Section 2 Contents

TABLES

Figures

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, 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 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 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). The boundary between 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*.

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 is defined by both geologic and jurisdictional boundaries (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.

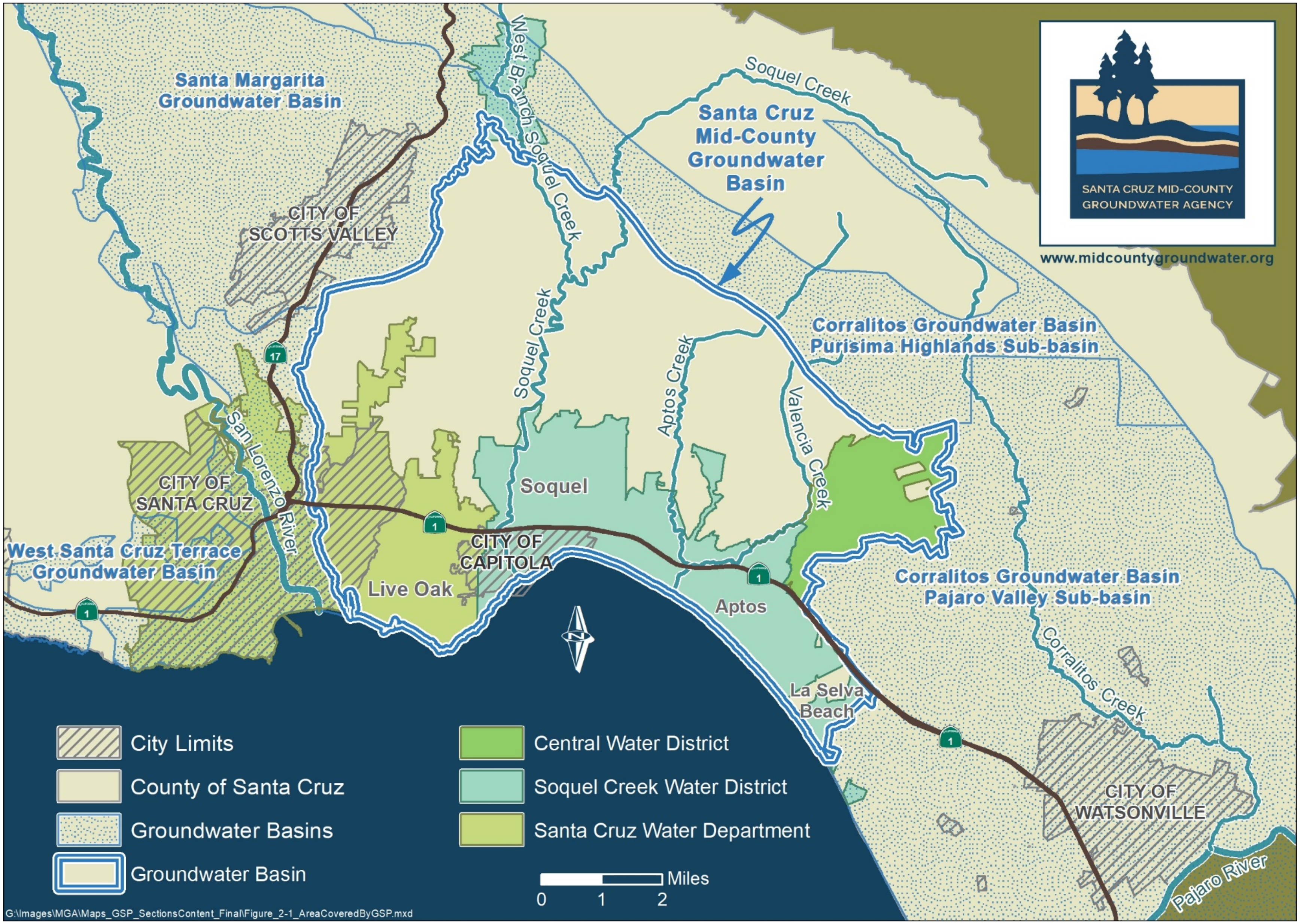

Figure 2-1. Area Covered by the MGA's Groundwater Sustainability Plan

The Basin is adjacent to four neighboring groundwater basins/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 (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, 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 GSP. No areas within the Basin are covered by an Alternative GSP. PV Water, the neighboring groundwater basin manager to the southeast, has a DWR approved Alternative Plan that covers the entire Pajaro Valley Subbasin (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 considered a functional equivalent to a GSP for the Pajaro Valley Subbasin to fulfill PV Water's SGMA planning requirements.

2.1.1.3 Jurisdictional Boundaries within the Basin

The Basin extends from the Santa Cruz Mountains to the Pacific Ocean and from the edge of the City of Santa Cruz near Twin Lakes in the 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).

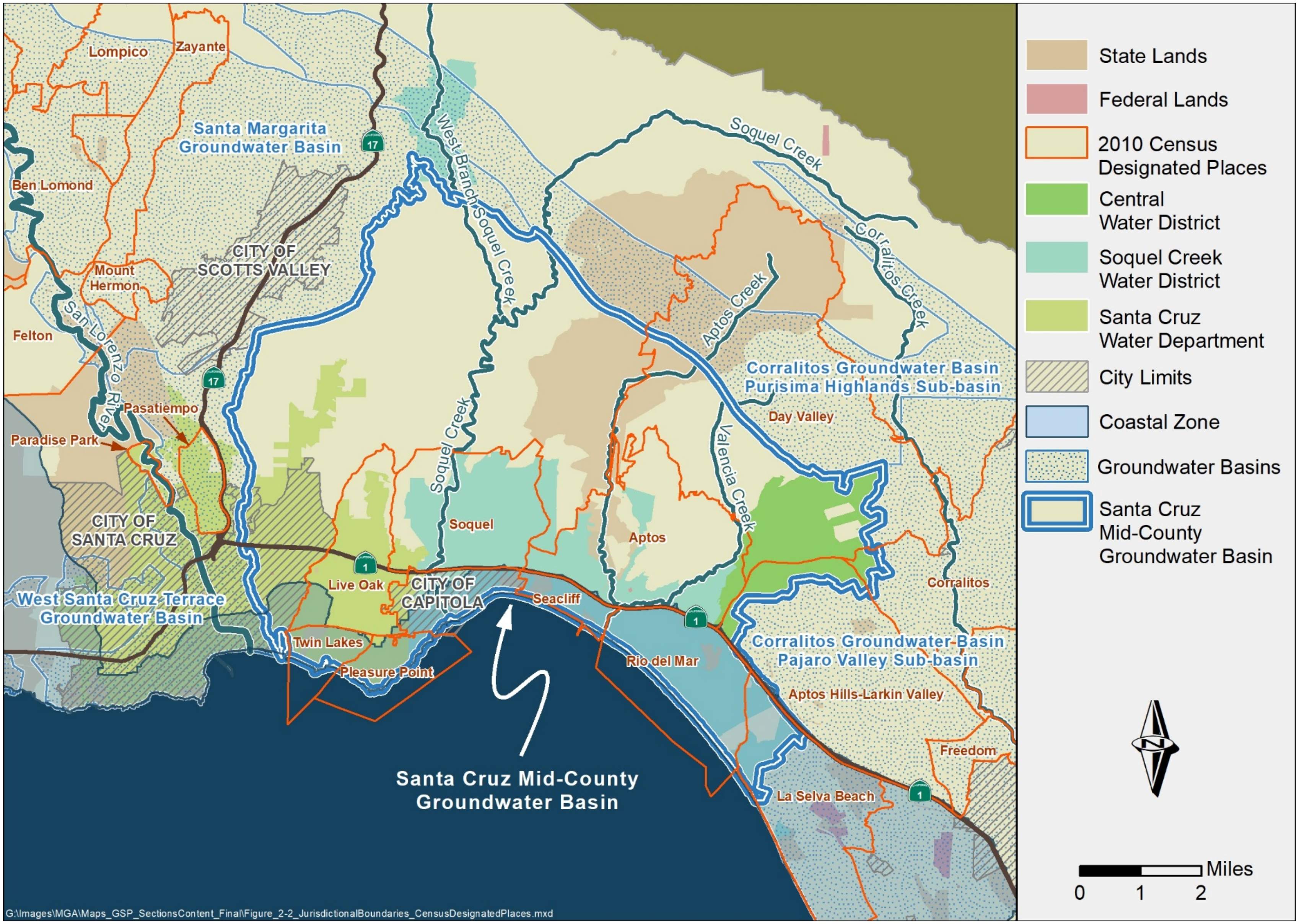

Figure 2-2. Jurisdictional Boundaries and Census Designated Places in or near the Santa Cruz Mid-County Groundwater Basin

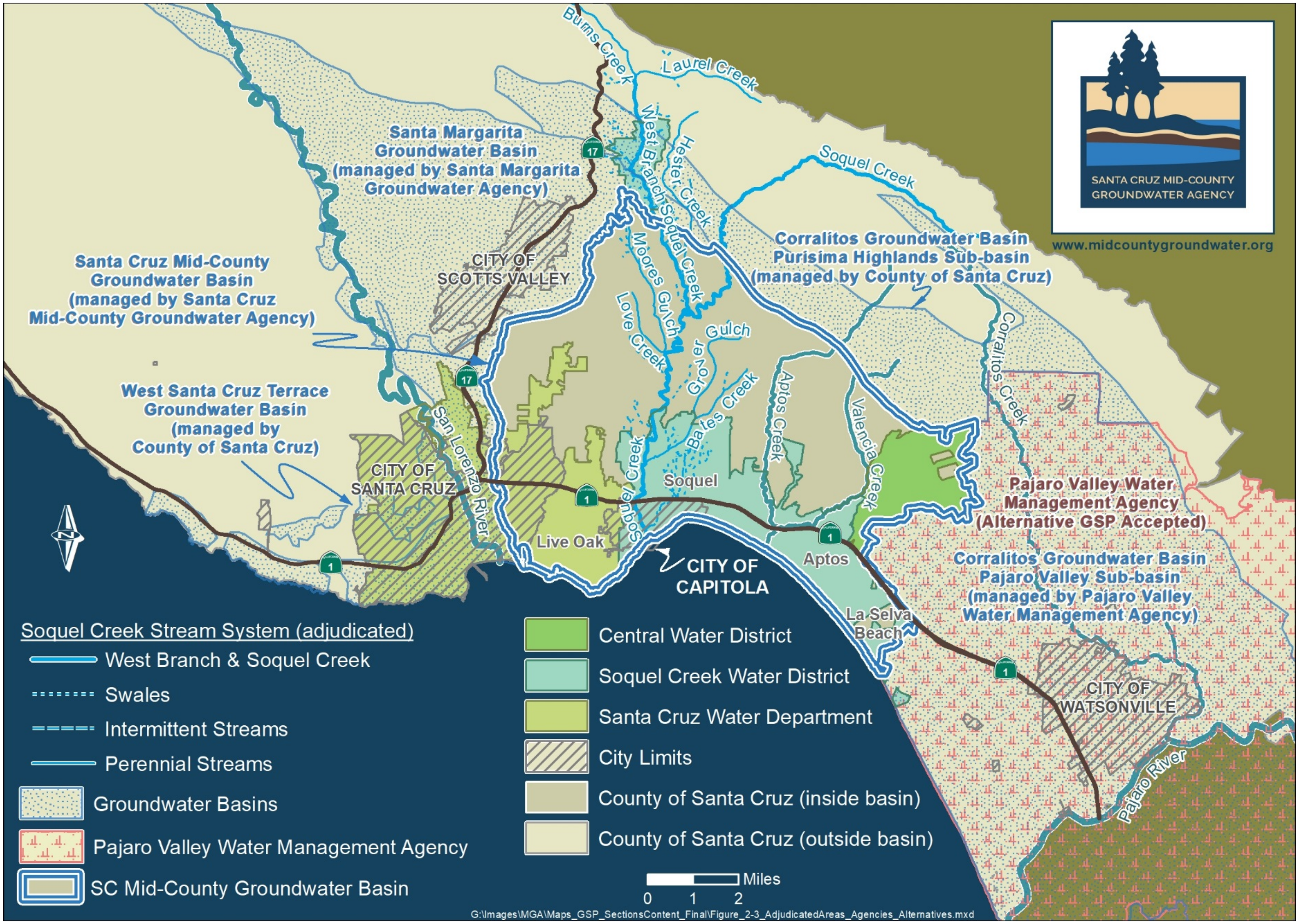

Figure 2-3. Adjudicated Areas, Other Agencies within the Basin, and Areas Covered by an Alternative Plan

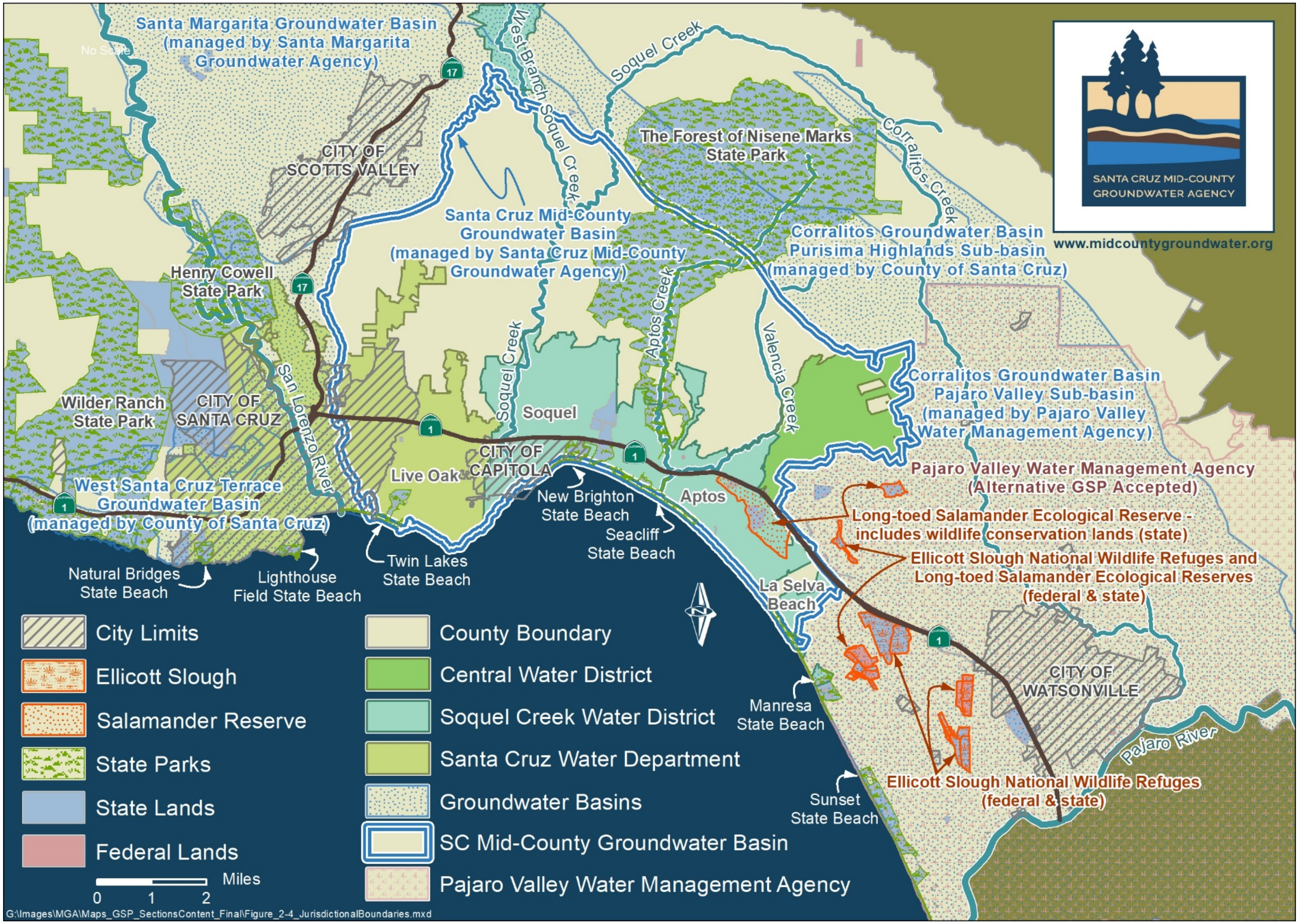

Figure 2-4. Jurisdictional Boundaries of Federal or State Lands

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 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 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 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, 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 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 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

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.

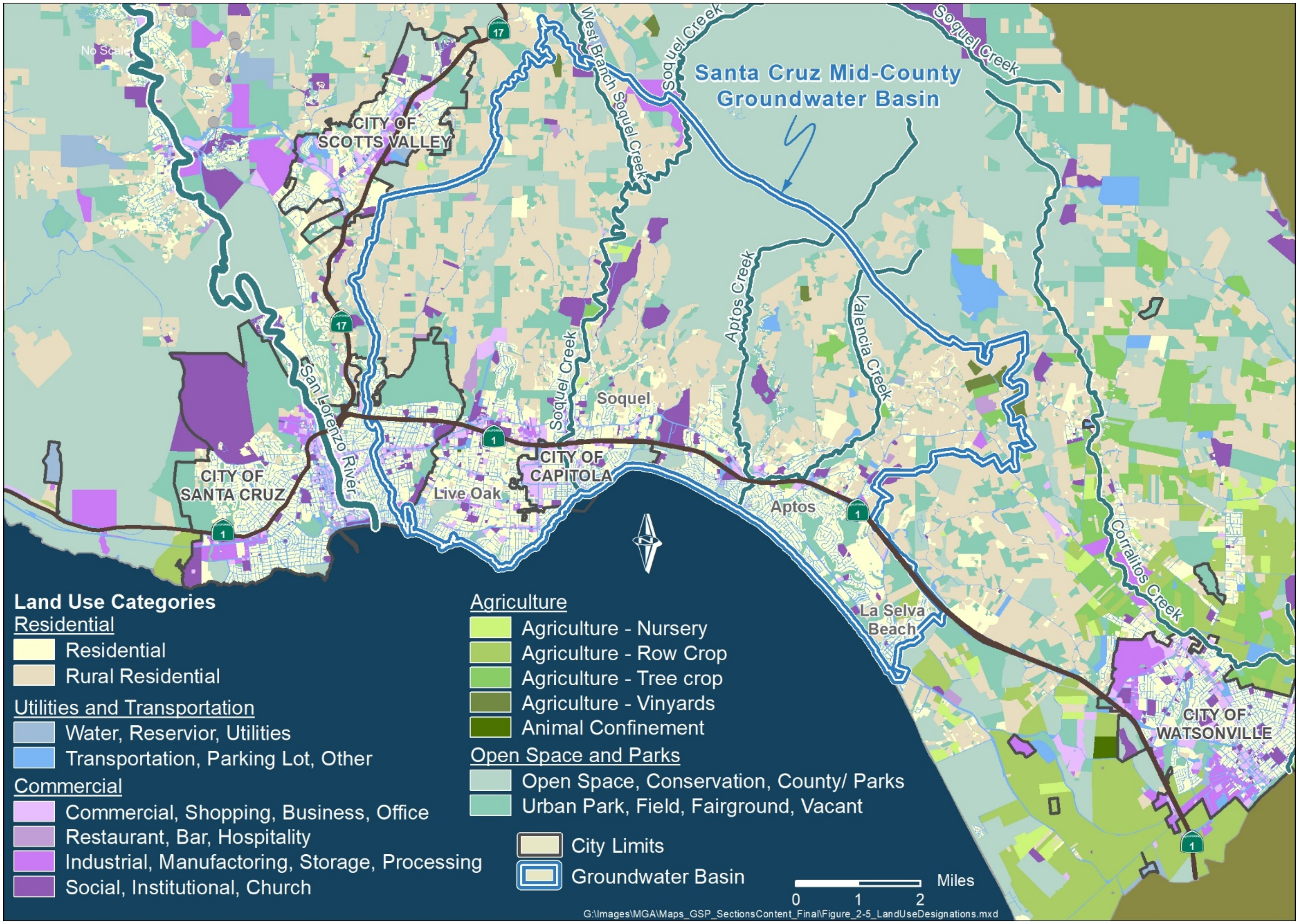

Figure 2-5. Existing Land Use Designations

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 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

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 non-municipal wells, shared wells, 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 non-municipal wells, small and mutual water 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 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 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 analyses to assess the compatibility and identify potential issues related to supplying treated surface water from the SCWD's system to SqCWD's distribution system, which normally only distributes groundwater. The pilot project supplies surface water treated to drinking water standards to a portion of 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 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 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, health concerns or operational constraints) SCWD and SqCWD 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 non-municipal wells drilled prior to 1971.

Because the actual number and location of all non-municipal water supply wells is unknown, the MGA developed a non-municipal well map that uses the best available data to 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. Per GSP regulations, a well density map on Figure 2-6 uses a one-mile square grid to show well density across the Basin. Most non-municipal wells are in inland developed rural areas with relatively fewer non-municipal wells occurring within a mile from the coast. The exception is near the town of Soquel's southwestern border with the City of Capitola, where Soquel SqCWD's service area does not extend more than one half mile from the coast. At this location there are approximately 70 non-municipal water supply wells within a mile of the coast.

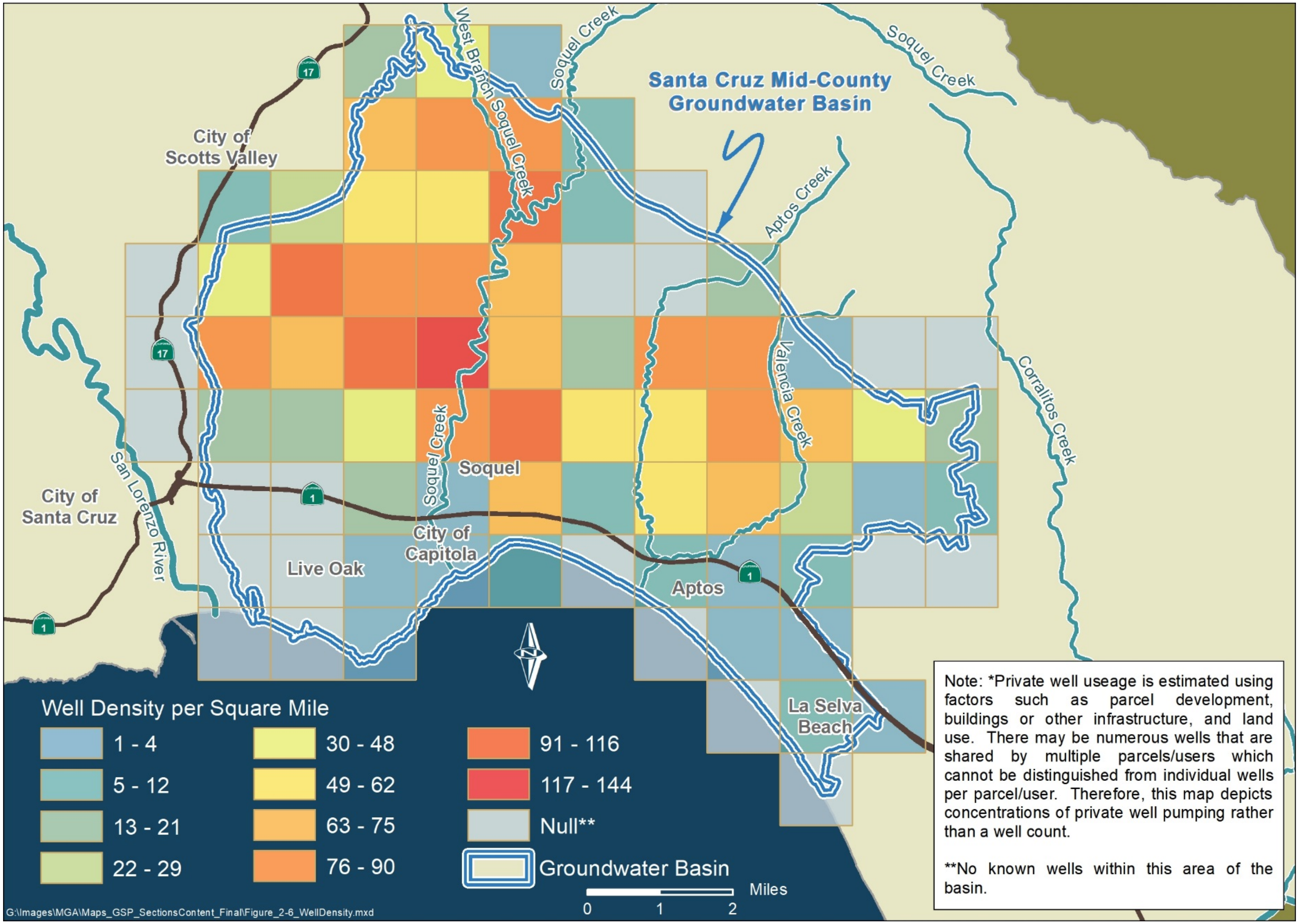

Figure 2-6. Well Density per Square Mile

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 (Hickey 1968) shortly after SqCWD and the 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 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 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 storm water management, and environmental stewardship. More than 80 projects and technical studies have been funded under this program. Prior projects provide data 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 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 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 to evaluate surface water 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 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 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, 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 groundwater quality related to seawater intrusion. These monitoring data 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 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 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 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 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 O'Neill or Polo production wells as part of a pumping redistribution, they cannot be fully utilized if restrictive 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 capabilities. Until December 2018, these interties were historically used only to transfer water between agencies in emergency circumstances. In recent years, as described below, 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, 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 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

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 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 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 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 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 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.

The Conservation and Open Space Element of the County General Plan includes many policies and programs for protection and management of groundwater resources, 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, 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.

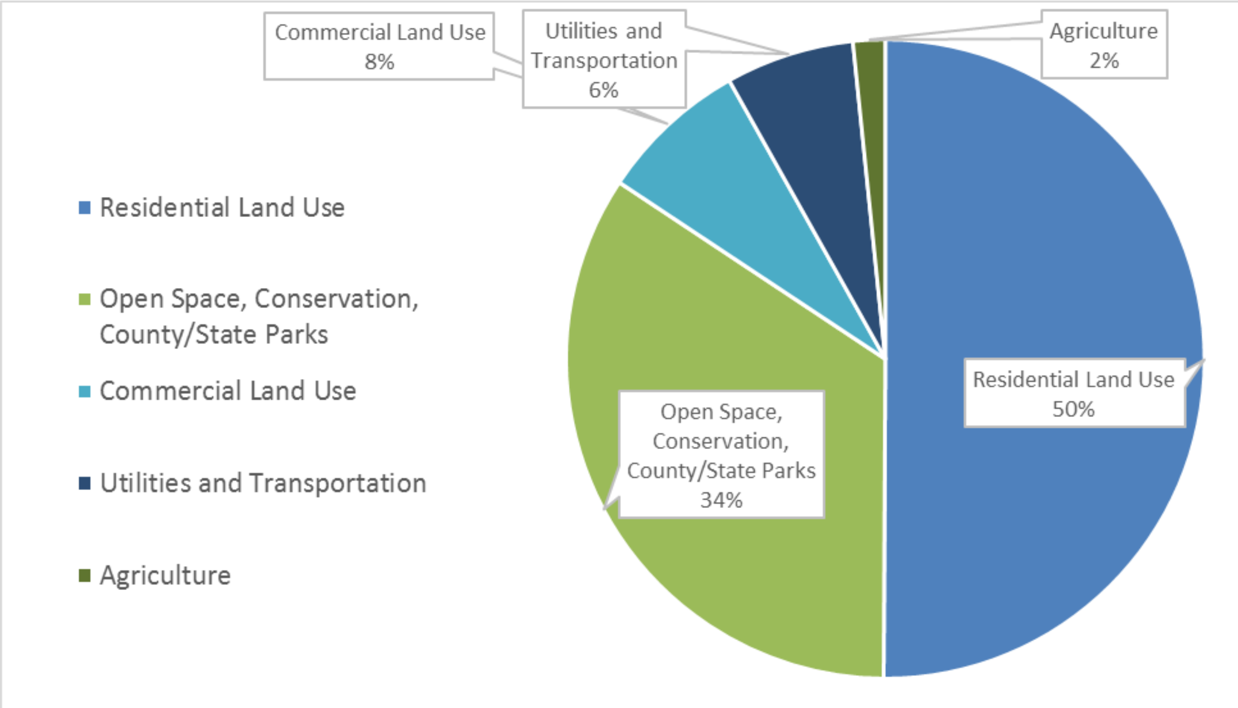

Figure 2-7. Basin Land Uses

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 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 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.

.

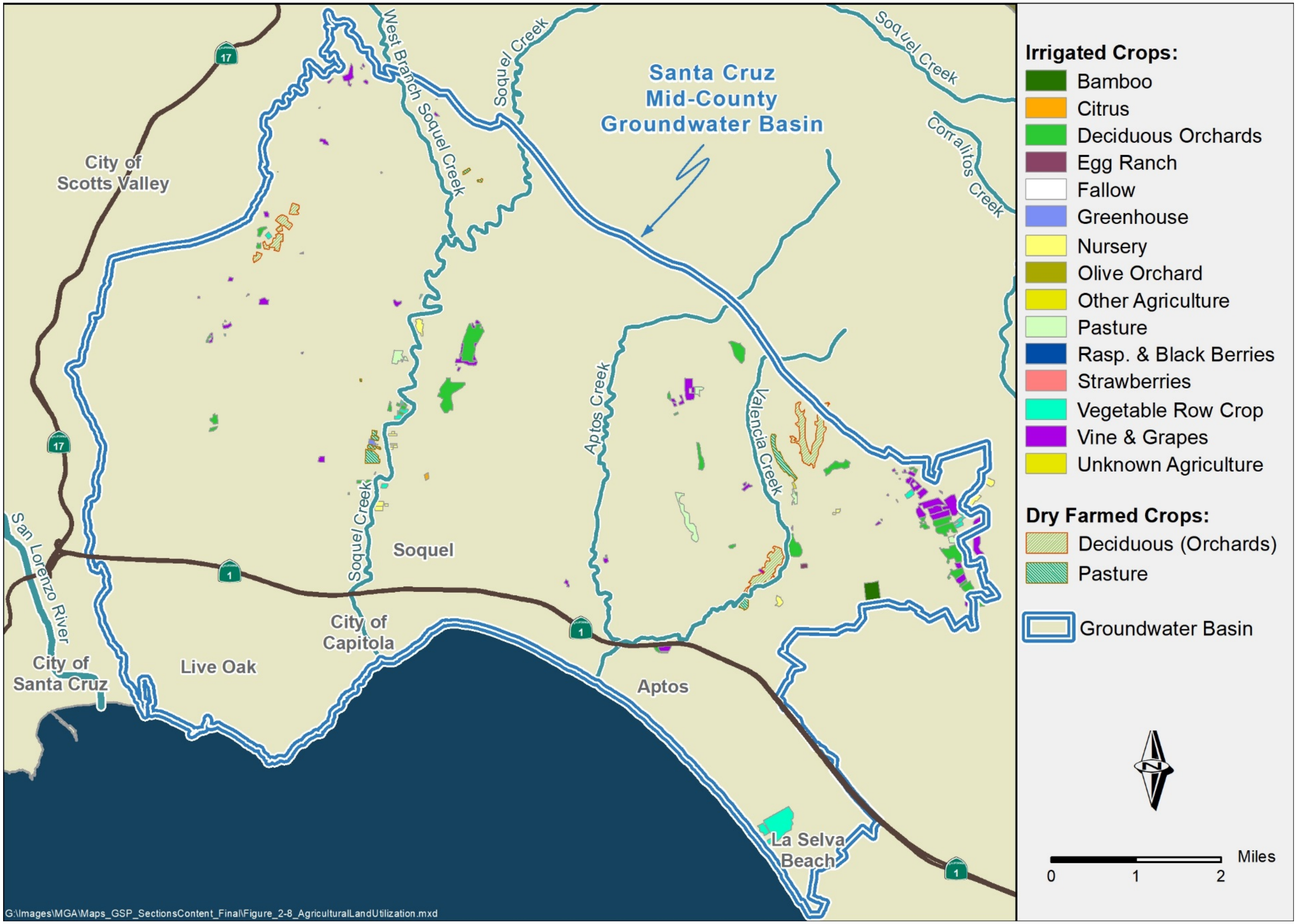

Figure 2-8. Agricultural Land Utilization within the Santa Cruz Mid-County Basin

The MGA acknowledges that there is room for error in this agricultural irrigation water use estimation process. To get a more accurate 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.

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 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 2-9 shows the amount of Basin groundwater produced by pumper category. Approximately 2% of the non-municipal domestic category includes use for small water systems.

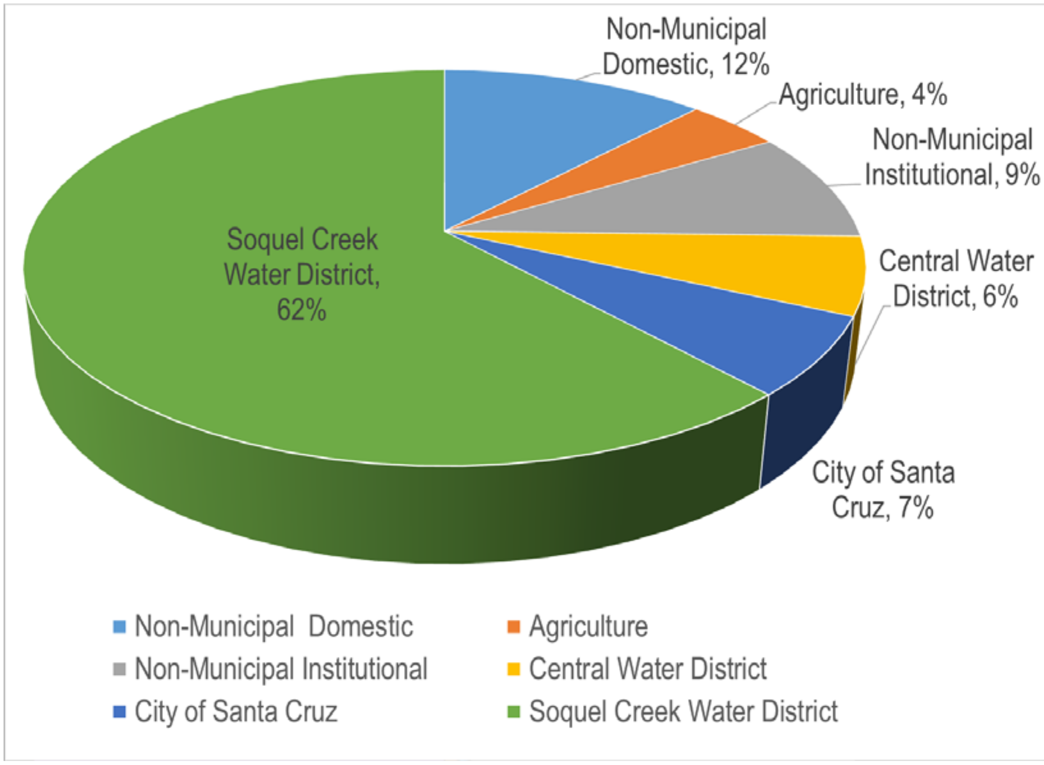

Figure 2-9. Average Annual Basin Groundwater Production by User Type

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 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 remains stable.

- City of Santa Cruz – projections of groundwater pumping in the Basin are based on City of Santa Cruz 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, 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, 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: https://www.codepublishing.com/CA/Capitola/#!/Capitola08/Capitola0824.html#8.24

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 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 alluvium 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 (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 is still considered in long-term overdraft due to ongoing seawater 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)) and in a technical memorandum titled Management Implications of SkyTEM Seawater Intrusion Results ((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 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 DWSAPs:
    - Soquel Creek Water District has submitted DWSAP for all its production wells. Access to 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 DWSAP reports for all its wells in 2009 (Johnson, 2009);
    - City of Santa Cruz has submitted DWSAP 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:

<u>Land Use - Sewage Disposal - Waste Water Management</u>
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.

<u>Hazardous Materials Programs - Certified Unified Program Agency (CUPA)</u>
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.

<u>Site Mitigation</u>
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.

<u>Water Resources</u>
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" (Fisher et al., 2017). The project studied the possibility for effective groundwater replenishment throughout Santa Cruz County, including within the Basin. 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 the Basin to provide storage for subsequent extraction. 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 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.

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 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 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 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 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 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. 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 above, MGA member agencies, City of Santa Cruz and Soquel Creek Water District, are pursuing conjunctive use underground storage projects. Both 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 Sections 2.1.4.12 and 2.1.5.2.2 below, 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 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:

- 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:

- 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 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 Nature Conservancy (2019) to identify important species present in 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.

Technical staff presented and discussed the information with the Surface Water Working Group 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	
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 GDEs will focus on:
  - Areas of highest groundwater extraction, and
  - Where streams are interconnected with groundwater.

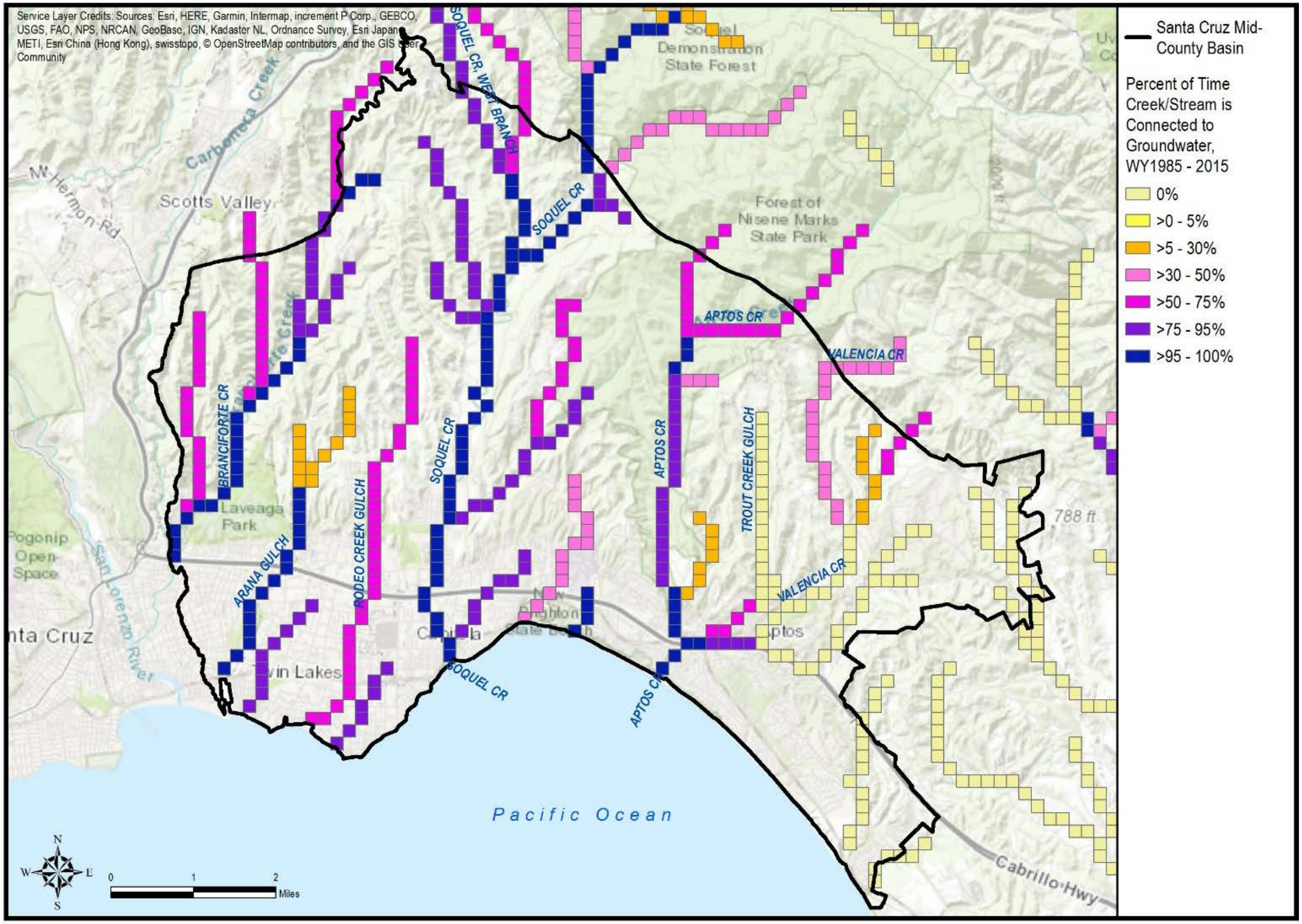

Figure 2-10. Percentage of Time Surface Water and Groundwater are Connected (Water Years 1985-2015)

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 temporary committee of the MGA Board made up of Board members and supported by MGA staff.

