ES EXECUTIVE SUMMARY

California's historic Sustainable Groundwater Management Act (SGMA) became effective on January 1, 2015, at the height of the state's last drought. SGMA mandated that groundwater resources be sustainably managed through development and implementation of a Groundwater Sustainability Plan (GSP or Plan) to ensure that groundwater will be available today and into the future for all beneficial users, including flora and fauna, municipal and domestic, agricultural, and business users. The Sonoma Valley Groundwater Sustainability Agency (Sonoma Valley GSA) was formed under SGMA to develop and implement this GSP for the Sonoma Valley Groundwater Subbasin (Subbasin) (refer to **Figure ES-1**).

This GSP lays out a management process for ensuring a sustainable groundwater supply in the future by improving the understanding of this hidden resource, measuring progress through metrics that will be monitored, actively implementing projects, and, as necessary, adopting management actions in response to groundwater levels if they continue to decline unacceptably, and developing the funding needed for long-term implementation. The GSP implementation process includes active engagement of local stakeholders by the GSA Board, Advisory Committee, and periodic community meetings.

The Subbasin is classified by California Department of Water Resources (DWR) as a high-priority basin, with groundwater levels declining in some areas. Based on the high-priority designation, the GSA must submit the GSP to DWR by January 31, 2022. The Sonoma Valley GSA began work on the GSP in 2018 to identify and quantify existing problems and data gaps, define local goals for sustainable management of the Subbasin, and develop a plan that achieves and maintains groundwater sustainability 50 years into the future.

Declining groundwater levels in Sonoma Valley were apparent long before the passage of SGMA and under the leadership of a diverse, stakeholder-based Basin Advisory Panel, the voluntary Sonoma Valley Groundwater Management Plan (GMP) was released in 2007. The GMP, which includes the Subbasin and contributing Sonoma Valley watershed, relied heavily on a 2006 U.S. Geological Survey (USGS) study funded by the Sonoma County Water Agency (Sonoma Water) and USGS.

The GMP advanced the characterization and monitoring of groundwater conditions and initial study and planning of potential projects within the Subbasin.

This GSP presents detailed, technical information to build upon the work done in the GMP and to better understand groundwater in the Subbasin. The GSP uses quantifiable, sustainability management criteria to define sustainability and includes projects, management actions, and an implementation plan to achieve locally determined sustainability goals.

Because Sonoma Valley once again faces historic drought conditions, and with climate change projections showing that longer, more severe droughts are inevitable, the GSP lays out a path for long-term sustainability and resiliency as defined by SGMA. While the current drought highlights water resource challenges, GSPs are not intended to address immediate short-term

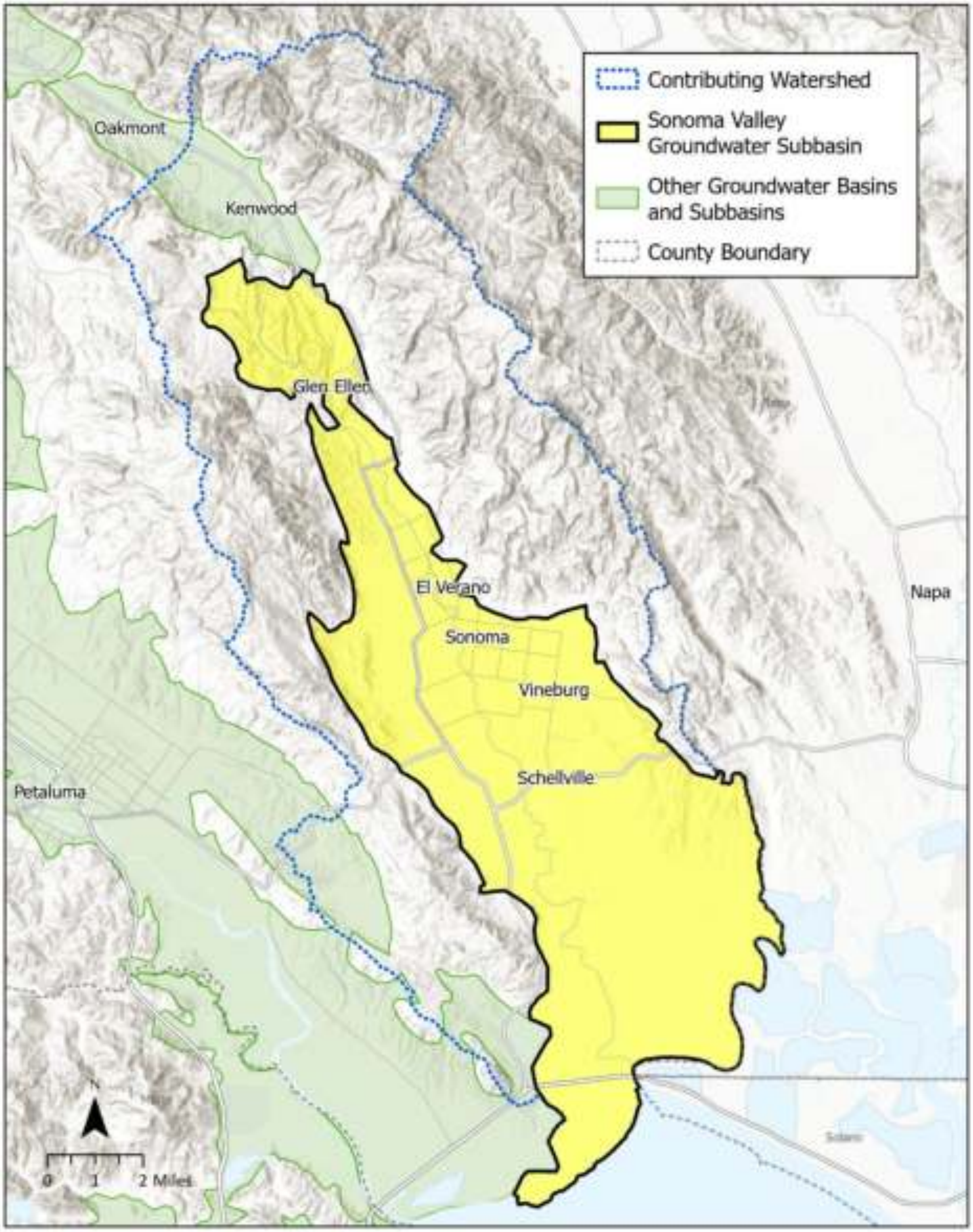

Figure ES-1. Plan Area/Sonoma Valley Groundwater Substation

issues, but are focused on long-term, systemic groundwater issues. For example, using a computerized model, described in **Section ES-3**, the GSP projects a 50-year climate future characterized by a few very dry years, followed by several wet or very wet years, and then a long drought. This scenario is representative of projected conditions in the North Bay, but is one of multiple options that could have been used. The climate scenario will be reevaluated as more refined projections become available, and at a minimum of every 5 years when the GSP is required to be updated. This approach reflects a key component of this GSP, which is adaptive management. The document identifies areas of uncertainty and describes how new information will developed and incorporated into GSP implementation to make adjustments and to correct course if necessary.

Adaptive Management

A key tenant of this GSP is adaptive management. Adaptive management is a structured, iterative process of robust decision making in the face of uncertainty, with an aim to reducing uncertainty over time via monitoring and through the incorporation of new information as it becomes available.

This GSP and Executive Summary are organized following DWR's guidance documents (DWR 2016a):

- Executive Summary
- Section 1 Introduction
- Section 2 Description of the Plan Area
- Section 3 Basin Setting
- Section 4 Sustainable Management Criteria
- Section 5 Monitoring Networks
- Section 6 Projects and Management Actions to Achieve Sustainability
- Section 7 Plan Implementation
- Section 8 References and Technical Studies Used to Develop the GSP

ES.1 Introduction

In June 2017, the Sonoma Valley GSA, whose jurisdiction is the Subbasin, was formed as a Joint Powers Authority with six member agencies: North Bay Water District, Sonoma County (County), Sonoma Water, Sonoma Resource Conservation District, Valley of the Moon Water District, and the City of Sonoma (**Figure ES-2**). The Sonoma Valley GSA Board of Directors (Board) includes one representative from each member agency. The Board meets approximately six times annually in meetings that are open to the public.

Figure ES-2. Groundwater Sustainability Agency Organization

In recognition of the importance of stakeholder input, the Board created a 12-member Advisory Committee to provide feedback and advice on all aspects of the GSP to the Board (**Figure ES-2**). The Advisory Committee meetings are open to the public, advertised through a monthly email update, and posted on the Sonoma Valley GSA website, sonomavalleygroundwater.org. GSP development was a collaborative effort among the Board, Advisory Committee, and technical consultants and was further informed by input from member agencies, resource agencies, and the community through open public meetings and workshops. Key policy issues were vetted, discussed, and modified based on this open, public exchange.

ES.2 Plan Area

Section 2 of the GSP describes the Plan Area, including government jurisdictions, land use, water sources and uses, topography, surface water features, current monitoring and water management programs, and the well-permitting process.

The Plan Area is the entire Sonoma Valley Subbasin (**Figure ES-1**), located immediately north of San Pablo Bay, and bounded on the west by Sonoma Mountains and on the east by the Mayacamas Mountains. The 44,000-acre Subbasin stretches from the Baylands northward, incorporating the City of Sonoma and the communities of Schellville, Buena Vista, El Verano, The Springs (Agua Caliente, Boyes Hot Springs, and Fetters Hot Springs), and Glen Ellen. Sonoma Creek is the principal stream draining the Subbasin, which is located within the larger Sonoma Creek watershed.

The major urban water suppliers in the Subbasin are the City of Sonoma and Valley of the Moon Water District, which rely primarily on imported Russian River water supplied by Sonoma Water, but which also pump groundwater for supplemental supply, and during droughts and in emergencies. These water suppliers serve most of the urban communities, which account for about 13 percent of land use. Agriculture—primarily wine grapes—which relies on groundwater, local surface water, and recycled water, accounts for 44 percent of land use. Native vegetation or water bodies make up 43 percent of land use (**Figure ES-3**). In 2020, imported surface water accounted for 35 percent of water supply in the Subbasin, groundwater accounted for 52 percent, recycled water accounted for about 10 percent and local surface water supplies accounted for about 3 percent.

Climate, groundwater, and streamflow conditions in the Subbasin are informed by robust monitoring networks. Multiple studies, programs, land-use plans, and regulations affect, inform, and protect current and future water resources, water use, and water quality in the Subbasin. The County is responsible for administering well permits in both the City of Sonoma and unincorporated areas.

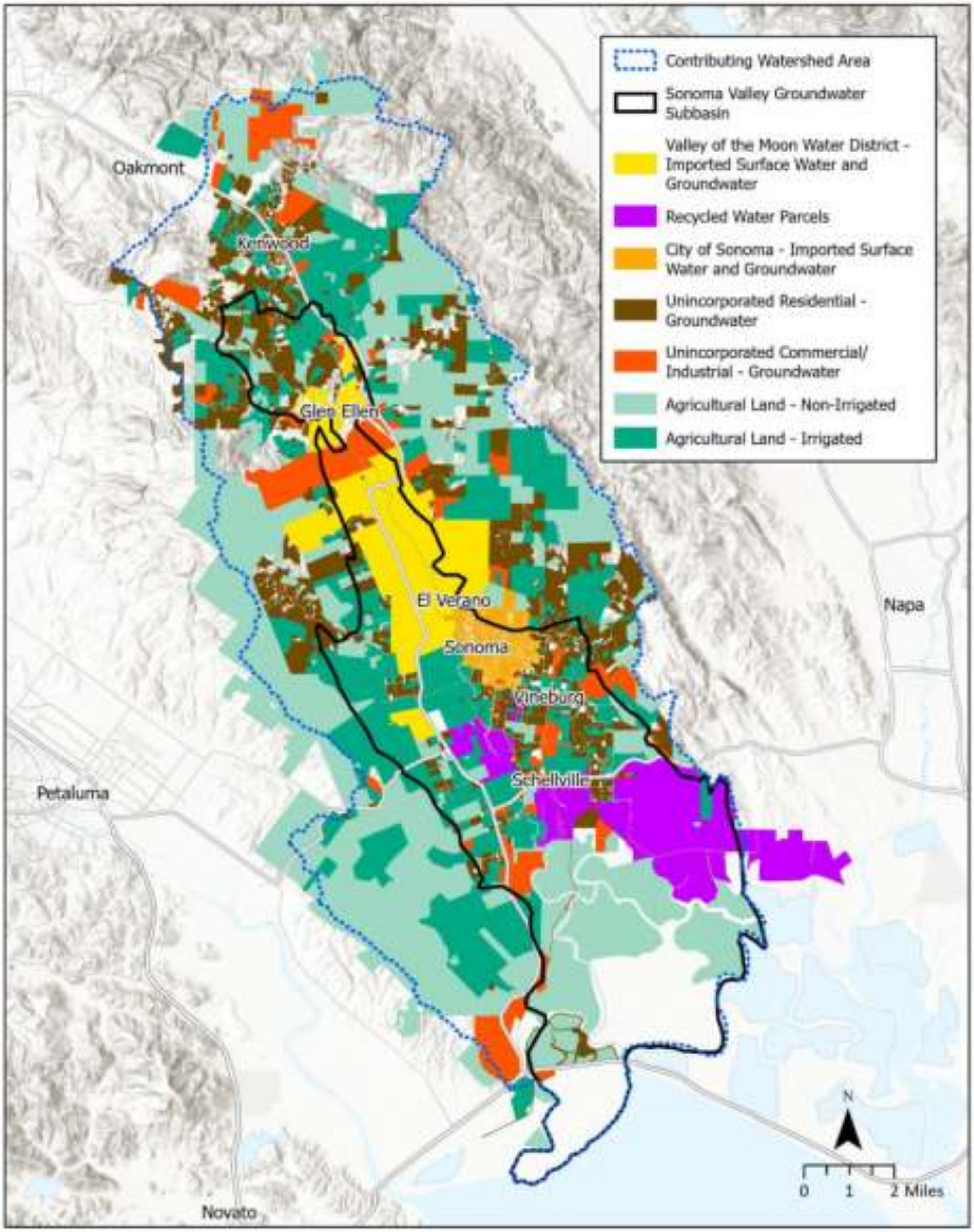

Figure ES-3. Water Sector and Land Use

ES.3 Subbasin Setting

Section 3 describes the Subbasin setting based on existing studies related to geology, climate, and historical groundwater conditions.

ES.3.1 Hydrogeologic Conceptual Model

The hydrogeologic conceptual model (HCM) characterizes the physical components of the surface water and groundwater systems, regional hydrology, geology, water quality, and principal aquifers and aquitards. The Subbasin is bordered by northwest trending faults that can impede, enhance, or redirect groundwater flow **(Figure ES-4).** Groundwater resources are variable throughout the Subbasin, with wells in lower-yielding geologic formations producing from 2 to 20 gallons per minute (gpm) and wells completed in some areas of the highest-yielding areas producing more than 100 gpm. The productive freshwater aquifers generally occur at shallower depths, where many residential wells are drilled. Municipal, industrial, and agricultural wells are constructed in both the shallow and deeper aquifer, with the Subbasin's deepest wells extending to approximately 1,200 feet and no known existing wells extending deeper than 1,500 feet.

In general, groundwater flows from the highlands to the valley axis turning south toward San Pablo Bay. The aquifer system is recharged primarily through precipitation infiltrating on the valley floor, along the Subbasin mountain fronts, and through streambed recharge along Sonoma Creek and its tributaries, providing water to the shallow aquifer on an annual basis. Deeper recharge occurs much more slowly, as evidenced by field tests and studies conducted in the Subbasin. For implementing SGMA, two principal aquifer systems are described: the shallow and deep aquifer systems. The properties and features that are the basis for grouping into shallow and deep aquifer systems include the degree of surface water connectivity, degree of confinement, and responses to hydraulic stresses such as recharge and pumping. Although the deep and shallow aquifer systems are grouped separately, the boundary between the shallow and deep aquifer systems is not a distinct boundary to groundwater flow.

The shallow aquifer system generally is separated from the underlying deep aquifer system by a sequence of discontinuous clay layers. The shallow aquifer system generally exhibits stable long-term groundwater levels. In many areas, the shallow aquifer system is locally and seasonally connected to Sonoma Creek and other tributaries within the Subbasin, and wells completed in the shallow aquifer system near streams show sharp seasonal increases in groundwater levels that correlate closely with precipitation and runoff.

The deep aquifer system is not spatially connected to surface water (although hydraulic connections between the shallow and deep aquifers do provide for hydraulic connectivity between surface water and the deep aquifer). In southern Sonoma Valley, many wells completed within the deep aquifer system have exhibited long-term declining groundwater levels.

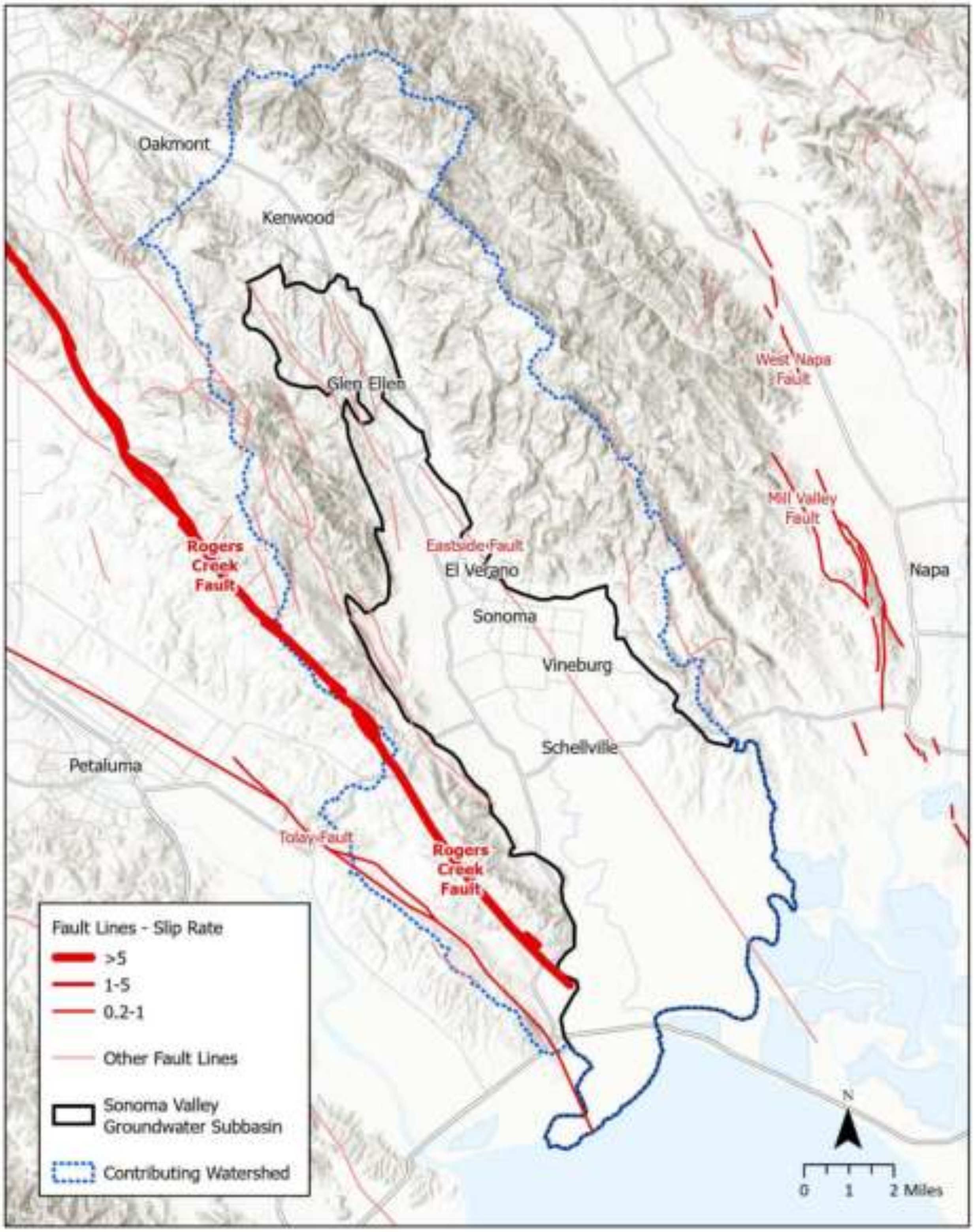

Figure ES-4. Fault Lines

Primary data gaps in the HCM include the geometry and properties of aquifer and aquitards, the origin and extent of brackish water in parts of the Subbasin, and how faults Subbasin, particularly the Eastside Fault, affect groundwater flow. Additionally, more data are needed to better understand groundwater recharge and discharge mechanisms in the Subbasin, including surface water-groundwater interactions and the amount and location of groundwater extractions.

ES.3.2 Current and Historical Groundwater Conditions

SGMA requires GSAs to evaluate groundwater conditions using six indicators of groundwater sustainability: groundwater levels, groundwater in storage, groundwater quality, land subsidence, seawater intrusion, and interconnected surface water and groundwater. In **Section 3**, previous studies, monitoring well data, and data from other monitoring networks are used to describe current and historical groundwater conditions for these six sustainability indicators.

Groundwater Levels: Groundwater levels for the majority of shallow aquifer wells are generally stable and predominantly above sea level. There are two persistent groundwater pumping depressions in the deep aquifer system in southern Sonoma Valley. Southeast of the City of Sonoma (and primarily east of the Eastside Fault), measured groundwater levels are as deep as 126 feet below mean sea level (msl) and southwest of El Verano groundwater levels are as deep as 28 feet below msl in the deep aquifer system. Declining groundwater levels have persisted and expanded in some portions of these areas. Most of the declines are considered likely to have resulted from increased local groundwater extraction.

Groundwater storage: The groundwater budget (described in a later section) finds that the amount of groundwater stored in the aquifers is declining on average by about 900 acre-feet per year (AFY).

Land Surface Subsidence: Existing data from both Interferometric Synthetic-Aperture Radar (InSAR) and global positioning system (GPS) stations do not indicate that inelastic (irrecoverable) land subsidence is occurring as a result of groundwater pumping. Small, measured changes in land surface elevation (between -0.05 to -0.08 inch annually) appear to reflect variations observed regionally.

Groundwater Quality: Groundwater quality monitoring performed throughout the Subbasin for numerous different studies and regulatory programs finds that groundwater quality is generally adequate to support existing beneficial uses. Groundwater quality is naturally poor in some local areas, related to the brackish waters of San Pablo Bay and tidal marshland areas, hydrothermal fluids associated with portions of the Sonoma Volcanics and/or fault zones, and deep connate waters related to ancient seawater. There are some locally limited human-caused impacts on groundwater quality from land-use activities, such as agriculture, commercial, industrial, septic systems, and wastewater treatment facilities.

Seawater Intrusion: The seawater/freshwater interface likely occurs beneath the tidal marshlands near the Subbasin’s boundary with San Pablo Bay. Limited data indicate possible inland movement of brackish water. However, the limited data make it difficult to discern whether potential groundwater quality changes are due to either the distribution of monitored wells over different timeframes and/or the presence of older connate or thermal water sources.

Interconnected Surface Water and Groundwater: Multiple years of measuring streamflow at different locations combined with high-frequency groundwater monitoring provide evidence of the connection between groundwater and Sonoma Creek and its primary tributaries. In addition, analysis of environmental beneficial users by a practitioners' working group identified aquatic species and habitats that could be adversely affected by the depletion of interconnected surface water caused by groundwater pumping. More data are needed from monitoring wells near creeks and from stream gages to determine the specific impacts of groundwater pumping on surface water and on these groundwater dependent ecosystems.

ES.3.3 Groundwater Flow Model

A computerized numerical groundwater flow model, the Sonoma Valley Integrated Groundwater Flow Model (SVIGFM V2), developed by Sonoma Water and used as a groundwater management tool calculates groundwater flows into and out of the Subbasin (**Figure ES-5**). The model accounts for precipitation, surface water, and groundwater entering the Subbasin through runoff, streams, septic systems, and other sources; and surface water and groundwater leaving the basin through evapotranspiration, streams, pumping, diversions, and other means.

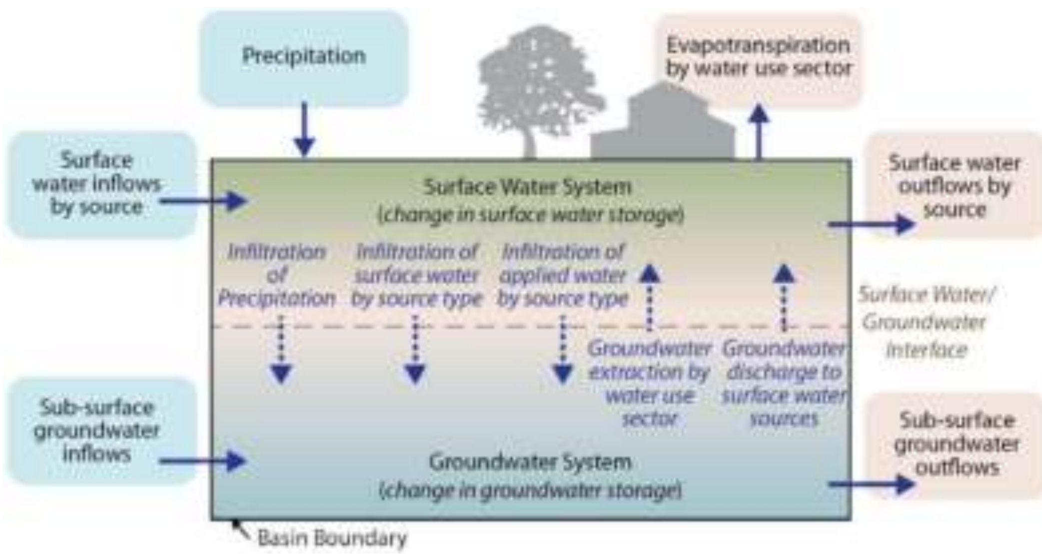

Figure ES-5. Conceptual Groundwater Budget

ES.3.4 Projected Future Basin Conditions, Land Use, and Climate Change

Sustainability in the Subbasin must be achieved and maintained even as conditions—including land use and climate—change.

Assumptions for future projected land use changes and water demands are estimated for rural-residential groundwater pumping, municipal demands, and agricultural land use. Two practitioner workgroups, and stakeholder surveys and input from the Advisory Committee, helped develop the model data used to project future conditions.

The Sonoma Valley GSA chose one potential climate change scenario to limit the number of model simulations and to provide better comparability between various potential projects and actions. The climate change scenario HadGEM2-ES RCP 8.5 simulation provides for several very dry years through 2025, normal and wetter years through 2050, and then a long-term drought after the mid-twenty-first century. This climate scenario allows for a significant stress test for groundwater resources planning during the GSP implementation horizon. The SVIGFM V2 was modified to simulate the 1-in-200 change (0.5 percent probability) sea level rise trajectory, which results in a projected sea level rise of 3.5 feet by the end of the projected 50-year model simulation. As part of its adaptive approach to groundwater management, the GSA anticipates revising and updating climate projections as part of the 5-year update.

ES.3.5 Water Budget

The water budget was developed using SVIGFM V2. The water budget provides an accounting and assessment of the total annual volume of surface water and groundwater entering and leaving the basin and the change of the volume of groundwater in storage under historical, current, and projected water budget conditions.

Figure ES-6 illustrates the major sources of groundwater inflows and outflows. Overall, 2012-2018 groundwater outflows are larger than inflows, resulting in a loss of groundwater in storage of about 900 AFY. As shown in **Table ES-1**, this loss in storage increased from an average decline of about 300 AFY in the historical period (1971-2018).

This is due to a combination of increased groundwater pumping and the drier climate, including the 2014-2016 drought, in the current period.

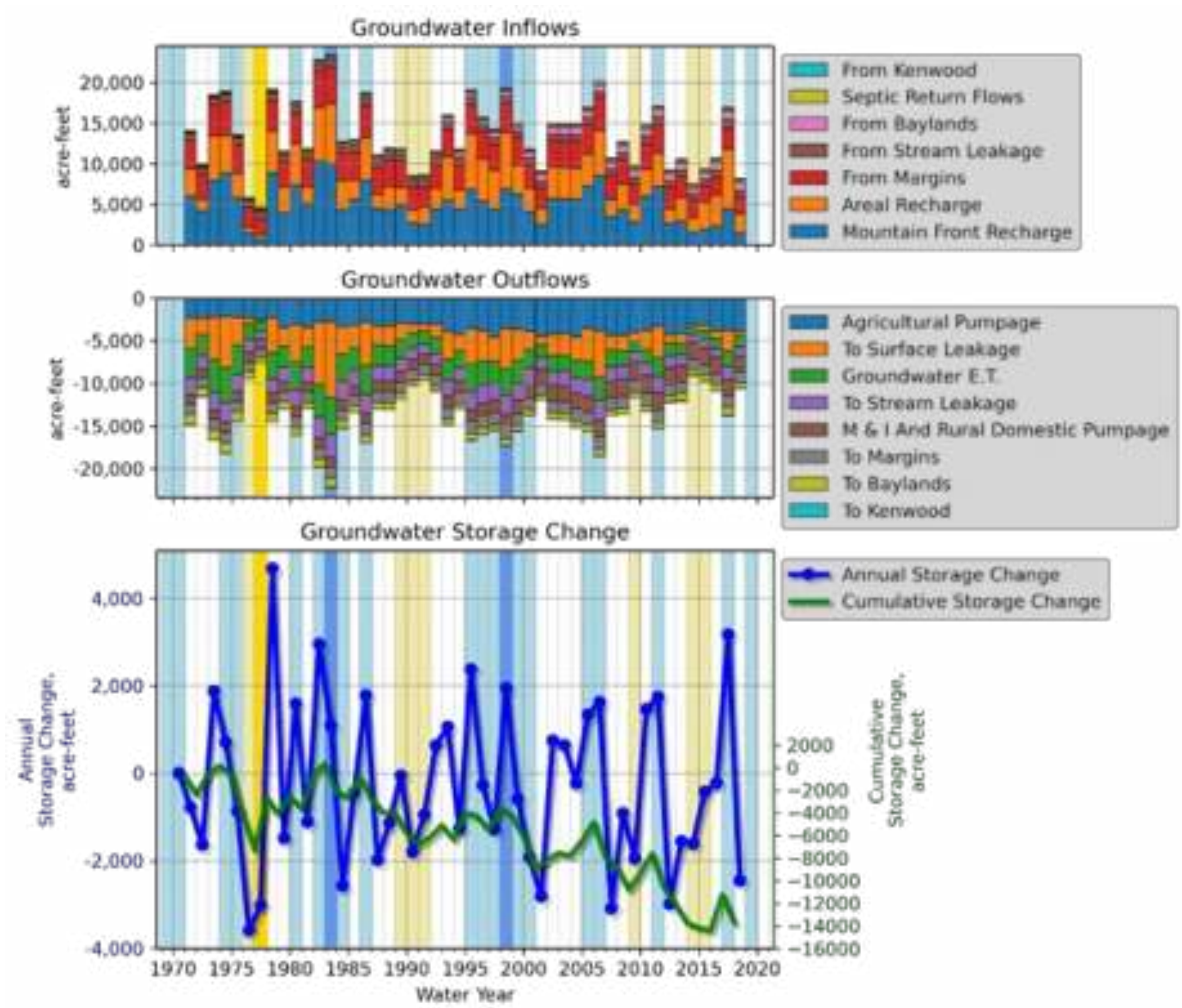

Figure ES-6. Groundwater Inflows and Outflows

The projected water budget covers the water years 2021-2070. Over this period, cumulative groundwater in storage has a modest decline from 2021 through 2050, with stable or even brief increases in groundwater storage associated with wet and very wet periods in the projected climate. The projected climate includes an extended drought beginning in 2050. As a result, the rate of groundwater lost from storage is greater from 2050 through 2070 (a cumulative loss of about 13,000 acre-feet) than during 2021 through 2050 (a cumulative loss of about 8,000 acre-feet). The total cumulative storage loss between 2021 and 2070 is projected to be 21,000 acre-feet with the climate change projections and assumed water demand increases. **Table ES-1** summarizes the historical, current, and projected annual changes in groundwater storage for the Subbasin.

Table ES-1. Average Changes in Groundwater Storage in Sonoma Valley Subbasin

Water Budget Periods	
Average, Historical Period (1971-2018)	-300
Average, Current Period (2012-2018)	-900
Future Period	
Average (2021-2070)	-300

ES.3.6 Sustainable Yield

The sustainable yield of the Subbasin is an estimate of the quantity of groundwater that can be pumped on a long-term average annual basis without causing undesirable results. Basin-wide pumping within the sustainable yield estimate is neither a measure of, nor proof of, sustainability.

The sustainable yield for the Subbasin is estimated to be approximately 5,400 AFY. This value is higher than the estimated historical average Subbasin-wide groundwater pumping of 4,900 AFY. However, both the current average of 5,700 AFY and the annual average projected pumping for the 50-year period from 2021 to 2070 of 6,500 AFY exceeds the sustainable yield, indicating that projects and management actions are needed to sustainably manage the Subbasin and avoid potential future undesirable results, as described in **Section ES-6**.

ES.4 Sustainable Management Criteria

SGMA provides specific language and criteria for establishing and maintaining groundwater sustainability, including the development of a sustainability goal, which Sonoma Valley GSA defines as follows:

The goal of this GSP is to adaptively and sustainably manage, protect, and enhance groundwater resources while allowing for reasonable and managed growth through:

- Careful monitoring of groundwater conditions
- Close coordination and collaboration with other entities and regulatory agencies that have a stake or role in groundwater management in the Subbasin
- A diverse portfolio of projects and management actions that ensure clean and plentiful groundwater for future uses and users in an environmentally sound and equitable manner

Central to SGMA is the development of sustainable management criteria (SMC) for six sustainability indicators, depicted on **Figure ES-7.** The Sonoma Valley GSA identified undesirable results, minimum thresholds (MTs), measurable objectives (MOs), and interim milestones for the sustainability indicators as discussed in GSP **Sections 4.4** through **4.10**. The six sustainability indicators required by SGMA are listed on **Figure ES-7** with a summary of what the GSA considers significant and unreasonable conditions for each indicator. **Table ES-2** provides the SMC for all sustainability indicators.

Figure ES-7. Sustainability Indicators

Chronic Lowering of Groundwater Levels: Chronic lowering of groundwater levels that significantly exceed historical levels or cause significant and unreasonable impacts on beneficial users.

Reduction in Groundwater Storage: Reduction of groundwater storage that causes significant and unreasonable impacts on the long-term sustainable beneficial use of groundwater in the basin, as caused by either:

- Long-term reductions in groundwater storage
- Pumping exceeding the sustainable yield

Seawater Intrusion: Seawater intrusion inland of areas of existing brackish groundwater that may affect beneficial uses of groundwater is significant and unreasonable.

Degraded Groundwater Quality: Significant and unreasonable water quality conditions occur if an increase in the concentration of constituents of concern (arsenic, nitrates, and salinity) in groundwater leads to adverse impacts on beneficial users or uses of groundwater, due to either:

- Direct actions by Sonoma Valley GSP projects or management activities
- Undesirable results occurring for other sustainability indicators

Land Surface Subsidence: Any rate of inelastic land subsidence caused by groundwater pumping is a significant and unreasonable condition, everywhere in the basin and regardless of beneficial uses and users.

Depletion of Interconnected Surface Water: Significant and unreasonable depletion of surface water from interconnected streams occurs when surface water depletion, caused by groundwater pumping within the Subbasin, exceeds historical depletion or adversely impacts the viability of groundwater dependent ecosystems (GDEs) or other beneficial users of surface water.

Table ES-2. Sustainable Management Criteria

Sustainability Indicator	Significant and Unreasonable Statement	Minimum Threshold	Measurement	Measurable Objective	Undesirable Result
Chronic Lowering of Groundwater Levels	Chronic lowering of groundwater levels that significantly exceed historical levels or cause significant and unreasonable impacts on beneficial users.	**Stable Wells:** Maintain near historical observed ranges while accounting for future droughts and climate variability. Metric: Historical low elevations minus four-year drought assumption. **Wells with Declining Trends:** Maintain above historical low elevations and protect at least 98 percent of nearby water supply wells. Metric: Shallower (more protective) of historical low elevations OR above the 98th percentile of nearby water supply well depths.	Monthly or monthly averaged groundwater levels measured at RMP wells.	**Stable Wells:** Maintain within historical observed ranges. Metric*:* Historical median spring groundwater elevation. **Wells with Declining Trends:** Recover groundwater levels to historical groundwater elevations prior to 2010. Metric*:* Historical (pre-2010) median spring groundwater elevation.	20% of RMPs exceed MT for 3 consecutive years.
Reduction in Groundwater Storage	Reduction of groundwater storage that causes significant and unreasonable impacts on the long-term sustainable beneficial use of groundwater in the Subbasin, as caused by: • Long-term reductions in groundwater storage • Pumping exceeding the sustainable yield	Measured using groundwater elevations as a proxy. MT for groundwater storage is identical to the MT for Chronic Lowering of Groundwater Levels.	Annual groundwater storage will be calculated and reported by comparing changes in contoured groundwater elevations. However, monitoring for the Chronic Lowering of Groundwater Levels will be used to compare with MT and MOs.	MO for groundwater storage is identical to the MO for Chronic Lowering of Groundwater Levels.	The undesirable result for groundwater storage is identical to the undesirable result for Chronic Lowering of Groundwater Levels.

Sustainability Indicator	Significant and Unreasonable Statement	Minimum Threshold	Measurement	Measurable Objective	Undesirable Result
Seawater Intrusion	Seawater intrusion inland of areas of existing brackish groundwater that may affect beneficial uses of groundwater is a significant and unreasonable condition.	The 250 mg/L chloride isocontour located in an area that is protective of beneficial users of groundwater. This MT isocontour is initially located between the currently approximate 250 mg/L isocontour (inferred interface of brackish groundwater) and beneficial users of groundwater (known water wells supplying beneficial users). This MT will need to be reassessed during early stages of GSP implementation once additional monitoring data and information are available, as the initial location is selected from very limited available data.	The chloride isocontour will be developed based on chloride concentrations measured in groundwater samples collected from an RMP network, which will be developed during the early stages of GSP implementation.	The 250 mg/L chloride isocontour at the currently inferred interface of brackishgroundwater (i.e., current conditions).	When two conditions are met: (1) 3 consecutive years of MT exceedances <u>and</u> (2) the MT exceedance is caused by groundwater pumping.
Subsidence	Any rate of inelastic subsidence caused by groundwater pumping is a significant and unreasonable condition, everywhere in the Subbasin and regardless of the beneficial uses and users.	0.1 foot per year of total subsidence.	DWR-provided InSAR dataset average annual subsidence for each 100 meter by 100-meter grid cell.	The MO is identical to the MT (0.1 foot per year of subsidence).	Annual MT of 0.1 foot total subsidence is exceeded over a minimum 50-acre area <u>or</u> Cumulative total subsidence of 0.2 foot is exceeded within 5-year period <u>and</u> MT exceedance is determined to be correlated with: (1) groundwater pumping, (2) an MT exceedance of

Sustainability Indicator	Significant and Unreasonable Statement	Minimum Threshold	Measurement	Measurable Objective	Undesirable Result
					the Chronic Lowering of GWLs SMC (that is, groundwater levels have fallen below historical lows).
Degraded water quality	Significant and unreasonable water quality conditions occur if an increase in the concentration of constituents of concern in groundwater leads to adverse impacts on beneficial users or uses of groundwater, due to: • Direct actions by Sonoma Valley GSP projects or management activities. • Undesirable results occurring for other sustainability indicators.	The MT is based on one additional supply well exceeding the applicable maximum contaminant level for (1) arsenic, (2) nitrate, or (3) salts (measured as TDS).	The number of public water supply wells with annual average concentrations of arsenic, nitrate, or TDS that exceed maximum contaminant levels in groundwater quality data available through State data sources.	The MO is based on zero additional supply wells exceeding the applicable maximum contaminant level for (1) arsenic, (2) nitrate or (3) salts (measured as TDS).	An undesirable result occurs if, during 2 consecutive years, a single groundwater quality MT is exceeded when computing annual averages at the same well, as a direct result of projects or management actions taken as part of GSP implementation.

Sustainability Indicator	Significant and Unreasonable Statement	Minimum Threshold	Measurement	Measurable Objective	Undesirable Result
Depletion of interconnected surface water	Significant and unreasonable depletion of surface water from interconnected streams occurs when surface water depletion, caused by groundwater pumping within the Subbasin, exceeds historical depletion or adversely impacts the viability of GDEs or other beneficial users of surface water.	Maintain estimated streamflow depletions below historical maximum amounts. **Metric:** Shallow groundwater elevations are used as a proxy for stream depletion. The MT is the equivalent groundwater level, representing the 3 years (2014-2016) during which the most surface water depletion due to groundwater pumping was estimated between 2004-2018.	Monthly averaged groundwater levels measured in representative monitoring points (shallow monitoring wells near interconnected surface water).	The MO is to maintain groundwater levels within historical observed ranges. **Metric:** Mean groundwater level for available dry-season observations between 2004 and 2020.	Undesirable result occurs if MTs are exceeded at 40 percent of RMP wells during drought years and 10 percent of RMP wells during non-drought years.

mg/L = milligram(s) per liter

RMP = representative monitoring point

TDS = total dissolved solids

ES.5 Monitoring Networks

SGMA requires monitoring networks to quantitatively measure Subbasin health and the GSA's progress in meeting or maintaining sustainability. **Section 5** describes the monitoring networks that are planned in the Subbasin and in the contributing watershed area. The section also discusses how the existing monitoring networks described in **Section 2** were evaluated and refined.

The purpose of the monitoring networks is to demonstrate progress toward achieving MOs, monitor impacts on groundwater users and uses, monitor changing groundwater conditions, and quantify changes in the water budget.

Components of Sustainable Management Criteria

Sustainability Goal: A succinct statement of the GSA's objectives and desired conditions and how the basin will achieve these conditions.

Significant and Unreasonable Condition: A qualitative statement regarding conditions that should be avoided.

Undesirable Results: A quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the Basin or Subbasin.

Minimum Thresholds: The quantitative values that reflect what is significant and unreasonable at every measuring site.

Measurable Objectives: Specific, quantifiable goals at each representative monitoring site to maintain or improve groundwater conditions to maintain or achieve the sustainability goal for the basin.

Representative Monitoring Sites: These are typical monitoring sites within the broader network of sites that reliably provide high-quality data that characterize groundwater conditions in the basin.

RMP networks are a subset of the larger monitoring network and are described in detail in **Section 5**. Representative monitoring points within the RMP network are wells where sustainability indicators are monitored. **Table ES-3** describes the monitoring network and the subset of RMP for each sustainability indicator, and **Figures ES-8 and ES-9** illustrate the RMP network for the chronic lowering of shallow and deep groundwater levels, respectively.

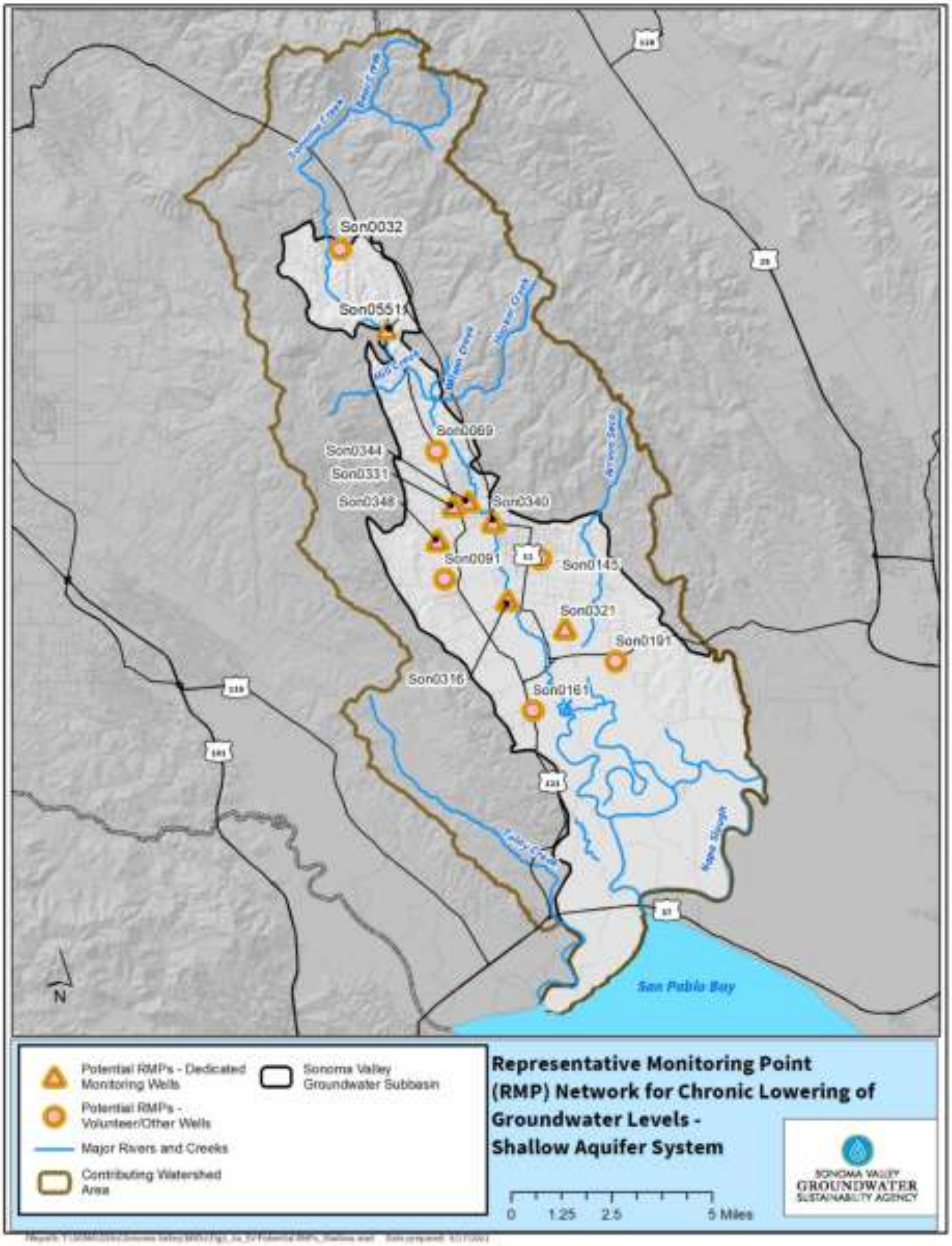

Figure ES-8. Representative Monitoring Points Network for Groundwater Levels, Shallow Aquifer System

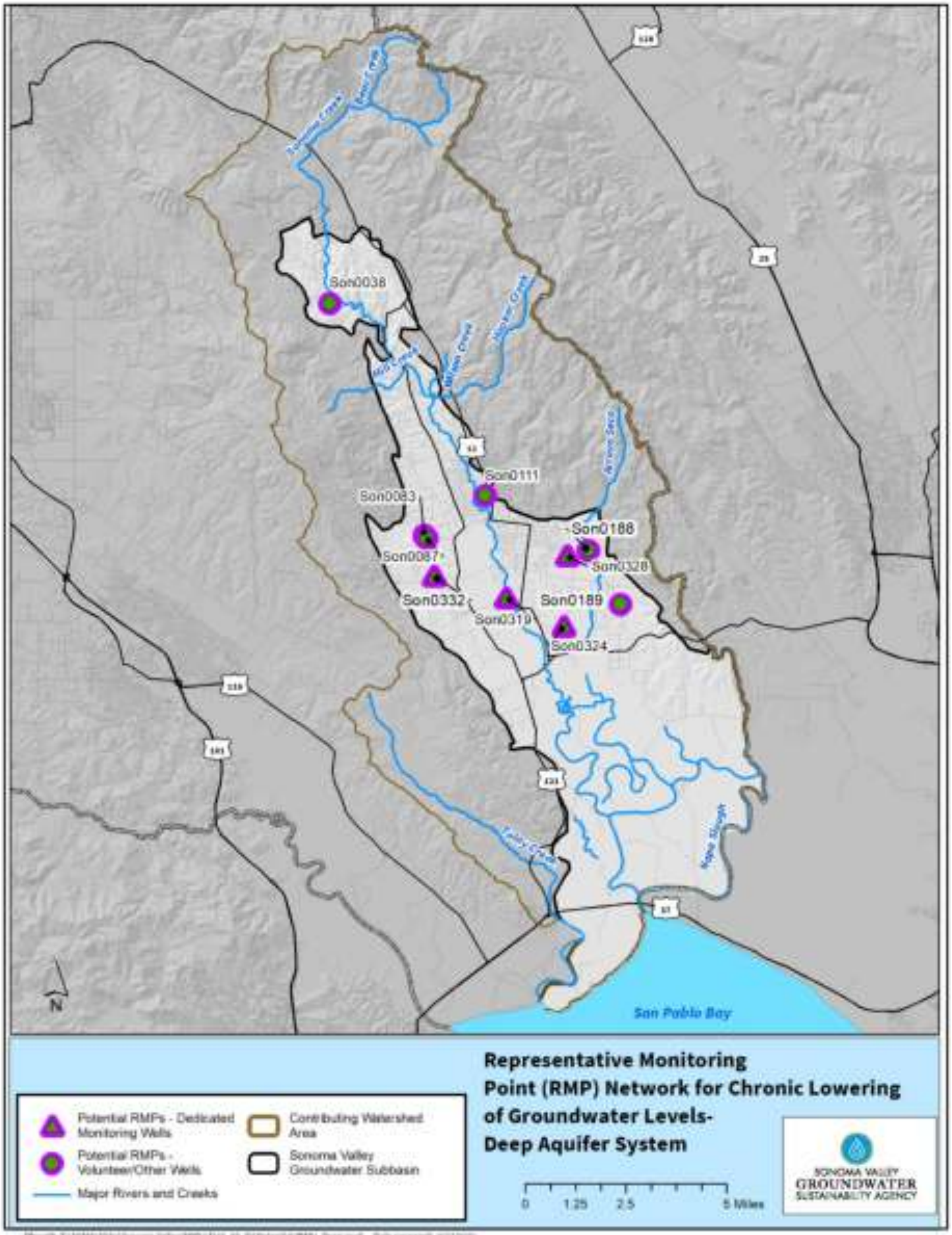

Figure ES-9. Representative Monitoring Points Network for Groundwater Levels, Deep Aquifer System

Table ES-3. Monitoring Networks and Initial Representative Monitoring Point Networks

Sustainability Indicator	Monitoring Network	Initial Representative Monitoring Point Network
Chronic Lowering of Groundwater levels	107 wells within the contributing watershed area (including 66 wells in the Subbasin) 53 wells are in the shallow aquifer 54 wells in the deep aquifer	13 wells screened within the shallow aquifer 10 wells screened primarily within the deep aquifer
Reduction in Groundwater Storage	107 wells within the contributing watershed area (including 66 wells in the Subbasin) 53 wells are in the shallow aquifer 54 wells in the deep aquifer	13 wells screened within the shallow aquifer 10 wells screened primarily within the deep aquifer
Seawater Intrusion	Within 1 mile of Baylands: 9 water supply wells; 1 dedicated monitoring well	Within 1 mile of Baylands: 9 water supply wells; 1 dedicated monitoring well
Degraded Water Quality	Existing supply well groundwater quality monitoring programs, as follows: Arsenic: 25 wells Nitrate: 40 wells Salts: 13 wells	Existing supply well groundwater quality monitoring programs, as follows: Arsenic: 25 wells Nitrate: 40 wells Salts: 13 wells
Land Surface Subsidence	3 GPS locations; InSAR satellite in most of the Subbasin	InSAR dataset
Interconnected Surface Water	5 stream gages; 17 shallow monitoring wells adjacent to streams; annual and monthly seepage runs that measure streamflows at multiple sites over a shorter time period	10 shallow monitoring wells adjacent to streams

Section 5 also identifies the data gaps that exist in the monitoring networks and describes how these gaps will be filled during GSP implementation. While a DWR Technical Support Services grant for 12 new shallow monitoring wells near streams and DWR Proposition 68 grant funding for 4 new multilevel monitoring wells have helped address some data gaps, the early years of GSP implementation will specifically focus on filling additional data needs to better monitor interconnected surface water, seawater intrusion, and groundwater levels in specific areas, such as identified depletion areas.

ES.6 Projects and Management Actions

GSPs are intended to help communities achieve groundwater sustainability as defined by the SMC and based on current and projected future groundwater conditions. **Section 6** of the GSP identifies conceptual projects and management actions that avoid the undesirable results and unsustainable groundwater conditions described in **Section 4**, primarily regarding loss of groundwater storage and declines in groundwater levels that could also result in lower stream flows.

ES.6.1 Projects

Projects are grouped into three categories and modeled to determine the potential impact on groundwater storage, inflows of brackish water from the Baylands, and reductions in streamflow depletion. The groupings are as follows:

Group 1

- Voluntary reductions in rural domestic, agricultural, commercial, and industrial groundwater use through water conservation tools (such as appliance rebates and replacement, smart irrigation controllers, and water use audits), stormwater capture, and greywater use. The programs and education offered to groundwater users will mirror programs offered to regional municipal water users, which have led to a 37 percent reduction in per capita water use since 2010. Many grape growers already use drip irrigation and rely on new technologies to determine when and how much to irrigate vines. This program would be focused on leveraging existing best management practices and working with farmers who have not had access to or the resources available to reduce water use. For the purposes of simulating these projects using the model, it was assumed that these tools would result in a 20 percent reduction in rural domestic groundwater use and a 10 percent reduction in agricultural groundwater use. This project will also include an assessment within the first year of GSP implementation on the exact types of water use efficiency tools and alternate water source projects that are expected to be most effective and feasible for Subbasin stakeholders. While implementation of these projects is initially planned to be on a voluntary basis, the assessment will also identify specific metrics for evaluating the benefits of the projects and assess Subbasin conditions that may lead to mandatory implementation of demand management actions.
- Implementation of existing recycled water contracts by the Sonoma Valley County Sanitation District (SVCSD).

Group 2A and 2B

- Expansion of recycled water system to 8th Street East/Napa Road areas and from West Study Area to Sonoma Creek by SVCSD.
- Aquifer storage and recovery (ASR).
- This project entails using dedicated groundwater wells in reverse during the rainy season to store treated Russian River drinking water when it is available. A feasibility study found that even during drought years, there are periods when river flows are high enough to store water in aquifers for use during the summer, in droughts, or during emergencies.

- Implementation of stormwater recharge projects. The focus of this project is to temporarily capture local stormwater during high-flow events in detention basins or by spreading on farmlands during the dormant season, letting it slowly sink into the ground to recharge the shallow aquifer and provide baseflow to streams near streams.

The project groups were modeled incrementally, with the following results:

Undesirable Results for Groundwater Levels: The projects, cumulatively, are projected to raise groundwater levels 25 feet to 90 feet in the vicinity of the projects and to reduce the frequency of MT exceedances within the deep aquifer system. In the deep aquifer, MT exceedances that could lead to undesirable results are still projected to occur during 2 years of excessive drought conditions.

Groundwater Storage: While groundwater storage would continue to fluctuate annually, the addition of all three project groups is projected to reduce storage losses by approximately 220 AFY.

Subsurface Inflows from Baylands: Inflows of brackish water from the Baylands will occur as groundwater levels decline. The addition of all three project groups is projected to reduce brackish water inflow to from 400 AFY to 100 AFY, thereby reducing the potential for seawater intrusion from the Baylands.

Stream-aquifer Interaction: Higher groundwater levels near streams can better support streamflows, particularly in the summer and fall months. The addition of the three project groups is projected to increase the amount of groundwater discharging to streams by approximately 300 AFY of groundwater contributing to streamflow.

Considering current uncertainties due to modeling and project information, these project scenarios provide a pathway for reaching sustainability and preparing for future changed conditions in the Subbasin to meet GSP requirements and help mitigate against future extreme droughts. Additional data collection and project conceptualization during early phases of GSP implementation will help refine these scenarios and allow for consideration of additional scenarios, including mandatory restrictions on groundwater extractions, if necessary to achieve sustainability.

ES.6.2 Management Actions

In addition to the projects described above, the GSA will initiate the following management actions in the first year of GSP implementation.

<u>Study of and Prioritization of Potential Policy Options</u>: This management action involves a collaboration between the GSA Board, local land use agencies, GSA member agencies, other Sonoma County GSAs, and stakeholders to assess and prioritize future policy options that may be appropriate for the GSA to consider adopting or recommending for adoption by other agencies. This study will prepare a prioritized list of potential policy options, including stronger demand management actions that may need to be adopted should the projects described

above not be implementable or successful. Based on input from the Advisory Committee and GSA Board, the following initial list of policy options has been developed for potential inclusion in the assessment:

- Water conservation plan requirements for new development
- Discretionary review of well permits for any special areas identified in GSP
- Expand low impact development or water efficient landscape plan requirements
- Modifications to the County well ordinance to improve monitoring of the deep aquifer system in areas of known groundwater depletion
- Well construction and permitting recommendations (for example, water quality sampling/reporting for contaminants of concern, the requirement for water-level measurement access, and procedures for preventing cross-screening of multiple aquifers)
- Well metering program
- Study of water markets
- Permitting and accounting of water hauling

Coordination of Farm Plans with GSP Implementation: This management action involves a collaboration between the three Sonoma County GSAs and interested members of the agricultural community to evaluate the feasibility of developing a program that coordinates farm plans, developed at individual farm sites, with the implementation of the basin-wide GSP. This effort will identify areas of mutual interest (for example, improved water use efficiency, increased groundwater recharge, increased monitoring and data collection, coordinated information sharing, and reporting) and recommend standards, metrics, and incentives for the program.

ES.7 Plan Implementation

Section 7 describes how the GSA will implement the projects and management actions while monitoring groundwater conditions, reporting to DWR, closing data gaps, engaging with stakeholders, and managing the organization. The GSA will continue to conduct business in meetings open to the public, maintain an Advisory Committee of representative basin stakeholders to provide recommendations on implementation activities and actions, and hold periodic community meetings to inform and receive input from the community.

Planning for and permitting projects and management actions will begin immediately and will be completed within 5 years (the exception is planning for recycled water expansion in the western area and an ASR project in the Napa/Denmark roads area).

Group 1 projects and management actions are planned to be implemented by Sonoma Valley GSA and partner agencies and SVCSD by 2025. Group 2A and Group 2B projects have a longer planning horizon and are anticipated to be implemented within 10 years (**Figure ES-10**).

Sonoma Valley GSA administration, finances, stakeholder engagement, monitoring, and reporting are ongoing activities that will take place throughout GSP implementation.

ES.7.1 Estimated Implementation Costs

Section 7 provides a high-level budget for estimated costs over the initial 5 years of GSP implementation. Costs are based on the best estimates available and reflect Sonoma Valley GSA's understanding ofthe effort necessary for effective management and to comply with SGMA requirement for monitoring and reporting.

Costs are divided into the following categories: Administration and operations (including legal and grants); communication and stakeholder engagement; routine monitoring, data evaluation, and reporting; addressing data gaps; model maintenance, updates, and improvements; conceptual projects and planning design; and 5-year GSP update.

The mid-range budget projections for the first 5 years total about $5.9 million, averaging $1.2 million annually. Potential capital project costs total an additional $8.6 million (**Figure ES-11**).

ES.7.2 Funding Sources and Mechanisms

Currently, the six GSA member agencies annually contribute funding for operations, outreach, and GSP development. The Sonoma Valley GSA has successfully applied for and received more than $2 million in funding for GSP development and to help address data gaps. Grant funding through Proposition 68 and future state bond measures continue to be a critical source of revenue, particularly for closing data gaps and for project planning and implementation. In addition, Sonoma Valley GSA has initiated a funding study to identify local financing options moving forward, including possible groundwater user fees.

ES.8 References and Technical Studies

The final section of the GSP includes a complete list of references and technical studies that supported the development of this GSP.

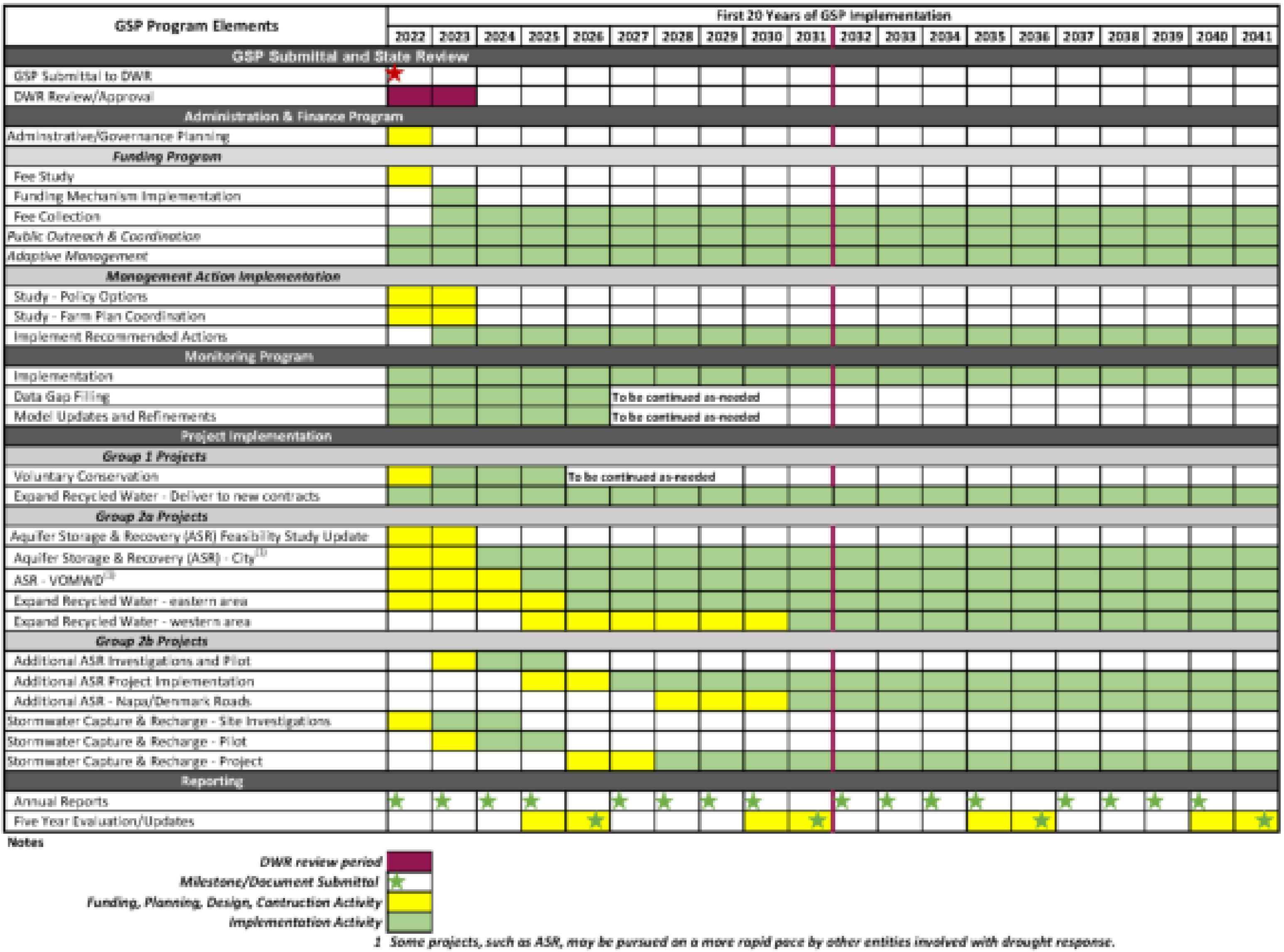

Figure ES-10. GSP Implementation Schedule

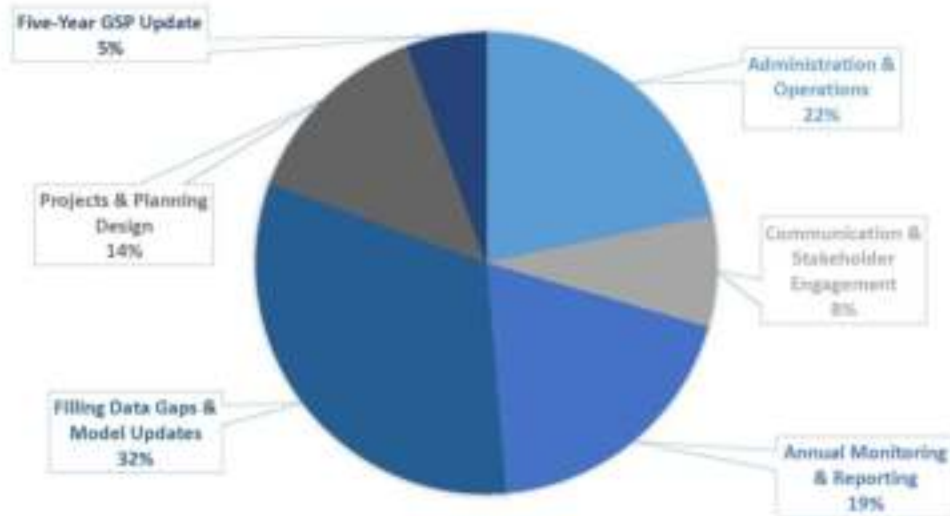

Figure ES-11. Average Budget Allocation for First 5 Years of GSP Implementation

DRAFT
Section 1: Introduction
Groundwater Sustainability Plan for Sonoma Valley Groundwater Subbasin

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1 INTRODUCTION

In 2014, the State of California enacted the Sustainable Groundwater Management Act (SGMA), which substantially changes the way groundwater is managed in California. This law requires groundwater basins and subbasins in California designated as critically overdrafted, high-, or medium-priority by the California Department of Water Resources (DWR) under SGMA to be managed sustainably.[1] Satisfying the requirements of SGMA generally involves four basic activities that must be completed by local agencies:

1) Forming one or more Groundwater Sustainability Agencies (GSAs) to fully cover the SGMA high- or medium-priority basin/subbasin

2) Developing one or multiple Groundwater Sustainability Plans (GSPs) that fully cover the SGMA high- or medium-priority basin/subbasin

3) Implementing the GSP and managing to achieve quantifiable objectives and sustainability within 20 years of GSP adoption

4) Regularly reporting data and GSP progress to DWR.

The Sonoma Valley Groundwater Subbasin (Subbasin), designated as basin number 2-002.02 in DWR's Bulletin No. 118 (DWR 2016a) and shown on **Figure 1-1**, is categorized as a high-priority basin by DWR (DWR 2020) and is, therefore, required to comply with SGMA and prepare a GSP.

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[1] DWR prioritizes groundwater basins as critically overdrafted, high-, medium-, low-, and very low-priority based on a variety of technical factors. Refer to https://water.ca.gov/Programs/Groundwater-Management/Basin-Prioritization.

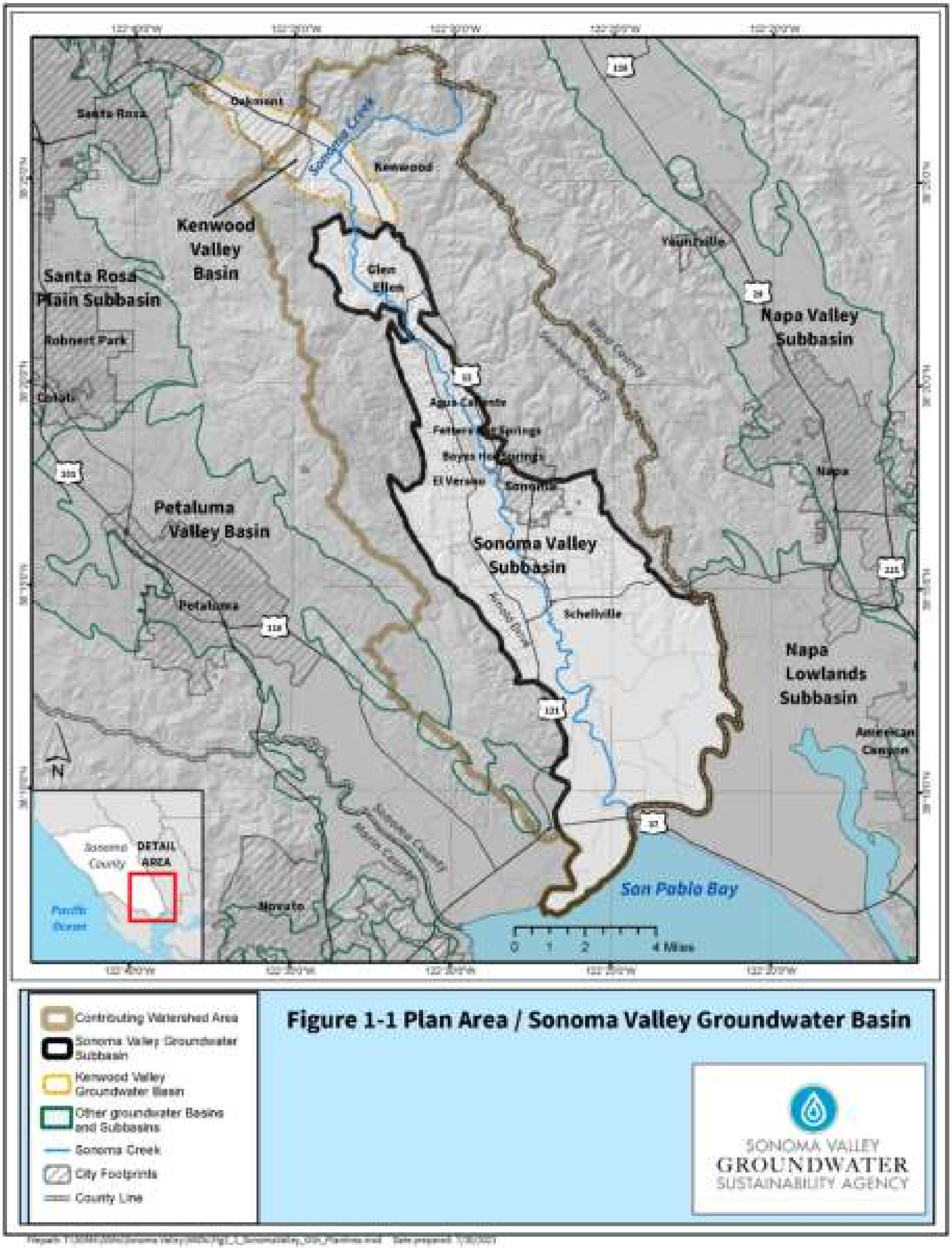

Figure 1-1. Plan Area/Sonoma Valley Groundwater Basin

1.1 Purpose of Groundwater Sustainability Plan

The purpose of this document is to fulfill the GSP requirement and present a path for sustaining groundwater resources in the Subbasin pursuant to the provisions of SGMA. Primary objectives addressed by this GSP are to:

- Meet the requirements of SGMA and DWR's GSP Emergency Regulations (GSP Regulations) by establishing criteria and management actions that will achieve and maintain sustainable groundwater management in the Subbasin within 20 years of GSP adoption, with a particular focus on addressing long-term and chronic declining groundwater levels identified within the deeper confined aquifers of the southern Sonoma Valley Subbasin.
- Incorporate the best available scientific and technical information by building on the strong technical foundation established through previous technical studies and voluntary groundwater management activities in Sonoma Valley.
- Integrate the perspectives and interests of the many diverse users and uses of groundwater resources within the Subbasin through a process that provides opportunity for significant public and community engagement.
- Leverage the limited available funding and local resources through continued regional coordination and information sharing with other local entities and GSAs.

The development of this GSP benefits from a long history of collaborative groundwater management and water-resource planning by local stakeholders, which had focused on addressing groundwater sustainability issues in the Subbasin prior to the passage of SGMA.

The purpose of the GSP is not to tackle water supply risk and resilience issues or prepare emergency response plans for community drinking water systems. The America's Water Infrastructure Act of 2018 requires community drinking water systems to develop or update risk assessments and emergency response plans to identify vulnerabilities, including malevolent acts and natural disasters, such as floods and droughts, that may potentially threaten the ability of community water systems to deliver safe drinking water.

The Sonoma Valley GSA, in collaboration with Sonoma Water, other Sonoma County GSAs, and local water suppliers, has and will continue to provide information to the local community on the severe multiyear drought occurring during the preparation of this GSP and other droughts in the future, including, but not limited to:

- News releases on the status of historically low surface water reservoir supplies
- Messaging to encourage communities to change everyday habits and adapt to eliminate water waste, conserve and reduce water usage
- Participate in public workshops on drought conditions and what the community can do to help address this issue

The GSAs do have the authority to mandate conservation and manage extractions but ultimately cannot affect water rights under SGMA.

1.2 Guide to the Groundwater Sustainability Plan

The Sonoma Valley GSP is organized sequentially, starting with a high-level overview of the Subbasin (**Section 2**), and drilling into more details on hydrology, geology, and the current and projected groundwater conditions (**Section 3**). A discussion of what sustainability means locally is provided in **Section 4**, and **Section 5** details how sustainability will be monitored over time. **Sections 6** (Projects and Management Actions) and **7** (Implementation Plan) describe how sustainability will be achieved. Each section builds on the prior section and contributes to the reader's understanding of the issues facing the Subbasin and the proposed solutions.

This document is composed of the following sections:

- **Front Matter** – This includes a table of contents that can help readers locate specific plan components, and a list of acronyms and abbreviations that can help readers navigate arcane water lingo.
- **Executive Summary** – A brief overview of the GSP, providing high-level information about the Subbasin, sustainability goals, and how the GSP will be implemented.
- **Section 1, Introduction** – Basic administrative information about the GSA, its composition and authorities, and how it communicates with and engages stakeholders.
- **Section 2, Plan Area** – A description of the Subbasin, including jurisdictions, land uses, water uses, and well permitting.
- **Section 3, Basin Settin**g – A detailed overview of the Subbasin, including its physical setting, climate, the hydrogeologic conceptual model (which includes the factors that describe and effect its hydrology, such as geologic features, aquifer, and aquitards), current and historical groundwater conditions, the current and projected water budget, and management areas.
- **Section 4, Sustainable Management Criteria** – This section describes proposed management criteria for each of SGMA's six sustainability indicators: groundwater levels, groundwater storage, water quality, land subsidence, seawater intrusion, and surface water depletion.
- **Section 5, Proposed Monitoring Plan** – The Sustainable Management Criteria (SMC) described in **Section 4** are quantifiable and are measured over time. This section describes the current monitoring network and proposed enhancements needed to accurately monitor data into the future.
- **Section 6, Projects and Management Action**s – This section describes and ranks projects and actions that could be used to achieve or maintain sustainability by 2042.

- **Section 7, Implementation Pla**n – This section describes how the GSP will be implemented over time, including a draft, high-level budget and potential funding sources.
- **Section 8, References** – This section provides a list of all documents cited in this GSP.
- **Appendices** – The appendices to this report provide a wealth of additional information.

Tables 1-1 and 1-2 provide a detailed list of the DWR-required GSP components from the GSP Regulations and SGMA statutes, respectively.

Table 1-1. Cross-Reference of GSP Regulations and GSP Section Numbers

Sub-article	Section	Paragraph	Requirement	GSP Section
1. Administrative Information	354.4. General Information	(a)	Executive summary	00
		(b)	List of references and links to technical studies	Appendices
	354.6. Agency Information	-	Agency information pursuant to CWC Section 10723.8 (notification of GSA formation to DWR), along with:	1.2 and Appendices
		(a)	Agency name and mailing address	1.2
		(b)	Agency organization and management structure, persons with management authority for GSP implementation	1.2
		(c)	GSP manager name and contact information	1.2
		(d)	Legal authority of agency	1.2
		(c)	Estimate of GSP implementation costs and description of how agency plans to meet costs	7
	354.8. Description of Plan Area	(a)	Maps of GSP area	Figure 2-1
		(b)	Written description of GSP area	2.1
		(c)-(d)	Identification of existing water-resource monitoring and management programs, and description of any such planned programs	2.4 and 2.5
		(c)	Description of conjunctive use programs	2.5
		(f)	Description of the land use elements or topic categories	2.6
		(g)	Description of additional GSP elements (CWC Section 10727.4)	2.7 and 2.8
	354.10. Notice and Communication	(a)	Description of the beneficial uses and users of groundwater in the subbasin	1.3
		(b)	List of public meetings	1.3
		(c)	Comments and responses regarding the GSP	Appendices
		(d)	Description of communication procedures	1.3

Sub-article	Section	Paragraph	Requirement	GSP Section
2. Basin Setting	354.12. Introduction to Basin Setting	-	Information about the basin setting (physical setting, characteristics, current conditions, data gaps, uncertainty)	3
	354.14. Hydrogeologic Conceptual Model	(a)	Description of the subbasin hydrogeologic conceptual model	3.1
		(b)	Summary of regional geologic and structural setting, subbasin boundaries, geologic features, principal aquifers, and aquitards	3.1
		(c)	Cross-sections depicting major stratigraphic and structural features	Figures 3-4
		(d)	Maps of subbasin physical characteristics	Figures 3-1 through 3-10
	354.16. Groundwater Conditions	(a)-(g)	Description of current and historical groundwater conditions, including: 1. Groundwater elevation 2. Change in storage 3. Seawater intrusion 4. Groundwater quality issues 5. Land subsidence 6. Interconnected surface water systems 7. Groundwater-dependent ecosystems	3.2
	354.17. Water Budget	(a)	Water budget providing total annual volume of groundwater and surface water entering and leaving the subbasin, including historical, current, and projected water budget conditions, and change in storage	3.3
		(b)-(f)	Development of a numerical groundwater and surface water model to quantify current, historical, and projected: 1. Total surface water entering and leaving by water source type 2. Inflow to the groundwater system by water source type 3. Outflows from the groundwater system by water use sector 4. Change in groundwater storage 5. Overdraft over base period 6. Annual supply, demand, and change in storage by water year type. 7. Estimated sustainable yield	3.3 and Appendices
	354.20. Management Areas	(a)	Description of management areas	3.4
		(b)	Describe purpose, minimum thresholds, measurable objectives, monitoring, analysis	NA
		(c)	Maps and supplemental information	NA

Sub-article	Section	Paragraph	Requirement	GSP Section
3. Sustainable Management Criteria	354.22. Introduction to Sustainable Management Criteria	-	Criteria by which an agency defines conditions that constitute sustainable groundwater management for the subbasin	4
	354.24. Sustainability Goal	-	Description of subbasin sustainability goal, including basin setting information used to establish the goal, sustainability indicators, discussion of measures to ensure the subbasin will be operated within its sustainable yield, and an explanation of how the sustainability goal is likely to be achieved and maintained	4
	354.26. Undesirable Results	(a)	Processes and criteria used to define undesirable results applicable to the subbasin	4
		(b)-(c)	Description of undesirable results, including cause of groundwater conditions and potential effects on beneficial uses and users of groundwater	4
	354.28. Minimum Thresholds	(a)	Establish minimum thresholds to quantify groundwater conditions for each applicable sustainability indicator	4
		(b)-(d)	Describe information and criteria to select, establish, justify, and quantitatively measure minimum thresholds	4
	354.30. Measurable Objectives	(a)-(g)	Establish measurable objectives, including interim milestones in increments of 5 years, to achieve and maintain the subbasin sustainability goal	4
4. Monitoring Networks	354.32. Introduction to Monitoring Networks	-	Description of monitoring network, monitoring objectives, monitoring protocols, and data reporting	5
	354.34. Monitoring Network	(a), (e)-(g)	Development of monitoring network to yield representative information about groundwater conditions	5
		(b)-(d)	Monitoring network objectives	5
		(h)	Maps and tables of monitoring sites	5
		(i)	Monitoring protocols	Appendices
	354.36. Representative Monitoring	(a)-(c)	Designation of representative monitoring sites	5

Sub-article	Section	Paragraph	Requirement	GSP Section
	354.38. Assessment and Improvement of Monitoring Network	(a)-(d)	Evaluation of monitoring network, including uncertainty, data gaps, and efforts to fill data gaps	5
		(e)	Adjustment of monitoring frequency and density to assess management action effectiveness	5
	354.40. Reporting Monitoring Data to the Department	(f)	Copy of monitoring data from data management system	Digital submittal
5. Projects and Management Actions	354.44. Projects and Management Actions	(a)-(c)	Description of projects and management actions to achieve and maintain the subbasin sustainability goal	6

Notes:

CWC = California Water Code

NA = not applicable

Table 1-2. Cross-reference of SGMA Statute and Associated GSP Sections

Requirement	GSP Section
Chapter 5. Powers and Authorities	
10726.9. REQUIREMENT OF PLAN TO TAKE INTO ACCOUNT GENERAL PLAN ASSUMPTIONS	
A groundwater sustainability plan shall consider the most recent planning assumptions stated in local general plans of jurisdictions overlying the basin.	2.6
Chapter 6. Groundwater Sustainability Plans	
10727. REQUIREMENT TO DEVELOP GROUNDWATER SUSTAINABILITY PLAN FOR MEDIUM- AND HIGH-PRIORITY BASINS; FORM OF PLAN	
(a) A groundwater sustainability plan shall be developed and implemented for each medium- or high-priority basin by a groundwater sustainability agency to meet the sustainability goal established pursuant to this part. The groundwater sustainability plan may incorporate, extend, or be based on a plan adopted pursuant to Part 2.75 (commencing with Section 10750).	1.0
10727.2. REQUIRED PLAN ELEMENTS A groundwater sustainability plan shall include all of the following:	
(a) A description of the physical setting and characteristics of the aquifer system underlying the basin that includes the following:	3.0
(1) Historical data, to the extent available.	3.2, 3.3
(2) Groundwater levels, groundwater quality, subsidence, and groundwater-surface water interaction.	3.2
(3) A general discussion of historical and projected water demands and supplies.	3.2, 3.3
(4) A map that details the area of the basin and the boundaries of the GSAs that overlie the basin that have or are developing GSPs.	Figure 3-1

Requirement	GSP Section
(5) A map identifying existing and potential recharge areas for the basin. The map or maps shall identify the existing recharge areas that substantially contribute to the replenishment of the groundwater basin. The map or maps shall be provided to the appropriate local planning agencies after adoption of the groundwater sustainability plan.	Figures 3-8a and 3-8b
(b) (1) Measurable objectives, as well as interim milestones in increments of 5 years, to achieve the sustainability goal in the basin within 20 years of the implementation of the plan.	4.0
(2) A description of how the plan helps meet each objective and how each objective is intended to achieve the sustainability goal for the basin for long-term beneficial uses of groundwater.	4.0
(3) (A) Notwithstanding paragraph (1), at the request of the groundwater sustainability agency, the department may grant an extension of up to 5 years beyond the 20-year sustainability timeframe upon a showing of good cause. The department may grant a second extension of up to 5 years upon a showing of good cause if the groundwater sustainability agency has begun implementation of the work plan described in clause (iii) of subparagraph (B). (B) The department may grant an extension pursuant to this paragraph if the groundwater sustainability agency does all of the following: (i) Demonstrates a need for an extension. (ii) Has made progress toward meeting the sustainability goal as demonstrated by its progress at achieving the milestones identified in its groundwater sustainability plan. (iii) Adopts a feasible work plan for meeting the sustainability goal during the extension period.	NA
(4) The plan may, but is not required to, address undesirable results that occurred before, and have not been corrected by, January 1, 2015. Notwithstanding paragraphs (1) to (3), inclusive, a groundwater sustainability agency has discretion as to whether to set measurable objectives and the timeframes for achieving any objectives for undesirable results that occurred before, and have not been corrected by, January 1, 2015.	4
(c) A planning and implementation horizon.	3.4.1.2
(d) Components relating to the following, as applicable to the basin: (1) The monitoring and management of groundwater levels within the basin.	4.0, 5.0, 6.0
(2) The monitoring and management of groundwater quality, groundwater quality degradation, inelastic land surface subsidence, and changes in surface flow and surface water quality that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin.	4.0, 5.0, 6.0
(3) Mitigation of overdraft.	4.0, 5.0, 6.0
(4) How recharge areas identified in the plan substantially contribute to the replenishment of the basin.	3.1.7
(5) A description of surface water supply used or available for use for groundwater recharge or in-lieu use.	2.3.2
(e) A summary of the type of monitoring sites, type of measurements, and the frequency of monitoring for each location monitoring groundwater levels, groundwater quality, subsidence, streamflow, precipitation, evaporation, and tidal influence. The plan shall include a summary of monitoring information such as well depth, screened intervals, and aquifer zones monitored, and a summary of the type of well relied on for the information, including public, irrigation, domestic, industrial, and monitoring wells.	5.0

Requirement	GSP Section
(f) Monitoring protocols that are designed to detect changes in groundwater levels, groundwater quality, inelastic surface subsidence for basins for which subsidence has been identified as a potential problem, and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater extraction in the basin. The monitoring protocols shall be designed to generate information that promotes efficient and effective groundwater management.	Appendix
(g) A description of the consideration given to the applicable county and city general plans and a description of the various adopted water resources-related plans and programs within the basin and an assessment of how the groundwater sustainability plan may affect those plans.	2.4, 2.5
10727.4. ADDITIONAL PLAN ELEMENTS In addition to the requirements of Section 10727.2, a groundwater sustainability plan shall include, where appropriate and in collaboration with the appropriate local agencies, all of the following:	
(a) Control of saline water intrusion.	
(b) Wellhead protection areas and recharge areas.	3.1.7
(c) Migration of contaminated groundwater.	2.1
(d) A well abandonment and well destruction program.	2.7
(e) Replenishment of groundwater extractions.	6.0
(f) Activities implementing, opportunities for, and removing impediments to, conjunctive use or underground storage.	2.1
(h) Measures addressing groundwater contamination cleanup, groundwater recharge, in-lieu use, diversions to storage, conservation, water recycling, conveyance, and extraction projects.	2.5, 6.0
(i) 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.	2.5.4
(j) Efforts to develop relationships with state and federal regulatory agencies.	7
(k) Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity.	7
(l) Impacts on groundwater-dependent ecosystems.	4
10727.8. PUBLIC NOTIFICATION AND PARTICIPATION; ADVISORY COMMITTEE (a) Prior to initiating the development of a groundwater sustainability plan, the groundwater sustainability agency shall make available to the public and the department a written statement describing the manner in which interested parties may participate in the development and implementation of the groundwater sustainability plan. The groundwater sustainability agency shall provide the written statement to the legislative body of any city, county, or city and county located within the geographic area to be covered by the plan. The groundwater sustainability agency may appoint and consult with an advisory committee consisting of interested parties for the purposes of developing and implementing a groundwater sustainability plan. The groundwater sustainability agency shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin prior to and during the development and implementation of the groundwater sustainability plan.	1.2, 1.3, Appendices
(b) For purposes of this section, interested parties include entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or a part of a groundwater basin managed by the groundwater sustainability agency.	NA

Requirement	GSP Section
10728. ANNUAL REPORTING BY GROUNDWATER SUSTAINABILITY AGENCY TO DEPARTMENT On the April 1 following the adoption of a groundwater sustainability plan and annually thereafter, a groundwater sustainability agency shall submit a report to the department containing the following information about the basin managed in the groundwater sustainability plan: (a) Groundwater elevation data. (b) Annual aggregated data identifying groundwater extraction for the preceding water year. (c) Surface water supply used for or available for use for groundwater recharge or in-lieu use. (d) Total water use. (e) Change in groundwater storage.	7.0
10728.2. PERIODIC REVIEW AND ASSESSMENT A groundwater sustainability agency shall periodically evaluate its groundwater sustainability plan, assess changing conditions in the basin that may warrant modification of the plan or management objectives, and may adjust components in the plan. An evaluation of the plan shall focus on determining whether the actions under the plan are meeting the plan's management objectives and whether those objectives are meeting the sustainability goal in the basin.	7.0
10728.4. ADOPTION OR AMENDMENT OF PLAN FOLLOWING PUBLIC HEARING A groundwater sustainability agency may adopt or amend a groundwater sustainability plan after a public hearing, held at least 90 days after providing notice to a city or county within the area of the proposed plan or amendment. The groundwater sustainability agency shall review and consider comments from any city or county that receives notice pursuant to this section and shall consult with a city or county that requests consultation within 30 days of receipt of the notice. Nothing in this section is intended to preclude an agency and a city or county from otherwise consulting or commenting regarding the adoption or amendment of a plan.	1.3, 7.0
10728.6. CEQA NOT APPLICABLE TO PLAN PREPARATION AND ADOPTION Division 13 (commencing with Section 21000) of the Public Resources Code does not apply to the preparation and adoption of plans pursuant to this chapter. Nothing in this part shall be interpreted as exempting from Division 13 (commencing with Section 21000) of the Public Resources Code a project that would implement actions taken pursuant to a plan adopted pursuant to this chapter.	5

Note:

CEQA = California Environmental Quality Act

1.3 Groundwater Sustainability Agency Authorities and Administrative Information

SGMA requires GSAs to be formed to cover high- and medium-priority basins/subbasins. Any local agency that has water supply, water management, or land use responsibility for a groundwater basin is eligible to form a GSA. The legislative intent of SGMA is to encourage GSA-eligible agencies to form one GSA that covers an entire SGMA basin/subbasin and prepare one GSP; however, SGMA offers local agencies the flexibility of forming multiple GSAs and preparing multiple GSPs in a basin/subbasin. SGMA empowers GSAs with new management tools and the authority to:

- Register groundwater wells
- Collect data/conduct studies

- Measure extractions (with the exception of de minimis wells [that pump fewer than 2 acre feet per year])
- Require reporting
- Manage extractions
- Assess fees

1.3.1 Sonoma Valley Groundwater Sustainability Agency

The Sonoma Valley GSA was formed to meet SGMA requirements in June 2017 and is one of three GSAs established in Sonoma County (the other two are Petaluma Valley and Santa Rosa Plain). The jurisdictional area of the Sonoma Valley GSA is the entire Sonoma Valley Subbasin, as defined by DWR, and no other GSAs have jurisdiction within the Subbasin. The Sonoma Valley GSA was formed through a Joint Exercise of Powers Agreement (JPA) entered into by the North Bay Water District (NBWD), Sonoma County, Sonoma County Water Agency (Sonoma Water), Sonoma Resource Conservation District (RCD), Valley of the Moon Water District (VOMWD), and the City of Sonoma, in accordance with requirements of CWC Section 10723 for establishing GSAs under SGMA. A copy of the resolution forming the JPA is included in **Appendix 1-A**.

Contact information for the Sonoma Valley GSA is:

Sonoma Valley Groundwater Sustainability Agency
404 Aviation Boulevard
Santa Rosa, California 95406
www.sonomavalleygroundwater.org
(707) 524-8378

GSA Administrator: Ann DuBay, Community & Government Affairs Manager, Sonoma County Water Agency

GSA Plan Manager: Jay Jasperse, Chief Engineer and Director of Groundwater Management, Sonoma County Water Agency

1.3.2 Sonoma Valley Groundwater Sustainability Agency Board and Advisory Committee

The Sonoma Valley GSA is governed by six board members and alternates from the six member organizations, which each appoint one member and one alternate member (board members as of September 1, 2021 are listed in **Appendix 1-B**). Sonoma Valley GSA Board (GSA Board) members are elected or appointed members of their governing bodies who serve at the pleasure of the member organization appointing them. GSA Board members annually elect the officers of the GSA Board for 1-year terms, which may be extended to multiple consecutive terms. The GSA Board role in the GSP development process is to provide guidance and direction on key components of the GSP and consider recommendations from the Sonoma Valley GSA Advisory Committee (Advisory Committee) and input from the public. The GSA Board is responsible for approving the GSP and authorizing its submission to DWR for evaluation, assessment, and approval.

The Sonoma Valley GSA formed an advisory committee of 12 members consisting of six at-large members appointed by the six member agencies, and six interest-based members appointed by the GSA Board, which include the following stakeholder groups:

- Environmental interests (from an organization with a presence in the Subbasin)
- Rural residential well owners
- Business community
- Agricultural interests (surface water or groundwater user)
- At-large community (hydrologist/geologist preference)
- At-large community

The role of the Advisory Committee is to work toward consensus and incorporate community and stakeholder interests into recommendations to the GSA Board on GSP development and SGMA implementation. Advisory Committee members also report to, and seek input, from their larger constituency groups on key components and proposals related to GSP development. The Advisory Committee meets between 8 and 12 times annually, and the meetings are open to the public in compliance with California's Ralph M. Brown Act (Government Code Section 54950).

The Advisory Committee makes written recommendations to the GSA Board that reflect the outcome of Advisory Committee discussions. To ensure that all viewpoints are heard and considered by the GSA Board, the Advisory Committee reports to the GSA Board identifying areas of agreement and disagreement among the Advisory Committee members. The names of GSA Board and Advisory Committee members can be found in **Appendix 1-B**, and the Advisory Committee Charter is provided in **Appendix 1-C**.

1.3.3 Groundwater Sustainability Agency Coordination

Implementation of SGMA in the Subbasin is closely coordinated with neighboring GSAs in Petaluma Valley and the Santa Rosa Plain and local agencies with land use responsibilities, including the City of Sonoma and the County of Sonoma. In addition to close coordination on managing and monitoring along shared basin boundaries, resources are leveraged and shared by the three existing GSAs in Sonoma County to maximize efficiencies, including shared templates and methodologies for certain GSP components, outreach resources, grant opportunities, and the development of data management system tools and technologies.

The Sonoma Valley GSA has an agreement with Sonoma Water for technical support, public outreach and community engagement, grant writing, and GSA administrative support. The GSA also has service agreements with outside firms for legal counsel, financial decision making, monitoring, and facilitation services for Advisory Committee meetings and other public meetings.

1.4 Stakeholder Engagement and Communication

SGMA requires that GSAs consider the beneficial uses and users of groundwater. As a result, GSP development included robust outreach and stakeholder engagement through a variety of methods and tools.

As described in **Section 1.3**, the Sonoma Valley GSA is governed by a local board, which receives and considers recommendations from an advisory committee representing multiple stakeholder interests. Both the GSA Board and Advisory Committee hold regular public meetings in compliance with California's laws governing public meetings (commonly known as the Brown Act). A list of meetings is provided in **Appendix 1-D**.

All phases of SGMA compliance in the Sonoma Valley Groundwater Subbasin have been, and will continue to be, characterized by an open collaborative process with strong stakeholder engagement allowing stakeholders and the public opportunities to provide input and to influence the process. Information is available through the website, www.sonomavalleygroundwater.org, where all meeting materials and notifications are posted.

1.4.1 Beneficial Uses and Users of Groundwater

SGMA requires GSAs to identify and consult with people and agencies who represent the "beneficial uses and users of groundwater in the basin, including the land uses and property interest potentially affected by the use of groundwater in the basin" (California Code of Regulations [CCR] Section 354.10). The *Community Engagement Plan for Development and Adoption of a Groundwater Sustainability Plan Sonoma Valley Groundwater Sustainability Agency* (Sonoma Valley GSA 2018) **Appendix 1-E** identifies beneficial users and uses as "interested parties" that include water suppliers, agricultural users, business and commercial uses, rural residents, disadvantaged communities, state and local landowners, and environmental users.

As described in **Section 1.3**, many of these beneficial users and those engaged in beneficial uses are included on the GSA Board or the Advisory Committee. Specific information regarding consultation with representatives of beneficial users and uses is described in the following sections.

1.4.2 Sustainable Groundwater Management Act Phases of Work

Outreach for SGMA is associated with the following four work phases:

Phase 1: GSA formation and Coordination – The formation of the Sonoma Valley GSA began in 2015, with an initial stakeholder assessment conducted by the Consensus Building Institute (CBI), followed by negotiations between GSA-eligible entities in the Subbasin. This phase was completed in June 2017, when the GSA was created by a JPA (described in **Section 1.2**).

Phase 2: GSP Preparation and Submission – This phase of work began in 2018, and will be completed in January 2022. During this phase, outreach was largely guided by the Community

Engagement Plan (**Appendix 1-E**). Pre-submission, the final draft GSP was released for public comments and review.

Phase 3: GSP Review and Evaluation – This phase began in 2019, with the majority of the review taking place in 2021. This phase will continue through 2022, when the GSP is submitted and DWR provides opportunity for additional public review and comments.

Phase 4: Implementation and Reporting – Following the submission of the GSP to DWR, the Sonoma Valley GSA will begin implementing projects and programs to reach sustainability in the Subbasin. This will be an ongoing phase, with 5-year updates that will include public input and feedback, as the GSA strives for sustainability by 2042.

1.4.2.1 Phase 1: Groundwater Sustainability Agency Formation and Coordination

From 2015 through 2017, local agencies worked with the CBI to facilitate the formation of the Sonoma Valley GSA. CBI began by conducting a stakeholder assessment in the three Sonoma County basins and subbasins that were immediately subject to SGMA. Assessment results were described in *Findings and Recommendations on Implementing the Sustainable Groundwater Management Act in Sonoma County* (**Appendix 1-F**).

The assessment included interviews with, and surveys of, representatives of key stakeholder groups, and resulted in recommendations for a transparent and inclusive process for local implementation of SGMA. The assessment also recommended that separate GSAs be created for each of the three basins/subbasins in order to reflect the local basin characteristics and stakeholder concerns. Other findings include the following:

- There is an overall commitment to long-term sustainable groundwater management and awareness of the importance of groundwater-surface water interaction, conjunctive use, and integrated water-resources management.
- Respondents respect local knowledge and control for water management and expressed concern about (1) needing to participate in management decisions for other basins; and (2) having agencies or stakeholders from external jurisdictions making decisions about local groundwater. At the same time, some recognized a need for a regional perspective on water resources and land use; those with this perspective feel confident that regional considerations can blend with local decisions.
- Agencies expressed concerns about costs and funding SGMA implementation.
- Stakeholders demonstrated a high level of expectation for public outreach and stakeholder involvement. Respondents urged expansive outreach to rural residential well owners and those seeking guidance and input from basin advisory panels and the public on forming the GSA.

The assessment prescribed a process for input and decision making, which involved representatives of the GSA-eligible entities in the Subbasin. The process was implemented, and included community forums that were held in 2016 to receive and consider input from the public on GSA formation.

Some areas of the Subbasin are classified as Disadvantaged Communities (DACs) by the California DWR (DWR 2021a), the Sonoma County Transportation Authority (SCTA 2017), and Sonoma County Department of Health Services (2014). Representatives of DAC stakeholders were included in the assessment survey, or were separately interviewed by staff during the GSA formation process.

The Subbasin beneficial users and uses, as defined by SGMA (CWC Section 10723.2), are represented in the structure of the GSA Board and the Advisory Committee. GSP beneficiaries include private domestic well owners, agriculture, businesses, municipal public water systems, DACs, and environmental users.

Stakeholders on the GSA Board and Advisory Committee include representatives from municipal water suppliers, agriculture, environmental organizations, businesses, rural well owners, and at-large community members. Refer to **Section 1.2** for additional information about GSA Board and Advisory Committee composition.

1.4.2.2 Phase 2: Preparation and Submission

The GSA Board and Advisory Committee were actively engaged in the development of the GSP, including:

- Reviewing and commenting on GSP sections as they were prepared
- Providing feedback and suggestions for SMC, discussed in **Section 4** of this GSP)
- Actively engaging and soliciting feedback from the stakeholders they represent

All meetings were publicly advertised and conducted in accordance with California's Ralph M. Brown Act (Government Code Section 54950). Meetings held during the pandemic were advertised and conducted in accordance with Governor Newsom's Executive Order N-25-20 issued on March 3, 2020. Public comment was included on every item, and meeting minutes were taken and are available at www.sonomavalleygroundwater.org.

Broader public input was determined to be a critical component of GSP development, and was guided by the *Community Engagement Plan for Development and Adoption of a Groundwater Sustainability Plan Sonoma Valley Groundwater Sustainability Agency* (Sonoma Valley GSA 2018) (**Appendix 1-D**), which was adopted by the GSA Board in January 2018. To encourage stakeholder engagement, key outreach tools included:

- Development of an Interested Parties List through both meeting attendance and by soliciting the public to sign up via the website (https://sonomavalleygroundwater.org)
- Monthly informational emails to the Interested Parties list that provided information regarding SGMA, GSP planning, and groundwater management

- Development of a website (https://sonomavalleygroundwater.org) with meeting information and GSP materials, including a location for public comments as draft GSP sections were released
- Public forums on the SGMA process, basin conditions, SMC development, draft SMC, and the draft GSP
- Forums coordinated with the other Sonoma County GSAs on cross-cutting issues, including climate change modeling and groundwater recharge
- Presentations to key stakeholder groups in the Subbasin
- A rural community engagement program that included research, and the development and implementation of a campaign targeted to informing and soliciting feedback from rural well owners.

An informational meeting and public hearing were held on the final draft Sonoma Valley GSP.

1.4.2.3 Phase 3: Groundwater Sustainability Plan Review and Evaluation

(Note to readers: This is a placeholder paragraph that will be finalized after the October 2021 public review.) Phase 3 began in 2019 with the majority of the review occurring in 2021. During this phase, the draft GSP was completed and sections were released sequentially for input from the GSA Board, Advisory Committee, and the public. In addition, the public was provided an opportunity to comment during a 30-day review period. A community workshop that provided an overview of GSP content and a public hearing allowed stakeholders the opportunity to comment. With the public review period completed, public comments will be considered, and will be incorporated into the final version of the GSP before submittal to DWR by January 31, 2022.

Following submittal, there will be a 60-day comment period through DWR's SGMA portal at http://sgma.water.ca.gov/portal. Comments will be posted to the DWR website prior to the state agency's evaluation, assessment, and approval.

1.4.2.4 Phase 4: Implementation and Reporting

Phase 4 will continue through the duration of the 50-year planning window to ensure that sustainability is achieved and maintained, and that the activities, programs, and policies of the GSA are transparent and inclusive.

DRAFT

Section 2: Description of Plan Area

Groundwater Sustainability Plan for
Sonoma Valley Groundwater Subbasin

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2 DESCRIPTION OF THE PLAN AREA (23 CCR 354.8 B)

In accordance with 23 CCR Section 354.8 b, this section provides a description of the area of the GSP (Plan Area), including the Subbasin's general physical setting and jurisdictional areas, topography and surface water features, land use characteristics, water source types and uses, existing monitoring and management programs, applicable land use plans, and the well permitting process. The numbers in parenthesis in each subheading indicate the applicable SGMA regulation.

2.1 General Setting and Jurisdictional Areas (23 CCR 354.8 b)

The Plan Area for this GSP is the entire Subbasin, which lies within a northwest trending structural depression in the coast ranges immediately north of San Pablo Bay. The Subbasin is one of three coastal alluvial subbasins of the Napa-Sonoma Valley Groundwater Basin in the San Francisco Bay Hydrologic Region (DWR 2003). It is generally bounded on the west by the Sonoma Mountains and on the east by the Mayacamas Mountains. As shown on **Figure 2-1**, the approximately 44,000-acre Subbasin extends from San Pablo Bay northward to about 2 miles south of the town of Kenwood and incorporates the City of Sonoma and communities of El Verano, Agua Caliente, Fetters Hot Springs, Boyes Hot Springs, Glen Ellen, Schellville, Buena Vista, and Vineberg. As shown on **Figure 2-2**, the principal stream draining the Subbasin is Sonoma Creek, which is tidally influenced from approximately Schellville downstream to its mouth at San Pablo Bay. The Subbasin is a subset of the larger Sonoma Creek watershed.

Neighboring groundwater basins and subbasins include the Petaluma Valley Basin (designated as basin 2-001 by DWR), Kenwood Valley Basin (designated as basin 2-019 by DWR), and the Napa-Sonoma Lowlands Subbasin (designated as basin 2-002.03 by DWR) (**Figure 2-1**). The Petaluma Valley Basin is a medium-priority basin that lies to the west and abuts southwestern portions of the Subbasin. The Petaluma Valley GSA formed in June 2017 and is responsible for implementing SGMA in the Petaluma Valley Basin. The Kenwood Valley Basin is a very low-priority basin that lies to the north of the Subbasin. The Napa-Sonoma Lowlands is a very low-priority basin located in Napa County that occupies lowland areas northeast of San Pablo Bay and shares a boundary with the Subbasin in the Carneros area and within the low-lying tidal marshlands along the margin of San Pablo Bay. As very low-priority groundwater basins, the Kenwood Valley and Napa-Sonoma Lowlands are not required to form GSAs or develop GSPs; only high- and medium-priority basins are required to meet SGMA mandates.

Available technical information related to the hydrologic connection between the Subbasin and the adjacent basins/subbasins is included in **Section 3** (Basin Setting), and provisions for coordinating with applicable GSAs and other local agencies within neighboring basins and subbasins are described in **Section 7** (Implementation Plan).

The Plan Area and jurisdiction of the Sonoma Valley GSA is the Sonoma Valley Groundwater Subbasin as defined by SGMA basin prioritization (DWR 2020) and DWR Bulletin 118 (DWR 2003). The Subbasin has been well-studied (Refer to **Section 3**) with technical information that indicates that areas of the Sonoma Creek watershed outside of the Subbasin are hydrologically connected and represent important sources of inflow (both in the form of surface streamflows and subsurface inflows). In recognition of the hydrologic connection with the contributing watershed areas, available data and information from these areas are also included in this GSP. Distinctions between metrics and features associated with the Bulletin 118 Subbasin and the contributing watershed areas are clearly indicated or displayed in relevant sections and figures.

Local agencies with water supply, water management, or land use responsibilities within the Subbasin include the Sonoma Valley GSA, City of Sonoma, VOMWD, NBWD, Sonoma Resource Conservation District (RCD), Sonoma Water, and Sonoma County. **Figure 2-3** shows the jurisdictional boundaries of these local agencies, state and federal lands, and protected lands within the Subbasin. State lands include the Sonoma Developmental Center and properties within tidal marshlands in the southern portions of the Subbasin managed by the California Department of Fish and Wildlife. Federal lands are also present within tidal marshlands in the southern portions of the Subbasin and are managed by the U.S. Fish and Wildlife Service. Other protected lands located within the Subbasin and contributing watershed areas shown on **Figure 2-3** include city parks and fields, county regional parks and preserves, special district properties and preserves, state parks and preserves, and non-profit preserves.

The California Legislature assigned primary responsibility for protecting and enhancing California's surface water and groundwater quality to the State Water Resources Control Board (SWRCB), and the nine regional water quality control boards (Regional Boards).The SWRCB provides state-level coordination for the water quality control program and regulatory monitoring by establishing statewide policies and plans for implementing state and federal laws and regulations. The Regional Boards adopt and implement water quality control plans (basin plans), recognizing the unique characteristics of each region's natural surface water and groundwater quality, actual and potential beneficial uses, and surface water and groundwater quality problems. Article 3 of Chapter 4 of the Porter-Cologne Act directs the Regional Boards to adopt, review, and revise basin plans, and provides specific guidance on factors that must be considered in the adoption of surface water and groundwater quality objectives and implementation measures.

The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) implements water quality regulations in the watershed, including establishing Total Maximum Daily Loads for pathogens and sediment in Sonoma Creek, adopting General Waste Discharge Requirements for agricultural lands, dairies, recycled water, and for stormwater and wastewater discharges. The SFBRWQCB and the California Department of Toxic Substances Control are responsible for regulating the cleanup of contaminant sites and contaminated groundwater; the GSA has no authority to regulate groundwater contaminant site cleanups or the migration of plumes.

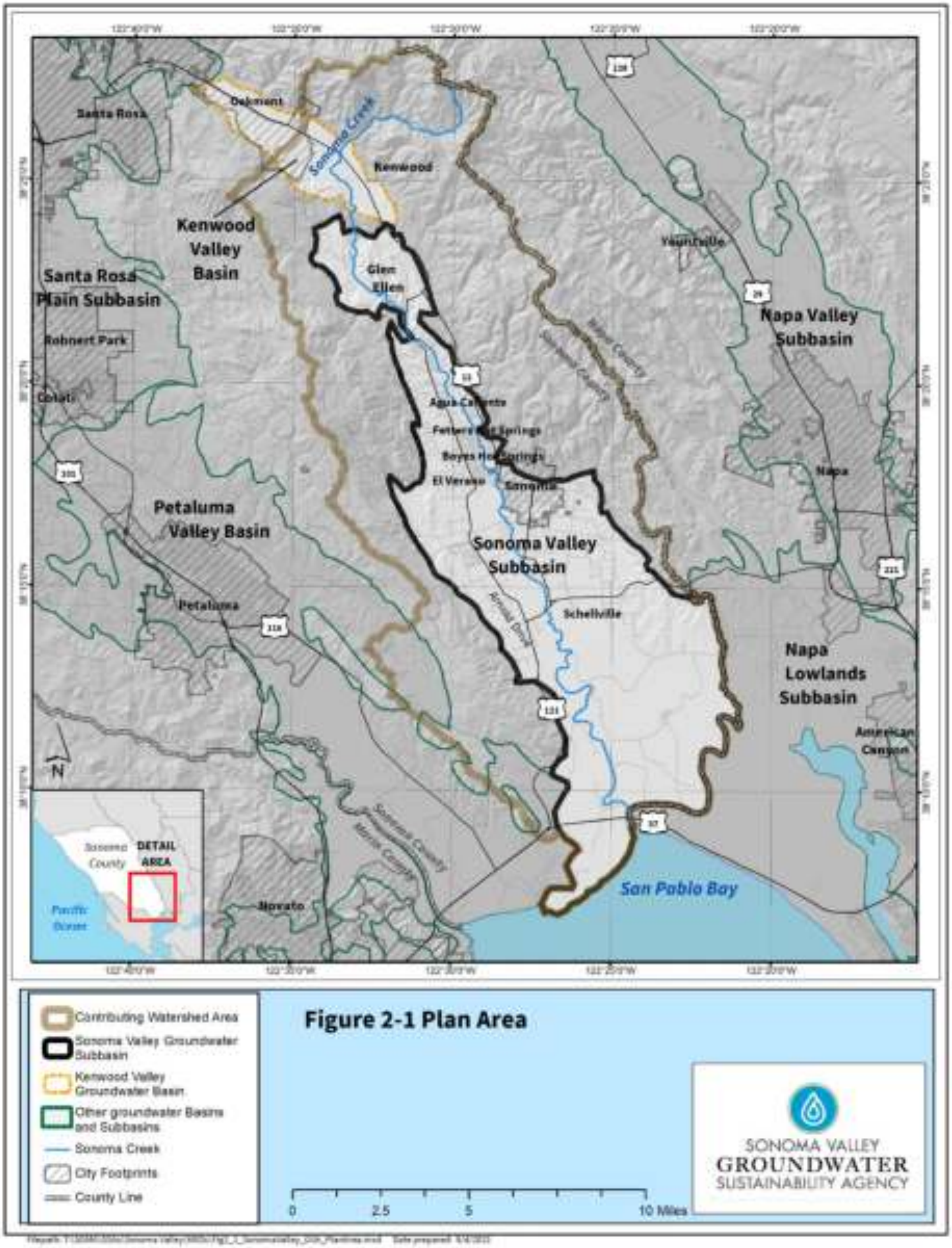

Figure 2-1. Plan Area

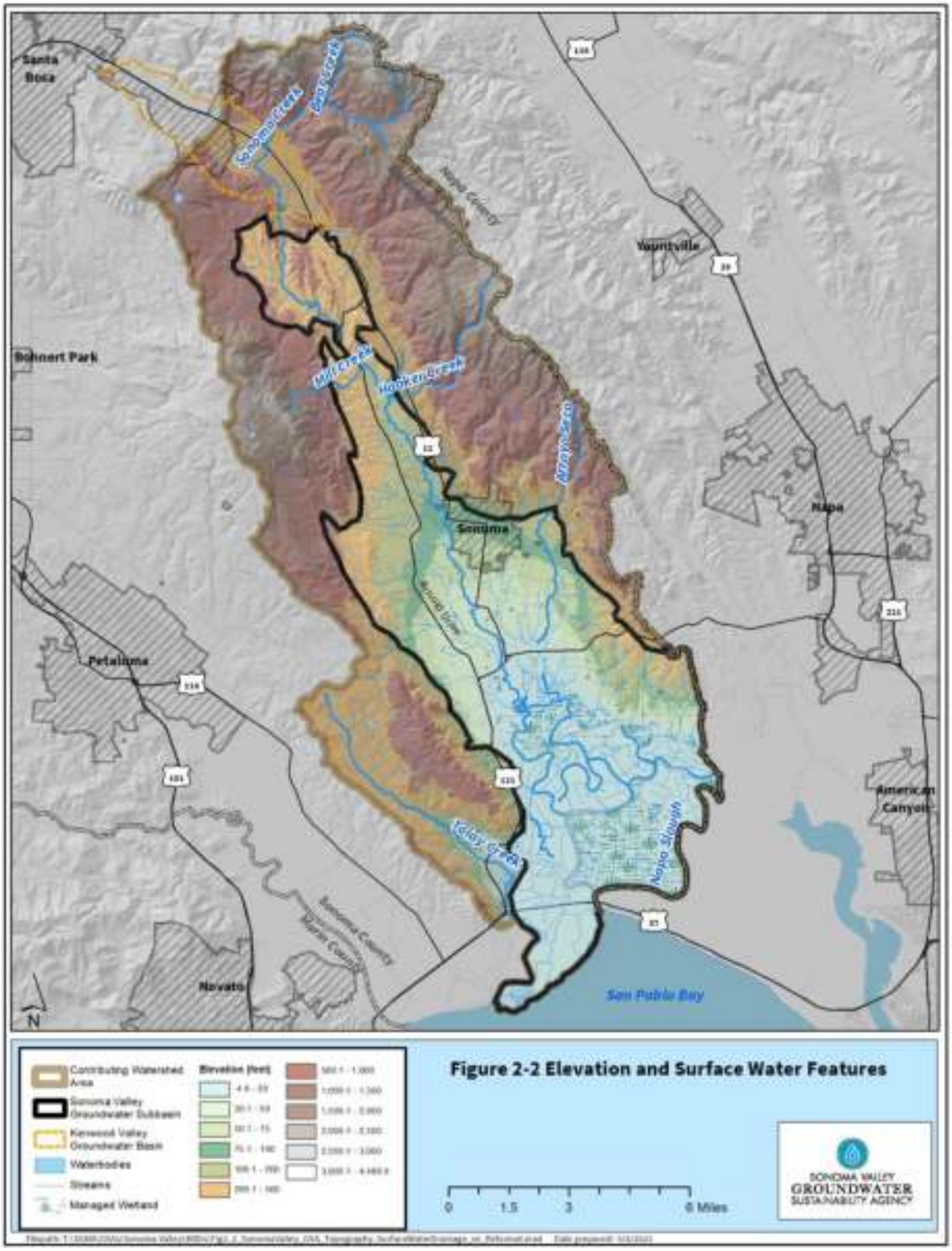

Figure 2-2. Elevation and Surface Water Features

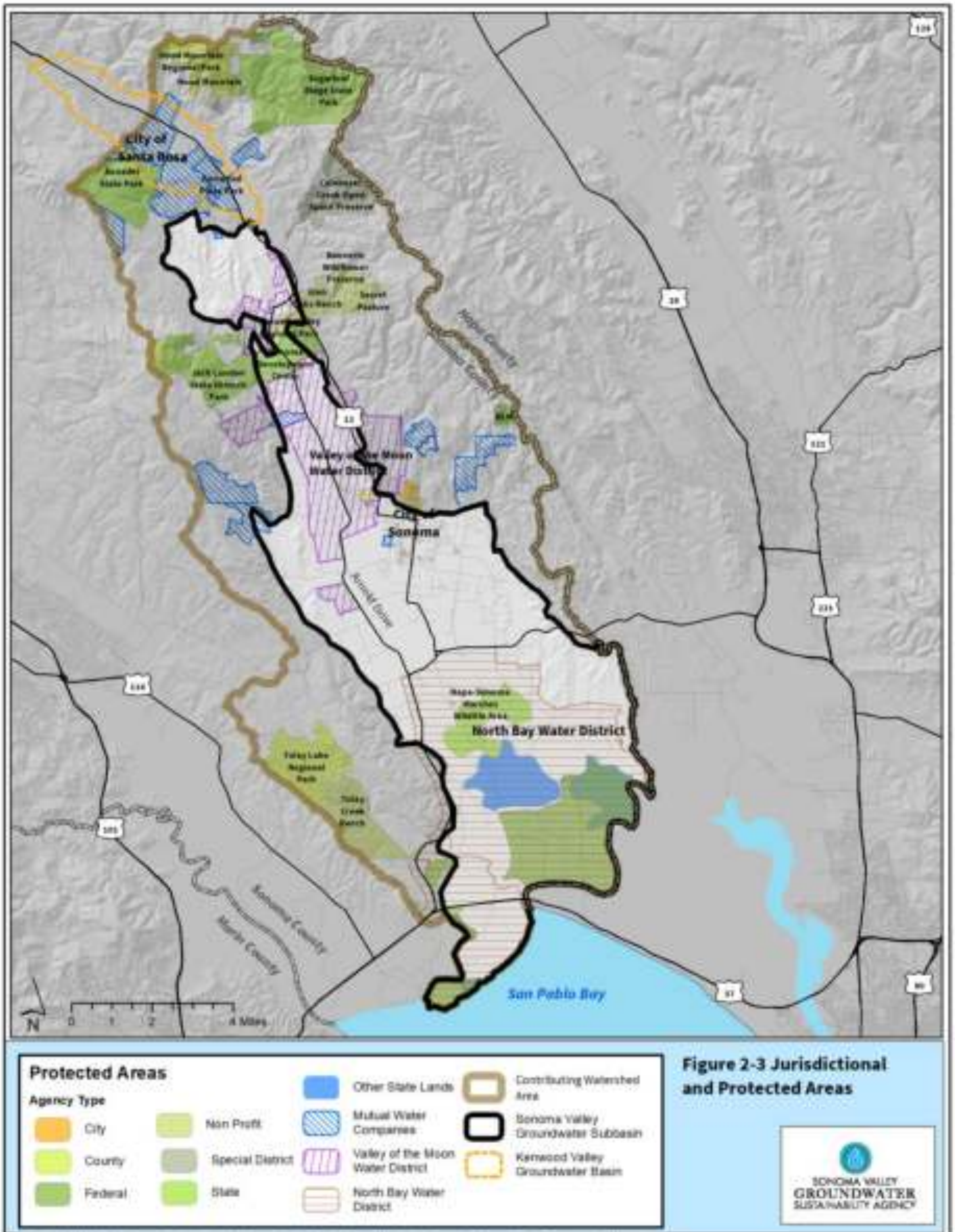

Figure 2-3. Jurisdictional and Protected Areas

2.2 General Land Use Characteristics (23 CCR 354.8 b)

Maps of existing land uses for 1999, 2012, and 2013 are shown on **Figures 2-4a**, **2-4b**, and **2-4c**, respectively. Existing conditions correlate most closely with the DWR 2012 land use survey (**Figure 2-4b**), which indicates the land uses within the Subbasin, as shown in **Table 2-1.**

Table 2-1. Major Land Uses in Subbasin

Land Uses in Subbasin	Percent of Subbasin
Agriculture	44
Native Vegetation or Water	43
Urbanized Uses (residential, commercial, industrial)	13

The majority of the native vegetation is located in the lower portions of the Subbasin along the tidal marshlands and in the upper portions of the Subbasin near Glen Ellen. For several decades, the primary agricultural crop has been vineyards for wine production. Non-irrigated pastures, grains and hay, and dairies are also important land use categories, with a total area comparable to irrigated agriculture. The urbanized and residential areas in the Subbasin are primarily along the Highway 12 corridor and include the City of Sonoma, several unincorporated communities, and areas of rural and semi-rural residential development.

Land use mapping over the past several decades illustrates the more significant growth and land use changes in the Subbasin, which most notably includes increases in irrigated agriculture and residential and commercial land uses (**Table 2-2** and **Figures 2-4a**, **2-4b**, and **2-4c**). In the Subbasin, native vegetation, which had been declining as a percent of land use, increased from 38 percent in 1993 to 43 percent in 2012, mostly owing to the restoration of tidal marshlands of southern Sonoma Valley that has replaced non-irrigated agriculture.

