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SECTION 3: **Basin Setting [Article 5, Subarticle 2]**

§354.12 Introduction to Basin Setting. This Subarticle describes the information about the physical setting and characteristics of the basin and current conditions of the basin that shall be part of each Plan, including the identification of data gaps and levels of uncertainty, which comprise the basin setting that serves as the basis for defining and assessing reasonable sustainable management criteria and projects and management actions. Information provided pursuant to this Subarticle shall be prepared by or under the direction of a professional geologist or professional engineer.

This section describes the basin setting based on existing studies related to the geology, climate, historical groundwater and surface water conditions. The purpose of this section is to provide an overview of what is currently know about the general physical characteristics related to regional hydrology, land use, geology and geologic structure, water quality, and principal aquifers and aquitards in the basin.

3.1 Hydrogeologic Conceptual Model [§354.14]

§354.14 Hydrogeological Conceptual Model.

(a) Each Plan shall include a descriptive hydrogeologic conceptual model of the basin based on technical studies and qualified maps that characterizes the physical components and interaction of the surface water and groundwater systems in the basin.

The hydrogeology of the Basin has been studied extensively over the last 70 years. The most significant reports include:

- Upson, J.E. and Thomasson, H.G. 1951. *Geology and Ground-Water Resources of the South-Coast Basins of Santa Barbara County, California*. U.S. Geological Survey Water Supply Paper 1108.
- Lian, H.M. 1952. The Geology and Paleontology of the Carpinteria District, Santa Barbara, California. unpublished Ph. D. dissertation, University of California at Los Angeles.
- Evenson, R.E., Wilson, H.D., Jr., and Muir, K.S. 1962. *Yield of the Carpinteria and Goleta Ground Water Basins, Santa Barbara County, California, 1941 – 58*. U.S. Geological Survey Open-File Report.
- Slade, R.C. 1975. Hydrogeologic Investigation of the Carpinteria Ground Water Basin, unpublished M.A. Thesis, University of Southern California.
- Geotechnical Consultants, Inc. 1976. *Hydrogeologic Investigation of Carpinteria Ground Water Basin*. Prepared for Carpinteria County Water District.
- Geotechnical Consultants, Inc. 1986. *Hydrogeologic Update, Carpinteria Groundwater Basin*. Prepared for Carpinteria County Water District.
- Sullwold, H.H. 1996. *Carpinteria Groundwater Basin, A Geological Up-date*. Prepared for Carpinteria Valley Water District.
- Pueblo Water Resources, Inc. 2012. *Carpinteria Groundwater Basin, Hydrogeologic Update and Groundwater Model Project*. Prepared for Carpinteria Valley Water District.

These documents describe the stratigraphy, structure, and hydraulic characteristics of the basin. Taken together, they also document the evolution of the understanding of the hydrogeology of the basin. The Hydrogeologic Conceptual Model (HCM) of the basin was initially developed by Geotechnical Consultants, Inc. (GTC) and is documented in their 1976 report. The 1976 GTC report is the most comprehensive report on the basin, and it built upon the previous work regarding the basin structure and hydraulic parameters to include a detailed analysis of the water budget for the basin. Sullwold (1996) later refined the structural and hydrostratigraphic delineations of the basin, taking into consideration water and oil wells drilled after 1975.

Most recently, PWR (2012) performed an update of the hydrogeologic conditions within the basin. Since the 1976 GTC report was published, significant additional information had been developed. In particular, the CVWD had constructed, tested, and operated several high-capacity municipal production wells in the basin, and had implemented basin-wide water level, water quality, and production data collection programs pursuant to the AB3030 Groundwater Management Plan. PWR (2012) also updated the water budget for the basin since the last time it was updated by GTC in 1986. The 2012 hydrogeologic update formed the basis for the development and calibration of the existing three-dimensional MODFLOW groundwater model of the basin (see Appendix F).

This section presents a current description of the HCM of the basin and is based largely on a compilation and synthesis of information from the sources listed above.

3.1.1 Regional Hydrology

3.1.1.1 Topography and Watershed Boundary [§354.14(d)(1)]

> **§354.14 Hydrogeological Conceptual Model.**
>
> **(d) Physical characteristics of the basin shall be represented on one or more maps that depict the following:**
>
> **(1) Topographic information derived from the U.S. Geological Survey or another reliable source.**

The Carpinteria Groundwater Basin (basin) consists of a low-lying alluvial plain that is physically bordered on the south by the Pacific Ocean and on the north and east by bedrock. The western boundary is an administrative boundary with the Montecito Groundwater Basin. As originally described by Thomasson (1951), the watershed area of the basin can be broadly categorized into three main parts: 1) a mountainous headwaters area, the principal area of surface water runoff; 2) the marginal part of the groundwater basin, the principal area of groundwater recharge; and 3) the central alluvial valley, which is underlain by low permeability deposits near the surface and constitute an area of confined groundwater conditions. A USGS topographic map of the basin area is shown in Figure 3-1. As shown, the basin is approximately 7 miles long in an east-west direction and extends northward from the coastline a maximum of about 2 miles. The lowest ground surface elevations occur in El Estero, an active intertidal salt marsh west of the City of Carpinteria. From this area, the topography gradually rises northward to elevations of up to approximately 650 feet above sea level along the northern and eastern boundaries of the basin. North of the basin boundary are the foothills of the Santa Ynez Mountains. The area of the contributing watersheds to the Basin are presented on Figure 3-2.

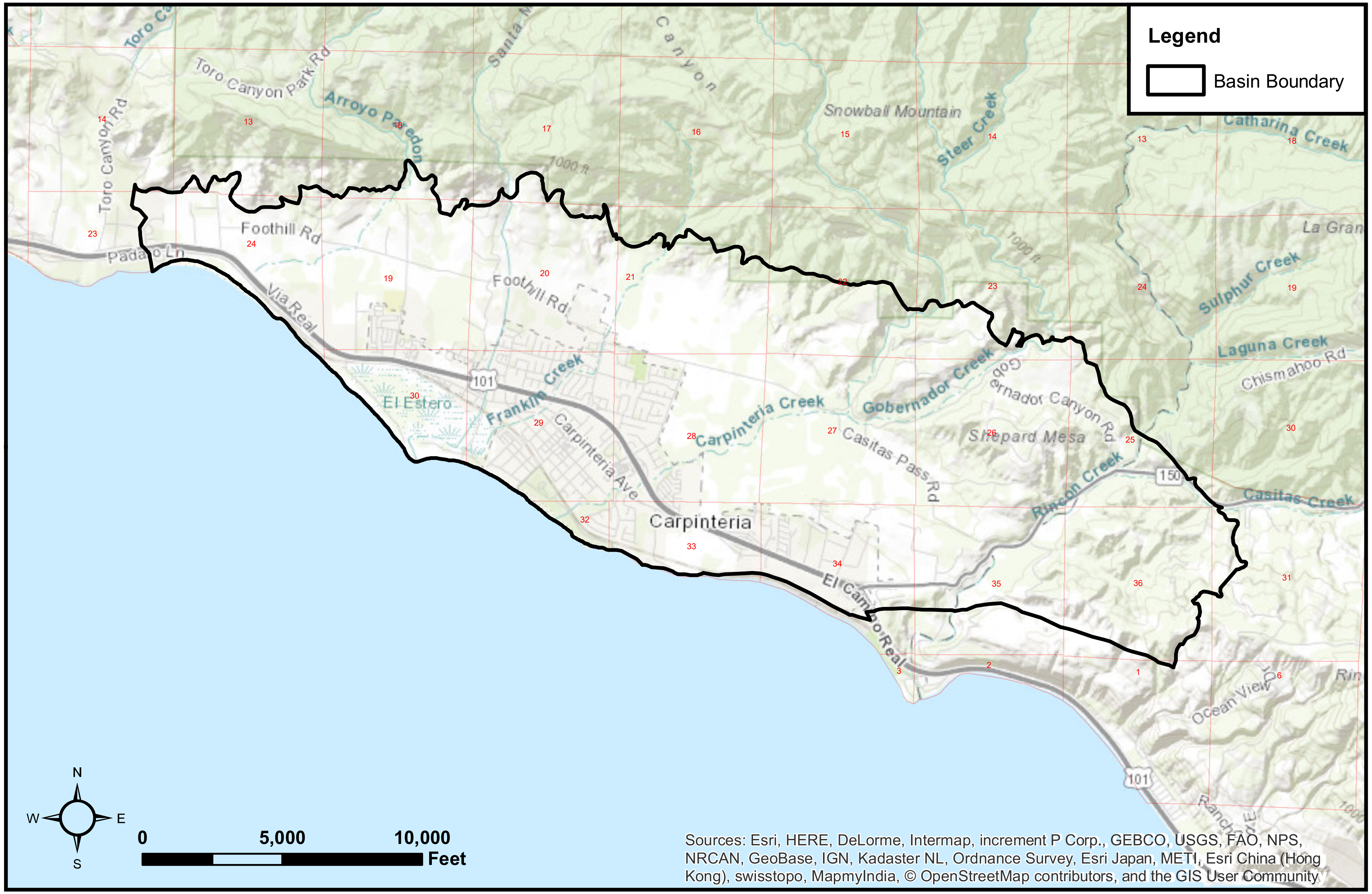

FIGURE 3-1

USGS Topographic Map

Carpinteria Basin Groundwater Sustainability Plan

CARPINTERIA GSA
GROUNDWATER SUSTAINABILITY AGENCY

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LEGEND

- Surface Water Sampling Location
- USGS Stream Gage
- Carpinteria Groundwater Basin
- Watershed Boundary
- County Boundary
- Railroad
- Major Road
- Watercourse

N

0 2,300 4,600 6,900
feet

CARPINTERIA GSA
GROUNDWATER SUSTAINABILITY AGENCY

FIGURE 3-2

Creek Location Map and Contributing Watershed Areas

Carpinteria Basin Groundwater Sustainability Plan

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As is typical of the entire southern and central coast of California, the Carpinteria Basin has undergone continuous and significant growth in population since early state settlement, with attendant changes in land use and water resources development. **Figure 3-3** presents a historical map of the Carpinteria Basin area circa 1869 alongside a recent air photo of the Basin. These figures demonstrate the significant historical changes in land use and the underlying hydrology over the past 150 years. Some of the significant changes apparent in the comparison of these figures include the following. The area occupied by the El Estero Salt marsh extends significantly farther to the southwest in 1869, nearly to Carpinteria Creek; much of that area has been reclaimed and is now used primarily as residential land within the City of Carpinteria boundaries. Orchards and agriculture are evident in the historical map and are obviously greatly expanded in the present day. Low lying areas along Carpinteria Creek and other creeks that are represented as marshy areas associated with overbank flood deposits and shallow groundwater have also been filled in and converted to residential use, with some of the former marsh areas used for agriculture. The dune system near Sand Point that is evident in the historical map has now been reclaimed for beachfront residential properties. The filling, reclamation, and redevelopment of dune and marsh coastal areas is significant; the historical development of the Basin has altered the stream drainage network in areas near the coast. As is discussed in later sections of this GSP, much of the growth and development in the Basin was made possible by development of groundwater resources within the Basin, resulting in changes from historical hydrogeologic conditions.

3.1.1.2 Surface Water Bodies [§354.14(d)(5)]

§354.14 Hydrogeological Conceptual Model.

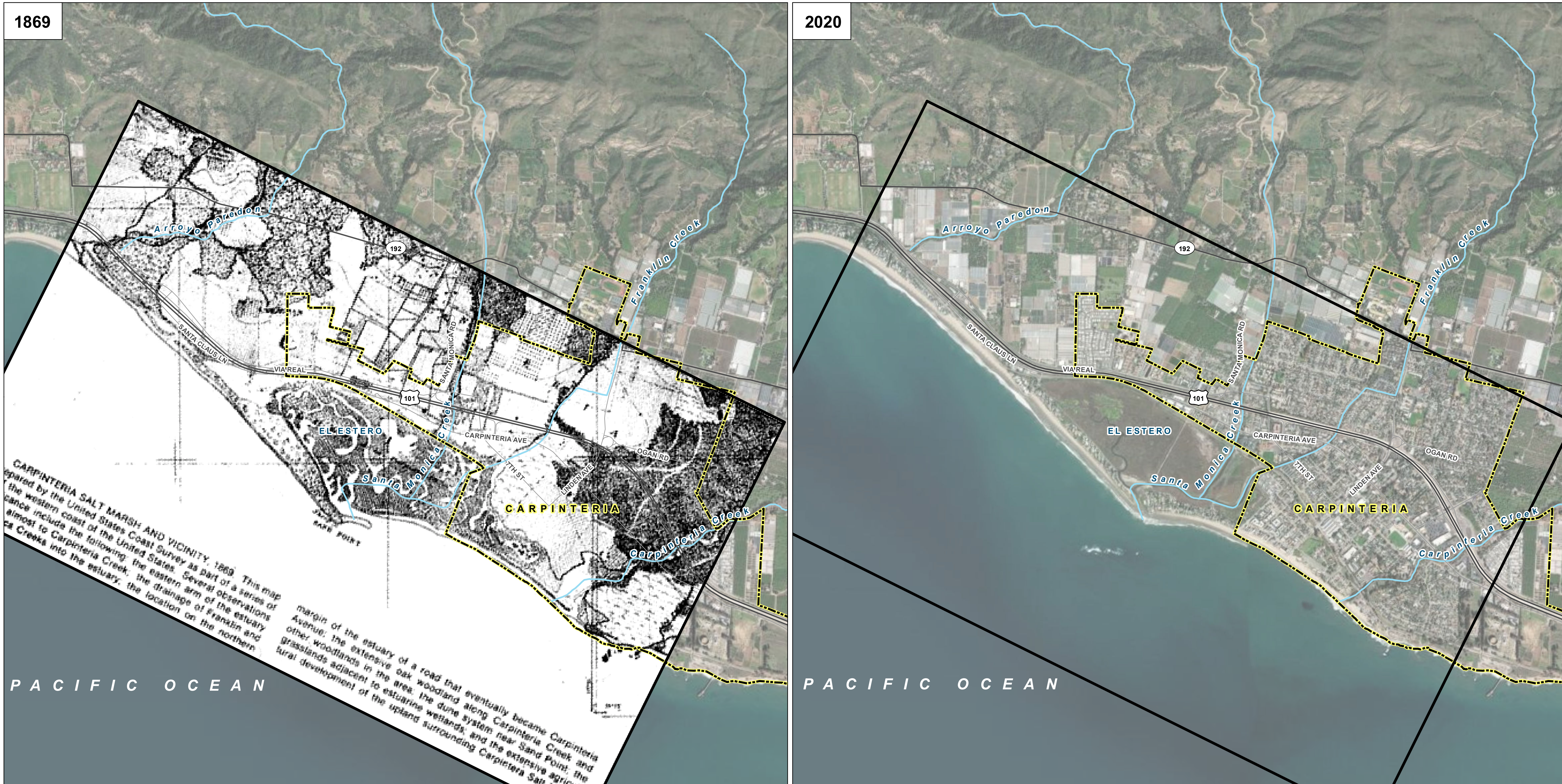
(d) Physical characteristics of the basin shall be represented on one or more maps that depict the following:

(5) Surface water bodies that are significant to the management of the basin.

There are five major creeks in the basin, each of which extends from the crest of the Santa Ynez Mountains and flows in a generally southerly direction across the basin to the Pacific Ocean. The creeks in the basin area are shown on **Figure 3-2**. As shown, Gobernador, Carpinteria and Santa Monica Creeks are the main drainages into the central portion of the basin. Rincon Creek crosses the east end of the basin and dissects the remnant terrace deposits and older alluvial fans in this area. Toro Creek enters the basin at the west end of the basin. Smaller drainages, including Franklin and Arroyo Paredon Creeks, are headed in the adjacent foothills and flow as a result of direct runoff following storms. It is noted that the channels of both Santa Monica and Franklin Creeks were concrete lined in 1973 to control flood flows.

There is only one active stream gage in the basin with a significant period of record, the USGS Carpinteria Creek gage (gage no. 11119500), located just downstream of the confluence of Gobernador and Carpinteria Creeks, as shown on **Figure 3-2**. This gage has a period of record from January 1941 through the current period, with annual discharge ranging between 0 and approximately 24,250 AFY and a long-term mean of approximately 2,700 AFY. Also shown on **Figure 3-2** are the locations of CVWD surface water sampling stations (discussed in Section 5).

The El Estero Salt Marsh is an approximate 215-acre intertidal marshland area west of the City of Carpinteria. Given the inter-tidal nature and location in the Confined Area of the basin (discussed in a later section), which limits the hydraulic connection between the marsh and the underlying principal aquifer, this surface water body is not considered to be significant to the management of the basin.



LEGEND

City Boundary

Watercourse

FIGURE 3-3

Historical versus Current Land Use

Carpinteria Basin Groundwater Sustainability Plan

N

0 1,250 2,500 3,750

feet

CARPINTERIA GSA
GROUNDWATER SUSTAINABILITY AGENCY

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3.1.2 Regional Geology [§354.14(b)(1),(d)(2), and (d)(3)]

§354.14 Hydrogeological Conceptual Model.

(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:

(1) The regional geologic and structural setting of the basin including the immediate surrounding area, as necessary for geologic consistency.

(d) Physical characteristics of the basin shall be represented on one or more maps that depict the following:

(2) Surficial geology derived from a qualified map including the locations of cross-sections required by this Section.

(3) Soil characteristics as described by the appropriate Natural Resources Conservation Service soil survey or other applicable studies.

The basin is located on the south flank of the Santa Ynez Mountains, one of the east-west trending ridges of the Transverse Range Geomorphic Province. The basin represents the north limb of a synclinal geologic structure, the deepest parts of which terminate against the traces of the Rincon Creek Fault. This structural depression has subsequently been filled with younger water-bearing deposits. Water-bearing deposits in the basin include all unconsolidated and semi-consolidated sediments of the Quaternary age, with older consolidated and generally non-water bearing rocks forming the definable boundaries of the basin.

Quaternary Age water-bearing basin deposits primarily consist of the following:

- Alluvial Deposits
- Carpinteria Formation (not exposed within or adjacent to the basin)
- Casitas Formation
- Santa Barbara Formation

Tertiary Age formations that form the primary bedrock boundaries of the basin include the following:

- Sisquoc Formation
- Monterey Formation
- Rincon Shale
- Vaqueros Formation
- Sespe Formation
- Coldwater Sandstone

The geologic contact between unconsolidated water-bearing deposits and bedrock formations delineates the northern and southeastern lateral boundaries and the definable bottom of the basin. The southwestern portion of the basin is bounded by the Pacific Ocean. The western boundary is a jurisdictional boundary with the Montecito Groundwater Sustainability Agency.

The most recent published geologic maps covering the basin area were utilized to refine the delineation of the basin boundaries as part of a formal Basin Boundary Modification (BBM) through DWR in 2018 based on the geologic contacts of the formations listed above. A geologic map showing the surficial geology from the recent geologic mapping and the corresponding current basin boundaries is presented on **Figure 3-4**. In addition, the 2018 BBM included removal of the Toro Canyon area from the formal Bulletin 118 basin delineation and created an approximate 3,000-foot-long jurisdictional boundary at the western edge of the basin coinciding with the boundary between the CVWD and Montecito Water District (MWD).

Within the basin, the Rincon Creek Thrust Fault has created a barrier to subsurface groundwater movement within the basin, and the surface trace of the fault has been used to segregate the basin into two Storage Units: Storage Unit No. 1 (SU-1) is on the north side of the fault trace, and Storage Unit No. 2 (SU-2) is to the south. The southeastern portion of SU-1 is hydrogeologically separated from the ocean by the Rincon Creek Thrust Fault; however, west of El Estero, basin deposits are understood to be in contact with the ocean. SU-1 contains all of the CVWD's principal municipal supply wells and the vast majority of agricultural wells and has accordingly been the primary focus of previous basin investigations and data collection programs. A map showing the boundaries of the two Storage Units is presented in **Figure 3-5**.

3.1.2.1 Soil Types

The soils of the basin are derived primarily from exposed geologic formations. Soil and vegetation affect how much precipitation can infiltrate into the soil to recharge the basin aquifer system. Soil data from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey Geographic Service Database (SSURGO) is shown by the four hydrologic groups and two dual classes present in the basin (A/D and C/D) on **Figure 3-6**. The groups are defined as follows:

- **Group A.** Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.
- **Group B.** Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.
- **Group C.** Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.
- **Group D.** Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter describes the condition of soils that are actively drained, and the second letter describes the condition of the soils in their natural (undrained) condition. Only the soils that in their natural condition are in group D are assigned to dual classes.

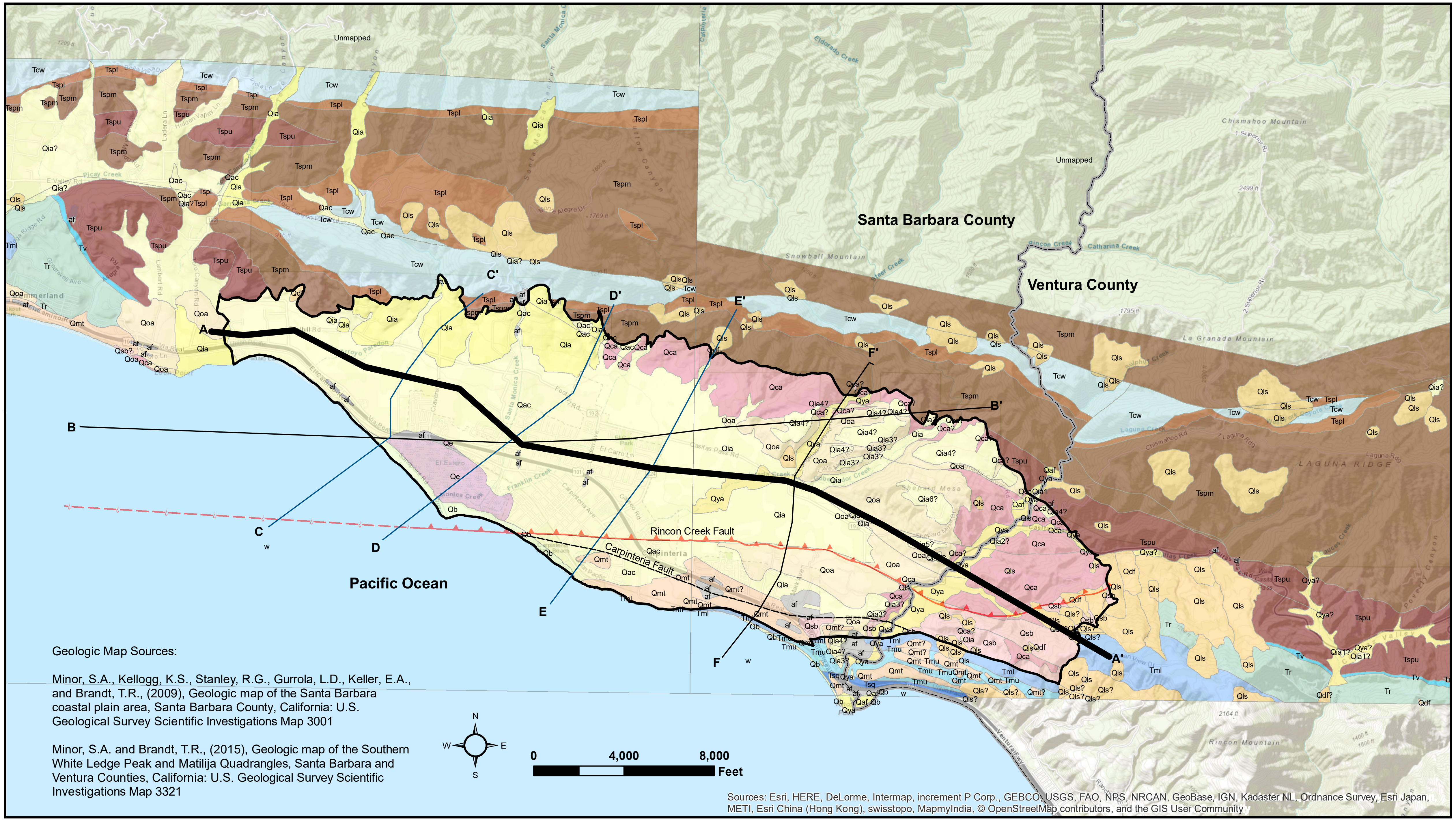

FIGURE 3-4

Geologic Map

Carpinteria Basin Groundwater Sustainability Plan

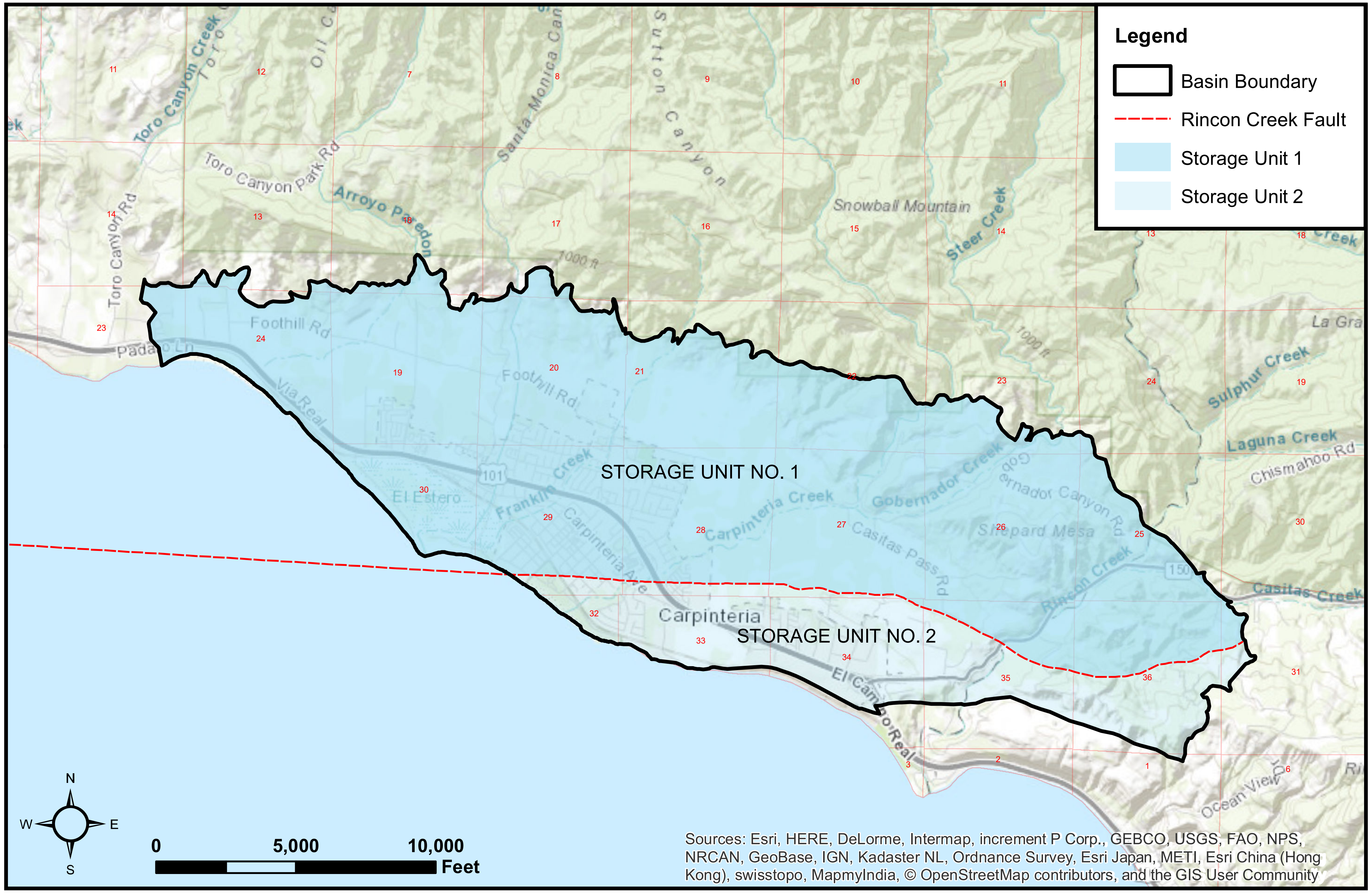

FIGURE 3-5

Storage Units 1 and 2 Map

Carpinteria Basin Groundwater Sustainability Plan

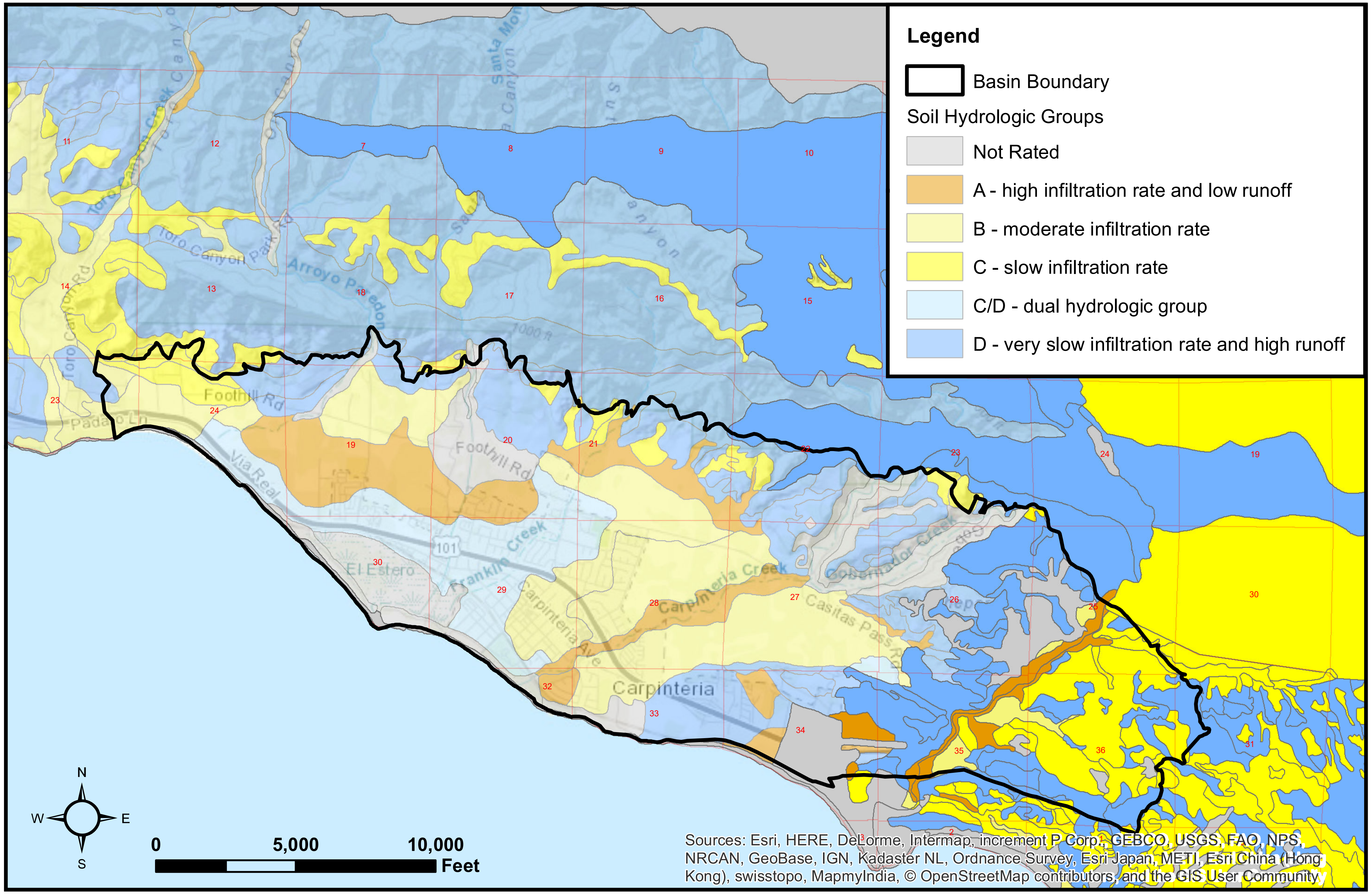

FIGURE 3-6

Soil Survey Map

Carpinteria Basin Groundwater Sustainability Plan

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3.1.3 Principal Aquifers and Aquitards [§354.14(b)(4)(A)]

§354.14 Hydrogeological Conceptual Model.

(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:

(4) Principal aquifers and aquitards, including the following information:

(A) Formation names, if defined.

In the basin a single principal aquifer occurs primarily within unconsolidated and semi-consolidated sediments of the Pleistocene- and upper Pliocene-aged Carpinteria and Casitas Formations. In some local alluvial valleys of Basin Creeks (Figure 3-2), wells penetrate and may possibly screen the sediments of the younger alluvium, but available data indicate that these wells usually are also screened in the Casitas formation, which provides most of the productive yield. There is no consistent low permeability strata separating the alluvium from Casitas sediments; these sediments function as a single hydrogeologic unit. Such deposits are readily capable of absorbing, storing, transmitting and yielding water to wells. Holocene-aged alluvial deposits are present as a thin veneer along the coastal plain and along all creek channels and comprise the sediment of alluvial fan deposits at canyon mouths along the northern basin boundary. Older Tertiary sedimentary bedrock units are considered to be generally non-water-bearing and constitute the boundaries of the groundwater basin.

In the vicinity of the City of Carpinteria, the Holocene alluvial deposits are comprised predominantly of silt and clay to depths of approximately 150 to 250 feet. Because these deposits do not readily transmit water, they limit the downward percolation of water and also serve to confine water in the underlying principal aquifer under artesian pressure (discussed further later).

The Carpinteria Formation is not exposed in the basin, although some investigators report it occurs in the subsurface in SU-1 with a maximum thickness of 75 feet. The term Carpinteria Formation was evidently first used by Lian (1952) for the flat lying terrace deposits exposed in sea cliffs and Slade (1975) used the term similarly, although he considered the basal member to constitute the A Zone (discussed in Section 3.1.3.1, below). Subsequent investigators (Dibble 1987 and Sullwold 1996), however, did not find it useful to distinguish and largely ignored it. Lithologically, the sediments of the Carpinteria Formation are similar to deposits of older alluvium and the upper Casitas Formation, thus precluding definitive separation and distinction from well logs. Given these characteristics, the Carpinteria Formation cannot be reliably delineated on the geologic cross-sections in the basin.

The principal aquifer system in the basin largely occurs in the Casitas Formation, which is contained in the entire basin area north of the Rincon Creek Fault and is exposed in outcrops along the northern and eastern boundaries (see Figure 3-4). The Casitas Formation is an assemblage of poorly to moderately consolidated clayey to gravelly sand with variable amounts of silt and cobbles reaching substantial thicknesses of 2,300 to 2,500 feet in SU-1. Sandy clay is abundant and sandy units are typically thin and lenticular and cannot be correlated over long distances. Notable exceptions to this are the major water producing zones delineated at the A, B, C and D Zones in the Confined Area of the basin (discussed in the following section).

Underlying the Casitas Formation is the marine Santa Barbara Formation, which unconformably overlies all older consolidated rocks in the basin. The formation is only exposed south of the Rincon Creek Fault in SU-2 where it unconformably overlies Miocene shales. The Santa Barbara formation consists of poorly to moderately consolidated, soft and massive, sandstone and siltstone with abundant clay shale. Available data indicate the formation is 750 to as much as 1,250 feet thick in SU-1 and at least 1,500 feet thick in SU-2. Although the formation represents a potential water-bearing deposit in the basin, no water wells are known to penetrate it and no major aquifers have been discerned within it (note: the wells shown on the cross-sections that do penetrate the Santa Barbara Formation are exploratory borings or wildcat oil wells).

3.1.3.1 Physical Properties of the Aquifers and Aquitards

§ 354.14 Hydrogeological Conceptual Model.

(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:

(2) Lateral basin boundaries, including major geologic features that significantly affect groundwater flow.

(3) The definable bottom of the basin.

(4) Principal aquifers and aquitards, including the following information:

(c) The hydrogeologic conceptual model shall be represented graphically by at least two scaled cross-sections that display the information required by this section and are sufficient to depict major stratigraphic and structural features in the basin.