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 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 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.

<u>Agricultural users</u>: There is limited farming within the Basin that only uses approximately four percent of total Basin groundwater extracted. The majority of agriculture is 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 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.

<u>Non-Municipal Domestic Well Users</u>: Private residential well owners are estimated to pump approximately 10% of the water used from the 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 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: 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 extract approximately 75% of all groundwater pumped from the Basin. The MGA 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.

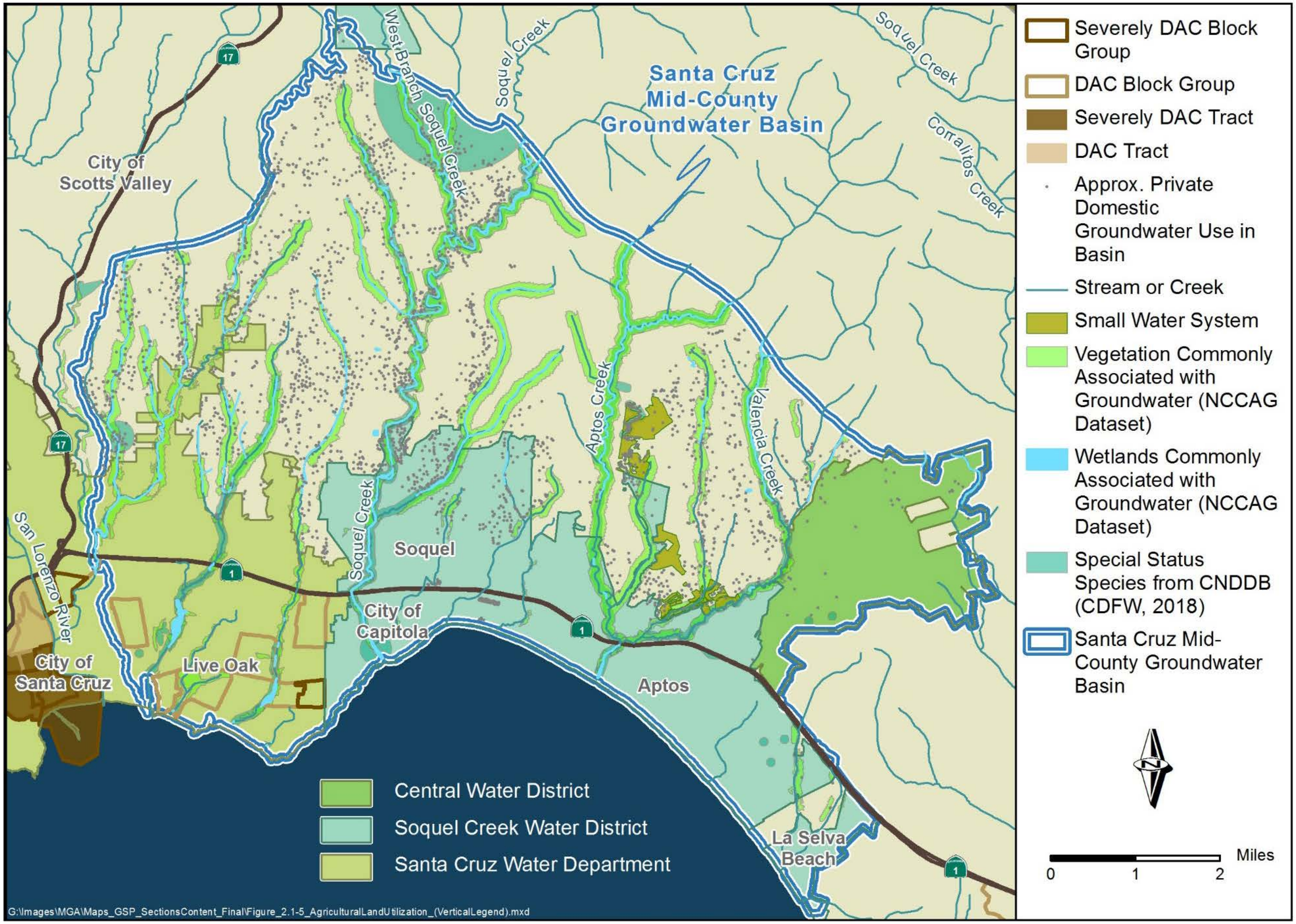

Figure 2-11. Locations of Beneficial Users in the Santa Cruz Mid-County Basin

Environmental Users of Groundwater: The Basin 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 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 depletion from groundwater extractions.

Surface Water Users with a Connection to Groundwater: The 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 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 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. County staff is in contact with representatives of the Amah Mutsun Tribal Band on Basin water issues.

Disadvantaged Communities (DAC) – Data from DWR's DAC mapping tool identifies seven DACs, including one severely disadvantaged community within the Basin; 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. The DAC designation is based upon median household income from the US Census American Community Survey 5-Year Data (2012 – 2016). Disadvantaged communities 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 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 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 created a GSP Nominating Committee to advertise GSP Advisory Committee openings, accept and review applications, interview candidates, and 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. 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. 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 JPA that created the MGA requires the regional 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 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 GSP Advisory Committee 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 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 support board 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 Committee's responsibilities 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 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 conditions. The Committee also agreed to work collaboratively in an open and public process to ensure community concerns 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.

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

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.

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 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.

<u>MGA Website:</u> 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.

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

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

<u>Bi-Monthly Board Meetings:</u> 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 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 2-2. 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 • 37 MGA, SAGMC, BIG, GSA FC meetings between February 2014 and 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	37 public Board meetings between February 2014 and 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

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 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 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 held two public outreach meetings on July 20th and 22nd to introduce and summarize the Plan. An additional Q&A session was held on August 28, 2019. The Board of Directors accepted comments on the Draft GSP during the MGA public comment period from July 18-September 19, 2019. The MGA Board of Directors established a temporary GSP Comment Committee on September 19, 2019 to provide MGA staff with oversight and 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).

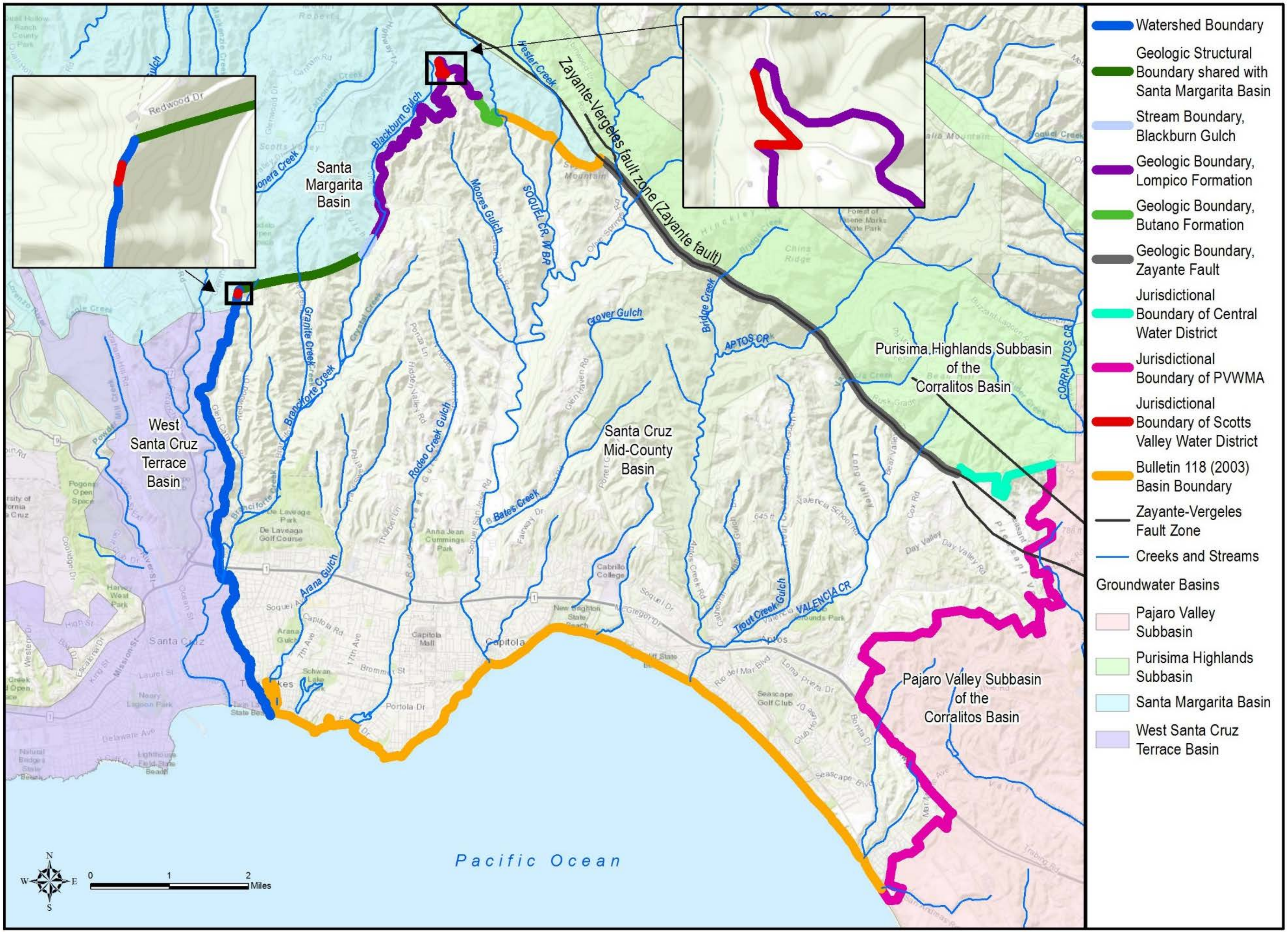

Figure 2-12. Santa Cruz Mid-County Basin Modification Rationale

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.

2.2.3 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 occurrence of groundwater and its movement in and out of the Basin. The HCM is also the conceptual model for developing the numerical integrated surface water-groundwater GSFLOW model used to simulate future Basin conditions based on changing climate and future groundwater projects and management 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 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).

Figure 2-13 provides a schematic basin conceptual model to describe general inflows and outflows within the Basin, including those to the Pacific Ocean and neighboring basins.

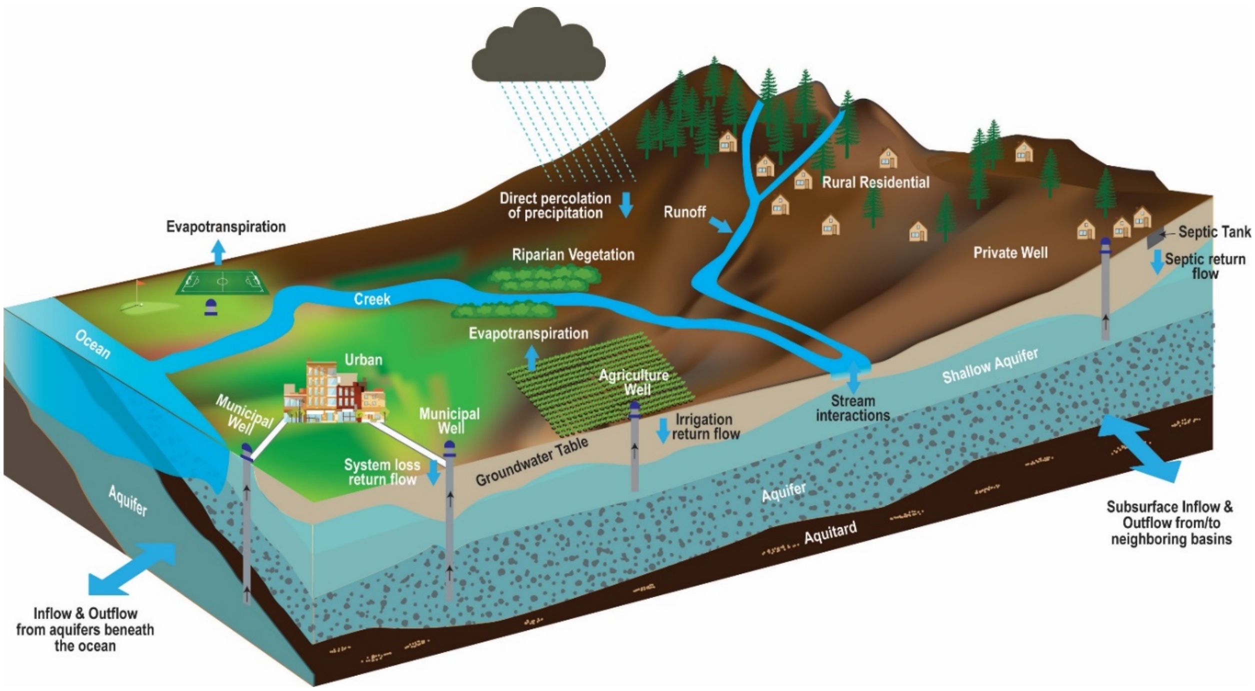

Figure 2-13. Santa Cruz Mid-County Basin Conceptual Model

The Basin extends ten miles from the Santa Cruz Mountains 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 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

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.

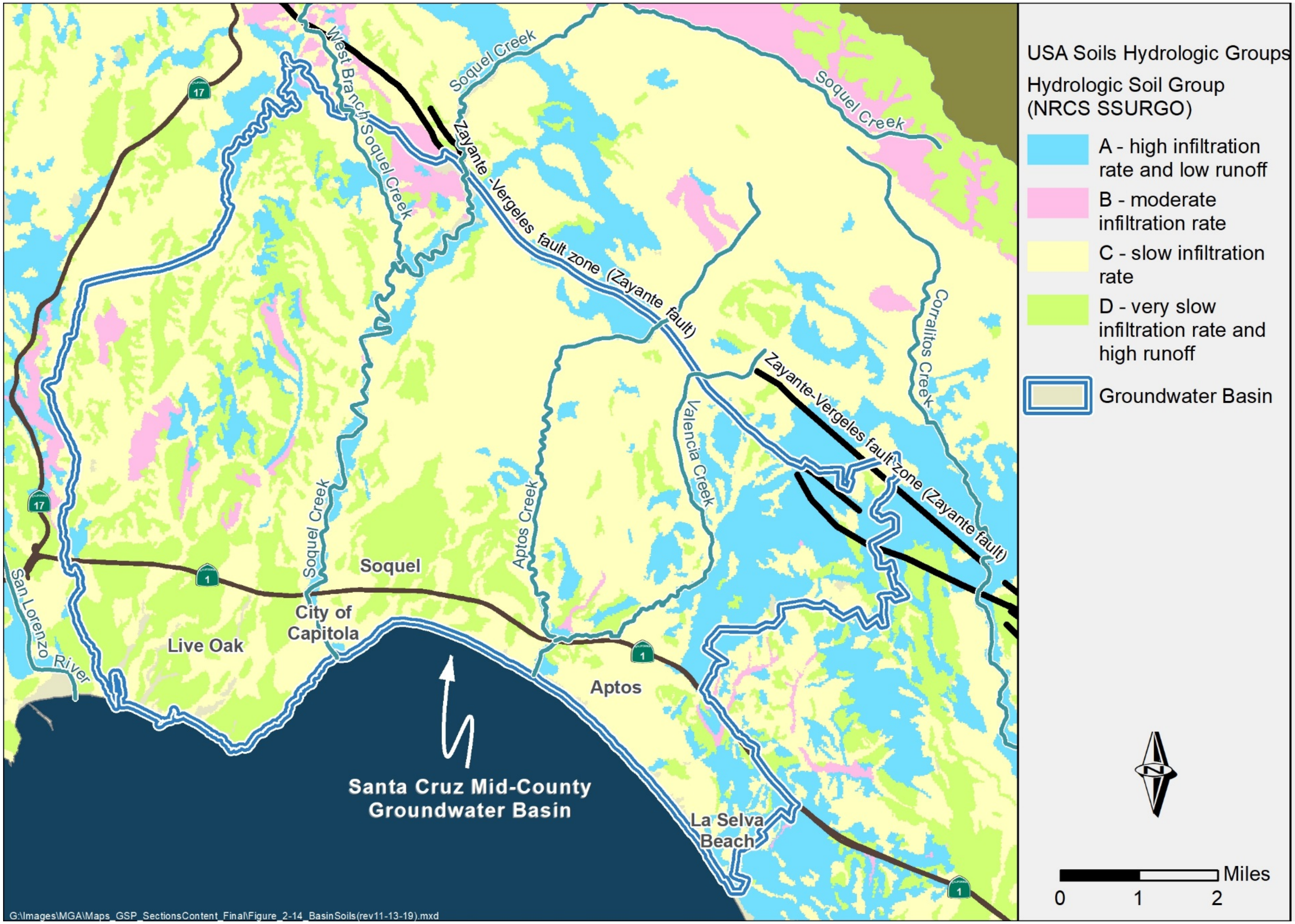

Figure 2-15. Basin Soils

2.2.3.3 Surface Geology

As discussed above, two main geologic formations occur across the Basin: the Purisima Formation and the Aromas Red Sands. 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

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 2-16).

2.2.3.3.2 Aromas Red Sands

The Pleistocene age Aromas Red Sands (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.

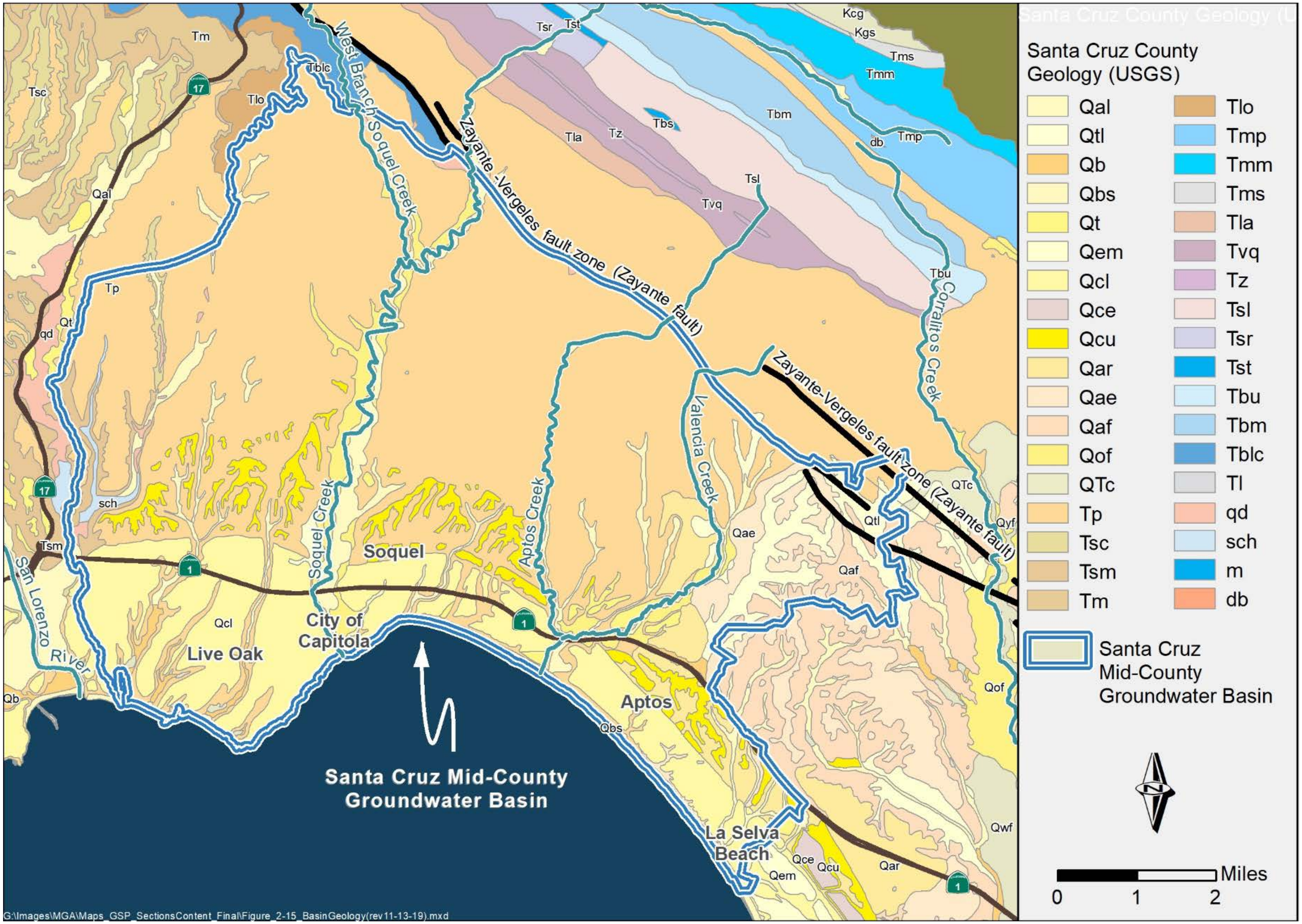

Figure 2-16. Basin Surface Geology

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. The Purisima Formation also occurs within a tightly folded syncline north of the Zayante-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

2.2.3.5.1 Aquifer and Aquitard 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. 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 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, 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).

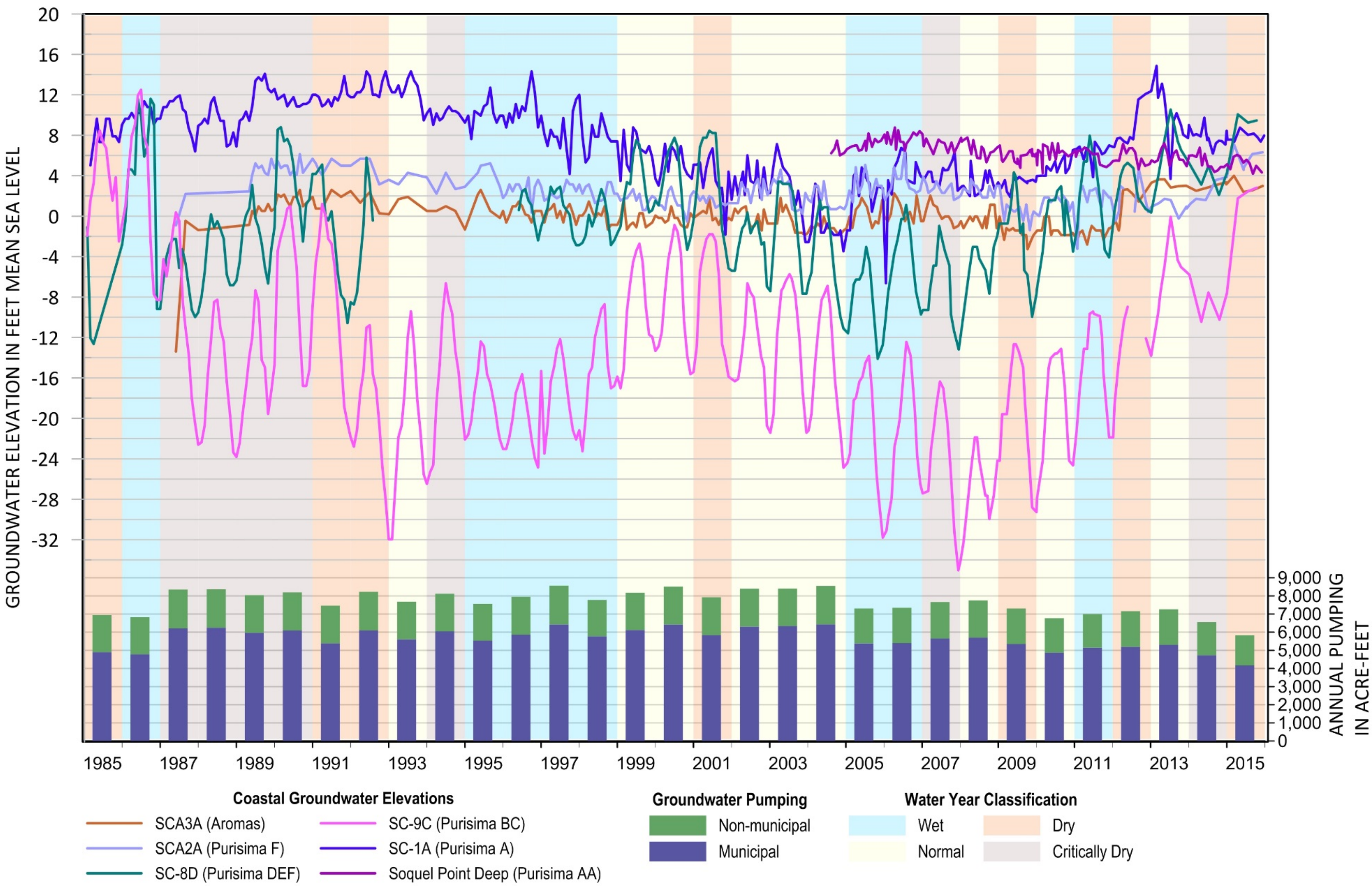

Figure 2-17. Coastal Groundwater Elevations Compared with Historical Basin Pumping (1985-2015)

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 feet of LSCE unit D is predominantly 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. (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.

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.

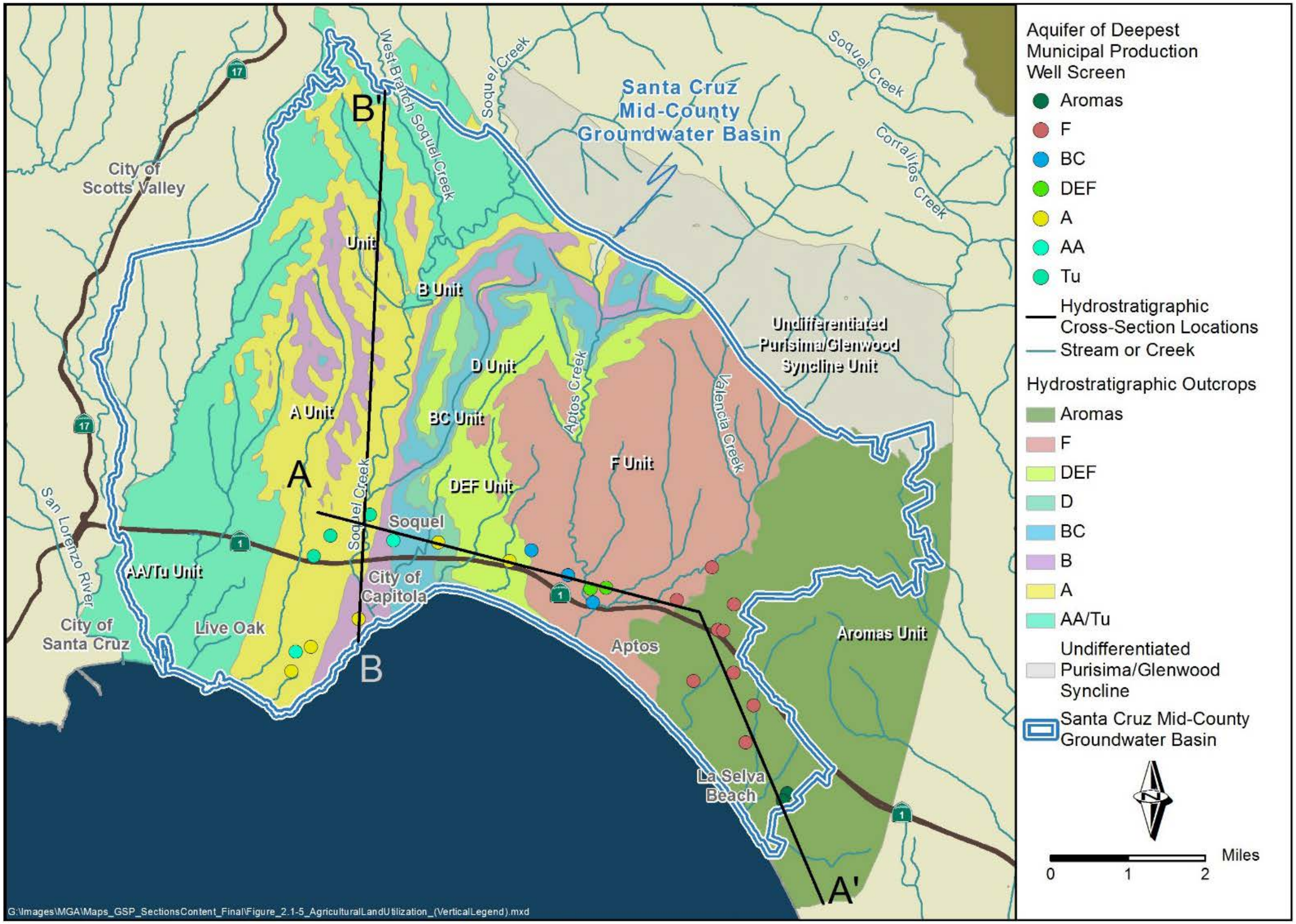

Figure 2-18. Aquifer and Aquitard Distribution Across the Basin

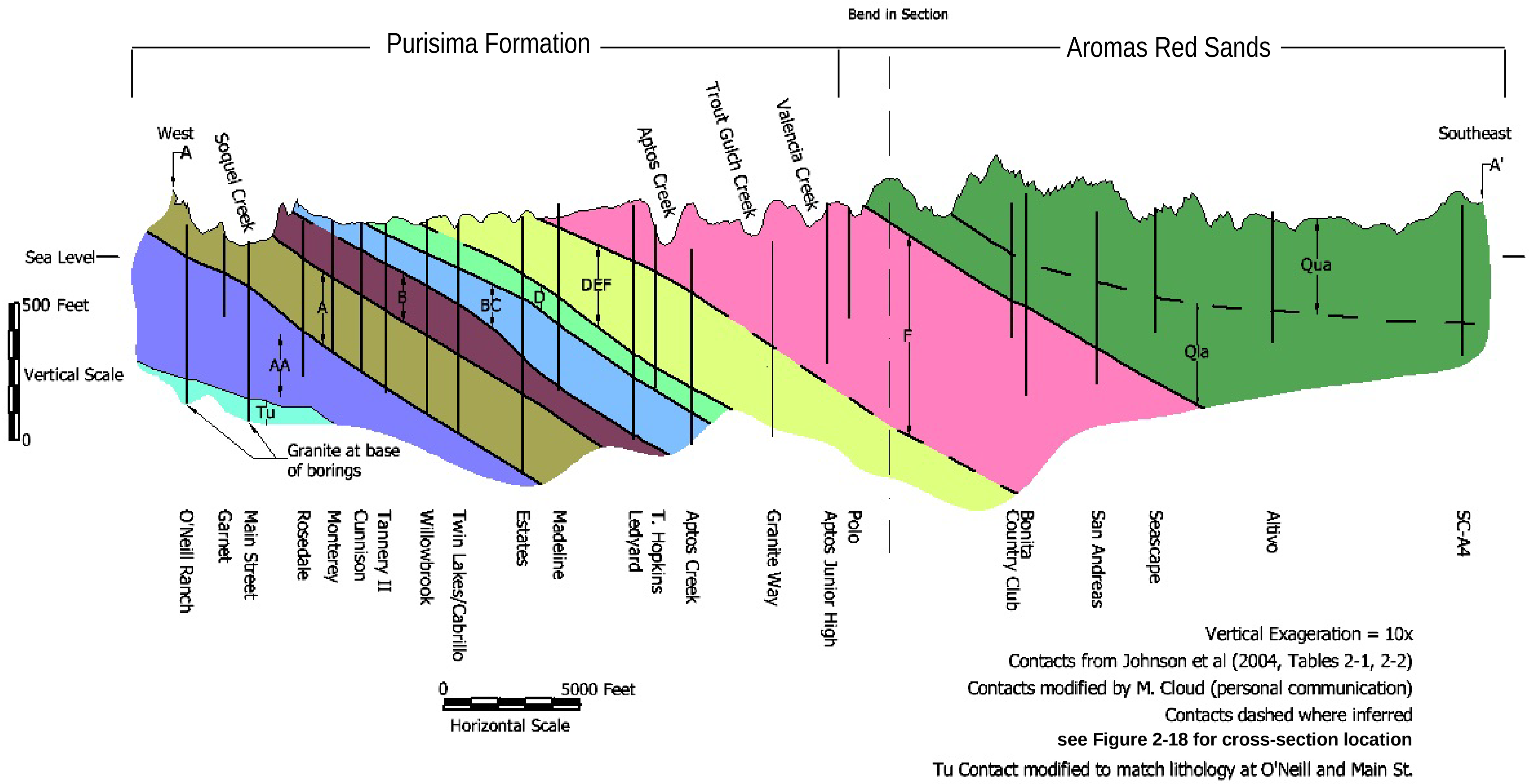

Figure 2-19. Hydrostratigraphic Cross-Section, A – A'

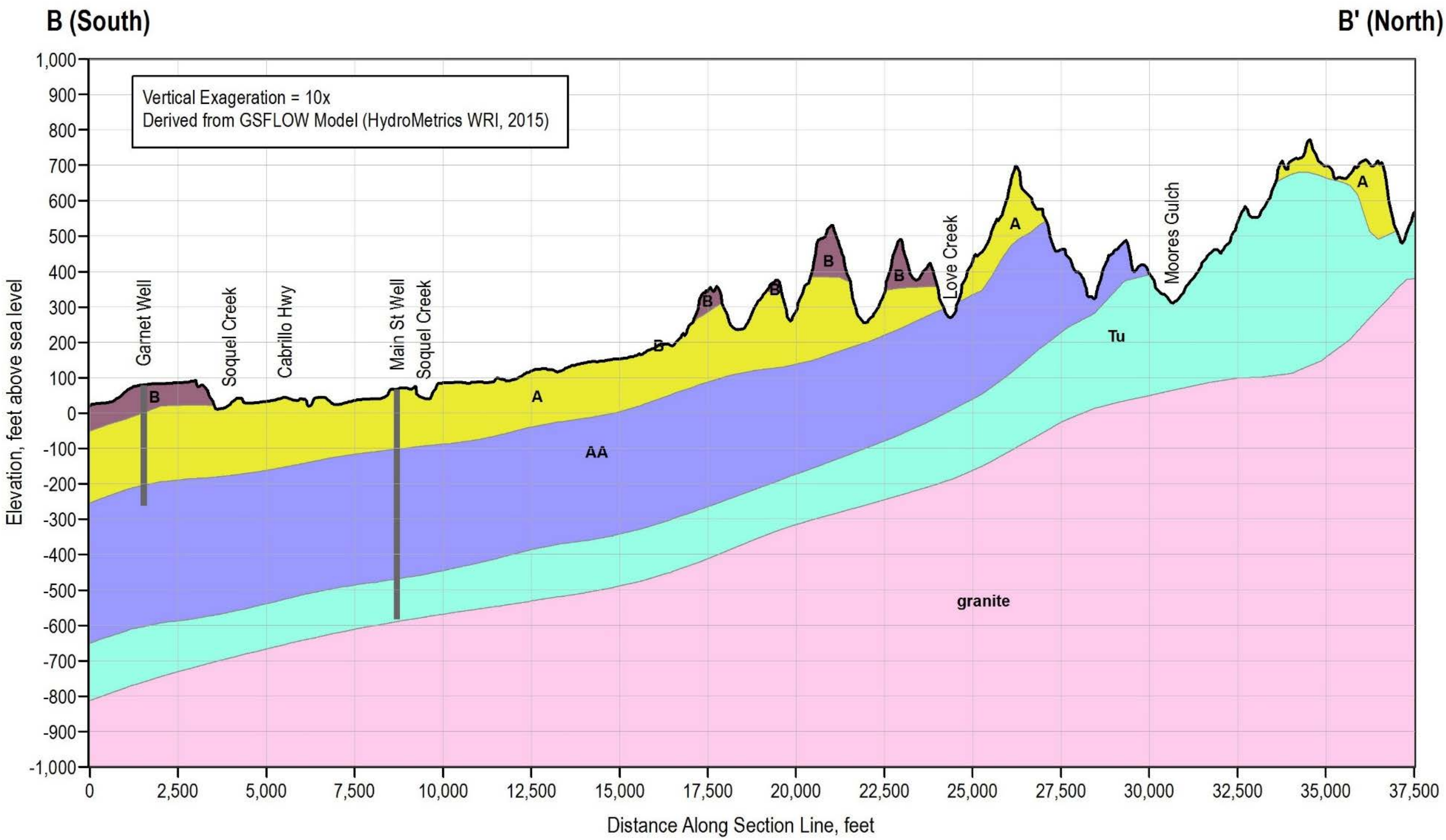

Figure 2-20. Hydrostratigraphic Cross-Section, B – B'

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.

2.2.3.6 Surface Water Bodies Significant to Basin Management

DWR regulations requires the 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 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 detail in Sections 2.1.4.12; 2.2.4.6; and 2.2.4.7. Figure 2-21 shows the location of significant surface water bodies in the Basin.

