SANTA CRUZ MID-COUNTY GROUNDWATER AGENCY

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Disclaimer

The attached comparison document is computer generated using Microsoft Word's (MS Word) Compare tool which is designed to compare two versions of a document and show the revisions made. In the output document, underlined red text indicates additions; ~~strikethrough red text indicates deletions~~, and green text indicates text moved within the document.

The comparison document shows the revisions made between the Santa Cruz Mid-County Groundwater Agency's Draft Groundwater Sustainability Plan (GSP), published in July 2019, and the GSP published in November 2019. MGA representatives have not reviewed every page of the output document to confirm the Compare tool produced a document that is without errors. Based upon prior experience using the Compare tool it is effective in capturing revision made to sentences and paragraphs, however it is not always accurate showing revisions within tables (e.g., text moved within a table), figures, headers, and footers. Table of contents appears as edited text where page numbers have changed between document versions.

This document is intended to serve as an aide for review purposes only. The MGA does not imply that the Compare tool output document is a perfect comparison of the documents.

~~GSP~~ Section 1 Contents

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1 INTRODUCTION

1.1 Purpose of the Groundwater Sustainability Plan

In 2014, Governor Edmund G. Brown, Jr. signed three laws that make up the Sustainable Groundwater Management Act (SGMA). SGMA took effect on January 1, 2015 requiring local water agencies to manage groundwater sustainably. This Groundwater Sustainability Plan (GSP or Plan) is a collaborative effort between local water agencies, technical experts, land use agencies, environmental managers, and community members to manage the groundwater basin sustainably. This Plan is prepared by the Santa Cruz Mid-County Groundwater Agency (MGA). Together the people involved in the preparation of this Plan represent water uses and users within the Santa Cruz Mid-County Groundwater Basin (Basin) (~~Figure 1-1).~~Figure 1-1). The intent of the Plan is to guide long-term management of the shared groundwater resource to ensure a reliable water supply for community needs and the natural environment now and into the future.

~~**Figure 1-1. Basin Location Map**~~

Statewide, California's groundwater basins support at least one-third of the water used by nearly 39 million people, sustain the nation's most robust agricultural industry, and support hundreds of billions of dollars in economic activity each year (DWR, 2018a).The Basin is located at the northern end of the Central Coast region. This region gets approximately 85% of its water supply from groundwater and is the most groundwater dependent hydrologic region in all of California (DWR, 2013). All the major water supply purveyors in Santa Cruz County rely upon local sources and receive no imported water from outside the County.

The Basin is a high priority groundwater basin in critical overdraft and threatened by seawater intrusion (DWR, 2018b). For many years, the amount of groundwater extracted from the Basin exceeded the amount naturally recharging groundwater through rainfall. Despite extensive water conservation efforts and reductions in groundwater pumping in recent years compared to prior decades, the long-term overdraft of the Basin lowered groundwater elevations along portions of the coast. Lowered groundwater levels have allowed seawater intrusion into coastal portions of the groundwater aquifers and pose the threat of more widespread seawater contamination of groundwater. Once contaminated with seawater, it can be irreversible and can result in either abandoning water supply wells or requiring costly treatment to make the water useable.

While the state's ~~historic~~ SGMA ~~groundwater~~ mandate now requires ~~regional~~ groundwater sustainability~~, it~~ for all high and medium priority groundwater basins, SGMA was not the catalyzing event for sustainable groundwater management in the Santa Cruz Mid-County Groundwater Basin. ~~Water~~The water management agencies that share responsibility for our groundwater resources have studied the Basin since the mid-1960s and developed groundwater management strategies to actively manage the Basin since the 1980s in response to the threat of further seawater intrusion impacts to the Basin's freshwater aquifers. Discussion of seawater intrusion is found throughout the GSP, especially in Sections 2.1.4.1; 2.2.4; 3.3.3.3; and 3.6.

Figure 1-1. Basin Location Map

~~since the~~

The Association of Monterey Bay Area Government projects the population within the Basin in 2018 is approximately 92,000 (AMBAG, 2018). Of those, approximately 50,000 Basin residents are primarily served by groundwater wells or municipal suppliers whose only source of water is groundwater. The remaining 42,000 are served by the City of Santa Cruz Water Department~~.~~, primarily with surface water. In years with average or above average precipitation the City's water supply is approximately 95% surface water from sources outside the Basin and 5% groundwater from the Basin (SCWD, 2016). The amount of groundwater needed from the Basin to fulfill the City of Santa Cruz's water demand goes up in years with below average rainfall.

The goal of SGMA legislation is to avoid undesirable results for the six sustainability indicators identified by the State of California. The six sustainability indicators are: groundwater level declines, groundwater storage reductions, land subsidence, interconnected surface water ~~depletions~~depletion, seawater intrusion, and water quality degradation.

The two key sustainability indicators in the Basin are seawater intrusion and interconnected surface water ~~depletions~~depletion. Successful implementation of projects and management actions to effectively protect against adverse impacts for these two regionally significant sustainability indicators should result in groundwater conditions that protect the Basin against undesirable effects for all six state identified sustainability indicators.

Sustainability Indicators

SGMA requires GSAs to develop and implement Groundwater Sustainability Plans (GSPs) for managing and using groundwater. Each GSP must consider the following sustainability indicators:

Groundwater-Level Declines

Long-term declines in groundwater levels occur when groundwater withdrawals exceed recharge of the aquifer system. Such declines are indicative of unsustainable groundwater use, and are the primary cause of the other sustainability indicators, described below.

Land Subsidence

Extensive groundwater withdrawals from aquifer systems have caused land subsidence in many California basins. Land subsidence can damage structures such as wells, buildings, and highways. They also can create problems in the design and operation of facilities for drainage, flood protection, and water conveyance. Groundwater-level and land-subsidence monitoring provide the information needed to guide mitigation efforts and management of future effects.

Seawater Intrusion

Seawater intrusion associated with lowering of groundwater levels is an important issue in many of California's coastal groundwater basins. Quantifying the rate and extent of seawater intrusion involves understanding the aquifer-ocean interconnection and distinguishing among multiple sources of saline water.

Groundwater-Storage Reductions

Long-term declines in groundwater levels, if predominant within a basin and not offset by rising groundwater levels, cause long-term reductions in groundwater storage. Changes in groundwater storage can be estimated by using direct measurements, such as measuring groundwater levels, and indirect measurements, such as remote sensing, coupled with modeling tools.

Interconnected Surface-Water Depletions

Groundwater and surface water are interconnected resources. Much of the flow in streams, and the water in lakes and wetlands, is sustained by the discharge of groundwater, particularly during dry periods. Coordinated measurement and modeling of surface and groundwater conditions generally are needed to estimate surface-water changes that result from groundwater development.

Water-Quality Degradation

Determining changes in groundwater quality over time, often associated with changing groundwater levels, involves systematic monitoring of constituents of concern, coupled with understanding of the dynamics of the groundwater-flow system.

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Figure 1-2. Sustainability Indicators[1]

1.2 Sustainability Goal

Regulations prepared by the Department of Water Resources (DWR) to implement SGMA require that each Plan develop a sustainability goal that "…culminates in the absence of undesirable results within 20 years…." (23 CCR § 354.24) The Plan must include Basin information used to establish the sustainability goal and a discussion of the measures that will be implemented to ensure that the Basin will be operated to achieve sustainability within the 20-year planning timeframe.

As discussed in ~~the GSP (~~Section 2.1.5~~),~~, the MGA selected a GSP Advisory Committee consisting of representatives of the Basin's groundwater users, interest groups and stakeholders. The Advisory Committee analyzed and provided recommendations to the MGA Board on key policy issues to inform the development of the GSP. Together with MGA ~~member agency~~ staff, technical consultants, and community input, the GSP Advisory Committee developed ~~a vision for~~the Basin sustainability goal and included it among its recommendations to the MGA Board. The MGA Board of Directors adopted the GSP Advisory Committee's recommendations on September 19, 2019.

~~The Basin~~As required by the SGMA regulations, the MGA developed a sustainability goal for the Basin, which is~~:~~ to:

> Manage the groundwater Basin to ensure beneficial uses and users have access to a safe and reliable groundwater supply that meets current and future Basin demand without causing undesirable results ~~and~~to:
>
> - ~~Ensures~~Ensure groundwater is available for beneficial uses and a diverse population of beneficial users;
> - ~~Protects~~Protect groundwater supply against seawater intrusion;
> - ~~Prevents~~Prevent groundwater overdraft within the Basin and resolves problems resulting from prior overdraft;
> - ~~Maintains~~Maintain or ~~enhances~~enhance groundwater levels where groundwater dependent ecosystems exist;
> - ~~Maintains~~Maintain or ~~enhances~~enhance groundwater contributions to streamflow;
> - ~~Supports~~Support reliable groundwater supply and quality to promote public health and welfare;
> - ~~Ensures~~Ensure operational flexibility within the Basin by maintaining a drought reserve;

[1] Figure courtesy USGS

- ~~Accounts~~Account for changing groundwater conditions related to projected climate change and sea level rise in Basin planning and management;~~ and,~~
- ~~Does~~Do no harm to neighboring groundwater basins in regional efforts to achieve groundwater sustainability.

MGA modeling results of the Basin and Projects and Management Actions (presented in Section 4) indicate that maintaining groundwater elevations needed to protect against seawater intrusion will largely prevent undesirable results occurring for all six sustainability indicators. As discussed in Section 2.2.4.5, Basin geology is not susceptible to land subsidence. While subsidence monitoring is recommended in Section 3.8, minimum thresholds and measurable objectives are not identified for this sustainability indicator.

Additional localized groundwater pumping management in the Purisima aquifers where those aquifers are connected to surface water may also be necessary. This additional pumping management may be needed to ensure significant and unreasonable depletion of surface water supporting groundwater dependent ecosystems does not occur from groundwater pumping.

The Basin water budget and water demand forecasts presented in Section 2 indicate that to achieve groundwater sustainability in the Basin will require multiple projects and management actions. These will include the continuation of Group 1 water conservation and demand management, the redistribution of municipal groundwater pumping, and the development of Group 2 water augmentation Projects and Management Actions as presented in ~~Section~~Sections 4.1 and 4.2

1.3 Agency Information

In March 2016, the Santa Cruz Mid-County Groundwater Agency (MGA) formed. The four member agencies include: Central Water District, City of Santa Cruz, County of Santa Cruz, and Soquel Creek Water District. These are the principal public agencies that extract groundwater from or regulate groundwater extraction and/or land use activities in the Basin. In May 2016, the MGA submitted an Initial Notice of Intent to DWR to become the Groundwater Sustainability Agency (GSA) for the Santa Cruz Mid-County Groundwater Basin. In August 2017, the MGA filed the initial notification to prepare a GSP for the Santa Cruz Mid-County Groundwater Basin.

The MGA contact information and mailing address is:

Santa Cruz Mid-County Groundwater Agency
c/o Soquel Creek Water District
Attention: Board Secretary
5180 Soquel Drive
Soquel, CA 95073

1.3.1 Organization and Management of the Santa Cruz Mid-County Groundwater Agency

The MGA was created in March 2016 under a Joint Exercise of Powers Agreement. The MGA is governed by an 11-member board of directors consisting of representatives from each member agency and private well representatives within the boundaries of the MGA. The MGA board is comprised of:

- Two representatives from the Central Water District appointed by the Central Water District Board of Directors.
- Two representatives from the City of Santa Cruz appointed by the City of Santa Cruz City Council.
- Two representatives from the County of Santa Cruz appointed by the County of Santa Cruz Board of Supervisors.
- Two representatives from the Soquel Creek Water District appointed by the Soquel Creek Water District Board of Directors.
- Three representatives of private well owners in the Basin appointed by majority vote of the eight public agency ~~member agency~~MGA directors.
- In addition, an alternate representative for each member agency and for the private well owners is appointed to act in the absence of a representative at Board meetings.

In May 2016, the MGA adopted bylaws establishing provisions relating to how the MGA conducts its affairs, including the duties of its directors and officers, provisions relating to committees and working groups, the framework for the MGA's administration, management and the collaborative staffing approach. The JPA and Bylaws serve as the governing documents for the MGA. The Board is to convene at minimum on a quarterly basis; currently the Board convenes its public meetings every other month (six times per year).

The MGA uses a collaborative staffing model to accomplish its work. Professional and technical staff from MGA member agencies provide staff leadership, management, work products, and administrative support for the MGA. MGA member agency executive staff, comprised of the member agency general managers and directors, provide staff support for MGA officers and Board members. The MGA also contracts with the Regional Water Management Foundation (RWMF) for administrative and planning support.

The development of the GSP was supported by MGA member agency staff, RWMF staff, and consultants providing hydrologic technical support, planning process and facilitation support of the GSP Advisory Committee, and public engagement support.

The contact information for the GSP manager is:

~~Darcelle Pruitt, Senior~~Sierra Ryan, Water Resources Planner
~~Regional Water Management Foundation~~
~~Community Foundation~~County of Santa Cruz ~~County~~ Environmental Health
~~7807 Soquel Drive | Aptos, CA 95003 | 831.662.2052~~
~~dpruitt@cfscc.org | www.cfscc.org |~~ Health Services Agency
701 Ocean Street | Room 312 | 831.454.3133
Sierra.Ryan@santacruzcounty.us
www.midcountygroundwater.org

1.3.2 Legal Authority of the Santa Cruz Mid-County Groundwater Agency

The MGA has legal authority to perform duties, exercise powers, and accept responsibility for managing groundwater sustainably within the Santa Cruz Mid-County Groundwater Basin. Legal authority comes from the Sustainable Groundwater Management Act, the JPA signed by MGA member agencies and effective on March 17, 2016 and the MGA Bylaws. The JPA is attached as Appendix ~~A1~~1-A to this document. These laws and agreements, taken together, provide the necessary legal authority for the MGA Board to carry out the preparation and implementation of the Basin's Groundwater Sustainability Plan.

1.3.3 Estimated Cost of Implementing the GSP and the MGA's Approach to Meet Costs

MGA is funded by its member agencies through annual contributions based on a cost sharing agreement of estimated impacts to Basin sustainability under SGMA. The member agreed cost sharing allocation has been in place prior to the inception of the agency in March 2016. Costs are allocated 70% to Soquel Creek Water District and 10% each to the County, the City, and Central Water District. This cost allocation may change as the MGA learns more about Basin sustainability impacts through GSP data collection and the beneficial impacts of agency projects and management actions that improve sustainability. Individual member agencies will pay the costs for their projects and management actions as discussed in Sections 4 and 5.

The estimated cost of implementing the GSP is presented by category identified below but also includes maintaining a prudent fiscal reserve and other miscellaneous costs. The major cost categories include:

- Agency Administration and Operations
- Legal
- Management & Coordination
- Data Collection, Analysis, and Reporting
- GSP Reporting (annual and 5-year reports) and

- Outreach and Education
- Contingency (10%)

As presented in Section 5, the estimated cost of implementing the GSP over a twenty-year time horizon is ~~approximately $12~~$15.8 million. These are based on the current best estimates with some uncertainties, so the actual costs may vary from those used in making the cost estimate projection. The MGA will not serve as the lead implementing agency for projects in the Basin, this is a role the individual member agencies will continue to fulfill. The various projects, costs and potential funding mechanisms are discussed individually in more detail in Sections 4 and 5.

The MGA's approach to meeting the GSP implementation costs is considered in two phases. In the initial GSP Implementation Phase 1 (2020 – 2025) funding is anticipated to be obtained from the annual contributions of the MGA member agencies. This funding approach has been used since the MGA's formation in 2016. The contribution amounts will be assessed based upon the MGA's annual budget. The MGA will continue to pursue funding from state and federal sources to support GSP planning and implementation activities.

The approach to meeting the GSP implementation costs in Phase 2 (2026 – 2040) will be further evaluated as ~~the~~ GSP implementation proceeds. As described in Section 5, the MGA conducted a preliminary evaluation of funding mechanisms and fee criteria to identify opportunities for the MGA to recover costs of GSP administration and Basin management. As authorized under Chapter 8 of SGMA, a GSA~~-~~ may impose fees, including, but not limited to, permit fees and fees on groundwater extraction or other regulated activity, to fund the costs including groundwater sustainability planning and program activities and administration. The MGA will further evaluate the funding mechanisms, the potential application of fees and the fee criteria for non-*de minimis* and *de minimis* users alike.

A key success factor is developing a cost allocation that is equitable to GSA members and ~~basin~~Basin users. MGA member agencies agreed early in the SGMA process that the general approach to fund the Plan implementation will be to spread the costs of achieving basin sustainability among groundwater users in a manner that allocates a greater share of costs to users with greater impacts upon groundwater sustainability indicators in the Basin. The findings from the MGA ~~Model~~model will support an assessment of impacts to the Basin and will inform the evaluation of funding mechanisms and fee criteria as the GSP implementation proceeds.

1.4 Member Agency Descriptions

1.4.1 Soquel Creek Water District

Soquel Creek Water District (SqCWD) was originally established as a county water district in 1961 to provide flood control and water conservation services. In 1964, SqCWD acquired Monterey Bay Water Company and began delivering water to customers. Today, SqCWD is a public agency that provides potable drinking water and groundwater resource management within its service area in the Santa Cruz Mid-County Groundwater Basin. SqCWD is the largest individual groundwater provider in the Basin and shares the Basin with the City of Santa Cruz Water Department (SCWD), Central Water District (CWD) and a variety of small private wells, small water systems, institutional, and agricultural groundwater pumpers. SqCWD serves a population of approximately 40,400 through ~~15,800~~14,438 service connections, of which 94 percent are residential. SqCWD's service area includes portions of the City of Capitola, and the unincorporated communities of Aptos, La Selva Beach, Rio Del Mar, Seascape, Seacliff, and Soquel. As a water district, SqCWD has no land use authority within its service area.

Except for pilot surface water transfers with SCWD during the winter months that began in 2018, the sole water source for SqCWD is groundwater from the Basin. The Basin is currently listed in critical overdraft by DWR. As a result of historic Basin overdraft, portions of the groundwater basin along the coastline have been impacted by seawater intrusion. The Basin is still in long-term overdraft with coastal groundwater elevations below protective levels at five of 13 coastal monitoring well locations (see Section 2.2.4.1.4 for a full discussion of protective elevations and how they are used to evaluate current groundwater levels).

1.4.2 City of Santa Cruz Water Department

The City of Santa Cruz (City), located on the northern shore of Monterey Bay, was established as a Spanish mission in 1791 and incorporated as a town in 1866. The City administers land use within its municipal boundaries and is the county seat of Santa Cruz County. The Santa Cruz Water Department (SCWD) provides water service to an area of approximately 20 square miles, including the entire City, adjoining unincorporated areas of Santa Cruz County, a small part of the City of Capitola, and coastal agricultural lands north of the City. SCWD is responsible for potable water supply in the SCWD's service area to 24,504 connections and a total population of approximately 98,000. The eastern half of the SCWD's service area is within the Basin with an estimated population of approximately 42,000.

The City first acquired an interest in the Basin in 1967 when it purchased its Beltz groundwater wells. SCWD relies on a water supply that is primarily dependent on local surface water runoff, with groundwater contributing only 5 percent of the annual water supply and no connection to an imported water source from outside the region. The strong reliance on local surface water sources and the system's limited ability to store wet season flows for use in the dry season as well as having its groundwater resources in an over-drafted basin that is subject to seawater intrusion are the primary threats to SCWD's water supply reliability. Due to the water system's limited ability to store wet season flows for use in the dry season, ~~the City~~SCWD is currently focused on increasing its drought supply and is exploring a number of alternatives, including strategies to store wet season flows in regional aquifers for use during droughts.

1.4.3 Central Water District

Central Water District (CWD) was first organized and approved as Central Santa Cruz County Water District in 1950 by local residents, voters, and the County Board of Supervisors to address the shortage of potable water in the Pleasant Valley area. By December 1953, it had acquired Valencia Water Works and was serving 80 customers. In 1980, the name was shortened to Central Water District. CWD's service area is approximately 3,200 acres or 5 square miles in area and is completely contained within the Basin. Compared to other MGA member agencies, CWD is a relatively small water district serving a rural community that is 98% residential and primarily made up of large residential and agricultural parcels. CWD is solely dependent on groundwater for its water supply and pumps an average of 400 acre-feet per year. Average water use for customers within CWD's service area is approximately 120 gallons per person per day. CWD has participated in groundwater management activities within the Basin since 1995 and has two seats on the MGA board of directors. The total number of CWD's active ~~services~~service connections is 899 providing water to an approximate population of 2,700. As a water district, CWD has no land use authority within its service area.

1.4.4 Santa Cruz County

The County of Santa Cruz (County) was founded in 1850 as one of the 27 original California counties at the time of statehood. The County has a total area of 607 square miles, 445 square miles of which is land area (73%) and the remaining 162 square miles is water (27%) ~~(US Census, 2010).~~ (US Census Bureau, 2012). The County is the land use jurisdiction for all unincorporated areas outside of city boundaries and is the largest land use jurisdiction within the Basin. The population residing in the unincorporated area of the County within the Basin is approximately 69,500. Of this number, approximately 11,600 people reside in the unincorporated County and do not receive water from a municipal supplier.

The County does not provide water service~~,~~ but does permit and regulate private groundwater wells and small water systems that serve this population. The County's Environmental Health Services Agency (EH) includes the Water Resources Division which participates in countywide planning and management efforts on a variety of water resource programs, including: groundwater management, water quality, stormwater management, water conservation, fish (steelhead) monitoring, watershed and stream habitat protection. The County participated in establishing the groundwater estimates incorporated into the MGA's ~~Model~~integrated surface water groundwater model (model) to estimate domestic private well and small water system groundwater pumping at 2,000 acre-feet per year. This estimate was based on groundwater production data from small water systems that are metered. Most private wells within the basin are not metered.

1.5 Private Well Owner Representation

Private well owner representatives participate in Basin groundwater management activities~~.~~ ~~Since at least the mid-1990s,~~ on the MGA Board of Directors. Private well owners, with four (4) or fewer households sharing a private well ~~owners~~, have been included in ~~discussions and oversight on~~ groundwater management activities in the Soquel-Aptos area since at least the mid-1990s. In 2015, the Soquel-Aptos Groundwater Management Committee (SAGMC), a predecessor groundwater agency to the MGA, expanded private well representation to three seats on the SAGMC board. The MGA governance structure continues this engagement approach by including three private well owners on the MGA ~~board~~Board of ~~directors~~Directors. MGA private well owner representatives are required to live within the Basin and receive their domestic or agricultural water supply from a private well, shared well, or small water system.

1.6 GSP Organization

1.6.1 Groundwater Sustainability Plan Organization

The MGA's GSP is organized based upon ~~the~~ DWR's GSP Annotated Outline with additional information to address content requirements found in the *Preparation Checklist for GSP Submittal* (DWR, 2016).

The GSP is organized as follows:

- **Executive Summary:** This section presents an overview of the GSP, background information on the groundwater conditions in the Basin, an overview the GSP development process, and key information from each ~~of the five~~GSP sections.
- **Section 1.0 Introduction:** This section presents the purpose of the GSP, the Basin's Sustainably Goal, information about the MGA, and ~~the~~ organization of the GSP.
- **Section 2.0 Plan and Basin Setting:** This section describes the Santa Cruz Mid-County Groundwater Basin, existing conditions in the Basin, provides historical data, and uses the data to make prospective estimates for future conditions in the Basin. It is this historic and projected data that set the stage for groundwater planning within the Basin. This section ~~summarizes historic groundwater management within~~also provides the Basin~~, and provides~~ water budget as context for this long-range groundwater planning effort.
- **Section 3.0 Sustainable Management Criteria:** This section presents the sustainability goal for the Basin and details the criteria for evaluating the SGMA's six sustainable management indicators and the associated undesirable results, minimum thresholds, and measureable objectives. These are the indicator's by which the sustainability of the Basin will be evaluated as ~~the~~ GSP implementation occurs.
- **Section 4.0 Projects and Management Actions to Achieve Sustainability Goal:** This section provides a description of projects and management actions necessary to achieve the Basin sustainability goal and to respond to changing conditions in the ~~basin~~Basin. These were developed to address sustainability goals, measurable objectives, and undesirable results. The projects and management actions are presented in three groups to provide the clearest description of how and when projects and management actions will be taken to reach sustainability. Group 1 includes projects and management actions that are already implemented and included in the model's baseline. Group 2 includes projects and management actions that are modeled and projected to reach

Basin sustainability. Group 3 includes projects and management actions that may be needed if Group 1 & 2 projects fail to achieve Basin sustainability.

- **Section 5.0 Plan Implementation:** This section presents an estimate of GSP implementation costs, the implementation schedule, and outlines the procedural and substantive requirements for the annual and periodic (5-year) evaluations of the GSP.

~~1.6.2 Preparation Checklist for GSP Submittal~~

~~An example *Preparation Checklist for GSP Submittal* based on the DWR's 2016 Guidance is presented in Appendix A1-B. The Checklist identifies where in this GSP each of the statutory requirements under SGMA are addressed. Currently, DWR is finalizing a spreadsheet Checklist tool. It is expected that the MGA will use this tool and the completed checklist will be included in the Final GSP.~~

REFERENCES

All references are located in Section 6

APPENDICES

Appendices are located on the MGA website both individually and within a compiled appendices document.

GSP Section 2 Contents

Tables

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~~PLan~~

2 PLAN AREA AND BASIN SETTING

GSP Section 2 describes the groundwater basin, existing basin conditions, provides historical data, and uses the data to make prospective estimates for future conditions in the Basin. It is this historic and projected data that set the stage for groundwater planning within the Basin.

Section 2 summarizes 50+ years of historic groundwater management within the ~~basin~~Basin, it also provides context for local citizens, interested parties, trustee agencies, and state regulatory agencies to understand and participate in this long-range groundwater planning effort.

2.1 Description of Plan Area

Describing the Basin plan area outlines more than just geography. It also summarizes available historical water monitoring information, identifies detailed scientific observations related to water management, documents land use policy over time, and synthesizes groundwater management practices within the Basin.

Agency staff are fortunate to have this wealth of data for the ~~groundwater basin.~~Basin. It provides a deep understanding of the ways in which groundwater has been managed and information on the results of groundwater management over time.

This information is an important lens through which to make Plan decisions going forward. It provides the perspective decision makers need on what has worked in the past, what hasn't worked, and points toward the changes needed to achieve groundwater sustainability as desired on the local level and as required by state law.

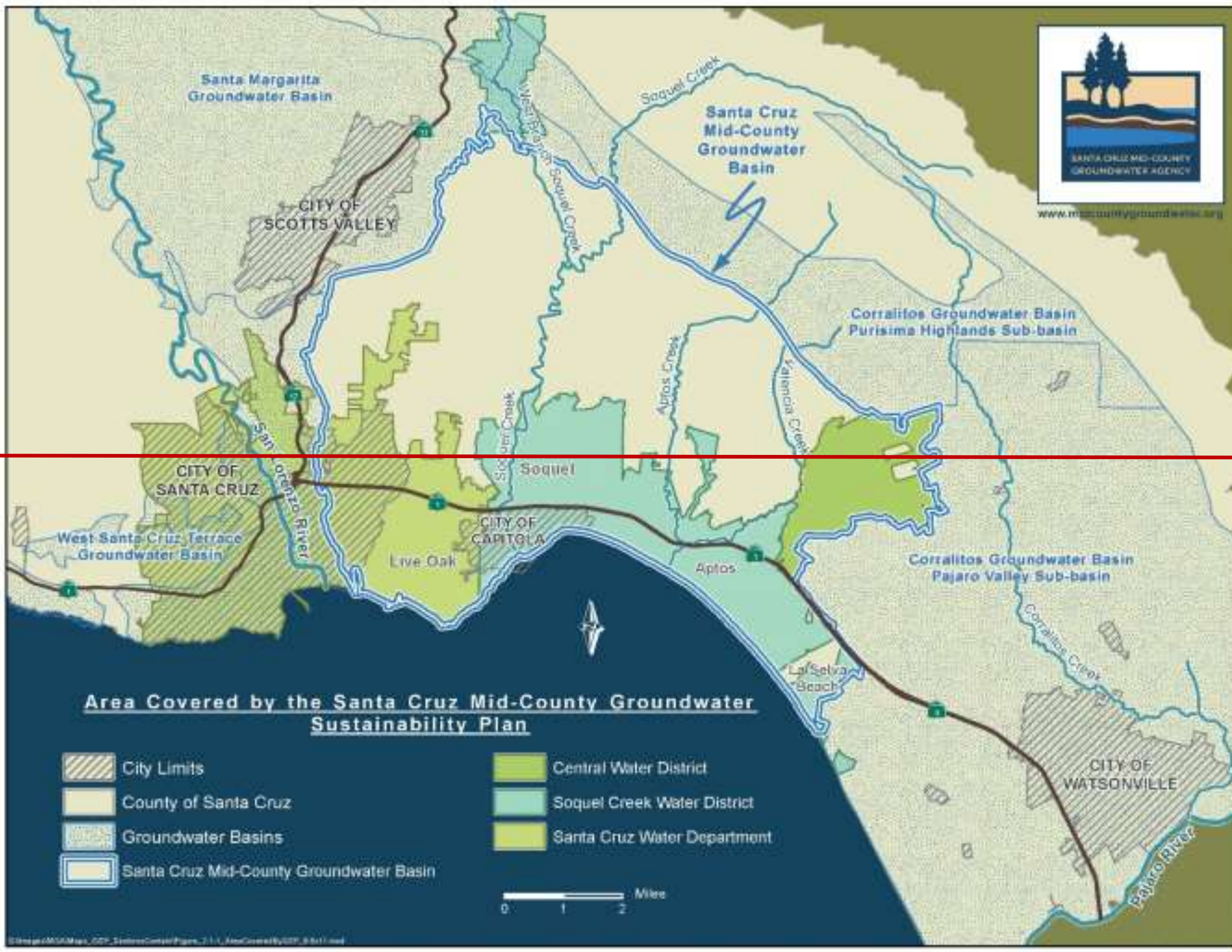
The Basin is located between two other groundwater basins that are also required to prepare a GSP under SGMA. To the northwest of the Basin is the Santa Margarita Groundwater Basin, a medium priority basin being managed under SGMA by the Santa Margarita Groundwater Agency. The boundary between these two basins is primarily based on the geology of the region. To the ~~Southeast~~southeast of the Basin is the Pajaro Valley Subbasin, a high priority basin in critical overdraft. The Pajaro Valley Subbasin is managed by the Pajaro Valley Water Management Agency (PV Water). ~~PV Water predates SGMA and was named specifically in the Act; as such, the~~ The boundary between ~~these two basins~~the Pajaro Valley Subbasin and the Santa Cruz Mid-County Basin is primarily jurisdictional.

2.1.1 Summary of Jurisdictional Area and Other Features

2.1.1.1 Area Covered by the Plan

2.1.1.1.1 Santa Cruz Mid-County Basin

The Santa Cruz Mid-County Basin is the subject of the Santa Cruz Mid-County Groundwater Agency (MGA)'s Groundwater Sustainability Plan (GSP or Plan). The Plan covers the entire Basin, located entirely within Santa Cruz County (Figure 2-1). The Basin is identified by the California Department of Water Resources (DWR) as Basin 3-001 in *Bulletin 118 Interim Update 2016*.



~~**Figure 2-1. Area Covered by the MGA's Groundwater Sustainability Plan**~~

The Basin was consolidated from all or part of four previously existing basins. The four previous basin and their associated Bulletin 118 basin numbers were the Soquel Valley (3-1), West Santa Cruz Terrace (3-26), Santa Cruz Purisima Formation (3-21), and Pajaro Valley Basins (3-2~~).~~) (DWR, Bulletin 118 Interim Update 2016).

The consolidated Basin boundary is intended to include all areas where the stacked aquifer system of the Purisima Formation, Aromas Red Sands, and certain other Tertiary-age aquifer units underlying the Purisima Formation constitute the shared groundwater resource to be managed by the MGA. Previous basin boundary definitions were based on surficial alluvium, and did not accurately represent the extent of the deeper aquifer units from which most groundwater is produced. The ~~basin~~Basin is defined by both geologic and jurisdictional boundaries~~.~~

~~2.1.1.1.2 Neighboring Groundwater Basins~~

(Hydrometrics WRI 2016). Basin boundaries to the west are primarily geologic. Basin boundaries to the east, adjacent to the Pajaro Valley Subbasin managed by PV Water, are primarily jurisdictional.

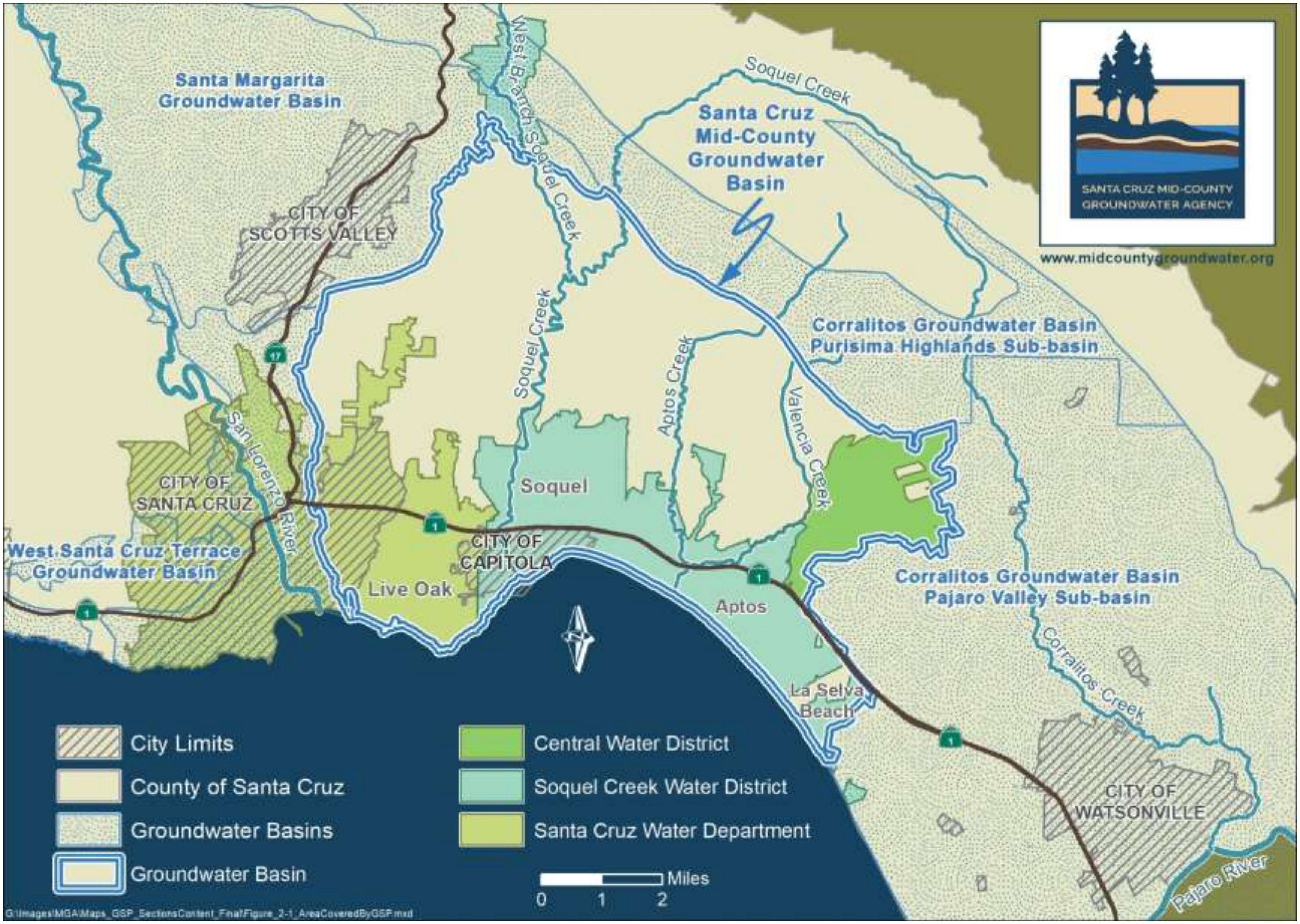


Figure 2-1. Area Covered by the MGA's Groundwater Sustainability PlanNeighboring Groundwater Basins

The Basin is adjacent to four neighboring groundwater basins/~~Subbasins~~subbasins: Pajaro Valley Subbasin (3-002.01), Purisima Highlands Subbasin (3-002.02), West Santa Cruz Terrace Groundwater Basin (3-026) and Santa Margarita Groundwater Basin (3-027). All of these basins and subbasins were re-delineated for purposes of SGMA groundwater management in the basin modification process with DWR approval in 2016~~. Figure 2-1~~ (DWR, Bulletin 118 Interim Update 2016). Figure 2-1 shows the location of the neighboring basins in relation to the Santa Cruz Mid-County Basin.

Purisima Highlands (3-002.02) and West Santa Cruz Terrace (3-026) were initially identified as medium priority basins and Santa Cruz County listed as basin manager. However, these are not true groundwater basins and have little groundwater use. DWR re-designated both basins to very low priority and a GSP is not required for SGMA purposes.

Pajaro Valley Water Management Agency (PV Water) manages the Pajaro Valley Subbasin (3-002.01). The Agency was created in 1984 by the Pajaro Valley Water Management Agency Act, legislation developed in response to DWR's 1980 Bulletin 118-80 which identified Pajaro Valley Subbasin as one of 11 groundwater basins in critical overdraft at that time. PV Water has authority to manage groundwater resources in the basin, and its activities typically focus on halting seawater intrusion by balancing overdraft conditions in the basin through promoting water use efficiency and developing and distributing supplemental irrigation water. PV Water's charter specifically prevents the supply of potable water, thus all projects approved in its Basin Management Plan supply non-potable irrigation water. PV Water activities do not include flood control, stream restoration or habitat management (except as mitigations for development projects), which are the responsibility of state and/or county jurisdictions.

The Santa Margarita Groundwater Agency (SMGWA) manages the Santa Margarita Groundwater Basin (3-027) which includes all or parts of three smaller groundwater basins previously identified by DWR as Santa Cruz Purisima Formation Basin (3-21), Scotts Valley Basin (3-27), and Felton Area Basin (3-50). SMGWA is a Groundwater Sustainability Agency (GSA) created in June 2017 by three member agencies: Scotts Valley Water District, San Lorenzo Valley Water District, and the County of Santa Cruz. It is governed by a board of directors with two representatives from each member agency, one representative each from City of Scotts Valley, City of Santa Cruz, Mount Hermon Association, and two private well owner representatives. SMGWA was created in response to SGMA with a mission to sustainably manage its regional groundwater basin. Santa Margarita Groundwater Basin is identified as a medium priority basin not in a state of critical overdraft. As a medium priority basin, SMGWA's GSP is not due until January 31, 2022.

SMGWA and MGA member agencies are in routine communications regarding management of the respective basins. Several MGA member agencies are also members or necessary participants in the groundwater sustainability management efforts of our neighboring basins

2.1.1.2 Adjudicated Areas, Other Agencies within the Basin, and Areas Covered by an Alternative Plan

2.1.1.2.1 Adjudicated Areas

The Basin contains no areas with adjudicated groundwater rights.

Surface water rights were adjudicated in Soquel Creek Watershed by the Santa Cruz County Superior Court in 1977~~.~~ (SWRCB 1977). At that time, just over 300 users were granted rights to draw from Soquel Creek, its tributaries and stream-feeding springs. First, second, and third priority rights were granted for a variety of uses including domestic, irrigation, recreational, stock watering, agriculture, and fire protection. Limited consideration was given to flows for fish or other environmental users of water, and the adjudication predates the standards expected under the Public Trust Doctrine. During the summer and fall, Soquel Creek regularly has insufficient flow to meet the allocations of all but the first priority right-holders. Most water right holders do not presently exercise their rights.

Soquel Creek has diminished flows late in the dry season (fall), posing limitations on the availability of water for legal diversions and adversely impacting salmonids, amphibians, and other water-dependent organisms and ecosystems. Though the vast majority of the adjudicated allocations are not being used, Santa Cruz County Environmental Health has periodically documented diversions from critical reaches of Soquel Creek. While most identified users have water rights under the adjudication, most have failed to file a Statement of Diversion with the State Water Resources Control Board or secure necessary approvals from the California Department of Fish and Wildlife. The Resource Conservation District of Santa Cruz County is working with state and local agencies and willing landowners with adjudicated water rights, in a non-regulatory context, to identify where winter water storage or other projects could be implemented to reduce diversions during the dry season when the impacts upon salmonids and other aquatic species are greatest.

2.1.1.2.2 Other Agencies within the Basin

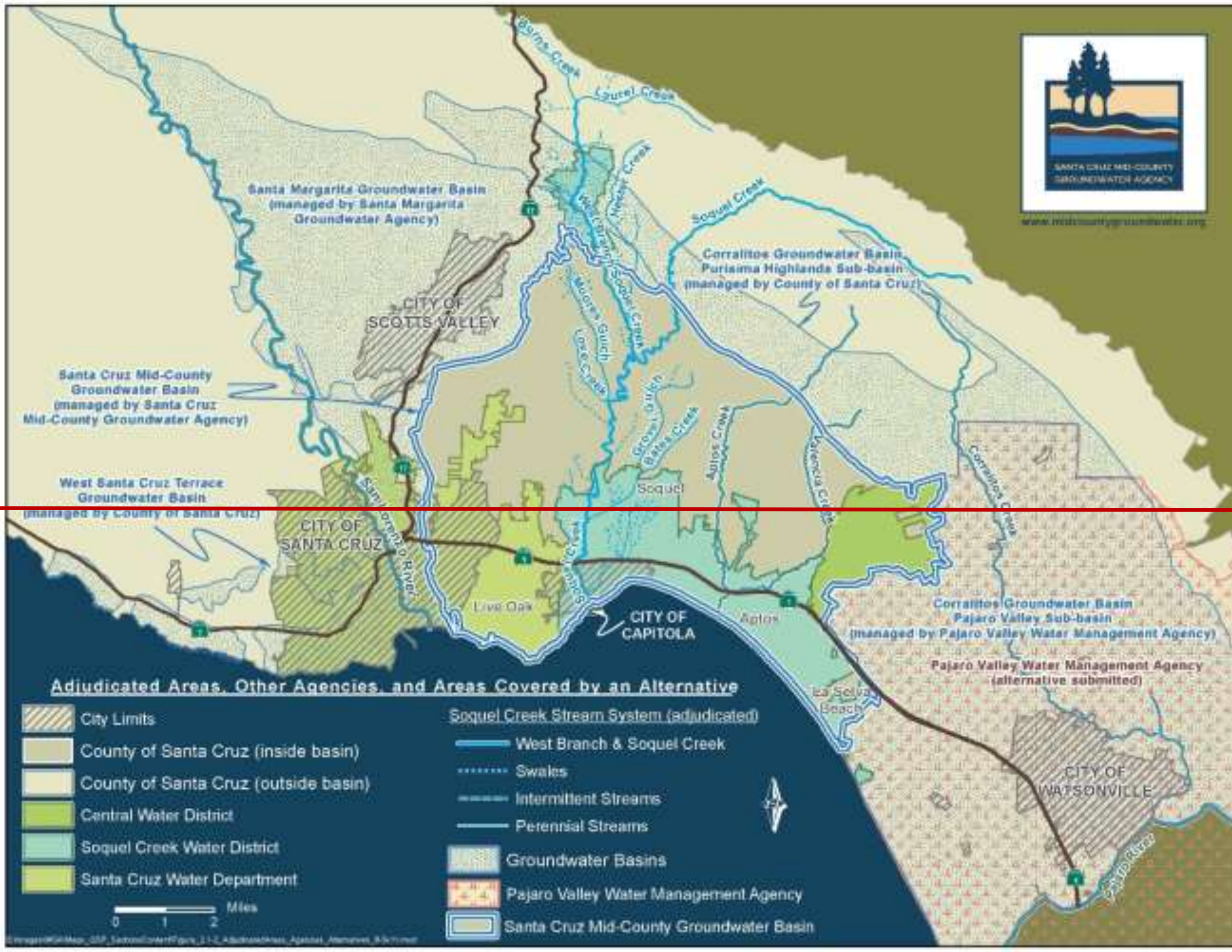
Apart from MGA member agencies, no other agencies have direct authority over groundwater within the Basin. The City of Capitola, located entirely within the Basin, has land use authority within its jurisdictional boundaries. Capitola's land use policies can influence the amount of groundwater used~~, however~~. However, Capitola water users must comply with water conservation and other water related resolutions passed by its water providers~~;~~: City of Santa Cruz Water Department and Soquel Creek Water District.

2.1.1.2.3 Areas Covered by an Alternative

The entire Basin is covered by the MGA and this ~~Groundwater Sustainability Plan (~~GSP~~)~~. No areas within the Basin are covered by an Alternative GSP~~.~~

~~The Pajaro Valley Water Management Agency (~~ or PV Water~~)~~, the neighboring groundwater basin manager to the ~~south, submitted an~~southeast, has a DWR approved Alternative Plan ~~to DWR~~ that covers the entire Pajaro Valley Subbasin (~~Figure 2-2). PV Water is awaiting~~

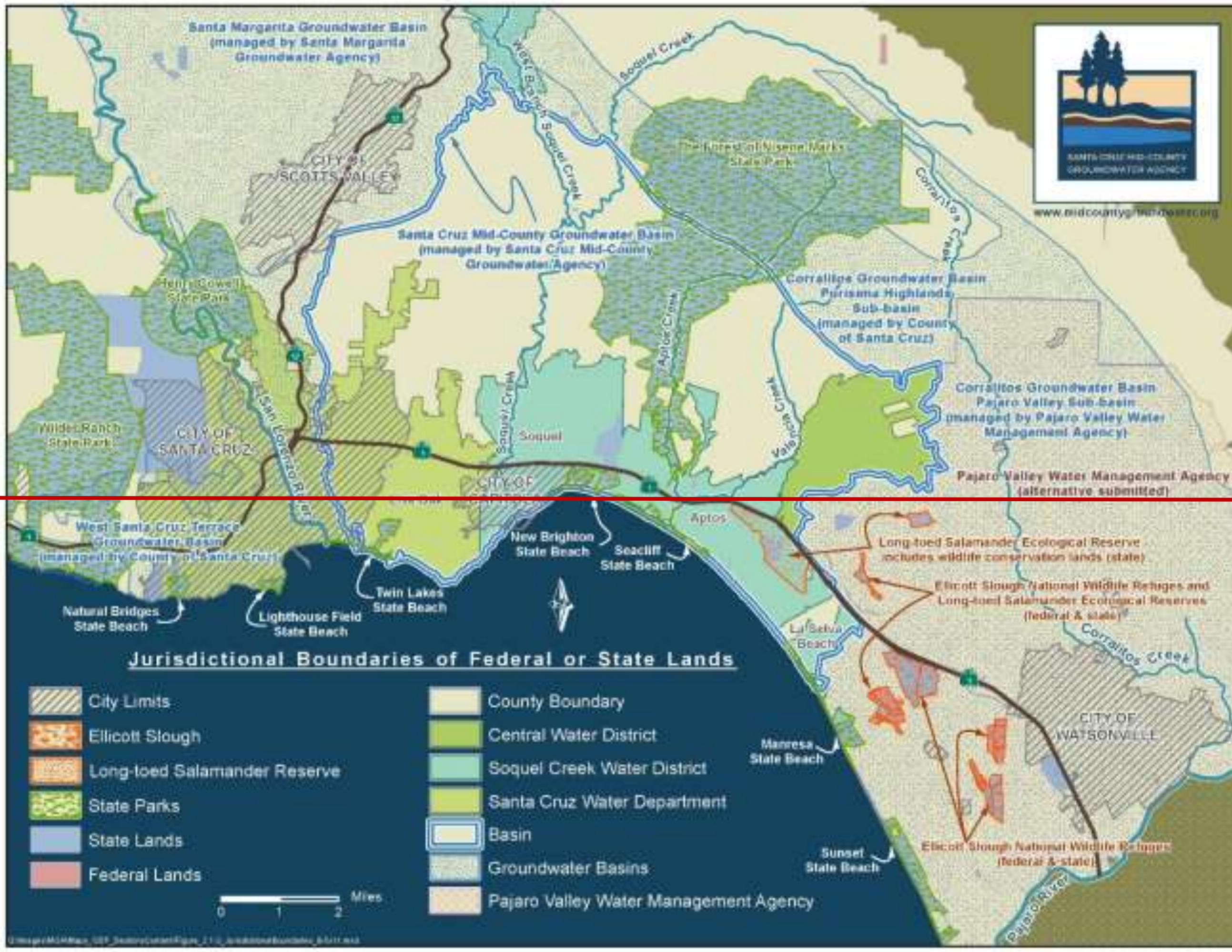
~~comments from DWR regarding whether its~~ Figure 2-3). Its Alternative Plan was approved on July 17, 2019 and its approval is based on DWR's finding that PV Water's Basin Management Plan is ~~approved, or if not,~~considered a functional equivalent to a GSP for the ~~additional information needed~~ Pajaro Valley Subbasin to fulfill ~~its~~PV Water's SGMA planning requirements.



~~**Figure 2-2.** Adjudicated Areas, Other Agencies within the Basin, and Areas Covered by an Alternative Plan~~

2.1.1.3 Jurisdictional Boundaries within the Basin

The Basin extends from the Santa Cruz Mountains to the Pacific Ocean and from the ~~eastern~~ edge of the City of Santa Cruz near Twin Lakes ~~to~~in the ~~western edge of~~ west to La Selva Beach~~.~~ in the east (Figure 2-2). The Basin includes portions of the City of Santa Cruz, the entire City of Capitola, Santa Cruz County census designated places of Twin Lakes, Live Oak, Pleasure Point, Soquel, Seacliff, Aptos, and Rio Del Mar. The Basin also includes portions of Santa Cruz County unincorporated census designated places of Day Valley, Corralitos, Aptos Hills-Larkin Valley, and La Selva Beach~~.~~



(DWR, Bulletin 118 Interim Update 2016).

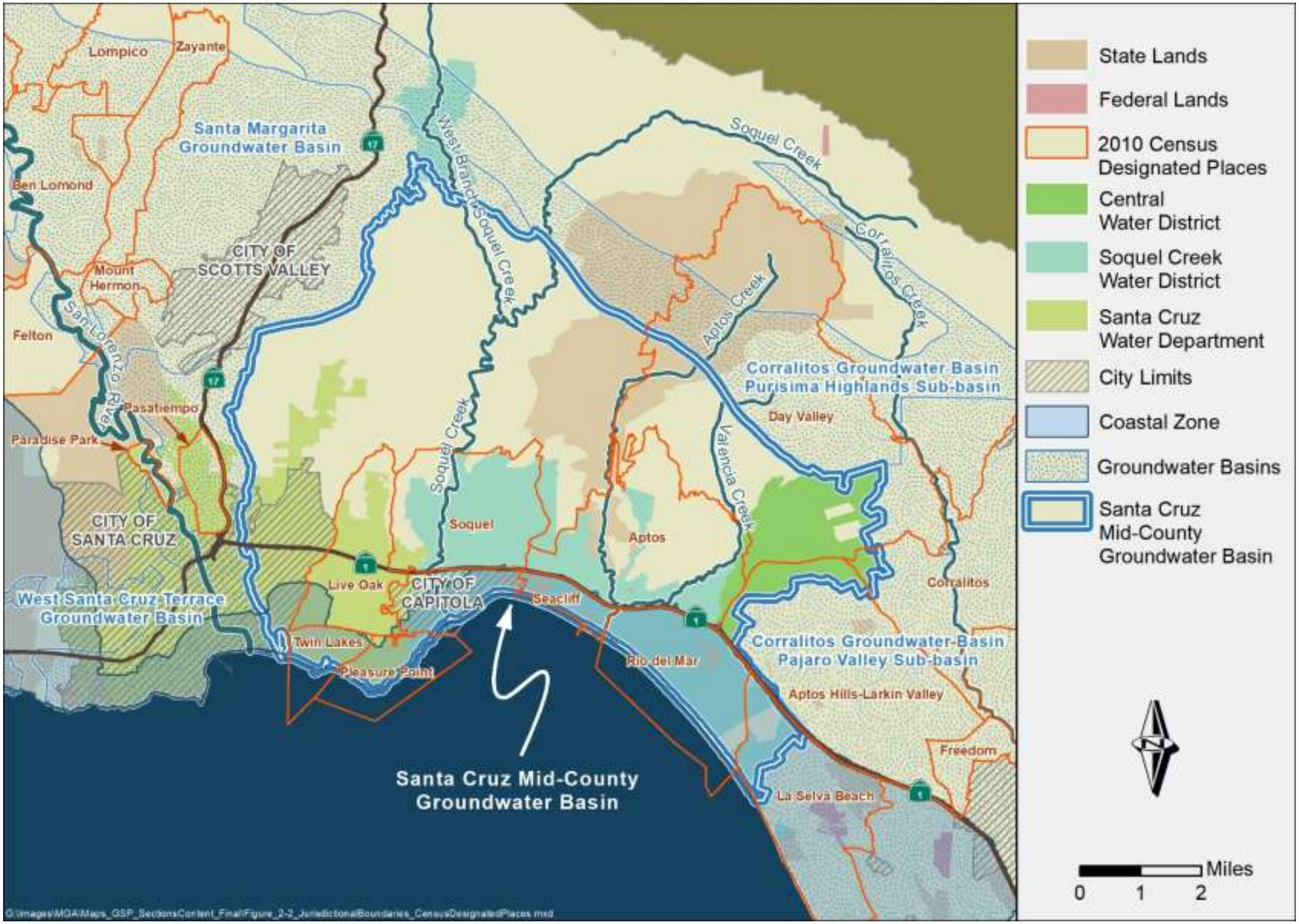


Figure 2-2. Jurisdictional Boundaries and Census Designated Places in or near the Santa Cruz Mid-County Groundwater Basin

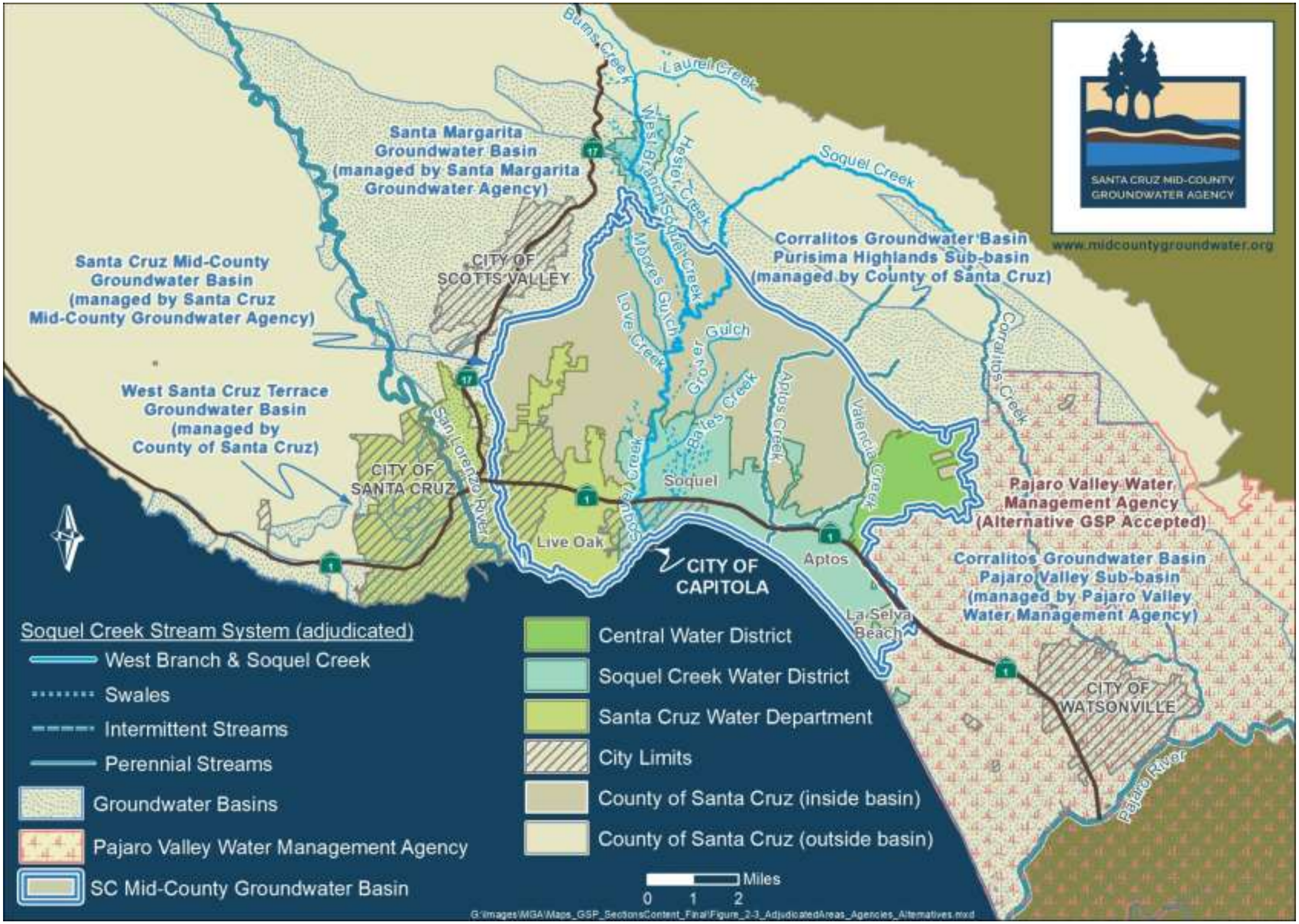


Figure 2-3. Adjudicated Areas, Other Agencies within the Basin, and Areas Covered by an Alternative Plan~~Jurisdictioinal Boundaries~~

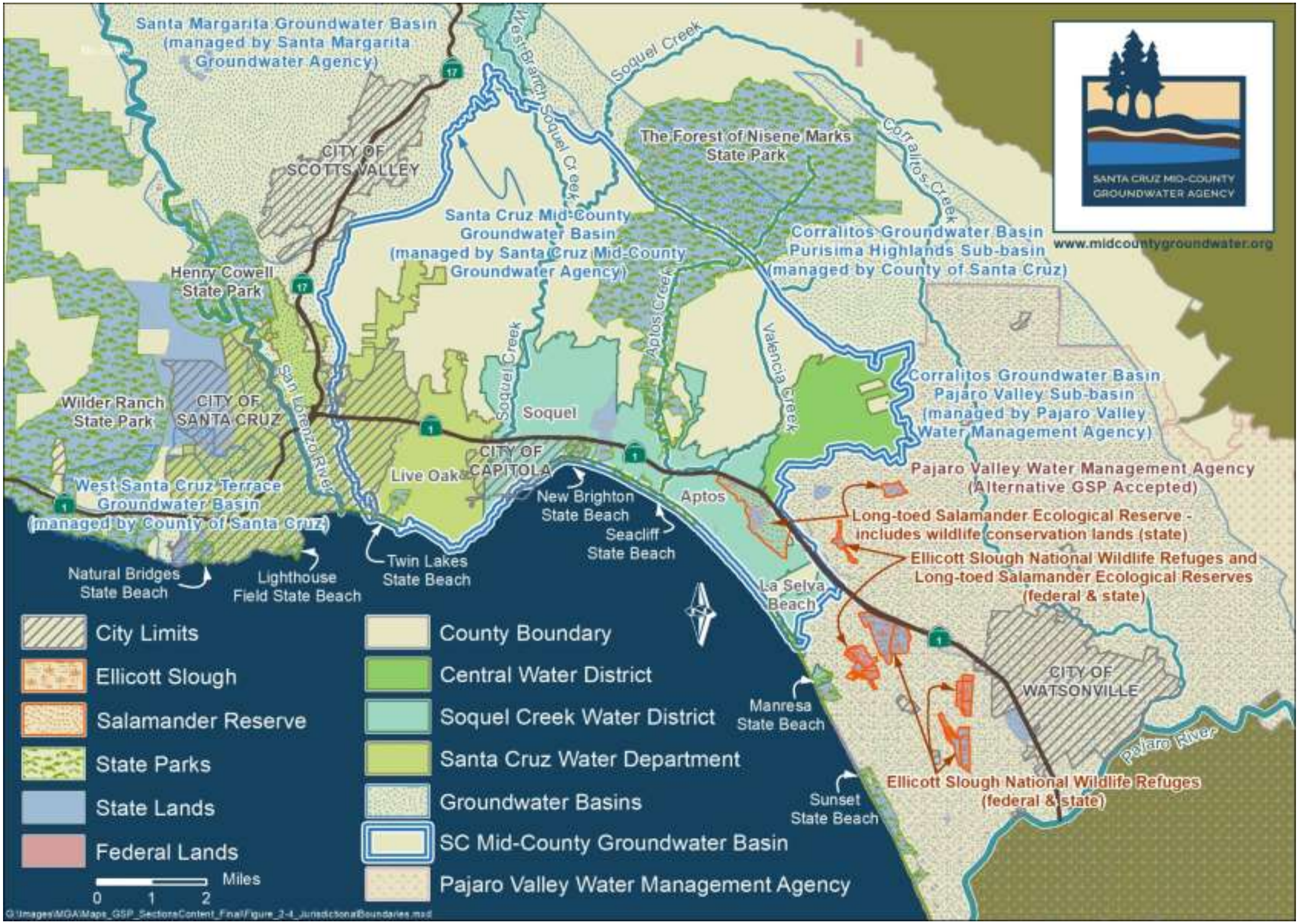


Figure 2-4. Jurisdictional Boundaries of Federal or State Lands

2.1.1.3.1 Federal or State Lands within the Basin

Federal Lands

The Basin contains no federal lands, however, Ellicott Slough National Wildlife Refuge is near the southern ~~basin~~Basin boundary. Ellicott Slough is managed by the U.S. Fish and Wildlife Service as part of the San Francisco Bay National Wildlife Refuge Complex~~.~~ (USFWS 2018). Ellicott Slough provides habitat for species federally listed as threatened due to habitat loss, including the Santa Cruz long-toed salamander subspecies, California red-legged frog, California tiger salamander, and robust spineflower. This area of federal land is not included within the Basin and falls outside the Plan area. Groundwater flow from the Basin is in the direction of Ellicott Slough, however, there does not appear to be a connection to the regional aquifer. For this reason, groundwater management consideration is not relevant for this important habitat area outside the Basin.

State Lands

The Basin includes a substantial area of state park lands managed by the California Department of Parks and Recreation~~.~~ (CSP&R 2018). The Basin includes portions of Twin Lakes State Beach and The Forest of Nisene Marks State Park. The ~~basin~~Basin also includes the entirety of New Brighton State Beach, Seacliff State Beach, and Rio Del Mar State Beach. The Basin also includes a portion of the Long-toed Salamander Ecological Reserve in the eastern portion of the Basin. This land is managed for resource conservation purposes by the California Department of Fish and Wildlife.

2.1.1.3.2 Tribal Lands

There are no federally designated tribal lands and no federally recognized tribes in the Basin. The Basin is located within a California Tribal and Cultural Area that historically belonged to a division of the Ohlone people known as the Awaswas~~.~~ (DWR 2011). The Awaswas people inhabited the land from present-day Davenport to Aptos. South of the Awaswas, and near the present-day basin boundary with Pajaro, were the Mutsun people, another division of the Ohlone. Decedents of both the Awaswas and Mutsun people are members of the Amah Mutsun Tribal Band. The Tribal Band is petitioning the federal government for tribal recognition and has recently formed the Amah Mutsun Land Trust in an effort to access, protect, and steward lands important to the tribe~~.~~ (AmahMutsun 2019).

2.1.1.3.3 Cities

The Basin contains two municipal city jurisdictions, the City of Capitola and a portion of the City of Santa Cruz. Santa Cruz County unincorporated areas make up the remainder of the Basin.

City of Santa Cruz

The site of the City of Santa Cruz was used by native people before it was discovered by Europeans in 1769. A Spanish mission was established in 1791 and the City of Santa Cruz was incorporated in 1866. The City has land use authority ~~over~~ within its municipal boundaries, including those portions that are within the Basin. The Santa Cruz Water Department (SCWD) provides water service to an area of approximately 20 square miles in size, including the entire

City, adjoining unincorporated areas of Santa Cruz County, a small part of the City of Capitola, and coastal agricultural lands north of the City. SCWD is responsible for potable water supply in the City's service area to 24,504 connections and a total population of approximately 95,000. The portion of the City's service area within the Basin has an estimated population of approximately 42,000~~.~~ (AMBAG 2018).

The City also provides wastewater services to City and County residents through its Waste Water Treatment Plant. The City's Public Works Department operates a collection system, treatment plant, and ocean disposal system. The Santa Cruz County Sanitation District, a special district operated to provide service to municipal customers and support to the Santa Cruz County Public Works Department, collects wastewater from the Live Oak, Capitola, Soquel, Aptos, and Seacliff areas. County wastewater is sent to the City's Waste Water Treatment Plant for treatment and disposal through the City's ocean outfall.

City of Capitola

The City of Capitola was incorporated in 1949 after a long history as a native village, as a pier for shipping locally produced resources, and as a resort destination with a train depot. Capitola does not have water management responsibilities. Capitola receives water services from the City of Santa Cruz west of 41st Street and from Soquel Creek Water District to the east. The municipal agencies that provide water to Capitola have regulatory authority to protect the regional water supply. Water users within Capitola are required to comply with the water conservation policies and other programs implemented by their municipal water service providers. Capitola has land use permitting authority over its jurisdictional area. Its municipal land use decisions can impact water demand within the Basin.

2.1.1.3.4 County

The County of Santa Cruz was established in 1850. The County is not a municipal water supplier within the Basin. The County regulates land use in unincorporated areas. The Environmental Health Division of the County Health Services Agency provides watershed management, well permitting oversight, regulatory compliance assistance, and oversight to small water systems and mutual water companies in the unincorporated areas. The Sanitation Division of Santa Cruz County Public Works Department provides staff to the Santa Cruz County Sanitation District, which collects wastewater and provides sewer services to portions of the county and Capitola within the Basin. The County Public Works Department oversees flood control services and storm drain maintenance within Capitola and the unincorporated areas, primarily through Zones 5 and 6 of the County Flood Control and Water Conservation District.

2.1.1.3.5 Water Agencies

Each local water agency with authority over drinking water within the Basin is an MGA member. The member agencies either produce and provide drinking water or regulate drinking water wells. The municipal water agencies have individual authority to pass regulations to protect water resources within their jurisdictional boundaries.

City of Santa Cruz Water Department

The City of Santa Cruz is a public water purveyor that provides water to a population of approximately 42,000 within the Basin~~.~~ (AMBAG 2018). As discussed in Section 2.1.1.3.3, the City's service area within the Basin is a subset of its total service area. The City's primary source of water supply is from surface water sources, including the north coast streams (Majors Creek, Laguna Creek ~~and~~, Liddell Creek, and Reggiardo Creek), the San Lorenzo River, and the Loch Lomond reservoir. The City also owns the Beltz groundwater wells within the Basin which make up approximately 5% of its total water supply in years with normal rainfall. In drought years, the City relies more heavily upon groundwater to meet its needs.

Central Water District

Central Water District (CWD) was established in 1950 and is located at the eastern edge of the Basin. The District was created to provide water service to the Pleasant Valley - Day Valley area east of Aptos. The District covers approximately 3,200 acres or 5 square miles in area. CWD operates groundwater wells within the Basin and is entirely dependent on groundwater for its water supply. It pumps an average of ~~400~~500 acre-feet per year. CWD is located almost entirely outside of the County's Urban Services Line and most customers utilize individual onsite wastewater treatment systems for wastewater disposal.

Soquel Creek Water District

Soquel Creek Water District was established in 1961 as a flood control and water conservation district. In 1964, it acquired the Monterey Bay Water Company, began delivering water service to customers, and discontinued flood control services. Soquel Creek Water District serves approximately 40,400 customers through ~~15,800~~14,438 connections within the Basin (AMBAG 2018). Ninety percent of Soquel Creek Water District's customers are residential and its sole source of water is groundwater. Soquel Creek Water District operates and maintains more than 80 monitoring wells, 15 active production wells, 2 standby production wells, 18 water storage tanks, and delivers water to its customers through more than 166 miles of pipeline. Soquel Creek Water District is working on a range of projects to develop alternative water sources so it is not entirely dependent upon groundwater.

2.1.1.4 Wastewater Management

Wastewater management within the Basin is primarily handled by City of Santa Cruz Public Works Department, the Santa Cruz County Sanitation District, and the Environmental Health Division of the County of Santa Cruz Health Services Agency. The City of Santa Cruz Public Works Department operates and maintains a regional wastewater treatment and disposal facility. Wastewater treatment and ocean outfall disposal are provided for the City of Santa Cruz and the Santa Cruz County Sanitation District, which includes Live Oak, Capitola, Soquel and Aptos. The County of Santa Cruz Health Services Agency permits and oversees all septic systems within Santa Cruz County.

2.1.1.5 Existing Land Use Designations

~~2.1.1.5.1 Land Use Designations~~

Land use jurisdictions within the Basin include the County of Santa Cruz, the City of Santa Cruz, and the City of Capitola. Each city has land use authority within its incorporated city boundaries. The County has land use authority within the unincorporated areas of the county. The cities collaborate with the County when planning within their respective spheres of influence to ensure that jurisdictional land use plans compliment the goals of each agency. The cities of Scotts Valley and Watsonville are outside the Basin and are within the neighboring groundwater basins of Santa Margarita and Pajaro Valley respectively.

The three land use jurisdictions with planning authority in the Basin each categorize land use broadly into residential, commercial, agricultural, open space and parks, and utilities and transportation designations. While each jurisdiction defines the specific land uses and development densities allowed in each land use category slightly differently, the general definition of what constitutes these land uses is compatible from jurisdiction to jurisdiction.

Land use within the Basin is further divided between urban and rural land uses. Development densities are greatest on the coastal terraces in the urban and suburban areas within and adjacent to incorporated city boundaries. Development densities are much lower and more rural in the foothills and upland areas of the Santa Cruz Mountains where urban infrastructure is not provided or is less available. A composite general plan map identifying land use designations in and around the Basin is provided to summarize existing land use (Figure 2-5).

2.1.1.5.1 Santa Cruz County

Santa Cruz County is the largest land use jurisdiction in the Basin. The County is the only land use jurisdiction to make a distinction between urban and rural land uses. The County has established urban services lines to focus new development where urban facilities and services already exist. This distinction preserves low densities and limits current levels of development in rural areas where development exists or is already planned, protects rural character by preserving prime agricultural lands, and protects natural and coastal resources from further development that is not compatible with County land use policies. Municipal water service and centralized sewage collection is generally limited to areas within the urban services line.

General plan designations within the county include residential, commercial, agricultural, utilities and transportation, and open space designations. Residential uses are the most prevalent both within the urban and rural services areas. Commercial and industrial uses are located within the urban areas of the Basin and open space and agricultural areas are located in mostly rural areas.

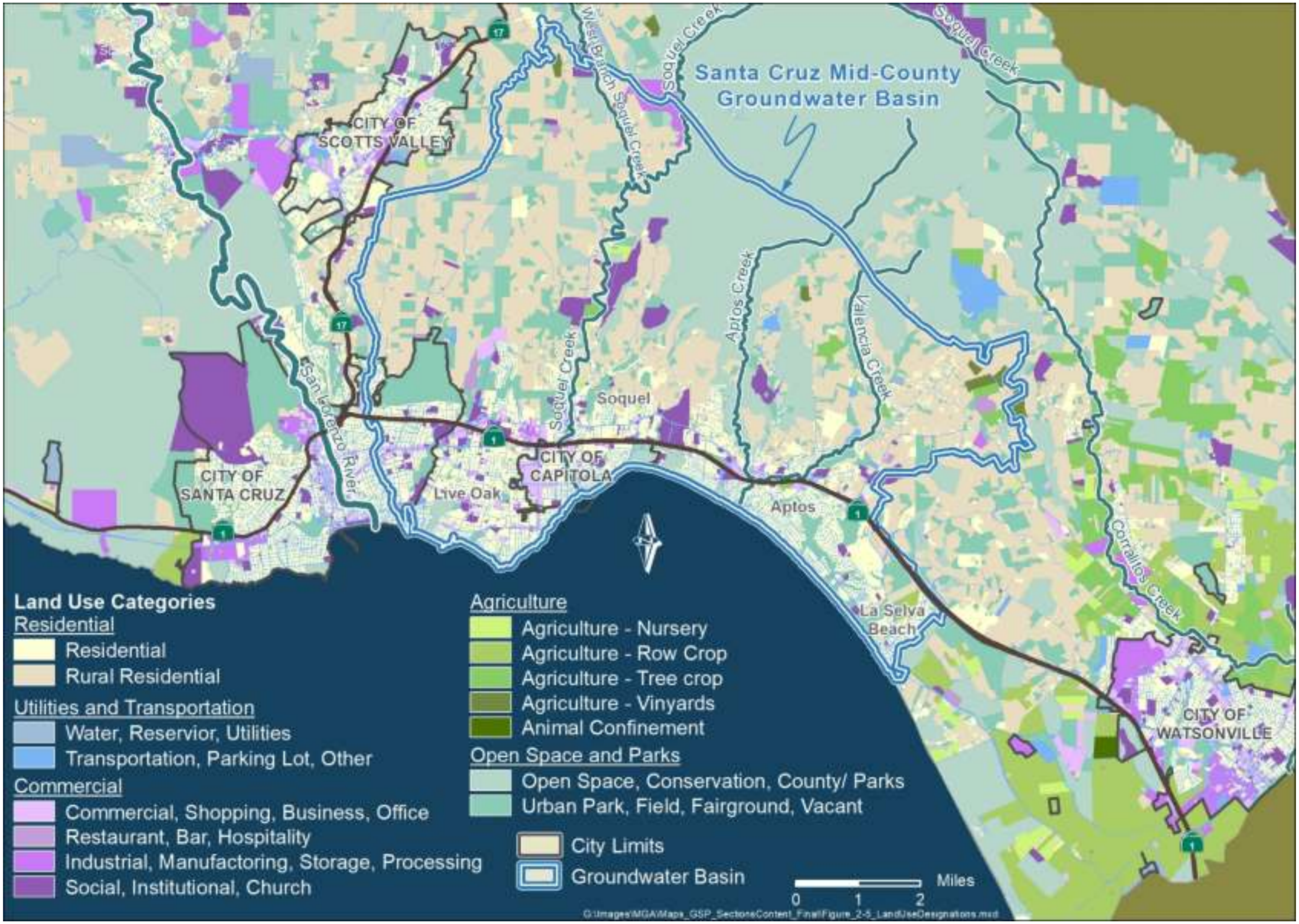


Figure 2-5. Existing Land Use Designations

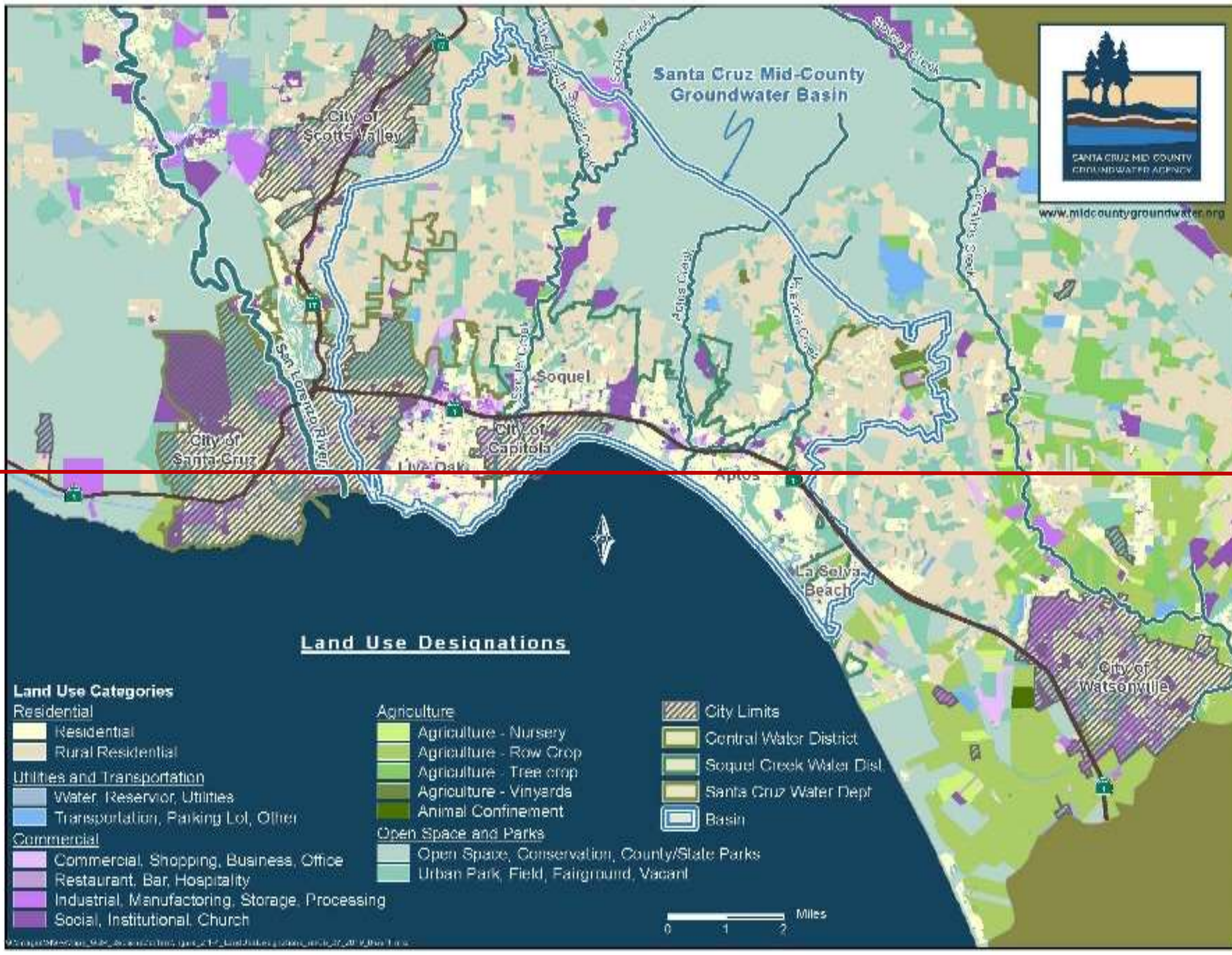
2.1.1.5.2 City of Santa Cruz

The eastern edge of the City of Santa Cruz is within the Basin. The majority of City land use within the Basin is devoted to residential uses. Parks and open space areas, including large open spaces at Arana Gulch and De Laveaga park and golf course, are the next most abundant land uses, followed by commercial, coastal dependent (Santa Cruz Harbor), and industrial uses.

2.1.1.5.3 City of Capitola

The City of Capitola is the smallest of the land use jurisdictions within the Basin. Approximately 442 acres (53%) of Capitola's total land area in residential use; about 187 acres (21%) is in commercial, industrial, and mixed uses; and 195 acres (23%) is categorized as other uses, such as open space/recreational (118 acres; 14%), public/quasi-public (44 acres; 5%), and vacant parcels (33 acres; 4~~%).~~%) (Capitola 2014).

Each of the three jurisdictions within the Basin has a recently adopted Housing Element that addresses its required regional fair share of the statewide housing needs allocated by the Association of Monterey Bay Area Governments ~~(AMBAG).~~(AMBAG 2014). These documents set forth goals and objectives for housing construction, rehabilitation, and conservation for the period 2015-2023. Water Use and Water Source Type



~~**Figure 2-4. Existing Land Use Designations**~~

~~2.1.1.5.2~~2.1.1.5.4 Water Use and Water Source Type

Municipal water delivery is one of the primary services that distinguish between urban and rural areas of the Basin. Urban areas within the Basin receive water from municipal suppliers and rural areas, generally, receive water from ~~private~~non-municipal wells, shared wells, ~~and~~ small and mutual water systems. The Basin population is approximately 92,100 people (AMBAG 2018). Of this population, approximately 80,500 receive water from municipal suppliers and 11,600 are supplied by ~~private~~non-municipal wells, small and mutual water ~~companies~~systems, and other systems.

Groundwater is the primary source of water for residents within the Basin. However, approximately 42,000 Basin residents are supplied by the City of Santa Cruz Water Department~~.~~ (SCWD). These Basin residents receive a mix of surface water and groundwater throughout the year. The ~~City of Santa Cruz's~~SCWD's water source is approximately 95% surface water and 5% groundwater in years with normal rainfall. The remainder of the Basin receives its water supply from groundwater. The Basin receives no imported water from outside Santa Cruz County.

The Basin is highly dependent on groundwater and susceptible to seawater intrusion due to historic overdraft of its productive aquifers. MGA member agencies and other regional partners are working to diversify the regional water supply. An example of this collaboration is the ~~City of Santa Cruz~~SCWD and Soquel Creek Water District (SqCWD) joint river water transfer pilot project which began in December 2018~~.~~ under an agreement dated 2016. The parties jointly funded scientific ~~analysis~~analyses to assess the compatibility and identify potential issues related to supplying treated surface water from the ~~City of Santa Cruz's~~SCWD's system to ~~Soquel Creek Water District's~~SqCWD's distribution system, which normally only distributes groundwater. The pilot project supplies surface water treated to drinking water standards to a portion of ~~Soquel Creek Water District's~~SqCWD's service area between December and April.

The transfer allows SCWD to divert surface water from its north coast streams when it is available in the winter months that would otherwise flow to the Pacific Ocean and allows ~~the~~ SqCWD to rest some of its groundwater wells. The goal is to maximize the use of regional surface water resources when available and leave more water in the aquifer to address the ~~basin's~~Basin's overdraft condition. Resting SqCWD's groundwater wells also increases groundwater in storage that can be used as a water supply in times of drought. If the pilot is successful (no adverse water quality ~~or~~, health concerns or operational constraints) SCWD and SqCWD ~~will~~plan to negotiate an ongoing agreement to continue the project. SCWD has also applied to amend its water rights to allow the additional diversion of surface water from its other sources to the Basin and neighboring regional groundwater basins.

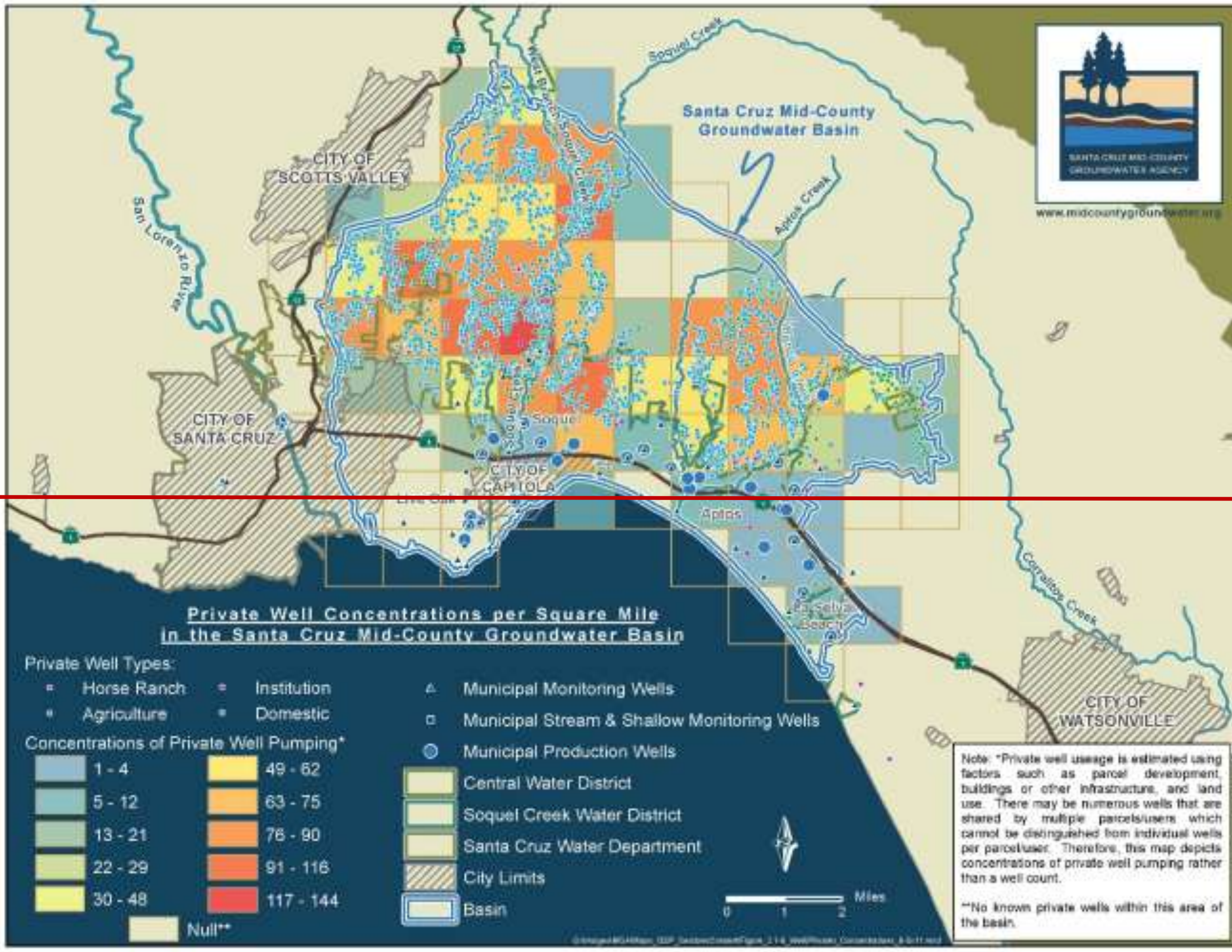
2.1.1.6 Well Density per Square Mile

In 1971, the County of Santa Cruz began requiring permits for water wells drilled within the County. The County collects data to record location, well depth, and local geology for each well drilled. Over time the County has gathered a significant amount of well data. The County estimates that 20 - 40% of water supply wells in use are unpermitted ~~private~~non-municipal wells drilled prior to 1971.

Because the actual number and location of all ~~private~~non-municipal water supply wells is unknown, the MGA developed a ~~private~~ non-municipal well map that uses the best available data to ~~estimate~~identify where non-municipal domestic, agricultural irrigation, and non-municipal institutional wells are in the Basin. The methodology used is described in Appendix 2-B which is a technical memorandum documenting water use estimates used in the Basin GSFLOW model (model). Estimated non-municipal well locations are used together with known well locations to depict Basin well density. ~~Well~~ Per GSP regulations, a well density ~~is estimated using: (1) all available County water well data and (2) supplements County permit data as needed by estimating one private well for each developed parcel that is not served by a municipal water supplier, a small water system, or a permitted private well. This methodology is the same as was used to estimate private wells for the MGA integrated groundwater surface water model (model).~~

~~The Private Well Concentration Map (Figure2-5) shows the location of municipal supply wells, and~~map on Figure 2-6 uses a ~~1~~one-mile square grid ~~overlay within the Basin to identify regional~~

~~well concentration. Few private production~~to show well density across the Basin. Most non-municipal wells are in inland developed rural areas with relatively fewer non-municipal wells ~~are located~~occurring within a mile from the ~~coastline. Most private wells are in developed rural areas farther inland.~~coast. The exception is near the town of Soquel's southwestern border with the City of Capitola, where ~~the~~ Soquel ~~Creek Water District Service Area~~SqCWD's service area does not extend more than one half mile from the coast. At this location there are approximately 70 ~~private~~non-municipal water supply wells within a mile of the coast.



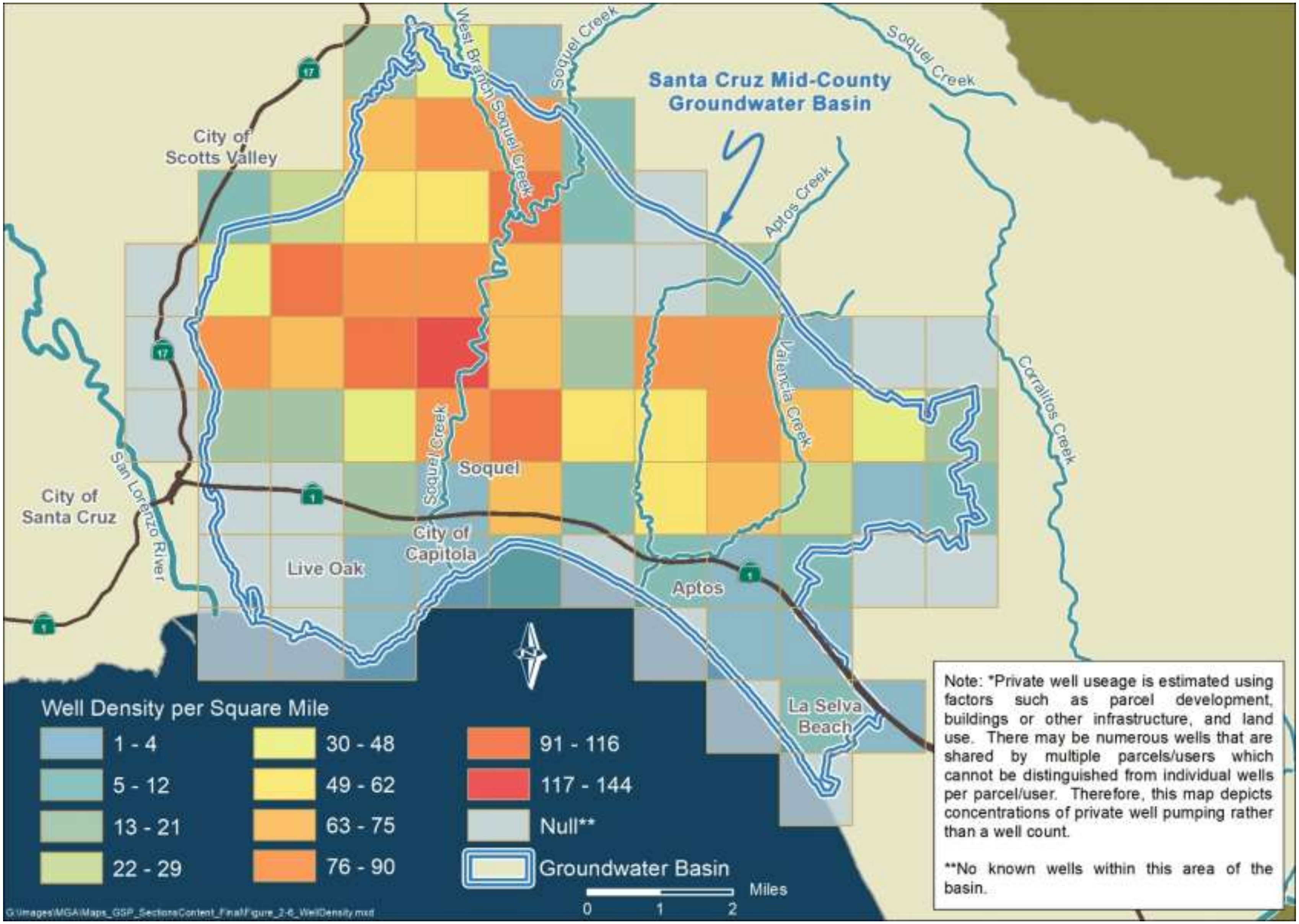


Figure 2-6. ~~Private~~ Well ~~Concentration~~Density per Square Mile

2.1.2 Water Resources Monitoring and Management Programs

MGA member agencies and other government and regional partners have actively evaluated, monitored, and managed the Basin for over 50 years. In the 1960's, the first studies of local groundwater conditions were initiated to understand regional aquifers and water supply challenges facing this coastal area. In 1967, the United States Geological Survey (USGS) led the first definitive regional groundwater resources study in collaboration with three local water management agencies: Soquel Creek Water District, the City of Santa Cruz, and the County of Santa Cruz (~~USGS~~Hickey 1968) shortly after SqCWD and the ~~City~~SCWD began operating groundwater wells inside the Basin.

The 1968 USGS study identified the Purisima Formation as a valuable source of regional water supply, identified the "saltwater wedge" threatening fresh aquifers in the Basin's Purisima and Aromas Red Sands aquifers, and noted that groundwater pumping from the Basin's aquifers had brought saltwater closer to shore. The study also identified seawater intrusion as the primary threat to regional groundwater supplies.

MGA member and regional partner agencies monitor and manage a variety of water resources within Santa Cruz County. There are several monitoring and management programs that MGA member agencies have implemented and use to inform management of municipal pumping in the Basin. These monitoring and management programs cover a variety of Basin water resources including: groundwater, surface water, treated drinking water, wastewater, non-point contaminant sources, and fish habitat.

2.1.2.1 Description of Water Resources Monitoring and Management Programs

Groundwater Management Plan (GMP) – In 1995, Soquel Creek and Central Water Districts partnered to develop a GMP under the provisions of AB 3030 through a Joint Exercise of Powers Agreement (JPA) that established the Basin Implementation Group (BIG). The City of Santa Cruz and County of Santa Cruz joined the GMP team as partner agencies in 2009 when the JPA was amended to expand the BIG. The GMP includes an extensive groundwater monitoring network to monitor productive aquifers together with stream flow and shallow groundwater. The GMP monitoring network extends throughout the Basin and was developed specifically to guide management of aquifers in the Basin. Monitoring is used to assess seawater intrusion, groundwater levels, groundwater quality, municipal production, and surface water interactions. Data collected for the GMP is used to better understand the Basin and to develop adaptive groundwater management strategies that protect the ~~basin~~Basin from harm. The GMP will be replaced by the GSP, which will serve as the groundwater management planning document for the Basin.

The GMP monitoring network includes:

- Approximately 80 dedicated groundwater monitoring wells at 30 locations are used to monitor groundwater levels and groundwater quality on a bi-annual basis in spring and fall
    - Coastal Groundwater Monitoring - 13 of these dedicated groundwater monitoring well locations are used as coastal monitoring wells. Because of the high threat of seawater intrusion in the Basin these 13 well locations are monitored much more frequently than wells further from the coast. These coastal wells are manually monitored for groundwater levels and water quality on a quarterly basis to assess the threat of seawater intrusion. Coastal monitoring wells are also equipped with data loggers to record groundwater levels at 15 minute intervals.
- 2 weather stations monitor temperature, humidity, solar radiation, and precipitation in the Basin,
- 4 rain gauges measure rainfall across the Soquel Creek watershed,
- 3 stream gauges monitor streamflow along different reaches of Soquel Creek,
- 5 shallow groundwater wells monitor the relationship between groundwater levels and stream flow [four on Soquel Creek, one on Valencia Creek],
- SCADA groundwater production monitoring system is used to track and manage groundwater production within Soquel Creek Water District's service area and City of Santa Cruz production wells in the Basin,
- WISKI Database is used to manage and analyze groundwater and surface water monitoring and groundwater production data gathered by the monitoring network.

Cooperative Monitoring/Adaptive Groundwater Management Agreement (CGMA) – In April 2015, the City of Santa Cruz Water Department (SCWD) and the Soquel Creek Water District (SqCWD) jointly developed an agreement to ensure the following groundwater management objectives are met:

1. Protect the shared groundwater resource in the Basin from seawater intrusion,
2. Allow for the redistribution of pumping inland away from the Purisima A-unit offshore outcrop area,
3. Maintain inland groundwater levels that promote continued groundwater flow toward coastal wells and the Purisima A offshore outcrop area to maintain coastal groundwater levels that will abate seawater intrusion,
4. Provide both agencies adequate flexibility to respond to changing water demands, changing water supply availability, and infrastructure limitations.

The CGMA identifies monitoring wells from both agency's existing monitoring networks that have been used to monitor the results of management actions taken to protect against seawater intrusion.

Cooperative Monitoring and Mitigation Measures in Response to Soquel Creek Water District's Operation of the Polo Grounds Well – In 2011, CWD and the SqCWD developed a memorandum of agreement to ensure that SqCWD's operation of a new municipal production well, Polo Grounds Well, would not cause excessive drawdown in nearby CWD municipal wells. The agreement is specifically to avoid substantial harm to CWD wells because of an increased risk of physical damage to any of its wells from groundwater levels falling below the well screen or the pump intake as the direct result of increased localized pumping by SqCWD. Monitoring since 2011 indicates that Polo Grounds Well pumping does not have an impact on groundwater levels in CWD municipal wells.

Monitoring and Mitigation Program for Private Wells (MMP) – SqCWD has agreements with private well owners within a 1,000 meter radius of three new municipal wells to monitor their wells for impacts potentially caused by operation of new municipal wells. As part of the program and at SqCWD's expense, private well owner's wells are installed with meters to monitor production and data loggers to record groundwater levels. Well owner participation is voluntary. The ten-year monitoring period is based upon the date each new municipal production well is put into service. Monitoring data from the municipal production well and nearby private wells are analyzed annually. Under these agreements, corrective action is taken to change municipal production operations if municipal pumping causes restrictive effects on private wells.

Soquel Creek Monitoring and Adaptive Management Plan (MAMP) – SqCWD has a monitoring and adaptive management plan for Soquel Creek. This involves monitoring for impacts on stream baseflow related to pumping in the vicinity of the District's O'Neill Ranch well to modify municipal pumping if pumping impacts are detected. As part of the MAMP, SqCWD installed a new shallow monitoring well, weather station, and stream groundwater level gauge (stilling well); and conducts ongoing monitoring of these and other shallow wells and stream level gauges. This monitoring is a requirement from the District's Well Master Plan Environmental Impact Report (EIR) Mitigation Monitoring and Reporting Program (MRMP). The District will have fulfilled its obligations for this monitoring if no impacts have been observed by 2020.

California Statewide Groundwater Elevation Monitoring (CASGEM) Program – The County administers a countywide collaborative groundwater level monitoring and reporting program to fulfill statewide requirements, with biannual groundwater elevation data provided by local water agencies. CASGEM uses monitoring locations throughout the county, including wells within the Basin, to evaluate regional groundwater levels. Statewide groundwater elevation monitoring through CASGEM has provided DWR with data needed to track seasonal and long-term groundwater elevation trends in groundwater basins throughout the state. CASGEM continues to exist as a tool to help achieve the goals set out in SGMA.

Drinking Water Supply Monitoring – MGA member agencies are responsible for monitoring, testing, and reporting drinking water quality to ensure safe drinking water supplies.

- The State Water Resources Control Board, Division of Drinking Water (DDW) – In addition to GMP groundwater monitoring, municipal water utilities collect, test and report on source water quality to DDW as required by federal and state law. This includes testing raw water supply sources, treated drinking water, and water within local distribution systems. Water is tested for 190 parameters to ensure delivered drinking water complies with all federal and state standards.

- County of Santa Cruz Environmental Health (EH) Drinking Water Program – The County is delegated authority by the State DDW to regulate "state small" water systems (5-14 connections) and small public water systems (15-199 connections) to ensure the water provided through these small water systems meets federal and state water quality standards. The County requires sampling, testing, and reporting of chemical and biological parameters and oversees regulatory compliance for these systems. All systems are also required to report their monthly water production at the end of each year.
    - State Small Water Systems with 5-14 connections are regulated under both county and state regulations through the EH Drinking Water Program. State small water systems are required to provide quarterly bacteriologic water quality results to the County, and additional results on a less frequent basis.
    - Public Water Systems located within communities serving 15-199 connections and those that serve more than 25 people for more than 60 days a year ~~though~~through non-community or transient uses (businesses, schools, restaurants, etc.) are regulated by the EH Drinking Water Program acting for the State Department of Health Services through a Local Primacy Agency agreement. Public water systems are required to provide monthly bacteriologic sampling results to the County, with other results provided on an annual or less frequent basis.

County Groundwater Level Monitoring – County Environmental Health has monitored groundwater levels at 20 private wells in the Basin on a biannual basis since May, 2008. The County will also measure groundwater levels at other wells upon request by the property owner.

County Groundwater Quality Testing – As a condition of approval for new development served by an individual well, County Environmental Health requires submission of data on well production and water quality (nitrate, chloride, total dissolved solids, iron and manganese). Since 2010, the County requires submittal of that data for any new well construction.

Wasteload Allocation Attainment Program (WAAP) for Watersheds in Santa Cruz County – the County of Santa Cruz provides countywide watershed water quality monitoring and reporting for all county jurisdictions to fulfill federal Clean Water Act storm water requirements. The County's WAAP identifies, prioritizes, and makes plans to resolve contaminant issues that could impact the health of the community's surface water and drinking water. The program monitors surface water quality for nitrate and E. coli, identifies impaired waters by comparing monitoring results to federal water quality standards, identifies the sources of pollution, and prioritizes best management practices to bring impaired surface waters into compliance with federal standards.

Integrated Regional Water Management (IRWM) Program - The Santa Cruz IRWM program provides a countywide framework for local stakeholders to manage the region's water and water-related resources. The region's initial IRWM Plan was completed in 2005 and substantially expanded in 2014. The program promotes an informed, locally-driven, consensus-based approach to water resources management. The Plan includes strategies for developing and implementing policies and projects to ensure sustainable water use, reliable water supply, better water quality, improved flood protection and ~~stormwater~~storm water management, and environmental stewardship. More than 80 projects and technical studies have been funded under this program. Prior projects provide data ~~on~~upon which to evaluate storm water capture and recharge projects.

Urban Water Management Planning (UWMP) - As urban water suppliers with more than 3,000 customers and/or distribution more than 3,000 acre-feet per year, SqCWD and SCWD are required to complete Urban Water Management Plans every 5 years under the UWMP Act administered by DWR. All agencies covered by the UWMP ~~act~~Act must assess their water resources needs and availability over a 20-year planning timeframe. The requirements also include a Water Shortage Contingency Plan (WCSP) which incorporates demand mitigation measures that plan for future water shortages. UWMP is used for the purpose of educating the community, providing information for land use planning agencies, and informing the IRWM Plan. The first UWMPs were completed in 1985/1986, with the most recent plans completed in 2015. The next UWMP update is due ~~in 2020~~on or before July 1, 2021.

Santa Cruz County Juvenile Steelhead and Stream Habitat (JSSH) Monitoring Program - The JSSH Monitoring Program is a partnership between the County of Santa Cruz and local water agencies. The annual monitoring program has been in place since 1989 and measures the density of juvenile steelhead across more than 40 sites throughout the San Lorenzo, Soquel, Aptos, and Pajaro watersheds. The program also assesses habitat conditions for steelhead and coho salmon and helps inform conservation priorities throughout the County. There are 27 JSSH monitoring locations within the Basin and 7 more upstream within the Basin watershed. Additional information on this program can be found at the County of Santa Cruz Environmental Health Steelhead Monitoring Program webpage http://scceh.com/steelhead.aspx.

2.1.2.2 Incorporating Existing Monitoring Programs into the GSP

The MGA will leverage current and historic data on groundwater, surface water, and habitat conditions to sustainably manage the Basin as required by SGMA. As discussed in Section 3, all of the sustainability indicators will be monitored primarily using the existing monitoring network but will also include some additional monitoring features that will be installed as part of GSP implementation.

The existing monitoring network will be used to assess sustainability indicators as follows:

- Chronic Lowering of Groundwater Levels – Representative monitoring wells from the existing network are used to directly monitor groundwater elevations in aquifers throughout the Basin.

- Reduction of Groundwater in Storage - All municipal production wells are included in the existing monitoring network and are used to monitor the extracted volume of groundwater in the Basin. Where small water systems and non-de-minimis users report their production data to Santa Cruz County, this information will be included in extraction calculations. Non-metered production will be estimated based on land use information and extrapolations as discussed in Section 2.1.3.

- Seawater Intrusion – The existing coastal monitoring wells are used as representative monitoring wells to monitor chloride concentrations and groundwater elevations relative to protective elevations designed to keep seawater offshore. Additionally, existing monitoring and production wells are used as representative monitoring wells to monitor chloride concentrations to directly monitor potential seawater intrusion.

- Degraded Groundwater Quality – Groundwater quality information from representative monitoring wells within the existing network are used to directly monitor groundwater quality.

- Depletion of Interconnected Surface Water – Groundwater elevations in representative shallow monitoring wells are used as a proxy to monitor impacts of groundwater management on depletion of interconnected surface water. Existing monitoring network stream flow gauges are also used ~~in evaluation of~~to evaluate surface water ~~depletions~~depletion.

- Land Subsidence – this sustainability indicator is not applicable as discussed in Section 3.8.

An important tool used in the development of the GSP is the ~~Basin's integrated groundwater-surface water~~Basin GSFLOW model (model). The model simulates a simplified version of how climate, geology, surface water, and groundwater interact regionally in a complex natural system. The model is calibrated to match known historic conditions and is used to predict future groundwater conditions based on Basin management strategies using the model's climate catalog and inputs related to groundwater demand. Model calibration relies on data collected from existing monitoring networks. Monitoring data will continue to be incorporated in to the model as the GSP is implemented and the groundwater model is improved with future data. In places where there are no measured data, the groundwater model can be used to simulate groundwater conditions until such time that monitoring features are established in these locations. Model development reports and technical memoranda are included in Appendix 2-B through Appendix 2-I. Information from the model and the existing groundwater~~ model and~~ monitoring networks provides a framework to understand regional water resources and their connection to groundwater pumping within the Basin.

2.1.2.3 Description of how those Programs may Limit Operational Flexibility in the Basin

As discussed in Sections ~~2.1.2.1 and 2.1.2.2,~~2.1.2.1 and 2.1.2.2, the existing groundwater monitoring network, developed for Basin management activities under the prior Groundwater Management Plan, is well suited to assessing groundwater pumping impacts on groundwater levels and ~~water~~groundwater quality related to seawater intrusion. ~~This~~These monitoring ~~well~~ data ~~will be~~are used to evaluate SGMA sustainability indicators.

The Soquel Creek Monitoring and Adaptive Management Plan (MAMP) was developed to provide data to evaluate potential stream and shallow groundwater ~~levels~~level impacts related to deep groundwater pumping near Soquel Creek. The MAMP could limit groundwater pumping if pumping impacts are identified. Stream gauges and shallow monitoring wells were installed as part of this monitoring and mitigation obligation that will sunset in 2020 if no impacts are documented. However, Basin monitoring of surface water ~~depletions~~depletion at this location would be hindered by loss of data from the MAMP program. MGA plans to maintain this monitoring effort if and when the MAMP program sunsets.

The Monitoring and Mitigation Program for ~~Private Wells~~private wells currently applies to two wells in SqCWD's service area within the Basin. Operational flexibility can be hindered at these two municipal production well if monitoring indicates impacts to private wells. When SqCWD developed municipal production wells at the Polo and ~~ONeill~~O'Neill sites, it agreed to limit impacts to surrounding private wells within 1,000 feet of these two municipal wells. If increased production is needed at the ~~ONeill~~O'Neill or Polo production wells as part of a pumping redistribution, they cannot be fully utilized if restrictive ~~effect~~effects occur at the nearby private wells. Similar agreements are in place and would take effect at the Granite Way and Cunnison Well sites if and when those municipal wells are developed.

2.1.2.4 Description of Conjunctive Use Programs

Conjunctive use refers to the coordinated use of surface water and groundwater resources to optimize regional water supply and storage management objectives. For the Basin, conjunctive use targets the use of surface water for managed aquifer recharge and/or in lieu recharge. Conjunctive use results in reduced groundwater extraction to leave groundwater in storage for times when excess surface water is not available. Reduced groundwater pumping can lead to increased groundwater levels that can reverse groundwater conditions that have led to overdraft in the Basin. It can also result in groundwater levels that would allow for additional groundwater pumping in times of drought.

The City of Santa Cruz relies upon surface water from outside the Basin (approximately 95% surface water in a typical year), while Soquel Creek and Central Water Districts are dependent upon Basin groundwater for their water supplies. This regional mix in availability of surface water and groundwater resources presents opportunities for future conjunctive use. Interties are in place between the City of Santa Cruz, SqCWD, and CWD but have limited capacity and ~~until~~capabilities. Until December 2018, these interties were historically used only to transfer water between agencies in emergency circumstances. In recent years, as described below, ~~the City~~SCWD and SqCWD have initiated efforts towards conjunctive use.

Current conjunctive use projects in the Basin include:

- Cooperative Water Transfer Pilot Project for Groundwater Recharge and Water Resource Management – In 2015, ~~the City~~SCWD and SqCWD entered into a Cooperative Water Transfer and Purchase Agreement to collect information to further assess the potential opportunities to reduce groundwater pumping in the Basin through surface water transfers from SCWD to SqCWD. Under this agreement, SqCWD purchases excess surface water from SCWD to meet part of its water demand. This allows SqCWD to reduce groundwater pumping, reduce the potential to accelerate seawater intrusion, and contribute to reversing Basin overdraft conditions that impacts beneficial users of groundwater. SCWD began transferring excess surface water to SqCWD in December 2018. ~~-~~This pilot study transfers surface water using an existing ~~interties~~intertie to determine if the introduction of surface water into SqCWD's groundwater only infrastructure could be accomplished without negative impacts to water quality~~.~~ delivered to SqCWD's customers. Operational and health considerations will also be used to evaluate water transfers.

- Aquifer Storage and Recovery (ASR) Pilot Testing – in 2017 SCWD made significant progress assessing the feasibility of ASR in the Basin and neighboring Santa Margarita Groundwater Basin. SCWD began its ASR pilot test in December 2018 at Beltz Well 12 located at the City's Research Park facility within the Basin. SCWD's pilot project injects excess surface water treated to drinking water standards near its service area boundary with SqCWD. The goal of ASR pilot testing is to assess the feasibility and potential impacts of ASR on groundwater levels and groundwater quality. Groundwater will be extracted and sampled for a variety of parameters. Groundwater level changes related to the pilot tests will be monitored by both SCWD and SqCWD. These ASR tests will also assess how much water is lost as outflow from the aquifer and how much water can be recovered for supply during times of drought.

2.1.3 Land Use Elements or Topic Categories of Applicable General Plans

2.1.3.1 Summary of General Plans and Other Land Use Plans ~~Additional GSP Elements~~

The Basin covers a land area of approximately 56 square miles and includes land areas under the jurisdiction of three municipalities: the County of Santa Cruz, the City of Santa Cruz, and the City of Capitola. Each municipality has an adopted general plan with land use classifications that identify desired development, open space, and conservation purposes. Also included within the Basin are state lands managed by the California Department of Parks and Recreation. The Soquel Creek Demonstration Forest, managed by the Department of Forestry and Fire Protection is located just outside the Basin but occupies much of the upper Soquel Creek Watershed.

All three municipal jurisdictions within the Basin have general plans, local coastal programs, zoning regulations, and development standards that determine the location, type, and density of growth allowed in the region. The ~~General Plan~~general plan serves as the principal policy and planning document guiding long-range land use and conservation decisions in cities and counties. General plans go through rigorous environmental review to understand and mitigate potential adverse impacts related to general plan implementation activities.

The cities of Santa Cruz and Capitola have both completed comprehensive updates to their ~~General Plans~~general plans in the last few years. The Santa Cruz City General Plan timeline extends to 2030, and Capitola's General Plan has a 20 to 30~~-~~-year planning horizon. The County's current General Plan was adopted in 1994. The County has recently prepared and adopted a Sustainable Santa Cruz County ~~plan~~Plan addressing sustainable land use, housing, economic development, and transportation objectives in the urban area of the County (Santa Cruz County, 2015). The time horizon of ~~that~~the County's plan is through 2035. The Housing Element of the County's General Plan was updated in 2015. The County is currently preparing a general plan update to incorporate the Sustainable Santa Cruz Plan into the County General Plan.

The County General ~~plan~~Plan contains two additional components that have significant effect on management of water resources in the Basin. In 1978, the voters passed Measure J, which called for a comprehensive growth management system, including population growth limits, the provision of affordable housing, preservation of agricultural lands and natural resources, and the retention of a distinction between urban and rural areas. This has resulted in greatly diminished development density and growth rates in areas outside of the urban services line that do not receive municipal water service. Each year when the Board of Supervisors adopts the growth goal and annual building permit allocation, limitations of water supply are taken into consideration.~~ Additionally, the~~

The Conservation and Open Space Element of the County General Plan includes many policies and programs for protection and management of groundwater resources~~ and recharge areas. Many of these polices are incorporated into County Code~~, recharge areas, wetlands, streams, riparian corridor, and sensitive habitat areas. Many of these polices are incorporated into the County Municipal Code. These policies, programs, and code requirements were reviewed during development of GSP elements for depletion of surface waters and groundwater dependent ecosystems. The County General Plan maps of recharge areas, sensitive habitats and biotic resources were also utilized. The Conservation and Open Space Element is currently in the process of being updated and wording has been proposed to incorporate references to the GSP into the updated General Plan.

Most growth and development that does happen going forward is expected to be concentrated within the confines of the areas served by MGA's municipal water agencies. Because of the relative scarcity of raw land for urban development, the majority of future growth in these area is likely to be achieved through redevelopment, remodeling, increased density on underutilized land, and infill development in the urban areas and along major transportation corridors, along with new construction on the little amount of vacant land remaining.

Within the Basin, the Coastal Zone extends approximately 1000 yards inland from the coast. Within that zone, many of the major decisions made by local governing bodies about public improvements and private development are also subject to the review and oversight of, or may be appealed to, the California Coastal Commission. Accordingly, land use changes tend to occur slowly, if at all, and only after extensive public review.

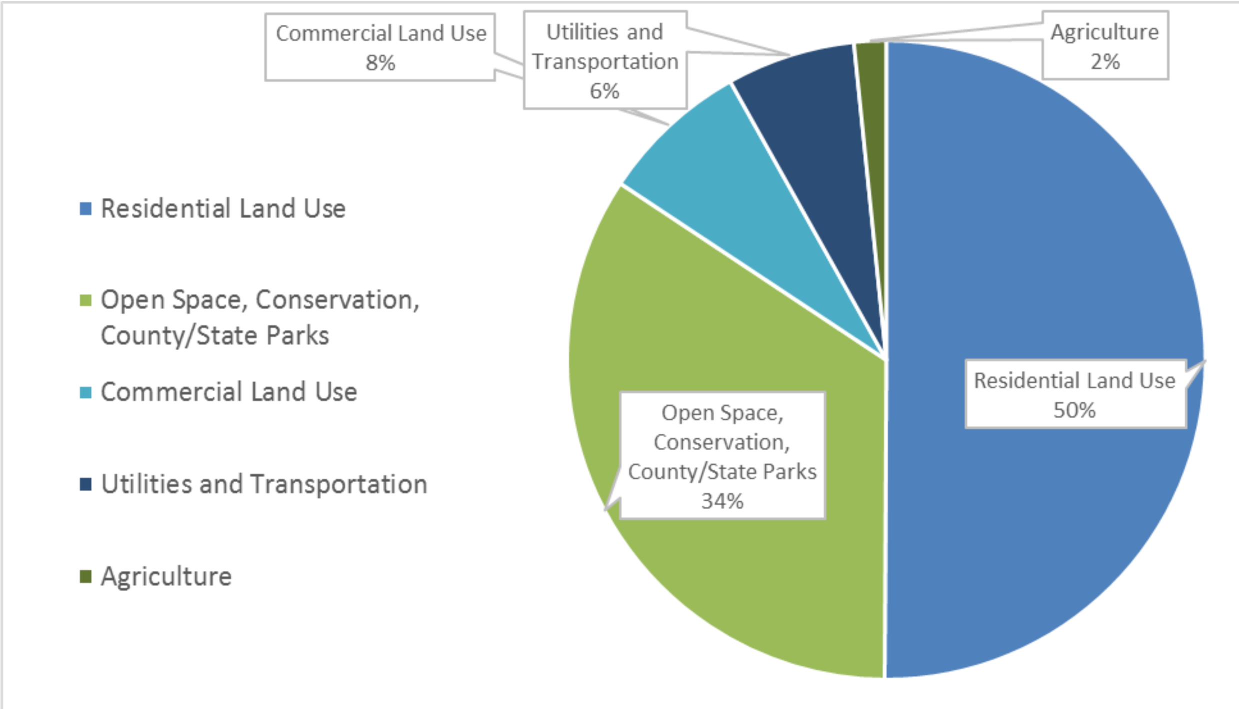
State general plan guidance was significantly revised in 2017. Changes to planning laws triggered these revisions, including SGMA's requirement that general plans consider water supply at their next update.[1] Any significant update to a general plan, including to its housing element,[2] will trigger the SGMA mandate to consider development impacts on groundwater supply. MGA staff met with panning staff from Santa Cruz County and the cities of Capitola and Santa Cruz during the public comment period on the Draft GSP. The purpose of these consultations was to discuss the purpose of SGMA, the content of the GSP, to support future comprehensive land use planning and GSP updates, and to facilitate ongoing compliance with SGMA land use planning consultation requirements.

2.1.3.1.1 Existing Land Use Designations

The Basin is dominated by residential land uses, which make up approximately 50% of Basin land acreage (Figure 2-7). Residential uses vary between large rural parcels with few impervious surfaces to suburban and urban residential parcels associated with higher development densities and surrounded by more impervious surfaces, wider roads and more sidewalks. The next most abundant land use in the Basin is open space, which makes up approximately 34% of Basin land area. Open spaces include areas reserved for conservation, or developed as county and state parks, urban parks, fields, ~~fairgrounds,~~ and undeveloped lands. The least abundant land use categories serve commercial, utilities and transportation, and agricultural uses.

[1] http://opr.ca.gov/planning/general-plan/

[2] General plans are long range planning documents, however, general plan housing element updates are required on either a five year or eight year planning cycle. This schedule strengthens the connection between housing and transportation planning, to better align the schedules for regional housing needs assessments and local government housing element updates with schedules for adopting regional transportation plans. All Basin municipalities are on an eight year housing element update schedule. The next update is due in 2023.



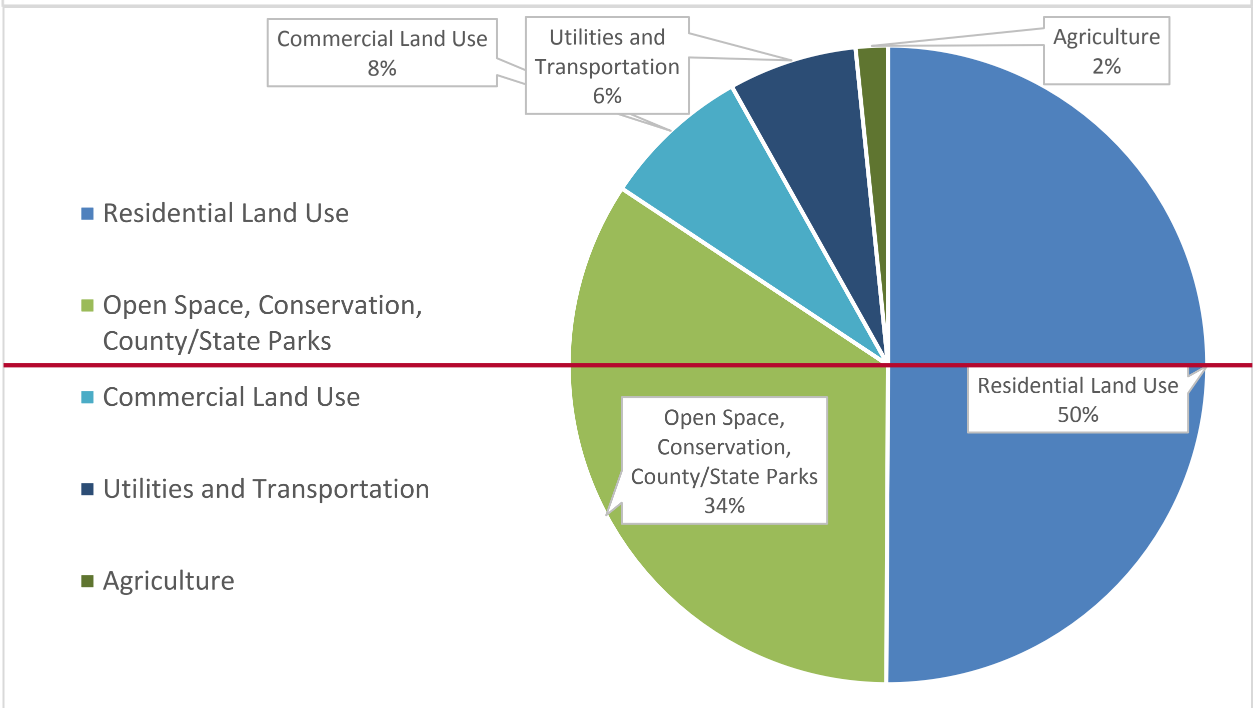


Figure 2-7. Basin Land Uses ~~in the Basin~~

2.1.3.1.2 Agricultural Water Demand – Specialized Evaluation

The Assessor's Use Codes that designate land uses on individual parcels based on the actual observed land use are a useful tool to evaluate the generalized land use within a large area. However, because the water demand for different crops varies widely, these land use designations do not necessarily reflect how water is being used on an individual parcel. More detail is particularly important to understand the water use characteristics for agricultural properties or sites with extensive irrigation (Figure 2-8).

Knowing that most large irrigators do not use municipal water, the MGA determined that it would be appropriate to conduct an exercise to improve the understanding of the amount of water used in the ~~basin~~Basin by agricultural irrigators. Staff from the County worked with technical consultants to map the location and acreage of irrigated land and nurseries in the Basin using aerial imagery. An initial assumption of crop type and irrigation status was made from the images and then verified in the field by County staff.

Crop-based water use factors – an annualized estimate of the amount of water required for different crops and land uses - were applied to the amount of land in production. According to ~~that~~this exercise, there is approximately 660 acre-feet per year of water being pumped from the Basin for use in agricultural production and large scale irrigation that is not being provided by the Basin's municipal water agencies. The model applies a 20% return flow rate to outdoor irrigation, making the net water impact closer to 528 acre-feet per year.

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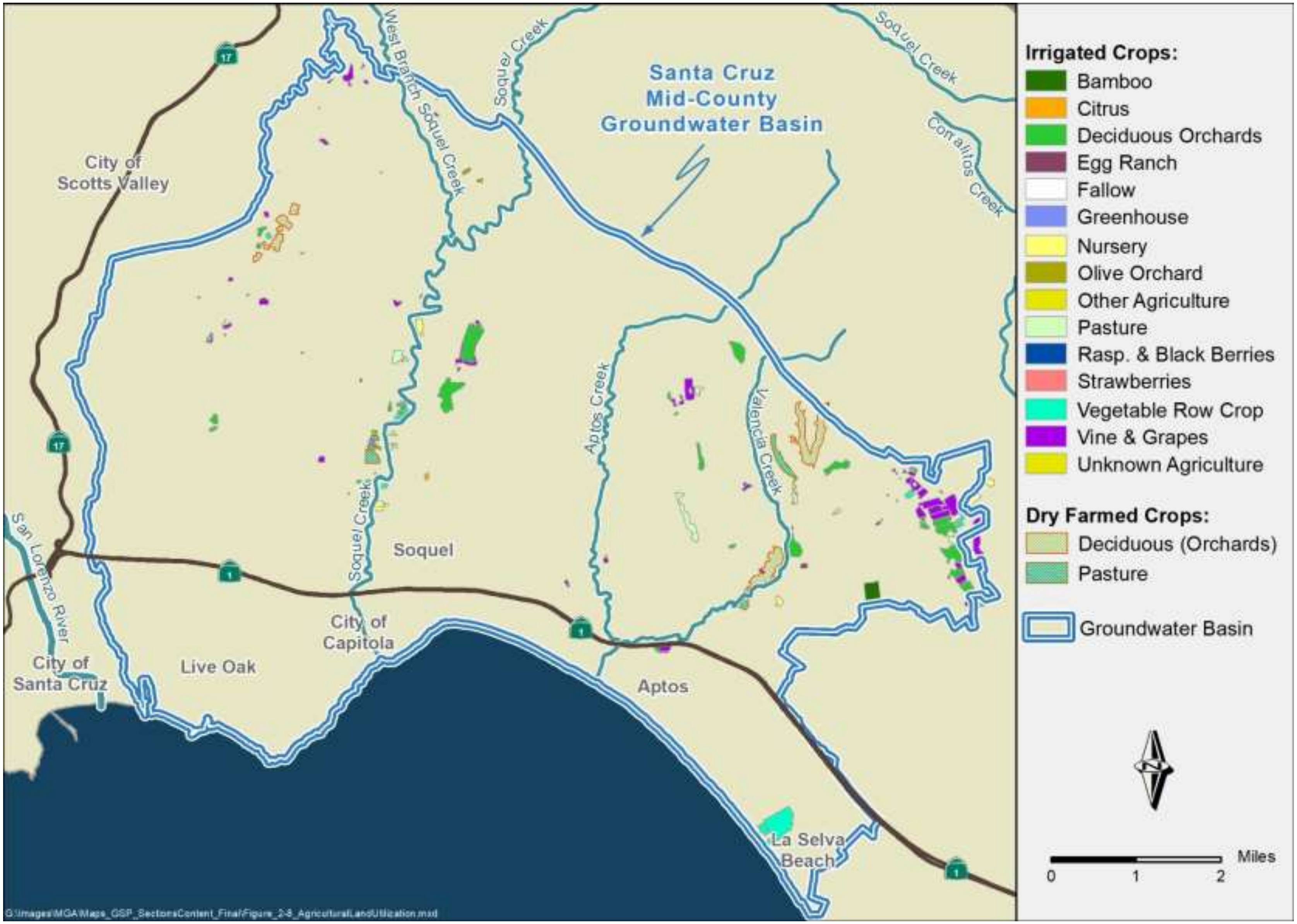
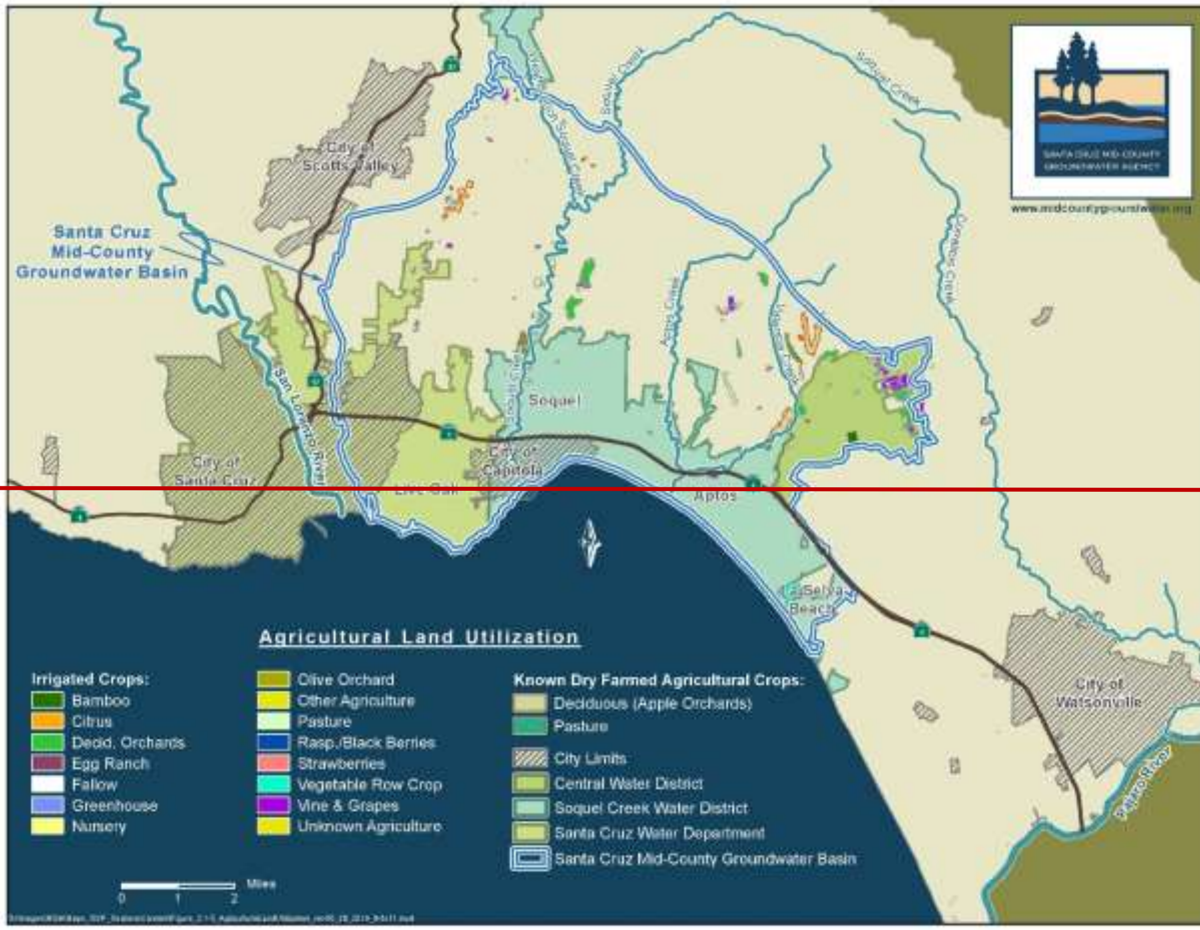


Figure 2-8. Agricultural Land Utilization within the Santa Cruz Mid-County Basin

The MGA acknowledges that there is room for error in this agricultural irrigation water ~~evaluation~~use estimation process. To ~~remedy that and therefore~~ get a more accurate ~~picture~~estimate of the impact of these users on the Basin, the MGA is proposing a metering program which is discussed in Section 5.1.1.4.3. The metering program will be applied to irrigators throughout the Basin estimated to use 5 acre-feet per year or more, or in priority areas using 2 acre-feet per year or more, based on the exercise described above.



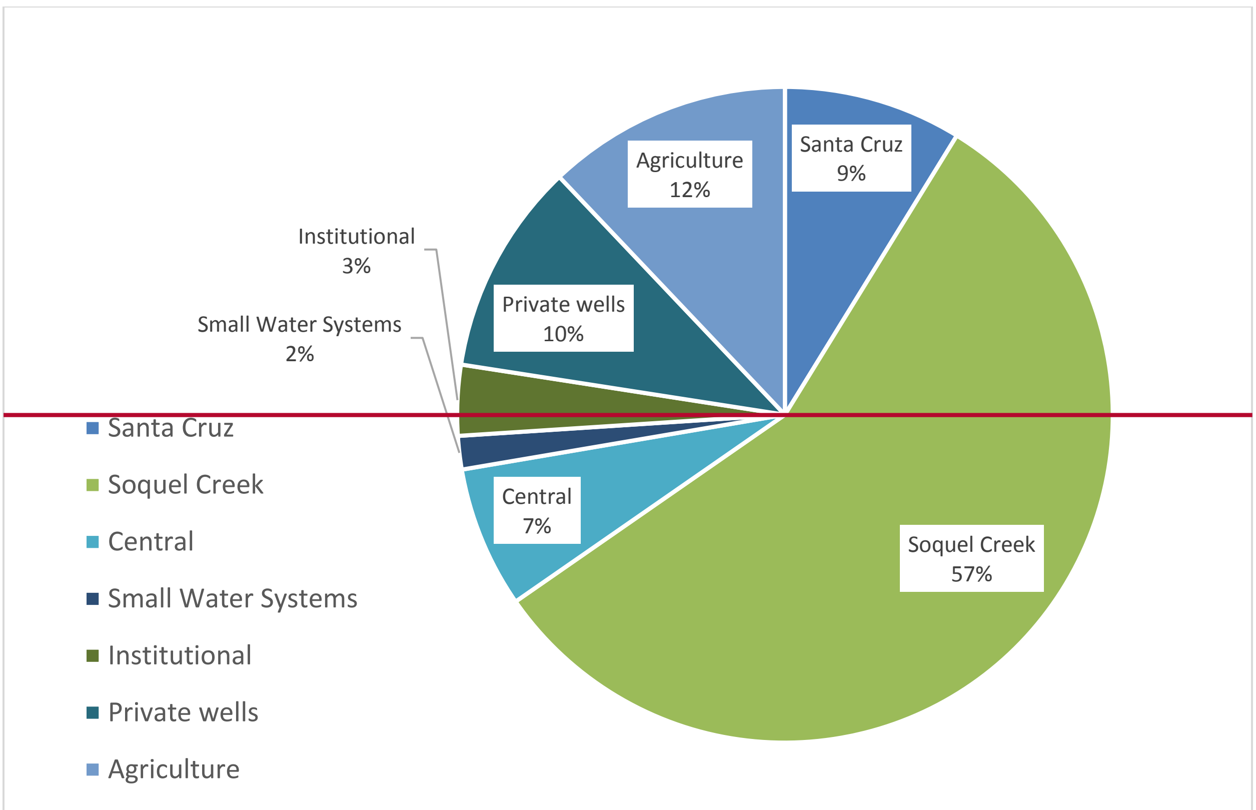
~~**Figure 2-7. Agricultural Land Utilization**~~

2.1.3.1.3 Basin Water Demand

Basin water demand is the amount of water used for an identified time period, typically per person per year for municipal residential uses, per parcel for rural residential land uses, per acre by crop type for acreage in agricultural production, and per acre per year for other land uses. The forecast of future Basin water demand is a complex and foundational component of sustainability planning to account for the water requirements of all Basin water users and uses.

In recent years, historical patterns of water demand have been upended by a variety of factors, including the cumulative effects of tighter efficiency requirements for appliances and plumbing fixtures, greater investments in water conservation, a significant uptick in water rates, an equally significant downturn in economic activity during the Great Recession, and greater awareness of the need for on-going water conservation because of long term droughts in California. These events have resulted in even more uncertainty than usual regarding future water demand and have placed even greater importance on sorting out the effect each has had on demand in recent years as well as how they are likely to affect water demand going forward.

Basin water production is measured by MGA's municipal water producers that supply water to customers. Basin water production by ~~private~~non-municipal wells that are not metered is estimated using data from wells serving similarly situated properties that are metered. Most small water systems and non-municipal institutional users are now metered and report annual use~~.~~ to the County. Agricultural water production is estimated by land area in production and water use by crop type~~.~~ as discussed in Section 2.1.3.1.2. ~~Figure 2-8~~ Figure 2-9 shows the amount of Basin groundwater produced by pumper category. Approximately 2% of the non-municipal domestic category includes use for small water systems.



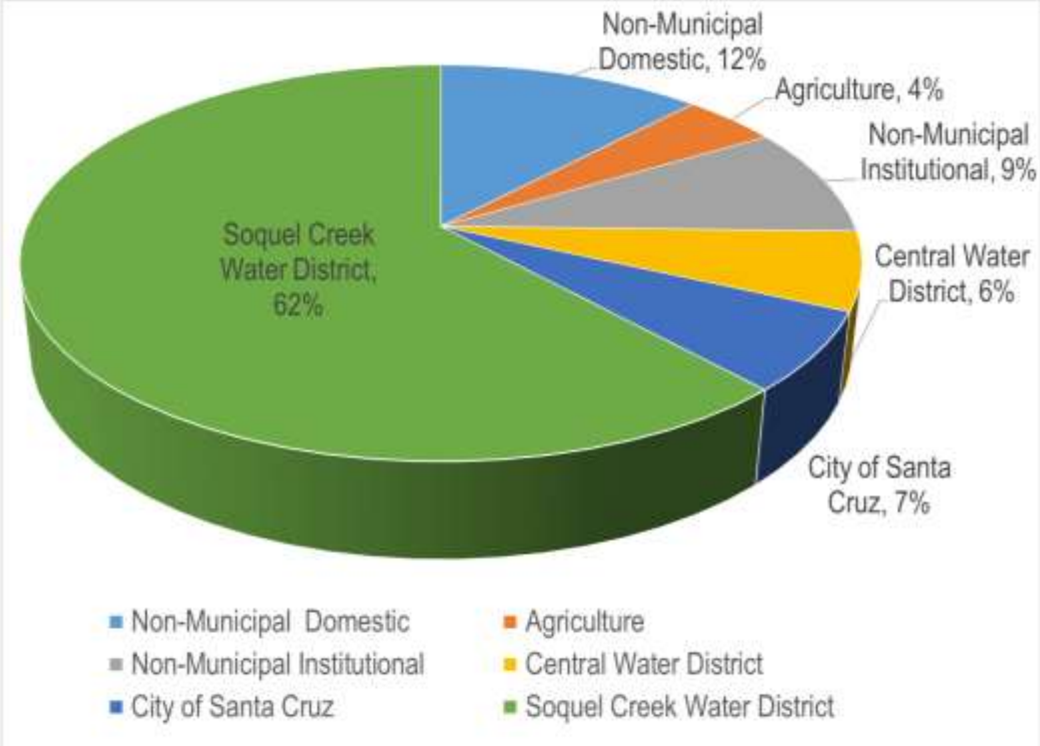


Figure 2-9. Average Annual Basin Groundwater Production by User Type

2.1.3.1.4 Projected Water Demand

Projected non-municipal groundwater demand for domestic use assumes pre-drought (2012 – 2015) water demand of 0.35 acre-feet per year per household. The assumed water demand is applied to projected annual population growths of 4.2% pre-2035 and 2.1% post-2035. Actual growth in non-municipal demand is expected to be much lower, based on current actual growth rates and more recent projected growth rates of only 0.2% per year through 2040 as estimated by the land use agencies. Groundwater demand for larger institutions such as camps, retreats, and schools, and agricultural irrigation remain the same as historical demands. The groundwater model also takes into account the significant amount of return flow from septic systems associated with most rural users.

Projected ~~baseline~~Baseline municipal groundwater demand (without projects and management actions) is based on several different assumptions:

- Central Water District - pre-drought average groundwater production of 550 acre-feet per year from Water Year 2008 through 2011.
- Soquel Creek Water District - 2015 Urban Water Management Plan (UWMP) projects demand to increase to 3,900 acre-feet per year after historically low pumping achieved from 2010-2015. The 2015 UWMP projects subsequent long-term decline of demand to 3,300 acre-feet per year, but these demands may have been underestimated; for example, new laws facilitating Accessory Dwelling Units have passed since 2015. For

projected water budget, the GSP projects that Soquel Creek Water District groundwater demand ~~will be~~remains stable.

- City of Santa Cruz – projections of groundwater pumping in the Basin are based on City of Santa Cruz ~~Confluence~~confluence modeling to meet demand during 2016-2018. The pumping is expected to be between 339 and 369 acre-feet per year. The City considers this demand appropriate for current planning because unlike most other communities in the Bay Area and California, City water demand has not increased much from restricted consumption during the 2012-2015 drought (~~SCWD, 2019, and M.Cubed, 2019~~ (SCWD, Water Commission Information Report on Joint Workshop with Former Water Supply Advisory Committee. Attachment 2 (Water Demand) 2019) and (M.Cubed 2019)).

2.1.3.2 Description of How Implementation of the GSP May Change Water Demands or Affect Achievement of Sustainability and How the GSP Addresses Those Effects

As discussed later in Section ~~2.2.2,~~2.2, Basin water managers' focus to reduce water demand and redistribute groundwater pumping to protect the Basin against seawater intrusion has resulted in significant progress toward recovering Basin groundwater levels. This progress toward Basin sustainability, that began to show results over the past 25 years, means that the Basin's GSP implementation strategies can focus on technically feasible locally sourced water augmentation strategies that are already well into engineering, permitting, and pilot testing phases by MGA member agencies.

The model was used to evaluate water augmentation projects outlined in Section 4 under climate and sea level rise scenarios. If these water augmentation strategies are implemented and perform as expected, no land use or water demand changes are expected to be required to attain sustainability in the Basin.

2.1.3.3 Description of How Implementation of the GSP May Affect the Water Supply Assumptions of Relevant Land Use Plans

The model calculates that the water supply assumptions of existing land use plans will be supported by ongoing water conservation, groundwater pumping redistribution as described in Section 4, Group 1, and the development of locally sourced water augmentation projects as described in Section 4, Group 2. Additional statewide water conservation legislation is likely to lead to further water use efficiency without requiring significant land use changes or water use curtailment in the Basin. However, should the MGA, its member agencies, or the state determine that the Basin is failing to achieve adequate progress toward sustainability, additional projects from Section 4, Group 3 may also be implemented.

2.1.3.4 Summary of the Process for Permitting New or Replacement Wells in the Basin

Basin well permits are issued by the county and cities within their respective municipal boundaries. These agencies include the cities of Santa Cruz and Capitola within city boundaries and the County of Santa Cruz in the unincorporated areas. Each agency relies on water well standards developed and updated by the California Department of Water Resources. Each agency then specifies any additional requirements in its municipal code that apply to well installation and destruction within its municipal boundaries.

The Water Director is responsible for issuing water well permits within the City of Santa Cruz boundaries. Santa Cruz City water well permit requirements are outlined in the city's municipal code section 16.06 found here: http://www.codepublishing.com/CA/SantaCruz/

The County Environmental Health Division of the Health Services Agency is responsible for issuing water well permits within Capitola city boundaries. City of Capitola water well permit requirements are outlined in the city's municipal code section 8.24 found here: http://www.codepublishing.com/CA/Capitola/?Capitola01/Capitola0101.html&?f

The County Environmental Health Division of the Health Services Agency is responsible for issuing water well permits within the unincorporated areas of Santa Cruz County. Santa Cruz County water well permit requirements are outlined in Chapter 7.70 of the County Code, found here:
http://www.codepublishing.com/CA/SantaCruzCounty/html/SantaCruzCounty07/SantaCruzCounty0770.html

Both Capitola and the County of Santa Cruz have well drilling restrictions that limit issuance of well permits within Soquel Creek Water District's service area due to concerns related to groundwater overdraft and seawater intrusion. These restrictions have been in place since 1981. The County also requires documentation of water efficiency measures as a condition of approval for any well serving any proposed groundwater use expected to use greater than two ~~(2)~~ acre-feet per year.

The County will update its well ordinance to implement elements of this GSP, including metering requirements for non de minimis users. The County will also address the need to prevent impact on public trust values in surface water from new wells, depending on how this issue evolves in the State. This could include a requirement for increased setbacks from streams and/or deeper seals to reduce the potential to draw from alluvim that is in direct hydraulic contact with a stream.

2.1.3.5 Information Regarding the Implementation of Land Use Plans Outside the Basin that Could Affect the Ability of the Agency to Achieve Sustainable Groundwater Management

Except for the City of Scotts Valley to the northwest Basin boundary, MGA member agencies control land use planning and implementation in the areas outside and contiguous to the Basin boundary. The City of Santa Cruz is the land use planning jurisdiction for the areas outside the western Basin boundary and the County of Santa Cruz has land use jurisdiction over the remainder of the areas adjacent to the Basin.

Santa Cruz County is a relatively small county and MGA member agencies have developed good regional partnerships with neighboring land use jurisdictions, water management agencies, and GSAs. The City of Scotts Valley is a participant in planning for groundwater sustainability in the Santa Margarita Groundwater Agency (SMGWA), as are MGA member agencies the City of Santa Cruz and Santa Cruz County. MGA members will continue to work collaboratively with our regional partners to coordinate groundwater management efforts that ensure groundwater sustainability is achieved throughout Santa Cruz County.

2.1.4 Additional GSP Elements

2.1.4.1 Control of Seawater Intrusion

The 1968 USGS groundwater study identified seawater intrusion as the greatest threat to the Basin's groundwater supplies (~~USGS~~Hickey 1968). The report documented a seawater wedge offshore of the Basin's productive aquifers and noted that seawater had likely moved toward the coast in response to groundwater pumping. Subsequent to those findings, saltwater began to appear in wells in the southern quarter of the Basin as well as at the Soquel Point area to the northwest. Coastal groundwater monitoring data in both the Purisima and Aromas Red Sands formations indicate that the seawater wedge has moved further onshore since the 1980s. In response to this and other information, and prior to the passage of the Sustainable Groundwater Management Act in 2014, the agencies that rely upon groundwater from the Basin identified management strategies to prevent further seawater intrusion.

Seawater intrusion management strategies include:

1. Research to understand the regional hydrogeology and groundwater budget, including the development of an Hydrogeologic Conceptual Model;
2. Develop water conservation programs to reduce water demand;
3. Implement tiered water pricing structures to incentivize water conservation;
4. Manage groundwater pumping to more accurately align groundwater extraction rates with groundwater recharge rates;

5. Relocate municipal groundwater pumping inland where extraction is less likely to draw seawater on shore;

6. Establish “protective groundwater elevations” to develop a freshwater “dam” to act as a barrier to prevent drawing seawater further on shore; and

7. Evaluate the effectiveness of the management strategies, conduct coastal groundwater quality and elevation monitoring.

In 2014 SqCWD declared a groundwater emergency and continues to implement provisions of a Stage 3 water shortage emergency and its Water Demand Offset Program requires that new development fund a net reduction in total water use as a pre-condition to receive water service.

As a result of better management and increased water conservation leading up to and during Water Year 2016, municipal pumping in the Basin was the lowest recorded since 1977 and average groundwater levels met established protective elevations at eight of the 13 coastal monitoring wells, the most since the monitoring well system was installed. The decrease in water demand corresponded with increased public awareness about the importance of sustained water conservation in response to the 2011-2015 California drought, curtailment programs instituted by local water agencies, and drought related actions by the state of California. Since the state declared an end to the drought, municipal water demand in the Basin has increased since Water Year 2016 with municipal pumping in Water Year 2018 totaling an estimated 4,360 acre-feet per year, an increase of 9% compared to Water Year 2017 and an increase of 11% compared to Water Year 2016.

The Basin remains vulnerable to seawater intrusion until coastal groundwater levels rise to protective elevations at all coastal monitoring wells. Currently, five coastal monitoring wells have average groundwater levels below their established protective elevations. Full basin recovery has not been achieved, and the ~~basin~~Basin is still considered in long-term overdraft due to ongoing sweater intrusion.

In 2017, MGA commissioned an aerial geophysical survey to determine the status of seawater intrusion in the upper aquifers near shore off the coast of the Basin. The survey is documented in Hydrogeological Investigation Salt-Fresh Water Interface – Monterey~~ (Ramboll 2018~~ (Ramboll 2018)) and in a technical memorandum titled Management Implications of SkyTEM Seawater Intrusion Results (~~Hydrometrics WRI 2018).~~ (Hydrometrics WRI 2018)). The survey confirmed the existing locations of known seawater intrusion and provided information on the current location of the advance of seawater in regional aquifers below the sea floor. The MGA intends to repeat this survey over time to track the movement of the freshwater-saltwater interface to inform the MGA’s assessment of seawater intrusion.

2.1.4.2 Wellhead Protection Areas

MGA member agencies act to maintain groundwater quality through land use policies and restrictions to protect well production sites, this includes:

- Working with land use agencies to regulate potentially hazardous land uses that could impact productive aquifers; and
- Following well construction and abandonment procedures outlined by the state and overseen by the county to limit the migration of contaminates into groundwater.

The 1996 federal Safe Drinking Water Act amendments require each state to develop and implement a Source Water Assessment Program. In response, California developed the Drinking Water Source Assessment and Protection (DWSAP) Program which includes a source water assessment program and a wellhead protection program. The DWSAP Program addresses both groundwater and surface water sources. The groundwater portion of the DWSAP Program serves as the wellhead protection program. In developing the surface water components of the DWSAP Program, the state integrated the existing requirements for watershed sanitary surveys. MGA member agencies maintain and update their DWSAP reports for each of their production well sites.

MGA member wellhead protection projects include:

- MGA member agencies implement the Santa Cruz County well abandonment requirements (see ~~subsection 2.1.4.4~~Section 0 below);
- Santa Cruz County, with funding support in part from a Proposition 50 IRWM grant, implemented a well destruction program in 2012 that destroyed four abandoned wells in the Basin;
- MGA member agencies submitted ~~DWSAP updates~~DWSAPs:
  - Soquel Creek Water District has submitted ~~a~~ DWSAP ~~report~~ for ~~the O'Neill Ranch well in 2014, Aptos Jr. High and Polo Grounds~~all its production wells. Access to ~~State Department of Public Health in 2011 (HydroMetrics WRI, 2011b and 2011c);~~all SqCWD DWSAP reports (SqCWD, 2019) is at: https://www.soquelcreekwater.org/documents/reports (use Report type "Water Quality", keyword "DWSAP" in search fields).
  - Central Water District submitted ~~updated~~ DWSAP reports for all its wells in 2009 (Johnson, 2009~~) to State Department of Public Health in Water Year 2009;~~);
  - City of Santa Cruz ~~updated DWSAP report for Beltz 10 in 2009 and~~has submitted ~~the~~ DWSAP ~~report~~reports for all their production wells with the most recent being the Beltz 12 DWSAP in 2015.

2.1.4.3 Migration of Contaminated Groundwater

The County of Santa Cruz Environmental Health Division (EH) administers programs to benefit groundwater and control the migration of contaminants:

Land Use - Sewage Disposal - Waste Water Management
In this role, EH provides guidance and regulatory oversite of onsite sewage disposal for new and existing development outside sewered areas. EH oversees design review of new onsite wastewater treatment and greywater systems as well as repairs and modifications to existing on-site wastewater treatment systems. This work includes the certification of wastewater system operators and siting systems to ensure waste water systems protect against degradation of groundwater wells and drinking water quality.

Hazardous Materials Programs - Certified Unified Program Agency (CUPA)
In 1996 the California Environmental Protection Agency designated EH as the "Certified Unified Program Agency" (CUPA) within the geographic boundaries of the County ~~(~~, including all four Cities~~)~~. As the CUPA, EH is responsible for enforcing State statutes, regulations, and local ordinances (Chapter 7.100) for the storage, use, and disposal of hazardous materials and hazardous wastes. EH oversees preparation and management of site specific Hazardous Materials Management Plans (Business Plans), Hazardous Waste Generator and Tiered Permitting, Underground Storage Tanks (UST), California Accidental Release Prevention (Cal ARP), and Aboveground Petroleum Storage Tanks.

Site Mitigation
EH oversees the cleanup of property contaminated with toxic chemicals through illegal dumping or disposal, from leaking underground storage tanks, or through accidental release during residential, industrial, or commercial activities. The site mitigation program protects public health and the environment through oversight of cleanup projects to verify that contaminated sites are adequately characterized, remediated, and closed under current cleanup standards.

Water Resources
EH provides collaborative support to other County departments, local agencies, city departments, special districts, and non-governmental organizations to solve water resources and environmental issues through long-range water supply planning, water quality protection, and watershed management. This work is important because Santa Cruz County waters are locally derived through rainfall and provide drinking water for residents and visitors, critical habitat to numerous threatened and endangered species, and opportunities for recreational and commercial activities. The County faces many water resource challenges including impaired water quality, inadequate water supply, overdrafted groundwater basins, depleted streams, and degraded riparian habitat.

2.1.4.4 Well Abandonment and Well Destruction Program

The County of Santa Cruz issues well destruction permits for wells being abandoned within the Basin. The purpose of the County's well abandonment and well destruction policies is to prevent inactive or abandoned wells from acting as vertical pathways for the movement of contaminants into groundwater. Well destruction requirements are found in the County Code, Chapter 7.70.100. A link to Santa Cruz County Code's water well requirements, including well abandonment and destruction is found here: http://www.codepublishing.com/CA/SantaCruzCounty/html/SantaCruzCounty07/SantaCruzCounty0770.html

2.1.4.5 Groundwater Recharge and Replenishment of Groundwater Extractions

The 1980 County General Plan included designation of primary groundwater recharge areas and included policies for the preservation of recharge quantity and quality. Those provisions have been maintained in subsequent general plan and code updates and have recently been strengthened through the adoption of stormwater management policies that require maintenance of pre-project infiltration rates for new development and redevelopment projects.

The Resource Conservation District of Santa Cruz County and the University of California, Santa Cruz - Hydrogeology Group recently completed a joint project funded by the California Coastal Conservancy, entitled "Regional Managed Aquifer Recharge and Runoff Analysis in Santa Cruz County, California" (~~Recharge and Runoff Study).~~Fisher et al., 2017). The project studied the possibility for effective groundwater replenishment throughout Santa Cruz County, including within the Basin. ~~The study~~It identified surface soils throughout the county where groundwater recharge was most probable as well as compiling a series of subsurface conditions that can impact recharge suitability. A program outline is available at: http://rcdsantacruz.org/managed-aquifer-recharge

Groundwater replenishment projects within the Basin fall in to three general categories:

- In-Lieu Recharge – The practice of using available excess water such as winter surface water, treated to drinking water standards, to supply existing water customers who typically rely on groundwater. This practice passively increasing groundwater stored in the Basin by resting groundwater production wells that would otherwise serve those customers.

  - The City of Santa Cruz and Soquel Creek Water District began piloting an in-lieu recharge project in November 2018. Project planning included scientific water quality and infrastructure studies to determine water compatibility and a determination that adequate surface water was available to supply the pilot study.

- Aquifer Storage and Recovery (ASR) – The process of injecting water treated to state standards into the groundwater basin to actively recharge ~~that basin~~the Basin to provide storage for subsequent extraction.

- ~~o~~ The City of Santa Cruz is actively pursuing drought storage solutions that include ASR project studies in both the Basin and the Santa Margarita Groundwater Basin to the north. Initial groundwater modeling results for the Basin indicate that a City ASR program can assist groundwater recharge in the Basin, but careful management is needed to balance groundwater withdrawals with ongoing groundwater sustainability requirements.

- Stormwater Recharge – The collection and treatment of stormwater runoff for the purpose of recharging the ~~groundwater basin.~~Basin. Stormwater treatment often relies on natural filter materials including bioswales and native soils to protect the groundwater from infiltration of contaminants present in stormwater. However, other filter materials and pretreatment can be used to address identified source contaminants present in stormwater. A best management practice for stormwater recharge is to allow at least a 10 foot zone of separation between the infiltration area and the seasonally high groundwater elevation, in order to allow for pollutant attenuation through the unsaturated zone.

    - Inside the Basin, the County of Santa Cruz is partnering with the Resource Conservation District of Santa Cruz County (RCD) and Soquel Creek Water District to further assess and develop groundwater recharge sites. The County has developed two stormwater recharge projects inside the Basin at Polo Grounds Park and Brommer Park.

    - Potential stormwater recharge sites identified in the Recharge and Runoff Study have been investigated further by using advanced geophysical techniques. Two of these sites are still in the selection process. Further studies and additional funding sources are needed to develop projects at these sites.

