Spadra Basin Groundwater Sustainability Agency

Groundwater Sustainability Plan
Advisory Committee Meeting

Tuesday, November 19, 2019 at 3:00 p.m.
Pomona City Hall
Administrative Board Room
505 S. Garey Avenue
Pomona, CA 91766

AGENDA

1. Call to Order
2. Roll Call

Agency/Stakeholder		Representatives		Alternate(s)
Cal Poly Pomona	__	Rick Hansen	___	George Lwin
Rowland Water District	__	Dave Warren	___	Tom Coleman
Three Valleys MWD	__	Timothy Kellett	___	Carlos Goytia
Forest Lawn	__	Bob Bowcock	___	Kevin Sage

3. Public Comment
4. Election of Advisory Committee Officers
   a) Elect Chair
   b) Elect Vice Chair
5. Review of Draft Technical Memorandum 1: *Conceptual Model of the Spadra Basin*
6. Next Steps
7. 2020 Advisory Committee Meeting Dates
8. Adjournment

Groundwater Sustainability Plan for the Spadra Basin
DRAFT - Technical Memorandum 1 Conceptual Model of the Spadra Basin

To: Groundwater Sustainability Agency for Spadra Basin

From: Wildermuth Environmental Inc.

Date: November 6, 2019

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List of Acronyms, Abbreviations, and Initialisms

µg/kg	micrograms per kilogram
µgl	micrograms per liter
1,1,1-TCA	1,1,1-trichloroethane
1,1-DCE	1,1-dichloroethene
1,2,3-TCP	1,2,3-Trichloropropane
afy	acre-feet per year
AGR	Agricultural Supply
application	Application for Well/Exploration Hole Permit
CASGEM	California Statewide Groundwater Elevation Monitoring
CDFM	cumulative departure from the mean
CDPH	California Department of Public Health
CFI	Consolidated Foundries Incorporated
cis-1,2 DCE	cis-1,2 dichloroethene
CPP	California State Polytechnic University of Pomona
DCA	1,1-dichloroethane
DDW	State Water Board's Division of Drinking Water
DIPAW	deep infiltration of precipitation and applied water
DLR	detection limit for the purposes of reporting
DTSC	California Department of Toxic Substances
DWR	California Department of Water Resources
ft-amsl	feet above mean sea level
ft-bgs	feet below ground surface
GAMA	Groundwater Ambient Monitoring and Assessment
GDE	groundwater-dependent ecosystems
gpm	gallons per minute
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
IND	Industrial Services Supply
InSAR	interferometric synthetic-aperture radar
LA Basin Plan	Water Quality Control Plan Los Angeles Region

List of Acronyms, Abbreviations, and Initialisms (continued)

LA Regional Board	California Regional Water Quality Control Plan Los Angeles Region
LA Sanitation Districts	Sanitation Districts of Los Angeles County
LACPWD	Los Angeles County Public Works Department
LADPH	Los Angeles County Department of Public Health
M&RP	Monitoring and Reporting Program
MCL	maximum contaminant limit
Metropolitan	Metropolitan Water District of Southern California
mgl	milligrams per liter
MS4 Permit	Municipal Separate Storm Sewer System Order No. R4-2012-0175
MTBE	methyl tert-butyl ether
MUN	Municipal and Domestic Supply
NEXRAD	Next-Generation Radar
NL	notification level
NPDES	National Pollutant Discharge Elimination System
OEHHA	California Office of Environmental Health Hazard Assessment
PCE	tetrachloroethane
PFAS	per- and polyfluoroalkyl substances
PHG	public health goal
Pomona	City of Pomona
PROC	Industrial Process Supply
Recycled Water Policy	Policy for Water Quality Control for Recycled Water
San Gabriel SNMP	The San Gabriel Valley Basin SNMP
SCAG	Southern California Association of Governments
SGMA	Sustainable Groundwater Management Act
SNMP	salt and nutrient management plan
State Water Board	State Water Resources Control Board
SVE	soil vapor extraction
TCE	trichloroethene
TDS	total dissolved solids
TM	technical memorandum

List of Acronyms, Abbreviations, and Initialisms (continued)

TVMWD	Three Valleys Municipal Water District
VOC	volatile organic compound
WDR	Waste Discharge Requirement
WEI	Wildermuth Environmental, Inc.
WQS	water-quality standard
WRP	Water Reclamation Plant
WRR	Water Reclamation Requirement
WVWD	Walnut Valley Water District

1.0 Introduction

The Spadra Basin is a small, non-adjudicated subbasin of the San Gabriel Valley Basin (Basin 4-013 as defined by the California Department of Water Resources [DWR]). Pursuant to the Sustainable Groundwater Management Act of 2014 (SGMA), the DWR has designated the San Gabriel Valley Basin as a "low-priority" basin. This basin is considered low-priority because the groundwater rights in most of the basin have been adjudicated; hence, the development of a Groundwater Sustainability Plan (GSP) for San Gabriel Valley Basin is not required by under SGMA. Although it is not a requirement of the SGMA, the Walnut Valley Water District (WVWD) and the City of Pomona (Pomona) collectively formed a groundwater sustainability agency (GSA) for the Spadra Basin (Spada Basin GSA) and decided to prepare and adopt a GSP with the objectives of maximizing the beneficial use of the Spadra Basin while ensuring long-term sustainability.

The Spadra Basin GSA contracted Wildermuth Environmental Inc. (WEI) to help prepare the GSP. WEI's scope of work is to prepare five technical memorandums in sequence. Each technical memorandum constitutes an interim milestone in the development of the final GSP for the Spadra Basin. The five technical memorandums include:

- *Technical Memorandum 1* (TM 1) – *Conceptual Model of the Spadra Basin*
- *Technical Memorandum 2* (TM 2) – *Construction and Calibration of the Spadra Basin Groundwater Model*
- *Technical Memorandum 3* (TM 3) – *Sustainable Management Criteria for the Spadra Basin*
- *Technical Memorandum 4* (TM 4) – *Sustainability of Future Baseline Conditions*
- *Technical Memorandum 5* (TM 5) – *Basin Optimization Scenarios to Achieve Sustainability*

TM 1 through TM 5 will ultimately become sections in the final GSP for the Spadra Basin and will be used to help prepare the GSP implementation plan in the final GSP. The outline of the final GSP for the Spadra Basin and mapping to each TM is as follows:

- Executive Summary
- Section 1: Introduction
- Section 2: Plan Area and Basin Setting (TM 1 and TM 2)
- Section 3: Sustainable Management Criteria (TM 3)
- Section 4: Projects and Management Actions to Achieve Sustainability (TM 4 and TM 5)
- Section 5: GSP Implementation
- Section 6: References

This *TM 1 – Conceptual Model of the Spadra Basin* describes the "Plan Area" and "Basin Setting" of the Spadra Basin as required in *Article 5—Plan Contents* of the DWR's GSP Regulations ([California Code of Regulations, Title 23, Division 2, Chapter 1.5, Subchapter 2](#)). TM 1 will become the first portion of *Section 2: Plan Area and Basin Setting* in the final GSP. The sections and subsections in TM 1 align with the sections and sub-sections intended for the final GSP.

The Plan Area is described in Section 2.1 and is a general description of the GSP area including jurisdictional boundaries, existing monitoring and management plans, and the overlying land uses, water uses and water disposal. In the final GSP, the Plan Area section will include a description of the stakeholder process that was implemented to develop the GSP.

The Basin Setting is described in Section 2.2 and includes a detailed description of the hydrogeologic conceptual model, the surface-water and groundwater hydrology of the Spadra Basin over a long-term historical period to current conditions, and a preliminary water budget. Also described are the identification of data gaps and levels of uncertainty of the description. The Basin Setting description will support later efforts for: the siting of a new monitoring well(s) to fill data gaps; the construction and calibration of the numerical groundwater-flow model that will be used to develop and evaluate the GSP, and the development of the Sustainable Management Criteria in TM3.

2.0 Plan Area and Basin Setting

2.1. Plan Area

The Plan Area is a description of the geographic area for the GSP and the interaction of the GSP with existing jurisdictions, monitoring and management plans, and land uses. The Plan Area description addresses the requirements of Article 5, Subarticle 1, Section 354.8 of the GSP Regulations and includes:

- A description of jurisdictional areas and other features.
- A description of the existing monitoring and groundwater management programs.
- A description of historical and current land use, water use, and water disposal.
- A description of the stakeholder process that was implemented to develop the GSP.

2.1.1 Jurisdictional Area and Other Features

The Spadra Basin is a relatively small groundwater basin—about seven square miles (4,200 acres)— in eastern Los Angeles County in Southern California. It sits at the eastern end of the northeast-southwest trending San Jose Valley between the San Jose Hills and Puente Hills. Figure 2-1 shows the location of the Spadra Basin and nearby groundwater basins. The Spadra Basin boundary shown on Figure 2-1 is the Spadra Basin GSA boundary, which is defined as the unadjudicated portion of the San Gabriel Valley Groundwater Basin as defined in the DWR's *Bulletin 118 California's Groundwater Update 2003* (Basin No. 4-013) exclusive of the adjudicated boundaries of the Main San Gabriel and Puente Basins. The eastern boundary of the Spadra Basin is the western boundary of the Chino subbasin of the Upper Santa Ana Valley Groundwater Basin (Basin No. 8-002.01 as defined in Bulletin 118). The Spadra Basin is surrounded by four adjudicated groundwater basins: the Puente Basin to the southwest, the Main San Gabriel Basin to the northwest, the Six Basins to the north, and Chino Basin to the east.

Figure 2-2 shows the location of the Spadra Basin and the water purveyors in the area. Pomona, the WVWD, and California State Polytechnic University of Pomona (CPP) are the local water purveyors with service area boundaries overlying the Spadra Basin. The water purveyors obtain water supplies from multiple sources including groundwater, local surface water, treated imported water from the State Water Project and Colorado River, and recycled water. The water purveyors purchase imported water from the Three Valleys Municipal Water District (TVMWD), a sub-agency of the Metropolitan Water District of Southern California (Metropolitan). The Spadra Basin lies within the TVMWD's service area. Pomona's service area overlies the majority of the Spadra Basin. WVWD's service area overlies a smaller portion of the Spadra Basin to the east and CPP's service area overlies a small portion in the north. In the western portion of the Spadra Basin, there is an overlap of the Pomona and WVWD service areas where water is served by both purveyors.

Figure 2-2 also shows the location of cities within and immediately adjacent to the Spadra Basin. The City of Pomona boundary overlies the majority of the Spadra Basin and is the same boundary as the Pomona water service area boundary. The City of Diamond Bar overlies a very small corner of the Spadra Basin to the south, and the Cities of Walnut and Industry are located just west of the Spadra Basin; all three cities are served by the WVWD.

2.1.2 Existing Water Resources Management and Monitoring Programs

The Spadra Basin is an unadjudicated portion of the Main San Gabriel Valley Groundwater Basin (Basin No. 4-013). There is no formal basin management plan for the water resources in the Spadra Basin and there are no defined restrictions on groundwater pumping. The Spadra Basin GSA agencies are parties to the Judgments for the adjacent adjudicated groundwater basins: Six Basins, Puente Basin, and Chino Basin. Pomona is a party to the Six Basins Judgment (*Southern California Water Company vs. City of La Verne, et al.*) and Chino Basin Judgment (*Chino Basin Municipal Water District vs. City of Chino et al.*); the WVWD is a party to the Puente Basin Judgment (*Puente Basin Water Agency et al. vs. The City of Industry et al.*).

There are some regional water management plans that include Spadra Basin groundwater, including Urban Water Management Plans prepared by water purveyors in the Spadra Basin area and the *Water Quality Control Plan, Los Angeles Region* (LA Basin Plan) prepared by the California Regional Water Quality Control Board, Los Angeles Region (LA Regional Board). These water management plans are described in more detail below.

Monitoring of water resources in the Spadra Basin generally consists of uncoordinated efforts by water purveyors to measure and record groundwater pumping, groundwater quality, and groundwater levels. Surface-water monitoring is conducted by the LA Sanitation Districts at the Pomona WRP for discharge and water quality.

2.1.2.1 Urban Water Management Plans

Urban Water Management Plans are prepared every five years pursuant to requirements in the California Water Code (§10610-10656 and §10608), by urban water purveyors who serve more than 3,000 acre-feet per year (afy) of water. These plans support the water purveyors' long-term resource planning to ensure that adequate water supplies are available to meet existing and future water needs. Spada Basin groundwater is described primarily as a non-potable water supply in several 2015 Urban Water Management Plans, including:

- *City of Pomona 2015 Urban Water Management Plan* (Pomona, 2016). Pomona pumps groundwater from three wells in the Spadra Basin primarily to supplement the City's non-potable water system. One of the wells can supply water to the City's potable water system on a limited basis.
- *Walnut Valley Water District 2015 Urban Water Management Plan* (Civiltec Engineering, 2016). The WVWD pumps groundwater from one well in the Spadra Basin to supplement the District's non-potable water system.
- *Rowland Water District 2015 Urban Water Management Plan* (RMC Water and Environment, 2016). Spadra Basin groundwater pumped by the WVWD and used to

supplement its non-potable water system can be delivered to Rowland Water District via an emergency recycled water connection.

2.1.2.2 LA Basin Plan

The responsibility for protecting water quality in California rests with the State Water Resources Control Board (State Water Board) and its nine Regional Water Quality Control Boards, who set policies and develop water quality control plans for their respective regions. The Spadra Basin is within the jurisdiction of the LA Regional Board who has developed the LA Basin Plan pursuant to state and federal water quality statutes and regulations to preserve and enhance water quality and protect beneficial uses of all regional waters in the Los Angeles Region (LA Regional Board, 2019). Specifically, the Basin Plan (i) designates beneficial uses for surface and groundwaters, (ii) sets objectives that must be attained or maintained to protect the designated beneficial uses and conform to the State's Antidegradation Policy, and (iii) describes implementation programs and other actions that are necessary to achieve the water quality objectives established in the Basin Plan. The Spadra Basin is part of the Bulletin 118 San Gabriel Valley Basin which has the following designated beneficial uses for groundwater indicated in Chapter 2, Table 2-2 of the Basin Plan:

- Municipal and Domestic Supply (MUN)
- Industrial Service Supply (IND)
- Industrial Process Supply (PROC)
- Agricultural Supply (AGR)

The State's policies and plans are based on the State Water Board's Antidegradation Policy (Resolution 68-16), which restricts the degradation of surface water or groundwater quality to protect their beneficial uses. Chapter 3 of the LA Basin Plan includes narrative water-quality objectives for regional groundwaters and specific numerical objectives for sub-basins in the region. The LA Basin Plan of the LA Regional Board contains numeric water-quality objectives for the Spadra Basin to maintain or protect the designated beneficial uses and conform to the State's Antidegradation Policy. When the existing water quality of a groundwater basin is better than its Basin Plan objective, then the water body has "assimilative capacity" for degradation. The Antidegradation Policy is implemented, in part, through Waste Discharge Requirements (WDRs) issued by the Regional Boards. In the Spadra Basin, this includes the reclamation requirements for dischargers to groundwater from recycled water reuse from the Sanitation Districts of Los Angeles County (LA Sanitation Districts) Pomona Water Reclamation Plant (WRP).

The LA Basin Plan also includes salt and nutrient management plans (SNMPs) for groundwater basins in the Los Angeles Region, that were developed pursuant to the State Water Board's 2009 *Policy for Water Quality Control for Recycled Water* (Recycled Water Policy). The Recycled Water Policy requires that a SNMP be prepared for all high-priority[1] groundwater basins in the State to address: the potential for salt and nutrient degradation in groundwater from all sources, the potential impairment of beneficial uses, and to support recycled water reuse programs. Pursuant

[1] The basin priority designation for the Recycled Water Policy is different than that used by DWR for the SGMA.

to this requirement, the Main San Gabriel Basin Watermaster in conjunction with other primary stakeholders[2] prepared *The San Gabriel Valley Basin SNMP* ([San Gabriel SNMP] Stetson Engineers Inc., 2016) to provide a framework for water management practices in the San Gabriel Valley Groundwater Basin to ensure beneficial uses and sustainability of groundwater resources, consistent with the LA Regional Board's water quality objectives. The San Gabriel SNMP was adopted by: the LA Regional Board on December 8, 2016, the State Water Board on May 16, 2017, and the Office of Administrative Law on December 19, 2018, and was subsequently included in Chapter 8 of the LA Basin Plan. The San Gabriel SNMP only incorporates the portions of the Bulletin 118 San Gabriel Valley Basin included in the Main San Gabriel Basin Judgment; the Spadra Basin was excluded from the San Gabriel SNMP. Consequently, there is no SNMP for the Spadra Basin.

2.1.2.2 Groundwater Monitoring

Figure 2-3 shows the locations of all known existing wells in the Spadra Basin. There are 10 known production wells: nine are municipal wells owned and operated by Pomona, WVWD, and CPP; one is owned by the Walnut Hills Mobil Home Park. Groundwater pumped from the municipal wells is primarily used as a supplemental supply source for non-potable uses by these water purveyors. With the exception of one production well owned by the WVWD, all wells are active—they are currently used to pump groundwater. The production wells are generally located along the axis of the Spadra Basin. And, their spatial density ranges from one to three wells per square mile. There may potentially be additional, privately owned production wells in the Spadra Basin that are yet to be identified.

There are 29 known monitoring wells in the Spadra Basin: 28 are associated with point-source contaminant sites at the Spadra Landfill, Teledyne Cast Parts, and Calsol Inc.; one is a WVWD monitoring well located near WVWD's inactive "Valley" well.

Figure 2-4 characterizes the groundwater data that have been collected at wells in the Spadra Basin within the last 10 years, from 2010 to 2019. Currently, groundwater monitoring in the Spadra Basin occurs at the municipal production wells owned by water purveyors, and at wells installed for monitoring at the three point-source contaminant sites. Groundwater-quality samples are collected at most of the active production wells by the well owners for informational and operational purposes or to comply with State Water Board's Division of Drinking Water (DDW) monitoring schedules for water systems. The following table summarizes the groundwater monitoring that has occurred at Spadra Basin wells over the last 10 years.

[2] Upper San Gabriel Valley Municipal Water District, San Gabriel Valley Municipal Water District, Three Valley's Municipal Water District, County of Los Angeles Department of Public Works, Metropolitan Water District, and Sanitation Districts of Los Angeles.

Summary of Groundwater Data Collected in the Last Ten Years (2010-2019) at Spadra Basin Wells

Well Type and Status	Total # of Wells in Spadra Basin	# of Wells with Production Data	# of Wells with Groundwater Quality Data	# of Wells with Groundwater Level Data
Active Municipal Production Well	8	8	5	5
Inactive Municipal Production Well	1	0	0	0
Active Private Production Well	1	0	0	0
Contaminant Site Monitoring Well	29	--	29	29
Other Monitoring Well	1	--	0	0
Total	40	8	34	34

Production data is measured at the eight of the active production wells (owned by water purveyors), and groundwater-quality and groundwater-level data are collected at some of these wells. No groundwater data have been collected from the active private production well (owned by Walnut Hills Mobile Home Park) or the inactive municipal production well.

At the 29 monitoring wells associated with the Spadra Landfill, Teledyne Cast Parts, and Calsol Inc. sites, groundwater-quality and groundwater-level data have been collected during the last ten years. There is one monitoring well where no groundwater data have been collected.

Four wells in the Spadra Basin are part of the DWR's California Statewide Groundwater Elevation Monitoring (CASGEM) Program—these wells are annotated with a "*" symbol in Figure 2-4. The Puente Basin Watermaster is the designated CASGEM monitoring entity for the Puente Basin and the Spadra Basin subbasins of the San Gabriel Valley Basin and has been reporting groundwater elevations for the four wells semi-annually since 2011. Five wells in the Spadra Basin are part of the State Water Board's Groundwater Ambient Monitoring and Assessment (GAMA) Program—these wells are annotated with a "#" symbol in Figure 2-4.

2.1.3 Land Use, Water Use, and Disposal in the Spadra Basin

This section describes the historical and current land use, water use, and disposal of water in the Spadra Basin. The overlying land use impacts water demand and supply patterns. For example, outdoor water uses can result in return flows to the groundwater basin. Indoor water uses generate wastewaters that are conveyed to a treatment plant or to a septic system. It is important to understand overlying land use, water use, and disposal together because different land uses have different imperviousness, irrigation practices, and disposal practices that affect the volume of return flows to the groundwater basin. Furthermore, land use, water use, and disposal are an important influence on groundwater quality: the concentration of dissolved constituents in return flows is typically higher relative to groundwater, causing degradation of groundwater quality.

2.1.3.1 Land Use and Source Waters

Figure 2-5 illustrates the overlying land use in the Spadra Basin in 1949, 1975, 1990, and 2017. Figure 2-6 shows he land-use changes in Figure 2-5 quantified by acreage. The land-use maps were developed from DWR land use surveys for 1949 and 1975, and from Southern California Association of Governments (SCAG) surveys for 1990 and 2017. The maps show a change in land use over time from primarily irrigated agriculture (crops, pastures, fruit, nuts, and citrus) and vacant lands in 1949 to urban (residential, commercial, and industrial) land uses by 2017. By 1975, about 78 percent of the overlying land use in the Spadra Basin was urban. By 2017, urban land uses accounted for about 93 percent of overlying land use, while irrigated agriculture accounted for six percent, associated with lands owned by the State of California and utilized by CPP for growing various crops for the university's horticultural program.

Pomona is the primary land use planning agency in the Spadra Basin. The urban and agricultural lands owned by CPP are not covered by Pomona and have a different land use planning process through the state. With the exception of a few vacant properties, the lands overlying the Spadra Basin are completely developed, and land and water use are not projected to change significantly in the future.

Potable water supplies utilized by water purveyors in the Spadra Basin for urban uses include: imported water from the Colorado River and the State Water Project; groundwater and surface water supplies from Chino Basin and Six Basins; and treated groundwater and imported water from the CPP's reverse-osmosis plant.

Non-potable supplies utilized by water purveyors in Spadra Basin for urban and agricultural land uses are Spadra Basin groundwater and recycled water from the LA Sanitation Districts Pomona WRP. Spadra Basin groundwater is used primarily as a non-potable water supply for the local water purveyors to supplement other water sources in their supply portfolios. The water purveyors with Urban Water Management Plans anticipate having sufficient water supplies from their various sources to serve the overlying land uses in the future. The development of the Spadra GSP is intended to maximize the beneficial use and reliability of Spadra Basin groundwater.

2.1.3.2 Outdoor Water Use and Return Flows

Irrigation return flows to groundwater are a function of land imperviousness and irrigation efficiency. When land was converted from vacant or agricultural to urban uses, the imperviousness of the Spadra Basin increased from near zero to between 20 and 100 percent, depending on the specific land use. The Los Angeles County Public Works Department (LACPWD) assumes a two percent impervious area for orchards and vineyards in their hydrology manual (LACPWD, 2006). By contrast, LACPWD assumes urbanized areas have a much higher fraction of imperviousness, typically ranging from about 20 percent for very low-density residential areas to about 90 percent or more for apartments, mobile home courts, and high-rise offices.

Irrigated agriculture and irrigated urban lands have different irrigation efficiencies.[3] The lower the efficiency, the more applied water will infiltrate past the root zone to the aquifer system. The typical efficiency of crop irrigation or flood-irrigated citrus groves is 60 percent or less. Modern irrigation methods, such as trickle irrigation, can achieve 90 percent efficiency (Pier, 2006). The combination of higher imperviousness and higher irrigation efficiency associated with urban land uses reduces the return flows of applied water. Thus, the change from agricultural to urban land uses in the Spadra Basin resulted in reduced irrigation return flows, and hence, reduced recharge to the basin.

Additionally, irrigation return flows typically degrade groundwater quality. Agriculture, and to a lesser degree urban landscape irrigation, is associated with the application of fertilizers and pesticides that dissolve in the applied water. Plant uptake of the water concentrates the dissolved constituents within the return flows. The return flows are a non-point source of contaminant loading to the groundwater basin that has affected, and continues to affect, the groundwater quality of the Spadra Basin.

2.1.3.3 Disposal of Water

Surface-water runoff over lands that does not infiltrate exits the Spadra Basin in concrete-lined storm-drain systems and flood-control channels. The two major concrete-lined channels exiting the Spadra Basin are the San Jose Creek and South San Jose Creek—their locations are shown in Figure 2-7. The surface-water runoff that exits the Spadra Basin in these channels is put to beneficial use by downstream entities mainly for groundwater recharge, is consumptively used by riparian vegetation in unlined stream reaches or flows to the ocean.

The land use agencies overlying the Spadra Basin are regulated by National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System Order No. R4-2012-0175 (MS4 Permit). As part of the MS4 Permit, new development and redevelopment projects are required to control pollutants, pollutant loads, and runoff volumes from development sites.

Figure 2-7 shows the current wastewater disposal and recycling facilities in the Spadra Basin. The Pomona WRP, located in the Spadra Basin, is a regional facility that receives and treats wastewater originating from indoor residential, commercial, and industrial uses within an 82 square-mile area in the eastern portion of Los Angeles County. It is owned and operated by the Joint Outfall System[4] of the LA Sanitation Districts. The tertiary-treated recycled water from the Pomona WRP is either discharged to South San Jose Creek, used for irrigation or commercial processes, or recharged outside the Spadra Basin, subject to the following permits:

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[3] Irrigation efficiency is defined as the ratio of the use of the applied water by the plants to the total water applied (UCCE, 2000).

[4] Signatory parties to the amended Joint Outfall Agreement effective July 1, 1995 includes County Sanitation Districts of Los Angeles County Nos 1, 2, 3, 5, 8, 15, 16, 17, 18, 19, 22, 22, 23, 28, 29, and 34, and South Bay Cities Sanitation District of Los Angeles County.

- NPDES No. CA0053619 Order No. R4-2014-0212 and WDRs for the Joint Outfall System Pomona Water Reclamation Plant Discharge to the South Fork San Jose Creek Via Outfall 001
- Water Reclamation Requirements (WRRs) for County Sanitation Districts of Los Angeles County and others, 1981 Order No. 81-24; readopted in 1997 Order No. 97-072
- Monitoring and Reporting Program (M&RP) No. 6241, ordered July 27, 1981
- WRRs for Groundwater Recharge at the Montebello Forebay Order No. 91-100

Recycled water from the Pomona WRP is reused at approximately 210 sites over approximately 2,319 acres (LA Sanitation Districts, 2018). Recycled water is directly reused by the LA Sanitation Districts at the Spadra Landfill and Gas-to-Energy facilities within the Spadra Basin, and by Pomona and the WVWD in the Spadra Basin and Puente Basin. Recycled water that is not delivered for direct reuse is discharged to the concrete-lined South San Jose Creek where it flows into the San Gabriel River about 15 miles downstream and recharged at the Montebello Forebay into the Main San Gabriel groundwater basin. In 2018, approximately 45 percent of the recycled water from Pomona WRP was reused within the Spadra Basin and Puente Basin, and 55 percent was used for recharge at the Montebello Forebay (LA Sanitation Districts, 2019).

Figure 2-7 also shows that some urbanized areas are not sewered, and the disposal of wastewater occurs via on-site waste disposal (septic) systems. These areas are mainly located in northern portion of the Spadra Basin along the San Jose Hills. This wastewater has the potential for adverse impact on groundwater quality in downgradient areas—particularly regarding nitrate. Studies have indicated that return flows from septic systems have a nitrate-nitrogen concentration ranging from 30-40 milligrams per liter (mgl) (Environmental Protection Agency [EPA], 2002; WEI, 2007; Kennedy/Jenks Consultants, 2013).

2.1.3.4 Permitting of New Wells and Destruction of Wells

The well permitting agencies in the Spadra Basin include the California Department of Public Health (CDPH) and the Los Angeles County Department of Public Health (LADPH). The CDPH regulates production well construction for municipal water purveyors with service connections of 200 or more.

The LADPH is responsible for reviewing plans and approving private residential water wells and small water systems that serve fewer than 200 service connections and for production well construction for municipal water purveyors with service connections of 200 or more after approval from the CDPH. The LADPH requires an *Application for Well/Exploration Hole Permit*[5] (application) be submitted for the construction, reconstruction, or destruction of a well. The LADPH is required to respond to an application within ten days after receiving it. For newly-constructed or reconstructed wells, the LADPH requires site visits to evaluate the location and

[5] http://publichealth.lacounty.gov/eh/docs/ep_dw_well_app.pdf

the installation of the well seal, the submittal of the well log, and the submittal of required water-quality testing results.

2.1.4 Additional GSP Elements

The GSP Regulations Section §354.8(g) requires a description in the "Plan Area" of any additional plan elements included in Water Code 10727.4 that the GSA determined to be appropriate. The Plan elements described in Water Code 10727.4 include:

- Control of saline water intrusion
- Wellhead protection areas and recharge areas
- Migration of contaminated groundwater
- A well abandonment and well destruction program.
- Replenishment of groundwater extractions
- Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage
- Well construction policies
- Measures addressing groundwater contamination cleanup, groundwater recharge, in-lieu use, diversions
- Efficient water management practices, as defined in Section 10902, for the delivery of water and water conservation methods to improve the efficiency of water use
- Efforts to develop relationships with state and federal regulatory agencies
- Processes to review land use plans and efforts to coordinate with land uses planning agencies to assess activities that potentially create risks to groundwater quality or quantity.
- Impacts on groundwater dependent ecosystems

The importance of a particular plan element to the sustainability of the Spadra Basin will be identified during the process to develop the GSP for the Spadra Basin. A description of the important and necessary plan elements and how they are being addressed in the Spadra Basin GSP will be incorporated in the final GSP in the Plan Area section, and other applicable sections of the GSP.

2.1.5 Notice and Communication

The GSP Regulations Section § 354.10(a-e) requires a summary of information related to the notification and communication with stakeholders by the GSA during the process to develop the GSP. A description of the stakeholder process will be incorporated in the GSP in the Plan Area section, and will include:

- List of interested persons established and maintained by the GSA.
- Description of the interests of beneficial uses and users of groundwater in the basin, and the persons or entities representing those interests, and the nature of consultation with those interests.
- Summary of public meetings at which the GSP was discussed or considered by the GSA.

- All comments regarding the GSP received by the GSA and a summary of responses.
- Communication plan adopted by the GSA

2.2 Basin Setting

The Basin Setting is a detailed description of the surface-water and groundwater hydrology of the Spadra Basin over a long-term historical period through current conditions, including the identification of data gaps and the level of uncertainty in the description. The Basin Setting addresses the requirements of Article 5, Subarticle 2 of the GSP Regulations, and will serve as the basis for the construction and calibration of the numerical groundwater-flow model and the development of Sustainable Management Criteria for the Spadra Basin.

2.2.1 Surface-Water Hydrology

The following subsections describe the surface water resources tributary to the Spadra Basin.

2.2.1.1 Tributary Sub-watersheds

Figure 2-8 shows the primary watersheds and sub-watersheds that are tributary to the Spadra Basin. Along the northern margin of the basin, there are three sub-watersheds in the San Jose Hills (San Jose 1, 2, and 3) which generally flow from north to south. Along the northern margin of the basin, there are three sub-watersheds in the Puente Hills (South San Jose 1, 2, and 3) which generally flow from south to north. These six sub-watersheds in the surrounding hills are part of the San Gabriel River watershed.

Precipitation falling on pervious areas within the sub-watersheds in the hills can combine with any applied water in the soils, infiltrate past the root zone, and recharge the Spadra Basin as underflow from the San Jose Hills and Puente Hills. Precipitation falling on pervious areas overlying the basin can combine with any applied water in the soils, infiltrate past the root zone, and recharge the Spadra Basin directly. Stormwater and dry-weather runoff in the basin and from the sub-watersheds in the hills typically enter concrete-lined flood-control storm drains and channels that exit the Spadra Basin via the San Jose Creek and South San Jose Creek and flow about 13 miles downstream into the San Gabriel River. Currently, there are no artificial recharge facilities in the Spadra Basin that can divert and recharge surface-water runoff.