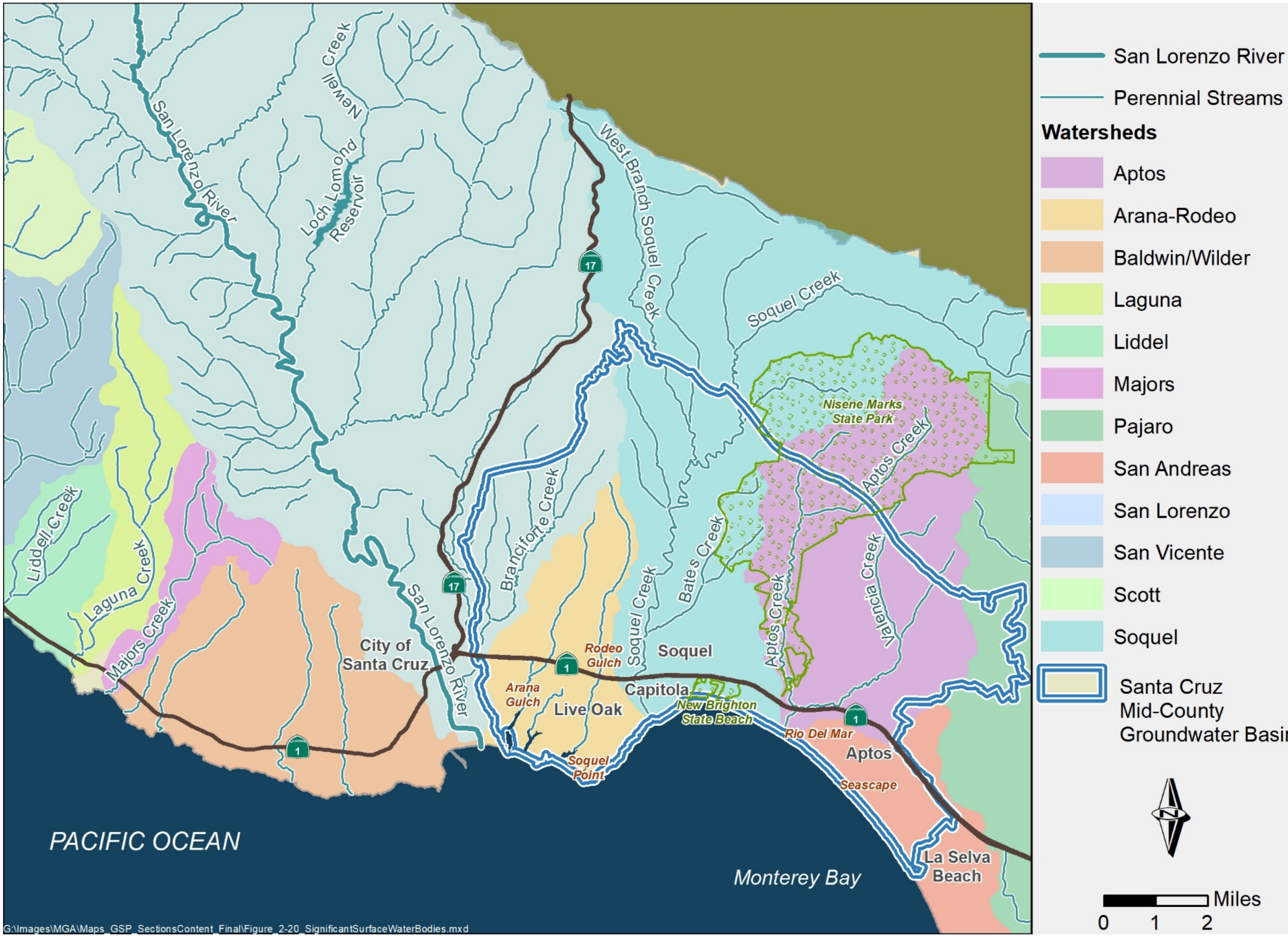

Figure 2-21. Significant Surface Water Bodies

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 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.

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, SCWD also has supplied SqCWD with treated drinking water when SCWD has excess surface water available. This water transfer from SCWD to SqCWD is part of a conjunctive use pilot project. The pilot project is an in-lieu water transfer that began delivering treated surface water to SqCWD customers in December 2018 to fulfill an agreement negotiated in 2016. This in-lieu water transfer allows less groundwater pumping from the wells that typically serve SqCWD customers. Reduced pumping allows natural recharge to occur.

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.

2.2.3.6.4 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; 2.2.4.6; and 2.2.4.7.

2.2.3.7 Recharge Areas and Water Deliveries

2.2.3.7.1 Basin Recharge Areas

Recharge to the Basin occurs through natural processes, groundwater recharge projects developed or permitted by MGA member agencies, or by percolation directly from water-related infrastructure, such as from leaks in water, wastewater, storm water delivery systems, and from septic systems in unsewered portions of the Basin. Natural recharge zones have been mapped 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 2-18 shows the “outcrop” of the Basin’s aquifers, however, the hydrostratigraphic units do not always outcrop at the surface as they are often covered by alluvium or coastal terrace deposits (Figure 2-16).

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 SCWD or as part of the in-lieu water transfer pilot project between SCWD and 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.

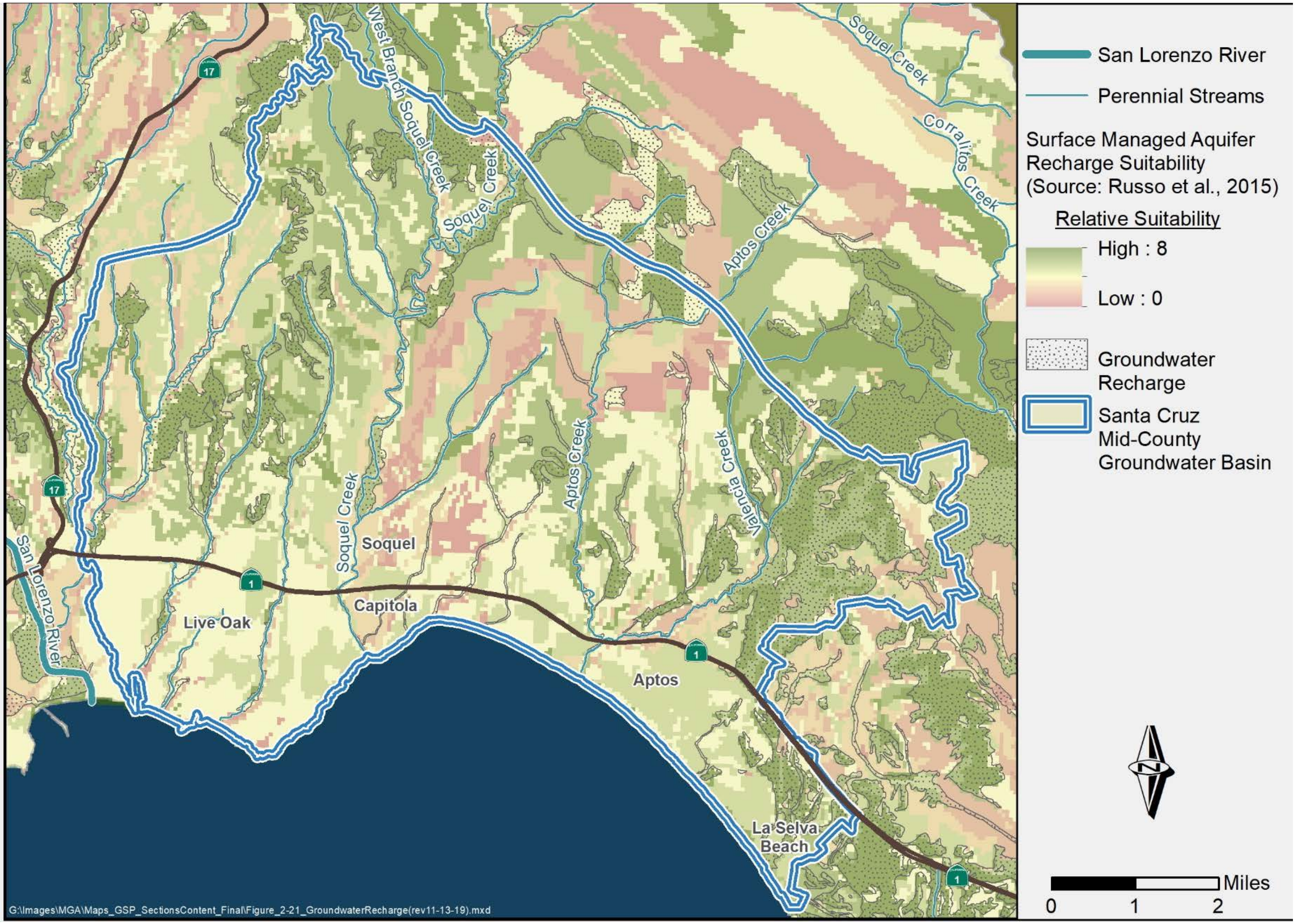

Figure 2-22. Groundwater Recharge Zones

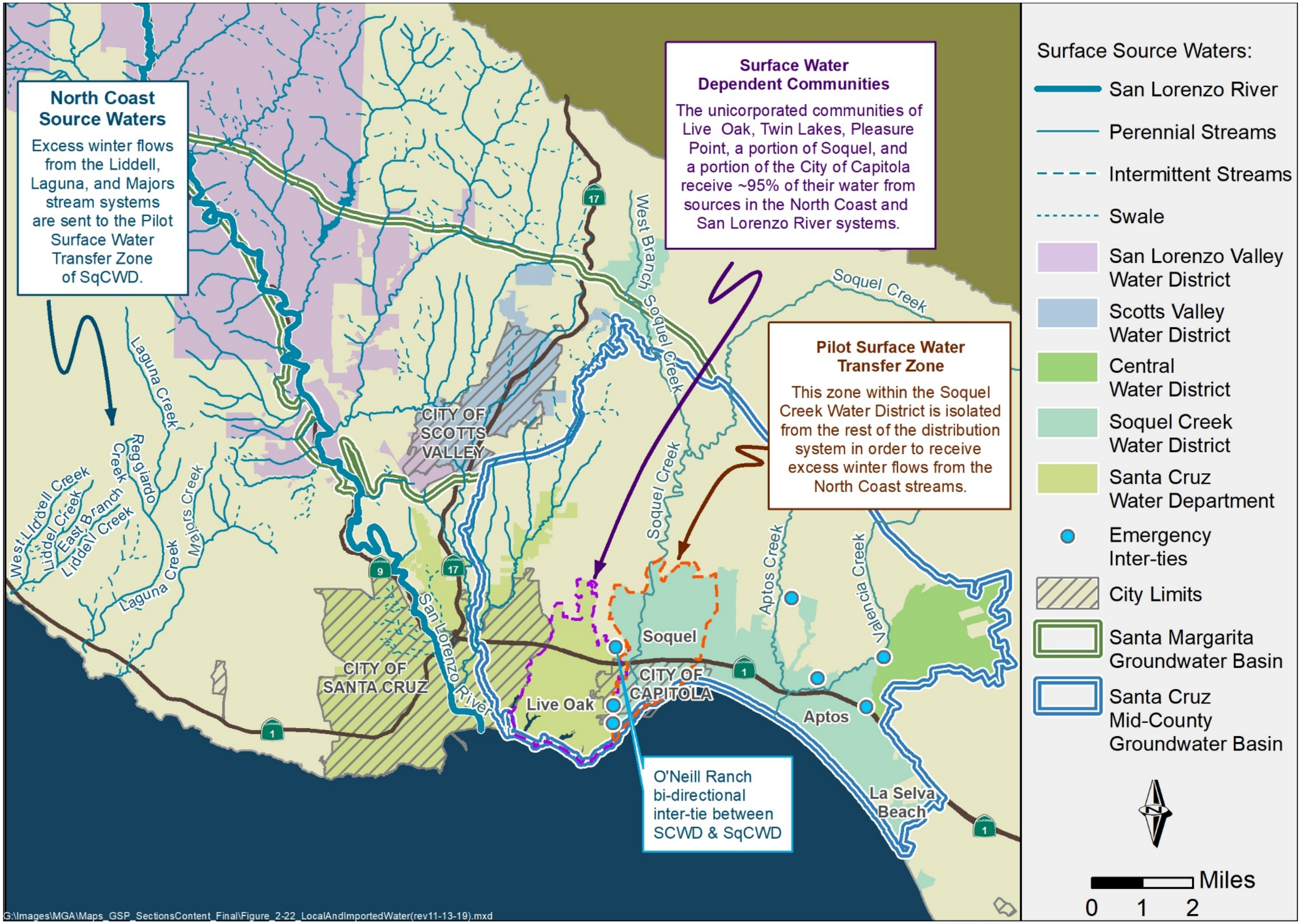

Figure 2-23. Local and Imported Water

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.

2.2.4 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.[3] 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, 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 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.

2.2.4.1 Groundwater Elevation Data

2.2.4.1.1 Historical Groundwater Elevations

Long-term overdraft of the Basin has led to ongoing 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 and Purisima F-unit aquifers. Only a small area south of the Country Club production well had

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

groundwater elevations below sea level. Hydrographs of Aromas and Purisima F-unit wells on 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.

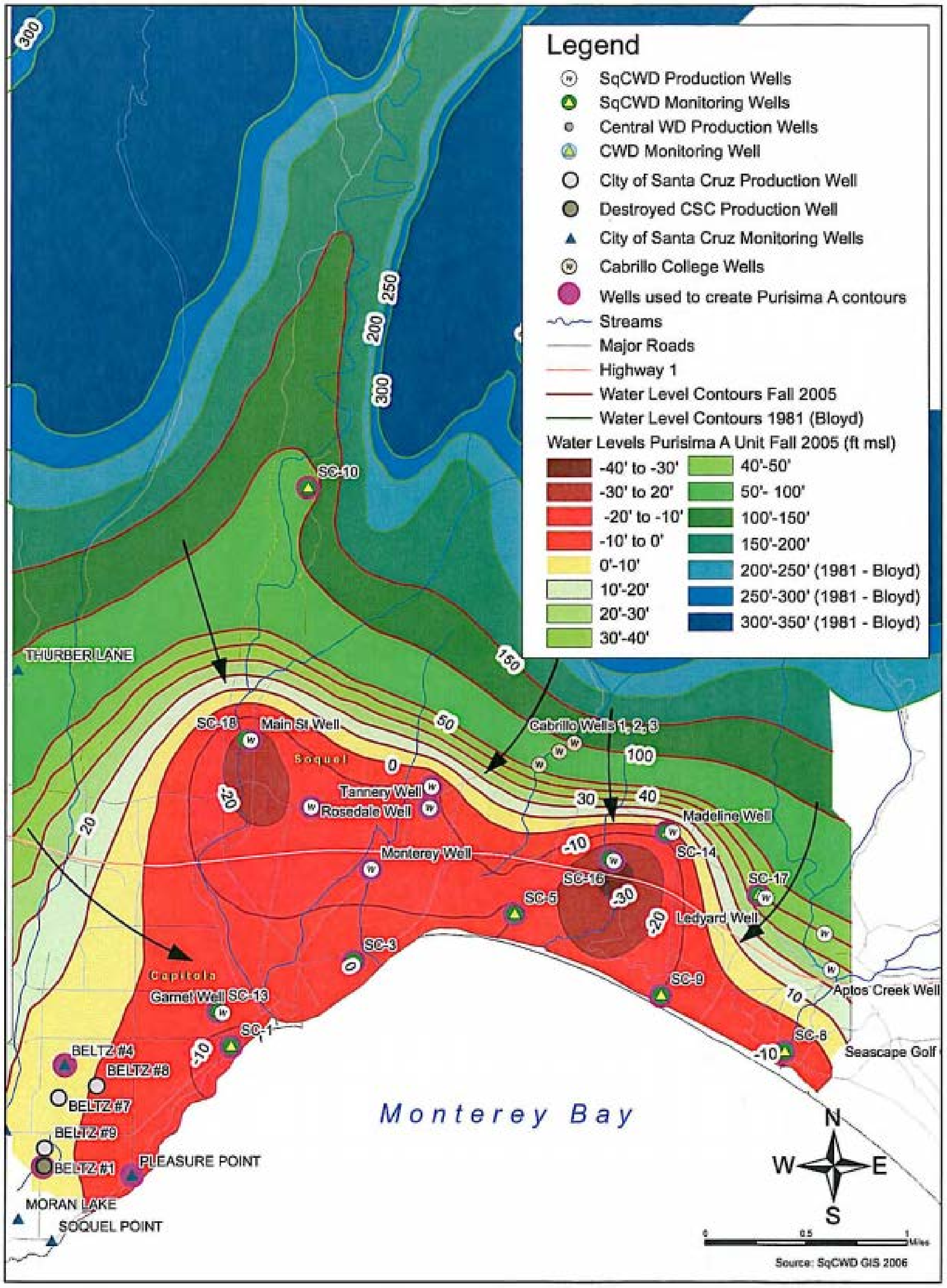

Figure 2-24. Groundwater Elevation Contours in Purisima A-Unit, Fall 2005

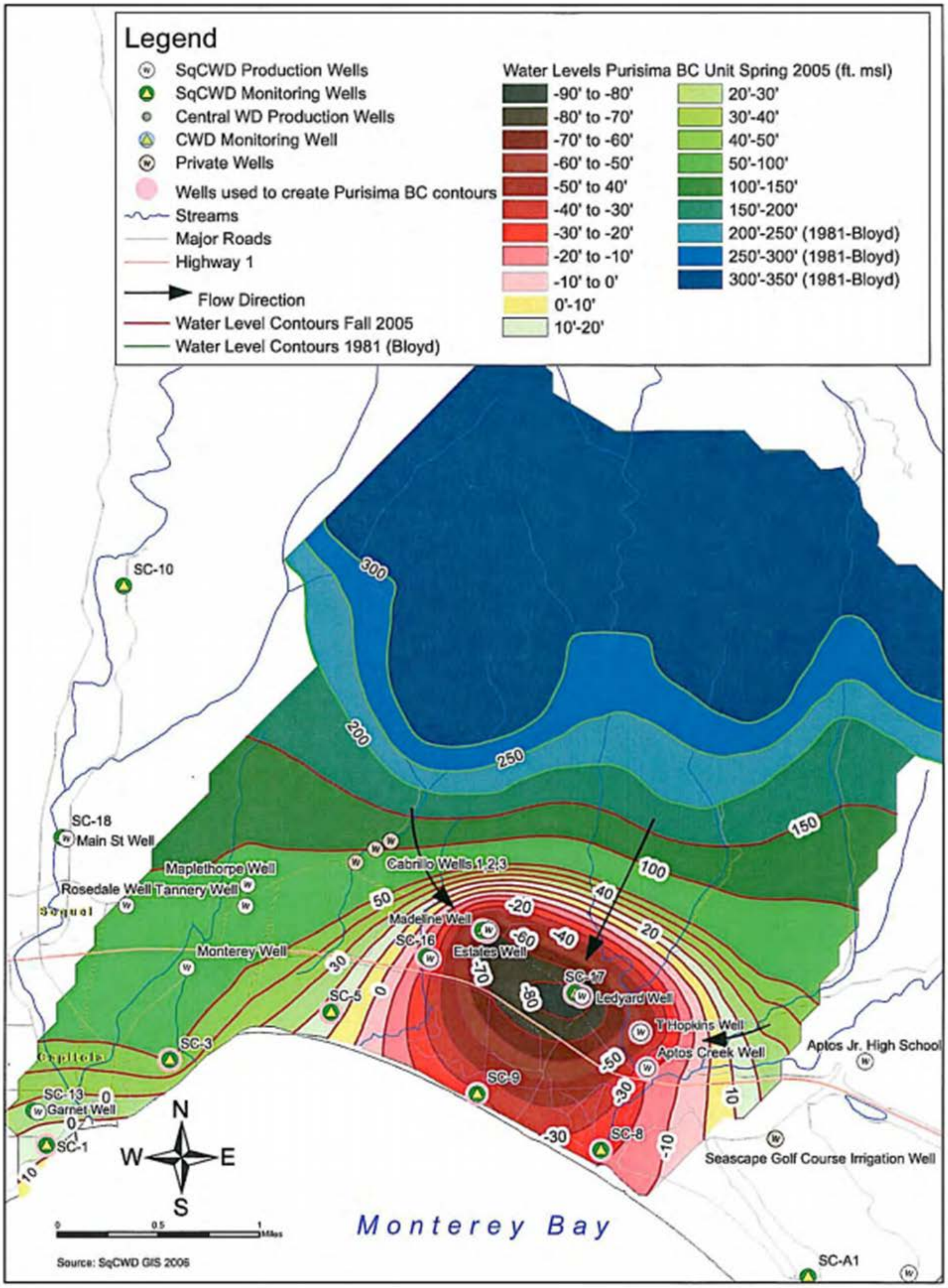

Figure 2-25. Groundwater Elevation Contours in Purisima BC- Unit, Fall 2005

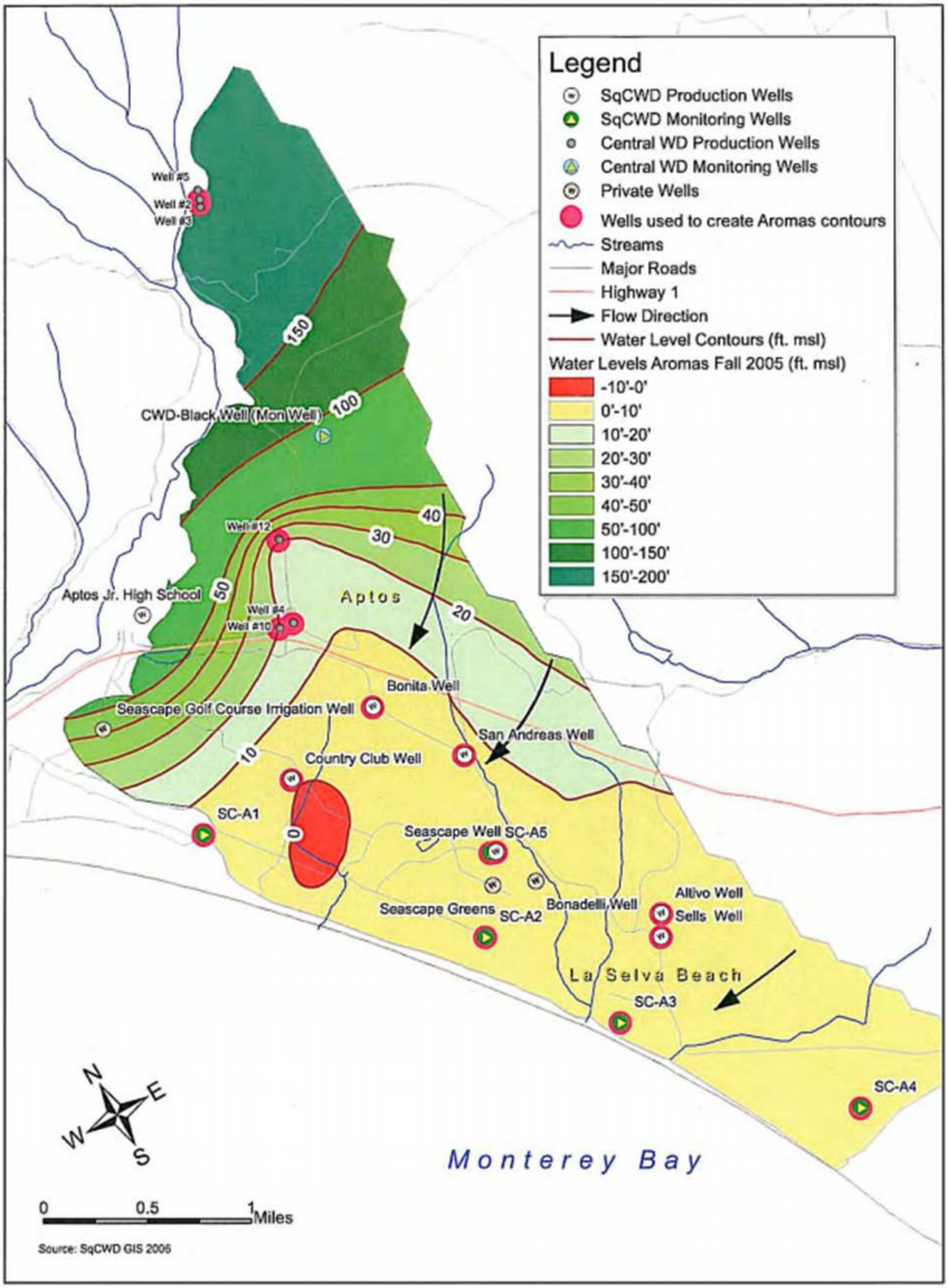

Figure 2-26. Groundwater Elevation Contours in Aromas Red Sands and Pursima F-Unit, Fall 2005

2.2.4.1.2 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).

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.

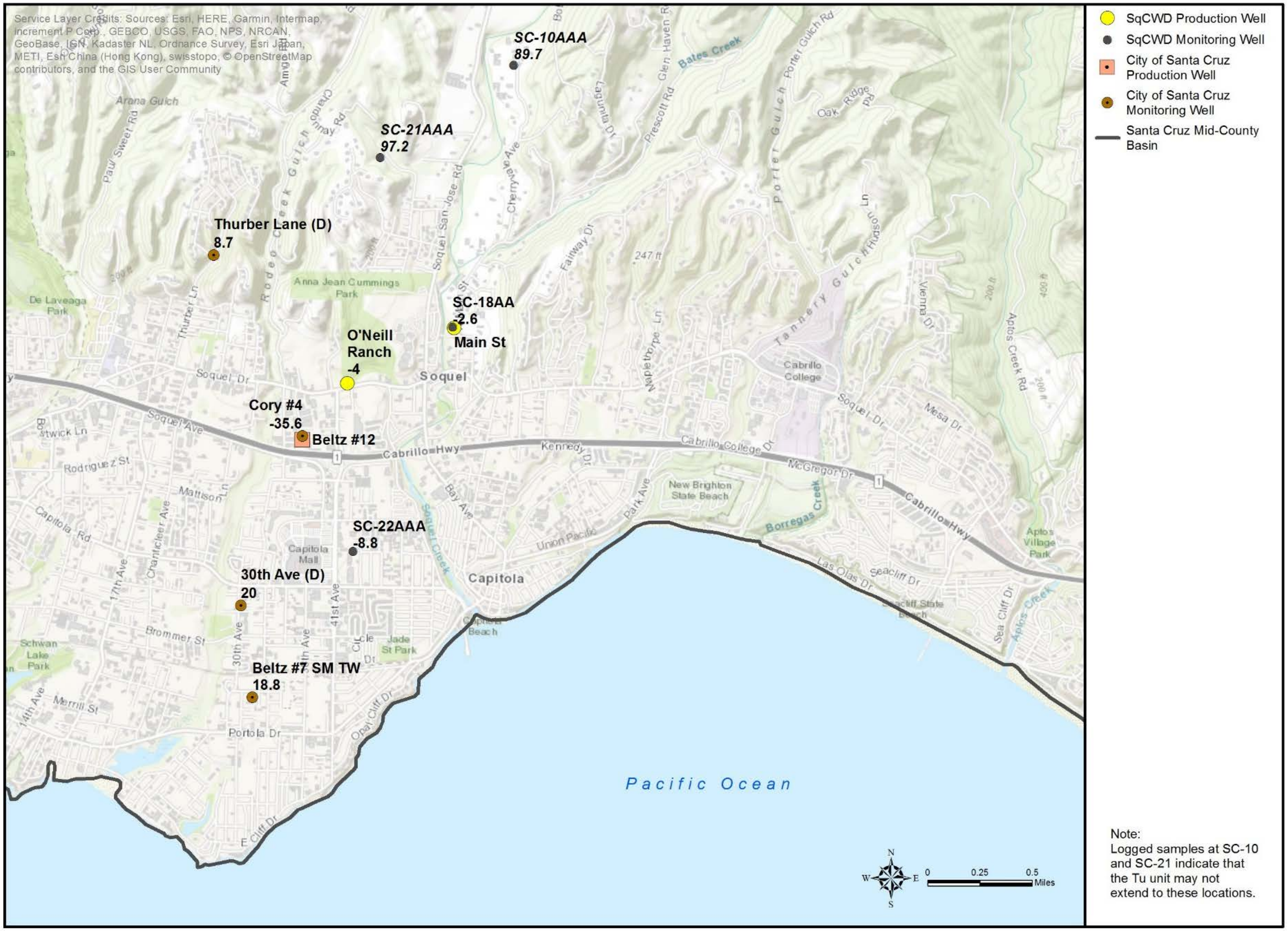

Figure 2-27. Groundwater Elevations in Tu-Unit, Fall 2016

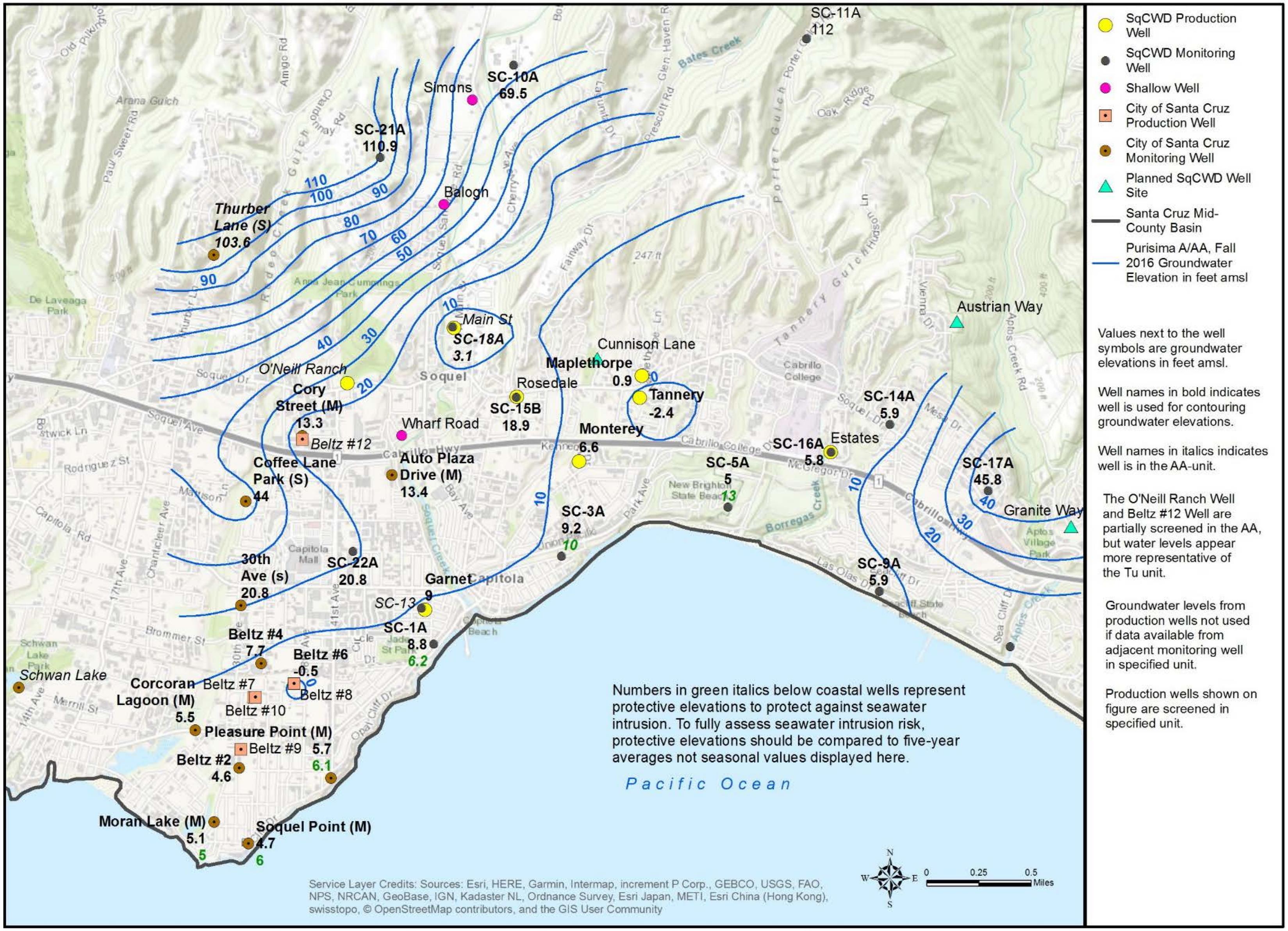

Figure 2-28. Groundwater Elevation Contours in Purisima A and AA-Unit, Fall 2016

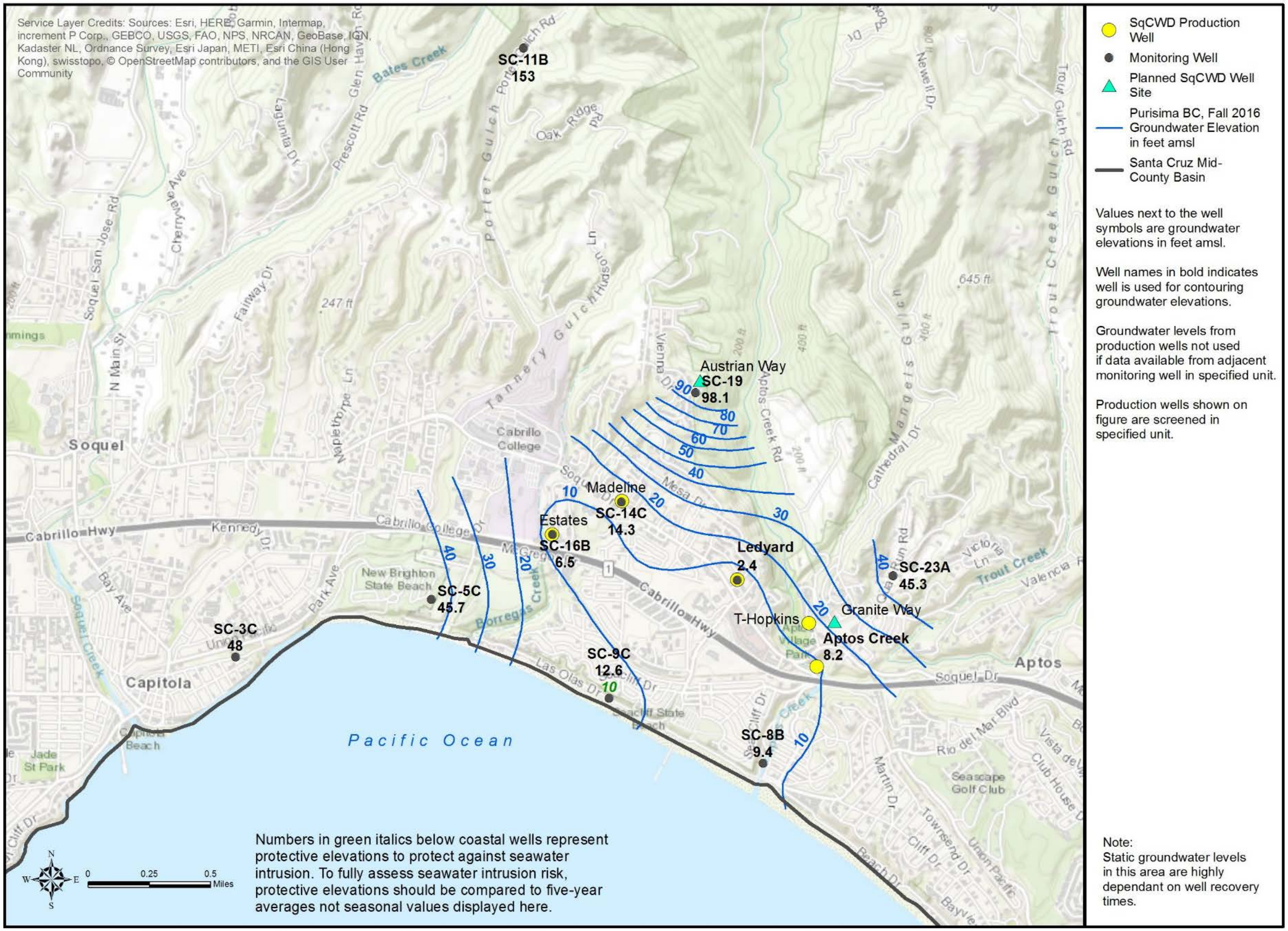

Figure 2-29. Groundwater Elevation Contours in Purisima BC-Unit, Fall 2016

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 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 and San Andreas production wells. These flows may not be sufficient to prevent seawater intrusion as coastal groundwater levels are sometimes below protective elevations.

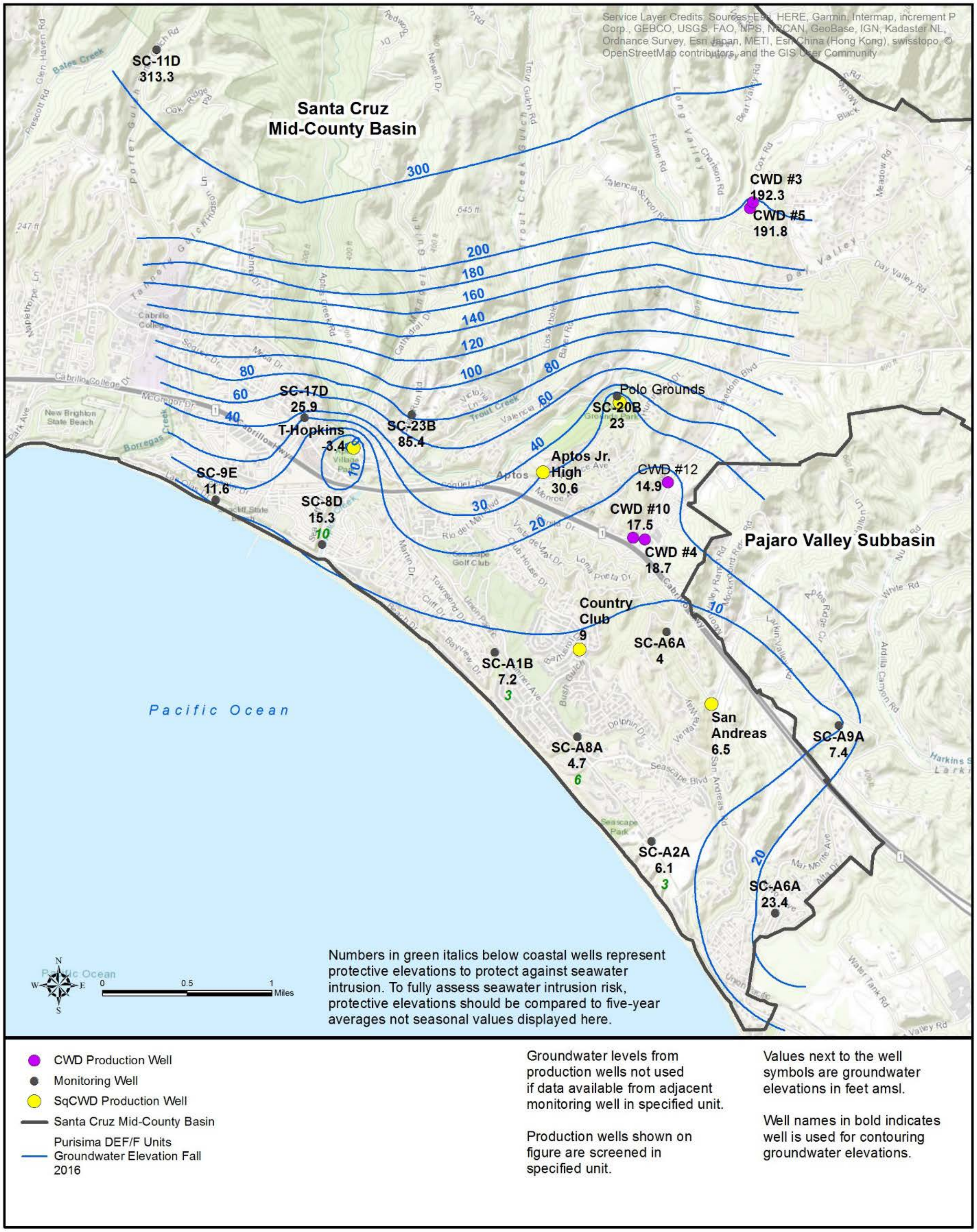

Figure 2-30. Groundwater Elevation Contours in Purisima DEF/F-Unit, Fall 2016

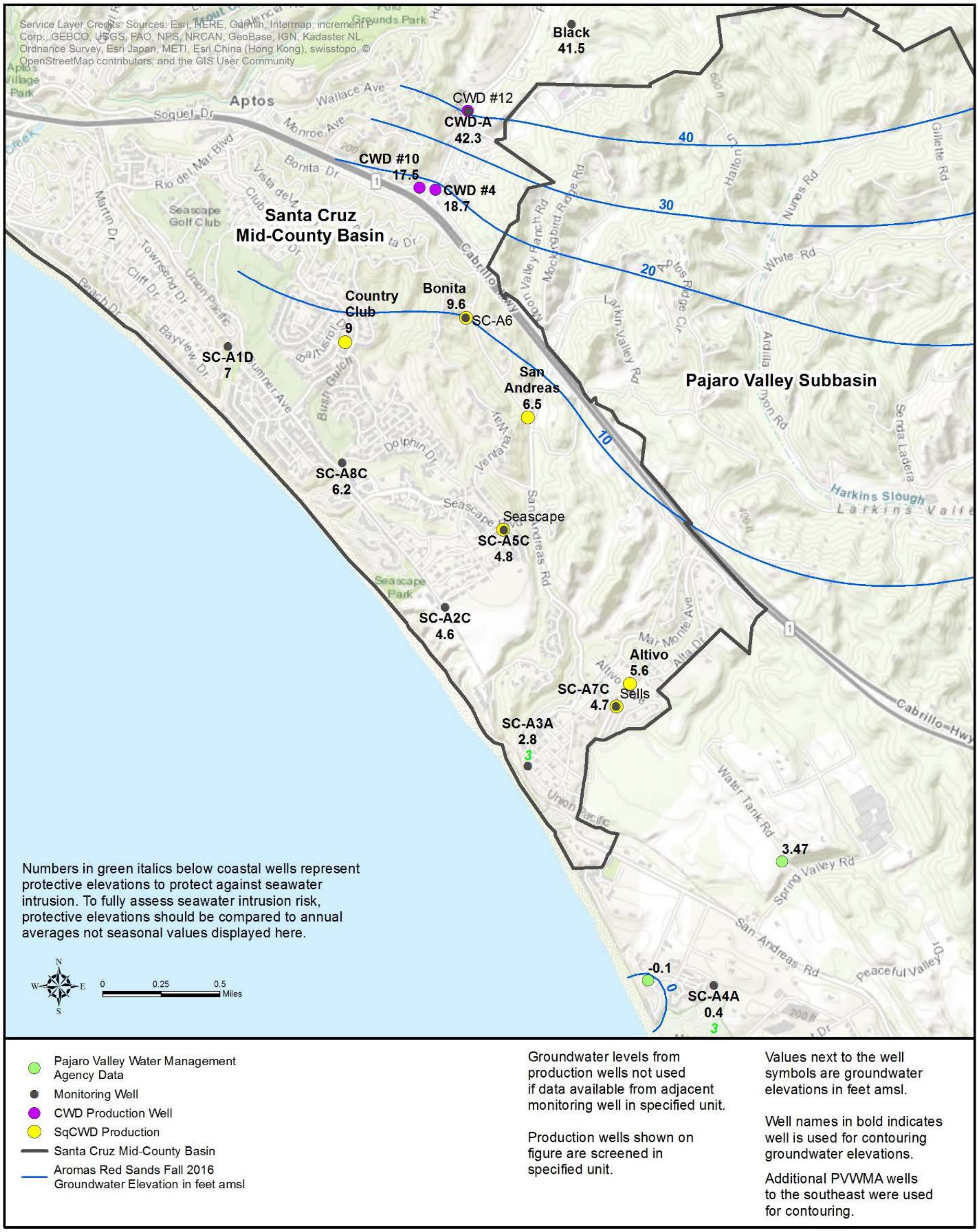

Figure 2-31. Groundwater Elevation Contours in the Aromas Area, Fall 2016

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 describe a history of over-production followed by 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 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[4], 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 level trends between 2012 and 2016. The round symbols indicate recovery continued in much of the Basin, particularly along the coast, during the 2011-2015 drought.

