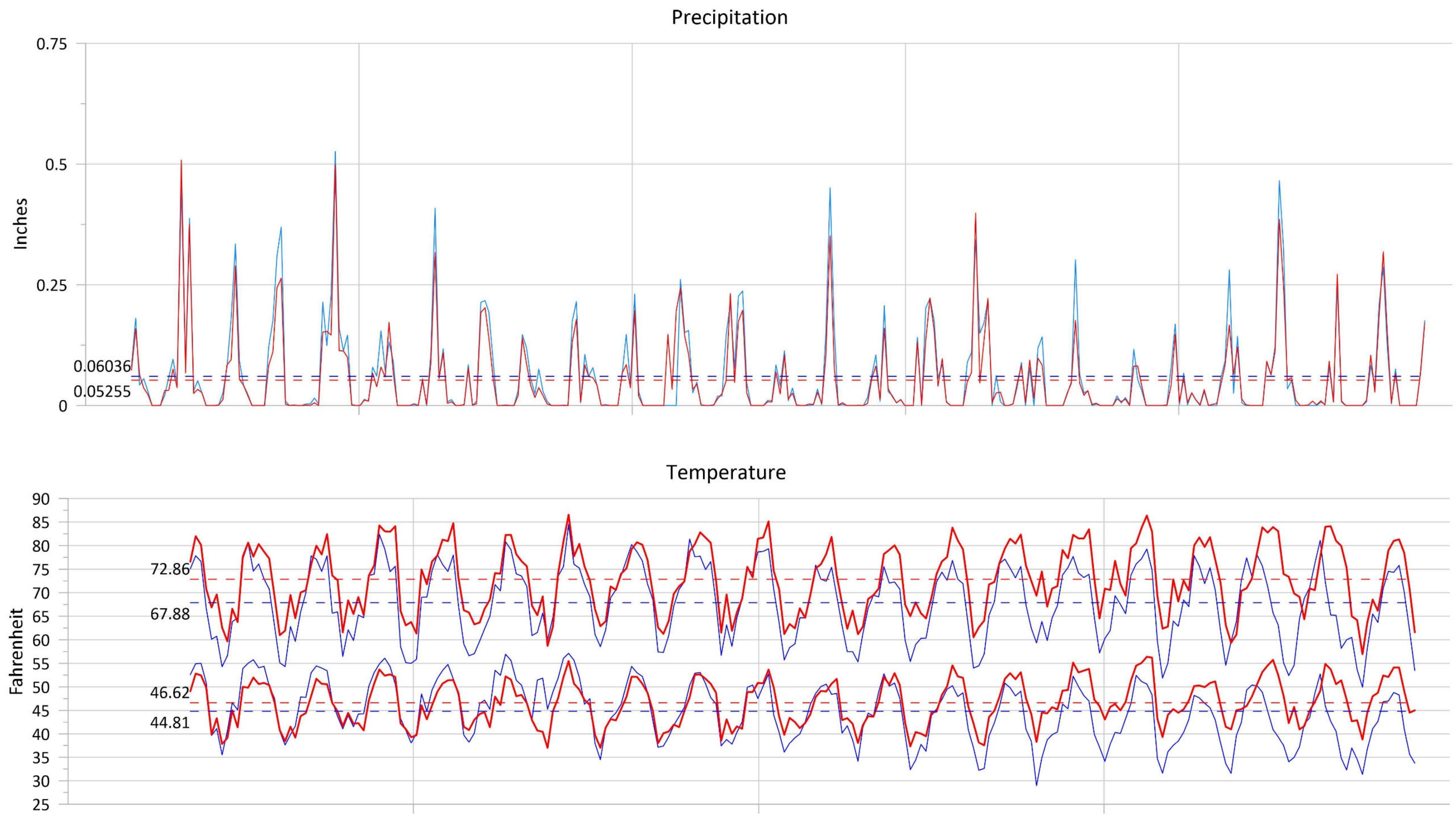
where:

1. evaluation of precipitation and temperature from Lopez Reservoir and PRISM datasets
2. optimization of solar radiation and PET
3. calibration of streamflow

The PRMS calibration period was based on available stream gage data, which spans from January 1994 to December 2018. Simulated values and model outputs were compared to calibration data sets generated from measured data. Data sets for solar radiation were derived from measurements recorded at the Cal Poly #52 weather station which was the closest weather station at a similar elevation available for use. Data sets for potential evapotranspiration were derived from pan evaporation and their respective coefficients measurements recorded at Lopez Reservoir weather station. Calibration data sets for streamflow were derived from the County stream gages and datasets provided by WHC.

Precipitation and Temperature

Precipitation and temperature records from Lopez Reservoir weather station was checked against precipitation and temperature data derived from PRISM for consistency. Evaluating the two datasets revealed PRISM data showed a close match with the precipitation data records at Lopez Reservoir. Moreover, PRISM data showed a discrepancy with the manually recorded and incomplete temperature records at Lopez Reservoir. Due to the uncertainty with the manually recorded temperature data and the close fit of the precipitation data from both datasets, it was determined to use the PRISM data as a substitute for the model input to ensure consistency and accuracy in representing precipitation and temperature in the model (Figure 2-11).



Prepared for:

Author: EC

12/03/2021

SAN LUIS OBISPO VALLEY BASIN GSP

Legend

Measured Discharge

PRMS Discharge

Notes:

1. Data Source: Lopez Resevoir and PRISM

Lopez Canyon Precipitation and Temperature

Figure 2-11

Figure 2--11. Lopez Canyon Precipitation and Temperature

Potential Evapotranspiration and Solar Radiation

PRMS solar radiation (SR) and PET parameters were first calibrated to measured SR at the Cal Poly weather station and calculated PET at the Lopez Reservoir weather station. PRMS calculates solar radiation using the ddsolrad module where the parameters are slope and intercept of the maximum temperature per degree day linear relationship. Monthly parameters (dday_intcp and dday_slope) are calibrated to monthly averages of solar radiation (Table 2-4). Based on calibrated air temperature and solar radiation, monthly coefficients (jh_coef) for the Jensen-Haise equation are adjusted to calibrate simulated potential evapotranspiration to average potential evapotranspiration at the stations (Table 2-4). The Jensen-Haise equation requires air temperature and solar radiation so average monthly air temperature and solar radiation from the Cal Poly weather station was used.

However, by using these data sets to fit the initial calibration values for SR and ET, the modeled basin average ET was 35% lower than the basin average ET of 72% from the calculated water budget from Chapter 6. This calculated water budget is an important guide to check calibration results against and flagged the calibration for review. Upon review, it was determined that SR and ET needed to be adjusted to achieve a basin average ET within 1% of the calculated water budget basin average ET.

SR was manually modified by increasing dday_slope in the warmer months (Figure 2-12). This increased the modeled basin average ET by 20%, however it was still lower than the calculated water budget basin average ET by 15%. ET was scaled up by increasing jh_coef monthly mean values by various scaling factors ranging from 2x – 10x until basin average ET was within 1% of the calculated water budget basin average ET. A final scaling factor of 7x was used to achieve this calibration target and it also preserves the seasonality of ET that was captured in the original calibration (Figure 2-12).

Table 2--4. Solar Radiation and Potential Evapotranspiration Monthly Calibration Paramters

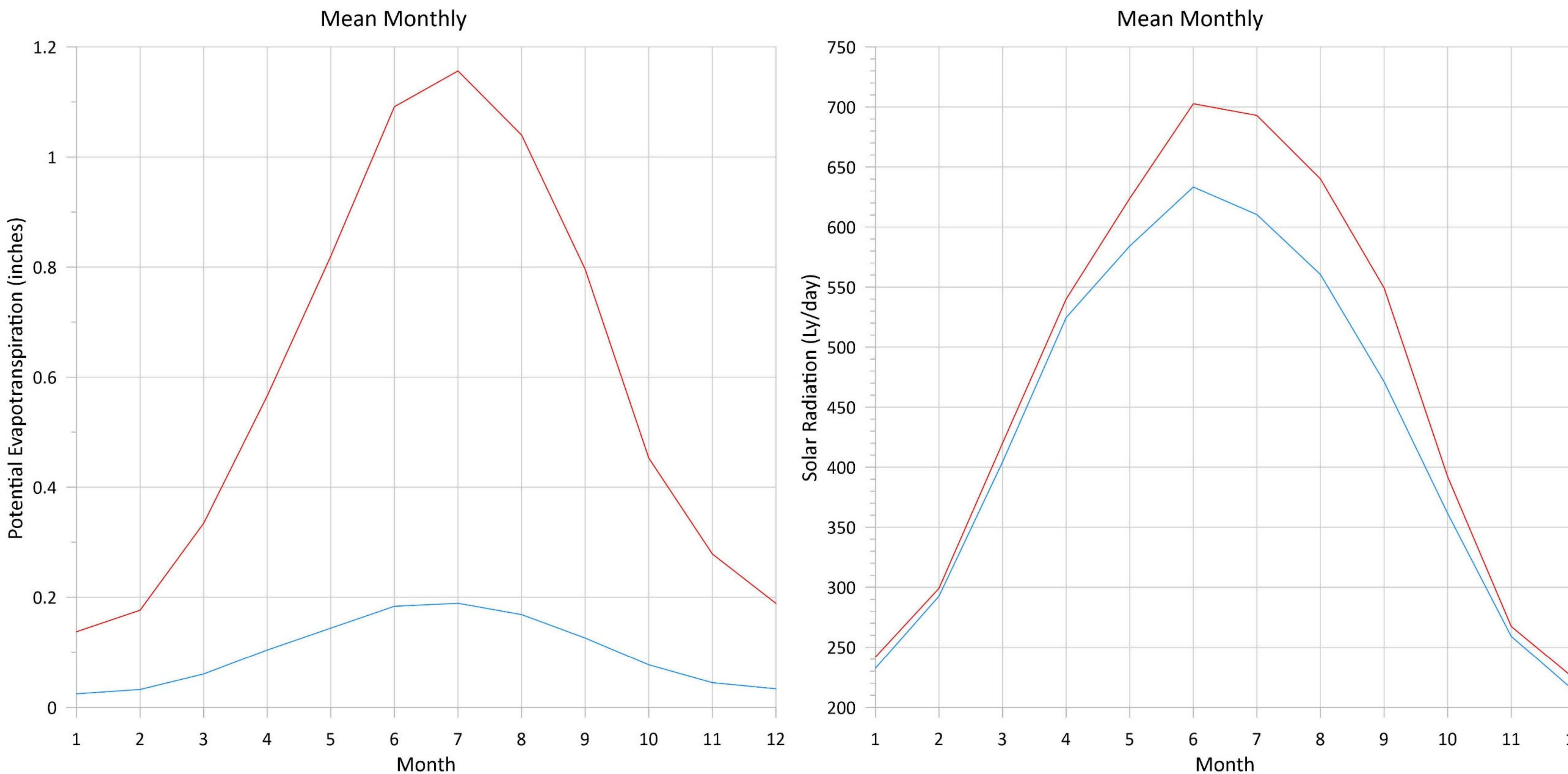
Type	Default	Initial calibration		Final calibration	
nmonths	dday_inctp[A]	dday_slope[B]	jh_coef[C]	dday_slope[B]	jh_coef[C]
January	-9	0.165	0.001151	0.195	0.008057
February	-9	0.175	0.001201	0.205	0.008407
March	-9	0.19	0.001601	0.22	0.011207
April	-7.8	0.19	0.002101	0.23	0.014707
May	-10	0.215	0.002559	0.245	0.017913
June	-22	0.385	0.002949	0.435	0.020642
July	-38	0.5625	0.003066	0.6125	0.021462
August	-36	0.5175	0.002966	0.5675	0.020762
September	-15	0.2325	0.002635	0.2925	0.018445
October	-15	0.2315	0.002134	0.2615	0.014938
November	-15	0.2325	0.002019	0.2625	0.014133
December	-10	0.1775	0.001720	0.2075	0.01204

Notes:

A - intercept in temperature degree-day relation

B - slope in temperature degree-day relation

C - monthly adjustment factor using in Jensen-Haise PET calculations



Prepared for:

Author: EC

12/03/2021

SAN LUIS OBISPO VALLEY BASIN GSP

Legend

Initial Calibration Output

Final Calibraiton Output

Notes:

1. Cal Poly Weather Station #52 used for solar radition calibration reference

ET and Solar Radiation Calibration

Figure 2-12

Figure 2--12. ET and Solar Radiation Calibration

Surface Water

Calibration of the surface water component consisted of adjusting various watershed parameters for Lopez Canyon, Rodriguez, Cecchetti, Arroyo Grande Creek, 22nd Street Bridge, and Los Berros stream gages. Lopez Canyon is located upstream of Lopez Reservoir and is a critical stream gage for calibration for inflows into Lopez Reservoir. Arroyo Grande Creek is located downstream of Lopez Reservoir and is near the bottom of the AG Subbasin before water flows down into the lower part of the SMRVB. Both stream gages have the most reliable and complete records available for use whereas the other gages have less reliable and incomplete records. Therefore, Lopez Canyon and Arroyo Grande Creek were the primary stream gages used for calibration and for model performance evaluation while the others were used to fine tune the model calibration but are omitted from evaluating model performance.

A series of parameters were used to calibrate the stream gages in PRMS. Some parameters represent the soil zone reservoir volumes and other parameters represent coefficients for empirical equations describing flows to and from soil zone reservoirs. Table 2-5 shows the watershed parameters and provides their calculated values.

The capillary zone capacities soil_moist_max and soil_rechr_max have spatial variation within each HRU based on calculations using the SSURGO/STATSGO soils datasets. In general, parameters representing flows from the soil zone are on the low end of the expected range while parameters representing soil moisture capacities (sat_threshold, soil_moist_max, and soil_rechr_max_frac) are relatively high. Soil moisture capacity variables were the most sensitive in influencing surface water flow outputs in the model.

Table 2--5. Surface Water Model Watershed Parameters

Parameter Name	Parameter Description	Associated flow	Min	Max	Average
Carea_max	Maximum possible area contributing to surface runoff as proportion of HRU	Hortonian Surface Flow	0	0.43	0.0016
fastcoef_lin	Linear coefficient to route preferential-flow storage down slope	Fast interflow	0.1	0.1	0.1
fastcoaf_sq	Non-linear coefficient to route preferential flow down slope	Fast interflow	0.4	0.95	0.8
gwflow_coef	Groundwater routing coefficient	Groundwater flow	0.01	0.05	0.014
gwsink_coef	Groundwater sink coefficient	Groundwater flow	0	0	0
gwstor_init	Storage in each GWR at the beginning of a simulation	Groundwater flow	1.0	2.0	1.88
imperv_stor_max	Maximum impervious area retention storage for each HRU	Hortonian Surface Flow	0.05	0.05	0.05
pref_flow_den	Preferential-flow pore density	Preferential flow	0.2	0.2	0.2
sat_treshold	Soil saturation threshold, above field-capacity threshold	gravity and preferential flow	0	6.84	1.28
slowcoef_lin	Linear coefficient to route gravity-flow storage down slope	Slow interflow	0	0.02	0.003
slowcoef_sq	Non-linear coefficient to route gravity-flow storage down slope	Slow interflow	0	1	0.015
smidx_coef	Coefficient in non-linear contributing area algorithm for each HRU	Hortonian Surface Flow	0.0001	0.01	0.008
smidx_exp	Exponent in non-linear contributing area algorithm for each HRU	Hortonian Surface Flow	0.3	0.3	0.3
soil_moist_max	Maximum available water holding capacity of soil profile. Soil profile is surface to bottom of rooting zone.	NA	0	6.84	1.28

Parameter Name	Parameter Description	Associated flow	Min	Max	Average
soil_rechr_max_frac	Fraction of capillary reservoir capillary reservoir water-holding capacity where losses occur as evaporation and transpiration	NA	0	3.42	0.9
soil2gw_max	Maximum amount of capillary reservoir excess that is routed directly to the groundwater reservoir	Direct recharge	0.1	5	0.43
ssr2gw_rate	Coefficient in equation used to route water from subsurface reservoirs to the groundwater reservoirs	Gravity drainage	0	672	0.16
ssr2gw_exp	Coefficient in equation used to route water from the subsurface reservoirs to the groundwater reservoirs	Gravity drainage	1.2	1.2	1.2

The surface water evaluation of the PRMS model consists of a 'weight of the evidence' approach (Donigian, 2002) where both qualitative graphical comparisons and quantitative statistical comparisons are made. Graphical comparisons generally include visual evaluation of timeseries plots comparing the measured and simulated flow rates at calibrated stream gages, while quantitative comparisons may include calculating a range of standard statistical measures.

For our purposes, the model was evaluated to verify the model accuracy does not exceed the accuracy or uncertainty associated with the data used to develop and calibrate the model. Since the surface water data measured at Rodriguez, Cechetti, 22nd Street, and Los Berros have inherent uncertainty and incomplete records, it's expected that the calibration may not achieve the best desirable relative calibration goals and we shouldn't expect to achieve exceptional calibration goals at each gage. However, Lopez Canyon and Arroyo Grande Creek due have a higher level of certainty and complete records, therefore, these two stream gages are expected to achieve best desirable relative calibration goals and we should expect to achieve good to exceptional calibration goals.

Relative calibration goals are proposed based on guidance from USGS (Woolfenden and Nishikawa, 2014 and Helsel et al., 2020) specific to PRMS and GSFLOW application. Simulated and measured streamflow was evaluated in the integrated model via comparison of daily mean, mean monthly, monthly mean, and annual mean hydrographs as well as using goodness-of-fit statistics. Goodness-of-fit statistics that were used include the reduced major axis regression (RMA) R^2, percent-average-estimation-error (PAEE), the absolute-average-estimation-error (AAEE), and the Nash-Sutcliffe model efficiency (NSME).

Reduced major axis (RMA; type II) linear regression analysis was chosen to calculate the R^2 for measured monthly mean streamflow versus simulated monthly mean streamflow to investigate the linear relationship between measured and simulated streamflow used in the calibrated model. RMA regression was used since there was relatively significant unexplained error in our predictor variable (measured monthly mean streamflow) that ordinary least squares (OLS) regression cannot adjust for (OLS assumes no error in predictor variable) resulting in a biased regression model which in our case, would provide erroneous results. RMA regression makes no assumptions about dependence (Friedman et al., 2013) and minimizes the sum of triangular areas between data points and the best fit line (Carr, 2012).

The RMA R^2 measures the linear goodness-of-fit and assumes estimation error in both simulated and measured data. The PAEE and AAEE measure the model bias, or systematic error, but cannot provide a definitive measure of goodness of fit alone. The NSME provides a measure of the mean square error, similar to the normalized root-mean-square error (RMSE) and can be a good indicator of the goodness of fit but can still have substantial estimation bias. Therefore, the combination of these statistics is used to represent goodness of fit. A model that exactly matches observed results would have RMA R^2 value of 1.0, PAEE and AAEE values of 0, and an NSME value of 1.0 (Woolfenden and Nishikawa, 2014; Helsel et al., 2020).

Table 2-6 presents the range of goodness-of-fit criteria as outlined for the Santa Rosa Plain Model (Woolfenden & Nishikawa, 2014) and includes the RMA R^2 categories to further evaluate model fit. The optimal goal is to achieve calibration results within the “Very Good” or “Excellent” range; however, this may not be feasible at each stream gage location due to the following limitations:

- Accuracy of the data and incomplete records at Rodriguez, Cechetti, 22nd Street, and Los Berros stream gages.

Table 2--6. Surface Water Model Goodness-of-fit Statistics Calibration Goals

Goodness-of-fit Category	RMA R^2	PAEE (%)	AAEE (%)	NSME
Excellent	1.0 - 0.9	-5 to 5	≤0.5	≥0.95
Very Good	0.9 - 0.8	-10 to -5 or 5 to 10	0.5 to 1.0	0.85 to 0.94
Good	0.8 - 0.7	-15 to -10 or 10 to 15	10 to 15	0.75 to 0.84
Fair	0.7 - 0.6	-25 to -15 or 15 to 25	15 to 25	0.6 to 0.74
Poor	< 0.6	< -25 or > 25	> 25	< 0.6

PRMS doesn’t model lakes the same way that is done in MODFLOW with the lakes package. Due to this limitation, Lopez Canyon and Los Berros were the only gages calibrated in PRMS-only mode. Lopez Canyon calibration model results are shown below for daily mean (Figure 2-13), mean monthly, annual mean, and monthly mean hydrographs of modeled and measured streamflow (Figure 2-14), and mean monthly streamflow goodness of fit metrics (figure 2-15) to determine if measured streamflow's were reasonably simulated at Lopez Canyon relative to measured values.

The Lopez Canyon stream gage calibration resulted in a reasonable fit of the simulated daily streamflow relative to measured streamflow as well as for mean monthly, annual mean, and monthly mean streamflow as shown in Figure 2-13 and Figure 2-14. In addition, the model produced anticipated goodness-of-fit statistics for the RMA R^2, PAEE, and AAEE as shown in Figure 2-15. The RMA R^2 for monthly mean streamflow values for Lopez Canyon was above 0.75 indicating a strong, positive relationship between measured and simulated streamflow which was expected.
The PAEE, AAEE, and NSME showed no indication of model bias, however, the average NSME was well below desired values. Upon inspection of the NSME values, there were four years in the model calibration period that had NSME values below -1.0; they were 1996, 2010, 2011, and 2017. There appears to be no obvious explanation for why these years fail to produce adequate NSME values other than being associated with extreme peak flow events. If NSME is calculated without accounting for these years, the model achieves an average NSME of 0.71 which would classify as a Fair goodness-of-fit value. Table 2-8 summarizes the goodness-of-fit statistics for Lopez Canyon calibration gage and the assigned goodness-of-fit determination. It's also important to note that volumetrically, the model total simulated flow relative to total measured flow are within 14% and this will allow the model in the upper Lopez Canyon area where Lopez Reservoir impounds to representatively simulate upper Lopez Canyon rainfall and streamflow.

Overall, the model fit the mean of the measured data and generally estimates high and low streamflow events reasonably well despite large simulated peak flows and elevated base flows relative to measured and the calibrated input PRMS parameters used for the Lopez Canyon watershed should be adequate for use in evaluating model scenarios based on daily, monthly, and annual changes when fully coupled into GSFLOW.

Further surface water calibration of the other stream gages downstream of Lopez Canyon will be discussed in Section 4.

Table 2--7. Streamflow Calibration Goodness-of-fit Statics for Monthly Mean Data

Calibrated Stream Gage	RMA R^2	PAEE (%)	AAEE (%)	NSME	Goodness-of-fit Determination
Lopez Canyon	0.8	-10.04	10.04	-6.24	Good

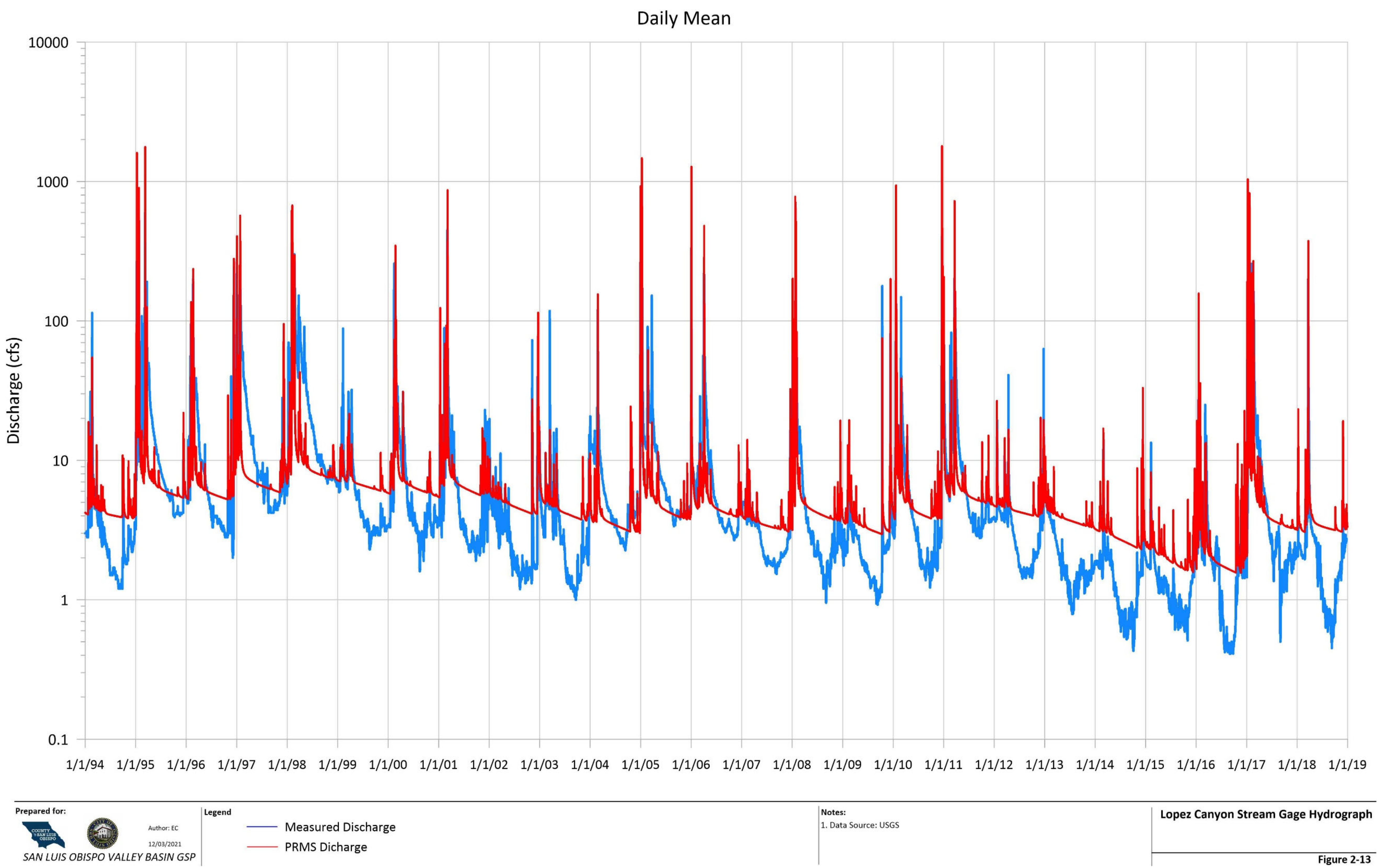


Figure 2--13. Lopez Canyon Stream Gage Hydrograph

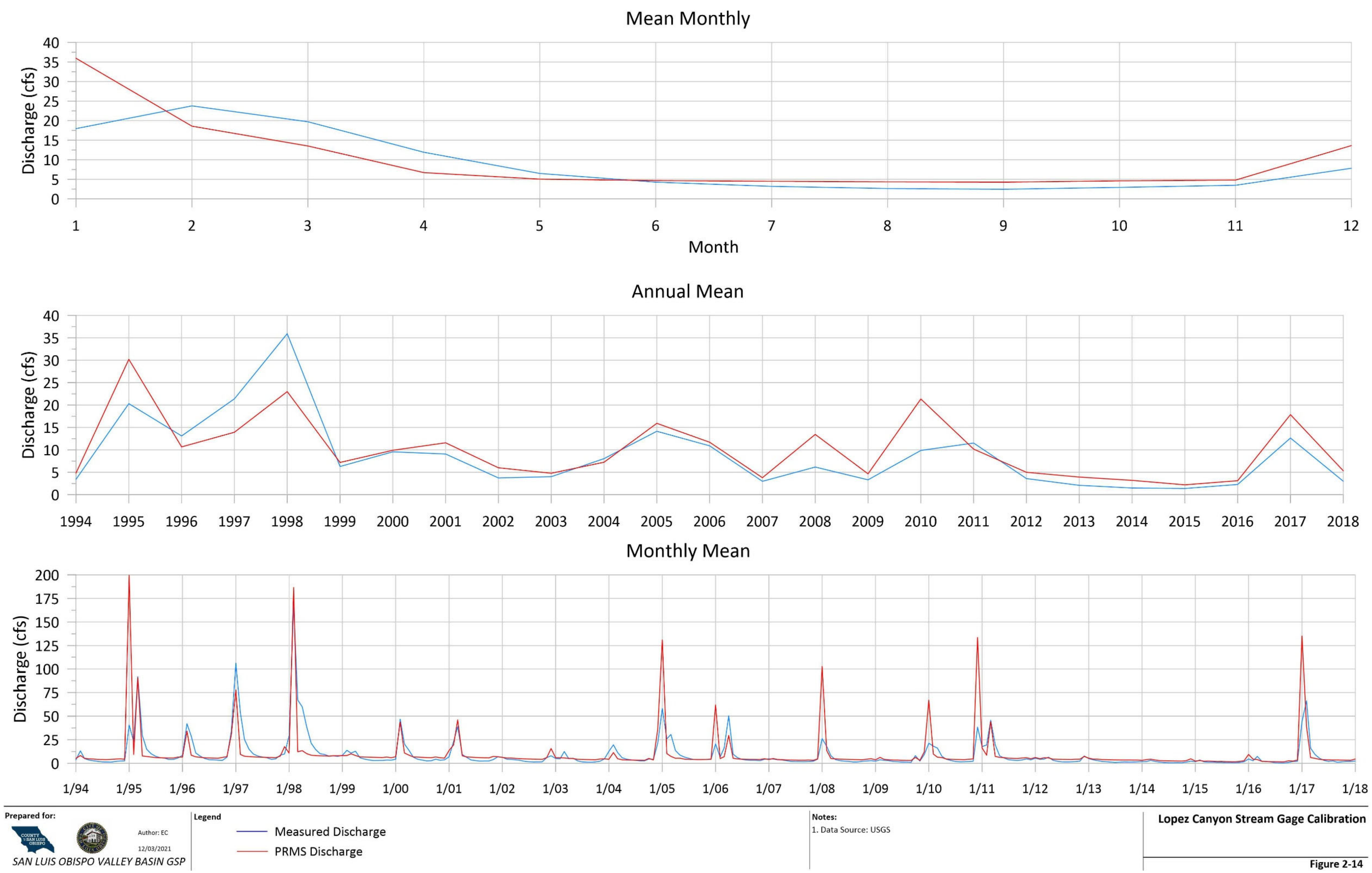


Figure 2--14. Lopez Canyon Stream Gage Calibration

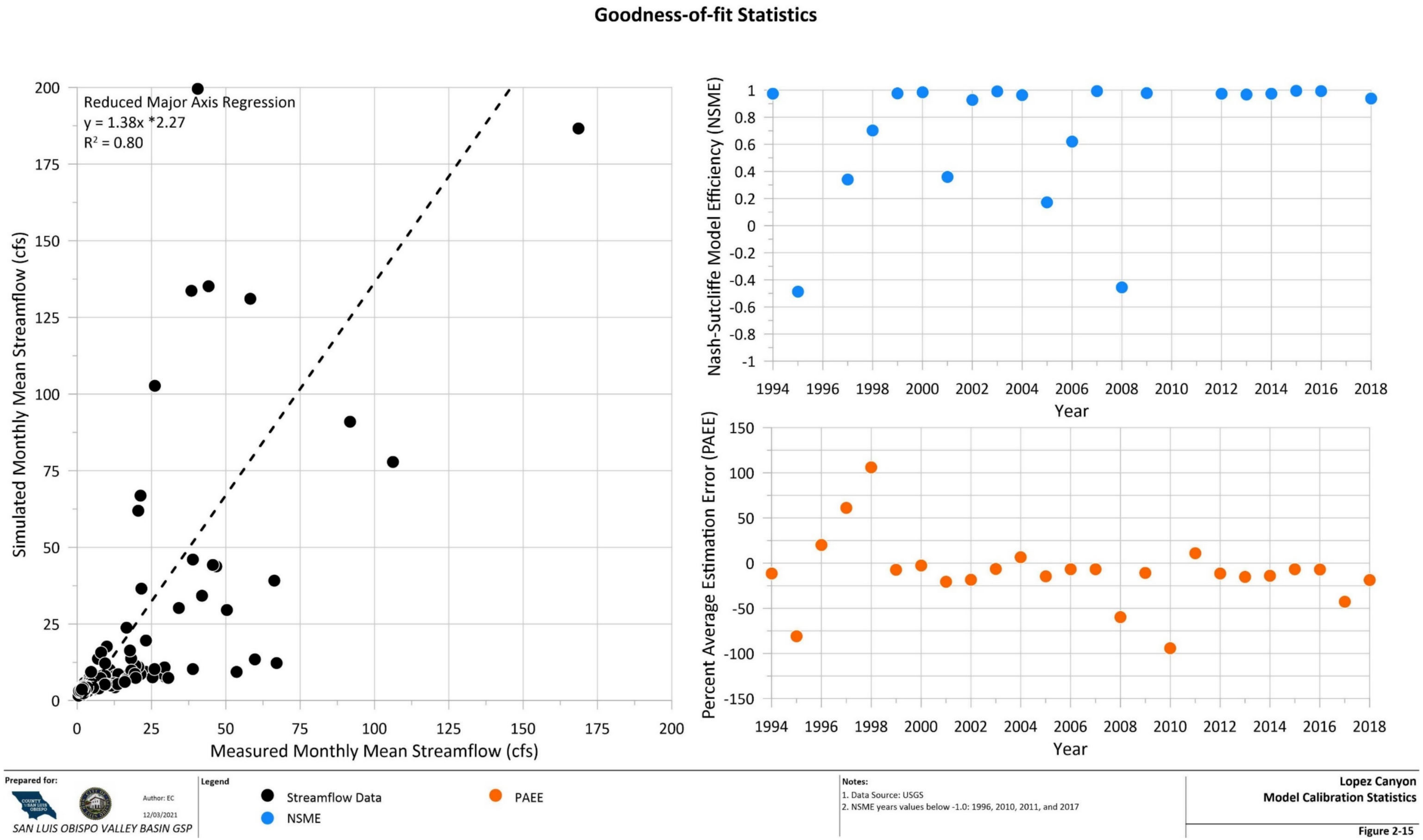


Figure 2--15. Lopez Canyon Model Calibration Statistics

3.0 Groundwater Model Development

This section summarizes the Hydrogeologic Conceptual Model (HCM) for the AG Subbasin, including summary discussion of both geologic formations and hydrogeologic conditions significant to the development of the numerical model.

Arroyo Grande Creek flows from the AG Subbasin to the SMRVS across the Wilmar Avenue Fault. The hydrogeologic settings of the Subbasin and the SMRVS are separate and distinct. There is little significant hydrogeologic communication between AG Subbasin and SMRVS (GSI, 2018). However, because one objective of the model is to assess conditions in Arroyo Grande Creek pertinent to future evaluations relevant to the HCP, the active area of the model will include the area drained by Arroyo Grande Creek in the SMRVS all the way to the ocean.

In most cases, the consolidated bedrock formations are not considered to be water-bearing compared to the saturated sediments that comprise the alluvial aquifer. Although bedding plane and/or structural fractures in some of these rocks may yield small amounts of water to wells (particularly in the Monterey Formation), they do not represent a significant portion of the pumping in the area.

In the contributing watershed to the Subbasin, the Pismo Formation bedrock is exposed at the surface in the mountains west of the valley, and in much of the area between Arroyo Grande Valley and Tar Springs Creek Valley. To the southeast of the Arroyo Grande/Tar Creek Springs Valley, the Monterey Formation crops out at the surface. The Edna Fault Zone and the Huasna Fault Zone cross the northern extent of the Arroyo Grande Valley; as a result, faulted and folded rocks of the Monterey Formation and Franciscan Assemblage crop out in the area northeast of the valley.

The Wilmar Avenue Fault Zone is located at the southern extent of the Subbasin. The location of the Wilmar venue Fault is presented on Figure 3-1.

The water-bearing sedimentary formations and the non-water-bearing bedrock formations are briefly described below, from the youngest to the oldest in both the Subbasin and SMRVS.

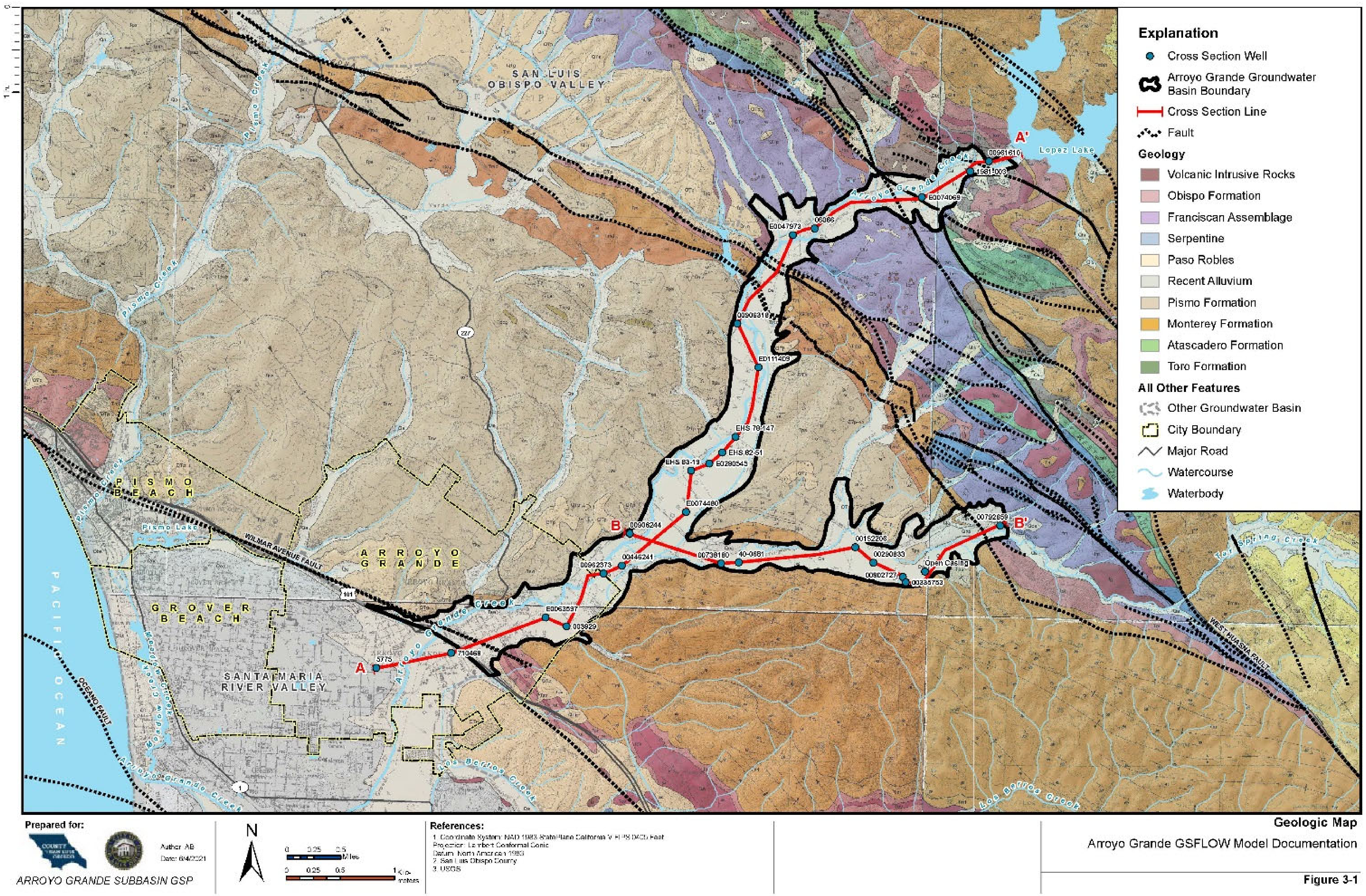


Figure 3--1. Arroyo Grande GSFLOW Model Documentation

3.1 Geologic Setting

Subbasin Sedimentary Formations

Recent Alluvium

The Recent and Older Alluvium is the mapped geologic unit composed of unconsolidated sediments of gravel, sand, silt, and clay, deposited by fluvial processes along the course of Arroyo Grande Creek, Tar Springs Creek, and their tributaries. Lenses of sand and gravel are the most productive geologic strata within the Alluvium. There is no significant difference in hydrogeologic properties between Recent and Older Alluvium. These strata have no significant lateral continuity across large areas of subsurface within the Basin. Thickness of Alluvium may range from just a few feet to greater than 100 feet. The lateral extent of the Subbasin is defined by the presence at the surface of the alluvium.

Subbasin Bedrock Formations

Pismo Formation

The youngest geologic unit that crops out around the Subbasin is the Pismo Formation. The Pismo Formation is a Pliocene-aged sequence of unconsolidated to loosely consolidated marine deposited sedimentary units composed of claystone, siltstone, sandstone, and conglomerate. There are five recognized members of the Pismo Formation, reflecting different depositional environments, and the variations in geology may affect the hydrogeologic characteristics of the strata. From the bottom (oldest) up, these are 1) the Edna Member, which lies unconformably atop the Monterey Formation, and is locally bituminous (hydrocarbon-bearing), 2) the Miguelito Member, primarily composed of thinly bedded grey or brown siltstones and claystones, 3) the Gragg Member, usually described as a medium-grained sandstone, 4) the Bellview Member, composed of interbedded fine-grained sandstones and claystones, and 5) the Squire Member, generally described as a medium- to coarse-grained fossiliferous sandstone of white to grey sands.

Monterey Formation

The Monterey Formation is a thinly bedded siliceous shale, with layers of chert in some locations. In other areas of the County outside of the Subbasin, the Monterey Formation is the source of significant oil production. While fractures in consolidated rock may yield small quantities of water to wells, the Monterey Formation is not considered to be an aquifer for the purposes of this Study. Some wells in the Subbasin screen both Basin sediments and the upper portion of the Monterey Formation. Of the bedrock formations discussed here, the Monterey Formation is the one most often used for water supply in the Subbasin. The Monterey Formation is assumed to receive rainfall recharge in the surrounding hills at higher elevations than the Subbasin. For this reason, it is assumed that an upward vertical flow gradient exists between the Monterey Formation and the overlying Basin sediments.

Franciscan Assemblage

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

Santa Maria River Valley Subbasin and Arroyo Grande Subbasin Formations

Alluvium and Dune Sands

In the SMRVS and AG Subbasin portions of the proposed model area, dune sands and alluvium are exposed at the surface. Recent dune sands are largely unsaturated. Many productive wells are associated with the alluvium of the Arroyo Grande Creek. The dune sands and alluvium are comprised of sands and gravels with lenses of clay and silt that are not laterally continuous over large areas. The alluvium is considered to be a productive aquifer in most areas especially in the AG Subbasin, while the dune sands are not considered to be aquifers.

Paso Robles Formation

The Paso Robles Formation underlies the alluvium and dune sands in the SMRVS part of the model area but is not present in the AG Subbasin. It consists of unconsolidated to poorly consolidated gravel, sand and clay of terrestrial origin. The sediments of the Paso Robles Formation are often difficult to distinguish from alluvial sediments in geophysical logs, or in drill cuttings. Along with the alluvium, the Paso Robles Formation is considered the predominant productive aquifer in the SMRVS part of the model area.

Careaga Formation

The Careaga Formation underlies the Paso Robles Formation in the SMRVS part of the model area. It is a marine sedimentary unit of yellow to blue and gray sand, gravel, silt, and clay. Sea shell fragments are commonly present throughout the formation. The Careaga Formation does not crop out at the surface but is only present at depth beneath the Paso Robles Formation. It is considered a productive aquifer, but relatively few wells are completed to this depth because the alluvium and Paso Robles Formation aquifers above it provide adequate yield for most purposes.

3.2 Groundwater Model Data Needs

The groundwater model developed in MODFLOW requires various data to model groundwater processes. The existing Phase 1B MODFLOW model was used to inform the portions of the integrated model domain in the SMRVS as shown in Figure 1-1. The data required for the model includes:

1. Well data – this data includes well location, construction, water levels, and pumping data.(including pumping estimates)
2. Geology – this data includes geologic map data and well lithology data that will be used to construct the model layers.
3. Additional data – this data includes groundwater dependent ecosystems (GDEs) location, spatial extent, and current condition. GDEs in the AG Basin are of particular concern and will be focused on to incorporate in developing, testing, and evaluating scenarios and management actions.
4. PRMS related data – this data will be generated from the PRMS output and includes recharge from deep percolation of precipitation/irrigation; recharge from spreading grounds (swales in our case); riparian ET of shallow groundwater (GDE cells)

Well Data

Well data assembled for the development of the MODFLOW portion of the GSFLOW model included the following:

5. Well Completion Reports on file with the County and DWR
6. Soil and lithologic boring logs in published government reports and private consultant reports
7. Any aquifer test data documented in published reports or made available from stakeholders in the subbasin.
8. Measured or estimated pumping data (municipal, agricultural, and private)
9. Measured water level data from County records or consultant's reports.
10. Once the decision was made to incorporate the NCMA and NMMA portions of the watershed in the SMRVS, calibration groundwater elevations data from the Central Coast Blue Phase 1B model were extracted directly from the model and used for model calibration of the GSFLOW model.

Geology

Geologic data assembled for the development of the MODFLOW model included the following:

1. Geologic Maps
2. Geologic Cross-Sections
3. Delineation of low-permeability strata in the vicinity of Arroyo Grande Creek

3.3 Model Construction

Model Domain and Grid

GSFLOW requires that all PRMS and MODFLOW utilize a common grid in order to more efficiently perform the numerical calculations required, and to more efficiently transmit the required data simulating the interface between the surface water and groundwater environments.

Because Lower Arroyo Grande Creek between the Subbasin and the ocean is relevant to the HCP, the model domain is defined to encompass the entire area drained by the AG Creek from its outlet to the ocean to the ridges that define the upstream boundary of the watershed (Figure 1-1).

Evaluation of aerial photography indicates that the width of the riparian zone (as defined by the width of tree canopy along the stream course) averages approximately 200 feet. Therefore, the decision was made to utilize a 200-foot square grid cell for both PRMS and MODFLOW over the entire watershed area.

Model Layers

The model is constructed with four vertical grid layers. Layer 1 represents the ocean, and this layer will be inactive over the land surface of the model domain. In the Subbasin area, Layer 2 will represent the alluvial sediments comprising the primary aquifer, and Layer 3 will represent undifferentiated bedrock (i.e., Layer 2 may represent the Franciscan, Monterey, or Pismo Formation, depending on the location in the watershed). Layer 3 would be a “dummy layer” populated with no flow cells. In the contributing watershed areas where no significant alluvium is mapped, both layers 1 and 2 will represent bedrock, allowing representation of hydraulic communication with the alluvium both laterally and vertically (Figure 3-2).

In the downstream watershed coincident with the SMRVS area, the layers will correspond to the three recognized water-bearing geologic formations in that area. Layer 1 will represent the ocean. Layer 2 represents the combined alluvium and dune sands mapped in this area. Layer 3 represents the Paso Robles Formation, and Layer 4 represents the Carreaga Formation. These formations function as the primary aquifers in the SMRVGB (Figure 3). The layering elevations in the SMRVGB will be obtained from the Phase 1B Model. (The Phase 1B model represents the Paso Robles and Careaga Formations with multiple layers to accommodate the utilization of SEAWAT and density-dependent flow, but the tops and bottoms of the appropriate layers will be honored.).A summary of the model layering for the Phase 1B model and the Arroyo Grande model is presented in Table 3-1.

Boundary Conditions

The most significant boundary condition within the model domain that affects the objectives of the model development is the representation of Arroyo Grande Creek and its primary tributary, Tar Spring Creek. MODFLOW's SFR package is used to represent these stream corridors. Site specific channel cross section data was not available, so the stream channels are represented as idealized 8-point cross sections representing a primary channel and overbank areas to accommodate high flows.

Groundwater elevations along the southern model boundary in the SMRVS portion of the model were represented using MODFLOW's General Head Boundary (GHB) Package, and heads were assigned based on the modeled water levels along that area as they were modeled in the Central Coast Blue Phase 1B model. There is a documented northward flow direction in the from the Santa Maria Management Area into the GSFLOW model domain, so this GHB boundary condition provides flow into the GSFLOW model domain to represent this condition.

Table 3--1. Geologic Formations and Model Layer Assignments

<table>
<tr><th rowspan="2">Geology</th><th rowspan="2">Phase 1B Model</th><th colspan="2">Arroyo Grande Model</th></tr>
<tr><th>AG Subbasin</th><th>SMRVGB</th></tr>
<tr><td>Ocean</td><td>Layer 1</td><td>Layer 1</td><td>Layer 1</td></tr>
<tr><td>Alluvium and Dune Sand</td><td>Layer 2</td><td>Layer 2</td><td>Layer 2</td></tr>
<tr><td rowspan="5">Paso Robles Formation</td><td>Layer 3</td><td rowspan="8">NA</td><td rowspan="5">Layer 3</td></tr>
<tr><td>Layer 4</td></tr>
<tr><td>Layer 5</td></tr>
<tr><td>Layer 6</td></tr>
<tr><td>Layer 7</td></tr>
<tr><td rowspan="3">Careaga Formation</td><td>Layer 8</td><td rowspan="3">Layer 4</td></tr>
<tr><td>Layer 9</td></tr>
<tr><td>Layer 10</td></tr>
<tr><td>Undifferentiated Bedrock</td><td>NA</td><td>Layer 3, 4</td><td>NA</td></tr>
</table>

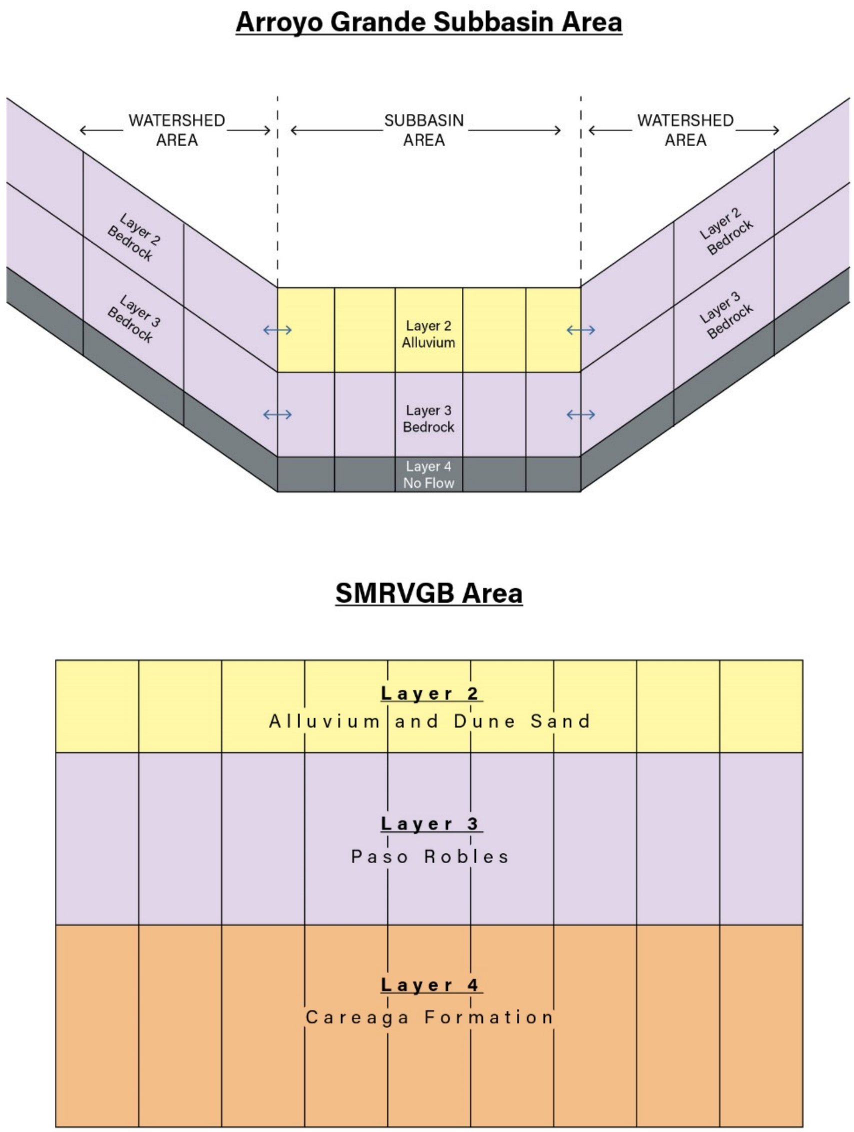


Figure 3--2. Model Layers

4.0 GSFLOW Model Development, Calibration, and Validation

The GSFLOW model is developed by integrating the PRMS and MODFLOW models described in Sections 2 and 3, respectively. The GSFLOW platform is designed to integrate PRMS and MODFLOW models and includes scripts for facilitating this integration. The GSFLOW model grid maintains the same 200-foot grid cells developed for PRMS and MODFLOW.

Model calibration of a groundwater model generally consists of matching simulated groundwater levels to historic water level measurements from wells in the Basin and of matching simulated surface water flows to historic streamflow gage data. This section describes the calibration process, including the modeling period, calibration approach and parameters, and specific calibration goals. In addition to the calibration goals listed below, the model output was evaluated to achieve a model mass-balance error that is within acceptable limits, defined as less than 1 percent based on USGS guidance (Reilly and Harbaugh, 2004).

Modeling Period

The GSFLOW modeling calibration period comprised a total of 33 years from Water Years 1988 through 2020. The model was developed using the period 1982-2020, wherein the first six years are considered a “windup” period wherein the model equilibrates prior to the formal calibration period beginning in Water Year 1988, which corresponds to the analytical water budget period. This period enables leveraging of the existing climate data and groundwater data that is available in the Basin. The model was run on daily time steps for the PRMS and GSFLOW and monthly groundwater modeling stress periods with daily time steps in MODFLOW.

Calibration Approach and Parameters

Calibration of the integrated GSFLOW model will consist of adjustment of specific parameters that govern the surface water and groundwater portions of the model domain. The model calibration approach and parameters that will be adjusted for the surface water and groundwater portions of the model are summarized in the following sections. While the individual calibration of the surface water and groundwater models are discussed in previous separate sections, the individual model calibrations will be confirmed in the coupled GSFLOW model and if further calibration adjustments were needed then parameters in PRMS, MODFLOW were altered

Surface Water

The surface water portion of the GSFLOW model was initially run in PRMS-only mode and then calibrated by comparing model-predicted flows to historic wet season streamflow gage data. Calibrating the model for wet-weather flows in advance of integrating the models was performed to prepare for the calibration of the groundwater portion of the model in GSFLOW by providing a well-defined spatial representation of groundwater recharge from rain events (Allander et al., 2014). The dry-weather surface water flows will be calibrated within the integrated GSFLOW model, due to the inherent dependence of the low flows on the groundwater model. The calibration of dry-weather flows will be based upon comparison to historic streamflow gages, manual streamflow measurements, and wet-dry maps across different seasons and years.

Groundwater

When the combined PRMS-MODFLOW integrated model was initially run in GSFLOW, the transient MODFLOW model was re-discretized temporally to simulate monthly stress periods with daily time step, as required in order to be consistent with the PRMS model. In addition, the Unsaturated Zone Flow Package was added to the MODFLOW model, which is a requirement of GSFLOW and provides the connection between surface and groundwater water from direct precipitation on land surface. After this, the integrated model was run in GSFLOW, and the results were evaluated to ascertain what changes were necessary to achieve a groundwater model calibration that meets the ASTM standards discussed previously.

The primary function of the contributing bedrock watershed area to the groundwater model is to receive output from PRMS, to generate and deliver streamflow to the SFR cells and ultimately to the main area of the basin, some recharge to the fractured bedrock, and flux between the bedrock and the basin sediments. In the conceptual model developed for this project, the combined bedrock of Franciscan Assemblage, Monterey Formation, and Pismo Formation is represented as a single layer, with appropriate parameter estimates assigned for hydraulic characteristics such as hydraulic conductivity, transmissivity, and storativity.

Calibration Goals

The model calibration goals for the surface water and groundwater portions of the model are presented in the following sections. While the surface water and groundwater calibration goals are discussed in separate sections, the final calibrations were performed in the coupled GSFLOW model.

Surface Water

The surface water evaluation of the GSFLOW model consists of a 'weight of the evidence' approach (Donigian, 2002) where both qualitative graphical comparisons and quantitative statistical comparisons are made. Graphical comparisons generally include visual evaluation of timeseries plots comparing the measured and simulated flow rates at calibrated stream gages, while quantitative comparisons may include calculating a range of standard statistical measures. This approach is nearly identical to the approach taken to evaluate the surface water model calibrated in PRMS-only mode.

Table 4-1- presents the range of goodness-of-fit criteria as outlined by Donigian, 2000, for percent flow error and daily and monthly Coefficient of Determination (R^2). Other goodness-of-fit statistics include Nash-Sutcliffe Efficiency, Observation Standard Deviation (RSR) and percent bias (PBIAS) categories to further evaluate model fit, (Morasi, 2007). The optimal goal is to achieve calibration results within the "Very Good" or "Excellent" range, however, as described in **Error! Reference source not found.** this may not be feasible, due to quality of measured data and/or calibration issues with the model.

Table 4--1: Surface Water Model Goodness-of-Fit Statistics Calibration Goals.

Qualitative Statistical Ratings	Percent Flow Error	Daily R^2	Monthly R^2	NSE	RSR	PBIAS
Very Good	<10	0.80 - 1	0.85 - 1	0.75 - 1	0 - 0.5	<10
Good	10 - 15	0.70 - 0.80	0.75 - 0.85	0.65 - 0.75	0.5 - 0.6	10 - 15
Satisfactory	15-25	0.60 - 0.70	0.65 - 0.75	0.50 - 0.65	0.6 - 0.7	15-25
Poor	>25	< 0.60	< 0.65	< 0.50	> 0.7	>25

Notes:

[3]Sources: For percent flow error and daily and monthly R^2 (Donigian, 2000) and NSE, RSR and PBIAS (Moriasi, 2007).

Annual volumetric calibration results for each gage moving in a downstream direction from Lopez Gage located upstream of the reservoir to the 22nd Street Gage located in the Cienega Valley are presented in the Table 4-2.

Table 4--2 Average annual volume calibration results

Streamflow Gage	Average Annual Flow				
	Measured	Modeled	Residual	Residual	Percent Flow Error
	acre-ft	acre-ft	acre-ft	cfs	(-)
LOPEZ C NR ARROYO GRANDE CA 11141280	5,823	6,447	-624	-0.90	-10.71
Rodriguez Sensor 733	3,077	3,489	-411	0.57	-13.36
Cecchetti Sensor 735	3,896	4,032	-136	0.19	-3.49
Arroyo Grande Creek Sensor 736	11,387	11,017	369	0.51	3.24
22nd Street Bridge Sensor 734	3,017	2,634	382	0.53	12.67

Other Goodness-of-Fit results of for each gage moving in a downstream direction are presented in the Table 4-3.

Table 4--3. Goodness-of Fit Calibration Results

Streamflow Gage	Coefficient of Determination (R^2)		Nash-Sutcliffe Efficiency (NSE)		RMSE²- Observation Standard Deviation Ratio (RSR)		Percent Bias (PBIAS)	
	Daily Flows	Monthly Flows	Daily Flows	Monthly Flows	Daily Flows	Monthly Flows	Daily Flows	Monthly Flows
	cfs	cfs	cfs	cfs	cfs	cfs	cfs	cfs
LOPEZ C NR ARROYO GRANDE CA 11141280	0.37	0.62	-5.50	-1.62	2.55	1.37	11	-4
Rodriguez Sensor 733	0.58	0.75	-6.61	0.63	2.76	0.82	-16	-17
Cecchetti Sensor 735	0.30	0.54	-5.49	0.80	2.55	0.66	-13	-20
Arroyo Grande Creek Sensor 736	0.63	0.93	0.63	0.93	0.63	0.93	-0.4	-0.3
22nd Street Bridge Sensor 734	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

NA means that observed data was deemed unreliable and statistics not calculated

It should be noted that groundwater processes in aquifers are significantly slower than surface water processes on land surface. Groundwater processes move on a monthly or greater time scales whereas surface water flows function on hourly time scales. This time scale difference makes it difficult for integrated groundwater/surface water models to simulate accurate timing of daily surface water flows that are controlled by groundwater processes such as base flow. This is also the case for daily surface water statistics presented in Table 4-3, with the exception of the Arroyo Grande Gage.

USGS Lopez Stream Gage

The Lopez stream gage is located upstream of Lake Lopez, and monitors streamflow entering the reservoir at that point. It is located at an elevation of 580 feet above mean sea level and drains an area of 20.9 square miles.

One estimate of surface water calibration is to view modeled and observed stream flow volumes and to assess the goodness-of-fit statistics as such as R^2 as summarized in Table 4.2 and 4.3. Lopez stream gage has an R^2 value of 0.62 for monthly flows and 0.18 for daily flows, both considered poor model fit. Although, the percent flow error is good (<10%), the other Goodness-of-Fit calibration statistics in Tables 4.2 and 4.3 for both daily and monthly calibration statistics are generally poor. In general, goodness-of-fit statistics are poor because the modeled flows at

Lopez stream gage are too “flashy” where the peak flows are overestimated and the baseflow underestimated.

A continuous hydrograph of modeled and observed flows at the Lopez gage are presented in Figures 4-1 and 4-2, for monthly and daily flows, respectively. Inspection of this graph indicates that modeled flows reach a value of approximately zero (less than 0.1 cfs on the logarithmic scale of the y axis) on a nearly annual basis, while the observed flows rarely drop below 1.0 cfs in the observed flow data. It is noteworthy that the observed flows never drop below 1 cfs, despite the fact that the gage is located at an elevation of 580 feet. Most streams in this region are seasonal, and routinely drop to zero flow during the summer under natural meteorological conditions. It is possible that this gage may be located downstream of a small spring or seep that maintains flow through the summer, but it is also possible that the rating curve developed for the gage is not completely accurate at low flows. In any event, this gage is located upstream of the reservoir, so has limited impact on conditions in the Subbasin, or further downstream in the SMRVS. Downstream releases are controlled through the dam gates and are represented in GSFLOW as such.

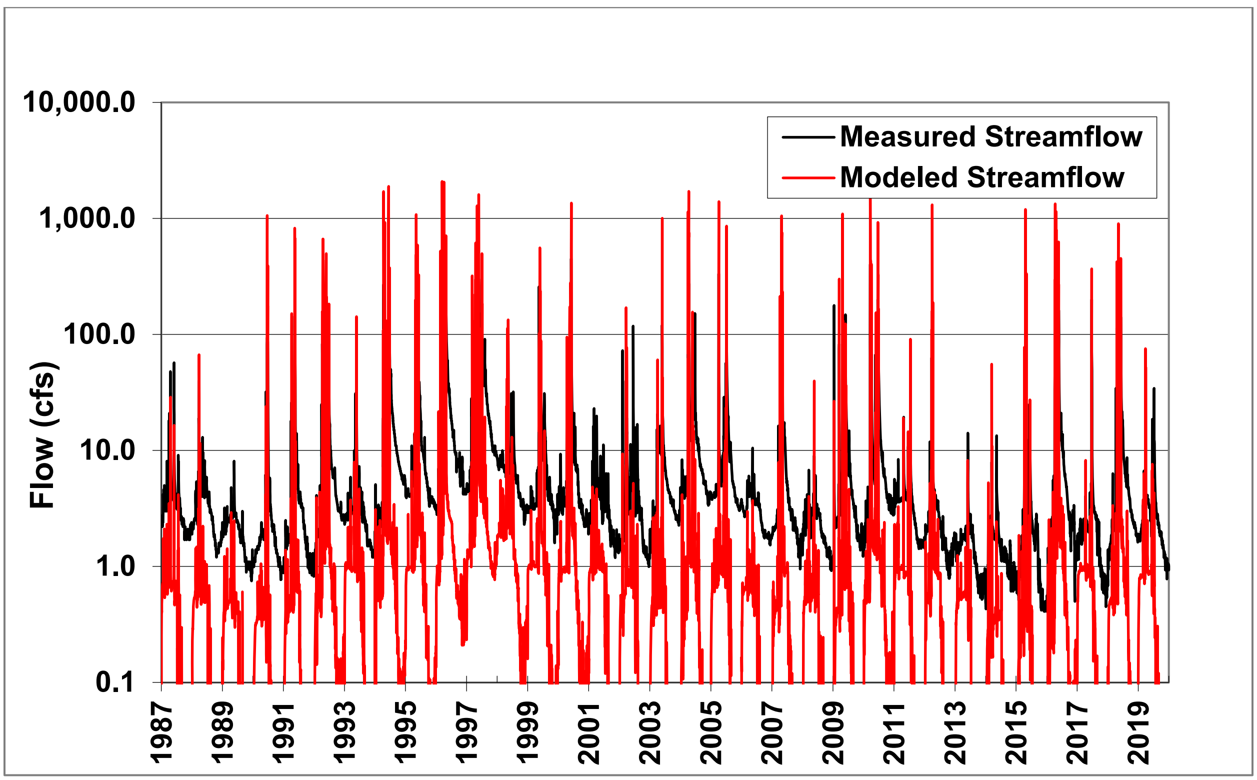


Figure 4--1. Daily Modeled and Observed Streamflow, Lopez Gage

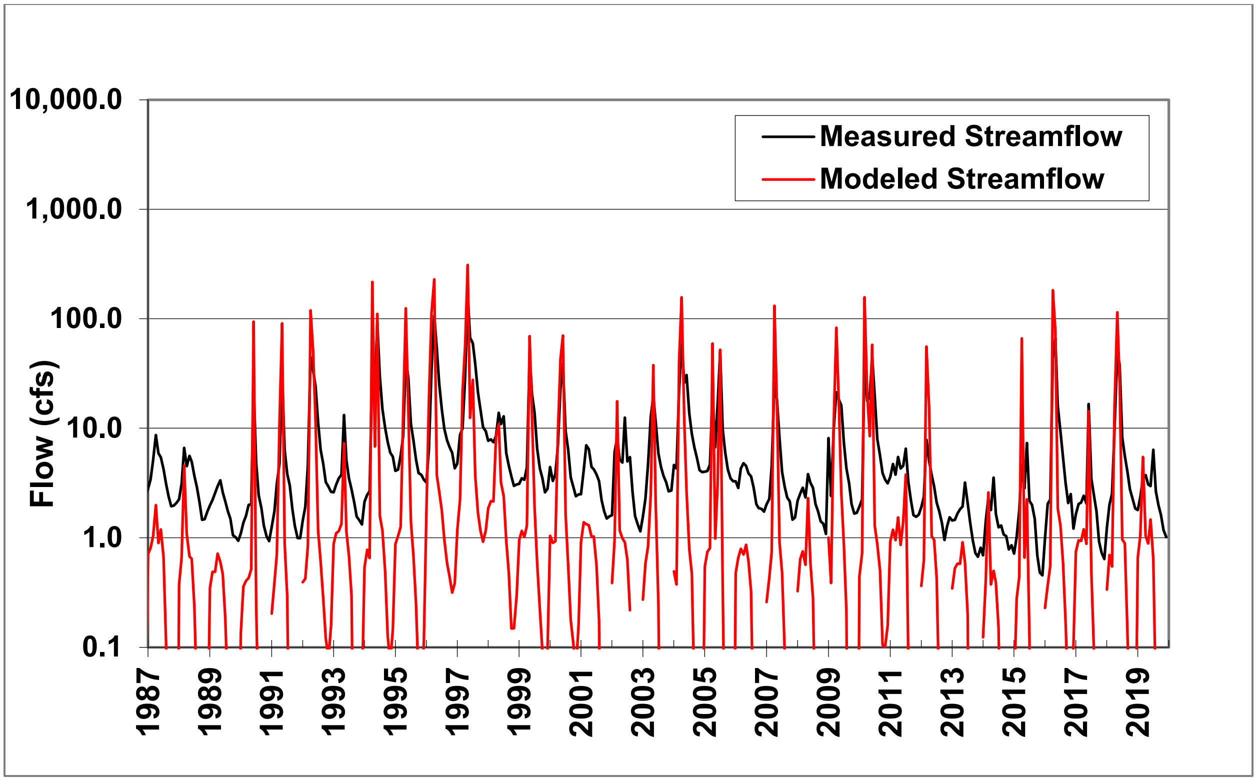


Figure 4--2. Monthly Modeled and Observed Streamflow, Lopez Gage

Figure 4-3 presents flow duration curves for the daily observed and modeled data for the modeled period. The flow duration curve represents how well the model statistically replicates the ranges of measured flows observed at a gage. This graph indicates the same message as Figure 4-2, that the modeled low flows are less than those calculated using the gage data. However, as previously discussed, this will have minimal impact on modeled conditions downstream of the dam.

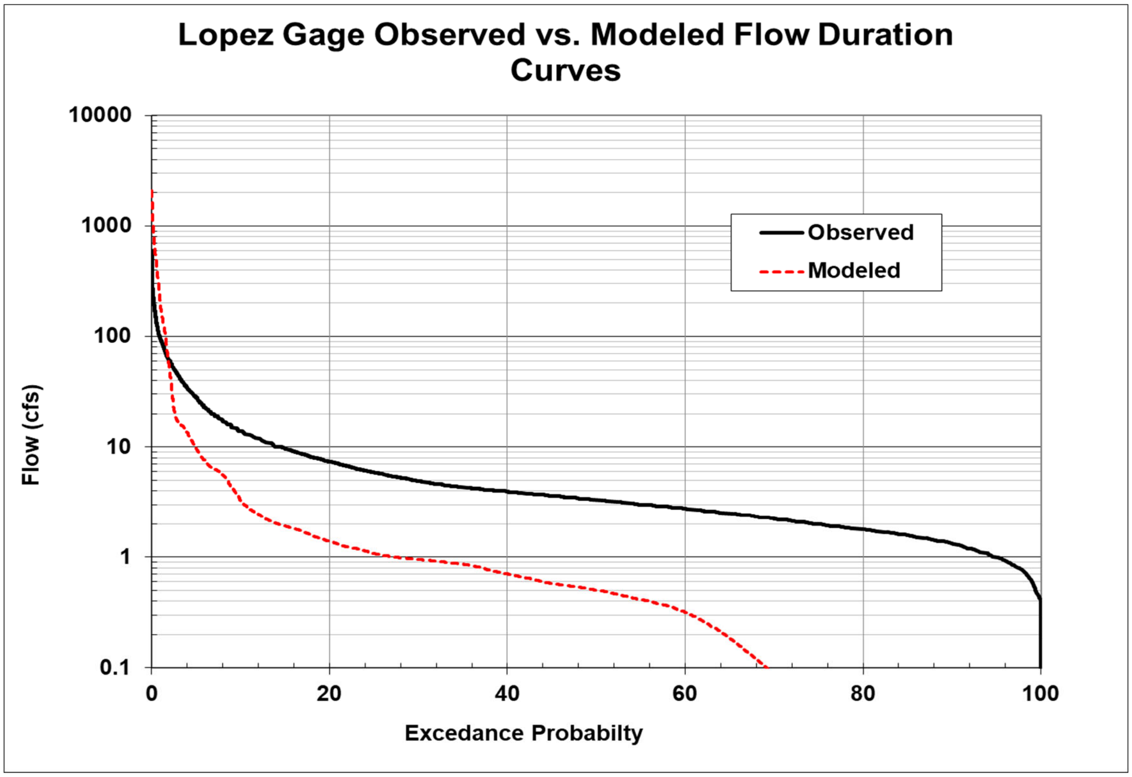


Figure 4--3. Modeled and Observed Flow Duration Curves, Lopez Gage

Rodriguez Gage

The Rodriguez Gage is located about ¾ of a mile downstream of Lopez Dam. It is an active County stream gage (Rodriguez Bridge – Sensor 733).

The Rodriquez stream gage has an R^2 value of 0.77 for monthly flows (good) and 0.63 for daily flows (poor). The percent flow error of -13.4 % is considered good, the other Goodness-of-Fit calibration statistics in Table 4.3 for both daily and monthly calibration statistics are generally poor, except NSE for monthly flow is thought of as a good model fit.

A continuous hydrograph of modeled and observed flows at the Rodriquez gage are presented in Figures 4-4 and 4-5, for monthly and daily flows, respectively. The data displayed here show observed flows at the gage from 2008 to 2012 as being significantly lower than modeled flow. But more significantly it indicates observed flow much lower than dam releases during this time period, with observed flows being reported as about 1/3 to ½ of the dam releases. This data seems unrealistic, as there is no indication from the synoptic flow study or any other observations that this volume of flow through the dam gates is lost to groundwater percolation. The data from 2013 to 2016 shows data relationships more in line with observed conditions, with slight amounts of flow lost between the dam gates and Rodriguez gage. For this reason, the data from WY 2008 to 2012 was omitted from the following calibration evaluation or discussion.

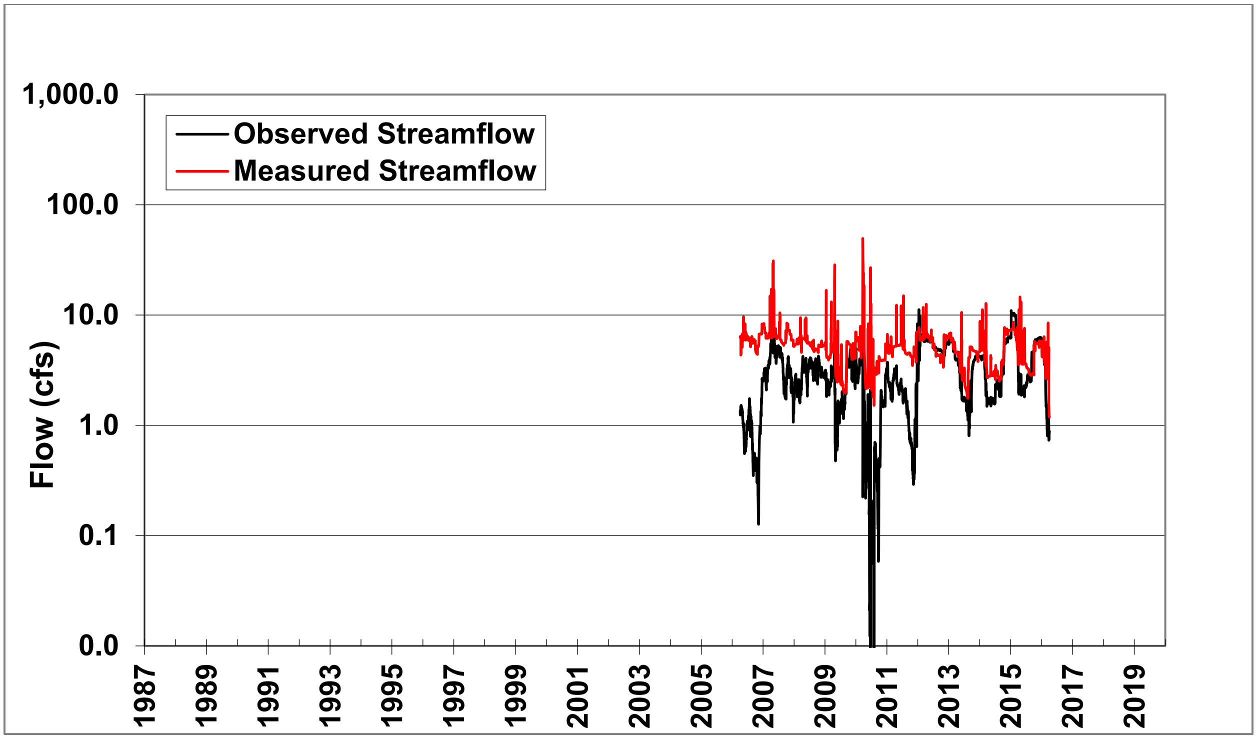


Figure 4--4. Daily Modeled and Observed Streamflow, Rodriguez Gage

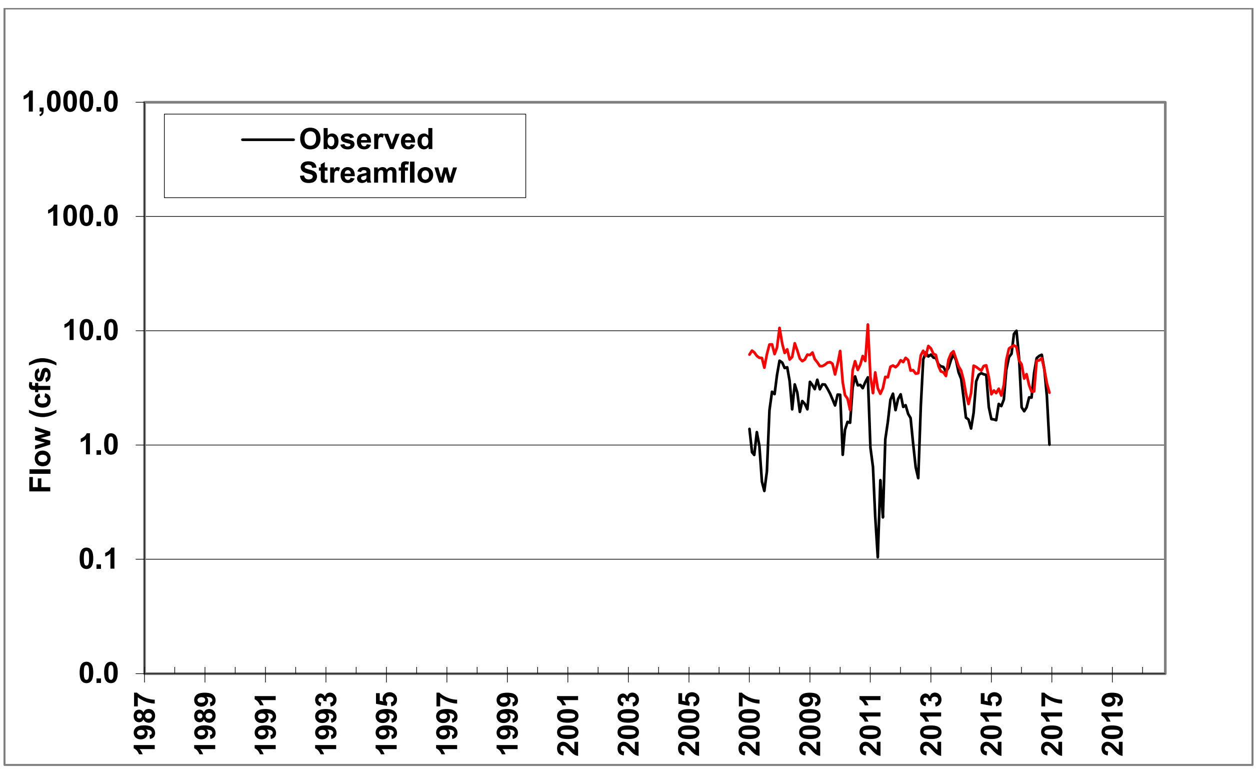


Figure 4--5. Monthly Modeled and Observed Streamflow, Rodriguez Gage

Figure 4-6 presents modeled and observed flow hydrographs at Rodriguez gage for the model period including the Lopez Dam releases. Inspection of this graph indicates the same relationship between dam releases and observed flow as Figure 4-4; prior to WY 2013, the observed flows at the gage are significantly lower than the dam releases. Again, there is no empirical evidence that this is true. The synoptic flow study indicates some loss to percolation between the dam and the gage, but not at such a significant volume. After WY 2013, observed flows are slightly less than dam releases, and there is a good correlation between modeled and observed flows.