Basin Boundary (Vertical and Lateral Extent of Basin) [§354.14(b)(2),(b)(3), and (c)]

The geologic contact between unconsolidated water-bearing deposits and bedrock formations delineates the northern and southeastern lateral boundaries and the definable bottom of the basin. The southwestern portion of the basin is bounded by the Pacific Ocean. The western boundary is a jurisdictional boundary with the Montecito Groundwater Sustainability Agency.

The most recent published geologic maps covering the basin area were utilized to refine the delineation of the basin boundaries as part of a formal Basin Boundary Modification (BBM) through DWR in 2018 based on the geologic contacts of the formations listed in Section 3.1.2. A geologic map showing the surficial geology from the recent geologic mapping and the corresponding current basin boundaries is presented on **Figure 3-4**. In addition, the 2018 BBM included removal of the Toro Canyon area from the formal Bulletin 118 basin delineation and created an approximate 3,000-foot-long jurisdictional boundary at the western edge of the basin coinciding with the boundary between the CVWD and MWD.

Water-bearing deposits in the basin include all unconsolidated and semi-consolidated sediments, with older consolidated non-water bearing rocks bounding the basin both laterally and vertically (see **Figure 3-4**). The top of bedrock represents the definable bottom of the basin. Structural contours of the top of bedrock for SU-1 and SU-2 based on the evaluation of wildcat oil wells in the basin (Sullwold, 1996) are shown on **Figure 3-7 and Figure 3-8**, respectively. As shown, in the deepest portion of the basin bedrock is as much as 4,000 feet below sea level in SU-1 and rises to approximately 500 feet above sea level along the northern boundary of the basin. As also shown, the bedrock contours and overlying basin deposits extend offshore beyond the formal basin boundary at the Pacific Ocean coastline. In SU-2 (where there is relatively little geologic control) the bedrock is estimated to reach depths of approximately 1,000 feet below sea level.

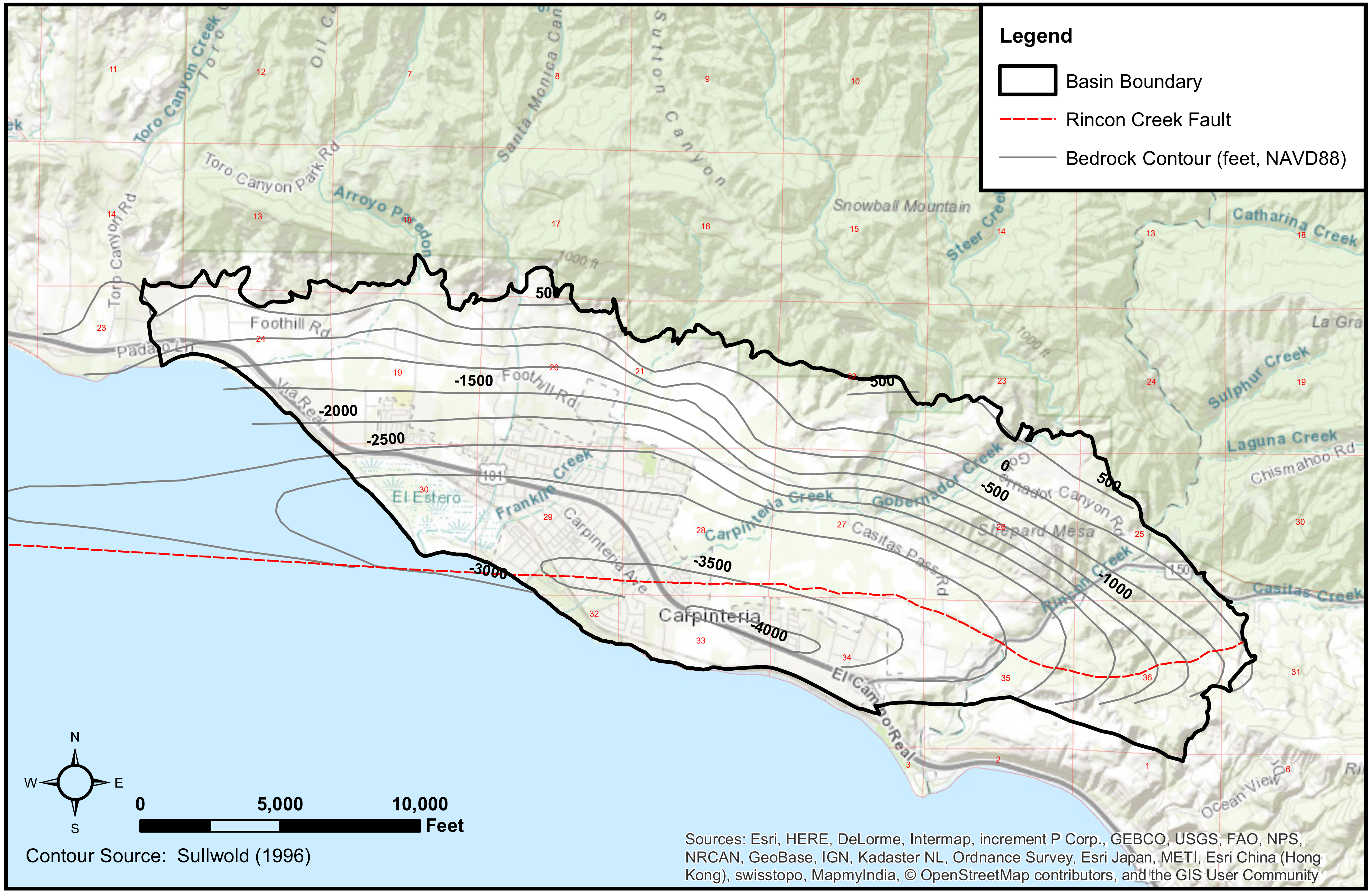

FIGURE 3-7

Bedrock Structural Contours – Storage Unit 1

Carpinteria Basin Groundwater Sustainability Plan

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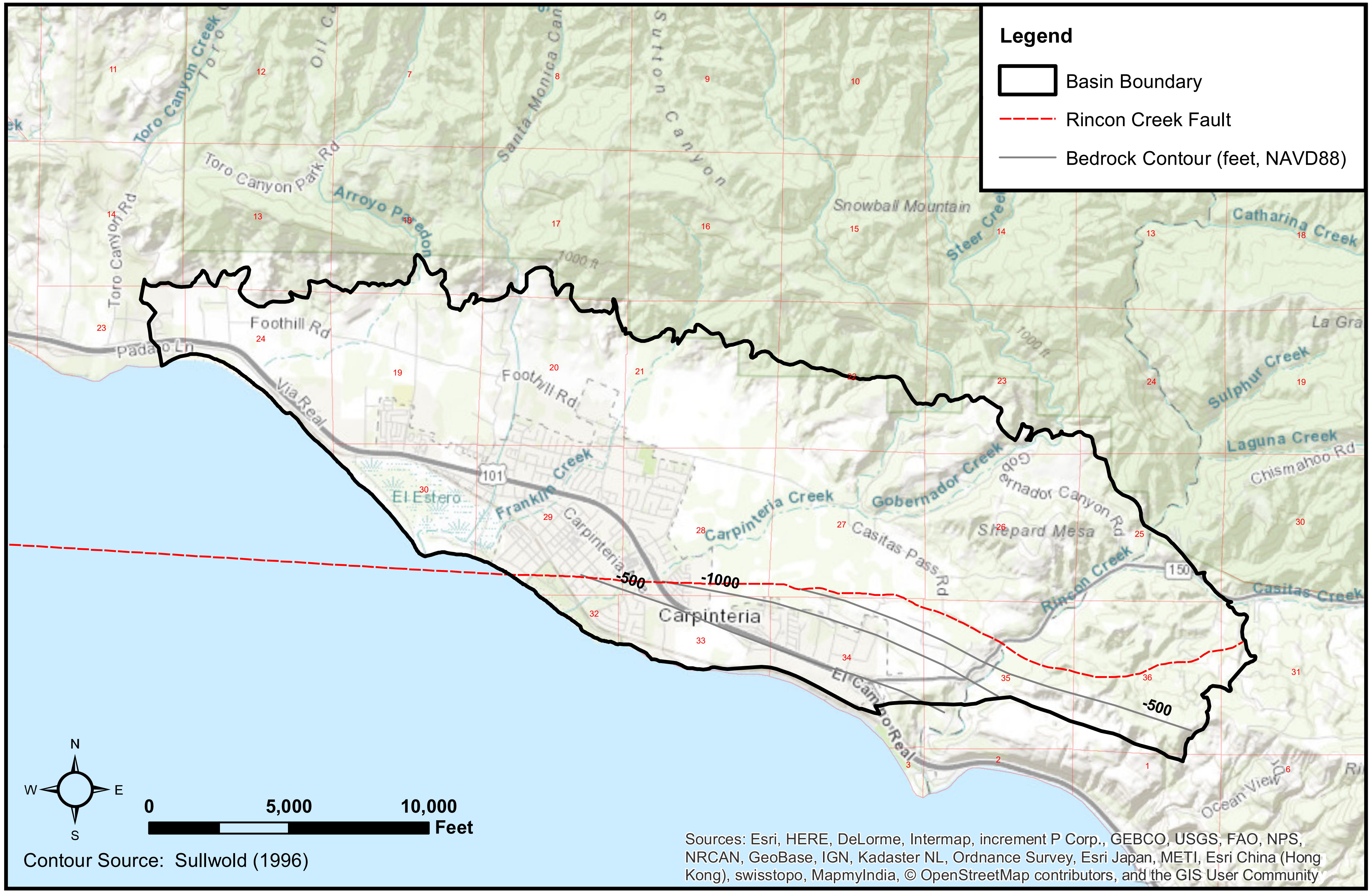

FIGURE 3-8

Bedrock Structural Contours – Storage Unit 2

Carpinteria Basin Groundwater Sustainability Plan

Lithologically, the primary water bearing deposits in the basin consist of interbedded unconsolidated and semi-consolidated sand, gravel, silt and clay (and combinations thereof) deposits. The coarser grained sandy/gravelly strata in these deposits comprise the individual primary water producing zones (A through D Zones) for wells in the central portion of the basin. These primary producing zones are generally on the order of 50 to 100 feet thick each. Finer grained strata of silt and clay are generally thicker and form a series of aquitards between the primary producing zones in this area. These aquitards are laterally extensive in the central alluvial plain portion of the basin and confine water held in the primary aquifers under artesian pressure. This area of the basin is referred to as the Confined Area (**Figure 3-9**).

Outside the Confined Area of the basin and extending to the bedrock boundaries, the A – D Zones become laterally discontinuous and generally non-correlatable. The alluvial deposits and Casitas Formation in these areas contain laterally discontinuous layers of both permeable and impermeable materials, and water held in these areas is generally unconfined (although various degrees of local confinement likely do occur). The source of recharge water to the basin is primarily by infiltration of precipitation, irrigation water and streamflow seepage (discussed later); however, in the Confined Area, downward percolation of water is limited due to the presence of fine-grained low-permeability materials overlying most of the area of the principal aquifers; therefore, recharge to the primary aquifers occurs primarily in the areas between the Confined Area and the boundaries of consolidated bedrock. This area is referred to as the Recharge Area (**Figure 3-9**).

It is noted that no new information since 2012 (i.e., correlatable producing zones and/or aquitards from recently drilled wells) indicates that the previous delineations of the Confined and Recharge Areas should be modified at this time; therefore, the previous delineations of these areas of the basin have been adopted for this GSP. A map showing the Confined and Recharge Areas is presented on **Figure 3-9**.

Well logs obtained for new wells in the basin have been used to refine the previous interpretations of the hydrostratigraphy of the Basin and prepare six geologic cross-sections through the Basin. The locations of the cross-section lines are shown on **Figure 3-4**. The cross-sections are shown in **Figures 3-10 through 3-15**. As shown, the cross-sections depict the overall basin structure and distribution of the A through D Zones discussed previously in this section.

The western edge of cross-section A – A' (**Figure 3-10**), and bedrock structural contours for SU-1 (**Figure 3-7**) show that basin sediments at the jurisdictional boundary with the MWD range from a maximum thickness of approximately 500 feet at the coastline and rapidly thinning to northern bedrock boundary. Given these conditions, groundwater can move freely across this boundary, depending on hydrologic conditions and water-level gradients at the boundary.

The western portion of cross-section B - B' (**Figure 3-11**) shows the current understanding of the relationship between the basin deposits and the Pacific Ocean. It is noted that the available geologic control offshore is limited to oil wells that have been drilled in the area, from which the geologic contact between unconsolidated sediments and the underlying bedrock have been established, but the lithologic descriptions for the overlying deposits are insufficient to reliably delineate the A – D Zones within the Carpinteria and Casitas Formations. The delineations of the A – D Zones shown are based on extrapolation of the structure from the onshore area to the offshore area and is accordingly shown as queried on the cross section. As shown, these zones are conceptualized to outcrop at (or near) the sea floor. It is noted that offshore geologic mapping does indicate that the seafloor surface consists of undifferentiated continental shelf sediments of unknown thicknesses, which may limit the hydraulic continuity between the Pacific Ocean and the basin deposits to an unknown extent.

The other cross-sections also show the physical relationship between the basin deposits and the Rincon Creek Fault and the northern and eastern basin boundaries. As shown, the thickness of basin deposits terminating at the base of the Rincon Creek Fault range between approximately 1,500 to over 3,000 feet and gradually thin towards the basin boundaries and contacts with the bedrock.

In the southeastern extent of the Basin in Ventura County, Younger Alluvium is present at the surface along Rincon Creek. The Rincon Creek Fault is mapped through this portion of the Basin, with the Casitas Formation exposed at the surface in the hills north of the fault and east of Rincon Creek, and the older Santa Barbara Formation cropping out south of the fault. The Monterey Formation is exposed along the ridge southeast of the Basin boundary. Most wells in this area are located in the low-lying area along Rincon Creek. However, as discussed previously, available well data indicate that wells in this area may screen some alluvial sediments, but usually penetrate through the Younger Alluvium to screen the underlying sediments of the Casitas Formation.

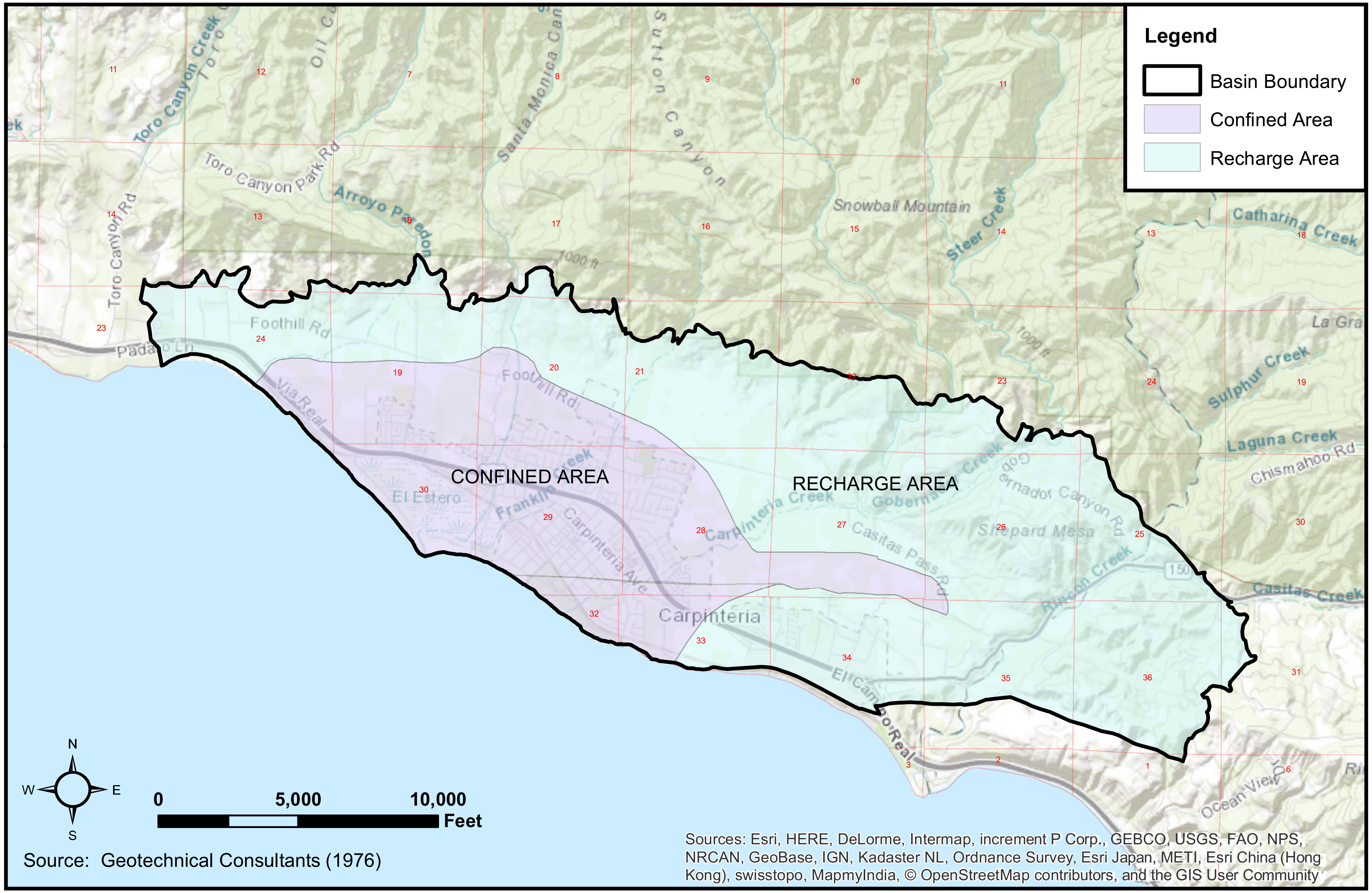

FIGURE 3-9

Confined and Recharge Areas Map

Carpinteria Basin Groundwater Sustainability Plan

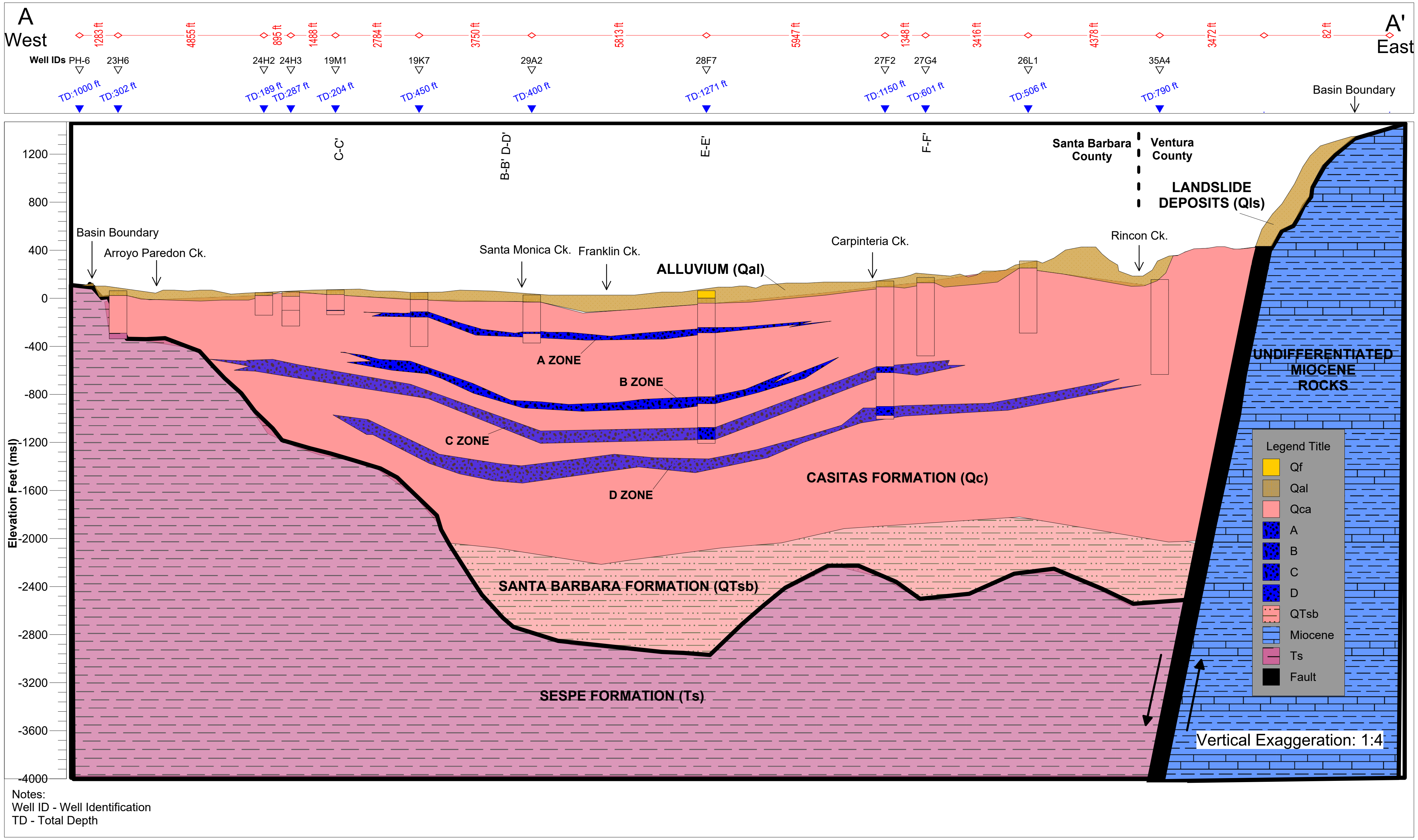

FIGURE 3-10

Geologic Cross-Section A – A'

Carpinteria Basin Groundwater Sustainability Plan

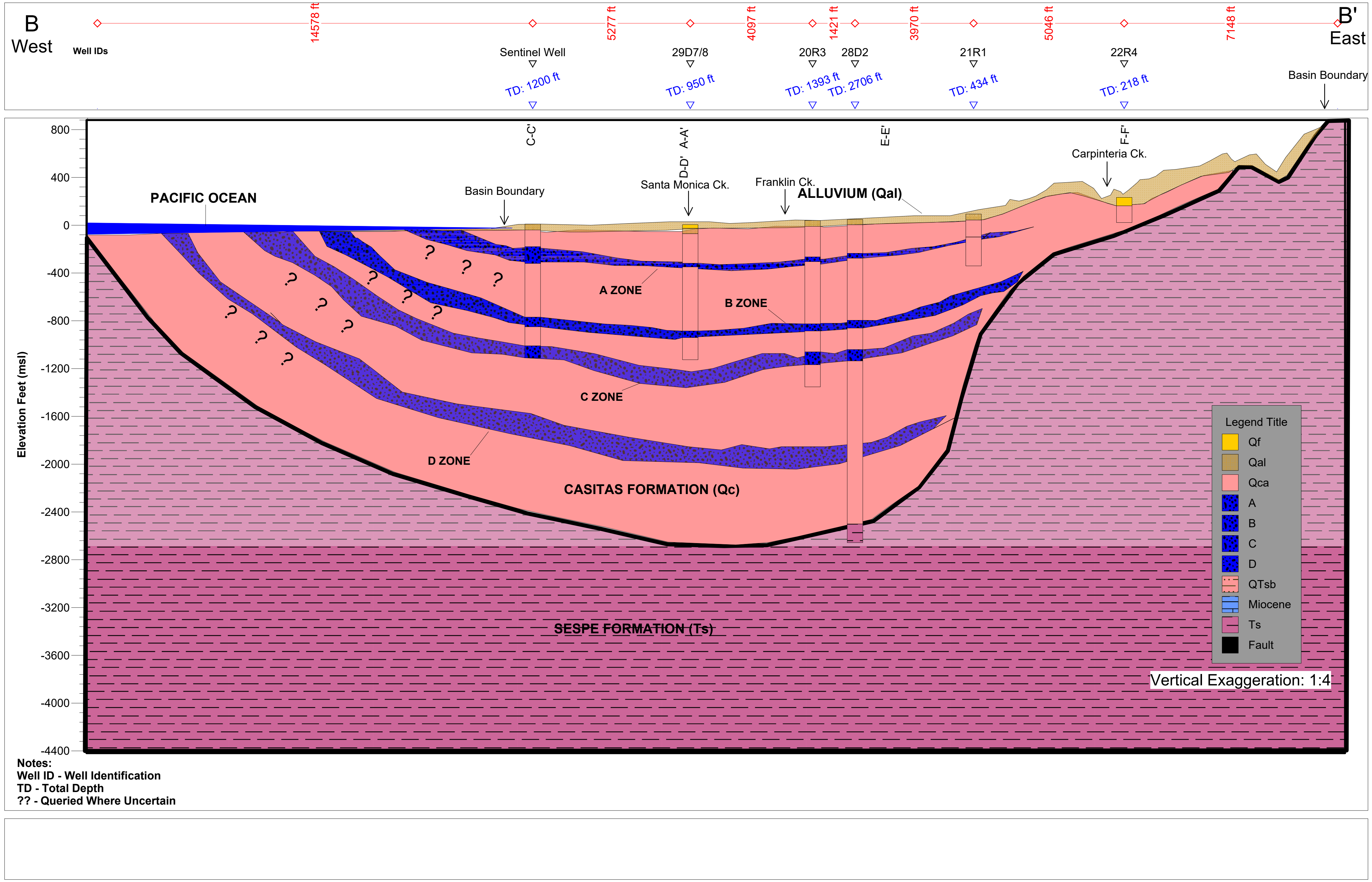

FIGURE 3-11

Geologic Cross-Section B – B'

Carpinteria Basin Groundwater Sustainability Plan

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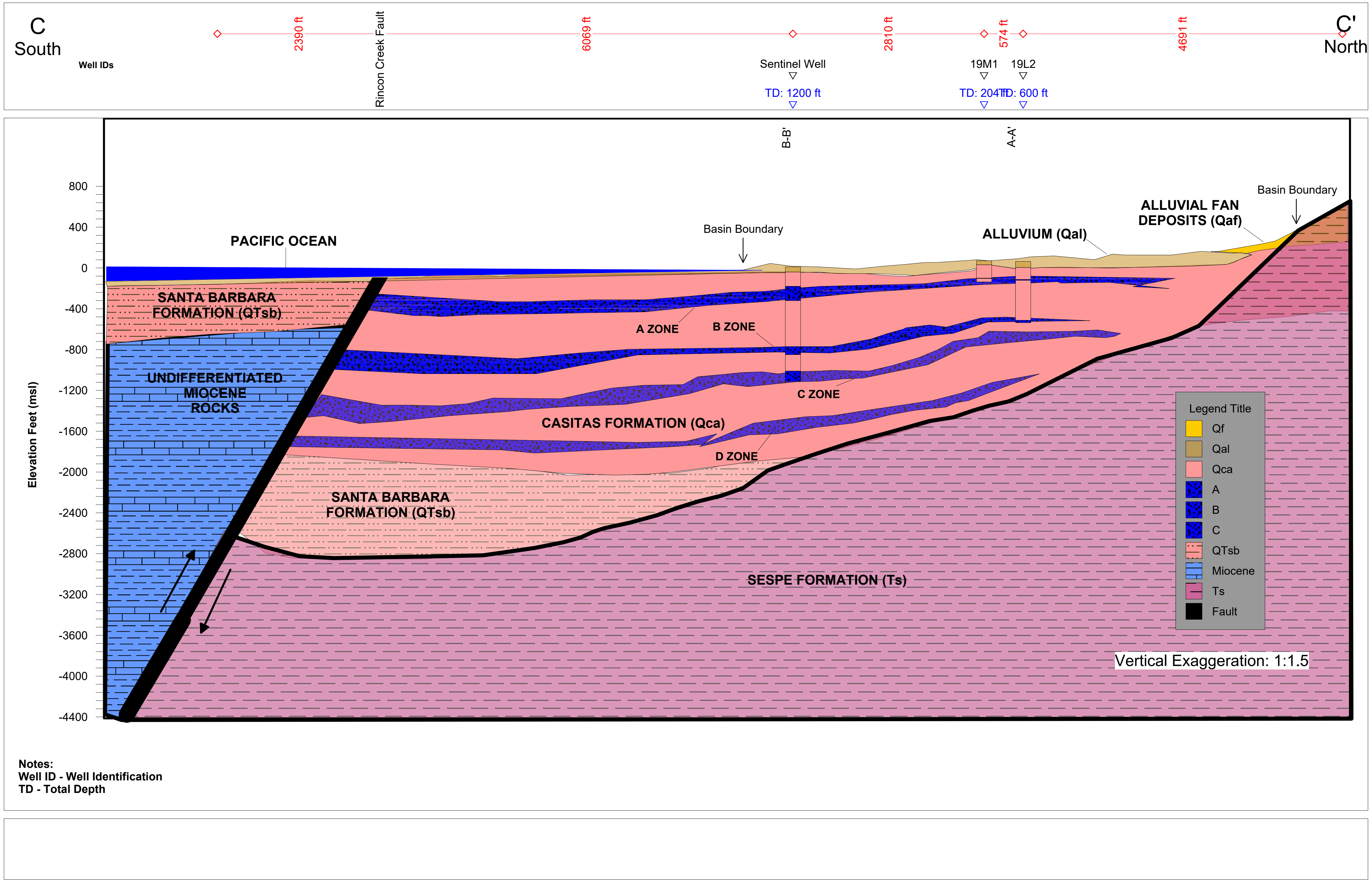

FIGURE 3-12

Geologic Cross-Section C – C'

Carpinteria Basin Groundwater Sustainability Plan

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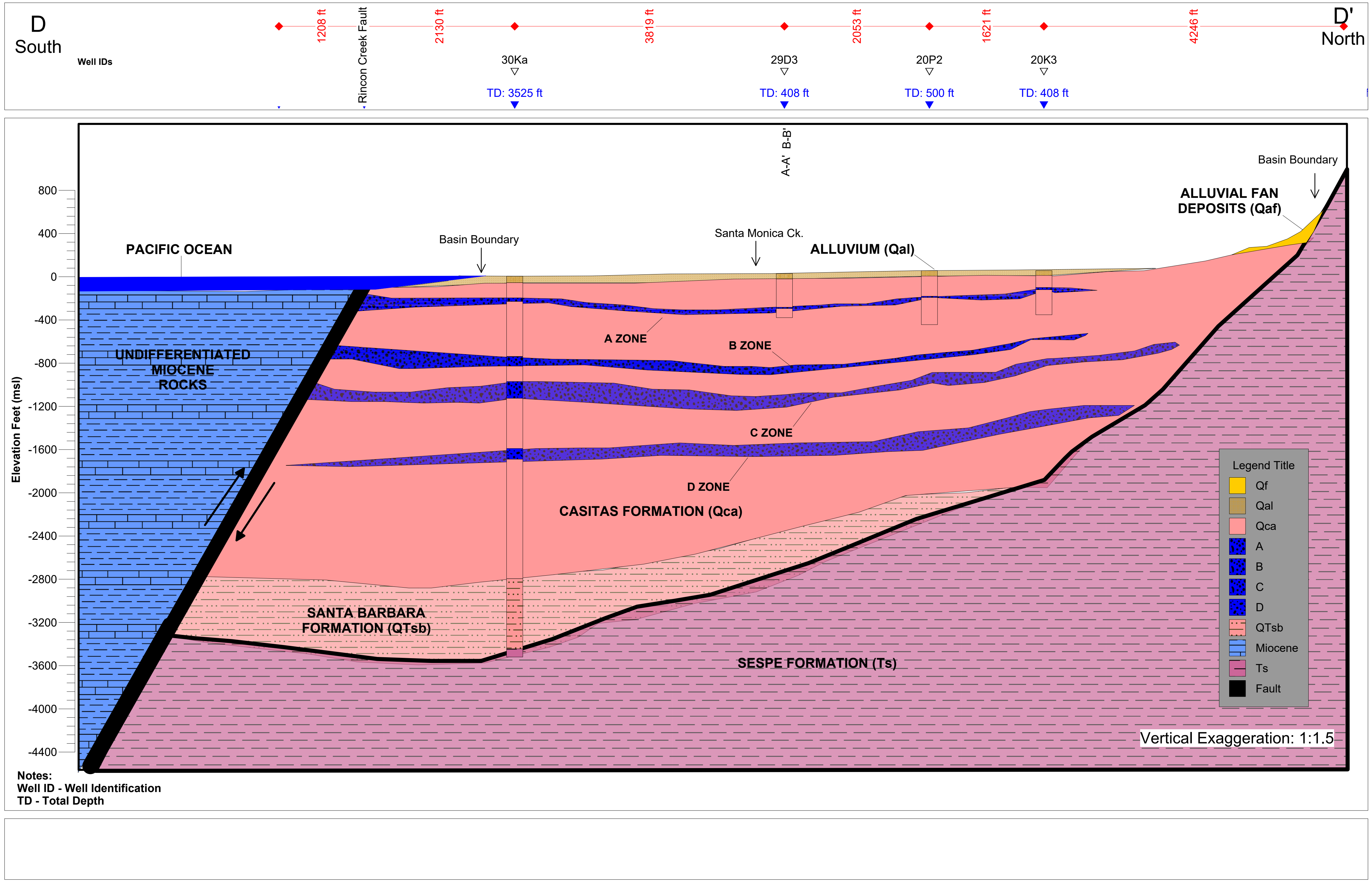

FIGURE 3-13

Geologic Cross-Section D – D'

Carpinteria Basin Groundwater Sustainability Plan

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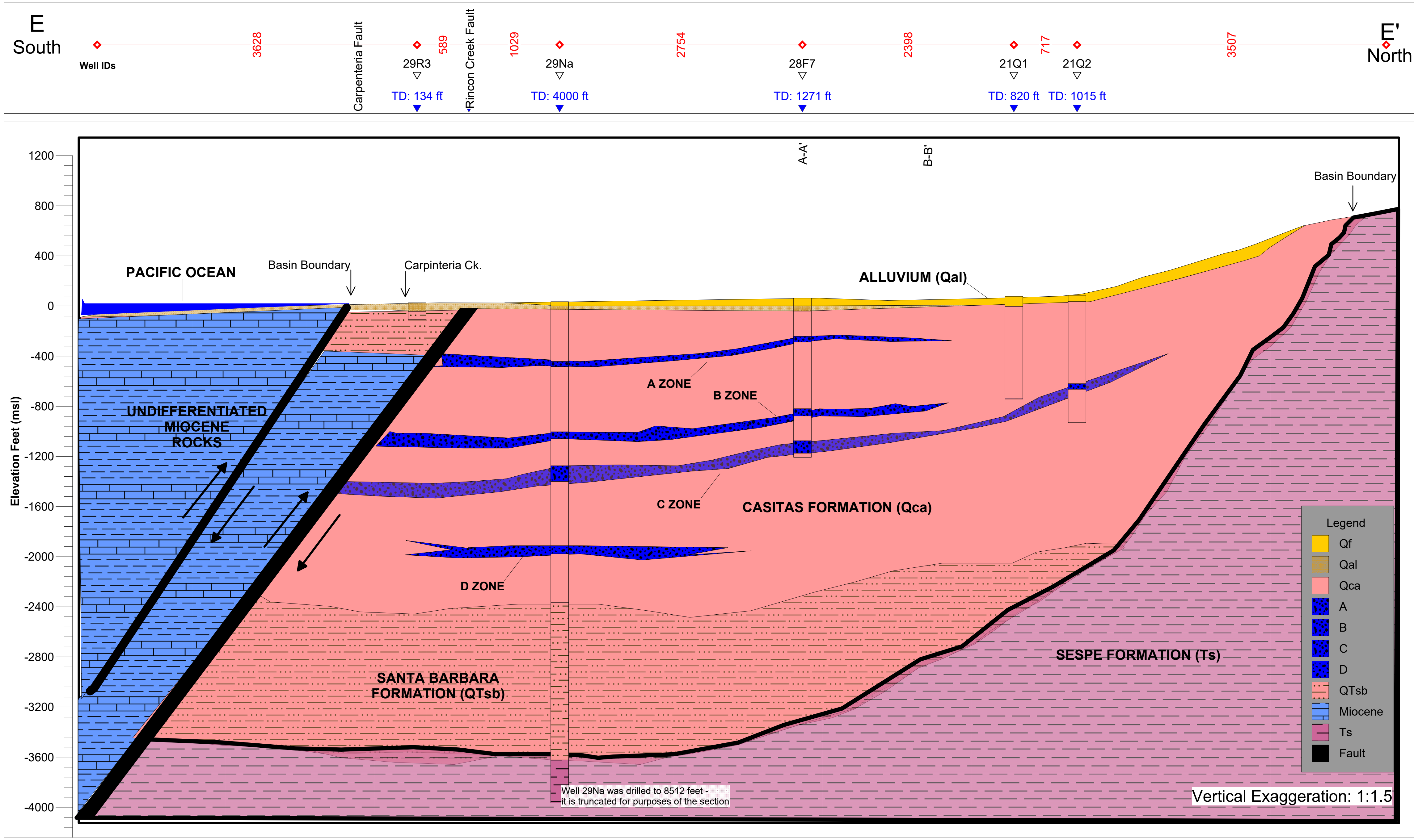

Notes:
Well ID - Well Identification
TD - Total Depth

FIGURE 3-14

Geologic Cross-Section E – E'

Carpinteria Basin Groundwater Sustainability Plan

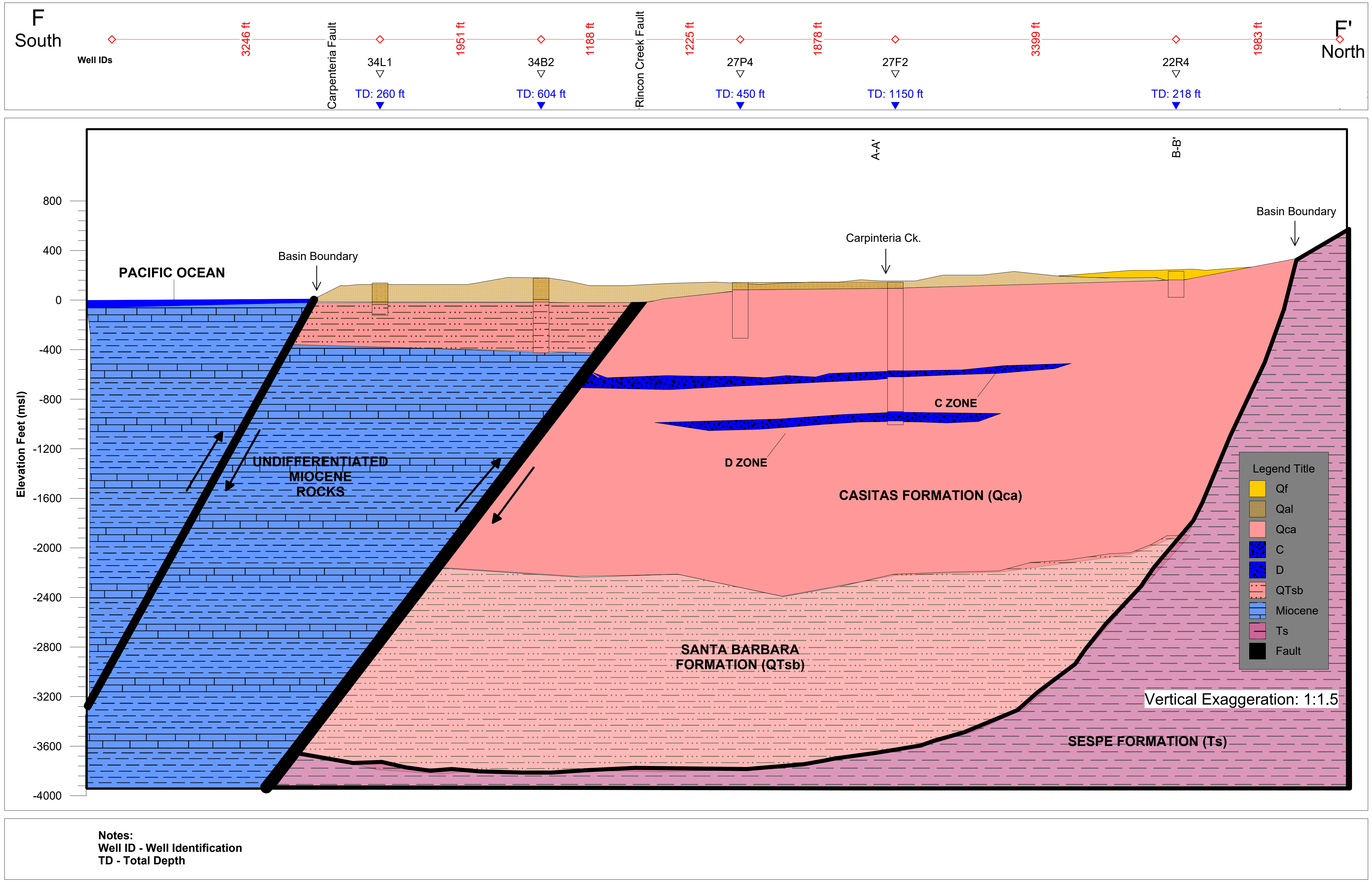

FIGURE 3-15

Geologic Cross-Section F – F'

Carpinteria Basin Groundwater Sustainability Plan

§ 354.14 Hydrogeological Conceptual Model.