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

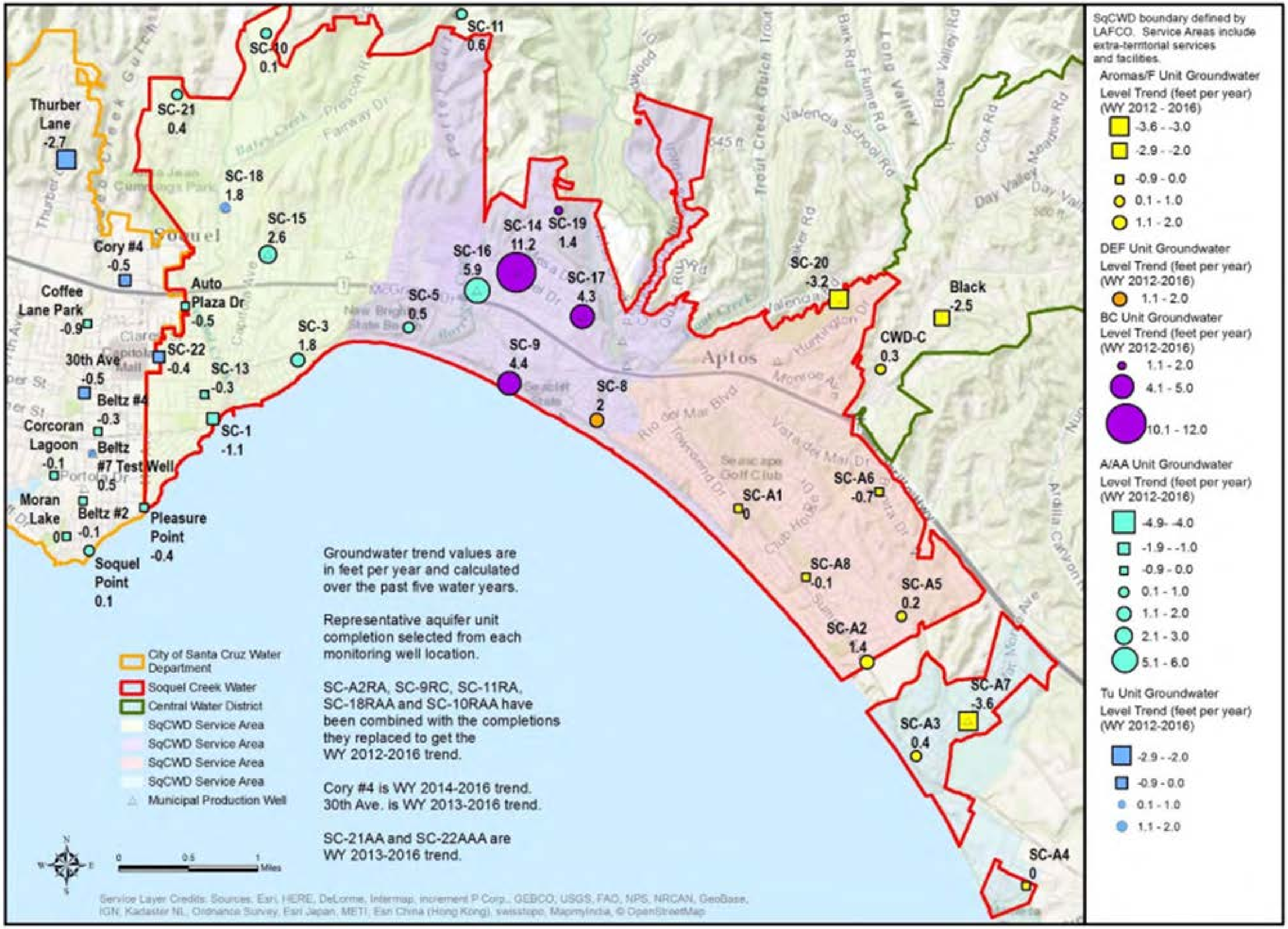

Figure 2-32. 2012-2016 Groundwater Level Trends

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 have declined between 0.4 to 4.0 feet in the coastal monitoring wells.

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).

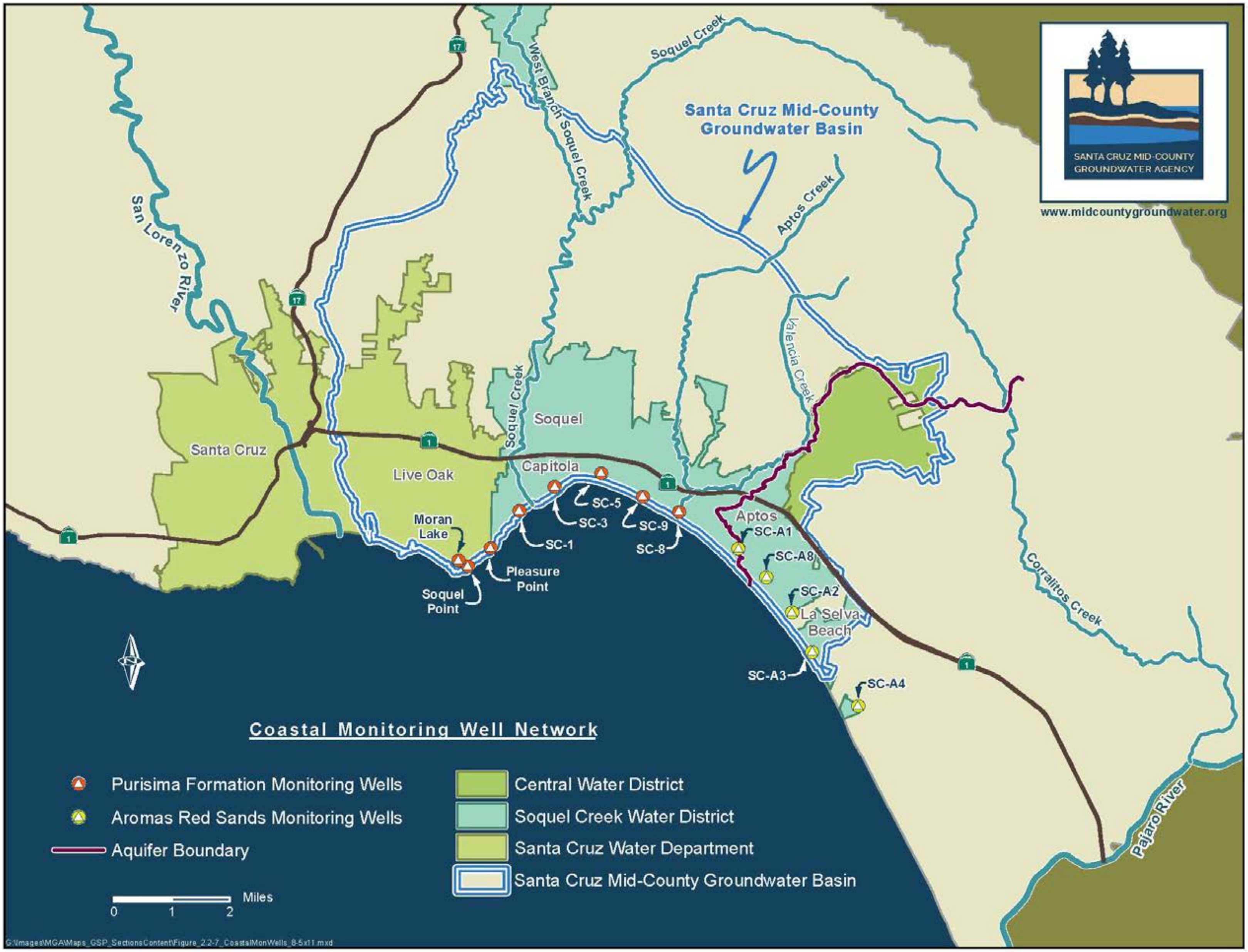

Figure 2-33. Location of Coastal Monitoring Wells

Soquel Creek Water District and the City of Santa Cruz have established protective groundwater elevations[5] 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[6] 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 overdraft 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 Average (ft amsl)	Protective Elevation (ft amsl)	Percent Runs Protective
Moran Lake Medium	9/30/2018	6.0	5.0	>GH[7]
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.

** SC-A4A is in the Pajaro Valley Subbasin, not the Santa Cruz Mid-County Basin.

ft amsl = feet above mean sea level

[5] 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.

[6] 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.

[7] 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.

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.

2.2.4.2 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.

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). With the exception of monitoring well cluster SC-A1, coastal monitoring clusters in the Aromas area were installed with 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.

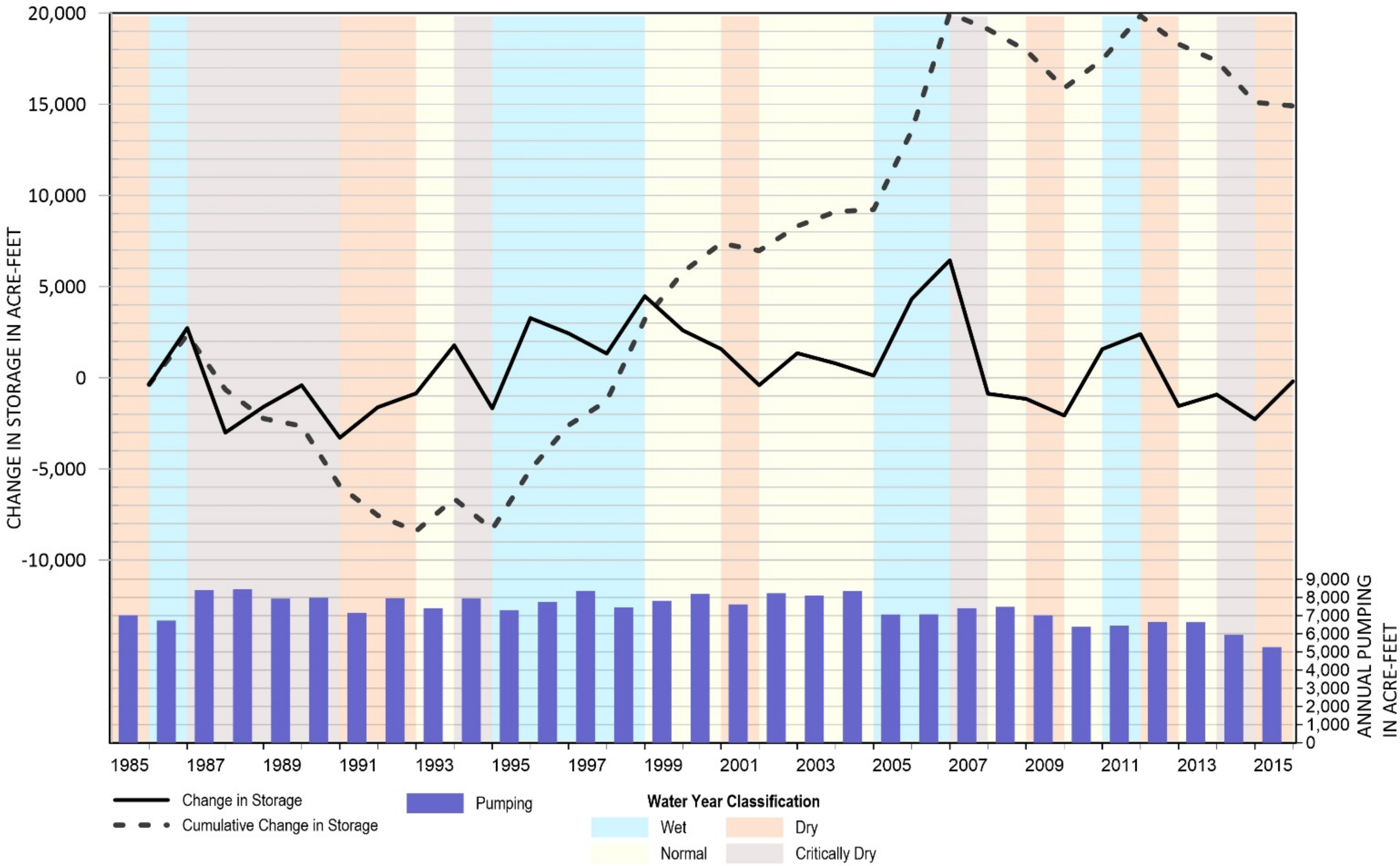

Figure 2-34. Cumulative Change in Groundwater in Storage

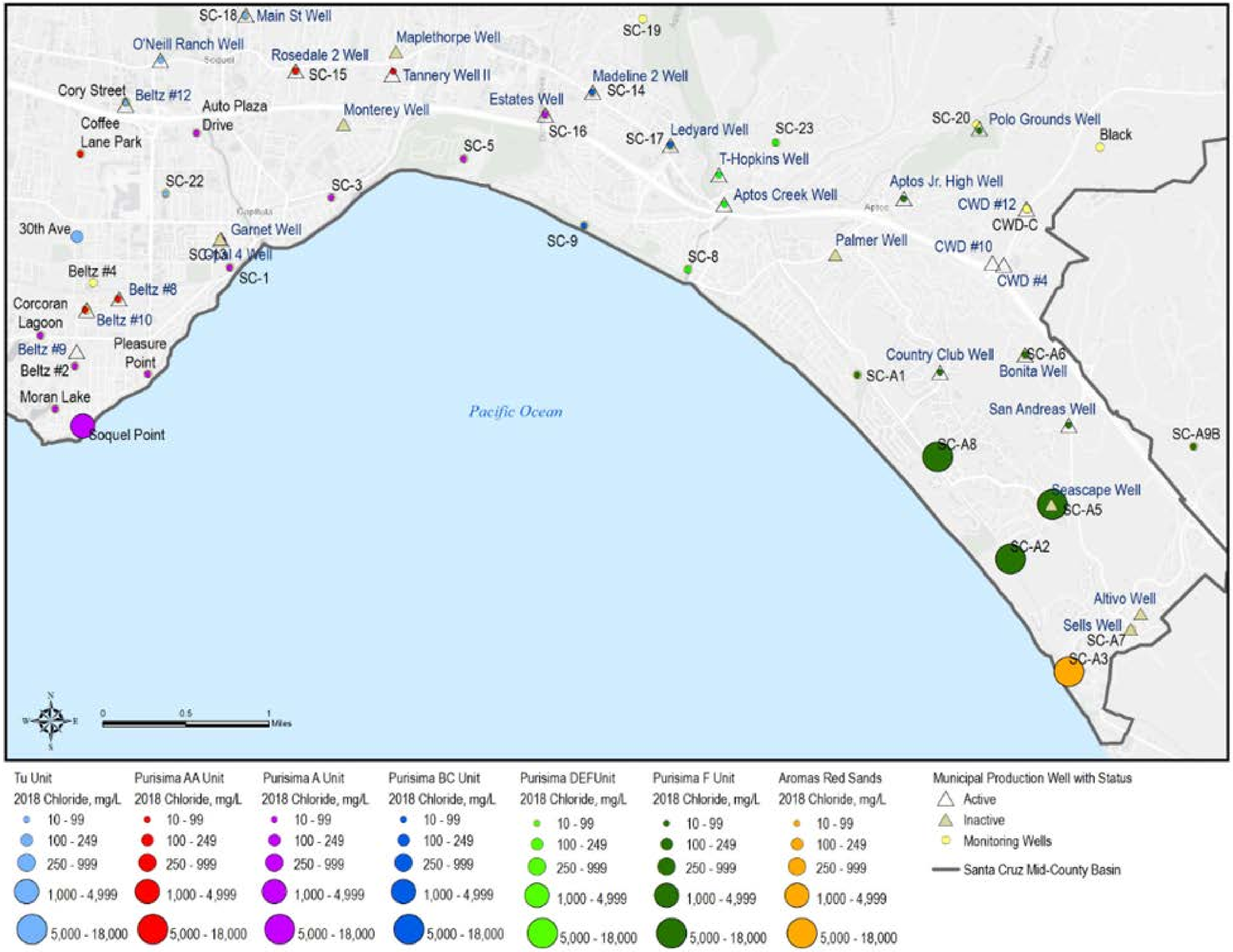

Figure 2-35. Water Year 2018 Chloride Concentrations

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).

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).

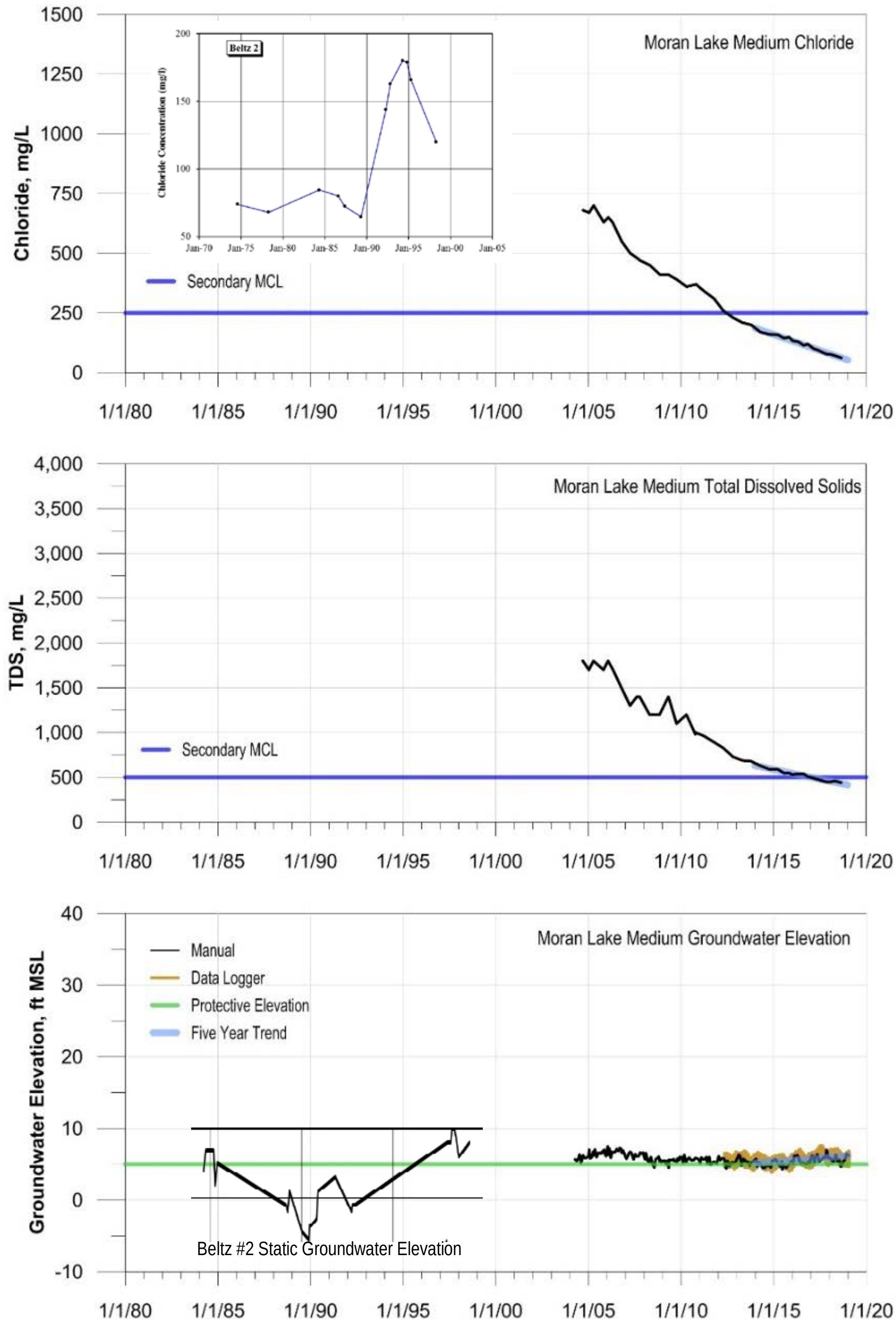

Figure 2-36. Hydrograph and Chemograph of Moran Lake Medium Well (Montgomery & Associates, 2019) Overlain by Hydrograph and Inset Chemograph of Beltz #2 Well (Johnson et al., 2004)

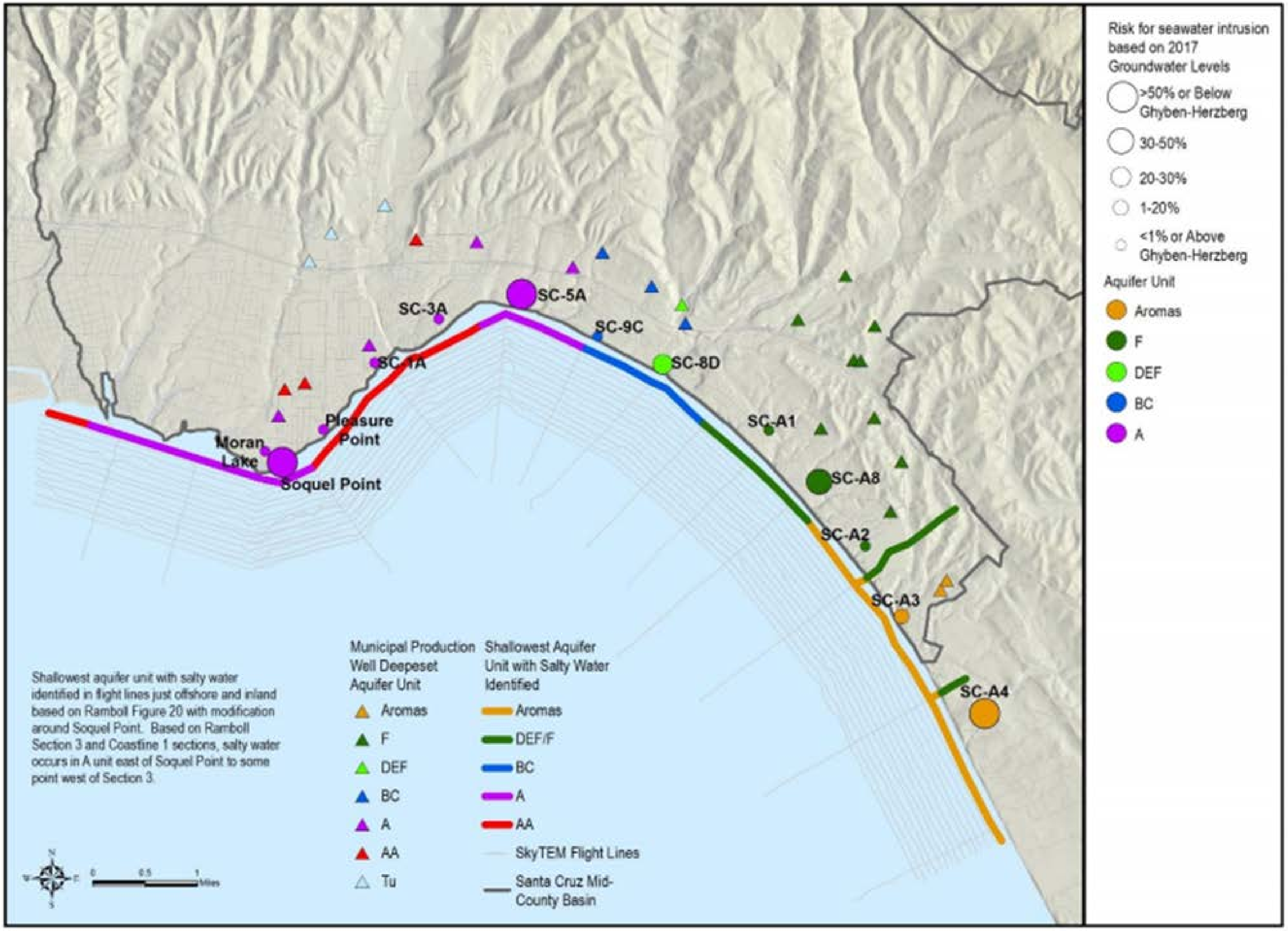

Figure 2-37. Water Year 2017 Risk of Seawater Intrusion into Pumped Aquifer Units Based on Groundwater Levels and SkyTEM Data on Shallowest Aquifer Unit with Salty Water Just Offshore

2.2.4.4 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 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 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 non-municipal well. Small water systems that supply groundwater to 15 – 199 service connections also report water quality to the County 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.

2.2.4.4.1 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 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. 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

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 trends in affected wells because the source of arsenic occurs naturally within the sediments and is not being added 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 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 SWRCB regulations in July 2014 was 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, the state 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.

2.2.4.4.2 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.

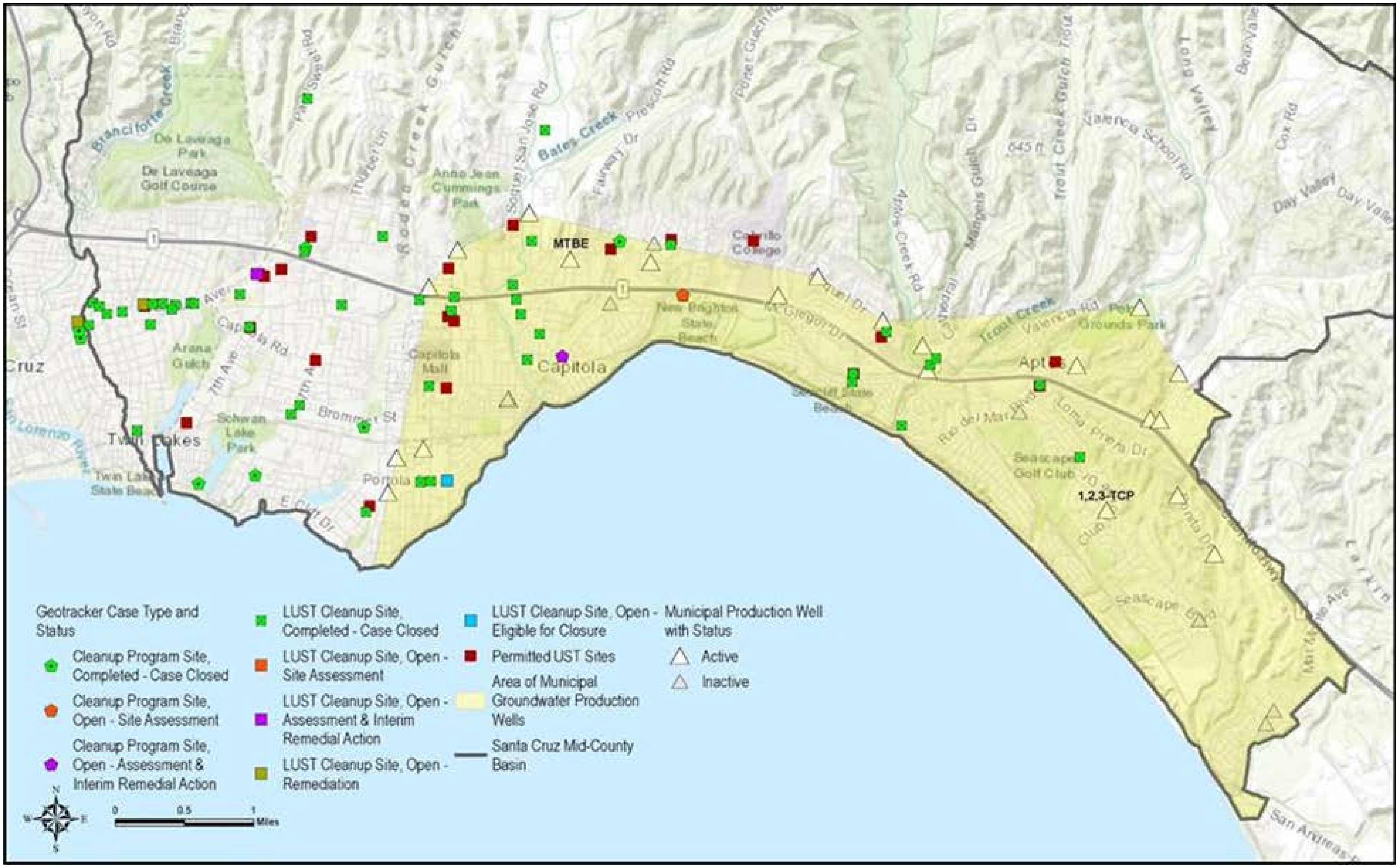

Figure 2-38. Known Contaminant Locations

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 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 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 are located within the area of municipal production, with none occurring in the inland portions of the Basin where 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 is overseen by the Regional Water Quality Control Board (RWQCB) and Santa Cruz County Environmental Health.

SqCWD has identified 1,2,3-trichloropropane (TCP) at its Country Club production well, which is drilled within the Aromas Red Sands and Purisima F unit aquifers. The source of the 1,2,3-TCP in groundwater at this location is believed to be past use of fumigants that contained 1,2,3-TCP as an impurity, based on past agricultural land uses near the well. The state drinking water standard 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 the Country Club well once a treatment plant for 1,2,3-TCP has been constructed and water from this well again meets or exceeds state drinking water quality standards.

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, per- and polyfluoroalkyl substances (PFAS) etc.

The Unregulated 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 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 two phases of a joint USGS – USEPA study on 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 Sells, Altivo, and Bonita. Sells is the La Selva area well with elevated nitrates as N that is currently inactive in the Aromas Red Sands aquifer. The CEC detected 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 in its Bonita well during standard five yearly UCMR testing.

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 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.

2.2.4.5.1 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.

2.2.4.5.2 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 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, it still hydraulically connected and has the same aquifers as the Santa Cruz Mid-County Basin and is representative of the Basin. Unfortunately, no CGPS stations are located in areas of the 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.

2.2.4.5.3 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, 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, 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 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.

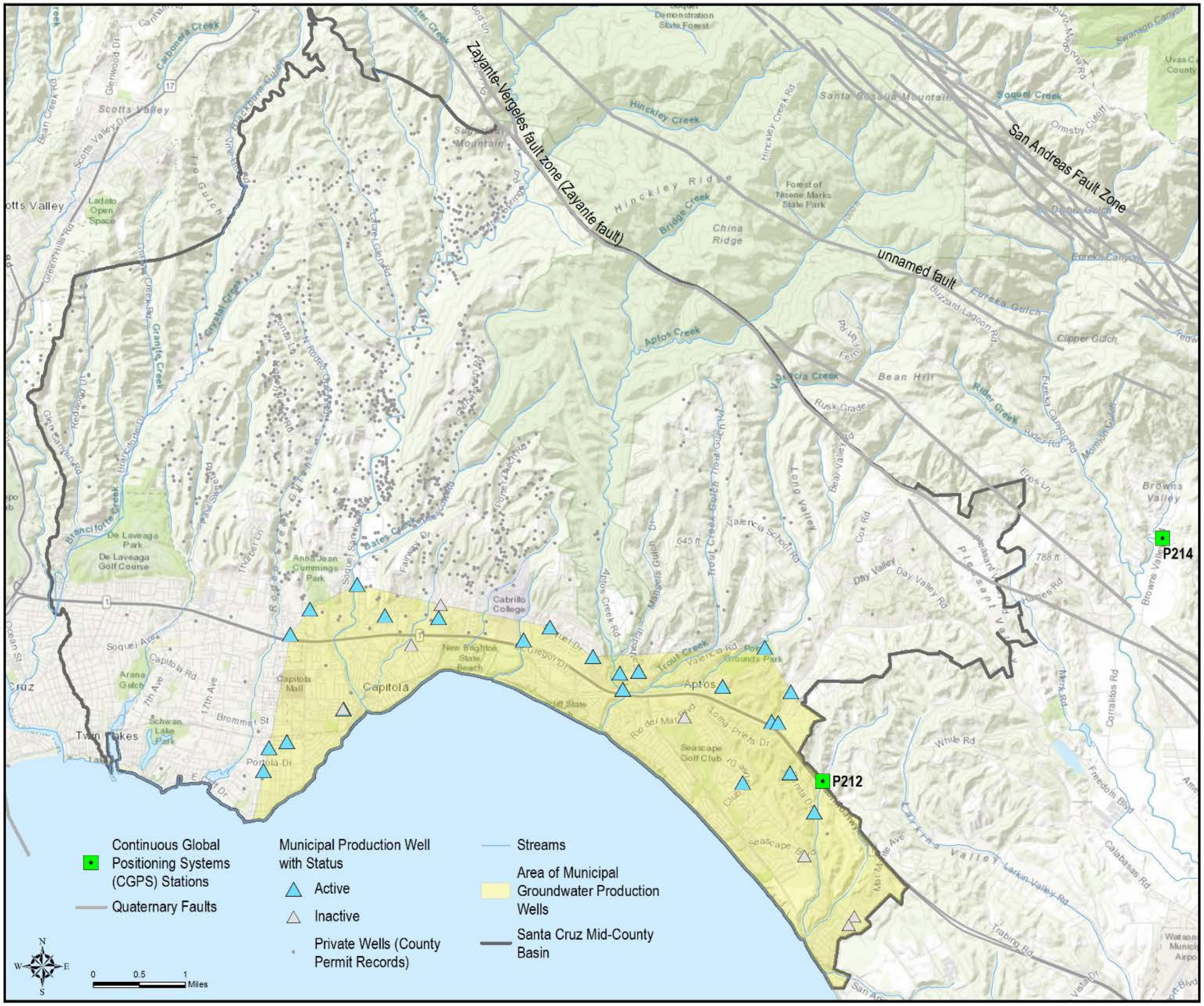

Figure 2-39. Location of Continuous GPS Stations near the Santa Cruz Mid-County Basin

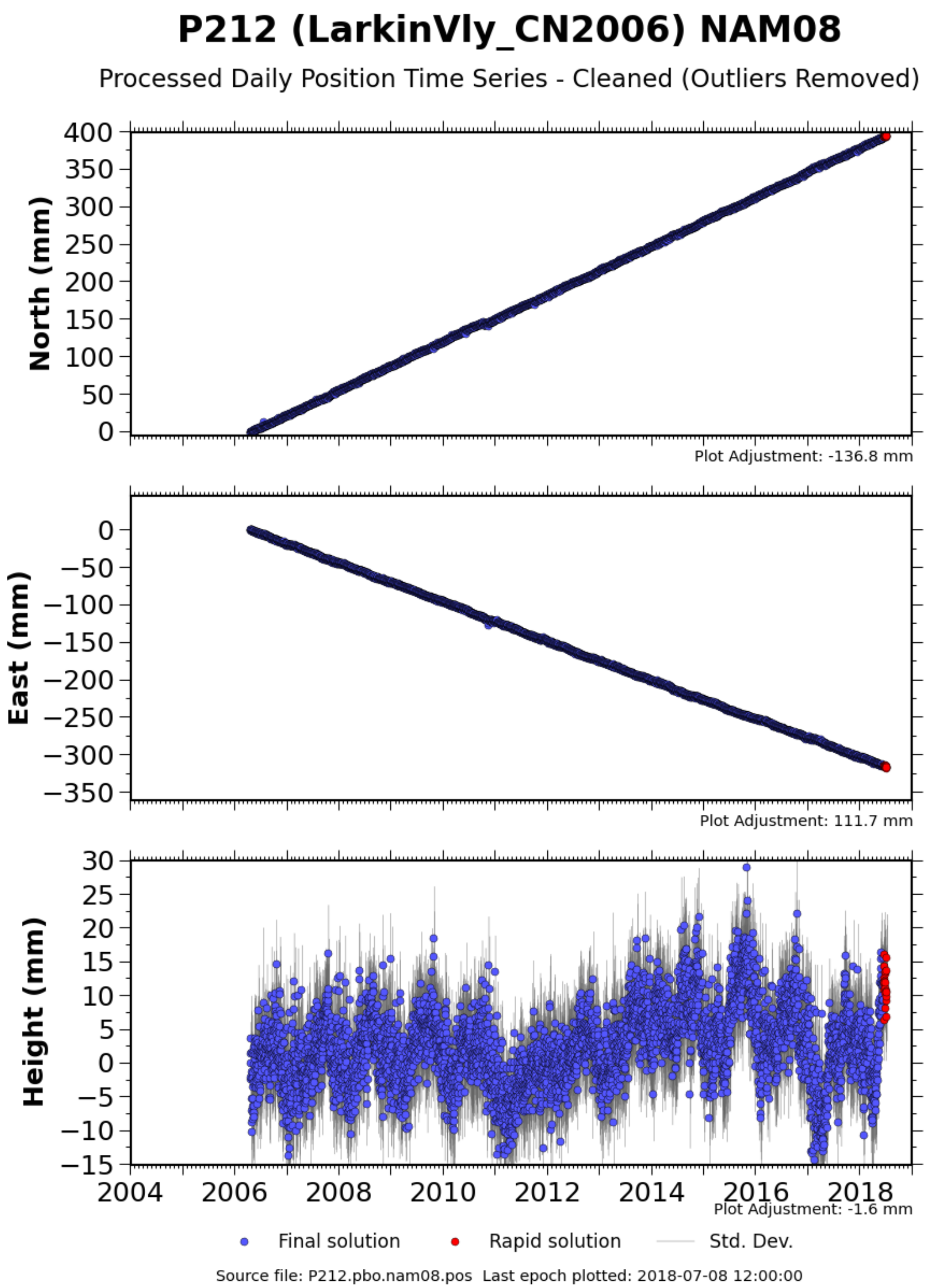

Figure 2-40. P212 Larkin Valley CGSP Station Daily Position

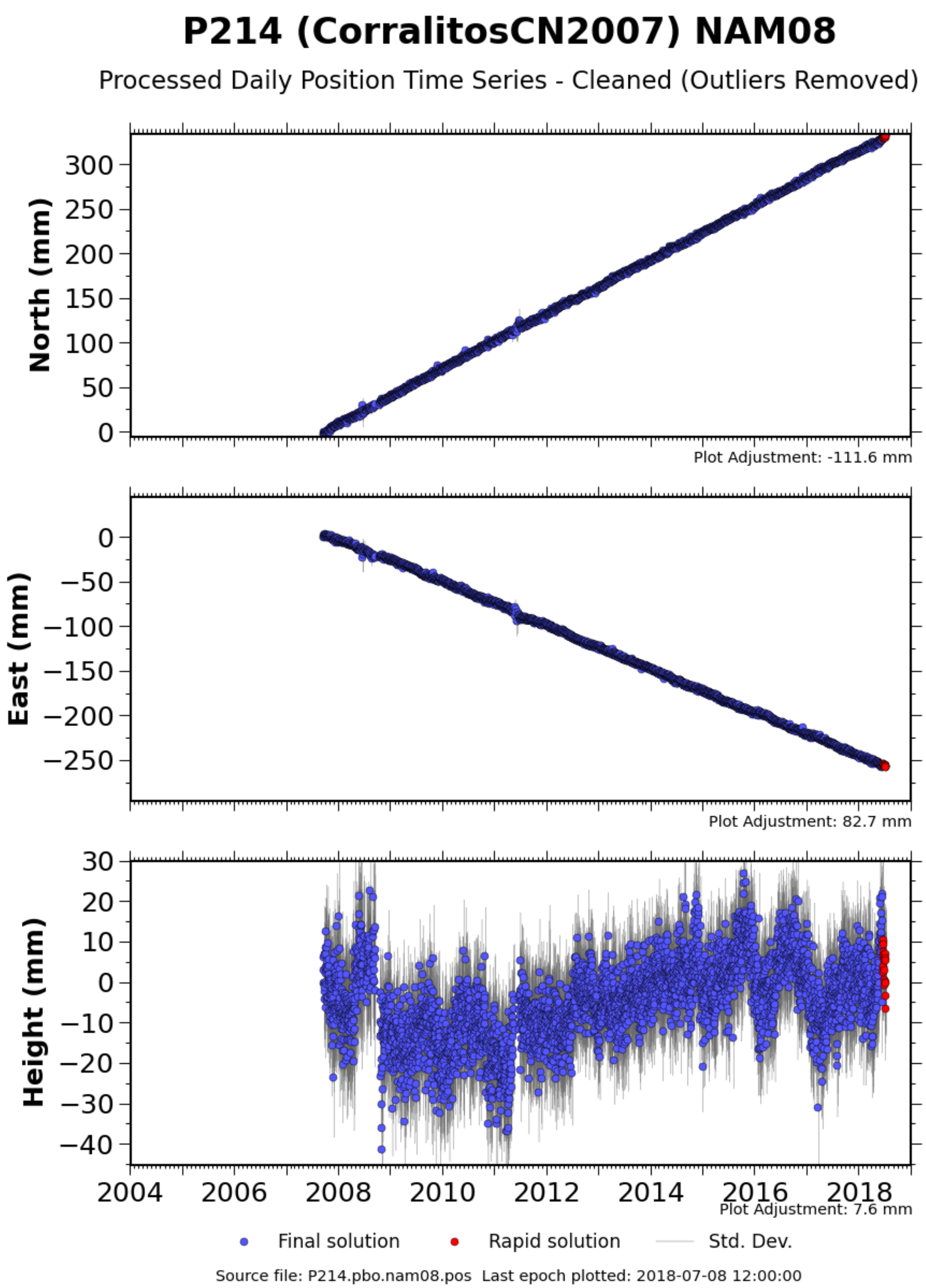

Figure 2-41. P214 Corralitos CGSP Station Daily Position

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 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.