A small area in the eastern portion of the Spadra Basin is part of the Santa Ana River watershed. Runoff generated in the Santa Ana River watershed flows south into the Prado Flood Control Basin in the southern portion of the Chino Basin.

2.2.1.2 Precipitation

The climate in the Spadra Basin area is characteristic of a semi-arid Mediterranean climate with generally dry summers and comparatively wet winters. Precipitation is a natural source of recharge to the Spadra Basin and can be characterized by looking at long-term records. Figure 2-8 shows the locations of active precipitation stations that have varying historical records dating as far back as the 1940s. The table below summarizes the active stations, their owner/operator, elevation, and period of record.

Active Daily-Precipitation Gages in the Spadra Basin

Station (Station ID)	Owner/Operator	Surface Elevation (ft-amsl)	Period of Record	
			Date Range	Length of Record (years)
Spadra Landfill (1260)	Los Angeles County Flood Control District	700	1988 - present	32
Pomona WRP (1271)	Los Angeles County Flood Control District	786	1981 - present	39
Puddignstone Dam (96C)	Los Angeles County Flood Control District	1,030	1931 - present	89
Pomona (78)	California Irrigation Management Information System (CIMIS)	730	1985 - present	35

Gridded data sets of precipitation data are also available including the National Oceanic and Atmospheric (NOAA) Next-Generation Radar[6] (NEXRAD), and the PRISM Climate Group (PRISM).[7] Monthly precipitation estimates from the PRISM gridded data (an 800-meter by 800-meter grid) were computed as a spatial average across the hydrologic area of Spadra Basin shown in Figure 2-8 to characterize precipitation in the Spadra Basin. Figure 2-9 shows the annual precipitation time-history, the long-term average annual precipitation, and the cumulative departure from mean (CDFM) precipitation for this hydrologic area of Spadra Basin for the 124-year period from 1895 to 2018. The CDFM plot is a useful way to characterize the occurrence and magnitude of wet and dry periods. When the slope of the CDFM plot trends downward from left to right, the annual precipitation is less than the average precipitation, and when the slope continues downward for more than one year, the CDFM indicates a dry period. When the slope of the CDFM plot trends upward from left to right, annual precipitation is greater than average precipitation, and when the slope continues upward for more than one year, the CDFM is indicates a wet period. Based on Figure 2-9, the precipitation trends in the region have been:

- an 8-year dry period from 1896 through 1903,
- an 18-year wet period from 1904 through 1921.
- a 14-year dry period from 1922 through 1935,
- a 9-year wet period from 1936 through 1944,
- a 32-year dry period from 1945 through 1976,
- a 9-year wet period from 1977 through 1982,
- an 8-year dry period from 1983 through 1990,
- a 7-year wet period from 1991 through 1997, and
- a 21-year dry period from 1998 through 2018.

[6] https://www.ncdc.noaa.gov/data-access/radar-data/nexrad

[7] http://www.prism.oregonstate.edu/

Figure 2-9 shows that precipitation is highly variable, and that there are generally three to five years of consecutive, below-average precipitation before an average or above-average year occurs. The last 21 years constitute a long dry period.

The monthly variation in precipitation is also important to understand the availability of storm water throughout the year. Figure 2-10 is a statistical characterization of monthly precipitation in Spadra Basin in the form of a Box and Whisker Plot based on the monthly precipitation estimates from PRISM Climate Group. The Box and Whisker Plot shows the minimum, lower quartile, median, upper quartile, and maximum, precipitation values. Over the period of record, the median monthly precipitation ranges from 0 to 2.7 and the minimum monthly precipitation total was zero inches in every month of the year. The plot shows that the majority of annual precipitation generally occurs during the period of November through March (the median greater than about two inches per month in these months), with the highest monthly precipitation occurring in January and February. A minor amount of precipitation (median less than one-half an inch per month) occurs during the period of May through October.

2.2.2 Hydrogeologic Conceptual Model

This section describes the evolution, structure, and composition of the Spadra Basin aquifer system and the occurrence and movement of groundwater. The section concludes with an initial estimate of the long-term yield that has been developed from the Spadra Basin and a discussion of data gaps.

The hydrogeology of the Spadra Basin area has been studied by various entities and authors in the past, including: Mendenhall (1908), Eckis (1934), California DWR (1947, 1966, 1970), Ecological Systems Corporation (1975), Donald R. Howard Consulting Engineers (1999), Fox/Roberts (2001), and WorleyParsons Resources and Energy (2009). The hydrogeologic description below was prepared from a review of prior studies and from original work performed for this effort.

2.2.2.1 Geologic Setting

Figure 2-11 is a geologic map of the Spadra Basin and the surrounding area (Morton and Miller, 2006). The Spadra Basin is a relatively narrow, alluvial-filled valley located between the San Jose Hills and Puente Hills at the northern end of the Peninsular Ranges. The Spadra Basin was formed as tectonic compression and faulting uplifted the Tertiary and pre-Tertiary consolidated bedrock formations of the San Jose Hills and Puente Hills. An eastward-flowing ancestral stream carved a narrow canyon into the bedrock formations that deepens to the east. In Quaternary time, as the San Gabriel Mountains to the north were elevated, sediments were eroded and washed out of the mountains by San Antonio Creek, depositing a broad alluvial fan that emanates from the mouth of San Antonio Canyon. The progradation of the alluvial fan began to fill the valley between the San Jose Hills and Puente Hills with unconsolidated sediments, as San Antonio Creek may have flowed through this valley towards the west. Sediments were also eroded and deposited in the valley from local tributaries flowing out of the San Jose Hills and Puente Hills.

The interconnected pore spaces within the Quaternary sediments are today's groundwater reservoirs of the Spadra Basin.

At present, San Antonio Creek flows south to the Santa Ana River. The main stream that drains the Spadra Basin is San Jose Creek, which flows to the west and ultimately merges with the San Gabriel River.

2.2.2.2 Basin Boundaries

The physical boundaries of the Spadra Basin are described below and are shown in Figure 2-11. The physical boundaries do not coincide exactly with the SGMA boundaries as defined by the Spadra Basin GSA, which are also shown in Figure 2-11.

San Jose Hills. The northern boundary of the Spadra Basin is the contact with impermeable Basement Complex and the Puente Group that outcrops along the southern front of the San Jose Hills.

San Jose Fault. The northeastern boundary of the Spadra Basin is the San Jose Fault, which separates the upgradient Six Basins from the Spadra Basin. The San Jose Fault is a known barrier to groundwater flow from the Six Basins into the Spadra Basin and the Chino Basin. The barrier effect is demonstrated by groundwater elevations that are hundreds of feet higher in the Six Basins compared to the Spadra Basin and Chino Basin.

Groundwater Divide. The eastern boundary of the Spadra Basin is a natural groundwater divide that extends from the eastern tip of the San Jose Hills southward to the Puente Hills. The groundwater divide is evidenced by groundwater-elevations measured at wells in the Six Basins, Chino Basin and Spadra Basin (described in Section 2.2.2.9). Eckis (1934) speculated that the origin of the groundwater divide is underflow from the Six Basins across the San Jose Fault. Groundwater flowing westward from the divide enters the Spadra Basin; groundwater flowing eastward from the mound enters the Chino Basin. The location of the groundwater divide is transient and can shift east or west depending on the rate of groundwater flow from the Six Basins and changes in groundwater levels in the Spadra Basin and/or Chino Basin.

Puente Hills. The southern boundary of the Spadra Basin is the contact with impermeable Basement Complex and the Puente Group that outcrops along the northern front of the Puente Hills.

Puente Basin. The western boundary of the Spadra Basin is a bedrock narrows that separates the Spadra Basin from the Puente Basin. Groundwater flows through the bedrock narrows as underflow from the Spadra Basin into the Puente Basin.

2.2.2.3 Stratigraphy

In this report, the stratigraphy of the Spadra Basin is divided into two generalized geologic formations: (1) the pervious formations that comprise the groundwater reservoir are termed *water-bearing sediments* and (2) the impermeable formations that enclose the groundwater reservoirs are termed *consolidated bedrock*. Water-bearing sediments overlie the consolidated bedrock, with the bedrock formations coming to the surface in the surrounding hills and highlands. Below, these geologic formations are described in stratigraphic order, with the oldest formations first.

The terms used in this report to describe bedrock, such as "consolidated," "non-water-bearing," and "impermeable," are used in a relative sense. The water content and permeability of these bedrock formations, in fact, is not zero. However, the primary point is that the permeability of the geologic formations in the areas flanking the groundwater basin is much less than the aquifer sediments within the basin.

2.2.2.3.1 Consolidated Bedrock

The consolidated bedrock formations that flank and underlie the Spadra Basin consist of very old crystalline rocks of the Basement Complex and younger sedimentary and volcanic rocks of the Puente Group.

The Basement Complex consists of deformed and recrystallized metamorphic rocks (e.g., banded gneisses) that have been intruded by masses of igneous rocks (e.g. granite). As shown in Figure 2-11, the Basement Complex outcrops in the eastern margins of the San Jose Hills and Puente Hills. Weathering and erosion of the Basement Complex in the San Gabriel Mountains is the major sediment source for the younger sedimentary formations—in particular, the water-bearing sediments of Spadra Basin.

The Puente Group, where present, overlies the Basement Complex and consists of interbedded shales, sandstones, conglomerates, lava flows, volcanic ash, and volcanic breccia (English, 1926). As shown in Figure 2-11, the Puente Group outcrops in the western San Jose Hills and Puente Hills.

2.2.2.3.2 Water-Bearing Sediments

During the Quaternary Period, sediments that eroded from the surrounding and distant mountains and hills were transported to the Spadra Basin by flooding and deposited atop the consolidated bedrock formations as interbedded, discontinuous layers of gravel, sand, silt, and clay to form the water-bearing sediments.

The water-bearing sediments are over 600 feet thick in places, but pinch-out to zero thickness along the northern and southern basin boundaries at the surface contact with the consolidated bedrock. Most water wells have their screens completed within the water-bearing sediments. Some of these wells in the Spadra Basin can pump over 400 gallons per minute (gpm).

The water-bearing sediments are typically composed of gneissic and granitic debris from the San Gabriel Mountains and can be differentiated into the Older Alluvium of Pleistocene age and Younger Alluvium of Holocene age. The general character of these formations is known from driller's logs and surface outcrops.

The Older Alluvium was deposited on top of the bedrock formations under conditions similar to today's depositional environments. The Older Alluvium is commonly distinguishable in surface outcrop by its red-brown or brick-red color. The red color comes from secondary clays that formed from the weathering and oxidation of sediments that were deposited in areas where the water table was deep and where sediments were not disturbed by stream erosion over long periods. The Older Alluvium contains many local unconformities because of the nature of the alluvial fan deposition process. The Older Alluvium is the main source of groundwater for today's wells.

The Younger Alluvium was deposited on top of the Older Alluvium after a period of weathering and erosion of the Older Alluvium. The Younger Alluvium is typically a fresh, un-weathered, grey or brown color, and exists in outcrop only along the recent streambed channels of San Jose Creek. The Younger Alluvium is absent in most places and is typically thin compared to the Older Alluvium. Where it exists, it is commonly unsaturated and lies above the regional water table. The Younger Alluvium is typically more permeable than the Older Alluvium.

Figure 2-12 is a map of the hydrologic soil types across the Spadra Basin area, as mapped by the Soil Conservation Service:

- **Type A Soils** have high infiltration rates, even when thoroughly wetted. Typically composed of sands and gravels.
- **Type B Soils** have moderate infiltration rates when thoroughly wetted. Typically composed of moderately fine to moderately coarse texture.
- **Type C Soils** have slow infiltration rates when thoroughly wetted. Typically include a layer that impedes downward movement of water and/or moderately fine to fine texture.
- **Type D Soils** have very slow infiltration rates when thoroughly wetted and a high runoff potential. Typically, are of fine texture and/or a thin soil over a nearly impervious material.

Note the absence of Type A soils across the Spadra Basin, which is consistent with the near absence of Younger Alluvium. Type B soils cover most of the eastern Spadra Basin and the older stream channels of San Jose Creek. Type C soils occur across most of the narrow western portion of the basin and along the basin fringes, likely representing the deposition of sediments eroded from the flanking San Jose Hills and Puente Hills. Type D soils occur across most of the San Jose Hills and Puente Hills, which are composed of the consolidated bedrock formations.

2.2.2.4 Bottom of the Aquifer

The consolidated bedrock formations underlying the water-bearing sediments of the Spadra Basin act as the effective base of the freshwater aquifer. Herein, the effective base of the freshwater aquifer is referred to as the "bottom of the aquifer."

Figure 2-13 is a contour map of equal depth to the bottom of the aquifer (i.e., the buried contact between the water-bearing sediments and consolidated bedrock). The units of depth are in feet below ground surface (ft-bgs). These contours were drawn from lithologic descriptions of borehole cuttings that were recorded on well driller's reports that were collected and reviewed for this study. Each well driller's report was reviewed, and best efforts were made to identify the driller's interpretation of depth to borehole penetration of the consolidated bedrock. The interpretations by the well drillers are often subjective and poorly described on the well driller's reports. The typical terminology used to describe bedrock on the reports were: "hill formation," "rock," or "decomposed granite," among others.

Depth to bedrock at each well-borehole location, which represents the bottom of the aquifer, were plotted on a map. Zero depth to bedrock was defined by the surface contact between the water-bearing sediments and the consolidate bedrock. Contours of the bottom of the aquifer were hand drawn and digitized in ArcGIS.

The contours on Figure 2-13 show that the bottom of the aquifer is a narrow trough aligned along the axis of the Spadra Basin. A bedrock "narrows" is located at the southwestern end of Spadra Basin (i.e. the boundary with the Puente Basin), where the bottom of the aquifer appears to be less than 200 ft-bgs. The bedrock trough deepens to the east, where at the eastern margins of the Spadra Basin (i.e. the boundary with the Chino Basin), the bottom of the aquifer is greatest at over 600 ft-bgs. The eastward-sloping bedrock trough appears to be related to erosion by ancestral streams that flowed from west to east as the San Jose Hills and Puente Hills were uplifted. Eckis (1934) speculated that the contact between the consolidated bedrock and the water-bearing sediments is unconformable, as indicated by an ever-present weathered zone in the consolidated bedrock directly underlying the contact with the water-bearing sediments. This observed relationship suggests that the consolidated bedrock in the Spadra Basin area was undergoing erosion prior to deposition of the water-bearing sediments. Eckis (1934) reported that the weathered zone is about 50-feet thick, and that beneath the weathered zone the bedrock is hard. Fractured and weathered zones in the bedrock formations may yield water to wells locally, but the storage capacity is typically inadequate for sustained production.

Like Figure 2-13, Figure 2-14 is a map of the bottom of the aquifer; however, depth of the bottom of the aquifer has been converted to elevation in feet above mean sea level (ft-amsl). The following steps were executed in ArcGIS Geostatistical Analyst to complete this conversion: (i) create a raster of the depth to the bottom of the aquifer from the contours and data shown on Figure 2-13; (ii) subtract the depth raster from the USGS 10-meter digital elevation model of the ground-surface elevation to create a raster of the elevation of the bottom of the aquifer; and (iii) create contours from the elevation raster.

2.2.2.5 Hydrostratigraphy and Aquifer Systems

As described above, the water-bearing sediments are composed of interbedded layers of gravel, sand, silt and clay, or layers that are a combination of one or more of these sediment types. The layers composed mainly of gravel and sand are permeable and groundwater flows through the interconnected pore space within these layers towards pumping wells. These layers of gravel and sand are referred to as "aquifers." The layers composed mainly of silt and clay are poorly permeable, and impede groundwater flow to pumping wells. Layers of silt and clay are referred to as "aquitards." Aquitards store groundwater and can transmit appreciable amounts of groundwater to the adjacent aquifers through vertical drainage. Together, the aquifers and aquitards are herein referred to as the "aquifer system."

Groundwater can exist within an aquifer system under two different hydraulic conditions: unconfined and confined. Where the groundwater table is exposed to the atmosphere through the overlying unsaturated zone, the aquifer system is unconfined, and the groundwater table can rise and fall freely under the stresses of recharge and pumping. Where deeper groundwater is separated from the atmosphere by significant thicknesses of aquitards, the aquifer system is confined, and the groundwater can be under a pressure head that is higher than the top of the aquifer. Depending on the spatial distribution of the aquitards, and their effectiveness as "confining layers," a groundwater reservoir can be vertically stratified into multiple aquifer systems that have different physical and chemical characteristics.

The aquifer and aquitard layers and their geometries are numerous and complex in the Spadra Basin and must be simplified into a hydrogeologic conceptual model that represents the three-dimensional distribution of the water-bearing sediments and their hydrogeologic properties. This conceptual model is described below and will be used as input to a numerical groundwater-flow model to support the development of the Spadra Basin GSP.

In order to depict the hydrogeologic conceptual model, five hydrogeologic cross-sections were constructed across the Spadra Basin. The plan-view locations of these cross-sections are shown on Figure 2-14 and the profile-view cross-sections are shown in Figure 2-15a through Figure 2-15e. Plotted on these cross-sections are well and borehole data, including: borehole lithology, well casing perforations, recent estimates of groundwater elevation (Fall 2018), specific capacities of the wells, and estimates of horizontal hydraulic conductivity of the saturated sediments (see *Section 2.2.2.6* on Initial Estimates of Aquifer Properties).

The hydrogeologic cross-sections depict a narrow, channel-like aquifer system that consists of about 100-200 feet of saturated sediments along the axis of the basin that thicken to about 400 ft near the western boundary with the Chino Basin. Along the northern and southern edges of the basin, the depth to bedrock becomes shallow and the saturated sediments pinch out against the buried contact with bedrock.

The thickness of the unsaturated zone along the axis of the basin varies from about 40 ft at the western boundary of the basin to about 250 ft at the eastern boundary of the basin.

There are no data to support a multiple-layer aquifer system within Spadra Basin. The saturated sediments are a relatively thin unit (typically less than about 200 feet thick) of interbedded, discontinuous layers of gravel, sand, silt, and clay mixtures. There are no thick, regionally-extensive, fine-grained layers (aquitards) that could create conditions for deeper confined aquifers. Flowing-artesian wells—an indication of confined aquifer conditions—have never been observed or mapped in the basin. The Spadra Basin is best characterized as a relatively thin, unconfined, alluvial aquifer system.

2.2.2.6 Initial Estimates of Aquifer Properties

The properties that characterize the ability of the water-bearing sediments of the Spadra Basin to store and transmit groundwater are specific yield (effective porosity) and hydraulic conductivity. The specific yield of the water-bearing sediments is a measure of its capacity to store water. Specific yield is the ratio of the volume of water that a given mass of saturated sediments will yield by gravity drainage to the volume of that mass. The ratio is typically stated as a percentage. The hydraulic conductivity of the water-bearing sediments is a measure of its capacity to transmit water. Hydraulic conductivity is the rate of flow of groundwater in gallons per day through a cross section of one square foot of sediment under a unit hydraulic gradient. The English units for hydraulic conductivity are feet per day (ft/d).

This section describes the initial estimation of specific yield and hydraulic conductivity for the saturated water-bearing sediments within the Spadra Basin. These estimates will be refined during the calibration of the numerical groundwater-flow model.

Hydraulic conductivity and specific yield are closely related to the texture of the sediments (McCuen et al., 1981). For example, the values of hydraulic conductivity and specific yield are generally higher in sands and gravels as compared to silts and clays. Several databases and publications have estimated values of hydraulic conductivity and specific yield based on sediment texture (Rawls et al., 1982; Schaap and Leij, 1998; Carsel and Parrish, 1988; Bouwer, 1978; Prudic, 1991; Reese and Cunningham, 2000; Kuniansky and Hamrick, 1998; Domenico and Schwartz, 1990; Freeze and Cherry, 1979; and Johnson, 1967). These estimates were used to assign hydraulic conductivity and specific yield to each sediment description on every available well driller's report for boreholes drilled in the Spadra Basin. Using the following formulas, thickness-weighted estimates of horizontal hydraulic conductivity and specific yield were computed for each borehole across the saturated thickness based on 2008 water level conditions, a time of relatively high groundwater elevations:

$$K_h = \sum_{i=1}^{n} \frac{K_i b_i}{b}$$

$$S_y = \sum_{i=1}^{n} \frac{S_{yi} b_i}{b}$$

Where,

K_h is the average horizontal hydraulic conductivity of the saturated sediments,

K_i is the hydraulic conductivity of *i* bed,

b_i is the saturated thickness of bed *i*,

b is the total thickness of the of the saturated sediments

S_y is average specific yield of the saturated sediments

S_{yi} is the specific yield for bed *i*.

Figure 2-16 shows the thickness-weighted, initial estimates for specific yield at 16 boreholes that penetrated the entire thickness of the water-bearing sediments. The figure also shows interpolated estimates of specific yield between boreholes to depict its spatial distribution. The interpolated surface is clipped to the area of the saturated sediments (i.e. the water-bearing sediments are thin and unsaturated along the margins of the basin, hence, estimates of aquifer properties are not needed). Specific yield of the saturate sediments is relatively low across the basin and ranges from about 5% to 22%. Generally, specific yield is higher along the basin axis and lower along the edges of the basin. There is a localized area of higher specific yield in the western portion of the basin, and in the east, specific yield appears to increase toward the Chino Basin.

Figure 2-17 shows the thickness-weighted, initial estimates for horizontal hydraulic conductivity at boreholes that penetrate the entire thickness of the water-bearing sediments. The figure also shows interpolated estimates of horizontal hydraulic conductivity between boreholes to depict its spatial distribution. Horizontal hydraulic conductivity of the saturated sediments ranges from about 30 to 230 ft/d. As with specific yield, hydraulic conductivities are higher along the basin axis and lower along the edges of the basin. There is a localized area of higher hydraulic conductivities in the western portion of the basin, and in the east hydraulic conductivity appears to increase toward the Chino Basin.

The initial estimates of vertical hydraulic conductivity are assumed to be ten percent of the horizontal hydraulic conductivity.

2.2.2.7 Groundwater Recharge

Groundwater recharge to the Spadra Basin primarily occurs by the following general mechanisms:

- *Subsurface inflow from the Six Basins across the San Jose Fault*. The San Jose Fault is a known barrier to groundwater flow from the Six Basins into the Spadra Basin; however, Eckis (1934) speculated that groundwater flows from the Six Basins into the Spadra Basin as underflow across the San Jose Fault near the eastern tip of the San Jose Hills.
- *Subsurface inflow from the saturated alluvium and fractures within the bordering bedrock hills (San Jose Hills and Puente Hills)*.
- *Deep infiltration of precipitation and applied water* (DIPAW). DIPAW includes the combination of precipitation that falls directly on a pervious land surface, precipitation that falls on impermeable land surface that subsequently flows onto pervious surfaces, and irrigation water applied to the land surface; all of which when combined is surplus to the evapotranspiration demand and soil water storage capacity. DIPAW migrates through the root zone and subsequently reaches the underlying groundwater reservoir. DIPAW is an important source of recharge from a water quality standpoint because it is typically high in TDS and nitrogen from land application of fertilizers and from consumptive use by vegetation.

- *Deep infiltration of septic tank discharge and leakage from water mains*.

2.2.2.8 Groundwater Discharge

Groundwater discharge from the Spadra Basin occurs primarily as:

- *Groundwater production from wells.*
- *Sub-surface outflow to the Puente Basin.* This component of discharge occurs as underflow through the saturated sediments in the narrow bedrock gap that connects the Spadra Basin to the Puente Basin. The rate of underflow is dependent on the hydraulic gradient and the hydraulic conductivity of the saturated sediments.
- *Sub-surface outflow to the Chino Basin*. This component of discharge occurs as underflow through the saturated sediments when the groundwater divide is located west of the boundary with the Chino Basin. The rate of underflow is dependent on the hydraulic gradient and the hydraulic conductivity of the saturated sediments.

2.2.2.9 Groundwater Flow

Figure 2-18a is an equal groundwater-elevation contour map for fall 2018. Figures 2-18b, 2-18c, and 2-18d are groundwater-elevation contour maps for: fall 1977, which represents a period of low groundwater elevations; fall 2008, which represents a period of relatively high groundwater elevations; and fall 2015, which represents the start of SGMA implementation. The procedure for constructing groundwater elevation contour maps follows:

- *Collect historical groundwater-elevation data for wells within the basin.* Main data sources included files from the Pomona, WVWD, CCP, DWR, Chino Basin Watermaster, and Six Basins Watermaster.
- *Prepare and analyze time-series charts of groundwater elevations for all wells.* The time-series charts can be used to distinguish between static and pumping groundwater levels. Groundwater-elevation data that were collected while the well was under the influence of pumping were not used in the preparation of the groundwater-elevation contour maps.
- *Extract groundwater-elevation data for specific time periods*. For example, for the Fall 2018 groundwater-elevation contour map, we extracted groundwater elevation data for wells with data between September 1 and December 31, 2018. After “pumping” data were discarded, we chose one groundwater-elevation data point for each well in the following order of priority: November, October, December, September.
- *Prepare maps of the groundwater-elevation data.* The maps included background hydrogeologic layers, such as surface geology, faults, and stream channels.
- *Prepare contours of equal groundwater elevation.* Groundwater elevation contours were hand drawn based on the plotted groundwater elevation point (well) data. The groundwater elevation contours were digitized and imported into the project GIS. The

contours are dashed where groundwater-elevation data are sparse or absent, and hence, groundwater-elevations contours are uncertain.

The groundwater elevation contour maps were used to analyze and interpret groundwater flow directions (perpendicular to the groundwater elevation contours). Groundwater-flow directions are perpendicular to the contours from higher elevation to lower elevation. Although groundwater elevations are different on these maps, the shape and orientation of the contours are similar, demonstrating that the groundwater-flow patterns within the Spadra Basin have been generally consistent over time and under different hydrologic conditions. The maps and interpretations from this report were compared to maps and interpretations publish in past literature. The main observations and interpretations from Figures 2-18a through 2-18d are:

- Groundwater elevations in the Six Basins may influence groundwater levels and groundwater-flow directions in the Spadra Basin. For example, when groundwater elevations in the Six Basins are higher than groundwater elevations in the Spadra Basin, the underflow across the San Jose Fault may help to create and maintain the groundwater divide that extends from the eastern tip of the San Jose Hills to the eastern Puente Hills. Note on the map figures the groundwater elevation at the P-3 well in the Six Basins, which helps to describe the head difference across the San Jose Fault. Consider the differences between Figure 2-18a and 2-18b which demonstrates the differences in groundwater levels and flow directions between 2018 and 1977:
    - Figure 2-18a is a map of groundwater elevations in 2018. The map shows that groundwater elevations were higher in the Six Basins compared to the Spadra Basin, which likely resulted in subsurface flow from the Six Basins across the San Jose Fault as a source of recharge to the Spadra Basin. Groundwater levels were relatively high in the Spadra Basin, and the groundwater divide was located just south of the eastern tip of the San Jose Hills (where the subsurface inflow from the Six Basins is most likely to occur).
    - Figure 2-18b is a map of groundwater elevations in 1977. The map shows that groundwater elevations were lower in the Six Basins compared to the Spadra Basin, which likely resulted in no subsurface flow from the Six Basins. Groundwater levels were relatively low in the Spadra Basin, and the groundwater divide was located further west of the tip of the San Jose Hills, likely because of the lack of subsurface flow from the Six Basins.
- From the groundwater divide, the main directions of groundwater flow within the Spadra Basin are: (i) eastward into the Chino Basin or (ii) westward and southwestward along the axis of the Spadra Basin toward the Puente Basin. The southwestward flowing groundwater that is not pumped ultimately migrates as underflow through the bedrock narrows into the Puente Basin.
- The hydraulic gradients shown by the groundwater-elevation contours on the figures are relatively constant in the eastward and westward directions, and hence, do not suggest

the existence of internal barriers that interrupt or impede the flow of groundwater. The only mapped fault within the Spadra Basin is the extension of the San Jose Fault along the northern margin of the basin. There are no wells (or groundwater data) in the Spadra Basin that are located north of the San Jose Fault that would help determine if the San Jose Fault is a barrier to groundwater flow within the Spadra Basin.

2.2.2.10 Groundwater Pumping

Groundwater pumping is the extraction of groundwater from the aquifer system by a well. In 2018, there were approximately 10 active production wells in the Spadra Basin. Pumping capacities at these wells are relatively low ranging between 200 to 400 gpm. Specific capacities at the pumping wells are also typically low (<25 gpm/ft-drawdown). The low pumping capacities and specific capacities at wells are likely due to the saturated sediments in the Spadra Basin being relatively thin and of low hydraulic conductivity.

Annual groundwater pumping from 1977-2018 is listed by well in Table 2-1 and shown graphically in Figure 2-19. The maximum discharge by pumping occurred in 1986 at about 2,200 afy; the minimum pumping occurred in 1991 at about 700 afy. The average annual pumping over the entire 1977-2018 period was about 1,280 afy. Average annual pumping over the last 10 years was about 970 afy—about 310 afy less than the long-term average. The percentage of the total pumping in the Spadra Basin between the three water purveyors during 1977-2018 was 51 percent by Pomona, 46 percent by CPP, and 3 percent by the WVWD.

2.2.2.11 Groundwater Levels and Storage

This section describes how groundwater levels and storage have changed over time across the Spadra Basin, and why those changes occurred.

Figure 2-19 shows time-series charts of groundwater elevation at four wells located across the Spadra Basin. The time-series charts indicate:

- At some wells, the short-term groundwater-level fluctuations are caused by including pumping and non-pumping measurements on the time series charts.
- Seasonal changes in groundwater levels at all wells are minimal, and do not exceed a few feet of seasonal change.
- The long-term trends in groundwater levels appear to be consistent at all wells across the basin, suggesting that all wells are being influence by the same regional stresses of recharge and pumping.

On Figure 2-19, the behavior of groundwater levels is compared to precipitation patterns and groundwater pumping to help describe why the changes in groundwater levels have occurred. Precipitation patterns are illustrated by the CDFM curve. The following describes the observations and interpretations from Figure 2-19 and Figures 2-18a through 2-18d:

- In 1977, groundwater elevations were relatively low in the Spadra Basin. This was true for two main reasons: (i) the period from 1945 through 1977 was a long-term drought and (ii) groundwater elevations in the Six Basins were near all-time lows (and in fact, lower than groundwater elevations in the Spadra Basin) (WEI, 2017) which likely resulted in cutting off subsurface inflow from the Six Basins.
- From 1978 to 1985, groundwater elevations increased in the Spadra Basin by 30-40 ft, even though groundwater pumping increased from about 1,200 afy to over 2,000 afy. This increase in groundwater levels was likely due to: (i) increased recharge from precipitation associated with the 1978-83 wet period and (ii) rapidly increasing groundwater levels in the Six Basins in the early 1980s (WEI, 2017) that likely resulted in increased recharge by subsurface flow across the San Jose Fault.
- From 1985 to 1992, groundwater elevations decreased by about 25-30 ft, even though groundwater pumping progressively decreased from over 2,000 afy in 1986 to about 700 afy in 1991. This decrease in groundwater levels was likely due to the 1984 to 1991 dry hydrologic period.
- From 1992 to 2008, groundwater elevations increased by about 40 ft. Groundwater pumping was variable over this period, but generally averaged about 1,200 afy. The increase was likely due to the 1991-98 wet hydrologic period which likely increased the recharge via DIPAW and subsurface inflow from the surrounding hills. Also during this period, groundwater levels in the Six Basins had increased by at least 300 ft compared to the late 1970s which likely resulted in increased subsurface inflow to the Spadra Basin across the San Jose Fault.
- From 2009 to 2018, groundwater elevations in the Spadra Basin gradually decreased by about 10-20 ft even though groundwater pumping decreased to an average annual rate of about 970 afy for the period. The decrease in groundwater levels was likely due to the 1999-2018 dry period from and a 50-ft decrease in groundwater levels in the Six Basins, both of which reduced the recharge to the Spadra Basin.

The changes in groundwater levels described above resulted in changes in groundwater storage. Figure 2-20 is a map that shows changes in groundwater levels from 1977 to 2018. Groundwater levels were about 25-35 ft higher in 2018 compared to 1977 across most of the Spadra Basin and were up to 70 ft higher near the boundary with the Chino Basin.