(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:

(4) Principal aquifers and aquitards, including the following information:

(C) Structural properties of the basin that restrict groundwater flow within the principal aquifers, including information regarding stratigraphic changes, truncation of units, or other features.

Groundwater Flow Barriers [§354.14(b)(4)(C)]

As discussed previously, the Rincon Creek Thrust Fault represents a hydraulic flow barrier within the basin. The fault plain has been intersected by several wildcat oil wells. As shown in Figure 3-4, the surface trace of the fault extends westerly across the basin from the Ventura County side of Rincon Creek, through El Estero, and then offshore. As shown on the cross-sections, in the central portions of the basin consolidated bedrock have been thrust up and over basin sediments. Subsurface data indicate fault plane dips south at angles ranging from 50 to 70 degrees with displacement as much as 3,000 to 4,000 feet. Analysis of available hydrogeologic data by previous investigators (GTC) strongly suggests that Rincon Creek Fault has created a barrier of the southward movement of groundwater in the basin and forms the basis for the delineation of SU-1 and SU-2 discussed previously.

As discussed in section 3.1.2, west of El Estero in SU-1, the water-bearing deposits of the basin are in contact with the Pacific Ocean. Otherwise, the remainder of the basin is hydrogeologically separated from the Pacific Ocean by the Rincon Creek Fault or by consolidated bedrock exposed near the shoreline in SU-2 as a result of smaller displacement (approximately 300 to 400 feet) of the Santa Barbara Formation by the Carpinteria Fault.

§354.14 Hydrogeological Conceptual Model.

(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:

(4) Principal aquifers and aquitards, including the following information:

(B) Physical properties of aquifers and aquitards, including the vertical and lateral extent, hydraulic conductivity, and storativity, which may be based on existing technical studies or other best available information.

Hydraulic Properties [§354.14(b)(4)(B)]

The primary aquifer parameters necessary to characterize the hydraulics of groundwater movement and calculate basin storage include transmissivity, hydraulic conductivity, and storativity. Transmissivity and hydraulic conductivity are related (transmissivity is the product of hydraulic conductivity and aquifer thickness) and characterize the permeability of aquifer materials. Storativity is a measure of the aquifer's ability to store and release water. These aquifer parameters are used in the construction of the numerical groundwater flow model of the basin (see Appendix F). Estimates of these parameters are ideally obtained from analysis of pumping test data; however, the number of controlled pumping tests conducted in the basin is relatively limited. Transmissivity can also be roughly estimated from specific capacity data (ratio of well yield to drawdown), which are a commonly measured parameter at pumping wells and are, therefore, more plentiful than pumping test data.

Data available to most previous investigations was generally limited to specific capacity data. Formal post-construction pumping tests conducted at the CVWD High School, El Carro, and Headquarters wells have been analyzed to determine aquifer parameters at those locations. In addition to pumping tests, transmissivities have also been estimated from specific capacity data for this GSP. For wells where only specific capacity data are available, the methods presented in Driscoll (1995, pg. 1021) to estimate transmissivity were utilized. Hydraulic conductivities were calculated by dividing transmissivity by total screen length of each well. Summaries of the aquifer parameters derived for the Confined and Recharge Areas are presented below:

- **Confined Area.** Transmissivities derived from pumping test and specific capacity data in the Confined Area range between approximately 5,500 and 21,600 gallons per day per foot (gpd/ft) and average approximately 12,100 gpd/ft. Storage coefficients average approximately 6.5×10^{-4} (dimensionless), indicative of confined conditions. Estimated hydraulic conductivities for the primary producing zones in the Confined Area range between approximately 9 and 18 feet per day (ft/d).
- **Recharge Area.** Transmissivities derived from pumping test and specific capacity data in the unconfined Recharge Area range between approximately 400 and 18,000 gpd/ft, averaging approximately 3,200 gpd/ft. Hydraulic conductivities range between 0.2 and 7 ft/d, averaging approximately 1.4 ft/d. Storage coefficients could not be calculated from the available pumping test data in the Recharge Area due to a lack a nearby monitoring well to base calculations.

3.1.3.2 Groundwater Recharge and Discharge Areas [§354.14(d)(4)]

§354.14 Hydrogeological Conceptual Model.

(d) Physical characteristics of the basin shall be represented on one or more maps that depict the following:

(4) Delineation of existing recharge areas that substantially contribute to the replenishment of the basin, potential recharge areas, and discharge areas, including significant active springs, seeps, and wetlands within or adjacent to the basin.

As discussed previously, outside the Confined Area of the basin and extending to the bedrock boundaries, the Carpinteria and Casitas Formations contain laterally discontinuous layers of both permeable and impermeable materials, and water held in these areas is generally unconfined. The primary sources of recharge to the Basin are percolation of precipitation, subsurface inflow, and percolation of irrigation water. This area is delineated as the Recharge Area as shown on **Figure 3-9**.

Groundwater within the principal aquifer of SU-1 does not discharge directly to the ocean in the southeastern portion of the basin due to the presence of overlying confining layers and the barrier created by the Rincon Creek Thrust Fault. Subsurface outflow from SU-1 is believed to occur in the general area from Serena Park to Sand Point (a distance of approximately 9,000 ft.) where there is no fault barrier between basin sediments and the Pacific Ocean. In SU-2, significant subsurface outflow is not believed to occur due to the onshore contact of unconsolidated water-bearing materials with consolidated bedrock, which effectively isolates SU-2 from the ocean (see **Figures 3-4, 3-14, and 3-15**).

3.1.3.3 Water Quality [§354.14(b)(4)(D)]

§354.14 Hydrogeological Conceptual Model.

(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:

(4) Principal aquifers and aquitards, including the following information:

(D) General water quality of the principal aquifers, which may be based on information derived from existing technical studies or regulatory programs.

Groundwater quality within the basin has historically been monitored as part of the CVWD's AB 3030 Groundwater Management Plan program through the analysis of samples collected from 25 wells located throughout the basin. Water samples are also collected from six surface water stations when surface water is present. The laboratory analytical program for the samples includes total dissolved solids and basic inorganic chemical constituents, including chloride and nitrate. Chemical hydrographs for the 25 wells monitored are presented in Figures 3-16 and 3-17. Figure 3-16 presents water quality data for wells located generally in the western portion of the basin and Figure 3-17 presents data for wells located in the eastern portion.

In general, the chemistry of groundwater within the basin has a calcium-bicarbonate character, with concentrations of total dissolved solids (TDS) within the range of 600 to 900 milligrams per liter (mg/L) mg/L, and chloride ion concentrations in the range of 40 to 80 mg/L (notable exceptions are discussed later). Specific constituents of concern are discussed in detail below.

TDS and Chloride. There are some notable trends in the basin with respect to TDS and chloride ion concentrations. At most of the monitored private wells in the western portion of the basin, TDS and chloride concentrations have been relatively stable; however, increasing trends have been observed in wells 19E1 and 19K5 (see Figure 3-16).

At 19E1, beginning in about 2010, the TDS concentration has increased steadily from approximately 1,100 to 1,500 mg/L, while the chloride concentration over this same period rose from about 300 to 500 mg/L, peaking at 600 mg/L in 2019, exceeding the secondary Maximum Contaminant Level (MCL) for chloride of 250 mg/L. At Well 19K5, the TDS concentration rose from about 1,200 to 1,370 mg/L between 2008 and the end of 2019, with some higher spikes in between. Similarly, the chloride concentration at that well rose from 160 to 190 mg/L during that period with some spikes in the middle of that period.

At well 19M1, on the other hand, the TDS concentration increased from approximately 1,000 to 2,500 mg/L between 1990 and 2006, but has since declined to about 1,750 mg/L. The chloride concentration at this well showed a similar trend, increasing from 100 to 500 mg/L between 1990 and 2005. Since 2005, the chloride concentration has been variable at 19M1, possibly experiencing a slight declining trend, with a concentration of 370 mg/L observed in 2019.

In the eastern portion of the basin, TDS and chloride concentrations have also been relatively stable at most of the monitored private wells. TDS and chloride concentration increases have been observed at wells 27E1, 28H1, and 34B4 (see Figure 3-17).

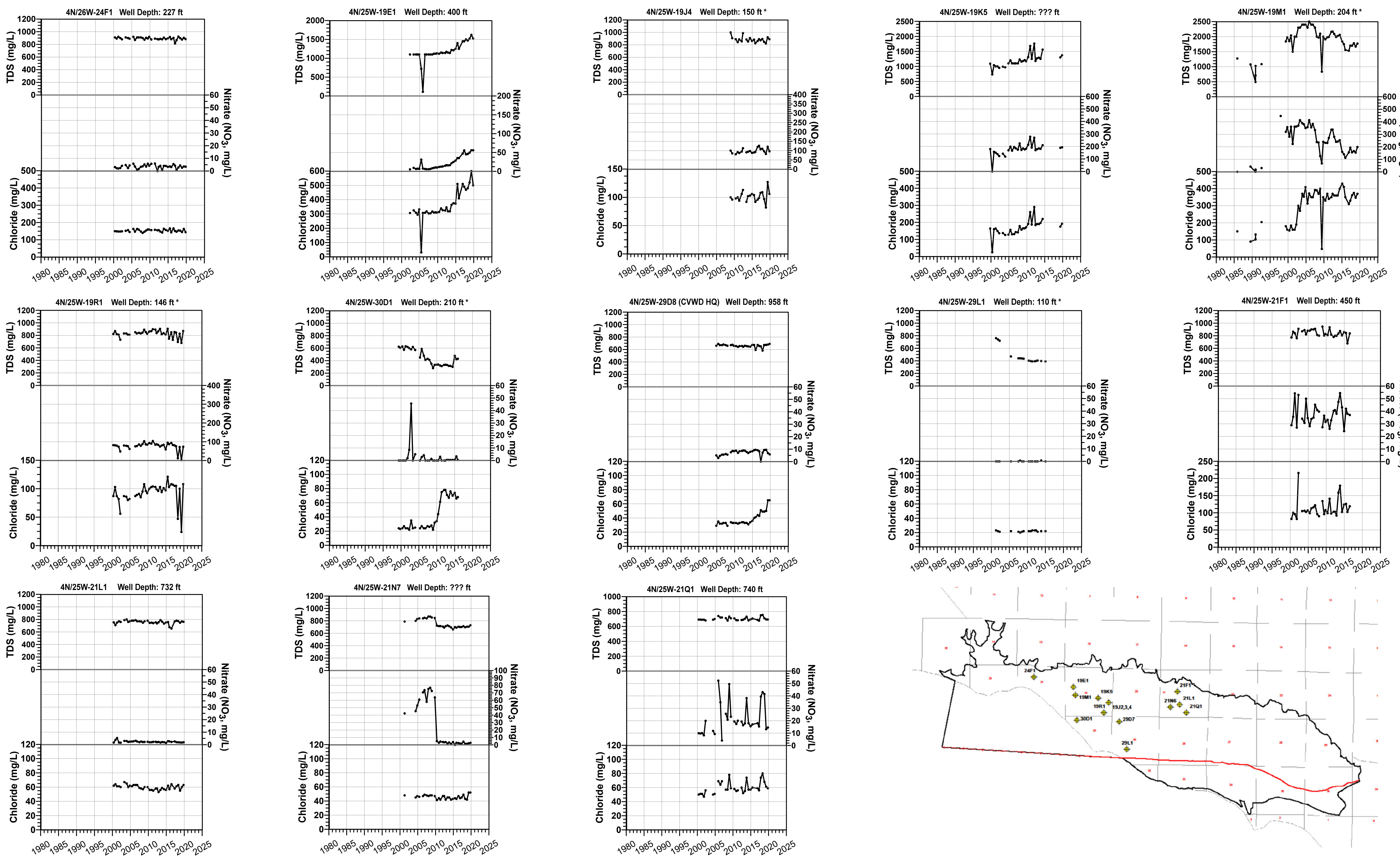

FIGURE 3-16

Water Quality Data – West

Carpinteria Basin Groundwater Sustainability Plan

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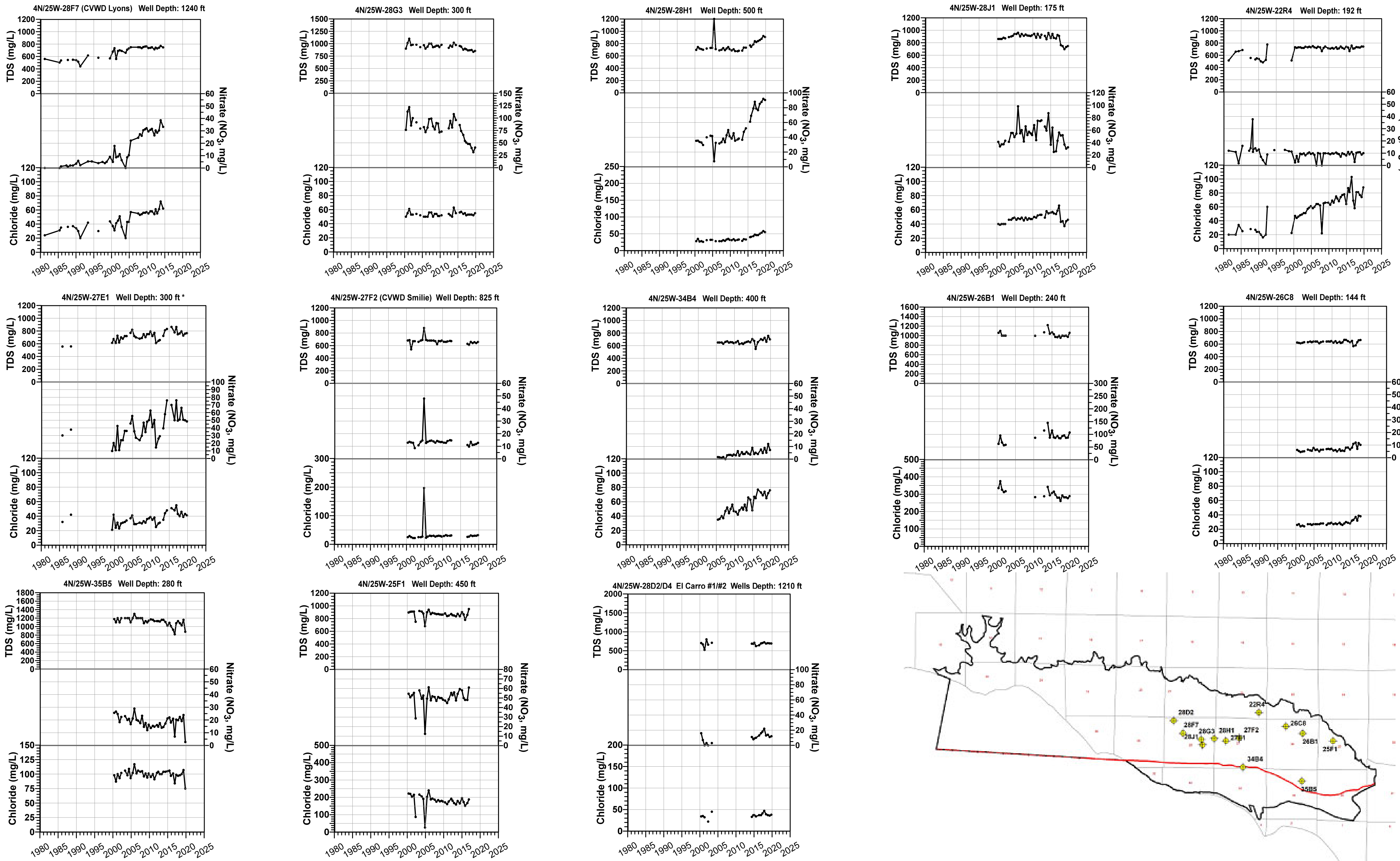

FIGURE 3-17

Water Quality Data – East

Carpinteria Basin Groundwater Sustainability Plan

Increasing trends of these constituents at well 27E1 began in the late 1990s. In the early 1990s the TDS concentration at this well was approximately 600 mg/L, peaking in 2006, and has generally been declining since then with a level of 860 recorded in 2019. The pattern of chloride concentrations at this well has been similar, starting at 20 mg/L, peaking at 55 mg/L, with an observed level of about 40 mg/L in 2019. At well 28H1, TDS and chloride concentrations have been steadily increasing since about 2013. In 2013, the TDS at this well was approximately 690 mg/L. The concentration at the end of 2019 was 907 mg/L. The chloride concentration in 2013 was about 30 mg/L and at the end of 2019 it was 55 mg/L. The TDS and chloride concentration at well 34B4 has also increased since monitoring of this well began in 2005, when the TDS concentration was 650 mg/L and the chloride concentration was 35 mg/L. The TDS and chloride concentrations in well 34B4 at the end of 2019 were 700 and 76 mg/L, respectively.

At well 22R4, while the TDS concentration has remained relatively stable over the monitoring period, the chloride concentration at this well has displayed an increasing trend, starting at approximately 20 mg/L in the early 1990s, reaching a level of 88 mg/L at the end of 2019.

The GSA will continue to track the water quality trends during GSP implementation to assess the potential cause of the trends discussed above, including whether degradation of groundwater quality is caused by groundwater extractions and is, hence, a sustainability issue that must be addressed by the GSA.

Nitrate. Nitrate concentrations (as NO_3) in the basin are generally lower in wells that are completed in relatively deep aquifer units, and higher in shallow wells located in agricultural areas. Some trends of increasing nitrate concentrations have been identified. In the western portion of the basin (see **Figure 3-16**), nitrate concentrations have been increasing at wells 19E1 and 19K5 since about 2005, coincident with increasing TDS and chloride concentrations during this same period at each of these two wells For 19E1, nitrate concentrations were below 10 mg/L during the mid- to late-2000s and have increased to 56 mg/L by the end of 2019. At 19K5, nitrate concentrations were at around 170 mg/L in the mid-1980s, peaked at 280 mg/L in 2010, and during 2019 were reported to be at 190 mg/L.

Nitrate concentration increases have also been occurring at private wells in the eastern portion of the basin (see **Figure 3-17**), most notably at wells 27E1 and 28H1. At 27E1, the nitrate concentration at this well was approximately 10 mg/L in 1980, peaked at 63 mg/L in 2009, and dropped to 50 mg/L in 2019. The MCL for nitrates in drinking water in California is 45 mg/L (as NO_3). The increases in nitrate concentrations in the noted wells appear to be localized and may be associated with well completion depths and/or agricultural practices.

CVWD Municipal Wells. Water quality at the CVWD municipal production wells is also monitored through the AB 3030 program. Chemical hydrographs for CVWD wells are also presented on **Figures 3-16 and 3-17**. In the western portion of the basin at the Headquarters well (29D8) (see **Figure 3-16**), while the TDS concentration has been relatively stable over the period of record, generally within the range of 640 mg/L to 680 mg/L, the chloride concentration at this well increased slowly from approximately 40 mg/L in 2015, to about 50 mg/L at the end of 2018, to 65 mg/L at the end of 2019. While the chloride concentration at the Headquarters Well is well below the secondary MCL of 250 mg/L, the steady increase over the past several years is noteworthy. Unlike other private wells in the western portion of the basin where increases in TDS and chlorides were sometimes accompanied by increases in nitrate concentrations, the nitrate concentration at the Headquarters Well has been stable and less than 10 mg/L over the period of record.

The CVWD production wells in the eastern portion of the basin are the El Carro No. 1 (28D2) and No. 2 (28D4) wells, Lyons (28F7) and the Smillie (27F2) wells (see **Figure 3-17**). At the El Carro well site[1], there does not appear to be any notable or significant trends in water quality, with concentrations of TDS,

[1] El Carro No. 1 was drilled in 1990 and was replaced by the El Carro #2 well in 2010.

chlorides, and nitrates at the end of 2019 at 691 mg/L, 38 mg/L, and 12 mg/L, respectively. At the Smillie well, water quality also appears to be stable with no notable trends, with concentrations of TDS, chloride, and nitrate at the end of 2019 of 658 mg/L, 32 mg/L, and 13 mg/L, respectively.

The Lyons well is currently inactive and has not been sampled since 2014, however; some notable trends of increasing concentrations of TDS, chlorides, and nitrates are apparent for this well during the period of record. Prior to 2000, the TDS concentration at this well was consistently under 600 mg/L. Since 2005, the TDS concentration at Lyons has ranged between about 730 and 770 mg/L, although the TDS concentration at this well does not appear to be recently increasing. Chloride concentrations at the Lyons well generally shows a steady increase from about 25 mg/L in the early 1980s to 62 mg/L in 2014. Nitrate concentrations have also increased over the period of record at this well, going from concentrations generally below 10 mg/L prior to 2005 to a concentration of 39 mg/L in 2013. It is noted that this well has a relatively shallow annular seal depth (50 feet), which may allow the vertical migration of poor-quality shallow water through the gravel-packed annular space into the screen zones of this well.

Surface Water Quality. Available surface water-quality data are presented on **Figure 3-18** and the locations of the surface water sampling locations are shown on **Figure 3-2**. As shown, a long-term trend of slightly increasing TDS concentrations for the surface water quality is apparent over the period of record, particularly on Arroyo Paredon Creek, although most recently the TDS concentrations were relatively stable, if not slightly diminished. Nitrate and chloride concentrations at surface water sampling stations appear to be relatively stable since monitoring began. It is noted that Arroyo Paredon Creek, located in the western portion of the basin, generally has significantly higher concentrations of both TDS and chloride compared to the other creeks in the basin. The reason(s) for this are not known but may be a contributing factor to the elevated levels of these constituents in groundwater at wells in this area (i.e., wells 19E1, 19K5 and 19M1).

3.1.3.4 Primary Beneficial Uses [§354.14(b)(4)(E)]

§354.14 Hydrogeological Conceptual Model.

(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:

(4) Principal aquifers and aquitards, including the following information:

(E) Identification of the primary use or uses of each aquifer, such as domestic, irrigation, or municipal water supply.

The primary uses of the principal aquifer in the basin are municipal and agricultural water supply. To the extent non-municipal small domestic wells provide water supply in the basin, it is considered de minimis and historically has not been quantified. Municipal pumping by the CVWD is metered and agricultural pumping is estimated by CVWD via annual land use surveys. The average proportion of pumping by these two user types from WY 1985 through WY 2020 is summarized below:

- Municipal = 36 percent
- Agricultural = 64 percent

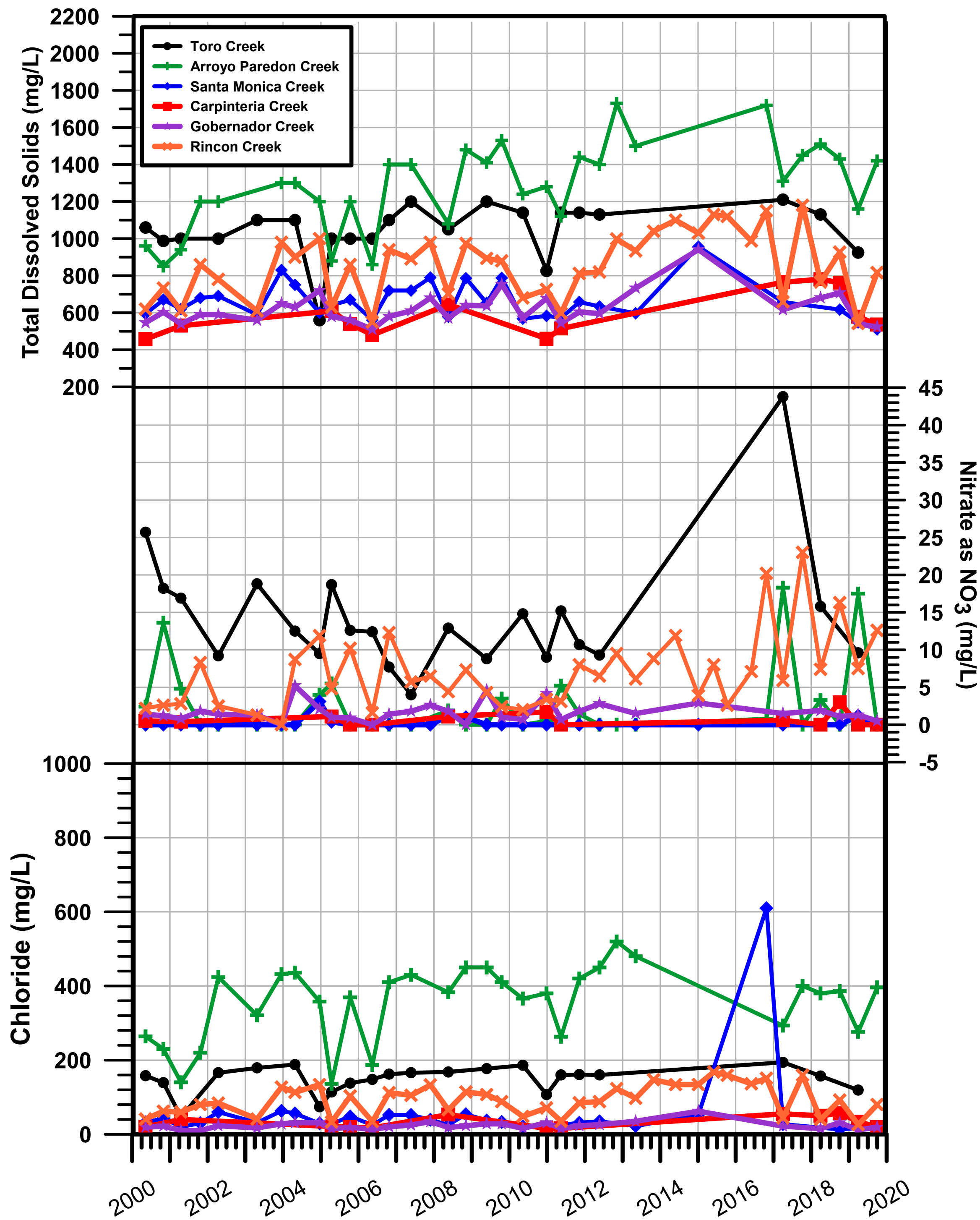

FIGURE 3-18

Water Quality Data – Surface Water

Carpinteria Basin Groundwater Sustainability Plan

3.1.4 Data Gaps and Uncertainty [§354.14(b)(5)]

§354.14 Hydrogeological Conceptual Model.

(b) The hydrogeologic conceptual model shall be summarized in a written description that includes the following:

(5) Identification of data gaps and uncertainty within the hydrogeologic conceptual model.

There is relatively good general hydrogeologic conceptual understanding of the central portion of the basin in SU-1, primarily because this is where the municipal and the majority agricultural production and monitoring wells, as well as wildcat oil wells, have been historically drilled and been the focus of previous hydrogeologic investigations in the basin. There are specific areas where the hydrogeologic conceptual understanding is less understood due to data limitations:

1. The stratigraphy of basin sediments offshore and the nature of the connection with the Pacific Ocean. While there is geologic control for the depth to bedrock formations and the trace of the Rincon Creek Fault offshore from oil well drilling, the geometry of the A – D Zones is currently based on extrapolation of the onshore surfaces to the offshore area.
2. The structure and aquifer parameters of SU-2 are not well understood due to the lack of wells drilled and pumping tests performed in this unit.
3. The structure, aquifer parameters and amounts of pumping in the Ventura County portion of the basin are not well understood, largely due to this area being outside the boundaries of the CVWD and a historical lack of hydrogeologic investigation in this area of the basin.
4. The hydraulic parameters of the individual A through D producing zones in the central portion of the basin can only be roughly estimated because most wells in the basin (except the recently drilled Sentinel Wells, discussed later) penetrate two or more of the main producing zones, and data developed from pumping tests therefore represent a composite of all of the zones penetrated by any given well.

3.2 Groundwater Conditions [§354.16]

3.2.1 Groundwater Elevations [§354.16(a)]

3.2.1.1 Groundwater Elevation Contours [§354.16(a)(1)]

§354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:

(1) Groundwater elevation contour maps depicting the groundwater table or potentiometric surface associated with the current seasonal high and seasonal low for each principal aquifer within the basin.

Analysis of water-level hydrographs presented in this section led to the identification of the historical basin high and the basin low periods within the WY 1985 – WY 2020 historical water budget base period (discussed in a later section). Water-level contours have been prepared for the basin high and low periods within the base period, as well as for January 2015 and current conditions. The specific periods for which water-level contours were prepared include:

- Fall 1991 –base period historical low
- Spring 1998 – base period historical high
- January 2015 - SGMA effective date
- Spring 2020 – current seasonal high
- Fall 2020 – current seasonal and historic low

The water-level contours for these periods are presented in **Figures 3-19 through 3-23**.

The primary purpose of the water-level contours is to help to identify general patterns in the flow regime within the basin, including those attributable to recharge sources and associated with discharge areas. The water-level contours show that in SU-1, groundwater generally flows in a northeast to southwesterly direction in the eastern half of the basin, and north to south in the western half of the basin. The directions of groundwater flow generally reflect the movement of groundwater from the primary sources of recharge in the Recharge Area to the primary sources of extraction (groundwater pumping) in the Confined Area in the central portion of the basin. It is noted that available data for SU-2 are limited, and water-level contours are not depicted for unit this reason.

The water-level contours for the base-period historical low of fall 1991 (**Figure 3-19**), coinciding with the extended drought period of 1987–1991, show the development of a water-level depression centered in the central portion of SU-1. In the center of the depression, water levels during this period declined to an elevation of more than 50 feet below msl.

The water-level contours for the base period historic high of spring 1998 (**Figure 3-20**) show the depression earlier in the decade being filled as a result of basin recharge, with water levels recovering to levels of as much as 50 feet above msl in the same area and a seaward gradient restored throughout the basin.

Water levels for January 2015 (**Figure 3-21**) show the development of a water-level depression again centered in the central portion of the basin. It is noted that this time period coincides with the most recent drought period of WY 2012 through WY 2016. This depression persists into WY 2020, with water levels as much as 50 to 60 feet below msl in both spring and fall 2020 (**Figures 3-22 and 3-23**, respectively), which are presented as the current seasonal high and low, as required in the GSP Emergency Regulations.

These water-level conditions result in a reversal of the natural seaward groundwater gradient, creating the potential for seawater intrusion in the western portion of the basin (i.e., in the general area from Sand Point to Serena) where basin deposits are exposed to the Pacific Ocean. It is noted that prior to 2019 seawater intrusion had not historically been detected in existing wells in the basin; however, before 2019 there were no monitoring wells along the coast that that could have detected seawater intrusion.

The CVWD has recognized this deficiency in the historical monitoring well network in the basin and recently drilled seawater intrusion “sentinel” wells near the coastline just west of El Estero (discussed in a later section).