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 recharge occurs through an unsaturated zone to the 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).

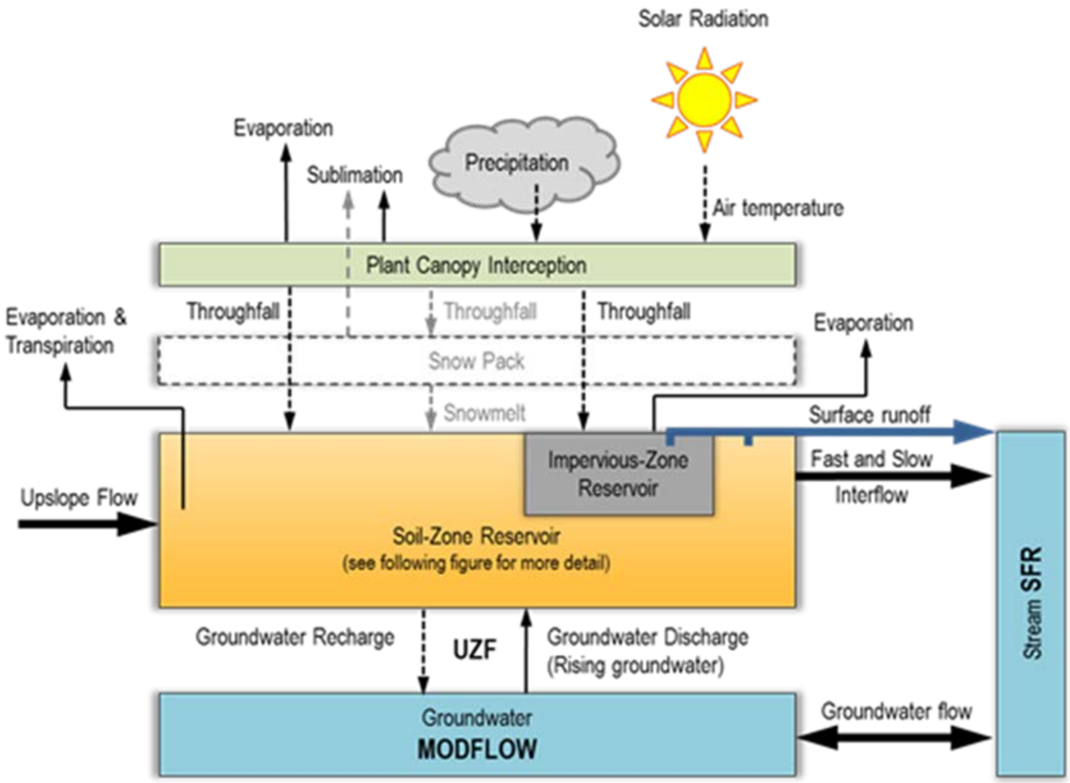

Figure 2-42. Hydrologic Process Simulated by the Precipitation-Runoff Modeling Systems (PRMS)

Throughout the Basin there is spatial variation in the percent of time surface waters are connected to groundwater (Figure 2-10). 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 changes do not impact streamflow.

- The Eastern side of the 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 relative to the model as a whole, and are near municipal pumping. In the months with lowest flows, groundwater flow to surface water contributes more than surface/near-surface runoff flows for these segments, but the groundwater contribution (< 0.5 cubic foot per second [cfs]) is small compared to the overall flow in each of these segments of Soquel Creek (Figure 2-44 and Figure 2-45). Most of the streamflow in those segments comes from higher up in the watershed (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.

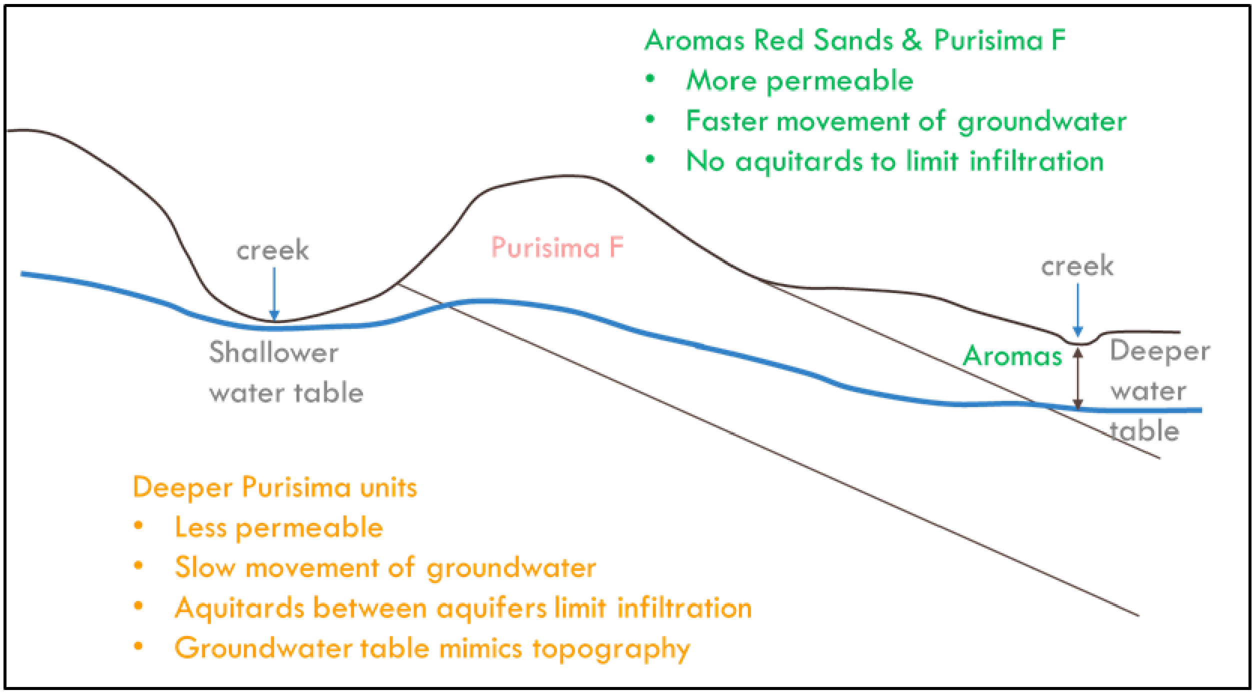

Figure 2-43. Differences Between Purisima and Aromas Connection to Groundwater

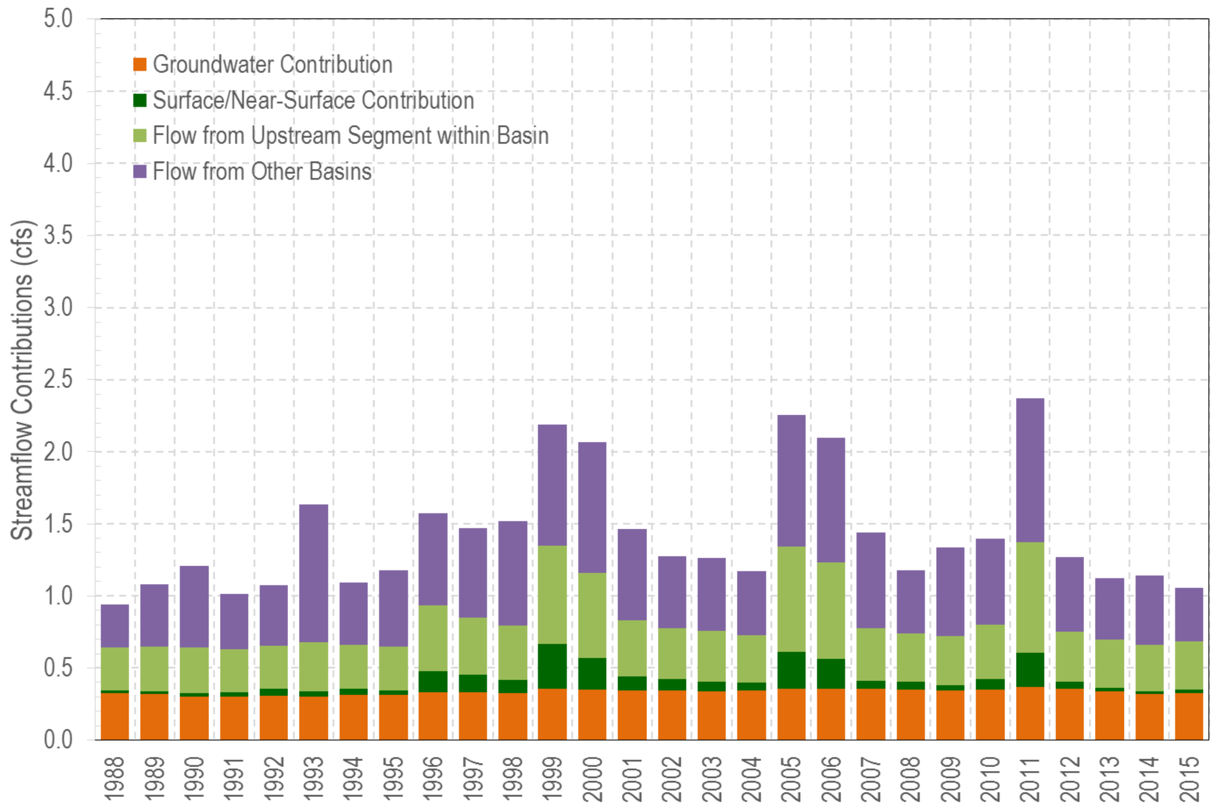

Figure 2-44. Simulated Minimum Monthly Flows from Moores Gulch to Bates Creek

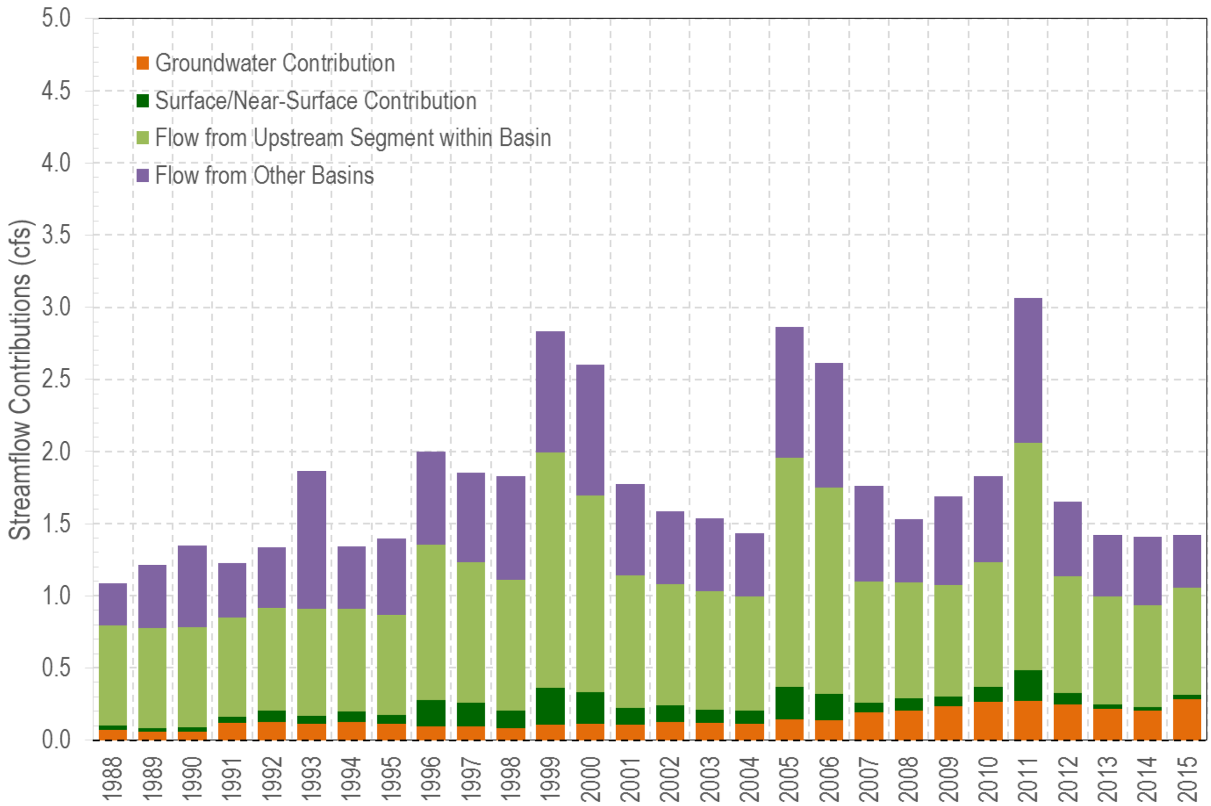

Figure 2-45. Simulated Minimum Monthly Flows Downstream from Bates Creek

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).

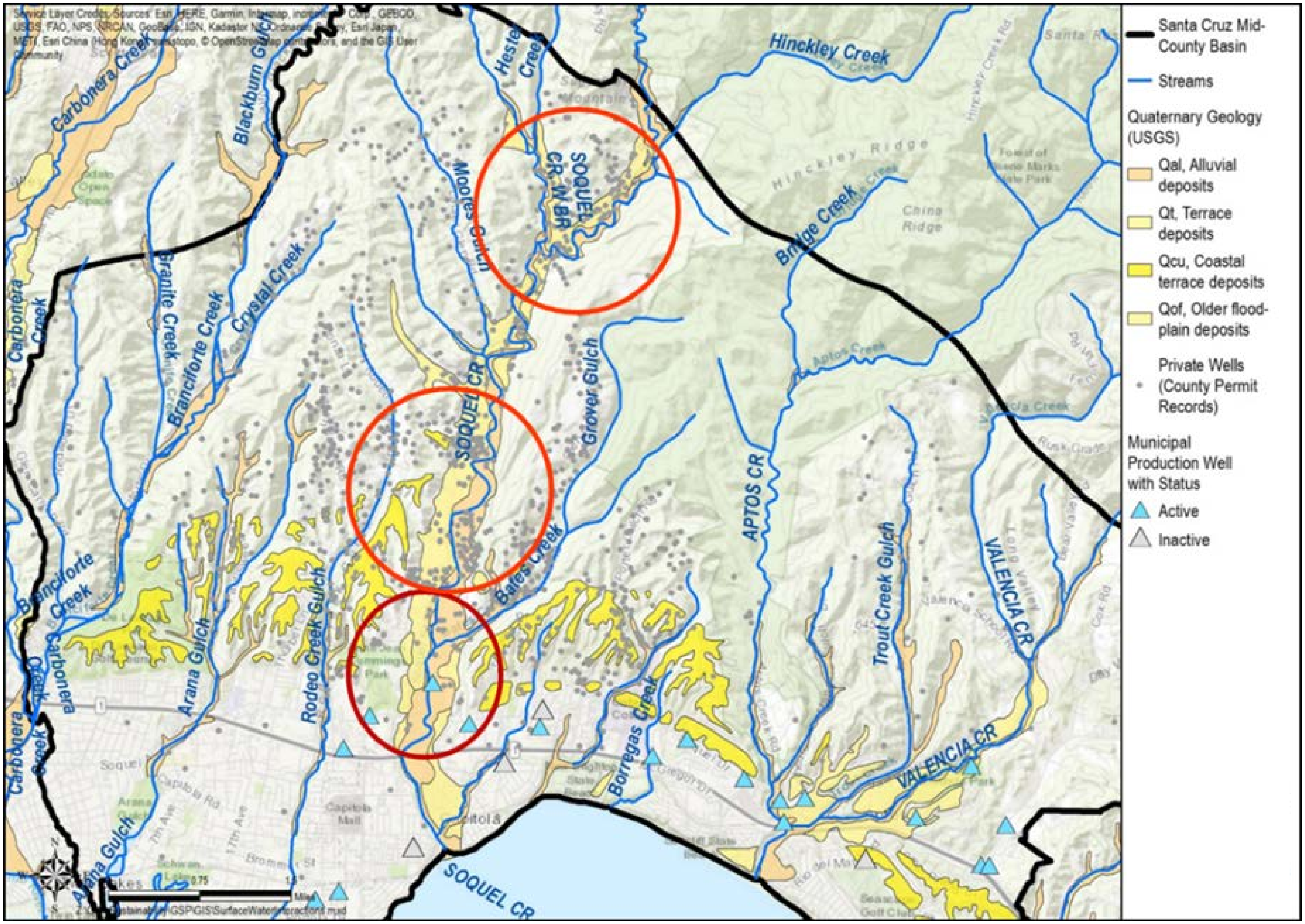

Figure 2-46. Areas of Concentrated Groundwater Pumping along Soquel Creek

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 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.

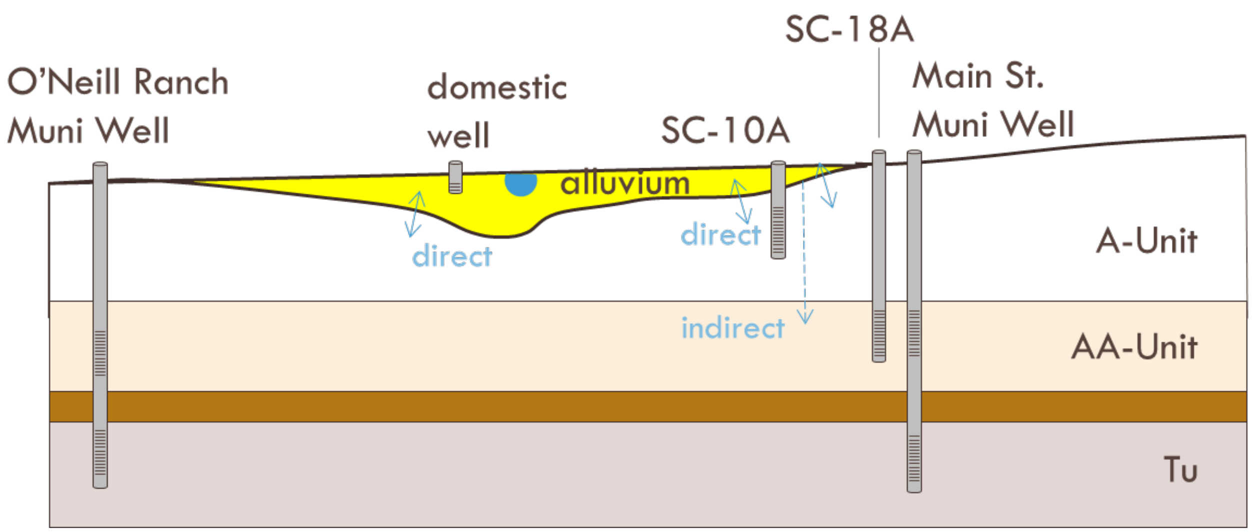

Figure 2-47. Conceptual Connections between Soquel Creek, Alluvium, and Underlying Aquifers

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 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.

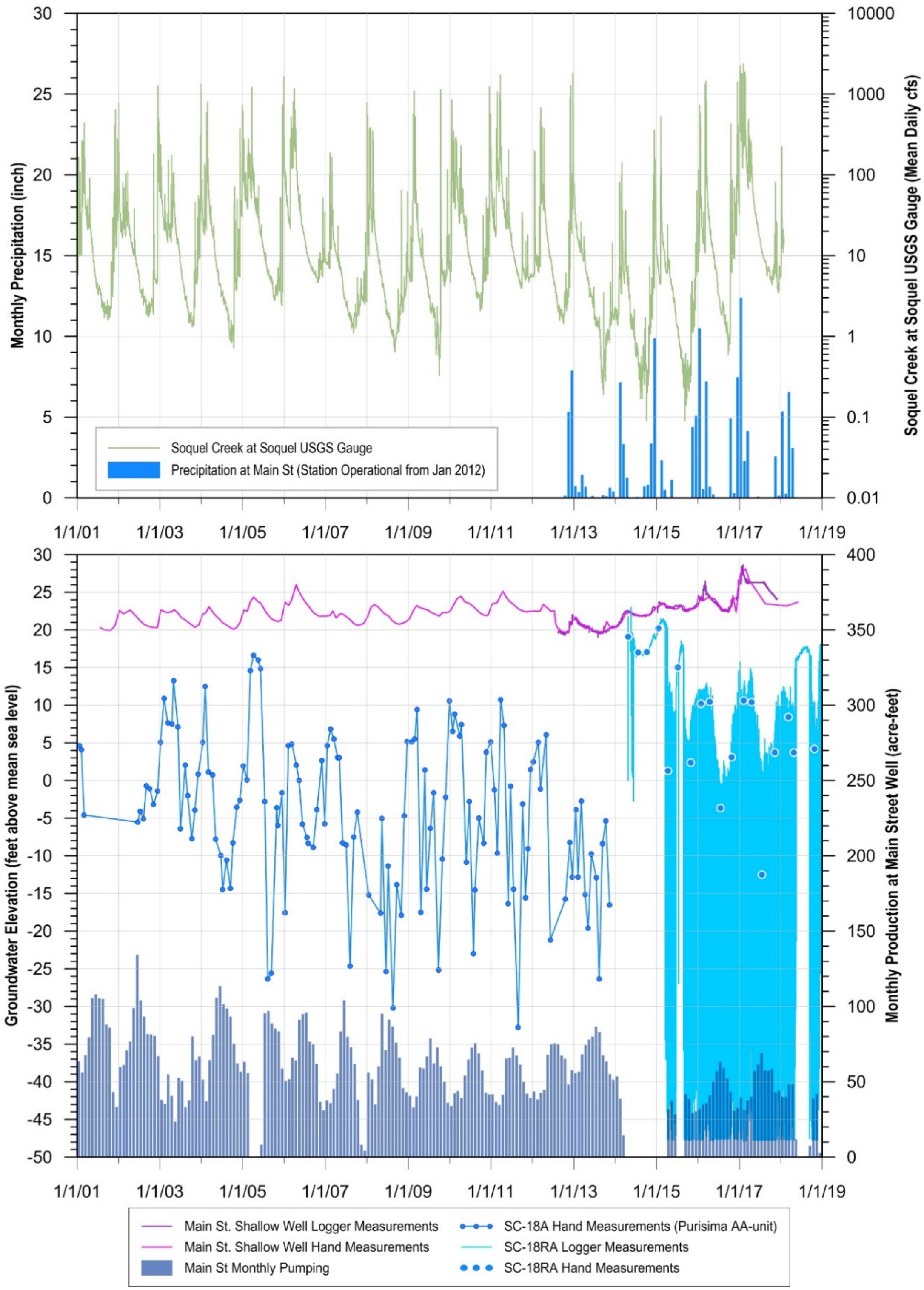

Figure 2-48. Hydrographs for Main Street Monitoring Wells Compared to Monthly Main Street Pumping, Creek Flow and Precipitation

2.2.4.7 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 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).

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 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.

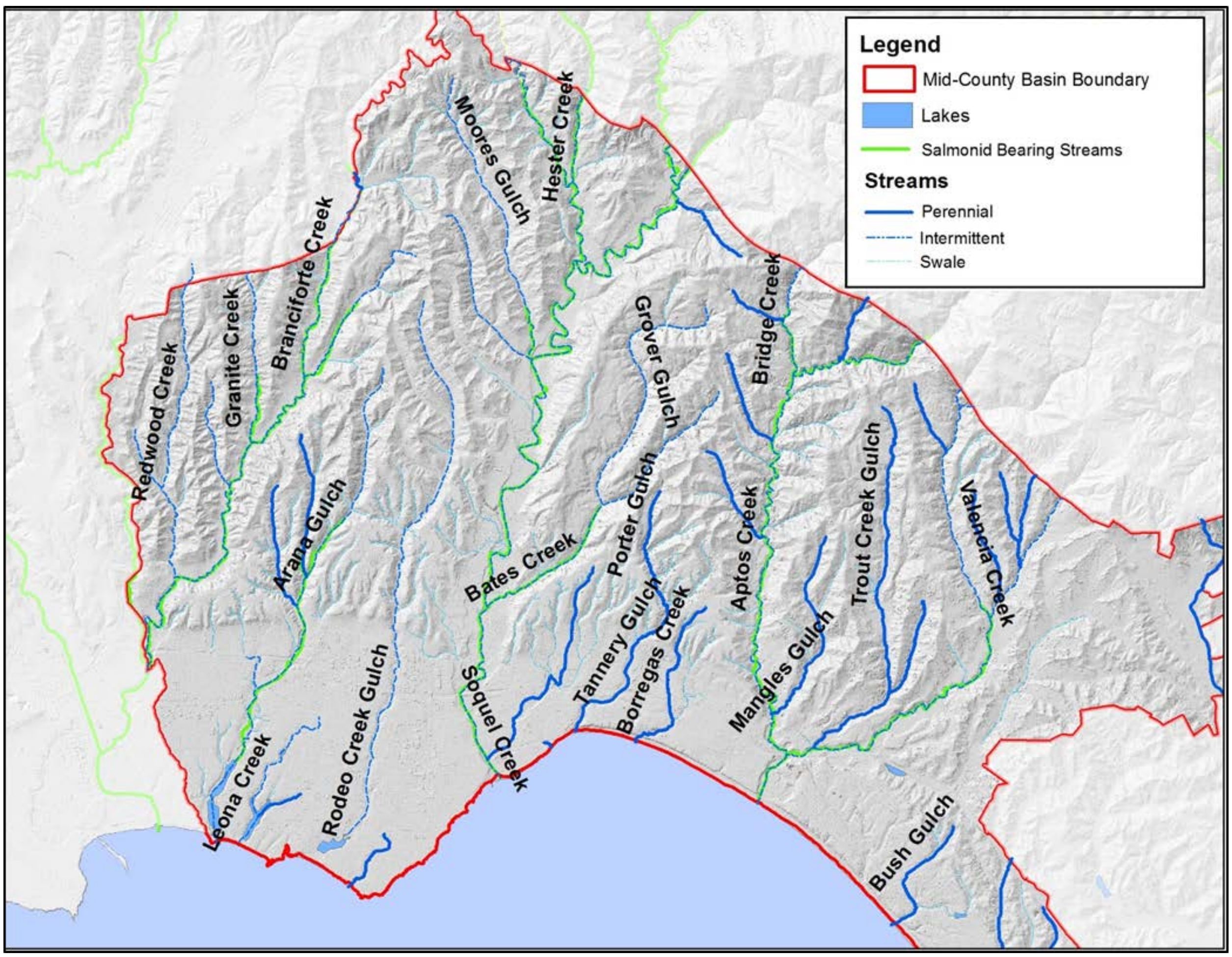

Figure 2-49. Stream Habitat in the Santa Cruz Mid-County Basin

Using guidance developed by 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 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 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 streams, the needs of other aquatic species of concern will also be met (see 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 2-51) they have been seen in the Basin through the County's monitoring program (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.

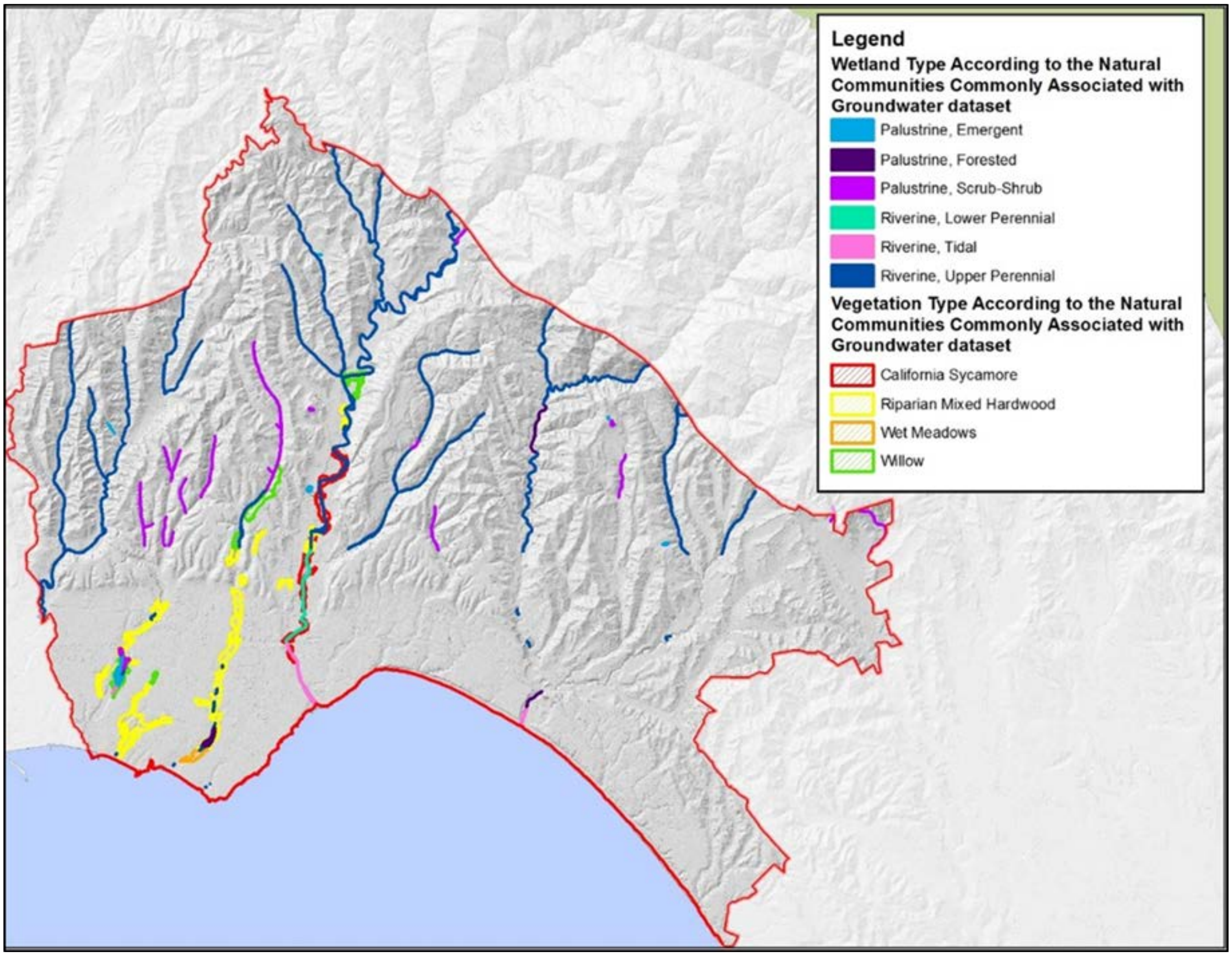

Figure 2-50. Wetland and Vegetation Types according to the Natural Communities Commonly Associated with Groundwater Dataset

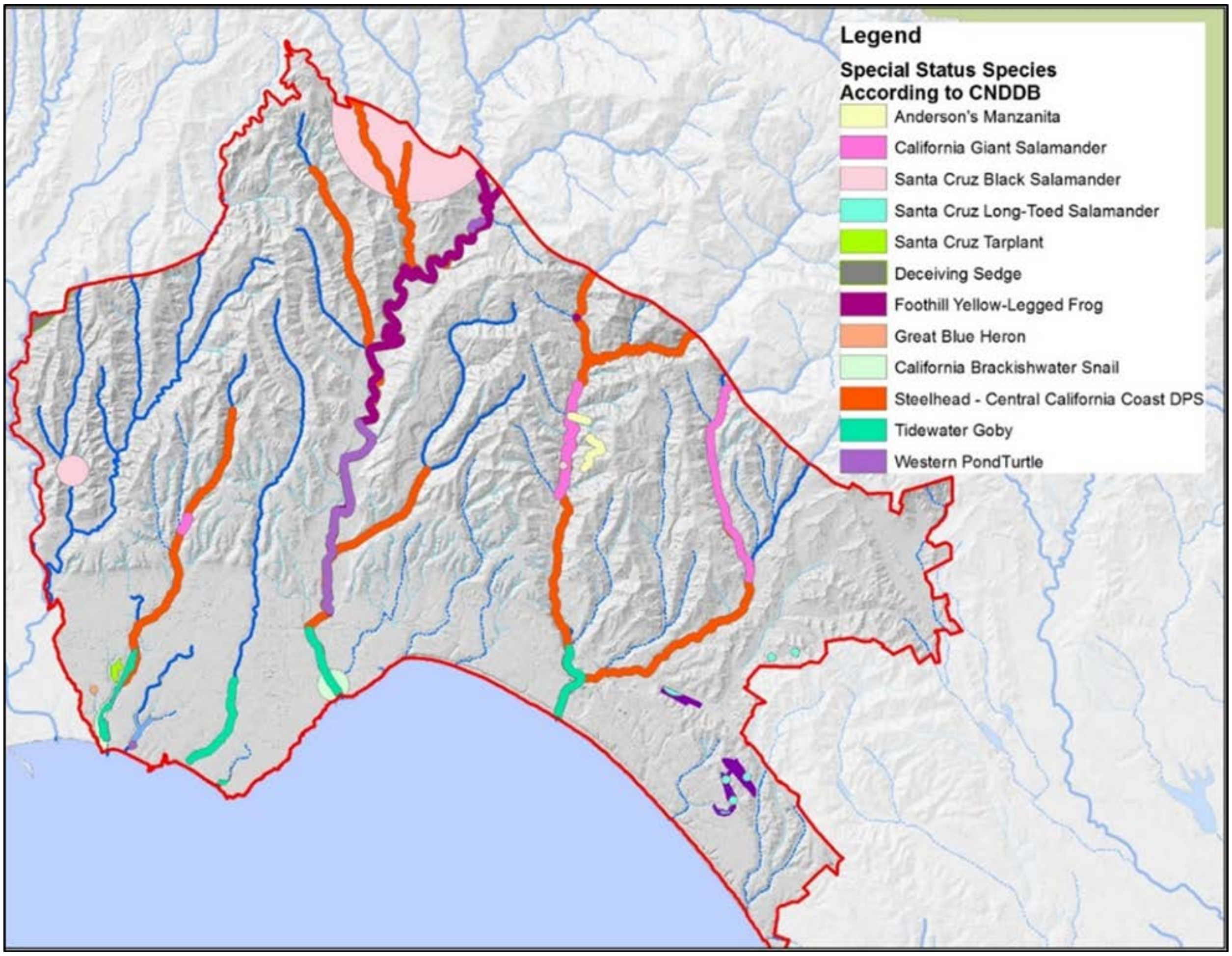

Figure 2-51. Distribution of Species throughout the Santa Cruz Mid-County Basin according to the California Natural Diversity Database [8]

[8] 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 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

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

2.2.5 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.

2.2.5.1 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 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.

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 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.