The data used to estimate groundwater in storage for a specific year included: bedrock elevation (shown on Figure 2-14); groundwater elevation (Figure 2-18b for 1977 and Figure 2-18a for 2018); and the thickness-weighted average specific yield of the saturated sediments (Figure 2-16). In ArcGIS, bedrock elevation, groundwater-level elevation, and specific yield were assigned to each cell of a 60 x 60-meter grid (196 x 196-ft) superimposed over the Spadra Basin. In Microsoft Excel, the volume of groundwater in storage within each grid cell was calculated and summed to estimate the total storage.

The following table summarizes the estimated water in storage in 1977 and 2018, and the change in storage over this period.

Groundwater in Storage and Change in Storage in the Spadra Basin
(1977-2018)

Year	Storage (af)
1977	23,678
2018	32,956
Δ Storage 1977-2018	+ 9,278

2.2.2.12 Initial Estimate of Developed Yield: 1977-2018

As defined herein, the "developed yield" is the annual average yield that was pumped from the groundwater basin over a finite period of time, but is corrected for the change in groundwater storage (described above) and the volume of supplemental-water recharge that occurred during the period of interest. The developed yield is reflective of the hydrology and water management practices of that period. It can be considered an estimate of the sustainable yield of a basin if: (i) it is computed over a long enough period to include both wet and dry hydrologic periods and (ii) there were no obvious undesirable results that occurred, such as chronic lowering of groundwater levels and reduction of storage.

Herein, the period of interest for computing an initial estimate of developed yield is 1977 to 2018. This period included wet periods (1978-83 and 1991-98) and dry periods (1984-90 and 1999-2018) and groundwater levels increased across the basin. No supplemental water recharge occurred in the Spadra Basin during 1977 to 2018.

The developed yield can be estimated using a pragmatic approach:

$$\text{Developed Yield} = (O_p - I_{ar} + \Delta S)/\Delta t$$

Where:

- Δt is the time period over which the developed yield is being estimated
- O_p is the total groundwater pumped from the basin(s) during Δt
- I_{ar} is the total supplemental water recharged to the basin(s) during Δt
- ΔS is the change in groundwater storage within the basin(s) during Δt

Developed Yield = (53,649 af – 0 af + 9,278 af)/42 yr = 1,498 afy

In TM2, a more rigorous analysis of the water budget and the developed yield of the Spadra Basin over the 1977 to 2018 time period will be performed through the development and calibration of a groundwater-flow model.

2.2.3. Groundwater Quality

Spadra Basin groundwater is used primarily for non-potable uses by the overlying water purveyors because of the general poor quality of groundwater. Groundwater from Spadra Basin that is used for potable supply often requires treatment or blending prior to use to comply with DDW drinking-water standards.

In the Spadra Basin, groundwater-quality data are available for production wells and monitoring wells. Groundwater-quality samples from production wells are sampled by well owners and are generally sampled for constituents required by the DDW monitoring schedules for municipal water systems. The frequency of water-quality sampling depends on the well use; some production wells in the Spadra Basin are rarely or never sampled because they are used for agricultural or other non-potable uses where water-quality monitoring is performed elsewhere in the distribution system. Groundwater-quality samples from monitoring wells in the Spadra Basin are collected by public entities, private companies and their consultants to characterize point-source contamination for which they are potentially responsible as determined by the LA Regional Board. The constituents and sampling frequency vary by contamination site.

All available groundwater-quality data from wells in the Spadra Basin over the last twenty years (2000-2019) was analyzed for exceedances of regulatory standards including: primary or secondary California maximum contaminant levels (MCLs) for drinking water; State notification levels (NLs) set by the DDW as advisory levels for potential negative health effects; and the numerical groundwater-quality objectives for the Spadra Basin as defined in the LA Basin Plan. There were 39 wells with available groundwater quality data during this period; the frequency of monitoring and constituents sampled for varies by well. Table 2-2 summarizes the number of wells in the Spadra Basin with constituent concentrations that exceed an MCL, NL, or a numerical Basin Plan objective. In one or more wells, there are 17 constituents that exceed a primary MCL, five constituents that exceed a secondary MCL, three constituents that exceed a NL, and four constituents that exceed a Basin Plan objective.

Understanding the spatial distribution of wells with concentrations greater than regulatory standards is important because it indicates areas in the basin where groundwater may be impaired from a beneficial use standpoint, and hence, poses current and future challenges that the pumpers may face in using the groundwater for certain end uses. A series of maps were prepared to depict the areal distribution of contaminants of concern in the Spadra Basin which are defined as follows:

- Constituents that exceed primary or Secondary MCLs in ten or more wells

- Constituents that are associated with salt and nutrient management planning: total dissolved solids (TDS) and nitrate.
- Constituents associated with known point-source contamination sites and exceed a primary MCL in ten or more wells. These constituents are trichloroethene (TCE), tetrachloroethene (PCE), 1,1-dichloroethene (1,1-DCE).
- Constituents for which the DDW is in the process of re-evaluating the current MCL that may impact the future beneficial use of groundwater and are found in several production wells. This constituent is perchlorate.

Figures 2-21 through 2-26 show the areal distribution of groundwater quality for the contaminants of concern listed above. The maximum concentration measured at each well from 2000 to 2019 is displayed using the following standardized class intervals based on the water-quality standard (WQS) for the constituent of concern:

Symbol	Class Interval
	Not Detected
	<0.5x WQS, but detected
	0.5x WQS to WQS
	WQS to 2x WQS
	2x WQS to 4x WQS
	> 4x WQS

2.2.3.1 TDS

TDS has a secondary MCL of 500 mgl. Figure 2-21 displays the areal distribution of the maximum TDS concentration at wells in the Spadra Basin from 2000 through 2019. During this period, 25 of the 39 wells with water-quality data were sampled for TDS, and TDS concentrations exceeded the secondary MCL at 24 (96 percent) of the wells sampled. The maximum TDS concentrations ranged from 424 to 2,380 mgl and averaged 1,265 mgl. The highest TDS concentrations are located along the western margin of the Spadra Basin adjacent to the Spadra Landfill. Higher TDS concentrations in groundwater can be related to the historical disposal operations at the landfill and the long history of agriculture in this area. Agricultural land uses impact TDS concentrations in the groundwater through the use of fertilizers on crops, and the concentrating effects on return flows from consumptive use by crops. All but one of the wells have maximum TDC concentrations that are above the Basin Plan objective of 550 mgl, indicating that the basin may not have assimilative capacity for TDS.

2.2.3.2 Nitrate

The California primary MCL for nitrate (as nitrogen) in drinking water is 10 mgl. By convention all nitrate values are expressed in this GSP as nitrate as nitrogen. The Basin Plan also has a nitrate objective of 10 mgl. Figure 2-22 displays the areal distribution of the maximum nitrate concentration at wells in the Spadra Basin from 2000 through 2019. During this period, 24 of the 39 wells with water-quality data were sampled for nitrate, and nitrate exceeded the primary MCL at 20 (87 percent) of the wells sampled. The maximum nitrate concentrations ranged from 0.8 to 43.4 mgl and averaged 17 mgl. The historical land use in the Spadra Basin included irrigated crops, pastures, and citrus where nitrate fertilizers were regularly applied to citrus and other crops. Furthermore, typical irrigation practices for citrus have low irrigation efficiencies, about 60 percent. The lower the irrigation efficiency of the practice, the more applied water percolates to groundwater. There are still portions of the Spadra Basin with irrigated citrus and other crops. These historical and current agricultural practices can result in high nitrate concentrations in groundwater.

2.2.3.3 PCE and TCE

PCE and TCE are regulated drinking water contaminants in California each with a primary MCL of 5 micrograms per liter (µgl). Figure 2-23 and Figure 2-24 display the areal distribution of the maximum PCE and TCE concentrations at wells in the Spadra Basin from 2000 to 2019, respectively. During this period, 39 out of 39 wells with water quality data were sampled for both PCE and TCE, and PCE concentrations exceeded the primary MCL at 26 (67 percent) of the wells sampled, and TCE concentrations exceeded the primary MCL at 25 (64 percent) of the wells sampled. PCE and TCE are common industrial solvents used as degreasers in metal-working industries. Wells with detectable levels of PCE and TCE occur predominantly in monitoring well clusters associated with known point-sources of contamination (see Figure 2-27) or in wells downgradient of these contamination sites. However, PCE and TCE are detected in some pumping wells in the Spadra Basin that are not located in proximity to these contamination sites and potential sources and responsible parties are yet to be identified. The known point-source contamination sites in the Spadra Basin will be discussed further in *Section 2.2.3.7*

2.2.3.4 1,1-DCE

1,1-DCE is a regulated drinking-water contaminant in California with a primary MCL of 6 µgl. Figure 2-25 displays the areal distribution of the maximum 1,1 DCE concentration at wells in the Spadra Basin from 2000 to 2019. During this period, 39 of the 39 wells with water quality were sampled for 1,1-DCE and, 1,1-DCE concentrations exceeded the primary MCL at 14 (39 percent) of the wells sampled. 1,1-DCE is a degradation by-product of TCE, PCE, and 1,1,1-trichloroethane (1,1,1-TCA) that is formed by reductive dehalogenation. Wells with detectable levels of 1,1-DCE occur predominantly in monitoring well clusters associated with the known point-sources of contamination (see Figure 2-27) or in wells downgradient of these contamination sites. However, 1,1-DCE is detected in a few wells that are not located in proximity to these contamination sites and potential sources and responsible parties are yet to be identified. The known point-source contamination sites in the Spadra Basin will be discussed further in *Section 2.2.3.7*.

2.2.3.5 Perchlorate

Perchlorate is a regulated drinking-water contaminant in California with a primary MCL of 6 µgl. Figure 2-26 displays the areal distribution of the maximum perchlorate concentration at wells in the Spadra Basin from 2000 to 2019. During this period, 15 of the 39 wells with water-quality data were sampled for perchlorate, and perchlorate concentrations exceeded the primary MCL at 4 (27 percent) of the wells sampled. Perchlorate sources in groundwater can include: (i) synthetic perchlorate, such as ammonium perchlorate used in the manufacturing of solid propellants used for rockets, missiles, and fireworks and (ii) natural perchlorate, such as that derived from Chilean caliche that was used as a fertilizer. It is known that Chilean nitrate fertilizer was used in Southern California in the early 1900s for the citrus industry, which covered the eastern and western portions of the Spadra Basin as shown in Figure 2-5. While Chilean nitrate fertilizer is no longer used, and citrus farming is almost non-existent today in the Spadra Basin, like nitrate, the legacy of perchlorate contamination in groundwater still exists[8].

In 2015, the California Office of Environmental Health Hazard Assessment (OEHHA) lowered the public health goal (PHG) for perchlorate from 6 to 1 µgl, which prompted the DDW to initiate a process to evaluate the current MCL of 6 µgl. The State Water Board approved a July 2017 DDW recommendation to lower the detection limit for the purposes of reporting (DLR) to 1 µgl to gather state-wide occurrence data and use this to support a potential MCL revision. Perchlorate data has not been collected in every pumping well in Spadra Basin, and at the pumping wells that have been sampled the perchlorate concentrations are above the new PHG, and most are above the MCL. Because of the historical citrus farming in the Spadra Basin and a potential lowering of the MCL by the DDW, perchlorate is a contaminant of concern in the Spadra Basin that could impact the beneficial uses of the groundwater.

2.2.3.6 1,2,3-Trichloropropane

1,2,3-Trichloropropane (1,2,3-TCP) is a newly regulated contaminant in California with a Primary MCL of 0.005 µgl, which was adopted and immediately effective in December 2017. 1,2,3-TCP was used historically as a solvent, an extractive agent, a paint remover, a cleaning and degreasing agent, and in the manufacturing of soil fumigants used for agriculture including citrus farming. During the period of 2000 to 2019, all of the 29 wells sampled for 1,2,3-TCP were non-detect for the contaminant, however all but two of the wells were sampled using laboratory methods with a DLR equivalent to, or lower than, the MCL of 0.005 µgl. The range in the DLR of the laboratory methods used to test for 1,2,3-TCP ranged from 0.5 to 100 µgl, equivalent to 100 to 20,000 µgl times the MCL – thus the occurrence of 1,23-TCP relative to the regulatory standard cannot be

[8] The Chino Basin Watermaster conducted a study analyzing the stable isotopes of oxygen and chlorine from perchlorate in samples from groundwater wells in west and central Chino Basin. This study concluded that Chilean fertilizer was the source of perchlorate in those portions of Chino Basin. The results of the study were not published by the Chino Basin Watermaster.

characterized. Because of the history of citrus and crop farming, and the existence of point-source contaminant sites related to solvent use, 1,2,3-TCP is a potential contaminant of concern in the Spadra Basin that could impact the beneficial uses of the groundwater.

2.2.3.7 Point-Source Contamination in the Spadra Basin

The State Water Board's GeoTracker[9] databases and California Department of Toxic Substances (DTSC) EnviroStor[10] database were queried to determine if there are any point-source contaminant sites with open cases for the monitoring and cleanup of groundwater within and adjacent to the Spadra Basin. Sites listed on GeoTracker and EnviroStor that contained no information about the contamination source, contaminants of concern, or contaminated media were not further investigated, as well as sites where the contaminated media is only soil. Figure 2-27 shows the general location of the point-source contaminant sites identified, categorized by investigation status. Three sites within the Spadra Basin were identified on GeoTracker and EnviroStor that have monitoring data and information indicating a potential impact to groundwater quality: the Teledyne Cast Parts, the Spadra Landfill, and Calsol Inc. These three sites are described below using the resources available on GeoTracker and EnviroStor for these sites.[11,12,13]

Teledyne Cast Parts

The Teledyne Cast Parts site (GeoTracker Case ID: SL0603791177), located at 4200 West Valley Boulevard in Pomona, is an approximately 12-acre facility operated by Consolidated Foundries Incorporated (CFI) for the manufacturing of aluminum and magnesium casting parts for the commercial and military aircraft industries. In 2000, CFI acquired the site from Teledyne Cast Parts who operated the facility since 1971. Teledyne Cast Parts documented the stockpiling of casting sands generated during casting processes. At the request of the LA Regional Board, the stockpiles were removed between 1994 and 1997 and initial site investigations began in 1990 with soil sampling. PCE and TCE were detected in soil samples at concentrations up to 630 to 11,000 micrograms per kilogram (µg/kg). In 1992, groundwater sampling was required in the investigation, including the installation of four on-site monitoring wells. Groundwater quality monitoring was conducted from 1994 to 2013. PCE and TCE were the primary volatile organic compound (VOC) contaminants detected in one of the four monitoring wells at concentrations up to 64.2 and 28.6 µgl, respectively. Additionally, cis-1,2 dichloroethene (cis-1,2 DCE) and vinyl chloride were detected in one of the four monitoring wells at concentrations up to 12 µgl and 6.4 µgl, respectively. A soil vapor extraction (SVE) system pilot study was conducted by PES

[9] https://geotracker.waterboards.ca.gov/

[10] https://www.envirostor.dtsc.ca.gov/public/

[11] https://geotracker.waterboards.ca.gov/profile_report.asp?global_id=SL0603791177

[12] https://geotracker.waterboards.ca.gov/profile_report.asp?global_id=L10001382782

[13] https://www.envirostor.dtsc.ca.gov/public/profile_report.asp?global_id=60000137

Environmental in 2000 and by Environ in 2012. A full-scale SVE system was operated from December 2012 through September 2013.

In August 2014, CFI requested closure of the site by the LA Regional Board, and in 2017 submitted additional monitoring documentation as requested by the LA Regional Board to prepare for closure. According to the 2017 report, TCE and cis-1,2 DCE were detected at one of the four monitoring wells at concentrations of 3.8 and 3.5 µgl, respectively, both of which are below their respective MCLs. There have been no updates from the LA Regional Board or CFI regarding the potential site closure since 2017.

Spadra Landfill

The Spadra Landfill (GeoTracker Case ID: L10001382782) is about 300 acres in size and is located at 4125 West Valley Boulevard in Pomona adjacent to the Spadra Basin. The site is owned by CPP and operated by the LA Sanitation Districts. The landfill opened as a Class II municipal solid waste disposal facility in 1957 and was certified as closed in 2002. Post-closure monitoring includes collecting groundwater-quality samples from 17 monitoring wells constructed adjacent to and within the Spadra Basin.

Groundwater monitoring began in 1994. VOCs were detected at three of the monitoring wells, and in 2000 it was concluded that the VOCs entered the groundwater due to contact with gas from the landfill, and that groundwater outside of the landfill had not been impacted. VOCs detected included: benzene, chlorobenzene, chloroform, o-dichlorobenzene, p-dichlorobenzene, 1,1-dichloroethane (DCA), 1,2-dichloroethane, 1,1-dichloroethylene, cis-1,2-dichloroethylene, trans-1,2-dichloroethylene, 1,2-dichloropropane, ethylbenzene, Freon-11, methylene chloride, PCE, TCE, toluene, and vinyl chloride. To address these detections, in 2001 the LA Sanitation Districts began operating groundwater extraction wells to capture contaminated groundwater from beneath the site. Pumped groundwater is treated at a air-stripper treatment facility onsite and discharged to the sewer system under an industrial wastewater discharge permit.

Post-closure monitoring includes collecting groundwater-quality samples from 17 monitoring wells constructed adjacent to and within the Spadra Basin. During the May 2019 sampling event, the following VOCs were detected in monitoring wells: cis-1,2-dichloroethene, 1,4-dioxane, DCA, PCE, TCE, chloroform, and vinyl chloride.

In May 2019, the LA Sanitation Districts submitted a work plan for assessing per- and polyfluoroalkyl substances (PFAS) at the landfill. This sampling is planned to occur concurrently with the existing semi-annual sampling (May and November of each year).

Calsol Inc.

The former Calsol facility (Envirostor Site Code: 60000137) is a 1.2-acre lot located at the southwest corner of the intersection of Hamilton Boulevard and Commercial Street in Pomona. Calsol Inc. was a solvent distributor and hazardous waste generator of waste oil, mixed oil, and liquids with halogenated VOCs. In 1997, initial investigations identified that soil, soil vapor, and groundwater were impacted with VOCs, specifically PCE and TCE. This was attributed to an accident that occurred in 1976 between a city refuse truck and a train, that resulted in damage to an above-ground storage tank and subsequent release of up to 5,300 gallons of PCE. Secondary sources have also been identified on the site as a result of site operations, which included 23 fuel and solvent storage tanks (above- and below-ground).

A removal action workplan was submitted to and approved by the California Department of Toxic Substances (DTSC) in 2016. The workplan recommended the operation of an SVE system after the successful implementation of two SVE pilots from 2015-2016. At the time the workplan was submitted, groundwater sampling had been minimal and the workplan required quarterly monitoring for a year to better understand the impacts of VOCs in groundwater and the connection between a perched aquifer and a "basal" aquifer. The quarterly groundwater monitoring conducted from 2016-2017, and subsequent semi-annual sampling show elevated concentrations of PCE, TCE, and 1,1-DCE at onsite and offsite monitoring wells. During the latest sampling event in March 2019, the following constituents were detected (maximum concentration detected): PCE (1,400 µgl), TCE (1,900 µgl), 1,1-DCE (51 µgl), and methyl tert-butyl ether (MTBE) (21 µgl).

As of March 2019, the SVE system is still in operation and quarterly groundwater sampling continues. To date, an estimated total of 6,800 pounds of VOCs have been removed by the SVE system.

2.2.4 Ground Levels

Vertical ground motion, in the form of subsidence and rebound of the land surface, occurs in all groundwater basins as groundwater levels change within the underlying aquifer system. This process has occurred in the Spadra Basin, as well as in the adjacent groundwater basins, such as well-documented occurrences in the Chino Basin (CBWM, 2019). It is important to understand and monitor vertical ground motion because land subsidence can cause damage to vulnerable infrastructure at the surface.

Although drawdown of groundwater levels is the driving force that causes land subsidence due to groundwater pumping, the geology of a groundwater basin also plays an important role in this process. Clay layers within the aquifer-system are relatively compressible materials. Therefore, aquifer-systems that contain thick and/or numerous clay layers are most susceptible to land subsidence or rebound when groundwater is extracted or recharged.

The process that describes pumping-induced land subsidence is termed the "aquitard-drainage model." Simply stated, an aquifer system consists of permeable sand and gravel layers interbedded with less-permeable silt and clay layers. The sand and gravel layers are the "aquifers" and groundwater flows through the aquifers toward pumping wells. The silt and clay layers are the "aquitards." Pumping wells cause groundwater-level drawdown in the aquifers which, in turn, cause the aquitards to slowly drain into the aquifers. The draining allows aquitard pore pressures to decay toward equilibrium with the reduced pore pressures in the adjacent aquifers. Since the pressure of the pore water provides some internal support for the sedimentary structure of the aquitards, this loss of internal support causes the aquitards to compress, resulting in subsidence at the land surface. When the pumping wells turn off, and groundwater levels recover in the aquifers, groundwater migrates back into the aquitards and they expand, resulting in rebound at the land surface. Over a limited range of seasonal groundwater-level fluctuations, this process can occur in a purely elastic fashion. That is, a recovery of groundwater levels to their original values causes the land surface to rebound to its original elevation. However, when drawdown falls below a certain "threshold" level, elastic compression transitions to a non-recoverable inelastic compaction of the aquitards, resulting in permanent land subsidence. The "threshold" level, referred to as the "preconsolidation stress," is taken to be the maximum past stress to which the sedimentary structure had previously equilibrated under the gradually increasing load of accumulating sediments.

The hydrogeologic cross-sections in Figures 2-15a-d show that the aquifer system in Spadra Basin contains numerous aquitard lenses of varying thickness that could be susceptible to compaction via the aquitard-drainage model. However, the Spadra Basin is a relatively thin aquifer system which limits the potential magnitude of aquitard compaction and land subsidence that could occur.

Aquitard drainage, and the resultant deformation of the ground surface, has been well documented in the Chino Basin where ground fissures damaged overlying infrastructure in the City of Chino in the early 1990s (WEI, 2006). The Chino Basin Watermaster has conducted extensive studies of the process, and based on those studies, developed a subsidence management plan to minimize or abate the occurrence of subsidence and ground fissuring in the Chino Basin (CBWM, 2015). Currently, the Watermaster's efforts are focused on developing a specific subsidence management plan for "Northwest MZ-1 Area", which is the area of the Chino Basin directly adjacent to the Spadra Basin.

Part of the Chino Basin Watermaster's subsidence management plan is to conduct ongoing monitoring of ground motion by Synthetic Aperture Radar Interferometry (InSAR), which is a method that utilizes radar imagery from an Earth-orbiting satellite to map ground motion over time. The Watermaster determines the scope of its monitoring efforts annually. The InSAR data collected and utilized in the subsidence studies in Chino Basin cover portions of the Spadra Basin as well. These InSAR estimates are the most complete and accurate record of vertical ground motion available for the Spadra Basin.

Figure 2-28 includes a series of maps that display the InSAR estimates of vertical ground motion across the Spadra Basin for the periods 1992-1995, 1996-1999, 2005-2010, and 2011-2018. The maps indicate that downward ground motion has occurred across the Spadra Basin over the period of record, even though groundwater levels have remained relatively stable over the same period (see Figure 2-19).

Figure 2-28 shows that the same gradual and persistent downward ground motion has occurred in the adjacent areas of the Chino Basin, although the magnitude of downward ground motion has been comparatively much less in the Spadra Basin. As in the Spadra Basin, groundwater levels in this part of the Chino Basin have been relatively stable or increasing during the 1992-2018 period. The Chino Basin Watermaster (2019) states that a plausible explanation for the gradual and persistent downward ground motion is that thick, slow-draining aquitards are permanently compacting in response to the historical declines in groundwater levels that occurred between 1930 and 1978. This same process could explain the downward ground motion observed in the Spadra Basin from 1992 to 2018, but not enough data and information are available to confirm.

The aquifer systems of the Chino Basin and Spadra Basin are connected across their common boundary. Changes in groundwater levels within one basin could cause changes in groundwater levels in the other, which could lead to aquitard drainage and associated land subsidence. Therefore, land subsidence is a potential undesirable result of groundwater management practices in both basins and should be a factor of consideration in the development and implementation of groundwater management plans in both basins.

2.2.5 Surface Water and Groundwater Dependent Ecosystems

Figure 2-29 is a map of depth-to-groundwater in the Spadra Basin in 2008, a period of highest recorded groundwater levels. Depth-to-groundwater in 2008 ranged from a maximum of about 220 ft-bgs in the eastern portion of the Spadra Basin to a minimum of about 40 ft-bgs at the western margin of the basin. Because depth-to-groundwater is greater than 40 ft-bgs, and because all stream channels in Spadra Basin are concrete-lined, there are no areas of interconnected groundwater and surface-water in the Spadra Basin. Furthermore, there are no groundwater-dependent ecosystems (GDEs) in the Spadra Basin.[14] The closest GDE is located about 15 miles downstream of the Spadra Basin at the confluence of San Jose Creek and the San Gabriel River in the Main San Gabriel Basin.

2.2.6 Data Gaps

Section § 354.12 of the GSP Regulations requires the identification of "data gaps" and levels of uncertainty in the description of the Basin Setting. A "data gap" refers to a lack of information that significantly affects the understanding of the basin setting or the future evaluation of the efficacy of GSP implementation to sustainably manage the basin.

The Basin Setting description above has revealed potential data gaps that may need to be filled as part of GSP implementation to improve the monitoring network. A preliminary list and description of the data gaps is listed below. The subsequent development and calibration of the numerical groundwater-flow model may also indicate areas of uncertainty in the model calibration and, hence, additional data gaps.

- There is a lack of hydrogeologic data and information to describe the groundwater interactions between the Spadra Basin, Six Basins, and Chino Basin. The Basin Setting describes: (i) the important role of the Six Basins as a source of recharge to the Spadra Basin just south of the eastern tip of the San Jose Hills and (ii) the transient groundwater divide that separates the Spadra Basin from the Chino Basin from the San Jose Hills to the

[14] Verified using the Natural Communities Commonly Associated with Groundwater dataset map viewer of GDEs https://gis.water.ca.gov/app/NCDatasetViewer/

Puente Hills. Understanding the geologic and current/future groundwater conditions in this area will likely be critical to assessing the long-term sustainable management of the Spadra Basin and the potential impacts of Spadra Basin management on the adjacent groundwater basins, and vice versa. There are very few deep boreholes/wells located in this area to characterize the geologic and current/future groundwater conditions, which represents a gap in the monitoring network. A new monitoring well(s) in this area may be needed to fill the data gap.

- Historically, groundwater-pumping and groundwater-level data been collected by well owners in the Spadra Basin in an uncoordinated fashion and at a maximum frequency of once per month. Improved methods to measure and record these data at higher frequency and accuracy will: improve the hydrogeologic conceptual understanding of the aquifer system and the fault barriers, which can be used to improve the GSA's groundwater model; provide groundwater-pumping and groundwater-level data of high accuracy and resolution which can be used to improve the GSA's groundwater model; support the design of capital facilities associated with GSP implementation, such as new wells and treatment facilities; and support any required monitoring and mitigation requirements associated with GSP projects. These data can be acquired by implementing a coordinated monitoring program that includes the installation of transducers in wells that measure and record high-frequency water-level data and utilizes the SCADA systems of the well owners.
- Historically, groundwater-quality monitoring in the Spadra Basin has been infrequent and limited in scope. The groundwater-quality analysis in Section 2.2.3 was not based on a robust data set regarding the number of monitoring locations, the frequency of sample collection, the constituents analyzed, and the laboratory detection limits used. Hence, there is a limited understanding of groundwater-quality conditions and their potential impact on the beneficial uses of the groundwater. For example, perchlorate and 1,2,3-TCP are groundwater contaminants that could have originated from various overlying agricultural and/or industrial land uses. However, both constituents have not been commonly analyzed for using laboratory detection limits equivalent to the regulatory standards. A more robust groundwater-quality monitoring program is necessary to characterize TDS, nitrate, regulated contaminants, and emerging contaminants in the Spadra Basin; assist in the identification of the sources of the contaminants; and assist in the development and evaluation of future treatment and cleanup projects.
- Currently, there is little information on the location and status of private wells in the Spadra Basin, and there is no coordinated monitoring of pumping, groundwater quality, and groundwater levels at the private wells. These data are fundamental to the development and implementation of sustainable groundwater management practices in

the Spadra Basin. A private well canvass should be performed, and based on the results of the canvass, a program to collect and compile groundwater data from the private wells may be recommended as part of the GSP monitoring program.

- Currently, there is no coordinated monitoring program of surface-water discharge from storm or dry-weather runoff. These discharges represent a potential source of artificial recharge to the Spadra Basin. A surface-water monitoring program is needed to better characterize the availability and magnitude of these potential sources of recharge.
- Land subsidence has occurred in the Spadra Basin, as well as in the adjacent groundwater basins, particularly the northwestern portion of the Chino Basin. It is important to understand and monitor land subsidence and its causes because it can cause damage to vulnerable infrastructure at the land surface. Currently, the only subsidence monitoring that is ongoing is the Chino Basin Watermaster's monitoring of ground motion by InSAR, which is a method that utilizes radar imagery from an Earth-orbiting satellite to map ground motion over time. However, the Watermaster's data sets cover only the eastern portion of the Spadra Basin. The Watermaster determines the scope of its monitoring efforts annually. The Spadra Basin GSA should consider future subsidence monitoring via InSAR that includes the entire basin. Collaboration with the Chino Basin Watermaster's subsidence monitoring program may be the most efficient method to conduct this monitoring effort.