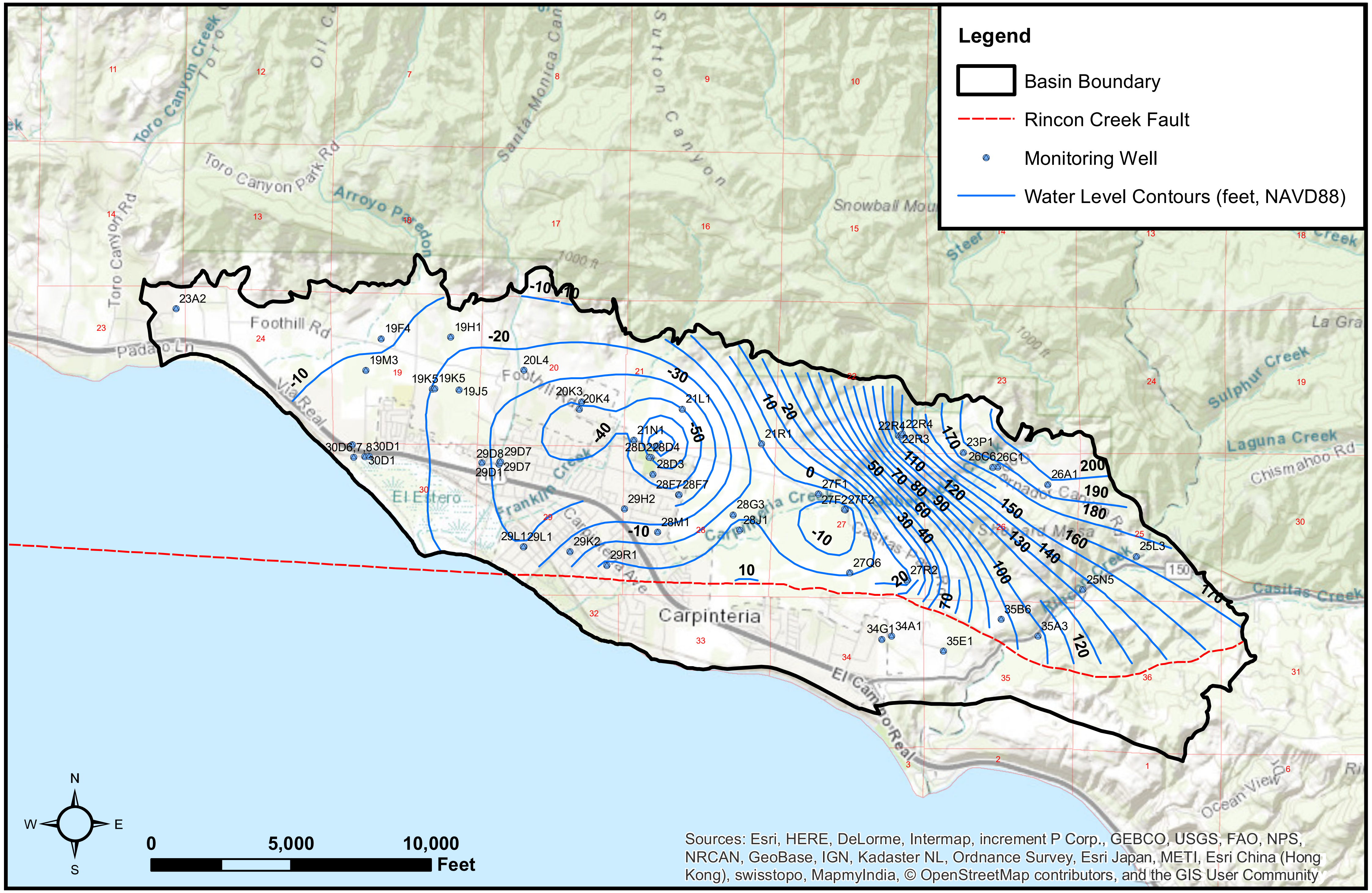

FIGURE 3-19

Groundwater Elevation Contours – Fall 1991

Carpinteria Basin Groundwater Sustainability Plan

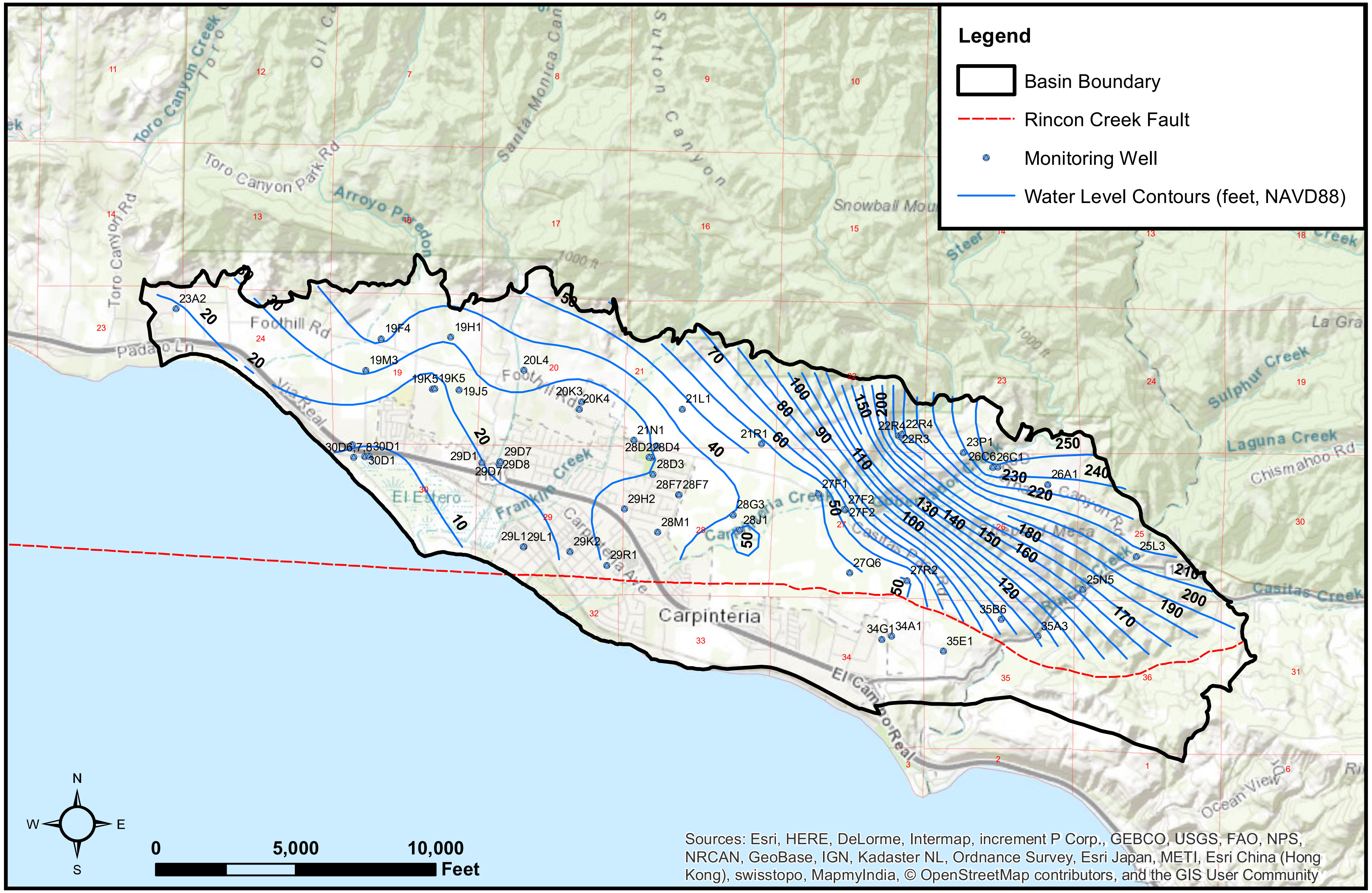

FIGURE 3-20

Groundwater Elevation Contours – Spring 1998

Carpinteria Basin Groundwater Sustainability Plan

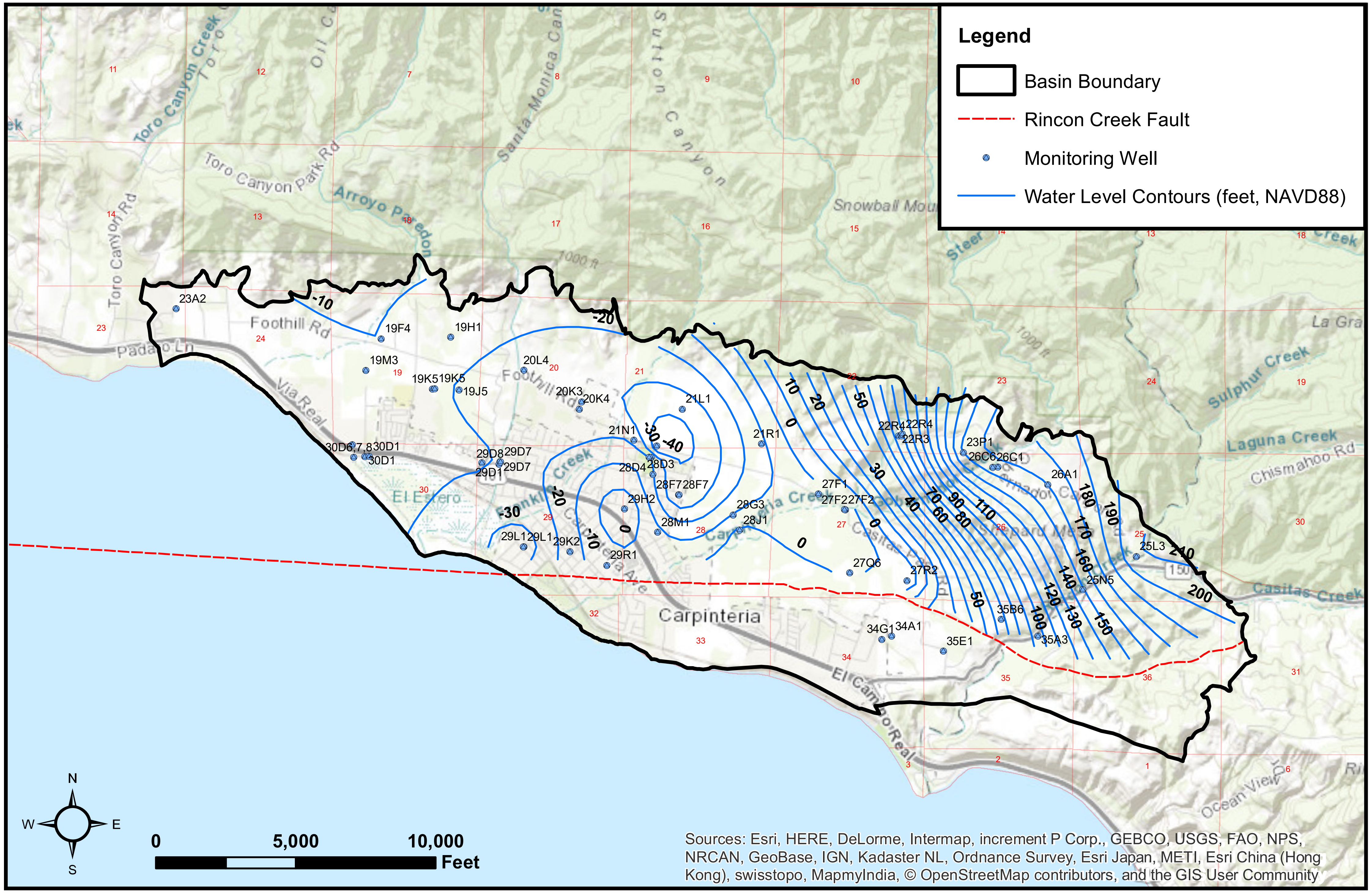

FIGURE 3-21

Groundwater Elevation Contours – January 2015

Carpinteria Basin Groundwater Sustainability Plan

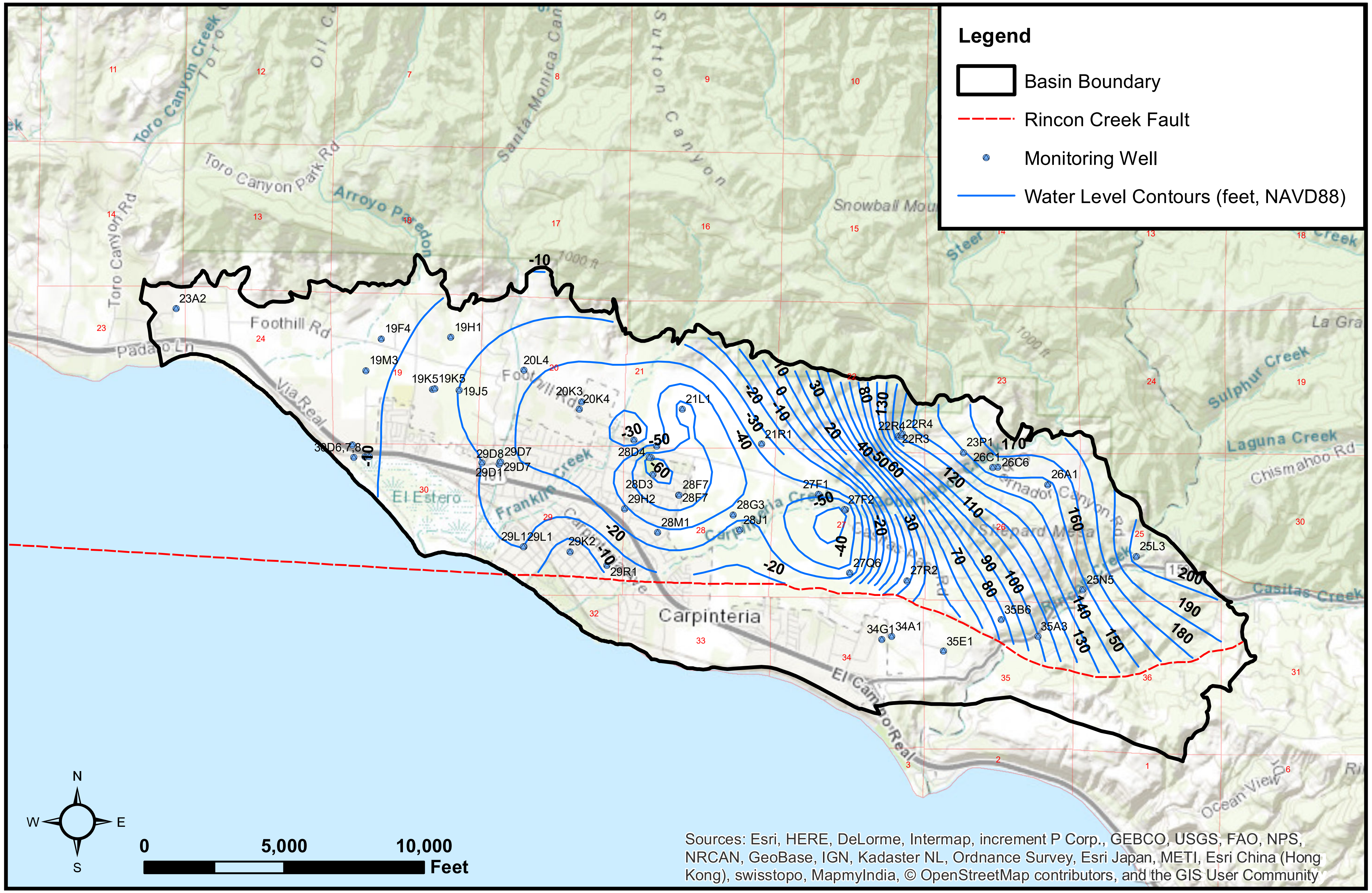

FIGURE 3-22

Groundwater Elevation Contours – Spring 2020

Carpinteria Basin Groundwater Sustainability Plan

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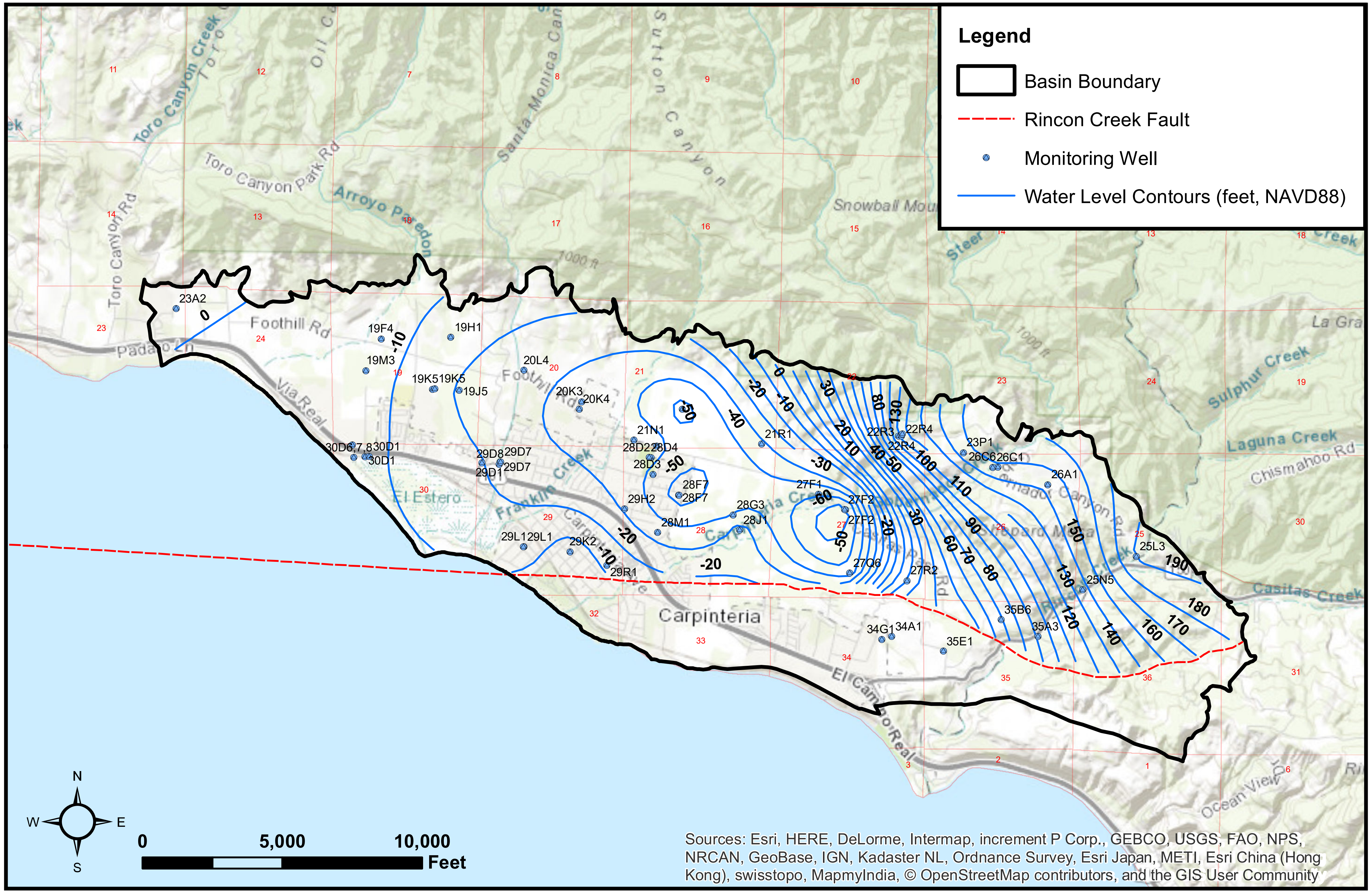

FIGURE 3-23

Groundwater Elevation Contours – Fall 2020

Carpinteria Basin Groundwater Sustainability Plan

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3.2.1.2 Groundwater Elevations [§354.16(a)(2)]

§354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(a) Groundwater elevation data demonstrating flow directions, lateral and vertical gradients, and regional pumping patterns, including:

(2) Hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients between principal aquifers.

Hydrographs for water-level monitoring wells in the CVWD database have been prepared for the GSP. The hydrographs are essential for understanding basin dynamics. They are used to identify water-level trends and assess aquifer response to various hydrogeologic conditions. They are also used as groundwater model calibration targets.

Water-level data in the basin have historically been collected and maintained by the USGS and the CVWD. The USGS database contains water-level records for 75 wells in the basin, dating back to as early as 1919 (State Well No. 4N/25W-28J1); however, most records begin in either the 1940s or 1970s. The USGS database does not extend beyond 2001. The CVWD has historically made monthly measurements at over 40 wells in the basin, and until 2001, provided the USGS with these data to supplement the USGS database. After 2001 the CVWD continued measuring water levels at these wells as part of the AB 3030 Groundwater Management Plan program and assumed the responsibility for maintaining the water-level records. Currently, there are records for 48 wells in the CVWD database. The locations of the monitoring wells are shown in **Figure 3-24** and hydrographs for selected wells are presented on **Figures 3-25 through 3-29**. The following discussion pertains to these selected hydrographs. A complete set of hydrographs with all available data is included in **Appendix D**.

In general, the long-term hydrographs for SU-1 display seasonal and small amplitude annual fluctuations superimposed upon some larger, more prominent trends. Prior to the historical water budget period of WY 1985 – WY 2020, the most notable trends occurred during the late-1940s through the mid-1950s when water levels in the basin declined substantially, and between approximately the early 1960s and about 1975 when water levels in the basin increased significantly. These trends are evident in the hydrographs depicted in **Figures 3-25 through 3-29** (wells 19F4, 26A1, 28J1, in the Recharge Area (**Figure 3**-9) and well 30D1 in the confined area.

There are notable trends within the historical WY 1985 – WY 2020 water budget period as well. Water levels declined relatively sharply starting at the beginning of the base period through the fall of 1991, corresponding to the extended six-year drought of 1987 – 1992. This was followed by a relatively steep upward trend in water levels peaking around the spring of 1998, which was the wettest year on record (approximately 55.5 inches of rainfall). After 1998, water levels throughout most of the basin displayed a gradual declining trend until the early- to mid-2000s when water levels essentially stabilized until around 2012. Water levels at most wells steadily declined during the extreme drought period of 2012 through 2016. Water levels have generally been stable or slightly rising at many, but not all, wells since 2016. It is notable that recent (2020) water levels at many locations are at lower elevations than occurred in during the 1987–1992 drought period and are approaching the historical lows observed during the 1950s at some locations. In wells 19F4 and 28J1 (Figures 3-25 and 3-28), current water levels are comparable to those observed in the 1940s/1950s drought, In wells 26A1 and 30D1 (Figures 3-26 and 3-29), water levels in the 1940s/1950s drought are lower than current water levels. All five hydrographs indicate that current water levels are lower than water levels observed in the 1980s/1990s drought.

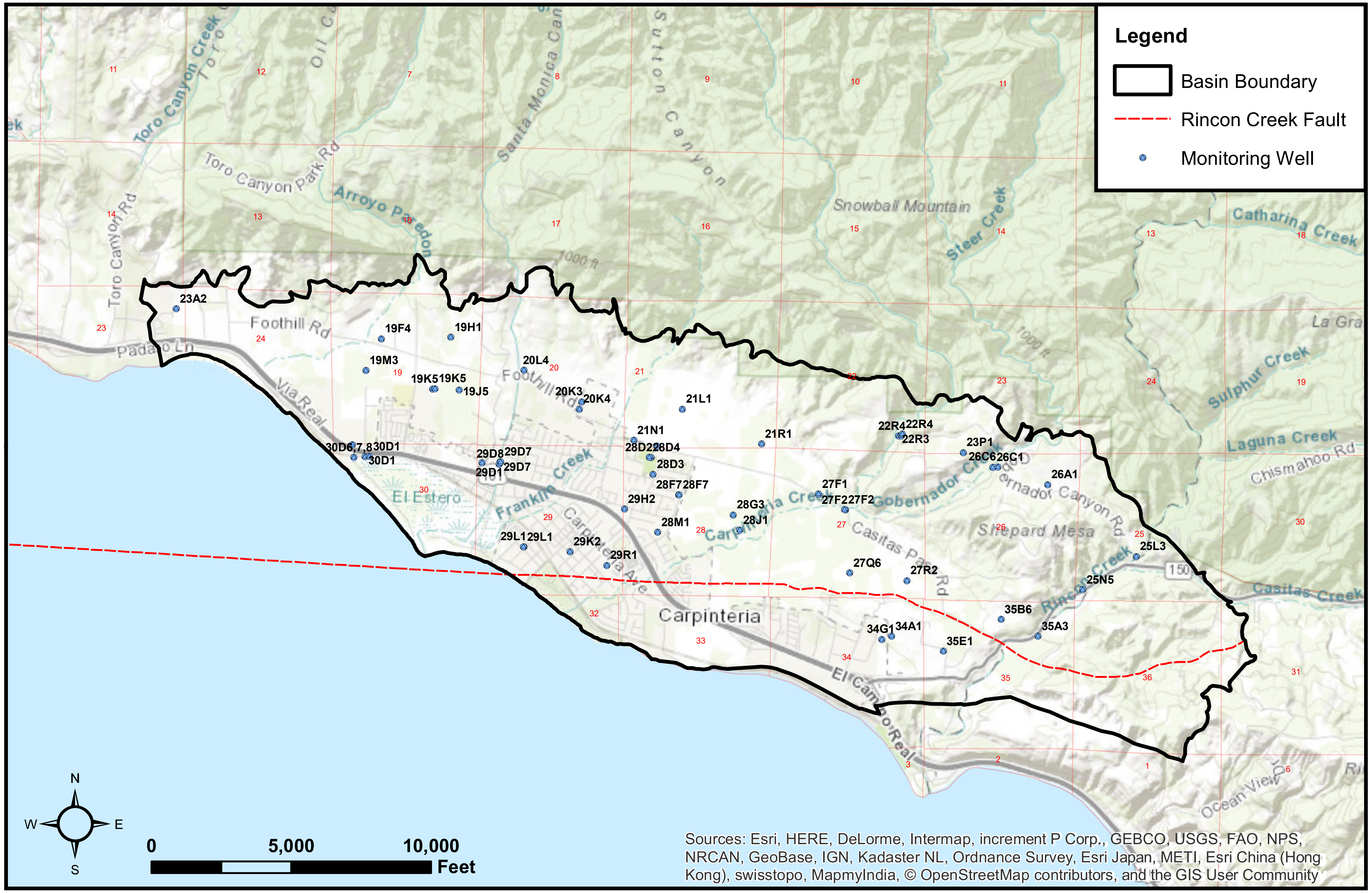

FIGURE 3-24

Monitoring Well Location Map

Carpinteria Basin Groundwater Sustainability Plan

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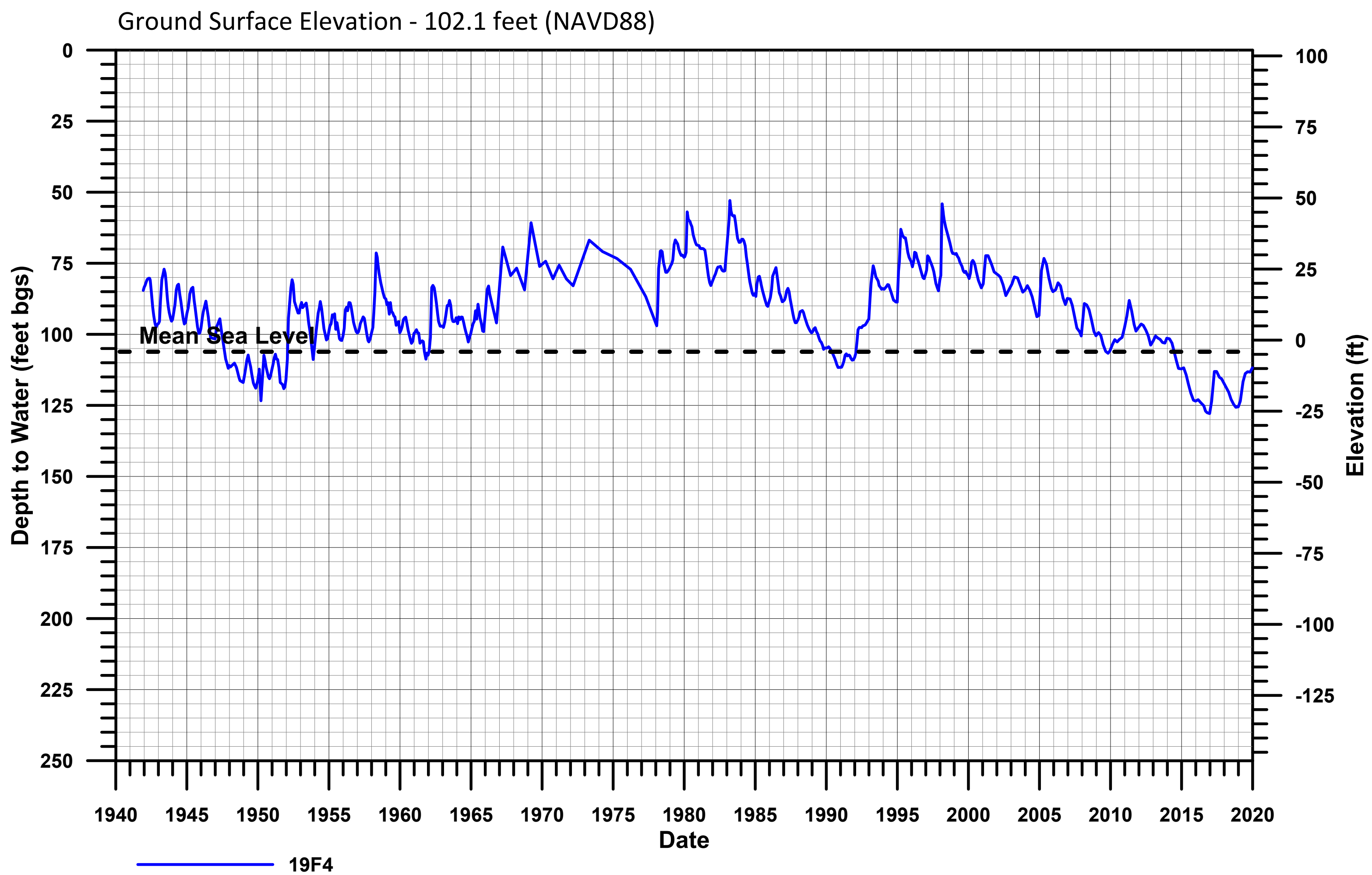


FIGURE 3-25

Water Level Data – 4N/25W-19F4

Carpinteria Basin Groundwater Sustainability Plan

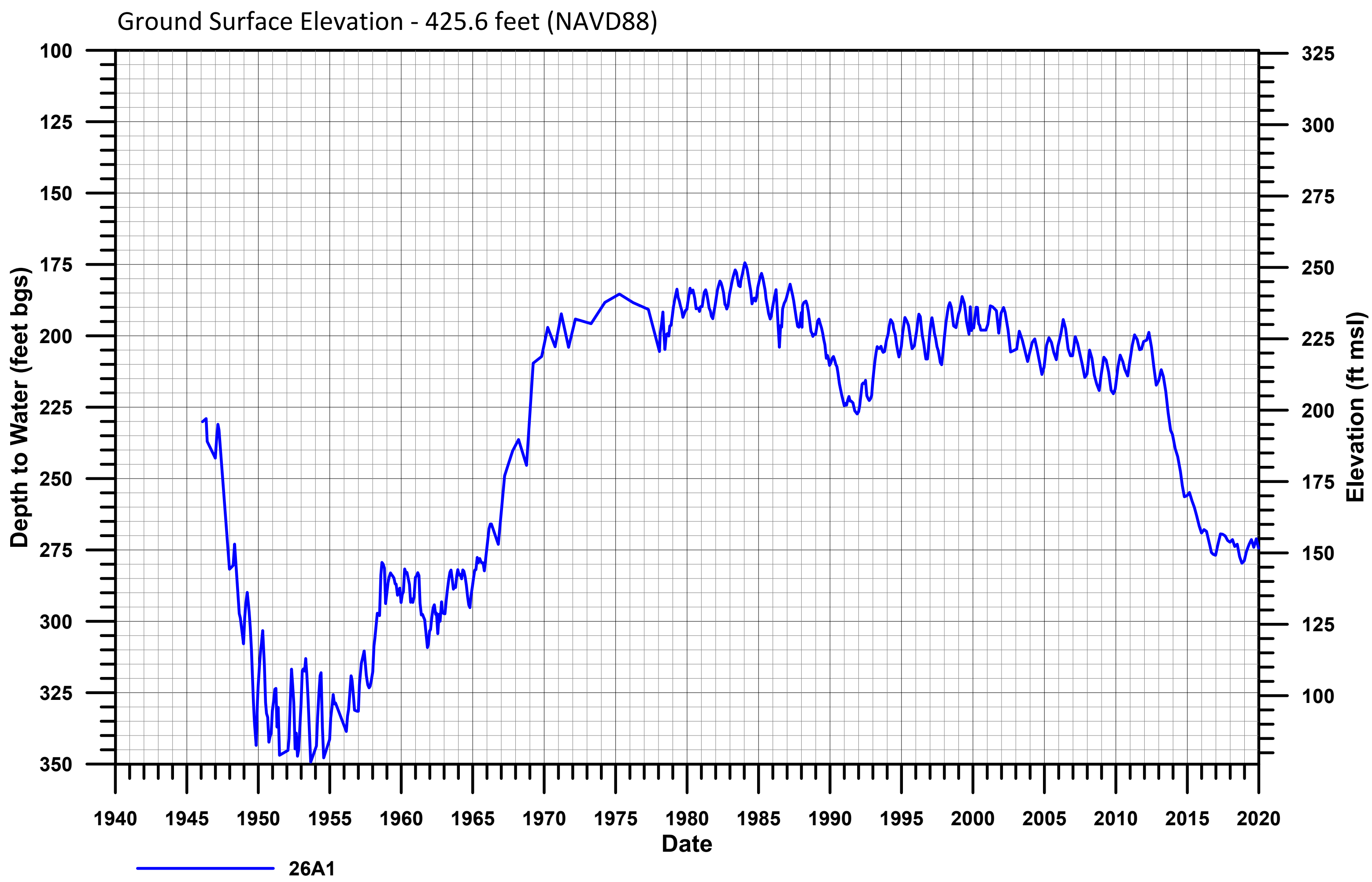


FIGURE 3-26

Water Level Data – 4N/25W-26A1

Carpinteria Basin Groundwater Sustainability Plan

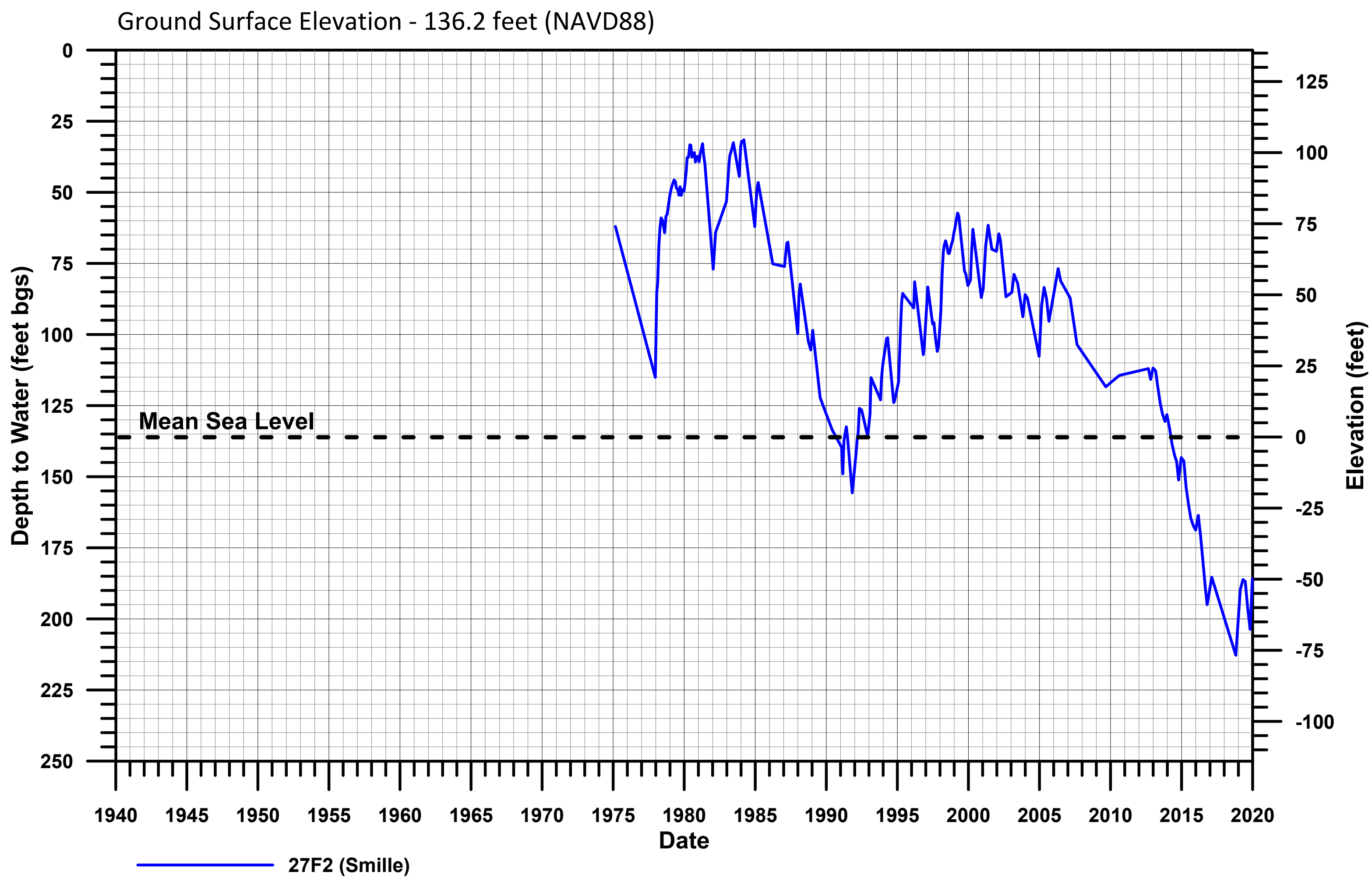


FIGURE 3-27

Water Level Data – 4N/25W-27F2 (Smille)