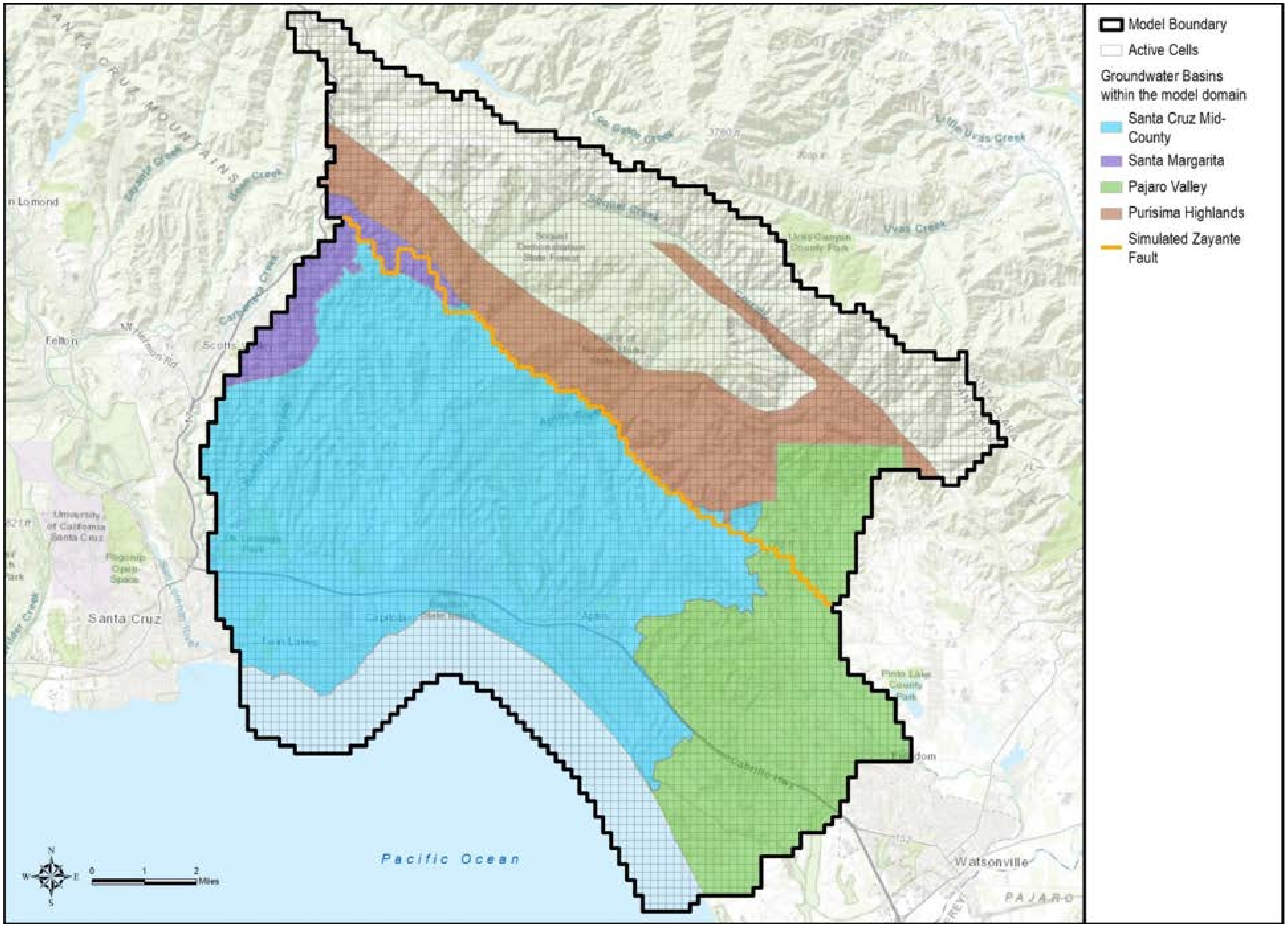

Figure 2-52. GSFLOW Model Domain

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	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 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 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

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 report (Appendix 2-F) discusses all model assumptions and uncertainty. The assumptions that cause the greatest uncertainty with respect to 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 area faulting than south of 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 area faulting than south of it.

- Model construction combines the Purisima F and DEF aquifer units into one model layer so there is greater uncertainty for 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.

2.2.5.3 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. Most of the different 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, 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 area faulting (Figure 2-53). South of the Aptos area faulting is where the majority of groundwater extraction, including all municipal extraction, takes place. A water budget south of the Aptos 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 area faulting only has 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.

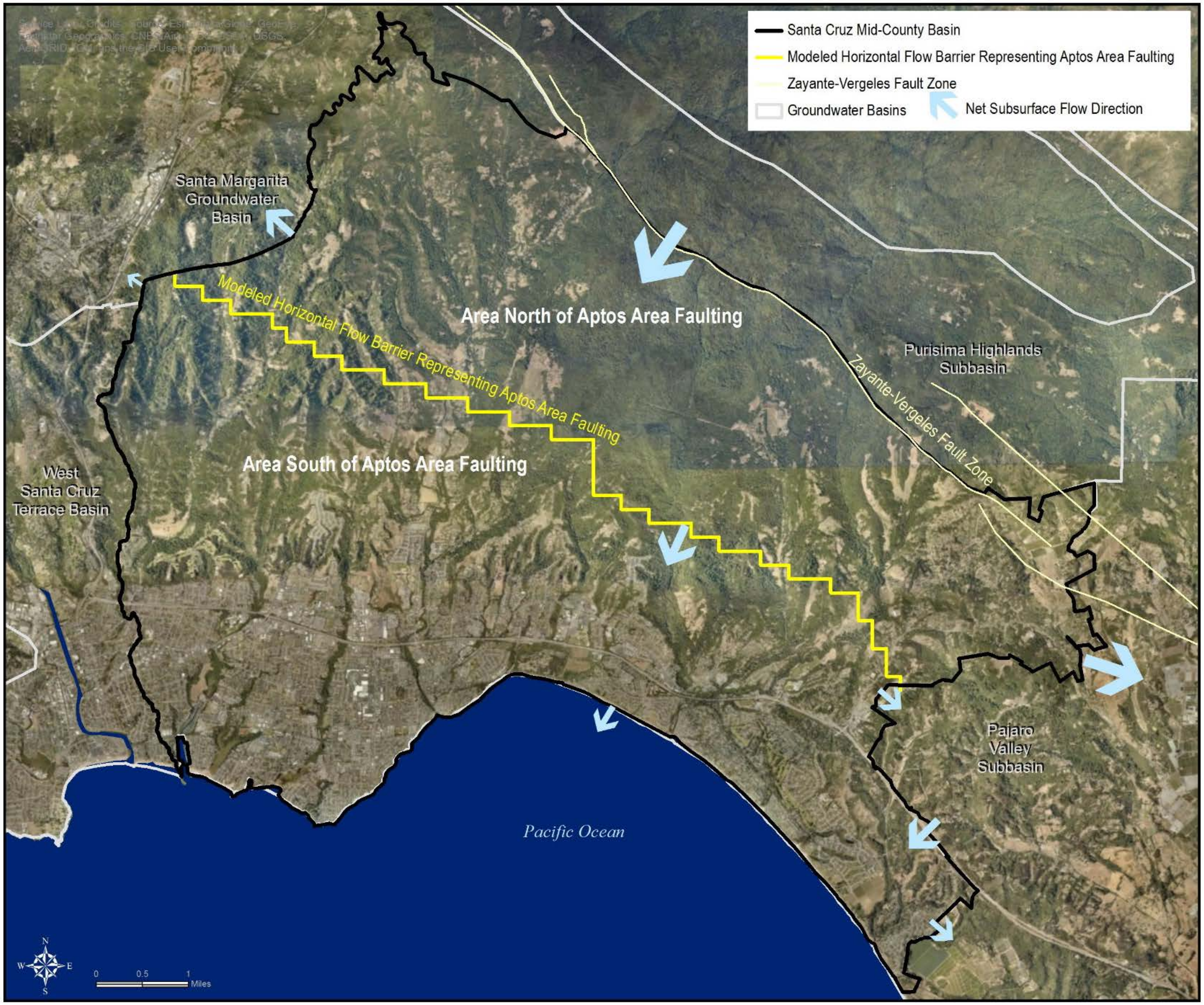

Figure 2-53. Groundwater Budget Subareas

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.

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 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 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.

2.2.5.3.3 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.

2.2.5.3.5 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 as a whole.

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.

2.2.5.4.1 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.

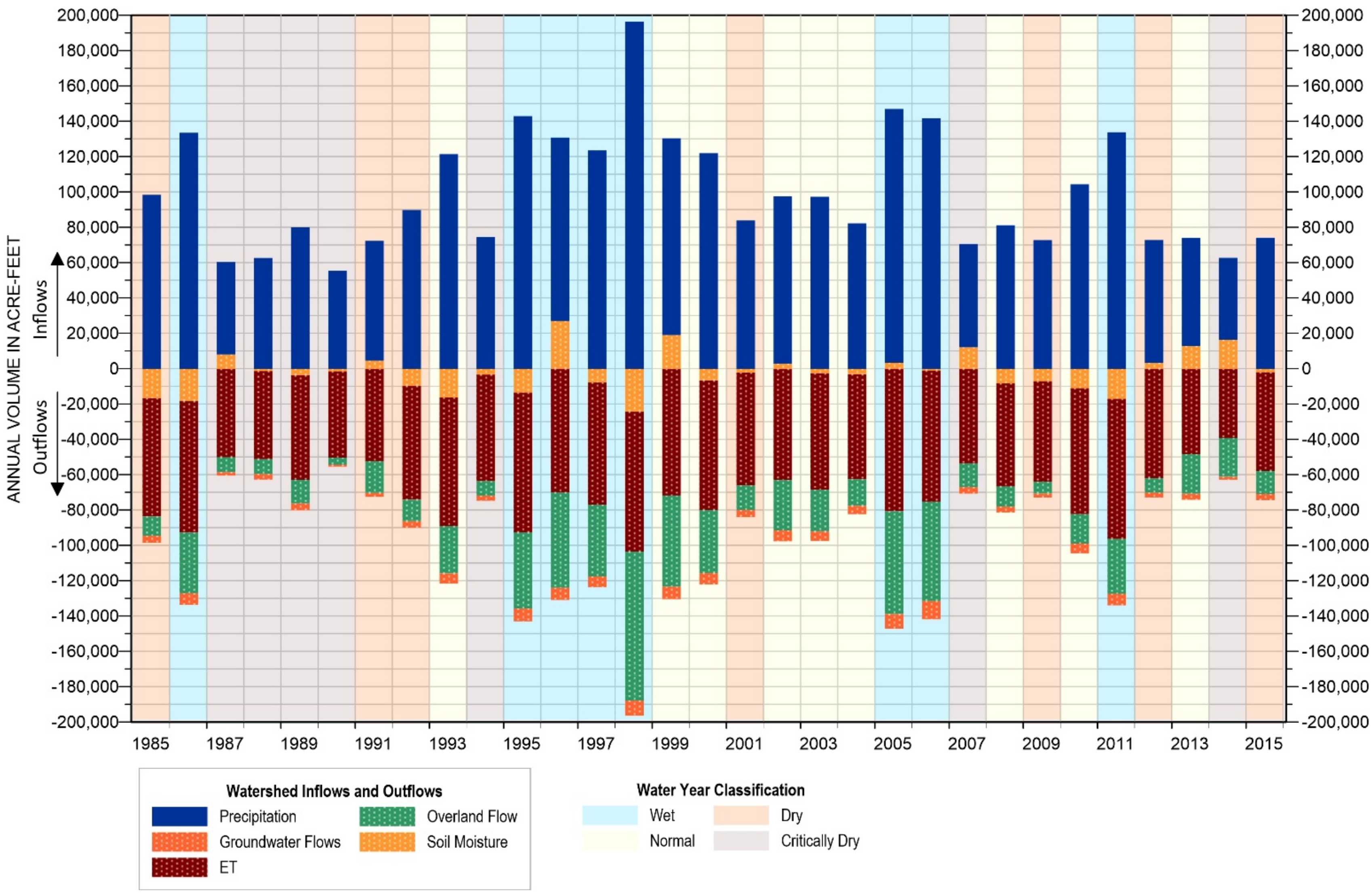

Figure 2-54. Apportionment of Precipitation in Santa Cruz Mid-County Basin Over the Historical Period

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.

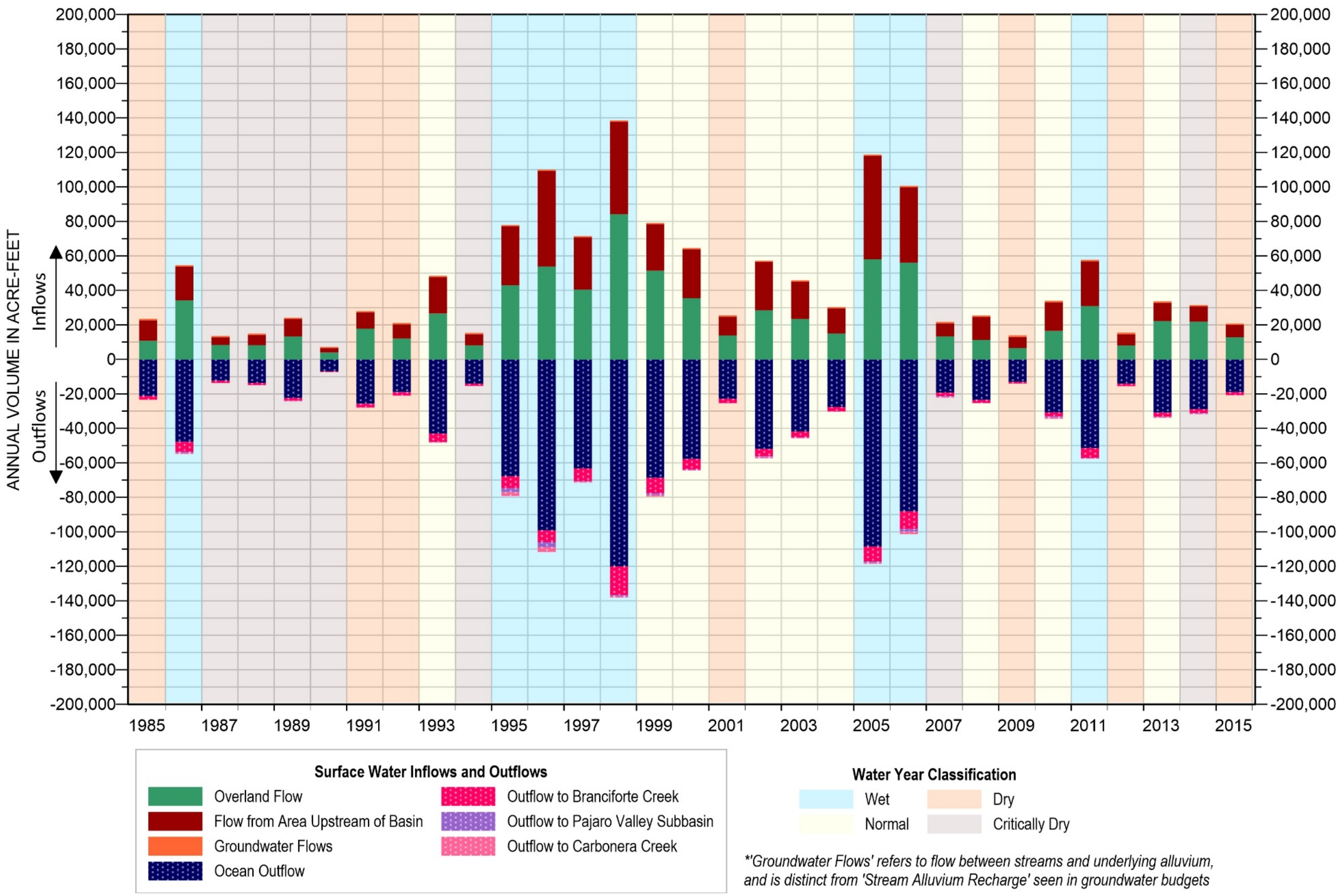

Figure 2-55. Santa Cruz Mid-County Basin Historical Surface Water Budget

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 groundwater dependent ecosystems that could be impacted by surface water depletion by groundwater use do occur in the Basin. Net groundwater flows into surface water are estimated to be a small component of the overall surface water budget but those flows could still be critical to groundwater 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 be based on the 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.

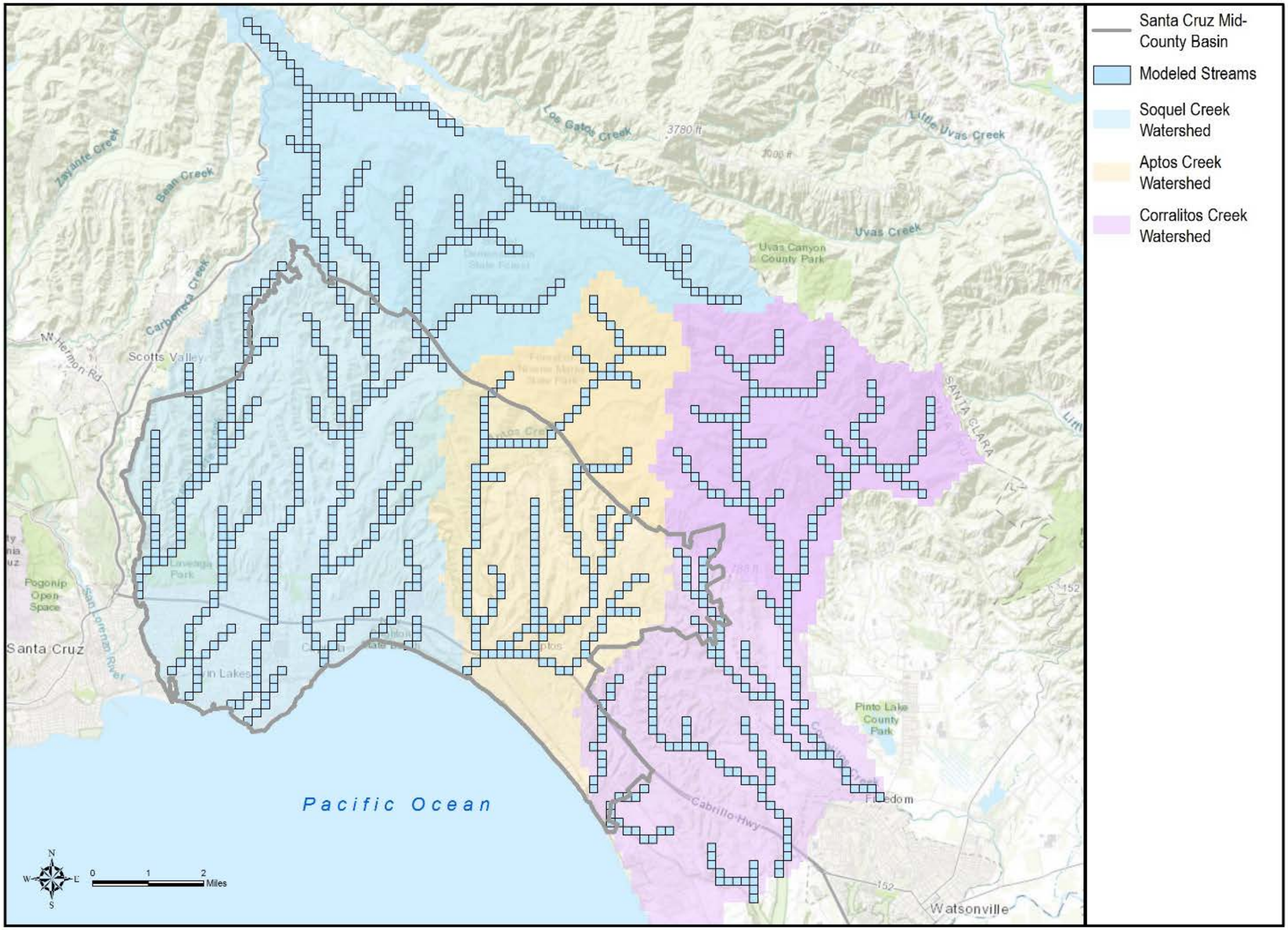

Figure 2-56. Santa Cruz Mid-County Basin Watersheds

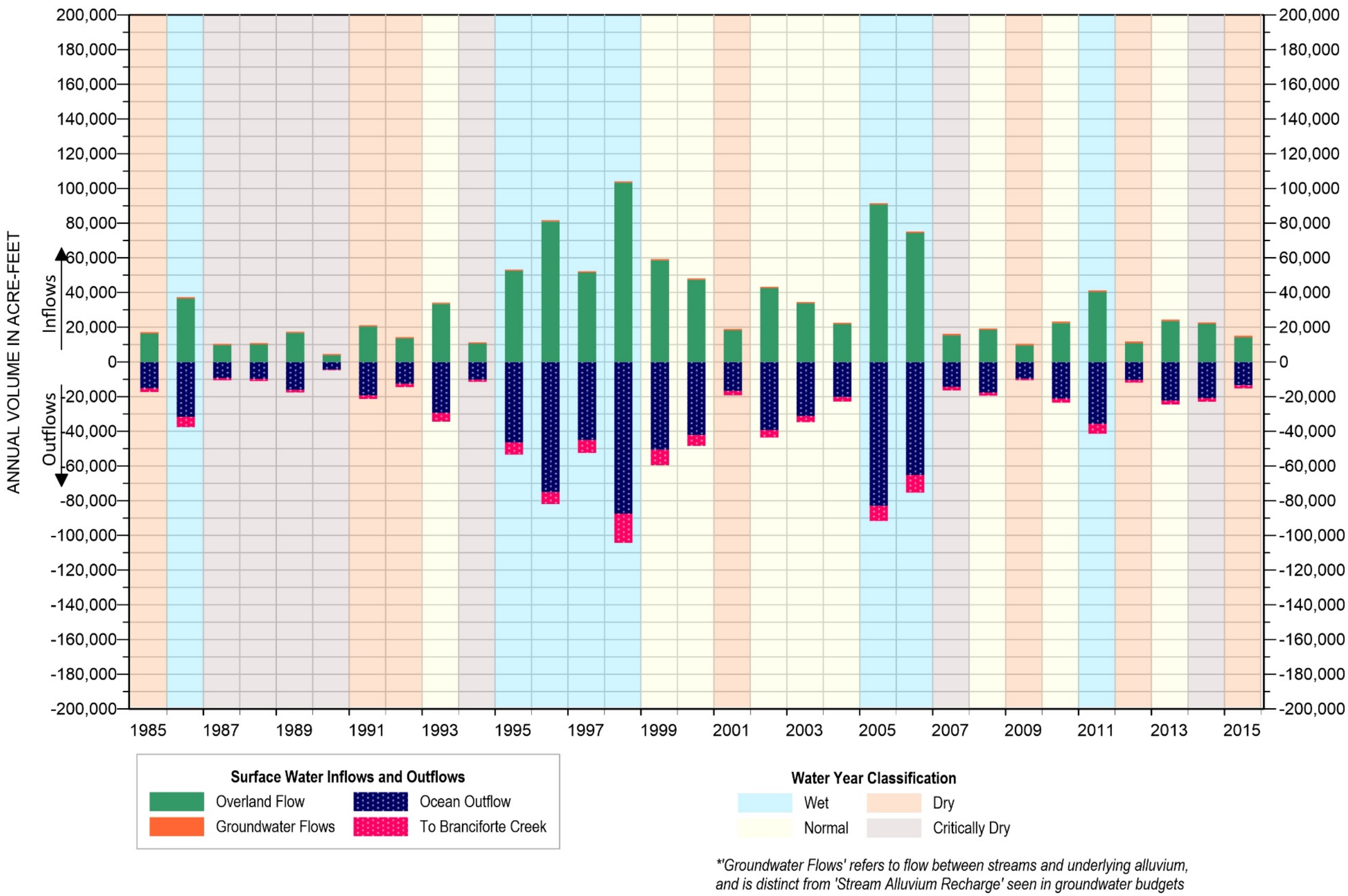

Figure 2-57. Soquel Creek Watershed Historical Budget

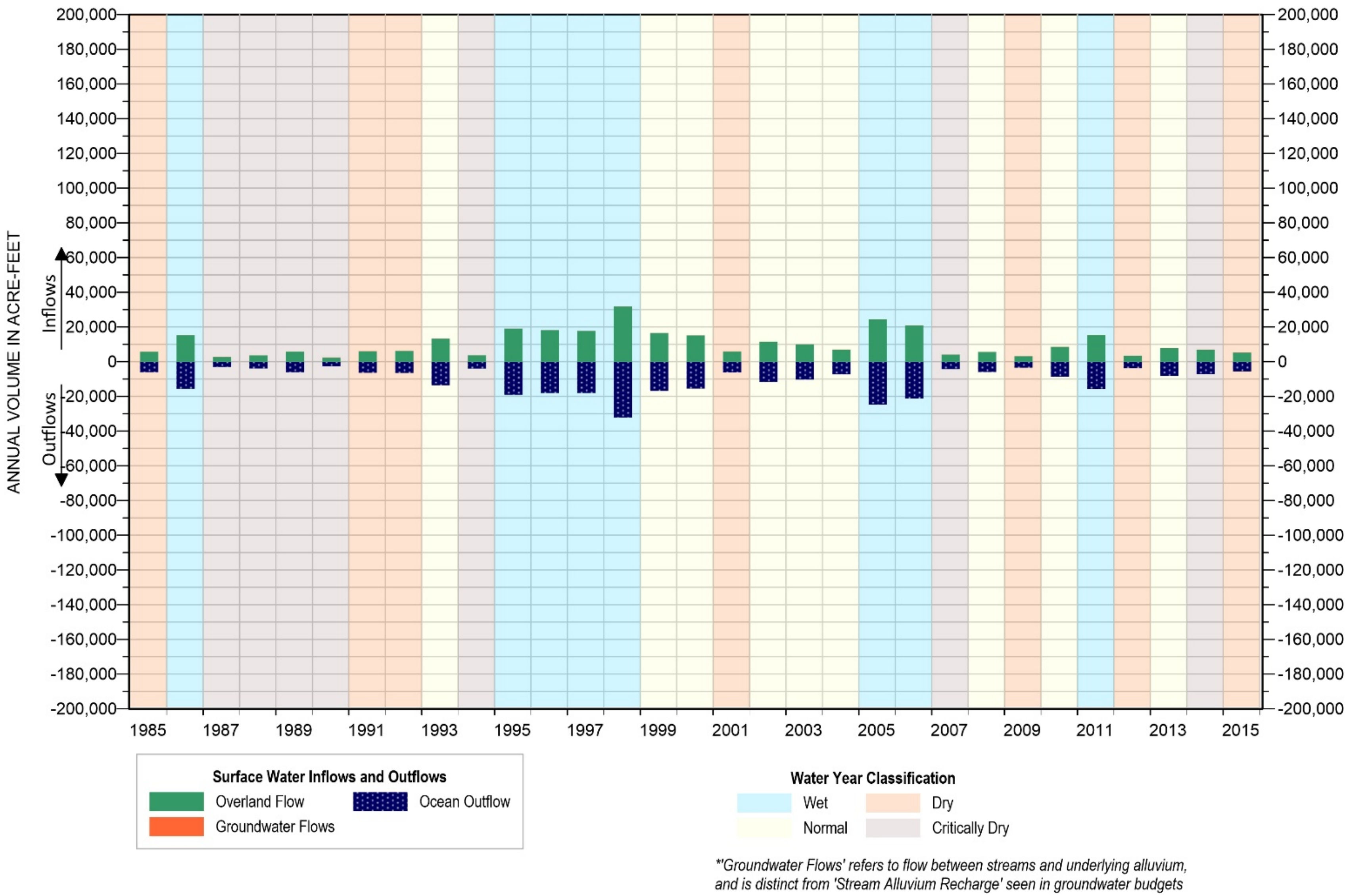

Figure 2-58. Aptos Creek Watershed Historical Budget

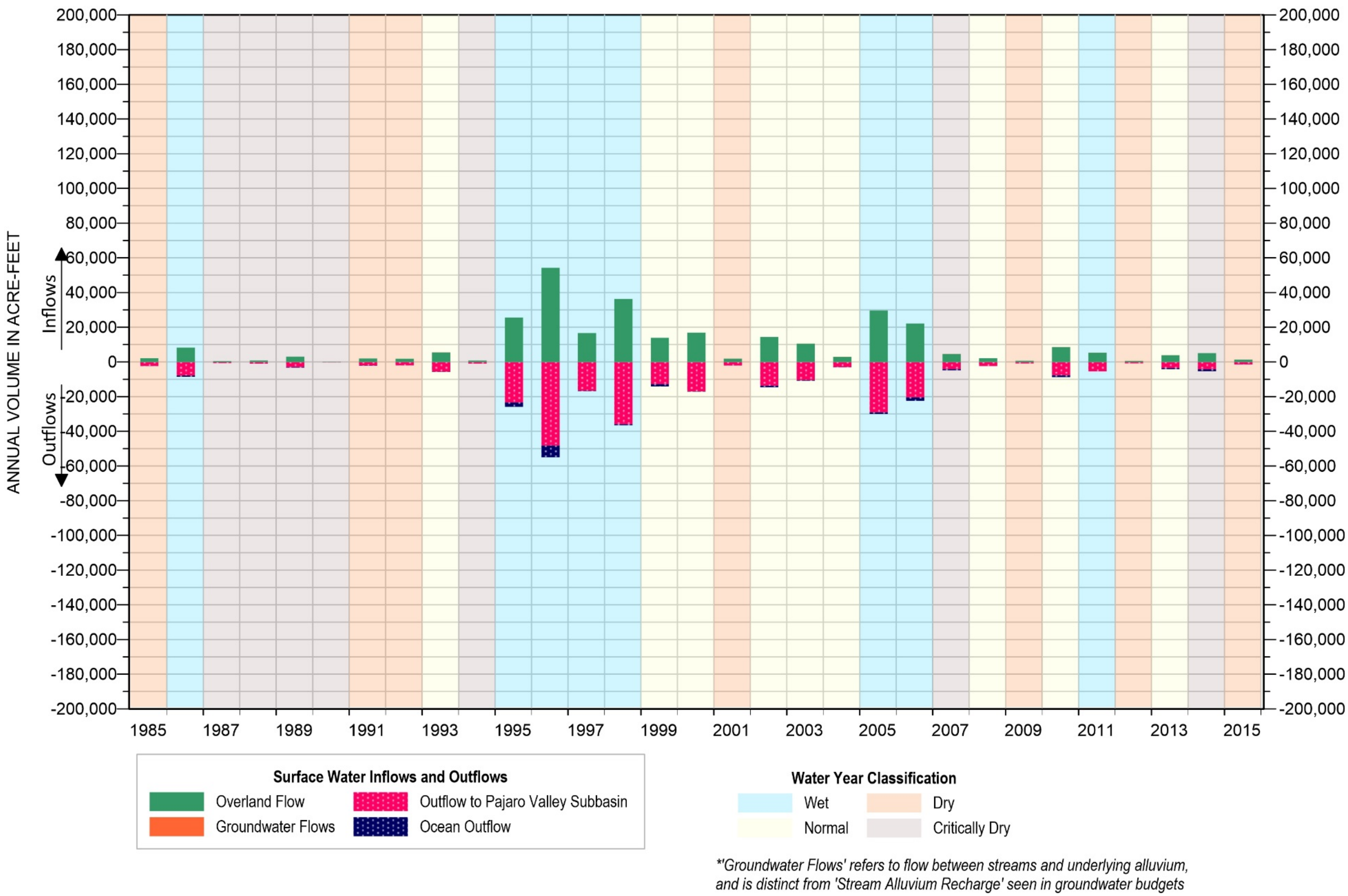

Figure 2-59. Corralitos Creek Watershed Historical Budget

2.2.5.4.2 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%**
	Cumulative		**Average**	
Change in Storage (acre-feet per year)	+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 also net recharge from stream alluvium to the primary aquifers of the Basin. Net recharge from stream alluvium occurs even where the stream alluvium discharges groundwater to streams because groundwater levels in the stream alluvium are generally higher than groundwater levels in 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 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 28,000 acre-feet (an average increase of 2,300 acre-feet per year). This 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 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 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. 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 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 3.

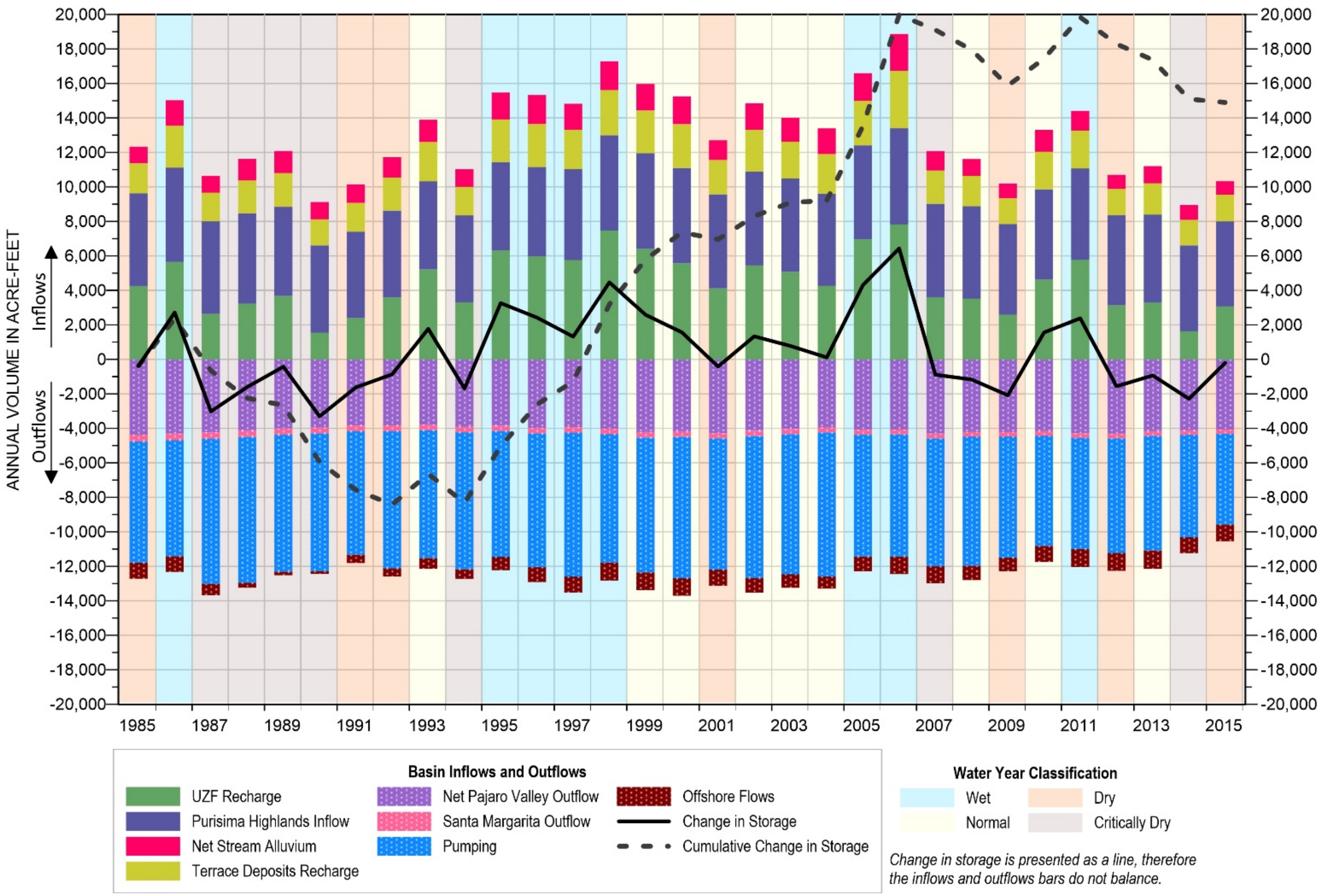

Figure 2-60. Santa Cruz Mid-County Basin Historical Annual Groundwater Budget (1985 – 2015)

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	770	780	200	190	220	570	540	1,190	4,460
Recharge from Stream Alluvium	530	130	_	280	_	380	190	10	1,520
Recharge from Terrace Deposits	1,050	170	_	290	100	230	240	_	2,080
Subsurface Inflow from Purisima Highlands Subbasin	_	2,870	330	320	360	590	780	20	5,270
Offshore Inflow	_	80	_	_	_	30	_	10	120
Inter-Layer Flow	_	740 (L2) 50 (L4)	_	100 (L4)	40 (L5)	140 (L6)	20 (L7)	_	1,090
Total Inflow	**2,350**	**4,820**	**530**	**1,180**	**720**	**1,940**	**1,770**	**1,230**	**14,540**
Annual Average Outflows (acre-feet per year)									
Pumping	980	2,130	<10	900	150	1,590	1,110	550	7,410
Discharge to Stream Alluvium	_	_	80	_	180	_	_	_	260
Subsurface Outflow to Santa Margarita Basin	_	_	_	_	_	_	_	310	310
Subsurface Outflow to Pajaro Valley Subbasin	420	2,590	300	100	150	330	190	_	4,080
Outflow Offshore	210	_	10	140	100	_	450	_	910
Inter-Layer Flow	740 (L3)	_	50 (L3) 100 (L5)	40 (L6)	140 (L7)	20 (L8)	_	_	1,090
Total Outflow	2,350	4,720	540	1,180	720	1,940	1,750	860	14,060
Change in Storage (acre-feet per year)	**0**	**100**	**-10**	**0**	**0**	**0**	**20**	**370**	**480**

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

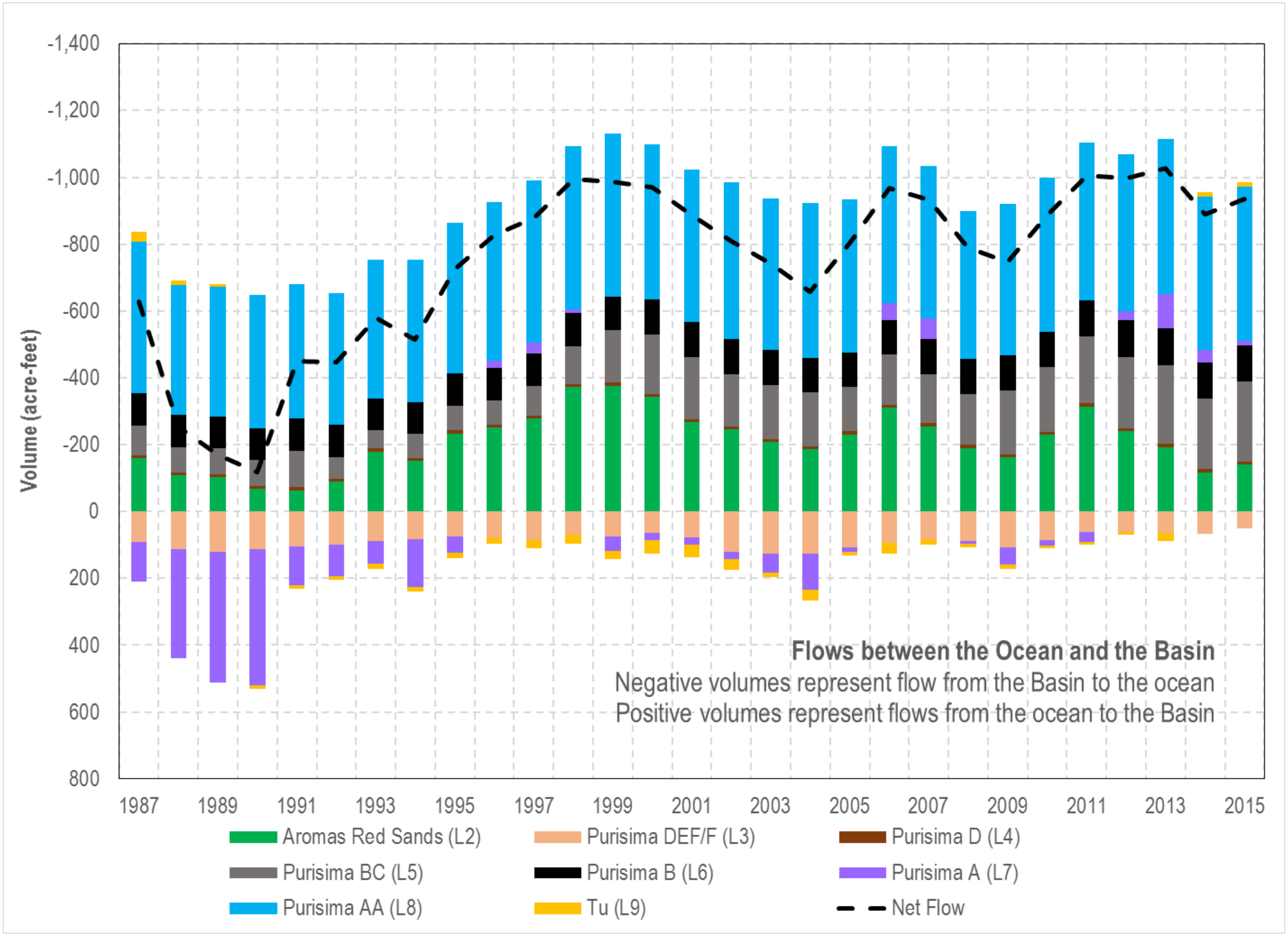

Figure 2-61. Offshore Groundwater Flow to Santa Cruz Mid-County Basin by Model Layer