Table 2-1
Groundwater Pumping in the Spadra Basin 1977-2018 (afy)

Year	City of Pomona				Walnut Valley Water District			California State Polytechnic University of Pomona					Other	Total
	P-19	P-28	P-31	Total	Industry	Valley	Total	CPP-1	CPP-2	CPP-3	CPP-4	Total	Walnut Hills	
1977	370	235	1	605	0	0	0	201	430	*35*	52	718		1,323
1978	380	304	0	684	0	0	0	149	67	*35*	140	391		1,075
1979	312	168	0	480	0	0	0	273	190	*35*	140	638		1,119
1980	473	339	0	811	0	0	0	176	150	*35*	43	403		1,214
1981	498	267	0	764	0	0	0	231	166	*35*	210	642		1,407
1982	677	413	59	1,149	0	0	0	178	107	*35*	86	406		1,555
1983	506	460	123	1,089	0	0	0	300	151	*35*	83	569		1,658
1984	479	413	0	891	0	0	0	165	20	*35*	253	473		1,364
1985	820	480	0	1,300	0	0	0	231	86	*35*	312	664		1,964
1986	854	568	83	1,505	0	0	0	302	113	*35*	240	690		2,195
1987	737	562	269	1,568	0	0	0	193	155	*35*	71	455		2,023
1988	563	501	235	1,299	0	0	0	105	60	*35*	319	520		1,820
1989	629	533	188	1,349	0	0	0	114	56	*35*	6	211		1,560
1990	394	476	32	902	0	0	0	165	47	*35*	130	377		1,279
1991	4	343	2	348	0	0	0	177	85	*35*	6	303		651
1992	103	507	0	611	0	0	0	160	90	*35*	261	546		1,157
1993	56	251	0	307	0	0	0	132	99	*35*	346	611		919
1994	259	329	0	588	0	0	0	180	90	*35*	260	565		1,153
1995	70	383	57	511	0	0	0	*231*	*166*	*35*	*210*	642		1,153
1996	201	387	112	701	0	0	0	*231*	*166*	*35*	*210*	642		1,343
1997	171	316	70	557	0	0	0	*231*	*166*	*35*	*210*	642		1,199
1998	20	376	37	434	0	0	0	*231*	*166*	*35*	*210*	642		1,076
1999	0	347	0	347	0	0	0	*231*	*166*	*35*	*210*	642		989
2000	0	529	98	628	0	0	0	*231*	*166*	*35*	*210*	642	no data	1,270
2001	570	514	334	1,418	0	0	0	*231*	*166*	*35*	*210*	642		2,060
2002	225	519	129	873	0	0	0	0	182	*35*	396	614		1,487
2003	120	499	199	818	30	0	30	0	183	*35*	396	614		1,463
2004	414	476	148	1,038	156	0	156	165	137	*35*	250	587		1,781
2005	149	489	74	711	154	0	154	252	18	72	200	542		1,407
2006	76	422	35	533	115	0	115	274	2	75	171	521		1,169
2007	65	460	29	554	84	0	84	240	5	74	276	595		1,234
2008	5	286	2	293	114	0	114	225	5	69	195	494		900
2009	18	534	3	555	115	0	115	201	0	104	209	515		1,184
2010	0	155	0	155	85	0	85	203	149	29	88	468		708
2011	0	278	0	278	70	0	70	167	269	52	132	620		968
2012	0	178	0	178	90	0	90	204	308	30	143	685		953
2013	4	162	0	166	121	0	121	270	422	14	283	990		1,276
2014	0	134	0	134	53	0	53	137	366	0	323	826		1,013
2015	0	123	0	123	63	0	63	159	204	15	226	604		790
2016	0	108	0	108	35	0	35	207	74	2	314	598		741
2017	0	158	0	158	68	0	68	293	253	0	256	803		1,028
2018	0	78	0	78	67	0	67	339	280	0	256	875		1,021
Minimum	0	78	0	78	0	0	0	0	0	0	6	211		289
Average	243	359	55	657	34	0	34	200	147	36	203	586		1,277
Maximum	854	568	334	1568	156	0	156	339	430	104	396	990		2,713
Total	10,222	15,061	2,320	27,603	1,419	0	1,419	8,384	6,182	1,518	8,543	24,627		**53,649**
Percent of Total				**51%**			**3%**					**46%**		**100%**

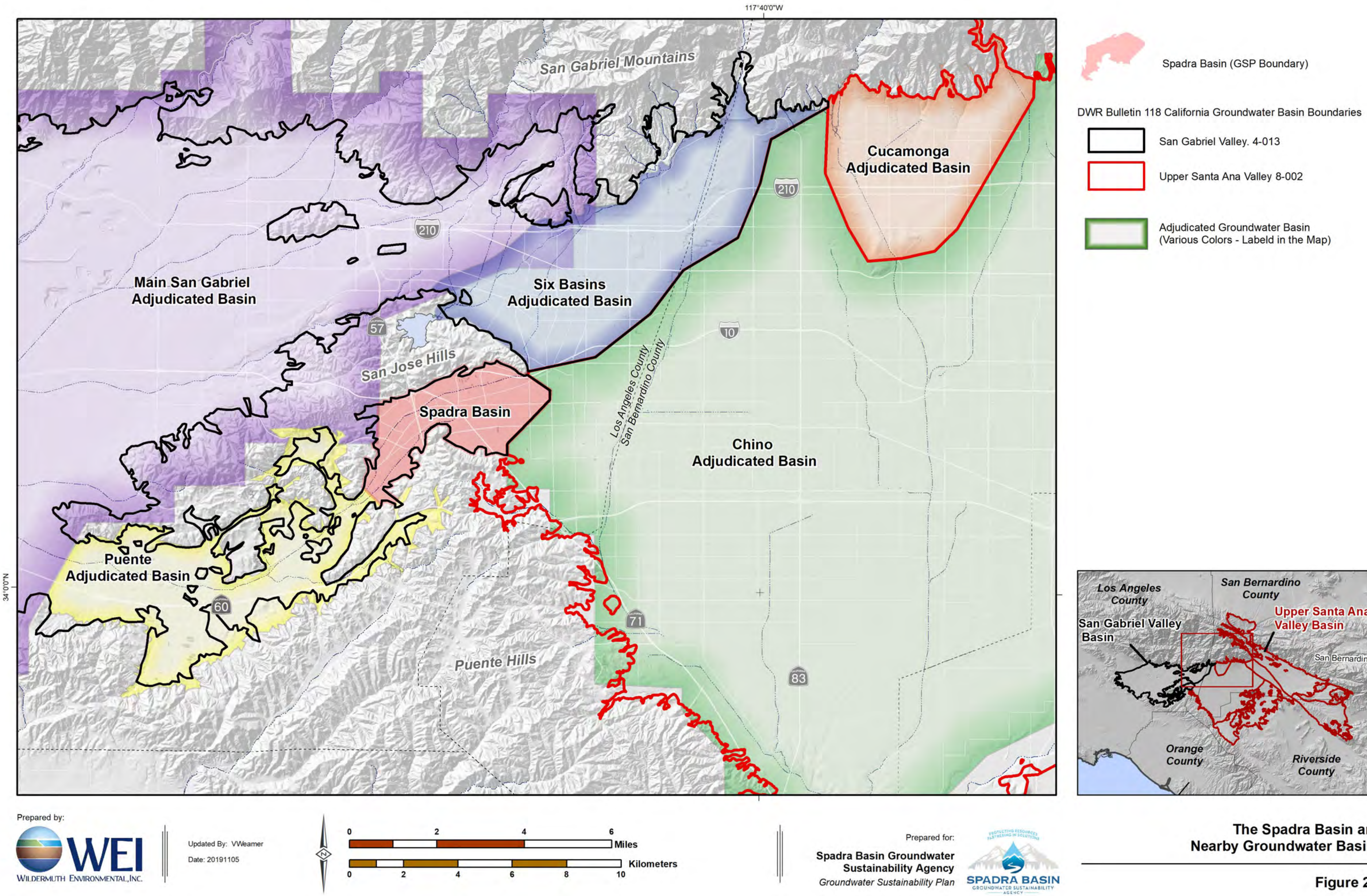
* Numbers in *italics* are estimated volumes of pumping. These estimates were prepared based on confirmation that the well was active and were determined using the average of the measured and recorded annual pumping volumes.

Table 2-2
Exceedances of Groundwater Quality Standards in the Spadra Basin 2000-2019

Analyte	Standard[1]	Number of Wells Sampled	Number of Wells with Exceedances	Percent of wells with Exceedance
Contaminant with Primary MCL				
1,1-Dichloroethene (1,1-DCE)	6 µgl	39	14	36%
1,2-Dibromo-3-chloropropane	0.2	27	1	4%
1,2-Dichloroethane	0.5 µgl	39	8	21%
Arsenic	0.01 µgl	17	4	24%
Benzene	1 µgl	36	4	11%
Cadmium	0.005 µgl	17	1	6%
Chromium	50 µgl	16	5	31%
cis-1,2-Dichloroethene (cis-1,2-DCE)	6 µgl	38	3	8%
Di(2-ethylhexyl)phthalate	4 µgl	14	1	7%
Methyl Tert-Butyl Ether (MTBE)	13 µgl	36	9	25%
Nickel	0.1 µgl	15	5	33%
Nitrate-Nitrogen	10 µgl	23	20	87%
Perchlorate	6 µgl	15	4	27%
Selenium	50 µgl	17	5	29%
Tetrachloroethene (PCE)	5 µgl	39	26	67%
Trichloroethylene (TCE)	5 µgl	39	25	64%
Vinyl Chloride	0.5 µgl	29	2	7%
Contaminant with Secondary MCL				
Chloride	500 mgl	25	1	4%
Manganese	0.05 mgl	7	1	14%
Methyl Tert-Butyl Ether (MTBE)	5 µgl	36	16	44%
Sulfate	250 mgl	25	11	44%
TDS	500 mgl	25	24	96%
Contaminant with California NL				
1,4-Dioxane	1 µgl	12	2	17%
Tert-Butyl Alcohol	120 µgl	33	1	3%
Vanadium	50 µgl	12	6	50%
Contaminant with Basin Plan Objective[2]				
TDS	550 mgl	25	24	96%
Nitrate-Nitrogen	10 mgl	23	20	87%
Sulfate	200 mgl	25	15	60%
Chloride	120 mgl	25	12	48%

1. All MCL standards used for this analysis are California Primary MCL standards; the Federal EPA MCL standards are either higher than, equivalent to, or non-existent for all the contaminants detected in Spadra Basin wells with a MCL exceedance.

2. There are no wells in the Spadra Basin that exceed the Basin Plan objective of 1 mgl for Boron.



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Updated By: VWeamer

Date: 20191105

Prepared for:

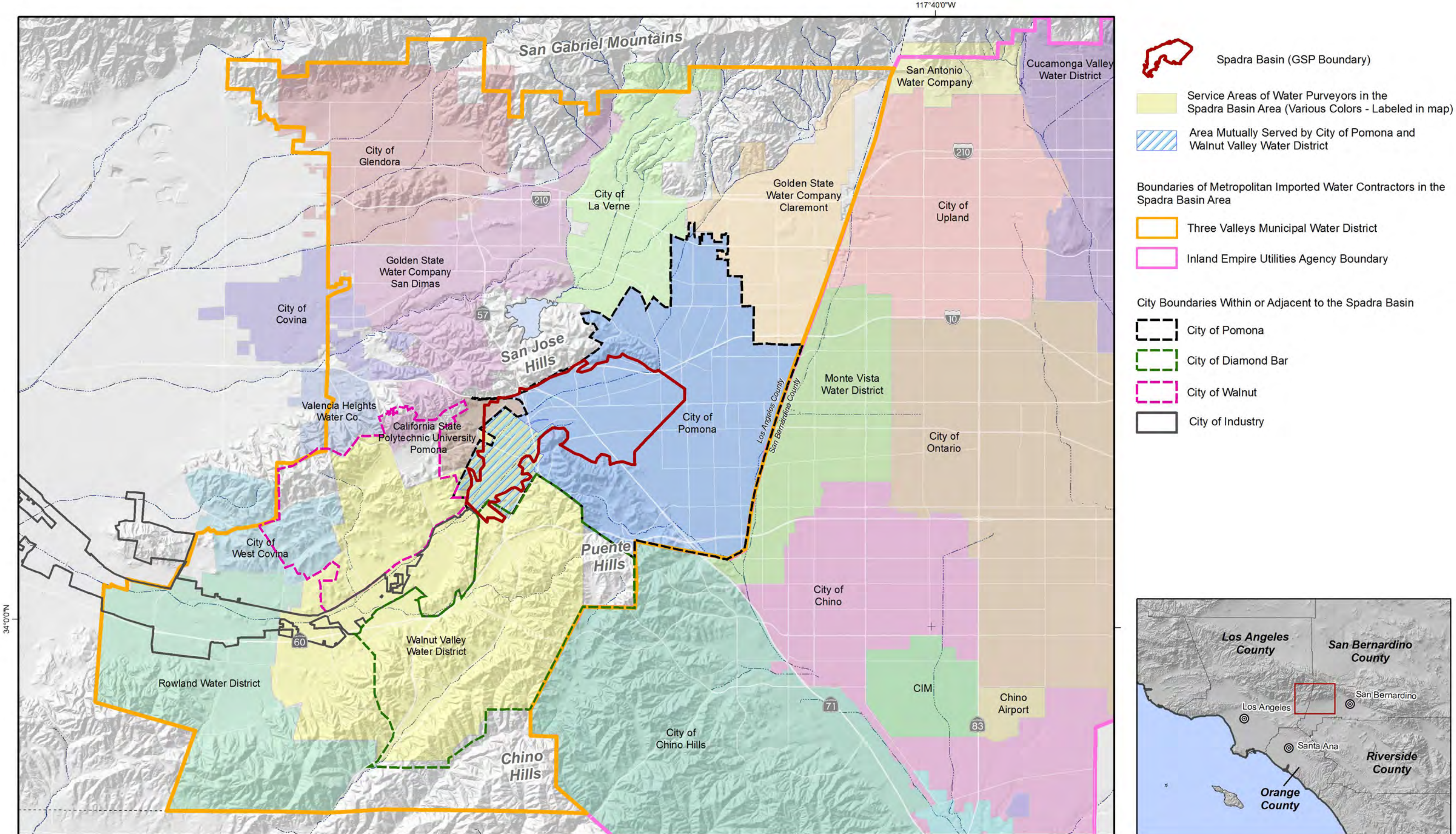
Spadra Basin Groundwater Sustainability Agency

Groundwater Sustainability Plan

SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

The Spadra Basin and Nearby Groundwater Basins

Figure 2-1



Prepared by:

WEI WILDERMUTH ENVIRONMENTAL, INC.

Updated By: aponcelet

Date: 20191105

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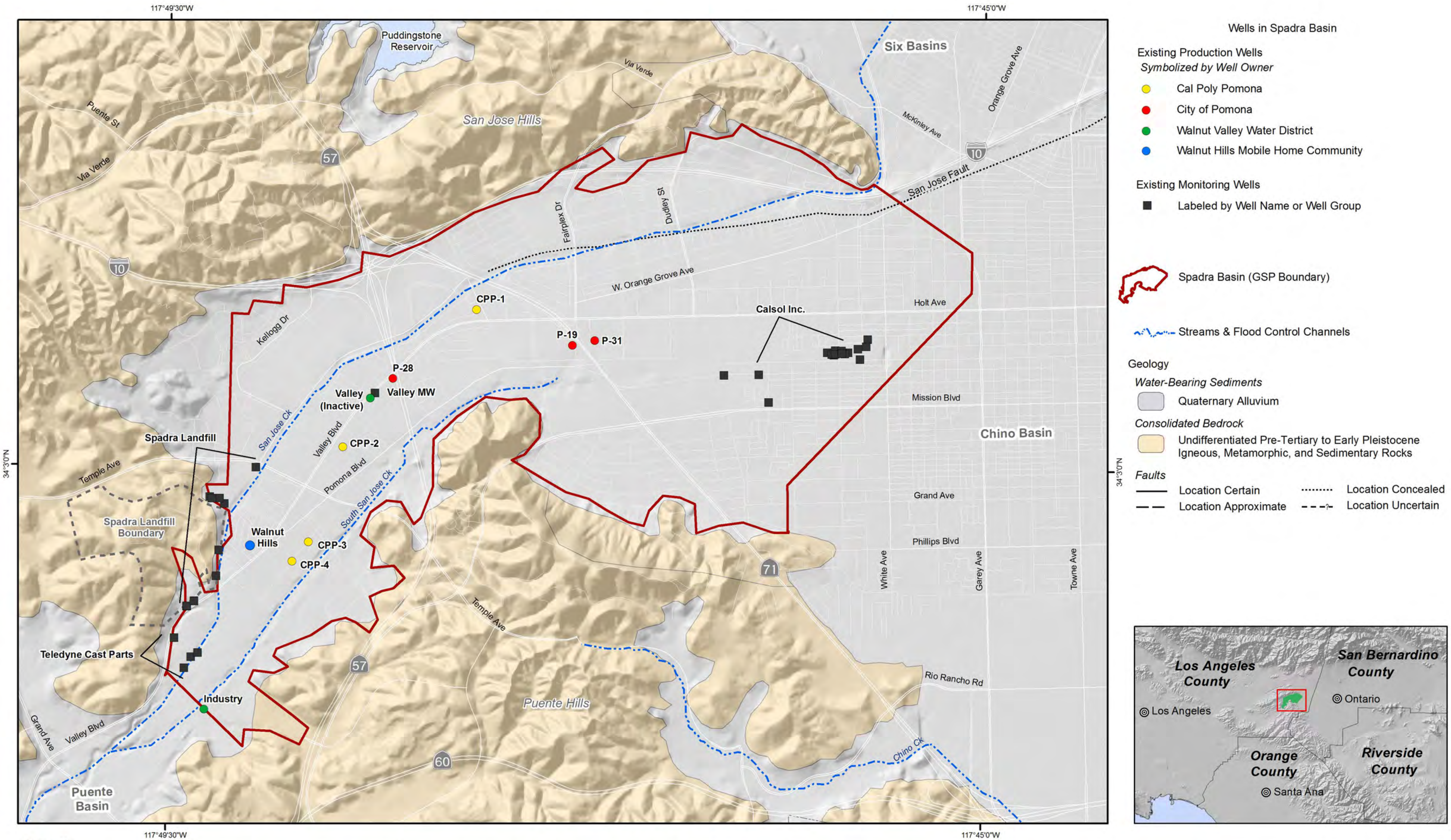
Water Purveyors and Jurisdictional Boundaries in the Spadra Basin Area

Figure 2-2



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Author: AP
Date: 11/5/2019
File: Fig2-3_Wells.mxd

0 0.5 1 1.5 Miles
0 0.5 1 1.5 2 Kilometers

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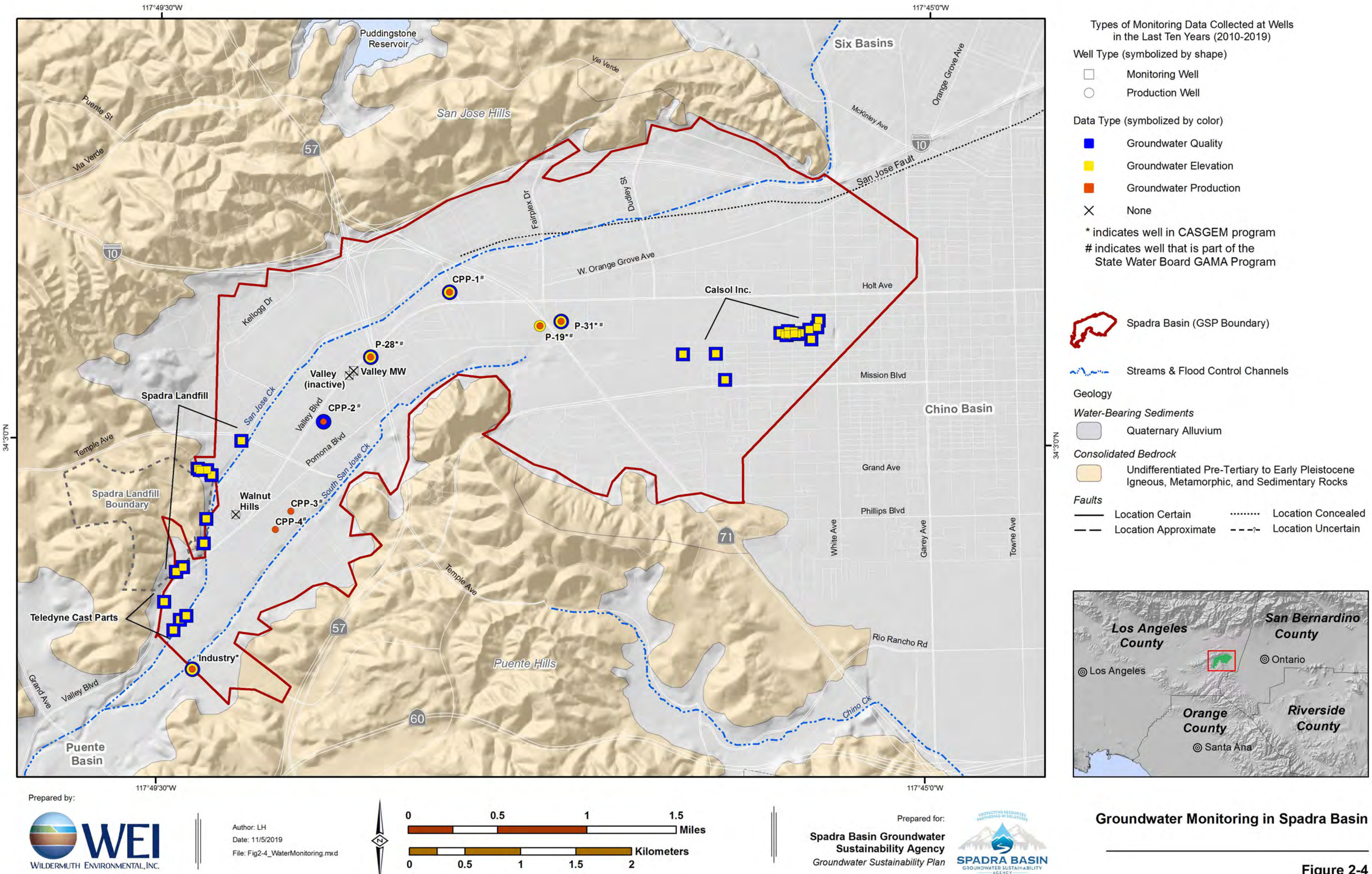
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Wells in the Spadra Basin

Figure 2-3



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Date: 11/5/2019
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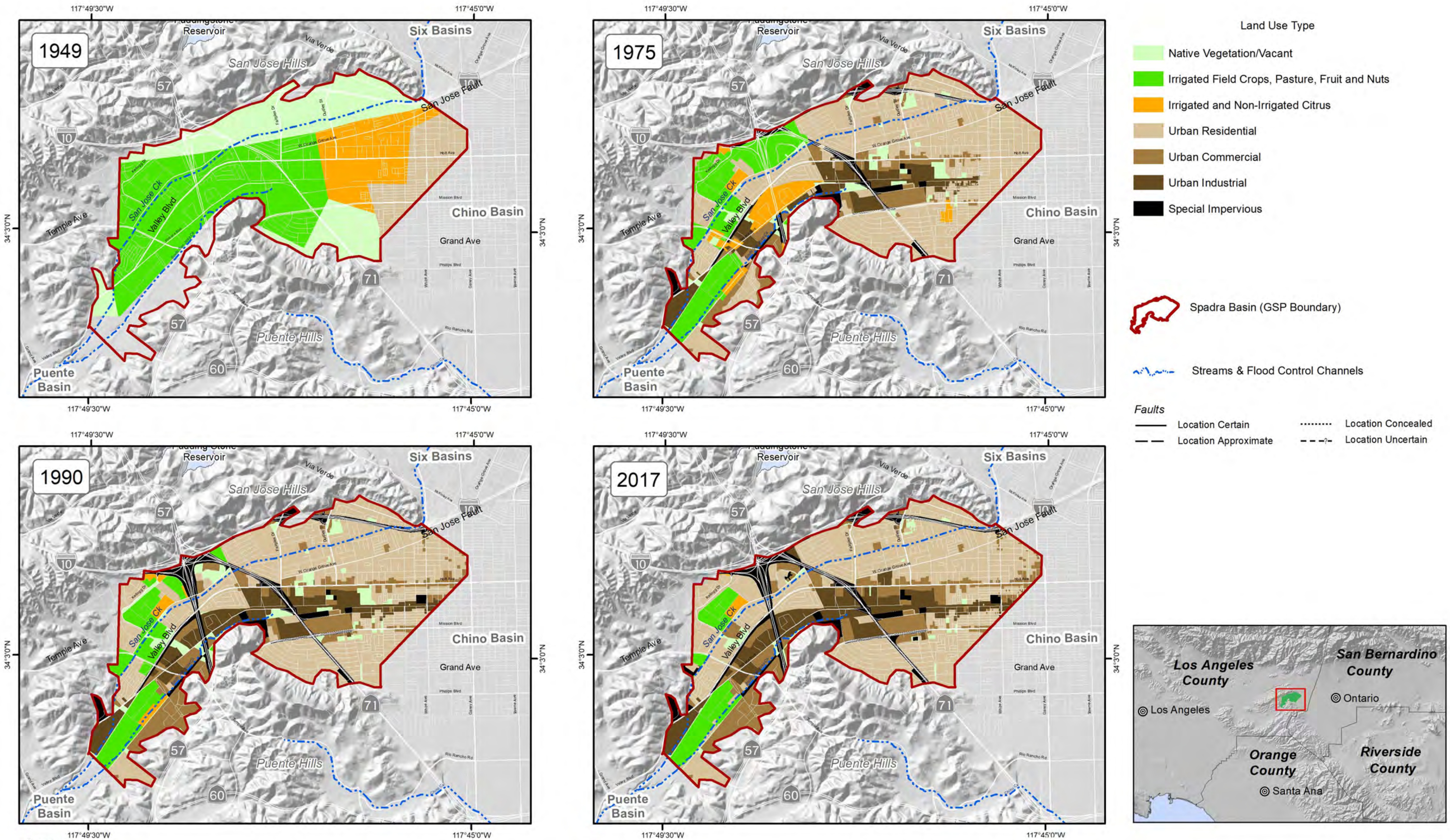
Groundwater Monitoring in Spadra Basin

Figure 2-4



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WEI
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Author: LH
Date: 11/6/2019
File: Fig2-5_LandUse.mxd

0 0.5 1 1.5 Miles

0 0.5 1 1.5 2 Kilometers

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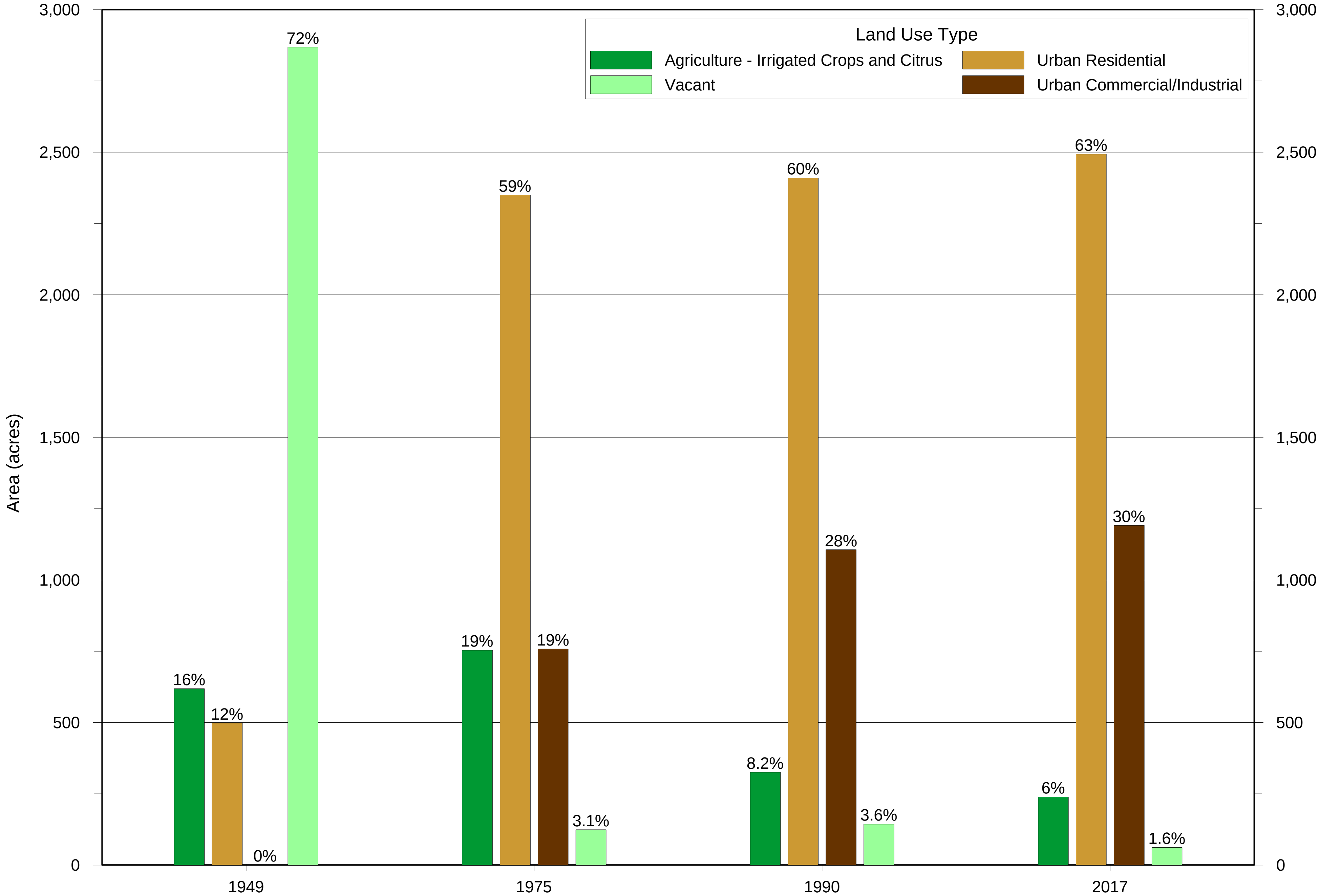
SPADRA BASIN
GROUNDWATER SUSTAINABILITY AGENCY

Land Use in the Spadra Basin
1949, 1975, 1990, and 2017

Figure 2-5



Prepared by:

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Author: CS
Date: 20191010
Filename: Fig2-5_LandUse

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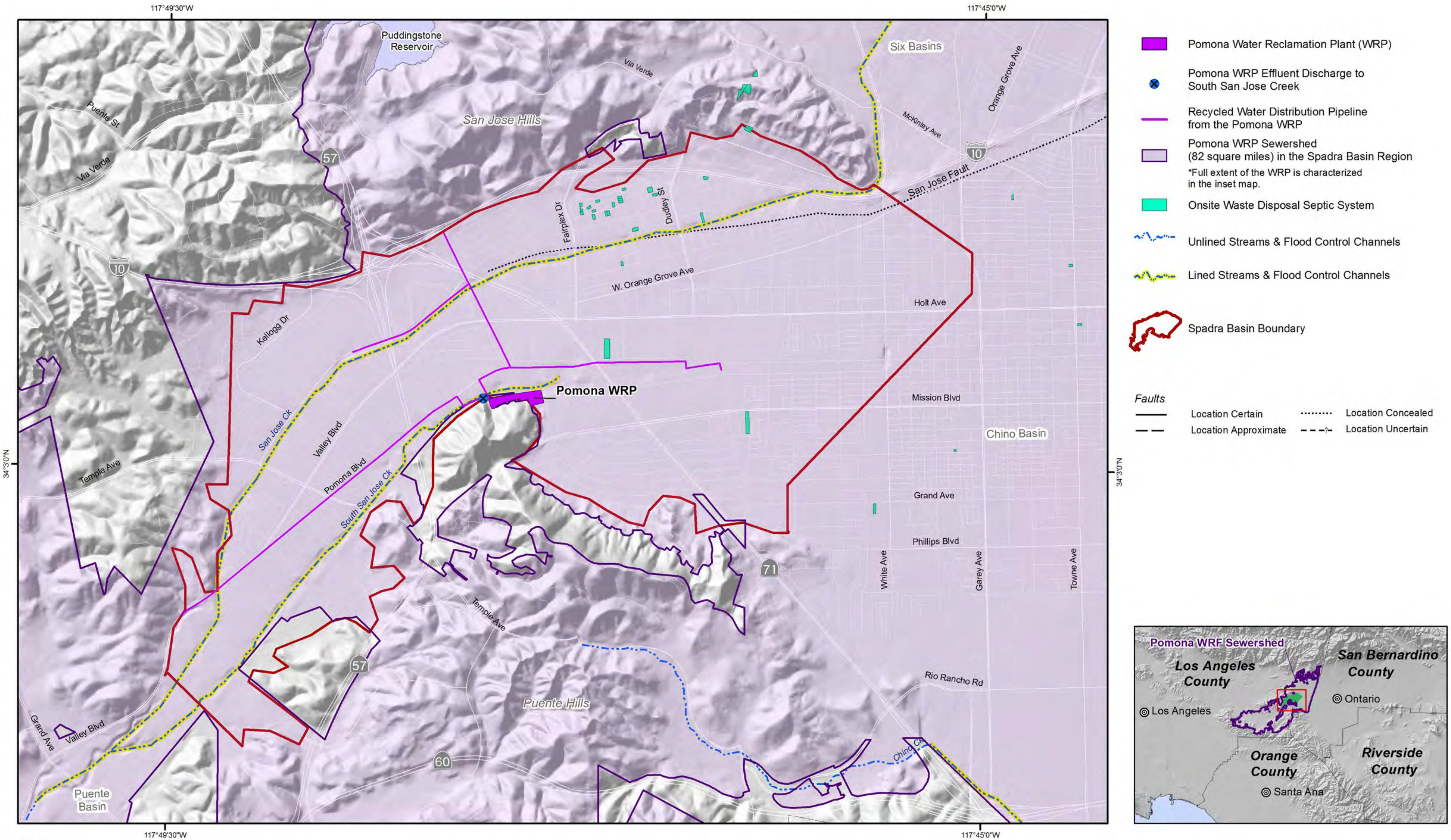
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Land Use Change by Type
Spadra Basin - 1949 to 2017

Figure 2-6



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Author: LH
Date: 11/5/2019
File: Fig2-7_Recycled-Wastewater.mxd

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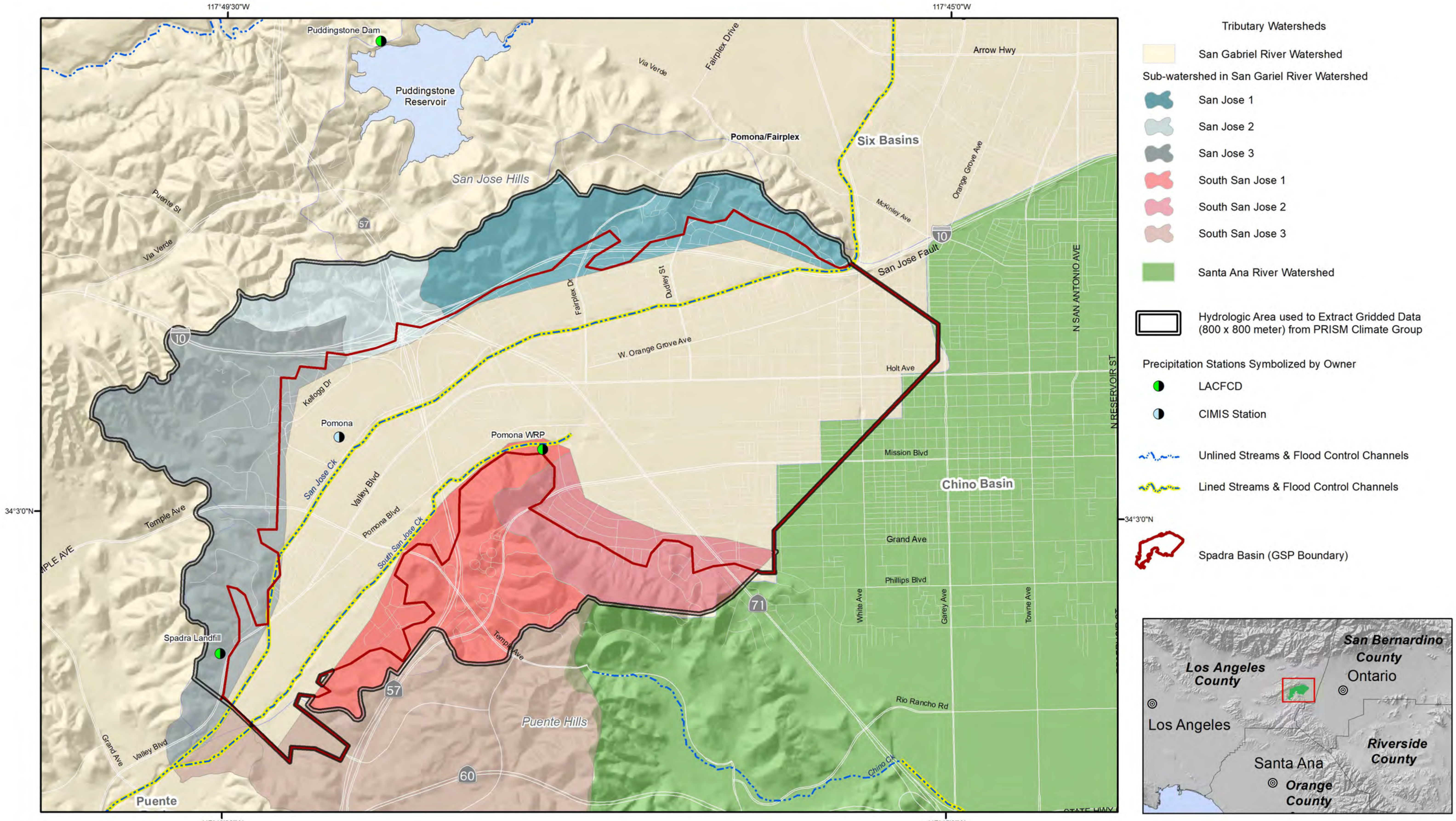
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Current Wastewater Disposal and Recycled Water Facilities

Figure 2-7



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WILDERMUTH ENVIRONMENTAL, INC.