Table 2-2. Land Use Changes in Subbasin

Land Use Type	Percent of Land Use Type					
	1974	1979	1986	1993	1999	2012
Non-irrigated agriculture	22	33.8	35.3	33.7	16.3	21.5
Irrigated agriculture	14.1	13.3	16.4	19.7	21.7	21.5
Native vegetation or water	54.2	44.9	39.2	37.5	49	42.6
Combined residential, commercial/ industrial, and unknown	9.7	8.0	9.1	9.1	13.0	13.3

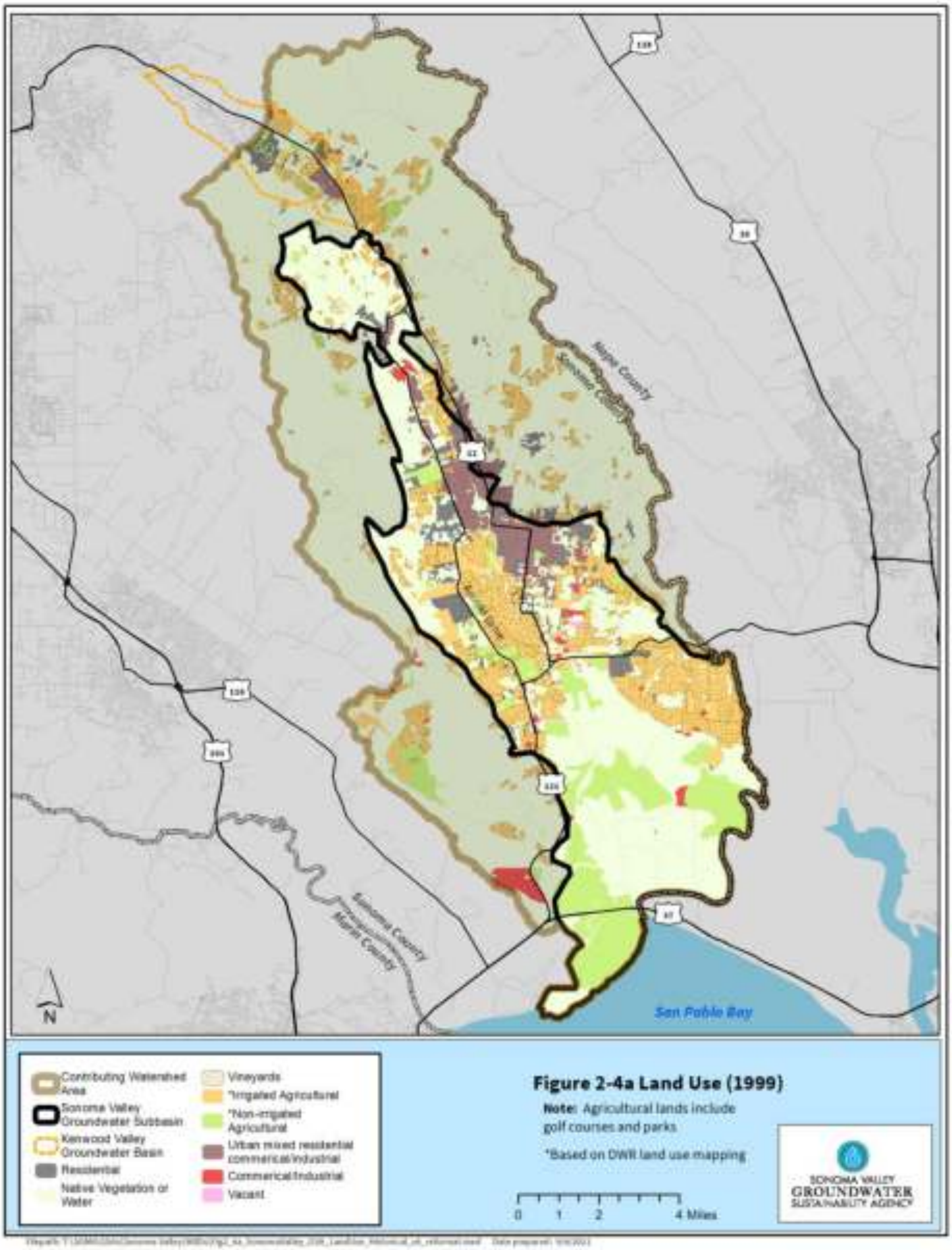

Figure 2-4a. Recent Land Use (1999)

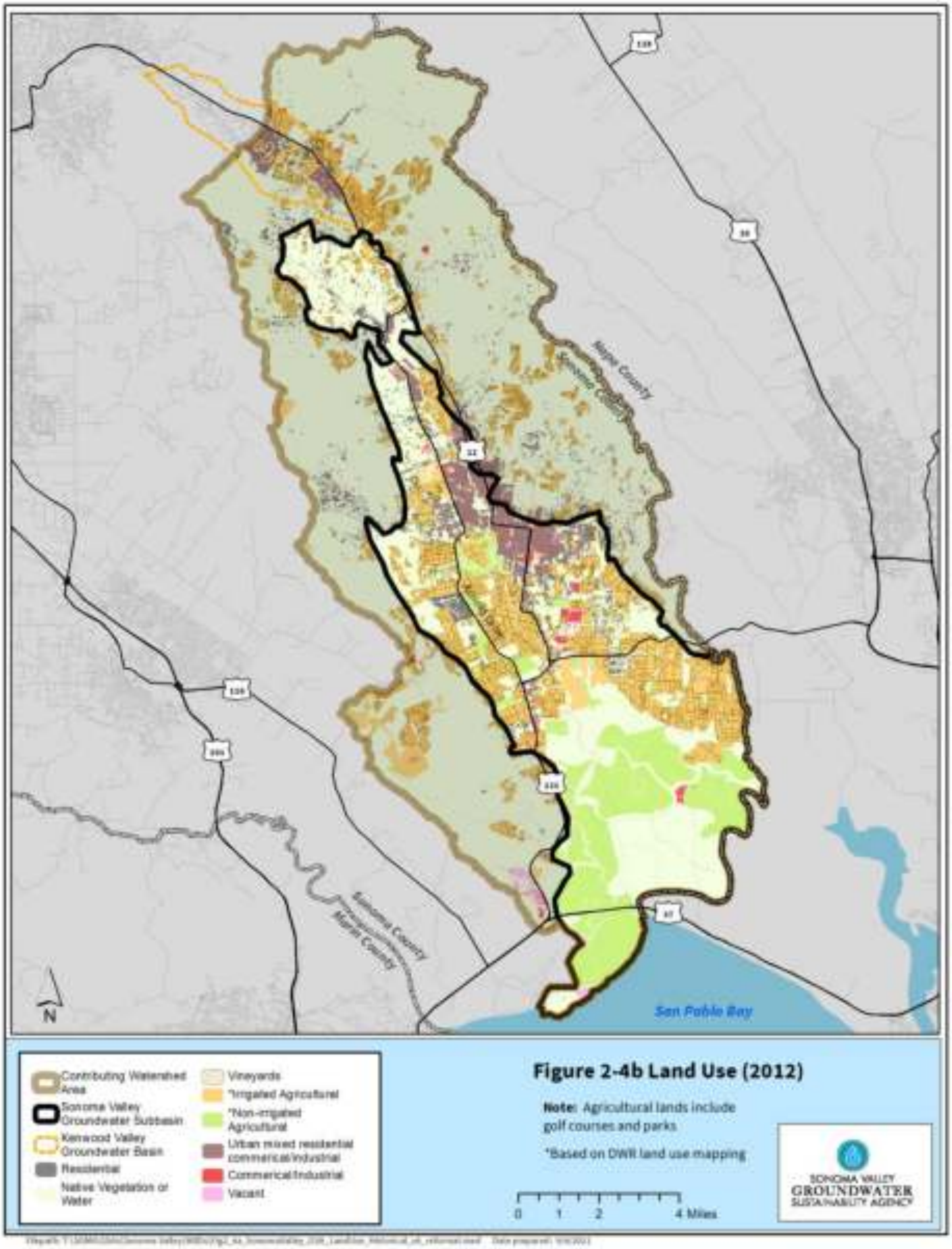

Figure 2-4b. Recent Land Use (2012)

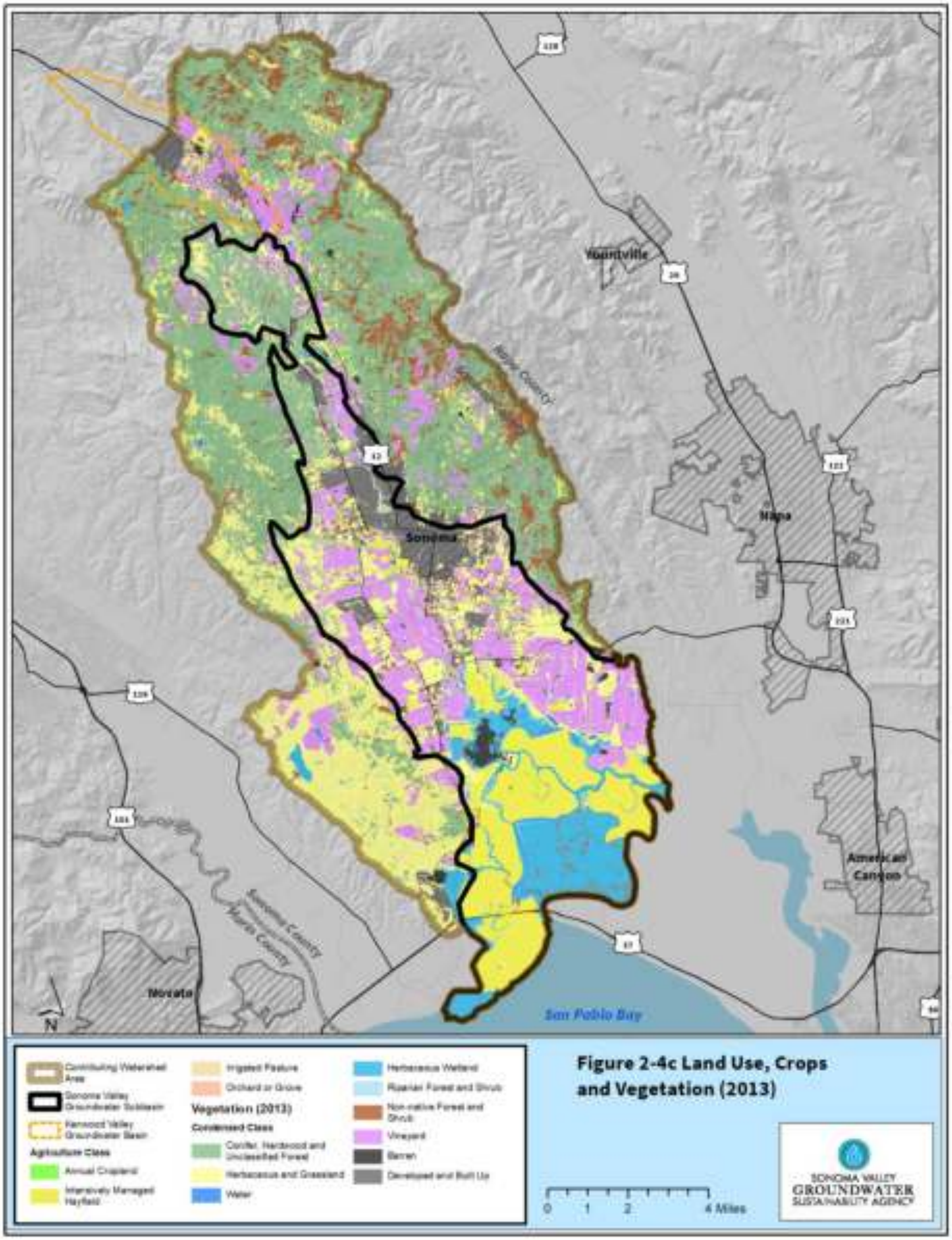

Figure 2-4c. Land Use, Crops and Vegetation (2013)

2.3 Water Source Types and Water Use Sectors (23 CCR 354.8 b)

This GSP recognizes that the efficient use and conjunctive management of the various available water sources is integral to achieving sustainable groundwater management in the Subbasin. The Subbasin has four primary water source types: groundwater, imported surface water, local surface water, and recycled water. An overview of the spatial distribution of the reliance on the four primary water source types by primary water use sectors in the Subbasin is shown on **Figure 2-5** and provided in the following paragraphs. Additional details on water uses associated with the Subbasin water budget are described in **Section 3** (Basin Setting) and additional information on the availability and feasibility for future uses is included in **Section 6** (Projects and Management Actions).

Early on, Sonoma Valley relied completely on abundant springs and surface water during its early settlement and growth period and the first and second incorporations of the City of Sonoma in 1850 and 1883, respectively. Census information for the City of Sonoma indicates relatively flat population growth from 1890 to 1940, and then growth of 1,000 to 2,000 per year until 2010 and has remained at around 11,000 into 2020.

Sonoma Valley relied completely on its local groundwater and surface water resources as it developed during the 1940s and 1950s, until March 1963 with the completion of the construction of the Sonoma Aqueduct and initiation of Russian River imported surface water deliveries. Deliveries to the Sonoma Valley have averaged approximately 4,000 acre-feet per year (AFY) during the current period, accounting for approximately 37 percent of the overall water supply.

Growth in the wine industry and increasing vineyards in the Sonoma Valley accounts for most of the agricultural demand expansion. Agricultural groundwater pumping has increased from approximately 1,000 AFY in the early 1970s to approximately 3,800 AFY during the current period. Urban and private systems well groundwater demands did not begin to ramp up until later due in part to the Sonoma Aqueduct imported water supplements beginning in the 1960s, and urban, rural domestic and industrial/commercial groundwater pumping increased from a few hundred AFY in the 1980s to about 1,900 AFY during the current period. Today, groundwater accounts for approximately 52 percent of the overall Subbasin water supply.

Deliveries of recycled water in 1990 with about 700 AFY for the irrigation of vineyards has replaced groundwater pumping. Recycled water ramped up in the early 2000s to 800 AFY, hit a peak of 1,400 AFY in 2013, and has been about 1,100 AFY for the last few years, accounting for about 10 percent of the water supply in the Subbasin.

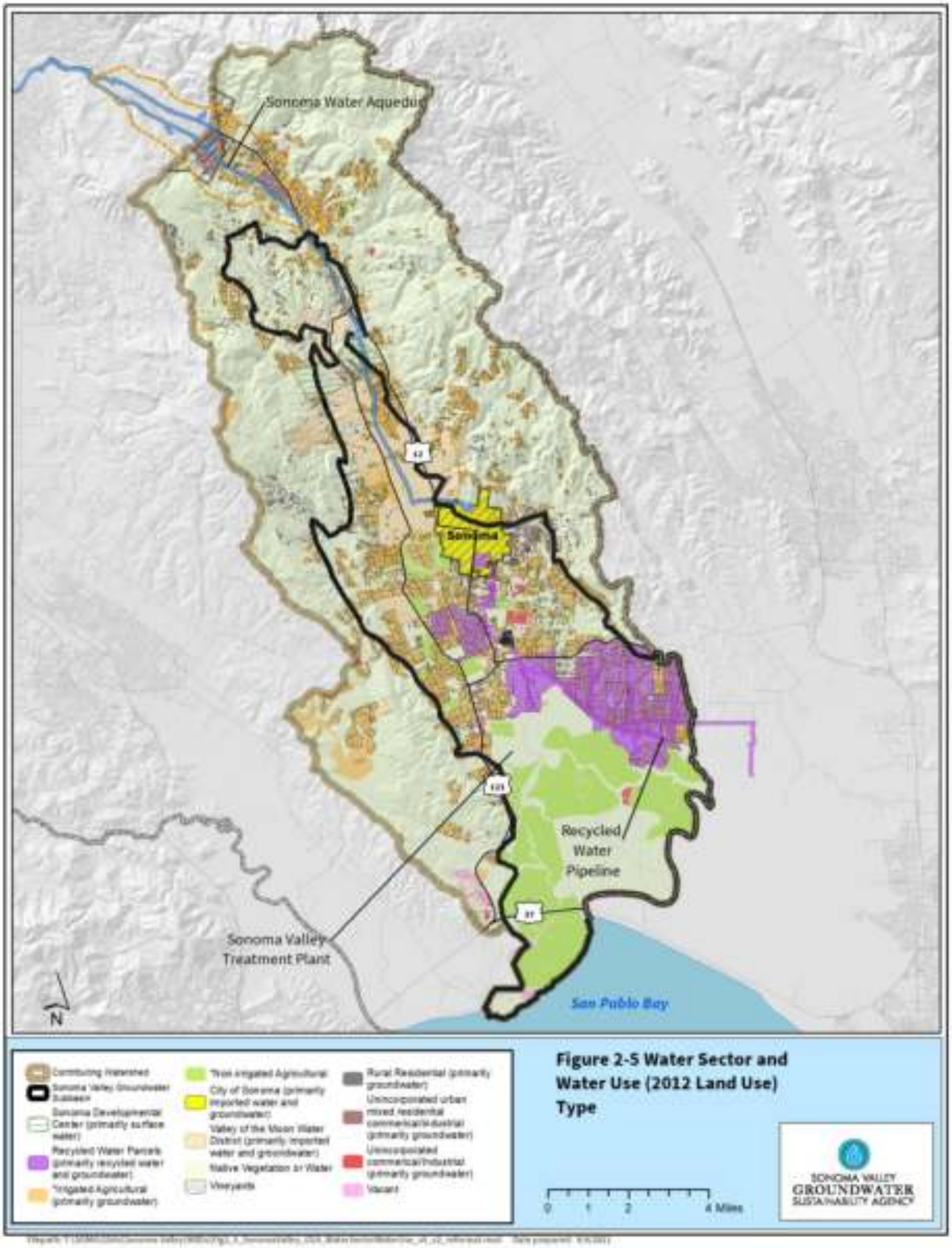

Figure 2-5. Water Sector and Water Use Type (2012 Land Use)

2.3.1 Groundwater

As described above, an average of approximately 50 percent of all Subbasin water demands are estimated to be met by local groundwater. **Figure 2-6** presents a map showing the approximate density of water wells within the Subbasin, based on available data from DWR. These groundwater resources are relied upon to varying degrees by rural and urban residents, vineyards and wineries, dairies, and other businesses, and also support streamflows and ecosystems present in Sonoma Valley. Groundwater represents the primary, or in some cases only, source of supply for agriculture, rural residents, mutual water companies, irrigated park lands, golf courses, and other commercial businesses located outside of the City of Sonoma and VOMWD service areas. Local groundwater represents an important supplemental source of supply for both the City of Sonoma and VOMWD, which operate municipal wellfields within the basin and watershed.

2.3.2 Imported Surface Water

Imported surface water consists of Russian River surface water sourced from Sonoma Water's production facilities near Forestville that is delivered via aqueduct to the City of Sonoma and VOMWD within the Subbasin, as shown on **Figure 2-5**. Imported surface water represents the primary source of water for urban residents and businesses that are served by the City of Sonoma and VOMWD. These two providers collectively serve approximately 75 percent of the population in Sonoma Valley and delivered approximately 4,000 AFY of imported surface water in the current period, representing approximately one-quarter of the total water demands in the watershed (City of Sonoma 2021 and VOMWD 2021).

2.3.3 Local Surface Water

Local surface water from Sonoma Creek and its tributaries represents an important source of supply for some water users. Information on the approximate amounts of surface water is available through reported surface water diversions filed with the California SWRCB. These local surface water diversions are estimated to represent less than 10 percent of the total water demands in the watershed (SVGMP 2014) and are primarily relied upon for agricultural purposes and for supplying drinking water to the site of the former Sonoma Developmental Center.

2.3.4 Recycled Water

Recycled water is treated to tertiary standards at the Sonoma Valley Wastewater Treatment Plant (**Figure 2-5**) and is used for crop and landscape irrigation in lieu of using groundwater or imported water. Recycled water deliveries are estimated to represent less than 10 percent of the total water demands in the watershed (SVGMP 2014) and are primarily relied upon for agricultural purposes to irrigate vineyards, dairies, and pasturelands in southern Sonoma Valley in the areas shown on **Figure 2-5**. Some playing fields and parks within the City of Sonoma are irrigated with recycled water.

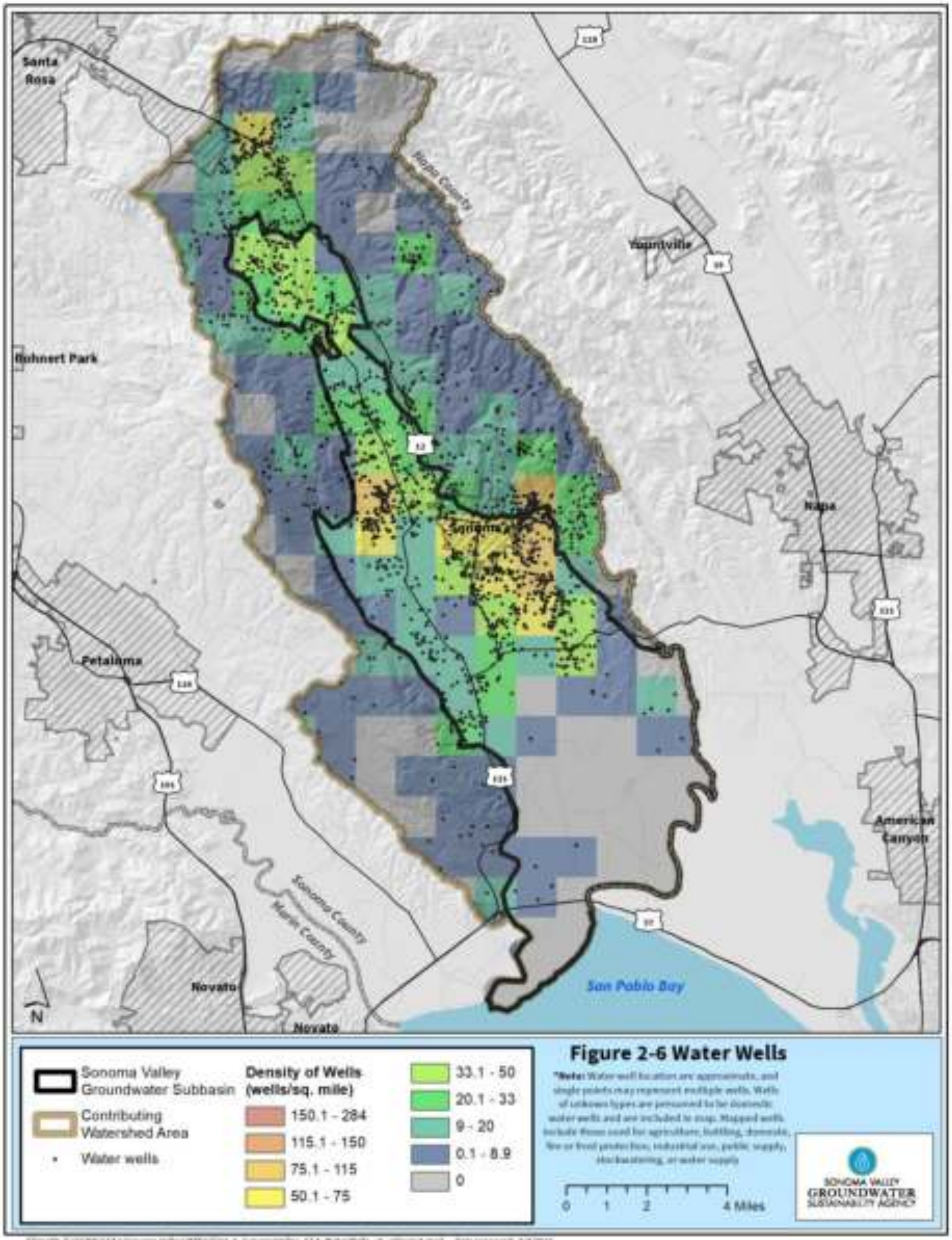

Figure 2-6. Water Wells

Over the past 20 years Sonoma Valley County Sanitation District (SVCSD) has produced an average of approximately 3,800 AFY of tertiary treated wastewater, which varies year to year based on climate conditions and water conservation efforts and has ranged from approximately 2,600 AFY (2013) to 4,100 AFY (2010). The total amount produced has declined in recent years due to the drought and water conservation efforts. Deliveries of recycled water to agricultural users in Sonoma Valley began in the early 1990s and has been used to offset groundwater pumping for vineyards, dairies, and pasturelands in the southern Sonoma Valley with demand and use increasing significantly between 2012 and 2014 to approximately 1,100 AFY. Additionally, beginning in 2012 recycled water has been used for environmental uses which, in 2014, included providing approximately 500 acre-feet for wetlands enhancement to the Napa-Sonoma Salt Marsh Restoration Project.

2.4 Existing Monitoring Programs and Networks (23 CCR 354.8 c, d, e)

As described in this section, existing monitoring programs and networks within the Subbasin have been developed and implemented by many agencies, organizations, and volunteers for a variety of purposes. Current monitoring efforts focus on tracking trends in groundwater levels, groundwater quality, climate, and surface water flows. An assessment of the existing monitoring networks and programs for their suitability to comply with DWR’s GSP regulations, including identification of data gaps, is described in **Section 5** of this GSP (Proposed Monitoring Plan).

2.4.1 Groundwater-level Monitoring

Numerous organizations within the watershed collect groundwater-level measurements, including DWR, Sonoma Water, City of Sonoma, VOMWD, Permit Sonoma, local volunteers, and many operators of small mutual water systems. Groundwater levels are measured from a combination of private wells, dedicated monitoring wells, and inactive and active public water supply wells. The Groundwater-level Monitoring Network expanded significantly under the voluntary Sonoma Valley Groundwater Management Program (SVGMP) through public outreach and education to private well owners who volunteered to have their wells monitored. In addition, the SWRCB GeoTracker program provides groundwater-level monitoring data on soil and groundwater cleanup sites in the Subbasin.

Groundwater-level monitoring is generally conducted twice a year, in the spring and fall, at 158 groundwater-level monitoring program wells within the watershed, as shown on **Figure 2-7a**. A subset of the wells is monitored on a more frequent basis, including continuous monitoring using pressure transducers. The 158 wells in the existing monitoring program were subdivided according to their well-screen depth or total depth, where known, into the following categories:

- 200 feet deep or less (67 wells)
- 200 to 500 feet deep (47 wells)
- Greater than 500 feet deep (33 wells)
- Unknown well-screen and depth (11 wells)

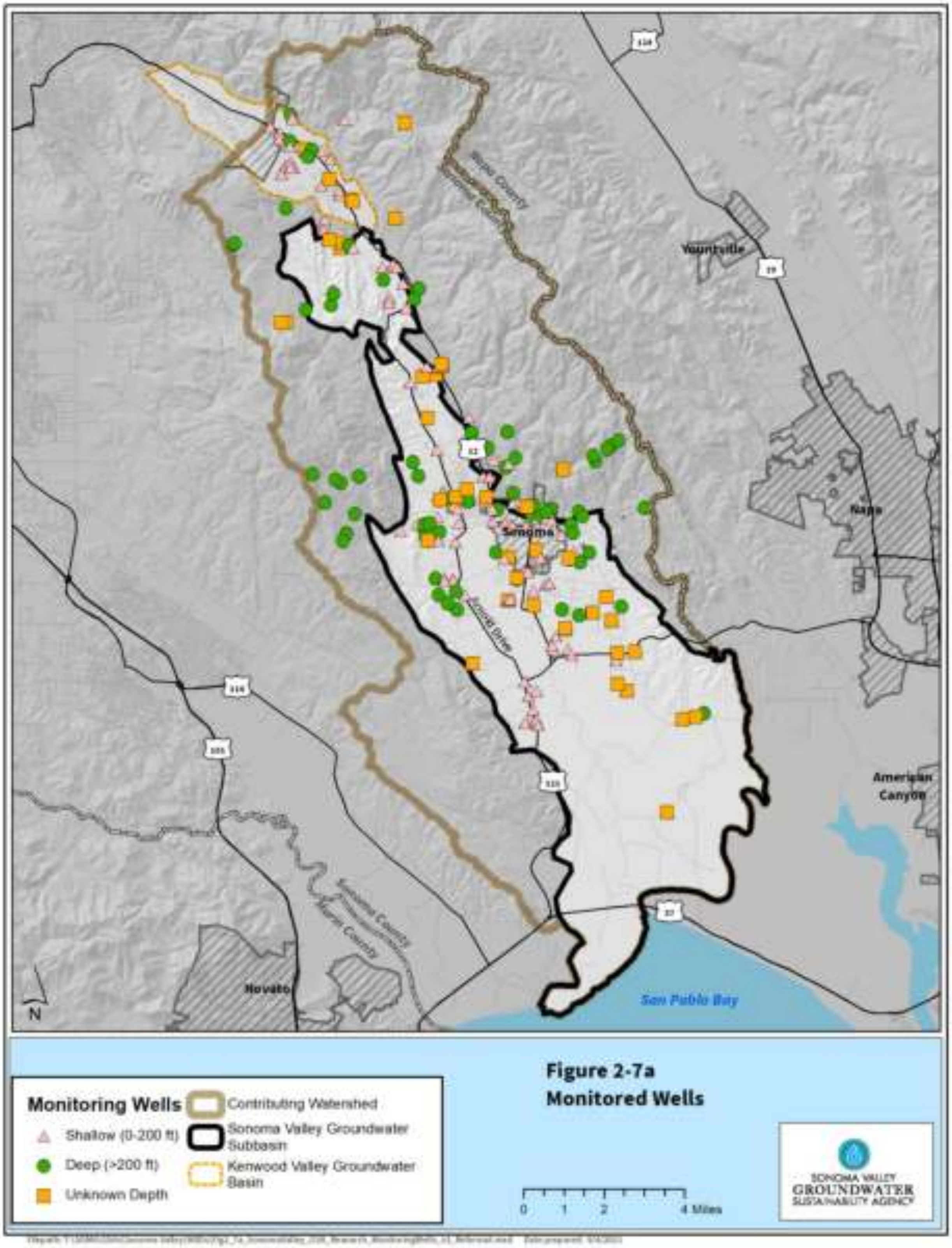

Figure 2-7a. Monitored Wells

DWR has measured groundwater levels in a network of wells within both the Subbasin and watershed for decades. Most of these wells were incorporated into DWR's monitoring network between the mid-1950s and 1981. Measurements are generally collected from these wells semiannually in the spring and fall, although a subset of wells are monitored on a monthly basis.

Since 2004, Permit Sonoma has administered a groundwater monitoring program, which requires the measurement and reporting of groundwater levels on a quarterly or monthly basis for all cannabis permits, and commercial/industrial projects requiring a use permit and that use over 0.5 AFY of water.

The DWR California Statewide Groundwater Elevation Monitoring (CASGEM) Program is a voluntary, collaborative state program established by Senate Bill 6 in 2009 to compile groundwater-level monitoring data statewide from local monitoring programs. Local agencies are required to submit groundwater-level monitoring data to be eligible for water grants and loans awarded by the state. A subset of the Subbasin groundwater-level monitoring data is reported to the CASGEM program.

2.4.2 Groundwater Quality Monitoring

Groundwater quality data has been collected through many different programs and initiatives, described in the following paragraphs. The synthesis and evaluation of results from these water quality monitoring programs are described in **Section 3** (Basin Setting).

2.4.2.1 Public Water Supply Well Monitoring

The SWRCB Division of Drinking Water (DDW) monitors public water system wells for CCR Title 22 requirements relative to levels of organic and inorganic compounds such as metals, microbial compounds, and radiological analytes. Data are available for active and inactive drinking water sources, for water systems that serve the public, and wells defined as serving 15 or more connections, or more than 25 people per day. In the watershed, DDW wells were monitored for Title 22 requirements, including pH, alkalinity, bicarbonate, calcium, magnesium, potassium, sulfate, barium, copper, iron, zinc, and nitrate.

2.4.2.2 Groundwater Ambient Monitoring and Assessment Program

In response to the Groundwater Quality Monitoring Act of 2001 (CWC Sections 10780 to 10782.3), the SWRCB established the Groundwater Ambient Monitoring and Assessment (GAMA) Program to monitor groundwater quality throughout the state of California. GAMA is intended to create a comprehensive groundwater monitoring program throughout California and increase public availability and access to groundwater quality and contamination information. GAMA receives data from a variety of monitoring entities including DWR, the U.S. Geological Survey (USGS), and the SWRCB. The GAMA data can be accessed at https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp.

2.4.2.3 Water Data Library

DWR monitors groundwater quality data. Samples are collected from a variety of well types, including irrigation, stock, domestic, and some public supply wells. Wells are sampled infrequently; therefore, most wells have only a few data points and there are large temporal gaps between the results. Constituents most frequently monitored include dissolved chloride, sodium, calcium, boron, magnesium, and sulfate. Measurements taken include conductance, pH, total alkalinity, and hardness. Additional dissolved nutrients, metals, and total dissolved solids (TDS) are also sampled but have fewer sample results available. DWR reports the results through the Water Data Library.

2.4.2.4 Sonoma Valley Salt and Nutrient Management Plan

In Sonoma Valley, 47 wells that are currently monitored by DWR, California Department of Public Health, and SVGMP are included in the Salt and Nutrient Management Plan (SNMP) monitoring program. Wells are monitored and results are reported through the GeoTracker database system to the Regional Water Board every 3 years in an SNMP Groundwater Monitoring Report. Parameters monitored include electrical conductivity (EC), TDS, and nitrate.

2.4.2.5 U.S. Geological Survey Studies

Special studies conducted by the USGS within the Subbasin have included the collection and analysis of groundwater quality data. Water quality analyses have included major ions, trace elements, nutrients, and stable isotopes (oxygen-18 and deuterium), tritium, the radioactive isotope of carbon (carbon-14), and the stable isotope carbon-13. Data collected by the USGS through these studies are available on the National Water Information System database (https://waterdata.usgs.gov/nwis).

2.4.3 Climate Monitoring

Climate-related monitoring stations in the watershed provide part of the information necessary for forecasting weather conditions, flood preparedness, drought preparedness, water supply planning, and for determining the Subbasin water budget. Climate monitoring stations may include sensors to collect data on rainfall, air temperature, relative humidity, wind speed and direction, solar radiation, and soil temperature and moisture.

The primary weather station in the Subbasin that has been used to calculate mean annual rainfall is Climate Station Sonoma (National Climatic Data Center #8351, Sonoma), which also collects temperature data. Data are available from 1953 to the present at this station, which is located in the City of Sonoma.

The California Irrigation Management Information System (CIMIS), operated by DWR (https://cimis.water.ca.gov/Stations.aspx), maintains a climate station in the Carneros area in Napa County. The Carneros station (CIMIS Station 109) is about 1,000 feet east of the Subbasin boundary and has been in operation since March 11, 1993. The station measures evapotranspiration (ET), precipitation, solar radiance, vapor pressure, temperature, relative humidity, dewpoint, windspeed and wind direction, and soil temperature.

Climate data (**Figure 2-7b**) are collected by other stakeholders in the watershed, including:

- Western Weather Group (http://www.westernwx.com/sonoma)
- Community Collaborative Rain, Hail and Snow Network (CoCoRaHS 2021)
- Sonoma Water, OneRain program (https://sonoma.onerain.com/home.php)

Local agencies are also working collaboratively with the National Oceanic and Atmospheric Administration (NOAA) and the USGS to develop better information on weather conditions, weather and river level forecasting, and climate change.

2.4.4 Surface Water Monitoring

Continuous streamflow data are collected by the USGS, Trout Unlimited, and Sonoma Water (**Figure 2-7c**). The USGS operates three streamflow gages in the watershed:

1. Kenwood (11458433 SONOMA CREEK A KENWOOD CA)
2. Agua Caliente (11458500 SONOMA C A AGUA CALIENTE CA)
3. Nathanson (11458600 NATHANSON C A SONOMA CA)

Synoptic streamflow measurements (seepage runs) were conducted on Sonoma Creek and its tributaries in 2003 and 2010 by the USGS. Sonoma Ecology Center has conducted seepage runs since 2014 and it is anticipated the organization will continue this work into the future. These seepage runs consist of a series of streamflow measurements made at multiple sites over a short time period (for example, single day to several days) along Sonoma Creek and its tributaries to quantify streamflow gains and losses for a specific time period. The seepage runs provide insights into stream reaches that rely on shallow groundwater to support streamflow and areas where surface water from streams provide a source of recharge to the groundwater system, as well as how these conditions can vary seasonally. Measurements have been collected at approximately 50 to 70 sites on a semiannual basis and at approximately 15 to 20 sites on a monthly to bimonthly basis (**Figure 2-7c**).

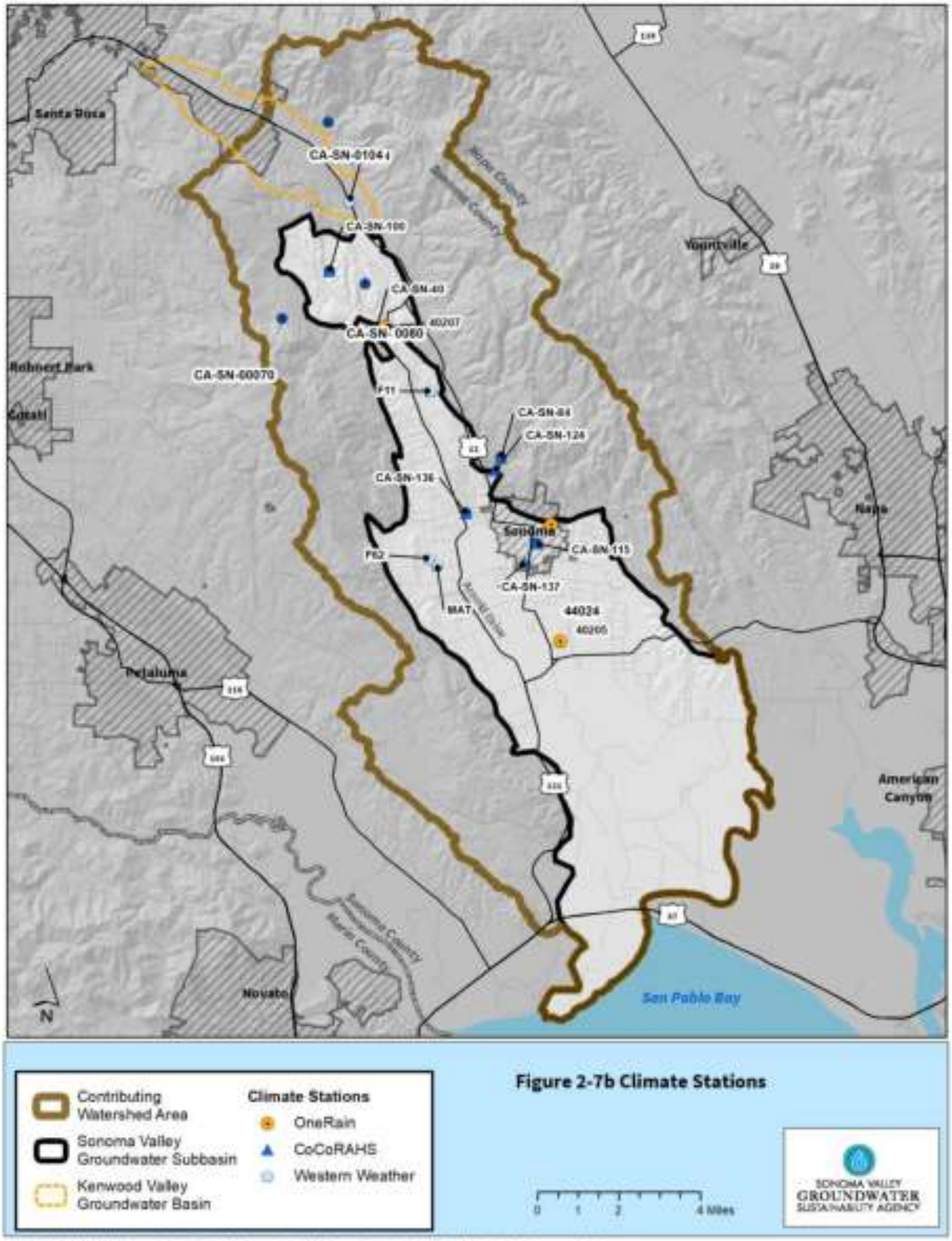

Figure 2-7b. Climate Stations

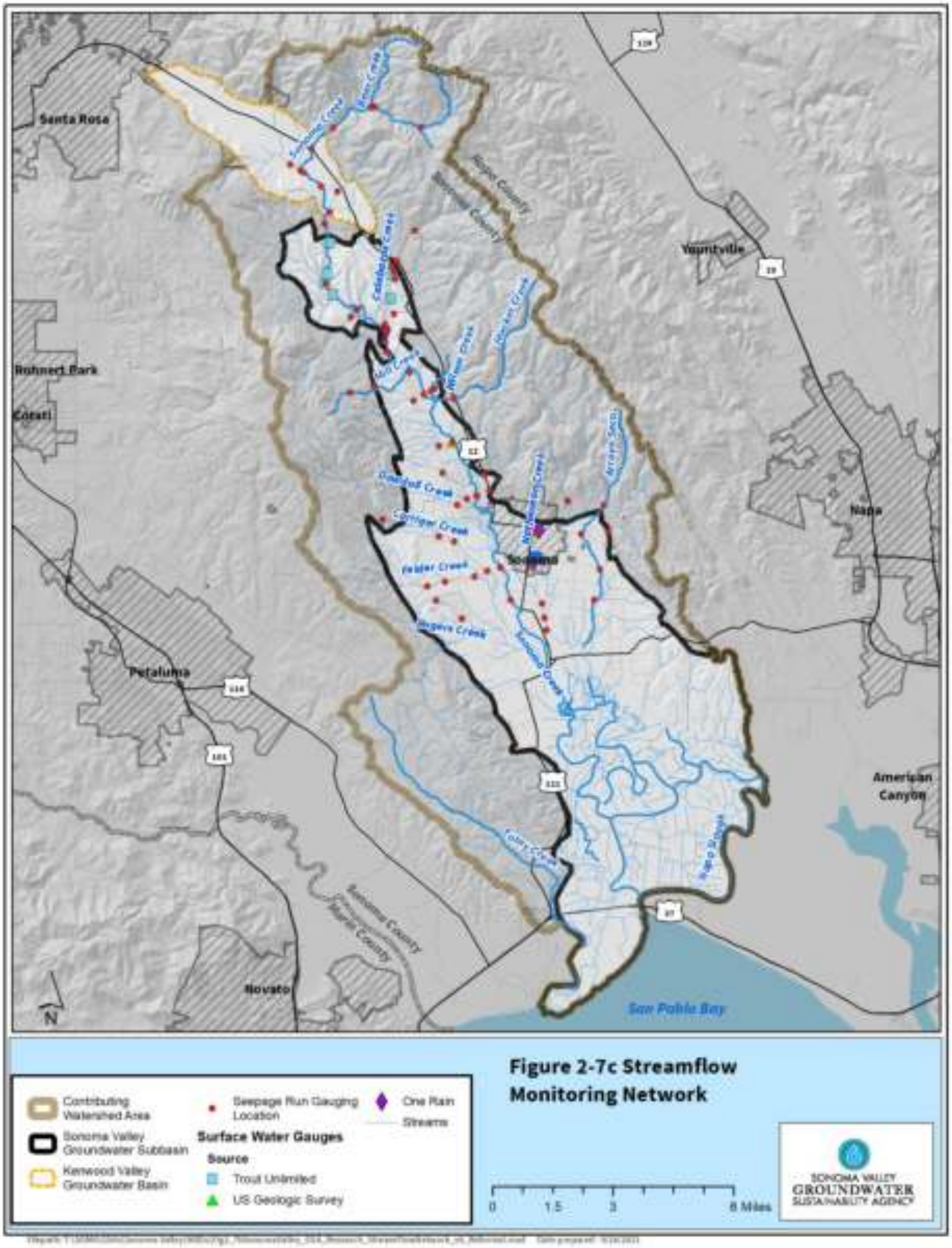

Figure 2-7c. Streamflow Monitoring Network

2.4.4.1 Land Surface Subsidence Monitoring

There are two primary systems for monitoring land surface subsidence in the Subbasin:

- To support the implementation of SGMA, subsidence is currently estimated every month by DWR using Interferometric Synthetic-Aperture Radar (InSAR) data. The InSAR data are spatially extensive (covering nearly the entire Subbasin) with data available monthly going back to 2015.

- Global positioning system (GPS) stations monitored by the University NAVSTAR Consortium's (UNAVCO's) Plate Boundary Observatory (PBO) program are an indicator for subsidence. There are currently no regularly scheduled theodolite (precision optical instruments used in land surveying) or total station surveys and no extensometers in the Sonoma Valley. The UNAVCO PBO consists of a network of about 1,100 continuous GPS and meteorology stations in the western United States used to monitor multiple pieces of information, including subsidence. There are two stations in the Subbasin and one in the upper watershed located: (1) near Highway 12 at Sonoma Creek, (2) on Rogers Creek near Temelec, and (3) on the ridgetop just south of Sugarloaf Ridge State Park. This is described in more detail in **Section 3**, Basin Setting.

2.5 Existing Management Programs and Studies (23 CCR 354.8 c, d, e)

There are many existing and previous water management programs, studies, and initiatives that cover the Sonoma Valley Subbasin that have been developed for a variety of purposes by multiple agencies and organizations. This section summarizes those deemed most relevant to groundwater management planning and indicates the type of information and details from these plans that is incorporated into subsequent sections of this GSP.

2.5.1 Sonoma Valley Groundwater Management Program

The current trend in declining groundwater levels was recognized in a 2006 USGS study (Farrar et al. 2006) conducted in cooperation with Sonoma Water. This study formed the basis of the 2007 Sonoma Valley Groundwater Management Plan, developed for the Sonoma Creek watershed under the leadership of a basin advisory panel, comprised of a diverse group of local stakeholders. The Groundwater Management Plan was prepared under the authority of the Groundwater Management Act, California Water Code Section 10750 et seq., originally enacted as Assembly Bill (AB) 3030 in 1992 to encourage voluntary, non-regulatory groundwater management at the local level.

The Groundwater Management Plan aimed to locally and voluntarily manage, protect, and enhance groundwater resources for all beneficial uses in a sustainable, environmentally sound, economical, and equitable manner for generations to come. This plan identified a range of voluntary water management actions, including groundwater recharge, groundwater banking, increased water use efficiency, and greater use of recycled water to reduce demand for groundwater. Key information, tools, and outcomes from these previous groundwater management planning activities include:

- Technical information on the Subbasin hydrology, hydrogeologic framework, water chemistry and source, surface water and groundwater interaction monitoring, and records of groundwater levels, including historical trends and documentation of groundwater depletion in southern Sonoma Valley
- Significant expansion of monitoring activities
- Initiation of studies and pilot programs for groundwater banking and stormwater recharge
- Development of a MODFLOW groundwater-flow model of surface water and groundwater systems in the Subbasin and contributing watershed area
- Initial scoping of projects and actions needed to address ongoing groundwater depletion and sustain groundwater resources in Sonoma Valley
- Engagement of local stakeholders in local groundwater planning and management

Prior to being discontinued in 2017, the Basin Advisory Panel and Technical Advisory Committee developed *Insights and Recommendations, Sonoma Valley Groundwater Conditions and Management* (Sonoma Valley GSA 2017) for the Sonoma Valley GSA to consider in developing this GSP.

2.5.2 Bay Area Integrated Regional Water Management Plan

In November 2002, California voters approved Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002. The Act encourages regional cooperation in water resources planning by providing grant funding for projects identified in a regional plan, referred to as an Integrated Regional Water Management Plan (IRWMP 2019). DWR designed the IRWMP planning process to be consistent with the California Water Plan, a statewide water resources planning document that is updated periodically and intends that IRWMPs and future updates of the California Water Plan be integrated further in the future.

The Bay Area IRWMP defines the Bay Area region according to the SFBRWQCB’s (Region 2) jurisdiction, which includes the Subbasin. This region includes all or major portions of the nine counties that surround the Bay. The Bay Area IRWMP is a living document and involves a diverse group of water supply, water quality, wastewater, stormwater, flood management, watershed and habitat agencies, local governments, environmental groups, business groups, and community-based organizations.

Stakeholders from the nine counties identified needs and challenges related to specific “Functional Areas,” described water management strategies to address these needs, and developed a list of potential strategies and implementation projects that maximize benefits and enhance opportunities for regional cooperation within a given functional area. The four Functional Areas are:

- Water Supply and Water Quality

- Wastewater and Recycled Water
- Flood Protection and Stormwater Management
- Watershed Management-Habitat Protection and Restoration

More information on the Bay Area IRWMP is available at http://bayareairwmp.org.

2.5.3 Urban Water Management Planning

Urban Water Management Plans (UWMPs) are prepared every 5 years by California's urban water suppliers to support long-term resource planning and ensure adequate water supplies are available to meet existing and future water demands. Every urban water supplier that either provides more than 3,000 AFY or serves 3,000 or more customers is required to assess the reliability of its water sources over a 20-year planning horizon considering normal, dry, and multiple dry years. The plans are submitted to DWR, which then reviews the plans to make sure they have completed the requirements identified in the Urban Water Management Planning Act (Division 6 Part 2.6 of the Water Code Sections 10610–10656).

Within the Subbasin, UWMPs are prepared by Sonoma Water as a wholesaler (Sonoma Water 2021), and the City of Sonoma (City of Sonoma 2021) and VOMWD (VOMWD 2021) as water retailers. The UWMPs discuss and describe:

- Existing water supplies and infrastructure
- Projected water demands over the next 20 years, based on population growth projections, land use designations, and growth policies in city and county general plans
- Projected water supplies available over the next 20 years, the reliability of that supply, and general plans for water supply projects
- Current and planned water conservation activities, targets, and compliance
- A water shortage contingency analysis
- A comparison of water supply and water demand over the next 20 years under different hydrological assumptions (normal year, single dry year, 4 consecutive dry years)

Because local groundwater makes up a portion of the urban water supply within the Subbasin, the UWMPs also discuss and describe groundwater-production facilities, historical and projected groundwater use, and the conditions of the groundwater basin. Thus, UWMPs serve as a routine mechanism for local urban water providers to coordinate and plan for future urban groundwater use. The most recent projections for future urban groundwater use are incorporated into the projected water budget described in **Section 3** (Basin Setting). However, it is noted that UWMPs do not consider rural residential, agriculture, and small municipal/mutual water systems.

In addition to the UWMPs required by the state, local urban water providers perform other water supply planning activities related to groundwater, including development of water master plans, preparation of water supply assessments for larger proposed developments (more than 500 dwelling units or equivalent), updates of city and county general plans, and other activities. Information regarding some of these activities is summarized below:

- City of Sonoma developed a Water Master Plan Update in 2018 (City of Sonoma 2018) and VOMWD developed a Water Master Plan in 2019 (VOMWD 2019).
- Sonoma Water developed the *2018 Water Supply Strategies Action Plan* (Sonoma Water 2018) in coordination with its water contractors (including the City of Sonoma and VOMWD) to increase water supply system reliability, resiliency, and efficiency in the face of limited resources, regulatory constraints, and climate change uncertainties. The *Water Supply Strategies Action Plan* was updated in 2018, and incorporates SGMA-related requirements and initiatives. The most recent version is available at http://www.scwa.ca.gov/water-supply-strategy.
- Beginning with the passage of Senate Bill (SB) 610 in 2002, water supply assessments must be furnished to local governments for inclusion in any environmental documentation for certain projects that are subject to the CEQA. The water supply assessments are required to determine water supply sufficiency for a 20-year projection in addition to the demand of existing and other planned future uses.

2.5.4 Water Conservation Programs

Numerous regional and local water conservation programs are operational in the Plan Area, including the Sonoma-Marin Saving Water Partnership, the LandSmart Program, and the Sustainable Winegrowing Program.

These programs are described in the following sections; however, it is anticipated that changes will likely occur as a result of sweeping legislation approved in 2018: AB 1668 (Friedman) and SB 606 (Hertzberg), which lay out a new long-term water conservation framework for California. The framework addresses both the urban and agricultural sectors, with goals to establish long-term improvements in water conservation and drought planning that recognize the need to adapt to climate change and the resulting longer and more intense droughts in California. The development of programs and initiatives is organized around four primary goals:

1. Use water more wisely
2. Eliminate water waste
3. Strengthen local drought resilience
4. Improve agricultural water use efficiency and drought planning

To fully plan, develop, and implement the new framework, DWR and the SWRCB are working together in collaboration with stakeholders to develop new standards for:

- Indoor residential water use

- Outdoor residential water use
- Commercial, industrial, and institutional (CII) water use for landscape irrigation with dedicated meters
- Water loss

Based on these standards, urban water suppliers will be required to stay within annual water budgets for their service areas. In addition, water suppliers will need to report the implementation of new performance measures for CII water use.

The legislation also made important changes to existing urban and agricultural water management planning, and enhanced drought preparedness and water shortage contingency planning for both urban water suppliers and small water systems and rural communities. Currently, state agencies are conducting needed studies and investigations, and developing standards and performance measures, web-based tools and calculators, data and data platforms, reports, and recommendations for the adoption of new regulations.

2.5.4.1 Sonoma-Marin Saving Water Partnership

The Sonoma-Marin Saving Water Partnership represents 10 water utilities in Sonoma and Marin Counties that are signatories to the California Water Efficiency Partnership and have joined to create a regional approach to water use efficiency. Within the Subbasin, these utilities include the City of Sonoma, VOMWD, and Sonoma Water. Each member utility has water conservation programs to assist its community with reducing water use. Water conservation and water use efficiency program elements specific to the Sonoma-Marin Saving Water Partnership include:

- Establishing a conservation coordinator, water waste prohibition, assistance, and water loss control programs (audits, leak detection, and repair)

- Urban water metering and conservation pricing (tiered structure)

- Developing and maintaining public information and school education programs on water and conservation

- Specific urban residential programs for indoor (high-efficiency toilets, fixtures, and washers) and outdoor landscaping assistance, surveys, and retrofits for increasing conservation

- Specific industrial and large landscape assistance, surveys, and retrofits for increasing conservation

- Rebate programs for high-efficiency appliances and fixtures

- Qualified water-efficient landscaper training that provides education on proper plant selection for local climates, irrigation system design and maintenance, and irrigation system programming and operation

- An online water-wise gardening website that offers a Mediterranean and native plant list, design and garden installation tips, and irrigation system design and maintenance information

- Green business program that provides businesses with water and energy conservation information and incentives to reduce waste and prevent pollution

More information is available at http://www.savingwaterpartnership.org.

2.5.4.2 Local Landscape Ordinances

The county, City of Sonoma, and VOMWD have developed individual water-efficient landscape ordinances. The new water-efficient landscape ordinances require a landscape plan check for certain projects, as described in the ordinance. It includes requirements for landscape water budgets, landscape and irrigation design, and irrigation scheduling.

2.5.4.3 LandSmart Program

The Sonoma RCD, Napa RCD, and the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) developed the LandSmart Program to help land managers identify and meet their natural resource management goals that support productive landscapes and thriving streams while meeting or exceeding environmental regulations. The program is applicable to a variety of agricultural lands. LandSmart Plans are developed by the agricultural producer, either independently, through workshops, or through one-on-one assistance from an RCD. Producers can also seek certification from the RCD’s certification team once plans are complete. LandSmart Plan templates and guidance materials are designed to assess current practices and identify recommendations for other practices that would benefit natural resources such as water quantity and quality. Practices are prioritized and tracked over time. Information on the LandSmart Program is available at www.LandSmart.org.

2.5.4.4 Sustainable Winegrowing Program

Members of the Wine Institute and the California Association of Winegrape Growers introduced the Sustainable Winegrowing Program in 2002 (California Sustainable Winegrowing Alliance et al. 2020) to promote environmental stewardship and social responsibility in the California wine industry. The workbook is a self-assessment tool for California’s vintners and growers and provides practical information on how to conserve natural resources, protect the environment, and enhance relationships with employees, neighbors, and local communities. The workbook addresses criteria for measuring performance, including Vineyard Water Management and Winery Water Conservation and Quality. More information on sustainable winegrowing practices is available at http://www.sustainablewinegrowing.org. Additionally, Sonoma County Winegrowers (https://sonomawinegrape.org) have developed a Sustainability Certification Program for vineyards, which includes water conservation assessments.

2.5.5 Climate Change Studies and Planning

Projected changes in climate include increased variability in precipitation and rises in air temperature, resulting in a shorter wet season, longer dry season, more frequent droughts, and more extreme high flows. To face these potential changes in climate, local organizations are working with federal and state partners, including the USGS, DWR, NOAA, and the U.S. Army Corps of Engineers to advance the science in the region in an effort to plan for and adapt to predicted changes. Local agencies have also partnered to form the Sonoma County Regional Climate Protection Authority and developed a regional climate action plan, *Climate Action 2020 and Beyond* (Sonoma County Regional Climate Protection Authority 2016). Findings and results from these efforts are described in **Section 3** (Basin Setting) and incorporated into model projections in this GSP.

2.5.6 Groundwater Banking Feasibility Study

Due to uncertainties in the reliability of future regional water supplies (both surface water and groundwater), Sonoma Water, City of Sonoma, and other local partners, including the cities of Rohnert Park and Cotati, VOMWD, and the Town of Windsor, conducted a Groundwater Banking Feasibility Study for a regional groundwater banking program. The purpose of the study was to investigate the viability of enhancing the conjunctive management of surface water and groundwater resources (GEI Consultants, Inc. et al. 2013).

Conceptually, the program would involve the diversion and transmission of surplus Russian River water produced at existing drinking water production facilities during wet weather conditions (that is, the winter and spring seasons) for storage in aquifers beneath the Santa Rosa Plain and/or Sonoma Valley—a concept referred to as Aquifer Storage and Recovery (ASR). The stored water would then be available for subsequent recovery and use during dry weather conditions (that is, the summer and fall seasons) or emergency situations. The Feasibility Study provided an evaluation of the regional needs and benefits, source water availability and quality, regional hydrogeologic conditions, and alternatives for groundwater banking.

Based on the findings from the study, pilot studies to further assess the technical feasibility of ASR as a method for groundwater banking were recommended and currently are being pursued in the City of Sonoma, where a pilot project was completed in fall 2018. The pilot project resulted in the empirical verification of specific hydrogeologic and water quality factors. The next steps are a technical and economic viability assessment of ASR technology in the region. If deemed feasible, the pilot project results could be used to complete environmental documentation and design for a full-scale or permanent ASR project in the region. Results from the pilot project also provided information on the technical feasibility for ASR in Sonoma Valley to other local agencies, including the VOMWD and the Sonoma Valley GSA.

2.5.7 Sonoma Valley Salt and Nutrient Management Plan

The SWRCB adopted a Recycled Water Policy in February 2009, subsequently updated in 2013 and 2018 (SWRCB 2018). The purpose of the Policy is to increase the use of recycled water in a manner that implements state and federal water quality laws. The Recycled Water Policy requires that SNMPs be completed to facilitate basin-wide management of salts and nutrients from all sources, to optimize recycled water use while protecting groundwater supply and beneficial uses, agricultural beneficial uses, and human health.

The SVCSD prepared a SNMP for the Subbasin (SVCSD 2013), which was approved by the SFBRWQCB in 2015. Components of the SNMP included:

- Water recycling goals and objectives
- Salt and nutrient source identification
- Basin loading – assimilative capacity estimates
- Anti-degradation analysis
- Implementation measures
- Basin-wide water quality monitoring
- Consideration of emerging constituents of concern

The SNMP concluded that basin-wide levels of salts (specifically TDS levels) and nutrients (specifically nitrate values) generally are acceptable as established by the Water Quality Objectives in the SFBRWQCB Water Quality Control Plan (or Basin Plan) (SFBRWQCB 2010) and are projected to increase very slowly over time. The contribution of future projected recycled water levels within the Subbasin was estimated to be a minor component of projected increases. A groundwater quality monitoring program is included as part of SNMP implementation, and is a subset of the GSP monitoring program, required to be reported separately to the SFBRWQCB every 3 years.

2.5.8 Stormwater Management Planning

In 2012, Sonoma Water completed a scoping study in Sonoma Valley to identify opportunities to alleviate urban flooding, while possibly recharging groundwater aquifers or providing other benefits (Sonoma Water 2012). Information and results from this study and others in the region have informed the development of a Stormwater Resources Plan (SWRP). SWRPs are required by SB 985 (Pavley 2014) to be eligible to seek funding from any future state bond measures for stormwater projects. A SWRP is a non-regulatory, watershed-based and stakeholder-driven plan that builds on local stormwater management objectives and identifies and prioritizes projects that capture, treat, or reuse stormwater and dry weather runoff. These projects must provide at least two benefits, which may include environmental enhancement, flood protection, groundwater recharge, water quality improvement, and/or recreational opportunities.

Sonoma Water, with support from a technical advisory committee, collaboratively developed with other local stakeholders the Southern Sonoma County Storm Water Resources Plan (Sonoma Water 2019) covering the Petaluma River and the Sonoma Creek watersheds (including the Subbasin). Through the planning process, more than 60 projects were identified and submitted by proponents for consideration and inclusion. The resulting plan provides a framework for submitting, quantifying, scoring, and ranking future projects in an objective and data-driven format.

2.6 General Plan and Related Land Use Planning

Existing city and county planning activities that are directly or indirectly linked with water supply and groundwater management include general plans, specific plans, and UWMPs, as described in the previous subsections. Under SGMA, cities and counties retain their land use authorities; however, in recognizing the linkages between land use and water management, SGMA does require increased coordination between land use planners and GSAs. Cities and counties must now refer proposed general plan changes to GSAs, and similarly GSPs must account for “the most recent planning assumptions stated in local general plans of jurisdictions overlying the basin” (CWC Section 10726.9). In addition, California State Government Code Title 7, Division 1, Article 6, Section 65350.5 stipulates that before general plans are adopted, they must review and consider GSPs.

The City of Sonoma and Sonoma County general plans and specific plans provide growth estimates based on the build out of land use designations that are used in the UWMPs and in this GSP to project future water demands. The growth estimates are also incorporated into the sustainable management criteria and metrics, including measurable objectives and interim milestones, the sustainability goal, proposed projects, and management actions. Projections of future groundwater availability and planned projects and actions needed for sustaining groundwater resources in the Subbasin will be shared with city and county planners for incorporation into their respective land use planning and decision making.

In addition to coordinating on activities within the Subbasin, coordination and information sharing between the GSA and land use planning agencies will be needed for the contributing watershed areas located outside of the GSA’s jurisdiction. These areas primarily fall within the purview of the Sonoma County General Plan.

Future land use planning and associated growth projections are incorporated into the analysis of the future water budget, over the planning and implementation horizon (**Section 3**, Basin Setting).

2.6.1 General Plans

Counties and cities are required to develop and adopt comprehensive general plans to guide future local physical development, as required by California State Government Code Title 7, Division 1, Article 5, Section 65300 et seq. Each general plan must contain a statement of policies, including maps or diagrams and text, setting forth objectives, principles, and standards, and designating land use densities and intensities. City general plans are focused on providing guidance on growth and development in the urban setting, while county general plans focus on the unincorporated areas of the county. Developing and updating general plans involves significant community involvement through workshops, hearings, and public review of draft plans and policies. The Subbasin includes areas covered by Sonoma County’s General Plan and the City of Sonoma’s General Plan (the northern portions of the City of Sonoma are outside the Subbasin).

While there are seven mandatory elements of a general plan, the conservation element is typically where water resources are addressed, although water-related topics may also be addressed in other elements. In particular, the conservation element of a general plan must account for "rivers, creeks, streams, flood corridors, riparian habitats, and land that may accommodate floodwater for purposes of groundwater recharge and stormwater management" (California State Government Code Section 65302[d][3]). The housing elements are updated on an 8-year cycle to correspond with state regional housing needs allocations (California State Government Code Section 65584[b]).

Specific plans are also used within the Subbasin to focus on planning defined areas within a jurisdiction.

2.6.1.1 Sonoma County General Plan 2020

The *Sonoma County General Plan 2020* (Sonoma County 2008) contains the seven mandatory elements of a general plan plus four optional elements: agricultural resources, air transportation, water resources, and public facilities and services. The water resources element was developed and included in the *Sonoma County General Plan 2020* in recognition of the importance of water resources within unincorporated areas of the county. The main purpose of the water resources element is to ensure that Sonoma County's water resources are sustained and protected. To achieve this main purpose, the water resources element states that water-resource management should consider the amount of water that can be used without exceeding the replenishment rates over time or causing long-term declines or degradation in available surface water or groundwater resources.

The water resources element includes goals, objectives, and policies for water quality and groundwater; public water systems; conservation and reuse; importing and exporting; and watershed management. These goals, objectives, and policies include supporting local groundwater studies and management programs, and encouraging activities that protect natural groundwater-recharge areas. The water resources element of the *Sonoma County General Plan 2020* can be reviewed at https://sonomacounty.ca.gov/PRMD/Long-Range-Plans/General-Plan/Water-Resources.

Other water-related topics incorporated in the *Sonoma County General Plan 2020* include water availability as a factor in land use map densities, which is addressed in the land use element. Land use designations based on the *Sonoma County General Plan 2020* are shown on **Figure 2-8**. The open space and resource conservation element addresses riparian corridors, wetlands, wildlife protection, tree protection, fishery resources and other biotic resources, water-oriented recreation, soil erosion, forestry, and mineral resources. The public facilities and services element addresses connections to public water systems. The public safety element addresses flood hazards, fire suppression, and hazardous materials.

It is anticipated that the next Sonoma County General Plan update will begin in 2022 and conclude in 2028.

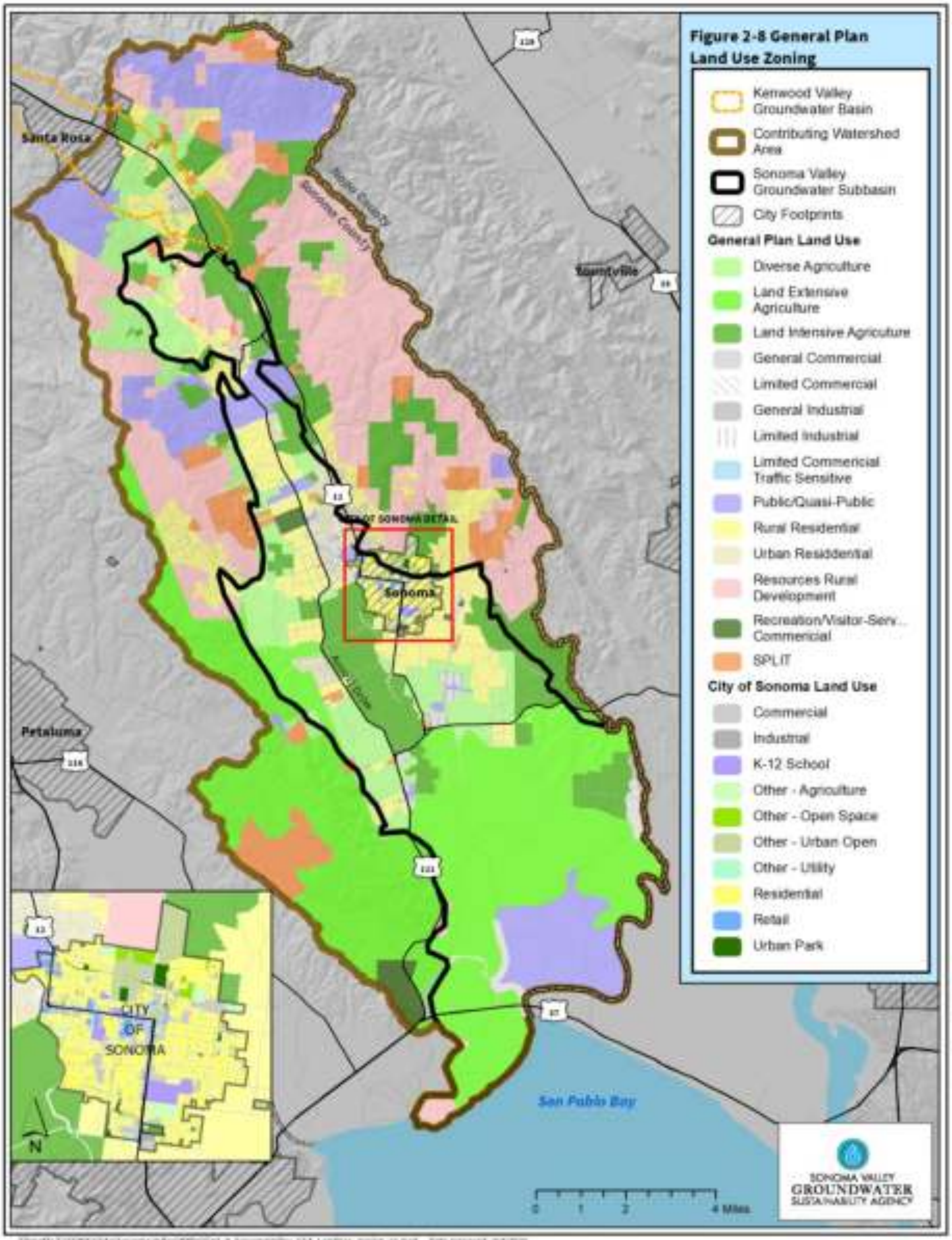

Figure 2-8. General Plan Land Use Zoning

2.6.1.2 City of Sonoma General Plan

City general plans guide growth and development in the urban community, and typically involve an urban-growth boundary. The UWMPs and general plans are clearly linked: UWMPs calculate future water demand based on growth and development projected in the associated general plan.

The *City of Sonoma 2020 General Plan* (City of Sonoma 2006) contains community development, environmental resources, local economy, circulation, public safety, noise, and housing elements. Each element contains goals, policies, and implementation measures that set a course for future land use in the city. Goals summarize how development and future growth should be directed to achieve the general plan vision by identifying physical, economic, and/or social ends that the community wishes to achieve.

The community development element defines the planned growth within the city, which is controlled by the City's Growth Management Ordinance. The Growth Management Ordinance limits residential construction in the city to an average of 65 units per year based, in part, on water-supply availability. A policy related to groundwater to "protect Sonoma Valley watershed resources, including surface and groundwater supplies and quality" is included within the Environmental Resources element.

2.6.2 Specific Plans

Specific plans are tools for implementing general plans and guiding the development of a defined geographic area within the county. A specific plan establishes a link between implementing policies of the general plan and the individual development proposals for the specified area. Any new developments or subdivisions within the defined area must be consistent with the general plan and specific plan.

The Sonoma County *Springs Specific Plan* is currently being developed by Permit Sonoma and, if adopted, will be the primary planning document and reference guide for future development in the Springs area of the Subbasin, which covers approximately 178 acres within portions of the unincorporated communities of Agua Caliente, Fetters Hot Springs, and Boyes Hot Springs (**Figure 2-1**). Growth and land use criteria from the Springs Specific Plan will be incorporated into the GSP once the specific plan is adopted.

Similarly, Permit Sonoma is developing a Specific Plan for the former Sonoma Developmental Center in unincorporated Glen Ellen and is expected to be completed in 2022. The Sonoma Developmental Center Specific Plan will address redevelopment of the approximately 200-acre campus, which is currently owned by the State of California. A mix of housing and commercial uses are expected to be planned for the site.

2.6.3 Sonoma County Local Agency Formation Commission

The Sonoma County Local Agency Formation Commission (LAFCO) is a state-created regulatory agency that approves or disapproves proposals to expand municipal water and wastewater services outside of existing service areas. Through this power, the LAFCO is an important agency in proposals to offset groundwater use with urban water for both new and existing development in the county.

LAFCO has responsibility in four areas affecting local government in Sonoma County:

1. To review and approve or disapprove proposals for changes in the boundaries and organization of the 9 cities and 54 special districts within Sonoma County, including the incorporation of new cities, formation of new special districts and mergers, and consolidations or dissolutions of existing cities and special districts

2. To conduct studies, including municipal service reviews, of existing local government services with the goal of improving the efficiency of services

3. To establish spheres of influence, which are plans for the probable physical boundaries of each local agency, for cities and special districts within the County, and to review and update those spheres of influence every 5 years

4. To assist the public and other government agencies concerning changes in local government boundaries and organization

2.7 Well Permitting Policies and Procedures

Permit Sonoma is the local agency responsible for administering permits for wells countywide and within both unincorporated and incorporated areas of the Subbasin. Permit Sonoma is also responsible for permitting certain development projects; for example, wineries, subdivisions, and cannabis production, in unincorporated areas.

2.7.1 Well Permitting

Permit Sonoma is the Sonoma County agency responsible for administering permits for water supply and monitoring wells within the Subbasin, including within the jurisdiction of cities. Sonoma County Department of Health Services administers permits for environmental drilling and wells, generally associated with contaminated sites. The purpose of the County's well-construction policies is to provide for the location, construction, repair, reconstruction, and destruction of wells and to address the abandonment of all wells to protect the groundwater resources of the County, because contamination may cause serious public health, safety, or economic problems.

The Sonoma County Well Ordinance contains regulations and requirements for constructing wells to prevent groundwater contamination from the surface, and between multiple water bearing zones (Chapter 25B of Sonoma County, California – Municipal Code). The well-construction standard does not regulate flow volumes or rates, nor does it evaluate water availability or local hydrogeology.

2.7.2 Project Permitting

Permit Sonoma reviews all development proposals within unincorporated areas that will rely on wells for their water supplies, including wineries, subdivisions, and cannabis permits. Permits for agricultural development projects are processed through the Sonoma County Agricultural Commissioner. Permit Sonoma uses a four-tier groundwater classification system map, based on geologic information and water yields, to designate general areas of groundwater availability (**Figure 2-9**), for reviewing certain development and building permit applications. Class 1 areas are Major Groundwater Basins, Class 2 areas are Major Natural Recharge Areas, Class 3 areas are Marginal Groundwater Availability Areas, and Class 4 areas are Areas with Low or Highly Variable Water Yield.

The Class 1 and Class 2 groundwater availability areas generally correlate, but do not completely correspond, with DWR's Bulletin 118 basin boundaries. Discretionary applications in Class 3 and 4 areas and in SGMA medium- and high-priority basins, including the Sonoma Valley Subbasin, are required to include hydrogeologic reports to establish that groundwater quality and quantity are adequate and will not be adversely impacted by the cumulative developments and uses allowed in the area.

Since 2004, Permit Sonoma has required groundwater-level measurement and volume reporting from water wells on a quarterly or monthly basis as standard conditions of approval for cannabis permits and commercial/industrial projects requiring a use permit and using more than 0.5 AFY of water. Projects in southern Sonoma Valley are also generally required to perform and report water quality monitoring due to concerns with elevated salinity in that area. For projects where significant impacts are identified, Permit Sonoma may require a demonstration of zero or de minimis net water use through onsite water conservation, rainwater or surface water storage, groundwater recharge, and/or offsite mitigation.

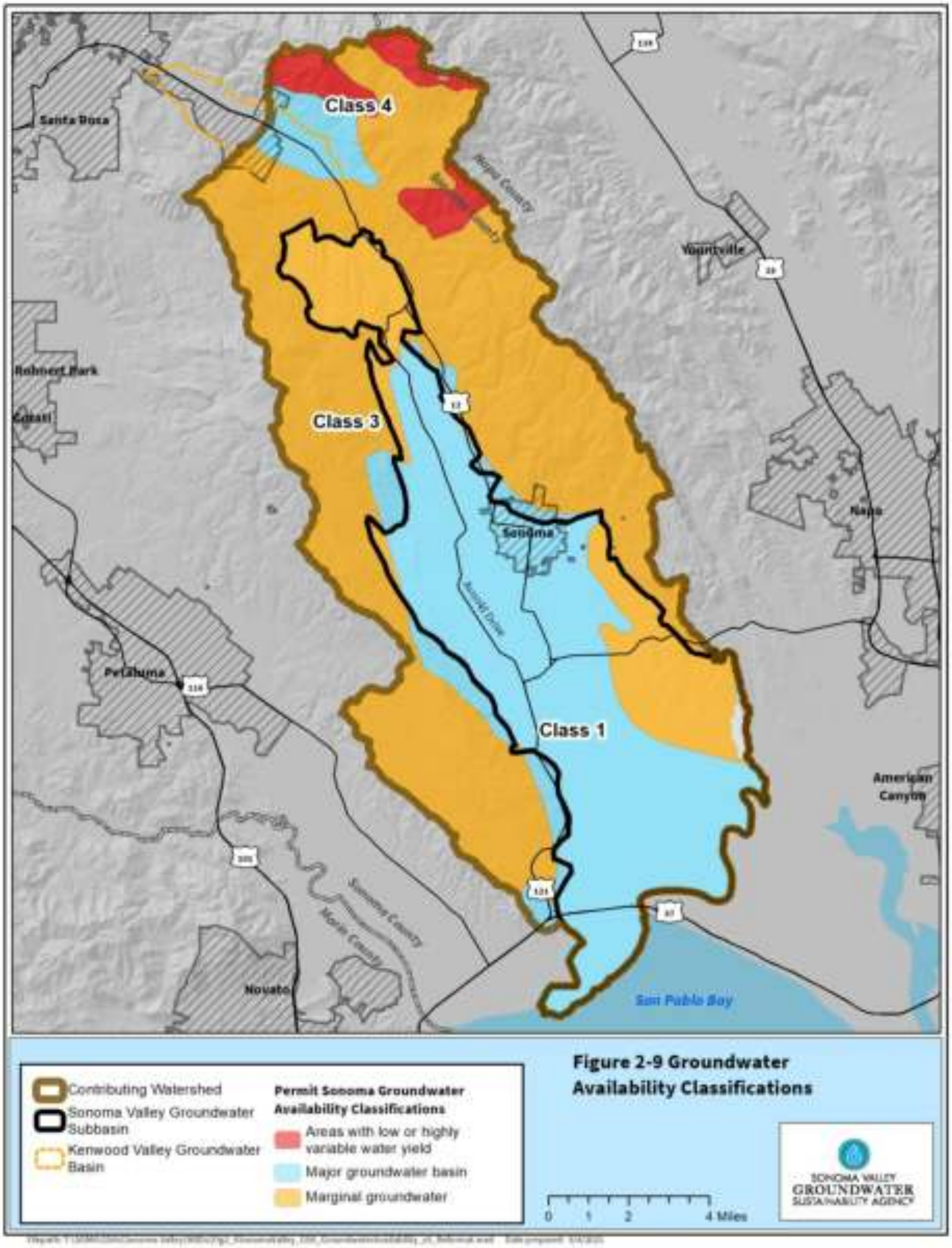

Figure 2-9. Groundwater Availability Classifications

DRAFT

Section 3: Basin Setting Section

Groundwater Sustainability Plan for
Sonoma Valley Groundwater Subbasin

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3 BASIN DESCRIPTION

This section provides information about the physical setting, characteristics, and current condition of the Subbasin, including the identification of data gaps and levels of uncertainty. The information included within this section represents the current understanding of the Subbasin based on available data and serves as the basis for defining and assessing SMC, potential projects, and management actions. This section contains four primary subsections:

- Hydrogeologic Conceptual Model (**Section 3.1**)
- Current and Historical Groundwater Conditions (**Section 3.2**)
- Water Budget (**Section 3.3**)
- Management Areas (**Section 3.4**)

This section draws upon new information developed for the refined groundwater flow model and previously published studies and reports, including the following primary data sources that document the conditions of the Sonoma Valley Subbasin and contributing watershed areas:

- *Five-Year Review and Update Report* (SVGMP 2014)
- *Sonoma Valley Groundwater Management Plan* (Sonoma County Water Agency 2007)
- *Geohydrological Characterization, Water-Chemistry, and Ground-Water Flow Simulation Model of the Sonoma Valley Area, Sonoma County, California* (USGS 2006)

3.1 Hydrogeologic Conceptual Model

This subsection describes the hydrogeologic conceptual model (HCM), which characterizes the physical components of the surface water and groundwater systems in the Subbasin. As defined in the GSP Regulations, the HCM shall provide the following:

- General physical characteristics related to regional hydrology, geology, geologic structure, water quality, principal aquifers, and principal aquitards of the basin setting
- Contextual information necessary to develop water budgets, mathematical (analytical or numerical) models, and monitoring networks
- A tool for stakeholder outreach and communication

As such, this subsection includes a description of the topography, geography, surface-water features, soil characteristics, geologic setting and formations, principal aquifers and aquitards, role of faults, groundwater recharge and discharge areas, and data gaps and uncertainties. This information is integrated into the water budget and numerical model described in **Section 3.3** (Water Budget) and monitoring networks described in **Section 5** (Monitoring Program). Additionally, figures and diagrams developed for the HCM are incorporated into community and stakeholder outreach materials.

3.1.1 Topography and Geography

The Subbasin is located in the North Coast Ranges geomorphic province of California, characterized by predominantly northwest trending mountains and valleys. The Subbasin is adjacent to and north of San Pablo Bay and is approximately 20 miles in length, encompassing the majority of Sonoma Valley between the Sonoma Mountains to the west and the Mayacamas Mountains to the east, as shown on **Figure 3-1**.

The Sonoma Mountains separate the Subbasin from the Petaluma Valley and Santa Rosa Plain to the west and are of moderate relief, sloping gently from a few hundred feet in the southern part to greater than 2,000 feet southwest of Glen Ellen and reaching a maximum elevation of about 2,295 feet on Sonoma Mountain. The Subbasin is bounded on the east by the Mayacamas Mountains that range from less than 100 feet elevation in the Carneros area, increasing from south to north to a maximum elevation of 2,730 feet at Hood Mountain northeast of the Subbasin.

The Subbasin between the two ranges is not uniform in width or slope and can be subdivided into two portions on the basis of topography. The northern portion of the Subbasin is much narrower than the lower portion and has a hilly topography. This portion of the valley is sometimes referred to as the Valley of the Moon and includes the Glen Ellen area and extends southward to near Boyes Hot Springs (**Figure 3-1**). In this part of the valley, elevations drop from about 400 feet to about 100 feet over an approximately 5-mile distance, from north to south. The southern portion of the Subbasin from Boyes Hot Springs southward to San Pablo Bay has a relatively flat topography and ranges as much as 5 miles in width and includes the City of Sonoma and communities of El Verano and Schellville. In this area, the elevation of the Subbasin floor gradually slopes from about 100 feet to sea level over a distance of about 12 miles.

3.1.2 Surface Water and Drainage Features

The Subbasin and contributing Sonoma Creek watershed is drained by Sonoma Creek, which discharges into San Pablo Bay in the northern part of San Francisco Bay (**Figure 3-1)**. Sonoma Creek flows for approximately 33 miles, beginning in the Mayacamas Mountains outside of the Subbasin in the northeastern portions of the Sonoma Creek watershed, at an elevation of about 1,600 feet within Sugarloaf Ridge State Park (**Figure 3-1**). The creek flows generally westward through a narrow canyon, with a steep gradient from the headwaters to the edge of the adjacent Kenwood Valley Groundwater Basin near the community of Kenwood. In this 3-mile reach, the creek drops about 1,100 feet to an elevation of about 500 feet. The course of the creek turns to the south near Kenwood and turns to the southeast where it enters the Subbasin near Glen Ellen. The gradient is much less steep in the 6.5-mile reach between the mountain front and Glen Ellen, dropping in elevation by about 280 feet. The gradient flattens further between Glen Ellen and San Pablo Bay. As it passes through the City of Sonoma, it is an urban creek that emerges into agricultural areas to the south. South of State Route 121 where Sonoma Creek flows through tidal marshland to San Pablo Bay, the stream drops only about 10 feet in 9 miles (USGS 2006). Primary tributaries to Sonoma Creek within the Subbasin include Calabazas Creek, Yulupa Creek, Carriger Creek, Fowler Creek, Nathanson Creek, Arroyo Seco, Schell Creek, Tolay Creek, and Fryer Creek (**Figure 3-1**).

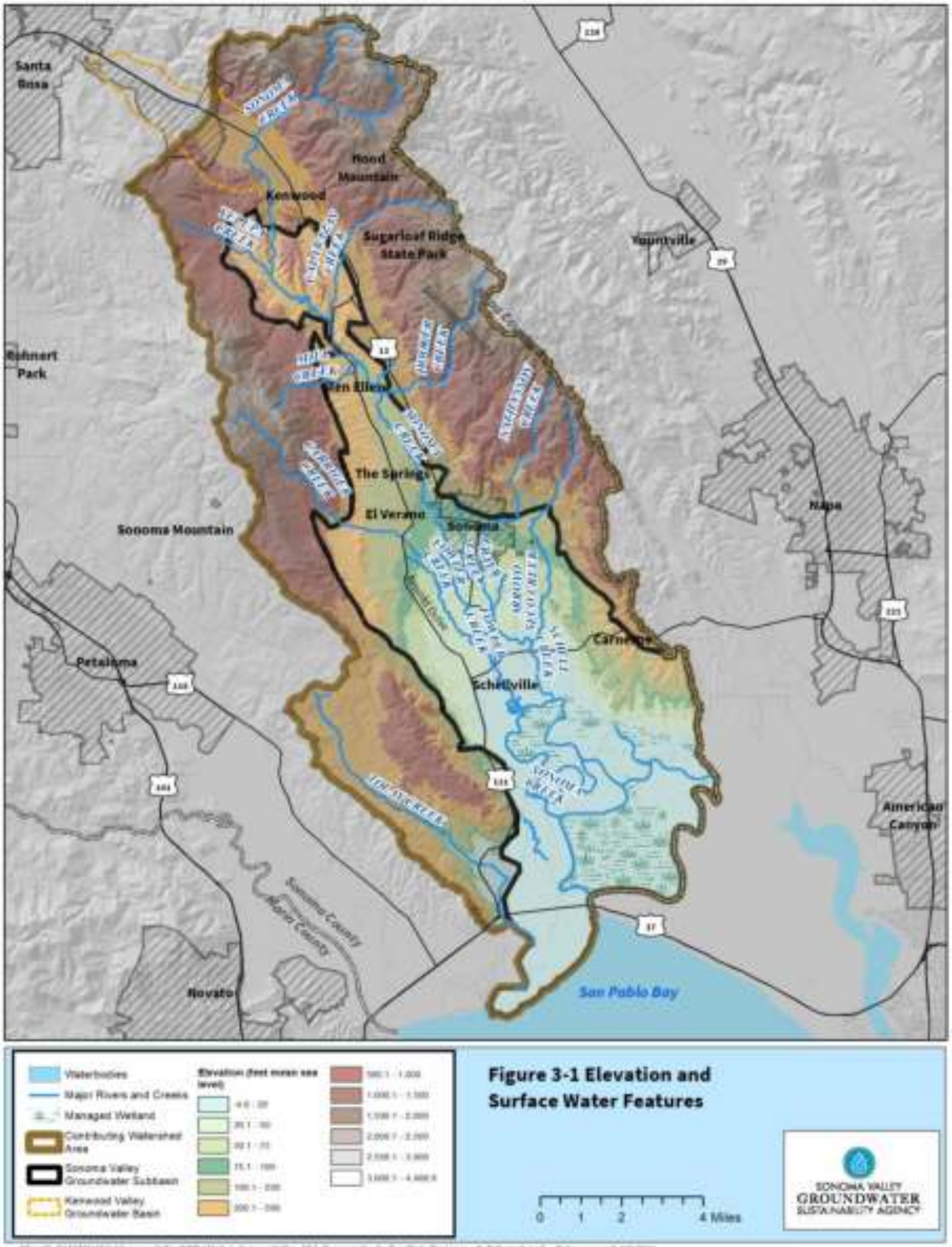

Figure 3-1. Elevation and Surface Water Features

3.1.3 Soil Characteristics

Soil types and characteristics in the Subbasin and contributing watershed have been mapped by the USDA NRCS, which developed a spatial database of soils for the entire United States (the Soil Survey Geographic Database [SSURGO]) (USDA NRCS 2007). The SSURGO database defines 17 different soil textures (excluding variable and unknown textures) present in the study area (**Figure 3-2a)**. The majority of the valley floor is characterized by clayey soils and loams, with gravelly and cobbly loams and more prevalent along alluvial fans and hilly areas. Gravelly and sandy soils are primarily limited to narrow stream channels within the Subbasin.

The SSURGO database also assigns saturated hydraulic-conductivity values to soil groups (**Figure 3-2b)**. Saturated hydraulic conductivity is a measurement of the representative or average water-transmitting properties of soils and is a good indicator of the soil's infiltration potential. As indicated on **Figure 3-2b**, the loams and clayey loam soils that predominate the floor of the Subbasin exhibit relatively low hydraulic-conductivity values (slow to moderate), on the order of 0.1 to 4 feet per day (ft/d). Coarser-grained soils present in and around the Subbasin, which exhibit higher hydraulic-conductivity values (moderate to rapid) on the order of 4 to 12 ft/d, are predominately in the hilly areas northwest of Glen Ellen and west of El Verano (Carriger Creek alluvial fan area). The highest saturated hydraulic-conductivity values (rapid to very rapid) on the order of 12 to 40 ft/d primarily occur within streambed channels.

3.1.4 Regional Geologic Setting

The Subbasin and contributing watershed are located within the northern Coast Ranges, a region of geologic complexity caused by long periods of active tectonic deformation, volcanic activity, and sea-level changes. Geologic formations within the Subbasin are grouped into two broad categories (Mesozoic Era basement rocks and younger Cenozoic Era volcanic and sedimentary units) based on the age, degree of consolidation, and amount of deformation (such as folding, faulting, and fracturing). The Subbasin is underlain at varying depths by Mesozoic Era (more than 66 million years old) basement rocks consisting of metamorphic, igneous, and metasedimentary rocks of the Jurassic/Cretaceous-aged Franciscan Complex, Coast Range Ophiolite, and Great Valley Sequence. A mixture of younger (Tertiary and Quaternary-aged) volcanic and sedimentary rocks and unconsolidated sediments of the Cenozoic Era (less than 66 million years old) overlies these basement rocks.

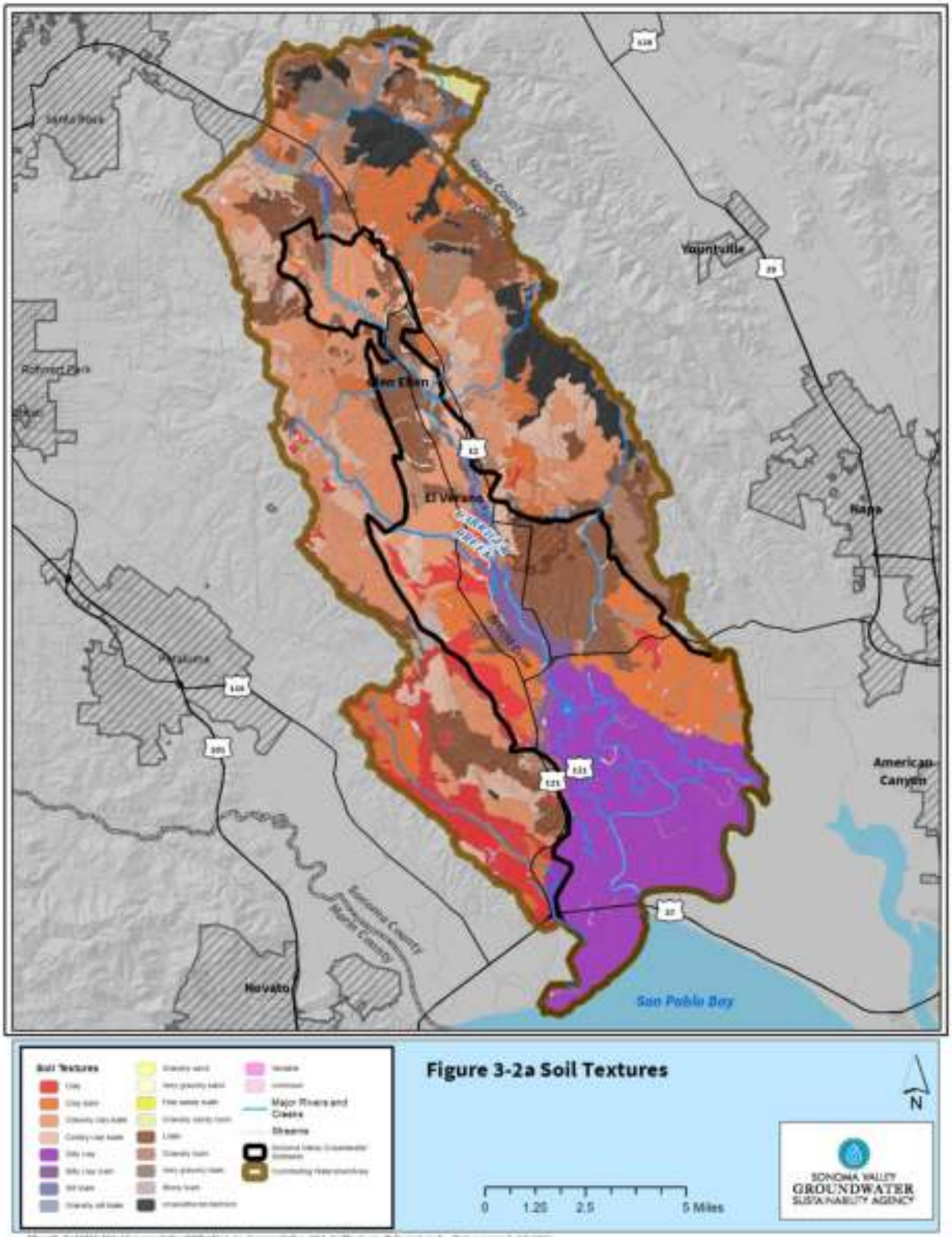

Figure 3-2a. Surficial Soil Textures

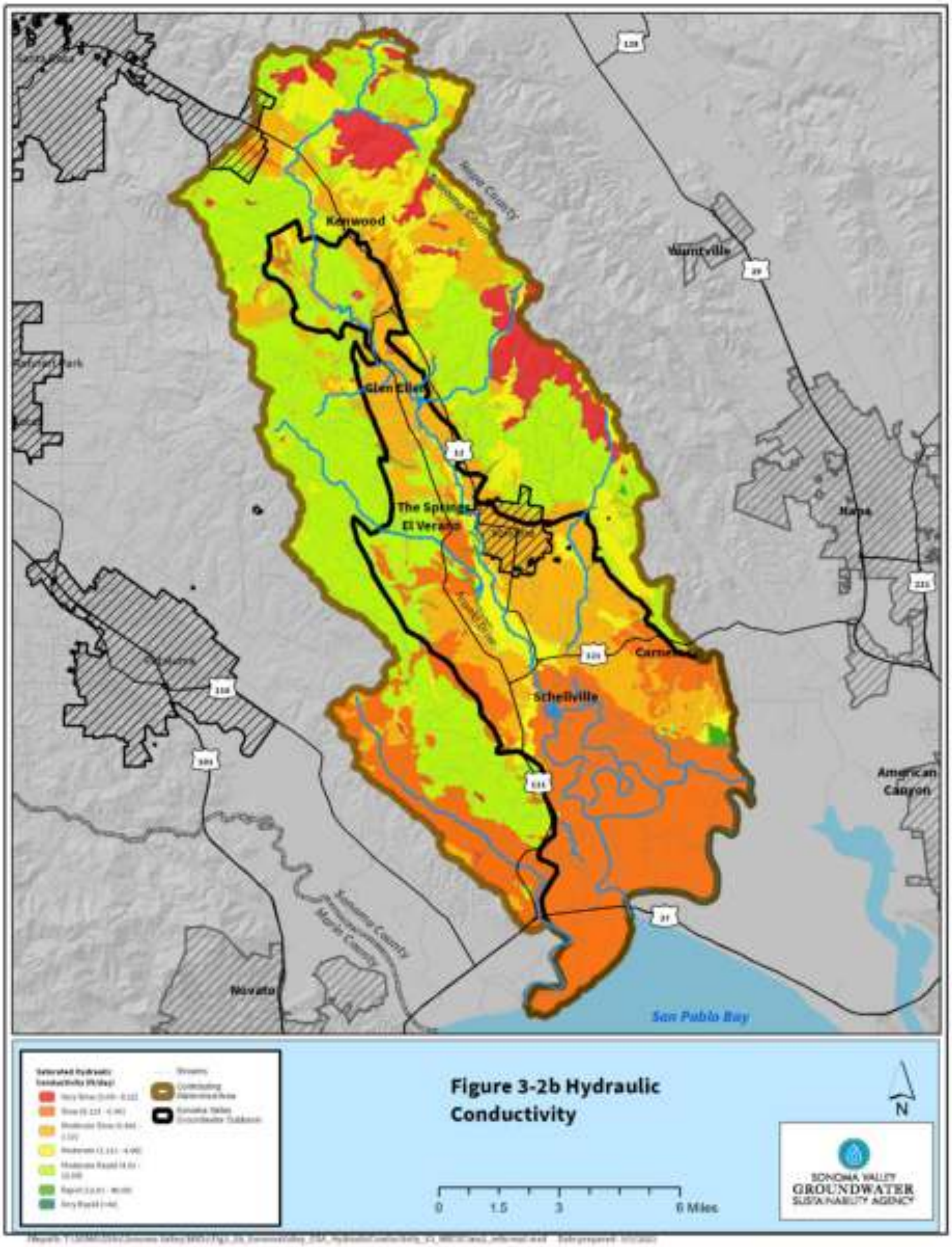

Figure 3-2b. Surficial Soils Hydraulic Conductivity

Figure 3-3a presents a geologic map of the watershed showing the surficial distribution of these geologic units, with the legend and relative ages for the units shown on **Figure 3-3b**. The locations of three geologic cross sections are displayed on **Figure 3-4a**, and the inferred subsurface distribution of the geologic units and lithologic descriptions from drillers logs are displayed on the hydrogeologic cross sections shown on **Figures 3-4b** through **3-4d**. The three cross sections are A-A’, B-B’, and C-C’. Cross section A-A’ strikes north-northwest along the southeastern portion of the Subbasin, B-B’ strikes parallel to A-A’ from its northernmost point near the Sonoma Developmental Center until its halfway point where it turns toward the terminus of the A-A’ section, and the C-C’ cross section strikes perpendicular to the other two cross sections passing through the southern boundary of the City of Sonoma. The cross sections illustrate the stratigraphy of the Tertiary and older units, the nature of the contacts between the units, and role of faults in the subsurface distribution of the geologic units. At depth the Sonoma Volcanics is generally fairly well distinguished in well logs, whereas the contact between the Huichica and the overlying Glen Ellen Formation is shown as gradational and interfingering or not readily distinguishable.

3.1.4.1 Geologic Structure

The northern Coast Ranges structure is dominated by the northwest trending San Andreas right-lateral transform fault system that marks the boundary between the Pacific oceanic and North American continental tectonic plates, including the San Andreas zone of faults to the west, and the Rodgers Creek, the Mayacama, and the Bennett Valley Fault zones, all of which are right-lateral strike slip faults. The regional tectonic structure has helped shape the Subbasin, the surrounding northwest trending valleys and ridges, and the underlying geology.

In Sonoma Valley, the geologic formations have undergone several episodes of folding and faulting that have resulted in a general synform (or U-shaped) structure to the valley with unit layering tilted towards the valley axis. This general structure is not uniform and is disrupted by many minor folds and faults (Farrar et al. 2006). As shown on **Figures 3-3a** and **3-3b**, both inactive and active faults are prevalent in the region and numerous faults and fault systems have been mapped within the hills surrounding Sonoma Valley, particularly within the southwestern hills and northwestern hills associated with the Rodgers Creek/Tolay Faults and the Bennett Valley Fault, respectively. Faults are generally not evident on the valley floor where they are concealed by younger sediments. However, along the east side of the valley, the Eastside Fault has been mapped based on geophysical studies and the outcrop pattern of Tertiary sediments of the Huichica Formation (**Figure 3-3b** and **Figure 3-4b**). Available information on the effects of faults on groundwater movement and groundwater quality is described in **Section 3.1.6**.

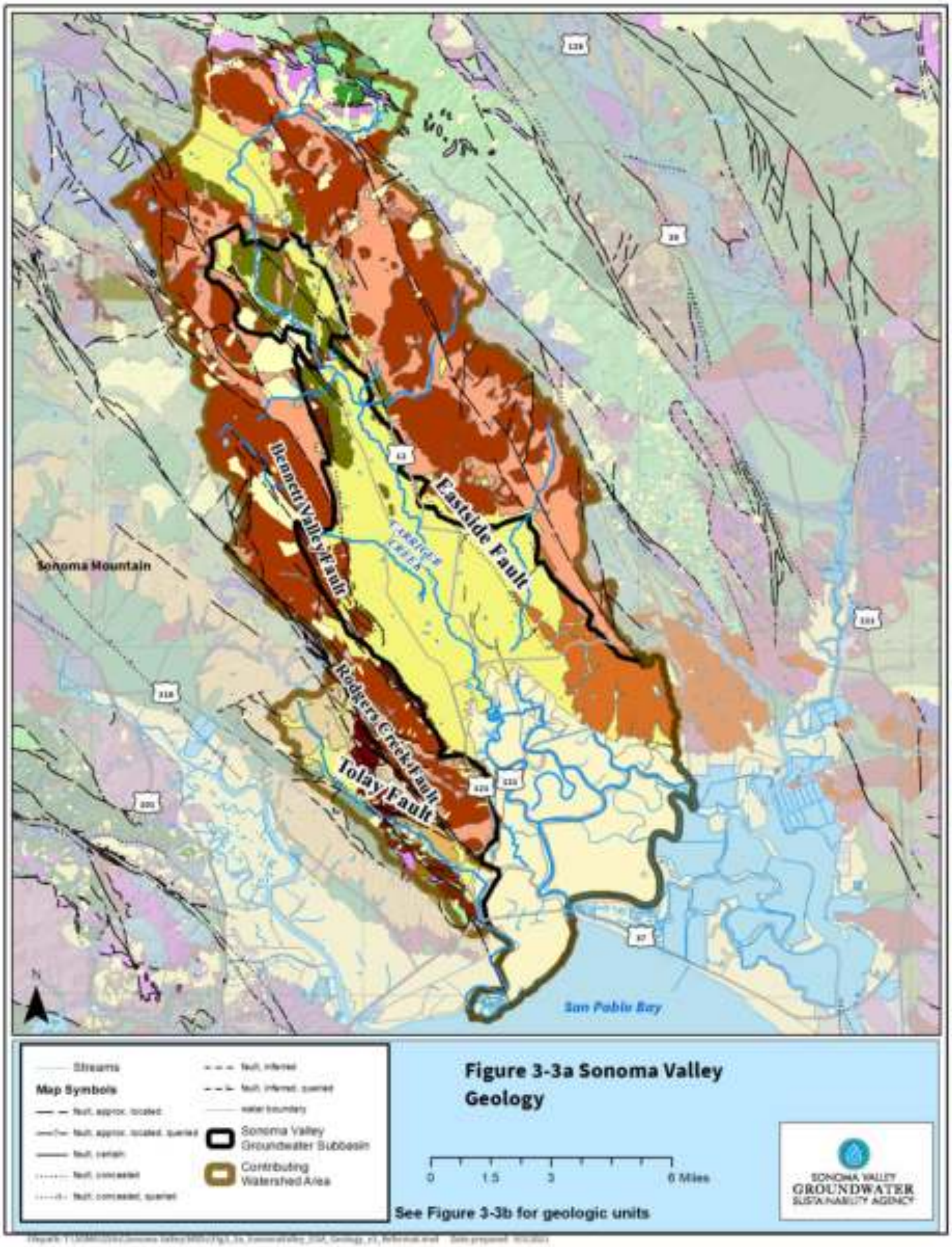

Figure 3-3a. Sonoma Valley Geology

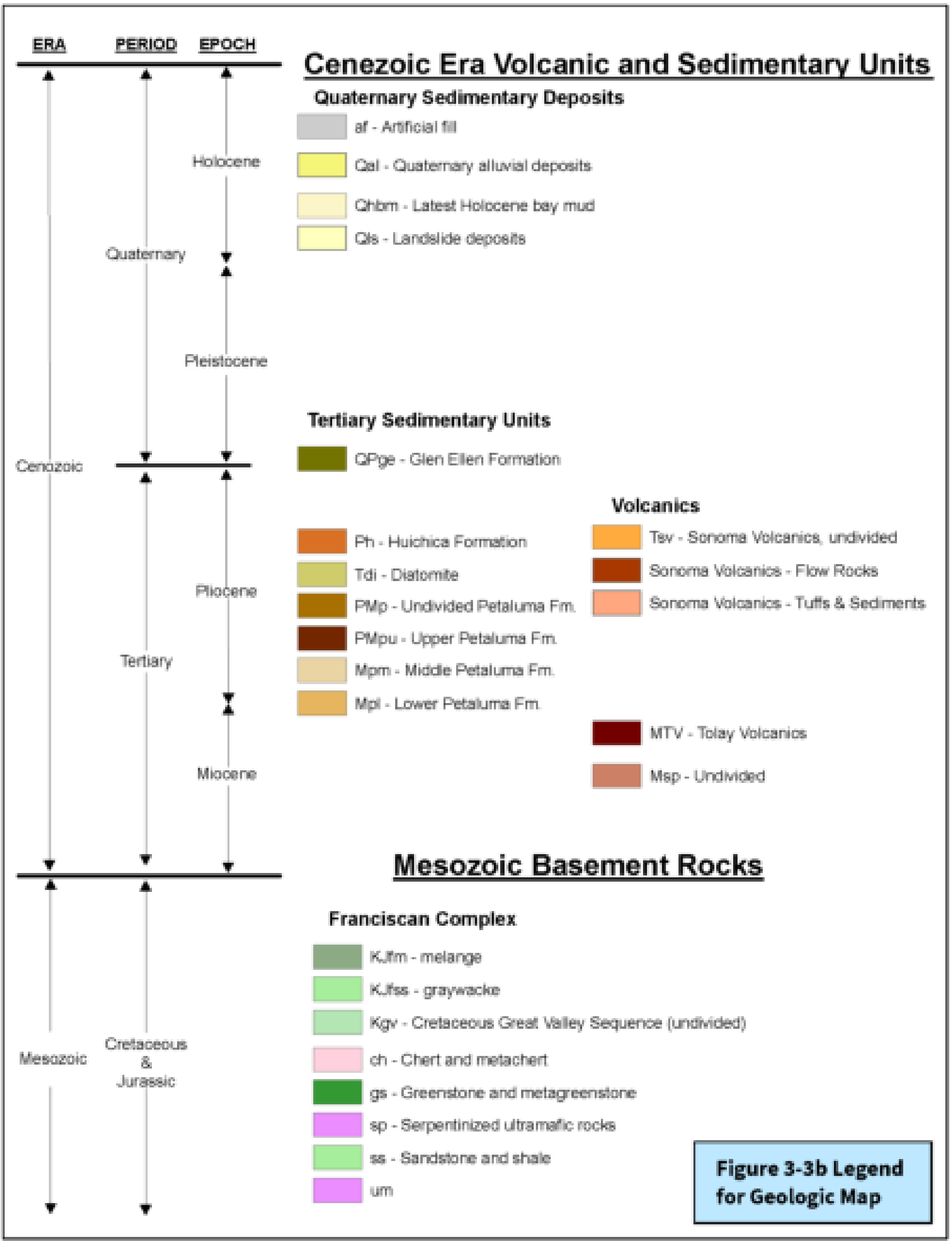

Figure 3-3b. Geologic Units

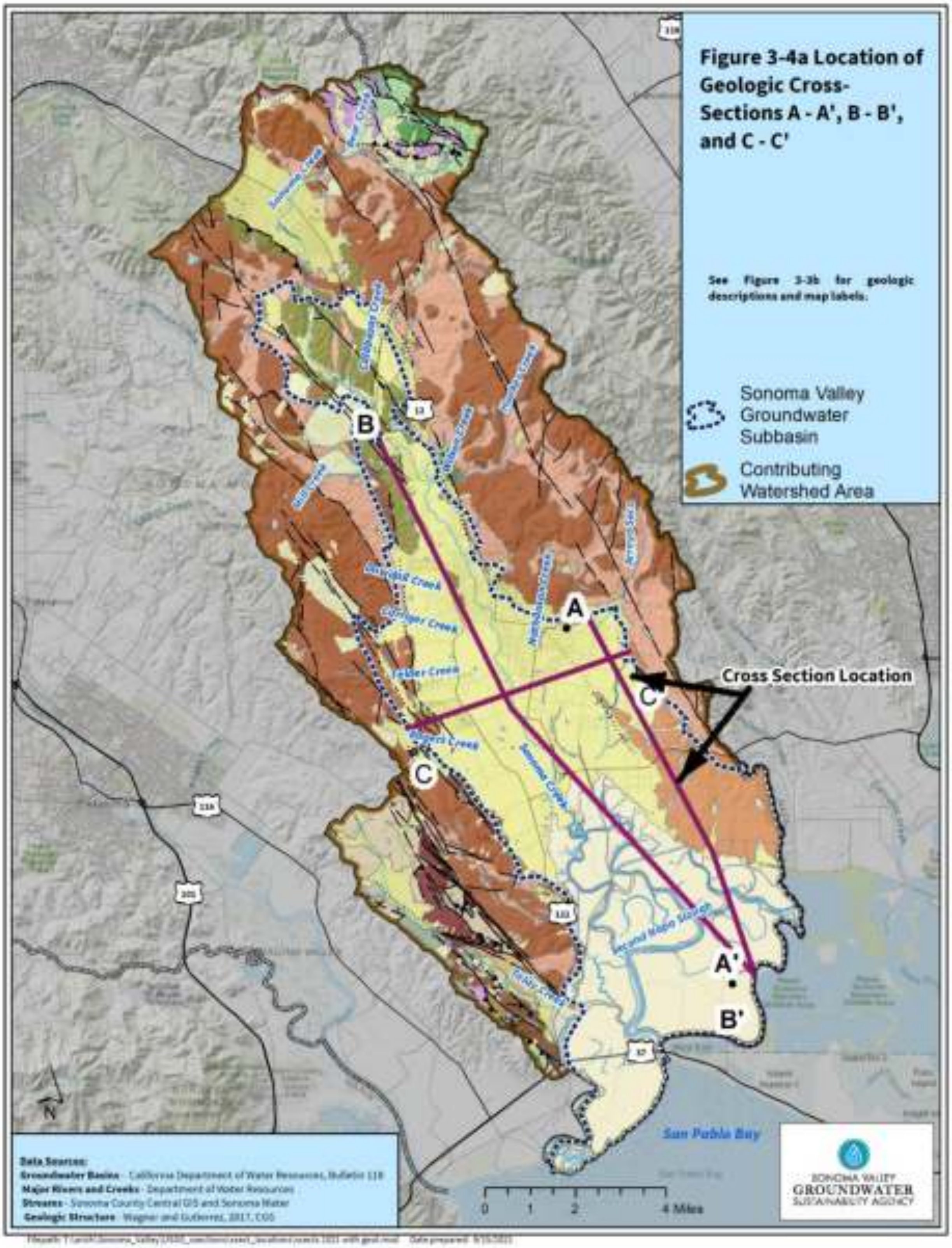

Figure 3-4a Geologic Cross Section Locations

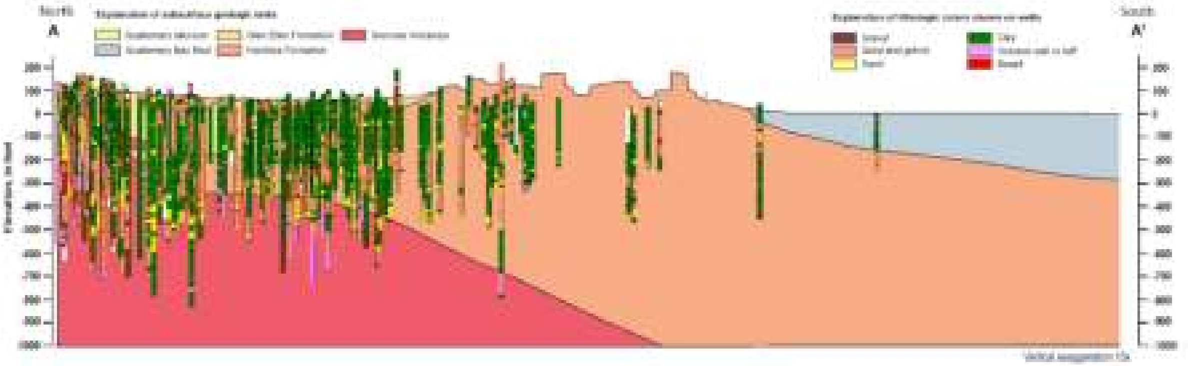

Figure 3-4b Geologic Cross Section A-A'

Figure 3-4c Geologic Cross Section B-B'

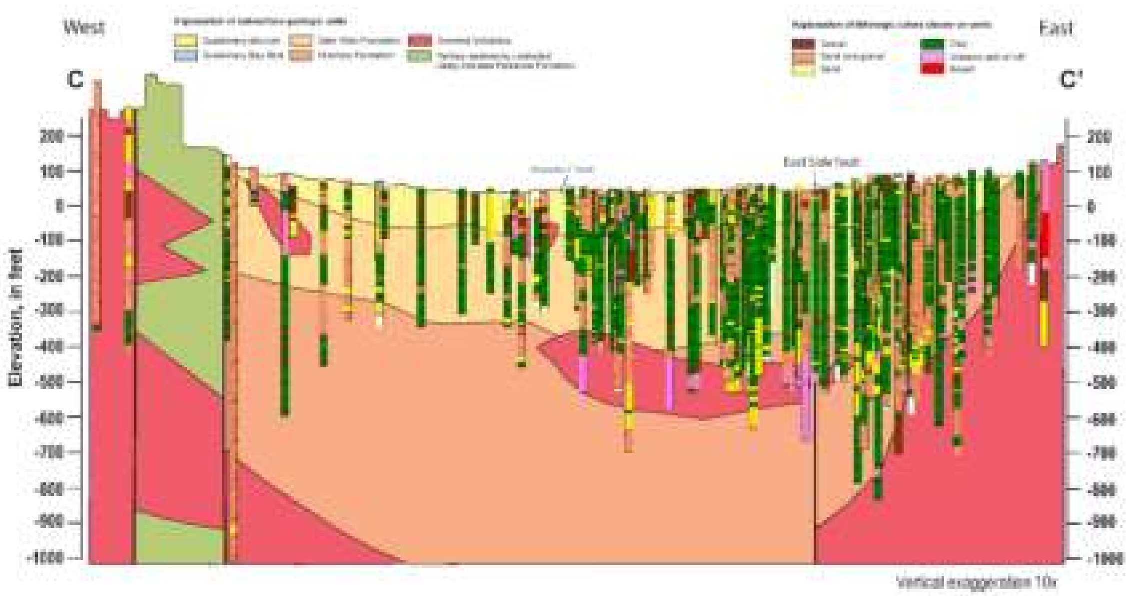

Figure 3-4d Geologic Cross Section C-C'

3.1.4.2 Mesozoic Era Basement Rocks

Mesozoic Era basement rocks generally yield very little water, as their porosity is primarily attributed to fractures, which are commonly limited in extent and water-transmitting capacity. The Mesozoic basement rocks are only exposed outside of the Subbasin within the northeast portions of the watershed where rocks of the Franciscan Complex and Coast Range Ophiolite, along with limited exposures of the Great Valley Sequence occur around Hood Mountain (**Figure 3-3a**). The depth to the Mesozoic basement rocks is inferred to range from approximately 1,000 feet in the northern portions of the Subbasin near Glen Ellen to greater than 10,000 feet adjacent to San Pablo Bay based on gravity data modeled by the USGS (Langenheim 2006), as indicated on **Figure 3-5**. Beneath the majority of the Subbasin, the modeling indicates that the depth to the Mesozoic basement rocks generally ranges from 3,000 to 6,000 feet (Langenheim 2006).

3.1.4.3 Cenozoic Era Volcanic and Sedimentary Units

Groundwater resources within the Subbasin are primarily located within the Cenozoic volcanic and sedimentary units deposited on top of the Mesozoic basement rocks. Geologic units that are of greatest importance for groundwater resources within Sonoma Valley include the Sonoma Volcanics, the Petaluma Formation, the Huichica Formation, the Glen Ellen Formation, and two Quaternary alluvial units (Farrar et al. 2006). The units are described below in general order of decreasing age (older to younger) and include both Tertiary-aged (between 66 to 2.5 million years old) and Quaternary-aged (younger than 2.5 million years old) units.

Sonoma Volcanics

The Sonoma Volcanics of Miocene to Pliocene age (approximately 8 to 2.5 million years old) are a thick and highly variable sequence of volcanic rocks interbedded with volcaniclastic sedimentary deposits (sediments derived from volcanic rocks). The unit consists of thick deposits of volcanic lava flows with some interbedded volcanic ash flows, mud flows, tuffs, and volcaniclastic sedimentary deposits of tuffaceous sands and volcanic gravels. The Sonoma Volcanics cover an area of approximately 1,200 square miles in Sonoma and Napa counties and have been grouped into western, eastern, and northern groups based on their age (Sweetkind et al. 2011).

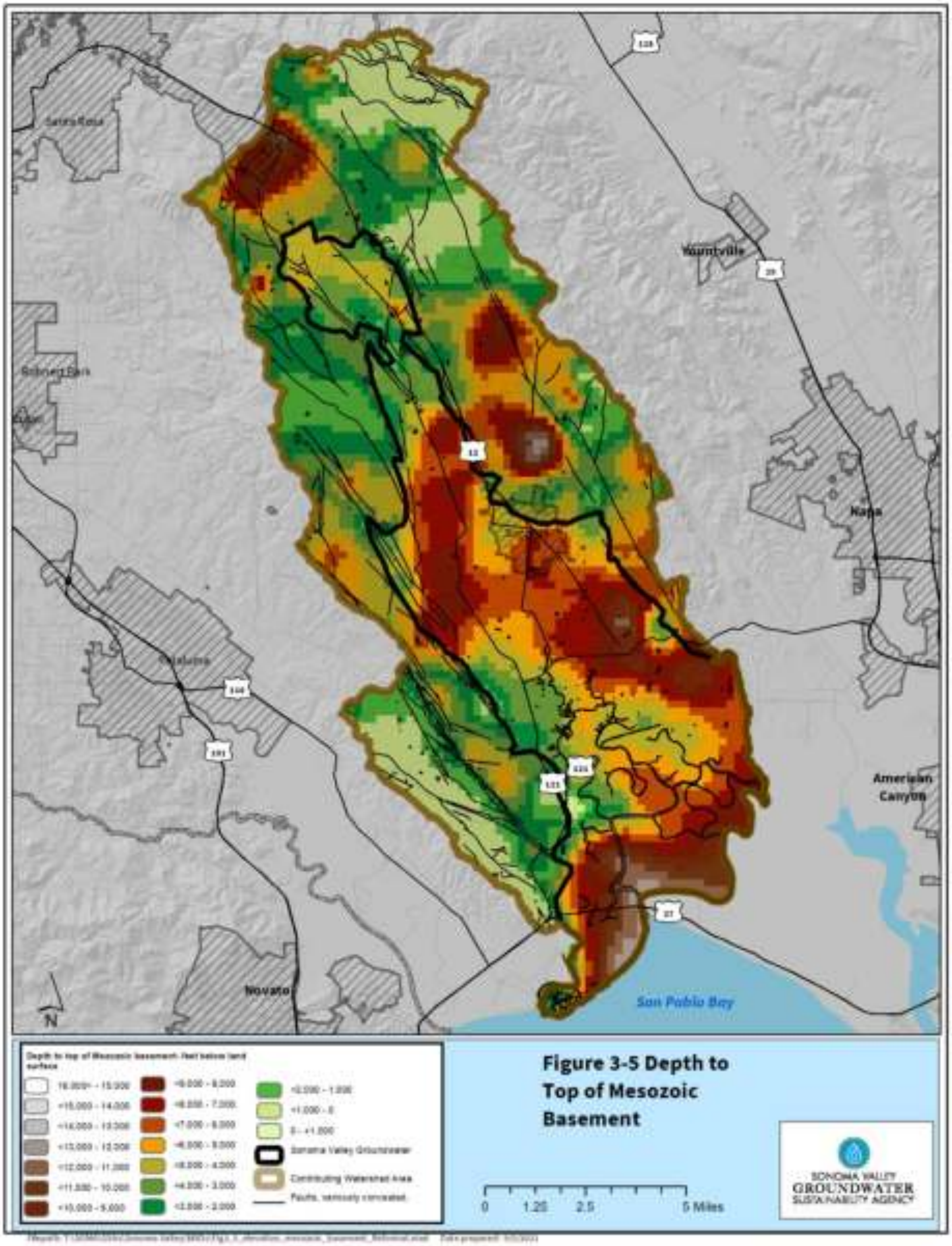

Figure 3-5. Depth to Mesozoic Basement

The Sonoma Volcanics are exposed throughout the Mayacamas and Sonoma mountains and along the margins of the Subbasin and extend beneath the valley floor where they are buried beneath younger geologic units (**Figures 3-4b** through **Figure 3-4d**). **Figure 3-6** displays the estimated depth to the top of the Sonoma Volcanics based on lithologic data obtained from well-completion reports for approximately 2,000 water wells in Sonoma Valley. As shown on **Figure 3-6**, the depth to the top of the Sonoma Volcanics ranges from less than 50 feet to at least 750 feet and is generally shallowest along the margins and northern portions of the Subbasin and is deepest in the southern portions of the Subbasin and within and north of the El Verano area. The Sonoma Volcanics are highly variable in lithology and their subsurface distribution is often difficult to discern from well-drillers' logs in the Sonoma Valley. Additionally, the upper part of the Sonoma Volcanics interfingers with the sedimentary units of the Glen Ellen and Huichica Formations in places further complicating the subsurface mapping of the volcanic units. The total thickness of the volcanic units is highly variable and has been estimated to be up to 3,000 feet thick near Sonoma Mountain (Farrar et al. 2006).