~~Outside the Basin, PV Water has implemented a pilot program with the RCD to develop recharge projects on suitable private lands to recharge groundwater in PV Water's management area, south of the Basin. The RCD is also developing a dry well storm water recharge project at the Watsonville Airport. Scott Valley Water District, MGA's neighbor to the north, has developed three groundwater recharge projects: (1) at Scotts Valley Transit Center, (2) at Scotts Valley Library, and (3) an infiltration project associated with a mixed use development on Scotts Valley Drive.~~

2.1.4.6 Conjunctive Use and Underground Storage

2.1.4.6.1 Conjunctive use

Conjunctive use refers to the coordinated management of surface water and groundwater resources to optimize availability of water supply and is discussed in more detail in Section ~~2.1.2.4~~2.1.2.4 above. In California's Mediterranean climate, this approach often involves a greater reliance upon surface water sources during the wet winter months and greater reliance upon groundwater during dry periods.

In the Santa Cruz region, MGA member agencies and member agencies of the Santa Margarita Groundwater Agency are actively pursuing conjunctive use strategies. For example, a ~~2013~~2011 study examined diverting surface water from the San Lorenzo River during wet winter months to transfer to neighboring water supply agencies that normally rely entirely upon groundwater~~.~~ (Kennedy/Jenks 2011). The receiving groundwater agencies could then reduce their groundwater pumping during the winter months enabling in-lieu recharge of the aquifers. One objective of surface water transfers would be to use existing underground aquifer storage capacity to recharge regional groundwater basins. Another objective would be to create supplemental supply to augment surface water resources during droughts.

In 2015, the County of Santa Cruz Environmental Health Services developed the Final Report on Conjunctive Use and Water Transfers with Proposition 50 Integrated Regional Water Management funds~~.~~ (Environmental Health Services 2015). The report outlines the opportunities and challenges of conjunctive use.

During years of normal rainfall, the City of Santa Cruz derives approximately 95% of its water supply from local surface water sources, while SqCWD and Central Water District currently rely solely on local groundwater for their water supplies. The MGA member agencies access to both surface water and groundwater presents opportunities for conjunctive use. Regional conjunctive use has numerous practical, water chemistry, legal, and regulatory hurdles to resolve before full scale conjunctive use can be implemented.

- Practical constraints – The primary practical constraints for sharing surface water between water agencies are water availability and adequate infrastructure to treat and move water within and between neighboring water agency boundaries.
    - Currently, the conjunctive use programs proposed in Santa Cruz County rely on surface water that is fed by local precipitation. The reliance on precipitation in California, with its dramatic swings in annual rainfall, means that water available for transfer is unpredictable from year to year. The City of Santa Cruz has an obligation to provide drinking water to its customers and plans conservatively to ensure this obligation can be met in dry years and during droughts. Thus water available for transfer is constrained by both climate conditions and City's duty to provide a reliable supply of water to its customers.
    - Water demand that can be augmented by in-lieu recharge is more limited during winter months, when supplemental surface water resources are most available, than it is during the dry season. This reduced demand places an upper limit on the amount of surface water that can be taken by the groundwater agencies and thus limits the amount and ~~groundwater basin~~Basin benefits of potential in-lieu recharge.
    - The City of Santa Cruz, Soquel Creek and Central Water Districts have each made infrastructure improvements in the form of "interties" to enable water transfers between neighboring agencies. These interties have functioned well for water sharing between agencies in emergency situations. While it is feasible to achieve

some significant benefits of water sharing using existing infrastructure, full scale water transfers to completely replace winter water in Soquel Creek and Central ~~water districts~~Water Districts would require additional infrastructure improvements.

- The City of Santa Cruz has scheduled significant infrastructure to improve the capabilities of its Graham Hill Water Treatment Plant. The City's goals are to increase capability to allow it to treat more turbid (sediment laden) winter water flows. These improvements will increase the availability of excess surface water for transfer and storage in local aquifers. The current treatment facility was built in the 1960s, was last updated in the 1980s, and does not have adequate treatment technology to utilize winter sediment laden waters. For these reasons winter storm flows that are highly turbid cannot currently be treated at the Graham Hill Treatment Plant so are not available for transfer or storage in the Basin.

- Water chemistry issues – Surface water and groundwater differ in their chemical composition. The water system infrastructure, such as distribution pipelines and water service lines and plumbing on customer properties, can respond to the change in water chemistry with source water changes and may, under certain conditions, adversely impact water quality. The City of Santa Cruz and Soquel Creek Water District conducted multi-year studies to evaluate the potential for water quality degradation associated with the transfer of surface water from the City's system into the District's system which historically has only used groundwater. An additional concern is the difference between surface and groundwater resources related to the formation of disinfection by-products. Disinfection by-products are formed by the chemical interaction of naturally occurring total organic carbon found in many surface water resources and chlorine or ozone based disinfectants. Groundwater resources ~~do not~~ typically have lower levels of total organic carbon in them and thus disinfectant byproduct levels of these sources will generally be lower than the levels of these chemicals in surface water resources. Disinfectant byproducts are regulated by both federal and state drinking water maximum contaminant level requirements. Even though City water used in in-lieu water transfers complies with all federal and state requirements it contains higher levels of disinfectant byproducts than found in Soquel Creek Water District's groundwater based system. The State Division of Drinking Water is requiring Soquel Creek Water District to monitor distribution system water quality before, during, and after pilot deliveries of surface water to its system to track any changes in water quality that may result from intermittent use of surface water resources if water transfers are implemented as part of a long term Groundwater Sustainability Plan.

- Legal constraints – The City of Santa Cruz water rights have places of use restrictions that limit the areas where water from the San Lorenzo River resources can be utilized. The San Lorenzo River is the City's main source of supply, providing approximately 47% of the total supply annually. The City is currently using excess water from its unrestricted, pre-1914 water rights north coast streams, to support the water transfer pilot study with Soquel Creek Water District. The City has also applied to the California State Water Resources Control Board to expand its places of use for all its San Lorenzo

River water rights to include neighboring water agency jurisdictions. If the place of use restrictions are modified, the amount of surface water available for transfer to both the Basin and the Santa Margarita Basin will be less constrained.

- Regulatory constraints – Transfer of surface water also includes regulatory program compliance for the City and Soquel Creek Water District.

- ~~o~~ The City must address fish flow requirements to preserve special-status species protected under state and federal Endangered Species Acts before it can determine the amount of water available for transfer. The City is in the process of preparing a Habitat Conservation Plan for its water diversions and has worked with federal and state fish and wildlife regulatory agencies to establish new bypass requirements to support all stages of the salmonid life cycle. The new fish flow requirements for migration, spawning, and rearing have significantly reduced the amount of water available for water supply and transfer.

2.1.4.6.2 Underground Storage

As discussed in Section ~~2.1.4.5 Groundwater Recharge and Replenishment of Groundwater Extractions~~2.1.4.5: Groundwater Recharge and Replenishment of Groundwater Extractions above, MGA member agencies, City of Santa Cruz and Soquel Creek Water District, are pursuing conjunctive use underground storage projects. Both ~~In-Leiu~~in-lieu and ASR projects use excess surface water treated to drinking water standards as their water source. The County of Santa Cruz and Soquel Creek Water District are also pursuing underground storage projects using storm water and advanced purified wastewater respectively as water sources. The County and Soquel Creek Water District are partnering in the Basin on storm water recharge projects and Soquel Creek Water District's Pure Water Soquel project would use advanced purified wastewater as its water source. All of these projects would store water underground as either a seawater intrusion barrier, as a future water supply source, or both.

2.1.4.7 Well Construction Policies

As discussed above in Section 2.1.3.4, Santa Cruz County permits water wells within the unincorporated areas of the Basin and within the City of Capitola. The Santa Cruz City Water Department permits wells within the Santa Cruz City limits. Well construction standards are found in the County Code, Chapter 7.70. The purpose of the County's well construction standards is to record and manage the location, construction, repair, and reconstruction of all wells to prevent groundwater contamination. County standards also ensure that water obtained from groundwater wells is suitable for the purpose for which it is used and will not jeopardize the health, safety, or welfare of the people of Santa Cruz County. The County implements the State Bulletin 74 Well standards by reference in the County Code. The County Code also prohibits new wells within the service area for the Soquel Creek Water District unless the well serves an agricultural use or is a replacement well.

2.1.4.8 Groundwater Contamination Cleanup, Recharge, Diversions to Storage, Conservation, Water Recycling, Conveyance and Extraction Projects

2.1.4.8.1 Groundwater Contamination Cleanup

As discussed above in Section 2.1.4.3, Santa Cruz County Environmental Health Services is the Certified Unified Program Agency (CUPA) for the entire County. As CUPA, the County is responsible to enforce laws regulating the storage, use, and disposal of hazardous materials and hazardous wastes. The County also oversees all hazardous materials cleanups. Where hazardous materials have contaminated groundwater, the clean-up is also overseen by the Central Coast Regional Water Quality Control Board or the State Department of Toxic Substances Control.

The State Water Resources Control Board's Geotracker database is an online data management system for sites that impact, or have the potential to impact water quality in California, with an emphasis on groundwater. Geotracker can be used to identify contamination sites under regulatory action. It is available at: https://geotracker.waterboards.ca.gov/

2.1.4.8.2 Groundwater Recharge

MGA member agencies have developed two storm water recharge projects within the Basin and are in the process of piloting ASR and In-Lieu recharge projects and Soquel Creek Water District is in the process of permitting its Pure Water Soquel projects as discussed in Sections 2.1.4.5 and 2.1.4.6 above. MGA member agencies are in the process of evaluating additional storm water recharge projects that could improve groundwater recharge and storage within the Basin and neighboring groundwater basins. County development and storm water management policies protect recharge areas and infiltration capacities as discussed in Section 2.1.4.5.

2.1.4.8.3 Diversions to Storage

There are presently no significant diversions to storage within the Basin. Outside the Basin the City of Santa Cruz created the Loch Lomond reservoir in 1960 by impounding Newell Creek with construction of the Newell Creek Dam. The reservoir is supplied by runoff from the Newell Creek watershed as well as by flows diverted from San Lorenzo River which is pumped from the Felton Diversion Dam to Loch Lomond. It is the City's only reservoir and is an integral part of the water system as it provides water supply for peak season demands and as a drought reserve.

Both the City of Santa Cruz and Soquel Creek Water District are evaluating and/or permitting water supply augmentation alternatives that would put more local water into storage in the Basin for future use and to prevent further seawater intrusion. The primary focus of these water augmentation alternatives is to recharge groundwater supplies in the Basin and neighboring basins. These water augmentation alternatives include in-lieu recharge through the treatment and use of excess surface water, aquifer storage and recovery (ASR), stormwater recharge, and the injection of advanced purified wastewater into the Basin.

2.1.4.9 Efficient Water Management Practices

MGA's member agencies have a full range of water conservation programs in place and have actively and successfully implemented policies and programs promoting and incentivizing water conservation and efficient water use. The City's and SqCWD's residential water usage are among the lowest in the state.

The City's and SqCWD's Urban Water Management Plans provide more detail on the various programs and policies of the specific agencies. The range of strategies in place to promote efficient water use includes:

- Water Waste Prevention Ordinances,
- Metering (widespread use of Automated Meter Reading (AMR) technology),
- Tiered Rate Structures to Promote Efficient Use,
- Programs to Assess and Manage Distribution System Losses,
- Water Conservation Programs with dedicated staff to conduct:
  - Public Awareness and Education
  - Water Demand Monitoring
  - Long-Term Water Conservation Programs:
  - Water Shortage Contingency Planning
- Residential and Commercial Demand Management Measures, including: Home Water Survey Program; High Efficiency Clothes Washer Rebate Program; Toilet Rebate Program, Laundry to Landscape Rebate Programs; Rain Barrel Program; and, Plumbing Fixture Retrofit Ordinance.
- Demand Management Measures for Commercial Customers, including: Smart Business Rebate Program (for installing water efficient fixtures including toilets, urinals and clothes washers) and the Monterey Bay Green Business Program.
- Demand Management Measures for Water Efficient Landscapes

All MGA member agencies participate in the Water Conservation Coalition of Santa Cruz County. The Water Conservation Coalition of Santa Cruz County has created a regional source for county-wide water reduction measures, rebates, and resources at: https://watersavingtips.org/

The County and the Resource Conservation District of Santa Cruz (RCD) provide outreach to rural landowners on recommendations for greater water use efficiency and methods to promote more groundwater recharge on their properties. The County requires implementation of water use efficiency measures for new wells serving agricultural uses and other non de minimis uses. The RCD also provides outreach and technical services specifically for agricultural users.

Additional conservation program information is described at the water agency's individual websites:

- Central Water District: https://sites.google.com/view/centralwaterdistrict/conservation
- City of Santa Cruz Water Department: http://www.cityofsantacruz.com/government/city-departments/water/conservation
- County of Santa Cruz: http://scceh.com/Home/Programs/WaterResources/WaterConservationProgram.aspx
- Soquel Creek Water District: http://www.soquelcreekwater.org/conserving-water

2.1.4.10 Relationships with State and Federal Regulatory Agencies

Section 2.1.2 includes a description of monitoring and management programs that involve coordination with state and federal agencies. The MGA coordinated with representatives from the DWR throughout the GSP development. The following state and federal agencies were consulted during the preparation of this GSP [provisional list]:

- California Department of Fish and Wildlife
- California Department of Water Resources
- Central Coast Regional Water Quality Control Board
- National Marine Fisheries Service (NMFS, formerly NOAA Fisheries)
- State Water Resources Control Board
- US Fish and Wildlife Service

As discussed in ~~Section 2.1.4.12~~Sections 2.1.4.12 and 2.1.5.2.2 below, ~~The~~the MGA, through its GSP Advisory Committee, established a Surface Water Working Group sub-committee that included five committee members, local issue area experts, non-governmental organizations with extensive resource management and protection experience, and state and federal resource and regulatory agencies. The purpose of this sub-committee was to gather issue area experts together to discuss the resources, agency mandates, and best available science to develop groundwater driven sustainability recommendations for the entire GSP Advisory Committee to consider when developing its recommendations for surface water ~~depletions~~depletion related to groundwater pumping.

In addition to working with various resource management agencies during the development of the GSP, MGA member agencies including the County of Santa Cruz, the City of Santa Cruz, and the Soquel Creek Water District have all established long-term working relationships with the resource management agencies identified above. Ongoing coordination and collaboration with these agencies focus on planning for and managing utility and resource protection programs and projects, utility operations, and development and construction of capital improvement projects.

2.1.4.11 Land Use Plans and Efforts to Coordinate with Land Use Planning Agencies to Assess Activities that Potentially Create Risks to Groundwater Quality or Quantity

MGA planners reviewed existing planning documents and consulted with land use planners from agencies with jurisdictional responsibilities for land use decisions within the Basin. The land use agencies within Basin are Santa Cruz County, California State Parks, City of Santa Cruz, and the City of Capitola.

Elected officials from the County of Santa Cruz and the City of Santa Cruz are on the MGA Board of Directors. These elected County and City representatives, whose responsibilities include oversight of land use policy decisions for their jurisdictions, are participants in groundwater sustainability policy making within the Basin.

During development of this GSP, the MGA conferred with governmental and non-governmental entities with regional land use interests and expertise in the Basin. This collaborative effort to address regional land use interests is intended to create a continuing dialog to heighten regional awareness of groundwater sustainability management as it relates to land use decisions.

Partners consulted include ~~[provisional list]:~~:

- City of Capitola
- City of Scotts Valley
- Pajaro Valley Water Management Agency (PV Water)
- Santa Margarita Groundwater Agency (SMGWA)
- Resource Conservation District of Santa Cruz County (RCD)
- National Marine Fisheries Service (NMFS, formerly NOAA Fisheries)
- The Nature Conservancy
- Environmental Defense Fund
- California Department of Fish and Wildlife
- State Water Resources Control Board
- Central Coast Regional Water Quality Control Board
- US Fish and Wildlife Service
- Friends of Soquel Creek
- Regional Water Management Foundation
- Managers and operators of small public water systems

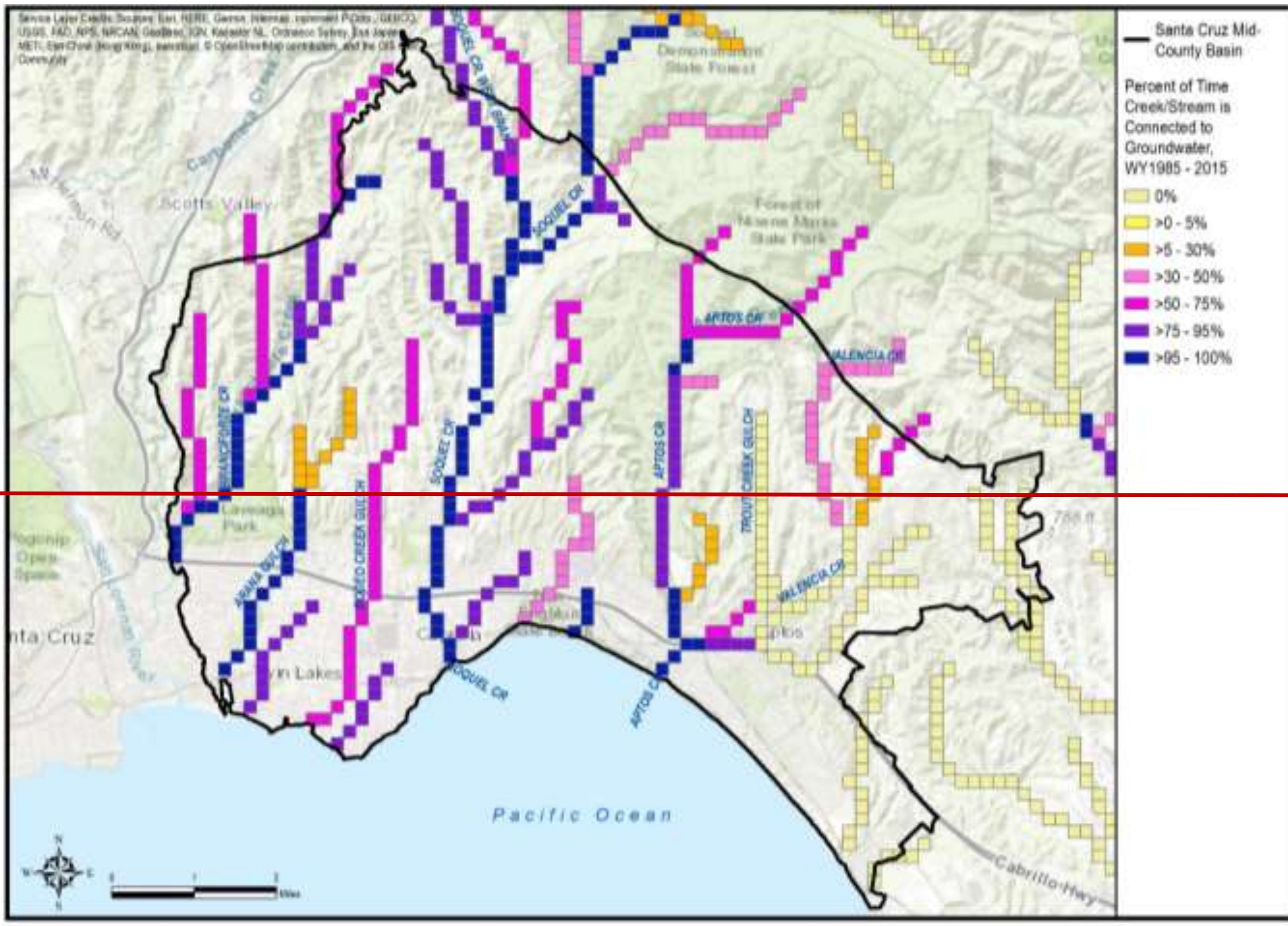
Planning documents reviewed during the preparation of this GSP include ~~[provisional list]:~~:

- Santa Cruz County General Plan

- Santa Cruz County Housing Element
- Santa Cruz County Town/Community Plans for:
  - Aptos Village
  - Pleasure Point
  - Seacliff Village
  - Soquel Village
- Sustainable Santa Cruz County Plan
- City of Capitola General Plan
- City of Santa Cruz General Plan and General Plan EIR
- City of Santa Cruz Housing Element
- City of Santa Cruz 2015 Urban Water Management Plan
- Soquel Creek Water District 2015 Urban Water Management Plan
- Scotts Valley General Plan
- Scotts Valley 2015 Urban Water Management Plan
- Soquel Aptos Area Groundwater Management Plan
- Santa Cruz Integrated Regional Water Management Plan

2.1.4.12 Impacts on Groundwater Dependent Ecosystems

The County of Santa Cruz assessed and identified Groundwater Dependent Ecosystems (GDE) where interconnected surface and groundwater exist within the Basin. As a first step to identify GDEs, where data were available MGA compared surface water and groundwater elevations to determine interconnections between surface water and groundwater. Where groundwater level data were unavailable, the surface water-groundwater model developed for the Basin ~~was~~is used to identify where surface water and groundwater are connected (Figure 2-10). County staff utilized available information from the California Natural Diversity Database (CDFW, 2019) and ~~the~~The Nature Conservancy (2019) to identify important species present in ~~the~~ areas where groundwater and surface water are interconnected. The only areas within the Basin where surface water and groundwater connections were identified were in riparian zones. No interconnected lakes or ponds were identified and no areas of shallow groundwater away from streams were noted within the Basin.



~~**Figure 2-9. Percent Time Surface Water and Groundwater are Connected (Water Years 1985-2015)**~~

Technical staff presented and discussed the information with the Surface Water Working Group ~~composed~~comprised of GSP Advisory Committee participants, resource agencies, local planning agencies, and environmental partners to confirm the habitats, plants, and animals dependent on groundwater within and adjacent to Basin boundaries. The groundwater dependent species identified for priority management are found in Table 2-1.

Table 2-1. Groundwater Dependent Species Identified for Priority Management

Species Common Name	Priority for GDE management	Needs Covered by Prioritized Species
Steelhead	X	
Coho Salmon	X	~~X~~
California Giant Salamander		X
Foothill Yellow-Legged Frog		X
Western Pond Turtle		X
Riparian forest including willow and sycamore	X	

The GSP Advisory Committee and the Surface Water Working Group found that:

- Maintaining groundwater contribution to support adequate stream flow for salmonids during the late summer and fall will support the needs of other identified critical species~~,~~ in Table 2-1,
- Fish habitat and streamflow are greatly influenced by many factors other than groundwater contribution. Maintaining groundwater levels to minimize depletion of flow during the dry season will help critical species, but will not resolve other stream flow impacts created by lack of precipitation, evapotranspiration, and surface water withdrawals during the dry season,
- Groundwater management criteria for GDE linked to priority species' basic aquatic needs is a reasonable proxy for monitoring management success in coordination with existing direct species monitoring, and
- Groundwater level monitoring for ~~GDE~~GDEs will focus on:
    - Areas of highest groundwater extraction, and
    - Where streams are interconnected with groundwater
    - .

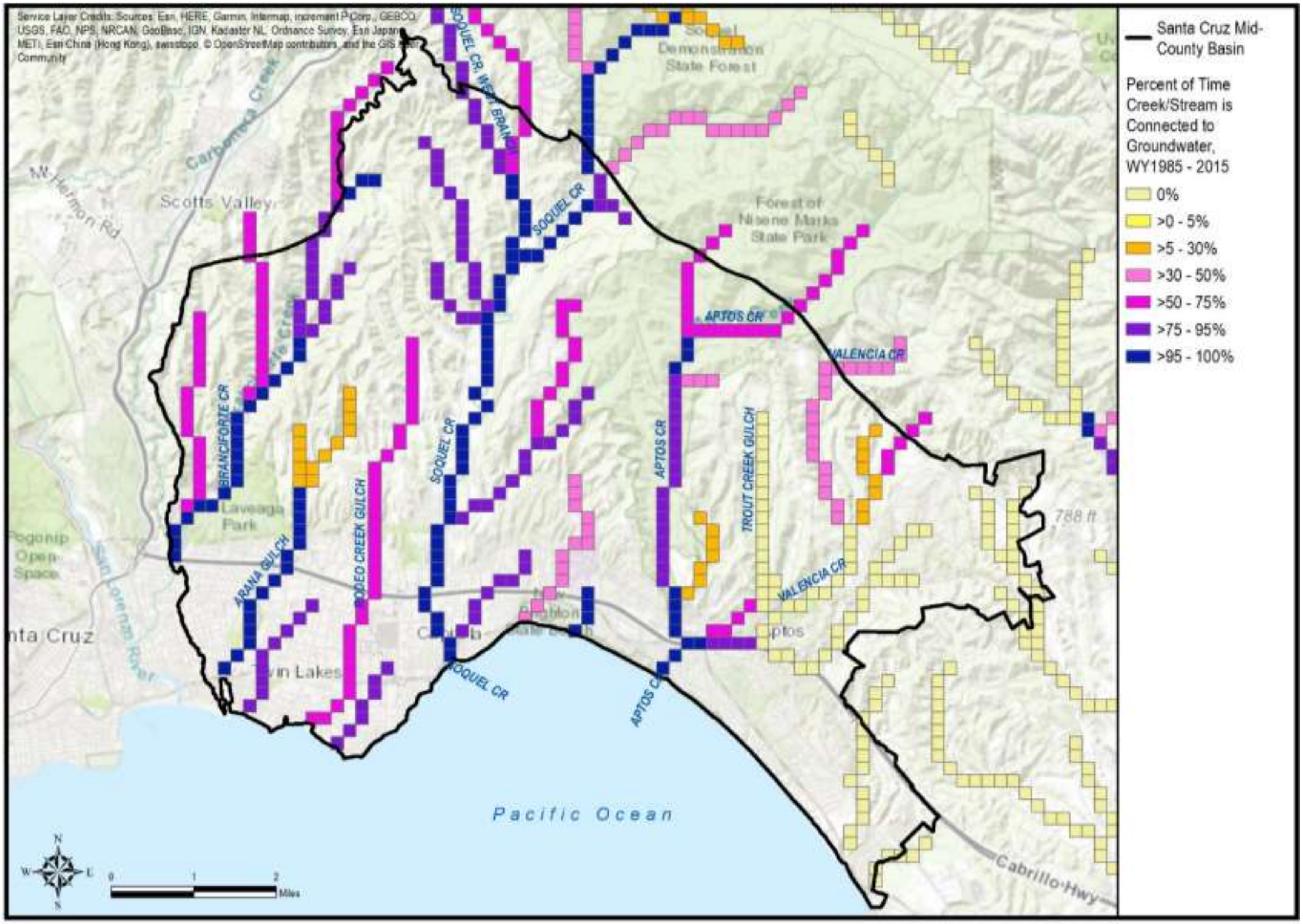


Figure 2-10. Percentage of Time Surface Water and Groundwater are Connected (Water Years 1985-2015)

2.1.5 Notice and Communication

SGMA requires the MGA develop an open public process to consider the interests of beneficial uses and users of basin groundwater and the land uses and property interests required to achieve groundwater sustainability. MGA has developed a variety of open meeting formats and uses many forms of public outreach to inform and engage the Basin public about the importance of groundwater sustainability.

MGA outreach efforts focus on educating the public about groundwater, the Basin, and SGMA sustainability requirements. The Basin community must know the challenges to our water supply security, the need to address these challenges to protect our water supply, and agree to implement regional solutions to protect fresh water supplies for current and future human and environmental uses to achieve sustainability.

MGA general outreach methods include: postcard mailers, news articles, informational handouts, stakeholder presentations, email newsletters, website content, signs posted on major driving corridors, community outreach events, and other opportunities to discuss groundwater resource management in public settings.

MGA also acknowledges that the public participation requirements of SGMA demand a high level of well-informed community input to represent the beneficial uses and users of groundwater within the Basin. For this reason the MGA created in-depth technical orientation materials, presented in person and recorded for later viewing, to educate groundwater users and other stakeholders to allow them to make highly informed comments on the Plan’s contents.

MGA’s detailed materials are specifically directed at the engaged members of the public who want to dive deeper into the subject matter. These materials include GSP Advisory Committee orientation session and meeting materials, groundwater management information and enrichment sessions, MGA Board meetings materials, and the basin-wide agency and project information provided during our publicly noticed GSP Advisory Committee field trip. Most of these detailed meeting materials (and their recorded presentations) are openly available on the MGA website.

2.1.5.1 Description of Beneficial Uses and Beneficial Users of the Basin

The MGA Board established a GSP Working Group to provide advice on how to achieve optimum SGMA compliance during the GSP planning process. The GSP Working Group was a limited duration ~~subcommittee~~temporary committee of the MGA Board made up of ~~board~~Board members and supported by MGA staff ~~members~~.

The charge of the GSP Working Group was to examine SGMA requirements and make compliance recommendations to the MGA Board. Based on the GSP Working Group’s advice, the MGA Board recommended creation of a GSP Advisory Committee to represent the interests of Basin water users and uses. The GSP Advisory Committee would then ~~take~~ accomplish the detailed public policy analysis required by SGMA to make detailed GSP sustainable management criteria recommendations to the MGA Board.

In Water Code Section 10723.2, SGMA requires the MGA consider the interests of all beneficial uses and users of groundwater within the Basin. These interests include, but are not limited to, the following:

- Holders of overlying groundwater rights, including:
  - Agricultural users
  - Domestic well owners
- Municipal well operators
- Public water systems
- Local land use planning agencies
- Environmental users of groundwater
- Surface water users, if there is a ~~hydrologic~~hydraulic connection between surface and groundwater bodies~~.~~
- The federal government, if there is a hydraulic connection between surface water and groundwater bodies
- California Native American tribes
- Disadvantaged communities, including but not limited to, those served by non-municipal domestic wells or small community water systems
- Protected Lands, including recreational areas
- Public Trust Uses, including wildlife, aquatic habitat, fisheries, recreation, and navigation
- Entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or a part of a groundwater basin

2.1.5.1.1 Interest Groups Representation

The GSP Working Group considered each of the interest groups named by SGMA to determine if they were present within the Basin and considered their current representation on the MGA Board.

Agricultural users: There is limited farming within the ~~basin boundary area, using~~Basin that only uses approximately ~~13%~~four percent of total ~~water pumped from the Santa Cruz Mid-County Groundwater Basin.~~Basin groundwater extracted. The majority of ~~farming~~agriculture is ~~done~~ by a few large operators. The agricultural sector is primarily served by private wells that support vineyards, vegetables, orchards, and berries. One of the private well owner representatives on the MGA ~~board~~Board includes a private agricultural well owner, and the GSP Advisory Committee includes an agricultural representative to ensure that the agricultural community is represented and informed about groundwater sustainability planning within the ~~basin~~Basin.

Non-Municipal Domestic Well Users: Private residential well owners are estimated to pump approximately 10% of the water used from the ~~Santa Cruz Mid-County Groundwater~~ Basin. To ensure private well owners are represented, the MGA Board includes three private well owner representatives, and one of those representatives also serves on the GSP Advisory Committee.

Private well owner water use extends primarily to residential, landscape, and some small-scale farming and livestock usage up to one half acre of land. Up to four service connections can be on one well for that well to be considered domestic. These wells are also considered de minimis users.

Small Water Systems: There are two categories for small water systems which are regulated by the County: State Smalls have between 5-14 service connections, and Small Public Water Systems are between 15-199 connections or serve at least 25 people for at least 60 days a year. These systems serve both individual domestic properties, commercial uses such as camps, and institutional uses such as schools. In total, small water systems use approximately ~~5~~2% of the water pumped every year from the Basin. Figure 2-11 shows the location of small water systems within the Basin.

Small public water systems in the Basin are represented by the County of Santa Cruz and private well owner representatives on the MGA Board. MGA staff is in regular communication with this group. The president of Trout Gulch Mutual, the largest small public water system in the Basin, is a private well owner alternate to the MGA Board. The County offers quarterly forums to small water system operators to promote compliance with state water quality and other applicable regulations. SGMA has been a recurring topic at these quarterly forums. MGA staff has presented information to public water system operators and all receive the MGA email newsletter.

Large Public and Municipal Well Operators: ~~There~~As discussed more specifically in Section 2.1.1.3.5, there are three large Public Water Systems, each serving over 800 connections in the Basin, the City of Santa Cruz Water Department (a municipal well operator), Central Water District, and Soquel Creek Water District~~.~~ (Figure 2-11). Together, these three systems supply approximately 90% of the water users within the Basin, however, most of the water supplied to City of Santa Cruz water customers is surface water derived from outside of the Basin. In total, these systems ~~pump~~extract approximately ~~72~~75% of ~~the water used~~all groundwater pumped from the ~~basin~~Basin. The MGA ~~board~~Board includes two elected representatives from each of these systems. Together these large water systems provide water for residential, commercial, industrial, institutional, and landscape uses.

Local Land Use Agencies: Three land use agencies are located within the Basin. These are Santa Cruz County, the City of Santa Cruz, and the City of Capitola. Two of the three agencies are represented on the MGA Board and planners with the City of Capitola were invited to participate in the GSP Advisory Committee. The City of Capitola declined a seat on the Committee and instead will participate as GSP document reviewer.

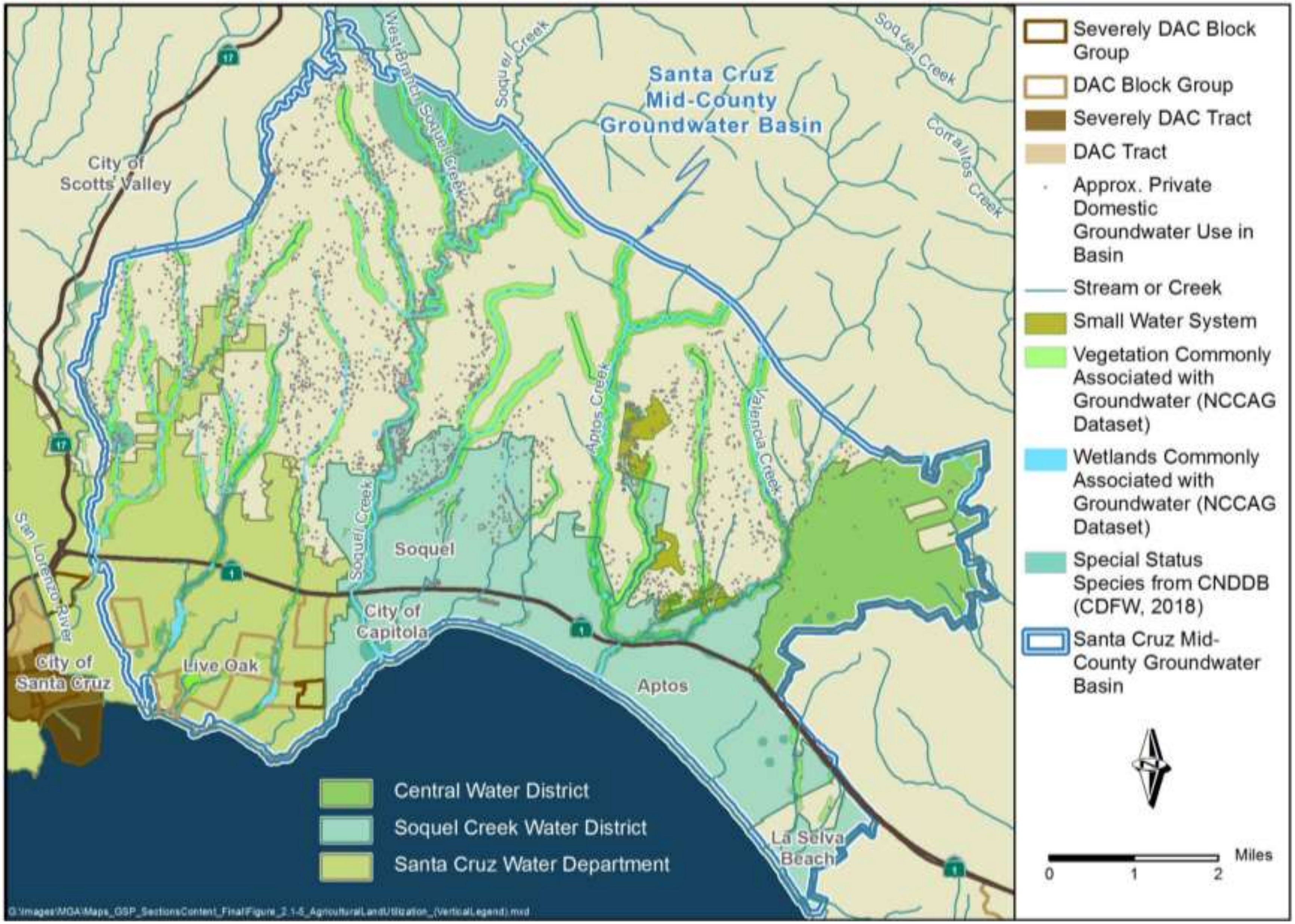


Figure 2-11. Locations of Beneficial Users in the Santa Cruz Mid-County Basin

Environmental Users of Groundwater: The ~~basin~~Basin includes creeks, streams, ponds and marshes, some of which are partially supplied by groundwater during the dry seasons when surface water from rain is not available. Some of the plants and animals found in ~~basin~~Basin habitats supported by groundwater are unique to the region and are state and federally listed as sensitive species. Many government agencies, individuals, and private groups are interested in environmental restoration of habitats and species within the Basin. These groups collaborated in the Surface Water Working Group, a subcommittee of the GSP Advisory Committee, to develop recommendations on groundwater dependent ecosystems and sustainability criteria to avoid surface water ~~depletions~~depletion from groundwater extractions.

Surface Water Users with a Connection to Groundwater: The ~~basin~~Basin includes several streams that are connected to groundwater in some of their reaches.

- *Branciforte Creek*, is connected to groundwater, but surface and groundwater use is limited to individual private users along the creek. Many of these properties are served by the City of Santa Cruz Water Department.

- *Soquel Creek*, is connected to groundwater in much of its watershed within the Basin. Surface water rights on Soquel Creek are limited by a 1977 adjudication of surface water rights. The Resource Conservation District of Santa Cruz County (RCD) is studying the creek to better understand surface water use and its impacts on stream flow. The RCD's study includes a technical advisory committee of local experts, some of whom are also involved with the MGA's work. A data gap that the MGA and RCD are working to fill is understanding how shallow wells drawing water from alluvial deposits near Soquel Creek may impact surface water flows. The MGA is planning additional monitoring to help refine the understanding of this relationship on sustainability.

- *Aptos Creek,* is connected to groundwater in some of its lower reaches. It runs through the Forest of Nisene Marks, a state park, and there are no significant surface water diversions and few groundwater wells to impact surface water flows~~.~~ in the upper reaches of Aptos Creek. There are at least two riparian users of surface water from Aptos Creek west of Soquel Drive where groundwater is connected to surface water.

- *Valencia Creek*, is not connected to groundwater currently and groundwater levels from the 1950's indicate that an historic connection to groundwater is unlikely.

Federal Government: there are no federal lands within the Basin (see Section 2.1.1.3.1). However, there are federally listed species dependent on groundwater in the Basin. Federal resource agencies including the National Oceanic and Atmospheric Administration National Marine Fisheries and US Fish and Wildlife Service ~~are participating~~participated in the MGA's Surface Water Working Group, a subcommittee of the GSP Advisory Committee. This group developed recommendations that were considered and incorporated into the Basin's groundwater dependent ecosystems and sustainability criteria to avoid surface water ~~depletions~~depletion that could impact federally listed species.

California Native American tribes: there are no tribal lands within the Basin (see Section 2.1.1.3.2). The Amah Mutsun Tribal Band were historically present in the region. ~~A representative~~County staff is in contact with representatives of the Amah Mutsun ~~will be notified when the draft GSP is available for comment.~~Tribal Band on Basin water issues.

Disadvantaged Communities (DAC) ~~-~~— Data from DWR's DAC mapping tool identifies ~~7~~seven DACs, including one severely disadvantaged community within the Basin; ~~the~~all seven DACs are located within the City of Santa Cruz water supply service area (Figure 2-11). The total DAC population in the Basin is approximately 8,375. ~~This~~The DAC designation is based upon median household income from the US Census American Community Survey 5-Year Data (2012 – 2016). ~~These~~Disadvantaged communities ~~receive water from the MGA's public water supply agencies.~~were identified with DWR's mapping tool using census tracts, blocks, and places. An assessment of the water related needs of DACs is occurring through a Proposition 1 ~~Integrated Regional Water Management (~~IRWM~~)~~ Disadvantaged Community Involvement Grant. MGA staff are in coordination with IRWM program to coordinate efforts in these communities.

As stated above, all disadvantaged communities identified within the Basin are served with municipal water from either SCWD or SqCWD. As discussed in section 2.2.4.4, water delivered to municipal customers is regularly sampled and tested to ensure it meets or exceeds all state and federal drinking water standards. No DAC within the Basin receives water from small community drinking water systems or domestic wells.

Entities Monitoring and Reporting Groundwater Levels: MGA member agencies are the only entities that monitor and report groundwater levels within the Basin.

2.1.5.1.2 GSP Advisory Committee Composition

~~The~~The GSP Working Group was established on November 17, 2016 as a temporary Board committee composed entirely of board members and supported by MGA staff. MGA Board members included: John Benich, Bruce Jaffe, and Jon Kennedy. The GSP Working Group was charged with examining the state's adopted GSP emergency regulations, developing a scope of work, strategy, and schedule for preparing the GSP.

Among other things, the GSP Working Group identified six categories of groundwater uses and users, land uses, and property interests within the Basin, in addition to those already represented on the MGA Board, that needed a sustained voice throughout the GSP planning process. These were:

- Agricultural Users
- Business Users
- Environmental Uses
- Institutional Users
- Small Water System Management
- Water Utility Rate Payers

The GSP Working Group recommended the creation of a GSP Advisory Committee to provide the sustained public input required by GSP regulations. MGA ~~advertised~~created a GSP Nominating Committee to advertise GSP Advisory Committee openings, ~~accepted~~accept and ~~reviewed~~review applications, ~~interviewed~~interview candidates, and ~~recommended~~recommend GSP Advisory Committee representatives to the MGA Board for each identified category. The MGA Board approved these and other recommendations on September 21, 2017. ~~The final~~ GSP Advisory Committee representatives included eight (8) members of the general public and five (5) MGA Board members*:

- Agricultural Representative (1)
- At~~-~~ Large Representatives (3) – 1 resigned during orientation and was replaced
- Business Representative (1) – 1 resigned after partial participation and was not replaced
- Central Water District Representative (1)*
- City of Santa Cruz Representative (1~~)~~)*
- County of Santa Cruz Representative (1)*
- Environmental Representative (1)
- Institutional Representative (1) - 1 resigned during orientation and was replaced
- Private Well Representative (1)*
- Small Water System Management (1)
- Water Utility Rate Payer (1)
- Soquel Creek Water District (1)*

Over its 21 month commitment, three GSP Advisory Committee members resigned for various personal reasons. Two members resigned during orientation (one at-large representative and the institutional representative) and were replaced by engaged members of the public~~ and one, the~~. The business representative~~,~~ resigned later in the planning process and was not replaced.

The eight general public GSP Advisory Committee members were: Agriculture - John Bargetto; At Large - Keith Gudger, Jonathan Lear, and Charlie Rous; Business - Douglas P. Ley (resigned 9/25/2018); Environmental - Kate Anderton; Institutional - Thomas Wyner for Cabrillo College; Small Water System Management - Richard Casale; Water Utility Rate Payer - Dana Katofsky McCarthy. The MGA Board approved all general public committee members and their replacements.

Private well owner representatives to the MGA Board and member agency governing bodies selected MGA representatives to serve on the GSP Advisory Committee. The MGA representatives were: Private Well Owner - Jon Kennedy; Central Water District - Marco Romanini; City of Santa Cruz - David Green Baskin; County of Santa Cruz - Allyson Violante, and Soquel Creek Water District - Bruce Jaffe.

2.1.5.2 Decision Making Process

2.1.5.2.1 MGA Board of Directors

The ~~Joint Powers Authority (~~JPA~~)~~ that created the MGA requires the regional ~~Groundwater Sustainability Agency (~~GSA~~)~~ to hold public meetings at least quarterly that are noticed and meet all of the requirements of the Ralph M. Brown Act for transparency in California government. To hold a valid meeting the MGA must have a quorum of the Board of Directors, which consists of an absolute majority of directors plus one director. With these requirements in mind, the MGA:

- Holds board meetings on a regular schedule (once every other month);
- Provides written notice of meetings with meeting agenda and meeting materials available at least 72-hours prior to the meeting time;
- Sends email meeting reminders to MGA's contact list that includes approximately ~~650~~700 unique email addresses; and
- Posts meeting agenda at the meeting location prior to the meeting as required.

Under SGMA, the MGA Board of Directors is responsible to approve a GSP and submit it to DWR on or before January 31, 2020. Once a quorum is present, most MGA decisions require a simple majority of all appointed directors participating in the vote. If a director is disqualified from voting on a matter before the board because of a conflict of interest, that director shall be excluded from the calculation of the total number of directors that constitute a majority.

There are certain matters that come before the MGA Board of Directors that require a unanimous vote of all water agency member directors participating in the vote. These include approval of any of the following:

- Capital expenditures estimated to cost $100,000 or more;
- Annual budget;
- GSP for the Basin or any amendment thereto;
- Levying of assessments or fees;
- Issuance of indebtedness; or
- Stipulations to resolve litigation concerning groundwater rights within or groundwater management for the Basin.

MGA agendas include general public comments at the beginning of each board meeting. General comments allow community members to raise any groundwater related issue that is not on the agenda. Public comment time is also given prior to a vote on all agenda items to ensure public opinion can be incorporated into MGA Board of Director decisions. The public may also make submissions to the board for inclusion in the meeting packet.

The MGA accepts requests from the public for additional presentation time and is responsive to requests for items to be added to the agenda. Examples of public items added to the MGA agenda are: in depth presentations on water supply alternatives that focus on different water sources (river water transfers, recycled water, and excess storm water). In response to a public request, the MGA held a joint session of the Board of Directors and ~~its~~ GSP Advisory Committee ~~representatives~~ on water supply alternatives in July 2018 at which members of the public and MGA member agencies made presentations to the joint assembly.

The MGA ~~board~~Board directs agency staff to fulfill the various requirements of SGMA. To do this, MGA staff provides the board with research and recommendation memos, work plans, technical summaries, budgets, and other work products as required to ~~carry out~~support board ~~decisions~~decision making.

2.1.5.2.2 GSP Advisory Committee

As discussed above in Section 2.1.5.1.2, the GSP Advisory Committee was created to provide sustained GSP public policy input from beneficial groundwater users and uses and to represent land uses and property interests within the Basin. The GSP Advisory Committee was directed to work with staff and technical consultants to support development of the GSP. ~~The GSP Advisory Committee provides the MGA Board with recommendations on how to address key policy issues required by the State's SGMA mandate.~~

The ~~committee's~~Committee's responsibilities ~~include~~included:

- Evaluate scientific information and recommendations from staff on the impacts to the Basin, and assess various management approaches to reach sustainability;
- Consider the effect of changing climate and sea level on groundwater conditions;
- Establish measurable objectives and minimum thresholds for ~~State~~state mandated sustainability indicators; and
- Promote public education about GSP decisions and Basin sustainability.

Committee members agreed to deliberate based on scientific data regarding current and projected ~~basin~~Basin conditions. The Committee also agreed to work collaboratively in an open and public process to ensure community concerns ~~are~~were addressed within the GSP.

Between October 2017 and June 2019, the GSP Advisory Committee met 20 times, on average, once per month. Three of these meetings were joint meetings with the MGA Board. The GSP Advisory Committee also hosted and participated in four (4) Surface Water Working Group sub-committee meetings, one (1) optional field trip, and two (2) enrichment sessions (one each on understanding the model and Water Demand). All GSP Advisory Committee meetings, enrichment sessions, and the field trip were open to the public and included opportunities for public participation.

The Surface Water Working Group meetings represented a collaboration of GSP Advisory Committee members, MGA staff and technical consultants, resource agencies and non-governmental organizations deeply involved with local, regional, national, and international habitat protection. ~~Sub-Committee~~

As a temporary subcommittee of the GSP Advisory Committee, Surface Water Working Group meetings were not open to the public. Meeting materials were posted on the MGA website and meeting summaries were reported back to the full GSP Advisory Committee during its open meetings. The GSP Advisory Committee discussed and developed its recommendations regarding surface water sustainability in its open meeting format.

Subcommittee participants included:

- California Department of Fish and Wildlife
- California Department of Water Resources (DWR)
- City of Santa Cruz Water Department
- Environmental Defense Fund (EDF)
- Friends of Soquel Creek
- GSP Advisory Committee
- The Nature Conservancy (TNC)
- National Marine Fisheries Service (NMFS, formerly NOAA Fisheries)
- Pajaro Valley Water Management Agency (PV Water)
- Resource Conservation District SCC (RCD)
- Santa Cruz County
- Regional Water Management Foundation
- US Fish and Wildlife Service

~~As a special purpose subcommittee of the GSP Advisory Committee, these Surface Water Working Group meetings were not open to the public.~~

On May 16, 2019 the MGA Board of Directors and GSP Advisory Committee held a joint meeting to discuss the committee's provisional recommendations for Basin sustainability goals and draft GSP Sustainable Management Criteria. The GSP Advisory Committee held its final meeting on June 19, 2019 where it deliberated and voted on revisions to its final GSP recommendations and the draft conveyance memorandum to submit its recommendations to the MGA Board of Directors.

On July 18, 2019 MGA staff presented the GSP Advisory Committee's final GSP recommendations to the MGA Board and staff presented the Draft GSP based on those recommendations. The MGA Board accepted the Committee's recommendations, the Draft GSP, and opened the public comment period on the Draft GSP. The public comment period on the Draft GSP was open from July 18, 2019 through September 19, 2019.

~~Meeting materials were posted on the MGA website and meeting summaries were reported back to the full GSP Advisory Committee during its open meetings. The GSP Advisory Committee discussed and developed its recommendations regarding surface water sustainability in its open meeting format.~~

2.1.5.3 Public Engagement Opportunities

The MGA uses a variety of ways to actively encourage public participation, as outlined in its *Communication and Engagement Plan* (Appendix ~~A2-A).~~ ~~**Error! Reference source not found.**~~ ~~provides a summary of the~~2-A). MGA's Communication and Engagement Plan was approved by the MGA Board at its September 21, 2017 meeting and posted to the MGA website shortly thereafter. Table 2~~-~~2 provides a summary of public engagement opportunities.

MGA Website: provides SGMA and agency information. Includes a calendar with upcoming events, meeting information, meeting materials, and links to meeting agendas and packets. The website provides links to agency resource materials, maps, FAQs, newsletters, presentation materials, and meeting recordings.

MGA Monthly E-Newsletter: provides information on regional developments in groundwater sustainability, MGA updates, and announces upcoming groundwater events to approximately 650 people.

MGA Road Signs: reaches private well owners living in the Santa Cruz Mountains, the MGA uses four road signs to advertise its meetings and events.

Bi-Monthly Board Meetings: MGA business meetings where public can present information to the Board on agenda items and introduce items of concern for future deliberation.

Bi-Monthly Drop in Sessions: MGA open forum for public to meet informally with MGA Board members and staff to discuss groundwater policy and other topics.

GSP Orientation and Enrichment Sessions: Public learning sessions to present technical background [recorded and available on the MGA Website~~.]~~].

GSP Advisory Committee Meetings: MGA committee selected by the MGA Board to represents ~~basin~~Basin water uses and users. Public meetings are held to provide detailed GSP policy input for staff and GSP recommendations [recorded and available on the MGA Website~~.]~~].

Stakeholder Meetings: Informational meetings to introduce the public to the SGMA sustainability process and to keep the public informed about the GSP planning process.

Public Outreach on the Draft GSP: MGA held a public comment period on the Draft GSP from July 18 through September 19, 2019. The public comment period included two open houses in July and a Q&A session in August. The purpose of each open house was to orient people to the information contained in the Draft GSP soon after it was available for review. The Q&A session was scheduled to answer public questions after the public had an opportunity to review the Draft GSP.

Postcard Mailers: Three rounds of postcards to approximately 1,600 private well owners to engage this group (2016 – 2018). Draft GSP notice of release on a large format informational postcard to every household and landowner within the Basin (June 2019).

Surveys: The first survey was targeted to Private Well Owners at the outset of GSP development to help understand the needs and concerns of this stakeholder group. Sixty-four people responded. A second survey was issued near the release of the draft GSP. This is to inform staff of the level of public knowledge about the Basin and inform the MGA's Draft GSP rollout and implementation outreach efforts.

Existing Outreach Venues: The MGA also used the member agencies existing outreach networks to provide regular updates about the GSP Development. This includes information via email newsletters, bill inserts, social media, and presentations to their decision-making bodies. The MGA presented groundwater information and GSP outreach to cities at their council meetings and participated in local and regional festivals to teach the general public about SGMA. Example events include: Connecting the Drops, Water Harvest Festival, Wharf to Wharf, Earth Day and others.

~~Table 2.~~Table 2-2. Summary of Public Outreach and Engagment Opportunities

Topic	Detail
Public Meetings	• 12 private well owner/stakeholder meetings between May 2014 and June 2018 • 6 informational sessions between October 2017 and April 2019 • 2-hour community drop-in sessions every other month since 2016 • 20 GSP Advisory committee meetings between October 2017 and June 2019 • 2 GSP Workshops and 1 GSP Q&A Session planned between July 2019 and August 2019 • ~~34~~37 MGA, SAGMC, BIG, GSA FC meetings between February 2014 and ~~June~~November 2019
Postcard Mailings and letters	• June 2019 – GSP Survey and Plan update to all Basin residents and owners • March 2018 – GSP update to private well owners and small water systems • June 2017 – GSP update meeting to private well owners and small water systems • January 2017 - GSP update meeting to Basin agricultural and commercial pumpers • December 2015 – GSP update meeting to private well owners
Survey	• June 2019 - GSP outreach mechanism and to inform future MGA outreach efforts • Nov 2017 to May 2018 - Private well owner outreach to inform GSP planning process
Email List-Serve	• Monthly E-newsletter to approximately 650 unique email addresses, including interested parties
Brochure	Targeted at rural users mailed to all private well owners and small water systems
Open House	3 GSP Open House events during Draft GSP public comment period
Road Signs	4 message boards placed at prominent thoroughfares before meetings and events
Public MGA Board Meetings	~~34~~37 public Board meetings between February 2014 and ~~June~~November 2019 for MGA, and predecessor agencies
GSP Advisory Committee	Total of 20 monthly public meetings from October 2017 through June 2019
Surface Water-Groundwater Working Group	4 Surface Water Working Group meetings consisting of GSP Advisory Committee participants, resource agencies, local planning agencies, and environmental groups.
Tabling and Presentations	Connecting the Drops, Water Harvest Festival, presentations and conferences
Website	midcountygroundwater.org
Miscellaneous	Newspaper articles/editorials, social media through partner agencies, handouts, tour, tabling events

2.1.5.4 Encouraging Active Involvement

~~Public input is gathered in many ways as~~As discussed in Section 2.1.5.3~~.~~, MGA gathers public input in many ways. GSP Advisory Committee meetings and MGA Board meetings provide multiple opportunities for public comment at each meeting. Notes from GSP Advisory

Committee meetings are kept by facilitation consultants, reviewed by committee members, and submitted to the MGA Board. MGA meeting minutes are recorded by agency staff, reviewed, and approved by the MGA Board. All meeting minutes and notes are collected on the MGA ~~Website~~website along with supporting agendas, packets, and presentation materials. The MGA Board of Directors is both interested in public opinion and regularly incorporates committee input and public suggestions into its deliberations and the decisions it makes during MGA Board meetings.

A partial list of examples when the MGA Board incorporated public input into its decision-making and recommendations include directing staff to:

- Record and post MGA Board of Director meetings;
- Obtain and use MGA road signs to advertise MGA events;
- Record and post GSP Advisory Committee meetings;
- Organize and hold a Basin field trip open to public participants;
- Consider MGA email policy to establish MGA email addresses to serve private well owner board representative and other non-agency GSP Advisory Committee members;
- Develop and publish MGA public participation guidelines;
- Hold regular drop-in meetings with staff and board members; and
- Hold a joint MGA Board of Director and GSP Advisory Committee meeting for the public to present water augmentation recommendations to the MGA Board.

2.1.5.5 Informing the Public on GSP Implementation Progress

The Draft GSP ~~will be~~was presented to the public on the July 12, 2019 as part of the MGA Board of Director's July 18th meeting packet. The MGA ~~will hold~~held two public outreach meetings on July 20th and 22nd to introduce and summarize the Plan. An additional Q&A session ~~will be~~was held on August 28, 2019. The Board of Directors ~~will accept~~accepted comments on the Draft GSP during the MGA public comment period from July 18-September 19, 2019. ~~At the direction of the~~The MGA Board of Directors~~,~~ established a temporary GSP Comment Committee on September 19, 2019 to provide MGA staff ~~will review~~with oversight and ~~respond to~~direction when responding to Draft GSP comments.

The MGA Board of Directors will adopt the Plan and submit it to DWR prior to the GSP deadline for critically overdrafted basins on January 31, 2020. The MGA will implemented the GSP through ongoing Basin monitoring and management. While the GSP Advisory Committee sunset at its final meeting on June 19, 2019, the MGA Board will continue to meet to guide the GSP implementation process. The MGA will continue to follow the adopted MGA Communication ~~&~~and Engagement Plan to guide future outreach during the GSP implementation process.

2.2 Basin Setting

This section describes the Basin setting based on existing studies relating to geology, climate, historical groundwater and surface water conditions and Basin management that predates SGMA. The purpose of this section is to provide an overview of what is known about the Basin and how the Basin has responded to groundwater management over time.

SGMA guidelines require a significant amount of scientific hydrogeological detail. The purpose of this detail is to describe how the Basin's physical components interact with the dynamic elements of climate to understand groundwater movement and groundwater and surface water interactions. A good conceptual understanding of the complex interaction between physical Basin structure and changing climate is needed to adapt Basin management strategies to achieve and maintain sustainability.

2.2.1 Basin Boundaries

The lateral boundaries of the Basin generally follow the definable limits of the stacked Purisima Formation aquifer system, as well as the Aromas Red Sands, plus some other Tertiary-aged units that occur between the base of the Purisima Formation and the granitic basement of the Basin (Johnson et. al., 2004). Figure 2-12 provides a map showing the rationale used in the basin modification request to DWR. These features are discussed in more detail below.

The western boundary of the Basin follows the watershed boundary between Carbonera Creek and Branciforte Creek where the Purisima Formation is eroded to the granitic basement so is considered a barrier to groundwater flow (Figure 2-12). The watershed boundary runs north from the Pacific Ocean separating the Basin from the West Santa Cruz Terrace Basin to the west. The watershed continues 1,300 feet north of the West Santa Cruz Terrace Basin thereby forming part of the shared boundary with the Santa Margarita Basin. The shared boundary between the Basin and the Santa Margarita Basin mostly follows a structural granitic high separating westward-dipping stacked aquifer units of the Santa Margarita Basin from the eastward-dipping stacked aquifer units of the Santa Cruz Mid-County Basin (Figure 2-12). The structural granitic high boundary continues to Blackburn Gulch where the shared basin boundary changes to coincide with the eastern boundary of the Lompico Formation outcrop and southern edge of the Butano Formation until it reaches the Zayante-Vergeles fault.

The Zayante-Vergeles fault forms the northern boundary of the Basin and extends from the shared Santa Margarita Basin boundary to CWD's jurisdictional boundary (Figure 2-12). The Zayante-Vergeles fault is considered a barrier to groundwater flow that separates stacked aquifer units of the Purisima Formation in the Basin south of the fault and undifferentiated sediments of the Purisima Formation of the Purisima Highlands Subbasin north of the fault. Where the Zayante-Vergeles fault crosses CWD's western jurisdictional boundary, the Basin boundary then continues along CWD's boundary, extending north of the Zayante-Vergeles fault (Figure 2-12).

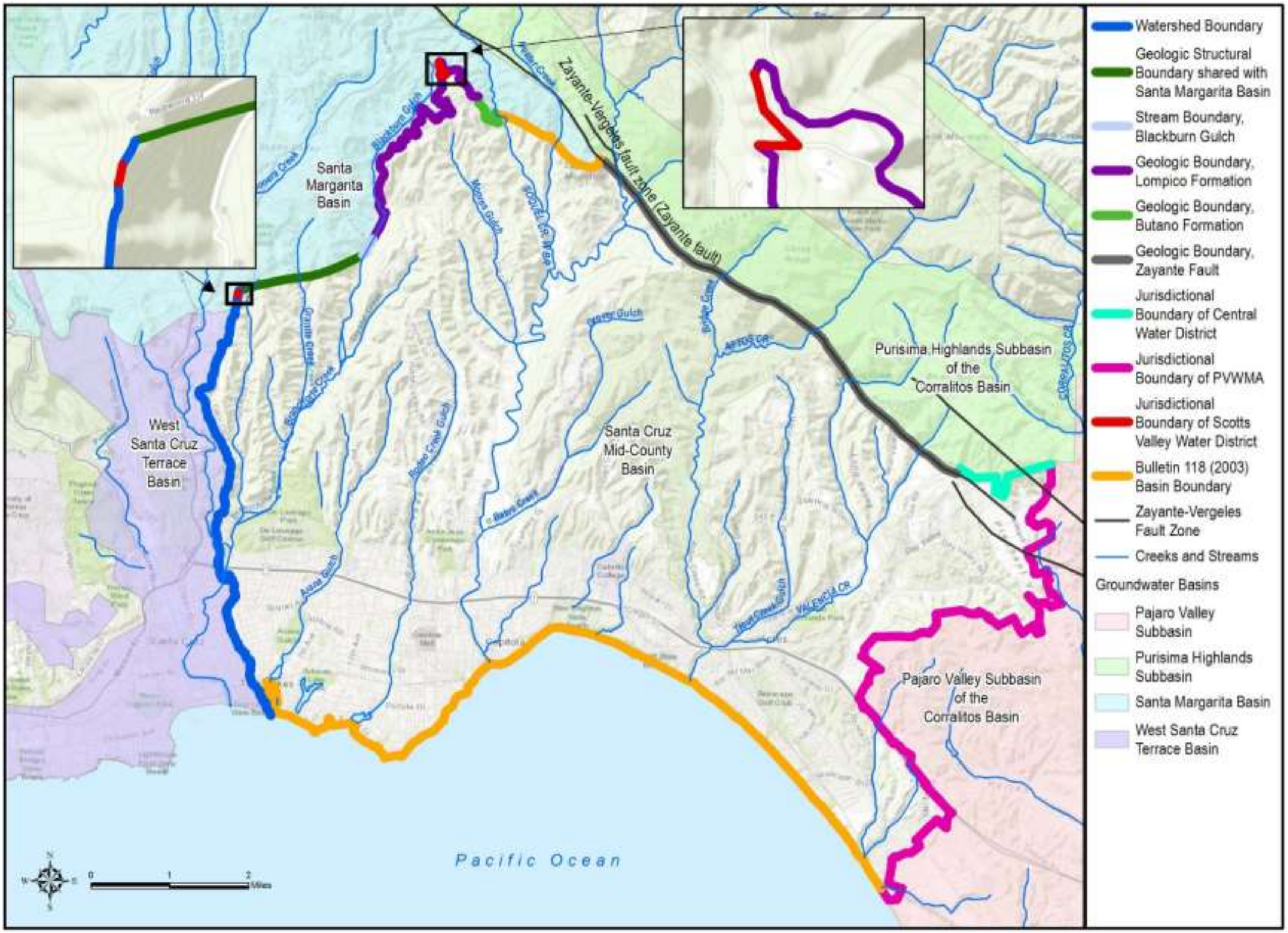


Figure 2-12. Santa Cruz Mid-County Basin Modification Rationale

The Basin's eastern boundary coincides with CWD's eastern boundary and PV Water's western boundary until it meets the Pacific Ocean (Figure 2-12). Even though the Basin's productive aquifer units outcrop offshore, the coastline constitutes the southern boundary of the Basin. This has implications for seawater intrusion as the offshore outcrop is an important boundary condition across which groundwater and seawater mix and area exchanged within the aquifer system.

Granitic basement rock constitutes the definable bottom of the Basin. Granitic rock is observable in boreholes and outcrops, and underlies the stacked aquifer system over the full Basin extent. There is also a limited area of the Basin where Lompico and/or Butano Formations that primarily occur in the Santa Margarita Basin are presumed to lie between the granitic rock and outcropping Purisima Formation aquifer unit.

2.2.2 Climate

The Basin has a Mediterranean climate characterized by warm, mostly dry summers and mild, wet winters. Due to its proximity to Monterey Bay, fog and low overcast are common during the night and morning hours, especially in the summer when warmer weather inland draws in the cool coastal marine layer (SCWD 2015). Annual rainfall recorded at the Santa Cruz Co-op station within the Basin averages 29.3 inches. In the Santa Cruz Mountains, rainfall averages nearly 50 inches per year. The majority of seasonal rainfall occurs between November and March. However, of all 50 states, California has the greatest climatic variability and rainfall can vary greatly from year to year. Monthly and annual climate data for the Santa Cruz Co-op station are summarized in Table 2-3.

Table 2-3. Average Santa Cruz Co-op Temperature and Precipitation

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temp. (ºF)	60.4	62.4	64.6	67.9	70.5	74.0	74.6	75.1	76.1	73.0	66.7	61.2	68.9
Average Min. Temp. (ºF)	38.8	40.9	41.9	43.3	46.1	48.8	51.1	51.4	49.9	46.7	42.2	39.1	45.0
Average Total Precipitation (inch)	6.14	5.42	4.33	1.92	0.80	0.22	0.06	0.07	0.42	1.39	3.31	5.24	29.33
Average Total Snowfall (inch)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Western Regional Climate Center - Period of Record: 01/01/1893 to 06/09/2016 Percent of possible observations for period of record.

Future average temperatures in the Basin are expected to increase and global climate models differ regarding whether rainfall will increase, decrease, remain the same, or shift both temporally in amount and intensity. The Climate Adaptation Study indicates changing temperatures and precipitation will impact ecosystems, fire risk, water quality and quantity, human and environmental health (City of Santa Cruz 2011).The USGS projected specific climate changes and impacts on water resources for the Santa Cruz Mountains (Flint and Flint, 2012). Municipalities in the region recognize the significance of climate change to the region's economic well-being, public health, and environment, and have begun taking steps to respond.

Simulated precipitation and temperatures used under projected conditions are discussed in greater detail in Section 2.2.5.6.1, with supporting documentation included in Appendix 2-G and 2-H.

~~2.2.1~~2.2.3 Hydrogeologic Conceptual Model

2.2.3.1 Overview

GSP regulations require a descriptive hydrogeologic conceptual model (HCM) of the Basin based on technical studies and qualified maps. The HCM's purpose is to characterize the physical components of the basin and describe ~~the interaction~~occurrence of ~~the surface water and~~ groundwater ~~systems~~and its movement in and out of the Basin. The HCM is ~~important~~ also the conceptual model for ~~understanding Basin conditions and differs from~~developing the numerical integrated surface water-groundwater GSFLOW model ~~(model)~~ used to ~~run simulations to evaluate~~simulate future Basin conditions based on changing climate and~~/or~~ future groundwater projects and management ~~scenarios. Instead, the HCM provides a general understanding of the Basin's physical setting and characteristics, and an understanding of the occurrence of groundwater and its movement within and outside of the Basin.~~actions.

Hydrogeologic studies of the Basin date back to 1968, when Soquel Creek Water District, the County of Santa Cruz, and the City of Santa Cruz collaborated to commission a USGS study of the groundwater characteristics of the Soquel Aptos Area. Until the mid-1960s, groundwater pumping in the Basin was limited to small water service providers and private wells. These water systems were dependent on groundwater and little was known hydrogeologically about the Basin. The USGS hydrogeologic study focused on groundwater conditions in the Soquel-Aptos area (Hickey, 1968). Hickey identified the regional aquifers that support groundwater production, described how groundwater pumping created conditions to draw the saltwater wedge closer to shore, and noted seawater intrusion as the greatest threat to regional groundwater production but that it had not yet come onshore. The natural groundwater discharge from the major Purisima aquifers was estimated to be 10,000 acre-feet per year (Hickey, 1968). In 1980, in response to observed seawater intrusion in the Purisima aquifers, the USGS produced a report on seawater intrusion and potential yield of aquifers in the Soquel-Aptos area (Muir, 1980). This report concluded the potential yields of the two principal aquifers in the Soquel-Aptos area were 4,400 acre-feet per year from the Purisima Formation and 1,500 acre-feet per year from the Aromas Red Sands (Muir, 1980).

A Basin HCM was first developed as part of a groundwater assessment of alternative conjunctive use scenarios (Johnson, et al. 2004). That report provided a comprehensive synthesis of information available at the time to characterize groundwater flow, evaluate the potential for seawater intrusion and diminished stream baseflow, and provide a foundation for subsequent analysis. The HCM in this GSP is primarily based on that report but ~~was~~has been updated for implementation in the numerical groundwater model developed for the Basin, including defining hydrostratigraphy of aquifer and aquitard units as well as model boundary conditions (HydroMetrics WRI, 2015).

~~The two primary aquifer systems that support groundwater production in the Basin are the Purisima Formation that underlies the entire Basin and the Aromas Red Sands Formation which overlies the Purisima Formation, east of Valencia Creek. Both the Purisima and Aromas aquifers are hydrologically connected to the Pacific Ocean. This connection creates a threat of seawater intrusion into the freshwater aquifers when groundwater pumping from the Basin exceeds natural and artificial groundwater recharge into the Basin.~~

~~Both the Purisima Formation and Aromas Red Sands are relatively undeformed in the Basin. Locally the Purisima Formation dips to the southeast. The Aromas Red Sands are assumed to be flat lying as no extensive structures have been identified that could be used to determine strike and dip. Groundwater flows by gravity following the local topography and also follows the orientation of local geologic stratigraphy. Basically, groundwater flows from the local mountains toward the ocean, but where present, also follows preferred pathway through the subsurface based on the local geology.~~

~~Because the Purisima Formation dips to the southeast, the groundwater flow direction in the Purisima aquifers is modified to flow southeast down the geologically tilted local stratigraphy toward the Basin boundary with the Pajaro Valley Subbasin. Because of the interlayering of aquifers with aquitards, groundwater is confined in some of the Purisima aquifers. Groundwater within confined aquifers can be under pressure, creating artesian conditions when wells are installed such that groundwater flows toward the surface without a pump. This is the case currently at a coastal monitoring well that is screened in the Purisima DEF-unit. Confining layers in an aquifer can also act as a barrier to the spread of contamination and can contribute to delay or prevent the spread of contamination between layered aquifers.~~

~~The Aromas Red Sands is poorly consolidated interbedded fluvial, marine, and aeolian material. Consistent with this varied depositional history, there are significant heterogeneities within the Aromas Red Sands. There is no identifiable stratigraphy and no continuous aquitard between the Aromas Red Sands and uppermost Purisima unit (the Purisima F-unit). Figure 2-10~~Figure 2-13 provides a schematic ~~HCM~~basin conceptual model to describe general inflows and outflows within the Basin ~~and outflows~~, including those to the Pacific Ocean and neighboring basins.

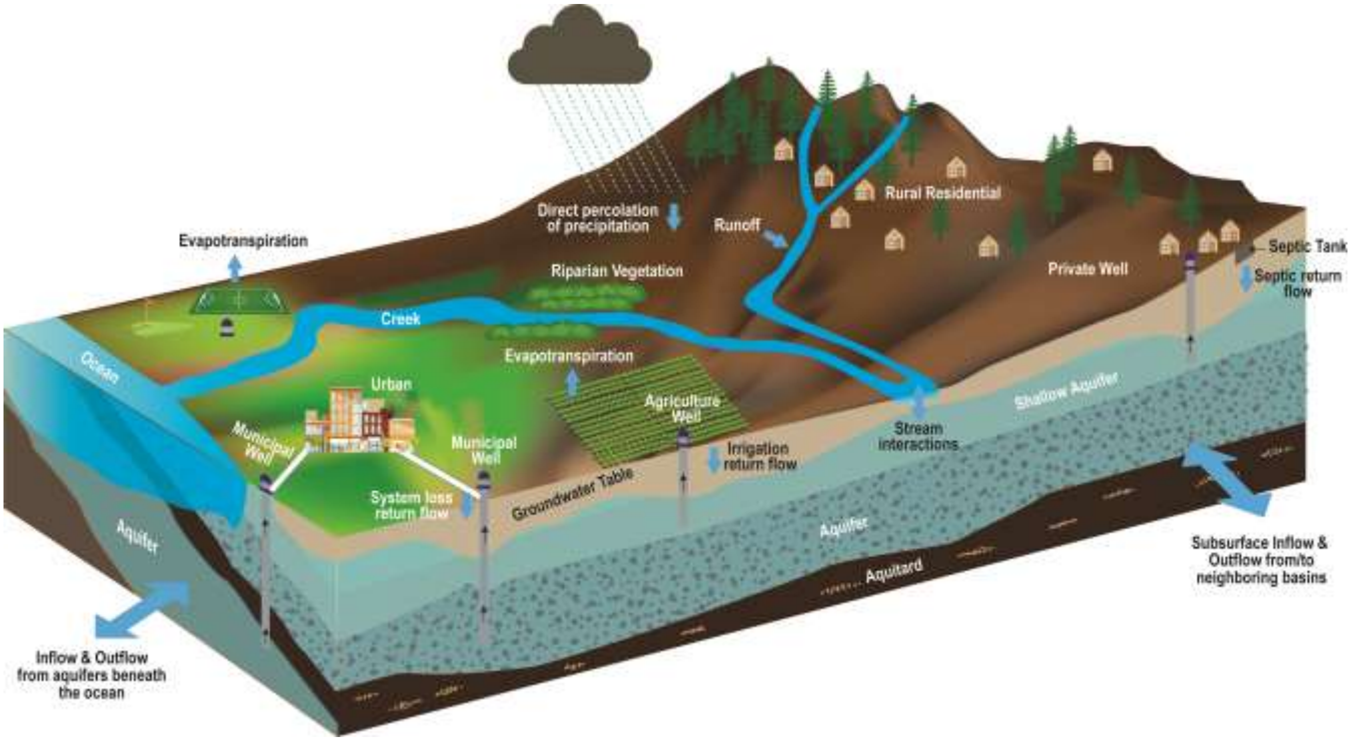


Figure 2-13. Santa Cruz Mid-County Basin Conceptual Model

~~2.2.1.1 Climate~~

~~The Basin has a Mediterranean climate characterized by warm, mostly dry summers and mild, wet winters. Due to its proximity to Monterey Bay, fog and low overcast are common during the night and morning hours, especially in the summer when warmer weather inland draws in the cool coastal marine layer. Rainfall in the City of Santa Cruz averages 29.3 inches annually. In the Santa Cruz Mountains, rainfall averages nearly 50 inches per year. The majority of seasonal rainfall occurs between November and March. However, of all 50 states, California has the greatest climatic variability and rainfall can vary greatly from year to year. Monthly and annual climate data for Santa Cruz are summarized in Table 2-3.~~

~~**Table 2-3. Average Temperature and Precipitation**~~

~~Parameter~~	~~Jan~~	~~Feb~~	~~Mar~~	~~Apr~~	~~May~~	~~Jun~~	~~Jul~~	~~Aug~~	~~Sep~~	~~Oct~~	~~Nov~~	~~Dec~~	~~Annual~~
~~Average Max. Temp. (F)~~	~~60.4~~	~~62.4~~	~~64.6~~	~~67.9~~	~~70.5~~	~~74.0~~	~~74.6~~	~~75.1~~	~~76.1~~	~~73.0~~	~~66.7~~	~~61.2~~	~~68.9~~
~~Average Min. Temp. (F)~~	~~38.8~~	~~40.9~~	~~41.9~~	~~43.3~~	~~46.1~~	~~48.8~~	~~51.1~~	~~51.4~~	~~49.9~~	~~46.7~~	~~42.2~~	~~39.1~~	~~45.0~~
~~Average Total Precipitation (inch)~~	~~6.14~~	~~5.42~~	~~4.33~~	~~1.92~~	~~0.80~~	~~0.22~~	~~0.06~~	~~0.07~~	~~0.42~~	~~1.39~~	~~3.31~~	~~5.24~~	~~29.33~~
~~Average Total Snowfall (inch)~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0.0~~	~~0.0~~

~~Source: Western Regional Climate Center - Period of Record: 01/01/1893 to 06/09/2016 Percent of possible observations for period of record.~~

~~Future average temperatures in the Basin are expected to increase and global climate models differ regarding whether rainfall will increase, decrease, remain the same, or shift both temporally in amount and intensity. The Climate Adaptation Study indicates changing temperatures and precipitation will impact ecosystems, fire risk, water quality and quantity, human and environmental health (City of Santa Cruz, 2009). The USGS projected specific climate changes and impacts on water resources for the Santa Cruz Mountains (Flint and Flint, 2012). Municipalities in the region recognize the significance of climate change to the region's economic well-being, public health, and environment, and have begun taking steps to respond.~~

~~2.2.1.2 Geology and Geologic Structures~~

~~2.2.1.2.1 Topography~~

The Basin extends ten miles from the Santa Cruz Mountains~~, to the north,~~ to the Pacific coastline and Monterey Bay. Elevations in the Basin range from sea level at the coast to approximately 1,200 feet above sea level in the coastal mountains (Figure 2-14).

The Basin has a narrow, relatively densely populated, coastal plain along the Pacific ~~coastline~~Ocean. The coastal plain is bounded landward by the Santa Cruz Mountains that rise to elevations of over 2,600 feet outside of the Basin. The most populated areas of the Basin lie on relatively flat topographic benches formed by marine wave erosion at a time when the land was lower relative to sea level than at present. The benches, referred to as marine terraces, were preserved by gradual uplift of the region. These terraces are separated from successively higher (older) terraces by steep slopes that mark ancient sea cliffs. The older terraces ascend stair-step like up the mountain front.

The lowermost of these terraces forms a broad, gently seaward sloping surface that terminates in a sea cliff at the modern shoreline. This modern sea cliff, or coastal bluff, is a result of wave erosion that is cutting a new marine terrace offshore. The marine terrace surfaces are cut by a series of south flowing creeks and seasonal streams that occupy smaller stream valleys.

Branciforte Creek is at the western edge of the Basin flowing southward from the Santa Cruz Mountains to the ocean. Soquel Creek has the largest watershed drainage and is centrally located within the Basin. Aptos and Valencia Creeks are located further east and merge together near State Route 1 before discharging into the Pacific Ocean at Rio Del Mar. The headwaters of all of these creeks originate in the Santa Cruz Mountains outside of the Basin.

Figure 2-14. Basin Topography

~~**Surficial Geology and**~~

~~2.2.1.2.2~~2.2.3.2 Soil Characteristics

The soils of the Basin are derived from exposed geologic formations, and influenced by other factors such as climate, vegetation, and local relief. Soil and vegetation affect how much precipitation can infiltrate into the soil to recharge the regional groundwater aquifers.

Saturated hydraulic conductivity of surficial soils is a good indicator of the soil's infiltration potential. Soil data from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO) (USDA NRCS, 2007) is shown by the four hydrologic groups on Figure 2-15. The soil hydrologic group is an assessment of soil infiltration rates that is determined by the water transmitting properties of the soil, which includes hydraulic conductivity and percentage of clays in the soil, relative to sands and gravels. The groups are defined as:

- Group A – High Infiltration Rate: water is transmitted freely through the soil; soils typically less than 10 percent clay and more than 90 percent sand or gravel.
- Group B – Moderate Infiltration Rate: water transmission through the soil is unimpeded; soils typically have between 10 and 20 percent clay and 50 to 90 percent sand.
- Group C – Slow Infiltration Rate: water transmission through the soil is somewhat restricted; soils typically have between 20 and 40 percent clay and less than 50 percent sand
- Group D – Very Slow Infiltration Rate: water movement through the soil is restricted or very restricted; soils typically have greater than 40 percent clay, less than 50 percent sand

The hydrologic group of the soil generally correlates with the hydraulic conductivity of underlying geologic units, with higher soil hydraulic conductivity zones, such as the Aromas Red Sands having higher infiltration capacities. Soils overlying many of the terrace deposits have a well-developed clay subsoil, with much lower hydraulic conductivity than the underlying deposits.

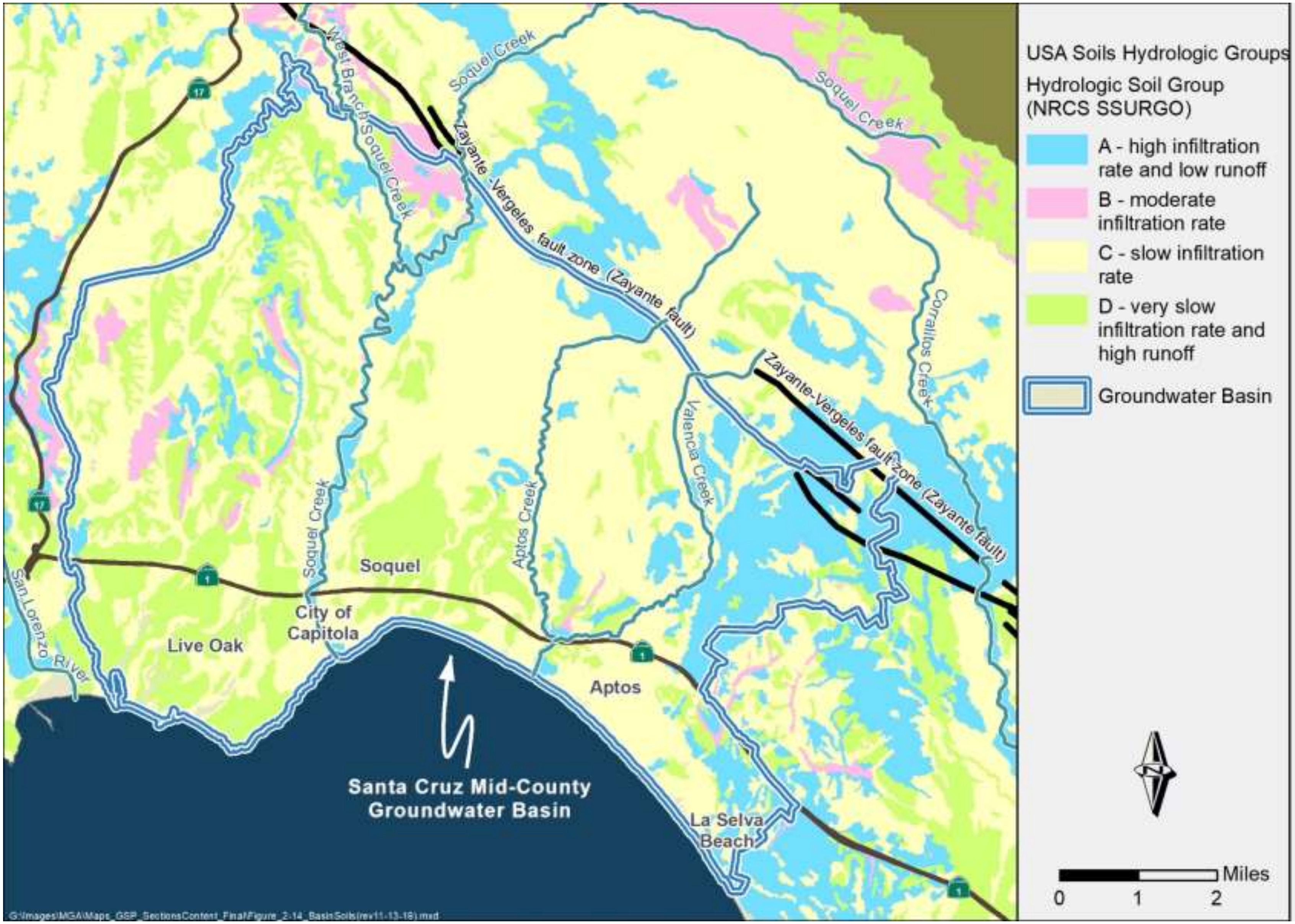


Figure 2-15. Basin Soils

2.2.3.3 Surface Geology

As discussed above, two main geologic formations ~~make up~~occur across the Basin: the Purisima Formation and the Aromas Red Sands~~ (Figure 2-12). The ~~. Other surficial deposits include Quaternary colluvium, alluvium, flood plain deposits, beach sands, and terrace deposits. USGS mapped surface geology is provided on Figure 2-16.

2.2.3.3.1 Purisima Formation ~~is composed of named aquifer and aquitard layers, where the Aromas Red Sands is considered a single aquifer unit, but has significant heterogeneities (Figure 2-13).~~

The Pliocene to late Miocene age Purisima Formation (Tp) is a sequence of grey, sometimes described as blue, moderately consolidated, silty to clean, fine- to medium-grained sandstones containing siltstone and claystone interbeds. It underlies the entire Basin; however, it is blanketed by the Aromas Red Sands in the eastern third of the Basin, and by relatively shallow intermittent alluvial and terrace deposits elsewhere (~~Figure 2-14). The ~~Figure 2-16).

2.2.3.3.2 Aromas Red Sands

The Pleistocene age Aromas Red Sands ~~are a sequence of~~(Qar) overlie the Purisima Formation in the hills and coastal terraces east of Valencia Creek (Figure 2-16). Aromas Red Sands comprises interbedded fluvial (Qaf) and aeolian (Qae) sediments that are generally brown to red, poorly consolidated, fine- to coarse-grained sands containing lenses of silt and clay. Consistent with this varied depositional history, there are significant heterogeneities within the Aromas Red Sands. They are assumed to be flat lying as no extensive structures have been identified that could be used to determine strike and dip.

2.2.3.3.3 Surficial Deposits

Quaternary surficial deposits overlying the Purisima Formation include colluvium, alluvium, flood plain deposits, beach sands, and terrace deposits.

Colluvium (Qtl) occurs primarily over parts of the Aromas Red Sands and western portion of the Purisima Formation (Figure 2-16). It comprises unconsolidated, heterogeneous deposits of moderately to poorly sorted silt, sand, and gravel. It was deposited by slope wash and mass movement, and has some minor fluvial reworking. Locally includes numerous landslide deposits and small alluvial fans. Its contacts with other deposits are generally gradational.

Alluvium (Qal) is generally associated with existing rivers and creeks (Figure 2-16). It is heterogeneous, with moderately sorted silt and sand containing discontinuous lenses of clay and silty clay. These deposits are generally relatively shallow. Older unconsolidated flood plain deposits (Qof) consisting of fine-grained sand, silt, and clay occur adjacent to the mainstem of Soquel Creek.

Since the Basin is bound on one side by the Pacific Ocean, there is a ribbon of beach sands (Qbs) that extend almost the length of the coastal boundary. These sediments are an unconsolidated and well-sorted sand that locally may contain layers of pebbles and cobbles.

Thin discontinuous lenses of silt are relatively common in back-beach areas. Its thickness is variable, in part due to seasonal changes in wave energy, but is usually less than 20 feet thick.

The Basin's terrace deposits are both fluvial and coastal. Fluvial terrace deposits (Qt) are weakly consolidated to semi-consolidated heterogeneous deposits of moderately to poorly sorted silt, silty clay, sand, and gravel. Their thickness is highly variable but can reach a thickness of 60 feet. Some of the deposits are relatively well indurated in the upper 10 feet of weathered zone.

There are two different mapped types of coastal terrace deposits. The lowest emergent coastal terrace deposit (Qcl) is a semi-consolidated, generally well-sorted sand with a few thin, relatively continuous layers of gravel. It was deposited in nearshore high-energy marine environment. Its thickness is variable but only reaches a maximum of approximately 40 feet. It thins northwards where it ranges from 5 to 20 feet thick. Undifferentiated coastal terrace deposits (Qcu), are semi-consolidated, moderately well sorted marine sands with thin, discontinuous gravel-rich layers. It also has a variable thickness and is generally less than 20 feet thick.

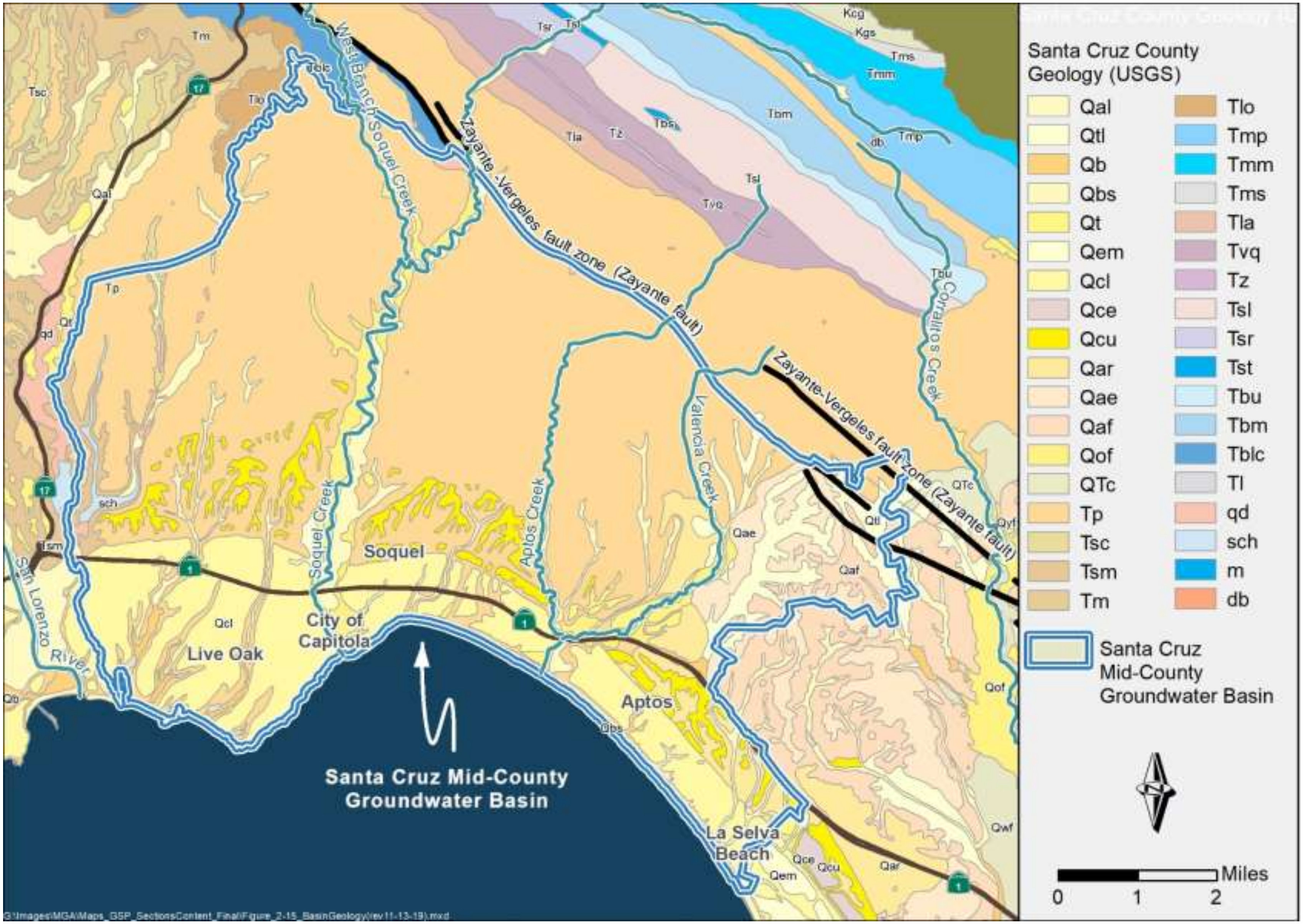


Figure 2-16. Basin Surface Geology

2.2.3.4 Regional Geologic Structures

The Zayante-Vergeles fault zone, which forms the northern Basin boundary, is a major northwest-striking structural element of the Santa Cruz Mountains restraining bend of the larger San Andreas fault zone. It is a major dextral reverse-oblique-slip fault with late Pleistocene and possible Holocene displacement with an estimated vertical slip rate of 0.2 mm per year (Bryant, 2000). The Zayante-Vergeles fault is considered a barrier to groundwater flow due to Purisima Formation being impacted by faulting and folding north of the fault such that sediments are not expressed as stacked aquifer units as in the Basin south of the fault zone.

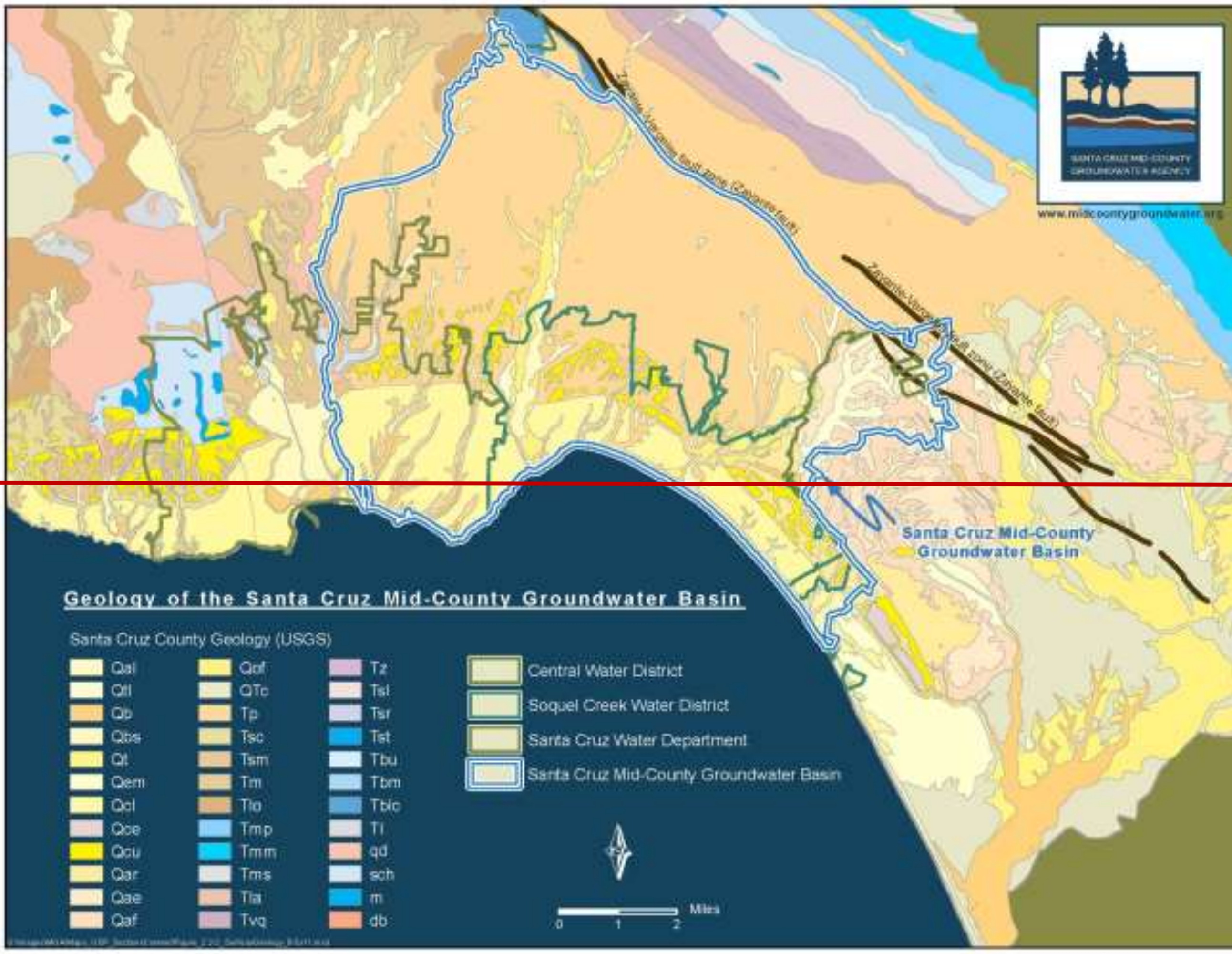
Although not a documented fault, during development of the MGA integrated groundwater-surface water model (model) a fault-like feature was added to the model to achieve the hydraulic gradients observed in monitoring wells in the central portion of the Basin. Additional evidence supporting the possibility of a fault in this location are 1) a U.S. Geological Survey report of earthquakes and faults within the greater San Francisco Bay Area, including Santa Cruz County (Sleeter, et al., 2004) indicates that, based on seismic activity in the area, there is evidence of some faulting south of the Zayante-Vergeles fault zone, and 2) Alexander (1953) observed deformation of the marine terraces near Capitola between Aptos and Rio del Mar; the axis of deformation appears to have an east-west alignment similar to faulting found in the USGS report and inferred from regional groundwater elevation gradients. A technical memorandum describing hydrogeological conceptual model changes incorporated in to the model is provided in Appendix 2-E. The model calibration report (Appendix 2-F) and model simulations report (Appendix 2-I) refer to this feature as the Aptos area faulting.

As described in Section 2.2.1, the definable bottom of the Basin is the granitic basement rock that is observed in boreholes and in outcrops throughout the Basin. The granitic basement structure has been defined by U.S. Geological Survey (USGS) gravity anomaly data (Roberts et al., 2004) and refined by use of borehole log and e-log data supporting development of the Basin model (Appendix 2-D). During the Paleocene (between 95 and 61 million years ago) regional uplift led to “unroofing” of the metasedimentary and granitic rock. “Unroofing” occurred where this overlying rock was removed by erosion (McLaughlin and Clark, 2004). After this “unroofing” event, the granitic rock formed the surface where subsequent deposition occurred.

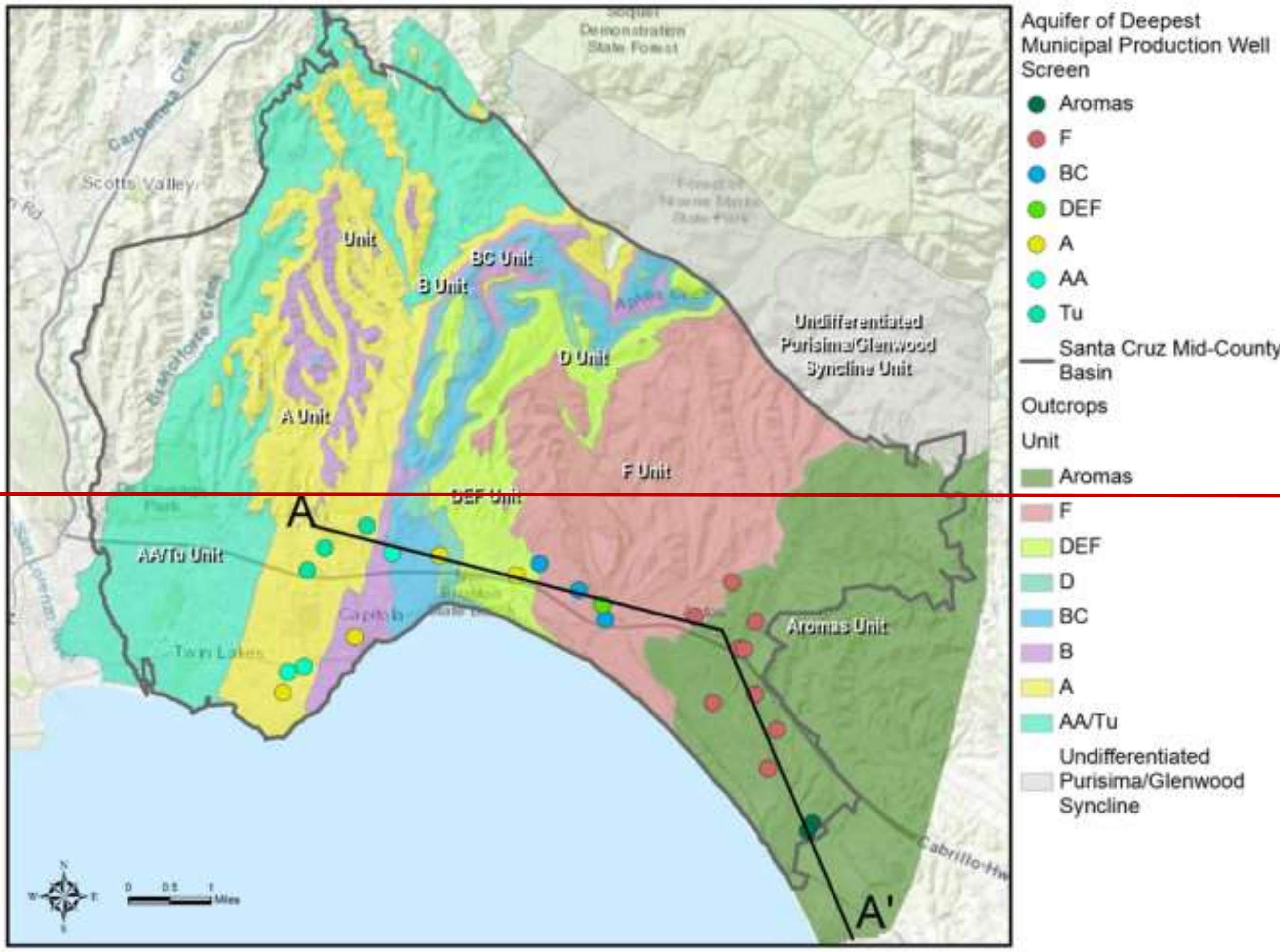
Both the Purisima Formation and Aromas Red Sands are relatively undeformed in the Basin. Locally, the Purisima Formation dips to the southeast at approximately 4 degrees (Figure 2-19). This dip results in remnants of the lower-most strata occurring only along ridge tops west of the study area. ~~Both the Purisima Formation and Aromas Red Sands are relatively undeformed in the Basin. Locally, the Purisima Formation dips to the southeast at approximately 4 degrees (Figure 2-15). This dip results in remnants of the lower-most strata occurring only along ridge tops west of the study area.~~ The Purisima Formation also occurs within a tightly folded syncline north of the Zayante~~-Fault~~-Vergeles fault zone outside the Basin, and along the upper portions of the Soquel and Aptos Creek watersheds.

2.2.3.5 Principal Aquifers and Aquitards

~~The Aromas Red Sands are assumed to be flat lying as no extensive structures have been identified that could be used to determine strike and dip. The outcrops of the Purisima Formation hydrostratigraphic units shown on Figure 2-13 are based on Johnson et al. (2004) and coastal terrace deposits mapped by Brabb et. al (1997) The hydrostratigraphic units do not outcrop in these areas, but are covered by coastal terrace deposits. Hydrostratigraphic cross-sections on Figure 2-15 and Figure 2-16include analyses incorporated into the Basin model (HydroMetrics WRI, 2015).~~



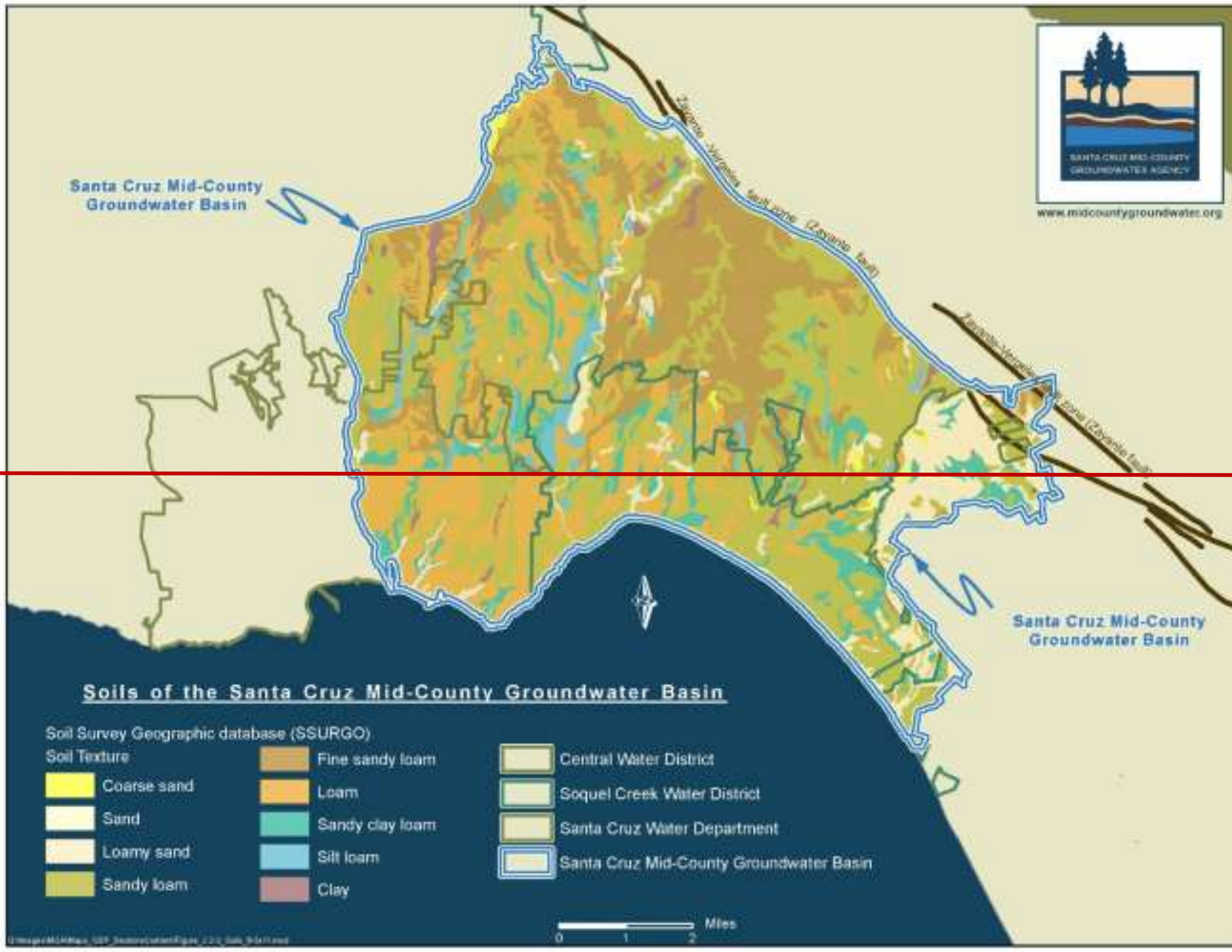
~~**Figure 2-12. Basin Geology**~~



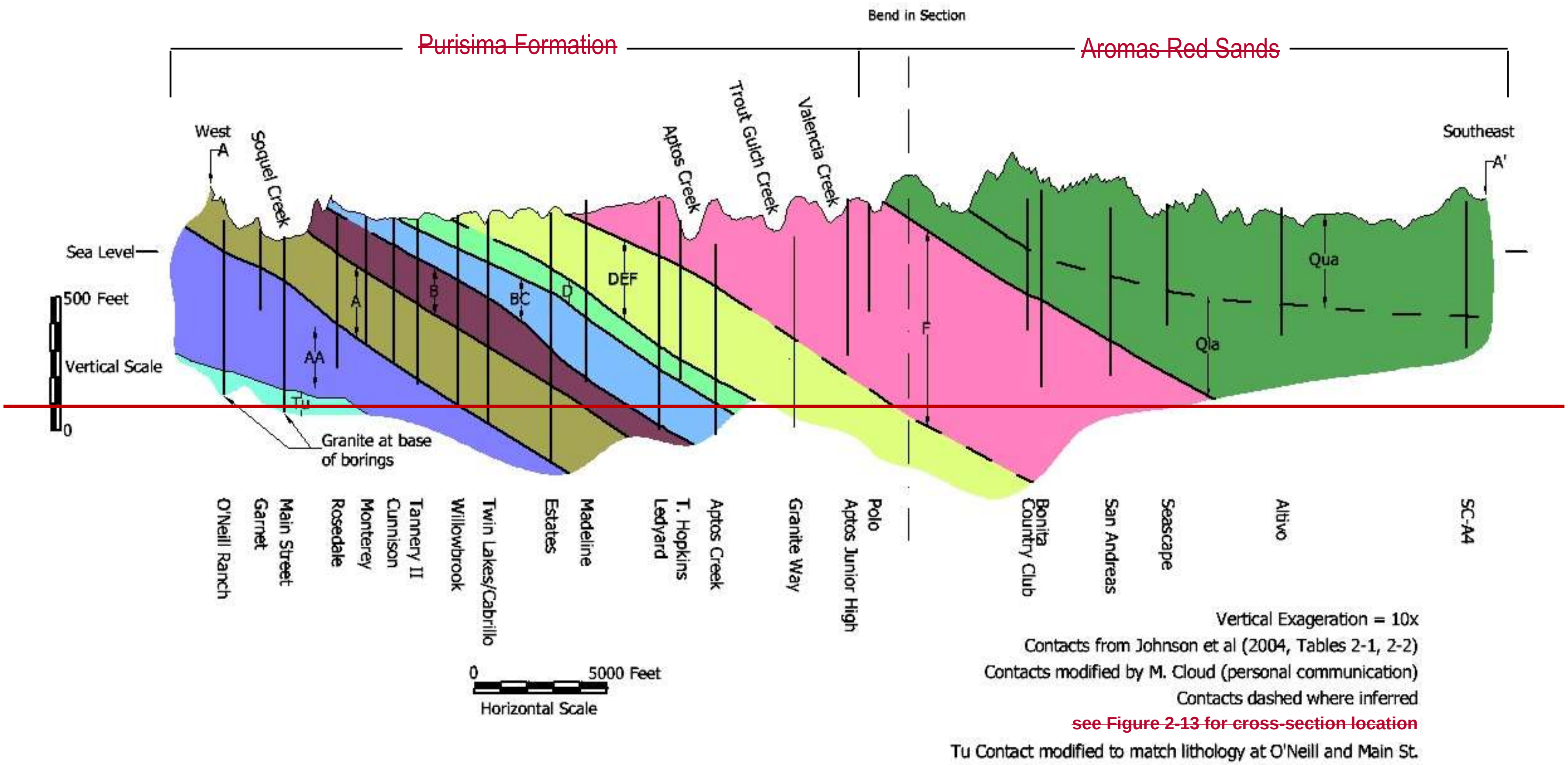
2.2.3.5.1 ~~Figure 2-13.~~ Aquifer and Aquitard ~~Outcrops~~Descriptions

There are two primary water-bearing geologic formations within the Basin: the Purisima Formation and the Aromas Red Sands. The Basin is dominated by the Purisima Formation which extends throughout the Basin and overlies granitic basement rock that outcrops in the west of the Basin. In the southeast of the Basin, east of Valencia Creek, the Purisima Formation is overlain by unconfined Aromas Red Sands.

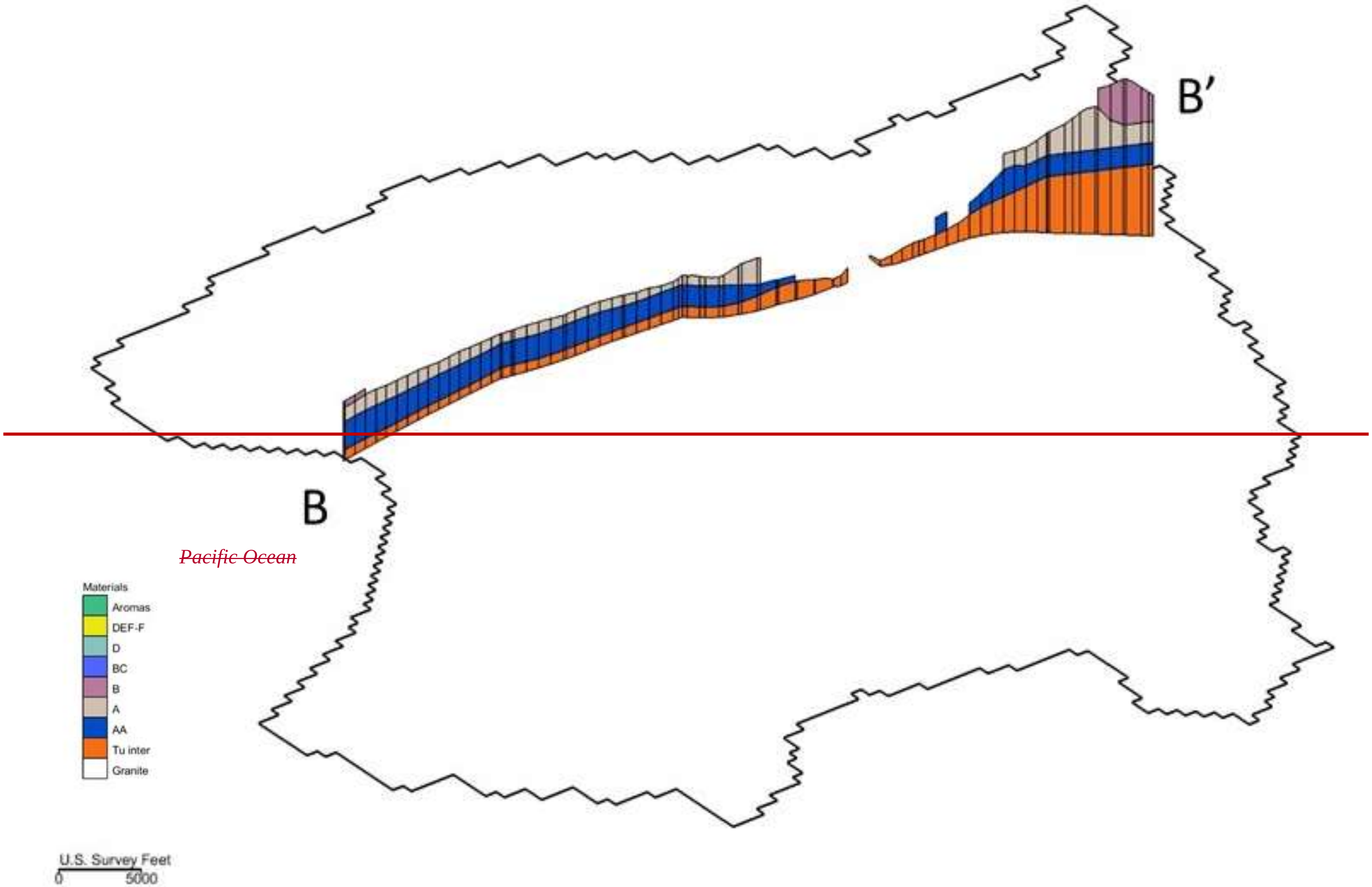
Since the Purisima Formation dips to the southeast and the Aromas Red Sands are assumed to be flat lying, groundwater flows by gravity following the local topography but also follows the orientation of local geologic stratigraphy. Essentially, groundwater flows from the local mountains toward the ocean, but where present, also follows preferred pathway through the subsurface based on the local geology.



Both the Purisima and Aromas aquifers are hydrologically connected to the Pacific Ocean. ~~Figure 2-14. Basin Soils~~



~~Figure 2-15. Hydrostratigraphic Cross-Section, A – A'~~



~~**Figure 2-16. Hydrostratigraphic Cross-Section from Model Output, B – B' (HydroMetrics WRI, 2015)**~~

~~2.2.1.3~~2.1.1.1 ~~Principal Aquifers and Aquitards~~

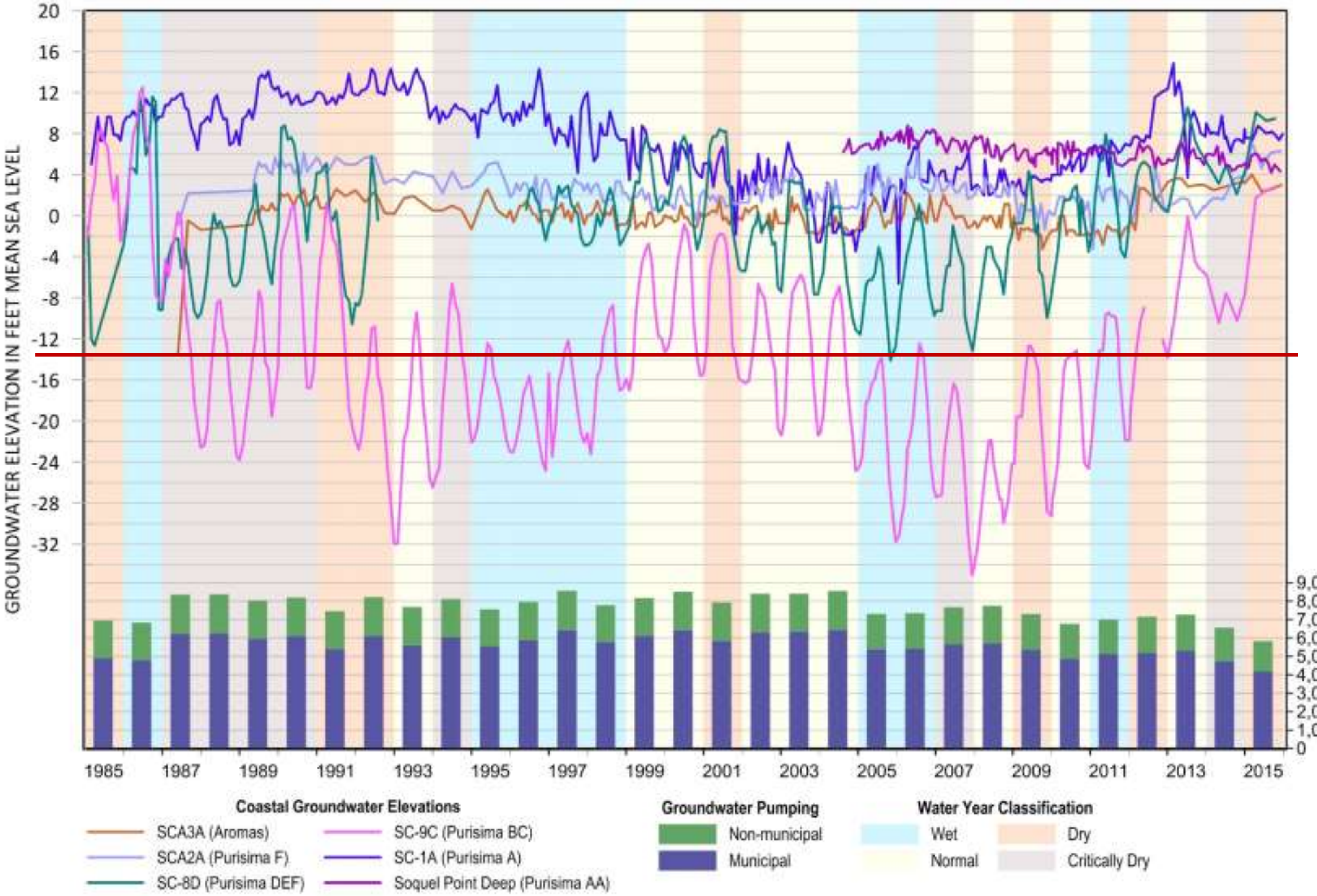
~~There are two primary water-bearing geologic formations within the Basin: the Purisima Formation and the Aromas Red Sands. The Basin is dominated by the Purisima Formation which extends throughout the Basin and overlies granitic basement rock, which outcrops in the west of the Basin. The sediments of the Purisima Formation are semi-consolidated to consolidated marine deposits compressed by the ocean into mudstone and sandstone and uplifted over time. The sediments are a sequence of gray-to-blue, silty to clean, fine- to medium-grained sandstone containing siltstone and claystone interbeds. This sequence may be described as a layer cake of water bearing aquifers and confining aquitards that sometimes create artesian well conditions. To the southeast, east of Valencia Creek, the Purisima Formation is overlain by unconfined Aromas Red Sands. The Aromas Red Sands Formation is generally brown to red, poorly consolidated, fine to coarse-grained sands containing lenses of silt and clay.~~

This connection creates a seawater intrusion threat to the freshwater aquifers when groundwater pumping from the Basin exceeds natural and artificial groundwater recharge into the Basin.

Hydrographs on ~~Figure 2-17~~Figure 2-17 showing groundwater levels in the Basins' aquifers display relatively large variations in groundwater levels in the deeper highly-confined aquifers, for example in the Purisima BC unit. This variation suggests that groundwater levels are highly influenced by pumping and less so by annual recharge. The hydrographs also show large vertical gradients between the different hydrostratigraphic units.

The Purisima Formation is composed of named aquifer and aquitard layers, where the Aromas Red Sands is considered a single aquifer unit, but has significant heterogeneities. Each of the principal aquifers and aquitards that occur in the Basin are discussed below.

Aromas Red Sands Formation (Qa ~400 feet thick): The southeastern portion of the ~~basin~~Basin, generally beginning east of Valencia Creek, is identified as the Aromas Red Sands aquifer. The poorly consolidated Aromas Red Sands consist of interbedded fluvial, marine, and eolian sands with lenses of silt and clay. Consistent with this varied depositional history, the Formation contains significant heterogeneities. The Aromas Red Sands overlie the Purisima Formation in the hills and coastal terraces east and southeast of Aptos. LSCE (1987) subdivided the Aromas Red Sands into an upper and a lower unit within Pajaro Valley. A large portion of the upper zone may be unsaturated, especially where the water table is drawn down to near sea level. Johnson et al. (2004) estimates that the hydraulic conductivity of the Lower Aromas Red Sands ranges between 6 and 50 feet per day, and the hydraulic conductivity of the Upper Aromas Red Sands ranges between 3 and 40 feet per day.



There is no identifiable stratigraphy and no continuous aquitard between the Aromas Red Sands and uppermost Purisima unit (the Purisima F-unit).

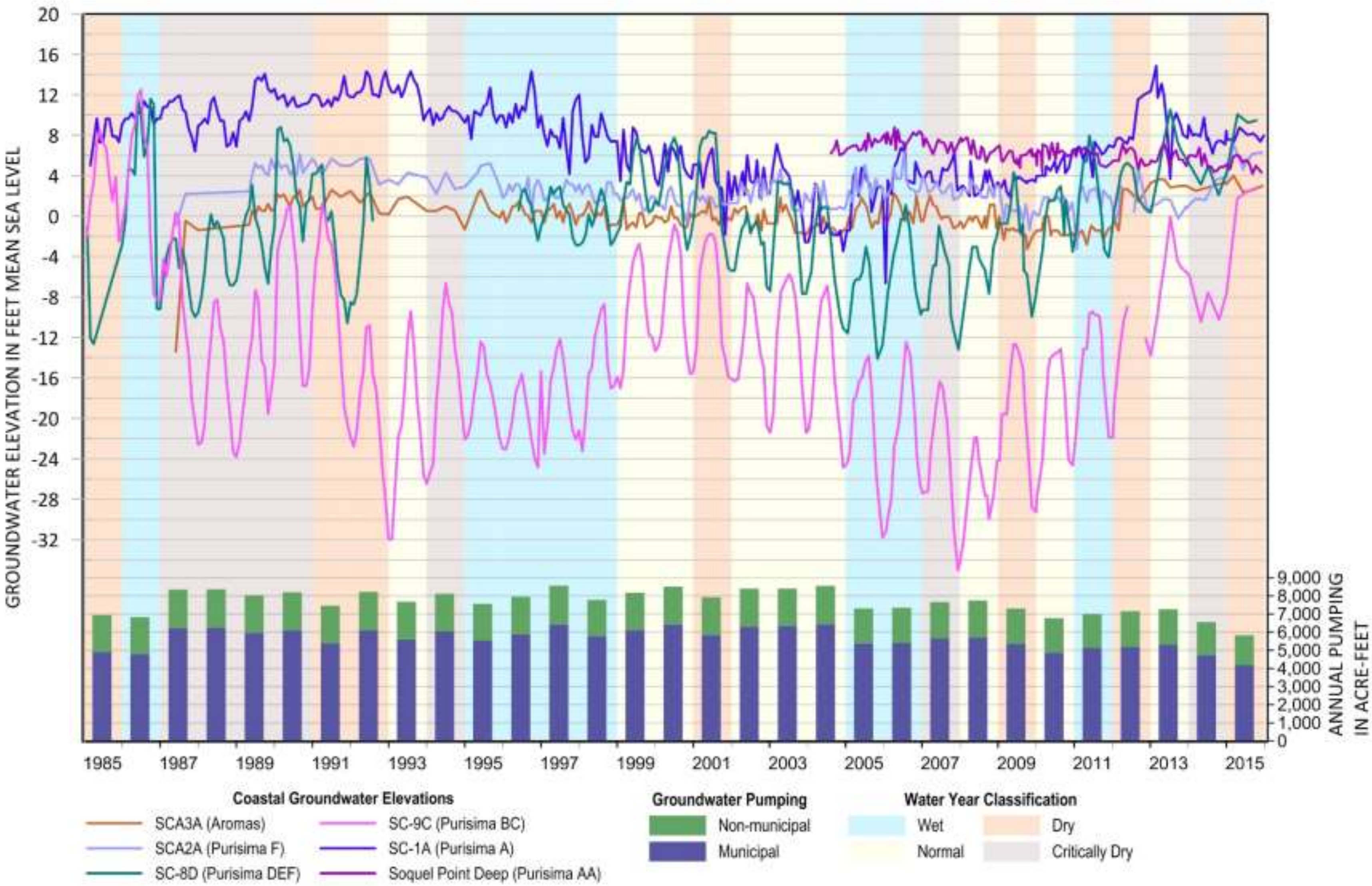


Figure 2-17. Coastal Groundwater Elevations Compared with Historical Basin Pumping (1985-2015)

Purisima Formation (Tp): The Purisima Formation has an uneroded total thickness of up to 2,000 feet (Hickey, 1968). The 1968 USGS Hydrogeologic Study subdivided the Purisima Formation into three hydrostratigraphic units in the Soquel-Aptos area, designated from oldest to youngest as A, B, and C (Hickey, 1968). In 2004, the current hydrostratigraphic model was developed by Johnson et al. reviewing additional geologic investigations by Luhdorff and Scalmanini Consulting Engineers (LSCE, 1984). Johnson et al. accepted the general layered aspect of the Purisima Formation, and by combining the AA through F units into hydrostratigraphic units that define regional aquifers and aquitards. These Purisima Formation hydrostratigraphic units are defined from oldest to youngest as follows:

Purisima-AA Aquifer Unit (150 to 300 feet thick). This unit comprises a sequence of interbedded, moderately coarse- and fine-grained zones underlying the well-defined A~~-~~-unit. A fine-grained zone 20 to 70 feet thick divides the AA unit from the overlying A unit. Johnson et al. (2004) estimates that the hydraulic conductivity of this hydrostratigraphic unit ranges between 1 and 10 feet per day.

Purisima-A Aquifer Unit (~250 feet thick). This distinct aquifer is the most consistently coarse-grained aquifer within the Purisima Formation. It is sometimes divided into an upper and lower zone, with the lower zone being more coarse-grained. Johnson et al. (2004) estimates that the hydraulic conductivity of this hydrostratigraphic unit ranges between 7 and 65 feet per day.

Purisima-B Aquitard Unit (~150 feet thick). This aquitard consists of the lower portion of the LSCE unit B. This portion of unit B is consistently fine-grained, with the lower 25 to 45 feet being the most highly correlated feature across the Soquel-Aptos Area Basin. A coarse-grained bed is often encountered in the middle of this otherwise fine-grained unit. Johnson et al. (2004) estimates that the hydraulic conductivity of this hydrostratigraphic unit ranges between 0.005 and 1 foot per day.

Purisima-BC Aquifer Unit (~200 feet thick). The LSCE unit C is grouped with the upper portion of the LSCE unit B to form Aquifer BC. This is a moderately coarse-grained unit with a distinct 15 to 20 foot thick coarse-grained unit at the top of the unit. Johnson et al. (2004) estimates that the hydraulic conductivity of this hydrostratigraphic unit ranges between 1 and 3 feet per day.

Purisima-D Aquitard Unit (~80 feet thick). The lower 60 to 80 ~~ft~~feet of LSCE unit D is predominantly ~~finegrained~~fine-grained, with one or two minor coarse-grained intervals. Johnson et al. (2004) estimates that the hydraulic conductivity of this hydrostratigraphic unit ranges between 0.005 and 1 foot per day.

Purisima-DEF Aquifer Unit (~330 feet thick). This moderately coarse aquifer includes intermittent fine-grained zones. The top of this aquifer seems poorly defined; Johnson et al. (2004) does not identify a distinct marker or aquitard separating this aquifer from the overlying Aquifer F. Johnson et al. (2004) estimates that the hydraulic conductivity of this hydrostratigraphic unit ranges between 2 and 6 feet per day.

Purisima-F Aquifer Unit (500+ feet thick). This unit consists of alternating moderately coarse- and fine-grained zones. Johnson et al. ~~Johnson et al. (2004) estimates that the hydraulic conductivity of this hydrostratigraphic unit ranges between 0.005 and 1 foot per day.~~

~~**Purisima-DEF Aquifer Unit (~330 feet thick).** This moderately coarse aquifer includes intermittent finegrained zones. The top of this aquifer seems poorly defined; Johnson et al. (2004) does not identify a distinct marker or aquitard separating this aquifer from the overlying Aquifer F. Johnson et al. (2004) estimates that the hydraulic conductivity of this hydrostratigraphic unit ranges between 2 and 6 feet per day.~~

~~**Purisima-F Aquifer Unit (500+ feet thick).** This unit consists of alternating moderately coarse- and fine-grained zones. Johnson et al.~~ (2004) identifies this aquifer as the upper portion of the Purisima F-unit that is often screened in conjunction with the lower Aromas Red Sands. Johnson et al. (2004) estimates that the hydraulic conductivity of this hydrostratigraphic unit ranges between 2 and 6 feet per day.

Because of the interlayering of aquifers with aquitards, groundwater is confined in some of the Purisima aquifers. Groundwater within confined aquifers can be under pressure, creating artesian conditions when wells are installed such that groundwater flows toward the surface without a pump. This is the case currently at a coastal monitoring well that is screened in the Purisima DEF-unit. Confining layers in an aquifer can also act as a barrier to the spread of contamination and can contribute to delay or prevent the spread of contamination between layered aquifers.

~~-unit that is often screened in conjunction with the lower Aromas Red Sands. Johnson et al. (2004) estimates that the hydraulic conductivity of this hydrostratigraphic unit ranges between 2 and 6 feet per day.~~

Purisima Formation hydrostratigraphic units shown on Figure 2-18 are based on Johnson et al. (2004) and coastal terrace deposits mapped by Brabb et al. (1997). The hydrostratigraphic units do not always outcrop at the surface as they are often covered by alluvium or coastal terrace deposits (Figure 2-16). Hydrostratigraphic cross-sections on Figure 2-19 and Figure 2-20 illustrate the Basin's aquifers and significant structural features.

Undifferentiated Sandstone of Tertiary Age (Tu, between 10 and 3,000 feet thick): The Tu unit is not a formal formation mapped by the USGS but it is a localized productive aquifer that includes all non-Purisima water-bearing units between the poorly defined base of the Purisima AA aquifer unit and the top of granitic basement. This unit is generally found in the western portion of the Basin and pinches out where the base of the Purisima Formation intersects the granitic basement.

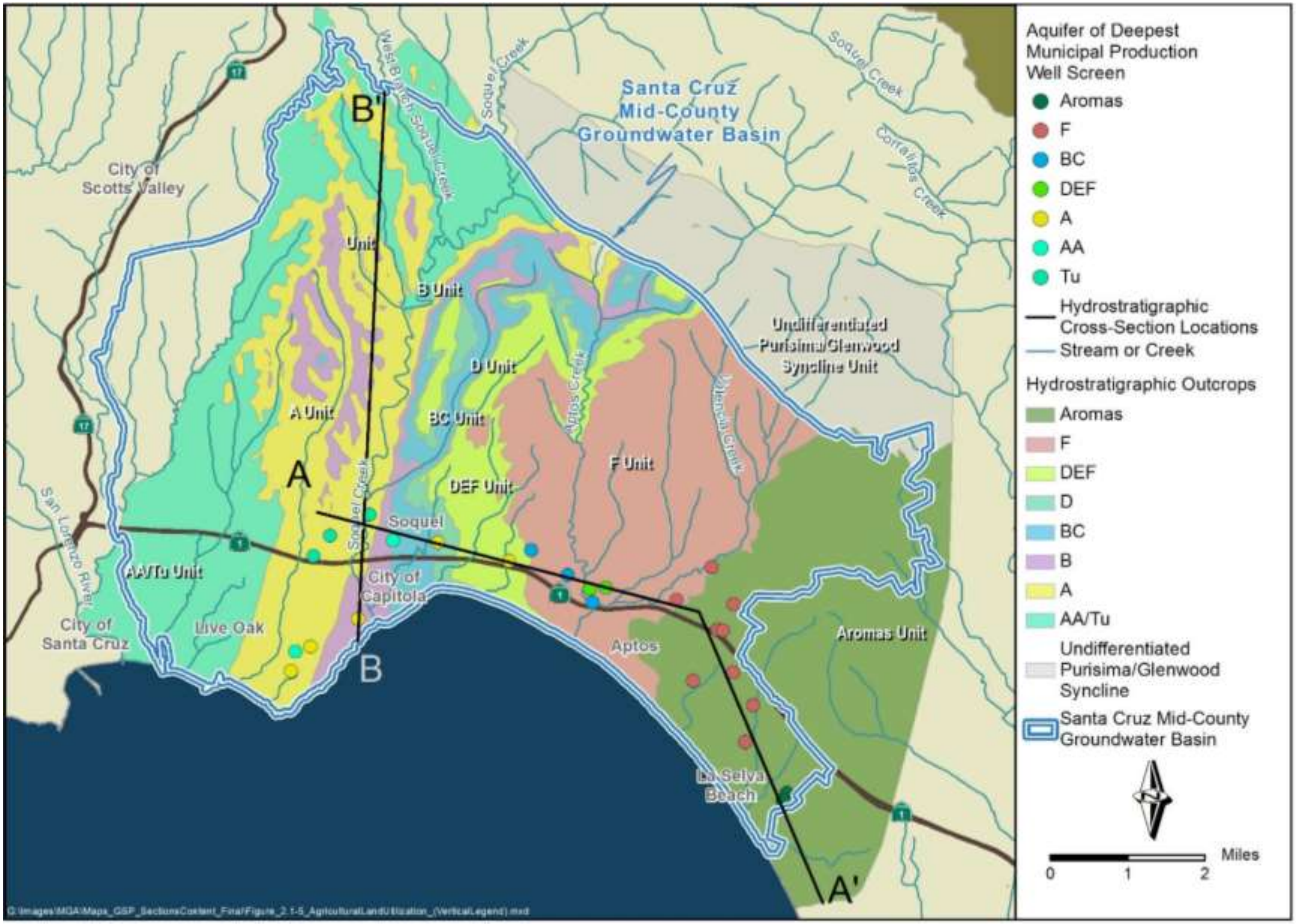


Figure 2-18. Aquifer and Aquitard Distribution Across the Basin

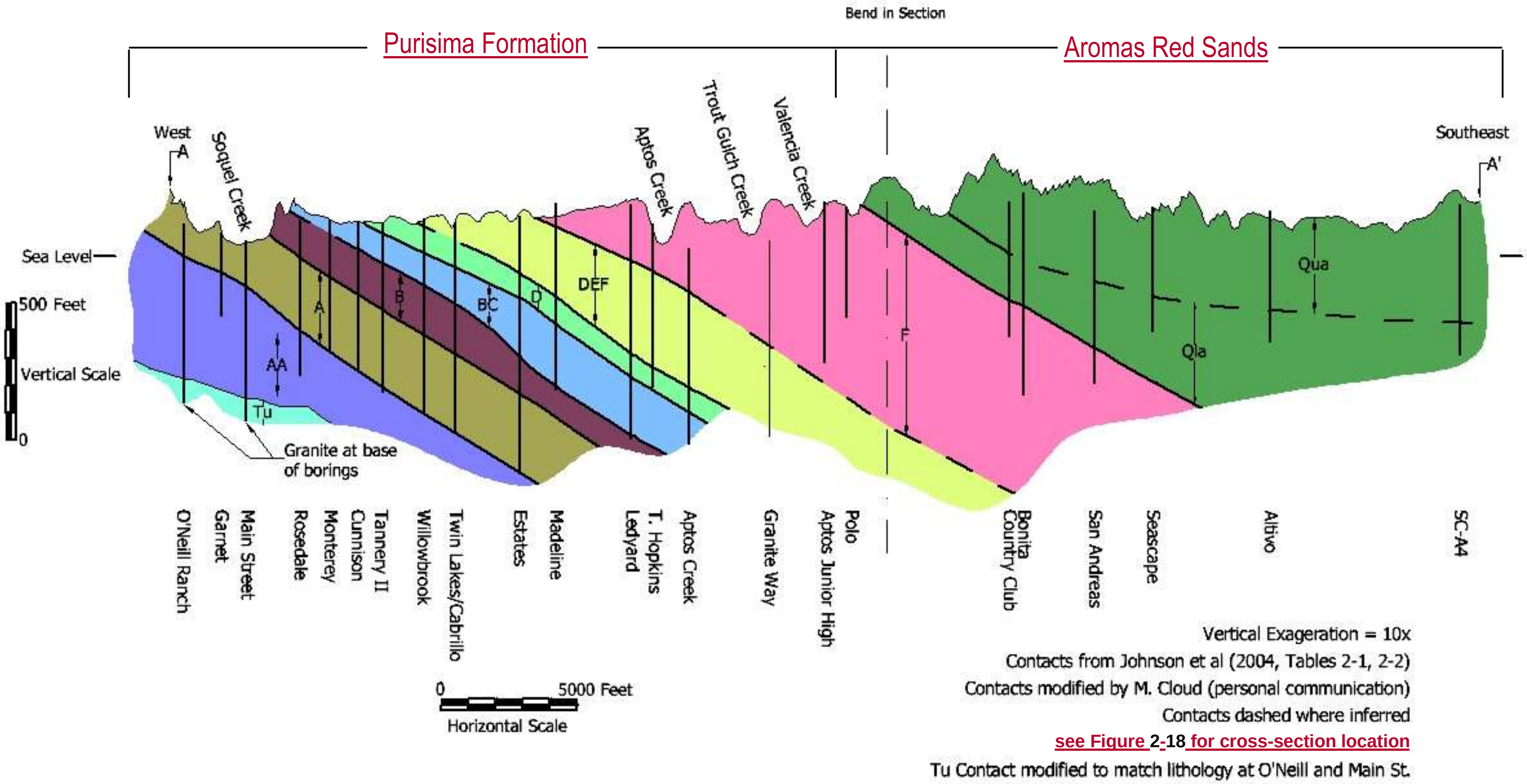


Figure 2-19. Hydrostratigraphic Cross-Section, A – A'

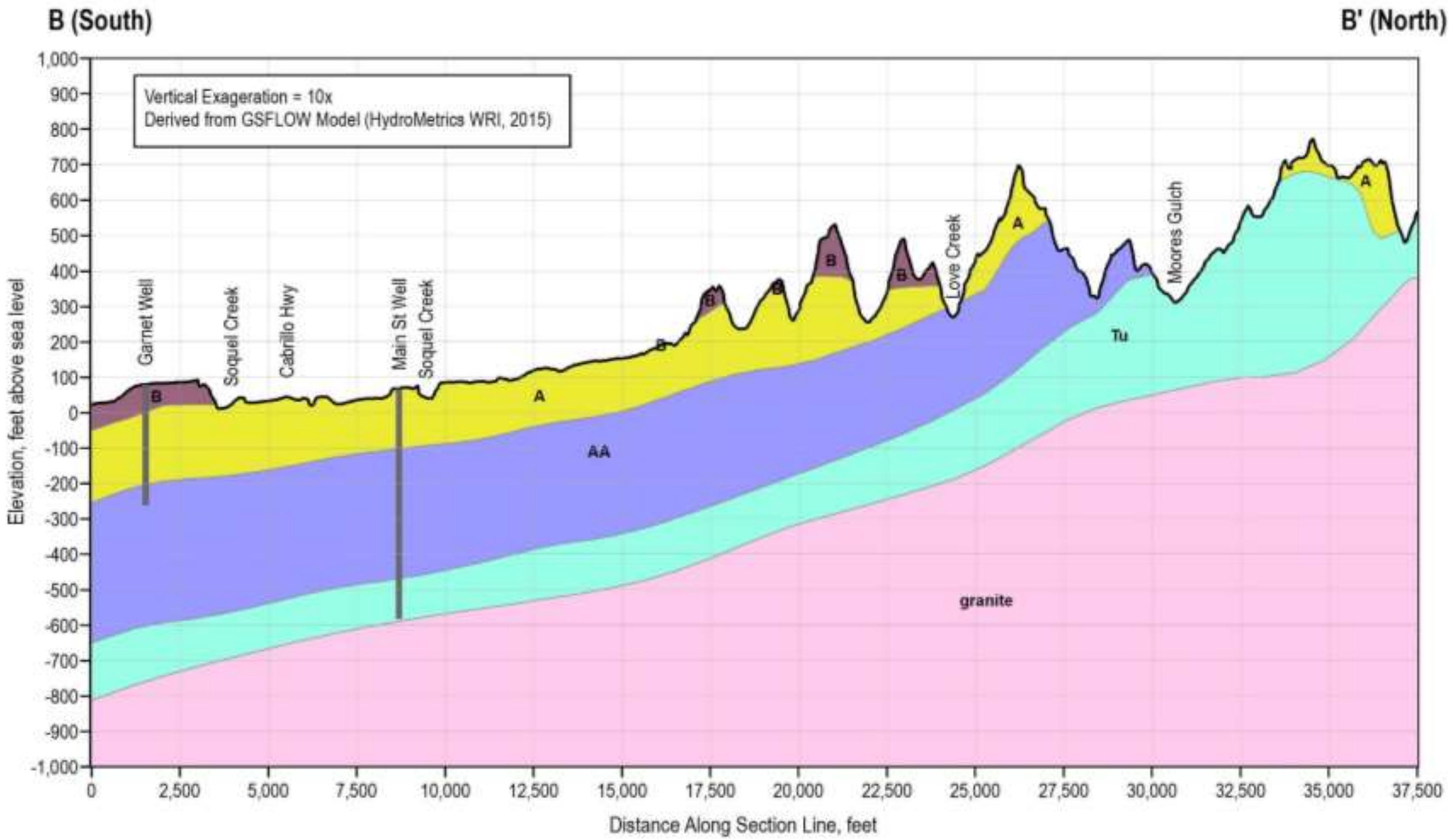


Figure 2-20. Hydrostratigraphic Cross-Section, B – B'

2.2.3.5.2 Primary Aquifer Use

The Purisima Formation aquifer units and the Aromas Red Sands aquifer are the primary aquifers pumped throughout the Basin by all extractors (Table 2-4). Non-municipal domestic and small scale agriculture users of groundwater generally complete their wells in the shallowest productive aquifers, while municipal extractors complete their wells in specific aquifer units that may be much deeper than domestic wells. For example, in the western portion of the Basin, most domestic wells pump from the Purisima A-unit which is the shallowest aquifer, while the City of Santa Cruz and SqCWD pump from the deeper Purisima AA-unit or Tu aquifer in addition to the overlying Purisima A-unit. Many municipal wells are screened through multiple Purisima aquifers to maximize well yield. Residential, agricultural, and municipal wells are often screened through both the Aromas Red Sands and Purisima F-unit aquifers when the Purisima F-unit is relatively shallow. The average proportion of pumping by aquifer and user type from 1985 through 2016 is summarized in Table 2-4.

Table 2-4. Proportion of Total Basin Extractions by Aquifer and Use Type

Aquifer	Non-Municipal Domestic	Non-Municipal Institutions	Agriculture	Municipal	All Pumpers
	Percent of Total Groundwater Extractions				
Aromas Red Sands	1%	<1%	2%	29%	34%
All Purisima Aquifer Units	12%	8%	2%	46%	66%
Total	13%	9%	4%	75%	100%

Data Source: metered pumping for municipal extractions and estimated extractions for non-municipal extractions. See Appendix 2-B for details on methodology for non-municipal extractions.

Municipal pumpers, SqCWD and CWD, have over the past few years been pumping less from the Aromas Red Sands than what they pumped historically because of naturally occurring Chromium-VI and elevated nitrate concentrations associated with septic systems and possibility fertilizer use. These groundwater quality issues are discussed in more detail in Section 2.2.4.4.

~~2.2.1.4~~2.2.3.6 Surface Water Bodies Significant to Basin Management

DWR regulations requires the ~~hydrogeologic conceptual model~~HCM describe surface water bodies significant to the management of the Basin. In the Basin, significant water bodies fall into four categories:

a) Surface water bodies that impact Basin water quality
b) Surface water bodies that supply water to Basin residents
c) Surface water bodies connected to Basin groundwater
d) Surface water supporting ~~Basin~~ Groundwater Dependent Ecosystems (GDE)

The first three categories are outlined in this subsection while the fourth category, surface water that supports GDE, is identified and discussed in ~~Section 3.9.~~detail in Sections 2.1.4.12; 2.2.2.6; and 2.2.2.7. Figure 2~~-~~-21 shows the location of ~~the~~ significant surface water bodies in the Basin.

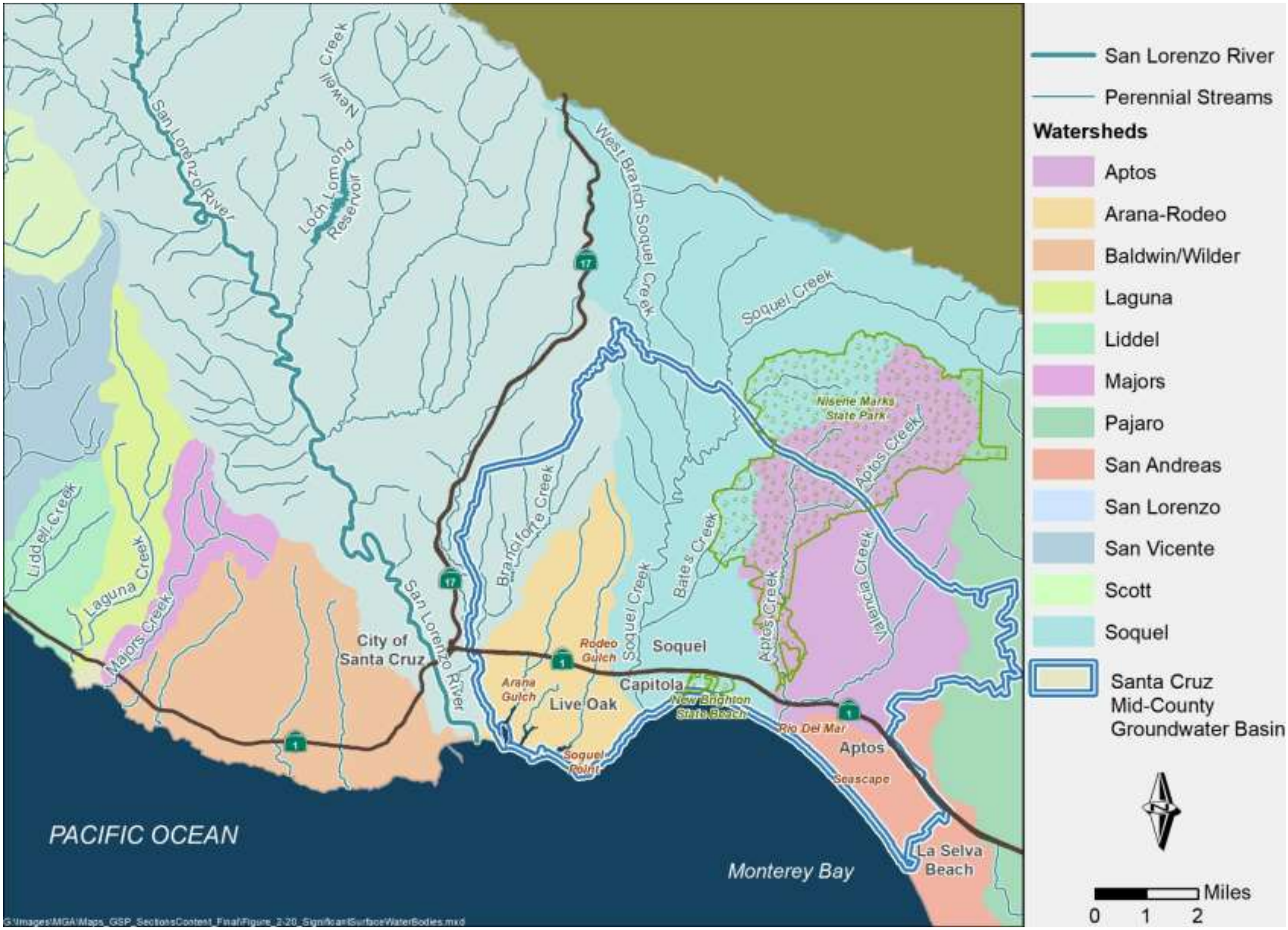


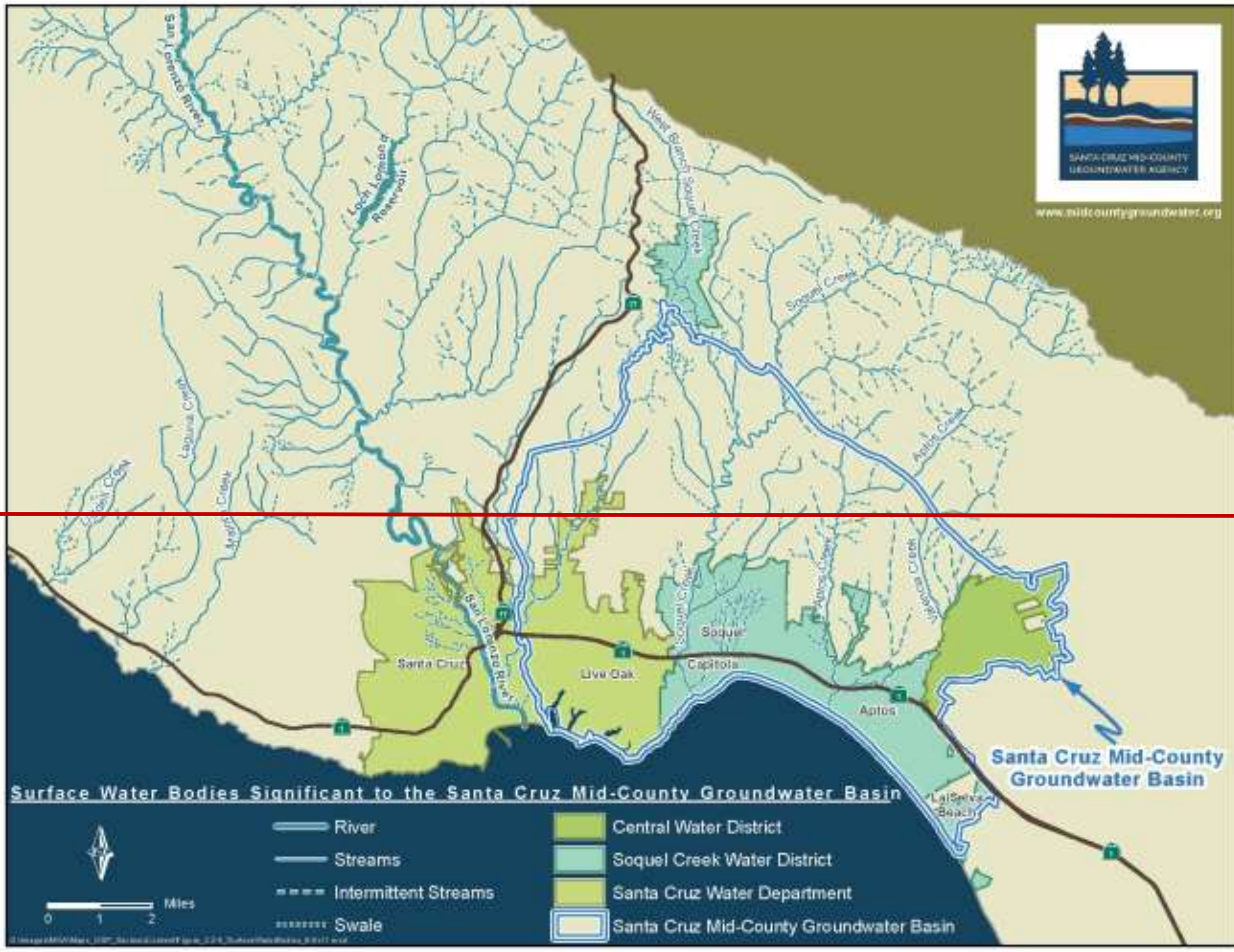
Figure 2-21. Significant Surface Water Bodies

~~2.2.1.4.1~~2.2.3.6.1 Surface Water Bodies that Impact Basin Water Quality

The Basin includes 10 miles of coastline along the Pacific Ocean inside of Monterey Bay. The Purisima and Aromas Red Sands groundwater aquifers used for water supply by Basin residents are hydrologically connected to the Pacific Ocean. This connection creates a threat of seawater intrusion into ~~our~~Basin freshwater supply aquifers. Because of this threat, the Pacific Ocean is the largest surface water body that impacts groundwater management practices in the Basin.

Both the Purisima and Aromas Red Sands have been impacted by seawater intrusion. The Purisima A-unit aquifer has experienced seawater intrusion at Soquel Point and the Aromas Red Sands aquifer has ongoing seawater intrusion in the Seascape and La Selva Beach areas. MGA sponsored geophysical research indicates that seawater intrusion is an active threat all along the Basin's coastal margin~~.~~ (Ramboll, 2018). Groundwater elevations and groundwater modeling indicate a high risk of additional seawater intrusion in the New Brighton and Seascape areas and the advance of seawater intrusion at Soquel Point and in La Selva Beach~~.~~ (Hydrometrics, 2018).

Basin management has and will continue to focus on controlling seawater intrusion. MGA member agencies have successfully developed water conservation and pumping management plans optimized to keep groundwater elevations high enough at the coast to prevent further onshore movement of seawater into the Basin's freshwater aquifers. These management efforts have resulted in some the lowest per capita municipal water demand in the state and reduced municipal groundwater pumping from approximately 7,000 acre-feet per year in the late 1980s to approximately 4,000 acre-feet ~~-~~per year in Water Year 2017. However, model simulations indicate that supplemental water supplies or groundwater use curtailment is needed to reach and maintain protective groundwater elevations and achieve groundwater sustainability in the face of climate change as modeled and discussed in Sections 4.2 and 4.3.