Author: LH
Date: 11/5/2019
File: Fig2-8_Watersheds.mxd

0 0.5 1 1.5 Miles
0 0.5 1 1.5 2 Kilometers

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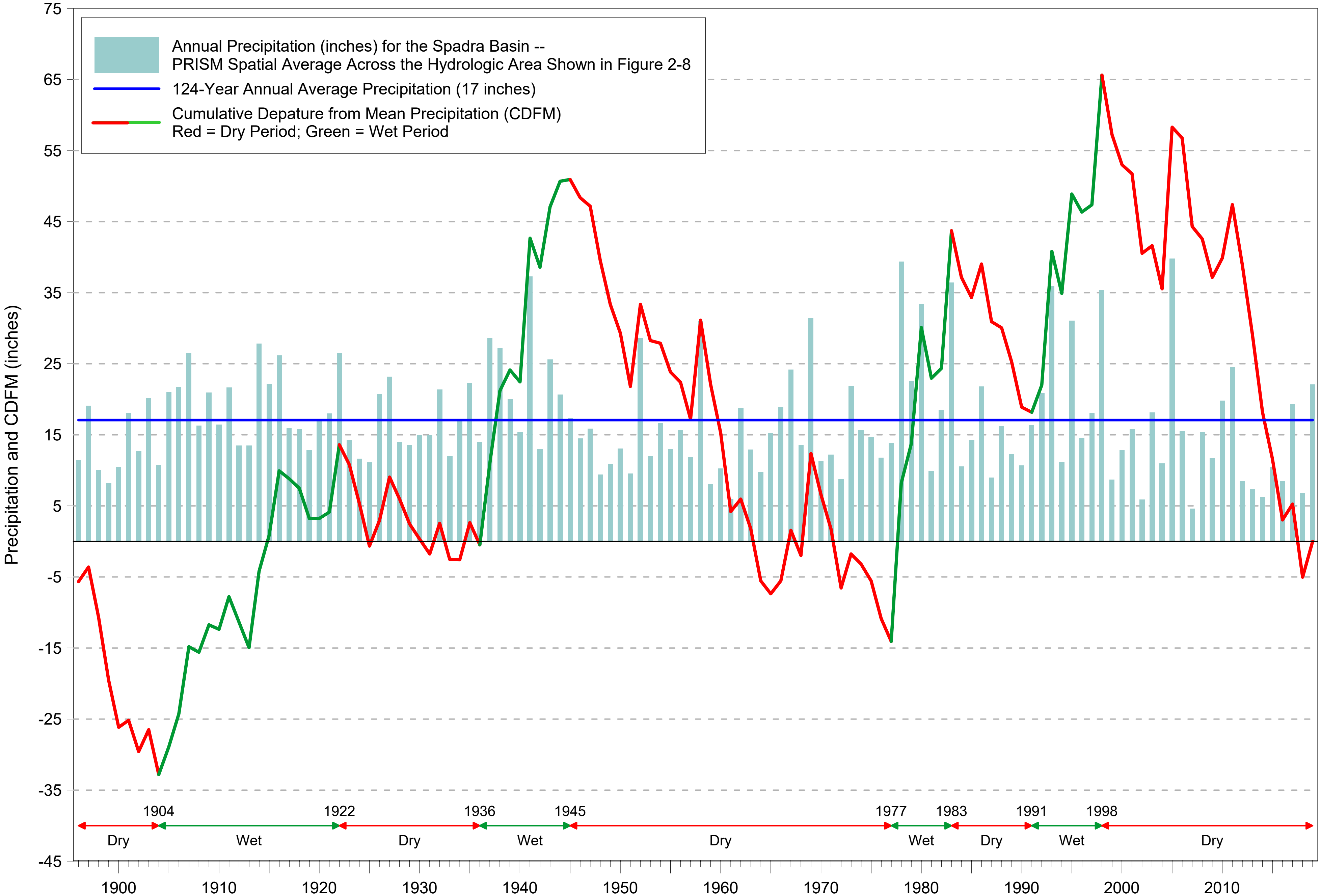
Groundwater Sustainability Plan

SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Watersheds Tributary to the Spadra Basin

Figure 2-8



Prepared by:

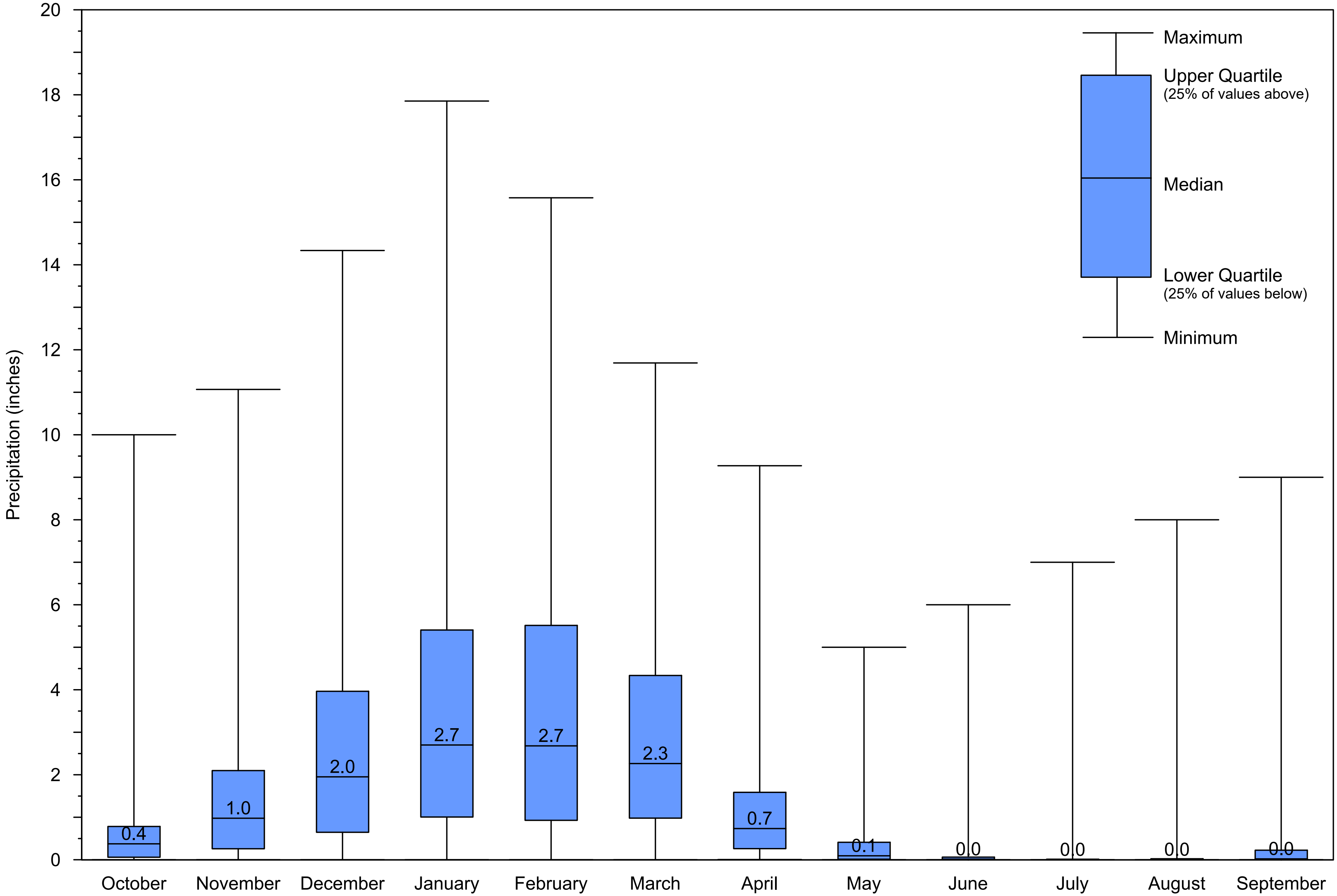
Wildermuth Environmental, Inc.

Author: SO
Date: 20191016
Filename: Figure 2-9_Precip CDFM

Spadra Basin Groundwater Sustainability Agency
Groundwater Sustainability Plan

Annual Precipitation and CDFM
Spadra Basin and Tributary Watersheds
Water Year 1896-2019

Figure 2-9



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: SO
Date: 20191016
Filename: Figure 2-10_Precip BoxWhisker

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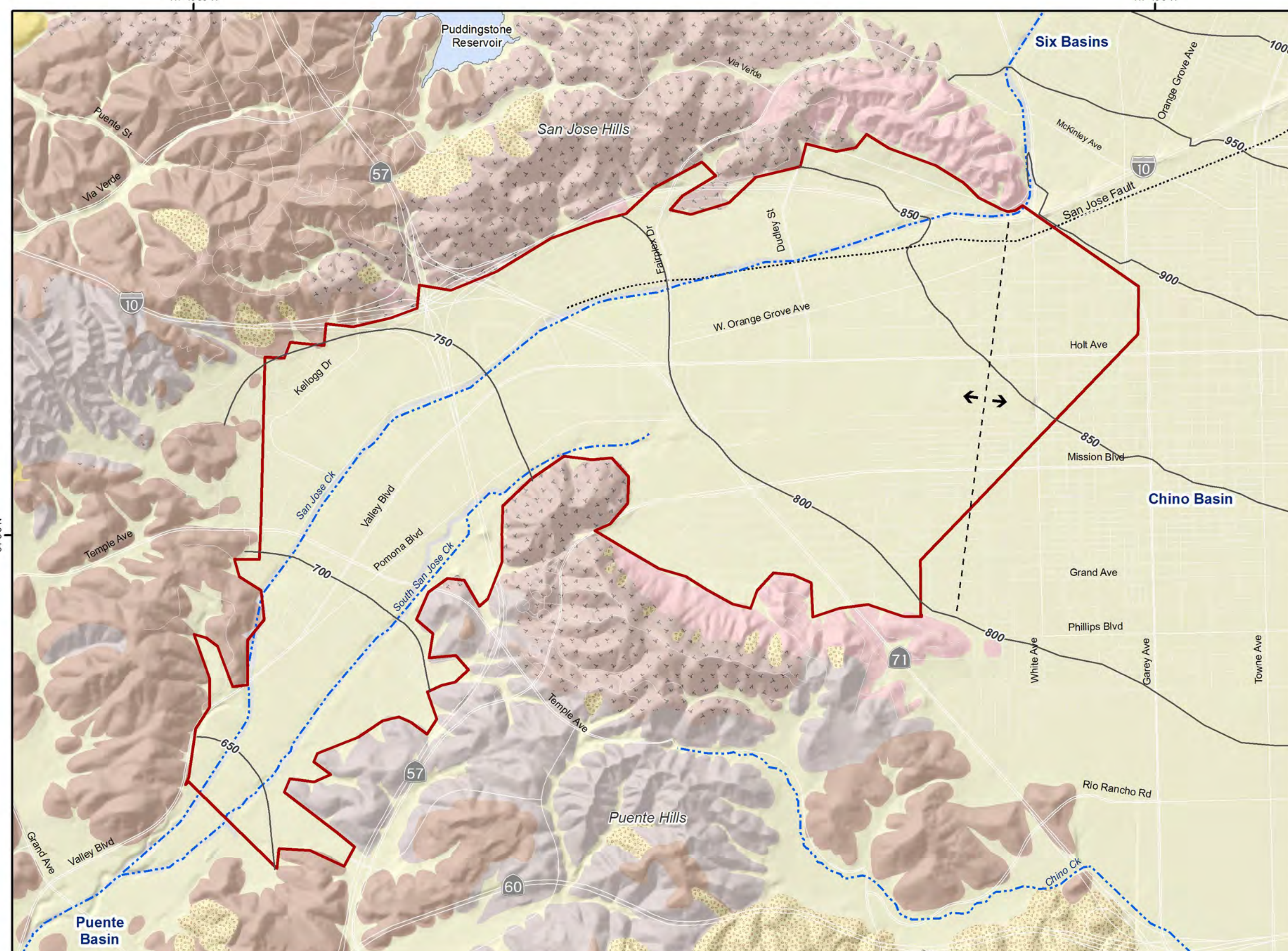
SPADRA BASIN
GROUNDWATER SUSTAINABILITY AGENCY

Box and Whisker Plot of Monthly Precipitation
Spadra Basin and Tributary Watersheds
Water Year 1896-2019

Figure 2-10



Surface Geology

Unconsolidated Sediments
(Source: CGS Special Report 217)

- Qyf — Undifferentiated Quaternary (younger) alluvial deposits
- Qoa — Undifferentiated Quaternary (older) alluvial deposits
- Qls — Landslide Deposits

Consolidated Bedrock Formations
(Source: CGS Special Report 217)

- Tss, Tsh, Tv — Puente Group: Tertiary sedimentary and volcanic rocks
- gr — Basement Complex: Cretaceous and Pre-Cretaceous igneous and metamorphic rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

—800— Topographic Elevation Contour

Groundwater Divide (approximate hydrologic boundary between Spadra Basin and Chino Basin)

Streams & Flood Control Channels

Spadra Basin (GSP Boundary)

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Wildermuth Environmental, Inc.

Author: AP
Date: 11/5/2019
File: Fig2-11_Geology.mxd

0 0.5 1 1.5 Miles

0 0.5 1 1.5 2 Kilometers

Prepared for:

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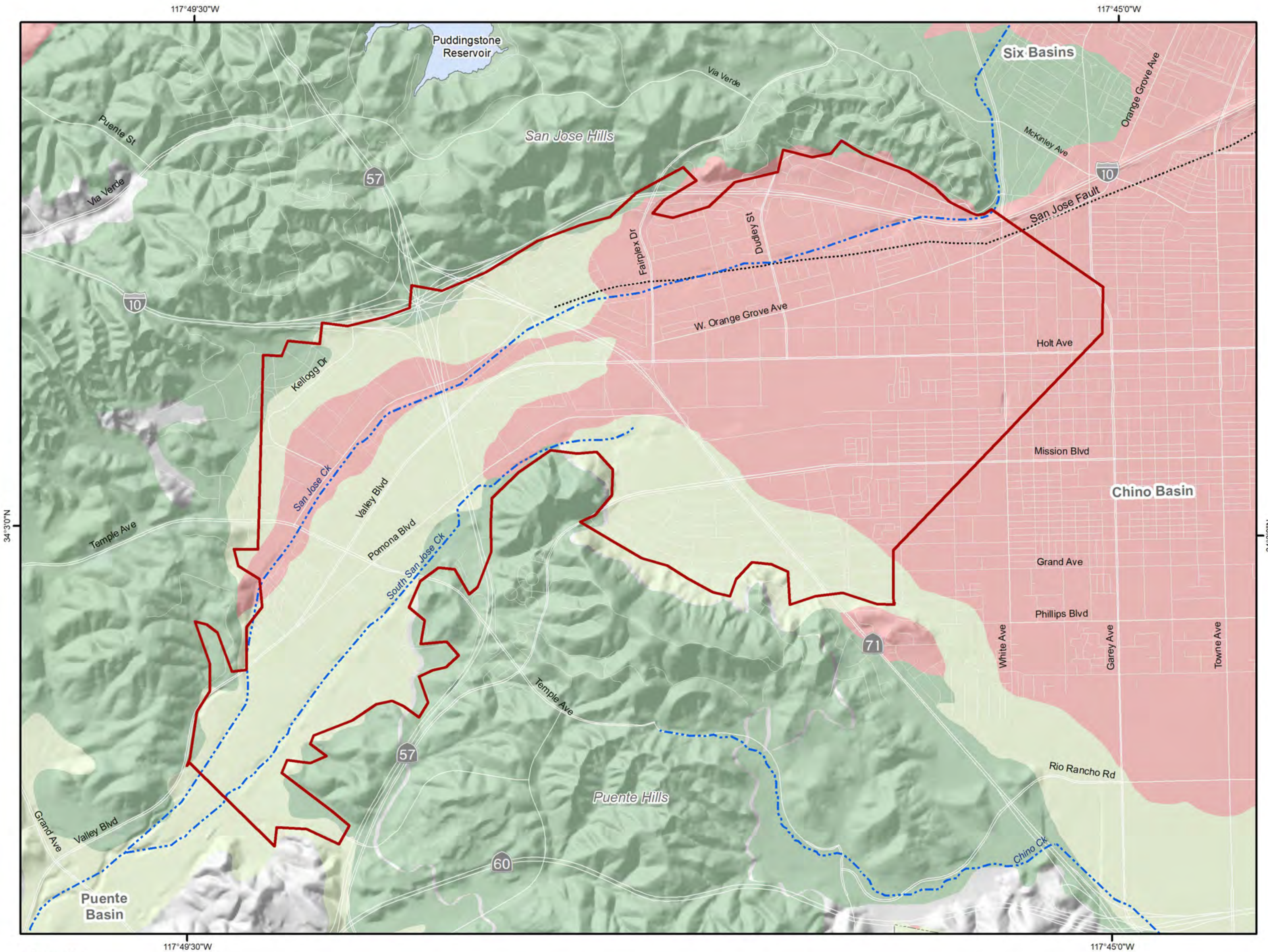
Groundwater Sustainability Plan

Geologic Map of the Spadra Basin Area

Figure 2-11



Hydrologic Soil Types

A Low runoff potential. Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

B Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

C Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D High runoff potential. Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or nearthe surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Source: Los Angeles County: United States Agriculture Dept
Soils Bureau, 1917
San Bernardino County: National Cooperative Soil Survey

Spadra Basin (GSP Boundary)

Streams & Flood Control Channels

Faults

Location Certain
Location Concealed
Location Approximate
Location Uncertain

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Author: LH
Date: 11/6/2019
File: Fig2-12_Soils.mxd

0 0.5 1 1.5 Miles

0 0.5 1 1.5 2 Kilometers

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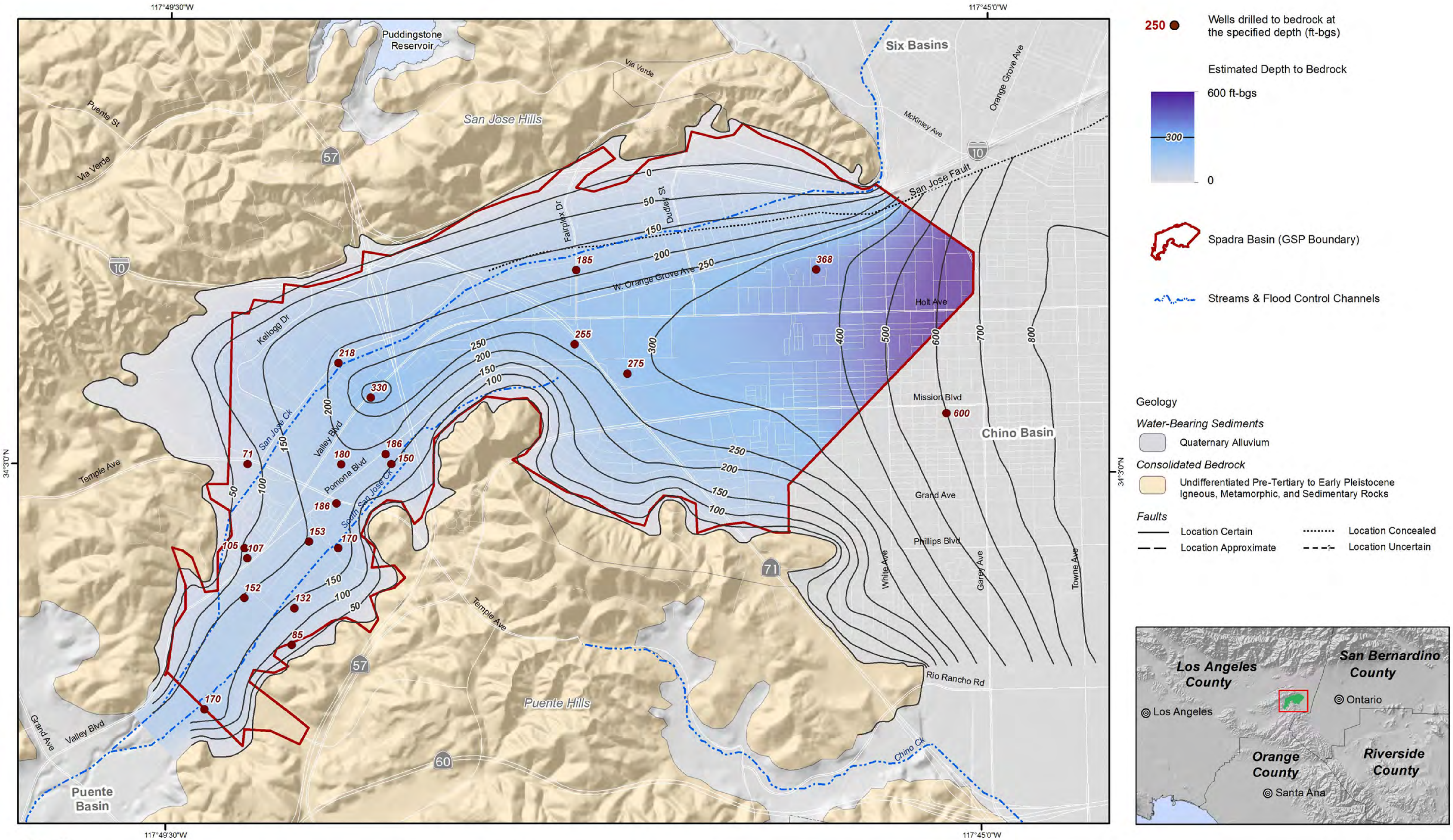
Groundwater Sustainability Plan

SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Hydrologic Soil Types of the Soil Cosnervation Service

Figure 2-12



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Author: AP
Date: 11/5/2019
File: Fig2-13_BOA_Depth.mxd

0 0.5 1 1.5 Miles
0 0.5 1 1.5 2 Kilometers

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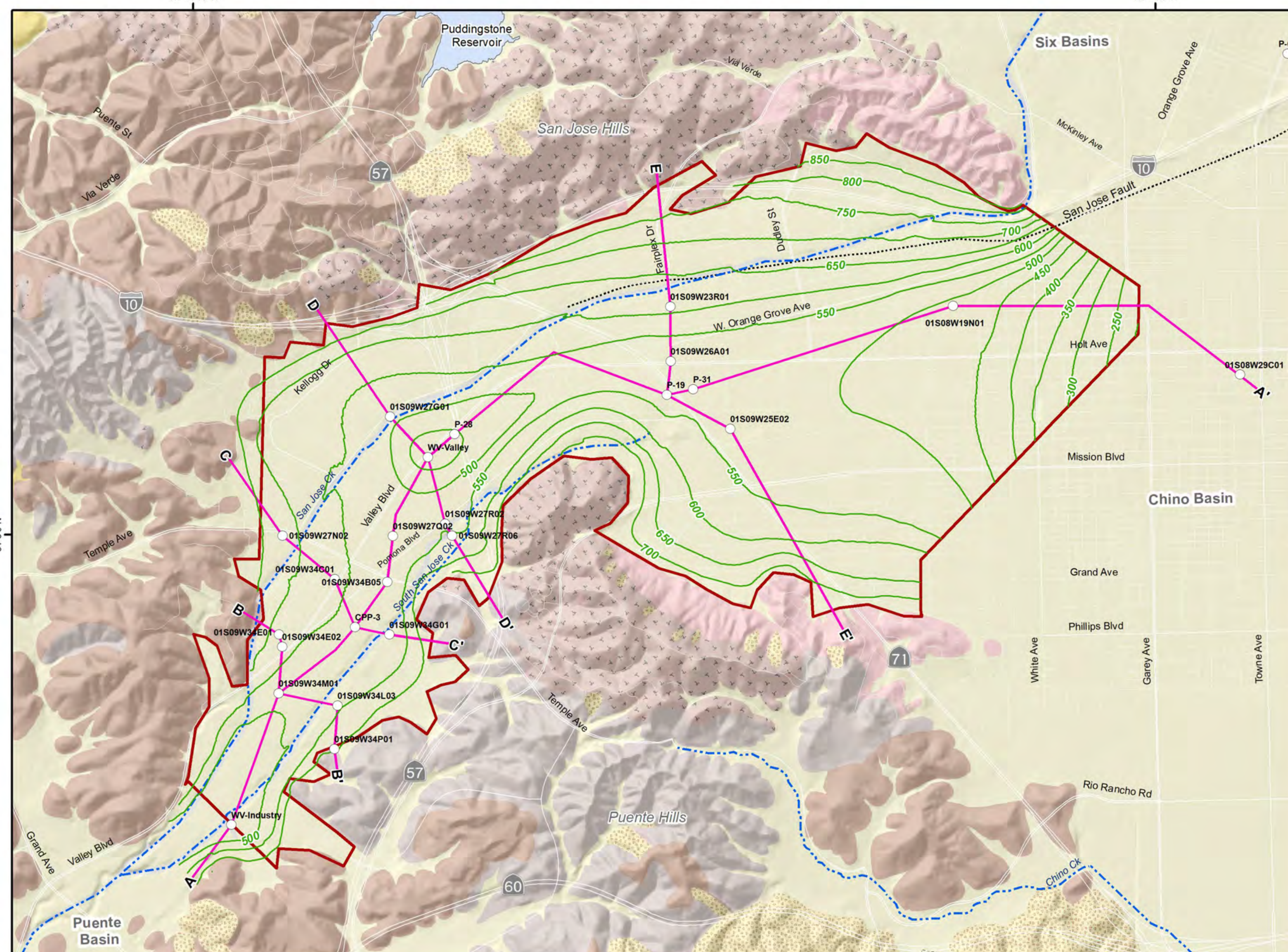
Groundwater Sustainability Plan

SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Depth to the Bottom of the Aquifer

Figure 2-13



Geologic Cross Section (shown in profile on Figures 2-15a through 2-15e)

Well Used on Cross Section

100 Contours and Raster Surface

Surface Geology

Unconsolidated Sediments (Source: CGS Special Report 217)

- Qyf — Undifferentiated Quaternary (younger) alluvial deposits
- Qoa — Undifferentiated Quaternary (older) alluvial deposits
- Qls — Landslide Deposits

Consolidated Bedrock Formations (Source: CGS Special Report 217)

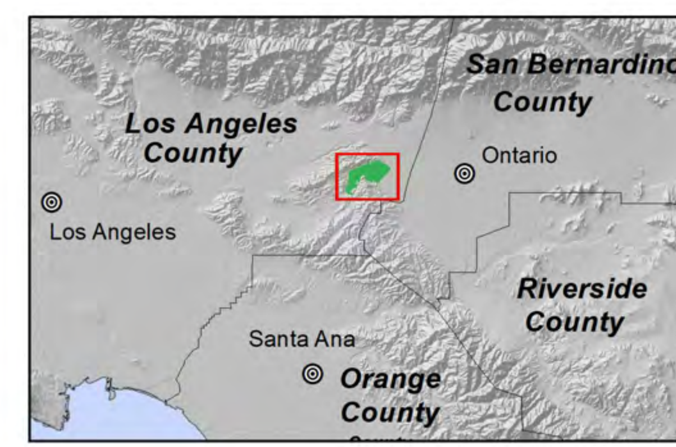
- Tss, Tsh, Tv — Puente Group: Tertiary sedimentary and volcanic rocks
- gr — Basement Complex: Cretaceous and Pre-Cretaceous igneous and metamorphic rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

Spadra Basin (GSP Boundary)

Streams & Flood Control Channels



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WEI
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Author: AP
Date: 11/6/2019
File: Fig2-14_BOA_Elevation..mxd