The Sonoma Volcanics exhibit the largest variability in water-bearing properties in the Sonoma Valley, with a mixture of fractured lava beds, unwelded tuffs, and interbedded volcaniclastic sedimentary deposits generally providing the best aquifer materials. Lava beds have extremely low primary permeability and only fractures or the tops and bottoms of individual flows yield significant water. Unwelded tuffs can yield water similar to high porosity, high permeability alluvial sediments. Estimated specific yield values for the Sonoma Volcanics vary from 0 to 15 percent and well-production yields generally range between 10 and 50 gallons per minute (gpm) and occasionally as much as several hundred gpm. Specific yield is defined as the ratio of the volume of water to the total volume of the rock that an unconfined aquifer will yield by gravity drainage, and is usually expressed as a percentage.

3.1.4.4 Tertiary Sedimentary Units

Petaluma Formation

The Petaluma Formation is a Pliocene-aged (approximately 5 million years old) sedimentary unit that was deposited in transitional continental and shallow-marine environments. The formation is dominated by more or less consolidated silt or clay-rich mudstone, with local beds and lenses of poorly sorted sandstone and minor conglomerate beds and has been subdivided into an upper, middle, and lower member. The occurrence of the Petaluma Formation in the Subbasin is limited to the upper member, which is exposed in fault-bounded blocks along the western hills south of Sonoma Mountain (**Figure 3-3a** and **Figure 3-4d**).

The vertical extent of the Petaluma Formation is unknown owing to its limited distribution and the lack of applicable data in Sonoma Valley. Due to the large amount of silt- and clay-sized particles, the specific yields of wells completed in the Petaluma Formation are generally low, varying from 3 to 7 percent. Domestic wells perforated in the Petaluma Formation yield on average about 20 gpm and vary from 10 to 50 gpm.

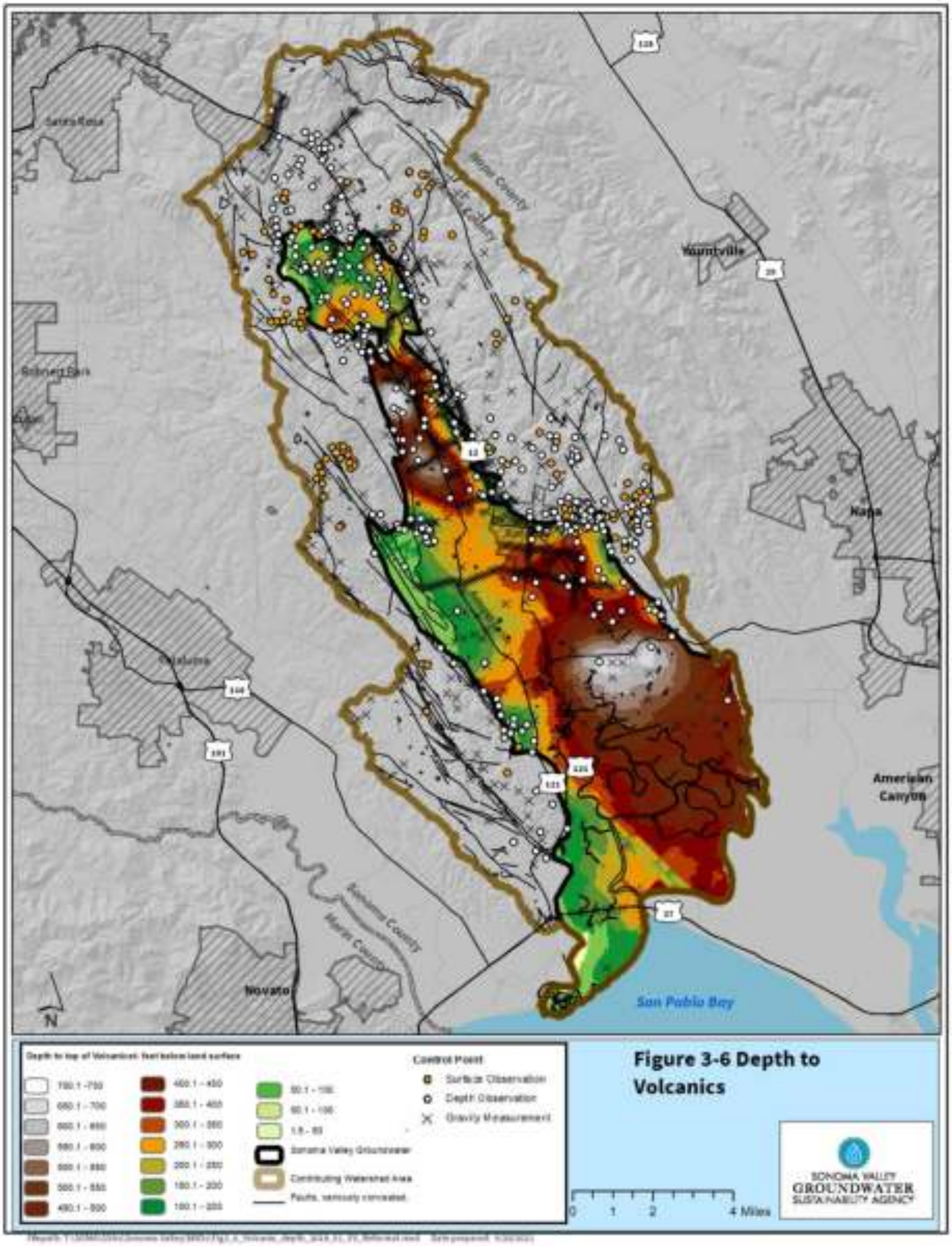

Figure 3-6. Depth to Volcanics

Huichica Formation

The Huichica Formation is a Pliocene- to Pleistocene-aged (approximately 3.5 to 4 million years old) fluvial sedimentary unit deposited by small streams into alluvial fans, lakes, and lagoons. The unit consists of massive yellow silt and yellow and blue clay with interbedded lenses of sands, gravels, and tuff beds. The Huichica Formation crops out primarily in the hills along the southeastern part of Sonoma Valley in the Carneros region and underlies younger deposits beneath much of the southern valley floor (**Figure 3-3a** and **Figure 3-4b**). The unit overlies and is partly interbedded with the Sonoma Volcanics, may interfinger with the Glen Ellen Formation beneath the central portions of the Subbasin, and may be indistinguishable in well logs and in outcrops.

The total thickness of the Huichica Formation is likely greater than 1,000 feet beneath parts of the valley floor (Farrar et al. 2006; **Figure 3-4b**). Well yields of the formation are low, typically 2 to 20 gpm; however, in some areas, the lower part of this formation can be higher yielding. The specific yield range for the Huichica is between 3 and 7 percent.

Glen Ellen Formation

The Glen Ellen Formation is also a Pliocene- to Pleistocene-aged (approximately 3 to 3.5 million years old) fluvial sedimentary unit deposited along alluvial fans and adjoining flood plains. The unit consists primarily of clay-rich stratified stream deposits of poorly sorted sand, silt, and gravel. Beds of these sediments vary from coarse- to fine-grained, commonly over distances of a few tens to hundreds of feet, both laterally and vertically. This unit interfingers with the Huichica Formation and lies on top of the Sonoma Volcanics in some regions and on the Franciscan Complex in other regions. The Glen Ellen Formation is primarily exposed along the northern margins of the Subbasin and within the Kenwood Valley north of the Subbasin (**Figure 3-3a**).

The Glen Ellen Formation is estimated to be about 600 feet thick near Glen Ellen, but the thickness may be greater beneath some portions of the Subbasin (**Figure 3-4c**; Farrar et al. 2006). The relatively high content of clay-sized material, degree of compaction, and cementation tend to limit the permeability of the Glen Ellen. Where sufficiently thick, the Glen Ellen Formation includes some beds of moderate- to well-sorted, coarse-grained materials that have high permeability and yield appreciable amounts of water to wells. Wells perforated in the Glen Ellen Formation typically produce a few 10 to 100 gpm, with well yields generally less than 20 gpm. The specific yield range for the Glen Ellen is between 3 and 7 percent.

3.1.4.5 Quaternary Sedimentary Deposits

Quaternary Alluvial Deposits

Quaternary alluvial deposits cover much of the valley floor and include Holocene (younger than 100,000 years) to modern stream channel and stream terrace deposits (loose alluvial sand, gravel, and silt) and surrounding late Pleistocene to Holocene undissected stream terrace deposits, older alluvium, and alluvial fan deposits. These deposits form a broad blanket in the lower valley, a narrower band and discontinuous patches through the hilly middle valley, and a wide blanket in the Kenwood Valley outside the Subbasin (**Figure 3-3a** and **Figures 3-4b** through **3-4d).** In general, the alluvial materials nearest the valley margins and directly along major stream courses contain the greatest proportions of coarse-grained sediments.

The Quaternary alluvial units are inferred to range in thickness from near zero at the valley margins to as much as 300 feet near the center of the valley. Where these deposits are thick and saturated, they are the highest yielding aquifers in the valley, with well yields of more than 100 gpm. The specific yield range for the Quaternary alluvial units is 3 to 15 percent.

Quaternary Bay Muds

Quaternary bay mud deposits of Holocene age cover the southern tidal marshlands of the Subbasin (**Figure 3-3a**). These deposits are primarily composed of organic rich muds and silts with small amounts of sand. The bay muds were deposited during a higher stand of sea level and, as such, contain entrapped brackish and saline water.

The thickness of the bay muds ranges from near zero at its margins to an estimated 200 feet along the shore of San Pablo Bay (Farrar et al. 2006). Due to the low permeability and poor water quality associated with the bay muds, they are generally not tapped for groundwater supply and their specific yield is estimated to be less than 3 percent.

3.1.4.6 Lateral and Vertical Extent of Subbasin

The structural setting and distribution of geologic units described above influence the Subbasin extents, which are defined by DWR, as documented in Bulletin 118 (DWR 2003). In general, the lateral extent of the Subbasin is defined from the surficial distribution of the Tertiary sedimentary units and their contact with the Tertiary Sonoma Volcanics based on the 1982 geologic map of the Santa Rosa Quadrangle (Wagner and Bortugno 1982). The boundary does not precisely match up with these contacts on the more recent geologic map shown on **Figure 3-3a**, which is more detailed and refined than the 1982 map (CGS 2017). Additionally, the southeastern portions of the Subbasin are defined based on the boundary between Sonoma and Napa counties. The lateral extent and boundaries of the Subbasin are defined as follows:

- The southernmost corner of the basin is aligned with Tolay Creek for 5 miles, from the mouth of Tolay Valley to Tubbs Point. The shoreline of San Pablo Bay is the boundary from Tubbs Point to the outlet of Sonoma Creek. From Sonoma Creek to near Highway 121, the boundary is the Sonoma and Napa county boundary.

- The depositional contact between the topographically higher Sonoma Volcanics and the Tertiary sedimentary units (Glen Ellen, Huichica, and Petaluma Formations) and overlying Quaternary alluvial deposits defines the remaining eastern, western, and northern boundaries, with portions of the boundary also coinciding with the Eastside and Bennett Valley faults.

The vertical extent of the Subbasin is not defined based on a transition in geologic materials, such as the Mesozoic basement rocks that occur at depths exceeding 10,000 feet in some areas.

Rather, the vertical extent of the Subbasin is defined based on the approximate depth at which viable water-supply aquifers are no longer present. The more productive freshwater aquifers are generally at shallower depths than the deepest wells within the Subbasin, extending to approximately 1,200 feet, and no existing known water wells extend deeper than 1,500 feet. At depths exceeding approximately 1,500 feet, aquifers are likely not usable for water supply due to a combination of (1) lower well yields related to increased consolidation and cementation of aquifer materials at these depths; and (2) poor water quality related, in part, to the presence of brackish connate water and geothermal fluids.

3.1.5 Principal Aquifer Systems and Aquitards

Principal aquifers are defined by DWR as "aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems." The GSP Regulations require the identification and following information for each principal aquifer and aquitard in the Subbasin:

- Characterization of physical properties, structural barriers, water-quality conditions, and primary uses
- Groundwater elevation contour maps
- Hydrographs
- Change in storage estimates
- Minimum thresholds and measurable objectives
- Sufficient monitoring network, including groundwater levels and water quality

To characterize the aquifer systems within the Subbasin for the purpose of implementing SGMA, two principal aquifer systems have been described based on available data and information: the shallow and deep aquifer systems. While previous investigators have evaluated and described hydraulic properties associated with the geologic formations discussed in this section, insufficient information and data are available to correlate distinct aquifer systems based solely on geologic information. The limitations on available information and data with which to draw correlations is due, in part, to the high degree of heterogeneity associated with the geologic units, deformation related to folding and faulting of Tertiary-aged units that are difficult to discern in the subsurface, similarities in texture and composition of many of the sedimentary units, and lack of high-quality lithologic descriptions for the subsurface.

A fairly high degree of correlation and distinctions can be made based on aquifer depth. The shallow and deep aquifer systems exhibit properties and features that allow for their grouping into separate aquifer systems, including degree of surface-water connectivity, degree of confinement, and responses to hydraulic stresses such as recharge and pumping. Although the deep and shallow aquifer systems are grouped separately, the boundary between the shallow and deep aquifer systems is not intended to represent a distinct boundary to groundwater flow.

The degree of hydraulic separation between the two is variable throughout the Subbasin, with some areas exhibiting stronger hydraulic communication, such as where clay aquitard materials between the two aquifer systems are thinner or absent. The identification of the boundary between the two aquifer systems is further complicated by the complex stratigraphic relationships and high degree of heterogeneity associated with the stratigraphic units (**Figures 3-4b** through **3-4d**). The appropriateness of the principal aquifer system designation within the Subbasin will continue to be evaluated and reconsidered as additional data and information are developed during implementation of the GSP regarding the lateral and vertical characteristics and hydraulic connections between the different stratigraphic units.

Attributes of the shallow and deep aquifer systems, which generally correlate throughout the Subbasin and facilitate distinguishing between the two, include the following:

- The shallow aquifer system generally is separated from the underlying deep aquifer system by sequences of clay, which form aquitards that predominantly occur within the sedimentary units of the Glen Ellen and Huichica Formations.

- The shallow aquifer system is generally unconfined to semiconfined, while the deep aquifer system is nearly always confined or semiconfined.

- The shallow aquifer system generally exhibits stable, long-term groundwater levels, while in southern Sonoma Valley many wells completed within the deep aquifer system have exhibited long-term declining groundwater levels (exceptions to this attribute are described in **Section 3.2.2**).

- Wells completed in the shallow aquifer system near streams exhibit sharp seasonal increases in groundwater levels that are correlative with precipitation and runoff events, while sharp increases and decreases in groundwater levels within the deep aquifer system appear to correlate more closely with groundwater pumping events.

- In many areas the shallow aquifer system is locally and seasonally connected to Sonoma Creek and other tributaries within the Subbasin, while the deep aquifer system is not physically connected with surface waters of the Subbasin and hydraulic communication between the deep aquifer system and surface waters is expected to exhibit a muted and delayed response.

- Differences in groundwater quality between the shallow and deep aquifer zones are common. Water samples from wells within the shallow aquifer system are typically isotopically heavier in comparison with the deep zone, and anthropogenic constituents, such as nitrate and tritium, are more commonly found in the shallow aquifer system in comparison to the deep aquifer system.

- As determined by age-dating, such as carbon-14 dating or tritium, the shallow and deep aquifers exhibit vastly different groundwater ages, with the deep aquifer containing water that was recharged up to 50,000 years before present, and the shallow aquifer generally containing waters recharged within the last 50 years.

Characteristics of the shallow and deep aquifer systems, including individual aquifer unit materials and properties, general water quality, and primary uses based on available data and limitations, are further described in the following subsections.

3.1.5.1 Shallow Aquifer System

The shallow aquifer system is generally present under unconfined or semiconfined conditions from the water table to depths ranging from 100 to 220 feet below land surface (bls). The shallow aquifer system is present over the entire lateral extent of the Subbasin and includes primarily the Quaternary alluvial deposits. However, in areas where these units are absent or thin, the shallow aquifer system locally includes the Glen Ellen and Huichica Formations and, in some areas, most notably in the northernmost portions of the Subbasin, the Sonoma Volcanics. In some localized and limited areas, very shallow and seasonally perched aquifers are present where infiltrating water can perch on very shallow lenses of clay; these are not considered to be part of the shallow aquifer system, as they are not continuous, not tapped for water supply, and not likely to contribute to the baseflow of streams.

Shallow Aquifer System Materials and Properties

The materials of the shallow aquifer system are primarily heterogeneous deposits of sand, silt, clay and gravel deposited along alluvial fans, stream channels, and floodplains, with sand and gravel sequences forming the more permeable and transmissive portions. The heterogeneity and variability in the Subbasin associated with these materials is displayed on **Figure 3-7a**, which was created from a lithologic textural model developed by Sonoma Water using lithologic data from well-completion reports for approximately 2,000 water wells in Sonoma Valley. The distribution of primary lithologic textural components (fine-grained [clays, blue clays, shales, etc.], coarse-grained [sands, gravels, cobbles, etc.], volcanic, and mixtures) are shown for the shallow aquifer system and provide an indication of where higher and lower aquifer storage and transmissivity values can be expected. In general, higher values are expected where the primary textures are either coarse-grained materials or mixtures in comparison with fine-grained materials. Areas with volcanic lithologic textures are expected to exhibit a high variability in aquifer storage and transmissivity values. Fine-grained materials make up the primary lithologic texture in the vicinity of and southeast of the City of Sonoma and east of El Verano (**Figure 3-7a**). The coarse-grained materials within the shallow aquifer system primarily occur west and south of the El Verano area (Rodgers Creek, Felder Creek and Carriger Creek drainages and alluvial fans) and in the Agua Caliente area (**Figure 3-7a).** Volcanic lithologic textures primarily occur along the margins of the Subbasin in some areas, such as near the Rodgers Creek drainage and most significantly in the northernmost areas of the Subbasin, north of Glen Ellen, and within the Kenwood Valley outside of the Subbasin (**Figure 3-7a**).

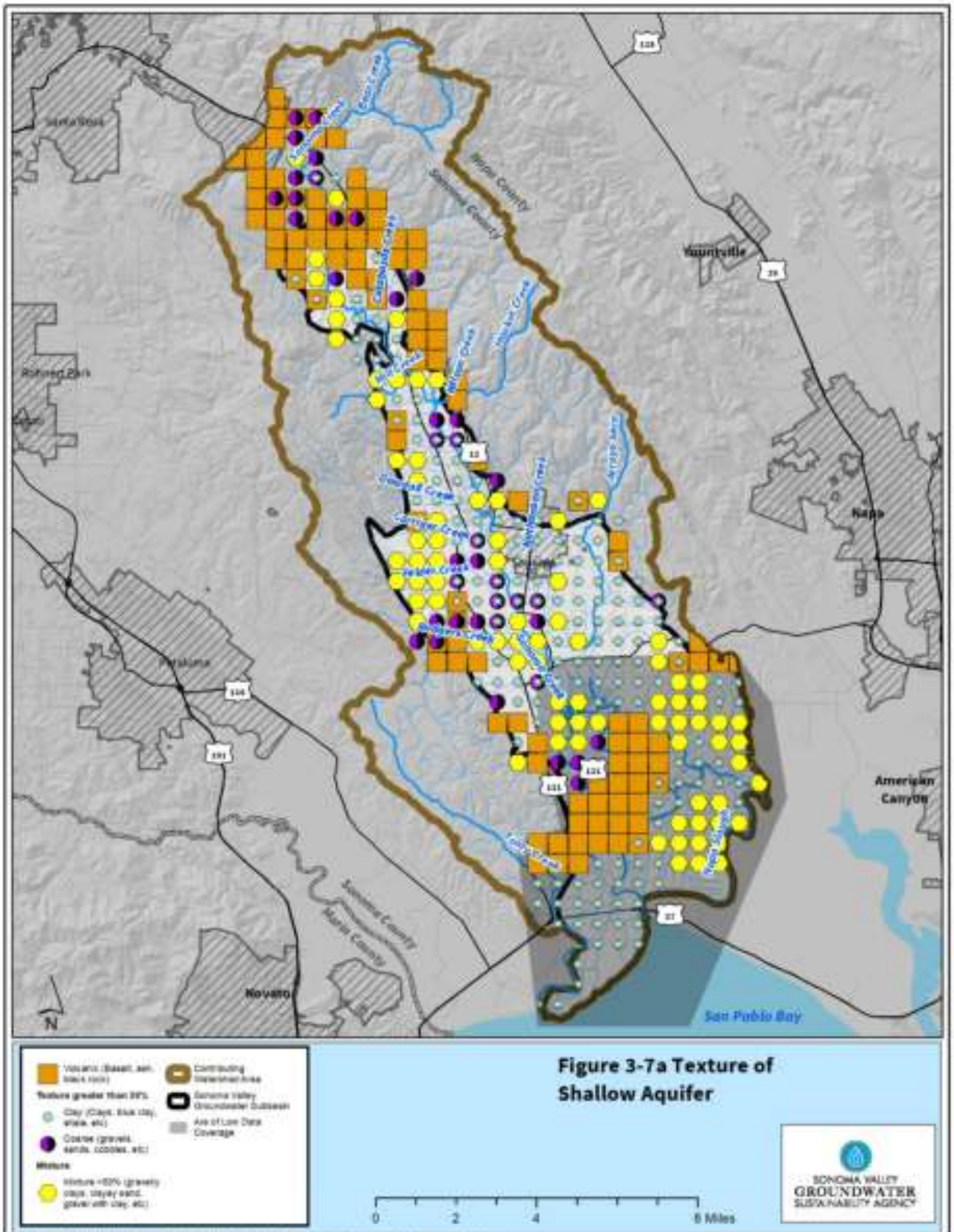

Figure 3-7a. Texture of Shallow Aquifer

Important aquifer characteristics include aquifer storage properties (specific yield for unconfined aquifers and storativity or specific storage for confined aquifers) and aquifer permeability (hydraulic conductivity and transmissivity). Specific yield and hydraulic conductivity were defined previously. Transmissivity is equal to the hydraulic conductivity of the aquifer multiplied by the thickness of the aquifer. Specific storage is a characteristic of confined aquifers and is the volume of water released from storage per unit area per unit decline in hydraulic head. While these properties can be estimated using lithologic texture descriptions and short-duration pump tests from well-drillers' logs, they are most accurately determined by conducting aquifer tests consisting of pumping a well at a known and controlled rate for a sufficient period of time (typically several days) and observing the groundwater-level response in the pumped well and neighboring observation wells. Very few aquifer tests have been conducted and reported within the Subbasin and none have been documented within the shallow aquifer system; therefore, estimates for the shallow aquifer system are primarily based on lithologic texture data and numerical-model calibration.

The specific yield of the shallow aquifer system was initially estimated to vary from approximately 3 to 15 percent based on the estimates for the Quaternary sedimentary deposits and Huichica and Glen Ellen Formation (DWR 1982). Updated estimates of specific yield and hydraulic-conductivity values for the shallow aquifer system were obtained through numerical modeling (Farrar et al. 2006; Bauer 2008). Specific yield was estimated to equal 10 percent and estimates of hydraulic conductivity range from 1 to 60 ft/d (Farrar et al. 2006; Bauer 2008).

Shallow Aquifer System General Water-Quality Characteristics

Groundwater samples collected from wells within the shallow aquifer system are most commonly characterized as a mixed-bicarbonate type water with relatively low dissolved solid concentrations (Farrar et al. 2006). Additionally, water samples from wells completed within the shallow aquifer system typically exhibit fairly young ages based on age-dating (carbon-14 and tritium). Anthropogenic constituents, such as nitrate, are more commonly found in the shallow aquifer system in comparison to the deep aquifer system. These characteristics are typical of shallow aquifer systems in general and consistent with water derived either directly from precipitation or indirectly from precipitation through infiltration from streams (Farrar et al. 2006).

Additional details on data and groundwater-quality conditions and trends are included in **Section 3.2**.

Shallow Aquifer System Primary Uses

The shallow aquifer system serves numerous different users and uses with the primary extractions being from domestic water-supply wells, which provide water to rural residential properties in the unincorporated areas of the Subbasin. In some areas, agricultural and public water-supply wells are also completed either completely or partially within the shallow aquifer system. The shallow aquifer system also provides a significant amount of baseflow to Sonoma Creek and some of its tributaries, which contributes to streamflow and provides benefits to ecosystems in the Subbasin (SVGMP 2014). Additionally, in some areas where groundwater levels are close to the ground surface, such as near streams and in the tidal marshland areas, the shallow aquifer system provides water for riparian vegetation in the Subbasin.

3.1.5.2 Deep Aquifer System

The deep aquifer system is generally present below approximately 400 feet bls and separated from the shallow aquifer system by thick sequences of clay aquitards. The thickness of individual permeable horizons within the deep aquifer system is highly variable and can range from several feet to hundreds of feet. In areas where multiple permeable zones occur within the deep aquifer system, these different zones can sometimes exhibit distinct features (for example, distinct water-quality signature or appreciable differences in piezometric heads), although the continuity of these distinct upper and lower portions is not well constrained nor correlative across the Subbasin due, in part, to the limited number of wells and lithologic information for the deep aquifer system. In areas where data are available, distinctions between the upper and lower portions of the deep aquifer system are discussed in this GSP.

Deep Aquifer System Materials and Properties

The deep aquifer system is primarily composed of relatively thin sand and gravel sequences interspersed within variable amounts of clay. The deep aquifer system generally occurs under confined conditions within sedimentary deposits of the Glen Ellen, Huichica and, to a lesser degree, Petaluma formations. Locally, the deep aquifer system also includes the Sonoma Volcanics where the volcanic units present within the hills extend beneath the alluvial fill of the valley floor. The heterogeneity and variability associated with these materials are displayed on **Figure 3-7b**, which was created from the lithologic textural model. In comparison with the shallow aquifer system, the deep aquifer system exhibits a much higher percentage of volcanic materials, which nearly make up the entire deep aquifer system from near Boyes Hot Springs to the northern Subbasin boundary (**Figure 3-7b**). Coarse-grained materials occur either as a predominant texture or mixed with clay in the central portions of the Subbasin. A mixture of fine- and coarse-grained materials is pervasive throughout the southern portions of the Subbasin.

There has been a limited number of aquifer tests conducted within the Subbasin’s deep aquifer system. Transmissivity estimates from these tests have ranged from approximately 3,000 to 30,000 gallons per day per foot (gpd/ft) for tests on wells perforated in the Sonoma Volcanics and from approximately 1,000 to 10,000 gpd/ft for wells perforated in the Glen Ellen and Huichica Formations (GHD 2014; LSCE 1999). Estimates for storativity (volume of water released from storage per unit surface area per unit decline in water level) from the tests were 0.0007 within the Sonoma Volcanics and ranged from 0.001 to 0.008 within the Glen Ellen Formation (GHD 2014; LSCE 1999). These values are generally reflective of confined aquifer conditions. Estimates of hydraulic conductivity from these tests are limited to the Sonoma Volcanics within the City of Sonoma, which yielded a range of approximately 5 to 34 ft/d (GEI Consultants, Inc et al. 2017).

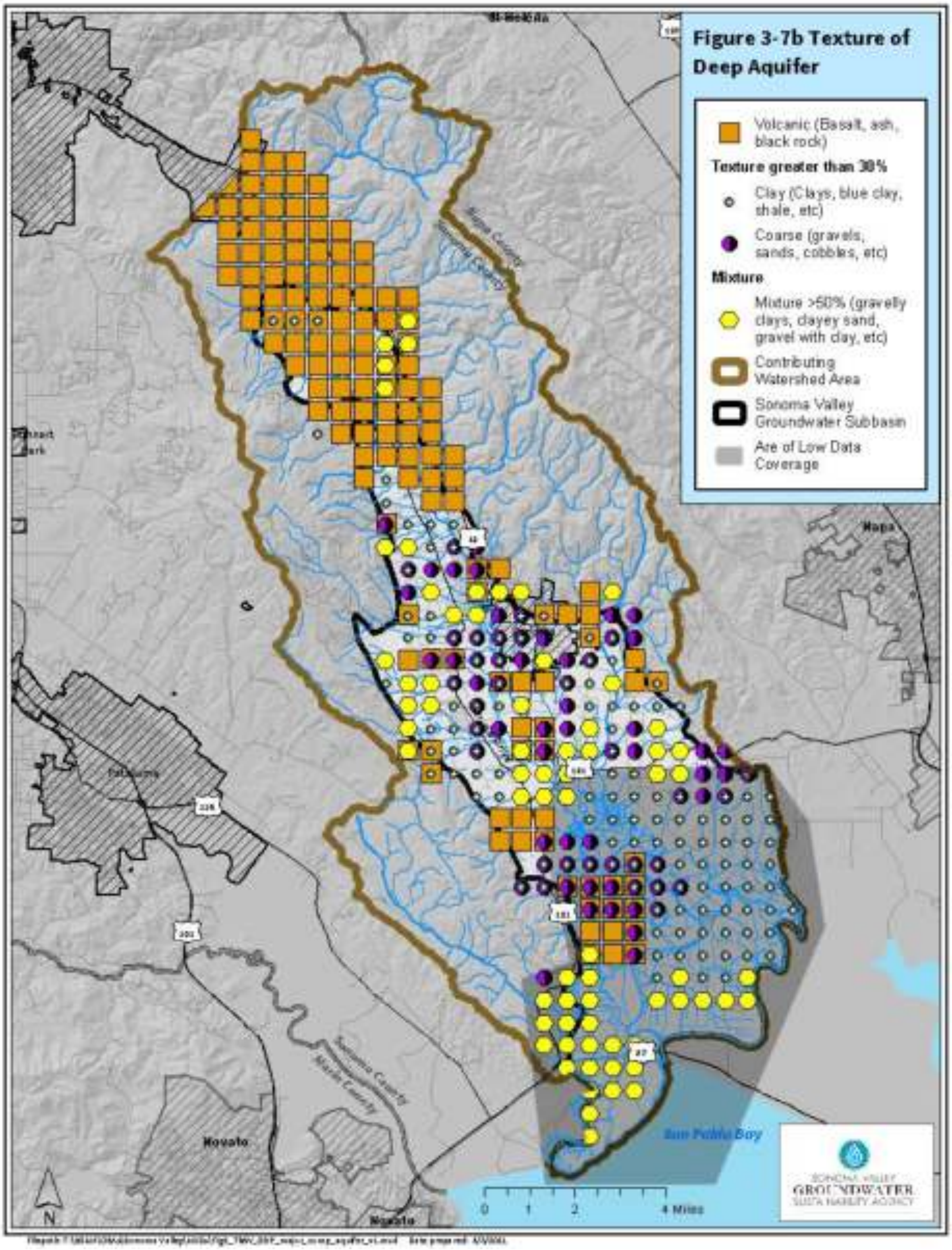

Figure 3-7b. Texture of Deep Aquifer

Specific storage and hydraulic-conductivity values for the deep aquifer system were estimated through numerical modeling (Farrar et al. 2006; Bauer 2008). Estimates of specific storage range from 0.0001 to 0.0000015 and estimates of hydraulic conductivity range from 0.5 to 25 ft/d (Farrar et al. 2006; Bauer 2008).

Deep Aquifer System General Water-Quality Characteristics

Groundwater samples collected from wells within the deep aquifer system are most commonly characterized as sodium-mixed anion or sodium-bicarbonate type water with relatively higher dissolved solid concentrations in comparison with the shallow aquifer system (Farrar et al. 2006). Additionally, water samples from wells within the deep aquifer system typically exhibit pre-modern ages (older than 50 years) based on age-dating (carbon-14 and tritium).A widely distributed, moderately shallow, low-temperature geothermal resource in the Sonoma Valley, which is more limited in extent in the northern portion of the valley. The low-temperature geothermal resource is characteristic of liquid-dominated hydrothermal convection systems, in which deep circulating fluids are warmed by the Earth's subsurface natural heat gradient and then ascend along faults and fracture zones into permeable deep aquifers in the Sonoma Valley (Campion et al. 1984). The geothermal fluids in the Sonoma Valley are found primarily in permeable units of the Sonoma Volcanics. The most prevalent geothermal area in the Sonoma Valley extends along the Eastside Fault zone, between the City of Sonoma north to the Sonoma Developmental Center. Further data and discussion of groundwater-quality conditions and trends are included in **Section 3.2**.

Deep Aquifer System Primary Uses

The deep aquifer system serves numerous different users and uses, with extractions being from a combination of domestic water-supply wells that provide water to rural residential properties in the unincorporated areas of the Subbasin, agricultural irrigation wells used for crop irrigation, industrial wells used for businesses, and public water-supply wells for municipal and smaller public supply systems.

3.1.5.3 Aquitards

Aquitards composed of clay deposits or volcanic flow rocks typically separate the shallow and deep aquifer systems and serve to locally confine the deeper aquifer system. In the southern portion of the Subbasin, the aquitard is variable in composition and thickness, and composed of thick sequences of clay, sand, and gravel mixtures, generally present between approximately 200 and 400 feet bls (**Figure 3-7c**). At several locations, the aquitard has been observed to range between 160 to 350 feet thick, and is composed of clay-rich sediments of the Glen Ellen and Huichica Formations with thin interspersed lenses of sand and gravel based on monitoring well installations. In the northern portions of the Subbasin (from approximately Boyes Hot Springs to the northern boundary), the aquitards separating the shallow and deep aquifer systems are likely composed of relatively impermeable volcanic flow rocks from the Sonoma Volcanics (**Figure 3-7c**). In some areas, such as along the southwestern margins of the Subbasin, the clay aquitards can be thinner and/or interspersed with lenses of sand and gravel. In such areas, the shallow and deeper aquifer systems may exhibit a stronger degree of hydraulic connection.

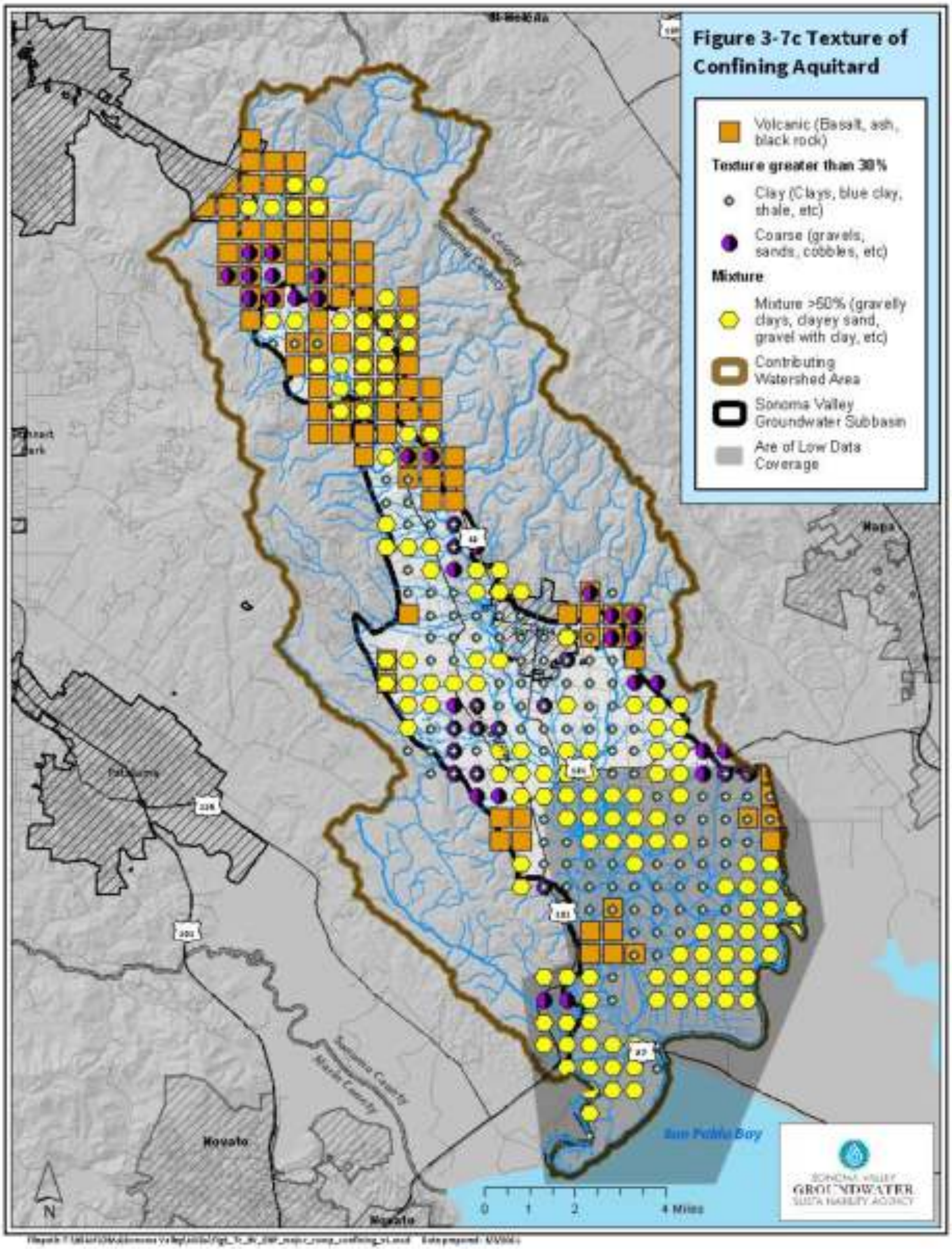

Figure 3-7c. Texture of Aquitard

The heterogeneity and variability associated with materials of these confining aquitards is displayed on **Figure 3-7c**, that was developed using the lithologic textural model. Interspersed coarse-grained units occur within the aquitard primarily within the Felder and Rodgers Creek drainages, which is an area where greater hydraulic communication may occur between the shallow and deep aquifer systems.

3.1.6 Effects of Faults on Groundwater

Faults can affect water flow and well production because groundwater movement may be inhibited or preferentially increased across or within faults and fault zones. Faulting can break even very strong rocks, producing fracture zones that tend to increase permeability, and may provide preferential paths for groundwater flow. Conversely, some faults can form groundwater barriers~~,~~ if the faulting grinds the broken rock into fine-grained fault gouge with low permeability, or where chemical weathering and cementation over time have reduced permeability. The hydraulic characteristics of materials in a fault zone, and the width of the zone, can vary considerably so that a fault may be a barrier along part of its length but elsewhere allow or even enhance groundwater flow across it. Faults also may displace rocks or sediments so that geologic units with very different hydraulic properties are moved next to each other.

Several faults have been mapped in the Sonoma Volcanics within the uplands surrounding the Subbasin, with the Tolay, Rodgers Creek, and Bennett Valley faults being the primary fault zones (**Figure 3-3a**). One northwest-striking fault has been mapped along the eastside of the valley floor. This fault, referred to as the Eastside Fault (**Figure 3-4d**), is a high angle fault with vertical offset that has down-dropped geologic units on the west side of the fault (**Figure 3-3a**). The fault may act as a hydrologic barrier to horizontal groundwater flow and appears to be a conduit for the upward circulation of deeper thermal waters (Farrar et al. 2006). Alignment of thermal wells and springs located along the fault, mainly on its east side in the Boyes Hot Springs area, are indicators that the fault is a conduit for warm water and/or groundwater barrier for subsurface horizontal flow (Campion et al. 1984). While it appears that the fault has offset aquifers, additional groundwater-level data are needed to further assess the fault's effect on groundwater flow.

Other faults that border portions of the Subbasin may also serve as groundwater-flow barriers and locally limit the amount of subsurface inflows from Subbasin boundaries. For example, along Carriger Creek the groundwater levels west of a splay of the Bennett Valley Fault zone are much higher than groundwater levels east of the fault zone. Additional groundwater data needed to make this determination in other areas along the Subbasin boundaries are limited.

3.1.7 Natural Groundwater Recharge and Discharge

3.1.7.1 Groundwater Recharge

Natural recharge to aquifers in the Subbasin primarily occurs through streambed recharge along portions of Sonoma Creek and its tributaries, as well as through direct infiltration of precipitation and along the margins of the valley areas (mountain-front recharge). The shallow aquifer system receives most of this recharge. Recharge that reaches the deeper aquifer zones is more poorly defined and likely comes from a combination of leakage from overlying shallow aquifers and mountain-front recharge along the margins of the valley.

Previous estimates of groundwater recharge in Sonoma Valley have primarily included qualitative assessments. Qualitative relative potential groundwater recharge mapping included a desktop study conducted by the Sonoma Ecology Center and Sonoma Water based on soil type, slope, vegetation, and underlying geology (**Figure 3-8a**; Sesser et al. 2011). The term potential recharge is used because the actual recharge rate also depends on other factors, such as the distribution of precipitation, the locations of streams and other surface-water bodies, and the connection to the deep aquifer system (which were not incorporated into that study). Areas showing a higher potential recharge using this desktop approach are generally located within the flatter areas of the Quaternary alluvial deposits and volcanic tuffs and sediments. Potential constraints or limitations that are not directly incorporated into the analysis include the presence of shallow or perched groundwater, natural springs, and existing groundwater quality.

To assess potential groundwater recharge in the Subbasin, **Figure 3-8b** was developed to show other factors and lines of evidence for potential recharge, including depth to groundwater within the shallow aquifer system, locations of losing stream reaches, lithologic texture of the shallow aquifer system, and groundwater ages. As shown on **Figure 3-8b**, areas identified as having a higher potential recharge based on two or more of these additional lines of evidence include the Carriger Creek, Felder Creek, and Rodgers Creek drainages and alluvial fans (coarser-grained texture of the shallow aquifer system, losing stream reaches, and some younger groundwater ages). Areas identified as having a lower or medium potential for recharge include areas east of the Eastside Fault where very old groundwater ages are observed, the northern portions of the Subbasin where shallow volcanic rocks likely impede recharge, and the central portions of the Subbasin in the vicinity of and south of the City of Sonoma where relatively shallow groundwater conditions occur in the shallow aquifer system.

3.1.7.2 Groundwater Discharge

Natural groundwater discharges occurs where groundwater levels are higher than either the land surface or water surface in stream channels. Natural groundwater discharge occurs in the Subbasin as stream baseflow (gaining streams), discharge at springs and seeps, and discharge at interconnected wetlands. Groundwater also discharges through ET from phreatophytes and groundwater pumping. These two components of groundwater discharge are described in **Section 3.3** (Water Budget).

Figure 3-9 shows the location of potential natural groundwater discharge areas, including the location of springs and seeps (USGS 2019a), gaining stream reaches based on seepage-run datasets collected intermittently from Sonoma Creek and its tributaries between 2003 and 2019, and wetlands mapped by the Sonoma County Vegetation Mapping and Light Detection and Ranging (LiDAR) Program (Sonoma Veg Map 2013).

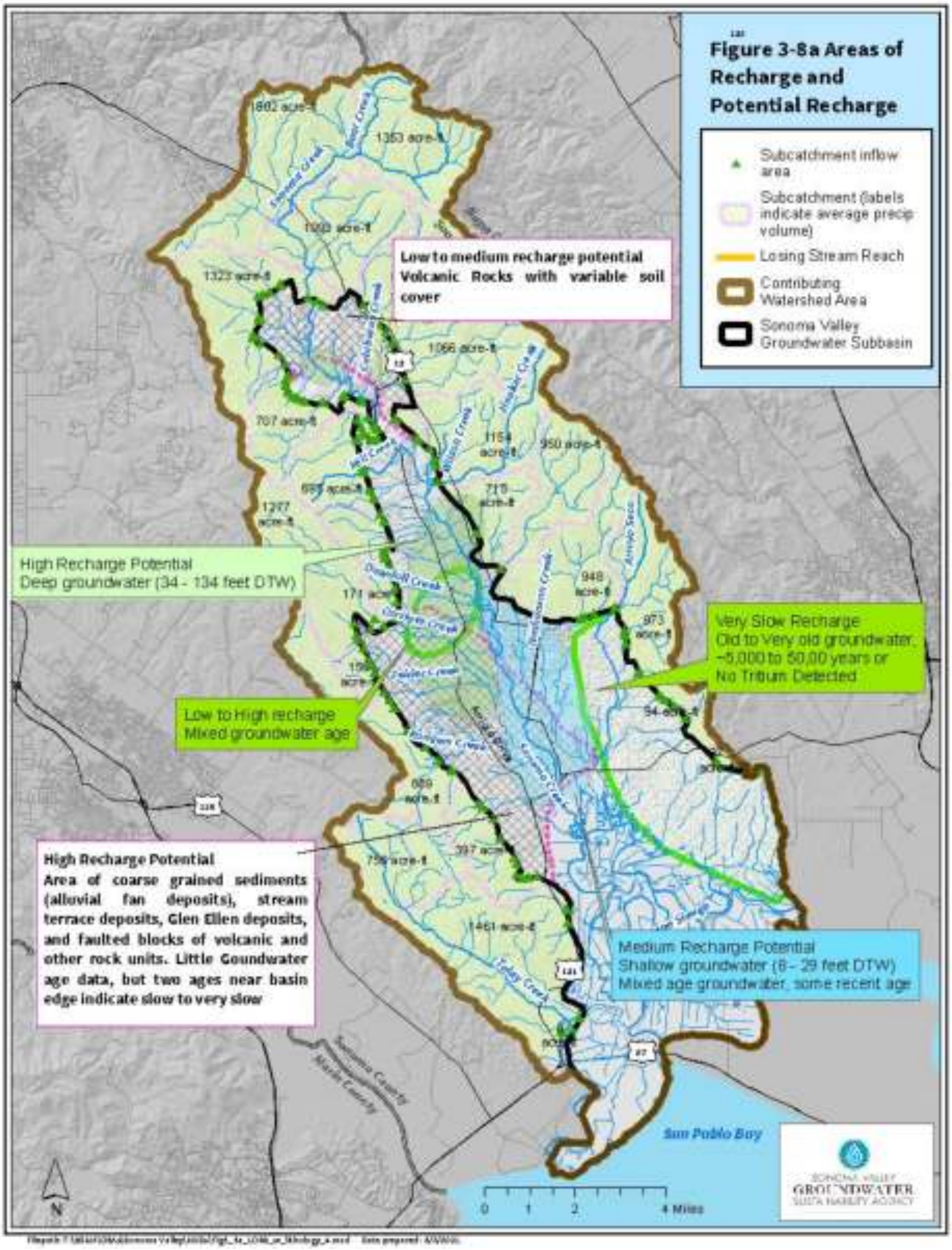

Figure 3-8a. Groundwater Recharge Potential Ranking

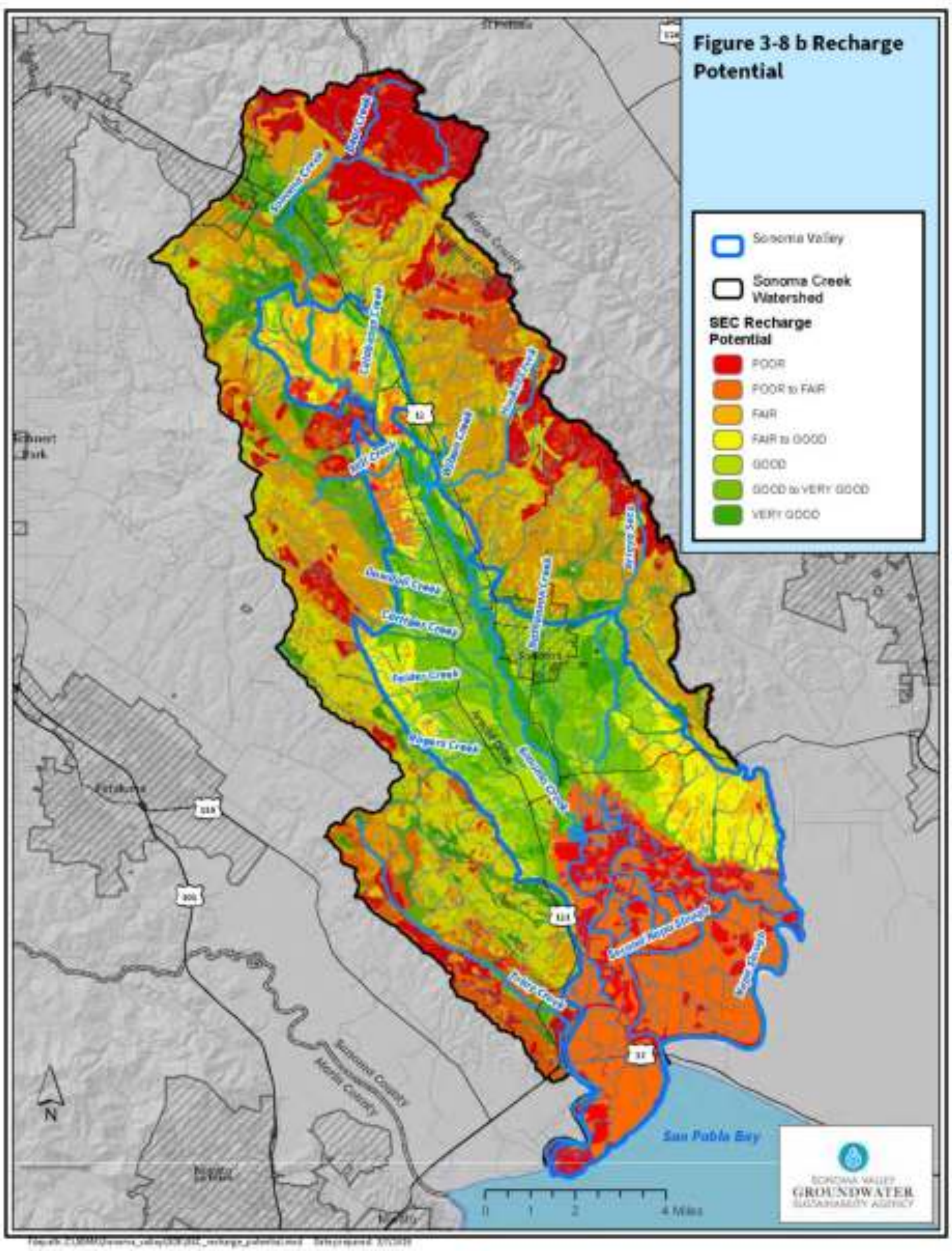

Figure 3-8b. Groundwater Recharge Potential - Additional Factors

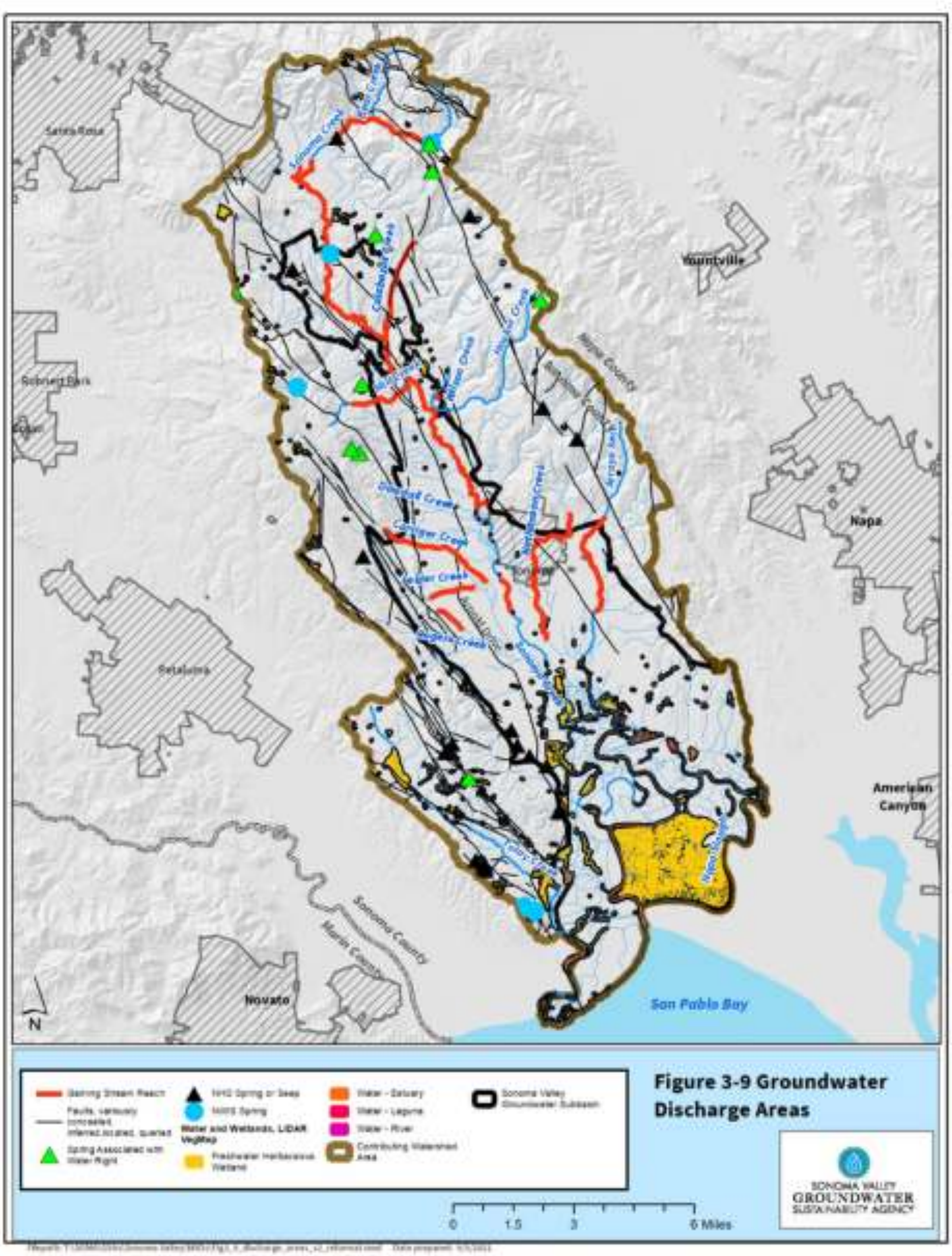

Figure 3-9. Groundwater Discharge Areas

The majority of springs and seeps occur outside of the Subbasin along fault traces within the Sonoma Volcanics (**Figure 3-9**). Springs and seeps located inside or along the margins of the Subbasin occur to the north at and in the vicinity of the Sonoma Developmental Center property and along the southeastern boundary of the Subbasin (**Figure 3-9**). Based on the results of seepage runs conducted on Sonoma Creek and its tributaries, gaining stream reaches are most prevalent along the mainstem of Sonoma Creek and some of its tributaries, including Calabazas Creek, Mill Creek, and Nathanson Creek. Gaining stream reaches also occur periodically along Carriger Creek, Felder Creek, Rodgers Creek, and Arroyo Seco. Wetlands that represent potential locations of groundwater discharge are located in small areas throughout the Subbasin and are most prevalent within and around the tidal marshlands at the southern portions of the Subbasin.

3.1.8 Data Gaps and Uncertainty

While this HCM incorporates the best available information and datasets, it is recognized that all HCMs contain varying degrees of uncertainty that can be improved upon through additional data collection and analysis. Addressing the data gaps identified in **Sections 3.1.6** would reduce uncertainty of the HCM for the Subbasin. Data gaps are discussed in **Section 6** (Projects and Actions) and **Section 7** (Implementation Plan).

3.1.8.1 Aquifer and Aquitard Continuity and Properties and Role of Fault Zones

As described in preceding sections, the geologic complexities of the Subbasin and limited high-quality subsurface lithologic data limit the understanding of the lateral and vertical continuity and properties of aquifers and aquitards in the Subbasin. Developing the following information would improve our understanding of aquifers and aquitards:

- Filling three-dimensional data gaps in the monitoring network for each primary aquifer in the Subbasin. Depth-dependent water-level and water-quality data are needed to improve understanding of the hydrogeology and aquifer systems, which could be improved through construction of dedicated nested monitoring wells in key areas.
- Improving estimates of aquifer properties, including hydraulic conductivity and storage coefficients through aquifer testing.
- Gaining a better understanding of the role of faults and associated geothermal waters within and along the boundaries of the Subbasin, with a focus on the roles of the Eastside and Bennett Valley faults. Potential methods for addressing this data gap could include the performance of aquifer tests and geophysical surveys, geochemical sampling, and analyses in the vicinity of these faults.
- Developing better information on basin boundary characteristics, such as the direction and magnitude of fluxes across Subbasin boundaries, including boundaries between the Subbasin and adjoining groundwater basins and boundaries between the Subbasin and the upper contributing watershed areas outside of the Bulletin 118 basins. Potential methods for addressing this data gap could include the construction of dedicated nested monitoring

wells and/or performance of aquifer tests and geophysical surveys in the vicinity of the boundaries.

- Improving the understanding of aquifer and aquitard continuity near areas of brackish water along southern Sonoma Valley will better characterize groundwater flow paths and support the appropriate setting of SMC in this area. Potential methods for addressing this data gap could include the construction of dedicated nested monitoring wells and/or and geophysical surveys in this area.

3.1.8.2 Recharge and Discharge Volumes, Areas and Mechanisms and Surface Water/Groundwater Interaction

Improved understanding of recharge and discharge volumes, areas, and mechanisms within the Subbasin for both the shallow and deep aquifer systems would support the appropriate selection of projects and actions needed for the Subbasin:

- Improve estimates of the annual volume of groundwater recharge and discharge, including pumping.
- Expand understanding of the interconnection of streams to the shallow aquifer system, including seasonal variability and how groundwater pumping affects streamflow. Additional shallow monitoring wells near stream courses, stream gages, and meteorological stations can help advance this understanding.
- Conduct geochemical or tracer studies. These studies can help better understand both recharge and discharge mechanisms to both the shallow and deep aquifer systems, as well as surface water/groundwater interaction within the Subbasin.

3.2 Current and Historical Groundwater Conditions

This subsection describes the current and historical groundwater conditions within the Subbasin and contributing watershed areas. As described in the GSP Regulations, "[e]ach Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following":

- Groundwater Elevation Data: contour maps, hydrographs
- Change in Storage Estimates: annual and cumulative changes, including groundwater use and WY type
- Seawater Intrusion: maps and cross sections for each principal aquifer
- Groundwater Quality: issues that may affect supply and beneficial uses, map of contaminant sites, and plumes
- Land Subsidence: extent and annual rate

- Interconnected Surface Water: timing of depletions, map of groundwater dependent ecosystems (GDEs)

To assess and evaluate the conditions for the watershed, this subsection includes a description of the following conditions based on available information and data:

- Climate conditions and trends
- Groundwater elevation data and trends
- Estimates of storage changes
- Groundwater-quality data and trends, including an assessment of seawater intrusion
- Land-surface subsidence data and trends
- Surface-water conditions and trends
- An assessment of interconnected surface water and GDEs

3.2.1 Climatic Conditions and Trends

The climate of the Subbasin is Mediterranean, with moderate temperatures and distinct wet and dry seasons. About 90 percent of the annual precipitation typically occurs during the months of November through April. Precipitation is highly affected by atmospheric rivers, which concentrate rainfall and runoff along narrow bands, typically a few hundred kilometers (km) wide and several thousand km long. Nearly 50 percent of the precipitation in the Sonoma County area is due to atmospheric rivers (Dettinger et al. 2011).

While the rainfall pattern is generally consistent, rainfall amounts can vary considerably throughout the Subbasin and contributing watershed based on elevation and geographic location. Estimates of mean annual precipitation for the period 1981 through 2010, obtained using the Parameter-elevation Regressions on Independent Slopes Model (PRISM; Daly et al. 2004), were used to indicate the spatial and temporal distribution of precipitation in Sonoma Valley. The PRISM model provides an estimate of spatial and temporal variability in precipitation in response to distance from moisture sources, average storm track, aspect of land surface in relation to storm tracks, and the effect of elevation (Daly et al. 2004). The average annual rainfall distribution for the contributing watershed for 1981 through 2010 estimated using the PRISM model is presented on **Figure 3-10**. Annual rainfall varies from a low of 22 inches on the valley floor to up to 47.5 inches in the highest areas of the Sonoma and Mayacamas Mountains.

Mean annual precipitation at Sonoma has been assessed using both observed data from Climate Station “SONOMA.C” (NCDC #8351, Sonoma), which is located at the General Vallejo Home State Park near the City of Sonoma at an elevation 97 feet (National Geodetic Vertical Datum of 1929 [NGVD 29]), as well as annual averages calculated using the PRISM model for the watershed. The General Vallejo Home station has operated from 1953 to present, with some periods of missing and incomplete records. The average annual precipitation measured from this station from 1953 to present is 28.80 inches, compared with 28.82 inches, as calculated by the PRISM model. This calculation is based on the annual WY standard nomenclature, which begins on October 1 and ends the following calendar year on September 30.

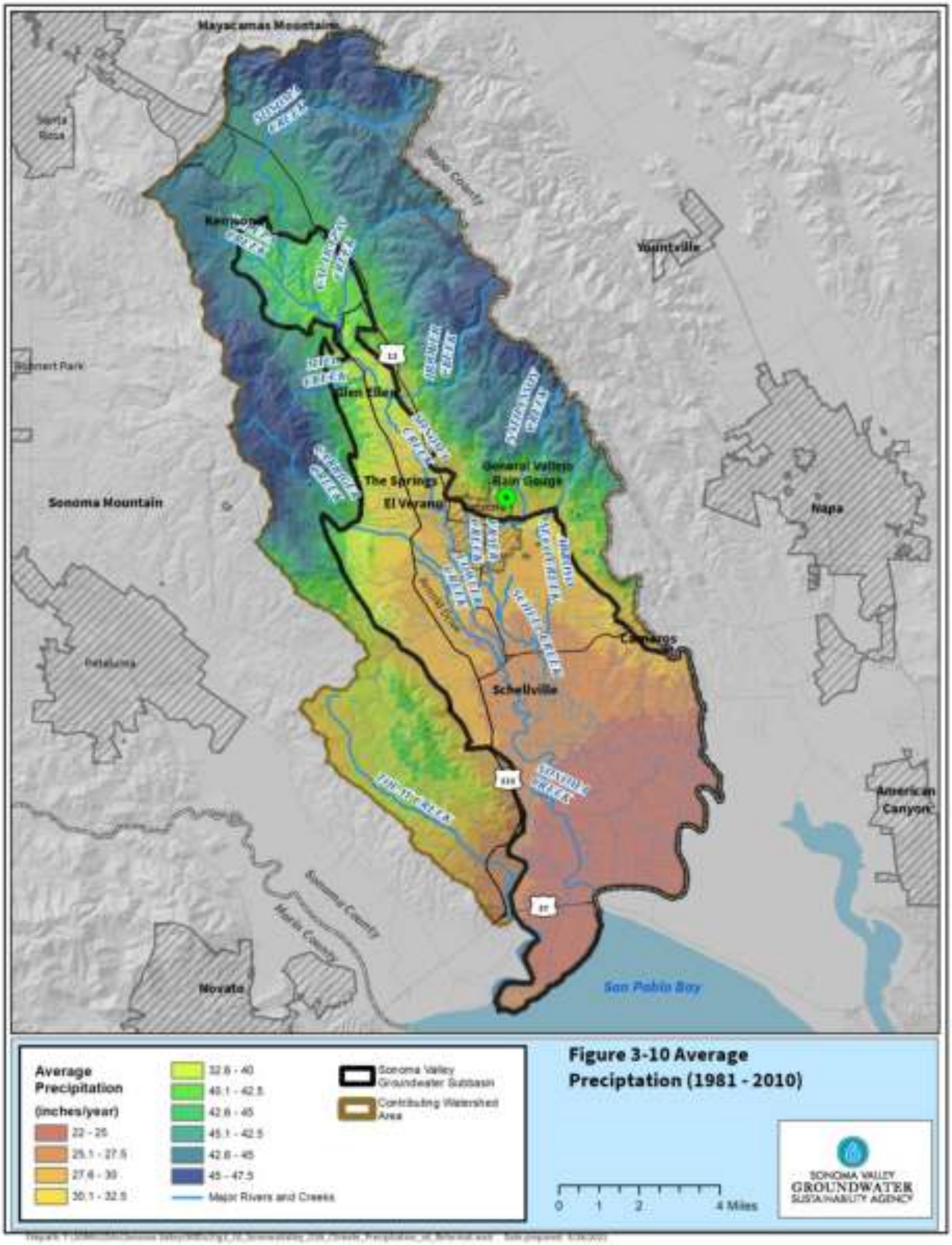

Figure 3-10. Average Precipitation (1981-2010)

For the purposes of comparing and classifying WY types for the GSP, data from the PRISM model and historical data were used from Sonoma Valley, Santa Rosa Plain, and Petaluma Valley to develop an aggregated WY classification for all three basins. The methodology and results are provided in **Appendix 3-A**.

Climate change projections are described in **Section 3.3** Water Budget.

3.2.2 Groundwater Elevations and Trends

This section describes current and historical groundwater elevation conditions and trends based on available data from the monitoring programs described in **Section 2.4**. While records for some wells extend back to the 1950s, the majority of available groundwater-level data are from the last 10 to 15 years. Data presented and evaluated as part of this section include:

- Groundwater-level contour maps for each principal aquifer (**Figures 3-11a** and **3-11b**)
- Long-term groundwater-level hydrographs (**Figures 3-12b** through **3-12f**)
- Groundwater-level trend maps (**Figures 3-13**)
- Short-term groundwater-level hydrographs (**Figure 3-14**)

3.2.3 Groundwater-Level Contour Maps

Groundwater-level elevation contour maps for spring 2015 for the shallow and deep aquifer systems are shown on **Figures 3-11a** and **3-11b**, respectively. Groundwater-level elevation contour maps are under development for fall 2015 (previous analyses of fall and spring contour maps for the Subbasin indicate that the general groundwater-flow patterns in spring and fall are similar). Spring 2015 groundwater-level elevations ranged from approximately:

- 363 feet above mean sea level (msl) in the north end of the Subbasin to 3 feet msl in the south end within the shallow aquifer system

- 592 feet msl in the north end of the Sonoma Valley to -126 feet below msl southeast of the City of Sonoma within the deep aquifer system.

Groundwater elevation contour maps for the shallow and deep aquifers are displayed for the fall and spring seasons for 2015 and 2018 on **Figures 3-11a** through **3-11h**.

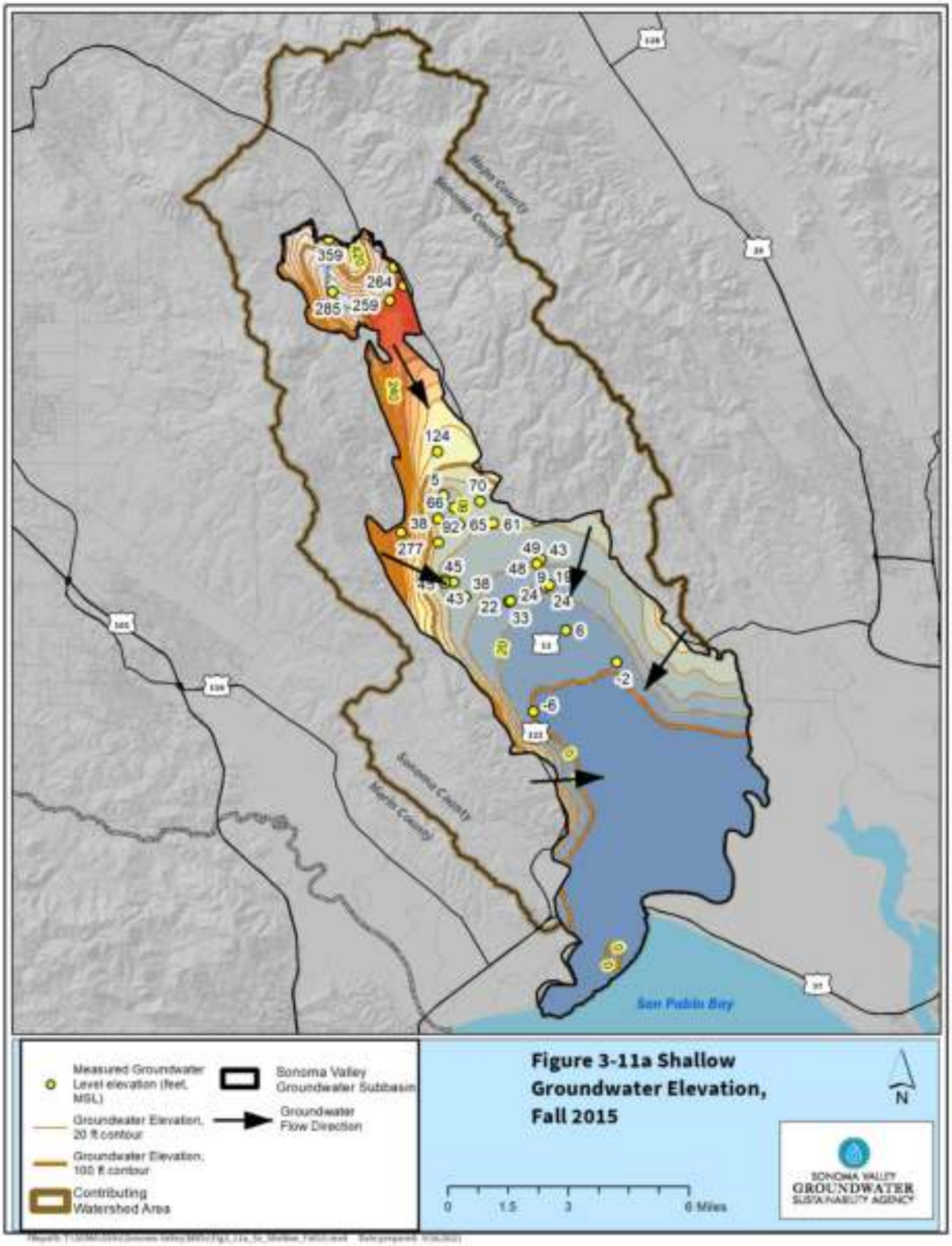

Figure 3-11a. Groundwater Elevation, Shallow Aquifer, Fall, 2015

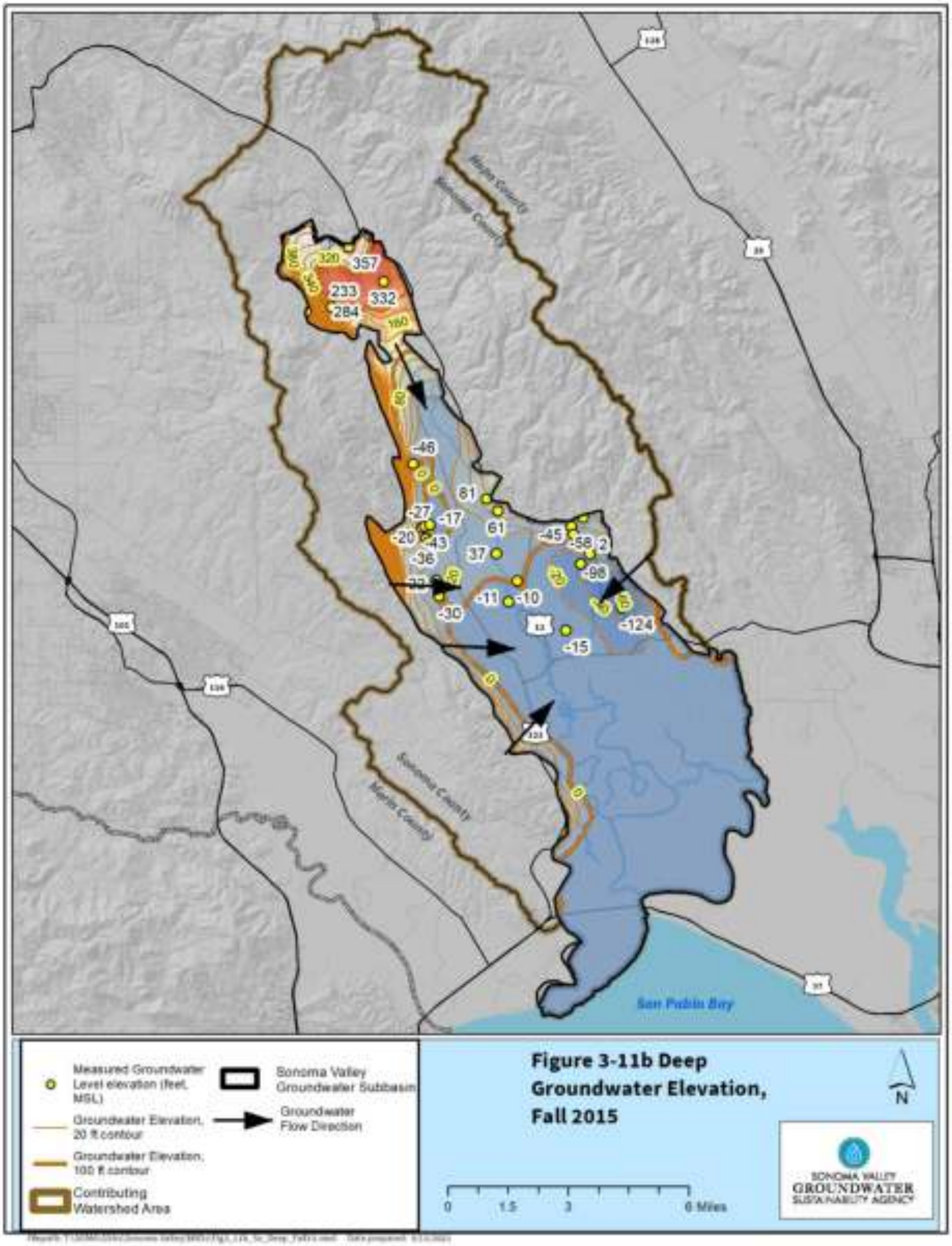

Figure 3-11b Groundwater Elevation, Deep Aquifer, Fall, 2015

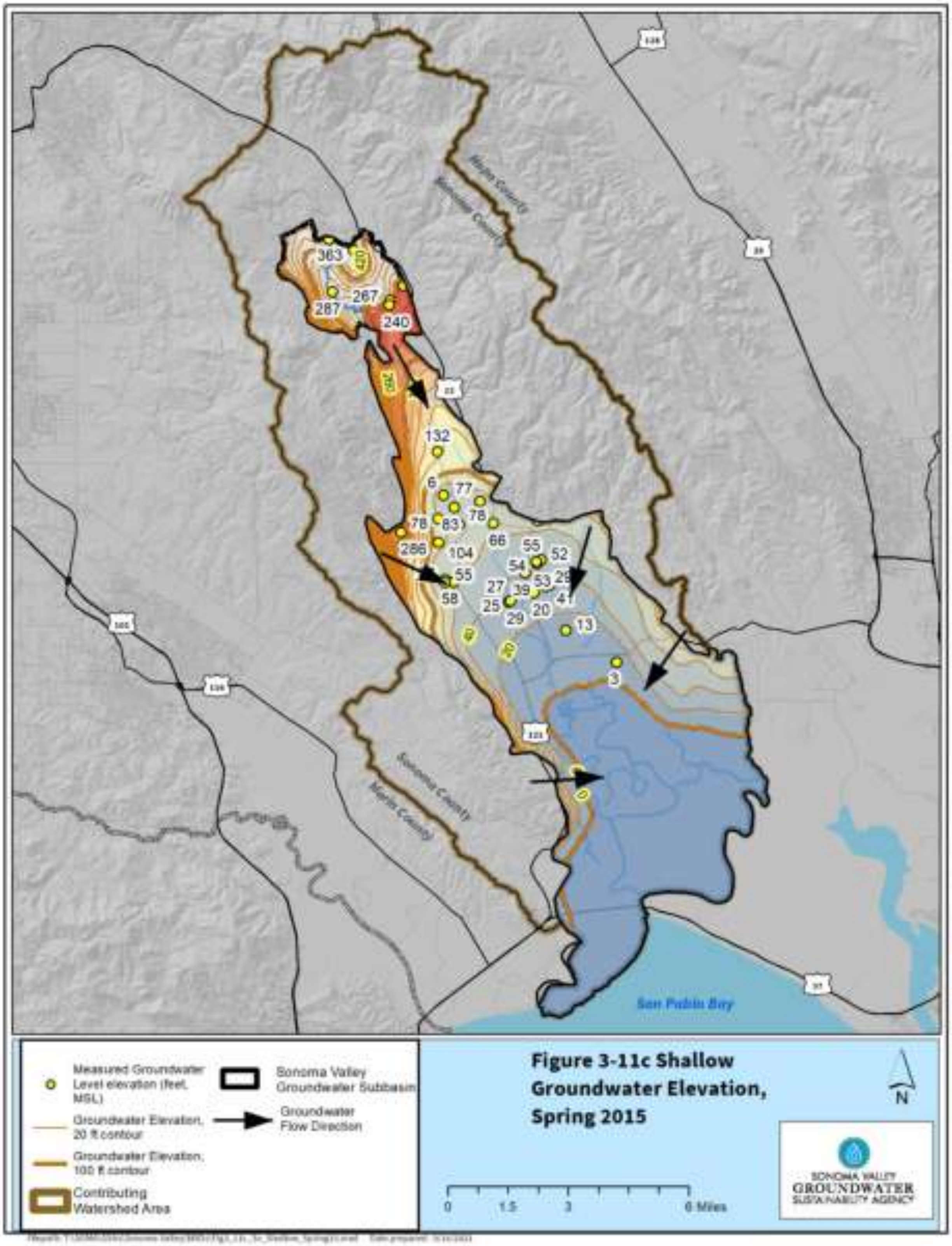

Figure 3-11c Groundwater Elevation, Shallow Aquifer, Spring, 2015

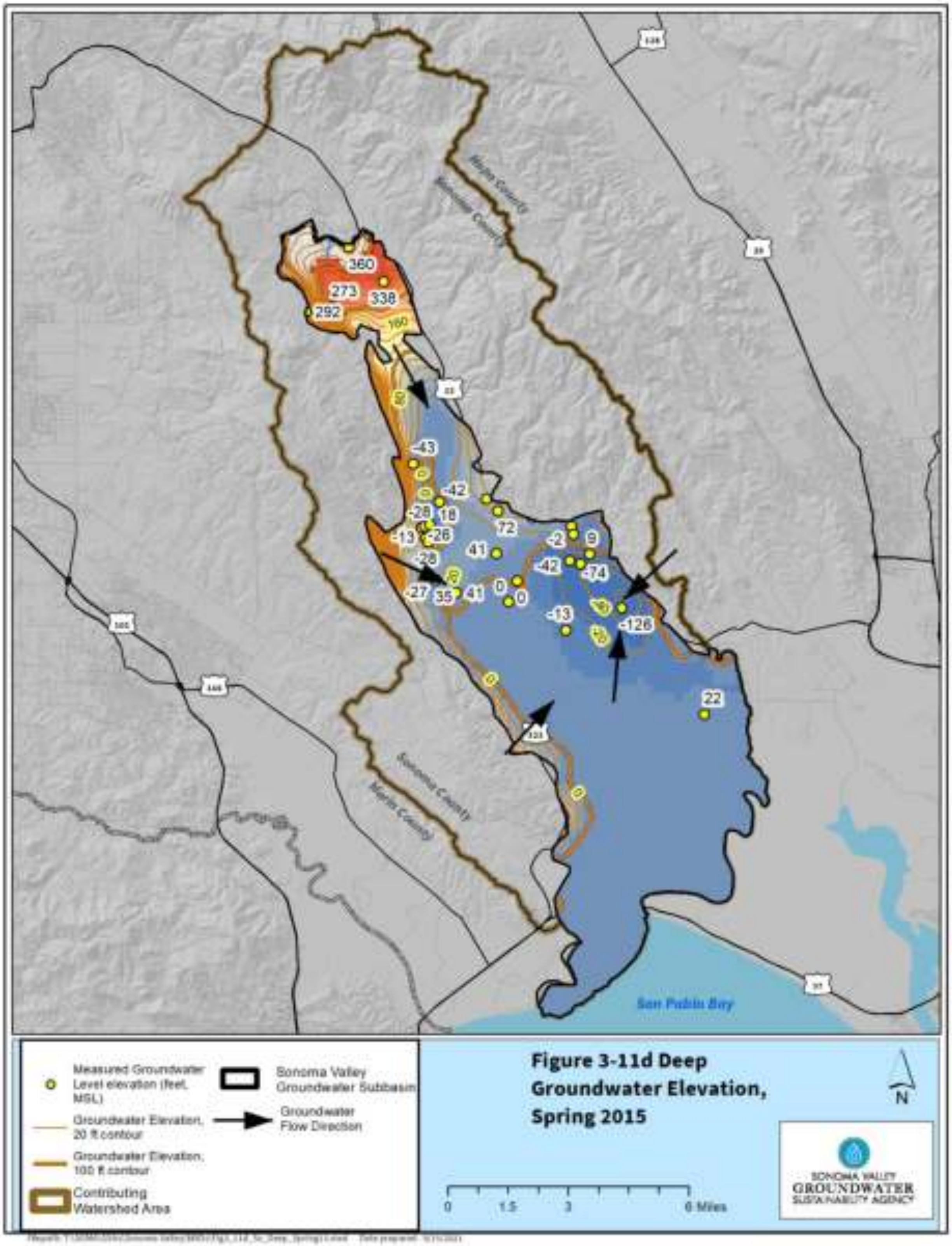

Figure 3-11d Groundwater Elevation, Deep Aquifer, Spring, 2015

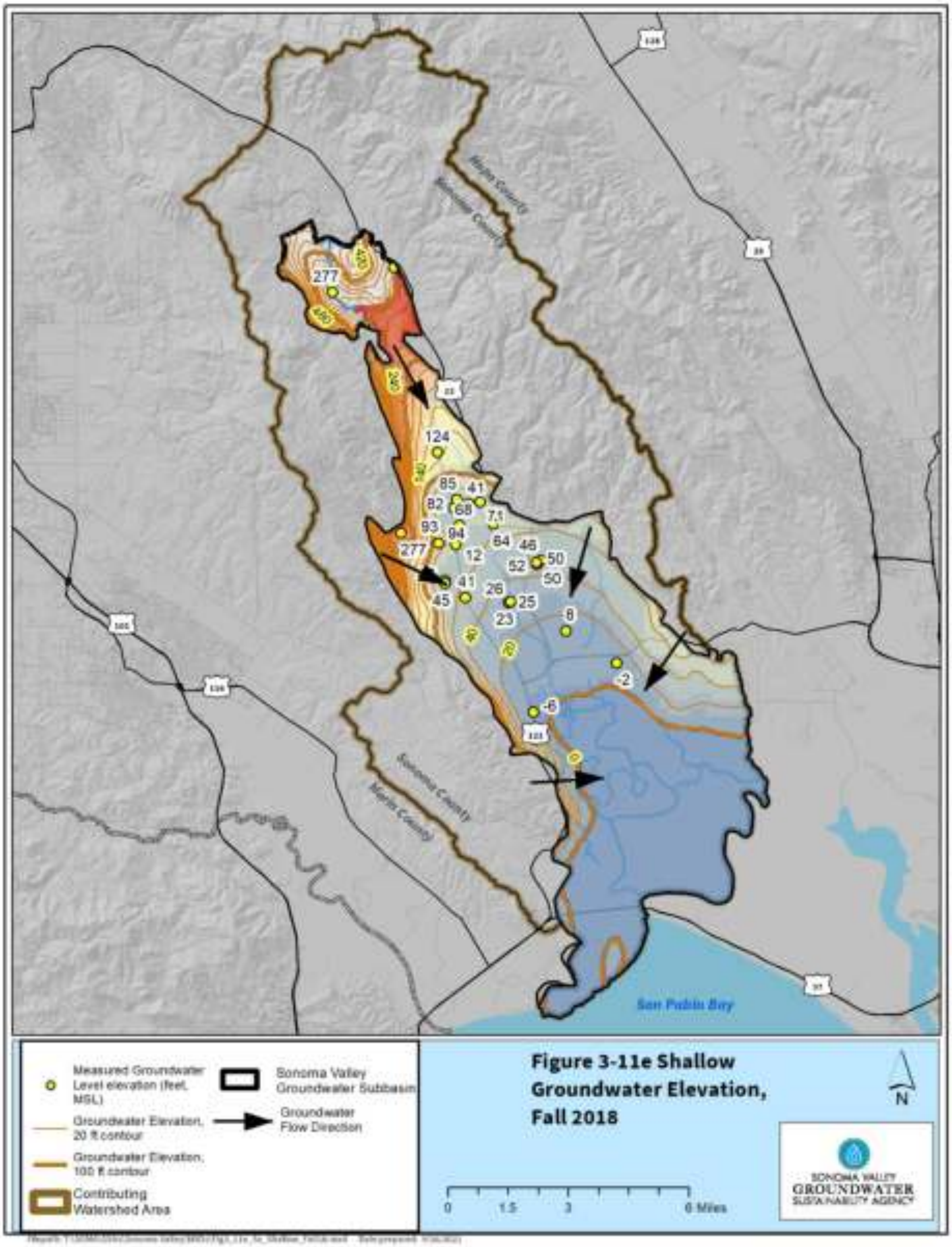

Figure 3-11e Groundwater Elevation, Shallow Aquifer, Fall, 2018

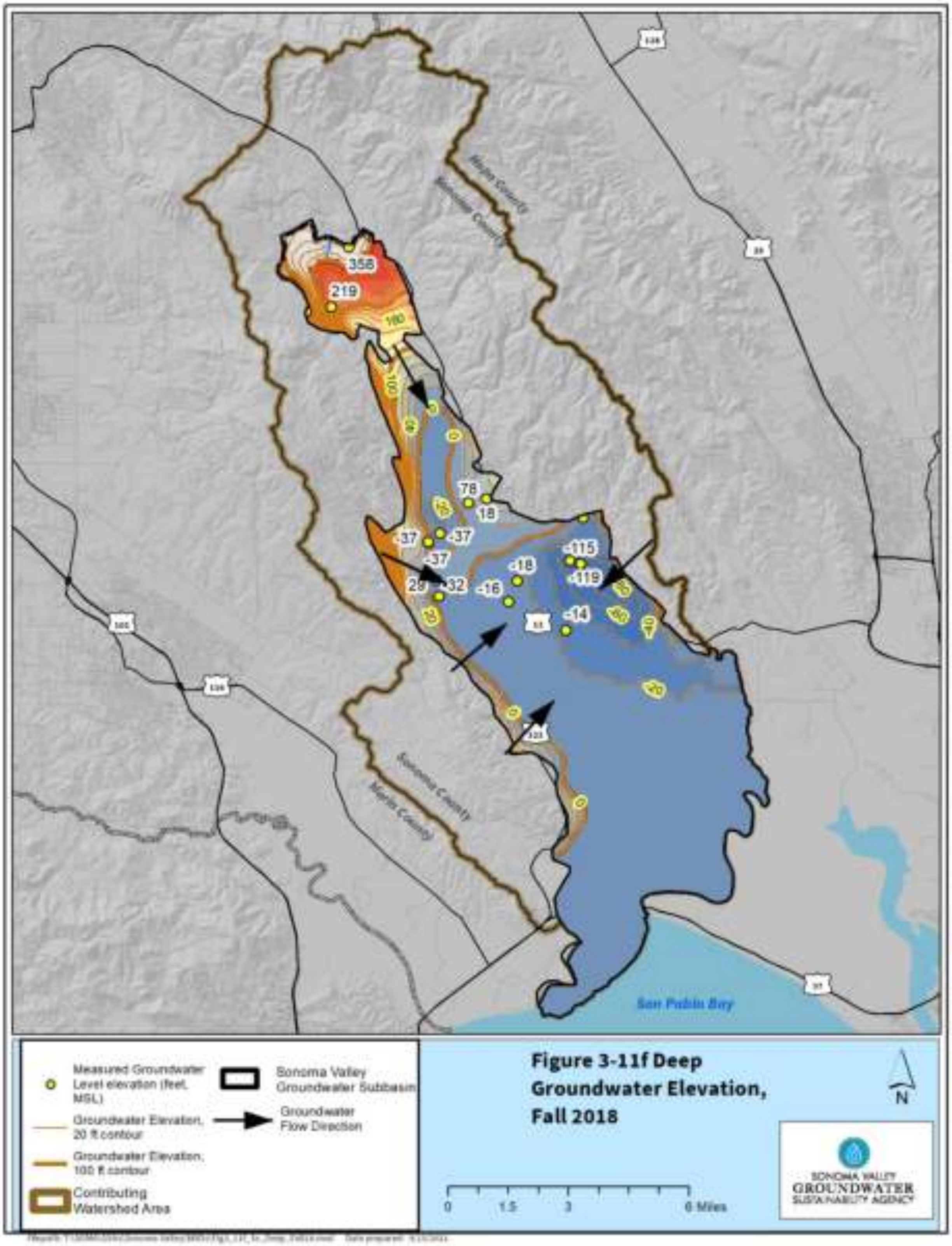

Figure 3-11f Groundwater Elevation, Deep Aquifer, Fall, 2018

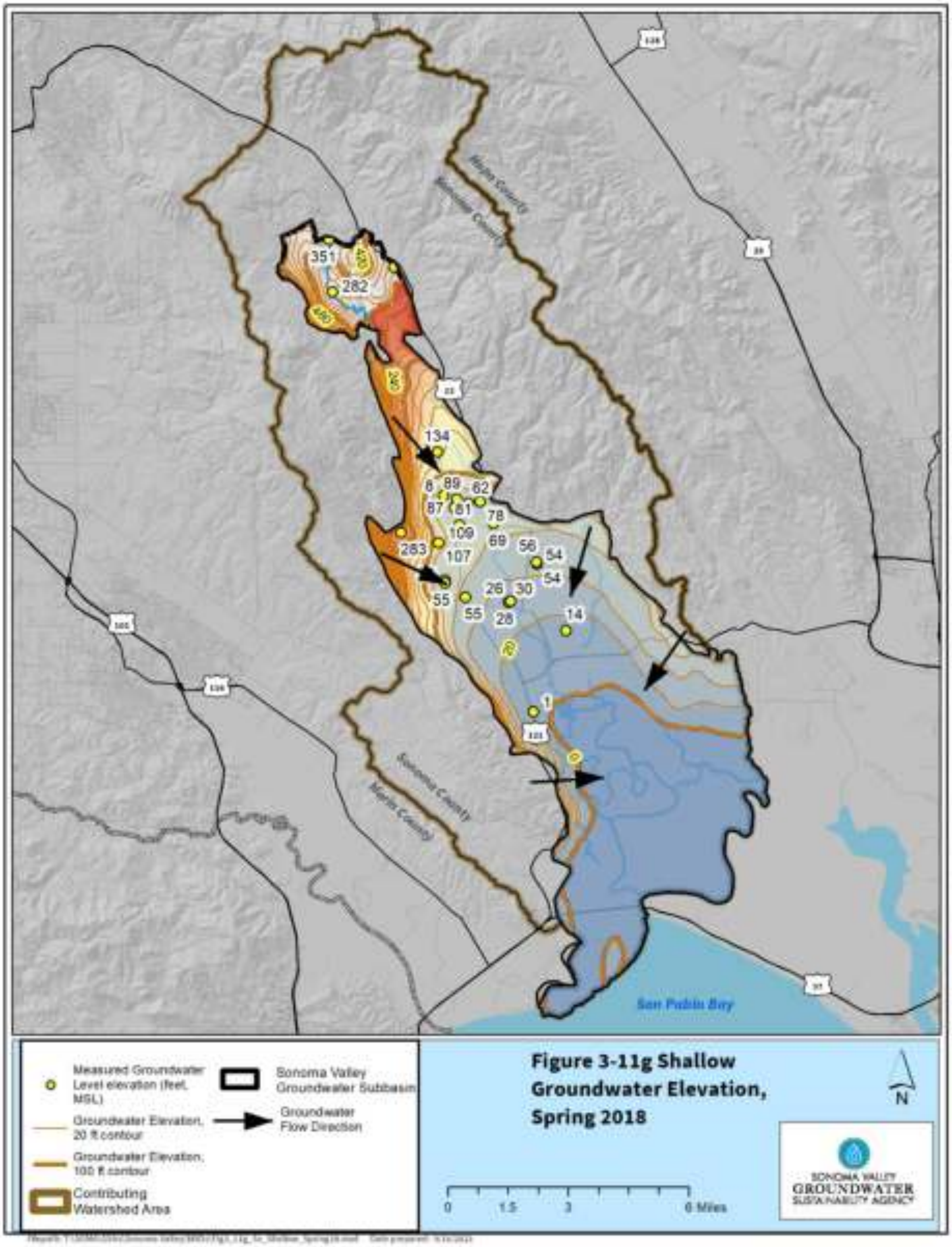

Figure 3-11g Groundwater Elevation, Shallow Aquifer, Spring, 2018

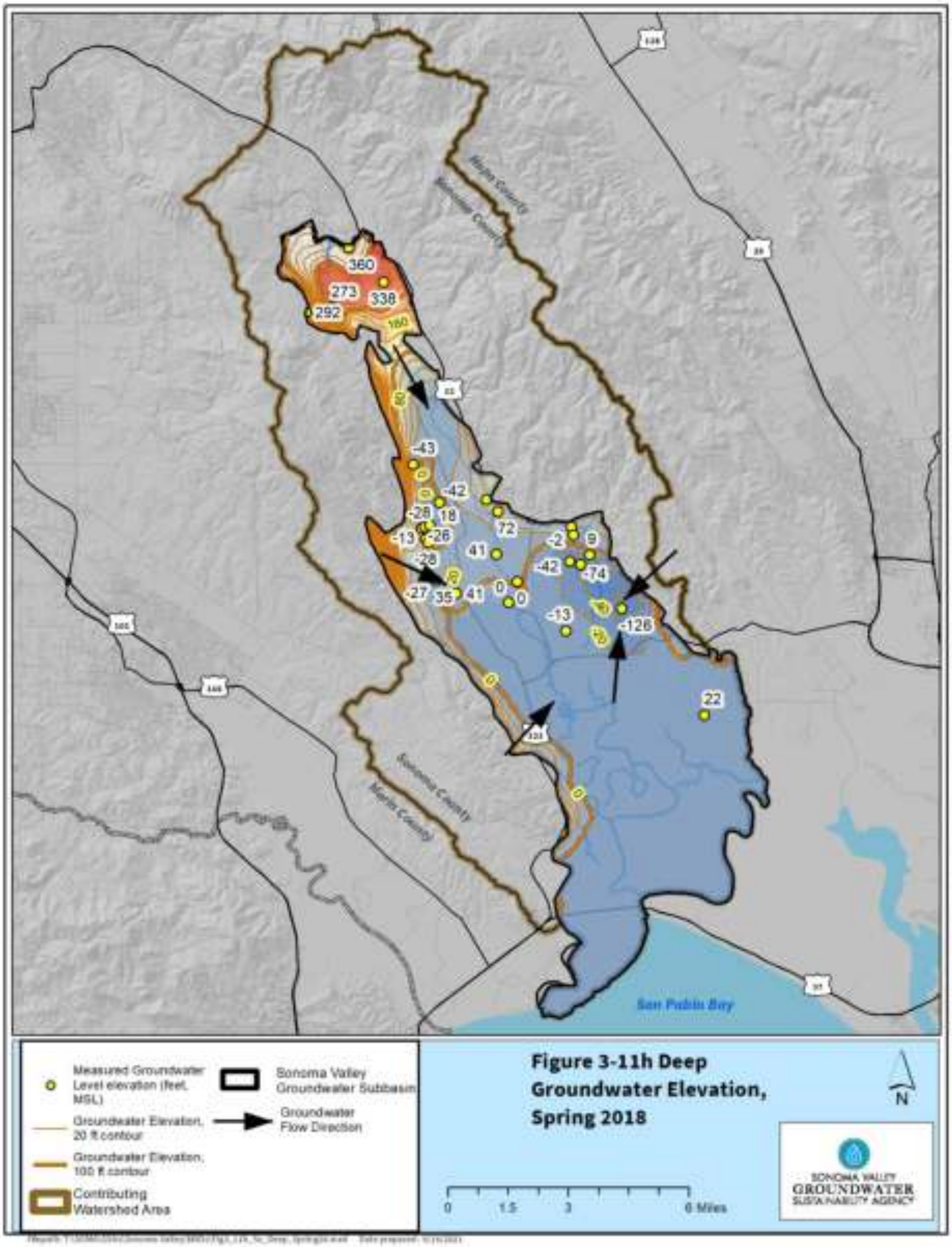

Figure 3-11h Groundwater Elevation, Deep Aquifer, Spring, 2018

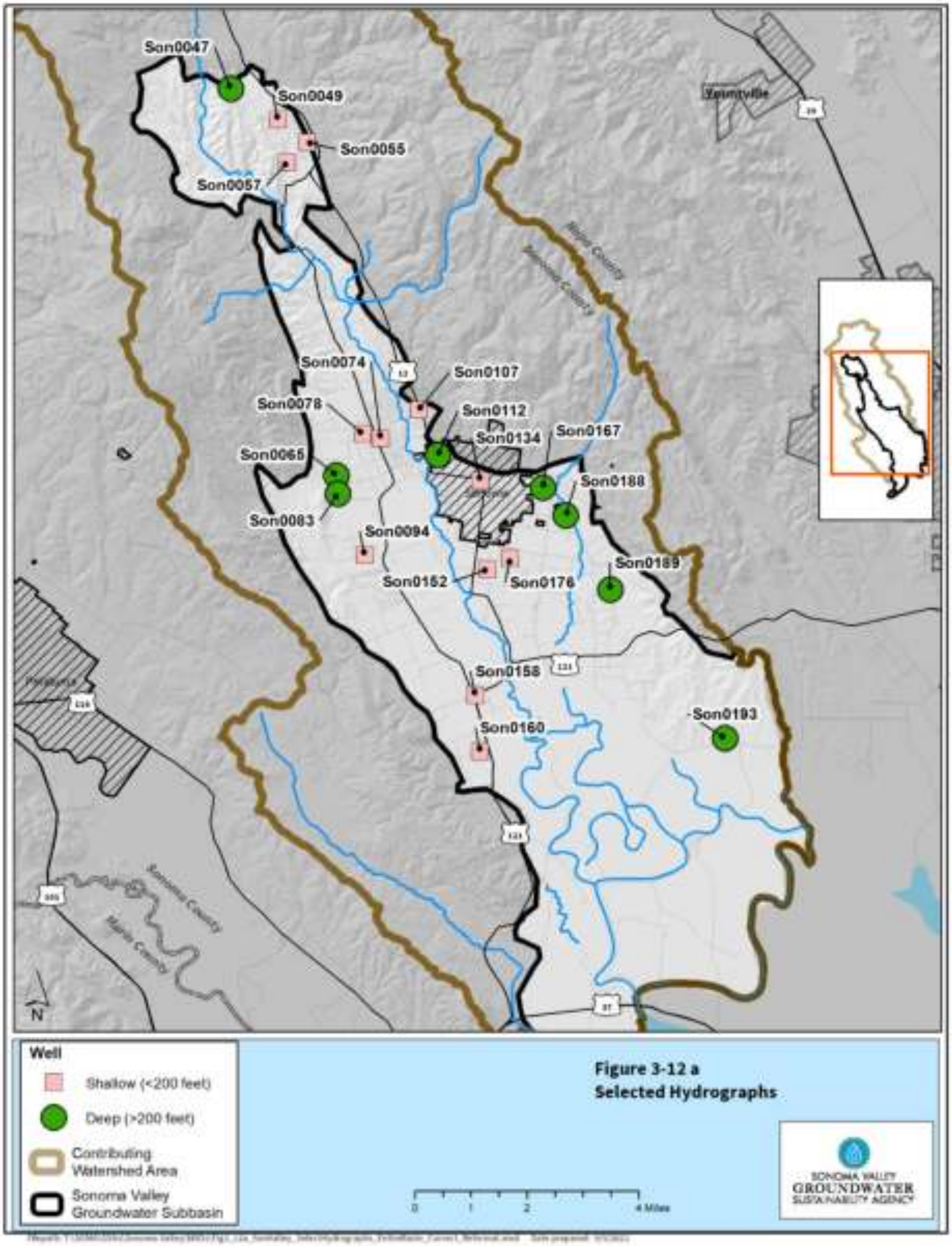

Figure 3-12a. Location of Selected Hydrographs

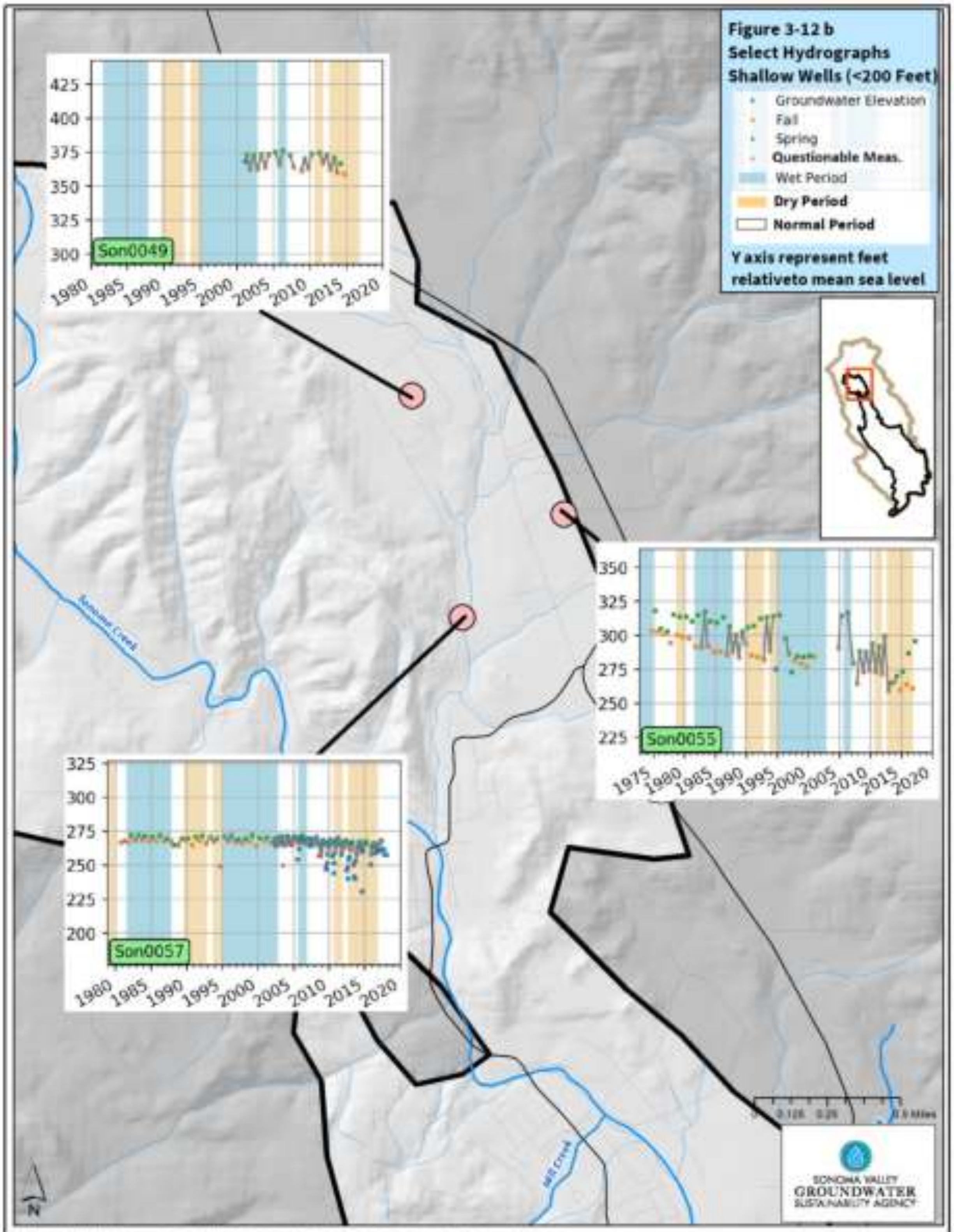

Figure 3-12b. Select Hydrographs - Shallow Aquifer Wells (<u><200 feet bls</u>)

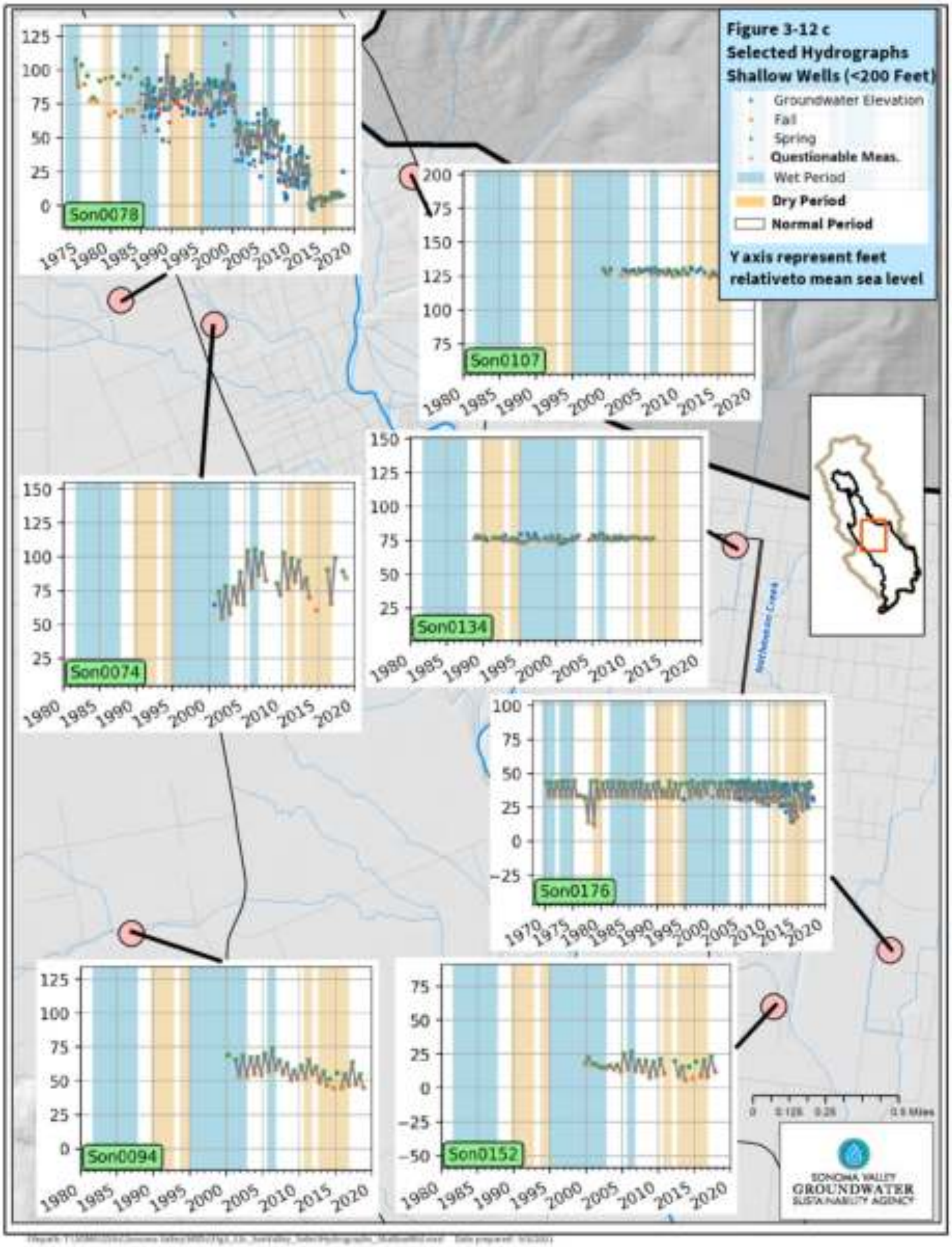

Figure 3-12c. Select Hydrographs - Shallow Aquifer Wells (<u><200 feet bls)</u>

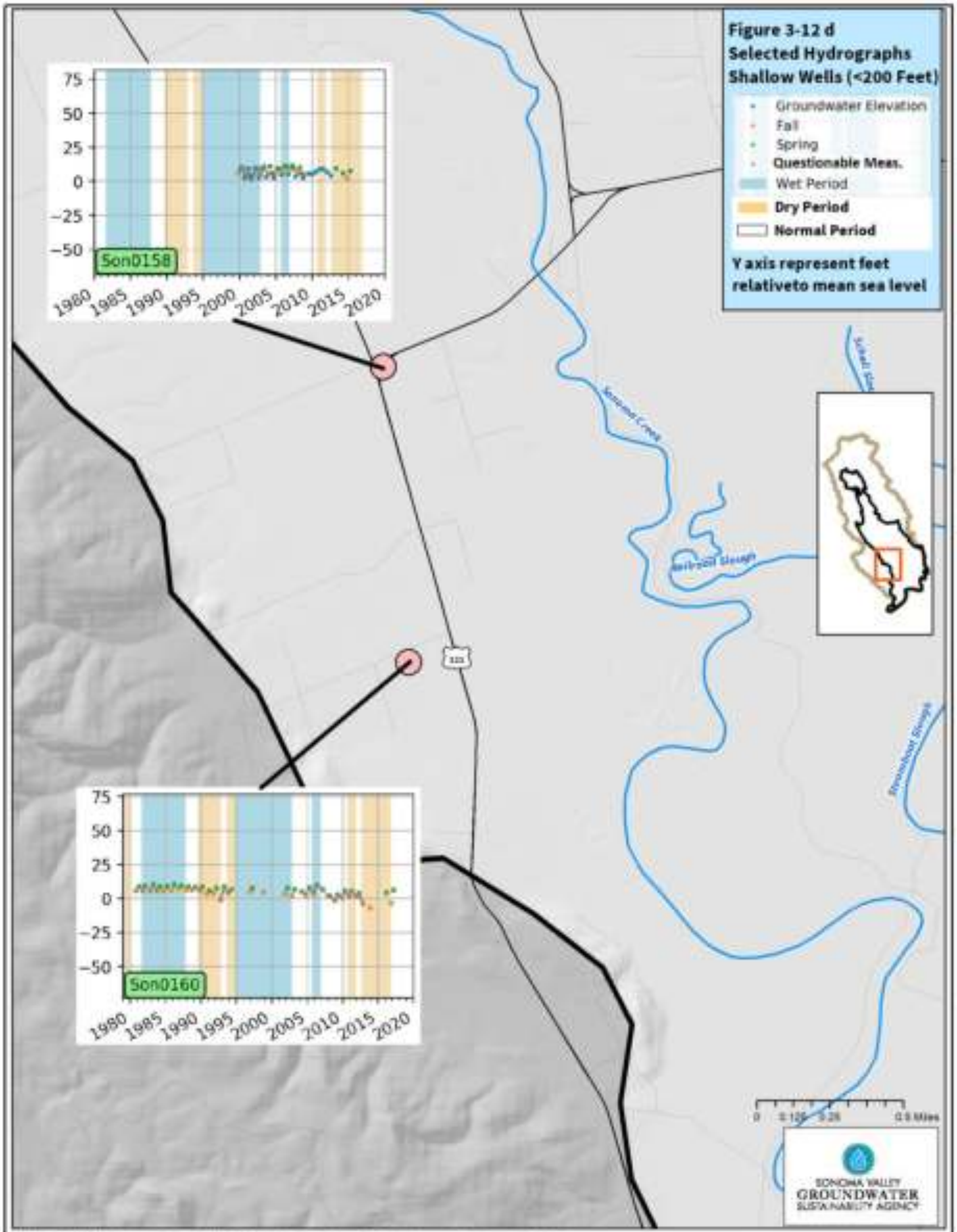

Figure 3-12d. Select Hydrographs - Shallow Aquifer Wells (>200 feet bls)

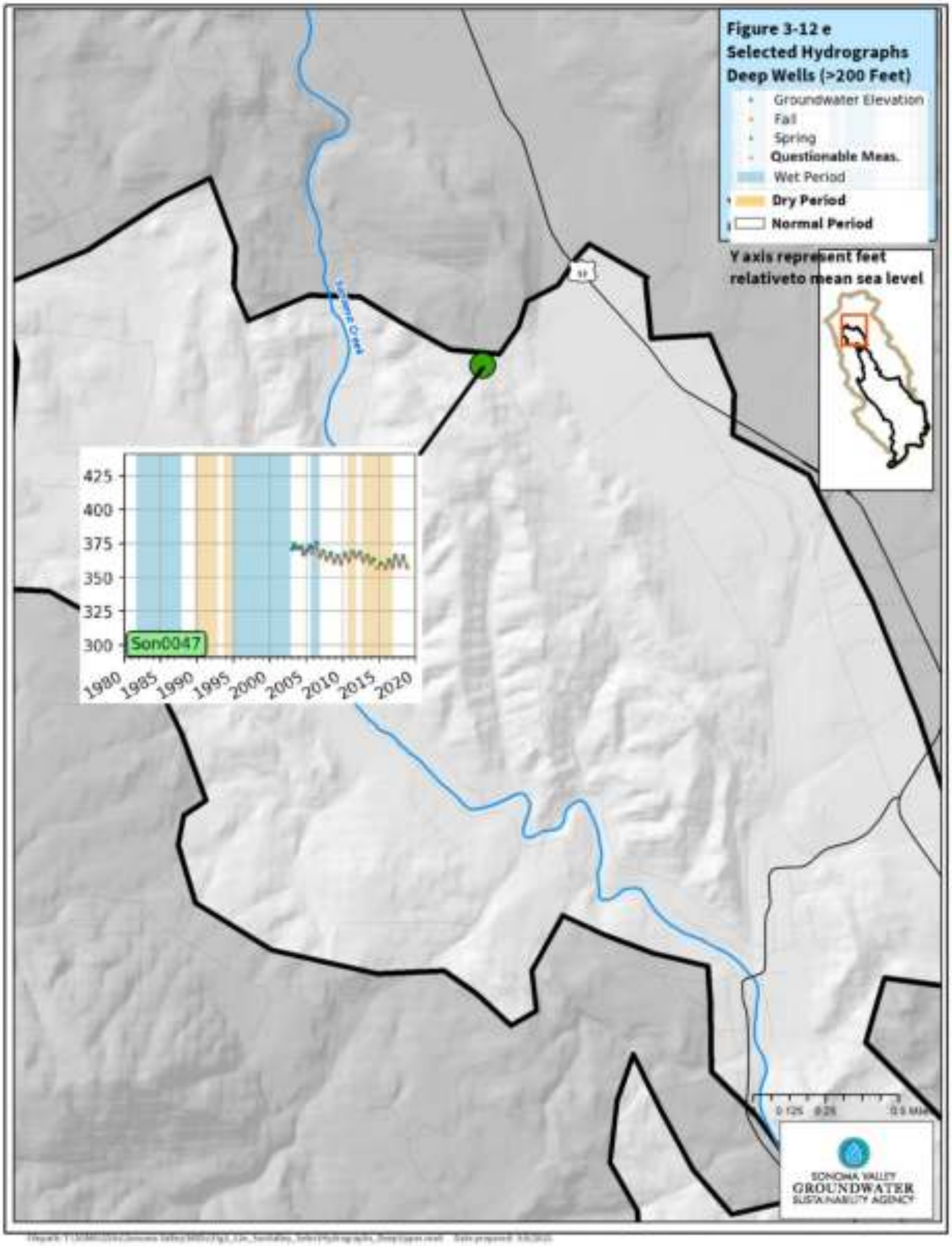

Figure 3-12e. Select Hydrographs - Deep Aquifer Wells (>200 feet bls)

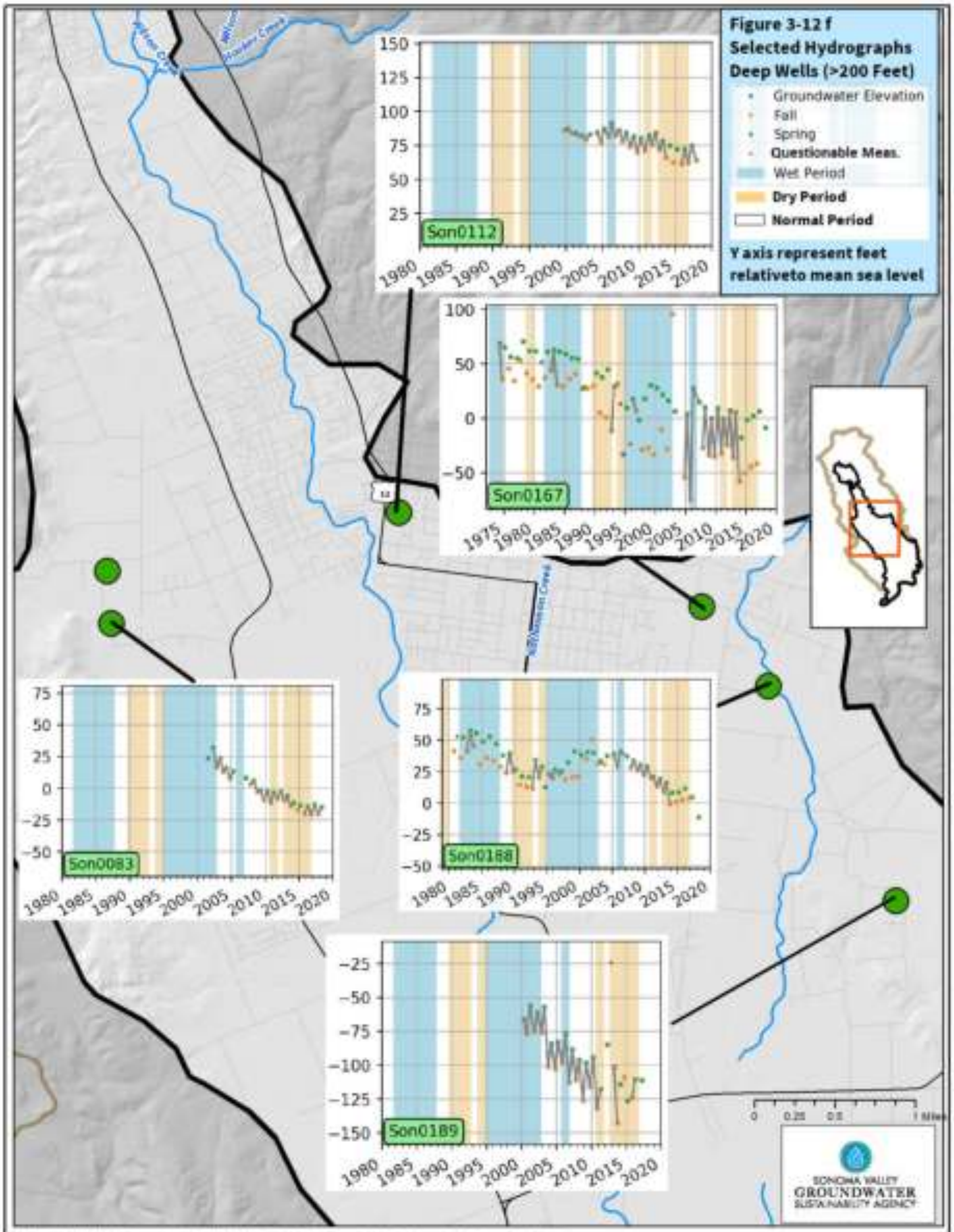

Figure 3-12f. Select Hydrographs - Deep Aquifer Wells (>200 feet bls)

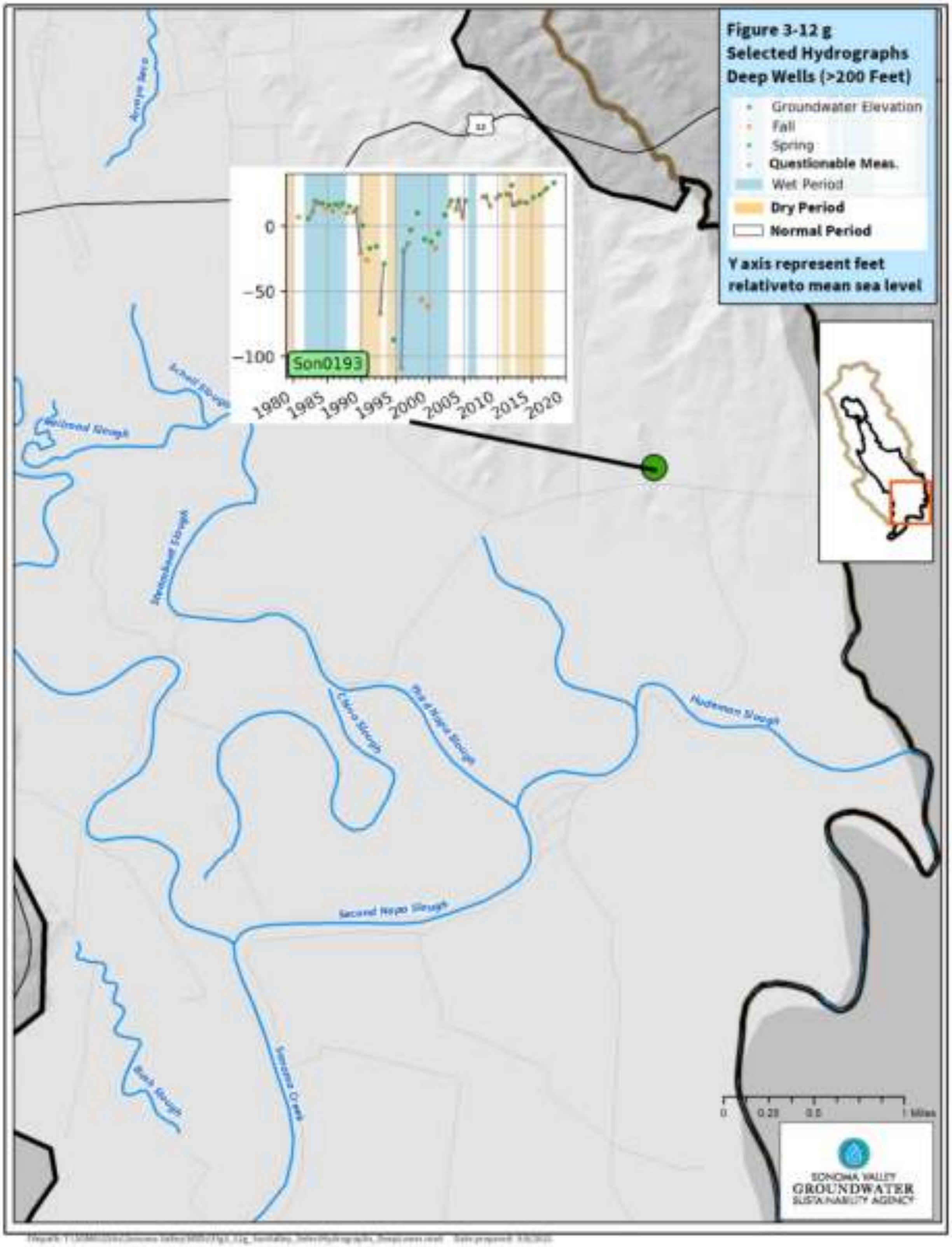

Figure 3-12g. Select Hydrographs - Deep Aquifer Wells (>200 feet bls)

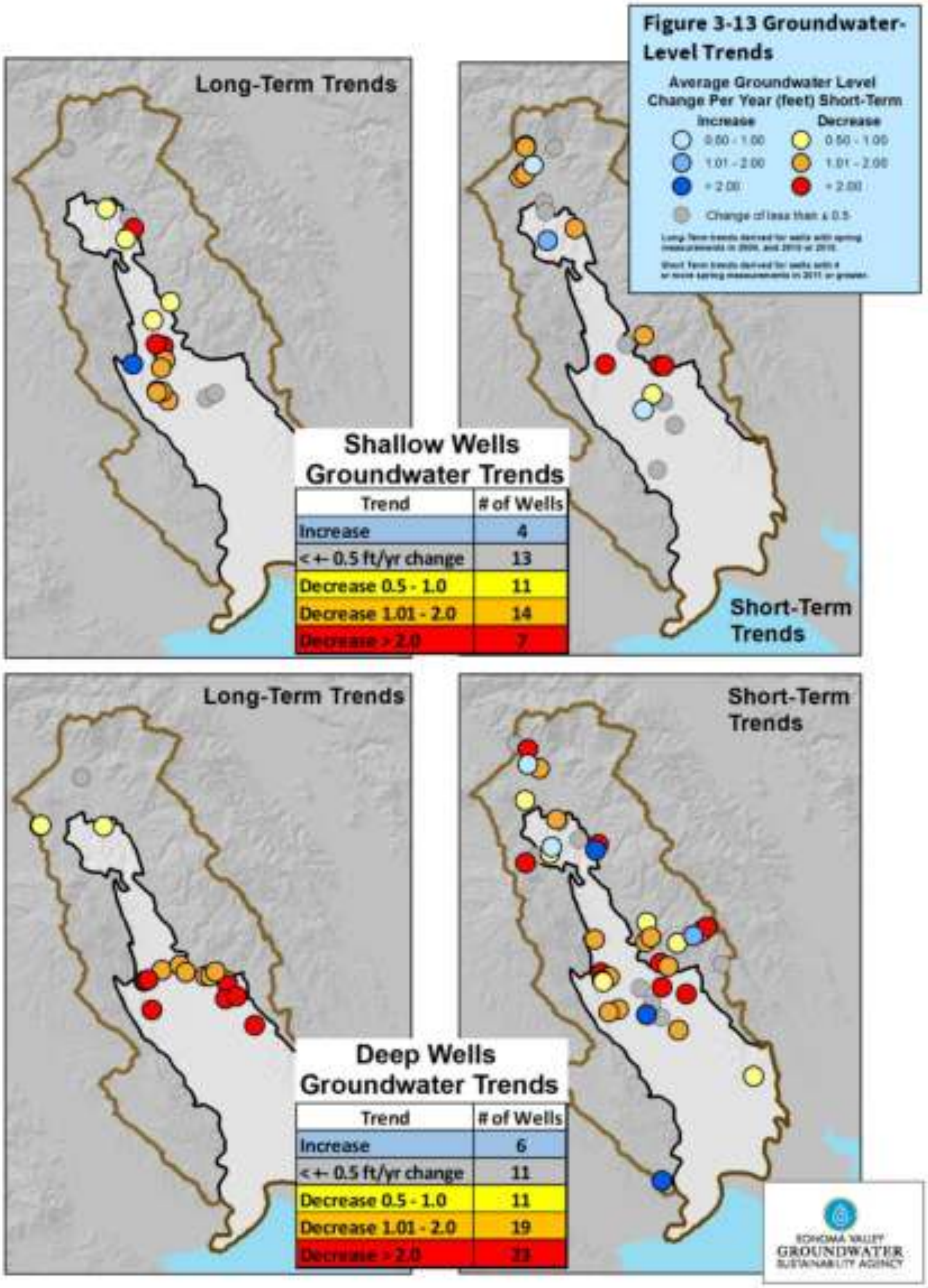

Figure 3-13 Groundwater Level Trends

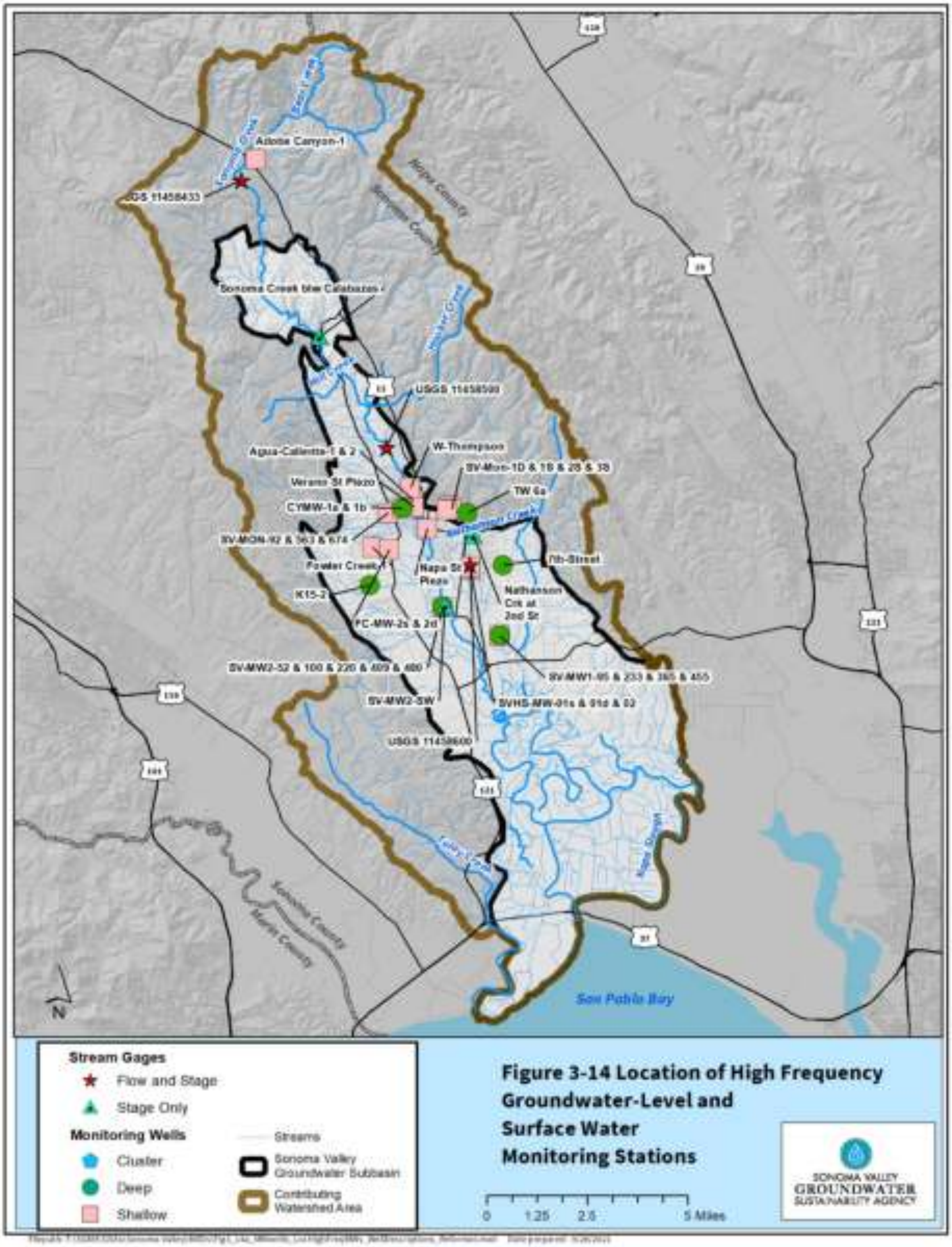

Figure 3-14. Location of High-Frequency Groundwater-Level and Surface Water Monitoring Stations

The fall 2015 groundwater-level contour maps for both the shallow and deep aquifer systems indicate that groundwater flows from recharge areas in the mountains toward the valley axis, in a generally southern direction towards San Pablo Bay (**Figures 3-11a** and **3-11b**). Comparison of shallow and deeper groundwater levels indicates that groundwater elevations in the deep aquifer system are approximately equivalent to groundwater elevations in the shallow aquifer system in the northern portions of the Subbasin and range up to 160 feet lower than groundwater elevations in the shallow aquifer system in portions of southern Subbasin, interpreted to be due to pumping in excess of recharge.