~~Figure 2-18. Significant Surface Water Bodies~~

~~2.2.1.4.2~~2.2.3.6.2 Surface Water Bodies that Supply Water to Basin Residents

The City of Santa Cruz Water Department supplies approximately 45% of Basin residents with water that is primarily sourced from surface water. The surface waters used by the City to serve its Basin customers are: San Lorenzo River, Majors Creek, Liddell Creek, Laguna Creek, Reggiardo Creek, and Loch Lomond Reservoir on Newell Creek. All of the City's surface water supply sources are located outside of the Basin.

In addition to the surface water supplied to its own customers within the Basin, ~~the City~~SCWD also has supplied ~~Soquel Creek Water District~~SqCWD with treated drinking water ~~sourced from Majors, Liddell, and Laguna Creeks~~ when ~~it~~SCWD has excess surface water available. This water transfer from ~~the City~~SCWD to ~~Soquel Creek Water District~~SqCWD is part of a conjunctive use pilot project. The pilot project is an in-lieu water transfer ~~focused on~~that began delivering treated surface water to ~~Soquel Creek Water District~~SqCWD customers in ~~its Service Area 1.~~December 2018 to fulfill an agreement negotiated in 2016. This in-lieu water transfer allows less groundwater pumping from the wells that typically serve ~~Service Area 1~~SqCWD customers. Reduced pumping allows ~~in-lieu~~natural recharge to occur.

~~2.2.1.4.3~~2.2.3.6.3 Surface Water Bodies Connected to Basin Groundwater

Groundwater elevation monitoring, stream elevations, stream gauging data, and integrated surface water-groundwater modeling (Figure 2-10) have all been used to identify streams that are connected to groundwater within the Basin. These data have also been used to determine the amount of time throughout the year that each surface water body within the Basin is connected to groundwater.

Soquel Creek has the largest watershed in the Basin and its complete catchment measures approximately 42 square miles (Figure 2-21). Soquel Creek's main upper tributary is the West Branch of Soquel Creek. Bates Creek is a lower tributary. Soquel Creek is connected to shallow groundwater during most of the year at most of its reaches within the Basin (Figure 2-10). Where data are available on lower Soquel Creek only, there are both gaining and losing reaches.

Two smaller streams within the Basin, Aptos Creek and Valencia Creek, are also connected to groundwater in their lower reaches for at least part of the year (Figure 2-10). In their upper reaches, groundwater elevation monitoring and stream elevations indicate that both Aptos Creek and Valencia Creek are not connected to groundwater. Current and historic groundwater elevations (dating to the 1950s) are significantly below stream elevations. This historic information, especially given that Aptos Creek is mostly within Nisene Marks State Park where few wells are located, indicates that these streams were unlikely to have been connected to groundwater in the historic past. However, both Aptos and Valencia Creeks become connected to groundwater near their confluence one half mile before Aptos Creek enters the Pacific Ocean at Rio Del Mar.

In the western portion of the Basin, Arana Gulch and Rodeo Gulch may be connected to groundwater in their lower reaches~~:~~. Branciforte Creek is the westernmost creek in the Basin, but much of the stream channel flows directly over the underlying granitic basement and has little influence on the Basin's aquifers. Maps and additional detailed recommendations for improved monitoring and management of surface water bodies connected to groundwater are found in Section 3.9.

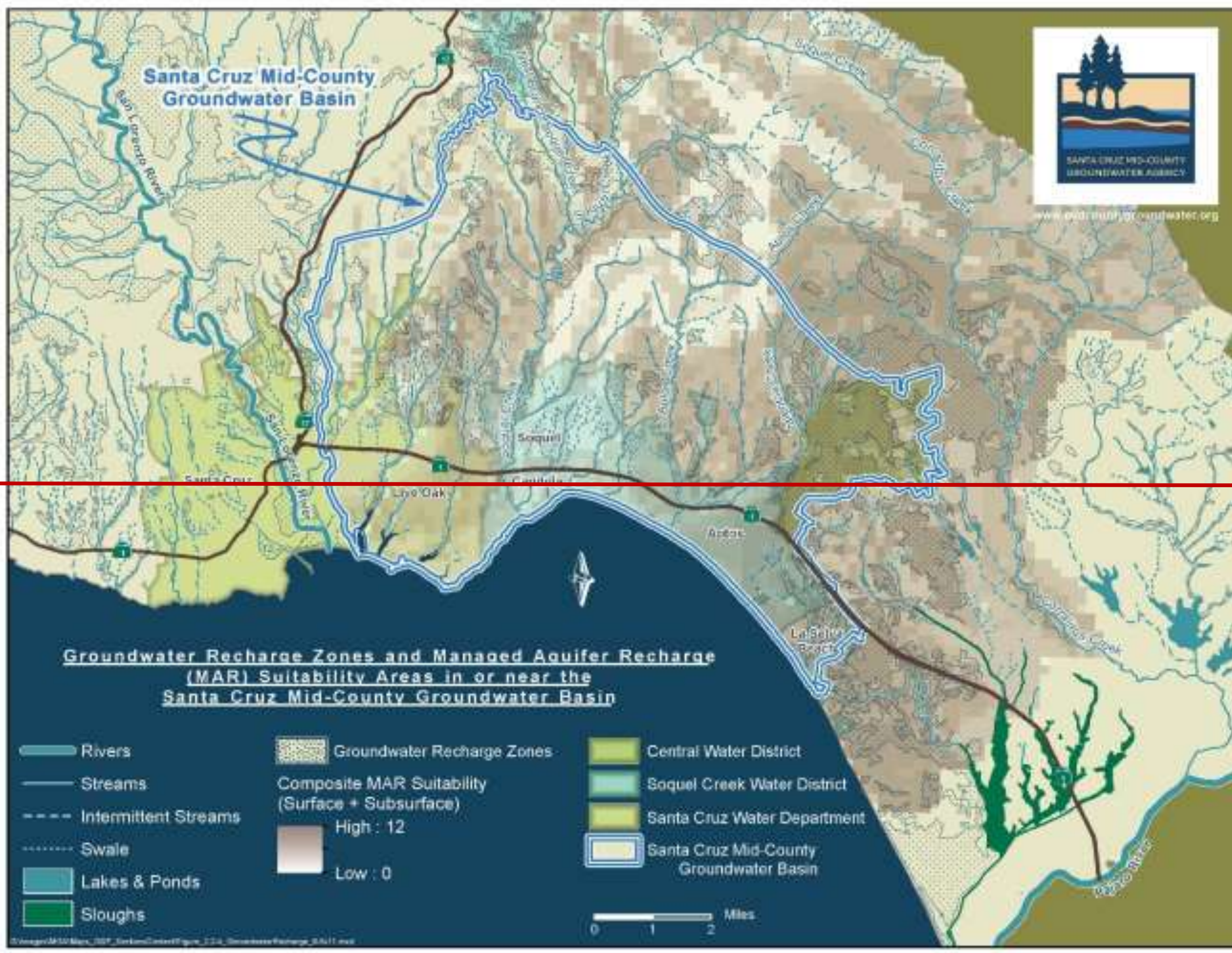
~~2.2.1.4.4~~2.2.3.6.4 Surface Water Supporting Basin Groundwater Dependent Ecosystems (GDE)

Significant surface water bodies supporting GDEs are mapped and discussed in detail in Section 2.1.4.12; 2.2.2.6; and 2.2.2.7.

~~2.2.1.5~~2.2.3.7 Recharge Areas and Water Deliveries

~~2.2.1.5.1~~2.2.3.7.1 Basin Recharge Areas

~~Currently, recharge~~ Recharge to the Basin occurs through natural processes, ~~through~~ groundwater recharge projects developed or permitted by MGA member agencies, or ~~through~~by percolation directly from water-related infrastructure, such as from leaks in water, wastewater, ~~and~~ storm water delivery systems, and from septic systems in unsewered portions of the Basin. Natural recharge ~~areas are~~ zones have been mapped ~~for the Basin (~~by the County of Santa Cruz and managed aquifer recharge suitability has been evaluated by Russo et al. (2014). The Basin's recharge zones and relative managed aquifer recharge surface suitability are shown on Figure 2-22~~).~~



~~**Figure 2-19. Groundwater Recharge Zones**~~

~~Given~~. Figure 2-18 shows the ~~impracticability of directly measuring groundwater recharge, the~~ "outcrop" of the Basin's ~~groundwater recharge has been previously evaluated to guide groundwater management. Prior to~~aquifers, however, the ~~development of the Basin model, the most recent historic estimate of groundwater recharge was completed by Hydrometrics WRI in~~

~~2011. The 2011 recharge estimate was developed using a Precipitation-Runoff Modeling System (PRMS) model and included review and evaluation of prior work on the subject, including deep recharge estimates developed~~hydrostratigraphic units do not always outcrop at the surface as ~~part of the prior hydrogeologic conceptual model (Johnson, et al. 2004). The area~~they are often covered by ~~the 2011 PRMS model was slightly smaller than the Santa Cruz Mid-County Basin now recognized in DWR Bulletin 118.~~alluvium or coastal terrace deposits (Figure 2-16).

~~The 2011 PRMS model estimated average annual deep groundwater recharge at 10,800 acre-feet per year over the model's calibration period.[3] The annual average was slightly higher than the corrected 2004 deep recharge estimate of 9,900 acre-feet per year (Johnson, et al., 2004). This difference is attributed to different assumptions about precipitation and evapotranspiration that were both considered to be within the expected rates for the Basin (Table 2-4).~~

~~Table 2-4. 2011 PRMS Average Annual Water Budget Summary~~

~~Method~~	~~Aquifer Outcrop~~	~~Precipitation~~	~~Streamflow~~	~~Evapo-transpiration~~	~~Deep Groundwater Recharge~~
		~~Acre-Feet per Water Year~~			
~~Johnson et al. (2004)~~	~~Purisima~~	~~93,500~~	~~24,700~~	~~61,800~~	~~7,000 (6,100)~~
	~~Aromas~~	~~18,900~~	~~1,800~~	~~14,200~~	~~2,900~~
	~~Total~~	**~~112,400~~**	**~~26,500~~**	**~~76,000~~**	**~~9,900 (9,000)~~**
~~2011 PRMS~~	~~Purisima~~	~~91,300~~	~~24,500~~	~~60,500~~	~~6,600~~
	~~Aromas~~	~~19,200~~	~~2,100~~	~~12,200~~	~~4,200~~
	~~Total~~	**~~110,500~~**	**~~26,500~~**	**~~72,700~~**	**~~10,800~~**

~~Notes: The values in parenthesis are values from the Johnson et al. (2004) report that are in error.~~
~~The values above the parenthesized values are the corrected values.~~
~~Totals may not add up due to rounding errors.~~
~~Purisima area = 51 square miles, Aromas area = 14 square miles.~~

~~Deep annual recharge estimates varied from 290 acre-feet to 42,900 acre-feet per year. The 2011 median deep groundwater recharge estimate was 5,900 acre-feet per year, almost half the annual average. This annual variability corresponds both to California's climate variability and to the uncertainty of predicting future conditions of groundwater recharge. Table 2-5 lists the 2011 PRMS model's average annual groundwater recharge estimated for each Purisima aquifer.~~

[3] ~~2011 PRMS Model calibration period is from October 1, 1983 to September 30, 2009 (Water Year 1984-Water Year 2009).~~

~~Table 2-5. 2011 PRMS Average Deep Groundwater Recharge for Outcropping Aquifers~~

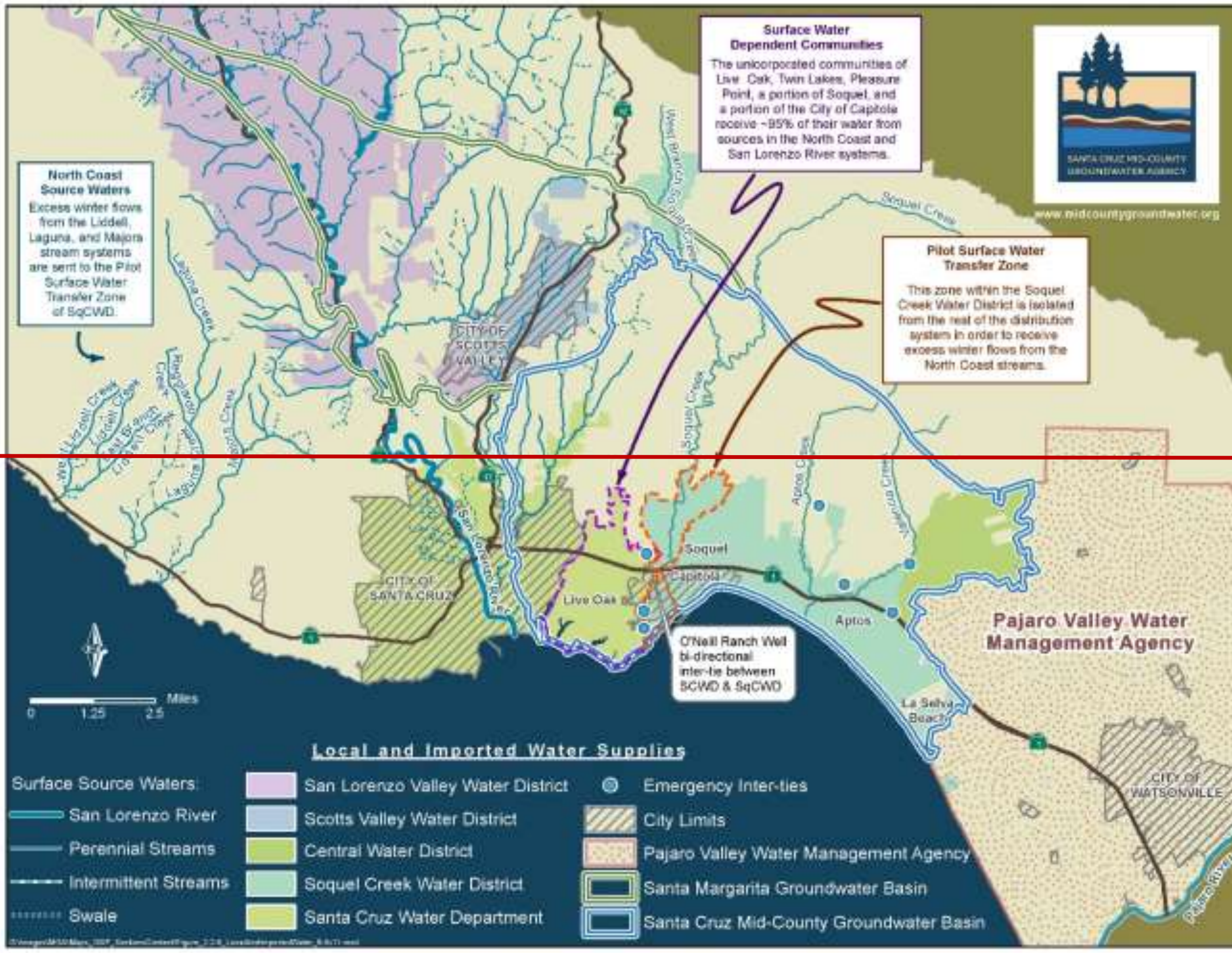
~~Purisima Aquifer Outcrop~~	~~Average Deep Groundwater Recharge (Acre-Feet per Year)~~
~~AA~~	~~1,600~~
~~A~~	~~1,300~~
~~BC~~	~~500~~
~~DEF~~	~~900~~
~~F~~	~~1,400~~

~~2.2.1.5.2~~2.2.3.7.2 Water Deliveries

A limited amount of water is imported from Santa Clara County to small water systems in the Summit Area of the Santa Cruz Mountains. This area is outside the Basin but within the Upper Soquel Creek watershed, which drains into the Basin.

Some Basin residents do receive water from outside the Basin, either as direct municipal customers who receive treated surface water supplied to them from the ~~City of Santa Cruz Water Department~~SCWD or as part of the in-lieu water transfer pilot project between ~~the City of Santa Cruz~~SCWD and ~~Soquel Creek Water District~~SqCWD (Figure 2-23).

Planned and emergency water transfers into the Basin take place between MGA member municipal water providers using interties that connect the individually owned and maintained agency water systems to each other. These interties were originally developed as emergency connections between water agencies to improve water supply reliability. Conjunctive use water transfers are expected to expand with increased water availability if water rights place of use changes are approved in the future. Conjunctive use is discussed in greater detail in Sections 2.1.4.5, 2.1.4.6, and 4.2.3.


Surface Water Dependent Communities
The unincorporated communities of Live Oak, Twin Lakes, Pleasure Point, a portion of Soquel, and a portion of the City of Capitola receive ~95% of their water from sources in the North Coast and San Lorenzo River systems.
SANTA CRUZ MID-COUNTY GROUNDWATER AGENCY
www.midcountygroundwater.org
North Coast Source Waters
Excess winter flows from the Liddell, Laguna, and Majors stream systems are sent to the Pilot Surface Water Transfer Zone of SqCWD.
Pilot Surface Water Transfer Zone
This zone within the Soquel Creek Water District is isolated from the rest of the distribution system in order to receive excess winter flows from the North Coast streams.
West Branch Soquel Creek
Soquel Creek
Laguna Creek
CITY OF SCOTTS VALLEY
Aptos Creek
Soquel
Capitola
Live Oak
Aptos
CITY OF SANTA CRUZ
San Lorenzo River
Pajaro Valley Water Management Agency
O'Neill Ranch Well bi-directional inter-tie between SCWD & SqCWD
La Selva Beach
Miles
0
1.25
2.5
CITY OF WATSONVILLE
Pajaro River
Local and Imported Water Supplies
Surface Source Waters:
San Lorenzo River
Perennial Streams
Intermittent Streams
Swale
San Lorenzo Valley Water District
Scotts Valley Water District
Central Water District
Soquel Creek Water District
Santa Cruz Water Department
Emergency Inter-ties
City Limits
Pajaro Valley Water Management Agency
Santa Margarita Groundwater Basin
Santa Cruz Mid-County Groundwater Basin

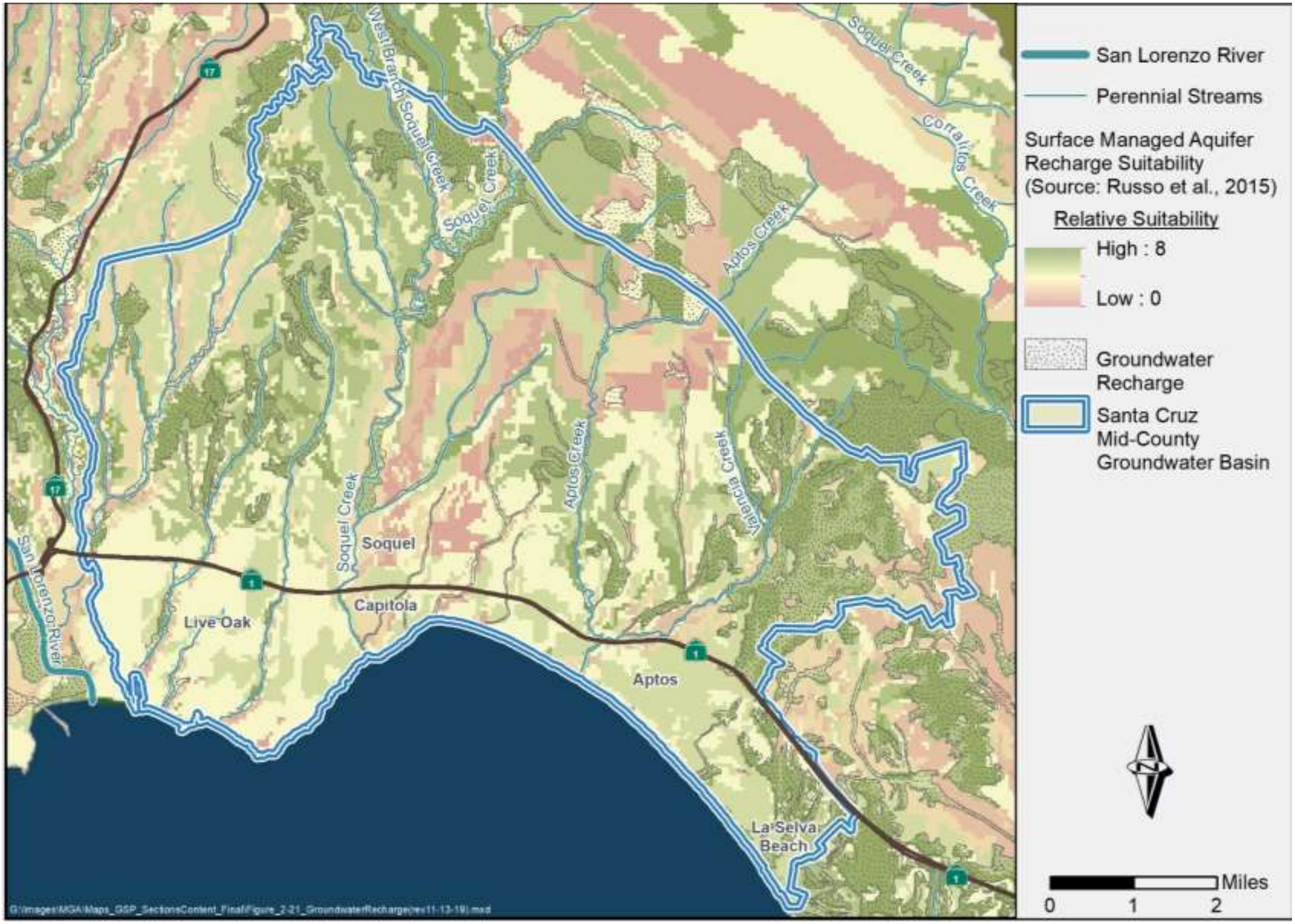


Figure 2-22~~.~~. Groundwater Recharge Zone

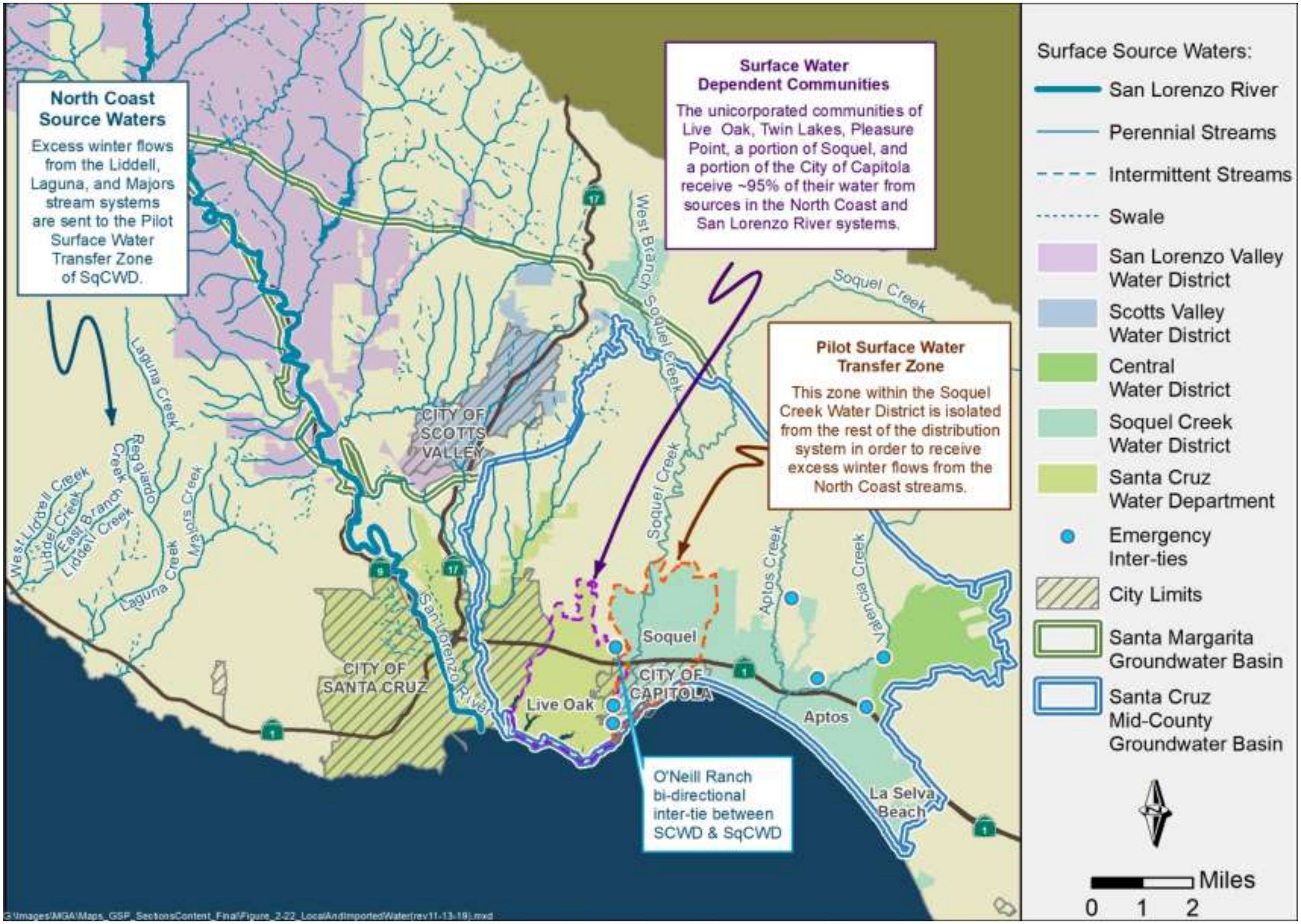


Figure 2-23. Local and Imported Water

2.2.3.8 Hydrogeologic Conceptual Model Data Gaps and Uncertainty

There is a good general hydrogeological conceptual understanding in the coastal portions of the Basin because this is where the municipal production and monitoring wells are located that have been drilled under the supervision of professional geologists. The stratigraphic detail obtained from wells logged by geologists is generally greater than those obtained from well driller's logs submitted to DWR or the County. There are specific areas that have data gaps due to a lack of deep wells to characterize parts of the Basin:

1. The lateral extent of the Tu unit beneath the lowermost Purisima AA-unit is uncertain due to limited wells that extend to the deeper depths where the Tu unit occurs. A few municipal wells in the western portion of the Basin are screened in the Tu unit, but no known private wells are screened in the Tu unit.

2. Recharge sources to the Tu unit are not well understood because of a lack of wells completed to the west of production wells in the Tu unit and lack of definitive correlation between Tu unit sediments and mapping of geologic outcrops.

3. The area north of the Aptos area faulting is poorly understood because there are only non-municipal domestic, agricultural, and non-municipal institutional wells that are relatively shallow and generally extend only to the shallowest water-bearing formation. The data from well driller's logs associated with these private wells generally do not allow for stratigraphy to be determined.

4. The Purisima units beneath the Aromas and Purisima F-unit in the eastern portion of the Basin are not well understood because wells are not drilled deeper than the Purisima F-unit.

5. The hydrogeology along the Basin's boundary with the Santa Margarita Basin is poorly understood because of limited good quality stratigraphy data.

6. The offshore outcrops of aquifer units are based on the intersection of seafloor elevations and offshore projections of hydrostratigraphic surfaces (described in Appendix 2-D). Due to the submarine nature of these outcrops, there is a high level of uncertainty as to the exact location and extent of the outcrops.

~~2.2.2~~2.2.4 Current and Historical Groundwater Conditions

Under SGMA, the Basin is defined as a high priority basin in critical overdraft principally because active seawater intrusion impacts its productive aquifers. Between 1964 and 1967, the City of Santa Cruz and Soquel Creek Water District began serving Basin water customers along the coast.[4] Each water agency had either been recently formed, acquired small groundwater-dependent water companies to serve its customers, or both. However, at that time neither agency had adequate information on the Basin's groundwater conditions nor its safe yield to serve customer's needs and manage the Basin to prevent seawater intrusion.

As discussed in Section 2.2.2, the first hydrogeological study (Hickey, 1968) in the Soquel-Aptos area identified that there was no seawater intrusion at that time but that it may be close to coming onshore. A follow up study by the USGS in 1980 in response to observed seawater intrusion ~~study~~, found that pumping from the Purisima Formation, averaging about 5,400 acre-feet per year since 1970, had caused groundwater levels along the coast to decline below sea level and allowed seawater to enter the aquifer (Muir, 1980). The report concluded that the potential yields of the two principal aquifers in the Soquel-Aptos area were 4,400 acre-feet per year from the Purisima Formation and 1,500 acre-feet per year from the Aromas Red Sands (Muir, 1980).

Prior to 1980, the water agencies that now make up the MGA believed they were operating within the ~~basin's~~Basin's safe yield. Since 1980, they have expanded the groundwater monitoring well network to better understand groundwater in the Basin, managed the Basin to prevent seawater intrusion by groundwater pumping redistribution and reducing pumping through water conservation programs, and implemented water pricing and other strategies to promote more efficient water use.

~~2.2.2.1~~2.2.4.1 Groundwater Elevation Data

~~2.2.2.1.1~~2.2.4.1.1 Historical Groundwater Elevations

Long-term overdraft of the Basin has led to ~~an~~ ongoing ~~risk of~~ seawater intrusion. The Basin's greatest groundwater level declines were measured in the Purisima BC-unit in 1984 where declines on the order of 140 feet occurred. In 1988, both the Purisima A and DEF-units reached their greatest groundwater level declines of 80 feet and 100 feet respectively.

By 2005, Basin groundwater levels in the Purisima aquifers had recovered somewhat, but were still characterized by a broad and persistent pumping trough surrounding municipal production wells that was below sea level. Groundwater elevation contours in the most productive Purisima aquifer units in fall 2005 showed depressed groundwater levels from 10 to 80 feet below sea level (Figure 2-24 and Figure 2-25). This was a significant improvement over groundwater levels in the 1980s but groundwater levels at the coast still ranged from sea level to 30 feet below sea level. Figure 2-26 shows fall 2005 groundwater contours combined for the Aromas Red Sands

[4] Central Water District formed in 1950 to serve the inland areas.

and Purisima F-unit aquifers. Only a small area south of the ~~County~~Country Club production well had groundwater elevations below sea level. Hydrographs of Aromas and Purisima F-unit wells on ~~Figure 2-17~~Figure 2-17 show that groundwater elevations along the coast were very close to sea level thereby continuing to increase the threat of seawater intrusion in this area.

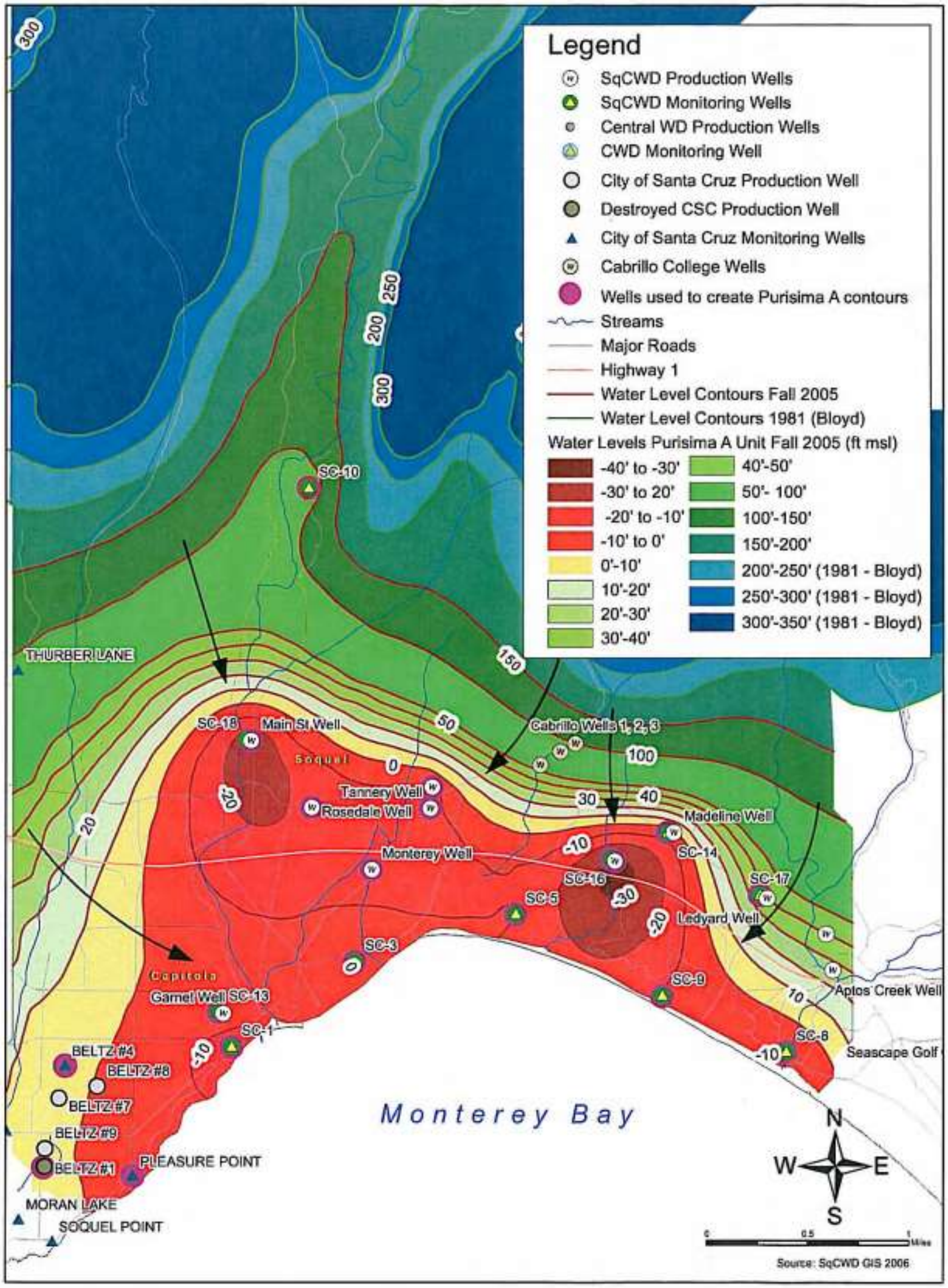


Figure 2-24. Groundwater Elevation Contours in Purisima A-Unit, Fall 2005

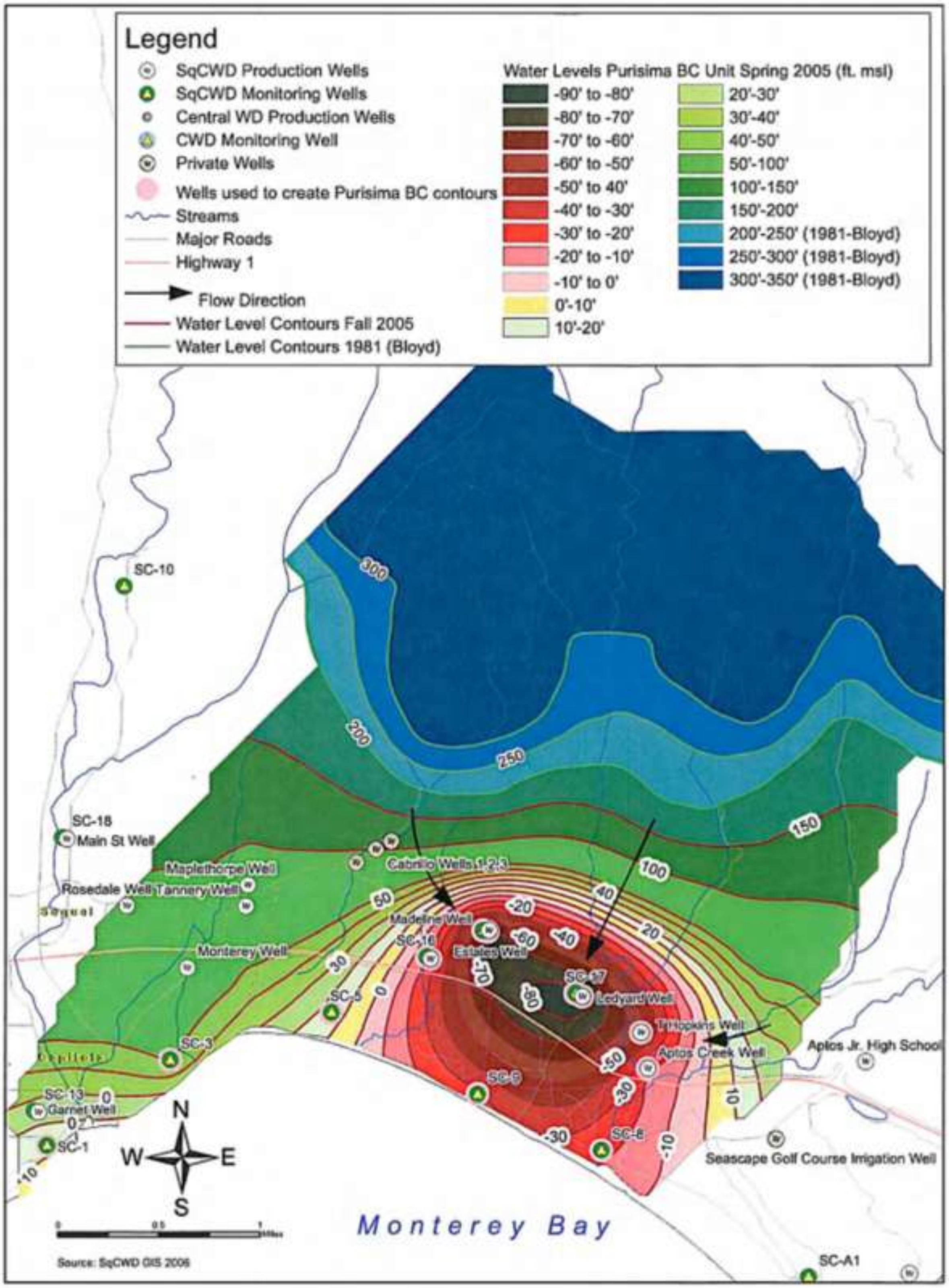


Figure 2-25. Groundwater Elevation Contours in Purisima BC- Unit, Fall 2005

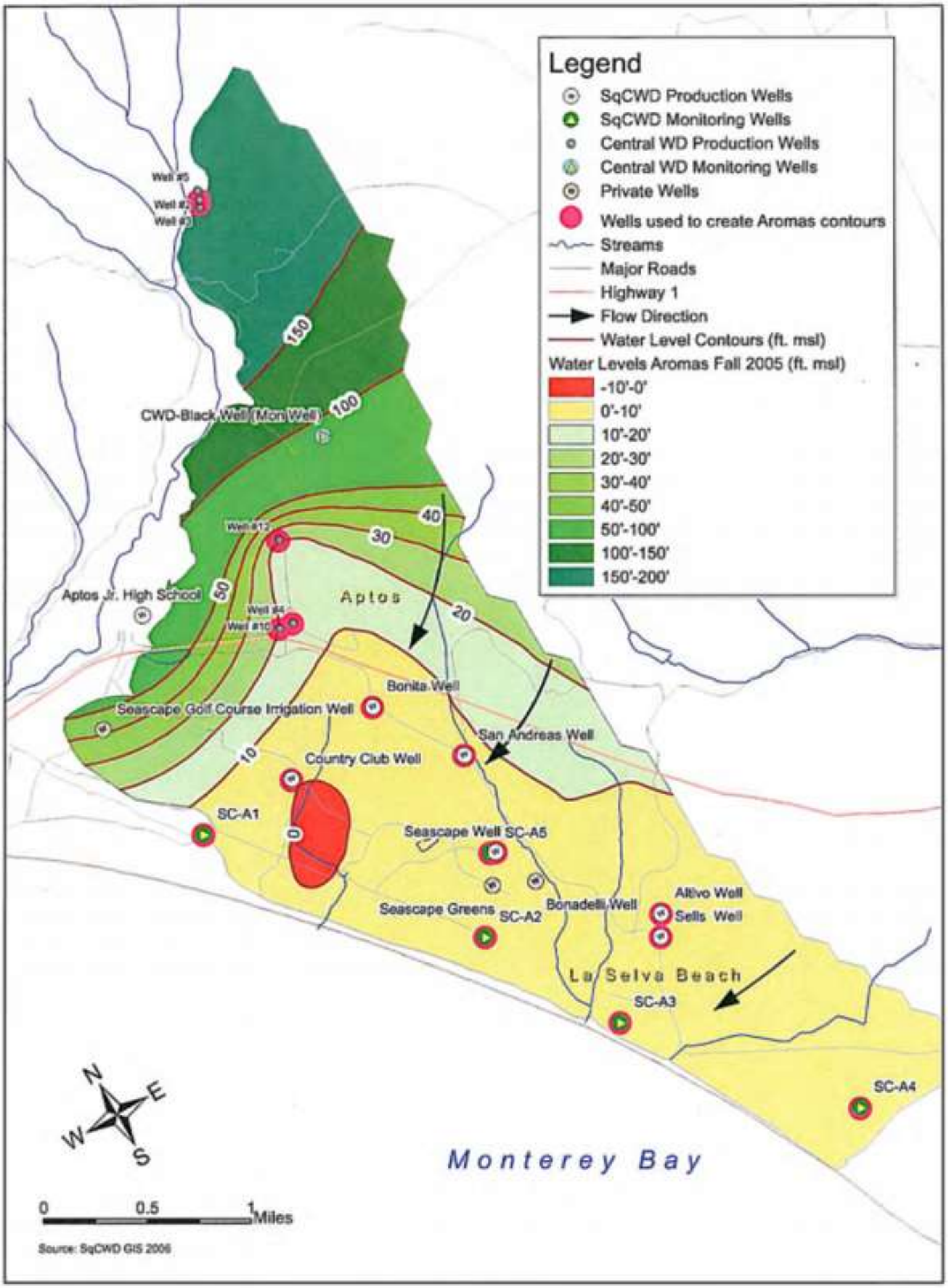


Figure 2-26. Groundwater Elevation Contours in Aromas Red Sands and Pursima F-Unit, Fall 2005

~~2.2.2.1.2~~2.2.4.1.2 Current Groundwater Elevations

Tu-Unit

Figure 2-27 shows fall 2016 groundwater elevations in the Tu-unit below the Purisima Formation as a snapshot of groundwater conditions after SqCWD's O'Neill Ranch and the City's Beltz 12 well came online in 2015. Flow tests at these wells indicate that significant flow in these wells comes from the Tu unit (also called the SM unit as it may be Santa Margarita Formation), but pumping tests at these wells showed slow recovery so monitoring groundwater levels in the Tu-unit will be important for assessing the reliability of supply from these wells. Fall groundwater levels were lower than spring groundwater levels in the Tu-unit for Water Year 2016 with Beltz 12 pumping primarily in summer and fall (HydroMetrics WRI, 2017). ~~Groundwater levels below sea level extend to the Beltz #7 Santa Margarita Test Well.~~

Purisima A and AA-Units

Contour maps of groundwater elevations in fall 2016 for the Purisima A and AA-units are shown in Figure 2-28. The contours show that fall coastal groundwater levels in the A-unit are lower than protective elevations in much of the area, with defined pumping depressions inland of the coast around SqCWD production wells. The area of pumping depressions below sea level is limited to the Tannery II well when as recently as Fall 2013, the area of groundwater elevations below sea level extended to the coast at SC-5A and SC-9A.

As inferred from the contour map, groundwater flows towards SqCWD's production wells but flows offshore also occur that reduce risk of seawater intrusion. Groundwater flows from inland toward the coast are intercepted by the City of Santa Cruz's production wells in the most western portion of the Purisima area. The contour map indicates significant flow from the northwest consistent with outcrop areas for the A and AA- units being towards the north and west (Johnson et al., 2004).

Purisima BC-Unit

Contour maps of groundwater elevations in fall 2016 for the Purisima BC-unit are shown in Figure 2-29. Fall 2016 coastal groundwater levels in the Purisima BC-unit were at protective elevations due to recovery in early 2016. Pumping depressions around production wells are shown but are much smaller than previous years. The figures show groundwater flows from all directions including from the coastal area towards the pumping depression in the Purisima BC-unit.

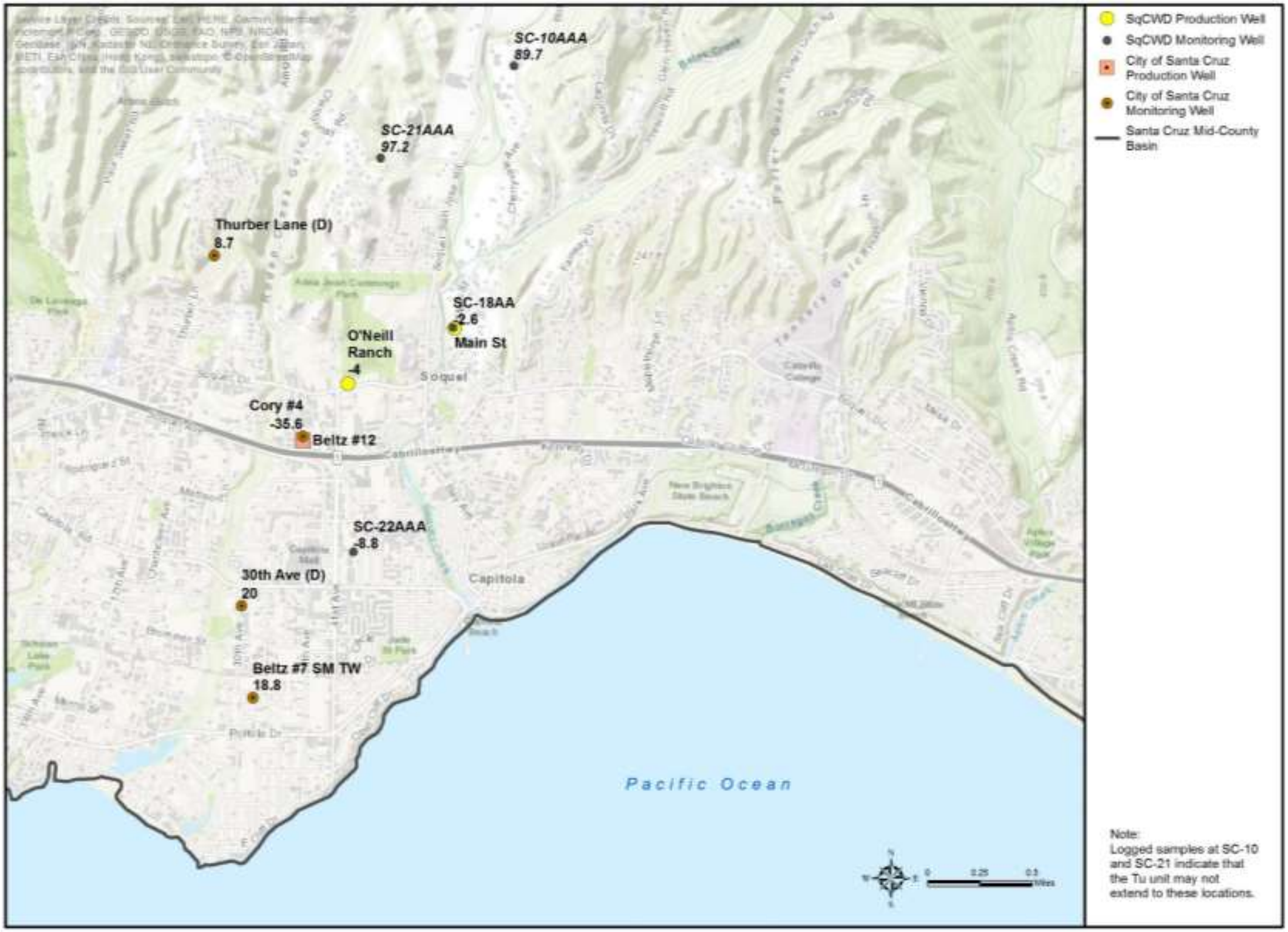


Figure 2-27. Groundwater Elevations in Tu-Unit, Fall 2016

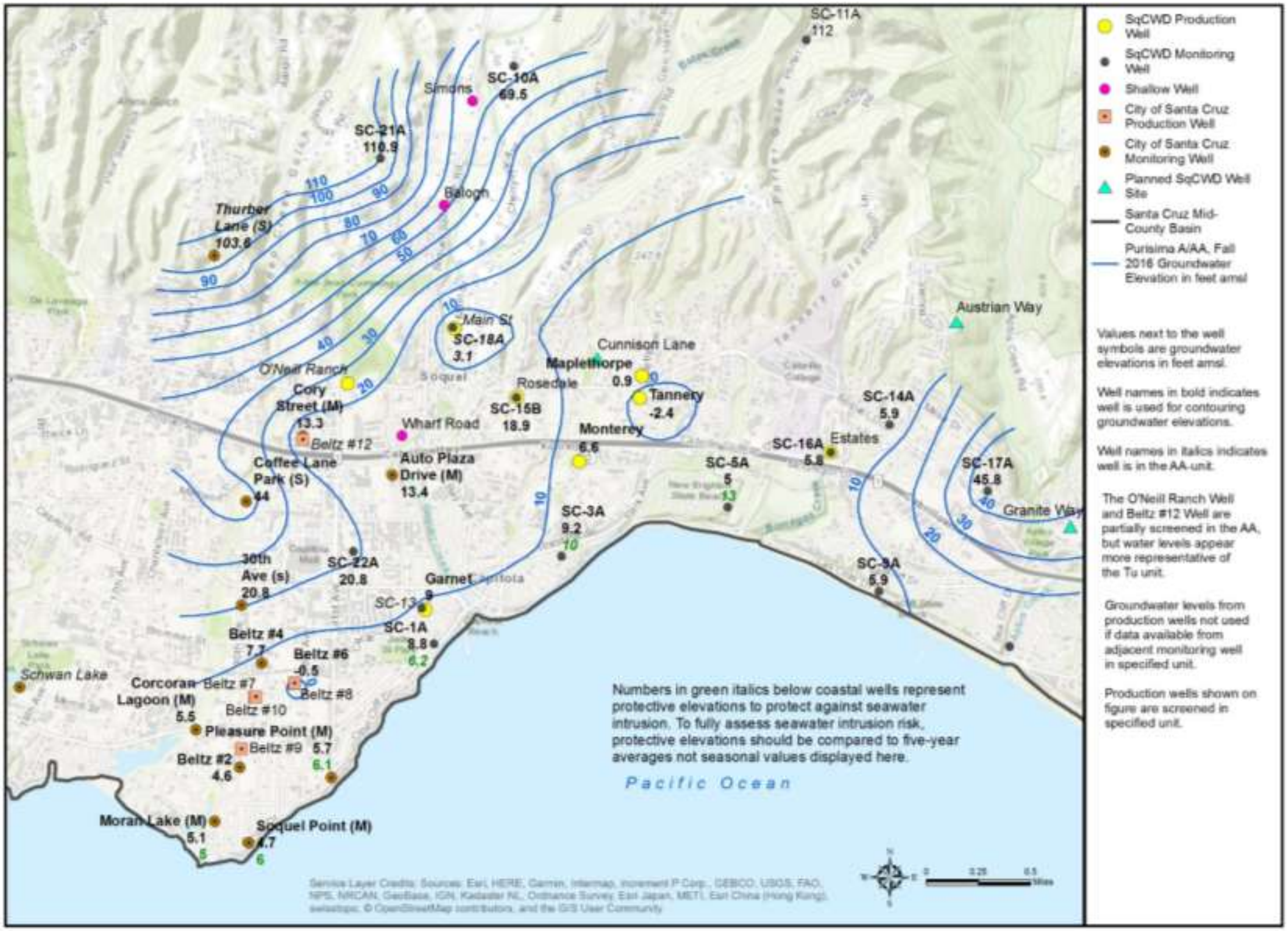


Figure 2-28. Groundwater Elevation ~~Countours~~Contours in Purisima A and AA-Unit, Fall 2016

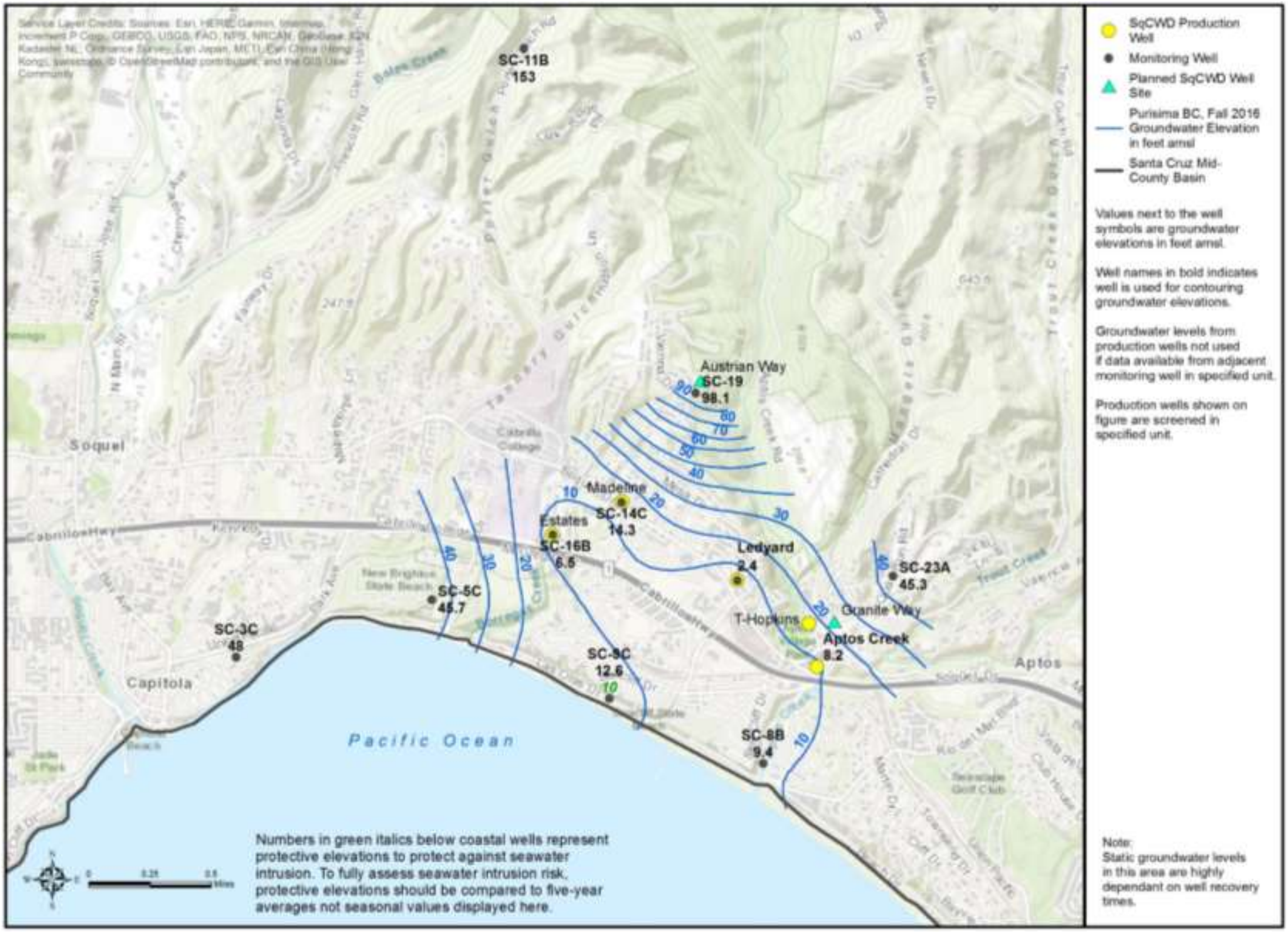


Figure 2-29. Groundwater Elevation ~~Countours~~Contours in Purisima BC-Unit, Fall 2016

Purisima DEF/F-Units

Contour maps of Purisima DEF/F-units groundwater elevations in fall 2016 are shown in Figure 2-30. The western area with SC-9, SC-8, T. Hopkins, and SC-23 wells represent the deeper Purisima DEF-unit groundwater levels. Figure 2-30 shows that the fall 2016 coastal groundwater levels in the Purisima DEF-unit were above protective elevations due to recovery in early 2016. Groundwater flows towards a pumping depression at the T. Hopkins well but flows offshore are also shown that reduce risk of seawater intrusion.

The contour map of groundwater elevations of the Purisima DEF and F-units (Figure 2-30) overlaps somewhat with the groundwater elevations shown on Figure 2-31 for the Aromas Red Sands. Figure 2-30's eastern area ~~with~~that includes SqCWD's Service Area 3 and Service Area 4 production wells and CWD's production wells represent the shallower Purisima F-unit groundwater levels. SqCWD's Aptos Jr. High and Polo Grounds wells and CWD's Cox well field (#3 and #5) are completed in the Purisima F-unit but do not underlie the Aromas Red Sands and a pumping depression at the Polo Grounds well is evident on Figure 2-30. East of this area, the Purisima F-unit mostly underlies Aromas Red Sands. Pumping depressions are evident at CWD #12 as well as between Country Club and San Andreas wells where production wells are screened in both the F unit and Aromas Red Sands. Groundwater flows towards production wells but also toward the coast that helps reduce risk of further seawater intrusion into the Purisima~~-~~ F~~-~~-unit.

Groundwater generally flows from the hills to the ocean with some of the flow pattern altered by pumping. There also appears to be a groundwater flow divide south and east of SqCWD and CWD. South and east of this divide, groundwater flows to Pajaro Valley. There is also a surface watershed divide in this area.

Aromas Red Sands

A contour map of groundwater elevations in fall 2016 for the Aromas Red Sands are shown in Figure 2-31. The contour map shows that groundwater levels were mostly above sea level, with coastal groundwater levels below protective elevations for some of the coast. Groundwater flows toward the coast where it is partially intercepted by SqCWD's Country Club ~~well to~~and San Andreas production wells. These flows may not be sufficient to prevent seawater intrusion as coastal groundwater levels are sometimes below protective elevations.

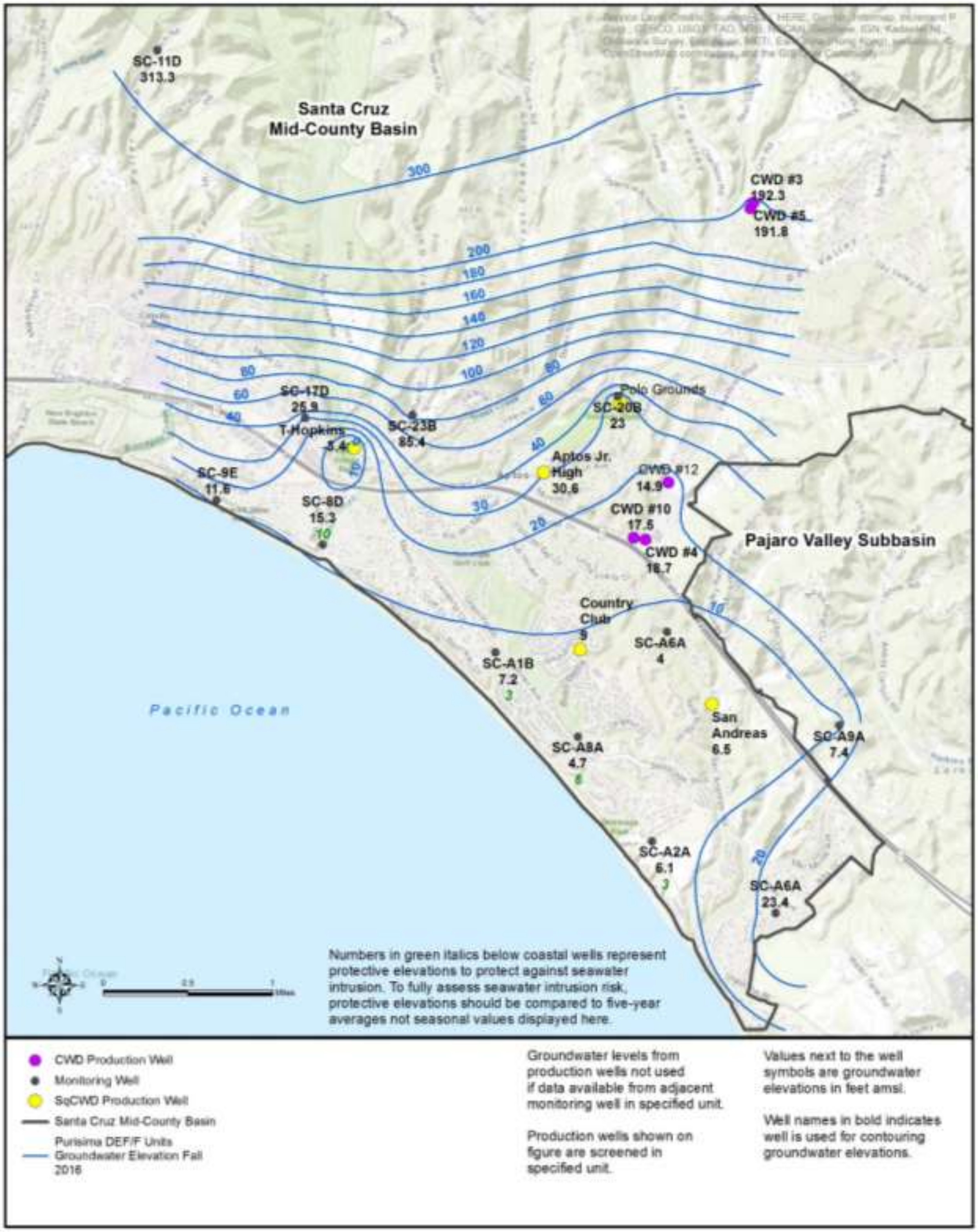


Figure 2-30. Groundwater Elevation ~~Countours~~Contours in Purisima DEF/F-Unit, Fall 2016

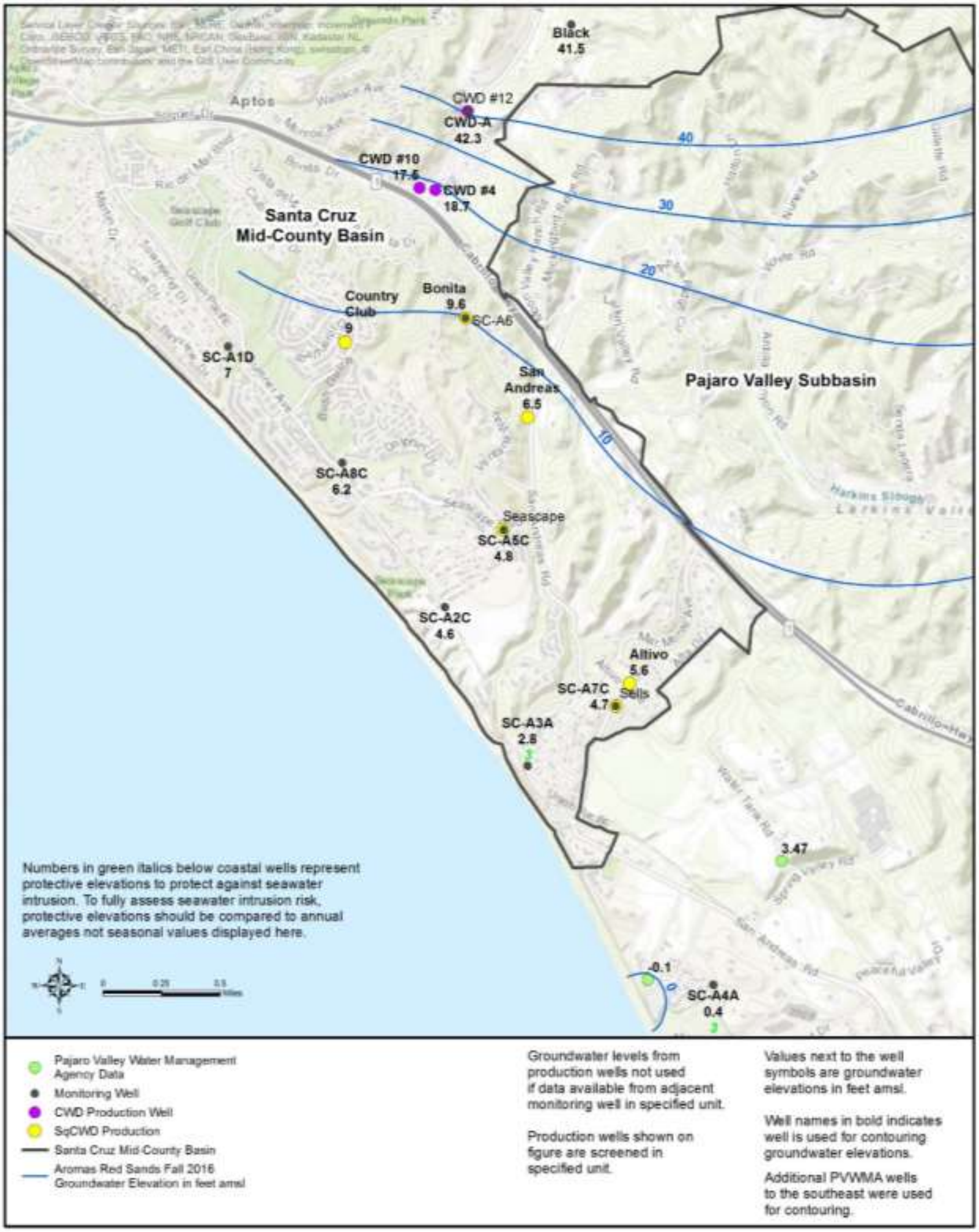


Figure 2-31. Groundwater Elevation ~~Countours~~Contours in the Aromas Area, Fall 2016

~~2.2.2.1.3~~**2.2.4.1.3** Groundwater Level Trends

Long-Term Groundwater Level Trends

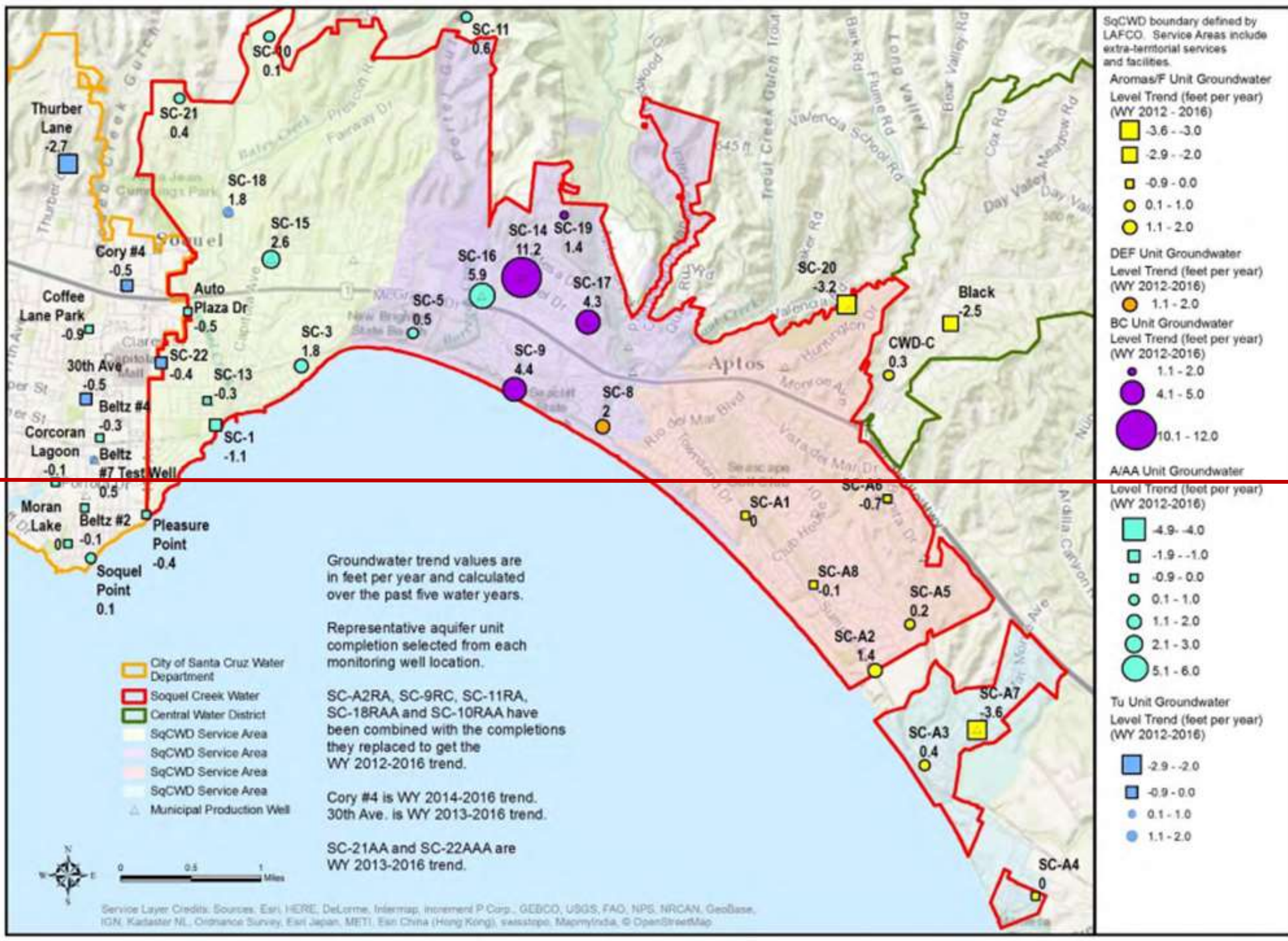
Over the past 30 years, and especially in the past ten years, groundwater levels in the Basin have recovered from dramatically low levels in the 1980s to the highest measured groundwater conditions in Water Year 2017. The hydrographs on ~~Figure 2-17~~Figure 2-17 describe a history of over-production followed by ~~sustainable~~sustained recovery:

- Declining groundwater levels as groundwater demand increased through 1988.
- Municipal groundwater demand peaked during the period from 1989 - 2004. Also during this period, there was a drought from 1984 through 1992. Together, high demand and drought caused groundwater levels to decline to historic lows measured in 1992/1993.
- In 2005, groundwater demand dropped and stayed fairly constant until 2009. Groundwater recovery started with two consecutive years of above average rainfall in 2005/2006. The economic recession starting around 2008 and further reduced water demand, possibly contributing to recovering groundwater levels during the period of below average rainfall from 2007-2009.
- A further drop in groundwater demand took place in 2010. Since 2010, groundwater demand has been less than previous years. Interestingly, the first two years of the recent drought (2012 and 2013) had increased demand, which is typical when there is below average rainfall. More recently there has been recovery of groundwater levels from 2014 through 2017. The 2014/2015 drop in demand and associated increase in groundwater levels corresponds with increased statewide water restrictions due to the 2012-2015 drought.

Operational changes in the ~~basin~~Basin show that the most influential factor in changing coastal groundwater levels is changing the amount of groundwater pumping in high yielding municipal supply wells. Recharge from rainfall generally has a less immediate effect on coastal groundwater levels because most aquifers are confined by less permeable layers, and areas where the aquifers are exposed at the surface and can be directly recharged are limited.

Short-Term Groundwater Level Trends

As a result of ongoing long-term recovery starting in 2005 and an acceleration of recovery in Water Years 2015-2016[5], by 2016 groundwater levels in the Purisima Formation were at their highest elevations since the groundwater monitoring network was installed. In the same locations where the 2005 pumping depression was previously located, groundwater levels had risen to between 2.4 feet below sea level to 6 feet above sea level, and 2016 groundwater elevations were above sea level in all coastal monitoring wells. Figure 2-32 shows five-year average groundwater ~~levels~~level trends between 2012 and 2016~~, which document ongoing basin~~. The round symbols indicate recovery continued in much of the Basin, particularly along the coast, during the 2011-2015 drought.



[5] California Water Years run from October 1 to September 30 of each year.

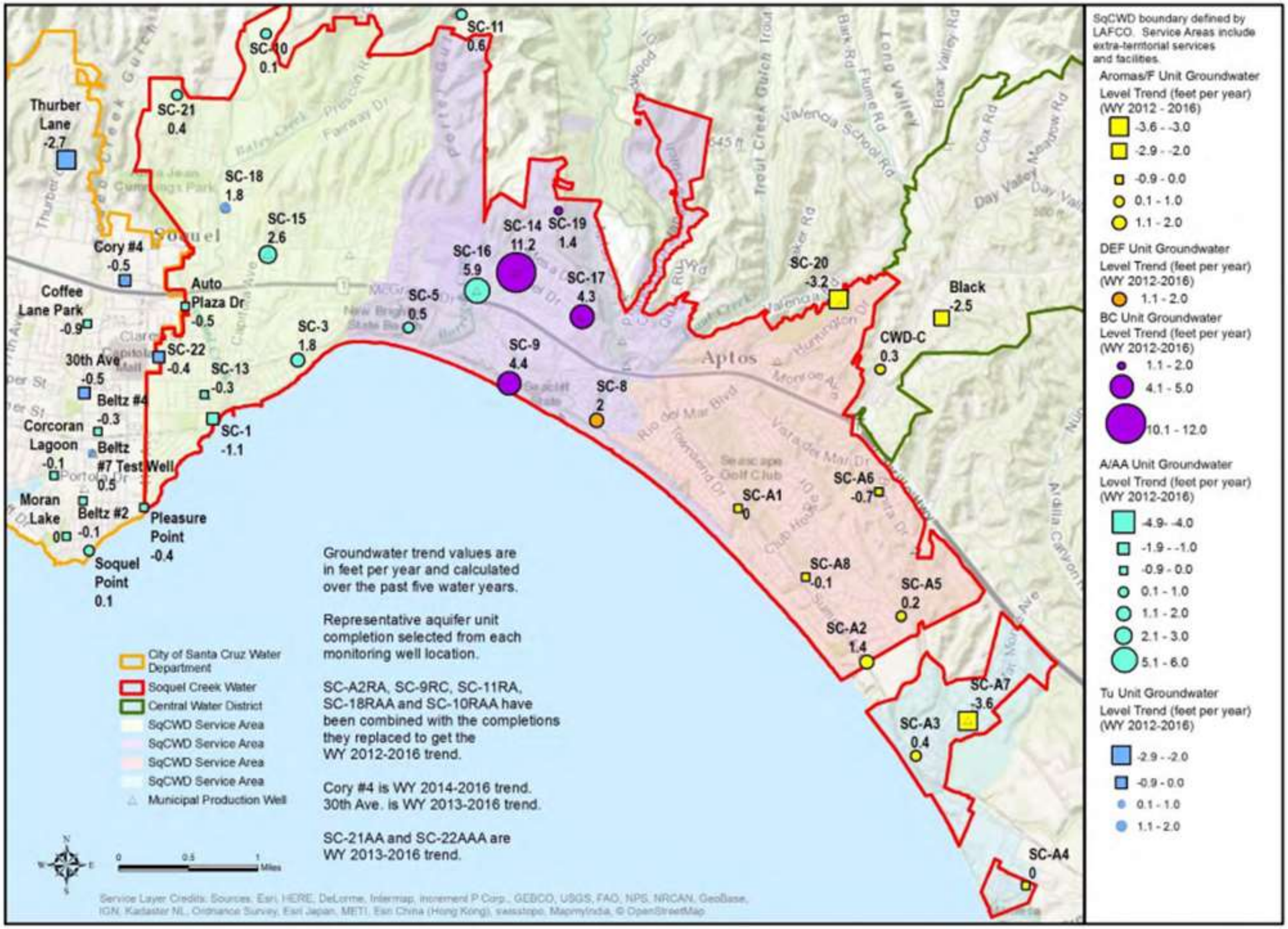


Figure 2-32. 2012-2016 Groundwater Level Trends

Much of this accelerated recovery is attributed to longstanding water conservation by Basin residents and by increasingly severe water use curtailment within the Basin, especially during the 2011-2015 drought. In Water Year 2015, Soquel Creek Water District and the City of Santa Cruz continued Stage 3 water shortage emergency with a drought curtailment target of 25% and Central Water District continued a Stage 2 water shortage alert with a drought curtailment target of 20%.

In Water Year 2016, the lower than average rainfall over the preceding five years led Soquel Creek Water District and Central Water District to maintain these curtailment targets. On-going water use curtailments in Water Years 2015 and 2016, resulted in municipal production of 4,121 and 3,928 acre-feet respectively which were the lowest municipal pumping totals since 1977.

Water Year 2017 was a very wet year, with the highest groundwater elevations seen within the Basin since coastal groundwater monitoring began. However, Water Year 2018, was a dry year with some increases in pumping since the State declared an end to the 2011-2015 drought. Drought restriction were lifted at the state level and within the City of Santa Cruz, however, SqCWD has remained at Stage 3 water usage curtailment because of risk of seawater intrusion. Since coastal groundwater elevations peaked in 2017, Basin groundwater levels ~~at the coast~~ have declined between 0.4 to 4.0 feet in the coastal monitoring wells.

~~2.2.2.1.4~~2.2.4.1.4 Protective Elevations and How They Are Used to Evaluate Current Groundwater Levels

Prior to SGMA, local water agencies focused their Basin management activities on raising groundwater levels at the coast to control seawater intrusion. Seawater intrusion is the primary threat to Basin water supply. In response to the 1980 USGS study (Muir, 1980) an extensive groundwater monitoring well network was developed throughout the Basin during the 1980s to better assess groundwater conditions, especially at the coast.

Figure 2-33 shows the 13 key coastal monitoring well locations used to assess the risk of seawater intrusion and the status of groundwater recovery in the Basin. These keys wells include three City of Santa Cruz wells in the Purisima Formation (Moran Lake Medium, Soquel Point Medium, and Pleasure Point Medium), five Soquel Creek Water District wells in the Purisima Formation (SC-1A, SC-3A, SC-5A, SC-9C and SC-8D), and five Soquel Creek Water District well clusters in the Aromas area (SC-A1A and B, SC-A8A and B, SC-A2A and B, SC-A3A and B, and SC-A4A and B).


Santa Cruz Mid-County Groundwater Basin
Coastal Monitoring Well Network
Purisima Formation Monitoring Wells
Aromas Red Sands Monitoring Wells
Aquifer Boundary
Central Water District
Soquel Creek Water District
Santa Cruz Water Department
Santa Cruz Mid-County Groundwater Basin
Miles
0
1
2
Santa Cruz
Live Oak
Soquel
Capitola
Aptos
La Selva Beach
Moran Lake
Soquel Point
Pleasure Point
SC-1
SC-3
SC-5
SC-8
SC-9
SC-A1
SC-A2
SC-A3
SC-A4
SC-A8
San Lorenzo River
Soquel Creek
West Branch Soquel Creek
Aptos Creek
Valencia Creek
Corralitos Creek
Pajaro River
www.midcountygroundwater.org

Figure 2-33. Location of Coastal Monitoring Wells

Soquel Creek Water District and the City of Santa Cruz have established protective groundwater elevations[6] for each coastal monitoring well. Groundwater levels are used to measure progress in preventing seawater intrusion. Because salt water is heavier than fresh water, groundwater elevations must be above sea level to have sufficient hydraulic head to keep seawater off shore and out of the Basin's productive aquifers.

Protective groundwater elevations are set for each individual coastal monitoring well completion[7] as determined to be feasible to protect the aquifer at that location against seawater intrusion. Groundwater elevations persistently below protective elevations are expected to lead to seawater intrusion over time and indicate ~~ongoing critical Basin~~ overdraft~~. Table 2-8~~ conditions. Table 2-5 compares annual average 2018 groundwater elevations with protective groundwater elevations.

Table 2-5. Groundwater Level Averages Calculated from Logger Data at Coastal Monitoring Wells

Well	Data Through	365 Day ~~Avg~~Average (ft ~~msl~~amsl)	Protective Elevation (ft ~~msl~~amsl)	Percent Runs Protective
Moran Lake Medium	9/30/2018	6.0	5.0	>GH[8]
Soquel Point Medium	9/30/2018	5.4	6.0	<GH
Pleasure Point Medium	9/30/2018	8.6	6.1	>GH
SC-1A	9/30/2018	10.2	6.2 (4*)	>99
SC-3A	9/30/2018	10.6	10	>70
SC-5A	9/30/2018	9.5	13	<50
SC-9C	9/30/2018	9.5	10	<70
SC-8D	6/5/2018	13.3	10	>99
SC-A1B	9/30/2018	7.9	3	>99
SC-A8A	9/30/2018	4.9	6	<50
SC-A2A	9/30/2018	6.6	3	>99
SC-A3A	9/30/2018	2.8	3	<60
SC-A4A**	9/30/2018	1.4	3	<50

* The protective elevation based on 70th percentile of cross-sectional models at SC-1A is 4 feet above mean sea level.

6 The freshwater elevation set at a particular monitoring well location necessary to prevent seawater intrusion with a certain level of certainty at that location. Protective elevations are set in response to geologic conditions and depend on scientific estimates and policy decisions related to feasibility.

7 Monitoring wells clusters in the Aromas have completions at multiple depths to allow sample collection and evaluation of water from different elevations within this unconfined coastal aquifer.

8 Protective elevations at City of Santa Cruz wells based on Ghyben-Herzberg (GH) relationship as opposed to 100 sets of cross-sectional model runs so percentage runs protective are not calculated. Instead, it is noted whether 365 day average is greater or less than Ghyben-Herzberg calculation.

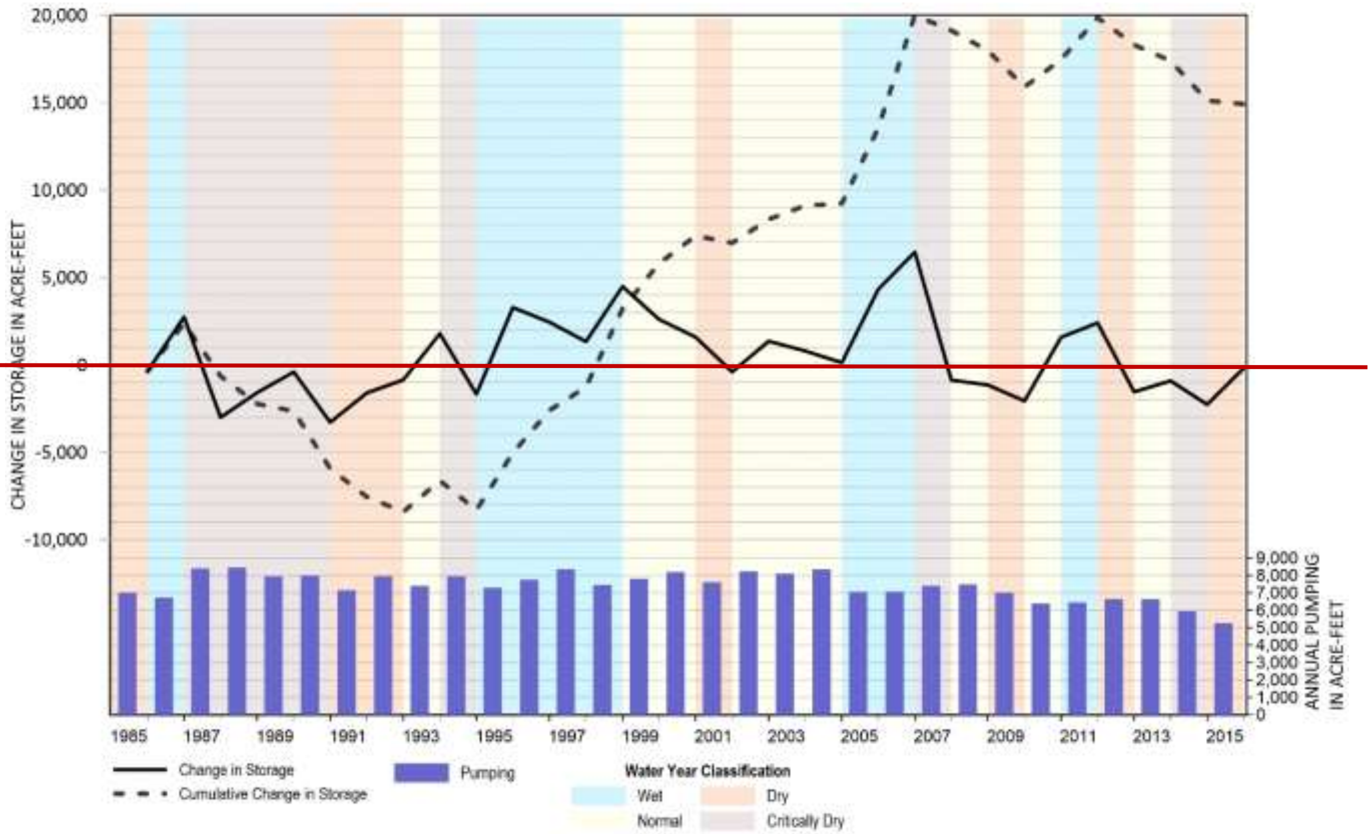
** SC-A4A is in the Pajaro Valley Subbasin, not the Santa Cruz Mid-County Basin.
ft amsl = feet above mean sea level

Through September 30, 2018, coastal monitoring wells in the Purisima with annual averages above the protective elevations are: Moran Lake, Pleasure Point, SC-1A, SC-3A, and SC-8D. Coastal monitoring wells in the Aromas with yearly averages above protective elevations are SC-A1 and SC-A2. Annual averages for the same time period are below protective elevations in the Purisima at Soquel Point, SC-5A, and SC-9C. Coastal monitoring wells in the Aromas with groundwater elevations below protective levels are: SC-A8A, and SC-A3A. Until all wells meet or exceed protective elevations the Basin will continue to be in critical overdraft due to seawater intrusion.

~~2.2.2.2~~2.2.4.2 Change in Groundwater in Storage

The amount of groundwater in storage in the Basin generally reflects changes in groundwater elevations over time as described in Section 0. Figure 2-34 shows the model simulated change in storage from Water Year 1985 through 2015. Groundwater elevations were at their lowest between the 1980s and 1997 when municipal groundwater pumping was between 5,000 and 7,000 acre-feet per year and overall Basin groundwater pumping was estimated at between 7,000 and 9,000 acre-feet per year. Figure 2-34 shows how groundwater was consistently lost from storage each year from 1985 to 1992. Three years of fairly balanced conditions marked the start of ten significant years of groundwater storage recovery of the Basin from 1995 through 2006. In 1997 municipal pumping declined to approximately 5,000 acre-feet per year.

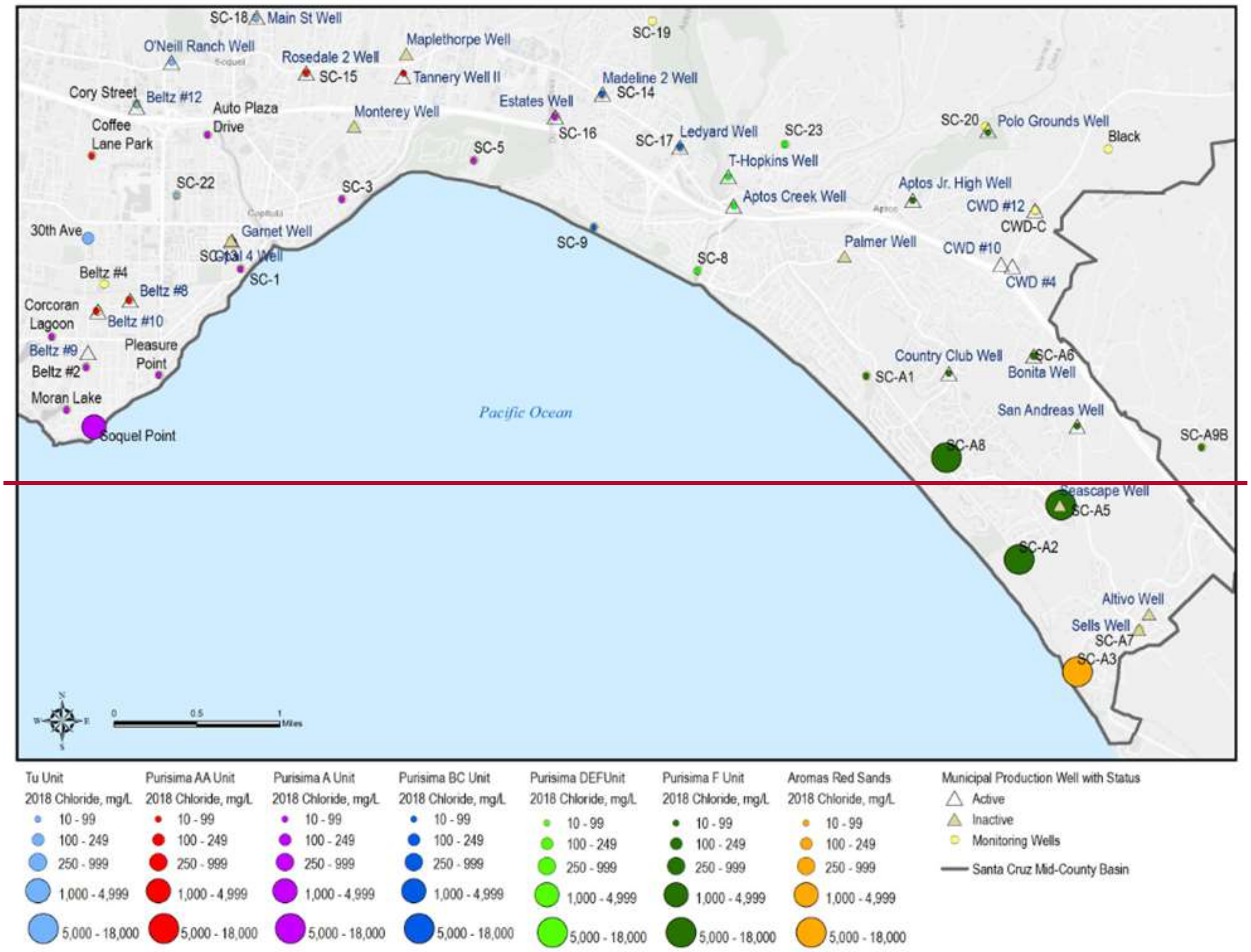
Over the period from 2009 through 2011, although there were both loses and gains in storage due to below average rainfall, there was no overall cumulative change. Despite slight overall Basin storage declines over the drought period from 2012 through 2015, groundwater elevations at the coast increased due to water conservation efforts and redistribution of pumping.



~~Figure 2-31. Cumulative Change in Groundwater in Storage~~

~~2.2.2.3~~2.2.4.3 Seawater Intrusion

Historically, seawater intrusion has been documented at Soquel Point in the Purisima A- and has been consistently detected at deep monitoring wells in all coastal monitoring clusters in the Aromas area (in both Purisima F-unit and Aromas Red Sands aquifers). ~~The~~With the exception ~~in the Aromas is~~of monitoring well cluster SC-A1, ~~which was~~coastal monitoring clusters in the Aromas area were installed with ~~its~~their deepest completion intentionally located below the freshwater-saltwater interface to monitor increases in chloride concentrations. Chloride data from Water Year 2018 shows that the extent of seawater intrusion has remained the same over the past few years (Figure 2-35). Coastal well locations where seawater intrusion has not been observed continue to show no indication of seawater intrusion. Groundwater quality where seawater intrusion has been observed is either stable or improving with the exception of one well. At SC-A2B, an increasing trend has been observed over the last two years and the latest sample exceeded the minimum threshold that is set for this well as part of the Basin's sustainable management criteria~~.~~ in Section 3. If any of the following three samples at SC-A2B exceed the minimum threshold, this would be considered an undesirable result based on the sustainable management criteria proposal contained in this GSP.



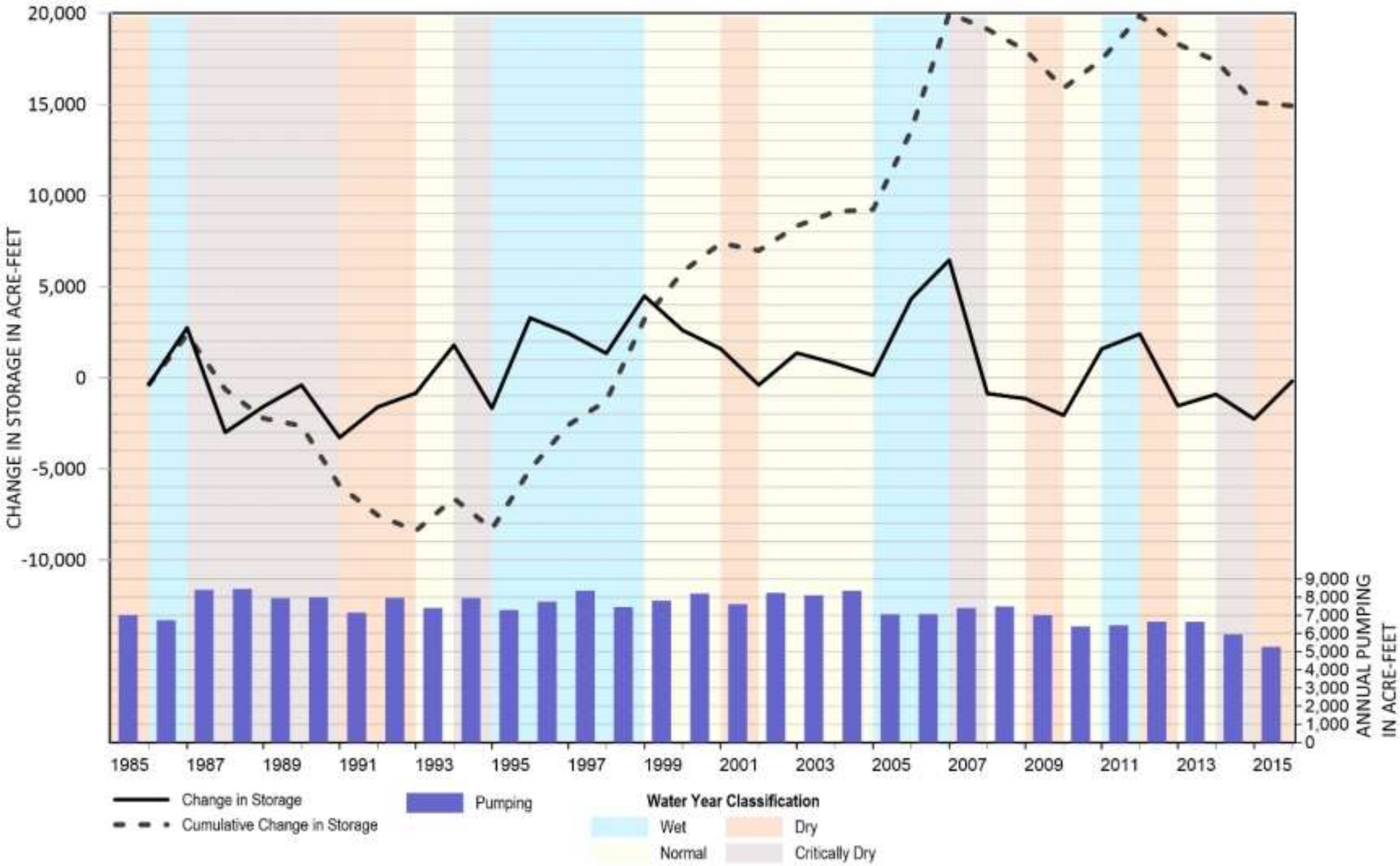


Figure 2-34. Cumulative Change in Groundwater in Storage

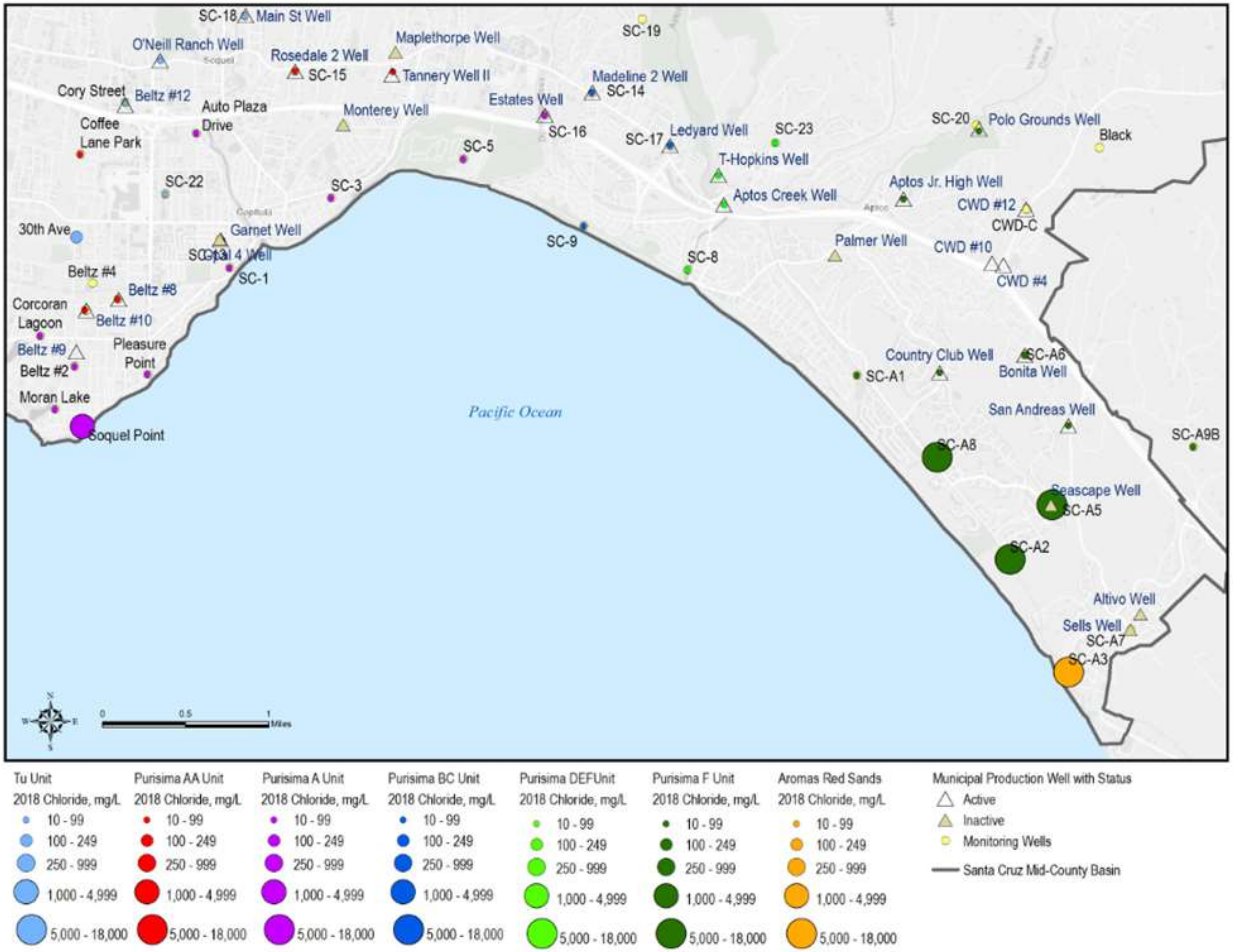
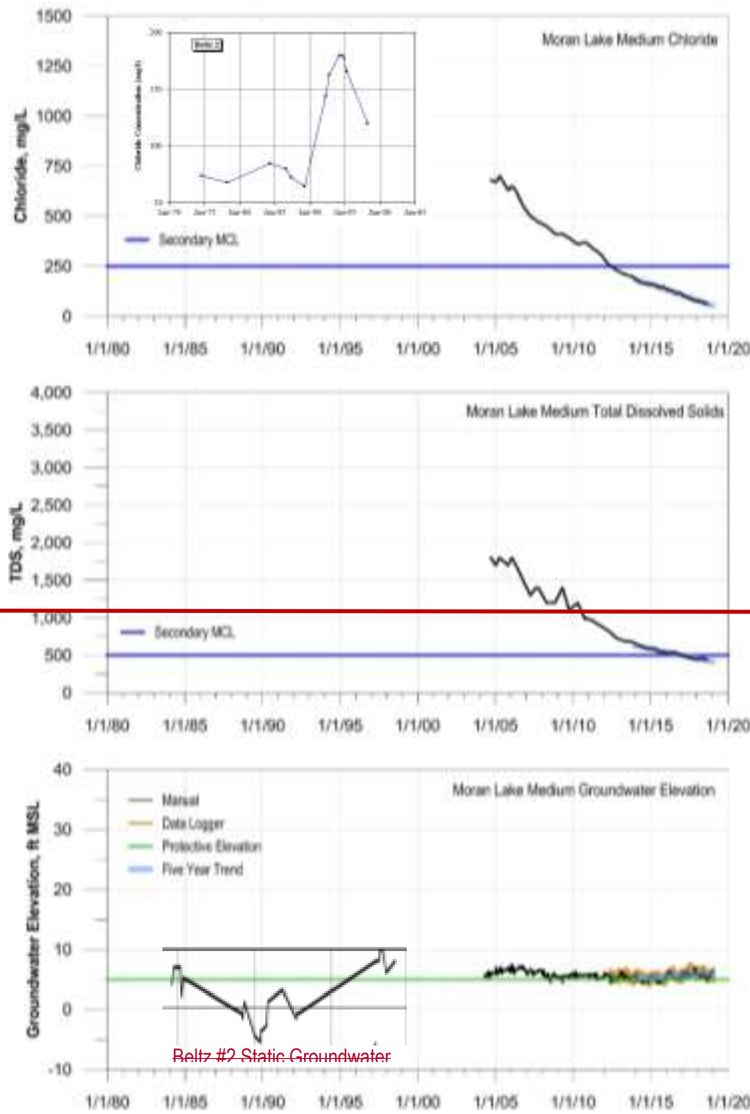


Figure 2-35. Water Year 2018 Chloride Concentrations

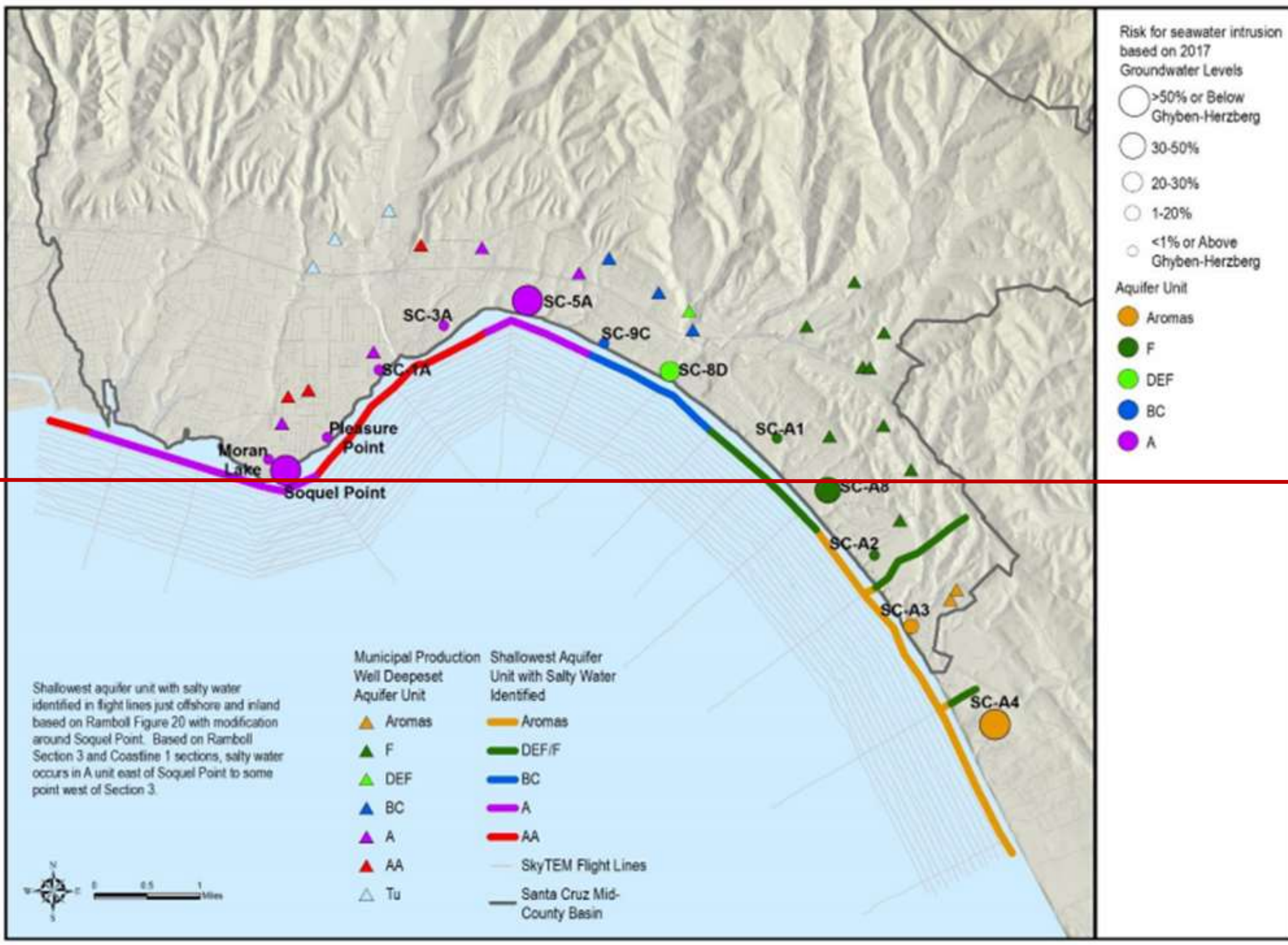
The Basin has one instance of seawater intrusion reversal. When the City of Santa Cruz's Moran Lake monitoring well was installed in 2005, the Medium well depth completion in the Purisima-A unit had chloride concentrations at levels indicating seawater intrusion (700 mg/L) Since 2005, average groundwater levels in the well have been at or above the protective elevation calculated for the well, and chloride concentrations have consistently dropped to concentrations now at 78 mg/L (Figure 2-36). This indicates that groundwater levels meeting protective elevations can reverse seawater intrusion. Although, groundwater levels were already above protective elevations at the time of the well's installation, there are data from nearby Beltz #2 well showing how low groundwater levels in 1995 correspond with a period of increased City of Santa Cruz pumping. The lower than normal groundwater levels associated



with increased pumping are thought to have resulted in an increase of chloride concentrations over at least a five-year period. As groundwater levels rose with a reduction in City pumping by more than 50%, chloride concentrations at Beltz #2 declined after 1994 showing the beginning of seawater intrusion reversal that continues to be observed at the Moran Lake monitoring well (inset and overlay on Figure 2-36).

Figure 2-33. ~~Hydrograph and Chemograph of Moran Lake Medium Well (Montgomery & Associates, 2019) Overlain by Hydrograph and Inset Chemograph of Beltz #2 Well (Johnson et al., 2004)~~

In May of 2017, when groundwater elevations were at historic highs, the MGA contracted the firms SkyTEM and Ramboll to fill seawater intrusion data gaps offshore of and between coastal monitoring network locations. SkyTEM used a helicopter to carry electronic geophysical equipment to survey the resistivity of subsurface geology over the coast and a mile off shore to look for areas of salty water in the land beneath the ocean. The survey identified seawater intrusion just offshore of the Basin's unintruded coastal aquifers and confirmed the location and extent of known seawater intrusion in the productive aquifer units at the Basin's coastal margins. Further review by MGA consultant's, HydroMetrics WRI, of the information provided in the Ramboll report identified areas near Soquel Point, New Brighton, Rio Del Mar and La Selva as facing the greatest potential for future seawater intrusion in the Basin (Figure 2-37).



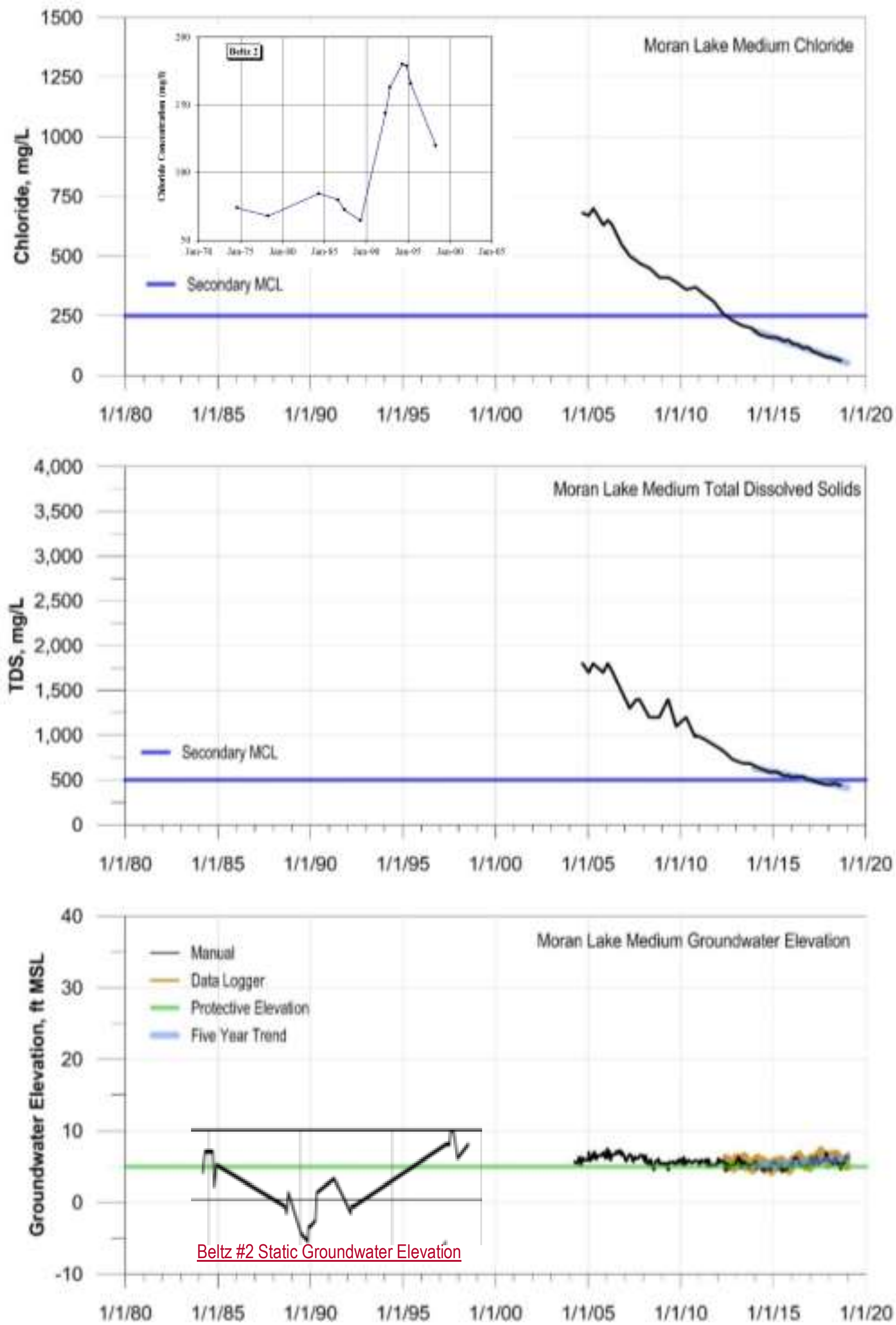


Figure 2-36~~-~~. Hydrograph and Chemograph of Moran Lake Medium Well (Montgomery & Associates, 2019) Overlain by Hydrograph and Inset Chemograph of Beltz #2 Well (Johnson et al., 2004)

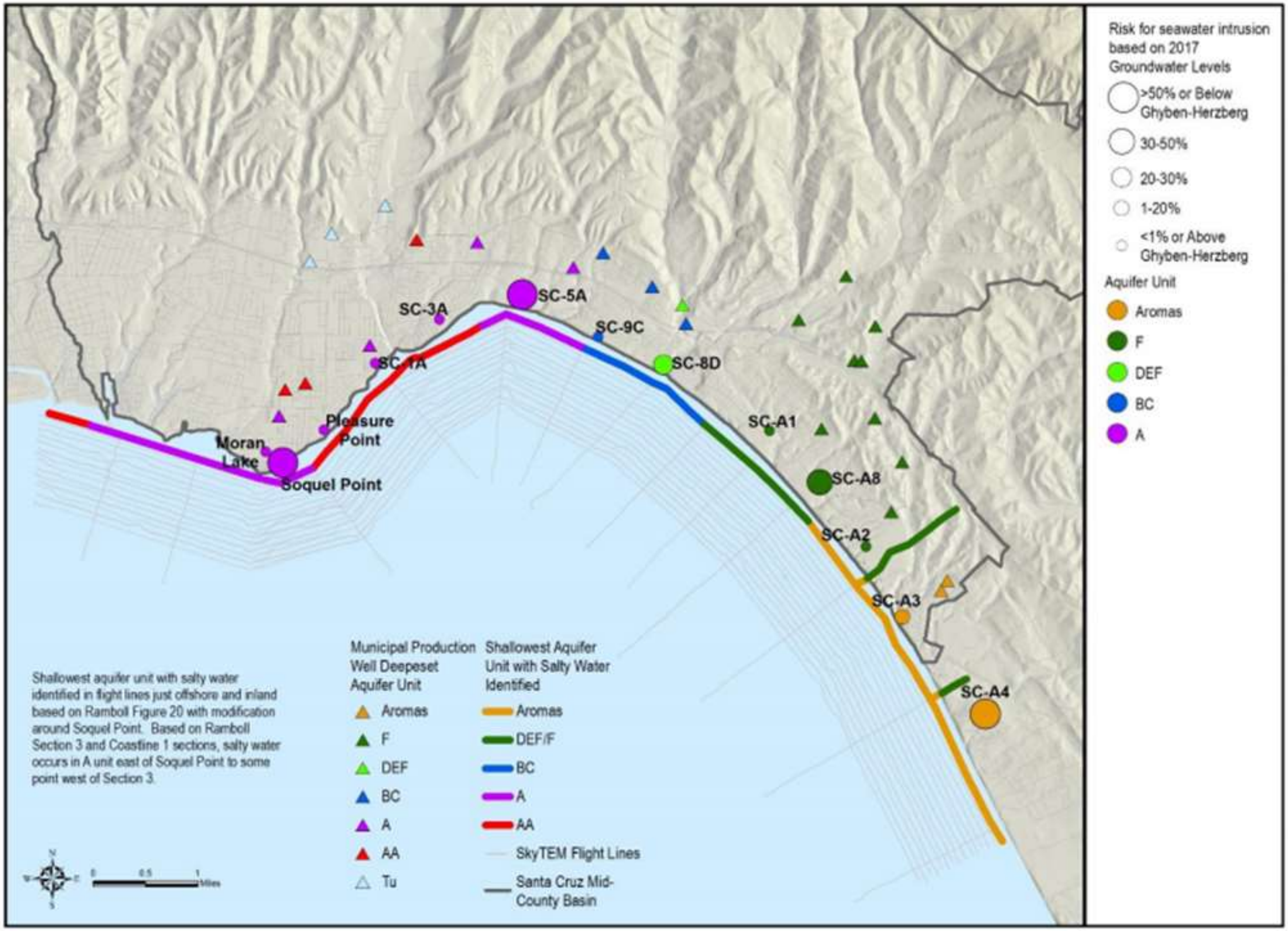


Figure 2-37. Water Year 2017 Risk of Seawater Intrusion into Pumped Aquifer Units Based on Groundwater Levels and SkyTEM Data on Shallowest Aquifer Unit with Salty Water Just Offshore

~~2.2.2.4~~2.2.4.4 Groundwater Quality

Groundwater produced in the Basin is generally of good quality and does not regularly exceed primary drinking water standards. A few naturally occurring constituents, including iron~~,~~ and manganese~~, arsenic and hexavalent chromium (also referred to as chromium VI),~~ exceed drinking water standards in parts of the Basin. As previously mentioned, some coastal monitoring wells have elevated chloride and TDS concentrations associated with seawater intrusion.

Treated groundwater delivered by MGA member municipal water agencies meets or exceeds all state and federal drinking water parameters. The municipal water agencies routinely analyze their untreated groundwater to determine the groundwater quality of the Basin and to comply with state water quality reporting requirements. Groundwater quality parameters analyzed include general minerals, general physical parameters, and organic/inorganic compounds. Analyses for these constituents are conducted in accordance with requirements of the California Code of Regulations, Title 22. Groundwater quality results are compared to primary and secondary drinking water standards, established by the ~~US~~U.S. Environmental Protection Agency (USEPA), and water quality standards established by the California State Water Resources Control Board's Division of Drinking Water (DDW).

Primary drinking water standards are concentrations that, in the judgment of the State Water Resources Control Board (SWRCB), may have an adverse effect on human health. Secondary standards are set for aesthetic concerns for constituents that are not health threatening, but public water systems still test and treat their water for these constituents to meet secondary standards, unless they obtain a waiver. Exceeding secondary standards may cause effects which do not damage the body but are still undesirable. These undesirable effects may include water tastes or odors, damage to water equipment, or reduced effectiveness of treatment for other constituents.

Private domestic use wells are not subject to DDW drinking water regulations. However, the County of Santa Cruz requires one-time testing of nitrate, total dissolved solids (TDS), chloride, iron and manganese for any new ~~private~~non-municipal well. Small water systems that supply groundwater to 15 – 199 service connections also report water quality to the County ~~that includes~~and the Public Utilities Commission (PUC) for PUC regulated systems. These water quality constituents include: inorganics, nitrates, arsenic, perchlorate, chromium, radiation, synthetic organic compounds, and volatile organic compounds (including methyl tertiary-butyl ether (MTBE)). The frequency of reporting ranges between one year and nine years depending on the constituents. Smaller water systems of between 5 – 14 service connections have limited one-time testing requirements for inorganics.

~~2.2.2.4.1~~2.2.4.4.1 Natural Groundwater Quality

Total Dissolved Solids (TDS) and Chloride Concentrations

TDS concentrations measured in production wells in the Purisima aquifers have historically ranged between 270 and 740 mg/L. TDS concentrations measured in municipal production wells in the Aromas Red Sands aquifer have historically ranged between 95 and 470 mg/L.

Inland ~~private~~non-municipal wells typically have TDS concentrations between 210 and 480 mg/L. The secondary maximum contaminant level for TDS is 1,000 mg/L. There is a small water system well near Pot Belly Beach Club, east of New Brighton State Beach, that historically had TDS concentrations close to 1,000 mg/L since at least 1994, but there is no increasing trend.

Chloride concentrations measured in production wells in the Purisima Formation have typically ranged between 10 and 100 mg/L. Chloride concentrations measured in production wells in the Aromas aquifer have historically ranged between 8 and 58 mg/L. Inland private wells generally do not have chloride concentrations greater than 20 mg/L. The secondary maximum contaminant level for chloride is 250 mg/L. The private well at Pot Belly Beach Club has historically had chloride concentrations no higher than 140 mg/L.

TDS and chloride concentrations in municipal production wells do not indicate any impacts from seawater intrusion. Chloride in groundwater that is associated with seawater intrusion is addressed separately from overall water quality by the seawater intrusion sustainability indicator.

The only changes in TDS and chloride trends that have been observed in the Basin are associated with seawater intrusion discussed in Sections 2.2.4.3 and 3.6.

Iron and Manganese

Groundwater in the Purisima Formation regularly has iron and/or manganese concentrations above secondary drinking water standards of 300 *µg*/L and 50 *µg*/L, respectively. Production wells with elevated iron concentrations can reach 3,000 *µg*/L, and manganese can reach up to 600 µg/L. Both iron and manganese occur naturally in the Purisima Formation as a result of the dissolution of metals within the aquifer. Concentrations within a well can fluctuate greatly and may range by two orders of magnitude. ~~Neither constituent poses a major health concern, but can result in undesirable aesthetics, causing discoloration of the water.~~The secondary drinking standards are based on aesthetics so iron and manganese at the concentrations found in the Basin can result in discoloration of the water. Neither constituent poses a major health concern at the levels found within the Basin, however, manganese has a DDW health-based Notification Level of 500 *µg*/L based on neurotoxic risk.. Because iron and manganese are naturally occurring, there have been no increasing trends in their concentrations. Groundwater pumped from the Purisima Formation for municipal purposes is treated to reduce iron and manganese levels prior to distribution.

The Aromas Red Sands aquifer does not have iron and manganese concentrations above secondary drinking water standards.

Arsenic

~~Very low arsenic concentrations near the laboratory detection limit are found throughout the basin (generally less than 1 µg/L). Slightly higher arsenic concentrations of between 1.6 and~~Arsenic concentrations of up to 5.5 *µg*/L are regularly detected at two municipal water supply wells that produce groundwater from the Purisima Formation, near Aptos Village. All concentrations are below the state drinking water standard of 10 *µg*/L.

Soquel Creek Water District conducted a special investigation of the low concentrations of arsenic in 2003 and concluded that the arsenic detections are most likely associated with the natural occurrence of arsenic resulting from the depositional and geochemical conditions in the coastal environment. Desorption or dissolution of arsenic oxyanions from iron oxide appears to be the most common cause of arsenic in groundwater. Managed aquifer recharge projects can cause dissolution and mobilization of arsenic in the aquifer that may increase the arsenic concentrations above drinking water standards.

There have been no increasing arsenic concentration ~~arsenic~~ trends in affected wells because the source of arsenic occurs naturally within the sediments and is not being added ~~to~~ from a contamination point source.

Chromium VI

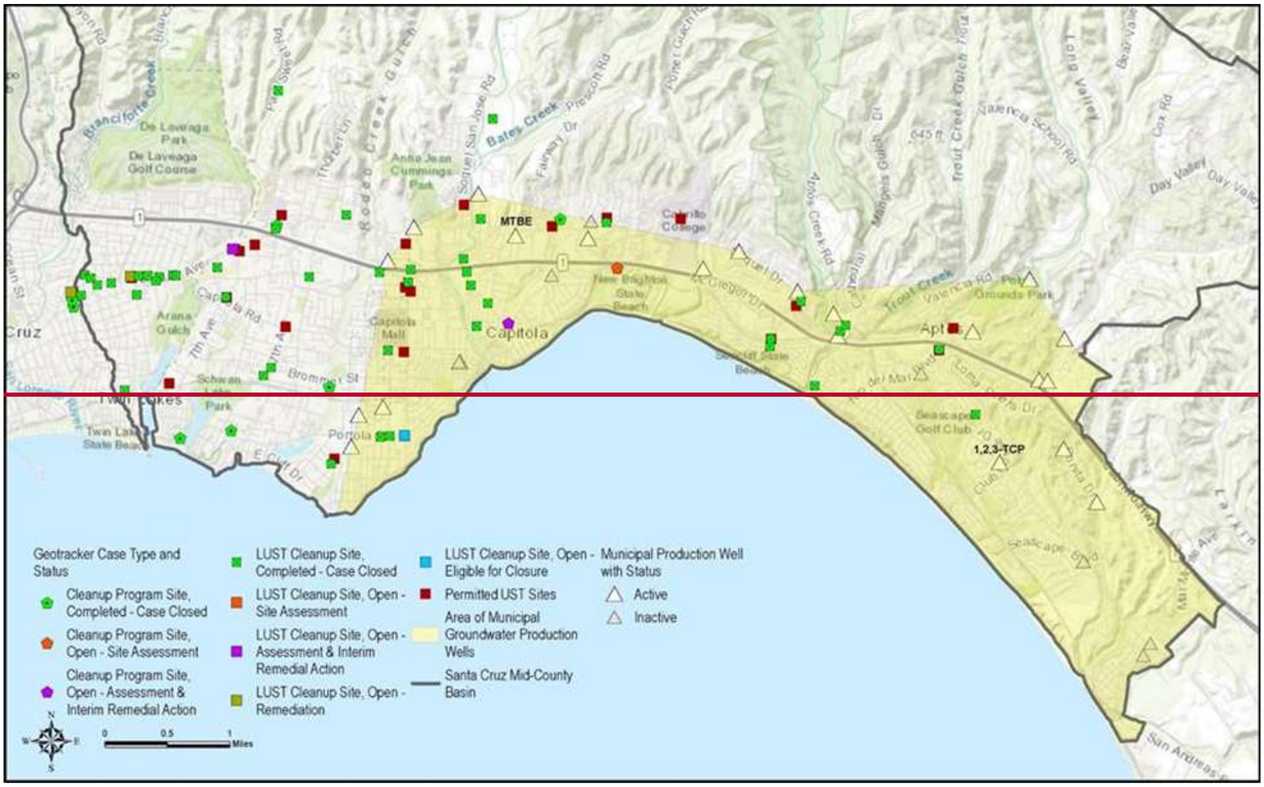
Chromium is a naturally occurring metallic element that can be found naturally in water, soil, and rocks, but it may also occur in groundwater due to industrial contamination. In water, chromium exists either in its more reduced form, trivalent chromium (chromium III), or its more oxidized form, hexavalent chromium (chromium VI). Chromium III is an essential nutrient; however, chromium VI may pose a potential public health risk, even when present at low levels. Inhalation of chromium VI is known to cause cancer in humans and is likely to be more toxic when inhaled than when ingested. Studies indicate that most of the total chromium in the ~~basin~~Basin comprises chromium VI.

Chromium VI, from natural sources, has been detected at concentrations ranging between 5 and 40 µg/L in the coastal Aromas aquifer where both SqCWD and Central Water District (CWD) have production wells. These concentrations are below the current state drinking water standard of 50 µg/L for total chromium. A lower chromium VI standard of 10 µg/L, set by the ~~State Water Resources Control Board (~~SWRCB~~)~~ regulations in July 2014 was ~~suspended~~deleted by a Sacramento trial court in May 2017 because the SWRCB failed to address the economic concerns of small water systems before setting the chromium VI standard. However, ~~it is expected that~~ the state ~~will likely~~may adopt a drinking water standard lower than 50 µg/L in the near future. There have been no increasing chromium VI concentration trends in affected wells.

Where the overlying Aromas aquifer has elevated chromium VI concentrations, the underlying Purisima F unit sometimes has very low detections of chromium VI. Groundwater in other Purisima Formation units does not have detectable chromium VI.

~~2.2.2.4.2~~2.2.4.4.2 Contaminated Groundwater Quality

The locations of known contaminant sites in 2018 are identified on Figure 2-38. Basin groundwater is primarily pumped from confined aquifer units deeper than the contamination at these sites. Thus, the likelihood that groundwater pumping induces contaminant plume movement towards water supply wells is relatively small. Several constituents of concern are discussed further below.


MTBE
1,2,3-TCP
Capitola
Aptos
Geotracker Case Type and Status
Cleanup Program Site, Completed - Case Closed
Cleanup Program Site, Open - Site Assessment
Cleanup Program Site, Open - Assessment & Interim Remedial Action
LUST Cleanup Site, Completed - Case Closed
LUST Cleanup Site, Open - Site Assessment
LUST Cleanup Site, Open - Assessment & Interim Remedial Action
LUST Cleanup Site, Open - Remediation
LUST Cleanup Site, Open - Eligible for Closure
Permitted UST Sites
Area of Municipal Groundwater Production Wells
Santa Cruz Mid-County Basin
Municipal Production Well with Status
Active
Inactive
0
0.5
1
Miles

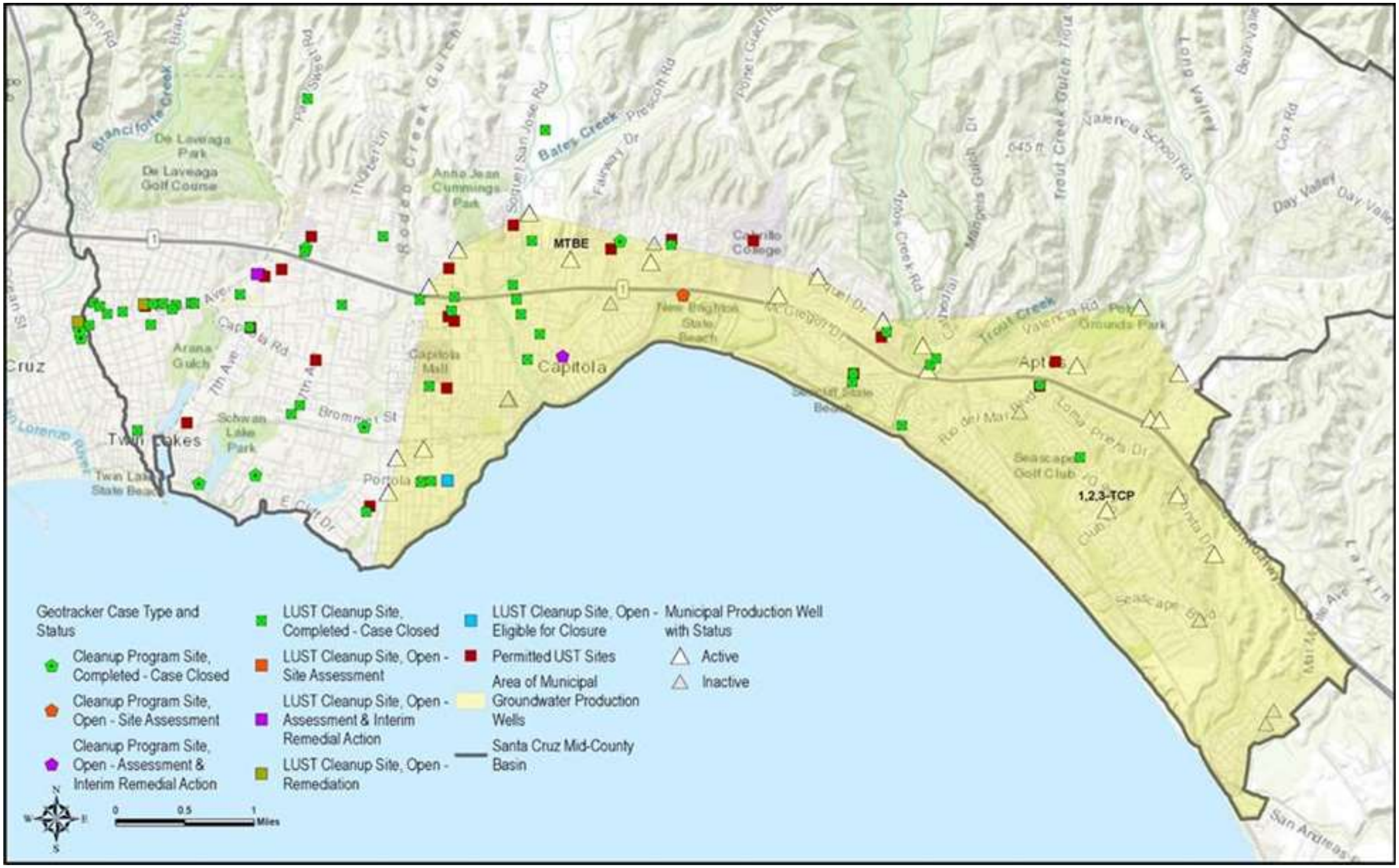


Figure 2-38. Known Contaminant Locations

Nitrates

Nitrate is a naturally occurring compound that is formed in the soil when nitrogen and oxygen combine. Elevated nitrate concentrations are most likely due to runoff and leaching from fertilizer use, leaching from septic tanks and sewage, and erosion of natural deposits. Infiltration of nitrate through the unsaturated zone and into groundwater is a greater concern in areas with highly permeable sandy soils. A large area of the ~~basin~~Basin is on septic systems because of the rural, low residential density, but only limited areas have highly permeable soils. High nitrate concentrations can cause health problems for infants that results in a dangerous condition called methaemoglobinaemia, also known as “blue baby syndrome”. State primary drinking water standards are 10 mg/L for nitrate as nitrogen (N); 10 mg/L for nitrate plus nitrite as N; and 1 mg/L for nitrite as N.

The Basin has historical nitrate as N concentrations in production wells that range from mostly non-detectable to a maximum of 11 mg/L. ~~The highest concentrations are found in the La Selva Beach area of the Aromas aquifer where concentrations have averaged 4 mg/L over the past five years. In multi-depth monitoring wells, the~~The highest nitrate as N concentrations are at shallowest depths. All recent nitrate as N concentrations are below the state drinking water standards and have not impacted the municipal water supplies that currently produce groundwater from depths greater than 200 feet. However, SqCWD had to inactivate the Sells production well in the Aromas Red Sands aquifer in 2009 because nitrate as N concentrations were above state drinking water standards.

In areas with sandy soils where septic systems are used, nitrate contamination can be an issue. However, groundwater quality data from private wells in the Basin, which generally produce groundwater from shallower depths than municipal production wells, suggests that septic systems have not adversely increased nitrate concentrations in private wells.

Organic Compounds

Organic compounds are those that include Volatile Organic Chemicals (VOCs) and pesticides. VOCs are chemicals that are carbon-containing and evaporate, or vaporize, easily into air at normal air temperatures. VOCs are found in a variety of commercial, industrial, and residential products, including gasoline, solvents, cleaners and degreasers, paints, inks and dyes, and pesticides. VOCs in the environment are typically the result of human activity, such as a spill or inappropriate disposal where the chemical has been allowed to soak into the ground. Once released into the environment, VOCs may infiltrate into the ground and migrate into the underlying production aquifers.

The SWRCB’s Geotracker database was used to provide the status and location of contamination sites within the Basin (Figure 2-38). Geotracker tracks regulatory data about leaking underground fuel tanks (LUFT), Department of Defense (DoD) cleanup sites, Spills-Leaks-Investigations-Cleanups (SLIC), and landfill sites. Figure 2-38 shows that just less than half of contaminant sites in the ~~basin~~Basin are located within the area of municipal production, with none occurring in the inland portions of the ~~basin~~Basin where ~~private~~non-municipal wells are used for water supply. The proximity of contaminated sites to municipal wells poses a greater risk to the municipal wells; however, most released contaminants remain shallow and rarely migrate down to the aquifers used by municipal production wells. Regulation and oversight of the remediation of contaminated sites in the ~~basin~~Basin is overseen by the Regional Water Quality Control Board (RWQCB) and Santa Cruz County Environmental Health.

~~The following bullets describe all known organic contaminant impacts to municipal production wells.~~

- ~~A localized plume of~~SqCWD has identified 1,2,3-trichloropropane (TCP) at ~~the SqCWD's~~its Country Club production well, which is drilled within the Aromas ~~aquifer~~Red Sands and Purisima F unit~~.~~ aquifers. The source of the 1,2,3-TCP in groundwater at this location ~~may~~ is believed to be ~~due to a legacy of fumigant~~past use ~~associated with the historic~~of fumigants that contained 1,2,3-TCP as an impurity, based on past agricultural ~~use of~~land uses near the well~~ site~~. The ~~maximum 1,2,3-TCP concentration has been 13 ppt in 2008 and 2010, and currently concentrations are generally less than 0.000009 mg/L. As the groundwater quality remains over the~~ state drinking water standard ~~of 0.000005 mg/L (or~~for 1,2,3-TCP is 5 parts per trillion~~),~~ (ppt). The recent average concentration in the Country Club well for 1,2,3-TCP is approximately 6 ppt. SqCWD is currently not pumping from this well, but has plans to use ~~it again~~ the Country Club well once a treatment plant for 1,2,3-TCP has been constructed~~.~~

~~SqCWD's Rosedale production well has had low MTBE concentrations associated with a former leaking underground storage tank (LUST) located on Soquel Drive east of the well that was reported to be leaking in 1989. After undergoing remediation and monitoring, the case was closed in March 2014. Beginning in October 2014, the Rosedale~~ and water from this well ~~had a confirmed detection of MTBE at 0.88 µg/L increasing to 1.2 µg/L in July 2016. Currently, MTBE concentrations are around 1 µg/L. The~~ again meets or exceeds state drinking water ~~standard is 13 µg/L, and the secondary standard for taste and odor concerns is 5 µg/L. MTBE has not been detected in any other municipal wells in the basin.~~quality standards.

~~Small water systems in the basin have had no detects of MTBE in their groundwater.~~

~~Perchlorate~~

~~Perchlorate can be manufactured or occurs naturally as a colorless, odorless chemical that is most commonly used in rocket fuel. As there is no rocket fuel use or manufacturing in the Basin, other possible sources of manufactured perchlorate and perchlorate salts may in: matches, dyes, rubber, lubricating oils, car air bag inflators, road flares, drying and etching agents, gunpowder, batteries, chlorine and chlorine-based cleaners, pool chlorination chemicals, electronic tubes, paint, enamel, fertilizers, and nuclear reactors. Perchlorates can form naturally in the atmosphere, leading to low levels of perchlorate in precipitation.~~

~~In the Basin, perchlorate has been found intermittently in a few Aromas area production wells. Concentrations are generally below 0.8 µg/L. In 2009, one well had the highest detection on record of 1.2 µg/L. The state's primary drinking water standard is 6 µg/L. A source of perchlorate in the Aromas area may be from fertilizer use in the area.~~

~~Small water systems in the basin have had no detections of perchlorate in their groundwater.~~

Contaminants of Emerging Concern

Contaminants of emerging concern (CECs), including pharmaceuticals and personal care products (PPCPs), are increasingly being detected at low levels in surface water and water infiltrating to groundwater from septic systems. Groundwater may be impacted by recharge of treated wastewater, surface water, and from septic systems. New and emerging contaminants are currently unregulated but may be subject to future regulation. Examples of new and emerging contaminants are N-Nitrosodimethylamine, a semi-volatile organic compound (NDMA and other nitrosamines), and 1,4-dioxane, ~~etc.~~per- and polyfluoroalkyl substances (PFAS) etc.

The Unregulated ~~contaminants for which monitoring~~ Contaminant Monitoring Rule (UCMR) was part of the federal Safe Drinking Water Act Amendments of 1996 and is administered by the USEPA. The UCMR has required ~~(UCMR) are tested by SqCWD~~ additional water quality testing within the Basin every five years~~.~~ since 2001. SqCWD conducts the UCMR testing within the Basin. Additionally, in 2007 and 2011 SqCWD participated in ~~the first phase~~two phases of a joint ~~U.S. Geological Survey (~~USGS~~) – U.S. Environmental Protection Agency (USEPA)~~ – USEPA study on ~~96~~ CECs in drinking water. This joint USGS-USEPA study tested for additional CECs that are not included in standard UCMR tests.

The production wells that have had detections of CECs are ~~the same wells in~~ Sells, Altivo, and Bonita. Sells is the La Selva area ~~where nitrates are~~well with elevated nitrates as N that is currently inactive in the Aromas Red Sands aquifer. ~~Both these wells are no longer pumped because of exceedances of drinking ing water standards. The~~ The CEC detected ~~CECs are pharmaceuticals,~~in Sells and Altivo is PPCPs, a pharmaceutical found during the USGS-USEPA joint test. SqCWD also identified 1,4-dioxane and 1,1-dichloroethane~~, which occur at extremely low concentrations.~~ in its Bonita well during standard five yearly UCMR testing.

~~CEC data has been collected since 2001, and there is a good baseline set of background data to compare against when potential projects that recharge treated wastewater into the basin as a supplemental source of water are implemented.~~

~~2.2.2.5~~2.2.4.5 Land Subsidence Conditions

Land subsidence is the gradual or sudden lowering of the land surface. For land subsidence to occur certain conditions are needed:

- Drainage and decomposition of organic soils,
- Underground mining, oil and gas extraction, hydrocompaction, natural compaction, sinkholes, and thawing permafrost, or
- Aquifer-system compaction

None of these conditions are known to be present within the Basin and there is no known or anecdotal evidence of subsidence related to groundwater extraction in the Basin. According to the County of Santa Cruz, there have been no formal studies on subsidence in this region.

There are also no known organic soils in the Basin. The depositional environments of the sediments comprising the ~~basin's~~Basin's aquifers are not conducive to deposition of organics. Neither is there is underground mining, oil and gas extraction, hydrocompaction, natural compaction, sinkholes, nor thawing permafrost occurring in the Basin.

Because there have been historical declines in groundwater levels greater than 50 feet, the possibility of aquifer-system compaction does exist. Susceptibility to land subsidence from groundwater level declines requires aquitards (fine-grained silts and clays) above- or within- which preconsolidation-stress thresholds are exceeded. Preconsolidation-stress is the maximum amount of *past effective stress the soil has ever experienced.*

There are aquitards in the Basin between the aquifer units. However, in areas with pumping, the bottom elevations of aquitards are generally more than 100 feet below sea level, which is deeper than typical groundwater levels. This means that the aquitards do not get dewatered, but may still be subjected to changes in preconsolidation stresses.

~~2.2.2.5.1~~2.2.4.5.1 Land Subsidence Relationship to Groundwater Elevations

The greatest groundwater level declines since recording levels started in 1984 are in the Purisima BC units where declines in the order of 140 feet historically occurred. The Purisima A and DEF units have also had significant historical declines that led to historic low levels, which have since recovered. Table 2-6 summarizes the maximum declines for each aquifer and the year in which it occurred.

Table 2-6~~.~~. Representative Aquifer Historic Groundwater Level Declines

Aquifer Unit	Maximum Decline in Feet (Monitoring Well)	Year of Historic Low
Aromas/Purisima F	5 (SC-A2A)	2000
Purisima DEF	100 (SC-17C)	1988
Purisima BC	140 (SC-14B)	1986
Purisima A	80 (SC-16A)	1988
Purisima AA/Tu	35 (SC-22AAA)	2017

Even during these periods of significant groundwater level declines, no subsidence has been documented in the Basin. This lack of evidence of subsidence linked to substantial groundwater level declines, the lack of susceptibility of Basin geology to subsidence, and existing regional subsidence monitoring near the Basin shows no evidence of subsidence indicates the inapplicability of the subsidence sustainability indicator in the Basin.

~~2.2.2.5.2~~2.2.4.5.2 Historical Land Subsidence Monitoring

No subsidence monitoring takes place in the Basin because subsidence has not occurred and is not a concern. There are, however, two continuous global positioning system (CGPS) stations in the vicinity of the ~~basin~~Basin in the Aromas area (Figure 2-39). These CGPS stations are part of the UNAVCO Plate Boundary Observatory network of CGPS stations~~.~~ (UNAVCO Community, 2006; UNAVCO Community, 2007).

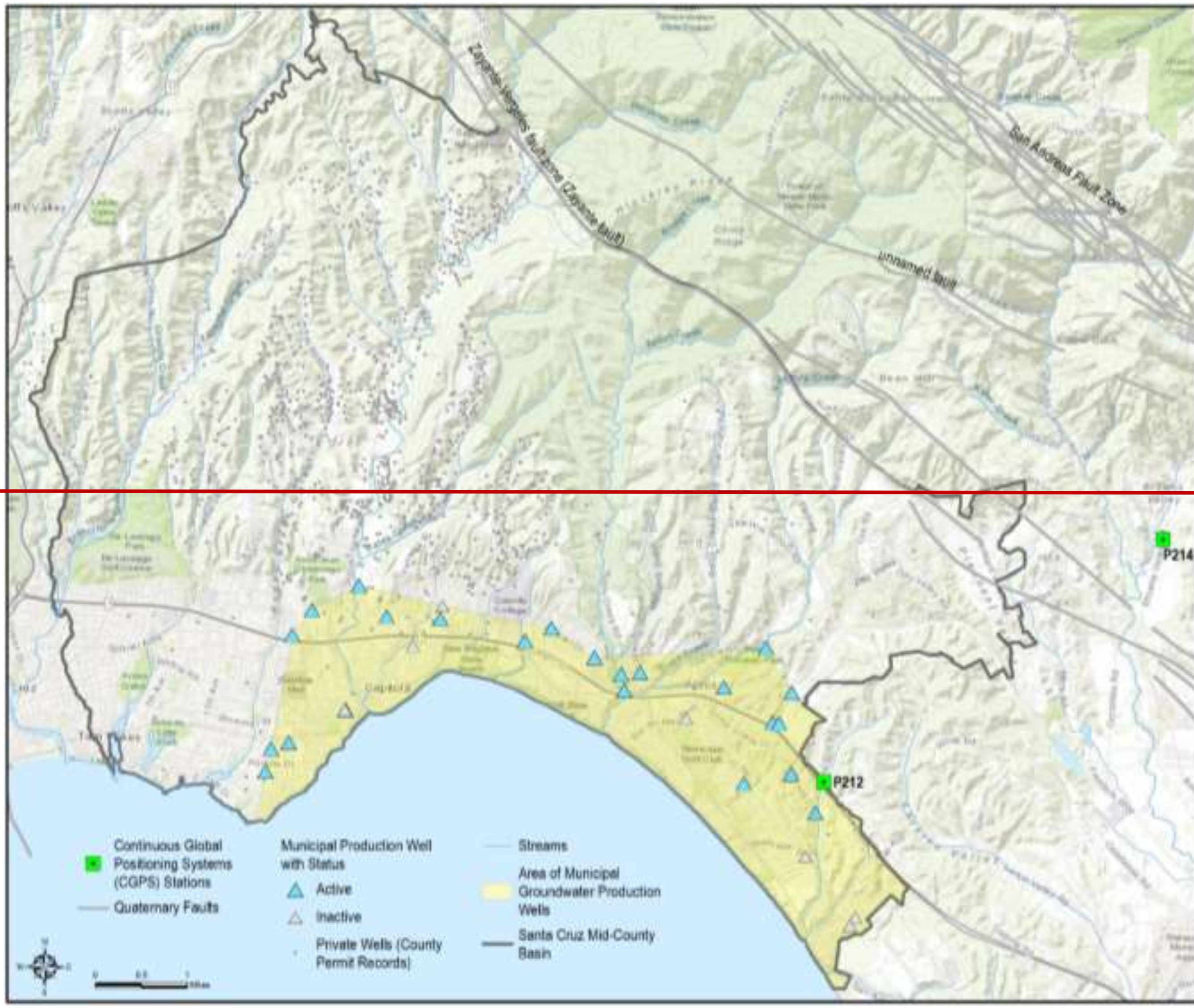
Both CGPS stations are located in areas underlain by the Aromas aquifer where groundwater levels have not experienced any significant declines. One of the stations, the Larkin Valley CGPS station (P212), is within 0.5 miles of some of the Soquel Creek Water District's production well pumping from the Aromas Red Sands and Purisima F-unit aquifers. Even though the station is outside of the ~~basin~~Basin, it still hydraulically connected and has the same aquifers as the Santa Cruz Mid-County Basin and is representative of the ~~basin~~Basin. Unfortunately, no CGPS stations are located in areas of the ~~basin~~Basin where the main Purisima aquifers are being pumped and where historic long-term declines in groundwater have occurred.

Horizontal (North and East) and vertical displacement charts are shown on Figure 2-40 for the Larkin Valley CGPS station (P212) and Figure 2-41 for the Corralitos CGPS station (P214). Both stations show small amounts of elastic subsidence in the vertical dimension (height charts at the bottom) that appear to be annual shifts of up to 2 inches, and are possibly related to seasonal changes in groundwater levels. Although 2 inches appears to be quite a bit of subsidence, the movement is not noticeable in buildings and other structures because it is not differential subsidence but occurs more or less uniformly over a very large area.

~~2.2.2.5.3~~2.2.4.5.3 Inapplicability of Land Subsidence in the Basin

The consolidated nature of the Purisima Formation, where groundwater level declines have historically occurred, is the main reason why land subsidence related to lowered groundwater levels has not occurred in the ~~basin~~Basin, and why subsidence is unlikely to occur in the future. Implementation of the GSP and avoiding undesirable results in the other five sustainability indicators will ensure that historic low groundwater levels are not repeated. This argument supports the assertion that land subsidence due to lowered groundwater levels will not occur in the future.

With no subsidence occurring in the ~~basin~~Basin, past, present or future, it is not an effective indicator of sustainability, and is not included in the GSP. In the highly unlikely event that land subsidence caused by lowered groundwater levels does occur in the ~~basin~~Basin and is identified as such by observational monitoring, the MGA will immediately regulate groundwater pumping in the area of land subsidence. The identification of active land subsidence will trigger the need for dedicated subsidence monitoring and an amendment to the GSP that includes development of Sustainable Management Criteria for the land subsidence sustainability indicator.