Carpinteria Basin Groundwater Sustainability Plan

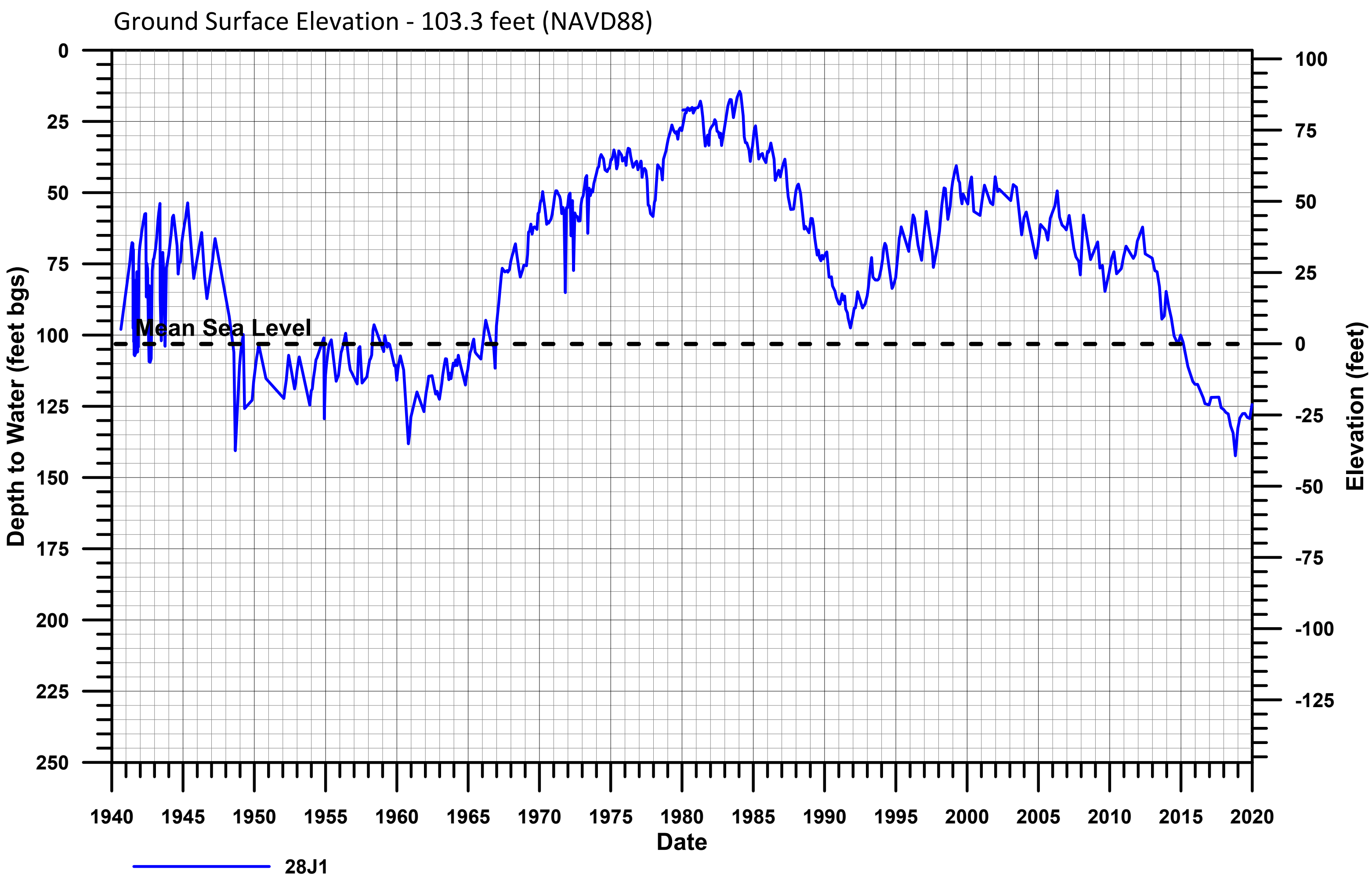


FIGURE 3-28

Water Level Data – 4N/25W-28J1

Carpinteria Basin Groundwater Sustainability Plan

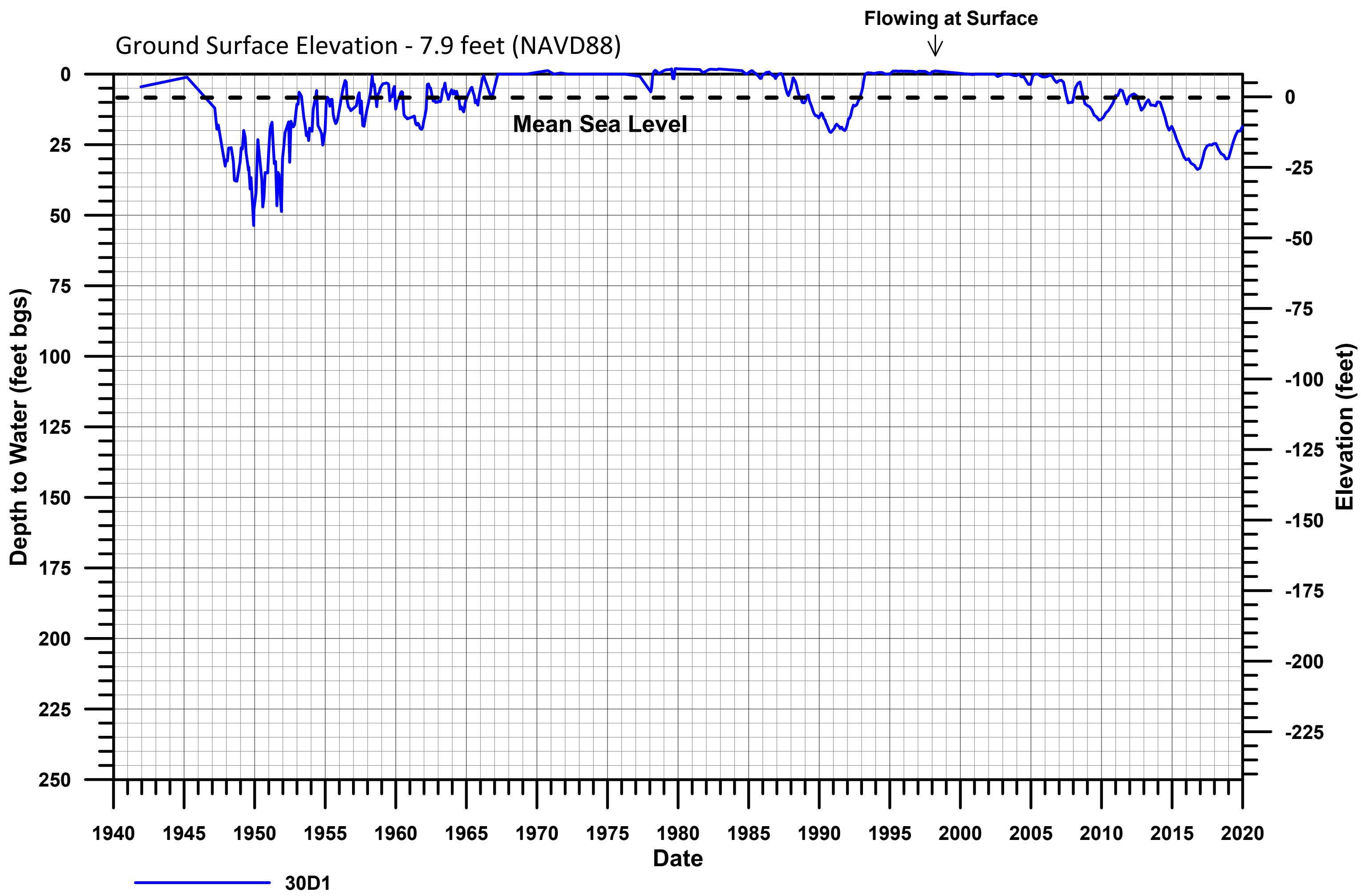


FIGURE 3-29

Water Level Data – 4N/25W-30D1

Carpinteria Basin Groundwater Sustainability Plan

3.2.2 Change in Storage [§354.16(b)]

§354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(b) A graph depicting estimates of the change in groundwater in storage, based on data, demonstrating the annual and cumulative change in the volume of groundwater in storage between seasonal high groundwater conditions, including the annual groundwater use and water year type.

The amount of groundwater in storage in the basin generally reflects changes in groundwater elevations over time. Figure 3-30 shows the changes in storage from WY 1985 through WY 2020 as calculated by the difference between annual inflows and outflows according to the historical water budget (see Section 3.3). During this period groundwater elevations were depressed in SU-1 during the late 1980s/early 1990s when groundwater pumping was between approximately 3,300 and 5,400 acre-feet per year (AFY) and during the more recent period of 2012 through 2020 when groundwater pumping was between approximately 3,400 and 6,700 AFY. As discussed later in the Water Budget section, these periods coincide with below-normal rainfall and recharge of the basin aquifers. Figure 3-30 shows how groundwater was consistently lost from storage most years during these dry periods as a result of the imbalance between recharge and pumping in the basin.

3.2.3 Seawater Intrusion [§354.16(c)]

§354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(c) Seawater intrusion conditions in the basin, including maps and cross-sections of the seawater intrusion front for each principal aquifer.

As discussed previously, the primary producing zones of SU-1 north of the Rincon Creek Fault to the vicinity of Serena Park is believed to be exposed to the Pacific Ocean and, therefore, at potential risk for seawater intrusion. From limited water-quality data from the 1930s for shallow wells in the vicinity of Serena Park, Upson (1951) observed that, although chloride ion concentrations in this area were relatively high, such concentrations were present in wells further inland as well. He concluded that seawater intrusion had not occurred in the basin but could occur if excessive pumping caused a lowering of groundwater levels in the basin. Subsequent studies conducted by the USGS during the 1950s showed that shallow wells near the coastline maintained relatively consistent chloride concentrations around 30 mg/L even though water levels had declined in areas of the basin to as much as 40 feet below msl.

GTC (1976) further concluded that the relatively high chloride concentrations in shallow wells discussed by Upson appeared to be the result of the chemical nature of the sediments (e.g., connate water still incompletely flushed), local degradation by irrigation returns and/or minor amounts of degradation of the shallow deposits where they are in direct communication with the Pacific Ocean. In the central Confined Area of the basin, the low-permeability confining layer was believed to prevent the vertical communication between the shallow and deeper aquifer system, although vertical communication between zones likely occurs at the western margins of the basin outside the Confined Area.

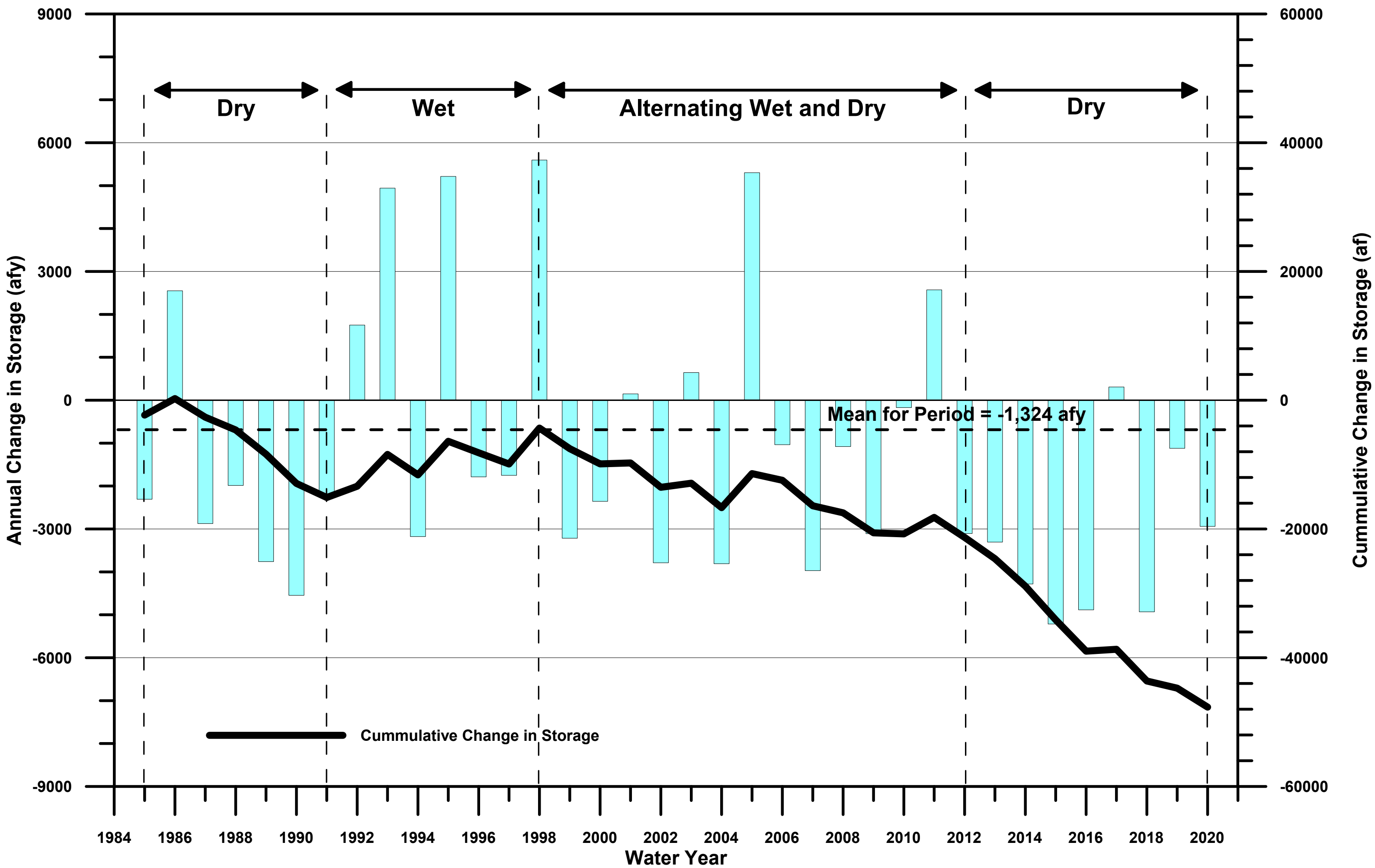


FIGURE 3-30

Change in Groundwater in Storage (WY 1985-2020)

Carpinteria Basin Groundwater Sustainability Plan

Thus, seawater intrusion has not historically been documented by previous investigations in the basin. Evaluation of basin conditions over recent years through the AB 3030 program, however, led to the identification of gaps in the existing monitoring well network, one of which was a monitoring well capable of the detection of seawater intrusion into the primary producing zones of the basin (i.e., the absence of evidence is not evidence of absence). This important data gap was initially identified in PWR (2012), which documented the Hydrogeologic Update and Groundwater Model Project and recommended that the CVWD should install at least one coastal sentinel monitoring well in the northwest portion of SU-1 of the basin that has dedicated monitoring wells completed in the A, B and C Zones. This recommendation was repeated in each subsequent AB 3030 annual reports.

Sentinel Monitoring Wells. In 2019 the CVWD implemented the CGB Sentinel Well Project, which consisted of the installation of a cluster of monitoring wells near the northwestern margin of the Carpinteria Salt Marsh (El Estero), a location considered to be key for the collection of water-level and water-quality data related to evaluating the potential for seawater intrusion in the basin. The primary purposes of the Sentinel Well Project were:

1. Determine baseline water-quality conditions at this key location in the basin;
2. Allow for the collection of water-level and water-quality data through routine monitoring;
3. Establish a mechanism to track water-quality changes in distinct water bearing zones through routine induction logging; and,
4. Serve as an early warning indicator (i.e., "sentinel") for seawater intrusion into the basin.

It is noted that, in addition to providing the first monitoring location capable of detecting seawater intrusion in the principal aquifer of the basin, the Sentinel Wells are also the first monitoring well cluster in the basin with discrete and isolated completions within the three main producing zones in the Confined Area (A, B and C Zones).

The drilling and construction of the wells occurred between May 20 and August 1, 2019. The wells are identified as the CGB Sentinel Monitoring Well Nos. 1, 2, and 3, with well completions (screens) within the C, B, and A zones of the basin, respectively. Well construction and completion details are provided in **Table 3-1.**

Table 3-1. Sentinel Well Completion Summary

Parameter	MW-1	MW-2	MW-3
Total Drilled Depth, (ft.)	1240	880	350
Casing Depth (ft.)	1130	870	340
Casing Diameter (in.)/PVC Grade	3 / sch. 120	3 / sch. 80	3 / sch. 80
Screened Interval (ft.)	1,020 – 1,120	780 to 860	190 – 330
Depth of Cement Grout Annular Seal (ft.)	955	709	150
Screened Producing Zone	C	B	A

Depictions of the monitoring well completions with respect to the hydrostratigraphic conditions at the Sentinel Well site are provided on **Figure 3-31**.

Following well completion, water-level transducer/dataloggers were installed in each of the Sentinel wells to continuously measure and record water levels. Water-quality samples are also collected on a quarterly basis, which includes chloride ion, a key indicator of seawater intrusion. The water-level and chloride data collected after the construction of the wells are presented graphically in **Figure 3-32** (MW-1), **Figure 3-33** (MW-2), and **Figure 3-34** (MW-3).

As shown on **Figure 3-32**, the initial water level in MW-1 in August 2019 was approximately -2.7 feet msl. As shown, during periods of limited pumping, such as during the winter/spring period of 2020/2021, water levels recovered to levels slightly above sea level. During periods of continuous pumping, such as fall/winter period 2021/2022, the water level declined to approximately 15 feet below msl.

As also shown on **Figure 3-32**, chloride concentrations at MW-1 have been steadily increasing throughout the limited period of record. The baseline chloride concentration in July 2019 in MW-1 (C Zone) was less than the recommended Secondary Maximum Contaminant Level (SMCL) of 250 mg/L at a level of 44 mg/L. Increasing chloride concentrations began to exceed the SMCL as early as December 2019 with the most recent concentration in February 2022 at 1,530 mg/L. Although the rate of increase does appear to moderate somewhat during periods of relatively higher water levels, such as winter/spring of 2021/2022, the overall increasing trend appears to be relatively insensitive to the approximate 10 to 15 feet of water level fluctuations observed to date at this well.

At MW-2 (**Figure 3-33**, B Zone) was also below the SMCL at a level of 24 mg/L with the initial water level in August 2019 well below sea level at an elevation of approximately -17.5 feet msl. The water levels at MW-2 appear to respond rapidly to Basin pumping. During periods of limited pumping, such as during the winter/spring of 2020/2021, water levels increased to levels just below sea level at elevations of approximately -3 to -5 feet msl. During periods of significant continuous pumping, such as the fall/winter of 2021/2022, water levels declined to levels greater than 30 feet below msl (as shown on **Figure 3-33**, the water levels during some of this period declined below the depth setting of the water-level transducer, which has recently been lowered). Interestingly, chloride concentrations have fluctuated significantly at this well, ranging between 44 and 577 mg/L, without an apparent correlation with either water level conditions or estimated pumping. Most recently, the chloride concentration was at the lowest recorded level of 44 mg/L in February 2022, well below the SMCL.

As shown on **Figure 3-34** (A Zone), the baseline chloride concentration in July 2019 was less than the SMCL of 250 mg/L, at a level of 22 mg/L, with the initial water level in August 2019 at an elevation of approximately -12.9 feet msl. Similar to MW-2, the water levels at MW-3 appear to respond rapidly to Basin pumping. During periods of limited pumping, such as the winter/spring of 2020/2021, water levels increased to elevations of approximately -4 to -5 feet msl. During periods of significant continuous pumping, such as the fall/winter of 2021/2022, water levels declined up to 17 feet below msl. Chloride concentrations at MW-3 have remained stable throughout the period record, fluctuating only between 21 and 24 mg/L, well below the SMCL of 250 mg/L.

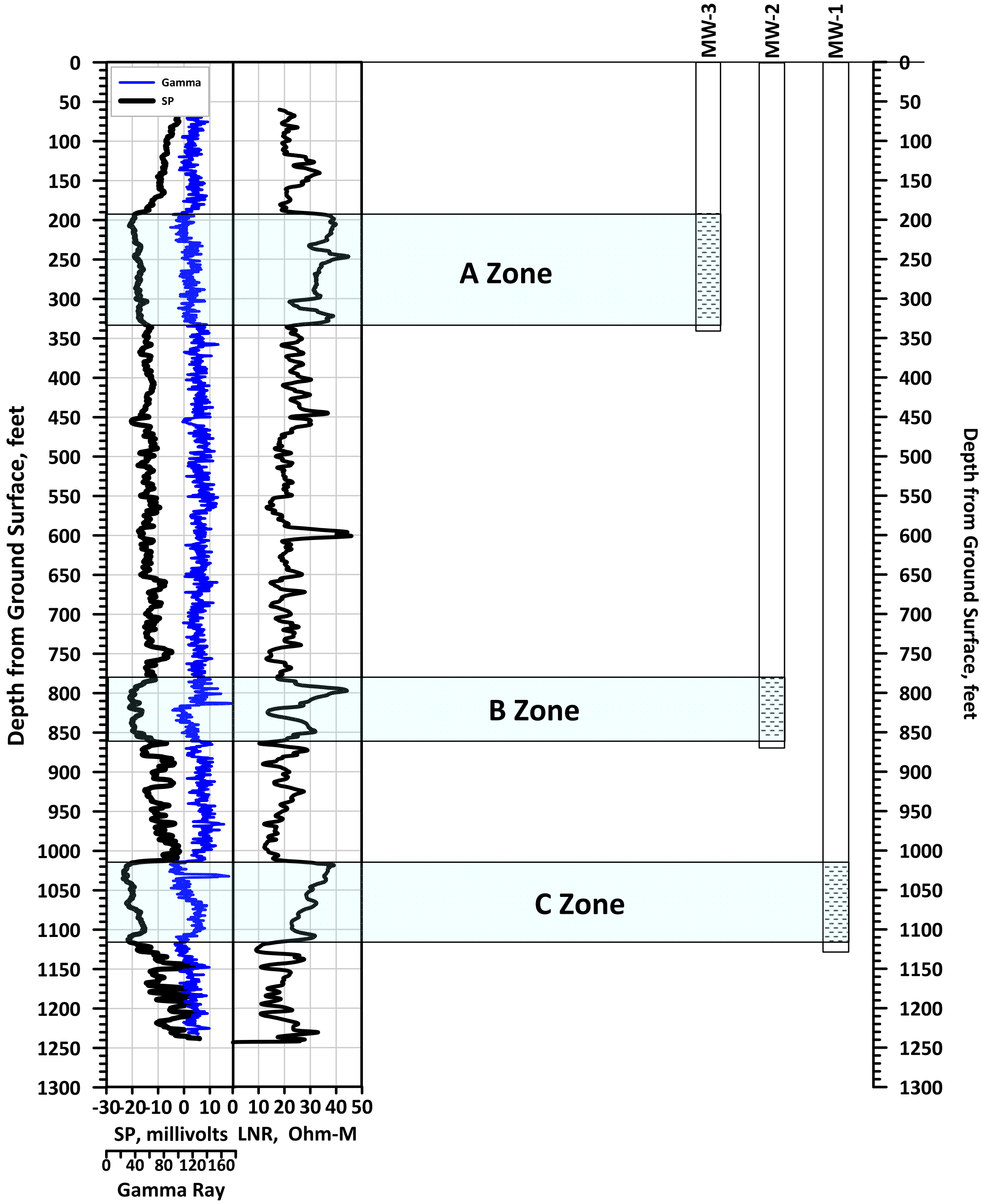


FIGURE 3-31

Sentinel Well Completions Schematic

Carpinteria Basin Groundwater Sustainability Plan

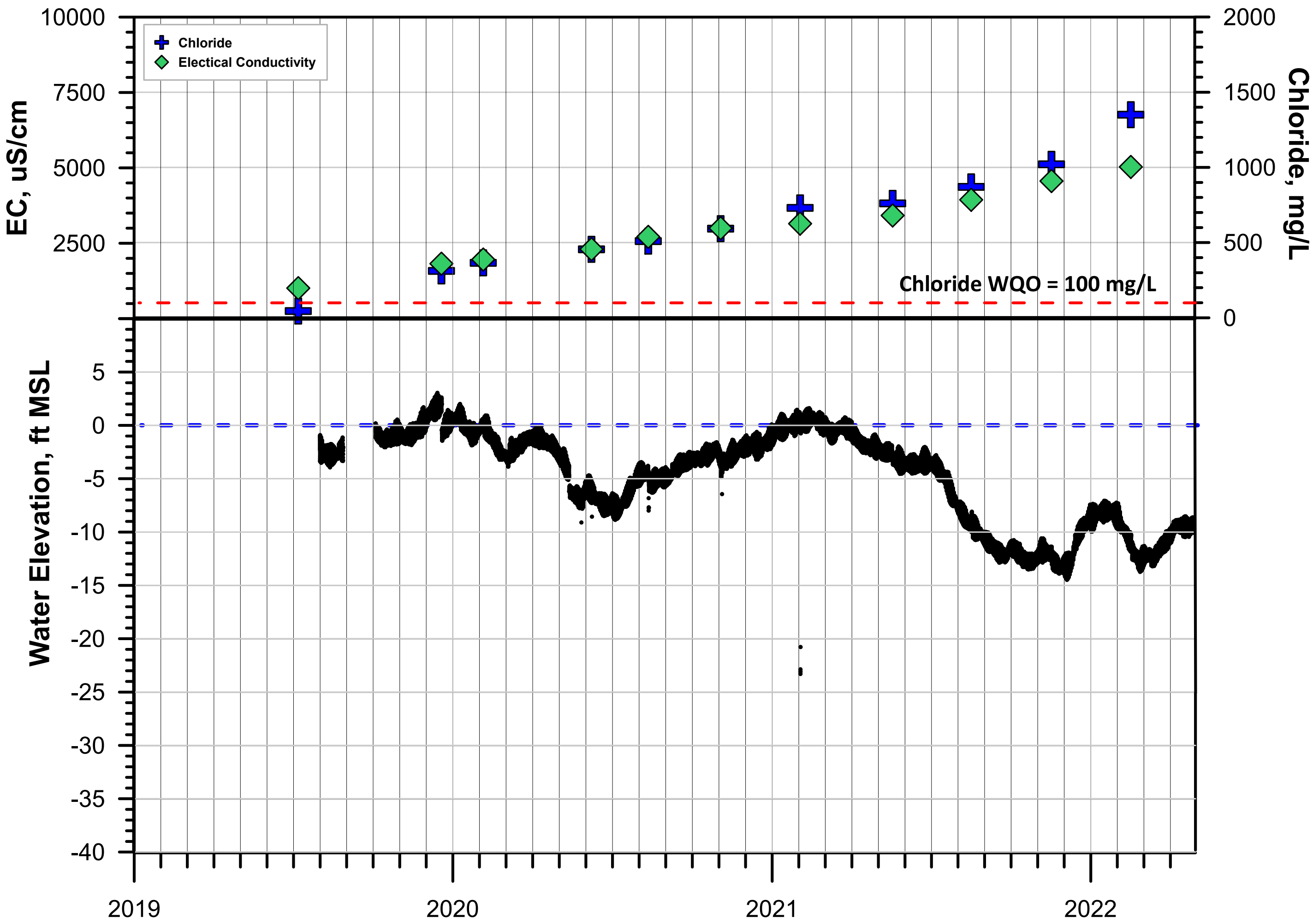


FIGURE 3-32

Sentinel Well Data – MW-1 (C Zone)

Carpinteria Basin Groundwater Sustainability Plan

CARPINTERIA GSA
GROUNDWATER SUSTAINABILITY AGENCY

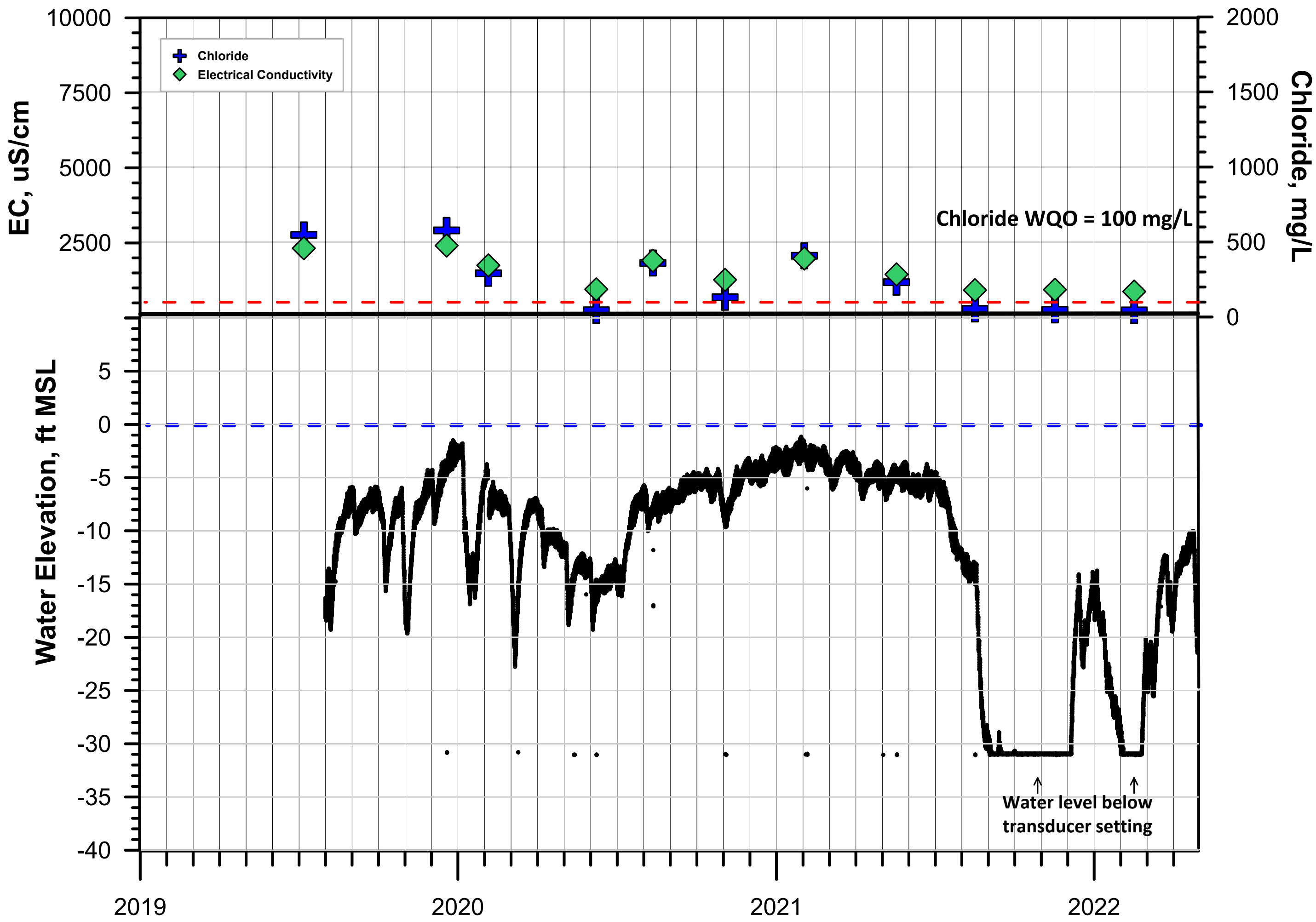


FIGURE 3-33

Sentinel Well Data – MW-2 (B Zone)

Carpinteria Basin Groundwater Sustainability Plan

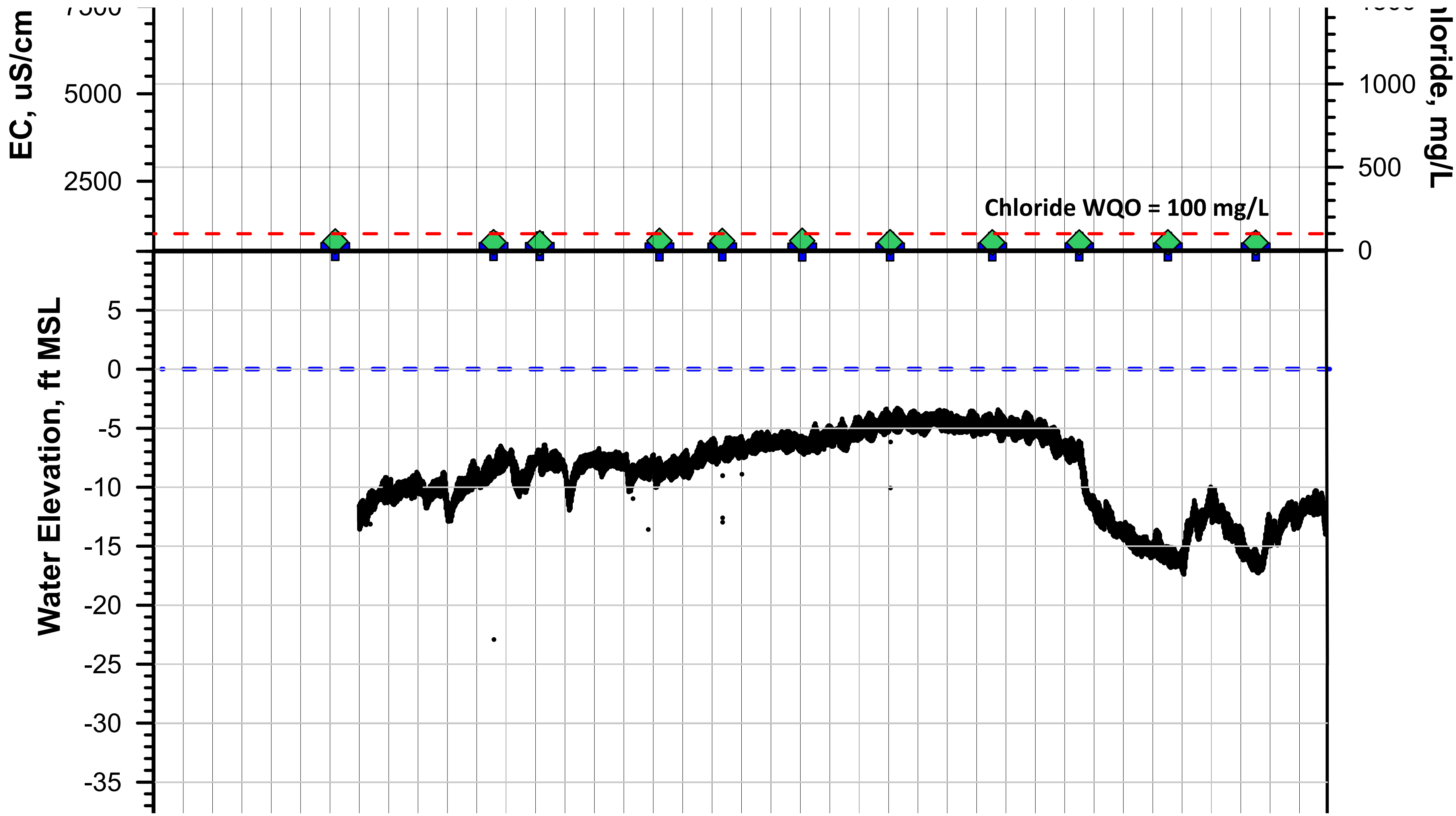


FIGURE 3-34

Sentinel Well Data – MW-3 (A Zone)

Carpinteria Basin Groundwater Sustainability Plan

In addition to the water-level and water-quality data discussed previously in this section, downhole induction logging is being performed at MW-1 on a quarterly basis. Induction logging measures the bulk electroconductivity of the aquifer materials and formation water within an approximate 6-foot diameter sphere of the tool. The tool is lowered down the well and captures the combined conductivity of the fluid and solids surrounding the casing for the length of the well. Its ability to capture changes in water quality is based on the fact that the solids (silt, sand and clay) that comprise the materials outside the casing have constant conductivities, whereas the conductivity of the pore fluid can change over time. If water of poorer or better quality replaces existing pore water in the formation, conductivities will increase or decrease, respectively, and the relative changes can be measured through induction logging. Sequential logging captures temporal conductivity changes in the aquifer system.