0 0.5 1 1.5 Miles

0 0.5 1 1.5 2 Kilometers

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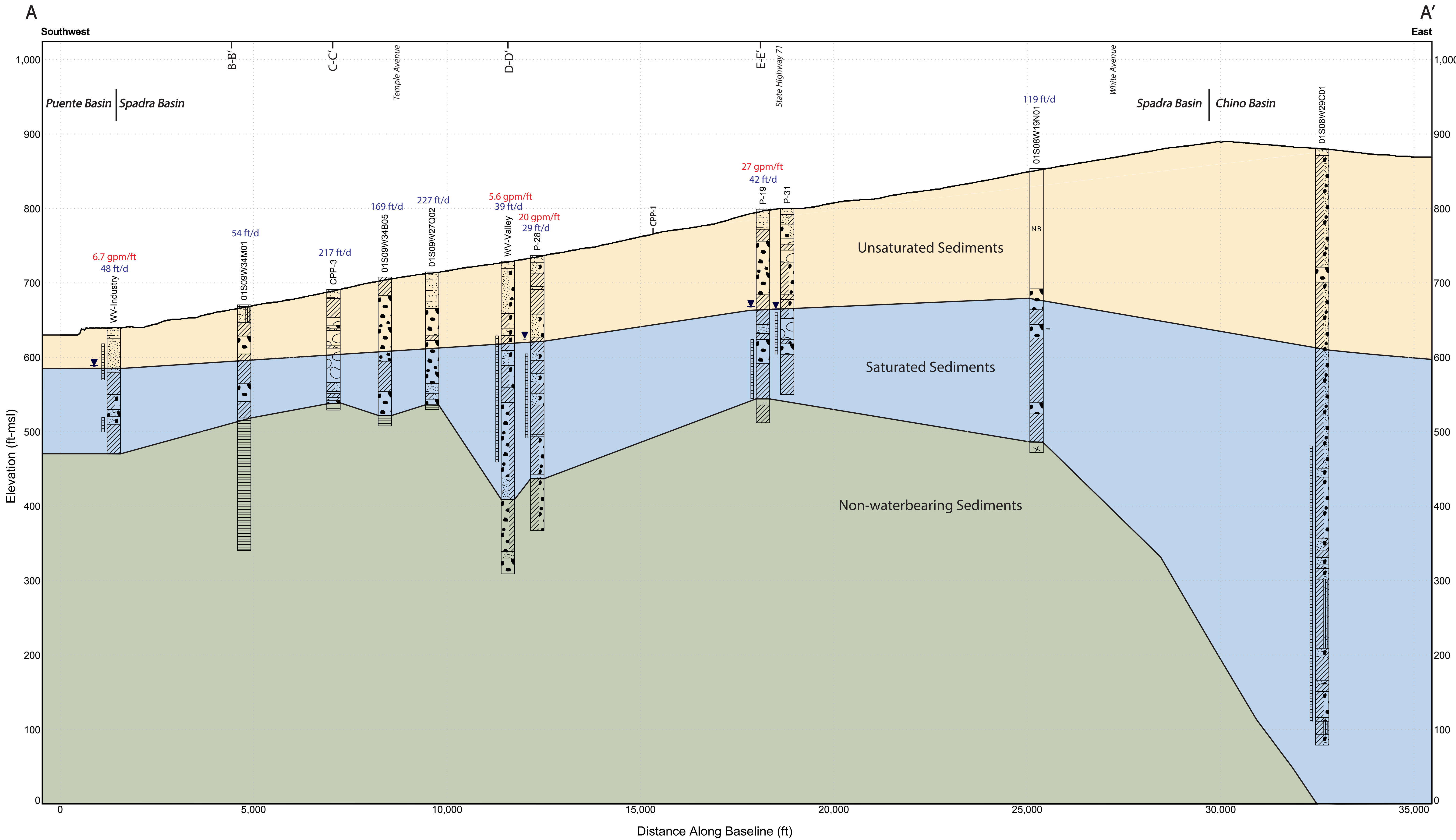
Groundwater Sustainability Plan

SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Elevation of the Bottom of the Aquifer and Location of Hydrogeologic Cross Sections

Figure 2-14



Prepared by:

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Vertical Scale: 1" = 120'
Horizontal Scale: 1" = 2310'
Vertical Exaggeration = 19:1

NR No Sample
Gravel
Clay
Crystaline Bedrock
Topsoil
Sand
Decomposed Granite
Sand with Gravel
Gravel with Clay
Clay with Gravel
Clay with Gravel and Sand
Sand with Gravel and Clay
Clay with Sand and Silt
Clay with Sand
Shale
Well Screen Interval
Groundwater Elevation (Fall 2018)
gpm/ft Specific Yield
ft/d Estimated Hydraulic Conductivity

Prepared for:

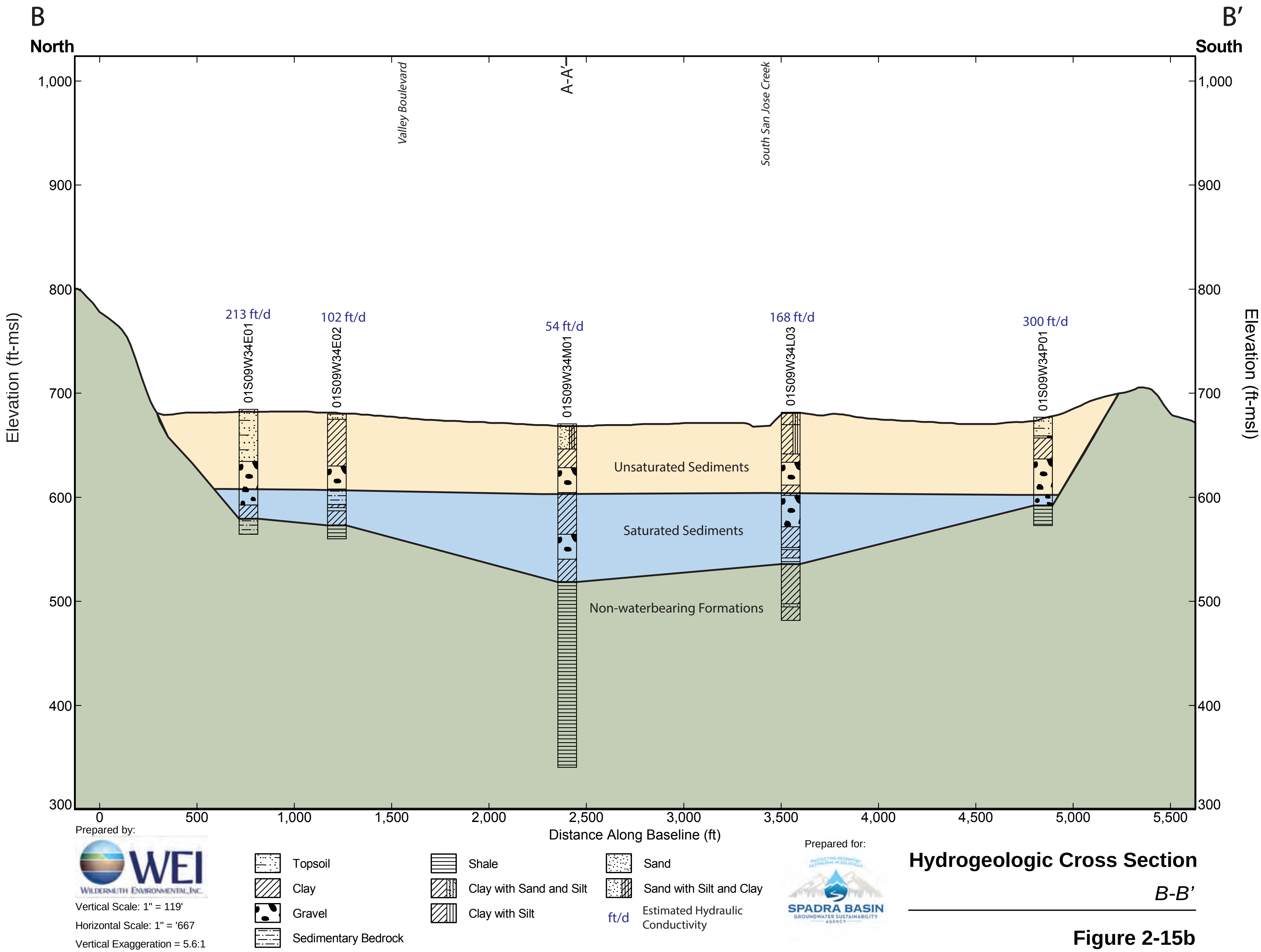
SPADRA BASIN
GROUNDWATER SUSTAINABILITY AGENCY

Hydrogeologic Cross Section

A-A′

Figure 2-15a

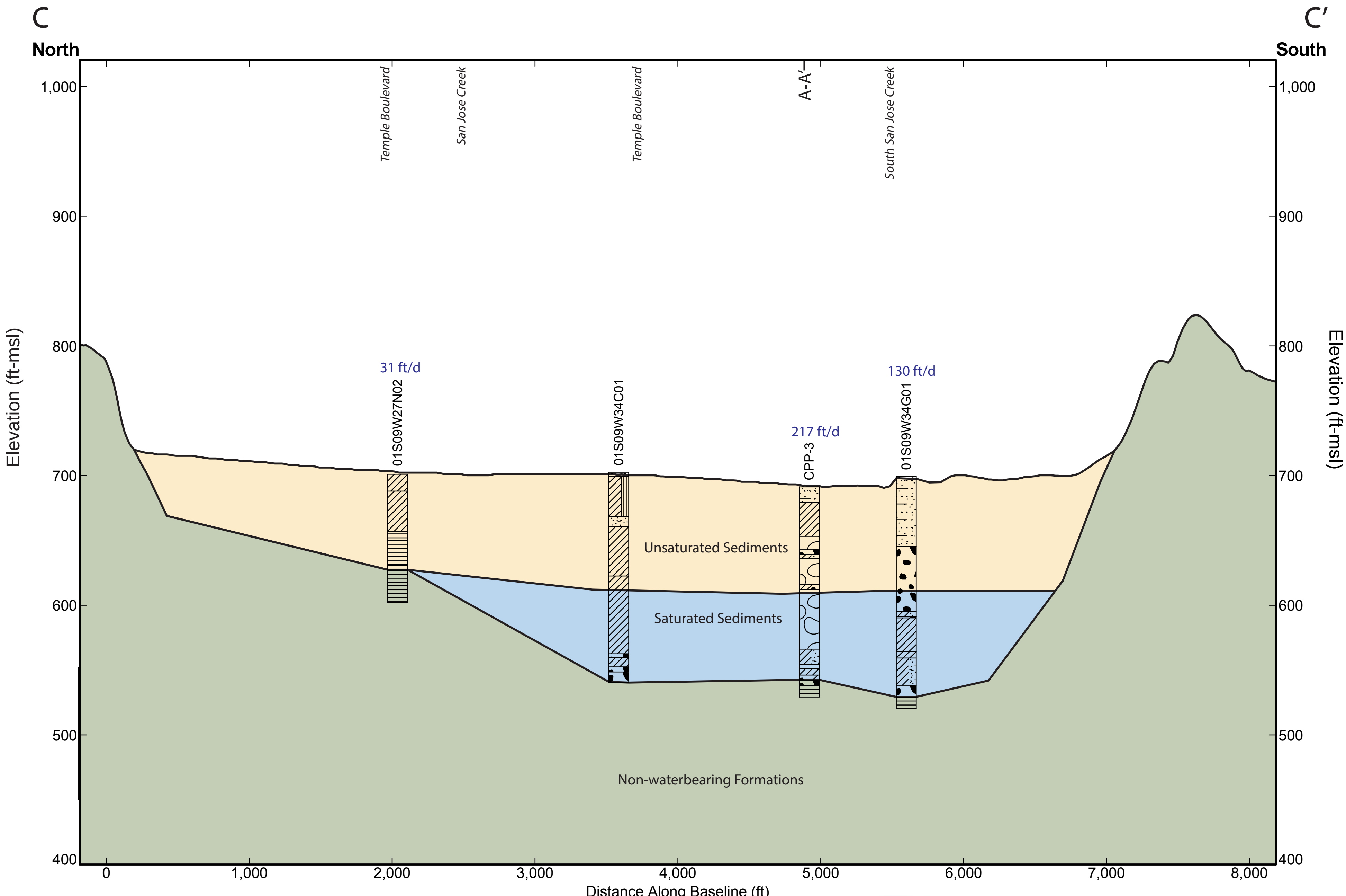
WILDERMUTH.GDT - 10/14/19 15:12 - N:\GINT\CLIENTS\SPADRABASIN\2019_SPADRABASIN_GSA.GPJ



Hydrogeologic Cross Section

B-B′

Figure 2-15b



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Vertical Scale: 1" = '102

Horizontal Scale: 1" = '929

Vertical Exaggeration = 9:1

Clay
Shale
Topsoil
Clay with Silt
Sand
Gravel
Clay with Sand
Cobbles and/or Boulders
Clay with Gravel
Gravel with Clay
ft/d Estimated Hydraulic Conductivity

Prepared for:

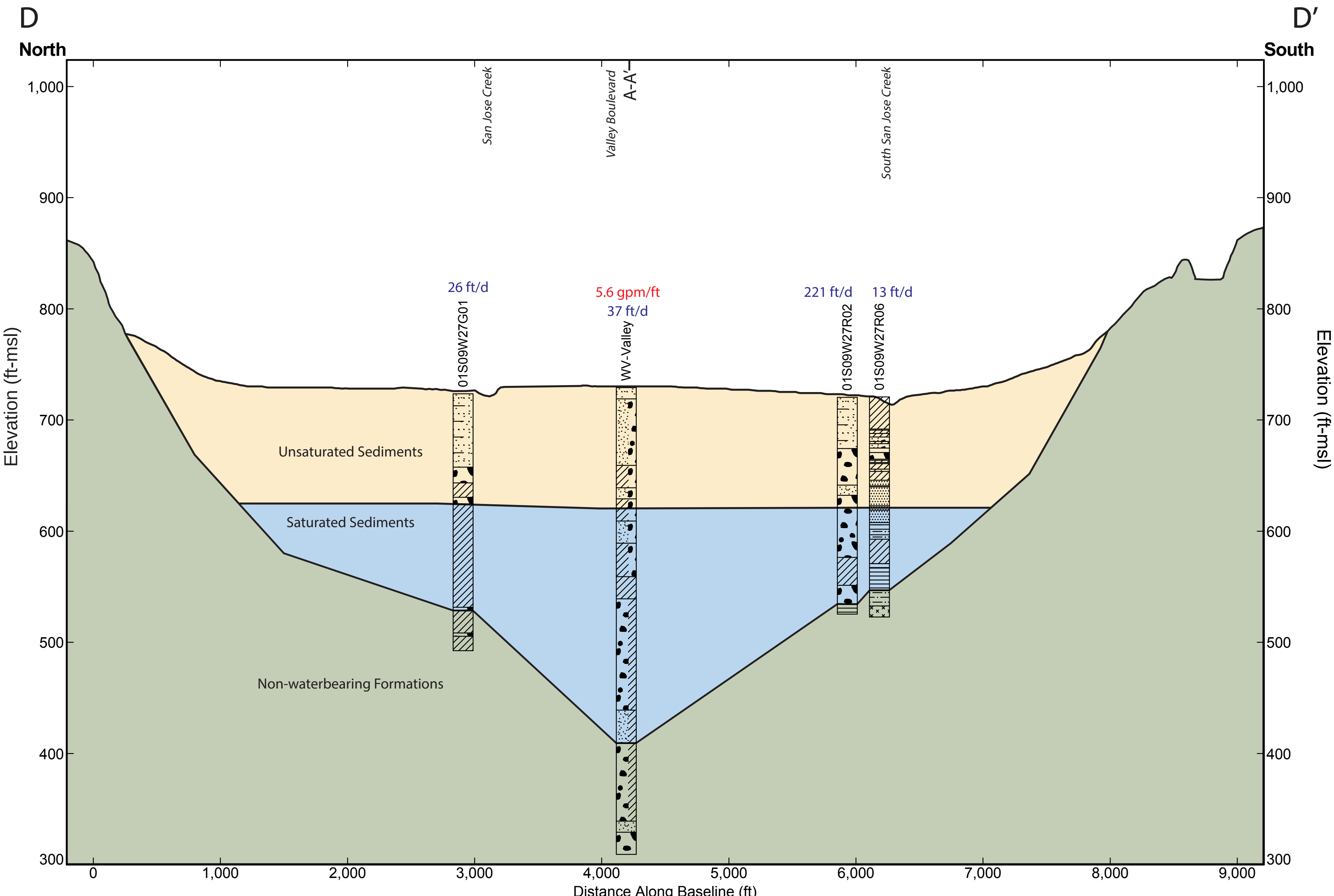
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Hydrogeologic Cross Section

C-C'

Figure 2-15c

WILDERMUTH.GDT - 10/14/19 15:12 - N:\GINT\CLIENTS\SPADRABASIN\2019_SPADRABASIN_GSA.GPJ



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Vertical Scale: 1" = '118

Horizontal Scale: 1" = '1043

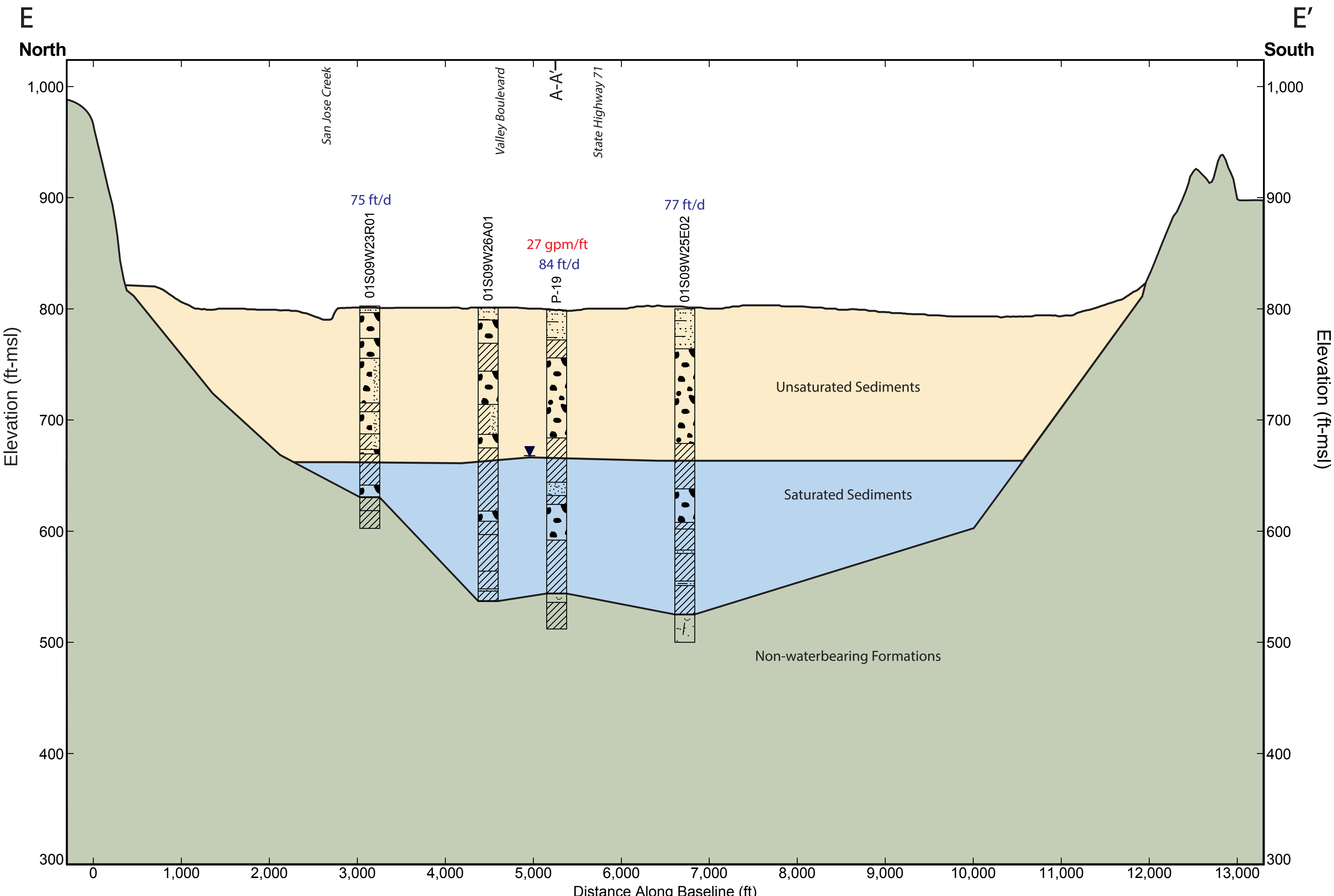
Vertical Exaggeration = 9:1

Topsoil
Gravel
Sand
Clay
Shale
Clay with Sand
Sand with Gravel
ft/d Estimated Hydraulic Conductivity
Sedimentary Bedrock
Clay with Gravel
Sandstone
gpm/ft Specific Yield
Basalt
Gravel with Clay
Sand with Clay

Hydrogeologic Cross Section

D-D'

Figure 2-15d



Prepared by:

WEI
Wildermuth Environmental, Inc.

Vertical Scale: 1" = '120

Horizontal Scale: 1" = '1508

Vertical Exaggeration = 12.5:1

Topsoil

Gravel

Clay

Sand

Sedimentary Bedrock

Decomposed Granite

Clay with Sand

Gravel with Sand

gpm/ft Specific Yield

ft/d Estimated Hydraulic Conductivity

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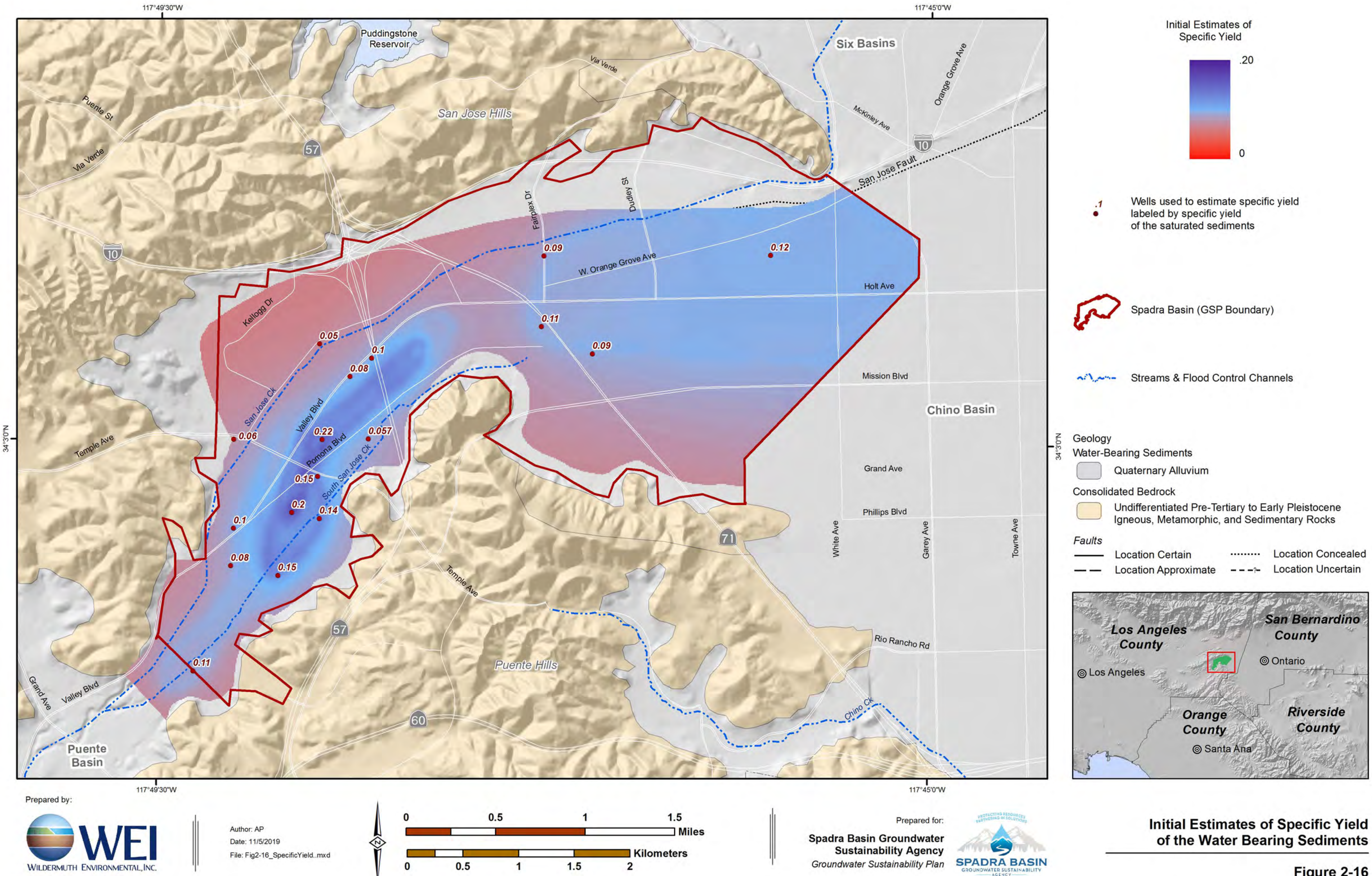
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Hydrogeologic Cross Section

E-E'

Figure 2-14e

WILDERMUTH.GDT - 10/14/19 15:12 - N:\GINT\CLIENTS\SPADRABASIN\2019_SPADRABASIN_GSA.GPJ



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Author: AP
Date: 11/5/2019
File: Fig2-16_SpecificYield..mxd

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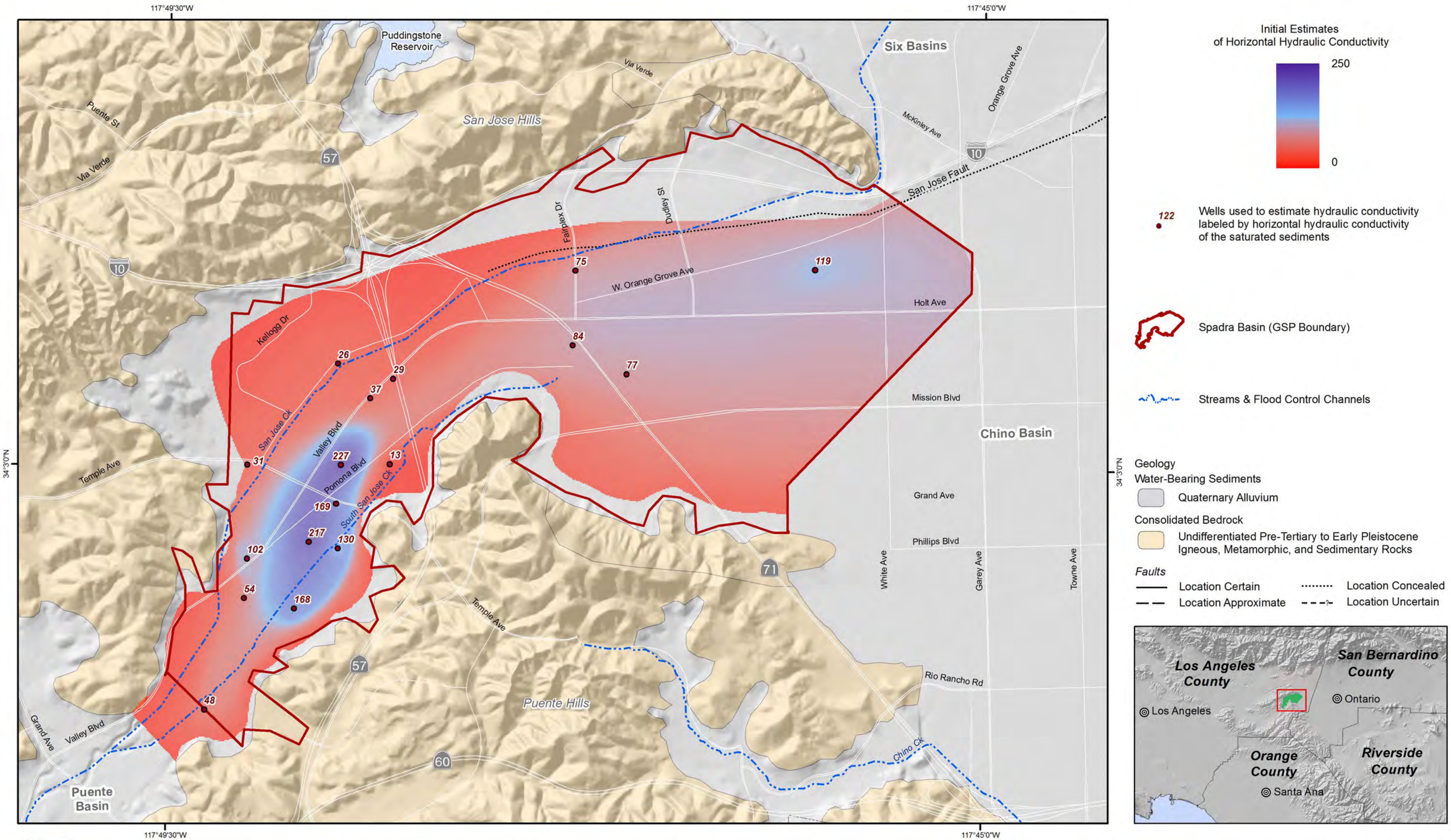
Groundwater Sustainability Plan

Initial Estimates of Specific Yield of the Water Bearing Sediments

Figure 2-16



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Author: AP
Date: 11/5/2019
File: Fig2-17_HorizontalHC.mxd

0 0.5 1 1.5 Miles
0 0.5 1 1.5 2 Kilometers

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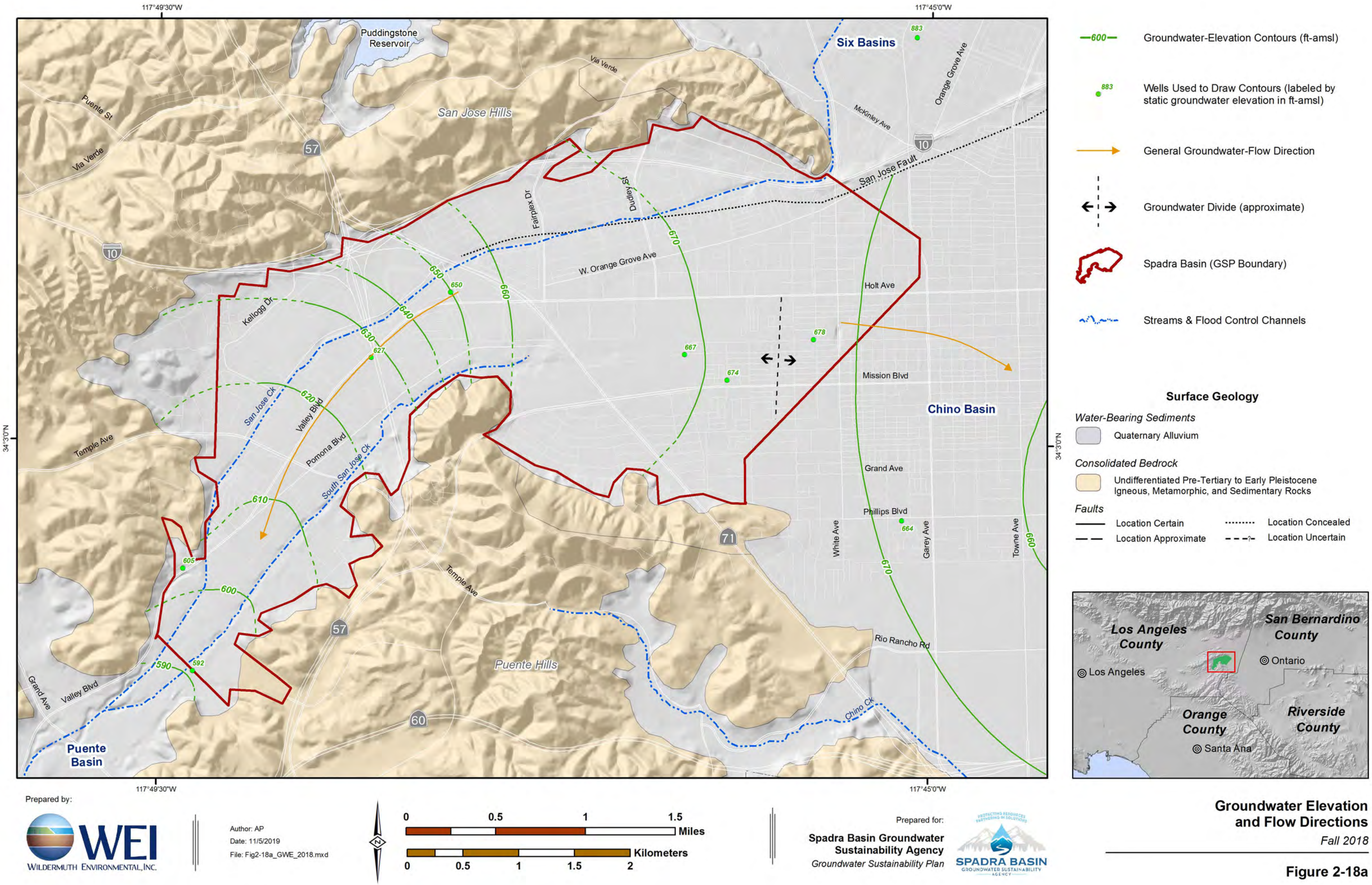
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Initial Estimates of Horizontal Hydraulic Conductivity