Zayante-Vergeles fault zone (Zayante fault)
San Andreas Fault Zone
unnamed fault
P214
P212
Continuous Global Positioning Systems (CGPS) Stations
Quaternary Faults
Municipal Production Well with Status
Active
Inactive
Private Wells (County Permit Records)
Streams
Area of Municipal Groundwater Production Wells
Santa Cruz Mid-County Basin

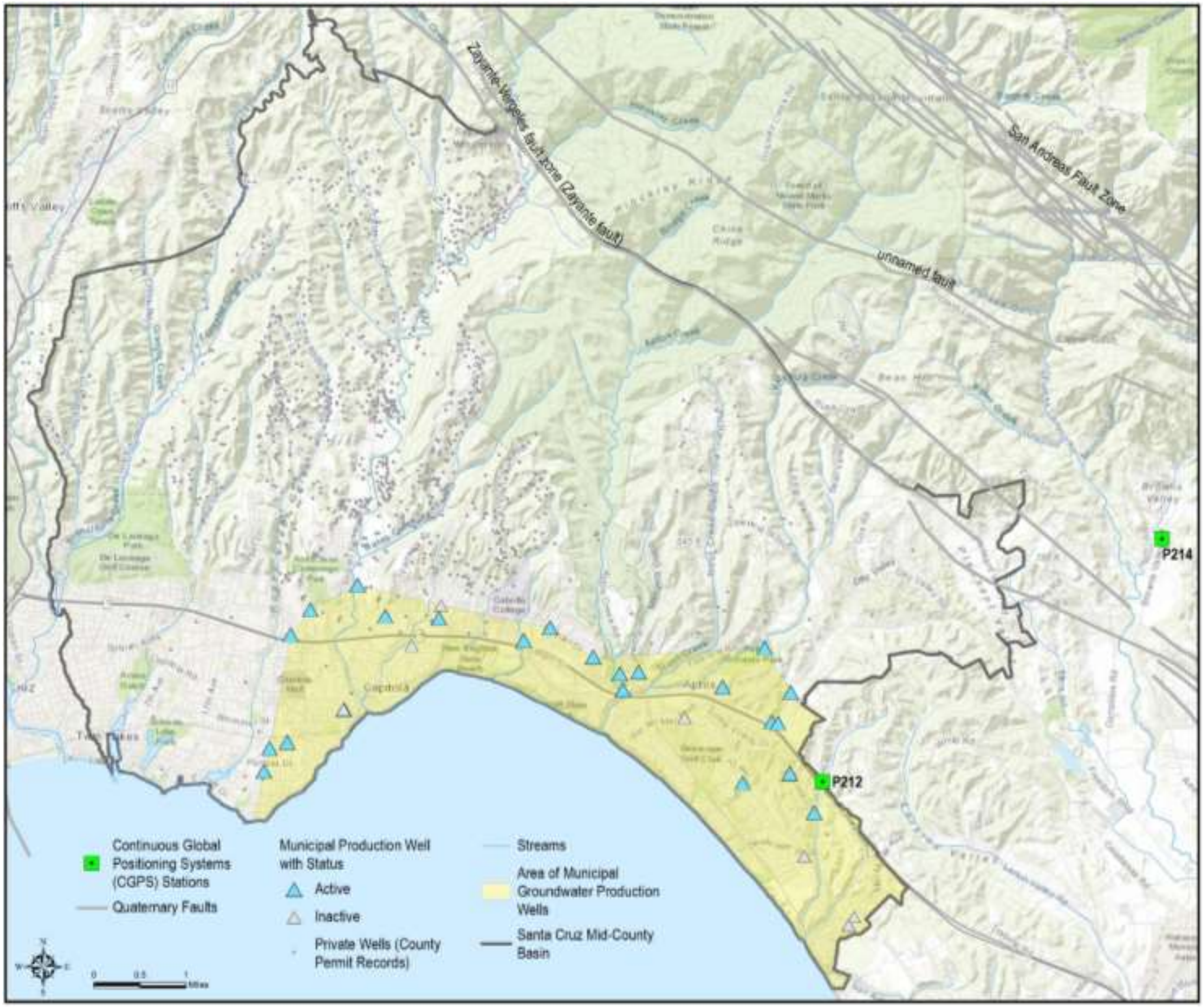
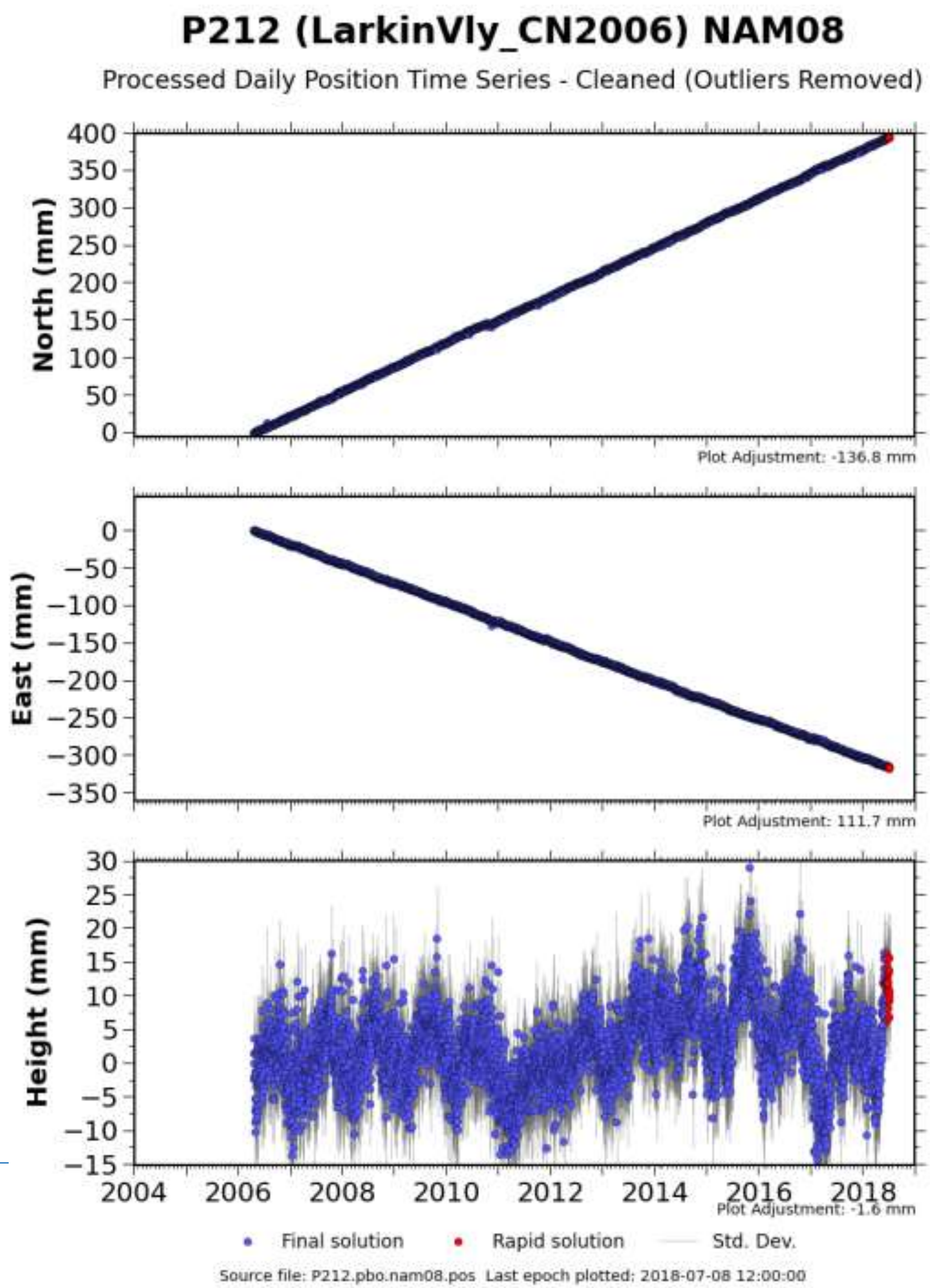


Figure 2-39. Location of Continuous GPS Stations near the Santa Cruz Mid-County Basin


P212 (LarkinVly_CN2006) NAM08
Processed Daily Position Time Series - Cleaned (Outliers Removed)
North (mm)
400
350
300
250
200
150
100
50
0
Plot Adjustment: -136.8 mm
East (mm)
0
−50
−100
−150
−200
−250
−300
−350
Plot Adjustment: 111.7 mm
Height (mm)
30
25
20
15
10
5
0
−5
−10
−15
2004
2006
2008
2010
2012
2014
2016
2018
Plot Adjustment: -1.6 mm
Final solution
Rapid solution
Std. Dev.
Source file: P212.pbo.nam08.pos Last epoch plotted: 2018-07-08 12:00:00

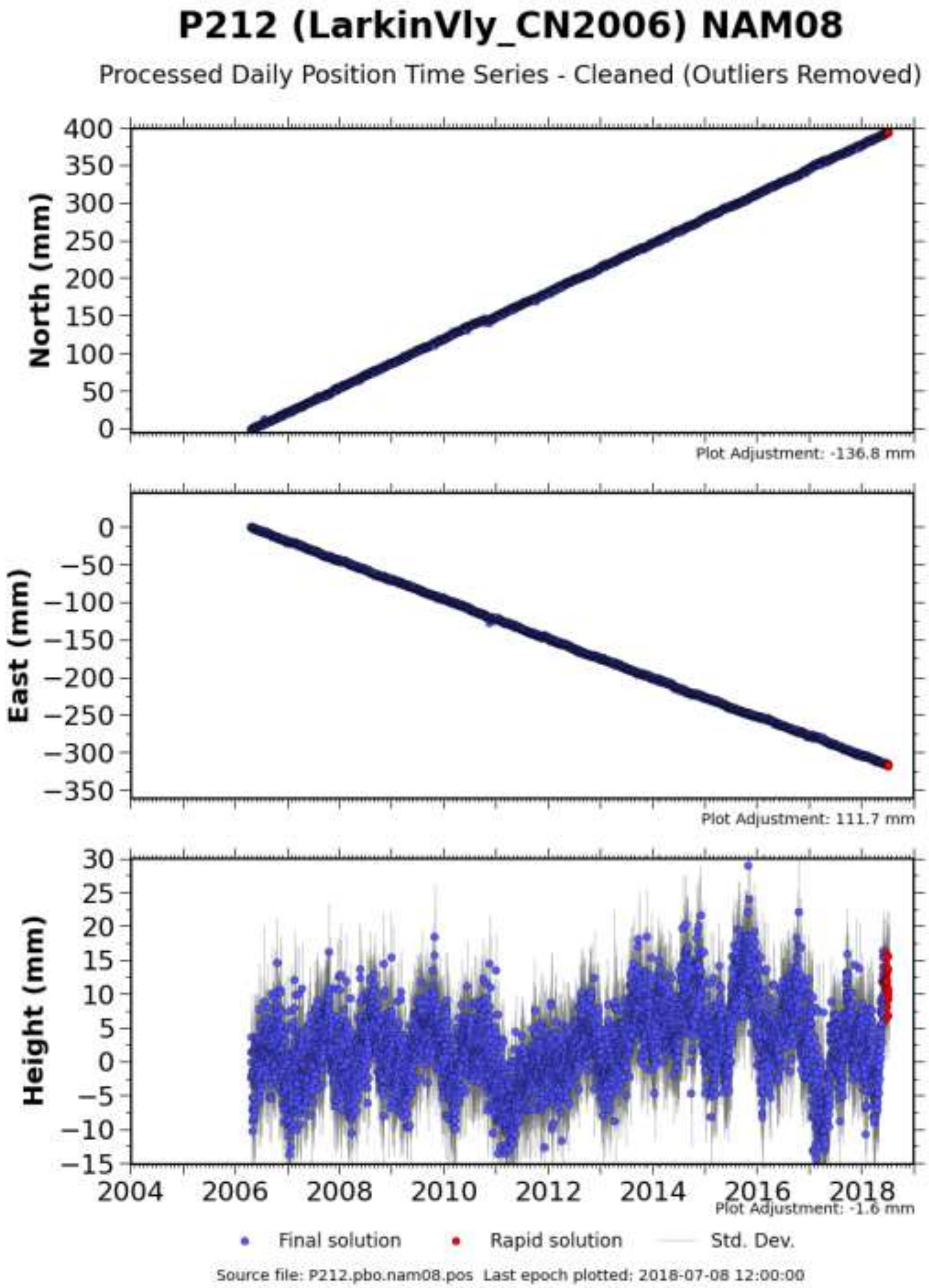


Figure 2-40. P212 Larkin Valley CGSP Station Daily Position

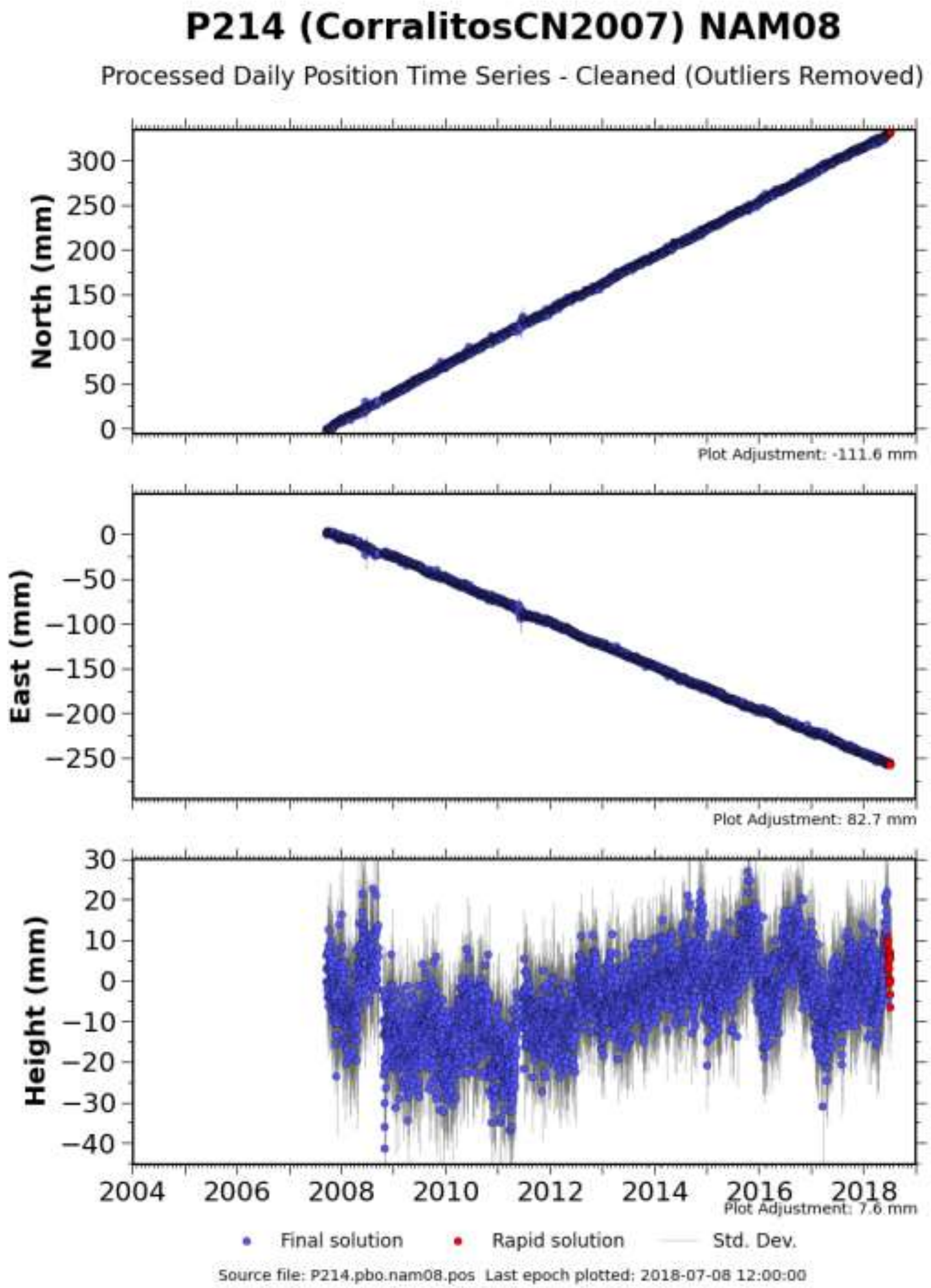


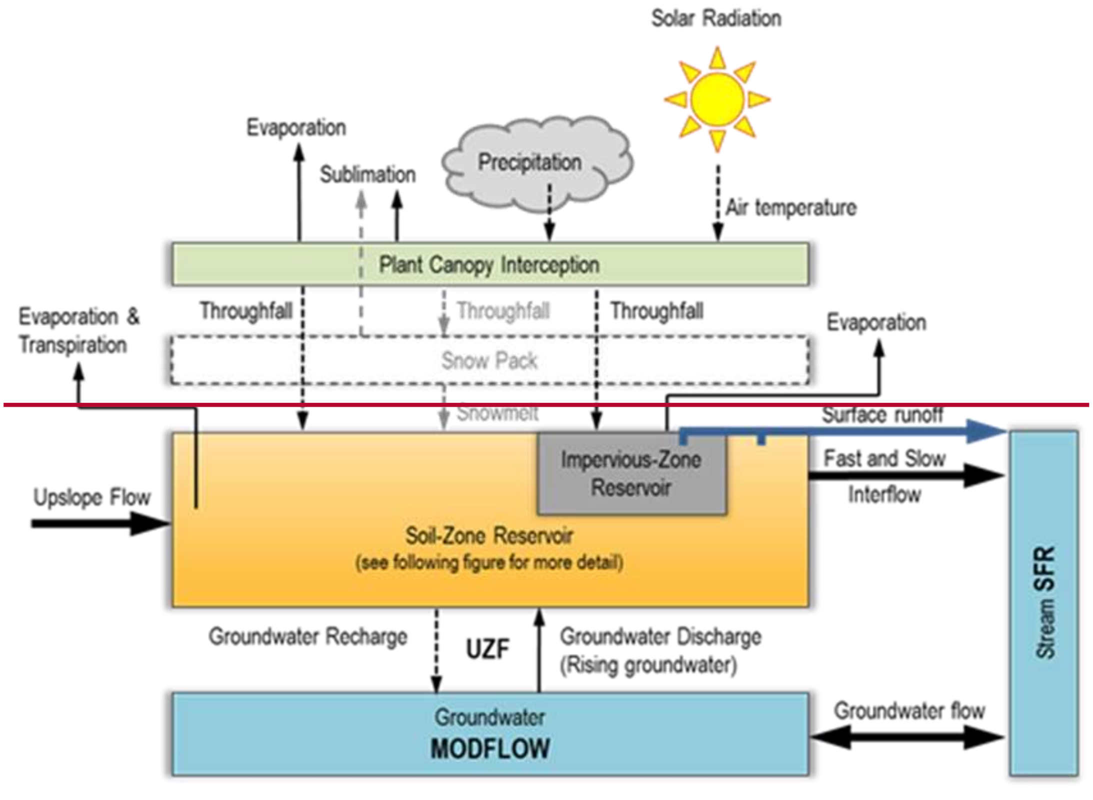
Figure 2-41. P214 Corralitos CGSP Station Daily Position

~~2.2.2.6~~2.2.4.6 Identification of Interconnected Surface Water Systems

In general, the relationship between surface water and groundwater can be described in the following ways: 1) a gaining stream that receives water from groundwater, 2) a losing stream that recharges the ~~groundwater basin~~Basin from surface water, 3) a stream that may be separated from groundwater by a hydrogeologic formation, such as an aquitard that prevents interaction between surface water and groundwater completely.

~~In gaining and losing streams, the change in~~Interconnected surface water is hydraulically connected to by a continuous saturated zone to the underlying aquifer. Interconnected streams can be both gaining and losing streams where the gradient between surface water and groundwater is what determines the extent to which water is gained or lost from the streams. In some cases, even relatively small changes in gradient can convert a gaining stream to a losing stream and vice versa. Some losing streams are defined as “disconnected” meaning the groundwater is so far below the surface water that ~~the surface water is essentially in free fall~~recharge occurs through an unsaturated zone to the ~~aquifer~~water table. In these cases, although water is typically percolating out of the stream down to the underlying groundwater, the rate of loss is not affected by the elevation of the groundwater.

The MGA’s current understanding of surface water and groundwater interactions are informed by both direct monitoring of streamflow and groundwater levels where those data are available, and by simulating surface and groundwater flow using the integrated surface water groundwater model (model). The interactions are simulated through several components of flow using both the surface water portion of the model, called the Precipitation-Runoff Modeling System (PRMS), and the groundwater portion of the model (MODFLOW). In particular, interactions with surface water (streams) occur through surface runoff, interflow, and groundwater (see Figure 2-42).



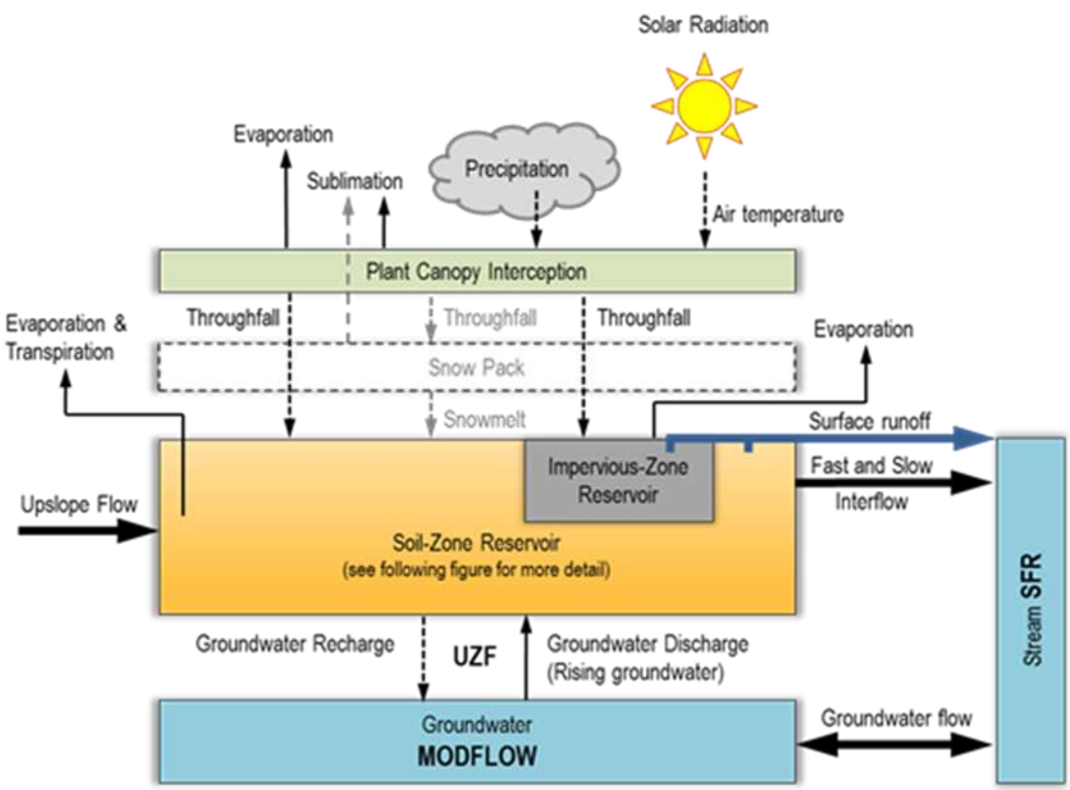


Figure 2-42. Hydrologic Process Simulated by the Precipitation-Runoff Modeling Systems (PRMS)

Throughout the Basin there is spatial variation in the percent of time surface waters are connected to groundwater (Figure 2-10~~). The~~). As described in the model calibration report provided in Appendix 2-F, the model was used to simulate the percent of time surface water was connected to groundwater between Water Year 1985 and 2015. This information is generally supported by observations of groundwater levels where the MGA currently has monitoring wells. As the MGA proceeds with GSP implementation, additional data will be collected and the model refined to improve understanding of the location and nature of the groundwater-surface water connections on priority streams. The following are findings from model simulations:

- Where streams are disconnected, groundwater levels are well below the bottom of the stream, thus, even substantial groundwater level ~~increases does~~changes do not impact streamflow.

- The Eastern side of the ~~basin~~Basin, specifically upper Valencia Creek, Trout Creek Gulch, and a number of ponds, are connected to groundwater less than 5% of the time. This may be a geologic condition of the highly permeable underlying Aromas and Purisima F units, and/or may be influenced by lowered groundwater levels in the adjacent Pajaro Valley Subbasin (Figure 2-43).

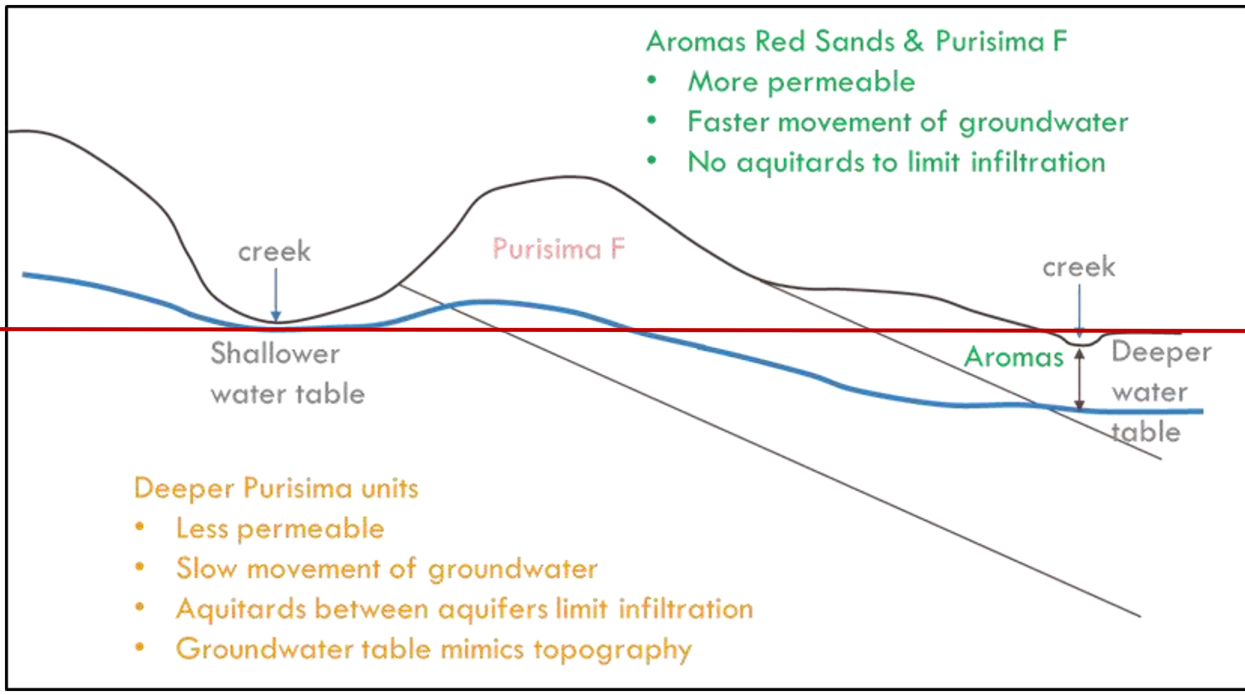
- Soquel and Branciforte Creeks have the most connection to groundwater. Some reaches in those streams are connected to groundwater more than 95% of the time (Figure 2-10).

- Most other Basin streams are connected to groundwater between 30-95% of the time (Figure 2-10).

- Results for two modeled stream segments on Soquel Creek, 1) Simons to Balogh, and 2) Main Street to Nob Hill, where there are shallow groundwater data from which to calibrate, show strong stream-aquifer interactions ~~are high~~ relative to the model as a whole, and are near municipal pumping. ~~Groundwater only~~In the months with lowest flows, groundwater flow to surface water contributes ~~a small amount of flow~~ more than surface/near-surface runoff flows for these segments, but the groundwater contribution (< 0.5 ~~cfs) to~~ cubic foot per second [cfs]) is small compared to the overall flow in each of these segments of Soquel Creek ~~in the months with lowest flows.~~(Figure 2-44 and Figure 2-45). Most of the streamflow in those segments comes from higher up in the watershed ~~outside the Basin. (~~(Figure 2-44 and Figure 2-45~~).~~). As data quantifying flows between the stream and shallow groundwater are not available for calibration, there is high uncertainty of the magnitude of simulated flows between stream and aquifer calculated by the model. The groundwater contribution to streamflow along these stretches of less than 0.5 cfs is consistent with estimates from previous studies that streamflow depletion has not been observed because depletion of up to 0.5 cfs cannot be observed from the data (Johnson et al., 2004).

- The model simulates the relative contribution of surface/near-surface flows for the entire watershed in minimum streamflow months is greater than groundwater contribution and drives the inter-annual variability in streamflow. The groundwater contribution is simulated as approximately 1 cfs.

- Measured streamflow is highly affected by evapotranspiration from streamside vegetation, which is not taken into account in the model. This creates a challenge for calibrating the model to measured flow.



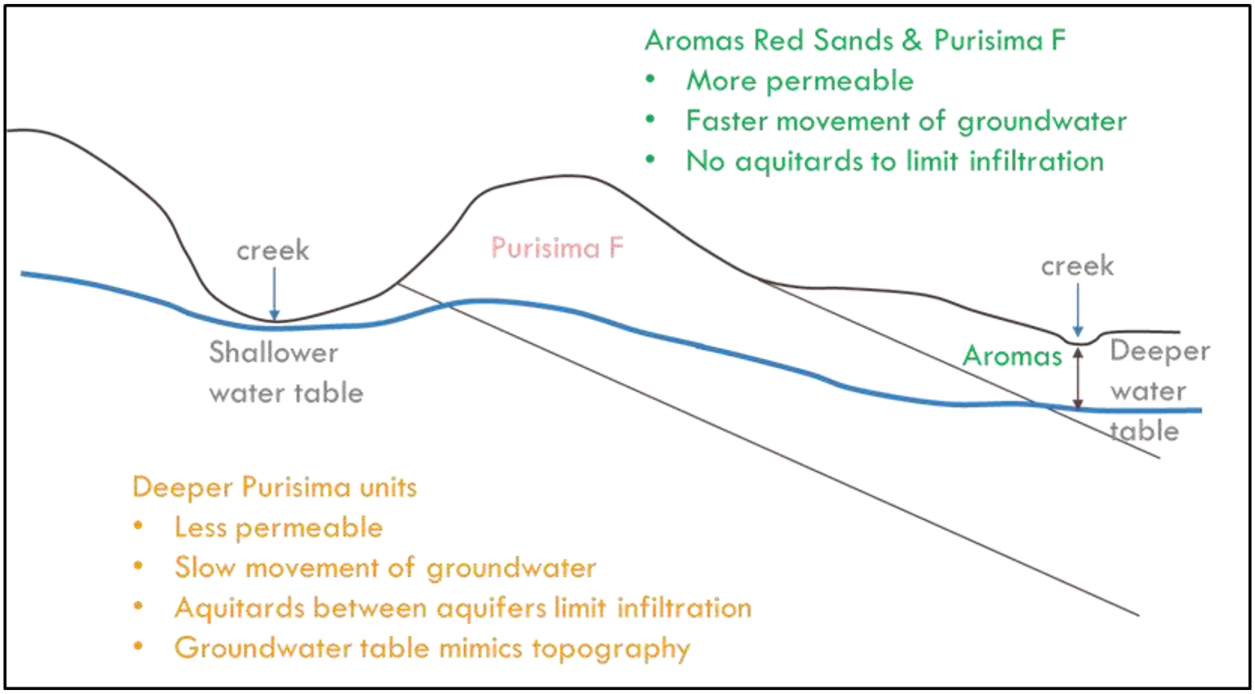
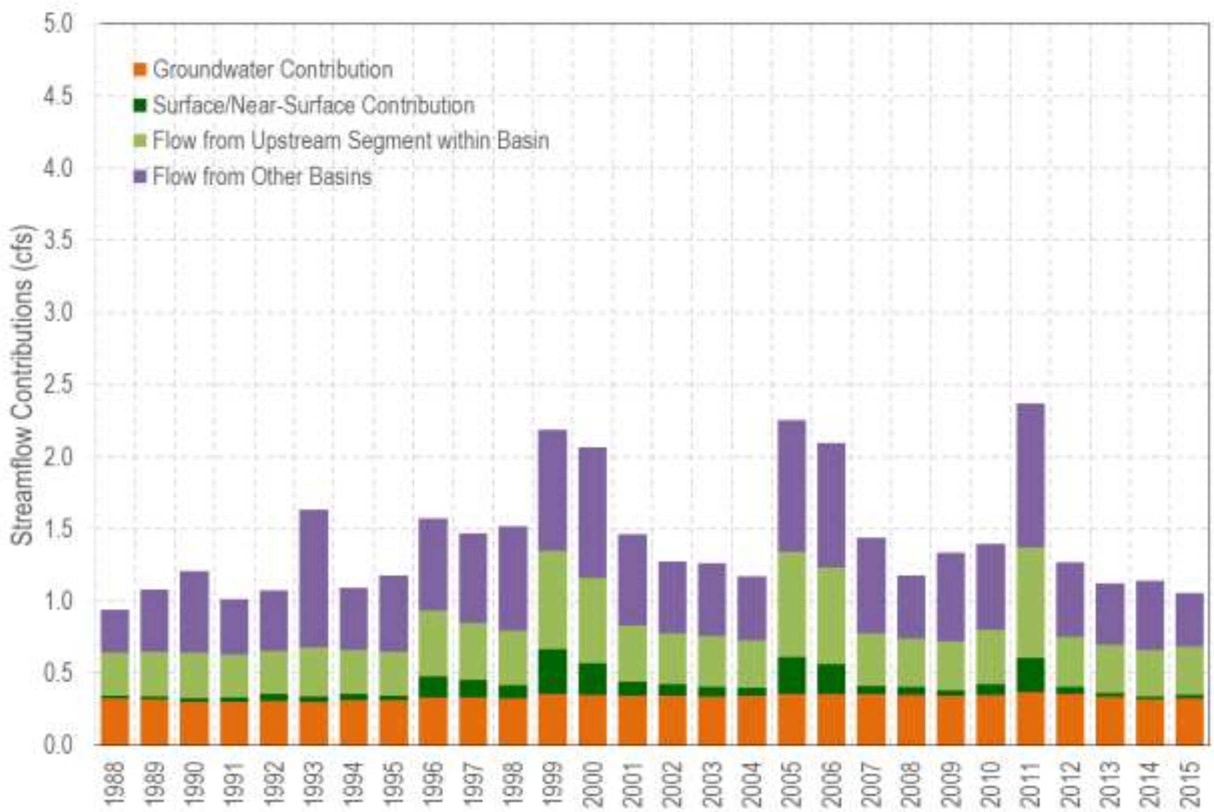


Figure 2-43. Differences Between Purisima and Aromas Connection to Groundwater



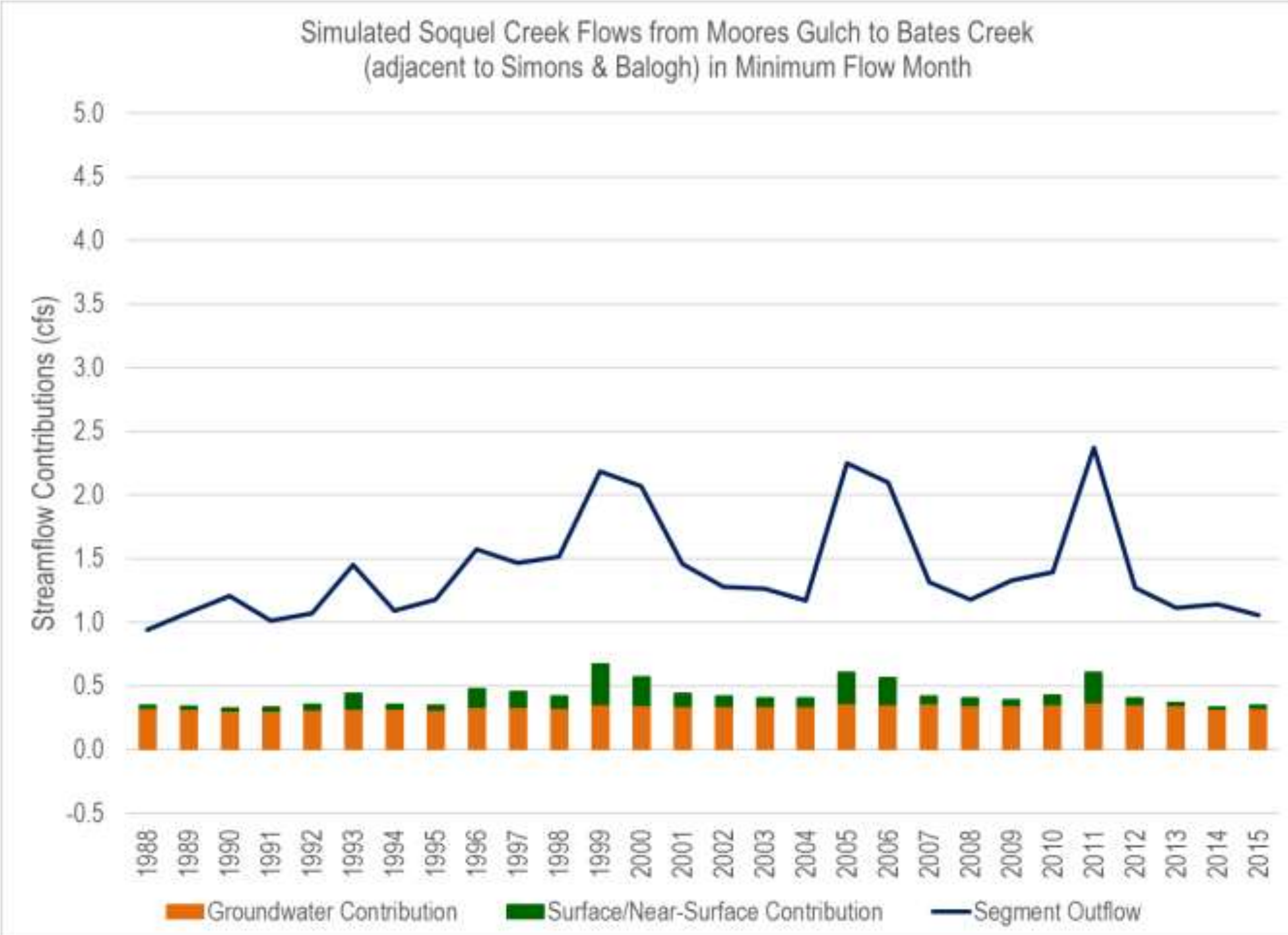


Figure 2-44. Simulated Minimum Monthly Flows from Moores Gulch to Bates Creek

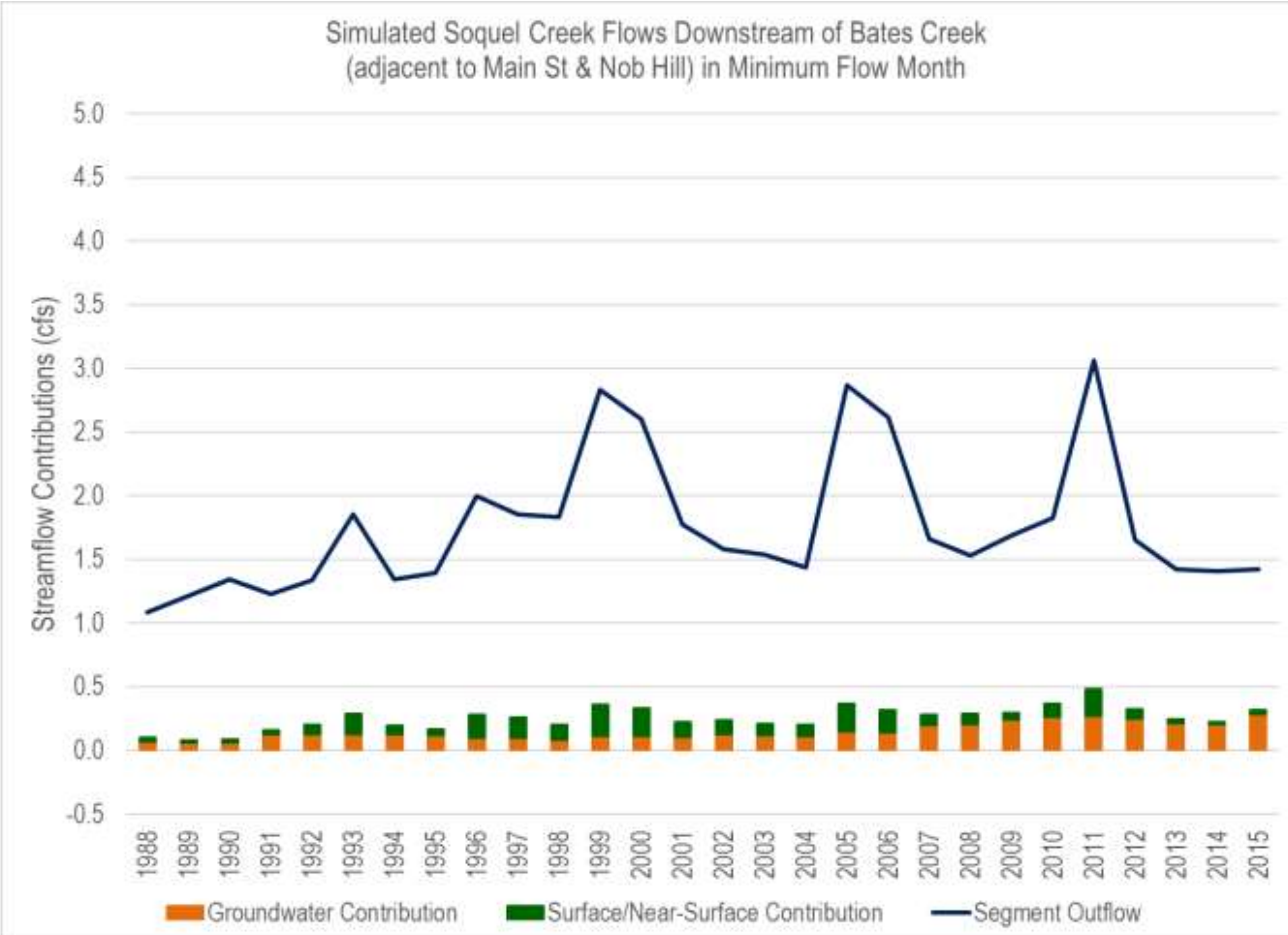
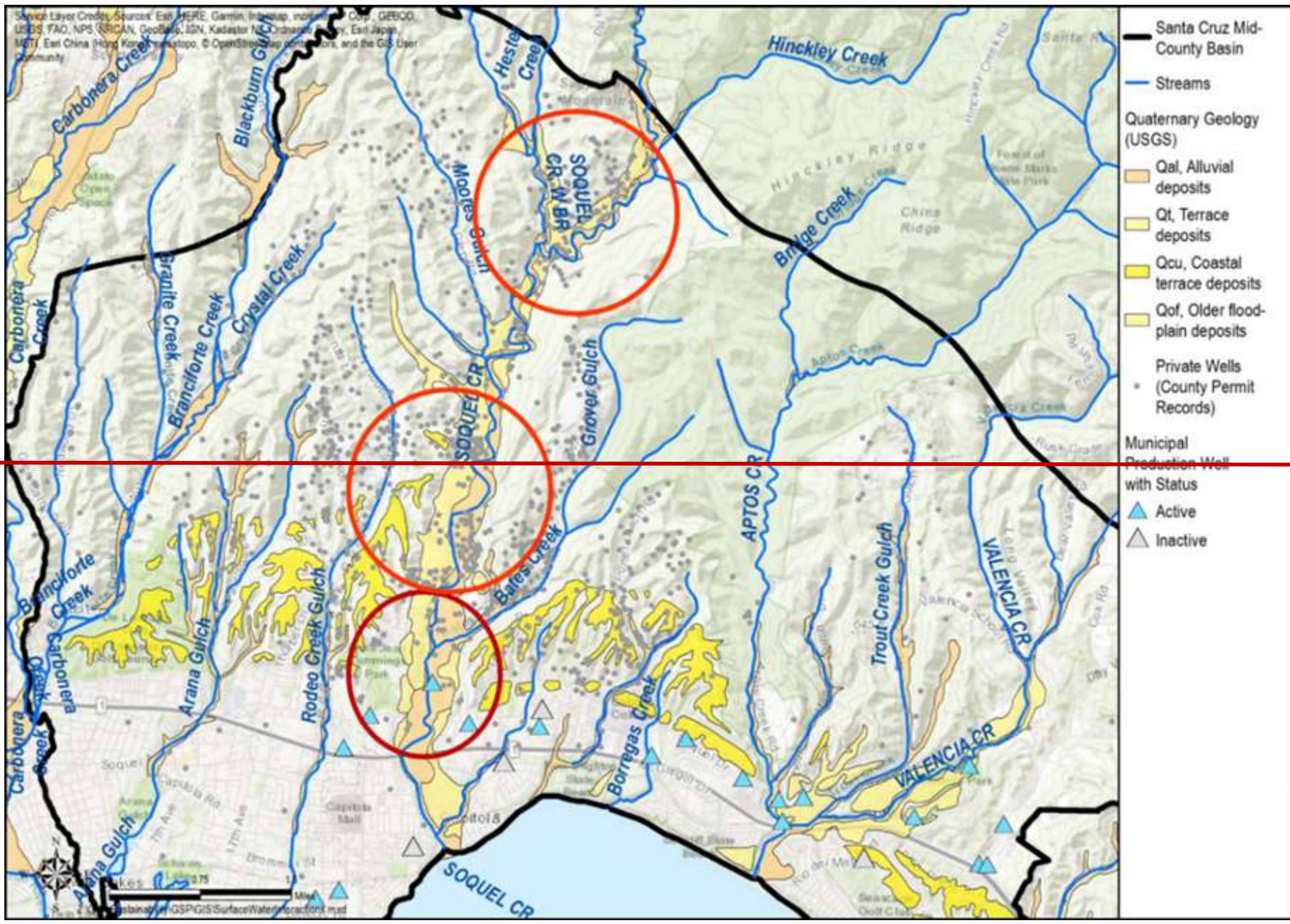


Figure 2-45. Simulated Minimum Monthly Flows Downstream from Bates Creek

Given the uncertainty in the groundwater modeling, the limited data available to assess surface water-groundwater interactions, and recognizing the possible importance of even small amounts of groundwater flow contributions or additional flow depletions during low flow periods, the MGA intends to improve Basin monitoring to better understand surface water-groundwater interactions over time, and revisit these estimates as new information is developed. This relationship and improvements to monitoring are discussed in more detail in Section 3.9.

Developing sustainable management criteria for depletion of interconnected surface water needs to consider not only how often there is connection with groundwater, but also how much that connection influences streamflow, and the location of groundwater pumping that may affect groundwater levels and streamflow. Soquel Creek is the primary stream in the Basin where there are major pumping centers and a connection between surface and groundwater (Figure 2-46).



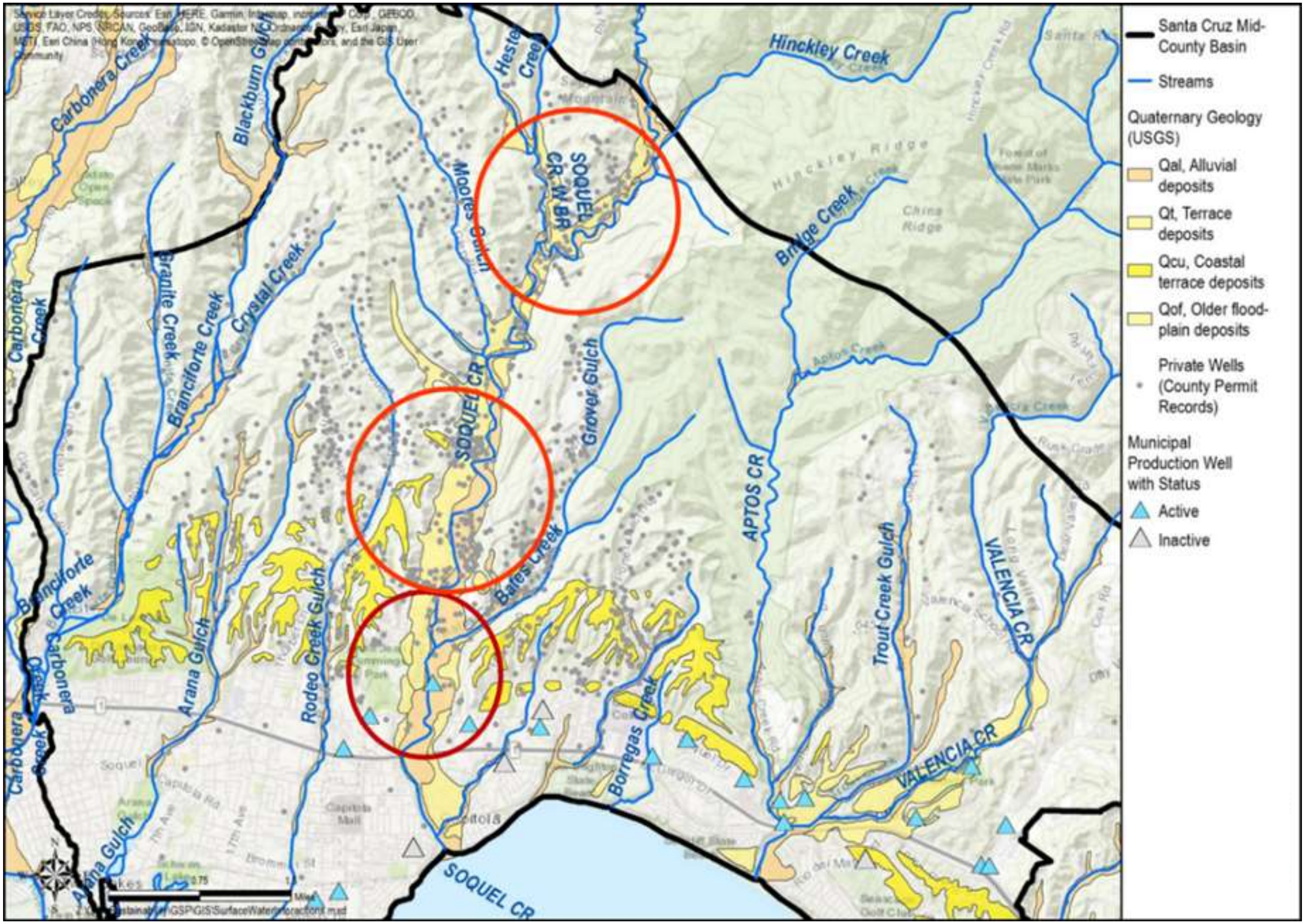
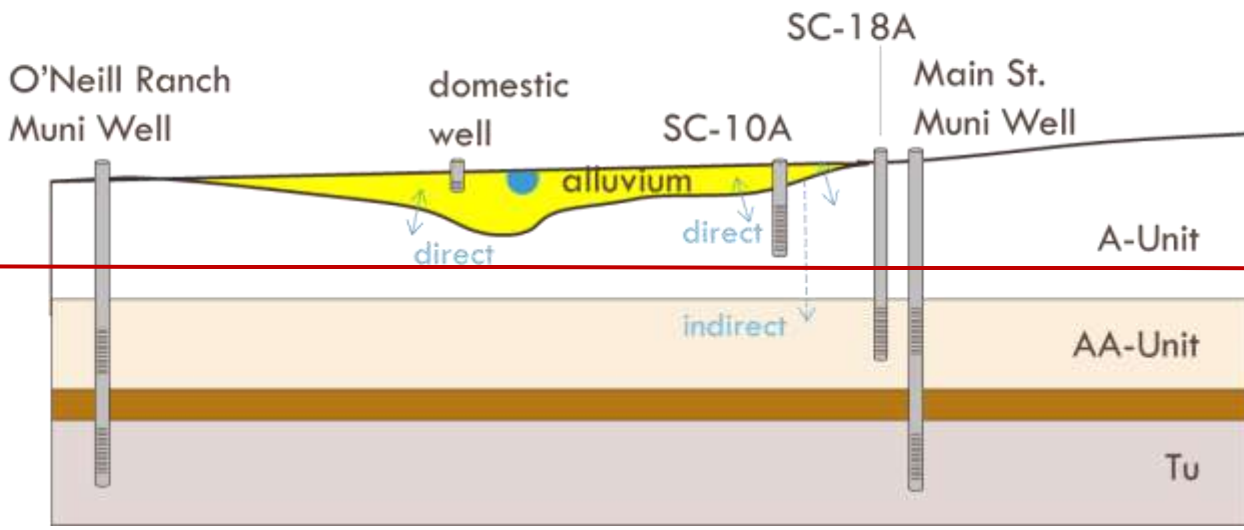


Figure 2-46. Areas of Concentrated Groundwater Pumping along Soquel Creek

Soquel Creek Water District has been monitoring surface water interactions near its Main Street municipal well with its monitoring well network for almost 20 years. Annual reports evaluating the connection between Main Street and other nearby municipal wells to Soquel Creek have been prepared since 2015~~.~~ (HydroMetrics, 2015; HydroMetrics, 2016; HydroMetrics, 2017). These reports have shown no direct measurable connection to creek flow or stage in response to pumping starting and stopping in the Main Street municipal well, which is screened in the Purisima AA-unit and Tu-unit (as shown in Figure 2-47). But there is an expected indirect influence of pumping ~~n~~on streamflow resulting from general lowering of groundwater levels and reduction of groundwater contribution to the stream. This is also indicated by the groundwater model.



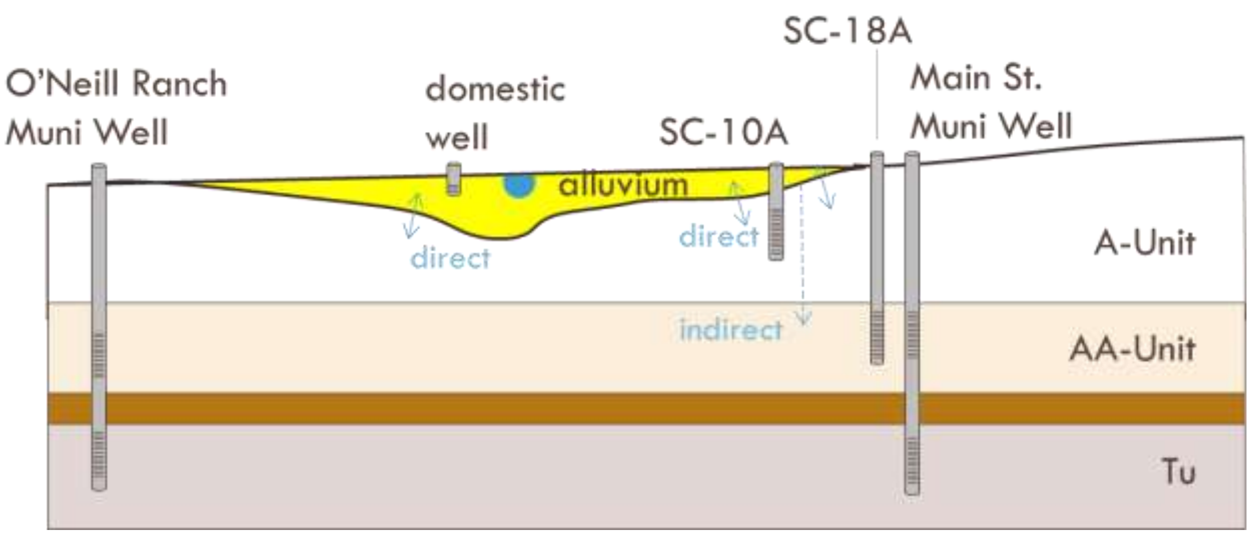


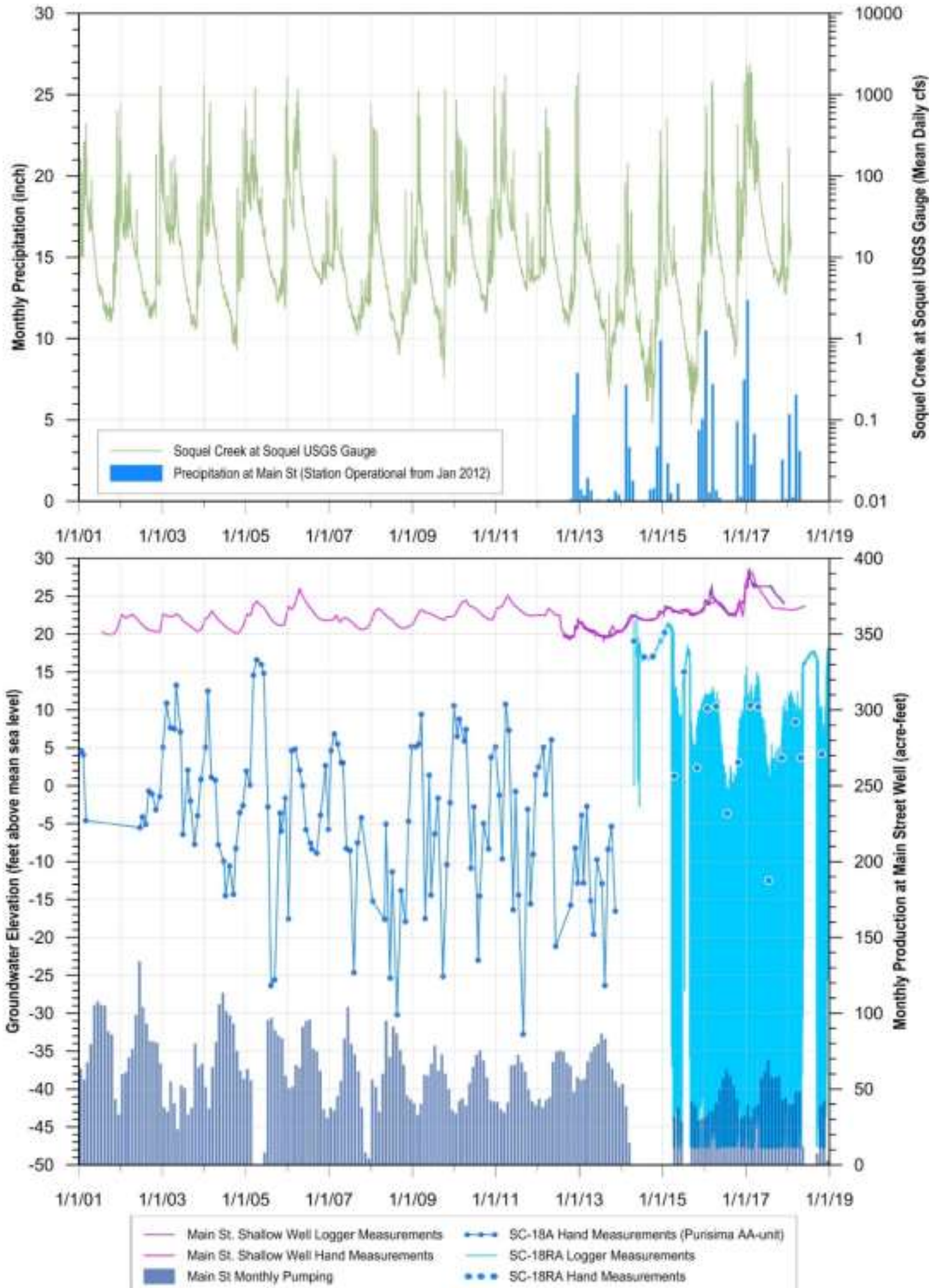
Figure 2-47. Conceptual Connections between Soquel Creek, Alluvium, and Underlying Aquifers

Figure 2-48 shows hydrographs for monitoring well SC-18A (screened in Purisima AA-unit) and the Main Street shallow monitoring well (screened in alluvium and top of the Purisima A-unit) plotted with: (1) streamflow at the USGS Soquel Creek at Soquel gauge located adjacent to the Main Street wells, (2) precipitation recorded at the Main Street site (since January 2012), and (3) monthly pumping at the Main Street municipal well.

Evaluation of the relationships between measurements shown on Figure 2-48 indicate:

- Shallow groundwater levels fluctuate in response to both pumping and rainfall.
- Shallow groundwater levels rose during the period between April 2014 and April 2015 when the Main Street municipal well was offline. The increase occurred even though it was the middle of the 2011-2015 drought and groundwater levels were below average.
- There is a 1-2 foot increase in shallow groundwater levels in the Main Street shallow well that corresponds to the increase in Purisima AA~~ Unit~~-unit groundwater levels in SC-18A (it also corresponds to rainfall). However, record high groundwater levels in SC-18A are not matched by record high shallow groundwater levels.

The above information suggests that the alluvium, and hence the creek, is connected to underlying aquifers. That connection appears to be more direct with the Purisima A-unit, and indirect with aquifers below the Purisima A-unit.



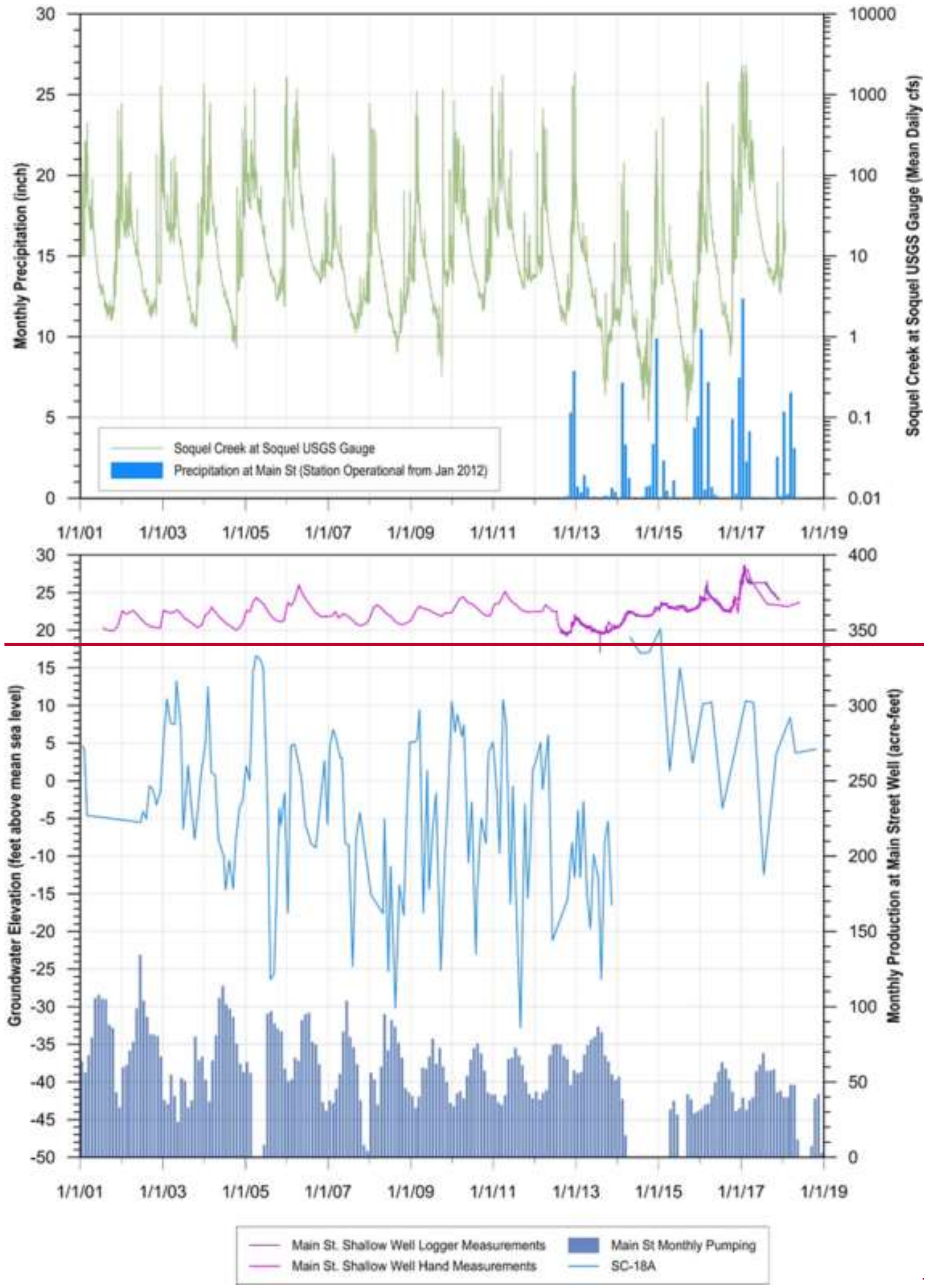


Figure 2-48. Hydrographs for Main Street Monitoring Wells Compared to Monthly Main Street Pumping, Creek Flow and Precipitation

~~2.2.2.7~~2.2.4.7 Identification of 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." In order to address this issue, it is necessary to identify the aquatic species and habitats that could be adversely affected by lowered groundwater levels in principle aquifers and interconnected surface water ~~depletions~~depletion. Because of the critical nature of this work, the MGA established the Surface Water Working Group to bring additional expertise to this important conversation and provide information to the GSP Advisory Committee. The Surface Water Working Group included staff and representatives from the following groups:

- GSP Advisory Committee
- California Department of Fish and Wildlife
- California Department of Water Resources
- City of Santa Cruz
- County of Santa Cruz
- Friends of Soquel Creek
- National Marine Fisheries Service (NMFS, formerly NOAA Fisheries)
- Pajaro Valley Water Management Agency (PV Water)
- Regional Water Management Foundation/MGA
- Resource Conservation District of Santa Cruz County
- The Nature Conservancy
- Environmental Defense Fund
- US Fish and Wildlife Service

The Surface Water Working Group began by identifying where ecosystems are connected to groundwater that could be impacted by groundwater pumping. Figure 2-10 in Section 2.1.4.12 identifies where surface water is connected to groundwater within the Basin and the percentage of time that that connection exists. Due to the stacked nature of the geology and the fact that pumping is typically happening in some of the lower aquifers, the focus of the group was narrowed to the habitats supported by surface water systems like streams (Figure 2-49).

~~Other ecosystems~~Numerous habitats (Figure 2-50) and species (Figure 2-51) are supported by surface water systems within the Basin. During the first meeting of the Working Group, staff led a discussion about these species and the best way to address them through the GSP. The Working Group requested an evaluation of the requirements for specific plant and animal species in relation to dependence on water for some or all of their life stages. Based on that evaluation, staff proposed that the highest water need was for steelhead trout, coho salmon, and several riparian trees including willow and sycamore. These were labelled "priority species." The remaining species evaluated either 1) were in an area sensitive to groundwater management, however their aquatic needs were less than those of the priority species, or 2) were not in an area sensitive to groundwater management due to either a lack of groundwater pumping or disconnected surface water.

MGA staff used the California Natural Diversity Database and National Wetlands Inventory to identify species whose ranges potentially overlap the Basin boundaries. Table 2-7 outlines all of the species evaluated from these databases. Table 2-8 lists species actually observed within the Basin through various monitoring programs discussed in Section 2.1.2.1.

The salamander ponds that were identified inside and outside of the eastern portion of the Basin (see Figure 2-4) were found to be generally supported by the interflow in perched groundwater~~,~~ and surface water runoff~~,~~ which were both considered beyond the scope of GSP management. The group also considered the issue of possible marine ecosystems dependent on freshwater outflow of groundwater into the marine environment. However, after discussions with ~~researchers~~experts in the field Dr. Charles Paull, MBARI; Dr. Willard Moore, University of South Carolina Distinguished Faculty Emeritus; and Dr. Adina Paytan, UCSC Research Scientist/Lecturer and further consideration, the group determined that any possible ecosystem effects in the marine environment would be challenging to evaluate, are likely quite small if they exist at all, and will benefit from the management policies put in place to protect priority aquatic species.

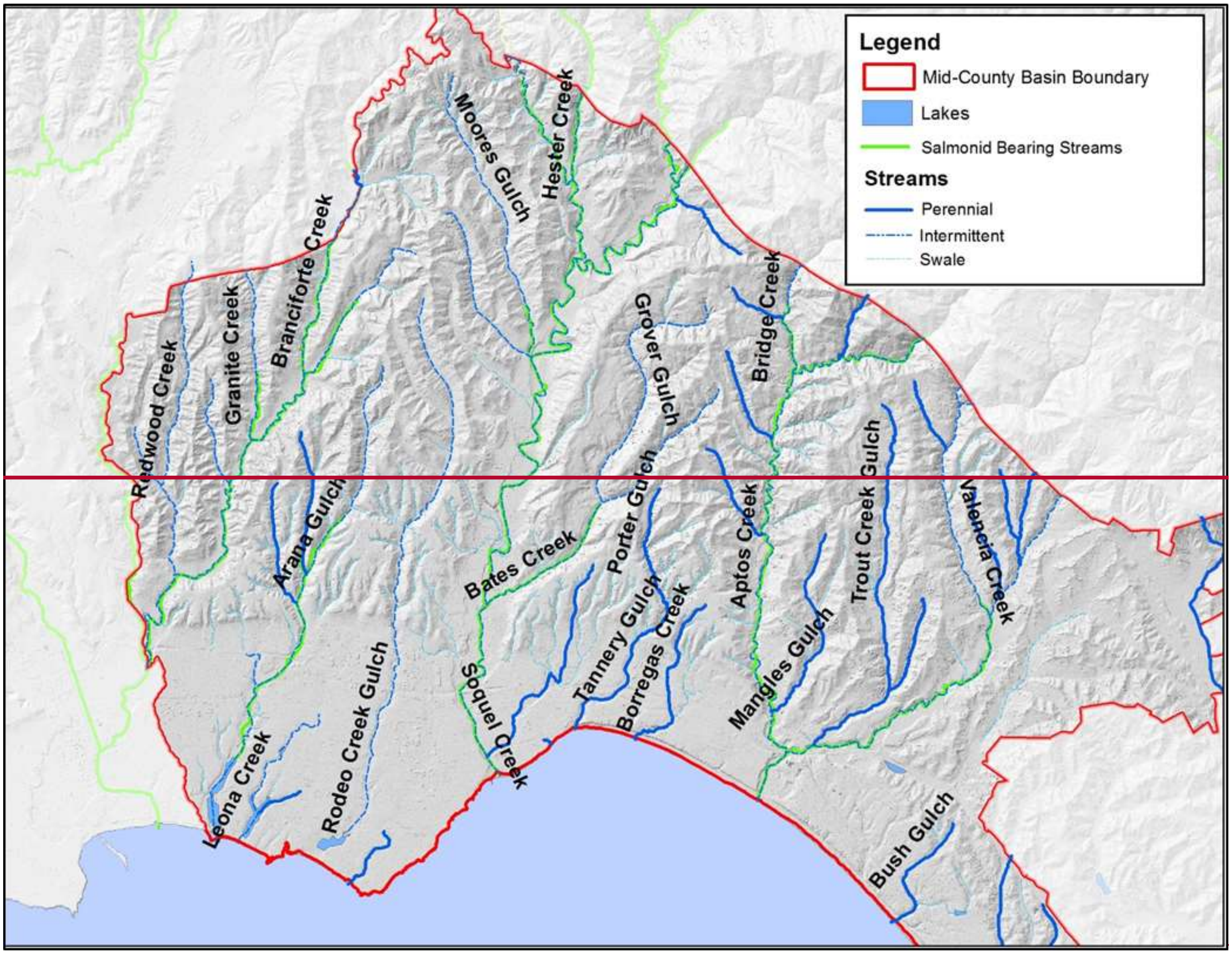
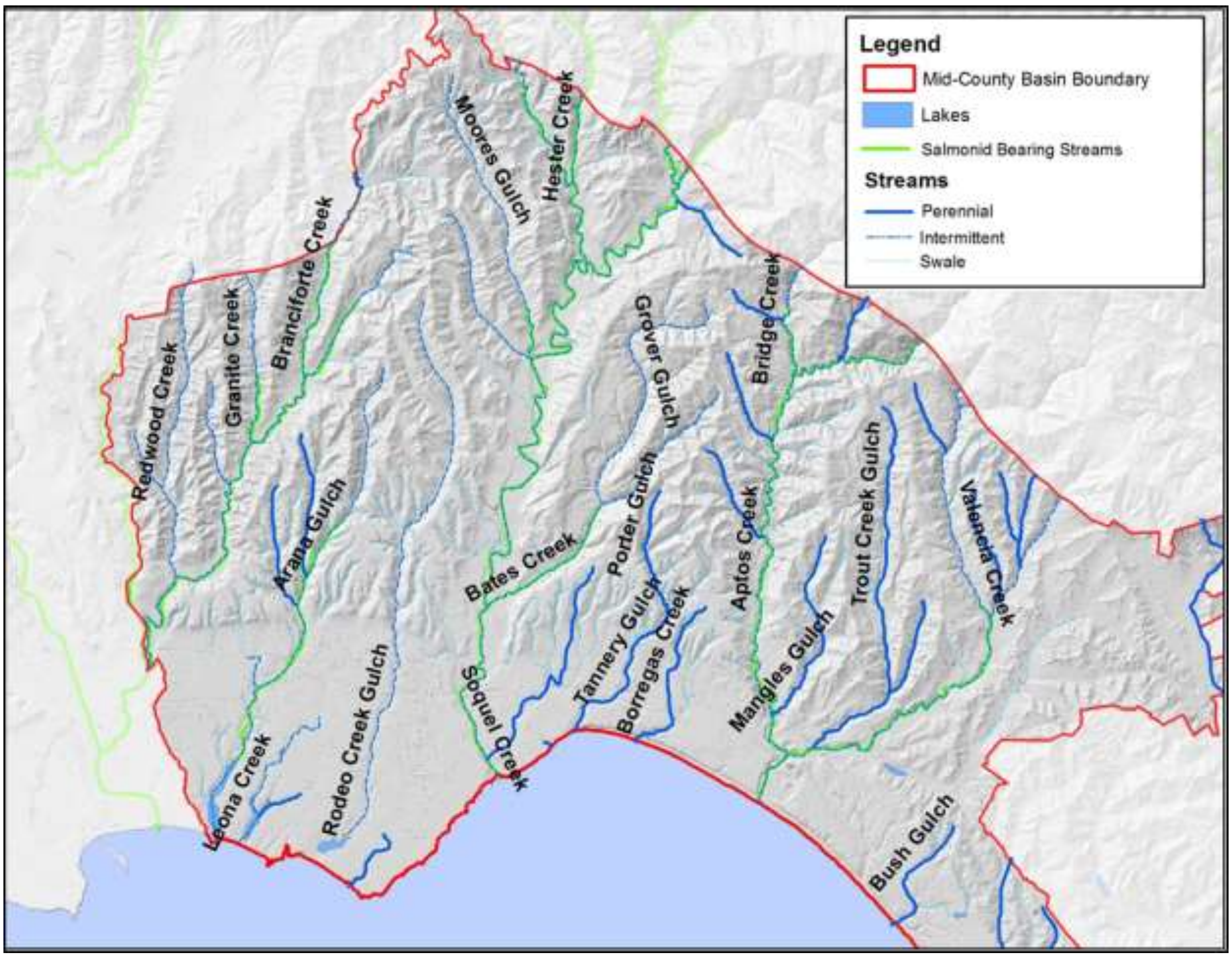

Legend
Mid-County Basin Boundary
Lakes
Salmonid Bearing Streams
Streams
Perennial
Intermittent
Swale
Moores Gulch
Hester Creek
Branciforte Creek
Granite Creek
Redwood Creek
Grover Gulch
Bridge Creek
Arana Gulch
Porter Gulch
Aptos Creek
Trout Creek Gulch
Valencia Creek
Bates Creek
Tannery Gulch
Borregas Creek
Mangles Gulch
Rodeo Creek Gulch
Soquel Creek
Leona Creek
Bush Gulch

Figure 2-49. Stream Habitat in the ~~Sant~~Santa Cruz Mid-County Basin

Using guidance developed by ~~The Nature Conservancy~~TNC (https://groundwaterresourcehub.org/), and input from MGA technical staff, the Surface Water Working Group reviewed information on the distribution of aquatic species throughout the ~~basin~~Basin and the habitat requirements for those species (Figure 2-50). Where applicable, the potential effect groundwater management could have on habitat was also discussed with the Surface Water Working Group.

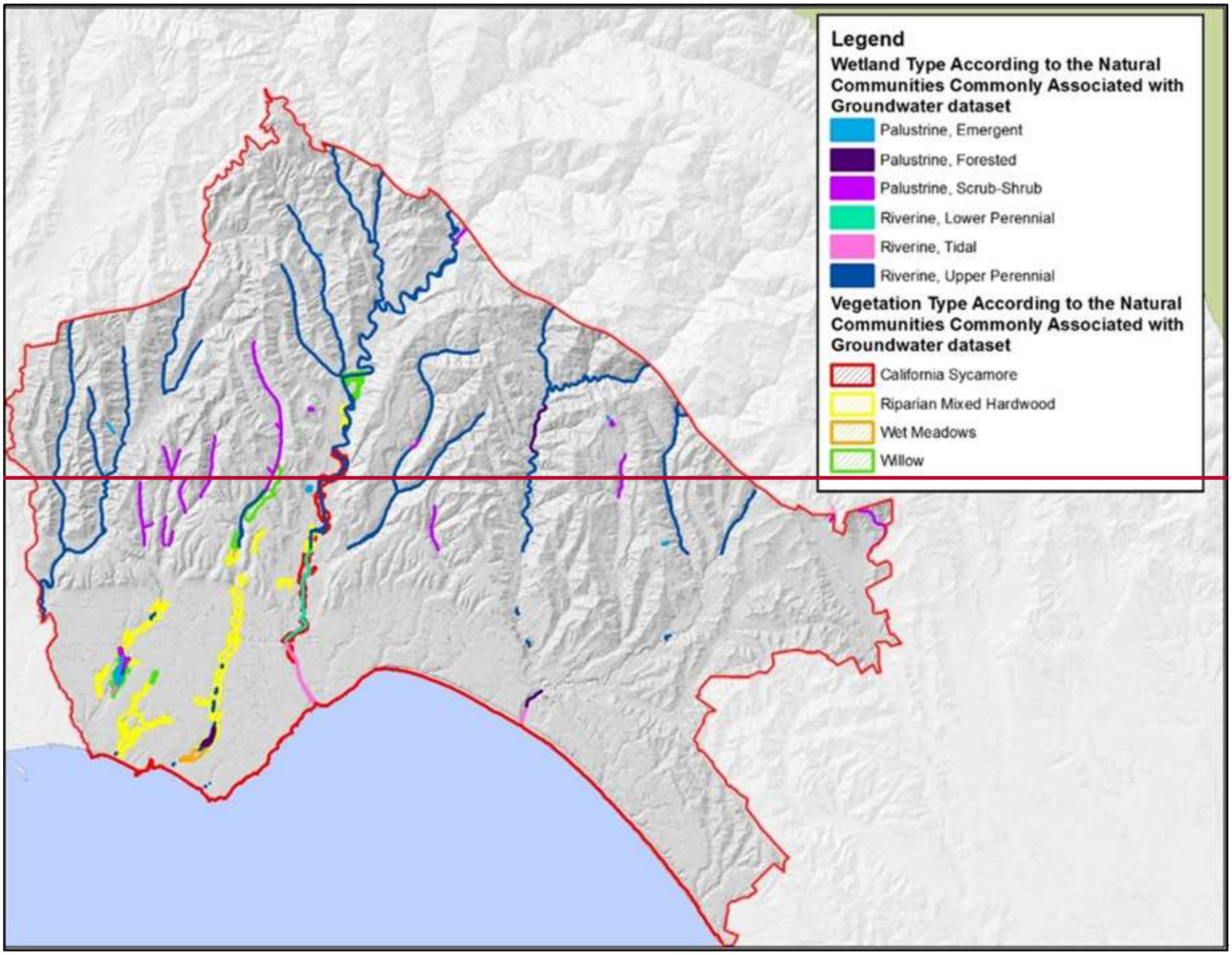
The Working Group agreed to the following:

- The GSP should only address impacts to surface water that are directly related to groundwater management. There are many factors that affect streamflow including



  rainfall, evapotranspiration, and surface water diversions, that are beyond the scope of the GSP. These factors were ~~accounted for in the analysis.~~considered when developing depletion of interconnected surface water sustainable management criteria..

- The Basin supports numerous aquatic species of concern. Steelhead and coho salmon are priority species for evaluating the effects of groundwater management. By managing for their specific habitat requirements in ~~basin~~Basin streams, the needs of other aquatic species of concern will also be met (see ~~Table 2.9~~Table 2-8 for occurrences of non-salmonid aquatic species found through the County's monitoring program).
- Maintaining flow for fish will also support other beneficial uses of streams and downstream lagoons, including recreational use and domestic supply, among others. Note that while coho do not appear in the California Natural Diversity Database (~~Figure 2-48~~Figure 2-51) they have been seen in the Basin ~~though~~through the County's monitoring program (~~Table 2-8~~Table 2-7). Branciforte, Soquel, and Aptos Creeks are designated as coho recovery streams.
- Similarly, riparian forest that includes native trees like cottonwood, willow and sycamore were identified as a habitat type that should be prioritized for management. For those species, if groundwater levels are maintained at a level to support streamflow for fish, the groundwater levels will also be high enough to supply the roots of the riparian vegetation.
- Modeling and management should focus on areas of highest groundwater extraction where streams are interconnected with groundwater~~.~~ as identified in Figure 2-46 along Soquel Creek.
- Linking the basic water needs of the species and habitats of concern, relative to groundwater elevations, is an appropriate way to move forward with the assessment and development of sustainable management criteria to benefit those species.


Legend
Wetland Type According to the Natural Communities Commonly Associated with Groundwater dataset
Palustrine, Emergent
Palustrine, Forested
Palustrine, Scrub-Shrub
Riverine, Lower Perennial
Riverine, Tidal
Riverine, Upper Perennial
Vegetation Type According to the Natural Communities Commonly Associated with Groundwater dataset
California Sycamore
Riparian Mixed Hardwood
Wet Meadows
Willow

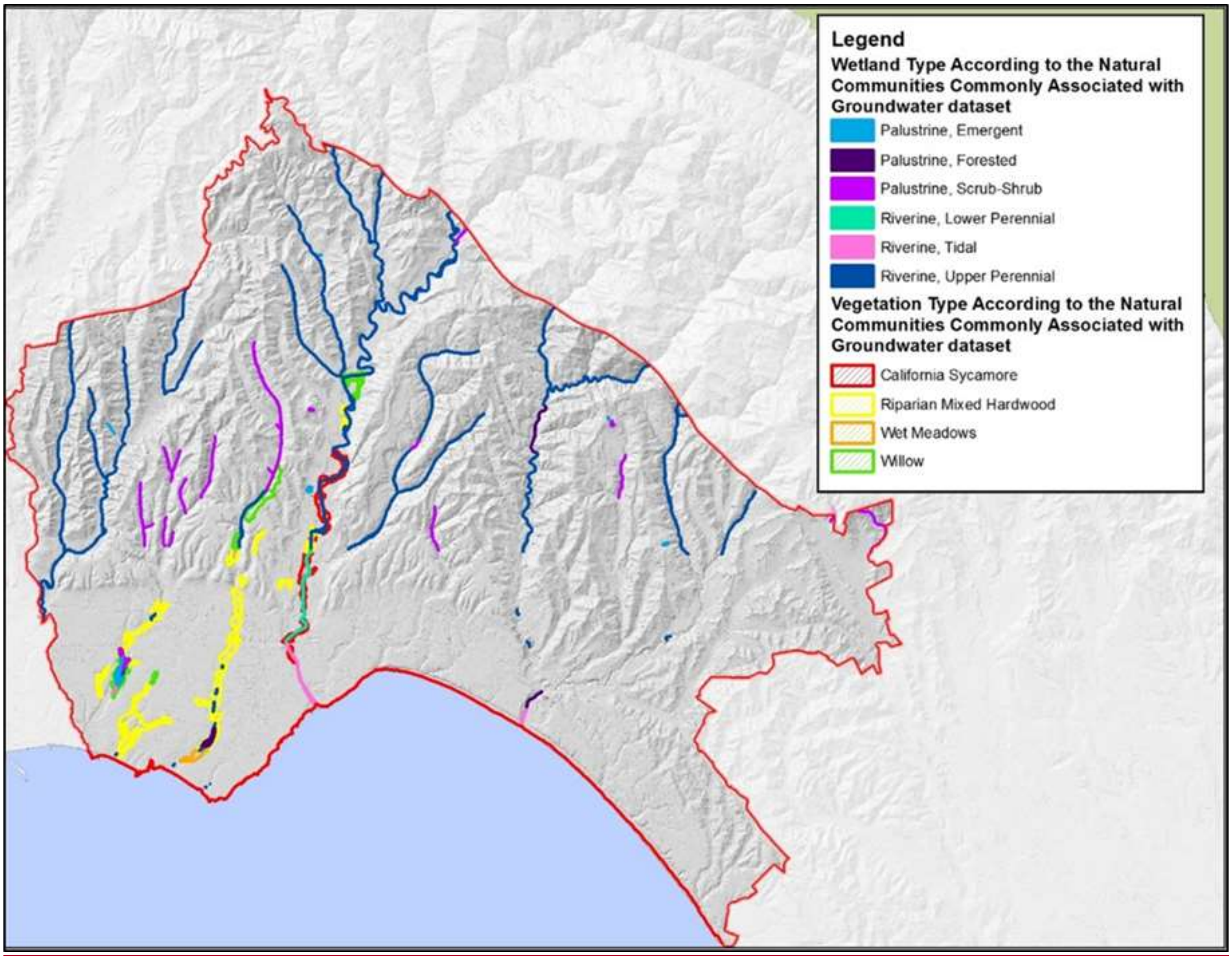
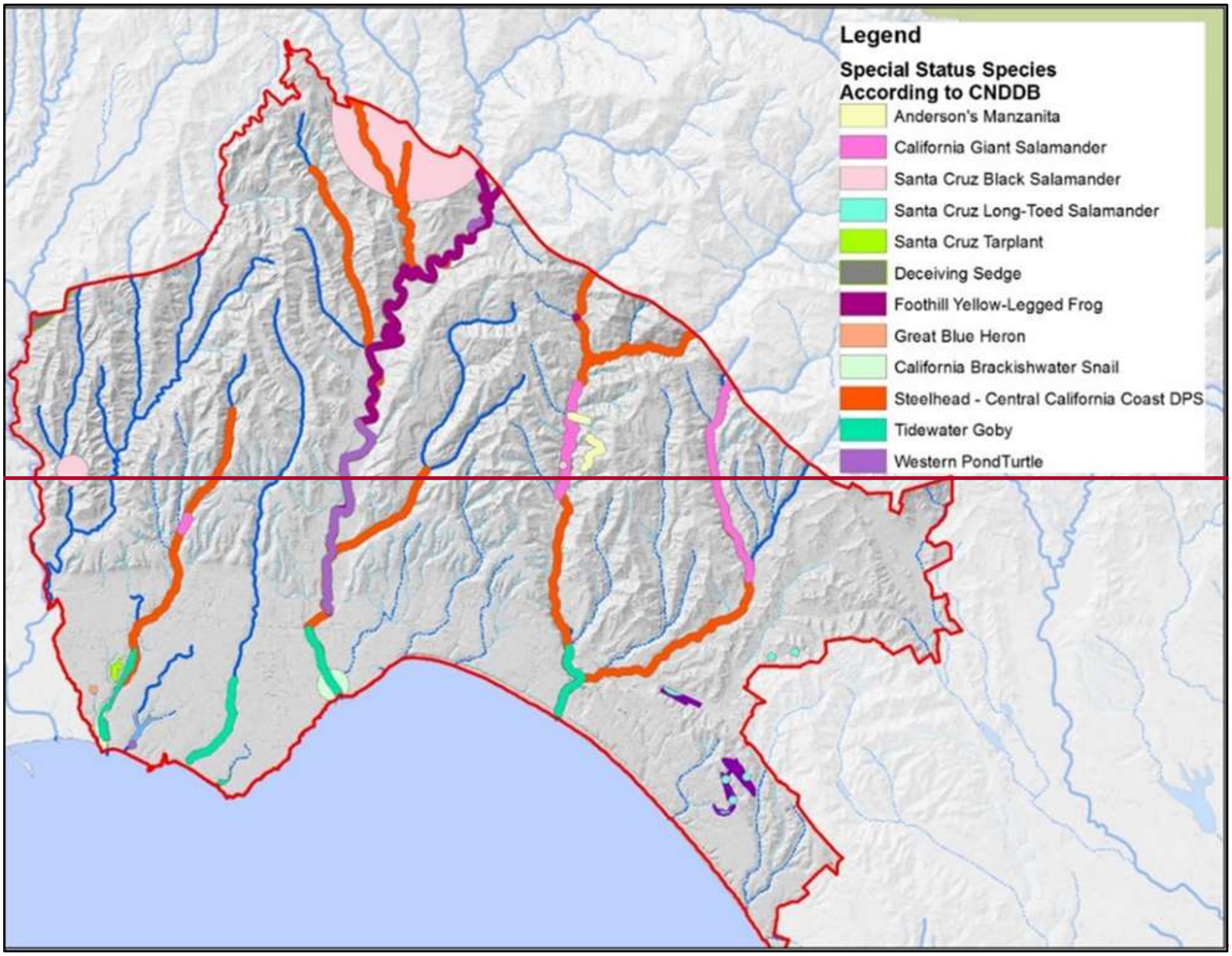


Figure 2-50. Wetland and Vegetation Types according to the Natural Communities Commonly Associated with Groundwater Dataset


Legend
Special Status Species According to CNDDB
Anderson's Manzanita
California Giant Salamander
Santa Cruz Black Salamander
Santa Cruz Long-Toed Salamander
Santa Cruz Tarplant
Deceiving Sedge
Foothill Yellow-Legged Frog
Great Blue Heron
California Brackishwater Snail
Steelhead - Central California Coast DPS
Tidewater Goby
Western PondTurtle

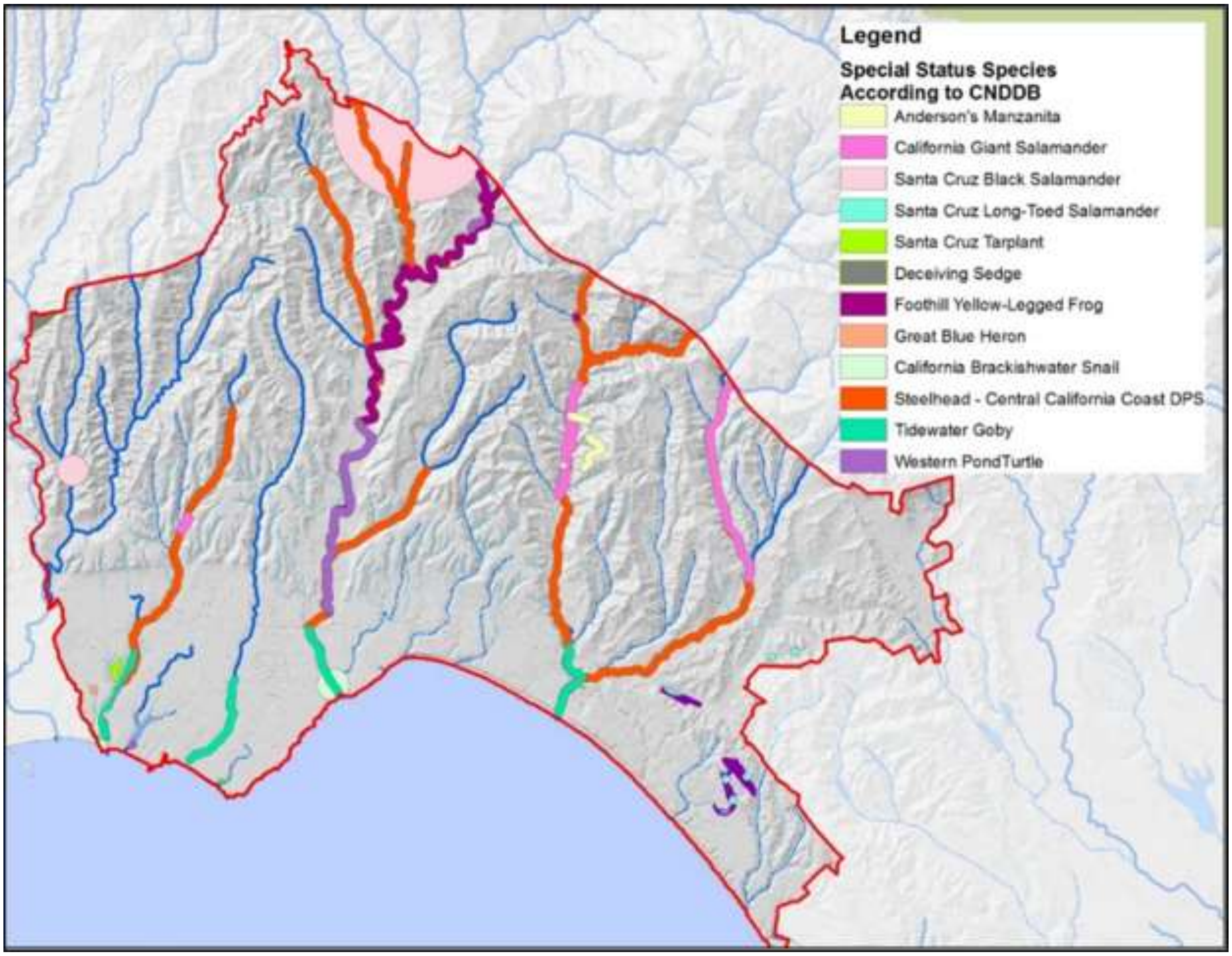


Figure 2-51. Distribution of Species throughout the Santa Cruz Mid-County Basin according to the California Natural Diversity Database~~.~~ [9]

[9] Several streams support multiple species. Note that due to the layering of species on the map, some species that use the entire stream reach.

Table 2-7. All Species Identified using California Natural Diversity Database and National Wetlands Inventory and Considered for Management with Potential for Range inside Basin Boundaries

Species common name	Priority for GDE management	Needs Covered by Priority Species (*), or Not Impacted by Groundwater Management
Steelhead	X	-
Coho Salmon	X	-
Riparian forest including willow and sycamore	X	-
California Brackishwater Snail	-	X
Tidewater Goby	-	X
Wet Meadows	-	X
amprey	-	X*
Santa Cruz Long-Toed Salamander	-	X
Santa Cruz Black Salamander	-	X
Foothill Yellow-Legged Frog	-	X*
California Red-Legged Frog	-	X*
Western Pond Turtle	-	X*
Anderson's Manzanita	-	X
Santa Cruz tarplant	-	X
Deceiving sedge/Santa Cruz Sedge	-	X

Table 2-8. Non-~~salmonid~~Salmonid Aquatic Species Identified in Mid-County Streams during Field Sampling Program, 1996-2017~~.~~

Site	Sample Count	Lamp-Rey	Giant Salamander	Yellow-Legged Frog	Tide-Water Goby	Red-Legged Frog	Western Turtle
SLR-bran-21a1	2	0	0	0	0	0	0
SLR-bran-21a2	15	10	0	0	0	0	0
SLR-bran-21b	10	2	0	0	0	0	0
SLR-bran-21c	5	0	0	0	0	0	0
SOQ-east-13b	4	0	0	1	0	0	0
SOQ-main-1	20	8	0	1	0	0	0
SOQ-main-2	9	1	0	0	0	0	0
SOQ-main-3	7	1	0	1	0	0	0
SOQ-main-4	21	8	1	14	0	0	0
SOQ-main-5	6	0	0	3	0	0	0
SOQ-main-6	9	1	0	3	0	0	0
SOQ-main-7	6	1	0	2	0	0	0
SOQ-main-8	7	1	0	5	0	0	0
SOQ-main-9	10	2	0	3	0	0	0
SOQ-main-10	22	6	2	10	0	0	0
SOQ-main-11	5	1	0	1	0	0	0
SOQ-main-12	21	10	2	11	0	0	0
SOQ-east-13a	22	5	3	9	0	0	0
SOQ-west-19	17	4	3	1	0	0	0
SOQ-west-20	9	0	3	0	0	0	0
SOQ-east-14	10	3	0	5	0	0	0
SOQ-west-21	13	2	9	0	0	0	0
APT-apto-3	13	1	1	0	1	0	0
APT-apto-4	13	1	3	0	0	0	0
APT-vale-2	9	0	0	0	0	0	0
APT-vale-3	9	0	1	0	0	0	0

~~1.~~Note: The Sample Count column indicates the number of times over the sampling period that the site was visited. The other Columns show the number of times

~~2.2.3~~2.2.5 Water Budget

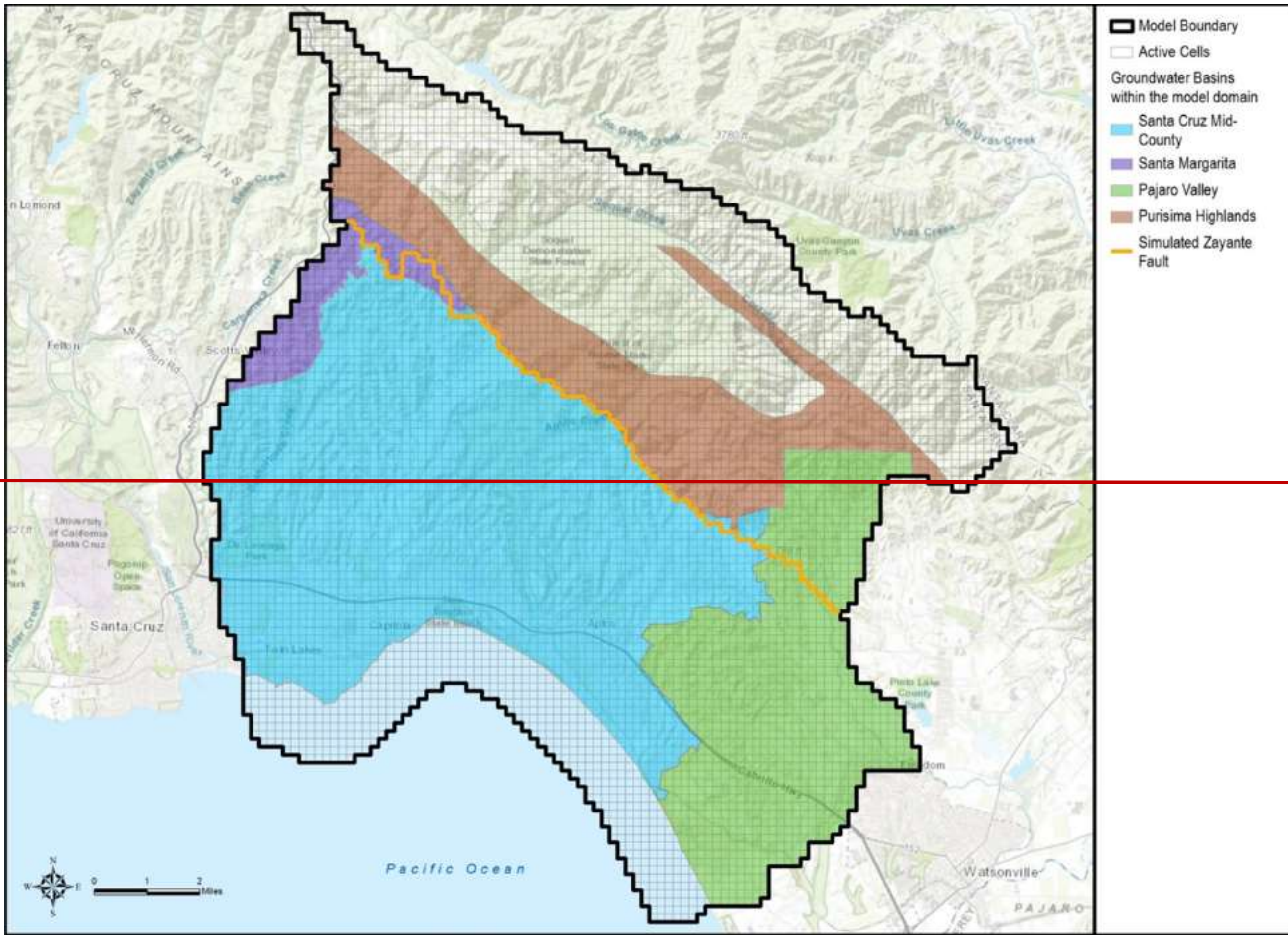
This section summarizes estimated water budgets for the Santa Cruz Mid-County Basin and contains information required by SGMA regulations in addition to other important information required in an effective GSP. According to SGMA Regulations (§354.18), the GSP must include basin-wide water budgets which include an assessment of total annual volume of surface water and groundwater entering and leaving the Basin during historical, current, and future conditions. These water budgets account for the change in the total volume of water stored in the Basin under these conditions.

~~2.2.3.1~~2.2.5.1 Water Budget Data Sources

All water budgets in this section are developed using outputs from the Basin GSFLOW model (model) which simulates basin-wide hydrogeologic and hydrologic conditions. The model is an integrated surface water and groundwater model, utilizing both ~~Precipitation-Runoff Modeling System (~~PRMS~~)~~ and MODFLOW code. PRMS handles watershed flows, MODFLOW simulates subsurface flow, and the MODFLOW Streamflow-Routing (SFR) package simulates streamflow. These components inform the integrated model which simulates both surface water and groundwater hydrology in order to obtain water budgets for the Basin.

The model domain covers the entire Basin area plus portions of the adjacent Santa Margarita Basin, Purisima Highlands Subbasin, and Pajaro Valley Subbasin (Figure 2~~-~~52). The model domain is bound by the Carbonera Creek and Branciforte Creek watersheds in the west and by the Corralitos Creek watershed in the east. The northern model boundary approximately follows Summit Road and Loma Prieta Avenue for about 17 miles along a northwest to southwest alignment that represents the watershed boundary, while the southern model boundary parallels the coastline approximately one mile offshore. The nine model layers simulate major hydrostratigraphic units in the Basin that include both aquifers and aquitards.

~~Figure 2-49. GSFLOW Model Domain~~



The model was calibrated using measured groundwater level data from 121 individual monitoring locations, streamflow data from 11 stream gauges, and potential ET and solar radiation data from two weather stations. Appendix ~~A2-B~~2-F contains the full model calibration report. Water budget components and an indication of if the component is a model input or output are summarized in Table 2-9. If the component is an input, Table 2-9 describes its data source.

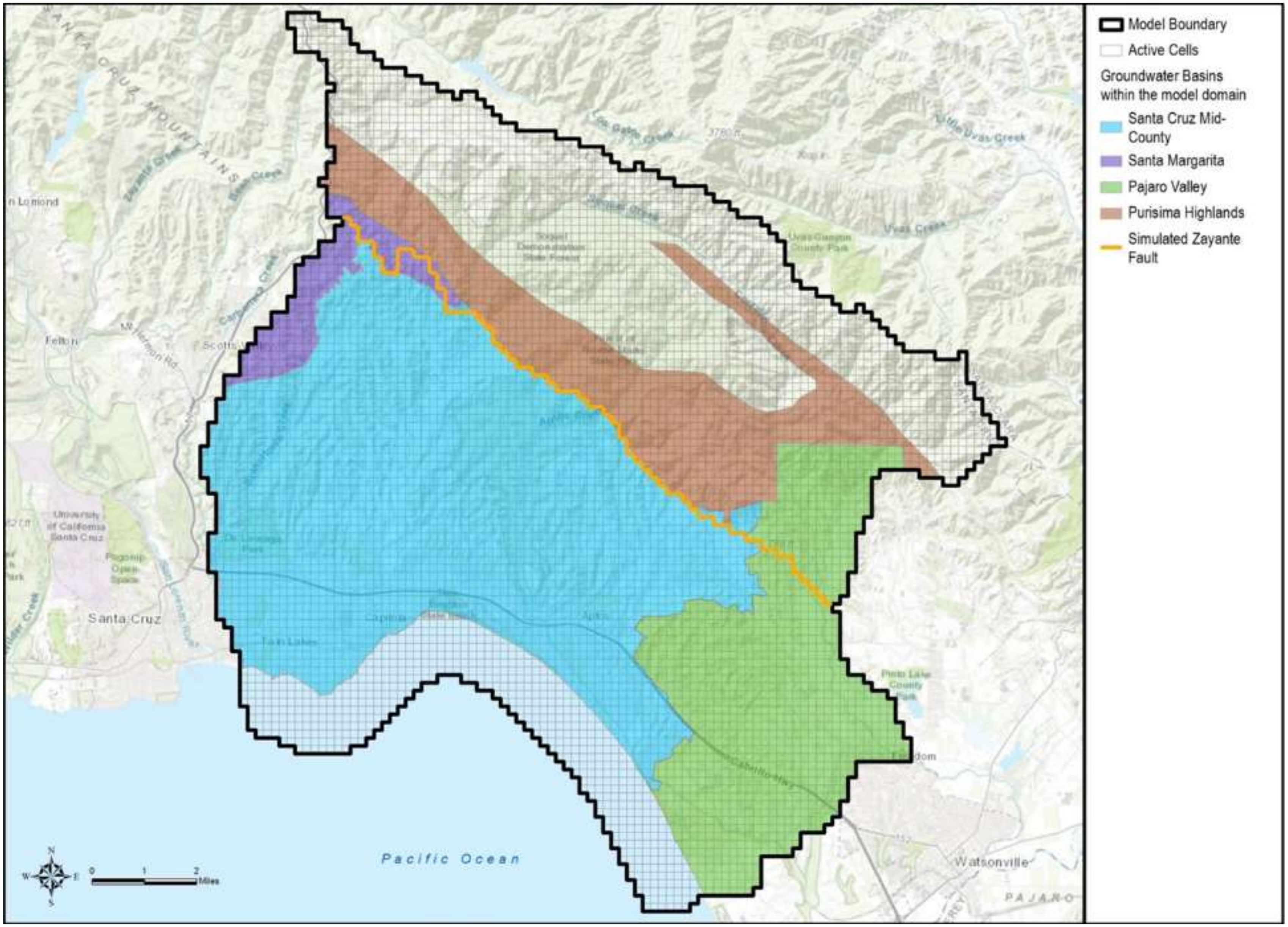


Figure 2-52. GSFLOW Model Domain

Table 2-9. Summary of Water Budget Component Data Sources

Water Budget Component	Source of Model Input Data	Limitations
Precipitation	Measured precipitation spatially distributed for historical simulations; climate catalog precipitation uses same spatial distribution as historical simulations	Spatial precipitation distribution may change with changing climate
Evapotranspiration	Measured and estimated temperature spatially distributed for historical simulations; climate catalog temperature uses same spatial distribution as historical simulations. Simulated from calibration to potential evapotranspiration. Simulated ET includes ET from shallow groundwater lumped together with surface ET	Not simulated from surface water bodies or streamside vegetation
Soil Moisture	Simulated from calibrated model	Not measured but based on calibration of streamflow to available data from gauged creeks
Surface Water Inflows		
Flow from Area Upstream of Basin	Simulated from calibrated model for all creeks	Not all creeks have data for calibration
Groundwater Discharge to Creeks	Simulated from calibrated model	For overall Basin, calibration to streamflow indicated groundwater interactions less significant than watershed characteristics
Overland Runoff	Simulated from calibrated model	Based on calibration of streamflow to available data from gauged creeks
Interflow from Unsaturated Zone	Simulated from calibrated model	Based on calibration of streamflow to available data from gauged creeks
Surface Water Outflows		
Groundwater Discharge	Simulated from calibrated model	Based on calibration of streamflow to available data from gauged creeks
Streambed Recharge to Groundwater	Simulated from calibrated model	Based on calibration of streamflow to available data from gauged creeks
Diversions	Not modeled	Diversions known to exist, but are currently limited in number and small in magnitude
Discharge to Ocean	Simulated from calibrated model	Based on calibration of streamflow to available data from gauged creeks
Groundwater Inflows		
Direct Percolation of Precipitation	Measured precipitation spatially distributed for historical simulations and percolation simulated by watershed component of calibrated model	Assumes percolation applies directly as recharge to water table without delay through unsaturated zone

Water Budget Component	Source of Model Input Data	Limitations
Groundwater Inflows cont.		
Streambed Recharge to Groundwater	Simulated from calibrated model	Shallow groundwater level data are only available for the lower Soquel Creek, therefore only area calibrated for surface water-groundwater interactions. For overall Basin, calibration to streamflow indicated groundwater interactions less significant than watershed characteristics controlling overland/near surface flow to creeks.
Irrigation Return Flows	Estimated from demands based on crop, acreage and temperature	Assumes return flow locations remain the same historically and in the future
Septic System Return Flows	~~Percentage~~Estimated based on percentage of indoor water use for non-sewered parcels	Assumes return flow locations remain the same historically and in the future
Subsurface Inflow (includes onshore flows)	Simulated from calibrated model	Assumes conditions in Santa Margarita Basin and Pajaro Valley Subbasin do not change in the future. Assumes specific amount of sea level rise in the future.
Managed Aquifer Recharge (MAR)	No MAR in historical water budget Used in projected water budget only based on assumed MAR implementation	Based on current plans for MAR that could be revised in future
Groundwater Outflows		
Groundwater Pumping	• Metered for historical municipal pumping and some small water systems • Estimated for ~~private~~non-municipal domestic pumping • Estimated for agricultural and large-scale turf irrigation • All future pumping is estimated	Future pumping based on current estimates for municipal demand. Future ~~private~~ non-municipal domestic pumping based on estimated growth rates higher than latest estimates
Groundwater Discharge to Creeks	Simulated from calibrated model	Groundwater level data from which to calibrated is only available for the lower Soquel Creek, therefore only area calibrated for surface water-groundwater interactions. For overall Basin, calibration to streamflow indicated groundwater interactions less significant than watershed characteristics
Subsurface Outflow to Adjacent Basins	Simulated from calibrated model	Assumes conditions in Santa Margarita Basin and Pajaro Valley Subbasin do not change in the future
Subsurface Outflow to Ocean	Simulated from calibrated model	Assumes specific amount of sea level rise
~~**Surface Water Inflows**~~		
~~Creek Flow Originating Outside of Basin~~	~~Simulated from calibrated model for all creeks~~	~~Not all creeks have data for calibration.~~

~~Groundwater Discharge to Creeks~~	~~Simulated from calibrated model~~	~~For overall Basin, calibration to streamflow indicated groundwater interactions less significant than watershed characteristics~~
~~Overland Runoff~~	~~Simulated from calibrated model~~	~~Based on calibration of streamflow to available data from gauged creeks~~
~~Interflow from Unsaturated Zone~~	~~Simulated from calibrated model~~	~~Based on calibration of streamflow to available data from gauged creeks~~
~~Surface Water Outflows~~		
~~Groundwater Discharge~~	~~Simulated from calibrated model~~	~~Based on calibration of streamflow to available data from gauged creeks~~
~~Streambed Recharge to Groundwater~~	~~Simulated from calibrated model~~	~~Based on calibration of streamflow to available data from gauged creeks~~
~~Diversions~~	~~Not modeled~~	~~Diversions known to exist, but not quantified~~
~~Evapotranspiration~~	~~Simulated from calibrated model~~	~~Based on calibration of potential evapotranspiration~~
~~Discharge to Ocean~~	~~Simulated from calibrated model~~	~~Based on calibration of streamflow to available data from gauged creeks~~

~~2.2.3.2~~2.2.5.2 Model Assumptions and Uncertainty Related to the Water Budget

All groundwater models contain assumptions and some level of uncertainty, particularly when predicting future conditions. Model uncertainty stems from heterogeneity in Basin geology, hydrology, and climate. However, inputs to the model are carefully selected using best available data, resulting in a model well suited to predict Basin hydrogeologic conditions. As GSP implementation proceeds, the model will be updated and recalibrated with new data to better inform model simulations of current and projected water budgets. Specific assumptions implemented when modeling future conditions are discussed in Section 2.2.5.6.1.

The model calibration ~~memo~~report (Appendix ~~A2-B~~2-F) discusses all model assumptions and uncertainty. The assumptions that cause the greatest uncertainty with respect to the ~~results from the~~ water budget are:

- Shallow monitoring wells are only available along one stretch of lower Soquel Creek. Calibration of the interaction of Soquel Creek with alluvium and the underlying Purisima A aquifer unit is based on the groundwater level data from a few wells. The remainder of the model area does not have the benefit of measured data from which to calibrate the model and therefore the simulation of shallow groundwater and stream-aquifer interaction is much more uncertain than in areas with shallow monitoring wells.

- Even where shallow groundwater level data are available, data quantifying flows between the stream and shallow groundwater are not available for calibration so there is high uncertainty of the magnitude of simulated flows between stream and aquifer calculated by the model.

- There is much less data for calibration north of the Aptos ~~Fault~~area faulting than south of ~~the Aptos Fault~~it where the vast majority of wells with groundwater level data are. As a result there is greater uncertainty in the water budget north of the Aptos ~~Fault~~area faulting than south of ~~the Aptos Fault~~it.

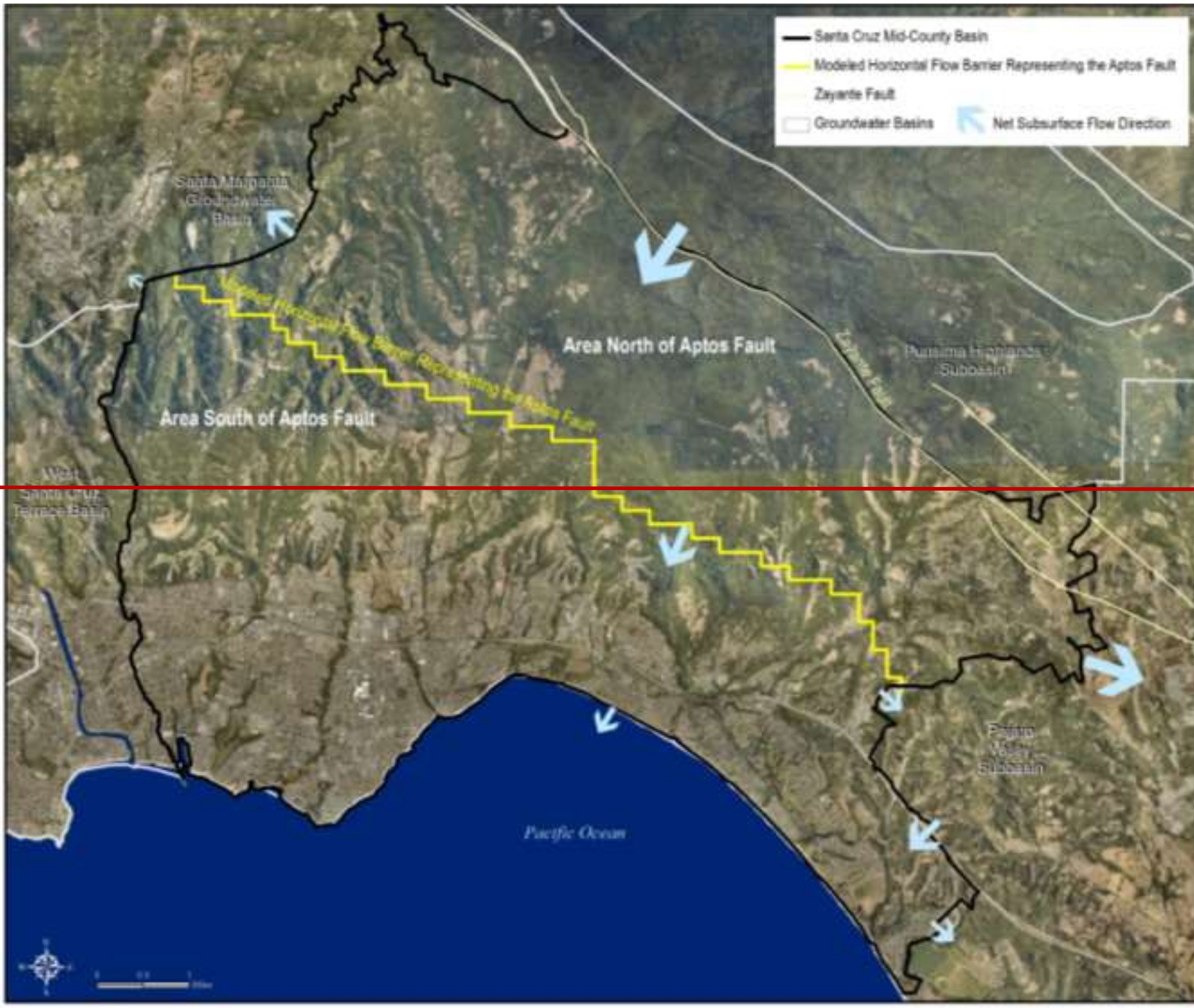
- Model construction combines the Purisima F and DEF aquifer units into one model layer so there is greater uncertainty for ~~calculations~~estimates of changes of groundwater in storage where the Purisima DEF aquifer unit is pumped. Pumping in this area is from the confined Purisima DEF aquifer unit but the model simulates combined Purisima DEF/F units as unconfined so inaccurately uses higher specific yield values for change in storage instead of specific storage.

~~2.2.3.3~~2.2.5.3 Water Budget Components

This subsection describes the different components of the Basin water budget inflows and outflows for both surface water and groundwater. Sustainable management criteria described in Section 3 are sometimes aquifer specific and so for management purposes it is important to break up the water budget by aquifer. ~~All~~Most of the different ~~aquifers~~aquifer units within the Basin are modeled as separate layers in the model and therefore the water budget can be broken down by model layer/aquifer. This additional functionality provides MGA with increased knowledge and operation flexibility for managing aquifers separately in order to achieve sustainability.

The groundwater budgets account for all flows entering and leaving the primary aquifers in the Basin. This includes subsurface inflows and outflows, pumping, and all forms of natural and managed aquifer recharge. Similarly the surface water budgets account for surface flows entering and leaving the ~~basin~~Basin, precipitation and evapotranspiration, and groundwater recharge through stream alluvium. For both surface water and groundwater, the change in storage is simply the difference between all inflows and outflows.

While basin-wide water budgets are required per SGMA regulations, subarea water budgets are also provided for areas north and south of the Aptos ~~Fault~~area faulting (Figure 2-53). South of the Aptos ~~Fault~~area faulting is where the majority of groundwater extraction, including all municipal extraction, takes place. A water budget south of the Aptos ~~Fault~~area faulting is also more instructive for evaluating seawater intrusion, which is the sustainability indicator that has driven designation of the Basin as being critical overdrafted. The area north of the Aptos ~~Fault~~area faulting only has ~~private~~non-municipal domestic and agricultural groundwater pumping and has a water budget more influenced by inter-basin flow.



Rainfall is the source of almost all water that becomes either surface water or groundwater in the Basin. The PRMS portion of the GSFLOW model distributes rainfall across the Basin's watersheds based on DAYMET mean annual rainfall distribution. Appendix 2-F provides details of the approach used to input rainfall into the model. Rainfall that falls in the Basin's watersheds is either evapotransported, flows overland and into streams, percolates into the subsurface and becomes groundwater recharge, or remains in the soil zone as soil moisture. Within the surface water inflow budget subsections below, an accounting of how rainfall is apportioned within the Basin is provided in the beginning of the discussion.

Evapotranspiration is calculated by the GSFLOW model based on calibration to potential evapotranspiration. Evapotranspiration includes water that never percolates to groundwater and groundwater that rises into the unsaturated soil zone. A small amount of water that is not used by evapotranspiration, and has not yet become surface water or groundwater is stored in the unsaturated soil zone as soil moisture.

Figure 2-53. Groundwater Budget Subareas

2.2.5.3.1 Surface Water Inflows

Surface water flows enter from across the northern Basin boundary. Creeks that have their headwaters upstream of the Basin include: Granite Creek, Branciforte Creek, West Branch of Soquel Creek, Soquel Creek, Hester Creek, Hinkley Creek, Bridge Creek, Aptos Creek, and Valencia Creek. There are no gauges at the Basin boundary and therefore inflows are simulated using the model, which encompasses the entire watershed of the Basin and is calibrated to measured flows at gauges within the Basin.

Apart from creek flows from outside the Basin, overland runoff into the creeks and groundwater discharge are additional sources of surface water inflows. These are simulated by the model using surface processes that are calibrated to measured flows at USGS gauges within the model domain.

Groundwater

~~2.2.3.3.1~~2.2.5.3.2 ~~Groundwater~~ Inflows

Groundwater enters the Basin's aquifers by: subsurface inflow, direct percolation of precipitation, streambed recharge, irrigation return flows, septic system return flows, and managed aquifer recharge in simulations of future ~~basin~~Basin conditions.

Substantial subsurface inflow enters the Basin from the Purisima Highlands Subbasin along the northern Basin boundary and from the Pajaro Valley Subbasin, south of the Aptos ~~Fault~~area faulting (Figure 2-53). There are lesser subsurface inflows across the Basin boundary from the Santa Margarita Basin, however, the net flow is an outflow to the Santa Margarita Basin (Figure 2-53). There are places along the coast where subsurface flows moving onshore from beneath the ocean occur, however over the entire coastal boundary net flows are outflows (Figure 2-53).

Aquifer recharge occurs from precipitation percolating directly into outcropping aquifers, streambed recharge, and recharge from precipitation percolating through stream alluvium and terrace deposits to underlying aquifers. Recharge also occurs due to percolation of irrigation and septic system return flows. In the model, areal recharge from direct percolation of precipitation is calculated using PRMS code for watershed processes while return flows from irrigation and septic systems are input using the MODFLOW Unsaturated Zone Flow (UZF) modeling package. The recharge from direct percolation of precipitation and return flows are then grouped together by MODFLOW using the UZF package. Therefore, the water budget groups these groundwater budget components together and refers to it as UZF recharge.

~~2.2.3.3.2~~2.1.1.1.1 Surface Water ~~Inflows~~

~~Surface water flows enter from across the northern Basin boundary. Creeks that have their headwaters north of the Basin include: Granite Creek, Branciforte Creek, West Branch of Soquel Creek, Soquel Creek, Hester Creek, Hinkley Creek, Bridge Creek, Aptos Creek, and Valencia Creek. There are no gauges at the Basin boundary and therefore inflows are simulated using the model, which encompasses the entire watershed of the Basin and is calibrated to measured flows at gauges within the Basin.~~

~~Apart from creek flows from outside the Basin, overland runoff into the creeks and groundwater discharge are additional sources of surface water inflows. These are simulated by the model using surface processes that are calibrated to measured flows at USGS gauges within the model domain.~~

~~2.2.3.3.3~~2.1.1.1.1 ~~Groundwater Outflows~~

~~Groundwater leaves the Basin by: subsurface outflows, groundwater pumping, and discharge to creeks. Relatively large subsurface outflows occur to the Pajaro Valley Subbasin north of the Aptos Fault, while lesser outflows into the Santa Margarita Basin occur depending on hydrologic conditions (Figure 2-50). Outflows offshore, which are necessary to prevent seawater intrusion, occur along the coastal basin boundary (Figure 2-50). Additional groundwater leaves the Basin when extracted by municipal, domestic, industrial, and agricultural users.~~

~~2.2.3.3.4~~2.2.5.3.3 ~~Surface Water~~ Outflows

Surface water outflows from the Basin are primarily to the ocean and through streambeds to underlying aquifers. There are some surface water diversions that take place for domestic use, irrigation, or stock watering but these are not included in the model and water budget because records are poor and there are likely some illegal diversions that are difficult to account for. The number of current observed diversions is relatively low. For modeling purposes, all rural water use in the Basin is assumed to come from groundwater extraction, even though a very small portion may actually be supplied by surface water diversions. A small amount of Basin surface flows out of the Basin in Branciforte Creek and then out to the Pacific Ocean.

2.2.5.3.4 Groundwater Outflows

Groundwater leaves the Basin by: subsurface outflows, groundwater pumping, and discharge to creeks. Relatively large subsurface outflows occur to the Pajaro Valley Subbasin north of the Aptos area faulting, while lesser outflows into the Santa Margarita Basin occur depending on hydrologic conditions (Figure 2-53). Outflows offshore, which are necessary to prevent seawater intrusion, occur along the coastal Basin boundary (Figure 2-53). Additional groundwater leaves the Basin when extracted by municipal, domestic, industrial, and agricultural users.

~~2.2.3.3.5~~2.2.5.3.5 Change in Groundwater in Storage

The change in groundwater in storage is the difference between groundwater inflows and outflows. Because the model is used to estimate change in storage, estimates can be made for each aquifer. Unconfined aquifers have volumetric changes in storage orders of magnitude greater than confined aquifers because they have much greater specific yields and are not under pressure as confined aquifers are. The water budgets provided below include inflows, outflows, and changes in storage by aquifer and for the ~~basin~~Basin as a whole.

~~2.2.3.4~~2.2.5.4 Historical Water Budget

According to the SGMA regulations (§354.18), the historical water budget included in the GSP must be created based on at least 10 years of recent historical data. The 31-year historical time period from 1985 - 2015 used for the historical water budget corresponds with the period selected for the model. The model period started in 1985 because groundwater extraction and groundwater levels data are available for the majority of the Basin from 1985 onwards. The average rainfall from 1985 – 2015 of 29 inches per year is almost the same as the long-term 1894 – 2015 average rainfall of 29.1 inches per year, and thus is a good representation of long-term historical climate.

~~2.2.3.4.1~~2.2.5.4.1 Santa Cruz Mid-County Basin Historical Surface Water Budget

Over the historical period, annual precipitation at the Santa Cruz Co-op station was between approximately 16 inches and 65 inches (1990 and 1998, respectively). On average in the historical model simulation, 66% of precipitation that falls in the Basin is evaporated or transpired without reaching a surface water body. Evapotranspiration includes water that never percolates to groundwater and groundwater that rises to the soil zone. Twenty six percent becomes overland flow that eventually enters streams and creeks within the Basin. Five percent of precipitation is simulated to percolate beyond the root zone and enter the underlying aquifer as UZF recharge, terrace deposits recharge, or stream alluvium recharge. The remaining portion (3%) reflects the net change in soil moisture stored in the soil layers overlying the Basin. In most years the soil moisture value is negative, reflecting gaining soil moisture conditions. However, in some years this value is positive, reflecting a loss of moisture in the soil zone. Typically, this occurs during relatively dry years following a wet period, as evapotranspiration (ET) occurs from the soil zone during the drier year. The model simulated apportionment of precipitation in the Basin is tabulated in Table 2-10, and presented graphically on Figure 2-54.

Table 2-10. Percentage Distribution of Historical Precipitation in Santa Cruz Mid-County Basin

Precipitation Budget Component	Average Annual (acre-feet)	Average Percent of Precipitation
Precipitation	96,200	100%
Evapotranspiration	63,650	66%
Overland Flow	25,320	26%
Groundwater Recharge from Precipitation	4,810	5%
Soil Moisture	2,420	3%

Approximately 55% of inflow to the Basin's surface water system occurs due to overland flow entering streams and rivers within the Basin. Another relatively large portion (43%) enters the Basin from areas upstream of the Basin. Primary surface water features which have this inflow include Soquel Creek, Hester Creek, Hinckley Creek, and Aptos Creek. The remaining 2% of inflow to the Basin's surface water system is net inflow from groundwater to streams.

Surface water outflows from the Basin are dominated by flows to ocean (89%). Nine percent leaves the Basin via Carbonera Creek, which flows into Branciforte Creek after it leaves the Basin and then flows into the Pacific Ocean. The remaining 11% of surface water outflows comprises flows to areas downstream of the Basin. The historical surface water system water budget is summarized in Table 2-11 and shown on an annual bar chart as Figure 2-55.

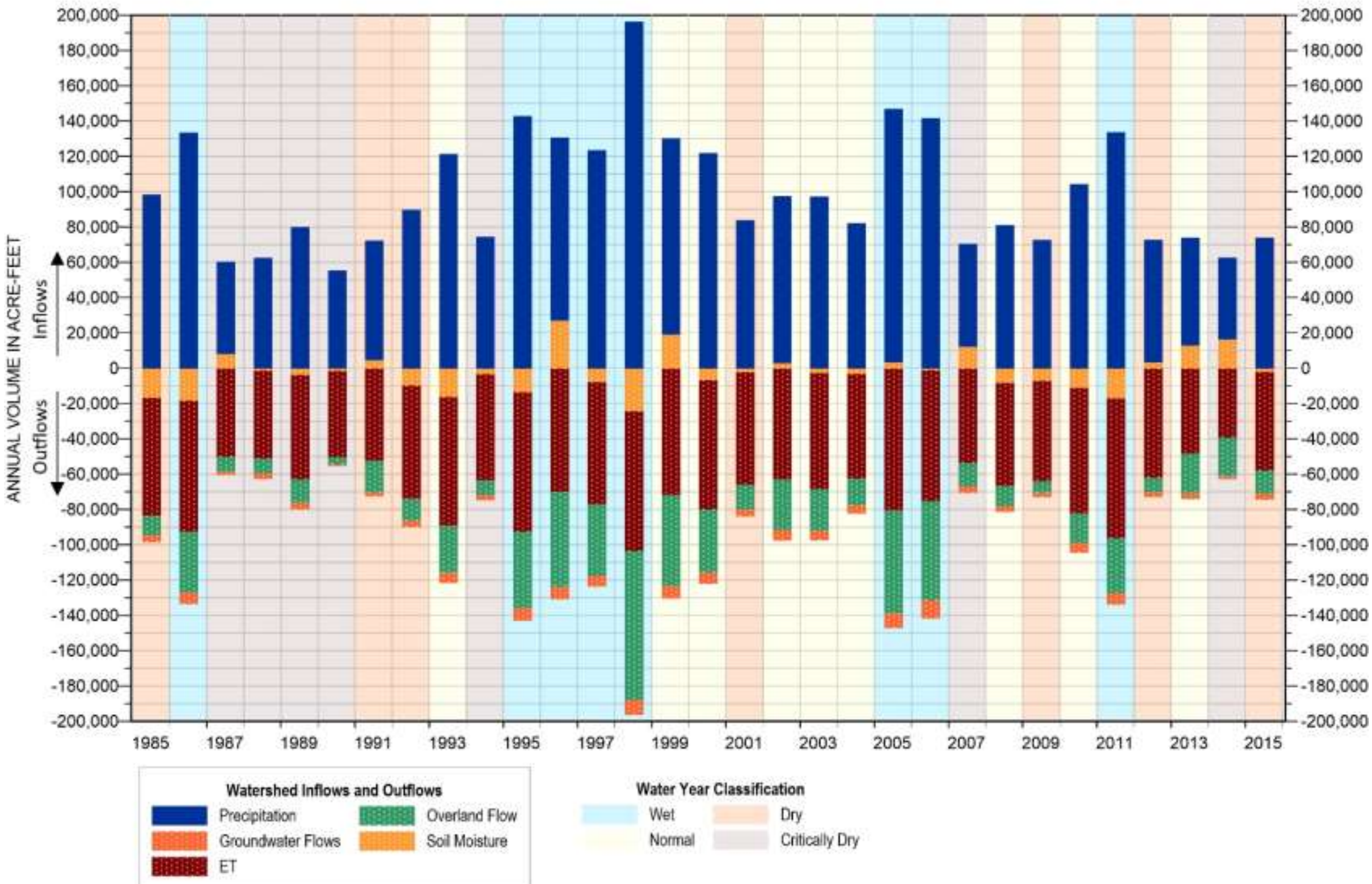


Figure 2-54. Apportionment of Precipitation in Santa Cruz Mid-County Basin Over the Historical Period

Table 2-11. Santa Cruz Mid-County Basin Historical Surface Water Budget

Surface Water Budget Component	Annual Minimum	Annual Maximum	Annual Average	Average % (rounded)
Inflows (acre-feet per year)				
Overland Flow	4,080	84,280	25,320	55%
Flows from Upstream of the Basin	2,540	59,920	19,690	43%
Net Flows From Groundwater	680	900	790	2%
		Total Inflow	**45,800**	100%
Outflows (acre-feet per year)				
Ocean Outflow	6,840	119,890	41,000	89%
Outflow in Branciforte Creek	400	16,840	4,120	9%
Pajaro Valley Subbasin	10	2,860	460	1%
Outflow to Carbonera Creek	20	970	220	<1%
		Total Outflow	**45,800**	100%

Note: ‘Groundwater Flows’ refers to flow between streams and underlying alluvium, and is distinct from ‘Stream Alluvium Recharge’ seen in groundwater budgets.

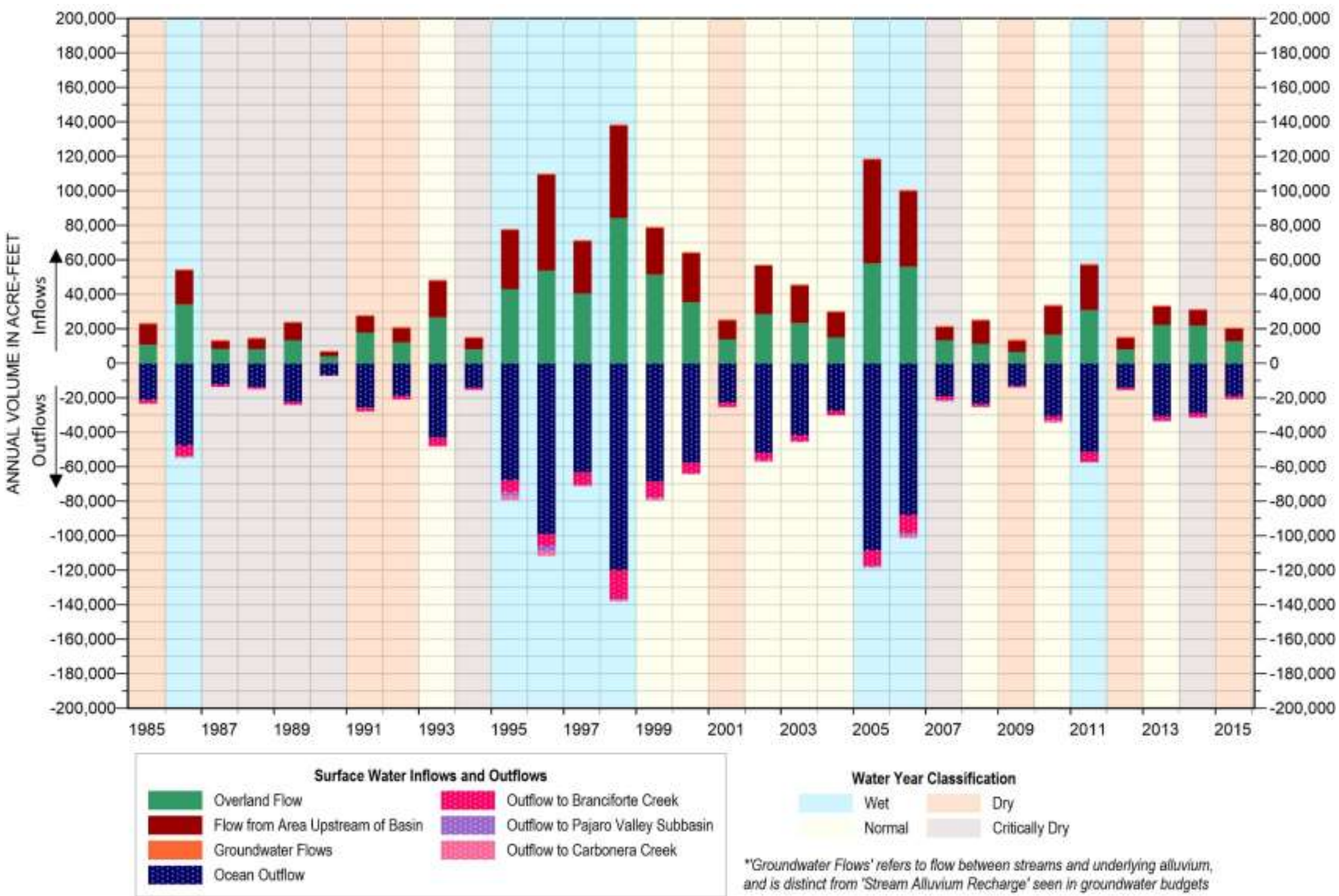


Figure 2-55. Santa Cruz Mid-County Basin Historical Surface Water Budget

During an average year, approximately 45,800 acre-feet of water flows into the Basin's surface water system. An example of the range in surface water inflows is shown on Figure 2-55 where in 1998, at the height of a four-year wet period, almost 140,000 acre-feet flowed into the Basin; while during the peak of the dry period from 1987-1990, surface water inflow was only 6,570 acre-feet .

Surface water within the Basin is not used extensively for water supply purposes. There are surface water diversions for minor domestic use, irrigation, or stock watering but these are not always reported. The most important aspect of the surface water budget from a water management perspective is its connection to groundwater, as ~~there are~~ groundwater dependent ecosystems that ~~rely on~~ could be impacted by surface water depletion by groundwater~~-fed baseflow. Inflows and outflows from~~ use do occur in the Basin. Net groundwater flows into surface water are estimated to ~~creeks and streams are included in the~~ be a small component of the overall surface water budget but those flows could still be critical to groundwater ~~budgets and separate surface water budgets are~~dependent ecosystems. The magnitude of estimated flows between surface water and groundwater is highly uncertain due to the limited shallow groundwater data available and lack of data quantifying interconnected flows. Therefore, sustainability management criteria should not ~~described for~~be based on the ~~rest of this section.~~estimated flow values.

The Basin is divided by three watersheds. In the east, the Soquel Creek watershed stretches over half of the Basin, from just east of Cabrillo College to the Basin's western boundary. This watershed includes the Rodeo Gulch, Arana and Branciforte Creek sub-watersheds, even though they do not actually drain into Soquel Creek. The Aptos Creek watershed covers the majority of the remaining portion of the Basin, while the Corralitos watershed overlies a relatively small area in the east (Figure 2-56). Surface water budgets for the Basin's three watersheds are provided on Figure 2-57, Figure 2-58, and Figure 2-59.

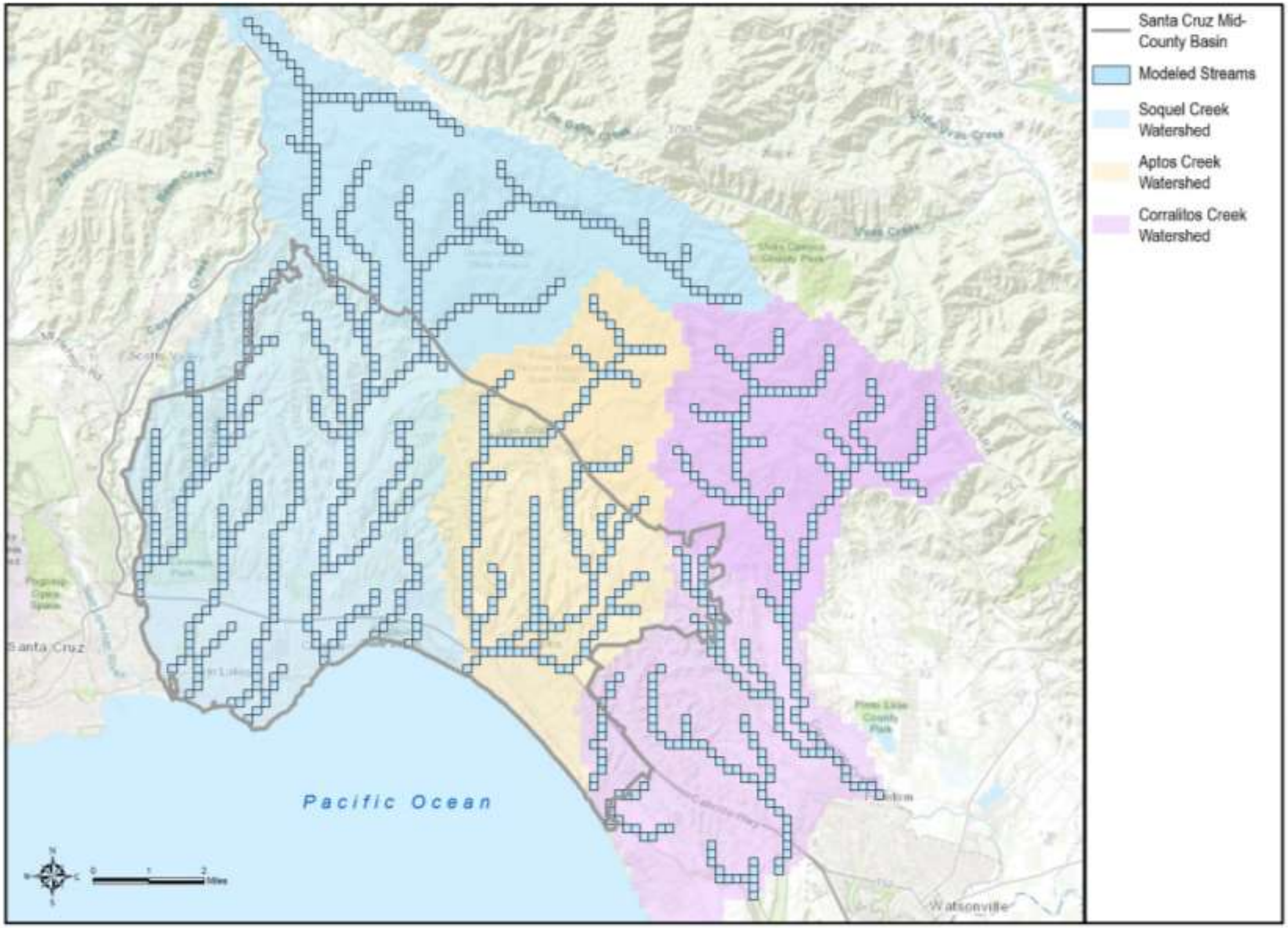


Figure 2-56. Santa Cruz Mid-County Basin Watersheds

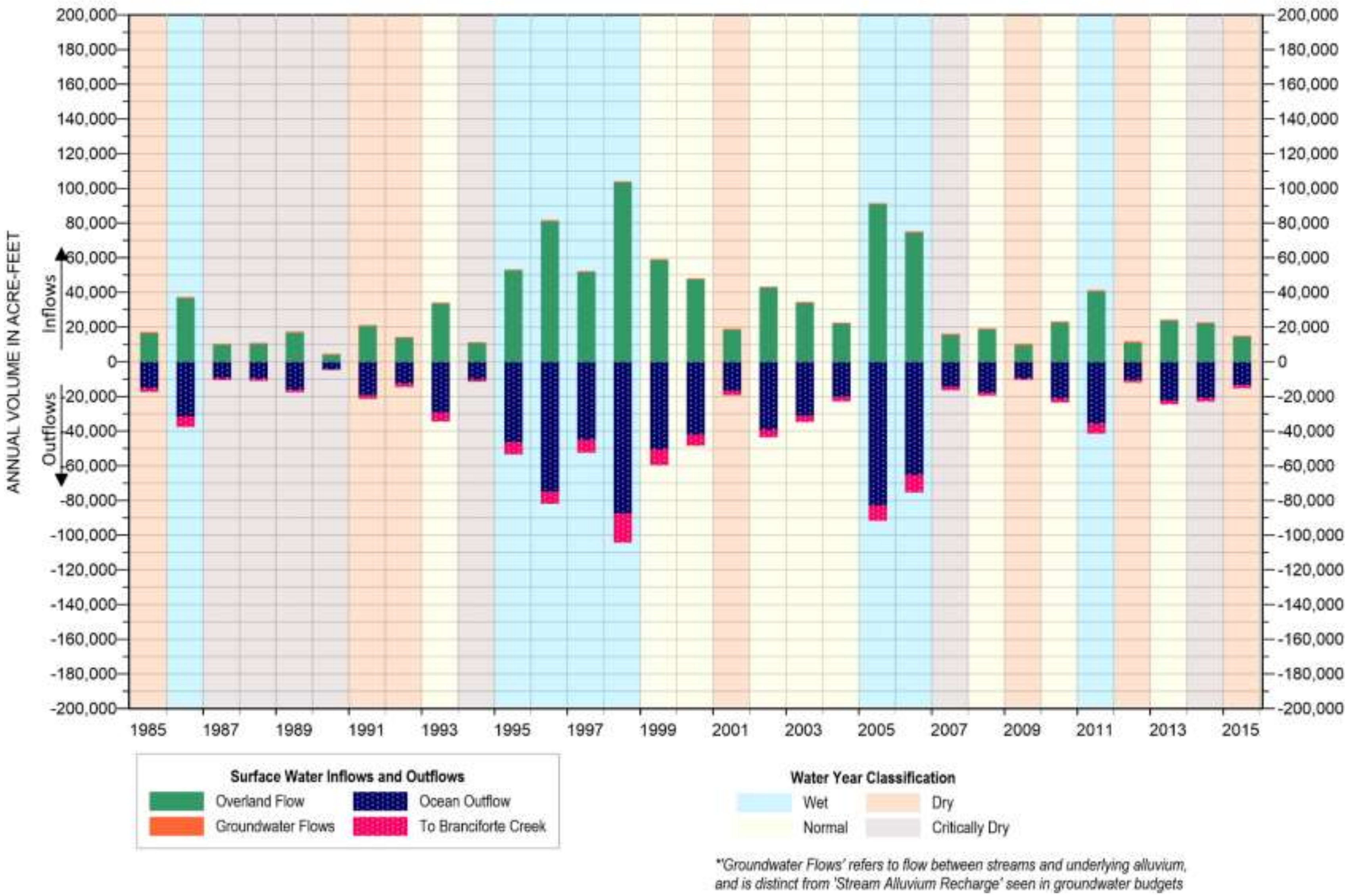


Figure 2-57. Soquel Creek Watershed Historical Budget

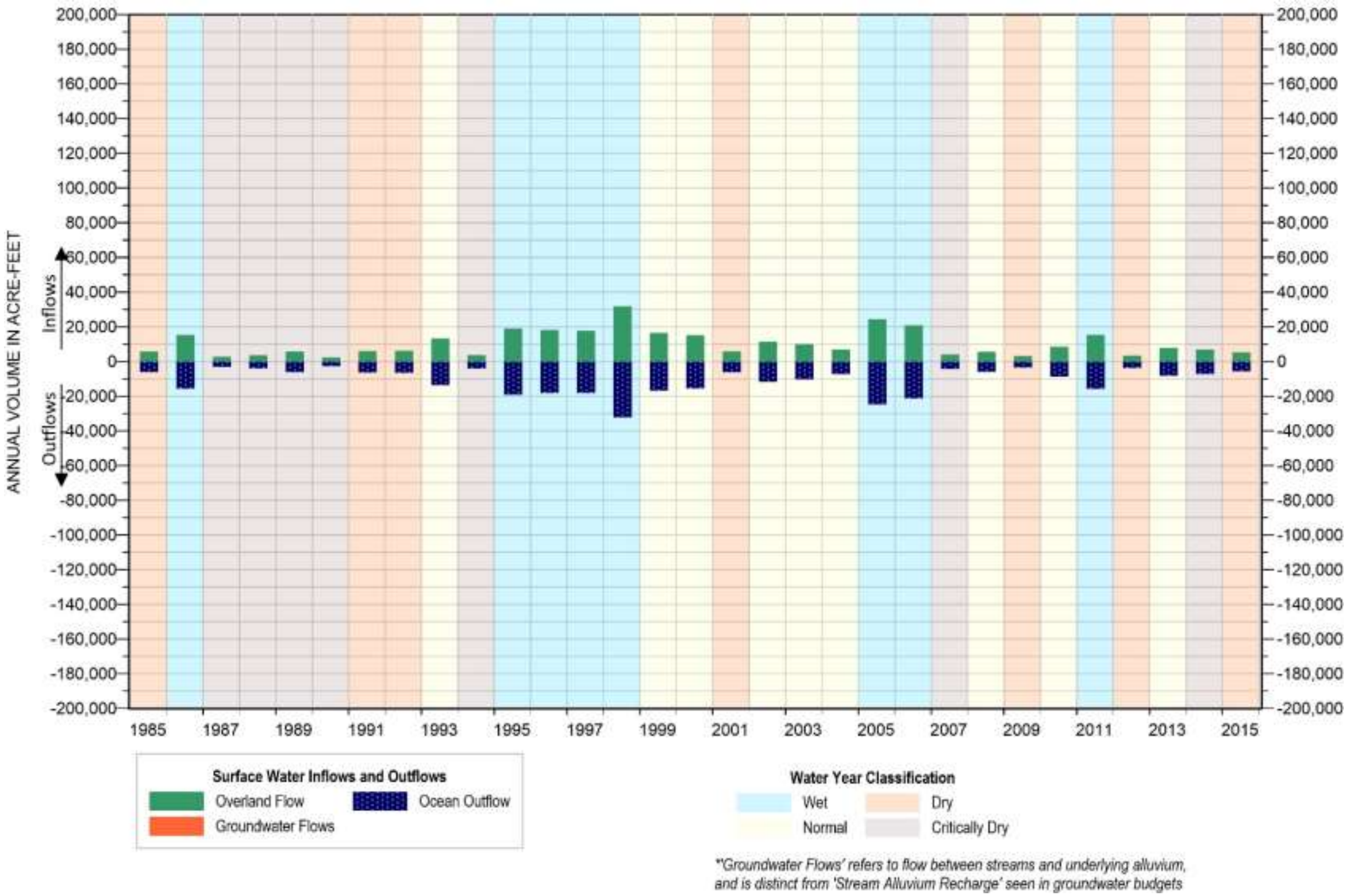


Figure 2-58. Aptos Creek Watershed Historical Budget

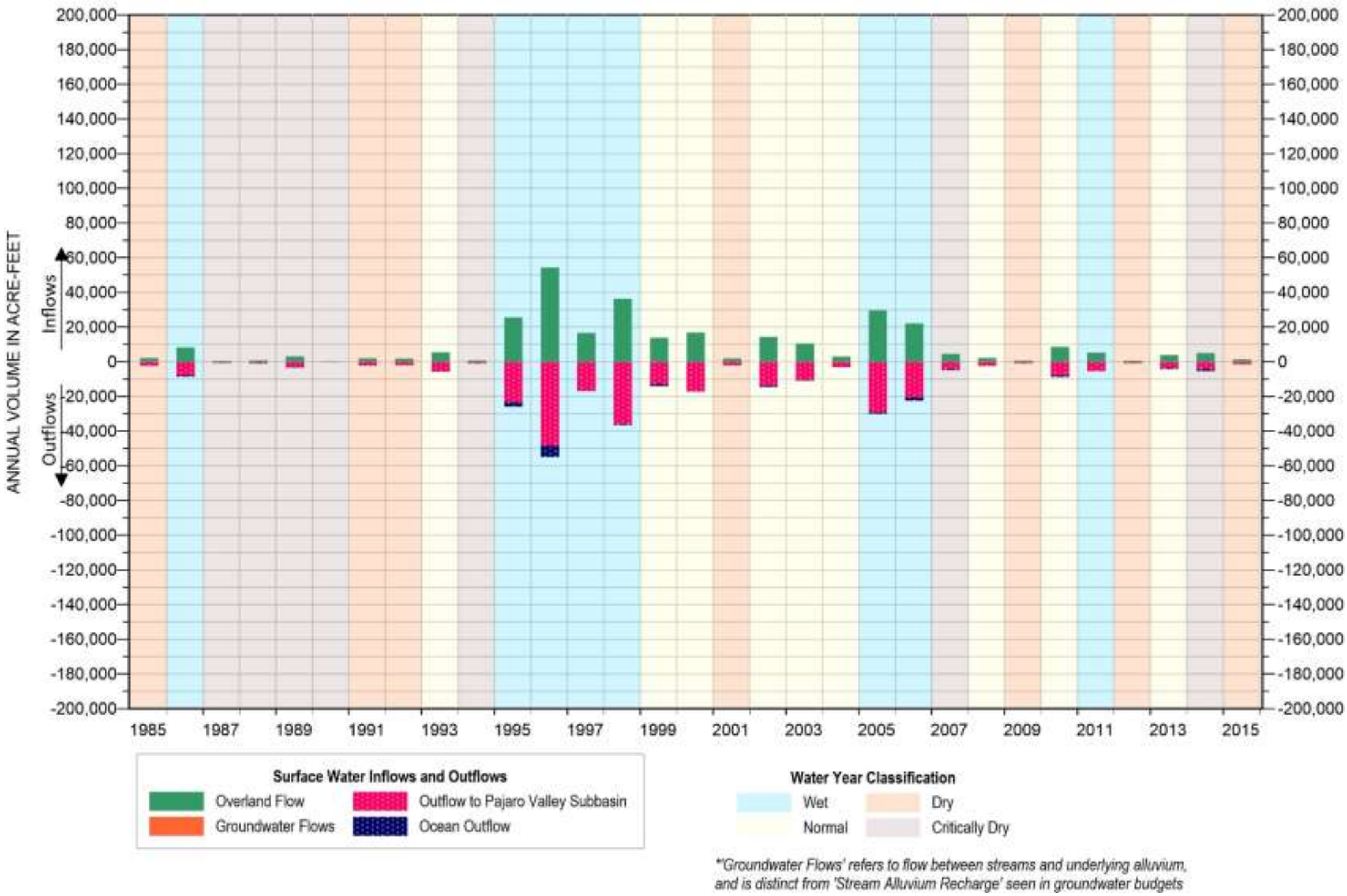


Figure 2-59. Corralitos Creek Watershed Historical Budget

~~2.2.3.4.2~~2.2.5.4.2 Santa Cruz Mid-County Basin Historical Groundwater Water Budget

Approximately 60% of Basin groundwater inflow during the historical period comes from surface recharge: UZF recharge (direct percolation of precipitation and return flows) constitutes 34%, while recharge from stream alluvium and terrace deposits contribute 10% and 16%, respectively (Table 2-12). The rest of Basin inflows are fairly consistent subsurface flows across the northern Basin boundary from the Purisima Highlands Subbasin (40% of inflows). Those inflow components that rely on rainfall (UZF recharge and recharge from stream alluvium and terrace deposits) are the most variable due to prolonged wet or dry climatic cycles, as described below.

Table 2-12. Santa Cruz Mid-County Basin Historical Groundwater Budget Summary (1985 – 2015)

Groundwater Budget Component	Annual Minimum	Annual Maximum	Annual Average	Average % (rounded)
Inflows (acre-feet per year)				
UZF Recharge	1,550	7,840	4,460	34%
Net Recharge from Stream Alluvium	780	2,130	1,260	10%
Recharge from Terrace Deposits	1,490	3,340	2,080	16%
Subsurface Inflow from Purisima Highlands Basin	4,940	5,570	5,270	40%
		Total Inflow	**13,070**	**100%**
Outflows (acre-feet per year)				
Pumping	5,260	8,460	7,410	59%
Subsurface Outflow to Santa Margarita Subbasin	260	390	310	3%
Net Subsurface Outflow to Pajaro Valley Subbasin	3,770	4,370	4,080	32%
Net Outflow to Offshore	150	1,060	790	6%
		Total Outflow	**12,590**	**100%**
Change in Storage (acre-feet per year)	**Cumulative**		**Average**	
	+14,910 acre-feet		+480	

Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage

Primary groundwater outflows during the historical period are groundwater pumping and subsurface flow to Pajaro Valley Subbasin, which are 59% and 33% of total outflows, respectively (Table 2-12). The remaining 9% of Basin outflow consists of flows offshore (6%) and subsurface flows to Santa Margarita Subbasin (3%).

Historically, the Basin experienced net recharge from stream alluvium to the primary aquifers and aquitards of the Basin (Table 2-12). There are locations where groundwater in stream alluvium discharges to streams but overall there is ~~more~~also net recharge from stream alluvium to the primary aquifers of the Basin. ~~The factors that influence this include 1) there are limited~~ Net recharge from stream alluvium occurs even where the stream alluvium discharges groundwater ~~discharges~~ to streams ~~in the western portion of the Basin where the Aromas Red Sands occurs (Figure 2-9)~~ because ~~it is highly permeable,~~ groundwater levels ~~are well below~~

~~streams, and thus surface water is not connected to groundwater, and 2) the historical period includes the time when~~in the stream alluvium are generally higher than groundwater levels in ~~the Basin were at historic lows which may have caused greater~~underlying aquifers. Therefore net recharge from stream alluvium~~.~~ does not necessarily mean the stream is recharging groundwater in that area.

Over the historical period, there is a Basin-wide average increase in groundwater in storage of approximately ~~481~~480 acre-feet per year, or 14,910 acre-feet cumulatively (Table 2-12). The cumulative change in storage line (dashed) on

Figure 2-60 shows three distinct cumulative change in storage trends:

- From 1985 to 1994 (10 years) basin-wide pumping in excess of 7,930 acre-feet per year and an extended dry climate which limited recharge contributed to a cumulative decline in groundwater in storage of about 8,000 acre-feet (an average decrease of 800 acre-feet per year) which corresponds to declining groundwater levels in the area of municipal production.

- The years from 1995 through 2006 had a cumulative increase of groundwater in storage of approximately ~~27~~28,000 acre-feet (an average increase of 2,~~077~~300 acre-feet per year). This ~~13~~12-year period only has one year classified as a dry water year, with all the other years being either normal or wet. Notably, the period starts and ends with wet years: four consecutive wet years from 1995 through 1998 and two wet years in 2005 and 2006 (

- Figure 2-60). Because of the normal to wet climatic conditions, surface recharge increased thereby causing an increase in groundwater in storage.

- From 2007 through 2015 (nine years), there are only three years of normal or wet water years, which resulted in less groundwater recharge than occurred in the prior ~~13~~12 years (

- Figure 2-60). Even though this period has below normal rainfall, there has only been a cumulative loss of 4,000 acre-feet (or an average of ~~444~~440 acre-feet per year) in groundwater in storage because from 2005 onwards, municipal groundwater pumping is on average 10% less compared to the average pumping from 1985 – 1994. ~~This~~Reduction in groundwater pumping was achieved through focused water conservation measures and responsive groundwater management.

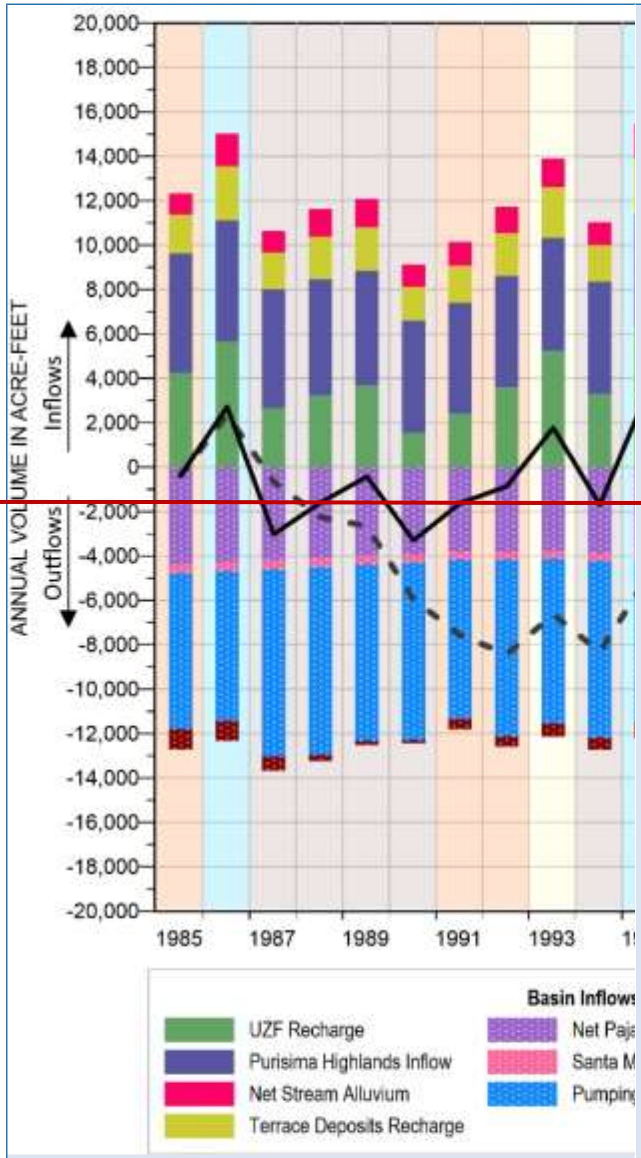
Overall, the Basin's historical groundwater budget consists of inflows from surface recharge and subsurface inflows from the Purisima Highlands Subbasin. Outflows are primarily from groundwater extraction and outflow to the Pajaro Valley. Over the 31 years of the historical water budget period, there has been an overall increase in groundwater in storage. This overview does not reflect the groundwater budgets of specific aquifers, some of which may still have overall losses of groundwater in storage and therefore cause undesirable results such as seawater intrusion. Table 2-13 provides a summary of the historical groundwater budget by aquifer and annual groundwater budgets for individual aquifers are contained in Appendix ~~A2-B~~2-F.