The results of the quarterly induction logging surveys performed at MW-1 are shown on Figure 3-35. A total of 10 surveys have been performed to date, with the baseline survey performed following well construction in August 2019 and the most recent performed in May 2022. As shown, there have been very limited changes occurring at this location in the A Zone. Some variations in the bulk conductivity have been occurring in B Zone, but the most recent log shows lower conductivity than was observed during several previous surveys and reverting close to baseline values.

In contrast to the observations in the A and B Zones, the induction surveys show consistent increases in bulk conductivity in the C Zone with every survey. The induction survey results are consistent with the water-quality sampling results discussed previously in this section. In particular both the induction surveys and water-quality sampling results display consistent increasing trends in conductivity and chloride concentrations in the C Zone, suggesting that seawater intrusion is likely occurring in this zone.

ERT Geophysical Surveys. In April 2021, electrical resistivity tomography (ERT) geophysical surveys were performed by BGC Engineering, Inc. (BGC) under contract with the CVWD for the purpose of mapping the presence (or absence) of seawater intrusion into the A, B, and C Zones. The ERT survey built upon the foundation of information acquired through the Sentinel Well project and was intended to provide three-dimensional characterization of basin stratigraphy and water quality conditions within the basin in the vicinity of the Sentinel Well site and the Carpinteria Salt Marsh (El Estero).

ERT is a geophysical technique for imaging the distribution of subsurface electrical resistivity in a cross-sectional format. Resistance data are collected through rolling linear arrays of electrodes, coupled to a DC resistivity transmitter and a receiver. Current is injected over specified time intervals between two electrodes. During each injection interval, voltages are measured between reception electrodes. The electrical resistivity of a given geological unit is related to the pore-fluid conductivity, clay content, liquid saturation, temperature, and matrix composition, and is used to map the extent of units with similar electrical properties when bounded by units with contrasting electrical properties. The final product of each line of survey is a 2-D cross-section plotting electrical resistivity versus depth. Raw geophysical and positional data is post-processed, and cross sections of the resistivity signatures along each survey line are generated.

Four ERT profiles were collected along lines shown on Figure 3-36. and the ERT profile results are shown on Figures 3-37 through 3-40. The full BGC report is presented in Appendix E, the details of which will not be repeated here. In summary, the suspected seawater intrusion into the C Zone based on the Sentinel Well data discussed previously in this section was not imaged in the ERT data. This has been attributed to an insufficient contrast in the electrical conductivities between the C Zone and the overlying confining layer, but could also be due to the C Zone being too deep, too thin, and/or at the limits of the ERT's spatial resolution. The ERT profile along the beach (see Figure 3-39) exhibited high electrical conductivities indicative of saltwater, including within the general depth range of the A Zone; however, there is no indication of seawater intrusion into the A or B Zones under the northern boundary of the saltmarsh in the ERT data (see Figure 3-38). BCG also interpreted that the A Zone may be thicker in places, as based on the ERT data, than what had been logged in the Sentinel Well boreholes.

Based on the results of the ERT survey, it was recommended that additional monitoring wells be installed to "ground-truth" ERT zones of interest, along with performing future ERT surveys to detect changes in these zones (i.e., time series of ERT surveys similar to the time-series of induction surveys at MW-1 discussed previously) would help to further refine the geophysical interpretation. Forward modelling in order to predict at what electrical conductivity the C Zone must reach to be resolvable by the ERT could help to determine the timing of future ERT surveys. In addition, extension of the beach ERT profile (see Figure 3-39) to the northwest, in addition to a parallel profile northwest-southeast through the saltmarsh, would further improve the overall understanding of conditions in this area of the basin.

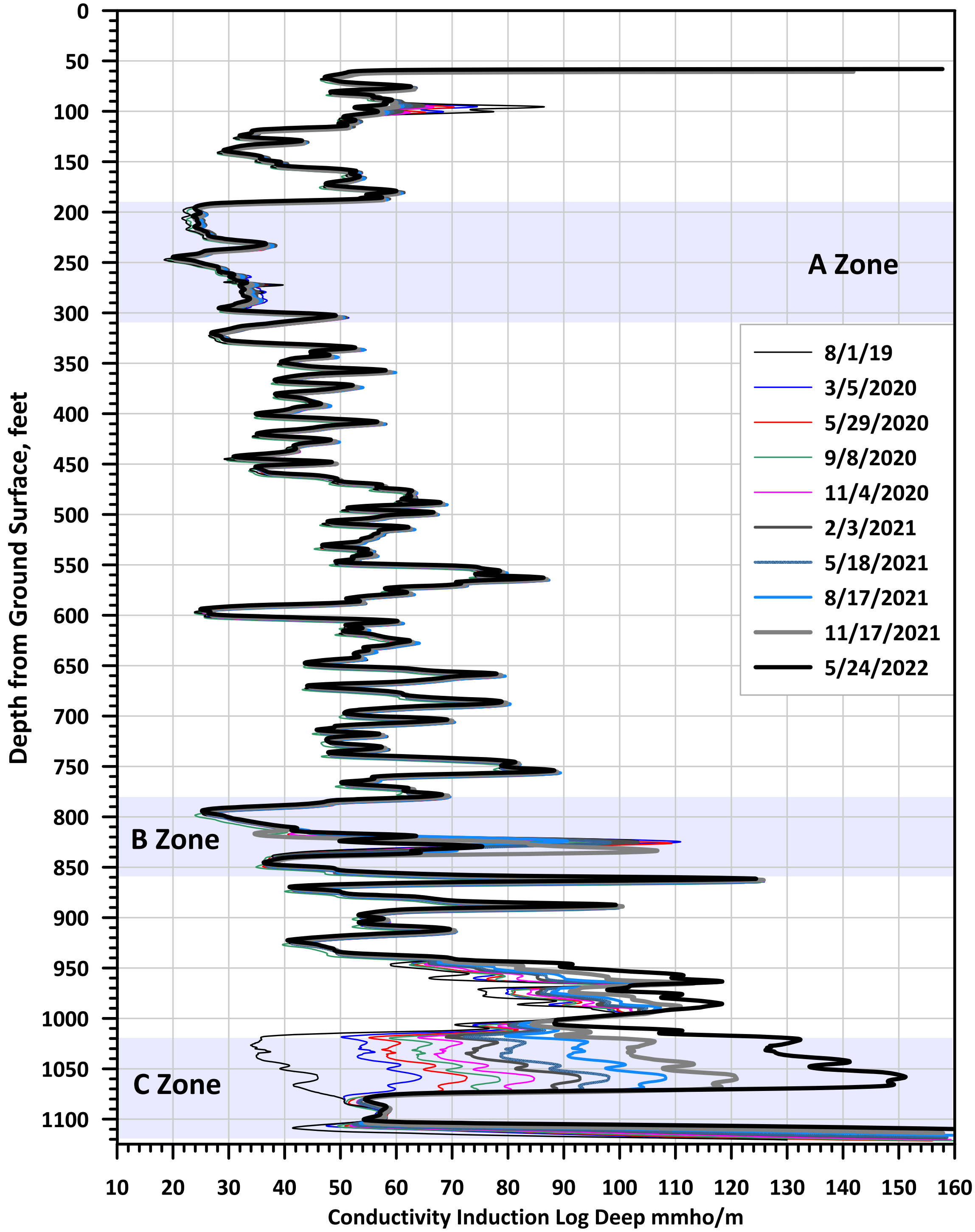
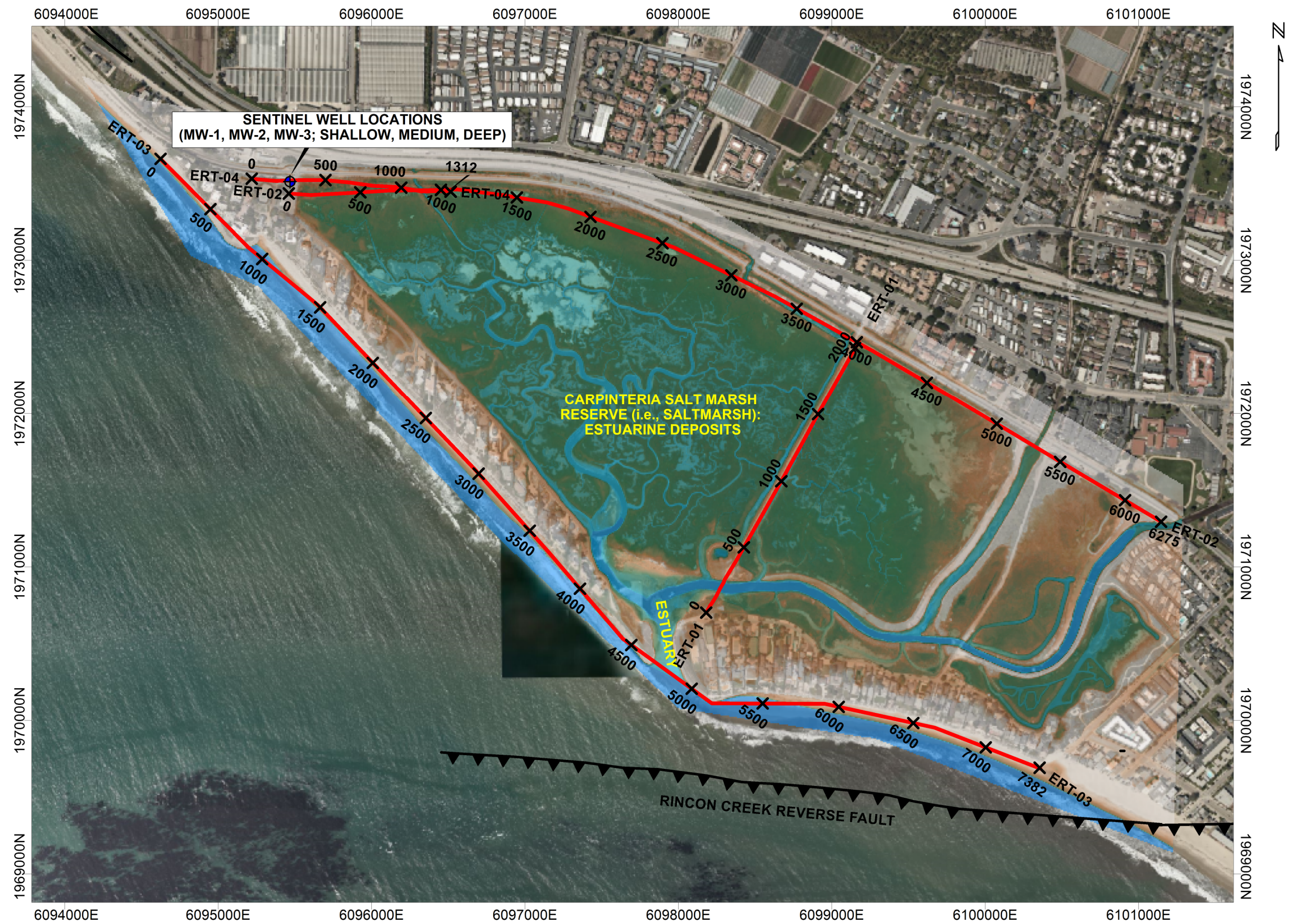


FIGURE 3-35

MW-1 Induction Surveys

Carpinteria Basin Groundwater Sustainability Plan

10-2021



100 0 100 200 300 400 500 600

(US SURVEY FEET)

1 2 3 4 5 6 7 8 9

DIGITAL ELEVATION MODEL (FEET)

LEGEND:

0 500 — ERT PROFILE LOCATION AND CHAINAGE (IN FEET)

SENTINEL WELLS: MW-1 (SHALLOW), MW-2 (MEDIUM), AND MW-3 (DEEP)

Notes:

1. This Figure should be read in conjunction with BGC's report titled "Electrical resistivity tomography (ERT) investigation to map saltwater intrusion in Carpinteria, California", and dated October, 2021.
2. The ERT surveys were collected as part of a saltwater intrusion study at Carpinteria, California between April 20 and 23, 2021.
3. ERT Field Parameters - Minimum Electrode Spacings: 22.5 m (73.8 feet) and 5 m (16.4 feet); Electrode Arrays: Gradient-Plus and Dipole-Dipole.
4. Coordinate system is NAD83 California State Plane Zone V (SPCS83; US Survey Feet). Vertical datum is CGVD2013.
5. Inset map imagery source: Bing Imagery (May 2018).
6. The Carpinteria Salt Marsh Reserve (i.e., saltmarsh) is comprised of an approximately 20 m (65.6 feet) thick estuarine deposit of locally organic-rich fine-grained materials and subordinate sand deposits (Minor et al., 2009).

PREPARED BY:	FIGURE TITLE:		
LGW	CARPINTERIA ERT SURVEY BASEMAP		
CHECKED BY:	CLIENT:		
AFM	CARPINTERIA VALLEY WATER DISTRICT (CVWD)		
APPROVED BY:	SCALE:	PROJECT NO:	FIGURE NO:
LGW	AS SHOWN	2252001	1

File Path: BGC Engineering Inc\Geophysics - Files\2.0_Current BGC Projects\2252001 - Carpinteria\3.0_Data_Processing\4.0_Oasis\Maps\2252001-Pueblo-Carpinteria_BaseMap-A.map

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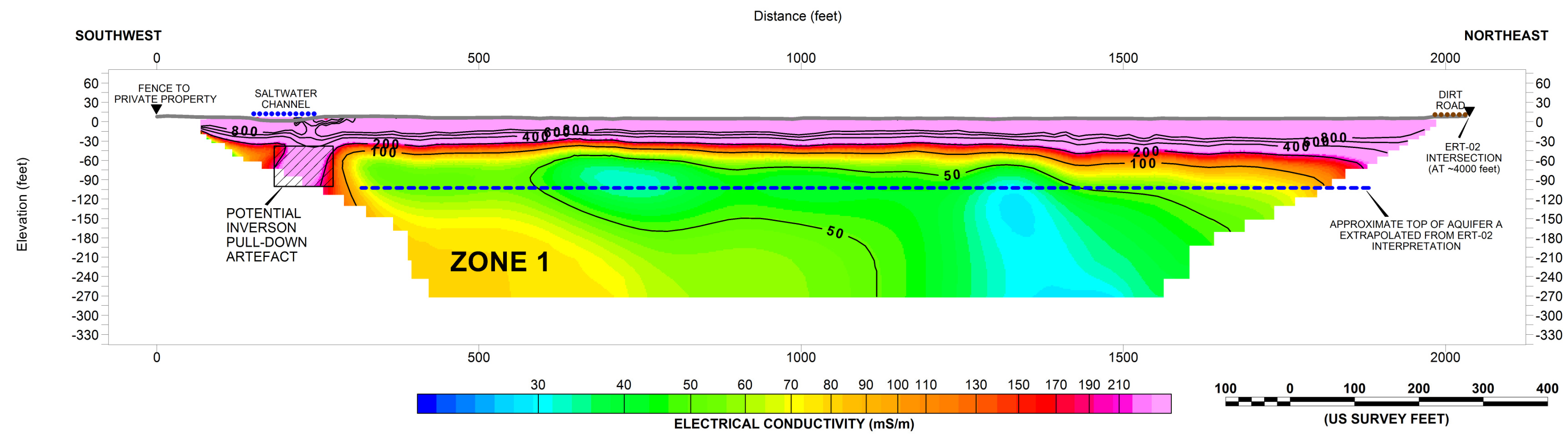
FIGURE 3-36

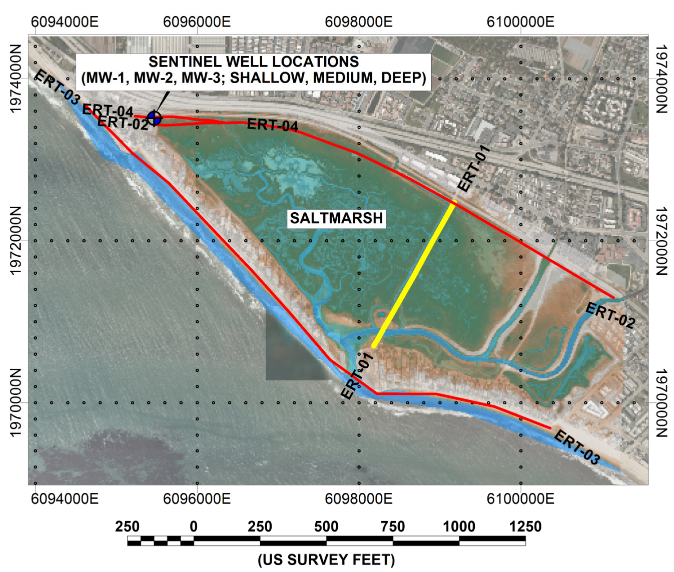
ERT Survey Line Location Map

Carpinteria Basin Groundwater Sustainability Plan

CARPINTERIA GSA
GROUNDWATER SUSTAINABILITY AGENCY

10-2021





Zone	Maximum Thickness (feet)	Interpretation
1	≥ 138	Possible saltwater intrusion into Aquifer A.

LEGEND:

CROSS-SECTION
- ELECTRICAL CONDUCTIVITY CONTOUR (mS/m)
- SENTINEL WELL LOCATION (PUEBLO WATER RESOURCES)
- NOTABLE WATER CROSSING (> 15 m)
- NOTABLE OBSERVED SURFACE FEATURE

INSET
- DISPLAYED 2021 ERT PROFILE LOCATION
- OTHER 2021 ERT PROFILE LOCATIONS
- SENTINEL WELL LOCATION (PUEBLO WATER RESOURCES)

Notes:
1. This Figure should be read in conjunction with BGC's report titled "Electrical resistivity tomography (ERT) investigation to map saltwater intrusion in Carpinteria, California", and dated October, 2021.
2. The ERT surveys were collected as part of a saltwater intrusion study at Carpinteria, California between April 20 and 23, 2021.
3. ERT-01 Field Parameters - Minimum Electrode Spacing 5 m (16.4 feet); Electrode Arrays: Gradient-Plus and Dipole-Dipole.
4. The ERT-01 section is modelled results of a combined array (i.e., gradient and dipole-dipole) inversion and is displayed as electrical conductivity (mS/m) on a log scale from 20 - 250 mS/m.
5. Coordinate system is NAD83 California State Plane Zone V (SPCS83; US Survey Feet). Vertical datum is CGVD2013.
6. Inset map imagery source: Bing Imagery (May 2018).

PREPARED BY:	FIGURE TITLE:		
LGW	CARPINTERIA SALTWATER INTRUSION: ERT-01		
CHECKED BY:	CLIENT:		
PDB	CARPINTERIA VALLEY WATER DISTRICT (CVWD)		
APPROVED BY:	SCALE:	PROJECT NO:	FIGURE NO:
LGW	AS SHOWN	2252001	2

File Path: BGC Engineering Inc\Geophysics - Files\2.0_Current BGC Projects\2252001 - Carpinteria\3.0_Data_Processing\4.0_Oasis\Maps\2252001-Pueblo-Carpinteria_ERT01-A.map

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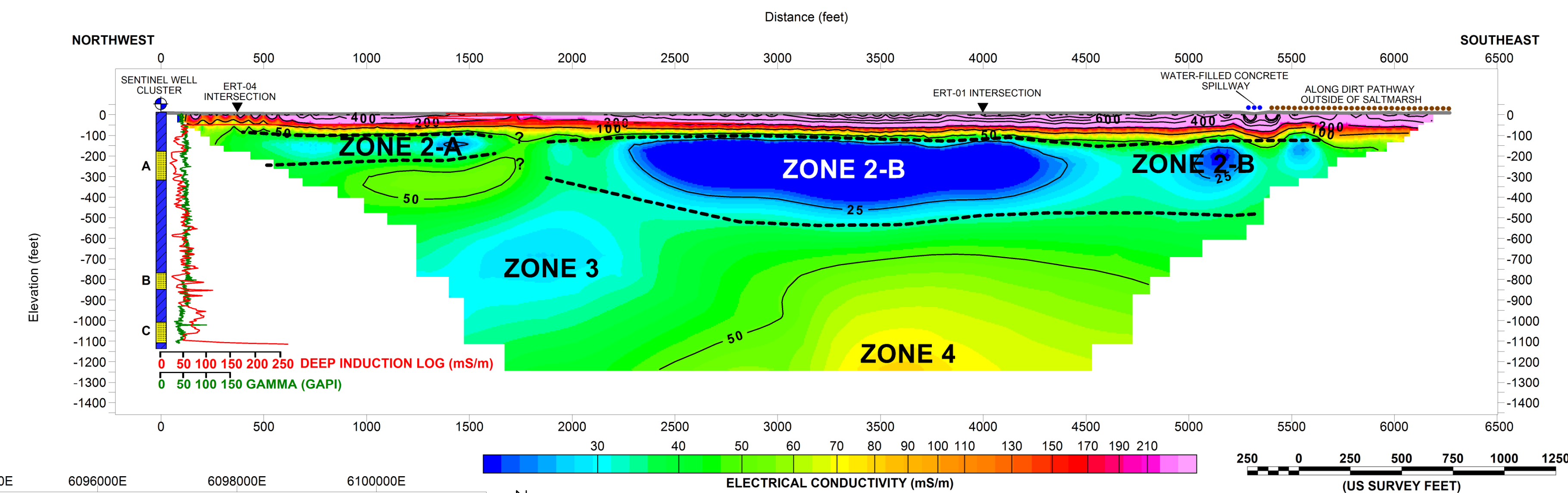
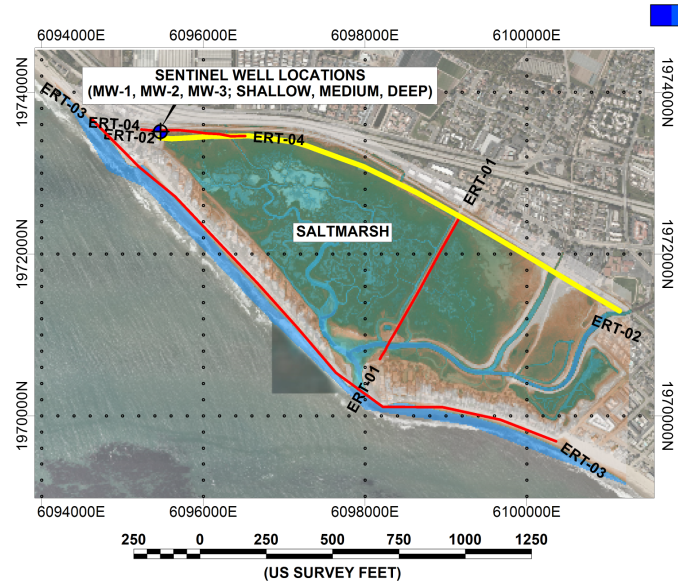
FIGURE 3-37

ERT Profile 01

Carpinteria Basin Groundwater Sustainability Plan

10-2021





Zone	Maximum Thickness (feet)	Interpretation
2-A	115	Aquifer A. No saltwater intrusion.
2-B	400	A thicker zone of Aquifer A. No saltwater intrusion.
3	400	Potential coarse-grained material (i.e., sands/gravels). Possibly Aquifer B.
4	≥ 250	At the bottom of the ERT section and the limits of the ERT profile's spatial resolution. Not considered to be notable or significant.

GENERAL HYDROSTRATIGRAPHIC UNITS:

- PREDOMINANTLY FINE-GRAINED CONFINING LAYERS
- AQUIFER UNITS (ZONE A, B, & C)

LEGEND:

CROSS-SECTION

- ELECTRICAL CONDUCTIVITY CONTOUR (mS/m)
- FEBRUARY 2021 DEEP CONDUCTIVITY LOG IN mS/m (PACIFIC SURVEYS)
- FEBRUARY 2021 GAMMA LOG IN GAPI (PACIFIC SURVEYS)
- SENTINEL WELL LOCATION (PUEBLO WATER RESOURCES)
- INTERPRETED AQUIFER A BOUNDS
- NOTABLE WATER CROSSING (> 15 m)
- NOTABLE OBSERVED SURFACE FEATURE

INSET

- DISPLAYED 2021 ERT PROFILE LOCATION
- OTHER 2021 ERT PROFILE LOCATIONS
- SENTINEL WELL LOCATION (PUEBLO WATER RESOURCES)

Notes:

1. This Figure should be read in conjunction with BGC's report titled "Electrical resistivity tomography (ERT) investigation to map saltwater intrusion in Carpinteria, California", and dated October, 2021.
2. The ERT surveys were collected as part of a saltwater intrusion study at Carpinteria, California between April 20 and 23, 2021.
3. ERT-02 Field Parameters - Minimum Electrode Spacing 22.5 m (73.8 feet); Electrode Arrays: Gradient-Plus and Dipole-Dipole.
4. The ERT-02 section is modelled results of a combined array (i.e., gradient and dipole-dipole) inversion and is displayed as electrical conductivity (mS/m) on a log scale from 20 - 250 mS/m.
5. Coordinate system is NAD83 California State Plane Zone V (SPCS83; US Survey Feet). Vertical datum is CGVD2013.
6. Inset map imagery source: Bing Imagery (May 2018).

PREPARED BY:	FIGURE TITLE:		
LGW	CARPINTERIA SALTWATER INTRUSION: ERT-02		
CHECKED BY:	CLIENT:		
PDB	CARPINTERIA VALLEY WATER DISTRICT (CVWD)		
APPROVED BY:	SCALE:	PROJECT NO:	FIGURE NO:
LGW	AS SHOWN	2252001	3

File Path: BGC Engineering Inc\Geophysics - Files\2.0_Current BGC Projects\2252001 - Carpinteria\3.0_Data Processing\4.0_Oasis\Maps\2252001-Pueblo-Carpinteria_ERT02-A.map

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FIGURE 3-38

ERT Profile 02

Carpinteria Basin Groundwater Sustainability Plan

CARPINTERIA GSA
GROUNDWATER SUSTAINABILITY AGENCY

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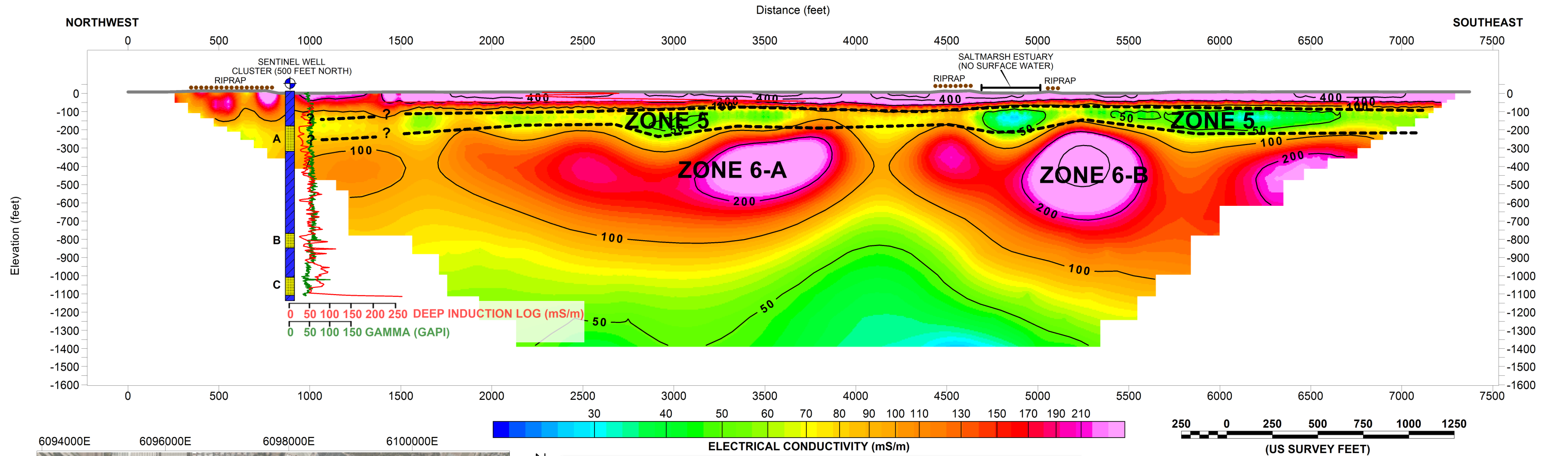

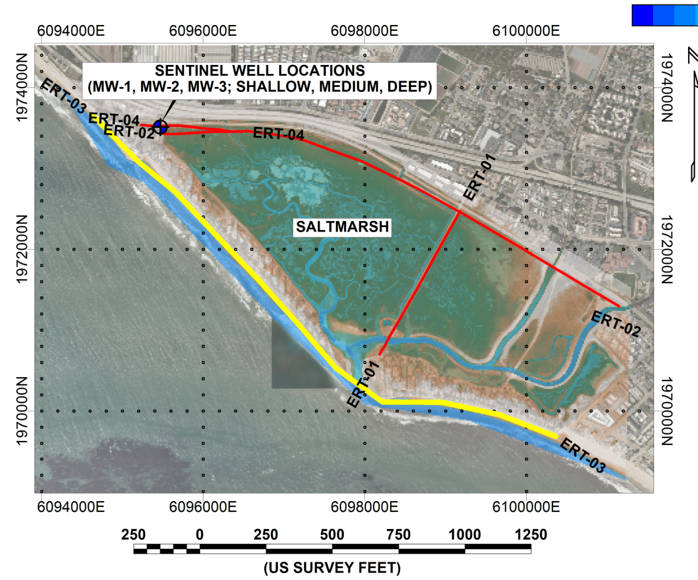

Zone	Maximum Thickness (feet)	Interpretation
5	130	Aquifer A. Zones of possible saltwater intrusion (i.e., electrical conductivities exceeding 70 mS/m).
6-A	600	1. Possible saltwater intrusion into the thickest portion of Aquifer A (as interpreted from ERT-02; Zone 2-B). 2. Possible saltwater-saturated fine-grained materials (i.e., clays) and relatively thin coarse-grained deposits (e.g., sand lenses and stringers) associated with confining layer between Aquifer A and B.
6-B	600	1. Possible saltwater intrusion into the thickest portion of Aquifer A (as interpreted from ERT-02; Zone 2-B). 2. Possible saltwater-saturated fine-grained materials (i.e., clays) and relatively thin coarse-grained deposits (e.g., sand lenses and stringers) associated with confining layer between Aquifer A and B.

GENERAL HYDROSTRATIGRAPHIC UNITS:
- PREDOMINANTLY FINE-GRAINED CONFINING LAYERS
- AQUIFER UNITS (ZONE A, B, & C)

LEGEND:

CROSS-SECTION
- ELECTRICAL CONDUCTIVITY CONTOUR (mS/m)
- FEBRUARY 2021 DEEP CONDUCTIVITY LOG IN mS/m (PACIFIC SURVEYS)
- FEBRUARY 2021 GAMMA LOG IN GAPI (PACIFIC SURVEYS)
- SENTINEL WELL LOCATION (PUEBLO WATER RESOURCES)
- INTERPRETED AQUIFER A BOUNDS
- NOTABLE WATER CROSSING (> 15 m)
- NOTABLE OBSERVED SURFACE FEATURE

INSET
- DISPLAYED 2021 ERT PROFILE LOCATION
- OTHER 2021 ERT PROFILE LOCATIONS
- SENTINEL WELL LOCATION (PUEBLO WATER RESOURCES)

Notes:
1. This Figure should be read in conjunction with BGC's report titled "Electrical resistivity tomography (ERT) investigation to map saltwater intrusion in Carpinteria, California", and dated October, 2021.
2. The ERT surveys were collected as part of a saltwater intrusion study at Carpinteria, California between April 20 and 23, 2021.
3. ERT-03 Field Parameters - Minimum Electrode Spacing 22.5 m (73.8 feet); Electrode Arrays: Gradient-Plus and Dipole-Dipole.
4. The ERT-01 section is modelled results of a combined array (i.e., gradient and dipole-dipole) inversion and is displayed as electrical conductivity (mS/m) on a log scale from 20 - 250 mS/m.
5. Coordinate system is NAD83 California State Plane Zone V (SPCS83; US Survey Feet). Vertical datum is CGVD2013.
6. Inset map imagery source: Bing Imagery (May 2018).

PREPARED BY:	FIGURE TITLE:		
LGW	CARPINTERIA SALTWATER INTRUSION: ERT-03		
CHECKED BY:	CLIENT:		
PDB	CARPINTERIA VALLEY WATER DISTRICT (CVWD)		
APPROVED BY:	SCALE:	PROJECT NO:	FIGURE NO:
LGW	AS SHOWN	2252001	4

File Path: BGC Engineering Inc\Geophysics - Files\2.0_Current BGC Projects\2252001 - Carpinteria\3.0_Data Processing\4.0_Oasis\Maps\2252001-Pueblo-Carpinteria_ERT03-4.map

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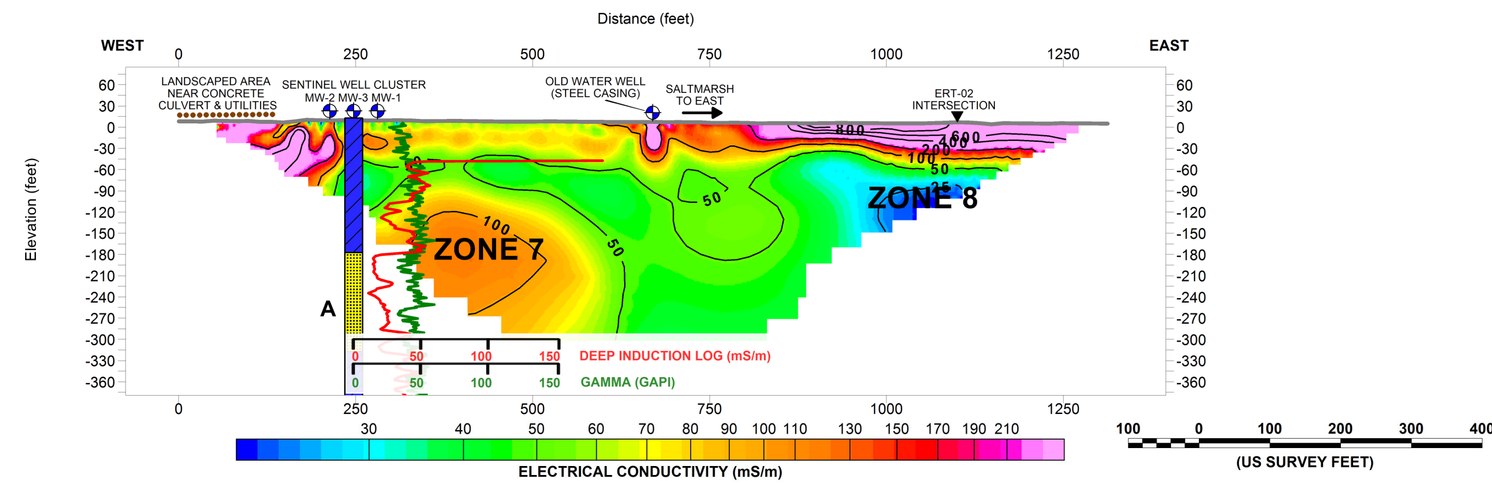
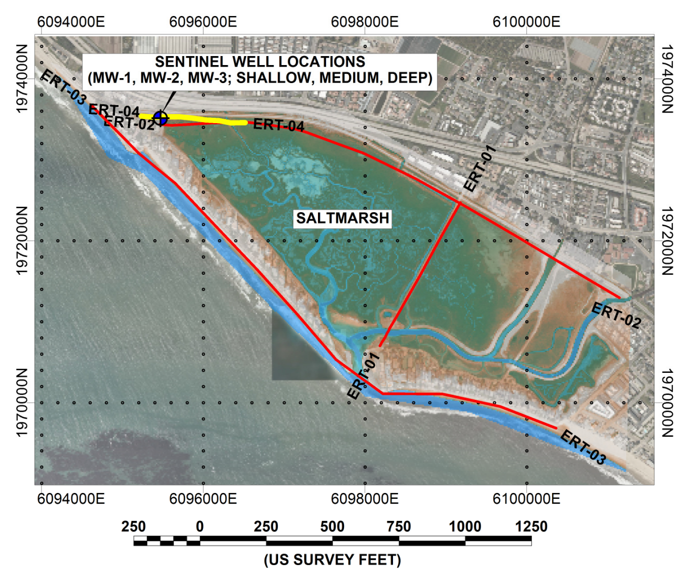
FIGURE 3-39

ERT Profile 03

Carpinteria Basin Groundwater Sustainability Plan

10-2021





Zone	Maximum Thickness (feet)	Interpretation
7	30?	Likely artificially thickened (the true thickness is unknown). The deep induction log indicates that Zone 7 could be approximately 30 feet thick and associated with a more clay-rich lithology within the confining layer overlying Aquifer A. No saltwater intrusion.
8	≥ 60	Likely associated with Zone 2-A on ERT-02, and therefore Aquifer A. No saltwater intrusion.