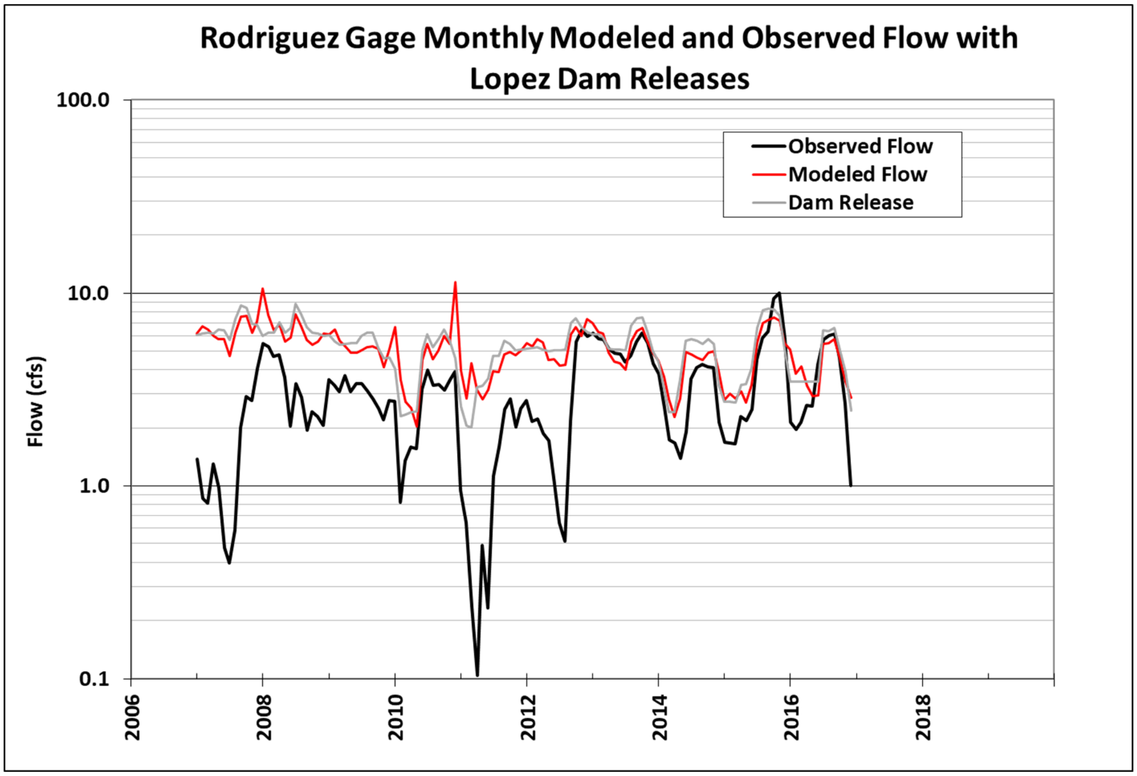


Figure 4--6. Rodriguez Gage Monthly Modeled and Observed Flow Hydrographs, with Lopez Dam Releases

Figure 4-7 presents the modeled and observed flow duration curves for the Rodriguez Gage. Although there are some noticeable discrepancies between observed and modeled results in the lowest and highest 10% exceedances on the x-axis, the middle 80% of flows are captured accurately by the model.

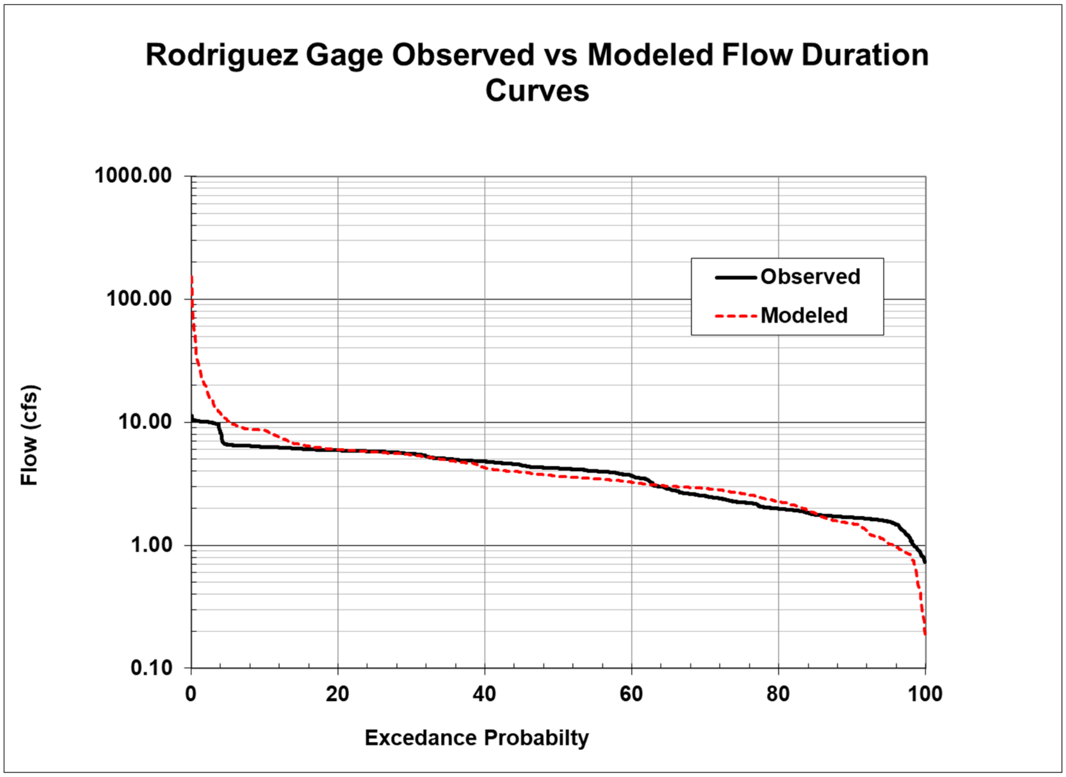


Figure 4--7. Rodriguez Gage Observed vs Modeled Flow Duration Curves

Cecchetti Gage

This gage site is about 4.8 miles downstream of Lopez Dam (Figure 1-1). There is an active County stream gage (Cecchetti – Sensor 735) at the site.

The Cecchetti stream gage has an R^2 value of 0.54 for monthly flows and 0.30 for daily flows both considered a poor model fit. On an annual average basis, the percent flow error of -3.49 % which is very good. The other Goodness-of-Fit calibration statistics in Table 4.3 for daily calibration statistics are poor but for monthly statistics in general satisfactory.

Figures 4-8 and 4-9 present hydrographs of observed and modeled daily and monthly flows at the Cecchetti gage for the available data. This graph indicates a reasonable approximation of observed flows by the model, with the model appearing to overestimate some of the highest flows during the period of record.

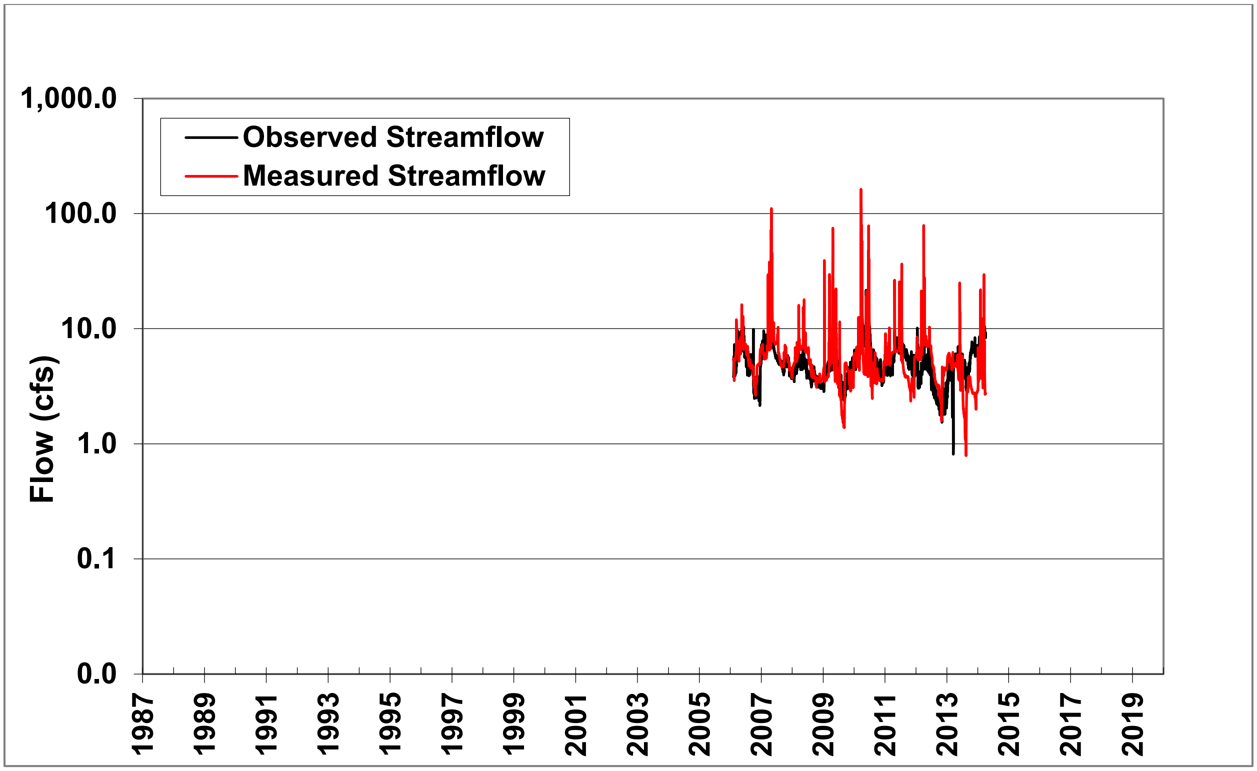


Figure 4--8. Daily Modeled and Observed Streamflow, Rodriguez Gage

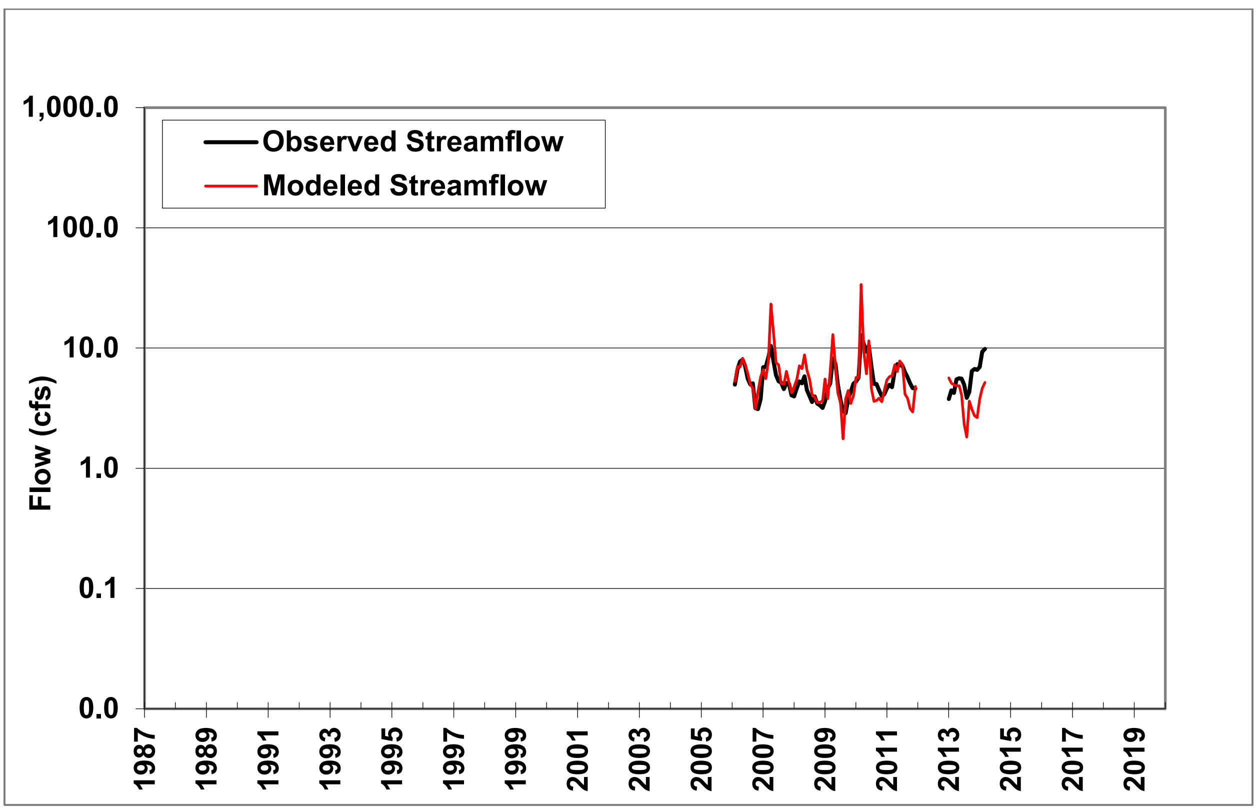


Figure 4--9. Monthly Modeled and Observed Streamflow, Rodriguez Gage

Figure 4-10 presents the modeled and observed flow duration curves for the Cecchetti Gage. Although there are some minor discrepancies between observed and modeled results in the highest 10% exceedances on the x-axis, the approximate match of the two curves indicates that the GSFLOW model has accurately captured the flow regime of Arroyo Grande Creek at this gage location.

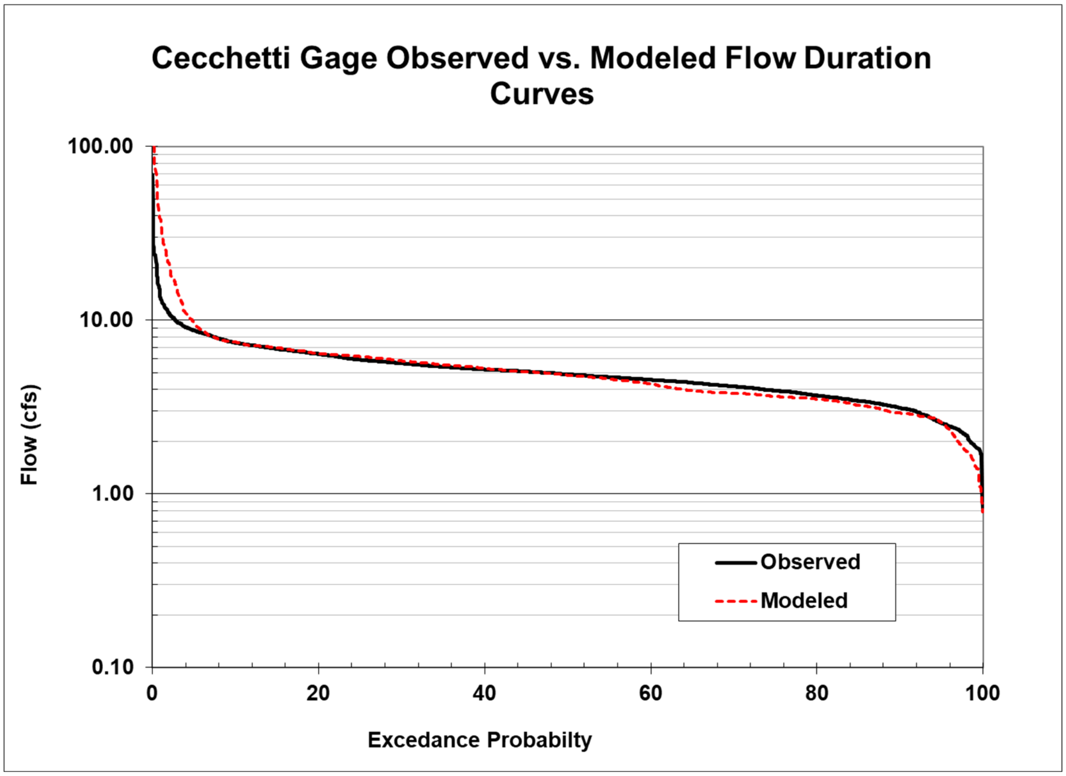


Figure 4-10. Cecchetti Gage Observed vs Modeled Flow Duration Curves

Arroyo Grande Gage

The Arroyo Grande gage is a USGS-operated gage. The site is about 8 miles downstream of Lopez Dam (Figure 1-1).

The Arroyo Grande stream gage has an R^2 value of 0.93 for monthly flows (very good) and 0.63 a satisfactory model fit for daily flows. The percent flow error of 3.24 % at Arroyo Grande Gage is considered very good. Most of the other Goodness-of-Fit calibration statistics in Table 4-3 for both daily and monthly calibration statistics are very good.

Figures 4-11 and 4-12 present hydrographs of daily and monthly observed and modeled flows at the Arroyo Grande stream gage for the available data. This graph indicates an excellent approximation of observed flows by the model.

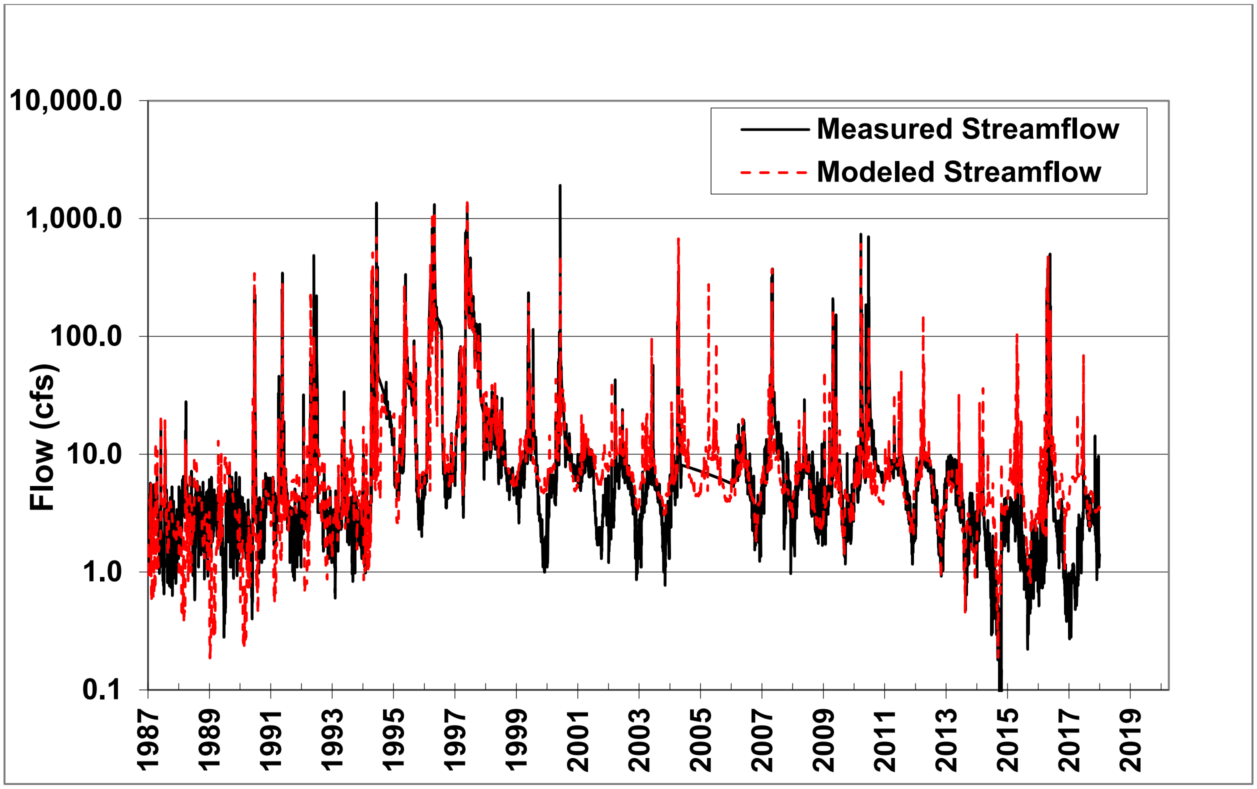


Figure 4--11. Daily Modeled and Observed Streamflow, Arroyo Grande Gage

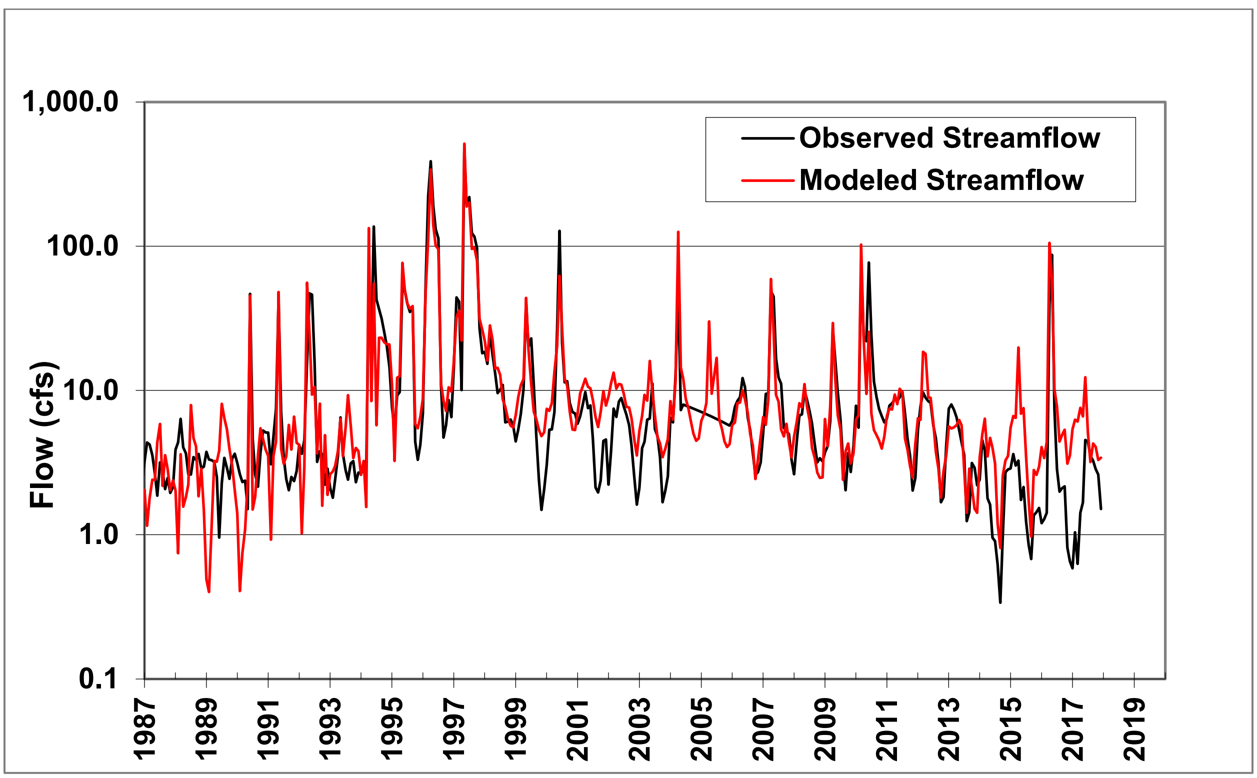


Figure 4--12. Monthly Modeled and Observed Streamflow, Arroyo Grande Gage

Figure 4-13 presents the modeled and observed flow duration curves for the Arroyo Grande Gage. The excellent match of the two curves indicates that the GSFLOW model has accurately captured the flow regime of Arroyo Grande Creek at this gage location.

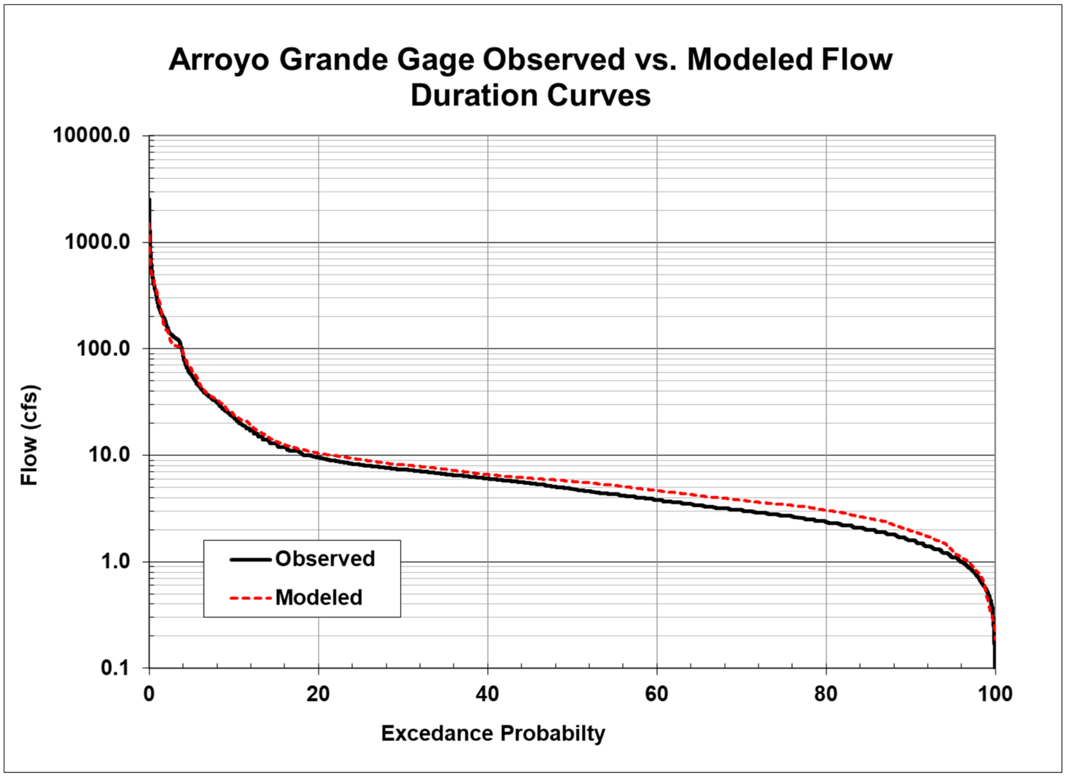


Figure 4--13. Arroyo Grande Gage Observed vs Modeled Flow Duration Curves

22nd Street Gage

The 22nd Street gage is approximately 11.6 miles downstream of Lopez Dam on the upstream side of the 22nd Street bridge. There is an active County stream gage (22nd Street – Sensor 734) at the site.

It was noted during the synoptic flow study performed during the summer of 2021 that on days when the County real time data indicated flows of up to 10 cfs being recorded at this gage, physical observations made during the synoptic study indicated that there was zero flow passing the gage. There is some standing water and zero flow pools in the vicinity of the gage, but there was no active flow observed or measured at the gage site on those days. Due to this fact the 22nd Street Gage was calibrated to measured peak flow and baseflows were qualitatively calibrated to zero to very little flow in the summer months. As such, goodness-of-fit statistics were not calculated because the measured data was not considered to be reliable. GSI did compare the annual average stream flow volumes to see if there was at least some reasonable comparison. The modeled percent flow error of 22nd Street Gage is 12.67 % which is considered good and deemed reasonable since most of the flow volume past the gage is from peak flows during storm events.

Figures 4-14 and 4-15 presents hydrographs of daily and monthly observed and modeled flows at the 22nd Street stream gage for the available data. These graphs indicate a fair approximation of observed peak flows by the model.

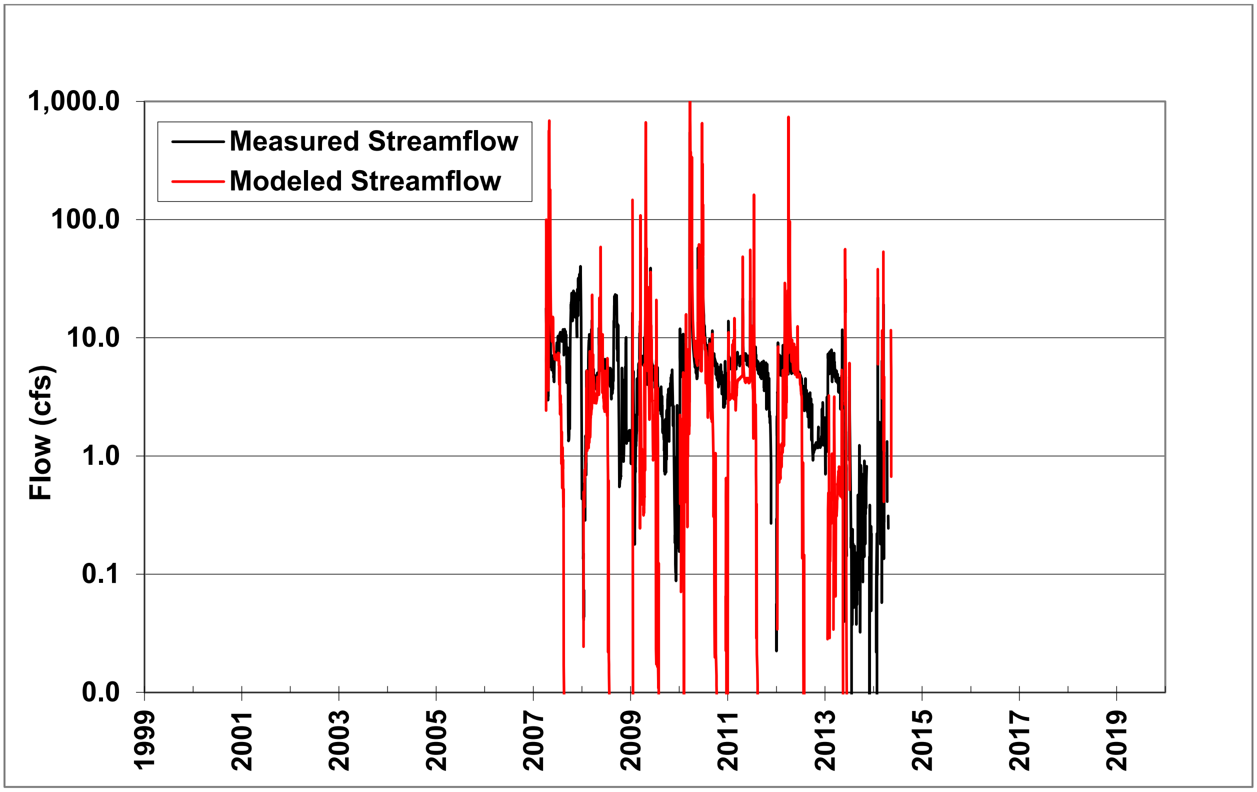


Figure 4--14. Daily Modeled and Observed Streamflow, 22nd Street Gage

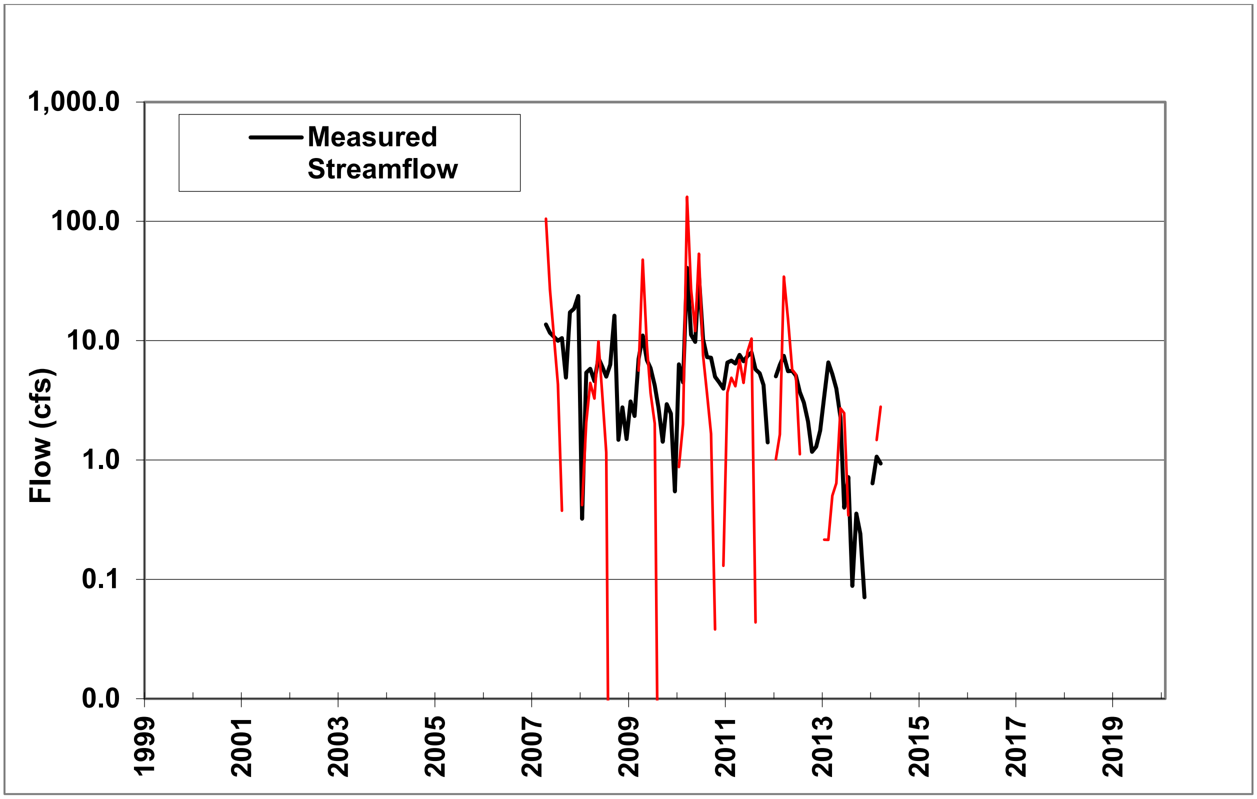


Figure 4--15. Monthly Modeled and Observed Streamflow, 22nd Street Gage

Figure 4-16 presents the modeled and observed flow duration curves at the 22nd Street gage. As previously explained, due to the circumstance of the county's observed data being consistently higher than actual observed conditions during low flow conditions, the flow duration curve matches poorly to measured data since it is qualitatively calibrated to the low flow data collected during the synoptic flow study. The active channel may have shifted since the rating curve was established, or the channel may have incised, or some other physical change in the stream channel may have occurred. The rating curve for this stream gage should be re-evaluated in the future.

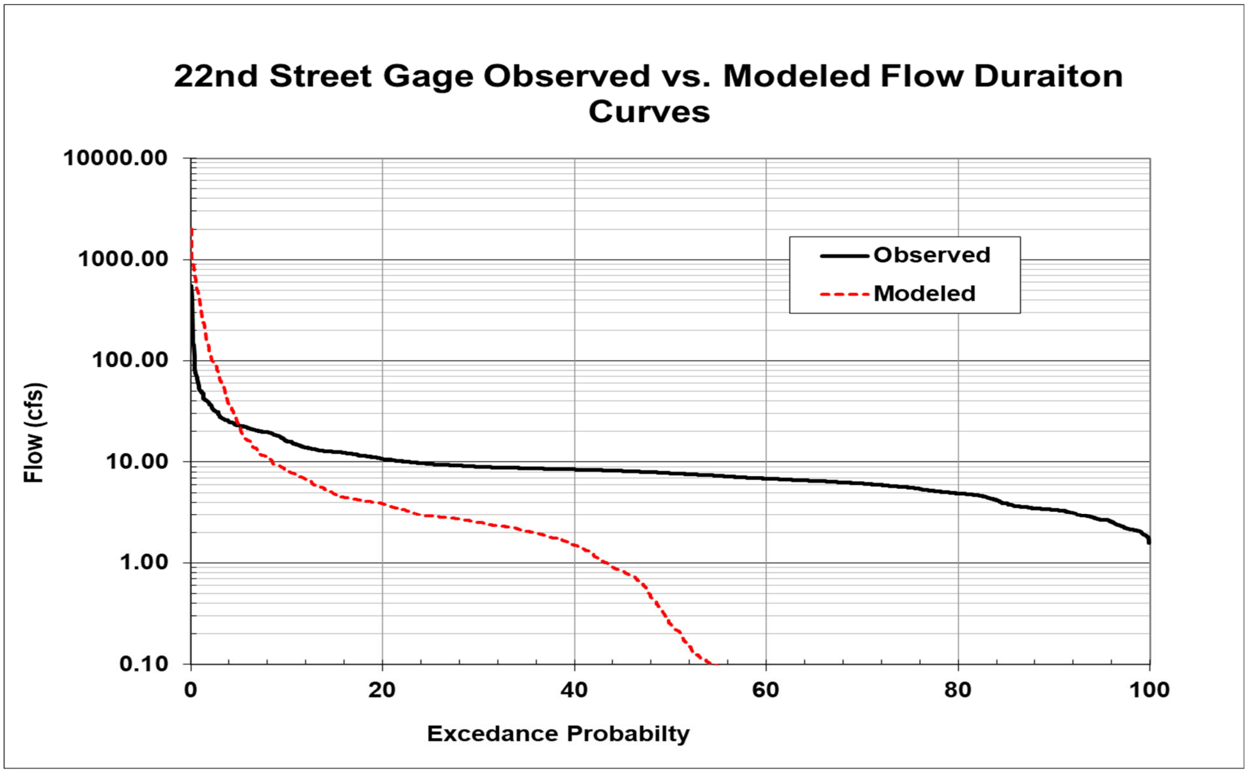


Figure 4--16. 22nd Street Gage Observed vs. Modeled Flow Duration Curves

Synoptic Flow Study Validation

The modeled representation of streamflows along Arroyo Grande Creek was examined and compared to the synoptic flow study results completed in the of Summer 2021. (The synoptic study TM is included as an appendix to this report). The synoptic streamflow study was conducted between 6/22/2021 and 9/8/202, with multiple tests at various release rates and time intervals from Lopez Dam. The synoptic flow test releases were measured at 13 locations between Lopez Dam and the Pacific Ocean. However, the Arroyo Grande GSP Model has a simulation time frame from 10/1/1987 to 9/30/2020, therefore a direct temporal comparison to the synoptic test is not possible.

To make a generalized model performance comparison to the synoptic streamflow study the following approach was taken by GSI. The weighted average flows, depending on the duration of each synoptic test, were calculated as 5.56 cfs and compared to similar GSFLOW simulated flows during the months of June through September from water year 1988 through 2020. To get a representative sample from the modeled flows, a range of +/- 0.4 cfs about the mean flow of the synoptic tests of 5.56 cfs were considered. This range of +/- 0.4 cfs about the synoptic mean of 5.56 cfs, included 1,665 daily modeled flow that met this condition. This relative comparison of model results to synoptic flow test are shown on Figure 4-17. The GSFLOW modeled flows display similar flow accretions and depletions in Arroyo Grande Creek with similar magnitudes of flow compared the measured flows of the average synoptic test flows. For most of the 13 synoptic flow measurement locations the GSFLOW modeled results display good agreement with a maximum deviation of approximately 1 cfs at 3 synoptic flow test locations.

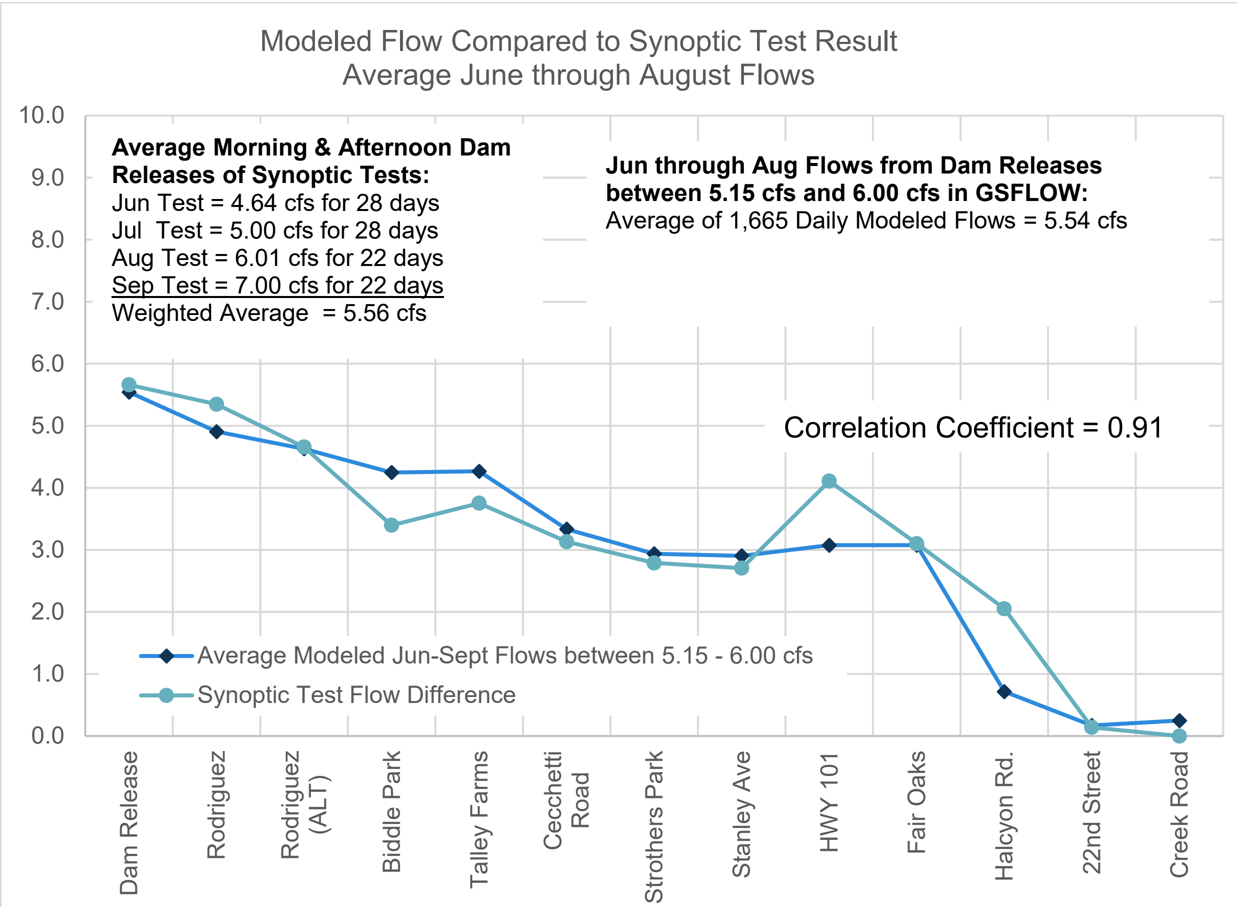


Figure 4--17. Comparison of Synoptic Flow Study Stream Measurements with Modeled Streamflows under Summer Conditions

Groundwater

The groundwater model is evaluated primarily on the statistical evaluation of residuals in modeled groundwater surface elevation across the model domain. As previously discussed, the primary goal is to achieve a relative error of less than 10% (ESI, Spitz and Moreno, ASTM). Additional analysis includes scatter plots of observed versus modeled residuals to identify any particular areas that are problematic in the model, and graphs of residuals versus time is presented to identify any model-wide change in residual with time, and to identify if the model has a bias toward positive or negative residuals. The final output of calibration statistics for the GSFLOW model is presented in Table 4-4 separately for the Arroyo Grande Subbasin and the total model area.

Table 4--4. Integrated GSFLOW Groundwater Model Statistics

	Total Model Area	Arroyo Grande Subbasin
Residual Mean	-7.0	-1.6
Residual Std. Deviation	12.1	11.5
Min. Residual	-86.4	-48.1
Max. Residual	354.1	31.9
Number of Observations	3,985	1,405
Range in Observations	440.5	287.5
Relative Error	2.7%	4.0%

Figures 4-18 and 4-19 presents a scatter plot of the modeled compared with observed values and the temporal distribution of residuals for the total model area. The modeled values plot closely to the 1:1 line and most of the values are within one standard deviation of the mean and the residuals versus time do not display any discernible bias.

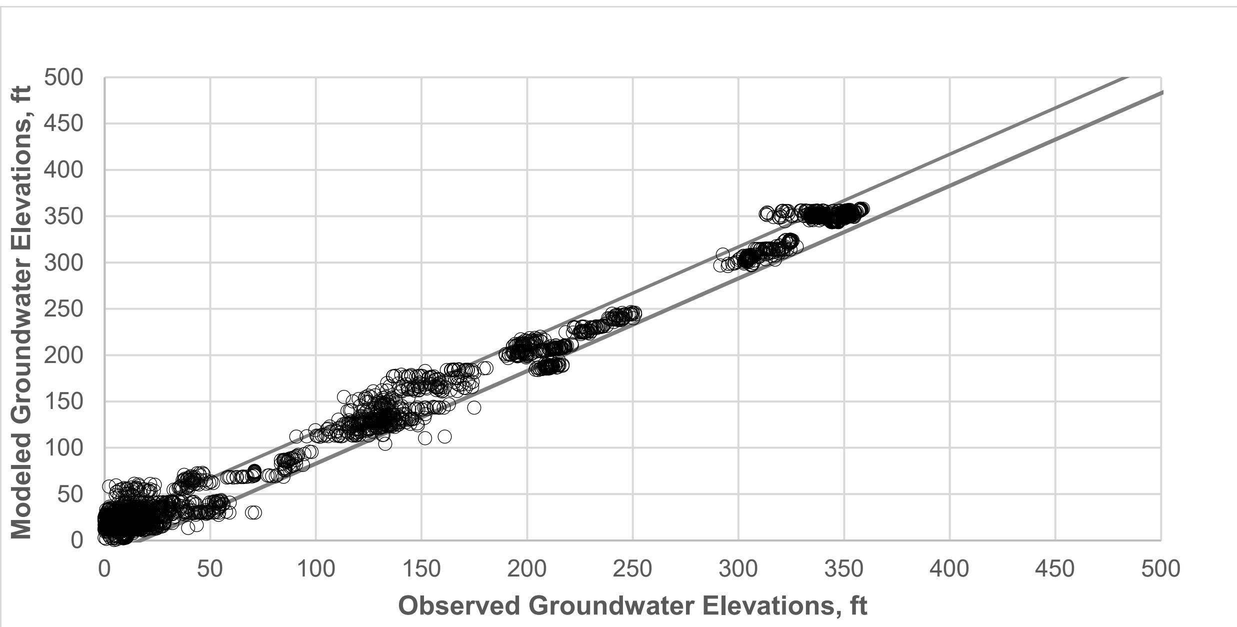


Figure 4--18. Scatterplot of Modeled Compared to Observed Groundwater Elevations for 87 Wells across the Total Model Area

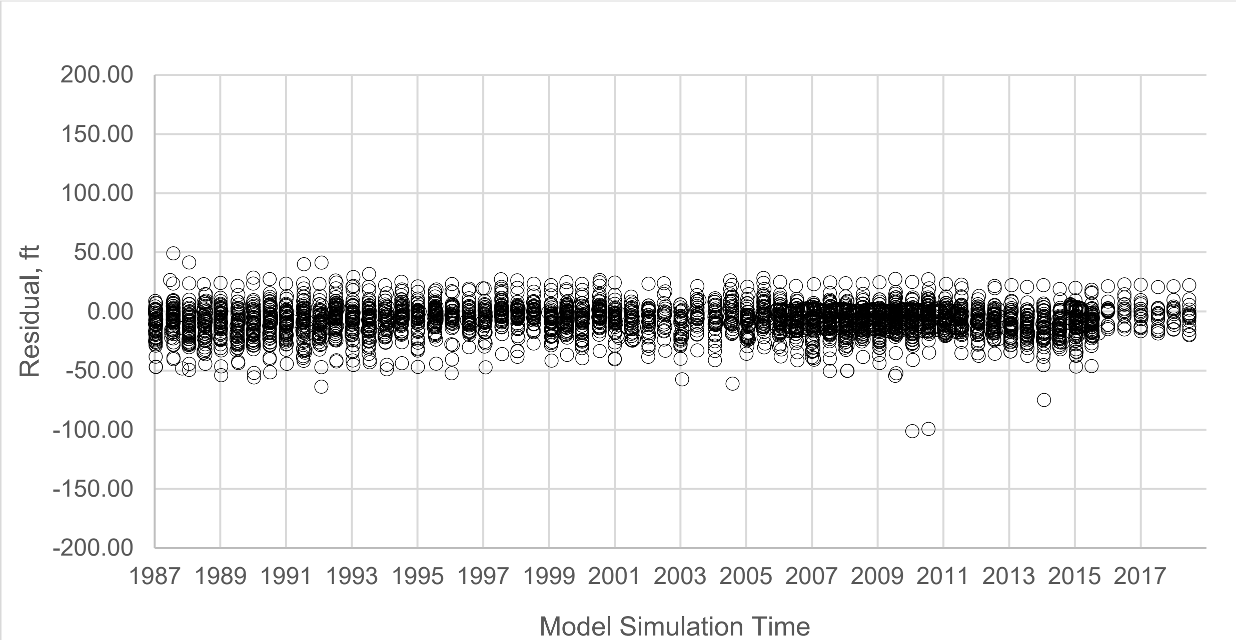


Figure 4--19. Residual Distribution for 87 Wells across the Total Model Area

Figures 4-20 and 4-21 presents a scatter plot of the modeled compared with observed values and the temporal distribution of residuals for the Arroyo Grande Subbasin. The modeled values plot closely to the 1:1 line and most of the values are within one standard deviation of the mean and the residuals versus time do not display any discernible bias.

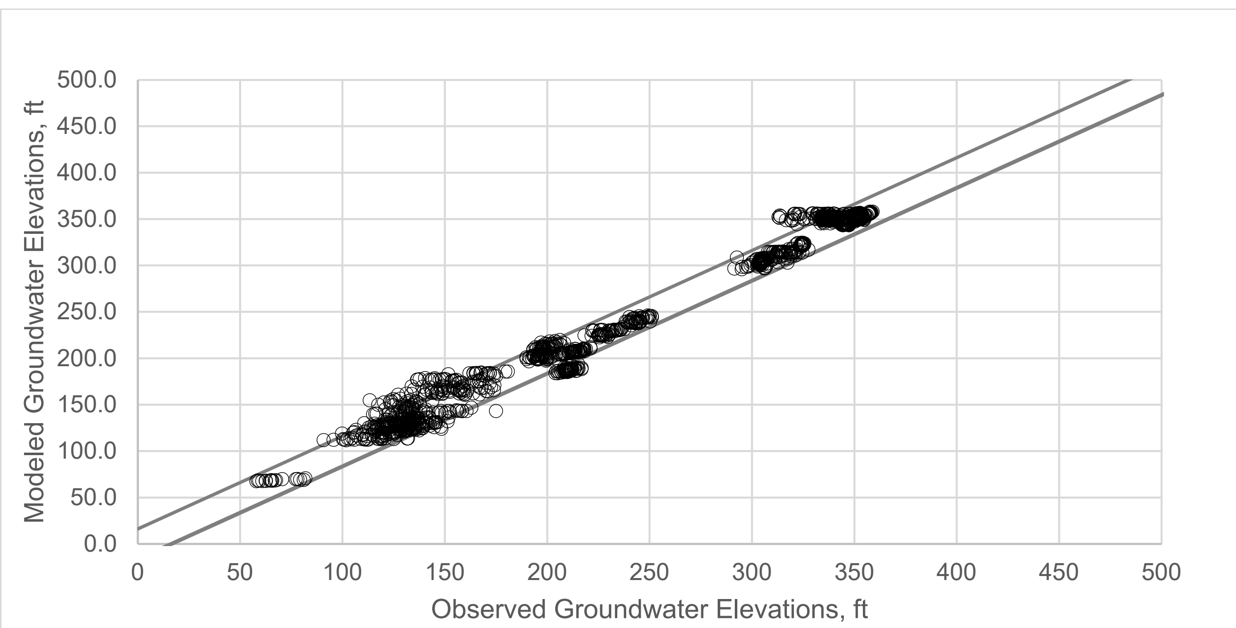


Figure 4--20. Scatterplot of Modeled Compared to Observed Groundwater Elevations for 87 Wells across the Total Model Area

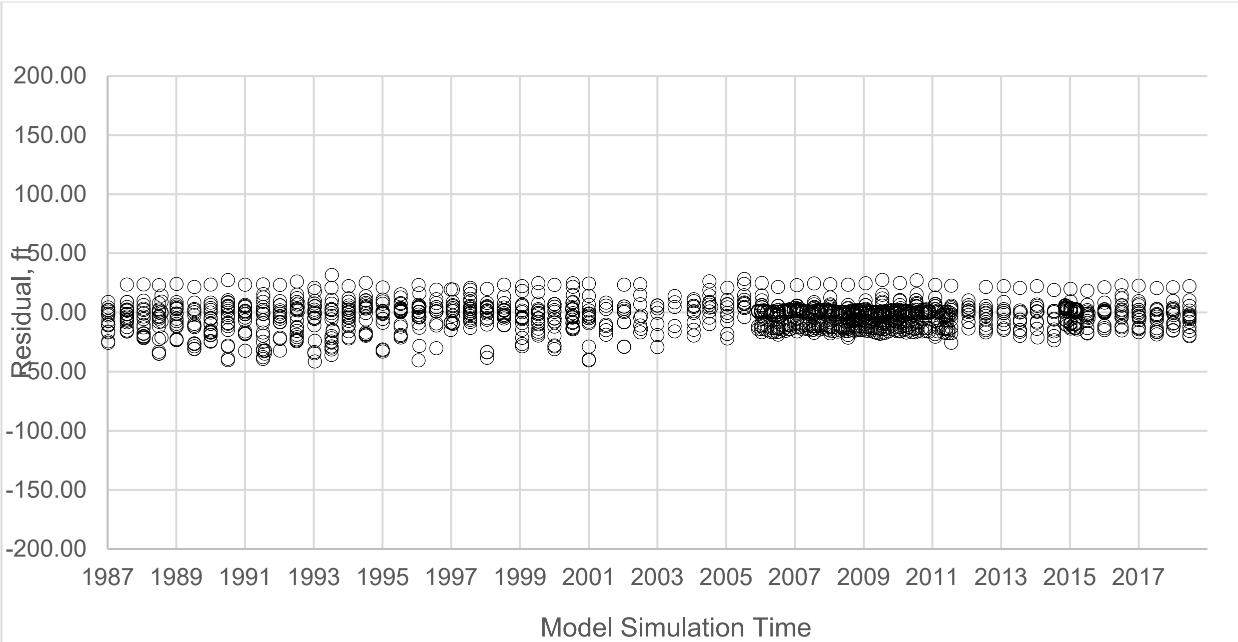


Figure 4--21. Residual Distribution for 31 Wells across the Arroyo Grande Subbasin

A common qualitative measure of goodness-of-fit for modeled results is a comparison of the observed versus modeled groundwater elevations using hydrograph of individual wells. The hydrographs show water level seasonality and trends during more prolonged dry and wet periods that a sufficiently calibrated model in general should be able to mimic. For the GSFLOW model 87 groundwater elevation hydrographs are considered in this statistical evaluation and are presented in Appendix A of this Tech Memo. A map displaying the locations of groundwater calibration targets is presented in Appendix A.

5.0 MODSIM Integration with GSFLOW

The development of the MODSIM model and its integration with the GSFLOW model is documented in a Technical Memo prepared by RTI and is included as Appendix B of this report.

6.0 Summary, Areas of Improvement and Next Steps

This TM has presented the data summary, HCM, and final model calibration results for the GSFLOW model of the Arroyo Grande Creek Watershed area and its primary aquifers. The model calibration results are within industry standards, and the model is judged by the modeling team to be adequate for the objective of assessing projects and management actions identified in the GSP or supporting HCP analyses in the future.

The GSP process mandated by SGMA requires updates to the GSP every 5 years. During these updates, models may be revised considering new data and information collected during the intervening period between the last version of the GSP and the new one. As such, it is expected that this GSFLOW model will be updated to incorporate new data generated by an improved monitoring network, updated water level data from existing calibration targets, potential revisions to the HCM, and other factors. During the development of the model, numerous areas were identified as areas for potential improvement when the GSP is updated in 5 years. Some of these are discussed below.

Potential areas for model revision and improvement are focused on the surface water interaction aspects of the GSFLOW model and include the following:

1. Incorporate surveyed channel cross section data into the representation of channel geometry in the SFR package. This would provide more realistic representation of stream conditions such as depth of flow, etc., that may be of interest in analyses supporting the HCP.
2. Improve surface water monitoring in the contributing watershed areas and confirm that there is continuous year-round base flow at the Lopez gage as indicated in the observed flow data for that gage.
3. As mentioned previously, during the synoptic flow study, observed flow data based on the rating curve indicated flows of up to 10 cfs at times when visual inspections observed no flow conditions. The rating curve for the 22nd Street gage should be re-evaluated to provide more reliable flow data at this location during low flow conditions.
4. After the five-year SGMA implementation period has passed, the model can be updated and re-calibrated with a new 5-year set of hydrology inputs and observed water levels to improve representation of the hydrologic system in the model area.
5. As specific questions that need to be analyzed for future HCP development become apparent, there may be additional areas of improvement identified in the future.

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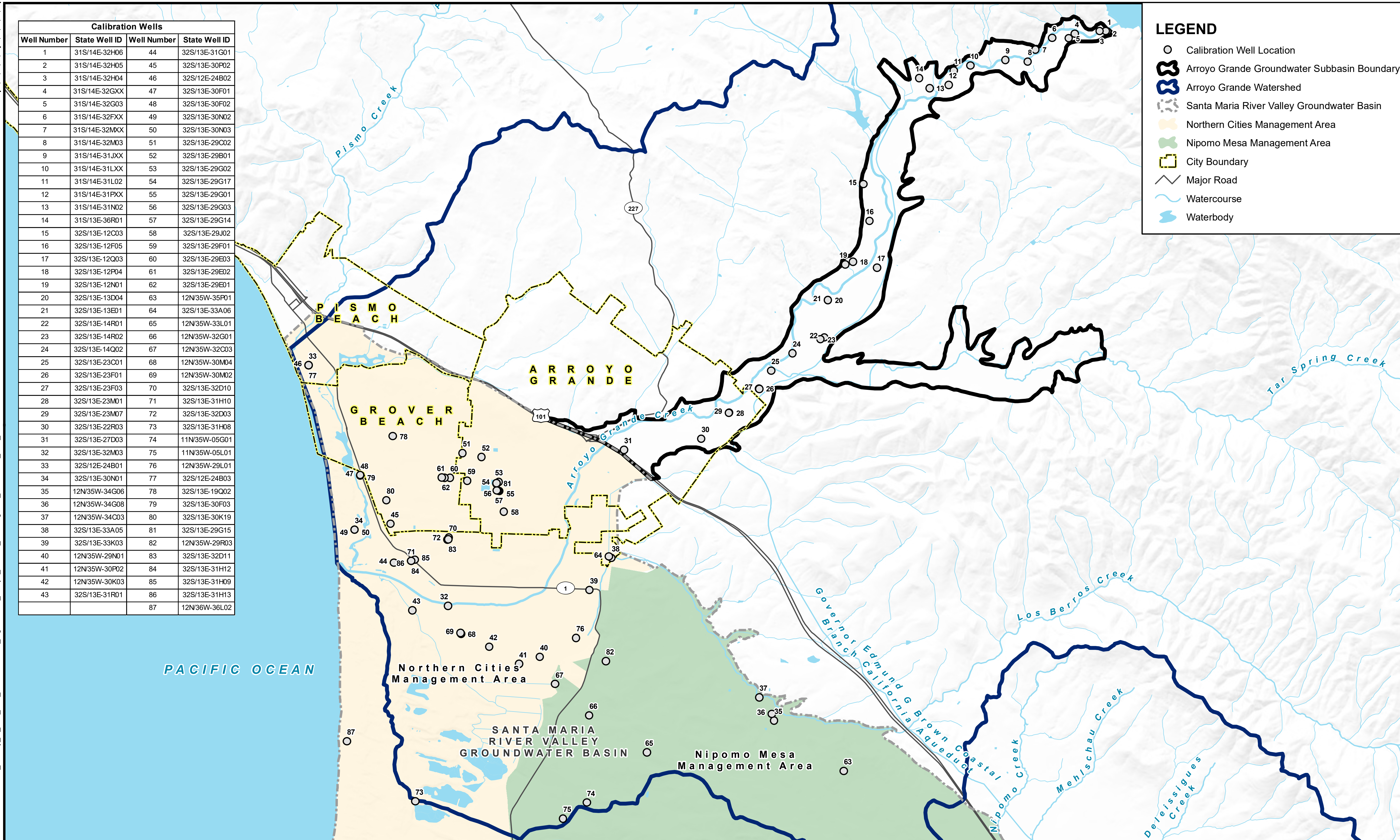
Appendix A Groundwater Elevation Hydrographs



Calibration Wells			
Well Number	State Well ID	Well Number	State Well ID
1	31S/14E-32H06	44	32S/13E-31G01
2	31S/14E-32H05	45	32S/13E-30P02
3	31S/14E-32H04	46	32S/12E-24B02
4	31S/14E-32GXX	47	32S/13E-30F01
5	31S/14E-32G03	48	32S/13E-30F02
6	31S/14E-32FXX	49	32S/13E-30N02
7	31S/14E-32MXX	50	32S/13E-30N03
8	31S/14E-32M03	51	32S/13E-29C02
9	31S/14E-31JXX	52	32S/13E-29B01
10	31S/14E-31LXX	53	32S/13E-29G02
11	31S/14E-31L02	54	32S/13E-29G17
12	31S/14E-31PXX	55	32S/13E-29G01
13	31S/14E-31N02	56	32S/13E-29G03
14	31S/13E-36R01	57	32S/13E-29G14
15	32S/13E-12C03	58	32S/13E-29J02
16	32S/13E-12F05	59	32S/13E-29F01
17	32S/13E-12Q03	60	32S/13E-29E03
18	32S/13E-12P04	61	32S/13E-29E02
19	32S/13E-12N01	62	32S/13E-29E01
20	32S/13E-13D04	63	12N/35W-35P01
21	32S/13E-13E01	64	32S/13E-33A06
22	32S/13E-14R01	65	12N/35W-33L01
23	32S/13E-14R02	66	12N/35W-32G01
24	32S/13E-14Q02	67	12N/35W-32C03
25	32S/13E-23C01	68	12N/35W-30M04
26	32S/13E-23F01	69	12N/35W-30M02
27	32S/13E-23F03	70	32S/13E-32D10
28	32S/13E-23M01	71	32S/13E-31H10
29	32S/13E-23M07	72	32S/13E-32D03
30	32S/13E-22R03	73	32S/13E-31H08
31	32S/13E-27D03	74	11N/35W-05G01
32	32S/13E-32M03	75	11N/35W-05L01
33	32S/12E-24B01	76	12N/35W-29L01
34	32S/13E-30N01	77	32S/12E-24B03
35	12N/35W-34G06	78	32S/13E-19Q02
36	12N/35W-34G08	79	32S/13E-30F03
37	12N/35W-34C03	80	32S/13E-30K19
38	32S/13E-33A05	81	32S/13E-29G15
39	32S/13E-33K03	82	12N/35W-29R03
40	12N/35W-29N01	83	32S/13E-32D11
41	12N/35W-30P02	84	32S/13E-31H12
42	12N/35W-30K03	85	32S/13E-31H09
43	32S/13E-31R01	86	32S/13E-31H13
		87	12N/36W-36L02

Document Path: Y:\0667_County_of_San_Luis_Obisbo\Source_Figures\023_Arroyo_Grande_GSP\FigureX_Calibration_Well_Locations.mxd

Prepared for:

COUNTY OF SAN LUIS OBISPO

ARROYO GRANDE SUBBASIN GSP

Author: WCK

Date: 10/10/2022

N

0 0.25 0.5 Miles

References:

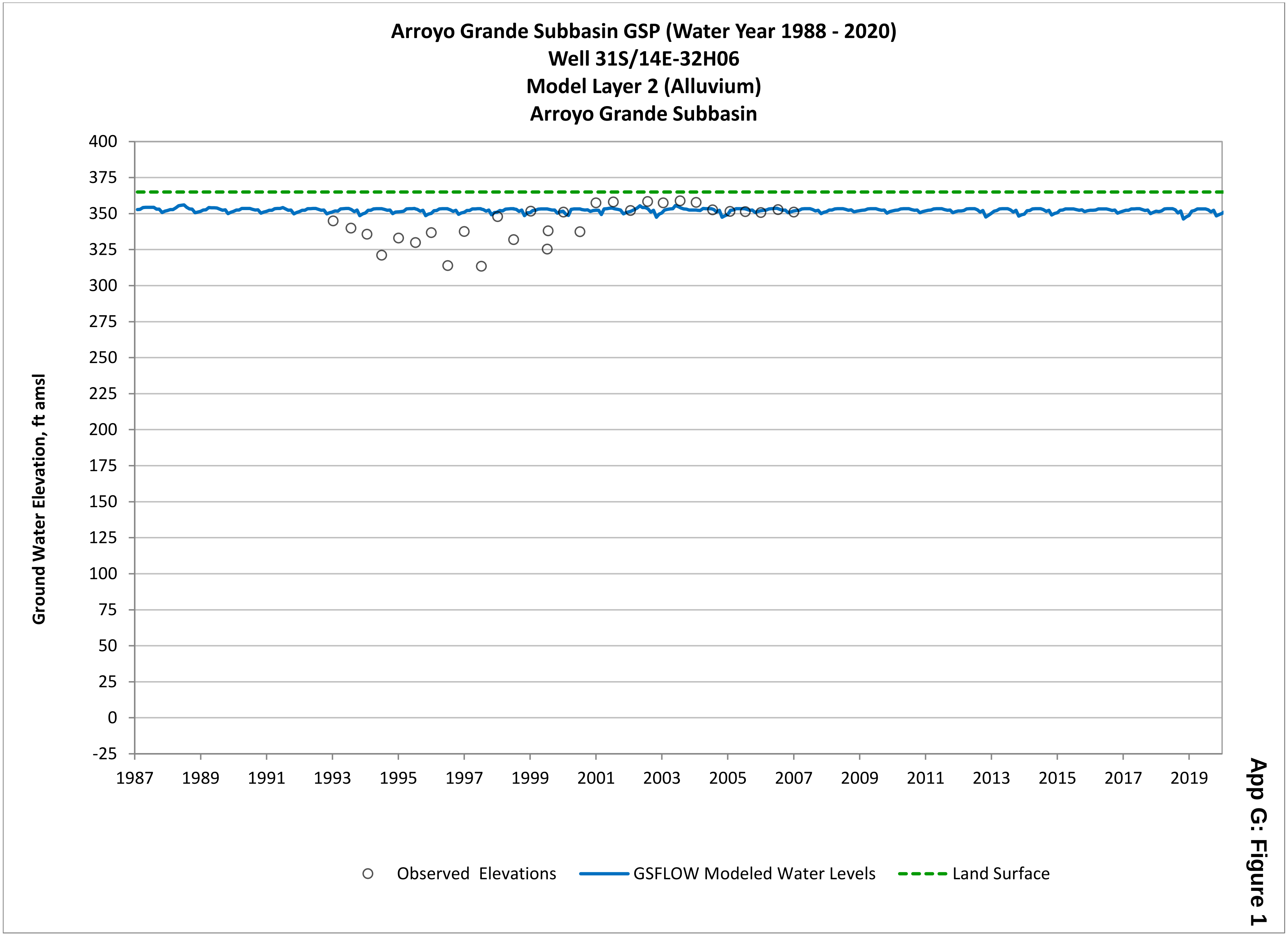
1. Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
2. San Luis Obispo County
3. USGS

Arroyo Grande GSFLOW Groundwater Model

Calibration Well Locations

Arroyo Grande GSP

Appendix Figure 1



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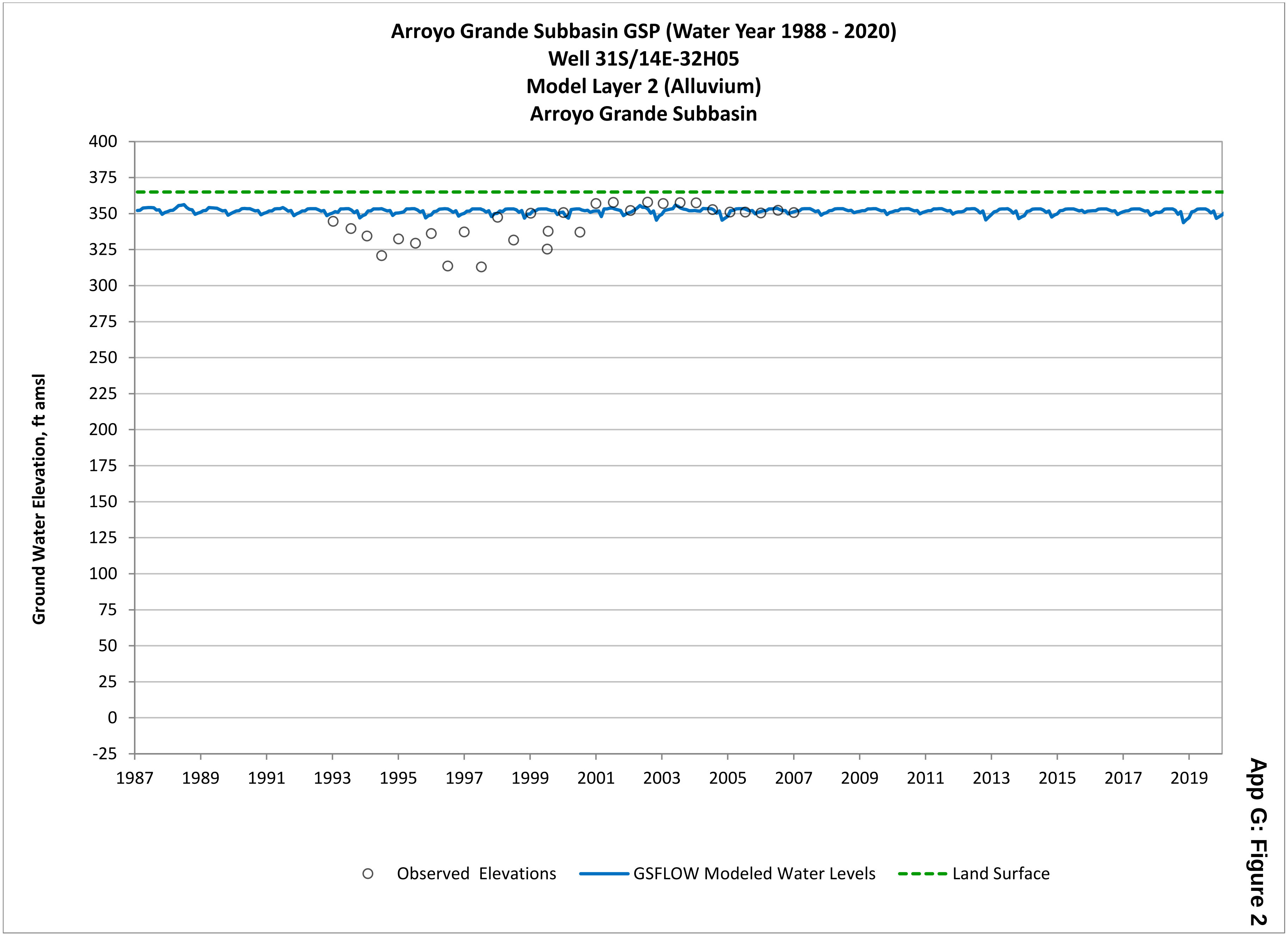

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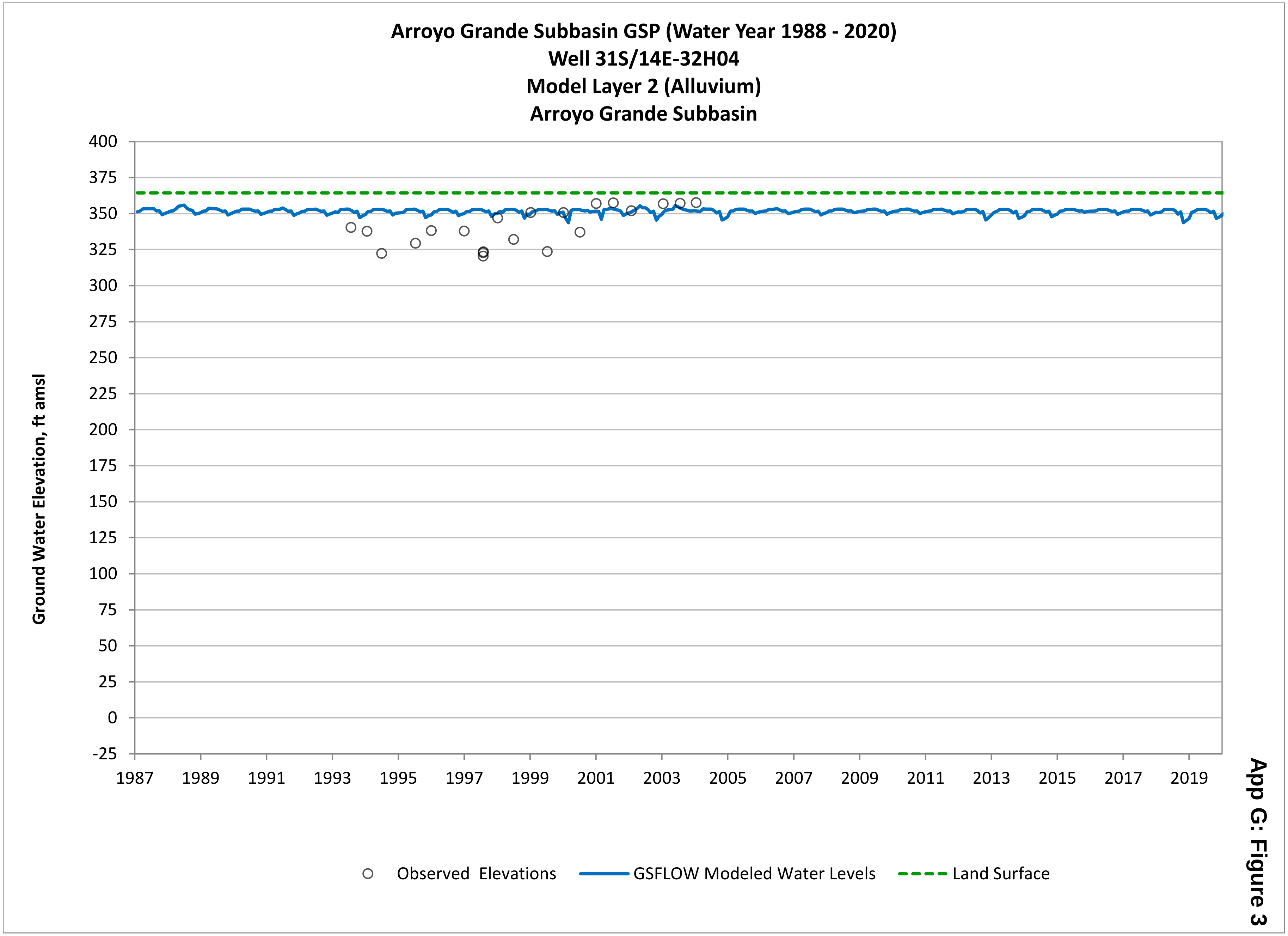

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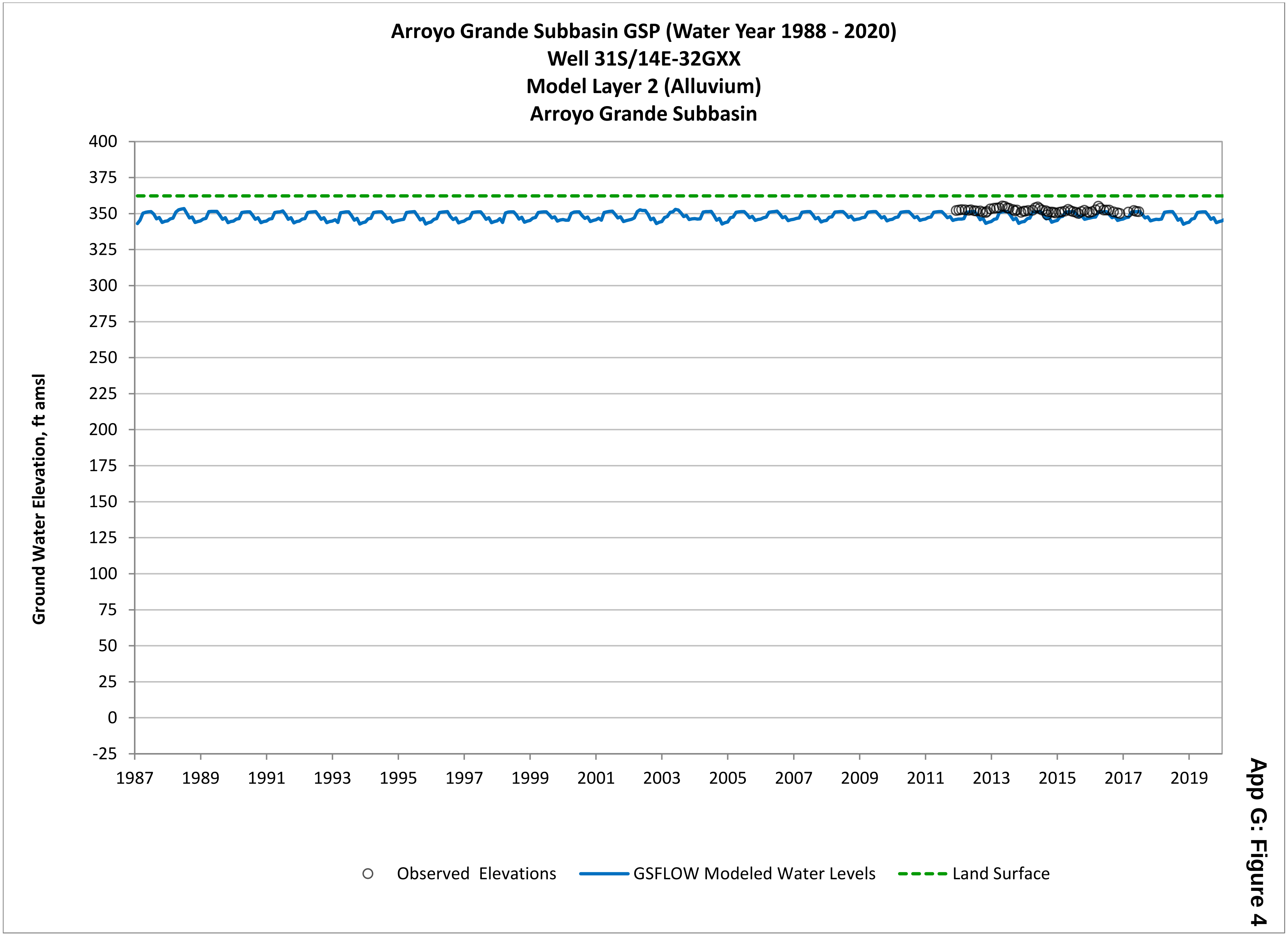