Flows between the Basin and the ocean (offshore) are an important component of the water budget for evaluating groundwater sustainability because seawater intrusion is the sustainability indicator that is the basis for the Basin's overdraft condition. Figure 2-61 plots each aquifer's offshore inflows and outflows. Net outflows (negative on the water budget chart on Figure 2-61) of some magnitude is required to prevent seawater intrusion. Net inflows (positive on the water budget chart on Figure 2-61) are indicative of flow conditions that will eventually result in seawater intrusion. Inflows from offshore consistently occur in the Purisima DEF/F and Purisima A aquifer units. These are the aquifers where seawater intrusion is occurring. The Tu aquifer has small volumes of inflow from offshore, which reverses to offshore flow in wet years.

Although inflows to the Basin from the ocean have decreased since 2005, corresponding with reduced municipal pumping (Figure 2-61), inflows from offshore still indicate seawater intrusion risk. However, groundwater budget results should not be the primary method for evaluating seawater intrusion because freshwater outflow offshore may not be enough to prevent denser seawater from intruding. In addition, net flows representing flows across the entire coastal boundary may not represent the localized risk near pumping centers. The primary model results for evaluating seawater intrusion should be simulated groundwater levels at coastal monitoring wells compared to established protective elevations as discussed in more detail in Section ~~5~~3.

~~Table 2-10. Santa Cruz Mid-County Basin Historical Groundwater Budget Summary (1985 – 2015)~~

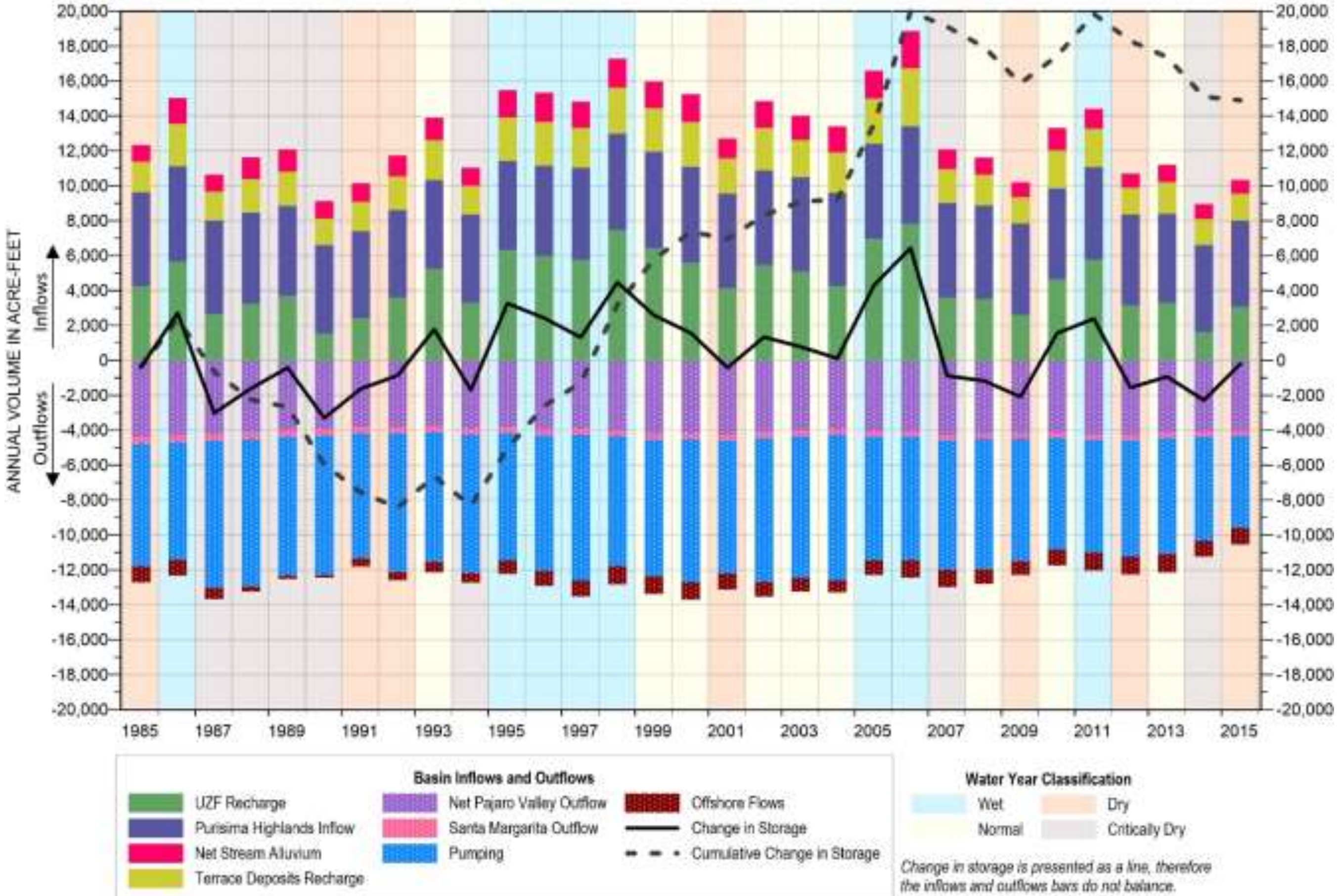
~~Groundwater Budget Component~~	~~Annual Minimum~~	~~Annual Maximum~~	~~Annual Average~~	~~Average % (rounded)~~
~~Inflows (acre-feet per year)~~				
~~UZF Recharge~~	~~1,552~~	~~7,844~~	~~4,462~~	~~34%~~
~~Net Recharge from Stream Alluvium~~	~~779~~	~~2,129~~	~~1,262~~	~~10%~~
~~Recharge from Terrace Deposits~~	~~1,488~~	~~3,337~~	~~2,078~~	~~16%~~
~~Subsurface Inflow from Purisima Highlands~~	~~4,941~~	~~5,569~~	~~5,273~~	~~40%~~
		~~Total Inflow~~	**~~13,075~~**	**~~100%~~**
~~Outflows (acre-feet per year)~~				
~~Pumping~~	~~5,263~~	~~8,456~~	~~7,407~~	~~59%~~
~~Subsurface Outflow to Santa Margarita Subbasin~~	~~255~~	~~389~~	~~314~~	~~3%~~
~~Net Subsurface Outflow to Pajaro Valley Subbasin~~	~~3,767~~	~~4,366~~	~~4,080~~	~~32%~~
~~Offshore~~	~~152~~	~~1,061~~	~~793~~	~~6%~~
		~~Total Outflow~~	**~~12,594~~**	**~~100%~~**



~~Cumulative~~ ~~Average~~

~~Note: all values~~

~~Change in Storage (acre-feet per year)~~	~~+14,910 acre-feet~~	~~+481~~	



~~are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage~~

Figure 2-60. Santa Cruz Mid-County Basin Historical Annual Groundwater Budget (1985 – 2015)

Table 2-13. Santa Cruz Mid-County Basin Historical Groundwater Budget by Aquifer Summary (1985 – 2015)

Groundwater Budget Component	Aromas Red Sands (L2)	Purisima DEF/F (L3)	Purisima D (L4)	Purisima BC (L5)	Purisima B (L6)	Purisima A (L7)	Purisima AA (L8)	Tu (L9)	Total
Annual Average Inflows (acre-feet per year)									
UZF Recharge	~~769~~770	~~779~~780	~~204~~200	~~188~~190	~~223~~220	~~569~~570	~~542~~540	1,~~188~~190	4,~~462~~460
Recharge from Stream Alluvium	~~529~~530	~~135~~130	–	280	–	~~375~~380	~~187~~190	~~11~~10	1,~~517~~520
Recharge from Terrace Deposits	1,~~052~~050	~~181~~170	–	~~283~~290	~~70~~100	~~250~~230	~~242~~240	–	2,~~078~~080
Subsurface Inflow from Purisima Highlands Subbasin	–	2,~~855~~870	330	~~332~~320	~~374~~360	~~586~~590	~~775~~780	~~21~~20	5,~~273~~270
Offshore Inflow	–	~~76~~80	–	–	–	~~32~~30	–	~~11~~10	~~119~~120
Inter-Layer Flow	–	~~741~~740 (L2) ~~51~~50 (L4)	–	~~97~~100 (L4)	~~39~~40 (L5)	~~137~~140 (L6)	~~23~~20 (L7)	–	1,~~088~~090
Total Inflow	**2,350**	**4,~~818~~820**	**~~534~~530**	**1,180**	**~~706~~720**	**1,~~949~~940**	**1,~~769~~770**	**1,~~231~~230**	**14,~~537~~540**
Annual Average Outflows (acre-feet per year)									
Pumping	~~981~~980	2,~~128~~130	~~4~~<10	~~902~~900	~~148~~150	1,590	1,~~108~~110	~~546~~550	7,~~407~~410
Discharge to Stream Alluvium	–	–	~~77~~80	–	~~178~~180	–	–	–	~~255~~260
Subsurface Outflow to Santa Margarita Basin	–	–	–	–	–	–	–	~~314~~310	~~314~~310
Subsurface Outflow to Pajaro Valley Subbasin	~~417~~420	2,~~587~~590	~~303~~300	~~101~~100	~~145~~150	~~334~~330	~~193~~190	–	4,080
Outflow Offshore	~~212~~210	–	~~9~~10	~~142~~140	~~101~~100	–	~~448~~450	–	~~912~~910
Inter-Layer Flow	~~741~~740 (L3)	–	~~51~~50 (L3) ~~97~~100 (L5)	~~39~~40 (L6)	~~137~~140 (L7)	~~23~~20 (L8)	–	–	1,~~396~~390

Total Outflow	2,~~351~~350	4,~~715~~720	~~541~~540	1,~~184~~180	~~709~~720	1,~~947~~940	1,~~749~~750	860	14,~~056~~060
Change in Storage (acre-feet per year)	~~-1~~**0**	~~103~~**100**	**-**~~7~~**10**	~~-4~~**0**	~~-4~~**0**	~~1~~**0**	~~19~~**20**	~~371~~**370**	~~481~~**480**

Notes: The abbreviation L is for model layer, e.g., L2 is model layer 2

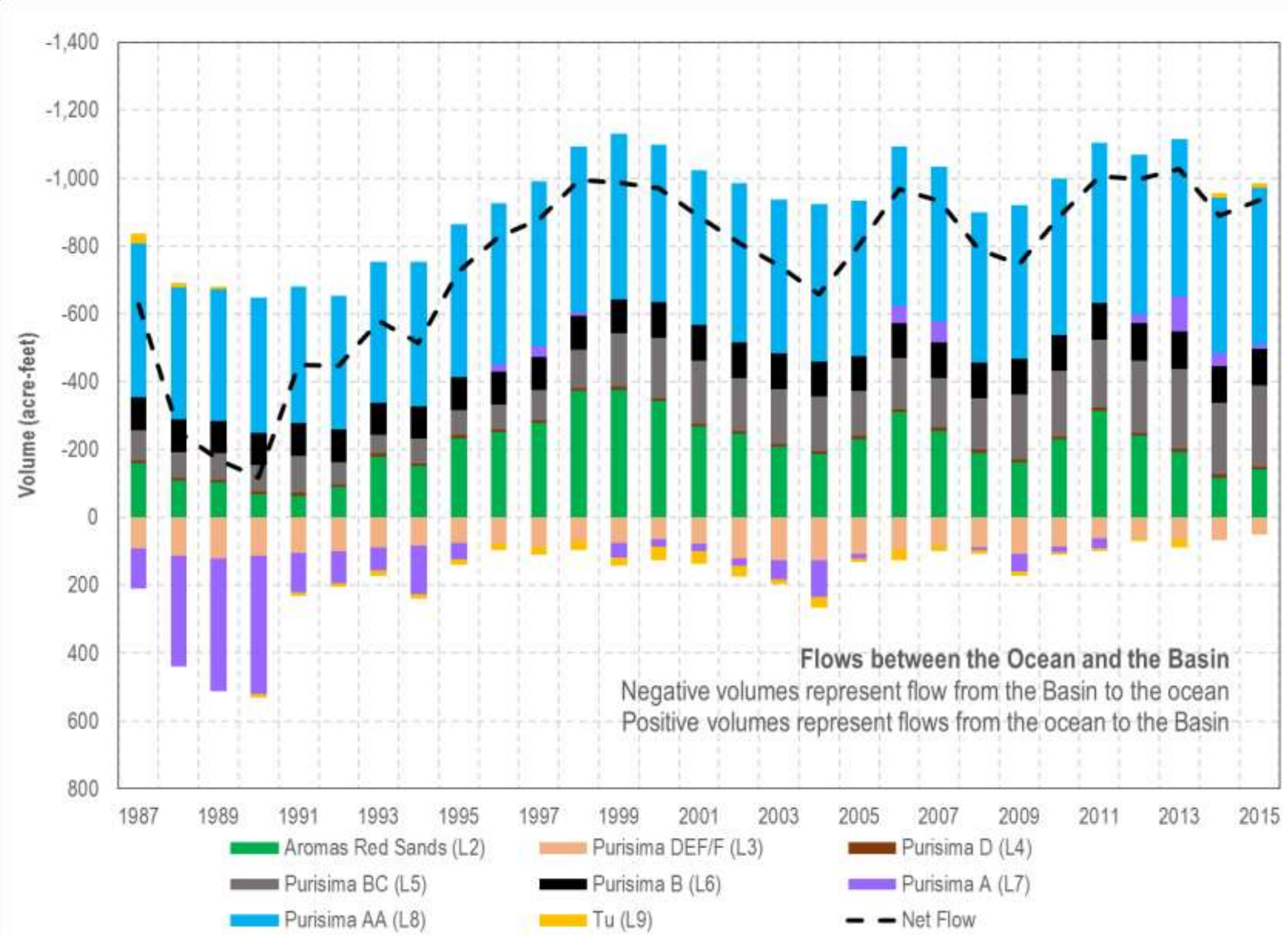


Figure 2-61. Offshore Groundwater Flow to Santa Cruz Mid-County Basin by Model Layer

~~2.2.3.4.3~~2.2.5.4.3 North of Aptos ~~Fault~~Area Faulting Historical Groundwater Budget

Historical groundwater inflows into the area north of the Aptos ~~Fault~~area faulting consist of inflows from the Purisima Highlands Subbasin (66%) and UZF recharge (34%) (Table 2-14).

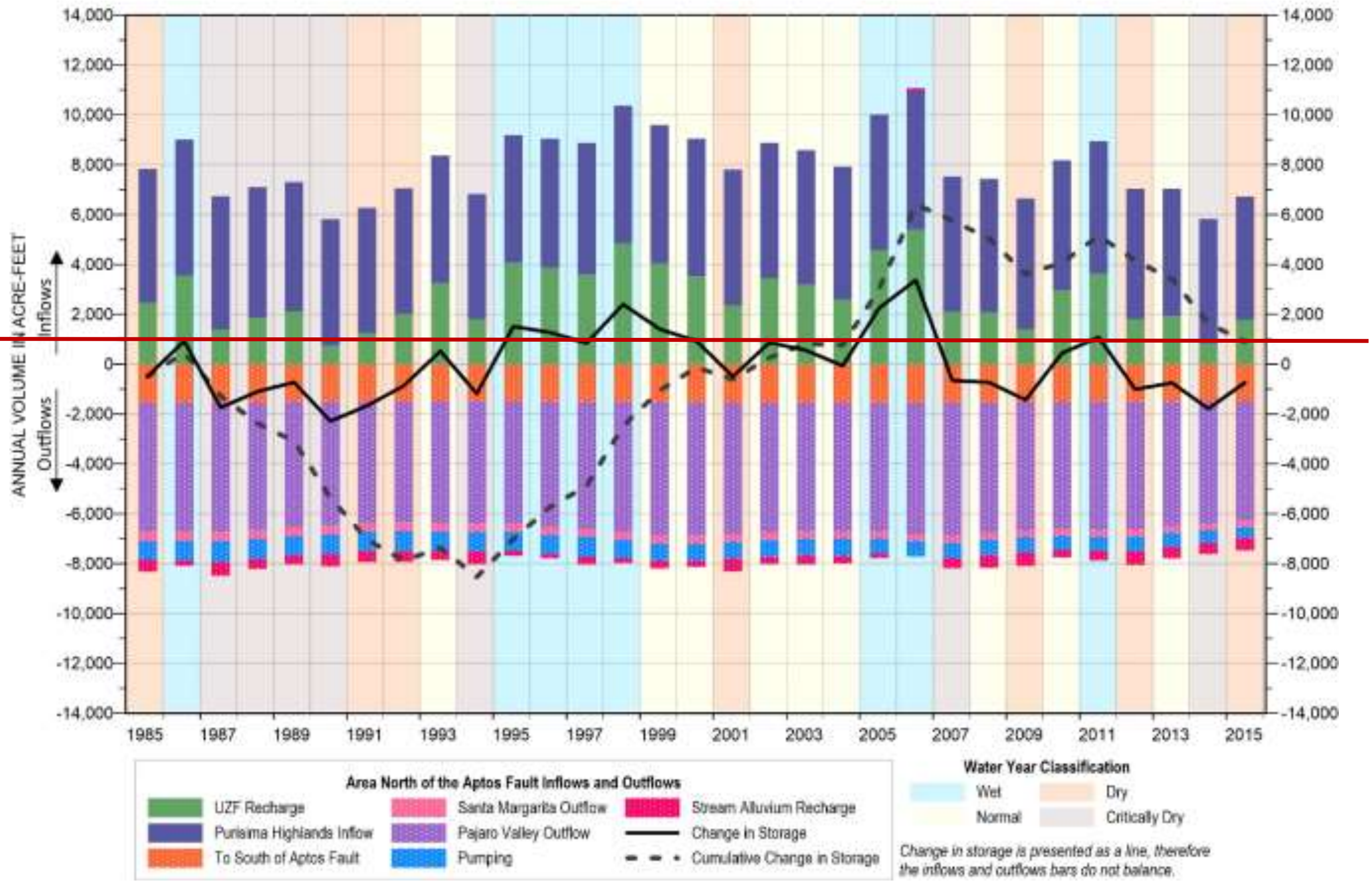
As the area north of the Aptos ~~Fault~~area faulting does not support a large population like the more urban area south of the Aptos ~~Fault~~area faulting, groundwater pumping is not the primary outflow. Instead 64% of the outflow is by means of subsurface outflow to Pajaro Valley. Nineteen percent of outflows are to the area south of the Aptos ~~Fault.~~area faulting. The remainder of outflows are from groundwater pumping (8%), subsurface outflow to the Santa Margarita Basin (4%), and groundwater discharge to streams (4%). The balance of inflows and outflows results in a slight increase in groundwater in storage of approximately ~~29~~30 acre-feet per year. This indicates that the historical water budget north of the Aptos ~~Fault~~area faulting is well balanced. A graphical representation of the historical annual water budget is provided in Table 2-14.

Cumulative change in storage trends for the area north of the Aptos ~~Fault~~area faulting are similar to the basin-wide change in storage trends: an extended dry period during the 1980's through to the mid-1990's contributing to storage losses, followed by a period of recovery and storage gain starting in 1995, and stabilizing from 2007 through 2015. The recent drought from 2012-2105 appears to have impacted the area north of the Aptos ~~Fault~~area faulting with cumulative storage declining 3,000 acre-feet from 2012 - 2015. The range in UZF recharge (maximum less minimum), which predominantly includes direct percolation of rainfall, is greater in the area north of the Aptos ~~Fault~~area faulting (Table 2-14) compared to the area south of the Aptos ~~Fault~~area faulting (Table 2-15). This may be due to the greater area that has impermeable surfaces in the more urban area south of the fault that limits areal recharge.

Table 2-14. North of Aptos ~~Fault~~Area Faulting Historical Groundwater Water Budget Summary (1985 – 2015)

Groundwater Budget Component	Annual Minimum	Annual Maximum	Annual Average	Average % (rounded)
Inflows (~~Acre-Feet~~acre-feet per year)				
UZF Recharge	~~752~~750	5,~~409~~410	2,~~733~~730	34%
Subsurface Inflow from Purisima Highlands Subbasin	4,~~941~~940	5,~~569~~570	5,~~273~~270	66%
		Total Inflow	**8,~~006~~000**	**100%**
Outflows (~~Acre-Feet~~acre-feet per year)				
Pumping	~~438~~440	~~851~~850	~~693~~690	8%
Discharge to Streams	~~171~~170	~~558~~560	~~364~~360	4%
Subsurface Outflow to Santa Margarita Subbasin	~~242~~240	380	~~302~~300	4%
Subsurface Outflow to Pajaro Valley Subbasin	4,~~813~~810	5,~~361~~360	5,~~113~~110	64%
Subsurface Outflow to South of Aptos ~~Fault~~Area Faulting	1,~~466~~470	1,~~534~~530	1,~~505~~510	19%
		Total Outflow	**7,~~977~~970**	100%
Change in Storage (acre-~~Feet~~feet per year)	Cumulative		Average	
	+~~912~~910 acre-feet		+~~29~~30	

~~Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage~~Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage


ANNUAL VOLUME IN ACRE-FEET
Inflows
Outflows
Area North of the Aptos Fault Inflows and Outflows
UZF Recharge
Purisima Highlands Inflow
To South of Aptos Fault
Santa Margarita Outflow
Pajaro Valley Outflow
Pumping
Stream Alluvium Recharge
Change in Storage
Cumulative Change in Storage
Water Year Classification
Wet
Dry
Normal
Critically Dry
Change in storage is presented as a line, therefore the inflows and outflows bars do not balance.

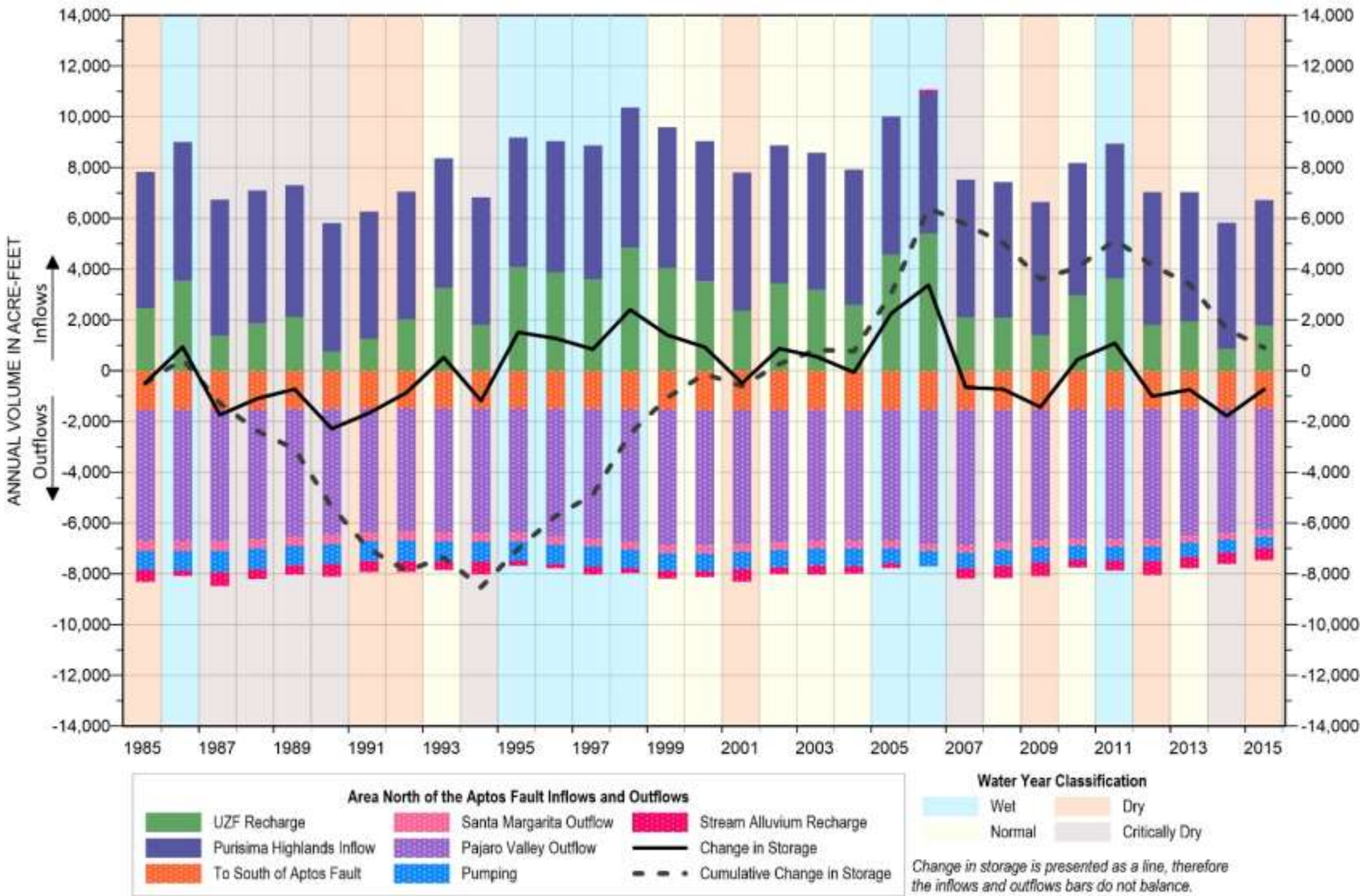


Figure 2-62. North of Aptos ~~Fault~~Area Faulting Historical Annual Groundwater Budget (1985 – 2015)

~~2.2.3.4.4~~2.2.5.4.4 South of Aptos ~~Fault~~Area Faulting Historical Groundwater Budget

Historical groundwater inflows to the portion of the Basin south of the Aptos ~~Fault~~area faulting are summarized in Table 2-15. Primarily inflows are from terrace deposits (26%), UZF recharge (22%), and recharge from stream alluvium (20%). Slightly lesser inflows are from subsurface sources: the area north of the Aptos ~~Fault~~area faulting (19%) and Pajaro Valley (12%). On average, combined natural recharge constitutes around 68% of groundwater inflow with subsurface inflow from the north and Pajaro Valley comprising the remaining 32%.

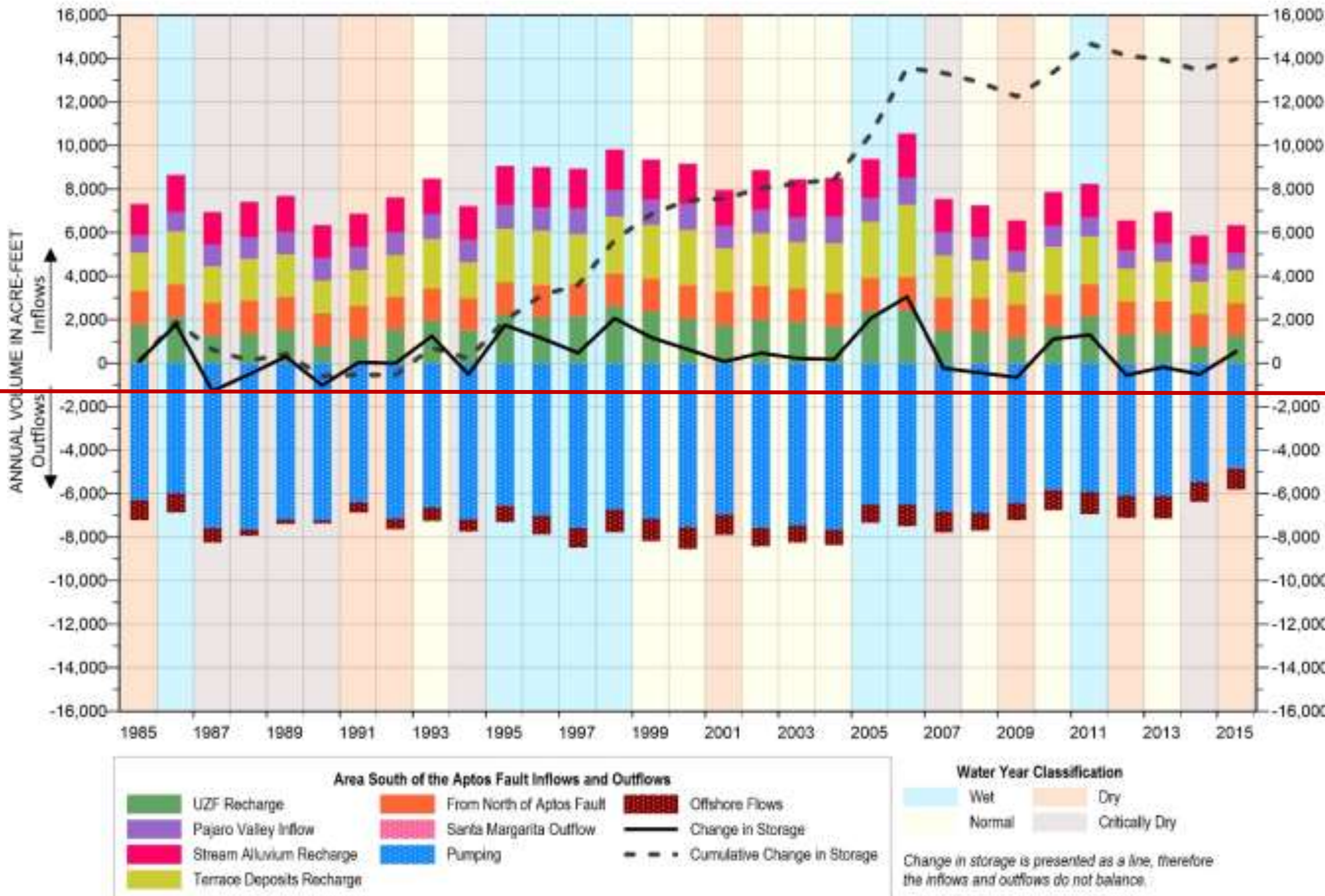
Groundwater outflows in the area south of the Aptos ~~Fault~~area faulting are primarily from groundwater pumping, which comprises ~~90~~89% of average outflows~~.~~ (Table 2-15). The remaining ~~10~~11% comprised almost completely of flows offshore, with a very minor amount of ~~12~~10 acre-feet flowing into the Santa Margarita Basin. For the area south of the Aptos ~~Fault~~area faulting, the average change in storage over the 31-year historical period is an increase of approximately ~~451~~470 acre-feet per year. A graphical representation of the historical groundwater budget over the historical period is provided in Figure 2-62.

Cumulative change in storage trends for the area south of the Aptos ~~Fault~~area faulting are similar to the whole Basin change in storage trends: an extended dry period during the 1980's through to the mid-1990's contributing to storage losses, followed by a period of recovery and storage gain starting in 1995, and stabilizing from 2007 through 2015. The storage loss in the area south of the Aptos ~~Fault~~area faulting (Figure 2-63) from 1985-1994 is less pronounced than in the area north of the Aptos ~~Fault~~area faulting (Figure 2-62) due in part to the presence of flows from offshore and seawater intrusion. As surface sources of recharge decrease during this period, flow offshore also decreases substantially, indicating conditions supporting seawater intrusion. From 1995 onward, cumulative storage is gained and flows offshore are consistent. Even though there is overall offshore flow, seawater intrusion and risk of further seawater intrusion is still present and MGA activities such as MAR will be necessary to prevent further seawater intrusion.

Table 2-15. South of Aptos ~~Fault~~Area Faulting Historical Groundwater Water Budget Summary (1985 – 2015)

Groundwater Budget Component	Annual Minimum	Annual Maximum	Annual Average	Average % (rounded)
Inflows (acre-feet per year)				
UZF Recharge	~~785~~790	2,~~622~~620	1,~~728~~730	22%
Recharge from Stream Alluvium	1,~~277~~280	2,~~028~~030	1,~~625~~630	20%
Recharge from Terrace Deposits	1,~~488~~490	3,~~337~~340	2,~~078~~080	26%
Subsurface Inflow from Pajaro Valley Subbasin	~~763~~760	1,~~233~~230	1,~~034~~030	13%
Subsurface Inflow from North of Aptos ~~Fault~~Area Faulting	1,~~466~~470	1,~~534~~530	1,~~505~~510	19%
		Total Inflow	**7,~~970~~980**	**100%**
Outflows (acre-feet per year)				
Pumping	4,~~825~~830	7,640	6,~~714~~710	89%
Subsurface Outflow to Santa Margarita Subbasin	~~8~~<10	~~14~~20	~~12~~10	<1%
Net Outflow Offshore	~~151~~150	1,~~061~~060	~~793~~790	11%
		Total Outflow	**7,~~519~~510**	**100%**
	Cumulative		**Average**	
Change in Storage (acre-feet per year)	+13,~~981~~980 acre-feet		+~~451~~470	

Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage


ANNUAL VOLUME IN ACRE-FEET
Inflows
Outflows
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
-8,000
-10,000
-12,000
-14,000
-16,000
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
Area South of the Aptos Fault Inflows and Outflows
UZF Recharge
Pajaro Valley Inflow
Stream Alluvium Recharge
Terrace Deposits Recharge
From North of Aptos Fault
Santa Margarita Outflow
Pumping
Offshore Flows
Change in Storage
Cumulative Change in Storage
Water Year Classification
Wet
Dry
Normal
Critically Dry
Change in storage is presented as a line, therefore the inflows and outflows do not balance.

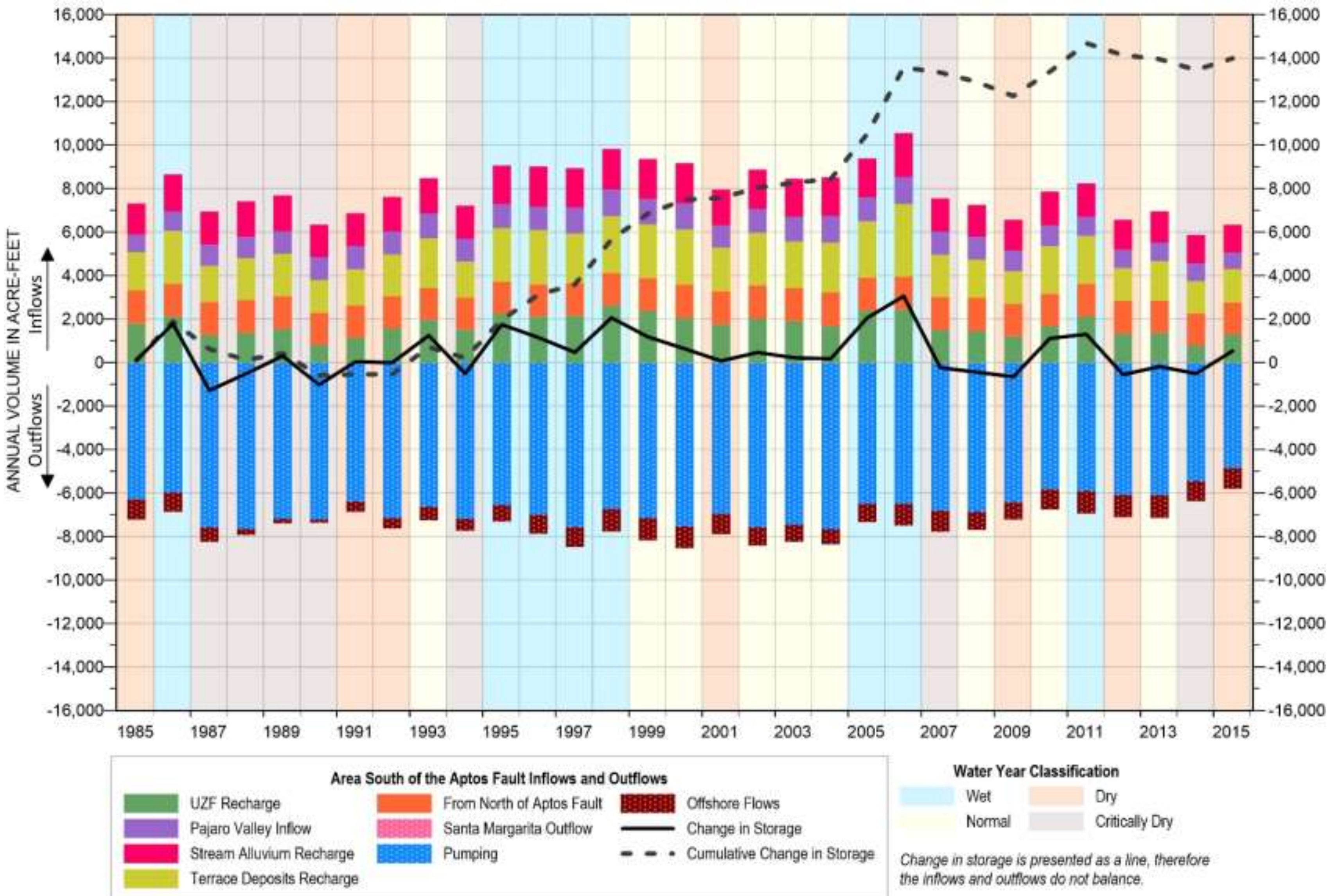


Figure 2-63. South of Aptos ~~Fault~~Area Faulting Historical Annual Groundwater Budget (1985 – 2015)

~~2.2.3.5~~2.2.5.5 Current Water Budget

The current water budget for the Basin includes the most recent information available, and covers the period from Water Year 2010-2015. This period was selected as it encompasses both the recent 2012 – 2015 drought and two relatively wet years resulting in an average rainfall of 24.3 inches per year~~.~~ at the Santa Cruz Co-op station. The current water budget period represents overall drier conditions with 5.7 inches less rainfall than the 1985 - 2015 average of 29 inches per year.

2.2.5.5.1 Santa Cruz Mid-County Basin Current Surface Water Budget

From Water Year 2010 through 2015, 5.7 inches less rainfall than historical conditions at the Santa Cruz Co-op station translates to an average of approximately 14,600 acre-feet per year less water available for evapotranspiration, overland flow, groundwater recharge and soil moisture (Table 2-10 and Table 2-16). Evapotranspiration during these drier years declined by approximately 4,350 acre-feet per year, but it used up relatively more of the available water in the Basin (72% compared to 66% in the historical period). Water available for overland flow was on average 6,750 acre-feet per year less than over the historical period. Groundwater recharge was on average 910 acre-feet less per year while the relative percentage of recharge remained the same. Conditions during the current period were so dry, water from soil moisture occurred, likely to evapotranspiration, which is why its value is negative in Table 2-16.

Table 2-16. Percentage Distribution of Current Precipitation in Santa Cruz Mid-County Basin

Precipitation Budget Component	Average Annual (acre-feet)	Average Percent of Precipitation
Precipitation	81,600	100%
Evapotranspiration	59,300	72%
Overland Flow	18,660	23%
Groundwater Recharge from Precipitation	3,910	5%
Soil Moisture	-270*	0%

Note: * a negative soil moisture value indicates soil moisture was lost and not gained

The lower rainfall results in the current surface water budget having 13,740 acre-feet less surface water flowing into the Basin and 11,940 acre-feet less flowing out to the ocean compared to the historical period (Table 2-11 and Table 2-17). Despite the overall inflow decrease, relative volumetric proportions between groundwater components are consistent with the historical budget. The surface water budget is shown graphically on Figure 2-64.

Table 2-17. Santa Cruz Mid-County Basin Current Surface Water Budget

Surface Water Budget Component	Annual Minimum	Annual Maximum	Annual Average	Average % (rounded)
Inflows (acre-feet per year)				
Overland Flow	8,060	30,580	18,670	58%
Flows from Upstream of the Basin	6,520	25,930	12,570	39%
Net Flows from Groundwater	810	900	870	3%
		Total Inflow	**32,110**	**100%**
Outflows (acre-feet per year)				
Ocean Outflow	14,000	51,310	29,070	91%
Outflow in Branciforte Creek	1,420	5,730	2,630	8%
Pajaro Valley Subbasin	10	690	280	<1%
Outflow to Carbonera Creek	70	350	130	<1%
		Total Outflow	**32,110**	**100%**

Note: 'Groundwater Flows' refers to flow between streams and underlying alluvium, and is distinct from 'Stream Alluvium Recharge' seen in groundwater budgets.

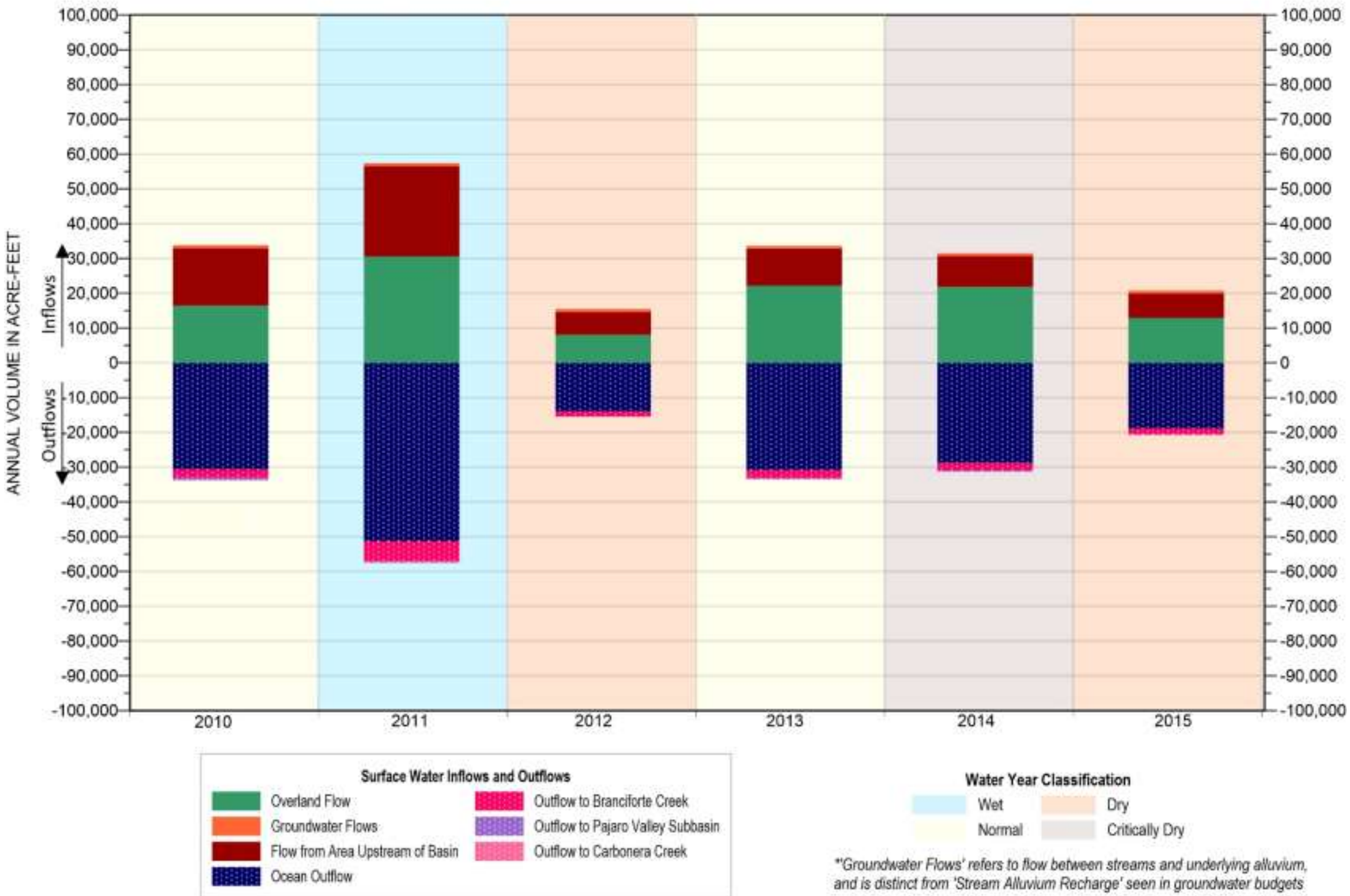


Figure 2-64. Santa Cruz Mid-County Basin Current Annual Surface Water Budget

~~2.2.3.5.1~~2.2.5.5.2 Santa Cruz Mid-County Basin Current Groundwater Budget

The inflow and outflow components for the current groundwater budget are the same components as the historical budget, and their relative contributions are similar. ~~Table 2-13~~Table 2-18 summarizes the minimum, maximum, and average annual inflows and outflows, and average annual change in groundwater in storage. A graphical representation of the current annual groundwater budget over the current period is provided in Figure 2-65.

On average, combined surface recharge sources constitute approximately 55% of Basin inflows, with inflow from subsurface flow from the Purisima Highlands Subbasin comprising the remaining 45%. Current inflows are about 1,580 acre-feet per year less than during the historical period due to below normal rainfall which occurred over most of this period.

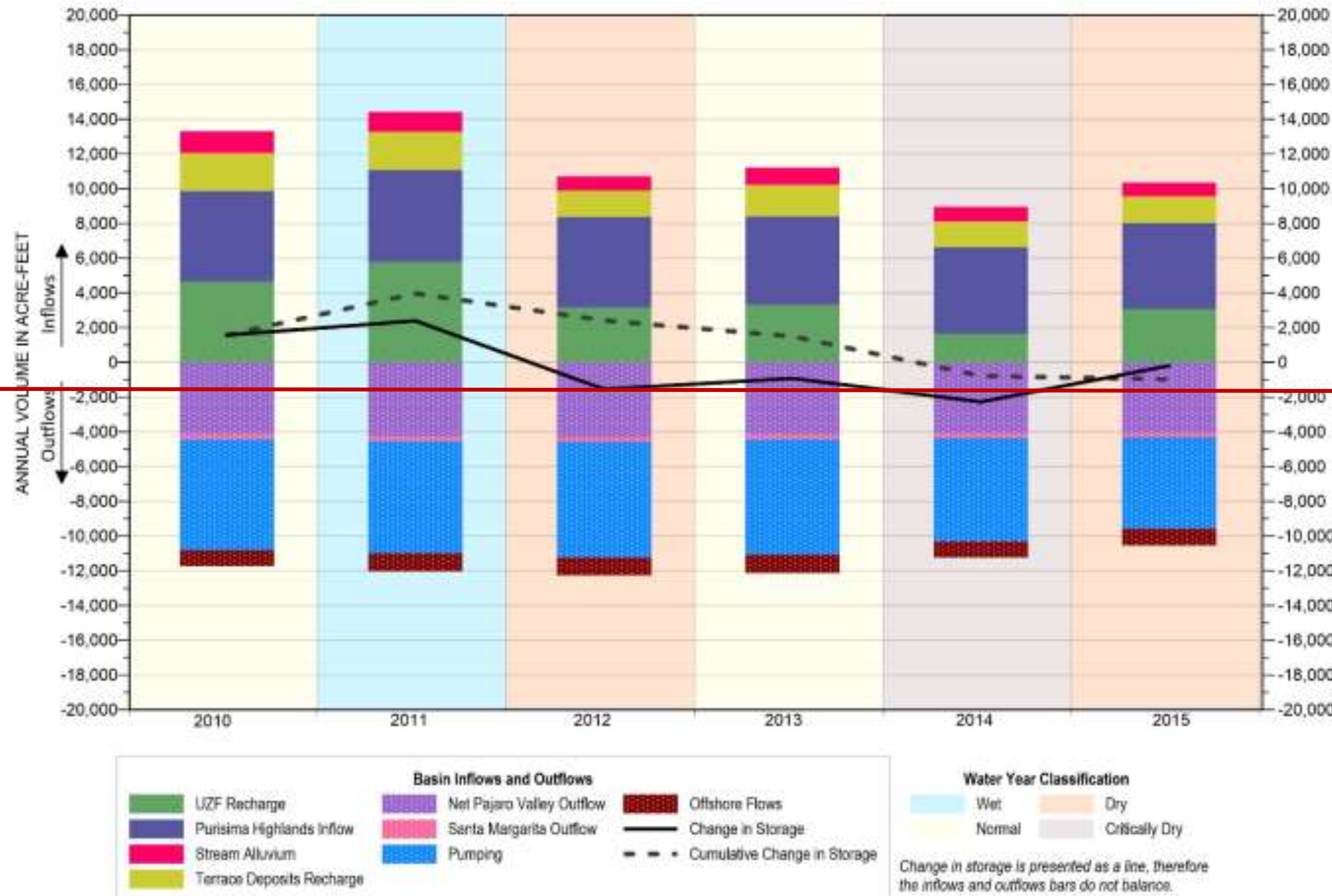
For the current water budget period, Basin outflow from groundwater pumping is on average 1,~~183~~190 acre-feet less than during the historical period. This reflects the reduction in pumping that occurred across the Basin through conservation in response to the 2012-2015 drought and the groundwater emergency declaration by Soquel Creek Water District. Subsurface outflow offshore is greater during the current period than the historical period because of higher groundwater elevations in the area of municipal production. Increased groundwater elevations are a direct result of historically low pumping in the Basin. The MGA anticipates a bounceback in groundwater demand so the GSP does not rely on historically low pumping continuing into the future to help achieve sustainability. Management actions employed also have included redistributing municipal pumping to increase groundwater levels along the coast to protective elevations.

The average loss of groundwater in storage for the Basin was ~~162~~160 acre-feet per year (Table 2-18) which is approximately ~~643~~320 acre-feet per year less than the historical period (Table 2-12). During the normal and wet years of 2010 and 2011, the Basin gained almost 2,000 acre-feet of cumulative groundwater in storage. By 2015, four consecutive dry years contributed to a loss of all the groundwater gained in 2010 and 2011, plus additional losses for an overall cumulative groundwater in storage loss of approximately 1,000 acre-feet over the six-year period. A comparison of Basin inflows and outflows between the current and historical periods is provided on Figure 2-66.

Table 2-18. Santa Cruz Mid-County Basin Current Groundwater Budget Summary (2010-2015)

Groundwater Budget Component	Annual Minimum	Annual Maximum	Annual Average	Average % (rounded)
Inflows (acre-feet per year)				
UZF Recharge	1,~~643~~640	5,~~774~~770	3,600	31%
Net Recharge from Stream Alluvium	~~7,79~~780	1,~~255~~260	~~972~~970	8%
Recharge from Terrace Deposits	1,~~488~~490	2,~~199~~200	1,~~793~~790	16%
Subsurface Inflow from Purisima Highlands Basin	4,~~941~~940	5,~~309~~310	5,~~129~~130	45%
		Total Inflow	**11,~~494~~490**	**100%**
Outflows (acre-feet per year)				
Pumping	5,~~263~~260	6,~~648~~650	6,~~223~~220	53%
Subsurface Outflow to Santa Margarita Basin	~~254~~250	~~274~~270	~~267~~270	2%
Net Subsurface Outflow to Pajaro Valley Subbasin	4,050	4,~~299~~300	4,~~173~~170	36%
Net Outflow Offshore	~~921~~920	1,~~061~~060	~~993~~990	~~8~~9%
		Total Outflow	**11,~~656~~650**	**100%**
	Cumulative		**Average**	
Change in Storage (acre-feet per year)	-~~974~~970 acre-feet		-~~162~~160	

Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage.


ANNUAL VOLUME IN ACRE-FEET
Inflows
Outflows
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
-8,000
-10,000
-12,000
-14,000
-16,000
-18,000
-20,000
2010
2011
2012
2013
2014
2015
Basin Inflows and Outflows
UZF Recharge
Purisima Highlands Inflow
Stream Alluvium
Terrace Deposits Recharge
Net Pajaro Valley Outflow
Santa Margarita Outflow
Pumping
Offshore Flows
Change in Storage
Cumulative Change in Storage
Water Year Classification
Wet
Normal
Dry
Critically Dry
Change in storage is presented as a line, therefore the inflows and outflows bars do not balance.

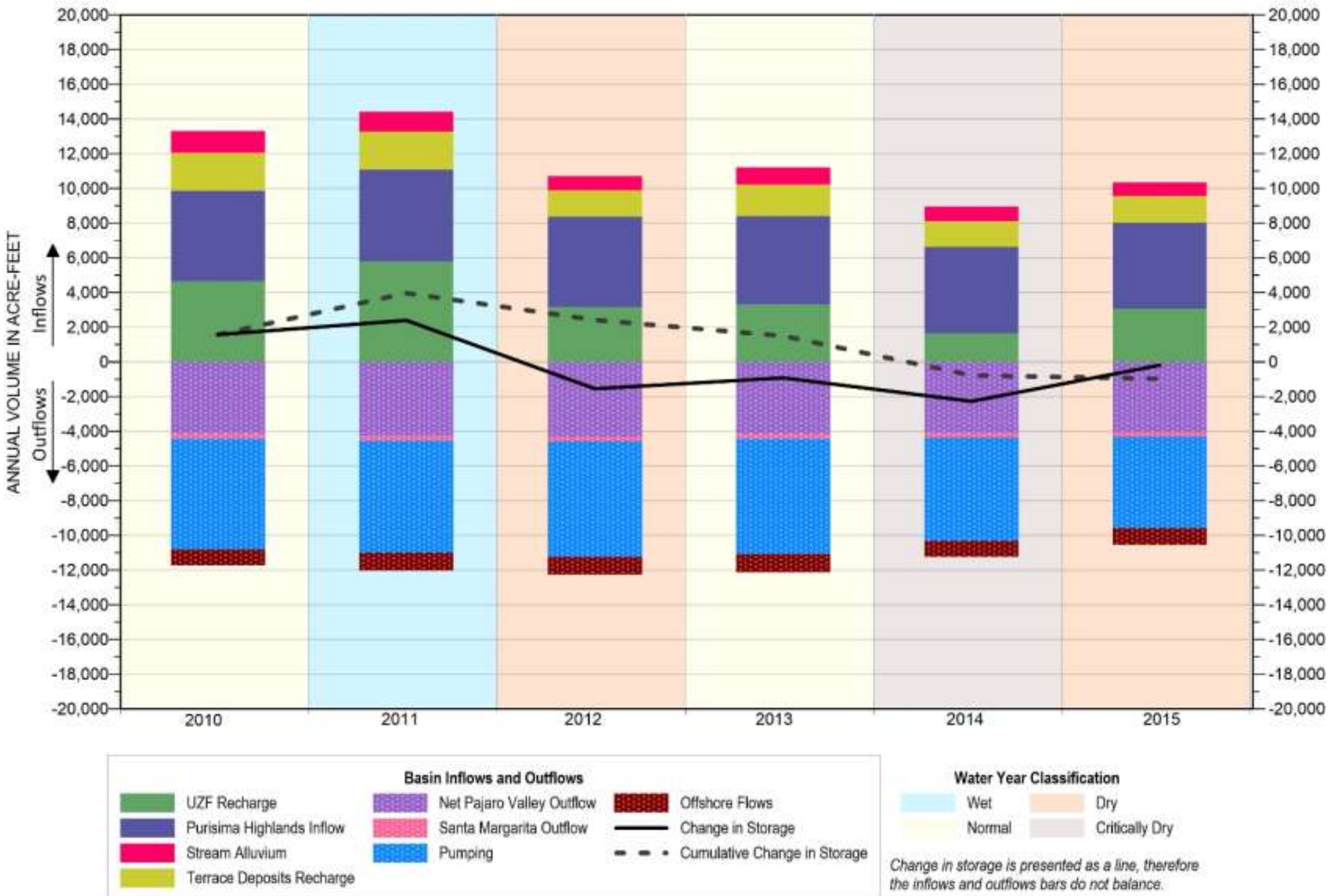
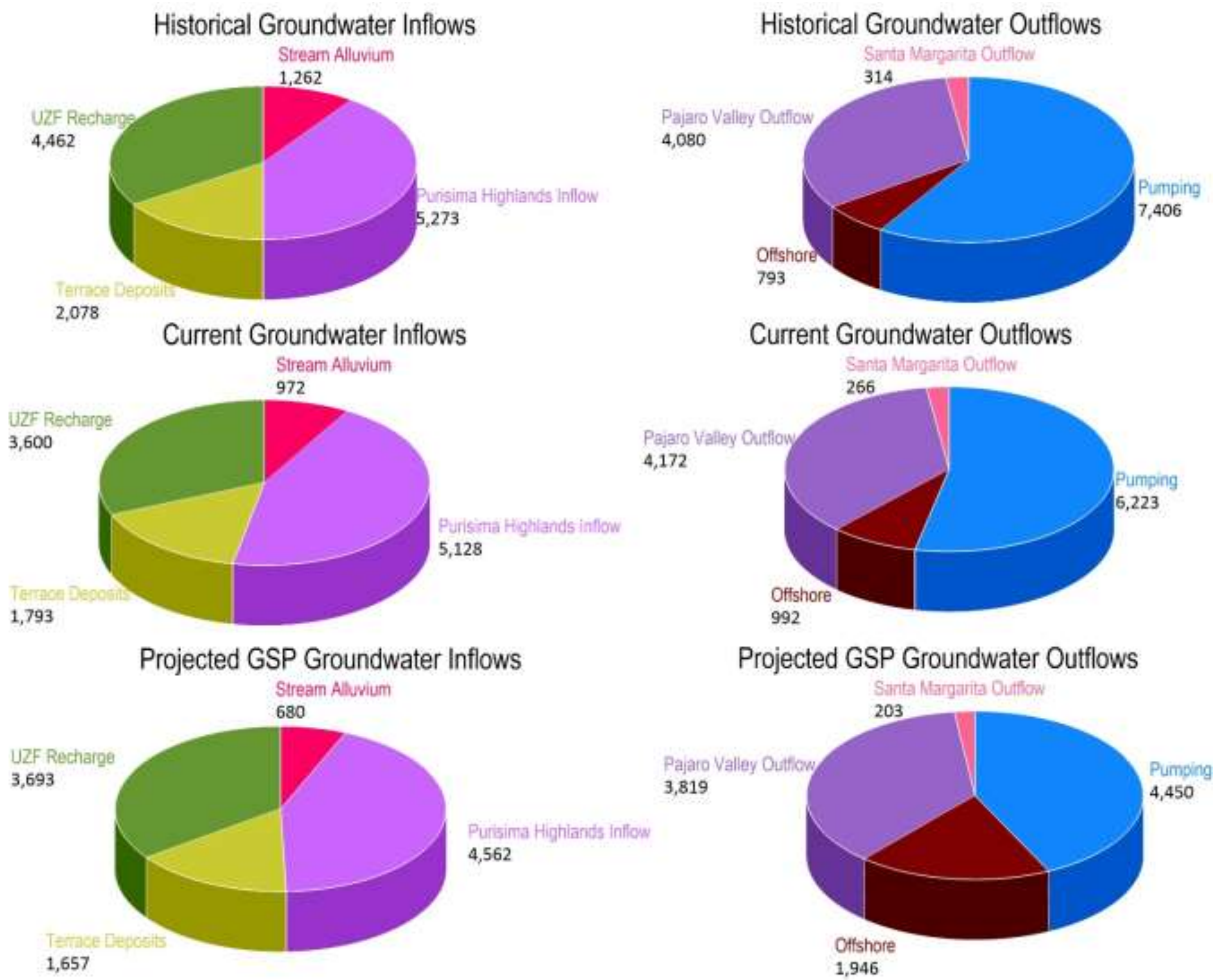


Figure 2-65. Santa Cruz Mid-County Basin Current Annual Groundwater Budget (2010 – 2015)


Historical Groundwater Inflows
Stream Alluvium
1,262
UZF Recharge
4,462
Purisima Highlands Inflow
5,273
Terrace Deposits
2,078
Historical Groundwater Outflows
Santa Margarita Outflow
314
Pajaro Valley Outflow
4,080
Pumping
7,406
Offshore
793
Current Groundwater Inflows
Stream Alluvium
972
UZF Recharge
3,600
Purisima Highlands Inflow
5,128
Terrace Deposits
1,793
Current Groundwater Outflows
Santa Margarita Outflow
266
Pajaro Valley Outflow
4,172
Pumping
6,223
Offshore
992
Projected GSP Groundwater Inflows
Stream Alluvium
680
UZF Recharge
3,693
Purisima Highlands Inflow
4,562
Terrace Deposits
1,657
Projected GSP Groundwater Outflows
Santa Margarita Outflow
203
Pajaro Valley Outflow
3,819
Pumping
4,450
Offshore
1,946

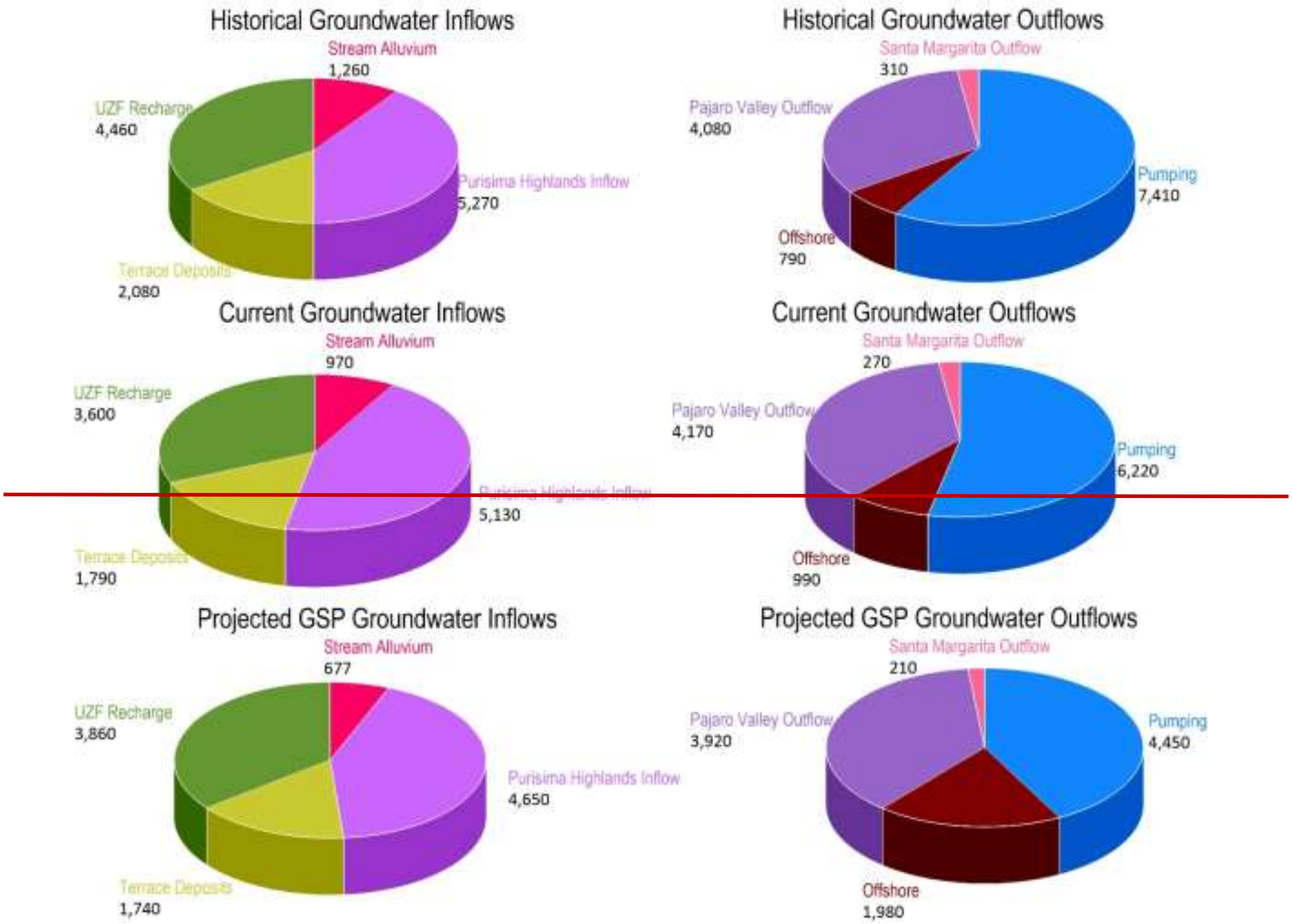


Figure 2-66. Comparison of Historical, Current, and Projected GSP Groundwater Inflows and Outlflows (acre-feet per year)

Table 2-19. Santa Cruz Mid-County Basin Current Groundwater Budget by Aquifer Summary (1985 – 2015)

Groundwater Flow Component	Aromas Red Sands (L2)	Purisima DEF/F (L3)	Purisima D (L4)	Purisima BC (L5)	Purisima B (L6)	Purisima A (L7)	Purisima AA (L8)	Tu (L9)	Total
Annual Average Inflows (~~Acre-Feet~~acre-feet per year)									
UZF Recharge	614	550	160	148	179	485	460	1,004	3,600
Recharge from Stream Alluvium	393	119	_	274	_	267	157	_	1,200
Recharge from Terrace Deposits	827	136	_	274	69	246	241	_	1,793
Inflow from Purisima Highlands	_	2,813	326	323	361	549	734	23	5,129
Offshore Inflow	_	54	_	_	_	_	_	4	58
Inter-Layer Flow	_	544 (L3) 50(L4)	_	79 (L4)	27 (L5)	112 (L6)	33 (L7)	_	1,214
Total Inflow	**1,834**	**4,256**	**486**	**1,098**	**636**	**1,659**	**1,625**	**1,031**	**12,994**
Annual Average Outflows (~~Acre-Feet~~acre-feet per year)									
Pumping	788	1,770	1	766	123	1,1284	1,019	482	6223
Discharge to Stream Alluvium	_	_	64	_	164	_	_	_	228
Outflow to Santa Margarita	_	_	_	_	_	_	_	267	267
Outflow to Pajaro Valley	515	2,597	302	100	143	328	188	_	4,173
Offshore Outflow	211	_	10	217	108	41	464	_	1,051
Inter-Layer Flow	544 (L3)	_	50 (L3) 79(L5)	27 (L6)	112 (L7)	33 (L8)	_	_	1,213
Total Outflow	**2,058**	**4,367**	**506**	**1,110**	**650**	**1,686**	**1,661**	**749**	**13,155**
Change in Storage	**-224**	**-111**	**-21**	**-12**	**-13**	**-26**	**-36**	**281**	**-162**

Notes: The abbreviation L is for model layer, e.g., L2 is model layer 2

~~2.2.3.5.2~~2.2.5.5.3 North of Aptos ~~Fault~~Area Faulting Current Groundwater Budget

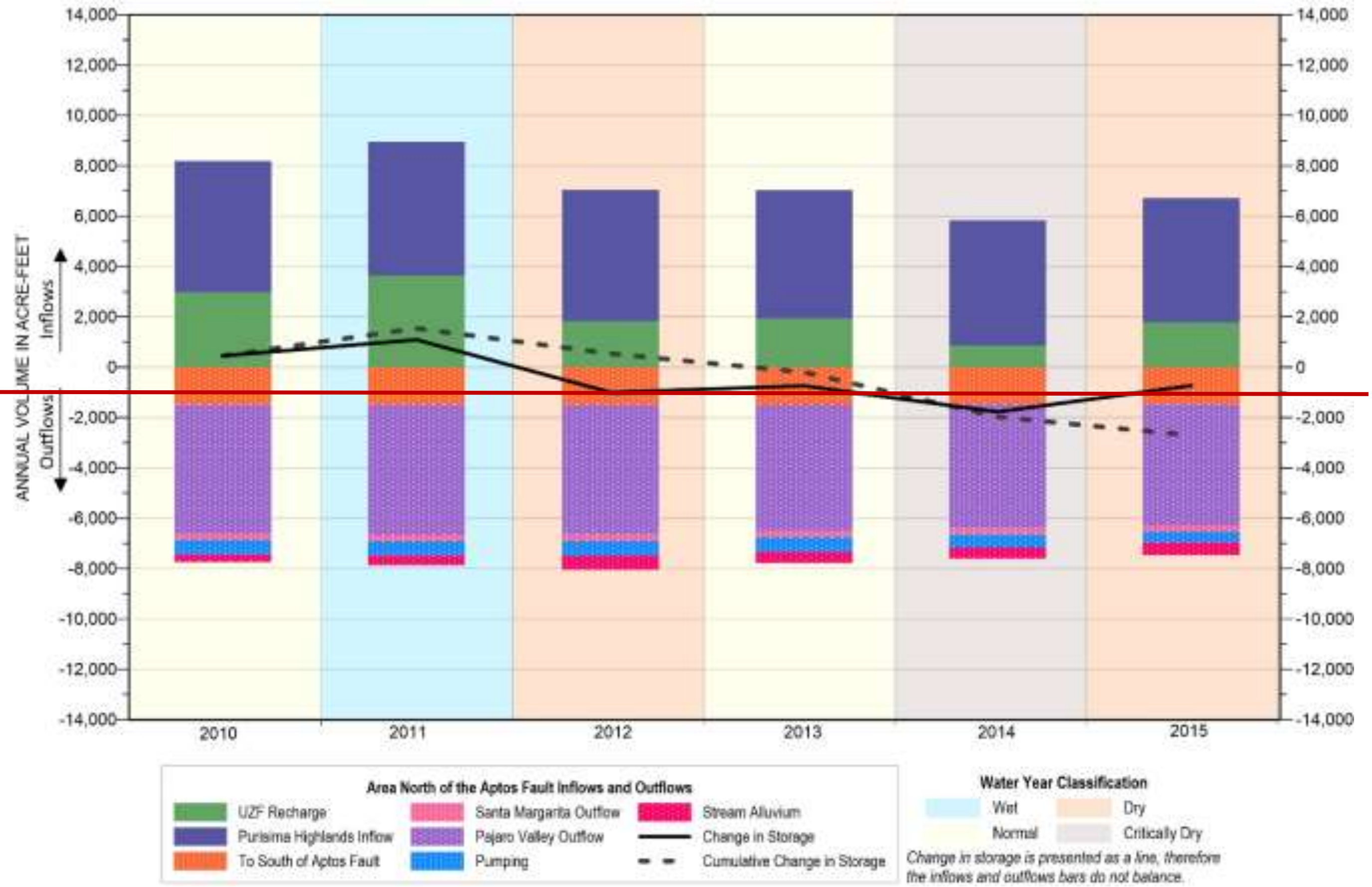
Similar to the historical period, groundwater inflows in the area north of the Aptos ~~Fault~~area faulting comprise inflow from Purisima Highlands (70%) and UZF recharge (30%) during the current period (Table 2-20). Outflows are primarily flows to Pajaro Valley (65%), with minor flows to Santa Margarita (3%) and discharge to streams (6%) (Table 2-20). During the current period, the average change in groundwater in storage represented a loss in storage of around ~~451~~450 acre-feet per year. A graphical representation of the historical annual groundwater budget north of the Aptos ~~Fault~~area faulting over the current period is provided on Figure 2-67.

The change from an average groundwater in storage gain during the historical period to an average storage loss for the current period is influenced by a decline in both average inflows from the Purisima Highlands Subbasin and UZF recharge. The recharge reductions are due to limited surface recharge during the 2012-2015 drought that is included in the current water budget period. Overall, the area north of the Aptos ~~Fault~~area faulting lost about 2,~~707~~710 acre-feet in cumulative storage over the six years included in the current water budget period (Table 2-20).

Table 2-20. North of Aptos ~~Fault~~Area Faulting Current Groundwater Budget Summary (2010 – 2015)

Groundwater Budget Component	Annual Minimum	Annual Maximum	Annual Average	Average % (rounded)
Inflows (~~Acre-Feet~~acre-feet per year)				
UZF Recharge	~~858~~860	3,~~642~~640	2,~~169~~170	30%
Subsurface Inflow from Purisima Highlands	4,~~941~~940	5,~~309~~310	5,~~128~~130	70%
		Total Inflow	**7,~~297~~300**	**100%**
Outflows (~~Acre-Feet~~acre-feet per year)				
Pumping	~~438~~440	~~588~~590	~~542~~540	7%
Discharge to Streams	~~303~~300	~~558~~560	~~441~~440	6%
Subsurface Outflow to Santa Margarita Subbasin	~~242~~240	~~261~~260	~~253~~250	3%
Subsurface Outflow to Pajaro Valley Subbasin	4,~~941~~940	5,~~309~~310	5,~~025~~030	65%
Subsurface Outflow to South of Aptos ~~Fault~~Area Faulting	1,~~466~~470	1,~~498~~500	1,~~487~~490	19%
		Total Outflow	**7,~~755~~750**	**100%**
	Cumulative		**Average**	
Change in Storage (acre-Feet per year)	-2,~~707~~710 acre-feet		-~~451~~450	

Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage


ANNUAL VOLUME IN ACRE-FEET
Inflows
Outflows
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
-8,000
-10,000
-12,000
-14,000
2010
2011
2012
2013
2014
2015
Area North of the Aptos Fault Inflows and Outflows
UZF Recharge
Purisima Highlands Inflow
To South of Aptos Fault
Santa Margarita Outflow
Pajaro Valley Outflow
Pumping
Stream Alluvium
Change in Storage
Cumulative Change in Storage
Water Year Classification
Wet
Normal
Dry
Critically Dry
Change in storage is presented as a line, therefore the inflows and outflows bars do not balance.

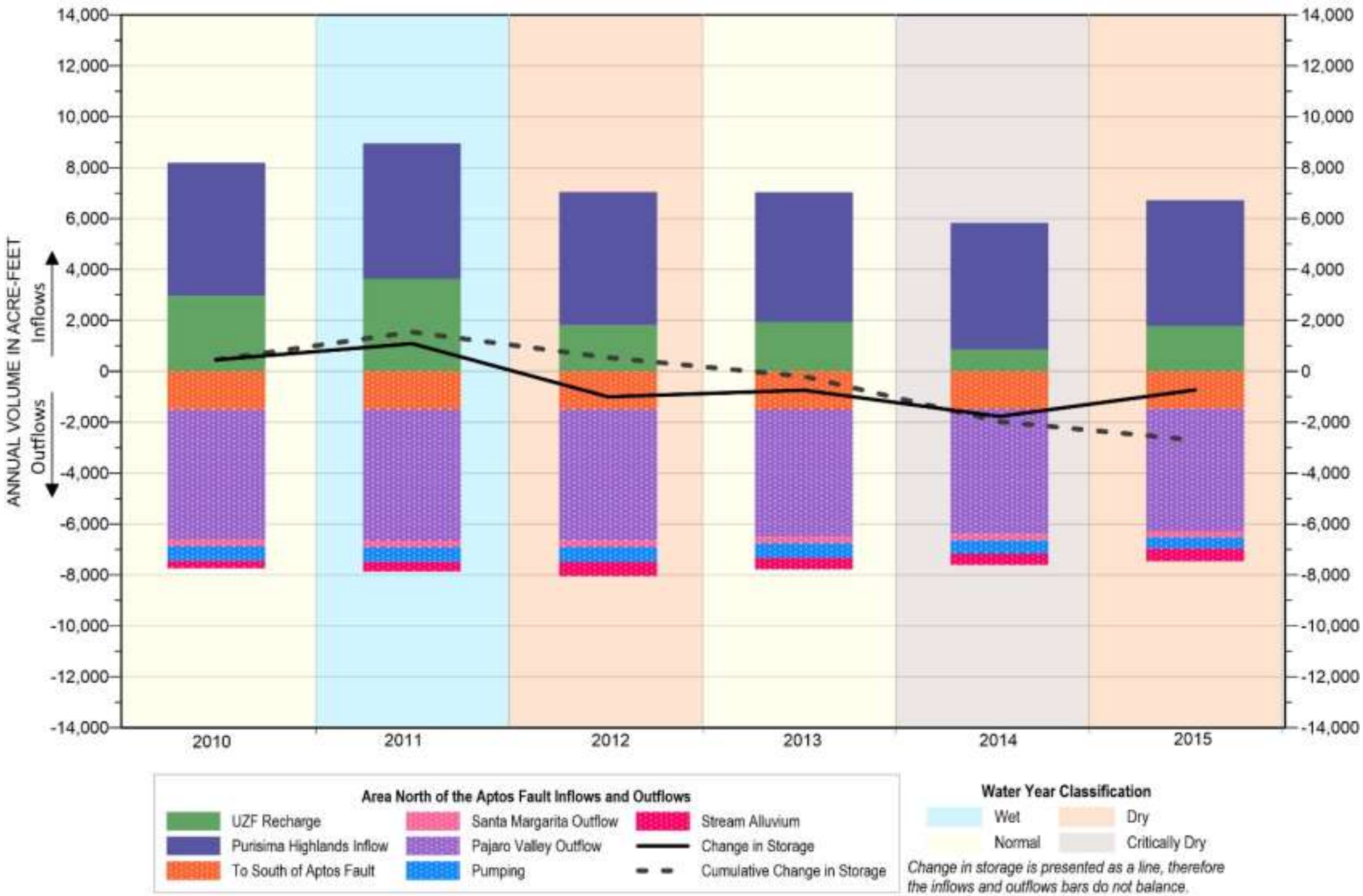


Figure 2-67. North of Aptos ~~Fault~~Area Faulting Current Annual Groundwater Budget (2010 – 2015)

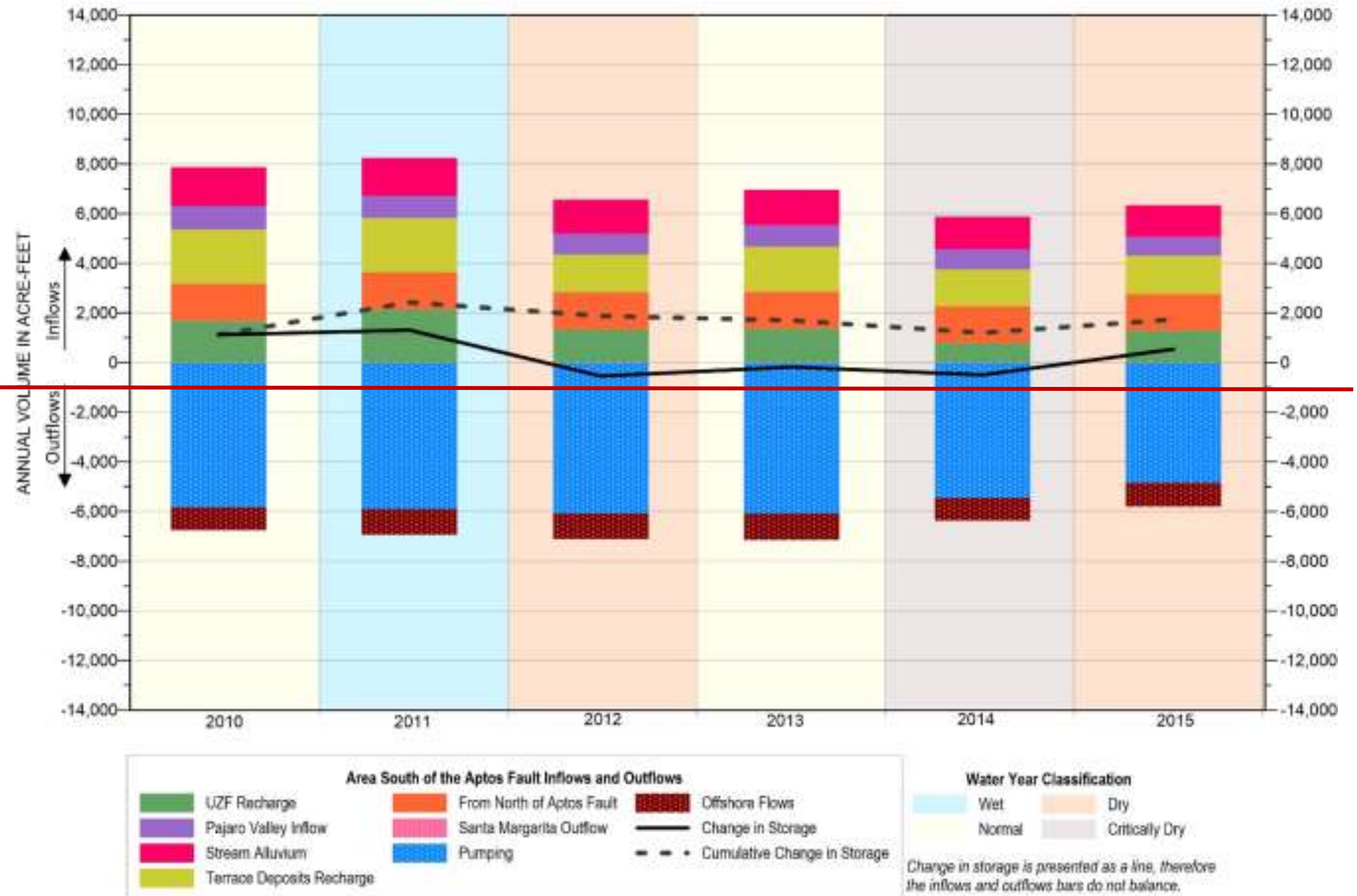
~~2.2.3.5.3~~2.2.5.5.4 South of Aptos ~~Fault~~Area Faulting Current Groundwater Budget

Similar to the distribution of groundwater inflows during the historical period, current groundwater inflows in the area south of the Aptos ~~fault~~area faulting are comprised of inflow from recharge through alluvium and terrace deposits (combined 46%), inflow from the area north of the Aptos ~~Fault (22~~area faulting (21%), UZF recharge (~~21~~22%), and from Pajaro Valley (12%) (Table 2-21). Outflows are primarily by groundwater pumping (85%) and offshore (14%) (Table 2-21). A graphical representation of the historical annual groundwater budget north of the Aptos ~~Fault~~area faulting over the current period is provided on Figure 2-68.

During the current water budget period, there is an increase in groundwater storage of ~~around 289~~approximately 290 acre-feet per year. Due to a reduction in overall groundwater inflow during the 2012-2015 drought, average change in groundwater in storage was ~~162~~180 acre-feet per year lower than during the historical period, yet still gaining. Overall, the area south of the Aptos ~~Fault~~area faulting gained approximately 1,~~734~~730 acre-feet in cumulative storage over the current water budget period (Table 2-21). Increased groundwater levels in the area of municipal pumping is the reason for this unexpected gain in storage during a drought period. As mentioned previously, increased groundwater elevations are a direct result of specific management actions focused on controlling seawater intrusion. Management actions include redistributing municipal pumping to increase groundwater levels along the coast to protective elevations and water conservation.

Table 2-21. South of Aptos ~~Fault~~Area Faulting Current Groundwater Budget Summary (2010 – 2015)

Groundwater Budget Component	Annual Minimum	Annual Maximum	Annual Average	Average % (rounded)
Inflows (acre-feet per year)				
UZF Recharge	~~785~~790	2,~~132~~130	1,430	~~22~~21%
Recharge from Stream Alluvium	1,~~277~~280	1,~~558~~560	1,~~413~~410	20%
Recharge from Terrace Deposits	1,~~488~~490	2,~~199~~200	1,~~793~~790	26%
Subsurface Inflow from Pajaro Valley Subbasin	~~763~~760	~~921~~920	~~854~~850	12%
Subsurface Inflow from North of Aptos ~~Fault~~Area Faulting	1,~~466~~470	1,~~498~~500	1,~~487~~490	21%
		Total Inflow	**6,~~977~~980**	**100%**
Outflows (acre-feet per year)				
Pumping	4,~~825~~830	6,~~067~~060	5,~~681~~680	85%
Subsurface Outflow to Santa Margarita Subbasin	~~12~~<10	~~14~~20	~~14~~10	<1%
Net Outflow Offshore	~~921~~920	1,~~061~~060	~~993~~990	15%
		Total Outflow	**6,~~688~~690**	**100%**
Change in Storage (acre-feet per year)	**Cumulative**		**Average**	
	+1,~~734~~730 acre-feet		+~~289~~290	



Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage

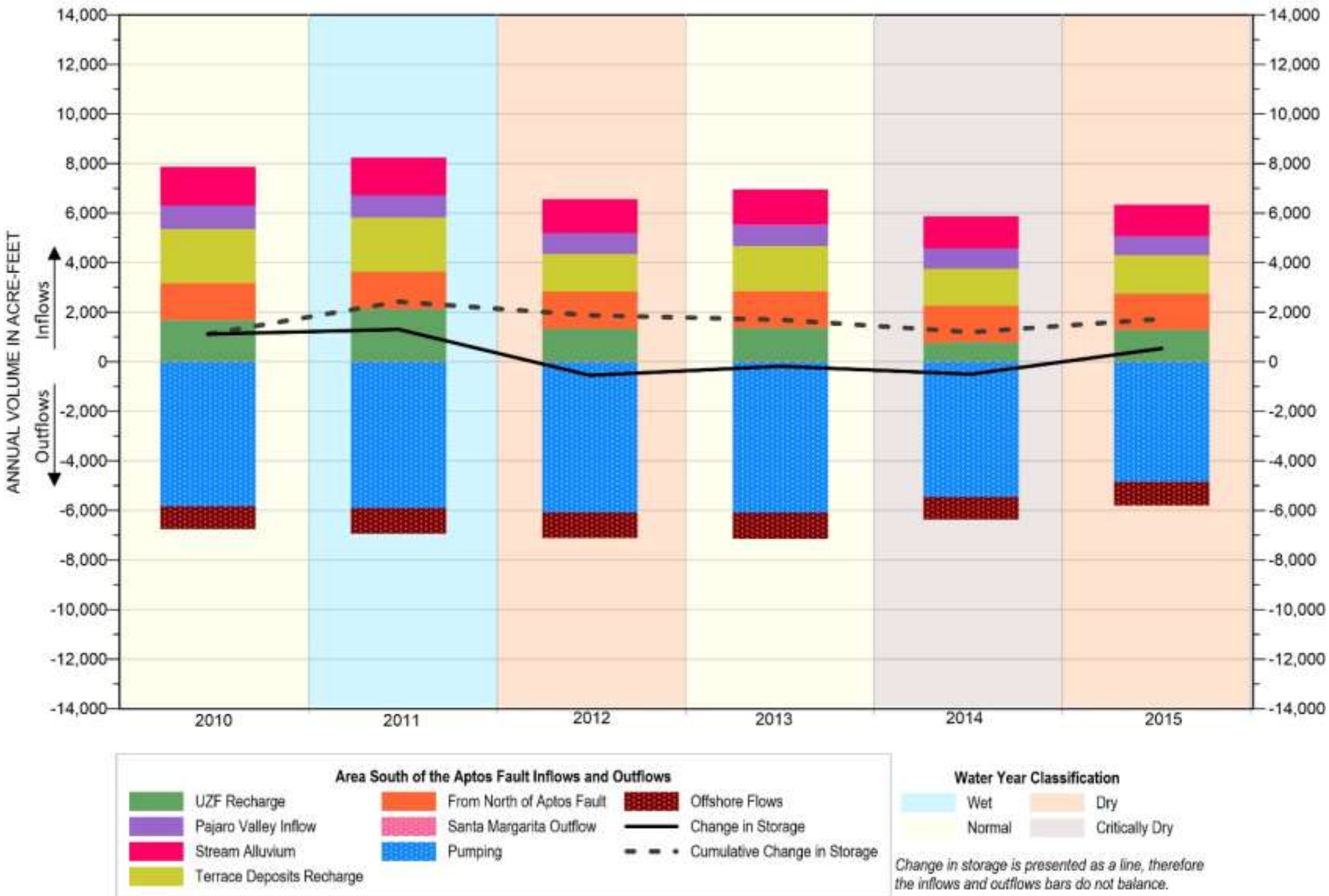


Figure 2-68. South of Aptos ~~Fault~~Area Faulting Current Annual Groundwater Budget (2010 – 2015)

~~2.2.3.6~~2.2.5.6 Projected Water Budget

SGMA regulations require the development of a projected water budget based on at least 50 years of historical data. The projected water budget is used to estimate changes in water supply, demand, and aquifer conditions in response to GSP implementation. The projected water budget covers a 54-year period from Water Years 2016 through 2069, and includes a predictive period of 53 years that starts in 2017. This projection provides a baseline that is used in the GSP to evaluate Basin impacts from GSP implementation. The water budgets included in this subsection are (1) a projected baseline water budget that does not include projects and management actions as part of GSP implementation (Baseline) and (2) a projected water budget with projects and management actions implemented as part of the GSP~~.~~ (GSP Implementation).

~~2.2.3.6.1~~2.2.5.6.1 Assumptions Used in Projected Water Budget Development

Assumptions included in the model used to estimate the projected water budget are made based on best available data to account for predicted changes in Basin climate, sea-level, projected groundwater demand, supplemental water sources, and management actions. ~~Assumptions are described~~More documentation on the projected simulations and assumptions are included in Appendix 2-I. Model assumptions for predictive simulations are summarized briefly below.

Climate

The projected water budgets account for future climate generated from a catalog of historical climate data from warm years in the Basin's past to simulate the warmer temperatures predicted by global climate change. Specifically, the Catalog Climate ~~utilizes~~uses historical data from the Santa Cruz Co-op and Watsonville Waterworks climate stations. ~~This~~This approach was recommended by the model Technical Advisory Committee (TAC) to address the uncertainty regarding precipitation forecasts in coastal California in a variety of global climate models. The catalog approach preserves the integrity of the climate data and ensures temperature and precipitation values are associated with real data. The Catalog Climate has an increase of 2.4 °F in temperature and decrease of 1.3 - 3.1 inches per year in precipitation over the long-term record at climate stations in Santa Cruz and Watsonville. There is a corresponding increase in evapotranspiration of about 6%. Appendix 2-G is a technical memorandum that describes the development of the Catalog Climate data in more detail.

In comparison to the CMIP5 ensemble of 10 Global Circulation Models (~~CGM~~GCM) often applied in California, the modeled catalog climate is slightly cooler and drier than most CMIP5 scenarios. A panel of local experts recommended the Catalog Climate approach as appropriate for Basin planning. More technical information on a comparison of climate change scenarios is contained in Appendix ~~A2-B~~2-H.

Sea-Level

Global sea-level rise is incorporated in projected water budgets because changes in sea-level impact the location of the saltwater/freshwater interface and can alter the volume and direction of flows offshore. The model includes projections from the California Ocean Protection Council and California Natural Resources Agency sea-level rise guidance (California Natural Resources Agency, 2018), which gives a range of sea-level rise predictions for Monterey based on possible greenhouse gas emission scenarios. Based on that data source, the model from which the water budgets are derived assumes around 2.3 feet of sea-level rise between 2000 and 2070.

Land Use

Future land use is assumed to remain the same as historical land use.

Projected Groundwater Demand

Historically, almost all water supply to the Basin is pumped from aquifers within the Basin. The Soquel Creek Water District and Central Water District rely solely on groundwater. The City of Santa Cruz water system relies predominantly on surface water supplies sourced from outside of the Basin, only 5% of its supply is from groundwater. Although a small component of its water supply, groundwater is a crucial component of the Santa Cruz water system for meeting peak season demands, maintaining pressure in the eastern portion of the distribution system, and for weathering periods of drought. Projected Basin water demand assumes groundwater will remain the main source of water supply, and that surface water sources within the Basin will not be used.

Projected non-municipal groundwater demand for domestic use assumes pre-drought (2012 – 2015) water demand of 0.35 acre-feet per year per household. The assumed water demand is applied to projected annual population growths of 4.2% pre-2035 and 2.1% post-2035. Groundwater demand for larger institutions such as camps, retreats, and schools, and agricultural irrigation remain the same as historical demands.

Municipal groundwater demand from the Basin is different for the projected ~~baseline~~Baseline (no projects) water budget and projected with projects and management actions water budget. This is because projects afford the MGA agencies the ability to operate wells differently.

Projected ~~baseline~~Baseline municipal groundwater demand (without projects and management actions) is based on several different assumptions:

- Central Water District - pre-drought average groundwater production from Water Year 2008 through ~~2011~~2011of 550 acre-feet per year.
- Soquel Creek Water District - 2015 Urban Water Management Plan (UWMP) projects demand to increase to 3,900 acre-feet per year after historically low

pumping achieved from 2010-2015. The 2015 UWMP projects subsequent long-term decline of demand to 3,300 acre-feet per year, but ~~these demands may have been underestimated; for example, new laws facilitating Accessory Dwelling Units have passed since 2015.~~ SqCWD has concluded that its demand projections may be underestimated when considering effects such as statewide efforts to address the housing crisis including laws facilitating accessory dwelling uses and is therefore not assuming a long-term decline in demand for planning purposes. For projected water budget, the GSP projects that Soquel Creek Water District groundwater demand will be stable~~.~~ at 3,900 acre-feet per year.

- City of Santa Cruz – projections of groundwater pumping based on City of Santa Cruz Confluence modeling to meet demand during 2016-2018. The City considers this demand appropriate for current planning because unlike most other communities in the Bay Area and California, City water demand has not increased much from restricted consumption during the 2012-2015 drought (SCWD, 2019, and M.Cubed, 2019). The GSP projects that City of Santa Cruz groundwater pumping will average approximately 350 acre-feet per year without any projects, but is assumed to vary annually based on surface water supplies.

Groundwater Management Activities

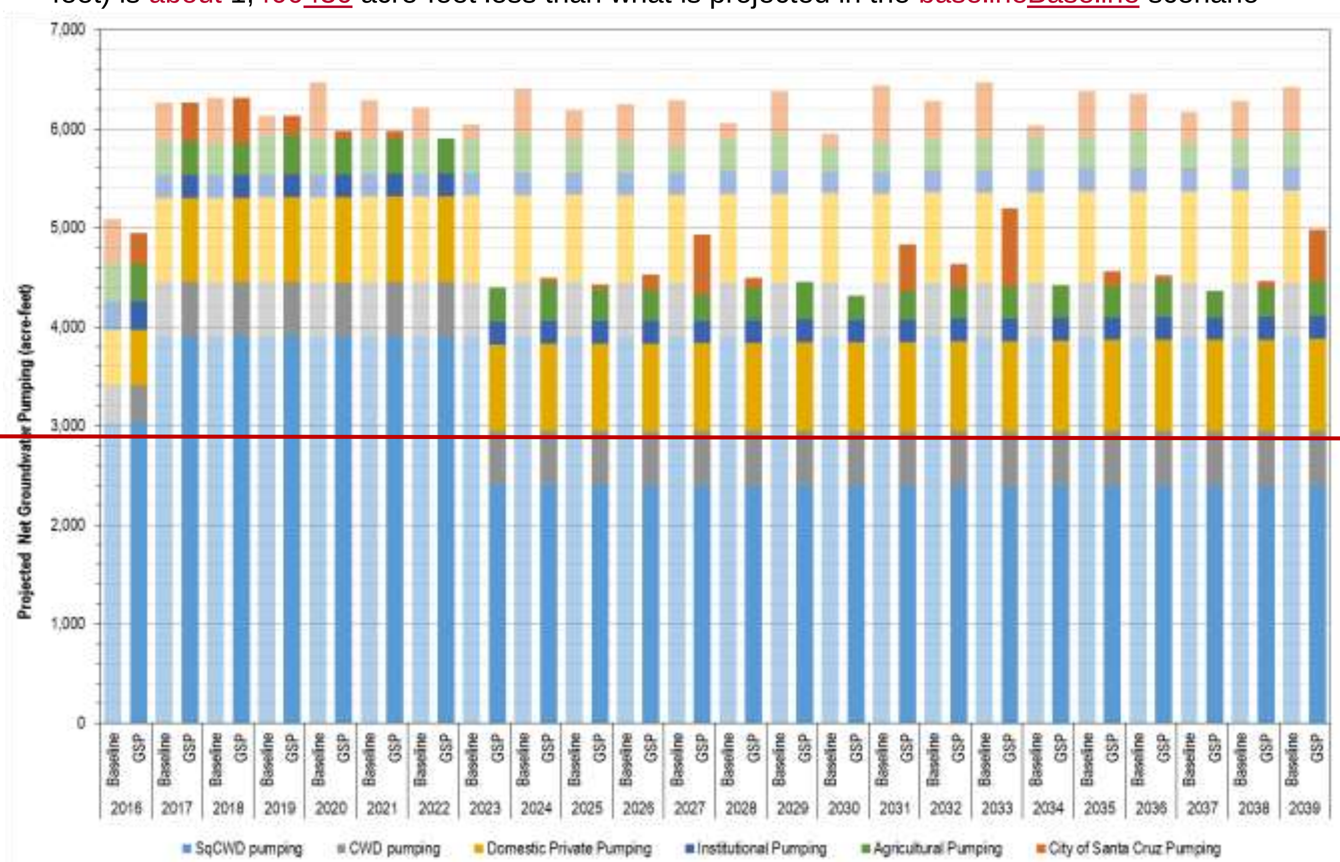
The projected water budget with projects and management actions accounts for activities to be conducted by MGA member agencies during GSP implementation. The general project types include in-lieu recharge, injection, and ~~aquifer storage and recovery (ASR).~~ASR. Projects included in the future simulations are:

- Pure Water Soquel to replenish the Basin and protect against further seawater intrusion using advanced water purification methods to purify recycled water, and

- City of Santa Cruz ASR of excess San Lorenzo River flows to meet City water shortfall (modeled as part of project feasibility study).

Management actions included are enhancements to municipal pumping distribution that are possible in combination with Pure Water Soquel.

Bar charts showing the projected net groundwater pumping for both the ~~baseline~~Baseline (transparent bars) and the scenario incorporating projects and management actions (non-transparent bars) are shown on ~~Figure 2-59~~Figure 2-69 ~~(~~for Water Years 2016 – 2039~~)~~ and Figure 2-70 ~~(~~for Water Years 2040 – 2069~~)~~.. There are no projects or management actions which would reduce demand from ~~baseline~~Baseline for Central Water District, domestic pumping, or agricultural pumping. Projected groundwater demand for the City of Santa Cruz is reduced by City of Santa Cruz ASR activities which store surplus surface water during wet years. Projected net groundwater pumping for Soquel Creek Water District is reduced significantly after the year 2023 by operation of Pure Water Soquel, which will inject approximately 1,500 acre-feet into the Purisima A and BC-unit aquifers annually. Overall, the average annual projected net pumping with projects and management actions (4,~~908~~910 acre-feet) is ~~about~~ 1,~~400~~430 acre-feet less than what is projected in the ~~baseline~~Baseline scenario



(6,~~336~~340 acre-feet).

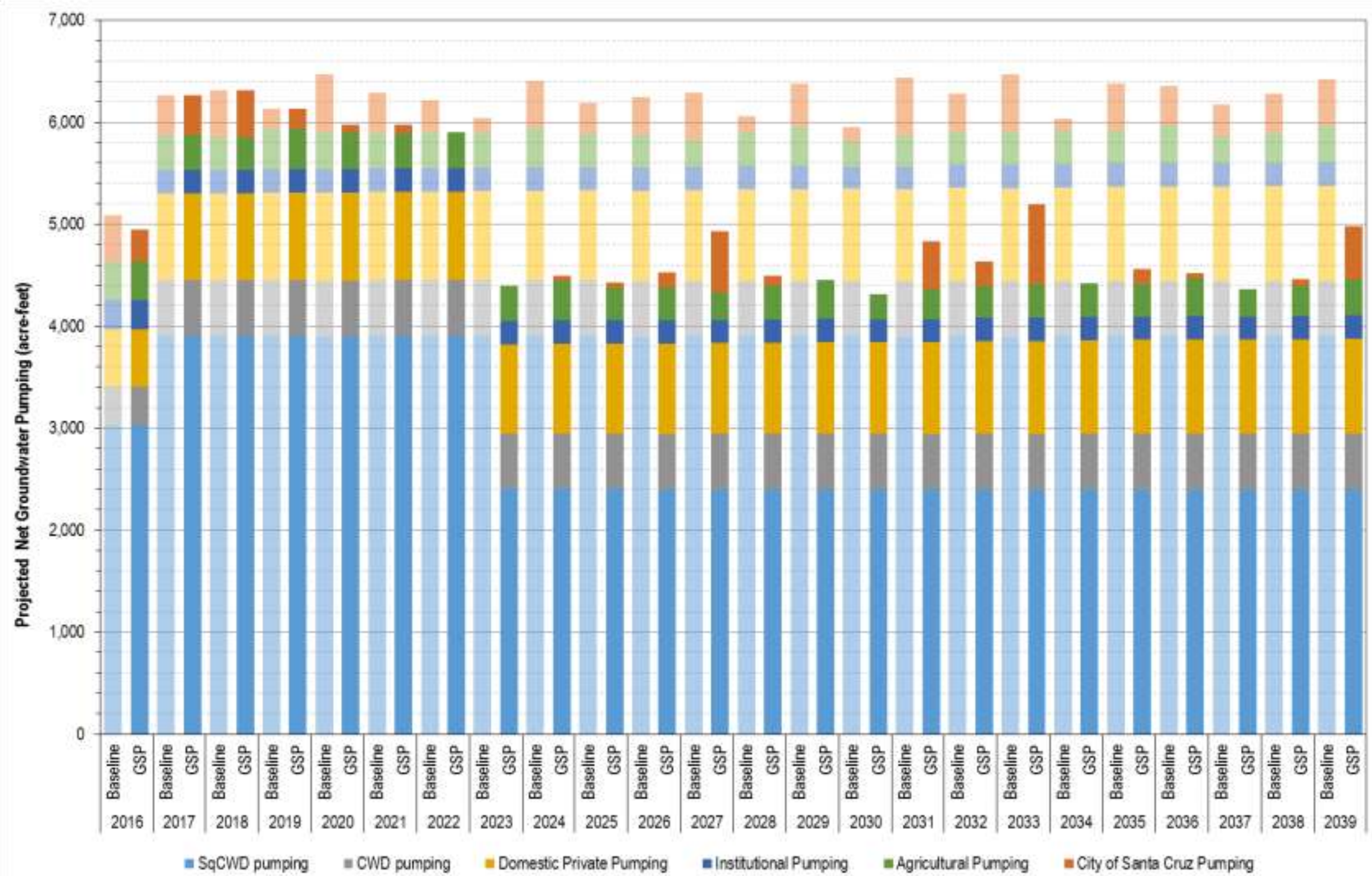


Figure 2-69. Projected Baseline ~~and with~~ vs. Projected GSP ~~Implemenation~~Implementation Net Groundwater Pumping in the Santa Cruz Mid-County Basin (2016-2039)

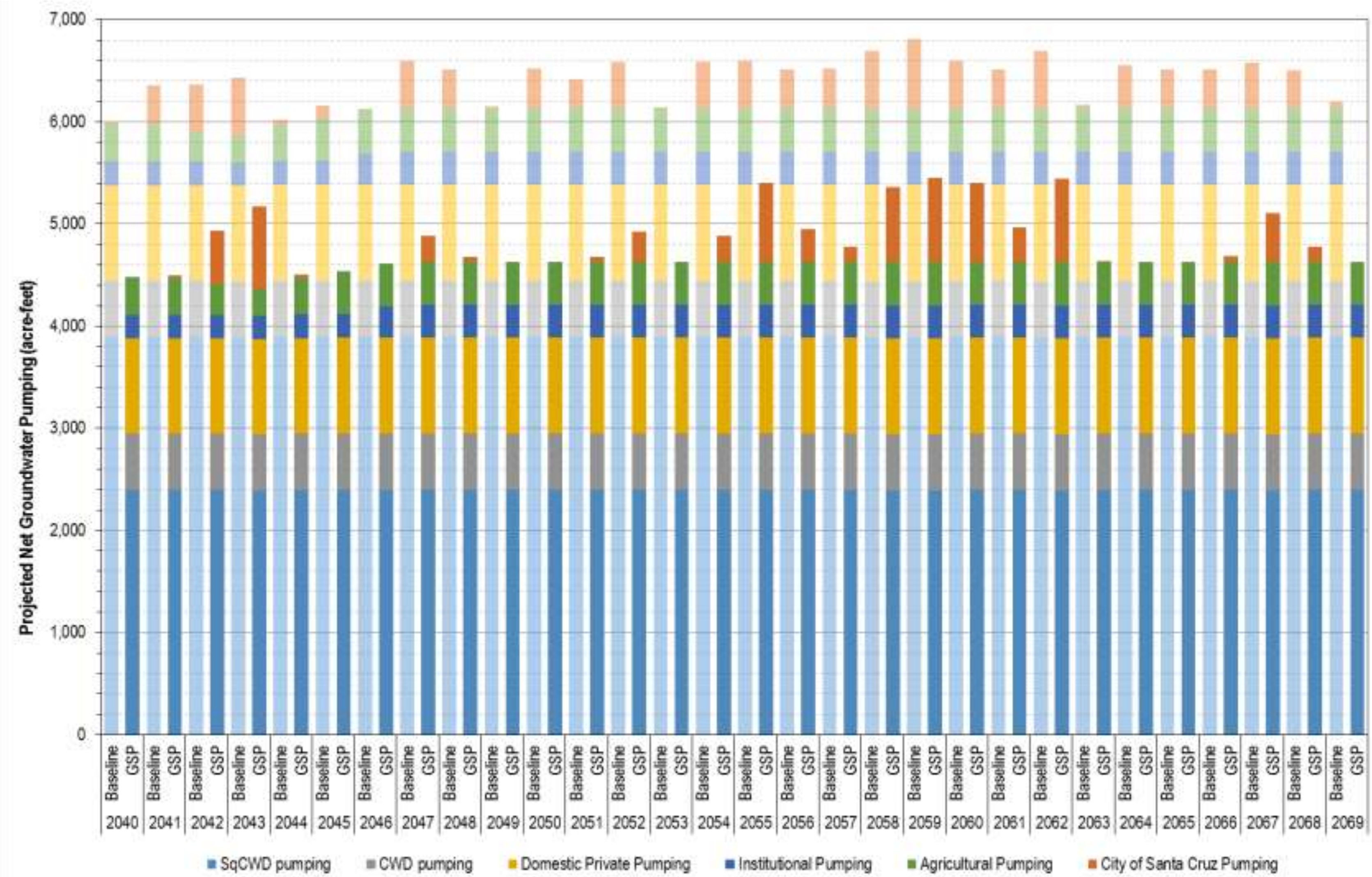


Figure 2-70. Projected Baseline ~~and with~~ vs. Projected GSP ~~Implemenation~~Implementation Net Groundwater Pumping in the Santa Cruz Mid-County Basin (2040-2069)

2.2.5.6.2 Santa Cruz Mid-County Basin Projected Surface Water Budget

Projected precipitation in the Basin is on average about 15% lower compared to the historical period. This translates to an average decrease in precipitation of just under 8,930 acre-feet annually (Table 2-10 and Table 2-22). Evapotranspiration, relative to other components, is simulated to increase by 3% (Table 2-10 and Table 2-22), which reflects higher average temperatures in the Basin over the projected period. With the decrease in precipitation and relative increase in evapotranspiration, overland flow and groundwater recharge are simulated to decrease on average by 2% and 1%, respectively. In terms of volume, it is projected that there will be 3,570 acre-feet less surface water and 2,330 acre-feet less groundwater recharge from precipitation available within the Basin (Table 2-10 and Table 2-22).

Table 2-22. Percentage Distribution of Projected Precipitation in Santa Cruz Mid-County Basin

Precipitation Budget Component	Average Annual (acre-feet)	Average Percent of Precipitation
Precipitation	87,280	100%
Evapotranspiration	60,000	69%
Overland Flow	22,030	25%
Groundwater Recharge from Precipitation	3,140	4%
Soil Moisture	2,110	2%

The relative percentages of projected surface water budget components mirror the historical budget. However, the projected surface water budget is characterized by a decrease in average surface water inflows of approximately 8,450 acre-feet per year compared with historical averages (Table 2-11 and Table 2-23). Over the projected period, total surface water inflows and outflows decrease by about 18% each, which reflects the drier climatic conditions predicted in the future. The amount of water flowing through the Basin's stream system ranges from 156,660 acre-feet to 6,270 acre-feet annually (Figure 2-71).

Despite the predicted drier conditions in the projected simulation, the average annual amount of groundwater contributing to surface water inflows will be slightly higher (280 acre-feet per year) than during the historical period due to overall higher groundwater levels predicted in response to projects and management actions.

As mentioned previously, surface water is not a significant agricultural, municipal, or domestic water source within the Basin, and is therefore not included in the projected model simulations since it is not expected that more surface water will be diverted for use in the future.

On a Basin-wide scale, the difference in average inflow and outflow surface water budget components between the projected Baseline condition and GSP Implementation with projects and management actions is only 350 acre-feet per year. However, slight decreases (<1%) in the inflow to surface water from groundwater is projected to result in relatively large increases in groundwater contribution to Soquel Creek. Starting around 2024, PWS and City ASR projects are simulated to increase groundwater inflow to Soquel Creek over the Baseline condition (Figure 2-72). This increase in baseflow reflects higher groundwater elevations throughout the Basin that supports increased creek baseflow that would not occur without those projects. As discussed in the calibration report in Appendix 2-F, the magnitude of groundwater flows to streams are not well calibrated so simulation results are only meant to demonstrate that there are expected benefits to streamflow from the projects as opposed to quantifying the benefit.

Table 2-23. Santa Cruz Mid-County Basin Projected GSP Implementation Surface Water Budget

Surface Water Budget Component	Annual Minimum	Annual Maximum	Annual Average	Average % (rounded)
Inflows (acre-feet per year)				
Overland Flow	3,750	89,840	22,040	59%
Flows from Upstream of the Basin	2,520	66,780	14,280	38%
Net Flows from Groundwater	850	1,190	1,080	3%
		Total Inflow	**37,400**	**100%**
Outflows (acre-feet per year)				
Ocean Outflow	6,870	141,570	33,580	89%
Outflow in Branciforte Creek	397	15,900	3,340	9%
Pajaro Valley Subbasin	<10	2,310	320	1%
Outflow to Carbonera Creek	20	890	160	<1%
		Total Outflow	**37,400**	**100%**

Note: ‘Groundwater Flows’ refers to flow between streams and underlying alluvium, and is distinct from ‘Stream Alluvium Recharge’ seen in groundwater budgets.

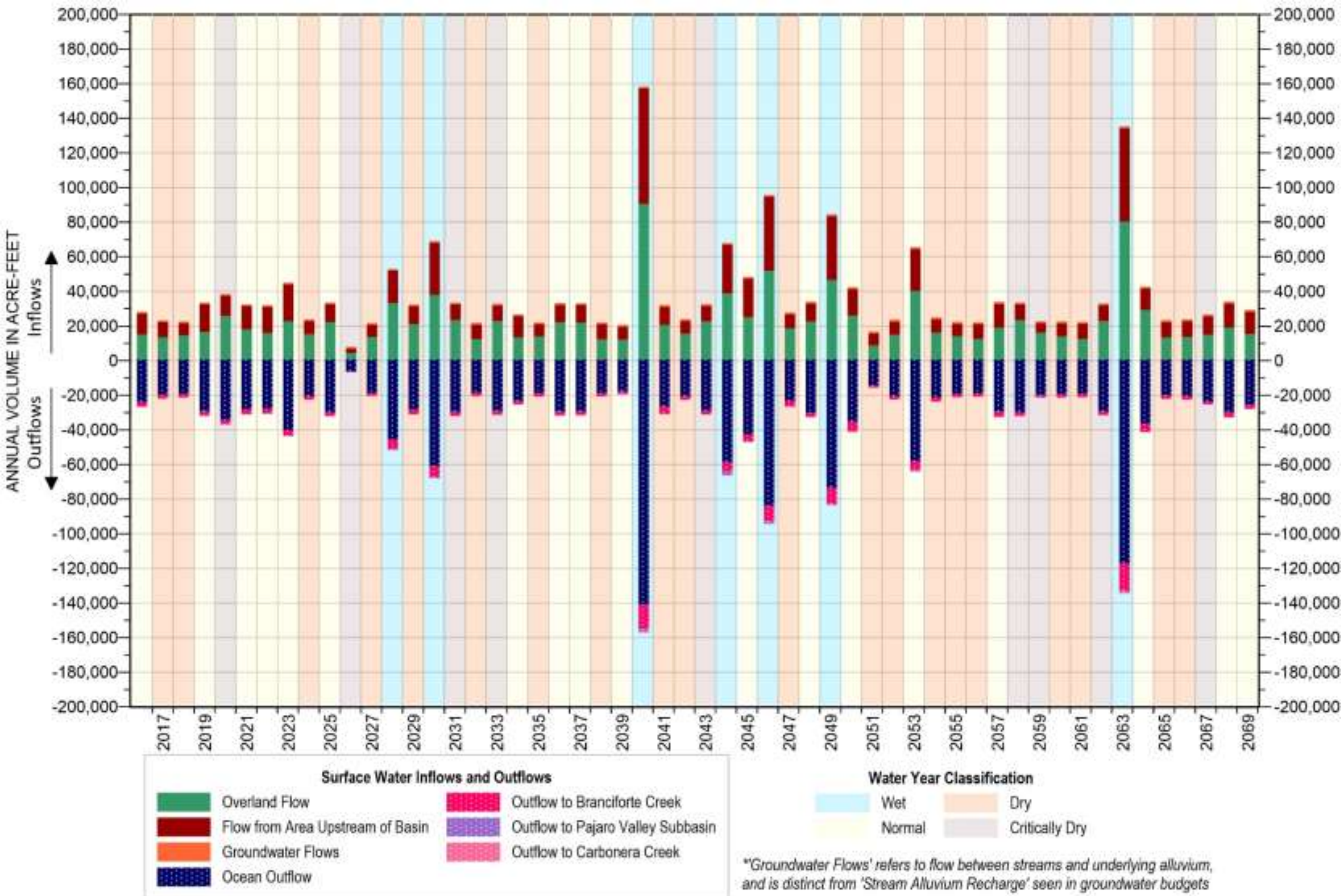


Figure 2-71. Santa Cruz Mid-County Basin Projected Annual Surface Water Budget (2016 – 2069)

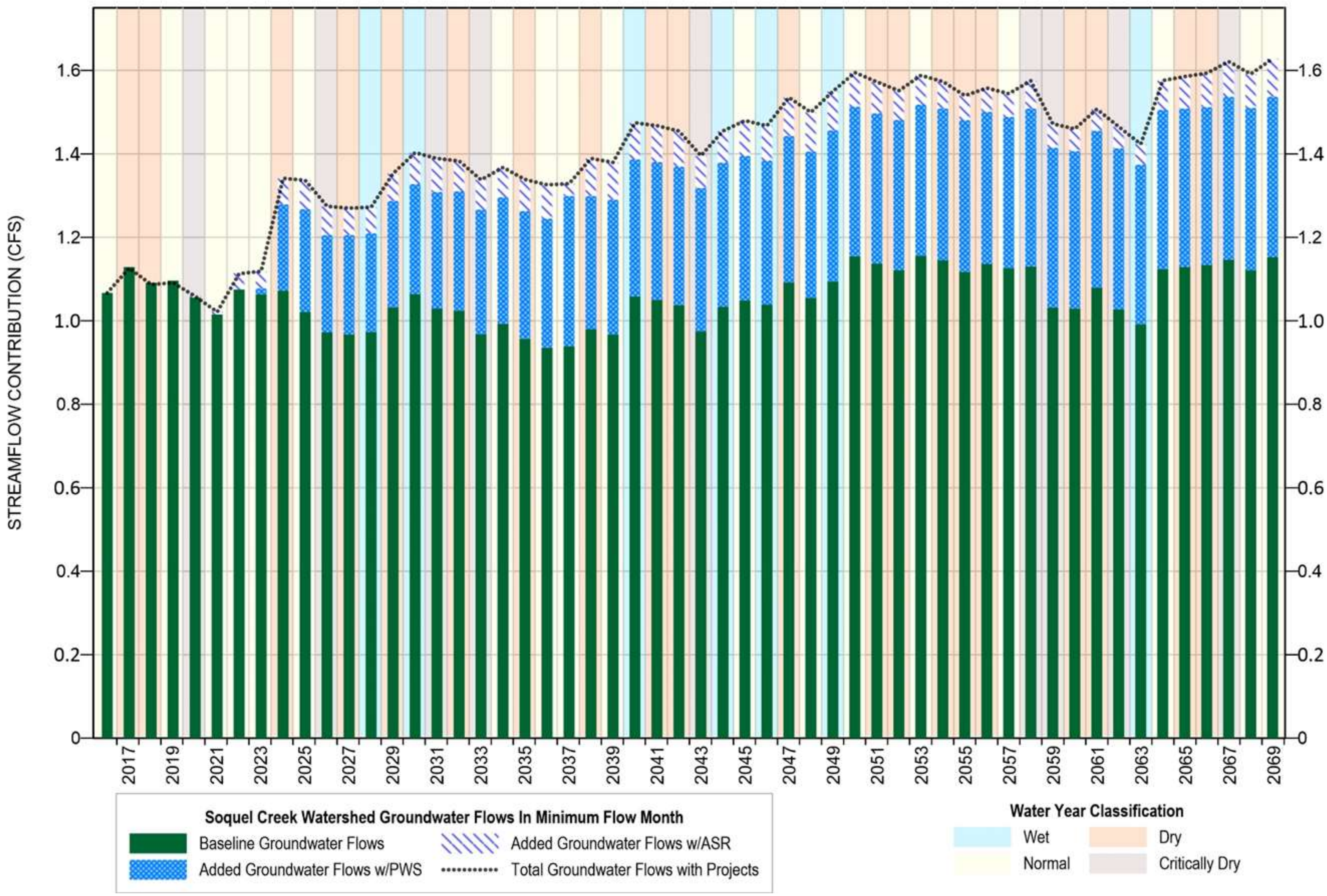


Figure 2-72. Effect of Projects and Management Actions on Soquel Creek Watershed Groundwater Contribution (2016 – 2069)

~~2.2.3.6.2~~2.2.5.6.3 Santa Cruz Mid-County Basin Projected Groundwater Budget

The projected inflow and outflow components for the projected groundwater budget are the same as the historical and current budgets, and their relative contributions are similar~~.~~ (Figure 2-66). For both projected water budgets, the catalog climate implemented to represent climate change only has three wet years over the 54-year period; reflecting overall warmer and drier conditions. This results in less natural recharge in both projected scenarios.

For the ~~baseline~~Baseline projection with no projects and management actions, groundwater inflows to the Basin are reduced by around ~~700~~200 acre-feet per year compared to current conditions and ~~2,000~~1,780 acre-feet per year compared to historical conditions. Projected groundwater pumping in the ~~baseline~~Baseline groundwater budget is almost the same as recent pumping. As a result of the projected recharge and pumping conditions, outflow to the ocean under Baseline conditions remains ~~virtually the same as~~ similar to current outflows which ~~will do little~~are not sufficient to ~~improve current~~prevent seawater intrusion. ~~The decrease is over 2,000 acre-feet annually if compared to the historical water budget period.~~

Without projects and management actions implemented to achieve groundwater sustainability (~~baseline~~Baseline scenario), it is projected the Basin will experience ~~only a very small~~a loss of groundwater in storage of ~~4,864~~3,240 acre-feet cumulatively over the fifty-four-year period. ~~Climate change results in an average decrease in projected Basin inflows of around 700 acre-feet per year. Projected groundwater pumping in the baseline groundwater budget is almost the same as recent pumping. As a result of the projected recharge and pumping conditions, outflow to the ocean remains virtually the same as current outflows which will do little to improve current seawater intrusion. However, even without projects and management actions implemented to achieve groundwater sustainability (baseline condition from Water Year 2016 - 2069), it is projected the Basin will experience only a very small loss of groundwater in storage of 4,679 acre-feet cumulatively over the fifty-four-year period.~~

With projects and management actions implemented to achieve groundwater sustainability~~,~~ (GSP Implementation), projected net pumping is reduced by 1,740 acre-feet per year because groundwater demand is offset by supplemental water injected into the Basin. This results in an increase in average groundwater outflow of ~~850~~840 acre-feet per year (an increase of ~~75~~73%) to the ocean that will ensure seawater intrusion does not move onshore farther than it is currently, ~~and will likely~~could potentially even push ~~it~~seawater intrusion back. It is projected that with projects and management actions, there will be an average annual increase in groundwater in storage of ~~170~~280 acre-feet, which equates to a cumulative gain over 54 years of ~~9,180~~18,530 acre-feet.

Table 2-24. Santa Cruz Mid-County Basin Projected Groundwater Budget Summary (2016 – 2069)

Groundwater Budget Component	Projected Baseline		Projected GSP Implementation		Difference between GSP Implementation and Baseline
	Annual Average	Average % (rounded)	Annual Average	Average % (rounded)	
Inflows (acre-feet per year)					
UZF Recharge	3,~~695~~860	~~30~~34%	3,~~693~~860	35%	~~-2~~0
Net Recharge from Stream Alluvium	1,~~014~~000	9%	~~680~~670	6%	-~~334~~330
Recharge from Terrace Deposits	1,~~702~~780	16%	1,~~657~~740	16%	-~~45~~40
Subsurface Inflow from Purisima Highlands Subbasin	4,~~575~~650	~~42~~41%	4,~~562~~650	43%	~~-13~~0
Total Inflow	**~~10,986~~11,290**	**100%**	**10,~~592~~920**	**100%**	**-~~394~~370**
Outflows (acre-feet per year)					
Pumping	6,~~193~~190	~~50~~55%	4,450	43%	-1,~~742~~740
Subsurface Outflow to Santa Margarita Subbasin	~~203~~210	2%	~~203~~210	2%	0
Net Subsurface Outflow to Pajaro Valley Subbasin	3,~~563~~670	~~35~~33%	3,~~819~~920	37%	~~257~~250
Net Outflow Offshore	1,~~111~~150	~~13~~10%	1,~~950~~990	19%	840
Total Outflow	**11,~~070~~220**	**100%**	**10,~~422~~570**	**100%**	**-~~648~~650**
Change in Storage (acre-feet per year)	**Average**	**Cumulative**	**Average**	**Cumulative**	**Average**
	~~-87~~+70	-~~4,679~~3,240 acre-feet	+~~170~~350	+~~9,180~~18,530 acre-feet	+~~254~~280

~~Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage~~

Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage

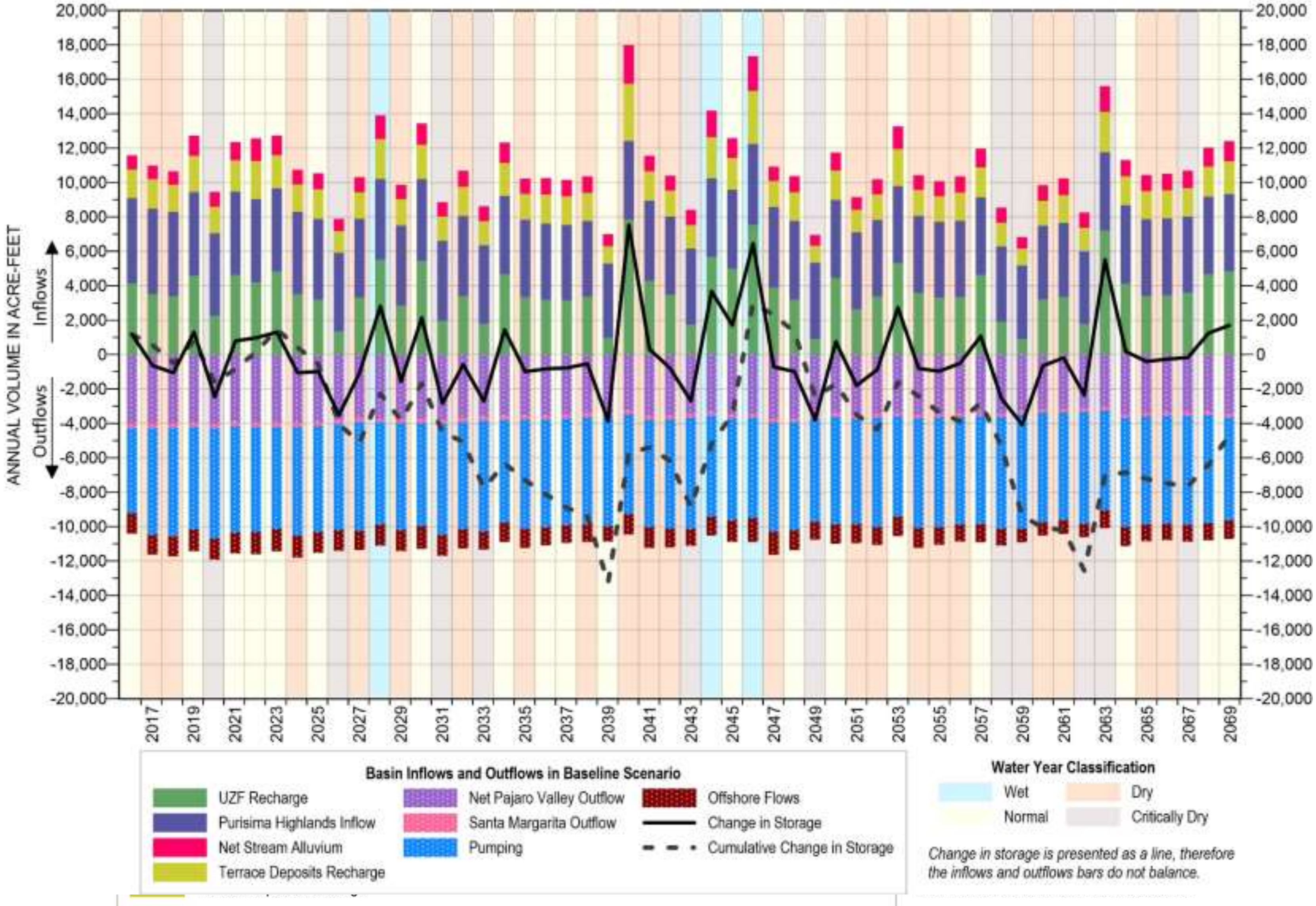


Figure 2-73. Santa Cruz Mid-County Basin Projected Baseline Annual Groundwater Budget (2016 – 2069)

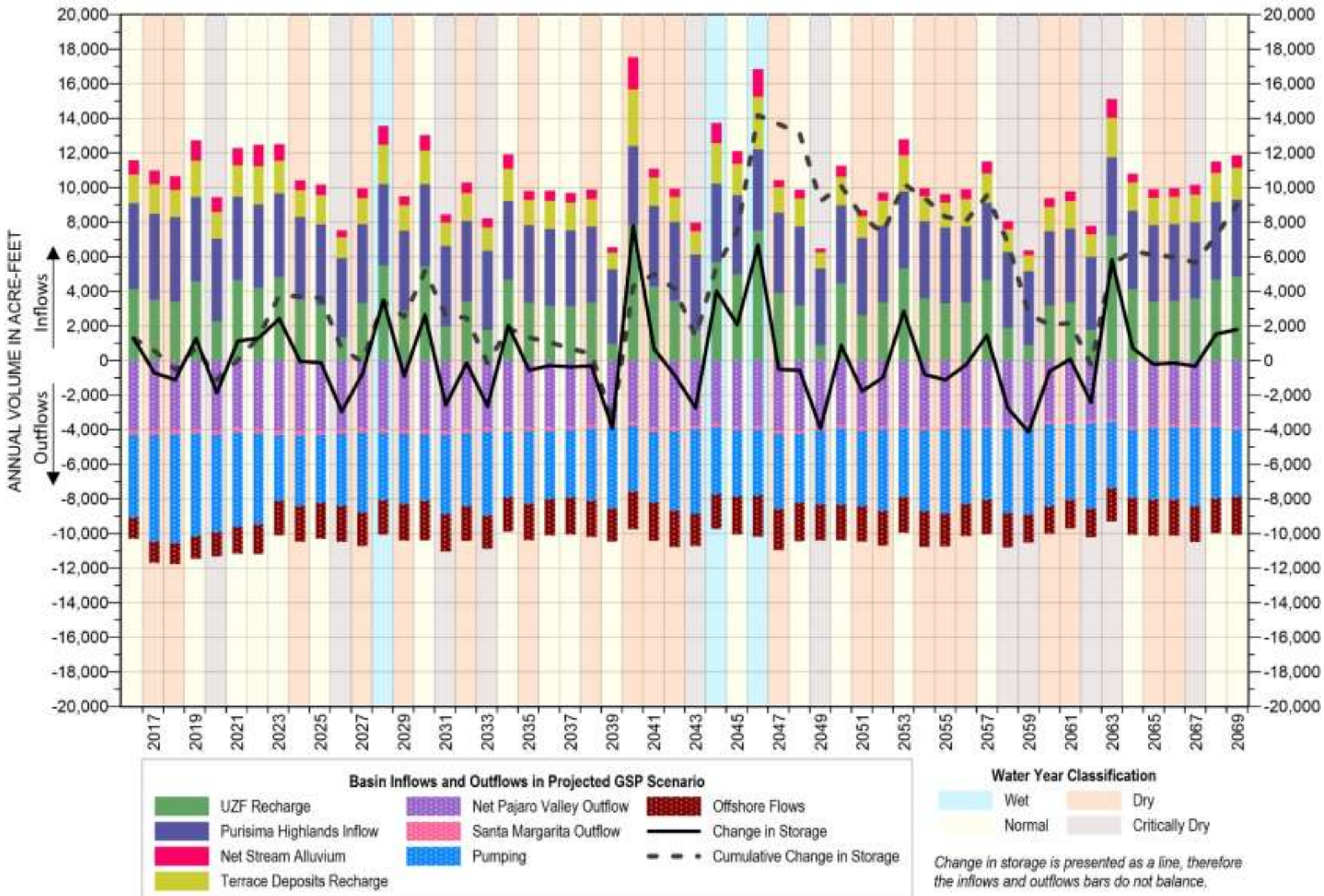


Figure 2-74. Santa Cruz Mid-County Basin Projected GSP Implementation Annual Groundwater Budget (2016 – 2069)

~~2.2.3.6.3~~2.2.5.6.4 North of Aptos ~~Fault~~Area Faulting Projected Groundwater Budget

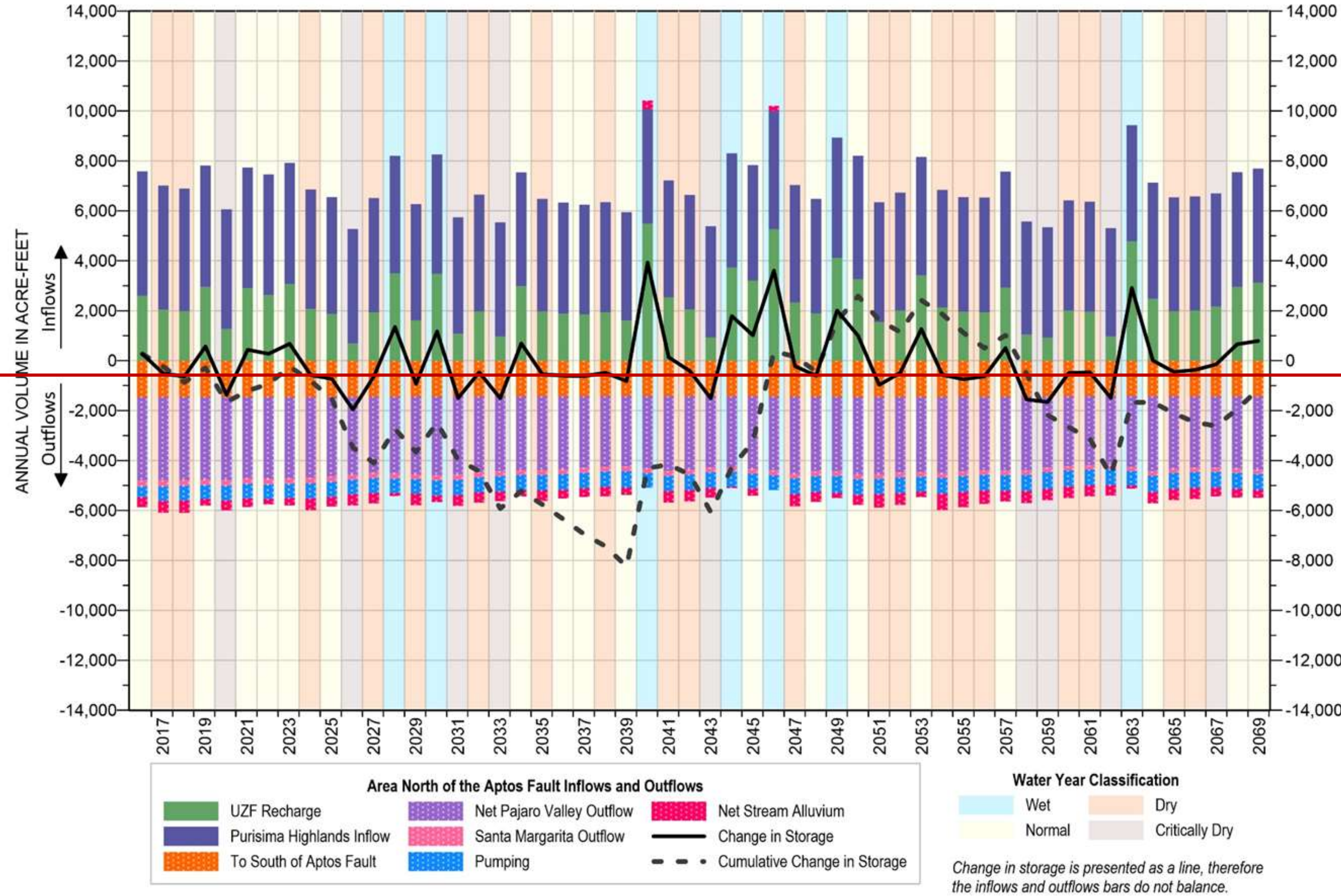
In both the projected groundwater budgets for the area north of the Aptos ~~Fault~~area faulting, the inflow and outflow components occur in relatively similar proportions to the historical period (Table 2-14). Both inflows (UZF recharge and inflow from Purisima Highlands) ~~are decreased substantially~~decrease due to the drier climate, amounting to ~~1,000~~970 acre-feet less in average annual inflow. Similarly, outflows ~~are~~ also ~~decreased~~decrease by about ~~1,000~~970 acre-feet when compared to the historical average. While all groundwater outflows ~~decreased~~decrease slightly, subsurface outflow to Pajaro Valley decreases by almost ~~750~~660 acre-feet annually (Table 2-14~~)..~~).

In the ~~baseline~~Baseline projection, an average loss of ~~93~~groundwater in storage of 20 acre-feet annually culminates in a total loss of nearly ~~5,000~~1,140 acre-feet over the 54-year projected period. With projects and management actions, the area North of the Aptos ~~Fault~~area faulting experiences ~~only 17 acre-feet less of a loss~~an average increase in groundwater in storage ~~(average~~ of ~~72~~30 acre-feet annually, culminating in a total ~~loss~~gain of ~~3,898~~1,710 acre-feet by 2069~~).~~. The difference may be attributable to overall increases in groundwater elevations in the area south of the Aptos ~~Fault~~area faulting where GSP projects are implemented. The increase groundwater elevations may reduce the hydraulic gradient across the Aptos ~~Fault~~area faulting thereby resulting in less outflow to the area south of the fault (Table 2-14).

Table 2-25. North of Aptos ~~Fault~~Area Faulting Projected Groundwater Water Budget Summary (2016 – 2069)

Groundwater Budget Component	Projected Baseline		Projected GSP Implementation		Difference between GSP Implementation and Baseline ~~and GSP~~
	Annual Average	Average % (rounded)	Annual Average	Average % (rounded)	
Inflows (acre-feet per year)					
UZF Recharge	2,~~268~~380	33%	2,~~268~~380	33%	0
Subsurface Inflow from Purisima Highlands	4,~~575~~650	67%	4,~~562~~650	67%	~~-13~~0
Total Inflow	**~~6,843~~7,030**	**100%**	**~~6,830~~7,030**	**100%**	**~~-13~~0**
Outflows (acre-feet per year)					
Pumping	~~611~~610	~~10~~9%	~~611~~610	9%	0
Discharge to Streams	~~341~~360	5%	~~346~~350	5%	~~5~~-10
Subsurface Outflow to Santa Margarita Subbasin	190	3%	190	3%	0
Net Subsurface Outflow to Pajaro Valley Subbasin	4,~~369~~450	~~62~~63%	4,~~371~~450	63%	2
Subsurface Outflow to South of Aptos ~~Fault~~Area Faulting	1,~~421~~440	20%	1,~~385~~400	20%	-~~36~~40
Total Outflow	**~~6,931~~7,050**	**100%**	**~~6,902~~7,000**	**100%**	**-~~29~~30**
Change in Storage (acre-feet per year)	**Average**	**Cumulative**	**Average**	**Cumulative**	**Average**
	-~~89~~20	- ~~4,999~~1,140 acre-feet	~~-72~~30	~~-3,898~~ +1,710 acre-feet	+~~17~~50

Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage



~~Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage~~

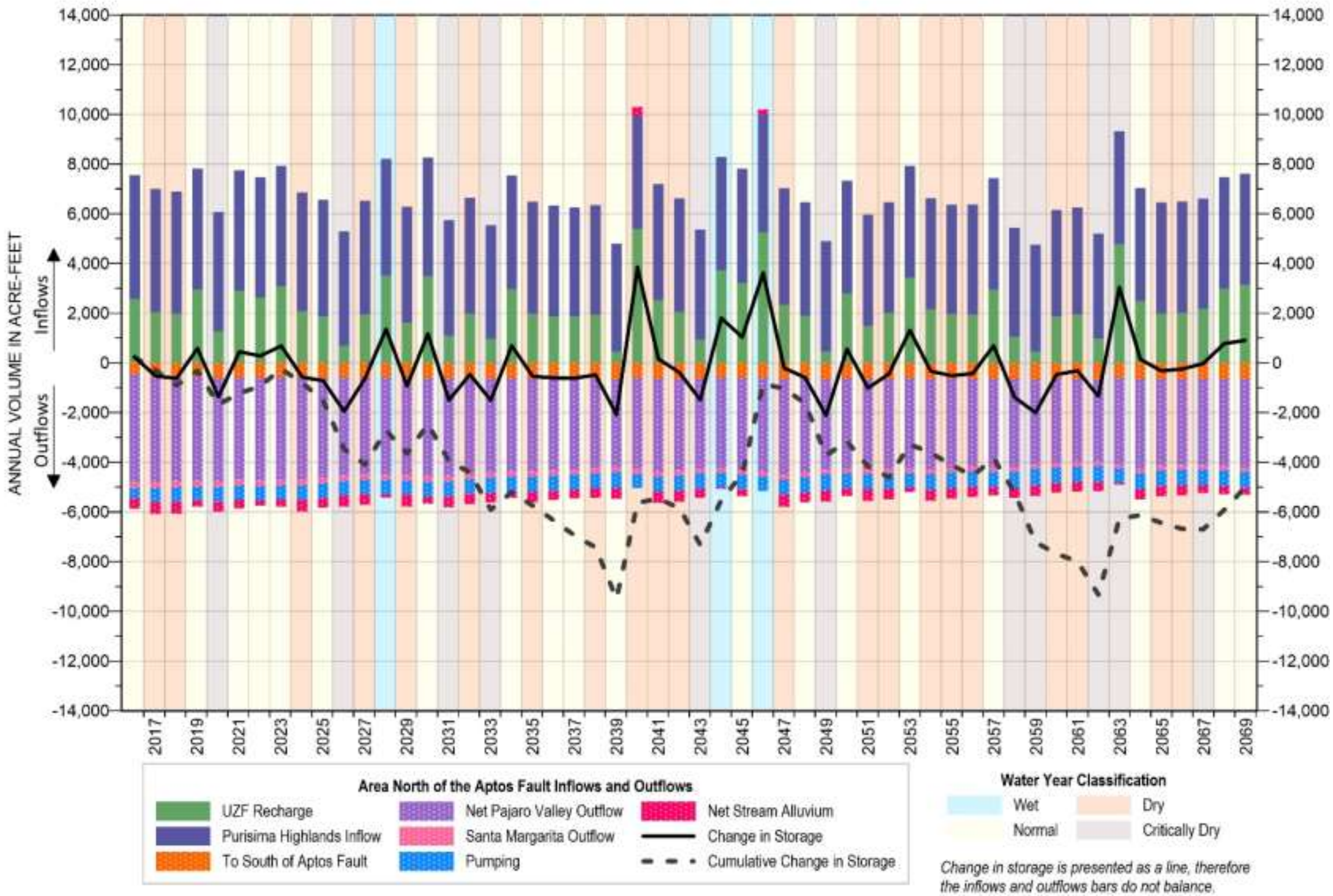


Figure 2-75. North of Aptos ~~Fault~~Area Faulting Projected Baseline Annual Groundwater Budget (2016 – 2069)

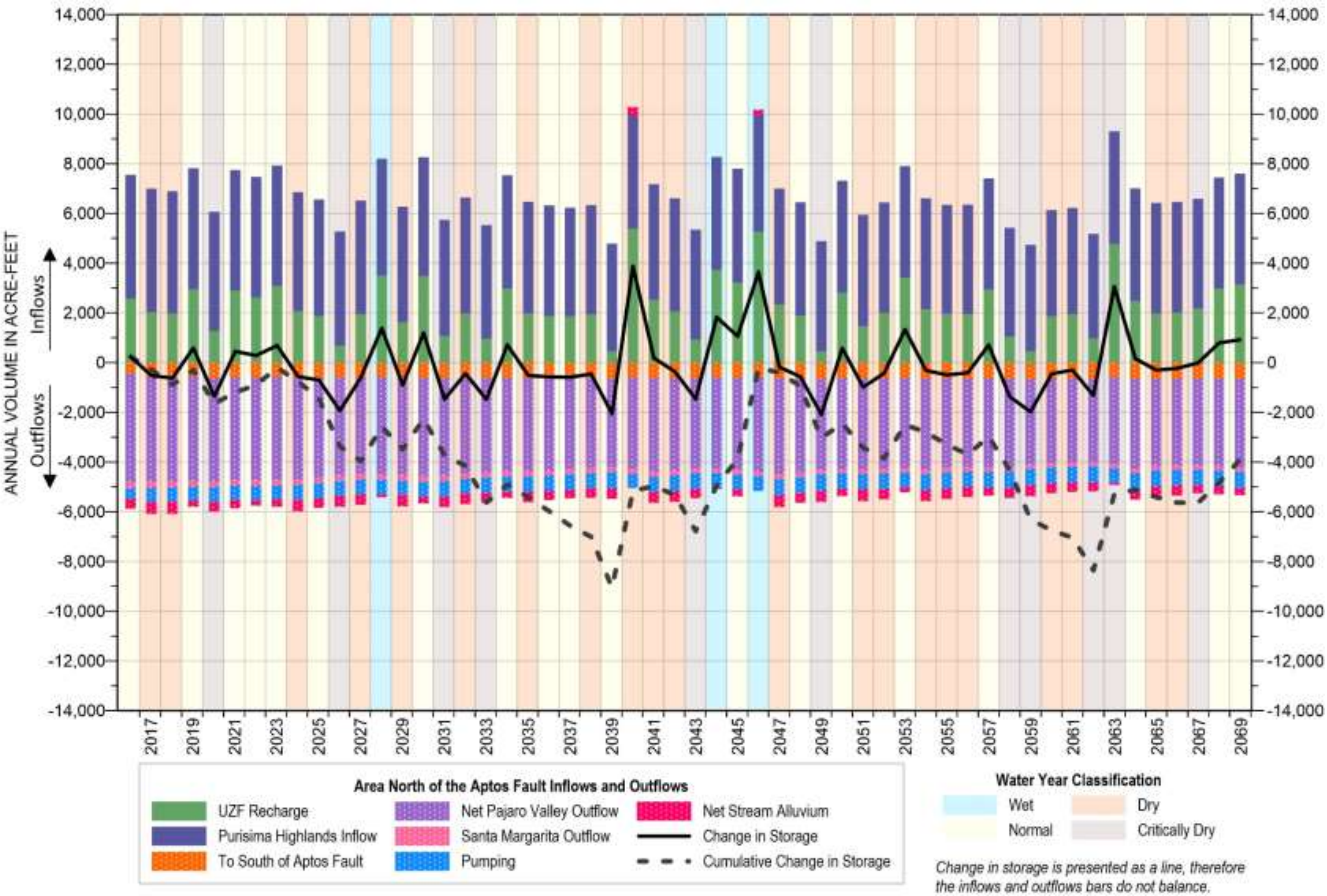


Figure 2-76. North of Aptos ~~Fault~~Area Faulting Projected GSP Implementation Annual Groundwater Budget (2016 – 2069)

~~2.2.3.6.4~~2.2.5.6.5 South of Aptos ~~Fault~~Area Faulting Projected Groundwater Budget

The relative proportions of projected groundwater inflow and outflow components for the area south of the Aptos ~~Fault~~area faulting are very similar to the historical and current periods. All inflows ~~are decreased~~decrease slightly due to the drier and warmer climate~~, with overall natural recharge reduced by more than 1,000 acre-feet~~ (~~Table 2-20). Subsurface inflow from neighboring basins is also decreased by approximately 300 acre-feet annually.~~Table 2-15 and Table 2-26). Groundwater pumping is decreased by about 1,~~600~~130 acre-feet annually in the ~~baseline~~Baseline projection when compared to the historical time period~~, due to coordinated~~ because of improved groundwater management practices and water conservation.

In the projected GSP Implementation scenario, pumping is further decreased by 1,~~711~~740 acre-feet per year from Baseline pumping because of projects that provide supplemental water as a supply source (Table 2-26~~). Offshore~~). With GSP Implementation, offshore flows are increased when compared to ~~both~~ the historical~~ and~~, current~~ water~~, and Baseline budgets~~, which~~. These increased offshore flows reflects higher groundwater elevations within the Basin~~. In the baseline projection~~ as a result of projects and management actions.

Under both Baseline and GSP Implementation projections, the area south of the Aptos ~~Fault is well balanced with a small increase~~area faulting is simulated to have increases in groundwater in storage ~~predicted of 5 acre-feet per year.~~(Table 2-26). In the ~~projected GSP~~Baseline scenario, ~~and~~an average annual gain in storage of ~~242~~70 acre-feet per year creates ~~about 12,907~~4,380 acre-feet of cumulative storage by 2069~~ (Table 2-20).~~

. In the projected GSP Implementation scenario, an average annual gain in storage of 320 acre-feet per year creates about 17,100 acre-feet of cumulative storage by 2069.

Table 2-26. South of Aptos ~~Fault~~Area Faulting Projected Groundwater Water Budget Summary (2016 – 2069)

Groundwater Budget Component	Projected Baseline		Projected GSP Implementation		Difference between GSP Implementation and Baseline
	Annual Average	Average % (rounded)	Annual Average	Average % (rounded)	
Inflows (acre-feet per year)					
UZF Recharge	1,~~427~~480	22%	1,~~425~~480	24%	~~-2~~0
Net Recharge from Stream Alluvium	1,~~356~~360	20%	1,~~026~~030	17%	-330
Recharge from Terrace Deposits	1,~~702~~780	25%	1,~~657~~740	27%	-~~45~~40
Subsurface Inflow from Pajaro Valley Subbasin	~~806~~780	11%	~~552~~530	9%	-~~254~~250
Subsurface Flow from North of Aptos ~~Fault~~Area Faulting	1,~~421~~430	22%	~~1385~~1,390	23%	-~~36~~40
Total Inflow	**6,~~711~~830**	**100%**	**6,~~045~~170**	**100%**	**-~~666~~660**
Outflows (acre-feet per year)					
Pumping	5,~~581~~580	83%	3,840	66%	-1,~~741~~740
Net Subsurface Outflow to Pajaro Valley Subbasin	~~13~~10	<1%	~~13~~10	<1%	0
Net Outflow Offshore	1,~~110~~150	17%	~~1,950~~2,000	34%	~~840~~850
Total Outflow	**6,~~706~~740**	**100%**	**5,~~802~~850**	**100%**	**-~~904~~890**
	Average	**Cumulative**	**Average**	**Cumulative**	**Average**
Change in Storage (acre-feet per year)	+~~5~~70	+~~124~~4,380 acre-feet	+~~242~~320	+~~12,907~~17,100 acre-feet	+~~237~~390

Note: all values are rounded to the nearest foot. This causes slight discrepancies between average and cumulative change in groundwater in storage

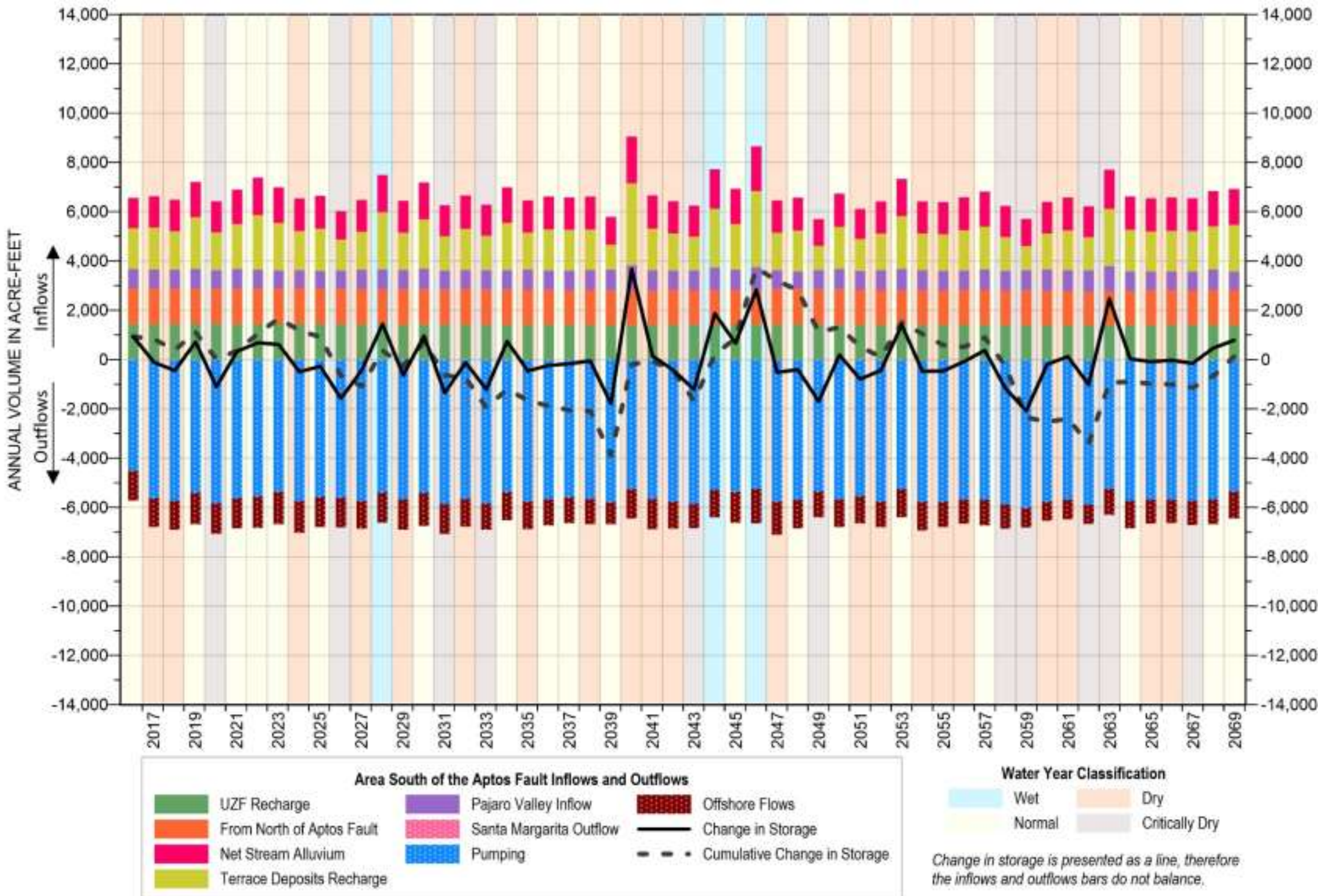


Figure 2-77. South of Aptos ~~Fault~~Area Faulting Projected Baseline Annual Groundwater Budget (2016 – 2069)

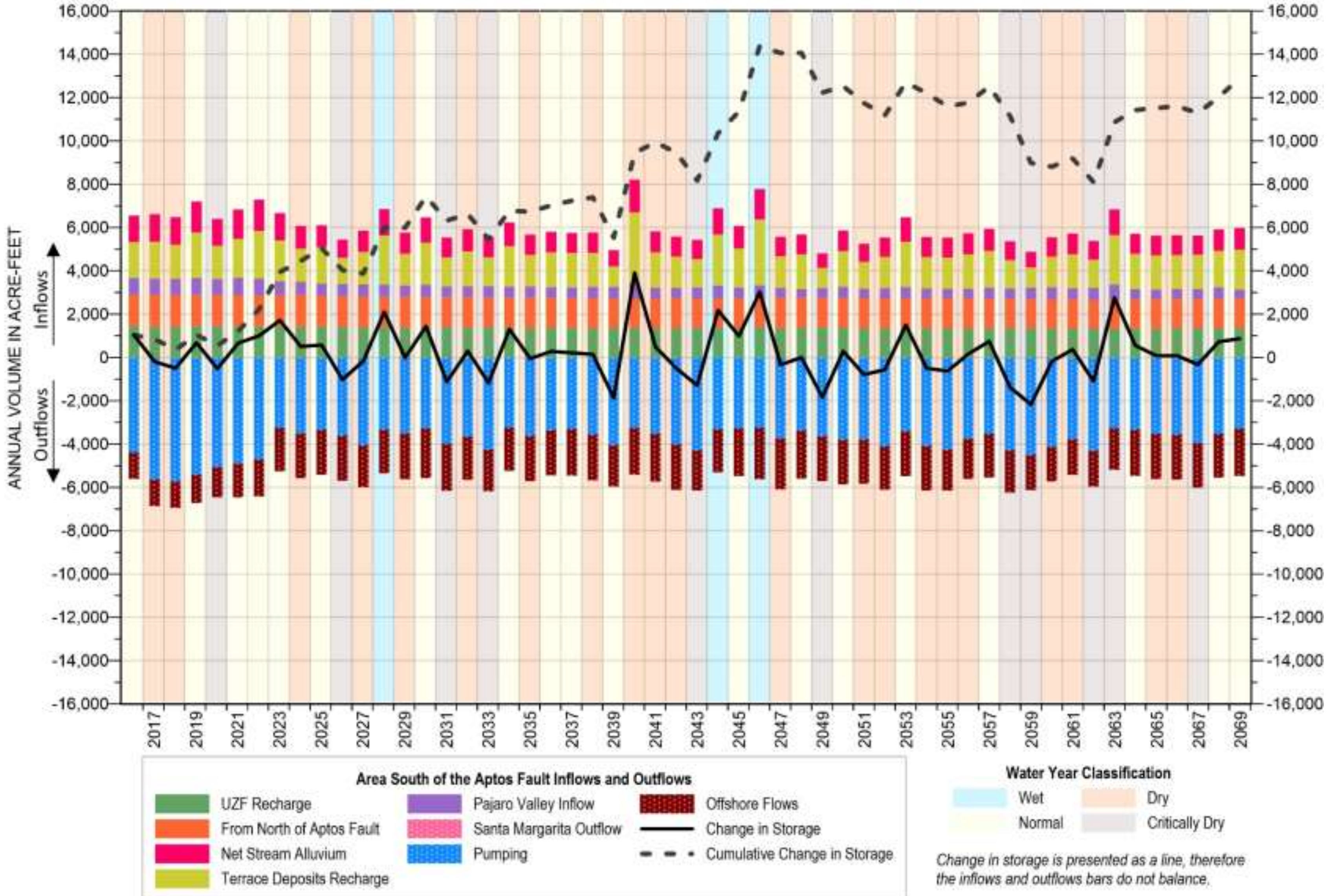


Figure 2-78. South of Aptos ~~Fault~~Area Faulting Projected ~~GSPAnnual~~GSP Implementation Annual Groundwater Budget (2016 – 2069)

~~2.2.3.7~~2.2.5.7 Projected Sustainable Yield

The projected sustainable yield is the amount of net Basin pumping that can occur while being able to avoid undesirable results for the applicable sustainability indicators described in Section 3. Section 4 describes the expected benefits of Soquel Creek Water District's Pure Water Soquel project and the City of Santa Cruz's Aquifer Storage and Recovery project as preventing undesirable results in the Basin. Therefore, once the projects are implemented, net Basin pumping is planned to be within the sustainable yield.