GENERAL HYDROSTRATIGRAPHIC UNITS:
- PREDOMINANTLY FINE-GRAINED CONFINING LAYERS
- AQUIFER UNITS (ZONE A, B, & C)

LEGEND:
CROSS-SECTION
- ELECTRICAL CONDUCTIVITY CONTOUR (mS/m)
- FEBRUARY 2021 DEEP CONDUCTIVITY LOG IN mS/m (PACIFIC SURVEYS)
- FEBRUARY 2021 GAMMA LOG IN GAPI (PACIFIC SURVEYS)
- SENTINEL WELL LOCATION (PUEBLO WATER RESOURCES)
- INTERPRETED AQUIFER A BOUNDS
- NOTABLE WATER CROSSING (> 15 m)
- NOTABLE OBSERVED SURFACE FEATURE

INSET
- DISPLAYED 2021 ERT PROFILE LOCATION
- OTHER 2021 ERT PROFILE LOCATIONS
- SENTINEL WELL LOCATION (PUEBLO WATER RESOURCES)

Notes:
1. This Figure should be read in conjunction with BGC's report titled "Electrical resistivity tomography (ERT) investigation to map saltwater intrusion in Carpinteria, California", and dated October, 2021.
2. The ERT surveys were collected as part of a saltwater intrusion study at Carpinteria, California between April 20 and 23, 2021.
3. ERT-04 Field Parameters - Minimum Electrode Spacing 5 m (16.4 feet); Electrode Arrays: Gradient-Plus and Dipole-Dipole.
4. The ERT-01 section is modelled results of a combined array (i.e., gradient and dipole-dipole) inversion and is displayed as electrical conductivity (mS/m) on a log scale from 20 - 250 mS/m.
5. Coordinate system is NAD83 California State Plane Zone V (SPCS83; US Survey Feet). Vertical datum is CGVD2013.
6. Inset map imagery source: Bing Imagery (May 2018).

PREPARED BY:	FIGURE TITLE:		
LGW	CARPINTERIA SALTWATER INTRUSION: ERT-04		
CHECKED BY:	CLIENT:		
PDB	CARPINTERIA VALLEY WATER DISTRICT (CVWD)		
APPROVED BY:	SCALE:	PROJECT NO:	FIGURE NO:
LGW	AS SHOWN	2252001	5

File Path: BGC Engineering Inc\Geophysics - Files\2.0_Current BGC Projects\2252001 - Carpinteria\3.0_Data_Processing\4.0_Oasis\Maps\2252001-Pueblo-Carpinteria_ERT04-A.map

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FIGURE 3-40
ERT Profile 04
Carpinteria Basin Groundwater Sustainability Plan

3.2.4 Groundwater Quality Distribution and Trends [§354.16(d)]

§354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes

An inventory of known contamination sites in the basin in 2022 was developed by searching the GeoTracker database maintained by the SWRCB. GeoTracker is a data management system for managing sites that impact groundwater in the State. The database contains information on leaking underground storage tanks (LUSTs), spills-leaks-investigations-cleanups (SLICs), landfills, military and other cleanup sites. The locations of the known contaminated sites and their current status is shown in **Figure 3-41**.

As shown, a total of 43 site have been identified in the basin. Of these, 38 have had their cases closed without land use restrictions and an additional 3 are closed cases with land use restrictions, which no longer pose a threat to aquifers used for drinking water supply. There are only 2 open sites, both of which are located on Carpinteria Avenue within the Confined Area. One is in the assessment stage (4819 Carpinteria Ave.) and the other is being actively remediated (5661-5675 Carpinteria Ave.); however, as discussed previously, in the Confined Area downward percolation of water is limited due to the presence of fine-grained low-permeability materials overlying the principal aquifer system; therefore, it is unlikely that contaminates associated with these sites would migrate vertically into the deep aquifer system.

3.2.5 Land Subsidence [§354.16(e)]

§354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(e) The extent, cumulative total, and annual rate of land subsidence, including maps depicting total subsidence, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

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

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

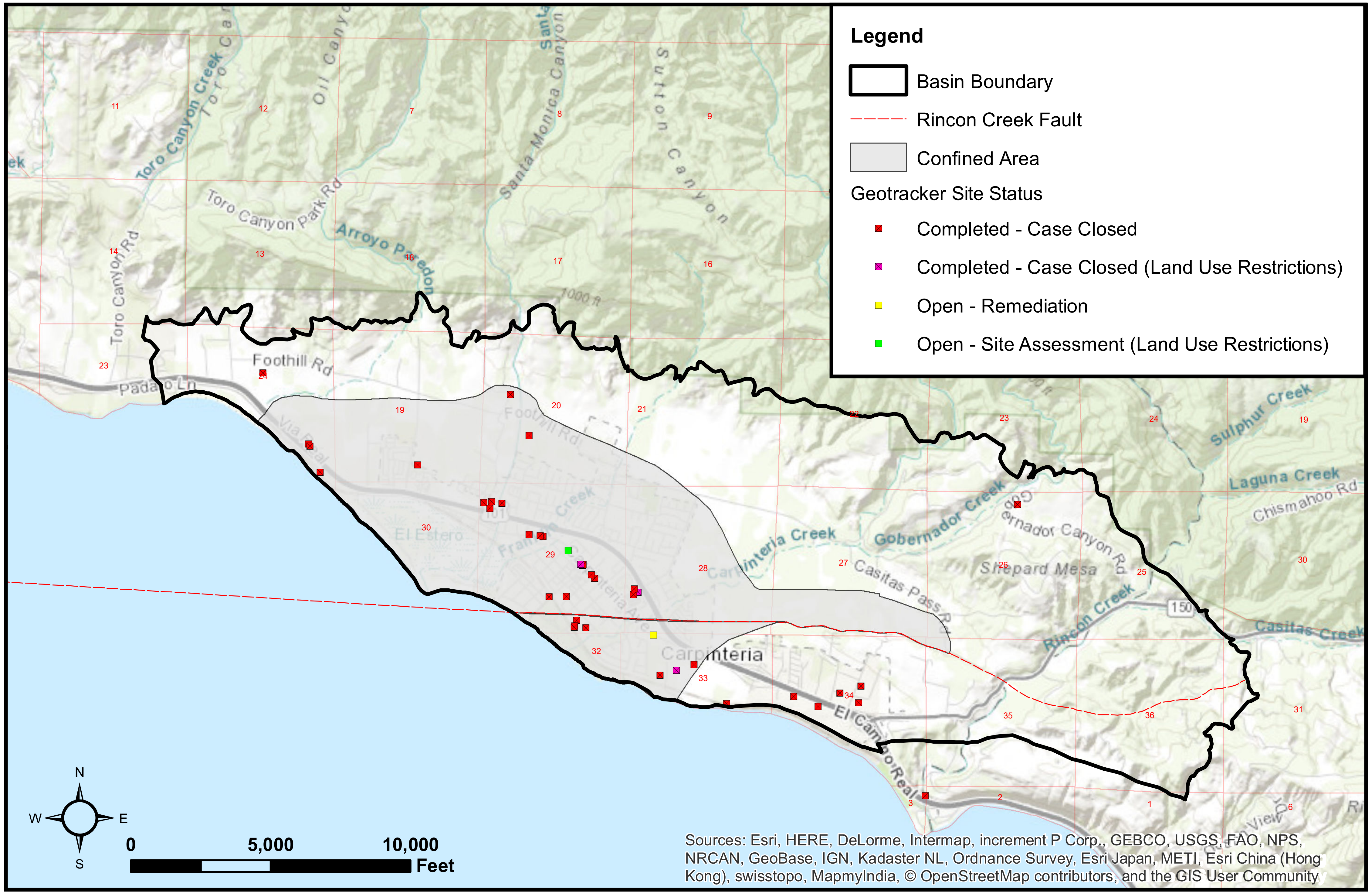

FIGURE 3-41

Known Contamination Sites Map

Carpinteria Basin Groundwater Sustainability Plan

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None of these conditions are known to be present in the basin and there is no known or anecdotal evidence of subsidence related to groundwater extraction in the basin. As discussed previously, there have been periods of historical water levels declines in the basin during the 1950s, the late 1980s/early 1990s, and the current period of the mid-to-late 2010s/early 2020s associated with prolonged droughts when water level declines on the order of 100 to 150 feet have occurred in some places in the basin. Even during these periods of significant groundwater level declines, no subsidence has been documented in the basin.

The DWR provides subsidence related data to support the development of GSPs from their "SGMA Data Viewer" (DWR, 2020b). These data include ground surface elevation estimates derived from Interferometric Synthetic Aperture Radar (InSAR) data provided by DWR are shown on Figure 3-42. These InSAR data are derived from satellite imagery to generate vertical deformation time series data, calibrated using data from ground-based, continuously operating Global Navigation Satellite System (GNSS) stations located throughout the state of California. Presented on Figure 3-42 is total vertical displacement as of July 1, 2022, relative to June 13, 2015, which is the period of record for the data provided by DWR.

The accuracy of the InSAR data is presented in a report (Towill, 2020), which states that "InSAR data accurately models change in ground elevation to an accuracy tested to be 16 millimeters (mm) at 95% confidence." The measurement accuracy when converting from the raw InSAR data to the maps provided by DWR is 0.048 feet with 95% confidence level. Therefore, the total estimated error is 0.1 ft.

As shown on Figure 3-42, the total vertical displacement during this period in ranges between approximately -0.129 and 0.0034 feet. Areas falling within the reported accuracy are shown in gray on Figure 3-42. Areas depicted in color indicate measurable subsidence above the accuracy tolerance. As shown, the highest total displacement occurs in the central portion of the Basin, immediately east of the City of Carpinteria. This area is not covered by InSAR data.

InSAR results do not differentiate between subsidence caused by groundwater withdrawal and other potential causes, such as tectonic activity. The Basin is located in an area characterized by high tectonic activity.

This lack of evidence of subsidence linked to substantial groundwater level declines indicates the inapplicability of the subsidence sustainability indicator in the basin.

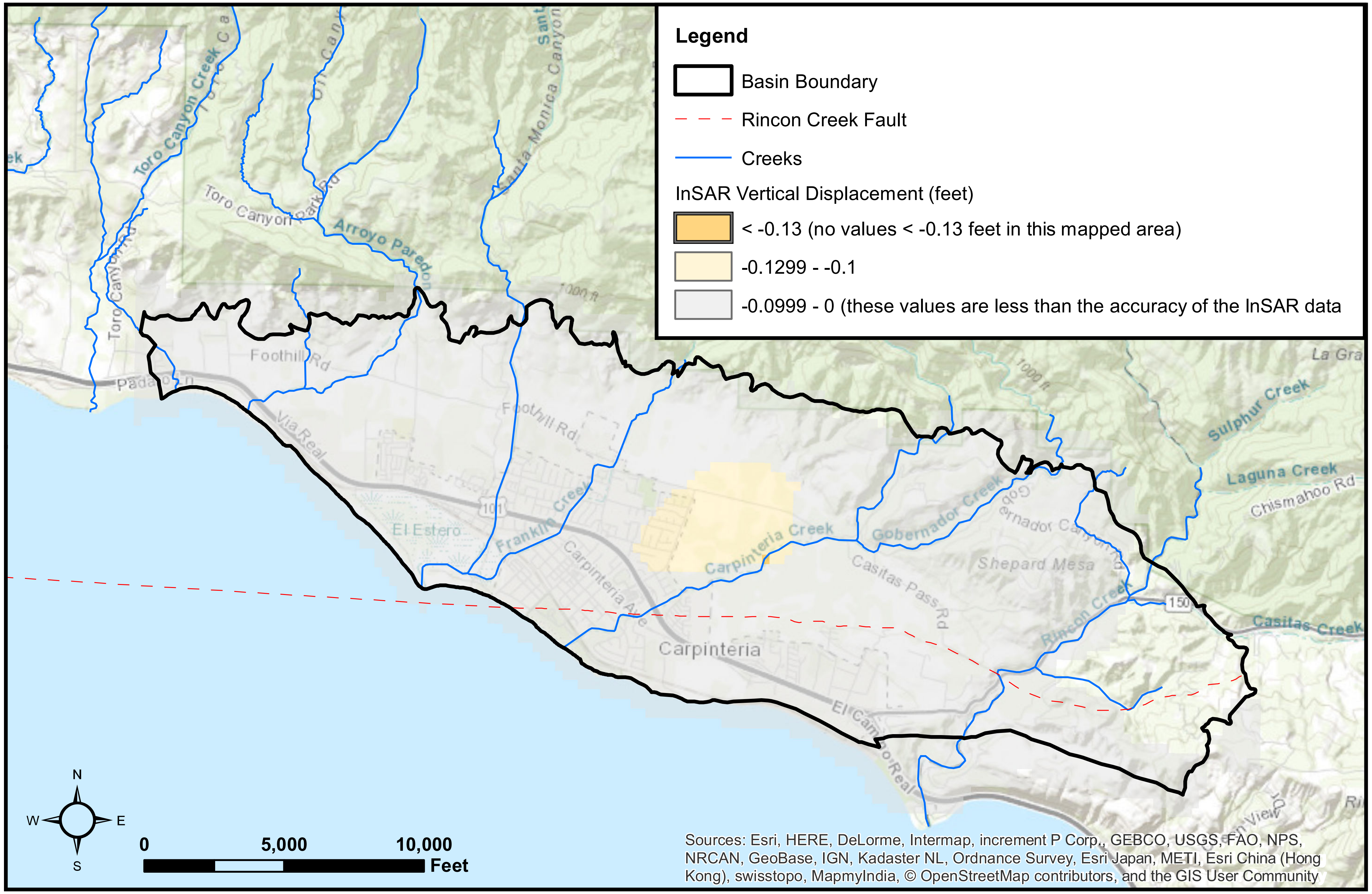

FIGURE 3-42

InSAR Vertical Displacement Map (6/13/15 – 7/1/22)

Carpinteria Basin Groundwater Sustainability Plan

3.2.6 Interconnected Surface Water Systems [§354.16(f)]

§354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(f) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

The potential interactions between surface water bodies (such as creeks) and groundwater in a basin can take place in three basic ways:

1. A gaining stream or creek that receives water from groundwater,
2. A losing stream or creek that recharges basin aquifers from surface water, or
3. A stream or creek that may be separated from groundwater by a hydrologic formation, such as a low-permeability aquitard that prevents interaction between surface water and groundwater completely.

As discussed previously, in the Confined Area of the basin is defined by the presence of fine-grained low-permeability materials overlying the principal aquifer; therefore, the third situation described above applies to the reaches of basin creeks in this area of the basin.

In the Recharge Area, for groundwater to discharge into a Basin creek (i.e., a gaining creek), the elevation of the water table in the vicinity of the creek must be higher than the elevation of the surface-water body surface. Conversely, for surface water to seep into groundwater (i.e., a losing creek), the elevation of the water table in the vicinity of the creek must be lower than the elevation of the surface-water body surface. Based on previous investigations in the basin, the current understanding of the basin HCM is that in the Recharge Area, basin creeks are all losing creeks and represent principal sources of recharge to the basin (discussed in the Water Budget section).

To corroborate this understanding, depth-to-water was calculated for the spring water levels for three different water year types in the recent past:

- WY 2005 – Wet water year type
- WY 2010 – Normal water year type
- WY 2015 – Critically Dry water year type

Groundwater elevations were contoured for each of these periods and these groundwater elevation surfaces subtracted from the Digital Elevation Model (DEM) of ground surface elevations to estimate depth-to-water contours in SU-1 (as discussed previously, available water-level data for SU-2 are limited and contours for this unit are not presented). This approach provides accurate contours of depth-to-water along the creeks. The depth-to-water contours for each of the above periods are shown in **Figures 3-43 through 3-45**.

The areas where the depth-to-water is less than 0 feet below ground surface are highlighted in a light blue color on the figures to indicate those areas where the aquifer water-level elevations are higher than the creek bottom elevations, indicating artesian conditions (note this condition only exists in the WY 2005 map). As shown, the water table elevations are below the creek bottom elevations at all locations in the Recharge Area during all three water year type conditions. The only areas where the water level elevations are higher than the creek bottom elevations are along Santa Monica and Franklin Creeks within the Confined Area, and this only occurred during the spring of wet water year of 2005 (see **Figure 3-43**). It is also noted that both of the creeks are concrete lined in the basin.

Based on the foregoing, it is concluded that there are no interconnected surface water systems in the basin.

3.2.7 Groundwater Dependent Ecosystems [§354.16(g)]

§354.16 Groundwater Conditions. Each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes the following:

(g) Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.

GSP Emergency Regulations require the identification of groundwater dependent ecosystems (GDEs) that could be adversely affected by lowered groundwater levels in principal aquifer.

As a starting point, the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) GIS shapefiles were downloaded from DWR and mapped in the basin to identify potential GFEs. The NC Dataset covering the Basin consists of both vegetation and wetlands areas, the locations of which are shown on **Figures 3-46 and 3-47**, respectively, with each potential GDE area consisting of a mapped polygon with an associated Polygon ID number, which are summarized in **Table 3-2**.

Table 3-2. NC Dataset Potential GDEs Summary

NC Dataset Polygon ID	Coverage Type	Description	T/R Section	Nearest Creek
51879	Vegetation	Coast Live Oak	19	Arroyo Paredon
52597	Vegetation	Riparian Mixed Hardwood	19	Arroyo Paredon
52596	Vegetation	Riparian Mixed Hardwood	24	Arroyo Paredon
51872	Vegetation	Coast Live Oak	20	Santa Monica
51866	Vegetation	Coast Live Oak	21	Franklin
48436	Vegetation	Coast Live Oak	22	Carpinteria
49435	Vegetation	Coast Live Oak	27	Carpinteria
42300	Vegetation	Riparian Mixed Hardwood	28	Carpinteria
52294	Vegetation	Riparian Mixed Hardwood	28	Carpinteria
52295	Vegetation	Riparian Mixed Hardwood	32	Carpinteria
48540	Vegetation	Coast Live Oak	23	Gobernador
48537	Vegetation	Coast Live Oak	26	Unnamed Tributary
51854	Vegetation	Coast Live Oak	25	Unnamed Tributary
52200	Vegetation	Riparian Mixed Hardwood	25	Unnamed Tributary
51848	Vegetation	Coast Live Oak	25	Casitas
49340	Vegetation	Coast Live Oak	25	Casitas
49326	Vegetation	Coast Live Oak	35	Rincon
49319	Vegetation	Coast Live Oak	35	Rincon
49318	Vegetation	Coast Live Oak	36	Unnamed Tributary
51844	Vegetation	Coast Live Oak	36	Unnamed Tributary
94554	Wetlands	Palustrine, Forested, Seasonally Flooded	23	Toro
94526	Wetlands	Palustrine, Forested, Seasonally Flooded	23	Toro
94525	Wetlands	Palustrine, Forested, Seasonally Flooded	19	Arroyo Paredon
94530	Wetlands	Palustrine, Forested, Seasonally Flooded	24	Arroyo Paredon
102946	Wetlands	Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded	19, 24	Arroyo Paredon
94533	Wetlands	Palustrine, Forested, Seasonally Flooded	19	Arroyo Paredon
200640	Wetlands	Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded	18	Arroyo Paredon
94531	Wetlands	Palustrine, Forested, Seasonally Flooded	19	NA
201660	Wetlands	Palustrine, Forested, Seasonally Flooded	20	NA
94527	Wetlands	Palustrine, Forested, Seasonally Flooded	20	NA
92340	Wetlands	Palustrine, Emergent, Persistent, Seasonally Flooded - Fresh Tidal	29	Franklin (El Estero)
102679	Wetlands	Riverine, Unknown Perennial, Unconsolidated Bottom, Semipermanently Flooded	30	Santa Monica (El Estero)
91225	Wetlands	Palustrine, Emergent, Persistent, Seasonally Flooded	22, 27	NA
93680	Wetlands	Palustrine, Forested, Seasonally Flooded	23	Gobernador
93681	Wetlands	Palustrine, Forested, Seasonally Flooded	23	Gobernador
102073	Wetlands	Riverine, Unknown Perennial, Unconsolidated Bottom, Semipermanently Flooded	23	Gobernador
93679	Wetlands	Palustrine, Forested, Seasonally Flooded	25	Rincon
95850	Wetlands	Palustrine, Scrub-Shrub, Seasonally Flooded	25	Rincon

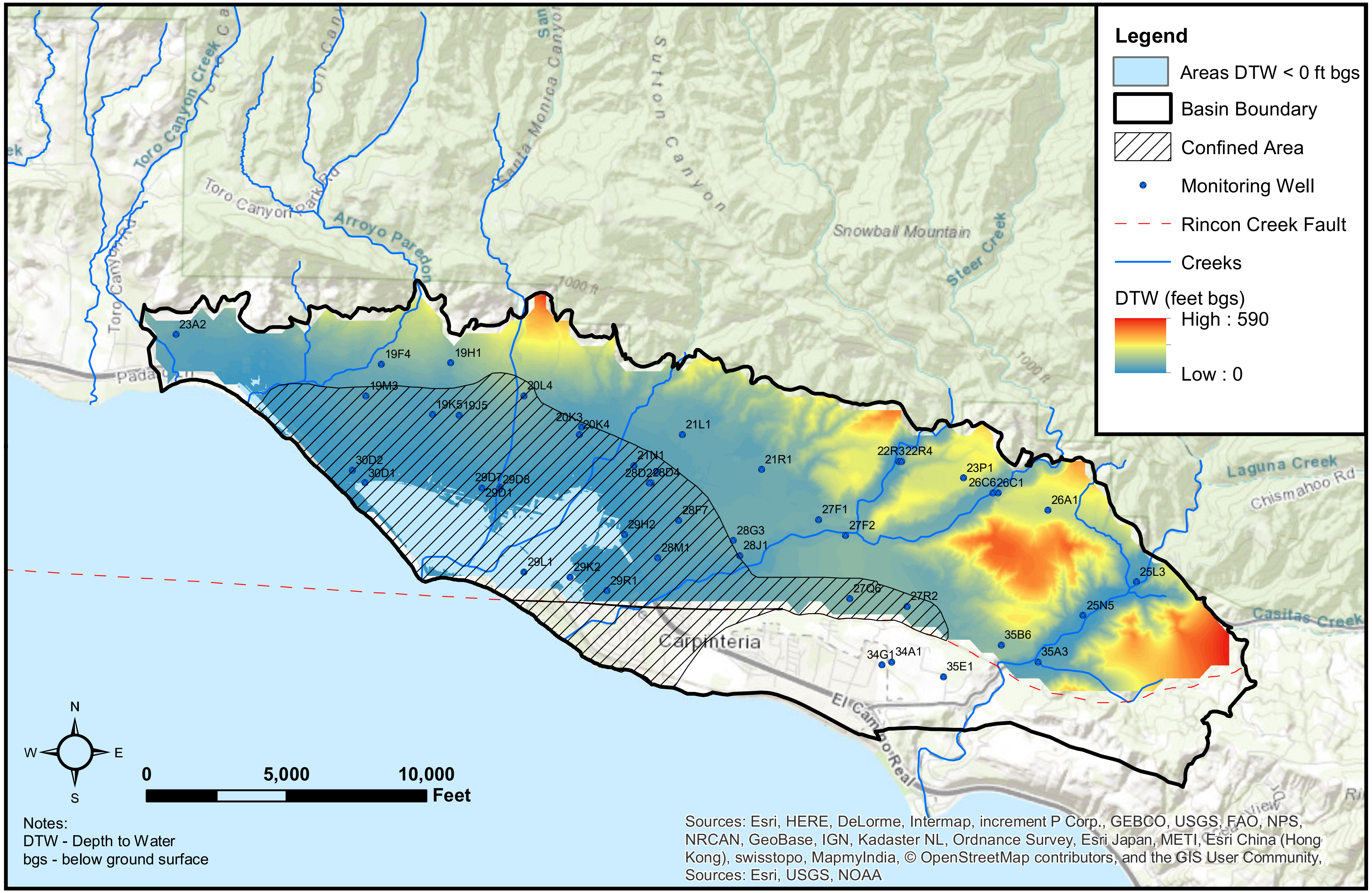

FIGURE 3-43

Depth to Water Map (Spring 2005)

Carpinteria Basin Groundwater Sustainability Plan

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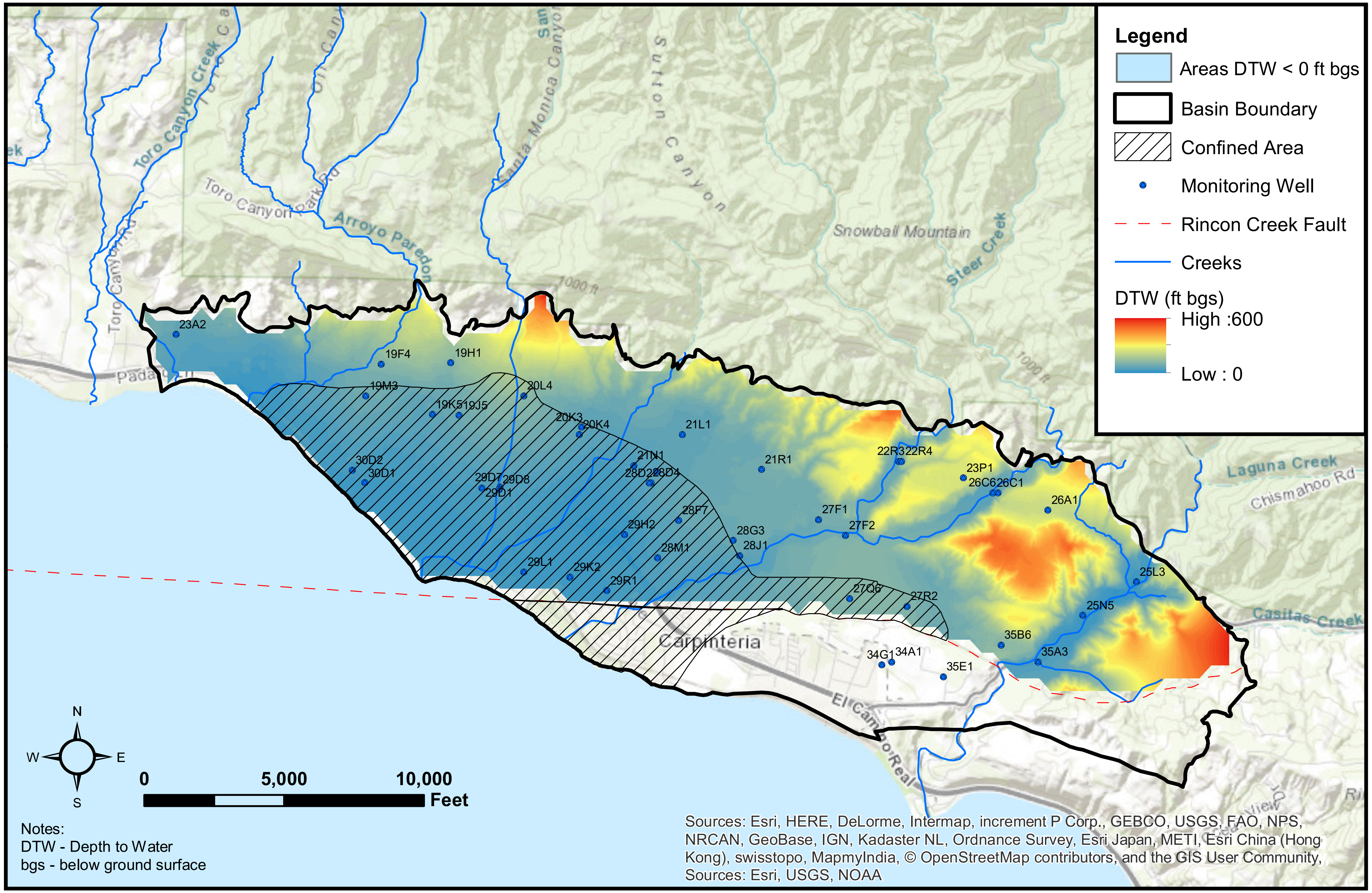

FIGURE 3-44

Depth to Water Map (Spring 2010)

Carpinteria Basin Groundwater Sustainability Plan

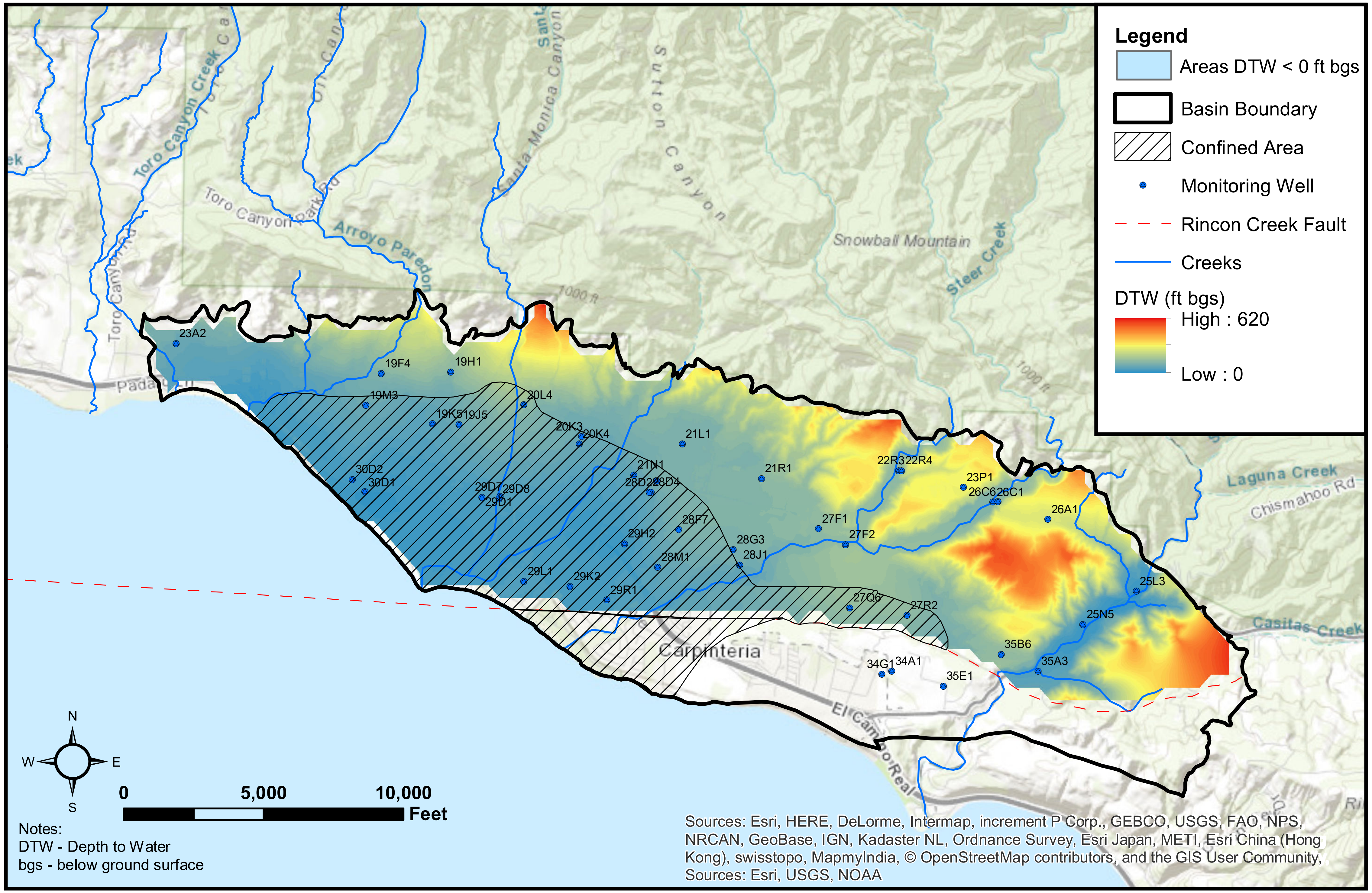

FIGURE 3-45

Depth to Water Map (Spring 2015)

Carpinteria Basin Groundwater Sustainability Plan

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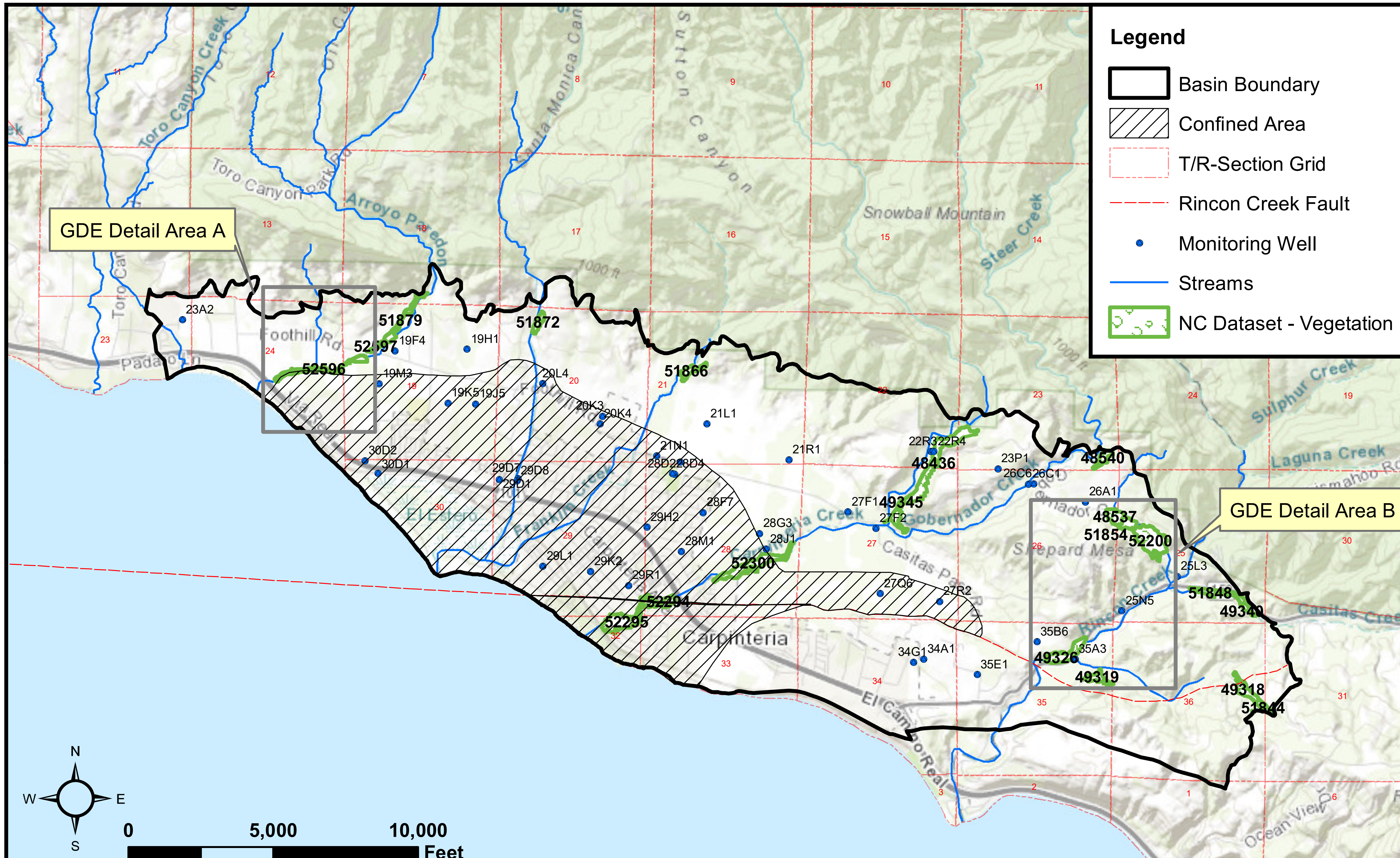