There are two persistent groundwater pumping depressions in the southern Sonoma Valley, which are most apparent in the groundwater-level contour maps of the deep aquifer system (**Figure 3-11b, d, f,** and **h**), first identified in 1999 (LSCE 1999) and further described by Farrar et al. (2006) and subsequent monitoring performed for the groundwater management program. Southeast of Sonoma (and most notably east of the Eastside Fault), measured groundwater levels were as deep as approximately 126 feet below msl, and southwest of El Verano, groundwater levels were as deep as approximately 28 feet below msl in the deep aquifer system. These areas exhibiting declining groundwater levels (pumping depressions) have persisted and expanded in some portions based on data collected through 2020. Most of the groundwater-level declines are considered likely to have resulted from increased groundwater withdrawals in localized areas (Farrar et al. 2006; SVGMP 2014). In the vicinity of groundwater-level pumping depressions located within these areas, groundwater demands are primarily a combination of agricultural and rural domestic pumping (**Figure 3-11b**; SVGMP 2014). In contrast to the deep aquifer, the shallow aquifer remains generally stable throughout the Subbasin (**Figure 3-11a, c, e,** and **g**) during the fall and spring seasons between 2015 and 2018.

It is important to note that groundwater elevations measured in nearby wells can be highly variable due to differences in well design (i.e., the depth and length of well screen intervals) and the spatial variations in aquifer materials (which can vary abruptly due to the complex geologic conditions and numerous fault zones present in Sonoma Valley). Therefore, the associated groundwater-level contour maps represent generalized groundwater-flow patterns and should not be used to interpret more localized or site-specific conditions.

3.2.4 Groundwater-Level Trends

Changes in groundwater levels were evaluated for both long-term trends (wells monitored for more than 10 years) and short-term and seasonal trends (wells monitored for less than 10 years) using data collected from the monitoring program. In general, long-term trends were evaluated using data collected on a monthly to semiannual basis from wells within the monitoring program and short-term trends were evaluated using data collected more recently on a more frequent basis (for example, hourly or less) using data from wells instrumented with pressure transducers.

3.2.4.1 **Long-Term Trends**

A select number of representative well hydrographs distributed throughout the valley (**Figure 3-12a**) are provided on **Figures 3-12b** through **3-12d** for the shallow aquifer system and

Figures 3-12e and **3-12g** for the deep aquifer system. Additionally, hydrographs for all wells included in the groundwater-level monitoring program are provided in **Appendix 3-B.** These hydrographs present the change in groundwater elevation (vertical axis in feet relative to msl) over time (horizontal axis in years). On the hydrographs, spring groundwater-level data are depicted in green and fall groundwater-level data are shown in red, along with wet and dry periods as defined by the methodology described in **Appendix 3-A**.

As indicated on **Figures 3-12b** through **3-12d**, groundwater-level trends for the majority of shallow aquifer wells are generally stable and predominantly remain above sea level. Long-term groundwater-level declines in shallow aquifer wells occurred in wells Son0055, Son0057, Son0078, Son0094 (**Figures 3-12b** and **3-12c**). A water-level decline of about 35 feet occurred between 1976 and 2019 in well Son0055 (**Figure 3-12b**). A water-level decline of about 10 feet occurred between 1981 and 2019 in well Son0057 (**Figure 3-12b**). A water-level decline of about 80 feet occurred between 1976 and 2019 in well Son0078 (**Figure 3-12c**). A water-level decline of about 15 feet occurred between 2000 and 2019 in well Son0094 (**Figure 3-12c**).

As indicated on **Figures 3-12e** and **3-12f**, declining groundwater-level trends are more pervasive in wells perforated in the deep aquifer system. Wells in the El Verano area and southeast of Sonoma are trending below sea level (e.g., wells Son0065, Son0083, and Son0167 shown on **Figure 3-12f**). Numerous hydrographs shown on **Figure 3-12f** exhibit groundwater-level declines of up to 60 feet (for example, Son0167) over the last 30 years. While the magnitude of the declining rate may be influenced in part by the lower than average rainfall that has occurred within the past decade, many of the wells with declining groundwater levels exhibit chronic declines that do not recover during relatively wetter years, indicating that groundwater withdrawals are occurring at a rate exceeding the rate of recharge or replenishment within the deeper zones. The hydrograph for well Son0193 on **Figure 3-12g** exhibits a decline in the early 1990s and subsequent recovery through the present. The timing of the recovery of groundwater levels correlates with the deliveries of recycled water to the Carneros area, which served to offset and reduce groundwater pumping in this area.

To further evaluate trends for wells that have a minimum of 10 years of groundwater-level data, 10-year trend lines (based on the span of available data) were applied to spring groundwater levels on the hydrographs to depict overall trends for these time periods. The slope of the trend lines was computed using the method of ordinary least squares linear regression to estimate the change in groundwater level in feet per year (ft/yr). These computed groundwater-level changes are provided on **Figure 3-13** for the shallow and deep aquifer systems, respectively, to display the average groundwater-level change per year at all wells with data spanning the most recent 10 years.

As shown on **Figure 3-13**, 37 of the 49 shallow aquifer system wells (76 percent) exhibited either a change of less than 1 ft/yr or increasing trends and 12 wells (24 percent) exhibited declines greater than 1 ft/yr. Ten wells (20 percent) exhibited declining trends of 1 to 2 ft/yr and two wells (4 percent) exhibited declining trends of more than 2 ft/yr. The majority of wells exhibiting declines exceeding 1ft/yr are located either along Subbasin boundaries or in the El Verano/Fowler Creek area (**Figure 3-13**).

As indicated on **Figure 3-13**, declining groundwater-level trends are more prevalent in deep aquifer system wells with 29 of the 62 wells (46 percent) exhibiting declining trends greater than 1 ft/yr. Fifteen wells exhibited declining trends of 1 to 2 ft/yr, seven wells exhibited declining trends of over 2 to 3 ft/yr, and seven wells exhibited declining trends of more than 3 ft/yr. The most pronounced long-term declines are within the El Verano/Fowler Creek area and southeast of the City of Sonoma. Thirty-three wells exhibited either a change of less than 1 ft/yr or an increasing trend.

3.2.4.2 Seasonal and Short-Term Trends

Higher frequency groundwater-level monitoring is necessary to understand seasonal and short-term trends, and interconnection between the shallow and deep aquifer systems. High-frequency groundwater-level data has been collected using pressure transducers at a number of dedicated monitoring wells, private wells, and inactive municipal wells over the past decade. **Figure 3-14** shows the locations of wells that are currently fitted with electronic pressure transducers and datalogger systems. Pressure-transducer data are collected at intervals of minutes or hours, and the data are downloaded periodically and converted to groundwater elevations. The high-frequency data collected at these locations provides insights into the seasonal and precipitation event related interaction between surface water and groundwater (where shallow wells near streams are instrumented), short-term and long-term groundwater-level responses to hydraulic stresses such as recharge or pumping, and the hydraulic relationship between the shallow and deep aquifer system.

As shown on **Figure 3-14**, details pertaining to wells currently fitted with pressure transducers collecting high-frequency groundwater-level data are provided in the following subsections.

Monitoring Wells Along Streams

Monitoring wells along streams include the following:

- Sonoma Creek in Adobe Canyon: One dedicated monitoring well (50 feet deep) north of the Subbasin, in the Kenwood Valley Groundwater Basin within the contributing watershed area (Adobe Canyon-1)
- Sonoma Creek at Aqua Caliente Creek: Four dedicated monitoring wells (50 feet or less in depth) located adjacent to Sonoma Creek and Agua Caliente Creek (Agua Caliente-1, W. Thompson, Napa St. Piezo, and Verano St. Piezo)
- Nathanson Creek: Three dedicated monitoring wells (25 feet or less in depth) located adjacent to Nathanson Creek at Sonoma Valley High School (SVHS-MW-01s, SVHS-MW-01d, and SVHS-MW-02)
- Carriger Creek: One dedicated monitoring well (80 feet deep) located adjacent to Carriger Creek (upstream of the FC-MW-2s/2d cluster) on Fowler Creek Road (Fowler Creek-1)

Dedicated Monitoring Wells - Single and Multiple-Depth Completion Nests

The dedicated monitoring wells are as follows:

- El Verano/Fowler Creek Area: One nested monitoring well FC-MW-[2s and 2d]) and one inactive private well (355 feet deep) (K15-2)
- Between City of Sonoma and El Verano/Fowler Creek Area: Two nested monitoring wells (CYMW-1[A and B] and SV-MON-[92, 563, and 674])
- City of Sonoma Area: The City of Sonoma's inactive Well No. 7 (860 feet deep) located at the Sonoma Garden Park on 7th Street East south of the City of Sonoma; one aquifer storage and recovery test well (230 feet deep) just outside the Subbasin, north of the Sonoma Plaza (TW-6a); and three monitoring wells (127 feet or less in depth) just outside the Subbasin, at the Montini Open Space Preserve (SV-MON-1s, SV-MON-1d, & SV-MON-3s)
- South of City of Sonoma: Two nested monitoring wells (SVMW-1-[95, 233, 365, and 455] and SVMW-2-[52, 100, 220, 409, and 480])

Detailed evaluation of data collected from these high-frequency monitoring wells, along with hydrographs with daily precipitation recorded at the General Vallejo Home Climate Station, and where applicable, the nearest streambed and surface water elevation are included in **Appendix 3-C**. The following subsections present a summary of key findings from the detailed evaluation included in **Appendix 3-C**.

Summary Results - High-Frequency Monitoring Along Streams

High-frequency monitoring with shallow depth (25 to 100 feet deep), dedicated monitoring wells along streams within the Sonoma Valley has provided the following summary results:

- Groundwater levels in the shallow aquifer system in general appear to respond rapidly, nearly instantaneously, to precipitation events and associated changes in streamflow, with the relative response timing and magnitude dependent upon the distance of the shallow well to nearby streams.
- Seasonal groundwater-level fluctuations in these wells typically range from approximately 5 to 20 feet.
- Timing of seasonal groundwater-level highs and lows vary somewhat by location, but generally highs range from December to April and lows range from September to November.

In addition to the details of this dataset provided in **Appendix 3-C**, further analysis relative to surface water and groundwater interaction is provided in **Section 3.2.6**.

Summary Results - High-Frequency Monitoring with Single and Multiple-Depth Completion

High-frequency monitoring of dedicated deep and multi-depth monitoring wells within southern Sonoma Valley have provided the following summary results:

- Comparison of groundwater levels measured in the shallow and deeper screened intervals demonstrate the vertical hydraulic separation and relationship between the shallow and deeper aquifers and downward vertical gradients between shallow and deep aquifers.
- Hydraulic vertical gradients between the shallow and deep aquifer systems are most pronounced within and near the pumping depressions (over 100 feet) in these areas and decrease toward the south (for example, approximately 30 feet at SVMW-2 to between 15 and 20 feet at SVMW-1).
- Shallow screened intervals (wells not near streams) appear to show a relationship of lag response to precipitation, and may also have an overprint of seasonal pumping with the similar undulating pattern in both the shallow and deep wells.
- Deeper well screens show some distinct patterns that appear to correlate with pumping influences, as evidenced by sharp declines and recovery patterns.
- A few wells are unique in their patterns including:
    - Well SV-MW1-233 is completed in a clay aquitard that appears to have more of a lag and is lower response to annual and seasonal changes.
    - Upward vertical hydraulic gradients are observed within portions of the deep aquifer system at two locations (SV-MW1 and SV-MW2).
    - Well CY-MW-1b has a relatively flat hydrograph indicative of hydraulic isolation and has chemistry and temperature suggesting geothermal origin.

3.2.5 Land-Surface Subsidence

Land-surface subsidence is defined as the gradual settling or sudden sinking of the Earth's surface owing to subsurface movement of earth materials (Galloway et al. 2000). The principal causes are aquifer system compaction, drainage of organic soils, underground mining, hydrocompaction, natural compaction, sinkholes, and thawing permafrost (National Research Council 1991). The compaction of unconsolidated aquifer systems that can accompany excessive groundwater pumping is by far the single largest cause of subsidence. Historically, the overdraft of such aquifer systems has resulted in permanent subsidence and related ground failures in places like the San Joaquin Valley, but not in the Subbasin.

From 2006 to 2019 the three GPS stations in Sonoma Valley (described in **Section 2.4** and shown on **Figure 3-15a**, along with other regional GPS stations) showed vertical changes of -0.75 inch (**Figure 3-15b**). From 2015 to 2019 the vertical change for the three stations was -0.15 to -0.25 inch, with annual changes of -0.05 to -0.08 inch. It is not possible to conclusively determine the cause of these small changes in land-surface elevation. If groundwater pumping within Sonoma Valley were causing subsidence in the groundwater basin, there would be a deviation from the regional trend with greater ground height change in those stations. This deviation is not observed and is consistent with observed data from stations in Bodega Bay, Marin, Napa, and in the Russian River area similar to that of Sonoma Valley (**Figure 3-15b**). Based on these observations, regional interannual variation in hydrologic isostatic loading is likely the best explanation, whereas groundwater pumping is a smaller potential contributor to the observed subsidence.

The spatial variation of land-surface change within the Sonoma Valley basin is shown on **Figure 3-15c**. This dataset is provided by DWR (DWR 2019) and represents changes from June 2015 to 2018 measured by InSAR. The maximum vertical changes are within the +0.25- to -0.25-foot range for the entire basin, with a majority of the basin within the 0.0 to -0.25-foot range over the 3-year period.

These findings do not suggest that land-surface subsidence due to groundwater extraction has occurred. However, it is noted that measurement stations are not located over areas within the Subbasin most susceptible to subsidence (that is, areas exhibiting groundwater-level declines with extensive clay deposits in southern Sonoma Valley) and the time period of analysis for available processed InSAR data do not extend back far enough to assess any long-term or historical subsidence that may have occurred.

3.2.6 Groundwater-Quality Conditions and Trends

Groundwater-quality sampling has been performed throughout the Subbasin for numerous different studies and regulatory programs. This section provides a summary of groundwater-quality conditions and trends from these studies and regulatory programs, which include the following:

- DWR periodic sampling of private wells from the 1950s to 2010 (DWR 2020b)
- SWRCB GAMA studies sampling of public water-supply wells in 2004 (Kulongoski et al. 2010) and private domestic wells in 2012 (Bennett 2018; Bennett and Fram 2014)
- USGS Geohydrological Characterization (USGS 2006)
- 2014 Salt and Nutrient Management Plan (RMC and Todd Engineers 2014)
- USGS 2016 water quality sampling (USGS 2016)
- Data from regulated public water-supply system sampling
- Regulated contaminant sites

Figure 3-15a. Regional UNAVCO GPS Stations

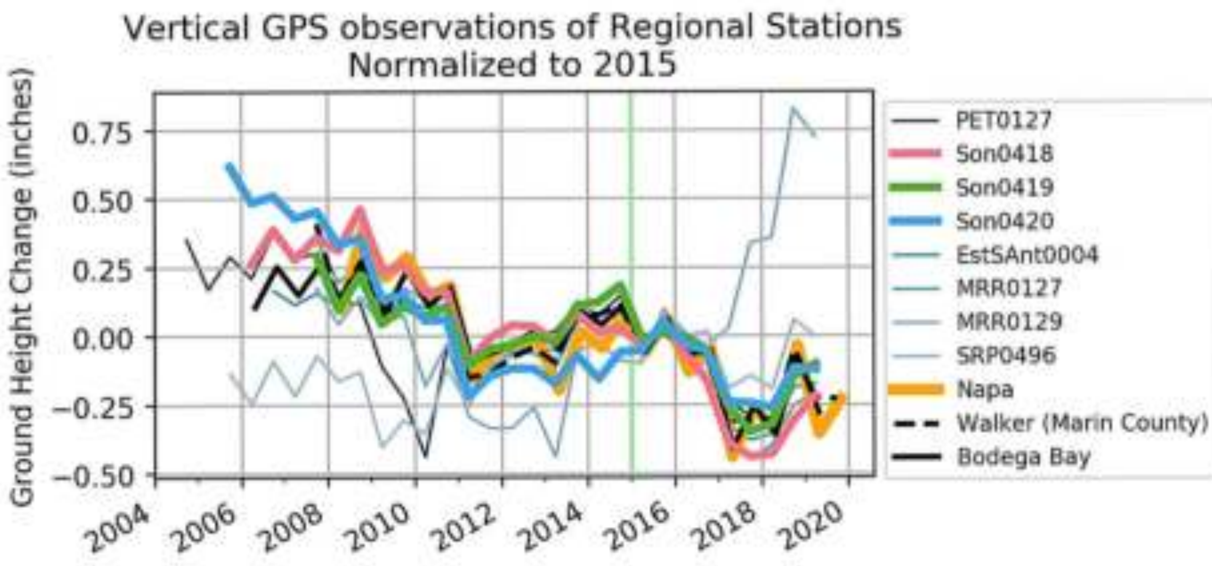

Figure 3-15b. Observed Vertical Displacement in Inches - UNAVCO GPS Stations

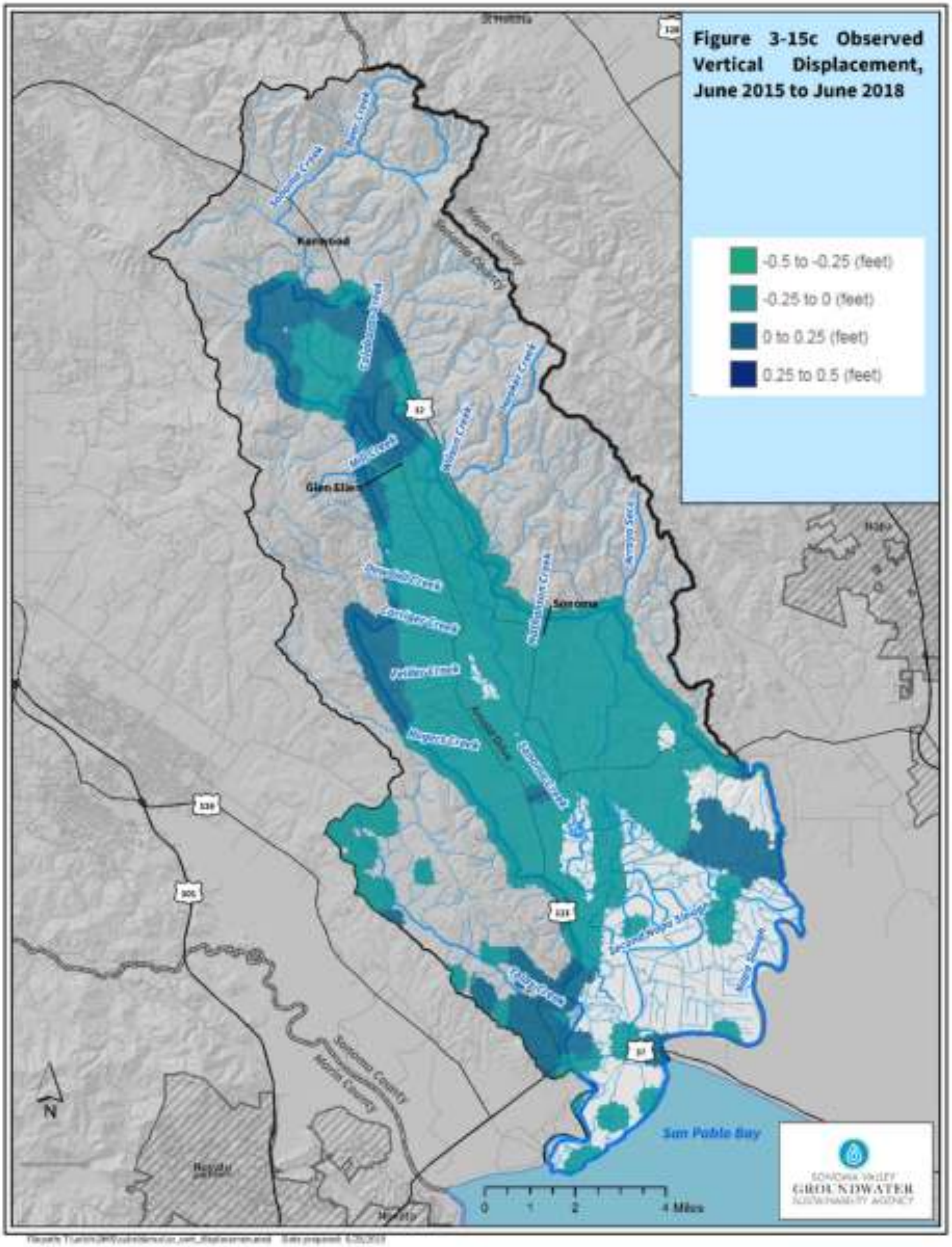

Figure 3-15c. InSAR Vertical Displacement in Feet

These studies and reports find that groundwater quality is generally adequate to support existing beneficial uses within most of the watershed. Localized areas of poor groundwater quality within the watershed are related primarily to the following potential sources of impairment: (1) brackish waters of San Pablo Bay and associated tidal marshland areas, (2) hydrothermal fluids associated with portions of the Sonoma Volcanics and/or fault zones, (3) deep connate waters associated with ancient seawater entrapped during deposition of Tertiary Era sedimentary units, and (4) anthropogenic inputs associated with certain land use activities (for example, industrial, agricultural, or urban land uses).

The following sections describe general groundwater-quality characteristics and the occurrence and distribution of naturally occurring and anthropogenic constituents of interest. Summary results are provided for general minerals; major-ion data; TDS and specific conductance; and arsenic, nitrate, boron and chloride, which have been identified as constituents of interest in previous studies within the Subbasin and/or serve as indicators for thermal, brackish, or saline groundwater. This section also includes a discussion of special focus parameters, including stable isotopes, age-dating tracer, and trace elements to provide insights on groundwater movement.

The following descriptions of these constituents within the Subbasin and contributing watershed areas are based on publicly available data collected within the last 10 years from public water-supply wells and special studies by the USGS and DWR, which included sampling of both public and private water-supply wells, as well as a limited number of dedicated monitoring wells. For wells that have been sampled multiple times within the past 10 years, the most recent sampling result is used in this analysis. The analytic results represent samples of native groundwater collected prior to any water-treatment systems and are not representative of the drinking water delivered by the public water systems, which are required to treat the water to applicable drinking-water standards prior to delivery.

3.2.6.1 General Groundwater-Quality Characteristics

Major-ion concentrations and stable isotopes were used to help classify and characterize the groundwater in the Sonoma Valley.

Major-Ion Concentrations

Major-ion concentrations are assessed by evaluating relative proportions of common ions and anions, and are used to group and classify by a water type. These data can help indicate groundwater flow paths and interconnection with surface water. The major-ion composition of groundwater is controlled by the natural chemistry of the recharge water, geochemical reactions in the subsurface, and anthropogenic factors. The general composition of groundwater in Sonoma Valley has been evaluated using a trilinear (“Piper”) diagram, which shows the relative proportions of common cations and anions for comparison and classification of water samples independent of total analyte concentrations, and are used to group samples that have similar relative ionic concentrations. Farrar et al. (2006) subdivided water samples from the watershed into the following three general groups, as indicated on **Figure 3-16a**:

- Group 1 is a mixed-bicarbonate type water, which generally occurs within the shallow aquifer system, with the exception of a few wells completed within the deeper aquifer system in the El Verano area. It is indicative of water derived either from direct infiltration of precipitation or indirectly from precipitation by means of groundwater losses to streams or streamflow losses to groundwater.

- Group 2 is a mixed-type water with sodium and chloride as the predominant cation and anion, respectively. The majority of wells that produce Group 2-type water are less than 500 feet deep and occur sporadically near the alignment of fault zones and in the southern portions of the Subbasin near San Pablo Bay; these areas are identified as having saline or thermal groundwater.

- Group 3 is a sodium-bicarbonate type water, which generally occurs within the deep aquifer system and appears to represent waters that may have acquired their sodium-bicarbonate composition through cation exchange along groundwater flow paths and are generally older waters that have undergone relatively long travel times and/or distances within the groundwater system.

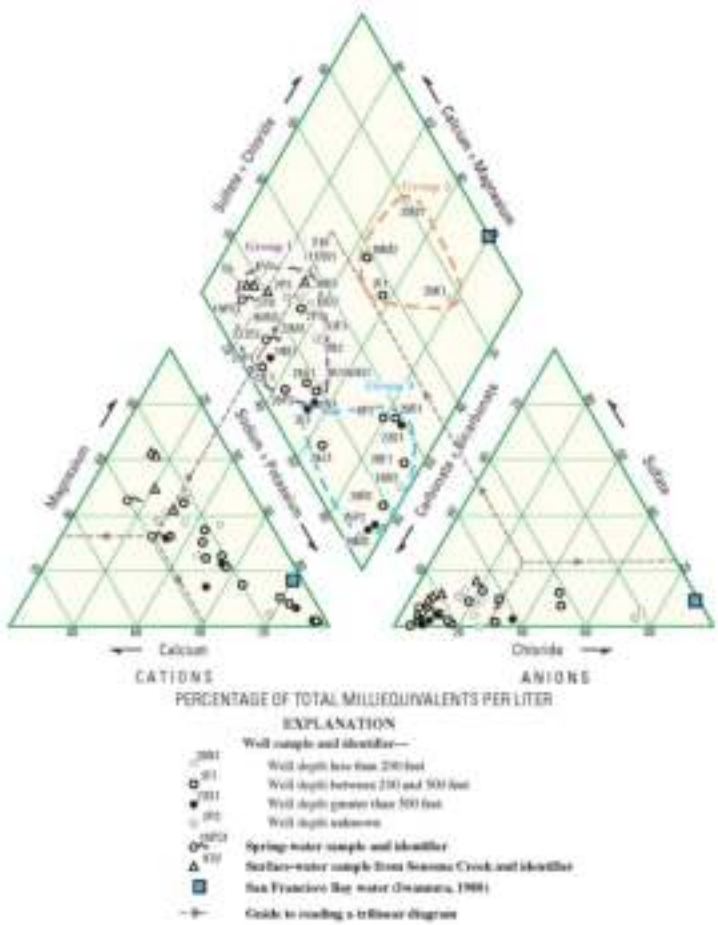

Figure 3-16a. Piper Diagram - Sonoma Valley, Groundwater, Surface Water, Springs and San Francisco Bay Samples

As indicated above, water samples that plot within the same group may be indicative of waters that are of similar origin or have undergone similar hydrogeochemical processes of transformations. In general, results of the major-ion analyses suggest groundwater in the Sonoma Valley is a more mixed-cation bicarbonate moving south to a sodium-bicarbonate type until reaching Highway 121 where chloride becomes a dominant anion associated with brackish water of the tidal marshlands at the south end of the valley.

Stable Isotopes and Age-Dating

The stable isotopes of oxygen and hydrogen can provide information on the source and movement of groundwater. The radioactive isotopes of hydrogen and carbon can provide information on the ages of groundwater.

Oxygen-18 (^{18}O) and deuterium (^{2}H or D) are stable (nonradioactive), naturally occurring isotopes of oxygen and hydrogen. The abundance of heavier oxygen-18 and deuterium relative to isotopically lighter oxygen-16 (^{16}O) and hydrogen-1 (H) can be used to infer the source and evaporative history of water. Water that condensed at cooler temperatures (precipitation that condenses at higher altitudes, cooler climatic regimes, or higher latitudes) tends to be isotopically lighter than precipitation that condenses at higher temperatures (precipitation that condenses at lower altitudes, warmer climatic regimes, and lower latitudes) (Muir and Coplen 1981). In general, results from the stable-isotope analyses suggest that groundwater recharge in the Subbasin is primarily from infiltration of precipitation and the infiltration of seepage from creeks. For additional information regarding the stable-isotope analyses, the reader is referred to Farrar et al. (2006).

Groundwater in shallow- and intermediate-depth wells near Sonoma Creek and in the southern portions of the Subbasin (Schellville vicinity) is generally isotopically heavier and contains water that is at least partly evaporated suggesting a connection with a surface-water source prior to infiltration and recharge (Farrar et al. 2006). Specifically, the data indicate that recharge was derived from local precipitation or storm runoff, but modified by evaporation prior to infiltration or mixed with evaporated waters from contributing sources (for example, seepage from Sonoma Creek, irrigation return flow, etc.) (Farrar et al. 2006).

Groundwater from wells completed within the deep aquifer system is generally isotopically lighter, which may indicate older groundwater with a colder, wetter, climatic source or water originating from a higher elevation in the watershed. Wells producing isotopically lighter groundwater, which was less affected by evaporation prior to infiltration and recharge, include wells located near Sonoma Creek or its tributaries in the northern portions of the Subbasin and contributing watershed area, in and along the margins of the Mayacamas and Sonoma Mountains (both areas where streams exhibit coarser sediments and steeper gradients allowing for faster runoff and infiltration and minimal evaporation), near mapped or inferred faults, and in areas of higher-salinity water (Farrar et al. 2006). Farrar et al. (2006) also noted that the relatively light isotopic composition of waters from several wells within the area of higher-salinity groundwater in the southeastern portions of the Subbasin is not characteristic of water influenced by modern saltwater or brackish waters, but rather is consistent with older connate waters that originated during a cooler and wetter climatic period.

Moran et al. (2010) sampled 10 domestic wells in the El Verano area that were completed in the shallow aquifer system. The stable-isotope data indicate that the main source of groundwater recharge is primarily dispersed infiltration of local precipitation with no significant component of water from higher elevations or evaporation before recharge (Moran et al. 2010).

Tritium (^{3}H) and carbon-14 (^{14}C) are radioactive isotopes of hydrogen and carbon, respectively, that are used to determine the ages of groundwater. Tritium is both a naturally occurring and an anthropogenically generated, short-lived (half-life of 12.32 years), radioactive isotope of hydrogen, whose presence can be used to identify relatively young (post-1952) groundwater. Carbon-14 is the naturally occurring, long-lived (half-life of 5,730 years), radioactive isotope of carbon that can sometimes be used to determine the age of groundwater far beyond the range for ^{3}H.

Age-dating analyses conducted by the USGS in 2015 and 2016 in the southern portions of the Subbasin found that tritium (indicative of modern water) was detected in water from all of the shallow aquifer system wells that were sampled and was generally not detected in deep aquifer system wells. Minor tritium concentrations were detected from a deep aquifer system well located in the El Verano area and near Sonoma Creek at Watmaugh Road. These wells likely contain mixtures of pre-modern and modern water. The data suggest that in general, water from the deeper aquifer system is pre-modern and was recharged prior to 1952 and water from the shallow aquifer system contains components of modern water. This finding is further corroborated by uncorrected carbon-14 age estimates which indicate that waters with the oldest carbon-14 signatures of greater than 11,000 years old occur within the deep aquifers system southeast of the City of Sonoma. On the basis of trace-element data, water in these wells is likely influenced by deep water from consolidated marine sediments (connate water), or a mixture of connate water and thermal water (Teague, pers. comm. 2016).

Moran et al. (2010) found that shallow aquifer wells in the El Verano area produced a mixture of modern (less than 50 years old) and pre-modern (more than 50 years old) water with the pre-modern component making up the majority and modern water ranging from 16 to 43 years old comprising between 2 percent to 25 percent based on tritium-helium age-dating (Moran et al. 2010). The youngest water ages in the study were found in wells closest to Carriger Creek, indicating that the creek and/or the associated Carriger Creek alluvial fan is likely an important source of groundwater recharge to the shallow aquifer system in this area.

3.2.6.2 Naturally Occurring Constituents of Interest

Arsenic, boron, TDS, and chloride have been identified as naturally occurring constituents of interest through previous studies within the Subbasin (for example, Farrar et al. 2006).

Arsenic

Arsenic is a relatively common element that occurs naturally in the environment. Arsenic is considered a carcinogen, and the maximum contaminant level (MCL) for arsenic has been set at 10 micrograms per liter (µg/L). Arsenic solubility increases with increasing water temperature, and also tends to desorb from aquifer matrix materials under alkaline conditions (pH greater than 8.0) (Kulongoski et. al 2010). Due to its increased solubility at higher temperatures, arsenic is commonly elevated in groundwater that is affected by hydrothermal fluids.

Water-sample analyses for arsenic were available from 112 wells within the Subbasin and contributing watershed between 2010 and 2019. The occurrence and distribution of arsenic in groundwater samples is displayed on **Figure 3-16b**. Groundwater samples from 19 of the 112 wells (17 percent) exceeded the MCL of 10 µg/L for arsenic. Areas of elevated arsenic concentrations are most notable north of Highway 121 along the 8th Street East corridor and in the vicinity of the Eastside Fault (which likely serves as a source of upwelling thermal water in this area). Other areas of higher arsenic concentrations are also associated with thermal water sources and/or known or inferred faults.

Figure 3-16c displays time-concentration plots of arsenic for wells with the longest periods of records based on available historical data. As indicated on the time-concentration plots, the majority of wells do not exhibit readily discernable long-term increasing or decreasing trends. Many of the wells do periodically exhibit significant fluctuations in arsenic concentrations over time, which may be related to sampling procedures or short-term changes in groundwater quality, as arsenic concentrations are strongly influenced by pH and other redox changes.

Boron

Boron is a naturally occurring element in rocks and soils, and also may be found in wastewater, fertilizers, and pesticides. Boron is a necessary nutrient for human health, but has been found to be a contaminant to the environment and may adversely impact human health, although it is not considered a carcinogen and not many comprehensive health studies have been completed. A State Notification Level of 1,000 µg/L has been established for public drinking-water supplies. However, boron in irrigation water at concentrations as low as 700 µg/L can be toxic to sensitive plants such as grapes (Ayers and Westcot 1985).

Water-sample analyses for boron were available from 56 wells within the Subbasin and contributing watershed between 2010 and 2019. The occurrence and distribution of boron in groundwater is displayed on **Figure 3-16d**. Groundwater samples from 10 of the 56 wells (18 percent) exceeded 1,000 µg/L for boron. Groundwater wells exhibiting elevated boron levels are commonly coincident with wells that exhibit elevated arsenic levels (Forrest et al. 2013), which indicate the distribution and occurrence of boron may be influenced by the presence of thermal water and faults.

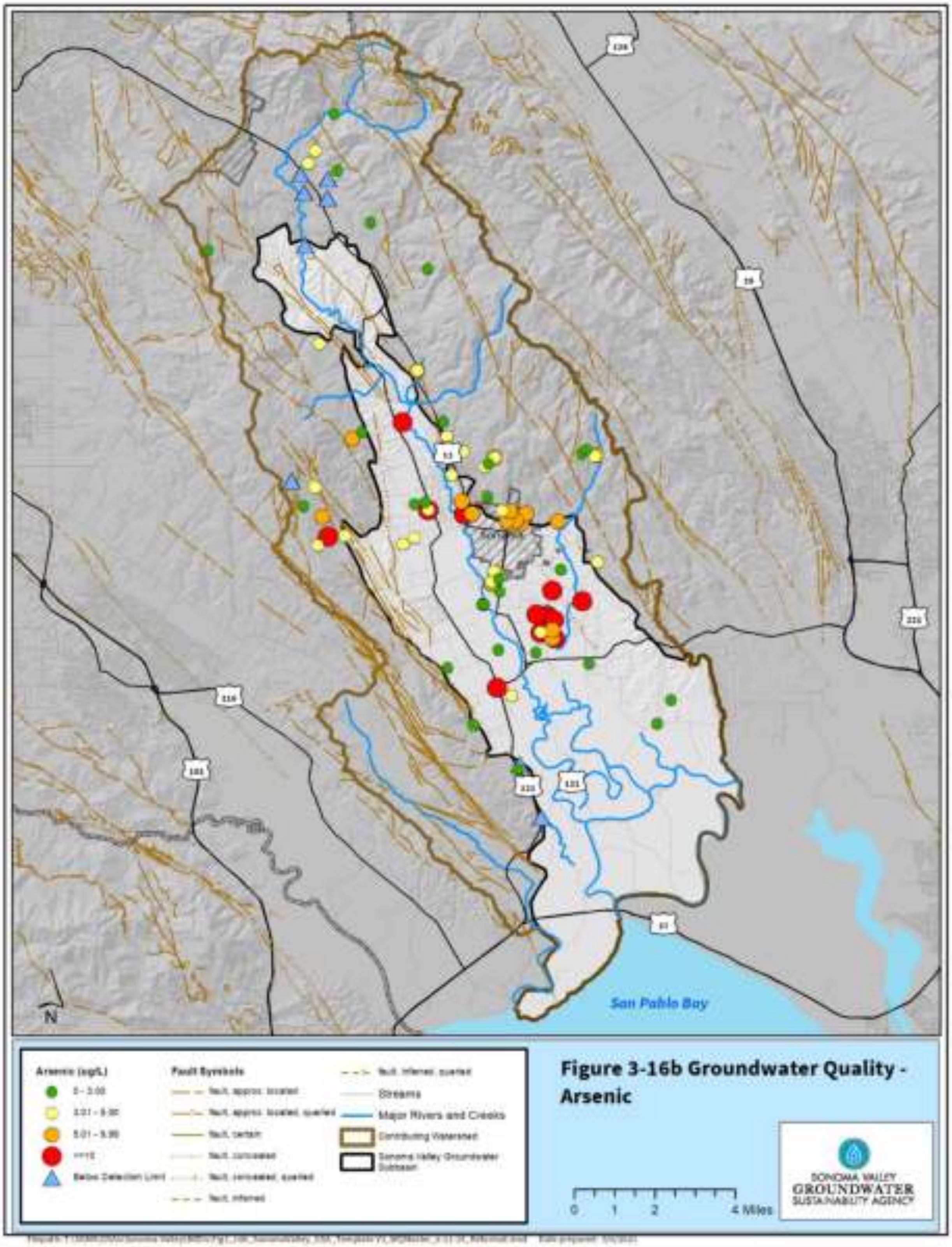

Figure 3-16b. Groundwater Quality - Arsenic

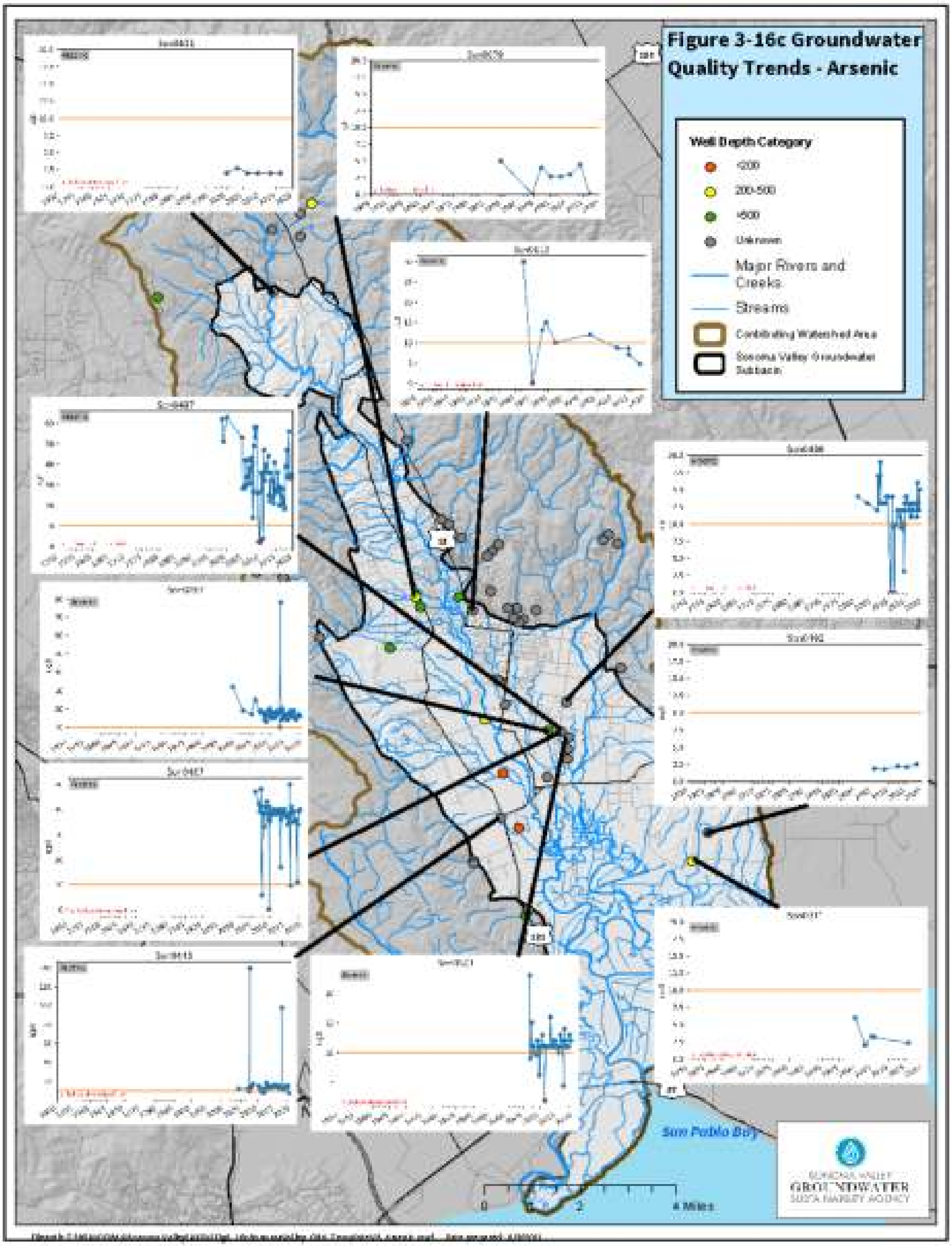

Figure 3-16c. Groundwater Quality Trends - Arsenic

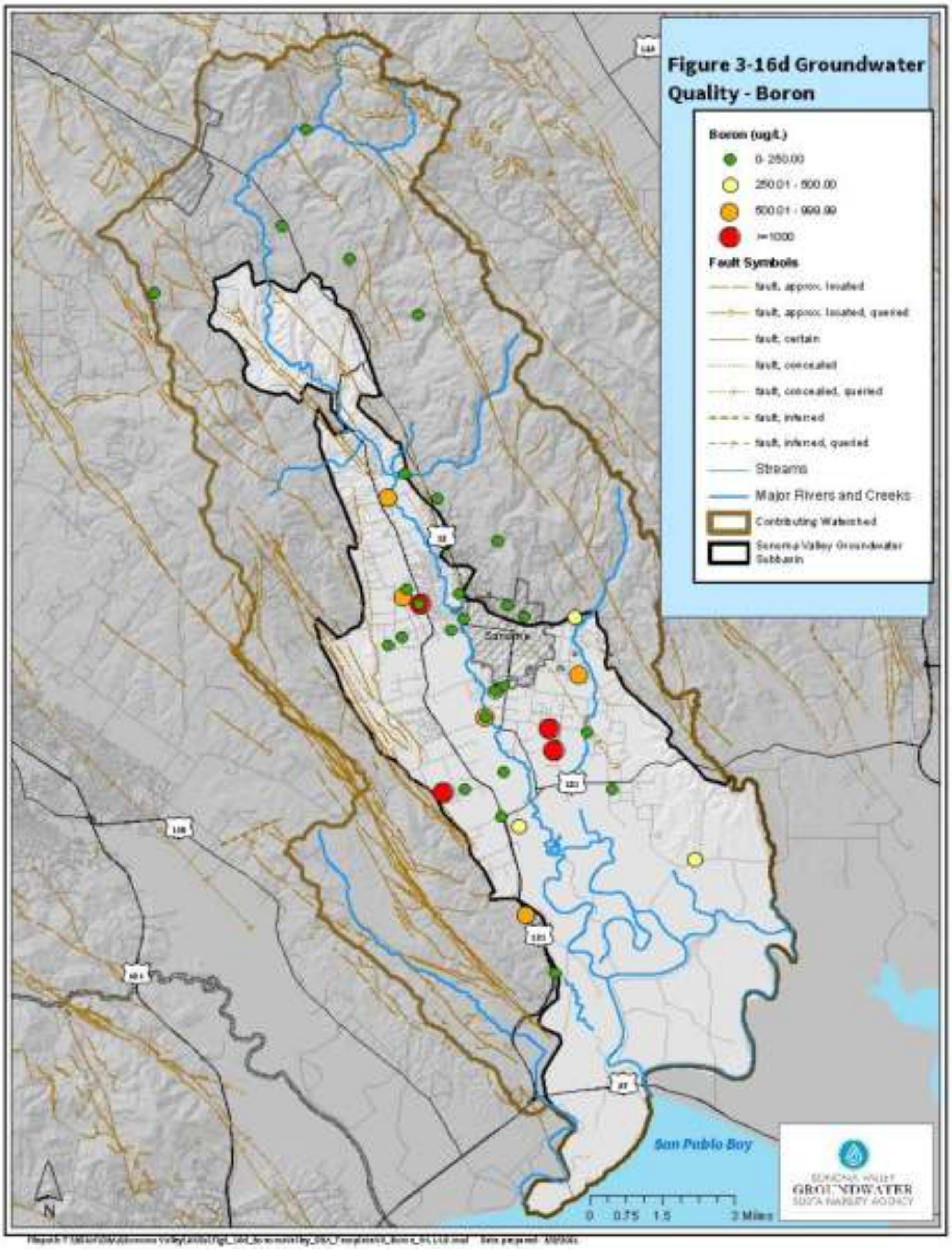

Figure 3-16d. Groundwater Quality - Boron

Chlorides

Chlorides are widely distributed in nature as salts of sodium, potassium, and calcium. Chlorides are leached from various rocks into soil and water by weathering and can also be an indicator for seawater intrusion. Chlorides have a U.S. Environmental Protection Agency (EPA) secondary MCL of 250 milligrams per liter (mg/L).

Water-sample analyses for chlorides were available from 111 wells within the Subbasin and contributing watershed areas between 2010 and 2019. The occurrence and distribution of chlorides in groundwater within the watershed is displayed on **Figure 3-16e**. No groundwater samples exceeded the secondary MCL of 250 mg/L for chlorides during the 2010 to 2019 timeframe. Concentrations of chlorides in excess of 100 mg/L are limited to the southeastern portions of the Subbasin from wells in the Carneros area and east of the Eastside Fault. These wells are either wholly or primarily completed within the Huichica Formation and the elevated chlorides in these wells that are too low to be indicative of seawater intrusion, are likely associated with deep connate waters associated with ancient seawater entrapped during deposition of the Tertiary Era Huichica Formation, which is consistent with the findings from the age-dating and trace-element data described above.

Figure 3-16f displays time-concentration plots of chlorides for wells with the longest periods of records based on available historical data. As indicated on the time-concentration plots, the majority of wells exhibit relatively stable concentrations of chlorides over time. It is important to note that many of the time-concentration plots do not include very complete records over time (sampling for several of the wells that were sampled in the 1950s through 1970s were discontinued and many of the wells with more complete recent data do not have data extending back over time). Additionally, spatial data gaps occur in both the shallow and deep aquifer system.

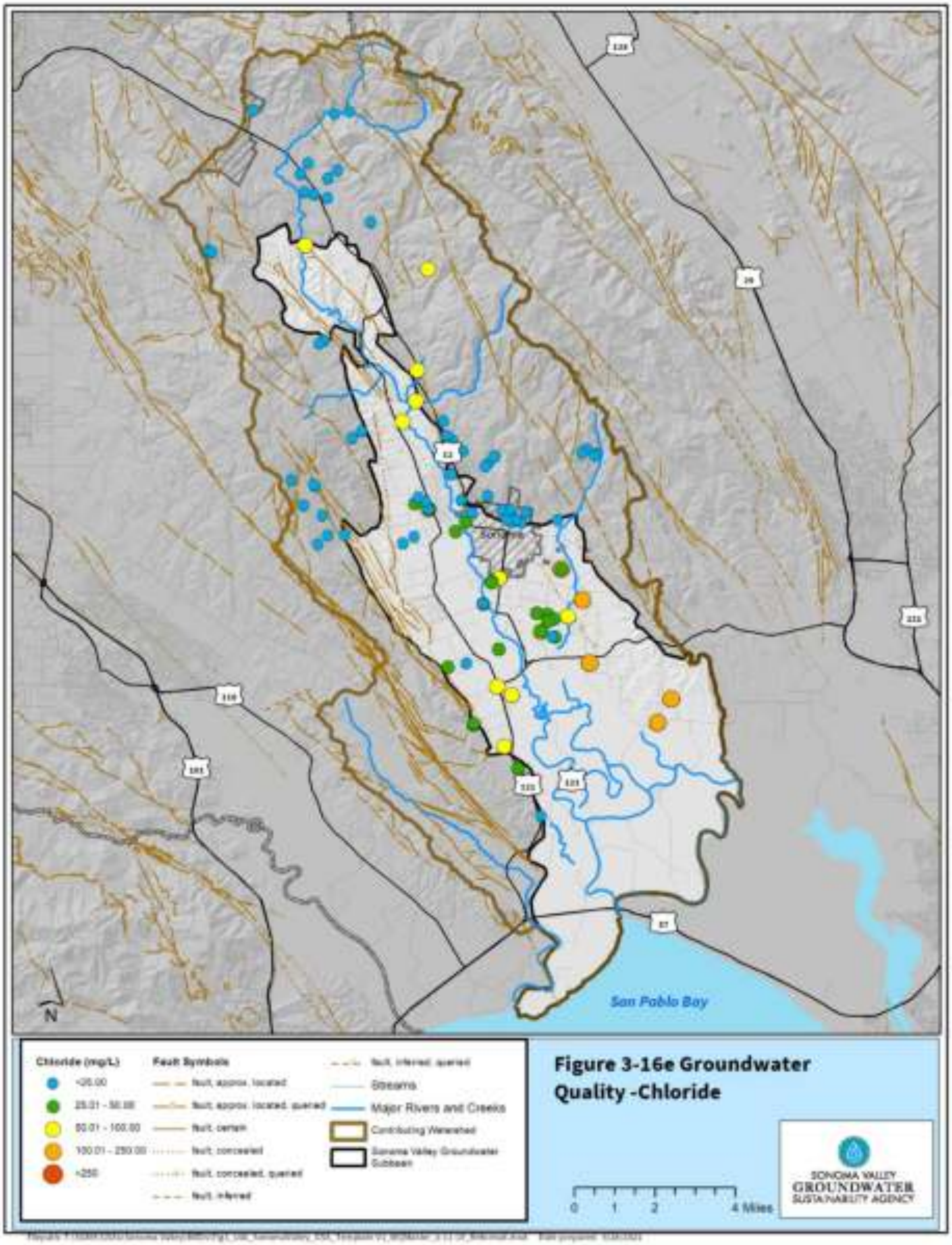

Figure 3-16e. Groundwater Quality - Chloride - Shallow Aquifer system

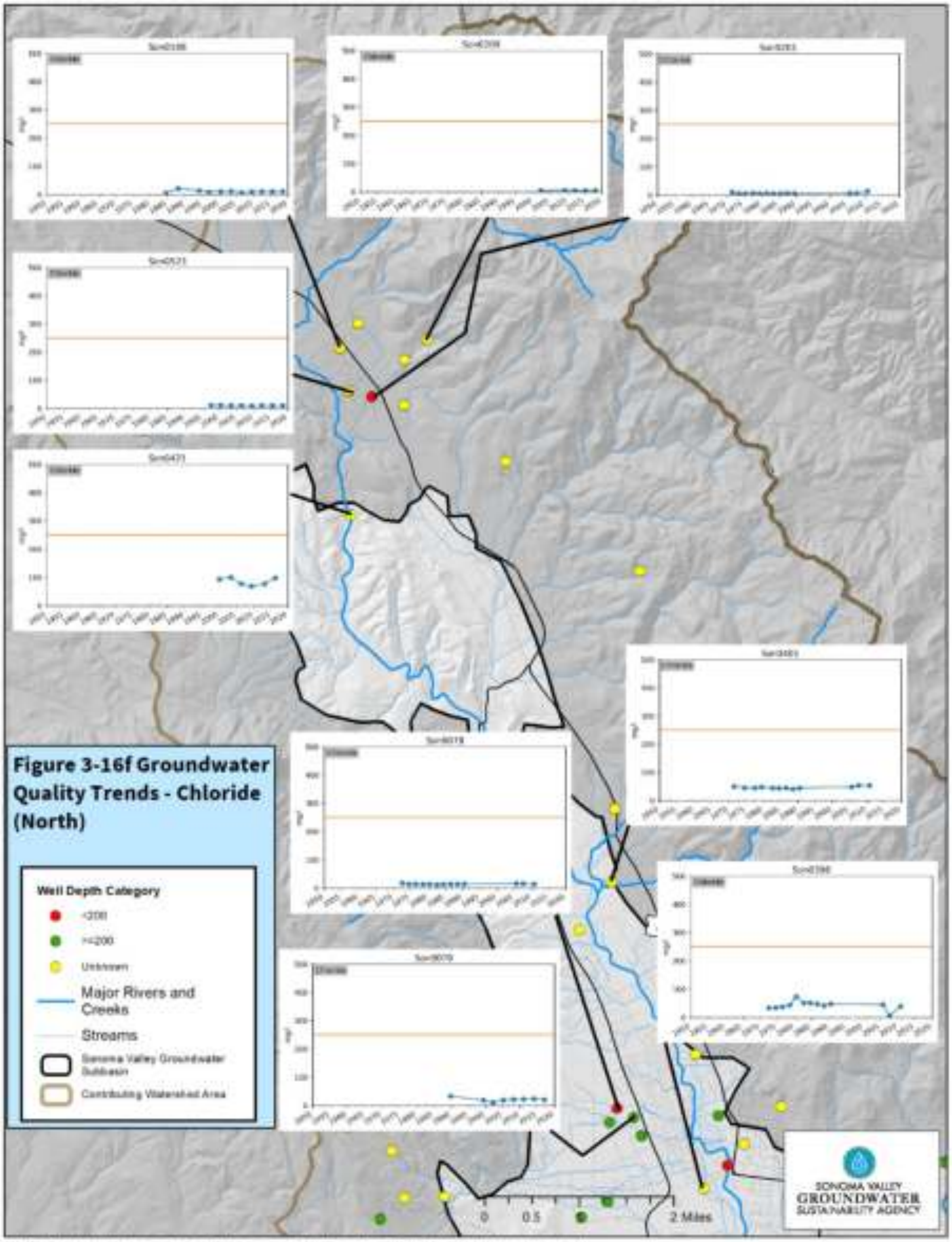

Figure 3-16f. Groundwater Quality Trends – Chloride (North)

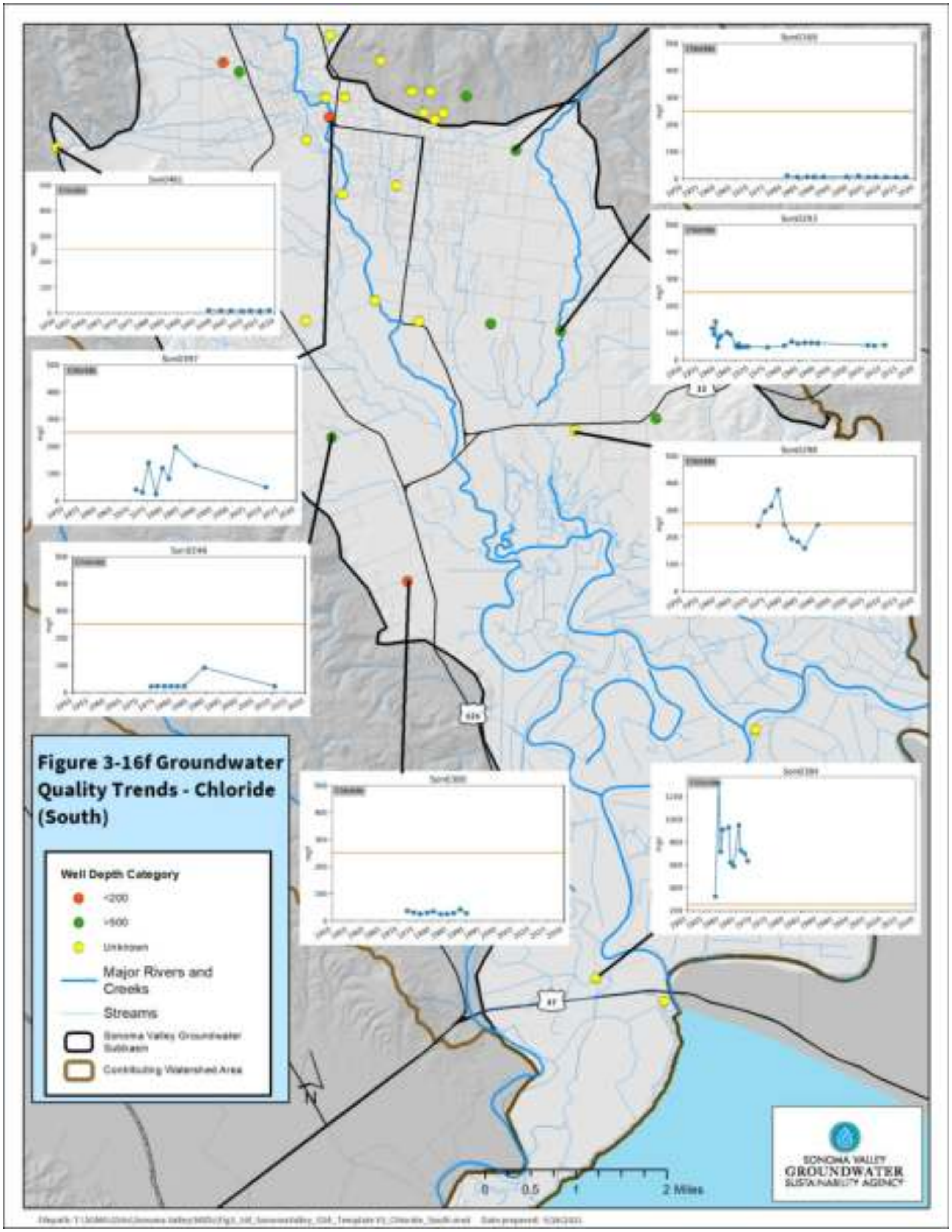

Figure 3-16f. Groundwater Quality Trends – Chloride (South)

Total Dissolved Solids

TDS refers to the amount of minerals, salts, metals, cations, and anions dissolved in water. Pure water will have a very low TDS, such as snow melt water and distilled water, and sea water, brackish water, older connate water, and mineralized thermal waters will exhibit high TDS concentrations. TDS has an EPA secondary MCL of 500 mg/L.

TDS concentrations can also be approximated by measuring the specific conductance (SC) of water, which is the measurement of the ability of the water to conduct electricity, in microSiemens per centimeter (µs/cm) and is dependent upon the amount of dissolved solids in the water. The relationship between TDS in mg/L usually ranges from approximately 0.5 to 1.0 times the SC, dependent upon nature of the dissolved solids and the temperature. In Sonoma Valley, because SC data are more readily available, previous studies have developed a relationship between SC and TDS using wells which contain measurements for both constituents, where the TDS value is equated to 0.63 times the SC value (Farrar et al. 2006; RMC and Todd Engineers 2014). For this GSP, the measured and converted TDS values are primarily used for displaying and describing water-quality conditions related to dissolved solids.

Water-sample analyses for TDS (and SC as a surrogate for TDS) were available from 139 wells within the Subbasin and contributing watershed between 2010 and 2019 (18 within the shallow aquifer system and 121 within the deep aquifer system). The occurrence and distribution of TDS in groundwater is displayed on **Figures 3-16g** and **3-16h** for the shallow- and deep aquifer systems, respectively. Groundwater samples from 3 of the 17 shallow aquifer system wells and groundwater samples from 19 of the 121 deep aquifer system wells exceeded the secondary MCL for TDS.

For the shallow aquifer system wells, the highest concentrations of TDS (greater than 1,000 mg/L) are from shallow wells completed within Quaternary Bay Muds in the tidal marshlands near San Pablo Bay, which is consistent with the brackish water present within the tidal marshlands. The only other sample within the shallow aquifer system which exceeds 500 mg/L for TDS occurs just south of Highway 121 in the vicinity of Hyde/Burndale roads. The distribution of TDS within the shallow aquifer system is not well constrained due to the relatively sparse amount of available data.

For the deep aquifer system, the highest concentrations of TDS (greater than 1,000 mg/L) occur outside of the Subbasin within the contributing watershed areas northeast of Glen Ellen and near Sears Point in the farthest southwestern portions of the watershed. Given that these wells are located within upland areas of the watershed within the Sonoma Volcanics and near fault zones, the elevated TDS in these wells is likely attributed to highly mineralized thermal groundwater sources or highly mineralized old groundwater upwelling along faults or fractures. The most widespread area of elevated TDS within the deep aquifer system occurs within the southeastern portions of the Subbasin from wells in the Carneros area and east of (or in the vicinity of) the Eastside Fault consistent with the occurrence of elevated chloride in groundwater.

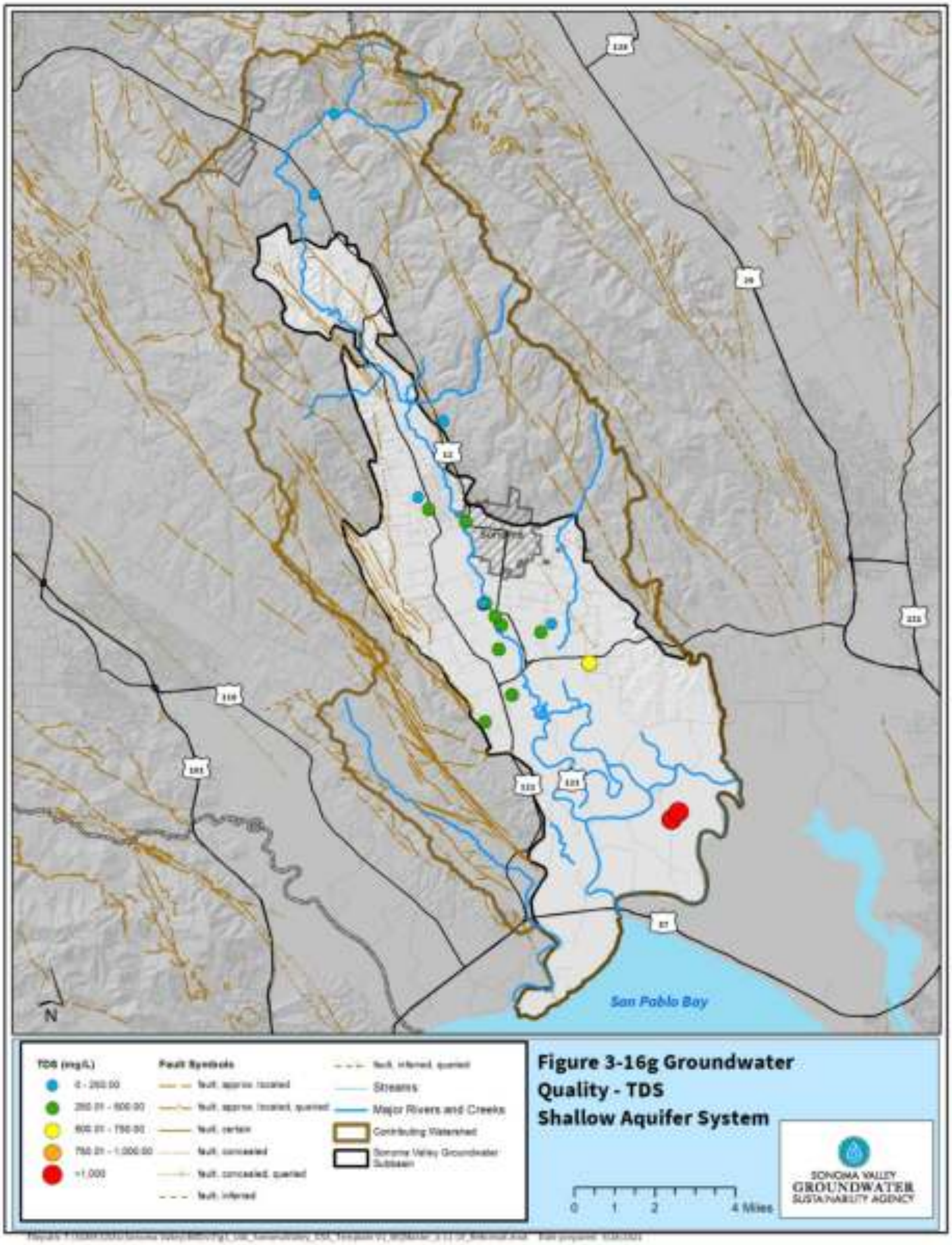

Figure 3-16g. Groundwater Quality - Total Dissolved Solids - Shallow Aquifer System

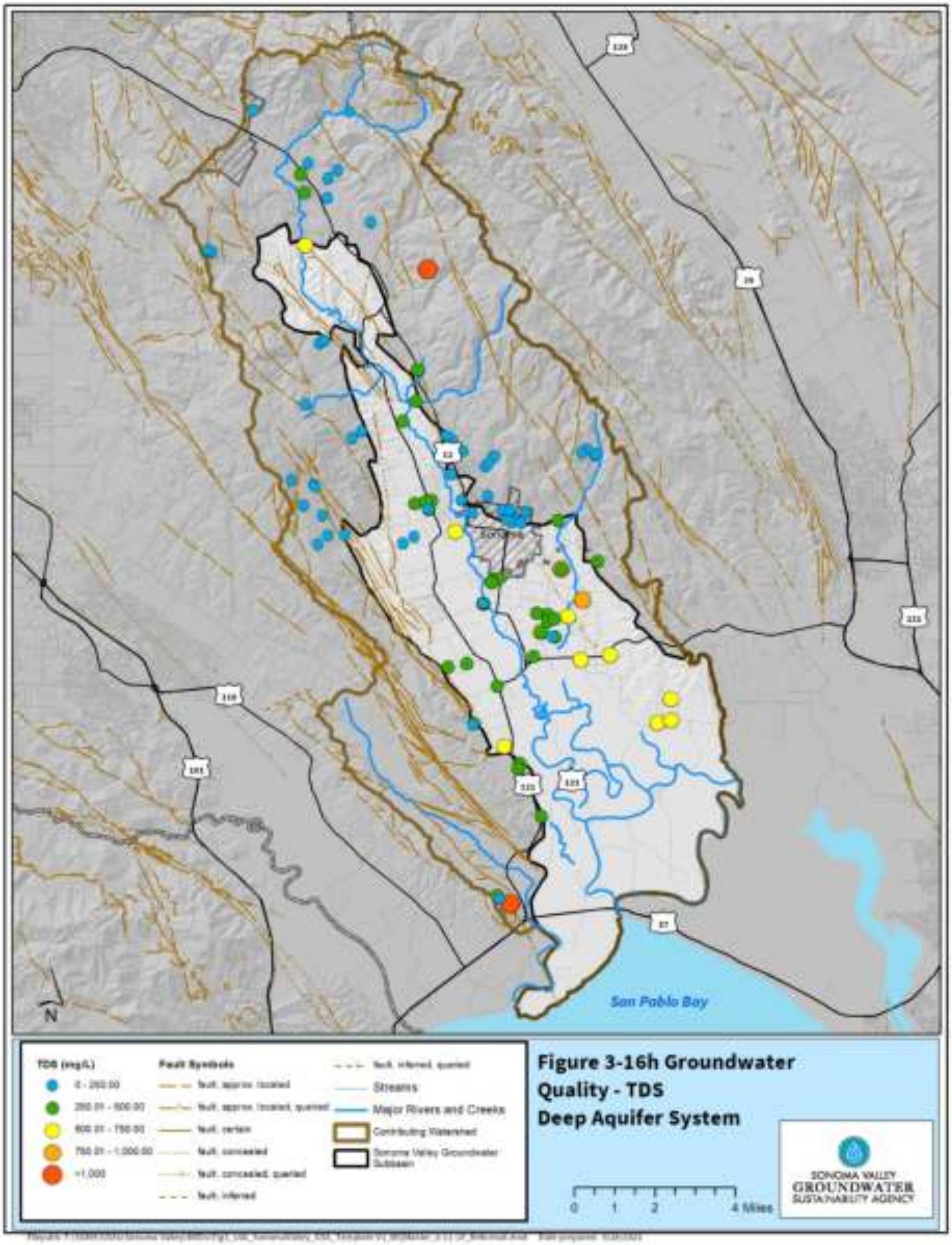

Figure 3-16h. Groundwater Quality - Total Dissolved Solids - Deep Aquifer System

In these areas, concentrations of TDS ranging between 750 and 1,000 mg/L occur east of the Eastside Fault in the vicinity of Arroyo Seco with somewhat lower concentrations (500 to 750 mg/L) occurring in the Carneros area and west of the Eastside Fault. These wells are either wholly or primarily completed within the Huichica Formation and the elevated TDS in these wells are likely associated with deep connate waters associated with ancient seawater entrapped during deposition of the Tertiary Era Huichica Formation, which is consistent with the findings from the age-dating, isotopic and trace-element data described above.

Figure 3-16i displays time-concentration plots of TDS (and SC as a surrogate for TDS) for wells with a sufficient amount of available historical data. As indicated on the time-concentration plots, the majority of wells exhibit relatively stable concentrations of TDS over time. It is important to note that many of the time-concentration plots do not include very complete records over time (sampling for several of the wells which were sampled in the 1950s through 1970s were discontinued and many of the wells with more complete recent data do not have data extending back over time). Additionally, spatial data gaps occur in both the shallow and deep aquifer system.

3.2.6.3 Anthropogenic Constituents of Interest

Nitrate

Nitrate is a widespread contaminant that is attributable to natural and anthropogenic sources. Natural sources include igneous rocks, the atmosphere, and decomposition of organic material. Anthropogenic sources include agricultural activities, septic systems, confined animal facilities, landscape fertilization and wastewater treatment facility discharges. Elevated levels of nitrate in drinking water are considered to be especially unhealthy for infants and pregnant women (SWRCB 2012) and the EPA MCL for nitrate (N) is 10 mg/L.

Water-sample analyses for nitrate were available from 133 wells within the Subbasin and contributing watershed between 2010 and 2019. The occurrence and distribution of nitrate in groundwater is displayed on **Figure 3-16j**. Concentrations of nitrate in excess of 10 mg/L occur sporadically in limited areas of the Subbasin, with the majority of these occurring within the shallow aquifer system. The majority of wells (approximately 88 percent) sampled for nitrate within the watershed exhibit very low (<2 mg/L) to non-detectable concentrations of nitrate.

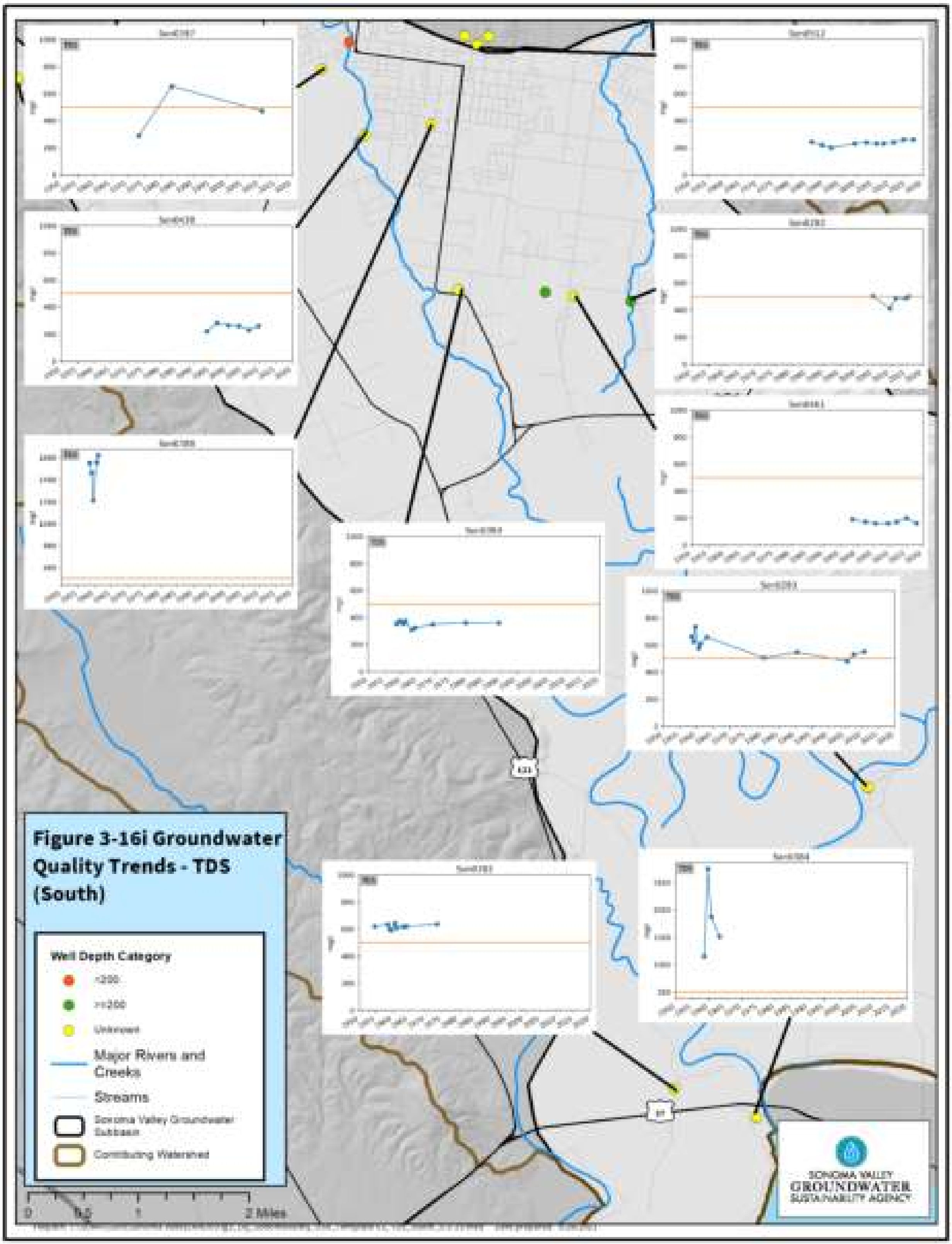

Figure 3-16i, Map 1. Groundwater Quality Trends - Total Dissolved Solids (South)

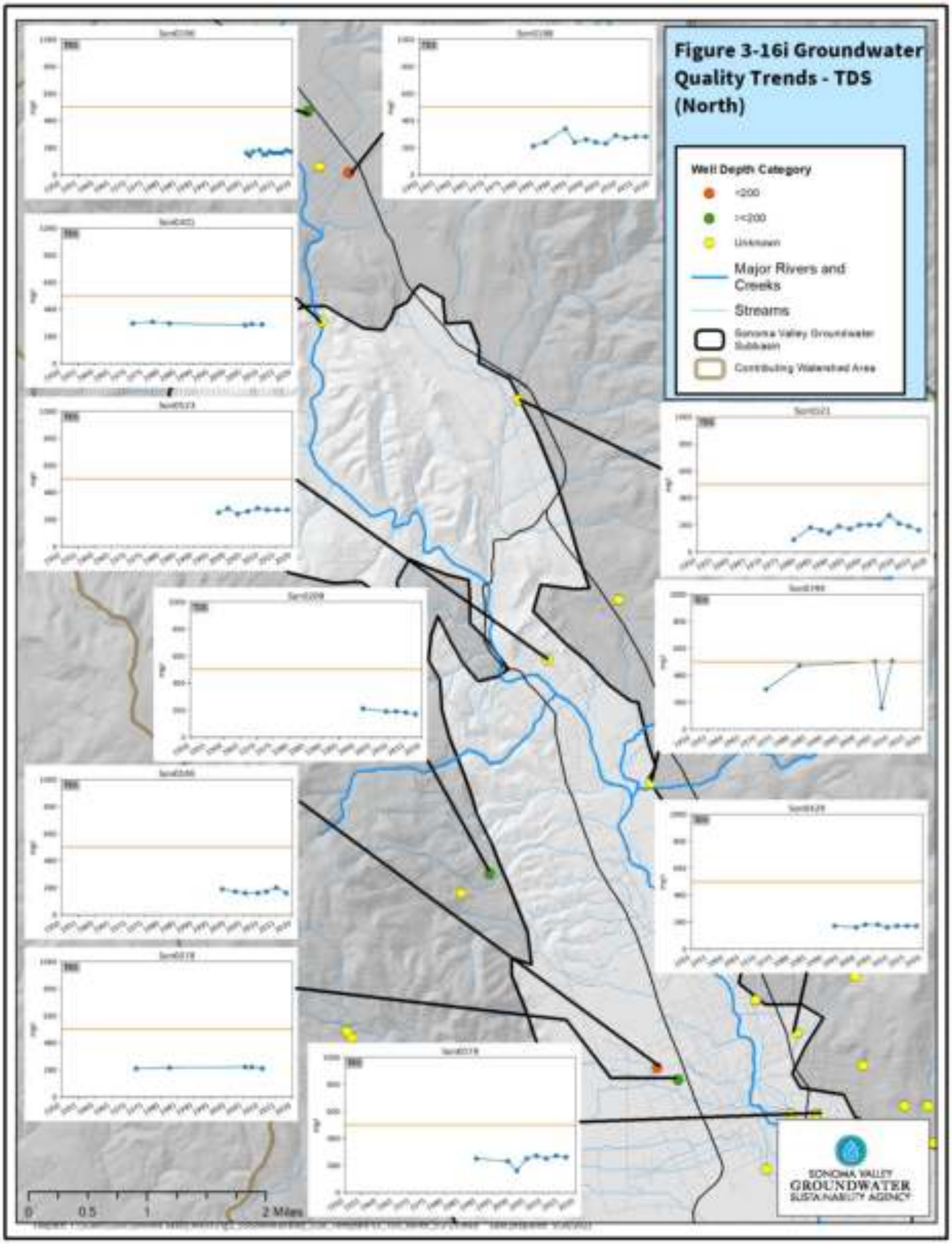

Figure 3-16i, Map 2. Groundwater Quality Trends - Total Dissolved Solids (North)

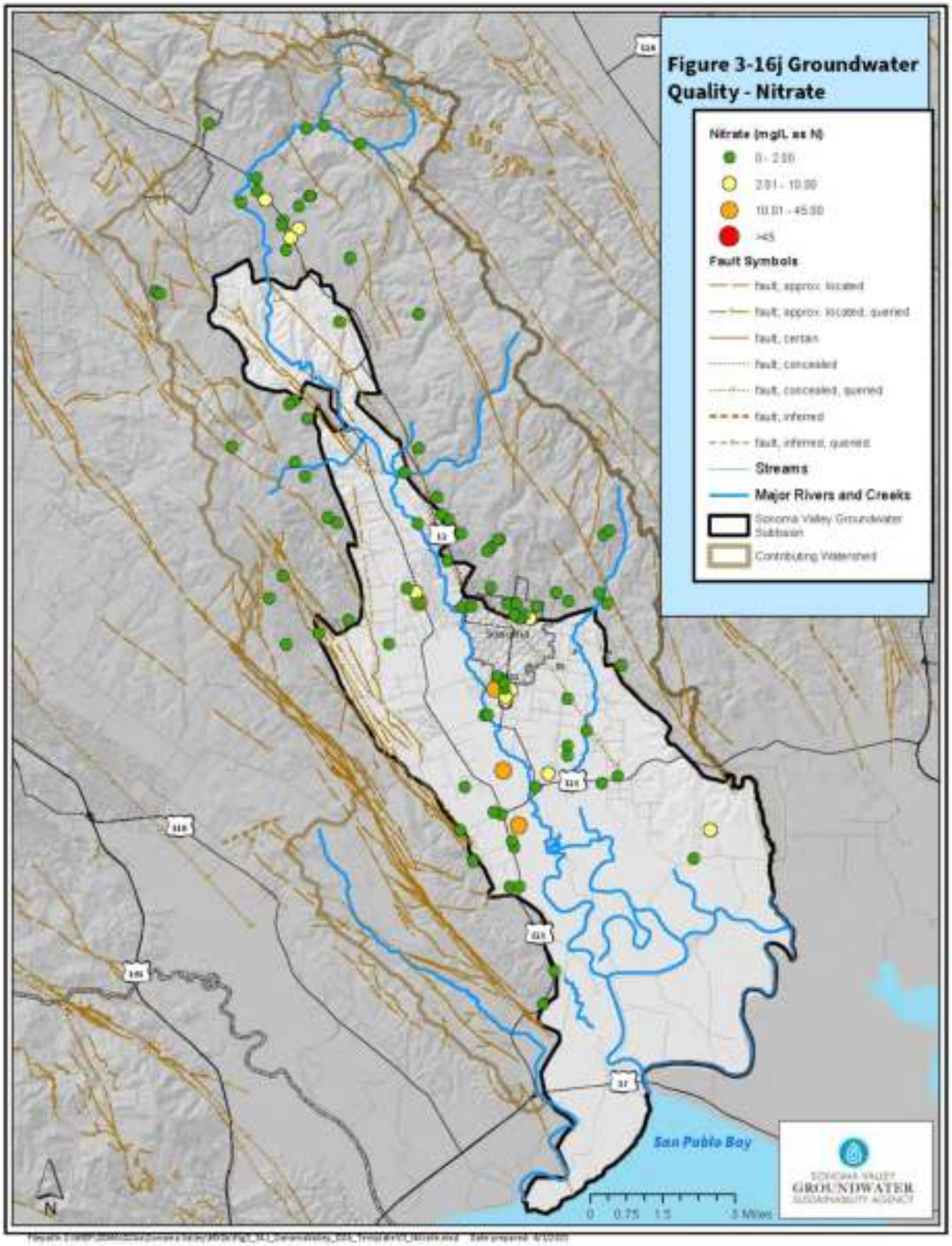

Figure 3-16j. Groundwater Quality - Nitrate

Regulated Contaminant Release Sites

There are numerous currently regulated contaminant release sites located in the Subbasin. Many of the sites are under active cleanup order by the Regional Water Quality Control Boards or County of Sonoma Department of Health Services, Environmental Health and Safety. These sites include leaking underground tanks from gasoline and solvent storage. The SWRCB's GeoTracker website identifies eight open site cases within the watershed (SWRCB 2021)**.** These releases, which include petroleum and chlorinated solvent contaminants and metals, are generally of limited areal extent, although impacts on private water-supply wells have occurred. No known impacts on public water-supply wells have occurred related to these release sites.

The SWRCB GAMA Priority Basin Project study of the North San Francisco Bay Groundwater Basins has included two studies by the USGS, which evaluated inorganic and organic constituents in groundwater, including constituents associated with regulated contaminant release sites (Kulongoski et al. 2010; Bennett and Fram 2014). The first study conducted in 2004 included samples from 18 public water-supply wells in the watershed (Kulongoski et al. 2010). The second study conducted in 2012 included samples from seven private domestic wells in the watershed (Bennett and Fram 2014). These samples were analyzed for up to 270 constituents and water-quality indicators, including volatile organic compounds, pesticides, nutrients, major and minor ions, trace elements, radioactivity, microbial indicators, dissolved noble gases, and naturally occurring isotopes (Kulongoski et al. 2010; Bennett and Fram 2014). Three of the 25 public and private wells sampled as part of the SWRCB GAMA program had very low-level detections of volatile organic compounds and/or pesticides, but all detections were significantly below the contaminant's respective MCLs (Kulongoski et al. 2010; Bennett and Fram 2014).

3.2.6.4 Hydrothermal System

In Sonoma Valley, hydrothermal fluids with temperatures greater than 20 degrees Celsius (°C; 68 degrees Fahrenheit [°F]), have been identified in wells and thermal springs across an area that extends north from the City of Sonoma to the Sonoma Developmental Center, and includes Fetter's Hot Springs, Boyes Hot Springs, and Agua Caliente (Waring 1915; Campion et al. 1984). The hydrothermal system in the northern portion of Sonoma Valley was identified in some wells as shallow as 50 feet bls based on temperature gradient data from wells ranging in depths up to 650 feet (Farrar et al. 2006). Hydrothermal fluids in the southern part of Sonoma Valley may be separate from the northern Sonoma hydrothermal system, and could be related to upflow along fractures in the Rodgers Creek Fault Zone (Farrar et al. 2006). The Eastside Fault is thought to form the western boundary for the main hydrothermal system (Campion et al. 1984).

Hydrothermal fluids in the Sonoma area generally are sodium-chloride type waters and often contain arsenic, boron, fluoride, and lithium in concentrations that exceed drinking-water standards (Campion et al. 1984; Farrar et al. 2006; Kulongoski et al. 2010). Hydrothermal fluids may be significant components in some wells in the Sonoma Valley, particularly in the area between Fetters Hot Springs and the City of Sonoma (Farrar et al. 2006).

Forrest et al. (2013) developed a mixing model based on multivariate statistical analysis using trace elements to broadly classify fresh groundwater, saline-impacted groundwater, hydrothermal fluids, and mixed hydrothermal/meteoric waters. This study found that helium isotopes and measured temperature, along with the elements lithium, chloride, and boron are most useful in evaluating the contribution of the hydrothermal system to the wells.

3.2.6.5 Seawater/Freshwater Interface

The seawater/freshwater interface likely occurs beneath the tidal marshlands near the boundary with San Pablo Bay. While the specific location of the interface has not been determined, historical sampling of water wells south of Highway 37 showed high concentrations of TDS potentially indicative of seawater intrusion (for example, chloride levels approaching or exceeding 1,000 mg/L and TDS levels exceeding 1,500 mg/L) (RMC and Todd Engineers 2014). The majority of groundwater beneath the tidal marshlands located south and east of Highway 121 is impacted with brackish groundwater and has an average TDS concentration of 1,220 mg/L (RMC and Todd Engineers 2014). The poor water quality in these areas is reflected in the well density map (**Figure 2-6**), which shows that very few water wells have historically been completed in these areas.

Groundwater-level declines along the northern margins of the tidal marshlands and the tidal reaches of Sonoma Creek could trigger the inducement of brackish water into fresher groundwater aquifers and represent potential pathways for brackish water in these areas to impact water quality in the Subbasin. Limited historical monitoring of groundwater quality in these areas has revealed seasonal fluctuations, and some possible inland movement of brackish water (Kunkel and Upson 1960; Farrar et al. 2006; RMC and Todd Engineers 2014). These historical observations are based on water-quality analyses from different monitoring networks and are primarily limited to TDS or SC, making it difficult to discern whether the potential water-quality changes are due to either: (1) the differing distribution of sampled wells for the different timeframes and/or (2) the presence of older connate or thermal water sources rather than recent brackish water. Additional data collection and monitoring in these areas will better inform the current conditions and provide future monitoring of this potential risk.

3.2.7 Surface Water and Groundwater Connectivity

As described in **Section 2.4** and shown on **Figure 2-7c**, continuous streamflow monitoring currently occurs at 12 gages in the watershed; however, the period of record for all but two of the gages is less than 2 years. The two gages with the longest periods of record are the Agua Caliente gage (USGS Station Number 11458500) and the Kenwood gage (USGS Station Number 11458433), both located on Sonoma Creek. The Agua Caliente gage operated from 1955 through 1981 and was then discontinued until 2001 when it was restarted. The Kenwood stream gage was installed in the fall of 2008.

Discharge measured at the Agua Caliente gage has varied considerably since WY 2003 (**Figure 3-17a).** The mean annual discharge of Sonoma Creek at the Agua Caliente gage is 50,241 acre-feet, on the basis of records for WY 1956–WY 1981 and WY 2002–WY 2020. The maximum discharge of 129,117 AFY was measured in 2017. While not shown on **Figure 3-17a**, the minimum discharge of 1,002 AFY was measured in 1977.

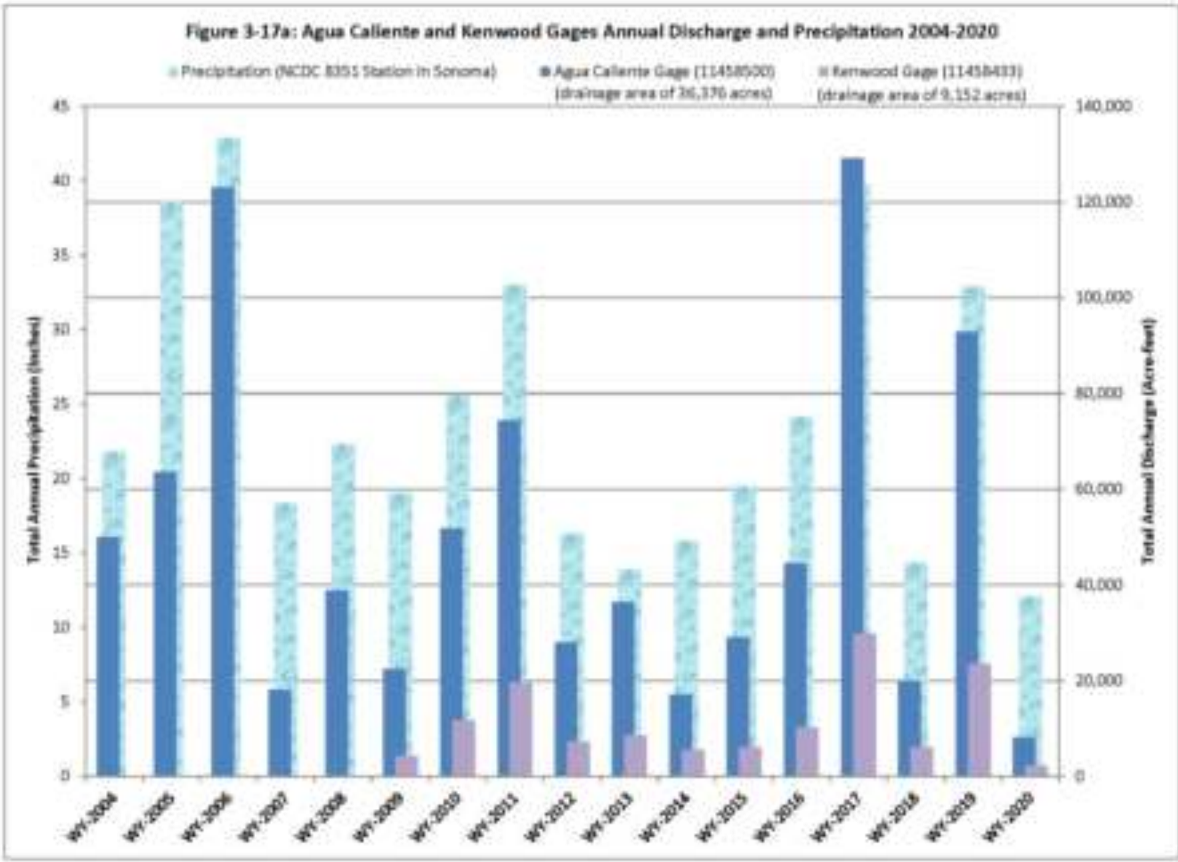

Figure 3-17a. Agua Caliente and Kenwood Gages Annual Discharge and Precipitation 2004–2020

The mean discharge of Sonoma Creek at the Kenwood gage (**Figure 3-17a**) for the 12 years it has been operating is approximately 11,200 AFY, ranging from approximately 2,149 AFY in WY 2020 to approximately 29,744 AFY in WY 2017. Between the two gages, Sonoma Creek gains an average of approximately 35,000 AFY, likely from a combination of tributary inflows and groundwater seepage between the two gages.

In most water years, daily discharge does not increase significantly until November or December, after which it begins to rapidly decrease in April or May in response to the normal annual cycle of precipitation (**Figure 3-17b**). The discharge measured in Sonoma Creek contains two primary components, baseflow and runoff. The baseflow component is primarily derived from groundwater, which seeps into the stream's bed and banks through adjacent shallow aquifers. To assess the amount of baseflow entering Sonoma Creek above the Agua Caliente gage, hydrograph separation techniques were used to estimate the ratio of baseflow (groundwater discharge) to total streamflow, termed the baseflow index (BFI). The BFI may be thought of as a measure of the proportion of the stream runoff that comes from groundwater discharge into streams. Streams which exhibit a higher BFI generally indicate that shallow aquifers are relatively permeable and contain shallow groundwater levels that can sustain streamflow during periods of dry weather.

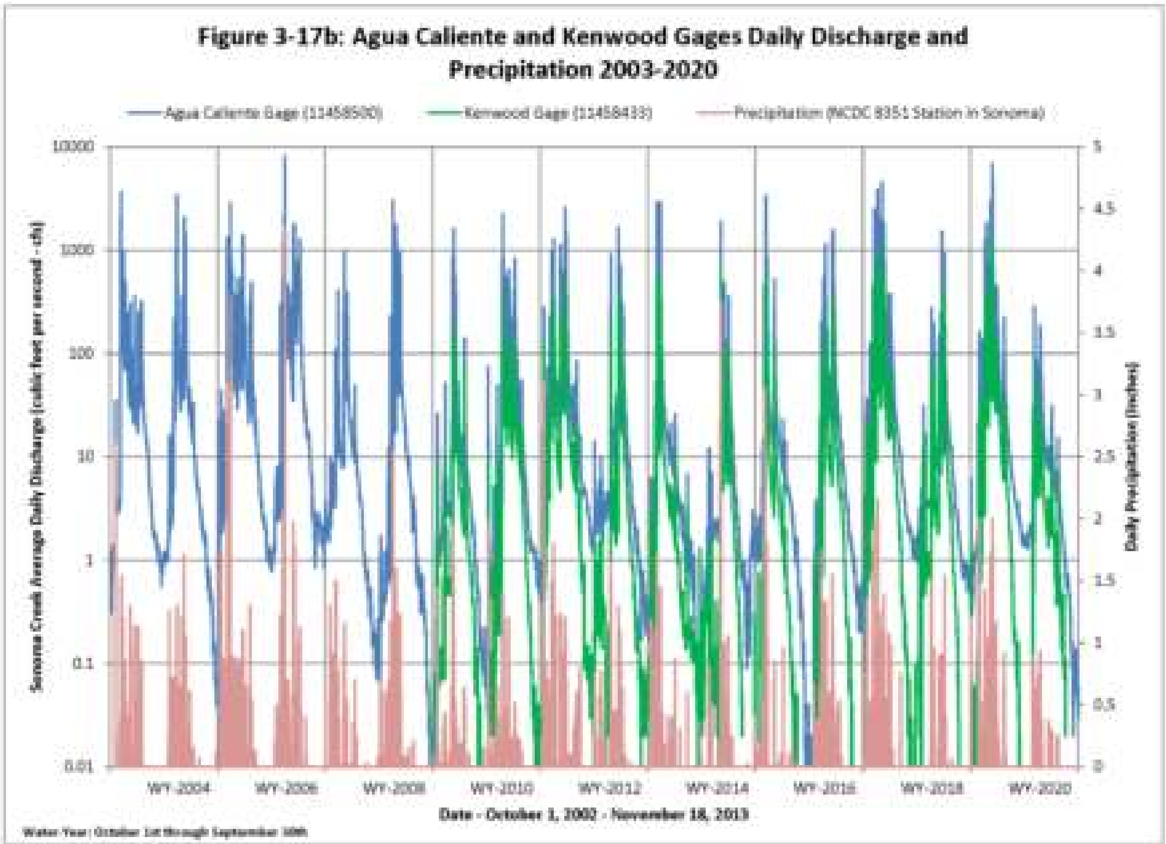

Figure 3-17b. Agua Caliente and Kenwood Gages Daily Discharge and Precipitation 2003–2020

Previous estimates for BFI were derived for Sonoma Creek at the Agua Caliente gage for WY 1970 to WY 2006 and indicated that baseflow was approximately 50 percent of the total streamflow (Bauer 2008). The BFI was extended to the total period of record for the Agua Caliente Bridge (WY 1956 to WY 2020; **Figure 3-18**). For the data gap from WY 1981 to WY 2001, the BFI was estimated using linear regression (Bauer 2008). The BFI for WY 1956 through WY 2013 was estimated to range from approximately 0.45 to 0.66, with an average of approximately 0.49. This indicates that in an average year approximately 50 percent of the flow of Sonoma Creek at Agua Caliente Bridge (approximately 25,000 AFY) is derived from groundwater discharging from shallow aquifers upstream of the Agua Caliente gage (Bauer 2008; SVGMP 2014). Annual precipitation is also plotted on **Figure 3-18** and shows that historically the BFI was generally highest (greater than 0.55) during the drier years (for example, 1957, 1972, 1976, 1977, and 2020), which indicates that in years when precipitation and total flow are low, the baseflow component of streamflow is proportionally higher. The overall long-term trend of baseflow over time upstream of the Agua Caliente gage appears relatively stable, which is consistent with the relatively stable groundwater levels observed in wells completed within the shallow aquifers in northern portions of the Subbasin.

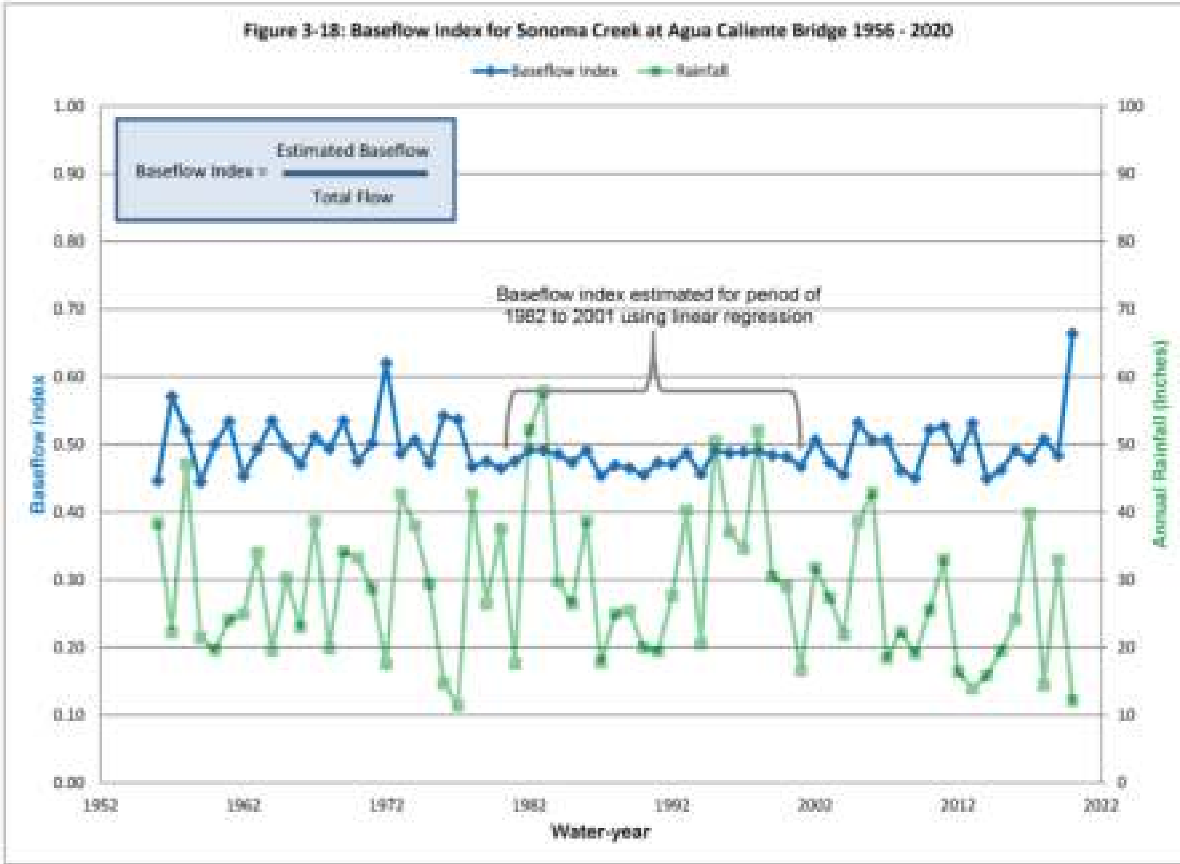

Figure 3-18. Baseflow Index for Sonoma Creek at Agua Caliente Bridge 1956–2020

3.2.7.1 Interconnected Surface Water

Interconnected surface water is defined in the GSP Regulations as “surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted” (CCR 350 et seq.). Reaches of interconnected surface water in the watershed are identified through several different lines of evidence, including (1) results of seepage-run monitoring, (2) frequency of observed or measured streamflow, (3) comparison of interpolated groundwater levels within the shallow aquifer system and streambed elevations, and (4) high-frequency groundwater-level observations from shallow monitoring wells located near streams. The surface waters assessed using these datasets include Sonoma Creek and its primary tributaries within the watershed, which have been monitored through these data-collection efforts.

Synoptic streamflow measurements (seepage runs) have been conducted on Sonoma Creek and its tributaries in May 2003 and spring and fall of 2010 by the USGS and routinely since 2014 by the Sonoma Ecology Center, which measures discharge at more than 50 locations semiannually and around 20 locations on a monthly basis. These seepage runs consist of a series of streamflow measurements made at several sites over a short-time period (for example, single day to several days) along Sonoma Creek and its tributaries to quantify streamflow gains and losses for a specific time period. Specifically, the discharge is measured at an upstream and downstream location along a stream reach. A positive change in discharge in the downstream direction indicates gaining conditions whereas a negative change indicates losing conditions. Under gaining conditions, the source of additional streamflow is groundwater inflow. For groundwater inflow to occur, it is a reasonable assumption that groundwater levels adjacent to a stream are higher than the stream stage. Under losing conditions, the loss of streamflow is from water percolating through the streambed to the underlying aquifer. For water to leave the stream, groundwater levels must be lower than the stream stage. Under conditions where the groundwater level is below the stream stage, interconnected surface water conditions can still occur if groundwater levels are at or above the streambed.

Stream reaches experiencing gaining groundwater conditions provide some of the strongest indications of interconnected surface water and groundwater. Gaining stream reaches are identified through seepage runs whereby the discharge is measured at an upstream and downstream location along a stream reach. A positive change in discharge in the downstream direction is a gaining stream condition whereas a negative change indicates a losing stream condition. In gaining stream conditions, the stream is assumed to be hydraulically connected with the groundwater system. In losing conditions, streamflow is percolating through the streambed causing a decline in flow.

The bullets below provide a brief explanation to help understand the seepage measurements displayed on **Figures 3-19** through **3-23**, and the narrative text that follows the bullets provides interpretation of the seepage measurement datasets.

- Results from the stream seepage measurements collected in the spring and fall between 2016 and 2018 are presented on **Figures 3-19a** and **3-19b** for the mainstem of Sonoma Creek and its tributaries, respectively. The seepage measurements indicate where stream reaches are gaining flow from groundwater (blue bars indicate net increase in flow in cubic feet per second [cfs]) and losing flow to groundwater (red bars indicate net decrease in flow in cfs). From the seepage-run data, it is clear that surface water-groundwater interactions vary spatially, change within a given year from spring to fall, and respond to interannual variations in precipitation.