The sustainable yield is higher than the net Basin pumping planned with project implementation because the projects have goals beyond achieving minimum thresholds that define undesirable results. Section 4 shows that the projects have expected benefits of achieving or approaching measurable objectives beyond the minimum thresholds that define undesirable results.

To estimate the sustainable yield that is higher than planned net Basin pumping but still avoids undesirable results, sensitivity model runs were conducted to test whether undesirable results would still be avoided if injection was reduced and/or pumping increased at municipal wells. The following summarizes the conclusions of the sensitivity model runs that inform the estimated sustainable yield.

- Long term net injection by City ASR develops a drought supply, but is not necessary for avoiding undesirable results. Reducing pumping at the City's Beltz wells can avoid undesirable results.
- Pumping reductions at Soquel Creek Water District's Garnet and O'Neill Ranch wells planned as part of the Pure Water Soquel project to meet measurable objectives are not necessary to meet minimum thresholds and avoid undesirable results.
- Planned injection at Pure Water Soquel seawater intrusion prevention wells help meet measurable objectives, but lower injection amounts can raise groundwater levels to avoid undesirable results.

Based on the sensitivity model runs, average pumping and injection at municipal pumping that avoid undesirable results is estimated and combined with projected non-municipal pumping to estimate sustainable yield for each of the following aquifer groups:

- Aromas Red Sands aquifer and Purisima F aquifer units,
- Purisima DEF, BC, A, and AA aquifer units, and
- Tu aquifer.

The aquifer groupings are based on how production wells are typically screened through multiple aquifers. The full rationale for the aquifer grouping is provided in Section 3.5.1: Undesirable Results - Reduction of Groundwater Storage.

There may be other combinations of injection and pumping using planned infrastructure or other combinations of projects that can avoid undesirable results. Other combinations would likely result in different estimates of sustainable yield for the aquifer groupings. The estimates of sustainable yield presented here are appropriate for use as minimum thresholds for the reduction in groundwater storage indicator in this GSP because they are estimated to avoid undesirable results and are achievable with the planned projects.

The sustainable yield for each of the aquifer groups and the entire Basin is presented in Table 2-27. The overall projected Basin sustainable yield is 4,870 acre-feet per year, which is just over 1,000 acre-feet less than what was pumped from 2010 to 2015.

Table 2-27. Projected Sustainable Yield

Aquifer Group	Sustainable Yield (acre-feet per year)
Aromas Red Sands and Purisima F	1,650
Purisima DEF, D, BC, A and AA	2,290
Tu	930
Total	**4,870**

~~2.2.4~~2.2.6 Management Areas

SGMA allows groundwater sustainability agencies to define one or more management areas within a groundwater basin if the agency determines that the creation of management areas will facilitate implementation of its GSP. Management areas may define different minimum thresholds and be operated to different measurable objectives than the basin at large, provided that undesirable results are defined consistently throughout the basin.

The GSP Advisory Committee and MGA technical staff considered whether or not to recommend the creation of management areas within the Basin during its meeting #12 on December 12, 2018. MGA technical staff outlined four potential management areas for the committee to consider within the Basin and the reasoning associated with each potential management area.

The GSP Advisory Committee considered the following management areas, and chose to recommend against management areas at this time.

1. **Inland Private Well Area**: Management area could be warranted in inland areas where less frequent monitoring is required because ~~private~~non-municipal domestic groundwater use has less influence on Basin sustainability, most notably seawater intrusion. The Committee discussed the potential impacts of ~~private~~non-municipal domestic groundwater use impacting nearby inland surface waters. Additional monitoring of sustainable management criteria for interconnected surface-water ~~depletions~~depletion

specified in Section 3.9 will likely indicate if further management actions are needed, thus creation of a management area is not required at this time.

2. **Aromas Red Sands Area**: Management area could be warranted where seawater intrusion currently occurs and different sustainable management criteria are set for this area. The Committee discussed that the Aromas Red Sands Area is hydraulically linked to the Pajaro Valley Subbasin and the MGA does not have sole influence over groundwater levels through its management actions. Ongoing monitoring in this area may require additional management actions and inter-basin coordination to address seawater intrusion in this area, but the Committee agreed that creation of a management area is not required at this time.

3. **Area of Municipal Groundwater Production**: Management area could extend one to two miles inland along the majority of the coastline of the Basin where all municipal wells are located that influence coastal groundwater levels. This area also includes larger institutional groundwater users: Cabrillo College and Seascape Golf Course. The Committee was asked to consider extending a management area inland to 50 feet above mean sea level groundwater elevation because this area is the most vulnerable to seawater intrusion and pumping in this area has the greatest impact on coastal groundwater levels. It is also the area where supplemental water supply projects are most likely to be implemented. While the Committee agreed that ongoing groundwater monitoring was necessary the Committee agreed that creation of a management area is not required at this time.

4. **Alluvial Channels of Major Creeks**: Management area could be warranted if pumping wells connected to shallow alluvium require the future installation of meters to monitor groundwater extractions that may influence creek baseflows. While the Committee agreed that this is an example of how a certain area may require a specific management approach, the Committee agreed that creation of a management area is not required at this time.

Management areas were not recommended because the overall sustainability goals (minimum thresholds and measurable objectives) apply to the entire MGA Basin. These goals are specifically defined for each sustainability indicator and each representative monitoring location. Because representative monitoring locations and monitoring requirements are set specifically for each sustainability indicator, the technical staff and the GSP Advisory Committee found no additional benefit to establishing separate management areas within the Basin.

REFERENCES

All references are located in Section 6

APPENDICES

Appendices are located on the MGA website both individually and within a compiled appendices document.

~~GSP~~Section 3 Contents

Tables

Figures

~~Appendices~~

3 SUSTAINABILITY MANAGEMENT CRITERIA

This section defines the conditions that direct sustainable groundwater management in the Santa Cruz Mid-County Basin, discusses the process by which the MGA characterizes undesirable results, and establishes minimum thresholds and measurable objectives for each sustainability indicator. The undesirable results, minimum thresholds, and measurable objectives define the Basin's future conditions and commits the MGA to meet these objectives. Defining Sustainable Management Criteria (SMC) requires a significant level of analysis and scrutiny, and this section includes explanation of how SMC were developed and how they influence all beneficial uses and users of groundwater.

3.1 Sustainability Goal

As required by the SGMA regulations, the MGA developed a sustainability goal for the Basin, which is to:

> Manage the groundwater Basin to ensure beneficial uses and users have access to a safe and reliable groundwater supply that meets current and future Basin demand without causing undesirable results ~~and~~to:

- ~~Ensures~~Ensure groundwater is available for beneficial uses and a diverse population of beneficial users;
- ~~Protects~~Protect groundwater supply against seawater intrusion;
- ~~Prevents~~Prevent groundwater overdraft within the Basin and resolves problems resulting from prior overdraft;
- ~~Maintains~~Maintain or ~~enhances~~enhance groundwater levels where groundwater dependent ecosystems exist;
- ~~Maintains~~Maintain or ~~enhances~~enhance groundwater contributions to streamflow;
- ~~Supports~~Ensure operational flexibility within the Basin by maintaining a drought reserve;
- Support reliable groundwater supply and quality to promote public health and welfare;
- ~~Ensures operational flexibility within the Basin by maintaining a drought reserve;~~
- ~~Accounts~~Account for changing groundwater conditions related to projected climate change and sea level rise in Basin planning and management;~~ and,~~
- ~~Does~~Do no harm to neighboring groundwater basins in regional efforts to achieve groundwater sustainability.

3.2 Sustainable Management Criteria

This section defines the groundwater conditions that constitute sustainable groundwater management, discusses the process by which the MGA characterizes undesirable results, and establishes minimum thresholds and measurable objectives for each applicable sustainability indicator. Undesirable results, minimum thresholds, and measurable objectives together define sustainable conditions in the Basin and commit the MGA to actions that will achieve those conditions. These SGMA specific terms and others are defined in the Glossary.

Defining Sustainable Management Criteria (SMC) requires significant analysis and scrutiny. This section presents the data and methods used to develop SMC and demonstrates how they influence beneficial uses and users. The SMC are based on currently available data and the application of best available science. As noted in this GSP, data gaps exist in the hydrogeologic conceptual model related to the interconnection of surface water and groundwater. Uncertainty caused by these data gaps was considered when developing the SMC. Due to uncertainty in the hydrogeologic conceptual model, the SMC are considered initial criteria that will be reevaluated and potentially modified in the future as new data ~~become~~becomes available.

This section is organized to address all of the SGMA regulations regarding SMC. To retain an organized approach that focuses on SMC for each individual sustainability indicators, the SMC are grouped by sustainability indicator. Each subsection follows a consistent format that contains the information required by Section §354.22 *et. seq* of the SGMA regulations and outlined in the Sustainable Management Criteria BMP (DWR, 2017). Each Sustainable Management Criteria section includes a description of:

- How locally defined significant and unreasonable conditions were developed.
- How undesirable results were developed, including:
    - The criteria defining when and where the effects of the groundwater conditions cause undesirable results based on a quantitative description of the combination of minimum threshold exceedances (§354.26 (b)(2)).
    - The potential causes of undesirable results (§354.26 (b)(1)).
    - The effects of these undesirable results on the beneficial users and uses (§354.26 (b)(3)).
- How minimum thresholds were developed, including:
    - The information and methodology used to develop minimum thresholds (§354.28 (b)(1)).
    - The relationship between minimum thresholds and the relationship of these minimum thresholds to other sustainability indicators (§354.28 (b)(2)).
    - The effect of minimum thresholds on neighboring basins (§354.28 (b)(3)).
    - The effect of minimum thresholds on beneficial uses and users (§354.28 (b)(4))
    - How minimum thresholds relate to relevant Federal, State, or local standards (§354.28 (b)(5)).
    - The method for quantitatively measuring minimum thresholds (§354.28 (b)(6)).
- How measurable objectives were developed, including:
    - The methodology for setting measurable objectives (§354.30).
    - Interim milestones (§354.30 (a), §354.30 (e), §354.34 (g)(3)).

~~3.2.1 Sustainable Management Criteria Definitions~~

~~Definitions of undesirable results, minimum thresholds, measurable objectives, and interim milestones are provided below:~~

~~**Undesirable Results:** Undesirable results occur when significant and unreasonable effects for any of the sustainability indicators defined by the Sustainable Groundwater Management Act (SGMA) are caused by groundwater conditions occurring in the Basin. Undesirable results are included as SMC as a quantitative description of the combination of minimum threshold exceedances that cause significant and unreasonable effects in the basin. Undesirable results may be defined by minimum threshold exceedances at a single monitoring site, multiple monitoring sites, a portion of a basin, a management area, or an entire basin.~~

~~**Minimum Thresholds:** Minimum thresholds are quantitative values that represent groundwater conditions at representative monitoring points. Minimum thresholds are used to define undesirable results.~~

~~**Measurable Objectives:** Measurable objectives are quantitative goals that reflect the MGA's desired groundwater conditions in the Basin and will guide the MGA to achieve its sustainability goal within 20 years. Measurable objectives are set for each sustainability indicator at the same representative monitoring points and using the same metrics as minimum thresholds.~~

~~Measurable Objectives are set so there is a reasonable margin of operational flexibility between the minimum threshold and measurable objective that will accommodate droughts, climate change, conjunctive use operations, or other groundwater management activities.~~

~~For some sustainability indicators, projects and management actions are needed to achieve measurable objectives. Although measurable objectives are not enforceable during implementation of the GSP, the GSP needs to demonstrate that there is a planned path toward achieving measurable objectives.~~

~~**Interim Milestones**: Interim milestones are defined in five-year increments at each monitoring site using the same metrics as the measurable objectives and minimum thresholds. Interim milestones will be used by the MGA and the Department of Water Resources (DWR) to track progress toward meeting the Basin's Sustainability Goal. Interim milestones are coordinated with projects and management actions proposed by the MGA to achieve the sustainability goal.~~

~~3.2.2~~3.2.1 Process of Developing Sustainable Management Criteria

Development of SMC involved initial proposals by staff, followed by discussion and refinement by the GSP Advisory Committee over multiple meetings. Prior to discussing SMCs for a particular sustainability indicator with the GSP Advisory Committee, the members were provided background information on the status of the indicator in the Basin and a brief on the groundwater conditions pertaining to the indicator. This information was provided both in written materials included in the meeting agenda packet and a presentation that was made during the meeting. Discussion during the meeting facilitated additional information sharing and clarity.

Once there was comfort in understanding Basin conditions related to the sustainability indicator, the technical consultant described possible options or proposals for indicator specific significant and unreasonable groundwater conditions that indicate the Basin was unsustainable.

Based on the qualitative statement of significant and unreasonable conditions that was formed by the Committee, the same approach of providing several options for the quantitative criteria: undesirable results and minimum thresholds, were provided to the GSP Advisory Committee for consideration. This approach was taken so that it could be understood that within the various options, there are relative levels of protectiveness. Meeting summaries posted on the MGA website reflect the discussions that took place for each sustainability indicator.

Farther along in the SMC development process when minimum thresholds were generally agreed upon, options for measurable objectives were presented and discussed by the Committee. Several iterations of providing options were afforded each sustainability indicator which allowed for continual improvements to the criteria. Additionally, opportunities for public comment on the topics being discussed at the GSP Advisory Committee meetings were provided and taken into consideration during development of the SMCs.

Interim milestones were developed based on current conditions and modeled groundwater levels and did not have direct GSP Advisory Committee input.

3.3 Monitoring Network

This subsection describes the monitoring networks that currently exist in the Basin to monitor Basin conditions and that will continue to be used during GSP implementation, Representative Monitoring Points (RMPs) for which sustainable management criteria are set, and improvements to the monitoring networks that will be made as part of GSP implementation. It also includes a description of monitoring objectives, monitoring protocols, and data requirements. The monitoring network subsection is before the sustainability management criteria (SMC) subsection because it is important to describe the representative monitoring networks that measure Basin sustainability before SMC associated with the RMPs in the networks are provided.

The monitoring networks included in this subsection are based on existing monitoring networks described generally in Section 2.1.2: Water Resources Monitoring and Management Programs. To be able to relate monitoring features to sustainability indicators, monitoring networks are described below for each of the information types that are needed to evaluate the applicable sustainability indicators.

3.3.1 Description of Monitoring Networks

The SGMA regulations require monitoring networks be developed to promote the collection of data of sufficient quality, frequency, and spatial distribution to characterize groundwater and related surface water conditions in the Basin, and to evaluate changing conditions that occur during implementation of the GSP. Monitoring networks should accomplish the following:

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

The Santa Cruz Mid-County ~~Basin~~Basin's existing monitoring networks have been used for several decades to collect information to demonstrate short-term, seasonal, and long-term trends in groundwater and related surface conditions. The monitoring networks include features for the collection of data to monitor the five groundwater sustainability indicators that are applicable to the Basin: chronic lowering of groundwater levels, seawater intrusion, depletion of interconnected surface water, reduction of groundwater in storage, and degraded groundwater quality (Table 3-1). As discussed in Section 2: Basin Setting, land subsidence is not an applicable sustainability indictor in the Basin and therefore monitoring of land surface elevations is not included in the current monitoring network. Section 3.3.1.5 does however include a source of monitoring data for land surface elevations in the Basin that is provided ~~for~~ by public agencies not part of the MGA.

Table 3-1. Applicable Sustainability Indicators in the Santa Cruz Mid-County Basin

Sustainability Indicator	Metric	Proxy
Chronic Lowering of Groundwater Levels	Groundwater elevation	-
Reduction of Groundwater in Storage	Volume of groundwater extracted	-
Seawater Intrusion	Chloride concentration	Groundwater elevation
Degraded Groundwater Quality	Concentration	-
Depletion of Interconnected Surface Water	Volume or rate of streamflow	Groundwater elevation

3.3.1.1 Groundwater Level Monitoring Network

Each MGA member agency has ~~their~~its own network of dedicated monitoring wells and production wells that monitor groundwater elevations in ~~their~~its own service area or area of jurisdiction. Many of these monitoring sites have been used to manage the Basin since the 1980's which was prior to completion of the 1995 Groundwater Management Plan (GMP) that covered the Soquel-Aptos area. These individual networks are combined into the ~~Groundwater Management (GMP)~~GMP monitoring network, as described in Section 2.1.2: Water Resources Monitoring and Management Programs. The GMP monitoring network has been added to and maintenance of the network has included replacing monitoring wells when they are damaged. Almost all monitoring wells and all production wells have data loggers to continuously monitor groundwater levels. Shallow monitoring wells used to monitor surface water / groundwater interactions are also included~~.~~ in this extensive GMP monitoring network.

Table 3-2 summarizes the number of wells included in the existing ~~extensive~~ GMP monitoring network across the Basin to monitor groundwater levels. Figure 3-1 is a map showing the basin-wide distribution of groundwater level monitoring wells. The aquifers monitored by each well with their frequency of monitoring are listed in Table 3-3. With ~~174~~168 wells in the Basin monitored at least twice a year, the network is demonstrably extensive and sufficient to evaluate short-term, seasonal, and long-term trends in groundwater for groundwater management purposes. Groundwater level data from many of the wells have been used since 2006 to generate fall and spring groundwater elevation contours for all of the Basin's aquifers. As there are multiple well clusters with monitoring wells completed in different aquifers at the same location included throughout the Basin, these are used to understand changes in vertical gradients between aquifers.

Table 3-2. Summary of MGA Member Agency Monitoring Well Network for Groundwater Levels

Member Agency	Number of Wells			
	Monitoring Wells	Production Wells	Total in Network	Representative Monitoring Wells
City of Santa Cruz	34	4	38	7
Soquel Creek Water District	80	18	98	26
Central Water District	6	3	9	2
Santa Cruz County	0	27	27	2
Total	*116*	*52*	*168*	*37*

Note: each well in a cluster of multi-depth wells is counted as a separate well

The groundwater level monitoring network accomplishes the following for each sustainability indicator that relies on groundwater levels either directly or using groundwater levels as a proxy to determine Basin sustainability:

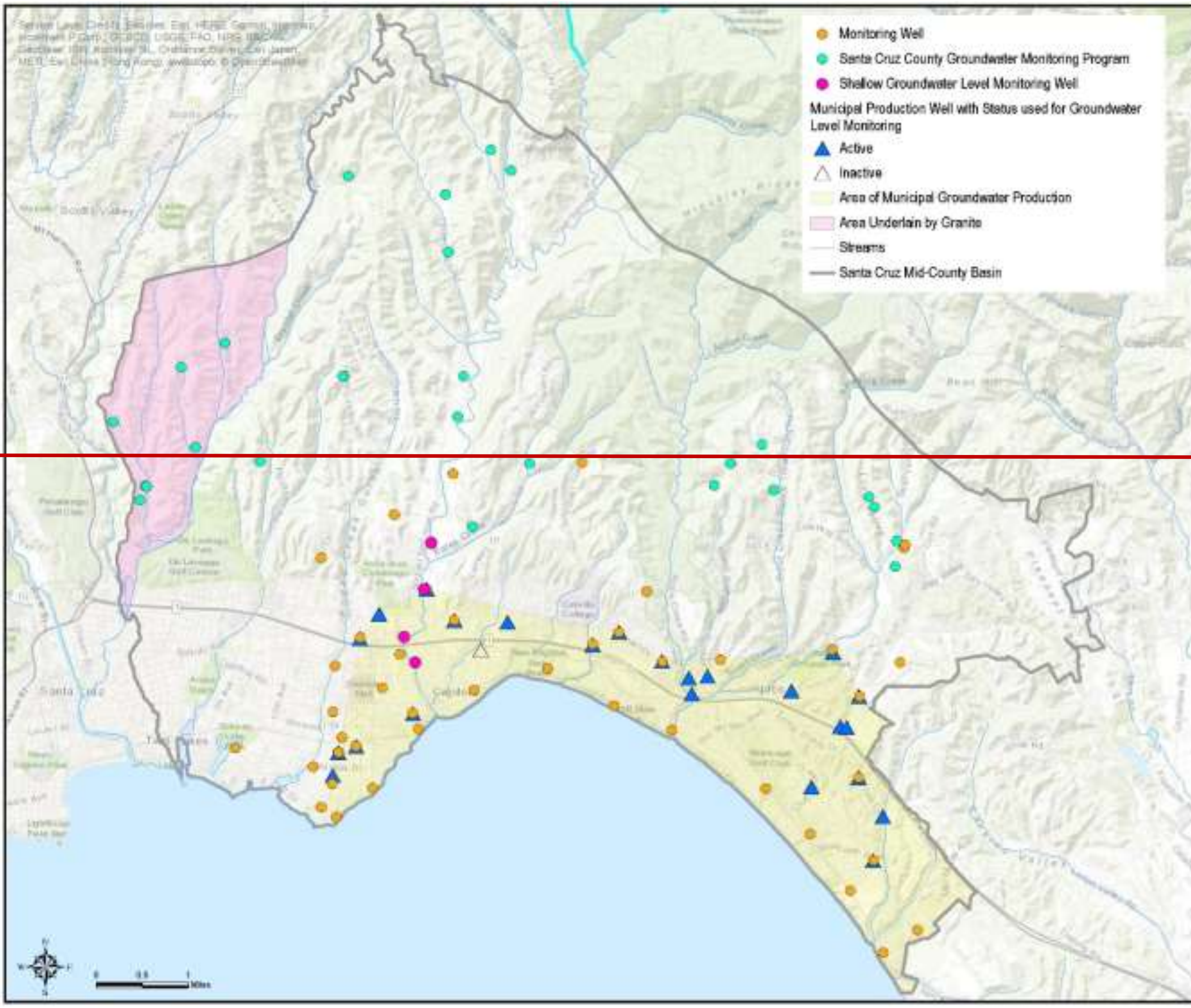
- Chronic Lowering of Groundwater Levels: Monitoring wells are distributed throughout the Basin in all the aquifers used for groundwater production, and the distribution of wells is sufficient to develop groundwater elevation contours for each aquifer.

- Seawater Intrusion: The monitoring network includes coastal monitoring wells that are used to monitor seawater intrusion through groundwater quality and groundwater levels as a proxy. Each location has multiple monitoring wells completed at different depths within the productive aquifers. Protective groundwater elevations are established at each of these locations to prevent seawater intrusion. Two additional monitoring wells, one in the Tu-unit and one in the Purisima AA-unit, are needed to complete the monitoring network as described in Section 3.3.4.1: Groundwater Level Monitoring Data Gaps.

- Depletion of Interconnected Surface Water: The current shallow monitoring wells used to monitor and evaluate interactions between surface water and groundwater are focused on the lower stretch of Soquel Creek where there are several ~~nearby~~ municipal production wells. In addition, there are multiple depth monitoring well clusters near Soquel Creek that are included in the evaluation of surface water and groundwater interactions. Eight new shallow monitoring wells will be added to complete the monitoring network to better evaluate the effects of groundwater extractions on streamflow in interconnected surface waters (see Section 3.3.4.1: Groundwater Level Monitoring Data Gaps.)

Each agency will use ~~their~~its own resources to continue to monitor these wells as the GSP is implemented. Groundwater level data collected, both hand soundings and recorded by data loggers, for each well will be stored in the WISKI DMS.

The only data gaps that exist for the groundwater level monitoring network are two deep coastal monitoring wells to monitor seawater intrusion in the Tu and Purisima AA aquifers, and eight shallow monitoring wells to monitor depletion of interconnected surface water. These are discussed in more detail in Section 3.3.4.1: Groundwater Level Monitoring Data Gaps.


Monitoring Well
Santa Cruz County Groundwater Monitoring Program
Shallow Groundwater Level Monitoring Well
Municipal Production Well with Status used for Groundwater Level Monitoring
Active
Inactive
Area of Municipal Groundwater Production
Area Underlain by Granite
Streams
Santa Cruz Mid-County Basin

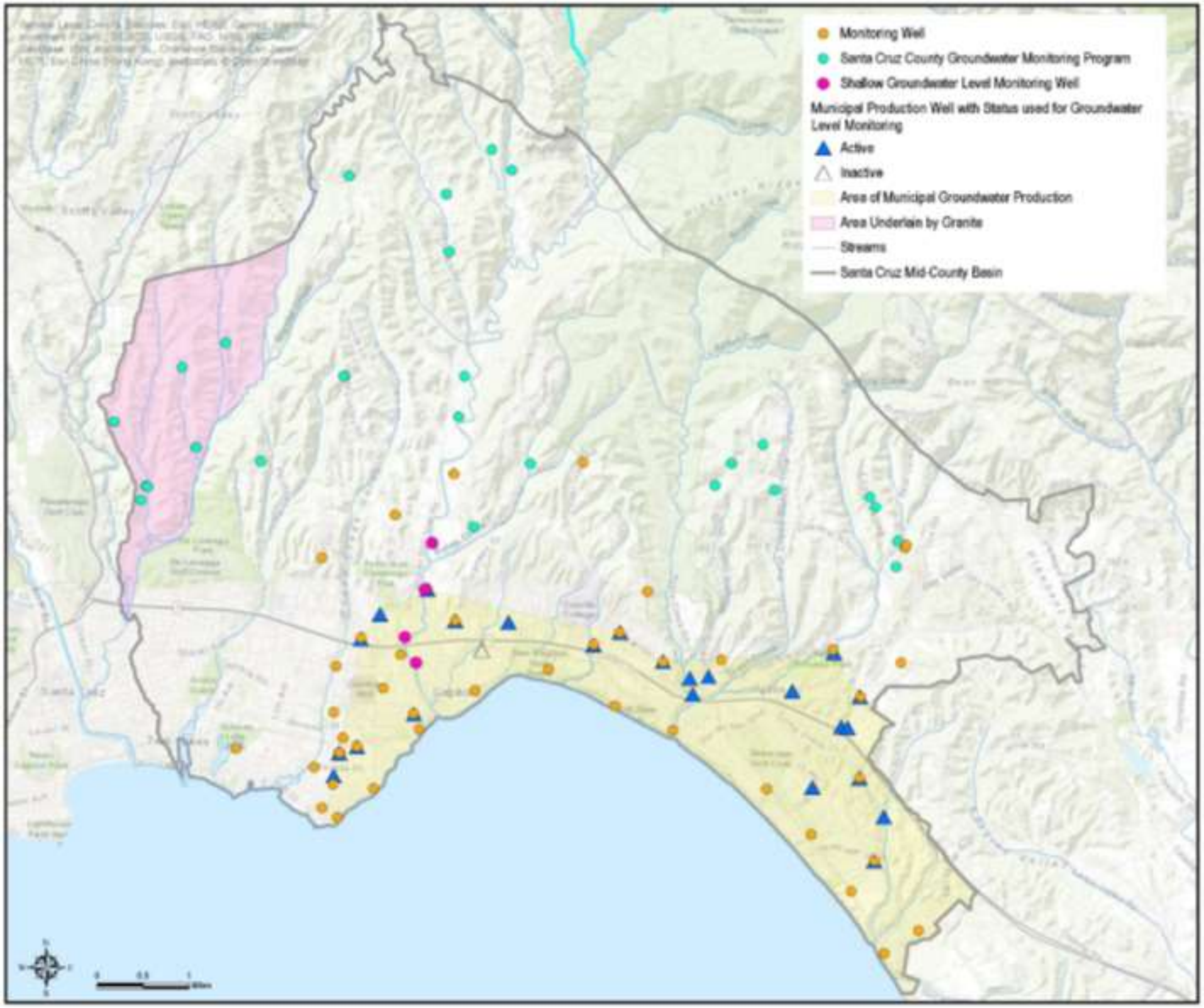


Figure 3-1. Location of Existing Basin-Wide Wells Used for Groundwater Level Monitoring

Table 3-3. Monitoring Wells for Groundwater Levels in the Santa Cruz Mid-County Basin

Aquifer Unit	Well Name	Monitoring Agency	Sounding Frequency	Data Logger
Shallow Well for Surface Water Interactions	**Balogh** [3]	SqCWD	Quarterly	y
	Main St Shallow [3]	SqCWD	Quarterly	y
	Wharf Road [3]	SqCWD	Quarterly	y
	Nob Hill [3]	SqCWD	Quarterly	y
Various	27 Private Domestic Wells Unnamed for Privacy Reasons **(2 wells used as RMPs)**	Santa Cruz County	Semi- Annually	n
Aromas	SC-A1C	SqCWD	Quarterly	y
	SC-A1D	SqCWD	Quarterly	y
	SC-A2RC	SqCWD	Quarterly	y
	SC-A3A [2]	**SqCWD**	**Quarterly**	**y**
	SC-A3B	SqCWD	Quarterly	y
	SC-A3C	SqCWD	Quarterly	y
	SC-A5C	SqCWD	Quarterly	y
	SC-A5D	SqCWD	Quarterly	y
	SC-A6C	SqCWD	Monthly	n
	SC-A7C [3]	**SqCWD**	**Monthly**	**n**
	SC-A7D	SqCWD	Monthly	n
	SC-A8B	SqCWD	Quarterly	y
	SC-A8C	SqCWD	Quarterly	y
	CWD-A	CWD	Quarterly	n
	CWD-B	CWD	Quarterly	n
	CWD-10 PW	CWD	Monthly	n
Aromas/ Purisima F	Polo Grounds PW	SqCWD	Annually	y
	Aptos Jr. High 2 PW	SqCWD	Annually	y
	Country Club PW	SqCWD	Annually	y
	Bonita PW	SqCWD	Annually	y
	San Andreas PW	SqCWD	Annually	y
	Seascape PW	SqCWD	Annually	y
	CWD-4 PW	CWD	Monthly	y
	CWD-12 PW	CWD	Monthly	y
Purisima F	SC-20A	SqCWD	Quarterly	y
	SC-20B	SqCWD	Quarterly	y

Aquifer Unit	Well Name	Monitoring Agency	Sounding Frequency	Data Logger
	SC-20C	SqCWD	Quarterly	y
	SC-23C [3]	**SqCWD**	**Quarterly**	**y**
	SC-8RF	SqCWD	Quarterly	y
	SC-A1B [2]	**SqCWD**	**Quarterly**	**y**
	SC-A2RA [2]	**SqCWD**	**Quarterly**	**y**
	SC-A2RB	SqCWD	Quarterly	y
	SC-A4A	SqCWD	Quarterly	y
	SC-A4B	SqCWD	Quarterly	y
	SC-A5A	SqCWD	Quarterly	y
	SC-A5B	SqCWD	Quarterly	y
	SC-A6A	SqCWD	Quarterly	n
	SC-A6B	SqCWD	Quarterly	n
	SC-A7A	SqCWD	Monthly	n
	SC-A7B	SqCWD	Monthly	n
	SC-A8A [2]	**SqCWD**	**Quarterly**	**y**
	CWD-C	CWD	Quarterly	n
	Black [3]	**CWD**	**Monthly**	**n**
	CWD-3	CWD	Monthly	n
	CWD-5 [3]	**CWD**	**Monthly**	**y**
Purisima DEF	**SC-8RD** [2]	**SqCWD**	**Quarterly**	**y**
	SC-8RE	SqCWD	Quarterly	y
	SC-9RE	SqCWD	Quarterly	y
	SC-11RD [3]	**SqCWD**	**Quarterly**	**y**
	SC-17C	SqCWD	Monthly	n
	SC-17D	SqCWD	Monthly	n
	SC-23B [3]	**SqCWD**	**Quarterly**	**y**
	SC-A1A	SqCWD	Quarterly	y
	T. Hopkins PW	SqCWD	Annually	y
	Granite Way PW	SqCWD	Annually	y
Purisima BC	SC-1B	SqCWD	Monthly April – Nov, otherwise Quarterly	y
	SC-3RC	SqCWD	Quarterly	y
	SC-5RC	SqCWD	Quarterly	y
	SC-8RB [2]	**SqCWD**	**Quarterly**	**y**

Aquifer Unit	Well Name	Monitoring Agency	Sounding Frequency	Data Logger
	SC-8RC	SqCWD	Quarterly	y
	SC-9RC [2]	**SqCWD**	**Quarterly**	**y**
	SC-11RB [3]	**SqCWD**	**Quarterly**	**y**
	SC-14B	SqCWD	Monthly	n
	SC-14C	SqCWD	Monthly	n
	SC-16B	SqCWD	Monthly	n
	SC-17B	SqCWD	Monthly	n
	SC-19 [3]	**SqCWD**	**Monthly**	**n**
	SC-23A [3]	**SqCWD**	**Quarterly**	**y**
	Madeline PW	SqCWD	Annually	y
	Ledyard PW	SqCWD	Twice monthly	n
	Aptos Creek PW	SqCWD	Annually	y
Purisima B	SC-3RB	SqCWD	Quarterly	y
	SC-5RB	SqCWD	Quarterly	y
Purisima A	**SC-1A [2]**	**SqCWD**	**Monthly April – Nov, otherwise Quarterly**	**y**
	SC-5RA [2]	**SqCWD**	**Quarterly**	**y**
	SC-8RA	SqCWD	Quarterly	y
	SC-9RA	SqCWD	Quarterly	y
	SC-10RA [1]	SqCWD	Quarterly	y
	SC-15B	SqCWD	Quarterly	y
	SC-17A	SqCWD	Monthly	n
	SC-21A	SqCWD	Quarterly	y
	SC-22A [3]	**SqCWD**	**Monthly April – Nov, otherwise Quarterly**	**y**
	Tannery 2 PW	SqCWD	Annually	y
	Monterey PW	SqCWD	Twice monthly	n
	Estates PW	SqCWD	Annually	y
	Garnet PW	SqCWD	Annually	y
	Main St. PW	SqCWD	Annually	y
	Rosedale PW	SqCWD	Annually	y
	Corcoran Lagoon Medium	City	Monthly	y
	Corcoran Lagoon Shallow	City	Monthly	n
	Moran Lake Medium [2]	**City**	**Monthly**	**y**
	Moran Lake Shallow	City	Monthly	n

Aquifer Unit	Well Name	Monitoring Agency	Sounding Frequency	Data Logger
	Beltz #2	City	Monthly	y
	Beltz #4 Deep	City	Monthly	y
	Beltz #4 Shallow	City	Monthly	n
	Soquel Point Shallow	City	Monthly	n
	Soquel Point Medium [2]	**City**	**Monthly**	**y**
	Pleasure Point Medium [2]	**City**	**Monthly**	**y**
	Pleasure Point Shallow	City	Monthly	n
	Coffee Lane Shallow [3]	**City**	**Monthly**	**y**
	Auto Plaza Med	City	Monthly	y
	Auto Plaza Shallow	City	Monthly	n
	Cory Street Medium	City	Monthly	y
	Cory Street Shallow	City	Monthly	n
	30th Ave Shallow	City	Monthly	y
	Beltz #8 PW	City	Annually	y
	Beltz #9 PW	City	Annually	y
	Beltz #7 Shallow	City	Monthly	n
	Beltz #6	City	Monthly	n
Purisima A/AA	SC-11RA	SqCWD	Quarterly	y
	SC-14A	SqCWD	Monthly	n
	SC-16A	SqCWD	Quarterly	y
	SC-3RA [2]	**SqCWD**	**Quarterly**	**y**
	Beltz #10 PW	City	Annually	y
	Beltz #7 Deep	City	Monthly	n
Purisima AA	**SC-10RAA [3]**	**SqCWD**	**Quarterly**	**y**
	SC-15A	SqCWD	Quarterly	y
	SC-18RA	SqCWD	Quarterly	y
	SC-21AA	SqCWD	Quarterly	y
	SC-21AAA	SqCWD	Quarterly	y
	SC-22AA [3]	**SqCWD**	**Monthly April – Nov, otherwise Quarterly**	**y**
	SC-22AAA	SqCWD	Quarterly, with Monthly visits April - Nov	y
	Corcoran Lagoon Deep	City	Monthly	y
	Moran Lake Deep [2]	**City**	**Monthly**	**y**

Aquifer Unit	Well Name	Monitoring Agency	Sounding Frequency	Data Logger
	Soquel Point Deep [2]	**City**	**Monthly**	**y**
	Pleasure Point Deep [2]	**City**	**Monthly**	**y**
	Schwan Lake	City	Monthly	y
	Coffee Lane Deep	City	Monthly	y
	Auto Plaza Deep	City	Monthly	y
	Cory Street Deep	City	Monthly	y
	30th Ave Medium	City	Monthly	y
	Thurber Lane Shallow	City	Monthly	y
Purisima AA/Tu	Beltz #12 PW	City	Annually	y
	O'Neill Ranch PW	SqCWD	Annually	y
Tu	SC-10AAA	SqCWD	Quarterly	y
	SC-13A [2]	**SqCWD**	**Quarterly**	**y**
	SC-18RAA	SqCWD	Quarterly	y
	Cory Street-4	City	Monthly	y
	30th Ave Deep	City	Monthly	y
	Beltz #7 Santa Margarita Test	City	Monthly	y
	Thurber Lane Deep	City	Monthly	y

PW = production well; City = City of Santa Cruz, SqCWD = Soquel Creek Water District; CWD = Central Water District; monitoring wells in bold are representative monitoring points (RMP) for groundwater elevations; [1] = RMP for depletion of interconnected surface water; [2] = RMP for seawater intrusion; [3] = RMP for chronic lowering of groundwater levels

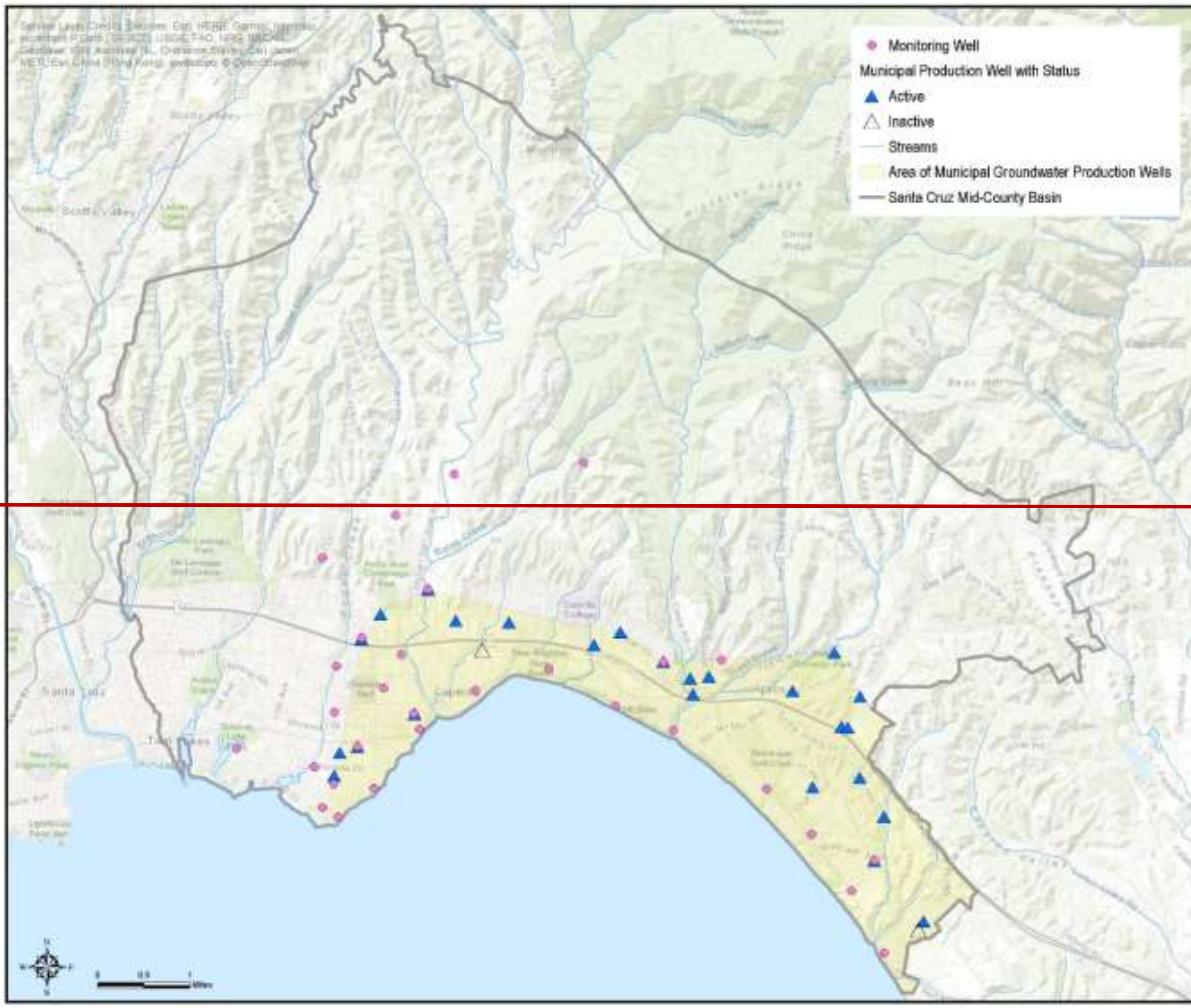
3.3.1.2 Groundwater Quality Monitoring Network

Each MGA member agency monitors a network of dedicated monitoring wells and production wells for groundwater quality in ~~their~~its service area or area of jurisdiction. These monitoring sites have been used to manage the Basin and added to since the 1980's which was prior to completion of the 1995 Groundwater Management Plan that covered the Soquel-Aptos area. Table 3-4 summarizes the wells included in the existing ~~extensive~~ monitoring network across the Basin. A map showing the distribution of monitoring wells used to sample groundwater quality is shown on Figure 3-2, and the aquifers monitored by each well with their frequency of sampling are listed in Table 3-5. There is no established inland groundwater quality monitoring network within the areas outside of the MGA member water supply agency sphere of influence where predominantly private domestic and agricultural extractions take place. As described in Section 2: Basin Setting, groundwater quality in the inland Purisima aquifer areas of the Basin is very good, with the exception of occasional low concentrations of native arsenic, and elevated naturally occurring iron and manganese. The Aromas area of the Basin is more susceptible to surface sources of contamination because the underlying aquifers are unconfined and highly permeable. The distribution and sampling frequency of monitoring and production wells used for sampling groundwater quality reflects locational and aquifer depth susceptibility to contamination, including from seawater. Iron and manganese are sampled more frequently in municipal production wells as a necessary step in the iron and manganese treatment process.

Table 3-4. Summary of MGA Member Agency Monitoring Well Network for Groundwater Quality

Member Agency	Number of Wells			
	Monitoring Wells	Production Wells	Total in Network	Representative Monitoring Wells
City of Santa Cruz	28	4	37	18
Soquel Creek Water District	51	18	69	48
Central Water District	0	3	3	3
Total	*79*	*25*	*104*	*69*

Note: each well in a cluster of multi-depth wells is counted as a separate well



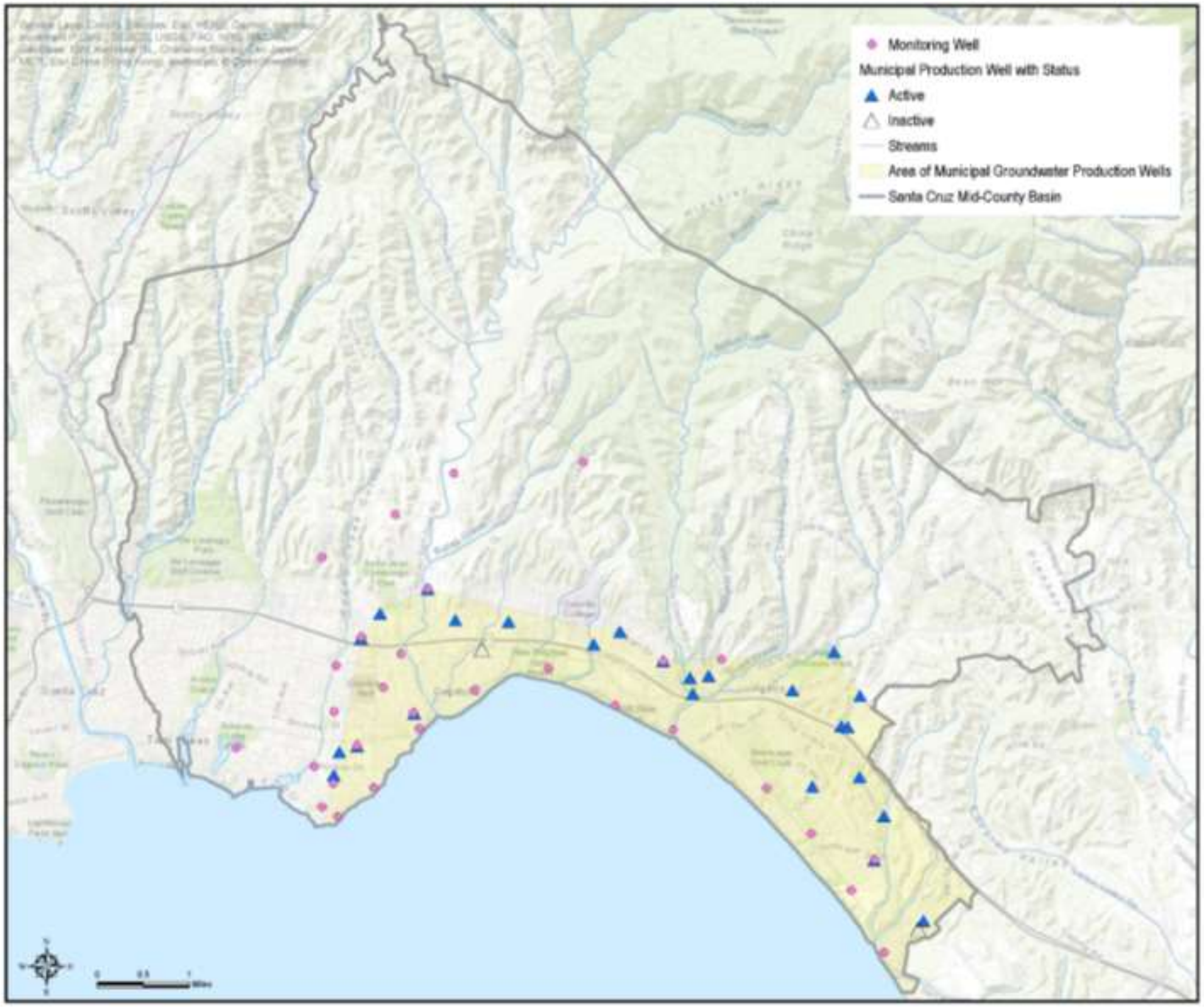


Figure 3-2. Location of Basin-Wide Wells Used for Groundwater Quality Monitoring

Table 3-5. Monitoring Wells for Groundwater Quality in the Santa Cruz Mid-County Basin

Aquifer Unit	Well Name	General Mineral Sampling Frequency	Chloride and TDS Sampling Frequency
Aromas	Altivo PW	Semi-Annually	Quarterly
	CWD-10 PW [1]	**Triennial, nitrate as (N) Annually**	**Triennial**
	SC-A1C [1]	**Annually**	**Quarterly**
	SC-A1D	Semi-Annually	Quarterly
	SC-A2RC [1]	**Semi-Annually**	**Quarterly**
	SC-A3A [1 2]	**Annually**	**Quarterly**
	SC-A3B [2]	**Annually**	**Quarterly**
	SC-A3C [1]	**Annually**	**Quarterly**
	SC-A5C	Semi-Annually	Quarterly
	SC-A5D	Annually	Quarterly
	SC-A8B [1 2]	**Semi-Annually**	**Quarterly**
	SC-A8C [1]	**Annually**	**Quarterly**
Aromas/ Purisima F	**Polo Grounds PW [1]**	**Semi-Annually, nitrate (as N) Annually**	**Quarterly**
	Aptos Jr. High 2 PW [1]	**Semi-Annually, nitrate (as N) Annually**	**Quarterly**
	Country Club PW [1]	**Semi-Annually, nitrate (as N) Annually**	**Quarterly**
	Bonita PW [1]	**Semi-Annually, nitrate (as N) Annually**	**Quarterly**
	San Andreas PW [1 2]	**Semi-Annually, nitrate (as N) Annually**	**Quarterly**
	Seascape PW [1 2]	**Semi-Annually, nitrate (as N) Annually**	**Quarterly**
Purisima F	**CWD-4 PW [1]**	**Triennial, nitrate as (N) Annually**	**Triennial**
	CWD-12 PW [1]	**Triennial, nitrate as (N) Annually**	**Triennial**
	SC-23C	Annually	Semi-Annually
	SC-8RF	Annually	Semi-Annually
	SC-A1B [2]	**Annually**	**Semi-Annually**
	SC-A2RA [1 2]	**Annually**	**Quarterly**
	SC-A2RB [2]	**Semi-Annually**	**Quarterly**
	SC-A5A [2]	**Annually**	**Quarterly**
	SC-A5B [2]	**Annually**	**Quarterly**
	SC-A8A [1 2]	**Annually**	**Quarterly**
Purisima	**T-Hopkins PW [1 2]**	**Annually**	**Annually**

Aquifer Unit	Well Name	General Mineral Sampling Frequency	Chloride and TDS Sampling Frequency
DEF	**Granite Way PW [1]**	**Annually**	**Annually**
	SC-8RD [1] [2]	**Annually**	**Semi-Annually**
	SC-8RE	Annually	Semi-Annually
	SC-9RE [1]	**Annually**	**Semi-Annually**
	SC-11RD	Semi-Annually	Semi-Annually
	SC-23B	Annually	Annually
	SC-A1A [1] [2]	**Semi-Annually**	**Quarterly**
Purisima BC	**Ledyard PW [1] [2]**	**Annually**	**Annually**
	Madeline PW [1]	**Annually**	**Annually**
	Aptos Creek PW [1]	**Annually**	**Annually**
	SC-3RC [1]	**Annually**	**Semi-Annually**
	SC-23A [1]	**Annually**	**Annually**
	SC-8RB [1] [2]	**Semi-Annually**	**Semi-Annually**
	SC-8RC	Semi-Annually	Semi-Annually
	SC-9RC [1] [2]	**Annually**	**Semi-Annually**
	SC-11B	Annually	Semi-Annually
	SC-17B	Annually	Semi-Annually
Purisima B (Aquitard)	SC-3RB	Annually	Annually
	SC-5RB	Annually	Annually
Purisima A	**30th Ave Shallow [1]**	**Semi-Annually**	**Semi-Annually**
	Auto Plaza Medium	Semi-Annually	Semi-Annually
	Auto Plaza Shallow	Semi-Annually	Semi-Annually
	Corcoran Lagoon Medium	Semi-Annually	Semi-Annually
	Corcoran Lagoon Shallow	Semi-Annually	Semi-Annually
	Cory Street Medium	Semi-Annually	Semi-Annually
	Cory Street Shallow	Semi-Annually	Semi-Annually
	Pleasure Point Medium [2]	**Quarterly**	**Quarterly**
	Pleasure Point Shallow [1]	**Quarterly**	**Quarterly**
	Beltz #2 [2]	**Semi-Annually**	**Semi-Annually**
	Moran Lake Medium [2]	**Quarterly**	**Quarterly**
	Moran Lake Shallow	Quarterly	Quarterly
	Soquel Point Medium [2]	**Quarterly**	**Quarterly**
	Soquel Point Shallow	Quarterly	Quarterly

Aquifer Unit	Well Name	General Mineral Sampling Frequency	Chloride and TDS Sampling Frequency
	Tannery II PW [1]	**Annually**	**Annually**
	Estates PW [1,2]	**Annually**	**Annually**
	Main Street PW [1]	**Annually**	**Annually**
	Rosedale 2 PW [1]	**Annually**	**Annually**
	Garnet PW [1,2]	**Annually**	**Annually**
	Beltz #6	Semi-Annually	Semi-Annually
	Beltz #8 PW [1,2]	**Triennial, iron & manganese quarterly, nitrate (as N) Annually**	**Triennial**
	Beltz #9 PW [1]	**Triennial, iron & manganese quarterly, nitrate (as N) Annually**	**Triennial**
	SC-1A [2]	**Annually**	**Annually**
	SC-3RA [2]	**Annually**	**Annually**
	SC-5RA [1,2]	**Semi-Annually**	**Semi-Annually**
	SC-8RA	Quarterly	Quarterly
	SC-9RA [1]	**Quarterly**	**Quarterly**
	SC-10RA [1]	**Annually**	**Annually**
	SC-21A	Annually	Annually
	SC-22A [1]	**Annually**	**Annually**
Purisima A/AA	**Beltz #10 PW [1]**	**Triennial, iron & manganese quarterly, nitrate (as N) Annually**	**Triennial**
	SC-11RA	Annually	Annually
Purisima AA	**SC-10RAA [1]**	**Annually**	**Annually**
	SC-18RA	Annually	Annually
	SC-21AA	Annually	Annually
	SC-21AAA	Quarterly	Quarterly
	SC-22AA [2]	**Semi-Annually**	**Quarterly**
	SC-22AAA [1]	**Semi-Annually**	**Quarterly**
	30th Ave Medium	Semi-Annually	Semi-Annually
	Auto Plaza Deep	Semi-Annually	Semi-Annually
	Coffee Lane Deep [1]	**Semi-Annually**	**Semi-Annually**
	Corcoran Lagoon Deep [2]	**Semi-Annually**	**Semi-Annually**
	Cory Street Deep	Semi-Annually	Semi-Annually
	Pleasure Point Deep [1,2]	**Quarterly**	**Quarterly**

Aquifer Unit	Well Name	General Mineral Sampling Frequency	Chloride and TDS Sampling Frequency
	Moran Lake Deep [2]	**Quarterly**	**Quarterly**
	Soquel Point Deep [2]	**Quarterly**	**Quarterly**
	Thurber Lane Shallow [1]	**~~Semi-~~Annually**	**~~Semi-~~Annually**
	Schwan Lake [1] [2]	**Semi-Annually**	**Semi-Annually**
Purisima AA/Tu	**O'Neill Ranch PW [1]**	**Annually**	**Annually**
	Beltz #12 PW [1]	**Triennial, iron & manganese quarterly, nitrate (as N) Annually**	**Triennial**
Tu	30th Ave Deep	Semi-Annually	Semi-Annually
	Cory Street-4	Semi-Annually	Semi-Annually
	Thurber Lane Deep [1]	**~~Semi-~~Annually**	**~~Semi-~~Annually**
	SC-10RAAA	Semi-Annually	Semi-Annually
	SC-13A [2]	**Quarterly**	**Quarterly**
	SC-18RAA [1]	**Semi-Annually**	**Quarterly**

PW = production well; monitoring wells in bold are representative monitoring points (RMP) for groundwater quality; [1] = RMP for degraded groundwater quality; [2] = RMP for seawater intrusion

The groundwater quality monitoring network accomplishes the following for the sustainability indicators relying on groundwater quality to determine Basin sustainability:

- Degraded Groundwater Quality: Monitoring wells are distributed throughout the Basin in all the aquifers used for groundwater production, and the distribution of wells and their sampling frequency is sufficient to determine groundwater quality trends over time for each aquifer. No additional monitoring wells for degraded groundwater quality are needed until projects are implemented.

- Seawater Intrusion: The monitoring network includes coastal monitoring wells that are used to monitor groundwater quality related to seawater intrusion. Most locations have multiple monitoring wells completed at different depths within the productive aquifers. All coastal monitoring wells are sampled for chloride and TDS quarterly to ensure increases in salinity are identified quickly. The two deep monitoring wells to be added for monitoring groundwater levels as a proxy for seawater intrusion will also be part of the network to monitor groundwater quality related to seawater intrusion. Like other coastal monitoring wells, these two deep monitoring wells will be monitored quarterly once constructed and equipped.

Each agency will use ~~their~~its own resources to continue to sample these wells as the GSP is implemented. Groundwater quality data collected for each well will be stored in the WISKI DMS.

3.3.1.3 Groundwater Extraction Monitoring

3.3.1.3.1 Metered Groundwater Extraction

Each ~~municipal~~ MGA member agency that supplies water meters ~~their~~its own groundwater extraction in ~~their~~its service area ~~or area of jurisdiction~~ by individual well. All municipal production wells have SCADA systems to automatically record groundwater extraction. Manual meter readings are also recorded. Monthly extraction data by well is stored in the WISKI DMS.

Small water systems (SWS) having between 5 and 199 connections are required to meter their groundwater production with monthly meter readings that are reported annually to Santa Cruz County. Monthly metered production is also required by the State Water Resources Control Board Division of Drinking Water (DDW) under California Code of Regulations ~~Section~~ §64561. This requirement also includes businesses or other operations that extract groundwater and that serve more than 25 people for more than 60 days a year. Annual extractions for reporting SWSs will be stored in the WISKI DMS.

3.3.1.3.2 Unmetered Groundwater Extraction

In areas outside of the municipal service areas, there are over one thousand private wells that each extract less than 2 acre-feet per year of groundwater for domestic purposes. These are called *de minimis* users and their wells are typically unmetered. Estimates of pumping for private domestic use are made based on the number of parcels with a residence and typical water use factor per connection derived from metered SWS water use per connection. To keep a current estimate of *de minimis* pumping, records of the number of rural parcels with residences and estimates of water use per connection from SWSs need to be updated annually.

Groundwater extraction for agricultural use (irrigation and livestock) is currently unmetered in the Basin. Annual agricultural demand is estimated based on the crop irrigated, monthly reference evapotranspiration that is measured at a nearby CIMIS station, and irrigated crop acreage. The MGA will need to monitor the acreage of irrigated lands in the Basin annually, and include cannabis which was not included in the agricultural use estimates in the historical groundwater model. As part of GPS implementation, the MGA will be implementing a metering plan that will require some of the larger agricultural and other non-*de minimis* users to meter their wells and provide the MGA with extraction data.

Estimated groundwater extractions will not be included in the WISKI DMS as the data are not measured. Spreadsheets and GIS containing the data used to estimate groundwater extractions for unmetered wells will be used to store estimated extraction data. These data will be included in annual reporting and to update the model periodically.

3.3.1.4 Streamflow Monitoring

The USGS streamflow gauge No. 11160000 (Soquel Creek at Soquel) is one of five streamflow gauges currently active in the Basin. The USGS gauge has been operational since 1951 and is part of the USGS's National Water Information System.

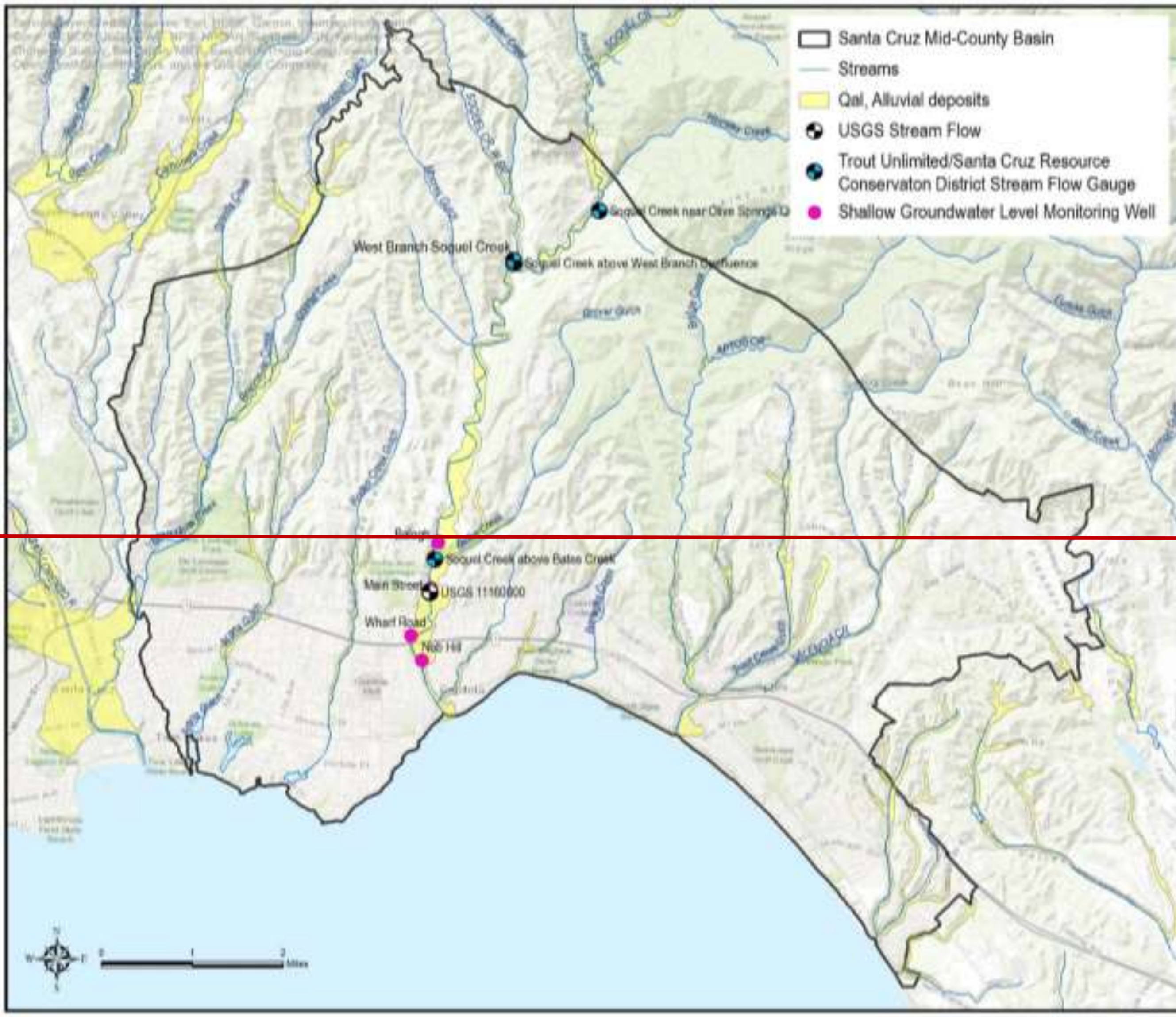
Other streamflow monitoring in the Basin is focused on Soquel Creek (Figure 3-3 and Table 3-6). This is because SqCWD recognized the potential of stream impacts from pumping their municipal supply wells close to Soquel Creek. As part of ~~their~~SqCWD's Soquel Creek Monitoring and Adaptive Management Plan (MAMP) described in Section 2.1.2~~:~~.1: Description of Water Resources Monitoring and Management Programs, SqCWD has stream water level loggers in Soquel Creek alongside the shallow monitoring wells shown on Figure 3-3. Since changes in stream levels from groundwater pumping of nearby municipal wells have not been measurable at the monitoring locations since monitoring started, stream water level monitoring may be terminated after five years of monitoring (after 2019).

Trout Unlimited is working in conjunction with the Resource Conservation District of Santa Cruz County (RCD) to monitor dry season flows at four locations on Soquel Creek (Figure 3-3) to help measure the impact of stream diversions and evaluate opportunities for streamflow enhancement. The current effort is funded through 2019 under a Proposition 1 Grant from the Wildlife Conservation Board for streamflow enhancement. After 2019, ongoing monitoring of the streamflow gauges will be continued by the MGA.

All streamflow data will be stored in the WISKI DMS.

Table 3-6. Streamflow Gauges in the Santa Cruz Mid-County Basin

Monitoring Entity	Streamflow Gauge Name
USGS	USGS 11160000 Soquel Creek at Soquel
Trout Unlimited / Santa Cruz Resource Conservation District	Soquel Creek West Branch
	Soquel Creek near Olive Springs
	Soquel Creek above West Branch Confluence
	Soquel Creek above Bates Creek


Santa Cruz Mid-County Basin
Streams
Qal, Alluvial deposits
USGS Stream Flow
Trout Unlimited/Santa Cruz Resource Conservaton District Stream Flow Gauge
Shallow Groundwater Level Monitoring Well
West Branch Soquel Creek
Soquel Creek above West Branch Confluence
Soquel Creek above Bates Creek
Main Street
USGS 11160000
Wharf Road
Nob Hill

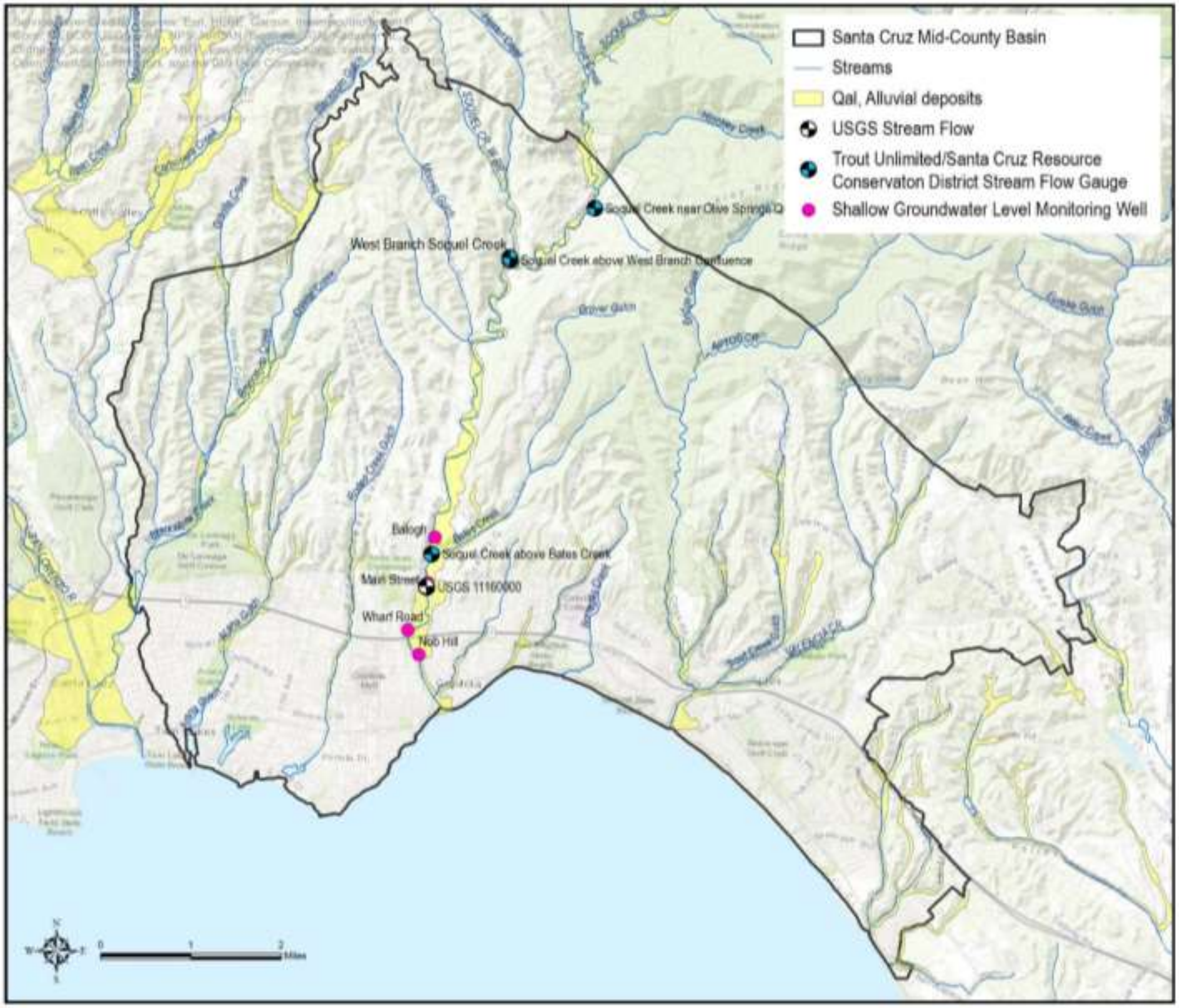


Figure 3-3. Location of Basin Streamflow Gauges

3.3.1.5 Land Elevation Monitoring

Land subsidence is not an applicable indicator of sustainability in the Basin and land surface elevations within the Basin have not been monitored historically, nor are there plans to monitor it in the future. There are however two land subsidence monitoring networks that are publicly available: (1) Continuous Global ~~positioning system~~Positioning System (CGPS) stations in the vicinity of the Basin that are part of the UNAVCO Plate Boundary Observatory network of CGPS stations, and (2) Interferometric Synthetic Aperture Radar (InSAR) data that are collected by the European Space Agency (ESA) Sentinel-1A satellite and processed by TRE ALTAMIRA Inc. (TRE).

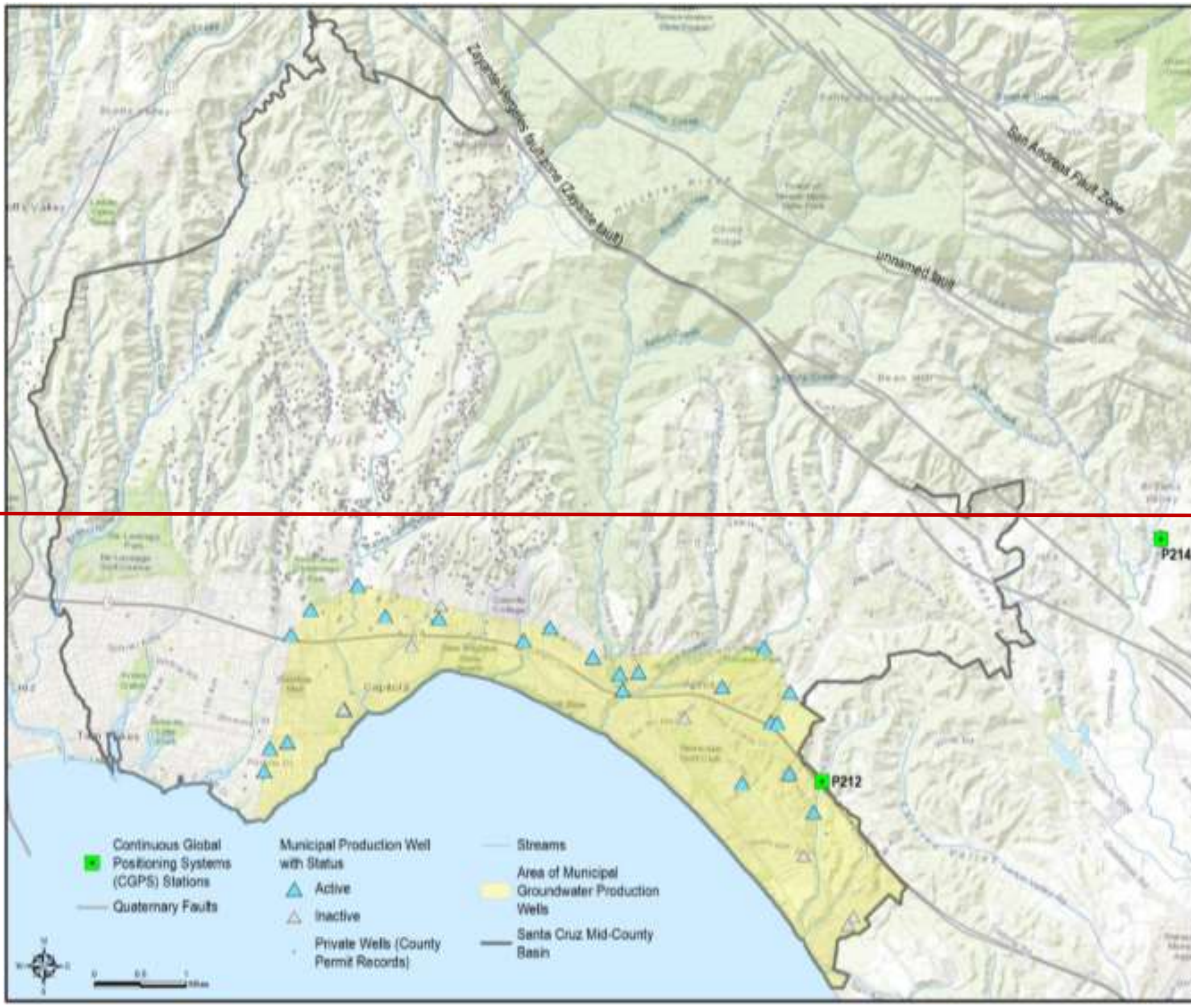
1. The CGPS data are a subset of Plate Boundary Observatory GPS with near real-time data streams made available by UNAVCO. The data is provided as elevation (Z) and longitude (X) and latitude (Y). There is one CGPS stations (Larkin Valley CGPS station (P212)) just outside of the Aromas area of the Basin that can be used to assess subsidence at the basin boundary (Figure 3-4).

2. Through a contract with TRE ALTAMIRA Inc. (TRE) and as part of DWR's SGMA technical assistance for GSP development and implementation, DWR has made available measurements of vertical ground surface displacement in more than 200 of the high-use and populated groundwater basins across California, including for the Santa Cruz Mid-County Basin. Vertical displacement estimates are derived from Interferometric Synthetic Aperture Radar (InSAR) data that are collected by the European Space Agency (ESA) Sentinel-1A satellite and processed by TRE. The InSAR dataset has also been ground-truthed to best available independent data. The current data covers the months between January 2015 and June 2018, and DWR is planning on supporting updating the dataset on an annual basis through 2022.

The CGPS data and TRE ALTAMIRA InSAR subsidence dataset can be used by the MGA annually to compare against groundwater elevations to confirm that subsidence is not occurring in the Basin.

3.3.1.6 Climate Monitoring

Climate conditions are collected by MGA member agencies and partners at various locations in the Basin. Monitored information includes precipitation and temperature to help provide information on recharge, soil moisture, and evapotranspiration. This information is also important to consider influences on streamflow. Consideration will be given to expanding this network and providing for more direct measurement of evapotranspiration and occurrence of fog cover.


Zayante-Vergeles fault zone (Zayante fault)
San Andreas Fault Zone
unnamed fault
P214
P212
Continuous Global Positioning Systems (CGPS) Stations
Quaternary Faults
Municipal Production Well with Status
Active
Inactive
Private Wells (County Permit Records)
Streams
Area of Municipal Groundwater Production Wells
Santa Cruz Mid-County Basin

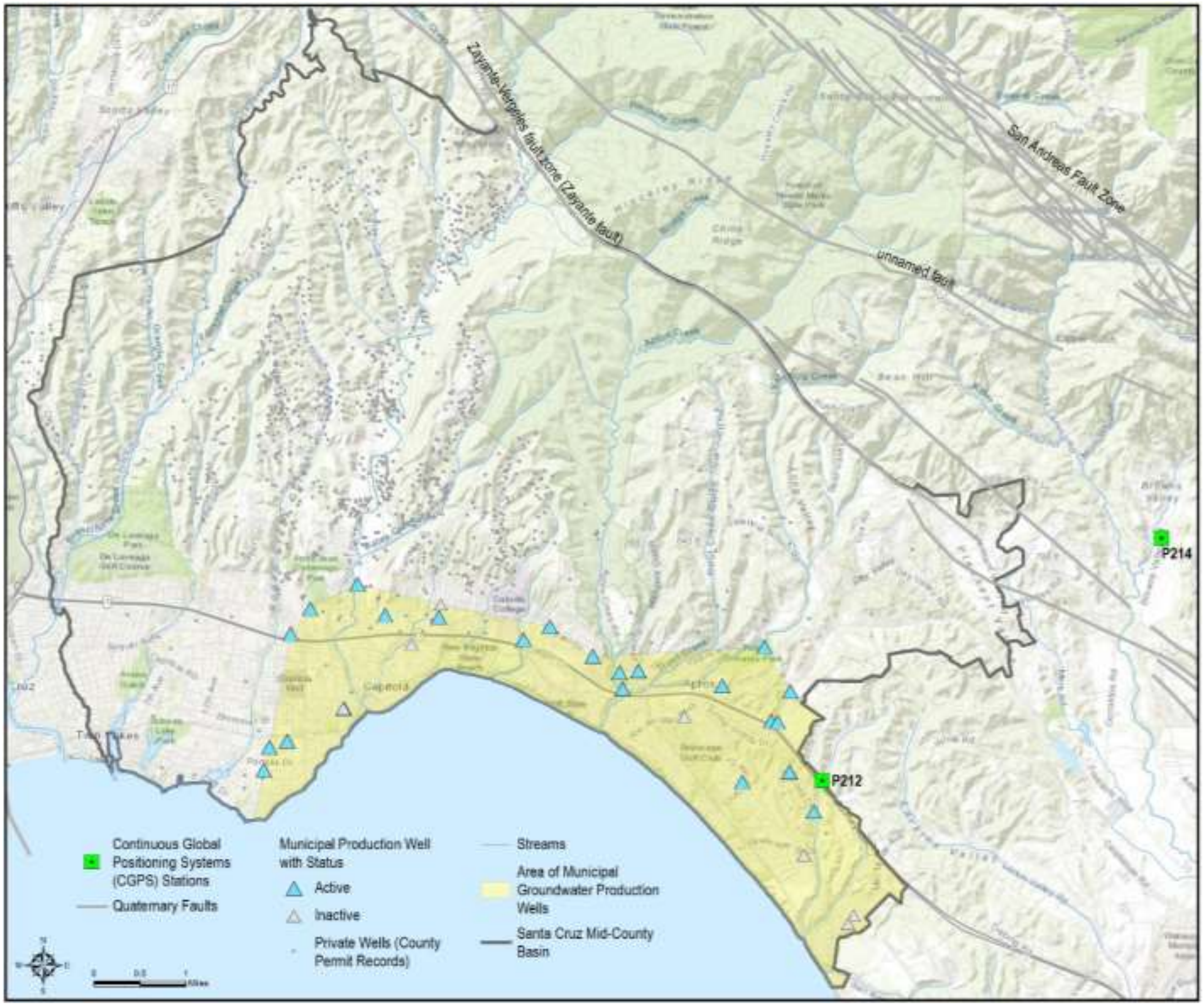


Figure 3-4. Location of Continuous GPS Stations near the Santa Cruz Mid-County Basin

3.3.2 Monitoring Protocols for Data Collection and Monitoring

Pursuant to the goals of SGMA, MGA member agencies use robust and reliable data collection protocols to monitor groundwater conditions in the Basin. Use of the monitoring protocols contained within this GSP ensure data is consistently collected by all member agencies, thereby increasing the reliability of data used to evaluate GSP implementation. Overall there are ~~four~~five types of data collected by MGA member agencies: groundwater elevations, groundwater quality, streamflow, volume of groundwater extracted, and climate conditions.

3.3.2.1 Groundwater Elevation Monitoring Protocols

Groundwater elevation monitoring is conducted to evaluate Basin conditions relative to the sustainable management criteria for chronic lowering of groundwater levels, seawater intrusion (proxy), and depletion of interconnected surface water (proxy), as shown in Table 3-1. Most groundwater levels in the Basin are measured and recorded at least daily using data loggers and measurements at most wells without loggers occur at least monthly. ~~-~~This allows the evaluation of a ‘snapshot’ of groundwater conditions for any given month.

All groundwater elevation measurements are referenced to a consistent elevation datum, known as the Reference Point (RP). For monitoring wells, the RP consists of a mark on the top of the well casing. For most production wells, the RP is the top of the well’s concrete pedestal. The elevation of the (RP) of each well is surveyed to the National Geodetic Vertical Datum of 1929 (NGVD 29). The elevation of the RP is accurate to at least 0.5 foot, and most MGA well RPs are accurate to 0.1 foot or less.

Groundwater level measurements are taken to the nearest 0.01 foot relative to the RP using procedures appropriate for the measuring device. Equipment is operated and maintained in accordance with manufacturer’s instructions, and all measurements are in consistent units of feet, tenths of feet, and hundredths of feet.

Groundwater elevation is calculated using the following equation:

$$GWE = RPE - DTW$$

where:

GWE = groundwater elevation

RPE = reference point elevation

DTW = depth to water

In cases where the official RPE is a concrete pedestal but the hand soundings are referenced off the top of a sounding tube, the measured DTW is adjusted by subtracting the sounding tube offset from the top of the pedestal.

All groundwater level measurements include a record of the date, well identifier, time (in 24-hour format), RPE, DTW, GWE, and comments regarding factors which may influence the recorded measurement such as nearby production wells pumping, weather, flooding, or well condition.

3.3.2.1.1 Manual Groundwater Level Measurement

Manual groundwater level measurements are made with electronic sounders or steel tape. All manual groundwater level measurements taken by MGA member agencies abide by the following protocols:

- Equipment usage follows manufacturer specifications for procedure and maintenance.
- Measurements are taken in wells that have not been subject to recent pumping. At least two hours of recovery must be allowed before a hand sounding is taken.
- For each well, multiple measurements are collected to ensure the well has reached equilibrium such that no significant changes in groundwater level are observed.
- Equipment is sanitized between well locations in order to prevent contamination and maintain the accuracy of concurrent groundwater quality sampling.

The majority of manual groundwater level measurements taken by MGA member agency utilize electric sounders. These consist of a long, graduated wire equipped with a weighted electric sensor. When the sensor is lowered into water, a circuit is completed and an audible beep is produced, at which point the sampler will record the depth to water. Some production wells may have lubricating oil floating on the top of the water column, in which case electric sounders will be ineffective. In this circumstance steel tape may be used. Steel tape instruments consist of simple graduated lines where the end of the line is chalked so as to indicate depth to water without interference from floating oil.

3.3.2.1.2 Groundwater Level Measurement with Continuous Recording Devices

In addition to manual groundwater level measurements, most municipal production wells, most monitoring wells, and the full subset of monitoring wells used as representative monitoring points are equipped with pressure transducers to collect more frequent data than manual measurements. Installation and use of pressure transducers abide by the following protocols:

- Prior to installation the sampler uses an electronic sounder or steel tape to measure and calculate the current groundwater level in order to properly install and calibrate the transducer. This is done following the protocols listed above.
- All transducer installations follow manufacturer specifications for installation, calibration, data logging intervals, battery life, and anticipated life expectancy.
- Transducers are set to record only measured groundwater level in order to conserve data capacity; groundwater elevation is calculated later after downloading.

- In any log or recorded datasheet, the well ID, transducer ID, transducer range, transducer accuracy, and cable serial number are all recorded.
- The sampler notes whether the pressure transducer uses a vented or non-vented cable for barometric compensation. If non-vented units are used, data are properly corrected for natural barometric pressure changes.
- All transducer cables are secured to the well head with a well dock or another reliable method. This cable is marked at the elevation of the reference point to allow estimates of future cable slippage.
- Transducer data is periodically checked against hand measured groundwater levels to monitor electronic drift, highlight cable movement, and ensure ~~data reliability.~~the transducer is operating correctly. This check occurs at least annually, typically during routine site visits.
- For wells not connected to SCADA, transducer data is downloaded as necessary to ensure no data is overwritten or lost. Data is entered into the data management system as soon as possible. When the transducer data is successfully downloaded and stored, the data is deleted or overwritten to ensure adequate data logger memory.

3.3.2.2 Groundwater Quality Monitoring Protocols

Groundwater quality samples are required to monitor the effect of GSP implementation on the degraded groundwater quality and seawater intrusion sustainability indicators (Table 3-1). All groundwater quality analyses are performed by laboratories certified under the State Environmental Laboratory Accreditation Program.

While specific groundwater sampling protocols vary depending on the constituent and the hydrogeologic context, the protocols contained here provide guidance which is applied to all groundwater quality sampling. Prior to sampling, the sampler contacts the laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements. Laboratories must be able to provide a calibration curve for the desired analyte and are instructed to use reporting limits that are equal to or less than the applicable data quality objectives, regional water quality objectives/screening levels, or state Detection Limit for Purposes of Reporting.

- Each well used for groundwater quality monitoring has a unique identifier (ID). This ID is written on the well housing or the well casing to avoid confusion.
- Sample containers are labeled prior to sample collection. The sample label includes: sample ID, sample date and time, sample personnel, sample location, preservative used, analyte, and analytical method.

- In the case of wells with dedicated pumps, samples are collected at or near the wellhead. Samples are not collected from storage tanks, at the end of long pipe runs, or after any water treatment.

- Prior to any sampling, the sampler cleans the sampling port and/or sampling equipment so that it is free of any contaminants, and also decontaminates sampling equipment between sampling locations to avoid cross-contamination between samples.

- At the time of sampling, groundwater elevation in the well is also measured following appropriate protocols described above in the groundwater level measuring protocols.

- For any well not equipped with low-flow or passive sampling equipment, at least three well ~~casings~~casing volumes are purged from the well to ensure that the groundwater sample is representative of ambient groundwater and not stagnant water in the well casing. If pumping causes a well to be go dry, the condition is documented and the well is allowed to recover to within 90% of original level prior to sampling.

- In addition to the constituent of interest, field parameters of dissolved oxygen, electrical conductivity, temperature, oxidation reduction potential and pH are collected for each sample during well purging, with dissolved oxygen and conductivity being the most critical parameters. Samples are not collected until these parameters stabilize. Parameters are considered stabilized at the following ranges: dissolved oxygen and oxidation reduction potential, ±10%; temperature and electrical conductivity, ±3%; and pH ±0.2%.

- All field instruments are calibrated each day of use, cleaned between samples, evaluated for drift throughout the day of use.

- Samples are collected exclusively under laminar flow conditions. This may require reducing pumping rates prior to sample collection.

- Samples are collected according to the appropriate standards listed in the Standard Methods for the Examination of Water and Wastewater and the USGS National Field Manual for the Collection of Water Quality Data. The specific sample collection procedures reflect the type of analysis to be performed and characteristics of the constituent.

- All samples requiring preservation are preserved as soon as practically possible and filtered appropriately as recommended for the specific constituent.

- Samples are chilled and maintained at 4 °C to prevent degradation of the sample.

- Samples must be shipped under chain of custody documentation to the appropriate laboratory promptly to avoid violating holding time restrictions.

3.3.2.3 Streamflow Monitoring Protocols

Streamflow discharge measurements are collected by MGA member agencies and partners to monitor streamflow interaction related to groundwater extractions, monitor stream conditions related to fish habitat, and help preserve other beneficial uses of surface water. There is one USGS gauge that is operated and monitored by the USGS according to procedures outlined by USGS (1982).

Surface water is most easily measured using a stream gauge and stilling well system, which requires development of ~~a ratings curve~~rating curves between stream stage and total discharge. Several measurements of discharge at a variety of stream stages are taken to develop an accurate ratings curve. ~~This relationship is sometimes developed with assistance from Acoustic Doppler Current Profilers (ADCPs). Following development of an accurate ratings curve, streamflow is evaluated on a frequent basis via use of a simple stilling well and pressure transducer.~~

3.3.2.4 Measuring Groundwater Extraction Protocols

Groundwater extraction volumes are collected to provide data for well field management and for assessment of the Basin's water budget. Additionally, the volume of groundwater extraction is the metric for the reduction of groundwater in storage sustainability indicator. Municipal MGA member agencies measure discharge from all their production wells with calibrated flow meters. Supervisory Control and Data Acquisition (SCADA) for individual wells are used to monitor and control production in close to real-time.

Small water systems (SWS) report their annual extractions to Santa Cruz County. ~~Meter readings~~Meters are typically read monthly.

3.3.3 Representative Monitoring Points

Representative Monitoring Points (RMPs) are a subset of the Basin's overall monitoring network. Designation of an RMP is supported by adequate evidence demonstrating that the site reflects general conditions in the area. Representative monitoring points are where numeric values for minimum thresholds, measurable objectives, and interim milestones are defined. Avoiding undesirable results based on data collected at RMPs demonstrates the Basin's sustainability.

Groundwater levels may be used as a proxy for sustainability indicators whose metric is not groundwater levels if the following can be demonstrated:

1. Significant correlation exists between groundwater elevations and the sustainability indicators for which groundwater elevation measurements serve as a proxy.

2. Measurable objectives established for groundwater elevation include a reasonable margin of operational flexibility taking into consideration the basin setting to avoid undesirable results for the sustainability indicators for which groundwater elevation measurements serve as a proxy.

Table 3-1 lists the metrics for each of the Basin's applicable sustainability indicators~~ and indicates the~~. The sustainability indicators for *seawater intrusion* and *depletion of interconnected surface water*~~ sustainability indicators~~ use groundwater levels as a proxy.

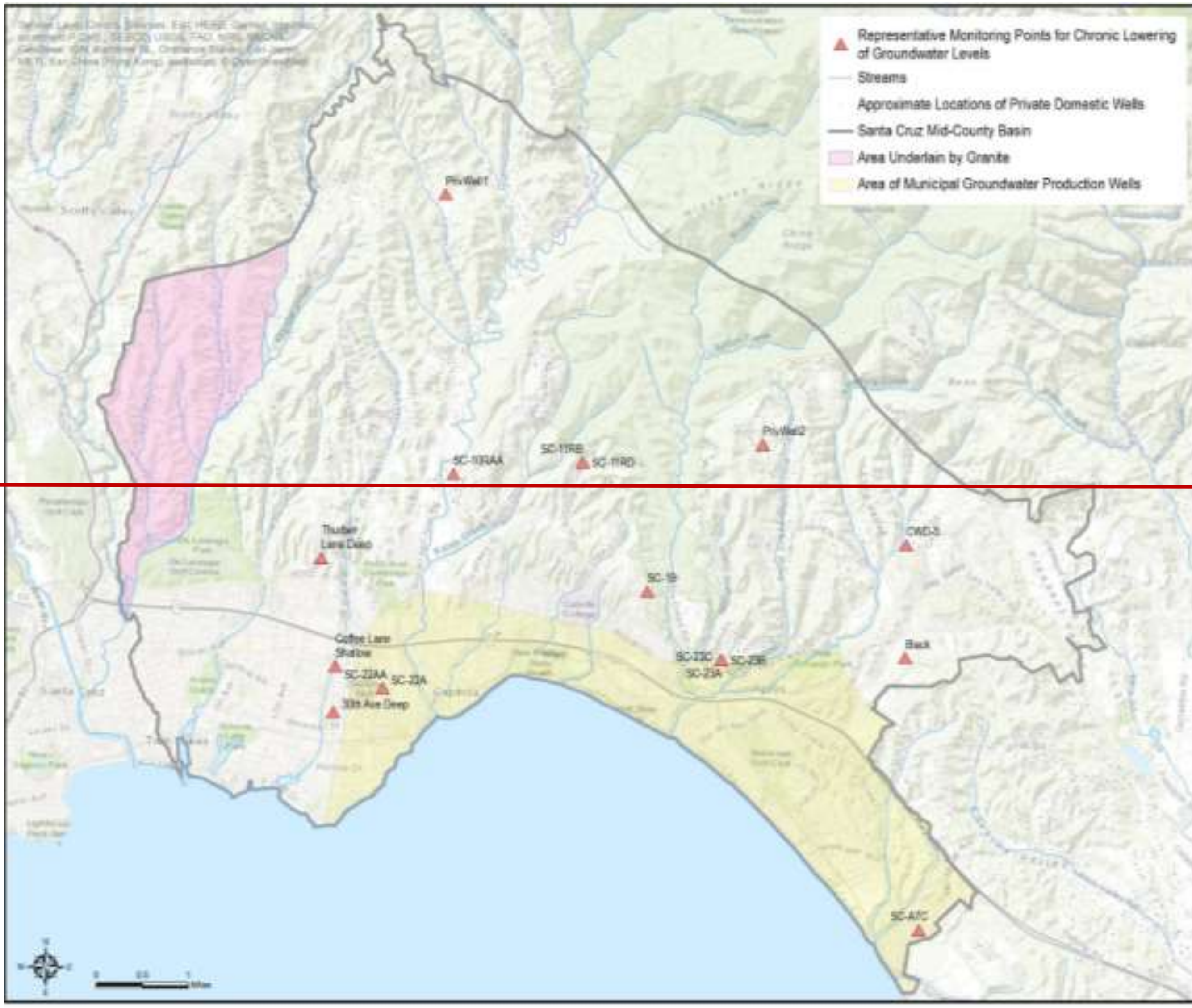
3.3.3.1 Chronic Lowering of Groundwater Level Representative Monitoring Points

The objective of the chronic lowering of groundwater levels representative monitoring network is to monitor areas where there is a concentration of groundwater extraction, but not immediately adjacent to municipal production wells. This is to avoid the dynamic drawdown caused by high-capacity wells. Use of dedicated monitoring wells in the network is preferable over wells actively used for groundwater extraction. Clustered multi-depth monitoring wells are included to evaluate groundwater elevations in different aquifers at the same location and to evaluate vertical gradients between aquifers. Because groundwater elevations to protect against seawater intrusion are higher (or more stringent) than groundwater elevations to prevent chronic lowering of groundwater levels, RMPs along the coast are not included in the chronic lowering of groundwater levels monitoring network. Groundwater elevations along the coast are instead controlled by the seawater intrusion sustainable management criteria in coastal monitoring wells.

Figure 3-5 includes all wells in the representative monitoring network used for monitoring chronic lowering of groundwater levels.

Table 3-7. Representative Monitoring Points for Chronic Lowering of Groundwater Levels

Aquifer Unit	Well Name	Rationale
Aromas	SC-A7C	Located near boundary with Pajaro Valley Subbasin
Purisima F	Private Well 2	Located in an inland area with a high concentration of private domestic wells
	Black	Located near boundary with Pajaro Valley Subbasin in an area with a high concentration of private domestic wells, and is a dedicated monitoring well
	CWD-5	Located in an area with a high concentration of private domestic wells and is a dedicated monitoring well
	SC-23C	Just inside the area of municipal production but close to municipal production wells pumping from the Purisima F-unit and a high concentration of private domestic wells
Purisima DEF	SC-11RD	Located in an area with a high concentration of private domestic wells
	SC-23B	Just inside the area of municipal production but close to municipal production wells pumping from the Purisima DEF-unit and a high concentration of private domestic wells
Purisima BC	SC-11RB	Located in an area with a high concentration of private domestic wells
	SC-19	Outside the area of municipal production but close to municipal production wells pumping from the Purisima BC-unit and in an area between private domestic well pumping centers
	SC-23A	Just inside the area of municipal production but close to municipal production wells pumping from the Purisima BC-unit and a high concentration of private domestic wells
Purisima A	Coffee Lane Shallow	Outside the area of municipal production but close to municipal production wells pumping from the Purisima A-unit
	SC-22A	Inside the area of municipal production but close to municipal production wells pumping from the Purisima A-unit
Purisima AA	SC-22AA	Inside the area of municipal production but close to municipal production wells pumping from the Purisima AA-unit
	SC-10RAA	Located in an area with a high concentration of private domestic wells
Purisima AA/Tu	Private Well 1	Located in an inland area with a high concentration of private domestic wells
Tu	30th Ave Deep	One of the few monitoring wells screened in the Tu aquifer located outside of the area of municipal production
	Thurber Lane Deep	One of the few monitoring wells screened in the Tu aquifer located outside of the area of municipal production


Representative Monitoring Points for Chronic Lowering of Groundwater Levels
Streams
Approximate Locations of Private Domestic Wells
Santa Cruz Mid-County Basin
Area Underlain by Granite
Area of Municipal Groundwater Production Wells
SC-11RB
SC-11RD
SC-19
SC-22AA
SC-22A
SC-23C
SC-23A

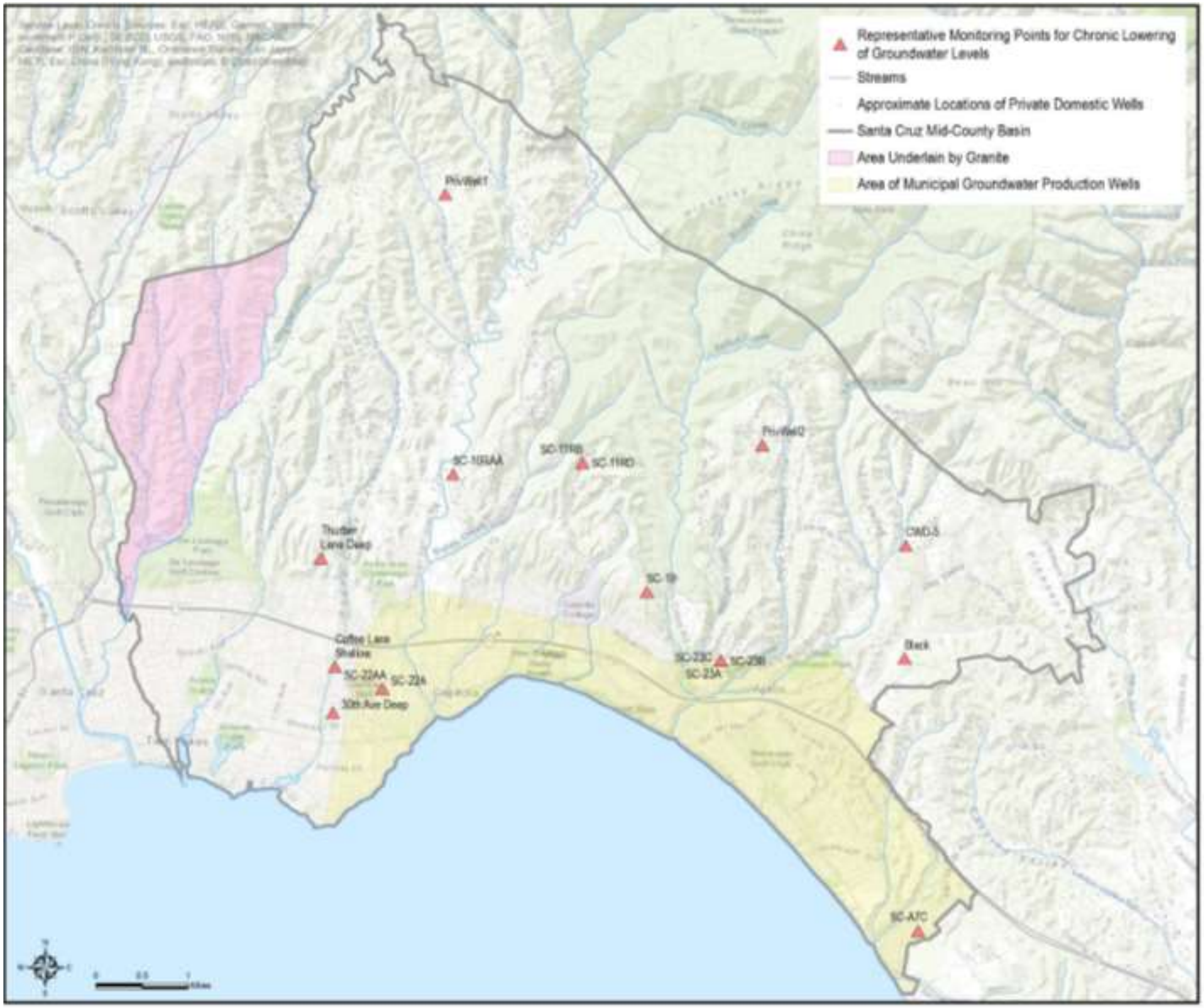
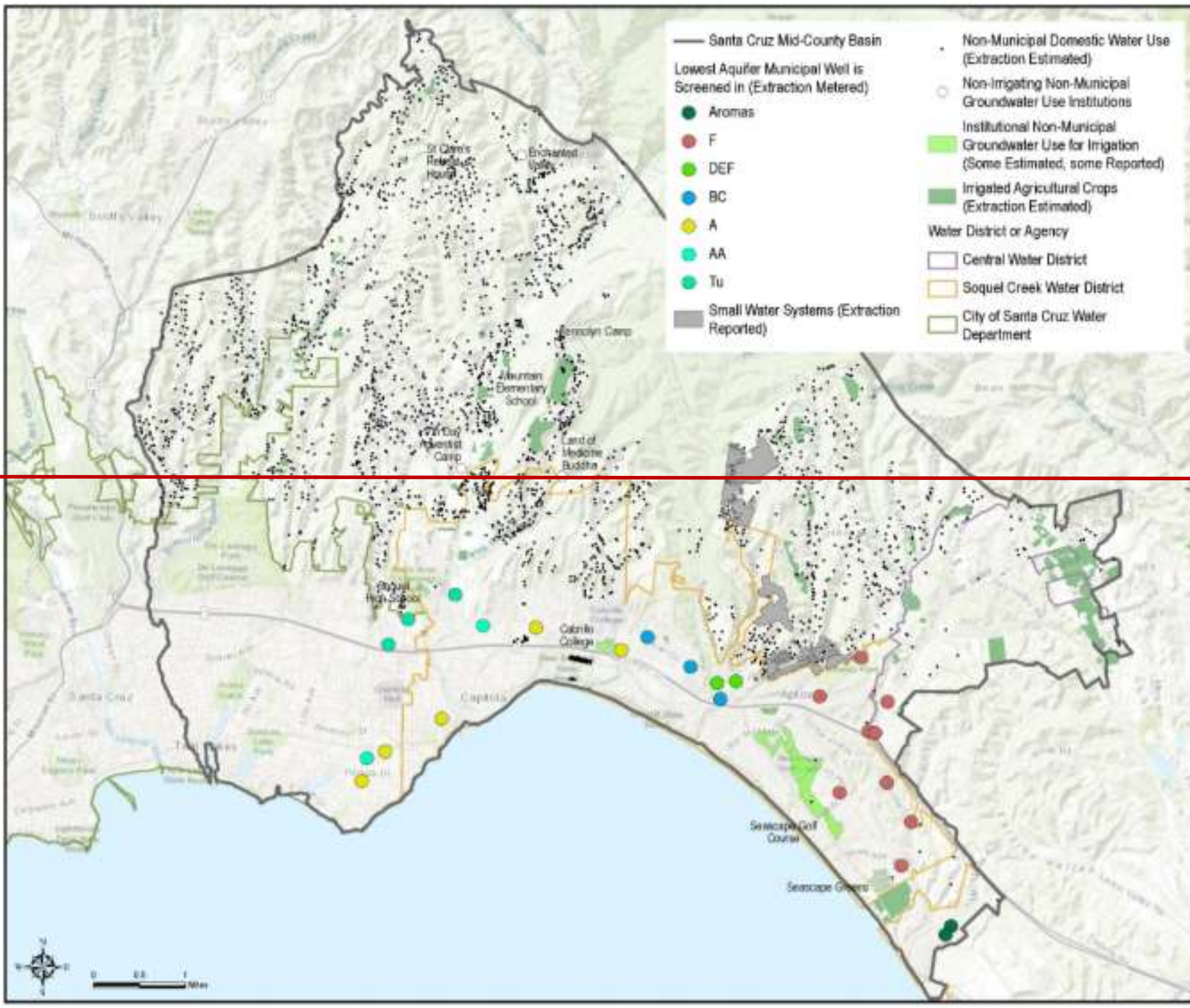


Figure 3-5. Chronic Lowering of Groundwater Level Representative Monitoring Network

3.3.3.2 Reduction of Groundwater in Storage Representative Monitoring Points

The physical well locations for the reduction of groundwater in storage representative monitoring network are all metered wells in the Basin (Figure 3-6). These are the only points where measured extraction data are available to evaluate the sustainability of the Basin with respect to reduction of groundwater in storage. All other groundwater extraction in the Basin will be estimated. Section 3.3.1.3 (Groundwater Extraction Monitoring) describes how small water systems, *de minimis* private pumping, and agricultural irrigation pumping will be estimated.

Wells that are metered as part of GSP implementation will be added as RMPs to the reduction of groundwater in storage representative monitoring network.



~~**Figure 3-6. Reduction of Groundwater in Storage Representative Monitoring Network**~~

3.3.3.3 Seawater Intrusion Representative Monitoring Points

The seawater intrusion monitoring network monitors both chloride concentration and groundwater elevations as a proxy for seawater intrusion. Chloride concentrations are monitored in wells which are at least 0.5 mile away from the coast and either side of the chloride isocontour representing a minimum threshold for seawater intrusion. The City of Santa Cruz and SqCWD have been using protective groundwater elevations in coastal monitoring wells since 2009 to monitor and manage seawater intrusion in the Basin, and these same wells plus some additional wells to monitor the very deepest aquifers will be included in the representative monitoring network for proxy monitoring of seawater intrusion. Groundwater levels are continuously monitored with data loggers in all ~~protective elevation~~ coastal monitoring wells~~, and hand~~ where protective elevations are set. Hand soundings are taken at least quarterly in these RMP coastal monitoring wells.

In the event of data logger failure, monthly soundings measured during the data gap should be used to replace missing data in calculating averages used to determine if undesirable results have occurred. If no sounding measurement occurred during the data gap, the average of available hourly readings in the 7 days before and the 7 days after the data gap (up to 336 total hourly readings) should be used to replace the missing data in calculating averages. If data logger groundwater level data are shown to be inconsistent with a sounding measurement, the sounding measurement should be used to replace the inconsistent logger data in the calculation of averages. Inconsistent logger data is considered a variation of 0.5-feet between data logger and manual well soundings.

Figure 3-7 shows the locations of all RMPs in the seawater intrusion monitoring network used for both chloride concentrations and groundwater elevation proxies. The wells used to measure chloride concentrations have a different symbol than those used to monitor protective groundwater elevations. Table 3-8 lists the wells in the representative monitoring network and provides a brief rationale why each well was selected as an RMP.

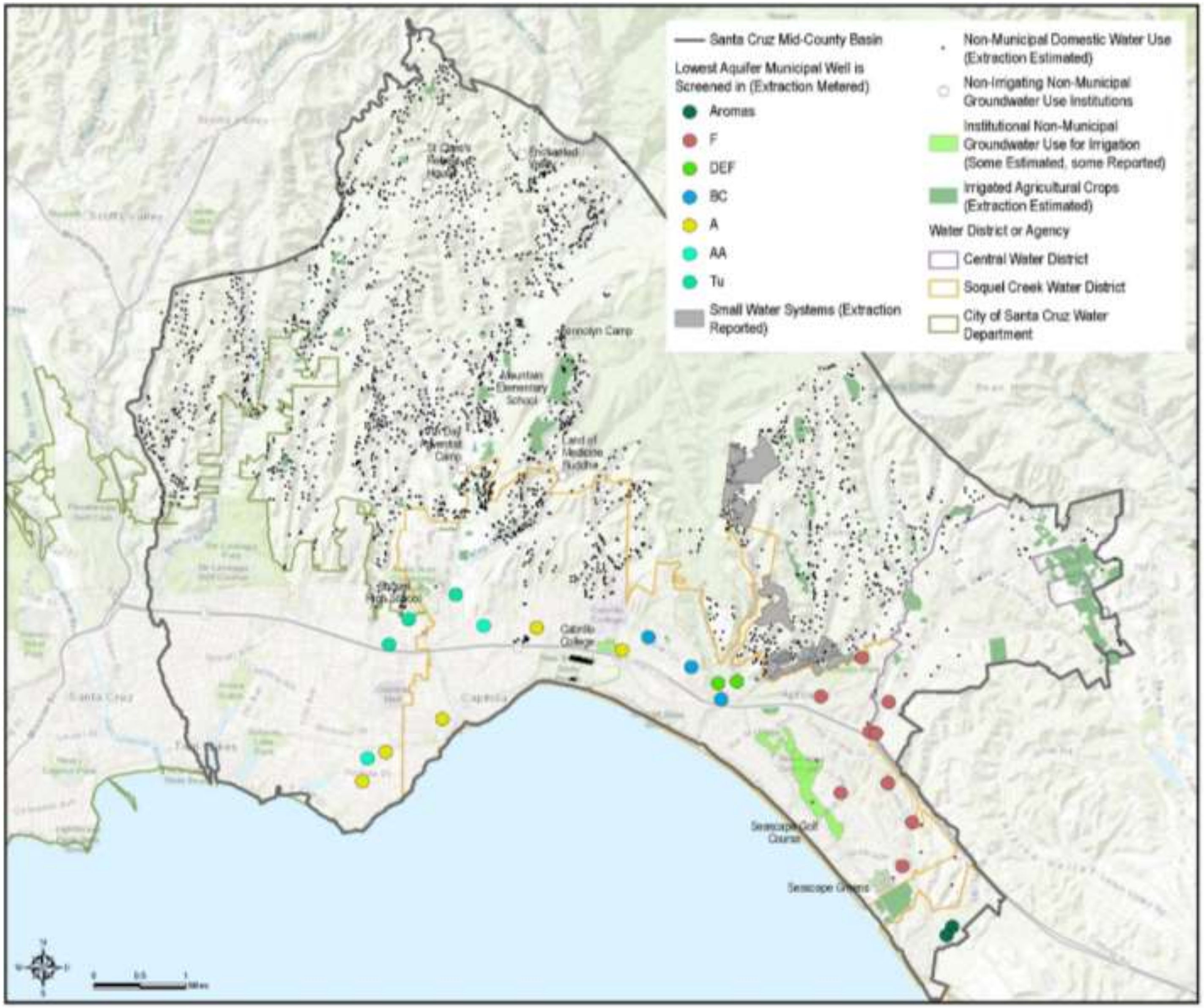


Figure 3-6. Reduction of Groundwater in Storage Representative Monitoring Network

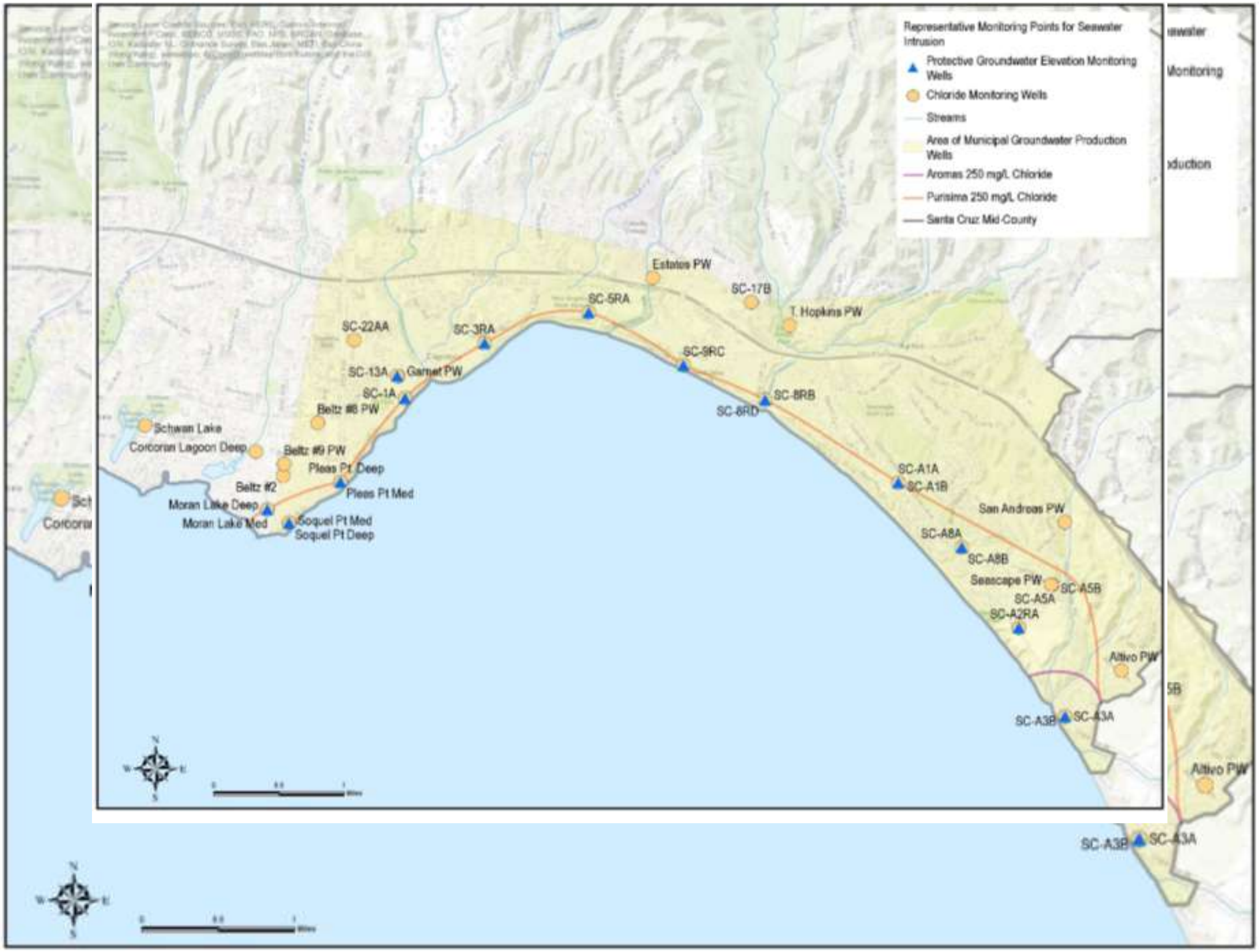


Figure 3-7. Seawater Intrusion Representative Monitoring Network

Table 3-8. ~~Seawater Intrusion Representative Monitoring Network~~

~~Table 3-9.~~ Representative Monitoring Points for Seawater Intrusion

Aquifer Unit	Well Name	Rationale	Metric
Aromas	Altivo PW	Municipal production well closest inland of the chloride isocontour	Chloride
	SC-A3B	Coastal monitoring well within the area intruded by seawater	Chloride
	SC-A3A	Coastal monitoring well within the area intruded by seawater	Chloride and GWL
	SC-A8B	Coastal monitoring well within the area intruded by seawater but at a depth above saltwater interface	Chloride
Aromas / Purisima F	Seascape PW	Municipal production well within the area intruded by seawater but at a depth above saltwater interface	Chloride
	San Andreas PW	Municipal production well closest inland of the chloride isocontour	Chloride
Purisima F	SC-A1B	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL
	SC-A2RA	Coastal monitoring well within the area intruded by seawater	Chloride and GWL
	SC-A2RB	Coastal monitoring well within the area intruded by seawater	Chloride and GWL
	SC-A8A	Coastal monitoring well within the area intruded by seawater	Chloride and GWL
	SC-A5A	Inland monitoring well with seawater intrusion; screened ~100 ft below Seascape PW	Chloride
	SC-A5B	Inland monitoring well at a depth above saltwater interface; screened ~20 ft below Seascape PW	Chloride
Purisima DEF	SC-8RD	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL
	SC-A1A	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride
	T. Hopkins PW	Municipal production well closest inland of the chloride isocontour	Chloride

Aquifer Unit	Well Name	Rationale	Metric
Purisima BC	SC-9RC	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL
	SC-8RB	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL
	Ledyard PW	Municipal production well between the Estates and T-Hopkins production wells	Chloride
Purisima A/BC	Estates PW	Municipal production well closest inland of the chloride isocontour	Chloride
Purisima A	Moran Lake Medium	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL
	Soquel Point Medium	Coastal monitoring well within the area intruded by seawater	Chloride and GWL
	Pleasure Point Medium	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL
	SC-1A	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL
	SC-3RA	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL
	SC-5RA	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL
	Beltz #2	Inland monitoring well that monitors inland of the chloride isocontour	Chloride
	Beltz #8 PW	Municipal production well closest inland of the chloride isocontour	Chloride
	Garnet PW	Municipal production well closest inland of the chloride isocontour	Chloride
Purisima AA	Moran Lake Deep	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL
	Pleasure Point Deep	Coastal monitoring well through which the 250 mg/L chloride isocontour runs through	Chloride and GWL

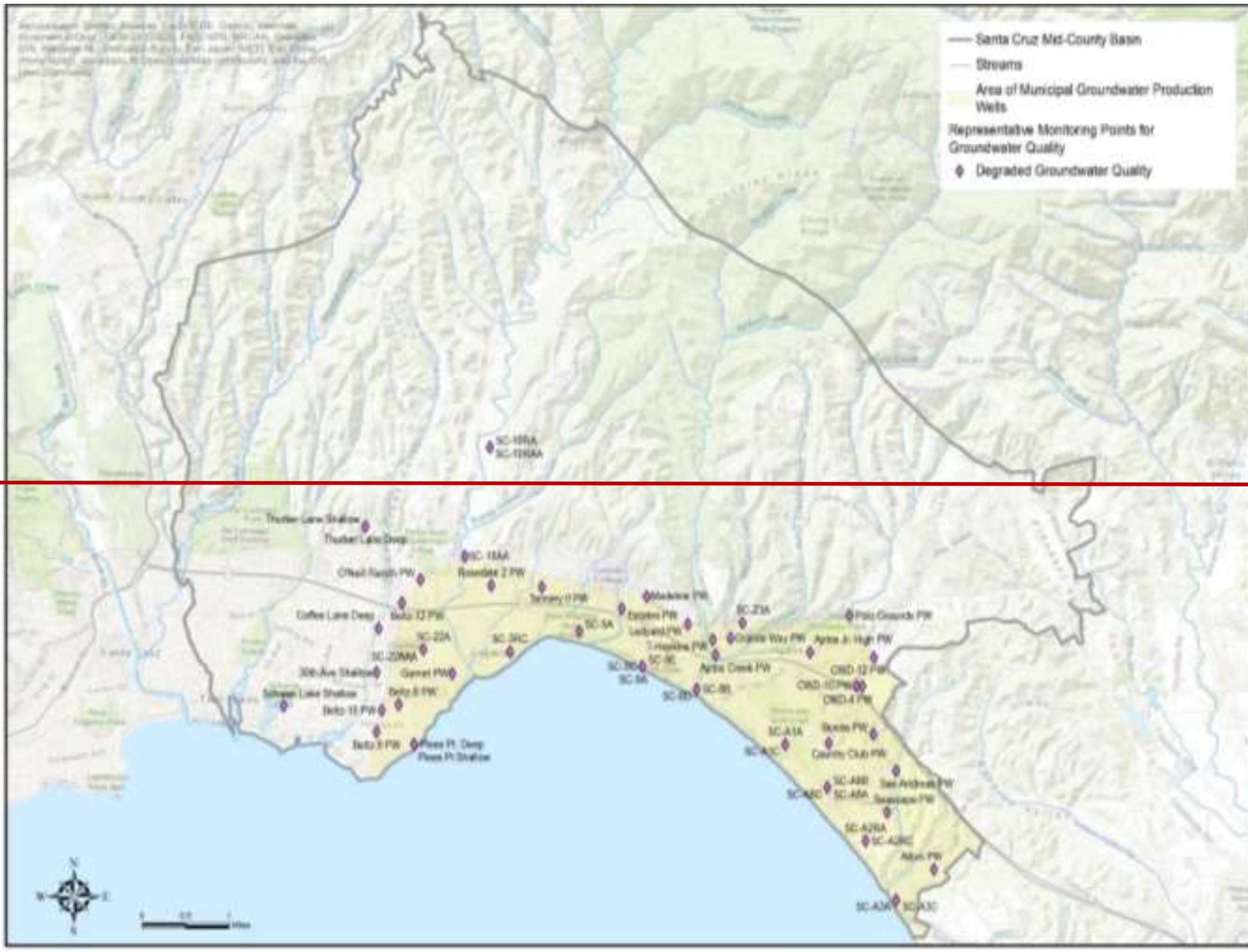
Aquifer Unit	Well Name	Rationale	Metric
	Soquel Point Deep	Coastal monitoring well within the area intruded by seawater but at a depth below intrusion	Chloride and GWL
	SC-22AA	Inland monitoring well that monitors inland of the chloride isocontour	Chloride
	Corcoran Lagoon Deep	Inland monitoring well that monitors inland of the chloride isocontour	Chloride
	Schwan Lake	Westernmost monitoring well	Chloride
Tu	SC-13A	Coastal monitoring well	Chloride and GWL

PW = production well; GWL = groundwater level

3.3.3.4 Degraded Groundwater Quality Representative Monitoring Points

Figure 3-8 shows the distribution of wells selected as RMPs for the degraded groundwater quality monitoring network. Since the sustainability of the degraded groundwater quality indicator is related to quality impacts caused by projects and management actions implemented as part of the GSP, its RMPs are located in areas where projects and management actions are most likely to be located in the future, i.e., within the water districts' and City service areas.

The majority of municipal production wells in the Basin are included as RMPs for degraded groundwater quality since they are the wells that provide groundwater to the largest beneficial user group. Municipal production wells are only excluded as RMPs if there is another nearby municipal production well screened in the same aquifer that is an RMP. In the area of municipal production (yellow shaded area on Figure 3-8), monitoring wells are added as RMPs in areas where there are no municipal production wells.



~~**Figure 3-7. Degraded Groundwater Quality Representative Monitoring Network**~~

Future projects implemented as part of the GSP to achieve sustainability will have designated monitoring wells, some existing and some new, as part of their permit conditions. ~~Wells~~Additional monitoring wells not ~~already an RMP~~currently identified as RMPs for degraded groundwater quality will be included as ~~RMP in~~needed to monitor future projects under the GSP~~, and the~~. The constituents monitored ~~as part of~~for each new RMP will comply with permit conditions for these future projects, will become constituents of concern for ~~those particular RMPs.~~

these new RMPs, and will be incorporated into monitoring and reporting requirements under this GSP.

Figure 3-8. Degraded Groundwater Quality Representative Monitoring Network

Table 3-9. Representative Monitoring Points for Degraded Groundwater Quality

Aquifer Unit	Well Name	General Water Quality Sampling Frequency	Rationale
Aromas	Altivo PW*	Semi-Annual	Production well and area impacted by nitrate
	CWD-10 PW	Triennial, nitrate as (N) annual	Production well
	SC-A1C	Annual	Coastal monitoring well in area with spare monitoring wells
	SC-A2RC	Semi-Annual	Coastal monitoring well, and located between an area of private well domestic and agricultural users
	SC-A3A	Annual	Southernmost coastal monitoring well
	SC-A3C	Semi-Annual	Southernmost coastal monitoring well
	SC-A8B	Semi-Annual	Coastal monitoring well
	SC-A8C	Annual	Coastal monitoring well
Aromas/ Purisima F	Polo Grounds PW	Semi-Annual, nitrate (as N) annual	Production well
	Country Club PW*	Semi-Annual, nitrate (as N) annual	Production well
	Bonita PW	Semi-Annual, nitrate (as N) annual	Production well
	San Andreas PW	Semi-Annual, nitrate (as N) annual	Production well
	Seascape PW	Semi-Annual, nitrate (as N) annual	Production well
Purisima F	CWD-4 PW	Triennial, nitrate as (N) annual	Production well
	CWD-12 PW	Triennial, nitrate as (N) annual	Production well, inland
	Aptos Jr. High 2 PW	Semi-Annual, nitrate (as N) annual	Production well
	SC-A2RA	Annual	Coastal monitoring well, and located between an area of private well domestic and agricultural users
	SC-A8A	Annual	Coastal monitoring well
Purisima DEF	SC-8RD	Annual	Coastal monitoring well
	SC-9RE	Annual	Coastal monitoring well
	SC-A1A	Semi-Annual	Coastal monitoring well in area with few monitoring wells
	Granite Way PW	Annual	Production well
	T-Hopkins PW	Annual	Production well
Purisima BC	Ledyard PW	Annual	Production well
	Madeline 2 PW	Annual	Production well

Aquifer Unit	Well Name	General Water Quality Sampling Frequency	Rationale
	Aptos Creek PW	Annual	Production well
	SC-23A	Annual	Inland of a production wellfield
	SC-3RC	Annual	Coastal monitoring well
	SC-8RB	Annual	Coastal monitoring well
	SC-9RC	Annual	Coastal monitoring well
Purisima A	30th Ave Shallow	Semi-Annual	Just outside of area of municipal production
	Pleasure Point Shallow	Quarterly	Coastal monitoring well
	Estates PW	Annual	Production well
	Garnet PW	Annual	Production well
	Tannery II PW	Annual	Production well
	Rosedale 2 PW	Annual	Production well
	Beltz #8 PW	Triennial, iron & manganese quarterly, nitrate (as N) annual	Production well
	Beltz #9 PW	Triennial, iron & manganese quarterly, nitrate (as N) annual	Production well
	SC-5RA	Annual	Coastal monitoring well
	SC-9RA	Annual	Coastal monitoring well
	SC-10RA	Annual	Inland monitoring well
	SC-22A	Quarterly	Between several municipal production wells
Purisima A/AA	Beltz #10 PW	Triennial, iron & manganese quarterly, nitrate (as N) annual	Production well
Purisima AA	SC-10RAA	Annual	Inland monitoring well
	SC-22AAA	Semi-Annual	Between several municipal production wells
	Coffee Lane Deep	Semi-Annual	Just outside of area of municipal production
	Pleasure Point Deep	Quarterly	Coastal monitoring well
	Thurber Lane Shallow	Semi-Annual	Inland monitoring well
	Schwan Lake	Semi-Annual	Westernmost monitoring well
Purisima AA/Tu	O'Neill Ranch PW	Annual	Production well
	Beltz #12 PW	Triennial, iron & manganese quarterly, nitrate (as N) annual	Production well
Tu	SC-18RAA	Semi-Annual	Next to production well
	Thurber Lane Deep	Semi-Annual	Inland monitoring well and one of the few Tu unit wells

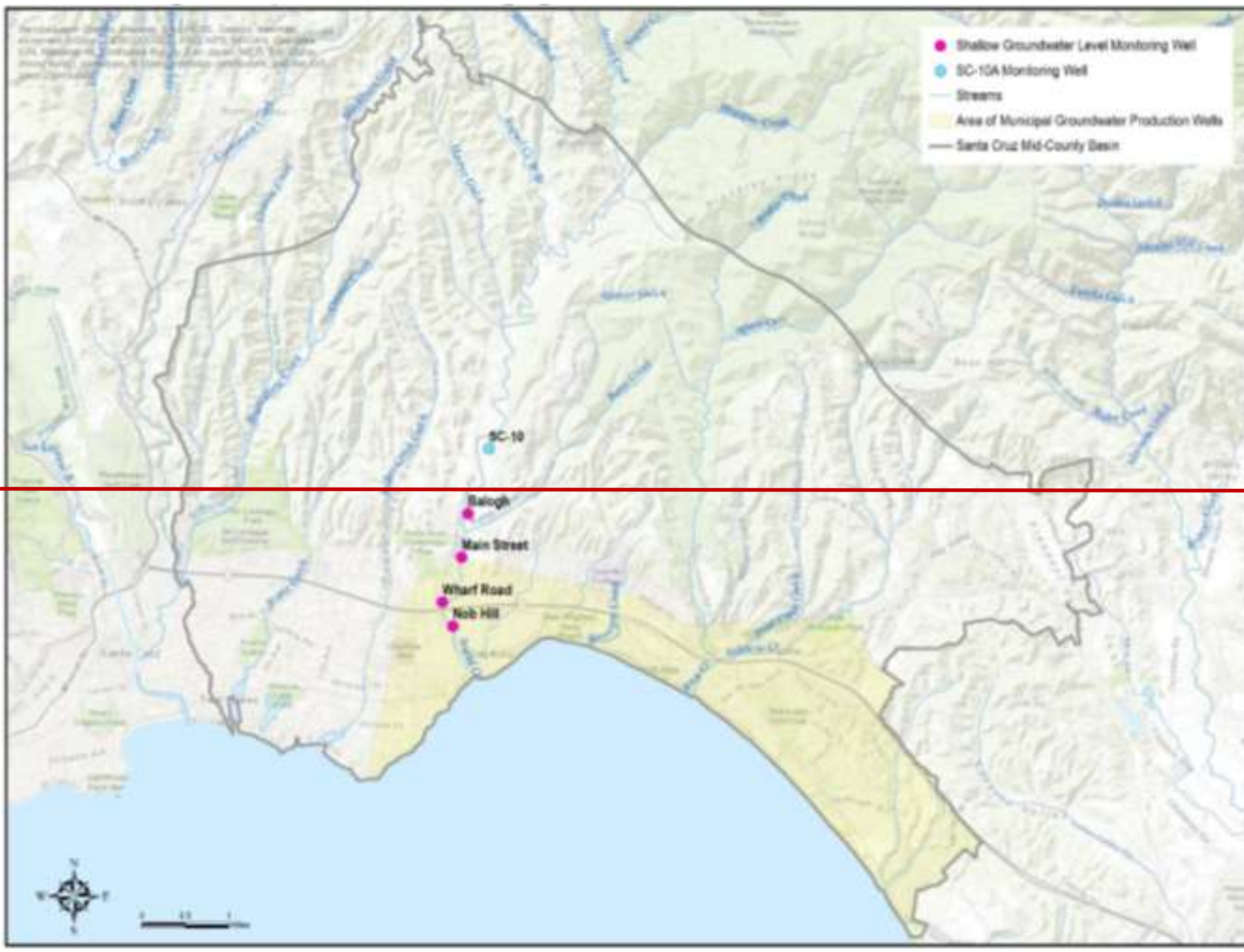
* Standby well that will not be sampled until a water treatment plant is constructed to treat 1,2,3-trichloropropane (TCP)

3.3.3.5 Depletion of Interconnected Surface Water Monitoring Representative Monitoring Points

The depletion of interconnected surface water ~~monitoring~~ representative monitoring network monitors shallow groundwater elevations adjacent to creeks that both support priority species and are interconnected with groundwater. Groundwater elevations as a proxy for surface water ~~depletions~~depletion are needed as a measure of sustainability because no direct measurable change in streamflow from deep groundwater extraction has been detected in over 18 years of monitoring shallow groundwater levels adjacent to lower Soquel Creek. Even though there is no measurable direct change in streamflow from groundwater extraction, there is a demonstrable indirect influence on shallow groundwater connected to the creek from deeper aquifers pumped by municipal and private wells. This is discussed in Section 2~~: Basin Setting~~.2.4.6: Identification of Interconnected Surface Water Systems.

~~Figure 3-1~~Figure 3-9 shows the location of four shallow monitoring wells currently used to monitor depletion of interconnected surface water. These four wells are designated as RMPs for groundwater level proxy measurements. One other monitoring well, SC-10RA, is also included as an RMP because it is located within 730 feet of Soquel Creek, is screened from 110-170 feet below ground in the Purisima A-unit aquifer underlying alluvium, and has groundwater levels that correspond to changes in creek flows. Table 3-10 lists the RMPs and summarizes rationale for selection.

Since these wells only monitor the lower reach of Soquel Creek, the MGA recognizes that other shallow wells are needed to better characterize the surface water / groundwater interaction for other reaches of Soquel Creek and for other creeks that are connected to groundwater. Section 3.3.4 discusses the monitoring data gaps for this sustainability indicator.



~~**Figure 3-8. Depletion of Interconnected Surface Water Existing Representative Monitoring Network**~~

Table 3-10. Representative Monitoring Points for Depletion of Interconnected Surface Water

Monitoring Type	Well Name	Rationale
Shallow Groundwater Levels	Balogh	Dedicated shallow groundwater / surface water monitoring well
	Main St. Shallow	Dedicated shallow groundwater / surface water monitoring well
	Wharf Road	Dedicated shallow groundwater / surface water monitoring well
	Nob Hill	Dedicated shallow groundwater / surface water monitoring well
Purisima A	SC-10RA	Shallow monitoring well 730 feet from Soquel Creek, screened in Purisima A-unit below alluvium. Groundwater levels show response to creek flows and rainfall

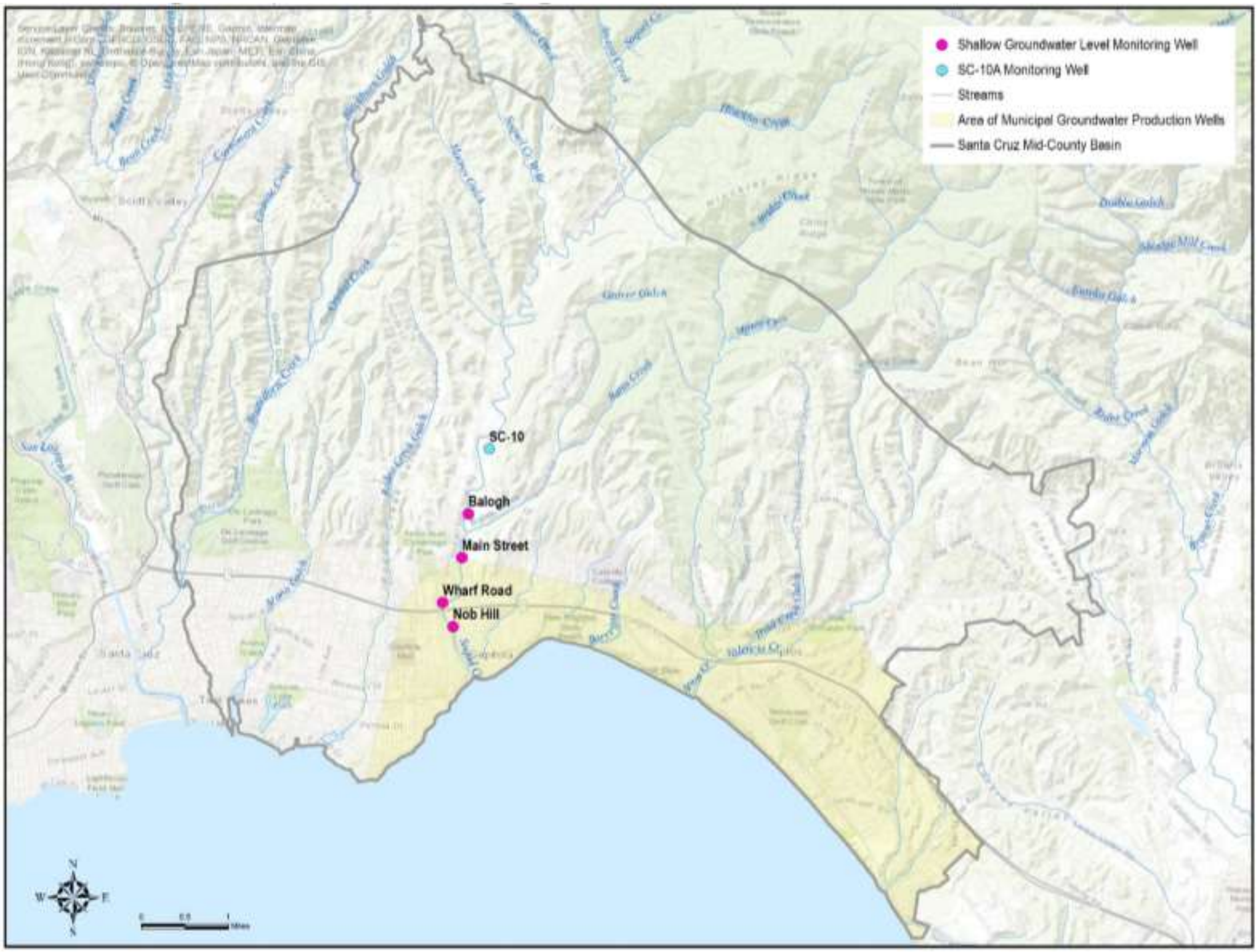


Figure 3-9. Depletion of Interconnected Surface Water Existing Representative Monitoring Network

3.3.4 Assessment and Improvement of Monitoring Network

3.3.4.1 Groundwater Level Monitoring Data Gaps

The existing groundwater level monitoring network described in ~~Section 3.3.1.1 (Groundwater Level Monitoring Network)~~3.3.1.1 is extensive laterally both across the Basin and vertically through all of the Basin's aquifers. There are however ~~a few~~some locations where new monitoring wells are required to evaluate groundwater levels for improved Basin characterization and to potentially include as RMPs once they have been constructed.

Seawater Intrusion monitoring: Additional deeper wells are needed in two locations along the coast. Existing monitoring wells at these locations do not extend down far enough to establish protective groundwater elevations for the deepest producing aquifers that are being used for production and in the near future potentially used for storage. Figure 3-10 shows the locations of the two proposed deep monitoring wells. One of the locations, SC-3 (AA), will involve adding a deeper monitoring well adjacent to an existing SqCWD monitoring well screened in the Purisima A-unit. The second location, will be a deep Tu monitoring well located between the City of Santa Cruz's Soquel Point and Pleasure Point monitoring cluster. The exact location is still to be determined.

Depletion of interconnected surface water monitoring: To more fully characterize interconnections between surface water and groundwater, additional monitoring of shallow groundwater levels is needed in the upper reaches of Soquel Creek and on other creeks that both support priority species and have a connection to groundwater. The locations for additional shallow wells are selected based on whether groundwater is connected to surface water, it is in an area of concentrated groundwater extraction, has a suitable nearby location for a streamflow gauge, and has potential site access. There is a fair degree of uncertainty regarding access at some of the proposed locations. The actual locations of future shallow wells will be determined based on a site suitability study that will include the ability to obtain easements~~.~~ or an access agreement. Figure 3-10 shows the locations of eight proposed shallow monitoring wells that fill monitoring gaps in the Basin. To indicate areas of concentrated groundwater extraction, Figure 3-10 shows the area of municipal pumping and the small dots are approximate locations of private domestic wells. The proposed shallow well on Lower Aptos is an example of a well site that may be moved, based ~~in~~on findings from the site suitability study, to a better location that may be on Valencia Creek above Aptos Creek. The shallow well on Rodeo Gulch is a lower priority site which may require synoptic measurements to establish where it is gaining and losing before finalizing a new shallow monitoring well site. Section 5 on Plan Implementation outlines how the MGA plans to finance and construct the eight shallow monitoring wells.

Table 3-11. Summary of Additional Monitoring Wells to Fill Groundwater Level Data Gaps

Sustainability Indicator being Monitored	General Location	Rationale
Seawater Intrusion	Deep well near Soquel Point	No existing coastal monitoring in the Tu unit in the SCWD area
	Deep well at the SC-3 well site	No existing coastal monitoring exclusively in the AA unit in the SqCWD area
Depletion of interconnected surface water	Shallow well on lower Aptos Creek	The majority of Aptos Creek flows through The Forest of Nisene Marks State Park and has no groundwater extractions. The lower reach of Aptos Creek is where private domestic and municipal extraction occurs
	Shallow well on Aptos Creel above Valencia Creek	
	Shallow well on the East Branch of Soquel Creek	In areas of concentrated private domestic pumping
	Shallow well on Soquel Creek below Moores Gulch	
	Shallow well near the existing SC-10 well cluster	Add a shallow well to the cluster of monitoring wells at SC-10 which already monitor the Purisima A and AA-units, and Tu Unit
	Shallow well near the Balogh stream gauge	Add two wells to supplement the existing shallow well. If feasible, wells are to be completed perpendicular to the creek to determine groundwater gradient
	Shallow well near the Balogh stream gauge	
	Shallow well on Rodeo Gulch	Near concentrated private domestic pumping

The locations of additional monitoring wells, and additional streamflow gauges discussed below in Section 3.3.4.2, have been selected to identify the location, quantity, and timing of surface water depletion caused specifically by groundwater use in areas where no monitoring features currently exist. Section 5.2 describes the timeline for completing installation of these new monitoring features.

Data obtained from these monitoring features will inform the validity of groundwater levels as a proxy for depletion of interconnected surface water, and better inform if changes are needed to minimum thresholds to avoid undesirable results. Groundwater level data collected will be evaluated annually with respect to streamflow, climate, groundwater usage, and noted biological responses. Biological responses will include information obtained from The Nature Conservancy's GDE Pulse application that monitors the health of vegetation and available fish count data from the Santa Cruz County Juvenile Steelhead and Stream Habitat Monitoring Program described in Section 2.1.2.1.

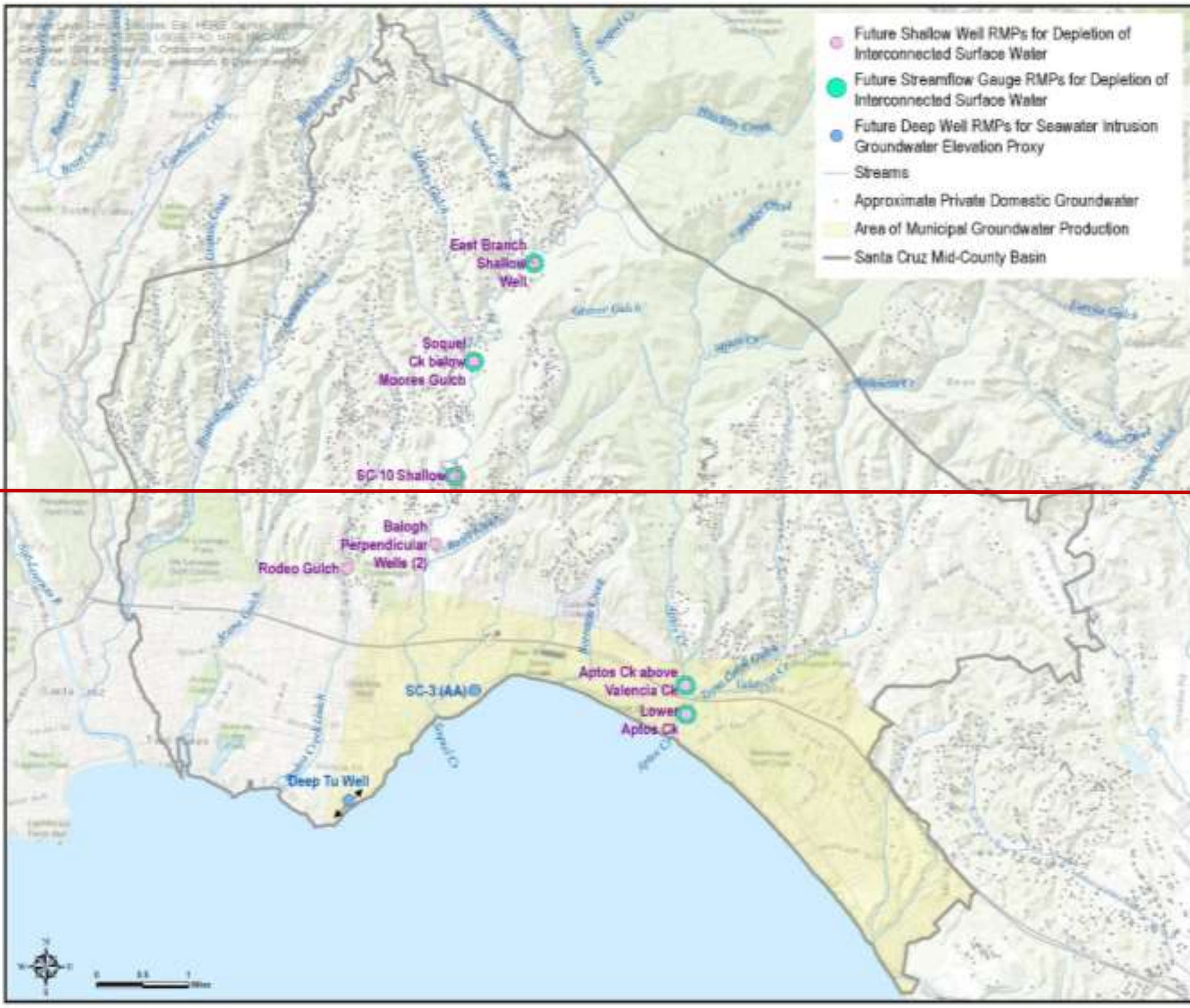
It is expected that based on all the different types of data collected over the first five years of GSP implementation, wherein some of the projects described in Section 4 will be operational, groundwater level proxies for depletion of interconnected surface water will be re-evaluated to determine if they are still needed as the sustainability metric in place of direct measurements of streamflow. At the first five-year review, data collected will also be evaluated to determine whether adjustments to minimum thresholds and measurable objectives are needed, or whether additional monitoring features are needed. It is expected that the participants of the Surface Water Working Group (see Section 2.2.4.7) established as part of GSP development will be involved in this re-evaluation process.

3.3.4.2 Streamflow Monitoring Data Gaps

Associated with the shallow groundwater level monitoring wells identified above, streamflow gauges to monitor changes in streamflow are needed to correlate changes in streamflow from groundwater extraction. The shallow monitoring wells and streamflow gauges need to be located adjacent to each other for the data to be meaningful. Figure 3-10 shows the locations of five proposed streamflow gauges that would be associated with shallow monitoring wells.

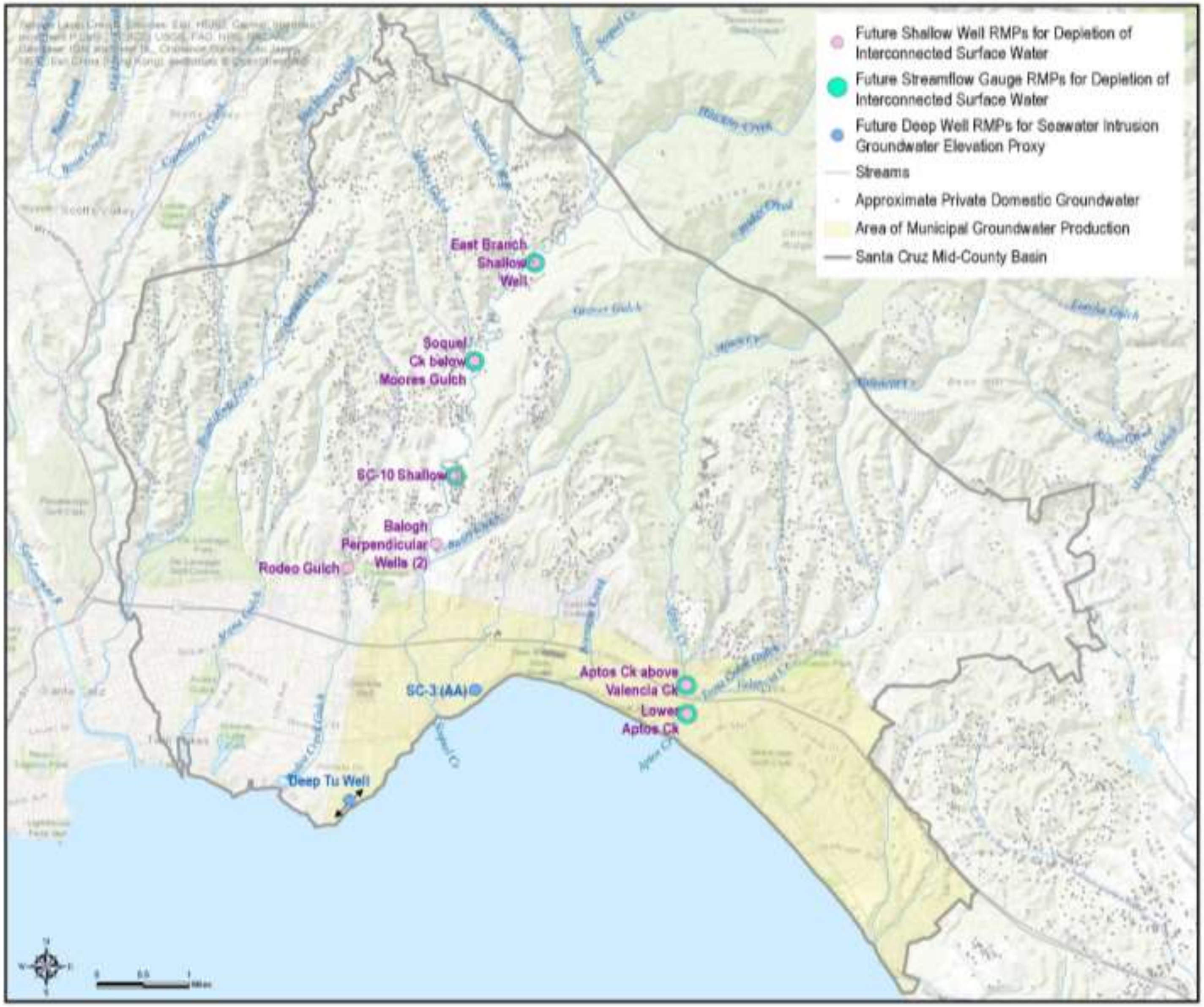
~~Section 5 on Plan Implementation outlines how the MGA plans to finance and construct the streamflow gauges.~~

Section 5 on Plan Implementation outlines how the MGA plans to finance and construct the



streamflow gauges.

Figure 3-10. Groundwater Level and Streamflow Monitoring Data Gaps



3.3.4.3 Groundwater Extraction Monitoring Data Gaps

As part of GSP implementation, the MGA will initiate a new well metering program on ~~new~~all private non-*de minimis* wells that meet the following criteria:

- Pump more than two (2) acre-feet per year within priority management zones to be defined by the County of Santa Cruz. These will be related to seawater intrusion and depletion of interconnected surface water.
- Wells outside of priority management zones that pump more than 5 acre-feet per year.

Implementation of a planned metering program is described in more detail in Section 5 on Plan Implementation.

3.4 Chronic Lowering of Groundwater Levels Sustainable Management Criteria

3.4.1 Undesirable Results - Chronic Lowering of Groundwater Levels

Chronic lowering of groundwater levels is considered significant and unreasonable when:

A significant number of private, agricultural, industrial, and municipal production wells can no longer provide enough groundwater to supply beneficial uses.

In the late 1980's, groundwater levels in parts of the Basin were between 35 and 140 feet lower than they are currently. Even at these lower levels, production wells were still able to extract groundwater to supply beneficial uses. Based on what is considered significant and unreasonable described above, chronic lowering of groundwater levels has not historically occurred and is not currently occurring in the Basin. Although groundwater users did not lose significant capacity historically during periods of lowered groundwater levels, those lower groundwater levels caused seawater intrusion which is the reason why the Basin is classified as critically overdrafted~~.~~ by DWR.

3.4.1.1 Criteria for Defining Chronic Lowering of Groundwater Levels Undesirable Results

Specific groundwater level conditions that constitute undesirable results for chronic lowering of groundwater levels are:

Any average monthly representative monitoring point's groundwater elevation falls below its minimum threshold.

The definition of undesirable results is based on MGA sentiment that groundwater levels in the Basin should be managed to support all existing and/or proposed overlying land uses and environmental water user's beneficial needs. Using the criteria of monthly average groundwater levels adequately monitors and identifies seasonal low groundwater elevations that could be much lower than average annual groundwater levels

3.4.1.2 Potential Causes of Undesirable Results

The possible causes of undesirable chronic lowering of groundwater level results are:

- a significant ~~changes~~change in Basin pumping distribution and volumes, or
- a significant reduction in natural recharge as a result of climate change.

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.

3.4.1.3 Effects on Beneficial Users and Land Use

Undesirable results will prevent a significant number of private, agricultural, industrial, and municipal production wells from supplying groundwater to meet their water demands. Lowered groundwater levels will reduce the thickness of saturated aquifer from which wells can pump. Some wells may even go dry and new much deeper wells will need to be drilled. This would effectively increase the cost of using groundwater as a water source for all users.

3.4.2 Minimum Thresholds - Chronic Lowering of Groundwater Levels

3.4.2.1 Information and Methodology Used to Establish Minimum Thresholds and Measurable Objectives

Information used for establishing the chronic lowering of groundwater levels minimum thresholds and measurable objectives include:

- Definitions of significant and unreasonable conditions and desired groundwater elevations discussed during GSP Advisory Committee meetings.
- Depths, locations, and logged lithology of existing wells used to monitor groundwater levels.
- Historical groundwater elevation data from wells monitored by the MGA agencies.
- Maps of current and historical groundwater elevation data.
- Department of Water Resources well drillers' logs of domestic and agricultural wells for determining aquifers pumped, well depths and diameters, screened intervals, and estimated yield in the vicinity of RMPs.

Minimum thresholds at RMPs for ~~RMPs~~chronic lowering of groundwater levels are based on the groundwater elevation required to meet the typical overlying water demand in the shallowest well in the vicinity of the RMP. The methodology used to estimate the groundwater elevation is based on ~~overlying~~ water demand for overlying land uses and is documented in Appendix 3-A. If the minimum threshold elevation ~~using this approach~~methodology is greater than 30 feet below historic low groundwater elevations, the minimum threshold elevation is increased ~~as excessively low groundwater elevations~~, even if overlying water demand can be met at these lower levels~~,~~. Groundwater levels 30 feet below historic low groundwater elevations may ~~cause undesirable results for~~ conflict with other sustainability ~~indicators.~~indicator minimum thresholds. The 30-foot limit rationale is explained more fully in Appendix 3-A.

3.4.2.2 Chronic Lowering of Groundwater Level Minimum Thresholds

~~Figure 3-5~~ shows the location of RMPs with chronic lowering of groundwater levels minimum thresholds. Table 3-12 lists minimum thresholds for all RMPs. Historical hydrographs for RMPs showing historical groundwater elevations versus minimum thresholds and measurable objectives are provided in Appendix 3-B.

Table 3-12. Minimum Thresholds and Measurable Objectives for Chronic Lowering of Groundwater Level Representative Monitoring Points

Representative Monitoring Point	Well Type	Aquifer	Minimum Threshold	Measurable Objective
			Groundwater Elevation, feet above mean sea level	
SC-A7C	Monitoring	Aromas	0	8
Private Well #2	Production	Purisima F	562	596
Black	Monitoring		10	41
CWD-5	Monitoring		140	194
SC-23C	Monitoring		15	49
SC-11RD	Monitoring	Purisima DEF	295	318
SC-23B	Monitoring		50	85
SC-11RB	Monitoring	Purisima BC	120	157
SC-19	Monitoring		56	95
SC-23A	Monitoring		0	44
Coffee Lane Shallow	Monitoring	Purisima A	27	47
SC-22A	Monitoring		2	44
SC-22AA	Monitoring	Purisima AA	0	22
SC-10RAA	Monitoring		35	76
Private Well #1	Production	Purisima AA/Tu	362	387
30th Ave Deep	Monitoring	Tu	0	30

Representative Monitoring Point	Well Type	Aquifer	Minimum Threshold	Measurable Objective
			Groundwater Elevation, feet above mean sea level	
Thurber Lane Deep	Monitoring		-10	33

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

Section §354.28 of the SGMA regulations requires that a description of all minimum thresholds include a discussion about the relationship between the minimum thresholds for each sustainability indicator. ~~In the SMC BMP~~In the Sustainable Management Criteria Best Management Practice Guide (DWR, 2017), DWR has clarified this requirement:

1. The GSP must describe the relationship between each sustainability indicator's minimum threshold (e.g., describe why or how a water level minimum threshold set at a particular representative monitoring site is similar to or different to groundwater level thresholds in nearby RMP).