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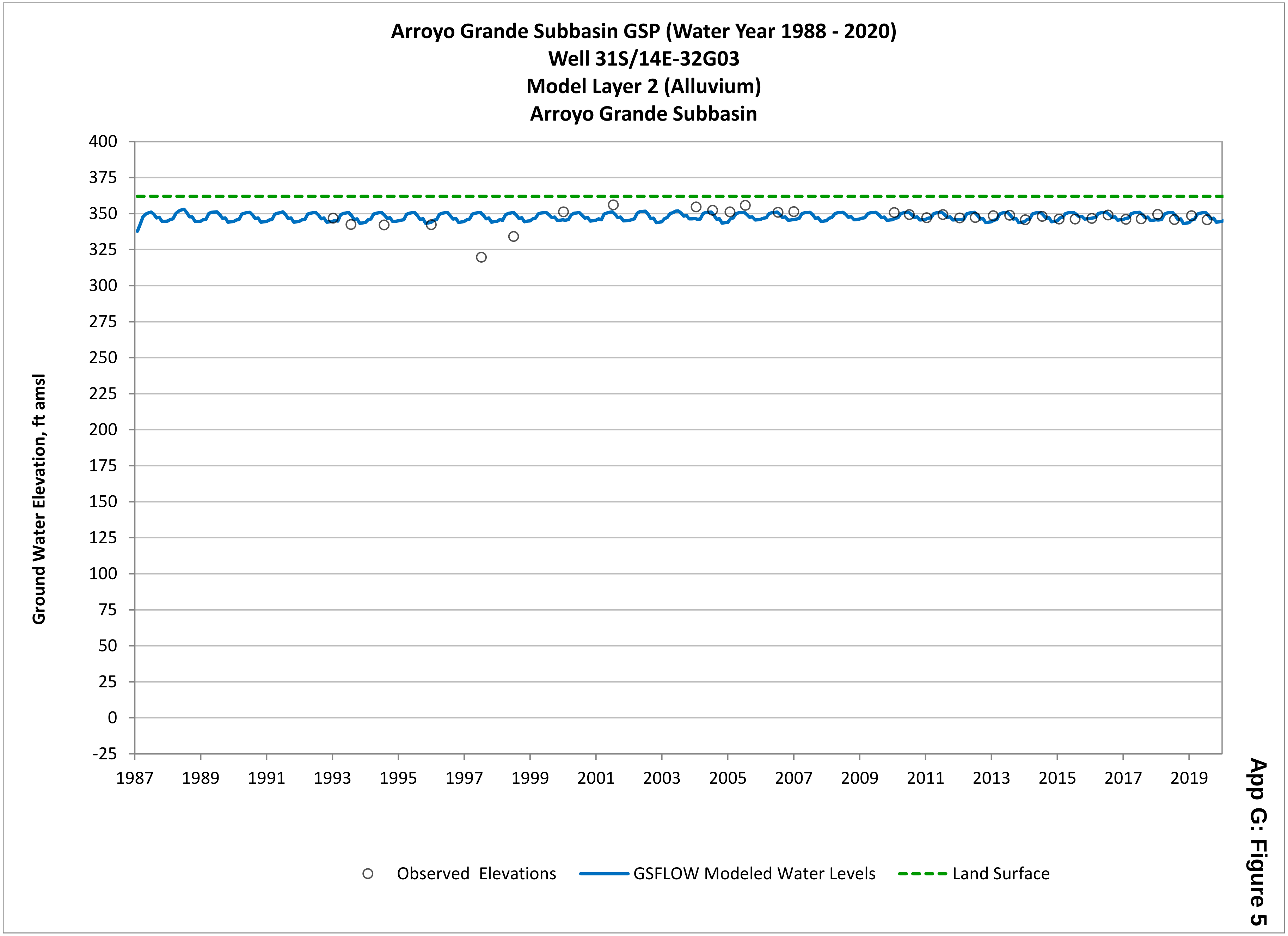

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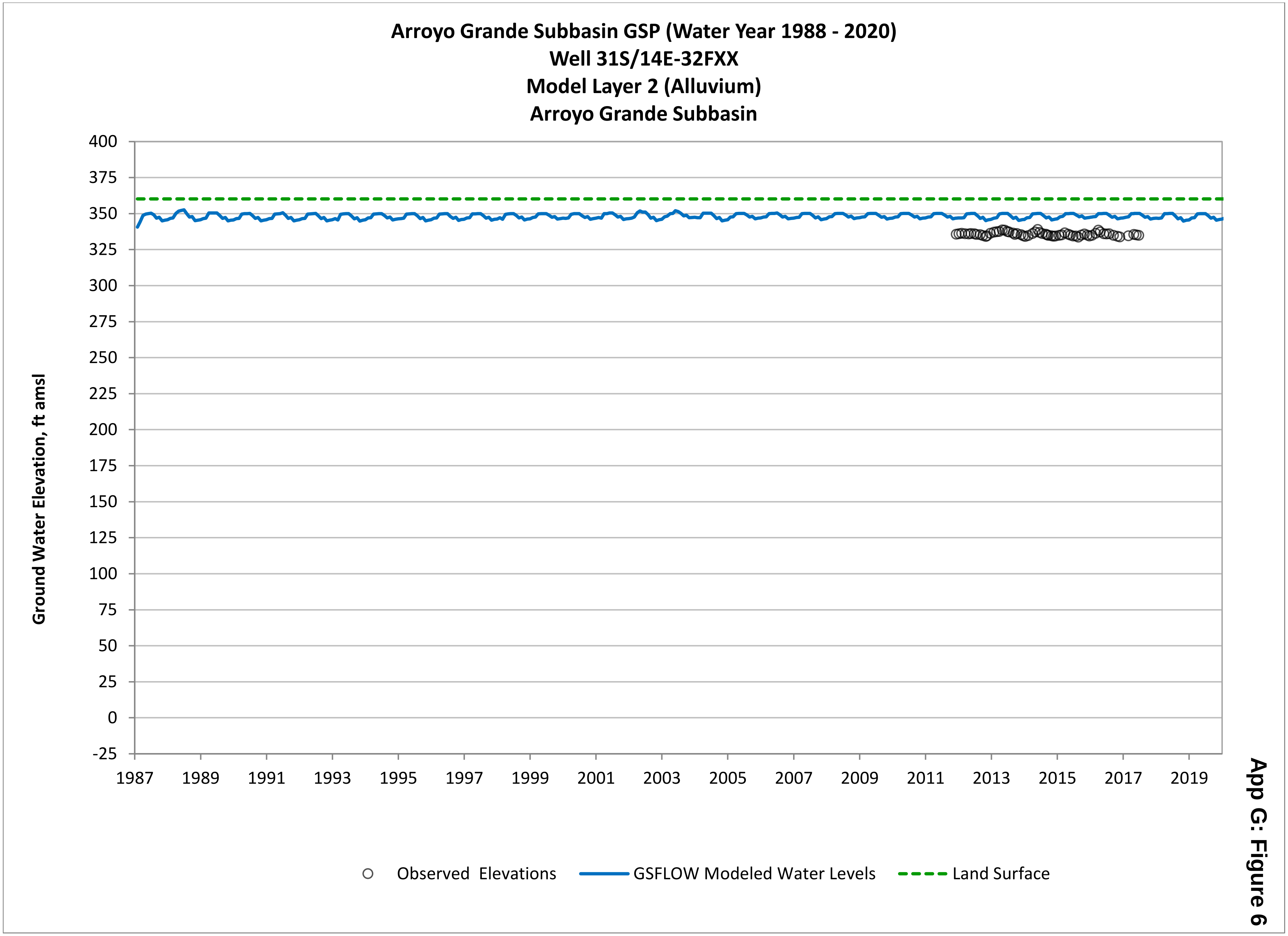

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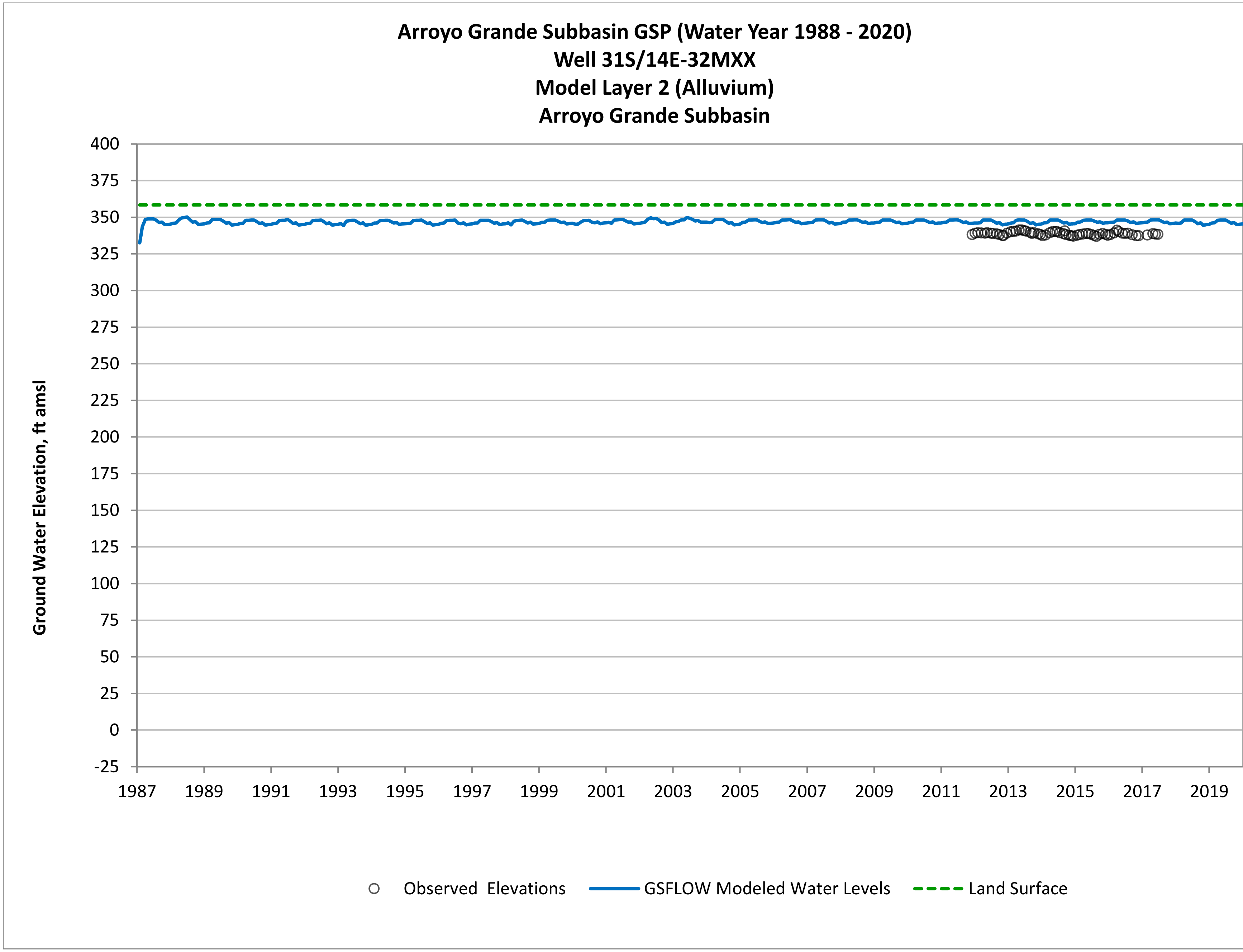

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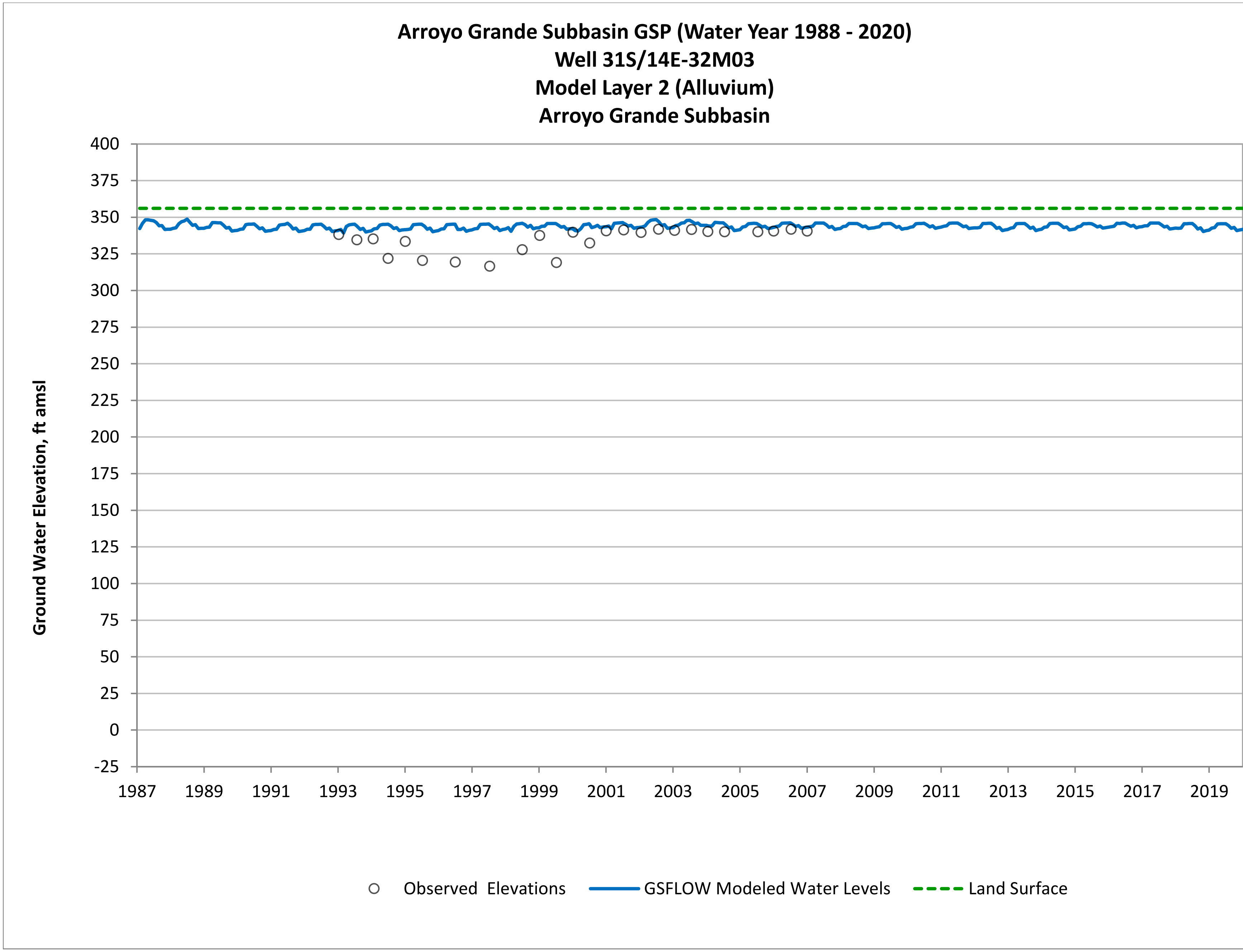

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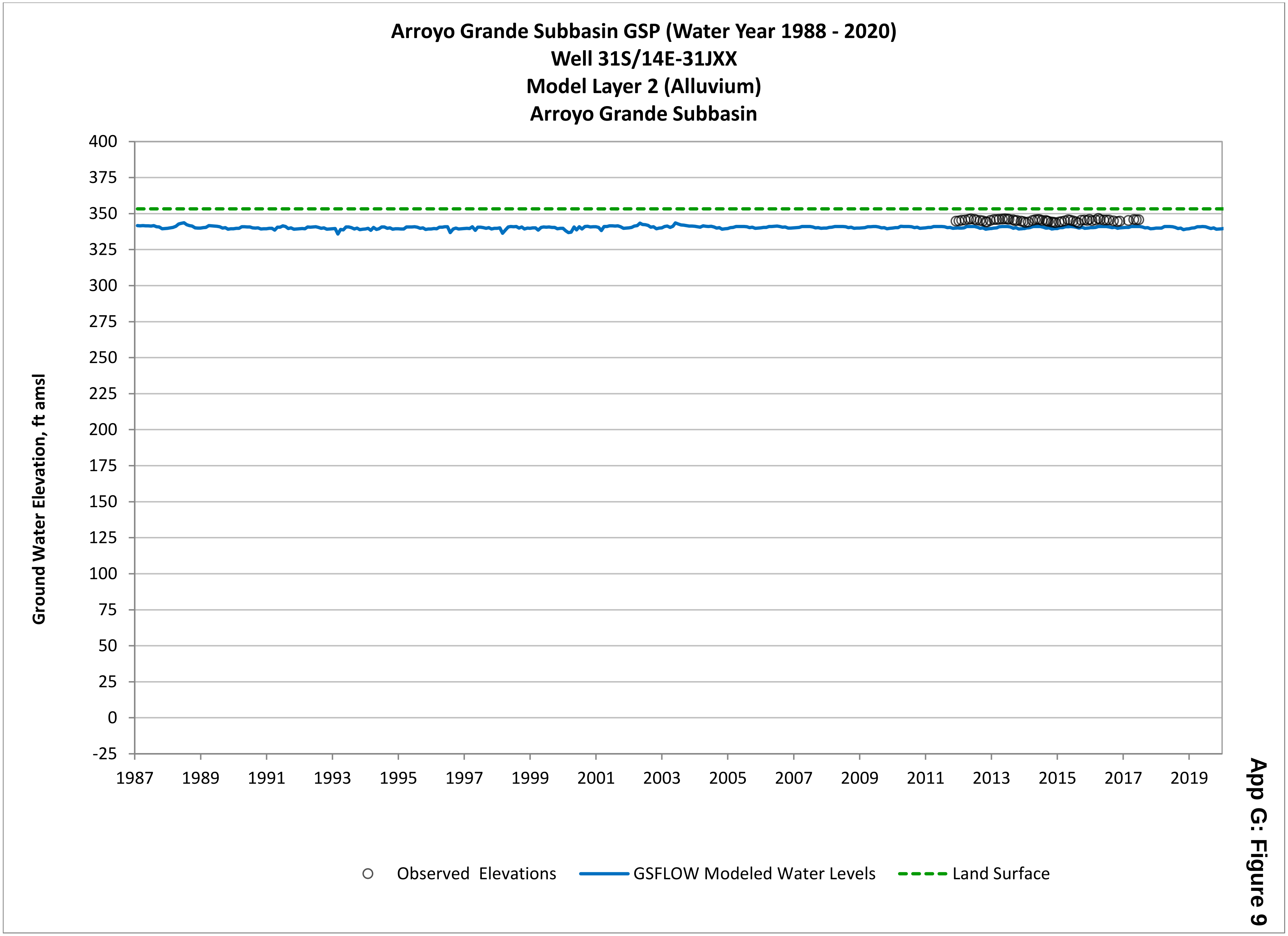

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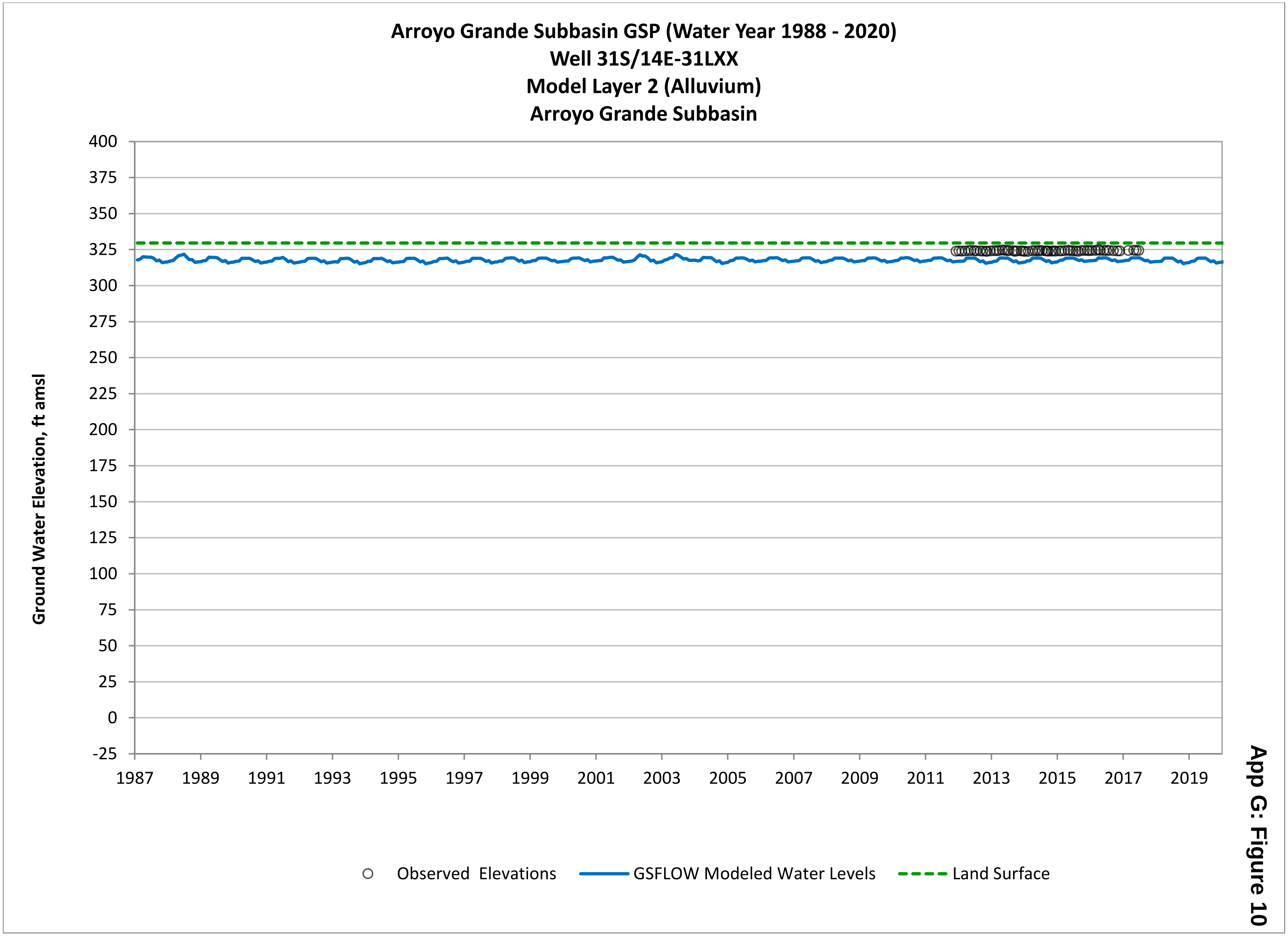

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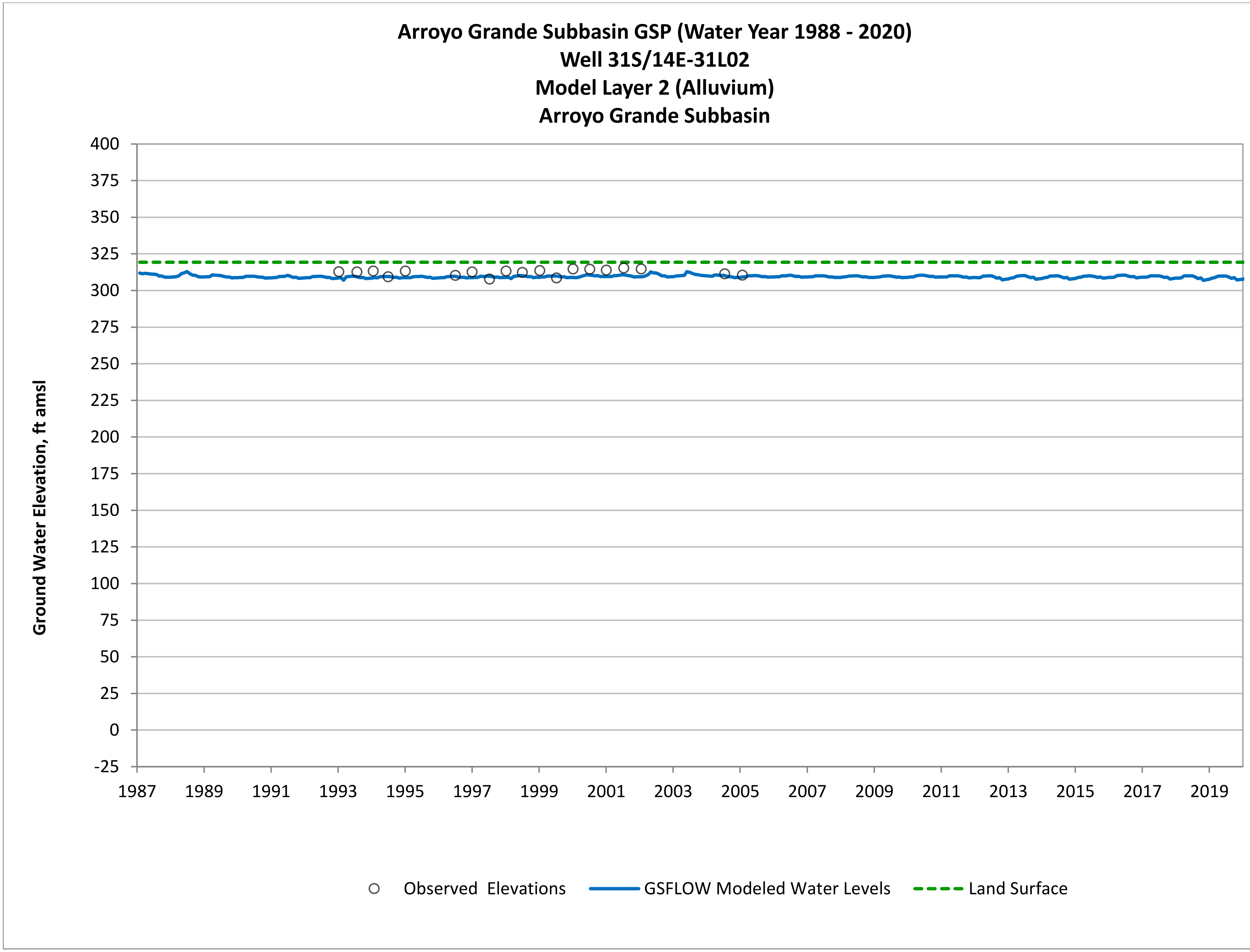

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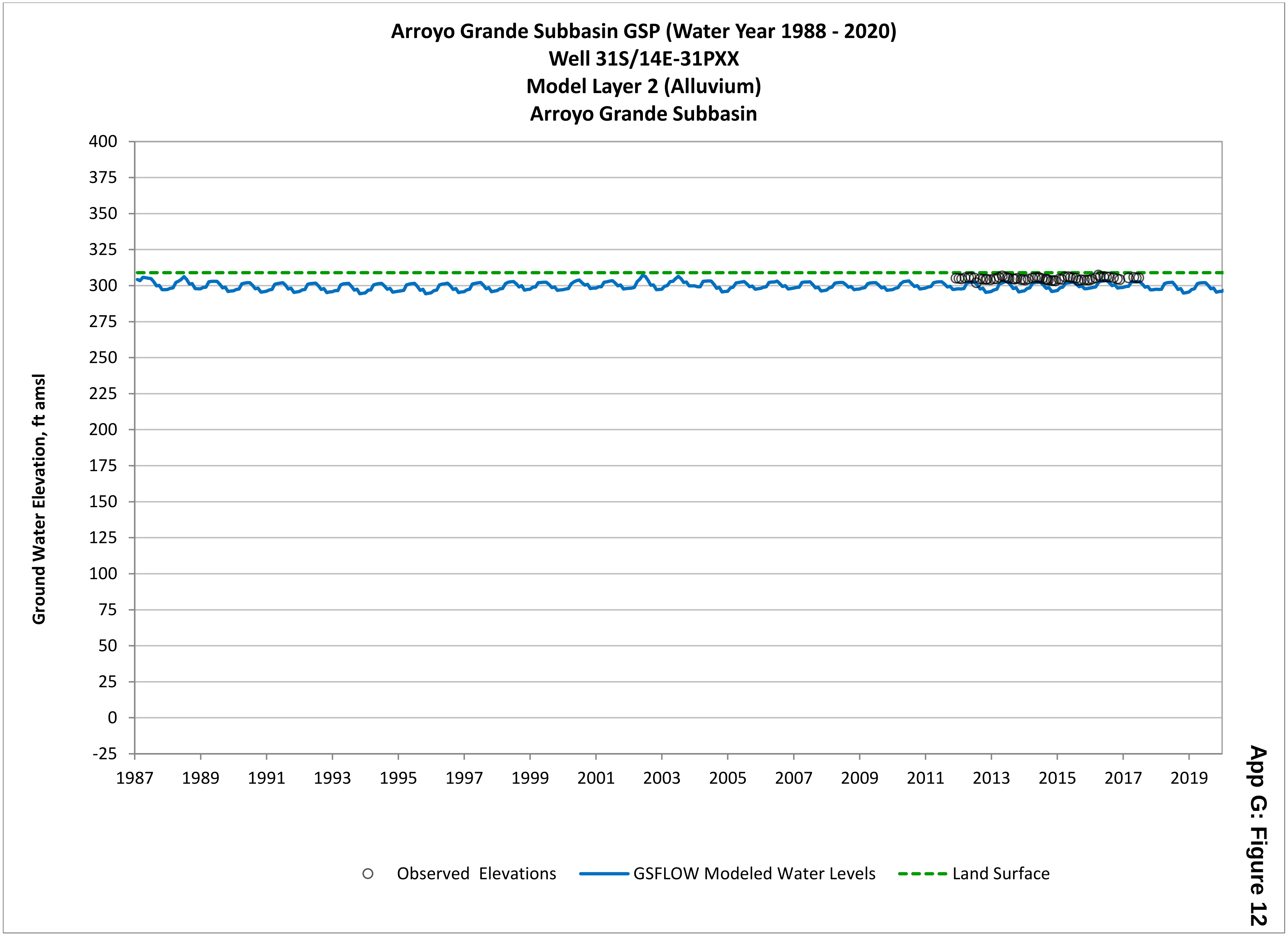

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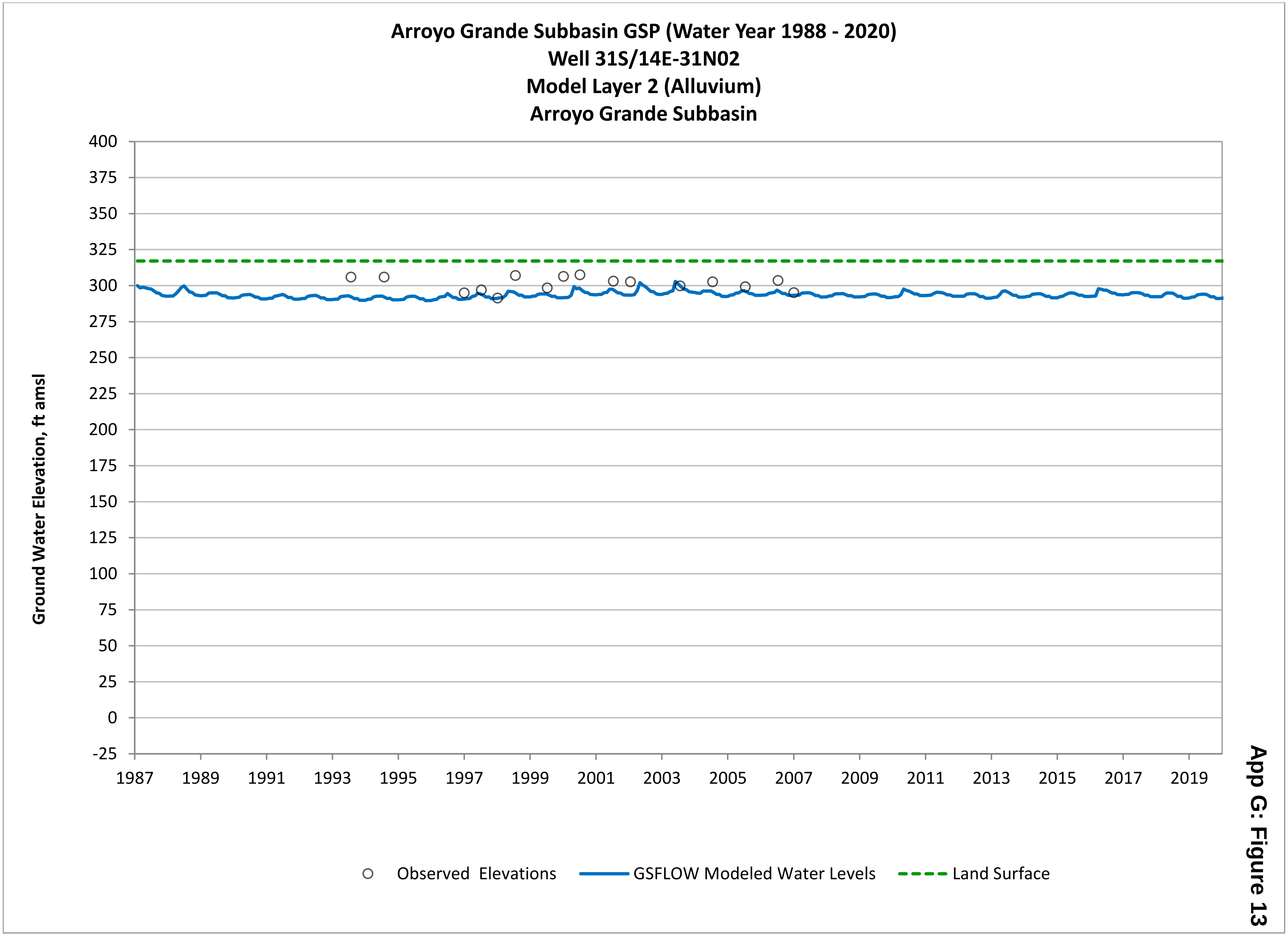

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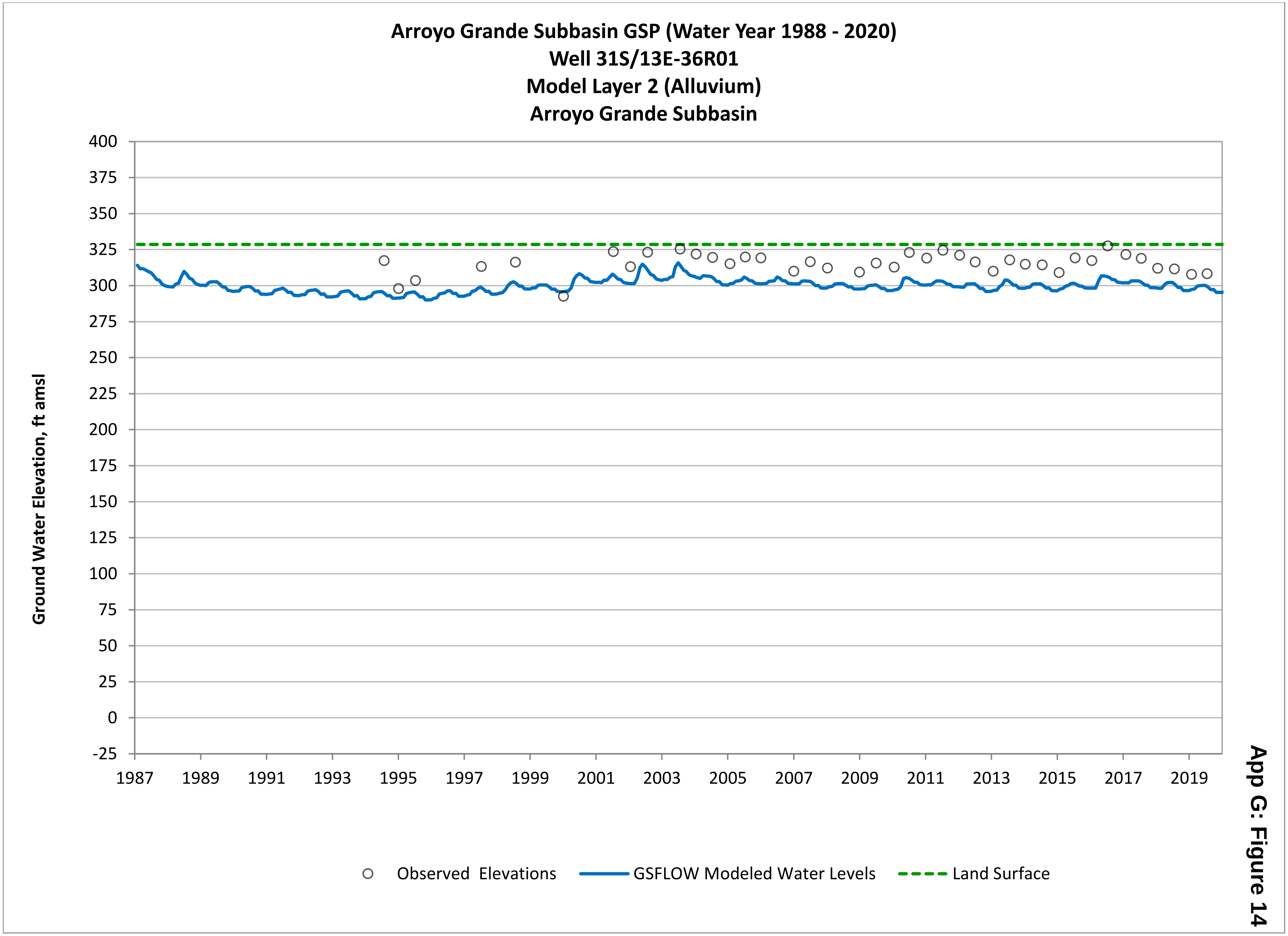

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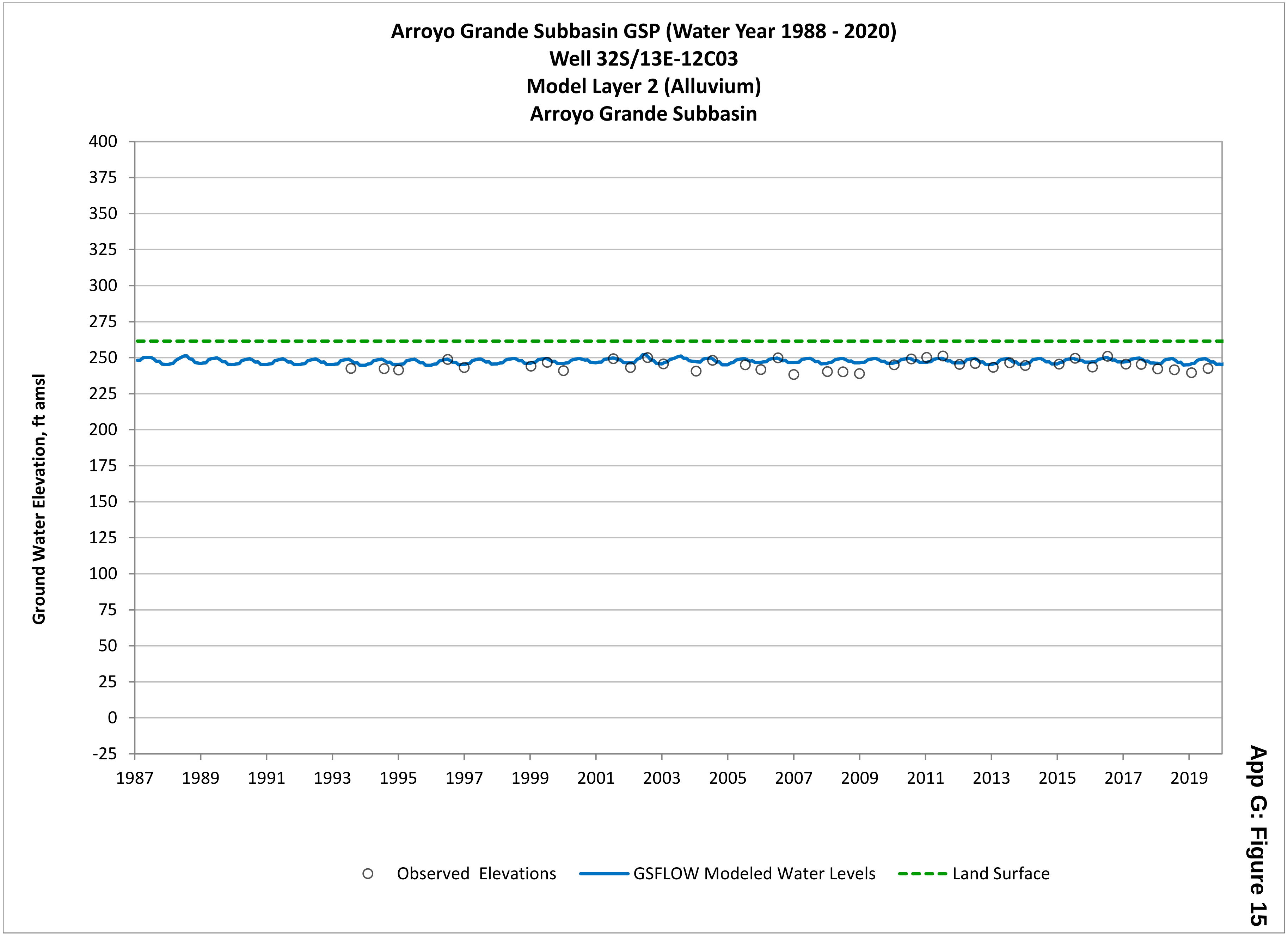

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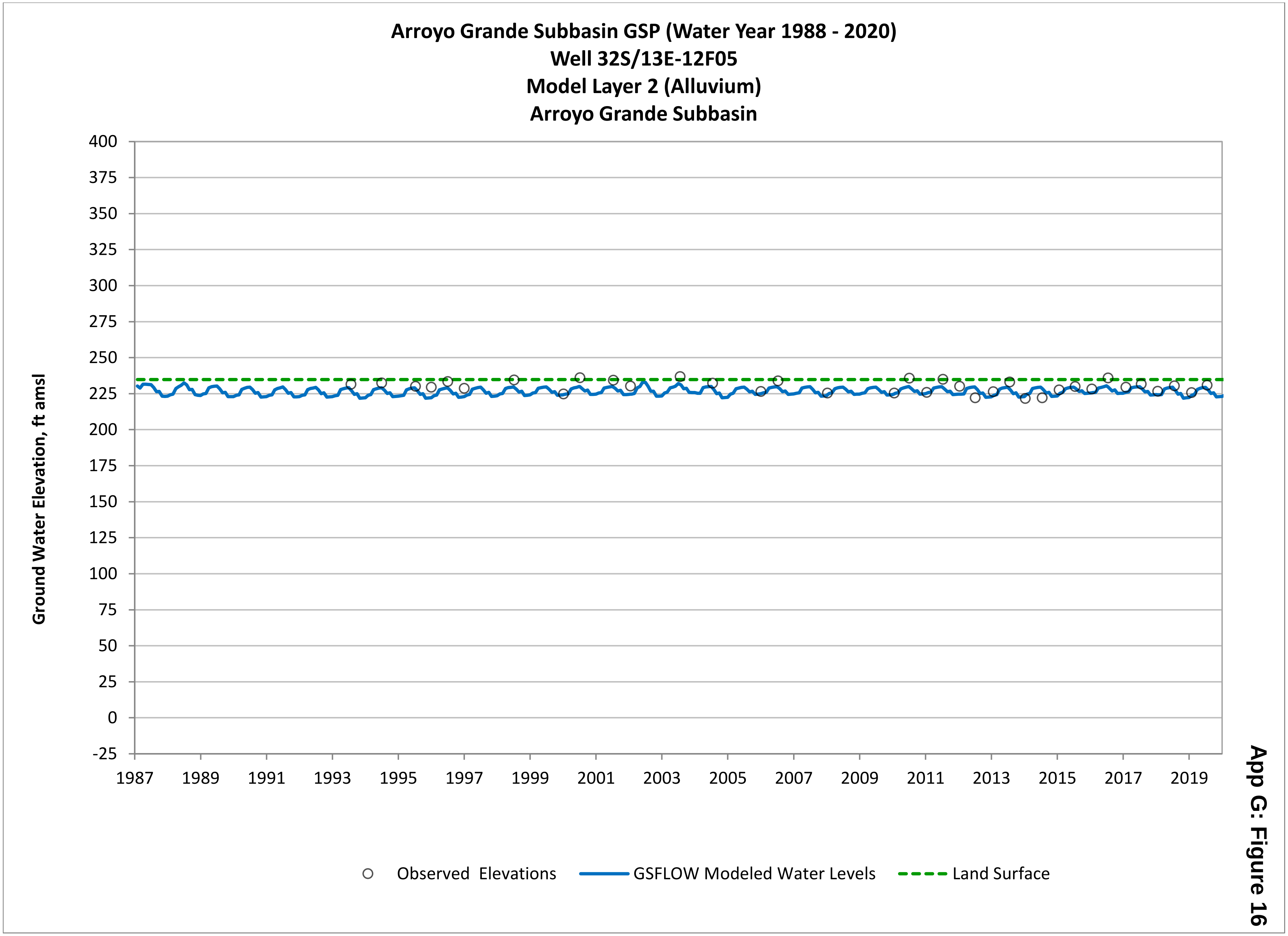

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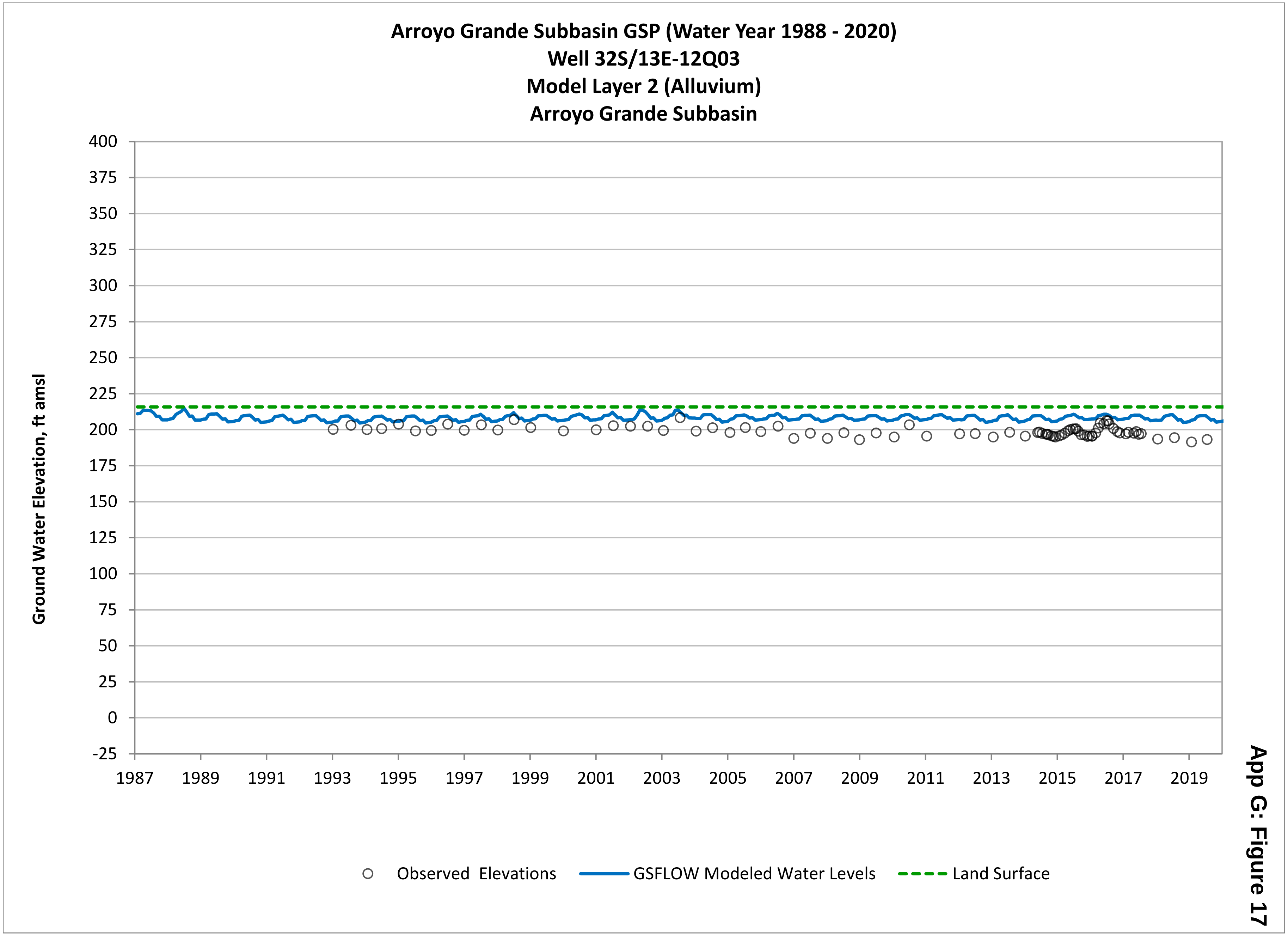

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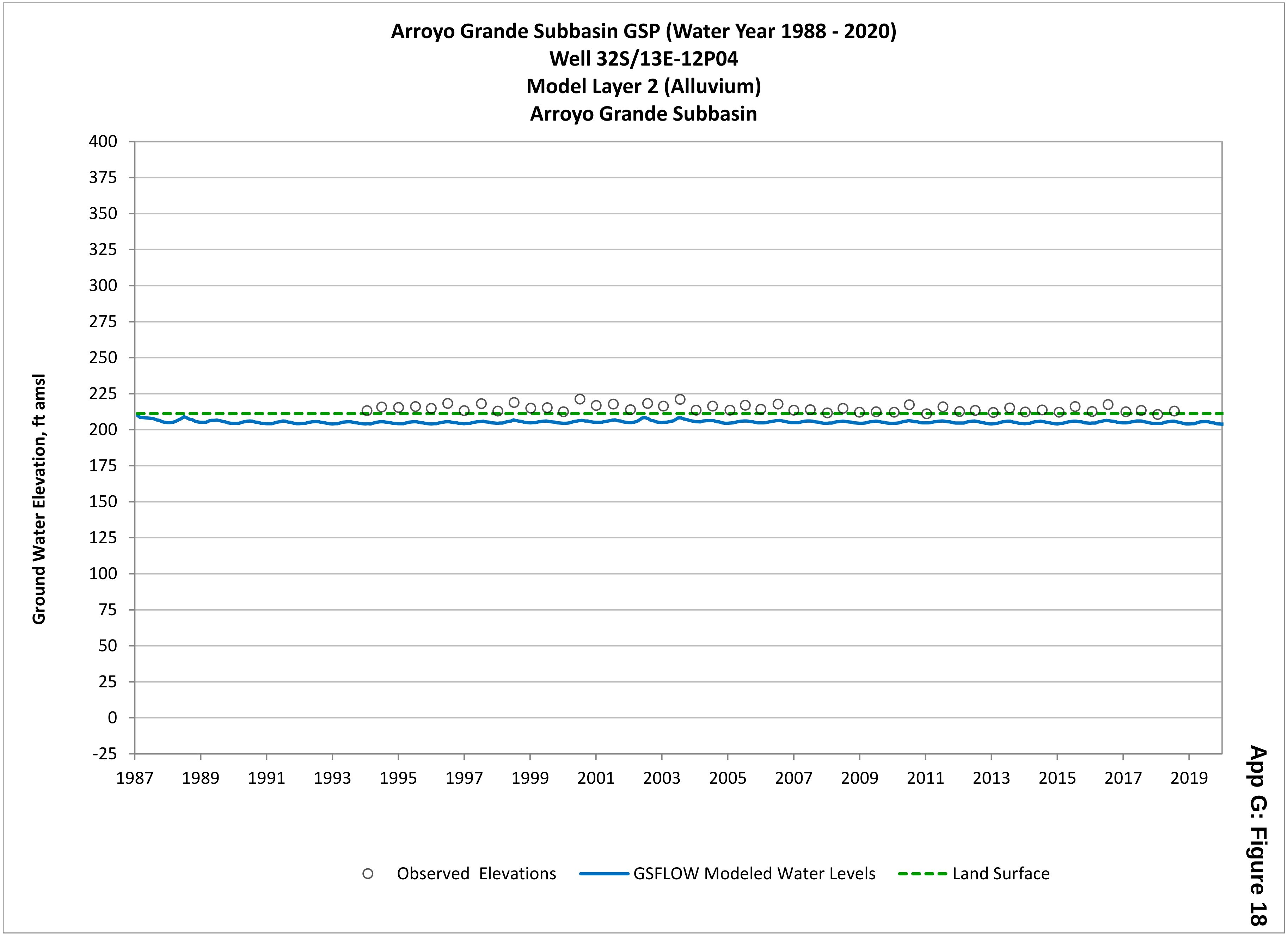

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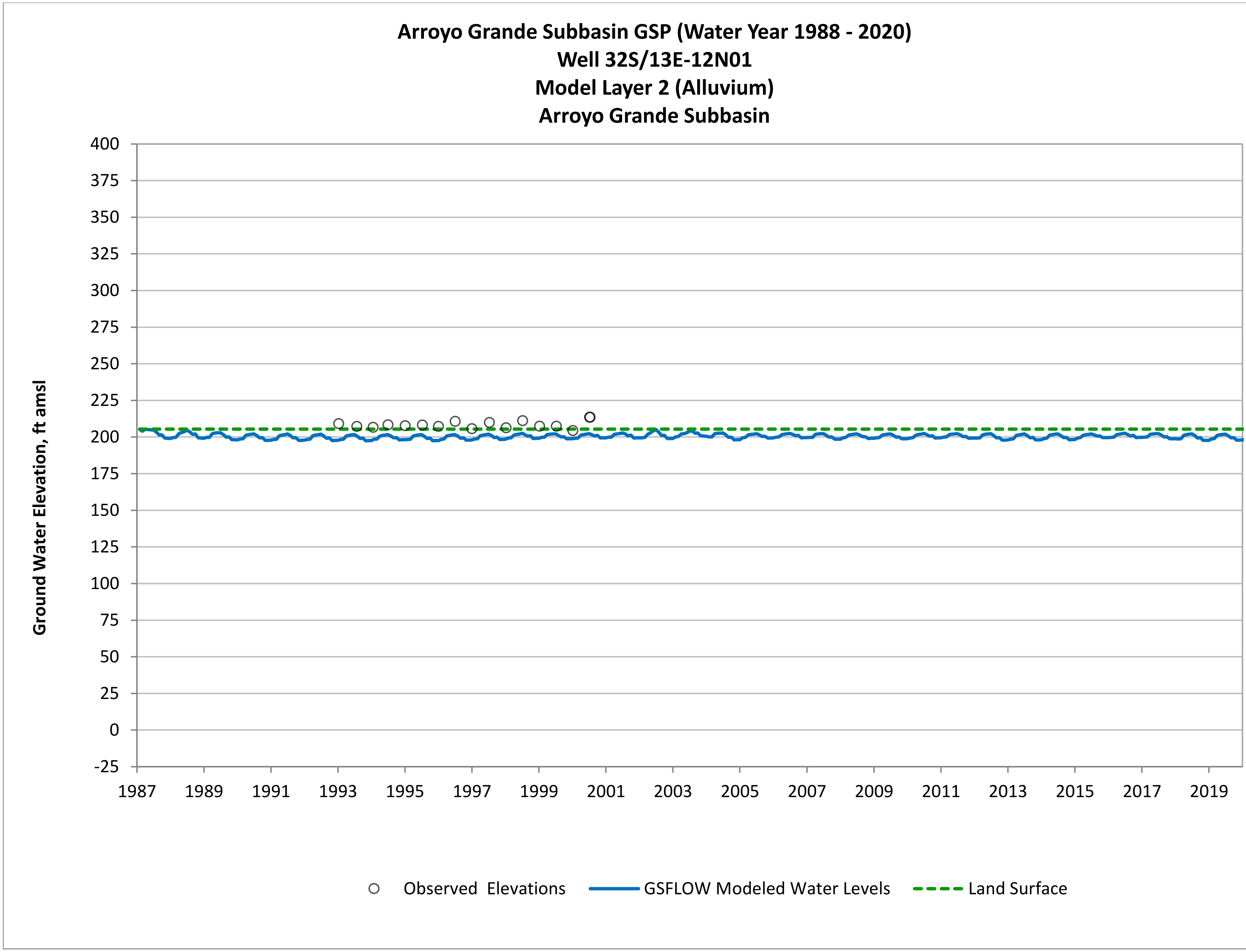

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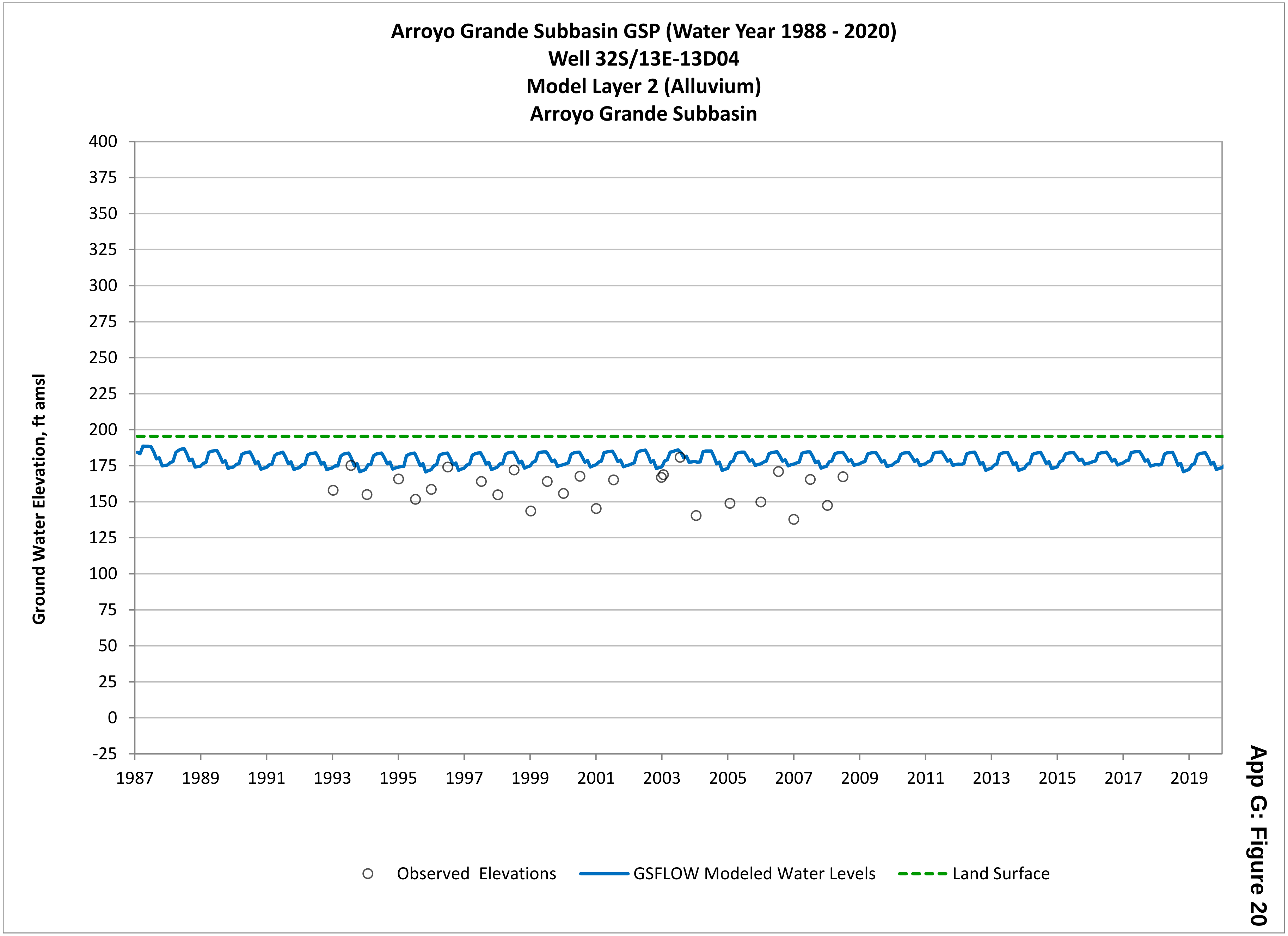

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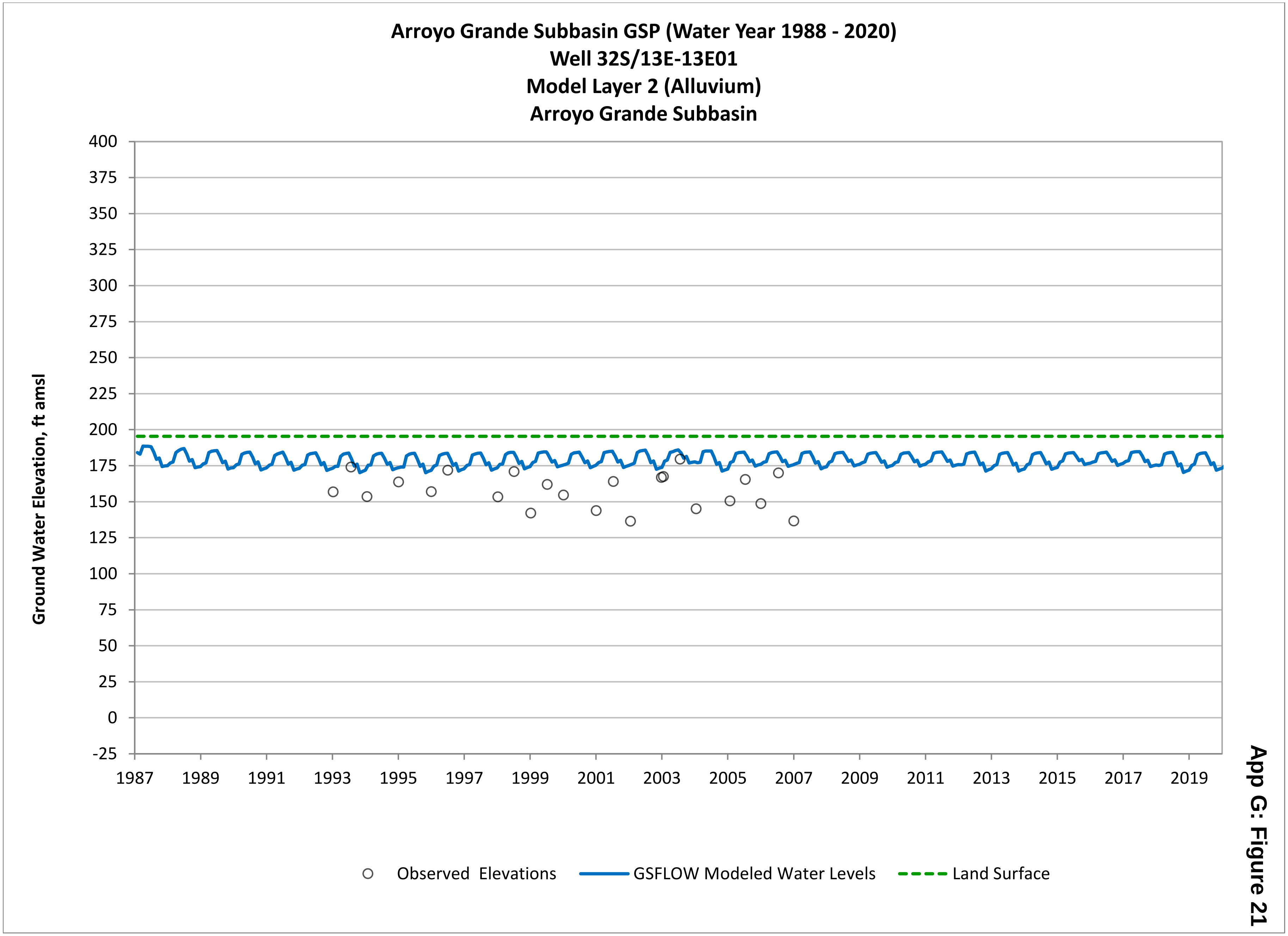

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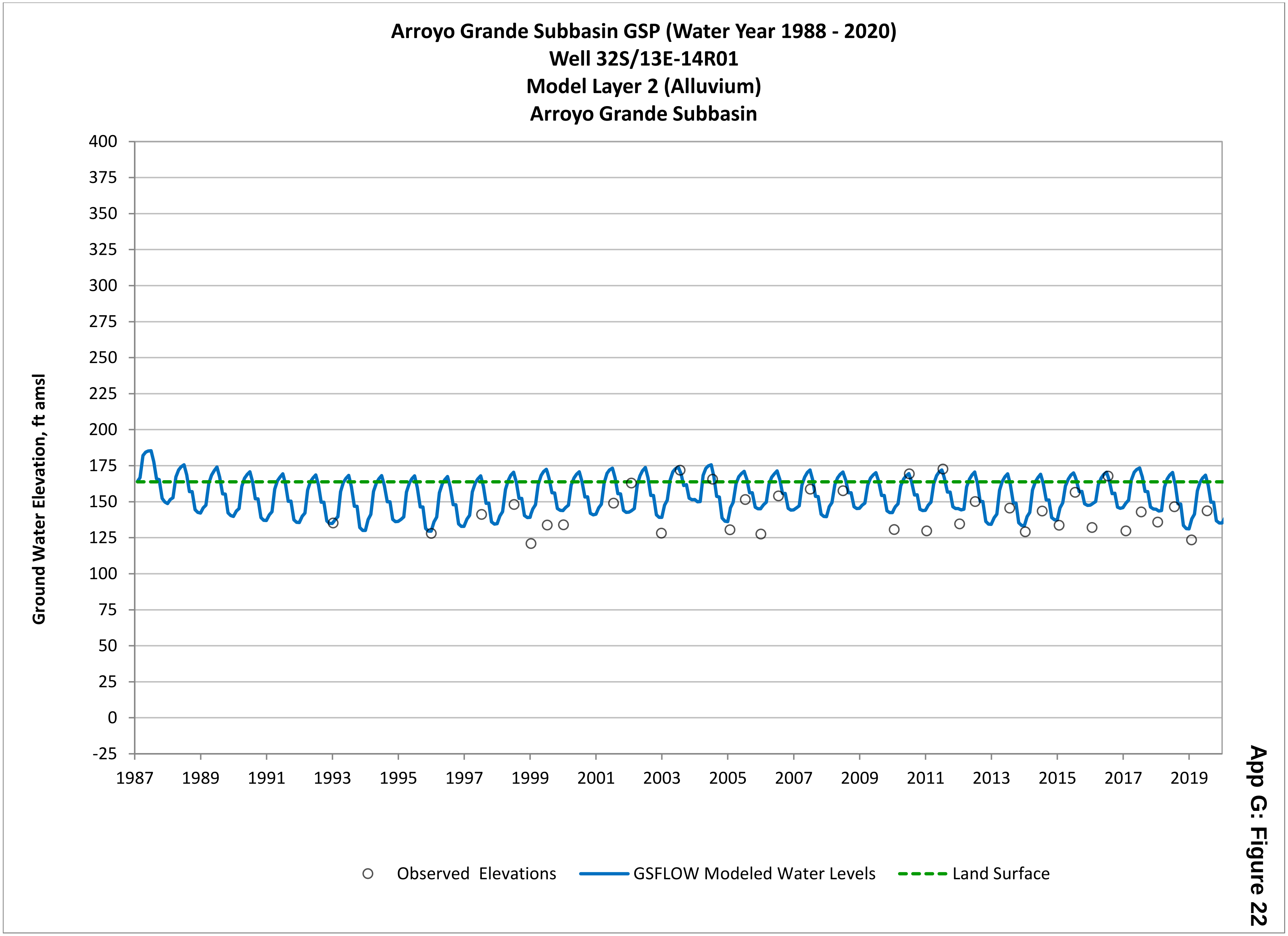

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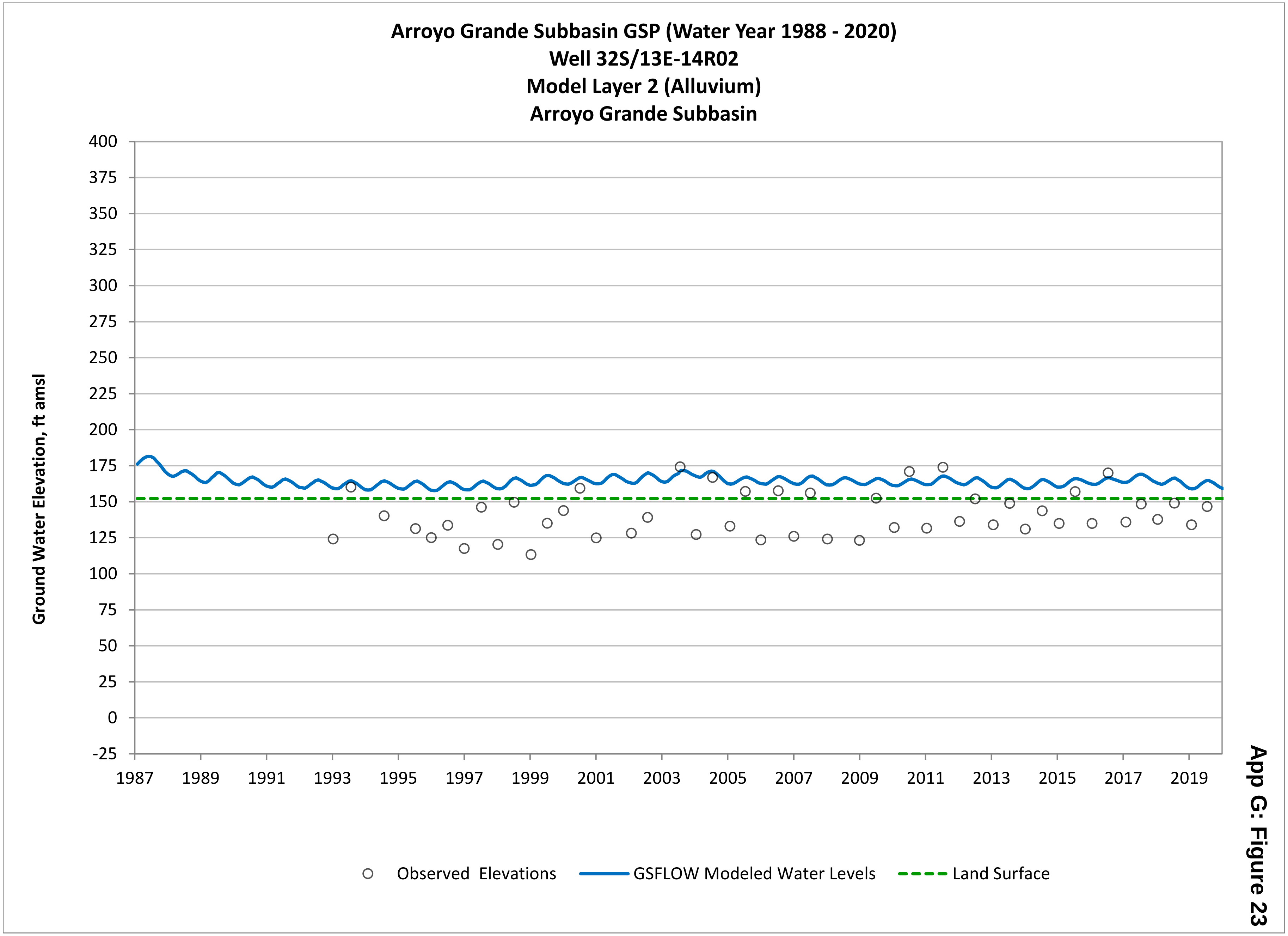

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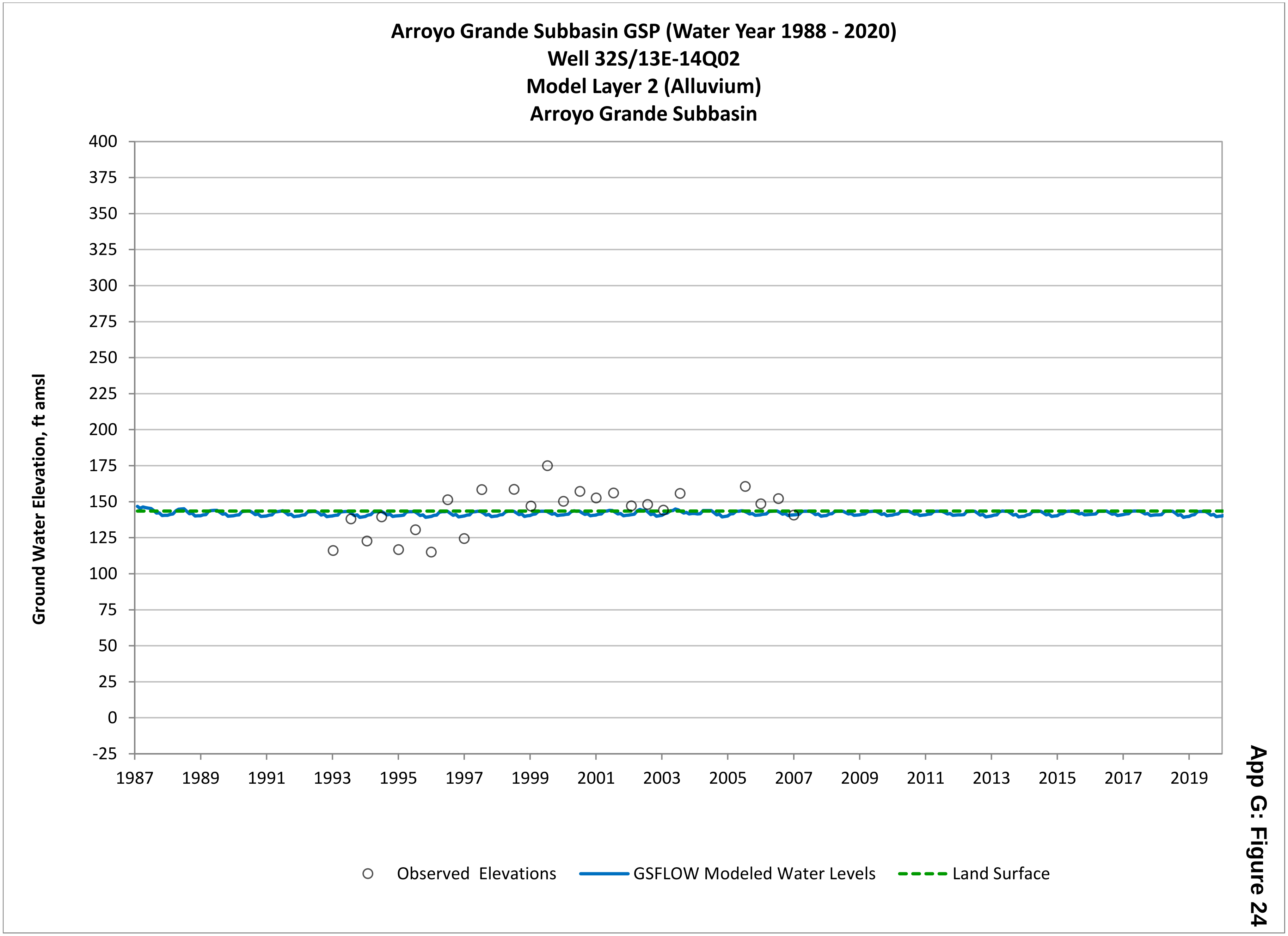

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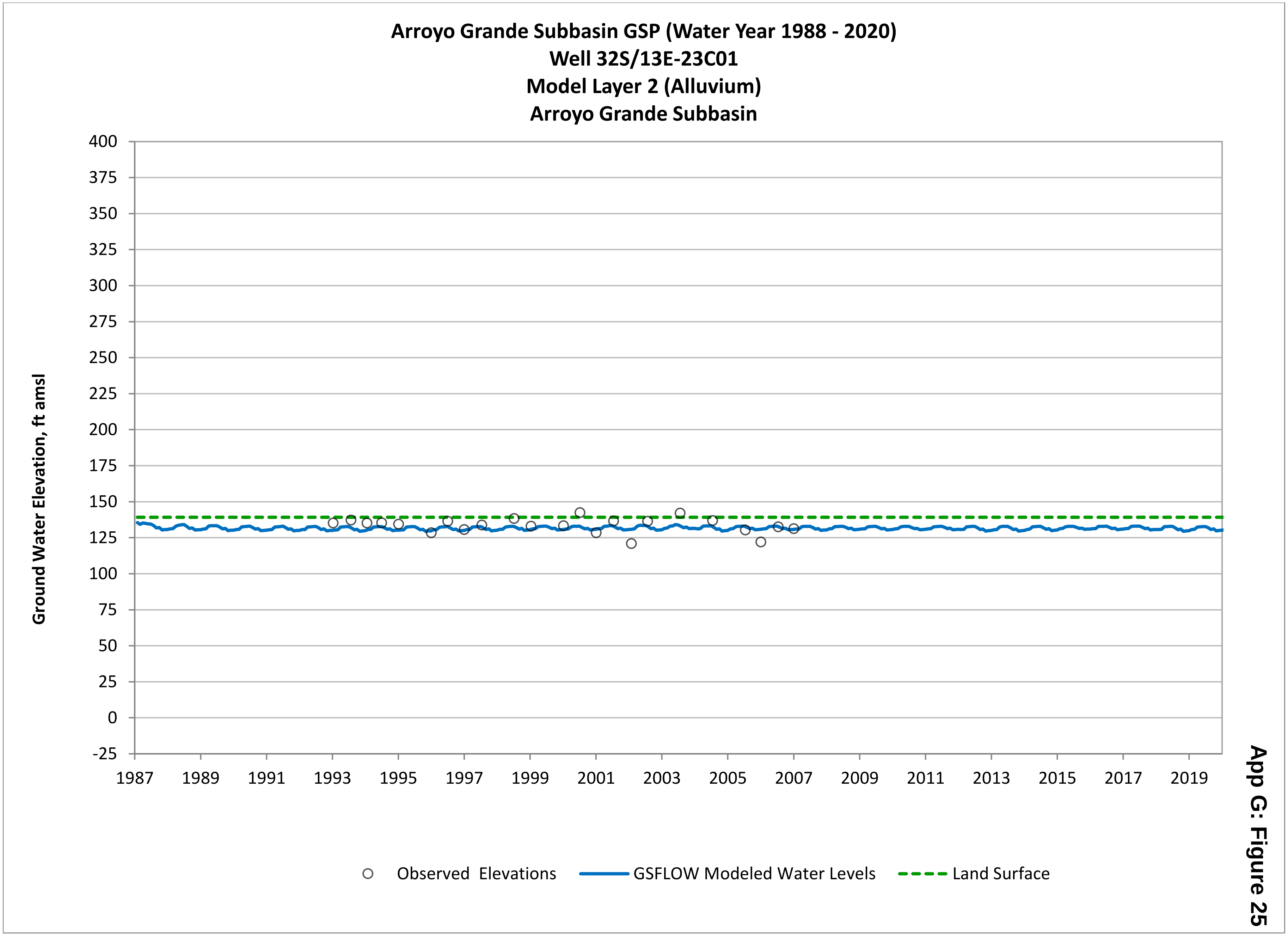