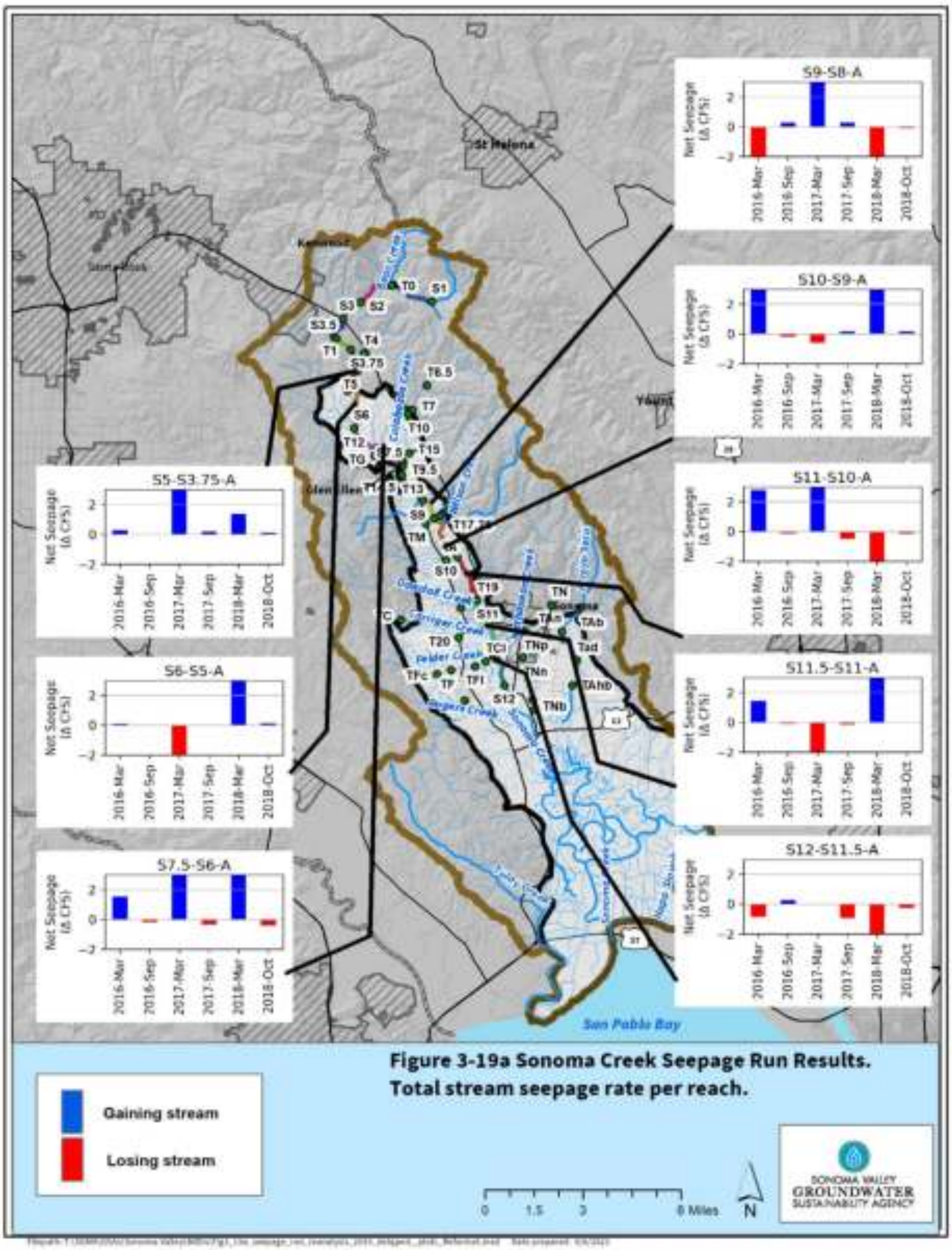

Figure 3-19a. Sonoma Creek Seepage-Run Results - Total Stream Seepage Rate Per Reach

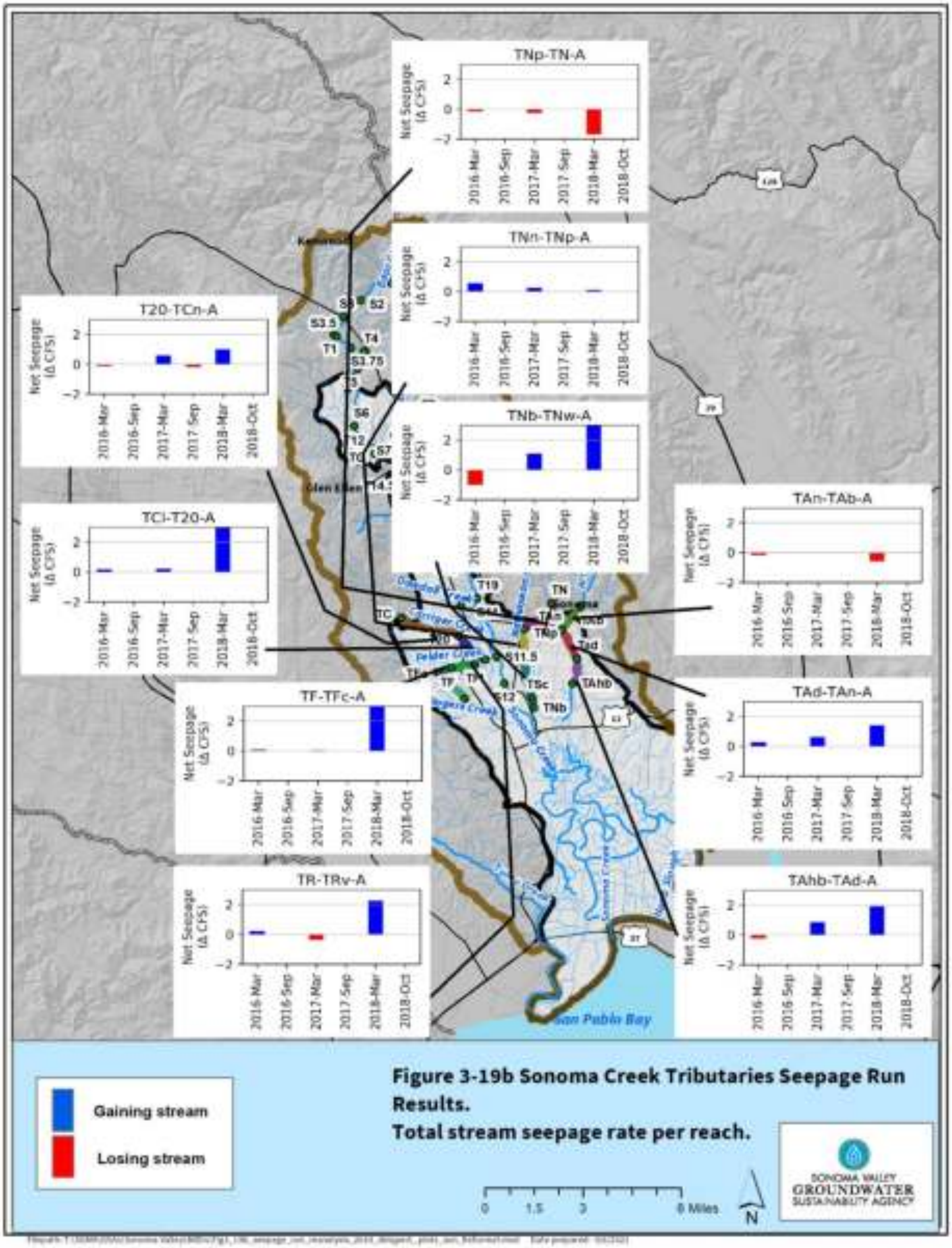

Figure 3-19b. Sonoma Creek Tributaries Seepage-Run Results - Total Stream Seepage Rate Per Reach

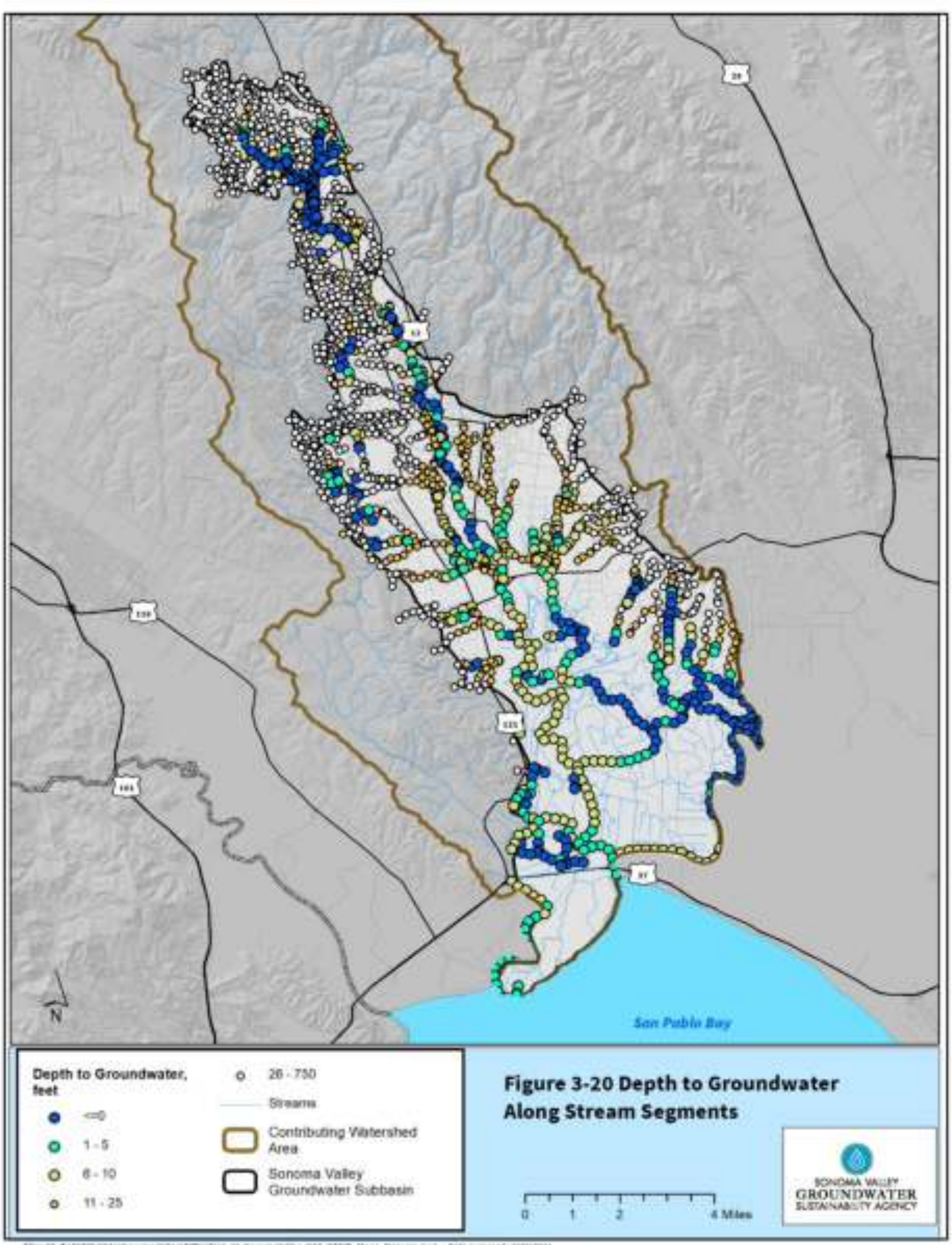

Figure 3-20. Depth to Groundwater Along Stream Reaches

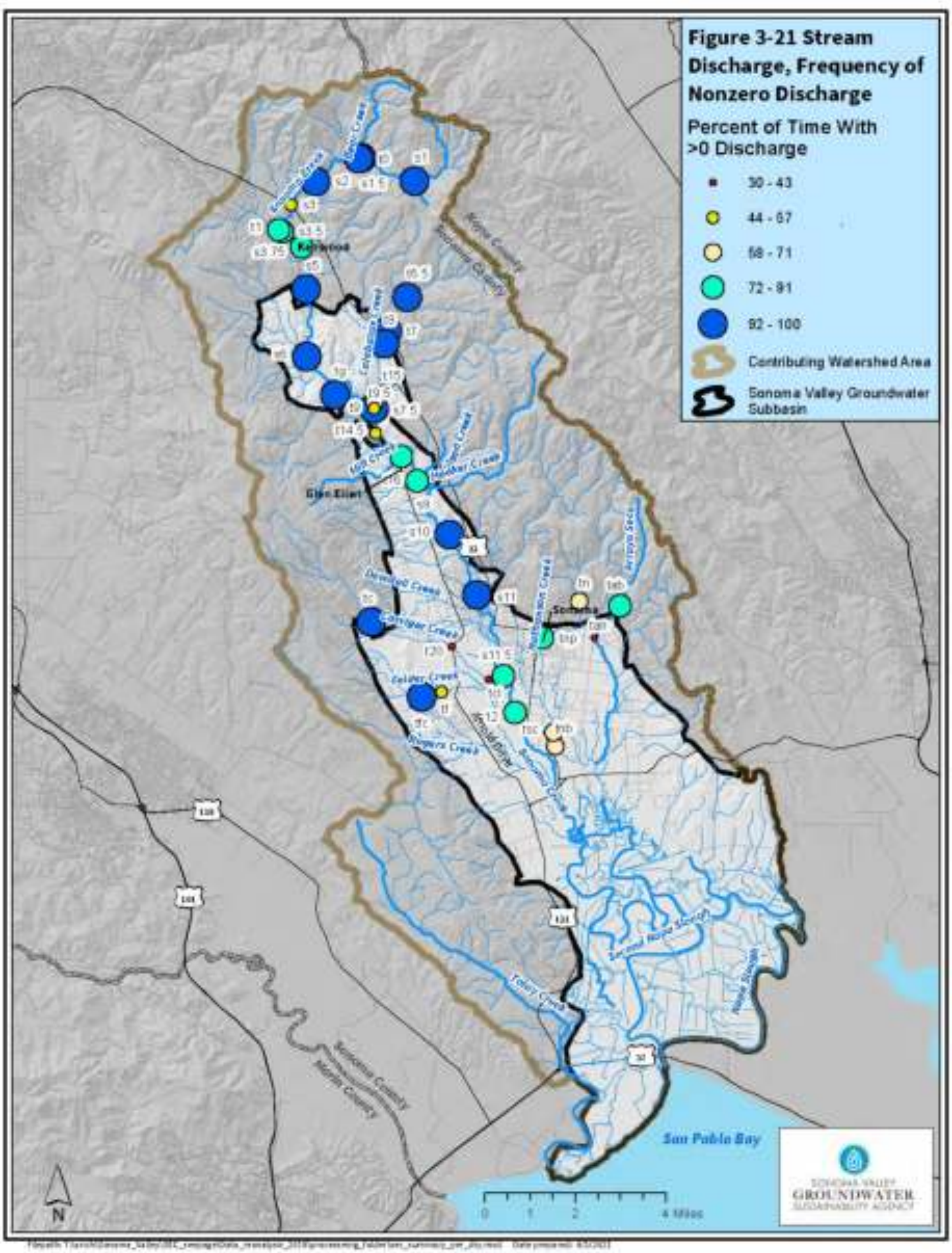

Figure 3-21. Stream Discharge and Frequency of Measurable Flow

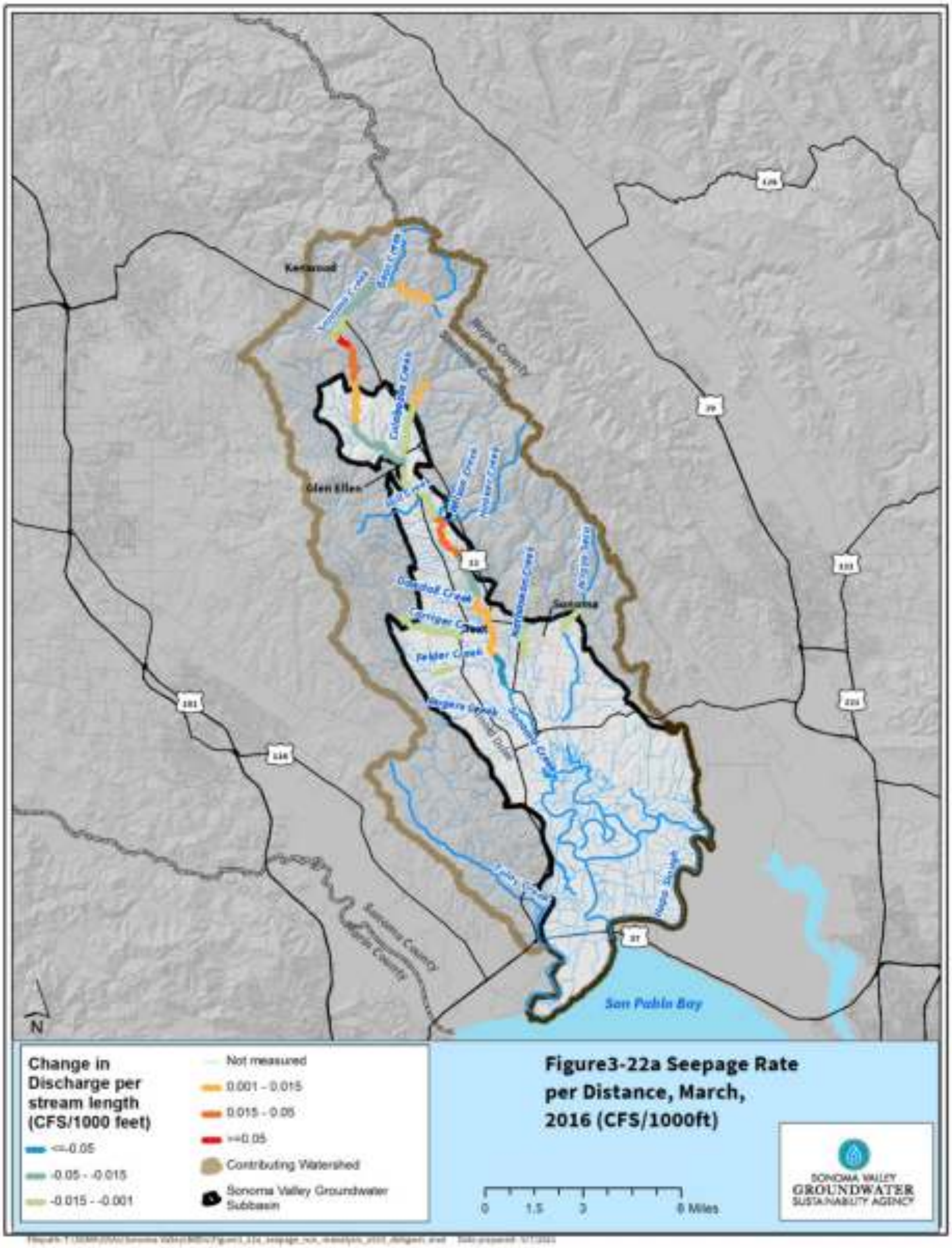

Figure 3-22a. Seepage Rate Per Distance - March 2016

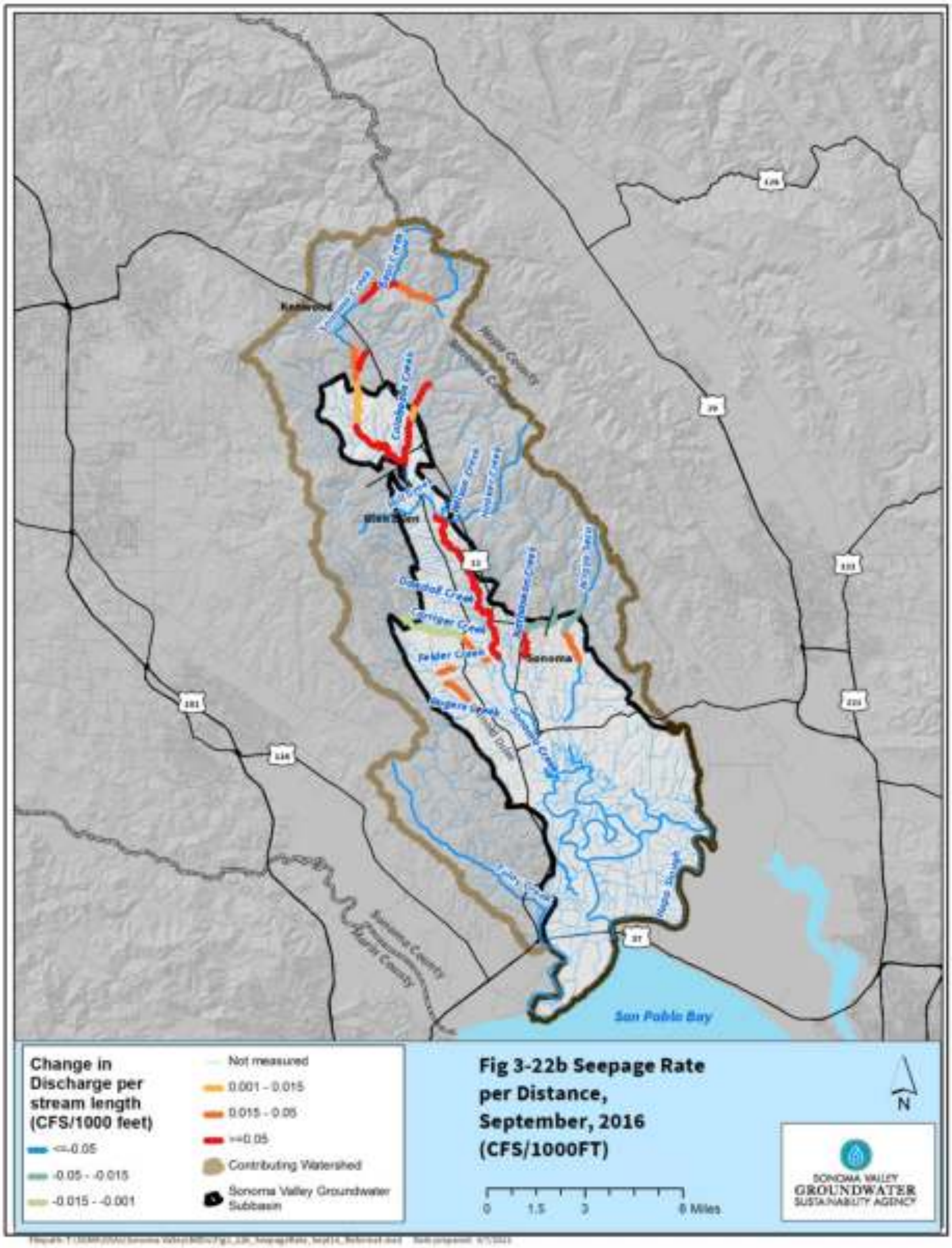

Figure 3-22b. Seepage Rate Per Distance - September 2016

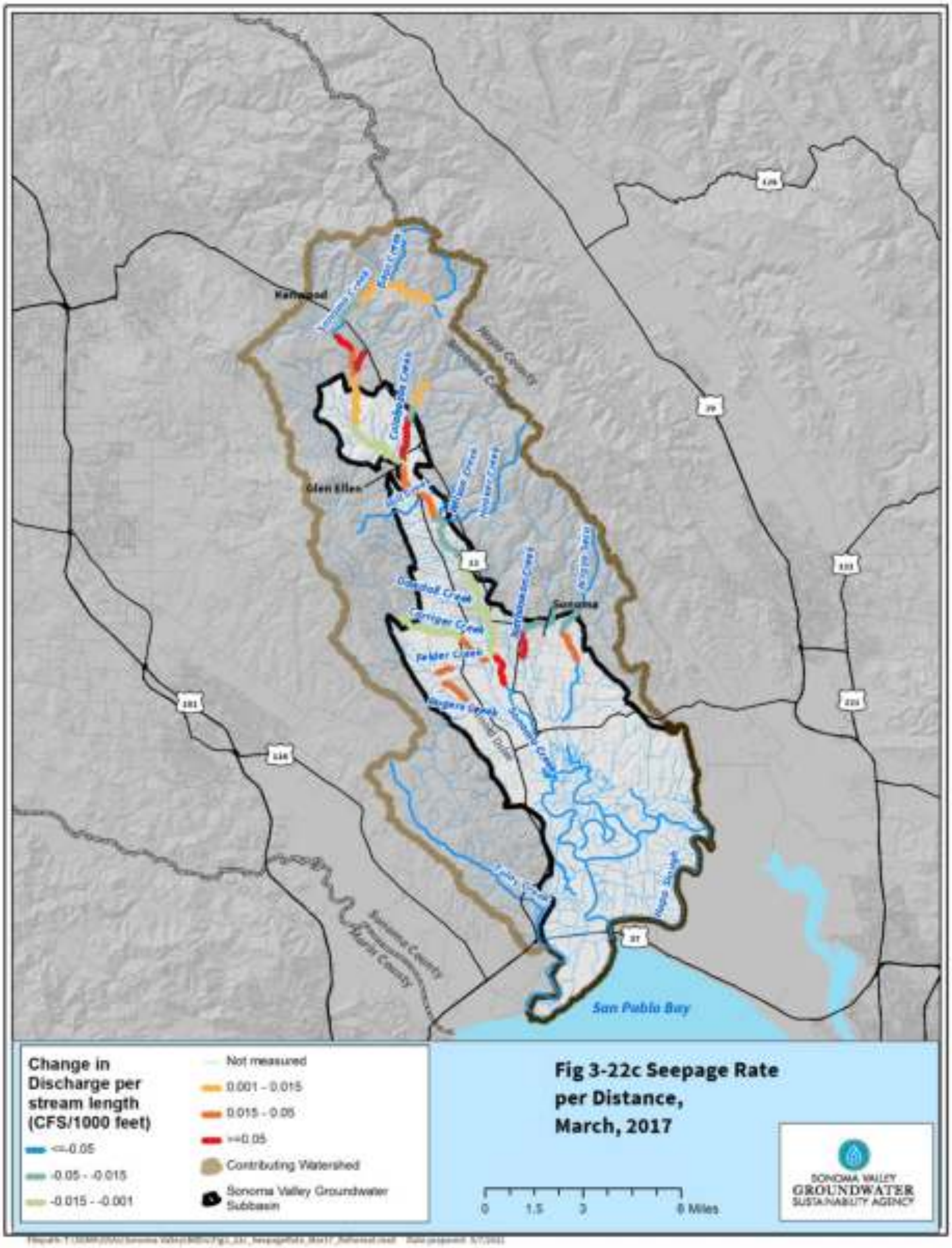

Figure 3-22c. Seepage Rate Per Distance - March 2017

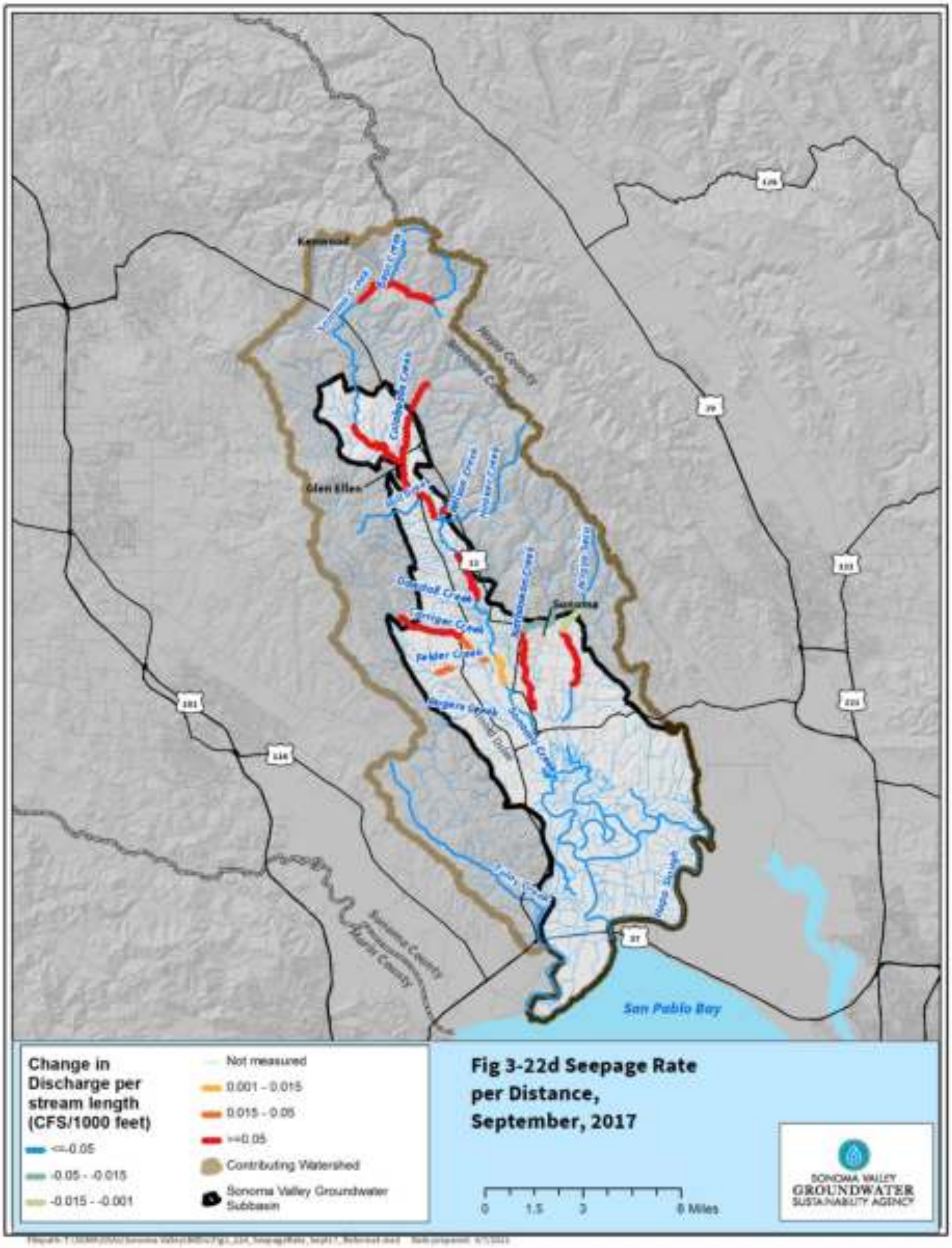

Figure 3-22d. Seepage Rate Per Distance - September 2017

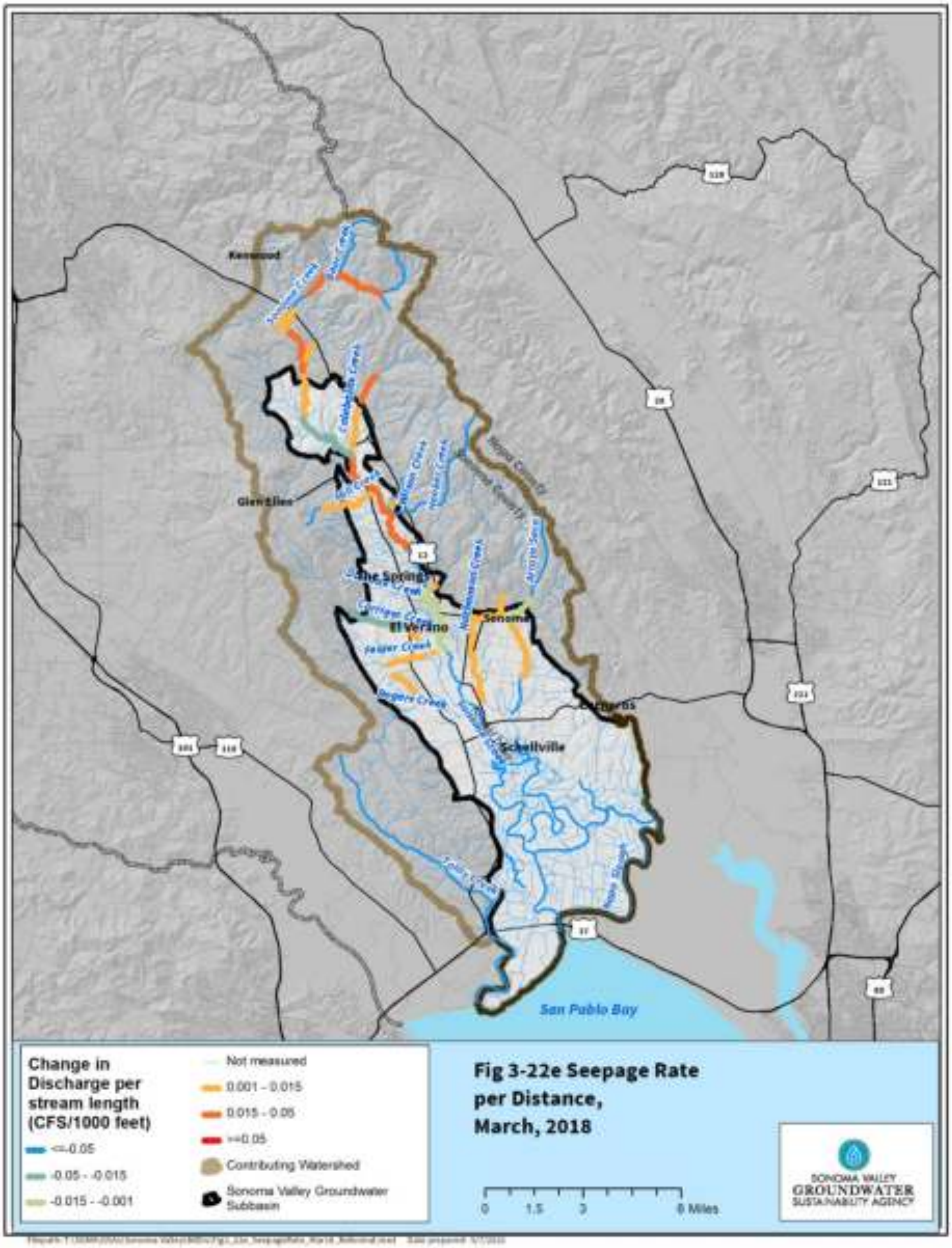

Figure 3-22e. Seepage Rate Per Distance - March 2018

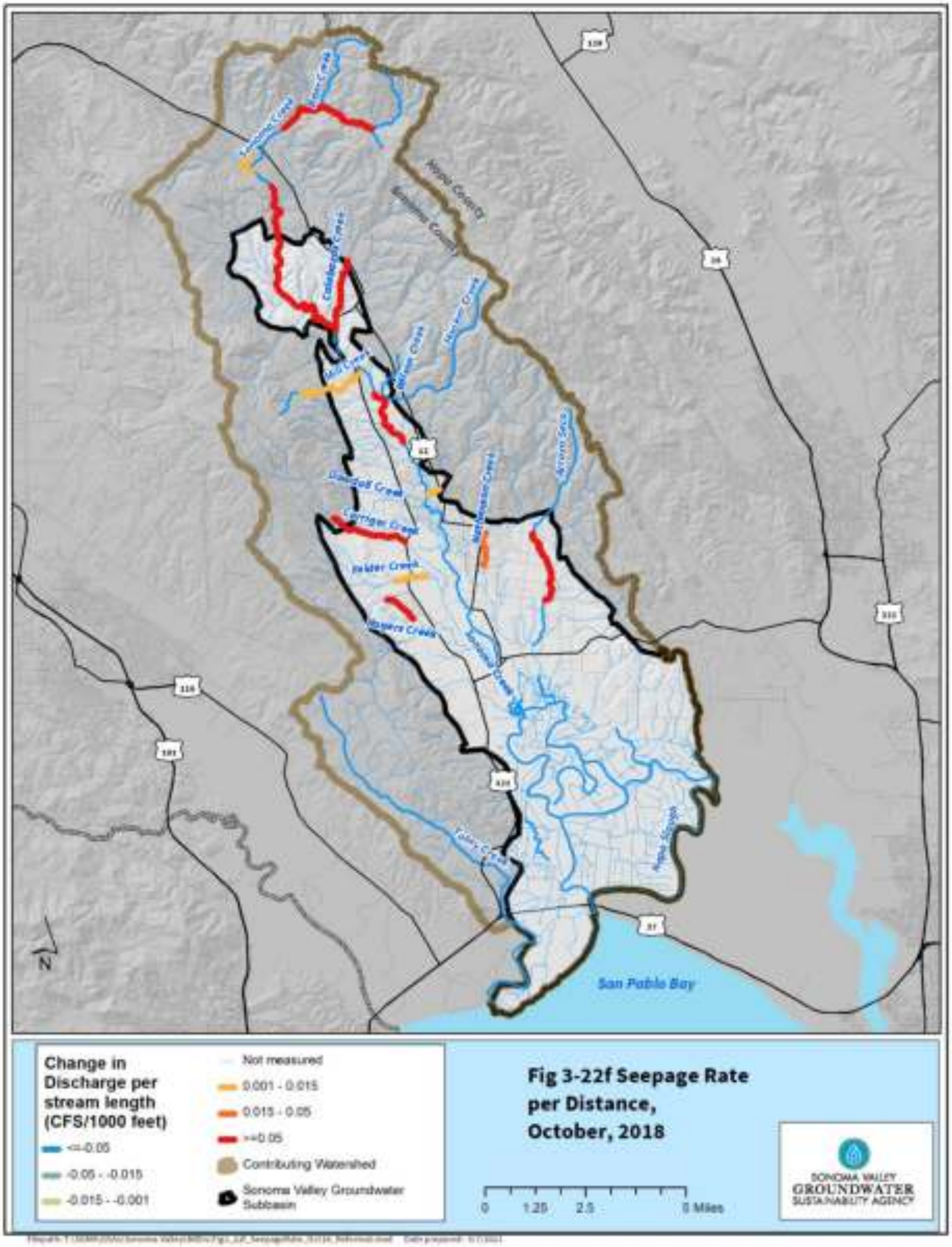

Figure 3-22f. Seepage Rate Per Distance - October 2018

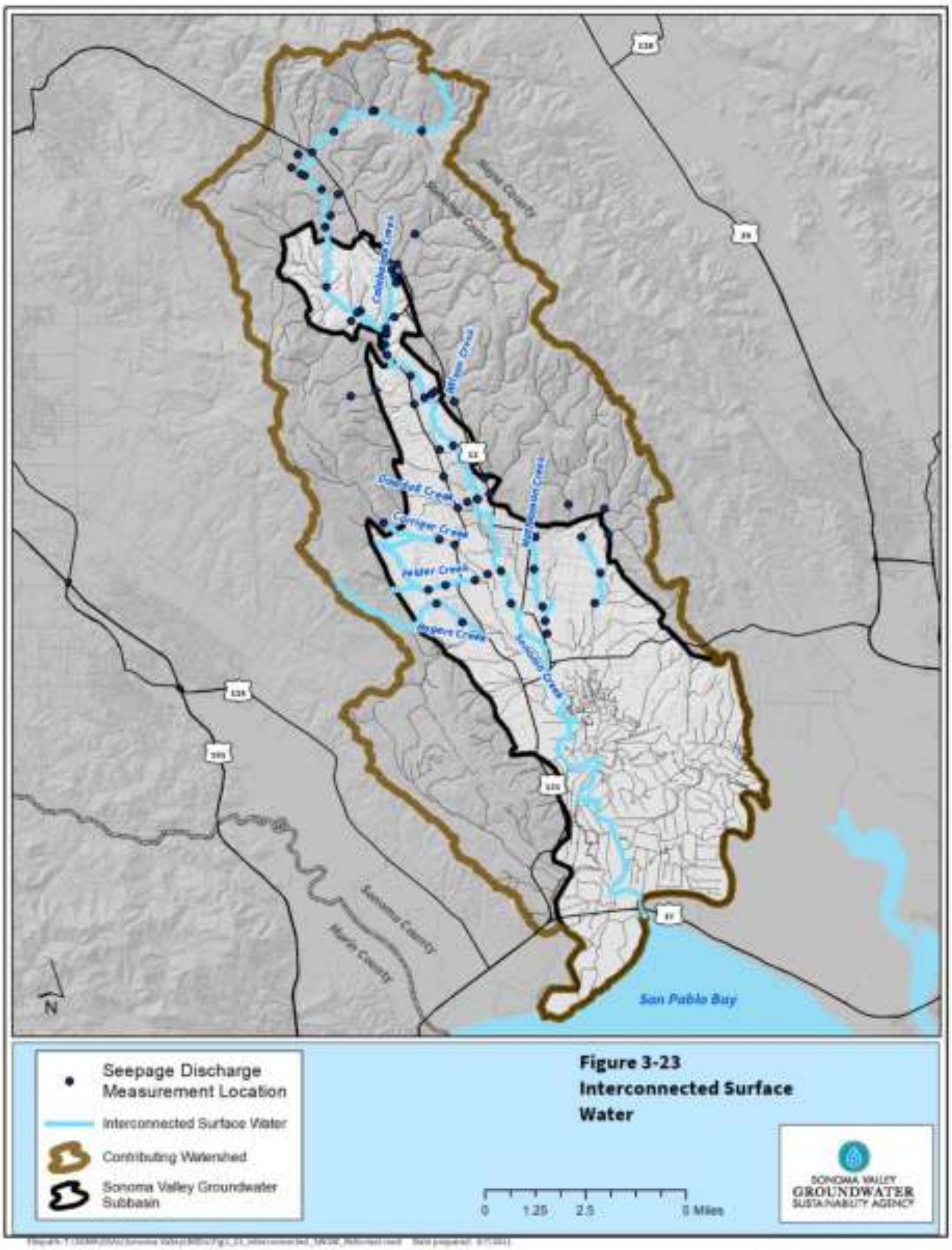

Figure 3-23. Interconnected Surface Water and Potential Surface Water Depletion Representative Monitoring Point Locations

- **Figure 3-20** provides a comparison of streambed elevations with interpolated spring 2015 groundwater levels within the shallow aquifer system. Areas of interconnected surface water occur where unconfined groundwater levels equal or exceed streambed or ground surface elevations (non-negative depths on **Figure 3-20**). Such areas are mapped in Sonoma Valley Subbasin by subtracting spring 2015 groundwater elevations from the streambed elevations. The streambed elevations were extracted from the Sonoma County Vegmap 2013 LiDAR (Watershed Sciences, Inc. 2016).

- **Figure 3-21** shows the percentage of measurements with measurable and zero discharge from the stream seepage runs. Stream reaches with zero discharge are indicative of the absence of interconnected surface waters.

- **Figures 3-22a** through **Figure 3-22f** show the semiannual seepage-run results in terms of rate of seepage for 2016 through 2018. Negative values/cooler colors indicate losing reaches and positive values/warmer colors indicate gaining reaches. Results from the semiannual seepage measurements were used to assess reaches likely to be interconnected based on occurrences of gaining stream conditions.

- **Figure 3-23** shows the likely areas of interconnected surface water within the watershed based on evaluation of the above seepage measurement datasets on **Figures 3-19a** through **3-22f**.

Reaches of Sonoma Creek north of Glen Ellen (S5 to S8) generally show strong gaining signal in the fall, have zero dry measurements and have groundwater elevations above streambed levels for much of the reach (**Figure 3-20**). Reach S9-S8 has been observed to go dry, has deeper unconfined groundwater levels (**Figure 3-20**), and two of its spring measurements are losing conditions (2016 and 2018 on **Figure 3-19a**). However, this reach exhibits gaining conditions in March 2017 (**Figure 3-19a**) following an above average wet winter. Downstream of S9, Sonoma Creek gaining conditions generally occur in the spring measurements, groundwater levels exceed streambed elevations, and the creek is observed to have zero dry measurements. From these lines of evidence, the entire mainstem of Sonoma Creek is likely to be interconnected surface water.

In the southwest area, Dowdall Creek, Carriger Creek, Felder Creek, and Rogers Creek enter the basin in an east-southeast direction. No seepage measurements were taken on Dowdall Creek; however, interpolated groundwater depths along these reaches are deep enough such that there is little interconnected surface water (**Figure 3-20**). Gaining conditions are documented along portions of Carriger Creek and Felder Creek (Tc-T20 and Tf-Tfc, respectively, on **Figure 3-19b**), and the lower reaches exhibit gaining in all of the seepage measurements, though there are the frequent dry conditions along the alluvial fan at T20, Tc, and Tf. The interpolated depth to groundwater at these locations corroborate the conclusion that the upper reaches are likely interconnected surface waters (**Figure 3-20**), whereas groundwater-level measurements collected from shallow wells near Carriger Creek (near Arnold Drive and at Tcn approximately 0.5 mile upstream) are 30 to 50 feet below the streambed, indicating this reach is primarily disconnected.

The upper reaches of Nathanson Creek (Tnp-Tn) and Arroyo Seco (Tan-Tab) are losing reaches (**Figure 3-19b**) with interpolated depth to groundwater greater than 26 feet (**Figure 3-20**). The lower reaches of Nathanson Creek and Arroyo Seco both are generally gaining reaches with relatively shallow groundwater (11-25 feet bls), though are commonly dry. The lower reaches are likely interconnected surface waters.

3.2.7.2 **Assessment of High-Frequency Groundwater-Level Measurements Near Streams**

Groundwater elevations from 17 shallow monitoring wells at 13 locations near streams in Sonoma Valley, equipped with high-frequency monitoring provided by dedicated pressure transducers, were used to further assess and corroborate the mapping of interconnected surface water in the Subbasin.[1] Streambed elevations near each monitoring well were obtained from LiDAR datasets to compare with groundwater elevations and assess interconnectedness, as only a few shallow wells have stream-surface water measurements near enough to assess the presence of gaining or losing conditions. A detailed description of the analysis is provided in **Appendix 3-D**. Summary results of a review of these hydrographs at the 13 locations indicate the following:

1. At all eight locations along the mainstem of Sonoma Creek, groundwater levels are always (at seven locations) or seasonally (at one location) above the streambed elevation and are indicative of interconnected surface water conditions (**Figure 3-23**). At two of the three locations where nearby surface water gage data are available along Sonoma Creek (Son0551 at Arnold Drive in Glen Ellen and Son0553 at Aqua Caliente Road), groundwater levels are always above the surface water level indicating gaining stream conditions persist year-round. At the third location where nearby surface water gage data are available (Son0315 at Watmaugh Road), the groundwater level is seasonally above the surface water level indicating gaining conditions in the winter and spring that typically transition to losing stream conditions in the late summer and fall.

2. At two of the locations along tributaries to Sonoma Creek (Son0325 on Aqua Caliente Creek and Son0342 on Nathanson Creek), groundwater levels are seasonally above the streambed elevations and are indicative of interconnected surface water conditions (**Figure 3-23**).

3. At three of the locations along tributaries to Sonoma Creek (Son0331 on Dowdall Creek and Son0348 and Son0557 on Carriger Creek), groundwater levels are always below the streambed elevation indicative of disconnected stream reaches (**Figure 3-23**). Groundwater levels range from 10 to 45 feet below the streambed at Dowdall Creek and 15 to 65 feet below the streambed at Carriger Creek.

[1] Three of the locations have multiple wells completed at different depths within the shallow aquifer system (Son0315 and Son0316 located along Sonoma Creek at Watmaugh Road and Son0341, Son0342, and Son03433 located along Nathanson Creek) or include a very shallow well completed across a shallow perched aquifer (Son0556 and Son0557 located along Carriger Creek). At these locations, the monitoring wells considered most representative for assessing interconnected surface water conditions for the shallow principal aquifer system are summarized in this section (Son0315, Son0342, and Son0557).

As displayed on **Figure 3-23**, these findings from the high-frequency groundwater-level monitoring are consistent with the results of the interconnected surface water analysis using 1) results of seepage-run monitoring, 2) frequency of observed or measured streamflow, and 3) comparison of interpolated groundwater levels within the shallow aquifer system and streambed elevations.

3.2.7.3 Groundwater Dependent Ecosystems

SGMA defines an undesirable result as “depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water” (California Water Code Section 10721[w][6]). To help characterize environmental beneficial users, it is necessary to identify the aquatic species and habitats that could be adversely affected by lowered groundwater levels in principal aquifers and interconnected surface water depletion. The GSA partnered with the Santa Rosa Plain and Petaluma Valley GSAs to form a practitioners’ work group to provide expert advice and perspectives, which met three times between July and November 2020. The GDE Work Group included staff, expert biologists from Sonoma Water, and representatives from the following groups/agencies:

- San Francisco Estuary Institute (SFEI)
- County of Sonoma Ag and Open Space Preservation District
- Sonoma Ecology Center
- California Department of Fish and Wildlife
- Permit Sonoma
- The Nature Conservancy (TNC)
- NOAA National Marine Fisheries Service
- Laguna Foundation

SGMA defines GDEs as “ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface” (23 CCR 350 et seq.), which generally includes plant and animal communities that rely on shallow groundwater levels or interconnected surface water to meet all or some of their needs. The GDE Work Group focused on mapping aquatic species GDEs and vegetation GDEs that can be affected by groundwater conditions and management and are within the jurisdiction of the GSA. The methodology for mapping potential GDEs used guidance developed by TNC (2018; https://groundwaterresourcehub.org/).

Aquatic Species GDEs

For mapping aquatic species GDEs, species listed in Critical Species LookBook (Rohde et al. 2019) were identified and include steelhead, Chinook salmon, coho salmon, California red-legged frog, and California tiger salamander. The Critical Species LookBook is a compendium of 84 state and federally listed species that are likely to be affected by groundwater management and merit consideration by GSAs under the SGMA. Also, the federal and state endangered California freshwater shrimp was added at the request of resource agency staff. California tiger salamander was excluded because this species has “no known reliance on groundwater” (Rohde et al. 2019). The distribution of target species (species or groups of species specifically chosen for long-term monitoring) is based on Leidy et al. (2005), Implementation of California Coastal Salmonid Population Monitoring in the Russian River Watershed (Sonoma County Water Agency and University of California Cooperative Extension/California Sea Grant 2015), and the California Natural Diversity Data Base (CNDDB 2020).

In Sonoma Valley, a total of 19 streams were identified as habitat for at least one target species. Steelhead was the most widespread species occurring in each of the 19 streams. The distribution of Chinook salmon, coho salmon, and California freshwater shrimp overlap entirely with steelhead streams. For this reason, steelhead are essentially used as a priority indicator species to cover all aquatic GDEs in the Subbasin.

Vegetation GDEs

For mapping vegetation, GDEs used high-resolution local mapping available from the Sonoma County Veg Map (Watershed Sciences, Inc. 2016). Classifications considered to have a potential reliance on groundwater included the following general classifications:

- Riparian Woodland
- Oak Woodland
- Freshwater Marsh and Aquatic

To identify where these vegetation classes are likely to have some connection with groundwater conditions within the Subbasin, the rooting depths of common tree species were compared to available depth-to-groundwater (DTW) mapping.

Following guidance from TNC, potential vegetation GDEs were mapped for areas with DTW of 30 feet or less to incorporate the potential rooting depths of oak trees (TNC 2018). The DTW mapping used available contoured springtime datasets for the shallow aquifer system (from 2015 and 2016) and high-resolution LiDAR data. To address GDE Work Group member concerns that groundwater levels were generally at lower levels in 2015 and 2016 due to dry conditions, minor adjustments in some areas were made to incorporate the shallowest depth to water on record for each well based on review of all available data from 2005 to 2020. Additionally, all Riparian Woodland and Oak Woodland habitat within 100 feet of mapped interconnected surface waters were included as potential vegetation GDEs.

Integrated Potential GDE Map

The potential aquatic species GDEs and the potential vegetation GDEs were then integrated into a single potential GDE map presented on **Figure 3-24**.

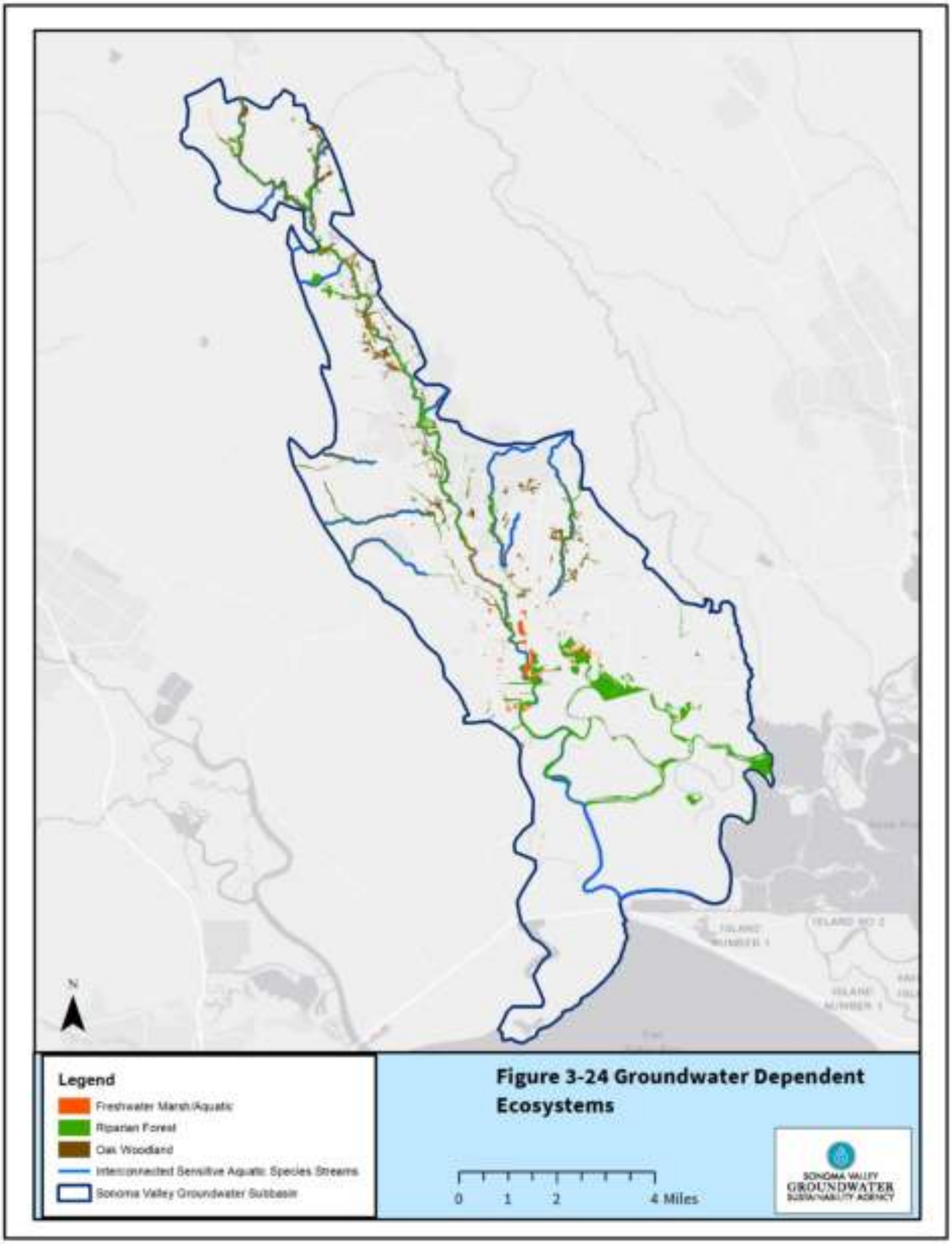

Figure 3-24. Potential Locations of Groundwater Dependent Ecosystems

As specified in **Sections 4 and 7**, additional studies and data gathering are recommended during the implementation of the GSP to better define the mapping and relationship of GDEs to groundwater conditions within the Subbasin.

3.3 Water Budget

This section summarizes the estimated water budgets for the Subbasin, including information required by the SGMA Regulations and information that is important for developing an effective plan to achieve sustainability. In accordance with GSP Regulations Section 354.18, this water budget provides an accounting and assessment of the total annual volume of surface water and groundwater entering and leaving the basin, including historical, current, and projected water budget conditions, and the change of the volume of groundwater in storage. Water budgets are reported in graphical and tabular formats, where applicable.

3.3.1 Overview of Water Budget Development

This section includes subsections on (1) historical water budgets, (2) current water budgets, and (3) projected future water budgets. Within each subsection, a surface water budget and groundwater budget are presented. Water budgets were developed using the Sonoma Valley Integrated Groundwater Flow Model Version 2 (SVIGFM V2). The SVIGFM V2 was developed by Sonoma County Water Agency (2020). An overview of the model construction and revisions made for this GSP are provided in **Appendix 3-E**.

Before presenting the water budgets, a brief overview of the inflows and outflows pertaining to the Sonoma Valley Subbasin is provided. In accordance with Section 354.18 of the GSP Regulations, one integrated groundwater budget was developed for the combined inflows and outflows for the two principal aquifers for each water budget period. Groundwater is pumped from both principal aquifers for beneficial use.

3.3.1.1 Water Budget Components

The water budget is an inventory of surface water and groundwater inflows (supplies) and outflows (demands) from the Subbasin. A few components of the water budget can be measured, such as streamflow at a gaging station or groundwater pumping from a metered well. Other components of the water budget are estimated, such as unmetered domestic groundwater pumpage and septic return flows. Additional components of the water budget are simulated by SVIGFM V2, such as in-place recharge from precipitation and irrigation, agricultural groundwater pumping, surface water diversions, and change in groundwater storage.

The water budgets for the Subbasin are calculated within the following boundaries:

- Lateral boundaries: The perimeter of the Subbasin as shown on **Figure 3-25**. The area for which the budget is presented excludes the Sonoma Baylands portion of the Subbasin as this area is assumed to be of limited use due to the presence of brackish, low water-quality waters.
- Bottom: Base of the groundwater Subbasin as described in this section. The water budget is not sensitive to the exact definition of this base elevation because it is defined as a depth below where there is not significant inflow, outflow, or change in storage.
- Top: Above the ground surface, such that surface water is included in the water budget.

Figure 3-26 presents the general schematic diagram of the hydrologic cycle.

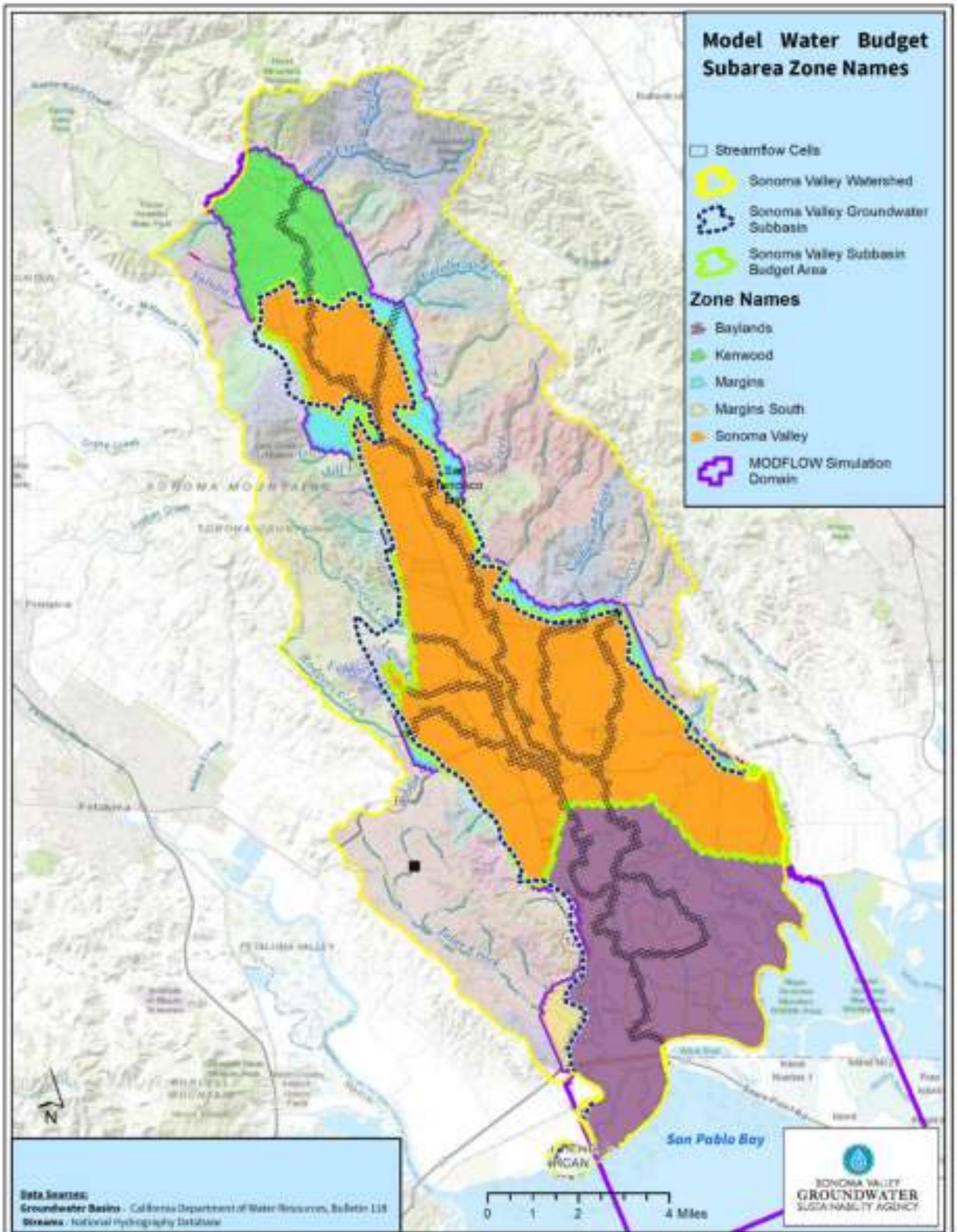

Figure 3-25. Model Water Budget Subarea Zone Names

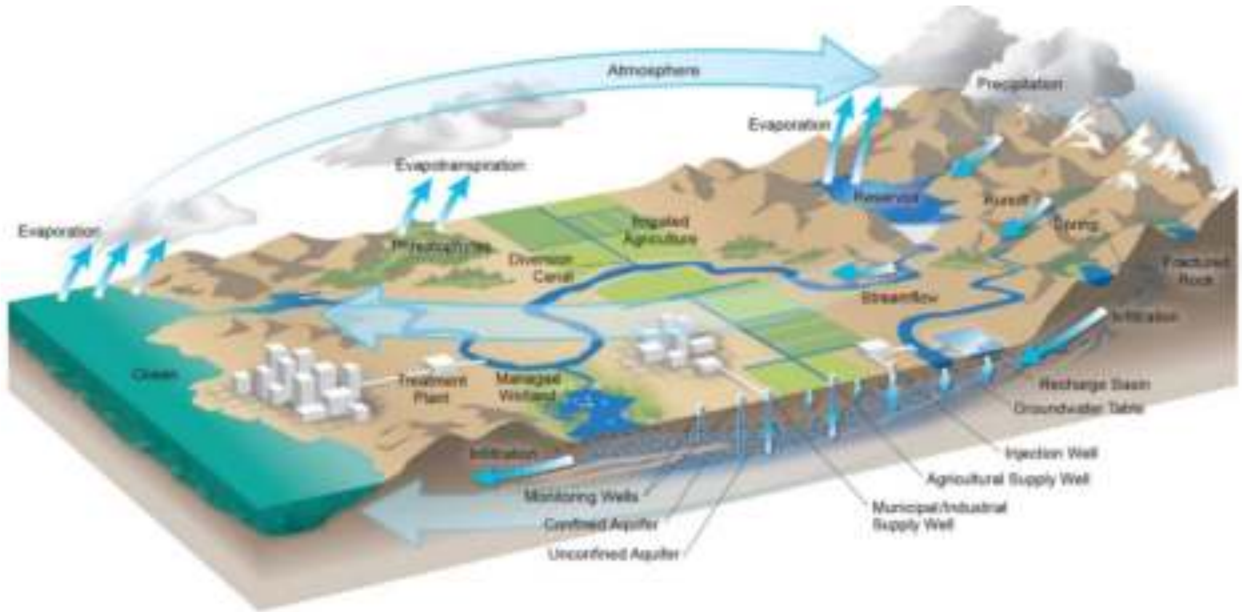

Figure 3-26. Schematic Hydrologic Cycle
Source: DWR 2016

The Subbasin includes the following inflows and outflows:

- Surface Water Inflows:
  - Overland flow – Runoff of precipitation and excess irrigation
  - Mountain-front runoff – Runoff of precipitation and excess irrigation generated in the mountain-front sub-catchment areas outside of the Subbasin boundary
  - Surface water inflow from streams entering the Subbasin – Sonoma Creek, Calabazas Creek, Rodgers Creek, Carriger Creek, Nathanson Creek, Arroyo Seco, combination of all other smaller streams
  - Groundwater discharge to streams
- Surface Water Outflows:
  - Streambed recharge to groundwater
  - Outflow at southern end of Subbasin budget area
  - Evaporation (negligible compared to other surface water outflows)
  - Surface water diversions from streams

- Groundwater Inflows:
  - Areal recharge (includes deep percolation from both precipitation and applied irrigation water)
  - Septic return flows
  - Streambed recharge to groundwater
  - Subsurface inflows:
    - Inflow from Kenwood Valley Subbasin
    - Inflow from Baylands
    - Inflow from Margins
  - Mountain-front recharge – Subsurface inflow from the surrounding watershed
- Groundwater Outflows:
  - Groundwater ET from crops, native vegetation, and riparian vegetation with roots below groundwater table
  - Groundwater pumpage (including municipal, rural domestic, and agricultural)
  - Groundwater discharge to streams
  - Subsurface outflows:
    - Outflow to Kenwood Valley Subbasin
    - Outflow to Baylands
    - Outflow to Margins
  - Surface leakage – Rejected recharge occurring where phreatic water levels exceed ground surface elevation

The surface water boundaries, inflow and outflow locations, and model area are shown on **Figure 3-27**. The difference between groundwater inflows and outflows is equal to the change in groundwater storage. **Figure 3-28** illustrates how the SVIGFM V2 represents the water budget components listed in the bullets above.

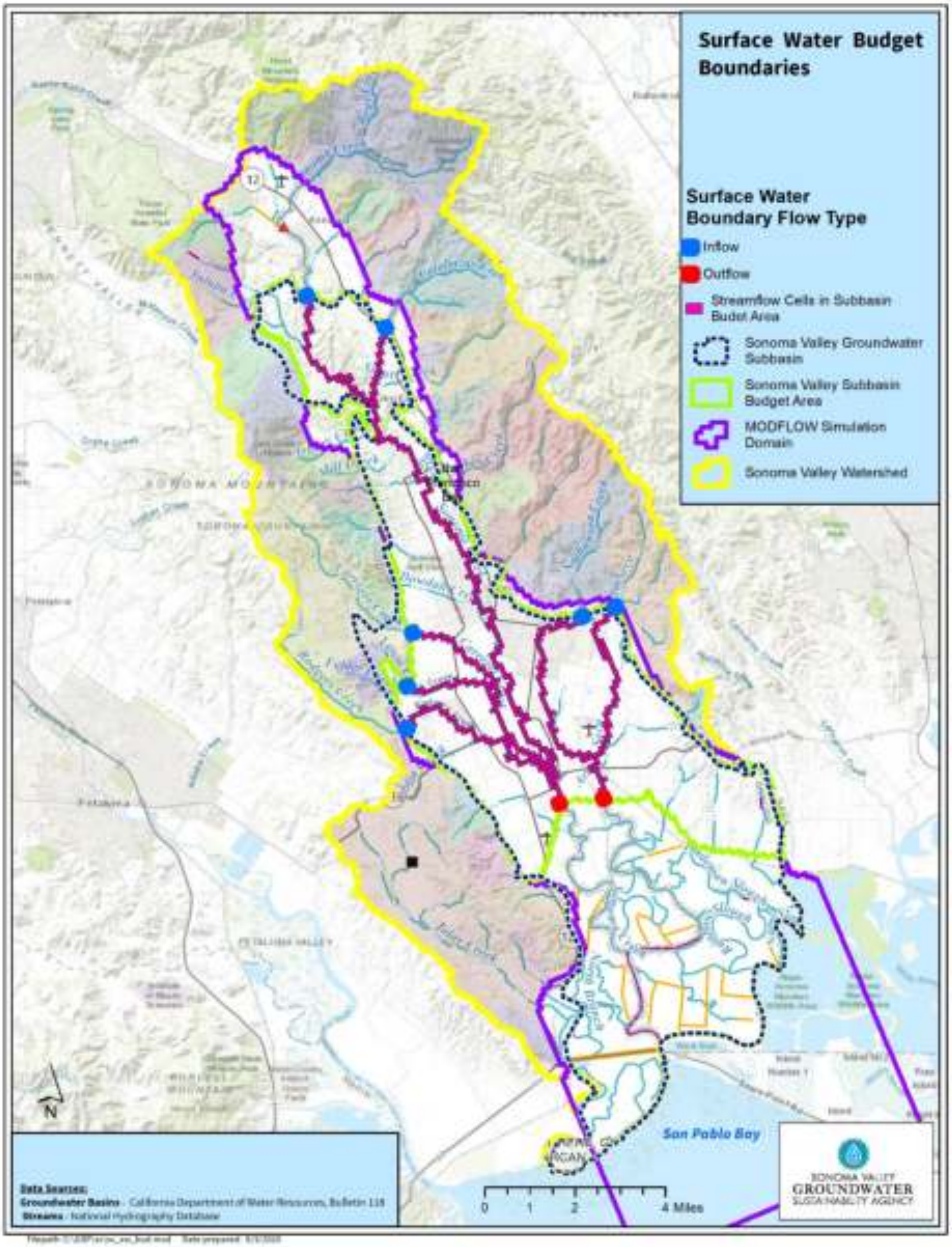

Figure 3-27. Surface Water Budget Boundaries

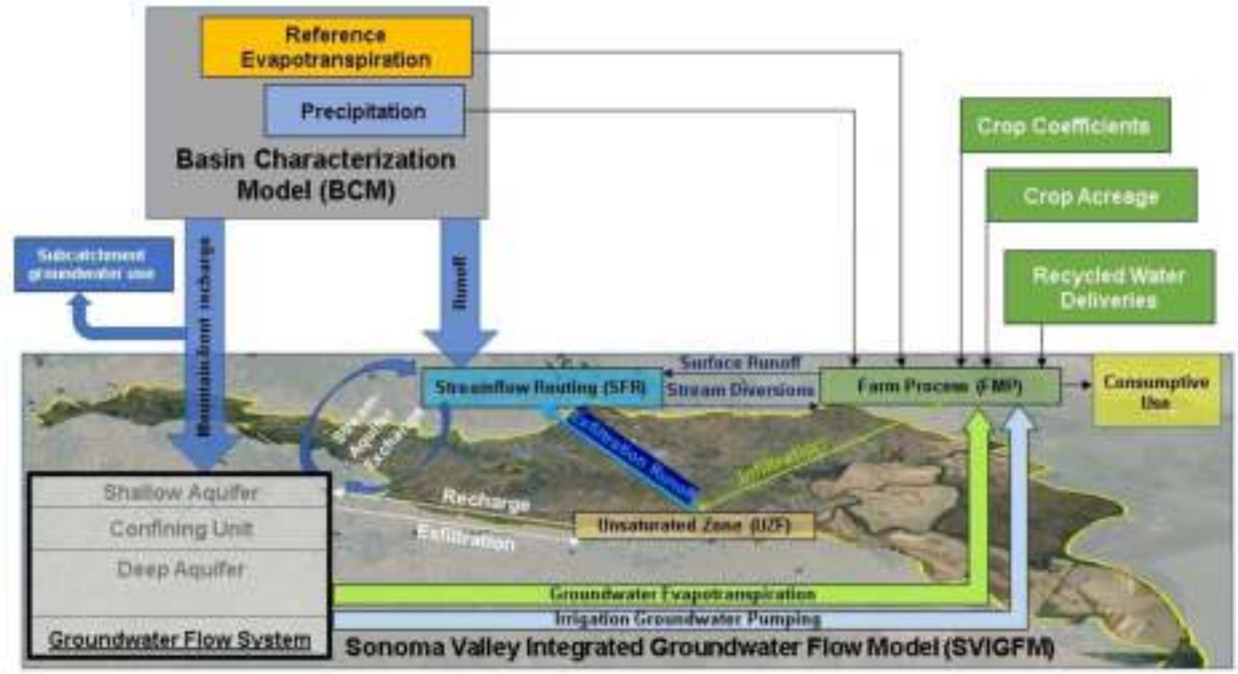

Figure 3-28. Representation of Water Budget Components in Sonoma Valley Integrated Groundwater Flow Model

3.3.1.2 Water Budget Timeframes

Timeframes need to be specified to estimate Subbasin water budgets. The GSP Regulations require water budgets for three different timeframes, representing (1) historical conditions, (2) current conditions, and (3) projected (future) conditions. Historical conditions should be based on the most reliable historical data that are available for GSP development and water budgets calculations. Current conditions are generally the “most recent conditions” for which adequate data are available. Current conditions are not well defined by DWR but can include an average over a few recent years with various climatic and hydrologic conditions (for example, centered around the most recent drought in 2015, which is also the effective date of SGMA). Projected conditions should include a timeframe of 50 years into the GSP planning and implementation horizon, including projected climate change, population, and land use changes.

In accordance with the GSP Regulation Title 23, CCR Section 354.18(c), the GSP quantifies a historical, current, and projected water budget for the Subbasin, as follows:

- The historical water budget is intended to evaluate how past water supply availability has affected aquifer conditions and the ability of groundwater users to operate within the sustainable yield. GSP Regulations require that the historical water budget include at least the most recent 10 years of water budget information.

- The current water budget is intended to allow the GSA and DWR to understand the existing supply, demand, and change in storage under the most recent population, land use, and hydrologic conditions.

- The projected water budget is intended to quantify the estimated future baseline conditions without implementation of GSP projects and management actions. The projected water budget is based on information from the historical budget and includes an assessment of uncertainty. The projected water budget estimates the future baseline conditions concerning hydrology, water demand, and surface water supply over a 50-year planning and implementation horizon. It is based on historical trends in hydrologic conditions, used to project forward 50 years, while considering projected climate change and sea-level rise (if applicable).

Although there is a significant seasonal variation between wet and dry seasons, the GSP does not consider seasonal water budgets. All water budgets are developed for complete WY(s) The current and historical water budget periods are shown in **Table 3-1** and on **Figure 3-29**.

Table 3-1. Summary of Historical and Current Water Budget Time Periods

Time Period	Date Range	Water Year Types Represented in Time Period	Rationale
Historical	WYs 1971 to 2018	Very dry: 1 Dry: 7 Normal: 23 Wet: 15 Very wet: 2	Based on entire model timeframe after a 1-year model spin-up period. Available datasets. Provides insights on water budget response to a wide range of variations in climate and groundwater use over an extensive period of record.
Current	WYs 2012 to 2018	Very dry: 0 Dry: 2 Normal: 4 Wet: 1 Very wet: 0	Best reflection of current land use and water use conditions with a range of recent climate variability.

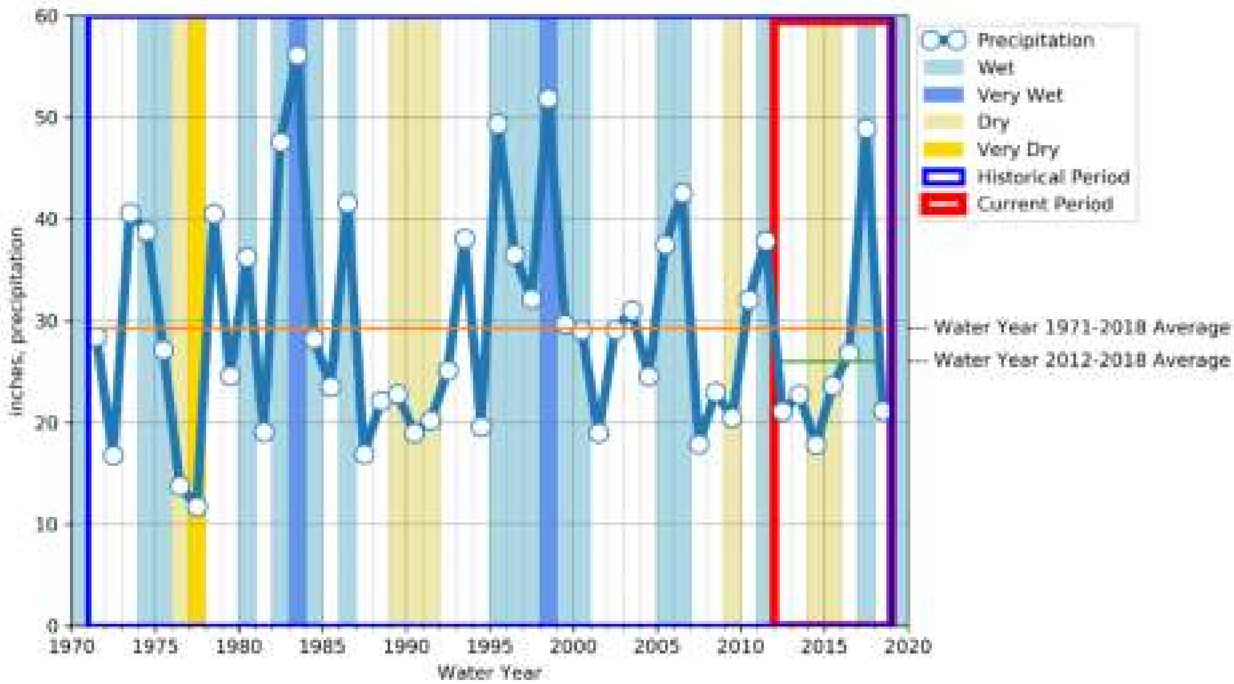

Figure 3-29. Climate and Precipitation for Historical and Current Water Budget Time Periods

Historical Water Budgets Time Period

The only specific GSP guideline requirement is that the historical water budget cover at least 10 years.

> **From CCR Section 354.18. Water Budget:** A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.

The historical water budget is computed using the SVIGFM V2. The first year of the model simulation is used as a “spin-up” period to allow the model to equilibrate with the initial conditions. The SVIGFM V2 simulates WYs 1970 through 2018; therefore, the historical period is selected to encompass WYs 1971 to 2018 (a 48-year period).

Current Water Budgets Time Period

The current water budget is based on the average of conditions between WYs 2012 and 2018 to include the entire recent drought period of WYs 2012 to 2016. In addition, this period includes some post drought WYs so that a variety of WY types are covered in the current average.

Future Projected Water Budgets Time Period

Future projected conditions are based on model simulations using SVIGFM V2 and using projected land use changes, population growth estimates, and a projected climate change scenario. Projected climate based on the selected general circulation model (GCM) will represent WY 2021 through 2072.

3.4 Overview of Model Assumptions for Water Budget Development

All groundwater models contain assumptions and some level of uncertainty, particularly when predicting future conditions. Model uncertainty stems from heterogeneity in the Subbasin and the surrounding watershed geology, hydrology, and climate, in addition to assumptions regarding unmetered groundwater pumping and recharge amount and distribution. However, inputs to the SVIGFM V2 are carefully selected using best available data, resulting in a model well suited to simulate Subbasin hydrogeologic conditions. As GSP implementation proceeds, the SVIGFM V2 will be updated and recalibrated with new data to better inform model simulations of current and projected water budgets.

Figure 3-28 depicts the SVIGFM V2 modules that contribute to the various water budget components. **Table 3-2** provides the detailed water budget components and model assumptions and limitations for each.

Table 3-2. Sonoma Valley Integrated Groundwater Flow Model Version 2 – Summary of Water Budget Component Data Sources

Water Budget Component	Source of Model Input Data	Limitations
Precipitation	Monthly, spatially distributed PRISM surfaces, interpolated to model grid	Spatial precipitation distribution may change with changing climate
Evapotranspiration	Monthly, spatially distributed potential ET surfaces computed by Basin Characterization Model v65 (Flint et al. 2013)	Not simulated from surface water bodies or streamside vegetation
Surface Water Inflows		
Inflow from Streams Entering Subbasin	Extracted from BCMv65 (Flint et al. 2013)	Subject to limitations of BCMv65
Mountain-Front Runoff	Extracted from BCMv65 (Flint et al. 2013)	Subject to limitations of BCMv65 and estimates of consumptive use in sub-catchments areas
Groundwater Discharge to Streams	Simulated from calibrated model	Based on calibration of streamflow to available data from gaged creeks
Overland Runoff	Simulated from calibrated model	Based on calibration of streamflow to available data from gaged creeks
Surface Water Outflows		
Streambed Recharge to Groundwater	Simulated from calibrated model	Based on calibration of streamflow to available data from gaged creeks
Diversions	Simulated from calibrated model	Based on estimates of crop coefficients and other factors of water demand

Water Budget Component	Source of Model Input Data	Limitations
Stream Discharge Outside of Basin	Simulated from calibrated model	Based on calibration of streamflow to available data from gaged creeks
Groundwater Inflows		
Areal recharge	Portion from precipitation calculated based on monthly precipitation in excess of effective precipitation Irrigation return flows calculated based on assumed irrigation efficiency	Based on calibrated fraction of inefficient losses to surface water
Streambed Recharge to Groundwater	Simulated from calibrated model	Based on calibration of streamflow to available data from gaged creeks
Septic System Return Flows	Locations match rural domestic pumpage and is calculated as a fraction of groundwater pumpage to satisfy indoor water use	Indoor home water usage and fraction of that water that becomes recharge are poorly constrained
Mountain-Front Recharge	Extracted from BCMv65 (Flint et al. 2013) and reduced by estimated sub-catchment groundwater pumpage	Modified by sectoral scaling factors, and subject to limitations of BCMv65
Subsurface Inflows	Simulated from calibrated model	Limited calibration data in adjacent boundaries
Groundwater Outflows		
Groundwater Pumpage	Metered for historical municipal pumpage and some small water systems	Agricultural and rural domestic pumping is unmetered
	Estimated for non-municipal domestic pumpage	
	Simulated for agricultural and large-scale turf irrigation	
Groundwater Discharge to Streams	Simulated from calibrated model	Based on calibration of streamflow to available data from gaged creeks
Subsurface Outflows	Simulated from calibrated model	Limited calibration data in adjacent boundaries
Evapotranspiration by crops, riparian, and native vegetation	Simulated from calibrated model	Based on uniform extinction depth, zero soil water storage, and other simplifying assumptions

BCMv65 = Basin Characterization Model (BCM) Version 65

Some of the more significant model limitations are the following:

- Estimates of agricultural and rural domestic pumpage
- Rates of mountain-front recharge and its movement into the Subbasin
- Aquifer hydraulic properties due to complexity of geology
- Data gaps on vertical distribution of hydraulic head in deeper aquifer zones

3.4.1 Historical and Current Water Budgets

3.4.1.1 Surface Water Budget

The surface water budget shows the inflows and outflows for the streams within the Subbasin. Surface water budget inflows include inflow from streams entering the Subbasin, overland runoff to streams, mountain-front runoff, and groundwater discharge to streams. Surface water budget outflows include streambed recharge to groundwater, surface water diversions, and stream discharge outside of the Subbasin.

Figure 3-30 shows the simulated surface water inflows for the historical period and the current period. **Table 3-3** shows summary statistics of the simulated surface water inflows for the historical and current periods.

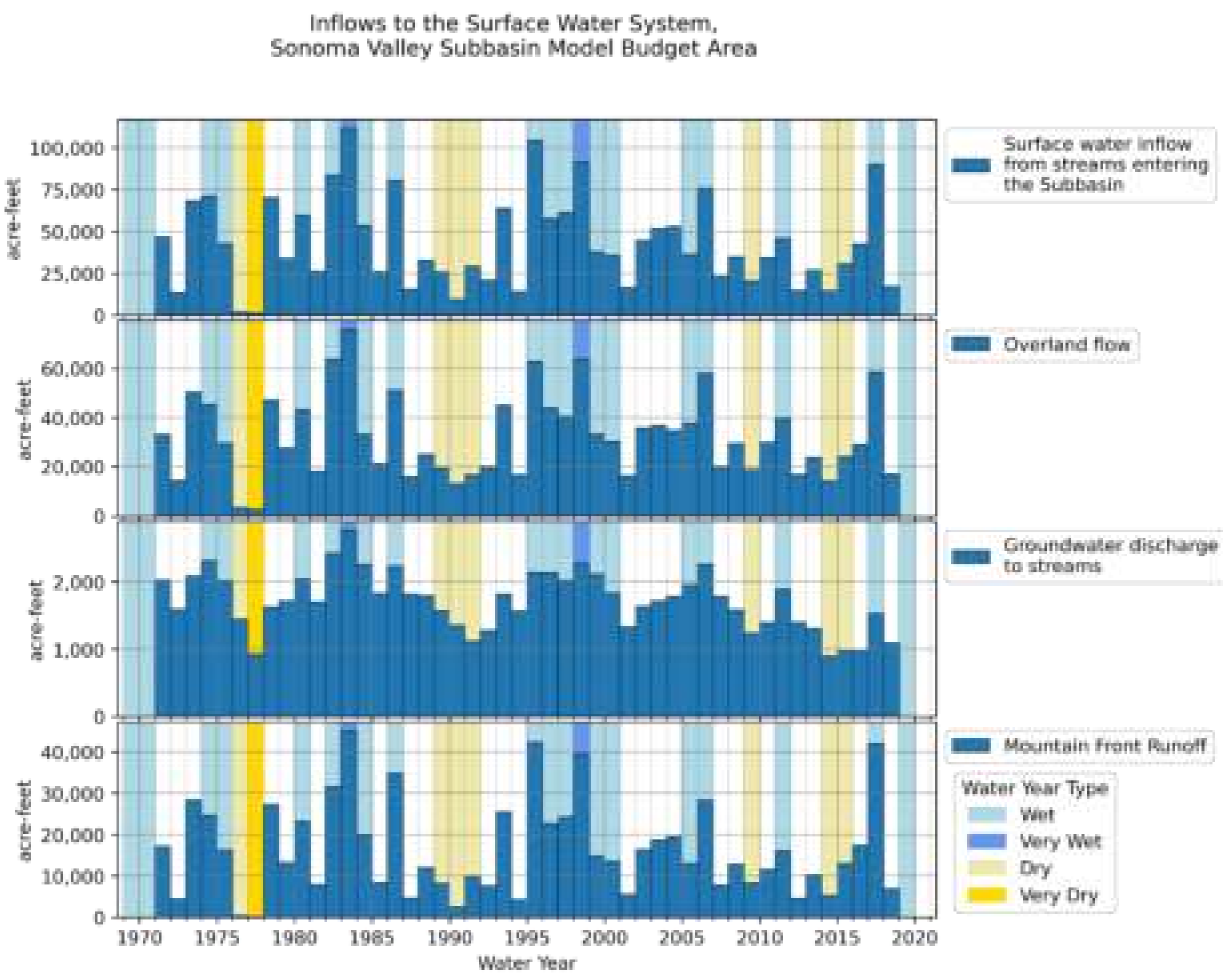

Figure 3-30. Simulated Total Annual Historical and Current Surface Water Inflows

Table 3-3. Summary of Simulated Historical (WY 1971 to WY 2018) and Current (WY 2012 to WY 2018) Surface Water Budget Inflows (AFY)[a]

	Historical (WY 1971 through WY 2018)				Current (WY 2012 through WY 2018)			
	Surface water inflow from streams	Overland flow	Groundwater discharge to streams	Mountain-front runoff	Surface water inflow from streams	Overland flow	Groundwater discharge to streams	Mountain-front runoff
Mean	43,000	32,200	1,700	16,500	33,800	26,200	1,200	14,200
Minimum	1,300	2,700	900	100	14,400	14,300	900	4,600
Maximum	111,300	75,900	2,800	45,100	89,700	58,500	1,500	41,900
Median	36,100	29,500	1,800	13,400	27,100	23,800	1,100	10,200

[a] Values are rounded to nearest 100.

Figure 3-31 shows the simulated surface water outflows for the historical period and the current period. **Table 3-4** shows summary statistics of simulated surface water outflows for the historical and current periods.

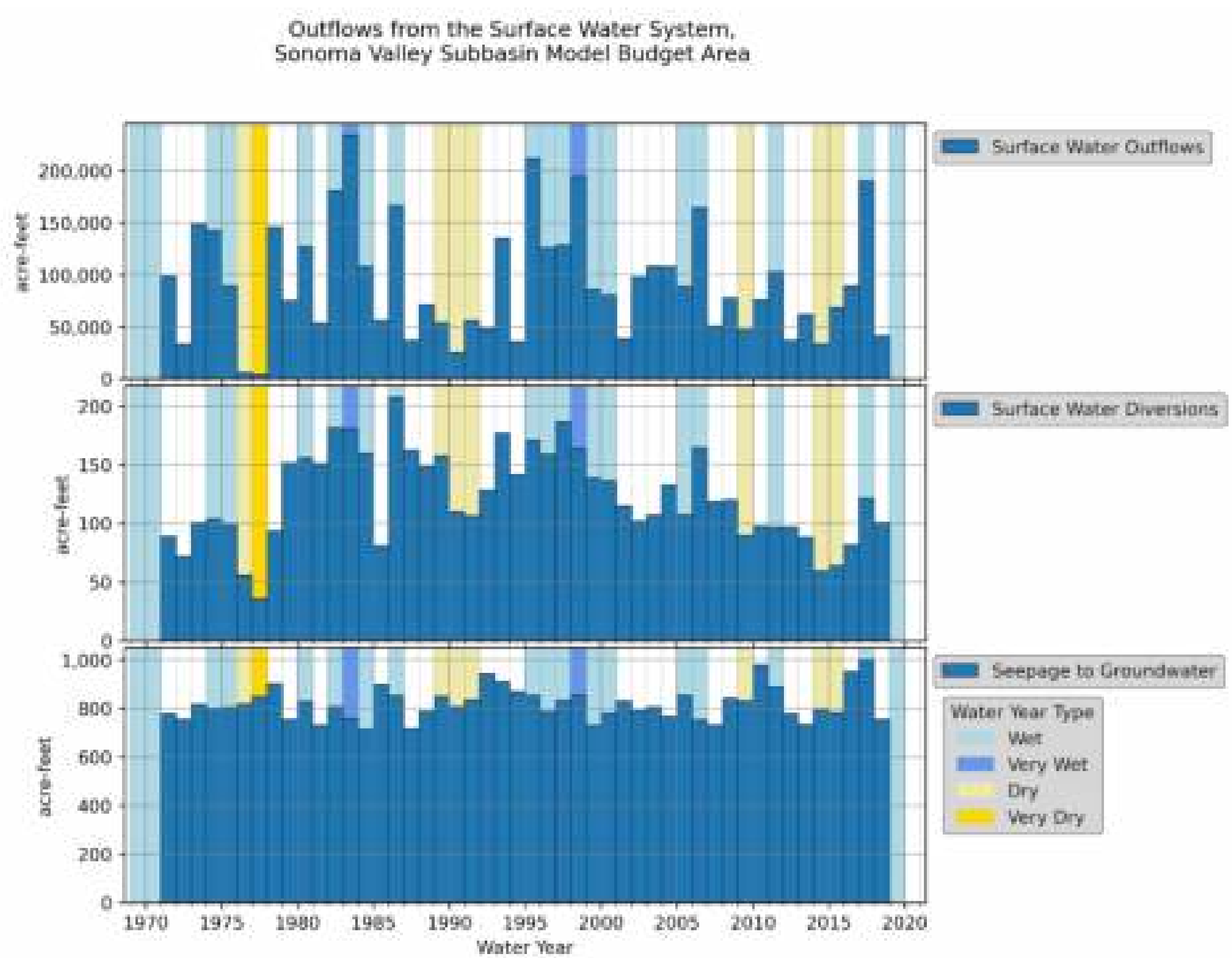

Figure 3-31. Simulated Total Annual Historical and Current Surface Water Outflows

Table 3-4. Summary of Simulated Historical and Current Surface Water Outflows (AFY)[a]

	Historical (WY 1971 to WY 2018)			Current (WY 2012 to WY 2018)		
	Surface Water Outflows	Surface Water Diversions	Seepage to Groundwater	Surface Water Outflows	Surface Water Diversions	Seepage to Groundwater
Mean	92,500	100	800	74,500	100	800
Minimum	4,100	0	700	33,700	100	700
Maximum	233,800	200	1,000	190,200	100	1,000
Median	83,200	100	800	61,800	100	800

[a] Values are rounded to the nearest 100 acre-feet

Figure 3-32 presents the simulated total net stream leakage of the Subbasin. Net stream leakage is the difference between groundwater inflows to streams and seepage to groundwater. Positive stream leakage values represent groundwater discharge to the stream system from the groundwater system. Net stream leakage varies with climatic variations, ranging from nearly 0 acre-feet in very dry years up to 2,000 acre-feet in very wet years (WY 1983). There is a decreasing trend in the 10-year mean for net stream discharge, with the last 5 years displaying 10-year mean values lower than the rest of the simulation period. Through WY 2009, this decreasing trend is inversely related to total groundwater pumpage (**Figure 3-32**).

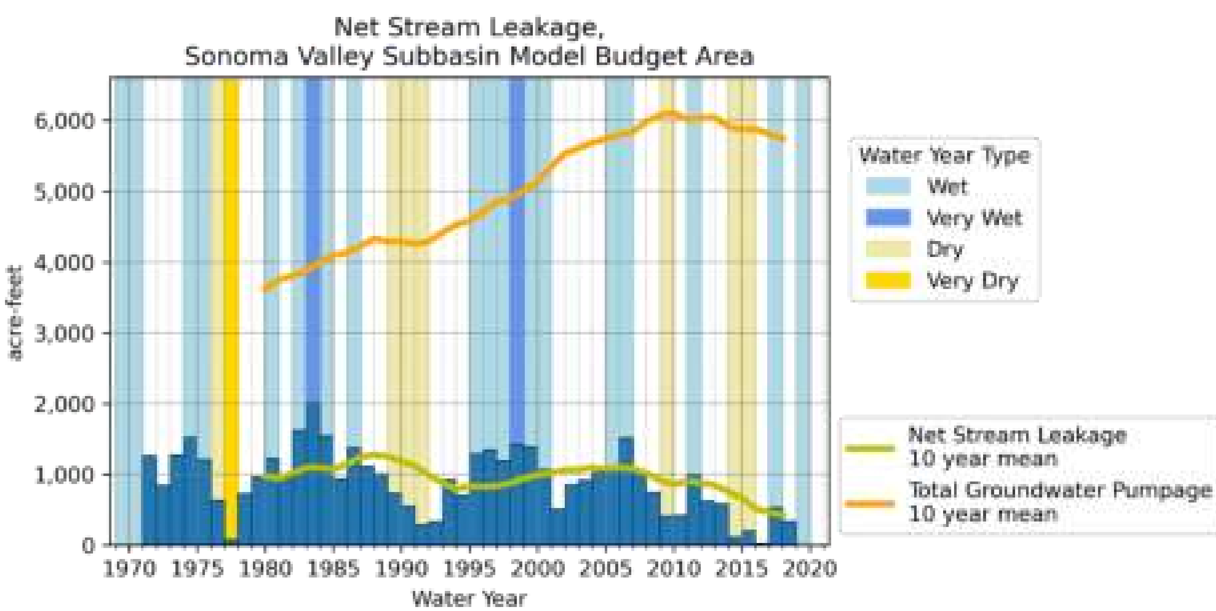

Figure 3-32. Net Stream Leakage

3.4.1.2 Groundwater Budget

The groundwater budget shows the inflows and outflows for the saturated aquifer system of the Subbasin. This includes inflows and outflows of groundwater at the Subbasin boundaries, areal recharge, pumpage, and flows of groundwater to and from streams, the surface, and ET.

Figure 3-33 shows simulated total inflows to the groundwater system for the historical and current time periods. **Table 3-5** and **Table 3-6** display summary statistics for groundwater inflows for the historical and current period, respectively. The largest inflow was mountain-front recharge, which, when combined with areal recharge constituted about 64 percent of total inflows during the historical period. Mountain-front recharge diminished by 51 percent during the current period compared to the historical period, which corresponds to the lower average precipitation of the current period (**Figure 3-29**). Inflow from the Baylands during the current period increased by 50 percent, which may be caused by the increase in groundwater pumpage (discussed below), and related decline in groundwater levels, during this period. Inflow from the margins constituted 23 percent of total inflows during the historical period; this value decreased by 28 percent in the current period. Similar to mountain-front recharge, this decrease may be related to the lower average precipitation of the current period (**Figure 3-29**).

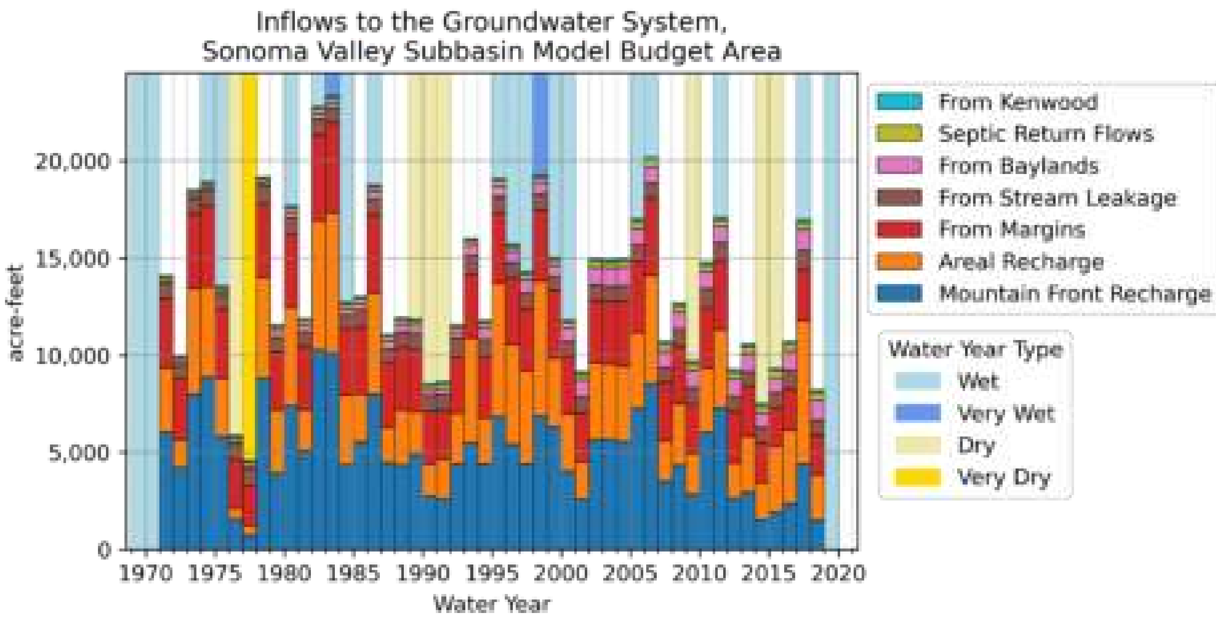

Figure 3-33. Simulated Total Annual Inflows to the Groundwater System

Table 3-5. Historical (WY 1971 to WY 2018) Groundwater Inflows Budget Summary (AFY)[a]

	From Baylands	From Kenwood	From Margins	Septic Return Flows	From Stream Leakage	Areal Recharge	Mountain-Front Recharge
Mean	600	100	3,200	300	800	3,600	5,100
Minimum	100	100	2,000	200	700	500	700
Maximum	1,100	200	4,600	300	1,000	7,400	10,300
Median	500	100	3,200	200	800	3,300	4,700

[a] Values are rounded to nearest 100.

Table 3-6. Current (WY 2012 to WY 2018) Groundwater Inflows Budget Summary (AFT)[a]

	From Baylands	From Kenwood	From Margins	Septic Return Flows	From Stream Leakage	Areal Recharge	Mountain-Front Recharge
Mean	900	200	2,300	300	800	3,300	2,500
Minimum	700	200	2,000	300	700	1,800	1,500
Maximum	1,100	200	2,600	300	1,000	7,400	4,400
Median	900	200	2,100	300	800	2,900	2,400

[a] Values are rounded to nearest 100.

Figure 3-34 shows simulated outflows from the groundwater system for the historical and current time periods. **Table 3-7** and **Table 3-8** provide summary statistics for groundwater outflows of the historical and current period, respectively. Agricultural groundwater pumpage was the biggest stress followed by surface leakage for the historical and current time periods. Mean total groundwater pumpage, including municipal and industrial (M&I), rural domestic, and agricultural constituted 36 percent and 46 percent of the total outflow from the groundwater system during the historical and current time periods, respectively. Total groundwater pumpage during the historical and current time periods did not display as much interannual variability as other major groundwater inflows and outflows (**Figure 3-34**). Because of this, when total outflows decreased during the current period, total groundwater pumpage increased to 46 percent of the total outflows during this period.

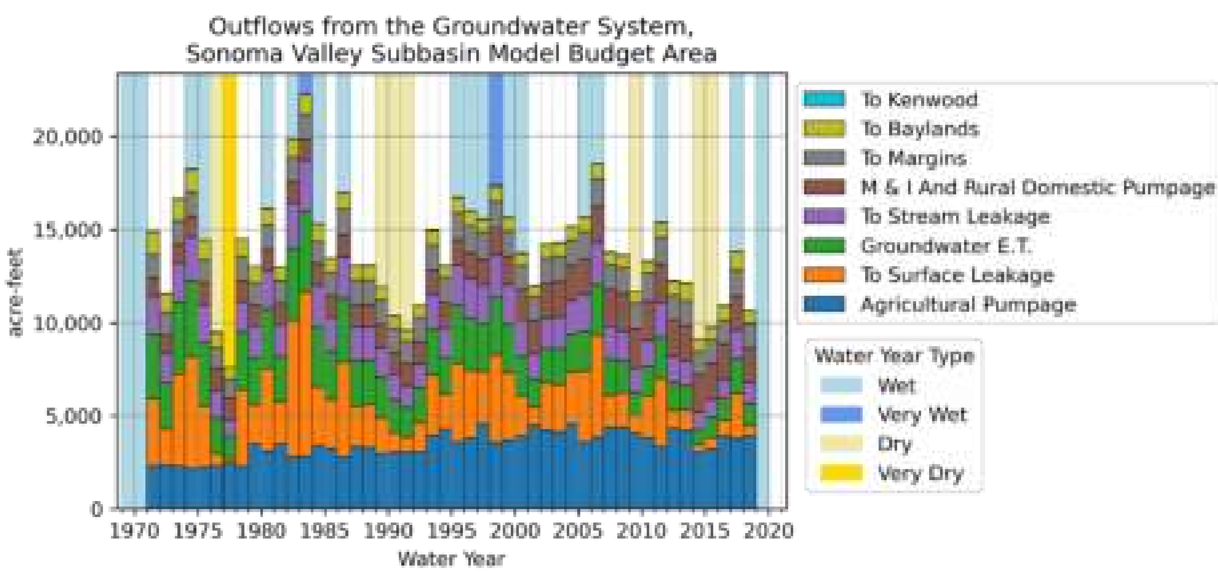

Figure 3-34. Simulated Total Annual Outflows from the Groundwater System

Table 3-7. Historical (WY 1971 to WY 2018) Groundwater Outflows Budget Summary (AFY)[a]

	To Baylands	Groundwater ET	To Kenwood	Agricultural Pumpage	To Margins	To Stream Leakage	To Surface Leakage	M&I and Rural Domestic Pumpage
Mean	800	2,300	0	3,400	1,300	1,700	2,700	1,500
Minimum	600	900	0	2,200	1,000	900	200	1,000
Maximum	1,200	4,300	0	4,600	1,500	2,800	8,800	2,100
Median	800	2,200	0	3,500	1,300	1,800	2,400	1,400

[a] Values are rounded to nearest 100.

Table 3-8. Current (WY 2012 to WY 2018) Groundwater Outflows Budget Summary (AFY)[a]

	To Baylands	Groundwater ET	To Kenwood	Agricultural Pumpage	To Margins	To Stream Leakage	To Surface Leakage	M&I and Rural Domestic Pumpage
Mean	800	1,300	0	3,800	1,300	1,200	1,000	1,900
Minimum	700	900	0	3,100	1,200	900	400	1,900
Maximum	900	1,800	0	4,300	1,400	1,500	2,400	2,000
Median	800	1,200	0	3,900	1,300	1,100	800	1,900

[a] Values are rounded to nearest 100.

Groundwater pumping in the basin by water-use sector from the 1970s to recent is shown graphically in **Figure 3-35** and displayed numerically in **Table 3-9**. Groundwater use data are required to be reported to the state by M&I pumpers. Reporting is not required for agricultural and domestic pumpers so pumping is estimated for these sectors (refer to **Appendix 3-F** for more information on estimates). Estimated groundwater pumping was relatively flat in the 1970's, increased in the early 1980s with land use changes, flattened out again in the early 1990s, peaked in the mid-1990s to 2005, and has shown a slightly declining trend since.

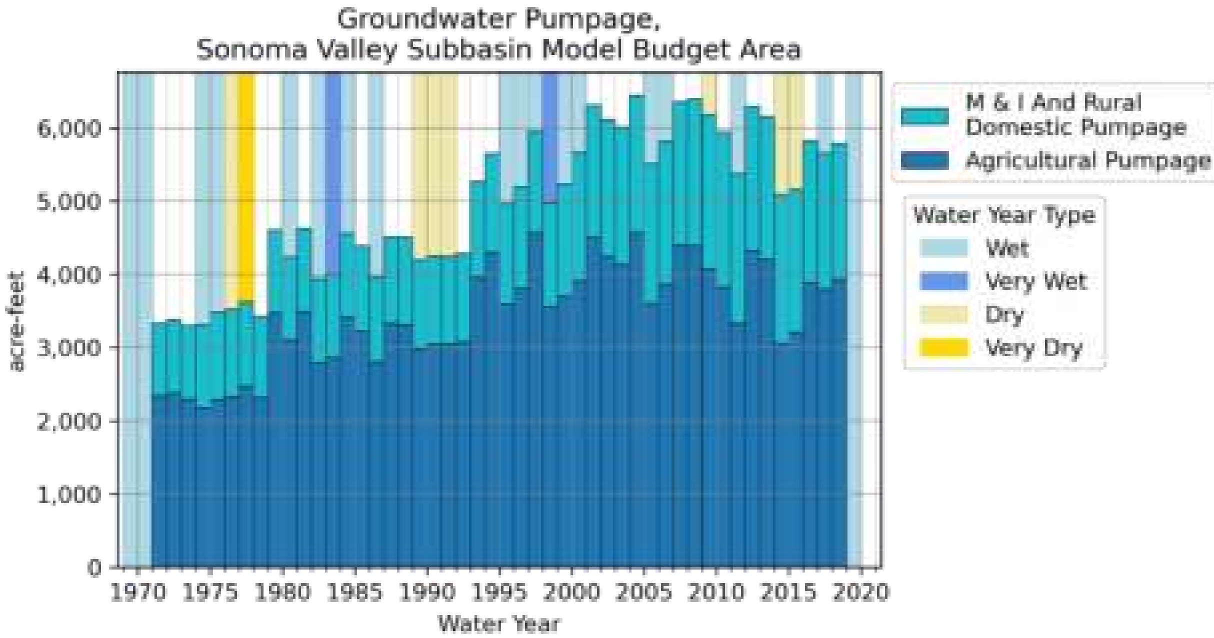

Figure 3-35. Groundwater Pumpage by Water-Use Sector

Table 3-9. Historical and Current Groundwater Pumpage by Water-Use Sector (AFY)[a]

	Historical (WY 1971 to WY 2018)		Current (WY 2012 to WY 2018)	
	M&I and Rural Domestic Pumpage	**Agricultural Pumpage**	**M&I and Rural Domestic Pumpage**	**Agricultural Pumpage**
Mean	1,500	3,400	1,900	3,800
Minimum	1,000	2,200	1,900	3,100
Maximum	2,100	4,600	2,000	4,300
Median	1,400	3,500	1,900	3,900

[a] Values are rounded to nearest 100.

3.4.1.3 Groundwater Storage Change

Figure 3-36 shows the entire groundwater water budget and the annual change of groundwater in storage. Change of groundwater in storage is equal to total inflow minus total outflow in the groundwater budget. A negative change of groundwater in storage indicates groundwater-storage depletion while a positive value indicates groundwater-storage accretion. **Table 3-10** shows the annual change of groundwater in storage for the historical and current time periods. On average, the historical period shows a negative change of groundwater in storage with a larger magnitude negative change of groundwater in storage during the current period, which includes the recent drought. The two largest drops in groundwater storage occurred in the drought of WY 1976–1978 and the largest increase in groundwater storage was the year following that drought (WY 1978; **Figure 3-36**). By about WY 1983, the cumulative change in groundwater storage rebounded to the initial storage from WY 1970. The groundwater storage decline has continued since WY 1983, with short temporary phases of storage recovery, to decrease to a total cumulative storage change of -14,000 acre-feet for water years 1970–2018.

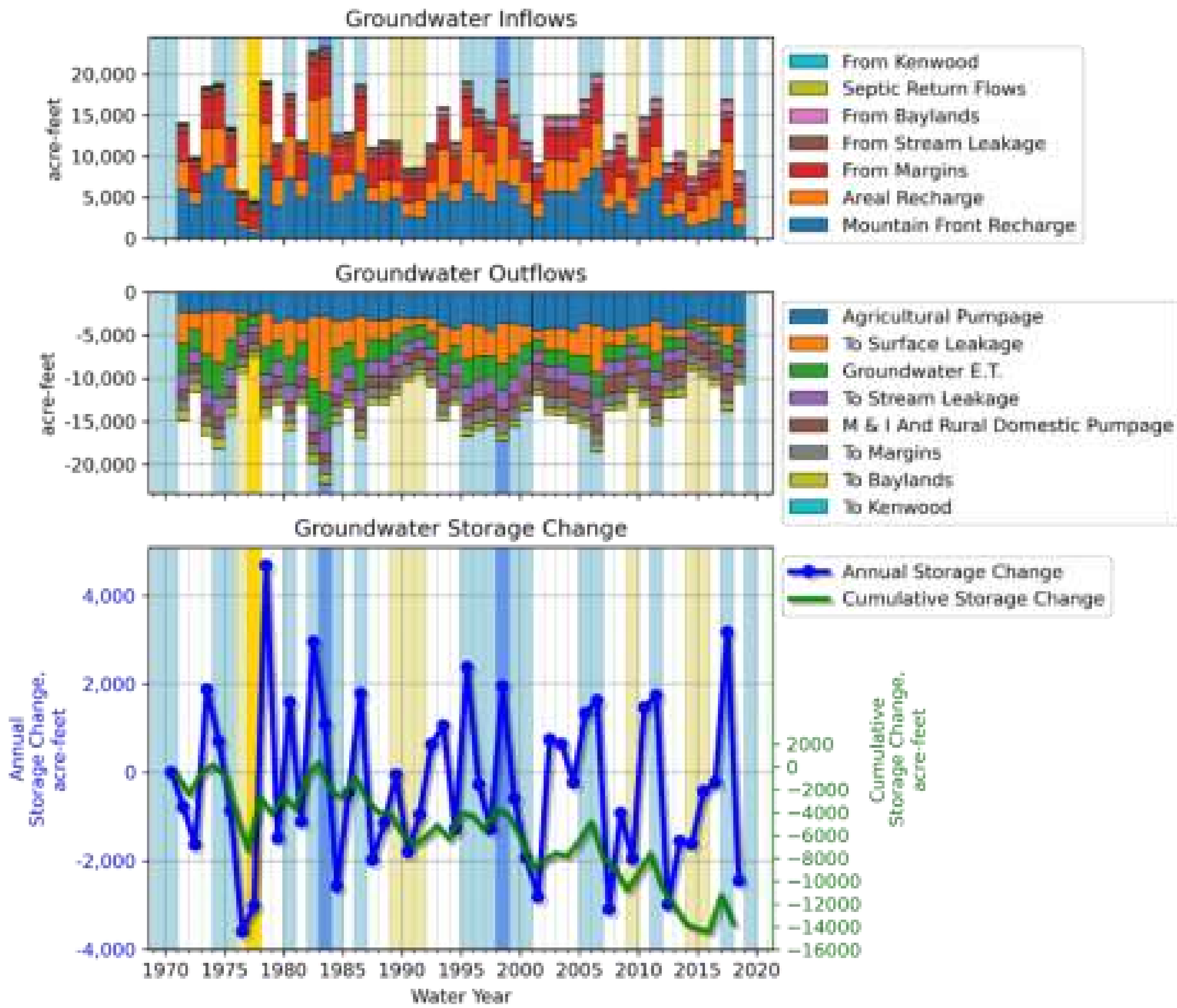

Figure 3-36. Simulated Historical and Current Groundwater Budget Components and Cumulative Change in Groundwater Storage.

Table 3-10. Average Annual Change in Groundwater Storage (AFY)[a][b]

	Historical (WY 1971 to WY 2018)	Current (WY 2012 to WY 2018)
Mean	-300	-900
Minimum	-3,600	-3,000
Maximum	4,700	3,200
Median	-500	-1,600

[a] Values may not equal inflows minus outflows due to rounding.
[b] Values are rounded to nearest 100.

Figure 3-37 illustrates how selected water budget terms (for example, net groundwater discharge to streams and inflow from the Margins and Baylands) respond to both an increase in groundwater pumpage and a variable, if not subtly declining total recharge (mountain-front plus areal recharge; the yellow line on **Figure 3-37** is the 10-year running mean). Evident in the net groundwater discharge to streams timeseries is a declining trend from water year 2007 to water year 2018 where the value declined by about 50 percent. This trend corresponds to a similar decrease in total recharge (**Figure 3-37**). Inflow from the Margins follows a similar trend as the net groundwater discharge to streams, whereas inflow from the Baylands increases from 1995 to 2010 and remains steady to 2018. The former may be related to the decrease in total groundwater recharge (probably mountain-front recharge; **Figure 3-37**) and the latter may be related to the increase in groundwater pumpage (**Figure 3-37**).

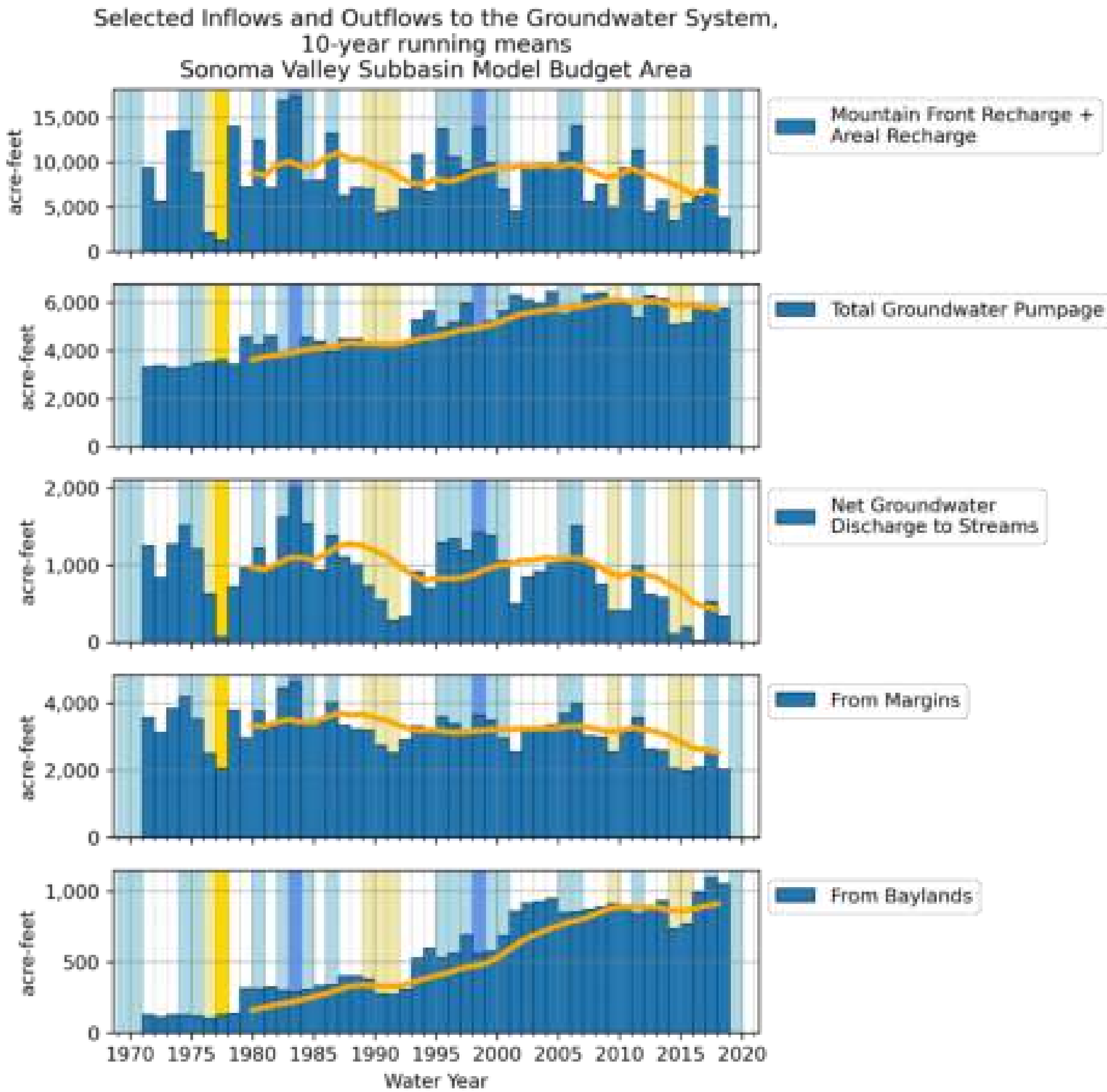

Figure 3-37. Selected Simulated Groundwater Inflows and Outflows

3.4.1.4 Water Budget Summary

The main groundwater inflows into the Subbasin are: (1) mountain-front recharge, (2) areal recharge, and (3) inflows from the margins. Together these inflows constitute 87 percent of the average historical inflows into the Subbasin. Streambed recharge to groundwater, subsurface inflow from the Baylands, and septic return flows and subsurface inflows from Kenwood are smaller inflows compared to the others. Agricultural pumpage, surface leakage, and groundwater ET comprise about 61 percent of groundwater outflows. The smaller outflow terms are groundwater discharge to streams, subsurface outflow to adjacent areas outside of the Subbasin, and M&I and rural domestic pumpage.

Overall, the groundwater outflows are greater than the groundwater inflows, resulting in an estimated decline in groundwater storage in both the historical and current water budget periods (**Figure 3-36**). The historical (water years 1971–2018) average annual change in storage was -300 AFY, whereas the current (water years 2012–2018) average annual change in groundwater storage was -900 AFY. For the historical period, storage depletion was about 6 percent of the average total groundwater pumpage. For the current period, storage depletion was about 16 percent of the average total groundwater pumpage.

From 1995 to 2018, total groundwater pumpage has increased from 4,900 AFY to 5,700 AFY, while in that same period recharge from mountain-front recharge and areal recharge peaked in about 2005 and dropped again by 2018. Net groundwater discharge to streams and inflows from the margins have responded similarly to each other in this period, reaching their minimums in water year 2018. Meanwhile inflow from the Baylands follows a similar trend to that of the total groundwater pumpage, growing from about 500 AFY in 1995 to about 900 AFY by 2010, and increasing to over 1,000 AFY in 2018.

A comparison of the historical water budget and current water budget shows greater stress on the Subbasin in the current period than historically on average. Conditions are drier in the current periods with approximately 10 percent less precipitation. This, along with other consumptive uses in the mountain-front sub-catchment areas, results in approximately 33 percent less recharge to groundwater in the Subbasin. Meanwhile, pumpage increased 16 percent in the current period compared to the historical period.

3.4.2 Subbasin Water Supply Reliability

Based on analysis conducted for Sonoma Water's 2020 UWMP (Sonoma Water 2021), Sonoma Water has adequate water supply to deliver imported surface water through the 2045 planning horizon analyzed in the 2020 UWMP. The exception are single-dry years, starting after 2025. For single-dry years, model simulations predict that storage levels in Lake Sonoma will drop below 100,000 AF prior to July 15th, thus requiring demand curtailments by Sonoma Water customers per SWRCB Decision 1610 (SWRCB 1986) for some portion of the year. In these circumstances, Sonoma Water will work with its customers to reduce demands on the imported surface water. Based on efforts over the last 5 years during dry conditions, Sonoma Water does not anticipate any difficulty in maintaining an adequate supply of imported surface water during the single-dry year. The magnitude of these single-dry year potential shortfalls is estimated to be about 19 percent of average annual demand by 2045. This condition is accounted for in the baseline projected water budget developed for this GSP by assuming higher levels of groundwater demands from Sonoma Water contractors during dry conditions.

3.4.3 Uncertainties in Water Budget Calculations

The level of accuracy and certainty is highly variable between water budget components. A few water budget components are directly measured, but most water budget components are estimated as input to the model or simulated by the model. Both estimated and simulated values are based on assumptions and there is additional model uncertainty for simulated results. Model uncertainty stems from an imperfect representation of natural conditions and is reflected in model calibration error. However, inputs to the model are carefully selected using best available data, the model's calculations represent the established science and mathematical calculations for groundwater flow, and the model calibration error is within acceptable bounds. Therefore, the model is the best available tool for estimating water budgets.

The following bullet list provides groups of water budget components in descending order of uncertainty; simulated components based on the calibrated model have the most uncertainty because those simulated results encompass uncertainty of other water budget components used in the model in addition to model calibration error:

- Measured: metered municipal and some small water system pumpage.
- Estimated: non-municipal domestic pumpage and septic system return flow, including depth and location
- Simulated by external BCM model based on climate data: precipitation, potential
- Simulated based on calibration model: actual ET, irrigation pumpage, including depth and location
- Simulated based on calibrated model: all other water budget components

Generally when using climate information for groundwater sustainability analysis, it is best to use multiple GCMs to characterize the range of change and to account for the role of natural climate variability and differences in this variability between models and historical observations, as well as better assess uncertainty in the projections ("ensemble average"). The 10 GCMs selected by the DWR Climate Change Technical Advisory Group (CCTAG) for the quality of their simulation of California's climate is a recommended data set. However, simulation of these 10 GCMs combined with two emission scenarios for water planning projects is still unrealistic for many practical applications in which climate change is not the main assessment driver.

3.4.4 Projected Water Budgets

SGMA Legislation and GSP Regulation requirements for projected water budgets are as follows:

- Simulate projected groundwater conditions 50 years into the future
- Incorporate projections of land use change, climate change, and other changes in groundwater demands (such as population increase)

The results of the projected conditions simulation will be used to assess how the sustainability indicators respond to the changing climate and groundwater demands in the future. If undesirable results are simulated to occur, the GSP will need to plan for projects and management actions that respond to the undesirable results.

Projected water budgets will be useful for showing that sustainability will be achieved in the 20-year implementation period and maintained over the 50-year planning and implementation horizon.

3.4.4.1 Method and Assumptions used to Develop Projected Water Budgets

Future projected conditions are based on model simulations using the SVIGFM V2 numerical flow model and using estimates of:

- Projected land use changes
- Projected population growth
- Projected climate change

Future Projected Land Use Change and Water Demand Assumptions

Projected land use changes and water demands were partly based on input from several workgroups, surveys, and from the Advisory Committee. Municipal purveyors (City of Sonoma and Valley of the Moon Water District) provided ranges of projected demands based on combination of historical and potential future use. Each set of projected data are described along with assumptions and results are provided in **Appendix 3-E**.

As further described in **Appendix 3-E**, the following steps were taken to capture these ranges and incorporate potential climate variability in the model:

- Annual future pumping was varied based on projected future climate year classifications (very dry, dry, normal, wet, very wet) using the calculated standard deviation from historical pumping records because both municipal purveyors have surface water and groundwater sources.
- Applied patterns of seasonality of groundwater production were based on historical wellfield operations.

Projected Climate Change Simulation Approach

SGMA requires the incorporation of climate change (including sea-level rise) as a potential projected future climate scenario for purposes of "stressing the system" and identifying uncertainties in future conditions when including projects and management actions and identifying SMC. For this first GSP, after review of DWR Climate Change Guidance and consideration of Staff, Advisory Committee, and Board recommendations, the GSA decided to choose one potential climate change scenario to limit the number of simulations and provide better comparability between various potential projects and actions. During the first 5-year GSP evaluation and assessment, the status of climate change science will be assessed, and the use of different climate futures will be considered, as appropriate.

The overall approach for selecting and simulating projected climate change can be summarized as follows:

1. Choose Projected GCM with a specific Greenhouse Gas Emission Scenario
    a. Review DWR recommended GCMs and chose one GCM and emissions scenario that best represents projected median conditions in Russian River Watershed area (including groundwater basins)
2. Update model inputs for:
    a. Precipitation
    b. Temperature/ET
    c. Surrounding watershed runoff and groundwater inflow
    d. Sea-level rise boundary condition at San Pablo Bay
3. Use climate data in model to:
    a. Define precipitation and calculate potential ET and actual evaporation and transpiration
    b. Calculate projected irrigation water demands and groundwater pumping
    c. Evaluate effects of projected sea-level rise on groundwater levels

Projections of future climate conditions are generally performed through GCMs forced with specific global greenhouse gas emission scenarios (IPCC 2013). Sea-level rise assumptions were developed and applied separately.

<u>GCM Projection</u> – The projections reviewed for purposes of developing this GSP relied upon available climate projections using the models and emissions scenarios included in the Coupled Model Intercomparison Project 5 (CMIP5). Twenty individual downscaled GCM projections were reviewed using ten different GCMs and two different Representative Concentration Pathways (RCPs), RCP4.5 and RCP8.5. The 10 GCMs were chosen by DWR CCTAG based on a regional evaluation of climate model ability to reproduce a range of historical climate conditions (DWR CCTAG 2015). For GSP planning purposes, it is desirable to identify projected climate scenarios that more specifically represent the climate and hydrologic conditions within the Russian River

watershed and Sonoma County. The evaluation identified the HadGEM2-ES GCM as best representing the middle of the ensemble for mean climate and hydrologic metrics for the Russian River watershed, as it did not stray to any of the extremes for other metric rankings.

Greenhouse Gas Emissions Scenario – Emissions scenarios are possible pathways that society might take in the emission of greenhouse gases in the future. Each are categorized as a RCP. DWR has recommended the use of two potential RCPs: RCP 4.5 and RCP 8.5. RCP 4.5 is sometimes considered “most likely” based on current projections of greenhouse gas emissions, and RCP 8.5 is often known as the “worst-case scenario.” However, experts and scientists may differ on this. Based on a review of groundwater model results from simulating the combination of each RCP with the chosen HadGEM2-ES GCM, and a discussion with the Advisory Committee and GSA Board, RCP 8.5 was selected for this GSP, as the HadGEM2-ES RCP 8.5 simulation provides a long-term drought after mid-twenty-first century that allows for a significant stress test for groundwater resources planning during the GSP implementation horizon.

Sea-Level Rise Assumptions – Future sea-level rise due to climate change may impact groundwater conditions beneath and upgradient (north) from San Pablo Bay. Sea-level rise guidance provided by the California Natural Resources Agency (CNRA 2018) was used to provide a sea-level rise trajectory to be simulated. The SVIGFM V2 was modified to simulate the 1-in-200 change (0.5 percent probability) sea-level rise trajectory under the high-emissions scenario, which results in a projected sea-level rise of 3.5 feet at the end of the projected 50-year water budget. The choice of the 1-in-200 change scenario is consistent with: (1) the choice of emissions scenario considered for future climate to be simulated by the model and (2) sea-level rise assumptions used for the Sonoma Creek Baylands Strategy (Sonoma Land Trust and San Francisco Bay Restoration Authority 2020). Exchange between the aquifer and San Pablo Bay is simulated in both the historical and future period as a head-dependent flow using the General Head Boundary package. Future sea-level rise was simulated by converting the 1-in-200, high-emissions sea-level rise trajectory to freshwater equivalent head and adding to the historic freshwater equivalent head used in the SVIGFM historical simulation.

Projected climate based on the selected GCM and emissions scenario represents water year 2021 through 2070.

Modifications to Modeling Platform to Simulate Future Projected Conditions

The SVIGFM V2 input files were modified to simulate future projected land use and climate as described above. **Appendix 3-A** provides a detailed summary of how future conditions were incorporated into the model, including projected climate summaries.

3.4.4.2 Projected Surface Water Budget

Precipitation is the main input that drives the changes to the surface water budget in the projected simulation compared to historical simulation. **Figure 3-38** compares historical and projected mean precipitation for the Subbasin. Projected mean annual precipitation is slightly higher than mean annual precipitation over the historic period.