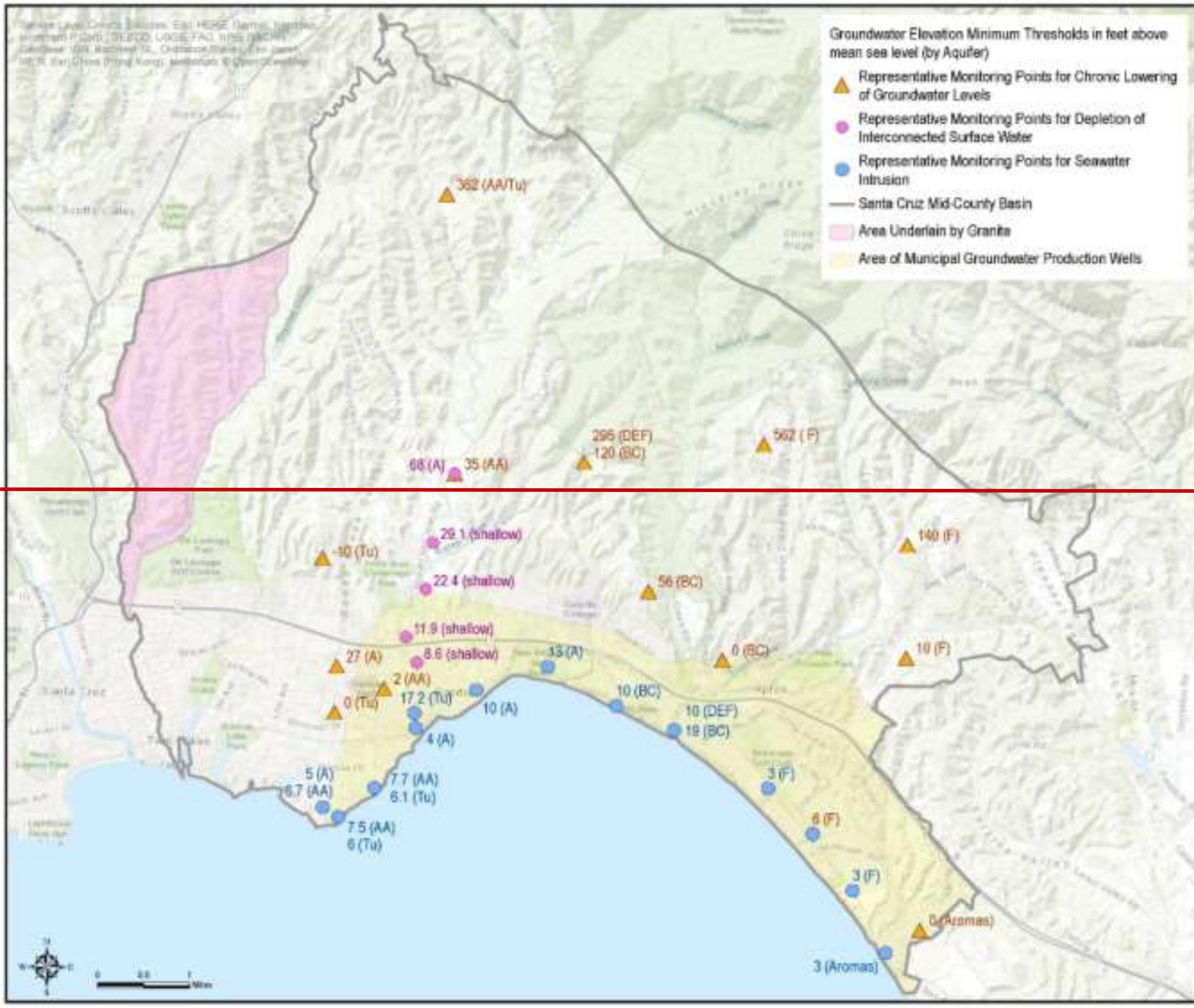
2. The GSP must describe the relationship between the selected minimum threshold and minimum thresholds for other sustainability indicators (e.g., describe how a groundwater level minimum threshold would not trigger an undesirable result for seawater intrusion).

Minimum thresholds are selected to avoid undesirable results for other sustainability indicators. If the same RMP was selected for chronic lowering of groundwater levels as another sustainability indicator's RMP that uses groundwater elevation as a metric, the shallowest groundwater elevation minimum threshold of the two sustainability indicators is set at that RMP and assigned to the sustainability indicator that has the shallowest elevation. The relationship between chronic lowering of groundwater level minimum thresholds and minimum thresholds for other sustainability indicators are discussed below.

- **Reduction of groundwater in storage**. The metrics for chronic lowering of groundwater level minimum thresholds (groundwater elevations) and reduction of groundwater in storage (volume of groundwater extracted) are different. However, since the reduction of groundwater in storage minimum thresholds are dependent on avoiding undesirable results for the Basin's other sustainability indicators, maintaining the chronic lowering of groundwater level minimum thresholds does not result in an undesirable reduction of groundwater in storage.
- **Seawater intrusion**. All near-coastal minimum thresholds for chronic lowering of groundwater levels are set at elevations no deeper than sea level so as to not interfere with seawater intrusion minimum thresholds (Figure 3-11). Where groundwater levels close to the coast determined from an estimated minimum saturated thickness are deeper than seawater intrusion's groundwater level proxy minimum thresholds, the chronic lowering of groundwater level minimum threshold is increased to ensure that it

does not restrict the ability to meet or exceed protective elevations for seawater intrusion. One of the chronic lowering of groundwater levels RMPs, Thurber Lane Deep, is inland and far enough away from RMPs for seawater intrusion that groundwater levels in the Tu unit are allowed to fall below sea level without causing undesirable seawater intrusion.

- **Degraded groundwater quality**. Protecting groundwater quality is critically important to all who depend upon the groundwater resource. A significant and unreasonable condition for degraded water quality is exceeding drinking water standards for constituents of concern in supply wells due to projects and management actions proposed in the GSP. Although chronic lowering of groundwater level minimum thresholds does not ~~direct effect~~directly affect degraded quality, groundwater quality could potentially be affected by projects and management action induced changes in groundwater elevations and gradients. These changes could potentially cause poor quality groundwater to flow towards supply wells that would not have otherwise been impacted. Currently, apart from one location with 1,2,3-TCP and more widespread nitrate in parts of the Aromas Red Sands aquifers, and saline water associated with seawater intrusion in two areas along the coast, the Basin’s groundwater quality is good with no non-native poor groundwater quality present within productive aquifers.
- **Subsidence**. This sustainability indicator is not applicable in the Basin.
- **Depletion of interconnected surface water**. Minimum thresholds for depletion of interconnected surface water are mostly set in shallow alluvial sediments and are based on shallow groundwater levels between 2001 and 2015. Chronic lowering of groundwater level minimum thresholds are set in the deeper Purisima aquifers where the majority of production occurs and are set substantially lower than groundwater levels observed between 2001-2015. As described in more detail in Section 2, there is no immediate measurable influence on surface water flow from extraction in the deeper Purisima aquifers, but there is likely some long-term indirect connection between the deeper Purisima aquifers and shallow groundwater. In the unlikely event that groundwater levels drop to minimum thresholds for chronic lowering of groundwater levels, the vertical gradient between shallow and deep aquifers will increase and may cause undesirable results in the shallow aquifers and interconnected surface waters.


Groundwater Elevation Minimum Thresholds in feet above mean sea level (by Aquifer)
Representative Monitoring Points for Chronic Lowering of Groundwater Levels
Representative Monitoring Points for Depletion of Interconnected Surface Water
Representative Monitoring Points for Seawater Intrusion
Santa Cruz Mid-County Basin
Area Underlain by Granite
Area of Municipal Groundwater Production Wells
362 (AA/Tu)
295 (DEF)
120 (BC)
562 (F)
68 (A)
35 (AA)
29.1 (shallow)
-10 (Tu)
140 (F)
22.4 (shallow)
56 (BC)
11.9 (shallow)
8.6 (shallow)
13 (A)
0 (BC)
10 (F)
27 (A)
2 (AA)
0 (Tu)
17.2 (Tu)
10 (A)
10 (BC)
10 (DEF)
19 (BC)
4 (A)
5 (A)
6.7 (AA)
7.7 (AA)
6.1 (Tu)
7.5 (AA)
6 (Tu)
3 (F)
6 (F)
3 (F)
0 (Aromas)
3 (Aromas)

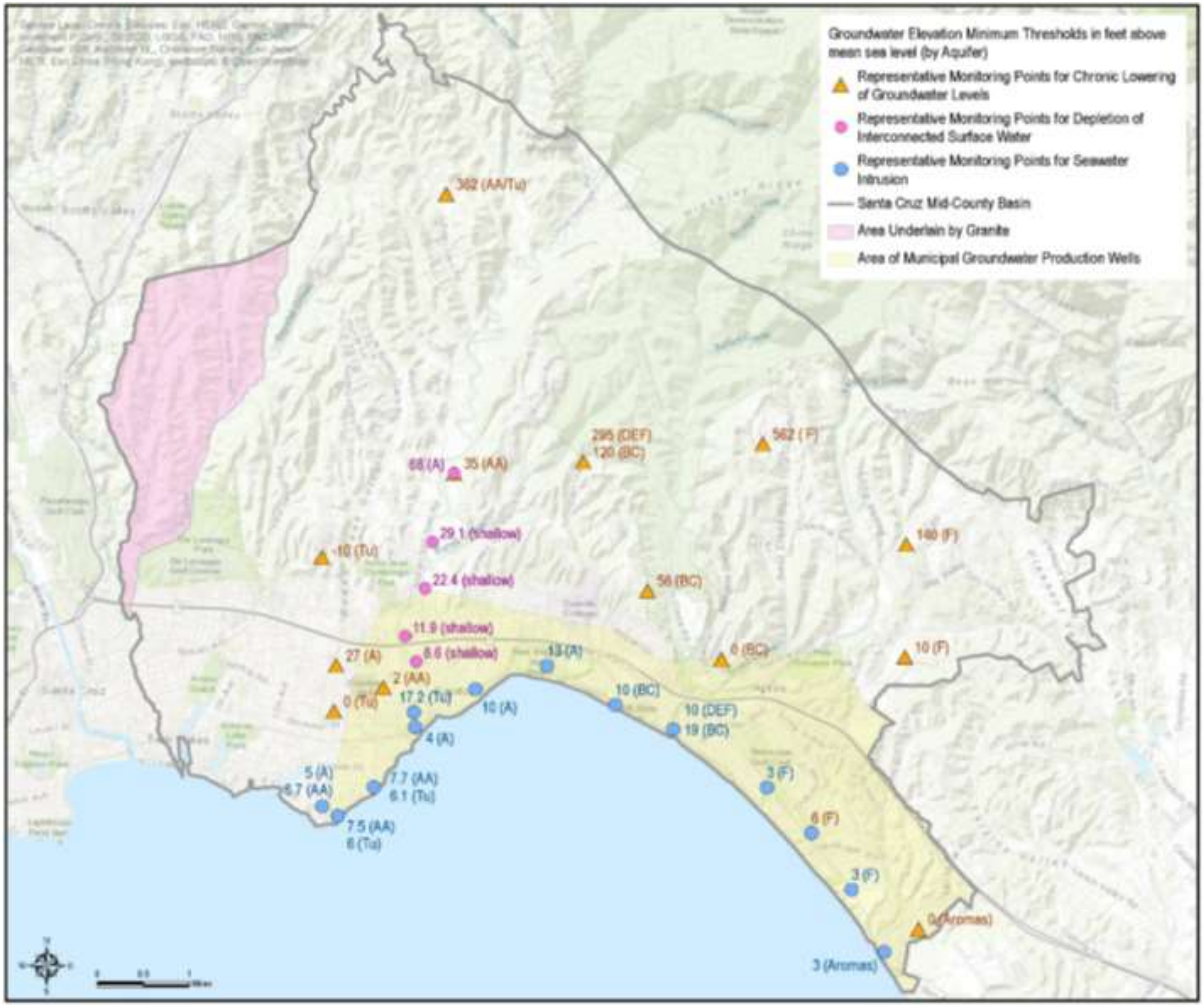


Figure 3-11. Minumum Thresholds for All Sustainability Indicators with Groundwater Elevation Minimum Thresholds

3.4.2.4 Effect of Minimum Thresholds on Neighboring Basins

Two neighboring groundwater basins are required to develop and adopt GSPs or have submitted an alternative: the medium-priority Santa Margarita Basin (to the northwest) and the critically-overdrafted Pajaro Valley Subbasin of the Corralitos Basin (to the east). There are two additional groundwater basins prioritized as very low and do not require GSPs: the Purisima Highlands Subbasin of the Corralitos Basin (to the north) and the West Santa Cruz Terrace Basin (to the west). Since the West Santa Cruz Terrace Basin is not significantly connected to the Santa Cruz Mid-County Basin due to the Purisima aquifers not extending westwards into that basin, effects of minimum thresholds on that basin are not discussed further. Anticipated effects of chronic lowering of groundwater levels minimum thresholds on the other three neighboring basins are addressed below and for subsequent sustainability indicators.

Pajaro Valley Subbasin of the Corralitos Basin (critically-overdrafted). The Pajaro Valley Subbasin is hydrogeological down- to cross-gradient of the Santa Cruz Mid-County Basin. Because of lower groundwater elevations in the Pajaro Valley Subbasin, groundwater along the coastal portion of the boundary generally flows from the Santa Cruz Mid-County Basin into the Pajaro Valley Subbasin. Purisima aquifers are not a major source of groundwater in the Pajaro Valley and are only pumped by a few deeper wells (Carollo Engineers, 2014). The Aromas Red Sands aquifer is the major producing aquifer within the Pajaro Valley Subbasin (Carollo Engineers, 2014). The Aromas Red Sands aquifer RMP (SC-A7A) in the Santa Cruz Mid-County Basin near the boundary with Pajaro Valley Subbasin has a minimum threshold that is a few feet lower than current levels. In the unlikely event that groundwater levels in this area fall to minimum thresholds, it may slightly reduce the amount of subsurface outflow to the Pajaro Valley Subbasin but would not be expected to hinder it from achieving sustainability.

Santa Margarita Basin (medium-priority). The Santa Margarita Basin is required to develop a GSP by 2022. Santa Margarita Basin is hydrogeologically downgradient of the Santa Cruz Mid-County Basin and based on the water budget, less than 400 acre-feet of groundwater flows from the Santa Cruz Mid-County Basin into the Santa Margarita Basin annually. The boundary where subsurface flows occur between the two basins is north of the Aptos Fault and four miles inland of the area where GSP projects and management actions would take place. Current groundwater levels are already well above the minimum thresholds for all RMPs and no GSP induced changes in elevations are expected as GSP activities are some distance away so it is not expected that Santa Margarita Basin will be adversely affected by activites under this GSP. However, if groundwater levels near the Santa Margarita basin drop to the minimum thresholds, flow from the Santa Cruz Mid-County Basin to Santa Margarita Basin could be reduced and could affect Santa Margarita Basin’s ability to achieve sustainability.

Purisima Highlands Subbasin of the Corralitos Basin (very low-priority). The Purisima Highlands Subbasin is hydrogeological up-gradient of the Santa Cruz Mid-County Basin. Groundwater flow, historically and projected in the future, will continue to be from the higher elevation Purisima Highlands Subbasin into the Santa Cruz Mid-County Basin. If groundwater levels in the northern portion of the Basin declined to minimum thresholds, the rate of subsurface outflow may increase slightly from the Purisima Highlands Subbasin.

3.4.2.5 Effects of Minimum Thresholds on Beneficial Users and Land Uses

Chronic lowering of groundwater elevation minimum thresholds may have several effects on beneficial users and land uses in the Basin.

Rural residential land uses and users. The chronic lowering of groundwater level minimum thresholds protects most domestic users of groundwater by protecting their ability to pump from domestic wells. However, if groundwater elevations fall to minimum thresholds, there may be limited water in some of the shallowest domestic wells (less than 100 feet deep) that may require well owners to drill deeper wells.

Agricultural land uses and users. Similar to rural residential uses and users, chronic lowering of groundwater level minimum thresholds protects agricultural users of groundwater by protecting their ability to meet their typical demands. Minimum thresholds for chronic lowering of groundwater level will not limit use of land for agricultural purposes.

Urban land uses and users. The chronic lowering of groundwater level minimum thresholds are set so that all users, including municipal groundwater pumpers can still meet their typical water demands. As most of the RMPs for the chronic lowering of groundwater levels are located inland of the area of municipal pumping which covers the majority of the Basin's urban area, it is the groundwater level proxy minimum thresholds for seawater that have a bigger influence on urban/municipal users of groundwater.

Ecological land uses and users. As described in Section 3.2.3.2, chronic lowering of groundwater level minimum thresholds are not set to protect the groundwater resource including those existing ecological habitats that rely upon it. In the unlikely event that groundwater levels drop to minimum thresholds for chronic lowering of groundwater levels, it could lead to a significant and unreasonable reduction of flow of groundwater toward streams, which could adversely affect ecological habitats.

3.4.2.6 Relevant Federal, State, or Local Standards

No federal, state, or local standards exist for chronic lowering of groundwater elevations.

3.4.2.7 Method for Quantitative Measurement of Minimum Thresholds

Groundwater elevations in RMPs will be directly measured to determine where groundwater levels are in relation to minimum thresholds. Groundwater level monitoring will be conducted in accordance with the monitoring plan outlined in Section 3.3. All RMPs will be equipped with continuous data loggers.

There are two privately-owned wells that do not currently have data loggers. Section 5 on Plan Implementation includes planned implementation budget to purchase, install and monitor those additional RMPs. All other agency monitoring wells assigned as RMPs already have data loggers installed.

3.4.3 Measurable Objectives - Chronic Lowering of Groundwater Levels

3.4.3.1 Measurable Objectives

Measurable objectives for RMPs are the 75th percentile of historical groundwater elevations for the period of record of each monitoring point. The 75th percentile is higher than median or average groundwater elevations and reflects where the MGA would like groundwater elevations to be in the future whilst allowing for operational flexibility.

Representative monitoring point hydrographs in Appendix 3-B include measurable objectives for chronic lowering of groundwater levels compared to minimum thresholds.

3.4.3.2 Interim Milestones

Groundwater levels in the Basin are currently above minimum thresholds for all RMPs with no significant changes in levels expected from projects and management actions implemented to achieve sustainability. Since the measurable objectives effectively represent current conditions, interim milestones are set at the same elevations as measurable objectives shown in Table 3-12.

3.5 Reduction of Groundwater in Storage Sustainable Management Criteria

3.5.1 Undesirable Results - Reduction of Groundwater in Storage

The reduction in storage sustainability indicator is not measured by a change in groundwater in storage. Rather, the reduction in groundwater in storage sustainability indicator is measured by “a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results.” (§354.28 (c)(2)).

Locally defined significant and unreasonable conditions for a reduction of groundwater in storage in the Basin are defined as:

> *A net volume of groundwater extracted (pumping minus annual volume of managed aquifer recharge) that will likely cause other sustainability indicators to have undesirable results.*

3.5.1.1 Criteria for Defining Reduction of Groundwater in Storage Undesirable Results

The net volume of groundwater extracted that constitutes undesirable results for reduction of groundwater storage is:

> *Five-year average net extraction exceeding the sustainable yield (minimum threshold) for any one of the groups of aquifers:*
>
> - *Aromas Red Sands aquifer and Purisima F aquifer units,*
> - *Purisima DEF, BC, A, and AA aquifer units, and*
> - *Tu aquifer.*

Although only a total volume for the whole basin is required as a metric for the reduction of groundwater in storage sustainability indicator per the SGMA regulations, this GSP has separate SMC for three aquifer groups in the Basin: (1) Aromas Red Sands and Purisima F, (2) Purisima DEF, BC, A, and AA aquifers, and (3) the Tu aquifer. The SMC metrics for this indicator are based on the sustainable yields for each of the three aquifer groups estimated in Section 2.2.3.7: Projected Sustainable Yield.

Developing reduction of groundwater storage SMC for separate aquifer units reflects the stacked aquifer units of the Basin where groundwater supply in different areas of the Basin are provided by different aquifer units. To maximize capacity, municipal wells are often screened across multiple aquifers: The aquifer groupings are based on how municipal wells are typically screened. Most municipal wells screened in the Aromas Red Sands aquifer are also screened in the deeper Purisima F-unit aquifer. Other typical multiple aquifer screened wells include: the Purisima DEF and BC-units; the Purisima BC and A-units; and the Purisima A and AA-units. Although municipal wells screened in the Tu unit are also screened in the Purisima AA-unit, a high percentage of the flow in these wells is observed to be from the Tu unit. Additionally, the vertical separation of flow between the Purisima AA and Tu units is observed to be greater than the vertical separation between the Purisima A and AA-units, which further supports the Tu unit being in a group on its own.

Although sustainable yield can be estimated for individual aquifers, monitoring how much is pumped from each aquifer is not possible because of production wells being screened through multiple aquifers. Therefore, the aquifer groupings account for the extraction from the aquifers production wells are typically screened in.

The purpose of this sustainability indicator is to prevent undesirable results for other sustainability indicators. Each of these sustainability indicators are monitored by individual aquifer units. If undesirable results are observed in any aquifer unit or related to pumping from a specific aquifer unit, the most likely management action to eliminate the undesirable result is to change net pumping from the aquifer unit. The change in net pumping will be determined by what is necessary to eliminate the undesirable result, not based on the reduction of groundwater in storage criteria. Recognizing this, developing reduction of storage SMC for each aquifer unit is not necessary for planning groundwater management and may restrict operational flexibility.

3.5.1.2 Potential Causes of Undesirable Results

Future increased well density and pumping amounts can contribute to reduction of groundwater in storage undesirable results. Since the locations of groundwater extraction and MAR are not static, new private or municipal wells, or changed operations could cause localized undesirable results. To optimize operations or locations of new high-capacity wells and MAR, groundwater modeling can be used to predict if undesirable results may occur.

3.5.1.3 Effects on Beneficial Users and Land Use

Undesirable reduced groundwater in storage caused by over-pumping may cause undesirable results in any of the other four applicable sustainability indicators that potentially impact beneficial users and land uses. Groundwater levels that are too low as a result of implementing the GSP may:

1. Prevent a significant number of private, agricultural, industrial, and municipal production wells from supplying groundwater to meet their water demands.

2. Induce seawater intrusion that will render impacted portions of the Basin’s aquifers unusable to its beneficial users. Land uses completely overlying seawater intrusion, such as agriculture, will need alternative sources of water if their wells are located in the affected areas.

3. Cause more surface water depletion in interconnected streams that support priority species than has occurred over the past 18 years.

4. Degrade groundwater quality if by implementation of the GSP there are changes in groundwater elevations and gradients that cause non-native poor-quality groundwater to flow towards extraction wells that were previously not impacted. Groundwater quality that does not meet state drinking water standards will need to be treated, which is a significant cost to users. For municipal pumpers, impacted wells can be taken offline until a solution is found. This will add stress on their water system by having to make up pumping in other unimpacted wells and increase the potential for further declines in groundwater levels.

3.5.2 Minimum Thresholds - Reduction of Groundwater in Storage

3.5.2.1 Information and Methodology Used to Establish Minimum Thresholds and Measurable Objectives

Information used for establishing the reduction of groundwater in storage minimum thresholds and measurable objectives include:

- Definitions of significant and unreasonable conditions discussed during GSP Advisory Committee meetings.
- Projected municipal agency, private domestic, institutional, and agricultural pumping at specific well locations.
- Projected injection for Pure Water Soquel and City of Santa Cruz ASR at assumed locations.
- Projected hydrographs comparing simulated groundwater levels compared to minimum thresholds for seawater intrusion and depletion of interconnected surface water.
- Sustainable yield estimates from Section 2.2.3.7.

The Basin's sustainable yields for three aquifer groups used as minimum thresholds for the reduction of groundwater in storage sustainability indicator rely on projected net pumping with GSP implementation, as described in Section 2.2.3.7: Projected Sustainable Yield. Net projected pumping for Water Years 2016 – 2069 is pumping that has been adjusted to avoid undesirable results. Adjustments to achieve minimum thresholds include redistributing pumping and the operation of City of Santa Cruz ASR and SqCWD's Pure Water Soquel.

3.5.2.2 Reduction of Groundwater in Storage Minimum Thresholds

Minimum thresholds for reduction of groundwater storage are the sustainable yields representing net annual volume of groundwater extracted (pumping minus volume of managed aquifer recharge) for each of the three groups of aquifers, as summarized in Table 3-13.

Table 3-13. Minimum Thresholds and Measurable Objectives for Reduction of Groundwater of Storage

Aquifer Unit Group	Minimum Threshold	Measurable Objective
	Groundwater Extracted, acre-feet per year	
Aromas Red Sands and Purisima F	1,740	1,680
Purisima DEF, BC, A and AA	2,280	960
Tu	930	620

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

As the sustainable yields for the three aquifer groups are based on avoiding undesirable results for all the other applicable sustainability indicators, net pumping at or below the sustainable yield should not conflict with minimum thresholds for the other sustainability indicators.

However, there could be discrepancies observed between the sustainable yields used as minimum thresholds and undesirable results observed for other sustainability indicators. Undesirable results in the other applicable sustainability indicators could still occur if net pumping is below minimum thresholds and undesirable results in the other applicable sustainability indicators might not occur if net pumping exceeds minimum thresholds. In addition to hydrologic uncertainty of the estimates for sustainable yield used for minimum thresholds, the sustainable yield estimates are highly dependent on the location of groundwater extraction and managed aquifer recharge (MAR) used to derive the estimates. Depending on the location of these activities, pumping within the sustainable yield may still cause seawater intrusion at the coast, such as if new production wells are located close to existing wells and close to the coastline.

If discrepancies with other sustainability indicators occur, the estimate for sustainable yields and the minimum thresholds should be revised to be consistent with whether or not there are undesirable results for the other sustainability indicators.

3.5.2.4 Effect of Minimum Thresholds on Neighboring Basins

Anticipated effects of the reduction of groundwater in storage minimum thresholds on neighboring basins are addressed below.

Pajaro Valley Subbasin of the Corralitos Basin (critically-overdrafted). To avoid undesirable seawater intrusion results in the Aromas area near the Basin's boundary with the Pajaro Valley, municipal extraction is currently and projected to be in the future very limited, unless a recharge project can provide supplemental water supplies. As a result of almost eliminating municipal extraction, groundwater levels in the Aromas area near the boundary with Pajaro Valley Subbasin are close to seawater intrusion proxy minimum thresholds. With GSP implementation, groundwater levels are expected to increase slightly higher and closer to measurable objectives at the Basin boundary. Decreased pumping in the Aromas, included in the reduction of groundwater in storage minimum threshold for the Aromas and Purisima F-unit aquifer group, is beneficial to both basins for controlling seawater intrusion. Therefore, it is unlikely that the reduction of groundwater storage minimum thresholds established for the Basin will prevent the Pajaro Valley Subbasin from achieving sustainability.

Santa Margarita Basin (medium-priority). The area of the Basin with potential to influence the Santa Margarita Basin is the western area north of the Aptos Fault where unsustainable conditions have not historically nor currently occurred. Groundwater use in this area is all for private use: mostly for *de minimis* private domestic purposes with two retreats that are non-*de minimis* users of groundwater. Groundwater use in this part of the Basin, as part of the sustainable yield, is projected to remain similar to historic use and therefore minimum thresholds for reduction of groundwater in storage will not negatively impact groundwater conditions in the Santa Margarita Basin.

Purisima Highlands Subbasin of the Corralitos Basin (very low-priority). Similar to the Basin's relationship with the Santa Margarita Basin, the area of the Basin that is closest to the Purisima Highlands Subbasin is mainly pumped by private *de minimis* groundwater users. Pumping in this area is projected to remain similar to historic use and therefore minimum thresholds for reduction of groundwater in storage will not negatively impact groundwater conditions in the Santa Margarita Basin.

3.5.2.5 Effects of Minimum Thresholds on Beneficial Users and Land Uses

The reduction of groundwater in storage (sustainable yield) minimum thresholds may have several effects on beneficial users and land uses in the Basin.

Rural residential land uses and users. Twenty-one percent of the projected sustainable yield comprises estimated pumping from *de-minimis* domestic wells. As changes in pumping in the Basin are focused on municipal wells closer to the coast to avoid undesirable seawater intrusion conditions, rural residential users are not impacted by required reductions in pumping. The model indicated that impacts of inland rural residential pumping on seawater intrusion is minimal and therefore reductions to their pumping would not help achieve protective groundwater elevations. There are therefore no effects on rural residential land uses and users from the reduction of groundwater in storage minimum thresholds.

Agricultural land uses and users. Nine percent of the projected sustainable yield comprises estimated pumping for agricultural purposes. At this time, reductions in agricultural pumping for irrigation purposes are not included in meeting the projected sustainable yield. Therefore, there are no effects on agricultural land uses and users from reduction of groundwater in storage minimum thresholds.

Urban land uses and users. Urban users and land uses are concentrated in a corridor along the coast. Municipal wells that supply water to these users are also located in this area and are therefore also close to the coast. Reductions in municipal pumping needed to increase coastal groundwater levels to control seawater intrusion need to be offset by other water sources. Reducing the amount of municipal groundwater pumping increases the cost of water for municipal users in the Basin because water agencies need to find other, more expensive water sources.

Ecological land uses and users. Groundwater dependent ecosystems would generally benefit from the reduction of groundwater in storage minimum threshold in the area of municipal pumping. Increasing groundwater levels above current levels will generally improve ~~already sustainable~~ conditions for groundwater dependent ecosystems.

3.5.2.6 Relevant Federal, State, or Local Standards

No federal, state, or local standards exist for reduction of groundwater in storage related groundwater extraction.

3.5.2.7 Method for Quantitative Measurement of Minimum Thresholds

Groundwater extractions in municipal and small water systems RMPs will be directly measured with water meters to determine the volume of groundwater produced in relation to minimum thresholds. Groundwater extraction monitoring will be conducted in accordance with the monitoring plan outlined in Section 3.3.2.4. For *de minimis* domestic and agricultural users that are unmetered, the groundwater extracted by these users will be estimated as described in Section 3.3.1.3.

Annual Basin extractions from each the three aquifer groups will be used in a five-year running average to compare against minimum thresholds to determine if undesirable results have occurred in any of the aquifer groups.

3.5.3 Measurable Objectives - Reduction of Groundwater Storage

3.5.3.1 Measurable Objectives

The reduction of groundwater in storage measurable objectives for each of the three aquifer groups are the maximum net annual amount of groundwater that can be extracted while ensuring that if there were four subsequent years of maximum projected net groundwater extraction, net annual groundwater extractions greater than the minimum threshold will not occur for any one of the three aquifer groups. Table 3-13 lists the measurable objectives for the three aquifer groups.

Annual net extractions for the different aquifer groups will be used to compare against measurable objectives, and not the five-year average of net extractions. This is because the measurable objective is the maximum that can be pumped if the next four years all had maximum projected pumping for undesirable results to be avoided.

It is not expected that the planned projects will achieve the measurable objective for the Purisima DEF, BC, A, and AA aquifer group; i.e., the planned projects will not provide for four consecutive years of maximum net pumping without avoiding undesirable results.

3.5.3.2 Interim Milestones

Interim milestones for this sustainability indicator track implementation of projects planned to meet sustainability described in Section 4. Section 4 describes the expected benefits of Soquel Creek Water District's Pure Water Soquel project and the City of Santa Cruz's Aquifer Storage and Recovery project as preventing undesirable results in the Basin and meeting measurable objectives in much of the Basin. The interim milestones are therefore the projected net pumping for the Basin as the projects get implemented. The interim milestones for 2025, 2030, and 2035 are the five-year averages for net pumping covering Water Years 2021-2025, Water Years 2026-2030, and Water Years 2031-2035, respectively.

Interim milestones for Water Year 2025 do not meet all of the sustainable yields because the operation of Pure Water Soquel with approximately 1,500 acre-feet per year of injection is not scheduled to begin operation until Water Year 2023. The interim milestones for 2030 and 2035 are lower than sustainable yield (minimum threshold) with planned operation of both projects occurring simultaneously by 2026. There will be no undesirable results for reduction of groundwater in storage by 2030.

Although below sustainable yield (minimum threshold), interim milestones are higher in 2035 than 2030 due to projected climate. Evaluations of net pumping versus interim milestones should consider effect of climate on injection and pumping volumes for the previous five years

.

Table 3-14. Interim Milestones for Reduction of Groundwater of Storage

Aquifer Unit Group	Interim Milestone 1 2025	Interim Milestone 2 2030	Interim Milestone 3 2035
	Trailing 5 Year Average of Groundwater Extracted, acre-feet per year		
Aromas Red Sands and Purisima F	1,930	1,630	1,670
Purisima DEF, BC, A and AA	2,110	1,970	2,120
Tu	720	710	760

3.6 Seawater Intrusion Sustainable Management Criteria

3.6.1 Undesirable Results - Seawater Intrusion

Locally defined significant and unreasonable seawater intrusion in the Basin is:

Seawater moving farther inland than has been observed from 2013 through 2017.

This statement reflects that the MGA does not want seawater intrusion to advance further into the Basin. The period from 2013 through 2017 is included in the statement because although there has not been much recent change in the distribution of seawater intrusion, there has been one seawater intruded monitoring well (Moran Lake Medium) that has experienced decreased chloride concentrations which are now below 250 mg/L. By specifying the years 2013-2017, we ensure that intrusion is not allowed back into this area, whereas if the historical maximum chloride concentration was used, Moran Lake Medium chloride concentrations could be allowed to increase back to 700 mg/L. Table 3-15 summarizes 2013-2017 average and maximum chloride concentrations for all coastal monitoring wells.

Table 3-15. Summary of Chloride Concentrations in Monitoring and Production Wells at the Coast

Well	Aquifer Unit	Historical Maximum Year	Historical Maximum	2013-2017 Average	2018 / 2017*
			Chloride Concentrations, mg/L		
Coastal Monitoring Wells - Intruded					
SC-A3A	Aromas	2010	22,000	17,955	18,000
SC-A3B	Aromas	2005	4,330	676	1,100
SC-A8A	Purisima F	2015	8,000	7,258	7,500
SC-A2RA	Purisima F	2001	18,480	14,259	15,000
SC-A2RB	Purisima F	2015 & 2018	470	355	470
Moran Lake Medium	Purisima A	2005	700	147	78
Soquel Point Medium	Purisima A	2005	1,300	1,104	1,100
Coastal Monitoring Wells - Unintruded					
SC-A8B	Aromas	2014	38	33	33
SC-A1B	Purisima F	2009	38	26	22
SC-A1A	Purisima DEF	2009	37	28	26
SC-8RD	Purisima DEF	2016	65	28	66
SC-9RC	Purisima BC	1984	63	28	31
SC-8RB	Purisima BC	2003	32	14	13
Pleasure Point Medium	Purisima A	2012	38	34	36
SC-1A	Purisima A	2013	51	41	38

Well	Aquifer Unit	Historical Maximum Year	Historical Maximum	2013-2017 Average	2018 / 2017*
			Chloride Concentrations, mg/L		
SC-5RA	Purisima A	2001	94	55	58
SC-3RA	Purisima A	1984	66	39	38
Moran Lake Deep	Purisima AA	2012	66	64	62*
Pleasure Point Deep	Purisima AA	2006	87	22	21*
Soquel Point Deep	Purisima AA	2016	144	137	140*
SC-13A	Tu	1986	114	NA	NA
Inland Monitoring and Production Wells - Unintruded					
SC-A5A	Purisima F	2015	9,800	8,575	53
SC-A5B	Purisima F	2018	130	95	83
San Andreas PW	Purisima F	2011	79	21	21
Seascape PW	Purisima F	1996	29	20	16
T. Hopkins PW	Purisima DEF	2011	71	46	42
Estates PW	Purisima BC & A	1990	63	45	45
Ledyard PW	Purisima BC	1986	87	35	33
Garnet PW	Purisima A	2009	90	81	84
Beltz #2	Purisima A	2008	97	63	61*
Beltz #8 PW	Purisima A	2012	56	51	52*
SC-22AA	Purisima AA	2018	45	39	36
Corcoran Lagoon Deep	Purisima AA	2011	120	20	21
Schwan Lake	Purisima AA	2008	97	91	94*

PW = production well; NA = not available

3.6.1.1 Criteria for Defining Seawater Intrusion Undesirable Results

Undesirable results for seawater intrusion listed below are related to the inland movement of the chloride isocontour which would be considered significant and unreasonable seawater intrusion. To be able to monitor the location of the isocontour, chloride concentrations in monitoring and production wells either side of the chloride isocontours are used in the definition of undesirable results. In addition to the chloride isocontour minimum threshold, protective groundwater elevations at coastal monitoring wells are used as a proxy for seawater intrusion minimum thresholds. For a decade, seawater intrusion in the Basin has been managed using protective groundwater elevations. Experience has shown that protective groundwater elevations are easier to measure and manage with respect to controlling seawater intrusion, compared to relying purely on chloride concentrations.

The Basin's seawater intrusion undesirable results are split into three categories as defined below.

1. Undesirable results for intruded coastal monitoring wells.
2. Undesirable results for unintruded coastal monitoring wells, and inland monitoring monitoring and production wells.
3. Undesirable results for protective groundwater elevations.

If any of these occur, undesirable results from seawater intrusion are occurring.

Undesirable Results for Intruded Coastal Monitoring Wells

Undesirable results for coastal wells hat already have experienced seawater intrusion are:

> *Any coastal monitoring well with current intrusion has a chloride concentration above the 2013–2017 maximum chloride concentration. This concentration must be exceeded in 2 or more of the last 4 consecutive quarterly samples.*

The rationale for this statement is that if seawater intrusion had not been reported in wells inland of the coastal monitoring wells when chloride concentrations in the coastal monitoring wells were at their historic high, the likelihood of seawater intruding them in the future if coastal monitoring well concentrations increased back to that level again is low. Using a five-year (2013 – 2017) historical maximum chloride concentration provides greater flexibility in avoiding undesirable results than using a five-year average concentration and is more protective than using the historical maximum, which is mostly higher than the 2013–2017 maximum concentration.

The number of chloride concentration exceedances should be set at two per year to account for occasional fluctuations not related to seawater intrusion. Two to four samples exceeding the recent historical maximum indicates that seawater intrusion has advanced farther inland, which would be considered significant and unreasonable. Table 3-15 includes a list of historical maximum chloride values versus 2013–2017 average and 2013–2017 maximum chloride concentrations for monitoring and production wells that have had or have seawater intrusion. Note that Moran Lake was previously impacted by seawater (700 mg/L) and its chloride concentration has decreased to below 250 mg/L.

Undesirable Results for Unintruded Coastal Monitoring Wells, and Inland Monitoring and Production Wells

Undesirable results for wells unintruded by seawater are broken down by general proximity to the coast:

A. Unintruded coastal monitoring wells

B. Unintruded inland wells (which includes municipal production wells closest to the coast and other non-coastal monitoring wells).

Undesirable results for unintruded coastal monitoring wells (A) are:

> *Any unintruded coastal monitoring well has a chloride concentration above 250 mg/L. This concentration must be exceeded in 2 or more of the last 4 consecutive samples (quarterly sampled wells).*

Coastal monitoring wells have been constructed to be the Basin's early warning system and first line of defense against seawater intrusion. If their chloride concentrations increase to 250 mg/L, this is a clear indication that seawater is advancing father onshore than it is currently. There are seven coastal monitoring well sites (each site contains several multi-depth monitoring wells) that currently do not show seawater intrusion. These wells' chloride concentrations are summarized in Table 3-15. Groundwater with more than 250 mg/L chloride has a salty taste but is still drinkable to 500 mg/L, which is the state's upper maximum contaminant level. To increase confidence that tested groundwater concentrations are not anomalies, the exceedance of 250 mg/L must be repeated within a year (quarterly sampled wells) to be undesirable.

Undesirable Results for unintruded inland monitoring wells (B) are:

> *Any Unintruded Inland Monitoring Well (which includes municipal production wells closest to the coast and other non-coastal monitoring wells) has a chloride concentration above 150 mg/L. This concentration must be exceeded in 2 or more of the last 4 consecutive quarterly samples*.

All unintruded wells used as data points to develop the chloride isocontour will have TDS and chloride tested on at least a semi-annual schedule until an exceedance occurs, which triggers quarterly testing. Additionally, for an undesirable result to occur, seawater must be the cause of the chloride increase and not another source, such as a localized chemical spill. These wells' chloride concentrations are summarized in Table 3-15.

Undesirable Results for Protective Groundwater Elevations

For coastal representative monitoring wells which have protective elevations:

> *Five-year average groundwater elevations below protective groundwater elevations for any Coastal representative monitoring well.*

A five-year averaging period is selected based on the reasoning that follows:

> Cross-sectional models used to develop most of the protective elevations are quasi-steady state models (HydroMetrics LLC, 2009). Therefore, the protective elevations estimated by the models represent long-term averages that need to be achieved to maintain the freshwater-seawater interface at the desired location. The Basin is currently considered in critical overdraft because groundwater levels are below protective elevations in a number of coastal monitoring wells. Therefore, seawater intrusion groundwater level proxies for minimum thresholds that define sustainability are based on a multi-year average to ensure that critical overdraft is considered eliminated only when groundwater levels achieve the long-term average estimated to maintain the freshwater-seawater interface at the desired location. Achieving protective elevations in a single year should not represent elimination of the Basin's critical overdraft condition.
>
> However, the multi-year averaging period cannot be too long because once protective elevations are achieved with a multi-year average, an overly long averaging period would allow for long periods of groundwater levels being below protective elevations and seawater to advance inland during those periods. A five-year period also corresponds with SGMA requirements for five-year updates of the GSP.

Currently, undesirable results are occurring within the Basin for seawater intrusion because five-year average groundwater elevations do not meet protective elevations at all 13 representative monitoring points. Eliminating undesirable results for seawater intrusion is essential to achieve Basin sustainability.

3.6.1.2 Potential Causes of Undesirable Results

Seawater intrusion is a direct result of groundwater levels falling below elevations that would keep seawater offshore. Water supply wells pumping close to the coast have the potential to cause seawater intrusion if the volumes extracted cause groundwater elevations to fall close to or below sea level. The effects on groundwater levels are increased when multiple wells pump cumulative in close proximity to each other.

3.6.1.3 Effects on Beneficial Users and Land Use

The primary detrimental effect on beneficial users and land users from seawater intrusion is that the groundwater supply will become saltier and thus impact the use of groundwater for domestic/municipal and agricultural purposes. Although groundwater with greater than 250 mg/L chloride has a salty taste, it is still drinkable. The state's upper maximum contaminant level is set at 500 mg/L, when it becomes undrinkable by humans.

Regarding effects on agriculture, chloride moves readily within soil and water and is taken up by the roots of plants. It is then transported to the stems and leaves. Sensitive berries and avocado rootstocks can tolerate only up to 120 mg/L of chloride, while grapes can tolerate up to 700 mg/L or more (Grattan, 2002).

Seawater intrusion renders impacted groundwater essentially unusable to its beneficial users without treatment. Desalinization would significantly increase the cost of water for all users. Land uses completely overlying seawater intrusion, such as agriculture, will need alternative sources of water if their wells are located in the affected areas. For municipal pumpers, impacted wells can be taken offline until a solution is found. This will add stress on their water system by having to make up pumping in other unimpacted wells and increase the potential for further declines in groundwater levels and possibly more seawater intrusion.

3.6.2 Minimum Thresholds - Seawater Intrusion

Contrary to the general rule for setting minimum thresholds for other sustainability indicators, seawater intrusion minimum thresholds do not have to be set at individual monitoring sites. Rather, the minimum threshold is set along an isocontour line in a basin or management area. However, for practical purposes of monitoring the isocontour, minimum thresholds are set at selected monitoring and production wells used to define the isocontour. Groundwater elevation minimum thresholds are also included as a proxy for seawater intrusion.

3.6.2.1 Information Used and Methodology for Establishing Seawater Intrusion Minimum Thresholds

3.6.2.1.1 Chloride Isocontours

Information used for establishing the chloride isocontour seawater intrusion minimum thresholds and measurable objectives include:

- Definitions of significant and unreasonable conditions and desired groundwater quality discussed during GSP Advisory Committee meetings.
- Depths, locations, and logged lithology of existing wells used to monitor groundwater quality.
- Historical and current chloride concentrations in monitoring and production wells near the coast as summarized in Table 3-15.

To provide for more spatial certainty of the chloride isocontour, the isocontour is anchored, where possible, to coastal monitoring wells which are mostly located within 1,000 feet of the coastline. Anchoring the isocontour at coastal monitoring wells provides a consistent point to ascertain if concentrations at a data point on the isocontour (coastal monitoring well) have increased beyond the minimum threshold concentration set for the isocontour. There are 12 points on the isocontour represented by a monitoring well from which concentration data can be obtained and no interpolation is necessary. Additionally, because the statement of significant and unreasonable seawater intrusion conditions is based on historical observations at monitoring wells, it is appropriate to use the same monitoring wells to gauge changes to the location of the isocontour in the future. It is difficult to monitor the chloride isocontour if it is set at the coast because there are no data points on the coast from which to obtain concentration data to know if that concentration has been exceeded or not.

3.1.1.1.1 Groundwater Elevations as a Proxy

The information used for establishing the seawater intrusion groundwater level proxy minimum thresholds and measurable objectives include:

- Information about local definitions of significant and unreasonable conditions and desired groundwater elevations discussed during GSP Advisory Committee meetings.
- Depths and locations of existing coastal monitoring wells used to monitor groundwater levels and seawater intrusion.
- Historical groundwater elevation data from wells monitored by the MGA agencies.
- Maps of current and historical groundwater elevation data.
- Model output from a variable density (SEAWAT 2000) cross-sectional groundwater models.
- SkyTEM geophysical resistivity data.

Cross-sectional models were used to develop both protective and target groundwater levels at coastal monitoring well clusters (HydroMetrics LLC, 2009). Using Monte Carlo uncertainty analysis, a range of protective groundwater levels were developed for each coastal monitoring well cluster (HydroMetrics LLC, 2009). This range represents the uncertainty in the aquifer characteristics. Protective groundwater elevations developed using the cross-sectional models have successfully been used by SqCWD to manage seawater intrusion in the Basin.

Protective groundwater elevations for the Basin are established using two different methods dependent on availability of cross-sectional models:

1. Cross-sectional model data available: minimum thresholds are groundwater elevations that represents at least 70% of cross-sectional model simulations being protective against seawater intrusion for each monitoring well with a protective elevation[1]. For wells

[1] The cross-sectional modeling to develop protective groundwater elevations could not use specific hydrogeologic properties (properties that influence how groundwater flows) with any certainty because there are insufficient data to calibrate the models to groundwater level or concentration data. Additionally, there are limited data for hydrogeologic parameter values offshore, adding further uncertainty. To develop reliable protective groundwater levels, it was necessary to perform an uncertainty analysis that evaluates the range of reasonable outcomes given the lack of precise hydrogeologic property/parameter data.

Each coastal monitoring well location where protective groundwater elevations were developed included 99 randomized parameters model simulations Parameters varied are horizontal hydraulic conductivities of the production unit and underlying unit, and vertical conductivities of the aquitards above the production unit.

where seawater intrusion has not been observed, cross-sectional models estimate protective elevations to protect the entire depth of the aquifer unit of the monitoring wells' lowest screen. For wells where seawater intrusion has been observed, the cross-sectional models estimate protective elevations to prevent seawater intrusion from advancing.

2. Cross-sectional model data not available: minimum thresholds are groundwater elevations that represent protective groundwater elevation estimated by using the Ghyben-Herzberg analytical method to protect to the bottom of the monitoring well screen.

3.6.2.1.2 Consideration of Sea-Level Rise

The chloride isocontour and associated well chloride concentrations established as seawater intrusion minimum thresholds are based on the description of significant and unreasonable conditions for the sustainability indicator. This describes seawater moving farther inland than has been observed in the past five years as significant and unreasonable conditions. Undesirable results that occur when chloride concentrations exceed minimum thresholds represent significant and unreasonable conditions even when the intrusion is a result of sea level rise. By defining chloride concentrations as minimum thresholds, the MGA is required to prevent significant and unreasonable seawater intrusion in the Basin resulting from sea level rise.

Groundwater level proxies for the seawater intrusion minimum thresholds also take into account current and rising sea levels. The seawater intrusion groundwater level proxies are established as groundwater elevations above mean sea level. The current datum is therefore current sea levels but the datum will rise in the future as sea levels rise. Although the elevation relative to sea level is set by the groundwater level proxy, the absolute elevations that define undesirable results will increase with rising sea levels.

This consideration of the effect of sea level rise is incorporated into the model evaluation of whether projects can raise and maintain groundwater elevations to meet and exceed the groundwater level proxies for minimum thresholds. The model incorporates projected sea level rise in the offshore boundary condition for simulations of future conditions. The boundary condition head for sea level is increased over time to 2.3 feet in 2070 over current sea level rise based on state of California projections for Monterey representing 5% probability under a High Emissions scenario (California Natural Resources Agency, 2018). Since the datum in the model is set at current sea level, simulated future groundwater levels were compared to the groundwater level proxies plus the total sea level rise of 2.3 feet. This allows evaluation of whether projects and management actions will raise and maintain groundwater elevations to meet groundwater level proxies relative to projections of higher sea levels.

3.6.2.2 Chloride Isocontour Minimum Threshold

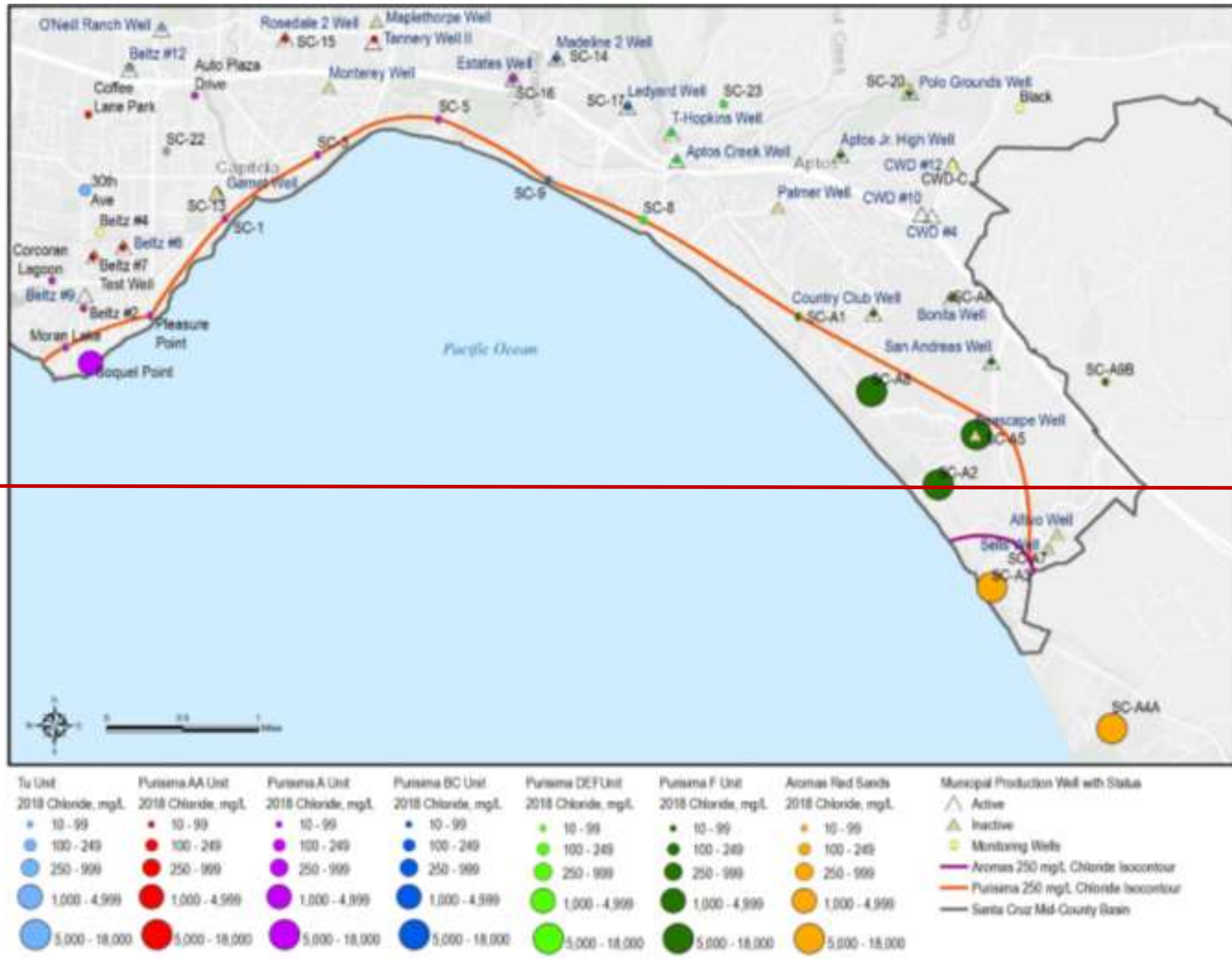
The current extent of seawater intrusion is indicated by the circle symbols on Figure 3-12. The larger the symbol the greater the chloride concentration. The symbols are also colored by aquifer to indicate depth. Figure 3-12 shows that in the Basin, the Aromas Red Sands aquifer has seawater intrusion only in the La Selva Beach area. However, the SC-A4 monitoring well outside of the Basin in the Pajaro Valley is also intruded thus it is assumed that seawater intrusion in the Aromas Red Sands aquifer extends southwards across the Basin boundary. Current seawater intrusion in the Purisima aquifers is found in one Purisima A-unit monitoring well in the Soquel Point area with a chloride concentration of 1,100 mg/L, and in the Seascape area where chloride concentrations up to 15,000 mg/L occur in three Purisima F-unit monitoring wells (Figure 3-12).

Considering the extent of current seawater intrusion, the chloride isocontours on Figure 3-12 represents seawater intrusion minimum thresholds in both the Aromas and Purisima aquifers. A chloride concentration of 250 mg/L is selected for the minimum threshold for the Basin because native chloride concentrations in groundwater are generally below 100 mg/L. Thus, an increase up to the basin water quality objective and state drinking water standard of 250 mg/L is considered significant and unreasonable. A chloride concentration of 250 mg/L is relatively low and likely represents some seawater mixed with native groundwater. Full strength seawater has a chloride concentration of 19,000 mg/L.

Since the location of the chloride isocontour is defined by concentrations in wells, wells either side of the contour are assigned minimum threshold concentrations that determine if the isocontour is moving inland. It is not required in the SGMA regulations but as discussed in the measurable objectives subsection, chloride concentration in these wells are also used to trigger early management actions if concentrations increase above measurable objectives but are still below minimum thresholds.

If chloride concentrations inland of the isocontour increase to above the minimum threshold concentration of ~~150~~250 mg/L, this indicates that seawater is moving inland and management actions to remedy it need to take place to ensure that by 2040, chloride concentrations inland of the 250 mg/L isocontour remain below the minimum threshold of 250 mg/L.

Table 3-16 summarizes the minimum thresholds for each of the wells used to define the chloride isocontour.


Pacific Ocean
Tu Unit
2018 Chloride, mg/L
Purisima AA Unit
2018 Chloride, mg/L
Purisima A Unit
2018 Chloride, mg/L
Purisima BC Unit
2018 Chloride, mg/L
Purisima DEF Unit
2018 Chloride, mg/L
Purisima F Unit
2018 Chloride, mg/L
Aromas Red Sands
2018 Chloride, mg/L
10 - 99
100 - 249
250 - 999
1,000 - 4,999
5,000 - 18,000
Municipal Production Well with Status
Active
Inactive
Monitoring Wells
Aromas 250 mg/L Chloride Isocontour
Purisima 250 mg/L Chloride Isocontour
Santa Cruz Mid-County Basin

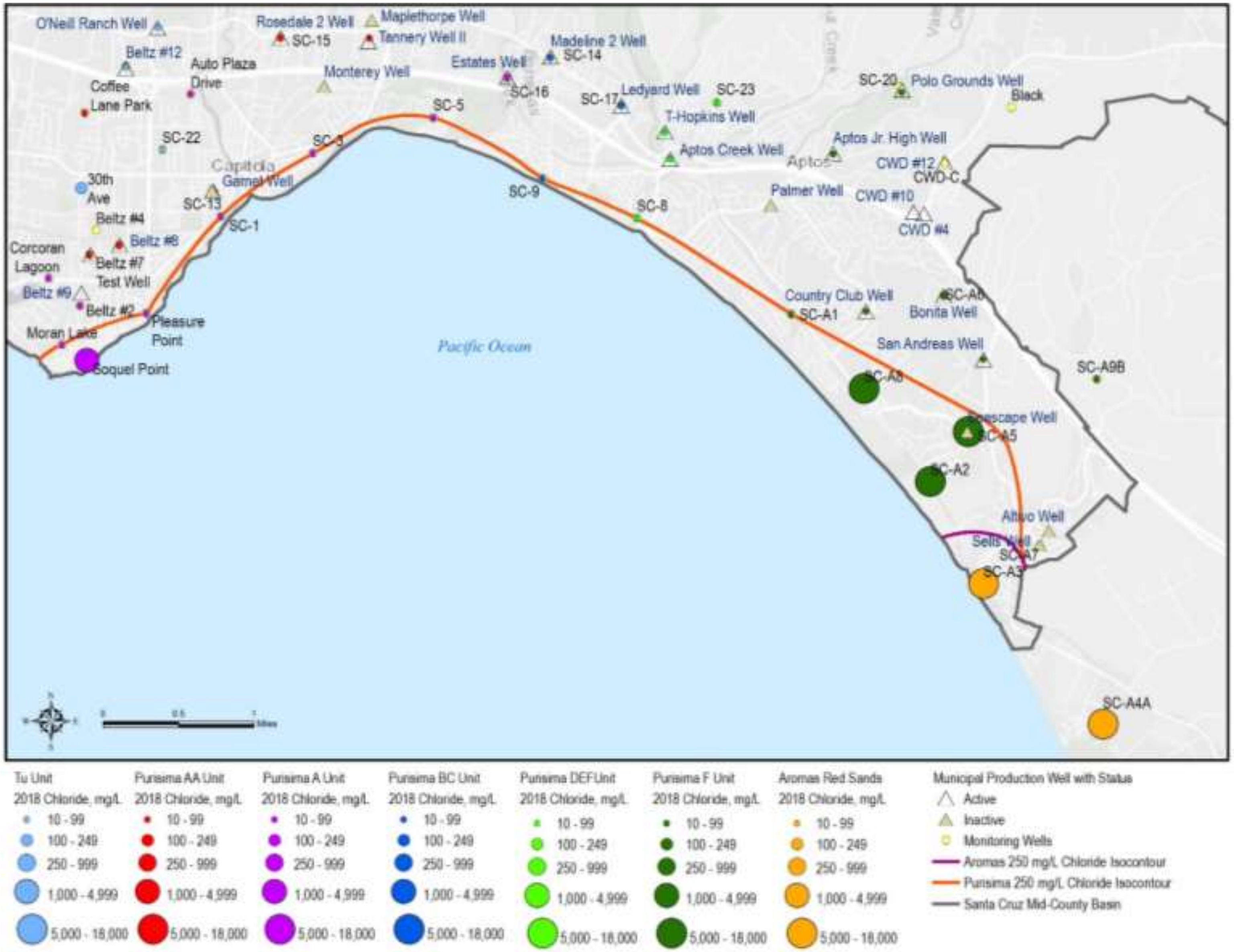


Figure 3-12. 250 mg/L Chloride Isocontour for the Aromas and Pursima Aquifers

Table 3-16. Chloride Minimum Thresholds and Measurable Objectives for Coastal and Inland Wells

Monitoring Well	Aquifer	Minimum Threshold	Measurable Objective
		Chloride Concentration, mg/L	
Coastal Monitoring Wells - Intruded			
SC-A3A	Aromas	22,000	17,955
SC-A3B	Aromas	4,330	676
SC-A8A	Purisima F	8,000	7,258
SC-A2RA	Purisima F	18,480	14,259
SC-A2RB	Purisima F	470	355
Moran Lake Med	Purisima A	700	147
Soquel Point Med	Purisima A	1,300	1,104
Coastal Monitoring Wells - Unintruded			
SC-A8B	Aromas	250	100
SC-A1B	Purisima F	250	100
SC-A1A	Purisima DEF	250	100
SC-8RD	Purisima DEF	250	100
SC-9RC	Purisima BC	250	100
SC-8RB	Purisima BC	250	100
Pleasure Point Medium	Purisima A	250	100
SC-1A	Purisima A	250	100
SC-5RA	Purisima A	250	100
SC-3RA	Purisima A	250	100
Moran Lake Deep	Purisima AA	250	100
Pleasure Point Deep	Purisima AA	250	100
Soquel Point Deep	Purisima AA	250	100
SC-13A	Tu	250	100
Inland Production and Monitoring Wells - Unintruded			
SC-A5A	Purisima F	150	100
SC-A5B	Purisima F	150	100
San Andreas PW	Purisima F	150	100
Seascape PW	Purisima F	150	100
T. Hopkins PW	Purisima DEF	150	100
Estates PW	Purisima BC & A	150	100
Ledyard PW	Purisima BC	150	100

Monitoring Well	Aquifer	Minimum Threshold	Measurable Objective
		Chloride Concentration, mg/L	
Garnet PW	Purisima A	150	100
Beltz #2	Purisima A	150	100
Beltz #8 PW	Purisima A	150	100
SC-22AA	Purisima AA	150	100
Corcoran Lagoon Deep	Purisima AA	150	100
Schwan Lake	Purisima AA	150	100

PW = production well

3.6.2.3 Groundwater Elevations as a Proxy for Seawater Intrusion Minimum Thresholds

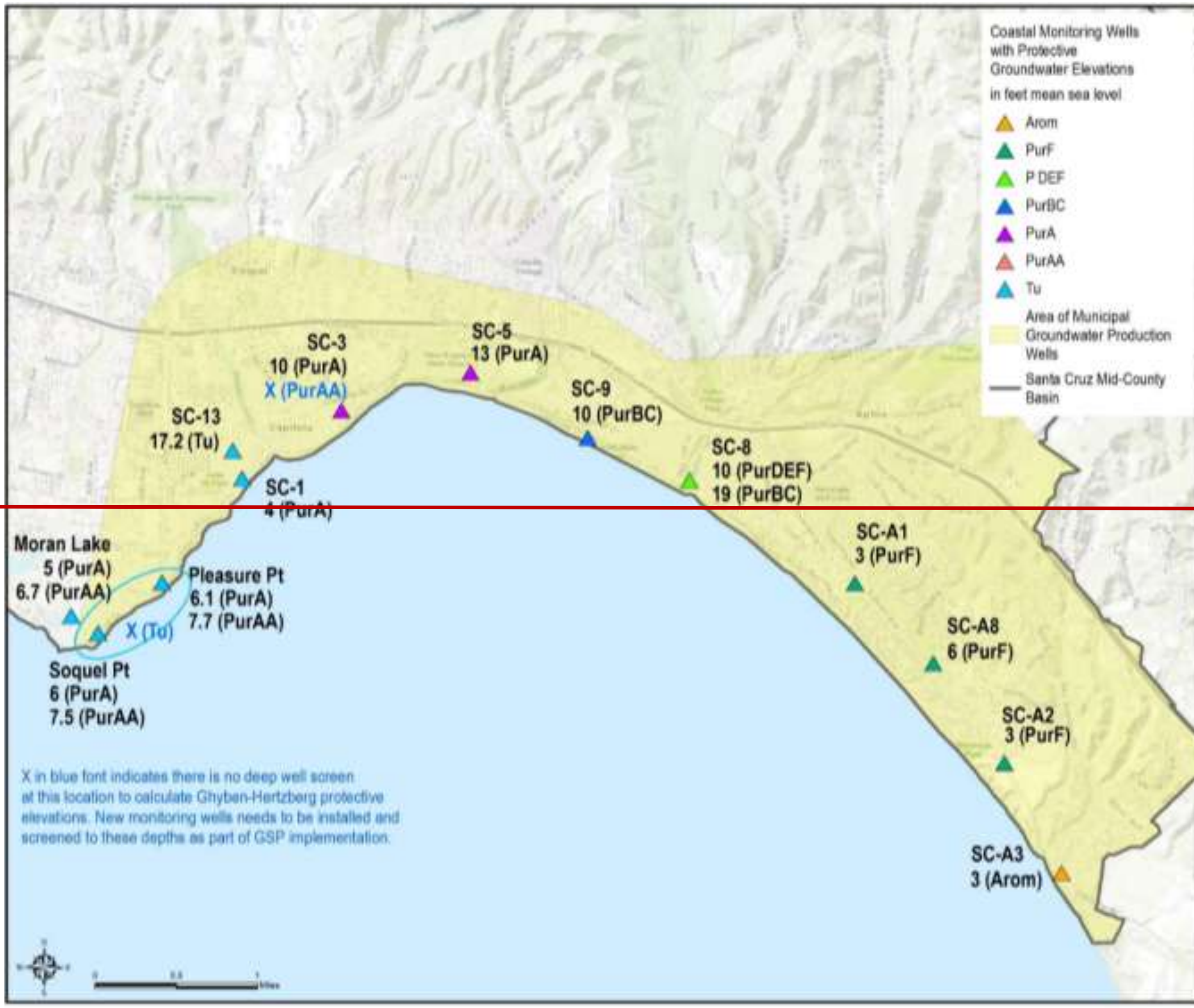
As indicated in the SGMA Regulations Section §354.36(b) "*groundwater elevations may be used as a proxy for monitoring other sustainability indicators*." For seawater intrusion, protective groundwater elevations are used as proxies for additional minimum thresholds. Use of a proxy is appropriate because there is significant correlation between groundwater elevations and seawater intrusion. When coastal groundwater levels in aquifers connected to the ocean fall to near or below sea level, flows across the ocean/land boundary become predominantly onshore flows. As higher density seawater flows inland, a wedge forms under the less dense fresh groundwater until the water table achieves equilibrium. The lower groundwater levels are, the less pressure there is from freshwater within the aquifer to resist the intruding seawater.

Minimum thresholds for seawater intrusion using groundwater elevation proxies are the current protective groundwater elevations set at coastal monitoring wells and used for groundwater management over the past 10 years. Current protective elevations for coastal monitoring wells are listed in Table 3-17 and shown on a map as Figure 3-13. New deep monitoring wells need to be constructed in the early part of GSP implementation and protective elevations will be established when the construction details of those wells are available. Table 3-17 and Figure 3-13 identify the two new deep Tu-unit monitoring wells.

Table 3-17. Minimum Thresholds and Measurable Objectives for Groundwater Elevations Used as Proxies at Seawater Intrusion Representative Monitoring Points

Coastal Monitoring Well with Aquifer Unit in Parenthesis	Minimum Threshold (feet mean ~~seal~~sea level)	Basis for Minimum Threshold	Measurable Objective (feet mean sea level)	Basis for Measurable Objective	Trigger for Early Management Action (feet mean sea level)
SC-A3A (Aromas)	3	XS 70th	4	XS >99th	1
SC-A1B (F)	3	XS 70th	5	XS >99th	1
SC-A8RA (F)	6	XS 70th	7	XS >99th	2
SC-A2RA (F)	3	XS 70th	4	XS >99th	1
SC-8RD (DEF)	10	XS 70th	11	XS >99th	2
SC-9RC (BC)	10	XS 70th	11	XS >99th	2
SC-8RB (BC)	19	XS 70th	20	SC-8RD + GH	2
SC-5RA (A)	13	XS 70th	15	XS >99th	2
SC-3RA (A)	10	XS 70th	12	XS >99th	2
SC-1A (A)	4	XS 70th	6	XS >99th	2
Moran Lake Medium (A)	5	GH BS	6.8	GH BU	2
Soquel Point Medium (A)	6	GH BS	7.1	GH BU	2
Pleasure Point Medium (A)	6.1	GH BS	6.5	GH BU	2
Moran Lake Deep (AA)	6.7	GH BS	16	GH BU	2
Soquel Point Deep (AA)	7.5	GH BS	16	GH BU	2
Pleasure Point Deep (AA)	7.7	GH BS	16	GH BU	2
SC-13A (Tu)	17.2	GH BS	19	GH BU	2

Notes:
GH BS = Ghyben-Herzberg bottom of screen
GH BU = Ghyben-Herzberg bottom of aquifer unit
XS 70th = Cross-sectional model with 70th percentile of runs being protective
XS >99th = Cross-sectional model with greater than 99th percentile of runs being protective


Coastal Monitoring Wells with Protective Groundwater Elevations
in feet mean sea level
Arom
PurF
P DEF
PurBC
PurA
PurAA
Tu
Area of Municipal Groundwater Production Wells
Santa Cruz Mid-County Basin
SC-3
10 (PurA)
X (PurAA)
SC-5
13 (PurA)
SC-9
10 (PurBC)
SC-13
17.2 (Tu)
SC-1
4 (PurA)
SC-8
10 (PurDEF)
19 (PurBC)
SC-A1
3 (PurF)
Moran Lake
5 (PurA)
6.7 (PurAA)
Pleasure Pt
6.1 (PurA)
7.7 (PurAA)
X (Tu)
Soquel Pt
6 (PurA)
7.5 (PurAA)
SC-A8
6 (PurF)
SC-A2
3 (PurF)
X in blue font indicates there is no deep well screen at this location to calculate Ghyben-Hertzberg protective elevations. New monitoring wells needs to be installed and screened to these depths as part of GSP implementation.
SC-A3
3 (Arom)

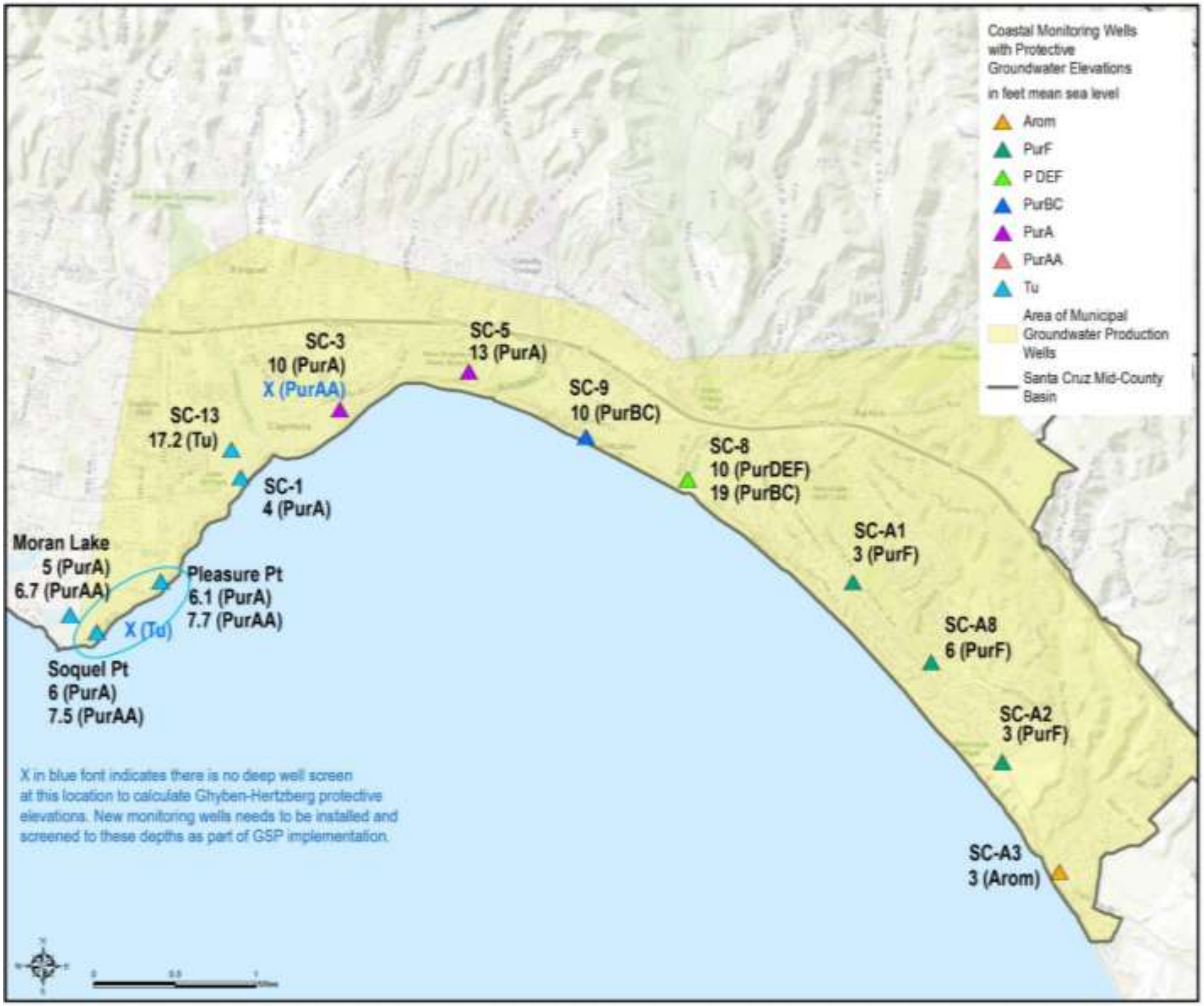


Figure 3-13. Protective Groundwater Elevations at Coastal Monitoring Wells

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

Considering the minimum thresholds for seawater intrusion are both groundwater quality and groundwater elevation metrics, the bullets below address the relationship between the seawater intrusion minimum thresholds and other sustainability indicator minimum thresholds.

- **Chronic lowering of groundwater levels.** Groundwater elevations associated with proxy minimum thresholds for seawater intrusion are more stringent than groundwater elevations that represent chronic lowering of groundwater levels. Minimum threshold groundwater elevations for chronic lowering of groundwater levels are raised from the level that would meet overlying demands so that they do not interfere with attaining minimum threshold elevations for seawater intrusion.

- **Reduction of groundwater in storage.** Minimum thresholds for reduction of groundwater in storage and seawater intrusion are dependent on each other. Minimum thresholds for reduction of groundwater in storage are volumes of groundwater, for each of the three aquifer groups that do not cause undesirable results in the other applicable sustainability indicators such as seawater intrusion.

- **Degraded groundwater quality.** The chloride isocontour minimum threshold for seawater intrusion is the same minimum threshold concentration assigned to chloride for degradation of groundwater quality. For the unintruded inland wells, a seawater intrusion chloride minimum threshold of 150 mg/L, although less than the degraded groundwater quality minimum threshold of 250 mg/L, is only used to represent if the chloride isocontour has moved inland and does not signify degraded quality.

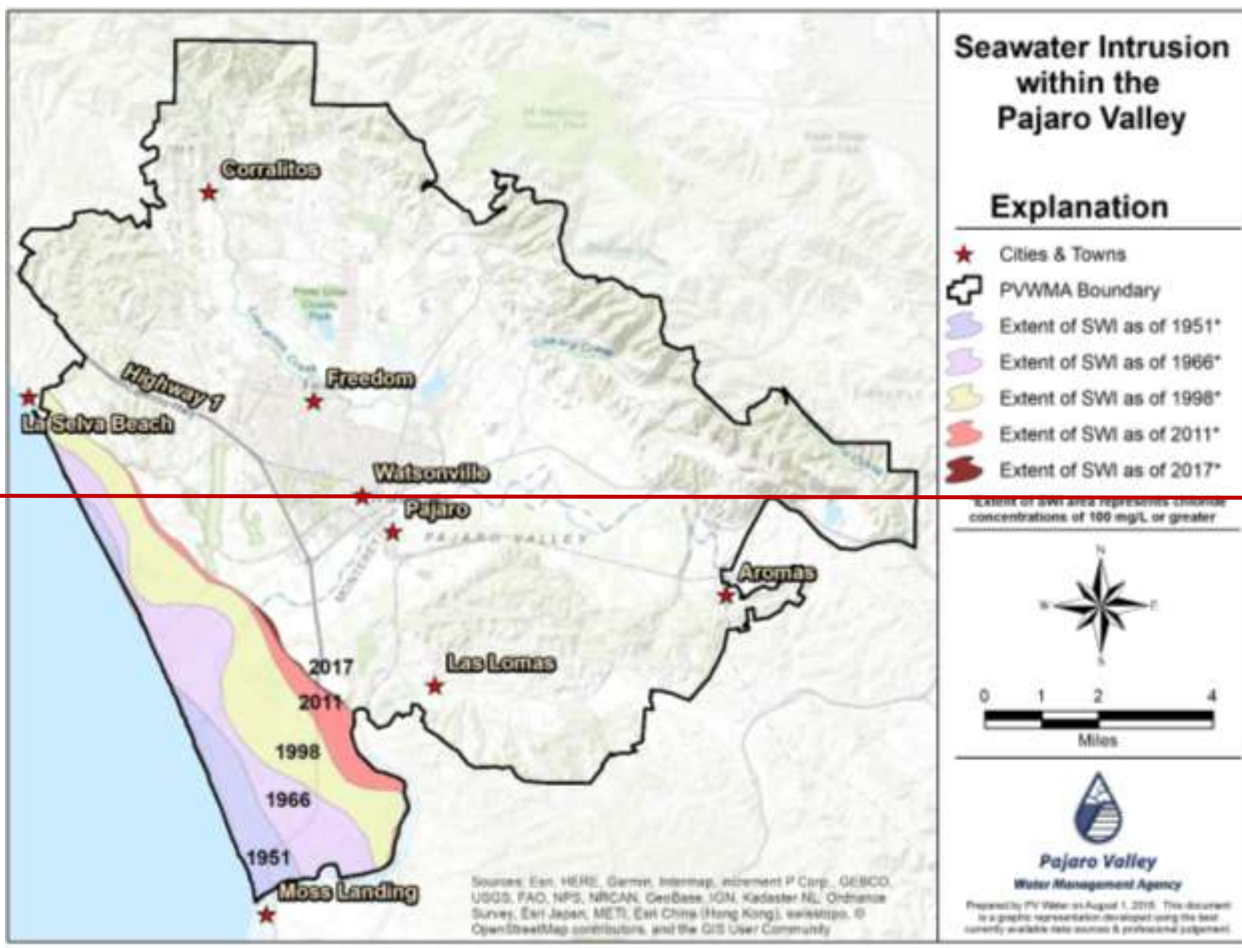
- **Subsidence.** This sustainability indicator is not applicable to the Basin.

- **Depletion of interconnected surface water**. Minimum thresholds for interconnected surface water are shallow groundwater levels (as a proxy) that have been set in existing RMPs. Groundwater elevations used as a proxy minimum threshold shown on Figure 3-11 are above sea level and do not interfere with the ability to attain proxy seawater intrusion groundwater elevation thresholds. Since shallow groundwater level proxies set as minimum thresholds for depletion of interconnected surface water are based on observations from 2001-2015, proxy seawater intrusion groundwater elevation minimum thresholds that are generally higher than groundwater elevations from 2001-2015 should not interfere with the ability to avoid undesirable results for depletion of interconnected surface water.

3.6.2.5 Effect of Minimum Thresholds on Neighboring Basins

The anticipated effect of the degraded groundwater quality minimum thresholds on each of the neighboring basins/subbasins are addressed below.

Pajaro Valley Subbasin of the Corralitos Basin (critically-overdrafted). The Pajaro Valley Subbasin is hydrogeological down- to cross-gradient of the Santa Cruz Mid-County Basin. Because of lower groundwater elevations in the Pajaro Valley Subbasin, groundwater along the coastal portion of the boundary flows from the Santa Cruz Mid-County Basin into the Pajaro Valley Subbasin. Chloride concentrations in the La Selva area of the Basin are similar to those in the Pajaro Valley Subbasin, which has more extensive seawater intrusion along its entire length of coastline (Figure 3-12 and Figure 3-14). The goal for seawater intrusion conditions in Pajaro Valley is to halt intrusion by reducing the rate of intrusion (Carollo Engineers, 2014). Since the groundwater level proxy minimum thresholds in the Santa Cruz Mid-County Basin in the Aromas area are intended to keep seawater intrusion where it is currently, the seawater intrusion minimum thresholds assist Pajaro Valley achieve its sustainability goals for seawater intrusion by causing increased subsurface flow into Pajaro Valley thus helping to reduce the rate



of intrusion. The increase in outflows to Pajaro Valley when minimum thresholds are achieved is supported by the projected groundwater budget in Section 2.

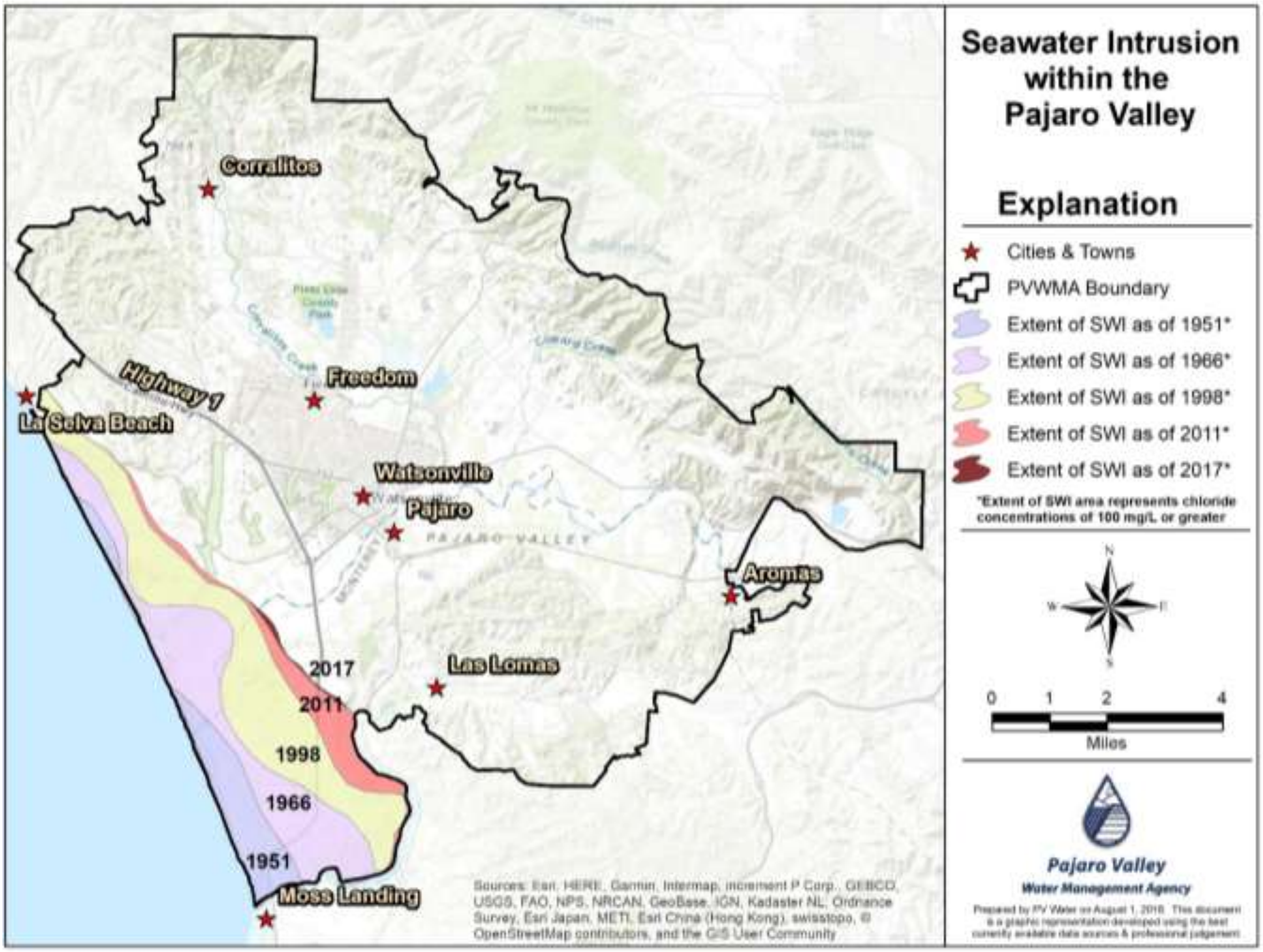


Figure 3-14. Seawater Intrusion within the Pajaro Valley (Source: PVWMA)

Santa Margarita Basin (medium-priority). The Santa Margarita Basin is an inland basin being at least 5.8 miles from the coast. Because of this distance and the fact that groundwater elevations at the chloride isocontour near the coast are roughly 550 feet lower than groundwater elevations at the boundary between the two basins, there is no potential for seawater intrusion minimum thresholds established for the Santa Cruz Mid-County Basin to affect the Santa Margarita Basin from achieving sustainability.

Purisima Highlands Subbasin of the Corralitos Basin (very low-priority). Similar to the Santa Margarita Basin, the Purisima Highlands Subbasin is an inland basin that is at an elevation of at least 340 feet above sea level and will not be impacted by seawater intrusion minimum thresholds at the coast.

3.6.2.6 Effects of Minimum Thresholds on Beneficial Users and Land Uses

Between the ocean and the chloride isocontour, land use is predominantly recreational, open space, agricultural, and residential. Private and agricultural users have their own wells while residential users of groundwater are supplied municipal water pumped in other parts of the Basin. Restricting the advancement of seawater intrusion to where it is currently will not impact more wells and an area greater than already impacted. Also, wells inland of the chloride isocontour will not be impacted by the seawater minimum thresholds.

3.6.2.7 Relevant Federal, State, or Local Standards

No federal or state standards exist for seawater intrusion. Locally, the City of Santa Cruz and Soquel Creek Water District have a cooperative monitoring / adaptive groundwater management agreement to: (1) ensure protection of the shared groundwater resource from seawater intrusion, (2) allow for the redistribution of pumping inland away from the Purisima A-unit offshore outcrop area, (3) maintain inland groundwater levels that promote continued groundwater flow toward coastal wells and the Purisima A offshore outcrop area while maintaining coastal groundwater levels that will abate seawater intrusion, and (4) provide both agencies adequate flexibility to respond to changing water demands, changing water supply availability, and infrastructure limitations. Protective groundwater elevations used as proxy measurements for seawater intrusion are aligned with the cooperative agreement’s target groundwater elevations.

3.6.2.8 Method for Quantitative Measurement of Minimum Thresholds

Chloride concentrations used to define the chloride isocontour in production and monitoring well RMPs will be directly measured to determine where chloride concentrations are in relation to minimum thresholds. Groundwater quality samples will be collected and tested in accordance with the monitoring plan outlined in Section 3.3. Sampling for all coastal monitoring wells is quarterly and unintruded inland wells are sampled semi-annually, unless an exceedance of a minimum threshold is measured, whereupon the sampling frequency will be increased to quarterly.

Groundwater elevations in RMPs will be directly measured to determine where groundwater levels are in relation to minimum thresholds used a proxy metric for seawater intrusion. Groundwater level monitoring will be conducted in accordance with the monitoring plan outlined in Section 3.3. All RMPs will be equipped with continuous data loggers.

3.6.3 Measurable Objectives - Seawater Intrusion

3.6.3.1 Chloride Isocontour Measurable Objective

3.6.3.1.1 Measurable Objectives

The measurable objective chloride isocontour has the same location as the minimum threshold isocontour shown on Figure 3-12. Since all historical unintruded coastal monitoring well concentrations are below 100 mg/L (Table 3-16), the isocontour concentration for measurable objectives is reduced from 250 mg/L (minimum threshold) to 100 mg/L (measurable objective). Having the measurable objective isocontour at the same location as the minimum threshold allows the same monitoring wells along that isocontour to be used to define its location. The measurable objectives for intruded wells are their 2013 – 2017 average concentration and is 100 mg/L for all unintruded wells. Table 3-16 lists the minimum threshold and measurable objective concentrations for all wells used to define the isocontour.

3.6.3.1.2 Chloride Concentration Triggers

Although not required by the SGMA regulations, the MGA will use chloride concentration exceedances of measurable objectives as a trigger for preemptive actions to prevent significant and unreasonable conditions from occurring. This approach is being taken for this specific sustainability indicator because it is the indicator for which the Basin is in critical overdraft. If chloride concentrations exceed measurable objectives and have a continuing increasing trend, it indicates that concentrations are moving toward minimum thresholds that define undesirable results. Such a trend will be addressed immediately.

For unintruded monitoring wells where chloride concentrations are below 250 mg/L, the measurable objective for chloride concentration is 100 mg/L. Variation of chloride concentrations below 100 mg/L is not necessarily indicative of seawater intrusion. Chloride concentrations above 100 mg/L in two of four quarterly samples are more likely indicative of seawater intrusion and warrant early management action.

For intruded monitoring wells where chloride concentrations are currently above 250 mg/L, the measurable objective for chloride concentrations is the 2013-2017average concentration. As this average concentration includes seasonal and measurement variation, an annual average of four quarterly chloride samples above the measurable objective is indicative of seawater intrusion moving inland and warrants early management action.

The recommended management action for exceedances of chloride measurable objectives is for pumping to be reduced at the municipal well nearest to the monitoring well with the exceedance. The objective of this action is to raise groundwater levels in the monitoring well and prevent further increases of chloride concentrations that could result in significant and unreasonable conditions.

If the groundwater level proxy minimum threshold is being met but chloride measurable objective is exceeded at any monitoring well, this indicates that the groundwater level proxy is not protective for preventing further seawater intrusion than observed over 2013-2017. In this case, the groundwater level proxy should be revised. The groundwater level proxy may not be sufficient because the level is too low or because the multi-year averaging period is too long. Based on an evaluation of groundwater levels and chloride concentrations for what appears insufficient, the level should be raised and/or the averaging period should be shortened.

3.6.3.1.3 Interim Milestones for Chloride

The measurable objective chloride isocontour of 100 mg/L is defined in part by RMPs that currently have chloride concentrations below their measurable objective of 100 mg/L (Figure 3-12). Inland of the isocontour, RMPs are also below their measurable objectives (Table 3-15). Projects and management actions included in the GSP are designed so that current seawater intrusion does not advance inland. Therefore, interim milestones are set at the same concentration as measurable objectives (100 mg/L) as no change in inland chloride concentrations are expected as the GSP is implemented.

For RMPs currently impacted by seawater intrusion and located on the coast-side of the chloride isocontour, current concentrations represented by average 2013 – 2017 chloride concentrations are their measurable objectives. Interim milestones for these wells are set at the same concentrations as measurable objectives shown in Table 3-16, effectively representing conditions that do not allow seawater intrusion to get worse than it is currently.

3.6.3.2 Groundwater Elevations as a Proxy Measurable Objectives

3.6.3.2.1 Measurable Objectives

Groundwater elevations as a proxy measurable objectives are determined based on whether the cross-sectional groundwater model is available for the area or not.

1. Cross-sectional model available: measurable objectives are groundwater elevations that represents >99% of cross-sectional model simulations being protective against seawater intrusion for each monitoring well with a protective elevation. For wells where seawater intrusion has not been observed, cross-sectional models estimate protective elevations to protect the entire depth of the aquifer unit of the monitoring wells' lowest screen. For wells where seawater intrusion has been observed, the cross-sectional models estimate protective elevations to prevent seawater intrusion from advancing.

2. Cross-sectional model not available: measurable objectives are the groundwater elevations that represent protective groundwater elevation estimated by using the Ghyben-Herzberg method to protect the entire depth of the aquifer unit the monitoring wells are screened in.

Measurable objectives established based on the approaches above are provided in Table 3-17.

3.6.3.2.2 Protective Groundwater Elevation Triggers

Similar to the chloride concentration triggers described in Section 3.6.3.1 that initiate action based on exceeding chloride concentration measurable objectives in monitoring and production wells near the chloride isocontour, groundwater level proxy triggers at coastal monitoring wells will also initiate early management actions. As with the chloride concentration triggers, these triggers are not required by SGMA regulations but are included in the GSP as a preemptive action to prevent significant and unreasonable conditions from occurring. This approach is being taken for this specific sustainability indicator because seawater intrusion is the indicator for which the Basin is in critical overdraft. Groundwater elevations dropping below these triggers over the short-term indicate an increased risk of seawater intrusion that may not be fully addressed by minimum thresholds and measurable objectives based on five-year average elevations.

The groundwater level proxy trigger is based on the minimum groundwater elevation at coastal monitoring wells included in the existing cooperative monitoring/adaptive management groundwater management agreement between the City of Santa Cruz and Soquel Creek Water District that has been in effect since 2015. The agreement lists a minimum groundwater elevation as 2 feet above mean sea level applied to a 30 day running average at the coastal monitoring wells Moran Lake Medium, Soquel Point Medium, Pleasure Point Medium, and SC-1A. In order to maintain consistency with the cooperative agreement, the following groundwater level proxy triggers are set for other coastal monitoring wells:

- 2 feet above mean sea level is set as the groundwater elevation trigger for wells with minimum threshold groundwater level proxies for seawater intrusion of 4 feet or higher: SC-A8RA, SC-A8RD, SC-9RC, SC-8RB, SC-5RA, SC-3RA, SC-1A, Moran Lake Medium, Soquel Point Medium, Pleasure Point Medium, Moran Lake Deep, Soquel Point Deep, Pleasure Point Deep, and SC-13A.

- In order to provide operational flexibility, 1 foot above mean sea level is set as the groundwater elevation trigger for wells with minimum threshold groundwater level proxies of less than 4 feet: SC-A3A, SC-A1B, and SC-A2RA.

Table 3-17 lists the groundwater elevation triggers for early management action compared to minimum thresholds and measurable objectives for RMPs that use proxy groundwater elevations for SMC.

If data show that a 30-day running average groundwater elevation has dropped below the groundwater elevation trigger at a coastal monitoring well, MGA member agencies that pump from the aquifer unit of the monitoring well will evaluate how municipal pumping quantities and distribution may have caused the decline in groundwater levels. The MGA member agencies will then adjust municipal pumping based on the evaluation to avoid future groundwater elevations below the triggers. If municipal pumping does not appear to have caused the groundwater elevations falling below triggers, the MGA will investigate the cause of the drop.

3.6.3.2.3 Interim Milestones for Groundwater Elevation Proxies

Groundwater elevations as proxy interim milestones are based on model simulations of projects showing how projects will raise coastal groundwater levels over time to prevent undesirable results related to seawater intrusion. Section 4 contains the model results which are used to describe the expected benefits of the projects.

Interim milestones are established at each of the coastal RMPs with proxy groundwater elevations for seawater intrusion. Interim milestones are based on the five year average of model simulated groundwater elevations in Water Years 2025, 2030, and 2035.

Interim milestones at Soquel Creek Water District's coastal monitoring wells (with names beginning in SC) are based on model simulation of Pure Water Soquel because the expected benefits of that project are to raise groundwater levels above or approaching measurable objectives at the District's wells as described in Section 4. The interim milestones at City of Santa Cruz's coastal monitoring wells (Moran Lake, Soquel Point, and Pleasure Point) are based on model simulation of Pure Water Soquel and City of Santa Cruz ASR in combination because the expected benefits of the City of Santa Cruz project are to raise groundwater levels above minimum thresholds at the City's wells as described in Section 4. Table 3-18 summarizes the interim milestones for coastal RMPs.

If simulated groundwater elevations in 2025 are above minimum thresholds, the minimum thresholds are used as the interim milestone because there is some uncertainty about when projects would begin. This GSP sets as an interim milestone the elimination of undesirable results by 2025 at locations where model results show it is achievable with project implementation. If modeled groundwater levels in 2030 and 2035 are above measurable objectives, the measurable objectives are used as the interim milestones.

The model does not reliably simulate groundwater elevations in the Purisima DEF unit where SC-8RD is located. The interim milestone for this well are set at the minimum threshold so that the MGA will evaluate whether Purisima DEF unit pumping is sustainable at each five year interval (Table 3-18).

Interim milestones at Moran Lake Deep well drop slightly between 2030 and 2035. This is a result of reduced surface water supply for City ASR during this time based on projected climate variability. Evaluation of groundwater elevations against these interim milestones should account for actual surface water supply used to recharge the Basin and climate variability.

Table 3-18. Interim MIlestones for Seawater Intrusion Groundwater Elevation Proxies

Representative Monitoring Well with Aquifer Unit in Parenthesis	Minimum Threshold (feet mean seal level)	Measurable Objective (feet mean sea level)	Interim Milestone 2025 (feet mean sea level)	Interim Milestone 2030 (feet mean sea level)	Interim Milestone 2035 (feet mean sea level)
SC-A3A (Aromas)	3	7	3	3.7	3.7
SC-A1B (F)	3	5	3	5	5
SC-A8RA (F)	6	7	4.5	6.0	6.9
SC-A2RA (F)	3	4	3	4	4
SC-8RD (DEF)	10	11	10	10	10
SC-9RC (BC)	10	11	4.6	11	11

Representative Monitoring Well with Aquifer Unit in Parenthesis	Minimum Threshold (feet mean seal level)	Measurable Objective (feet mean sea level)	Interim Milestone 2025 (feet mean sea level)	Interim Milestone 2030 (feet mean sea level)	Interim Milestone 2035 (feet mean sea level)
SC-8RB (BC)	19	20	8.4	16.6	18.1
SC-5RA (A)	13	15	13	15	15
SC-3RA (A)	10	12	10	12	12
SC-1A (A)	4	6	4	6	6
Moran Lake Medium (A)	5	6.8	5	6.8	6.8
Soquel Point Medium (A)	6	7.1	6	7.1	7.1
Pleasure Point Medium (A)	6.1	6.5	6.1	6.5	6.5
Moran Lake Deep (AA)	6.7	16	6.7	8.1	7.8
Soquel Point Deep (AA)	7.5	16	7.5	8.3	8.3
Pleasure Point Deep (AA)	7.7	16	7.7	11.8	11.9
SC-13A (Tu)	17.2	19	8.3	16.7	18.1

3.7 Degraded Groundwater Quality Sustainable Management Criteria

3.7.1 Undesirable Results - Degraded Groundwater Quality

Locally defined significant and unreasonable groundwater quality degradation in the Basin is:

> *Groundwater quality, attributable to groundwater pumping or managed aquifer recharge, that fails to meet state drinking water standards.*

Recognizing there are naturally occurring groundwater quality issues in the Basin, this statement reflects that any project implemented or management actions taken by the MGA to achieve sustainability must not cause groundwater quality degradation that results in groundwater quality to be worse than drinking water standards.

3.7.1.1 Criteria for Defining Degraded Groundwater Quality Undesirable Results

For the Santa Cruz Mid-County Basin, groundwater quality degradation is unacceptable as a direct result of GSP implementation. Therefore, the degradation of groundwater quality undesirable result is:

> *Groundwater quality undesirable results in the Basin occur when as a result of groundwater pumping or managed aquifer recharge, any representative monitoring well exceeds any state drinking water standard.*

Because degraded groundwater quality undesirable results can only occur due to projects and management actions implemented to achieve sustainability in the GSP, it is important to correlate groundwater quality impacts to RMPs with quality and hydraulic gradient changes caused by projects implemented or management actions taken to achieve sustainability.

3.7.1.2 Potential Causes of Undesirable Results

Conditions that may lead to undesirable results for degraded groundwater quality include the following:

- **Changes to Basin Pumping**. If the location and rates of groundwater pumping change as a result of projects implemented or management actions taken under the GSP, these changes could alter hydraulic gradients and cause movement of poor-quality groundwater towards a supply well at concentrations that exceed state drinking water standards.
- **Groundwater Recharge.** Active recharge of water or captured runoff could modify groundwater gradients and move poor-quality groundwater towards a supply well in concentrations that exceed state drinking water standards.
- **Recharge of Poor-Quality Water.** Recharging the Basin with water that exceeds state drinking water standards may lead to an undesirable result. Since the State Water Control Board who is responsible for regulating recharge activities enforces an anti-

degradation policy, there is minimal likelihood of poor-quality water being recharged into the Basin.

3.7.1.3 Effects on Beneficial Users and Land Use

The undesirable result for degradation of groundwater quality is groundwater degradation due to actions directly resulting from GSP implementation. Degradation for this sustainability indicator only occurs if two conditions occur together: (1) there are induced changes in groundwater elevations and gradients, and (2) there is non-native poor-quality groundwater. If both these conditions occur together, the changed hydraulic gradients may move poor-quality groundwater flows towards supply wells that would not have otherwise been impacted.

Currently, apart from one location with 1,2,3-TCP and more widespread nitrate in parts of the Aromas Red Sands aquifers and saline water associated with seawater intrusion in two areas along the coast, the Basin's groundwater quality is good with no non-native poor-quality groundwater present within productive aquifers.

If undesirable results are allowed to take place, groundwater quality that does not meet state drinking water standards needs to be treated, which is a significant cost to users. For municipal suppliers, impacted wells can be taken offline until a solution is found. This will add stress on their water system by having to make up pumping in other unimpacted wells and increase the potential for further declines in groundwater levels.

This undesirable result does not apply to groundwater quality changes that occur due to other causes not in the control of the MGA. There are a number of federal, state, and local regulatory policies related to the protection of groundwater quality that will continue to be enforced by relevant federal, state, and local agencies. A summary of these regulations is included in Appendix 3-C.

3.7.2 Minimum Thresholds - Degraded Groundwater Quality

3.7.2.1 Information and Methodology Used to Establish Minimum Thresholds and Measurable Objectives

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

- Feedback about significant and unreasonable conditions from the GSP Advisory Committee and the public.
- Historical and current groundwater quality data from production and monitoring wells in the Basin.
- Federal and state drinking water quality standards.
- Depths, locations, and logged lithology of existing wells used to monitor groundwater quality.

The historical and current groundwater quality used to establish groundwater quality minimum thresholds are discussed in Section 2.2.2.4: Groundwater Quality. Based on review of historical and current groundwater quality data, federal and state drinking water standards, and irrigation water quality needs, the MGA agreed that state drinking water standards are appropriate to define degraded groundwater quality minimum thresholds.

3.7.2.2 Degraded Groundwater Quality Minimum Thresholds

Minimum thresholds are state drinking water standards for constituents of concern monitored in RMPs for degraded groundwater quality. Table 3-19 lists the constituents of concern in the Basin together with why it is of concern and their state drinking water standards that represent minimum thresholds.

Table 3-19. Constituents of Concern with Minimum Thresholds

Constituent of Concern	Reason for Concern	Minimum Threshold/ Drinking Water Standard
Total dissolved solids	basic health of basin	1,000 mg/L
Chloride	basic health of basin	250 mg/L
Iron	naturally elevated	300 µg/L
Manganese	naturally elevated	50 µg/L
Arsenic	naturally elevated	10 µg/L
Chromium (Total)	naturally elevated	50 µg/L
Chromium VI	naturally elevated	none set yet
Nitrate as Nitrogen	septic systems & agriculture	10 mg/L
Perchlorate	agriculture related	6 µg/L
Organic compounds	human introduced	various

Each project implemented as part of the GSP will have its own unique constituents of concern that will apply to monitoring and production wells included in their use permits granted by the State Water Resources Control Board Division (SWRCB) of Drinking Water (DDW). For example, projects injecting purified recycled water into the Basin are classified as groundwater replenishment reuse projects (GRRP) and permits from SWRCB DDW are required. A compendium of groundwater replenishment reuse regulations (GRRR) (Title 22, Division 4, Chapter 3) were issued by the SWRCB in 2014 (SWRCB, 2018). Specific monitoring wells and a list of constituents to monitor are part of specific permit conditions. The GRRR Section 60320.200 (c) requires at least four quarters of background groundwater quality data to characterize groundwater quality in each aquifer that will be receiving recycled water before injection of purified recycled water starts.

For Aquifer Storage & Recovery (ASR) projects, the SWRCB has adopted general waste discharge requirements for ASR projects that inject water of drinking water quality 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. Oversight of these regulations is through the Regional Water Quality Control Board (RWQCB) and obtaining coverage under the General ASR Order requires the preparation and submission of a Notice of Intent (NOI) application package. The NOI includes a technical report that, amongst other things, identifies and describes target aquifers, delineates the Areas of Hydrologic Influence, identifies all land uses within the delineated Areas of Hydrologic Influence, identifies known areas of contamination within the Areas of Hydrologic Influence, identifies project-specific constituents of concern, and groundwater degradation assessment.

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

As SGMA regulations do not require projects or management actions to improve existing groundwater quality, there are no direct actions under the GSP associated with achieving groundwater quality minimum thresholds. Therefore, there are no actions that directly influence other sustainability indicators. However, preventing migration of poor-quality groundwater may limit activities needed to achieve minimum thresholds for other sustainability indicators.

- **Chronic lowering of groundwater levels.** Degraded groundwater quality minimum thresholds could influence groundwater level minimum thresholds by limiting the types of water that can be used for recharge to raise groundwater levels in the unlikely event that levels started to approach minimum thresholds.
- **Change in groundwater storage**. Degraded groundwater quality minimum thresholds do not promote pumping in excess of the sustainable yield. Therefore, the degraded groundwater quality minimum thresholds will not result in an exceedance of the groundwater storage minimum threshold.
- **Seawater intrusion**. Degraded groundwater quality minimum thresholds could influence groundwater level proxy minimum thresholds for seawater intrusion by limiting the types of water that can be used for recharge to raise groundwater levels.
- **Subsidence**. This sustainability indicator is not applicable to this Subbasin
- **Depletion of interconnected surface waters.** Degraded groundwater quality minimum thresholds do not promote additional pumping or lower groundwater elevations adjacent to interconnected surface waters. Therefore, the degraded groundwater quality minimum thresholds will not result in a significant or unreasonable depletion of interconnected surface waters.

Minimum thresholds for all constituents of concern and RMPs are uniform throughout the Basin, thus there is no conflict between individual minimum thresholds.

3.7.2.4 Effect of Minimum Thresholds on Neighboring Basins

The anticipated effect of the degraded groundwater quality minimum thresholds on each of the neighboring basins is addressed below.

Pajaro Valley Subbasin of the Corralitos Basin (critically-overdrafted). The Pajaro Valley Subbasin is hydrogeological down- to cross-gradient of the Santa Cruz Mid-County Basin. Because of lower groundwater elevations in the Pajaro Valley Subbasin, groundwater along the coastal portion of the boundary generally flows from the Santa Cruz Mid-County Basin into the Pajaro Valley Subbasin (Figure 2-50. Groundwater Budget Subareas). The groundwater quality on either side of the Basin boundary with the Pajaro Valley Subbasin is similar; having overall good quality with the exception of elevated nitrates and salinity associated with seawater intrusion at the coast. The quality of groundwater in Pajaro Valley is documented in its Salt and Nutrient Management Plan (PVWMA, 2016). The degraded groundwater quality minimum threshold is set to maintain the good-quality groundwater in the Basin that flows into the Pajaro Valley Subbasin. Therefore, it is unlikely that the groundwater quality minimum thresholds established for the Basin will prevent the Pajaro Valley Subbasin from achieving sustainability with regards to groundwater quality.

Santa Margarita Basin (medium-priority). Limited groundwater currently flows from the Santa Cruz Mid-County Basin into the Santa Margarita Basin. Groundwater quality in the vicinity of the basins' boundary is generally good with the exception of naturally occurring elevated iron, manganese, and occasionally arsenic. No GSP projects or management actions are likely in this area as it is far from the coast where projects and management actions to raise coastal groundwater levels preventing seawater intrusion will take place. Therefore, it is unlikely that the groundwater quality minimum thresholds established for the Basin will prevent the Santa Margarita Basin from achieving sustainability.

Purisima Highlands Subbasin of the Corralitos Basin (very low-priority). The Purisima Highlands Subbasin is hydrogeological up-gradient of the Santa Cruz Mid-County Basin. Groundwater flow, historically and projected in the future, is from the Purisima Highlands Subbasin into the Santa Cruz Mid-County Basin. For this reason, there is no possibility of groundwater quality in the Basin impacting the Purisima Highlands Subbasin. Furthermore, minimum thresholds for groundwater quality are set to maintain the good groundwater quality in both basins.

3.7.2.5 Effects of Minimum Thresholds on Beneficial Users and Land Uses

In general, degraded groundwater quality minimum thresholds will not have any negative effects on beneficial users and land uses in the Basin.

Rural residential land uses and users. The degraded groundwater quality minimum thresholds benefit domestic water users in the Basin. Ensuring constituents of concern in additional drinking water supply wells remain below state drinking water standard protects groundwater for domestic use.

Agricultural land uses and users. The degraded groundwater quality minimum thresholds generally benefit agricultural water users in the Basin. Drinking water standards are more stringent than some agricultural water quality standards, with the exception of strawberries which are very sensitive to salt in irrigation water.

Urban land uses and users. The degraded groundwater quality minimum thresholds benefit the urban water users in the Basin. Preventing groundwater for drinking water supply from exceeding state drinking water standards ensures an adequate supply of groundwater for municipal use.

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

3.7.2.6 Relevant Federal, State, or Local Standards

The degraded groundwater quality minimum thresholds specifically incorporate state drinking water standards.

3.7.2.7 Method for Quantitative Measurement of Minimum Thresholds

Groundwater quality in production and monitoring well RMPs will be directly measured to determine where groundwater quality concentrations are in relation to minimum thresholds. Groundwater quality samples will be collected and tested in accordance with the monitoring plan outlined in Section 3.3.

3.7.3 Measurable Objectives - Degraded Groundwater Quality

3.7.3.1 Measurable Objectives

Measurable objectives for each RMP are the 2013 – 2017 average concentrations for each constituent of concern for each RMP. Table 3-20 summarizes the measurable objectives for each RMP. If a representative monitoring well does not have groundwater quality data during this period, the most recent concentrations are used.

3.7.3.2 Interim Milestones

Groundwater quality in the Basin is currently above minimum thresholds for all RMPs with no changes in quality expected from projects and management actions implemented to achieve sustainability. Since the measurable objectives effectively represent current conditions (average of 2013 – 2017 concentrations), interim milestones are set at the same concentration as measurable objectives shown in Table 3-20.

Table 3-20. Measurable Objectives for Degradation of Groundwater Quality

Aquifer Unit	Well Name	Total Dissolved Solids, mg/L	Chloride, mg/L	Iron, µg/L	Manganese, µg/L	Arsenic, µg/L	Chromium (Total), µg/L	Chromium VI, µg/L	Nitrate as Nitrogen, mg/L	Perchlorate, µg/L	Organic compounds
	Minimum Threshold	**1,000**	**250**	**300**	**50**	**10**	**50**	**NA**	**10**	**6**	**various**
Aromas	Altivo PW	209	18.9	41	4	0.2	26.5	22	1	0.2	ND
	CWD-10 PW	340	26	ND	ND	ND	11	ND	25	ND	ND
	SC-A1C	348	29	232	1378	ND	ND	ND	1	ND	ND
	SC-A2RC	355	41	114	11	ND	6	ND	4	ND	ND
	SC-A3A*	33,000	17,995	478	258	ND	1	ND	ND	ND	ND
	SC-A3C	390	62	251	17	ND	8	ND	7	ND	ND
	SC-A8B	321	33	20	188	ND	ND	ND	ND	ND	ND
	SC-A8C	298	35	23	8	ND	12	ND	4	ND	ND
Aromas/ Purisima F	Polo Grounds PW	265	21	18	181	0.4	ND	ND	ND	0.3	ND
	Aptos Jr. High 2 PW	301	31	28	181	0.9	0.9	ND	ND	ND	ND
	Country Club PW	311	34	18	6	0.4	7.5	6	4	ND	ND
	Bonita PW	287	27	21	4	0.4	9.3	11	3	ND	ND
	San Andreas PW	242	21	10	5	0.7	17.5	16	2	ND	ND
	Seascape PW	288	20	34	6	0.3	15	16	1	ND	ND
Purisima F	CWD-4 PW	30	30	0	0	ND	12	ND	25	ND	ND
	CWD-12 PW	310	24	0	0	ND	ND	ND	1.2	ND	ND

Aquifer Unit	Well Name	Total Dissolved Solids, mg/L	Chloride, mg/L	Iron, µg/L	Manganese, µg/L	Arsenic, µg/L	Chromium (Total), µg/L	Chromium VI, µg/L	Nitrate as Nitrogen, mg/L	Perchlorate, µg/L	Organic compounds
	Minimum Threshold	**1,000**	**250**	**300**	**50**	**10**	**50**	**NA**	**10**	**6**	**various**
	SC-A2RA*	28,947	14,259	1,019	1,608	ND	ND	ND	ND	ND	ND
	SC-A8A*	15,174	7,258	380	3,633	ND	6	ND	1	ND	ND
Purisima DEF	SC-8RD	319	28	5	9	ND	ND	ND	2	ND	ND
	SC-9RE	507	28	46	57	ND	ND	ND	ND	ND	ND
	SC-A1A	224	28	1842	57	ND	ND	ND	ND	ND	ND
	T. Hopkins PW	355	46	33	106	2.3	2.4	ND	ND	ND	ND
Purisima BC	Ledyard PW	363	35	98	12	0.2	0.2	ND	ND	ND	ND
	Madeline 2 PW	408	34	187	10	ND	ND	ND	ND	ND	ND
	Aptos Creek PW	463	40	405	412	4	ND	ND	ND	ND	ND
	SC-23A	272	20	530	12	ND	ND	ND	ND	ND	ND
	SC-8RB	433	14	87	10	ND	ND	ND	2	ND	ND
	SC-9RC	381	27	16	9	ND	ND	ND	ND	ND	ND
Purisima A	30th Ave Shallow	822	56	107	1,231	NT	NT	NT	ND	NT	NT
	Pleasure Point Shallow	288	37	106	119	NT	NT	NT	ND	NT	NT
	Estates PW	465	45	212	99	0.2	0.2	ND	ND	ND	ND
	Garnet PW	619	81	1,400	416	ND	ND	ND	ND	ND	ND

Aquifer Unit	Well Name	Total Dissolved Solids, mg/L	Chloride, mg/L	Iron, µg/L	Manganese, µg/L	Arsenic, µg/L	Chromium (Total), µg/L	Chromium VI, µg/L	Nitrate as Nitrogen, mg/L	Perchlorate, µg/L	Organic compounds
	Minimum Threshold	1,000	250	300	50	10	50	NA	10	6	various
	Tannery 2 PW	574	60	224	140	0.18	ND	ND	ND	ND	ND
	Rosedale 2 PW	496	44	715	255	0.18	ND	ND	ND	ND	ND
	Beltz #8 PW	448	51	1478	178	2	ND	ND	ND	ND	ND
	Beltz #9 PW	447	50	47	747	200	ND	ND	ND	ND	ND
	SC-3RC	461	46	63	36	ND	ND	ND	ND	ND	ND
	SC-5RA	534	55	2,778	180	ND	ND	ND	ND	ND	ND
	SC-9RA	390	15	14,424	19	ND	ND	ND	ND	ND	ND
	SC-10RA	349	29	223	522	ND	ND	ND	ND	ND	ND
	SC-22A	419	20	502	540	ND	ND	ND	ND	ND	ND
Purisima A/AA	Beltz #10 PW	621	58	836	277	2	ND	ND	ND	ND	ND
Purisima AA	SC-10RAA	231	10	93	72	ND	ND	ND	ND	ND	ND
	SC-22AAA	579	57	21	36	ND	ND	ND	ND	ND	ND
	Coffee Lane Deep	928	41	8	134	NT	NT	NT	ND	NT	NT
	Pleasure Point Deep	610	22	553	208	NT	NT	NT	ND	NT	NT
	Thurber Lane Shallow	No samples collected since 2006									
	Schwan Lake	400	91	316	113	NT	NT	NT	ND	NT	ND

Aquifer Unit	Well Name	Total Dissolved Solids, mg/L	Chloride, mg/L	Iron, µg/L	Manganese, µg/L	Arsenic, µg/L	Chromium (Total), µg/L	Chromium VI, µg/L	Nitrate as Nitrogen, mg/L	Perchlorate, µg/L	Organic compounds
	Minimum Threshold	**1,000**	**250**	**300**	**50**	**10**	**50**	**NA**	**10**	**6**	**various**
Purisima AA/Tu	O'Neill Ranch PW	402	34	651	281	0.18	ND	ND	ND	3	ND
	Beltz #12 PW	472	33	1,021	354	ND	ND	ND	ND	ND	ND
Tu	SC-18RAA	243	18	64	77	ND	ND	ND	ND	ND	ND
	Thurber Lane Deep	No samples collected since 2006									

NA = State Water Resources Control Board is still developing the maximum contaminant level for Chromium VI
ND = non-detect; NT = not tested
* well impacted by seawater intrusion therefore measurable objective is the same as the seawater intrusion measurable objective.

3.8 Land Subsidence Sustainable Management Criteria

3.8.1 Undesirable Results - Land Subsidence

The sustainability indicator is not applicable in the Santa Cruz Mid-County Basin as an indicator of groundwater sustainability and therefore no SMC are set. Section 2.2.2.5: Land Subsidence provides the evidence for subsidence's inapplicability as an indicator of groundwater sustainability. Even though the indicator is not applicable, a statement of significant and unreasonable subsidence caused by lowering of groundwater levels was discussed by the GSP Advisory Committee and is included below:

> *Any land subsidence caused by lowering of groundwater levels occurring in the basin would be considered significant and unreasonable.*

3.8.2 Minimum Thresholds - Land Subsidence

Subsidence is not applicable in the Santa Cruz Mid-County Basin as an indicator of groundwater sustainability and therefore no minimum thresholds are set.

3.8.3 Measurable Objectives - Land Subsidence

Land subsidence is not applicable in the Santa Cruz Mid-County Basin as an indicator of groundwater sustainability and therefore no measurable objectives or interim milestones are set.

3.9 Depletion of Interconnected Surface Water Sustainable Management Criteria

Development of ~~SMCs~~sustainable management criteria for depletion of interconnected surface water is based on the only shallow well and associated streamflow data available in the Basin. Figure 3-3 shows the monitoring features concentrated along the lower Soquel Creek where the closest municipal pumping center occurs to surface water. From these data and other studies, it is understood that late summer streamflow in the mainstem of Soquel Creek between its forks and the USGS streamflow gage is influenced by many other factors in addition to contributions by groundwater. Annual rainfall, flows from the upper Soquel Creek watershed outside of the Basin, temperature and evapotranspiration individually have a much greater measurable influence on streamflow than groundwater pumping. For this reach of Soquel Creek, it has been concluded over several years of monitoring that there is not a direct measurable depletion of surface water ~~flows from~~flow correlated with municipal pumping. There are, however, indications that there is an indirect influence where shallow groundwater levels mimic deeper regional groundwater level trends, which have been influenced by municipal pumping. As these observations are made from a few wells on the lower Soquel Creek only, further study as part of GSP implementation will revise the current understanding. This might necessitate a future change in the ~~SMC~~sustainable management criteria for this sustainability indicator.

3.9.1 Undesirable Results - Depletion of Interconnected Surface Water

Significant and unreasonable depletion of surface water due to groundwater extraction, in interconnected streams supporting priority species, would be undesirable if there is more depletion than experienced since the start of shallow groundwater level monitoring through 2015.

3.9.1.1 Groundwater Elevations as a Proxy for Depletion of Interconnected Surface Water Minimum Thresholds

The metric for depletion of interconnected surface water is a volume or rate of surface water depletion. This is a very difficult metric to quantify in the Basin since the depletion of interconnected surface water by municipal groundwater extraction is so small that it is not possible to directly measure through changes in streamflow~~, although these changes can potentially be seen in model results.~~. The SGMA regulations allow for the use of groundwater elevations as a proxy for volume or rate of surface water depletion. To use a groundwater elevation proxy there must be significant correlation between groundwater elevations and the sustainability indicator for which groundwater elevation measurements are to serve as a proxy. Significant correlation is difficult to prove because depletion of surface water by groundwater extractions is so small compared to the other streamflow factors mentioned in Section 3.9 above, and is not directly measurable in the streamflow. ~~However, if~~Even though changes in streamflow from groundwater extractions cannot be directly measured, those changes can be simulated by a model.

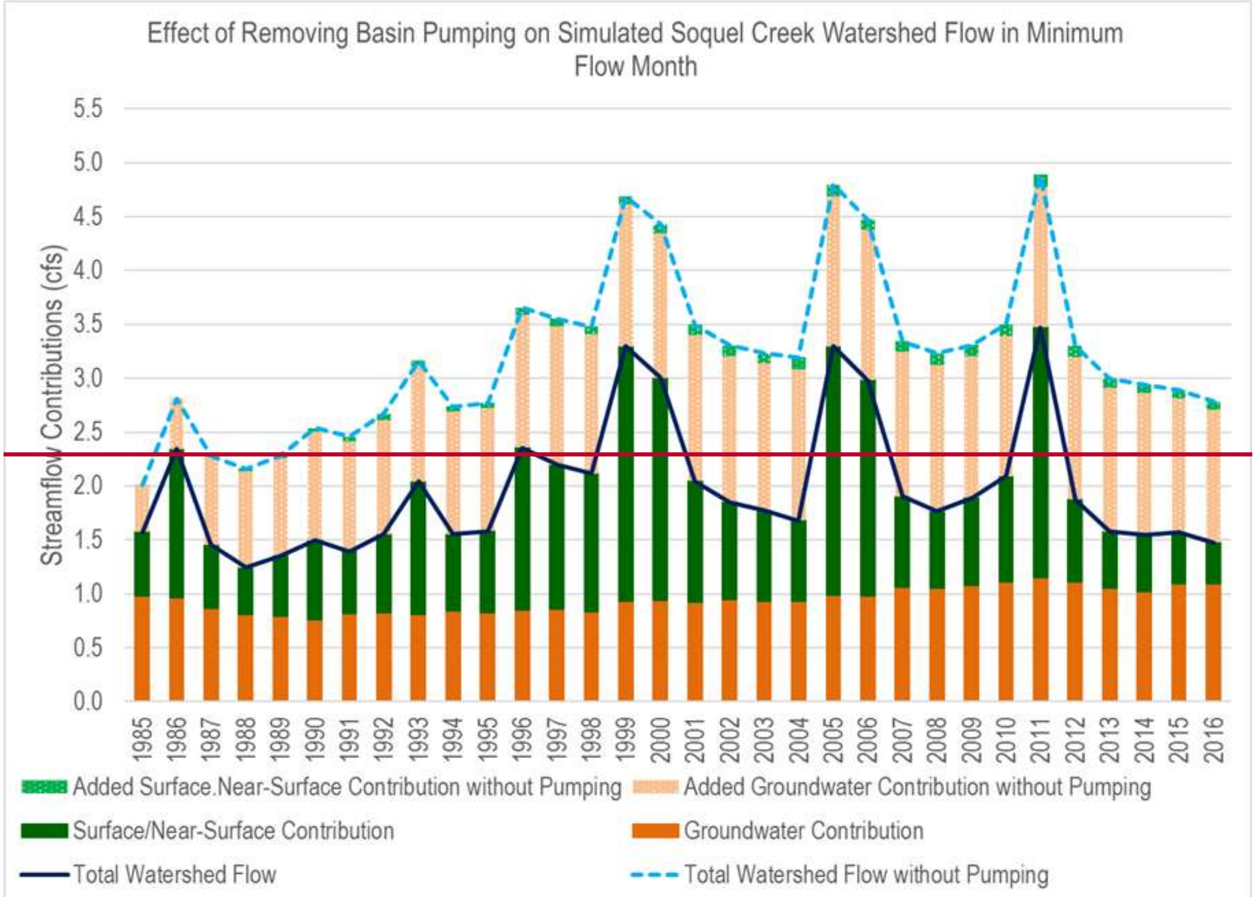
An example of the complexities of showing significant correlation can be seen at the Main Street shallow well. Data collected at the well site show precipitation and creek stage to have much greater impact on shallow groundwater levels than nearby municipal pumping. Since undesirable results are related to significant and unreasonable depletion of surface water due to groundwater extraction, future monitoring and analysis efforts need to specifically identify groundwater level changes resulting from groundwater extractions. If groundwater levels are responding to factors other than groundwater extractions, it will be challenging to determine whether minimum thresholds are not being met due to just groundwater extractions or because of these other factors.

If groundwater elevations connected to streams are kept at or above current elevations, which are close to ~~period of~~ record high levels, there will be no more ~~depletions~~depletion in surface water than experienced over the past 18 years. Essentially, the minimum thresholds seek to maintain a groundwater gradient toward the stream by controlling groundwater levels near the stream. Lower minimum thresholds than those included in this GSP may also prevent increased surface water depletion. However, as there is uncertainty around this relationship, higher minimum thresholds have initially been selected to be more conservative for habitat and sensitive species.

In an effort to show correlation between volume or rate of streamflow and groundwater level proxies for minimum thresholds, groundwater model output is used to estimate the relationship.

The groundwater model is used to estimate streamflow depletion from pumping during the 2001-2015 period, which is the period where shallow groundwater level data are available and from which minimum thresholds are derived. The streamflow depletion estimate is ~~accomplished~~derived by testing the sensitivity of simulated groundwater contribution of streamflow to pumping within the Basin. ~~This sensitivity test is outside the bounds of conditions under which the model is calibrated and adds to uncertainty of the simulated results~~It is important to acknowledge that data quantifying flows between the stream and shallow groundwater are not available for calibration so there is high uncertainty of the magnitude of simulated flows between stream and aquifer calculated by the model. Adding to the uncertainty of the estimate, this sensitivity test is outside the bounds of real world conditions (i.e., removing all Basin pumping) under which the model is calibrated to shallow groundwater elevation and streamflow data. Due to this uncertainty, the model results represent an estimate of historical streamflow depletion, but the model result value should not be used as quantitative criteria.

Figure 3-15 shows the sensitivity results of groundwater contribution to streamflow from changes in Basin pumping. This analysis is for the entire Soquel Creek watershed during minimum flow months. Removing all ~~Basin~~modeled private domestic, agricultural, and municipal pumping ~~in~~within the ~~model~~Basin, while continuing pumping outside of the Basin, results in an increased groundwater contribution to Soquel Creek of up to 1.4 cubic-feet per second (cfs) for the 2001-2015 modeled period. This ~~means that if more than approximately 1.4 cfs of surface water depletion~~ is ~~caused by groundwater extractions during low flow periods, undesirable results will occur. The~~an estimate of ~~1.4 cfs simulated over 2001-2015 is~~ the ~~minimum threshold~~relationship between the groundwater level proxies for minimum thresholds and streamflow depletion~~. To reiterate, the uncertainty of~~, but it is too uncertain to represent a value to specify as a minimum threshold. For this ~~estimate~~reason and due to the difficulty measuring streamflow depletion from pumping ~~affirm the appropriateness of using~~, it is appropriate to use a groundwater level proxy to prevent the undesirable result of increases in streamflow depletion above what occurred from 2001-2015.



The estimate of historical streamflow depletion may be revised in the future as more information becomes available as a result of more refined modeling, collection of additional monitoring data, or future testing of aquifer and stream properties. In addition, future methods or use of new information may be able to better quantify current depletion from pumping. In order to assess whether undesirable results have occurred, values estimated by different methods or new estimates should be compared to streamflow depletion for 2001-2015 estimated in a consistent manner as opposed to the 1.4 cfs estimated above.

Sections 3.3.4.1 and 3.3.4.2 discuss data gaps associated with establishment of minimum thresholds for depletion of interconnected surface water and the plan to address them.

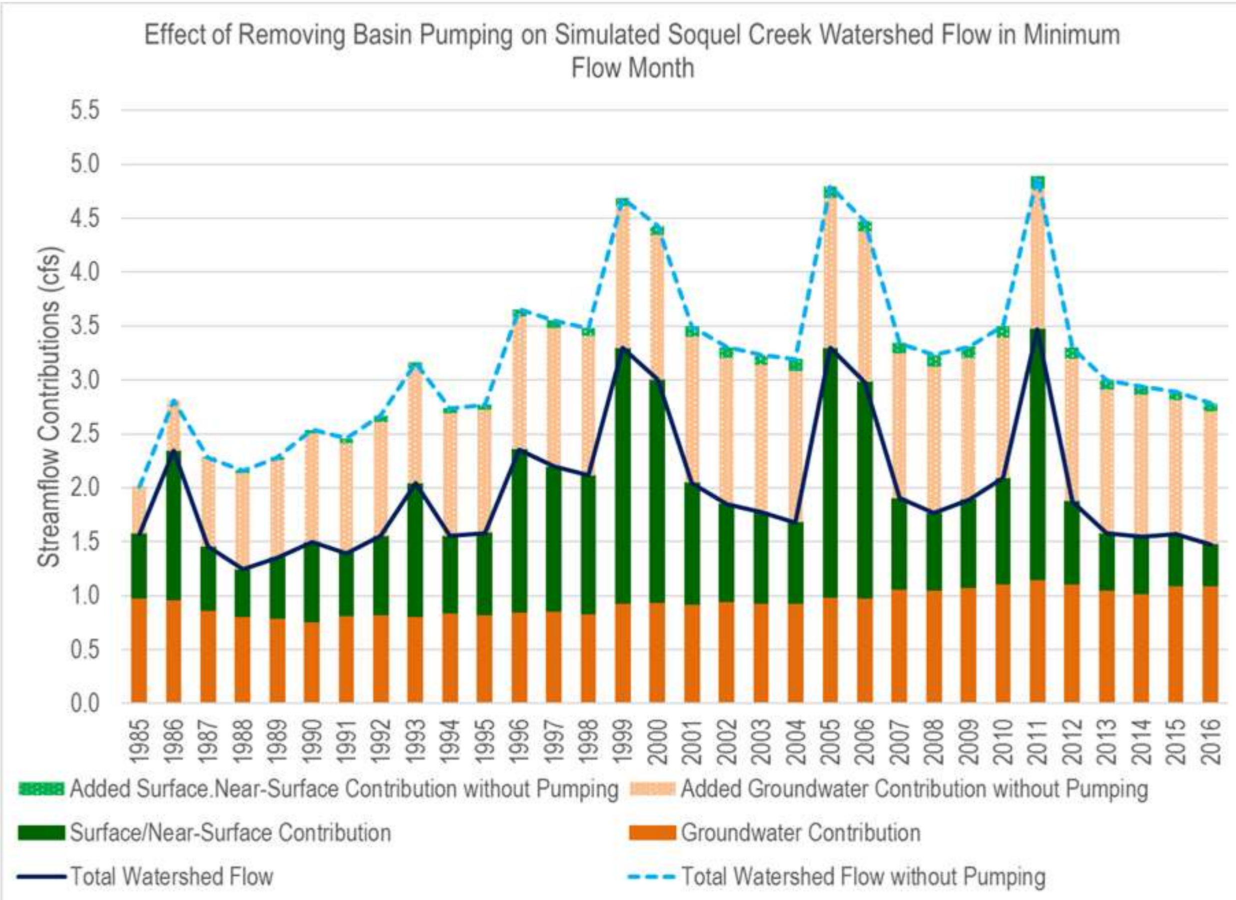


Figure 3-15. Simulated Contributions to Streamflow for Soquel Creek Watershed with and without Historical Pumping

3.9.1.2 Criteria for Defining Depletion of Interconnected Surface Water Undesirable Results

There was support in the Surface Water Working Group to move towards managing shallow groundwater so that interconnected streams have gaining flow from groundwater and are not losing flow to groundwater. Additionally, ensuring that streams do not experience more depletion than has occurred since the start of shallow groundwater level monitoring was another key condition. The Surface Water Working Group elected to take a conservative approach to defining undesirable results where any shallow RMP's groundwater elevation falling below its minimum threshold would be an undesirable result.

It should be noted that since the direct relationship between impacts on sensitive species or habitat and shallow groundwater levels has not been established, current observations do not indicate shallow well groundwater levels below minimum thresholds have a significant and unreasonable impact on sensitive species or habitat. Separate from the GSP, MGA member agencies are monitoring streams within the Basin for fish abundance and habitat conditions. Where feasible, these observations will be compared to groundwater levels and streamflow to attempt to establish a better understanding of the relationships between them.

3.9.1.3 Potential Causes of Undesirable Results

As mentioned previously, there are many factors aside from groundwater that effect streamflow in Soquel Creek and likely other streams in the Basin. Undesirable results for depletion of interconnected surface water in the context of the GSP are related purely to the extraction of groundwater from the Basin. Increased pumping~~ close to interconnected creeks and streams~~ is a potential cause of undesirable results that may manifest itself in reduced groundwater levels in both the shallow and deeper underlying Purisima aquifers. Shallow groundwater data show a relationship with long-term trends in groundwater levels of deeper underlying Purisima aquifers resulting from changes in pumping. However, deep aquifer pumping by municipal wells near Soquel Creek has not found any direct measurable impact on creek flows in studies done to date (HydroMetrics, 2015; HydroMetrics, 2016; HydroMetrics, 2017). Long-term impacts from this pumping on streamflow are being studied as part of the monitoring program outlined in Section 3,4,1,1 of this GSP.

From well permit records it is known there are ~~some~~ private domestic wells screened in shallow alluvial sediments ~~which~~and upper Purisima units that are directly connected to surface water. ~~These~~It is possible these wells may have a larger impact on shallow groundwater levels than municipal pumping from the deeper Purisima aquifers. A sensitivity run documented in the model calibration report in Appendix 2-F assumes that non-municipal pumping occurs in the stream alluvium as opposed to the underlying aquifer unit and shows there would be impacts on shallow groundwater levels of pumping the shallow aquifer as opposed to the deeper aquifer.

3.9.1.4 Effects on Beneficial Users and Land Use

Undesirable results for the depletion of interconnected surface water from groundwater extraction will ~~primarily effect~~affect aquatic systems mainly during the late summer. Under low flow conditions, there is a direct linear relationship between streamflow and the amount of suitable habitat. Reduction of flow directly reduces the amount of suitable rearing habitat for steelhead, by reducing the amount of wetted area, stream depth, flow velocity, cover, and dissolved oxygen. Reduced flow can also result in increased temperature. In extreme conditions, dewatering of channel segments eliminates the ability of the fish to move to more suitable areas and can cause outright mortality. In even more extreme conditions lowering of groundwater levels below the root zone of riparian vegetation can result in the loss of that vegetation.

3.9.2 Minimum Thresholds - Depletion of Interconnected Surface Water

Using shallow groundwater levels adjacent to streams as a proxy for surface water depletion, undesirable results will occur if the average monthly groundwater levels fall below the minimum threshold, which is established as the highest seasonal low elevation during below- average rainfall years from the start of monitoring through 2015.

3.9.2.1 Information and Methodology Used to Establish Minimum Thresholds and Measurable Objectives

Information used ~~for establishing~~to establish the depletion of interconnected surface water minimum thresholds and measurable objectives include:

- Definitions of significant and unreasonable conditions and desired groundwater elevations discussed during Surface Water Working Group and GSP Advisory Committee meetings.
- Depths, locations, and logged lithology of existing wells used to monitor shallow groundwater levels near creeks.
- Historical groundwater elevation data from shallow wells monitored by SqCWD.
- Streamflow and stream stage data collected by the USGS, SqCWD, County of Santa Cruz, and Trout Unlimited.
- Past hydrologic reports, including annual reports for SqCWD's Soquel Creek Monitoring and Adaptive Management Plan.

The approach for developing minimum thresholds for the depletion of interconnected surface water sustainability indicator is to select groundwater elevations in shallow RMPs below which significant and unreasonable ~~depletions~~depletion of surface water due to groundwater extractions would occur.

~~Since significant and unreasonable conditions have not occurred since at least 2001 when shallow groundwater level monitoring began~~Initially, minimum thresholds were proposed as the lowest groundwater level measured in the shallow wells over the period of record since those years did not appear to have significant or unreasonable conditions. The Surface Water Working Group, however, selected a more conservative minimum threshold due to uncertainty in the relationship between shallow groundwater levels and groundwater contributions to creek flow. It should be noted that there was not consensus around use of specific minimum thresholds, and that these thresholds may need to be adjusted in future updates to the GSP as better monitoring data or more refined modeling results become available.

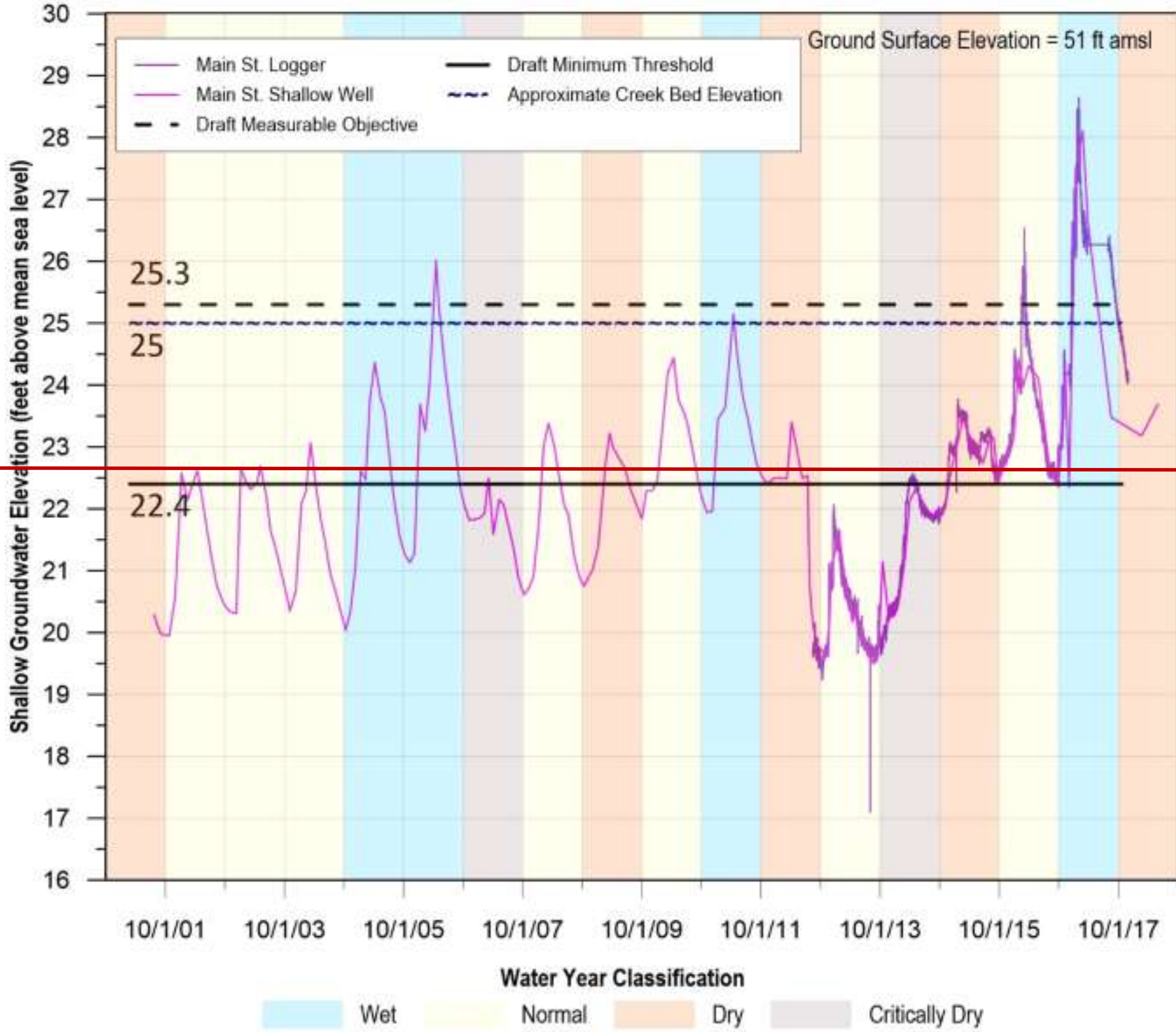
Based on Surface Water Working Group input, minimum thresholds for shallow groundwater elevations in the vicinity of interconnected streams are ~~based on~~ the highest seasonal-low groundwater elevation during below-average rainfall years, over the period from the start of shallow groundwater level monitoring through 2015. The years after 2015 are not included because 2016 was an average rainfall year and 2017 was extremely wet, which increased overall Basin shallow groundwater elevations above all previous levels.

3.9.2.2 Depletion of Interconnected Surface Water Minimum Thresholds

Table 3-21 lists the minimum thresholds for RMPs currently available to monitor depletion of interconnected surface water. Hydrographs showing historical groundwater elevation data compared to the minimum threshold are provided in Appendix 3-D. An example of one of the RMP hydrographs with its minimum threshold is shown on Figure 3-16.

Table 3-21. Minimum Thresholds and Measurable Objectives for Representative Monitoring Points for Depletion of Interconnected Surface Water

Aquifer Unit	Well Name	Minimum Threshold	Measurable Objective
		Groundwater Elevation, feet above mean sea level	
Shallow Groundwater	Balogh	29.1	30.6
	Main St. Shallow	22.4	25.3
	Wharf Road	11.9	12.1
	Nob Hill	8.6	10.3
Purisima A	SC-10RA	68	70


Ground Surface Elevation = 51 ft amsl
Main St. Logger
Main St. Shallow Well
Draft Measurable Objective
Draft Minimum Threshold
Approximate Creek Bed Elevation
25.3
25
22.4
Shallow Groundwater Elevation (feet above mean sea level)
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
10/1/01
10/1/03
10/1/05
10/1/07
10/1/09
10/1/11
10/1/13
10/1/15
10/1/17
Water Year Classification
Wet
Normal
Dry
Critically Dry

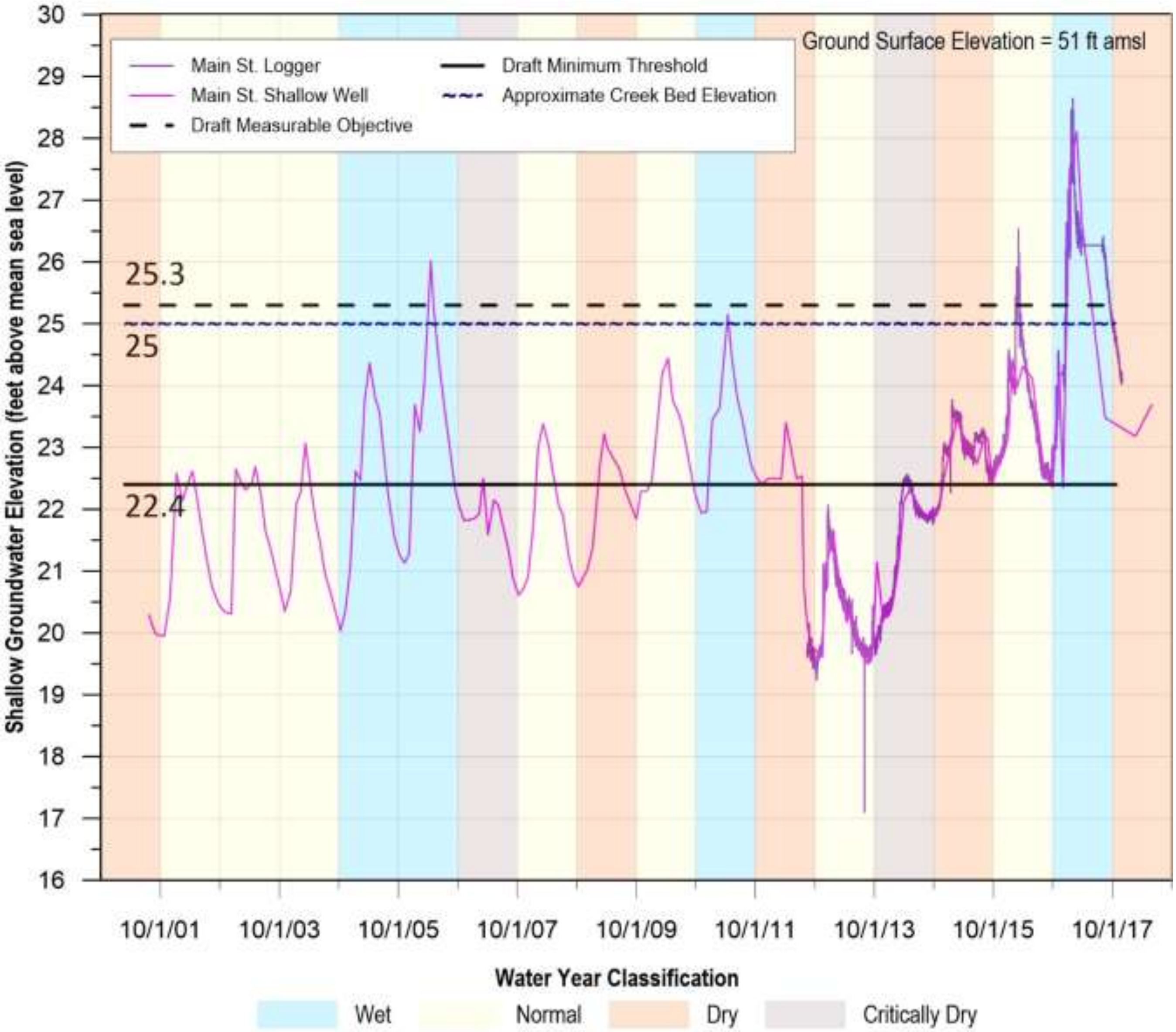


Figure 3-16. Main Street Shallow Monitoring Well Hydrograph with Minimum Threshold and Measureable Objective

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

Figure 3-11 shows proxy shallow groundwater elevations in relation to both individual minimum thresholds and other sustainability indicator minimum thresholds that use groundwater levels as a metric. Proxy groundwater elevation minimum thresholds decline in elevation downstream thereby following the surface elevation and avoiding unnatural groundwater elevations that would not be physically attainable. There are also no conflicts with other sustainability indicator minimum thresholds as upper Purisima unit RMPs for other indicators close to the creek were purposely avoided because the groundwater elevations for the depletion of interconnected surface water are much more stringent than for other indicators.

3.9.2.4 Effect of Minimum Thresholds on Neighboring Basins

None of the creeks in the Basin are upstream of any of the neighboring basins. Therefore, there will be no effects on those basins from depletion of interconnected surface water minimum thresholds.

3.9.2.5 Effects of Minimum Thresholds on Beneficial Users and Land Uses

Maintenance of interconnected surface water minimum thresholds will not have any negative effects on beneficial users and land uses in the Basin.

Rural residential and agricultural land uses and users. With the minimum thresholds for depletion of interconnected surface water being similar to shallow groundwater levels over the past few years, there will be no declines in shallow groundwater which is a general benefit for private domestic and agricultural well groundwater users. There is a possibility that when additional studies are conducted to improve understanding of this sustainability indicator, restrictions on pumping of wells close to streams may be instituted for wells screened in shallow alluvium that have a direct connection to the stream. The few existing older shallow wells could be replaced by deeper wells screened in the deeper units to minimize any direct impact on flow. There are no other anticipated effects on rural residential or agricultural land uses from the minimum thresholds.

Urban land uses and users. Where streams and creeks flow through urban areas of the Basin, there will be a small increase to no change in shallow groundwater levels. Since there are no major changes in shallow groundwater levels expected in urban areas, the depletion of interconnected surface water minimum thresholds will not negatively impact urban land uses ~~and users.~~. Urban users of groundwater, the City of Santa Cruz and SqCWD, may be negatively impacted since some of the municipal production wells that are part of their water supply are located near Soquel Creek and potential restrictions on pumping to meet minimum thresholds in RMP shallow wells may impact their ability to provide drinking water to their customers. For example, SqCWD groundwater extractions from the Purisima A and AA-units, and Tu aquifer that occur below Soquel Creek are approximately 2,000 acre-feet per year and account for about 50% of the water served to its customers.

Ecological land uses and users. The main benefit of these minimum thresholds is to protected species and GDEs in streams connected to groundwater. Meeting minimum thresholds effectively increases overall hydraulic gradients from the shallow groundwater to the streams allowing for more groundwater to flow into the stream.

3.9.2.6 Relevant Federal, State, or Local Standards

No explicit federal, state, or local standards exist for depletion of interconnected surface water. However, both state and federal endangered species provisions call for the protection and restoration of conditions necessary for steelhead and coho salmon habitat in Soquel and Aptos Creeks. ~~This would include restoring unimpaired stream flows during low flow conditions and during other critical life stages.~~

3.9.2.7 Method for Quantitative Measurement of Minimum Thresholds

Groundwater elevations in RMPs will be directly measured to determine where groundwater levels are in relation to minimum thresholds. Groundwater level monitoring will be conducted in accordance with the monitoring plan outlined in Section 3.3. All RMPs will be equipped with continuous data loggers.

In the future, as the MGA increases its understanding of groundwater and surface water interconnections along other reaches of Soquel Creek and other streams, areas where measurable depletion from groundwater extraction may be identified. Where these conditions exist, RMPs to monitor streamflow will be added to the representative monitoring network.

3.9.3 Measurable Objectives - Depletion of Interconnected Surface Water

3.9.3.1 Measurable Objectives

Measurable objectives at RMPs are groundwater elevations greater than the minimum thresholds by the range in seasonal-low shallow elevations over the period of record through 2015. In all cases, this results in groundwater elevations that are higher than the creek bed elevation at each RMP. Increased hydraulic gradient increases groundwater contributions to streamflow.

The range in seasonal-low elevations represents known change in seasonal-low elevations that can occur and includes the years when overall groundwater elevations in the Basin have increased. The range effectively provides the operational flexibility that measurable objectives are intended to provide.

3.9.3.2 Interim Milestones

Groundwater elevations as proxy interim milestones are based on model simulations of projects and management actions to prevent undesirable results related to seawater intrusion will also raise shallow groundwater levels along Soquel Creek over time. These model results are shown in Section 4 describing the expected benefits of the projects.

Interim milestones are established at each of the shallow RMPs with proxy groundwater elevations for surface water depletion. Since the groundwater elevation proxies for surface water depletion are compared to minimum groundwater elevations each year and the minimums vary from year to year due to climate, the interim milestones are based on minimum simulated groundwater elevations at the wells over five-~~-~~year periods in order to be less dependent on climate simulated for a specific year. The interim milestones for Water Years 2025, 2030, and 2035 are based on the minimum model simulated groundwater elevations over Water Years 2021-2025, Water Years 2026-2030, and 2031-2035, respectively.

Interim milestones are based on model simulation of Pure Water Soquel because the expected benefits of that project are to raise groundwater levels above or approaching measurable objectives at shallow wells, as described in Section 4.

If modeled groundwater levels for 2021- 2025 are above minimum thresholds, the minimum thresholds are used as the interim milestone because there is some uncertainty about when projects would begin. This GSP sets as an interim milestone the elimination of undesirable results by 2025 at locations where model results show it is achievable with project implementation. If modeled groundwater levels in 2030 and 2035 are above measurable objectives, the measurable objectives are used as the interim milestones. Table 3-22 summarizes the interim milestone for each RMP.

Table 3-22. Interim Milestones for ~~Deletion~~Depletion of Interconnected Surface Water Groundwater Elevation Proxies

Representative Monitoring Point	Minimum Threshold (feet mean seal level)	Measurable Objective (feet mean sea level)	Interim Milestone 2025 (feet mean sea level)	Interim Milestone 2030 (feet mean sea level)	Interim Milestone 2035 (feet mean sea level)
Balogh	29.1	30.6	29.1	30.6	30.6
Main St. Shallow	22.4	25.3	20.7	22.9	23.2
Wharf Road	11.9	12.1	11.3	12.1	12.1
Nob Hill	8.6	10.3	7.3	9.5	9.9
SC-10RA	68	70	68	70	70

REFERENCES

All Groundwater Sustainability Plan references were moved to Section 6

APPENDICES

All Santa Cruz Mid-County Groundwater Sustainability Plan Appendices are found on the MGA website as a separate Appendices document.

GSP Section 4 Contents

Tables

Figures

4 PROJECTS AND MANAGEMENT ACTIONS

DWR regulations require each GSP to include a description of projects and management actions necessary to achieve the basin sustainability goal. This must include projects and management actions to respond to changing conditions in the Basin.

In November 2018, the MGA Board discussed the MGA's role in implementing projects and management actions and agreed that the most efficient approach to project and management action implementation was to have the MGA member agencies perform this function. A major rationale for this decision was the long-standing engagement of MGA member agencies in groundwater management and water supply reliability planning work. In particular, both the City of Santa Cruz Water Department (SCWD) and the Soquel Creek Water District (SqCWD) have evaluated a number of supplemental supply options over the last five years, and in several cases work has proceeded far enough to make it significantly more efficient for these agencies to continue their efforts rather than switching project implementation actions to the MGA.

Projects and management actions discussed in this section ~~have been~~are in the process of being developed to address sustainability goals, measurable objectives, and undesirable results identified for the Basin in Section 3. The primary applicable undesirable result that must be avoided is seawater intrusion. In addition, surface water depletions and impacts to groundwater dependent ecosystems (GDEs) ~~was~~were separately evaluated. The GSP's approach to address seawater intrusion is anticipated to provide ancillary benefits to interconnected surface waters and GDEs. Because the SCWD water system relies heavily on surface water, an additional focus of several of the management actions discussed in this section is creation of a supplemental drought supply to improve the reliability of the Santa Cruz water supply. SCWD is pursuing several alternative approaches for storing available wet season surface water flows in regional aquifers for eventual use in augmenting supply during dry conditions. SCWD acknowledges that the operation of its existing groundwater system in the Basin and the design and operation of any new facilities for groundwater storage and recovery would need to function in a manner that supports Basin sustainability.

Each MGA member agency will manage the permitting and other specific implementation oversite for its own projects. Inclusion in this GSP does not forego any obligations under local, state, or federal regulatory programs. While the MGA does have an obligation to oversee progress towards groundwater sustainability, it is not the primary regulator of land use, water quality, or environmental project compliance. It is the responsibility of the implementing agency to ensure that it is working with outside regulatory agencies to keep its projects and management actions in compliance with all applicable laws. That said, the MGA may choose to collaborate with regulatory agencies on specific overlapping interests such as water quality monitoring and oversight of projects developed within the Basin.

Section 4 is presented in three groups to provide the clearest description of how and when projects and management actions will be taken to reach sustainability.