Figure 2-17



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Author: AP
Date: 11/5/2019
File: Fig2-18a_GWE_2018.mxd

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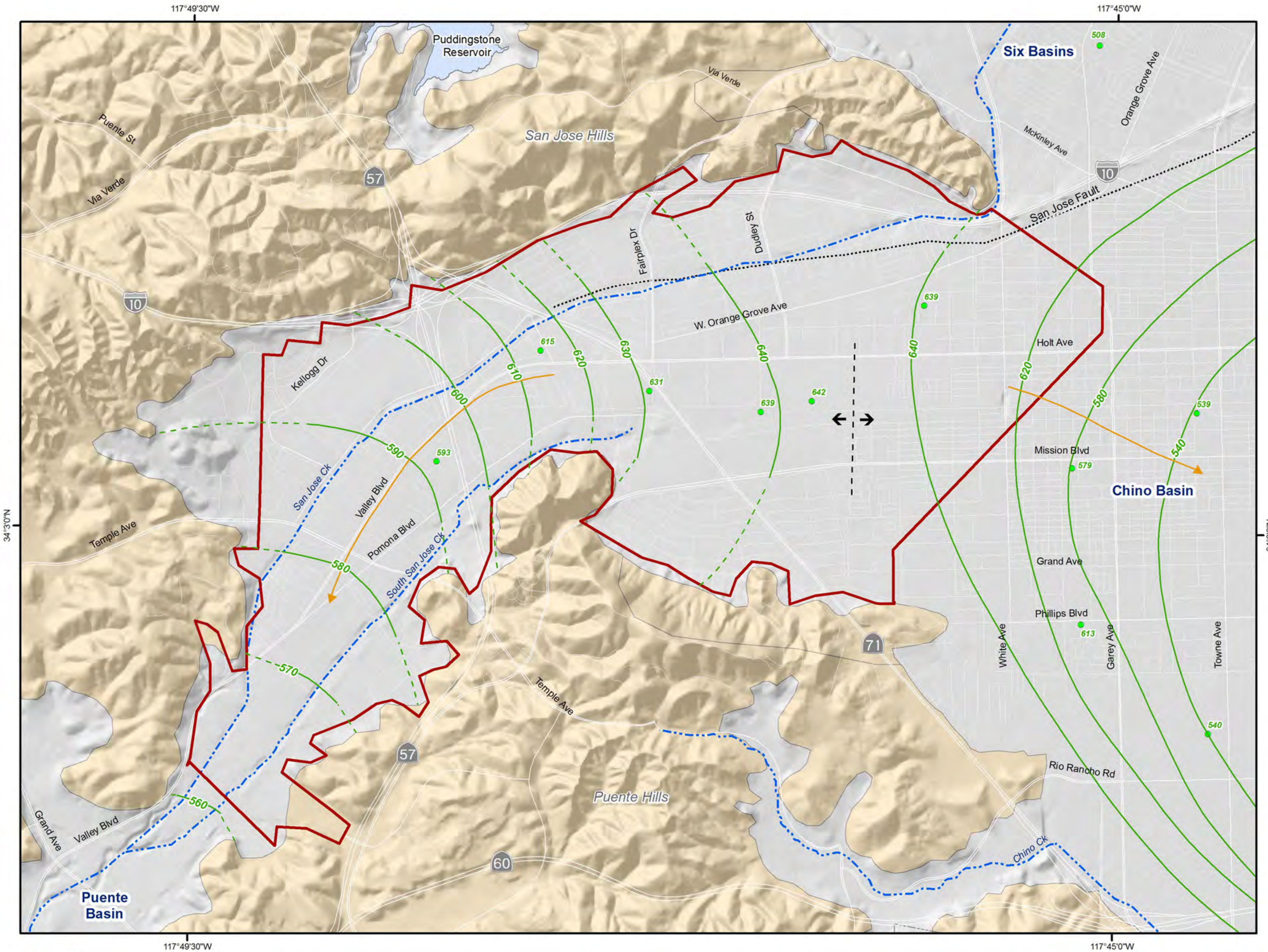
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Groundwater Elevation and Flow Directions

Fall 2018

Figure 2-18a



- 600 Groundwater-Elevation Contours (ft-amsl)
- 883 Wells Used to Draw Contours (labeled by static groundwater elevation in ft-amsl)
- General Groundwater-Flow Direction
- Groundwater Divide (approximate)
- Spadra Basin (GSP Boundary)
- Streams & Flood Control Channels

Surface Geology

Water-Bearing Sediments

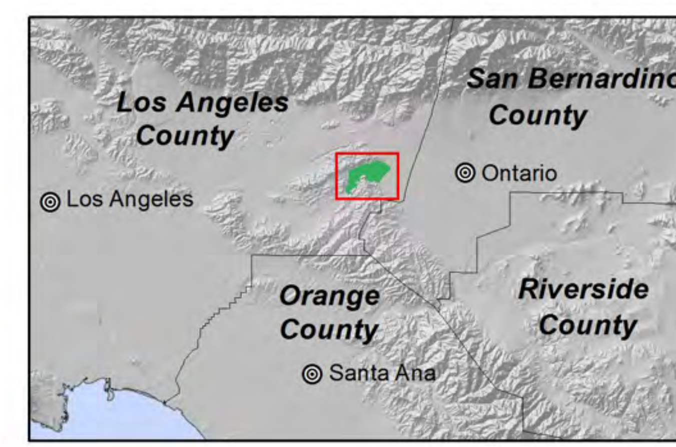
- Quaternary Alluvium

Consolidated Bedrock

- Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain



Prepared by:

WEI
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Author: LH
Date: 11/5/2019
File: Fig2-18b_GWE_1977.mxd

0 0.5 1 1.5 Miles

0 0.5 1 1.5 2 Kilometers

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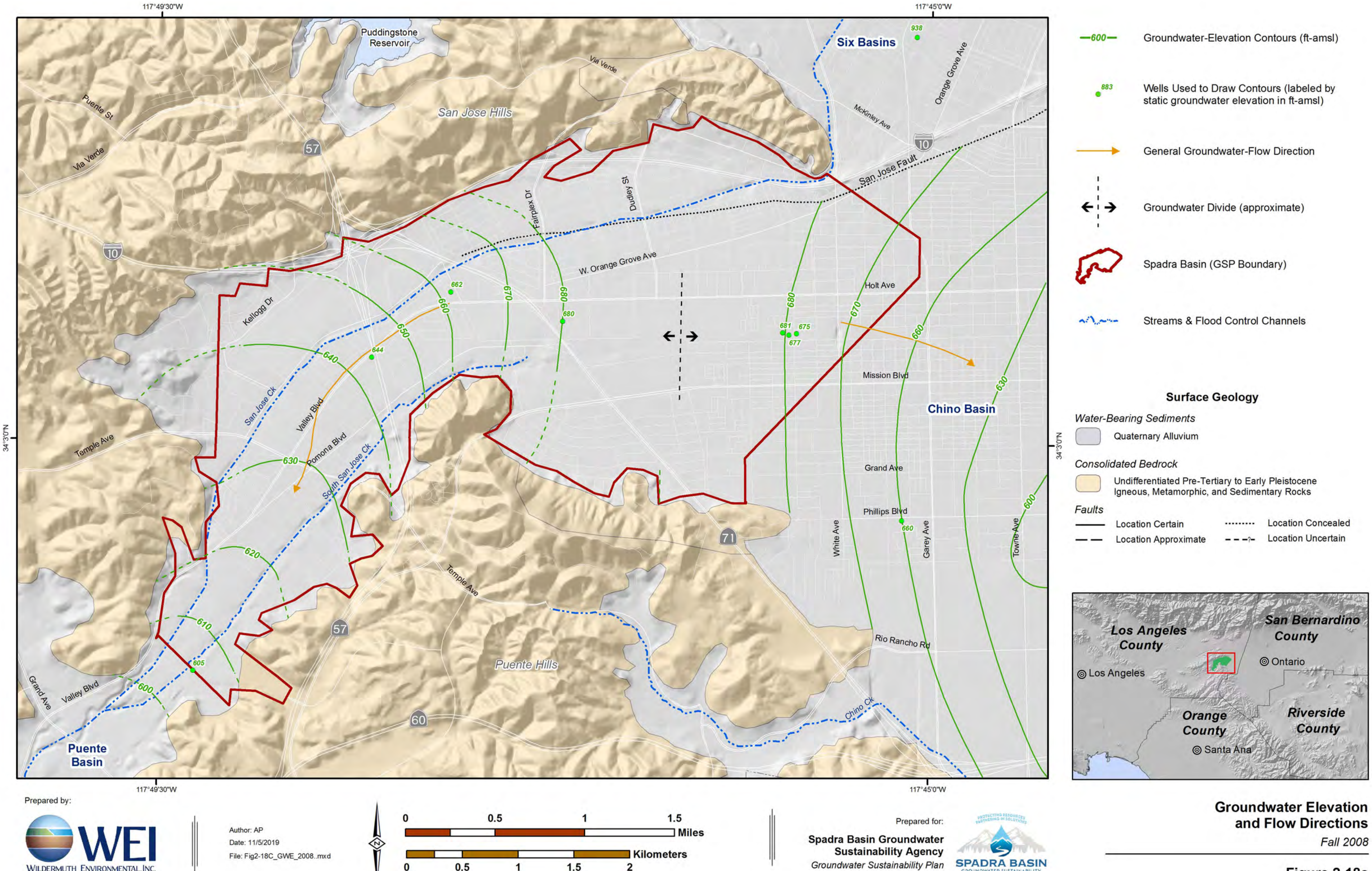
Groundwater Sustainability Plan

Groundwater Elevation and Flow Directions

Fall 1977

Figure 2-18b



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Author: AP
Date: 11/5/2019
File: Fig2-18C_GWE_2008..mxd

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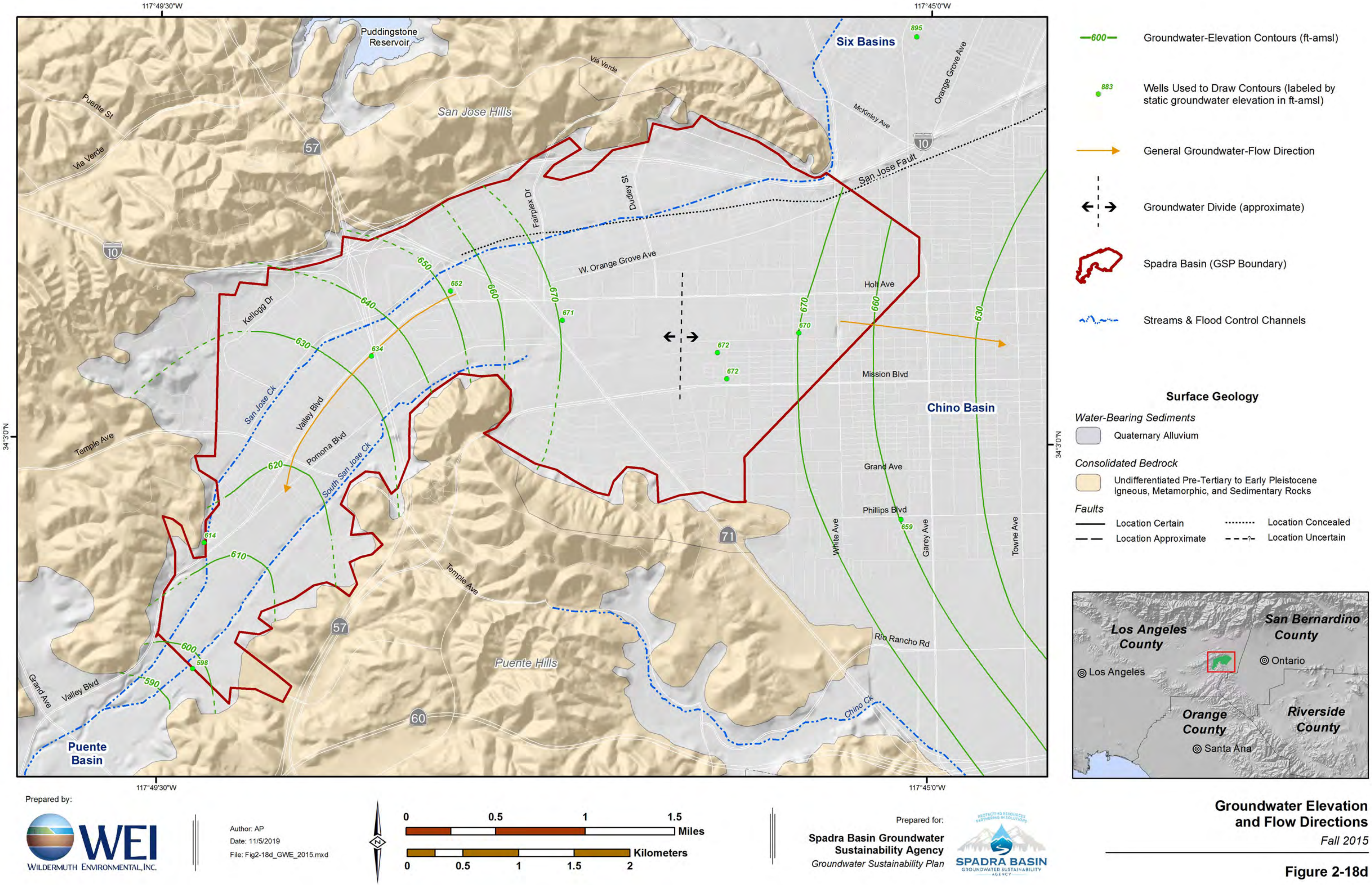
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Groundwater Elevation and Flow Directions
Fall 2008

Figure 2-18c



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WEI WILDERMUTH ENVIRONMENTAL, INC.

Author: AP
Date: 11/5/2019
File: Fig2-18d_GWE_2015.mxd

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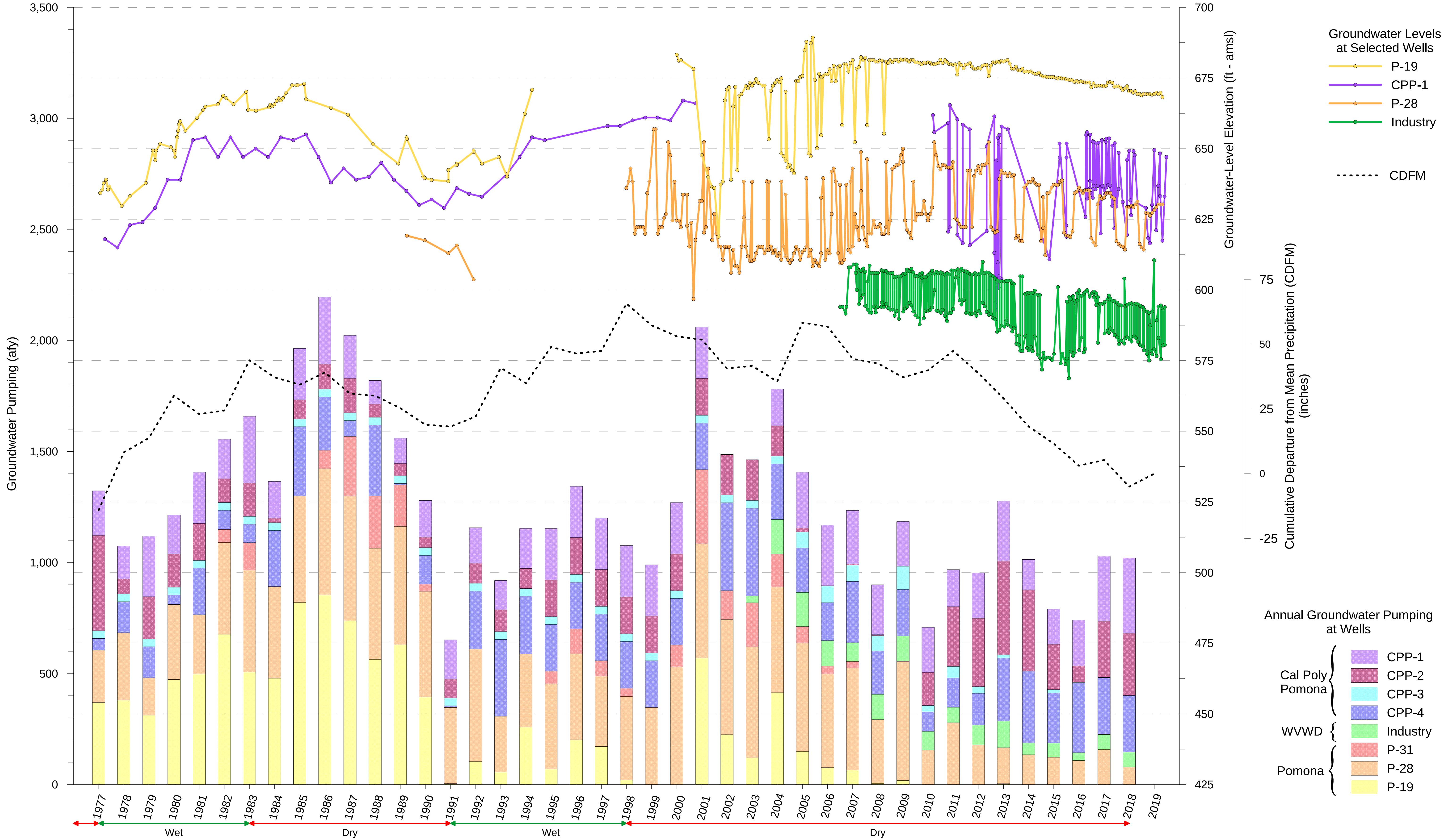
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Groundwater Elevation and Flow Directions

Fall 2015

Figure 2-18d



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

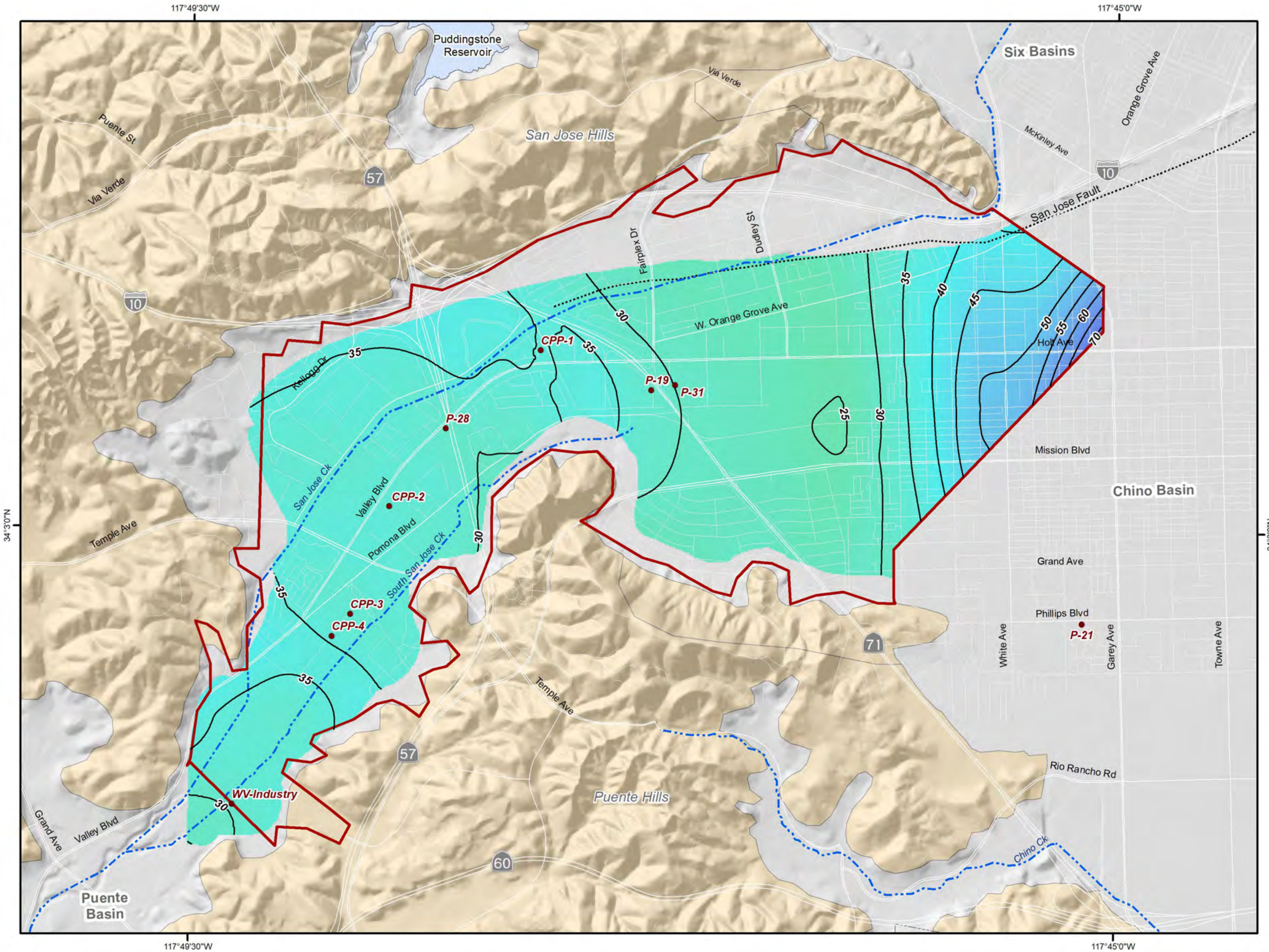
Author: LH
Date: 20191021
Filename: Fig2-23_Production_GWE

Spadra Basin Groundwater Sustainability Agency
Groundwater Sustainability Plan

SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Precipitation, Groundwater Pumping, and Groundwater Levels in the Spadra Basin

Figure 2-19



Groundwater Elevation Change

80 ft

40

0 ft

Active Production Wells

Spadra Basin (GSP Boundary)

Streams & Flood Control Channels

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

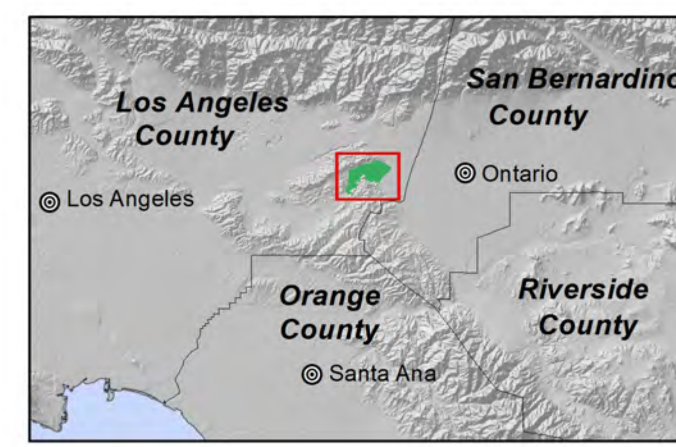
Faults

Location Certain

Location Approximate

Location Concealed

Location Uncertain



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: AP
Date: 11/6/2019
File: Fig2-20_1977-2018_Change.mxd

0 0.5 1 1.5 Miles

0 0.5 1 1.5 2 Kilometers

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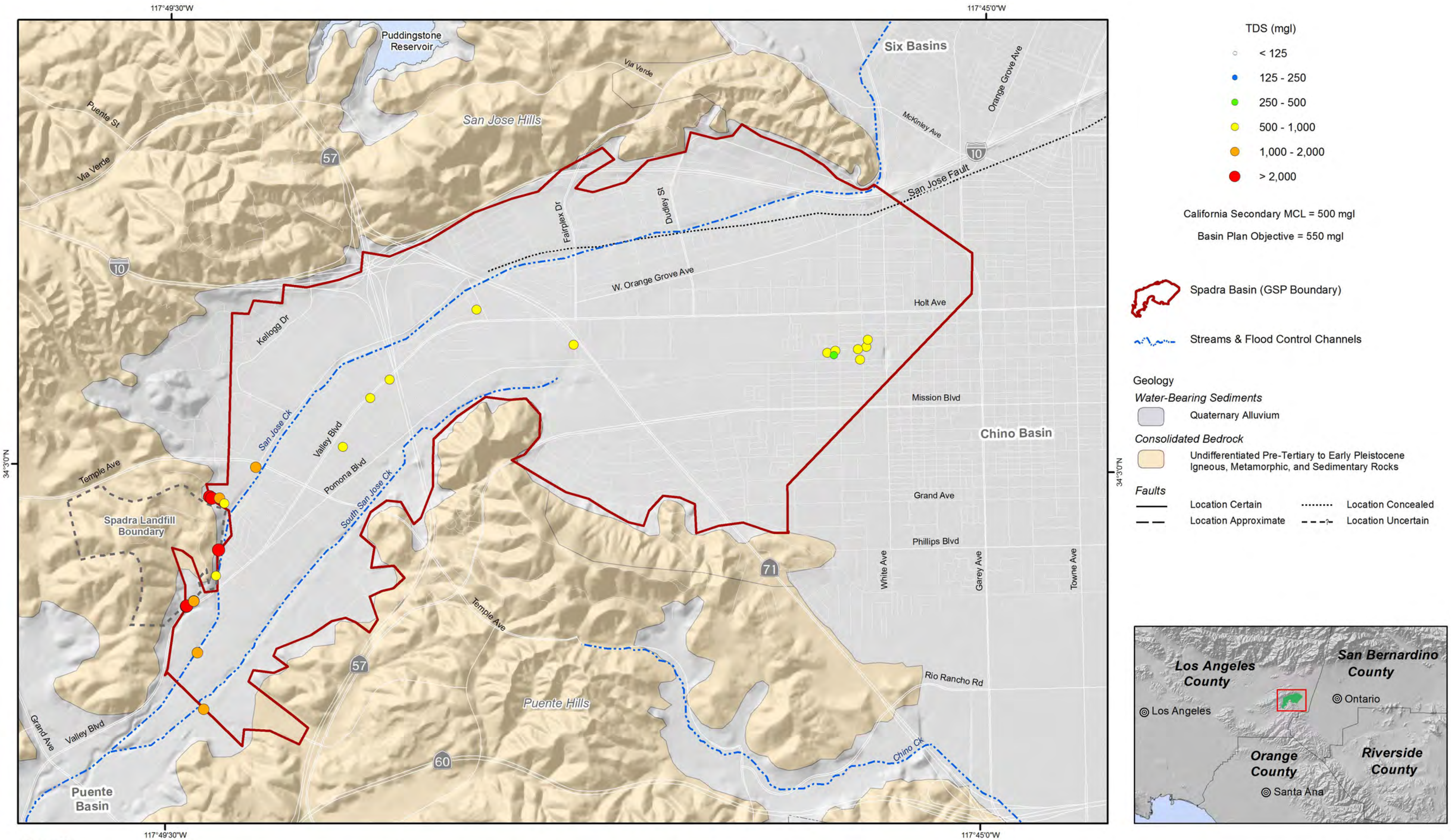
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Change in Groundwater Levels
Fall 1977 - Fall 2018

Figure 2-20



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WEI Wildermuth Environmental, Inc.