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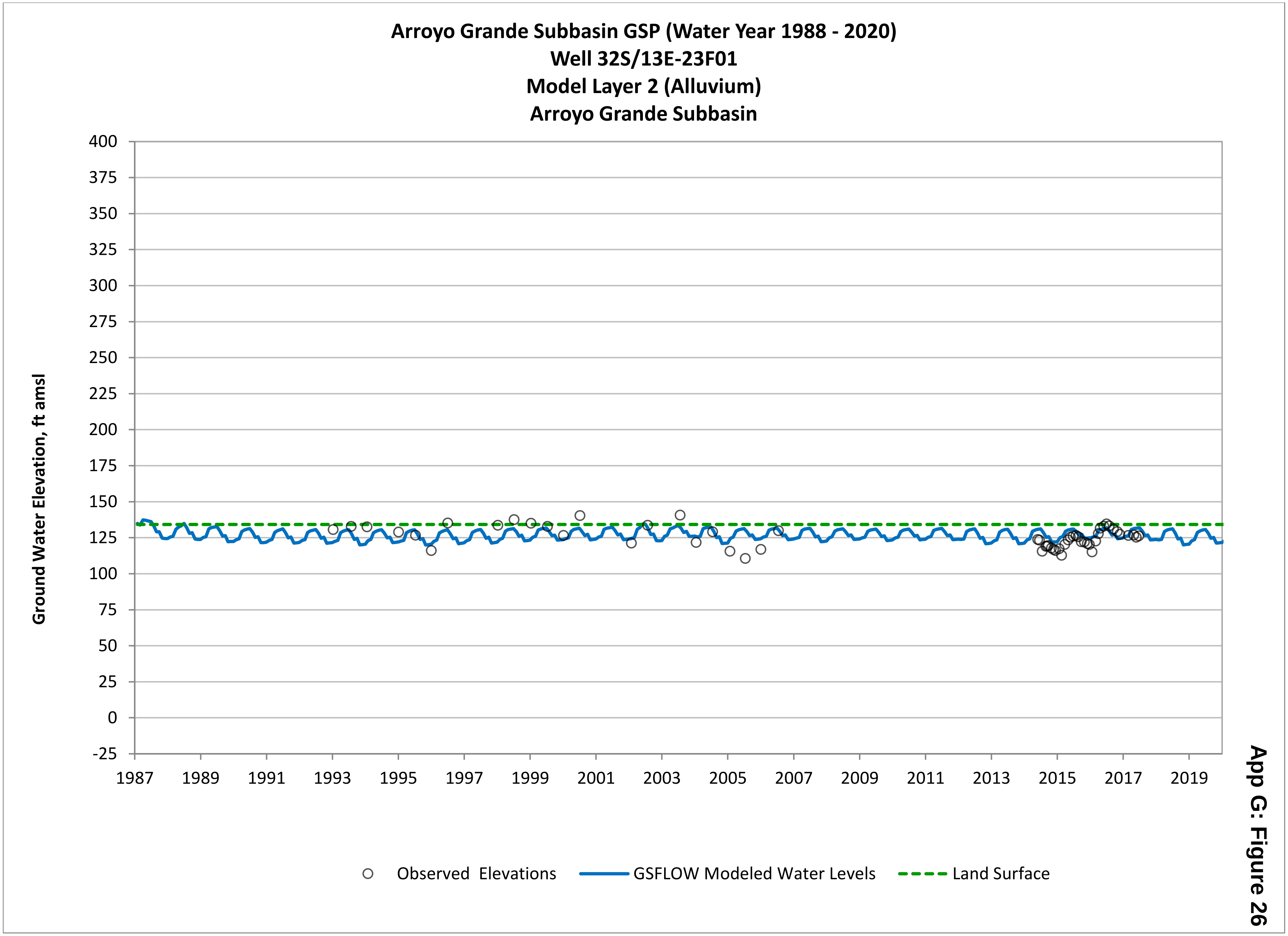

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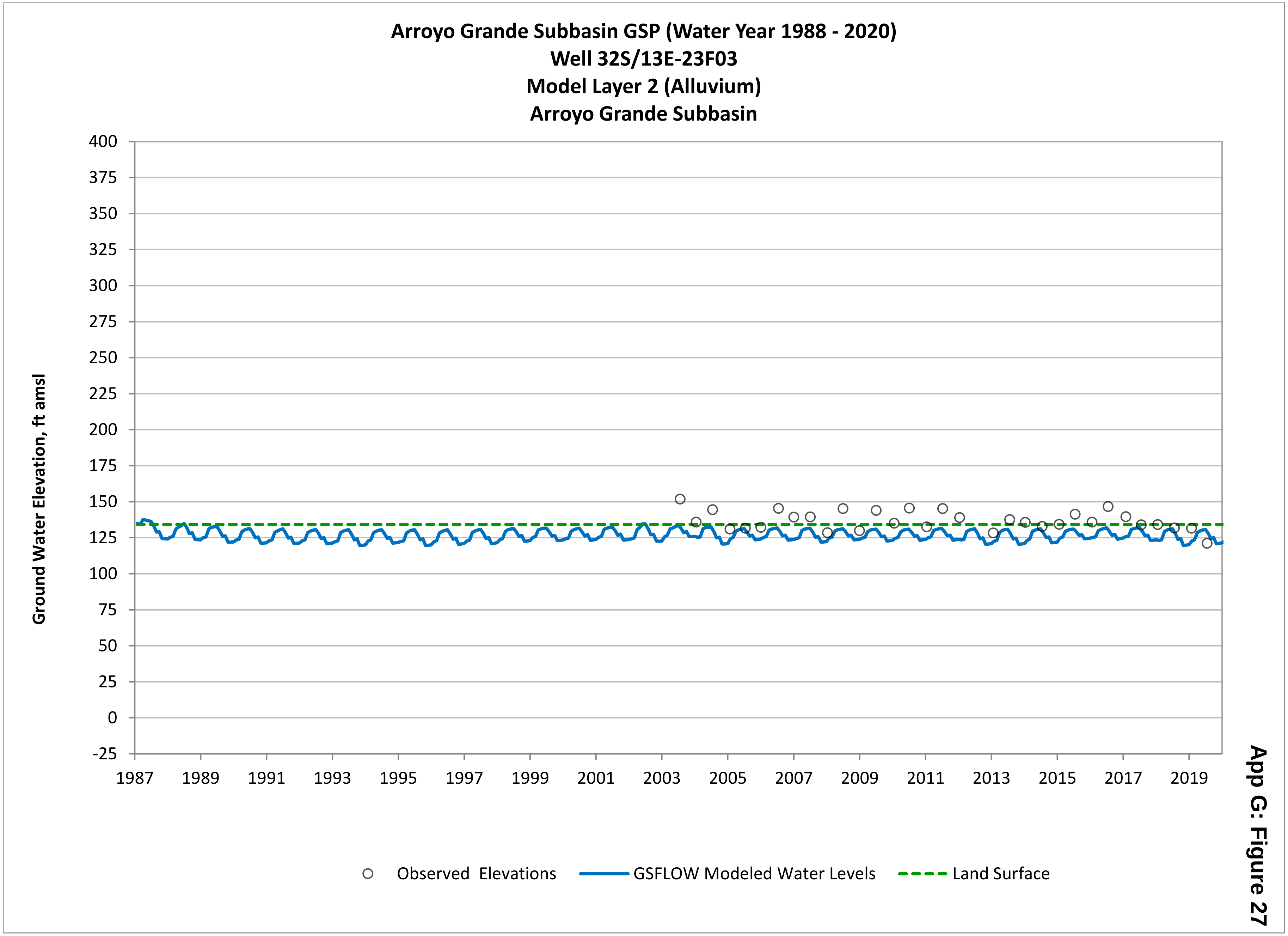

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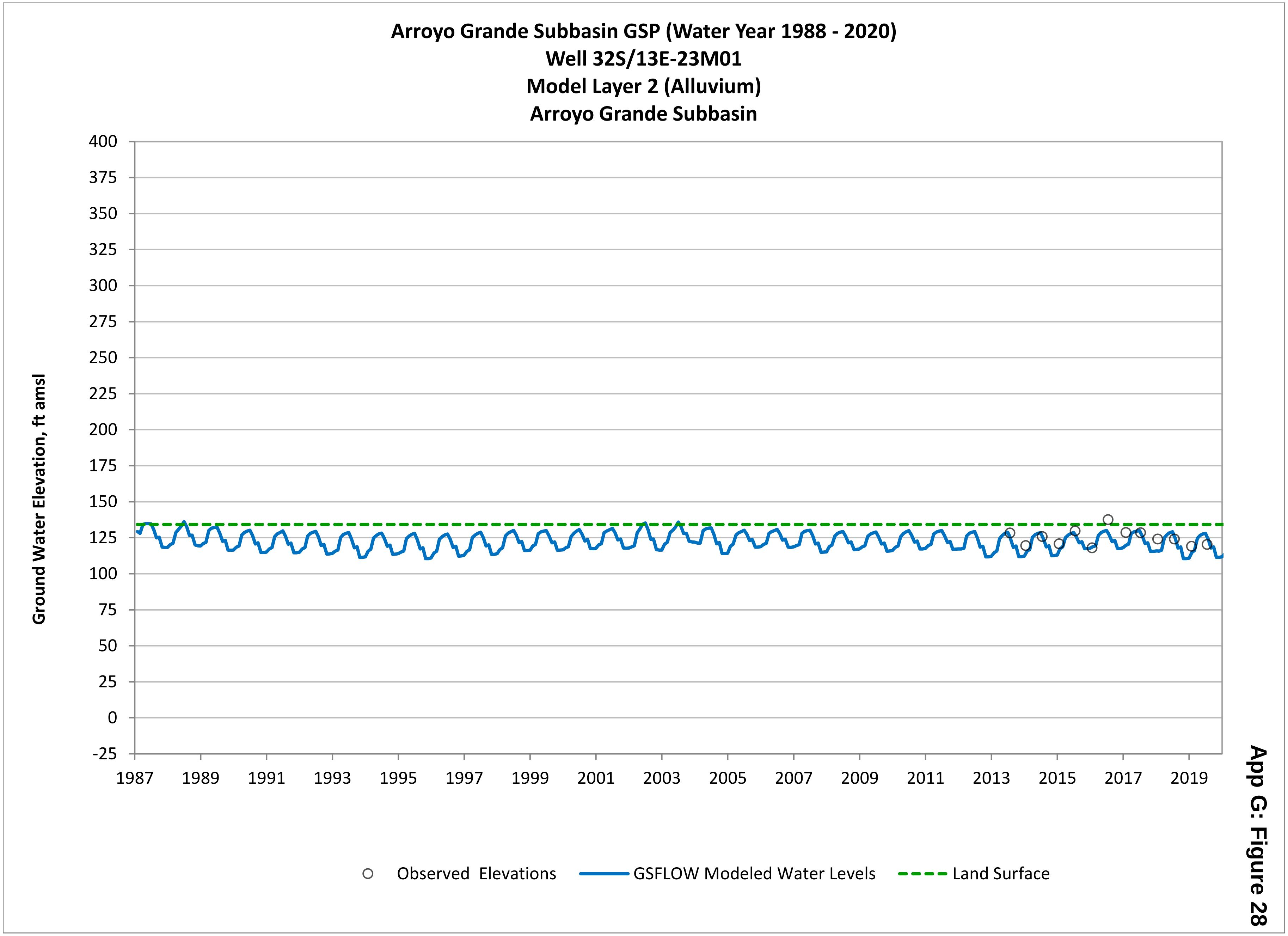

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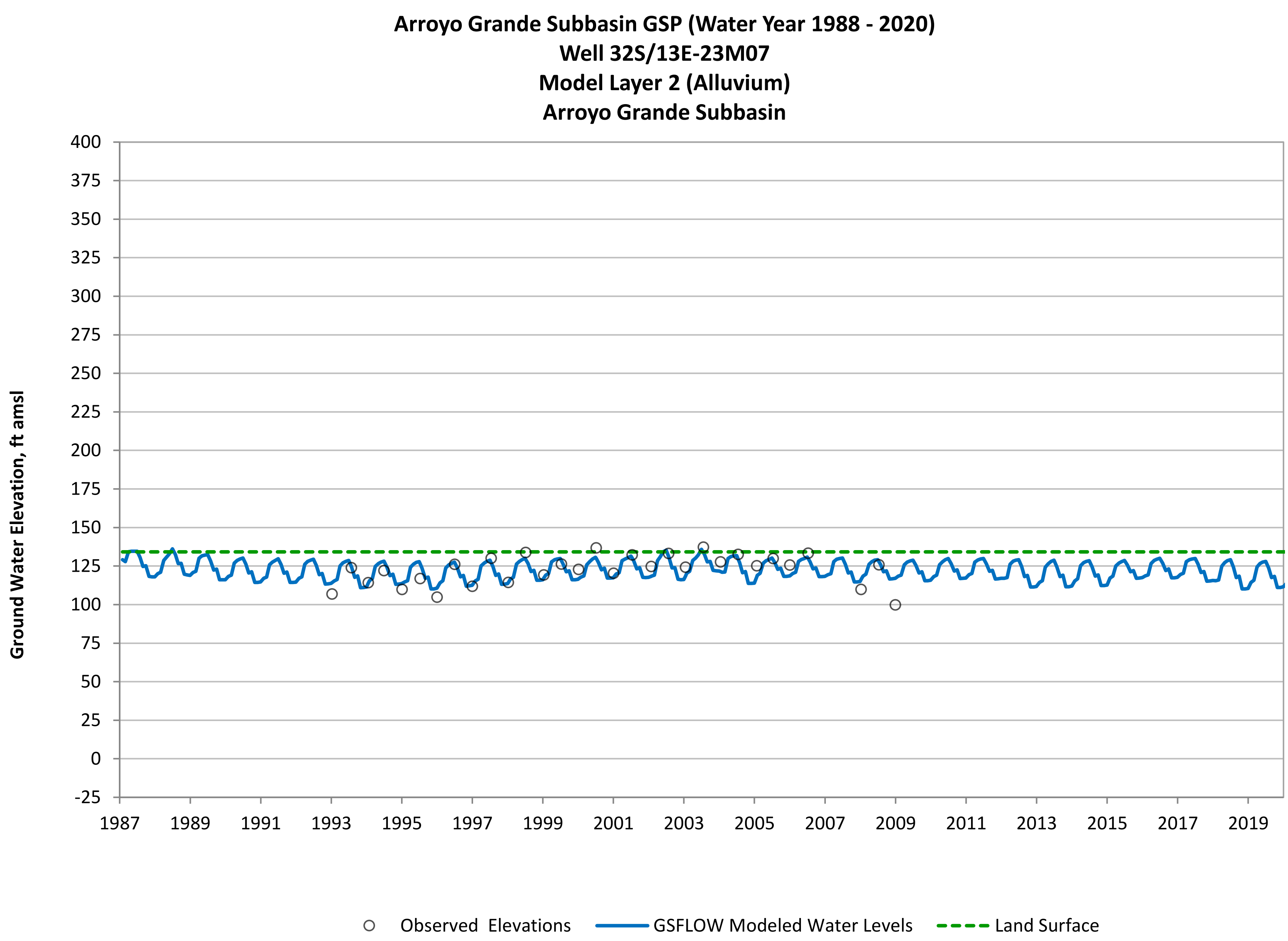

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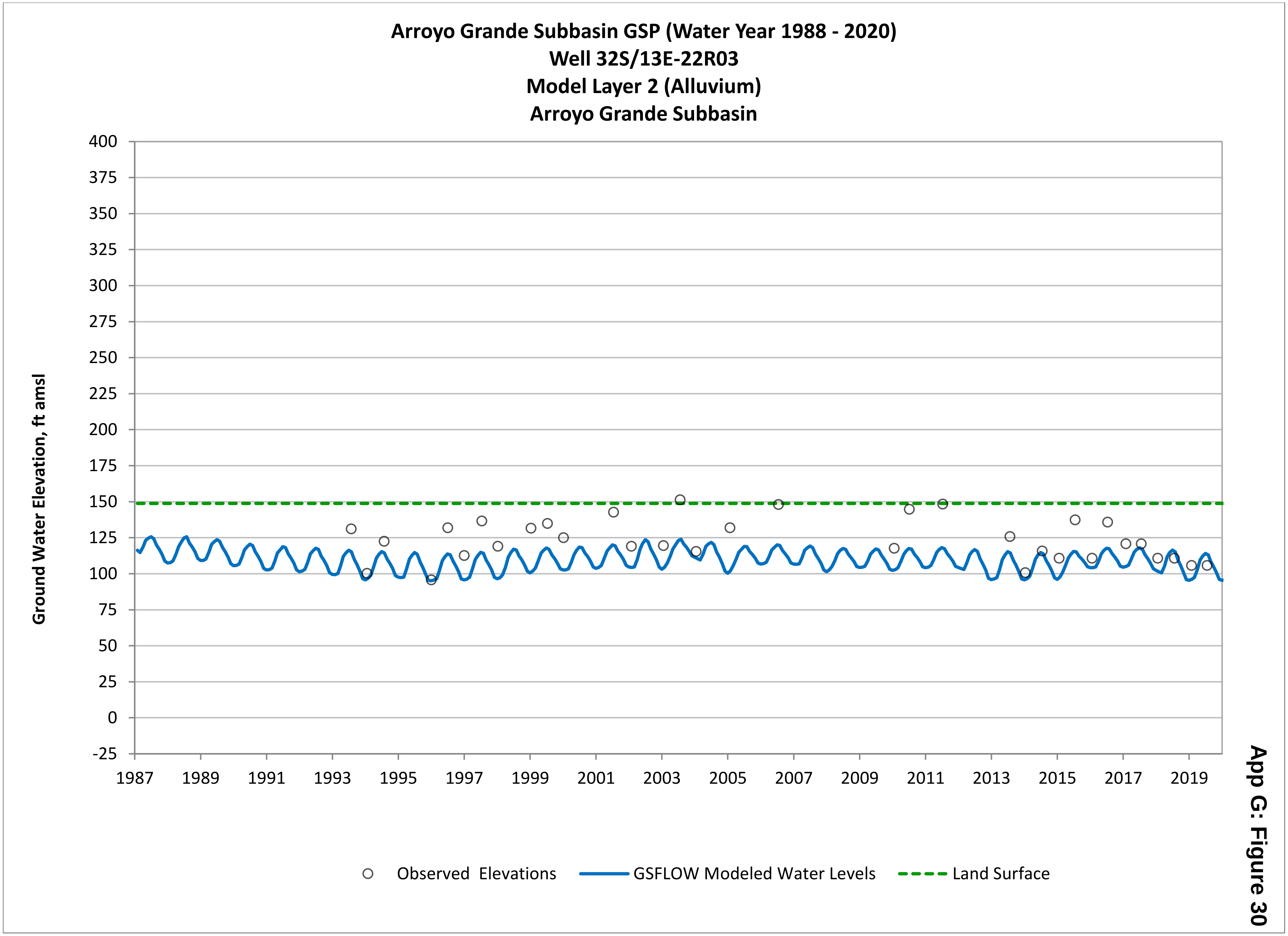

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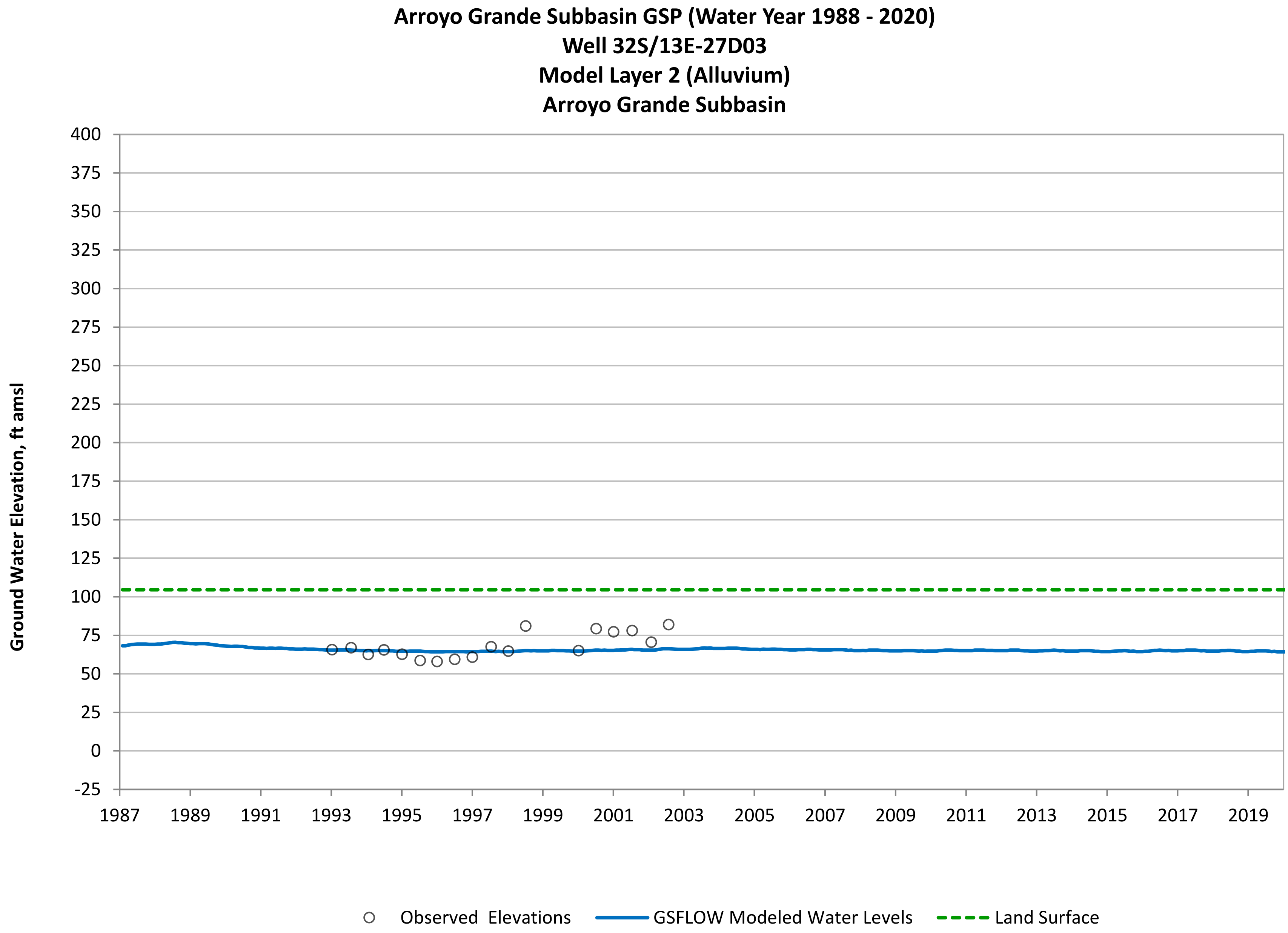

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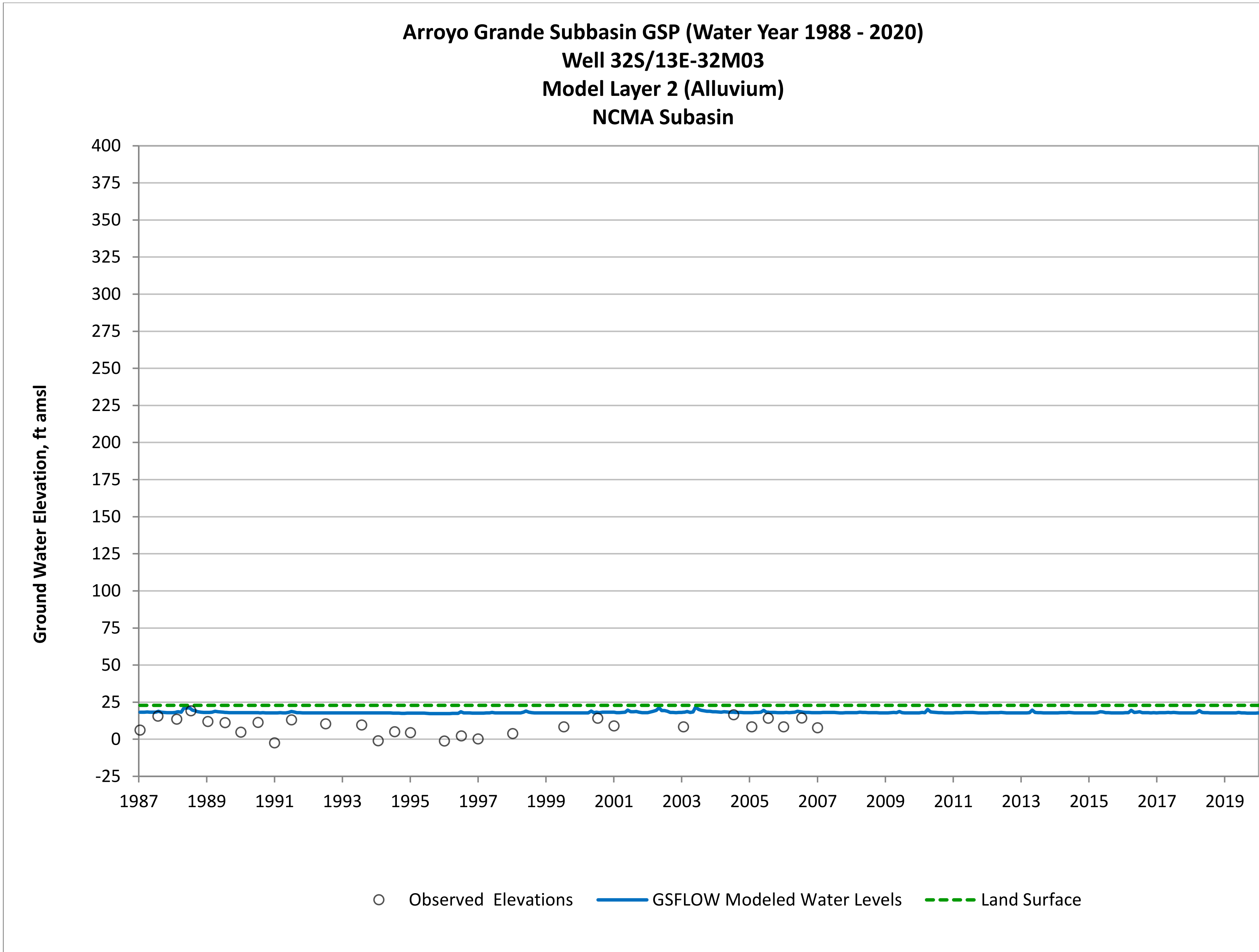
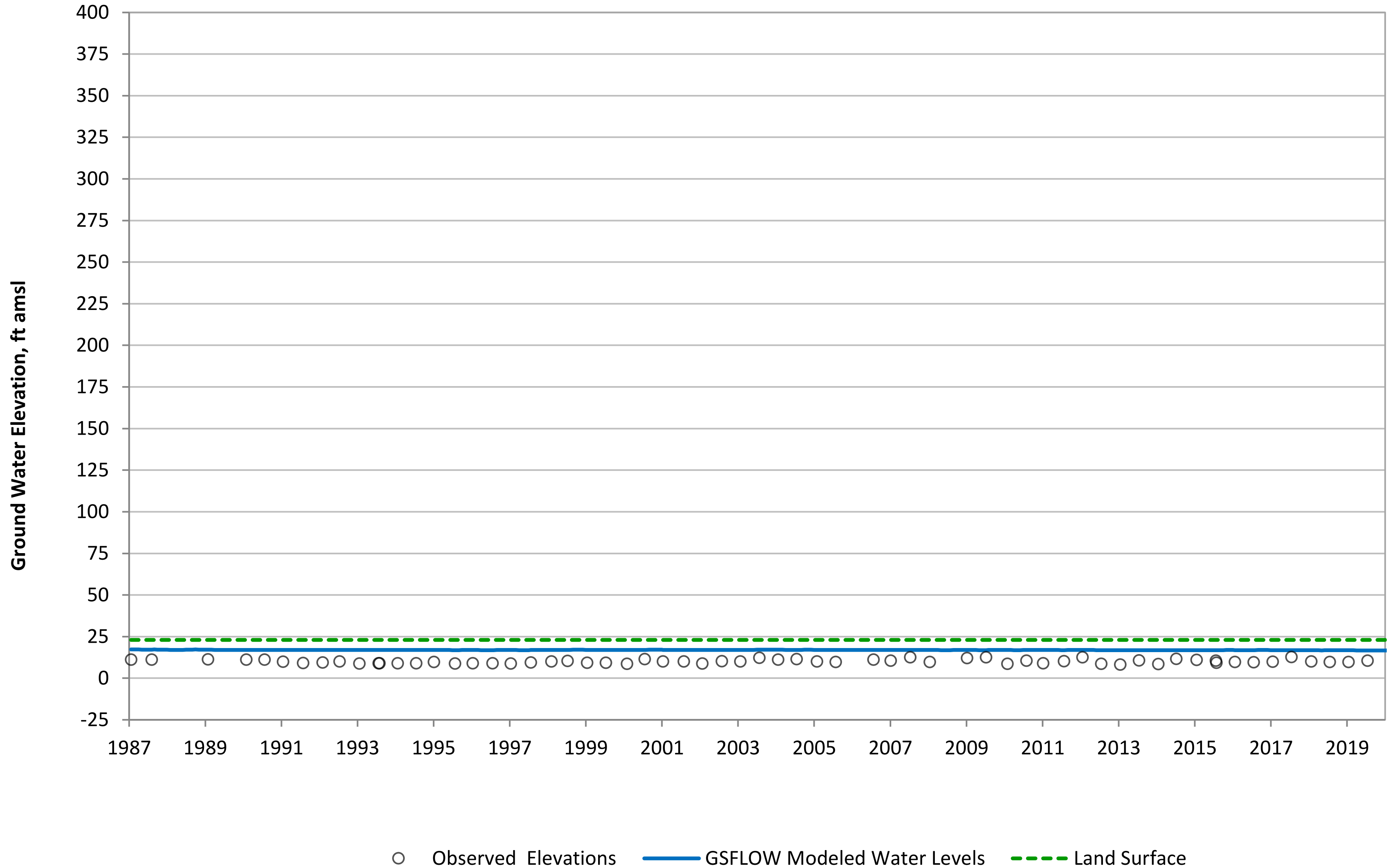


App G: Figure 32

Arroyo Grande Subbasin GSP (Water Year 1988 - 2020)
Well 32S/12E-24B01
Model Layer 2 (Alluvium)
NCMA Subasin



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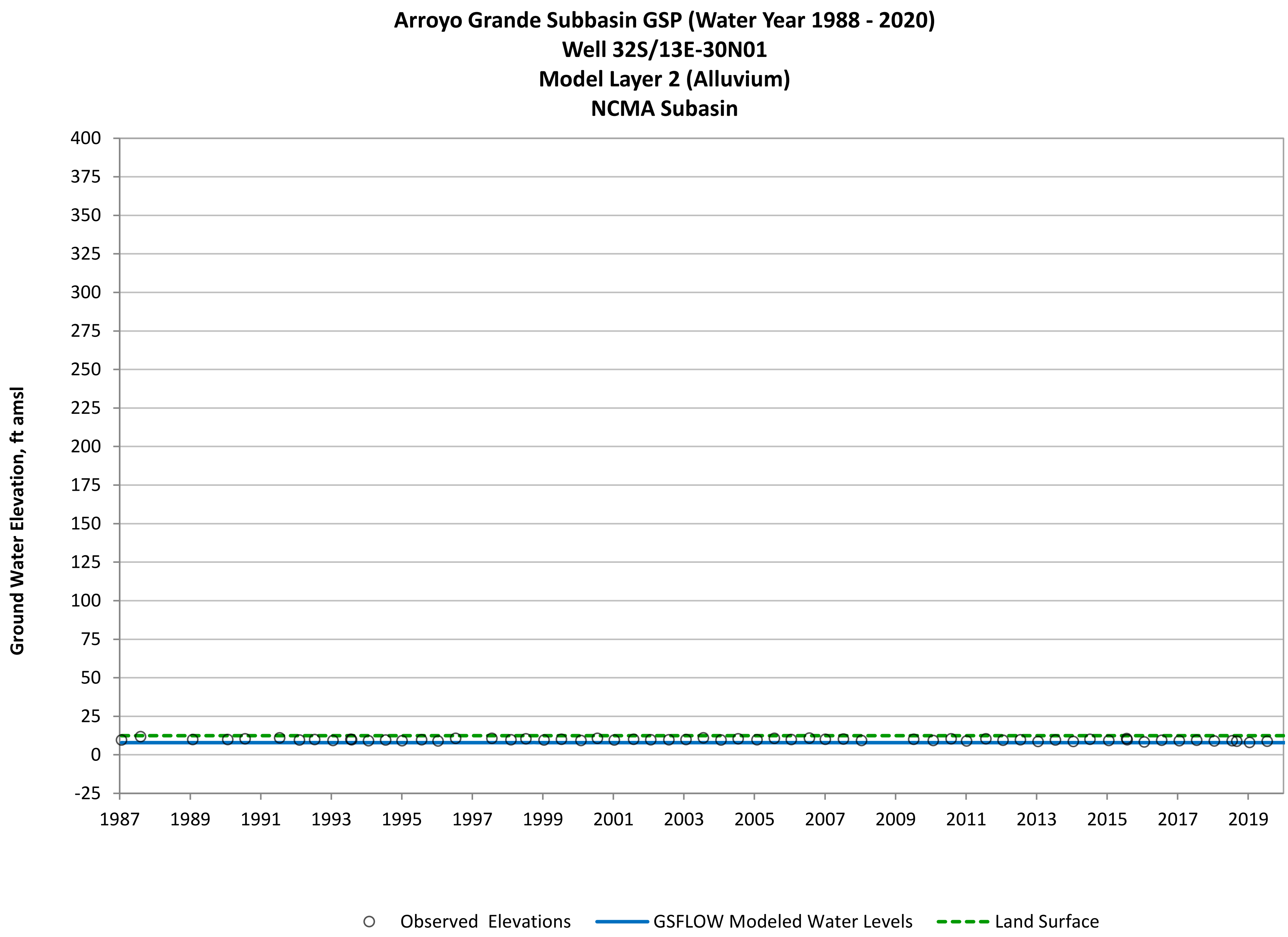

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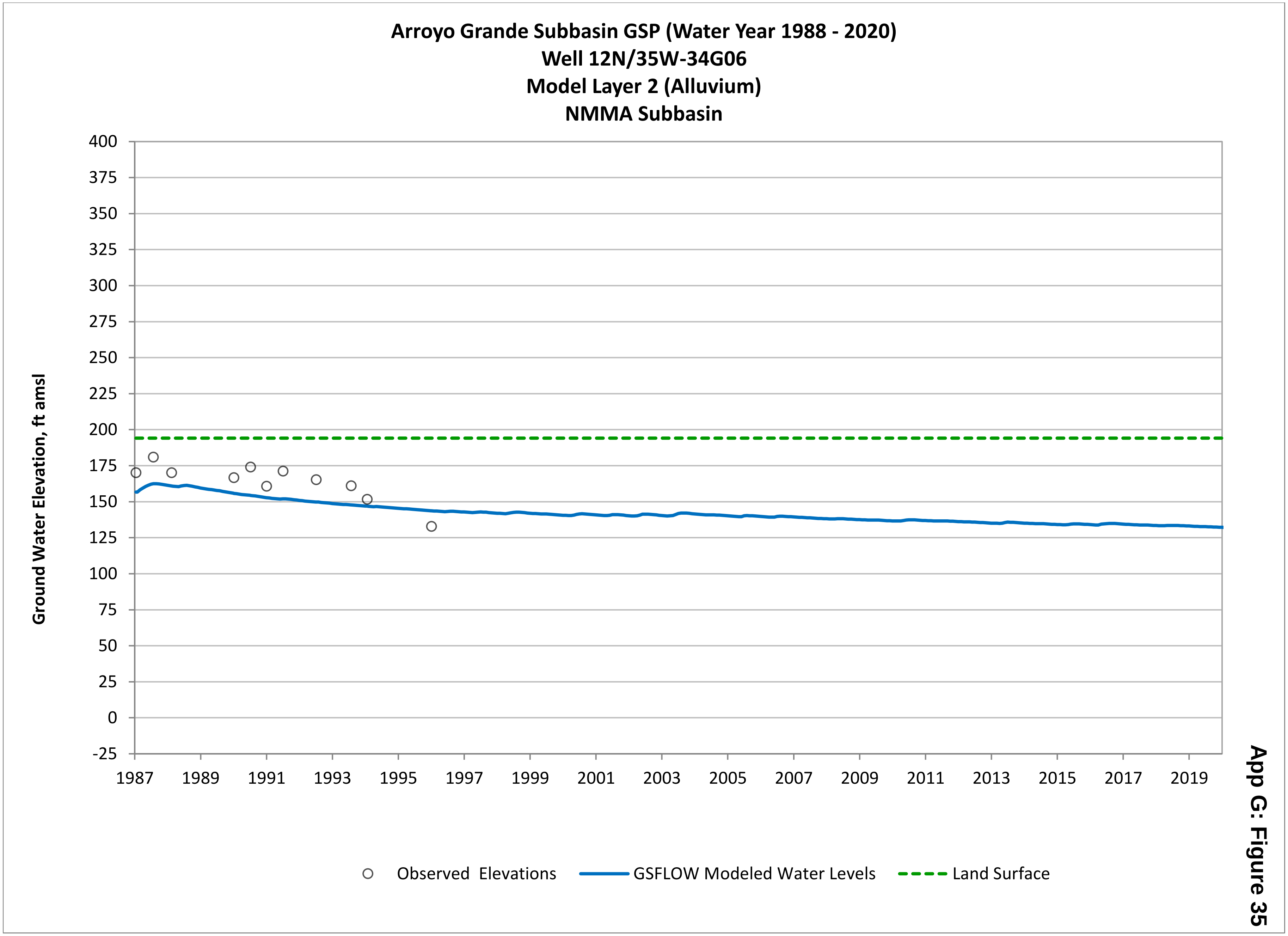

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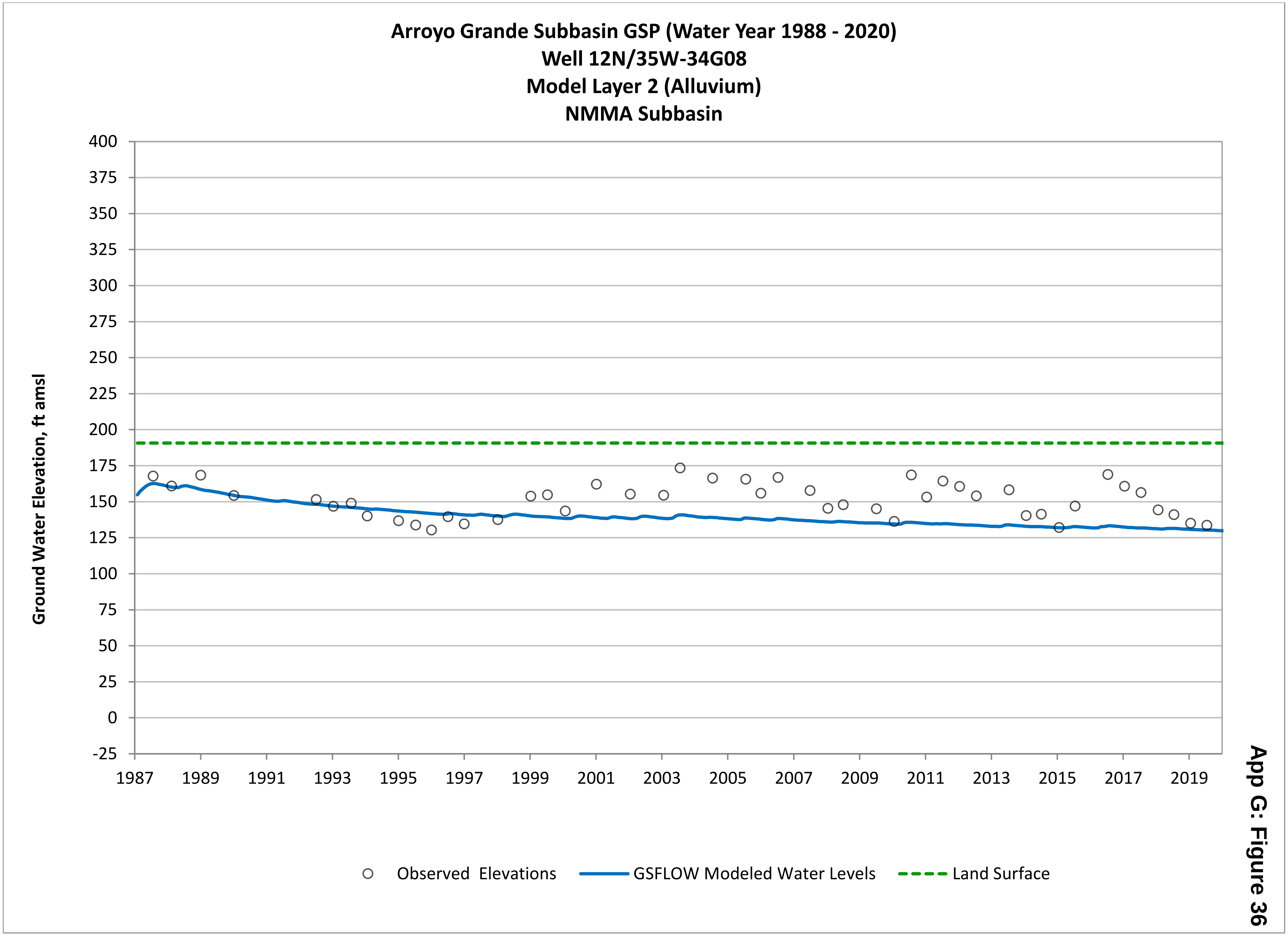

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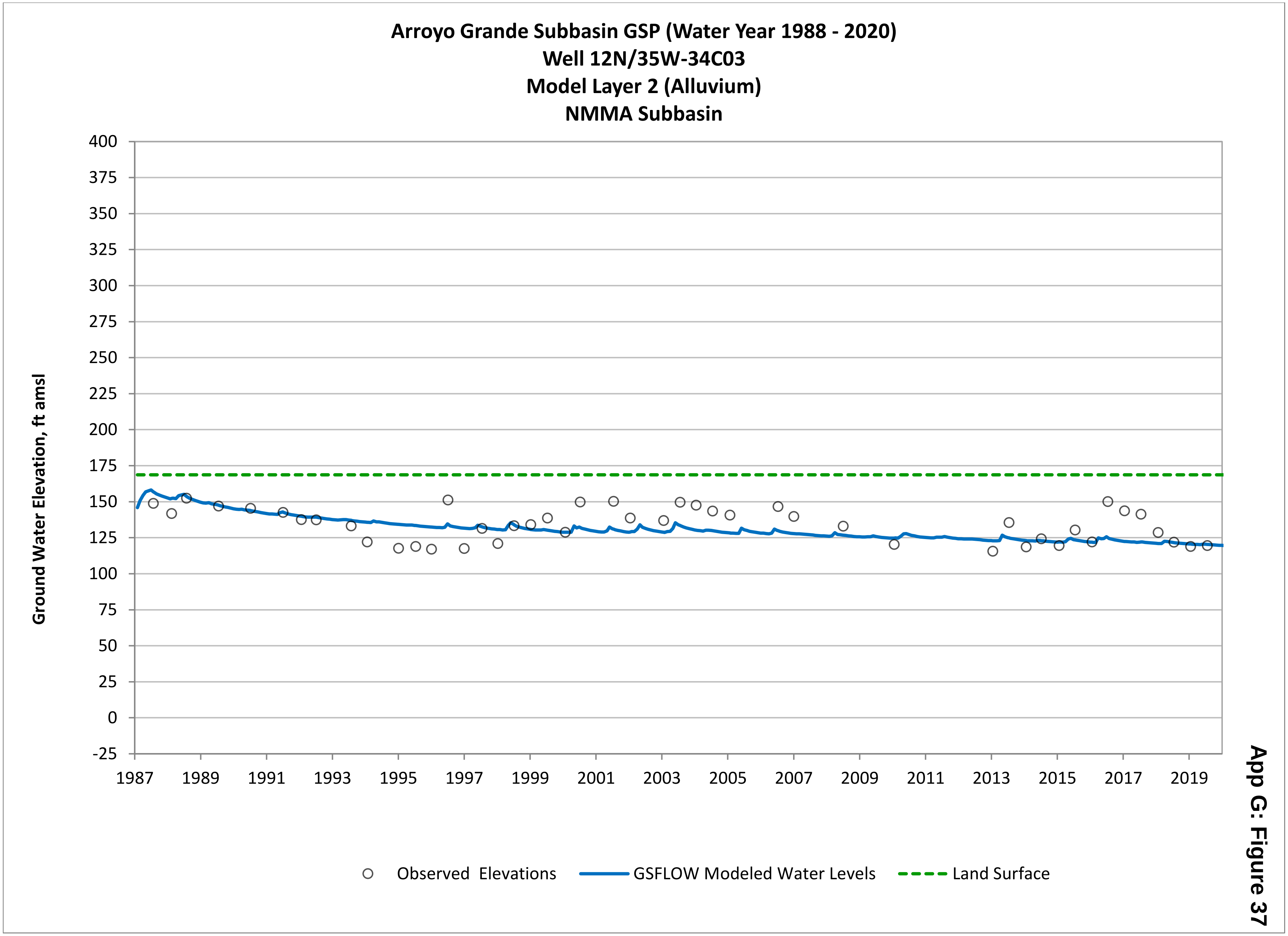

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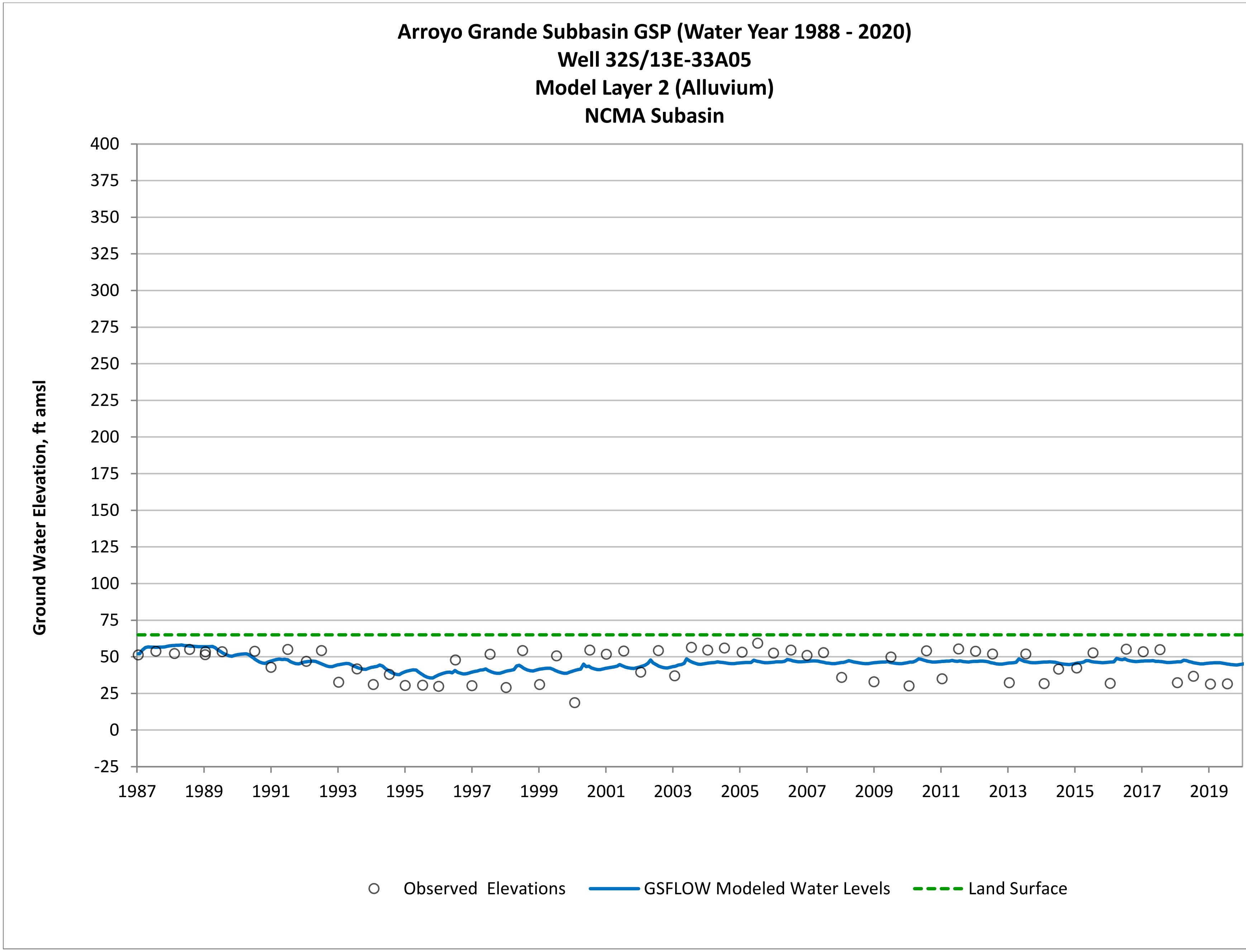

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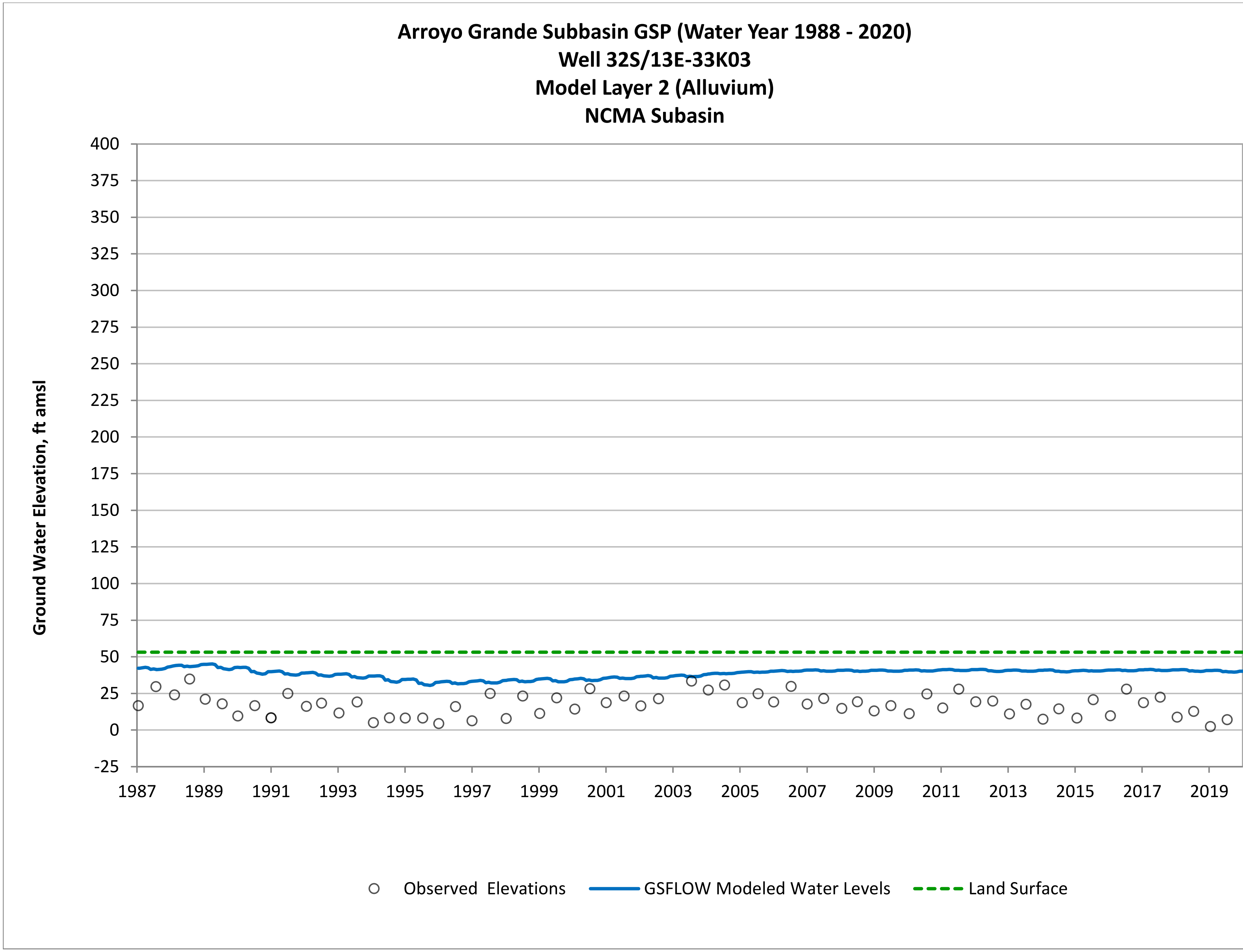

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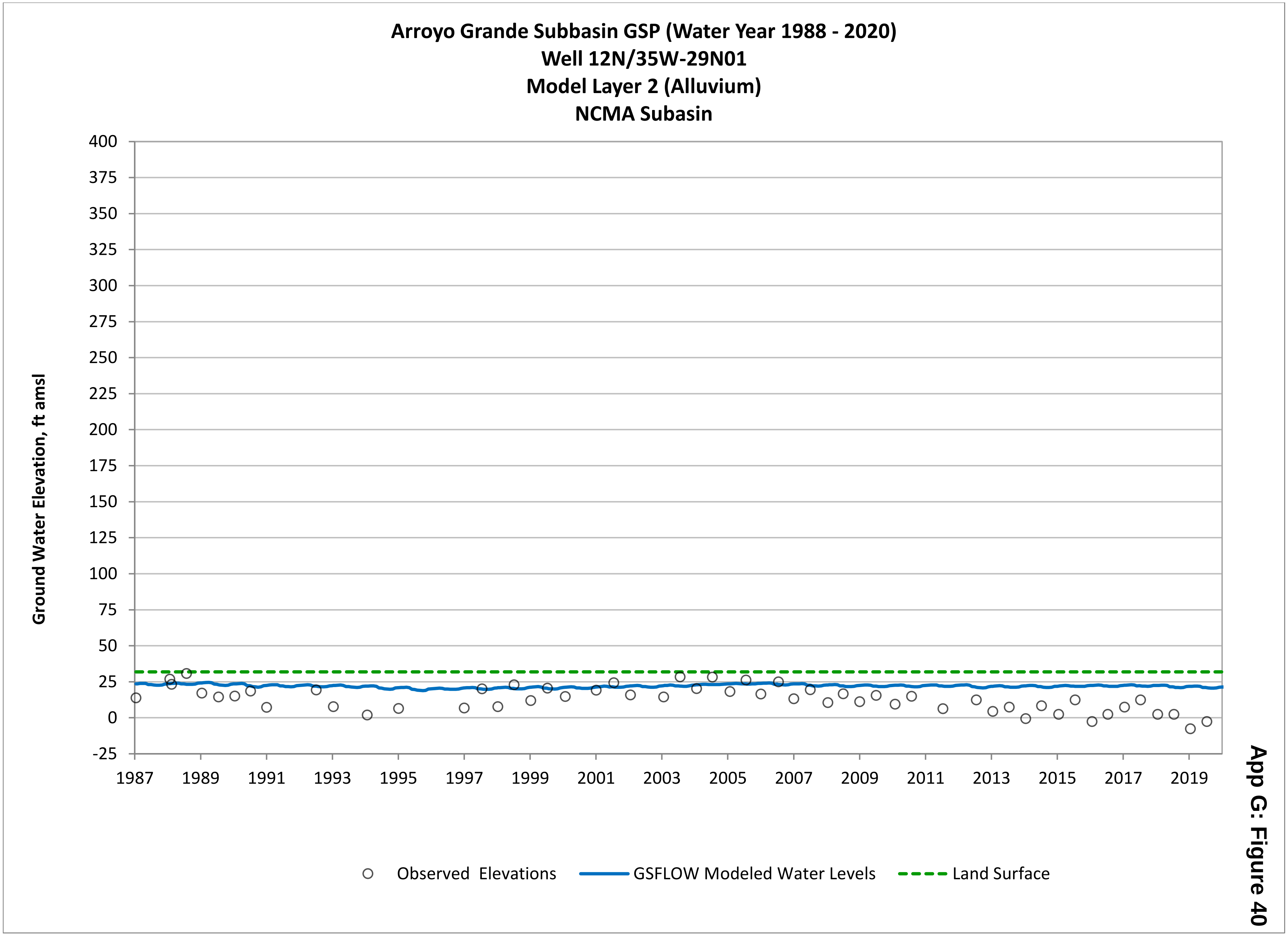

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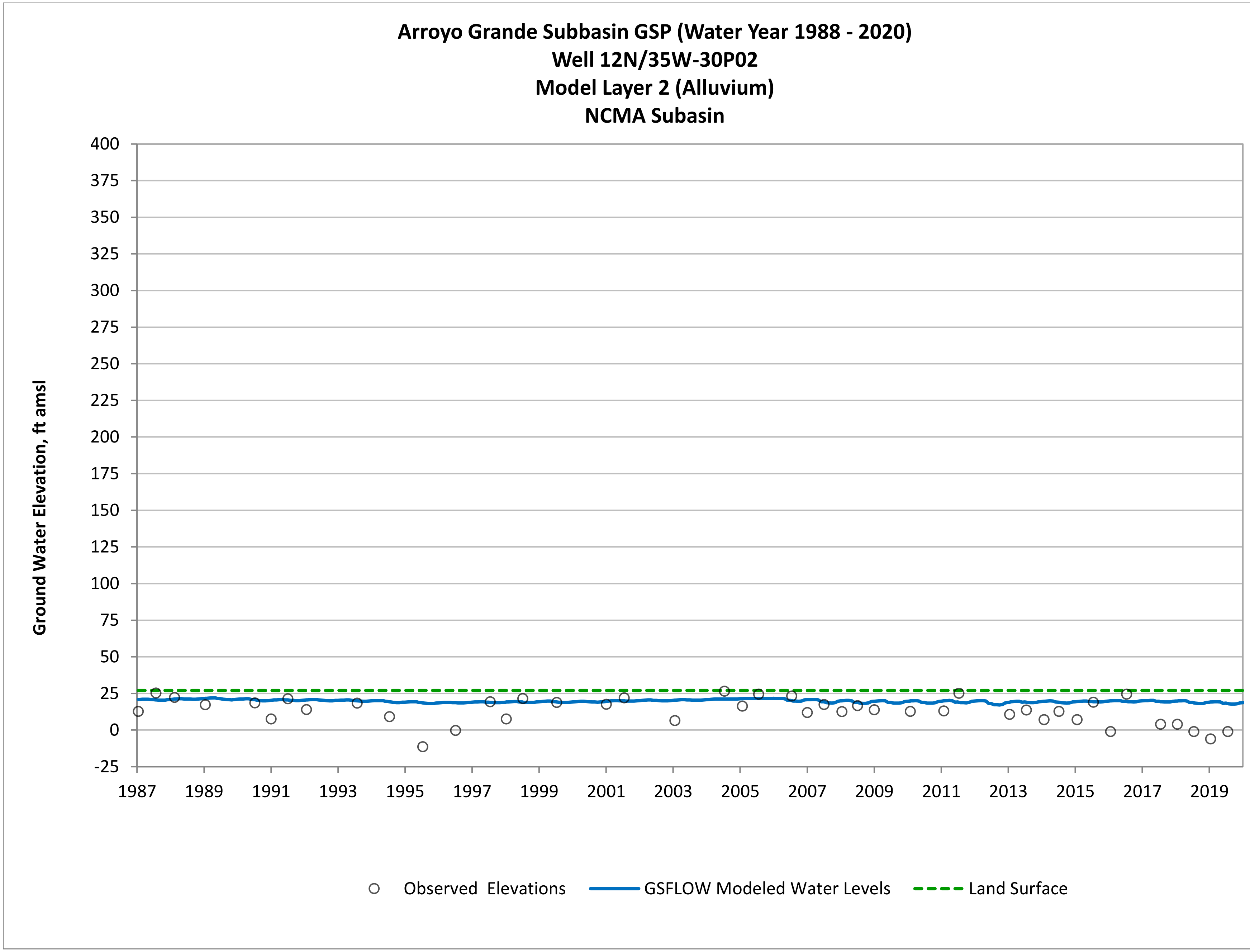

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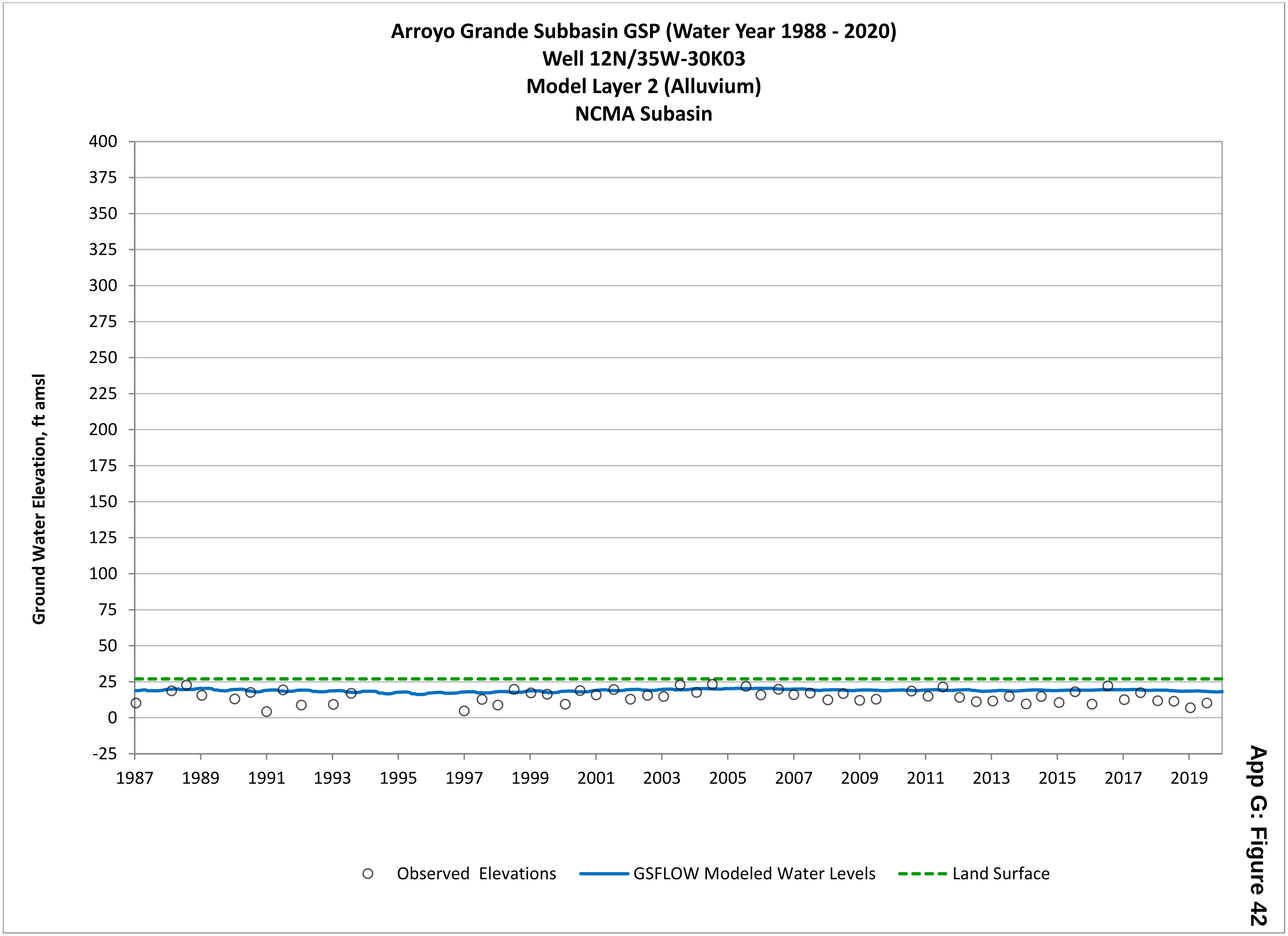

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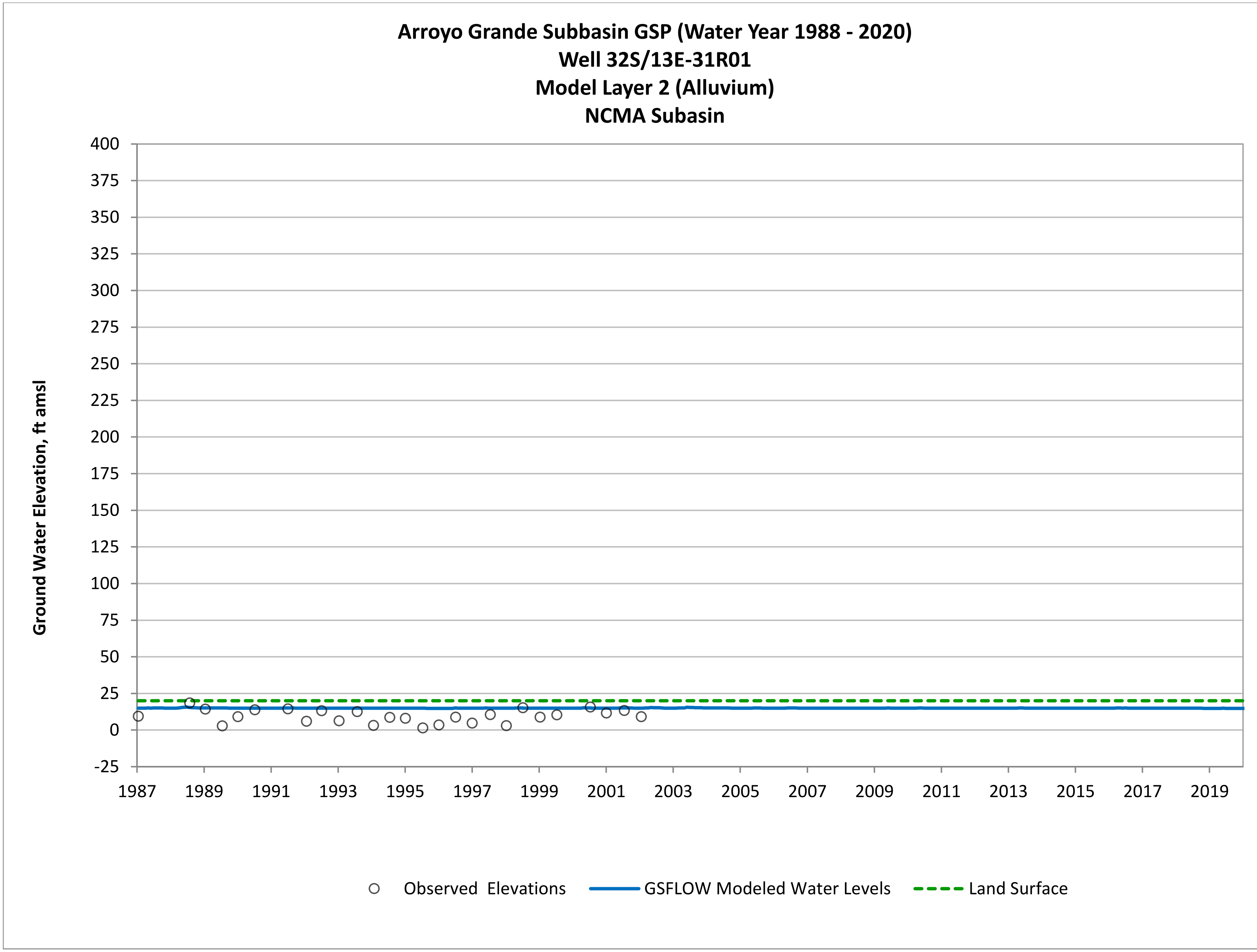

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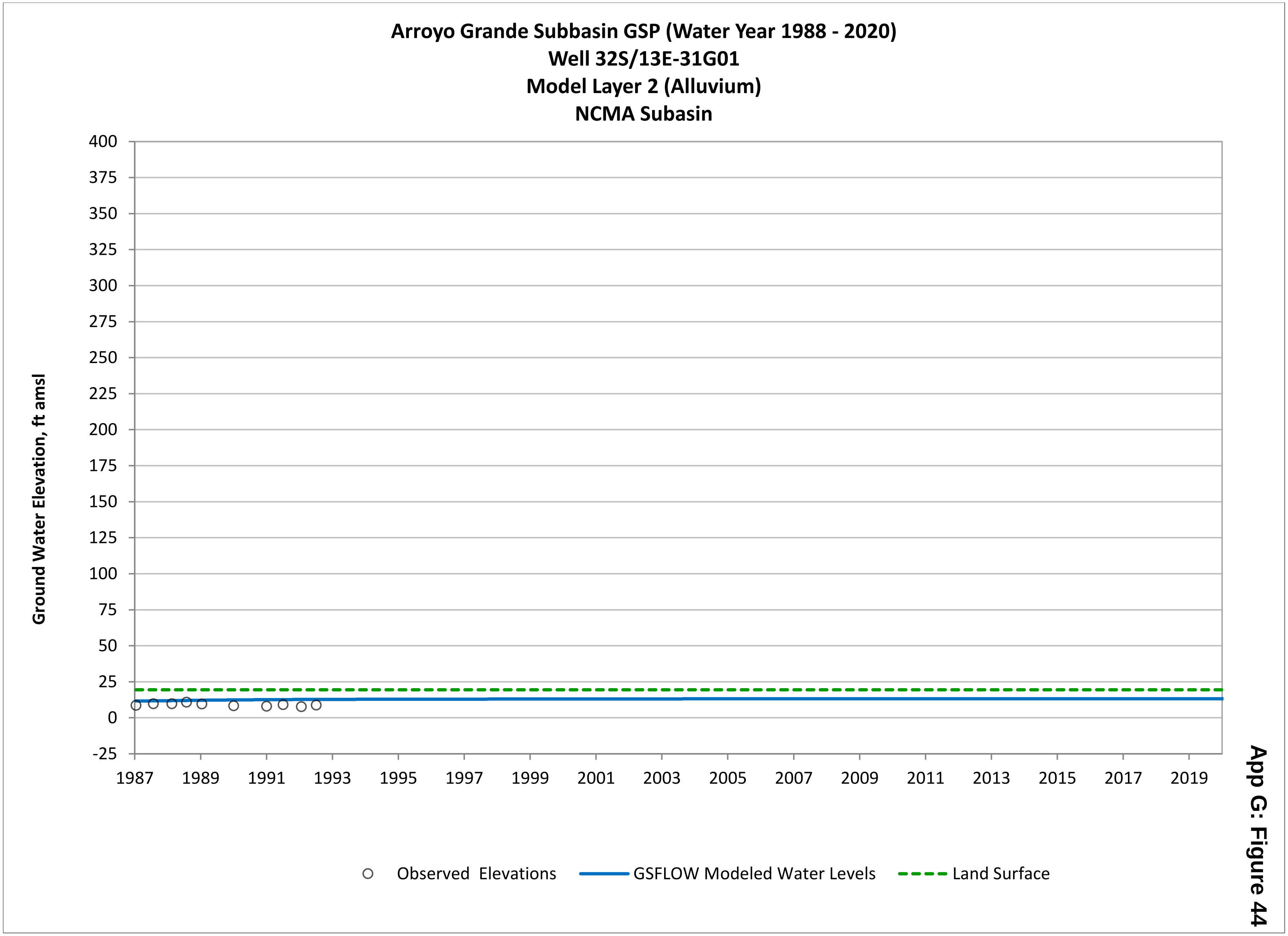

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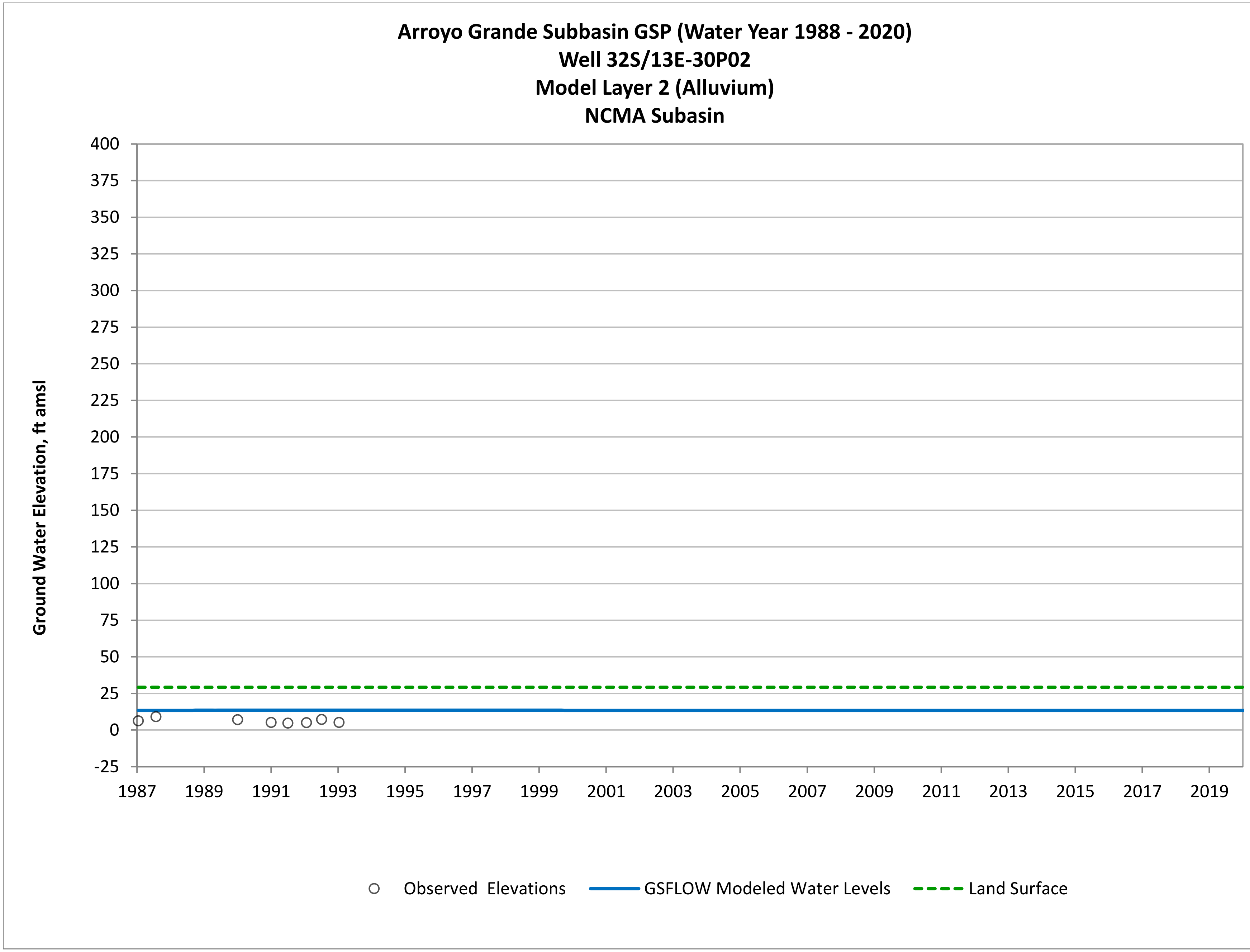

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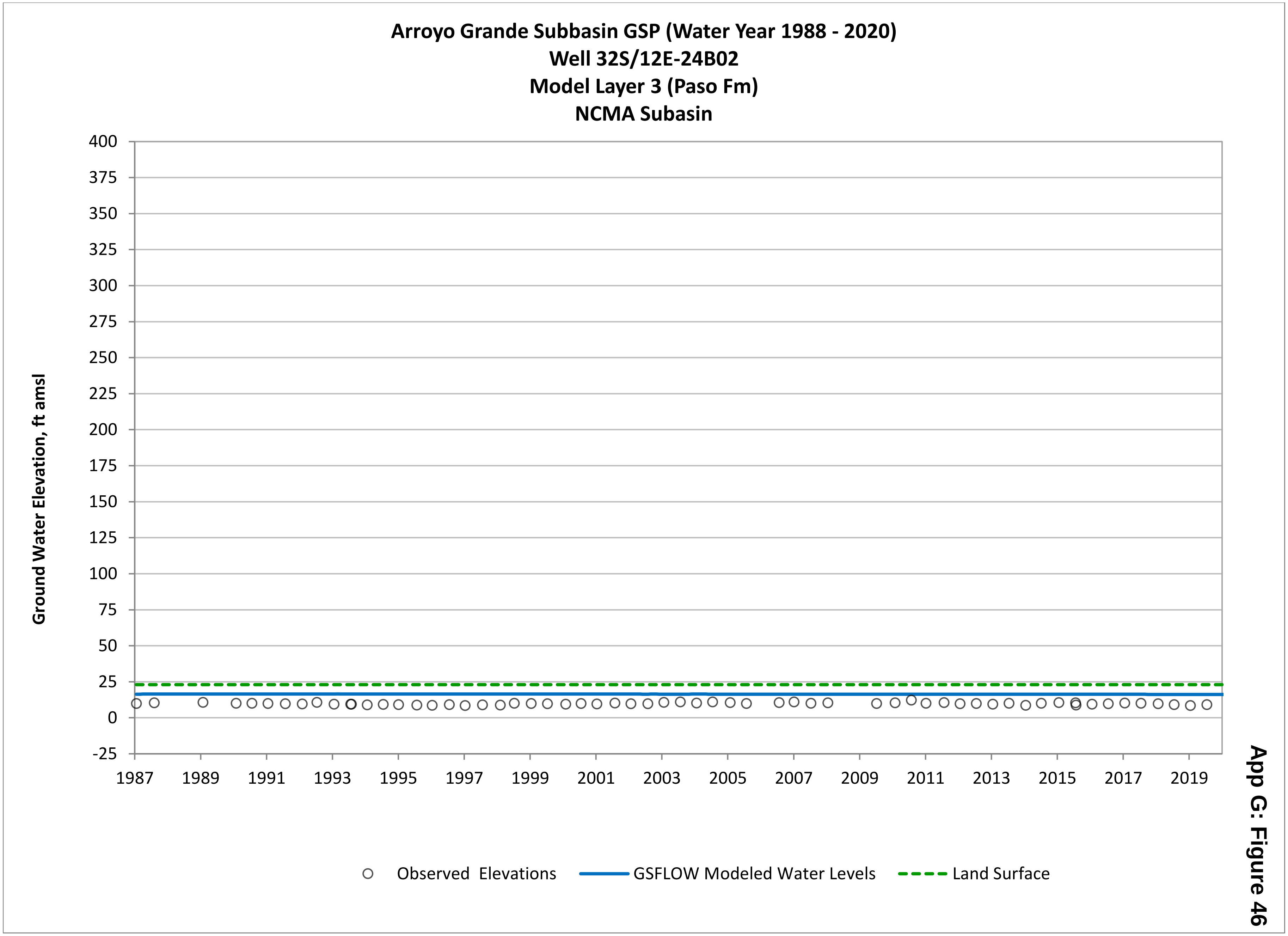