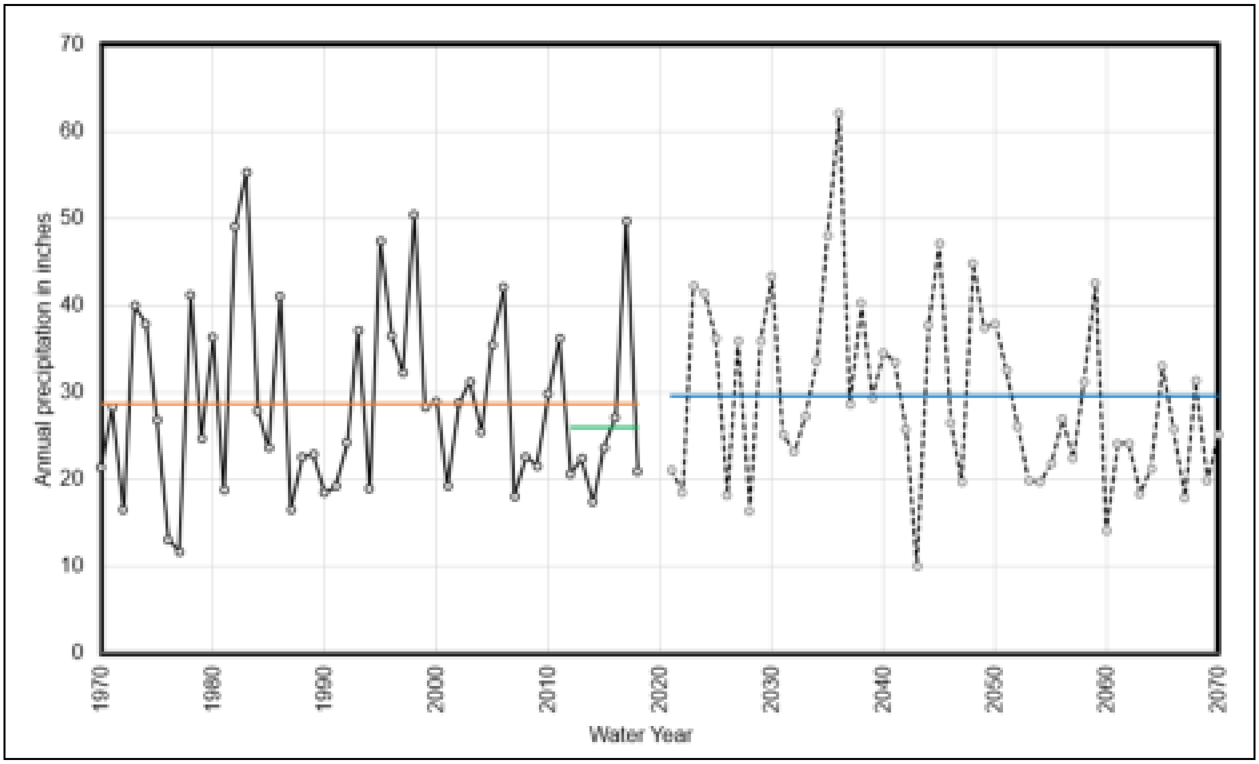

Figure 3-38. Projected Mean Precipitation Under Future Climate Scenario

Projected precipitation from water year 2021 through 2050 includes a number of years with above average precipitation. However, from 2050 to 2070, only 4 years have above average precipitation and 5 years are characterized as dry.

Figure 3-39 shows projected surface water inflows, overland runoff, groundwater inflows, and mountain-front runoff to the Subbasin. For reference, color codes representing projected water year type (based on the classification described in **Appendix 3-A**) are also included on **Figure 3-39** and the subsequent figures for reference.

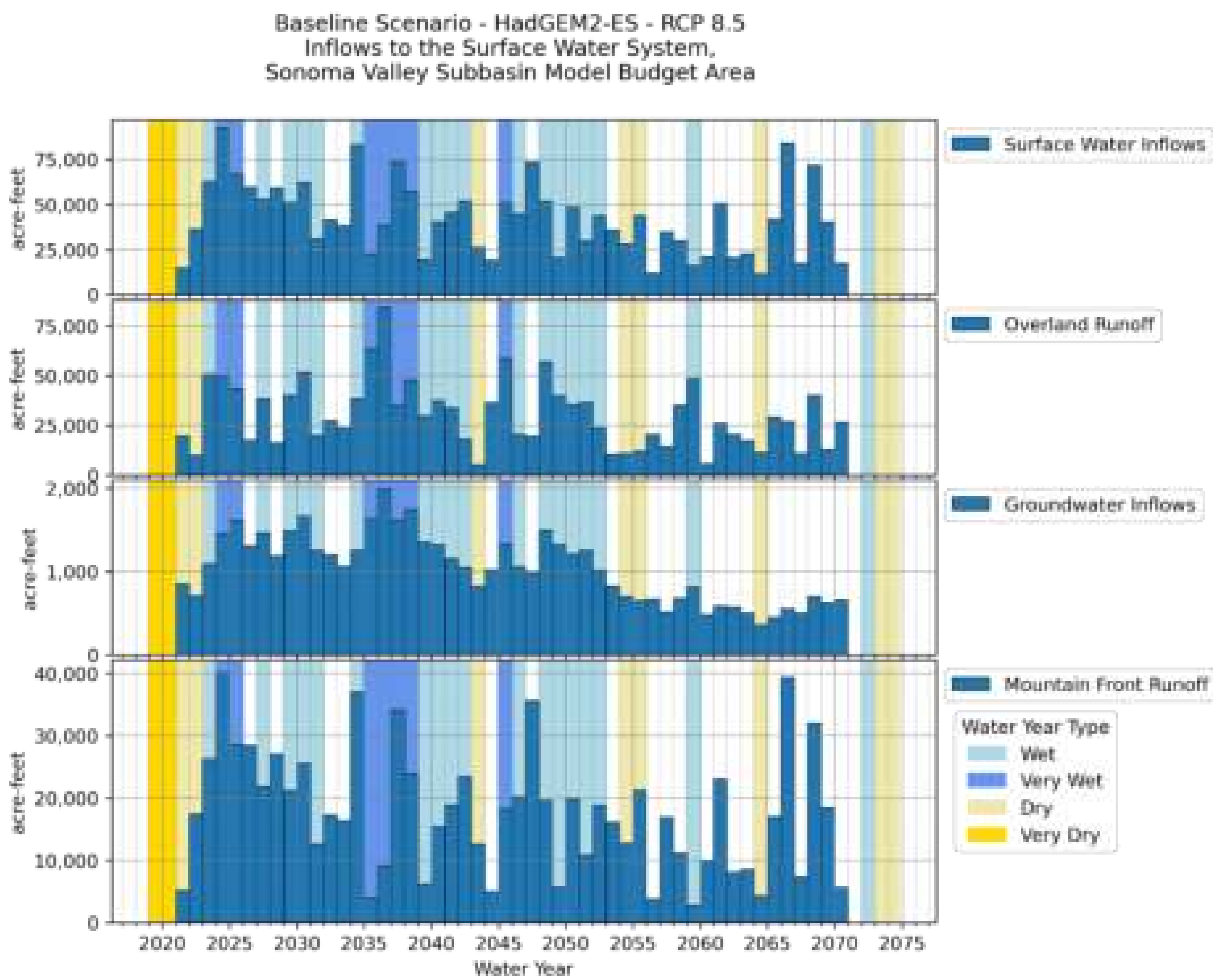

Figure 3-39. Projected Surface Water Inflows

Table 3-11 provides summary statistics of projected surface water inflow components. Mean annual surface water inflow from streams, overland flow, and mountain-front runoff are all higher in the future period compared with the current period (**Table 3-11**). Mean annual groundwater discharge to streams is lower in the future period compared with the current period (**Table 3-11**).

Table 3-11. Historical (WY 1971–WY2018), Current (WY 2012–WY2018), and Projected (WY 2021–WY 2070) Surface Water Inflows (AFY)[a]

	Surface water inflow from streams	Overland flow	Groundwater discharge to streams	Mountain-Front Runoff
Historical and Current Periods				
Mean, Historical Period	43,000	32,200	1,700	16,500
Mean, Current Period	33,800	26,200	1,200	14,200

	Surface water inflow from streams	Overland flow	Groundwater discharge to streams	Mountain-Front Runoff
Future (Projected) Period				
Mean	42,300	30,100	1,000	17,700
Minimum	11,500	5,100	400	2,800
Maximum	92,400	83,900	2,000	40,100
Median	40,900	27,100	1,100	17,300

[a] Values rounded to nearest 100.

Figure 3-40 shows projected surface water outflows, surface water diversions, and seepage to groundwater from the Subbasin. **Table 3-12** provides summary statistics for projected surface water outflows. Surface water outflows and seepage to groundwater are higher in the future period compared to the current period. Projected surface water diversions are unchanged from the current period because it is assumed that surface water diversions/rights will remain unchanged over the projected period.

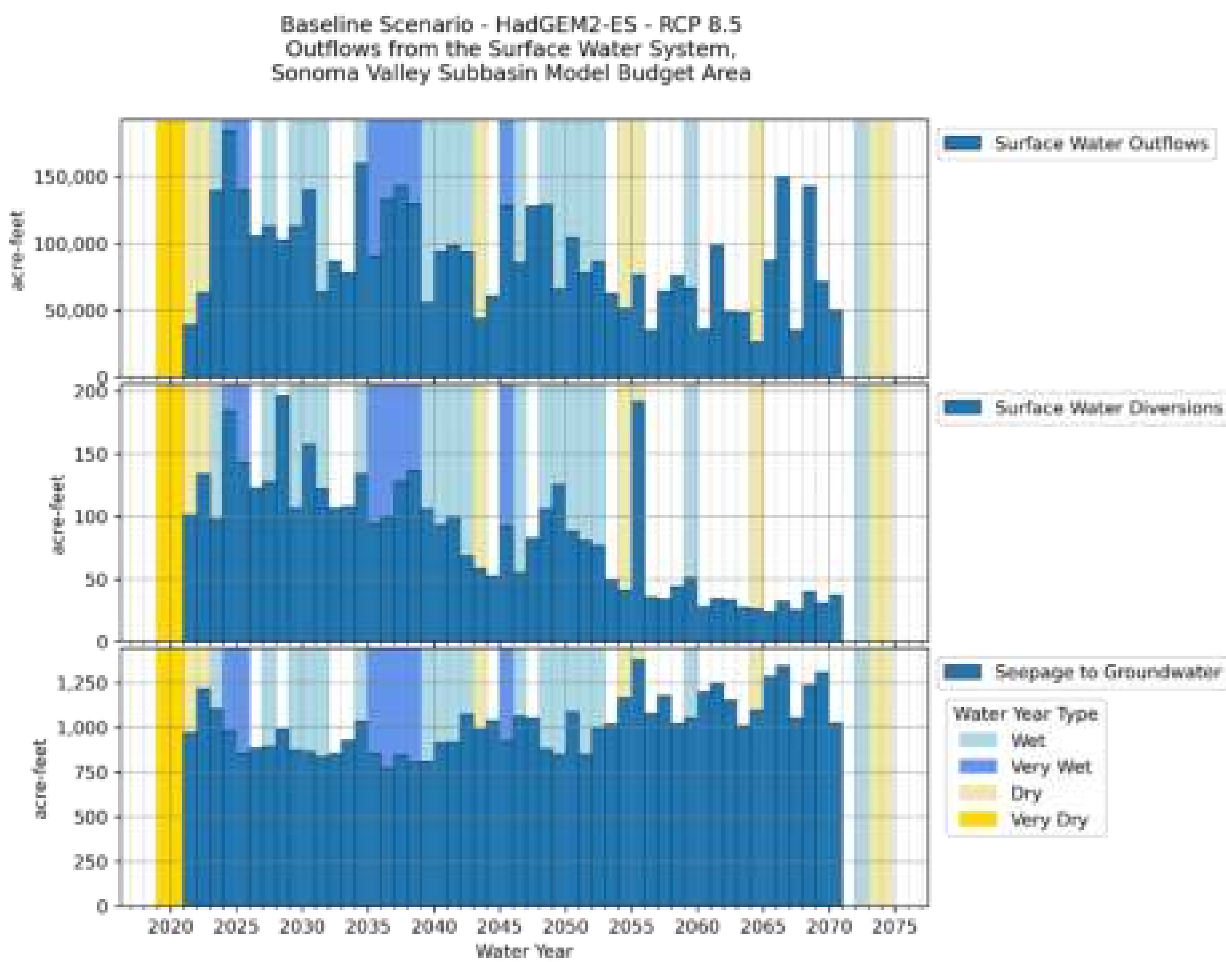

Figure 3-40. Projected (WY 2021–WY 2070) Surface Water Outflows

Table 3-12. Historical (WY 1971–WY 2018), Current (WY 2012–WY 2018), and Projected (WY 2021–WY 2070) Surface Water Outflows (AFY)[a]

	Surface Water Outflows	Surface Water Diversions	Seepage to Groundwater
Historical and Current Periods			
Mean, Historical Period	92,500	100	800
Mean, Current Period	74,500	100	800
Future (Projected) Period			
Mean	90,100	100	1,000
Minimum	26,100	0	800
Maximum	183,600	200	1,400
Median	86,500	100	1,000

[a] Values rounded to nearest 100.

3.4.4.3 Projected Groundwater Budget

Figure 3-41 shows projected groundwater inflows to the Subbasin. **Table 3-13** provides summary statistics for projected groundwater inflows. Projected inflows for all inflow components, except for inflow from the Kenwood basin, exceed the equivalent inflows during the current period. The two components with the largest increases are inflow from the Baylands and mountain-front recharge.

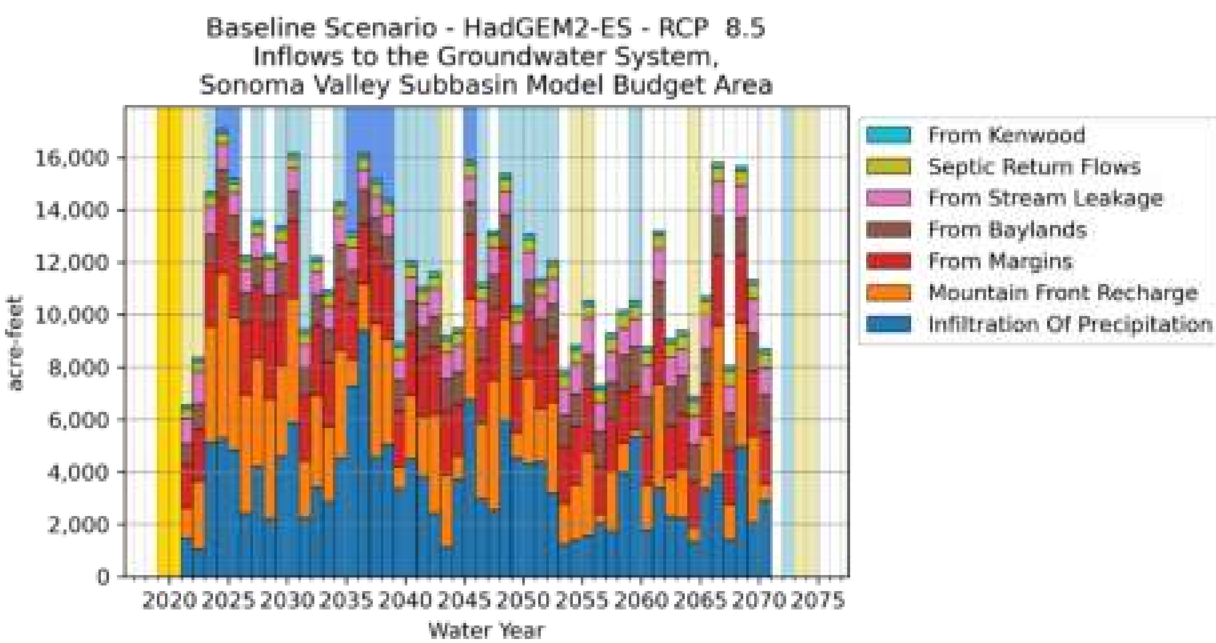

Figure 3-41. Projected Groundwater Inflows

Table 3-13. Summary Statistics for Historical (WY 1971–WY 2018), Current (WY 2012–WY 2018), and Projected (2021-2070) Groundwater Inflows (AFY)[a]

	From Baylands	From Kenwood	From Margins	Septic Return Flows	From Stream Leakage	Areal Recharge	Mountain -Front Recharge
Historical and Current Periods							
Mean, Historical Period	600	100	3,200	300	800	3,600	5,100
Mean, Current Period	900	200	2,300	300	800	3,300	2,500
Future (Projected) Period							
Mean	1,300	200	2,400	500	1,000	3,500	2,800
Minimum	800	200	1,700	400	800	1,100	300
Maximum	1,500	200	2,900	600	1,400	9,400	6,300
Median	1,200	200	2,400	500	1,000	3,400	2,800

[a] Values rounded to nearest 100.

Figure 3-42 shows projected groundwater outflows from the Subbasin. **Table 3-14** provides summary statistics for projected groundwater outflows. Outflow to the Baylands, agricultural pumpage, and M&I and rural domestic pumpage during the future period exceed the equivalent outflows during the current period. Of those outflows, agricultural pumpage shows the largest increase of 500 AFY. Projected groundwater ET, leakage to streams, and surface leakage are lower than during the current period. Outflow to the margins is the same during the current and future periods.

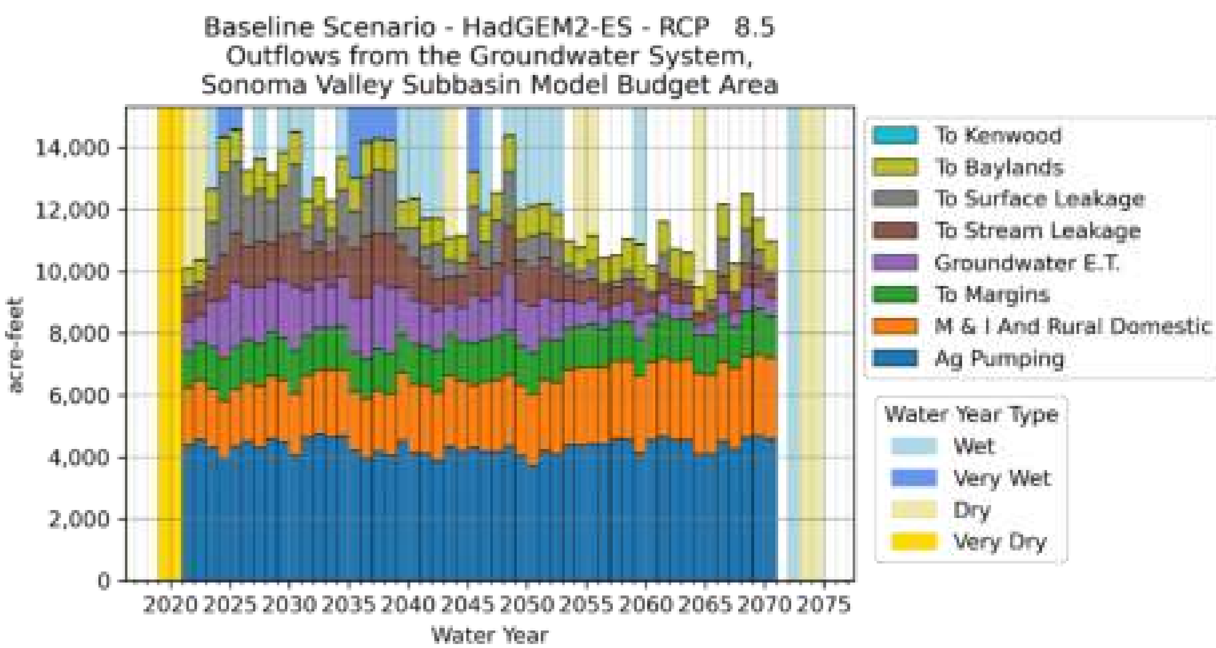

Figure 3-42. Projected Groundwater Outflows

Table 3-14. Summary Statistics for Historical (WY 1971–WY 2018), Current (WY 2012–WY 2018), and Projected Groundwater Outflows (AFY)[a]

	To Baylands	Groundwater ET	To Kenwood	Agricultural Pumpage	To Margins	To Stream Leakage	To Surface Leakage	M&I and Rural Domestic Pumpage
Historical and Current Periods								
Mean, Historical Period	800	2,300	0	3,400	1,300	1,700	2,700	1,500
Mean, Current Period	800	1,300	0	3,800	1,300	1,200	1,000	1,900
Future (Projected) Period								
Mean	900	1,200	0	4,300	1,300	1,000	900	2,200
Minimum	600	300	0	3,700	1,100	400	100	1,800
Maximum	1,100	2,100	0	4,800	1,500	2,000	2,600	2,600
Median	900	1,300	0	4,400	1,300	1,100	800	2,300

[a] Values rounded to nearest 100.

Figure 3-43 shows projected groundwater pumpage by water-use sector. **Table 3-15** provides summary statistics for groundwater pumpage by water-use sector. Groundwater pumpage is projected to increase for both the combined M&I/rural domestic sector and for the agricultural sector compared to the current period. Mean agricultural pumping is projected to increase by 500 AFY, which is primarily due to an increase in crop ET and agricultural water demands. M&I and rural domestic pumping is projected to increase by 300 AFY on average, due to anticipated population growth.

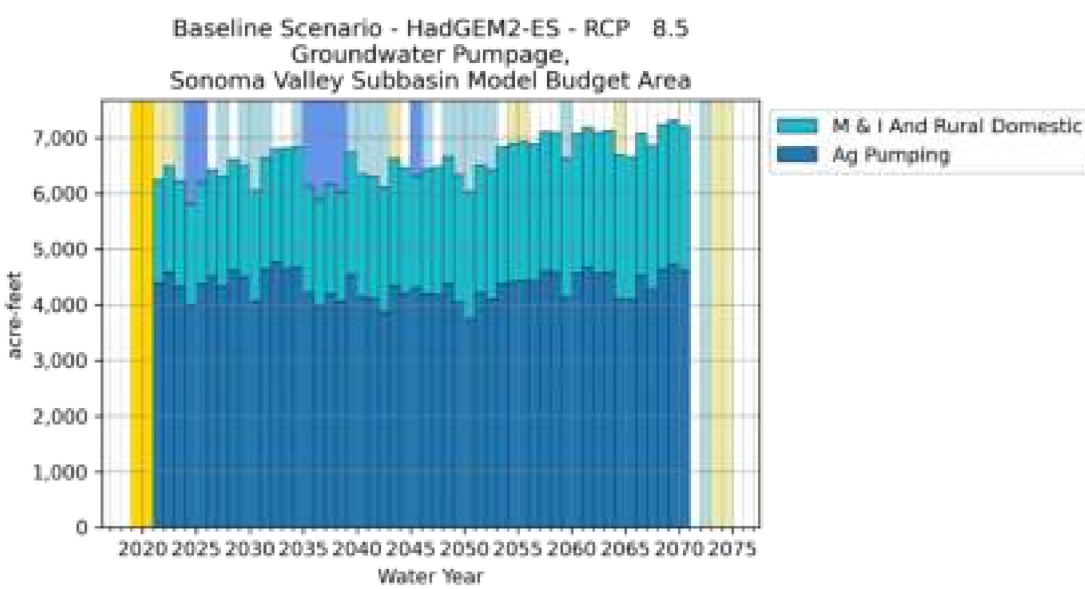

Figure 3-43. Projected Groundwater Pumping by Water-Use Sector

Table 3-15. Summary Statistics for Historical (WY 1971–WY 2018), Current (WY 2012–WY 2018), and Projected Groundwater Pumping (AFY)[a]

	M&I And Rural Domestic Pumpage	Agricultural Pumpage
Historical and Current Periods		
Mean, Historical Period	1,500	3,400
Mean, Current Period	1,900	3,800
Future (Projected) Period		
Mean	2,200	4,300
Minimum	1,800	3,700
Maximum	2,600	4,800
Median	2,300	4,400

[a] Values rounded to nearest 100.

3.4.4.4 Projected Storage Change

Figure 3-44 shows projected groundwater inflow and outflows by water budget category, projected annual change in groundwater storage, and projected cumulative change in groundwater storage relative to the beginning of the historical period (water year 1971). **Table 3-16** provides summary statistics for annual changes in groundwater storage.

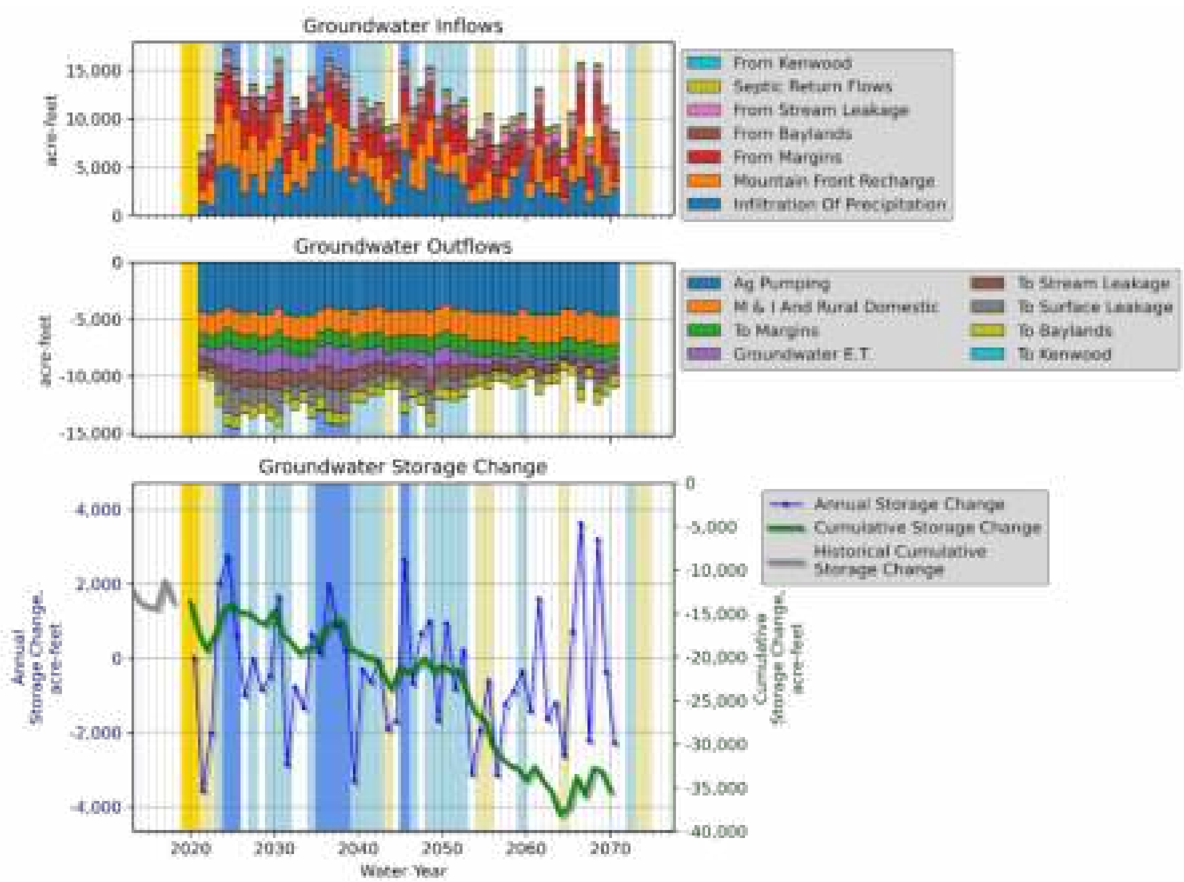

Figure 3-44. Projected Groundwater Budget and Change in Groundwater Storage

Table 3-16. Summary Statistics for Historical (WY 1971–WY 2018), Current (WY 2012–WY 2018), and Projected (2021–2070) Annual Change in Groundwater Storage (AFY)[a]

Historical and Current Periods	
Mean, Historical Period	**-300**
Mean, Current Period	**-900**
Future Period	
Mean	-400
Minimum	-3,600
Maximum	3,600
Median	-600

[a] Values rounded to nearest 100.

The projected cumulative groundwater storage change on **Figure 3-44** exhibits a modest decline from 2021 through 2050, with stable or even brief increases in groundwater storage associated with wet and very wet periods in the projected climate. The projected climate used for the projected water budgets includes an extended drought beginning in 2050 (**Figure 3-38**). As a result, the cumulative groundwater storage loss is greater from 2050 through 2070 (approximately -13,000 acre-feet) than during 2021 through 2050 (approximately -8,000 acre-feet). The total cumulative storage change between 2021 and 2070 is projected to be -21,000 acre-feet with the selected climate change projections and assumed water demand increases.

The mean annual change in groundwater storage over the future period is -400 AFY. The projected rate of annual groundwater storage loss is substantially lower than the rate of groundwater storage loss during the relatively dry current period (900 AFY; **Table 3-10**).

3.4.4.5 Projected Water Budget Summary

The relative importance and magnitude of the groundwater budget inflow and outflow components is generally similar between the current and future periods, with mountain-front recharge, areal recharge, and inflow from the Margin providing the bulk of groundwater inflows. Mean annual mountain-front recharge is higher during the future period compared to the current period. This is due to the projected climate scenario, which is characterized by mean annual precipitation (over the entire future period, 2021–2070) that is slightly higher than historic precipitation.

Projected groundwater demand in the M&I, rural domestic, and agricultural water-use sectors is greater than groundwater demand during either the historic or current period. Continuing growth in agricultural groundwater demand is driven by projected land use changes, and the climate scenario, which is characterized by higher temperatures and, therefore, higher crop irrigation requirements. Continuing growth in M&I and rural domestic demand is driven by projected population growth over the future period.

Groundwater outflows exceeded inflows during the current period, and these conditions are projected to continue through the future period under baseline conditions. As a consequence, the rate of projected groundwater storage loss is similar between the historical period and the first 30 years of the future period. From 2050 through 2070, projected groundwater storage loss accelerates due to projected below-average precipitation and corresponding reductions to groundwater inflows.

3.4.4.6 Uncertainties in Projected Water Budget Simulations

Generally when using climate information for water resources analysis, a common and valuable approach is to apply multiple GCMs to characterize the range of change and to account for the role of natural climate variability, as well as better assess uncertainty in the projections. The 10 GCMs selected by the DWR CCTAG for the quality of their simulation of California's climate is a recommended data set. However, simulation of these 10 GCMs combined with two emission scenarios (20 total simulations) is unrealistic for many practical applications, such as for water planning projects, in which climate change is not the main assessment driver.

Changes in the projected water budgets compared with the historic and current water budgets reflect assumptions about future population growth, land use, and climate. These assumptions reflect the best information currently available but are inherently uncertain. Consequently, the projected water budgets detailed in this GSP are uncertain as well. Actual future land use changes, water demand estimates, and potential alternate climate projections will be tracked and evaluated during implementation of the GSP, and revisions and updates to the projected water budget assumptions will be considered for future GSP updates to reduce this uncertainty, as described in **Section 7** (Implementation Plan).

3.5 Sustainable Yield

The sustainable yield of the Subbasin is an estimate of the quantity of groundwater that can be pumped on a long-term average annual basis without causing undesirable results. Basinwide pumping within the sustainable yield estimate is neither a measure of, nor proof of, sustainability. Sustainability under SGMA is only demonstrated by avoiding undesirable results for the six applicable sustainability indicators in the Subbasin. However, estimates of sustainable yield using the historical simulations may prove useful in estimating the need for projects and management actions to help achieve sustainability.

The role of sustainable yield estimates in SGMA, as described in the SMC BMP (DWR 2016), are as follows:

> "In general, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. Sustainable yield is referenced in SGMA as part of the estimated basinwide water budget and as the outcome of avoiding undesirable results.
>
> Sustainable yield estimates are part of SGMA's required basinwide water budget. Section 354.18(b)(7) of the GSP Regulations requires that an estimate of the basin's sustainable yield be provided in the GSP (or in the coordination agreement for basins with multiple GSPs). A single value of sustainable yield must be calculated basinwide.

This sustainable yield estimate can be helpful for estimating the projects and programs needed to achieve sustainability."

The 16-year period from WY 2025 to 2040 is used to determine the sustainable yield of the Subbasin (**Figure 3-45**). This period is selected based on the following factors:

- The sustainable yield is derived from a portion of the Projected Baseline conditions that include impacts of climate change. The selected period is representative of long-term conditions. There is a mix of wet (5, 31 percent), very wet (1, 6 percent), dry (1, 6 percent), and normal years (9, 56 percent), during a warming climate
- Simulated net groundwater storage change is greater than zero
- There are no simulated undesirable results related to chronic lowering of groundwater during this period.

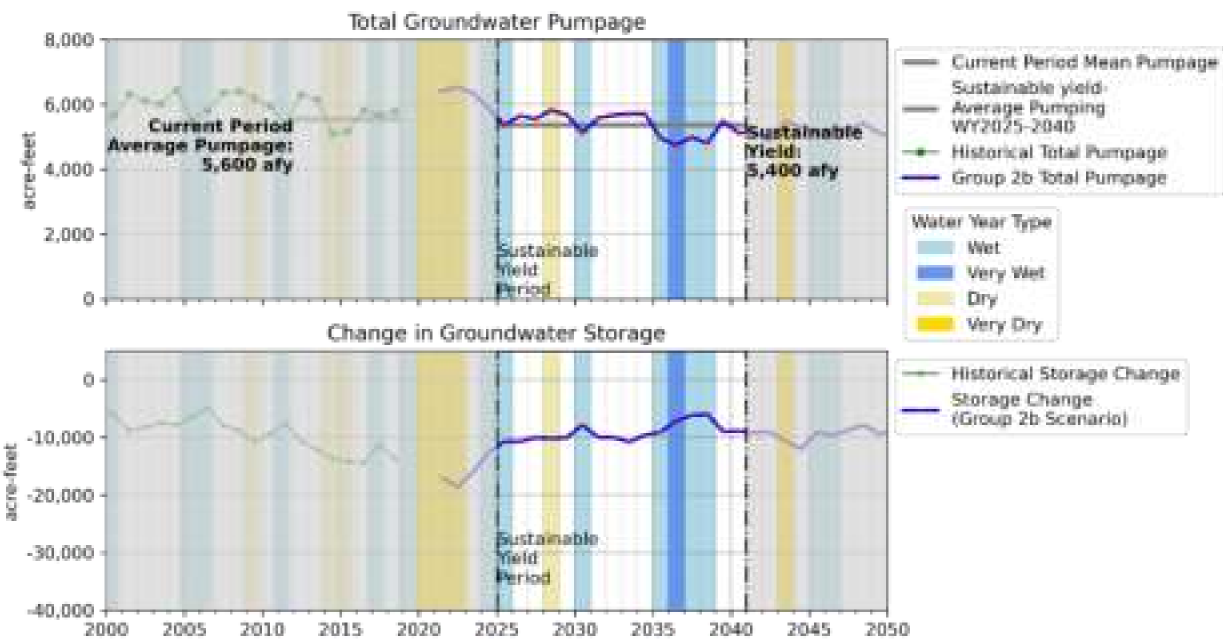

Figure 3-45. Sustainable Yield - Total Groundwater Pumpage and Change in Groundwater Storage

The average total groundwater pumpage for this period is 5,400 AFY, which is defined here as the sustainable yield. This value is 39 percent of the total groundwater inflows into the Subbasin for historic period, and is less than the average total groundwater pumpage that occurred during the current budget period. The sustainable yield for the Subbasin is predicated on the implementation of Group 2b projects. The Group 2b projects are summarized in **Appendix 6-A and 6-B**. The Group 2b scenario includes the projects from Group 1 and Group 2a. The projects implement a combination of conservation, aquifer storage and recovery, managed aquifer recharge, and increased delivery of recycled water to avoid undesirable results. The total volume of water provided by the implementation of the projects is 824 AFY by the end of the implementation period, at WY 2040. This excludes the impact of the conservation measures implemented in Group 1. All but one of the implemented projects has a start date before the beginning of the Sustainable Yield period. A recycled water project would begin delivery of 142AFY at WY2035, or 10 years into the period. The prorated average volume of project water is 735AFY for the 16-year period. During the implementation phase of the GSP, when sufficient water cannot be delivered or recharged, the sustainable yield will likely be smaller than 5,400 AFY. Conversely, during years of increased recharged water, the sustainable yield may increase.

The sustainable yield is dependent on the climate conditions during this period (Loaiciga 2016). If future climate conditions are better represented by the hotter and drier conditions observed in the WY 2050–WY 2070 period of the projected scenario rather than the wetter WY 2025–WY 2040 period, then the sustainable yield will need to be reduced, further projects and management actions will need to occur, or both, to allow for the Subbasin to avoid undesirable results.

The sustainable yield pertains to a basinwide pumping value. Changes in the location of pumping may induce greater depletion of surface waters or movement of waters of poor water quality, for example, which may lead to undesirable results. As described in Section 7, the water budget and estimated sustainable yield will continue to be evaluated with new information and alternative climate scenarios during the five-year GSP updates. Additionally, while the initial minimum thresholds for depletion of interconnected surface water are not projected to be exceeded during this time period, these will also be further refined during the five-year GSP update in order to better account for the potential impact of basinwide pumpage on surface-water depletion.

3.6 Management Areas

SGMA provides GSAs with the ability to define one of more management areas within a basin if the GSA determines that the creation of management areas will facilitate implementation of the GSP. Management areas can be used to define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin (23 CCR 354.20).

Management areas were not defined for the Subbasin. Management areas may be considered in the future if the GSA finds that doing so will facilitate implementation of the GSP.

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Section 4: Sustainable Management Criteria

Groundwater Sustainability Plan
Sonoma Valley Groundwater Subbasin

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4 SUSTAINABLE MANAGEMENT CRITERIA

This section identifies the sustainability goal, defines the conditions that constitute sustainable groundwater management, discusses the process by which the GSA will characterize undesirable results, and establishes minimum thresholds (MTs) and measurable objectives (MOs) for each applicable sustainability indicator.

The MOs, MTs, and undesirable results detailed in this section define the Subbasin's future desired conditions and inform the selection, prioritization, and planning for projects and management actions to achieve these conditions. Establishing these SMC involved a significant level of technical analysis using currently available data, best available scientific knowledge, and substantial input from stakeholders. This section includes a description of how SMC were developed and how they influence all beneficial uses and users. Uncertainty caused by data gaps in the HCM and existing monitoring networks was considered when developing SMC. Due to this uncertainty, these SMC are considered initial criteria and will be reevaluated and potentially modified in the future as new data become available.

SMC are provided for the following sustainability indicators:

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

Each sustainability indicator subsection follows a consistent format that contains the information required by Section 354.22 et. seq of the GSP Regulations and outlined in the SMC Best Management Practices (BMPs) (DWR 2017). The subsection for each sustainability indicator includes a description of:

- How locally defined significant and unreasonable conditions were developed
- How MTs were developed, including:
  - The information and methodology used to develop MTs, (Section 354.28 [b][1])
  - The relationship between MTs for other sustainability indicators, (Section 354.28 [b][2])
  - Potential effects of MTs on neighboring basins, (Section 354.28 [b][3])
  - Potential effects of MTs on beneficial uses and users, (Section 354.28 [b][4])
  - Relationship of MTs to relevant federal, state, or local standards, (Section 354.28 [b][5])
  - The method for quantitatively measuring MTs (Section 354.28 [b][6])
- How MOs were developed, including:
  - The methodology for setting MOs (Section 354.30)
  - Interim milestones, where applicable (Section 354.30 [a], Section 354.30 [e], Section 354.34 [g][3])
- How undesirable results were developed, including:
  - The criteria for defining undesirable results (Section 354.26 [b][2])

- Potential causes of undesirable results (Section 354.26 [b][1])
- Potential effects of these undesirable results on the beneficial users and uses (Section 354.26 [b][3])

4.1 Definitions

The SGMA legislation and GSP Regulations contain terms relevant to the SMC. These terms are defined in this section based on the GSP Regulations (CCR Title 23 Section 351) and where appropriate, additional explanatory text is provided. This explanatory text is not part of the official definitions of these terms but provides useful clarifications.

- **Interconnected surface water** refers to surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted. Interconnected surface waters are sections of streams, lakes, or wetlands where the groundwater table is at or near the ground surface or surface water body/stream channel bottom. Interconnection between surface water and groundwater may be seasonal.

- **Interim milestone** refers to a target value representing measurable groundwater conditions, in increments of 5 years. Interim milestones are targets such as groundwater elevations that should be achieved every 5 years to demonstrate progress towards sustainability.

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

- **Minimum threshold** refers to a numeric value for each sustainability indicator used to define undesirable results. MTs are indicators of an unreasonable condition. For example, groundwater levels that maintain operational capacity for water wells may be a MT because groundwater levels dropping below levels that significantly impact well production capacities or dewater wells would be an unreasonable condition.

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

- **Significant and unreasonable conditions** is a phrase used to identify conditions that lead to undesirable results but are not specifically defined in the definitions section of the GSP Regulations (Section 351). This expression is often confused with, or used interchangeably with, undesirable results. This GSP defines significant and unreasonable conditions as a narrative description of physical conditions to be avoided; an undesirable result is a quantitative assessment based on MTs. Defining significant and unreasonable conditions early in the process of developing SMC for each sustainability indicator helps set the framework by which the quantitative SMC metrics are determined.

- **Sustainability indicator** refers to any of the effects caused by groundwater conditions occurring throughout the basin that, when significant and unreasonable, cause undesirable results, as described in CWC Section 10721(x). The six sustainability indicators relevant to this Subbasin are chronic lowering of groundwater levels, reduction of groundwater storage, degraded water quality, land subsidence, seawater intrusion, and depletion of interconnected surface waters.

- **Uncertainty** refers to a lack of understanding of the basin setting that significantly affects an agency's ability to develop SMC and appropriate projects and management actions in a plan, or to evaluate the efficacy of plan implementation, and therefore may limit the ability to assess whether a basin is being sustainably managed.

- **Undesirable Result** is one or more of the following effects caused by groundwater conditions occurring throughout the basin, as described in CWC Section 10721(x):

  - Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.

  - Significant and unreasonable reduction of groundwater storage.

  - Significant and unreasonable seawater intrusion.

  - Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.

  - Significant and unreasonable land subsidence that substantially interferes with surface land uses.

  - Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

Undesirable result is not defined in the definitions section of the GSP Regulations (Section 351). However, the regulations' description of undesirable result states that it should be a quantitative description of the combination of MT exceedances that cause significant and unreasonable effects in the Subbasin. Undesirable results should not be confused with significant and unreasonable conditions.

4.2 Sustainability Goal

Per Section 354.24 of the GSP Regulations, the sustainability goal for the Subbasin has three parts:

- A description of the sustainability goal

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

4.2.1 Description of Sustainability Goal

The goal of this GSP is to adaptively and sustainably manage, protect, and enhance groundwater resources, while allowing for reasonable and managed growth through:

- Careful monitoring of groundwater conditions
- Close coordination and collaboration with other entities and regulatory agencies that have a stake or role in groundwater management in the Subbasin
- A diverse portfolio of projects and management actions that ensure clean and plentiful groundwater for future uses and users in an environmentally sound and equitable manner

4.2.2 Measures to Achieve Sustainability Goal

Projects and actions that the GSA has identified as potential measures to be implemented to ensure sustainability are included in **Section 6** of this GSP. These measures include actions proposed to fill data gaps, improve monitoring, and reduce uncertainty to inform future refinement and possible modification of the initial SMC described herein. While all of the identified measures may not be implemented, some combination of these measures will be implemented to ensure the Subbasin is operated within its sustainable yield and achieves sustainability. The measures to achieve sustainability are centered on advancing the following four projects within the Subbasin while also developing and prioritizing demand management policy options for the GSA Board to consider in the early stages of GSP implementation:

- Implementation and assessment of voluntary conservation and groundwater-use efficiency projects
- Implementation of planned recycled water expansion and assessment of additional recycled water irrigation opportunities
- Implementation and planning for ASR projects
- Planning and implementation of stormwater capture and recharge projects

Section 6 also describes the following management actions to supplement the above-described projects:

- Assessment and prioritization of potential policy options, including demand management measures, for future GSA consideration

- Coordination with agricultural groundwater users within the Subbasin to integrate measures that support sustainable groundwater management with Farm Plans that are developed at individual farm sites

The projects and management actions will be implemented using an adaptive management strategy, which will allow the GSA to react to the progress and outcomes of projects and management actions implemented in the Subbasin and to make management decisions to redirect efforts in the Subbasin as necessary to more effectively achieve the sustainability goal. **Section 7** of this GSP describes the initial prioritization and sequencing of measures considered for the early stages of GSP implementation.

4.3 General Process for Establishing Sustainable Management Criteria

The SMC presented in this section were developed using a technical analysis of publicly available information, meetings with GSA and member agency staff, Advisory Committee members, the GSA Board, practitioner work groups, discussions with regulatory agencies, and feedback gathered during public meetings. The general process included the following:

- Identification of technical data sources in the Subbasin and review of information developed for the Sonoma Valley Basin Management Plan.
- Discussions with GSA technical staff to develop the initial overarching methodologies for the SMC and the specific approaches for each sustainability indicator.
- Public meeting presentations to the Advisory Committee outlining the approach to developing SMC and discussing initial SMC ideas. The public was provided opportunity to comment during these presentations. The Advisory Committee provided feedback and suggestions for the development of initial SMC.
- Discussions and meetings with staff from other regulatory agencies and local organizations that have shared interests or responsibilities for components of some sustainability indicators, including practitioner work groups convened to inform and support development of SMC for depletion of interconnected surface water.
- Public meeting presentations to the GSA Board on the SMC requirements, proposed methodology for establishing MTs and MOs, options for establishing undesirable results, and implications of the SMC.

Modifying MTs, MOs, and undesirable results, where appropriate, based on technical analyses and input from the GSA and member agency staff, Advisory Committee members, GSA Board members, and the public.

4.4 Sustainable Management Criteria Summary

Table 4-1 provides a succinct summary of the SMC for each of the six sustainability indicators. Further descriptions of the SMC, including the rationale and background for developing these criteria are described in detail in **Sections 4.5 through 4.10**.

4.5 Chronic Lowering of Groundwater Levels SMC

Chronic lowering of groundwater levels was the first sustainability indicator addressed in the SMC process described in **Section 4.3**, as it contains the most readily available and robust datasets and is directly related to most of the other indicators. Additionally, SGMA allows for use of groundwater levels as proxy for other sustainability indicators if a significant correlation is established between groundwater levels and the other metrics. In this GSP, groundwater levels are used as a proxy for two other sustainability indicators: reduction of groundwater storage and depletion of interconnected surface water. This is further described in **Sections 4.6 and 4.10**, respectively.

For the chronic lowering of groundwater levels SMC, the SGMA definition (DWR 2017) of an undesirable result assisted in characterizing significant and unreasonable conditions for the Subbasin and establishing the SMC described below:

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon.
- Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.

As described in **Section 3.2.2**, chronic lowering of groundwater levels has been occurring in portions of the deep aquifer system within the southern portions of the Subbasin, while groundwater levels generally exhibit relatively stable long-term trends within the shallow aquifer system.

Taking these conditions and stakeholder input into account, the following overall approach guided development of the SMC for chronic lowering of groundwater levels:

- For areas with stable trends, maintain groundwater levels within or near historical conditions while accounting for future droughts and climate variability.
- For areas with declining trends, protect beneficial users that could be impacted by the declining groundwater levels and stabilize and reverse the declining trends.

Table 4-1. Sustainable Management Criteria Summary

Sustainability Indicator	Significant and Unreasonable Statement	Minimum Threshold	Measurement	Measurable Objective	Undesirable Result	Interim Milestones
Chronic lowering of groundwater levels	Chronic lowering of groundwater levels that significantly exceed historical levels or cause significant and unreasonable impacts on beneficial users.	Stable Wells: Maintain near historical observed ranges while accounting for future droughts and climate variability. Metric: Historical low elevations minus 4-year drought assumption.	Monthly or monthly-averaged groundwater levels measured at RMP wells.	Stable Wells: Maintain within historical observed ranges. Metric*:* historical median spring groundwater elevation	20 percent of RMPs exceed MT for 3 consecutive years	Stable Wells: Identical to MO Wells with Declining Trends: Set at current conditions for first five years, then linear increase from current conditions to MO through 2022
		Wells with Declining Trends: Maintain above historical low elevations and protect at least 98 percent of nearby water supply wells. Metric: Shallower (more protective) of historical low elevations OR above the 98th percentile of nearby water supply well depths.		Wells with Declining Trends: Recover groundwater levels to historical groundwater elevations prior to 2010. Metric*:* Historical (pre-2010) median spring groundwater elevation		
Reduction in groundwater storage	Reduction of groundwater storage that causes significant and unreasonable impacts on the long-term sustainable beneficial use of groundwater in the Subbasin, as caused by: • Long-term reductions in groundwater storage; or • Pumping exceeding the sustainable yield	Measured using groundwater elevations as a proxy. MT for groundwater storage is identical to the MT for chronic lowering of groundwater levels.	Annual groundwater storage will be calculated and reported by comparing changes in contoured groundwater elevations. However, monitoring for the chronic lowering of groundwater levels will be used to compare with the MT and MOs.	MO for groundwater storage is identical to the MO for chronic lowering of groundwater levels.	Undesirable result for groundwater storage is identical to the undesirable result for chronic lowering of groundwater levels.	

Sustainability Indicator	Significant and Unreasonable Statement	Minimum Threshold	Measurement	Measurable Objective	Undesirable Result	Interim Milestones
Seawater intrusion	Seawater intrusion inland of areas of existing brackish groundwater that may affect beneficial uses of groundwater is a significant and unreasonable condition.	The 250 mg/L chloride isocontour located in an area that is protective of beneficial users of groundwater. This MT isocontour is initially located between the currently approximate 250 mg/L isocontour (inferred interface of brackish groundwater) and beneficial users of groundwater (known water wells supplying beneficial users). This MT will need to be re-assessed during the early stages of GSP implementation, once additional monitoring data and information are available, as the initial location is selected from very limited available data.	The chloride isocontour will be developed based on chloride concentrations measured in groundwater samples collected from an RMP network, which will be developed during the early stages of GSP implementation.	The 250 mg/L chloride isocontour at the currently inferred interface of brackish groundwater (that is, current conditions).	When two conditions are met: (1) 3 consecutive years of MT exceedances and (2) The MT exceedance is caused by groundwater pumping.	The MO is set at current conditions; therefore, interim milestones are also identical to current conditions.
Degraded water quality	Significant and unreasonable water quality conditions occur if an increase in the concentration of COCs in groundwater leads to adverse impacts on beneficial users or uses of	The MT is based on one additional supply well exceeding the applicable maximum contaminant level for (1) arsenic, (2) nitrate, or (3) salts (measured as TDS).	The number of public supply wells with annual average concentrations of arsenic, nitrate, or TDS that exceed maximum contaminant levels in groundwater quality	The MO is based on zero additional supply wells exceeding the applicable maximum contaminant level for (1) arsenic, (2) nitrate, or	An undesirable result occurs if, during 2 consecutive years, a single groundwater quality MT is exceeded when computing annual	The MO is based on current conditions; therefore, interim milestones are identical

Sustainability Indicator	Significant and Unreasonable Statement	Minimum Threshold	Measurement	Measurable Objective	Undesirable Result	Interim Milestones
	groundwater due to either of the following activities: • Direct actions by Sonoma Valley GSP projects or management activities • Undesirable results from other sustainability indicators		data available through state data sources.	(3) salts (measured as TDS).	averages at the same well, as a direct result of projects or management actions taken as part of GSP implementation.	to current conditions.
Subsidence	Any rate of inelastic subsidence caused by groundwater pumping is a significant and unreasonable condition, everywhere in the Subbasin and regardless of the beneficial uses and users.	0.1 ft/yr of total subsidence.	DWR-provided InSAR dataset average annual subsidence for each 100-meter by 100-meter grid cell.	The MO is identical to the MT (0.1 ft/yr of subsidence)	Annual MT of 0.1 foot total subsidence is exceeded over a minimum 50-acre area **OR** Cumulative total subsidence of 0.2 foot is exceeded within a 5-year period **AND** MT exceedance is determined to be correlated with: (1) groundwater pumping and (2) MT exceedance of the chronic lowering of GWLs SMC (that is, groundwater levels have fallen below historical lows).	The MO is set at current conditions; therefore, interim milestones are also identical to current conditions.

Sustainability Indicator	Significant and Unreasonable Statement	Minimum Threshold	Measurement	Measurable Objective	Undesirable Result	Interim Milestones
Depletion of interconnected surface water	Significant and unreasonable depletion of surface water from interconnected streams occurs when surface water depletion, caused by groundwater pumping within the Subbasin, exceeds historical depletion or adversely impacts the viability of GDEs or other beneficial users of surface water.	Maintain estimated streamflow depletions below historical maximum amounts. Metric: Shallow groundwater elevations are used as a proxy for stream depletion. The MT is the equivalent groundwater level, representing the 3 years (2014–2016) during which the most surface water depletion due to groundwater pumping was estimated between 2004–2018.	Monthly-averaged groundwater levels measured in RMPs (shallow monitoring wells near interconnected surface water).	The MO is to maintain groundwater levels within historical observed ranges. Metric: Mean groundwater level for available dry-season observations between 2004 and 2020.	Undesirable result occurs if MTs are exceeded at 40 percent of RMP wells during drought years and 10 percent of RMP wells during non-drought years.	The MO is based on current conditions; therefore, interim milestones are identical to current conditions.

Notes:

COC = constituent of concern

GWL = Groundwater levels

RMP = representative monitoring point

4.5.1 Locally Defined Significant and Unreasonable Conditions

Locally defined significant and unreasonable conditions were determined based on public meetings, and discussions with GSA staff, Advisory Committee members, and the GSA Board. Significant and unreasonable chronic lowering of groundwater levels in the Subbasin are defined as:

Chronic lowering of groundwater-levels that significantly exceed historical levels or cause significant and unreasonable impacts on beneficial users, such as the following:

- Declining groundwater levels that limit the ability of domestic, municipal, or agricultural well owners to access groundwater for beneficial uses (for example, falling groundwater levels below pumping depths of water supply wells), causing significant and unreasonable economic burden on those who rely on basin groundwater

- Groundwater levels falling near basin boundaries that indicate impacts on or from neighboring basins

- Falling groundwater levels that cause impacts on groundwater-dependent vegetation (shallow aquifer only)

4.5.2 Minimum Thresholds

Section 354.28 (c)(1) of the GSP Regulations states that “The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results.” The GSP Regulations further specify that MTs for chronic lowering of groundwater levels are to be supported by information on the rate of groundwater elevation decline based on historical trends, WY type, projected water use in the basin, and potential effects on other sustainability indicators.

The process for developing the MTs for the chronic lowering of groundwater levels involved development of numerous alternatives for stakeholder consideration, which include the following:

(1) GSP Regulations
(2) Consideration of differing patterns of historical groundwater-level trends
(3) The significant and unreasonable statement

The alternatives were developed on behalf of the GSA by Sonoma Water staff and subconsultants based on the evaluation of historical groundwater elevations over the available period of record, including consideration of average water levels over various time periods, long-term trends, response to the recent drought; well construction data; and input from stakeholders. **Sections 4.5.2.1** through **4.5.2.6** provide details on the development of MTs.

4.5.2.1 Information and Methodology Used to Establish Chronic Lowering of Groundwater Levels Minimum Thresholds

The information used for establishing the MTs for the chronic lowering of groundwater levels sustainability indicator included:

- Historical groundwater elevation data
- Depths and locations of existing wells
- Maps of current and historical groundwater elevation data
- Input from stakeholders regarding significant and unreasonable conditions as well as the desired current and future groundwater elevations communicated during public meetings
- Results of modeling of future groundwater-level conditions

As described in in this section and in **Section 3.2.2**, different patterns of historical groundwater-level trends are observed within the Subbasin, with chronic declining trends evident in some areas of the deep aquifer system in the southern portions of the Subbasin and relatively stable trends observed in the shallow aquifer system and in some areas of the deep aquifer system. To account for the distinct patterns of historical groundwater-level trends observed within the Subbasin, different methodologies were applied to the following two categories of RMPs based on observed patterns in historical and recent groundwater-level trends:

- RMPs with relatively stable long-term groundwater levels, defined as less than 0.5 ft/yr of decline during dry years and measurable groundwater level recovery following wet years
- RMPs exhibiting chronic groundwater level declines (greater than 0.5 ft/yr of decline with no or incomplete recovery in wet years)

These two different patterns were distinguished based on trend lines calculated by linear regression of observed groundwater levels at each RMP (or from a similarly constructed nearby monitoring well where historical records are limited). The calculated trends are included with the hydrographs in **Appendix 4-A** and **Figures 4-1** and **4-2** show which RMPs are associated with each pattern.

The MTs were set at each RMP based on three primary factors:

1. Review of groundwater-level data and hydrographs to identify the lowest historical groundwater elevation at each RMP after removing any measurements flagged as “questionable measurements” or otherwise anomalous measurements from the datasets.
2. Calculation of “well impact depths” in the vicinity of each RMP to identify depths at which lowering of groundwater levels may impact well users, including domestic, agricultural, public supply, and industrial wells.

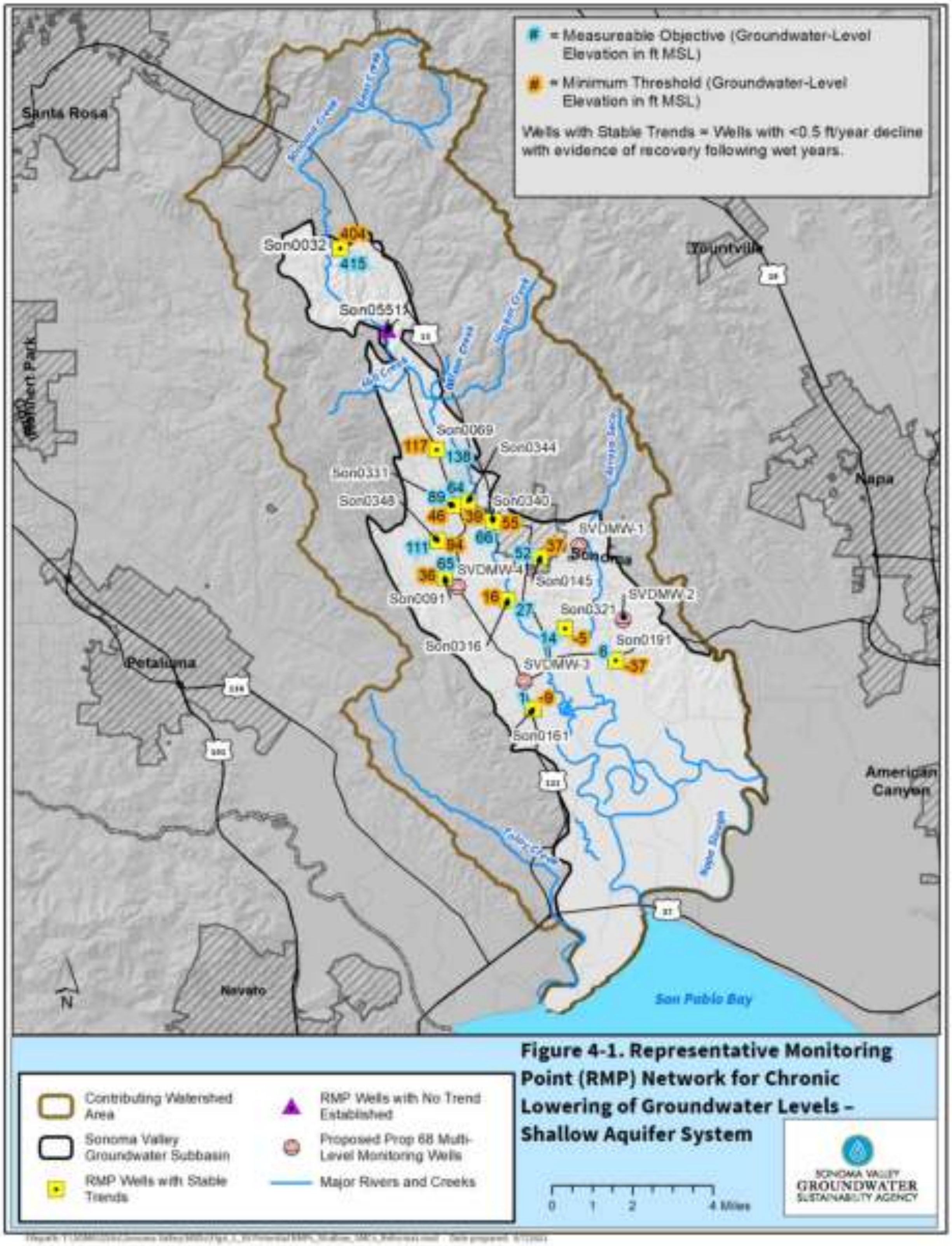

Figure 4-1. Representative Monitoring Points for Chronic Lowering of Groundwater Level – Shallow Aquifer System

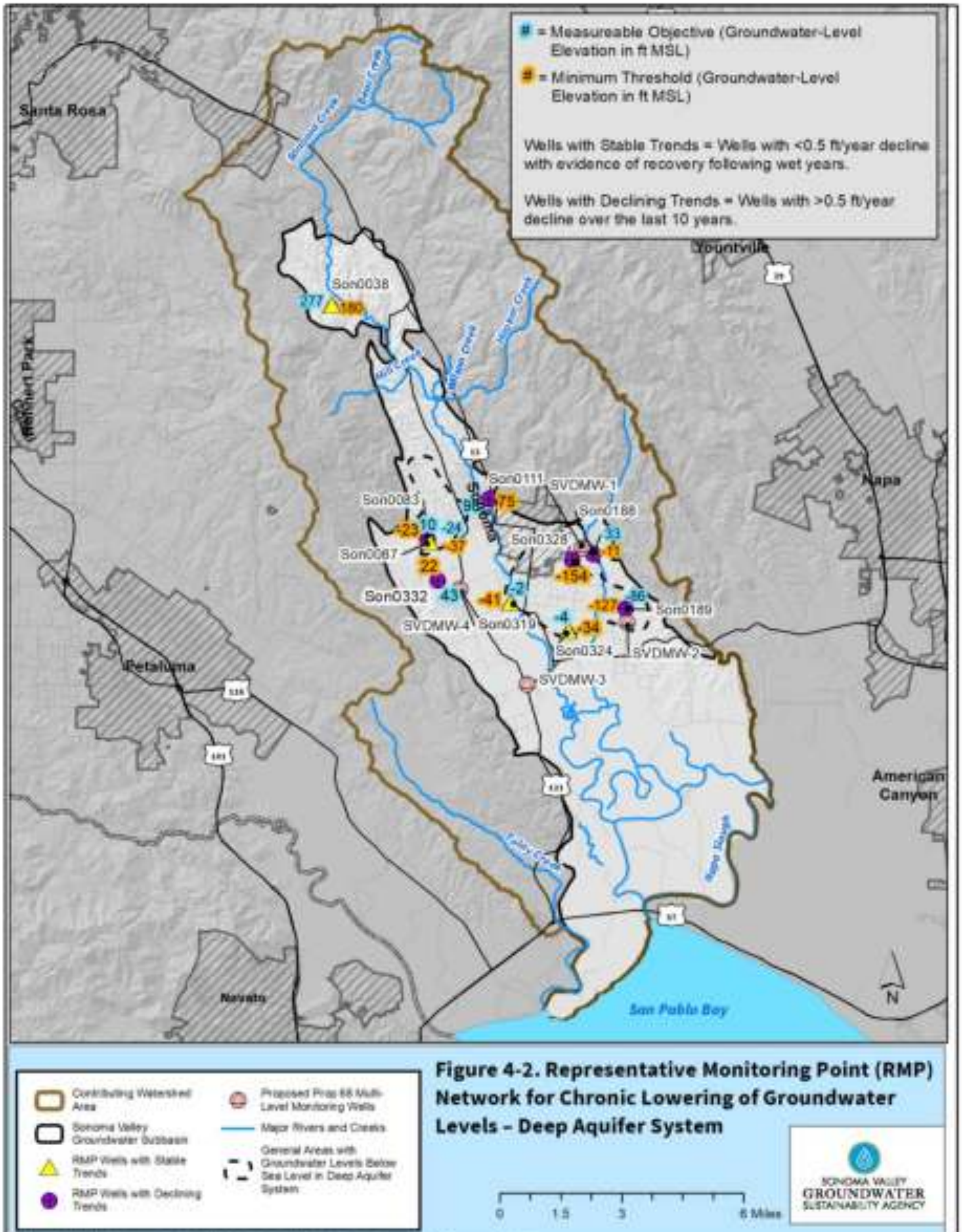

Figure 4-2. Representative Monitoring Points for Chronic Lowering of Groundwater Level – Deep Aquifer System

3. Calculation of a “drought factor or buffer” to account for reasonably foreseeable future droughts at each RMP with recent groundwater levels that are not below or approaching the above calculated well impact depth.

Calculation of Well Impact Depths

The methodology for incorporating the potential impact on existing well users involved the statistical evaluation of known completion information for water supply wells located within the vicinity of each potential RMP. These statistics were calculated by drawing polygons for each potential RMP area and querying Sonoma Water’s Water Well Database (sourced from DWR’s Online System for Well Completion Reports, Permit Sonoma, and the USGS). Generally, the Subbasin boundary and midpoints between potential RMPs were used to draw the vicinity areas. In some cases, physical features that appear to have a direct influence on groundwater movement were used as boundaries to the vicinity areas, such as the Eastside Fault or Sonoma Creek. The total number of supply wells, shallowest supply well total depth, 98th percentile shallowest supply well total depth, and the average supply well depth were calculated for each vicinity area polygon. For each RMP, the analysis included all types of supply wells contained within the datasets (domestic wells, irrigation wells, public supply wells, and industrial wells) with the listed total depth occurring in the same aquifer system as the RMP.

To ensure that the analysis accounts for drawdown due to a reasonable level of production from existing wells, the calculated well impact depths incorporate “saturated thickness factors,” which are added to the 98th percentile shallowest supply well depths and are described for each principal aquifer system:

- Shallow aquifer system wells (wells with total depth greater than 40 feet and less than 200 feet):
    - Wells shallower than 40 feet were filtered out from the database to remove records for non-supply wells (for example, monitoring wells) and some older (more than 50-year old wells) that have likely been replaced.
    - A saturated thickness factor of 10 feet was added to the total depths for the 98th percentile shallowest supply wells.
- Deep aquifer system wells (wells with total depth greater than 200 feet and more than half of screened interval below 200 feet below ground surface):
    - A saturated thickness factor of 50 feet was added to the total depth to compensate for increased drawdown responses within confined aquifer systems (Winters et al. 1999) and the typical higher production rates of deeper wells.

Factoring for Future Drought Conditions

A factor to account for reasonably foreseeable future droughts was calculated at each RMP using the following methodology:

- For wells with 10 or more years of historical data, the largest consecutive 4-year decline during historical dry periods was used.
- For wells with less than 10 years of historical data, the future simulated largest consecutive 4-year decline was used.

As the degree of groundwater-level responses to yearly climate conditions varies based on localized hydrogeologic condition, calculating a factor specific to each RMP incorporates observed groundwater-level responses specific to each RMP vicinity area into the MTs. The calculated drought factors range from 4 to 22 feet, with the larger ranges generally corresponding to deep aquifer system RMPs that are generally representative of confined conditions.

The historical low minus the drought factor was applied as the MT to RMPs; this level is above the well impact depth. For RMPs where the well impact depth is shallower than the historical low minus the drought buffer, the well impact depth was applied as the MT. **Table 4-2** provides a summary of these metrics and presents the final criteria used for calculating the MT at each RMP. As indicated in **Table 4-2**, MTs for 3 of the 10 deep aquifer system RMPs represent the calculated well impact depths. (At these locations the well impact depth is shallower than the historical low with the drought factor and is considered more protective of beneficial users.) For shallow aquifer system RMPs, the MTs calculated using the historical low elevations minus a drought factor were compared with the calculated well impact depths at each RMP. These MTs were determined to be at or above (that is, protective of) the calculated well impact depths.

Adaptive Management to Address Data Gaps and Improve/Refine SMC

There is uncertainty regarding the SMC developed for the chronic lowering of groundwater levels sustainability indicator. Specific planned data collection activities that will inform future adjustments or refinements to the chronic lowering of groundwater-level SMC include the following:

- Refine information pertaining to depths of nearby water wells from the well log database and information obtained through future well registration program implementation
- Improve mapping and correlation of well depth data with stratigraphic data
- Assess and develop plans to fill data gaps in monitoring networks through additional targeted dedicated monitoring wells and suitable volunteered private wells based on:
    - Hydrogeologic properties and geologic features
    - Areas of boundary inflows and outflows
    - Distribution of pumping
    - Location of sensitive beneficial users (such as, shallow well owners, ecosystems)

Table 4-2. Summary of Calculations for Minimum Thresholds and Measurable Objectives

Shallow Aquifer System (stable)							Minimum Threshold	Measurable Objective	Interim Milestones
Well ID	Observed Historical Low (feet msl)	Year of Observed Historical Low	Calculated Drought Factor (feet)	Drought Factor Years	Historic Low minus Drought Factor (feet msl)[a]	Well Impact Depths (feet msl)[a]	Shallower of Historical Low minus 4-year Drought or well impact depth	Historical Spring Median (entire)	Same as MO
Son0069	123.90	10/26/2018	7.00	2011-2015	**117**	88	117	138	138
Son0091	45.40	10/29/2015	9.90	2011-2015	**36**	28	36	65	65
Son0145	43.19	10/27/2015	6.19	2012-2015	**37**	5	37	52	52
Son0161	-6.57	10/16/2013	5.00	2012-2013	**-12**	-28	-12	1	1
Son0191	-7.89	10/16/2014	5.13	2010-2014	**-13**	-59	-13	6	6
Son0316	20.54	9/11/2013	4.16	2016-2020	**16**	-2	16	27	27
Son0321	3.29	10/10/2013	8.10	2018-2020	**-5**	-32	-5	14	14
Son0331	65.06	12/13/2019	18.93	2011-2015	**46**	**46**	46	89	89
Son0032	408.81	10/30/2018	22.00	Projected	**387**	364	387	415	415
Son0340	61.37	9/10/2015	6.18	2019-2020	**55**	35	55	66	66
Son0344	39.32	12/6/2016	5.00	Projected	**34**	28	34	64	64
Son0348	93.68	11/8/2018	9.00	Projected	**85**	82	85	111	111
Son0551	222.91	11/30/2019	0.00	NA	**223**	145	223	226	226

Deep Aquifer System (stable)							**Minimum Threshold**	**Measurable Objective**	**Interim Milestones**
Well ID	**Observed Historical Low (feet msl)**	**Year of Observed Historical Low**	**Calculated Drought Factor (feet)**	**Drought Factor Years**	**Historic Low minus Drought Factor (feet msl)**	**Well Impact Depths (feet msl)**	**Shallower of Historical Low minus 4-year Drought or well impact depth**	**Historical Spring Median (entire)**	**Same as MO**
Son0038	216.3	6/29/2009	36.55	2014-2018	**179.75**	128.3	180	277	277
Son0087	-39.2	10/30/2009	11.7	2011-2014	-50.9	**-37.2**	-37	-24	-24
Son0319	-26.81	9/17/2020	13.75	2016-2020	**-40.56**	-159.59	-41	-2	-2
Son0324	-21.4	9/17/2020	12.72	2017-2020	**-34.12**	-287.17	-34	-4	-4
Deep Aquifer System (declining)							**Minimum Threshold**	**Measurable Objective**	**Interim Milestones**
Well ID	**Observed Historical Low**	**Year of Observed Historical Low**	**Calculated Drought Factor**	**Drought Factor Years**	**Historic Low minus Drought Factor**	**Well Impact Depths**	**Historical Low minus 4-year Drought or 98th percentile well depth plus 50-feet**	**Historical Spring Median (Pre-2010)**	**5-, 10-, and 15-Year Milestones (2027/2032/ 2037)**
Son0083	-23.2	11/4/2019	0		**-23.2**	-24.9	-23	10	-15/-7/2
Son0111	75.2	10/23/2017	12	2009-2013	**63.2**	-78.3	63	98	90/93/95
Son0188	-11.13	3/19/2018	22.8	2009-2013	**-33.93**	-158.73	-34	32	-15/1/16
Son0189	-142.7	10/3/2013	0		-142.7	**-127.2**	-127	-86	-110/-102/-94
Son0328	-160.04	9/17/2020	0		-160.04	**-153.82**	-154	-21	-90/-67/-44
Son0332	21.99	10/9/2014	17.2	2011-2015	**4.79**	-144.4	5	43	30/34/39

[a] Bold values indicate criteria used for final MT value.

msl = mean sea level

4.5.2.2 Relationship between Individual Minimum Thresholds and Relationship to Other Sustainability Indicators

Section 354.28 of the GSP Regulations requires that the description of all MTs include a discussion of the relationship between the MTs for each sustainability indicator. In the SMC BMPs (DWR 2017), DWR clarified that the GSP must describe the relationship between each sustainability indicator's MT by describing why or how a water level MT set at a particular RMP is similar to or different to water level thresholds in a nearby RMP. Additionally, the GSP must describe the relationship between the selected MTs and the MTs for other sustainability indicators.

Groundwater elevation MTs are derived from examination of the historical record reflected in hydrographs at each individual RMP and depths of nearby water wells. Therefore, the MTs are unique at every well, but when combined represent reasonable and achievable groundwater conditions and flow paths.

Assessment of how other sustainability indicators could be influenced by the chronic lowering of groundwater levels MT indicates the following:

- **Reduction in groundwater storage**. Changes in groundwater elevations are directly correlated to changes in the amount of groundwater in storage and groundwater levels are used as a proxy for the reduction in groundwater storage sustainability indicator. The groundwater elevation MTs are set to establish a minimum elevation that will not lead to undesirable conditions and that is acceptable to the stakeholders in the area. Therefore, if the groundwater elevation MTs are met, they will not result in long-term significant or unreasonable changes in groundwater storage.

- **Seawater Intrusion**. A significant and unreasonable condition for seawater intrusion is seawater intrusion inland of areas of existing brackish groundwater that may affect beneficial uses of groundwater. While available data does not indicate increasing trends in salinity indicators in wells located near the Baylands, lower groundwater elevations, particularly in areas near the margins of the Baylands, could cause seawater to advance inland. For areas with declining groundwater levels, MTs are set near or at recent groundwater elevations with the goal of halting chronic groundwater level declines. Therefore, the groundwater elevation MTs are intended to not exacerbate, and may help control, the rate of seawater intrusion.

- **Degraded water quality**. A significant and unreasonable condition for degraded water quality would occur if an increase in the concentration of COCs in groundwater leads to adverse impacts on beneficial users or uses of groundwater, due to direct actions by Sonoma Valley GSP projects or management activities or undesirable results occurring for other sustainability indicators. Continued chronic lowering of groundwater levels could potentially impact water quality by inducing poor-quality water into areas not previously impacted by water quality degradation. However, since MTs are set to avoid significant declines of groundwater levels below historically observed levels, this is not expected to occur.

- **Subsidence**. A significant and unreasonable condition for subsidence is the occurrence of inelastic subsidence caused by groundwater pumping. While continued decline of groundwater levels due to groundwater pumping within the Subbasin could trigger inelastic subsidence in areas with clay-rich aquifer materials, this is not expected to occur because MTs are set to avoid significant declines of groundwater levels below historically observed levels.
- **Depletion of interconnected surface water**. MTs for chronic lowering of groundwater levels do not promote additional pumping and aim to maintain groundwater elevations near historical levels in the vicinity of interconnected surface water. Therefore, the chronic lowering of groundwater elevations' MTs is not anticipated to result in a significant or unreasonable depletion of interconnected surface water.

4.5.2.3 Effect of Minimum Thresholds on Neighboring Basins and Subbasins

The potential for groundwater flow between the Sonoma Valley Subbasin and the Petaluma Valley Basin is limited to the southern margins of the Subbasin in the Baylands area where very little current groundwater pumping occurs due to the natural presence of brackish water. Similarly, the shared boundary between the Sonoma Valley Subbasin and the Napa Lowlands Subbasin to the east also primarily occurs within the Baylands area. Where the shared boundary between the Sonoma Valley Subbasin and the Napa Lowlands Subbasin occurs outside of the Baylands, current groundwater use is also limited due to the historical presence of brackish groundwater and generally low-yielding water wells (for these reasons recycled water and surface water are primarily used for irrigation along this boundary in the Carneros area). Future groundwater use is expected to remain very low in these areas due to these conditions. There are also no GSP projects or management actions planned for these areas of the Subbasin that might change hydraulic gradients near these shared boundaries. Therefore, the MTs for chronic lowering of groundwater, which aim to maintain near current groundwater levels, are unlikely to affect groundwater conditions along these two boundaries.

Groundwater flow between the Kenwood Valley Basin occurs along the northern boundary of the Subbasin with groundwater flowing south from the Kenwood Valley Basin into the Sonoma Valley Subbasin along the boundary. Since the Kenwood Valley Basin is hydraulically upgradient from the Sonoma Valley Subbasin and the MTs for chronic lowering of groundwater aim to maintain groundwater levels near current levels, the likelihood of impacting the Kenwood Valley Basin is considered low.

While not required to be evaluated by SGMA, the potential effect of the chronic lowering of groundwater levels' MTs are also very unlikely to influence groundwater levels in other adjoining areas that are not classified as groundwater basins or subbasins by DWR. Groundwater use in these upland areas that flank the eastern and western boundaries of the Subbasin primarily occurs within the Sonoma Volcanics upgradient of the Subbasin.

The potential for impacts to occur along all of the described boundaries will be evaluated as part of the GSA's routine Monitoring and Reporting Program (MRP), which includes both RMP wells and other wells monitored for groundwater levels in the Subbasin and contributing watershed areas (including the southern portions of the Kenwood Valley Basin). Additionally, the Sonoma Valley GSA will continue to closely coordinate with neighboring GSAs and the County for areas that are not under a GSA's jurisdiction should any future issues arise.

4.5.2.4 Effect on Beneficial Uses and Users

MTs for chronic lowering of groundwater levels are set at the more protective of historical low conditions with allowances for future droughts and the depths at which existing wells could be impacted by lowering of groundwater levels. The MTs are generally advantageous to beneficial users and land uses in the Subbasin as described in the paragraphs that follow.

Agricultural land uses and users. The chronic lowering of groundwater-level MTs protect existing agricultural users' ability to meet typical demands by maintaining groundwater levels near current conditions. However, the chronic lowering of groundwater-level MTs do place a practical limit on the acceptable lowering of groundwater levels in the Subbasin, thus conceptually restricting the current level of agriculture in the Subbasin. These restrictions could reduce the amount of agricultural pumping; however, the projects and management actions detailed in **Section 6** will be pursued to allow for alternatives to reductions in agricultural pumping.

Urban land uses and users. The chronic lowering of groundwater-level MTs protect existing municipal groundwater users' ability to meet typical demands by maintaining groundwater levels near current conditions. However, the chronic lowering of groundwater-level MTs do place a practical limit on the acceptable lowering of groundwater levels in the Subbasin, thus conceptually restricting the current level of municipal and industrial pumping in some areas of the Subbasin. These restrictions could reduce the amount of agricultural pumping; however, projects and management actions detailed in **Section 6** will be pursued to allow for alternatives to reductions in municipal pumping.

Domestic land uses and users. The chronic lowering of groundwater levels MTs are established to protect as many rural residential domestic wells as possible. Therefore, the MTs will likely have an overall beneficial effect on existing domestic land uses by protecting the ability to pump from domestic wells within the Subbasin.

Ecological land uses and users. Maintaining groundwater near or above historical levels will maintain the interconnected nature of groundwater and surface water in the Subbasin. This will protect GDE habitat and generally benefit environmental land uses and users.

4.5.2.5 Relation to State, Federal, or Local Standards

No federal, state, or local standards exist that are specific to chronic lowering of groundwater levels.

4.5.2.6 Method for Quantitative Measurement of Minimum Thresholds

Depth to groundwater will be directly measured at the RMPs identified in **Section 5.3.1** for comparison to MTs. The RMP network includes 13 existing shallow aquifer wells and 10 existing deep aquifer wells, plus 4 new multi-level monitoring clusters with wells in both the shallow and deep aquifer (8 total wells). This results in a total of 31 RMPs, with 17 in the shallow aquifer and 14 in the deep aquifer. The groundwater-level data will be collected in accordance with the monitoring protocols outlined in **Section 5.3.1** and converted to groundwater elevation by subtracting the measured depth to water from the reference point elevation used to take the depth to water measurement.

Available groundwater-level data, including historical data used for calculation of the MTs and MOs, contains a variety of measurement frequencies ranging from hourly to semiannually. Groundwater-level measurement frequency for the 23 existing wells in the RMP monitoring network include the following:

- Ten measured more than once per day
- Three measured monthly
- Ten measured semiannually

As indicated in **Section 5.3.1**, the goals for groundwater-level measurement frequency will be: (1) measure groundwater levels at least monthly for all RMPs during GSP implementation, and (2) use pressure transducers where feasible to provide a higher level of quality control, as potential short-term or residual pumping influences can be identified and flagged. Consistent with the monitoring protocols, only static groundwater levels will be compared to MTs.

For reporting seasonal highs and lows for future comparison with MTs, all subdaily measurements will be reported as monthly averages to better align with the measurement frequency within historical datasets used to calculate the MTs. During GSP implementation, individual groundwater-level measurements collected manually and by data loggers will be reviewed for quality control and analyzed for MT exceedances during compilation of GSP annual and 5-year update reports.

Data gaps have been identified in some areas of the Subbasin in the monitoring networks discussion (**Section 5**). The GSP includes a plan to expand the monitoring network as described in the GSP implementation discussion (**Section 7**).

4.5.3 Measurable Objectives

MOs for chronic lowering of groundwater levels represent target groundwater elevations for 2042, considering realistic project implementation plans and allowing for operational flexibility over a range of climate and hydrologic variability.

4.5.3.1 Method for Setting Measurable Objectives

Similar to the approach and methodology used for setting MTs, MOs are reflective of the distinct patterns of historical groundwater-level trends observed within the Subbasin.

For RMPs exhibiting relatively stable long-term groundwater-level trends, the MO is calculated as the historical median spring groundwater elevation, since the aim of the MO is to maintain groundwater levels within historical ranges for these areas.

For RMPs exhibiting historical chronic groundwater level declines, the MO is calculated as the median of spring groundwater elevations that occurred prior to 2010, since the aim of the MO is to stabilize and reverse the declining trends in these areas. Groundwater elevations data prior to 2010 were selected for use because most wells with declining trends have data going back to approximately 2000, allowing for estimation of a “recovery level” based on at least 10 years of data and prior to the 2012–2016 drought.

MOs for each RMP are listed in **Table 4-2**.

4.5.3.2 Interim Milestones

For RMPs exhibiting relatively stable long-term groundwater-level trends, the MO is essentially set at recent conditions (specifically, the aim of the MO for these wells is to maintain groundwater levels within historical and recent ranges); therefore, interim milestones are essentially equivalent to the MO throughout the GSP implementation period.

Interim milestones for wells exhibiting historical chronic groundwater-level declines were generally selected to define a smooth linear increase in groundwater levels between the observed groundwater elevation at the RMP in 2020, and the MO as presented in **Table 4-2**. For the initial 5-year interim milestone in 2027, the interim milestones are set at current groundwater levels to allow time to implement the multi-phased projects and management actions described in **Section 6**. Interim milestones at 5-year intervals for the 2022 through 2042 time period are established at each RMP are included in **Table 4-2**. Interim milestones may be adjusted at any time during the SGMA timeline. It is expected that they will be reconsidered at 5-year intervals when the GSP is revised and updated. The monitoring of basin conditions during the initial 5-year period will provide good indicators on whether the interim milestones are close to being met. Failure to meet interim milestones is not in and of itself an indication of undesired conditions but is meant to provide information determining whether the 20-year goals are on track to being achieved. Alternative projects and management actions may be considered or pursued if the interim milestones are not being met.

4.5.4 Undesirable Results

4.5.4.1 Criteria for Defining Undesirable Results

The chronic lowering of groundwater levels undesirable result is a quantitative combination of groundwater elevation MT exceedances. For the Subbasin, the specific groundwater condition that constitutes an undesirable result is if groundwater levels in 20 percent of the RMPs in either principal aquifer system exceed their MTs for three consecutive fall measurements.

Consistent with DWR guidance, if MT exceedances are caused by emergency operational issues or droughts that extend for longer than the 4-year drought factor incorporated into the MTs (as described in **Section 4.5.2.1**), it is not considered an undesirable result unless the groundwater levels do not rebound to above the thresholds during future normal and wet years following long-term droughts.[1]

Exceedances of MTs at a single well will require investigation to determine if any actions should be considered to avoid potential future onset of undesirable results, as described in **Section 4.5.4.2**.

The consecutive 3 years of MT exceedances were selected by the GSA Board to: (1) balance protection of beneficial users with costs related to response actions, and (2) limit the potential for shorter-duration MT exceedances that may not be chronic in nature to trigger undesirable results.

4.5.4.2 Potential Causes of Undesirable Results

The potential causes of undesirable results for chronic lowering of groundwater levels include:

- Continuation of chronic groundwater-level declines within the deep aquifer system in the southern portions of the Subbasin
- Increased groundwater pumping in other areas of the Subbasin leading to chronic groundwater-level declines
- A significant reduction in natural recharge as a result of climate change, reduced groundwater and surface water interaction, or other land surface processes

If the location and volumes of groundwater pumping change as a result of unforeseen rural residential, agricultural, and urban growth that depend on groundwater as a water supply without supplemental supplies, these increased demands might lower groundwater to undesirable levels. Reduction in recharge or changes in rainfall patterns could also lead to more prolonged periods of lowered groundwater levels than have occurred historically.

As described in **Section 6**, projects and actions are being considered for implementation to augment recharge and reduce groundwater pumping to mitigate the potential for these conditions to occur.

Additionally, to respond to these potential conditions prior to the onset of an undesirable result, the following actions would be implemented if an MT is exceeded at a single RMP that does not trigger an undesirable result:

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[1] The draft SMC BMP (DWR 2017) provides information on how droughts may affect the groundwater level SMC: "Undesirable results are one or more of the following effects: Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods."

- Review available data from full monitoring network (that is, non-RMP monitoring wells) to assess potential scale of areas exhibiting declines
- Assess whether exceedance is climate-related
- Review any known or potential changes in groundwater pumping patterns (for example, new wells brought online, changes in land/water use)
- Consider whether additional RMPs are needed
- Share information with nearby well owners as appropriate
- Consider planning or implementing projects/actions, as appropriate (for example, begin with lower cost and/or voluntary projects/actions)

The approach is a proactive means for avoiding exceedance of undesirable results when warning signs are available. Not all actions would be implemented for each individual exceedance of a MT. The tasks described above would generally be performed sequentially based on potential severity of the occurrence.

4.5.4.3 Effects on Beneficial Users and Land Use

The potential effects of undesirable results for chronic lowering of groundwater levels on beneficial users and land use could be the inability of a significant number of private, agricultural, and municipal and industrial production wells from supplying groundwater to meet water demands. Lowered groundwater levels reduce the saturated thickness of aquifers from which wells can pump, which could lead to increased pumping costs, reduced pumping capacity, or the need to drill new deeper wells. This would effectively increase the cost of using groundwater as a water source for all users. Avoiding undesirable results for the chronic lowering of groundwater levels will limit the potential for these conditions to occur in the future.

4.6 Reduction in Groundwater Storage SMC

The reduction in groundwater storage SMC will be evaluated using groundwater levels as a proxy based on well-established hydrogeologic principles that the volume of groundwater in storage is directly proportional to groundwater elevations. The groundwater elevations' MTs and MOs are established to maintain adequate groundwater supplies for all beneficial uses and users. Therefore, preventing groundwater elevations from dropping below MTs, by definition, maintains adequate amount of water in storage. Maintaining groundwater elevations within the operational range between MTs and MOs is equivalent to no long-term change in storage.

4.6.1 Locally Defined Significant and Unreasonable Conditions

Locally defined significant and unreasonable conditions were determined based on public meetings and discussions with GSA staff, Advisory Committee members, and the GSA Board. Significant and unreasonable reduction in groundwater storage in the Subbasin is defined as:

Reduction of groundwater storage that causes significant and unreasonable impacts on the long-term sustainable beneficial use of groundwater in the basin, as caused by:

- Long-term reductions in groundwater storage
- Pumping exceeding the sustainable yield

4.6.2 Minimum Thresholds

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

This GSP will monitor changes in groundwater level at the RMPs as a proxy for the change in groundwater storage metric. As allowed in Section 354.36(b)(1) of the GSP Regulations, groundwater elevation data at the RMPs will be reported annually as a proxy to track changes in the amount of groundwater in storage.

Based on well-established hydrogeologic principles, stable groundwater elevations maintained above the MTs will indicate that groundwater storage is not being depleted (Freeze and Cherry 1979). Therefore, using groundwater elevations as a proxy, the MT for groundwater storage will be met if MTs for the chronic lowering of groundwater levels are not exceeded.

4.6.2.1 Information and Methodology Used to Establish Groundwater Storage Minimum Thresholds

Similar to the chronic lowering of groundwater levels SMC, the information used for establishing the MTs for the groundwater storage sustainability indicator included:

- Historical groundwater elevation data
- Depths and locations of existing wells
- Maps of current and historical groundwater elevation data
- Input from stakeholders regarding significant and unreasonable conditions as well as desired current and future groundwater elevations communicated during public meetings
- Results of modeling of future groundwater-level conditions

4.6.2.2 Relationship between Individual Minimum Thresholds and Relationship to Other Sustainability Indicators

The MTs for reduction in groundwater storage are the same as those used for the chronic lowering of groundwater sustainability. Because groundwater elevations will be used as a proxy for estimating changes in groundwater storage, the reduction in groundwater storage sustainability indicator cannot cause undesirable results for the chronic lowering of groundwater levels sustainability indicator.

The relationship between the groundwater storage sustainability indicator and other sustainability indicators is the same as the relationship between chronic lowering of groundwater levels and other sustainability indicators, as described in **Section 4.5.2.2**.

4.6.2.3 Effect of Minimum Thresholds on Neighboring Basins and Subbasins

The potential effect of the groundwater storage MT on neighboring basins, subbasins, and other adjoining areas is the same as the relationship described for chronic lowering of groundwater levels in **Section 4.5.2.3**.

4.6.2.4 Effect on Beneficial Uses and Users

The MT for reduction in groundwater storage will maintain stable average groundwater elevations and encourages minimal long-term net change in groundwater elevations and storage.

The potential effects of the groundwater storage MT on beneficial uses and users are the same as the potential effects described for chronic lowering of groundwater levels in **Section 4.5.2.4**.

4.6.2.5 Relation to State, Federal, or Local Standards

No federal, state, or local standards exist that are specific to groundwater storage.

4.6.2.6 Method for Quantitative Measurement of Minimum Thresholds

Storage MTs will be measured by collecting groundwater-level measurements at the RMP sites in the monitoring network, as described in **Sections 4.5.2.6 and 5.3.1**. This data will be used to monitor groundwater elevations and compare with MTs. Annual groundwater storage will also be calculated and reported by comparing changes in contoured groundwater elevations to assess changes in groundwater storage.

4.6.3 Measurable Objectives

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

Additionally, even though groundwater levels are being used as a proxy in lieu of using the total volume of groundwater pumped, the achievement of MOs for chronic lowering of groundwater levels will require that groundwater levels either increase or are maintained at their current levels. Therefore, the MOs will necessitate pumping within the sustainable yield calculated for the Subbasin in order to have zero long-term change in storage once sustainability is reached.

4.6.3.1 Method for Setting Measurable Objectives

The methods for setting the MO for groundwater storage incorporates the same methods for setting the MO for chronic lowering of groundwater levels described in **Section 4.5.3.1**.

4.6.3.2 Interim Milestones

Interim milestones for groundwater storage are the same as those established for chronic lowering of groundwater levels. Achieving the chronic lowering of groundwater levels interim milestones will prevent long-term reductions in groundwater in storage.

4.6.4 Undesirable Results

4.6.4.1 Criteria for Defining Undesirable Results

Assessment of groundwater storage will be evaluated with the same RMPs, MTs, and MOs as the chronic lowering of groundwater levels sustainability criteria.

Therefore, for the purposes of this GSP, the definition of undesirable conditions for the reduction of groundwater storage is the same as following definition for the chronic lowering of groundwater levels:

Groundwater levels in 20 percent of the RMPs in either principal aquifer system exceed their MTs for three consecutive fall measurements.

4.6.4.2 Potential Causes of Undesirable Results

The potential causes of undesirable results for reduction of groundwater storage are the same as those identified for chronic lowering of groundwater levels in **Section 4.5.4.2**:

- Continuation of chronic groundwater-level declines within the deep aquifer system in the southern portions of the Subbasin, as described in **Section 3.2.4**
- Increased groundwater pumping in other areas of the Subbasin leading to chronic groundwater-level declines
- A significant reduction in natural recharge as a result of climate change or other processes

4.6.4.3 Effects on Beneficial Users and Land Use

The potential effects of undesirable results for groundwater storage on beneficial users and land use are the same as those identified for the chronic lowering of groundwater levels, as described in **Section 4.5.4.3**, which could include the inability of a significant number of private, agricultural, industrial, and municipal and industrial production wells from supplying groundwater to meet their water demands. Lowered groundwater levels reduce the thickness of saturated aquifer from which wells can pump, which could lead to increased pumping costs or the need to drill new deeper wells. This would effectively increase the cost of using groundwater as a water source for all users. Avoiding undesirable results for the chronic lowering of groundwater levels will limit the potential for these conditions to occur in the future.

4.7 Seawater Intrusion SMC

There are several factors to be considered when developing SMC for seawater intrusion, including the occurrence of significant and unreasonable conditions, the GSA's ability to determine where and when seawater intrusion is occurring, and its relationship to groundwater pumping.

As indicated in **Section 3.2.4.5** of the Basin Setting, available data, although limited, does not indicate that seawater intrusion has been occurring and impacting beneficial users of groundwater. However, seawater intrusion has the potential to occur within the Subbasin due to observed declining groundwater levels, which have dropped below sea level in areas of the southern part of the Subbasin. Significant data gaps have been identified in the southern portions of the Subbasin that prevent adequate mapping and characterizing of the spatial and temporal distribution of salinity in groundwater, as identified in **Section 3.1.8**. In particular, groundwater quality data for both principal aquifers and well construction are limited in this area and comprehensive monitoring infrastructure is lacking. The GSA has prioritized addressing these data gaps, described further in **Section 7** of this GSP.

Because of the significant data gaps, an adaptive approach for refining the initial SMC for seawater intrusion will be completed during GSP implementation. Additional characterization described in **Section 7** will provide a more robust understanding of not only current conditions, but also potential future impacts from climate change (such as sea level rise) and land use practices in the Baylands area of the Subbasin.

4.7.1 Locally Defined Significant and Unreasonable Conditions

This section summarizes information relevant to identification of significant and unreasonable conditions and development of SMC.

Naturally-occurring brackish groundwater currently exists in the Baylands area**.** Freshwater and saltwater zones within coastal aquifers are separated by a transition zone (sometimes referred to as the zone of dispersion) where there is mixing between freshwater and saltwater. The transition zone is characterized most commonly by measurements of chloride concentrations in groundwater ranging from about 250 to 19,000 mg/L. As described in **Section 3.2.4.5** of the Basin Setting, it is understood that the natural brackish groundwater in the Baylands area represents this transition zone of the Subbasin between the saline waters of San Pablo Bay and fresh groundwater from the more inland areas of the Subbasin north of the Baylands area.

The limited number of existing groundwater users in the Baylands do not appear to be negatively impacted by the brackish groundwater. As indicated on **Figure 2-5** in **Section 2**, the majority of agricultural crops in the Baylands area are either not irrigated or use recycled water for irrigation. Existing beneficial uses of groundwater in this area are limited to very few agricultural and residential supply wells, which have been pumping groundwater influenced by brackish water for decades, indicating that beneficial users have not been negatively impacted by the natural brackish groundwater in this area. Therefore, current conditions are not considered a significant and unreasonable condition.

Sea level rise impacts may occur in the future. According to communications with DWR SGMA staff during GSP development, the GSA is not required to address future impacts from sea level rise because the impacts from sea level rise are not a result of GSA activities or groundwater pumping. It is expected that monitoring and assessment of sea level rise impacts, including use of numerical modeling, will be ongoing throughout the implementation of the GSP.

Land use changes affect the Baylands area. Historical changes in land use in the Baylands area of the Subbasin have affected the distribution of saline and fresh surface water, which, in turn, affect the distribution and occurrence of salinity in underlying groundwater. GSA staff have had initial discussions with Sonoma Land Trust staff, who are leading ongoing planning activities associated with wetlands restoration that could affect the occurrence and distribution of saline groundwater in the future. Although the GSA has no authority over such activities, the GSA will continue to coordinate with parties involved in the restoration activities and work with those parties to assess potential impacts of these projects on seawater intrusion that may affect beneficial uses of groundwater in the Subbasin.

Locally defined significant and unreasonable conditions were determined based on the above information and discussions at public meetings, and discussions with GSA staff, Advisory Committee members, and the GSA Board.

Significant and unreasonable conditions are defined as: “Seawater intrusion inland of areas of existing brackish groundwater that may affect beneficial uses of groundwater” (CITATION).

Examples of potential adverse impacts related to seawater intrusion are described in **Sections 4.7.2.4 and 4.7.4.3**.

4.7.2 Minimum Thresholds

CCR Title 23 Section 354.28 (c)(3) of the GSP Regulations states that “The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results.” The GSP Regulations require the following information to support the descriptions of seawater intrusion MT and MO:

- Section 354.28(c)(3)(A): Maps and cross sections of the chloride concentration isocontour that defines the MT and MO for each principal aquifer.
- Section 354.28(c)(3)(B): A description of how seawater intrusion MT considers the effects of current and projected sea levels.

There are two principal aquifers in the Subbasin, but for purposes of establishing seawater intrusion SMC, they pertain to both aquifers. In other words, both principal aquifers have initially been assigned the same SMC for seawater intrusion. Future refinement of the SMC for both aquifer systems will be considered, as additional information is developed to better characterize and monitor the distribution of chloride within both the shallow and deep principal aquifer systems.

The MT for seawater intrusion is the 250 mg/L chloride isocontour located in an area that is protective of beneficial users of groundwater, as shown on **Figure 4-3**.

4.7.2.1 Information and Methodology Used to Establish Seawater Intrusion Minimum Thresholds and Measurable Objectives

The MT was defined in the aquifers as the 250 mg/L chloride concentration isocontour in order to protect beneficial use of groundwater outside the Baylands area, as native chloride concentrations in the inland portions of the Subbasin are generally below 100 mg/L. This concentration is the drinking water secondary MCL (SMCL) for chloride and is also less than the chloride concentration that can be tolerated by grapes (262 mg/L) without showing adverse effects (University of California Cooperative Extension 2006). Hay cultivars also grown in this area are known to be tolerant of much higher chloride concentrations.

The Baylands area of the Subbasin near San Pablo Bay has very few wells used for groundwater supply because of the naturally brackish conditions. Consequently, minimal water quality monitoring has been conducted in this area in the past. Because there are significant monitoring well data gaps in both the shallow and deep aquifers, the GSA lacks the data needed at this point to adequately map the current 250 mg/L chloride concentration isocontour and to confidently establish the most appropriate location for the MT. The following adaptive methodology uses existing data and provides management flexibility while data is collected during GSP implementation. This approach is anticipated to result in future updates and refinements of the seawater intrusion SMC:

1. The current 250 mg/L chloride isocontour is interpolated from existing groundwater monitoring data, which has been collected through several groundwater monitoring programs and spans multiple years. It is understood that these data are not derived from RMPs, or collected contemporaneously; however, this data represents the best available information currently. The estimated baseline 250 mg/L chloride isocontour developed from this data is shown on **Figure 4-3** as the yellow isocontour.

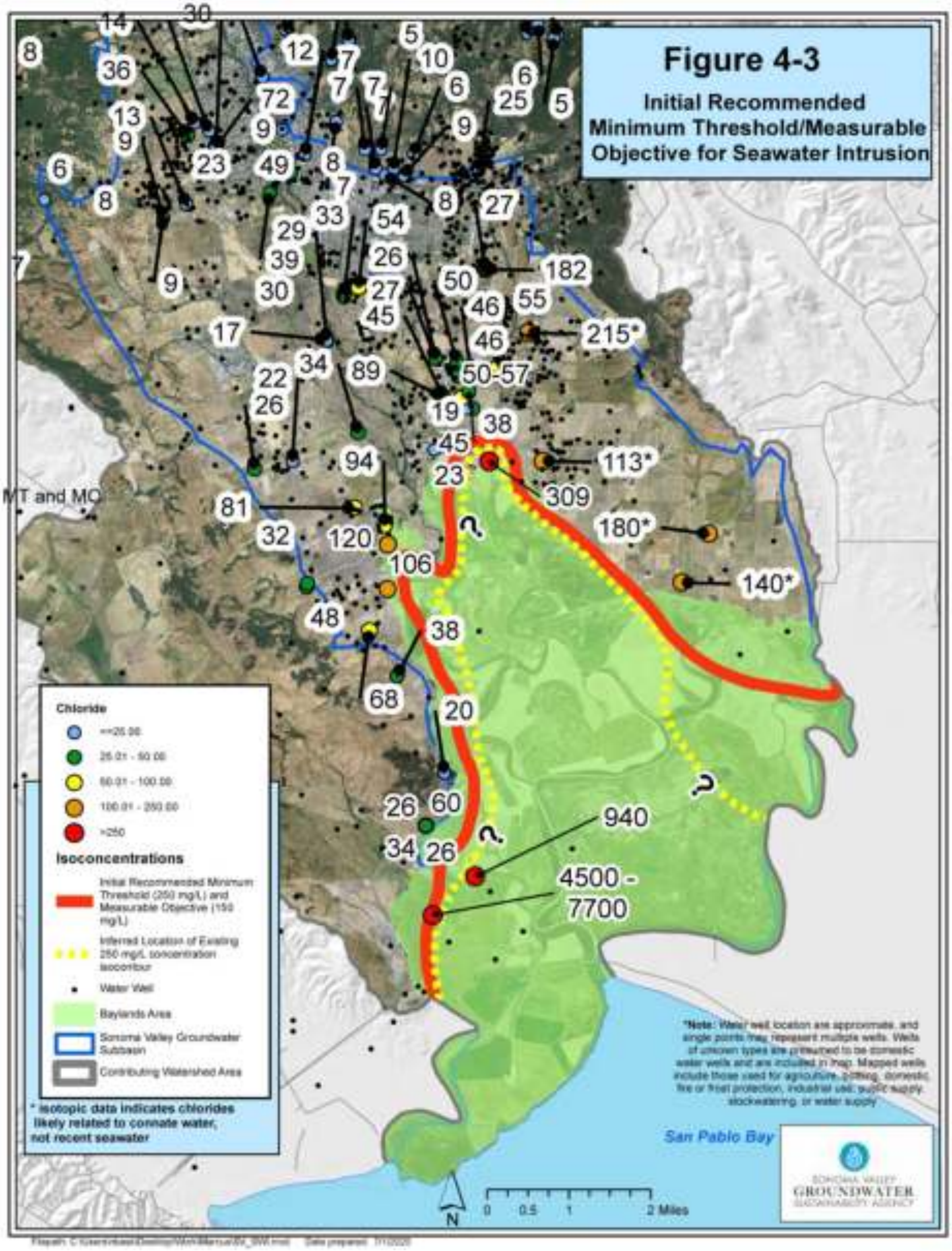

Figure 4-3. Seawater Intrusion Minimum Threshold and Measurable Objective

2. The MT isocontour is initially set between (inland) of the baseline 250 mg/L chloride isocontour and areas with known existing water wells serving beneficial users, as shown on **Figure 4-3**. It is anticipated that the MT isocontour will be updated and refined in future GSP updates once additional data are available.

4.7.2.2 Relationship between Individual Minimum Thresholds and Relationship to Other Sustainability Indicators

Assessment of how other sustainability indicators could be influenced by the seawater intrusion MT indicates the following:

- **Chronic lowering of groundwater levels**. Nothing in the seawater intrusion MTs would promote additional pumping that could impact groundwater elevations. Therefore, the seawater intrusion MTs will not result in an exceedance of the chronic lowering of groundwater levels MT.
- **Reduction in groundwater storage**. Nothing in the seawater intrusion MTs promotes pumping in excess of the sustainable yield. Therefore, the seawater intrusion MTs will not result in an exceedance of the groundwater storage MT.
- **Degraded water quality**. The seawater intrusion MTs may have a beneficial impact on groundwater quality by preventing increases in chloride concentrations in supply wells.
- **Subsidence**. Nothing in the seawater intrusion MTs promotes additional pumping that could cause subsidence. Therefore, the seawater intrusion MTs will not result in an exceedance of the subsidence MT.
- **Depletion of interconnected surface water**. Nothing in the seawater intrusion MTs promotes additional pumping or lower groundwater elevations adjacent to interconnected surface waters. Therefore, the groundwater quality MTs will not result in a significant or unreasonable depletion of interconnected surface waters.

4.7.2.3 Effect of Minimum Thresholds on Neighboring Basins and Subbasins

Since the seawater intrusion MT is designed to prevent additional seawater intrusion related to groundwater pumping, it is likely that the MTs will not prevent the Petaluma Valley GSA from achieving and maintaining sustainability. The Sonoma Valley GSA will coordinate closely with the neighboring Petaluma Valley GSA as they both set MTs to ensure that the subbasins do not prevent each other from achieving sustainability. Similarly, it is unlikely that the MT for seawater intrusion will negatively impact the Napa Lowlands Subbasin for the same reasons. The Kenwood Valley Basin is not adjacent to the Subbasin in the area subject to potential seawater intrusion.

4.7.2.4 Effect on Beneficial Uses and Users

The MT is the secondary drinking water standard, which is inherently protective of drinking water as a beneficial use. The MT is also less than the concentration of chloride thought to impact grapes and hay crops, which are the primary crops currently grown in this area. It is recognized that there are groundwater users within the brackish groundwater areas of the Subbasin with wells that exhibit elevated chloride concentrations (**Figure 4-3**). There are several vineyards in this area that use recycled water for irrigation purposes for that reason.

The potential effects of the seawater intrusion MT on other beneficial uses and users in the Subbasin is as follows:

Agricultural land uses and users. The seawater intrusion MTs generally provide positive benefits to the Subbasin's agricultural water users. Preventing seawater intrusion, ensures that a supply of usable groundwater will exist for beneficial agricultural use.

Urban land uses and users. The seawater intrusion MTs generally provide positive benefits to the Subbasin's urban water users. Preventing additional seawater intrusion will help ensure an adequate supply of groundwater for urban supplies.

Domestic land uses and users. The seawater intrusion MTs generally provide positive benefits to the Subbasin's domestic water users. Preventing additional seawater intrusion will help ensure an adequate supply of groundwater for domestic supplies.

Ecological land uses and users. Although the seawater intrusion MTs do not directly benefit ecological uses, it can be inferred that the seawater intrusion MTs provide generally positive benefits to the Subbasin's ecological water uses. Preventing additional seawater intrusion will help prevent unwanted high salinity levels by the coast from impacting ecological groundwater uses. Additionally, coordination between the GSA and entities involved in restoration activities within the Baylands area will help better identify and avoid potential effects on ecological water uses in this area.

4.7.2.5 Relation to State, Federal, or Local Standards

While no federal, state, or local standards exist that are specific to seawater intrusion, the MT is set at the recommended SMCL for chloride established by the SWRCB DDW and is therefore consistent with existing available standards for drinking water.

4.7.2.6 Method for Quantitative Measurement of Minimum Thresholds

As previously noted, and further described in **Section 5**, the monitoring network for seawater intrusion represents a significant data gap that will need to be developed during the early stages of GSP implementation. Monitoring for seawater intrusion just north and along the perimeter of the San Pablo Baylands area will be conducted using a combination of existing water supply wells and additional proposed new dedicated monitoring wells constructed during implementation of the GSP, depending upon well access, construction, and funding availability. Until an adequate monitoring network is developed for seawater intrusion, chloride concentrations measured in groundwater samples from public supply wells within or near the margins of the Baylands area will be used to provide an indication of potential inland incursion of the chloride isocontour. The future monitoring network will be designed to more accurately map the location of the 250 mg/L chloride isocontour.

4.7.3 Measurable Objectives

The MO for seawater intrusion is shown as being coincident with the baseline 250 mg/L chloride isocontour as shown on **Figure 4-3** and is defined to be 250 mg/L chloride isocontour at the currently inferred interface of brackish groundwater.

The currently inferred interface of brackish groundwater is defined as the same location as the currently inferred 250 mg/L chloride isocontour. In other words, the goal of the MO is to protect beneficial users by maintaining this interface at its current location and avoiding any future inland incursion of seawater.

4.7.3.1 Method for Setting Measurable Objectives

The MO isocontour was set at the best estimate of current conditions and will be refined with future monitoring data. The goal is to not move the brackish groundwater interface further inland because it might start to impact beneficial users of groundwater.

4.7.3.2 Interim Milestones

The MOs for seawater intrusion are set at current conditions; therefore, the expected interim milestones are identical to current conditions.

4.7.4 Undesirable Results

4.7.4.1 Criteria for Defining Undesirable Results

The seawater intrusion undesirable result is a quantitative combination of chloride concentrations MT exceedances. Undesirable results for seawater intrusion occur in the Subbasin when two conditions are met as follows:

1. Three consecutive years of MT exceedances (the MT exceedances occur when the monitoring data indicate that the current extent of groundwater with 250 mg/L of chloride is inland relative to the MT isocontour).

2. The MT exceedance is determined to be caused by groundwater pumping.

The 3 consecutive years of MT exceedances was selected by the GSA Board to account for (1) the significant uncertainty associated with the mapping of the chloride isocontour due to current data limitations and (2) potential future short-term (for example, drought-related or seasonal) incursions of the chloride isocontour that have historically occurred along the margins of the Baylands (Kunkel and Upson 1960).

To ensure that undesirable results are tied to conditions which the GSA can feasibly manage (that is, groundwater levels and groundwater pumping), a correlation methodology will be used to determine if seawater intrusion related undesirable results have occurred as a result of groundwater-level declines due to groundwater pumping. This methodology will be implemented in conjunction with the GSP monitoring plan approach that includes regular evaluation of groundwater quality (including chloride) and groundwater levels.

Exceedance of a seawater intrusion MT will trigger implementation of the following methodology to determine if the seawater intrusion is related to groundwater pumping and, therefore, if an undesirable result may be occurring that requires action:

- Review of related chloride and TDS groundwater quality data, including WY average and standard deviations, and multi-year averages and standard deviations
- Review of groundwater elevation measurements and trends in RMP and other nearby wells being monitored, including an assessment as to whether groundwater levels have declined below historical lows or sea level
- Evaluation of time series plots of groundwater levels relative to sea level, chloride, and TDS data from nearby monitoring wells
- Evaluation of known or estimated groundwater pumping patterns near potential seawater intrusion
- Numerical modeling to evaluate the above, as necessary
- Compilation of pertinent data and assessment of any data gaps

This methodology data will be evaluated to determine whether the cause of seawater intrusion is declining groundwater levels due to groundwater pumping, if this constitutes an undesirable result, and proposed actions needed to halt additional seawater intrusion in the future. Other methods may also be considered based on the specific occurrence and available data and technical tools at the time. Should future MT exceedances occur, the results of the correlation methodology review and evaluation of data and monitoring will be provided with annual reports submitted to DWR. Additionally, any seawater intrusion is of great concern to the GSA and would likely trigger additional studies and potential monitoring efforts to better assess and understand the hydrogeologic framework and causes to prevent further movement inland of chloride in groundwater.

4.7.4.2 Potential Causes of Undesirable Results

Conditions that may lead to an undesirable result include groundwater-level declines along the northern margins of the tidal marshlands and the tidal reaches of Sonoma Creek. Groundwater-level declines in these areas could trigger the inducement of brackish water into fresher groundwater aquifers and may impact water quality for beneficial use. Such groundwater-level declines could be caused by ongoing or additional future pumping from supply wells near the margins of the Baylands area.

Other conditions, such as sea level rise or land use changes (including planned restoration activities), could cause future MT exceedances; however, these are not conditions which the GSA has the ability or authority to control and would not be considered an undesirable result. The methodology described above will help determine whether the causes of potential future MT exceedances constitute an undesirable result. The GSA has initiated discussions and is committed to future close coordination with organizations leading the planned restoration activities to limit the potential for future undesirable results and to appropriately monitor effects of future restoration activities.

4.7.4.3 Effects on Beneficial Users and Land Use

The primary detrimental effect on beneficial users and land uses from seawater intrusion is that the groundwater supply will become saltier and thus impact the use of groundwater for domestic/public supply and agricultural purposes. Seawater intrusion renders non-brackish groundwater essentially unusable for many beneficial users and land uses without expensive mitigation or treatment. Once seawater intrudes into aquifers, reversing and mitigating seawater intrusion can require significant resources and time to address and would significantly increase the cost of water for all users.

4.8 Degraded Water Quality SMC

Unlike most other sustainability indicators, degraded water quality is the subject of robust federal, state, and local regulatory regimes carried out by different entities and is not regulated by SGMA. The GSA is not responsible for enforcing existing water quality standards or collecting data to support existing water quality programs, nor is the GSA responsible for natural changes in groundwater quality or groundwater degradation caused by others. However, potential groundwater quality degradation needs to be considered during GSP development to ensure that activities associated with implementing the GSP, such as GSP projects and actions, do not degrade current water quality conditions.

One of the primary challenges in implementing the degraded water quality SMC will be to assess in the future if any degradation to groundwater quality is due to SGMA activities, and specific projects and management actions may include focused groundwater quality monitoring, as appropriate.

4.8.1 Locally Defined Significant and Unreasonable Conditions

Locally defined significant and unreasonable conditions were determined based on public meetings, and discussions with GSA staff, Advisory Committee members, and the GSA Board.

Significant and unreasonable water quality conditions occur if an increase in the concentration of COCs in groundwater leads to adverse impacts on beneficial users or uses of groundwater, due to either:

1. Direct actions by Sonoma Valley GSP projects or management activities
2. Undesirable results occurring for other sustainability indicators

Examples of potential adverse impact are described in **Sections 4.8.2.7** and **4.8.4.3**.

As noted in CCR Title 23 Section 354.28 (c)(4) of the GSP Regulations, MTs are based on a degradation of water quality, not an improvement of water quality. Therefore, this GSP is designed to avoid taking any action that may inadvertently move groundwater constituents that have already been identified in the Subbasin in such a way that the constituents have a significant and unreasonable impact that would not otherwise occur.

SMC were developed for all COCs, which were identified based on the following three criteria:

1. They have an established level of concern such as an MCL or SMCL, or a level that reduces crop production.

2. They have been found in the Subbasin at levels above the level of concern and are routinely analyzed and reported through existing regulatory monitoring programs.

3. The occurrence of the COC is extensive throughout the Subbasin.

Based on the review of groundwater quality in **Section 3.2.5**, three COCs were identified that may affect groundwater supply in the Subbasin: arsenic, nitrate, and salinity (measured as TDS).

There are other point source contaminants found sporadically in the Subbasin, but these are not regional in extent, are monitored through various other regulatory programs, and consequently SMC are not established in the GSP. Additionally, while boron is identified as a naturally-occurring constituent of interest in **Section 3.2.5**, boron is not routinely sampled through existing regulatory monitoring programs. New or additional water quality constituents may be identified as potential COCs applicable to the GSP implementation activities through routine consultation and information sharing with other regulatory agencies. The GSA would then consider adding potential COCs and assigning SMC during the 5-year GSP updates.

Future GSP implementation projects or actions that require their own site-specific monitoring network would take into consideration any localized COCs and regulatory requirements.

4.8.2 Minimum Thresholds

The GSP Regulations allow three options for setting degraded water quality MTs. CCR Title 23 Section 354.28(c)(2) of the GSP Regulations states that "The minimum threshold shall be based on the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the Agency to be of concern for the basin." In this Subbasin, MTs are based on a number of supply wells that exceed concentrations of constituents determined to be of concern for the Subbasin.

The currently available supply wells for monitoring COCs that have an MCL or SMCL are public supply wells. Should domestic wells or agricultural irrigation wells be incorporated into future monitoring programs established by the GSA or other entities, they could also be included in monitoring COCs during future GSP updates.

4.8.2.1 Existing Water Quality Monitoring Programs and Networks

The SMC are based on a number of supply wells, and the GSA identified sets of supply wells that are currently monitored (or are proposed to be monitored in the future) for various groundwater constituents and supply uses, such as drinking water and irrigation water. Because these supply wells are monitored under different programs and may have different required sampling schedules (even under the same program), no one set of constituents will be sampled in all wells.

The goal is to use existing monitoring programs for supply well water quality assessment and not create new water quality monitoring networks that the GSA would be responsible for sampling. Initially, it is anticipated that RMPs will come from public supply wells that are already monitored. The only additional sampling the GSA would perform is on a project as-needed basis to specifically identify potential impacts on supply wells due to the development of a project related to GSP implementation (such as recharge ponds, ASR).

Existing monitoring programs identified in this Subbasin include:

- Public supply wells, regulated by the SWRCB DDW. Public drinking water supply wells are included in the water quality monitoring network because they are routinely sampled to meet CCR Title 22 water quality reporting requirements as regulated by the SWRCB DDW. Title 22 analyses include arsenic, nitrate, and TDS, which are the Subbasin COCs. This dataset can be obtained from the SWRCB through the GAMA online portal.

- The SNMP includes sampling and analysis of water quality constituents in a network of existing wells (RMC and Todd Engineers 2014). The SNMP monitoring network includes 26 public supply wells, 2 multi-level monitoring well clusters that were installed as part of the SVGMP, and 12 wells of unknown type that have been routinely sampled by DWR. The public supply wells proposed for the MRP are already included in the DDW dataset. The SVGMP monitoring wells have been sampled periodically (last in 2016) and the wells sampled by DWR have not been reported as sampled since 2010, when they were sampled for nitrate, EC, and TDS. The analytical datasets from the SNMP wells will be available from the SWRCB through the GAMA online portal.

- Existing and future water quality monitoring programs may be used to help collect data during GSP implementation and establish consistency with other programs. Additional information on each of the existing monitoring programs is provided in **Table 4-3**. **Table 4-4** provides information on future monitoring networks to be used specifically for monitoring projects and management actions for GSP implementation.

Table 4-3. Sonoma Valley Subbasin Monitoring Networks

Monitoring Network	Responsible Party	Type of Wells	Constituents Sampled	Sampling Frequency	Purpose of Network
Salt and Nutrient Management Plan	Sonoma Valley Sanitation District	Public Supply; Monitoring	EC, TDS, Nitrate	Varies	Abide by SNMP requirements
DDW Public Supply Wells	Cities and small water systems	Public Supply	Subset of Title 22 constituents	Varies	Protect drinking water beneficials users

Table 4-4. Future Monitoring Networks for Project-specific Monitoring

Future As-needed Monitoring Network	Responsible Party	Type of Wells	Constituents Sampled	Sampling Frequency	Purpose of Network
Future Project Implementation Monitoring Network	GSA	To be determined (public and private wells)	COCs identified as part of the GSP and the constituents as required by project permitting	To be determined	Identify water quality impacts related to site-specific project and action implementation

Each of these well networks are monitored for different purposes and overseen by different entities; therefore, sampling frequency and analytical suites vary. Water quality MTs for each well are selected based on which constituents are analyzed in water samples per existing programs, summarized in **Table 4-5**.

Table 4-5. Summary of Constituents Monitored at Each Well Network

Constituent	Public Supply	SNMP
Arsenic	✓	
Nitrate	✓	✓
TDS	✓	✓

4.8.2.2 Level of Concern for each Constituent of Concern

Each COC has an associated level of concern for each category of beneficial user. For the drinking water supply well category, the level of concern is represented by the MCL or SMCL, as applicable.

The SFBRWQCB Basin Plan designates municipal and agricultural water quality management objectives for the Sonoma Valley. The municipal designation aims to maintain water quality for public supplies below the California MCL and SMCL drinking water standards (SFBRWQRCB 2019). The agricultural designation aims to maintain water quality for irrigation below specific thresholds that may be harmful to certain crops (SFBRWQCB 2019).

The basis for establishing MTs for each COC in the Subbasin are summarized in **Table 4-6**. This table does not identify the total number of supply wells that may exceed the level of concern, but rather identifies how many additional wells will be allowed to exceed the level of concern. Wells that already exceed this level are not counted against the MTs.

Table 4-6. Groundwater Quality Minimum Thresholds Basis

Constituent of Concern	Minimum Threshold Based on Number of Wells
Arsenic	One additional supply well exceeds the arsenic MCL of 0.010 mg/L.
Nitrate	One additional supply well exceeds the nitrate measured as nitrogen MCL of 10 mg/L.
TDS	One additional supply well exceeds the TDS recommended SMCL of 500 mg/L.

4.8.2.3 Development of Minimum Thresholds at Supply Wells

The MTs for degraded water quality for the supply wells are based on the number of additional exceedances of any MCL or SMCL in existing supply wells shown in **Table 4-6**. Establishing the MT as the number of additional exceedances accounts for supply wells with previous exceedances, assuming these exceedances will likely continue into the future. The GSA Board selected one as the number of additional supply wells with exceedances to represent the MT. The MT for the number of allowed exceedances is therefore equal to the baseline number of exceedances (calculated as the number of supply wells with any MCL or SMCL exceedance between 2015 and 2020) plus one additional supply well with an exceedance. Based on the number of supply wells in the existing water quality monitoring network, the number of existing exceedances since 2015 for each constituent is tabulated in **Table 4-7** and the distribution of exceedances are shown on **Figures 4-4** through **4-6**, along with all of the other supply wells included in the initial RMP network.