Baseline Projects and Management Actions (Group 1)

Activities in Group 1 are considered existing commitments by ~~the~~ MGA member agencies. These include ~~project~~projects and management actions that are currently being implemented and are expected to continue to be implemented, as needed, to assist in achieving the sustainability goal throughout the GSP implementation period. In the groundwater modeling scenarios ~~of projects and management actions~~, the Group 1 projects and management actions are ~~assumed to be part of the~~incorporated into baseline conditions. As shown in modeling results of the baseline condition for seawater intrusion presented later in this section, Group 1 projects and management actions, by themselves, are not sufficient to ~~result in achieving~~achieve groundwater sustainability (Table 4-1).

Projects and Management Actions Evaluated Against the Sustainable Management Criteria (Group 2)

Activities in Group 2 have been developed and thoroughly vetted by ~~the~~ MGA member agencies and are planned for near-term implementation by ~~those~~individual member agencies. The MGA used an integrated groundwater/surface water model (~~MGA Model~~model) to evaluate the Group 2 projects against the Sustainable Management Criteria to determine if they contribute to achieving sustainability. The expected benefits of ~~the~~ each of the projects presented in Section 4.2 as informed by the groundwater modeling simulations~~,~~ and documented in the model simulations report (Appendix 2-I), show that the implementation of a combination of these projects will be sufficient to achieve and maintain sustainability even under climate change scenarios. Therefore, ongoing implementation of Group 1 activities, coupled with the implementation of Group 2 ~~Projects~~projects and ~~Management Actions~~management actions, are required to reach sustainability ~~and~~to comply with SGMA (Table 4-1).

Identified Projects and Management Actions That May Be Evaluated in the Future (Group 3)

The MGA's analysis indicates that the ongoing implementation of Group 1 and the added implementation of Group 2 projects and management actions will bring the Basin into sustainability. However, if one of the projects and management actions required for sustainability in Group 2 either fails to ~~take places~~be implemented or does not have the expected results, further actions will be required to achieve sustainability. In that case, appropriate projects and/or management actions will be chosen from those listed under Group 3. As work on supplemental water supply and resource management efforts is ongoing, it may be the case that additional projects will be identified and added to the list in future GSP updates (Table 4-2).

The specific Group 3 activity selected ~~will~~would be based on factors such as size of the water shortage, speed of implementation, scale of regulatory and political hurdles, and the metrics of success achieved in basin sustainability. The level of detail provided for Group 3 is significantly less detailed than Groups 1 and 2 because the activities listed are not currently planned for implementation.

Table 4-1. Projects and Management Actions (Groups 1 and 2)

Description	Agency	Category	Status	Anticipated Timeframe[1]
Group 1 – Baseline Projects and Management Actions				
Water Conservation and Demand Management	All	Mgmt. Actions	Ongoing	2020-2070 adaptive management
Installation and Redistribution of Municipal Groundwater Pumping	SCWD; SqCWD	Mgmt. Actions & Projects	Ongoing	2020-2070 adaptive management

Description	Agency	Category	Status	Anticipated ~~Timeframe[1]~~Timeframe[2]
Group 2 – Projects and Management Actions Planned to Reach Sustainability				
Pure Water Soquel	SqCWD	Project	Permitting	2020-2022 development 2023-2070 operations & adaptive management
Aquifer Storage and Recovery (ASR)	SCWD	Project	Pilot Testing	2021-2027 development 2021-2070 operations & adaptive management
Water Transfers / In Lieu Groundwater Recharge	SCWD ; SqCWD	Project	Pilot Testing	2020-2025 development 2025-2070 operations & adaptive management
Distributed Storm Water Managed Aquifer Recharge (DSWMAR)	SCCo; SqCWD	Project	Few current facilities; ongoing assessment	Timing is project specific; ongoing operations & adaptive management

1. SGMA's required planning implementation horizon is 50 years.
2. Phased projects may include overlapping periods of development and operations. Adaptive management is ongoing during implementation.

Table 4-2. Identified Potential Future Projects and Management Actions (Group 3)

Group 3 - Identified Projects and Management Actions That May Be Evaluated in the Future		
Description	**Category**	**Comment**
Recycled Water – Groundwater Replenishment and Reuse (GRR)	Project	A new or expanded centralized GRR project could be developed by SCWD, the Soquel Creek Water District or as a joint project of these agencies. SCWD Recycled Water Facilities Planning Study (2018) identifies a GRR project as a future (mid-term) possibility requiring additional studies to confirm feasibility to meet drought shortfall needs and/or support basin sustainability goals in either or both the Mid-County and Santa Margarita groundwater basins. In addition, the Soquel Creek Water District Feasibility Study (2017) and the Pure Water Soquel EIR (2018) also identify expansion opportunities, if needed. Future need anticipated to be assessed as GSP Implementation proceeds.
Recycled Water – Surface Water (Reservoir) Water Augmentation	Project	Reservoir Augmentation would use advanced treated Santa Cruz WWTF effluent, to replenish Santa Cruz's Loch Lomond Reservoir. SCWD evaluated this option in its 2018 Recycled Water Facilities Planning Study and did not identify it as a preferred alternative. Conceptually this approach could serve to augment supply to the Basin as well as improve the reliability of Santa Cruz's water supply. Future need anticipated to be assessed as GSP Implementation proceeds.
Recycled Water – Direct Potable Reuse	Project	Current state regulations do not allow the introduction of advanced treated recycled water directly into a public water system. State drinking water and public health regulatory agencies continue to assess the possible framework for the regulation of potable reuse projects. As state regulations develop, the feasibility and potential future need for this option will continue to be evaluated.
Groundwater Pumping Curtailment and/or Restrictions	Mgmt. Action	Potential policy to curtail and/or restrict groundwater extractions from areas at high risk of seawater intrusion or surface water depletions would be considered if the planned Projects and Management Actions are insufficient to reach and/or maintain sustainability and one or more sustainability indicator is likely to dip below the minimum threshold by 2040.
Local Desalination	Project	Previously considered by SCWD in partnership with SqCWD. This is no longer being actively pursued, but given the Basin's proximity to the Pacific Ocean this option will continue to be a potential option.
Regional Desalination	Project	DeepWater Desal LLC., is a private company seeking to establish a regional supply facility in Moss Landing. It would produce an estimated 25,000 acre-fee per year (22 million gallons per day) of treated desalinated water available for purchase by local agencies.

4.1 Baseline Projects and Management Actions (Group 1)

4.1.1 Water Conservation and Demand Management

As described in Section 2, the MGA's member water agencies have a full range of water conservation programs in place and have actively and successfully implemented policies and programs promoting and incentivizing water conservation and efficient water use. SCWD's and SqCWD's residential water usage (gallons capita per day) are among the lowest in the state. All MGA member agencies participate in the Water Conservation Coalition of Santa Cruz County (watersavingtips.org). The Coalition serves as a regional information source for county-wide water reduction measures, rebates, and resources.

Soquel Creek Water District's Water Demand Offset (WDO) program is a targeted water conservation program developed to mitigate the water demand of new and expanded development in Soquel Creek Water District's service area. This management action originally required new development to be "net neutral" to ensure that each new project contributed toward conservation projects proportional to their expected new water demand. Development project applicants have met this requirement through direct replacement of inefficient water fixtures for SqCWD customers or through payment into a SqCWD conservation fund that supports similar demand management projects and programs. Since 2013, WDO requires new development to offset 200% of their project's expected water demand so that new development will actually reduce water use in the Basin. Participation in this program is required to be eligible for SqCWD will-serve approval and installation of the new water service. Will-serve letters are also required to obtain building permits from land use jurisdictions where the new development is located.

~~SCWD~~The City of Santa Cruz Water Department (SCWD) uses fees paid by developers to support a robust rebate program that, along with its "retrofit on resale" program has resulted in a significant reduction in water demand from current customers and a long term demand forecast that is flat rather than increasing. The County of Santa Cruz (County), in order to promote more efficient water use in rural areas, adopted code requirements that all small water systems meter and report monthly water production beginning in October 2015. Additionally, by October 2017, all ~~community~~small water systems with 15 or more connections were required to install individual meters on each connection to be able to track individual water use and potentially excessive usage.

4.1.1.1 Project Implementation Discussion

Water Conservation and Demand Management strategies use a variety of management actions to reduce water demand that then results in reduced groundwater pumping. Depending on where pumping reductions occur, groundwater levels near the coast may increase, which results in reducing the threat of seawater intrusion, and surface water depletions may also be reduced, which supports maintaining or enhancing groundwater levels where groundwater dependent ecosystems exist. These management actions are implemented, planned to continue, and will continue to evolve with technological advances and future legislative requirements to reduce regional water demand.

Management actions to reduce water demand were initially implemented in the 1990s and there is no plan to end these successful water use reduction strategies. Benefits are monitored with the Basin-wide groundwater monitoring network by comparing groundwater levels and groundwater quality against past observations. Costs of conservation and demand management programs are built into MGA member agency ongoing budgetary commitments and are not anticipated to be passed on to the MGA.

As water conservation and demand management projects and management actions within the Basin continue to evolve over time~~ they~~, any significant changes will be publicly noticed ~~and permitted~~ as necessary by MGA member's governing bodies. Existing California state law gives water districts the authority to implement water conservation programs. Local land use jurisdictions have police powers to develop similar permitting programs to conserve water. The Sustainable Groundwater Management Act of 2014 grants the MGA legal authority to pass regulations necessary to achieve sustainability. MGA member agencies are committed to successful implementation of their conservation programs and have among the lowest water consumption rates in California.

4.1.2 Planning and Redistribution of Municipal Groundwater Pumping

Municipal water agencies serve the majority of the population within the Basin. Although surface water from the Santa Cruz water system serves some customers in the Basin, all municipal groundwater supplies that are produced within the Basin come solely from groundwater pumped by MGA member agencies within their respective service areas.

Prior to SGMA, regional groundwater management planning identified the need to move groundwater production further from the coast to reduce the threat of seawater intrusion related to pumping impacts from municipal wells. MGA member agencies developed and have already begun implementing plans to move municipal groundwater production further inland to reduce these pumping impacts. The SCWD has completed its planning and well development project with the installation of its Beltz 12 well and supporting infrastructure at its Research Park facility~~.~~ (SCWD 2012). Soquel Creek Water District's Well Master Plan (ESA 2010), identified moving pumping further inland by developing four new groundwater production well locations and the conversion of an existing irrigation well at a fifth location. The Polo Grounds irrigation well conversion in Aptos was completed in 2012. Two of the four new well sites, O'Neill Ranch in Soquel (completed in 2015) and Granite Way in Aptos (anticipated completion in 2019) have been constructed. Two remaining production well sites at Cunnison Lane in Soquel and Austrian Way in Aptos have yet to be constructed.

MGA member agencies have also adjusted the timing, and pumping amounts from existing wells to redistribute pumping both vertically and horizontally within Basin aquifers. These efforts have been used to achieve more uniform drawdown of the Basin, to minimize localized pumping depressions, and reduce the Basin's susceptibility to seawater intrusion. In addition, in 2015 the City of Santa Cruz and Soquel Creek Water District signed the Cooperative Monitoring and Adaptive Groundwater Management Agreement to more conservatively manage groundwater pumping in the shared aquifer units of the Basin. Redistribution of municipal pumping is designed to be paired with projects (such as Pure Water Soquel ~~and~~, In-Lieu Recharge, and ASR) as a way to rest and reduce pumping of coastal wells and be consistent with Basin sustainability goals to protect the groundwater supply against seawater intrusion; prevent overdraft within the Basin, and resolve problems resulting from prior overdraft; support reliable groundwater supply and quality to promote public health and welfare; maintain or enhance groundwater levels where groundwater dependent ecosystems exist; and maintain or enhance groundwater contributions to streamflow.

4.1.2.1 Implementation Discussion

Planning, municipal well construction at locations further from the coast, and redistribution of municipal groundwater pumping is used to reduce the ongoing threat of seawater intrusion within the Basin. These projects and management actions are implemented, planned to continue, and will continue to evolve as we learn more about Basin groundwater management and climate change. Additional well construction within the Basin will be publicly noticed and permitted as necessary by MGA member agencies. Redistribution of municipal groundwater pumping was initially implemented in 1995 and has improved with careful expansion of municipal production wells further from the coast. There is no plan to end these successful water production strategies which have made significant progress to reduce groundwater pumping depressions and improve groundwater levels at the coast. Benefits are monitored using municipal production well meters, the Basin-wide groundwater monitoring network, and data management systems to compare production impacts with groundwater levels and groundwater quality over time.

Redistribution of groundwater pumping is direct management of groundwater extraction. While these management actions don't reduce overall Basin groundwater production, they do allow municipal groundwater production to consider and respond to changes in groundwater levels across the portions of the Basin within municipal service areas. These groundwater production management strategies do not require an additional water source. Costs of planning, new municipal well construction, and redistribution of municipal groundwater pumping are or are anticipated to be built into the City of Santa Cruz's, Central Water District's, and Soquel Creek Water District's operational budgetary commitments that would be paid for through water rates and/or grant funds. These costs are not anticipated to be passed on to the MGA. Redistributed groundwater pumping has contributed to increased Basin groundwater levels and supports the additional GSP elements outlined in section 2.1.4 and the Basin's sustainability goals to protect groundwater supplies against seawater intrusion and maintain or enhance groundwater levels where groundwater dependent ecosystems exist.

4.2 Projects and Management Actions Planned to Reach Sustainability (Group 2)

4.2.1 Pure Water Soquel

4.2.1.1 Project Description

Pure Water Soquel (PWS) would provide advanced water purification to existing secondary-treated wastewater that is currently disposed of in the Monterey Bay National Marine Sanctuary. The project would replenish the Basin with approximately 1,500 acre-feet per year of advanced purified water that meets or exceeds drinking water standards into aquifers within the Basin. Replenishment is currently planned at three locations in the central portion of Soquel Creek Water District's service area to mix with native groundwater. Purified water would contribute to the restoration of the groundwater basin, provide a barrier against seawater intrusion, and provide a drought proof and sustainable source of water supply. The conveyance infrastructure of PWS is being sized to accommodate the potential for future expansion of the Project's treatment system (if desired at a later time) and to convey up to approximately 3,000 AFY of purified water (ESA 2018).

4.2.1.2 Measurable Objective

Use of advanced purified water made from highly treated wastewater as a source has a proven track record and is already widely used in California and elsewhere throughout the world as a water supply. ~~MGA~~ Model results indicate that consistent and ongoing ~~injection~~recharge of advanced purified water into the groundwater basin would create a barrier against further seawater intrusion and could be leveraged to shift groundwater production to improve sustainability throughout the entire Basin.

4.2.1.3 Circumstances for Implementation

Groundwater management policies that predate this GSP established protective groundwater elevations at 13 coastal monitoring well locations necessary to prevent seawater intrusion. Protective elevations have been included in this GSP as a sustainability indicator for seawater intrusion. Currently, protective elevations have been met at eight of the 13 coastal monitoring locations, which is an increase since these wells were installed in the mid-1980s. Projects identified by the MGA and its member agencies to improve ~~basin~~Basin sustainability will be implemented ~~until~~to achieve and maintain protective elevations ~~are achieved~~ at all 13 well locations. Pure Water Soquel is included in Group 2 projects, along with Aquifer Storage and Recovery (ASR), Water ~~transfer~~Transfer/In Lieu Groundwater Recharge, and Distributed Storm Water Managed Aquifer Recharge as projects planned for near-term implementation by MGA partner agencies to reach Basin sustainability.

4.2.1.4 Public Noticing

PWS was developed from public input received during Soquel Creek Water District's Community Water Plan (CWP) to develop a timely solution to seawater intrusion. The PWS project was developed by staff and refined during Soquel Creek Water District's publicly noticed

Board of Director's meetings as well as community meetings, workshops during the development of the CWP and the evaluation of the ~~Project~~PWS project. The project is also discussed at publicly noticed meetings of Soquel Creek Water District's Water Resources Management and Infrastructure Committee. CEQA environmental review of PWS was first publicly noticed through the State Clearinghouse in November 2016 and review completed in December 2018. Applicable PWS project permits will be publicly noticed for meetings of the issuing agencies, as required.

4.2.1.5 Overdraft Mitigation and Management Actions

The Santa Cruz Mid-County Basin (Basin 3-001 (DWR 2016)) is identified by the State of California as ~~critically~~a high priority basin in critical overdraft (DWR 2019). Groundwater levels have recovered from critically low levels identified in the 1980s. However, seawater intrusion exists in several Basin locations and remains a significant threat to regional groundwater supplies as groundwater levels at five of the Basin's 13 key coastal monitoring wells remain below protective elevations. In 2018, groundwater levels declined between 0.4 feet to 4.0 feet at various Basin locations from all-time highs recorded in Water Year 2017. As the first line of defense along the coastline, the replenishment with advanced purified water will increase Basin groundwater levels and create a fresh water barrier to reduce the threat of further seawater intrusion into the Basin.

4.2.1.6 Permitting and Regulatory Process

Soquel Creek Water District completed the California Environmental Quality Act (CEQA) review for Pure Water Soquel in December 2018 and is undergoing the permitting phase of project implementation. Implementation could require several permits for construction and operations as described in the Pure Water Soquel ~~EIR (2018).~~Environmental Impact Report (EIR) (ESA 2018).

4.2.1.7 Time-table for Implementation

The Pure Water Soquel ~~Environmental Impact Report (~~EIR~~)~~ and project were approved by the lead agency in December 2018. The project is currently in the design and permitting phase and construction is anticipated to be complete in late 2022 with the project to come online in early 2023.

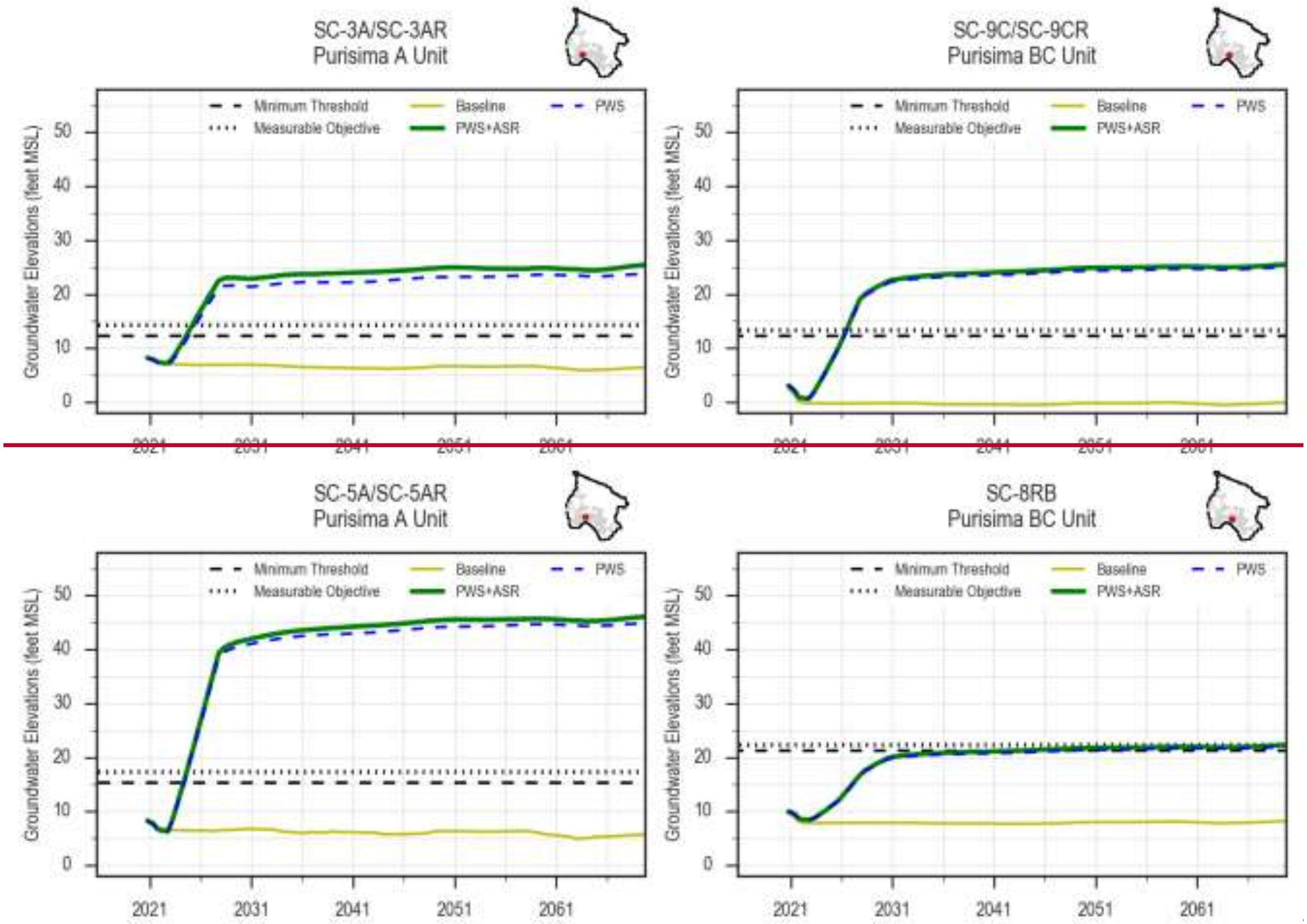
4.2.1.8 Expected Benefits

The Pure Water Soquel project is designed to replenish the Basin with approximately 1,500 acre-feet per year of advanced purified water into three locations in the Basin to increase groundwater elevations and create a seawater intrusion barrier~~.~~ (ESA 2018). The tertiary treatment portion of the project is also designed to produce an additional 300 acre-feet per year tertiary treated wastewater supply for reuse by the City of Santa Cruz suitable for non-potable landscape and other uses. PWS also supports in-lieu recharge in aquifer units and areas where water is not injected. ~~This~~In the simulation of PWS for the GSP, in-lieu recharge is facilitated by increasing pumping from the Purisima A and BC aquifer units that benefit from PWS injection to allow for pumping reductions in the Tu, Purisima F, and Aromas Red Sands aquifer units. Therefore, project benefits are expected to raise groundwater elevations at all of Soquel Creek Water District's coastal monitoring wells to prevent seawater intrusion and improve groundwater levels at shallow wells along Soquel Creek to prevent additional surface water depletions. Expected benefits will be evaluated using the existing monitoring well network and data management systems to compare groundwater levels over time.

A simulation of the PWS project under projected future climate conditions using the ~~MGA Model~~model (Appendix 2-I) demonstrates expected Basin sustainability benefits ~~include~~including raising average groundwater levels at coastal monitoring wells throughout Soquel Creek Water District's service area to reduce the risk of seawater intrusion (Figure 4-1 and Figure 4-2). The figures below show running five-year averages of simulated groundwater levels at representative monitoring points for seawater intrusion (section 3.3.3.3) in the SqCWD's service area. The simulated groundwater levels are compared to groundwater level proxies (section 3.6) for minimum thresholds (black dots) and measurable objectives (black dashes) adjusted for sea level rise.[1]

Without the project (yellow line labeled Baseline), five-year averages of simulated groundwater levels are projected to be below the minimum threshold in the aquifer units pumped by Soquel Creek Water District. In the Purisima A and BC aquifer units where PWS injection occurs, groundwater levels are projected to rise to or above measurable objectives (blue dashes labeled PWS) even as pumping is increased from these aquifer units. In the Purisima F and Aromas Red Sands aquifer units where pumping is reduced under PWS, groundwater levels (blue dashes labeled PWS overlying green line labeled PWS+ASR) are projected to rise above or near measurable objectives by 2040 and to be maintained above minimum thresholds thereafter so that undesirable results for seawater intrusion do not occur. Figure 4-5 in Section 4.2.3.8 below shows how pumping reduction from the AA and Tu units under PWS (blue dashes) also is projected to raise groundwater levels above minimum thresholds to prevent undesirable results for seawater intrusion.

[1] Projected sea level rise of 2.3 feet is added to the groundwater level proxies (see Section 3.6.2.1.1).


SC-3A/SC-3AR
Purisima A Unit
SC-9C/SC-9CR
Purisima BC Unit
SC-5A/SC-5AR
Purisima A Unit
SC-8RB
Purisima BC Unit
Minimum Threshold
Measurable Objective
Baseline
PWS+ASR
PWS
Groundwater Elevations (feet MSL)
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10
20
30
40
50
2021
2031
2041
2051
2061

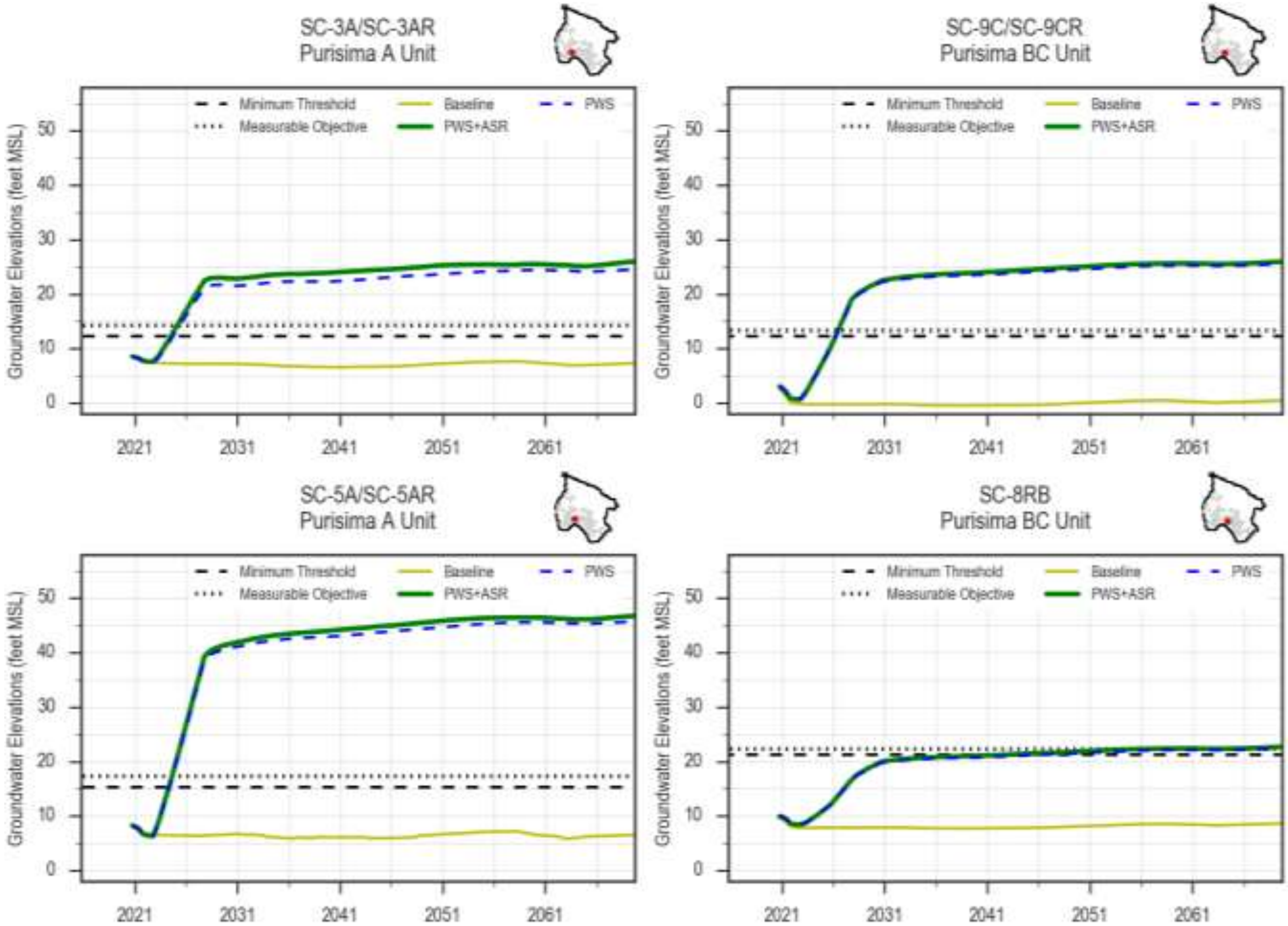
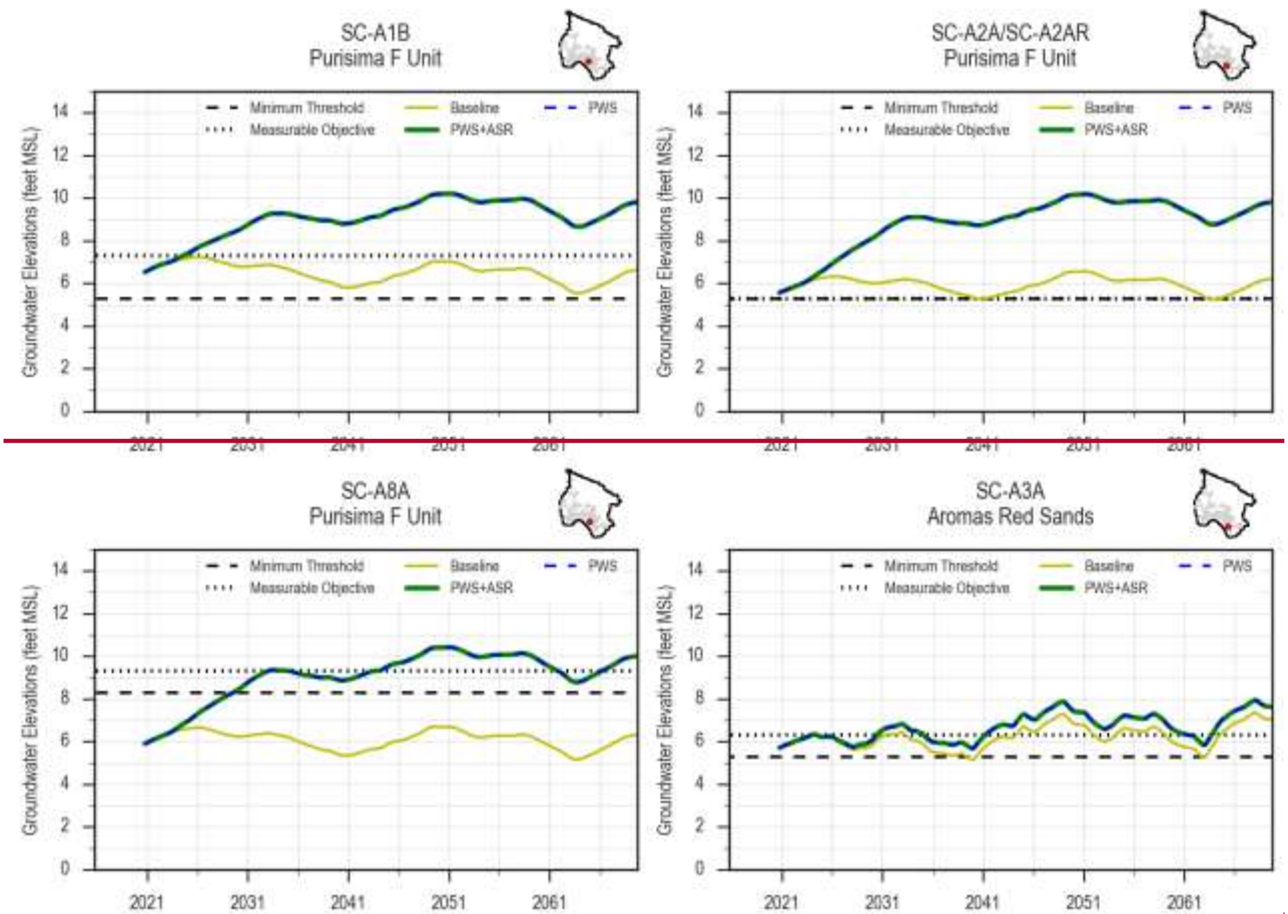


Figure 4-1. Five Year Averages of Model Simulated Groundwater Elevations at Coastal Monitoring Wells in Purisima A and BC Units


SC-A1B
Purisima F Unit
Minimum Threshold
Measurable Objective
Baseline
PWS+ASR
PWS
Groundwater Elevations (feet MSL)
SC-A2A/SC-A2AR
Purisima F Unit
SC-A8A
Purisima F Unit
SC-A3A
Aromas Red Sands
2021
2031
2041
2051
2061

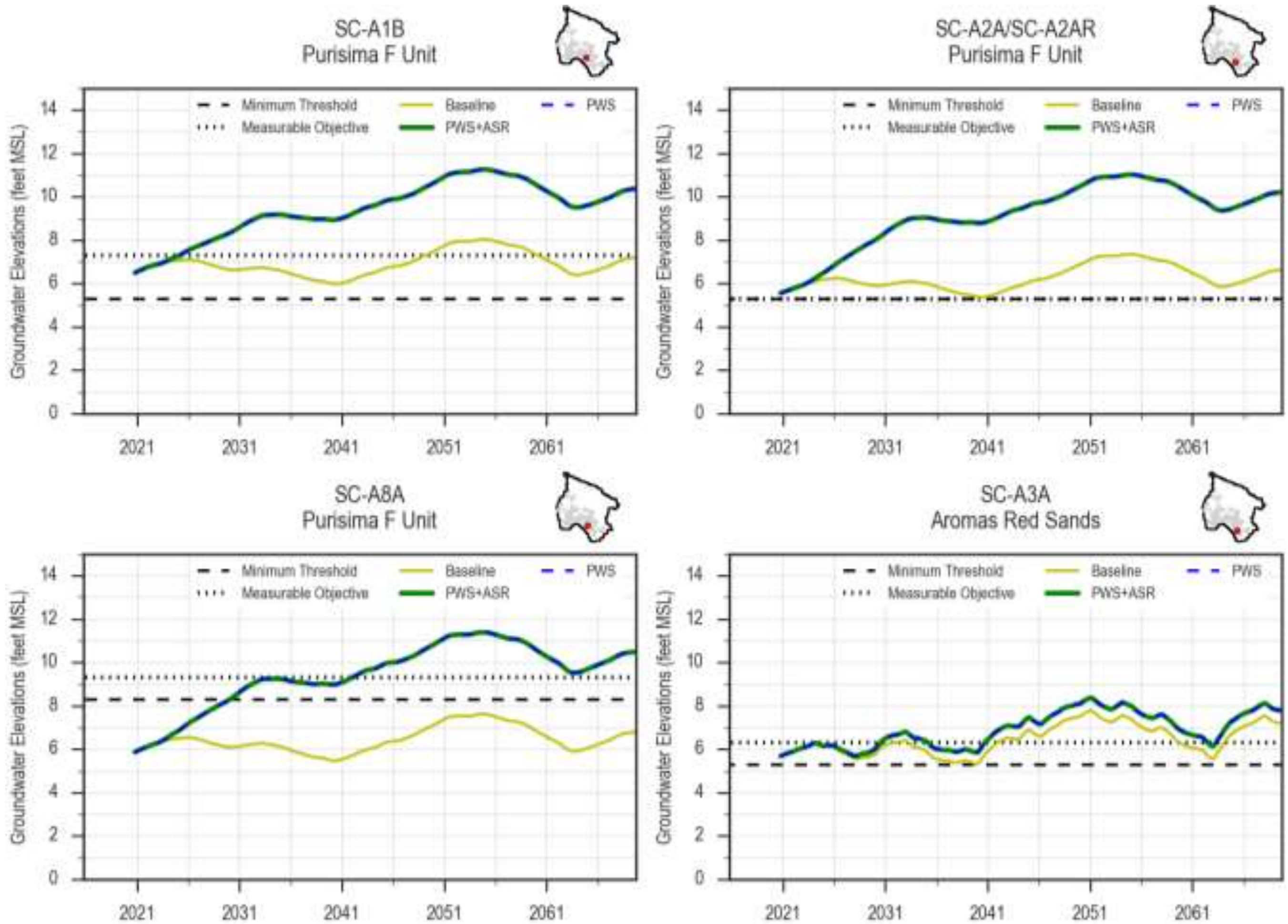
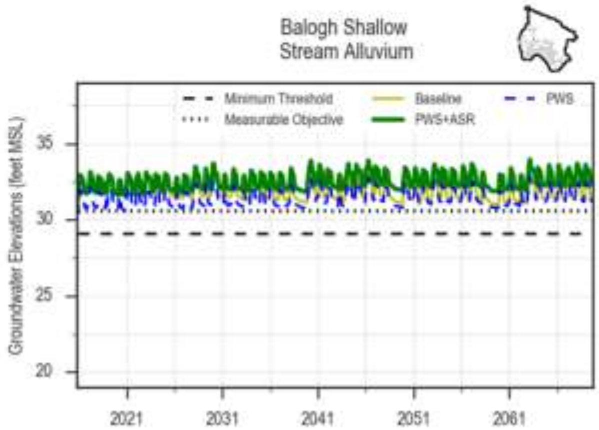
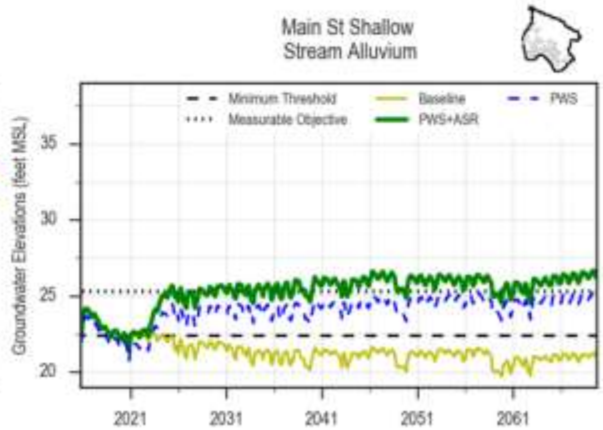


Figure 4-2. Five Year Averages of Model Simulated Groundwater Elevations at Coastal Monitoring Wells in Purisima F and Aromas Red Sands Units

Pure Water Soquel replenishment into the Purisima A unit also is expected to benefit the streamflow depletions indicator by raising shallow groundwater levels along Soquel Creek. Without the project (yellow line labeled Baseline), simulated monthly groundwater levels are projected to be below the minimum threshold at most of the shallow wells. With the PWS project, shallow groundwater levels (blue dashes labeled PWS) are projected to rise to measurable objectives and be maintained above minimum thresholds to prevent undesirable results for surface water depletions (Figure 4-3).


Balogh Shallow
Stream Alluvium
Minimum Threshold
Measurable Objective
Baseline
PWS+ASR
PWS
Groundwater Elevations (feet MSL)
35
30
25
20
2021
2031
2041
2051
2061


Main St Shallow
Stream Alluvium
Minimum Threshold
Measurable Objective
Baseline
PWS+ASR
PWS
Groundwater Elevations (feet MSL)
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2021
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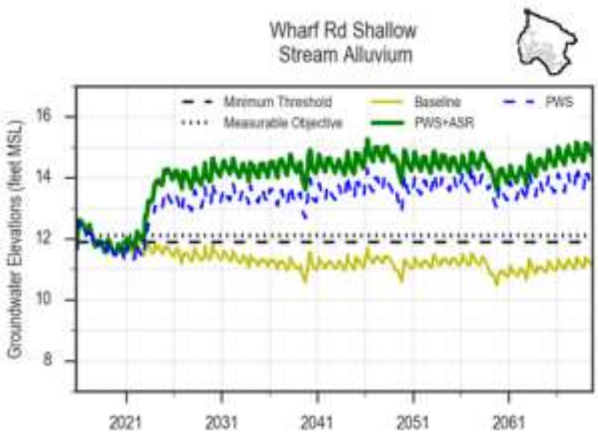
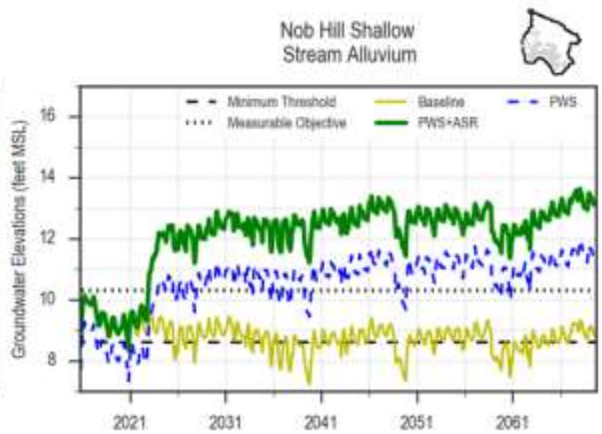

Wharf Rd Shallow
Stream Alluvium
Minimum Threshold
Measurable Objective
Baseline
PWS+ASR
PWS
Groundwater Elevations (feet MSL)
16
14
12
10
8
2021
2031
2041
2051
2061


Nob Hill Shallow
Stream Alluvium
Minimum Threshold
Measurable Objective
Baseline
PWS+ASR
PWS
Groundwater Elevations (feet MSL)
16
14
12
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8
2021
2031
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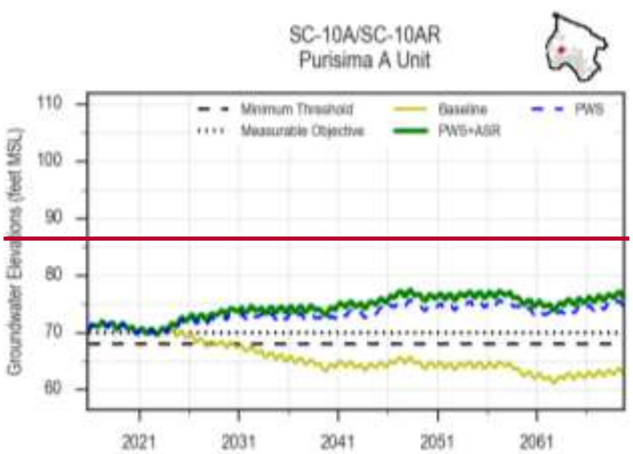

SC-10A/SC-10AR
Purisima A Unit
Minimum Threshold
Measurable Objective
Baseline
PWS+ASR
PWS
Groundwater Elevations (feet MSL)
110
100
90
80
70
60
2021
2031
2041
2051
2061

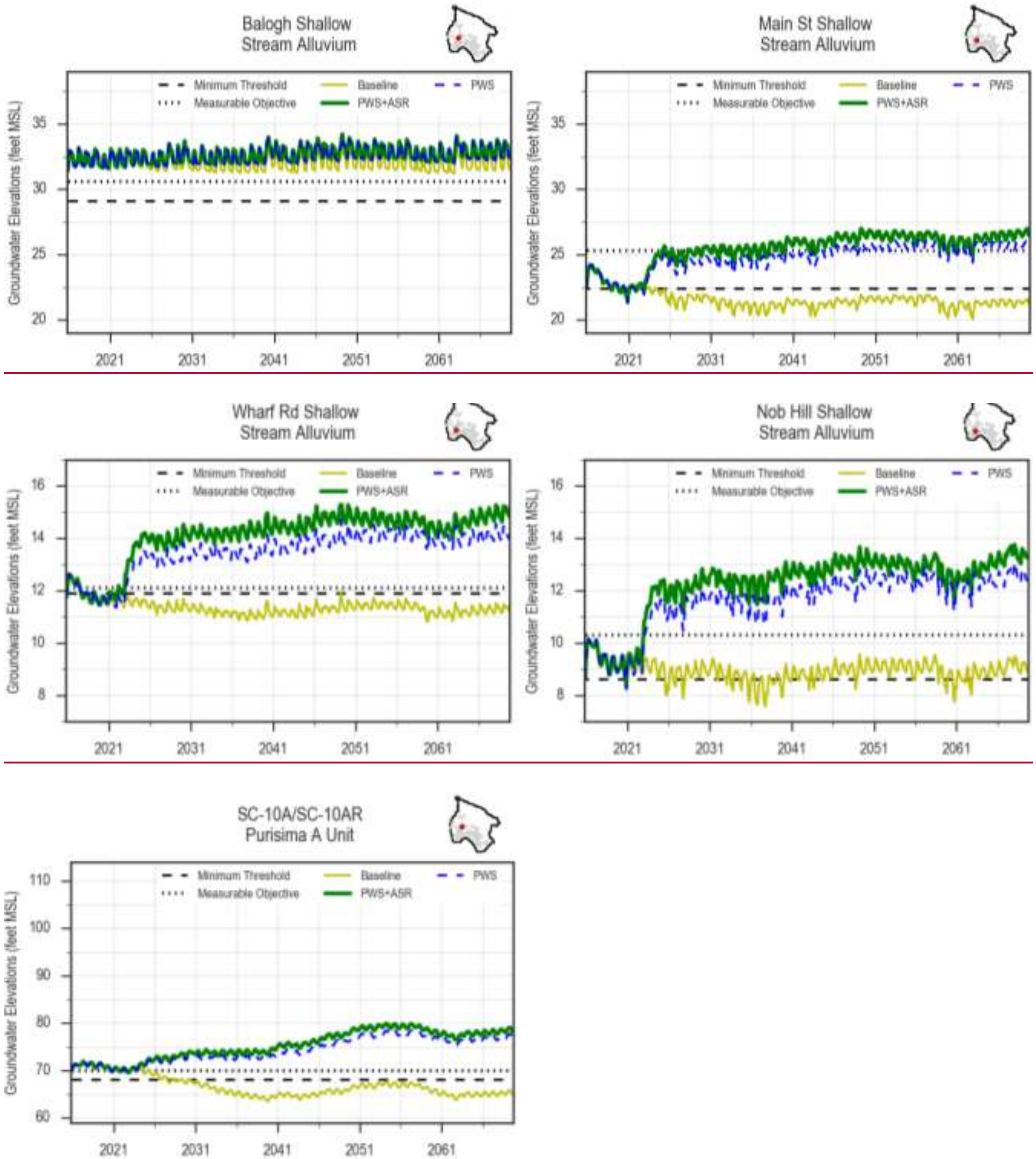


Figure 4-3. Monthly Model Simulated Groundwater Elevations in Shallow Wells along Soquel Creek

The hydrographs also show that the expected benefits are maintained when combining SCWD's ASR project to Pure Water Soquel (green line labeled PWS+ASR).

4.2.1.9 How the Project will be Accomplished

Pure Water Soquel would use advanced water treatment technology to reuse locally available treated secondary effluent for advanced purified water that meets or exceeds drinking water standards. Advanced purified water would then be replenished into the groundwater aquifer to ultimately mix with native groundwater and contribute to the restoration of the groundwater basin, provide a barrier to seawater intrusion, and contribute to a sustainable water supply. The source of supply is secondary treated wastewater from the City of Santa Cruz Wastewater Treatment Plant. In 2019, Soquel Creek Water District and the City of Santa Cruz ~~have~~ approved a 35 year contractual project agreement to supply Soquel Creek Water District with enough secondary effluent to produce 1,500 acre-feet per year of advanced treated water for replenishment and an additional amount of secondary effluent for PWS to provide the City with 300 acre-feet per year of tertiary treated water for non-potable reuse by the City for irrigation and other purposes. At the end of the 35 year wastewater agreement, the ~~contract~~project agreement contractual terms for source water automatically renews for consecutive 5 year periods. The proposed amount of secondary effluent to be provided is approximately 25% of the annual wastewater treated by the City Wastewater Treatment Plant.

If needed, the project has potential to be expanded~~,~~ if ~~the basin SMGA~~Basin sustainability goals have not been achieved.

4.2.1.10 Legal authority

California state law gives Water Districts the authority to take actions necessary to supply sufficient water for present or future beneficial use. Land ~~Use Jurisdictions~~use jurisdictions have regulatory authority to develop similar programs.

4.2.1.11 Estimated Costs and Funding Plan

Pure Water Soquel is projected to cost $90 million to permit and construct to deliver the 1,500 AFY of purified water to the Basin and ~300 AFY of tertiary treated water for City uses. The project will be funded entirely through SqCWD's water rates and/or low interest loans or grant funds; no direct costs are anticipated to the MGA. Soquel Creek Water District has received over $2M in planning grants from the State Water Resources Control Board and a $150,000 planning grant from the US Bureau of Reclamation to evaluate the PWS project. The project is eligible to compete for implementation money ($50M under Prop 1 Groundwater and $20M under Title XVI). Both grant applications were submitted in early 2019. SqCWD is also pursuing low-interest loans through USEPA's Water Infrastructure Finance and Innovation Act (WIFIA) program and State Revolving Funds (SFR).

4.2.1.12 Management of groundwater extractions and recharge

Monitoring wells and data management systems are used to record and compare groundwater elevations in the Basin to evaluate pumping impacts and ongoing sustainability. Municipal groundwater extraction is monitored by metering municipal production wells operated by SCWD and Soquel Creek Water District in the areas where the Pure Water Soquel project would be located. Project recharge wells to recharge the aquifer would be metered to control the amount and rate of water injected into the regional aquifer.

4.2.1.13 Relationship to Additional GSP Elements

Soquel Creek Water District's Pure Water Soquel project will be managed to ensure no negative impacts to any of the additional GSP elements outlined in GSP Section 2.1.4. ~~Groundwater injection~~The project will recharge the groundwater with purified recycled water to support groundwater replenishment. Increased groundwater levels will improve progress toward the Basin's sustainability goals to protect groundwater supplies against seawater intrusion and to maintain or enhance groundwater levels where groundwater dependent ecosystems exist.

4.2.2 Aquifer Storage and Recovery

4.2.2.1 Project Description

Aquifer Storage and Recovery (ASR) would inject excess surface water, treated to drinking water standards, into the natural structure of Basin aquifers for use as an underground storage reservoir. The ASR project modeled for this GSP optimizes existing SCWD infrastructure as a more efficient use of available resources to inject excess drinking water into Basin aquifers. However, since SCWD is in the process of developing its plans for the ASR project, eventual implementation of the ASR project may include new infrastructure. SCWD can produce excess surface water by improving the treatment process at its Graham Hill Water Treatment Plant to improve its ability to treat available surface water (within its water rights, above the amount of water required for City operations, and respecting water for fish flows). Drinking water stored in the Basin as a result of an ASR project would provide a drought supply for the SCWD service area and any ASR project would need to be designed with additional capacity to contribute to the restoration of the Basin. (Note: A SCWD ASR project to store treated drinking water in the Santa Margarita Groundwater Basin is also being evaluated.)

SCWD is actively evaluating the feasibility of injecting treated drinking water from its surface water sources into regional groundwater aquifers and is currently conducting pilot tests of ASR in the Basin. Pilot testing involves injecting ~~treated~~potable drinking water into the Basin's aquifers and recovering it to assess injection and recovery capacities and monitor water quality ~~implications~~impacts to ~~both the injected and~~ native groundwater resources. Information generated by pilot test evaluations will ~~determine~~help inform the degree to which ASR is a feasible part of SCWD's strategy to improve the reliability of its water supply~~ and~~, 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~~ needs~~.

4.2.2.2 Measurable Objective

A well designed and operated ASR project has the potential to raise groundwater levels in the Basin, thus reducing the threat of seawater intrusion, and store available surface water in regional aquifers for use as drought supply. ~~ Any~~However, any ASR project would need to manage groundwater ~~extraction~~extractions to prevent adverse impacts.

~~4.2.2.34.1.1.1 Circumstances for Implementation~~

4.2.2.3 Circumstances for Implementation

SCWD water system simulation model analyses of projected water availability from ~~City~~SCWD surface water sources indicates that surface water from SCWD's water system, as a sole source, is insufficient to meet both drought supply demands and restore the Basin within the 20-year planning horizon. This result is based on an assessment of the availability of surface water to ~~be to~~ either offset existing pumping or create a reliable supply for a seawater barrier after the ~~City~~SCWD meets its own needs to provide instream flows, meet daily municipal and industrial demand and store water for its drought supply. Availability of surface water for possible use to achieve both Basin sustainability and ~~City~~SCWD drought supply objectives is constrained by a number of factors, including drinking water treatment capacity, water rights, fish flows, and potential climate change impacts on the availability of surface water resources~~ The ~~. To determine the feasibility of an ASR project~~ also includes Basin hydrogeologic characteristics, including Basin capacity to store water for later recovery, excessive loses due to off-shore movement of injected water, and the requirement to design and operate any ASR project to ensure that protective groundwater elevations are maintained at~~, the ~~coast. Any of these considerations may result in a project that doesn't meet the City's Basin sustainability and drought supply objectives.~~ SCWD will be looking at:

- Basin hydrogeologic characteristics (well efficiency, specific capacity and injectivity)
- Loses of injected water due to off-shore movement
- Injection well plugging rates (both active and residual)
- Long-term sustainable injection rates
- Local aquifer response to injection and extraction, particularly to ensure that protective groundwater elevations are maintained at the coast.
- Water-quality changes during aquifer storage and recovery pumping

If any of these issues yields unfavorable results or information, it may result in a project that doesn't meet the SCWD's Basin sustainability and drought supply objectives.

4.2.2.4 Public Noticing

Public notice for aspects of the ASR pilot project was carried out by SCWD and the Santa Cruz City Council prior to initiating of the ASR project pilot tests (SCWD 2018). For the full-scale ASR project, public noticing is anticipated to occur through compliance with the California Environmental Quality Act (CEQA) for any facilities or plans associated with the project, as part of development of a Groundwater Storage Supplement to permit the storage of water from the City's water rights in the Basin that is required by the State Water Resources Control Board and through publically noticed discussions of the proposed project at City Water Commission and City Council meetings.

4.2.2.5 Overdraft Mitigation and Management Actions

The Department of Water Resources designates the Santa Cruz Mid-County Basin (Basin 3-001 (DWR 2016)) as a high priority basin in ~~a state of~~ critical overdraft (DWR 2019). To respond both to the state's designation and to the Basin's condition, which has been a high priority focus of local agencies for decades, in 2015 the City and the Soquel Creek Water District entered into the Cooperative Monitoring/Adaptive Groundwater Management Agreement. ~~-~~This agreement sets limits for each agency's use of groundwater under normal and drought conditions. Basin pumping limits in this agreement were specifically intended to support stabilizing basin drawdown and restoring and maintaining protective groundwater levels at the coast. Work done as part of that agreement, along with work done as part of ongoing groundwater management for the ~~development of the GSP~~Basin indicates that groundwater levels have ~~recovered from critically low levels identified in the 1980s.~~improved. However, seawater intrusion exists in ~~several~~some locations throughout the basin and remains a significant threat to regional groundwater supplies as groundwater levels at five of the Basin's 13 key coastal monitoring wells remain below protective elevations including the Soquel Point Medium well in the SCWD area. In 2018, groundwater levels declined from 0.4 feet to 4.0 feet from all-time highs recorded in Water Year 2017. ASR, if withdrawals are carefully managed, may help to increase groundwater levels and reduce the threat of further seawater intrusion into the Basin.

4.2.2.6 Permitting and Regulatory Process

As part of its efforts to update and align its water rights on the San Lorenzo River to incorporate fish flow requirements and provide additional operational flexibility, the SCWD has initiated a water rights change process with the State Water Resources Control Board (State Water Board). ~~-~~No additional water rights are being requested. SCWD is also working with the State Water Board to obtain the necessary Groundwater Storage Supplement for an ASR project in the Basin. An Environmental Impact Report is being developed to comply with CEQA and updated water rights and petitions are expected to be noticed for public comment before the end of calendar year 2019. Upon completion of the CEQA water rights process, and any necessary ASR CEQA process for a full-scale project, the Santa Cruz Water Commission and the City Council take actions to certify the CEQA work and approve projects. ~~Any additional permitting for facilities would be completed as needed.~~

The State Water Resources Control Board (SWRCB) has recently 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. The City's ASR Pilot Tests and any future permanent ASR facility will be permitted under the ASR General Order. Oversight of these regulations is done through the Regional Water Quality Control Boards (RWQCBs) and will require SCWD 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 would be obtained as needed.

4.2.2.7 Time-table for Implementation

ASR pilot tests began in early 2019 at SCWD's Beltz 12 well. Additional pilot testing at ~~Beltz 12 may occur during the winter of 2019/2020 and~~ an additional Beltz well is slated to ~~be retrofitted for pilot testing during the~~occur this coming winter~~ as well~~. Assuming results from the initial pilot testing conducted at SCWD's Beltz 12 well during 2019 continues to be ~~positive~~favorable, full scale implementation of ASR at that facility would occur on a phased basis beginning in 2021. The current plan for developing ASR in the Basin would utilize to the greatest extent possible existing infrastructure, meaning that new infrastructure would be greatly limited and allowing for both incremental drought supply and groundwater sustainability benefits to begin accruing as early as 2022.

~~As noted earlier in this discussion, any City ASR project would need to be designed and operated to produce benefits to both SCWD's water supply reliability and to the Basin's sustainability, particularly with respect to protecting the basin against seawater intrusion.~~

4.2.2.8 Expected Benefits

Basin groundwater elevations are expected to increase with ASR's injection of excess surface water, treated to drinking water standards, and continued basin management. ASR withdrawals would be managed to ensure they do not impact the attainment of or ongoing Basin sustainability. Benefits are evaluated using the existing groundwater monitoring well network and data management systems to compare groundwater levels over time. Potential impacts of recovering water from the Basin through ASR would be monitored to ensure ongoing groundwater sustainability is maintained.

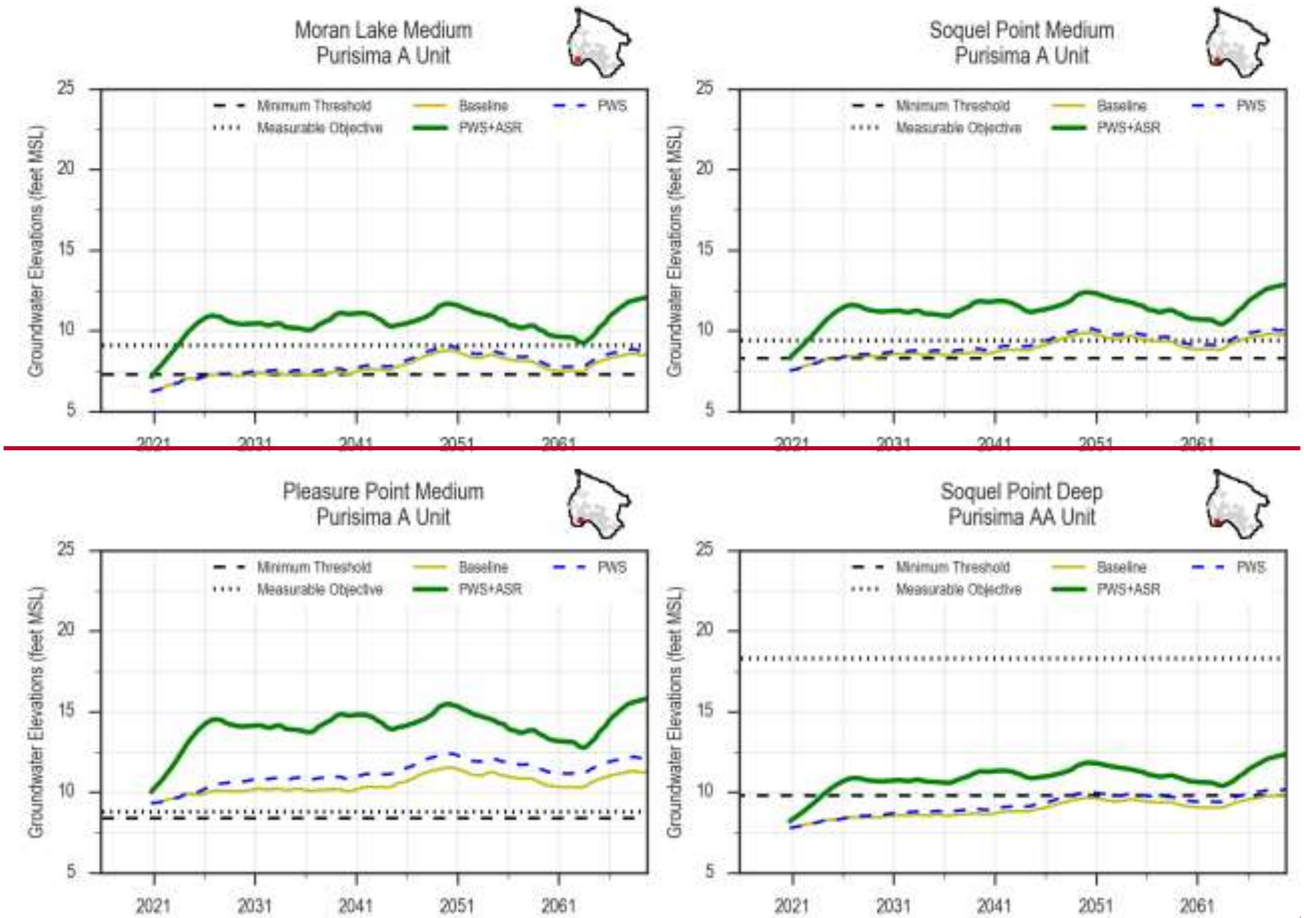
Expected benefits for sustainability are evaluated based on a simulation of a potential ASR project, in combination with the Pure Water Soquel project, under projected future climate conditions using the model (Appendix 2-I).. The potential ASR project simulated for evaluation of expected benefits is based on using existing SCWD Beltz wells for injection and recovery pumping. SCWD is in the process of evaluating different configurations of the project so the ASR project simulated for the GSP likely does not represent the ASR project that will be implemented.

The model simulation shows that expected benefits for sustainability are to raise average groundwater levels at coastal monitoring in SCWD's service area and reduce the risk of seawater intrusion. ~~A simulation of the project, in combination with the Pure Water Soquel project, under projected future climate conditions using the MGA Model demonstrates these expected benefits. The figure below (Figure 4-4~~The figure below (Figure 4-4) shows running five-year averages of simulated groundwater levels at representative monitoring points for seawater intrusion (section 3.3.3.3) in SCWD's service area. The simulated groundwater levels are compared to groundwater level proxies (section 3.6) for minimum thresholds (black dots) and measurable objectives (black dashes) adjusted for sea level rise.~~[2]~~ Projected sea level rise of 2.3 feet is added to the groundwater level proxies (see Section 3.6.2.1.1).

Without ~~SCWD's~~a SCWD ASR project, five-year averages of simulated groundwater levels are not projected to achieve and maintain measurable objectives at the representative monitoring points and are below the minimum threshold in the AA unit. This is the case whether or not the Pure Water Soquel project is implemented (yellow line labeled Baseline without Pure Water Soquel and blue dashes labeled PWS with Pure Water Soquel but no ASR) as the simulated Pure Water Soquel project does not substantially raise groundwater levels in much of the SCWD service area. With a simulated project that injects water at the existing SCWD Beltz wells and reduces overall pumping at the Beltz wells (green line labeled PWS+ASR), it is projected that measurable objectives will be achieved and maintained in the A unit that is the main source of groundwater supply for SCWD and minimum thresholds will be achieved and maintained in the AA unit such that undesirable results for seawater intrusion do not occur. The project is projected to raise groundwater levels sufficiently such that sustainability is maintained even as SCWD increases recovery pumping to meet drought demand from the 2050s into the

~~[2] Projected sea level rise of 2.3 feet is added to the groundwater level proxies (see Section 3.6.2.1.1).~~

early 2060s.



The model simulation also shows that an ASR project can help prevent undesirable results for the interconnected surface water depletion indicator. Figure 4-3 shows that adding an ASR project to Pure Water Soquel (green line labeled PWS+ASR) is projected to raise groundwater levels in shallow wells along Soquel Creek in almost all times and groundwater levels are maintained above the groundwater elevation proxies set as minimum thresholds.

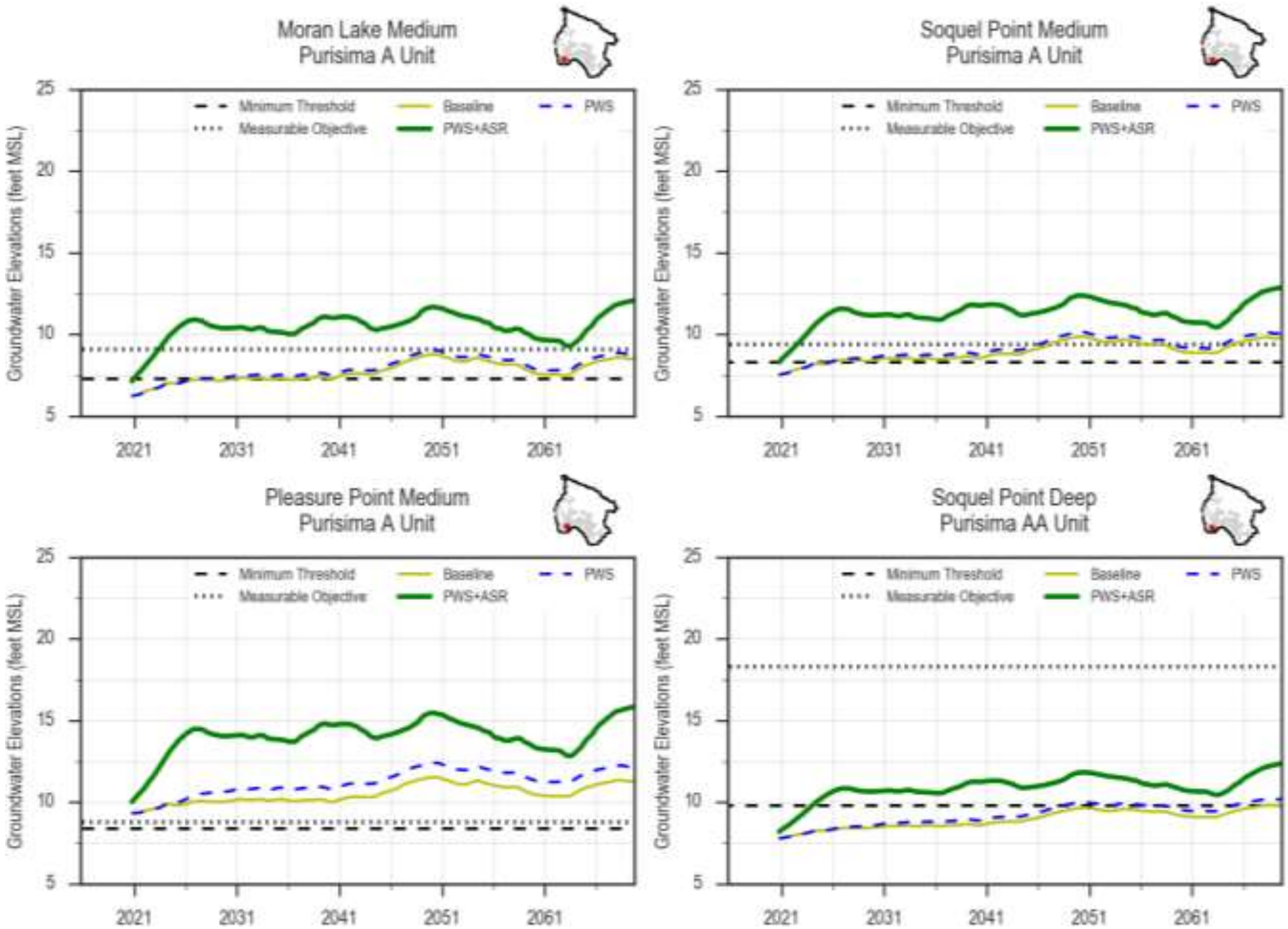


Figure 4-4. Five Year Averages of Groundwater Elevations at Purisima AA and A Units

4.2.2.9 How the Project will be Accomplished

Following the successful completion of additional ASR pilot testing, SCWD would develop a phased implementation plan for ASR in the Basin. The initial phases would emphasize leveraging existing water system infrastructure to the greatest extent possible, with new infrastructure being mostly limited to retrofitting existing wells in the Beltz system to function as both injection and extraction wells rather than just extraction wells. ~~-~~Available wet season surface water within the City's existing water rights quantities and diversion rates and after fish flow commitments are met would be treated to meet both primary and secondary federal and state drinking water ~~levels~~standards at the Graham Hill Water Treatment Plant and distributed to the Beltz wells using existing water system infrastructure. ~~-~~During the dry season or drought periods, ASR water and native groundwater would be withdrawn from the Basin, treated as needed at existing groundwater treatment facilities and delivered to water system customers using existing water system infrastructure. ~~System operation would be constrained to avoid~~Operation of an ASR system would be conducted in such a way that it avoids negative impacts on protective groundwater elevations and chloride concentrations at coastal monitoring wells. ~~-~~Over time, and depending on the availability of both additional surface water and aquifer storage space, additional ASR system facilities in the western part of the Basin could be developed and operated to protect groundwater resources and provide additional drought supply.

4.2.2.10 Legal Authority

The City of Santa Cruz is a land use jurisdiction with police powers necessary to take actions to supply sufficient water for present and future beneficial uses. The City also has the authority to work with the State Water Resources Control Board as needed to pursue necessary updates to its water rights and authorization to store surface water in regional aquifers for both water supply benefits and to provide groundwater sustainability benefits.

4.2.2.11 Estimated Costs and Funding Plan

As described above, the current plan for development of ASR in the basin is intended to leverage the use of existing infrastructure to the greatest extent feasible. As proposed, this approach is substantially less expensive than an ASR project that was discussed by the Water Supply Advisory Committee during its work between April of 2014 and October of 2015. SCWD hasn't necessarily abandoned a potentially larger and significantly more expensive ASR project that might involve storing water and supporting groundwater sustainability objectives in both the Mid-County and Santa Margarita groundwater basins but, rather is pursuing a project in the Mid-County Basin first. This direction provides the opportunity to make near-term incremental improvements in the reliability of SCWD's water supply and also to take near term action to address and mitigate the threat of further seawater intrusion in the Basin.

SCWD staff have estimated that ~~the~~a more limited ASR project ~~described throughout this discussion~~using existing Beltz well infrastructure as simulated for the GSP would cost roughly $21,000,000 in 2019 dollars. These funds would be used to support ongoing pilot testing of ASR at Beltz system wells, necessary design for permanent retrofitting of existing wells, any needed improvements or modifications to SCWD's groundwater treatment facilities, and planning for additional ASR facilities in the western portion of the Basin if and as needed. The SCWD will continue to develop and fund the ASR project planning and implementation through its individual agency budget at no cost to the MGA. Project funding is expected to come from the SCWD water rate payers generated funds and from grant programs if such funds are available and can be successfully obtained.

4.2.2.12 Management of Groundwater Extractions and Recharge

Monitoring wells and data management systems are in use in the Basin to record and compare groundwater elevations to evaluate pumping impacts and for monitoring the performance of the basin relative to the various Sustainable Management Criteria. SCWD's ASR project would inject ~~treated~~potable drinking water into the Basin during the wet season, storing injected water for use during the dry season and ~~accumulate stored water for use~~ during droughts~~ and ~~, along with allowing the stored water to ~~recharge~~recover the Basin. ~~Sustainable groundwater~~Groundwater levels exceeding minimum thresholds may allow SCWD to also extract additional groundwater when needed.

4.2.2.13 Relationship to Additional GSP Elements

SCWD's ASR project is a conjunctive use project that will be managed to ensure no negative impacts to any of the additional GSP elements outlined in GSP Section 2.1.4. Injection of surface water, treated to potable drinking water standards, is expected to support groundwater replenishment and improve progress toward the Basin's sustainability goals ~~to~~. An ASR project will help protect groundwater supplies against seawater intrusion and maintain or enhance groundwater levels where groundwater dependent ecosystems exist, as well as provide drought supply to City water system customers.

4.2.3 Water Transfers / In Lieu Groundwater Recharge

4.2.3.1 Project Description

Water ~~transfer~~Transfers/In Lieu Groundwater Recharge would deliver ~~available~~excess SCWD surface water, treated to drinking water standards, to ~~Soquel Creek Water District~~SqCWD to reduce groundwater pumping and allow an increase in groundwater in storage~~.~~ in order to help prevent seawater intrusion. If ~~the benefits of transferring~~ water ~~on~~transfers benefit groundwater levels, is sustainable over time, and the Basin's performance ~~on meeting the goals set under the Sustainable Management Criteria are~~ consistently ~~reaching~~reaches sustainability targets, then SCWD could recover some of the ~~transferred water to use~~increase in groundwater in storage as a supplemental supply during droughts.

In the summer of 2016, SCWD and SqCWD signed an agreement to work together to conduct a five-year pilot water transfer project. Prior to initiating the pilot, evaluations of the potential for unintended consequences due to differing chemical characteristics of surface and groundwater resources were completed.

A water transfer pilot test was conducted between December 2018 and April 2019 in which SCWD delivered treated drinking water to SqCWD to ~~the~~ serve a portion of SqCWD's service area. The pilot test used an existing intertie between the two water agencies, providing on average 400,000 gallons per day to ~~the~~ SqCWD. During the pilot test, ~~the~~ SqCWD reduced or eliminated pumping in its O'Neill Ranch, Garnet, and Main Street wells. It also tracked water quality as concerns about the potential incompatibility of surface and groundwater sources, particularly related to elevated levels of lead, copper, or colored water from exposing public and private plumbing used to less corrosive groundwater to more corrosive surface water. ~~Soquel Creek Water District nor its customers experienced water quality issues during the pilot test apart from the expected higher levels of disinfection by products in the surface water supply than typically found in groundwater supplies.~~ Additional pilot testing is expected to ~~be conducted this fall~~begin in late 2019 with a larger pilot area within ~~Soquel Creek Water~~

~~District's~~SqCWD's service area to continue evaluating operational and water quality conditions to help inform the feasibility for a long-term transfer. ~~-~~For a long term project, additional surface water could be provided from the City's North Coast sources and the San Lorenzo River (if water rights allow) to meet more of ~~the~~ Soquel Creek Water District's wet season demand, rebuild groundwater storage by eliminating or reducing pumping during some part of the year within the ~~SCWD's~~SqCWD's western area of its service area~~, and potentially provide the SCWD reserves in times of drought~~.

4.2.3.2 Measurable Objective

Water ~~transfer~~Transfers/In Lieu Groundwater Recharge is a project to passively recharge groundwater by resting ~~Soquel Creeks Water District's~~SqCWD's groundwater wells using treated drinking water from SCWD as a source of supply. In Lieu Groundwater Recharge has the potential to reduce the threat of seawater intrusion and possibly create additional groundwater in storage ~~for use by the SCWD~~ if adequate amounts of treated surface water are consistently and reliably available ~~and can be used by Soquel Creek Water District~~when SqCWD customers have the demand needed to use SCWD excess surface water.

~~4.2.3.3~~4.1.1.1 ~~Circumstances for Implementation~~

4.2.3.3 Circumstances for Implementation

Water Transfers/In Lieu Groundwater Recharge is in pilot testing ~~but may be constrained in future years by the availability of excess surface water for sale to Soquel Creek Water District~~. Availability of excess surface water is constrained by a number of factors, including drinking water treatment capacity, water rights place of use restrictions, required minimum fish flows, and availability of adequate surface water supplies to serve SCWD's customers prior to selling excess drinking water outside the SCWD's service area. Climate change factors could also impact water availability. The amount of in lieu groundwater recharge that can be achieved is also limited by the relatively low water demand in ~~the Soquel Creek Water District~~SqCWD's service area during the winter months when SCWD has excess surface water ~~is~~ available.

4.2.3.4 Public Noticing

In Lieu Groundwater Recharge pilot testing began in the winter of 2018-2019. Public Notice for all aspects of the project was carried out by SCWD and Soquel Creek Water District prior to the start of pilot tests~~.~~, including a CEQA Negative Declaration adopted for the pilot project (SCWD 2016). Future notification of the public for any additional pilot testing or long-term implementation would be done prior to initiation of the transfer.

4.2.3.5 Overdraft Mitigation and Management Actions

The Department of Water Resources designates the Basin 3-001 as in a state of critical overdraft. To respond both to the state's designation and to the Basin's condition, which has been a high priority focus of local agencies for decades, in 2015 SCWD and ~~the Soquel Creek~~

~~Water District~~SqCWD entered into the Cooperative Monitoring/Adaptive Groundwater Management Agreement. This agreement sets limits for each agency's use of groundwater under normal and drought conditions. ~~-~~Basin pumping limits in this agreement were specifically intended to support stabilizing basin drawdown and restoring and maintaining protective groundwater levels at the coast. ~~-~~Work done as part of the development of the GSP indicates that groundwater levels have recovered from critically low levels identified in the 1980s. However, seawater intrusion exists in several locations and remains a significant threat to regional groundwater supplies as groundwater levels at five of the Basin's 13 key coastal monitoring wells remain below protective elevations. In 2018, groundwater levels declined from 0.4 feet to 4.0 feet from all-time highs recorded ~~in~~during Water Year 2017. Water transfer and in lieu groundwater recharge would reduce groundwater pumping and is likely to increase Basin groundwater levels and reduce the threat of further seawater intrusion into the Basin. Surface water transfers from SCWD would be expected to reduce regional groundwater dependence.

4.2.3.6 Permitting and Regulatory Process

SCWD completed a CEQA analysis, including opportunity for public comment, for the Pilot Water Transfer project~~.~~ (SCWD 2016). That CEQA analysis was completed in 2016 and focused on water from the City's North Coast Sources pre-1914 water rights, which are not constrained by formalized places of use. The City has initiated a process with the State Water Board Resources Control Board to update its San Lorenzo River water rights, and one of its requests to the State Board is to expand the places of use for all its San Lorenzo River water rights (Newell Creek License, Felton Permits, and Tait Diversion Licenses) to cover the boundaries of the municipal water providers and the general basin boundaries for the Santa Cruz Mid-County and Santa Margarita groundwater basins. No new water rights are being requested in this effort. An Environmental Impact Report (EIR) on the City's water rights changes is underdevelopment and is expected to be released for public review in the fall of 2019. A final EIR and State Board action on the requests is anticipated during calendar year 2020.

Prior to initiating the Pilot Water Transfer, ~~Soquel Creek Water District~~SqCWD was required work with the State Division of Drinking Water (DDW) to modify its Operating Permit to allow it to take surface water during the pilot testing efforts. Any long-term water transfer would also need to be reflected in its Operating Permit from DDW.

4.2.3.7 Time-table for Implementation

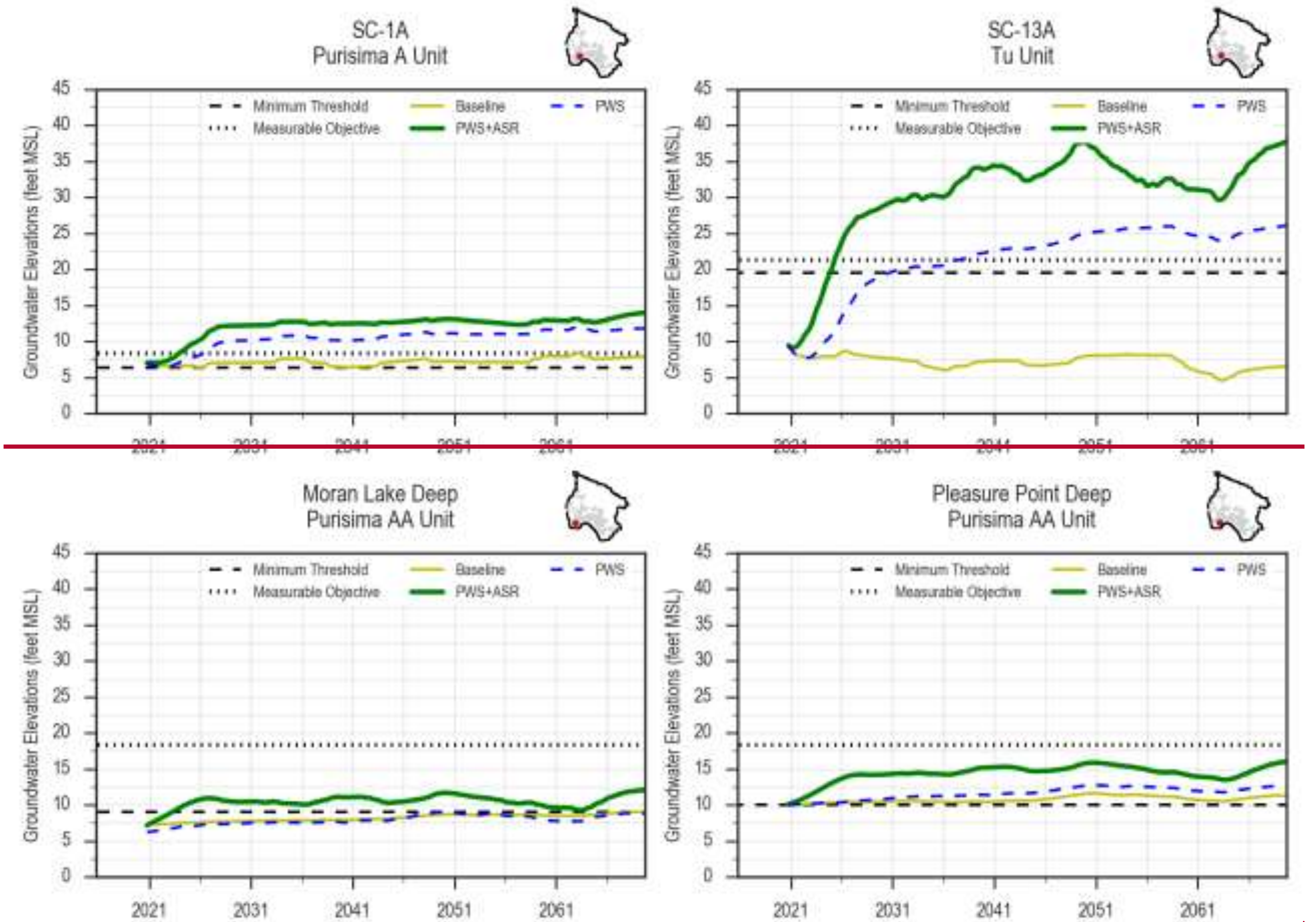
Water Transfer/In Lieu Groundwater Recharge projects have been in the planning and engineering process for four years. In Lieu Groundwater Recharge ~~being~~is in pilot tested now and pilot testing will continue through at least the winter of 2019/2020. Longer term implementation of water transfers will require ~~developing~~ a new agreement, including ~~complying~~compliance with ~~the requirements of~~ Proposition 218 ~~in setting~~requirements to set the cost of service for water delivered and, depending on the annual quantity transferred, waiting for resolution of the places of use changes of the City's San Lorenzo River water rights. Given these factors, a likely timeline for implementation of a longer-term water transfer project is a minimum of two years.

The Basin is expected to see groundwater elevations continue to improve but model analysis of projected water availability from all surface water sources and groundwater recharge projections appear insufficient to restore the Basin within the 20-year planning horizon without additional water augmentation projects. The Basin is required to be sustainable by 2040, even during times of drought, which could limit large scale water transfers back to SCWD.

4.2.3.8 Expected Benefits

Groundwater elevations are expected to continue to increase with continued basin management and implementation of In Lieu Groundwater Recharge~~ could play a role in producing these improvements.~~. Benefits are evaluated using the existing groundwater monitoring well network and data management systems to compare groundwater levels over time.

The potential expected benefits of in-lieu recharge is demonstrated by model simulations of the Pure Water Soquel project~~,~~ (Appendix 2-I), which similarly implements in-lieu recharge by reducing pumping in the three westernmost ~~Soquel Creek Water District~~SqCWD production wells. It is most feasible for operation of a surface water transfer from SCWD to facilitate reduction of pumping at these wells closest to the interchange between SCWD and ~~Soquel Creek Water District.~~SqCWD. Reduction of pumping at these wells can raise groundwater levels at nearby representative monitoring points for seawater intrusion as shown by plots of five-year average simulated groundwater levels at the wells under Pure Water Soquel (blue dashes labeled PWS) compared to the baseline (yellow line labeled Baseline) in Figure 4-5. The simulation of Pure Water Soquel shows the concept of benefits of in-lieu recharge in this area, but does not simulate expected volumes of surface water transfer, the seasonality of the transfer, or any additional pumping to transfer water to SCWD to meet its drought ~~shortages~~shortage needs.



The MGA will continue to evaluate the amount and timing of water transferred between SCWD and SqCWD as part of the pilot and permanent In Lieu Groundwater Recharge projects. Use of this collected data and any changes to groundwater elevations will be used to better analyze the effect of project implementation on groundwater sustainability over time.

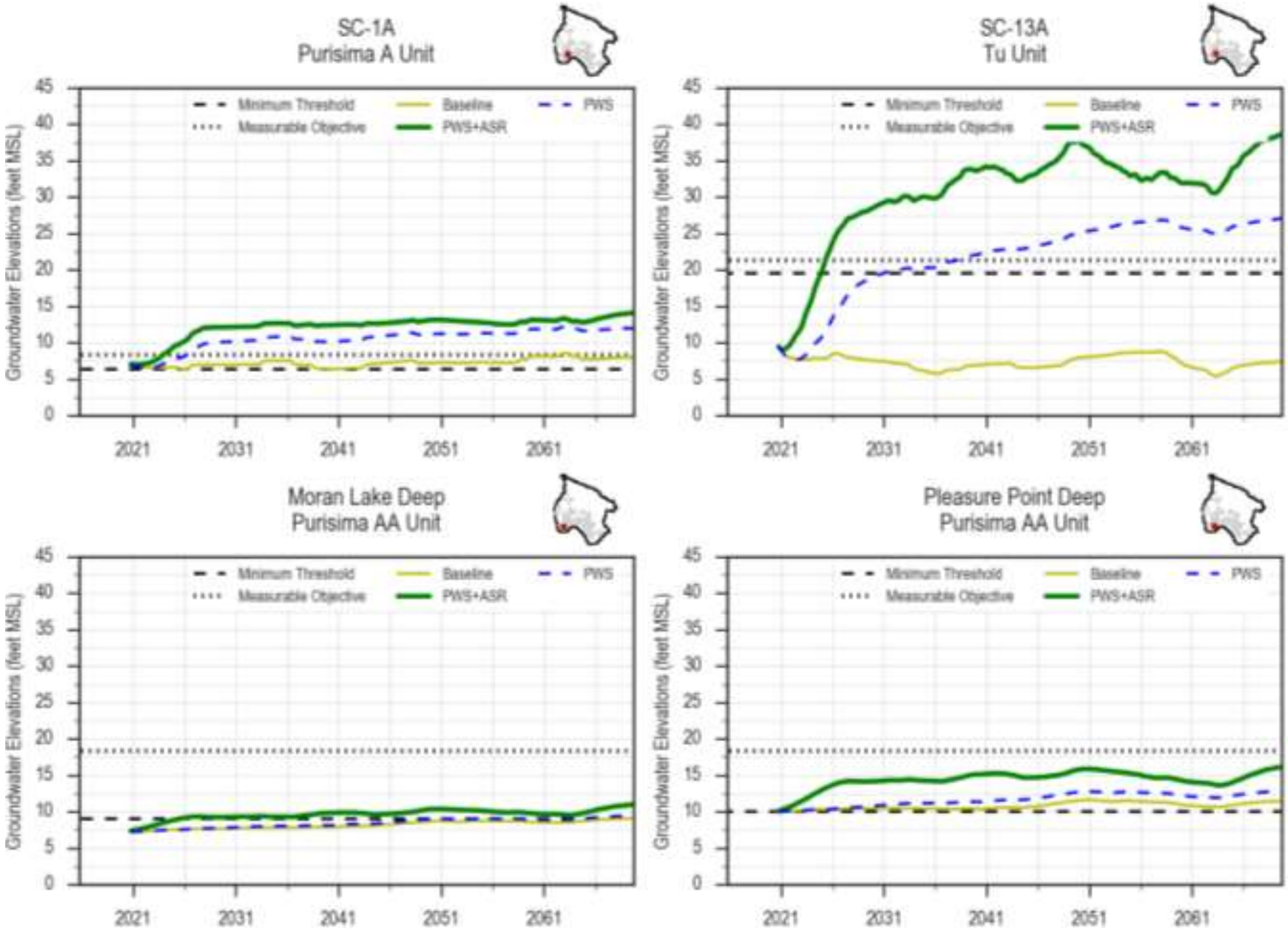


Figure 4-5. Five Year Averages of Groundwater Elevations at Coastal Monitoring Wells in Tu and Purisima AA and A Units (includes in-lieu recharge from Group 2 projects)

4.2.3.9 How the Project will be Accomplished

Water ~~transfer~~Transfers/In Lieu Groundwater Recharge projects can be implemented when SCWD has available excess surface water to provide to ~~Soquel Creek Water District.~~SqCWD. When available, water would come from SCWD's surface water sources ~~outside the Basin,~~and treated at the Graham Hill Water Treatment Plant, ~~and~~then delivered to the SqCWD via existing infrastructure ~~and~~at the O'Neill Ranch intertie. Excess surface water transferred by SCWD to SqCWD is treated at SCWD's Graham Hill Water Treatment Plant to meet both primary and secondary federal and state drinking water standards. Treated water delivered to customers is sampled by SqCWD, as required by the State Water Resource Control Board (SWRCB) regulators and tested to ensure the water delivered to its customers meets safe drinking water standards, these water quality sampling results will be reported monthly to SWRCB. If any water quality samples fail to meet safe drinking water standards, then notification of customers will be directed by the SWRCB staff.

Because of San Lorenzo surface water place of use restrictions, the volume of water available ~~in the~~ could be limited until place of use issues with the San Lorenzo River water rights are resolved. Volumes of water in the range of 300 to 500 acre feet per year (≈100 to 165 million gallons per year) are consistently available from the City's North Coast Sources. Larger volumes may be available in some years, but likely require use of water from San Lorenzo River sources. Analysis by ~~the~~ SCWD shows that there is insufficient water available via Water Transfers to meet SCWD's drought supply requirements. ~~This is because the amount of wet season demand generated by Soquel Creek Water customers that would be offset by In-Lieu water transfers from the SCWD to the SqCWD isn't large enough to accumulate the volume of water SCWD needs to store for its drought supply. In addition, MGA groundwater modeling shows that In-Lieu water transfers alone do not result in achieving Basin sustainability.~~In addition, Water transfers are constrained by both, the availability of water in the SCWD system and the demands of SqCWD's customers. There is no evidence to date that indicates an In Lieu Groundwater Recharge project by itself would achieve Basin sustainability.

4.2.3.10 Legal authority

California state law gives water districts the authority to take actions necessary to supply sufficient water for present or future beneficial use. Land use jurisdictions have police powers to develop similar programs. The Sustainable Groundwater Management Act of 2014 grants MGA legal authority to pass regulations necessary to achieve sustainability. San Lorenzo River water rights are restricted to place of use areas within SCWD water service areas. The City is applying to the State Board to expand the places of use for its San Lorenzo River water rights to allow for the expansion of the In Lieu Groundwater Recharge project.

4.2.3.11 Estimated Costs and Funding Plan

Water ~~transfer~~Transfer/In Lieu Groundwater Recharge projects utilize a significant amount of existing infrastructure. Costs for additional infrastructure to optimize In Lieu/Water Transfers are largely in the form of increased operating costs and could include increased water quality monitoring, increased public notification, and the cost of purchased water. Cost of ~~purchased~~ water ~~for Soquel Creek Water District would need to legally~~purchases between SCWD and SqCWD must comply with the legal requirements of Proposition 218 ~~(~~, which sets the cost of service for water delivered~~)~~..

4.2.3.12 Management of groundwater extractions and recharge

Water Transfer/In Lieu Groundwater Recharge projects are conjunctive use projects. In Lieu Groundwater Recharge reduces groundwater pumping to allow passive recharge that can contribute to groundwater level increases. Monitoring wells and data management systems are used to record and compare groundwater elevations in the Basin to evaluate pumping impacts and ongoing sustainability. ~~In Water transfer/In Lieu projects are conjunctive use projects. In Lieu reduces groundwater pumping to allow passive recharge that can contribute to~~

~~groundwater level increases. Sustainable groundwater levels may allow SCWD to extract additional groundwater during times of drought when surface water flows are low.~~ Relationship to Additional GSP Elements

~~4.2.3.13 Relationship to Additional GSP Elements~~

SCWD and ~~Soquel Creek Water District's~~SqCWD's joint Water ~~transfer~~Transfer/In Lieu Groundwater Recharge projects are conjunctive use projects that will be managed to ensure no negative impacts to any of the additional GSP elements outlined in GSP Section 2.1.4. Passive recharge through resting groundwater wells by delivering excess surface water treated to drinking water standards to ~~Soquel Creek Water District~~SqCWD customers is expected to support groundwater replenishment. Increased groundwater levels will improve progress toward the Basin's sustainability goals to protect groundwater supplies against seawater intrusion and to maintain or enhance groundwater levels where groundwater dependent ecosystems exist.

4.2.4 Distributed Storm Water Managed Aquifer Recharge (DSWMAR)

4.2.4.1 Project Description

Distributed Storm Water Managed Aquifer Recharge (DSWMAR) redirects storm water flows for use as a groundwater recharge supply to increase groundwater storage~~.~~ (RCD 2014). Where feasible, small to medium scale (up to 10 acre-feet/year/site) facilities are installed to capture and treat storm water for shallow groundwater recharge zones in Basin groundwater aquifers. Projects would be accomplished through surface spreading and/or the construction of dry wells.

4.2.4.2 Measurable Objective

DSWMAR is a groundwater recharge project to increase groundwater storage in the shallow aquifer layers in the Basin for increased groundwater storage and added protection against seawater intrusion and improved surface water quality.

4.2.4.3 Circumstances for Implementation

The County has installed DSWMAR projects in the Live Oak and Aptos areas of the Basin. Bioswale filtration systems and dry wells were installed at Brommer Street County Park with a capacity to recharge 1 acre-foot per year from the parking lot runoff. Bioswales and dry wells were also installed to capture runoff from two parking lots at Polo Grounds County Park with a capacity to recharge 19 acre-feet per year. Eight more DSWMAR sites were evaluated in 2018. Three of these sites were identified for further site investigation. One of these sites was recently eliminated because depth to groundwater was too shallow for recharge to be effective at that site. The availability of suitable sites and the limited scale of DSWMAR projects may be a constraint to project implementation.

Topography, ground cover, local vegetation, and surface and sub-surface geology/hydrogeology can provide significant constraints for siting DSWMAR projects. DSWMAR introduces water to the upper levels of aquifers and most drinking water production draws from deeper levels. Depending on the configuration of aquifers, DSWMAR may never reach the aquifers from which drinking water is produced. DSWMAR projects vary in size and benefit to the Basin and are likely to be prioritized according to recharge efficiency/needs and implemented when funding is available.

4.2.4.4 Public Noticing

Installed DSWMAR projects were publicly noticed and approved by the Santa Cruz County Board of Supervisors during its regularly scheduled board meetings. This process included statewide notice of the submission of Negative Declarations under CEQA to the state clearing house. Future DSWMAR projects would be noticed by the lead agency when a DSWMAR project is proposed.

4.2.4.5 Overdraft Mitigation and Management Actions

Groundwater levels have recovered from critically low levels identified in the 1980s. However, seawater intrusion exists in several Basin locations and remains a significant threat to regional groundwater supplies as groundwater levels at five of the Basin's 13 key coastal monitoring wells remain below protective elevations. In 2018, groundwater levels declined between 0.4 feet to 4.0 feet at various Basin locations from all-time highs recorded in Water Year 2017. The introduction of storm water into shallow Basin aquifers may increase groundwater levels in localized areas where DSWMAR projects are installed.

4.2.4.6 Permitting and Regulatory Process

Installed DSWMAR projects required permits from or notice to the following agencies:

- CEQA documentation
- Santa Cruz County grading permit
- USEPA - Class 7 dry well notice

Future projects may also require:

- Regional Water Quality Control Board - may require notice/permit

4.2.4.7 Time-table for Implementation

The County has developed and installed two DSWMAR projects to date, one in Aptos and another in Live Oak. The County installed dry wells in Aptos at Polo Grounds County Park that became operational in 2012 to add an estimated 19 acre-feet per year to the local shallow groundwater aquifer. In Live Oak, dry wells were installed and became operational at Brommer Street County Park in 2015 to add an estimated one acre-foot per year to the local shallow groundwater aquifer. The Polo Grounds project was accomplished with planning and funding through the Integrated Regional Water Management (IRWM) program and the Live Oak project was completed with IRWM and stormwater grant funding.

Eight potential future sites were screened in 2018. Three of these eight potential sites were identified for further investigation, and one was eliminated after borings showed depth to groundwater too shallow to provide adequate conditions for recharge at that location. The two remaining sites are still under investigation. Time-table for development and expected benefits to groundwater recharge at these or any other potential future DSWMAR project sites are not available and would be speculative at this time

4.2.4.8 Expected Benefits

DSWMAR projects are expected to recharge shallow groundwater aquifers. Future projects of small to medium scale would be installed where feasible to capture storm water and recharge more shallow zones of aquifers through surface spreading or construction of dry wells. Existing projects in Live Oak and Aptos use recorded local rainfall observations and project design parameters to estimate project recharge rates. Future DSWMAR projects would likely be designed to more accurately measure recharge rates to the groundwater aquifer. The expected benefit from each project would vary based on both project design parameters and the amount/timing of storm water runoff. Benefits are evaluated using the existing monitoring well network and data management systems to compare groundwater levels over time. Time-table for accrual of expected benefits to groundwater recharge for potential future DSWMAR projects is not currently available and would be speculative at this time.

Although a specific DSWMAR project was not specifically modeled, a theoretical project in Aptos was modelled and was shown to raise groundwater levels in the Aromas Red Sands aquifer and allow for pumping from the aquifer unit more than what simulations of Pure Water Soquel show is necessary to achieve measurable objectives to prevent seawater intrusion into the aquifer.

4.2.4.9 How the Project will be Accomplished

Future DSWMAR projects would be developed by identifying sites receptive to groundwater recharge in areas where shallow groundwater recharge would be beneficial to the Basin. The Resource Conservation District of Santa Cruz County (RCD) is working with land owners in the neighboring Pajaro Valley Sub-basin on surface spreading projects and has developed data to show project effectiveness with the right surface and subsurface hydrogeologic conditions. The County has installed dry wells to capture and recharge storm water in Live Oak and Aptos. MGA member agencies will leverage existing project information from members and regional partner agencies, like the RCD, to identify sites and design future DSWMAR projects within the Basin. DSWMAR water supply would come from redirecting local storm water runoff to areas suitable for shallow groundwater recharge.

4.2.4.10 Legal authority

California state law gives Water Districts the authority to take actions necessary to supply sufficient water for present or future beneficial use. Land Use Jurisdictions have police powers to develop similar programs. The Sustainable Groundwater Management Act of 2014 grants MGA legal authority to pass regulations necessary to achieve sustainability.

4.2.4.11 Estimated Costs and Funding Plan

Existing DSWMAR projects were developed with local and grant funding sources. Future DSWMAR projects sites are under investigation. Two of the three potential storm water recharge sites evaluated in a report prepared for the County (MME, June 2019) were found suitable for project development. Both suitable sites are at different locations on Seascape Golf Course. The MME report estimates costs per unit of water infiltrated over a 20 year project lifespan. These costs were developed per acre-foot of stormwater recharge and varied between $1,649 and $2,786 per acre-foot. Project development costs for initial project installation were estimated at $450,000 at the Los Altos site and $650,000 at the 14th Fairway site. MGA policy developed to date indicate project funding would come from member agencies and grants.

4.2.4.12 Management of groundwater extractions and recharge

Groundwater extraction is monitored by metering municipal production wells, small water systems, and ~~is estimated for~~the model estimates production by non-municipal private wells~~ by the MGA Model~~. DSWMAR projects recharge shallow groundwater. Basin recharge attributable to DWSMAR projects is estimated according to project design parameters and recorded precipitation. Basin groundwater recharge is monitored through a basin wide monitoring well network and data management system.

4.2.4.13 Relationship to Additional GSP Elements

Environmental impacts of future DSWMAR projects will be reviewed under the California Environmental Quality Act (CEQA). If implemented, future projects would avoid significant impacts to the environment including to the additional GSP elements outlined in GSP Section 2.1.4. Groundwater recharge related to DSWMAR is expected to support shallow groundwater replenishment and improve progress toward the Basin’s sustainability goals to maintain or enhance groundwater levels where groundwater dependent ecosystems exist.

4.3 Identified Projects and Management Actions That May Be Evaluated in the Future (Group 3)

4.3.1 Recycled Water - Groundwater Replenishment and Reuse

Soquel Creek Water District: The Soquel Creek Water District Feasibility Study~~ (Carollo, 2017)~~ (Carollo 2017) and the Pure Water Soquel EIR~~ (ESA, 2018)~~ (ESA 2018) both identify expansion opportunities for Pure Water Soquel Project. The conveyance infrastructure of Pure Water Soquel Project is currently being sized to accommodate the potential for future expansion of the Project’s treatment system (if desired at a later time) which is centrally-located and to convey up to approximately 3,000 AFY of purified water. This could be developed should SCWD need supplemental water supplies to meet drought needs or the Basin needs additional supplies to meet MGA sustainability goals based on project performance and monitoring of the GSP's implementation measures.

City of Santa Cruz: SCWD conducted planning and assessments of the potential use of recycled water to supplement SCWD's water supply. The City's Water Supply Advisory Committee's (WSAC) 2015 recommendations were to pursue a strategy of water conservation and enhanced groundwater storage, with a back-up option of advanced treated recycled water or desalinated water. WSAC recommended further evaluation of these water supply alternatives ~~(City of Santa Cruz WSAC Final Report, 2015).~~ (SCWD 2015). The WSAC's charge, as represented in its final recommendations, was focused on addressing SCWD's water supply gap of 3,700 acre-feet (or 1.2 billon gallons) per year during times of extended drought. However, the potential recycled water strategies to augment SCWD's water supply could also potentially benefit the Basin if implemented in a manner that targeted groundwater storage or seawater intrusion prevention.

In 2018, in response to WSAC's recommendations, SCWD concluded a Recycled Water Facilities Planning Study (RWFPS) that evaluated recycled water alternatives ~~(Kennedy/Jenks, 2018).~~ (Kennedy/Jenks 2018). This included a high-level feasibility study and conceptual level design of alternatives for recycled water. In addition to evaluating water supply benefit to SCWD, the RWFPS also provided a broader range of potential beneficial uses of the treated effluent from the regional Santa Cruz Wastewater Treatment Facility (WWTF). The RWFPS evaluated eight project alternatives, which included:

1) Centralized Non-Potable Reuse
2) Decentralized Non-Potable Reuse
3) SqCWD Led Groundwater Replenishment Reuse Project (Includes Pure Water Soquel)
4) Santa Cruz Led Groundwater Replenishment Reuse Project
5) Surface Water Augmentation
6) Streamflow Augmentation
7) Direct Potable Reuse
8) Regional GRRP

The evaluation of the project alternatives consisted of a conceptual-level engineering analysis to evaluate each project and to score and rank projects based on screening criteria for engineering and operational considerations, economic factors, environmental, and social considerations.

The RWFPS identified the near-term preferred alternative as strategies/projects under Alternative 1 Centralized Non-Potable Reuse; this consists of two separate projects (1. SCPWD Title 22 Upgrade (Alternative 1A) and 2. BayCycle (Alternative 1B Phase 4)) to increase production and recycled water reuse. Both would benefit SCWD but they are located outside of Basin and would not assist in achieving sustainability within the Basin and therefore are not under consideration by the MGA.

The RWFPS identified a mid-term opportunity for a centralized Groundwater Replenishment Reuse Project (GRRP) led by the SCWD (Alternative 4). This alternative evaluated a GRRP (independent of Pure Water Soquel) in the Santa Cruz service area with a centralized Advanced Water Treatment Facility (AWTF) at or near the Santa Cruz Wastewater Treatment Facility (WWTF) to send advanced treated water for injection in the Beltz wellfield area and also deliver advanced treated water for non-potable reuse (NPR) along the way.

The Beltz wellfield is located in the Basin, so this potential project to assist with replenishing the Purisima aquifer and protecting against from seawater intrusion. The Santa Cruz WWTF secondary effluent would serve as the source of the water. The effluent would receive AWTF at or near Santa Cruz WWTF employing full advanced treatment with microfiltration, reverse osmosis (RO) and ultra-violet (UV)/Peroxide for advanced oxidation. It is estimated the project would provide up to 2.0 MGD (2,240 AFY) advanced treated water for groundwater replenishment at the Beltz Wellfield. In addition, it would provide an estimated 0.11 MGD (120 AFY) for NPR irrigation at approximately 35 customer sites in City along the pipeline alignment from the AWTF to SCWD's GRR injection sites. The RWFPS summarizes the other infrastructure required to implement the project including: advanced treated water pump station; approximately 43,000 linear feet (LF) of new advanced treated water pipeline (6 to 12-inch) to distribute water to the Beltz wellfield; 5 injection wells and 5 monitoring wells and associated buildings. The study's summary of probable costs estimated the total capital costs at $70.5 million (includes treatment, pipelines, pump station, site retrofit costs, wells) and presents a summary of loaded capital costs, by facility component, as well an annual unit life cycle costs.

The RWFPS summarizes the significant limitations and challenges of the project as:

1. Operational complexity and energy for treatment and injection;
2. Additional studies to confirm the groundwater basin capacity, ability to capture recharged flow and meet all regulatory requirements;
3. The produced water quality exceeds the needs for non-potable reuse.

Based upon the identified limitations and challenges, this project is included in Group 3 because there is insufficient information at this stage to fully evaluate its feasibility and merits. Pending the potential implementation of Group 2 projects and management actions and the Basin's hydrologic response as indicated in the assessments of the sustainable management criteria during the GSP implementation, the MGA may reevaluate the need and further evaluate a centralized Groundwater Replenishment Reuse Project (GRRP) led by SCWD.

4.3.2 Recycled Water – Surface Water (Reservoir) Augmentation

As discussed in Section 4.3.1 above, SCWD's Recycled Water Facilities Planning Study (RWFPS) evaluated recycled water alternatives~~ (Kennedy/Jenks, 2018).~~ (Kennedy/Jenks 2018).

This included an evaluation of recycled water use for a Surface Water Augmentation (SWA) project (Alternative 5) to convey advanced treated water from the Santa Cruz WWTF to blend with raw water and store in Loch Lomond Reservoir, a source of municipal drinking water supply for the SCWD service area. Water from Loch Lomond would be conveyed to and treated at SCWD's Graham Hill Water Treatment Plan (GHWTP) before entering SCWD's potable water distribution system.

The study found that a SWA project at Loch Lomond would maximize the beneficial reuse of wastewater in summer months, and potentially provide more operational flexibility for reservoir operations. Instead of preserving storage to assure sufficient water supply for SCWD in the dry months, in all seasons Loch Lomond could be used as a climate independent resource for the region. Based upon the project assumptions and operational conditions, the project is estimated to produce up to 1,777 AFY of recycled water. The available supply for a SWA project would depend on the amount of secondary effluent available for reuse, the dilution ratio and the retention time in the reservoir needed to meet state regulations on the use of recycled water. Due to the distance and lift required to convey advanced treated water to Loch Lomond Reservoir, there would be significant additional infrastructure, pumping and energy requirements for conveyance. The study estimated the total cost at $106.5 million ~~an~~and presents a summary of loaded capital costs, by facility component, as well an annual unit life cycle costs.

The RWFPS identifies the project's significant limitations and challenges as:

- High capital and unit costs due to extensive infrastructure required
- Challenging Regulatory, CEQA/NEPA And Permitting Requirements
- Operational complexity for treatment and reservoir management
- Significant energy for conveyance and treatment
- May limit future expansion at the Santa Cruz WWTF
- Additional limnological studies needed to confirm assumptions

The SWA project was not selected as a preferred alternative in the RWFPS; in the evaluation and sensitivity analysis of the eight alternatives, the SWA ranked towards the bottom. It should be noted that the assessment of this project was done within the context of the WSAC recommendations, to evaluate supplemental supply alternatives to address SCWD's water supply gap during times of extended drought. The MGA's principal planning objective is the Basin's sustainability goal. The initial feasibility assessment did not identify any regulatory "fatal flaws" for the implementation of a SWA project at Loch Lomond Reservoir. The identified limitations and challenges pertain to either addressing drought supply or the MGA's needs. Pending the potential implementation of Group 2 projects and management actions and the Basin's hydrologic response as indicated in the assessments of the sustainable management criteria as the GSP implementation progresses, the MGA may reevaluate the need to further evaluate SWA.

4.3.3 Recycled Water – Direct Potable Reuse

Current California regulations do not allow for the use of recycled water for Direct Potable Reuse (DPR). DRP is generally defined as the introduction of recycled water directly into a public water system. In 2010, the California Senate enacted ~~legislation~~legislation[3] to expand the Water Code regarding potable reuse of recycled water. In the decade since, state drinking water and public health regulatory agencies have continued the assessment and possible framework for the regulation of potable reuse projects. In its 2016 *Investigation on the Feasibility Of Developing Uniform Water Recycling Criteria For Direct Potable Reuse,* the State Water Resources Control Board concluded “the use of recycled water for DPR has great potential but it presents very real scientific and technical challenges that must be addressed to ensure the public’s health is reliably protected at all times (SWRCB, 2016).

No DPR projects currently exist in California and existing regulations have not been developed. However, it is conceivable that DPR becomes a future strategy to augment public water supplies. Accordingly, SCWD’s Recycled Water Facilities Planning Study (RWFPS) evaluated the use of recycled water for Direct Potable Reuse (DPR) (Alternative 7) (Kennedy/Jenks, 2018). The source of supply would be wastewater effluent receiving secondary at the Santa Cruz WWTF. This effluent would receive full advanced treatment prior to blending with raw water coming from City’s other flowing sources for further treatment at the GHWTP prior to distribution as potable water. The Advanced Water Treatment Facility’s (AWTF) capacity would be sized based on the secondary effluent available in the summer, less secondary effluent delivered for other potential project demands. Up to 3.2 MGD (3,585 AFY) of advanced treated water production capacity at the City’s WWTF would be utilized year-round. The study estimated the total cost at $110.6 million. In the future, if a mandate for additional treatment of wastewater effluent or a ban on ocean discharge is enacted SCWD would evaluate water recycling to achieve zero or near-zero discharge. If this situation occurs, DPR could be revisited to increase the amount of beneficial reuse.

The RWFPS evaluated these alternatives principally as a means to address SCWD’s water supply needs during drought. However, conceptually DPR could serve to as a supplemental supply to address the sustainability goals of the GSP by reducing the need for groundwater pumping in the Basin. Conceptually, this would likely entail a dual-purpose approach designed to meet SCWD’s drought needs and as well as serve as a supplemental supply to the MGA to assist in maintaining or enhancing protective water level elevations.

Based upon the current regulations and considerable uncertainty related to scientific, technical, and social considerations, DPR is not considered a viable strategy to achieve the basin sustainability goal. However, as the GSP implementation proceeds over the coming decades, the MGA anticipates evaluating the potential applicability of DPR in managing the Basin in a sustainable manner.

[3] Senate Bill (SB) 918 (Chapter 700, Statutes of 2010), which added sections 13560-13569 (Division 7, Chapter 7.3)

4.3.4 Groundwater Pumping Curtailment and/or Restrictions

In many of the groundwater basins subject to SGMA throughout the State, pumping restrictions are one of the key components of the GSP. The MGA believes that the current level of Basin pumping can be continued with the effective implementation of the Group 1 and Group 2 Projects and Management Actions. However, the MGA also acknowledges that pumping restrictions are an effective tool to achieve groundwater sustainability that may need to be used in the future.

For the purpose of the GSP, pumping restrictions are defined as reductions or limitations in the amount of water a current or future groundwater user can pump from the Basin. This would be applied in the case of a situation where the planned Projects and Management Actions are insufficient to reach and/or maintain sustainability and one or more sustainability indicator is likely to dip below the minimum threshold by 2040. Under such a curtailment scenario, the MGA would determine the amount of water that affected pumpers could take sustainably, and the pumpers would be required to reduce their groundwater extraction to that allocation. All pumpers subject to allocations and restriction would be required to be metered.

SGMA legislation allows for charging fees for pumping in excess of allocations or non-compliance with other GSA regulations (CWC Section 10732 (a)). The MGA will consider the adoption of fees and/or other penalties for violations of pumping allowance and/or reporting in the event that restrictions are implemented.

In the event of a need to restrict pumping, pumping restrictions could also be placed on new wells. Restrictions on permits for new groundwater wells would be considered if there was high demand for wells that, if constructed, could lead to the basin water extractions exceeding the sustainable yield for the basin. Alternatively, restrictions on permits in specific areas would be considered if additional localized pumping could drive one or more sustainability indicators below the minimum threshold. Limits could also be placed on which aquifers could be drawn from if there was a potential adverse impact in a particular zone that might affect seawater intrusion or surface water depletions. In the absence of a basin adjudication, pumping restrictions on new uses would need to be applied equitably and in a similar proportion to restrictions on existing users.

Considerably more work and discussion would need to be done to define the policies and procedures for pumping restrictions in the event that is determined to be needed to attain and maintain sustainability.

4.3.5 Local Desalination

The treatment techniques and processes used to produce drinking water from seawater have a track record of performance and are in use in California and elsewhere in the United States and the world. Concerns raised during the consideration of an earlier local desalination project known as scwd^2 jointly sponsored by SCWD and the Soquel Creek Water District included the energy intensive nature of desalination facilities and potential impacts to marine life in the Monterey Bay National Marine Sanctuary related to the proposed project intake.

The City's Water Supply Advisory Committee (WSAC) identified local desalination as an element 3 project that could be pursued if element 1 and 2 projects either failed to be feasible or failed to fulfill SCWD's agreed upon water supply shortfall in a cost efficient manner~~.~~ (SCWD 2015). However, since WSAC prioritized projects in 2015, additional state regulatory requirements have substantially increased to permit a desalination ocean intake. These additional regulatory requirements and the potential project timing issues related to them, have led the City to further de-prioritize local desalination as a potential water supply source. In addition to regulatory hurdles, any project involving the City of Santa Cruz would also require voter approval before a legislative action could authorize, permit, construct, operate and/or acquire a desalination plant or incur any indebtedness for that purpose by the City.

While desalination is technologically feasible it has become an unlikely source of water supply in the foreseeable future based on local political opposition, environmental concerns, and regulatory uncertainties.

4.3.6 Regional Desalination

After the scwd[2] local desalination project was put on hold in 2014, Soquel Creek Water District completed its Community Water Plan~~.~~ (SqCWD 2015). During the development of that Plan, community input gathered recognized the need for a timely solution to the threat of seawater intrusion. Along with ongoing conservation projects, community members rated regional desalination among three water augmentation strategies for Soquel Creek Water District to pursue to increase its water supply and reduce groundwater pumping in the Basin.

Based on the Community Water Plan, Soquel Creek Water District entered into a memorandum of interest (MOI) with DeepWater Desal, LLC. to express its interest in purchasing up to 1,500 acre-feet per year of desalinated water produced from a proposed desalination facility in Moss Landing. The MOI is non-binding and does not obligate Soquel Creek Water District to make any financial commitment.

The DeepWater Desal project is in evaluation, with development of a draft Environmental Impact Report (EIR) and studies to support compliance with the California Ocean Plan Desalination Amendments ~~(State Water Board, 2015).~~ (State Water Board 2015). For water supply planning to meet the sustainability goals of the Basin, there is a high degree of uncertainty on the potential availability of water from the proposed regional desalination facility given the regulatory hurdles required to permit an ocean intake for the plant within the Monterey Bay National Marine Sanctuary and other factors.

REFERENCES

All references are located in Section 6

APPENDICES

Appendices are located on the MGA website both individually and within a compiled appendices document.

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5 PLAN IMPLEMENTATION

5.1 Estimate of GSP Implementation Costs

This subsection provides an estimate of the cost to implement the Groundwater Sustainability Plan (GSP or Plan) and a general description of how the Santa Cruz Mid-County Groundwater Agency (MGA) plans to meet those costs. Implementation cost considerations include MGA administration, management actions, monitoring protocols, data management, maintaining a prudent fiscal reserve, and other costs estimated over a twenty-year time horizon. The estimated costs of projects and management actions are presented in this section. The funding sources and mechanisms and an estimated schedule for GSP implementation are also presented.

As noted in prior Sections of the GSP, the MGA Board is in agreement that the individual MGA member agencies will principally lead the implementation of projects and management actions. A major rationale for this decision was the long-standing engagement of MGA member agencies in groundwater management and water supply reliability planning work. The City of Santa Cruz and the Soquel Creek Water District (SqCWD) have evaluated a number of supplemental supply options over the last five years, and in several cases work has proceeded far enough to make it significantly more efficient for these agencies to continue their efforts rather than switching project implementation actions to the MGA.

5.1.1 Estimate of Ongoing Costs by Major Category

This subsection presents estimates of costs by the major categories. Presented are the estimated annual cost of ongoing activities as well as the estimated cost of events for activities that do not occur annually but are anticipated within the next five years. This approach enables calculating the 5-year total cost estimate which is annualized to better inform the MGA’s general estimate of the costs by the major categories. Since the costs are based on the best estimates at the time of this report, actual costs may vary from those used in the projections below.

5.1.1.1 Agency Administration and Operations

This category includes the costs related to the administration of the MGA, including administrative staff support, finance staff support and related expenses, insurance, organizational memberships and conferences, miscellaneous supplies and materials. The estimated costs are presented in Table 5-1.

The MGA uses a collaborative staffing model to accomplish its work. Professional and technical staff from MGA member agencies provide staff leadership, management, work products, and administrative support for the MGA. Since 2016, the MGA has contracted with the Regional Water Management Foundation (RWMF), a subsidiary of the Community Foundation of Santa Cruz County, to provide core staff support to the MGA for planning and administration. As the MGA shifts from GSP development into implementation starting in 2020, the staffing support needs will be further evaluated to determine the ongoing administrative and management framework. It is anticipated staffing needs will be evaluated annually during the early years of GSP Implementation as a clearer understanding of the support required evolves over time.

Table 5-1. Estimated Agency Costs by Major Category

Category	Annual Cost	Event Cost	5-Year Total	Annualized Cost (5-Years)
Agency Administration & Operations				
Administrative Staff Support	$150,000	$0	$750,000	$ 150,000
Treasurer & Finance Staff	$12,000	$0	$60,000	$ 12,000
Accounting and other software	$2,500	$0	$12,500	$ 2,500
Annual financial audit	$9,000	$0	$45,000	$ 9,000
Professional organizations	$2,500	$0	$12,500	$ 2,500
Insurance	$1,000	$0	$5,000	$ 1,000
Office supplies, materials, misc. expenses	$2,500	$0	$12,500	$ 2,500
Legal	$20,000	$0	$100,000	$ 20,000
Management & Coordination				
Technical Work: Groundwater Model	$20,000	$100,000	$200,000	$ 40,000
Technical Work: Consultants	$15,000	$0	$75,000	$ 15,000
Planning/Program Staff Support	$25,000	$0	$125,000	$ 25,000
Data Collection, Analysis, & Reporting				
Monitoring: Groundwater Elevation	$10,000	$160,000	$210,000	$ 42,000
Monitoring: Groundwater Quality[1]	$0	$0	$0	$ 0
Monitoring: Groundwater Extractions	$15,000	$15,000	$90,000	$ 18,000
Monitoring: Streamflow	$~~10,000~~12,500	$~~30~~80,000	$~~80,000~~142,500	$ ~~16,000~~28,500
Data Collection: Offshore AEM Surveys	$0	$150,000	$150,000	$ 30,000
Data Collection: Other	$10,000	$0	$50,000	$ 10,000
Data Management	$20,000	$~~25~~50,000	$~~125~~150,000	$ ~~25~~30,000

GSP Reporting				
Annual Reports	$25,000	$0	$125,000	$ 25,000
5-year GSP Evaluations	$0	$100,000	$100,000	$ 20,000
Outreach & Education	$20,000	$0	$100,000	$ 20,000
Contingency (10%)	$~~36,950~~37,200	$~~58,000~~65,500	$~~242,750~~251,500	$ ~~48,550~~50,300
TOTAL	**$~~406,450~~409,200**	**$~~638,000~~720,500**	**$2,~~670,250~~766,500**	**~~$534,050~~$ 553,300**
1. Groundwater quality monitoring is conducted by the individual member agencies				

The SqCWD Finance Manager serves as MGA Treasurer and is responsible, with support from the SqCWD Finance staff, for the accounting and billing functions of the MGA. This budget category includes finance related costs for accounting software and the annual financial audit. Also included is the annual membership dues for the Association of California Water Agencies (ACWA) and the annual insurance costs from Association of California Water Agencies Joint Powers Insurance Authority (ACWA/JPIA).

5.1.1.2 Legal Services

The MGA receives legal services from the County of Santa Cruz (County) on an as-needed basis. If legal services are needed on issues requiring specific expertise on groundwater, the Sustainable Groundwater Management Act (SMGA), other specific matters as necessary, or if there is a conflict of interest for County Counsel, the MGA will employ other counsel. The estimated cost of legal services is presented in Table 5-1.

5.1.1.3 Management and Coordination

5.1.1.3.1 Technical Work: Groundwater Model Simulations and Updates

The Basin groundwater model informs the management activities and ongoing performance assessment of the sustainable management criteria. 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 data, and related work to support ongoing simulations of projects and management actions. The model will be an important tool to inform the evaluation of Basin management strategies over time. This task will be performed by technical consultants. The estimated cost of this task is presented in Table 5-1.

5.1.1.3.2 Technical Work: Consultants

It is anticipated the MGA will have an ongoing need for technical support to inform Basin management. The specific needs and costs are yet to be identified but it is expected, as the initial GSP implementation efforts proceed, that these needs will become evident. Examples of technical consultant support are potential tasks such as: hydrologic technical support (not groundwater model specific); economic (e.g., cost-benefit analysis) and programmatic assessment of funding mechanisms; supplemental studies to address data gaps; vulnerability assessments for climate change and sea-level rise; additional assessment of managed aquifer recharge opportunities; among other tasks. In recognition of the potential need for technical support, the funding for this category is included in Table 5-1.

5.1.1.3.3 Planning/Program Staff Support

This category is broadly intended to include various planning and programmatic support to the MGA for ongoing GSP and SGMA related requirements.

5.1.1.4 Data Collection, Analysis, and Reporting

The MGA's proposed monitoring program is presented in the monitoring section (Section 3.3). The individual member agencies will continue to lead the semi-annual monitoring of groundwater elevation and water quality within their jurisdictions to inform the management of their respective agencies. It is anticipated that costs resulting from improvements to or expansion of existing monitoring networks necessary to evaluate the Sustainable Management Criteria (SMC), or otherwise added at the request of the MGA, will be funded by the MGA. Individual member agencies conduct streamflow monitoring. It is anticipated the MGA will assume responsibility to coordinate and fund streamflow monitoring within the Basin and this is to be a phased transition over the next five years.

5.1.1.4.1 Monitoring: Groundwater Elevation

There is a combined network of 174 wells in the Basin monitored at least twice a year. This network is made up of individual member agency wells combined into the Groundwater Management Plan (GMP) monitoring network, as described in Section 2.1.2: Water Resources Monitoring and Management Programs. This existing network is sufficient to evaluate short-term, seasonal, and long-term trends in groundwater elevations for groundwater management purposes. Each individual member agency will continue to use its own resources to monitor its wells as the GSP is implemented. Monitoring is described in detail in Section 3.1.1.1 Groundwater Level Monitoring Network.

Deep Wells: Section 3.~~4~~3.4.1 presents the Groundwater Level Monitoring Data Gaps. To fill an identified data gap to improve the ability to monitor seawater intrusion requires installation of two new deep coastal monitoring wells. One of these is a deep Tu-Unit monitoring well is within the City of Santa Cruz service area and the other is a Purisima AA-Unit at the site where existing monitoring well SC-3 is located within the Soquel Creek Water District's service area. The well data will inform groundwater management by the respective member agencies within the Basin. It is anticipated the construction and operation of these wells will be funded the respective member agencies, not the MGA.

Shallow Wells: As discussed in Section 3.~~4~~3.4.1, the addition of up to eight new shallow monitoring wells is proposed to improve the ability to monitor surface water/groundwater interactions. These wells will serve to inform the performance assessment of the sustainable management criteria for depletion of interconnected surface waters, as required under SGMA.

The proposed eight shallow monitoring wells are anticipated to be installed in a phased approach at prioritized locations within the next 5 years. The MGA will continue to assess the prioritization and schedule for new shallow well locations as the network expands. Because this is monitoring that would not otherwise be conducted by the individual member agencies, the MGA will assume the costs associated with this monitoring. The MGA's cost to improve the monitoring network with the addition ~~of~~up to 8 new shallow monitoring wells~~ is estimated to be approximately $20,000 per~~. This includes costs related to site~~.~~ assessment, planning, design, construction, and instrumentation. These are approximate cost estimates as there are uncertainties~~-~~ such as site-specific considerations, construction bid environment as well as a variety of other factors that will ultimately determine the cost to install and operate each well.

5.1.1.4.2 Monitoring: Groundwater Quality

Each MGA member agency has its own network of dedicated monitoring wells and production wells that monitor groundwater quality in their service area or area of jurisdiction. These are described in detail in Section 3.1.1.2 Groundwater Quality Monitoring Network. Each agency will use its own resources to continue to sample these wells as the GSP is implemented. No new MGA-specific groundwater quality monitoring wells are proposed at this time. Monitoring for seawater intrusion will continue; the cost of the efforts is captured under groundwater elevation and other categories. The future need for new MGA groundwater quality monitoring wells will continue to be periodically evaluated as project and management actions are implemented.

5.1.1.4.3 Groundwater Extraction Monitoring

5.1.1.4.3.1 Metered Groundwater Extraction Public and Small Water Systems

Each MGA municipal water agency meters its own groundwater extraction by individual well and utilizes Supervisory Control and Data Acquisition (SCADA) systems to record groundwater extraction data. Each individual member agency will continue use its own resources to monitor these wells as the GSP is implemented.

As described in Section 3.1.1.3, small water systems with 5 to 199 connections and other applicable businesses/operations are required to be metered and report annually to Santa Cruz County. The cost to meter and report will continue to be the responsibility of the individual small water system and the applicable businesses/operations.

5.1.1.4.3.2 Metered Groundwater Extraction Non-*De Minimis* Users

The MGA will initiate a new well metering program to collect volumetric data on groundwater usage in the Basin that will inform the assessment and refinement of the sustainable yield of the Basin. The program will apply to two categories of users: (1) all non-de minimis pumping operations expected to extract more than 5 acre-feet per year, and (2) all non-de minimis pumping operations expected to extract more than 2 acre-feet per year that may impact seawater intrusion or an interconnected stream where groundwater dependent ecosystems are identified in Section 3.9. The boundaries of these zones will be established when the enabling ordinances are developed, but it is anticipated the zones will include the areas along the coast where groundwater is less than 50 feet above sea level and areas within 500 -1000 feet of Soquel Creek.

The costs to implement the metering program include: program administration; coordination of program set-up and implementation; participant tracking; and coordination of annual reporting by the ~~participating users. The~~participants. The MGA will initiate planning in 2020 to develop the program. It is anticipated the participating users are responsible for the all costs related to the purchase, installation, calibration, and operation of the meters as well as annual reporting to the MGA.

5.1.1.4.4 Monitoring: Streamflow

As detailed in Section 3.1.1.4, streamflow monitoring is conducted by the MGA member agencies and partners to assess possible streamflow depletion related to groundwater extractions, monitor stream conditions related to fish habitat, and help preserve other beneficial uses of surface water.

To inform the assessment of the performance of the SMC, there are up to five new streamflow gauges associated with shallow monitoring wells that need to be installed by the MGA. The paired wells and gauges (adjacently located) are to evaluate a potential correlation between streamflow, shallow groundwater level and groundwater extraction.

The MGA estimated cost to ~~construct~~install, calibrate and maintain the streamflow gauges are presented in Table 5-1~~.~~. This includes one-time costs related to the initial establishment of the five new stations. The cost estimate includes planning, site selection, designs/specifications, and related pre-installation tasks. It includes the cost to install the monitoring instrumentation, conduct surveys and related work to establish each monitoring site. It includes costs to develop a rating curve to establish a stream stage-discharge relationship for each site. It includes the costs of routine data collection and station maintenance. The assignment of roles and responsibilities (consultants and agency staff) will be evaluated as implementation proceeds.

It is anticipated the new monitoring locations will be installed over in a phased approach over the next five years. The MGA's Proposition 1 GSP Planning grant is providing $125,000 towards funding at least one streamflow and/or shallow groundwater elevation monitoring installation. The MGA will seek additional grant funding available from the Department of Water Resources (DWR) and consider other state and federal programs to partially fund the installation of new streamflow gauges and related monitoring.

5.1.1.4.5 Data Collection: Offshore Airborne Electromagnetics Geophysical Surveys

In May 2017, the MGA successfully completed an offshore Airborne Electromagnetic (AEM) geophysical survey to assess groundwater salinity levels and map the approximate location of the saltwater/freshwater interface in the offshore groundwater aquifers. This important data will inform the assessment of the extent and progress of seawater intrusion into the Basin and the management responses. The MGA anticipates repeating the AEM survey on a five-year interval

(2022) to identify movement of the interface and assess seawater intrusion. The estimated cost is presented in Table 5-1.

5.1.1.4.6 Data Collection: Other

Additional data collection costs include a funding contribution toward a countywide fish and stream habitat monitoring program. Since 2006, this multi-agency partnership between the County and local water agencies has measured juvenile steelhead population density at more than 40 sites throughout the San Lorenzo, Soquel, Aptos, and Pajaro watersheds. The program also assesses habitat conditions for steelhead and coho salmon and helps inform conservation priorities throughout the County. These data are anticipated to generally inform the MGA's ongoing consideration of potential groundwater management impacts to groundwater dependent ecosystems.

5.1.1.4.7 Data Management

The MGA's anticipated initial costs in this category include engaging a consultant to conduct a data management assessment and develop a data management plan that is based upon the monitoring protocols outlined in Section 3 and leverages the existing data management efforts of the member agencies. Ongoing costs in this category includes maintaining a data management system (DMS) that provides necessary functions and capabilities for data, such as: input, organization, storage, accessibility; quality assurance/quality control; security and redundancy; report outputs; and data sharing~~.~~.

The City of Santa Cruz and Soquel Creek Water District Groundwater utilize a data management system (DMS) based upon the commercial software platform Water Information Systems by KISTERS (WISKI). This DMS is used for management and analyses of groundwater elevation, groundwater quality, groundwater extractions, streamflow, precipitation / weather data. For data management consistency, it is anticipated the MGA will also use WISKI as its principal data management platform. The platform options will be evaluated further. The anticipated MGA costs for data management are presented in Table 5-1. Costs ~~are anticipated to~~ include software purchase and license, set-up and configuration, software annual support and maintenance.

5.1.1.5 GSP Reporting to DWR

5.1.1.5.1 Annual Reports

SGMA regulations require the MGA submit annual reports to DWR on status the GSP Implementation. The reporting requirements are presented in Section 5.3. It is anticipated these reports will be prepared by technical consultants in coordination with the MGA member agency staff. The estimated cost of the annual reports in presented in Table 5-1.

5.1.1.5.2 Periodic (5-year) Evaluations

SGMA regulations require the MGA evaluate the GSP at least every 5 years and whenever the Plan is amended. The reporting requirements of the periodic evaluation are presented in Section 5.3. The initial 5-year GSP evaluation is due to DWR in 2025. The roles and responsibilities for the preparation of the updated GSP are not yet determined. In recognition that this mandatory requirement will be completed by the MGA, for the purposes of estimating the costs, the estimated cost for the preparation of the document by technical consultants is presented in Table 5-1.

5.1.1.6 Community Outreach & Education

In 2018, the MGA Board approved a Communication and Engagement Plan that outlined a phased approach to conducting stakeholder outreach, engagement, and education activities. Ongoing activities in the GSP Implementation phase starting in 2020 are anticipated to include outreach such as: maintaining the MGA website and related online/social media through the member agencies (e.g., Facebook; Nextdoor); electronic newsletter; promoting and conducting community meetings, workshops, events; coordination with the Water Conservation Coalition of Santa Cruz County; conducting informational surveys; youth engagement efforts; developing brochures and print materials; and similar engagement activities. The estimated costs are presented in Table 5-1.

5.1.1.7 Financial Reserves and Contingencies

Prudent financial management requires that the MGA carry a general reserve in order to manage cash flow and mitigate the risk of expense overruns due to unanticipated expenditures and in case actual expenses are greater than anticipated in the annual budget. General reserves have no restrictions on the types of expenses they can be used to fund. The ending balance in general reserves becomes the beginning balance of cash reserves for the next fiscal year.

The MGA annual budget includes a contingency amount in recognition that the MGA and the GSP implementation is new and there is the potential for unanticipated expenses. Since 2016, the MGA’s contingency fund been set annually at either 5% or 10% of the total annual operating budget. For the purposes of conservatively estimating the cost to implement the GSP, the budget estimate includes a 10% contingency based upon the annual fiscal year budget estimate.

5.1.2 Activities of the MGA Member Agencies

5.1.2.1 Monitoring Activities

The individual MGA member agencies conduct groundwater, streamflow and watershed monitoring activities in the Basin that inform the management of their respective agencies. The MGA does not contribute towards these individual monitoring efforts and these costs are not included in the MGA’s estimate of the cost to implement the GSP. However, the results of monitoring activities relevant to the MGA will be included in the DMS. The costs are provided below for reference and to provide context for the extent of relevant monitoring activities that are conducted within Basin.

Table 5-2. Member Agency Groundwater Elevation and Quality Monitoring Annual Costs in Basin

AGENCY	Equipment	Data Mgmt & Software	Lab/ Analytical	Personnel	Estimated Total[1]
Soquel Creek Water District	$ 7,500	$ 7,500	$ 20,000	$ 65,000	$ 100,000
City of Santa Cruz[2]	$ 3,000	$ 5,000	$ 10,000	$ 37,000	$ 55,000
Central Water District	$ 1,000	$ 1,000		$ 1,000	$ 3,000
County of Santa Cruz	$ 1,000	$0	$0	$ 10,000	$ 11,000
1. Costs estimates based upon FY 2018-19 amounts 2. City's Live Oak Groundwater Monitoring Program					

Table 5-3. Member Agency Streamflow, Precipitation, and Fish Monitoring Annual Costs in Basin

AGENCY	Services[1]	Site Use	Fish Monitoring	Personnel	Estimated Total[2]
Soquel Creek Water District	$17,000	$1,500	$12,000	$4,500	$35,000
County of Santa Cruz			$~~-~~10,000	$10,000	$~~-~~20,000
1. Consultants and USGS; 2. Costs estimates based upon FY 2018-19 amounts; 3. These are approximate costs within the MGA Basin only; 4. City of Santa Cruz contributes to Fish Monitoring program in Soquel Creek and groundwater impacts monitoring.					

5.1.2.2 Member Agency Projects

The MGA's individual member agencies are implementing projects and management actions. This includes the continuation of existing programs, such as demand management and water conservation programs that have been in place for many years and proven effective in reducing per capita demand in the region to among the lowest levels in the state. Also included are specific existing and proposed projects of the individual member agencies to provide supplemental supply to the Basin. It is largely the projects and management actions of individual agencies, rather than any direct actions taken by the MGA, that will collectively determine the sustainable management of the Basin. While these program and project costs are not included the MGA's budget, the costs outlined in Table 5-4 provide context for the level of investment in the Basin's long-term sustainability.

Table 5-4. Member Agency Projects

Project	Agency	Cost Considerations
Aquifer Storage and Recovery (ASR)	SCWD	Approximate cost of this project within the Purisima aquifer locations only is $21M.
Water Transfers / In Lieu Groundwater Recharge and	SCWD; SqCWD	To be determined after the pilot project is complete. This will need to consider Prop. 218 if/when the City provides water to the District to determine appropriate cost for the water.
Pure Water Soquel	SqCWD	Projected cost is $90 million to permit and construct. The project will be funded entirely through water rates

		and/or low interest loans or grant funds; at no direct costs are anticipated to the MGA.
Distributed Storm Water Managed Aquifer Recharge (DSWMAR)	County; SqCWD	A report developed for the County estimates costs per acre-foot of water infiltrated over a 20 year project lifespan varied between $1,649 and $2,786 per acre-foot for the specific projects evaluated. Project development costs for initial project installation were estimated at $450,000 (Los Altos) and $650,000 (14th Fairway) (MME, 2019).

5.1.3 Total Estimated Implementation Costs Through 2040

The estimated total cost ~~of~~to implement the GSP ~~Implementation~~ over the 20-year planning horizon is $~~11,997,315 as shown in~~ 15,866,700 (Table 5-5~~.~~). This projection uses the 2020 annualized cost (5-Year) for the baseline. The estimated cost is presented by major budget category, which includes: Agency Administration and Operations; Legal; Management and Coordination; Data Collection, Analysis, and Reporting; GSP Annual and Periodic (5-Year) Reporting to DWR; and, Outreach ~~&~~and Education. The annual costs include a 10% contingency and an annual rate of inflation of 3.0~~% is factored into the cost projection.~~%. These estimated costs are based on the best available information at the time of Plan preparation~~ and submittal. It~~. Grant awards may offset some costs. This represents the~~ MGA's~~ current understanding of Basin conditions and the current roles and responsibilities of the MGA under SGMA.

Table 5-5. Groundwater Sustainability Plan Estimated Implementation Cost Through 2040

Fiscal Year	Agency Administration & Operations	Legal	Management & Coordination	Data Collection, Analysis, & Reporting	GSP Reporting (Annual & 5-Year)	Outreach & Education	10% Contingency	Total
2020	$179,500	$20,000	$~~60~~80,000	$~~65,000~~158,500	$~~25~~45,000	$20,000	$~~36,950~~50,300	$~~408,470~~553,300
2021	$184,885	$20,600	$~~61,800~~82,400	$~~66,950~~163,255	$~~25,750~~46,350	$20,600	$~~38,059~~51,809	$~~420,665~~569,899
2022	$190,432	$21,218	$~~63,654~~84,872	$~~68,959~~168,153	$~~26,523~~47,741	$21,218	$~~39,200~~53,363	$~~433,225~~586,996
2023	$196,144	$21,855	$~~65,564~~87,418	$~~71,027~~173,197	$~~27,318~~49,173	$21,855	$~~40,376~~54,964	$~~446,162~~604,606
2024	$202,029	$22,510	$~~67,531~~90,041	$~~73,158~~178,393	$~~28,138~~50,648	$22,510	$~~41,588~~56,613	$~~459,487~~622,744
2025	$208,090	$23,185	$~~69,556~~92,742	$~~75,353~~183,745	$~~100,000~~52,167	$23,185	$~~49,937~~58,311	$~~551,332~~641,426
2026	$214,332	$23,881	$~~71,643~~95,524	$~~77,613~~189,257	$~~23,881~~53,732	$23,881	$~~43,523~~60,061	$~~480,781~~660,669
2027	$220,762	$24,597	$~~73,792~~98,390	$~~79,942~~194,935	$~~24,597~~55,344	$24,597	$~~44,829~~61,863	$~~495,145~~680,489
2028	$227,385	$25,335	$~~76,006~~101,342	$~~82,340~~200,783	$~~25,335~~57,005	$25,335	$~~46,174~~63,719	$~~509,939~~700,904
2029	$234,207	$26,095	$~~78,286~~104,382	$~~84,810~~206,807	$~~26,095~~58,715	$26,095	$~~47,559~~65,630	$~~525,178~~721,931

2030	$241,233	$26,878	$~~80,635~~107,513	$~~87,355~~213,011	$~~115,927~~60,476	$26,878	$~~57,891~~67,599	$~~638,827~~743,589
2031	$248,470	$27,685	$~~83,054~~110,739	$~~89,975~~219,401	$~~27,685~~62,291	$27,685	$~~50,455~~69,627	$~~557,040~~765,897
2032	$255,924	$28,515	$~~85,546~~114,061	$~~92,674~~225,983	$~~28,515~~64,159	$28,515	$~~51,969~~71,716	$~~573,691~~788,873
2033	$263,602	$29,371	$~~88,112~~117,483	$~~95,455~~232,763	$~~29,371~~66,084	$29,371	$~~53,528~~73,867	$~~590,842~~812,540
2034	$271,510	$30,252	$~~90,755~~121,007	$~~98,318~~239,745	$~~30,252~~68,067	$30,252	$~~55,134~~76,083	$~~608,507~~836,916
2035	$279,655	$31,159	$~~93,478~~124,637	$~~101,268~~246,938	$~~134,392~~70,109	$31,159	$~~67,111~~78,366	$~~740,258~~862,023
2036	$288,045	$32,094	$~~96,282~~128,377	$~~104,306~~254,346	$~~32,094~~72,212	$32,094	$~~58,492~~80,717	$~~645,443~~887,884
2037	$296,686	$33,057	$~~99,171~~132,228	$~~107,435~~261,976	$~~33,057~~74,378	$33,057	$~~60,246~~83,138	$~~664,746~~914,521
2038	$305,587	$34,049	$~~102,146~~136,195	$~~110,658~~269,836	$~~34,049~~76,609	$34,049	$~~62,054~~85,632	$~~684,629~~941,956
2039	$314,754	$35,070	$~~105,210~~140,280	$~~113,978~~277,931	$~~35,070~~78,908	$35,070	$~~63,915~~88,201	$~~705,107~~970,215
2040	$324,197	$36,122	$~~108,367~~144,489	$~~117,397~~286,269	$~~155,797~~81,275	$36,122	$~~77,800~~90,847	$~~857,842~~999,321
Total	**$5,147,429**	**$573,530**	**$~~1,720,589~~2,294,119**	**$~~1,863,972~~4,545,223**	**$~~988,846~~1,290,442**	**$573,530**	**$1,~~086,790~~442,427**	**$~~11,997,315~~15,866,700**
1. Assumes inflation factor of 3% annually								

5.1.4 Funding sources and mechanisms

Initial GSP Implementation Phase (2020 – 2025)

The initial funding for GSP implementation will be obtained from the annual contributions of the four MGA member agencies. MGA bases annual member contributions on estimated Basin sustainability impacts. Costs are currently allocated 70% to Soquel Creek Water District and 10% each to the County, the City, and Central Water District. This funding approach has been used since the MGA's formation in 2016. ~~The~~This cost allocation may change as the MGA learns more about Basin sustainability impacts through GSP data collection and the beneficial impacts of agency projects and management actions that improve sustainability. The annual contribution total and individual agency amounts ~~will be~~are assessed annually based upon the MGA's annual budget. ~~This funding approach will be reevaluated over time as the GSP implementation progresses. The MGA obtained~~In 2017, the MGA was awarded a $1.5M grant from ~~DWR~~DWR's Sustainable Groundwater Management Program to fund, in part, the development of the GSP. The MGA will continue to pursue funding from state and federal sources to support GSP planning and implementation.

Ongoing GSP Implementation (2026 – 2040)

SGMA authorizes groundwater sustainability agencies to charge fees necessary to fund the costs of groundwater management, pumping, permitting, and other groundwater sustainability programs. A public finance consulting firm prepared a detailed memorandum outlining the funding mechanisms, necessary policies, and data required to develop a fee program that is equitable, complies with SGMA and California's complex public finance laws~~.~~). This detailed memorandum from Raftelis is included for reference only as Appendix ~~A5~~5-A. In ~~their white paper~~its memorandum Raftelis:

1. Presents a suite of options to recover MGA costs from large private groundwater pumpers based on geographic location, proximity to surface water and the coast, volume of water pumped, and other criteria;
2. Calculates fees using preliminary data based on parcels, acreage, and volumetric production of water
3. Assesses the costs and benefits of each fee structure and mechanism for implementing each fee
4. Relates the implications of each fee type to the requirements of Proposition 218 and Proposition 26
5. Describes the conditions, if any, whereby de-minimis users can be charged for a fair share of MGA costs

As initial GSP implementation proceeds, the MGA will further evaluate funding mechanisms, potential application of fees, and fee criteria. The MGA may perform a cost-benefit analysis regarding fee collection to build upon the initial funding mechanism assessment and to better inform its evaluation of fee alternatives.

5.2 Schedule for Implementation

The final GSP ~~is anticipated to be~~was presented to the MGA Board for adoption ~~in~~at its November 21, 2019 meeting and will be submitted to DWR no later than January 31, 2020. Figure 5-1 provides an overview of the preliminary schedule for agency administration, management and coordination activities, GSP reporting, and community outreach and education. Many of these categories consist of ongoing tasks and efforts that will ~~be conducted~~continue throughout GSP Implementation.

Management & coordination in the schedule at Figure 5-1 includes data collection, analysis, and reporting. This category includes the installation of stream gages and development of associated shallow wells to fill data gaps for depletions of interconnected surface water monitoring discussed in Section 3.3.4.1 and 3.3.4.2. MGA has applied for and been awarded grant funds that include both grant and match funding to make these improvements to the monitoring network. In early 2020 MGA will release a request for proposal (RFP) to acquire land access and conduct installation of stream gages and shallow monitoring wells. MGA staff expects the work included in the RFP to begin prior to October 2022.

The timing of periodic events, such as offshore aerial electromagnetics (AEM) surveys of the freshwater-saline water interface, are best estimates and may shift as GSP Implementation proceeds ~~and~~ based upon the needs at the time. 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 (2025, 2030, 2035, and 2040). The contents of Annual and Periodic reports are described in the following Sections 5.3 and 5.4.

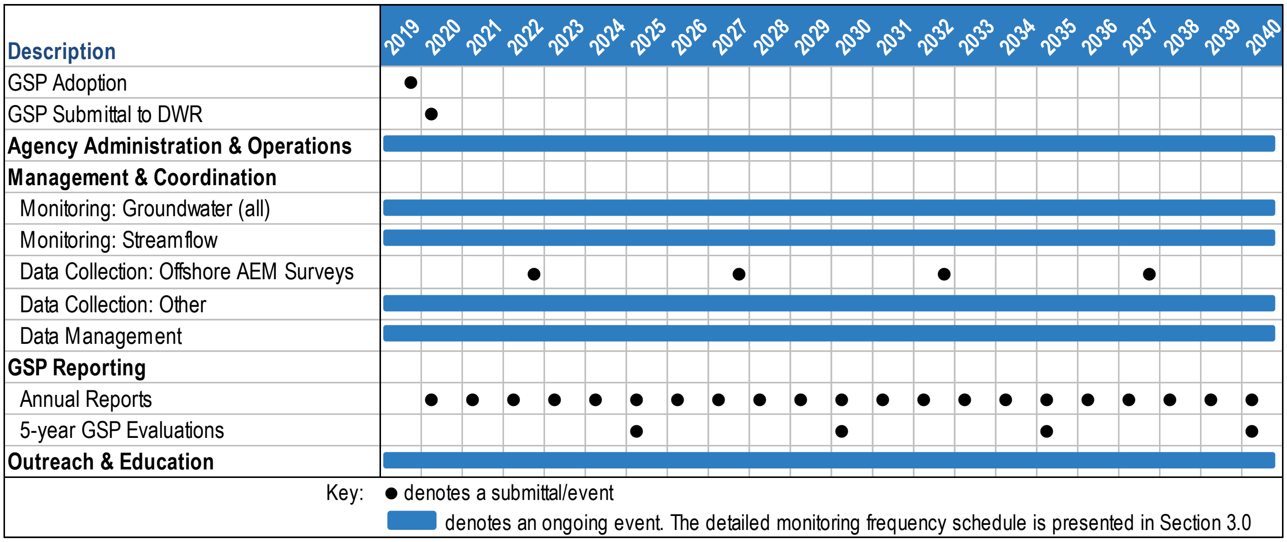

Figure 5-1. GSP Implementation Schedule

5.2.1 Projects and Management Actions

The estimated schedule for the individual MGA member agency projects and management actions is presented in Figure 5-2. The Group 1 Baseline projects are anticipated to be evaluated through the GSP planning and implementation horizon of 50 years. All of these efforts will be periodically assessed as part of an ongoing adaptive management approach.

The Group 2 estimated schedules for the individual member agency projects are also provided. These schedules are based upon current estimates. Some projects, such as Distributed Stormwater Managed Aquifer Recharge include multiple individual projects at separate locations, thus the overlap in the phases of development and implementation. Each of the projects is dependent upon individual factors such as permitting, approval, and funding that may impact the estimated general timeline presented below.

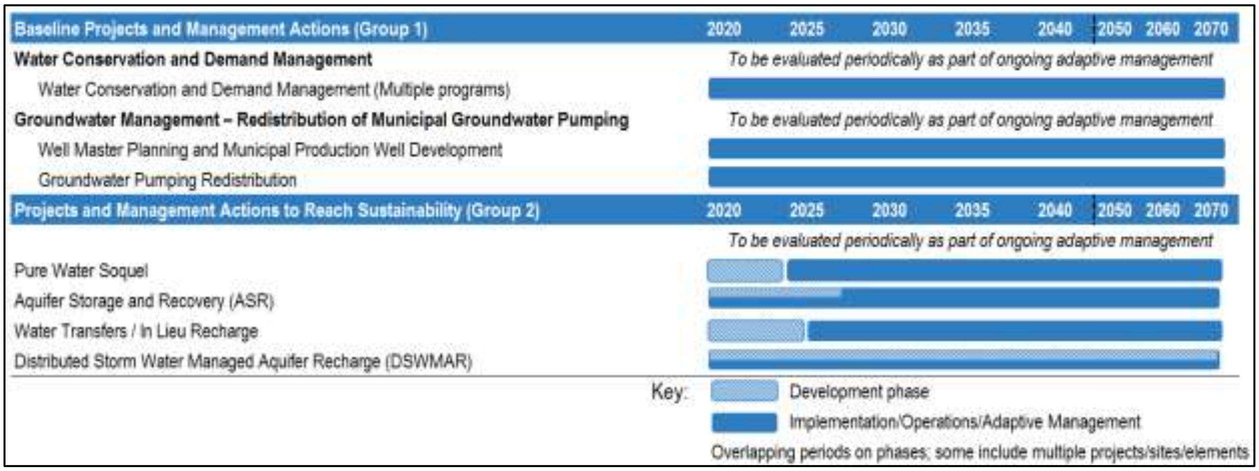

Figure 5-2. Member Agency Projects and Management Actions Estimated Timeline

5.3 Annual Reporting

SGMA regulations require the submittal of an annual report on the implementation of the GSP to DWR (Water Code 10727.2, 10728, and 10733.2). An outline of the procedural and substantive requirements for the annual reports is presented below.

The MGA shall submit an annual report to DWR by April 1 of each year following the adoption of the Plan. The annual report shall include the following components for the preceding water year:

1. General information, including an executive summary and a location map depicting the basin covered by the report.

2. A detailed description and graphical representation of the following conditions of the basin managed in the Plan:

    a. Groundwater elevation data from monitoring wells identified in the monitoring network shall be analyzed and displayed as follows:

        i. Groundwater elevation contour maps for each principal aquifer in the basin illustrating, at a minimum, the seasonal high and seasonal low groundwater conditions.

        ii. Hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year.

    b. Groundwater extraction for the preceding water year. Data shall be collected using the best available measurement methods and shall be presented in a table that summarizes groundwater extractions by water use sector, and identifies the method of measurement (direct or estimate) and accuracy of measurements, and a map that illustrates the general location and volume of groundwater extractions.

c. Surface water supply used or available for use, for groundwater recharge or in-lieu use shall be reported based on quantitative data that describes the annual volume and sources for the preceding water year.

d. Total water use shall be collected using the best available measurement methods and shall be reported in a table that summarizes total water use by water use sector, water source type, and identifies the method of measurement (direct or estimate) and accuracy of measurements. Existing water use data from the most recent Urban Water Management Plans or Agricultural Water Management Plans within the basin may be used, as long as the data are reported by water year.

e. Change in groundwater in storage shall include the following:

   i. Change in groundwater in storage maps for each principal aquifer in the basin.

   ii. A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.

3. A description of progress towards implementing the Plan, including achieving interim milestones, and implementation of projects or management actions since the previous annual report.

5.4 Periodic (5-Year) Evaluations

SGMA regulations require the MGA to evaluate this GSP at least every five years and whenever the Plan is amended, and provide a written assessment to the DWR. (Water Code Sections 10727.2, 10728, 10728.2, 10733.2, and 10733.8). An outline of the procedural and substantive requirements for the periodic evaluations reports is presented below.

To comply with the regulations, the MGA's assessment shall describe whether the Plan implementation, including implementation of projects and management actions, are meeting the sustainability goal in the Basin, and shall include the following:

1. A description of current groundwater conditions for each applicable sustainability indicator relative to measurable objectives, interim milestones, and minimum thresholds.

2. A description of the implementation of any projects or management actions, and the effect on groundwater conditions resulting from those projects or management actions.

3. Elements of the GSP, including the Basin setting, management areas, or the identification of undesirable results and the setting of minimum thresholds and measurable objectives, shall be reconsidered and revisions proposed, if necessary.

4. An evaluation of the Basin setting in light of significant new information or changes in water use, and an explanation of any significant changes. If the MGA's evaluation shows that the Basin is experiencing overdraft conditions, the MGA shall include an assessment of measures to mitigate that overdraft.

5. A description of the monitoring network within the Basin, including whether data gaps exist, or any areas within the Basin are represented by data that does not satisfy the requirements of Sections 352.4 and 354.34(c). The description shall include the following:

    a. An assessment of monitoring network function with an analysis of data collected to date, identification of data gaps, and the actions necessary to improve the monitoring network, consistent with the requirements of Section 354.38.

    b. If the MGA identifies data gaps, the Plan shall describe a program for the acquisition of additional data sources, including an estimate of the timing of that acquisition, and for incorporation of newly obtained information into the Plan.

    c. The Plan shall prioritize the installation of new data collection facilities and analysis of new data based on the needs of the basin.

6. A description of significant new information that has been made available since Plan adoption or amendment, or the last five-year assessment. The description shall also include whether new information warrants changes to any aspect of the Plan, including the evaluation of the basin setting, measurable objectives, minimum thresholds, or the criteria defining undesirable results.

7. A description of relevant actions taken by the MGA, including a summary of regulations or ordinances related to the Plan.

8. Information describing any enforcement or legal actions taken by the MGA in furtherance of the sustainability goal for the basin.

9. A description of completed or proposed Plan amendments.

10. Where appropriate, a summary of coordination that occurred between multiple agencies in a single basin, agencies in hydrologically connected basins, and land use agencies.

11. Other information the MGA deems appropriate, along with any information required by the DWR to conduct a periodic review as required by Water Code Section 10733.

APPENDICES

Appendices are located on the MGA website both individually and within a compiled appendices document.