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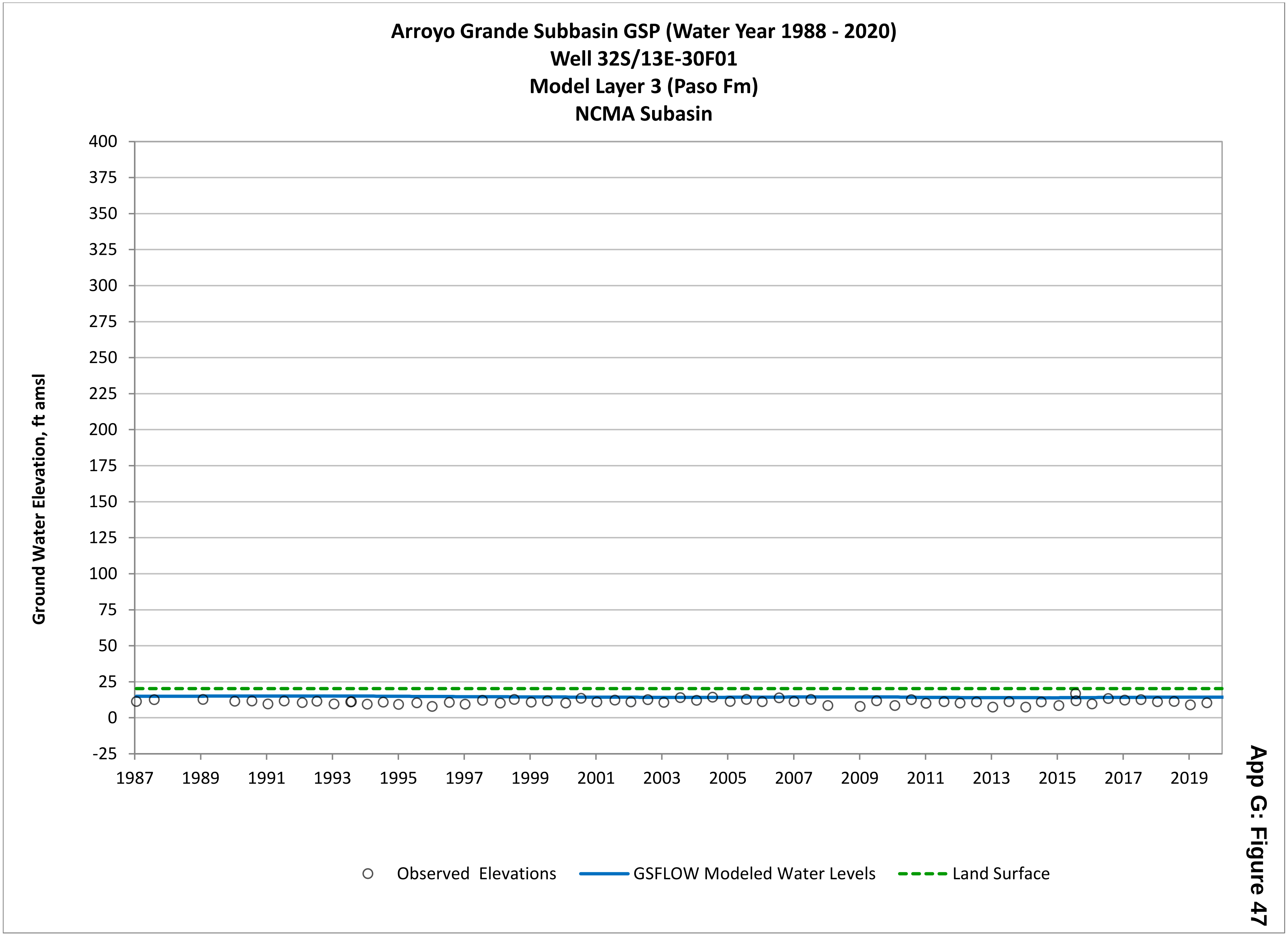

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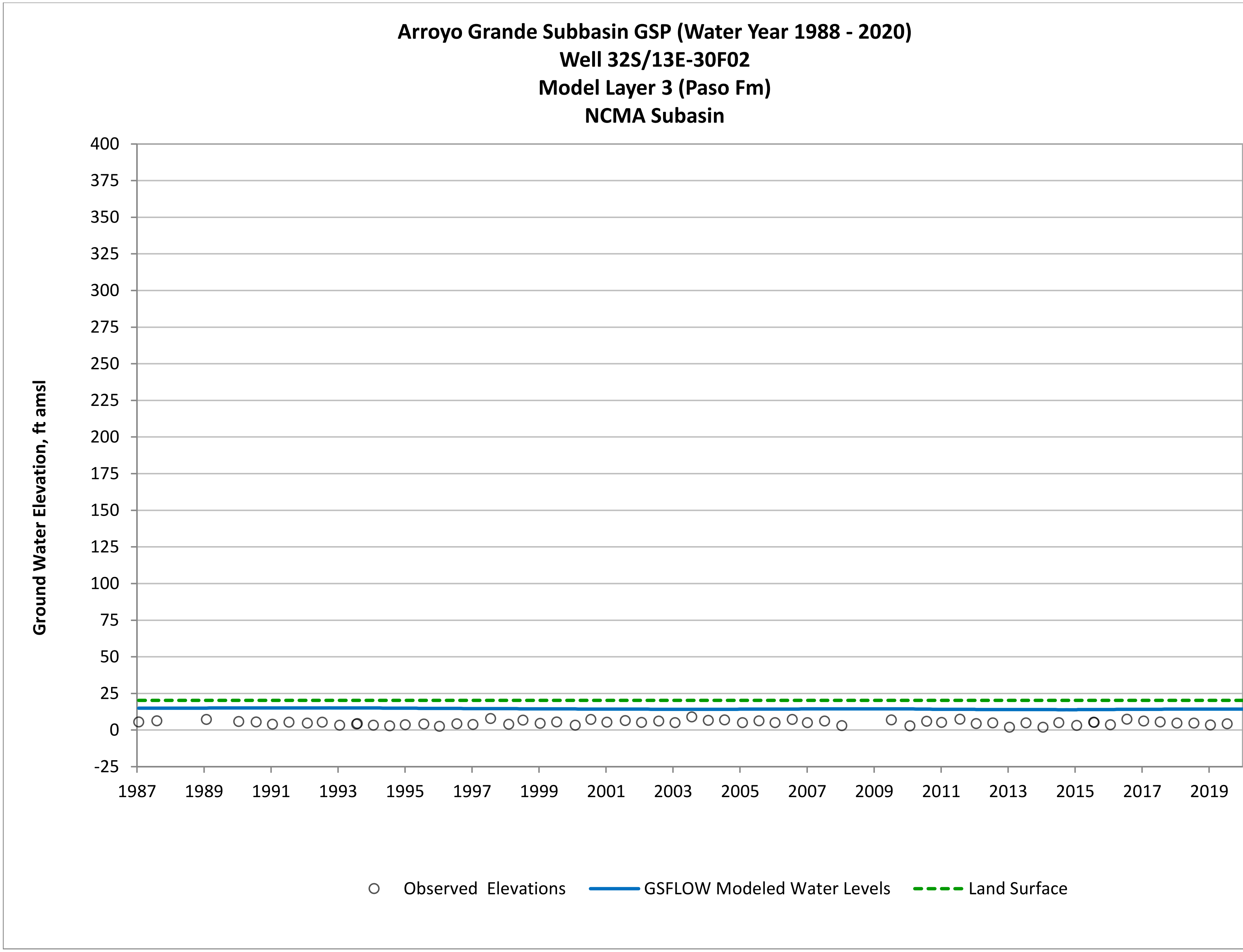

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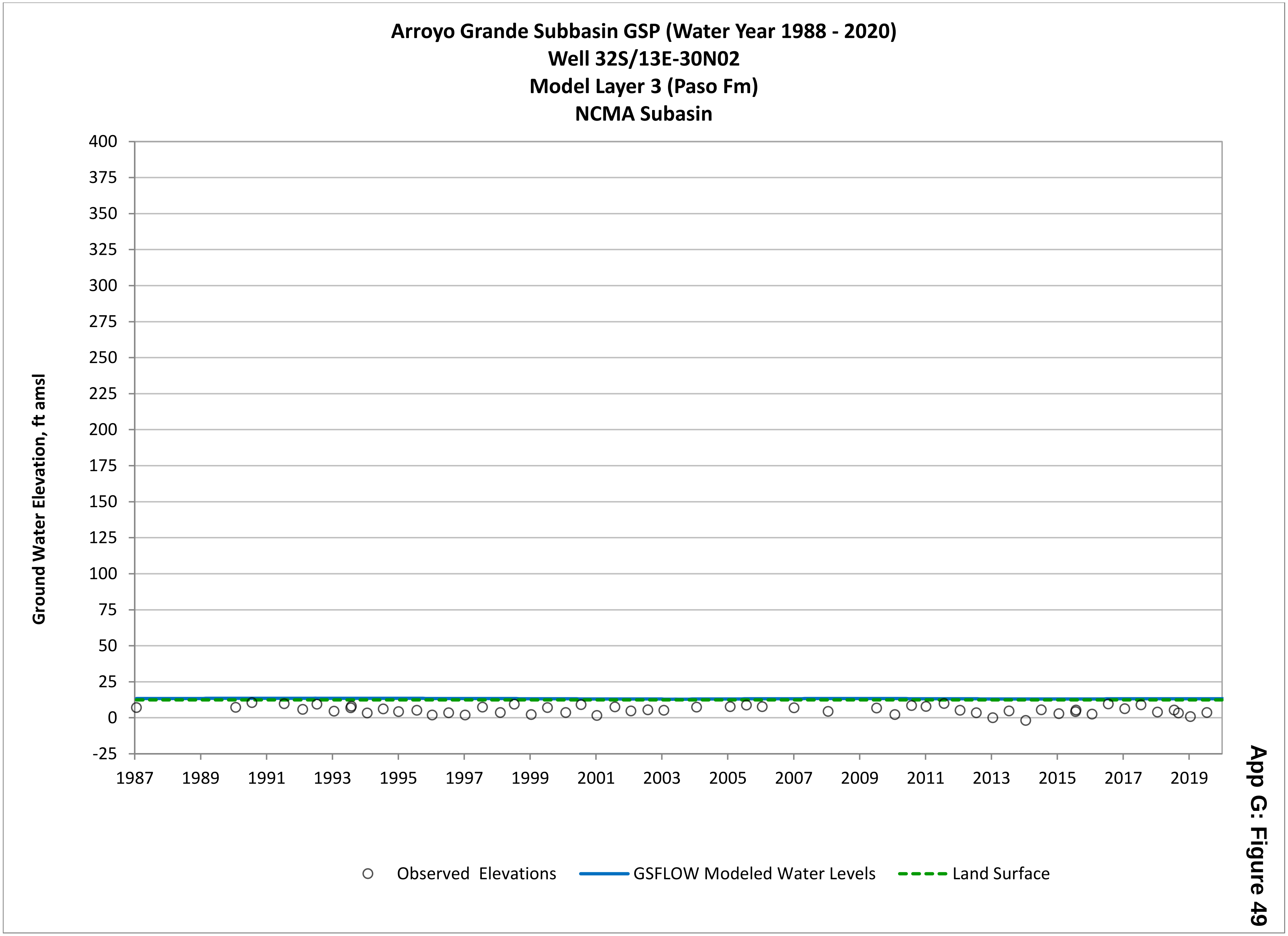
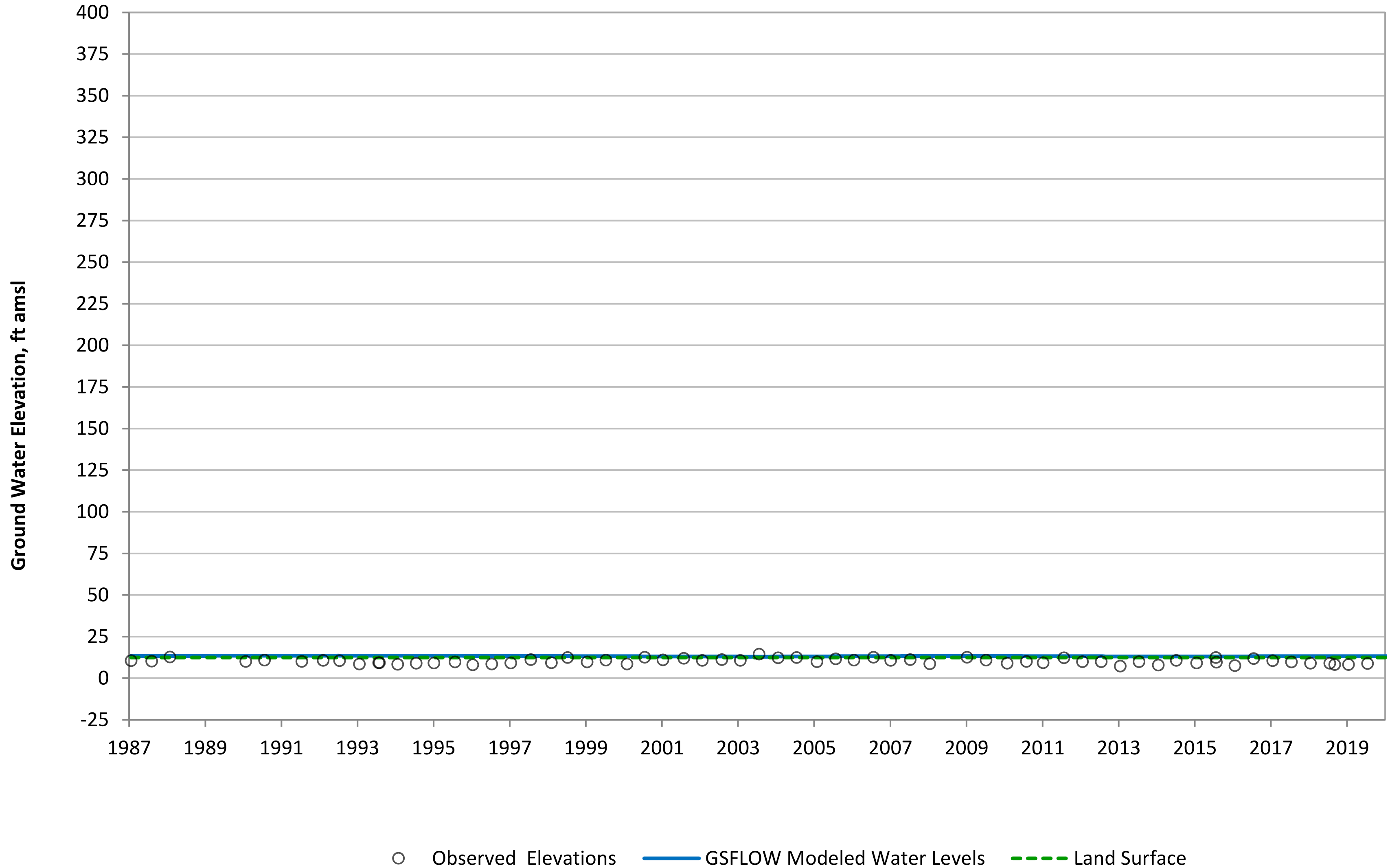


App G: Figure 49

Arroyo Grande Subbasin GSP (Water Year 1988 - 2020)
Well 32S/13E-30N03
Model Layer 3 (Paso Fm)
NCMA Subasin



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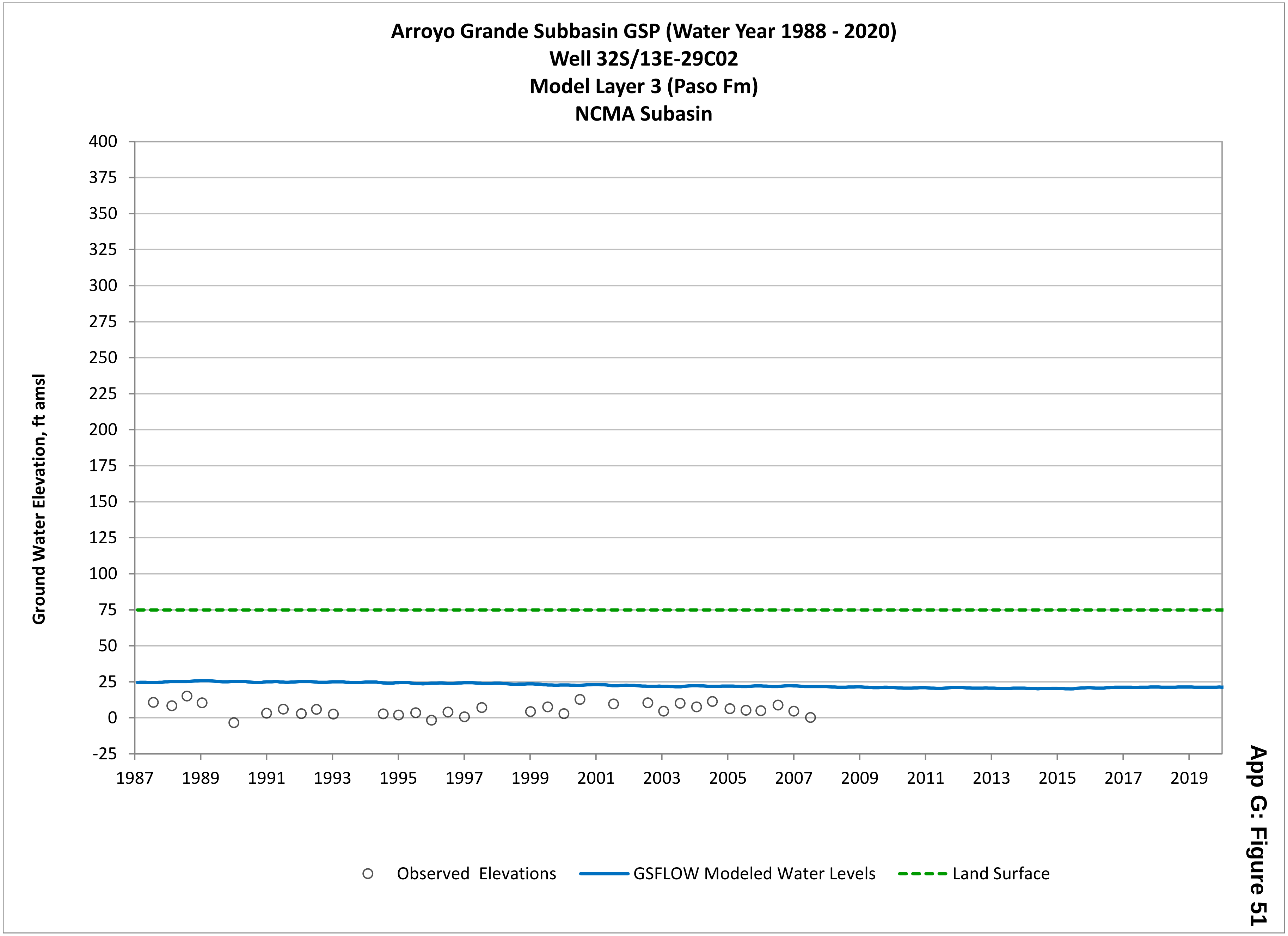

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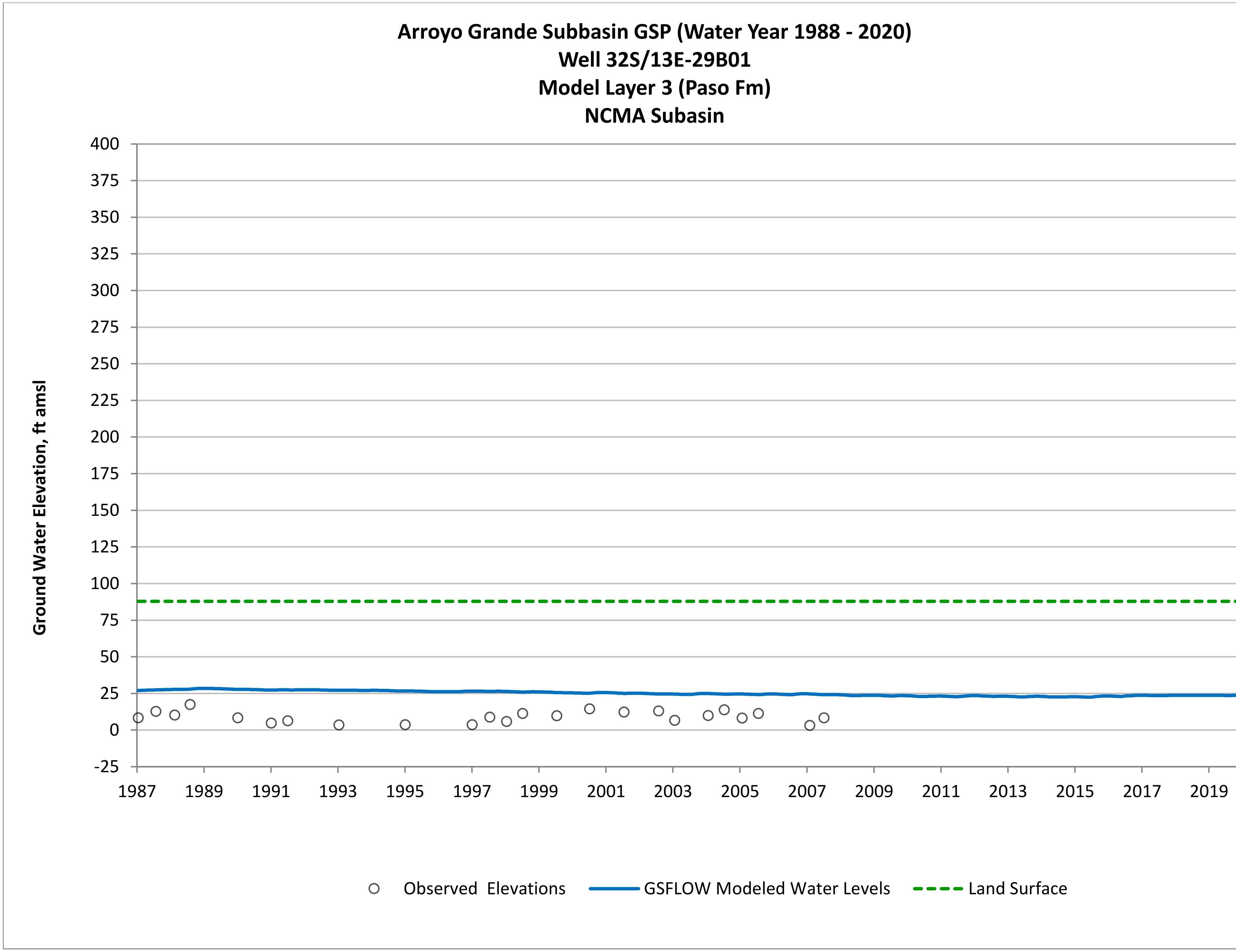

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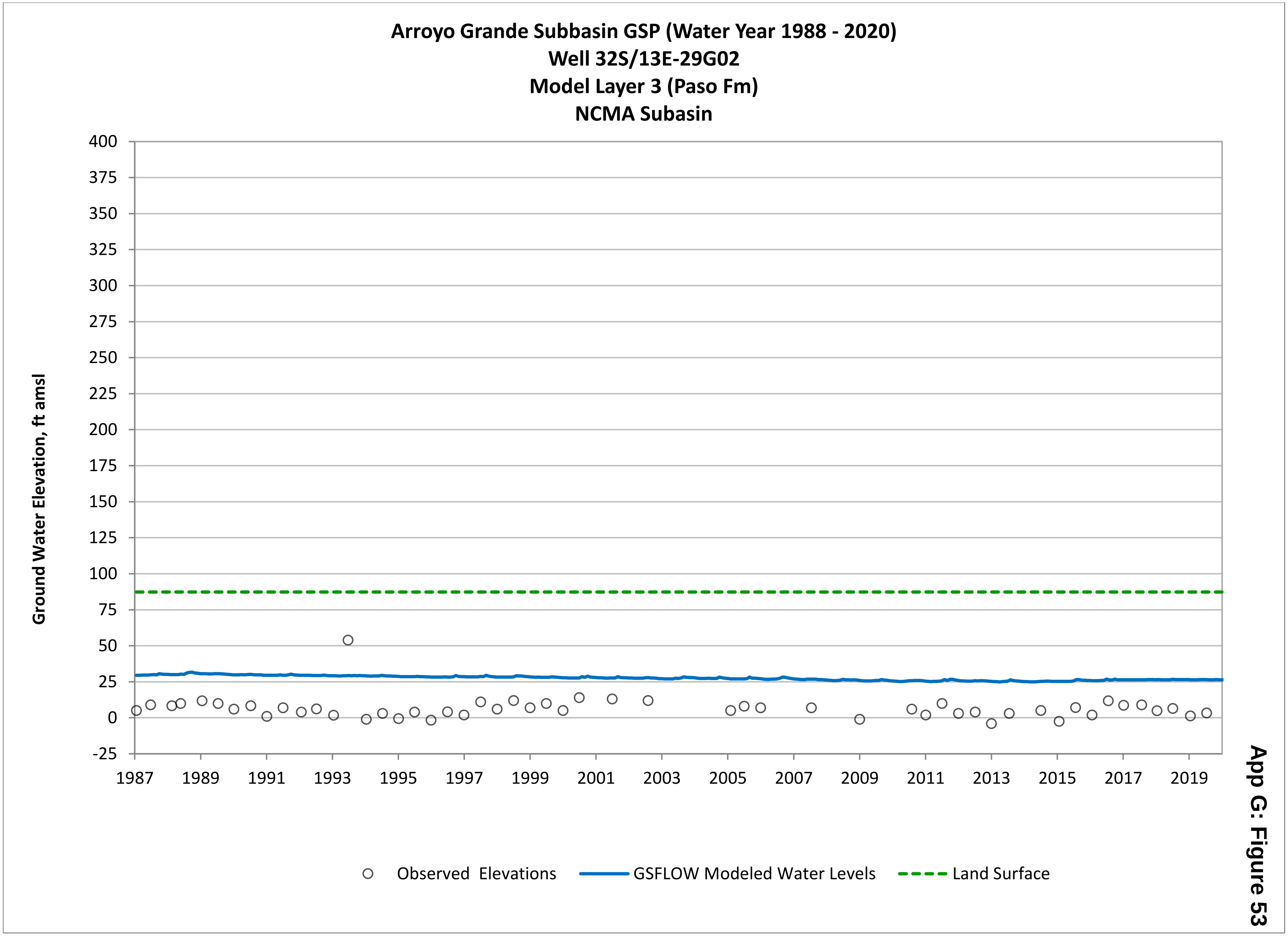

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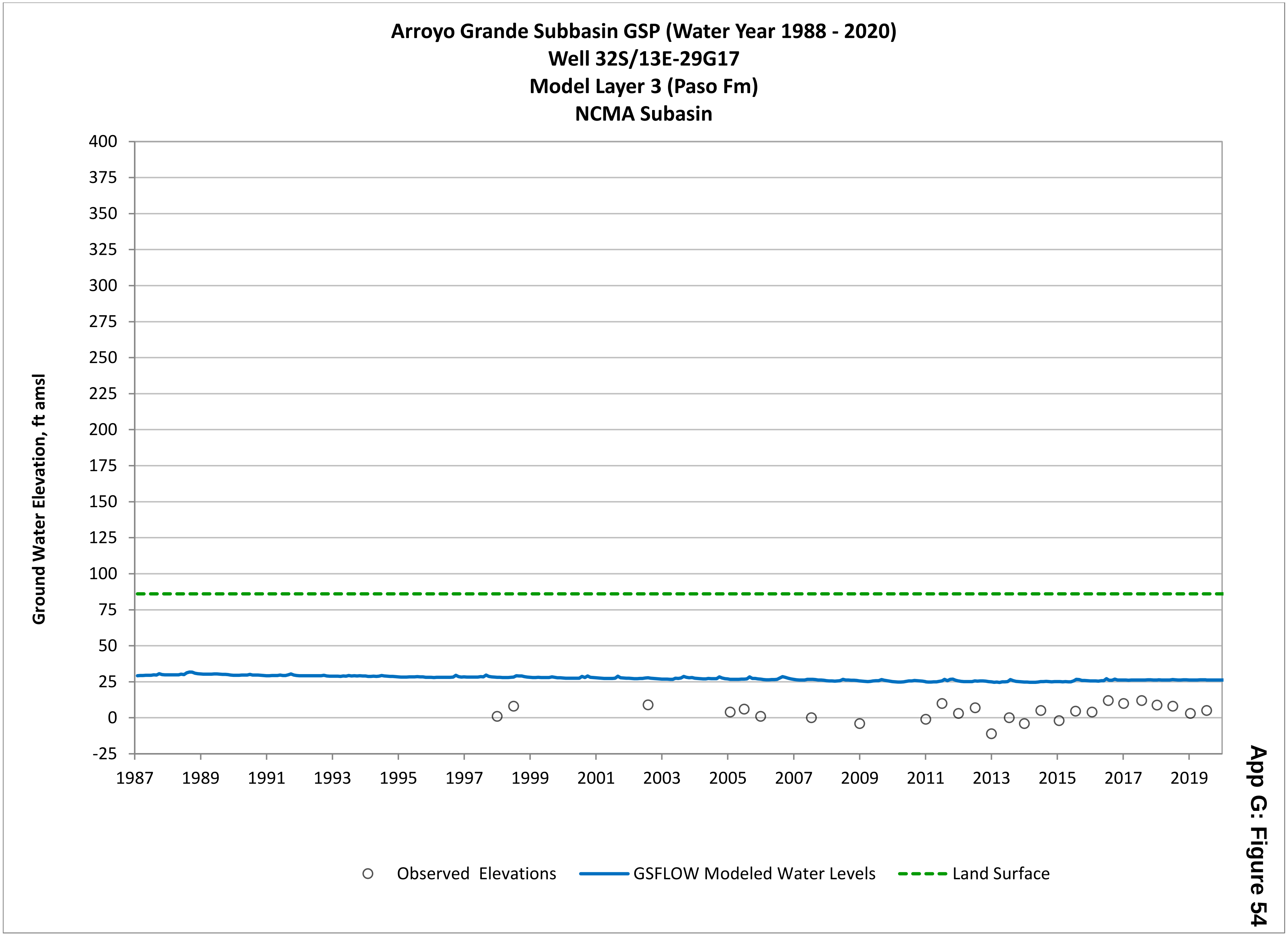

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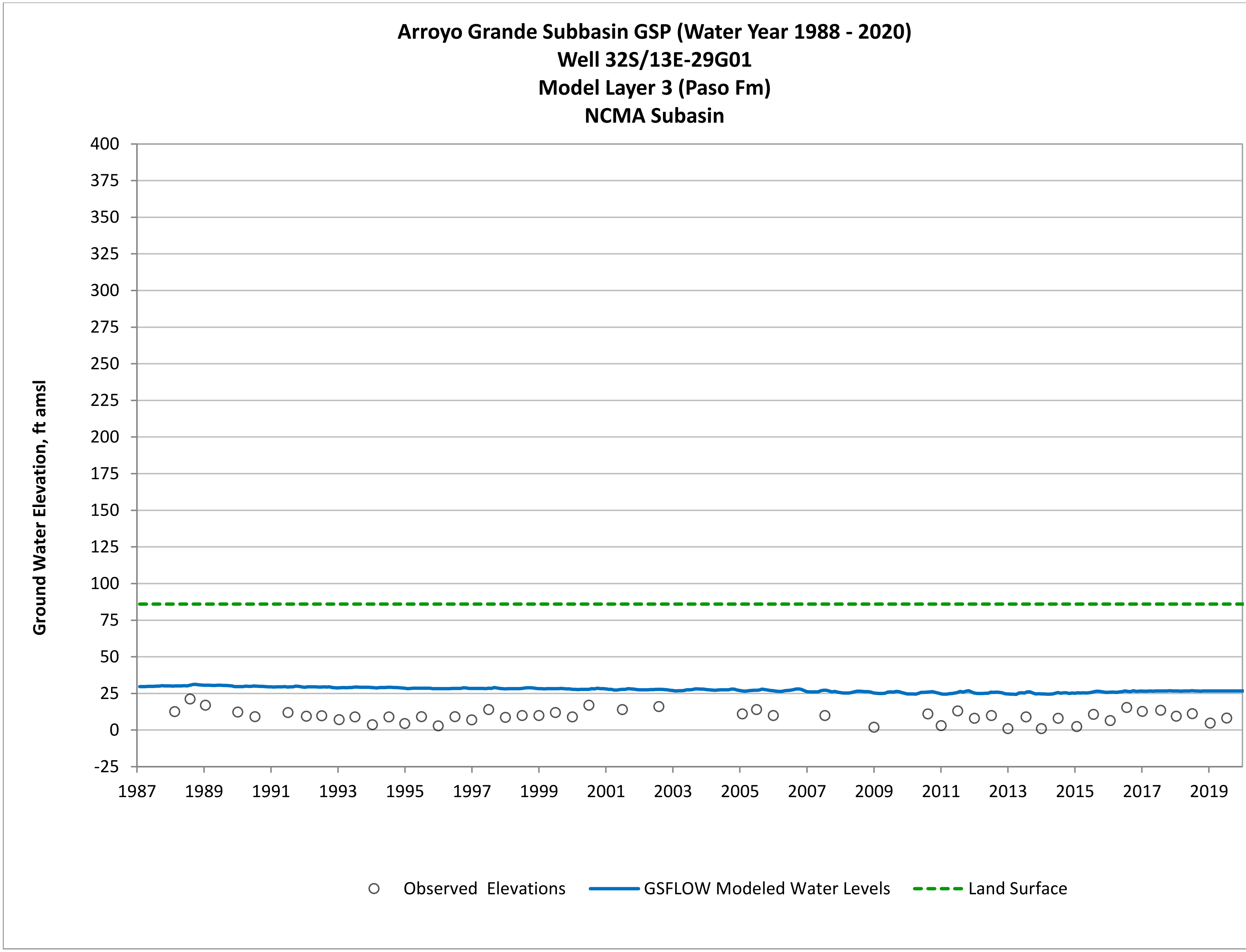

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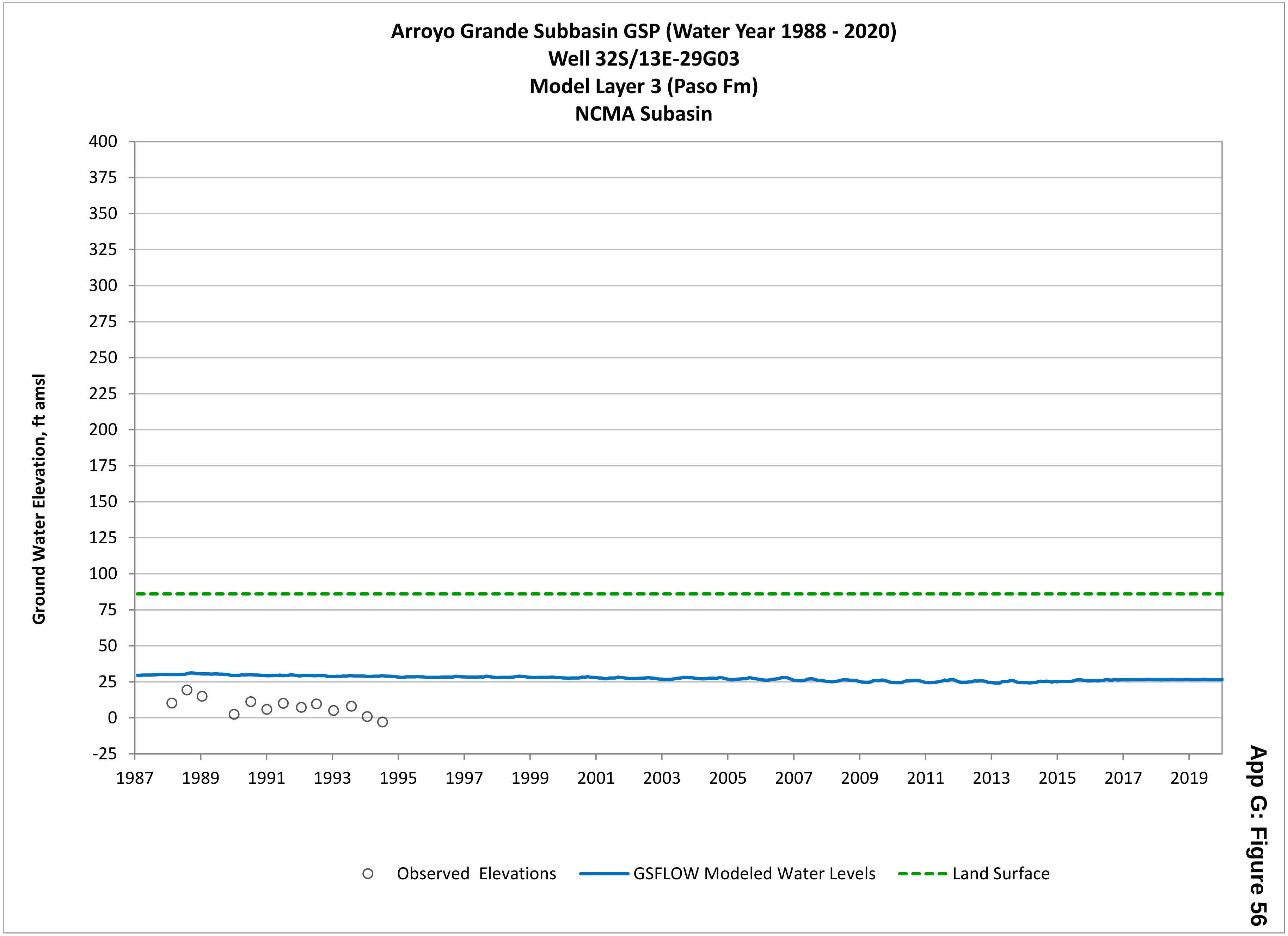

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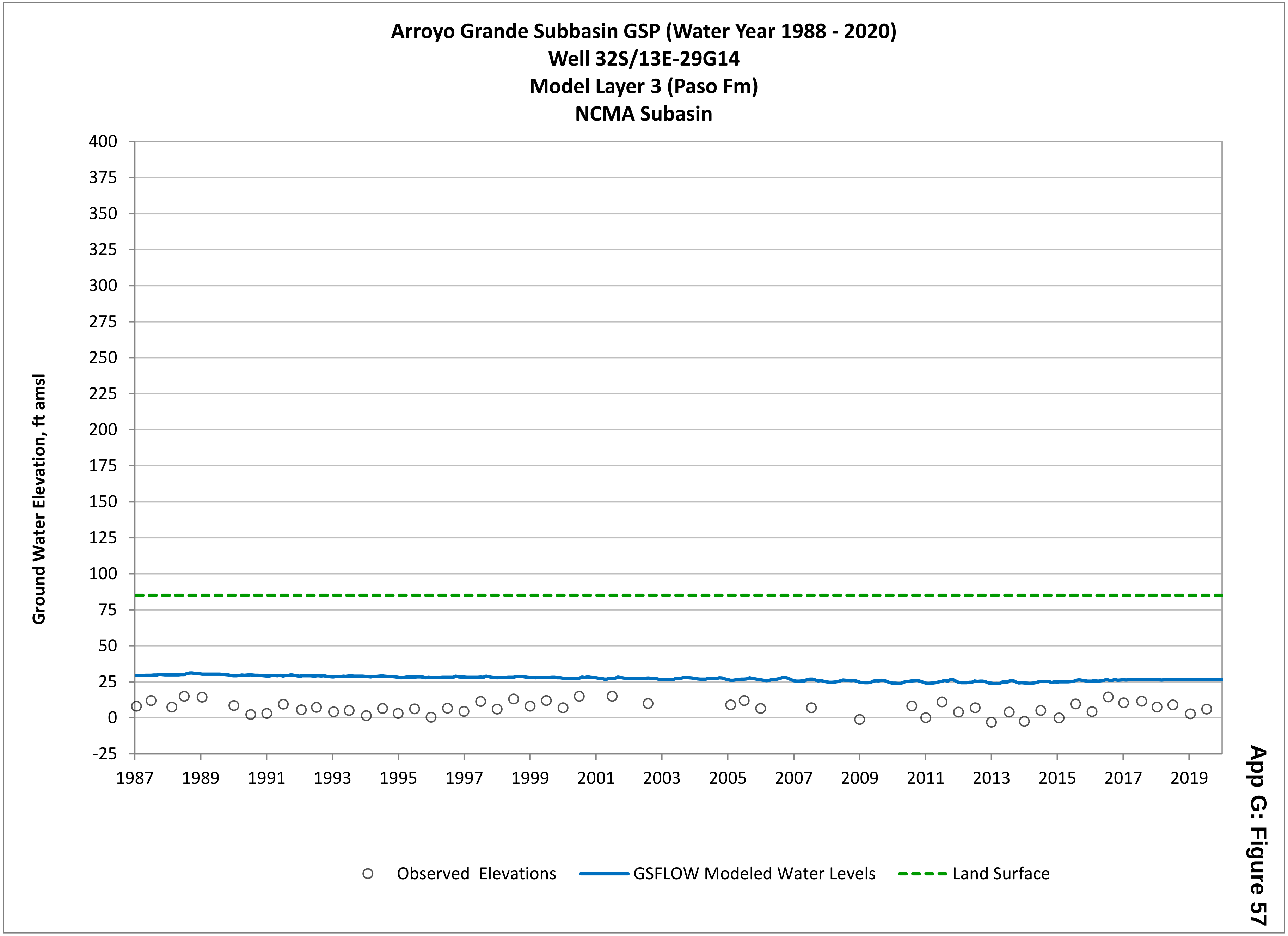

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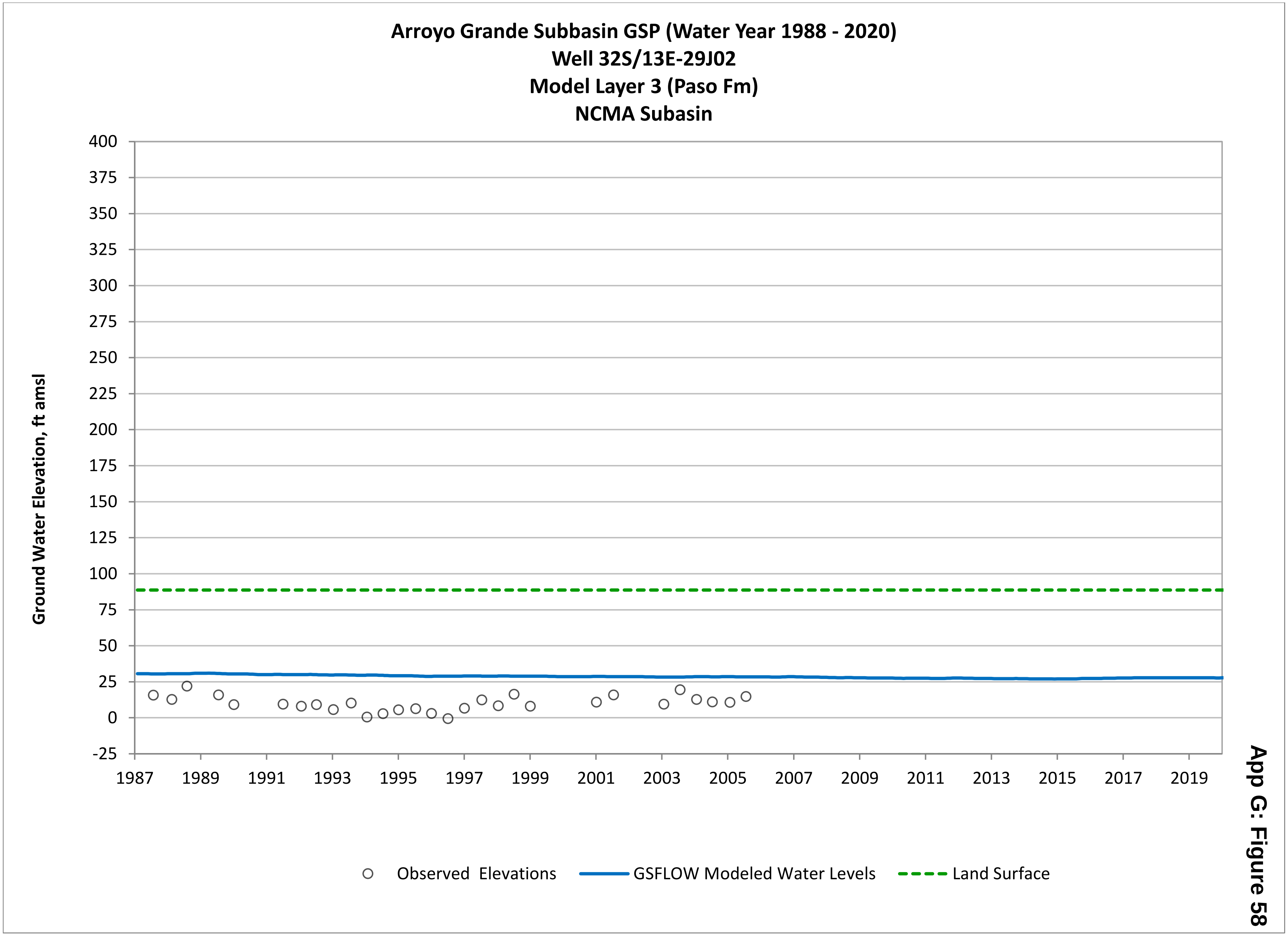

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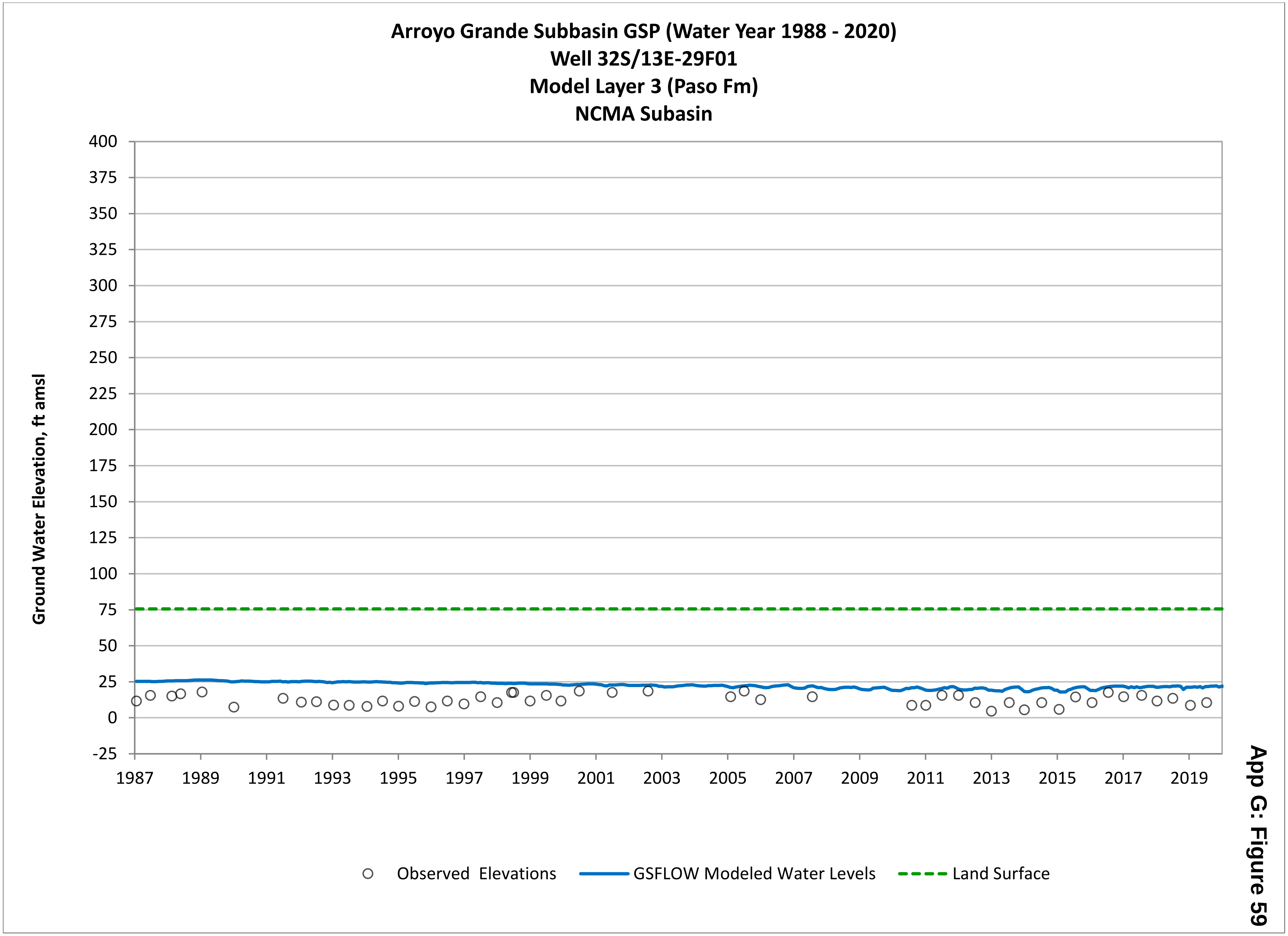

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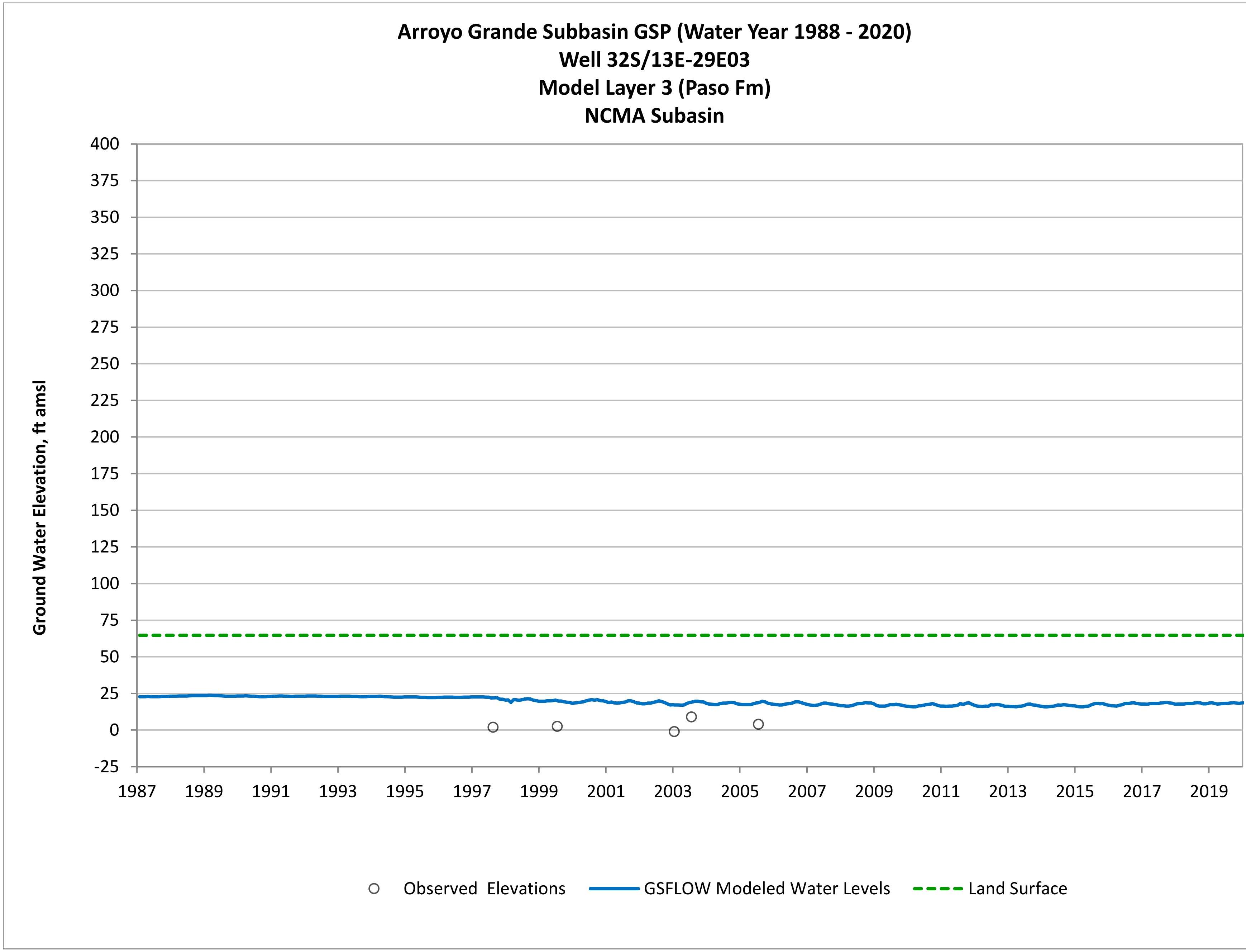

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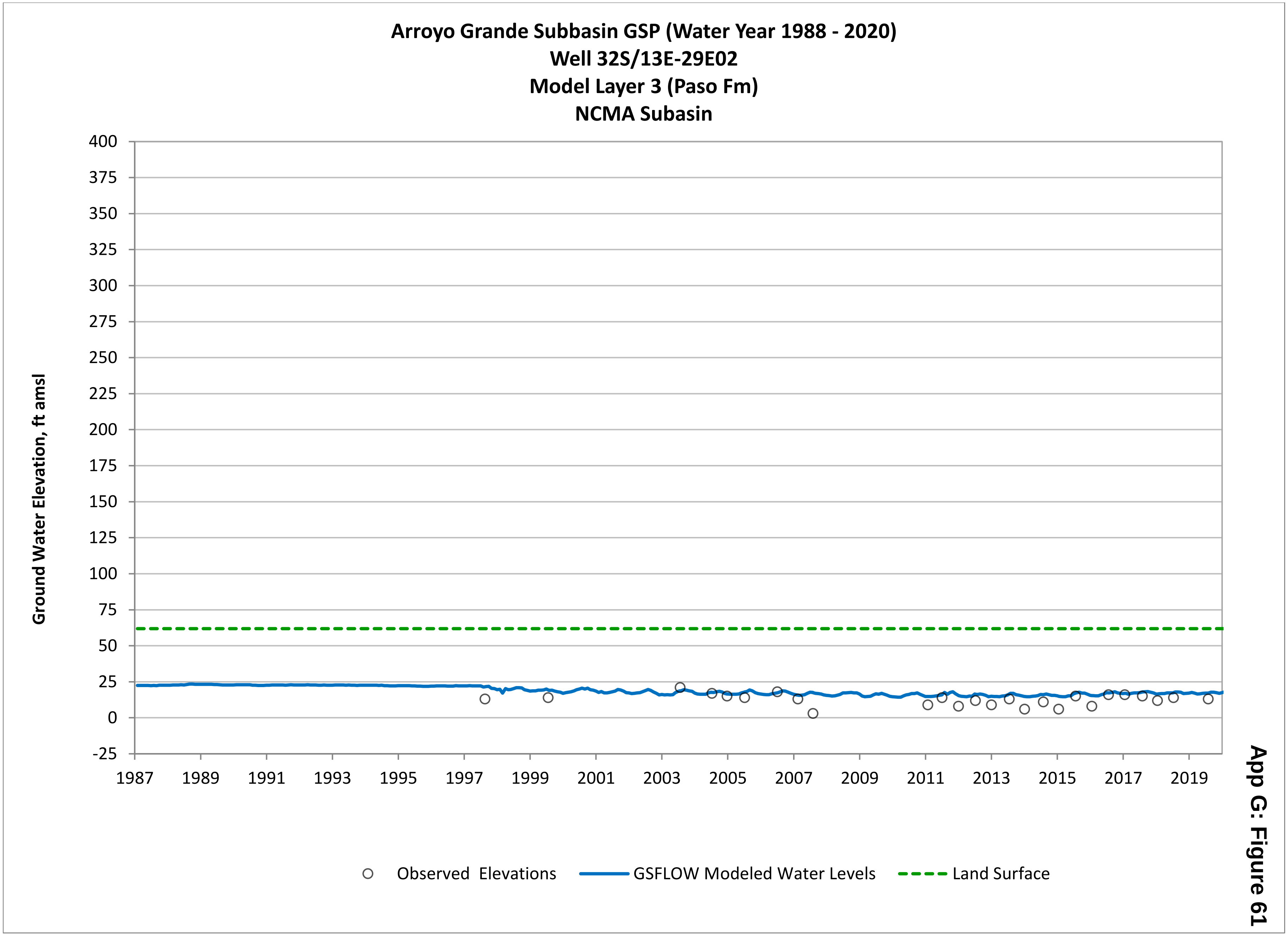

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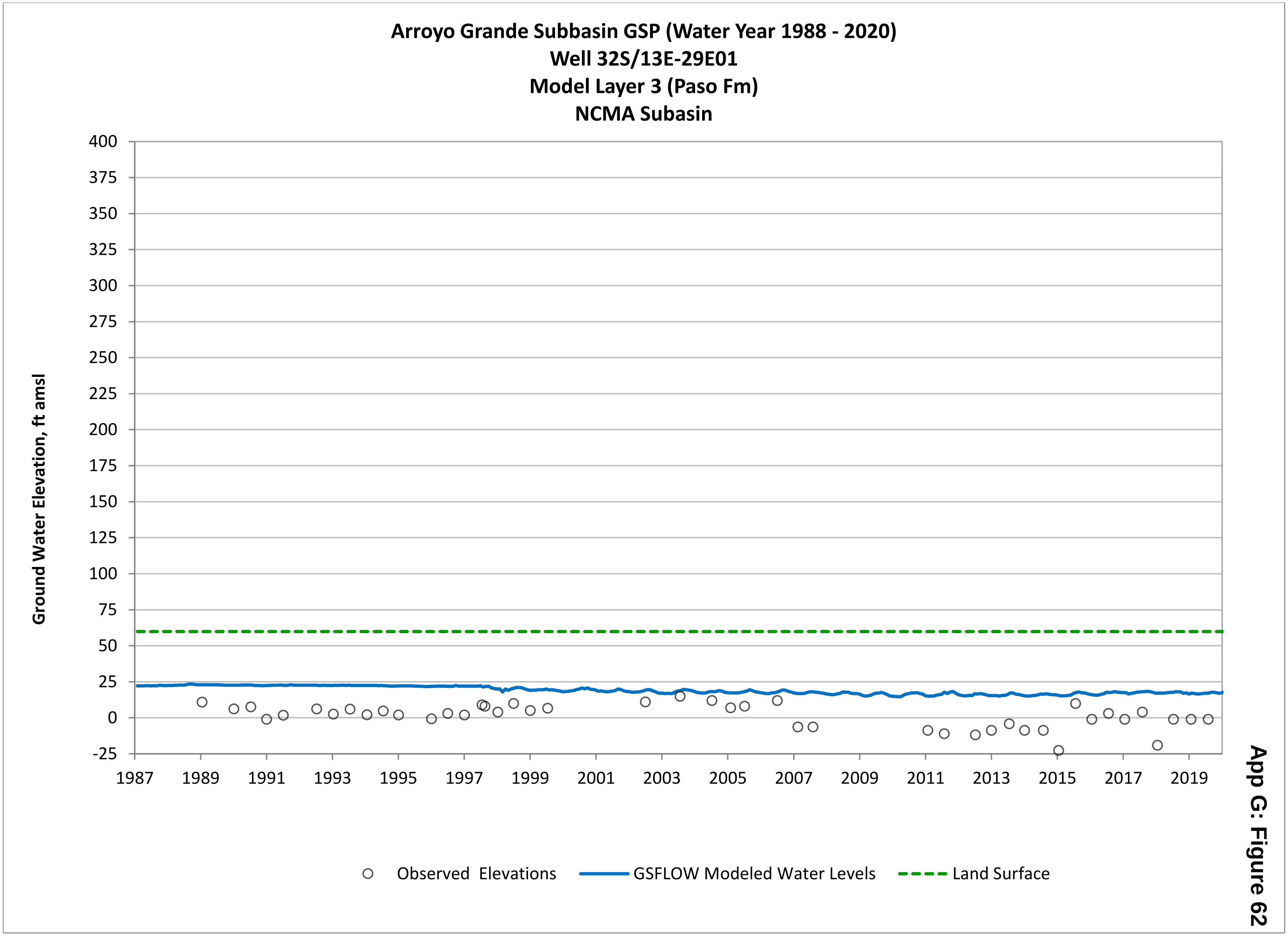

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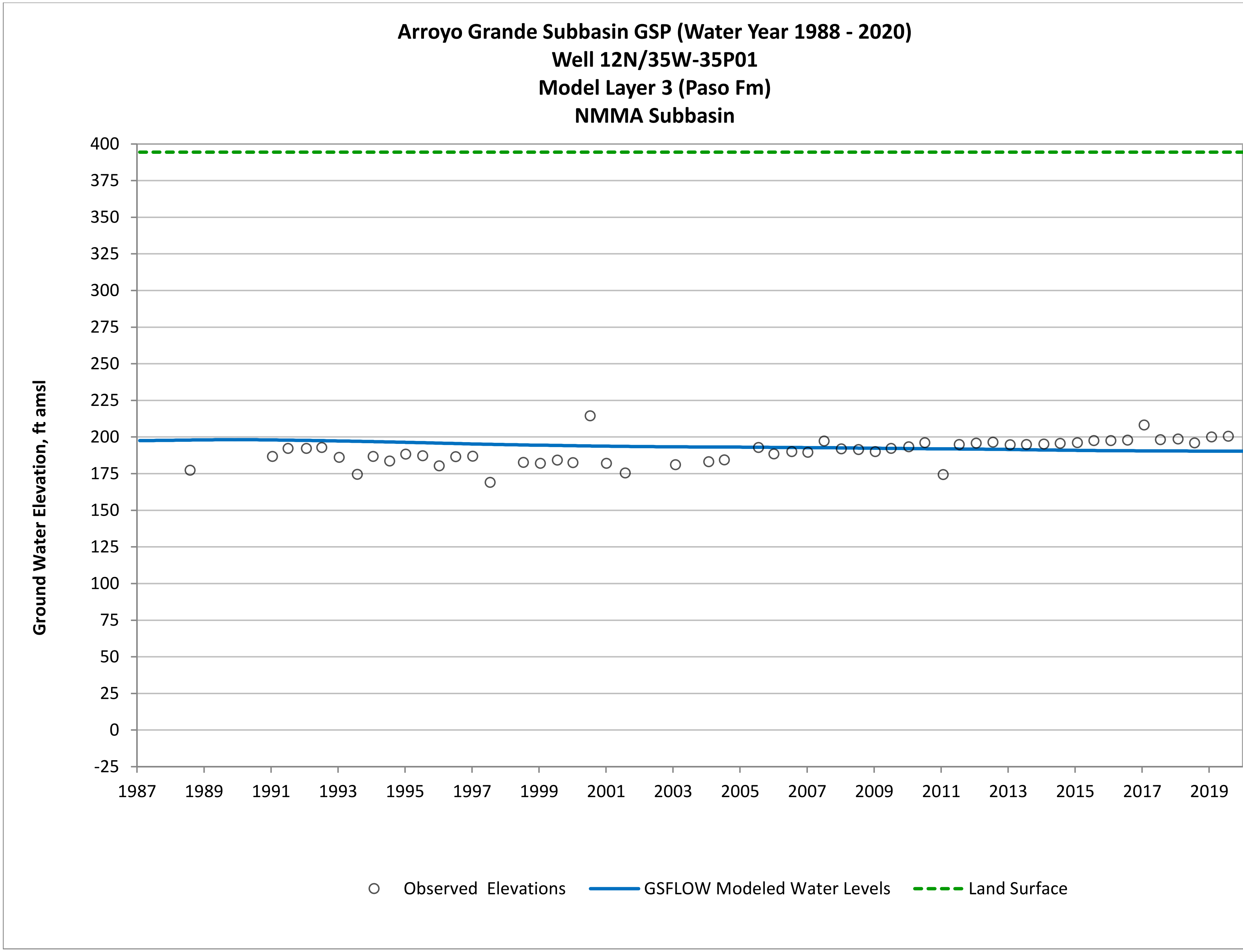

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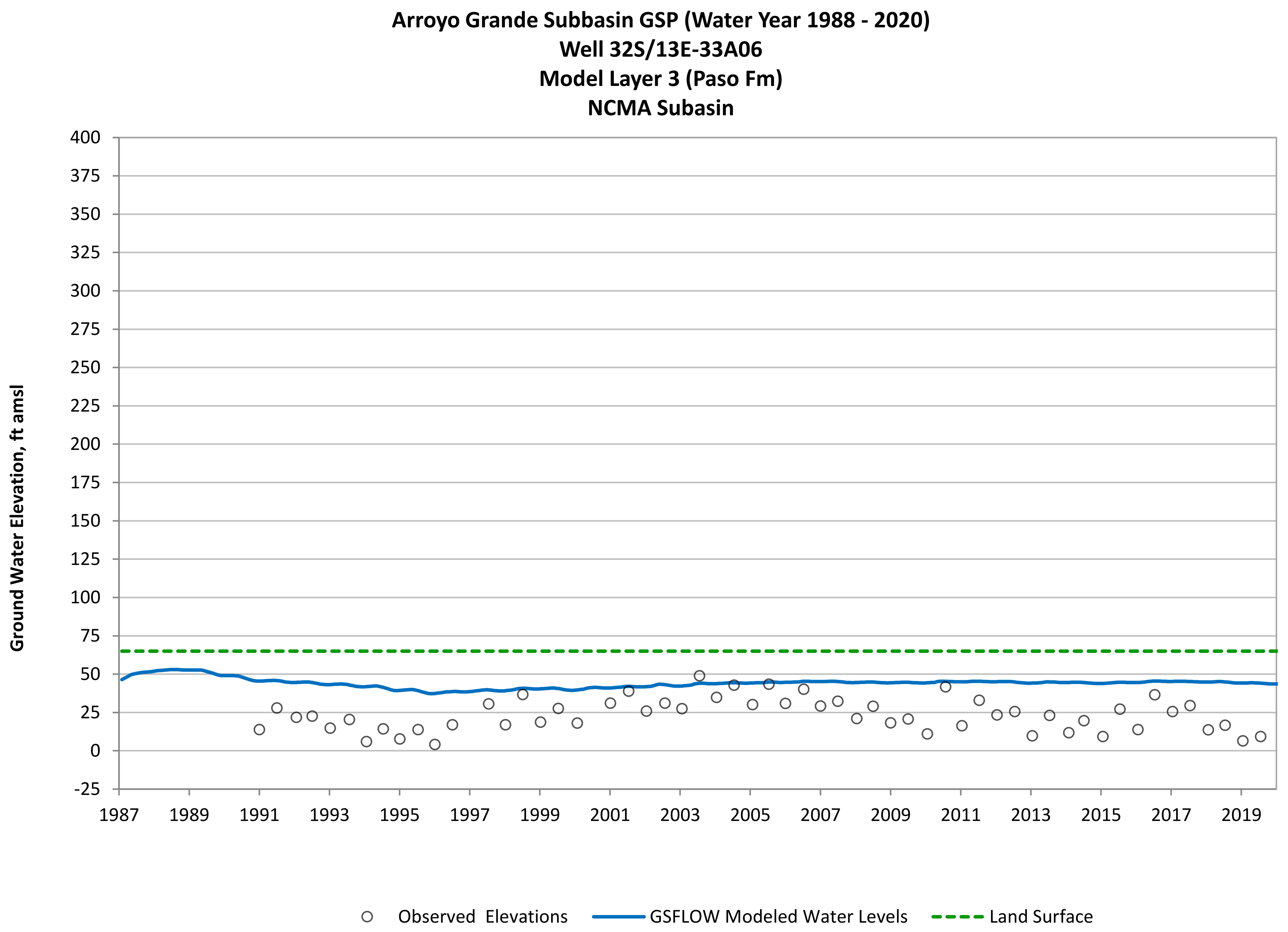

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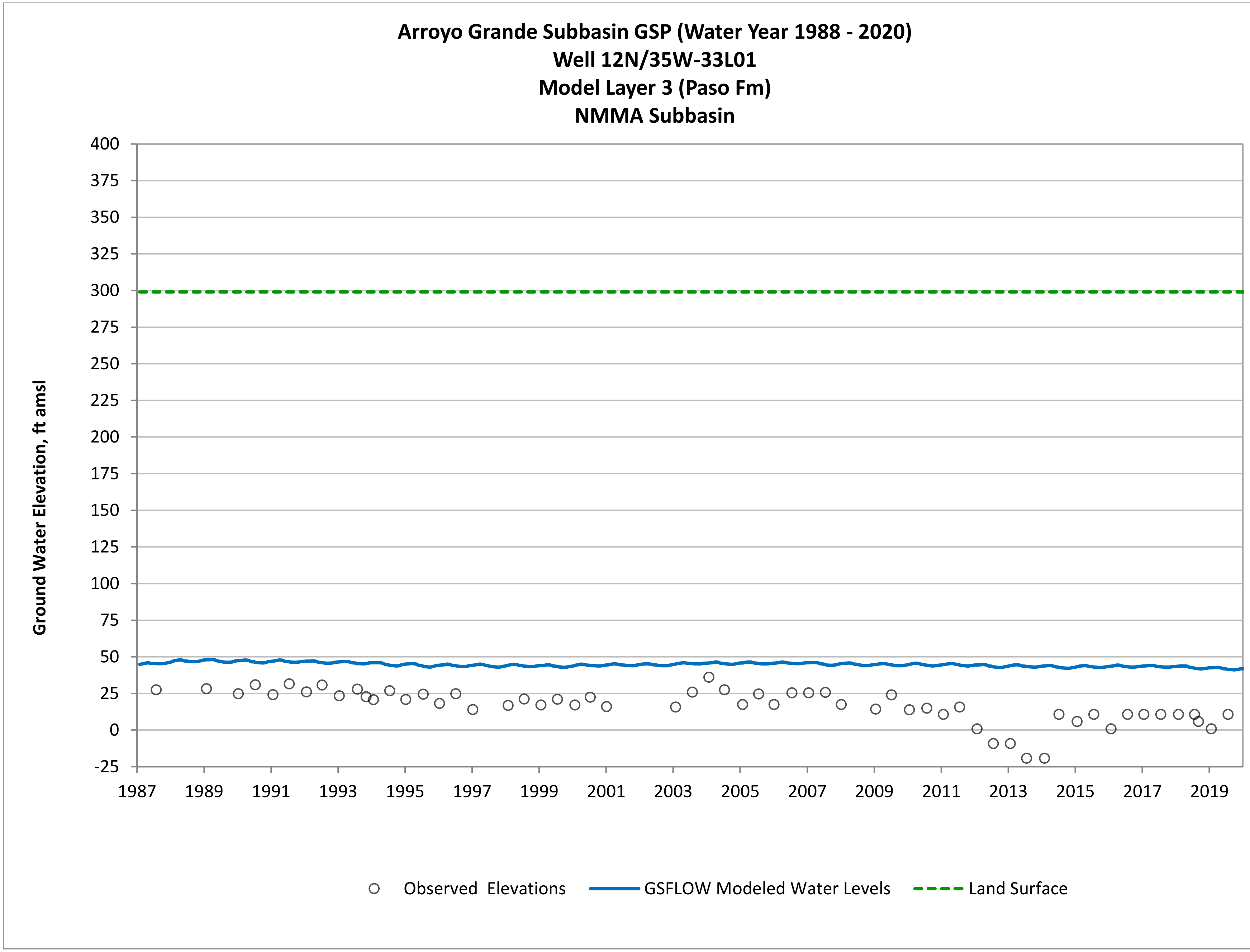

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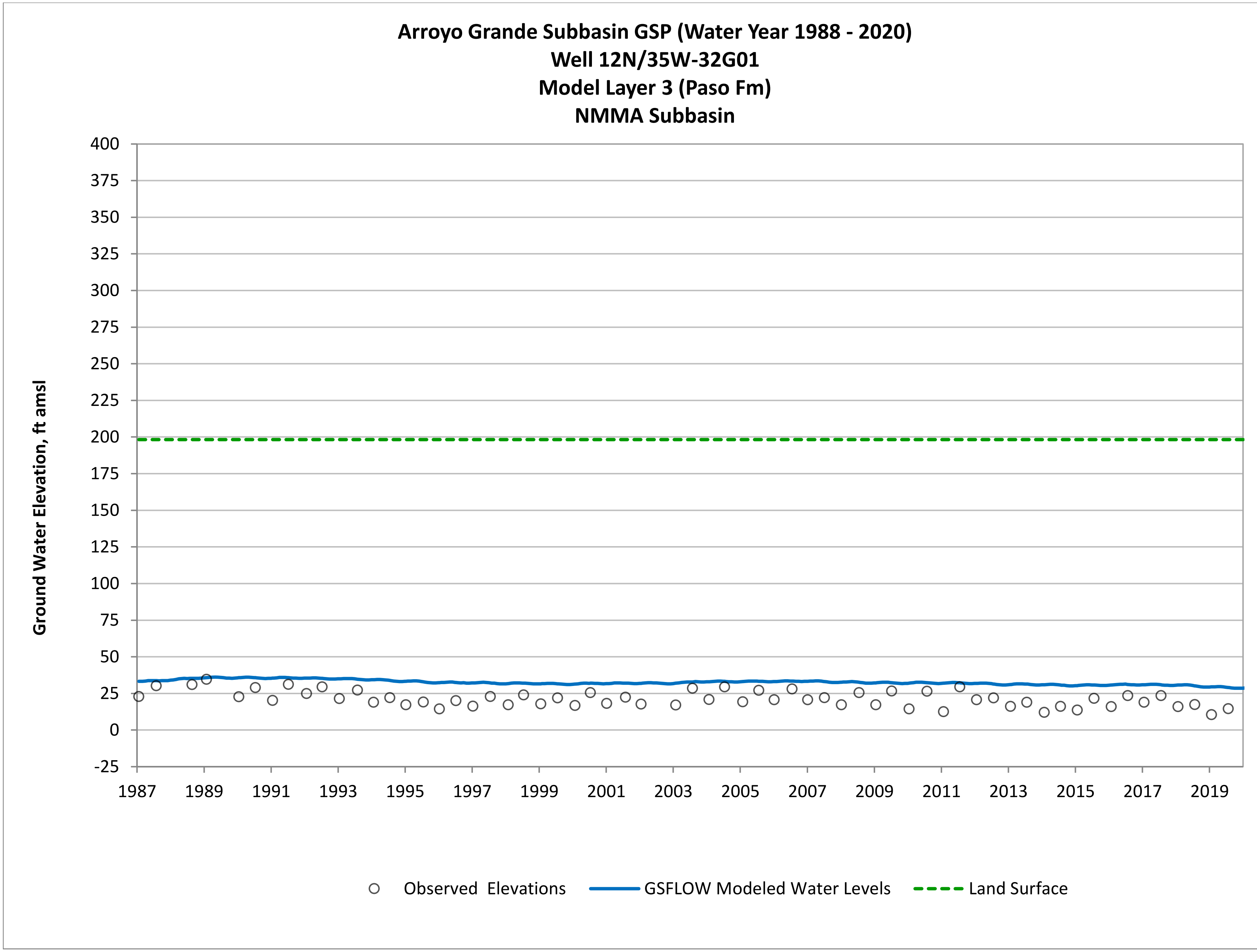

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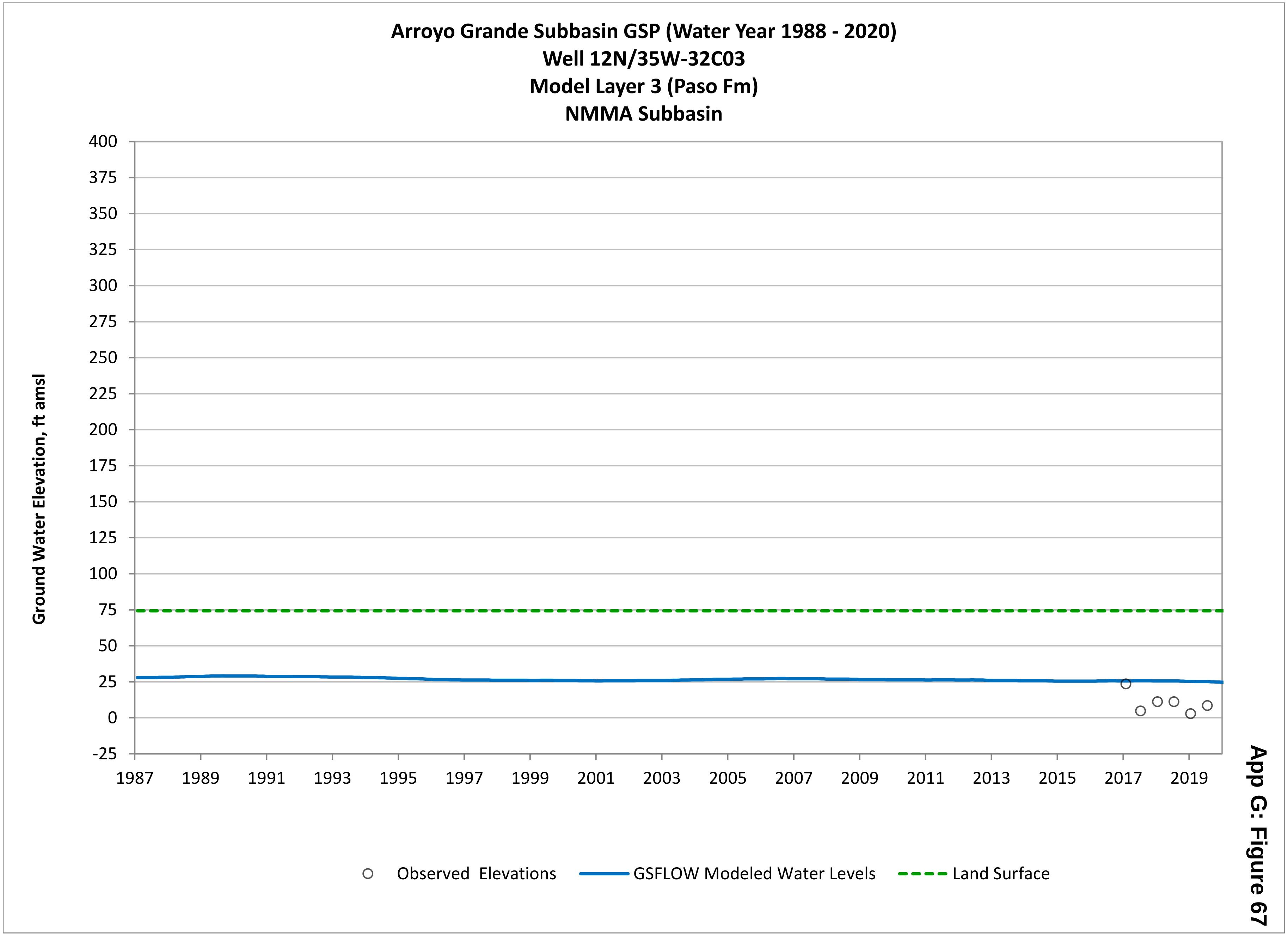

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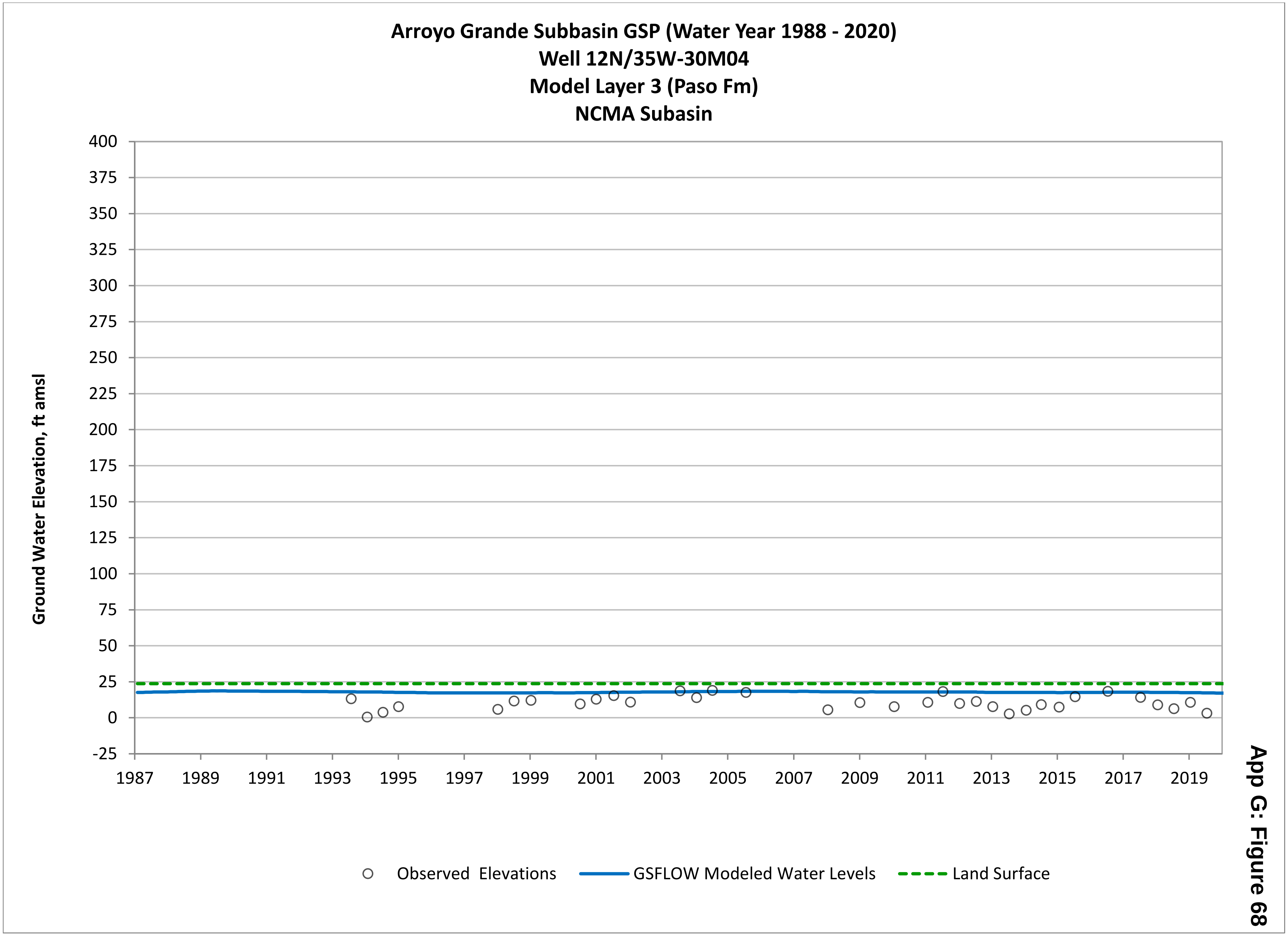