MT exceedances are based on existing supply wells only. According to the GSP Regulations, the MTs are based on the same number of supply wells to have exceedances, not necessarily the same wells. The well networks will be re-assessed every 5 years to identify any new supply wells that could be added to the monitoring networks. The MT will be increased by one for each new supply well added to the monitoring network with an initial measured concentration exceeding the MCL or SMCL. Additionally, if the MCL or SMCL changes for a GSP-identified COC, the specific MT should be examined and updated as appropriate.

If new exceedances of MTs are observed that are not due to GSP implementation, those new levels may be used to modify the MT to better reflect Subbasin conditions regardless of the GSP implementation actions.

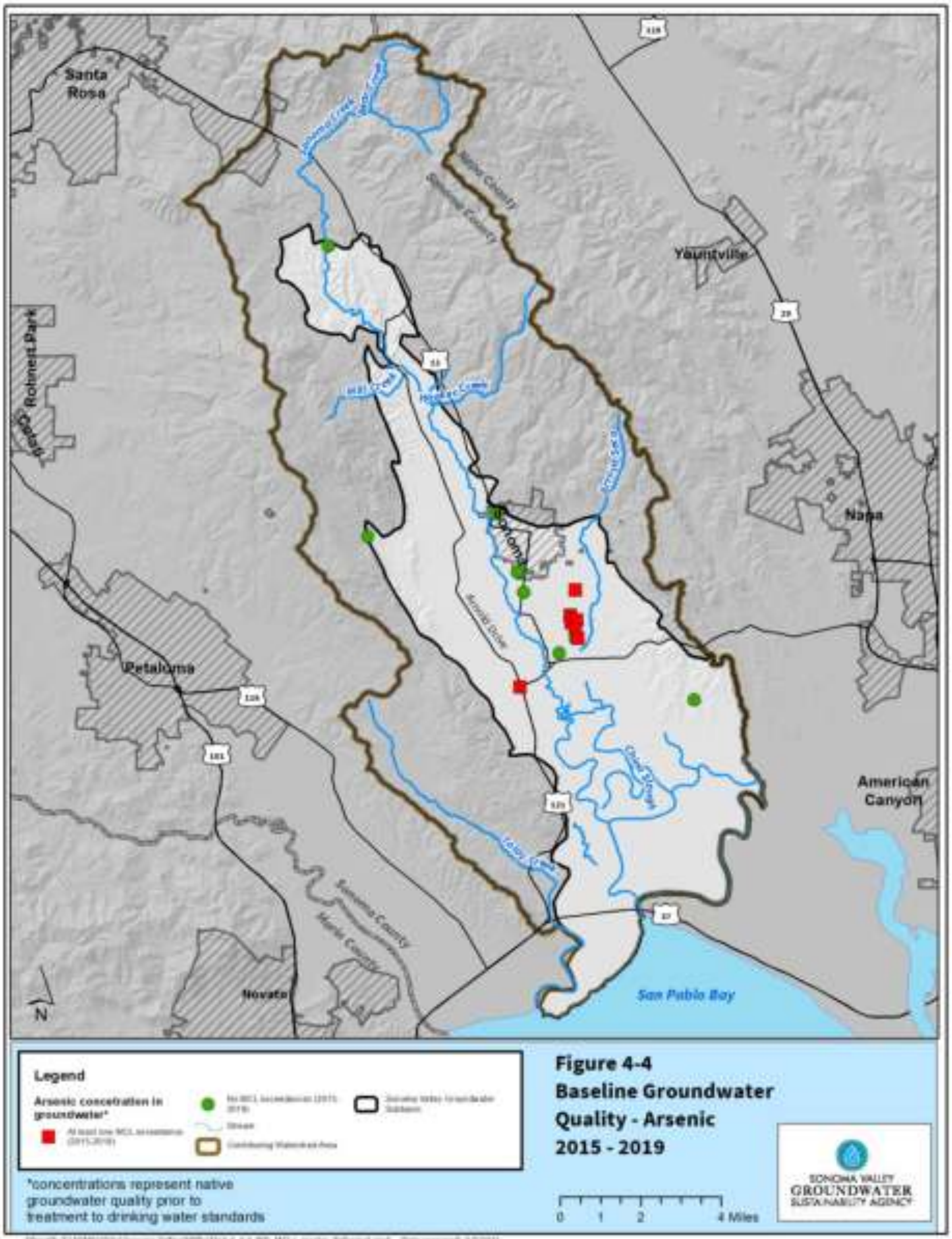

Figure 4-4. Baseline Groundwater Quality – Arsenic 2015–2020

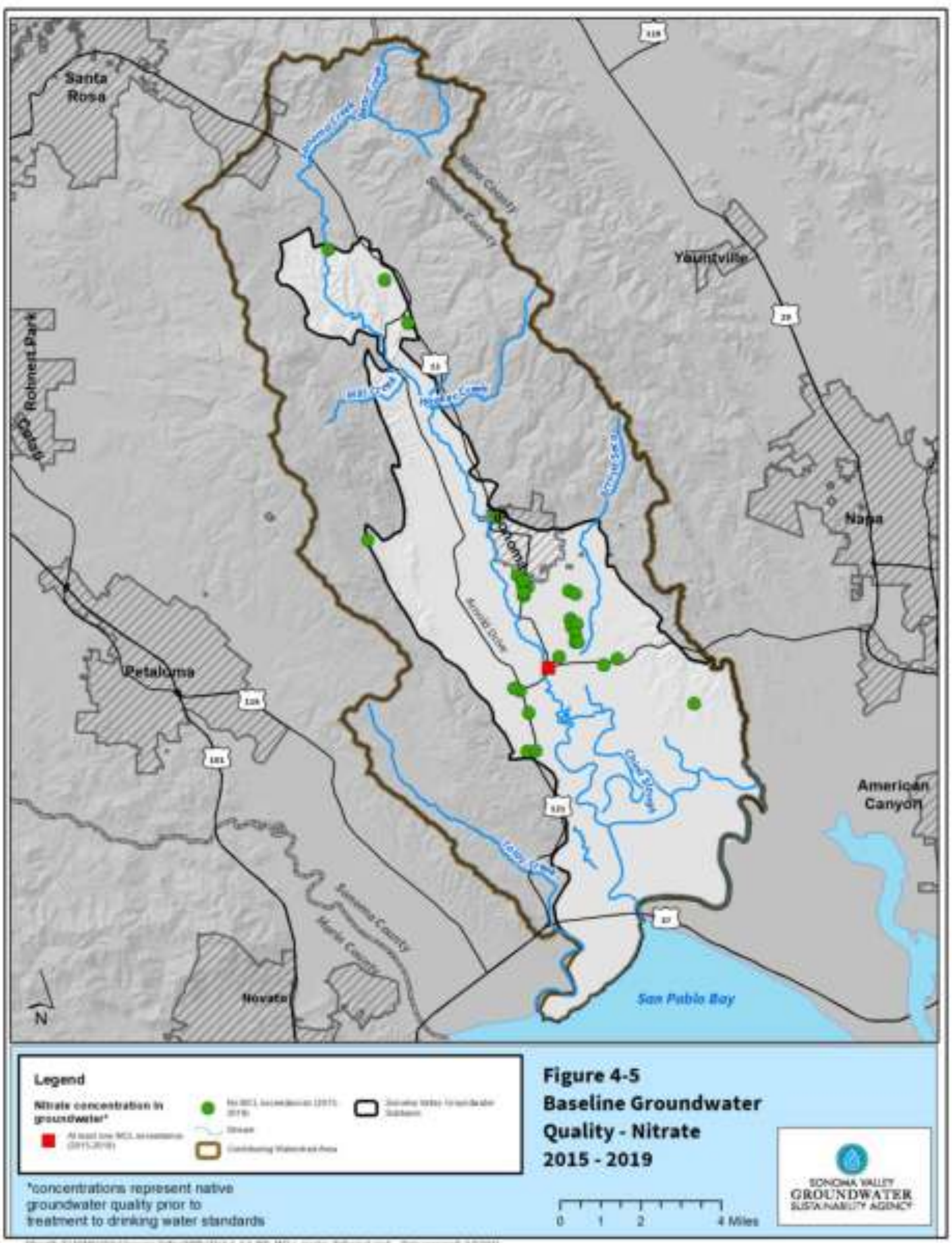

Figure 4-5. Baseline Groundwater Quality – Nitrate 2015–2020

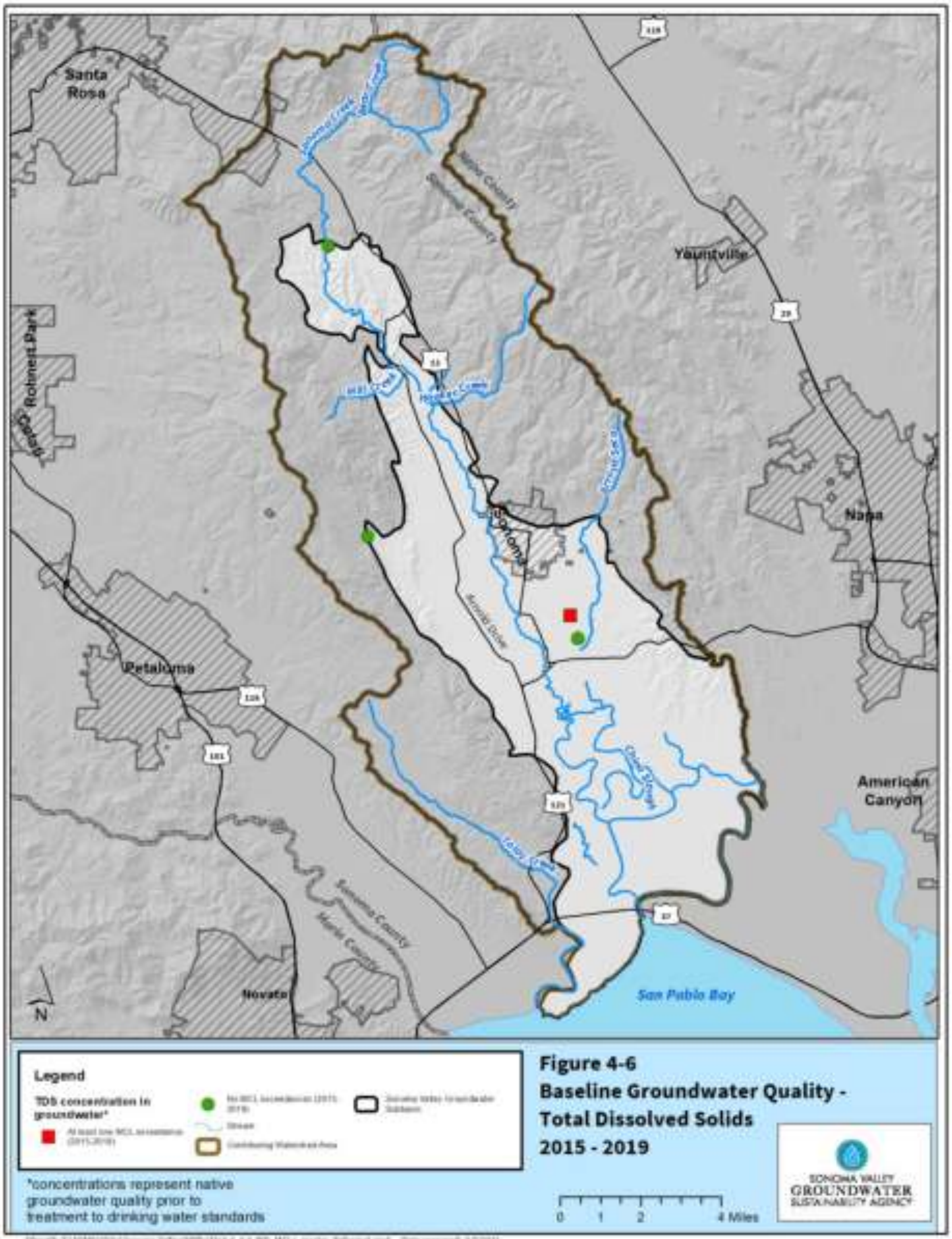

Figure 4-6. Baseline Groundwater Quality – TDS 2015–2020

Table 4-7. Minimum Thresholds for Degradation of Groundwater Quality for the Public Supply Wells Under the Current Monitoring Network

Constituent of Concern	Regulatory Exceedance Standard	Standard Units	Number of Sampled Wells in Monitoring Network (2015-2020)	Total Number of Exceedances (2015-2020)	Number of Wells Exceeding Regulatory Standard (2015-2020)	Minimum Threshold
Arsenic	10	µg/L	25	160	11	12
Nitrate	10	mg/L	40	1	1	2
TDS	500	mg/L	13	3	2	6

4.8.2.4 Information and Methodology Used to Establish Water Quality Minimum Thresholds and Measurable Objectives

The exceedances shown in **Table 4-7** were based on a review of recent datasets. The information used for establishing the degradation of groundwater quality MTs includes:

- Historical groundwater quality data from public supply in the Subbasin
- Federal and state drinking water quality standards
- Feedback from GSA staff members and Advisory Committee members.

The historical groundwater quality data used to establish groundwater quality MTs are presented in **Section 3.2.5**. Based on the reviews of historical and current groundwater quality data, and federal and state drinking water standards, these standards are appropriate to define groundwater quality MTs.

4.8.2.5 Relationship between Individual Minimum Thresholds and Relationship to Other Sustainability Indicators

Because SGMA does not require projects or actions to improve groundwater quality, there will be no direct actions under the GSP associated with the groundwater quality MTs; therefore, there are no actions that directly influence other sustainability indicators. However, preventing migration of poor groundwater quality may limit activities needed to achieve MTs for other sustainability indicators:

- **Chronic lowering of groundwater levels**. Groundwater quality MTs could influence groundwater elevation MTs by limiting the types of water that can be used for recharge to raise groundwater elevations. Water used for recharge cannot result in exceedances of any of the groundwater quality MTs. In addition, a change in groundwater elevations may cause a change in groundwater flow direction which in turn could cause poor water quality to migrate into areas of good water quality.

- **Change in groundwater storage**. Nothing in the groundwater quality MTs promotes pumping in excess of the sustainable yield. Therefore, the groundwater quality MTs will not result in an exceedance of the groundwater storage MT.

- **Seawater intrusion**. Nothing in the groundwater quality MTs promotes additional pumping that could cause seawater intrusion. Therefore, the groundwater quality MTs will not result in an exceedance of the seawater intrusion MT. Avoiding the water quality MTs for TDS, which is a measure of salinity, would also benefit the seawater intrusion MT.

- **Subsidence**. Nothing in the groundwater quality MTs promotes additional pumping that could cause subsidence. Therefore, the groundwater quality MTs will not result in an exceedance of the subsidence MT.

- **Depletion of interconnected surface water**. Nothing in the groundwater quality MTs promotes additional pumping or lower groundwater elevations adjacent to interconnected surface waters. Therefore, the groundwater quality MTs will not result in a significant or unreasonable depletion of interconnected surface waters.

4.8.2.6 Effect of Minimum Thresholds on Neighboring Basins and Subbasins

Because the MTs in the Sonoma Valley Subbasin are to prevent migration of poor-quality water, it is likely that the MTs will not prevent the Petaluma Valley GSA from achieving and maintaining sustainability. The MTs are also not likely to negatively impact the Kenwood Valley Basin or Napa Lowlands Subbasin. The Sonoma Valley GSA will coordinate closely with the neighboring Petaluma Valley GSA as they both set MTs to ensure that the subbasins do not prevent each other from achieving sustainability.

4.8.2.7 Effect on Beneficial Uses and Users

Agricultural land uses and users. The degradation of groundwater quality MTs is designed to avoid negative effects to groundwater quality associated with implementation of the GSP. Avoiding degradation of groundwater quality for the identified COCs, including salts which can impact agricultural irrigation, helps maintain groundwater quality and provides positive benefits to the Subbasin’s agricultural water users.

Urban land uses and users. The degradation of groundwater quality MTs is designed to avoid negative effects to groundwater quality associated with implementation of the GSP. Avoiding degradation of groundwater quality from the identified COCs helps maintain municipal drinking water quality providing positive benefits to the Subbasin’s urban water users.

Domestic land uses and users. The degradation of groundwater quality MTs is designed to avoid negative effects to groundwater quality associated with implementation of the GSP. Avoiding degradation of groundwater quality from the identified COCs helps maintain drinking water quality providing benefits for domestic well users.

Ecological land uses and users. Although the groundwater quality MTs are not designed to directly benefit ecological uses, it can be inferred that the degradation of groundwater quality MTs provide generally positive benefits to the Subbasin’s ecological water uses by helping maintain groundwater quality.

4.8.2.8 Relation to State, Federal, or Local Standards

The degradation of groundwater quality MTs specifically incorporate state and federal standards for drinking water.

4.8.2.9 Method for Quantitative Measurement of Minimum Thresholds

Degradation of groundwater quality MTs will be measured directly using analysis of samples collected from public drinking water supply wells reported through SWRCB DDW. An average concentration of water quality samples will be used for wells that are sampled more than once a year. If any other routine monitoring of supply wells is initiated in the Subbasin at a later date, these wells will also be considered for inclusion in the water quality monitoring network. The data review will focus on exceedances of MTs, or MCLs and SMCLs for the COCs identified for this GSP. However, if during review of the water quality data additional constituents appear to frequently exceed MCLs and SMCLs, MTs and MOs will be considered for these additional constituents during GSP 5-year updates.

4.8.3 Measurable Objectives

The MOs for degradation of groundwater quality represent target groundwater quality distributions in the Subbasin. SGMA does not mandate the improvement of groundwater quality. Therefore, the GSA has set the MO for each COC to the number of existing supply wells that exceeded the MCL or SMCL from 2015 to 2020, as shown in **Table 4-7**. In other words, the MO is to have zero additional supply wells exceeding the applicable MCL or SMCL for any of the COCs.

4.8.3.1 Method for Setting Measurable Objectives

As described above, MOs are established using a similar method to the MTs detailed in **Section 4.8.2**, except the target number of additional MCL or SMCL exceedances will be zero.

4.8.3.2 Interim Milestones

The MOs for degradation of groundwater quality are set at current conditions; there is no anticipated degradation of groundwater quality during GSP implementation that results from the implementation of projects and actions as described in **Section 6**. Therefore, the expected interim milestones are identical to current conditions.

4.8.4 Undesirable Results

4.8.4.1 Criteria for Defining Undesirable Results

By regulation, the degradation of groundwater quality undesirable results is a quantitative combination of groundwater quality MT exceedances. Some groundwater quality changes are expected to occur independent of SGMA activities; because these changes are not related to SGMA activities, they do not constitute an undesirable result. Therefore, the degradation of groundwater quality undesirable results occurs if, during 2 consecutive years, a single groundwater quality MT is exceeded when computing annual averages at the same well, as a direct result of projects or management actions taken as part of GSP implementation.

4.8.4.2 Potential Causes of Undesirable Results

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

- If the location and rates of groundwater pumping change as a result of projects implemented under the GSP, these changes could alter hydraulic gradients and associated flow directions, and cause movement of one of the COCs towards a supply well at concentrations that exceed relevant standards.
- Active recharge of imported water or captured runoff could modify groundwater gradients or alter local geochemical conditions and move one of the COCs towards a supply well in concentrations that exceed relevant limits.
- Recharging the Subbasin with water that exceeds an MCL, SMCL, or level that reduces crop production may lead to an undesirable result.
- The exceedance of an undesirable results for another sustainability indicator may lead to an undesirable result for degraded water quality.

Prior to determining whether an undesirable result has occurred based on MT exceedances, an investigation of the cause for the exceedance(s) will be conducted by the GSA. Such investigation would likely include the following steps, as needed: (1) Is a project or action by the GSA located in the vicinity and can be reasonably linked to the exceedance and/or (2) are undesirable results occurring for any other sustainability indicators that could impact water quality?

If the answer to either (1) or (2) is yes, then the following additional steps would be taken:

- Evaluate monitoring data from any projects and actions in the vicinity of the exceedance and correlate to the data from the well that had an exceedance
- Review of any other available groundwater quality data in the vicinity of the exceedance
- Review available laboratory analytical data and laboratory quality assurance/quality control measures
- Resample wells with exceedances if it is established that GSA projects or actions may be the cause of the exceedance

For any projects and actions implemented under the GSP, additional groundwater quality monitoring in the vicinity of the project or actions sites may be implemented to determine the possibility of causing undesirable results. Any needed mitigation measures to avoid the negative conditions will be included.

4.8.4.3 Effects on Beneficial Users and Land Use

The undesirable result for degradation of groundwater quality is adverse impacts on beneficial uses and users in the Subbasin from groundwater degradation due to actions directly resulting from GSP implementation. Adverse impacts include diminished supply due to water quality impacts that cause non-compliance with drinking water standards or undue costs for mitigating impacts through wellhead treatment or well replacement. If water quality degradation due to GSP implementation activities is avoided, there will be no impact on the use of groundwater and there will be no negative effect on the beneficial users and uses of groundwater. However, if projects and actions are shown to cause the degradation of localized groundwater quality, the GSA will develop mitigation actions.

This undesirable result only applies to groundwater quality changes directly caused by projects or management actions implemented as part of this GSP. This undesirable result does not apply to groundwater quality changes that occur due to other causes.

4.9 Subsidence SMC

Land surface subsidence is the change in land surface elevation caused by an increase in effective stress due to groundwater overdraft, tectonics, or other natural processes such as hydrologic isostatic loading. Land surface subsidence may be elastic or inelastic. Elastic subsidence is recoverable as groundwater conditions change. Inelastic subsidence is unrecoverable and is primarily due to irreversible compaction of clay-rich sediments. Per the GSP Regulations, the GSAs are only responsible for managing inelastic land subsidence caused by lowered groundwater elevations. They are not responsible for managing elastic subsidence or subsidence conditions caused by something other than groundwater pumping, such as tectonic activity.

Available land surface subsidence datasets for the Subbasin do not indicate the occurrence of inelastic subsidence due to groundwater pumping. Subsidence measurements have been collected in the Subbasin at three discrete locations since 2006 and by satellite in most of the Subbasin since 2015. The available datasets are summarized in the Basin Setting section of this GSP (**Section 3.2.3**). Total subsidence measured by GPS at the three discrete locations was less than 0.75-inch (or 0.063 foot) since 2006. Total land subsidence measured by satellite InSAR was less than 0.25-inch (or 0.021 foot) since 2015. Together, the subsidence datasets indicated that there is a very slight downward land subsidence trend throughout the Subbasin and wider region. This trend was apparent in areas of the Subbasin and beyond both with and without groundwater pumping. It is unknown if the noted subsidence was elastic or inelastic; however, since the subsidence was found to be regionally consistent, it is not likely attributed to groundwater pumping and more likely due to natural causes such as tectonics or hydrostatic loading. Consequently, it appears that no significant inelastic subsidence has occurred within the Subbasin due to groundwater pumping.

4.9.1 Locally Defined Significant and Unreasonable Conditions

As described in **Section 4.9** and detailed further in **Section 3.2.3**, available Subbasin-wide datasets (while limited to recent time periods) do not indicate the occurrence of inelastic land surface subsidence due to groundwater pumping within the Subbasin. There have been no problems reported by Subbasin stakeholders related to historical inelastic subsidence (for example, damage to infrastructure or modified drainage patterns). However, the risk of future inelastic land surface subsidence and consolidation of clay-rich portions of the Subbasin's aquifer system exists if there are chronic declines of groundwater levels.

Locally defined significant and unreasonable conditions were determined based on public meetings, and discussions with GSA staff, Advisory Committee members, and GSA Board. Significant and unreasonable land subsidence in the Subbasin was defined as follows:

Any rate of future inelastic subsidence caused by groundwater pumping is a significant and unreasonable condition, everywhere in the Subbasin and regardless of the beneficial uses and users.

4.9.2 Minimum Thresholds

CCR Title 23 Section 354.28(c)(5) of the GSP Regulations states that the "minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results." As such, the defined metric from the GSP Regulations for measuring total subsidence includes the rate of change in land surface elevation. This can be measured with extensometers, continuous GPS stations, levelling surveys, or by satellite with InSAR. It is difficult to assess a-priori whether subsidence interferes with surface land uses to address the second portion of the GSP Regulation; therefore, the GSA has selected a single protective MT for subsidence for the entire Subbasin. While zero inelastic subsidence due to pumping is the desire to avoid significant and unreasonable conditions, there is an inherent 0.1-foot potential error in the InSAR technology. To account for this potential measurement error of the data collection method, the MT for subsidence in the Subbasin is 0.1 ft/yr of inelastic subsidence measured by InSAR for each of the 100-square-meter, or approximately 2.5-acre, grids or pixels in the Subbasin.

4.9.2.1 Information and Methodology Used to Establish Subsidence Minimum Thresholds and Measurable Objectives

The subsidence MT and MO do not allow for measurable additional inelastic subsidence in the Subbasin due to groundwater pumping. The MT allowance of 0.1 ft/yr of subsidence was developed based on the inherent measurement error of InSAR technology.

The InSAR pixels serve as the RMPs. The reported total subsidence value is an average of many individual measurements within each InSAR pixel. InSAR is the method used for establishing MTs and MOs given the spatial coverage, accuracy, and availability at no cost to the GSA (state funded program for SGMA). Disadvantages of InSAR are that it measures total subsidence rather than inelastic subsidence and the available data record only extends to 2015.

4.9.2.2 Relationship between Individual Minimum Thresholds and Relationship to Other Sustainability Indicators

Subsidence MTs have little or no impact on other MTs:

- **Chronic lowering of groundwater levels**. Nothing in the subsidence MT promotes additional pumping that could cause chronic lowering of groundwater levels. Therefore, the subsidence MT will not result in an exceedance of the groundwater storage MT.

- **Change in groundwater storage**. Nothing in the subsidence MT promotes pumping in excess of the sustainable yield. Therefore, the subsidence MT will not result in an exceedance of the groundwater storage MT.

- **Degraded water quality**. Nothing in the subsidence MT promotes additional pumping that could cause degradation of groundwater quality. Therefore, the subsidence MT will not result in an exceedance of the groundwater quality MT.

- **Depletion of interconnected surface water**. Nothing in the subsidence MT promotes additional pumping or lower groundwater elevations adjacent to interconnected surface waters. Therefore, the subsidence MT will not result in a significant or unreasonable depletion of interconnected surface waters.

4.9.2.3 Effect of Minimum Thresholds on Neighboring Basins and Subbasins

Because the subsidence MT in the Sonoma Valley Subbasin is intended to prevent any measurable inelastic subsidence due to groundwater pumping, it is likely that the MTs will not prevent the Petaluma Valley GSA from achieving and maintaining sustainability. The MTs are also not likely to negatively impact the Kenwood Valley Basin or Napa Lowlands Subbasin. The Sonoma Valley GSA will coordinate closely with the neighboring Petaluma Valley GSA as they both set MTs to ensure that the subbasins do not prevent each other from achieving sustainability.

4.9.2.4 Effect on Beneficial Uses and Users

Agricultural land uses and users. The subsidence MT is designed to avoid negative effects to infrastructure associated with implementation of the GSP. Avoiding land subsidence helps protect wells and water conveyance infrastructure that are critical to the Subbasin’s agricultural water users.

Urban land uses and users. The subsidence MT is designed to avoid negative effects to infrastructure associated with implementation of the GSP. Avoiding land subsidence helps protect buildings, roads, utilities, wells, and other infrastructure. This provides positive benefits to the Subbasin’s urban water users.

Domestic land uses and users. The subsidence MT is designed to avoid negative effects to infrastructure associated with implementation of the GSP. Avoiding land subsidence helps protect buildings, roads, utilities, wells, and other infrastructure. This provides positive benefits to the Subbasin's domestic water users.

Ecological land uses and users. The subsidence MT is not designed to directly benefit ecological uses. Preventing future subsidence in the Subbasin will not harm or benefit ecological water users.

4.9.2.5 Relation to State, Federal, or Local Standards

There are no federal, state, or local regulations related to land subsidence.

4.9.2.6 Method for Quantitative Measurement of Minimum Thresholds

There are two existing subsidence monitoring networks in the Subbasin: InSAR and three continuous GPS monitoring locations. The continuous GPS data are temporally extensive, but spatially limited. Therefore, the GSA intends to use the InSAR method for assessment of the subsidence SMC. Statewide subsidence data are currently estimated every month by satellite using InSAR methodology. DWR maintains a database of InSAR data and makes them publicly available for use in GSPs.

Quantitative measurements for InSAR data are provided on a monthly timestep by DWR. The DWR database and webmap report an average total subsidence value of many individual measurements within a single 100 square-meter, or approximately 2.5-acre pixel. The average for each pixel will be used for the subsidence MT. On a statewide level, the DWR has stated that the errors for the total vertical displacement measurements between June 2015 and June 2019 are as follows:

1. The error between InSAR data and continuous GPS data is 16 millimeters (0.052 foot) with a 95 percent confidence level (DWR 2021b).
2. The measurement accuracy when converting from the raw InSAR data to the maps provided by DWR is 0.048 foot with 95 percent confidence level.

For the purposes of this GSP, the cumulative error for InSAR data is considered the sum of errors 1 and 2, for a combined total error of 0.1 foot.

The InSAR data provided by DWR reflect both elastic and inelastic subsidence. While it is difficult to compensate for elastic subsidence, visual inspection of monthly changes in ground elevations suggest that elastic subsidence is largely seasonal. Due to the seasonal elastic fluctuations, annual subsidence will be calculated by comparing InSAR datasets at the same time each year to reduce the effect of any seasonal elastic fluctuations of elevation on observed data.

4.9.3 Measurable Objectives

The MO is the aspirational goal to achieve optimal protection of groundwater conditions. The recommended MO is the same as the MT given that zero subsidence related to groundwater pumping is the significant and unreasonable condition. In other words, there is not a more stringent condition for land subsidence than the MT. Similar to the MT, the subsidence MO allows for 0.1 foot of measurement error per year.

4.9.3.1 Method for Setting Measurable Objectives

MOs are set to be identical to the MTs and therefore follow the same method as detailed in **Section 4.9.2**.

4.9.3.2 Interim Milestones

The MOs for subsidence are set at current conditions and there is no anticipated additional subsidence during GSP implementation that results from groundwater pumping; therefore, the expected interim milestones are identical to current conditions, MTs, and MOs.

4.9.4 Undesirable Results

By regulation, the subsidence undesirable result is a quantitative combination of subsidence MT exceedances. For the Subbasin, any inelastic subsidence as a direct result of groundwater pumping is considered unacceptable. Since the GSP Regulations allow for elastic and inelastic subsidence due to natural conditions, such as plate tectonics and hydrostatic loading, any subsidence resulting from these phenomena are not included in the definition of undesirable results.

A land subsidence undesirable result will occur in the Subbasin if:

- The land subsidence MT of 0.1 foot of total subsidence is exceeded over a geographic area of 50 acres in a single year; or
- Cumulative total subsidence of 0.2 foot is exceeded over a geographic area of 50 acres within a 5-year period; and
- The MT exceedance is determined to be correlated with: (1) groundwater pumping (2) an MT exceedance of the chronic lowering of groundwater levels SMC.

The geographic area of 50 acres was selected to reduce the likelihood that a very small area or a single data point anomaly within a single 2.5-acre grid could result in Subbasin-wide undesirable results. The cumulative cap of 0.2 foot within a 5-year period was selected to account for the risk of cumulative small amounts of annual total subsidence less than 0.1 foot, adding up to a more significant level of subsidence. The 0.2 foot cumulative total represents an estimated minimum limit for elastic subsidence due to groundwater pumping from the Santa Rosa Plain (an area with similar clay-rich geologic materials and a historical pattern of groundwater-level decline and subsequent recovery), while maintaining protections to avoid the potential for future inelastic subsidence. The undesirable result is tied to groundwater pumping and an exceedance of the chronic lowering of groundwater levels SMC to isolate subsidence caused by groundwater pumping from other causes such as plate tectonics and hydrostatic loading.

4.9.4.1 Criteria for Defining Undesirable Results

An important aspect of the recommended SMC is the determination of whether total subsidence measured by InSAR is correlated to groundwater-level declines caused by pumping.

Some of the activities that the GSAs will conduct to evaluate if inelastic land subsidence occurred due to groundwater pumping include the following:

- Review of land surface elevation data from InSAR, continuous GPS stations, or other measurement devices in the Subbasin
- Review of groundwater elevation measurements and trends in RMPs (established as part of the declining groundwater-level SMC) and other nearby wells being monitored, including an assessment as to whether groundwater levels are below historical lows or exceeding MTs
- Evaluation of time series plots of groundwater levels from nearby monitoring wells
- Review of seismic related data and records that might explain land subsidence observations
- Evaluation of known or estimated groundwater pumping patterns within the vicinity of any observed potential land subsidence

A compilation of pertinent data, including continuous GPS stations and assessment of any data gaps will also be conducted.

4.9.4.2 Potential Causes of Undesirable Results

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

- Continued decline of groundwater levels due to groundwater pumping within the Subbasin could trigger inelastic subsidence in areas with clay-rich sediments.
- If the location and rates of groundwater pumping change as a result of projects implemented under the GSP, subsidence may occur.
- Shifting a significant amount of pumping to an area that is susceptible to subsidence could trigger subsidence that has not been observed before.
- The exceedance of an undesirable result for another sustainability indicator may lead to an undesirable result for subsidence.

4.9.4.3 Effects on Beneficial Users and Land Use

The undesirable result for subsidence does not allow any subsidence to occur in the Subbasin. Therefore, there is no negative effect on any beneficial uses and users.

4.10 Depletion of Interconnected Surface Water SMC

The SMC for depletion of interconnected surface water is technically complex to develop and requires robust modeling tools, historical records of streamflow and groundwater levels near streams, and identification of potential impacts from streamflow depletion. To develop these SMC, staff convened two practitioner work groups to provide expert input on: (1) mapping of GDEs and (2) development of the SMC for depletion of interconnected surface water. Collectively, these work groups met seven times between July 2020 and March 2021. The work group focused on the development of the SMC for depletion of interconnected surface water and included the following participants:

- Rick Rogers, National Marine Fisheries Service
- Jessie Maxfield, California Department of Fish and Wildlife
- Natalie Stork, SWRBC
- Val Zimmer, SWRBC
- Sam Boland-Brien, SWRBC
- Maurice Hall, Environmental Defense Fund
- Melissa Rohde, TNC
- Andrew Renshaw, DWR

Key themes and outcomes from work group members that assisted in developing the SMC for interconnected surface water are documented in **Appendix 4-B**. As described in **Appendix 4-B**, the SMC for depletion of interconnected surface water are unique in that information in the historical record linking surface water depletion directly to groundwater usage under the jurisdiction of the GSAs is very limited. Variable levels of correlation between simulated streamflow depletion and groundwater levels, a lack of existing instream flow targets, and limited data for assessing the presence of any historically significant and unreasonable conditions complicate the development of these SMC. [2] An additional complication is that depletions of surface water can be caused by diversions under surface water rights (for example, direct surface water diversions or wells pumping under appropriative or riparian rights) that are outside the jurisdiction of SGMA and the GSAs. Therefore, the cause of the depletion must be evaluated to assess if such depletions are caused by pumping under the jurisdiction of the GSA.

Empirical data are not currently available on potential causes and effects of surface water depletion due to groundwater pumping to adequately determine when and how it adversely

[2] While it is recognized that low summer baseflows in certain years can impact aquatic species, until we know how much water they need to survive and thrive (for example, via instream flow targets), an MT is difficult to determine. The current approach requires using historical data and avoiding conditions lower than historical surface water depletion amounts.

impacts GDEs or other beneficial surface water users. For this reason, this GSP includes the following:

- A detailed adaptive management plan for developing new information and data to refine the SMC during initial years of GSP implementation
- Initial SMC focused on not exceeding historical levels of depletion based on available data and modeling tools

4.10.1 Locally Defined Significant and Unreasonable Conditions

Locally defined significant and unreasonable conditions were determined based on public meetings, and discussions with GSA staff, work group members, Advisory Committee members, and the GSA Board. Significant and unreasonable depletion of interconnected surface water in the Subbasin was defined as:

Significant and unreasonable depletion of surface water from interconnected streams occurs when surface water depletion, caused by groundwater pumping within the Subbasin, exceeds historical depletion or adversely impacts the viability of groundwater dependent ecosystems (GDEs) or other beneficial users of surface water.[3]

4.10.2 Minimum Thresholds

CCR Title 23 Section 354.28(c)(6) of the GSP Regulations states that “The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results.”

Available data are currently insufficient to directly calculate the rate or volume of surface water depletions from streamflow measurements or reliably estimate depletions from a surface water budget. Quantifying surface water depletion due to pumping is a challenge because: (1) it cannot be measured directly and (2) the influence of surface water depletion by pumping is often obscured by other factors, such as precipitation and runoff, surface water diversions, ET, and natural groundwater/surface water interactions. Therefore, groundwater levels are used as a proxy for the rate or volume of surface water depletion for these initial SMC. Groundwater levels as a proxy metric for the depletion of interconnected surface water sustainability indicator are considered the best option because:

[3] Important definitions related to the significant and unreasonable statement (CITATION) include:

- Groundwater pumping excludes any diversions by surface water rights holders
- Historical depletion estimated as simulated surface water depletion caused by groundwater pumping as informed by available historical measured data (2004-2018)
- GDEs includes aquatic species and vegetation, as defined in **Section 3.**
- Other beneficial users of surface water include surface water rights holders and recreational uses (where applicable)

- The depletion of interconnected surface water is driven by the gradient between water surface elevation in the surface water body and groundwater elevations in the connected, shallow aquifer system.
- Groundwater levels are one of the controlling factors in supporting rooting depths for vegetation-based GDEs.
- Groundwater levels represent criteria that the GSA has direct authority to manage within the Subbasin (for example, compared with streamflows that can be strongly influenced by the factors described above, as well as inflows from upland areas outside of the Subbasin).

4.10.2.1 Information and Methodology Used to Establish Surface Water Depletion Minimum Thresholds

The information used for establishing the MTs and MOs for the depletion of interconnected surface water sustainability indicator included:

- Results of seepage run monitoring (described in **Section 3.2.7.1**)
- Frequency of observed or measured streamflow
- Comparison of interpolated groundwater levels within the shallow aquifer system and streambed elevations
- High-frequency groundwater-level observations from shallow monitoring wells located near streams
- Map of interconnected surface water reaches within the Subbasin
- Map of the distribution of GDEs within the Subbasin
- Input from the practitioner work group for interconnected surface water

Appendix 4-C provides a description of the specific methodology used for developing the SMC for the depletion of interconnected surface water sustainability indicator, including: (1) the selection of appropriate RMPs for depletion of interconnected surface water, (2) methodology for demonstrating correlation between groundwater levels and interconnected surface water depletion, and (3) methodology for determining MTs and MOs for depletion of interconnected surface water at the RMPs.

As detailed in **Appendix 4-C**, the initial SMC for depletion of interconnected surface water were developed based on simulated data and the best available historical information. The SMC will be refined, as needed, with observed data during the implementation phase. The general procedure for developing the initial SMC involves the following:

1. Use groundwater levels measured at shallow monitoring wells near streams (RMPs) as a proxy for surface water depletion.

2. Use this model to estimate the 3 years with highest levels of simulated streamflow depletion between 2004 and 2018.

3. Calculate the percentile ranking of simulated dry-season groundwater levels associated with these years.

4. Set initial MTs at this percentile ranking using available datasets for wells measured near RMPs. As further detailed in **Appendix 4-C**, for RMP locations with insufficient groundwater-level period of record, the initial MTs are set based on either: (1) match points from nearby wells with a sufficient period of record or (2) the adjacent streambed elevation.

5. Set initial MO as mean of dry-season measured groundwater levels from historical record.

The MTs developed using this methodology are provided in **Table 4-8**, below and represent: The equivalent groundwater level, representing the [3] years (2014-2016) during which the most surface water depletion due to groundwater pumping was estimated between 2004-2018 or (for locations with insufficient available data) the streambed elevation.

The goal of the MTs is to maintain estimated rates and volume of streamflow depletion below historical levels, using groundwater-level measurements as a proxy.

Table 4-8. Minimum Thresholds and Measurable Objectives for Depletion of Interconnected Surface Water

RMP Well	MT (feet above msl)	MO (feet above msl)
SON0315	23.4	24.2
SON0325	78.2	79.9
SON0327	89.0	91.1
SON0339	69.5	70.5
SON0340	61.4	62.5
SON0342	48.0	48.9
SON0551	211.0	222.9
SON0552	148.5	155.3
SON0553	101.3	106.0
SON0554	37.0	37.7

Adaptive Management to Address Data Gaps and Improve/Refine SMC

In recognition of the significant information and data limitations, and the importance of interconnected surface water to beneficial users within the Subbasin, potential future studies and activities have been identified and prioritized in coordination with the work group according to relative importance and potential costs. These studies and activities attributed to the two groups are described more thoroughly in **Section 7**, for implementation in the early stages of the GSP. Additionally, at this time, none of the streams in the Subbasin have instream flow criteria established by the state. If and when the state agencies conduct habitat and other studies to establish instream flow criteria, the GSA will use this information to evaluate surface water depletions to ensure compliance with SGMA.

Group 1

This group will focus on improved characterization of causes and effects of depletion, lower cost studies, and outside funding or leveraged funding opportunities with partners:

- Improve data/information on existing water wells and stream diversions
- Model improvements – focused calibration of surface water and groundwater interaction
- Improve GDE mapping/remote sensing for vegetation health (for example, use of Normalized Difference Vegetation Index, GDE pulse)
- Compile and evaluate existing and relevant habitat field surveys
- Evaluate future airborne geophysical data

Group 2

This group will focus on monitoring network improvements, higher cost studies, and related tasks:

- Additional shallow monitoring wells and stream gauges
- Focused geophysical studies
- Geomorphic and streambed conductivity assessments
- Additional focused habitat field mapping in partnership with other agencies, as needed

4.10.2.2 Relationship between Individual Minimum Thresholds and Relationship to Other Sustainability Indicators

Assessment of how other sustainability indicators could be influenced by the depletion of interconnected surface water MT indicates the following:

- **Chronic lowering of groundwater levels**. Groundwater levels are used as a proxy for monitoring the depletion of interconnected surface water MTs. Because the MTs for the depletion of interconnected surface water are generally set within close proximity to streambed elevations within the Subbasin, they are shallower (more protective) than MTs set for nearby RMPs for the chronic lowering of groundwater levels. Maintaining groundwater elevations above the depletion of interconnected surface water MTs will similarly maintain groundwater levels above the chronic lowering of groundwater levels

MTs. Therefore, the depletion of interconnected surface water MTs do not cause exceedances of chronic lowering of groundwater level MTs.

- **Reduction in groundwater storage**. The chronic lowering of groundwater levels MTs are used as a proxy for the change in groundwater storage MTs. Therefore, maintaining groundwater elevations above the depletion of interconnected surface water MTs will not result in an exceedance of the groundwater storage MTs, for the same reasons described for the chronic lowering of groundwater levels sustainability indicator.
- **Seawater Intrusion**. MTs for depletion of interconnected surface water are intended to maintain groundwater levels near streams above historical levels which is not anticipated to lead to seawater intrusion.
- **Degraded water quality**. MTs for depletion of interconnected surface water are intended to maintain groundwater levels near streams above historical levels which is not anticipated to lead to degradation of water quality.
- **Subsidence**. MTs for depletion of interconnected surface water are intended to maintain groundwater levels near streams above historical levels and are not anticipated to lead to subsidence.

4.10.2.3 Effect of Minimum Thresholds on Neighboring Basins and Subbasins

The reaches of interconnected streams within the Subbasin that are subject to the MTs for depletion of interconnected surface water are downstream from the Kenwood Valley Basin and are separated by surface water divides from the Petaluma Valley Basin and Napa Lowlands Subbasin. Therefore, the MTs for depletion of interconnected surface water depletion will not have an effect on these neighboring basins and subbasins.

4.10.2.4 Effect on Beneficial Uses and Users

The MTs for depletion of interconnected surface water measured using groundwater levels as a proxy assumes that maintaining groundwater levels at or above historical low levels in the Subbasin will avoid surface water depletion that exceeds historical levels. Avoiding surface water depletion at levels greater than historical conditions will provide a benefit to beneficial users and land uses that rely on interconnected surface water. The following specifically describes how MTs will benefit land and beneficial water use in the Subbasin:

- **Agricultural land uses and users**. Maintaining historical levels of surface water depletion should not impact agricultural land uses or irrigation water supplies.
- **Urban land uses and users.** Municipal groundwater pumpers are not anticipated to be affected if depletion from groundwater pumping remain similar to historical levels.

- **Domestic land uses and users**. Maintaining rates of surface water depletion from groundwater pumping at or above historical levels will protect residential beneficial users of groundwater by keeping groundwater levels at or above historical low levels.

- **Ecological land uses and users**. The main benefit of the surface water depletion MTs is to GDEs (primarily aquatic species and riparian vegetation). Maintaining shallow groundwater levels near streams at or above historical low levels helps maintain interconnected conditions and historical levels of baseflow. Better understanding the causal effects of interconnected surface water depletion due to groundwater pumping on GDEs and habitat is a primary focus of the early stages of GSP implementation and will be used to refine the MTs in future GSP updates, as appropriate.

4.10.2.5 Relation to State, Federal, or Local Standards

No federal, state, or local standards exist that specifically address depletion of interconnected surface water; however, state and federal endangered species provisions call for the protection and restoration of conditions necessary for steelhead and coho salmon. These provisions were considered in development of the surface water depletion MTs.

If and when new standards are developed by other agencies, such as instream flow targets, they will be evaluated and incorporated into any potential future refinements to the MTs for depletion of interconnected surface water.

4.10.2.6 Method for Quantitative Measurement of Minimum Thresholds

Groundwater elevations will be measured in 10 RMPs used to monitor surface water depletion as a proxy. Groundwater-level monitoring will be conducted in accordance with the monitoring protocol outlined in **Section 5.3.3**. For reporting seasonal highs and lows for future comparison with MTs, all subdaily measurements will be reported as monthly averages to better align with the measurement frequency within historical datasets used to calculate the MTs. During GSP implementation, individual groundwater-level measurements collected manually and by data loggers will be reviewed for quality control and analyzed for MT exceedances during compilation of GSP annual and 5-year update reports.

4.10.3 Measurable Objectives

MOs for depletion of interconnected surface water represent achievable target groundwater elevations near streams that allow for operational flexibility over a range of climate and hydrologic variability. Based on input from the work group, the Advisory Committee, and the GSA Board, it was decided that MO values at RMP locations should reflect the observed average dry-season groundwater elevations from recent years (2004–2020). **Table 4-8** lists the MOs for each RMP.

4.10.3.1 Method for Setting Measurable Objectives

A description of the specific methodology used for developing the MOs for the depletion of interconnected surface water sustainability indicator is provided in **Appendix 4-C**.

4.10.3.2 Interim Milestones

Interim milestones are intended to show how MOs will be achieved during the initial 20-year implementation period of the GSP. As the MOs are set at the average groundwater elevations during recent years (average of 2004-2020), interim milestones are identical to the groundwater levels associated with the MOs.

4.10.4 Undesirable Results

4.10.4.1 Criteria for Defining Undesirable Results

The depletion of interconnected surface water undesirable result is defined using groundwater levels as a proxy. Per the GSP Regulations, the description of undesirable results is based on a quantitative description of the combination of MT exceedances that cause significant and unreasonable effects in the Subbasin. For the Subbasin, the specific groundwater conditions that constitute an undesirable result is: Undesirable result occurs if MTs are exceeded at 40 percent of RMP wells during drought years and 10 percent of RMP wells during non-drought years.

The different percentages associated with drought years versus non-drought years were selected to help address the concerns expressed by some work group and Advisory Committee members that setting MTs at levels experienced during significant droughts could be detrimental to aquatic species and associated habitat if allowed during future normal and wet years. Placing the different weights on drought and non-drought years helps address the expressed concern by ensuring that during normal/wet years the higher levels of estimated streamflow depletion from 2014–2016 are avoided.

Exceedances of MTs at a single RMP will require investigation to determine if any actions should be considered to avoid potential future onset of undesirable results, as described in **Section 4.10.4.2**.

4.10.4.2 Potential Causes of Undesirable Results

Many factors influence surface water flows and interconnected surface water depletion, which are outside the control of the GSA. For undesirable results to occur, the cause of surface water depletion must be related to the extraction of groundwater or other project and management actions implemented for groundwater sustainability, and not due to lack of precipitation during periods of prolonged drought or surface water diversions under the jurisdiction of the SWRCB.

Undesirable results may occur in the future to GDEs if groundwater-level declines near creeks are caused by groundwater pumping or if there is reduced recharge in the shallow aquifer system.

Prior to determining if undesirable results are occurring based on MT exceedances, the GSA would need to assess whether potential causes of exceedances are related to depletions associated with groundwater pumping or other activities not under the jurisdiction of the GSA. Staff is currently working with staff of the SWRCB to develop a description of a coordination process with SWRCB to address this. The goal of the coordination process is to assess whether potential causes of exceedances are related to depletions (entirely or in part) associated with groundwater conditions under the jurisdiction of the GSA or other activities not under the jurisdiction of the GSA and will include (1) information and data sharing, (2) conferring on potential causes of exceedances, and (3) improving the SMC as needed based on outcomes and new information.

Additionally, to respond prior to the onset of undesirable results, the following actions would be implemented if an MT is exceeded at a single RMP that does not trigger an undesirable result:

- Review available data from full monitoring network (that is, non-RMP monitoring wells) to assess potential scale of areas exhibiting declines
- Assess whether exceedance is climate-related
- Review of any known or potential changes in groundwater pumping patterns (for example, new wells brought online, changes in land/water use)
- Consider whether additional RMPs are needed
- Share information with other stakeholder, as appropriate

4.10.4.3 Effects on Beneficial Users and Land Use

If depletions of interconnected surface water were to reach undesirable results, adverse effects could include the reduced ability of the streamflows to meet instream flow requirements for local fisheries and critical habitat in the Subbasin. Reduced surface flows can also negatively affect permitted surface water diversions. Consideration of the above was included as part of SMC development.

DRAFT

Section 5: Monitoring Networks

Groundwater Sustainability Plan for Sonoma Valley Groundwater Subbasin

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5 MONITORING NETWORKS

This section describes the monitoring networks that are planned in the Subbasin and contributing watershed area for implementation of the GSP and how the existing monitoring networks described in **Section 2.4** were evaluated and refined. RMPs, for which SMC are set, are identified in this section and the processes used to select suitable RMPs, along with monitoring objectives, are described. This section also presents an assessment of the monitoring networks identified for GSP implementation, including identification of data gaps and planned improvements to the monitoring networks.

5.1 Monitoring Network Objectives

SGMA regulations require monitoring networks be developed to collect data of sufficient quality, frequency, and spatial distribution to characterize groundwater and related surface water conditions in the Subbasin, and to evaluate changing conditions that occur during implementation of the GSP. Monitoring networks should accomplish the following:

- Demonstrate progress toward achieving MOs described in the GSP.
- Monitor impacts on the beneficial uses and users of groundwater.
- Monitor changes in groundwater conditions relative to MOs and MTs.
- Quantify annual changes in water-budget components.

Specific objectives for each monitoring network in the Subbasin are described in **Sections 5.2** through **5.4**. To ensure the quality and consistency of the data collected, monitoring protocols have been established and are presented in **Appendix 5-A**.

5.2 Description of Monitoring Networks for Groundwater Sustainability Plan Implementation

The monitoring networks included in this subsection are based on existing monitoring networks described generally in **Section 2.4** (Existing Monitoring Programs and Networks). To relate monitoring stations to sustainability indicators, monitoring networks are described in **Sections 5.2.1** through **5.2.5** for each of the information types that are needed to evaluate the sustainability indicators described in **Section 4**.

5.2.1 Groundwater-level Monitoring Network

The existing groundwater-level monitoring network described in **Section 2.4** was evaluated in accordance with SGMA regulations and guidelines, with the monitoring network objectives in mind, and refined into the Groundwater-level Monitoring Network for GSP Implementation (GSP Implementation Network).

SGMA requirements and guidance for monitoring are described in the GSP Regulations and DWR's BMPs for Monitoring Protocols, Standards and Sites (DWR 2016b) and BMPs for Monitoring Networks and Identification of Data Gaps (DWR 2016c). These include the following data and reporting standards and guidance related to groundwater levels:

- Well location, accurate to within 30 feet

- Elevation of the ground surface and reference point, accurate to within 0.5 foot
- Field measurements measured and reported to accuracy of 0.1 foot
- Description of the well type (for example, public supply, irrigation, domestic, or monitoring) and whether the well is active or inactive
- Construction information (casing perforations, borehole depth, and total well depth)
- Well completion reports, if available, from which the names of private owners have been redacted
- Identification of principal aquifers monitored
- Selection of aquifer-specific wells and avoidance of wells that are screened across more than one aquifer
- Active water supply wells (for example, agricultural or municipal wells) that can be used temporarily until either dedicated monitoring wells can be installed or an existing well can be identified that meets the required criteria
- Any active water supply wells used for monitoring must be screened across a single water-bearing unit, and care must be taken to ensure that pumping drawdown has sufficiently recovered before collecting data from a well

Specific objectives for the Groundwater-level Monitoring Network are to provide a sufficient number of monitoring sites with adequate spatial distribution, monitoring frequency, and data quality to achieve the following:

- Produce seasonal maps of potentiometric surfaces for the shallow and deep aquifer systems throughout the Subbasin that clearly identify changes in groundwater-flow direction and gradient.
- Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features.
- Demonstrate groundwater occurrence, flow directions, and hydraulic gradients across basin boundaries, when combined with data from adjacent basins.
- Identify short-term and long-term trends and seasonal fluctuations when combined with historical data.
- Track water levels relative to MTs and MOs.
- Support water-budget calculations and calibration of the groundwater model for the Subbasin.

5.2.1.1 Rationale for Selection of Groundwater-level Monitoring Network for Groundwater Sustainability Plan Implementation Sites

The following criteria were used for assessment and initial screening of the entire existing Groundwater-level Monitoring Network to identify which wells are suitable for inclusion into the GSP Implementation Network:

- Well Construction: Wells with known complete construction information (that is, total depth, casing diameter, depth of screened intervals) are preferred; wells to be included in the GSP Implementation Network should be screened within a single aquifer system. For wells selected for inclusion into the GSP Implementation Network that have incomplete construction information, attempts will be made to ascertain the information through records searches of applicable databases or records requests directly to the well owner, or applying for video-logging services through the DWR's Technical Support Services program.

- Historical Data Record: Wells with complete data records of 10 years or longer that are part of a current monitoring program are preferred. In some cases, for wells where monitoring has been discontinued in the past few years (2017 or later), efforts are being made to reinstate monitoring as a part of GSP implementation.

- Well Type: Dedicated monitoring wells are preferred. Secondary preference is given to inactive supply wells and the lowest preference is given to active supply wells (that is, domestic, irrigation, or municipal). For active supply wells included in the GSP Implementation Network, special precautions will be taken to ensure representative measurements are collected as described in **Appendix 5-A**, Monitoring Protocols. Environmental monitoring wells were not considered for the GSP Implementation Network because they are typically privately owned and somewhat temporary in nature.

- Spatial Coverage: Monitoring sites were selected to maximize horizontal and vertical coverage of the entire Subbasin. Special considerations were given to areas near streams and areas of uncertainty such as near faults or basin boundaries. Where available, wells outside of the Subbasin, but within the contributing watershed areas, are included in the GSP Implementation Network.

- Well Ownership: Wells owned by a GSA member agency are preferred. Privately owned wells are also included in the GSP Implementation Network to maximize spatial coverage of the Subbasin.

5.2.1.2 Description of Refined Groundwater-level Monitoring Network for Groundwater Sustainability Plan Implementation

The GSP Implementation Network for the shallow and deep aquifer systems is shown on **Figures 5-1a** and **5-1b**, respectively. This network consists of a total of 107 wells within the contributing watershed area, including 66 wells within the Subbasin itself. For the shallow aquifer system, there are a total of 53 wells within the contributing watershed area, including 34 wells within the Subbasin itself. Of the 53 shallow (less than 200 feet deep) wells in the GSP

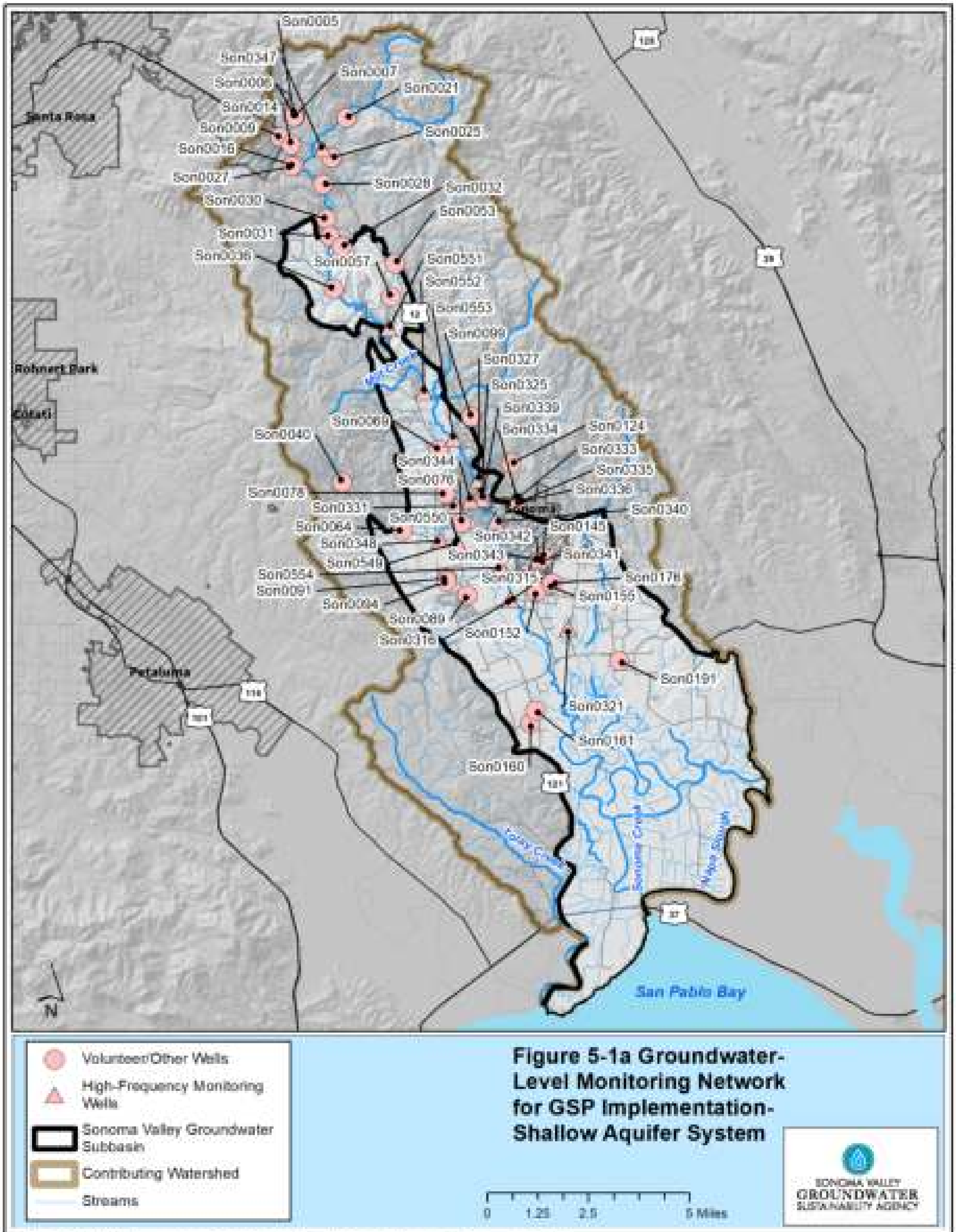

Figure 5-1a. Groundwater-Level Monitoring Network for GSP Implementation – Shallow Aquifer System

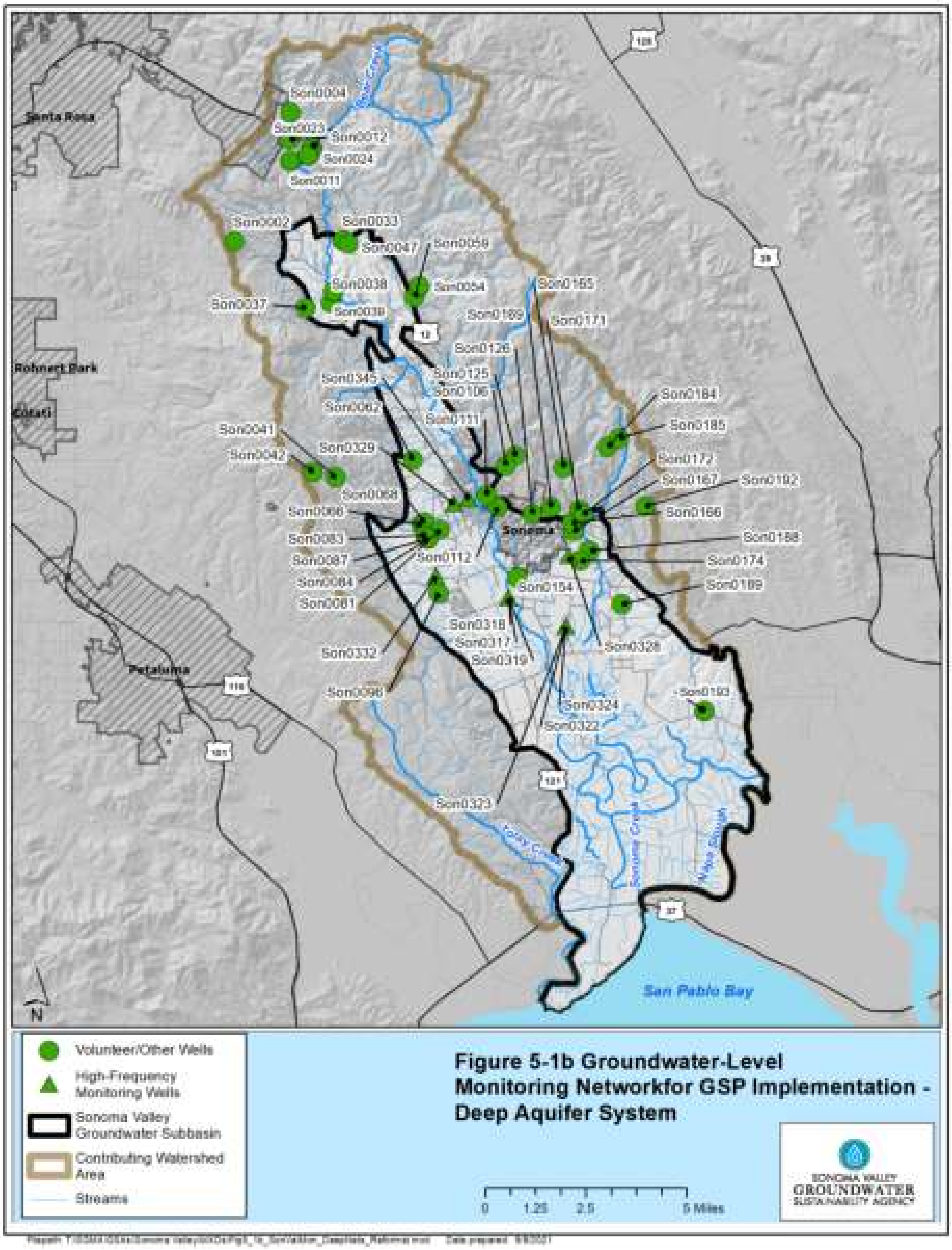

Figure 5-1b. Groundwater-Level Monitoring Network for GSP Implementation – Deep Aquifer System

Implementation Network, 25 are dedicated monitoring wells (including municipal test wells), 1 is a public supply well, 1 is an irrigation well, and 26 are domestic supply wells. For the deep aquifer system, there are a total of 54 wells within the contributing watershed area, including 32 wells within the Subbasin itself. Of the 54 deep (greater than 200 feet deep) wells in the GSP Implementation Network, 12 are dedicated monitoring wells (including municipal test wells), 9 are public supply wells, 29 are domestic supply wells, and 4 are irrigation wells. Details for wells in the GSP Implementation Network, including well construction, well use, and length of monitoring record are presented in **Tables 5-1a and 5-1b**.

Monitoring frequencies for wells in the GSP Implementation Network are shown in **Tables 5-1a and 5-1b**. Of the 107 wells in the GSP Implementation Network, 36 are high-frequency monitoring points with water-level data collected at least daily. Of the 36 high-frequency monitoring points, 24 are part of the shallow aquifer system monitoring network and 12 are part of the deep aquifer system monitoring network. The remaining 71 wells are monitored semiannually, with a subset of 4 wells monitored monthly.

5.2.2 Groundwater Quality Monitoring Network

As described in **Section 4.8.2.1**, the Groundwater Quality Monitoring Network for the Subbasin is based on existing supply well monitoring programs. The GSA has identified sets of supply wells that are currently monitored (or are proposed to be monitored in the future) for various groundwater constituents and supply uses such as drinking water and irrigation water. Because these supply wells are monitored under different programs and may have different required sampling schedules (even under the same program), no one set of constituents will be sampled in all wells.

Table 5-1a. Groundwater-Level Monitoring Network for GSP Implementation - Shallow Aquifer System

Data Management System ID	Data Management System ID						Data Record	Data Record	
Station Name	Station Number	Type of Well	Well Depth[a]	Well Depth Category	Screened Interval(s)[a]	Monitoring Frequency	From	Until	Additional Information
Monitored Wells within the Sonoma Valley Groundwater Subbasin									
High-Frequency Monitoring Wells									
Son0315	SV-MW2-52	Observation	52	Shallow (0-200 feet)	32-52	Hourly	9/11/2013	Present	Local Grid ID: SV-M15-04A
Son0316	SV-MW2-100	Observation	100	Shallow (0-200 feet)	80-100	Hourly	9/11/2013	Present	Local Grid ID: SV-M15-04B
Son0321	SV-MW1-95	Observation	95	Shallow (0-200 feet)	85-95	Hourly	9/11/2013	Present	Local Grid ID: SV-N16-06A
Son0325	SCWA_Agua-Caliente-1	Observation	?	Shallow (0-200 feet)	?	Hourly	9/11/2013	Present	
Son0327	SCWA_W-Thompson	Observation	?	Shallow (0-200 feet)	?	Hourly	6/27/2013	Present	
Son0331	SV-MON-92	Observation	92	Shallow (0-200 feet)	72-82	Hourly	5/7/2001	Present	
Son0339	SCWA_Verano_St_Piezo	Observation	50	Shallow (0-200 feet)	?	Hourly	7/29/2014	Present	
Son0340	SCWA_Napa_St_Piezo	Observation	50	Shallow (0-200 feet)	?	Hourly	7/29/2014	Present	
Son0341	SCWA_SVHS-MW-01S	Observation	15	Shallow (0-200 feet)	10-15	Hourly	6/17/2014	Present	Local Grid ID: SV-M14-09
Son0342	SCWA_SVHS-MW-01D	Observation	25	Shallow (0-200 feet)	20-25	Hourly	6/17/2014	Present	Local Grid ID: SV-M14-08
Son0343	SCWA_SVHS-MW-02	Observation	15	Shallow (0-200 feet)	10-15	Hourly	6/17/2014	Present	Local Grid ID: SV-M14-07
Son0344	SCWA_CYMW-1a	Observation	135	Shallow (0-200 feet)	110-130	Hourly	6/28/2016	Present	Local Grid ID: SV-L13-09A
Son0348	SCWA_Fowler_Creek-1	Observation	80	Shallow (0-200 feet)	60-80	Hourly	8/25/2016	Present	
Son0549	SCWA_FC-MW-2s	Observation	17	Shallow (0-200 feet)	12-17	Hourly	7/18/2018	Present	
Son0550	SCWA_FC-MW-2d	Observation	80	Shallow (0-200 feet)	60-80	Hourly	7/18/2018	Present	
Son0551	SV-J08-06_Arnold	Observation	52.5	Shallow (0-200 feet)	37-52	Hourly	11/26/2019	Present	Local Grid ID: SV-J08-06
Son0552	SV-J10-02_Madrone	Observation	45.5	Shallow (0-200 feet)	35-45	Hourly	11/26/2019	Present	Local Grid ID: SV-J10-02
Son0553	SV-K11-02_St Leos	Observation	55.5	Shallow (0-200 feet)	40-55	Hourly	11/26/2019	Present	Local Grid ID: SV-K11-02
Son0554	SV-L14-02_Leveroni	Observation	45.5	Shallow (0-200 feet)	25-45	Hourly	11/26/2019	Present	Local Grid ID: SV-L14-02
Volunteer Program Wells and Wells Monitored by Other Entities									
Son0031	SV-H06-02	Domestic	100	Shallow (0-200 feet)	?	Semi-Annual	2/7/2004	10/22/2019	CASGEM ID: 383957N1225516W001
Son0032	SV-H06-03	Domestic	159	Shallow (0-200 feet)	78-99, 119-159	Semi-Annual	10/31/1977	4/30/2021	
Son0036	SV-H07-01	Domestic	152	Shallow (0-200 feet)	?	Semi-Annual	5/1/2010	10/23/2019	
Son0053	SV-J07-01	Domestic	108	Shallow (0-200 feet)	30-108	Semi-Annual	4/28/2001	11/9/2019	State ID: 006N006W09A002M
Son0064	SV-J13-01	Domestic	60	Shallow (0-200 feet)	40-60	Semi-Annual	11/9/1999	10/23/2019	CASGEM ID: 382903N1225178W001
Son0069	SV-K11-01	Domestic	68	Shallow (0-200 feet)	?	Semi-Annual	11/5/1999	11/9/2019	CASGEM ID: 383194N1225014W001
Son0076	SV-K13-07	Domestic	146	Shallow (0-200 feet)	?	Semi-Annual	10/19/2000	10/31/2019	State ID: 005N006W11F001M

Data Management System ID	Data Management System ID						Data Record	Data Record	
Station Name	Station Number	Type of Well	Well Depth[a]	Well Depth Category	Screened Interval(s)[a]	Monitoring Frequency	From	Until	Additional Information
Son0078	SV-K13-09	Domestic	171	Shallow (0-200 feet)	150-167	Monthly	4/3/1974	7/13/2021	CASGEM ID: 383037N1224984W002
Son0089	SV-K15-01	Domestic	90	Shallow (0-200 feet)	?	Semi-Annual	1/27/2000	10/23/2019	
Son0091	SV-K15-03	Domestic	86	Shallow (0-200 feet)	?	Semi-Annual	4/3/2000	11/7/2019	CASGEM ID: 382733N1224975W001
Son0094	SV-K15-06	Domestic	84	Shallow (0-200 feet)	?	Semi-Annual	4/3/2000	11/7/2019	
Son0145	SV-M14-02	Domestic	85	Shallow (0-200 feet)	?	Semi-Annual	11/12/2009	9/16/2020	
Son0152	SV-M15-01	Domestic	220	Shallow (0-200 feet)	67-200	Semi-Annually	11/19/1999	12/1/2017	
Son0155	SV-M15-04	Domestic	150	Shallow (0-200 feet)	?	Semi-Annually	7/1/2009	8/6/2018	
Son0161	SV-M18-03	Irrigation	198	Shallow (0-200 feet)	65-105, 120-198	Semi-Annual	4/19/2012	11/9/2019	
Son0176	SV-N15-02	Domestic	150	Shallow (0-200 feet)	15-134	Monthly	3/25/1970	9/25/2017	CASGEM ID: 382716N1224496W002
Son0191	SV-O17-01	Domestic	93	Shallow (0-200 feet)	?	Semi-Annual	6/10/2009	4/28/2021	CASGEM ID: 382439N1224189W001
Monitored Wells Outside of the Subbasin but within the Contributing Watershed Area									
High-frequency Monitoring Wells									
Son0333	SV-MON-1S	Observation	76	Shallow (0-200 feet)	55-75	Hourly	2/11/2014	Present	Local Grid ID: SV-M13-15
Son0334	SV-MON-1D	Observation	127	Shallow (0-200 feet)	95-125	Hourly	12/20/2013	Present	Local Grid ID: SV-M13-16
Son0335	SV-MON-2S	Observation	60	Shallow (0-200 feet)	38-58	Hourly	12/20/2013	Present	Local Grid ID: SV-M13-17
Son0336	SV-MON-3S	Observation	50	Shallow (0-200 feet)	?	Hourly	2/11/2014	Present	Local Grid ID: SV-M13-18
Son0347	SCWA_Adobe_Canyon-1	Observation	50	Shallow (0-200 feet)	30-50	Hourly	8/25/2016	Present	
Volunteer Program Wells and Wells Monitored by Other Entities									
Son0005	SV-G03-03	Domestic	215	Medium (200-500 feet)	?	Semi-Annual	5/4/2003	10/25/2019	
Son0006	SV-G03-04	Domestic	180	Shallow (0-200 feet)	?	Semi-Annual	8/27/2003	10/25/2019	
Son0007	SV-G03-06	Domestic	225	Medium (200-500 feet)	?	Semi-Annual	5/4/2003	10/25/2019	
Son0009	SV-G04-02	Domestic	149	Shallow (0-200 feet)	30-149	Monthly	3/25/1970	7/13/2021	CASGEM ID: 384310N1225745W002
Son0014	SV-G04-07	Domestic	75	Shallow (0-200 feet)	50-75	Semi-Annual	5/1/2012	4/23/2019	
Son0021	SV-H03-01	Domestic	80	Shallow (0-200 feet)	?	Semi-Annual	5/1/2010	10/22/2019	
Son0025	SV-H04-05	Domestic	123	Shallow (0-200 feet)	?	Semi-Annual	5/1/2010	10/21/2019	
Son0016	SV-G04-09	Domestic	93	Shallow (0-200 feet)	33-93	Semi-Annual	5/5/2016	10/21/2019	
Son0027	SV-H05-01	Domestic	200	Shallow (0-200 feet)	?	Semi-Annual	11/8/2008	10/21/2019	CASGEM ID: 384170N1225640W001
Son0028	SV-H05-02	Domestic	80	Shallow (0-200 feet)	?	Semi-Annual	10/5/2003	10/22/2019	CASGEM ID: 384144N1225550W001

Data Management System ID	Data Management System ID						Data Record	Data Record	
Station Name	Station Number	Type of Well	Well Depth[a]	Well Depth Category	Screened Interval(s)[a]	Monitoring Frequency	From	Until	Additional Information
Son0030	SV-H06-01	Domestic	55	Shallow (0-200 feet)	?	Semi-Annually	5/1/2010	11/2/2017	
Son0040	SV-H12-01	Public Supply	200	Shallow (0-200 feet)	100-196	Semi-Annually	10/27/2008	11/17/2017	
Son0099	SV-L11-01	Domestic	57	Shallow (0-200 feet)	57-102	Semi-Annually	7/11/2003	10/27/2017	
Son0124	SV-M12-01	Observation	146	Shallow (0-200 feet)	134-140	Semi-Annually	4/3/2008	10/5/2017	

[a] Well depth and screened interval(s) reported in feet below top of casing

Table 5-1b. Groundwater-Level Monitoring Network for GSP Implementation

Data Management System ID	Data Management System ID						Data Record	Data Record	
Station Name	Station Number	Type of Well	Well Depth[a]	Well Depth Category	Screened Interval(s)[a]	Monitoring Frequency	From	Until	Additional Information
Monitored Wells within the Sonoma Valley Groundwater Subbasin									
High-Frequency Monitoring Wells									
Son0317	SV-MW2-220	Observation	220	Medium (200-500 feet)	200-220	Hourly	10/8/2012	Present	Local Grid ID: SV-M15-04C
Son0318	SV-MW2-409	Observation	409	Medium (200-500 feet)	374-384	Hourly	9/11/2013	Present	Local Grid ID: SV-M15-04D
Son0319	SV-MW2-480	Observation	480	Medium (200-500 feet)	460-480	Hourly	10/8/2012	Present	Local Grid ID: SV-M15-04E
Son0322	SV-MW1-233	Observation	233	Medium (200-500 feet)	223-233	Hourly	9/11/2013	Present	Local Grid ID: SV-N16-06B
Son0323	SV-MW1-365	Observation	365	Medium (200-500 feet)	355-365	Hourly	9/11/2013	Present	Local Grid ID: SV-N16-06C
Son0324	SV-MW1-455	Observation	455	Medium (200-500 feet)	440-455	Hourly	9/11/2013	Present	Local Grid ID: SV-N16-06D
Son0328	SCWA_7th-Street	Municipal	860	Deep (>500 feet)	473-666	Hourly	9/11/2013	Present	
Son0329	SV-MON-563	Observation	563	Deep (>500 feet)	?	Hourly	5/2/2001	Present	
Son0330	SV-MON-674	Observation	674	Deep (>500 feet)	?	Hourly	5/7/2001	Present	
Son0332	SCWA_K15-2	Domestic	355	Medium (200-500 feet)	255-355	Hourly	11/5/1999	Present	
Son0345	SCWA_CYMW-1b	Observation	665	Deep (>500 feet)	580-660	Hourly	6/28/2016	Present	Local Grid ID: SV-L13-09B
Volunteer Program Wells and Wells Monitored by Other Entities									
Son0038	SV-H08-02	Domestic	310	Medium (200-500 feet)	?	Semi-Annual	6/29/2009	4/26/2021	
Son0039	SV-H08-03	Domestic	250	Medium (200-500 feet)	?	Semi-Annual	5/1/2010	4/24/2019	
Son0047	SV-I06-01	Domestic	320	Medium (200-500 feet)	197-317	Semi-Annual	2/1/2003	10/22/2019	CASGEM ID: 383930N1225425W001
Son0062	SV-J12-05	Domestic	400	Medium (200-500 feet)	195-400	Semi-Annually	4/15/2009	4/11/2016	CASGEM ID: 383149N1225122W001
Son0066	SV-J13-03	Domestic	735	Deep (>500 feet)	235-735	Semi-Annually	11/13/2002	5/8/2018	
Son0068	SV-J13-05	Domestic	595	Deep (>500 feet)	260-300, 420-460, 480-590	Semi-Annual	3/23/2006	10/27/2017	
Son0081	SV-K13-13	Domestic	720	Deep (>500 feet)	500-720	Semi-Annual	12/3/1997	11/15/2019	
Son0083	SV-K14-01	Domestic	595	Deep (>500 feet)	495-595	Semi-Annual	7/24/2001	11/4/2019	
Son0084	SV-K14-02	Domestic	274	Medium (200-500 feet)	?	Semi-Annual	11/5/1999	11/4/2019	CASGEM ID: 382867N1225053W001
Son0087	SV-K14-06	Domestic	600	Deep (>500 feet)	300-600	Semi-Annual	10/10/2001	11/4/2019	State ID: 005N006W10Q003M
Son0096	SV-K15-10	Irrigation	1080	Deep (>500 feet)	655-855, 980-1080	Semi-Annual	4/15/2009	10/23/2019	
Son0111	SV-L13-01	Irrigation	555	Deep (>500 feet)	445-545	Semi-Annual	4/24/2002	10/7/2019	CASGEM ID: 383025N1224786W001
Son0112	SV-L13-02	Municipal	730	Deep (>500 feet)	530-730	Semi-Annually	10/13/1999	12/1/2017	City Well #5
Son0154	SV-M15-03	Domestic	440	Medium (200-500 feet)	210-430	Semi-Annual	11/20/2009	10/23/2019	
Son0166	SV-N13-01	Domestic	320	Medium (200-500 feet)	220-320	Semi-Annually	5/4/2000	12/1/2017	

Data Management System ID	Data Management System ID						Data Record	Data Record	
Station Name	Station Number	Type of Well	Well Depth[a]	Well Depth Category	Screened Interval(s)[a]	Monitoring Frequency	From	Until	Additional Information
Son0167	SV-N13-02	Domestic	245	Medium (200-500 feet)	170-240	Semi-Annually	4/3/1974	3/3/2021	CASGEM ID: 382899N1224390W002
Son0172	SV-N13-09	Domestic	660	Deep (>500 feet)	200-660	Semi-Annual	10/27/2015	10/22/2019	
Son0174	SV-N14-02	Domestic	580	Deep (>500 feet)	200-580	Semi-Annual	11/12/2009	10/23/2019	
Son0188	SV-O14-01	Domestic	470	Medium (200-500 feet)	330-470	Monthly	10/13/1980	7/13/2021	CASGEM ID: 382828N1224313W001
Son0189	SV-O15-01	Domestic	508	Medium (200-500 feet)	307-507	Semi-Annually	5/4/2000	11/20/2019	CASGEM ID: 382635N1224166W001
Son0193	SV-Q18-01	Irrigation	375	Medium (200-500 feet)	41-290	Semi-Annually	10/30/1980	3/3/2021	CASGEM ID: 382252N1223786W001
Monitored Wells Outside of the Subbasin but within the Contributing Watershed Area									
High-Frequency Monitoring Wells									
Son0346	SCWA_TW_6a	Observation	230	Medium (200-500 feet)	130-220	Hourly	8/25/2016	Present	
Volunteer Program Wells and Wells Monitored by Other Entities									
Son0002	SV-F06-02	Public Supply	510	Deep(>500 feet)	330-510	Semi-Annually	10/31/1987	10/7/2017	
Son0004	SV-G03-02	Domestic	450	Medium (200-500 feet)	?	Semi-Annually	5/4/2003	11/3/2017	
Son0011	SV-G04-04	Domestic	240	Medium (200-500 feet)	80-100, 200-240	Semi-Annual	5/1/2010	10/21/2019	
Son0012	SV-G04-05	Domestic	700	Deep(>500 feet)	100-700	Semi-Annual	5/4/2012	10/24/2019	
Son0023	SV-H04-03	Domestic	265	Medium (200-500 feet)	80-100, 120-160, 180-220, 240-260	Semi-Annual	5/20/2009	10/22/2019	State ID: 007N006W30M001M
Son0024	SV-H04-04	Domestic	250	Medium (200-500 feet)	110-250	Semi-Annual	8/14/2004	10/21/2019	CASGEM ID: 384248N1225611W001
Son0033	SV-H06-04	Domestic	?	Medium (200-500 feet)	273-573	Semi-Annual	2/21/2004	10/22/2019	
Son0037	SV-H08-01	Domestic	554	Deep(>500 feet)	334-554	Semi-Annual	5/30/2009	10/21/2019	
Son0041	SV-H12-02	Public Supply	740	Deep(>500 feet)	400-740	Semi-Annually	10/27/2008	11/17/2017	
Son0042	SV-H12-03	Public Supply	559	Deep(>500 feet)	193-294, 334-558	Semi-Annually	10/29/2008	11/17/2017	
Son0054	SV-J07-02	Domestic	956	Deep(>500 feet)	95-955	Semi-Annual	4/26/2009	10/23/2019	State ID: 006N006W10M001M
Son0059	SV-J08-03	Domestic	800	Deep(>500 feet)	?	Semi-Annual	4/28/2009	10/23/2019	State ID: 006N006W15M001M
Son0106	SV-L12-02	Observation	388	Medium (200-500 feet)	308-388	Semi-Annually	4/3/2008	10/5/2017	
Son0125	SV-M12-03	Observation	250	Medium (200-500 feet)	170-250	Semi-Annually	4/3/2008	10/5/2017	
Son0126	SV-M13-01	Municipal	405	Medium (200-500 feet)	200-405	Semi-Annually	11/17/1999	12/1/2017	
Son0165	SV-N12-02	Irrigation	540	Deep(>500 feet)	160-280; 300-535	Semi-Annually	10/22/2012	11/22/2017	
Son0169	SV-N13-06	Municipal	500	Medium (200-500 feet)	?	Semi-Annually	4/6/1999	12/1/2017	

Data Management System ID	Data Management System ID						Data Record	Data Record	
Station Name	Station Number	Type of Well	Well Depth[a]	Well Depth Category	Screened Interval(s)[a]	Monitoring Frequency	From	Until	Additional Information
Son0171	SV-N13-08	Domestic	440	Medium (200-500 feet)	140-440	Semi-Annual	4/11/2014	10/23/2019	
Son0184	SV-O11-02	Public Supply	570	Deep(>500 feet)	330-560	Semi-Annually	10/14/2008	9/1/2017	
Son0185	SV-O11-03	Public Supply	795	Deep(>500 feet)	500-795	Semi-Annually	10/21/2008	9/1/2017	
Son0192	SV-P13-01	Domestic	800	Deep(>500 feet)	600-800	Semi-Annually	4/20/2009	4/26/2017	

[a] Well depth and screened interval(s) reported in feet below top of casing

The following existing monitoring programs are included in the Groundwater Quality Monitoring Network:

- Public supply wells, regulated by the SWRCB DDW. Public drinking water supply wells are included in the Groundwater Quality Monitoring Network because they are routinely sampled to meet CCR Title 22 water quality reporting requirements as regulated by the SWRCB DDW. Title 22 analyses include arsenic, nitrate, and TDS, which are the Subbasin COCs. This dataset can be obtained from the SWRCB through the GAMA online portal.
- The Sonoma Valley SNMP includes sampling and analysis of water quality constituents in a network of existing wells (RMC and Todd Engineers 2014). The SNMP monitoring network includes 26 public supply wells, 2 multilevel monitoring well clusters that were installed as part of the SVGMP, and 12 wells of unknown type that have been routinely sampled by DWR. The public supply wells proposed for the SNMP MRP are already included in the DDW dataset previously described. The SVGMP monitoring wells have been sampled periodically (last in 2016) and the wells sampled by DWR have not been reported as sampled since 2010, when they were sampled for nitrate, EC, and TDS. The analytical datasets from the SNMP wells will be available from the SWRCB through the GAMA online portal.

Existing and future water quality monitoring programs may be used to help collect data during GSP implementation and establish consistency with other programs. There are not currently any identified data gaps in the Groundwater Quality Monitoring Network. Additional water quality monitoring networks will be developed specifically for monitoring projects and management actions during GSP implementation.

5.2.3 Surface Water Monitoring Network

The Surface Water Monitoring Network in the Subbasin has been developed with the following objectives:

- Quantify inflow and outflow of surface water to and from the Subbasin
- Characterize spatial and temporal exchanges between surface water and groundwater
- Calibrate the tools and methods necessary to calculate depletions of surface water caused by groundwater extraction

There are three active stream gages operated by the USGS and partner agencies located in the Subbasin and contributing watershed area. The USGS gages have data records extending back to between 2001 and 2016. Additional surface water monitoring stations include two OneRain gages operated by Sonoma Water with data records extending back to 2018. Details for the stream gages including parameters measured and length of data record are included in **Table 5-2**. The locations of the stream gages are shown on **Figure 5-2**.

Table 5-2. Surface Water Monitoring Network - DRAFT

USGS ID	Location Description	Parameters Measured	Data Record From	Data Record Until	Continuous/ Seasonal[a]	Adjacent Shallow Monitoring Well
11458433	Sonoma Creek at Kenwood, CA	Discharge, Stream Stage, Temperature, Specific Conductance	10/1/2008	Present	Continuous	
11458500	Sonoma Creek at Agua Caliente, CA	Discharge, Stream Stage	10/1/2001	Present	Continuous	Son0553
11458600	Nathanson Creek at Sonoma, CA	Discharge, Stream Stage	10/13/2016	Present	Seasonal	Son0342
	Sonoma Creek Downstream of Calabazas Creek (Glen Ellen, CA)	Stream Stage	3/1/2018	Present	Continuous	Son0551
	Nathanson Creek at 2nd Street East (Sonoma, CA)	Stream Stage, Precipitation	7/10/2018	Present	Continuous	

[a] Seasonal gage operates from October through April

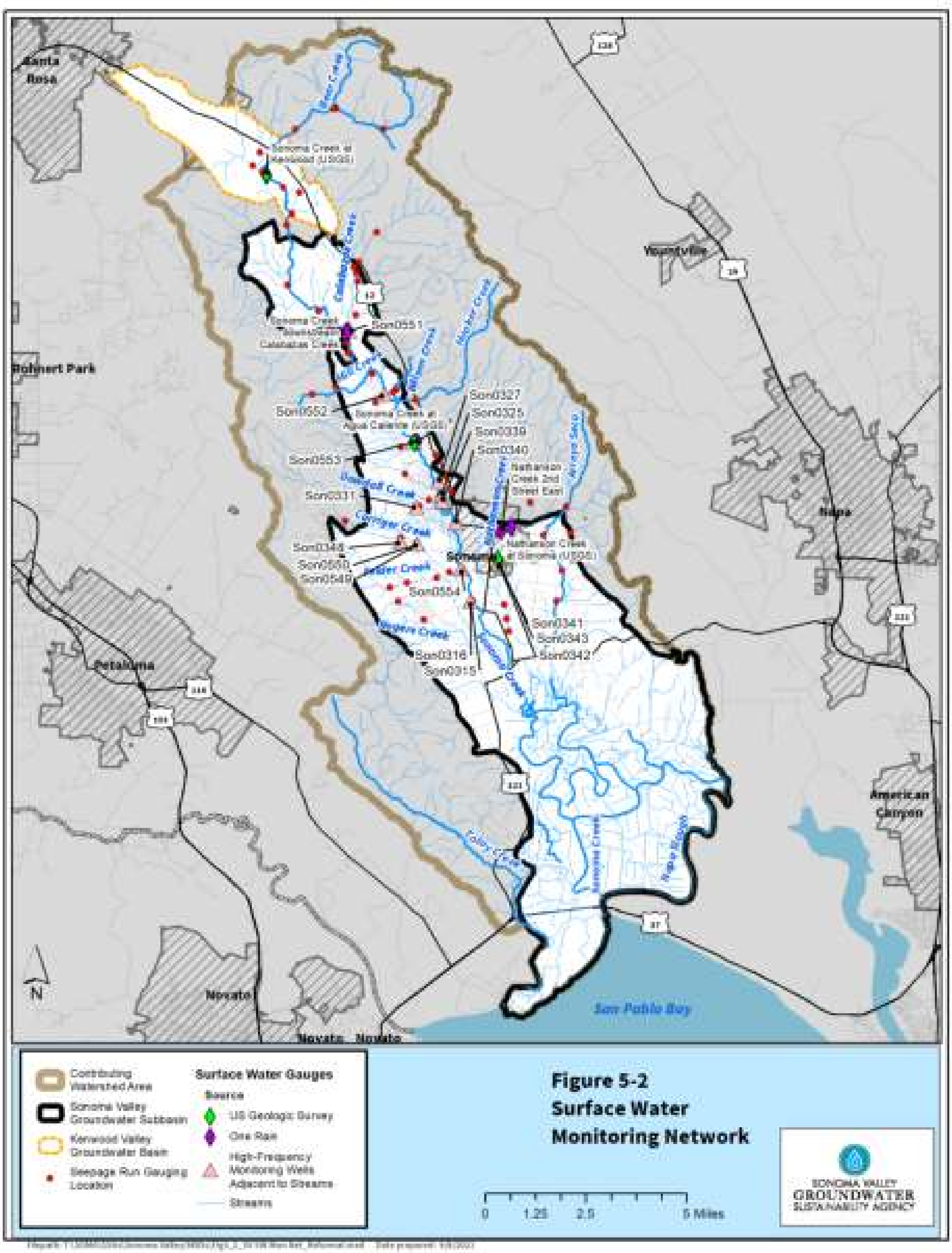

Figure 5-2. Surface Water Monitoring Network

In 2019, the GSA partnered with DWR's Technical Support Services program to install four shallow groundwater monitoring wells adjacent to streams in the Subbasin to further the understanding of groundwater-surface water interaction. As shown on **Figure 5-2**, one of these shallow monitoring wells was installed adjacent to the USGS gage on Sonoma Creek at Agua Caliente and one was installed adjacent to the OneRain gage on Sonoma Creek downstream of Calabazas Creek. Sonoma Water monitors an additional 13 shallow monitoring wells adjacent to Sonoma Creek and its tributaries primarily in the central portion of the Subbasin (illustrated on **Figure 5-2**). All 17 of the shallow stream-adjacent monitoring wells are equipped with pressure transducers for collection of hourly temperature and groundwater-level data. Details for the stream-adjacent shallow monitoring wells, including well construction, monitoring frequency, and length of monitoring record are shown in **Table 5-1a**.

Synoptic streamflow measurements (seepage runs) were conducted on Sonoma Creek and its tributaries in 2003 and 2010 by the USGS and have been conducted by the Sonoma Ecology Center on a regular basis since 2014. These seepage runs consist of a series of streamflow measurements made at multiple sites over a short time period (for example, single day to several days) along Sonoma Creek and its tributaries to quantify streamflow gains and losses for a specific time period. The seepage runs provide insights into stream reaches that rely on shallow groundwater to support streamflow and areas where surface water from streams provide a source of recharge to the groundwater system, as well as how these conditions can vary seasonally. Measurements have been collected at between approximately 50 and 70 sites on a semiannual basis and at approximately 15 to 20 sites on a monthly to bimonthly basis. The seepage run measurement sites are shown on **Figure 5-2**.

5.2.4 Land Surface Elevation Monitoring Network

Available land surface elevation datasets for the Subbasin and contributing watershed area include measurements collected at three discrete GPS locations since between 2005 and 2007 and by InSAR satellite in most of the Subbasin since 2015. The GPS stations are monitored by the UNAVCO's PBO program. There are two stations in the Subbasin and one in the upper watershed: (1) P200, located on Highway 12 at Sonoma Creek; (2) P199, located along Rogers Creek near Temelec; and (3) P202 located on the ridgetop just south of Sugarloaf Ridge State Park. The GPS station locations are shown on **Figure 3-15a** in **Section 3**.

5.2.5 Seawater Intrusion Monitoring Network

The GSA has identified nine existing public water supply wells and one existing multi-depth dedicated monitoring well for inclusion in the Seawater Intrusion Monitoring Network for the Subbasin. As illustrated on **Figure 5-3**, these wells are all within approximately 1 mile of the Baylands portion of the Subbasin. The GSA is in the process of contacting well owners to facilitate semiannual sampling for chloride and collection of groundwater-level measurements at the nine existing public supply wells. The existing SV-MW1 multi-depth monitoring well cluster includes four discrete well casings with total depths ranging from 95 to 455 feet. A minimum of two wells (one screened in the shallow aquifer system and one screened in the deep aquifer system) in the SV-MW1 cluster will be sampled semiannually for chloride. All wells in the SV-MW1 cluster are instrumented with pressure transducers for hourly groundwater-level and temperature data collection. A summary of proposed improvements to the Seawater Intrusion Monitoring Network is included in **Section 5.4.3**.

5.3 Representative Monitoring Point Networks

As stated in the GSP Regulations, "Representative monitoring sites may be designated by an Agency as the point at which sustainability indicators are monitored, and for which quantitative values for minimum thresholds, measurable objectives, and interim milestones are defined" (23 CCR 354.36).

5.3.1 Representative Monitoring Point Network for Chronic Lowering of Groundwater Levels

The same data and reporting standards and guidance related to groundwater levels described for the GSP Implementation Network in **Section 5.2.1** apply to the RMP Network for the Chronic Lowering of Groundwater Levels (Groundwater-level RMP Network). In addition, the following SGMA requirements and guidance from the GSP Regulations and DWR's BMPs for Monitoring Protocols, Standards and Sites (DWR 2016b) and Monitoring Networks and Identification of Data Gaps (DWR 2016c) apply to the selection of RMPs:

- "The designation of a representative monitoring site shall be supported by adequate evidence demonstrating that the site reflects general conditions in the area" (23 CCR 354.36).

- "If RMPs are used to represent groundwater elevations from a number of surrounding monitoring wells, the GSP should demonstrate that each RMP's historical measured groundwater elevations, groundwater elevation trends, and seasonal fluctuations are similar to the historical measurements in the surrounding monitoring wells" (DWR 2016b).

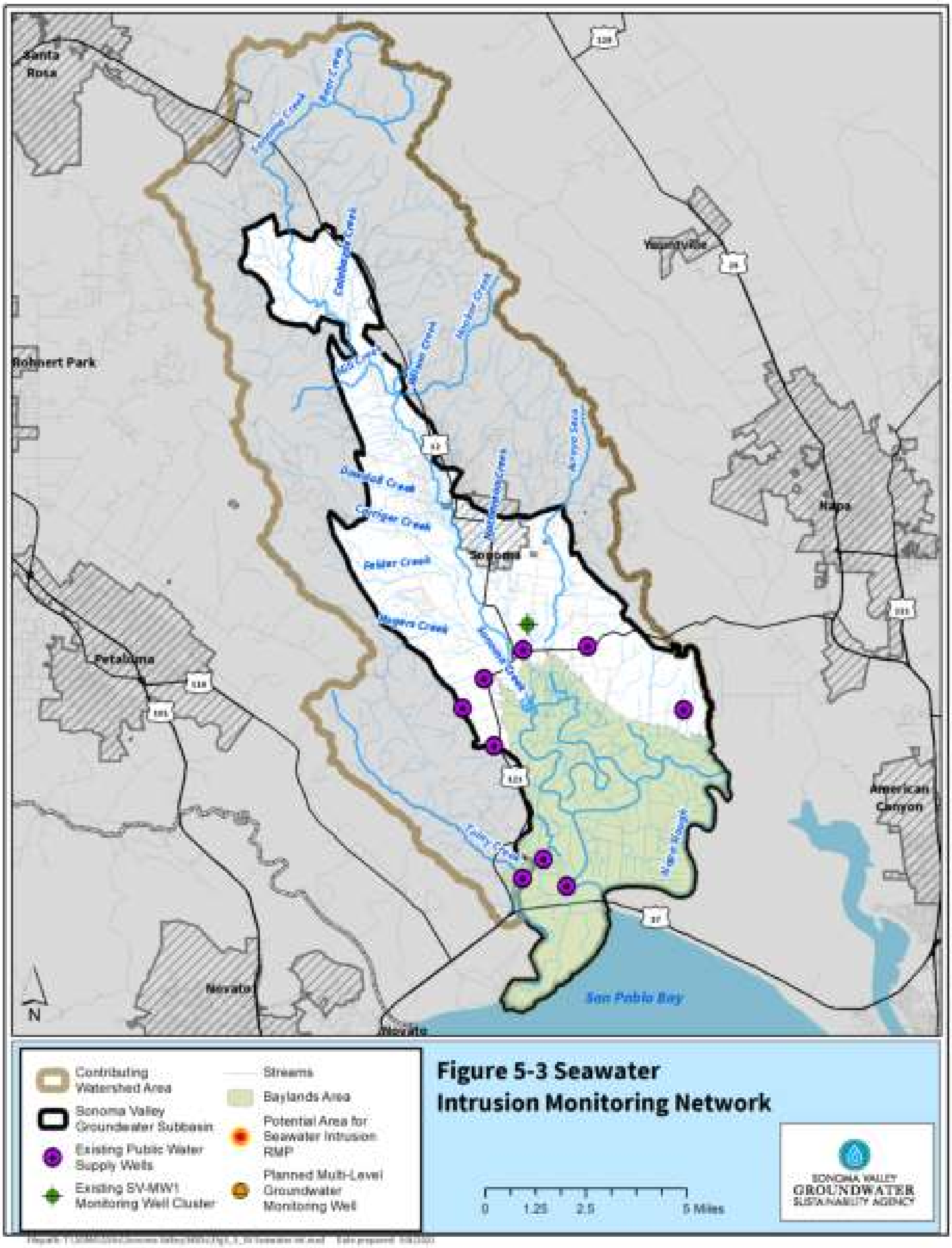

Figure 5-3. Seawater Intrusion Monitoring Network

Rationale for Selection of RMP Network for Chronic Lowering of Groundwater Levels Sites

Potential groundwater-level RMPs were assessed using the same criteria used for the selection of GSP Implementation Network sites, as described in **Section 5.2.1**. These criteria include well type, well construction, well ownership, historical data record, and spatial coverage. In addition, the following criterion was used to assess potential groundwater-level RMPs:

- **Hydrograph Comparability**: Once potential RMPs were identified using the criteria described in **Section 5.2.1**, groundwater-level hydrographs were plotted for the potential RMPs along with hydrographs for nearby wells with available data. Linear regression trend lines were plotted for spring groundwater levels. Potential RMPs were further evaluated by comparing overall trends and the magnitude of seasonal variations in groundwater levels with nearby wells to determine if the potential RMP could be considered representative of a given region. The comparative hydrographs for the potential RMPs and other nearby monitored wells are included in **Appendix 5-B**.

In some cases, newer wells (including new wells constructed specifically for SGMA compliance) with limited historical data records were selected as groundwater-level RMPs because they have favorable well type, well construction, well location, and/or well ownership attributes. For these wells, available historical data for nearby wells screened within the same aquifer system are plotted on the RMP comparative hydrographs (**Figure 5-3**) to help assess historical groundwater levels and trends in the vicinity of the newer RMP well.

Description of RMP Network for Chronic Lowering of Groundwater Levels

The Groundwater-level RMP Network for the shallow and deep aquifer systems is shown on **Figures 5-4a** and **5-4b**, respectively. This network consists of 13 wells screened within the shallow aquifer system and 10 wells screened primarily within the deep aquifer system. All of the RMP wells are located within the Subbasin. For the shallow aquifer system, seven of the groundwater-level RMPs are dedicated monitoring wells, five are private domestic wells, and one is a private irrigation well. For the deep aquifer system, two of the groundwater-level RMPs are dedicated monitoring wells, one is a municipal supply well, one is a public irrigation well, and six are private domestic wells. Details for wells in the Groundwater-level RMP Network including well construction, well use, and length of monitoring record are presented in **Tables 5-3a and 5-3b**.

Monitoring frequencies for wells in the Groundwater-level RMP Network are shown in **Tables 5-3a** and **5-3b**. A total of 11 of the 23 groundwater-level RMP wells are equipped with pressure transducers for hourly water-level data collection, 1 of the RMP wells is monitored monthly, and the remaining 11 are monitored semiannually.

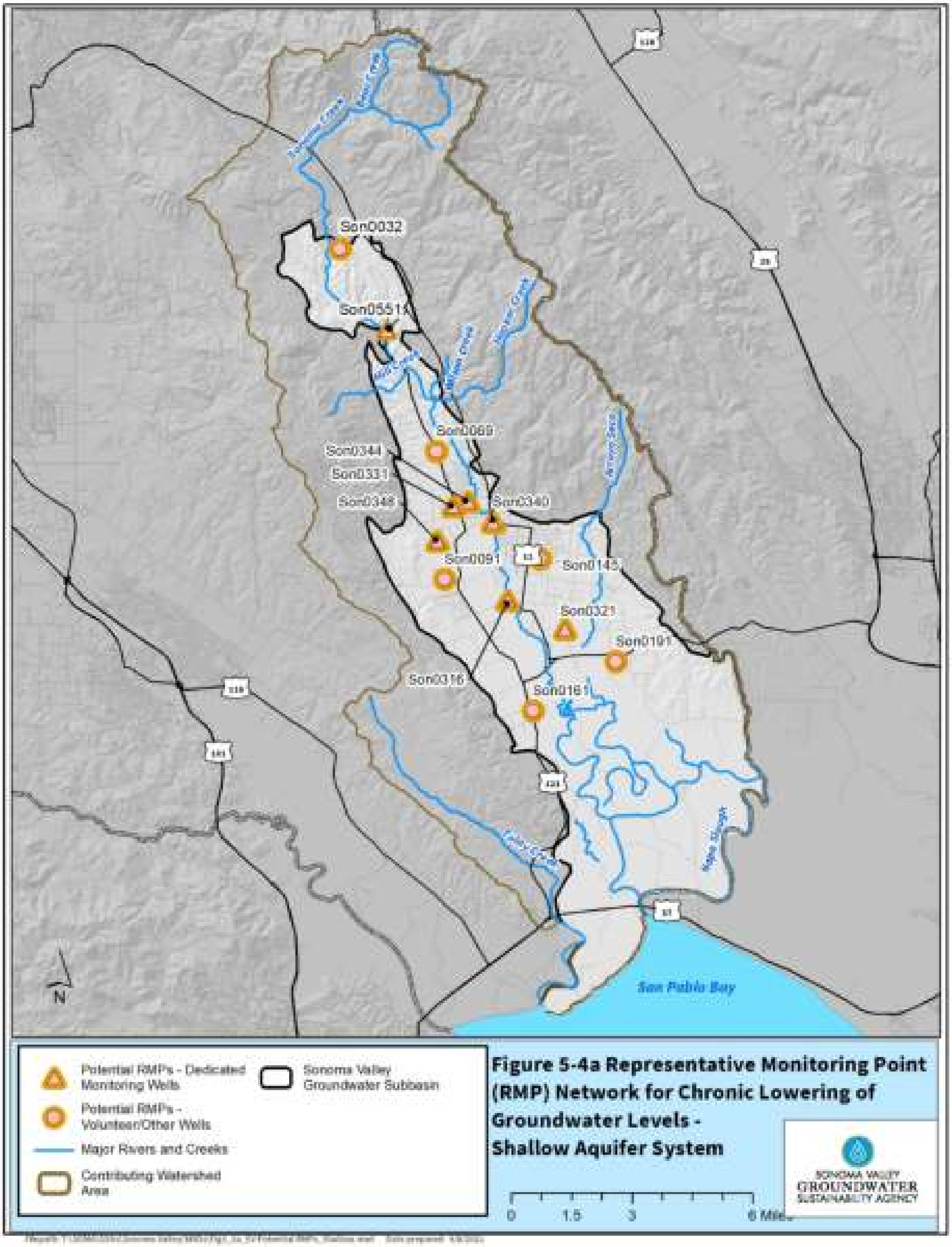

Figure 5-4a. Representative Monitoring Point Network for Chronic Lowering of Groundwater Levels – Shallow Aquifer System

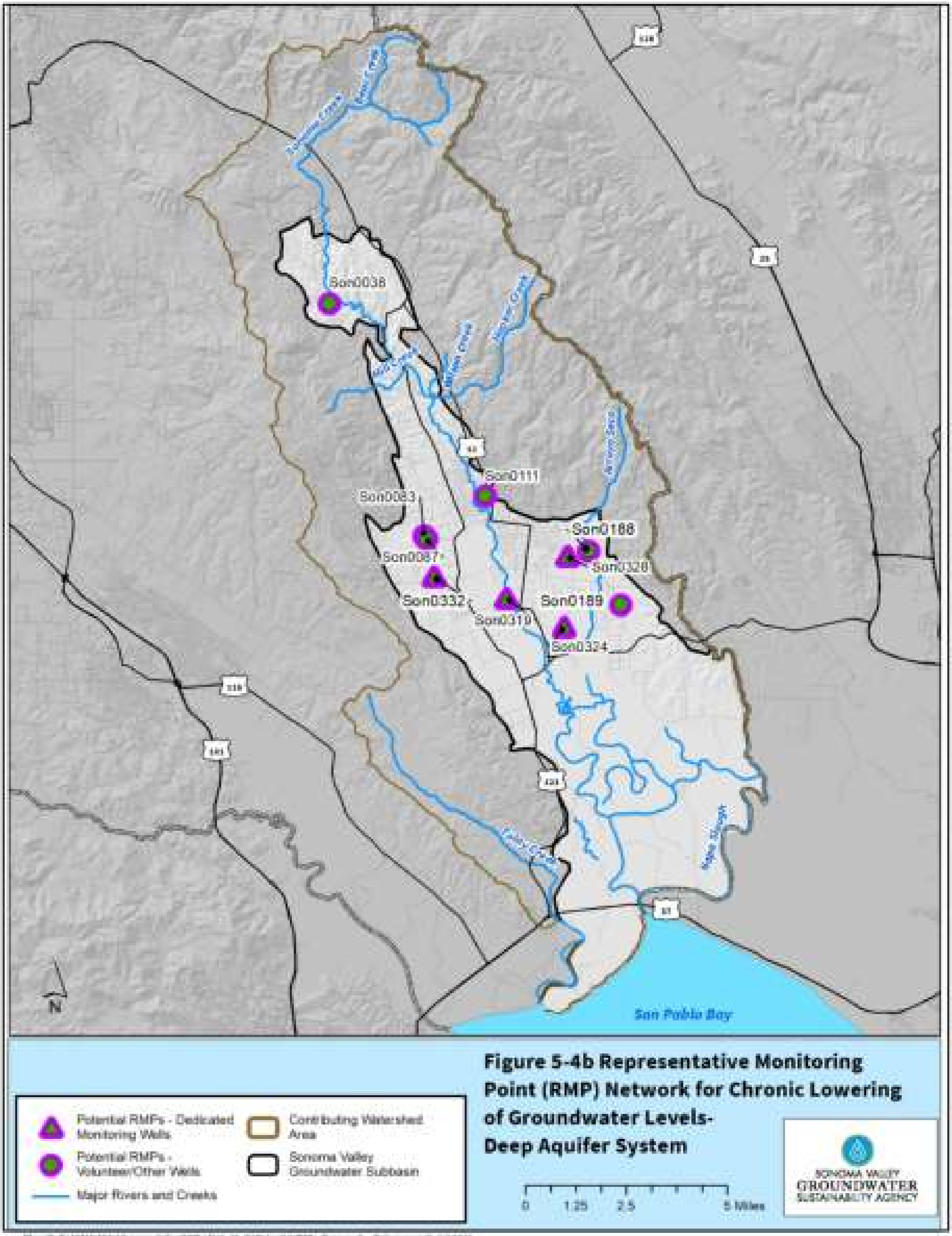

Figure 5-4b. Representative Monitoring Point Network for Chronic Lowering of Groundwater Levels – Deep Aquifer System

Table 5-3a. Representative Monitoring Point Network for Chronic Lowering of Groundwater Levels - Shallow Aquifer System

Data Management System ID	Data Management System ID					Data Record	Data Record		
Station Name	Station Number	Type of Well	Well Depth[a] (feet)	Screened Interval(s)[a] (feet)	Monitoring Frequency	From	Until	Additional Information	Well Owner
Son0316	SV-MW2-100	Monitoring	100	80-100	Hourly	9/11/2013	Present		Sonoma County Water Agency
Son0321	SV-MW1-95	Monitoring	95	85-95	Hourly	9/11/2013	Present		Sonoma County Water Agency
Son0340	SCWA_Napa_St_Piezo	Monitoring	50	?	Hourly	7/29/2014	Present		Sonoma County Water Agency
Son0344	SCWA_CYMW-1a	Monitoring	135	110-130	Hourly	6/28/2016	Present		Valley of the Moon Water District
Son0331	SV-MON-92	Monitoring	92	72-82	Hourly	5/7/2001	Present		Valley of the Moon Water District
Son0348	SCWA_Fowler_Creek-1	Monitoring	80	60-80	Hourly	8/25/2016	Present		Sonoma County Water Agency
Son0032	SV-H06-03	Domestic	159	78-99, 119-159	Semi-Annual	10/31/1977	4/30/2021		Private
Son0551	SV-J08-06_Arnold	Monitoring	52.5	37-52	Hourly	11/26/2019	Present		Sonoma Valley Groundwater Sustainability Agency
Son0069	SV-K11-01	Domestic	68	?	Semi-Annual	11/5/1999	11/9/2019	CASGEM ID: 383194N1225014W001	Private
Son0091	SV-K15-03	Domestic	86	?	Semi-Annual	4/3/2000	11/7/2019	CASGEM ID: 382733N1224975W001	Private
Son0145	SV-M14-02	Domestic	85	?	Semi-Annual	11/12/2009	9/16/2020		Private
Son0161	SV-M18-03	Irrigation	198	65-105, 120-198	Semi-Annual	4/19/2012	11/9/2019		Private
Son0191	SV-O17-01	Domestic	93	?	Semi-Annual	6/10/2009	4/28/2021	CASGEM ID: 382439N1224189W001	Private

[a] Well depth and screened interval(s) reported in feet below top-of-casing

Table 5-3b. Representative Monitoring Point Network for Chronic Lowering of Groundwater Levels - Deep Aquifer System

Data Management System ID	Data Management System ID					Data Record	Data Record		
Station Name	Station Number	Type of Well	Well Depth[a] (feet)	Screened Interval(s)[a] (feet)	Monitoring Frequency	From	Until	Additional Information	Well Owner
Son0324	SV-MW1-455	Monitoring	455	440-455	Hourly	9/11/2013	Present		Sonoma County Water Agency
Son0319	SV-MW2-480	Monitoring	480	460-480	Hourly	10/8/2012	Present		Sonoma County Water Agency
Son0328	SCWA_7th-Street	Municipal	860	473-666	Hourly	9/11/2013	Present		City of Sonoma
Son0111	SV-L13-01	Irrigation	555	445-545	Semi-Annual	4/24/2002	10/7/2019	Maxwell, CASGEM ID: 383025N1224786W001	Sonoma County Regional Parks
Son0332	SCWA_K15-2	Domestic	355	255-355	Hourly	11/5/1999	Present		Private
Son0083	SV-K14-01	Domestic	595	495-595	Semi-Annual	7/24/2001	11/4/2019		Private
Son0087	SV-K14-06	Domestic	600	300-600	Semi-Annual	10/10/2001	11/4/2019	State ID: 005N006W10Q003M	Private
Son0038	SV-H08-02	Domestic	310	?	Semi-Annual	6/29/2009	4/26/2021		Private
Son0188	SV-O14-01	Domestic	493	330-470	Monthly	10/13/1980	7/13/2021	CASGEM ID: 382828N1224313W001	Private
Son0189	SV-O15-01	Domestic	508	307-507	Semi-Annual	5/4/2000	11/20/2019	CASGEM ID: 382635N1224166W001	Private

[a] Well depth and screened interval(s) reported in feet below top of casing

5.3.2 Representative Monitoring Point Network for Degraded Water Quality

All of the public supply wells in the existing monitoring programs described in **Section 5.2.2** that have been sampled for the COCs between 2015 and 2020 are initial RMPs for degraded water quality. This includes 25 wells sampled for arsenic, 40 wells sampled for nitrate, and 13 wells sampled for TDS. The locations of the initial RMPs for each COC are shown on **Figure 5-5**.

5.3.3 Representative Monitoring Point Network for Depletion of Interconnected Surface Water

The 17 stream-adjacent shallow groundwater monitoring wells shown on **Figure 5-2** were evaluated as potential RMPs for depletion of interconnected surface water. The monitoring wells have been instrumented with pressure transducers for collection of hourly groundwater-level and temperature data. After a minimum of 1 year of data collection, the groundwater-level data was compared with streambed elevation data at each location to assess groundwater-surface water interconnection. Based on the assessment of interconnection, 10 of the 17 shallow stream-adjacent monitoring wells were initially selected as RMPs for depletion of interconnected surface water. Stream-adjacent shallow groundwater monitoring wells not used as RMPs were either in areas where data indicate disconnected conditions or in the same area as a selected (more suitable) RMP. Hydrographs showing groundwater-level data for the 10 RMP wells alongside streambed elevation data and stream stage data, where available, are presented in **Appendix 5-B.** The RMPs include eight wells adjacent to Sonoma Creek, one well adjacent to Nathanson Creek, and one well adjacent to Agua Caliente Creek near the confluence with Sonoma Creek. Locations of the RMPs for depletion of interconnected surface water are shown on **Figure 5-6**. Details for the RMPs including well construction and proximity to creeks are presented in **Table 5-4**.

5.3.4 Representative Monitoring Point Network for Land Subsidence

As described in **Section 4.9**, each 100-square-meter InSAR pixel is considered an RMP for land subsidence. As illustrated on **Figure 3-15c** in **Section 3**, the InSAR dataset covers virtually the entire Subbasin except some areas in the southernmost portion. Groundwater pumping is minimal in these areas, so they are not considered data gaps.

5.3.5 Representative Monitoring Point Network for Seawater Intrusion

The nine existing public water supply wells and one existing multi-depth dedicated monitoring well shown on **Figure 5-3** are all considered initial RMPs for Seawater Intrusion. As described in **Section 5.4.3** and in **Section 7**, the GSA will explore the installation of new dedicated monitoring wells and incorporation of additional existing water supply wells into the Seawater Intrusion Monitoring Network. The RMP Network for Seawater Intrusion will be refined as these activities are completed.