Author: LH
Date: 11/5/2019
File: Fig2-21_TDS.mxd

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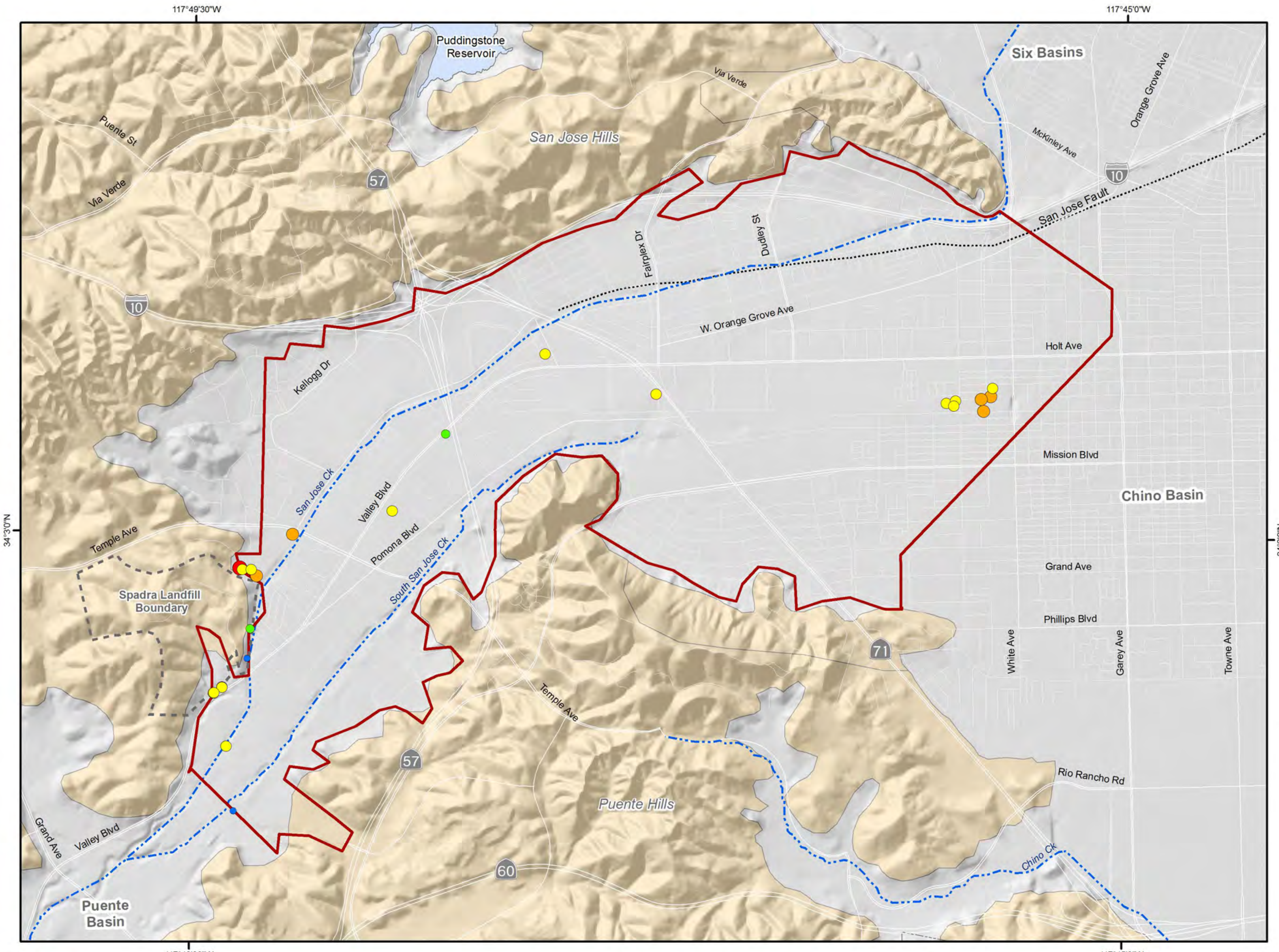
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Total Dissolved Solids in Groundwater
Maximum Concentration (2000-2019)

Figure 2-21



Nitrate-Nitrogen (mgl)
- ND
- < 5
- 5 - 10
- 10 - 20
- 20 - 40
- > 40

California Primary MCL = 10 mgl

Spadra Basin (GSP Boundary)

Streams & Flood Control Channels

Geology

Water-Bearing Sediments

Quaternary Alluvium

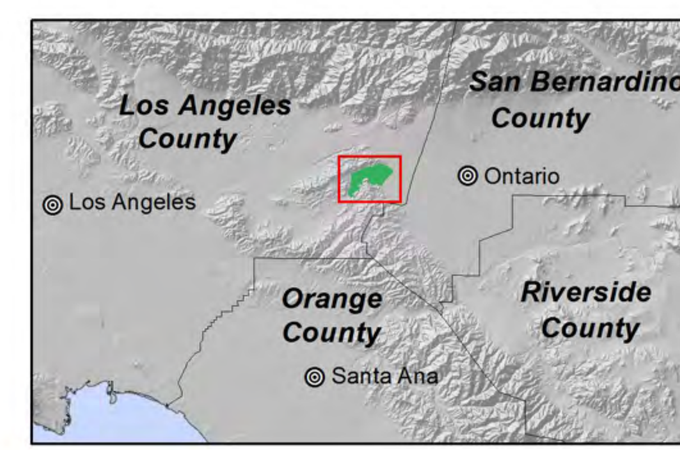
Consolidated Bedrock

Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

Faults

Location Certain — Location Concealed

Location Approximate — Location Uncertain



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: LH
Date: 11/5/2019
File: Fig2-22_NO3.mxd

0 0.5 1 1.5 Miles

0 0.5 1 1.5 2 Kilometers

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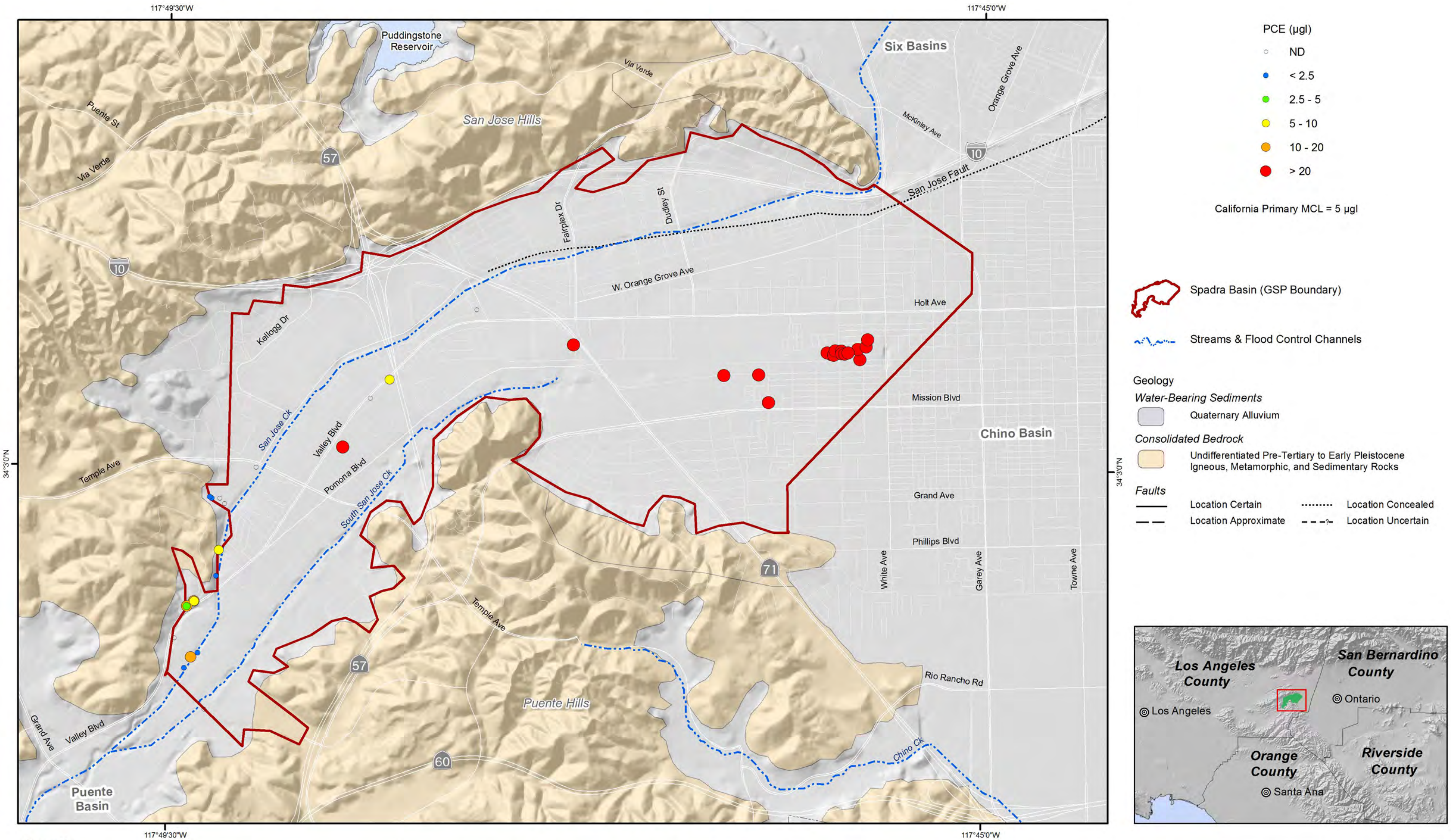
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Nitrate-Nitrogen in Groundwater
Maximum Concentration (2000-2019)

Figure 2-22



Prepared by:

WEI WILDERMUTH ENVIRONMENTAL, INC.

Author: AP
Date: 11/5/2019
File: Fig2-23_PCE.mxd

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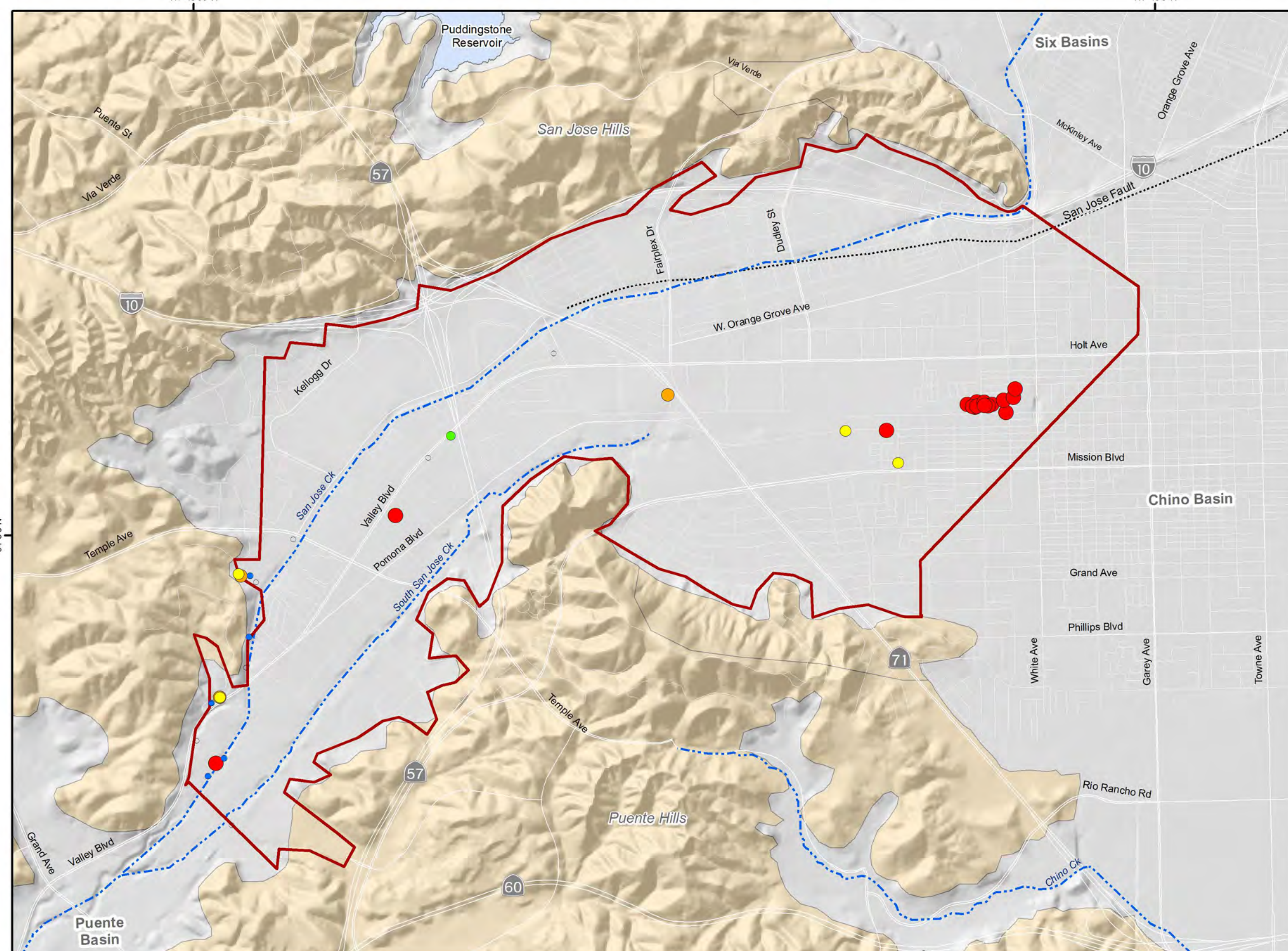
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Tetrachloroethene (PCE) in Groundwater
Maximum Concentration (2000-2019)

Figure 2-23



TCE (µgl)

- ND
- < 2.5
- 2.5 - 5
- 5 - 10
- 10 - 20
- > 20

California Primary MCL = 5 µgl

Spadra Basin (GSP Boundary)

Streams & Flood Control Channels

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

Faults

Location Certain — Location Concealed

Location Approximate — Location Uncertain

0 0.5 1 1.5 Miles

0 0.5 1 1.5 2 Kilometers

Prepared by:

WEI Wildermuth Environmental, Inc.

Author: LH
Date: 11/5/2019
File: Fig2-24_TCE.mxd

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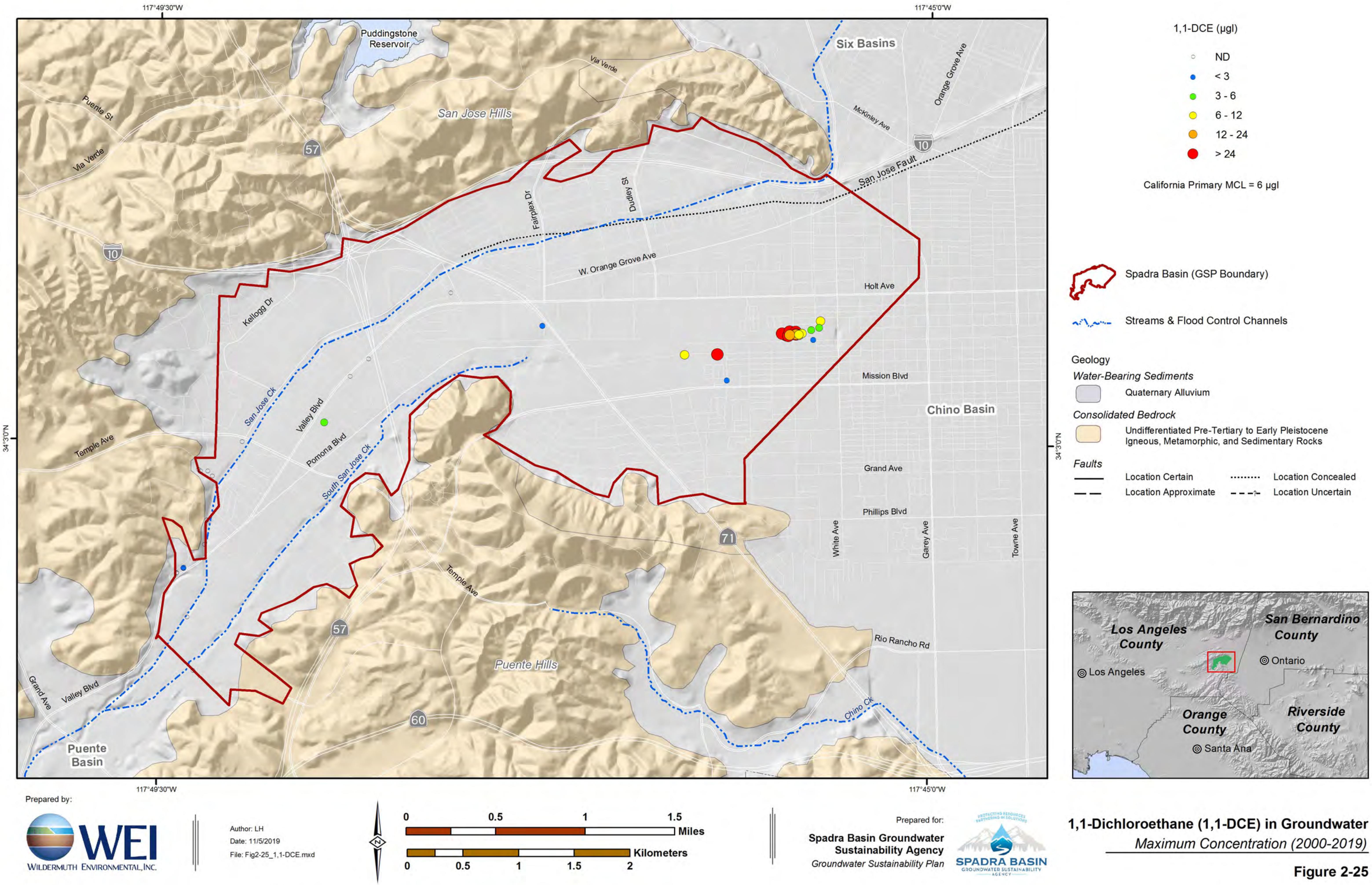
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Trichloroethene (TCE) in Groundwater
Maximum Concentration (2000-2019)

Figure 2-24



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: LH
Date: 11/5/2019
File: Fig2-25_1,1-DCE.mxd

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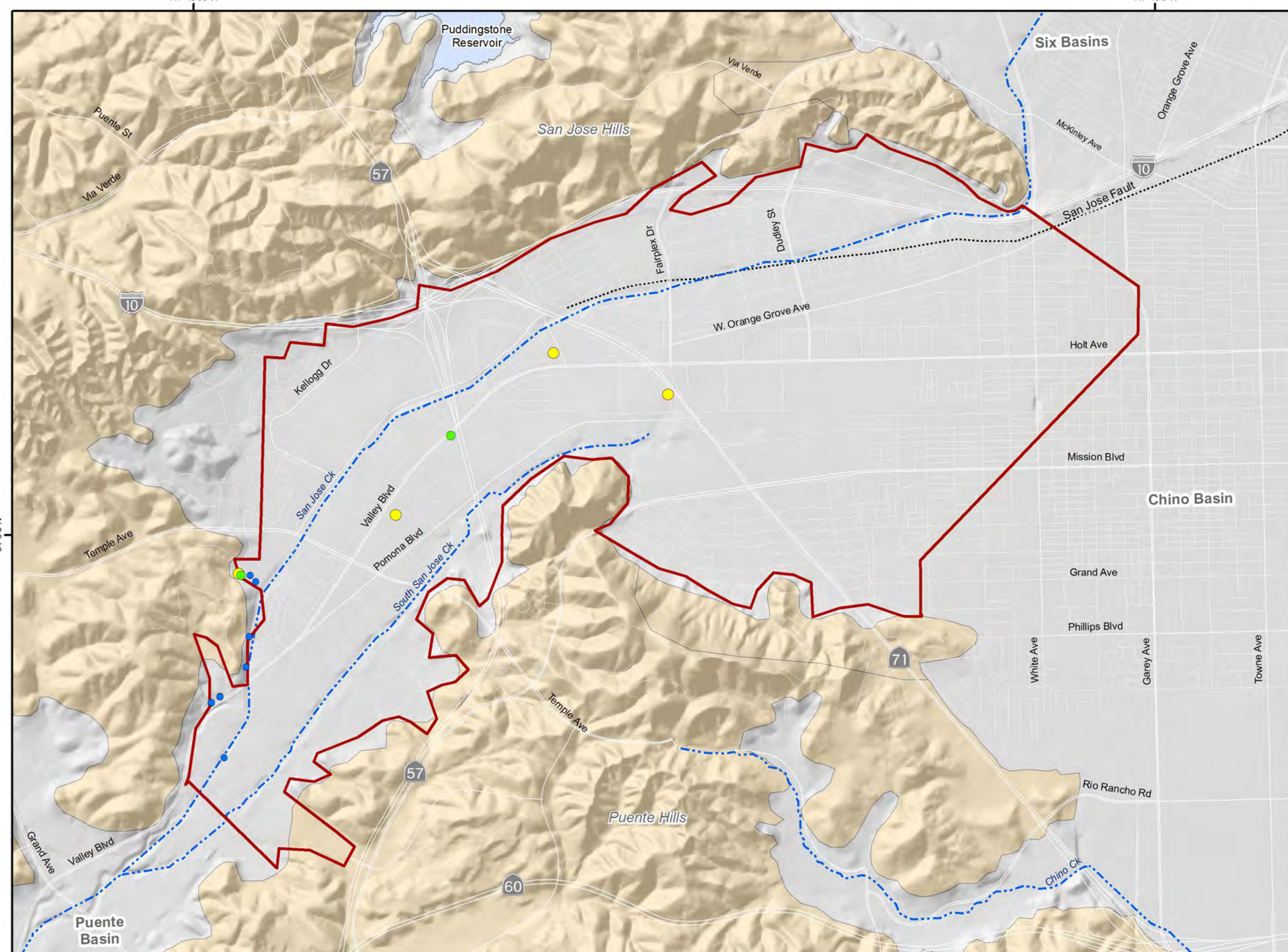
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

1,1-Dichloroethane (1,1-DCE) in Groundwater

Maximum Concentration (2000-2019)

Figure 2-25



Perchlorate (µgl)

- ND
- < 3
- 3 - 6
- 6 - 12
- 12 - 24
- > 24

California Primary MCL = 6 µgl

Spadra Basin (GSP Boundary)

Streams & Flood Control Channels

Geology

Water-Bearing Sediments

Quaternary Alluvium

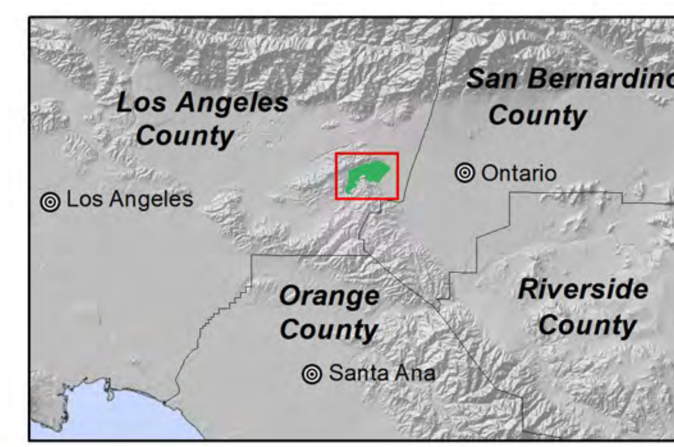
Consolidated Bedrock

Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

Faults

Location Certain — Location Concealed

Location Approximate — Location Uncertain



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: LH
Date: 11/5/2019
File: Fig2-26_Perchlorate.mxd

0 0.5 1 1.5 Miles

0 0.5 1 1.5 2 Kilometers

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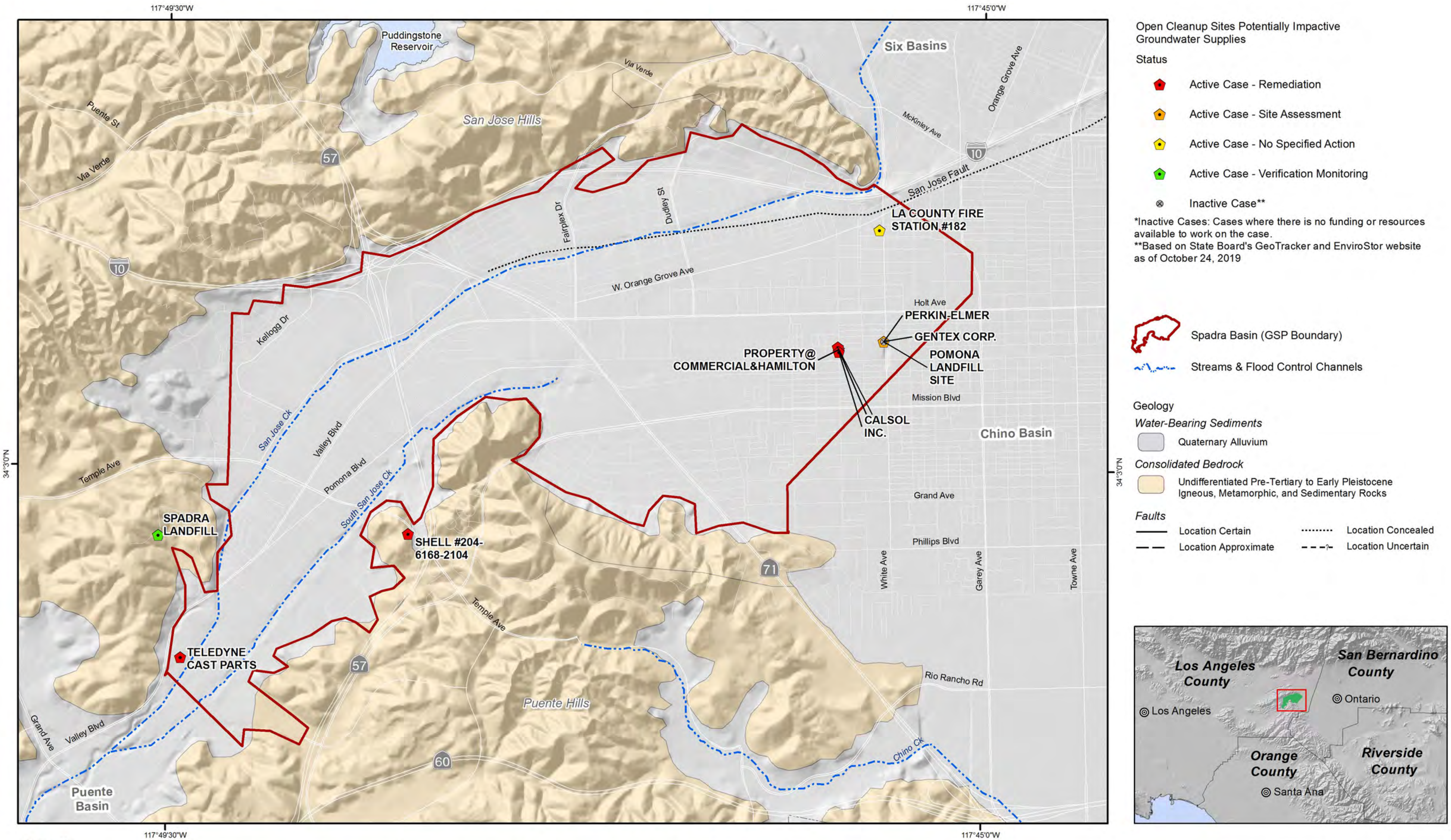
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Perchlorate in Groundwater

Maximum Concentration (2000-2019)

Figure 2-26



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Author: LH
Date: 11/5/2019
File: Fig2-27_GeoTrackerEnviron.mxd

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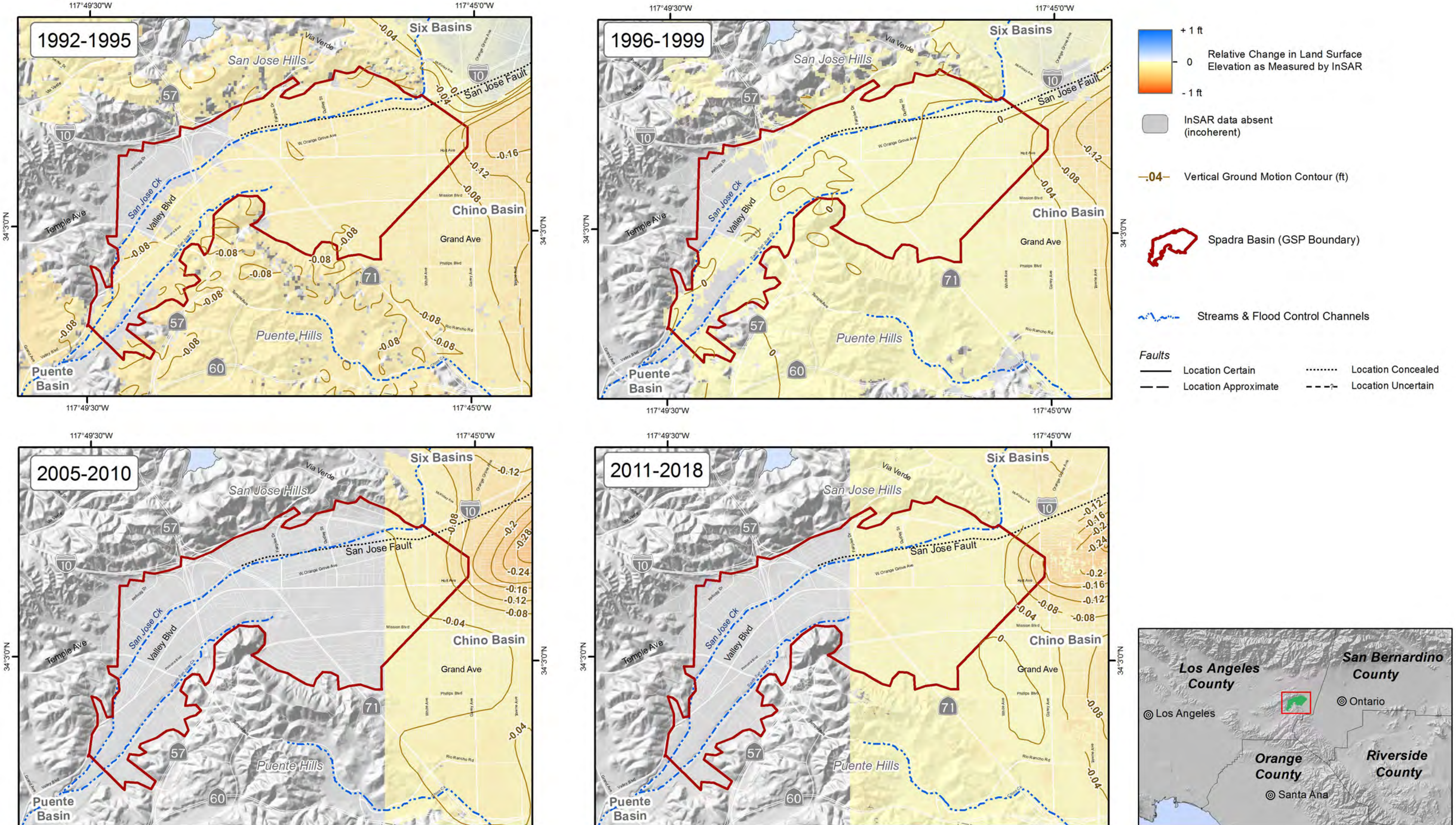
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Point Source Groundwater Contamination Sites

Open Cleanup Sites in the Spadra Basin

Figure 2-27



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: LH
Date: 11/5/2019
File: Fig2-28_Vertical_Ground_Motion.mxd

0 0.5 1 1.5 Miles
0 0.5 1 1.5 2 Kilometers

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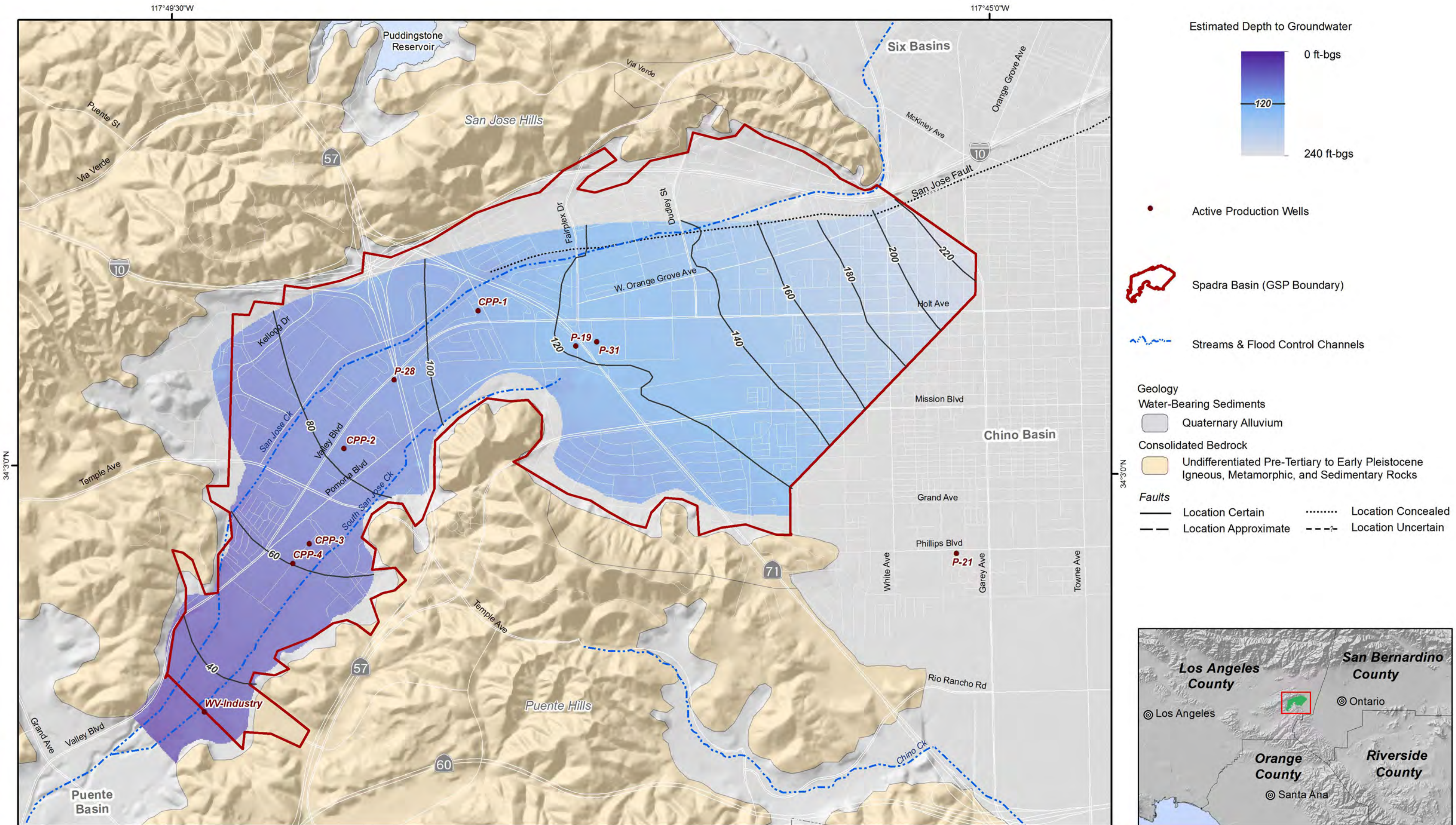
SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Vertical Ground Motion
Various Years, 1992 - 2019

Figure 2-28



Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: LH
Date: 11/5/2019
File: Fig2-29_GWDepth_2008_Raster.mxd

0 0.5 1 1.5 Miles
0 0.5 1 1.5 2 Kilometers

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SPADRA BASIN GROUNDWATER SUSTAINABILITY AGENCY

Shallowest Depth to Groundwater
Fall 2008

Figure 2-29

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