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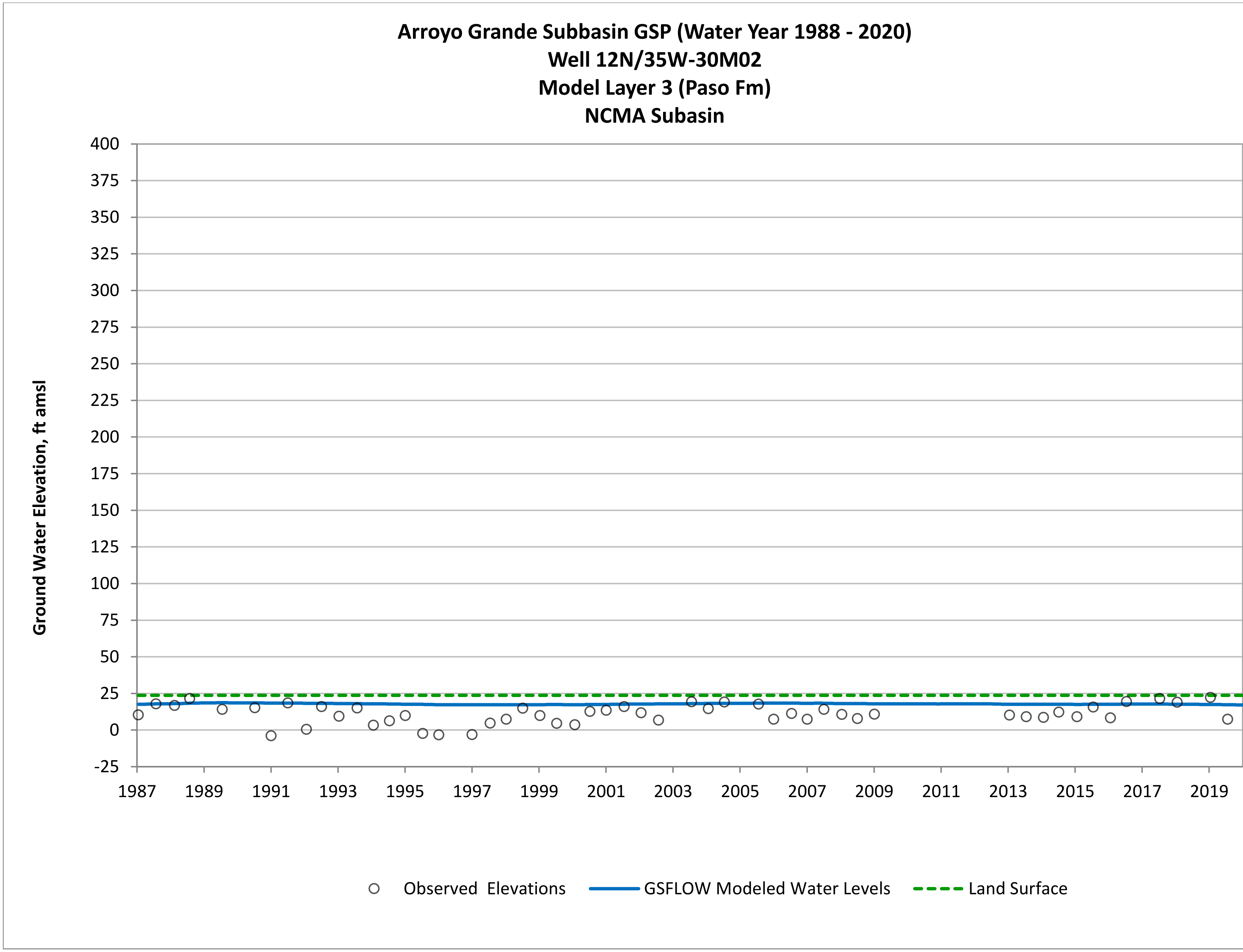

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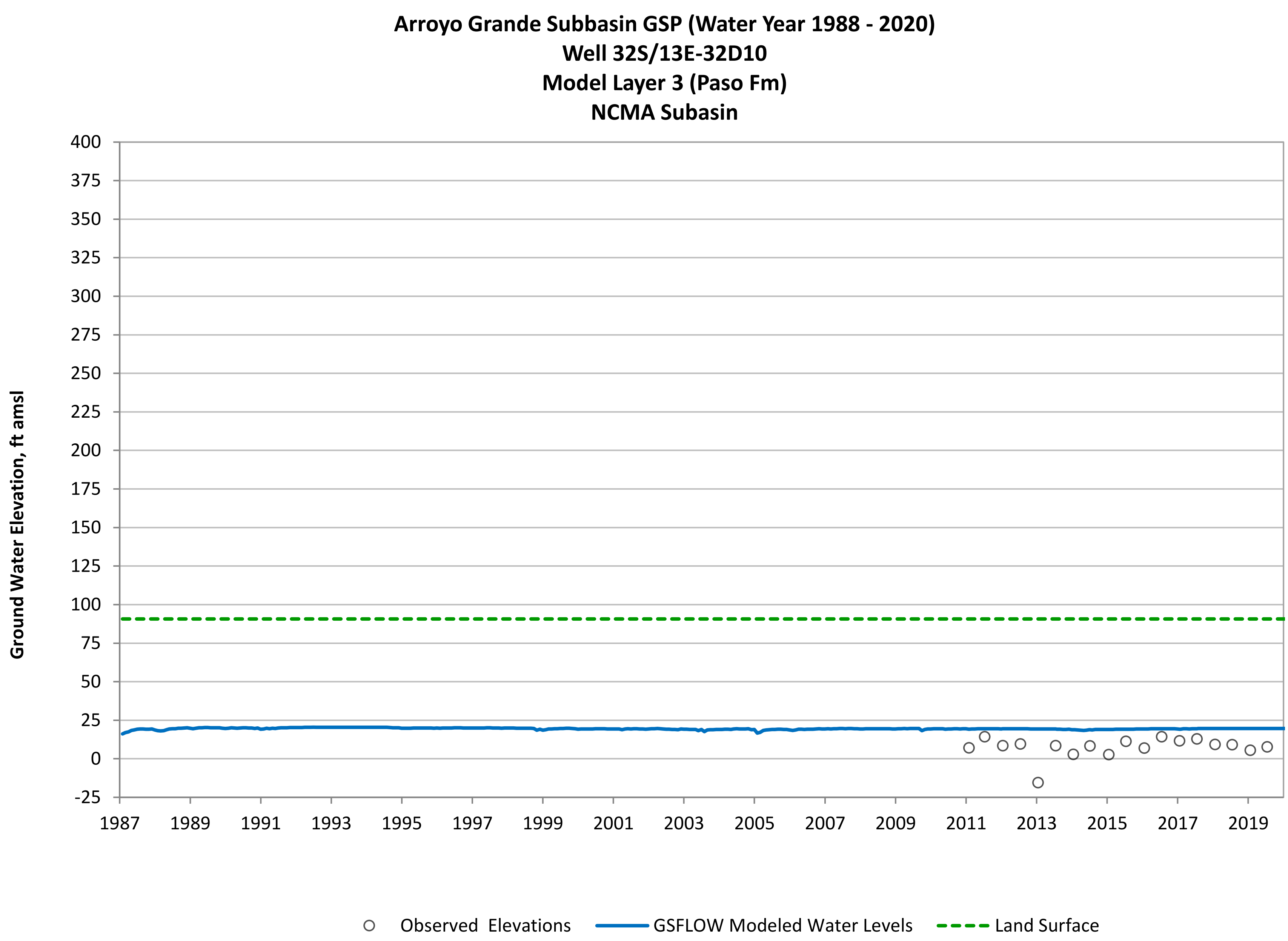

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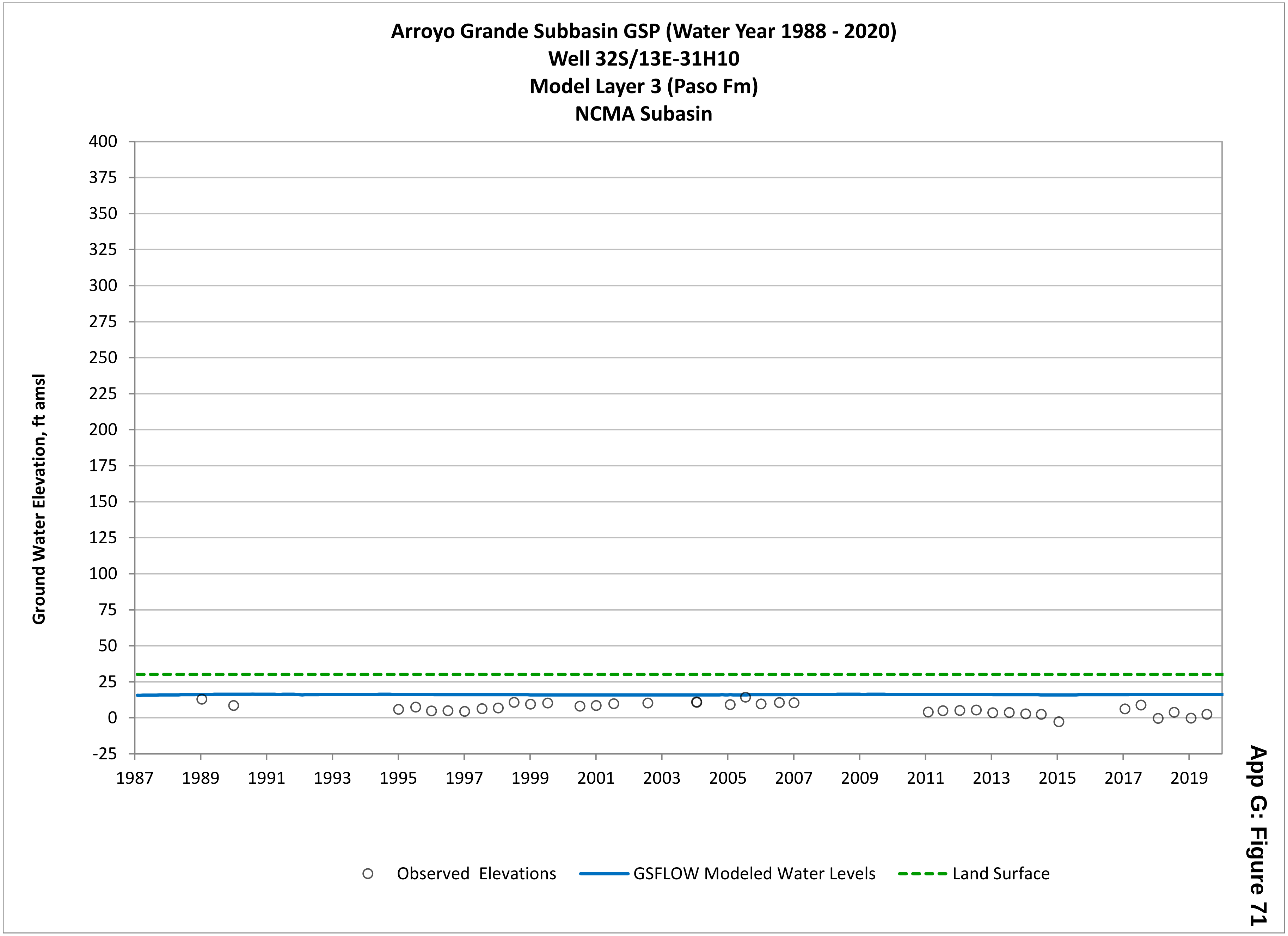

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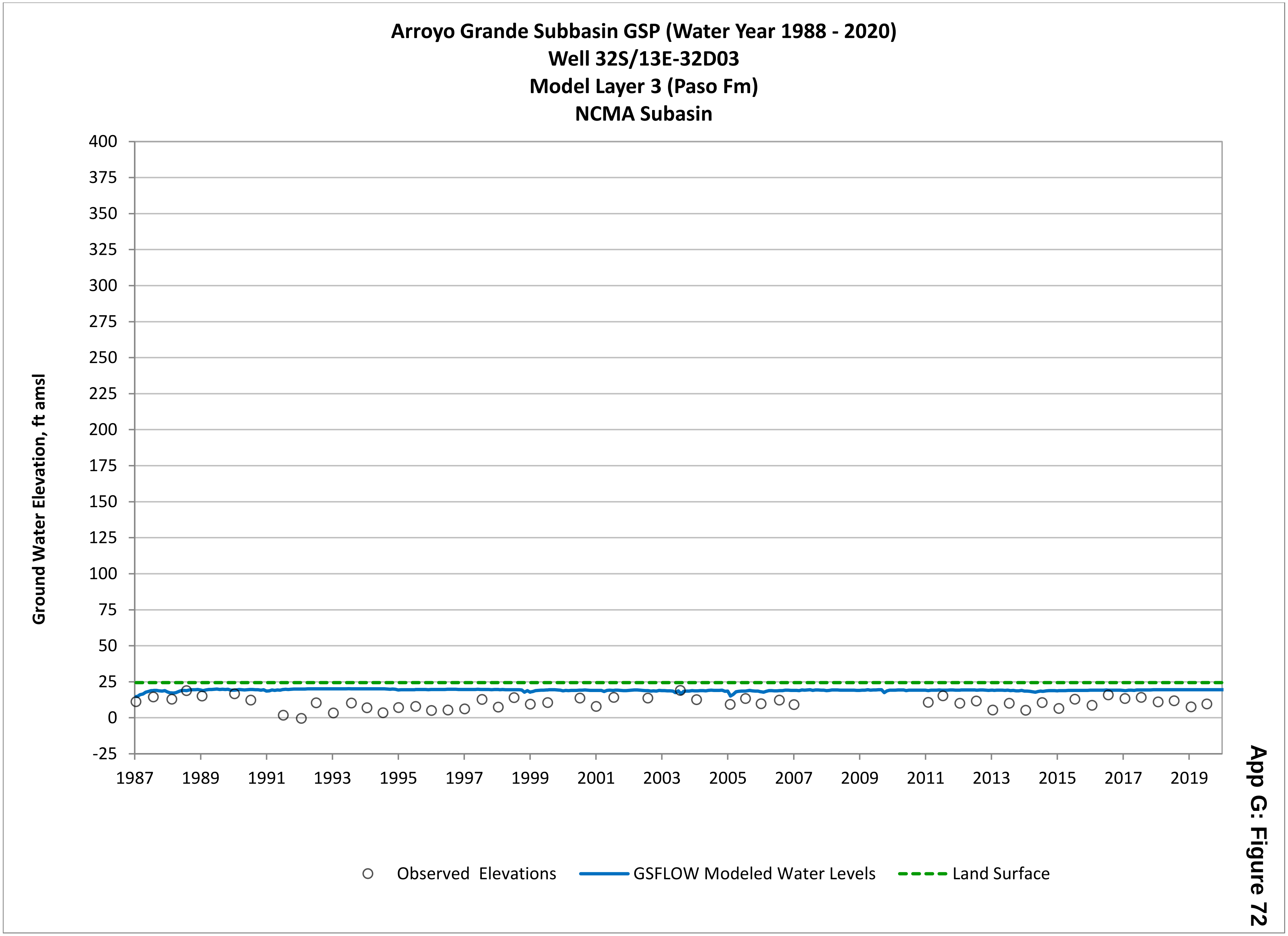

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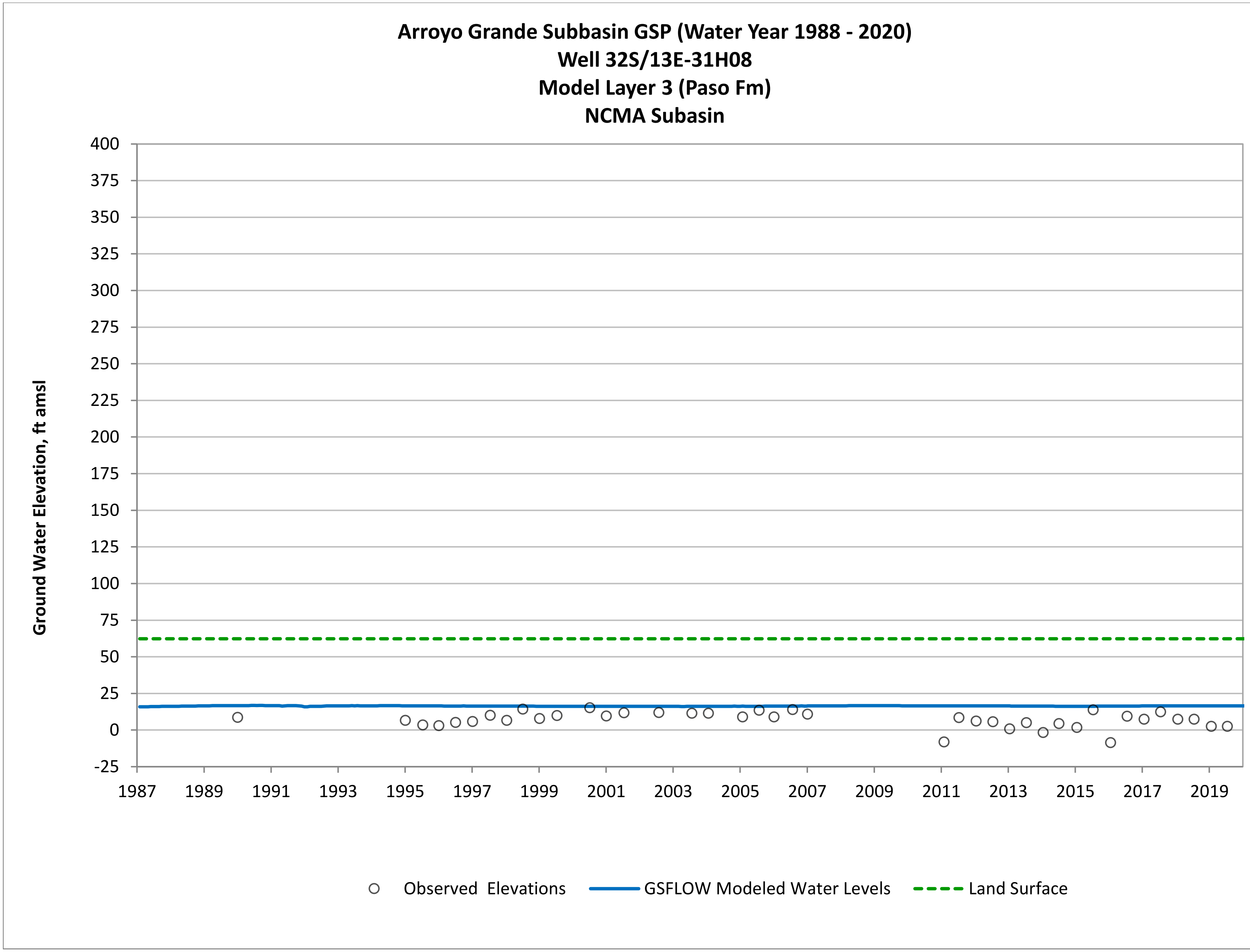

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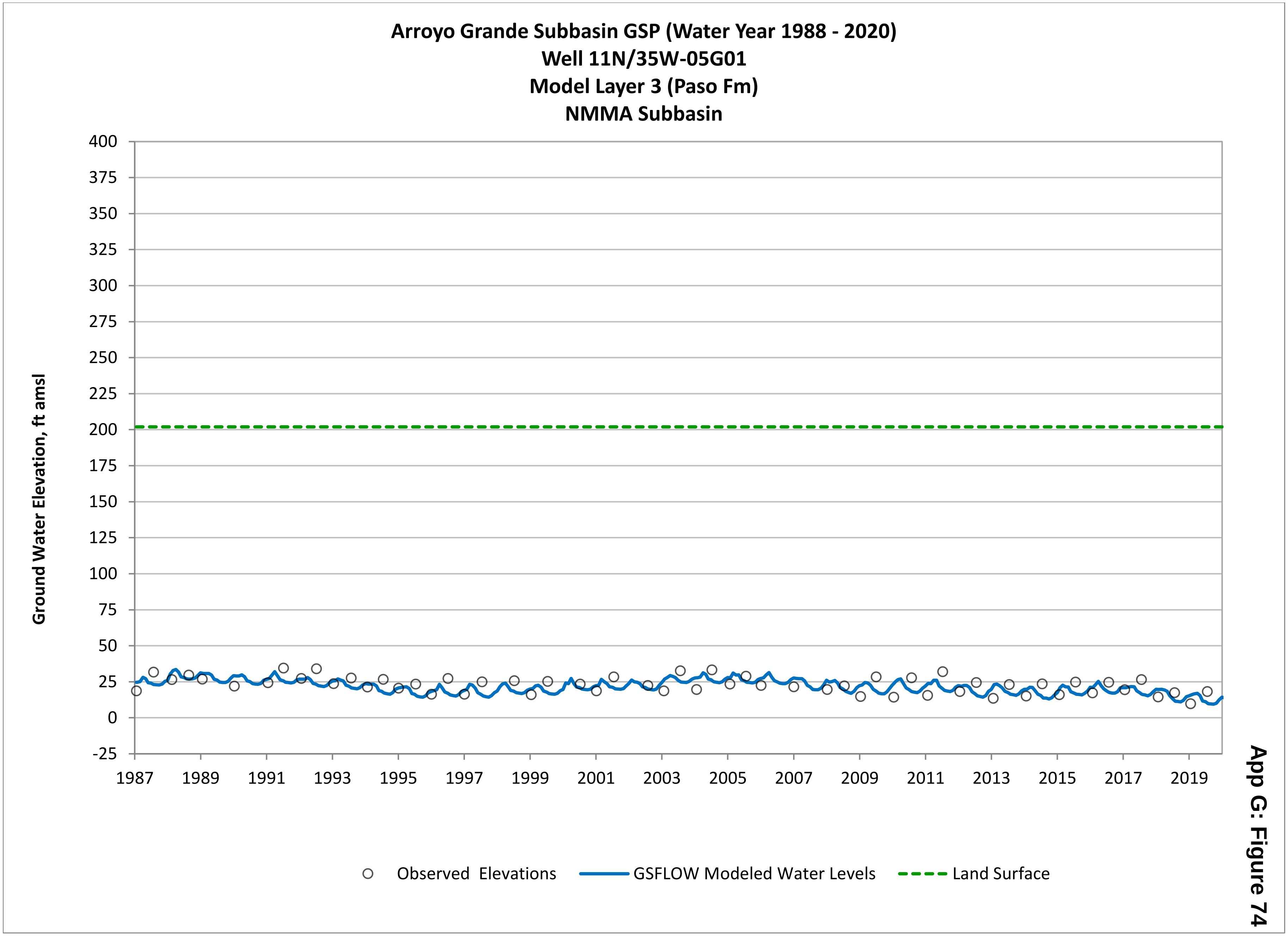

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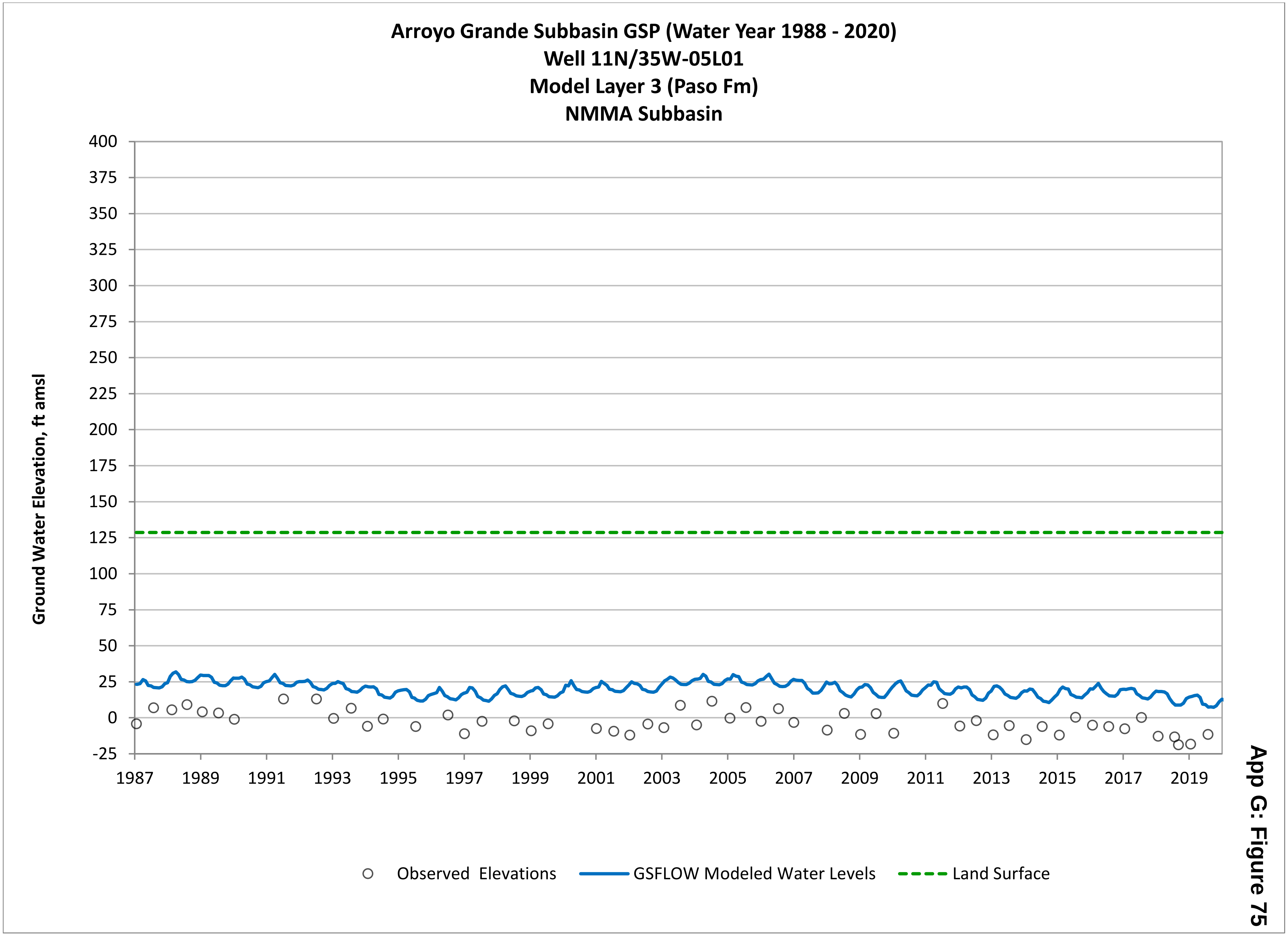

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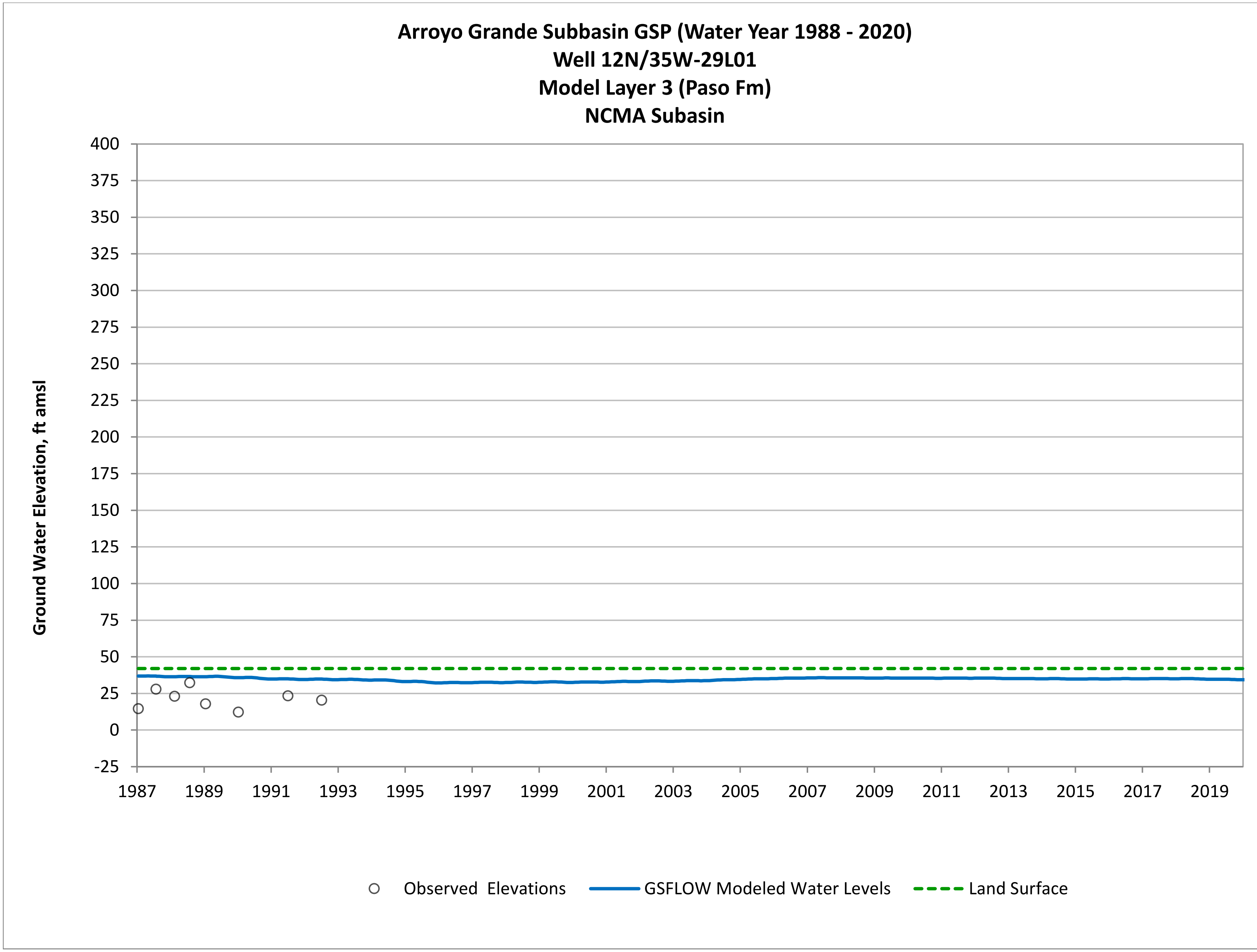

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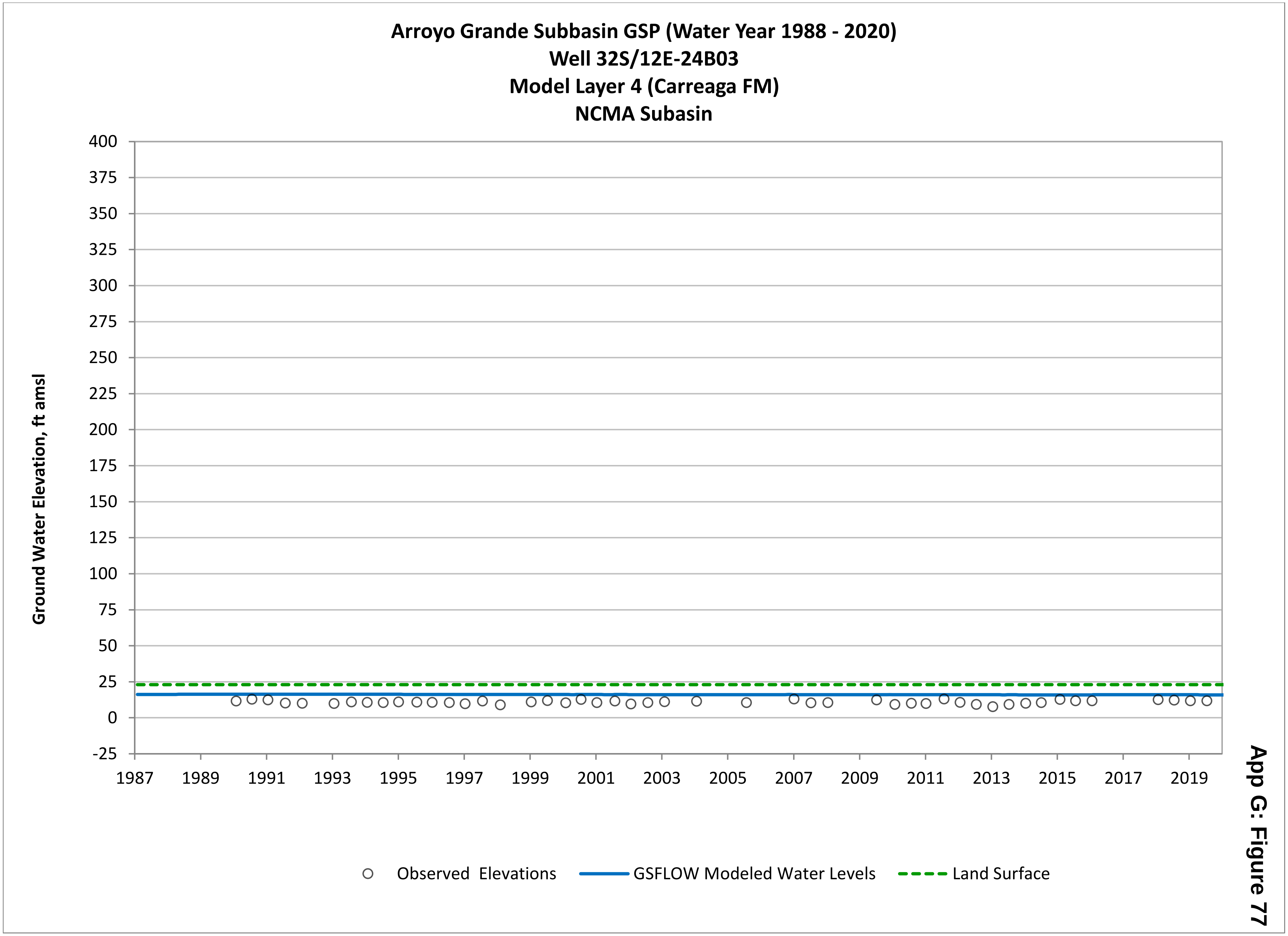

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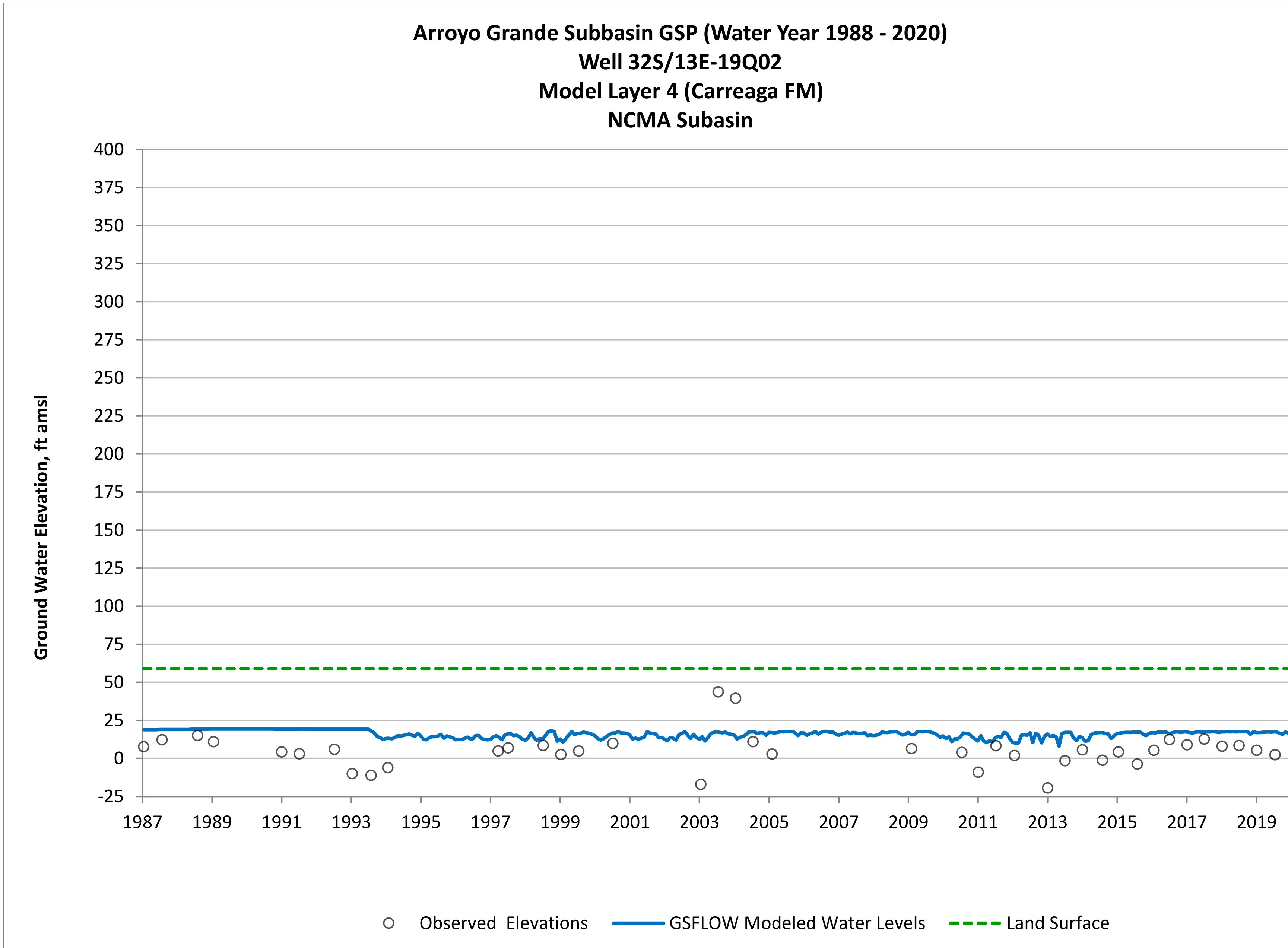

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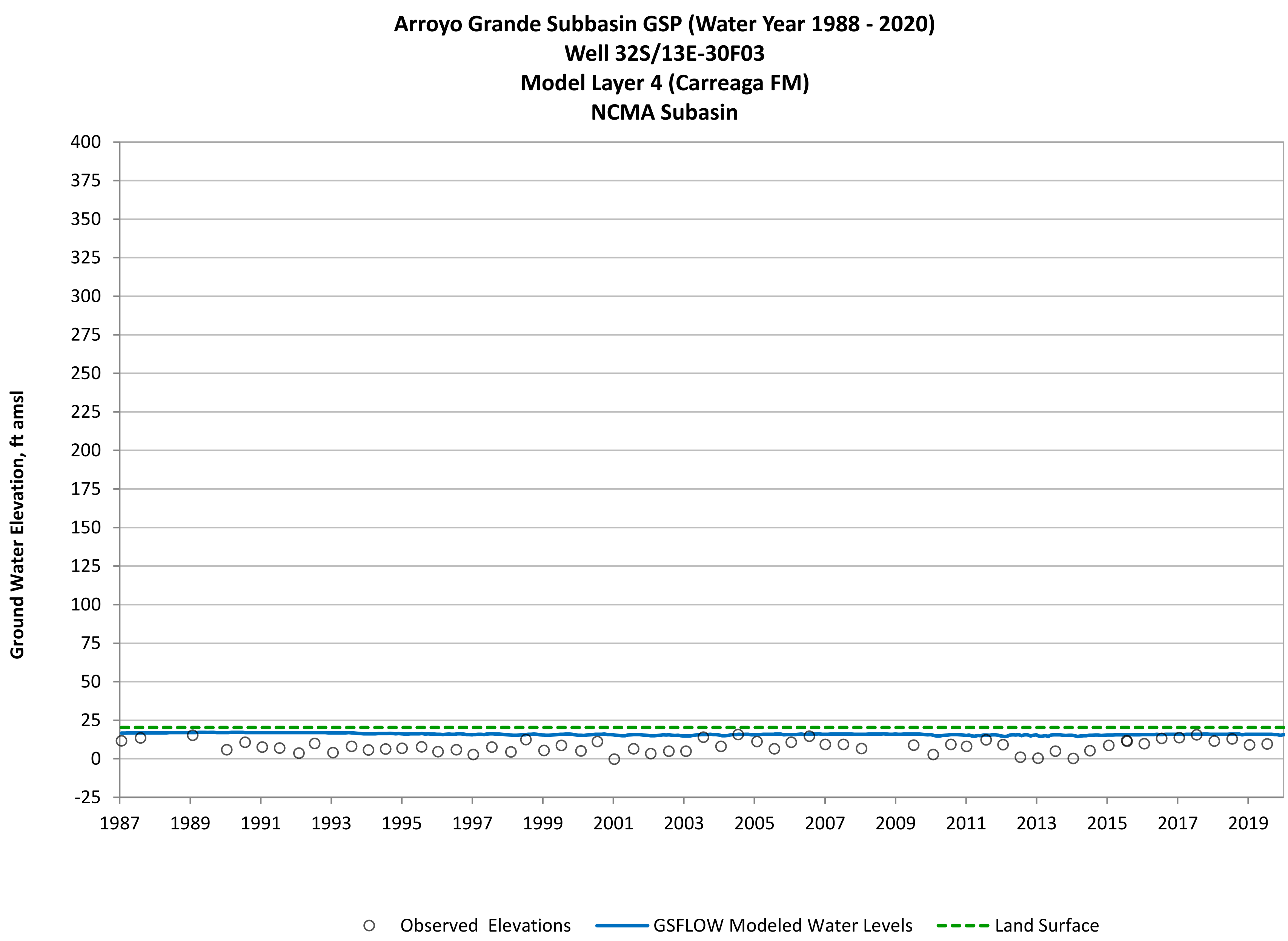

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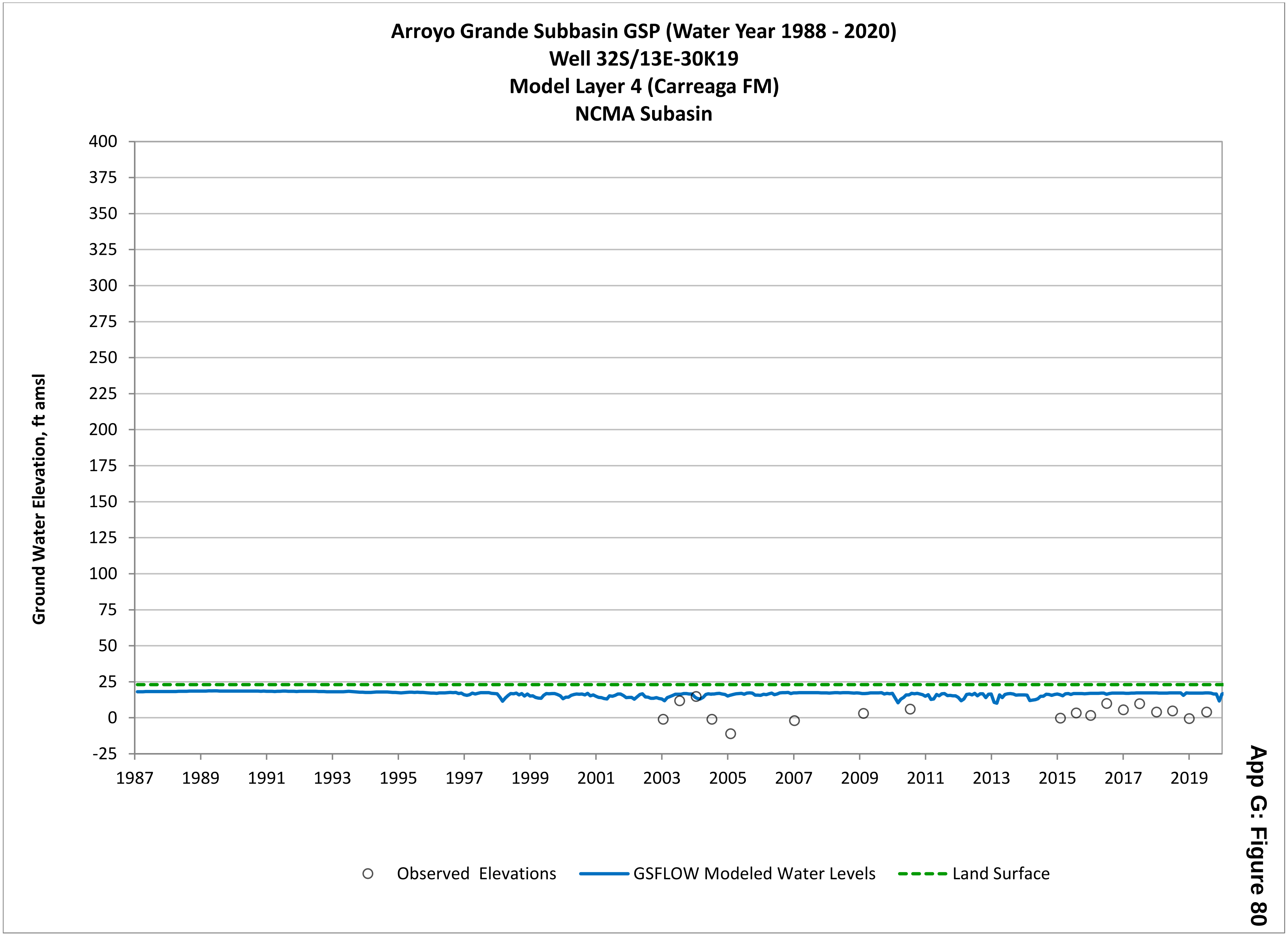

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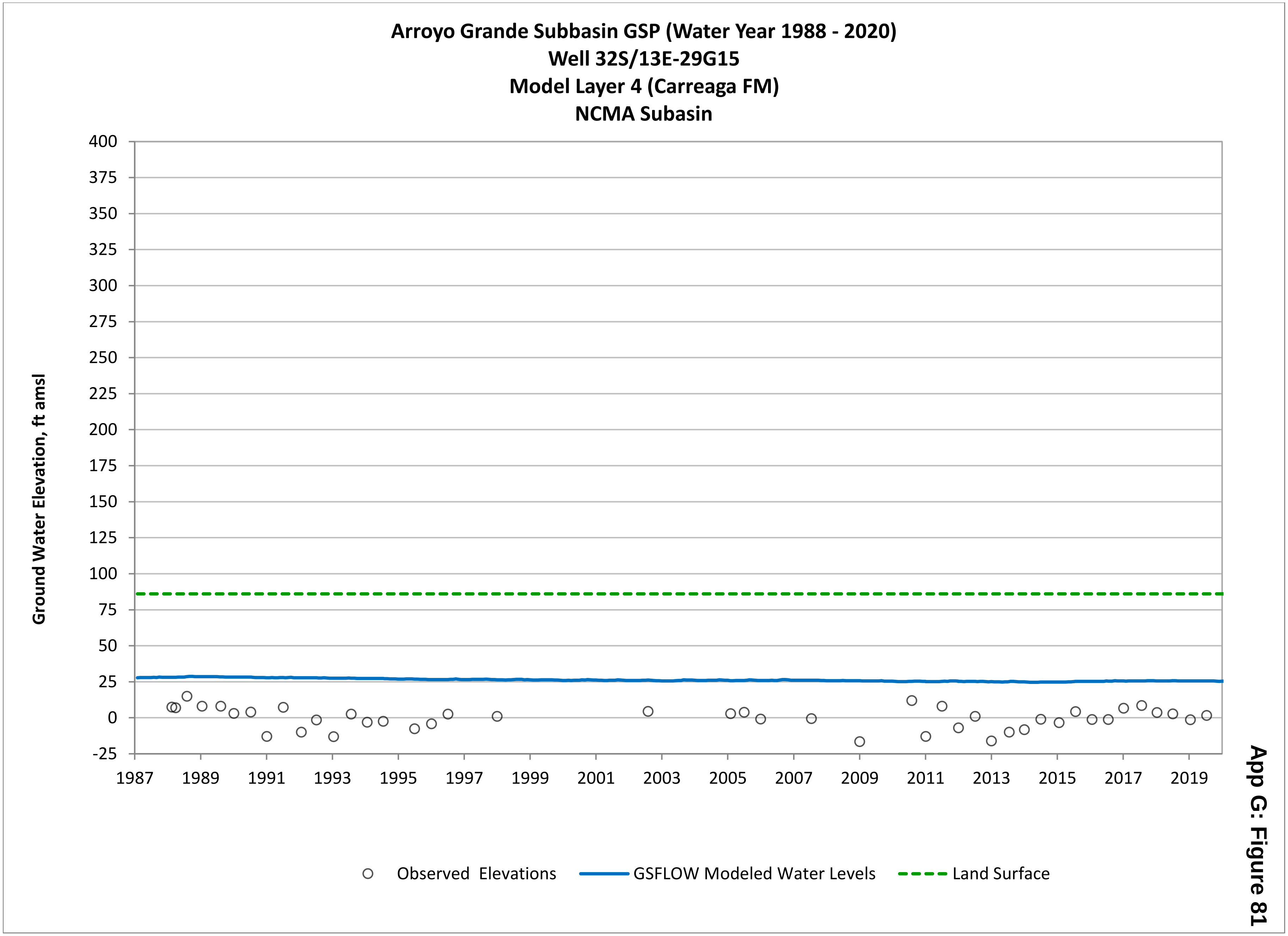

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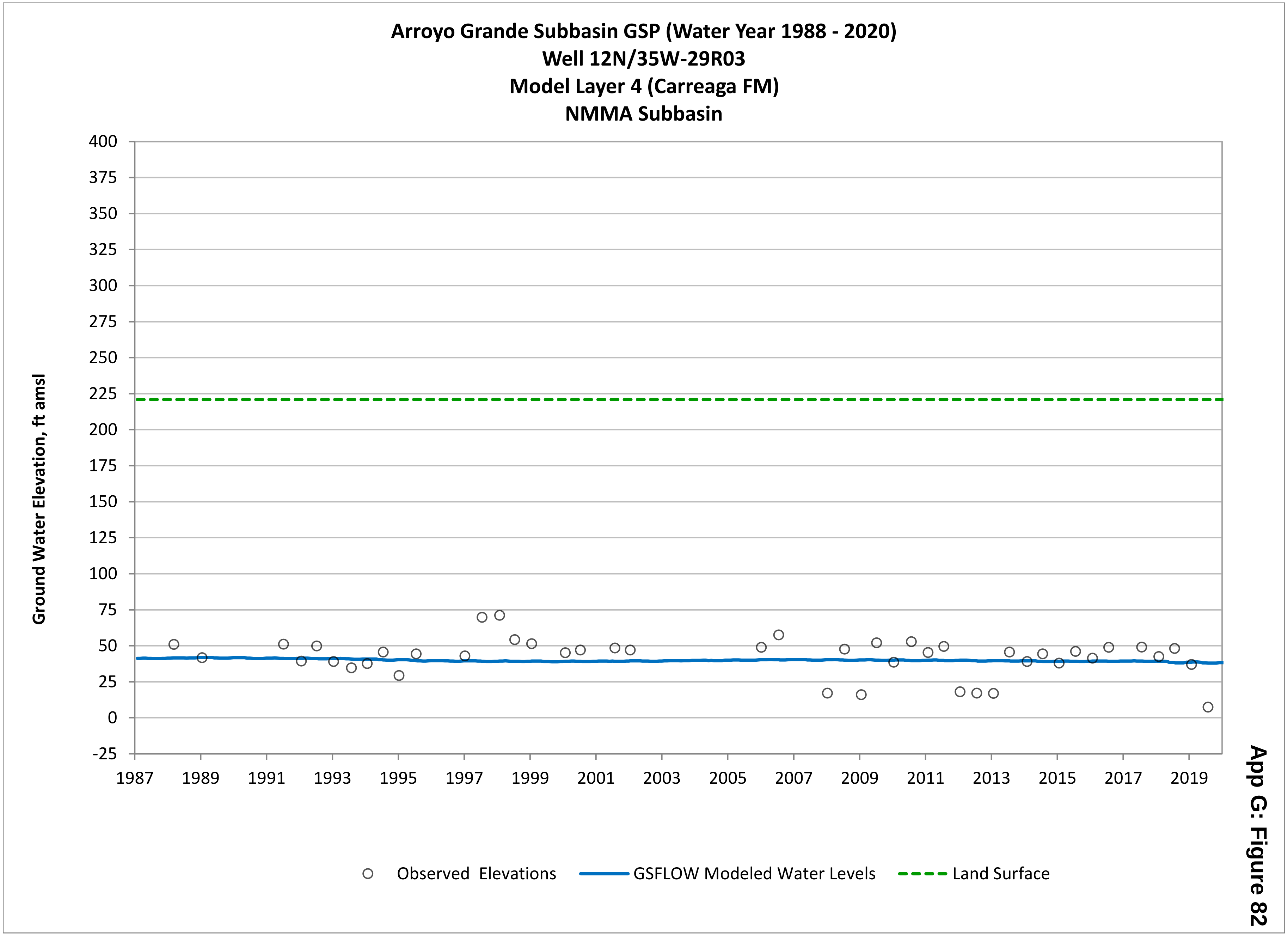

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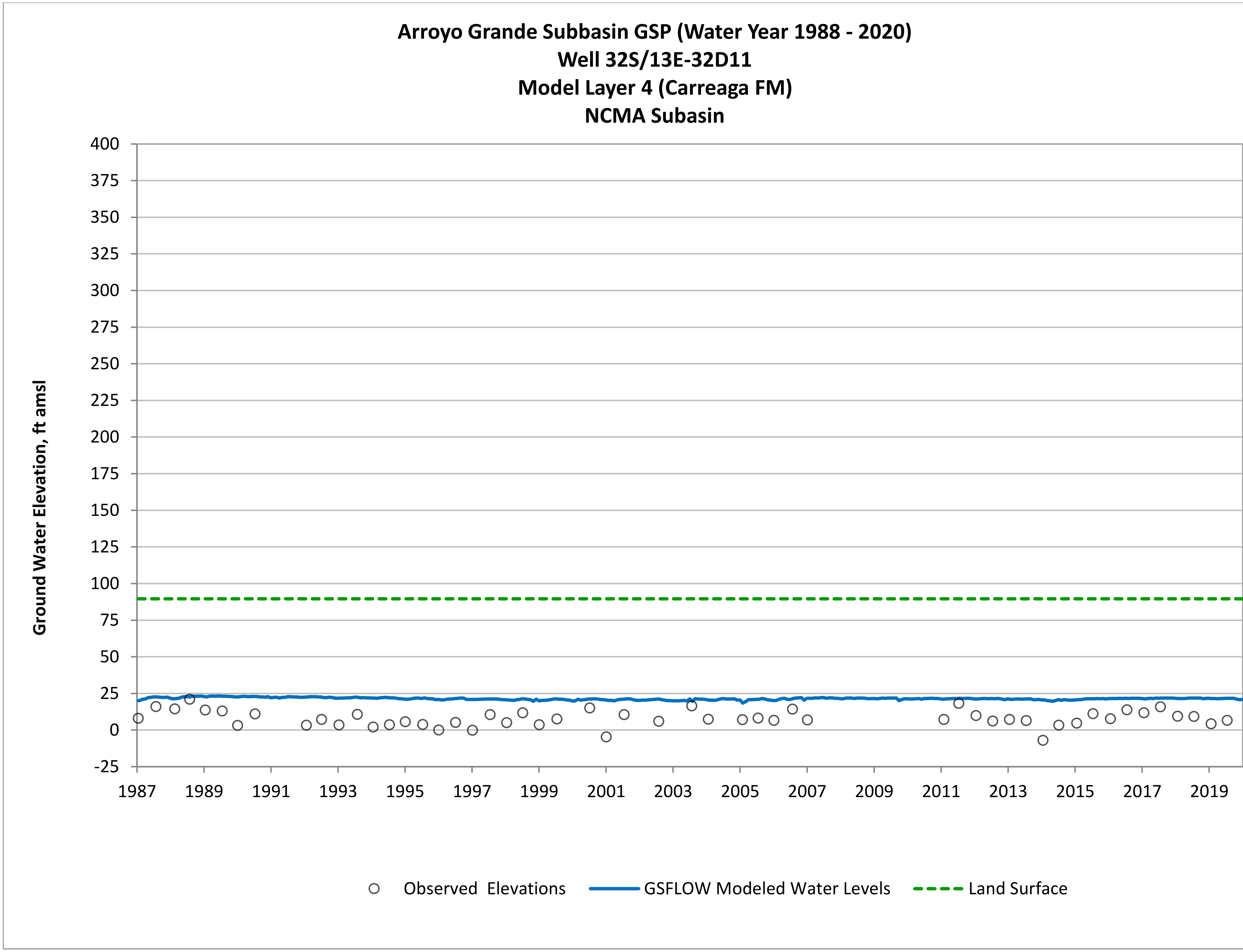

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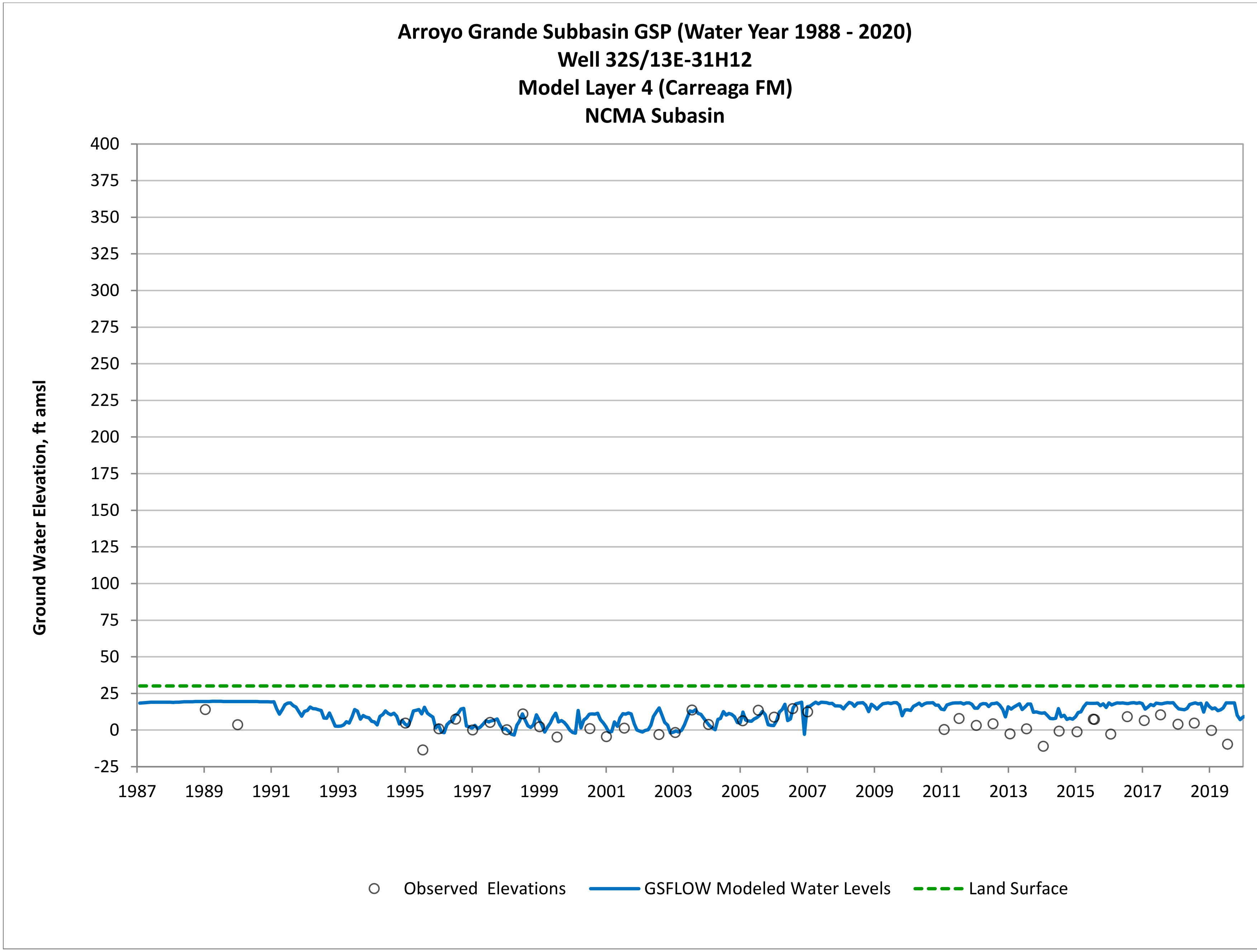

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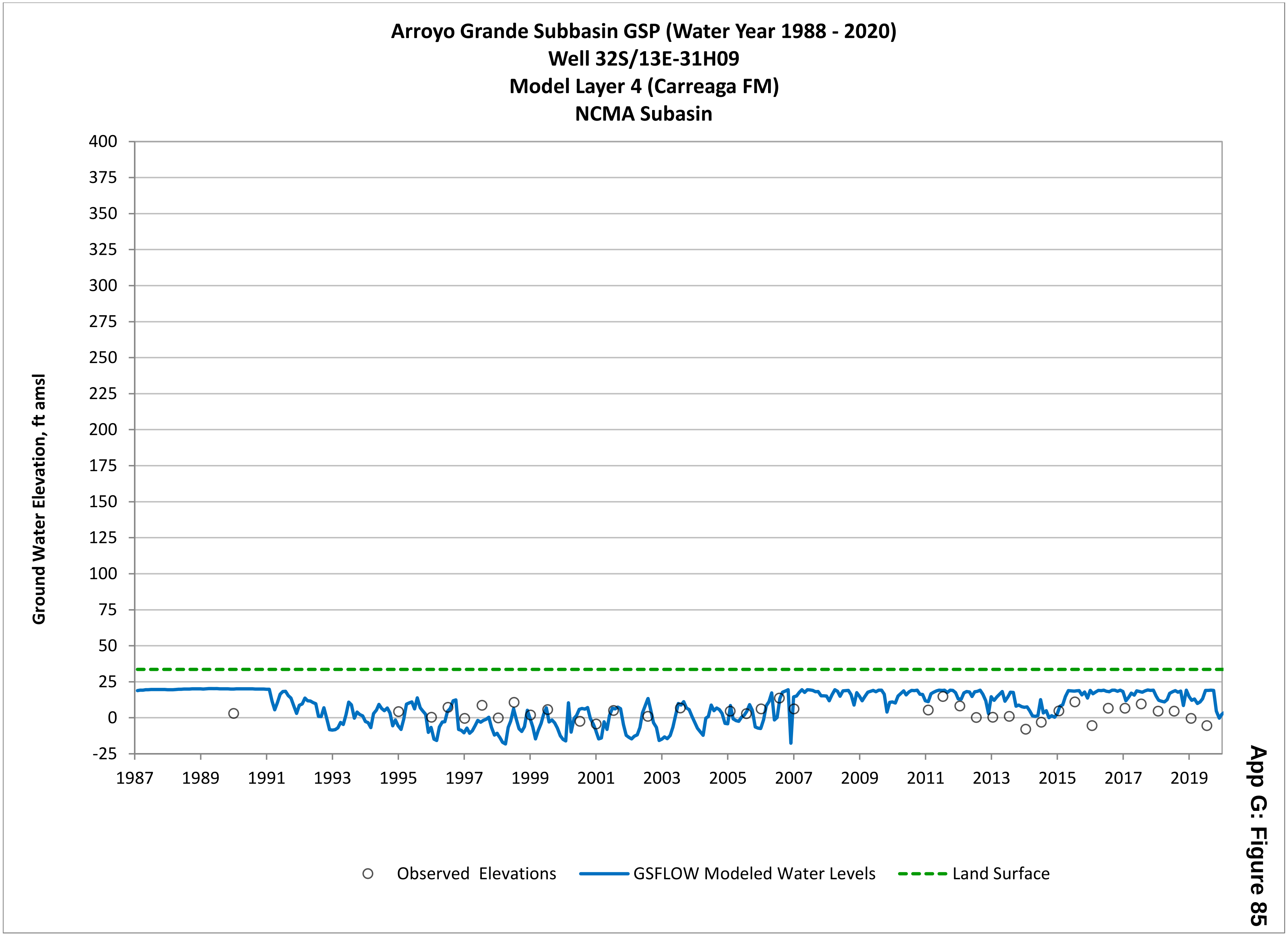

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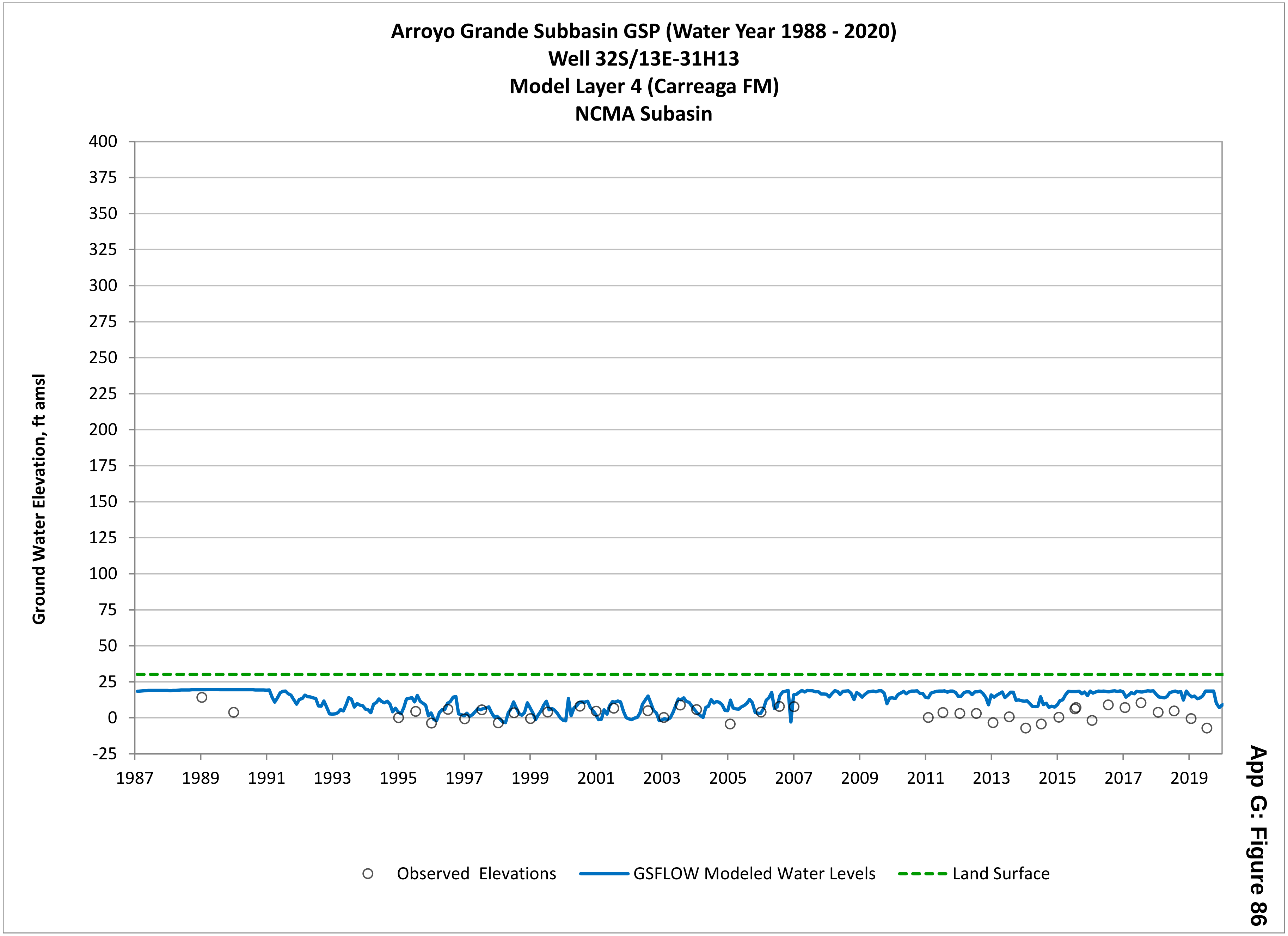

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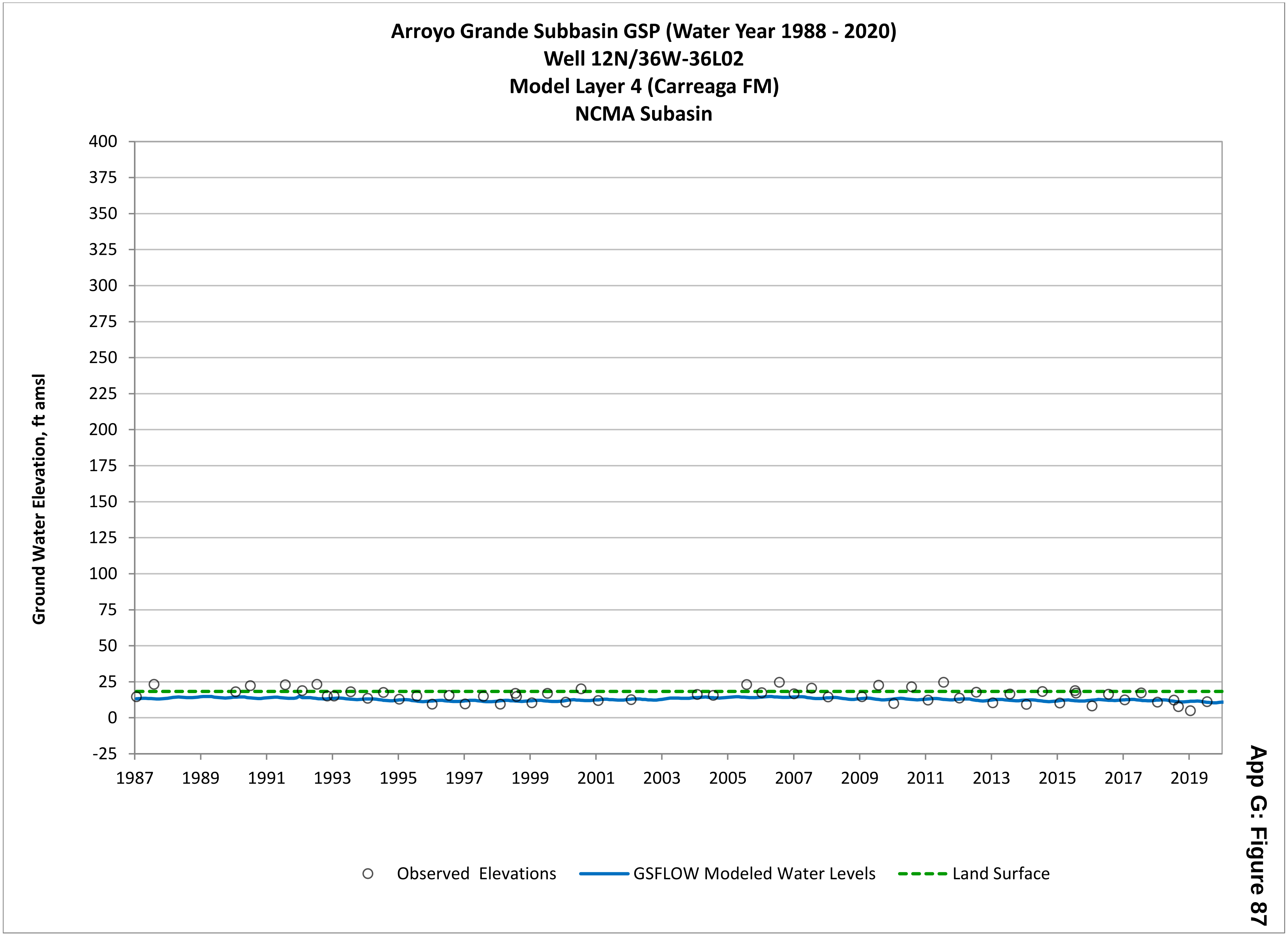

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Appendix B Development of a MODSIM Modeling for Conjunctive Surface and Ground water simulation in the Arroyo Grande Creek Basin

Topic: ***Development of a MODSIM Modeling for Conjunctive Surface and Ground water simulation in the Arroyo Grande Creek Basin***
Project: ***SLO County GSFLOW Modeling Support***
Date: ***September 30, 2022***
By: ***Enrique Triana and Paul Micheletty***

This memo outlines and summarizes the MODSIM implementation of the water system for the San Luis Obispo County Flood Control and Water Conservation District.

1 Introduction

This modeling effort attempts to build a system that increases the detail in representing the conjunctive surface and groundwater system in the Arroyo Grande Creek Basin. The Groundwater Sustainability Plan developed a GSFLOW model (Markstrom et al., 2008) which couples PRMS, to represent the rainfall-runoff processes, and MODFLOW, to represent water movement in the groundwater system. GSFLOW provides a detailed representation of the stream-aquifer interaction, based on the conditions in the aquifer and the water flowing in the surface water. In turn, the surface water operations, including storage operations, water accounts, flow requirements and diversions under priority, drives the water flows in the surface water system. MODSIM (Labadie, 2005), a river basin decision support system developed by Colorado State University, is coupled with GSFLOW to incorporate the simulated stream-aquifer interaction (i.e., gains and losses to the streams) in the simulation of the surface water system and provide GSFLOW with information about surface water diversions and storage operations that affects the aquifer recharge, pumping and flow in each stream segment. In this basin, the surface water operations have been simulated in the OASIS model (Western Hydrologics, 2021), so the first step in the development of the conjunctive surface and groundwater modeling system is developing a MODSIM model that leverages the design, the elements and operational logic included in the OASIS model. The MODSIM model developed in the first step is then converted to a model that is synchronized with the GSFLOW stream network and contains the elements and the operational logic to enable the coupled simulation and estimate the system behavior and resulting operations to changes in hydrology, water use.

2 MODSIM Model Structure and Logic

The MODSIM model structure in the phase of the project is based off the OASIS model developed by Western Hydrologics. The goals of this water system model operations are to meet to all the historical consumptive demands while maintaining balance on the water sources distribution, minimum release requirements, reservoir storage pools, and physical system constraints (ECORP Consulting, Inc., 2015). The MODSIM model was also set up with water-user account reservations to simulate ownership and exclusive use of the storage water. Figure 1 shows a schematic of the full MODSIM modeling network for the Lopez Water Project. The blue dots are nodes or points of interest (i.e., junctions, diversion points, inflow points, etc.). The red triangles represent reservoir objects, and the purple squares are demands. The black lines are links between objects and represents the flow of water (i.e., river reach, pipeline, canal, etc).

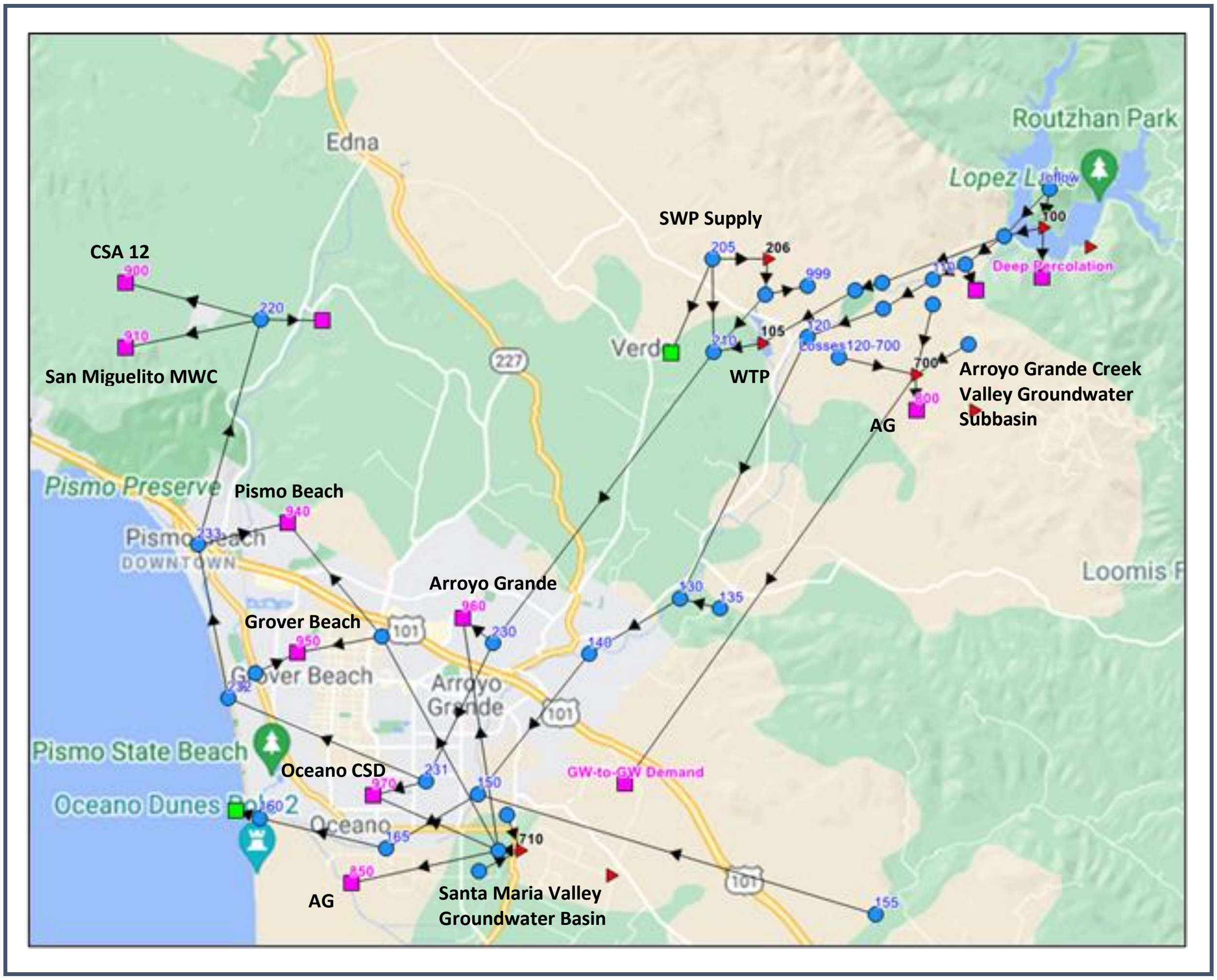

Figure 1. Lopez Water Project MODSIM model network

Operating constraints were built into the model to represent the current physical capacities of the Lopez Water Project as well as the current regulatory and contractual requirements the project. Physical capacities built into the model include maximum reservoir storage, maximum pipeline/diversion flow capacities, and minimum operational levels (for reservoirs and diversions). Examples of regulatory and contractual requirements include current requirements for minimum instream flows, water rights for diversions for consumptive demand, and District contractual water delivery requirements (ECORP Consulting, Inc., 2015).