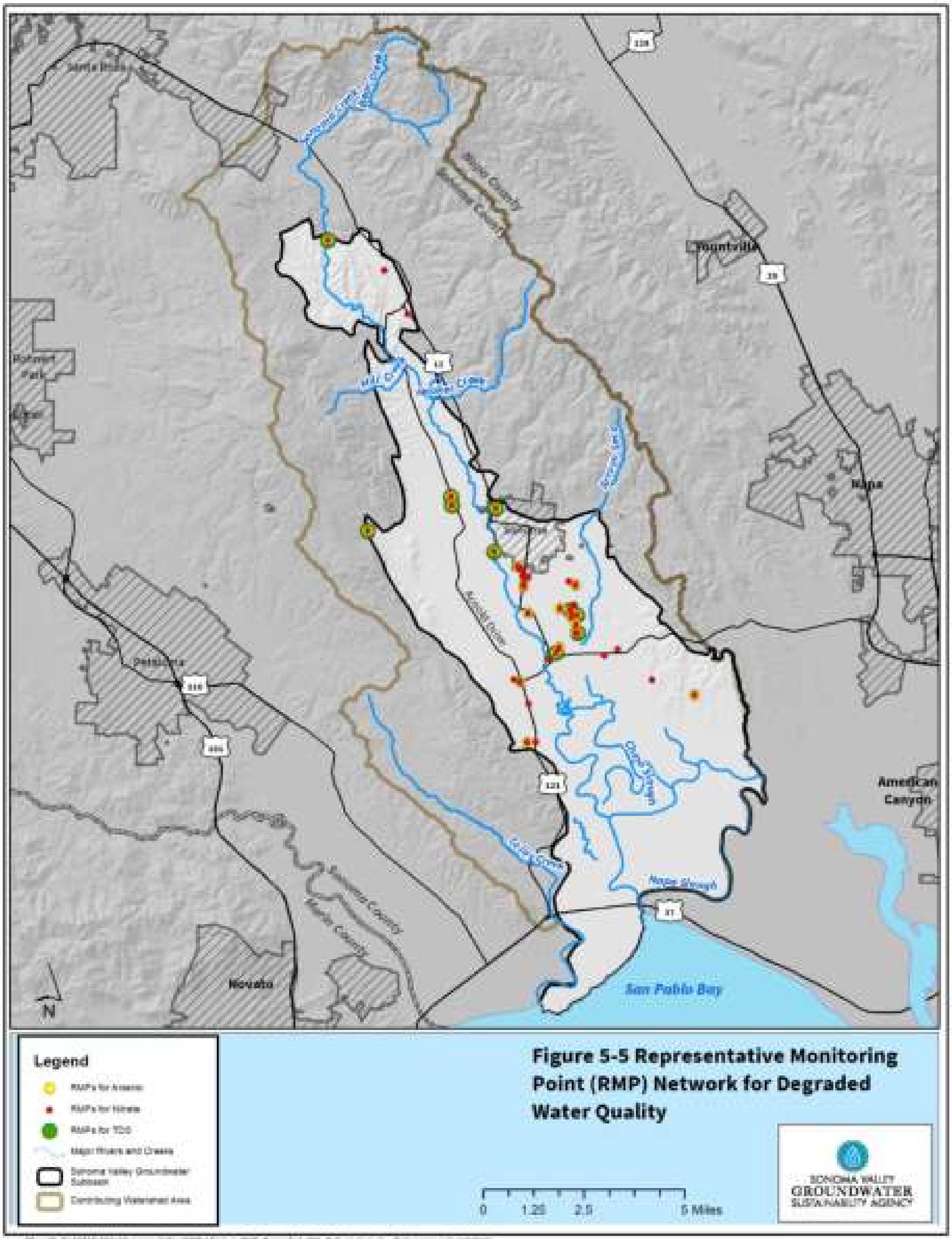

Figure 5-5. Representative Monitoring Point Network for Degraded Water Quality

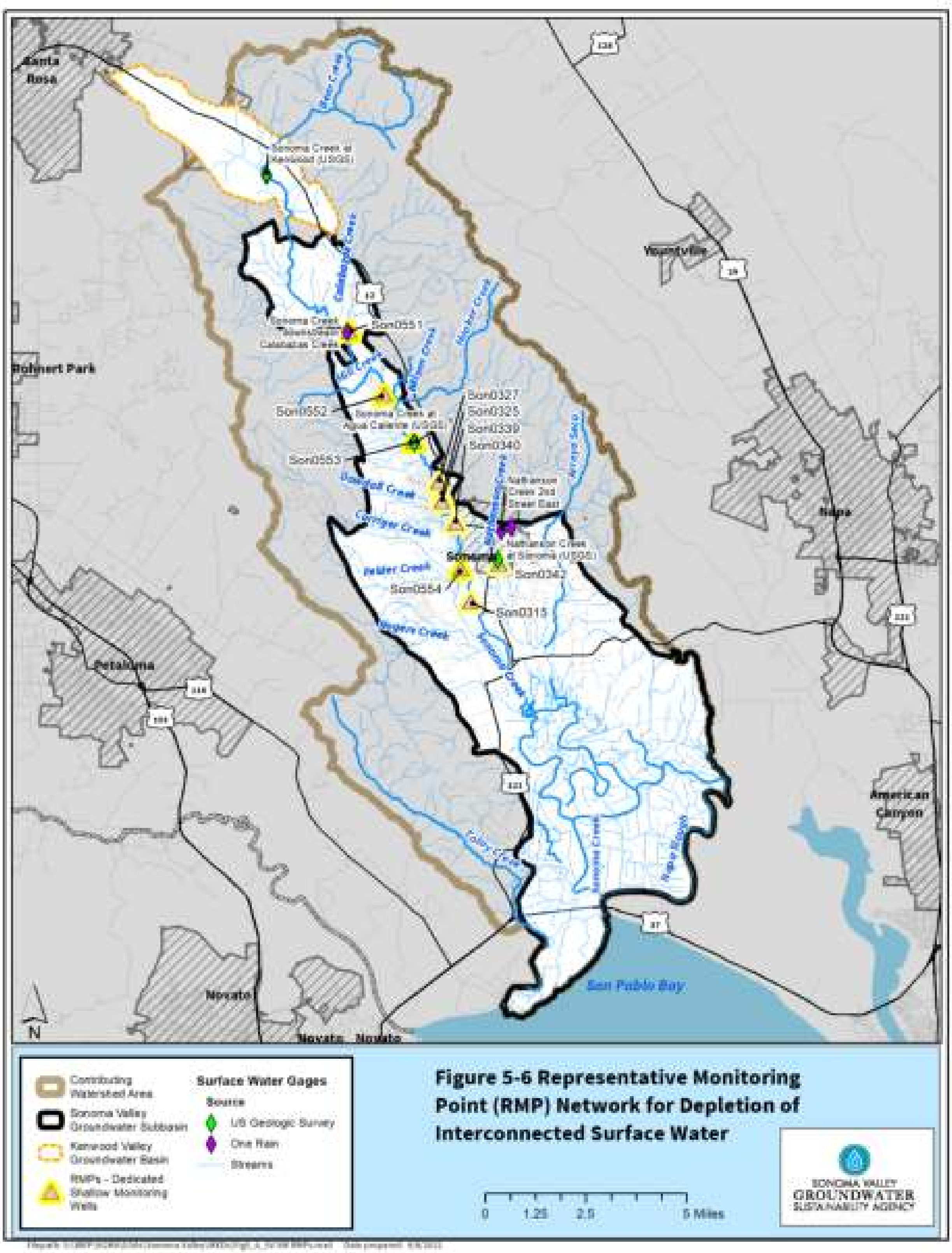

Figure 5-6. Representative Monitoring Point Network for Depletion of Interconnected Surface Water

Table 5-4. Representative Monitoring Point Network for Depletion of Interconnected Surface Water

Station Name	Station Number	Location Description	Well Depth[a] (feet)	Screened Interval[a] (feet)	Approximate Distance from Well to Creek (feet)	Direction of Well from Creek
Son0551	SV-J08-06_Arnold	Sonoma Creek at Arnold Drive	52.5	37-52	140	east
Son0552	SV-J10-02_Madrone	Sonoma Creek at Madrone Road	45.5	35-45	225	west
Son0553	SV-K11-02_St Leos	Sonoma Creek at W. Agua Caliente Road	55.5	40-55	80	west
Son0554	SV-L14-02_Leveroni	Sonoma Creek at Leveroni Road	45.5	25-45	275	west
Son0327	SCWA_W-Thompson	Sonoma Creek at W. Thompson Avenue	?	?	420	northeast
Son0325	SCWA_Agua-Caliente-1	Agua Caliente Creek at Old Maple Avenue	?	?	50	southeast
		Sonoma Creek at Verano Avenue			360	east
Son0339	SCWA_Verano_St_Piezo	Sonoma Creek at Maxwell Farms Park	50	?	500	east
Son0340	SCWA_Napa_St_Piezo	Sonoma Creek at Riverside Drive	50	?	360	east
Son0342	SCWA_SVHS-MW-01D	Nathanson Creek at Sonoma Valley High School	25	20-25	260	southeast
Son0315	SV-MW2-52	Sonoma Creek at Watmaugh Road	52	32-52	300	west

[a] Well depth and screened interval reported in feet below top-of-casing

5.4 Assessment and Improvement of Monitoring Networks

The GSP Regulations require a Plan to include a review and evaluation of each monitoring network. As stated in the Regulations, "Each Agency shall identify data gaps wherever the basin does not contain a sufficient number of monitoring sites, does not monitor sites at a sufficient frequency, or utilizes monitoring sites that are unreliable, including those that do not satisfy minimum standards of the monitoring network adopted by the Agency" (23 CCR 354.38).

5.4.1 Assessment and Identification of Data Gaps – Groundwater-level Monitoring Network

With 53 monitored wells in the shallow aquifer system and 54 monitored wells in the deep aquifer system, the GSP Implementation Network contains a sufficient number of monitoring sites to meet the monitoring objectives for the Subbasin. In the deep aquifer system, monitoring sites are well distributed throughout the Subbasin. In the shallow aquifer system, monitoring sites are well distributed throughout the Subbasin, with some clustered around streams and major creeks, which is appropriate and consistent with monitoring objectives.

5.4.1.1 Spatial Distribution Data Gap Assessment

A preliminary assessment of spatial coverage data gaps in the GSP Implementation Network is presented on **Figures 5-7a** and **5-7b** for the shallow and deep aquifer systems, respectively. The data gap areas shown on **Figures 5-7a** and **5-7b** apply to the Groundwater-level RMP Network as well as the GSP Implementation Network. If a dedicated monitoring well is installed in the future in one if the GSP Implementation Network data gap areas, it will likely also serve as a groundwater-level RMP. This assessment was conducted during the GSP preparation process and used to inform monitoring network improvement projects, particularly the installation of four multilevel monitoring wells under a Proposition 68 grant planned for 2022.

As illustrated on **Figure 5-7a**, the initial assessment for the shallow aquifer system identified the following spatial data gaps:

- In the northern-central portion of the Subbasin along the western Subbasin boundary
- The area along and to the northwest of Highway 121, between Highway 12 and Arnold Drive
- In the vicinity of the eastern Subbasin boundary to the southeast of Sonoma

The shallow aquifer system GSP Implementation Network was compared with the well density map presented in the Description of Plan Area section (**Figure 2-6**). This comparison indicated that all areas within the Subbasin with relatively high densities of water supply wells have shallow monitoring sites within a reasonably close vicinity except for the data gap areas discussed previously. The two southernmost identified data gap areas are planned to be addressed through the installation of Proposition 68-funded multilevel monitoring wells in 2022. The GSA will attempt to incorporate additional existing wells into the monitoring network in the remaining northern-central data gap area. Several previously identified data gaps in the shallow aquifer system monitoring network were addressed through the installation of four shallow monitoring wells completed through DWR's Technical Support Services program in 2019.

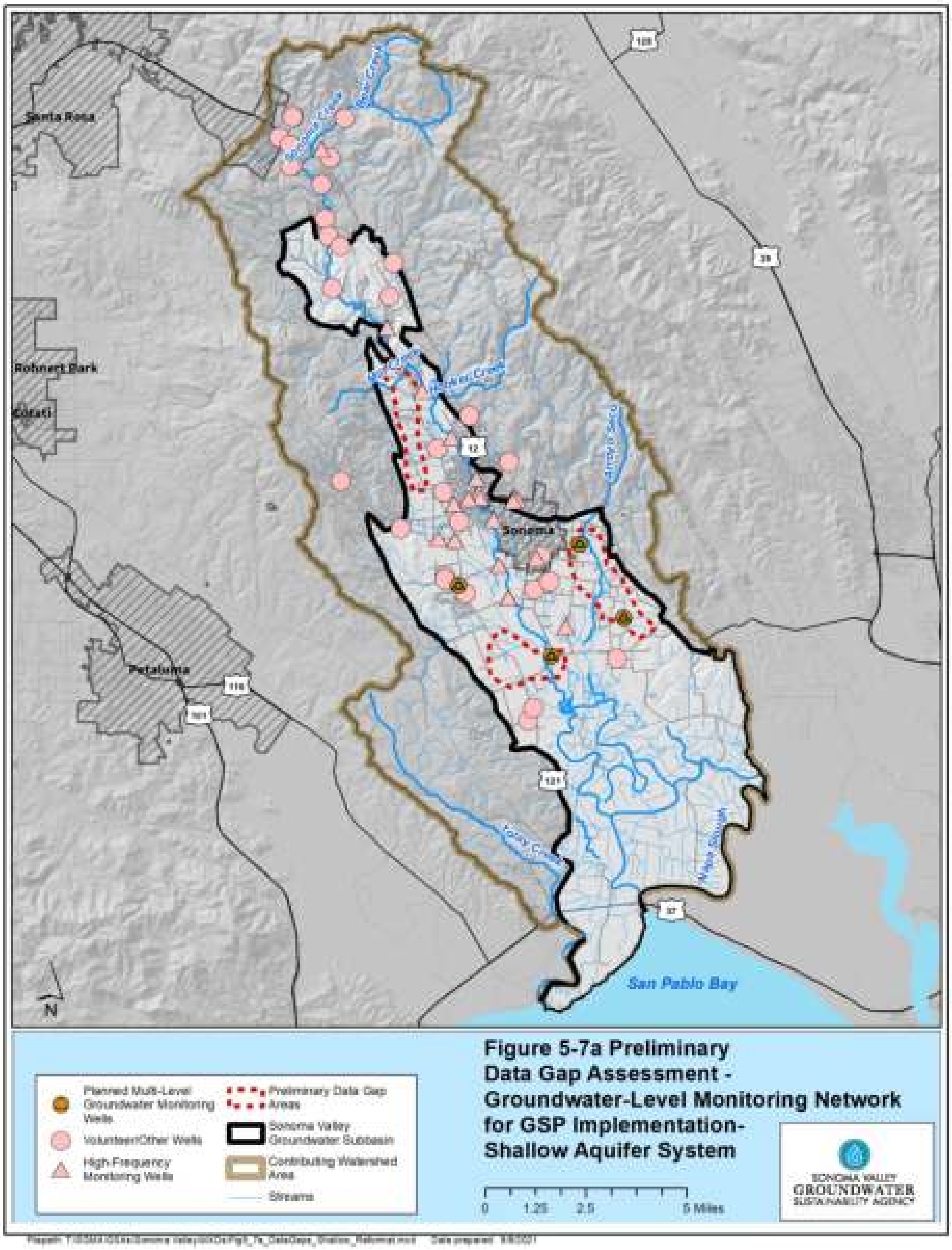

Figure 5-7a. Preliminary Data Gap Assessment – Groundwater-Level Monitoring Network for GSP Implementation – Shallow Aquifer System

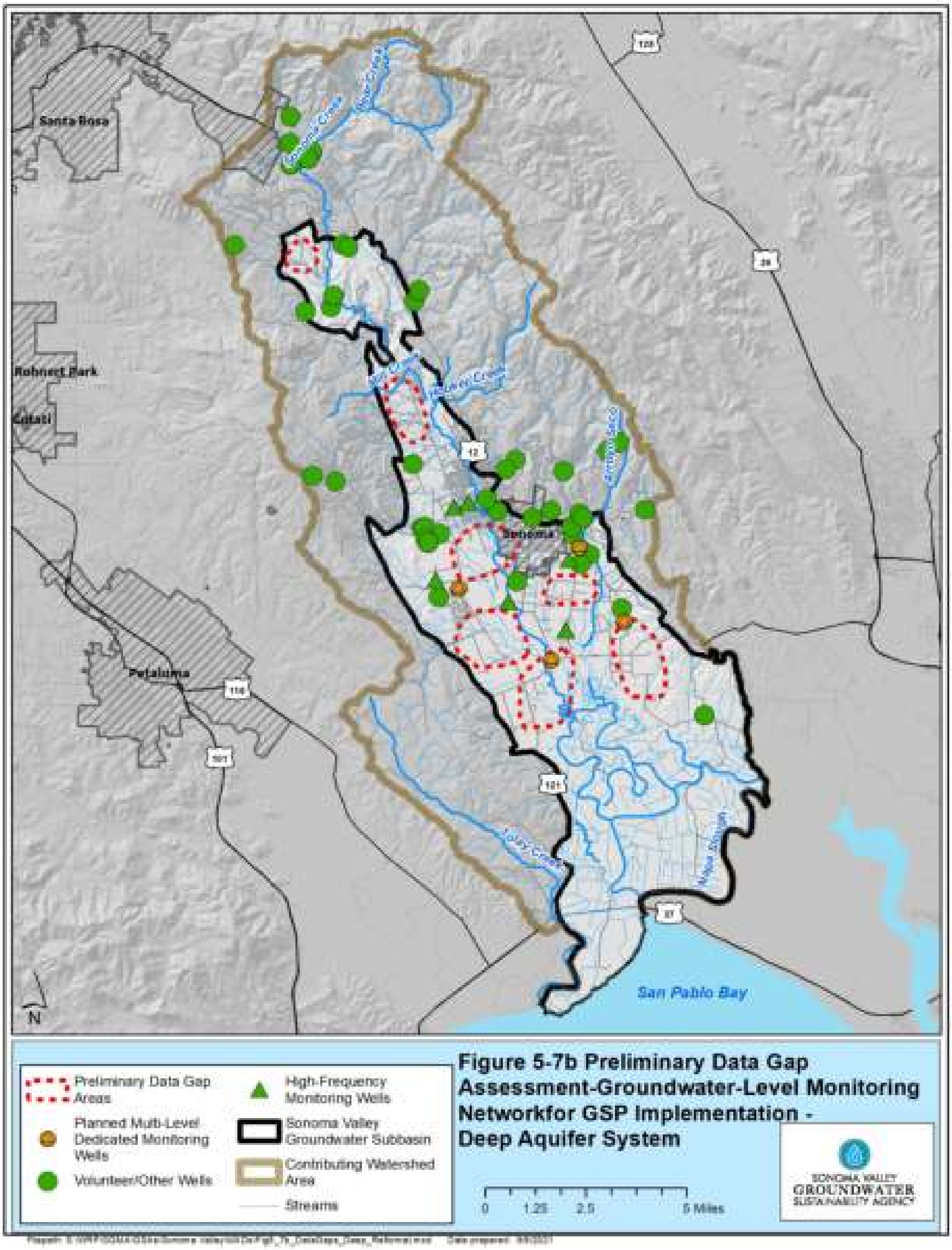

Figure 5-7b. Preliminary Data Gap Assessment – Groundwater-Level Monitoring Network for GSP Implementation – Deep Aquifer System

As illustrated on **Figure 5-7b**, the initial assessment for the deep aquifer system identified the following spatial data gaps:

- In the northwestern corner of the Subbasin
- In the northern-central portion of the Subbasin near Mill Creek
- In the area of observed groundwater-level declines southeast of the City of Sonoma
- In the eastern portion of the Subbasin along Highway 12
- In the area along and to the south of Highway 121, between Highway 12 and Arnold Drive
- Between Arnold Drive and Highway 12, north of Leveroni Road and south of Petaluma Avenue
- Between Sonoma Creek and the western Subbasin boundary, south of Watmaugh Road

The deep aquifer system GSP Implementation Network was compared with the well density map presented in **Section 2** (**Figure 2-6**). This comparison indicated that all areas within the Subbasin with relatively high densities of water supply wells have deep monitoring sites within a reasonably close vicinity except for the data gap areas previously discussed. The two southernmost identified data gap areas are planned to be addressed through the installation of Proposition 68-funded multilevel monitoring wells in 2022. For the remaining data gap areas, the GSA will look for opportunities to incorporate existing wells into the monitoring network and/or potentially install dedicated monitoring wells in the future. The GSA intends to conduct outreach and expand the voluntary groundwater-level monitoring program in the Subbasin during GSP implementation.

5.4.1.2 Monitoring Frequency Data Gap Assessment

Water-level data is collected at least daily (typically hourly) using pressure transducers from 36 (high-frequency monitoring wells) of the 107 wells in the GSP Implementation Network. Manual water-level measurements are collected at least semiannually for all wells in the network. Included in the high-frequency monitoring wells are four shallow monitoring wells installed adjacent to streams and major creeks in 2019 with the intended purpose of monitoring shallow groundwater levels relative to nearby surface water levels. A total of 11 of the 23 wells in the Groundwater-level RMP Network are equipped with pressure transducers for subdaily water-level data collection. One of the RMP wells is monitored monthly and the remaining 11 are monitored semiannually. The monitoring frequencies are sufficient to meet the monitoring objectives for the Subbasin. Increased monitoring frequencies are recommended for the 11 RMP wells that are currently monitored semiannually. The GSA will contact well owners to request permission to increase monitoring frequency to quarterly or monthly. The GSA will explore the possibility of installing remote monitoring equipment such as pressure transducers for subdaily data collection in the 12 RMP wells that are not currently high-frequency monitoring wells dependent on funding availability, well owner willingness, and well compatibility.

5.4.1.3 Data Quality Assessment

An initial assessment of data gaps related to the ability of groundwater-level monitoring sites to satisfy applicable SGMA standards was conducted during GSP preparation. This subsection presents the initial assessment of data quality and identifies data gaps to be addressed during the GSP implementation phase. Specific SGMA standards or guidance for which data gaps were identified are as follows:

- Reference point elevations shall be measured and reported in feet to an accuracy of at least 0.5 feet, or the best available information, relative to NAVD88 [North American Vertical Datum of 1988], or another national standard that is convertible to NAVD88, and the method of measurement described" (23 CCR 352.4).
- For wells used to monitor groundwater conditions [the GSA] shall provide the following information: casing perforations, borehole depth, and total well depth.
- Wells that are part of the monitoring program should be dedicated groundwater monitoring wells with known construction information. The selection of wells should be aquifer specific and wells that are screened across more than one aquifer should be avoided where possible.

The initial assessment of the groundwater-level monitoring networks indicated the following:

- Sixty-three of the 107 wells in the GSP Implementation Network lack sufficient reference point vertical survey data (that is, top-of-casing elevation). This includes 5 of the 23 wells in the Groundwater-level RMP Network.
- Thirty-one of the 107 wells in the GSP Implementation Network lack complete construction information (that is, missing screened intervals and/or total depth information). This includes 6 of the 23 wells in the Groundwater-level RMP Network.
- A total of 14 of the 54 wells in the deep aquifer system GSP Implementation Network have screened intervals that extend into the shallow aquifer system.

The GSA will work to improve data quality in groundwater-level monitoring networks by a combination of the following activities:

- Performing survey activities for wells that lack sufficient reference point vertical survey data, as funding becomes available
- Obtaining well construction information from well owners or by conducting investigations (that is, video logging) as funding or technical assistance becomes available

- Replacing wells in the monitoring network that have data quality issues with dedicated monitoring wells, as funding becomes available

5.4.2 Assessment and Identification of Data Gaps – Surface Water Monitoring Network

The three active USGS stream gages and two OneRain gages operated by Sonoma Water provide a well-distributed surface water monitoring network in the Subbasin and contributing watershed area. Seventeen stream-adjacent shallow groundwater monitoring wells, combined with the Surface Water Monitoring Network, monitor groundwater-surface water interaction throughout the Subbasin. Data gaps in the understanding of interconnected surface water in the Subbasin are illustrated on **Figure 5-8**. These data gap areas include Sonoma Creek in the northernmost portion of the Subbasin, Felder and Rogers Creeks near the western Subbasin boundary, Arroyo Seco near the eastern Subbasin boundary, and Sonoma Creek north of Highway 121. Multilevel groundwater monitoring wells planned for installation in 2022 will provide data on shallow groundwater conditions in the Arroyo Seco, Felder and Rogers Creeks, and Sonoma Creek north of Highway 121 data gap areas. The GSA will explore the potential for installation of additional stream gages in these data gap areas and in the vicinity of existing stream-adjacent shallow monitoring wells that are not already paired with surface water gages. The GSA will also evaluate existing Trout Unlimited stream gages in the northern portion of the Subbasin for potential inclusion into the Surface Water Monitoring Network.

5.4.3 Assessment and Identification of Data Gaps – Seawater Intrusion Monitoring Network

Significant data gaps have been identified in the southern portions of the Subbasin that prevent adequate mapping and characterization of the spatial and temporal distribution of salinity in groundwater. In particular, groundwater quality data for both principal aquifers and well construction data are limited in this area and appropriate monitoring infrastructure is lacking. The GSA has prioritized addressing these data gaps as a high-priority action, as further described in **Section 7** of this GSP.

The GSA is working to incorporate existing water supply wells in and near the Baylands area into the Seawater Intrusion Monitoring Network. An additional five or more new dedicated multi-depth monitoring wells are anticipated to be needed in the shallow and deep aquifer systems to better characterize the distribution of chloride in groundwater, refine the initial locations of the baseline and reference 250 mg/L chloride concentration isocontours, and serve as RMPs during GSP implementation. Potential areas for new Seawater Intrusion RMPs are shown on **Figure 5-9**. A multi-depth monitoring well planned for installation in 2022 near the intersection of Highway 12 and Highway 121 (**Figure 5-9**) will also serve as a Seawater Intrusion RMP.

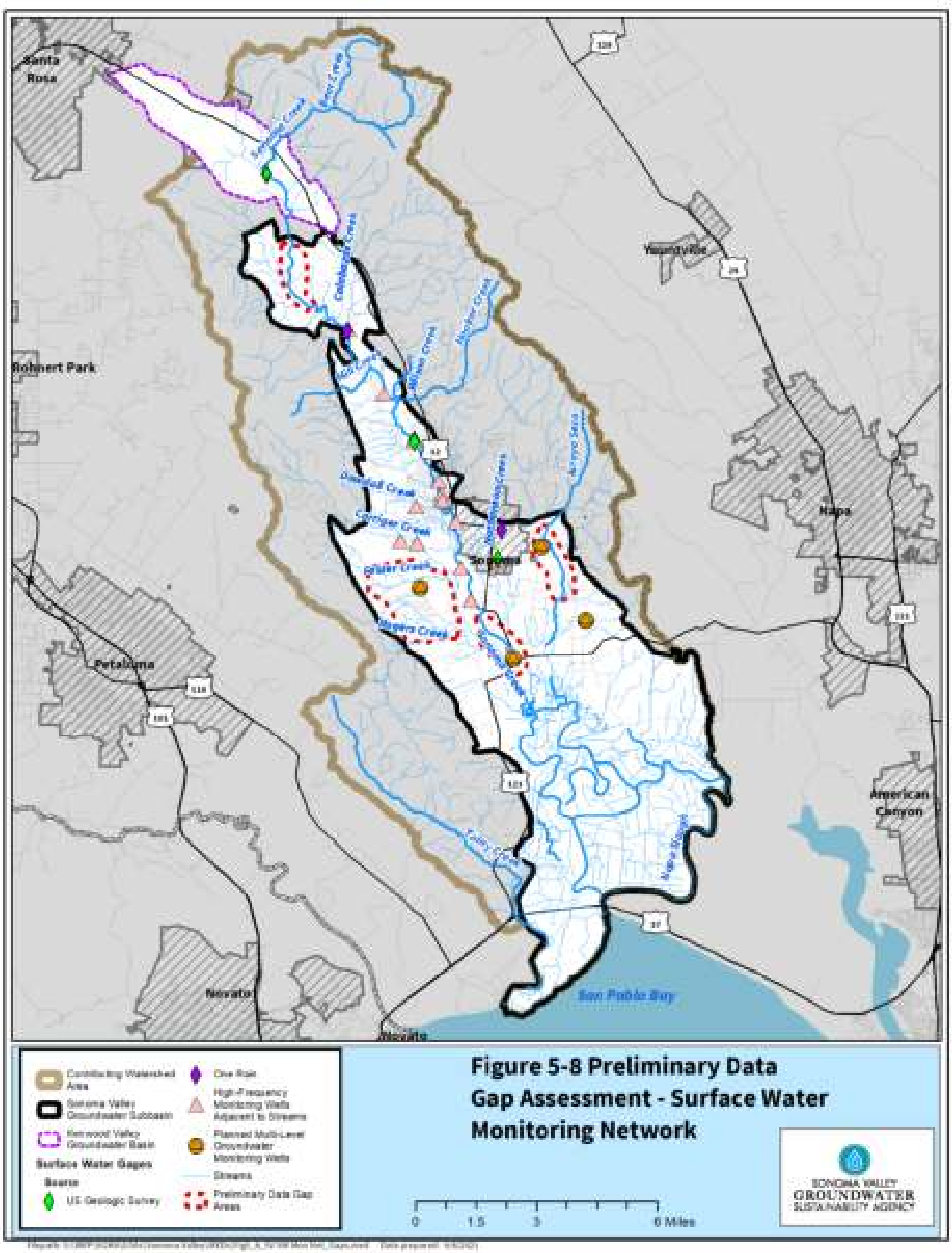

Figure 5-8. Preliminary Data Gap Assessment – Surface Water Monitoring Network

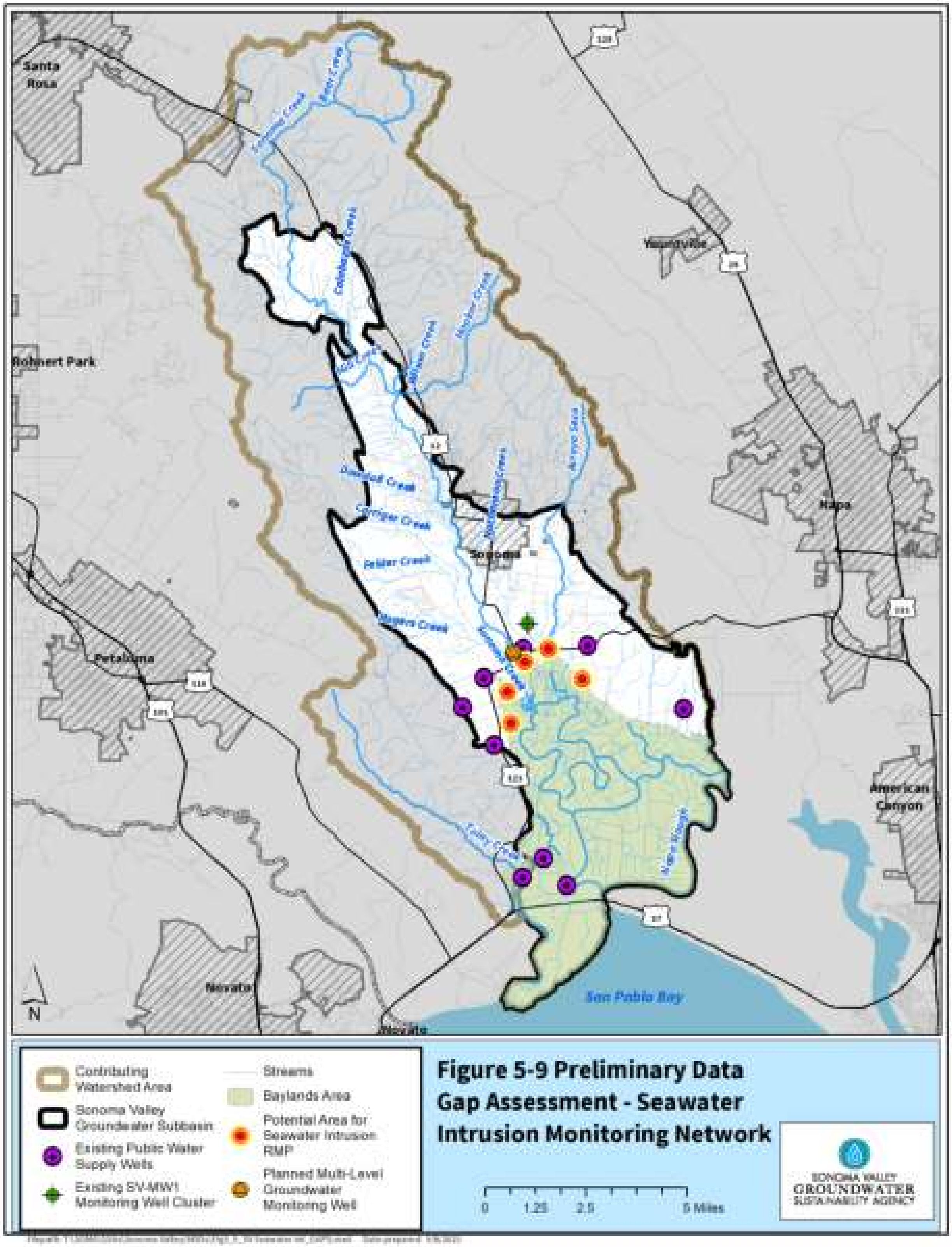

Figure 5-9. Preliminary Data Gap Assessment – Seawater Intrusion Monitoring Network.

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Section 6: Projects and Management Actions

Groundwater Sustainability Plan

Sonoma Valley Groundwater Subbasin

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6 PROJECTS AND MANAGEMENT ACTIONS

This section satisfies Sections 354.42 and 354.44 of the SGMA regulations, which require that GSPs include descriptions of projects and management actions that the GSA has determined will help achieve and maintain the sustainability goal as well as respond to changing conditions in the basin over the 50-year planning horizon. Additionally, the GSP is required to include:

1. Which MO will benefit from a specific project or management action
2. Criteria and circumstances that would trigger implementation and future termination
3. The process by which the GSA will determine a project or management action is necessary to execute Projects and management actions can be used to attain the MOs, meet interim milestones, and avoid MT exceedances and undesirable results.

The management actions and projects covered in this chapter outline a framework for achieving sustainability; however, many details must be negotiated and finalized before many of the projects and management actions can be implemented. The costs for management actions and project implementation are additional to the funding required to sustain the operation of the GSA and for monitoring and reporting. The projects and management actions discussed in this section demonstrate that sufficient options exist to reach and maintain sustainability. Not all projects and actions have to be implemented to attain sustainability. Therefore, the projects and management actions included herein should be considered a list of options that will be refined during GSP implementation.

6.1 Identification of Projects and Management Actions

The identification of projects and management actions was an iterative process which included significant Advisory Committee and GSA Board input, and a substantial amount of staff work. Input received from the Advisory Committee and GSA Board helped refine and categorize the selection of projects and management actions into those that could be initially evaluated as part of this GSP and those that require further assessment or study prior to implementation. For example, recharge net-metering programs, water markets, and zero-net water use requirements for new development need further refinement. Management actions the GSA has under its authority, such as mandatory conservation or pumping reductions, will also be studied and considered during the first 5 years of GSP implementation, as described in **Section 6.4**.

- The projects and management actions considered for implementation and further planning build upon the successful, historical groundwater management activities conducted within the Subbasin listed below: Use of imported surface water by the City of Sonoma and VOMWD municipalities (Sonoma Water's water contractors) in lieu of local groundwater supplies.
- Development and use of recycled water supplies for meeting agricultural and landscape irrigation demands.

- Implementation of water-use efficiency and conservation programs within the urban water-use sector.
- Studies and implementation of water-use efficiency measures within the agricultural sector.
- Studies and initial planning for managed aquifer recharge, including:
    - Feasibility study and initial planning for ASR
    - Studies, data collection, and pilot testing for stormwater recharge projects

While some of these initiatives and activities have historically been developed and planned specifically to address groundwater conditions within the Subbasin, many have been developed and implemented to achieve other benefits, objectives, and purposes. Inclusion and further assessment of these initiatives and activities during implementation of the GSP will facilitate coordination and optimization of these initiatives and activities to support sustainable groundwater management. **Sections 6.2** through **6.4** describe the identified projects, summarize initial assessment of projects using scenario modeling, and describe identified management actions.

6.2 Project Descriptions

To prevent potential undesirable results and to achieve MOs, projects, and management actions are planned as part of GSP implementation. Based on the frequency of chronic lowering of groundwater levels in portions of the deep aquifer system and the results of projected baseline model scenarios, a portfolio of projects and management actions is needed to limit future MT exceedances and avoid future undesirable results. The GSA plans to immediately implement selected projects and management actions. In some cases, initial implementation steps include performing studies or analyses to refine the concepts into actionable projects. **Sections 6.2.1** through **6.2.4** provide descriptions of the projects included in the portfolio, including information required by Section 354.44 of the GSP Regulations. The projects described were assembled into different groups for the purposes of performing an initial assessment of benefits using model scenarios:

<u>Group 1:</u>

- Water-Use Efficiency and Alternate Water Source Projects
- Recycled Water Expansion Projects (addition of existing contracts along existing alignments only)

<u>Group 2A:</u>

- Recycled Water Expansion Projects (additional deliveries to new contracts along new alignments)
- ASR (City of Sonoma and VOMWD service areas)

Group 2B:

- ASR (other areas)
- Stormwater Capture and Recharge

Details of the methodology and results of model scenarios developed to assess projects are summarized in **Section 6.3** and provided in **Appendix 6-A**.

6.2.1 Water-Use Efficiency and Alternate Water Source Projects

The water-use efficiency and alternate water source projects include smaller-scale dispersed land-owner projects, such as turf removal, rainwater harvesting, and distributed stormwater capture/reuse. These projects are initially planned as voluntary, incentive-based projects focused on groundwater users, primarily rural, residential, agricultural, and commercial/industrial groundwater users. The programs and education offered to rural, domestic, and commercial groundwater users will mirror programs offered to regional municipal water users, which have led to a 37 percent reduction in per capita water use since 2010. It is assumed that existing water-use efficiency by municipal groundwater users will continue through the Sonoma-Marin Saving Water Partnership. In addition to the Sonoma-Marin Saving Water Partnership, described in **Section 2.6**, numerous other regional and local water conservation programs are operational in the Plan Area, including the LandSmart Program and the Sustainable Winegrowing Program. Many grape growers already use drip irrigation and rely on new technologies to determine when and how much to irrigate vines. This program would be focused on leveraging existing tools and BMPs and working with farmers who have not had either access or the resources available to reduce water use. Examples of the tools and BMPs included in these programs are:

- Indoor (high-efficiency toilets, fixtures, and washers) and outdoor (landscaping assistance, surveys, and retrofits) water-use efficiency
- Conservation rebate programs for high-efficiency appliances and fixtures, landscape water budgets, landscape and irrigation design, and irrigation scheduling
- Stormwater management through low-impact development practices
- Rain water harvesting
- BMPs for conserving water use in commercial processing, including wineries
- Soil moisture monitoring and efficient irrigation scheduling

During the first year of GSP implementation, this project will include an assessment of the exact types of water-use efficiency tools and alternate water source projects that are expected to be most effective and feasible for Subbasin stakeholders, including groundwater-use characteristics, existing levels of conservation and water-use efficiency, and recommendations on preferred tools and strategies for implementation (such as incentive options). While implementation of these projects is initially planned to be on a voluntary basis, the assessment will also identify specific metrics for evaluating the benefits of the projects and assess Subbasin conditions that may lead to mandatory implementation of management actions.

6.2.1.1 Objectives, Circumstances and Timetable for Implementation

Objectives for implementing the water use efficiency and alternate water source projects are to help achieve MOs and avoid undesirable results for the chronic lowering of groundwater levels sustainability indicator. Achieving MOs and avoiding undesirable results for the chronic lowering of groundwater levels sustainability indicator is also expected to benefit the groundwater storage, seawater intrusion, and land subsidence sustainability indicators. Additionally, depending upon the locations within the Subbasin where projects are implemented, there may be benefits to the MOs for the depletion of interconnected surface water sustainability indicator.

After a short planning period, it is assumed that water-use efficiency and alternate water source projects will begin in 2023. Initial implementation of these projects will include an assessment of the exact types of water-use efficiency tools and alternate water source projects that are expected to be most effective and feasible for Subbasin stakeholders. The assessment will also identify specific metrics for evaluating the benefits of the projects and assess Subbasin conditions that may lead to mandatory implementation of management projects.

6.2.1.2 Expected Benefits

Expected benefits from implementation of water use efficiency and alternate water source projects are described in detail in **Appendix 6-A**. For the purpose of estimating the potential benefits of these projects, it was assumed that the Group 1 scenario simulates the impacts of a 20 percent reduction in all rural domestic use and a 10 percent reduction in consumptive use for all vineyards, beginning in 2025. This assumption was considered to represent a reasonable level of groundwater use reduction based on the outcomes from existing BMPs and other water-use efficiency programs. Other groundwater-use sectors would be included in the project, including commercial, industrial, and agricultural crops. However, for the purpose of conducting the scenario modeling, only reductions in rural domestic and vineyard groundwater use were applied, as these components were most readily able to be incorporated in the model.

Based on these assumptions and as described in **Appendix 6-A**, expected benefits include reduction in the number of potential future MT exceedances for the chronic lowering of groundwater levels sustainability indicator, as well as decreasing the decline in groundwater storage, reducing inflows from the Baylands area, and improving net surface water and groundwater exchange. Benefits simulated by the model relative to the baseline scenario for the Group 1 scenario, which primarily includes the water-use efficiency projects but also includes the addition of existing recycled water contracts, are summarized as follows:

- Simulated project yields: total of 651 AFY (377 AFY from reduction in vineyard consumptive use, 223 AFY reduction in rural domestic groundwater use, and 51 AFY of recycled water delivery offsets)
- Simulated increase in groundwater levels: 5- to 30-foot increase, with largest increases east of the Eastside Fault
- Simulated increase in groundwater storage: 110 AFY
- Simulated net reduction in surface water depletion: 140 AFY
- Simulated reduction to inflows from the Baylands area: 120 AFY

The planned initial assessment of projects will include recommendations for evaluating specific metrics for the actual benefits of the projects during implementation.

6.2.1.3 Public Noticing, Permitting and Regulatory Process

Public notice and outreach communications will be a critical component to the success of implementing water use efficiency and alternate water source projects, as these actions are initially planned as voluntary and will rely on Subbasin stakeholders clearly understanding their importance and benefits. Activities described in **Section 7.2.2** will include outreach to rural, residential, commercial, industrial, and agricultural stakeholders focused on highlighting the benefits of participation.

Some of the water use efficiency and alternate water source projects do not have permitting or regulatory requirements. Any projects that may include permit or regulatory requirements, such as graywater systems, would need to comply with local requirements and ordinances.

6.2.1.4 Estimated Costs and Funding Plan

A total of $80,000 is included in the initial 5-year budget provided in **Section 7.2** to perform the assessment of water use efficiency and alternate water source projects and to fund initial rollout of voluntary measures. To continue and expand implementation of water use efficiency and alternate water source projects, the GSA will seek grant funding. The GSA is also planning to apply for funding for high-efficiency toilet replacement and agricultural BMP implementation through the State's 2021 Drought Relief Program.

6.2.1.5 Legal Authority

No legal authority is anticipated to be needed to voluntarily implement the water use efficiency and alternate water source projects.

6.2.2 Recycled Water Expansion

Recycled water is water that goes into the wastewater system from within the service area of the SVCSD and is treated to tertiary standards at the Sonoma Valley Wastewater Treatment

Plant. Recycled water has been and will continue to be an important source of irrigation water to offset the use of local groundwater and potable water supplies in Sonoma Valley. Recycled water can be used in applications where potable water is often used, such as the irrigation of public parks and golf courses, and for agriculture. In addition to allowing for potable water offsets, recycled water use can facilitate in lieu groundwater recharge. For example, if a farm that has historically used well water for crop irrigation begins using recycled water instead, the groundwater aquifer beneath will recover through reduced pumping and natural recharge. Additionally, using recycled water for irrigation also means a decrease in discharge of treated wastewater to local water bodies such as the San Pablo Bay.

Initial assessment and study for expanding recycled deliveries within the Subbasin are included in SVCSD's Recycled Water Plan (West Yost 2018), which focused on East Study, West Study, and City of Sonoma Study Areas. To reliably deliver recycled water during the irrigation season, it is assumed that additional storage facilities would need to be developed to seasonally store wintertime recycled water flows. For the purpose of evaluating recycled water expansion projects in this GSP, the recycled water system expansion focused on the East Study Area and portions of the West Study Area located to the east of Sonoma Creek (included with Group 2A model scenario). Future expansion within the City of Sonoma Study Area was not included in the model scenarios for this GSP, as the city primarily uses imported Russian River water, and would therefore represent a relatively lower benefit to groundwater within the Subbasin.

The SVCSD has included the construction of the Napa Road Recycled Water Pipeline and associated storage alternative in the Phase 2 Environmental Impact Report (EIR) developed through the North Bay Water Reuse Program (Environmental Science Associates 2018). This proposed pipeline alternative is located within the East Study Area and would expand the recycled water service area in the unincorporated areas of Sonoma County east of the City of Sonoma along Napa Road. Pipeline construction would include 11,500 linear feet (LF) of 12-inch diameter pipeline located within the roadway or roadway shoulder and associated storage. The pipeline would connect to existing pipelines and extend eastward from 5th Street East to serve additional customers. The implementation of the West Study Area is also incorporated into the Group 2A scenario evaluated in this GSP and includes construction of 8,410 LF of new 12-inch diameter recycled water pipeline located within the roadway or roadway shoulder. Collectively, recycled water is assumed to be delivered to approximately 900 acres of farmland currently using groundwater for irrigation in the East and West Study Areas.

6.2.2.1 Objectives, Circumstances and Timetable for Implementation

Objectives for expanding recycled water deliveries are to help achieve MOs and avoid undesirable results for the chronic lowering of groundwater levels sustainability indicator. Achieving MOs and avoiding undesirable results for the chronic lowering of groundwater levels sustainability indicator is also expected to benefit the groundwater storage, seawater intrusion, and land subsidence sustainability indicators. Additionally, depending upon the locations within the Subbasin where recycled water projects are expanded, there may be benefits to the MOs for the depletion of interconnected surface water sustainability indicator.

Recycled water projects require permitting, environmental analysis, and engineering design. The SVCSD has included the Napa Road Recycled Water Pipeline in the Final EIR developed for the Phase 2 North Bay Water Reuse Program (Environmental Science Associates 2018). Initiation of design is dependent upon securing funding for the project. For the purposes of evaluating using model scenarios, it is assumed that the Napa Road Recycled Water Pipeline would be initiated in 2025. The timing of projects is based on best estimates and may shift as GSP implementation proceeds, depending upon project needs at the time.

6.2.2.2 Expected Benefits

Potential benefits from implementation of recycled water projects are described in **Appendix 6-A**. Using the assumptions described in **Appendix 6-A**, potential benefits include reduction in the number of potential future MT exceedances for the chronic lowering of groundwater levels, as well as decreasing the projected decline in groundwater storage. Benefits from recycled water projects would primarily be evaluated using changes in measured groundwater levels and improvements to groundwater storage changes. Benefits are simulated by the model for the Group 2A scenario (relative to the Group 1 scenario). Group 2A primarily includes the recycled water system expansion, but also includes the addition of ASR at two locations, with benefits summarized as follows:

- Simulated project yields: total of 342 for expanded recycled water deliveries (Group 2A also includes 140 AFY for ASR at City of Sonoma and VOMWD existing well sites)
- Simulated increase in groundwater levels: 15- to 20-foot increase, with largest increases east of the Eastside Fault
- Simulated increase in groundwater storage: 60 AFY
- Simulated net reduction in surface water depletion: 80 AFY
- Simulated reduction to inflows from the Baylands area: 80 AFY

6.2.2.3 Public Noticing, Permitting and Regulatory Process

Public notice for aspects of the recycled water projects will be carried out by the lead agency, which is anticipated to be the SVCSD. For recycled water projects where the GSA is not the lead agency, the GSA will provide support for outreach activities to nearby well owners and the local community. Compliance with CEQA is incorporated into the existing EIR for the Phase 2 North Bay Water Reuse Project (Environmental Science Associates 2018). Any additional recycled water projects would be included in future CEQA analysis, as needed.

Existing wastewater treatment and recycled water production occur at the SVCSD Waste Water Treatment Plant in compliance with Order No. R2-2014-0020 (National Pollution Discharge Elimination System [NPDES] Permit No. CA0037800) issued by the SFBRWQCB. It is anticipated that future expansion of recycled water deliveries would also occur under this or future revised or amended orders.

6.2.2.4 Estimated Costs and Funding Plan

Preliminary costs for the recycled water system improvements for the East and West Study Area are estimated to be $7,946,000 and $4,590,000, respectively, which does not include the needed storage facilities (West Yost 2018). Preliminary costs to develop the Napa Road Pipeline portion of the East Study Area and associated storage are estimated to be approximately $3,600,000 (Brown and Caldwell 2017). This project is included in the Phase 2 North Bay Water Reuse Program and the GSA will closely coordinate with project proponents to advance and support opportunities to obtain grant funding for the project.

A total of $70,000 is included in the initial 5-year budget provided in **Section 7.2** for the GSA to perform an assessment of additional recycled water opportunities in collaboration with SVCSD. It is anticipated that the assessment will include:

- Evaluation of existing and future availability, delivery commitments, and constraints
- Assessment of options for optimization of existing and projected future available supplies
- Preliminary cost and benefit analyses for future options

6.2.2.5 Legal Authority

The SVCSD has the legal authority to treat wastewater and deliver recycled water for irrigation uses.

6.2.3 Aquifer Storage and Recovery

As described in **Section 2.6**, regional planning for ASR and well-specific assessments have been performed by local agencies within the Subbasin (GEI Consultants, Inc. et al. 2013 and West Yost 2018). Conceptually, an ASR program would involve the diversion and transmission of surplus Russian River water produced at existing drinking water production facilities during wet weather conditions (that is, the winter and spring seasons) for storage in the deep aquifer system of the Subbasin. The stored water would then be available for subsequent recovery and use during dry weather conditions (that is, the summer and fall seasons) or emergency situations. The Groundwater Banking Feasibility Study (GEI Consultants, Inc. et al. 2013) provided an evaluation of regional needs and benefits, source water availability and quality, regional hydrogeologic conditions, and alternatives for groundwater banking. Based on the findings from the study, pilot studies to further assess the technical feasibility of ASR as a method for groundwater banking were recommended and in 2018 a pilot project was completed in the City of Sonoma along the margins of the Subbasin (GEI et al. 2020).

The feasibility study also found that adequate water for the hypothetical 5,000 AFY groundwater recharge program would be available for diversion from Sonoma Water's diversion facilities along the Russian River more than 90 percent of the time. This divertible flow was calculated by simulating the river system operations to meet Water Agency demands, simulating Water Agency diversions, and then subtracting minimum flows needed to meet the Biological Opinion and other instream requirements. In general, water is expected to be available for groundwater recharge in most years during the months of December through May. Because of the high-flow rates in these winter and spring months (with 100 cfs or more divertible flow expected 90 percent of the time), this pattern of availability is expected to be present under higher future levels of demand. Some water would also be available for diversion to groundwater storage during June through November, though less frequently (GEI Consultants, Inc. et al. 2013). An updated assessment of water available for recharge will be performed during the early stages of GSP implementation.

For the purpose of this GSP, initial assessment of ASR was conducted for the following two general phases:

- Phase 1: Implementation of ASR operations at two locations within the City of Sonoma and VOMWD service areas (simulated under the Group 2A scenario):
  - City of Sonoma: Based on the outcome of the 2018 pilot study, it is recommended that a new well, specifically designed for ASR operations, be constructed in the vicinity of the city's existing municipal Well No. 6 (which is nearly 70 years old) in addition to two new groundwater monitoring wells and associated equipment. Preliminary estimates of work needed to implement the project include construction of one new ASR well (and associated pump and equipment), two new monitoring wells, and 500 LF of 6-inch-diameter pipelines.
  - VOMWD: The potential VOMWD ASR site consists of an existing municipal well (Verano Avenue Well), which has recently been upgraded and designed to accommodate ASR operations. The project would include construction of two groundwater monitoring wells and associated equipment, as well as the implementation of a pilot study to refine operational parameters for the ASR project.
- Phase 2: Study additional potential ASR locations and implementation of ASR at three additional locations within the Subbasin (simulated under the Group 2B scenario). For the purpose of conducting an initial assessment of potential benefits, locations were selected to coincide with areas of largest groundwater withdrawals and/or substantial historical groundwater level declines. The three locations incorporated into the simulations are the Carriger Road area in El Verano near 8th Street East and Napa Road, and at Denmark Street and Napa Road.

Prior to implementing long-term ASR programs, pilot projects are recommended to verify location-specific feasibility, including aquifer capacity for recharge and recovery operations and geochemical compatibility. Pilot testing involves injecting potable drinking water into the Subbasin's aquifers and recovering it to assess injection and recovery capacities and monitor potential water quality impacts to native groundwater resources. Information generated by pilot test evaluations will help inform the degree to which ASR is a feasible strategy to improve reliable water supply, along with helping to evaluate whether or not an ASR project can be developed and operated in a manner that will achieve both supply reliability and groundwater sustainability benefits. A pilot project has already been implemented in the City of Sonoma, and another one will be conducted by VOMWD before going forward with full-scale implementation of ASR at the potential VOMWD ASR location.

Additionally, it is recognized that other water purveyors are pursuing initiation of ASR in the Subbasin on a more expedited timeframe in response to the 2020/2021 drought and associated funding opportunities. The GSA will coordinate and provide support for planning and implementation of ASR projects that may be developed and implemented by Sonoma Water and other project proponents in response to current drought conditions, as these projects are also expected to help achieve MOs and avoid undesirable results.

6.2.3.1 Objectives, Circumstances and Timetable for Implementation

Objectives for implementing ASR projects are to help achieve MOs and avoid undesirable results for the chronic lowering of groundwater levels sustainability indicator. Achieving MOs and avoiding undesirable results for the chronic lowering of groundwater levels sustainability indicator is also expected to benefit the groundwater storage and land subsidence sustainability indicators. Additionally, depending upon the locations within the Subbasin where ASR projects are implemented, benefits to the MOs for the depletion of interconnected surface water sustainability indicator may also be realized.

ASR projects require permitting, environmental analysis, and engineering design, which would begin in 2022. Depending upon results of pilot studies, full-scale implementation of the City of Sonoma and VOMWD ASR projects is anticipated to begin in 2024 and 2025, respectively. The timing of projects is based on best estimates and may shift as GSP implementation proceeds, depending upon project needs at the time. This timeframe may be further accelerated in response to the 2021/2022 drought.

6.2.3.2 Expected Benefits

Expected benefits from implementation of ASR projects include:

- Limiting the potential for chronic lowering of groundwater levels and undesirable results for other associated sustainability indicators.
- Enhanced reliability of the regional water supply during droughts, natural hazard events (such as earthquakes), and periods of peak seasonal water demands.

Potential benefits from implementation of ASR projects based on the scenario modeling are described in **Appendix 6-A**. Based on the assumptions described in **Appendix 6-A**, benefits simulated include reduction in the number of potential future MT exceedances for the chronic lowering of groundwater levels, as well as decreasing the decline in groundwater storage. Benefits from ASR projects would primarily be evaluated using changes in measured groundwater levels and improvements to groundwater storage changes. The potential project yields associated with the ASR projects were simulated to be approximately 140 AFY for Phase 1 (simulated under the Group 2A scenario) and 180 AFY for Phase 2 (simulated under the Group 2B scenario). Because the ASR projects were simulated with both expanded recycled water deliveries (Group 2A scenario) and stormwater capture and recharge projects (Group 2B scenario), the estimated quantified benefits to water budget terms are difficult to discern.

Benefits to groundwater levels primarily occur within the deep aquifer system and are inferred to range from 5- to 90-foot increases depending upon the location, with the highest simulated increases occurring closer to the ASR wells and east of the Eastside Fault.

6.2.3.3 Public Noticing, Permitting and Regulatory Process

Public notice for aspects of the ASR pilot projects will be carried out by the lead agency for each project. For ASR projects where the GSA is not the lead agency, the GSA will provide support for outreach activities to nearby well owners and the local community. The Phase 1 ASR projects are included at a programmatic CEQA level in the existing EIR for the Phase 2 North Bay Water Reuse Project (Environmental Science Associates 2018). For the full-scale ASR project, public notice is anticipated to occur through compliance with CEQA as well as local and state permitting requirements for any facilities or plans associated with the project. This includes the development of an underground storage supplement to permit the storage of water in the Subbasin that is required by the SWRCB, and through discussions of the proposed project at public meetings.

The SWRCB has recognized that it in the best interest of the state to develop a comprehensive regulatory approach for ASR projects, and has adopted general waste discharge requirements for ASR projects that inject drinking water into groundwater (Order No. 2012-0010-DWQ or ASR General Order). The ASR General Order provides a consistent statewide regulatory framework for authorizing both pilot ASR testing and permanent ASR projects. Pilot tests and any future permanent ASR facility will be permitted under the ASR General Order. Oversight of these regulations is done through the RWQCBs and will require project proponents to comply with the monitoring and reporting requirements of the ASR General Order. Any additional permits required for the construction and operation of an ASR facility will be obtained by the lead agency for each ASR project as needed.

6.2.3.4 Estimated Costs and Funding Plan

Preliminary cost estimates to test, permit, and construct project facilities for ASR is estimated to range from about $300,000 to $3,600,000, depending upon the complexity of each project, with the lower cost estimates representing the use of existing wells that have the necessary monitoring infrastructure (GEI Consultants, Inc. et al. 2013). For the purpose of estimating the approximate 5-year costs for implementing the Phase 1 ASR projects, a total of $5,000,000 is estimated for capital project costs associated with the City of Sonoma and VOMWD projects. The range of the costs also varies dependent upon whether existing facilities could be retrofitted or new facilities would need to be constructed. Preliminary costs will need to be further refined and provided upon completion of site-specific evaluation and pilot testing. The current plan for developing ASR in the Subbasin would use existing infrastructure, meaning that new infrastructure would be limited, thus allowing for earlier onset of both incremental drought supply and groundwater sustainability benefits. Costs for implementing Phase 2 ASR in other areas of the Subbasin requires additional study and project development prior to estimating.

A total of $325,000 is included in the GSA's initial 5-year budget provided in **Section 7.2** to contribute to an updated regional ASR feasibility study and to complete site-specific investigations of favorable areas. To continue and expand implementation of ASR projects, the GSA will coordinate with other project proponents who may be pursuing ASR projects, consider providing additional funding in future years, and will seek opportunities for grant funding.

6.2.3.5 Legal Authority

Local water supply agencies and the GSA have the authority to develop water supply projects such as ASR for both water supply benefits and to provide groundwater sustainability benefits.

6.2.4 Stormwater Capture and Recharge

As described in **Section 2.6**, planning for stormwater capture and recharge efforts, including site investigations and pilot studies, has been initiated by local agencies and growers within the Subbasin. Stormwater capture projects could be implemented in three areas that were evaluated under the Group 2B scenario:

- Carriger, Felders, and Rodgers Creek alluvial fan
- Arroyo Seco Creek alluvial fan
- Sonoma Creek near Glen Ellen

Stormwater capture and recharge projects are intended to cover two general types of stormwater capture activities that have been identified in the Russian River Storm Water Resource Plan (Russian River Watershed Association 2018). The first stormwater capture activity involves retaining and recharging onsite runoff. Examples of this type of activity include low-impact development and on-farm recharge of local runoff. The second stormwater capture activity involves recharge of unallocated storm flows. These actions require temporary diversions of storm flows from streams and conveyance of those flows to recharge locations. State programs and grants (such as FLOOD-MAR, Proposition 68) and local entities (such as RCDs) can be used as resources to move forward on stormwater capture and recharge efforts.

Prior to implementing long-term stormwater capture and recharge programs, site-specific field investigations and assessments will be needed to identify suitable locations. Therefore, early stages of implementing stormwater capture and recharge projects are anticipated to include site-specific investigations and pilot studies of on-farm and other dispersed recharge opportunities that consider and include the following:

- Water available for recharge

- Areas with permeable near-surface soils

- Optimal methods and techniques

- Outreach to interested landowners with locations that could help sustain baseflows to streams and support GDEs

6.2.4.1 Objectives, Circumstances and Timetable for Implementation

Objectives for implementing the stormwater capture projects are primarily anticipated to help achieve MOs and avoid undesirable results for the depletion of interconnected surface water sustainability indicator. Depending upon the location of stormwater capture and recharge projects, and hydraulic connection between surficial recharge locations and the shallow aquifer system, there may be benefits to the chronic lowering of groundwater levels, groundwater storage, and land subsidence sustainability indicators.

Stormwater capture and recharge projects require permitting, environmental analysis, and engineering design, which would begin with planning for site investigations in 2022. Depending upon results of site investigations and pilot studies, planned to be initiated in 2023, full-scale implementation of stormwater capture and recharge projects is anticipated to begin in 2028. However, implementation of smaller-scale low-impact development type projects may proceed sooner, as permitting requirements are anticipated to be much less involved than projects that involve recharging diverted streamflows. The timing of projects is based on best estimates and may shift as GSP implementation proceeds, depending upon project needs at the time, permitting timelines, and resources available.

6.2.4.2 Expected Benefits

Expected benefits from implementation of stormwater capture and recharge projects are described in **Appendix 6-A**. Based on the assumptions described in **Appendix 6-A**, benefits simulated include increases in spring and summertime streamflows, reduction in the number of potential future MT exceedances for the chronic lowering of groundwater levels, as well as decreasing the decline in groundwater storage. Benefits from stormwater capture and recharge projects would primarily be evaluated using changes in measured groundwater levels and surface water flows near and downstream of project locations. The potential project yields associated with the stormwater capture and recharge projects were simulated to be approximately 166 AFY. Because the stormwater capture and recharge projects were simulated with ASR projects (Group 2B scenario), the estimated quantified benefits to many water budget terms are difficult to discern. Benefits to groundwater levels primarily occur within the shallow aquifer system and are inferred to range from 5- to 15-foot increases in the vicinity of the recharge locations. Benefits to net surface water and groundwater exchange are simulated to be approximately 90 AFY under Group 2B, which is primarily inferred to be caused by the stormwater capture and recharge projects.

6.2.4.3 Public Noticing, Permitting and Regulatory Process

Public outreach would be conducted to identify landowners interested in participating in stormwater capture and recharge projects. The degree of public noticing will vary depending upon the scale and type of recharge project.

Recharge of stormwater by retaining and recharging onsite runoff may require local grading permits depending upon the scale and need for grading or excavation activities. Recharge of unallocated storm flows is currently subject to the SWRCB’s streamlined permit program for groundwater recharge by capturing high-flow events. Recharge of unallocated storm flows will be subject to the terms of these 5-year permits. Stormwater capture may also be subject to CEQA permitting. Additionally, stormwater management projects will need to comply and coordinate with existing NPDES and MS4 permits for regional municipal stormwater systems.

6.2.4.4 Estimated Costs and Funding Plan

A total of $160,000 is included in the initial 5-year budget provided in **Section 7.2** to perform site-specific investigations and fund a pilot study. To continue and expand implementation of stormwater capture projects, the GSA will coordinate with other project proponents who may be pursing multi-benefit projects, consider providing additional funding in future years, and seek opportunities for grant funding.

6.2.4.5 Legal Authority

Other than acquiring required permits and the right to divert stormwater, there are no other legal authorities required to implement stormwater capture and recharge.

6.3 Evaluation of Projects Through Scenario Modeling

For the purposes of conducting an initial evaluation of projects for this GSP, staff assembled conceptual projects that are likely to be initiated within the first 5 years of implementation into two general categories:

- Group 1 projects are those that have identified potential funding sources, or are voluntary or incentive-based with lower costs. The Group 1 projects include the voluntary, incentive-based water-use efficiency and alternate water source projects focused on non-municipal groundwater users. Examples include smaller-scale dispersed land-owner projects, such as turf removal, rainwater harvesting, and irrigation efficiency practices. The exact types of these dispersed projects are not distinguished for the purposes of evaluating potential benefits using model scenarios. Group 1 projects also include recycled water deliveries to recent rural domestic and agricultural customers for existing contracts that began after the baseline scenario period.

- Group 2A and Group 2B projects are new or significantly expanded, and are more costly projects and actions. This includes projects that require further studies and planning for implementation:

  - Group 2A projects expand upon the Group 1 scenario projects by increasing recycled water deliveries and adding managed aquifer recharge. The managed aquifer recharge consists of operation of two ASR wells in the service areas of City of Sonoma and VOMWD to offset existing localized pumping. The expansion of recycled deliveries includes new deliveries and storage along 8th Street East and Napa Road, which includes a 50 percent build out of West Study Area described in the Recycled Water System Plan (West Yost 2018).

- Group 2B projects represent additional managed aquifer recharge projects that aim to raise and maintain groundwater levels in depletion areas in the shallow and deep aquifers and benefit streamflows. The Group 2B projects consist of additional ASR projects in the El Verano area and east of the Eastside Fault, and stormwater capture and recharge projects that could specifically benefit shallow aquifer system groundwater levels and streamflows within the Subbasin.

These general categories formed the basis for model scenarios of potential project and management actions. The model scenarios were performed as an initial evaluation of benefits of the Groups 1, 2A, and 2B projects and management actions relative to the baseline 50-year projected scenario. **Table 6-1** summarizes the simulated yields expected for each group.

Table 6-1. Summary of Project Grouping and Yields

Project	Group 1	Group 2A	Group 2B	Total Annual Simulated Yields
Reduce Vineyard Consumptive Use	Averages 377 AFY less agricultural pumping than baseline simulation	Same as Group 1	Same as Group 1	377 AFY
Reduce Rural Domestic Pumping	Averages 223 AFY less rural domestic pumping than the baseline simulation	Same as Group 1	Same as Group 1	223 AFY
Recycled Water Deliveries	Average deliveries of 51 AFY to Group 1 Farms (begins in in WY2020)	In addition to Group 1 deliveries, average deliveries of 200 AFY at 8th Street and Napa Road area beginning in WY2025; average deliveries of 142 AFY at the West Study Area beginning in WY 2035	Same as Group 2A	393 AFY
ASR	None	Injection of 80 AFY at the VOMWD Verano Well beginning in WY 2024. Injection of 60 AFY at City of Sonoma Well 6 beginning in WY 2025	In addition to Group 2A injection, injection of 60 AFY at each of three wells (8th Street, Napa Road/Denmark Street, and Golf Course wells) beginning in WY 2025	320 AFY
Stormwater Managed Aquifer Recharge	None	None	Recharge averaging 66 AFY at Sonoma Creek and 25 AFY (approximately) at each of the four tributaries (all begin in WY 2025)	166 AFY

Approximate locations of the projects are shown on **Figure 6-1**. The methodology and results of the scenario modeling are described in **Appendix 6-A** and summary results of potential benefits are provided after the figure.

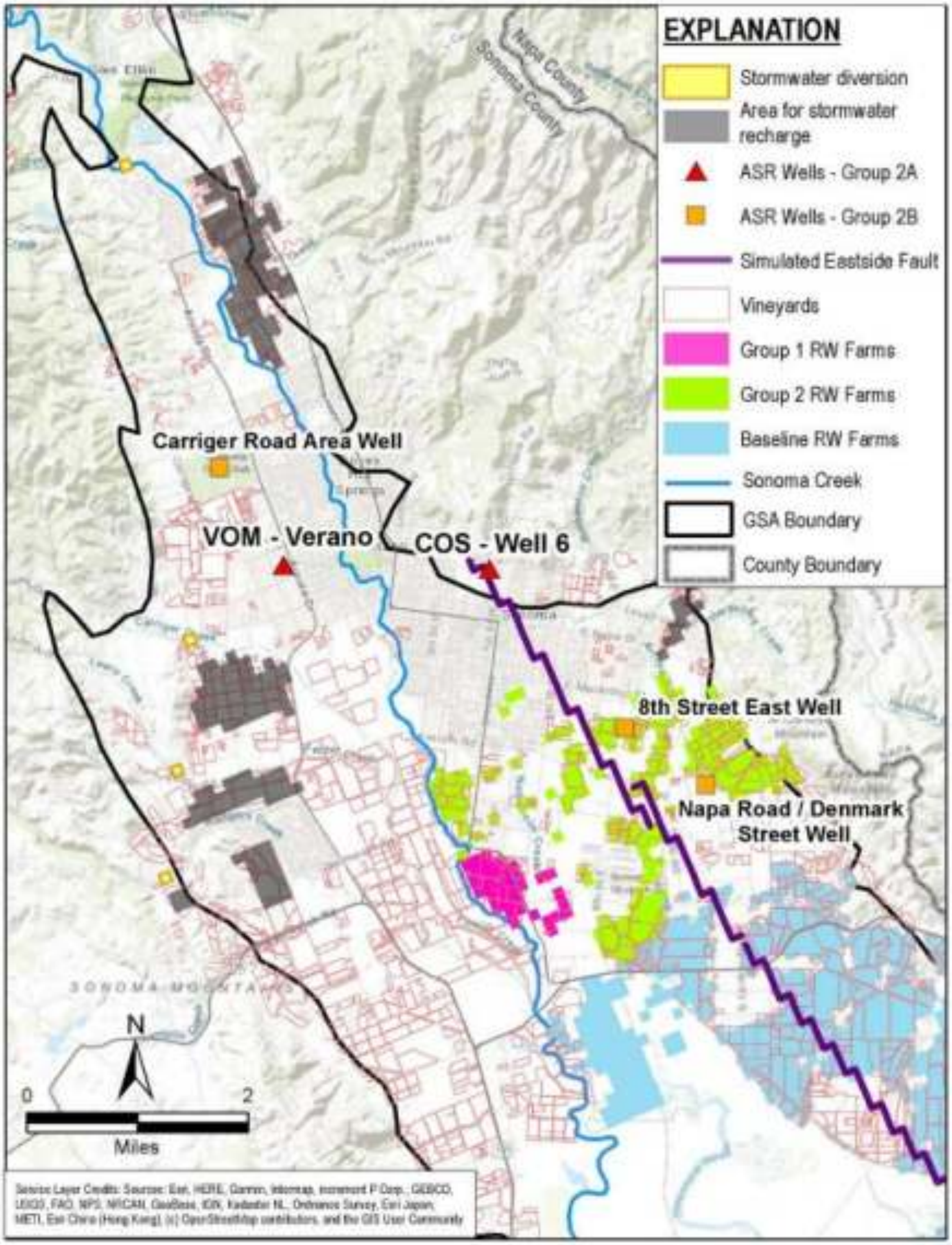

Figure 6-1. Locations of Simulated Projects

General findings from the model scenarios indicate the following:

- **Groundwater Levels**: In the baseline scenario (2021 – 2070), groundwater levels in the shallow aquifer are generally above MTs and no undesirable results are projected to occur within the initial 20-years of the simulation. For the deep aquifer system, MT exceedances and undesirable results are projected to occur during the initial 20 years of the simulation. For the later stages of the 50-year simulation, MT exceedances are projected to occur more frequently in response to the simulated 20-year drought:
    - During future normal and wetter climactic cycles, Group 1 projects are projected to raise groundwater levels 5 to 30 feet in some areas of the Subbasin and reduce the frequency of MT exceedances within the deep aquifer system; however, Group 1 projects alone are not projected to address chronic groundwater level declines within the deep aquifer system.
    - Group 2A projects are projected to raise groundwater levels an additional 5 to 20 feet in the vicinity of the projects and further reduce the frequency of MT exceedances within the deep aquifer system. Group 2A projects are not projected to fully address chronic groundwater level declines within the deep aquifer system.
    - Group 2B projects are projected to raise groundwater levels an additional 25 to 90 feet in the vicinity of the projects and further reduce the frequency of MT exceedances within the deep aquifer system. For the deep aquifer, no simulation avoids undesirable results for the entire simulation period. However, there are only 2 years with undesirable results during the Group 2B simulation period. These 2 years correspond to excessive drought conditions.
- **Groundwater storage:** Groundwater in storage under a baseline scenario without projects is estimated to decline by an average of 290 AFY over the entire 50-year projection period that includes a simulated extreme 20-year drought between 2050 and 2070. Cumulatively, the Groups 1, 2A, and 2B projects are simulated to mitigate the average decline by approximately 220 AFY over the entire 50-year projection (that is, the simulated 290 AFY baseline storage decline improves to 70 AFY storage decline over the entire 50-year projection). For all three scenarios, average annual change in storage is positive from 2021-2040, which represents a wetter period in the future projected climate record. All scenarios have a negative average annual change in storage during 2041-2070, which represents drought conditions included as part of the future climate scenario selected for the GSP. The definition of undesirable results for change in groundwater storage is identical to the definition for chronic lowering of groundwater. Therefore, the three project groups have groundwater storage undesirable results identical to the groundwater level undesirable results.
- **Stream-Aquifer Interaction:** While undesirable results cannot be explicitly assessed for the surface water depletion sustainability indicator using the model scenarios, due to the initial nature and need for improving focused simulation of surface water and groundwater

interaction processes, general benefits to simulated streamflows were assessed. Higher groundwater levels near streams can better support streamflow, particularly in the summer and fall months. Results show that with Group 1, Group 2A, and Group 2B projects, there is a projected reduction in net streamflow depletion due to reduced pumping and increased recharge. Simulated results indicate that streams within the Subbasin change from a net losing stream leakage of 120 AFY under the baseline scenario to a net gaining system of 190 AFY under the cumulative Group 1, 2A, and 2B scenarios (net improvement of approximately 310 AFY). In general, the most significant benefits to net groundwater-surface water exchange occur in spring to early summer, along Carriger Creek and Sonoma Creek.

- **Potential for Seawater Intrusion:** Higher groundwater levels near the Baylands area can reduce the inflow of higher salinity groundwater from the Baylands area. Similar to stream-aquifer interaction, undesirable results could not be explicitly assessed for seawater intrusion due to the initial nature and need for improving characterization and monitoring of seawater intrusion. However, results show that with Group 1, Group 2A, and Group 2B projects, there is a projected reduction in net inflows from the Baylands area of approximately 380 AFY, which would help reduce the potential for future minimum threshold exceedances and undesirable results.

The Group 1, Group 2A, and Group 2B project scenarios improve groundwater declines but do not avoid all MT exceedances. The Group 2B project scenarios show the largest improvement to the water budget as well as to groundwater elevations. The Group 2B Scenario helps improve groundwater declines during the latter portion of the projected period (affected by the major drought) in both the shallow and deep aquifers. Although MT exceedances are not completely avoided during this more extreme dry period under these scenarios, the exceedances during severe droughts are not representative of undesirable results unless groundwater levels do not recover during subsequent wetter time periods.

Considering current uncertainties pertaining to modeling, data gaps, and project information, these project scenarios provide a pathway for reaching sustainability and preparing for future changed conditions in the Subbasin to meet GSP requirements. Additional data collection and project conceptualization during early phases of GSP implementation will help refine these scenarios and allow for consideration of additional scenarios, including mandatory restrictions on groundwater extractions if necessary to achieve sustainability. The projects will also be supplemented by the planned management actions outlined in **Section 6.4**, which include an assessment and prioritization of policy options that focus on demand management for the GSA Board's consideration.

6.4 Management Actions

In addition to initiating the projects detailed in this section, the GSA will further assess and implement the following management actions:

- Assessment and prioritization of potential policy options

- Coordination of Farm Plans with GSP implementation

Additionally, as provided by SGMA, should the above-described projects and management actions not be sufficient to eliminate undesirable results during implementation of the GSP, the GSA has authorities to limit groundwater pumping. **Section 6.4.1.5** further describes these authorities and potential situations where they may be considered.

6.4.1 Assessment of Potential Policy Options for GSA Consideration

SGMA provides several authorities to GSAs, which can be used to achieve groundwater sustainability and requires coordination between GSAs and land use agencies. This management action involves a collaboration between the GSA Board, local land use agencies, GSA member agencies, and stakeholders to assess future policy options that may be appropriate for the GSA to consider adopting or recommending for adoption by other agencies. This study will prepare a prioritized list of potential policy options, including stronger demand management actions that may need to be adopted should the projects not be implementable or successful. Based on input from the Advisory Committee and GSA Board, the following initial list of policy options has been developed for potential inclusion in the assessment:

- Water conservation plan requirements for new development
- Discretionary review of well permits for any special areas identified in GSP:
    - Restrictions on permits in specific areas could be considered if additional localized pumping drives one or more sustainability indicators below MTs, leading to undesirable results.
    - Limits could also be placed on which aquifers could be extracted from if there was a potential adverse impact in a particular zone that might affect certain sustainability indicators.
- Low-impact development or water efficient landscape plan requirements expansion
- Modifications to county well ordinance to improve monitoring of the deep aquifer system in areas of known groundwater depletion
- Well construction and permitting recommendations (for example, water quality sampling and reporting for COCs, requirement for water-level measurement access, and procedures for preventing cross-screening of multiple aquifers)
- Well metering program
- Study of water markets
- Permitting and accounting of water hauling

6.4.1.1 Objectives, Circumstances and Timetable for Implementation

The objectives for this management action are to develop, prioritize, and vet potential policy options that may be needed to supplement or replace the projects. As the timeframe for conducting the community outreach, studies, and procedural requirements for adopting policy options can be lengthy, the assessment and prioritization will be initiated in the first year of GSP implementation. The circumstances and timetable for adopting and implementing any of the recommended policy options will be based on ongoing monitoring of groundwater conditions and progress of project implementation. Policy options that focus on demand management would be applied in the case of a situation where planned projects and management actions are determined to be insufficient to reach and/or maintain sustainability, and undesirable results are occurring and are not projected to be eliminated by 2040 using other available projects and management actions.

6.4.1.2 Expected Benefits

Specific expected benefits for this management action will depend upon the type and scope of any policy options that are recommended and adopted by the GSA Board and partner agencies. However, the types of policy options considered and recommended will be those that focus on avoiding undesirable results and achieving the sustainability goal. Given the ongoing chronic lowering of groundwater levels in the deep aquifer system, it is anticipated that policy options that focus on stabilizing and improving groundwater levels within the deep aquifer system will be a primary focus.

6.4.1.3 Public Noticing, Permitting and Regulatory Process

Public noticing will be a key aspect of implementing this management action, as considerable engagement with stakeholders will be needed to assess potential benefits and impacts to current and future groundwater users. Any policy options that result in limitations or curtailments of groundwater users would be conducted in an open and transparent process. The permitting and regulatory process associated with this management option will also depend upon the type of policy options under consideration.

6.4.1.4 Estimated Costs and Funding Plan

A total of $75,000 is included in the initial 5-year budget provided in **Section 7.2** for the GSA to perform the assessment and initiate implementing recommendations. The total cost associated with implementing the management action will depend upon the type and scope of any policy actions considered for implementation.

6.4.1.5 Legal Authority

The legal authorities required for implementing any policy options will depend upon the type of policy options being considered. For policy options that include mandatory reductions or limitations on groundwater use, CWC Section 10726.4(a)(2) provides GSAs the authority to control groundwater extractions by regulating, limiting, or suspending extractions from individual groundwater wells or extractions from groundwater wells in the aggregate. Legal authorities for policy options which involve land use policy changes are retained by the County and City of Sonoma. Similarly, for any policy options related to well permitting, the legal authorities reside with the county.

6.4.2 Coordination of Farm Plans with GSP Implementation

Farm Plans are voluntary plans developed by third party organizations in collaboration with individual landowners that identify BMPs and provide site-specific actions to mitigate issues like sediment runoff or to improve water quality. In some areas of California, regulatory fees are reduced for landowners with Farm Plans that are certified by agreed-upon third parties. Currently, most Farm Plans do not include aspects of groundwater management that would directly support the GSA's efforts to comply with the requirements of the SGMA.

This management action involves a collaboration between the three Sonoma County GSAs and interested members of the agricultural community to evaluate the feasibility of developing a program that coordinates Farm Plans, developed at individual farm sites, with the implementation of the basin-wide GSP. This effort will identify areas of mutual interest (for example, improved water use efficiency, increased groundwater recharge, increased monitoring and data collection, coordinated information sharing, and reporting) in addition to challenges that need to be addressed (such as data confidentiality, data quality requirements, and verification of Farm Plan performance).

6.4.2.1 Objectives, Circumstances and Timetable for Implementation

Objectives of the management action include:

- Strengthening partnerships and coordination between the GSA and growers
- Identifying requirements or standards that need to be met to demonstrate that the implementation of the Farm Plan contributes to compliance with SGMA
- Developing metrics that will be measured and verified during implementation of the Farm Plan
- Considering options for Farm Plan sites to receive a form of credit for the contributions of the subject farm to the compliance with SGMA.

Coordination activities will begin in the first year of GSP implementation and it is anticipated that within 1 year of funding approval, staff would submit a report to the GSA Board with recommendations on the viability of such a program and next steps, as appropriate.

6.4.2.2 Expected Benefits

Expected benefits would include information sharing and coordination between the GSA and growers within the Subbasin. Other benefits will depend upon the outcome of the coordination activities and identification of mutual areas of interest to incorporate into Farm Plans. Potential areas of benefit include improvements to the GSAs monitoring network, filling key data gap areas, and advancing projects (such as water-use efficiency or recharge projects) that support the sustainability goal and avoid undesirable results to sustainability indicators.

6.4.2.3 Public Noticing, Permitting and Regulatory Process

Public notice of actions and outcomes from the coordination process would be provided at the GSA's regular Board and Advisory Committee meetings. The permitting and regulatory process would depend upon the outcome of the coordination and identification of mutual areas of interest to include within the Farm Plans.

6.4.2.4 Estimated Costs and Funding Plan

A total of $40,000 is included in the initial 5-year budget provided in **Section 7.2** for developing and beginning implementation of the work plan. It is assumed that costs for portions of the study will be shared with the Petaluma Valley and Sonoma Valley GSAs.

6.4.2.5 Legal Authority

Any needed legal authorities would depend upon the outcome of the coordination and identification of mutual areas of interest to include within the Farm Plans.

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Section 7: Implementation Plan

Groundwater Sustainability Plan for Sonoma Valley Groundwater Subbasin

Tables

Figures

7 IMPLEMENTATION PLAN

This implementation plan serves as an initial roadmap for addressing GSP implementation activities between 2022 and 2042 with a primary focus on implementation activities within the initial 5 years (2022 through 2026). This section describes the plans for implementing the activities and actions identified in **Section 4** through **Section 6** in this GSP, including:

- The GSA's governance structure and planned administrative approach
- Main implementation components and estimated costs for the first 5 years
- Initial approach to funding
- A schedule

This implementation plan is based on the current understanding of Subbasin conditions, identified data gaps, monitoring needs, and projects and management actions. To successfully implement the GSP, the GSA will adapt the implementation plan over time based on new information and data, model development, and input from Subbasin stakeholders.

7.1 Governance Structure and Planned Administrative Approach

The GSA anticipates that the current governance and general administrative structure will remain in place through the implementation period. As described in **Section 1.3.2**, the six member agencies currently plan to continue operating under the Joint Powers Authority agreement that created the GSA. The Board will continue to serve as the governing body and make decisions regarding the implementation of projects and management actions; close data gaps; handle contracts, administration, and funding; and perform other governance issues as needed. A stakeholder-based Advisory Committee representing multiple stakeholder interests will continue providing guidance and recommendations to the Board and GSA staff. Both the GSA Board and Advisory Committee will continue to hold regular public meetings in compliance with California's laws governing public meetings (commonly known as the Brown Act).

Currently, the GSA contracts with Sonoma Water for technical, outreach, grant administration and GSA management services and contracts with other consultants for legal facilitation and some monitoring services. Starting in 2022, when the GSA transitions from GSP development to implementation, staffing needs will be evaluated to determine how to efficiently and effectively move forward. To reduce costs and to provide consistency for groundwater users within Sonoma County, it is possible that the GSA will coordinate management and other services with the Petaluma Valley and Santa Rosa Plain GSAs.

7.2 GSP Implementation Components and Estimated Costs

This section describes details of each of the main implementation components, assumptions, and estimated costs for the initial 5 years.

7.2.1 Administration and Finance

Administration and finance costs include day-to-day management of the agency, as-needed legal costs, applying for and administering grants, tasks associated with implementation of a fee, auditing and accounting services, administration of the well registration program, facility fees, and office supplies. Annual administration costs total $245,000 annually.

7.2.2 Communication and Stakeholder Engagement

The GSA will continue the communication and stakeholder activities described in **Section 1**, including:

- Hold regular meetings of a diverse, stakeholder-based Advisory Committee to receive feedback on implementation efforts and to solicit outreach ideas and assistance
- Inform, educate, and solicit feedback from stakeholders on progress implementing projects and management actions and on Subbasin conditions through social media, the GSA website, periodic community meetings, focused stakeholder briefings, and paid and free media
- Approach and engage a diverse set of stakeholders and groundwater users by reaching out to and meeting with organizations that represent disadvantaged communities, farmers, environmental interests, rural landowners, and business interests.

The GSA will maintain and improve two products currently under development: The Groundwater User Information Data Exchange program, which allows well owners to review and correct well and groundwater use information, and the Groundwater Data Dashboard, which will provide groundwater data in a visual, user-friendly format.

In addition, the GSA will continue to engage and coordinate with local, state and regional agencies (including City of Sonoma, Valley of the Moon Water District, Permit Sonoma, other GSAs, Agricultural Commissioner, Sonoma County Ag + Open Space District, DWR, SWRCB's Division of Drinking Water (DDW) and Water Rights Division, and SFBRWQCB) on filling data gaps and implementation of projects and actions. This coordination will include discussions of partnering opportunities for funding implementation components that are mutually beneficial.

An important component of this engagement will be ongoing coordination with agencies responsible for regulating groundwater quality. The GSA will regularly coordinate with SFBRWQCB, SWRCB-DDW, and others to understand and develop a process for determining if groundwater management is resulting in degraded water quality.

The GSA will engage in and review General Plan amendments that could impact groundwater resources and will also engage with specific planning processes in Sonoma Valley, including development of the Springs Specific Plan and Sonoma Developmental Center Specific Plan, and will coordinate and share information with local planning commissions such as the Sonoma Valley Citizens Advisory Commission and the Springs and North Valley Municipal Advisory Councils.

Annual outreach and communication is estimated to cost $80,000 during the first 4 years of implementation, and $100,000 in the fifth year, when additional outreach will be needed for the preparation of the 5-year GSP update.

7.2.3 Annual Monitoring, Data Evaluation and Reporting

Monitoring of the six sustainability criteria is a key component for successful implementation of the GSP. Most monitoring relies on existing monitoring programs, some of which will be enhanced or expanded as described in **Section 5** and **Section 7.2.4.2**. Data from the monitoring programs will be routinely evaluated to ensure progress is being made toward sustainability and to identify the occurrence of undesirable results, and assess and investigate conditions that may lead to undesirable results. Data will be maintained in the data management system and will be used by the GSA to guide decisions on projects and management actions and to prepare annual reports to Subbasin stakeholders and DWR.

7.2.3.1 Monitoring and Data Evaluation

Specific planned monitoring activities are summarized in the bullet list below and in **Table 7-1** and are more fully described in **Section 5**:

- Groundwater level monitoring activities will include the collection of groundwater level data at the 31 RMPs (consisting of 23 existing and 8 new RMPs) identified in **Section 5.3.1** for comparison to MTs and MOs. Groundwater level monitoring will also include coordination and evaluation of measurements from 84 additional wells within the Subbasin and contributing watershed areas, described in **Section 5.2.1**, to continue tracking trends in these wells with historical data and support the development of groundwater level contour maps and storage change estimates. The groundwater level data will be collected in accordance with the monitoring protocols outlined in **Section 5.3.1**. Monitoring network data gaps identified in **Section 5.4.1** will be addressed through the activities described in **Section 7.2.4**. Groundwater elevation data will be uploaded to the DWR data portal semiannually; before January 1 and July 1 of each year.

- Water quality monitoring activities will include the compilation and evaluation of water quality data reported from existing public water supply wells and compared with the MTs and MOs for the seawater intrusion and water quality sustainability indicators.

- For the water quality sustainability indicator, the data review will focus on exceedances of MTs, or MCLs and SMCLs, for the three COCs (arsenic, nitrate, and TDS) identified for this GSP. However, if during review of the water quality data additional constituents appear to frequently exceed MCLs and SMCLs, MTs and MOs will be considered for these additional constituents during GSP 5-year updates. The number of public water supply wells routinely monitored for each COC is shown in **Table 7-1**. If any other routine monitoring of supply wells is initiated in the Subbasin at a later date, these wells, will also be considered for inclusion in the water quality monitoring network.

- Monitoring for seawater intrusion just north and along the perimeter of the San Pablo Baylands area will be conducted using a combination of existing water supply wells and additional proposed new dedicated monitoring wells constructed during implementation of the GSP, depending upon well access, construction, and funding availability. Initially, this network will include nine existing public water supply wells and one existing multi-depth dedicated monitoring well located within 1 mile of the Baylands area. The future monitoring network will be designed to accurately map the location of the 250 mg/L chloride isocontour.

- Monitoring for land surface subsidence will be measured using satellite InSAR data provided by DWR. InSAR data will be downloaded from the DWR website annually, checked and verified for completeness and reasonableness, and used to develop annual change in elevation maps. The average value for each 100 square meter pixel and elevation change maps will be used to compare with MTs and MOs for the land surface subsidence sustainability indicator.

- Monitoring for surface water and groundwater interaction will include the following monitoring activities:
  - Compilation and evaluation of surface water data from five active stream gages within the Subbasin and contributing water shed area.
  - Continued collection and evaluation of streamflow measurements collected as part of the seepage run program at approximately 50 to 70 sites on a semiannual basis and 15 to 20 sites on a bimonthly basis.
  - Measurement and evaluation of groundwater elevations from the 10 RMPs used to monitor surface water depletion as a proxy. For reporting seasonal highs and lows for future comparison with MTs, all sub-daily measurements will be reported as monthly averages to better align with the measurement frequency within historical datasets used to calculate the MTs.

Plans for assessing and improving the monitoring network for surface water and groundwater interaction are described in **Section 7.2.4.1**.

Table 7-1. Monitoring Networks and Initial Representative Monitoring Point Networks

Sustainability Indicator	Monitoring Network	Initial Representative Monitoring Point Network
Chronic Lowering of Groundwater levels	107 wells within the contributing watershed area (including 66 wells in the Subbasin) 53 wells are inferred to primarily monitor the shallow aquifer 54 wells are inferred to primarily monitor the deep aquifer	13 existing wells and 4 new dedicated shallow aquifer wells 10 existing wells and 4 new dedicated deep aquifer wells
Reduction in Groundwater Storage	Same as Chronic Lowering of Groundwater levels Monitoring Network	Same as Chronic Lowering of Groundwater levels Monitoring Network
Seawater Intrusion	Within 1 mile of Baylands: 9 water supply wells, 1 dedicated monitoring well	Within 1 mile of Baylands: 9 water supply wells; 1 dedicated monitoring well
Degraded Water Quality	Existing supply well groundwater quality monitoring programs, as follows: Arsenic: 25 wells Nitrate: 40 wells Salts: 13 wells	Existing supply well groundwater quality monitoring programs, as follows: Arsenic: 25 wells Nitrate: 40 wells Salts: 13 wells
Land Surface Subsidence	3 GPS locations, InSAR satellite in most of the Subbasin	InSAR dataset
Interconnected Surface Water	5 stream gages, 17 shallow monitoring wells adjacent to streams, annual and monthly seepage runs that measure streamflows at multiple sites over a short time period	10 shallow monitoring wells adjacent to streams

7.2.3.2 Annual Reports

Annual reports will be developed to present data, information, and the implementation status for each WY and meet SGMA requirements. As defined by DWR, annual reports must be submitted for DWR review by April 1 of each year following the GSP adoption, except in years when 5-year or periodic assessments are submitted. Annual reports are anticipated to include three key sections: general information, Subbasin conditions (including SMC status and progress towards achieving measurable objectives), and implementation actions and activities.

General Information

The general information section will include an executive summary that highlights the key content of the annual report. This section will include a map of the Subbasin, a description of the sustainability goal, a description of GSP projects and their progress, as well as an annual update to the GSP implementation schedule.

Subbasin Conditions

Subbasin conditions will describe the current groundwater conditions and monitoring results. This section will include an evaluation of how conditions have changed over the previous year and will compare groundwater data for the WY to historical groundwater data. Estimated pumping data, effects of project implementation (if applicable), surface water deliveries, total water use, and groundwater storage data will be included. Key required components include:

- Groundwater level data from the monitoring network, including contour maps of seasonal high and seasonal low water-level maps
- Hydrographs of groundwater elevation data at RMPs
- Groundwater extraction data and estimates by water use sector, to be informed by public supply well reporting and compilation and evaluation of land use change data and well permit approvals
- Groundwater quality at RMPs
- Surface water supply availability and use data by water use sector and source
- Streamflow data
- Total water use data
- Change in groundwater in storage
- Subsidence rates and associated data

As part of the monitoring program reporting, status of the SMC will also be reported, including MT and MO status for RMPs.

GSP Implementation Progress

Progress toward GSP implementation will be included in the annual reports. This section of the annual report will describe the progress made toward achieving interim milestones as well as implementation of projects and management actions. Key required components include:

- GSP implementation progress, to be measured by whether the GSA is achieving the milestones provided in the Implementation Schedule (**Figure 7-1**)
- Progress toward achieving the Subbasin sustainability goals
- Changes that may be considered necessary for successful GSP implementation

Development of an annual report will begin following the end of the WY, September 30, and will include an assessment of the previous WY. The annual report will be submitted to DWR before April 1 of the following year. The 2022 annual report covering WY 2021 will be submitted to the GSA by April 1, 2022. Four annual reports for the Subbasin will be submitted to DWR each April between 2022 and 2025, prior to the first 5-year update of this GSP, which will be prepared in 2026 and submitted to DWR in January 2027.

The estimated annual cost of performing annual monitoring, data evaluation, and reporting ranges from $225,000 to $275,000, with a cumulative 5-year cost ranging from $1,125,000 to $1,375,000.

7.2.4 Addressing Data Gaps

Through development of this GSP a number of key data gaps have been identified in **Section 3** through **Section 5**. These data gaps were shared and discussed with Subbasin stakeholders to prioritize activities and actions needed to address the data gaps:

- Amounts, locations, and depths of groundwater pumping (rural, residential, agricultural, public water systems, commercial, and industrial)
- Role of faults within and along the boundaries of the Subbasin, particularly the Eastside Fault
- Distribution and extent of brackish groundwater along margins of Baylands area
- Interconnection of streams to the shallow aquifer system, including seasonal variability and how groundwater pumping and surface water diversions affect streamflow
- Basin boundary characteristics, such as the direction and magnitude of groundwater fluxes across Subbasin boundaries
- Aquifer hydraulic properties, recharge, and discharge mechanisms and volumes for both the shallow and deep aquifer systems
- Three-dimensional data gaps in the monitoring network for each primary aquifer

Studies and activities planned to address these identified data gaps within the initial 5 years of GSP implementation are identified in **Section 7.2.4.1** and categorized as either studies and information gathering or monitoring network improvements.

7.2.4.1 Studies and Information Gathering

Planned studies and information gathering includes the activities described herein.

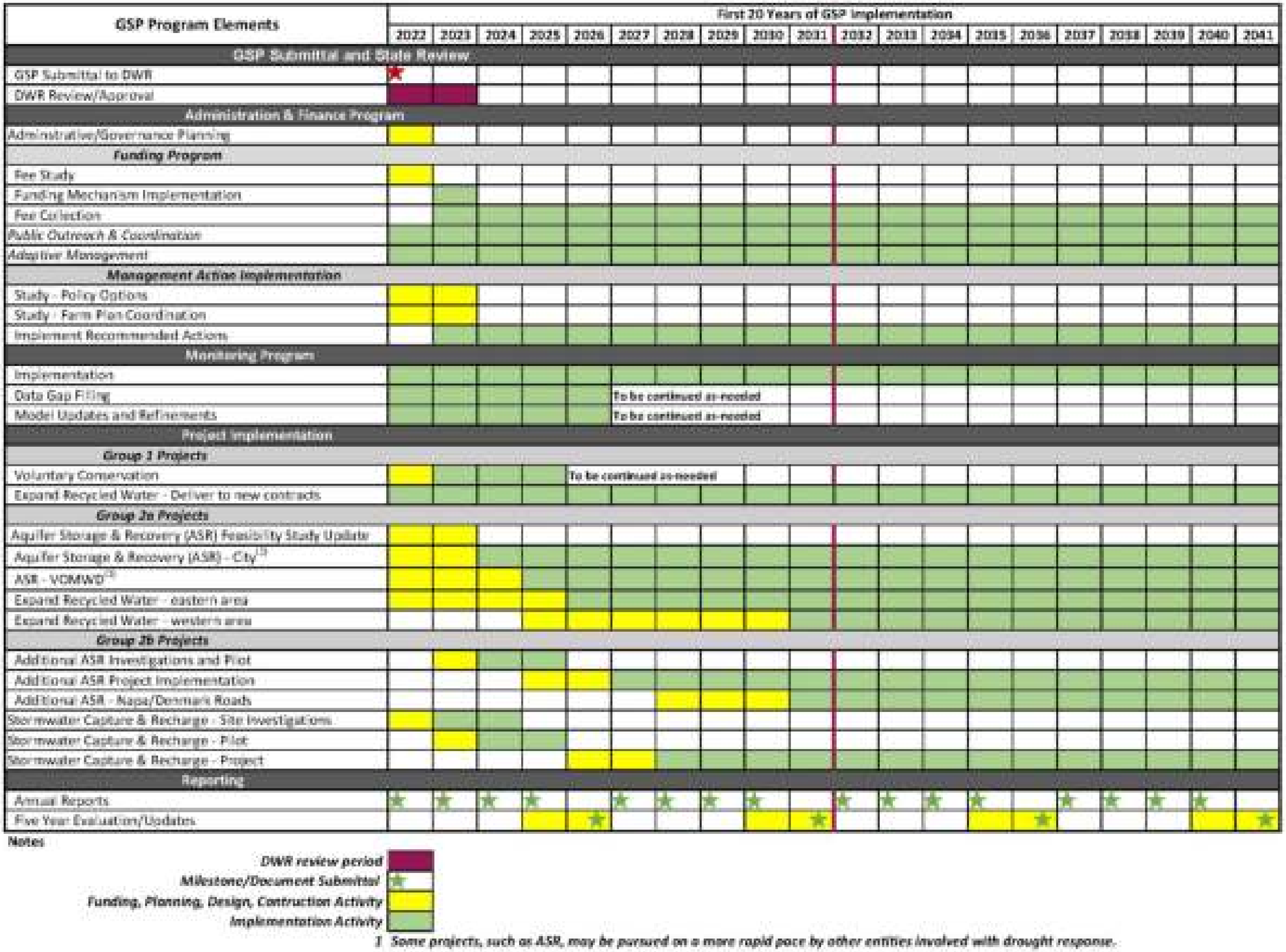

Figure 7-1. Implementation Schedule

Improve information on existing water wells and groundwater extraction: The objective of this task is to better assess the locations, depths, volumes and timing of groundwater pumping. This will improve assessment of potential impacts from groundwater pumping to beneficial users and uses within the Subbasin, including existing residential and other water wells and GDEs, and help refine water budget information including rates of storage losses. The task will include the following activities, which will be performed within the initial two years of GSP implementation:

- Integration of parcel-specific information obtained through the planned well registration program with existing well log databases.
- Assessment of available remote sensing data on actual ET to help constrain the estimates of groundwater demands for irrigation supplies.

Aquifer system properties assessment: The objective of this task is improve the understanding of the aquifer system hydrogeologic framework, distribution and potential effects of faults on groundwater flow, and basin boundary characteristics. Completion of this task will also improve the GSAs ability to assess potential impacts from groundwater pumping to beneficial users and uses within the Subbasin, including existing residential and other water wells and GDEs. As part of this task, the GSA will:

- Evaluate the airborne electromagnetic (AEM) survey results (data collection and compilation funded by DWR) and incorporate into the existing HCM. DWR is planning to collect geophysical data from the Subbasin through its AEM survey program in 2021 or 2022. Additional focused geophysical surveys to refine information in key areas (for example, areas identified for potential managed aquifer recharge projects) will also be considered.
- Based on the planned data collection and evaluation, perform aquifer testing at up to three locations. It is anticipated that the aquifer testing will be completed within the initial 3 years of GSP implementation. Wells for testing will be identified using the following criteria:
  - Wells are owned by willing well owners
  - Wells have known well completion information
  - Wellheads are completed such that water elevations in wells can be monitored with data loggers
  - Wells are equipped with accurate flow meters
  - Wells have area or system for discharge of test water
  - Preferred wells will have nearby wells that can be monitored during the test and will be located near key data gap areas, such as the Eastside Fault, groundwater depletion areas, basin boundaries, and interconnected surface water.

Baylands area voluntary water quality sampling program: The objective of this task is to improve the understanding of the distribution and extent of brackish groundwater along margins of Baylands area and provide data to assist in the selection of locations for future RMPs needed for the seawater intrusion monitoring network. The study will be designed to supplement data collected through previous studies and monitoring programs and is planned to be completed within the first two years of GSP implementation. The task will include the following activities:

- Outreach to well owners within and near the Baylands area through the outreach activities described in **Section 7.2.2**.
- Assessment of potential candidate wells for sampling.
- Collection of water quality samples for analysis of chloride and TDS from up to 25 existing water wells.
- Evaluation of water quality sampling results to inform development of seawater intrusion monitoring network.

Interconnected surface water and GDE studies: As indicated in **Section 4.10.2.1**, in recognition of the significant information and data limitations and the importance of interconnected surface water to beneficial users within the Subbasin, the following studies and activities are planned:

- Develop improved information on the locations and amounts of surface water diversions under the jurisdiction of the SWRCB, including both direct diversions from streams and diversions that may occur from water wells near streams. This information will be developed through the coordination process established between the GSA and SWRCB related to depletions of interconnected surface water.
- Perform studies that determine impact of groundwater pumping on surface water depletion through combination of differential stream gaging, tracer experiments, temperature profiling, and other methods.
- Assess the influence of groundwater pumping and groundwater levels on GDE health using available remote sensing tools and datasets. The GDE Pulse web app developed by the Nature Conservancy provides data on long-term temporal trends of vegetation metrics. This information will be integrated with available groundwater level data to assess the relationship between groundwater conditions and GDEs. Field visits will be conducted as-needed to verify findings from the remote sensing assessment on GDE locations and health. The potential GDEs identified in this GSP will be field verified to ensure that groundwater dependent communities exist, and that the shallow groundwater is connected to regional aquifers that will be managed as part of this GSP.
- Compile and evaluate existing and relevant habitat field surveys that aid in understanding potential impacts of groundwater pumping on habitat associated with interconnected surface water.

7.2.4.2 Monitoring Network Improvements

Based on the assessment of data gaps in **Section 5**, this section describes the activities for improving the monitoring networks are planned.

Development of seawater intrusion monitoring network: Following completion of the voluntary water quality sampling program, the GSA will develop an improved sea water intrusion monitoring network. It is anticipated that the network will include a combination of appropriately constructed and existing wells through a long-term voluntary sampling program and new dedicated monitoring wells. The monitoring network will be designed to adequately map the chloride concentration isocontour in both the shallow and deep aquifer system. For the purposes of estimating costs, it is assumed that three new dedicated multi-level monitoring wells would be constructed for the seawater intrusion monitoring network between the second and fourth year of GSP implementation.

Refinement of groundwater level monitoring network: As described in **Section 5**, many of the identified data gaps in the groundwater level monitoring network are being addressed through new wells being constructed under the Proposition 68 grant. A focus of groundwater level monitoring network improvement will be to refine the understanding of areas that are experiencing chronic lowering of groundwater levels in the deep aquifer system in the southern portions of the Subbasin. For remaining data gap areas, the GSA will evaluate both use of existing voluntary wells and construction of new dedicated monitoring wells. For the purposes of estimating costs, it is assumed that two new dedicated multi-level monitoring wells would be constructed for the groundwater level monitoring network. The GSA intends to conduct outreach and expand the voluntary groundwater level monitoring program in the Subbasin during GSP implementation.

Additionally, the GSA will work to improve data quality in groundwater level monitoring networks by a combination of the following activities:

- Performing survey activities for wells that lack sufficient reference point vertical survey data, as funding becomes available
- Obtaining well construction information from well owners or by conducting investigations (for example, video logging) as funding or technical assistance becomes available
- Replacing wells in the monitoring network that have data quality issues with dedicated monitoring wells, as funding becomes available

Refinement of interconnected surface water monitoring network: Following completion of the interconnected surface water and GDE studies and information gathering, improvements to the interconnected surface water monitoring network will be developed. For the purpose of estimating costs, it is assumed that two new dedicated shallow aquifer system monitoring wells would be constructed for the interconnected surface water monitoring network between the second and fourth years of GSP implementation. Additionally, it is assumed that remote sensing assessments of vegetation health will continue to be performed and reported at key intervals, such as the 5-year GSP updates.

The 5-year costs of addressing data gaps are estimated to be from $1,000,000 to $1,500,000.

7.2.5 Maintaining, Updating, and Making Improvements to the Model

The Subbasin groundwater model (SVIGFM V2) informs the project and management activities and ongoing performance assessment of the SMC. Periodic updates to the groundwater model will be required to continue to refine and improve its capabilities and maintain ongoing functionality. This includes incorporating new model tools and features, updates to the HCM, incorporating new monitoring data, and related work to support ongoing simulations of projects and management actions. Improvements will be focused on the first 3 years of implementation to facilitate reassessing preliminary SMC, as appropriate, and planning for any projects and actions. Model updates and refinements will be informed by data and information collected during early stages of implementation, including the planned activities for assessing data gaps, described in **Section 7.2.4**. A detailed plan for model improvements and updates is provided in **Appendix 7-A**. The preliminary areas of focus identified for model updates and improvements include:

- Update model code to MODFLOW-OWHM V2
- Focused calibration of surface water and groundwater interaction
- Assessment of aquifer properties
- Calibration contingent on availability of groundwater level observation data, aquifer pump tests, simulation results, and other data
- Assessment of model boundary conditions, including mountain front recharge, general head boundaries, and simulated faults
- Improve model estimates of groundwater pumping, including response to changing climate, impact of surface water diversions, and recycled water

The 5-year costs of making updates and improvements to the model are estimated to be from $200,000 to $300,000.

7.2.6 Study and Implementation of Projects and Actions

To prevent potential undesirable results and to achieve MOs, projects and management actions are planned as part of GSP implementation. As described in **Section 6**, a portfolio of projects and management actions has been developed with the goal of addressing relevant sustainability indicators, including the circumstances under which they may be implemented.

Based on the occurrence of chronic lowering of groundwater levels in portions of the deep aquifer system and results of projected baseline model scenarios, and to ensure that basin sustainability will be achieved by 2042, the GSA plans to immediately begin implementation of selected projects and management actions. In some cases, initial implementation steps include performing studies or analyses to refine the concepts into actionable projects. Therefore, the initial activities for project implementation will include both initiation of Group 1 and 2a projects and actions, and refining the projects and actions identified in **Section 6**. Studies and work efforts may include, but are not limited to, CEQA studies and documentation, engineering feasibility studies, and preliminary design reports.

After necessary initial studies are completed, projects and management actions will undergo, as necessary, final engineering design (in the case of infrastructure projects) and public noticing and outreach, after which construction projects can occur followed by ongoing operations and maintenance.

The following activities related to projects and actions are planned during the first 5 years of implementation:

Implementation of Group 1 Projects:

- Assessment and implementation of conservation and groundwater use efficiency opportunities. This project would include an assessment of groundwater use characteristics, existing levels of water use efficiency, and recommendations on preferred tools, strategies and incentives for implementing. While implementation of these projects is initially planned to be on a voluntary basis, the assessment will also identify specific metrics for evaluating the benefits of the projects and assess Subbasin conditions that may lead to mandatory implementation of demand management actions. Implementation of planned recycled water expansion to new users with existing contracts.

Planning and Implementation of Group 2a Projects:

- Develop a work plan and implement expanded ASR operations with City of Sonoma and Valley of the Moon Water District. Group 2A ASR projects require permitting, environmental analysis, and engineering design, which would begin in 2022.
- Support and coordination with existing grant-funding applications for recycled water expansion opportunities (such as North Bay Water Reuse Authority Phase 2 Napa Road Project)

Planning for Group 2b Projects:

- Update 2013 feasibility study for other ASR opportunities:
  - Update source water (Russian River) availability and transmission system capacity assumptions
  - Assessment of locations/operations that benefit GSP implementation (that is, areas of depletion)
  - Design and implement pilot studies for favorable areas
- Assessment of additional recycled water opportunities:
  - Optimization of existing and projected future available supplies
  - Cost/benefit analysis for future alignment options
  - Identify optimal locations for future storage
- Site-specific investigations and pilot study of on-farm and other dispersed recharge opportunities:
  - Water available for recharge
  - Areas with permeable near-surface deposits

  - Optimal methods and techniques
  - Focus on locations that could help sustain baseflows/support GDEs for recharge

Management Actions:

- Study of potential policy options for future GSA consideration or recommendation, which will build upon and advance initial work initiated by Permit Sonoma under a Proposition 68 grant to update the well permitting process and database and update Permit Sonoma's policy and database for groundwater monitoring requirements on commercial use permits. This study will prepare a prioritized list of potential policy options, including stronger demand management actions that may need to be adopted should the projects described above not be implementable or successful. The following initial list of potential policy options has been developed for potential inclusion in the assessment:
  - Water conservation plan requirements for new development
  - Discretionary review of well permits for any special areas identified in the GSP or through data collected during GSP implementation, such as areas of the southern Subbasin currently experiencing ongoing groundwater level declines in the deep aquifer system and/or areas near streams with sensitive habitat
  - Expand low impact development or water efficient landscape plan requirements
  - Well construction and permitting recommendations (for example, water quality sampling/reporting for COCs, requirement for water-level measurement access, prevent cross-screening multiple aquifers)
  - Metering program
  - Permitting and accounting of water hauling
- Coordinate farm plans, developed at individual farm sites, with implementation of the basinwide GSP:
  - Identify areas of mutual interest (such as improved water use efficiency, increased groundwater recharge, increased monitoring and data collection, coordinated information sharing, and reporting) in addition to challenges that need to be addressed (for example, data confidentiality, data quality requirements, verification of farm plan performance)
  - This project would: (1) identify requirements or standards to demonstrate benefits to GSP implementation, (2) develop metrics that would be measured and verified, and (3) consider options to incentivize actions of mutual benefit.

The estimated costs of refining and implementing the above-described projects and actions are estimated to be from $485,000 to $980,000, as summarized in **Table 7-2**.

Table 7-2. Summary of Estimated Five-year Costs for Projects and Management Actions, Excluding Capital Project Costs

Project/Action	Project Scenario Group	Estimated 5-year Costs	Other Potential Funding Sources	Assumptions
Conservation/Water-Use/Efficiency/Alternate Water Sources	1	$50,000 to $85,000	Other GSAs	Split equally amongst 3 GSAs
Recycled Water Expansion	2a	$60,000 to $80,000	SVCSD	
Aquifer Storage and Recovery	2a/2b	$250,000 to $400,000	Other GSAs, Sonoma Water/ Water Contractors	Other GSAs and Sonoma Water/Water Contractors will also contribute funding
Stormwater Capture and Recharge	2b	$80,000 to $230,000		
Farm Plan Coordination		$20,000 to $60,000	Other GSAs	Other GSAs will also contribute funding
Policy Options		$25,000 to $125,000		Other GSAs will also contribute funding
		$485,000 to $980,000 $740,00	Total Range Midrange	

It is anticipated that the capital project costs within the first 5 years will be paid for by some combination of individual project proponents/beneficiaries and grant funding. Specific details regarding roles of project proponents and the cost share mechanisms are anticipated to be determined as the projects are further defined and scoped. Therefore, costs associated with implementation of capital project implementation is not included in the GSP implementation budget estimate shown in **Table 7-2**.

Screening level capital costs for implementing Group 2a projects are provided in **Table 7-3**, along with assumptions. As noted, some projects such as ASR within the City of Sonoma and Valley of the Moon Service Areas may be on a more expedited timeframe, as they are being considered for drought resiliency grant funding opportunities.

Table 7-3. Estimate of Potential Capital Project Costs for Group 2a Projects

Project Group	Year 1	Year 2	Year 3	Year 4	Year 5	5-year Total
GSP Implementation Item[a]	**2022 to 2023**	**2023 to 2024**	**2024 to 2025**	**2025 to 2026**	**2026 to 2027**	**2022 to 2027**
Recycled Water Expansion: Napa Road Pipeline[b]		$600,000	$1,000,000	$1,000,000	$1,000,000	$3,600,000
Aquifer Storage and Recovery: City of Sonoma and Valley of the Moon Service Areas[c]	$500,000	$1,500,000	$1,500,000	$1,000,000	$500,000	$5,000,000
Total	$500,000	$2,100,000	$2,500,000	$2,000,000	$1,500,000	$8,600,000

[a] Costs to GSA would need to be determined based on availability of future grant funding, future studies and evaluation of relative benefits of project to GSA and other entities

[b] Project included in Phase 2 programmatic Environmental Impact Report and feasibility study for North Bay Water Reuse Authority

[c] Projects to be included in forthcoming Drought Funding application

It is also anticipated that each implemented project will have its own set of monitoring objectives and data collection requirements to allow for project evaluation and confirmation assessments, and, if necessary, modifications to improve project effectiveness. The costs of specific projects that are not covered by beneficiaries/project proponents will include assumptions about financing the projects over time.

7.2.7 Five-year Update to Groundwater Sustainability Plan

As required by SGMA regulations, an evaluation of the GSP and the progress toward meeting the approved SMC and the sustainability goal will occur at least every 5 years and with every amendment to the GSP. A written 5-year evaluation report (or periodic evaluation report) will be prepared and submitted to DWR. The following information will be included in the evaluation reports:

- A sustainability evaluation will contain a description of current groundwater conditions for each applicable sustainability indicator and will include a discussion of overall sustainability in the Subbasin. Progress toward achieving interim milestones and MOs will be included, along with an evaluation of status relative to MTs. If interim milestones are not being achieved, the evaluation will identify obstacles to achieving the interim milestones. The evaluation will include a plan for overcoming those obstacles and provide a new assessment of interim milestones that achieve sustainability by 2042.

- An implementation plan progress section will describe the current status of project and management action implementation and whether any adaptive management actions have been implemented since the previous report. An updated project implementation schedule will be included, along with any new projects identified that support the sustainability goals of the GSP and a description of any projects that are no longer included in the GSP. The benefits of projects and management actions that have been implemented will be described and updates on projects and management actions that are underway at the time of the report will be documented.

- GSP elements will be reconsidered as additional monitoring data are collected, land uses and community characteristics change, and GSP projects and management actions are implemented. It may become necessary to reconsider elements of this GSP and revise the GSP as appropriate. GSP elements to be reassessed may include basin setting, management areas, undesirable results, MTs, and MOs. If appropriate, a revised GSP, completed at the end of the 5-year evaluation period, will include revisions informed by findings from the monitoring program and changes in the Subbasin, including changes to groundwater uses, demands, or supplies, and results of project and management action implementation.

- A description of the monitoring network will be provided. An assessment of the monitoring network's function will be included, along with an analysis of data collected to date. If data gaps are identified, the GSP will be revised to include a method and implementation schedule for addressing these data gaps, along with a description of how the GSA will incorporate updated data into the GSP.

- New information available since the last 5-year evaluation or GSP amendment will be described and evaluated. If the new information should warrant a change to the GSP, this will also be included.
- A summary of the regulations or ordinances related to the GSP that have been implemented by DWR or others since the previous report will be provided. The report will include a discussion of any required updates to the GSP.
- Legal or enforcement actions taken by the GSA in relation to the GSP will be summarized, including an explanation of how such actions support sustainability in the Subbasin.
- A description of amendments to the GSP will be provided in the 5-year evaluation report, including adopted amendments, recommended amendments for future updates, and amendments that are underway.
- Ongoing coordination will be required among the GSA; members of the Advisory Committee; other local, state, and federal partners; and the public. The 5-year evaluation report will describe coordination activities between these entities, such as meetings, joint projects, data collection and sharing, and groundwater modeling efforts.
- Outreach activities associated with the GSP implementation, assessment, and GSP updates will be documented in the 5-year evaluation report.

The initial 5-year GSP evaluation is due to be submitted to DWR in 2027. The estimated cost of preparing the initial 5-year GSP update is estimated to be from $200,000 to $300,000.

7.2.8 Estimated Five-year Implementation Costs

The cost of the items described in **Section 7.1.1** through **Section 7.1.7** will vary from year to year, but the average cost of implementation is approximately $1.2 million annually for the first 5 years (fiscal year 2022-2023 through fiscal year 2027-2028), excluding the construction costs of specific capital projects, as summarized in **Table 7-4**.

To enhance efficiencies and provide similar benefits to nearby groundwater users in Santa Rosa Plain and Petaluma Valley GSAs, it is assumed that the development costs of common projects and actions will be shared among the three GSAs. In addition, the budget assumes that costs will be shared for the development of projects and actions conducted in cooperation with local, regional, and state partners (such as sanitation districts, water suppliers, RCDs, and others).

Table 7-4. Total Estimated Five-year Implementation Costs

GSP Implementation Item	Year 1	Year 2	Year 3	Year 4	Year 5
	2022 to 2023	**2023 to 2024**	**2024 to 2025**	**2025 to 2026**	**2026 to 2027**
GSA Administration and Operations	$245,000	$235,000	$230,000	$220,000	$235,000
Communication and Stakeholder Engagement[a]	$80,000	$80,000	$80,000	$80,000	$100,000
Annual Monitoring, Evaluation, and Reporting	$230,000	$200,000	$200,000	$200,000	$200,000
Data Gap Filling[a]	$30,000	$345,000	$805,000	$290,000	$0
Conceptual Projects and Planning Design[a]	$100,000	$150,000	$200,000	$200,000	$90,000

GSP Implementation Item	Year 1 2022 to 2023	Year 2 2023 to 2024	Year 3 2024 to 2025	Year 4 2025 to 2026	Year 5 2026 to 2027
Model Updates[a]	$0	$30,000	$50,000	$100,000	$70,000
Five-year GSP Updates[a]	$0	$0	$0	$100,000	$200,000
Subtotal	$685,000	$1,040,000	$1,565,000	$1,190,000	$895,000
10 Percent Contingency (rounded to nearest $5,000)	$70,000	$105,000	$155,000	$120,000	$90,000
Total	$755,000	$1,145,000	$1,720,000	$1,310,000	$985,000

Preliminary average annual costs are equal to approximately $1.2 million.
[a] Potential for bond funding/technical services support

Estimates of future implementation costs (Year 6 through Year 10) will be provided in the 5-year GSP update.

7.3 Funding

Development of this GSP was partially funded through grants from DWR through the Water Quality, Supply, and Infrastructure Improvement Act of 2014 (Proposition 1) and the California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access for All Act of 2018 (Proposition 68). Additional support was provided through DWR Technical Support Services program, which included the drilling of 12 shallow monitoring wells. GSA member agencies, as described in **Section 1.3.1**, funded the remainder of the GSP development and GSA administration. The grant funding ends after submittal of this GSP, and the member-agency funding agreement ends on June 30, 2022. Therefore, additional funding streams are needed for GSP implementation.

GSP implementation will partially be funded by an implementation fee that is the current subject of an ongoing fee study. Other potential funding sources include grants through DWR, SWRCB, and federal and local entities; DWR technical support; and partnerships with member agencies, other GSAs, and entities interested in leveraging mutually beneficial programs, projects and studies.

7.3.1 Fees, Grants and Other Funding Sources

SGMA provides GSAs the authority to impose certain fees, including groundwater pumping fees. In September 2022, the GSA engaged a consultant to conduct a fee study to evaluate and provide recommendations for GSP implementation funding. The study includes outreach and education to inform and solicit feedback from groundwater users and other stakeholders. Any imposition of a fee, tax, or charge will comply with California law and all applicable Constitutional requirements, based on the nature of the fee.

The fee will be designed to pay for the costs of implementing the GSP that will not be covered by grants, low interest financing, project beneficiaries and project partners. An implementation budget provided in **Table 7-4** provides a high-level overview of costs, and indicates items that could be eligible for grant funding. Administrative and operational costs are generally not eligible for grants or loans, but the remainder of the items listed in the budget (with the exception of contingency funds) may be partially or fully eligible for grant funding, depending on the grant source and availability. The GSA has successfully applied for and received more than $2.2 million in grant funding and technical support services, and will continue to pursue grants and low-interest financing to offset the costs of monitoring, filling data gaps, and for planning and implementing projects and actions.

In addition, funding could be provided by project partners (such as other agencies) or project beneficiaries (such as farmers, businesses and nearby groundwater users) who directly benefit from project implementation.

A more detailed budget will be developed as part of the fee study process and will be available in Winter 2022. The GSA Board will consider adoption of the implementation fee in Spring 2022, and fee collection is anticipated to begin in December 2022.

7.4 Schedule

The implementation schedule is shown on **Figure 7-1.** The final GSP will be submitted to DWR no later than January 31, 2022. While DWR has 2 years to review the GSP, the schedule on **Figure 7-1** assumes that implementation begins immediately, and provides an overview of the preliminary schedule for agency administration and finance, monitoring, project implementation, and reporting. Many of these categories consist of ongoing tasks and efforts that will continue throughout GSP implementation.

Administration and finance items on **Figure 7-1** include:

- Completion and implementation of the fee study
- Adaptive management tasks related to ongoing development and assessment of the SMC for seawater intrusion and interconnected surface water (as described in **Section 4**)
- Outreach and communication
- Studies and implementation of management actions, including farm plan coordination and development of the policy options (described in **Section 7.1.6**).

The monitoring task includes collecting and analyzing data from existing and future RMPs, and planning for new monitoring sites to fill the data gaps discussed in **Section 5**. Specifically, this category includes the installation of stream gages and development of associated shallow wells to fill data gaps for depletion of interconnected surface water and the development of additional monitoring sites to assess seawater intrusion.

The project implementation schedule includes the development and implementation of Group 1, Group 2A, and Group 2B projects, as described in **Section 6**. After a short planning period, it is assumed that Group 1 project implementation will begin in 2023. Group 2A projects require permitting, environmental analysis, and engineering design, which would begin in 2022. Implementation of Group 2A projects is anticipated to begin in 2026. Group 2B projects require significant financial commitments, planning, and permitting. The schedule assumes that planning and permitting for Group 2B projects will begin in 2028. The timing of projects is based on best estimates and may shift as GSP implementation proceeds based upon the needs at the time.

The implementation of the two management actions (assessment and prioritization of potential policy options and coordination of Farm Plans with GSP implementation) will begin at the outset of implementation with the goal of having initial recommendations on scope and prioritization for the GSA Board to consider within the first year of implementation.

GSP reporting will occur on an annual and a 5-year basis as required under SGMA. Annual reports will be submitted to DWR by April 1 of each year. Periodic reports (every 5-years or following substantial GSP amendments) will be submitted to DWR by April 1 at least every 5 years (2027, 2032, 2037, and 2042). The contents of annual and periodic reports are described in **Section 7.3**.

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Section 8: References

Groundwater Sustainability Plan for
Sonoma Valley Groundwater Subbasin

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8.2 Sonoma Valley GIS Data Sources

Bureau of Indian Affairs - California Department Forestry and Fire Protection Land Ownership

City Footprints– Permit and Resource Management Department (PRMD), County of Sonoma, 2006

City of Sonoma Land Use - City of Sonoma

Climate Station Locations - MesoWest, CoCoRaHS and UC Davis, Sonoma Water

County Line – County of Sonoma GIS Central

Elevation - Sonoma County Vegetation Mapping and LiDAR Program, North American Vertical Datum 1988 (NAVD88)

General Plan Land Use - Sonoma County Permit Resource Management Department, 2020 General Plan

GSP Study Area Watershed - Sonoma Water

Groundwater Availability - Sonoma County Permit and Resource Management Department (Permit Sonoma)

Groundwater Basins - California Department of Water Resources, Bulletin 118

Land Use Survey - Department of Water Resources, 2012 land use survey

Major Rivers and Creeks - Department of Water Resource, National Hydrography dataset

Managed Wetlands - Department of Water Resources, 2014 Crop Mapping

Other State Lands - California Department Forestry and Fire Protection

Protected Areas - California Protected Areas Database, 2017 holdings

Resource Conservation District (RCD) - County of Sonoma GIS Central

Seepage Run Locations - Sonoma Ecology Center

Stream Gauge Locations - US Geologic Survey, Trout Unlimited

Vegetation and Agriculture classes - Sonoma County LiDAR and Vegetation Mapping Program and Sonoma Water

Water Companies & Other Public Water Suppliers - County of Sonoma GIS Central

Water Infrastructure - Sonoma Water

Water Wells and Well Density - by Sonoma County Water Agency with source data courtesy of California Department of Water Resources Online System for Well Completion Reports (OSWCR - https://data.cnra.ca.gov/dataset/well-completion-reports), Permit Sonoma, and the USGS Well Density and Known well Locations – U.S. Geological Survey dataset developed for Hydrologic and Geochemical Characterization of the Santa Rosa Plain Watershed, Sonoma County, California (https://pubs.usgs.gov/sir/2013/5118/)