2.2.5.4.3 North of Aptos Area Faulting Historical Groundwater Budget

Historical groundwater inflows into the area north of the Aptos 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 area faulting does not support a large population like the more urban area south of the Aptos 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 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 30 acre-feet per year. This indicates that the historical water budget north of the Aptos 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 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 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 area faulting (Table 2-14) compared to the area south of the Aptos 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 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	750	5,410	2,730	34%
Subsurface Inflow from Purisima Highlands Subbasin	4,940	5,570	5,270	66%
		Total Inflow	**8,000**	**100%**
Outflows (acre-feet per year)				
Pumping	440	850	690	8%
Discharge to Streams	170	560	360	4%
Subsurface Outflow to Santa Margarita Subbasin	240	380	300	4%
Subsurface Outflow to Pajaro Valley Subbasin	4,810	5,360	5,110	64%
Subsurface Outflow to South of Aptos Area Faulting	1,470	1,530	1,510	19%
		Total Outflow	**7,970**	100%
	Cumulative		Average	
Change in Storage (acre-feet per year)	+910 acre-feet		+30	

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

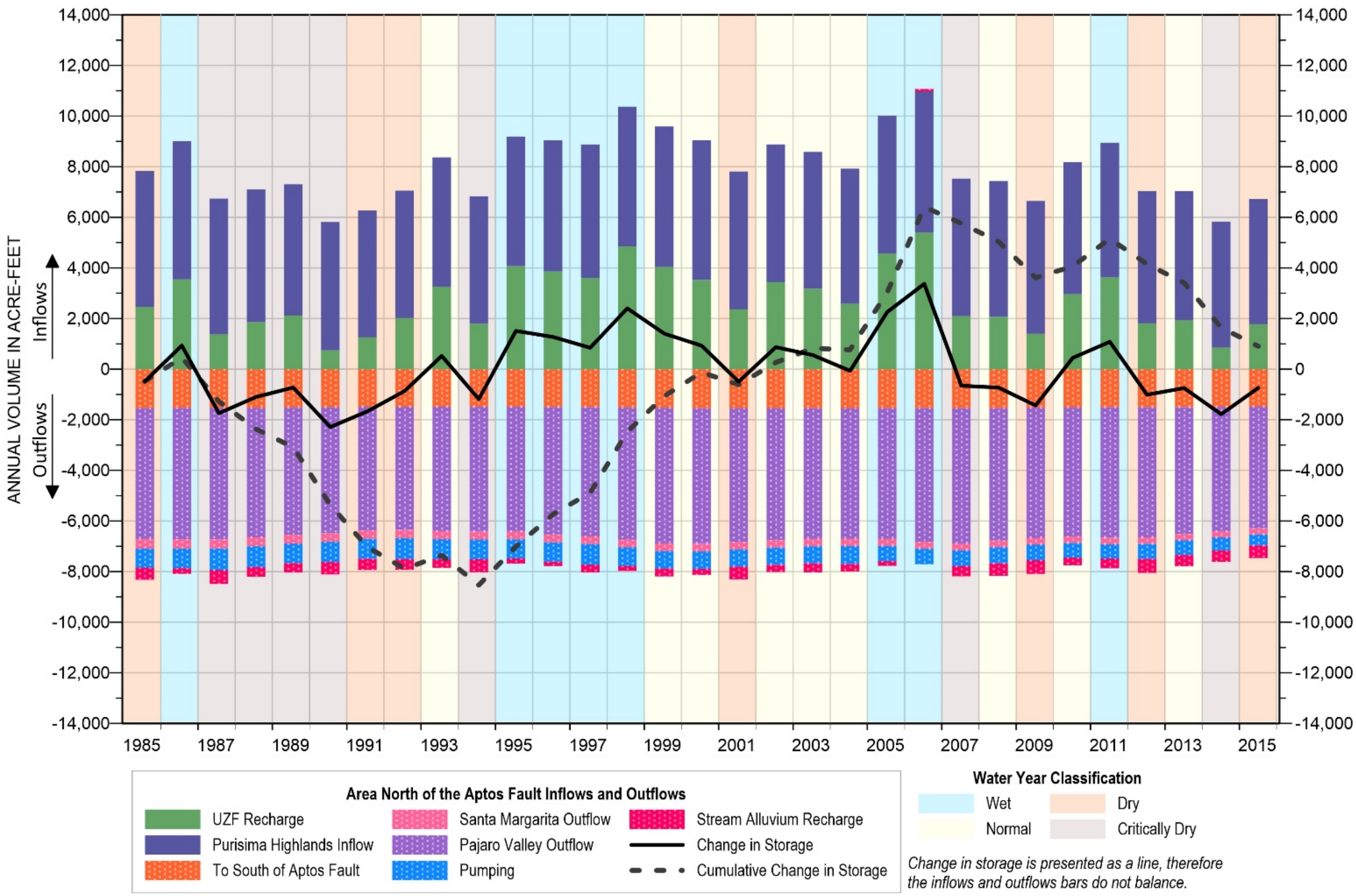

Figure 2-62. North of Aptos Area Faulting Historical Annual Groundwater Budget (1985 – 2015)

2.2.5.4.4 South of Aptos Area Faulting Historical Groundwater Budget

Historical groundwater inflows to the portion of the Basin south of the Aptos 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 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 area faulting are primarily from groundwater pumping, which comprises 89% of average outflows (Table 2-15). The remaining 11% comprised almost completely of flows offshore, with a very minor amount of 10 acre-feet flowing into the Santa Margarita Basin. For the area south of the Aptos area faulting, the average change in storage over the 31-year historical period is an increase of approximately 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 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 area faulting (Figure 2-63) from 1985-1994 is less pronounced than in the area north of the Aptos 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 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	790	2,620	1,730	22%
Recharge from Stream Alluvium	1,280	2,030	1,630	20%
Recharge from Terrace Deposits	1,490	3,340	2,080	26%
Subsurface Inflow from Pajaro Valley Subbasin	760	1,230	1,030	13%
Subsurface Inflow from North of Aptos Area Faulting	1,470	1,530	1,510	19%
		Total Inflow	**7,980**	**100%**
Outflows (acre-feet per year)				
Pumping	4,830	7,640	6,710	89%
Subsurface Outflow to Santa Margarita Subbasin	<10	20	10	<1%
Net Outflow Offshore	150	1,060	790	11%
		Total Outflow	**7,510**	**100%**
	Cumulative		**Average**	
Change in Storage (acre-feet per year)	+13,980 acre-feet		+470	

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

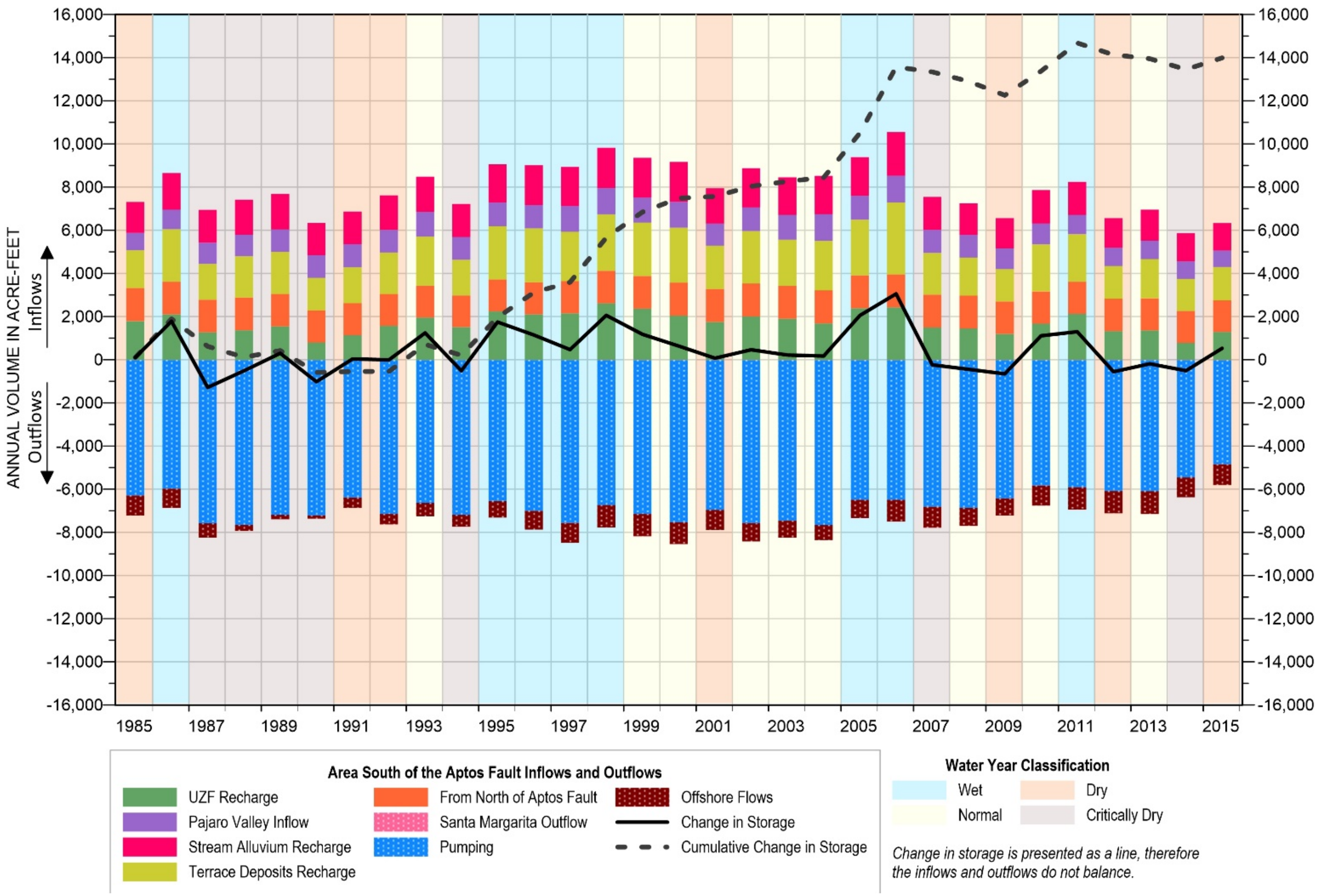

Figure 2-63. South of Aptos Area Faulting Historical Annual Groundwater Budget (1985 – 2015)

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.

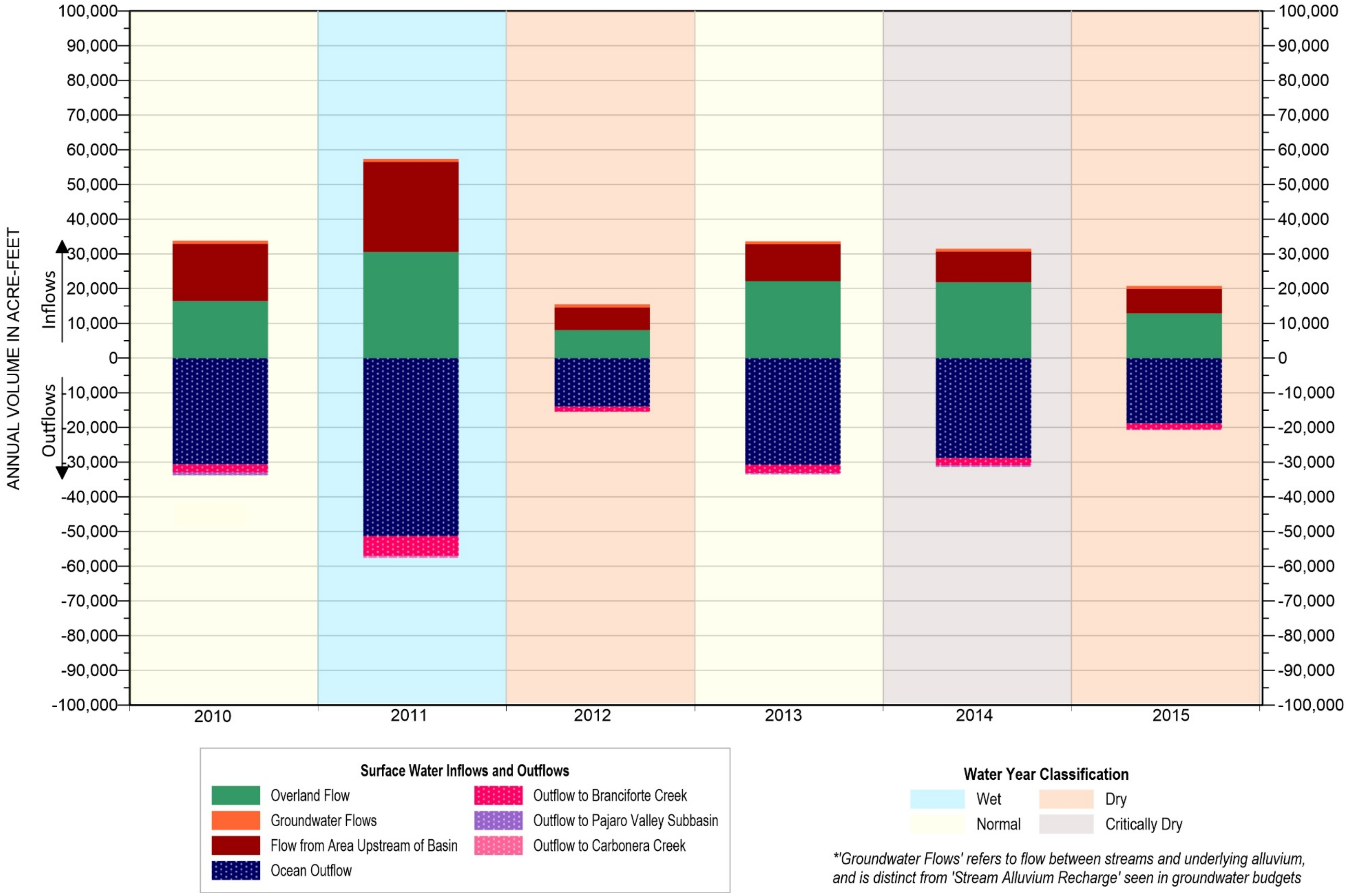

Figure 2-64. Santa Cruz Mid-County Basin Current Annual Surface Water Budget

2.2.5.5.2 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 2-18 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 1,190 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 160 acre-feet per year (Table 2-18) which is approximately 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	1,640	5,770	3,600	31%
Net Recharge from Stream Alluvium	780	1,260	970	8%
Recharge from Terrace Deposits	1,490	2,200	1,790	16%
Subsurface Inflow from Purisima Highlands Basin	4,940	5,310	5,130	45%
		Total Inflow	**11,490**	**100%**
Outflows (acre-feet per year)				
Pumping	5,260	6,650	6,220	53%
Subsurface Outflow to Santa Margarita Basin	250	270	270	2%
Net Subsurface Outflow to Pajaro Valley Subbasin	4,050	4,300	4,170	36%
Net Outflow Offshore	920	1,060	990	9%
		Total Outflow	**11,650**	**100%**
	Cumulative		**Average**	
Change in Storage (acre-feet per year)	-970 acre-feet		-160	

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

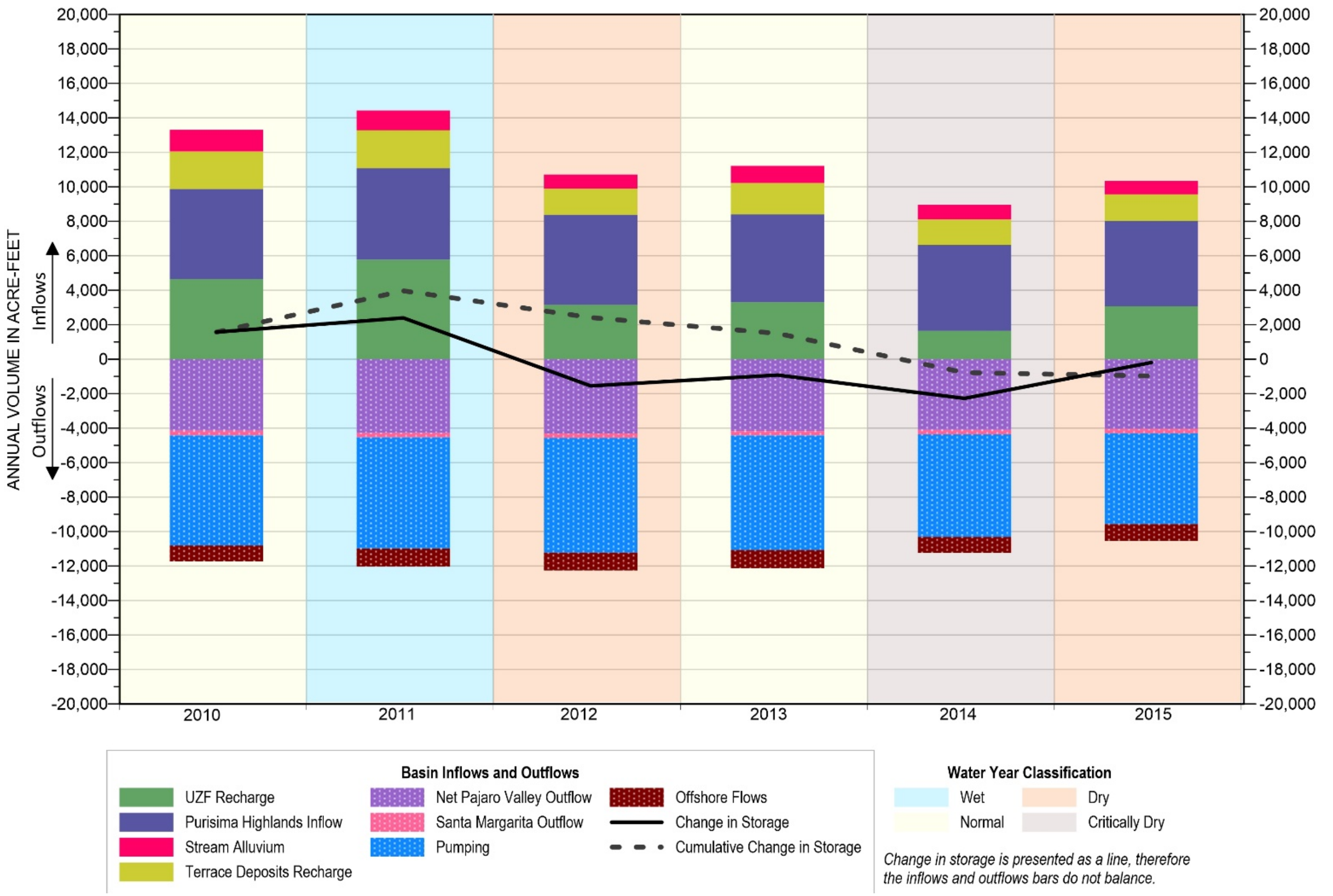

Figure 2-65. Santa Cruz Mid-County Basin Current Annual Groundwater Budget (2010 – 2015)

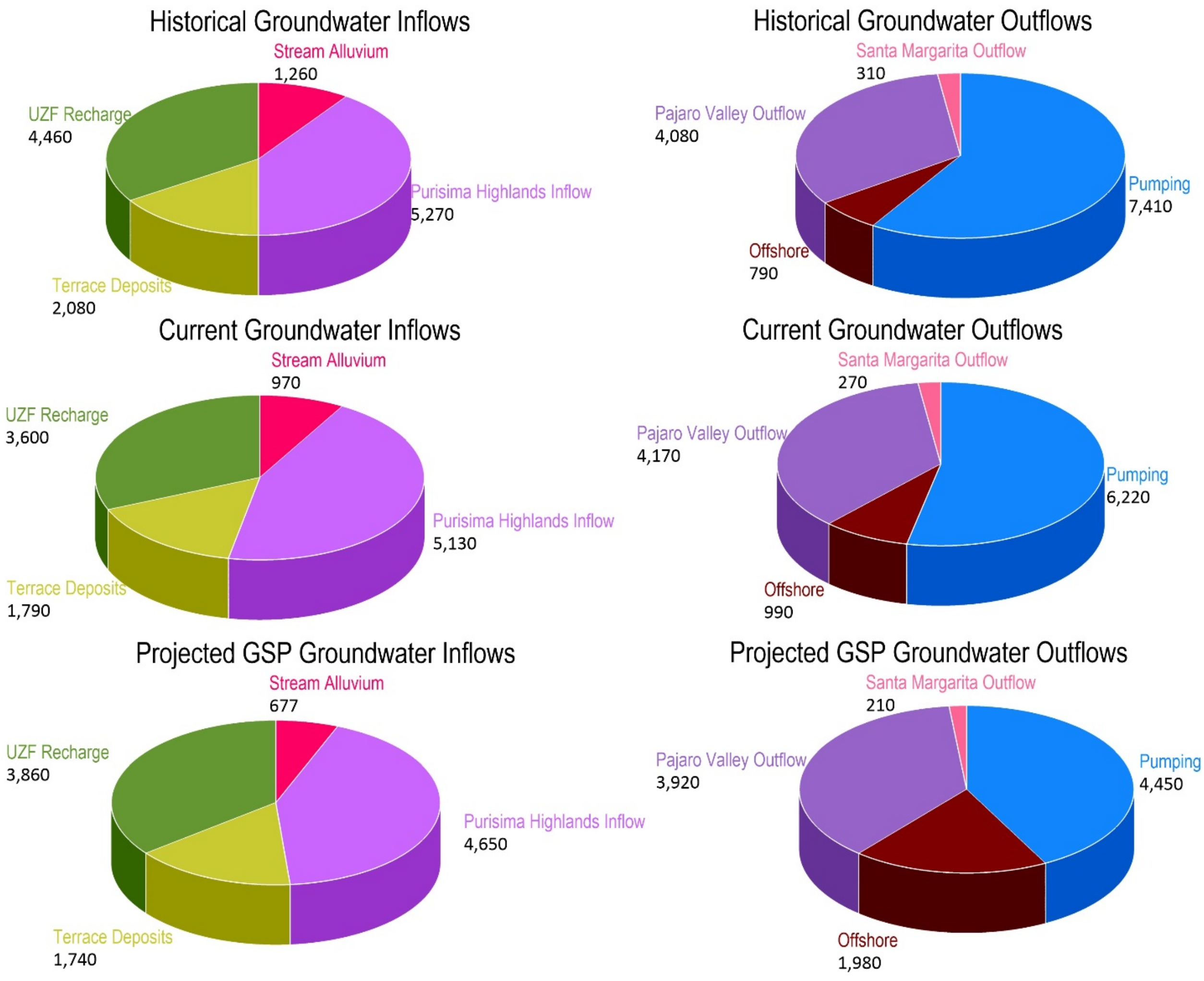

Figure 2-66. Comparison of Historical, Current, and Projected GSP Groundwater Inflows and Outlflows (acre-feet per year)

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 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 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

2.2.5.5.3 North of Aptos Area Faulting Current Groundwater Budget

Similar to the historical period, groundwater inflows in the area north of the Aptos 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 450 acre-feet per year. A graphical representation of the historical annual groundwater budget north of the Aptos 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 area faulting lost about 2,710 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 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	860	3,640	2,170	30%
Subsurface Inflow from Purisima Highlands	4,940	5,310	5,130	70%
		Total Inflow	**7,300**	**100%**
Outflows (acre-feet per year)				
Pumping	440	590	540	7%
Discharge to Streams	300	560	440	6%
Subsurface Outflow to Santa Margarita Subbasin	240	260	250	3%
Subsurface Outflow to Pajaro Valley Subbasin	4,940	5,310	5,030	65%
Subsurface Outflow to South of Aptos Area Faulting	1,470	1,500	1,490	19%
		Total Outflow	**7,750**	**100%**
	Cumulative		**Average**	
Change in Storage (acre-Feet per year)	-2,710 acre-feet		-450	

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

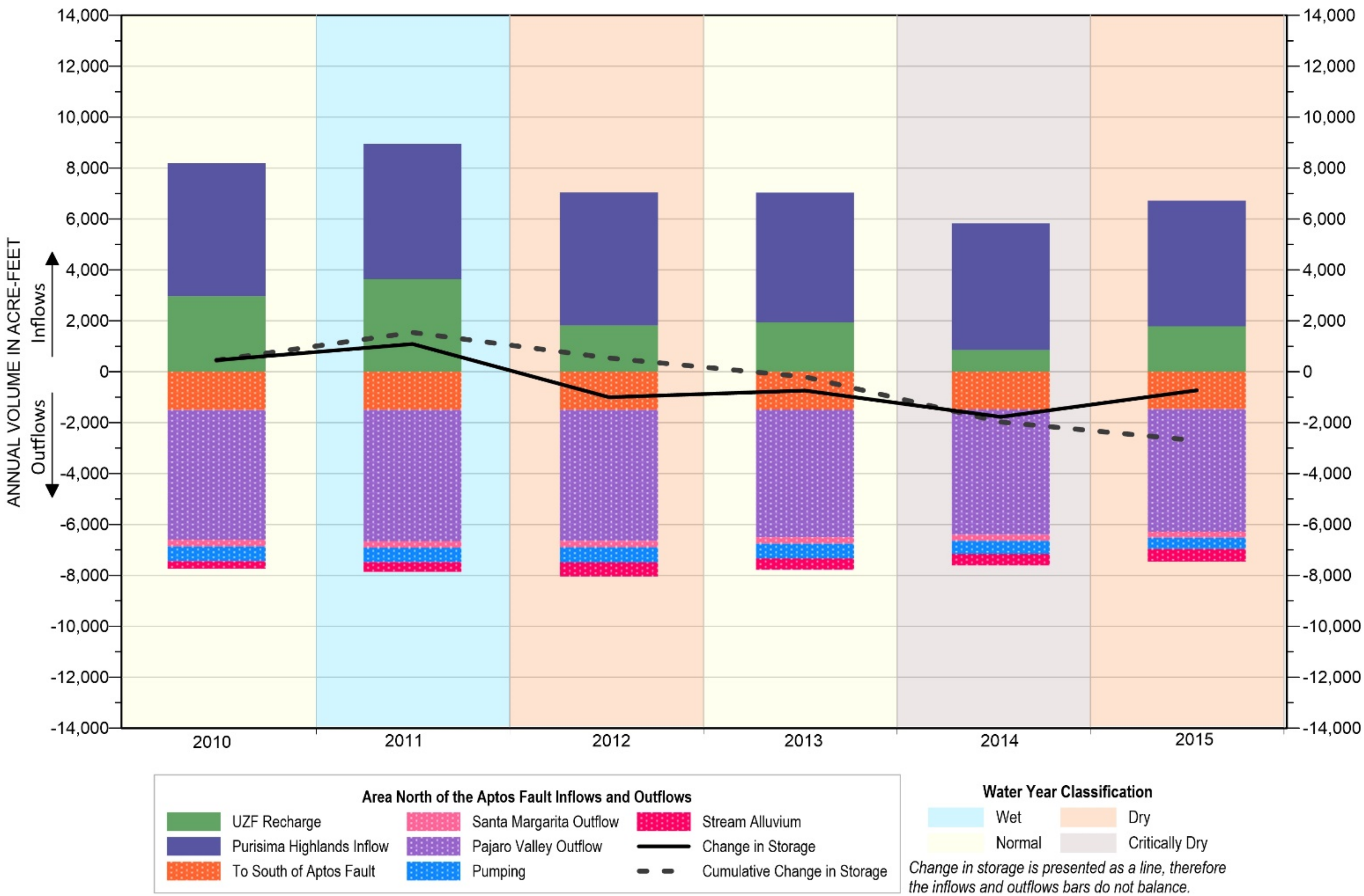

Figure 2-67. North of Aptos Area Faulting Current Annual Groundwater Budget (2010 – 2015)

2.2.5.5.4 South of Aptos 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 area faulting are comprised of inflow from recharge through alluvium and terrace deposits (combined 46%), inflow from the area north of the Aptos area faulting (21%), UZF recharge (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 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 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 180 acre-feet per year lower than during the historical period, yet still gaining. Overall, the area south of the Aptos area faulting gained approximately 1,730 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 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	790	2,130	1,430	21%
Recharge from Stream Alluvium	1,280	1,560	1,410	20%
Recharge from Terrace Deposits	1,490	2,200	1,790	26%
Subsurface Inflow from Pajaro Valley Subbasin	760	920	850	12%
Subsurface Inflow from North of Aptos Area Faulting	1,470	1,500	1,490	21%
		Total Inflow	**6,980**	**100%**
Outflows (acre-feet per year)				
Pumping	4,830	6,060	5,680	85%
Subsurface Outflow to Santa Margarita Subbasin	<10	20	10	<1%
Net Outflow Offshore	920	1,060	990	15%
		Total Outflow	**6,690**	**100%**
Change in Storage (acre-feet per year)	**Cumulative**		**Average**	
	+1,730 acre-feet		+290	

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

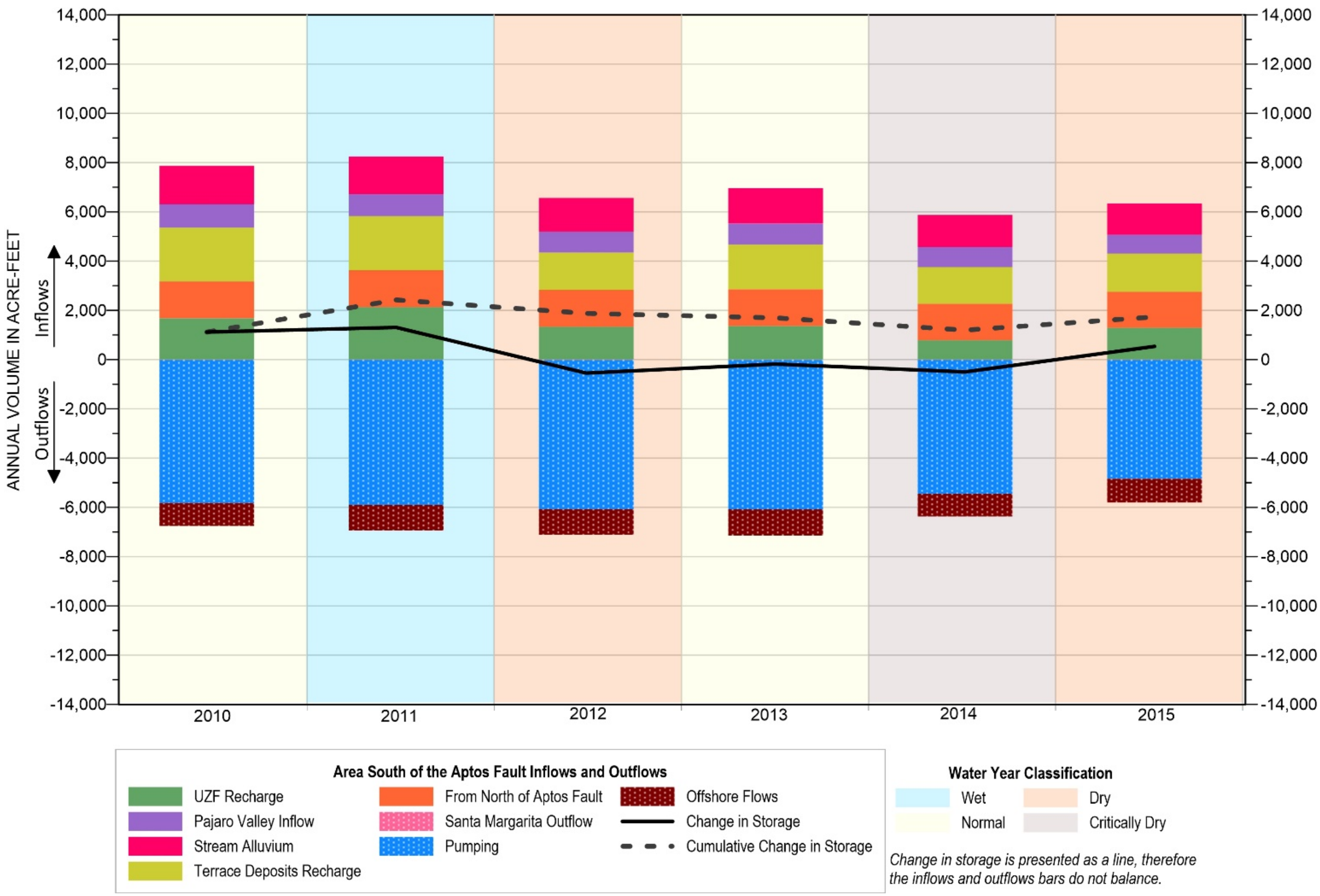

Figure 2-68. South of Aptos Area Faulting Current Annual Groundwater Budget (2010 – 2015)

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).

2.2.5.6.1 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. 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 uses historical data from the Santa Cruz Co-op and Watsonville Waterworks climate stations. 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 (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 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 (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 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 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 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 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 (transparent bars) and the scenario incorporating projects and management actions (non-transparent bars) are shown on 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 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 (4,910 acre-feet) is 1,430 acre-feet less than what is projected in the Baseline scenario (6,340 acre-feet).

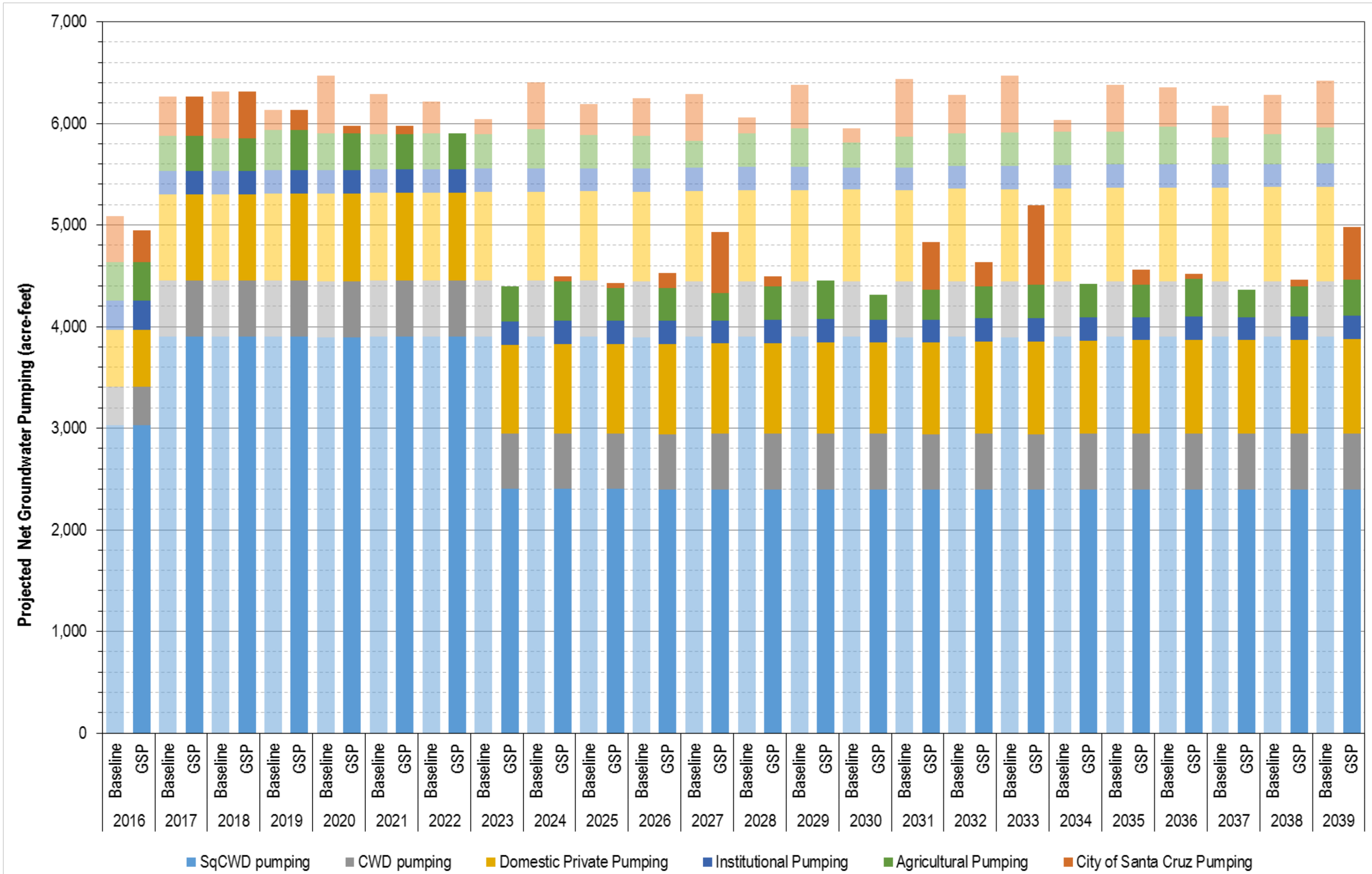

Figure 2-69. Projected Baseline vs. Projected GSP Implementation Net Groundwater Pumping in the Santa Cruz Mid-County Basin (2016-2039)

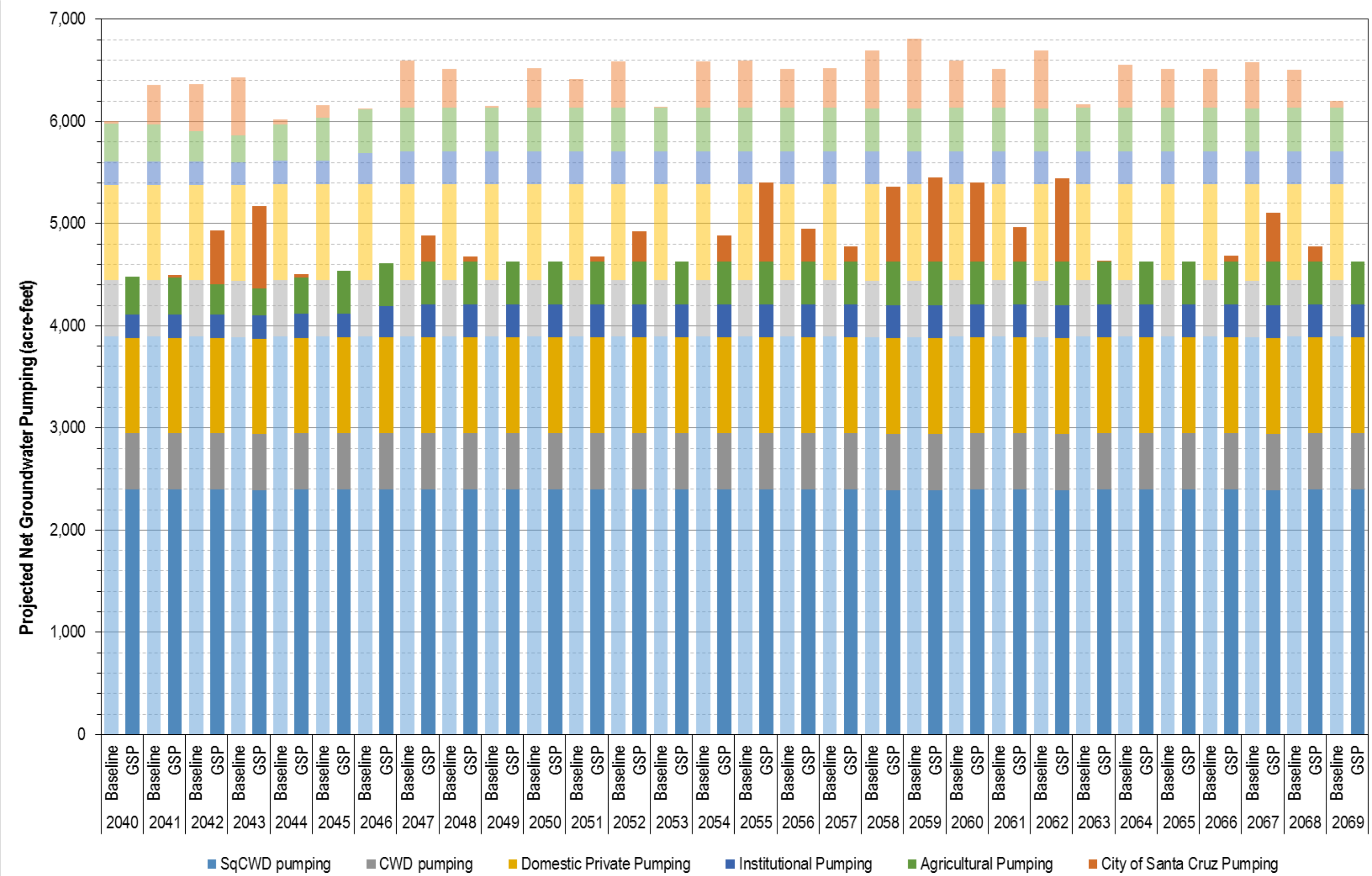

Figure 2-70. Projected Baseline vs. Projected GSP Implementation Net Groundwater Pumping in the Santa Cruz Mid-County Basin (2040-2069)

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.