2.1 Hydrology Inputs

The model contains daily input hydrology from 10/1/1968 – 9/30/2020. The historic input hydrology data was provided by Western Hydrologics for inputs to Lopez Lake, the State Water Project, and different points along the Arroyo Grande Creek.

2.2 System Storage

The Lopez Water Project consists of the following main constructs: Lopez Reservoir (100), Lopez water treatment plant (WTP; 105), State Water Project (SWP), Arroyo Grande Creek Valley groundwater basin (700), Santa Maria Valley groundwater basin (710), and consumptive demands. Other inputs provided by Western Hydrologics include precipitation and evaporation estimates, storage-area-elevation curves, and a time series of estimated deep percolation for Lopez Lake. The estimates of evaporation, precipitation, and deep percolation were used directly in the MODSIM model, over the historical period of record. The deep percolation is simulated as a loss directly from Lopez Lake.

2.3 Demands

Lopez Lake flows into Arroyo Grande Creek which flows southwest before emptying into the Pacific. The model simulates deliveries to six municipal purveyors (i.e., water utilities) and two generalized agricultural demands along the Arroyo Grande Creek. The annual demands for the purveyors by source are shown in Table 2-1, and agricultural demands are shown in Table 2-2. These demands were estimated by Western Hydrologics, and included in the OASIS model, based on historical delivery patterns and diversions. In addition to modeling the monthly patterns shown below, the MODSIM model uses Storage Right Accounts. The storage right accounts are set up based on storage capacity the users own in the reservoirs. During the simulation, water is accrued in each storage account reservoir (e.g. SWP, Lopez Lake, and Santa Maria Valley Groundwater basin) based on a priority – this would compete with other priorities on what is similar to a natural flow allocation in river basins. Once flow has accrued to the storage account, individual or group owners can receive water from these accounts based on ownership type and relative priority. Storage right accounting in MODSIM maintains strict accounting such that owners receive only what is available in their accounts and no one else in the network can take water out of the owners' account. The accounts have a maximum amount (owned amount) that are entitled to accrue each year and they reset each year to the space available for storage in the account.

Table 2-1. Municipal Purveyors Annual Demand and Supply

Oasis Node	Purveyor	Lopez Lake Reservation, AF	State Water Project Reservation, AF	Groundwater Supply, AF
900	County Service Agency 12	241	113	0
910	San Miguelito MWC	0	0	0
940	Pismo Beach	896	1720	175
950	Grover Beach	800	1221	351
960	Arroyo Grande	2290	2213	330
970	Oceano CSD	303	725	224
Total		**4530**	**5992**	**1080**

Table 2-2. Agricultural demands

<table>
<tr><th>Node Number</th><th>Description</th><th>January through June precipitation, Inches</th><th>Demand, AF</th></tr>
<tr><td rowspan="2">800</td><td rowspan="2">Arroyo Grande Subbasin agricultural demand</td><td>>= 14</td><td>1950</td></tr>
<tr><td>< 14</td><td>1450</td></tr>
<tr><td>850</td><td>Other agriculture</td><td></td><td>2400</td></tr>
</table>

The total demands are then disaggregated to monthly demands based on historical patterns. Table 2-3 shows the fraction of the annual total demand used to calculate the monthly demands.

Table 2-3. Monthly defined patterns as fraction of annual total demand.

Month	900	940	950	960	970
1	0.068	0.0706	0.079	0.0673	0.0738
2	0.0658	0.0638	0.074	0.0643	0.0671
3	0.0711	0.0638	0.0784	0.0705	0.0751
4	0.0794	0.051	0.0828	0.0789	0.078
5	0.0932	0.0648	0.0919	0.0944	0.0907
6	0.1016	0.0857	0.0889	0.0972	0.0932
7	0.123	0.109	0.0879	0.0989	0.104
8	0.1093	0.1082	0.0845	0.0943	0.0957
9	0.0899	0.1134	0.0867	0.0918	0.0897
10	0.0776	0.1098	0.0909	0.0915	0.0858
11	0.0634	0.0872	0.0818	0.0795	0.0732
12	0.0577	0.0728	0.0734	0.0716	0.0737

2.3.1 State Water Project Supplies

The State Water Project (SWP) supplies are also provided by Western Hydrologics and were taken from the SWP's Delivery Reliability Report's Calsim II modeling studies. These studies have a period of record 1922 through 2003. The model uses historical SWP final allocations for years 2004 through 2020. The inflow to node 205 is set to the SWP allocation percentage times the annual contract amount of 25,000 AF times the overall monthly patterns.

2.4 Groundwater Interactions

There are two groundwater basins are being simulated in this model based on logic in the Western Hydrologics OASIS model. Particularly, there are instream depletions that are simulated at three locations along the stream (nodes 110, 120, and 150).

2.4.1 Node 110

The depletions at node 110 are equal to the inflow at node 110 unless the receiving groundwater subbasin (700) is full.

2.4.2 Node 120

Groundwater depletions in the Arroyo Grande subbasin (node 700) are mainly taken from node 120. Groundwater Depletions are estimated using a linear equation as a function of flow, with seasonal factors used in the equation. The seasonal factors are shown in Table 2-4, and the depletion rate is calculated as in the equation below, with units in cfs:

$$Node\ 120\ Groundwater\ Depletion\ Rate = Q * Factor_{120} + Constant_{120}$$

Where Q is equal to the flow in link 110.120. However, this Depletion Rate can be overridden in the model. This is due to an assumed fraction of the total agricultural demand that is assumed to be met with riparian pumping and therefore directly effecting the river regardless of groundwater depletions.

In the model this fraction is assumed to be 60%, therefore the total depletion at node 120 is equal to the maximum of the Groundwater Depletion Rate and 60% of the total agricultural demand at node 800.

However, the model does not know the flow in link 110.120 when setting the groundwater depletion rate and needs to make a guess about the likely value of the flow in that link. This flow is estimated as:

$$Q = Max(60\%\ of\ agricultural\ demand + (Min\ Flow\ 140.150 - inflow120 - inflow140)$$
$$, Downstream_{Release_{Irr}} + 3\ cfs$$
$$, Min\ Flow\ 100.110$$
$$)$$

In addition, there is a 20 cfs cap on the depletion in all months.

Table 2-4. Groundwater depletion coefficients

	Node 120		Node 150	
Month	**Factor**	**Constant**	**Factor (Inflow < 10)**	**Factor (Inflow >= 10)**
Jan	-0.2778	0.3277	0.5	0.1
Feb	-0.5317	1.7267	0.5	0.15
Mar	-0.1668	-0.8061	0.55	0.1
Apr	-0.2411	-0.4430	0.5	0.02
May	-0.9053	3.1492	0	0
Jun	-0.8972	2.7841	0	0
Jul	-0.9570	3.0319	0	0
Aug	-0.8134	2.0767	0	0
Sep	-0.6698	1.4555	0.1	0.1
Oct	-0.7087	2.6880	0	0
Nov	-1.0478	5.2876	0	0
Dec	0	0	0	0

2.4.3 Node 150

Depletions at Node 150 are calculated as in the equation below:

$$Node\ 150\ Groundwater\ Depletion\ Rate = Q * Factor_{150}$$

The Factor at Node 150 is dependent on the inflow to node 120 plus the inflow at node 140. The factor changes depending on whether the inflow is above or below 10 cfs (Table 2-4). The Q in the equation refers to the sum of the links 140.150 and 155.150.

2.5 Minimum Flows

There are minimum flows defined below Lopez Dam which varies each year on April 1st based on the storage of Lopez Lake and fluctuate between 3 and 5 cfs. There is also a pulse flow simulated below Lopez Dam that was based on historical flows and mandates. The flow release patterns immediately below Lopez, used in the MODSIM model, were taken from the OASIS model (Table 2-5)

2.6 Water Sources

Water purveyors have multiple sources available to meet their demand. The operation logic implements distributions of the water sources for each demand to simulate their preferences in supply. In general, the preference is to use water from Lopez Lake and SWP and lastly their groundwater sources. However, there are multiple demands in which the sources are simulated concurrently. For example, Pismo Beach (940) and Grover Beach (950) both use source water Lopez and the Santa Maria Valley groundwater basin throughout the simulation. Oceano CSD (960), split the demand between Lopez Lake and the SWP source. The distribution and limits for each source for the demands were based on the OASIS model simulation.

2.7 Lopez Lake Releases

The operation of Lopez Lake provides water to water utilities demands and releases for the creek. Releases for the utility demands are a function of the amount of water available in their reservoir group account and a water use pattern specified for each demand. Minimum releases to the creek are driven by a release schedule (Table 2-5) and regular releases are constrained by the outlet capacity of 100 cfs, with forced reservoir spills above the outlet capacity flowing to the creek. These release patterns could be used to analyze the effects of pulse flows (magnitude, timing and duration).

Table 2-5. Minimum flow release pattern estimated from the OASIS simulation

Date	Flow Rate (AF/Day)
10/01	12.28
01/01	11.29
01/02	10.29
01/03	9.52
01/08	8.53
01/09	7.54
01/10	6.54
01/11	5.95
04/01	7.93
04/02	9.92
04/03	11.9
04/04	12.28
07/01	14.88
09/01	12.28

3 Validation

The performance of the MODSIM model was validated against the simulation of operations in the OASIS model. The validation includes comparison of flows, use of sources of water and system storage.

3.1 Storage and Flow through the system

The primary goal of this model development was to ensure that the demands were met based on the monthly distributions in the tables above. The stream losses, although modeled based on the OASIS documentation, were not calibrated in detail since the GSFLOW model would be replacing this piece of the modeling by representing the depletions from the stream based on the conditions in the stream and the groundwater system. Figure 2 is a summary figure comparing some simulation results at different locations between the MODSIM simulation and the OASIS model simulation.

Figures 2a, 2b, and 2c are the main simulated storage reservoirs in the system consisting of Lopez Lake (a), the Santa Maria Groundwater basin (b), and the Arroyo Grande Creek Groundwater basin (c). The simulated storage in Lopez Lake is comparable to that simulated by the OASIS model. The simulated storage at Lopez Lake has an average difference of 449 AF over full period of record, with the MODSIM model being slightly higher. In the Santa Maria Groundwater basin, the MODSIM implementation simulates less storage than the OASIS model based on the provided inflows. However, in the Arroyo Grande Creek Groundwater basin, the simulated storage is slightly higher than the OASIS simulation.

Figures 2d and 2e show flow in the system and a couple key locations. Figure 2d shows flow at the most downstream end of the Arroyo Grande Creek (link 165.160). Overall, the flow is comparable except for a few large peaks. Overall, the average difference, across the full period of record, in simulated flow between the MODSIM and OASIS model at this location is <1.3 af/day. Figure 2e shows the flow in the pipeline that is used to meet demands from Lopez Lake. This simulated flow is comparable that in the OASIS results except for a few drops in flow that OASIS simulates. The MODSIM flow in this link (100.110) is generally lower than the OASIS model but doesn't show the spiked decreases. The overall total flow is nearly identical.

Figure 2. Comparison of model simulations results for the MODSIM and OASIS models.

Figure 3 is a comparison of flow in link 130.140. This link is near an observed streamflow gage (Cecchetti Rd Gage) and below the modeled stream depletions at node 120. Overall, the simulated flows are comparable throughout the period and flow range. The Nash-Sutcliffe efficiency (NSE) is a normalized statistic that determines the relative magnitude of the residual variance compared to the measured data variance. In this case, the measured data is the OASIS model simulation. A perfect NSE is 1. The statistical tests (Table 3-1) show a Nash-Sutcliffe efficiency of 0.97 between the MODSIM and OASIS simulated flow in link 130.140. The MODSIM flow in this link is slightly lower than the OASIS model which also corresponds to the slightly higher storage in the Arroyo Grande Creek Groundwater basin upstream. Overall, this analysis shows a similar estimation of streamflow depletions in this area of the creek and releases from Lopez Lake.

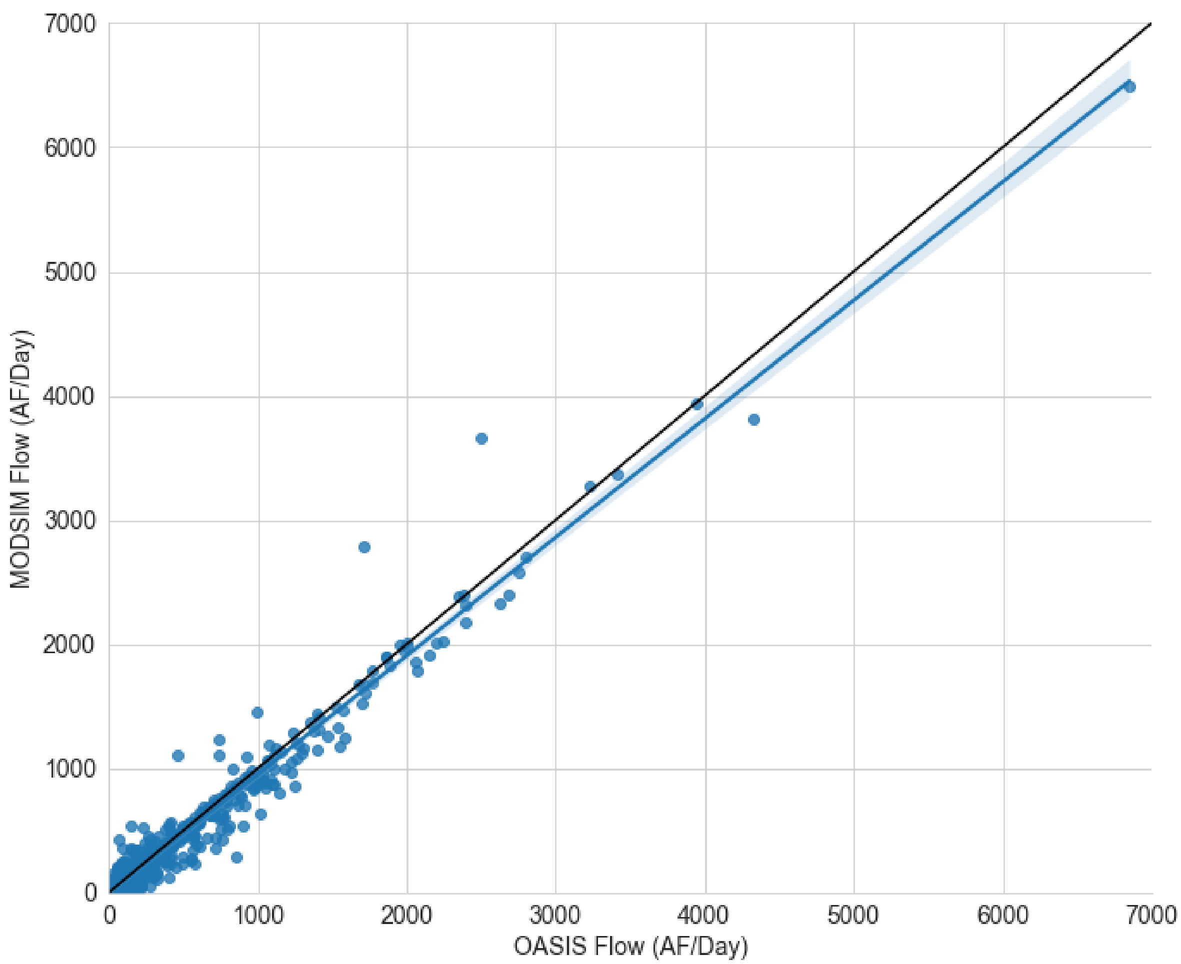

Figure 3. Comparison of simulated flow between the OASIS and MODSIM models at link 130.140. The figure also includes a fitted linear regression line with estimated confidence interval to show goodness-of-fit (blue line). The black line represents the 1-to-1 line.

Table 3-1. Statistical tests for comparison of flow in link 130.140 between OASIS and MODSIM

Statistic	**Value**
Avg. OASIS simulated (AF/day)	26.78
Avg. MODSIM simulated (AF/day)	25.55
Nash-Sutcliffe	0.97
Avg. annual volume error (AF)	-4.59
Coeff. Determination (R2)	0.97

3.2 Demands

Overall, both models were able to simulate meeting all the demands in the system for the full period, except for Grover Beach (950). Both models simulated small shortages at this location.

As stated above, the priority here was to ensure that the model simulated the sources correctly for each demand. Figure 3 below shows an example of the inflows for the Oceano CSD (970) demand. In this example, the demand is met from both the SWP and Lopez Lake sources. This demand can also supplement a small amount at a lower priority from groundwater as well, but in this period of record it is never needed.

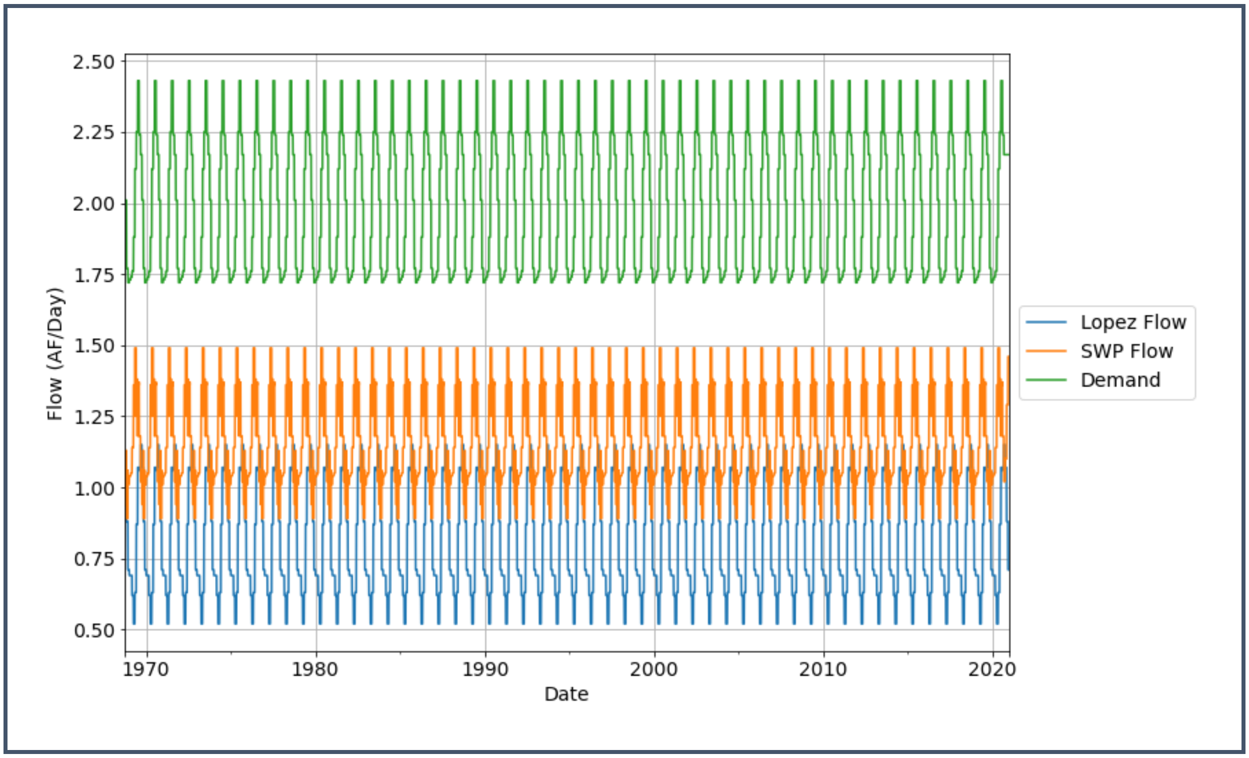

Figure 4. Example of demand sources at Oceano CSD (970).

Since the limits and distribution of sources at each demand were taken directly from the simulated OASIS results, they match with the MODSIM results.

3.3 Discussion

The MODSIM model generated for this task was based of Western Hydrologics reports, memos, and simulation results. As shown above, there are slight differences in storage and flow downstream on the Arroyo Grande Creek between the two models. These differences are likely based on slightly different assumptions in the OASIS model that were used to model stream losses on the Arroyo Grande Creek. Although the logic was duplicated based on the documentation, there appears be small differences. As stated above, for this project, these constructs along the Arroyo Grande Creek are being replaced by the GSFLOW groundwater model. Therefore, our main priority was to ensure that the simulated flow to the demands were being satisfied in the same way in the OASIS model. In that sense, the MODSIM modeling is successful and adequate for coupling with the GSFLOW model.

4 Conjunctive Surface and Groundwater Modeling

The goal of this task is to develop the modeling files to perform a conjunctive surface and groundwater system simulation using the GSFLOW model coupled with a MODSIM model. For this purpose, the MODSIM model elements and operational logic to simulate the surface operations in Arroyo Creek were ported into a MODSIM network developed based on the GSFLOW Streamflow-Routing Package (SFR) network. The new MODSIM network includes links that represent each of the SFR segments and their connectivity, allowing the MODSIM model to simulate stream accretions and depletions at the SFR segment level with the detail captured by MODFLOW of the interaction between the groundwater system and the stream. The SFR network connects segments with lakes, which are represented as reservoir nodes in the MODSIM network. The SFR segments and MODSIM links coupling algorithm uses a SQLite database, referred as the Synchronization Database, that contains a table (MS-GSF_mapping_Info) with the segments to links relationships and another table (MS-GSF_Lake_Mapping_Info) containing the reservoir to lakes relationship. Figure 5 shows the SFR network shapefile and the corresponding MODSIM network for the Arroyo Grande Creek Basin, which extends from the headwaters to the ocean, including the Lopez Lake. Figure 6 shows the MODSIM network with the operational constructs and the distribution infrastructure for simulating operations with the GSFLOW model. This network includes the features included in the model task 1, including the State Water Project and supplemental groundwater sources, demand time series and patterns, capacities and constraints and target release patterns. Lopez lake is simulated with the historical net evaporation rate time series and area-elevation-capacity curve. This model does not include the inflows to Lopez Lake nor the construct to simulate stream losses, since those will be simulated by GSFLOW.

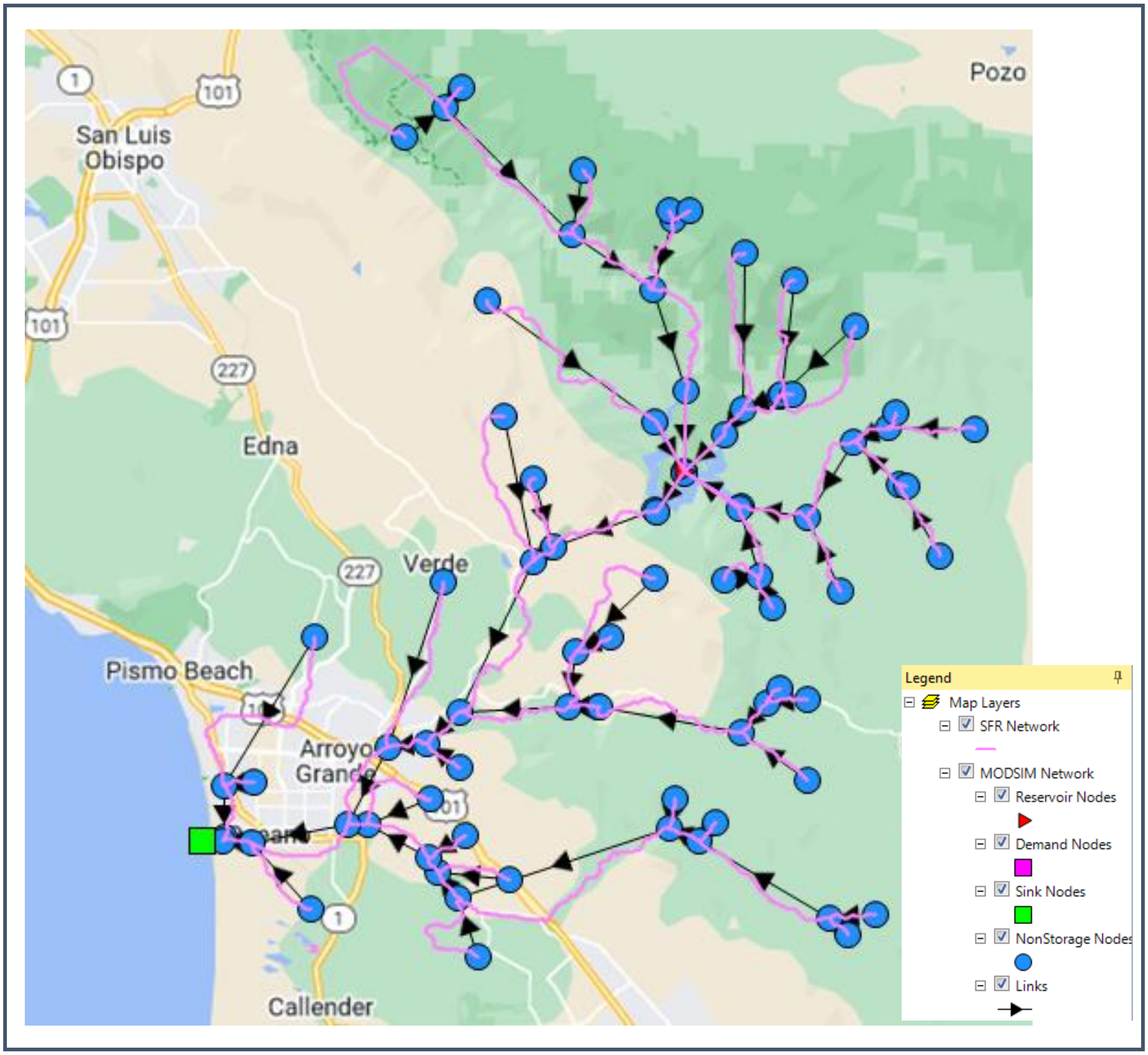

Figure 5. Arroyo Grande Creek Basin MODSIM model network based on the SFR Network

Table 4-1 shows the name of the files generated for the GSFLOW-MODSIM coupled simulation, including the synchronization database and the MODSIM network files.

Table 4-1. Files Generated for the coupled GSFLOW-MODSIM Simulation

File Description	**File name**
GSFLOW-MODSIM Synchronization Database (Sqlite format)	ArroyoGrande.waprj
Base MODSIM Network	GSFLOWNet.xy
Baseline operations MODSIM Network	GSFLOWNet_Modsim_Baseline_v3.xy

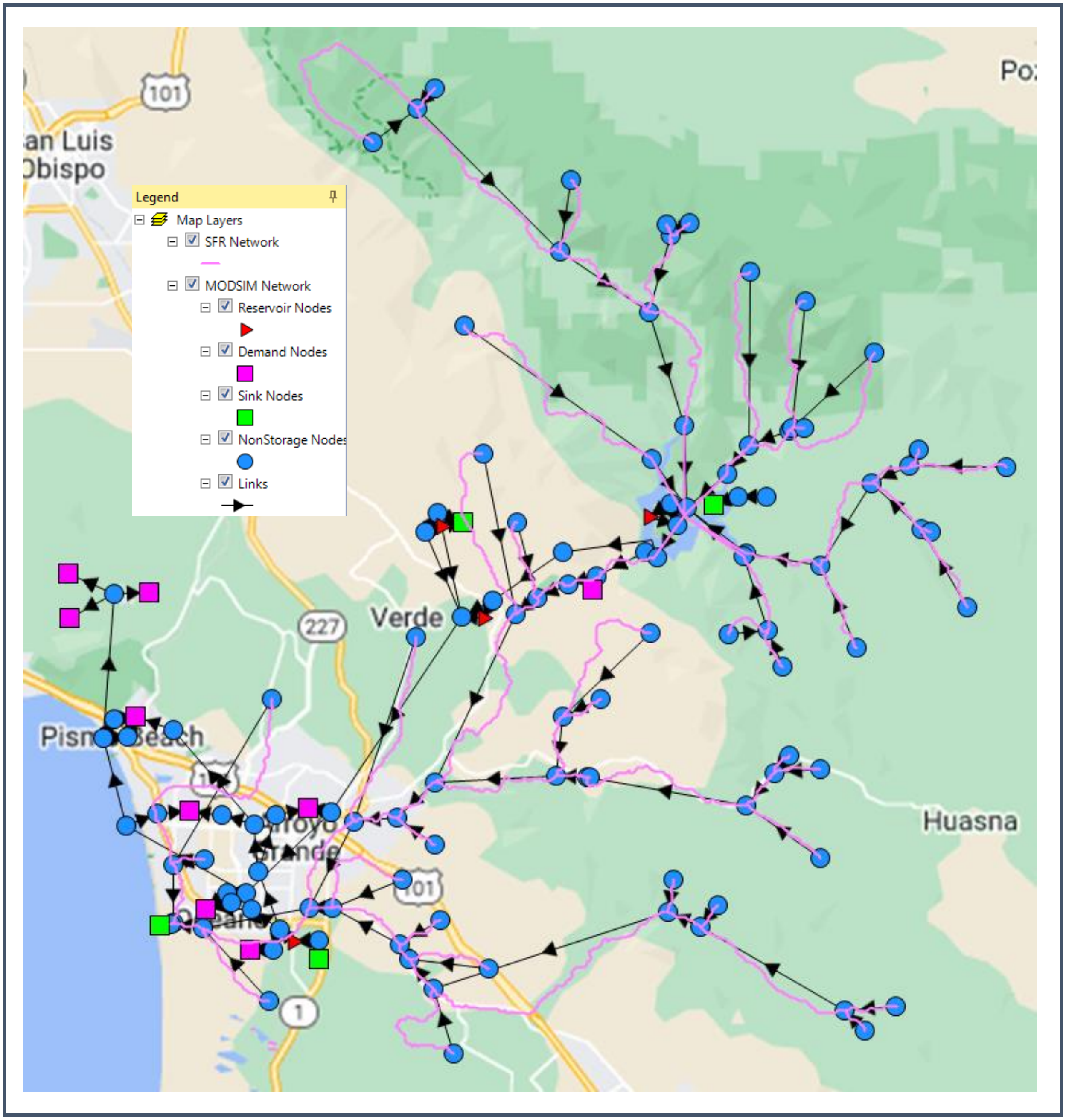

Figure 6. Arroyo Grande Creek Basin MODSIM model network based on the SFR Network with operational constructs

4.1 Coupled GSFLOW-MODSIM Simulation

A coupled simulation with the historical GSFLOW run was performed to test the MODSIM network and the synchronization database with the coupling algorithm. The coupling algorithm is implemented in the C# language, using the MODSIM libraries (dlls) and a special version of the GSFLOW library (dll) that can exchange variables with MODSIM at run time. The compiled coupling code consist of an executable file and a set of supporting libraries that uses the GSFLOW control file to run the conjunctive surface and groundwater simulation. Figure 7 shows the settings added to the control file required for the MODSIM-GSFLOW run mode, which specify the name and relative path of the MODSIM model file and the synchronization database. The project deliverables include binary files and a modified control file for the MODSIM-GSFLOW simulation. The names of the deliverable files and folders are shown in the Table 4-2. Similar to the GSFLOW executable, the coupled GSFLOW-MODSIM executable is started using the control file as argument.

```
####
executable_desc
1
4
MODSIM-GSFLOW Sep 2022 - develop branch
####
xyFileName
1
4
..\MMSFiles\MODSIM\GSFLOWNet_Modsim_Baseline_v2.xy
####
mappingFileName
1
4
..\MMSFiles\ArroyoGrande.waprj
####
model_mode
1
4
MODSIM-GSFLOW
```

Figure 7. GSFLOW Control File Settings for the MODSIM-GSFLOW run mode

Table 4-2. Files Generated for the coupled GSFLOW-MODSIM Simulation

File Description	File/Folder Name
Folder with the executable of the coupling algorithm	*Bin\Release* folder
GSFLOW Control file	ag-gsp_MODSIM.control

Note that the GSFLOW input files were converted to the version 5, which uses rain and temperature fractions and offsets. The new parameters file was generated using the convert function of GSFLOW.

```
..\..\bin\gsflow_v2.exe .\ag-gsp.control -set model_mode CONVERT
```

The parameter file created was placed in the input\prms folder and the new parameter file was added to the control file. This parameter files allow simulation with **GSFLOW5** and **MODSIM-GSFLOW** modes.

4.1.1 Modeling Approach

The coupling algorithm uses the GSFLOW control file to initialize the GSFLOW model and provide the MODISM file and synchronization database. The control file also provides the start and end dates of the simulation, which is applied to both models at run time. The synchronization database provides settings for the coupled simulation including maximum number of iterations and volumetric convergence criteria between the models. Figure 8 shows the settings used for the Arroyo Grande Creek coupled simulation.

Table: Settings

	ID	Description	Value	Key
	Filter	Filter	Filter	Filter
1	2	MODSIM-GSFLOW Max Iter	100.0	MaxIter
2	3	Flow Tolerance [ft3]	5000.0	FLowTolerance
3	4	Volume Tolerance [ft3]	5000.0	VolumeTolerance

Figure 8. Coupling Algorithm Settings in the Synchronization Database

The algorithm creates a set of high-priority links that carry the GSFLOW's calculated accretions and depletions in and out of the MODSIM links that represent the SFR segments. The accretions are simulated in links named "MF_Acc_*" for each link name (*) and the depletion are simulated using the "MF_Dep_*" for each link name (*). These links are created by the coupling algorithm for all the links related to segments in the synchronization database and are connected to a source and a sink that provides the source of the accretions and dispose the depletions. These links are created in a MODSIM layer[1] "GSFLOW_AccDep" which allows hiding these constructs and show only the real network. The network with these adjustments is saved with the suffix "MSGSF" in the name. This network is with the artificial constructs is shown in Figure 9.

The coupled GSFLOW-MODSIM simulation was performed in two steps using the GSFLOW calculated accretions and depletions with the historical (calibration) model which uses the historical releases from Lopez Lake in the GSFLOW model. The second step is updating the GSFLOW releases with the MODSIM calculated releases from the run in the first step to evaluate the model sensitivity revised releases based on the simulated water supply operations. Both simulations were performed for the same period of the calibration model, from June 1, 1980 to September 30, 2020.

[1] Only on versions 8.6.1 and later.

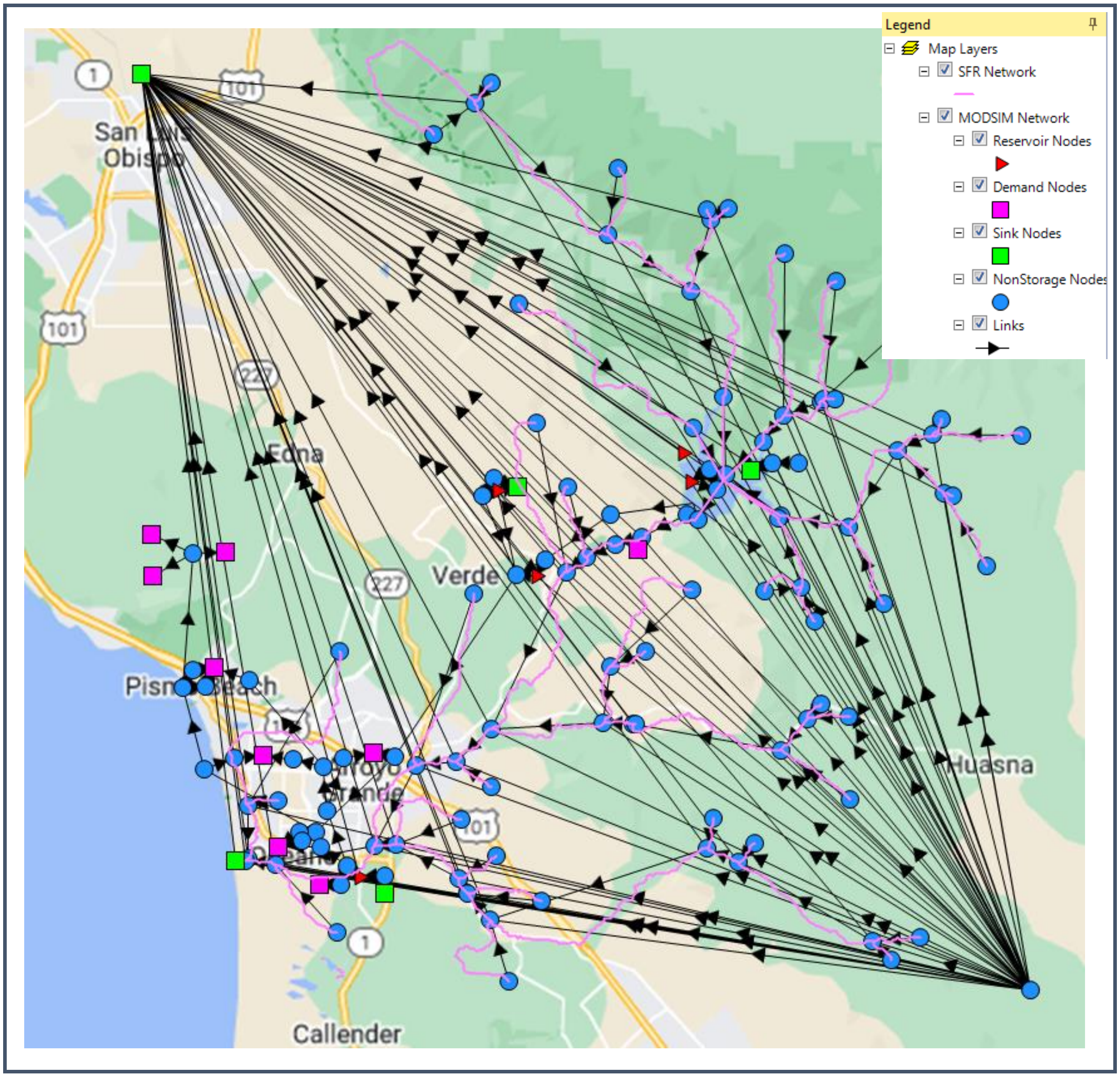

Figure 9. MSGSF Arroyo Grande Creek Basin MODSIM model network artificial constructs for accretions/depletions simulation.

4.1.2 Groundwater pumping

Groundwater pumping is simulated in the MODFLOW model, spatially in the general location where it occurs. The effects of pumping in the surface system are reflected in the simulated accretions and depletions to the streams in MODSIM. However, for the MODSIM model the supplemental pumping to the municipal users is simulated using a separate construct that provides an infinite source of water with the water permits constraints. The pumping amounts are not synchronized during the coupled GSFLOW-MODSIM simulation, so a post-processing check, and possible iterative adjustment, would be required for scenarios where MODSIM pumping amounts are considered significantly different than the base pumping simulated in GSFLOW.

4.1.3 Inflows to Lopez Lake

The inflows to Lopez Lake shown in these results are simulated in MODSIM using inputs from the GSFLOW accretions and depletions data from the historical simulation. Figure 8 shows the inflows to Lopez Lake over the historical period 1981-2020. The plot also shows the input inflows used in the OASIS model and the MODSIM task 1 model. As shown, the GSFLOW estimated inflows are generally larger over the historical period (Table 4-3).

Table 4-3. Comparison of summary statistics of Lopez Lake Inflows over full simulation period (1981-2020).

Statistic	GSFLOW Simulated	OASIS Model Input
Mean (AF/day)	57.4	41.7
Min (AF/day)	1.8	0.4
25% Percentile (AF/day)	4.0	7.5
50% Percentile (AF/day)	6.4	13.3
75% Percentile (AF/day)	11.9	25.9
Max (AF/day)	10265.9	4833.2

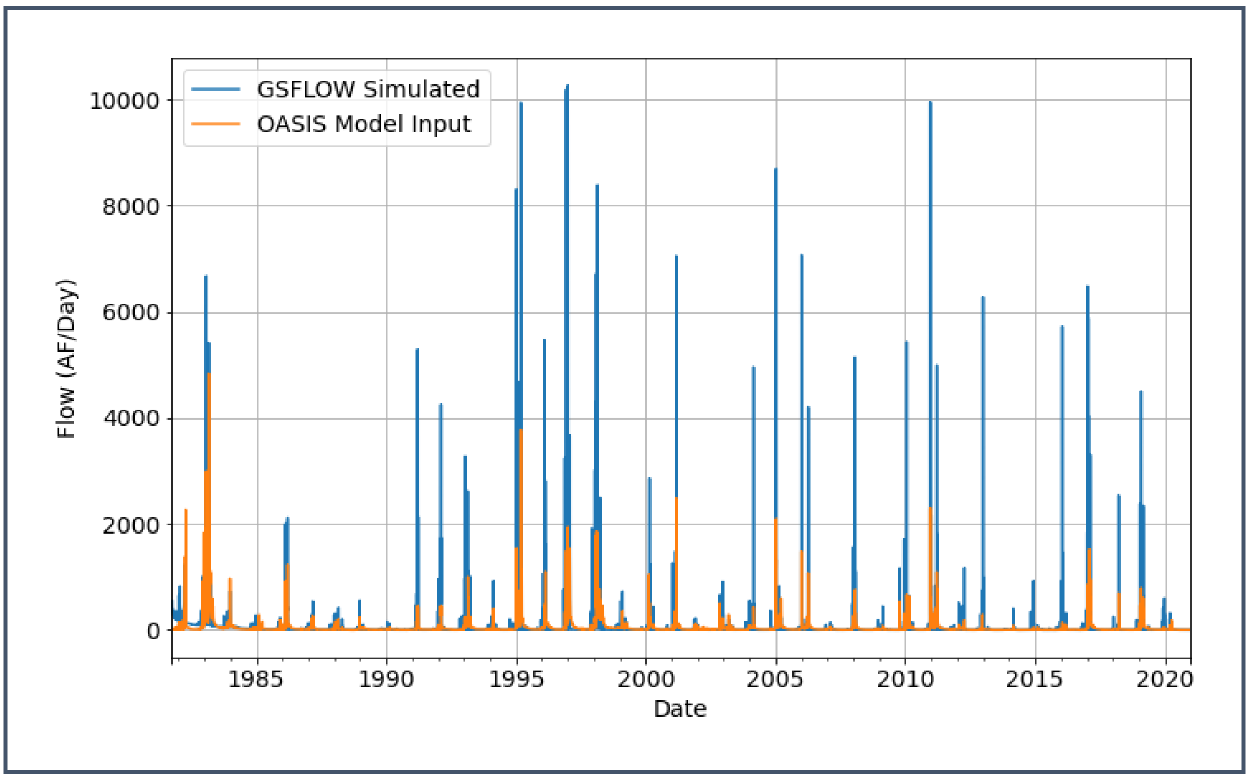

Figure 10. Simulated inflows at Lopez Lake. The inflows include a comparison to the inflows in the OASIS model and the Task 1 MODSIM model.

4.1.4 Lopez Lake Releases

In this historical run the GSFLOW accretions and depletions data is loaded into the MODSIM model and then simulated in conjunction with the demands and logic from the MODSIM developed in task 1. The result of the operation is a set or releases to meet demands and operational objectives. Figure 11 shows the releases from Lopez Lake to the Arroyo Grande Creek. The releases to Arroyo Grande Creek are driven by the Arroyo Grande Creek minimum release pattern defined in task 1, spill, and could potentially consider the downstream depletions along the creek estimated by the GSFLOW model for meeting operational targets. Overall, some of the releases are larger than the task 1 model simulation based on the larger inflows. For example, in the 1995-1998 period, the large releases (or spills) correspond to large inflows and the reservoir storage being full.

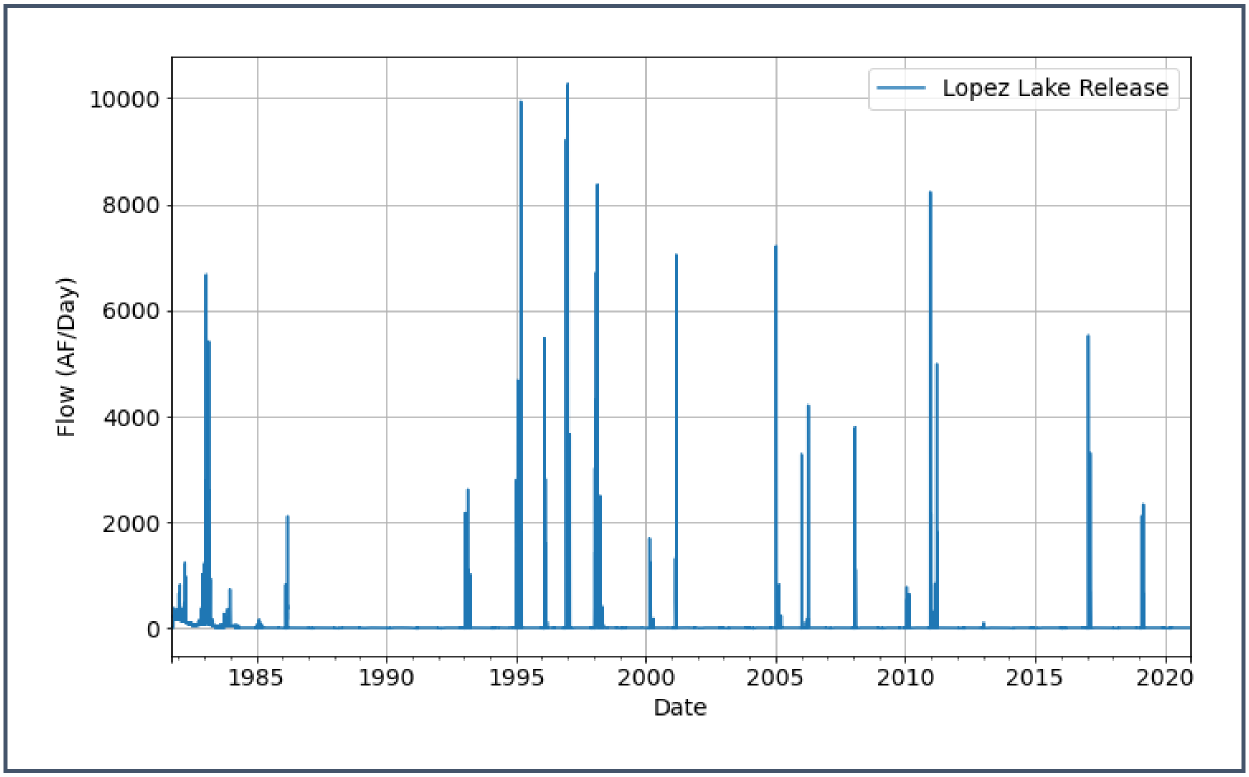

Figure 11. Lopez releases to Arroyo Grande Creek

The figure below shows the simulated flow through the pipeline to the water treatment plant and is used to meet downstream demands (Figure 12). The flow in this link should be comparable to that shown in Figure 2e. Overall the flow through this link is adequate to meet all demands from the Lopez allocation except for two shortages at the Arroyo Grande (960) demand. The total shortage was 3.5 AF over the simulation period. This demand can be supplemented by additional groundwater flow based on the logic in the MODSIM model. However, it's noteworthy that in this simulation, the additional groundwater used for demands is not in-sync with the GSFLOW model simulation of groundwater. The small shortages simulated in this model as compared to the task 1 model simulation, are likely due to differences in simulated streamflow along the mainstem of the Arroyo Grande Creek.

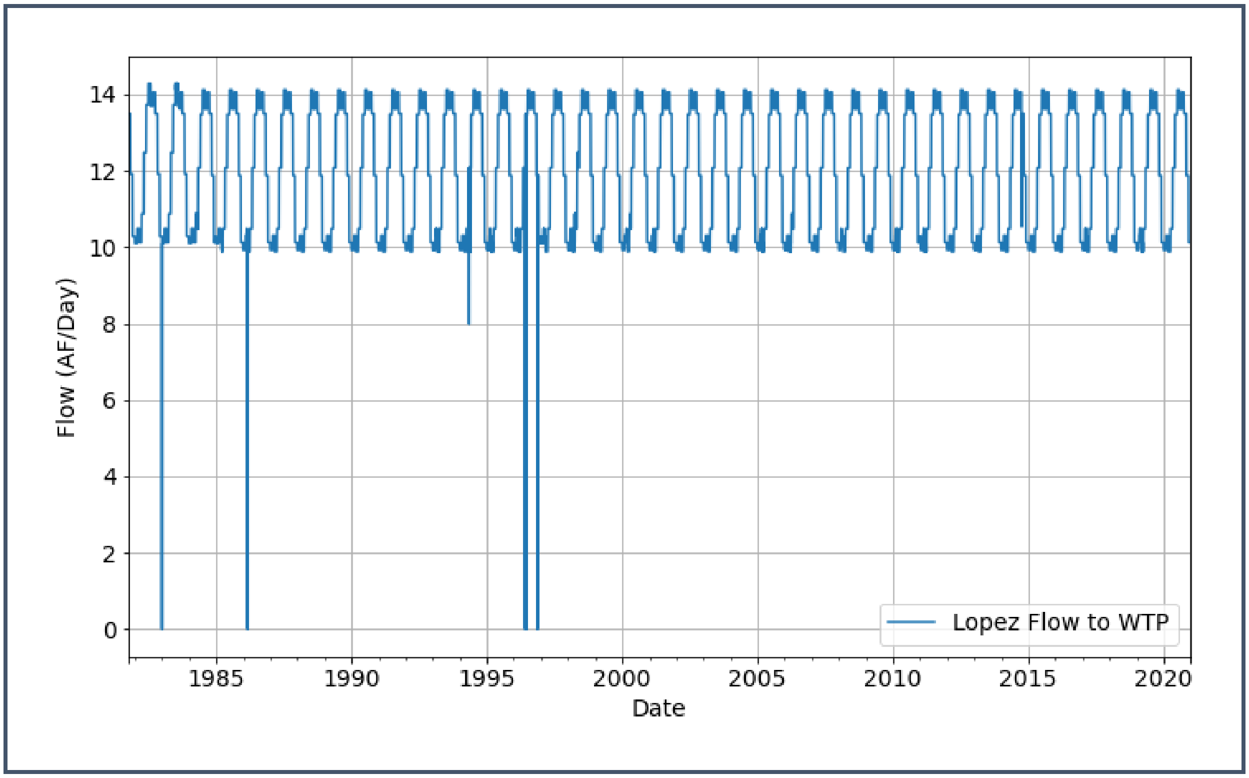

Figure 12. Lopez Lake flow to the water treatment plant (WTP)

The simulated storage at Lopez Lake is shown in Figure 13 and is the result of the simulated operations, i.e., the simulated inflows, downstream demands, target release pattern, and accretions and depletions along the Arroyo Grande Creek.

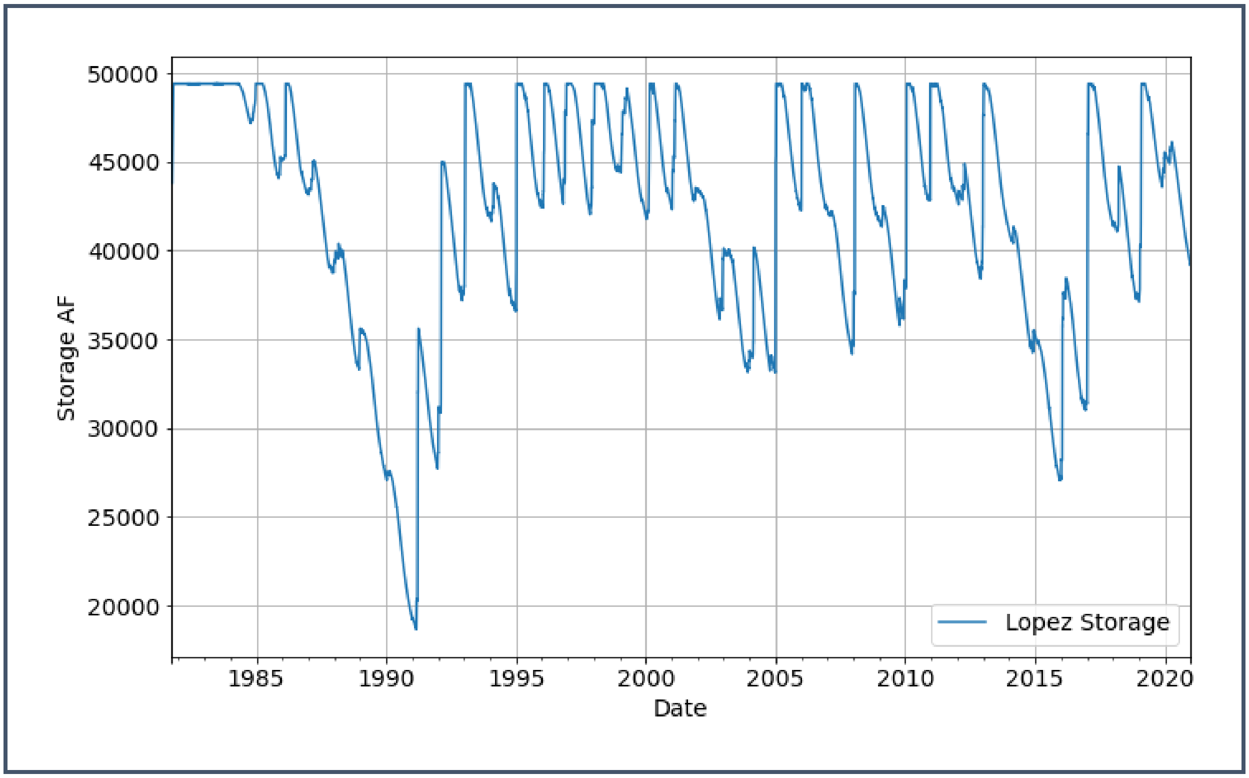

Figure 13. Lopez simulated storage

4.1.5 Depletions / Accretions

The MODSIM model simulates accretions (and depletions) from GSFLOW for the entire basin. The following results are from the MODSIM model with the imported GSFLOW data from the historical run. This section summarizes accretions and depletions along the mainstem of the Arroyo Grande Creek. The accretions and depletions are estimated by the GSFLOW model simulation and then used by MODSIM in the water allocation solution. Figure 14 shows the accretions for the simulation period from 1981-2020. The accretions are defined by the GSFLOW model and include tributary inflows and agricultural return flows.

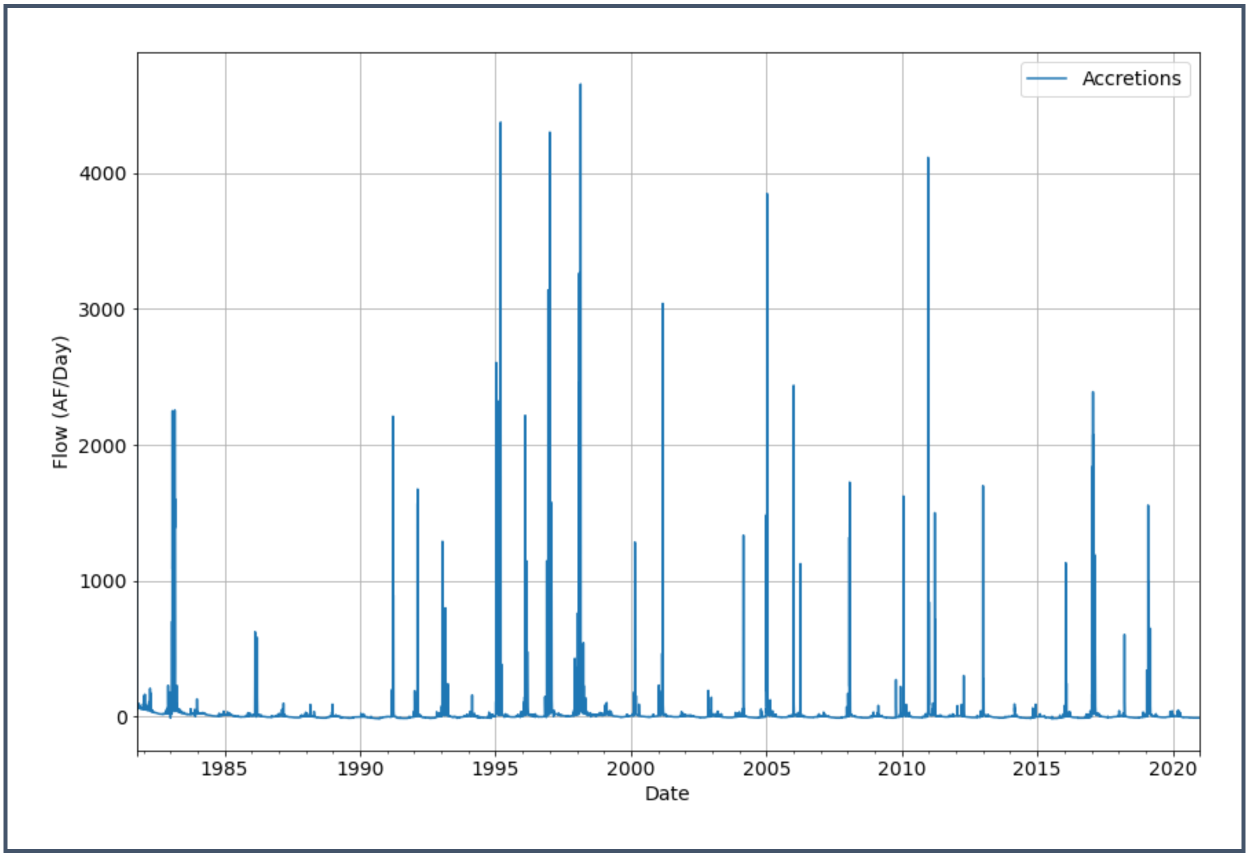

Figure 14. Total simulated accretions along Arroyo Grande Creek.

The depletions are summarized into an upstream area above Cecchetti Rd gage which is similar to the area defined as the Arroyo Grande Creek Valley Groundwater Subbasin in the task 1 model, and below the Cecchetti Rd gage which would be comparable to the Santa Maria Valley Groundwater Basin (Figure 15). The depletions below the Cecchetti Rd are considerably larger than the above the Cecchetti Rd gage.

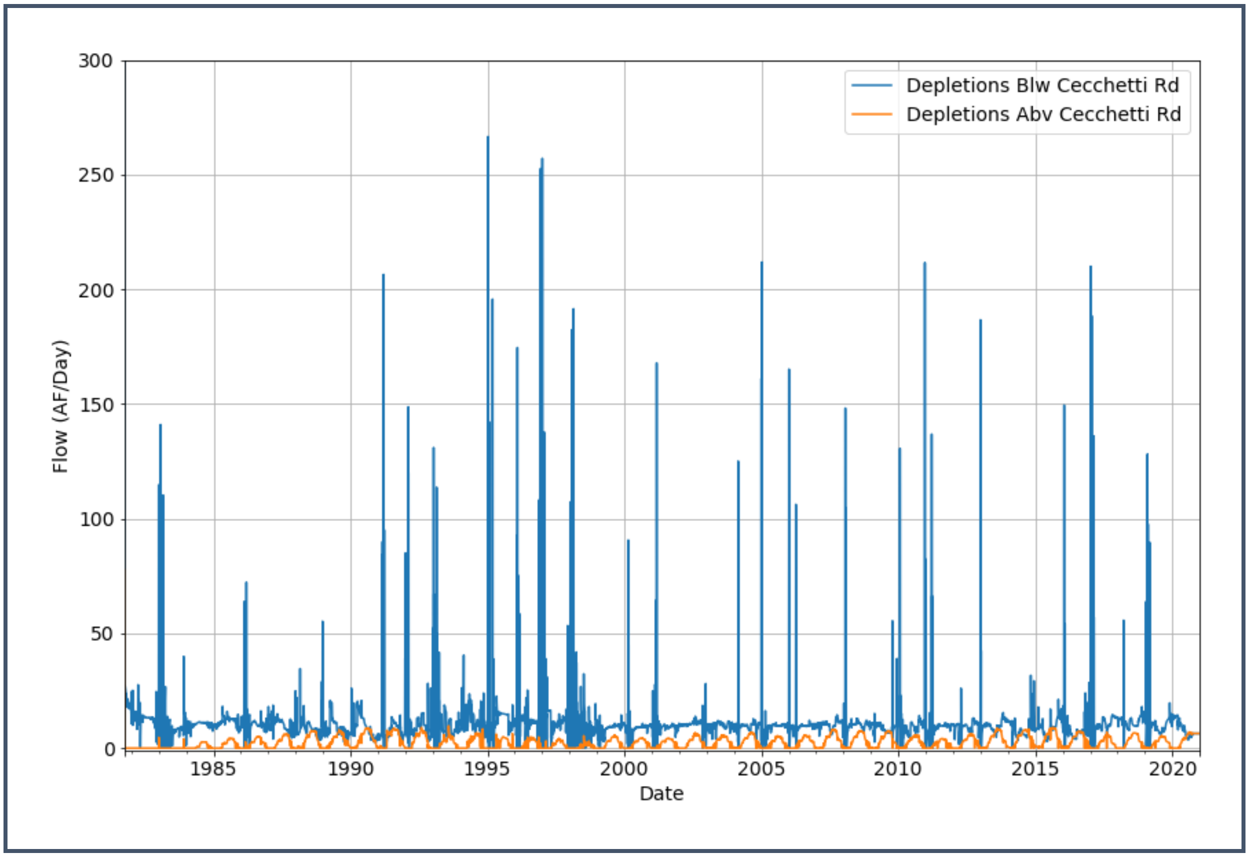

Figure 15. Total simulated depletions (b) along Arroyo Grande Creek.

Above the Cecchetti Rd, the depletion pattern is similar to the agriculture demand pattern at node 800 in the OASIS model (Figure 16). The magnitude of the depletions in this section of the creek seems correlated with the stresses (i.e., pumping), and with a lower magnitude than the stress. Figure 17 summarizes the total annual depletions simulated along for the full Arroyo Grande Creek.

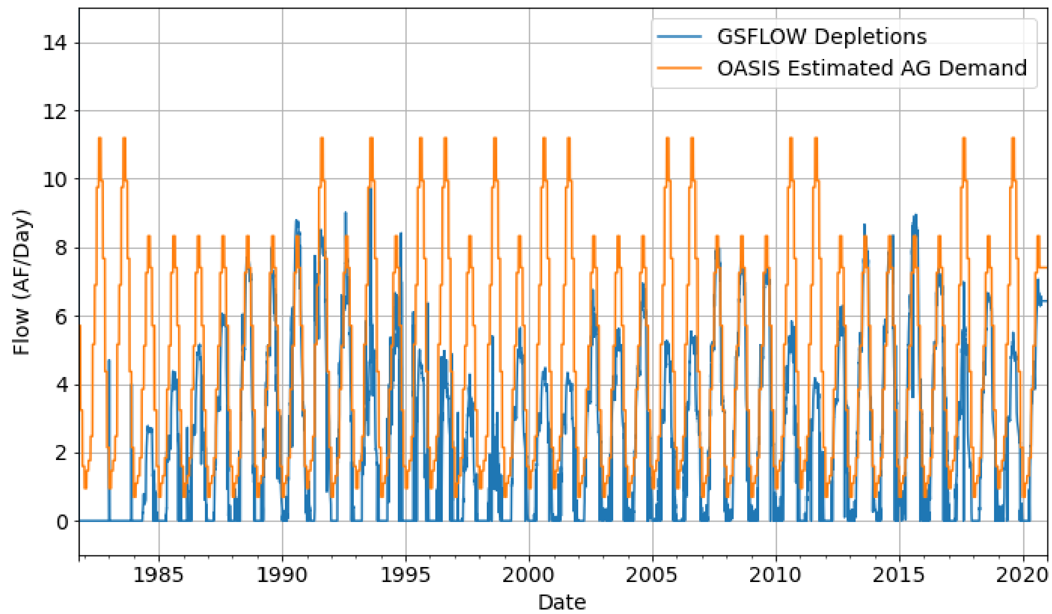

Figure 16. Comparison of GSFLOW depletions above Cecchetti Rd and the estimated Ag demand for the Arroyo Grande Creek Groundwater basin in the OASIS model

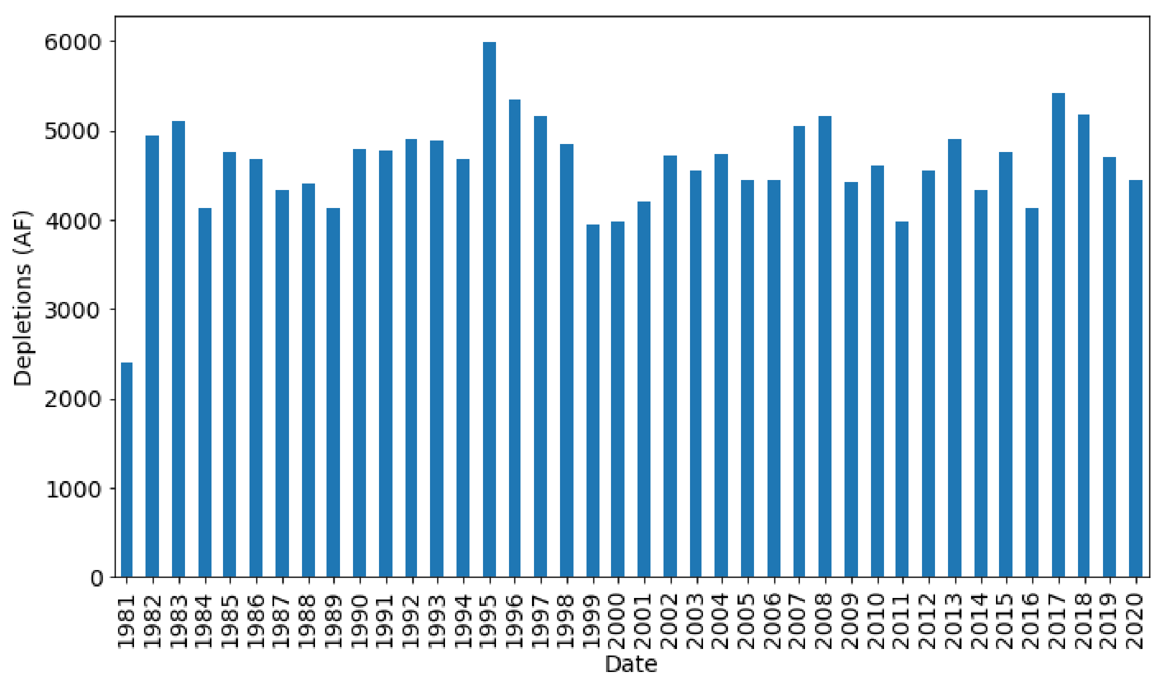

Figure 17. Total annual depletions along the Arroyo Grande Creek.

4.2 Stream-Aquifer Interaction Sensitivity

The sensitivity of the GSFLOW model to MODSIM simulated Lopez Lake releases was performed using the MODSIM simulated releases for the calibration period (Figure 10) as the specified releases in the calibration model. The simulated accretions and depletions with MODSIM releases, compared with the base run (Figure 14 and Figure 15) with historical releases, give us a sense of the sensitivity of the simulated stream-aquifer interaction to the detailed simulation of the lake operations (Table 4-4).

Table 4-4. Comparison of summary statistics for simulated accretions and depletions along the Arroyo Grande Creek

	Depletions				**Accretions**	
Location	**Abv Cecchetti Rd**		**Blw Cecchetti Rd**		**Total**	
Model Run	**MODSIM Release**	**Historical Release**	**MODSIM Release**	**Historical Release**	**MODSIM Release**	**Historical Release**
Mean (AF/day)	2.4	2.5	11.6	10.4	24.0	22.1
Standard Deviation (AF/day)	2.8	2.5	18.1	11.2	164.7	158.1
Min (AF/day)	0.0	0.0	0.0	0.0	0.0	0.0
25% Percentile (AF/day)	0.0	0.0	8.8	7.7	0.0	0.0
50% Percentile (AF/day)	2.1	2.1	10.1	9.7	0.6	0.1
75% Percentile (AF/day)	4.1	4.3	11.4	11.2	8.4	7.2
Max (AF/day)	76.8	77.6	515.3	512.8	4935.0	4655.3

The simulated accretions and depletions along the Arroyo Grande Creek show some small differences when compared. The model run where the model uses the MODSIM releases, estimates larger accretions from the GSFLOW simulation, as well as larger depletions below Cecchetti Rd compared to the run using historical releases (i.e. the “snapshot” run discussed above). Above Cecchetti Rd, however, the depletions estimated by GSFLOW are slightly smaller on average than those estimated using the historical releases. In all cases, the estimated accretions and depletions from the GSFLOW model using the MODSIM releases, are more variable through the simulation period, primarily driven by the larger variability in peaks in the simulated releases. Figure 18 shows the same comparison across the full range of flows.

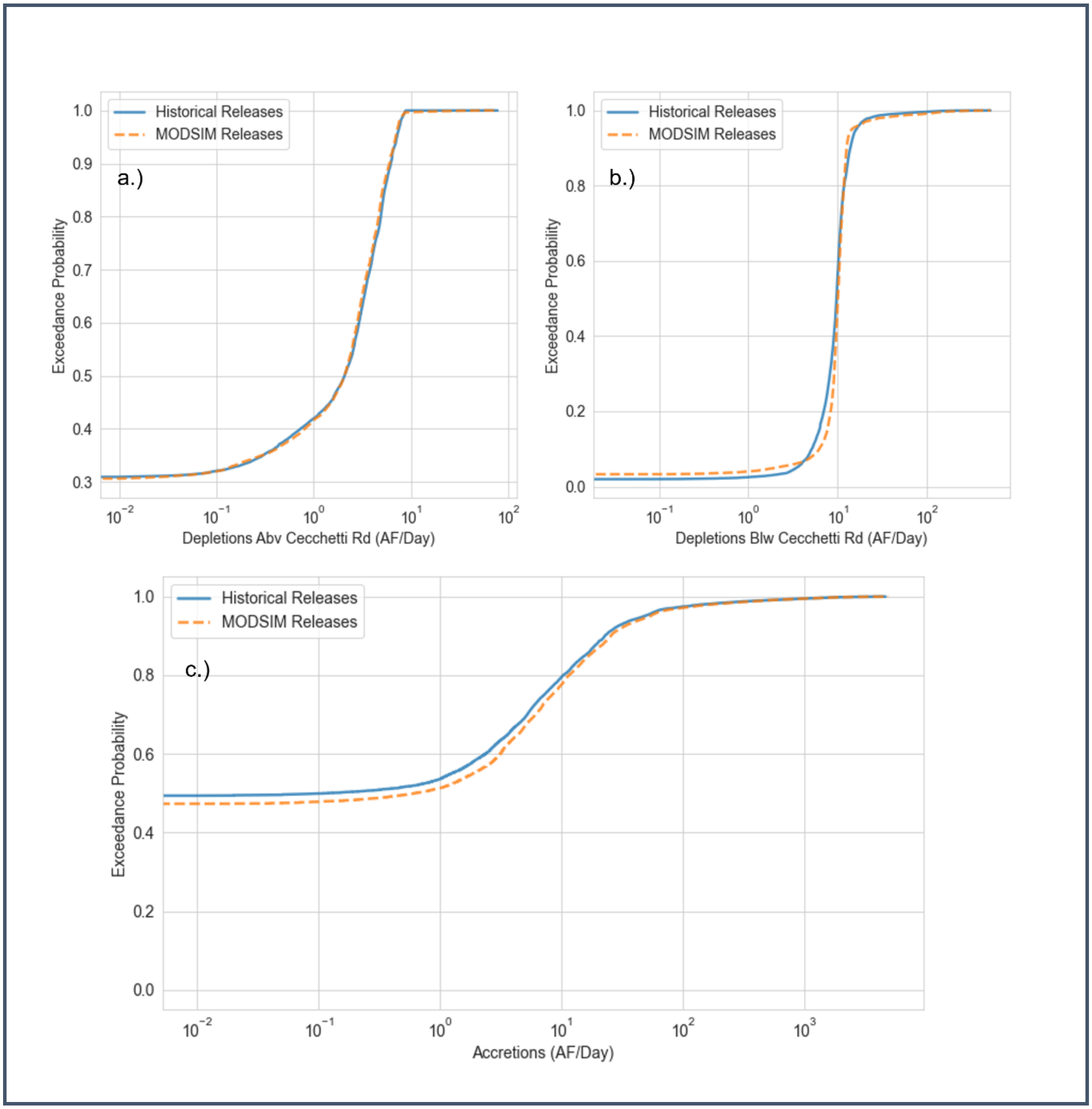

Figure 18. Comparison of accretions (c) and depletions (a; b) along the Arroyo Grande Creek from the two model simulations (log-scale). These comparisons are shown as Empirical Cumulative Distribution Functions (ECDFs) of simulated flow.

The overall difference in simulated flow below Lopez Dam, between the two models is compared in Figure 19. The results show the simulated releases in the run with previous MODSIM releases still different, which indicates that the models have not converged and could improve the solution by iterating one more time with the new releases that should be closer to the net accretions and depletions in the system.

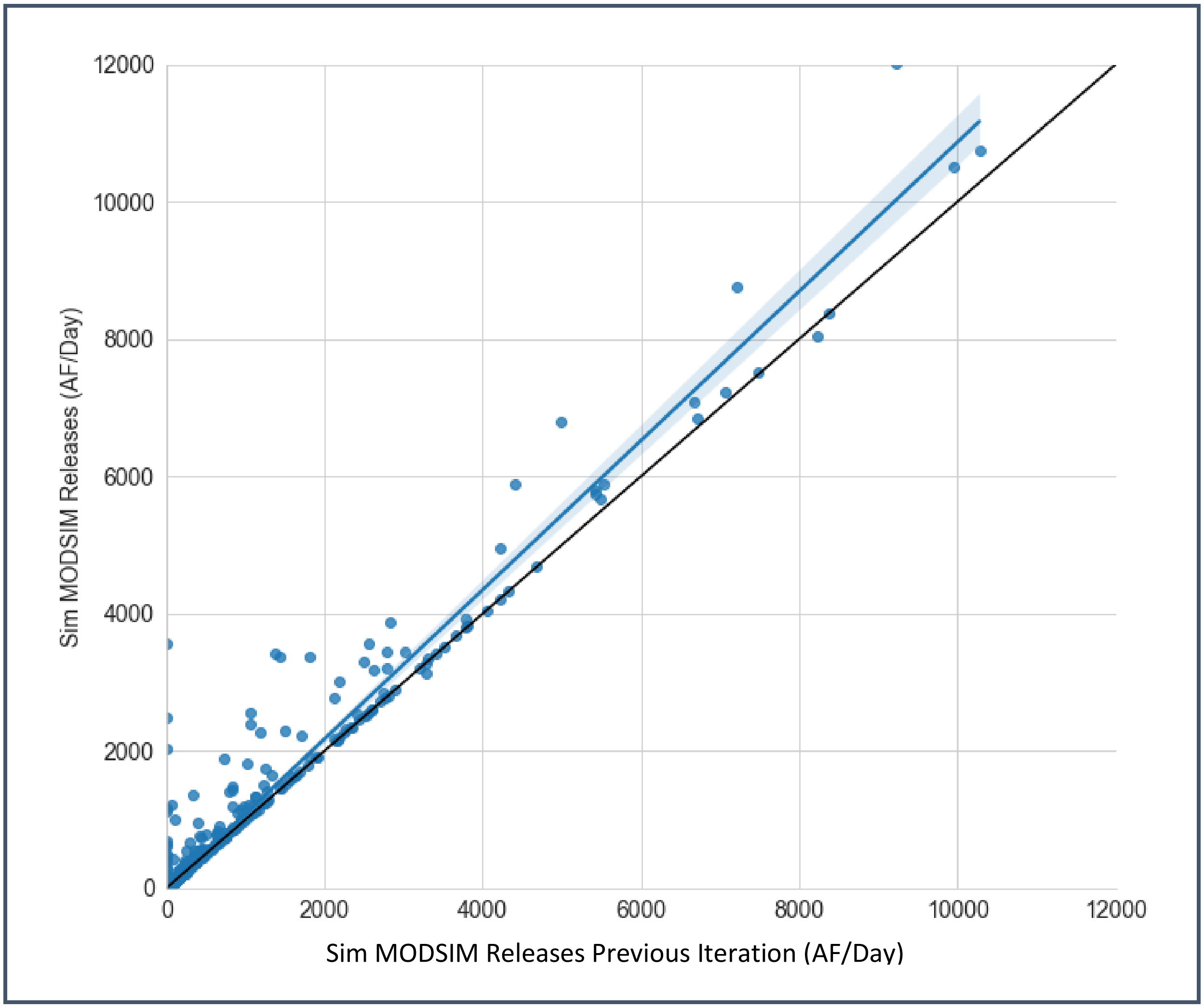

Figure 19. Comparison of simulated release right below Lopez Dam. The figure shows a fitted linear regression line with estimated confidence interval to show goodness-of-fit (blue line) and the 1-to-1 line (black line).

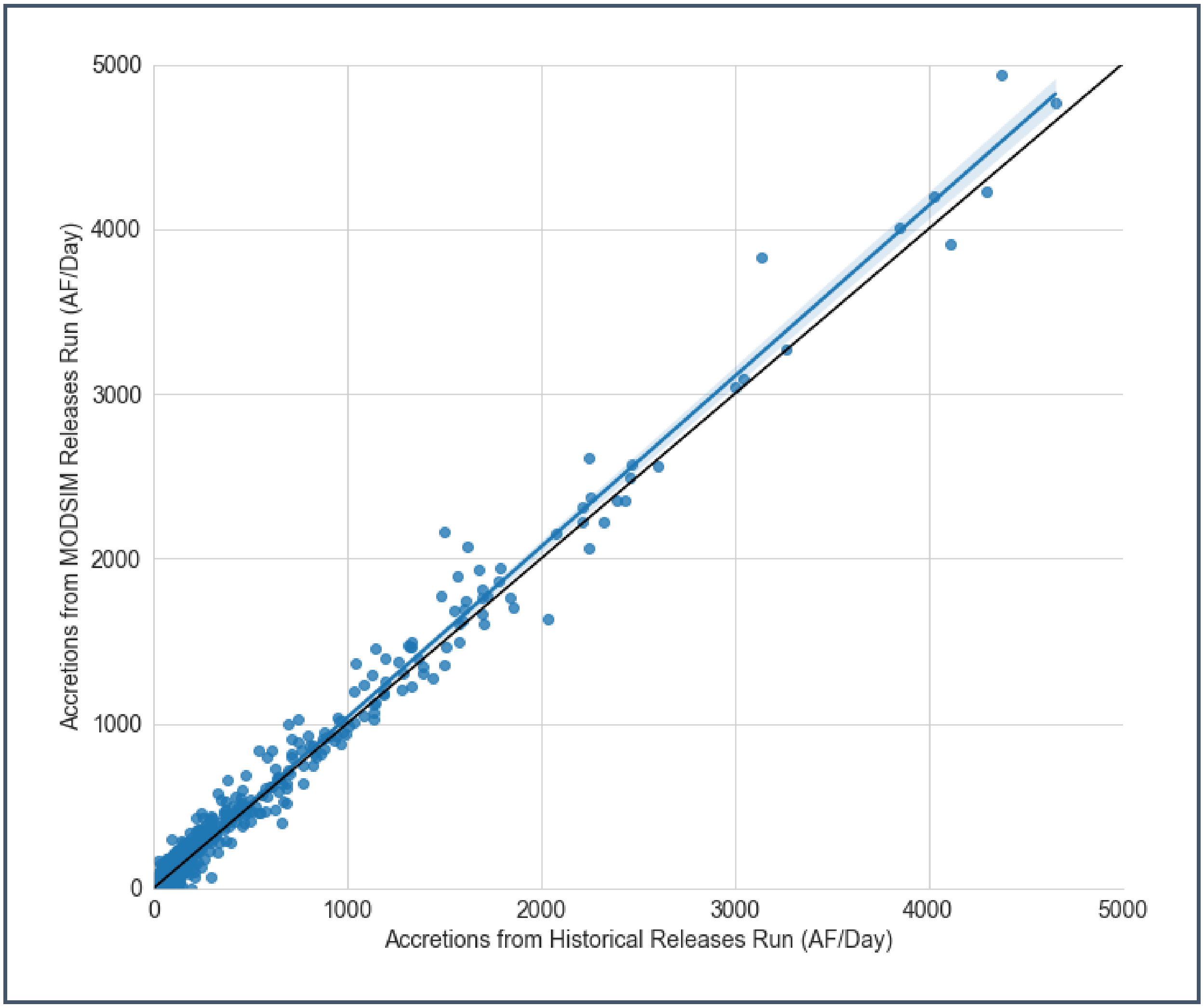

Figure 20. Comparison of total accretions between the two model runs. The figure shows a fitted linear regression line with estimated confidence interval to show goodness-of-fit (blue line) and the 1-to-1 line (black line).

4.3 Features of Modeling System

While at the time of this report, the current version of the MODSIM-GSFLOW coupling code was only able to run the Arroyo Grande model without synchronizing Lopez Lake, the modeling files required for the full application of the coupled code were created and are provided as deliverable. The synchronization of the lake with MODSIM was not converging at this time and it was not apparent the root of the problem. The GSFLOW model that includes the lake could be improved to simulate the releases to the water treatment plan and include a more detailed representation of the area-capacity-elevation that would smooth the calculation of the lake volume. Current work on the coupling code attempts to improve the convergence of the lakes with MODSIM, so future releases could include elements that accelerate and ensure easier convergence during the MODSIM-GSFLOW iteration process. The analysis performed for this project was done either using tools that allow ingesting GSFLOW accretion/depletions as a snapshot to MODSIM or running the coupled code with dynamic syncing of accretions and depletions but with GSFLOW releases specified from the previous MODSIM run.

The accretions and depletions used in the coupled simulation are estimated by the GSFLOW model and represent the effect of the simulated pumping, return flows, flow in the creek, physical parameters of the groundwater system and the stream bed and natural runoff inflows in the Arroyo Grande basin for the historical period. The detail calculation of net accretions by GSFLOW replaces the calculated stream losses in Task 1. The stream gains and losses have significant effects in operations, especially if the model uses target flows at a location in the creek, to drive the releases.

The coupled system simulates the conditions at the reservoir based on the inflows and the releases, both the creek itself and the water treatment plant needs, allowing a more accurate simulation of the water stored in the reservoir, the storage available, the spills and the storage left. The operation of the lake would be performed with upon new demand conditions and release patterns and will estimate evaporation.

The pumping is simulated spatially based on the need and the distance to the stream drives the influence on depletions from the creek. These spatially varied effects are an improvement over the simulated groundwater demand lumped used in the Task 1.

The sensitivity of the accretions and depletions in Arroyo Grande creek to the releases in MODSIM demonstrate the value of this model and the coupled simulation because it allows to analyze more accurately the response of the system to changes in operations, pumping and hydrology regimes.

4.4 Deliverable Files

The files provided with this deliverable include:

File Description	File/Folder Name
Compress folder with the input files for the MODSIM-GSFLOW coupled simulation. These files include the calibration GSFLOW model files (Ver 62), the MODSIM file, the Synchronization database and the executable for the coupled simulation.	ModelFiles\SLO_Model_MODSIMGSFLOWInputFiles.7z
MODSIM input and output files for the models with historical releases and MODSIM releases	ModelFiles\ModelFilesDeliverables.7z
Memorandum (PDF format)	RTI - MODSIM Model Development Memo.pdf

5 References

ECORP Consulting, Inc. (2015, December) Lopez Water Project Habitat Conservation Plan Hydrogeologic Services Modeling Technical Memorandum

Markstrom, S. & Niswonger, R. & Regan, R. & Prudic, D. & Barlow, Paul. (2008). GSFLOW—Coupled ground-water and surface-water flow model based on the integration of the Precipitation-Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW-2005). 10.13140/2.1.2741.9202.

Labadie, J. 2005. MODSIM: River basin management decision support system. Watershed Models. CRC Press, Boca Raton, Florida.

Western Hydrologics (2021). OASIS model documentation documents and personal communications.

H

Appendix H Monitoring Network Data Management Plan

Groundwater Level Measurement Procedures for the
Arroyo Grande Groundwater Subbasin GSP

Introduction

This document establishes procedures for measuring and recording groundwater levels for the SLO Basin Groundwater Monitoring Program, and describes various methods used for collecting meaningful groundwater data.

Static groundwater levels obtained for the groundwater monitoring program are determined by measuring the distance to water in a non-pumping well from a reference point that has been referenced to sea level. Subtracting the distance to water from the elevation of the reference point determines groundwater surface elevations above or below sea level. This is represented by the following equation:

$$E_{GW} = E_{RP} - D$$

Where:

E_{GW} = Elevation of groundwater above mean sea level (feet)
E_{RP} = Elevation above sea level at reference point (feet)
D = Depth to water (feet)

References

Procedures for obtaining and reporting water level data for the SLO Basin Groundwater Monitoring Program are based on a review of the following documents.

- State of California, Department of Water Resources, 2016, *Best Management Practices for the Sustainable Management of Groundwater: Monitoring Protocols, Standards, and Sites*, December 2016.
- State of California, Department of Water Resources, 2014, *Addendum to December 2010 Groundwater Elevation Monitoring Guidelines for the Department of Water Resources' California Statewide Groundwater Elevation Monitoring (CASGEM) Program,* October 2, 2014.
- State of California, Department of Water Resources, 2010, *Groundwater Elevation Monitoring Guidelines*, prepared for use in the California Statewide Groundwater Elevation Monitoring (CASGEM) program, December 2010.
- U.S. Geological Survey, 2011, *Groundwater Technical Procedures of the U.S. Geological Survey*, Techniques and Methods 1-A1, compiled by William L. Cunningham and Charles W. Schalk.
- U.S. Geological Survey, 1977, *National Handbook of Recommended Methods for Water-Data Acquisition*, a Unites States contribution to the International Hydrological Program.

Well Information

Table 1 below lists important well information to be maintained in a well file or in a field notebook. Additional information that should be available to the person collecting water level data include a description of access to the property and the well, the presence and depth of cascading water, or downhole obstructions that could interfere with a sounding cable.

Table 1
Well File Information

Well Completion Report	Hydrologic Information	Additional Information to be Recorded
Well name	Map showing basin boundaries and wells	Township, Range, Section and ¼-¼ Section
Well Owner	Name of groundwater basin	Latitude and Longitude (Decimal degrees)
Drilling Company	Description of aquifer	Assessor's Parcel Number
Location map or sketch	Confined, unconfined, or mixed aquifers	Description of well head and sounding access
Total depth	Pumping test data	Reference point elevations
Perforation interval	Hydrographs	Well use and pumping schedule if known
Casing diameter	Water quality data	Date monitoring began
Date of well completion	Property access instructions/codes	Land use

Reference Points and Reference Marks

Reference point (RP) elevations are the basis for determining groundwater elevations relative to sea level. The RP is generally a point on the well head that is the most convenient place to measure the water level in a well. In selecting an RP, an additional consideration is the ease of surveying either by Global Positioning System (GPS) or by leveling.

The RP must be clearly defined, well marked, and easily located. A description, sketch, and photograph of the point should be included in the well file. Additional Reference Marks (RMs) may be established near the wellhead on a permanent object. These additional RMs can serve as a benchmark by which the wellhead RP can be checked or re-surveyed if necessary. All RMs should be marked, sketched, photographed, and described in the well file.

All RPs for Groundwater Monitoring Program wells should be reported based on the same horizontal and vertical datum by a California licensed surveyor to the nearest tenth of one foot vertically, and the nearest one foot horizontally. The surveyor’s report should be maintained in the project file.

In addition to the RP survey, the elevation of the ground surface adjacent to the well should also be measured and recorded in the well file. Because the ground surface adjacent to a well is rarely uniform, the average surface level should be estimated. This average ground surface elevation is referred to in the USGS Procedural Document (GWPD-1) and DWR guidelines as the Land Surface Datum.

Water Level Data Collection

Prior to beginning the field work, the field technician should review each well file to determine which well owners require notification of the upcoming site visit, or which well pumps need to be turned off to allow for sufficient water level recovery. Because groundwater elevations are used to construct groundwater contour maps and to determine hydraulic gradients, the field technician should coordinate water level measurements to be collected within as short a period of time as practical. Any significant changes in groundwater conditions during monitoring events should be noted in the Annual Monitoring Report. For an individual well, the same measuring method and the same equipment should be used during each sampling event where practical.

A static water level should represent stable, non-pumping conditions at the well. When there is doubt about whether water levels in a well are continuing to recover following a pumping cycle, repeated measurements should be made. If an electric sounder is being used, it is possible to hold the sounder level at one point slightly above the known water level and wait for a signal that would indicate rising water. If applicable, the general schedule of pump operation should be determined and noted for active wells. If the well is capped but not vented, remove the cap and wait several minutes before measurement to allow water levels to equilibrate to atmospheric pressure.

When lowering a graduated steel tape (chalked tape) or electric tape in a well without a sounding tube in an equipped well, the tape should be played out slowly by hand to minimize the chance of the tape end becoming caught in a downhole obstruction. The tape should be held in such a way that any change in tension will be felt. When withdrawing a sounding tape, it should also be brought up slowly so that if an obstruction is encountered, tension can be relaxed so that the tape can be lowered again before attempting to withdraw it around the obstruction.

Despite all precautions, there is a small risk of measuring tapes becoming stuck in equipped wells without dedicated sounding tubes. If a tape becomes stuck, the equipment should be left on-site and re-checked after the well has gone through a few cycles of pumping, which can free the tape due to movement/vibration of the pump column. If the tape remains stuck, a pumping contractor will be needed to retrieve the equipment. A dedicated sounding tube may be installed by the pumping contractor at that time.

All water level measurements should be made to an accuracy of 0.01 feet. The field technician should make at least two measurements. If measurements of static levels do not agree to within 0.02 feet of each other, the technician should continue measurements until the reason for the disparity is determined, or the measurements are within 0.02 feet.

Record Keeping in the Field

The information recorded in the field is typically the only available reference for the conditions at the time of the monitoring event. During each monitoring event it is important to record any conditions at a well site and its vicinity that may affect groundwater levels, or the field technician's ability to obtain groundwater levels. Table 2 lists important information to record, however, additional information should be included when appropriate.

Table 2
Information Recorded at Each Well Site

Well name	Changes in land use	Presence of pump lubricating oil in well
Name and organization of field technician	Changes in RP	Cascading water
Date & time	Nearby wells in use	Equipment problems
Measurement method used	Weather conditions	Physical changes in wellhead

Sounder used	Recent pumping info	Comments
Reference Point Description	Measurement correction(s)	Well status

An example of a field log sheet from DWR is attached.

Measurement Techniques

Four standard methods of obtaining water levels are discussed below. The chosen method depends on site and downhole conditions, and the equipment limitations. In all monitoring situations, the procedures and equipment used should be documented in the field notes and in final reporting. Additional detail on methods of water level measurement is included in the reference documents.

<u>Graduated Steel Tape</u>
This method uses a graduated steel tape with a brass or stainless steel weight attached to its end. The tape is graduated in feet. The approximate depth to water should be known prior to measurement.

- Estimate the anticipated static water level in the well from field conditions and historical information;
- Chalk the lower few feet of the tape by applying blue carpenter's chalk.
- Lower the tape to just below the estimated depth to water so that a few feet of the chalked portion of the tape is submerged. Be careful not to lower the tape beyond its chalked length.
- Hold the tape at the RP and record the tape position (this is the "hold" position and should be at an even foot);
- Withdraw the tape rapidly to the surface;
- Record the length of the wetted chalk mark on the graduated tape;
- Subtract the wetted chalk number from the "hold" position number and record this number in the "Depth to Water below RP" column;
- Perform a check by repeating the measurement using a different RP hold value;
- All data should be recorded to the nearest 0.01 foot;
- Disinfect the tape by wiping down the submerged portion of the tape with single-use, unscented disinfectant wipe, or let stand for one minute in a dilute chlorine bleach solution and dry with clean cloth.

The graduated steel tape is generally considered to be the most accurate method for measuring static water levels. Measuring water levels in wells with cascading water or with condensing water on the well casing causes potential errors, or can be impossible with a steel tape.

<u>Electric Tape</u>
An electric tape operates on the principle that an electric circuit is completed when two electrodes are submerged in water. Most electric tapes are mounted on a hand-cranked reel equipped with batteries and an ammeter, buzzer or light to indicate when the circuit is completed. Tapes are graduated in either one-foot intervals or in hundredths of feet depending on the manufacturer. Like graduated steel tapes, electric tapes are affixed with brass or stainless steel weights.

- Check the circuitry of the tape before lowering the probe into the well by dipping the probe into water and observe if the ammeter needle or buzzer/light signals that the circuit is completed;

- Lower the probe slowly and carefully into the well until the signal indicates that the water surface has been reached;
- Place a finger or thumb on the tape at the RP when the water surface is reached;
- If the tape is graduated in one-foot intervals, partially withdraw the tape and measure the distance from the RP mark to the nearest one-foot mark to obtain the depth to water below the RP. If the tape is graduated in hundredths of a foot, simply record the depth at the RP mark as the depth to water below the RP;
- Make all readings using the same needle deflection point on the ammeter scale (if equipped) so that water levels will be consistent between measurements;
- Make check measurements until agreement shows the results to be reliable;
- All data should be recorded to the nearest 0.01 foot;
- Disinfect the tape by wiping down the submerged portion of the tape with single-use, unscented disinfectant wipe, or let stand for one minute in a dilute chlorine bleach solution and dry with clean cloth;
- Periodically check the tape for breaks in the insulation. Breaks can allow water to enter into the insulation creating electrical shorts that could result in false depth readings.

The electric tape may give slightly less accurate results than the graduated steel tape. Errors can result from signal “noise” in cascading water, breaks in the tape insulation, tape stretch, or missing tape at the location of a splice. All electric tapes should be calibrated annually against a steel tape that is maintained in the office and used only for calibration.

<u>Air Line</u>
The air line method is usually used only in wells equipped with pumps. This method typically uses a 1/8 or 1/4-inch diameter, seamless copper tubing, brass tubing, stainless steel tubing, or galvanized pipe with a suitable pipe tee for connecting an altitude or pressure gage. Plastic (i.e. polyethylene) tubing may also be used, but is considered less desirable because it can develop leaks as it degrades. An air line must extend far enough below the water level that the lower end remains submerged during pumping of the well. The air line is connected to an altitude gage that reads directly in feet of water, or to a pressure gage that reads pressure in pounds per square inch (psi). The gage reading indicates the length of the submerged air line.

The formula for determining the depth to water below the RP is: **d = k – h** where d = depth to water; k = constant; and h = height of the water displaced from the air line. In wells where a pressure gage is used, h is equal to 2.31 ft/psi multiplied by the gage reading. The constant value for k is approximately equivalent to the length of the air line.

- Calibrate the air line by measuring an initial depth to water (d) below the RP with a graduated steel tape. Use a tire pump, air tank, or air compressor to pump compressed air into the air line until all the water is expelled from the line. When all the water is displaced from the line, record the stabilized gage reading (h). Add d to h to determine the constant value for k.
- To measure subsequent depths to water with the air line, expel all the water from the air line, subtract the gage reading (h) from the constant k, and record the result as depth to water (d) below the RP.

The air line method is not as accurate as a graduated steel tape or electric and is typically accurate to the nearest one foot at best. Errors can occur from leaky air lines, or when tubing becomes clogged with mineral deposits or bacterial growth. The air line method is not desirable for use in the Groundwater Monitoring Program.

Pressure Transducer

Electrical pressure transducers make it possible to collect frequent and long-term water level or pressure data from wells. These pressure-sensing devices, installed at a fixed depth in a well, sense the change in pressure against a membrane. The pressure changes occur in response to changes in the height of the water column in the well above the transducer membrane. To compensate for atmospheric changes, transducers may have vented cables or they can be used in conjunction with a barometric transducer that is installed in the same well or a nearby observation well above the water level.

Transducers are selected on the basis of expected water level fluctuation. The smallest range in water levels provides the greatest measurement resolution. Accuracy is generally 0.01 to 0.1 percent of the full scale range.

Retrieving data in the field is typically accomplished by downloading data through a USB connection to a portable computer or data logger. A site visit to retrieve data should involve several steps designed to safeguard the stored data and the continued useful operation of the transducer:

- Inspect the wellhead and check that the transducer cable has not moved or slipped (the cable can be marked with a reference point that can be used to identify movement);
- Ensure that the instrument is operating properly;
- Measure and record the depth to water with a graduated steel or electric tape;
- Document the site visit, including all measurements and any problems;
- Retrieve the data and document the process;
- Review the retrieved data by viewing the file or plotting the original data;
- Recheck the operation of the transducer prior to disconnecting from the computer.

A field notebook with a checklist of steps and measurements should be used to record all field observations and the current data from the transducer. It provides a historical record of field activities. In the office, maintain a binder with field information similar to that recorded in the field notebook so that a general historical record is available and can be referred to before and after a field trip.

Quality Control

The field technician should compare water level measurements collected at each well with the available historical information to identify and resolve anomalous and potentially erroneous measurements prior to moving to the next well location. Pertinent information, such as insufficient recovery of a pumping well, proximity to a pumping well, falling water in the casing, and changes in the measurement method, sounding equipment, reference point, or groundwater conditions should be noted. Office review of field notes and measurements should also be performed by a second staff member.

All field tapes (both steel and electric) used for the monitoring program should be calibrated annually against another acceptable steel tape. An acceptable steel tape is one that is maintained in the office for use only in calibrating the field tapes. Adjustments for tape calibration should be applied and noted.

STATE OF CALIFORNA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

WELL DATA

STATE WELL NUMBER	COUNTY	REFERENCE POINT ELEV.	MEASURING AGENCY
			DWR

NO MEASUREMENT	QUESTIONABLE MEASUREMENT
0. Measurement discontinued 1. Pumping 2. Pump house locked 3. Tape hung up 4. Can't get tape in casing 5. Unable to locate well 6. Well has been destroyed 7. Special 8. Casing leaky or wet 9. Temporarily inaccessible	0. Caved or deepened 1. Pumping 2. Nearby pump operating 3. Casing leaky or wet 4. Pumped recently 5. Air or pressure gauge measurement 6. Other 7. Recharge operation at or nearby well 8. Oil in casing

DATE	N M	Q M	TAPE AT RP	TAPE AT WS	RP to WS	OBSR VR	COMMENTS

DWR 1213

Figure 4 – Example of Water Level Well Data Field Collection Form

Streamflow Measurement in Natural Channels

The most practical method for measuring streamflow in natural channels is the velocity-area method, which has the following computation[1]:

$$Q = \sum_{i=1}^{n} (a_i v_i)$$

where:

Q = total discharge (reported in cubic feet per second).

a_i = cross-sectional area of flow for the *i*th segment of the *n* segments into which the cross section is divided (square feet), and

v_i = the corresponding mean velocity of flow normal to the *i*th segment (feet per second).

The conceptual model for the velocity area-method is shown below. A stream is divided into segments, each with an individual area and velocity, which are then multiplied and summed using the above equation.

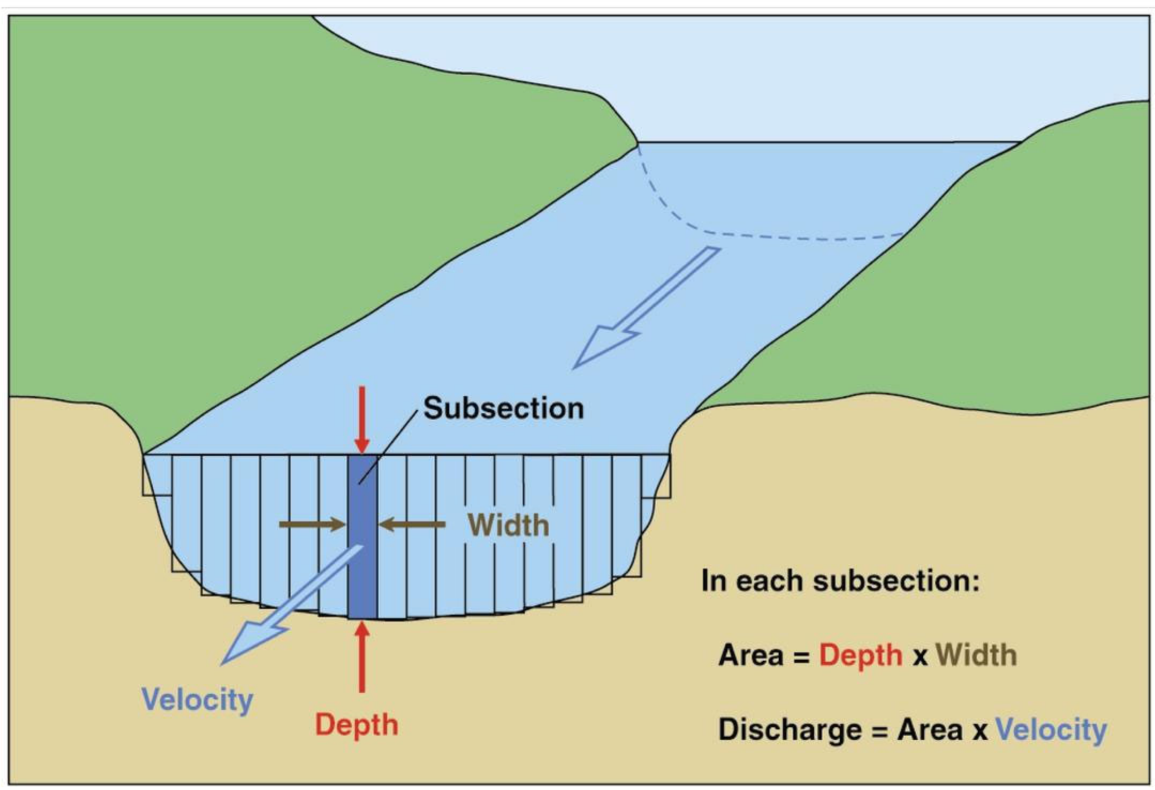

Diagram of Channel cross-section with segments for discharge computation (USGS)

In natural channels, stream gages are used to record stage (feet), which is the height of water in the stream above an arbitrary point, usually at or below the stream bed. The stage is then

[1] Turnipseed, D.P. and Sauer, V.B., 2010. Discharge Measurements at Gaging Stations, USGS Techniques and Methods 3-A8.

converted to streamflow through the use of a rating curve, or stage-discharge relation. A rating curve incorporates information collected that is specific to each site, including the cross-sectional area of the channel and the average velocity for a given flow stage. These rating curves are developed using depth profiles and average flow velocity measurements during storm-runoff events. Rating curves may need to be revised periodically as they can shift due to changes in channel geometry. Measuring average flow velocity across a channel at different stream stages is the most challenging part of developing a rating curve.

Arroyo Grande Subbasin Data Management Plan

Data Management System to Support Implementation of the Sustainable Groundwater Management Act

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August 31, 2020

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Figures

Tables

1. Introduction

The purpose of this Data Management Plan (DMP) is to describe the planned Data Management System (DMS) and the process for collection, review, and upload of data used to develop a Groundwater Sustainability Plan (GSP) for the Arroyo Grande Subbasin (AG Basin). This document does not provide final specifications for a complete DMS. Rather, it describes the data needed to comply with SGMA, the method to be used for data collection, and the plan for DMS development.

1.1 SGMA DMS Requirements

The Sustainable Groundwater Management Act (SGMA) requires development of a DMS. The DMS stores data relevant to development of a groundwater basin's GSP as defined by the GSP Regulations (California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2).

The GSP Regulations give general guidelines for a DMS:

> ***§ 352.6. Data Management System***
>
> *Each Agency shall develop and maintain a data management system that is capable of storing and reporting information relevant to the development or implementation of the [Groundwater Sustainability] Plan and monitoring of the basin.*
>
> *Note: Authority cited: Section 10733.2, Water Code.*
> *Reference: Sections 10727.2, 10728, 10728.2, and 10733.2, Water Code.*
>
> ***§ 352.4. Data and Reporting Standards***
>
> *(c) The following standards apply to wells:*
>
> *(3) Well information used to develop the basin setting shall be maintained in the Agency's data management system*
>
> *Note: Authority cited: Section 10733.2, Water Code.*
> *Reference: Sections 10727.2, 10727.6, and 10733.2, Water Code.*
>
> ***§ 354.40. Reporting Monitoring Data to the Department***
>
> *Monitoring data shall be stored in the data management system developed pursuant to Section 352.6. A copy of the monitoring data shall be included in the Annual Report and submitted electronically on forms provided by the Department.*
>
> *Note: Authority cited: Section 10733.2, Water Code.*
> *Reference: Sections 10728, 10728.2, 10733.2, and 10733.8, Water Code.*

To comply with SGMA, the SLO Basin DMS will store data that is relevant to development and implementation of the GSP as well as for monitoring and reporting purposes.

2. Data Needs for SGMA

The AG Subbasin is in San Luis Obispo County, California. The county spans multiple groundwater basins – 6 of which are engaged in SGMA activity. Each basin complying with SGMA is required to store data in a DMS. Rather than host several systems, a county-wide DMS will be implemented to support county data initiatives for SGMA and other non-SGMA data initiatives.

Figure 1. Groundwater Basins in San Luis Obispo County[1]

SGMA defines sustainable groundwater management as "the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results."[2] Furthermore, SGMA outlines six undesirable results as follows:[3]

> *One or more of the following effects caused by groundwater conditions occurring throughout the basin:*
>
> *(1) Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to*

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[1] Source: California Department of Water Resources, SGMA Data Viewer, accessed August 14, 2020.
[2] §10721(v)
[3] §10721(x)

establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.

(2) Significant and unreasonable reduction of groundwater storage.

(3) Significant and unreasonable seawater intrusion.

(4) Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.

(5) Significant and unreasonable land subsidence that substantially interferes with surface land uses.

(6) Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

The presence or absence of the six undesirable results in a groundwater basin is determined by monitoring and reviewing data for six sustainability indicators (one for each undesirable result). A set of associated measurable objective and minimum threshold will be assigned for each indicator and will be included in the DMS.

There are multiple metrics by which the sustainability indicators may be observed. The sustainability indicators and their respective metrics, as defined in the GSP Regulations and described by the California Department of Water Resources (DWR) in the Sustainable Management Criteria Best Management Practice (BMP) document,[4] are shown in **Figure 2**.

Figure 2. DWR's Sustainability Indicators and Metrics

Sustainability Indicators	Lowering GW Levels	Reduction of Storage	Seawater Intrusion	Degraded Quality	Land Subsidence	Surface Water Depletion
Metric(s) Defined in GSP Regulations	• Groundwater Elevation	• Total Volume	• Chloride concentration isocontour	• Migration of Plumes • Number of supply wells • Volume • Location of isocontour	• Rate and Extent of Land Subsidence	• Volume or rate of surface water depletion

[4] https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Sustainable_Management_Criteria_2017-11-06.pdf.

Table 1 describes the types of data that may possibly be monitored for each sustainability indicator. Sustainability indicators do not need to be tracked by every available monitoring type.

Table 1. Monitoring data for the SGMA sustainability indicators

Sustainability Indicator	Monitoring Data Types							
					Water Quality			
	Water Level	Extensometer	GPS	InSAR	Chloride	±10 constituents	Stream stages	Well and/or Site Data
Lowering groundwater levels	✓							✓
Reduction of storage	✓							✓
Seawater intrusion	✓				✓			✓
Degraded quality	✓				✓	✓		✓
Land subsidence	✓	✓	✓	✓				✓
Surface water depletion	✓						✓	✓

The DMS will accommodate data relevant to each sustainability indicator. The monitoring data types listed in **Table 1** represent the various data sets required to populate the DMS for tracking sustainability indicators. However, there is additional data that is readily available and may be included in the DMS to assist with preparation of GSPs and to support annual reporting.

3. Data Sources

Table 2 illustrates the data sources that will be used to populate the DMS to support GSP development, sustainability indicator monitoring, and annual reporting. The data categories listed below inform the design of the DMS and support the data needs presented previously in **Table 1**.

Table 2. Data Sources to Populate the DMS

Data Category	State and Federal Data Sources						Local Data Sources	
	California Statewide Groundwater Elevation Monitoring (CASGEM)	Well Logs	California Data Exchange Center (CDEC)	Geotracker Groundwater Ambient Monitoring and Assessment (GAMA)	United States Geological Survey (USGS)	Irrigated Lands Program	Participating Agencies	Other Groundwater Users*
Well and Site Info	✓	✓		✓	✓		✓	✓
Lithology	✓	✓		✓	✓		✓	
Water Level	✓				✓		✓	✓
Water Quality				✓	✓	✓	✓	
Subsidence					✓		✓	
Precipitation			✓				✓	
Land Use							✓	
Surface Water (Diversions, Stream Gages)			✓				✓	
Pumping							✓	✓

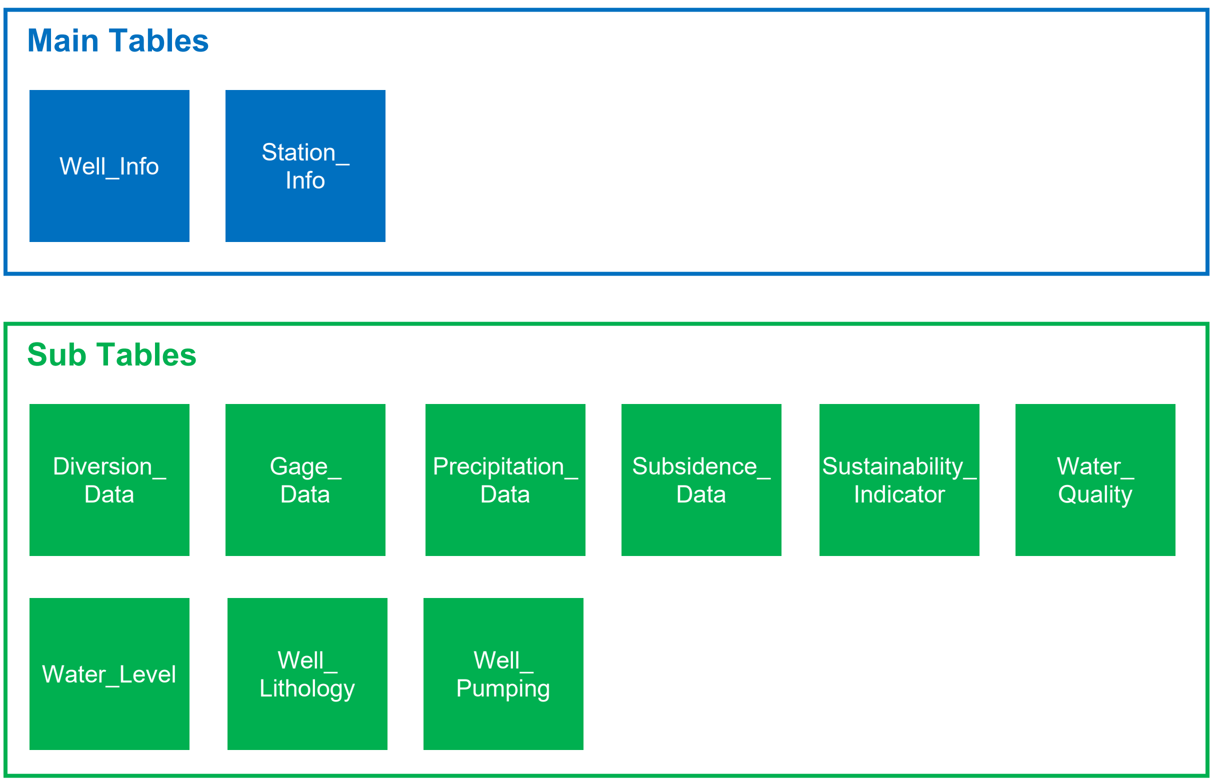
*Private parties and mutual water companies

4. Data Structure

The DMS will be comprised of a database plus an online web viewer. Data stored in the DMS will be separated by categories into tables. The tables shall contain columns and rows of data. Each field will hold a specific type of data, such as a number, text, or date. The planned DMS data tables are shown as **Figure 3**. The figure is color-coordinated to show the relationship between tables:

- **Main tables (Blue)** – Each dataset will be associated with EITHER a well or a station (e.g., extensometer). These are the main tables and include point data with unique identification and locations.
- **Sub tables (Green)** – Sub tables are related to the main tables and hold additional details about a well or site (e.g., correlation of a well with a water level measurement).

Figure 3. DMS Tables



A brief description of the main and sub tables is provided as **Table 3**.

Table 3. DMS Table Descriptions

Table	Description
Main Tables	
Station_Info	Information about type of station (recharge site, diversion, gage, extensometer, GSP) and location information
Well_Info	General information about well, including well construction and screen information
Sub Tables	
Diversion_Data	Diversion volume measurements for a diversion site or managed recharge
Gage_Data	Measurements collected at river or stream gages
Precipitation_Data	Volumetric measurements collected at precipitation monitoring stations
Subsidence_Data	Measurements collected at subsidence monitoring stations (e.g., extensometer)
Sustainability_Indicator	Minimum Thresholds and Measurable Objectives set for monitoring network sites tracking Sustainable Management Criteria for SGMA compliance
Water_Quality	Contains water quality data for wells or any other type of site
Water_Level	Water level measurements for wells
Well_Lithology	Lithologic information at a well site (each well may have many lithologies at different depths)
Well_Pumping	Pumping or recharge measurements for wells

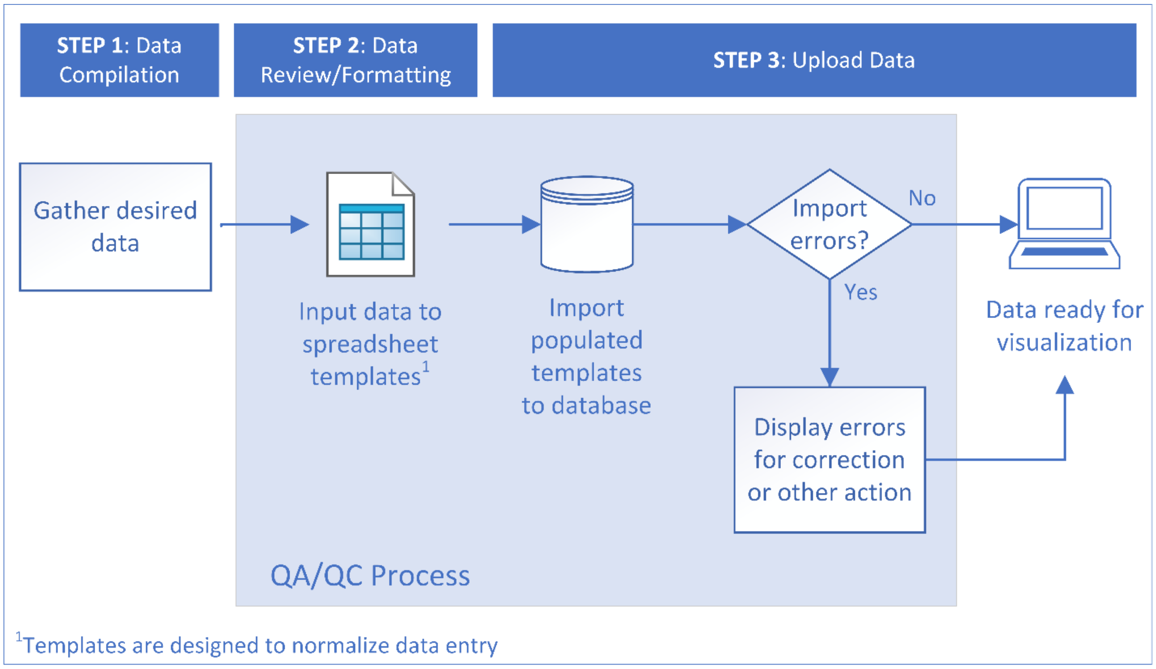
5. Data Import

Importing data to the DMS consists of three steps, as shown on **Figure 4** and listed below:

1. Data compilation
2. Data review and formatting
3. Upload data

The DMS shall be designed to use this process to import data for all basins in San Luis Obispo County. The DMS development team will upload data to support the SLO Basin GSP. Data for other basins will be loaded by other teams' GSP efforts.

Figure 4. Template Import Process for Local Data



5.1 Data Compilation (STEP 1)

Historical data must be gathered to populate the DMS. Select state and federal data (as provided earlier in **Table 2**) for the AG Subbasin will be compiled by the GSAs and their consultant(s). Participating agencies and other stakeholders will compile local data and data for other basins in the County.

5.2 Data Formatting and Review (STEP 2)

After the data is compiled, it shall be normalized by use of Microsoft Excel templates designed exclusively for the DMS. Each of the main and sub tables, described previously in **Section 4**, will have a template.

The tables below list and describe the templates planned for the DMS. There are three types of data templates:

- Groundwater well data templates: for data associated with a well.
- Station data templates: for data associated with a station. A station is defined as any site, that isn't a groundwater well, tracking DMS data (e.g., extensometer).
- Independent data templates: for data that is not associated with a single well or station.

Table 4. Well Data Templates

Template	Description
WELL_INFO	Well site information including construction and location
WELL_SCREEN	Screened intervals associated with a well site
WELL_AQUIFER	Aquifers associated with a well site
WELL_LITHOLOGY	Lithologic information at a well site (each well may have many lithologies at different depths)
WELL_WATER_LEVEL	Water level measurements taken at wells
WELL_PUMPING	Pumping or recharge measurements for wells
WELL_WATER_QUALITY	Water quality data collected at well sites
WELL_SUST_INDICATOR	Minimum Thresholds, Measurable Objectives, and Interim Milestones set for wells (not stations)

Table 5. Station Data Templates

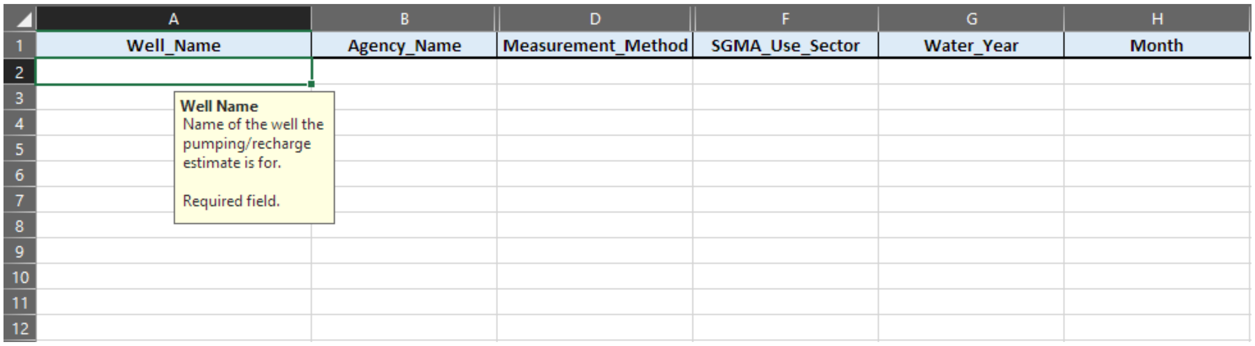
Template	Description
STATION_INFO	Information about a non-well station (e.g., recharge site) and location information
STATION_PRECIPITATION_DATA	Volumetric measurements collected at stations such as precipitation monitoring sites
STATION_SUBSIDENCE_DATA	Measurements from subsidence stations
STATION_GAGE_DATA	Measurements collected at river and stream gages
STATION_WATER_QUALITY	Water quality data collected at non-well stations
STATION_DIVERSION_DATA	Diversion volume measurements for a diversion site or managed recharge
STATION_SUST_INDICATOR	Minimum Thresholds, Measurable Objectives, and Interim Milestones set for stations (not wells)

Table 6. Independent Data Templates

Template	Description
AGENCY	Addresses and other identifying information about the source agencies for data in the system
WATER_YEAR	Water year type (e.g., dry)
DOCUMENT	Document information including file type, name, and file path

The data templates will include rules restricting formatting and alphanumeric properties to provide quality assurance/quality control (QA/QC) and to prevent errors and duplication when importing. The templates include pop-up windows to describe the type of data that should be entered in each column. If a specific filter must be applied, then only values that meet the criteria will appear in a drop-down list. **Figure** 5 provides a screenshot of an example Excel template.

Figure 5. Example Template (Well Pumping)



When data is compiled it must also be reviewed for accuracy. The template restrictions described above provide one level of QA/QC. As a second level of QA/QC, the initial set of compiled historical data will be reviewed by the consulting team before it is migrated into the database. This review will be focused and limited in scope. It will include the following manual checks:

- Identifying outliers that may have been introduced during the original data entry process
- Identifying potential duplication of data
- Removing or flagging questionable data
- Visualizing data in various software platforms outside the DMS to further assess the quality of the data

After the historical data is populated, future data will be reviewed by the County before it is fully imported to the DMS.

5.3 Data Upload (STEP 3)

Once the data is formatted and reviewed it will be uploaded to the DMS and displayed with a visualization tool (described in the next section). When loading the data, an automated check will be run by the DMS to capture errors or duplicates, if any, and a response will be generated to indicate errors so they may be corrected.

The upload templates will be available for download in the DMS interface to load future data.

6. SGMA Data Viewer

The DMS will include a user-friendly web viewer to display the SGMA data including the SGMA-specific sustainable management criteria (SMC) information such as representative monitoring sites, minimum thresholds, measurable objectives, and interim milestones.

The DMS SGMA data will display both with a map view and a detail view. Clicking on a point on the map will reveal details of the selected well or feature. The viewer will generate a hydrograph for points with water level data, and time-series graphs for water quality and subsidence data. The visual design of the Data Viewer (with test data) is shown in **Figure 6.**

Figure 6. Design for Data Viewer

The types of data to be visualized on the map and available via the map's navigation menu are listed in **Table 7**.

Table 7. Map Viewer Navigation

Menu Navigation	Description
Groundwater Levels	Water level data and associated wells with well completion reports.
Groundwater Storage	GSA groundwater storage monitoring network sites.
Water Quality	Water quality well and station data for greater than 100 constituents.
Land Subsidence	Subsidence data from extensometers and other stations plus InSAR data.
Interconnected Surface Water	Data related to the interconnected surface water sustainability indicator such as proximity wells, river and stream gages, precipitation stations, and more.
Seawater Intrusion	Sites tracking the SGMA seawater intrusion sustainability indicator.

Hydrogeologic Conceptual Model (HCM)	Data useful for development of a hydrogeoglogic conceptual model of the basin including suitability of soil for recharge, geologic maps, and fault maps.
Boundaries	GSA and other relevant boundaries.

There are two categories of data displayed on the map viewer: data stored in the DMS and reference data drawn directly from outside sources that is useful for groundwater management. All the data discussed in the previous sections, **3. Data Sources** and **4. Data Structure**, referred to data to be stored in the DMS database. **Table 8** below displays a list of reference data that is available for display in the map viewer but is tied directly to an external source (such as CDEC), not to the data stored in the DMS.

Table 8. Reference Data Not Stored in the DMS Database

Menu Navigation	Data Title	Source
Groundwater Levels	DWR Periodic Groundwater Measurements	• California Natural Resources Agency Open Data Platform https://data.cnra.ca.gov/dataset/periodic-groundwater-level-measurements • Water Data Library http://wdl.water.ca.gov/waterdatalibrary
	DWR Continuous Groundwater Measurements	• https://data.cnra.ca.gov/dataset/continuous-groundwater-level-measurements • http://wdl.water.ca.gov/waterdatalibrary
	USGS Periodic Groundwater Measurements	• https://nwis.waterdata.usgs.gov/usa/nwis/gwlevels
	Seasonal Groundwater Level Reports	DWR Enterprise Water Management database (EWM), which includes water level data previously stored in the DWR Water Data Library and CASGEM databases.
	Well Completion Reports	• https://data.cnra.ca.gov/dataset/well-completion-reports • https://gis.water.ca.gov/arcgis/rest/services/Environment/i07_WellCompletionReports/FeatureServer • https://gis.water.ca.gov/arcgis/rest/services/Environment/i07_WellCompletionReports/MapServer
Water Quality	Water Quality Portal (WQP)	• https://www.waterqualitydata.us/
Land Subsidence	DWR Extensometers	• https://data.cnra.ca.gov/dataset/wdl-ground-surface-displacement
	USGS Extensometers	• https://waterservices.usgs.gov/rest/Site-Test-Tool.html
	TRE ALTAMIRA InSAR Dataset	• Image Server: https://gis.water.ca.gov/arcgisimg/rest/services/SAR • Download @OpenData: https://data.cnra.ca.gov/dataset/tre-altamira-insar-subsidence
	NASA JPL InSAR Dataset	• Image Server: https://gis.water.ca.gov/arcgisimg/rest/services/SAR • Download @OpenData: https://data.cnra.ca.gov/dataset/nasa-jpl-insar-subsidence
Interconnected Surface Water	CDEC Stations	• http://cdec.water.ca.gov/

Menu Navigation	Data Title	Source
Water Budget	Statewide Crop Mapping 2014	• Feature Server: https://gis.water.ca.gov/arcgis/rest/services/Planning/CropMapping2014/FeatureServer • Map Server: https://gis.water.ca.gov/arcgis/rest/services/Planning/CropMapping2014/FeatureServer • Download and API @OpenData: https://data.cnra.ca.gov/dataset/crop-mapping-2014
Hydrogeologic Conceptual Model	UC Davis SAGBI	• California Soil Resource Lab at UC Davis and UC-ANR.
	Soil Survey Geographic Database	• https://services.arcgis.com/P3ePLMYs2RVChkJx/ArcGIS/rest/services/DownloaderBasinsv2/FeatureServer/0 • http://www.arcgis.com/home/item.html?id=c2b408ba5c0a4fe1a79377906935c1a4
	CGS Geologic Map - 750k Generalized	• Metadata: https://maps.conservation.ca.gov/cgs/metadata/GDM_002_GMC_750k_v2_metadata.html • Webmap: https://maps.conservation.ca.gov/cgs/gmc/ • Service: http://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS/GeologicMapCA/MapServer/21
	Quaternary Surficial Deposits	• Project Website: http://www.conservation.ca.gov/cgs/fwgp/Pages/sr217.aspx • Metadata: https://maps.conservation.ca.gov/cgs/metadata/QSD_metadata.html • Webmap: https://maps.conservation.ca.gov/cgs/qsd/ • Service: https://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS/GeologicMapCA/MapServer
	Fault Activity Map of California	• Metadata: https://maps.conservation.ca.gov/cgs/metadata/GDM_006_FAM_750k_v2_metadata.html • Webmap: https://maps.conservation.ca.gov/cgs/fam/ • Service: https://spatialservices.conservation.ca.gov/arcgis/rest/services/CGS/FaultActivityMapCA/MapServer
Boundaries	GSA Boundaries	• DWR Bulletin-118 basin boundaries or as provided by client
	County Boundaries	• https://data.cnra.ca.gov/dataset/california-counties
	Canals and Aqueducts	• https://data.cnra.ca.gov/dataset/canals-and-aqueducts-local
	Disadvantaged Communities Blocks	• https://data.cnra.ca.gov/dataset/census-block-group-2010
	Disadvantaged Communities Places	• https://data.cnra.ca.gov/dataset/census-place-2016
	Disadvantaged Communities Tracts	• https://data.cnra.ca.gov/dataset/census-tract-2010
	Water Agencies	• https://data.cnra.ca.gov/dataset/water-districts
	CASGEM Groundwater Basins Prioritization – 2019 -	• https://data.cnra.ca.gov/dataset/ca-bulletin-118-groundwater-basins

7. DMS User Types

All data stored in the DMS will be accessible by administrative users, based on user permissions. Some sensitive data, such as private well data, may require a higher level of permission to retrieve. These permissions will be determined by the client.

Monitoring sites and their associated datasets are added to the DMS by managing entity administrators. In addition to user permissions, access to the monitoring datasets is controlled through assigning one of three options to the data type as follows:

- **Private data** – Private data are monitoring datasets only available for viewing, depending on user type, by the entity's associated users in the DMS.
- **Shared data** – Shared data are monitoring datasets available for viewing by all users in the DMS, except for public users.
- **Public data** – Public data are monitoring datasets that are available publicly that can be viewed by all user types in the DMS; public datasets may also be published to other websites or DMSs as needed.

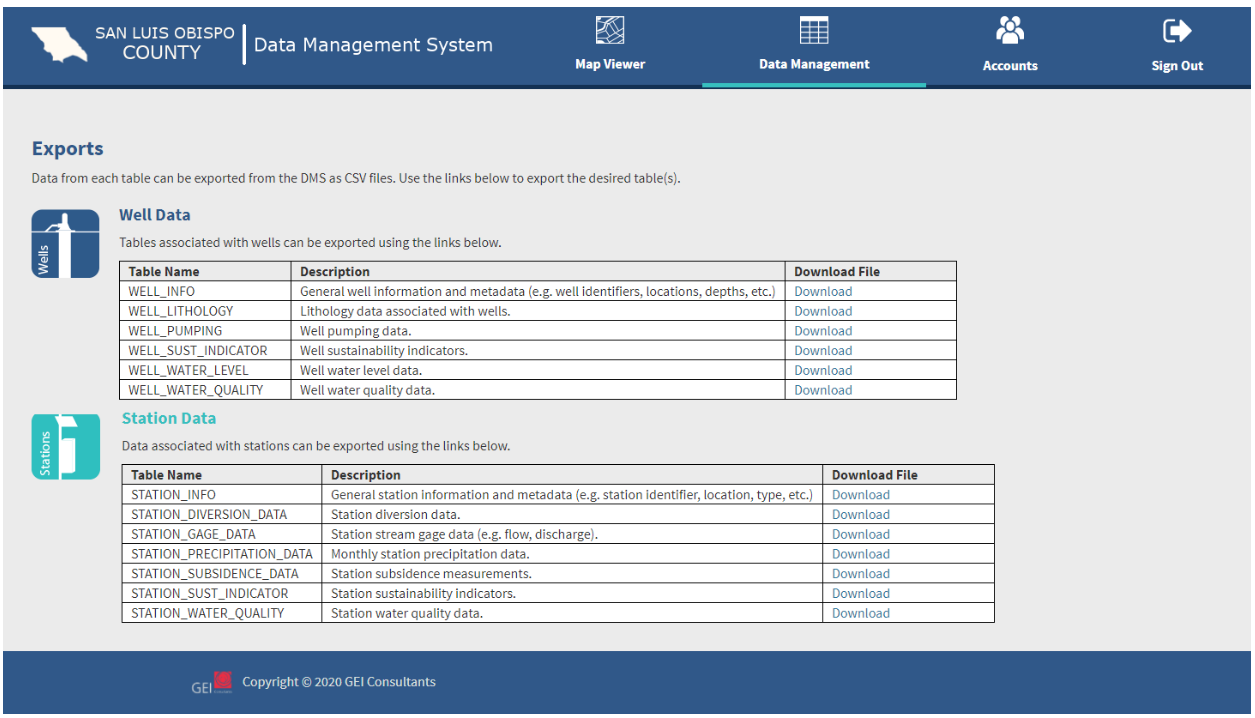
Managing entity administrators can set and maintain data access options for each data type associated with their entity.

8. Data Retrieval

Data may be retrieved in several ways: via the map viewer, by table, or by report type.

- **Map Viewer**: The map viewer will be used to retrieve small amounts of data currently displayed on screen.
- **By Table**: The Exports page will allow for export of entire DMS tables as comma-separated values (CSV) files. **Figure 7** illustrates the design for the Exports page.
- **By Report Type**: Reporting templates will be created to extract the specific group of data required for annual reporting to DWR.

Figure 7. SLO County Exports Page Design



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Exports

Data from each table can be exported from the DMS as CSV files. Use the links below to export the desired table(s).

Wells

Well Data

Tables associated with wells can be exported using the links below.

Table Name	Description	Download File
WELL_INFO	General well information and metadata (e.g. well identifiers, locations, depths, etc.)	Download
WELL_LITHOLOGY	Lithology data associated with wells.	Download
WELL_PUMPING	Well pumping data.	Download
WELL_SUST_INDICATOR	Well sustainability indicators.	Download
WELL_WATER_LEVEL	Well water level data.	Download
WELL_WATER_QUALITY	Well water quality data.	Download

Stations

Station Data

Data associated with stations can be exported using the links below.

Table Name	Description	Download File
STATION_INFO	General station information and metadata (e.g. station identifier, location, type, etc.)	Download
STATION_DIVERSION_DATA	Station diversion data.	Download
STATION_GAGE_DATA	Station stream gage data (e.g. flow, discharge).	Download
STATION_PRECIPITATION_DATA	Monthly station precipitation data.	Download
STATION_SUBSIDENCE_DATA	Station subsidence measurements.	Download
STATION_SUST_INDICATOR	Station sustainability indicators.	Download
STATION_WATER_QUALITY	Station water quality data.	Download

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Appendix I Response to Comments

Commenter	Source	Date Received	Comment No.	Page	Chapter/Section	Comment	Response
Jeff Gardner	Email	6/14/2021	1	22	Chapter 3 - Description of Plan Area - Section 3.6.1.4	Question? Figure 3-10 refers to CDFM. What is CDFM? Could not find reference in text.	CDFM is described in the text on page 19.
Matthew Scrudato	GSP Website	6/23/2021	2	vi	Chapter 3 - Description of Plan Area - List of Terms Used	I notice the abbreviation list, but shouldn't each abbreviation be spelled out at least the first time it is used in this document?	Previous chapters that have been released (ch. 1 - 2) and future chapters will use abbreviations in the abbreviations list. Some abbreviations were first time spelled out in the previous chapters and are not spelled out again in this chapter for that reason.
Matthew Scrudato	GSP Website	6/23/2021	3	vii	Chapter 3 - Description of Plan Area - List of Terms Used	Not sure if I like this referenced as AG Subbasin as opposed to the full name Arroyo Grande Subbasin. Seems lazy to me.	This is the agreed upon term that our team has decided to use for brevity.
Matthew Scrudato	GSP Website	6/23/2021	4	6	Chapter 3 - Description of Plan Area - Section 3.4	Discuss history and current ag in basin. What was area used for in relation to groundwater and SW use?	This will be discussed in future chapters in greater detail.
Matthew Scrudato	GSP Website	6/23/2021	5	17	Chapter 3 - Description of Plan Area - Section 3.6	We're following SGMA guidelines here and looking to manage possible issues. Want to mention no issues with seawater intrusion?	Seawater intrusion will be called out and addressed in future chapters in relation to SGMA guidelines.
Matthew Scrudato	GSP Website	6/23/2021	6	17	Chapter 3 - Description of Plan Area - Section 3.6	Want to provide a general discussion on history and trends in water levels? Maybe best for Chapter 5?	This will be discussed in chapter 5.
Matthew Scrudato	GSP Website	6/23/2021	7	7	Chapter 3 - Description of Plan Area - Section 3.4	Would be nice to provide a detailed map in 3.1 with features being described (faults, geology, creeks, etc.)	This will be provided in chapter 4.
Matthew Scrudato	GSP Website	6/23/2021	8	2	Chapter 3 - Description of Plan Area - Section 3.1	Don't agree with muted-rainshadow effect in this area. You see a rain-shadow in Cuyama for example (not Arroyo Grande). You always see more precipitation in mountains as a result of orographic uplift.	The text will be revised to reflect this change.
Matthew Scrudato	GSP Website	6/23/2021	9	19	Chapter 3 - Description of Plan Area - Section 3.6	Weather and precipitation information very general. Discuss patterns. Drought trends. Etc. Would be great to break out Wet, Normal, and Dry years in Figure 3-1 and 3-10 to better visualize patterns.	This will be discussed in chapter 6.
Matthew Scrudato	GSP Website	6/23/2021	10	2	Chapter 3 - Description of Plan Area - Section 3.1	Plan to expand on geology somewhere else?	This will be discussed in chapter 4.
Matthew Scrudato	GSP Website	6/23/2021	11	4	Chapter 3 - Description of Plan Area - Section 3.3.5	3.3.5, NCMA not in abbreviation list. Suppose this is Nipomo?	NCMA well be added to the abbreviation list and updated in 3.3.5.
Matthew Scrudato	GSP Website	6/23/2021	12	6	Chapter 3 - Description of Plan Area - Section 3.4	3.4 Need to fix sentence.........summarized by group in .	The sentence will be updated.
Matthew Scrudato	GSP Website	6/23/2021	13	8	Chapter 3 - Description of Plan Area - Section 3.4.1	3.4.1 second paragraph. City should be City of Arroyo Grande. Ocean should be Oceano.	City is an abbreviated term for City of Arroyo Grande.
Matthew Scrudato	GSP Website	6/23/2021	14	8	Chapter 3 - Description of Plan Area - Section 3.4.1	3.4.1, IDRS not in abbreviation list	IDRS will be added to the abbreviation list.
Matthew Scrudato	GSP Website	6/23/2021	15	8	Chapter 3 - Description of Plan Area - Section 3.4	Maybe I don't understand 3-4. Water available to basin includes 4,530 AFY which is allocated and distributed to municipalities. How is this quantity also available to the basin?	The Zone III contract entitlements that totals 4,530 AFY comes from the Lopez Reservoir and is distributed to the Lopez Water Treatment Plant and then distributed to the agencies listed in Table 3-2. This water is a component of the dependable yield of 8,730 AFY from Lopez Reservoir. Text will be modified to clarify which water is available to the subbasin.
Matthew Scrudato	GSP Website	6/23/2021	16	12	Chapter 3 - Description of Plan Area - Section 3.4	Figure 3-4 legend mentions GDE (groundwater dependent ecosystem) yet there's no mention of this term anywhere else in document.	GDE is mentioned on pages 11 and 27.
Matthew Scrudato	GSP Website	6/23/2021	17	13	Chapter 3 - Description of Plan Area - Section 3.5	Table 3-5. Should LOPEZ RES say DWR instead?	This typo will be fixed.
Matthew Scrudato	GSP Website	6/23/2021	18	13	Chapter 3 - Description of Plan Area - Section 3.5	3-5 did you check for duplicates in these data sets?	Yes duplicates where checked.
Matthew Scrudato	GSP Website	6/23/2021	19	13	Chapter 3 - Description of Plan Area - Section 3.5	3-5. Section makes reader think these are all the wells located in the basin when in reality these are the wells you managed to locate. May want to mention that there may be additional wells that are unknown.	We call out that "these maps should be considered representative of well distributions, but are not definitive. It is also important to note that both the DWR and EHS well databases are not updated with information regarding well status and the well locations are not verified in the field. Therefore, it is uncertain whether the wells in these databases are currently active or have been abandoned or destroyed." to address the uncertainty of the data. Text will be reviewed and modified if necessary.
Matthew Scrudato	GSP Website	6/23/2021	20	17	Chapter 3 - Description of Plan Area - Section 3.6.1	3.6.1 Makes reader believe that the GAMA network is monitored by these other public entities. That is not the case. Some of the GAMA program (data collected by USGS) are public wells. Public entities have their own programs outside of GAMA.	We call out in 3.6 in several subsections that there are several programs and agencies that monitor wells throughout the area and the data is stored in various databases that may not necessarily be associated with the GAMA program. Text will be reviewed and modified if necessary.
Matthew Scrudato	GSP Website	6/23/2021	21	17	Chapter 3 - Description of Plan Area - Section 3.6.1.2	3.6.1.2 GAMA is not collected on a routine basis as stated here. USGS GAMA program collected data in 2008 for the Coastal Study that I'm aware of. Possibly there was another sample run? Not routine.	Some wells that are associated with GAMA are a part of the SLOFCWCD monitoring program and are collected on a routine basis. Text will be reviewed and modified if necessary.
Matthew Scrudato	GSP Website	6/23/2021	22	17	Chapter 3 - Description of Plan Area - Section 3.6.1.2	3.6.1.2 Are you referring to to NWIS when mentioning the California Water Data Library? There's absolutely no groundwater data available for the basin in NWIS. Please explain. There is a separate GAMA report available.	We are referring to the California Water Data Library , there are wells that have data available in the basin, and that some of this data can also be found in GAMA and other databases. Text will be reviewed and modified if necessary.
Matthew Scrudato	GSP Website	6/23/2021	23	19	Chapter 3 - Description of Plan Area - Section 3.6.1.3	3.6.1.3 Station 11141400 AG at AG (736) was operated by the USGS from 1939-1986. There are discharge data available in NWIS. Gage now operated by County. Station 11141400 Tar Springs was operated by the USGS from 1967-1979. Not mentioned in this section.	We will update the table to include the description of the data availability.
Matthew Scrudato	GSP Website	6/23/2021	24	19	Chapter 3 - Description of Plan Area - Section 3.6.1.4	3.6.1.4 paragraph 2 mentions Table 3-6. This is the wrong table for rainfall, temp, etc. Should this be Table 3-8?	The typo will be fixed.
Matthew Scrudato	GSP Website	6/23/2021	25	21	Chapter 3 - Description of Plan Area - Section 3.6	Maybe add GW basin boundary to Figure 3-9	The Arroyo Grande groundwater basin boundary is included in figure 3-9.

Commenter	Source	Date Received	Comment No.	Page	Chapter/Section	Comment	Response
Anthony Spina	Letter	8/11/2022	26		Chapter 8	The Groundwater Sustainability Plan's (GSP) draft Chapter 8 for the Arroyo Grande (AG) subbasin does not adequately address the following requirement for minimum thresholds as defined in the Sustainable Groundwater Management Act (SGMA) regulations: "The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators." (CCR 23 §354.28(b)(2) The GSP has not explained how the proposed minimum threshold for streamflow depletion (i.e., maintaining groundwater levels below historically observed ranges) avoids significant and unreasonable impacts to beneficial uses of surface water, including maintaining critical habitat for rearing juvenile steelhead (Oncorhynchus mykiss) in Arroyo Grande Creek (Figure 1). Surface water beneficial uses are not described or characterized in the GSP, nor is the ability of the proposed sustainable management criteria to avoid impacting those uses appropriately analyzed. The proposed GSP's minimum thresholds essentially mimic those groundwater and surface water conditions experienced during California's recent drought conditions (one of the driest periods on record). Utilizing these minimum thresholds, will likely harm ESA-listed steelhead and its critical habitat within Arroyo Grande Creek. See Figure for the extent of designated critical habitat within Arroyo Grande Creek. The developing GSP utilizes the minimum thresholds and measurable objectives derived for undesirable results of Chronic Lowering of Groundwater Levels, and applies these thresholds to undesirable result #6 (interconnected surface water depletion), without any reasonable ecological justification as to how the proposed thresholds would avoid streamflow-depletion impacts to instream beneficial uses. The justification presented appears to be limited to three unsupported conclusory statements in Section 8.9.2.4 (see further comments below) and the following confusing statement: "Although only groundwater levels in Arroyo Grande Creek valley wells are moderated by Lopez Reservoir releases and spills, none of the RMS wells in the Subbasin indicate a chronic lowering of groundwater levels (see Section 5.2), nor have Subbasin stakeholders reported experiencing any undesirable results related to lowering of groundwater levels." This statement raises two questions: were impacts to ecological beneficial users (i.e., groundwater dependent ecosystems) expressly considered, as is required per SGMA regulations? And if no impacts to ecological beneficial users were reported, was there any effort by SLO County to investigate or independently document those impacts?	The text in Chapter 8 has been revised to provide further detail and explanation for the use of groundwater elevations as a proxy for the amount of flux between the stream and the adjacent aquifer, including a discussion of Darcy's law and flow direction between stream and aquifer. Flux between a stream and the surrounding aquifer may be theoretically calculated using Darcy's Law: Q = KIA, WHERE Q = rate of the flux (ft3/d) K = Hydraulic conductivity of Aquifer (ft/day) i = Hydraulic gradient between groundwater elevation and surface water elevations (ft/ft) A = Cross Sectional Area of Groundwater Flow (ft2) Of the variables of Darcy's Law presented above, it is assumed that hydraulic conductivity and area of flow do not change with changing groundwater elevations; only the hydraulic gradient changes based on the groundwater elevation in the aquifer and the surface water elevation. A high groundwater elevation corresponds to a specific quantity of flux, while a lower groundwater elevation corresponds to a lesser flux quantity. So, although it is the quantity of flux that impacts GDEs, for the purposes of this GSP, this flux is defined and expressed in terms of the water level in the nearby alluvial sediments that results in the flux. If the groundwater elevation in the aquifer is greater than the elevation of the water surface in the stream, then the direction of flow is from the aquifer to the stream. If the water surface elevation of the stream is higher than the groundwater elevations, the direction of flow is from the stream to the surrounding aquifer. In order to accurately make this calculation, surveyed elevations of groundwater and surface water are necessary, as well as an estimate of hydraulic conductivity of the alluvial aquifer. If groundwater elevations in the vicinity of a stream are maintained such that the direction and magnitude of hydraulic gradient between the creek and the aquifer are not significantly changed, it follows that there will not be a significant or unreasonable depletion of Interconnected Surface Water flux between stream and aquifer. Therefore, groundwater levels in appropriate wells are judged to be a valid proxy for the quantification of depletion of interconnected surface water, and MTs defined. Currently, there is no reliable survey data defining the streambed channel elevation near the RMS wells. This data would help to better define this flux, and may be collected when the implementation start period has been defined. The confusing language referenced was intended to differentiate between wells along Arroyo Grande Creek that are affected by Lopez releases, and those along Tar Spring Creek that are not. This text has been clarified. Recent drought conditions are part of the historical record which were considered during the establishment of the MTs. However, it is important to note that it is not intended that groundwater should be managed to maintain the groundwater elevations defined by the MTs; these are levels which define undesirable conditions. It is intended for groundwater management to maintain elevations between the MT and the MO, and the MTs define the start of undesirable conditions. It is also noteworthy that the water budget analysis presented in chapter 6 indicates that there has been no significant change in aquifer storage over the hydrologic base period, which indicates no increase in stream/aquifer flux over this time.
Anthony Spina	Letter	8/11/2022	27		Chapter 8	The minimum thresholds for the streamflow depletion undesirable result are inadequate to avoid significant impacts to ESA-listed salmonids and their habitat. As noted above, the minimum thresholds identified in the GSP would essentially promote instream habitat conditions similar to those experienced during recent extreme drought conditions, which do not support growth and survival of threatened steelhead in Arroyo Grande Creek. The GSP, therefore, does not adequately analyze or consider the ecological effects of managing groundwater levels associated with extreme drought conditions. SGMA regulations require that minimum thresholds must "represent a point in the basin that, if exceeded, may cause undesirable results." (emphasis added). The chosen minimum thresholds do not represent a point at which those effects may arise, but instead represent a likely impact level beyond that point (i.e., effects are already occurring). SGMA regulations also direct GSAs to describe in their plans "[h]ow state, federal or local standards relate to the sustainability indicator[s]" for each of the applicable undesirable results. For the reasons stated above, the GSP has not provided an adequate explanation for how the sustainability indicator for streamflow depletion is responsive to federal standards under the ESA, i.e., avoiding unlawful take of ESA-listed species.	It is not the objective of the MTs to define the level at which groundwater elevations will be maintained in the Subbasin. Rather, it is the intent that the MTs represent a point in the basin that, if exceeded, may cause undesirable results. It is the intent that the basin should be managed such that water levels do not go lower than the MTs, and if they do, they may cause undesirable results. As mentioned in the previous response, many factors other than groundwater pumping impact stream flow conditions, including rainfall and reservoir operations.
Anthony Spina	Letter	8/11/2022	28		Chapter 8	GSPs must describe and consider impacts to GDEs (Water Code § 10727.4(l); see also 23 CCR § 354.16(g)). The GSP fails this requirement with regard to GDEs where groundwater accretion supports steelhead migration, rearing and spawning within Arroyo Grande and Tar Spring creeks. The draft Chapter 8 only offers the following generalized statement on page 7-20 regarding GDE impacts: "Lopez Reservoir releases are regular and continue through the dry season within the Subbasin, which can affect groundwater recharge and support GDEs to a greater extent than would otherwise occur with naturally drained watershed." This statement does not address the question of whether groundwater pumping may be impacting instream GDEs, or the degree of any impacts. Thus, the GDE analysis within the GSP is inadequate.	Interaction between streamflow and the adjacent aquifers is recognized as a relationship that will require more data/information when the GSP implementation start period has been defined. Releases from Lopez Dam, and direct removal of water from the creek, will have a more significant impact to fisheries conditions in Arroyo Grande Creek. Various modeling scenarios may be considered during the development of the HCP.
Anthony Spina	Letter	8/11/2022	29		Chapter 8	The proposed trigger for the undesirable result from streamflow depletion occurs when the groundwater elevation in any Representative Monitoring Site falls below the minimum threshold in two or more consecutive years. ESA-listed steelhead require the persistent presence of water, and are unlikely to survive in Arroyo Grande Creek if the streamflow or water quality within Arroyo Grande Creek is significantly diminished and degraded. Allowing two consecutive years of minimum threshold violations will not adequately protect surface water beneficial uses and groundwater dependent ecosystems, including juvenile steelhead rearing habitat, from groundwater pumping impacts.	It is not established that the occurrence of an MT in an RMS will correlate to a lack of water within the stream for steelhead. The criterion of two consecutive years is commonly used in other regional GSPs to confirm that the undesirable effects are persistent, and not a temporary condition that may be caused by local operations.

Commenter	Source	Date Received	Comment No.	Page	Chapter/Section	Comment	Response
Anthony Spina	Letter	8/11/2022	30		Chapter 8	When developing sustainable management criteria, and related projects and management actions, the GSP appears to be devoid of adequate analysis and consideration of public trust resources, including, but not limited to, anadromous salmonids, as required by the Public Trust Doctrine. A recent California Court of Appeal decision held that the public trust doctrine must be considered—and public trust resources protected whenever feasible—in any decision governing groundwater withdrawals hydrologically connected to public trust surface waters. As noted above, South-Central California Coast Steelhead are listed as threatened under the U.S. Endangered Species Act, inhabit Arroyo Grande Creek, and should be considered a public trust resource. Moreover, Arroyo Grande Creek appears to meet the definition of public trust surface waters. Overall, streamflow conditions associated with the proposed sustainability criteria are expected to impair steelhead spawning and rearing habitat, and thus harm public trust resources. The GSP does not conduct a public trust analysis, nor does it discuss applicable public trust resources within the subbasin. Likewise, no weighing of public trust benefits or impacts occurs within the GSP. Finally, the GSP does not adequately consider and evaluate alternative measures that would likely protect ecological public trust resources, such as the feasibility of adopting more conservative sustainable management criteria that will avoid harming steelhead and its designated critical habitat in Arroyo Grande Creek.	The concerns are noted. However, the issues and the Court's holding in Environmental Law Foundation, et al. v. State Water Resources Control Board, et al. (2018) 26 Cal.App.5th 844, 851 (if this is the case that is being referenced) are extraordinarily limited by the Court's own admission: "But the supplemental briefing also illuminates the narrowness of the issue before us. We are asked to determine whether the [Siskiyou] County and the [State Water Resources Control] Board have common law fiduciary duties to consider the potential adverse impact of groundwater extraction on the Scott River, a public trust resources, when issuing well permits and if so, whether SGMA on its face obliterates that duty." In addition, in reaching its conclusion regarding SGMA, the Court notes that SGMA is a "more narrowly tailored piece of legislation" and that "the public trust is not expressly mentioned in SGMA (finding that SGMA does not replace or fulfill public trust duties). Id. at 866-867.
Anthony Spina	Letter	8/11/2022	31		Chapter 8	Section 7.1 (page 7-6): The draft Chapter 7 notes the proposed monitoring network "must …. accomplish the following monitoring objectives", which includes, "monitor impacts to the beneficial uses and users of groundwater." As stated earlier, the draft chapters do not describe ecological beneficial uses (i.e., migration, spawning/rearing, and cold-water habitat), do not analyze how the proposed sustainable management criteria will likely affect those uses, and does not propose a monitoring component addressing this data gap.	At present, the RMS wells established for the Depletion of Interconnected Surface Water sustainability criteria, and the associated SMCs, are the monitoring component of the GSP designed to address this issue. Future monitoring wells, stream gages, habitat studies, etc. may be considered as part of the implementation period, which has not yet been defined.
Anthony Spina	Letter	8/11/2022	32		Chapter 8	Section 7.2.3.1: Surface Flow Monitoring Data Gaps: Tar Spring Creek is an important tributary for Groundwater Dependent Ecosystems. No streamflow gage currently exists on the tributary, and there appears to be no plan to install one and evaluate interconnection between surface water and groundwater levels from existing wells (Figure 7-1) in Tar Spring Creek Valley. We recommend the GSA install a streamflow gage on Tar Spring Creek.	This recommendation may be considered when the implementation period has been defined.
Anthony Spina	Letter	8/11/2022	33		Chapter 8	Section 7.6, page 7-23: The draft chapters contain no ecological reasoning why the chosen sustainable management criteria are appropriate for avoiding impacts to surface water beneficial uses, including steelhead spawning, rearing, migration, and ultimately survival. As a result, the conclusion that no critical data gaps with respect to sustainable management of the subbasin currently exist is unsupported.	A Darcy's Law analysis has been added to the text in section 8.9 and provides the rationale for using water levels as a proxy for flux, and explains how the water levels selected intend to prevent significant or unseasonable depletion of flux from the stream to the surrounding aquifer. Future additional monitoring efforts may be considered as part of the implementation start period, when the start period has been determined.
Anthony Spina	Letter	8/11/2022	34		Chapter 8	Section 7.7, page 7-23: The following statement: "Because the Subbasin is a very low priority, however, it is not required to submit an Annual Report or five-year updates." should be supported with the appropriate rationale, and not simply cite SGMA regulations, or unofficial DWR staff statements.	This statement is an accurate description of the pertinent regulations / requirements for this basin (Water Code Section 10720.7 and Water Code Section 10727).
Anthony Spina	Letter	8/11/2022	35		Chapter 8	Section 8.9.1.3, page 8-38: The draft Chapter 8 states: "If depletions of interconnected surface water were to reach undesirable results, adverse effects could include the reduced ability of the stream flows to meet instream flow requirements for local fisheries and critical habitat, or reduced ability to deliver surface water supplies to direct users of surface water in the Basin." While the draft chapter acknowledges that streamflow depletion could reduce the ability of streamflows to meet the requirements for ESA-listed steelhead and its critical habitat, it does not propos specific monitoring or analysis within the Chapter 7 to address this issue. The GSP should address this significant omission.	At present, the RMS wells established for the Depletion of Interconnected Surface Water sustainability criteria, and the associated SMCs, are the monitoring component of the GSP designed to address this issue. Future monitoring efforts may be established when the implementation period is established.
Anthony Spina	Letter	8/11/2022	36		Chapter 8	Section 8.9.2.1, page 8-40: As noted earlier, the minimum thresholds proposed for interconnected surface water depletion are simply carried over from the "groundwater in storage" undesirable result thresholds. No justification or reasoning is provided as to why these criteria will likely be effective in protecting instream beneficial uses, including but not limited and ESA-listed steelhead in Arroyo Grande Creek. The justification provided on page 8-41 is not directly relevant to streamflow depletion or the resulting ecological impacts, but instead focuses on domestic wells going dry.	The text in Chapter 8 has been revised to provide further detail and explanation for the use of groundwater elevations as a proxy for the amount of flux between the stream and the adjacent aquifer including discussion of Darcy's law and flow direction between a stream and aquifer. If groundwater elevations in the vicinity of a stream are maintained such that the direction and magnitude of hydraulic gradient between the creek and the aquifer are not significantly changed, it follows that there will not be a significant or unreasonable depletion of Interconnected Surface Water flux between stream and aquifer. Therefore, groundwater levels in appropriate wells are judged to be a valid proxy for the quantification of depletion of interconnected surface water, and MTs defined. It is important to recognize that many factors contribute to instream flow conditions that are beyond the ability of a groundwater management plan to control (rainfall, temperature, reservoir operations, etc.). The objective with respect to interconnected surface water (ISW) SMCs is to avoid groundwater management leading to conditions that result in significant or unreasonable increase in ISW depletion.

Commenter	Source	Date Received	Comment No.	Page	Chapter/Section	Comment	Response
Anthony Spina	Letter	8/11/2022	37		Chapter 8	Section 8.9.2.4: The draft Chapter 8 provides: "The practical effect of this GSP for protecting against the Depletion of Interconnected Surface Water MTs is that it encourages minimal long-term net change in groundwater elevations in the vicinity of Arroyo Grande Creek. Seasonal and drought cycle variations are expected, but during average conditions and over the long-term, beneficial users will have access to adequate volumes of water from the aquifer to service the needs of all water use sectors. The beneficial users of groundwater are protected from undesirable results." As NMFS has noted in previous comment letters concerning the San Luis Obispo Valley subbasin GSP, SGMA's requirement (and overarching goal) is achieving groundwater sustainability by 2042, with sustainability defined as groundwater management that avoids undesirable results, including impacts to surface water beneficial uses caused by groundwater extraction (Undesirable Result #6). Proposing sustainable management criteria mimicking groundwater conditions below the lowest recorded measurements is inconsistent with the goals of SGMA, and is not consistent with the life history and habitat requirements of threatened steelhead. The second and third statements are unsupported by either outside reference or analysis within the chapters, and should therefore be substantiated or omitted.	The MTs define water levels which define conditions which should not be exceeded. Current conditions are reflective of the severe drought that we are currently in, and should be considered as part of the historical record to define MTs. The proposed MTs are intended to provide for the prevention of significant or unreasonable changes in flux from the stream to the aquifer, and are therefore consistent with the goals of minimizing the impact of pumping on conditions within the stream channel. The implementation start period has not yet been defined; however the GSAs may choose to revisit GSP implementation should a change in subbasin conditions arise or a reprioritization of the basin by DWR.
Anthony Spina	Letter	8/11/2022	39		Chapter 8	On page 8-42, the following statement is likewise unsupported, and should be substantiated or omitted: "Groundwater dependent ecosystems would generally benefit from this MT (minimum threshold). Maintaining groundwater levels close to within (sic) historically observed ranges will continue to support groundwater dependent ecosystems."	The MTs define water levels which define conditions which should not be exceeded. Current conditions are reflective of the severe drought that we are currently in, and should be considered as part of the historical record to define MTs. It is the GSAs' contention that the proposed MTs provide for the prevention of significant or unreasonable changes in flux from the stream to the aquifer, and are therefore consistent with the goals of minimizing the impact of pumping on conditions within the stream channel, including the continued support of groundwater dependent ecosystems.
Anthony Spina	Letter	8/11/2022	40		Chapter 8	Section 8.9.2.6: Measuring and evaluating groundwater elevations on a semi-annual schedule is likely insufficient for tracking, and effectively responding to rapidly changing ground and surface water conditions that may have significant and unreasonable impacts to surface water beneficial uses, including but not limited to ESA-listed steelhead within Arroyo Grande Creek.	The concerns are noted. Additional monitoring efforts that that may better characterize groundwater-streamflow interactions may be considered when the implementation start period has been defined.