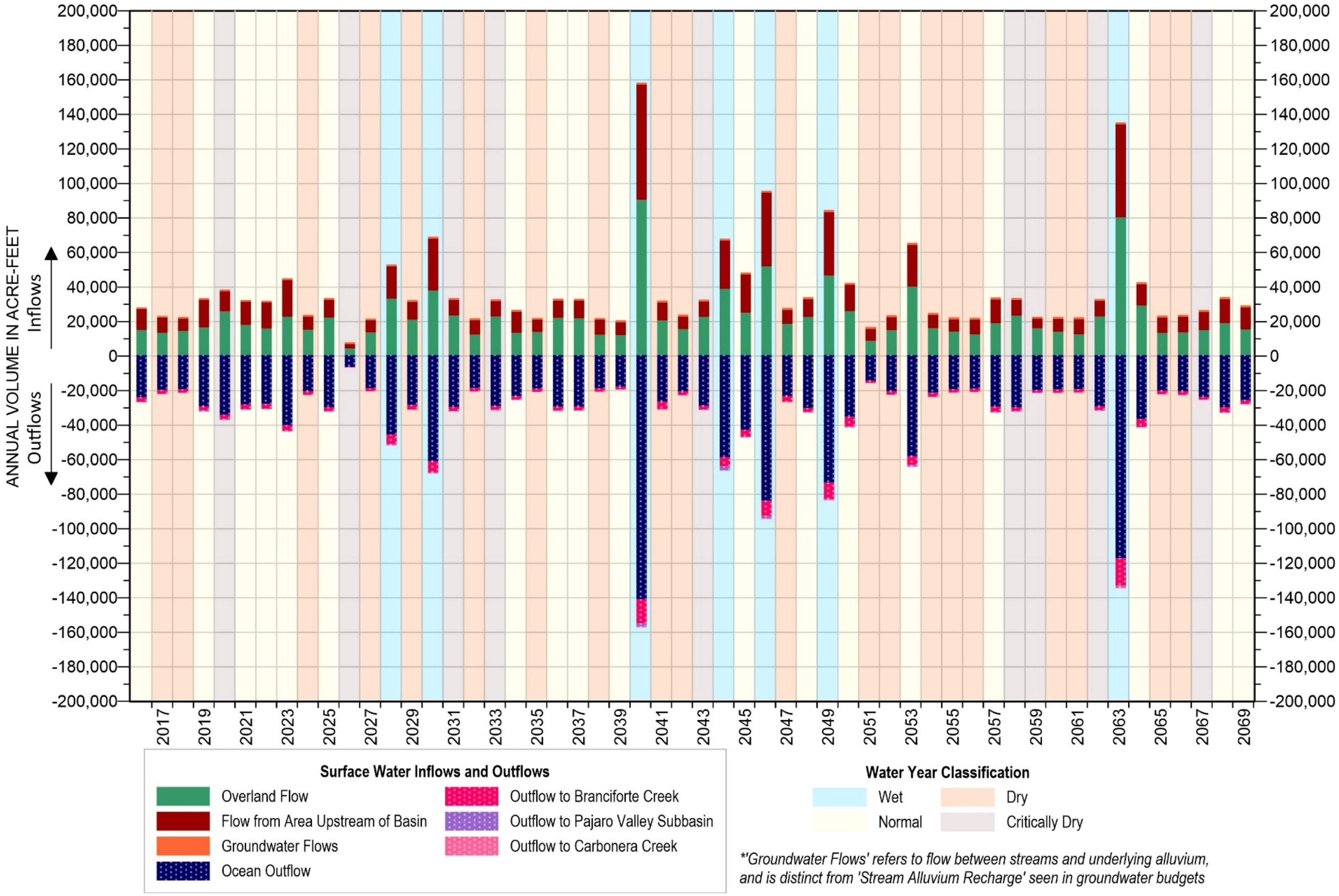

Figure 2-71. Santa Cruz Mid-County Basin Projected Annual Surface Water Budget (2016 – 2069)

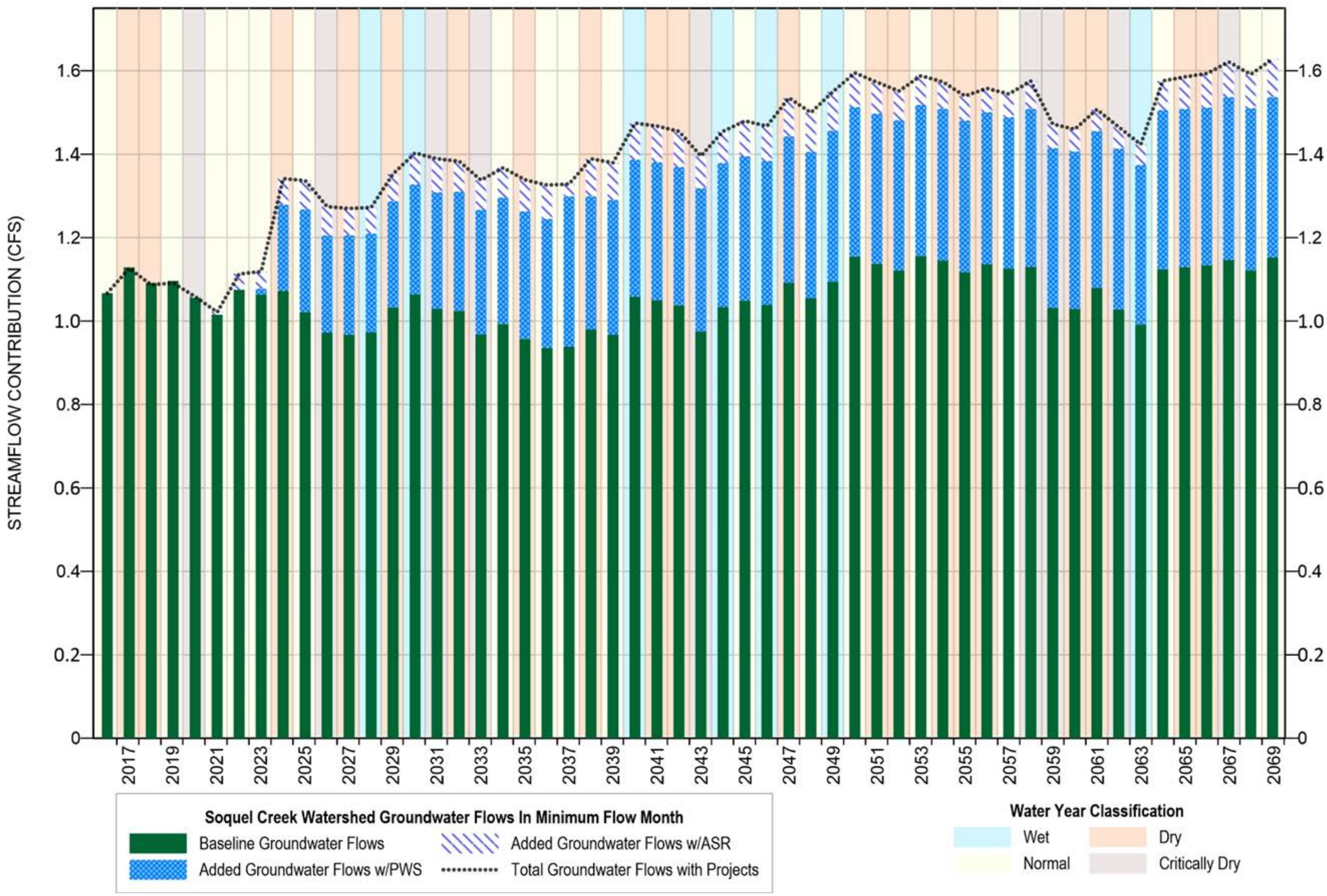

Figure 2-72. Effect of Projects and Management Actions on Soquel Creek Watershed Groundwater Contribution (2016 – 2069)

2.2.5.6.3 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 projection with no projects and management actions, groundwater inflows to the Basin are reduced by around 200 acre-feet per year compared to current conditions and 1,780 acre-feet per year compared to historical conditions. 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 under Baseline conditions remains similar to current outflows which are not sufficient to prevent seawater intrusion. Without projects and management actions implemented to achieve groundwater sustainability (Baseline scenario), it is projected the Basin will experience a loss of groundwater in storage of 3,240 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 840 acre-feet per year (an increase of 73%) to the ocean that will ensure seawater intrusion does not move onshore farther than it is currently, could potentially even push seawater intrusion back. It is projected that with projects and management actions, there will be an average annual increase in groundwater in storage of 280 acre-feet, which equates to a cumulative gain over 54 years of 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	3,860	34%	3,860	35%	0
Net Recharge from Stream Alluvium	1,000	9%	670	6%	-330
Recharge from Terrace Deposits	1,780	16%	1,740	16%	-40
Subsurface Inflow from Purisima Highlands Subbasin	4,650	41%	4,650	43%	0
Total Inflow	**11,290**	**100%**	**10,920**	**100%**	**-370**
Outflows (acre-feet per year)					
Pumping	6,190	55%	4,450	43%	-1,740
Subsurface Outflow to Santa Margarita Subbasin	210	2%	210	2%	0
Net Subsurface Outflow to Pajaro Valley Subbasin	3,670	33%	3,920	37%	250
Net Outflow Offshore	1,150	10%	1,990	19%	840
Total Outflow	**11,220**	**100%**	**10,570**	**100%**	**-650**
	Average	**Cumulative**	**Average**	**Cumulative**	**Average**
Change in Storage (acre-feet per year)	+70	-3,240 acre-feet	+350	+18,530 acre-feet	+280

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

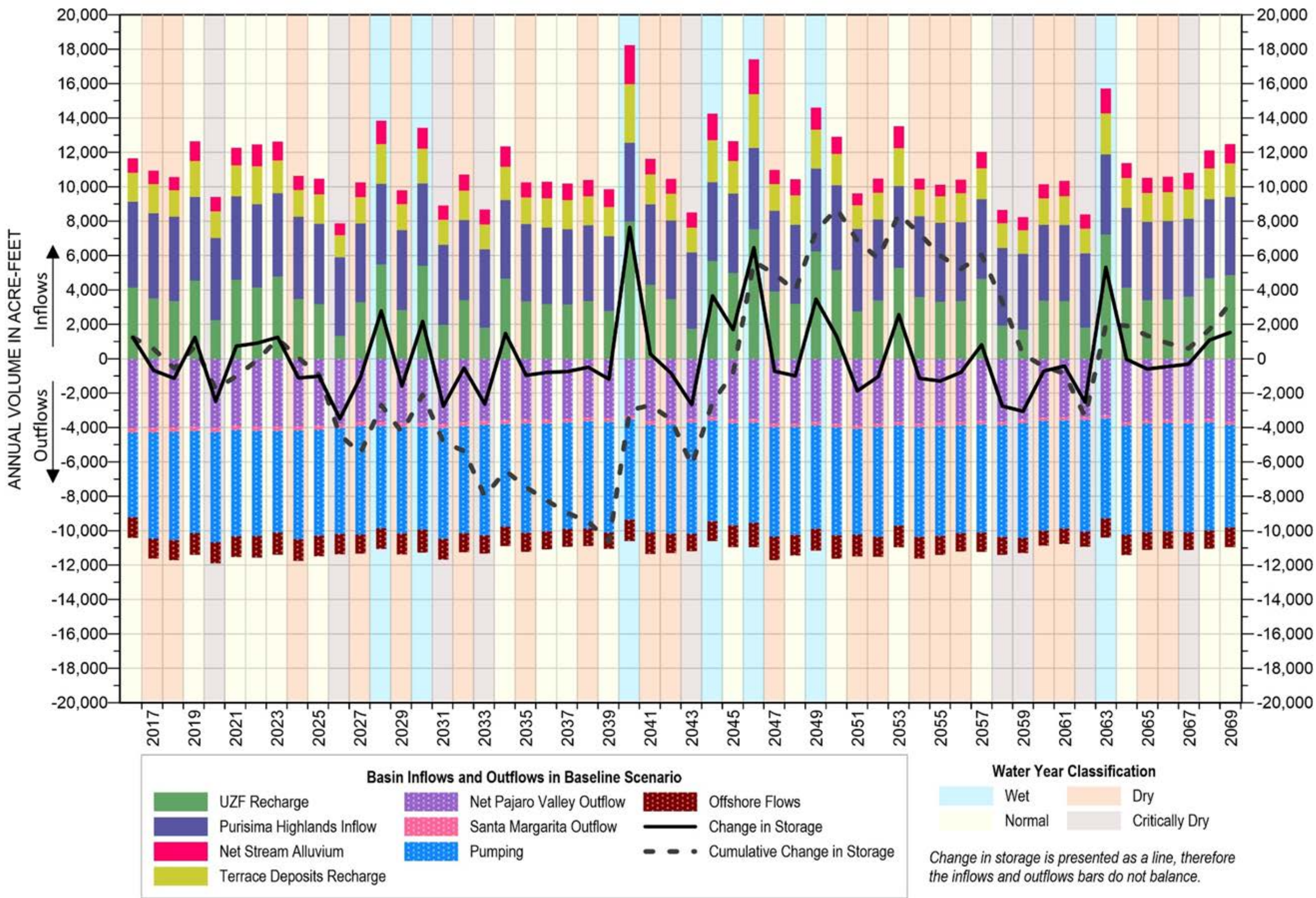

Figure 2-73. Santa Cruz Mid-County Basin Projected Baseline Annual Groundwater Budget (2016 – 2069)

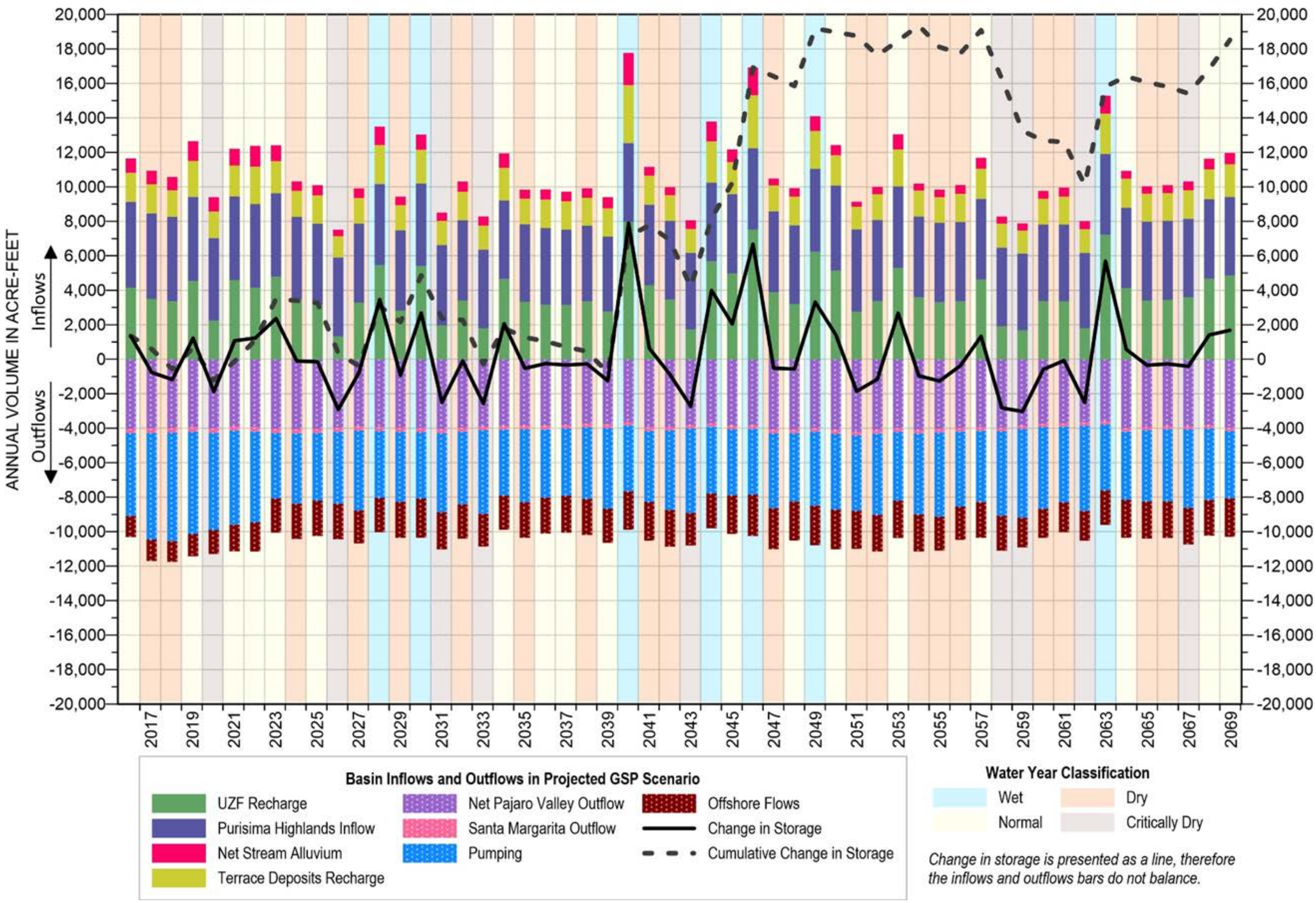

Figure 2-74. Santa Cruz Mid-County Basin Projected GSP Implementation Annual Groundwater Budget (2016 – 2069)

2.2.5.6.4 North of Aptos Area Faulting Projected Groundwater Budget

In both the projected groundwater budgets for the area north of the Aptos 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) decrease due to the drier climate, amounting to 970 acre-feet less in average annual inflow. Similarly, outflows also decrease by about 970 acre-feet when compared to the historical average. While all groundwater outflows decrease slightly, subsurface outflow to Pajaro Valley decreases by almost 660 acre-feet annually (Table 2-14).

In the Baseline projection, an average loss of groundwater in storage of 20 acre-feet annually culminates in a total loss of nearly 1,140 acre-feet over the 54-year projected period. With projects and management actions, the area North of the Aptos area faulting experiences an average increase in groundwater in storage of 30 acre-feet annually, culminating in a total gain of 1,710 acre-feet by 2069. The difference may be attributable to overall increases in groundwater elevations in the area south of the Aptos area faulting where GSP projects are implemented. The increase groundwater elevations may reduce the hydraulic gradient across the Aptos area faulting thereby resulting in less outflow to the area south of the fault (Table 2-14).

Table 2-25. North of Aptos 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	2,380	33%	2,380	33%	0
Subsurface Inflow from Purisima Highlands	4,650	67%	4,650	67%	0
Total Inflow	**7,030**	**100%**	**7,030**	**100%**	**0**
Outflows (acre-feet per year)					
Pumping	610	9%	610	9%	0
Discharge to Streams	360	5%	350	5%	-10
Subsurface Outflow to Santa Margarita Subbasin	190	3%	190	3%	0
Net Subsurface Outflow to Pajaro Valley Subbasin	4,450	63%	4,450	63%	2
Subsurface Outflow to South of Aptos Area Faulting	1,440	20%	1,400	20%	-40
Total Outflow	**7,050**	**100%**	**7,000**	**100%**	**-30**
	Average	**Cumulative**	**Average**	**Cumulative**	**Average**
Change in Storage (acre-feet per year)	-20	-1,140 acre-feet	30	+1,710 acre-feet	+50

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

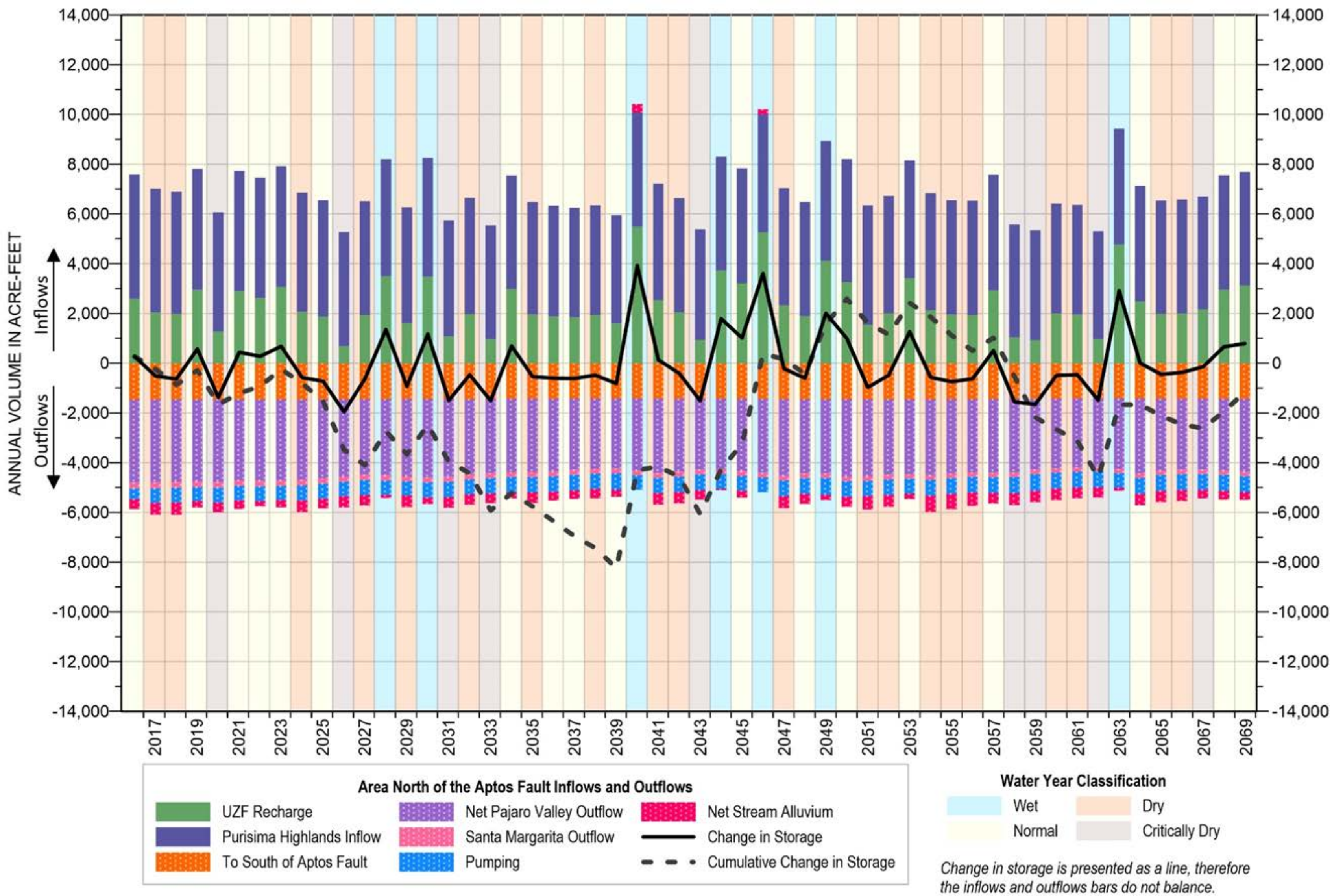

Figure 2-75. North of Aptos Area Faulting Projected Baseline Annual Groundwater Budget (2016 – 2069)

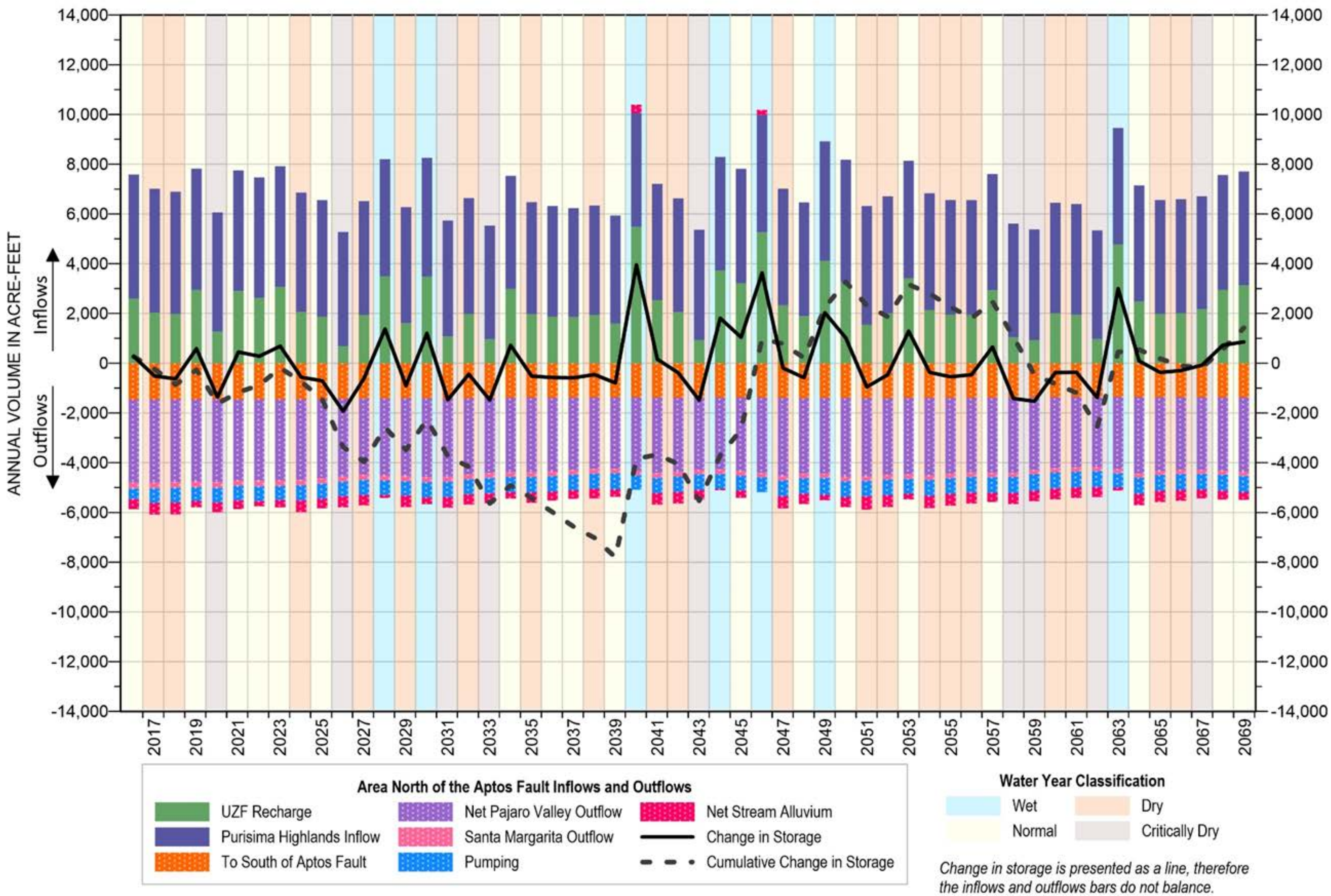

Figure 2-76. North of Aptos Area Faulting Projected GSP Implementation Annual Groundwater Budget (2016 – 2069)

2.2.5.6.5 South of Aptos Area Faulting Projected Groundwater Budget

The relative proportions of projected groundwater inflow and outflow components for the area south of the Aptos area faulting are very similar to the historical and current periods. All inflows decrease slightly due to the drier and warmer climate (Table 2-15 and Table 2-26). Groundwater pumping is decreased by about 1,130 acre-feet annually in the Baseline projection when compared to the historical time period because of improved groundwater management practices and water conservation.

In the projected GSP Implementation scenario, pumping is further decreased by 1,740 acre-feet per year from Baseline pumping because of projects that provide supplemental water as a supply source (Table 2-26). With GSP Implementation, offshore flows are increased when compared to the historical, current, and Baseline budgets. These increased offshore flows reflects higher groundwater elevations within the Basin as a result of projects and management actions.

Under both Baseline and GSP Implementation projections, the area south of the Aptos area faulting is simulated to have increases in groundwater in storage (Table 2-26). In the Baseline scenario, an average annual gain in storage of 70 acre-feet per year creates 4,380 acre-feet of cumulative storage by 2069. 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 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	1,480	22%	1,480	24%	0
Net Recharge from Stream Alluvium	1,360	20%	1,030	17%	-330
Recharge from Terrace Deposits	1,780	25%	1,740	27%	-40
Subsurface Inflow from Pajaro Valley Subbasin	780	11%	530	9%	-250
Subsurface Flow from North of Aptos Area Faulting	1,430	22%	1,390	23%	-40
Total Inflow	**6,830**	**100%**	**6,170**	**100%**	**-660**
Outflows (acre-feet per year)					
Pumping	5,580	83%	3,840	66%	-1,740
Net Subsurface Outflow to Pajaro Valley Subbasin	10	<1%	10	<1%	0
Net Outflow Offshore	1,150	17%	2,000	34%	850
Total Outflow	**6,740**	**100%**	**5,850**	**100%**	**-890**
Change in Storage (acre-feet per year)	**Average**	**Cumulative**	**Average**	**Cumulative**	**Average**
	+70	+4,380 acre-feet	+320	+17,100 acre-feet	+390

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

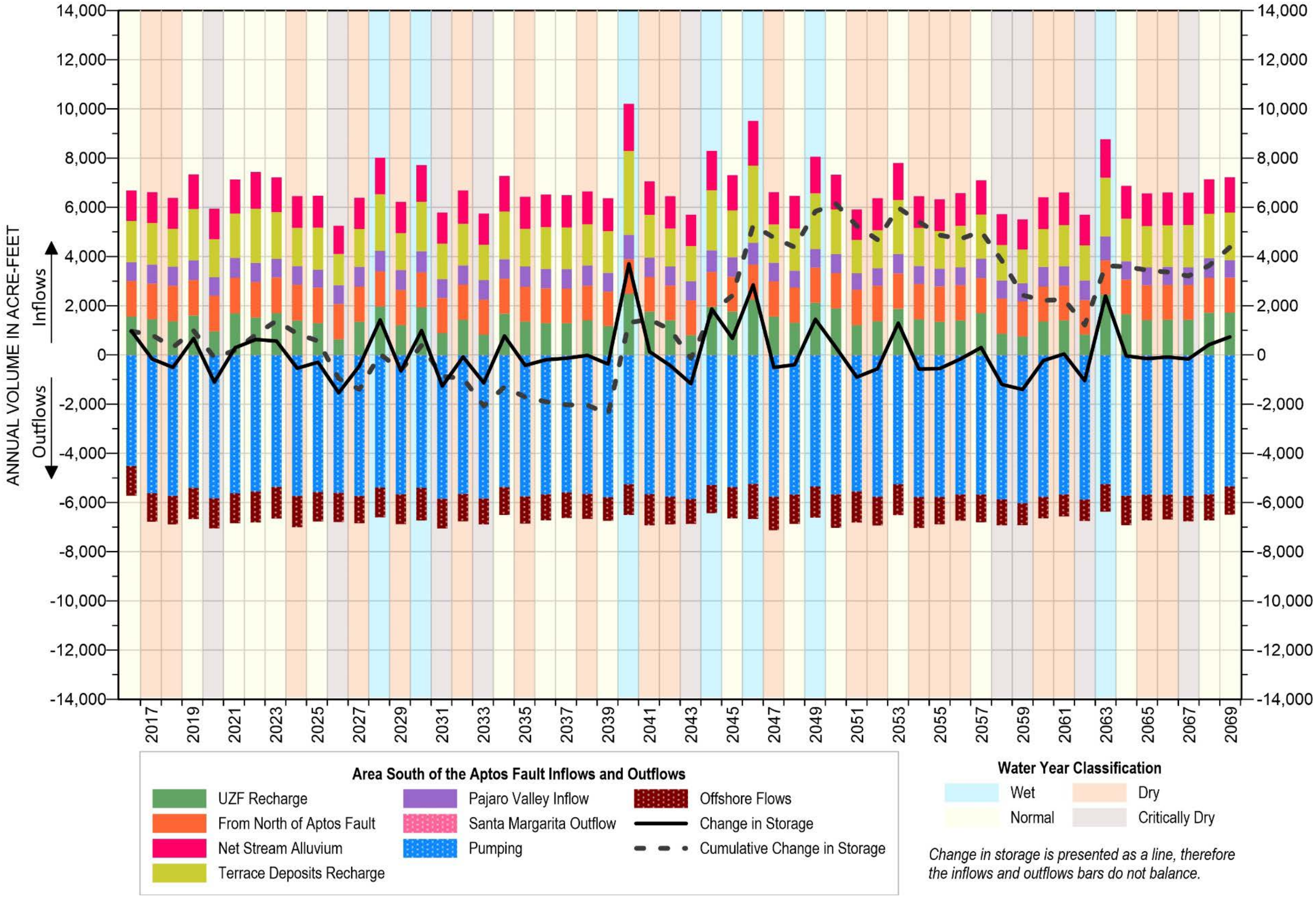

Figure 2-77. South of Aptos Area Faulting Projected Baseline Annual Groundwater Budget (2016 – 2069)

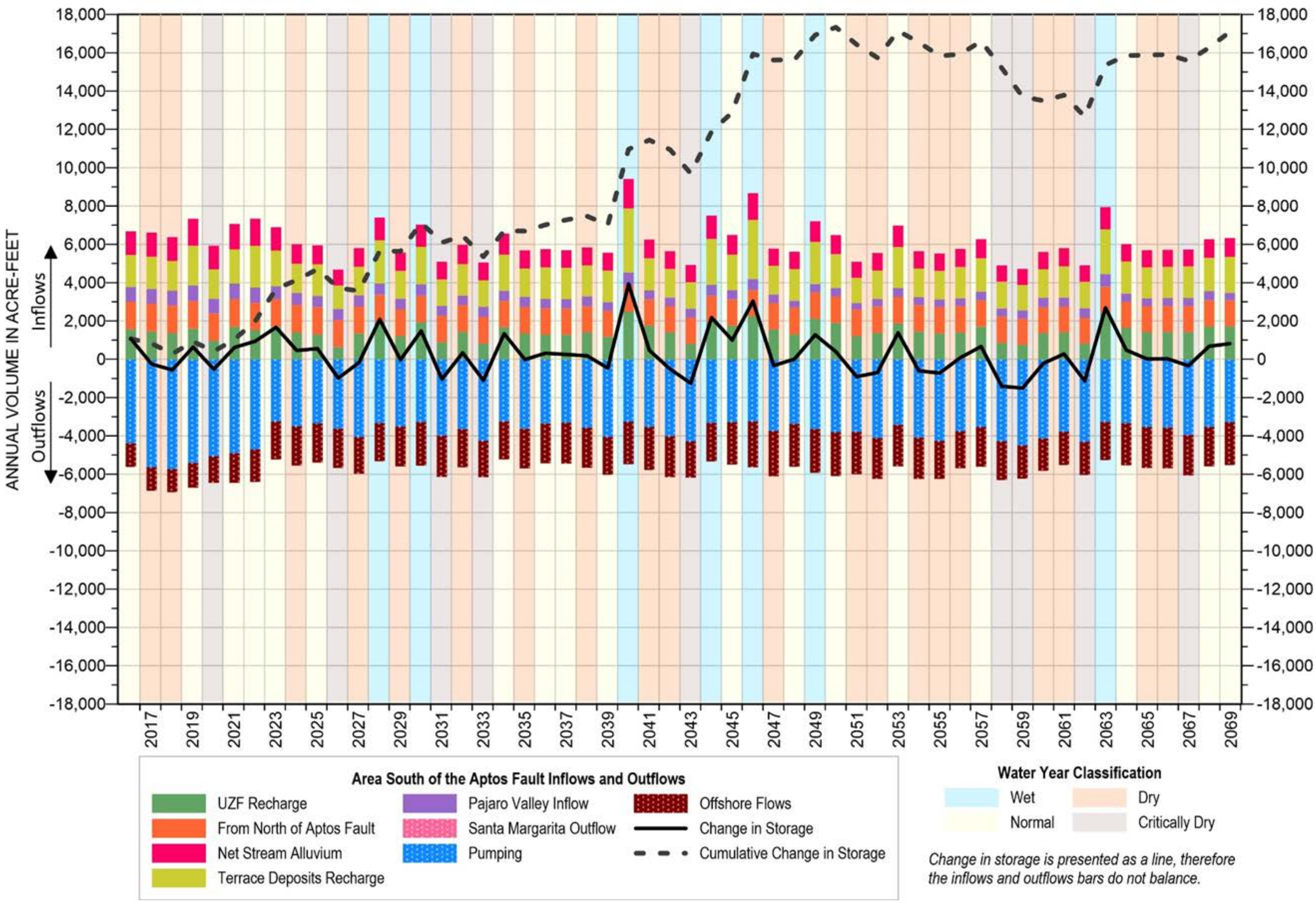

Figure 2-78. South of Aptos Area Faulting Projected GSP Implementation Annual Groundwater Budget (2016 – 2069)

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**

2.2.6 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 non-municipal domestic groundwater use has less influence on Basin sustainability, most notably seawater intrusion. The Committee discussed the potential impacts of non-municipal domestic groundwater use impacting nearby inland surface waters. Additional monitoring of sustainable management criteria for interconnected surface-water 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.