Notes:
NC Dataset - Natural Communities Commonly Associated with Groundwater Dataset

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

FIGURE 3-46

Potential GDE Location Map – Vegetation

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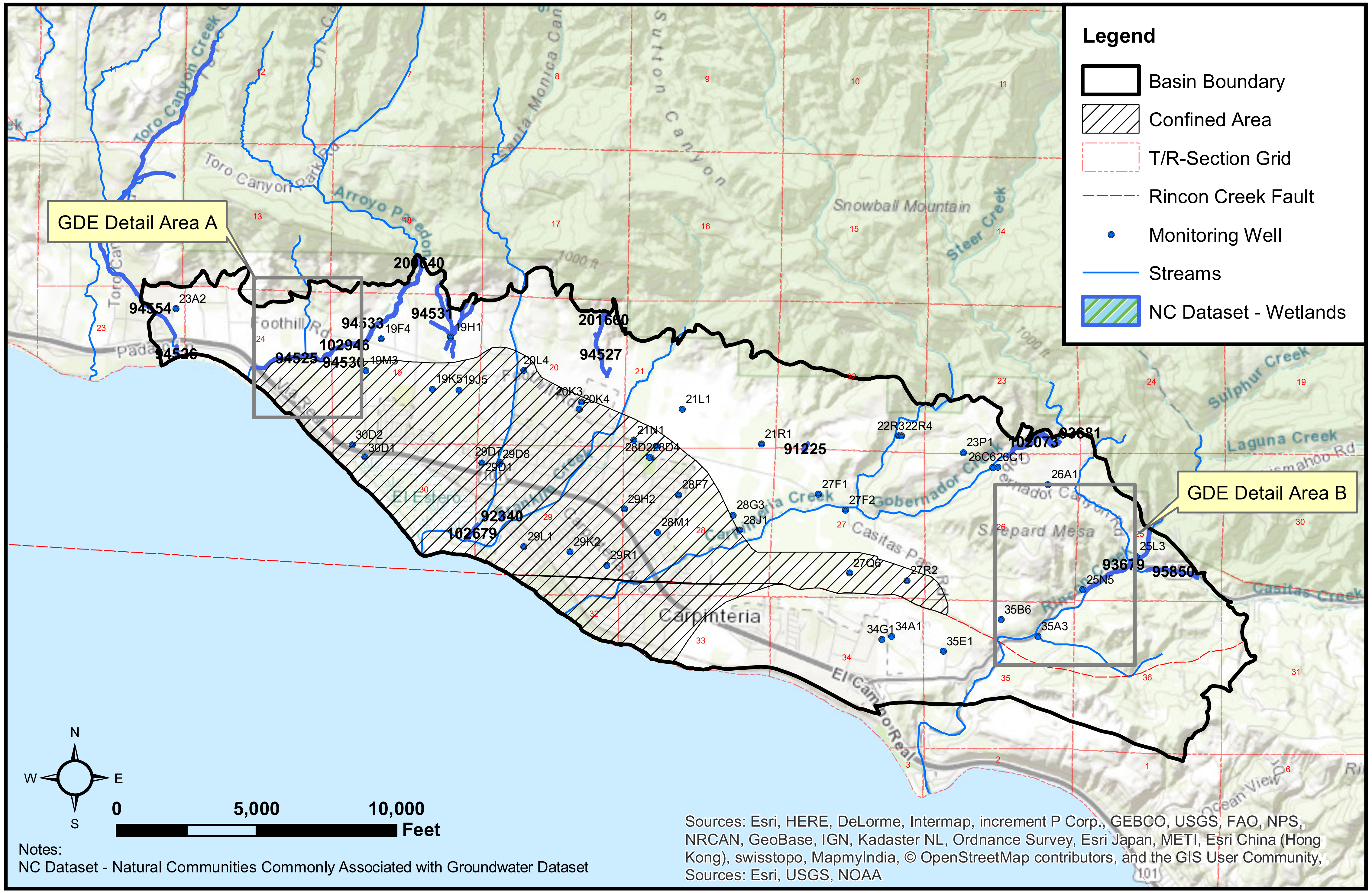

FIGURE 3-47

Potential GDE Location Map – Wetlands

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As shown on **Figures 3-46 and 3-47**, the potential GDEs are largely concentrated along the primary creeks in the basin. As shown in **Table 3-2**, there are 20 vegetation and 18 wetland individual polygon areas. The potential GDE vegetation areas consist of the following types:

- Coast Live Oak
- Riparian Mixed Hardwood

The potential GDE wetland areas consist of the following types:

- Palustrine, Forested, Seasonally Flooded
- Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded
- Palustrine, Emergent, Persistent, Seasonally Flooded - Fresh Tidal
- Riverine, Unknown Perennial, Unconsolidated Bottom, Semipermanently Flooded
- Palustrine, Scrub-Shrub, Seasonally Flooded

Verification of whether the mapped potential GDE areas in the NC Dataset are likely to be dependent on groundwater from the principal aquifer consisted of the use of the best currently available science on the hydrogeologic setting and groundwater levels in the basin to screen the mapped areas for further analysis. The initial screening consisted of determining whether a mapped potential GDE area is located in the Confined Area or unconfined Recharge Area of the basin. As discussed previously, the principal aquifer in the Confined Area consists of the A, B and C Zones which underly a low-permeability confining layer, and groundwater management is not likely to affect water levels in the overlying shallow zone or the ecosystems in the area.

In the unconfined Recharge Area, using the depth-to-water to the rooting depth of the vegetation is a reasonable method to infer the groundwater dependence of potential GDE areas. As discussed in the previous section, basin creeks in the Recharge Area are disconnected from groundwater; therefore, stream depletion due to pumping is not expected to occur. Similarly, if the groundwater levels are well below the rooting zone of the plants and any wetland features, groundwater management is not likely to affect the ecosystem in the area.

Depth-to-water groundwater levels of less than 30 feet[2] of the land surface is a generally accepted method to initially screen potential GDEs for groundwater dependence; however, many of the potential GDEs in California have adapted to dealing with intermittent periods of water stress; therefore, utilizing groundwater data from one point in time can misrepresent groundwater levels required by GDEs. To consider the interannual variability of the areas of the basin where the depth-to-water has been less than 30 feet, depth-to-water was calculated as described in the preceding section for the spring water levels for three different water year types in the recent past:

- WY 2005 – Wet water year type
- WY 2010 – Normal water year type
- WY 2015 – Critically Dry water year type

[2] The Nature Conservancy (2018), *Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans*.

As described in the previous section, groundwater elevations were contoured for each of these periods and these groundwater elevation surfaces subtracted from the DEM of ground surface elevations to estimate depth-to-water contours across the basin. Again, this approach provides accurate contours of depth-to-water along the creeks (and other land surface depressions) where the potential GDEs tend to be located. The areas of the basin where the depth-to-water is less than 30 feet for each of the above periods are shown on **Figures 3-48 through 3-50**.

Each potential GDE polygon was inspected with respect to whether the depth-to-water was less than 30 feet under each of the above water year types. Potential GDEs that had depth-to-water *greater than 30 feet* during two or more of the above water year types were deemed to not be dependent on groundwater from the principal aquifer and is, therefore, not considered a GDE. Potential GDE polygons areas located outside of the Confined Area that had depth-to-water *less than 30 feet* under at least two of the above conditions were retained for further evaluation. The results of the initial GDE screening are summarized in **Table 3-3**.

As shown on **Figures 3-46 and 3-47** and **Table 3-3**, three of the vegetation and two of the wetlands potential GDE polygons are located in the Confined Area and, as such are not considered dependent on groundwater in the principal aquifer subject to basin management. Of the remaining 17 vegetation and 16 wetlands potential GDE polygons located in the unconfined Recharge Area, two vegetation and two wetlands areas met the screening criteria of having depth-to-water less than 30 feet under at least two of the above water-year types. As shown in **Figures 3-51 and 3-52**, these four potential GDE polygons are located in and along Arroyo Paredon and Rincon Creeks. The remaining 15 vegetation and 14 wetlands potential GDE polygons areas, located primarily along the upper reaches of Carpinteria and Gobernador Creeks, are not considered GDE's based on consistent groundwater depths occurring below the root zone.

The remaining four potential GDE polygon areas located along Arroyo Paredon (GDE Detail Area A) and Rincon Creeks (GDE Detail Area B) are shown in greater detail in **Figures 3-51 and 3-52** (see **Figures 3-46 and 3-47** for the detail area map locations). These potential GDEs were analyzed further by identifying existing monitoring wells in the vicinity of each area, also shown on **Figures 3-51 and 3-52**. Well logs (where available) and water-level hydrographs for these monitoring wells were reviewed to further examine seasonal and interannual variability in ground water levels in the vicinity of the potential GDEs.

The available information for the existing monitoring wells in the vicinity of these remaining potential GDE polygon areas is summarized in **Table 3-4** and discussed below.

Table 3-3. Potential GDE Initial Screening Summary

NC Dataset Polygon ID	Coverage Type	Nearest Creek	Basin Area	Spring DTW < 30 ft bgs?		
				2005 [2]	2010 [3]	2015 [4]
51879	Vegetation	Arroyo Paredon	Recharge	No	No	No
52597	Vegetation	Arroyo Paredon	Recharge	No	No	No
52596	**Vegetation**	**Arroyo Paredon**	**Recharge**	**Yes**	**Yes**	**No**
51872	Vegetation	Santa Monica	Recharge	No	No	No
51866	Vegetation	Franklin	Recharge	No	No	No
48436	Vegetation	Carpinteria	Recharge	Yes	No	No
49435	Vegetation	Carpinteria	Recharge	No	No	No
42300	Vegetation	Carpinteria	Both	Yes	No [5]	No
52294	Vegetation	Carpinteria	Confined	Yes	Yes	No
52295	Vegetation	Carpinteria	Confined	No	No	No
48540	Vegetation	Gobernador	Recharge	No	No	No
48537	Vegetation	Unnamed Tributary	Recharge	No	No	No
51854	Vegetation	Unnamed Tributary	Recharge	No	No	No
52200	Vegetation	Unnamed Tributary	Recharge	No	No	No
51848	Vegetation	Casitas	Recharge	Yes	No	No
49340	Vegetation	Casitas	Recharge	No	No	No
49326	**Vegetation**	**Rincon**	**Recharge**	**Yes**	**Yes**	**No**
49319	Vegetation	Rincon	Recharge	No	No	No
49318	Vegetation	Unnamed Tributary	Recharge	No	No	No
51844	Vegetation	Unnamed Tributary	Recharge	No	No	No
94554	Wetlands	Toro	Recharge	No	No	No
94526	Wetlands	Toro	Recharge	Yes	No	No
94525	**Wetlands**	**Arroyo Paredon**	**Recharge**	**Yes**	**Yes**	**No**
94530	Wetlands	Arroyo Paredon	Recharge	No	No	No
102946	Wetlands	Arroyo Paredon	Recharge	Yes	No	No
94533	Wetlands	Arroyo Paredon	Recharge	No	No	No
200640	Wetlands	Arroyo Paredon	Recharge	No	No	No
94531	Wetlands	NA	Recharge	No	No	No
201660	Wetlands	NA	Recharge	No	No	No
94527	Wetlands	NA	Recharge	No	No	No
92340	Wetlands	Franklin (El Estero)	Confined	Yes	Yes	No
102679	Wetlands	Santa Monica (El Estero)	Confined	Yes	Yes	No
91225	Wetlands	NA	Recharge	No	No	No
93680	Wetlands	Gobernador	Recharge	No	No	No
93681	Wetlands	Gobernador	Recharge	No	No	No
102073	Wetlands	Gobernador	Recharge	No	No	No
93679	**Wetlands**	**Rincon**	**Recharge**	**Yes**	**Yes**	**Yes**
95850	Wetlands	Rincon	Recharge	Yes	No	No

Notes

Potential GDE Polygon areas meeting screening criteria shown in **BOLD TYPE**.

[1] Ground surface elevation at center of GDE polygon.

[2] Wet Water Year Type

[3] Normal Water Year Type

[4] Critically Dry Water Year Type

[5] Portion of mapped polygon area in unconfined Recharge Area.

DTW = depth to water

GDE = groundwater dependent ecosystem

Table 3-4. Potential GDE Water-Level Monitoring Well Summary

NC Dataset Polygon ID	GS Elevation[1]	Nearest MWs	Distance (ft) [2]	WCR? (y/n)	Water Level Record		Comments
					Start	End	
52596	38	19F4	1145	n	12/8/49	8/27/20	Up to 9 years DTW > 30 ft during extended dry periods
		19M3	1020	n	12/14/49	12/18/13	Up to 7 years DTW > 30 ft during extended dry periods
94525	27	19F4	1920	n	12/8/49	8/27/20	Up to 6 years DTW > 30 ft during extended dry periods
		19M3	1390	n	12/14/49	12/18/13	**Available data show DTW consistently < 30 ft**
93679	206	25L3	68	n	5/30/96	8/26/20	**Available data show DTW consistently < 30 ft**
		25N5	125	y	5/30/96	2/14/17	Available data show DTW consistently > 30 ft
49326	142	35A3	195	n	1/25/78	2/24/05	**Available data show DTW consistently < 30 ft**
		35B6	870	n	6/18/96	4/27/07	**Available data show DTW consistently < 30 ft**

Notes

Potential GDE Polygon areas meeting screening criteria shown in **BOLD TYPE**.

[1] Ground surface elevation at center of GDE polygon.

[2] Distance from subject well to center of GDE polygon.

DTW = depth to water

ft = feet or foot

GDE = groundwater dependent ecosystem

GS = ground surface

MW = monitoring well

n = no

NA = Not Available

NC = Natural Communities

y = yes

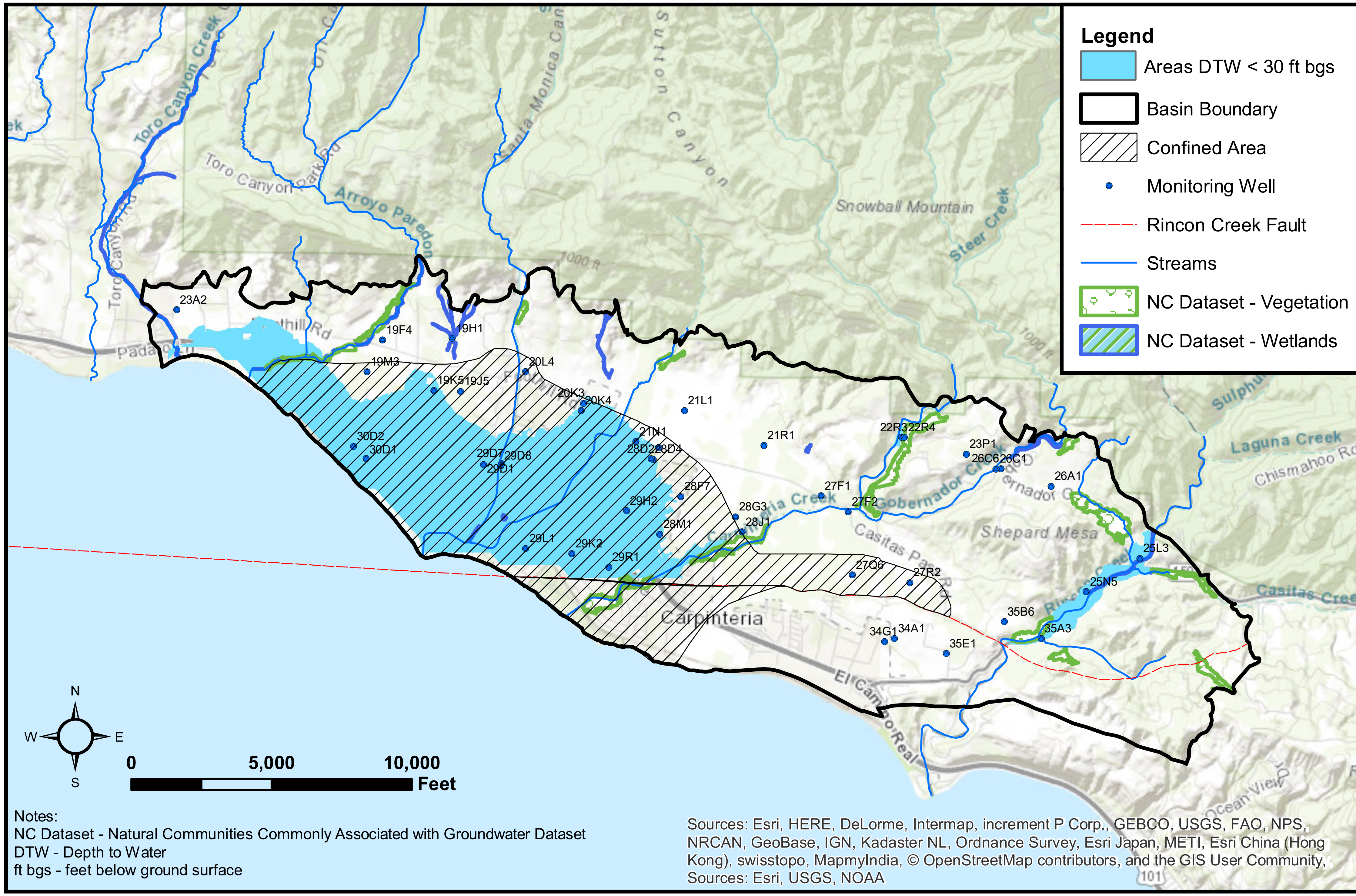

FIGURE 3-48

GDE Screening – DTW < 30 ft bgs (Spring 2005)

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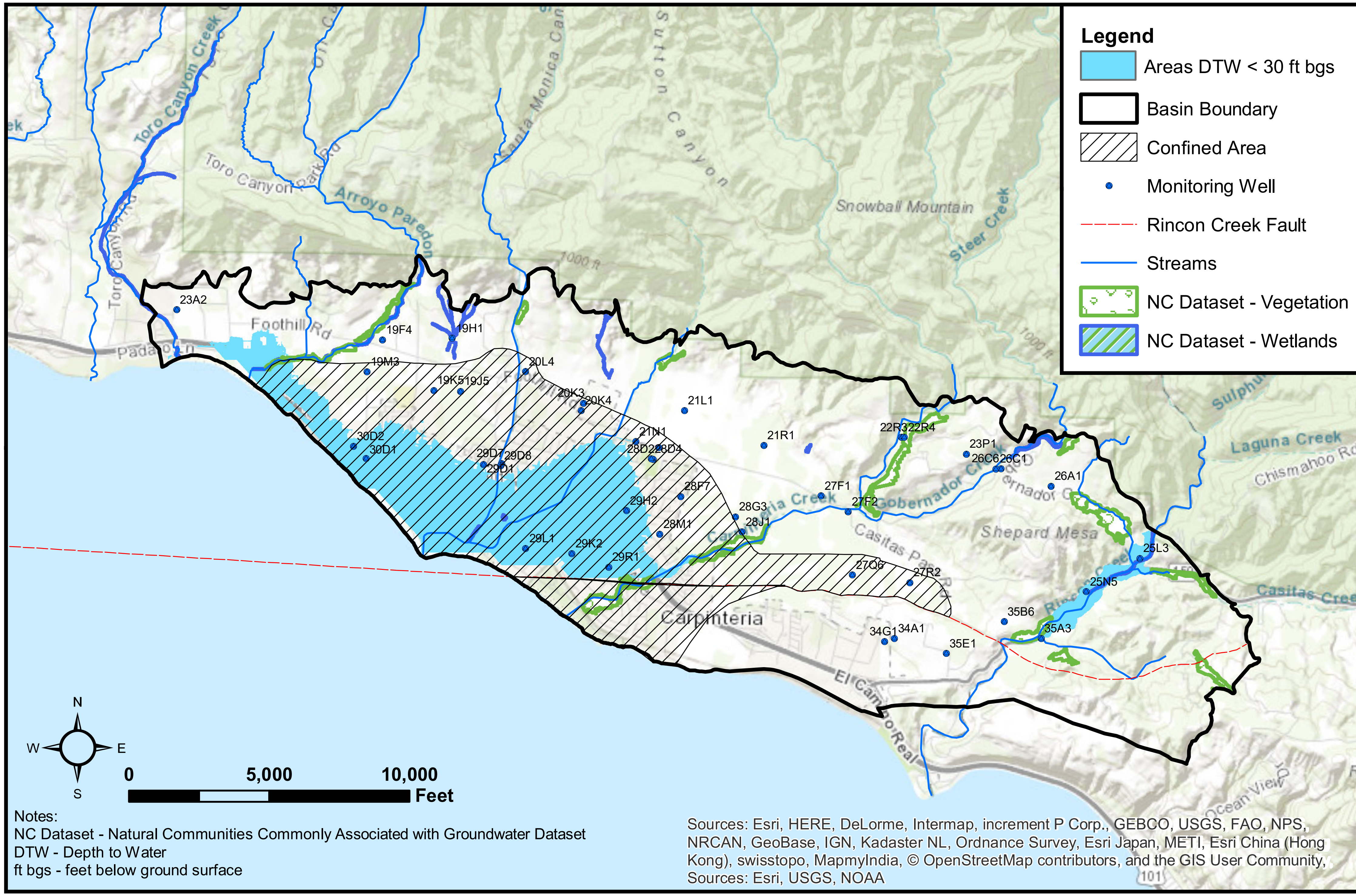

Notes:
NC Dataset - Natural Communities Commonly Associated with Groundwater Dataset
DTW - Depth to Water
ft bgs - feet below ground surface

FIGURE 3-49

GDE Screening – DTW < 30 ft bgs (Spring 2010)

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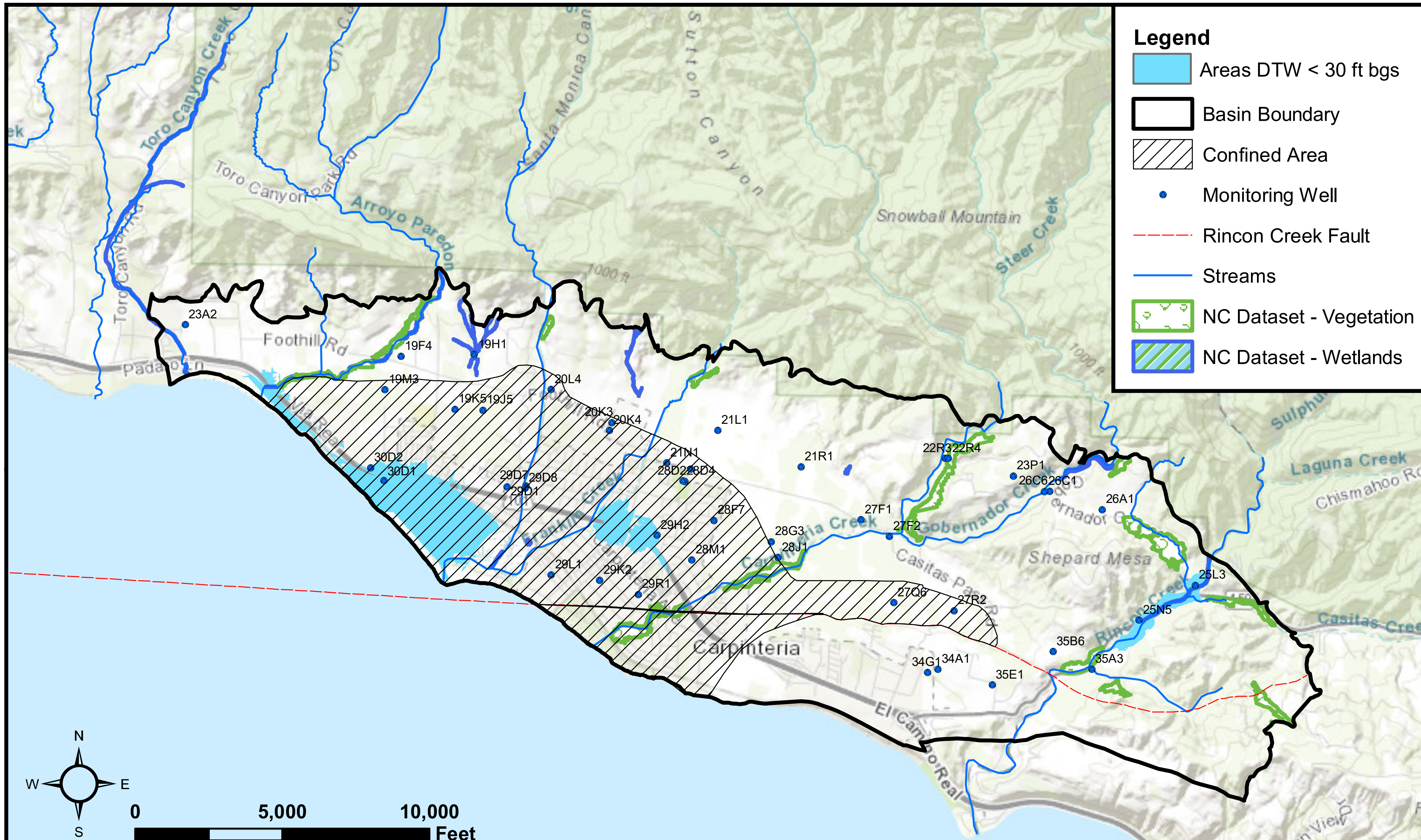

Notes:
NC Dataset - Natural Communities Commonly Associated with Groundwater Dataset
DTW - Depth to Water
ft bgs - feet below ground surface

Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community, Sources: Esri, USGS, NOAA

FIGURE 3-50

GDE Screening – DTW < 30 ft bgs (January 2015)

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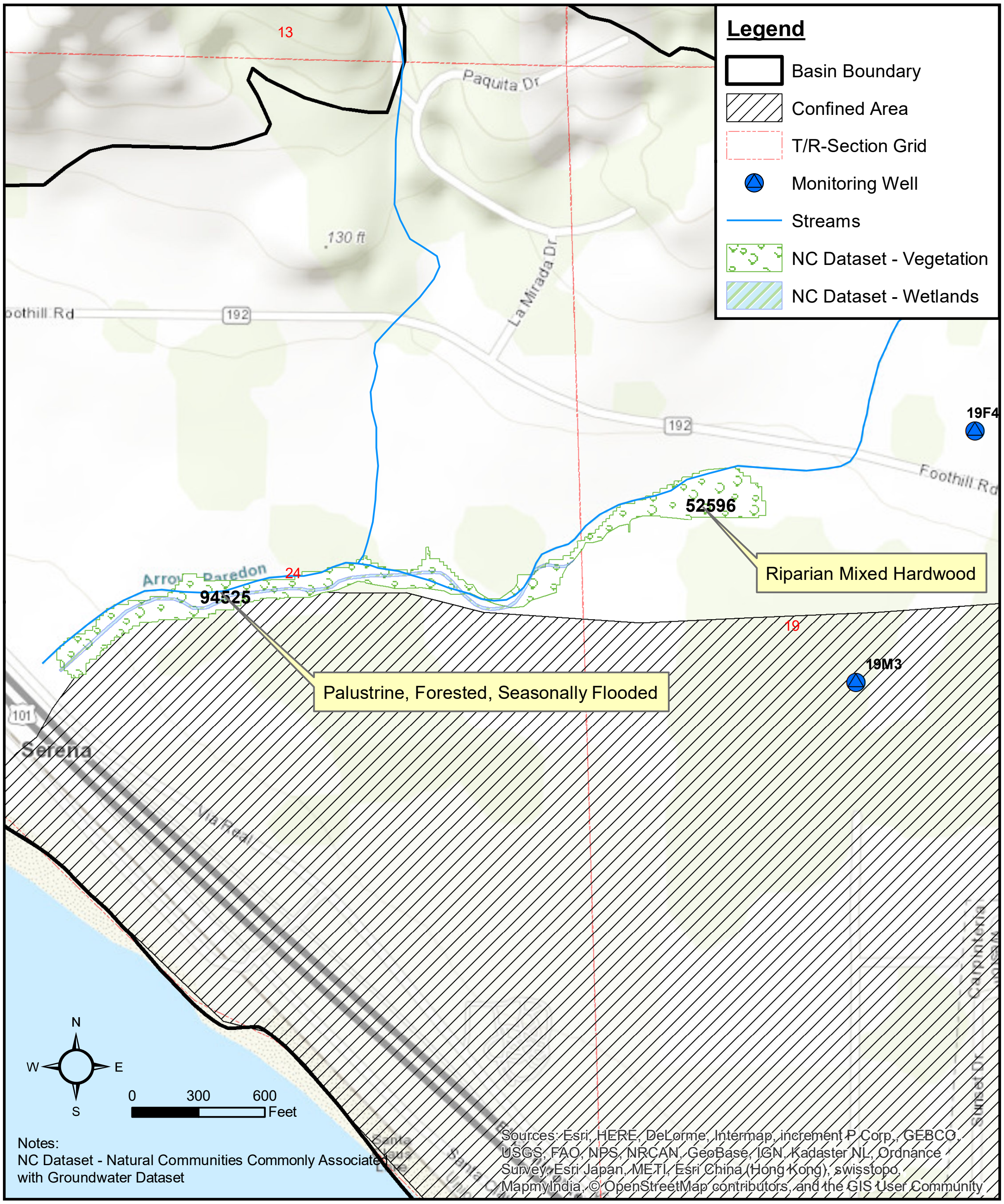

FIGURE 3-51

GDE Screening – Detail Area A Map

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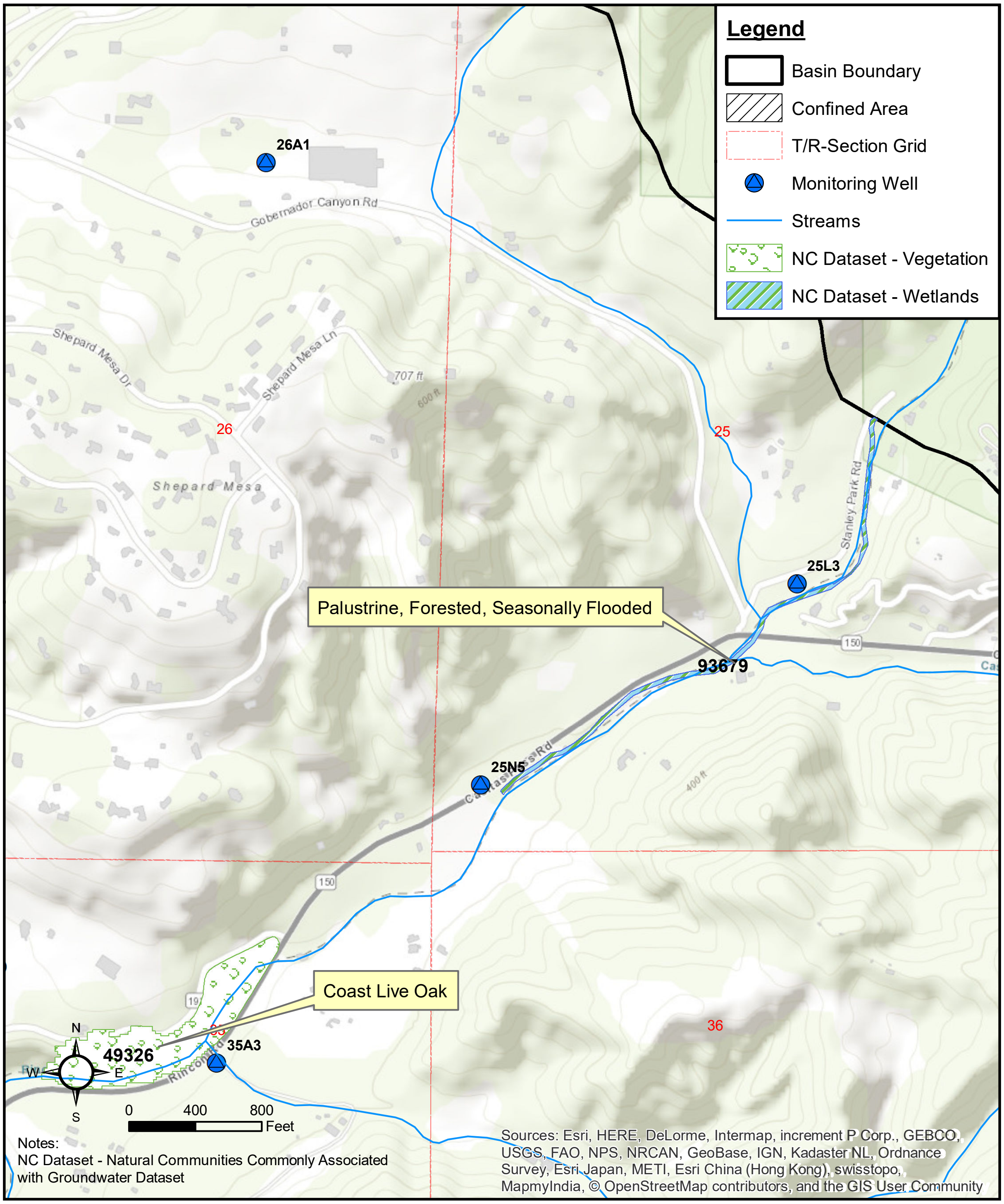

FIGURE 3-52

GDE Screening – Detail Area B Map

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As shown in **Table 3-4**, only one of the monitoring wells in the vicinity of the subject potential GDE's has a well log available (25N5). Although water-level data are available for all of these proximate wells, and represent the best currently available information, their depths and screened intervals are unknown.

Nevertheless, water-level hydrographs for the two existing monitoring wells located in the vicinity of the Arroyo Paredon Creek potential GDEs (19F4 and 19M3) are shown on **Figures 3-53 and 3-56**. Also shown are the bottom elevations of the potential GDE polygons (at the center nearest the subject monitoring well) and the associated 30 feet depth-to-water distances. As shown on the hydrographs for 19F4 (**Figures 3-53 and 3-54**), there are up to 6 to 9 consecutive years (depending on the GDE polygon) during which water levels are greater than 30 feet below the potential GDE.

As shown on the hydrographs for 19M3 (**Figures 3-55 and 3-56**), there are up to 6 consecutive years where the depth-to-water below potential GDE polygon 52596 (vegetation - riparian mixed hardwood) is greater than 30 feet; however, for potential GDE polygon 94525 (wetlands - palustrine, forested, seasonally flooded), the depth-to-water is consistently less than 30 feet during the period of record. It is noted that the period of record for 19M3 ends in December 2013; therefore, water-level data during the current cumulatively dry period of WY 2012 through WY 2020 are not available.

Based on the water-level data available for monitoring wells 19F4 and 19M3, there are numerous consecutive years when depths-to-water are greater than 30 feet below the potential GDE. Based on these observations, it appears that these potential GDEs along Arroyo Paredon Creek may not be dependent on groundwater; however, as discussed previously, well logs for these two monitoring wells are unavailable. These potential GDE polygons will be further evaluated during GSP implementation.

Water-level hydrographs for the four existing monitoring wells located in the vicinity of the Rincon Creek potential GDEs (25L3, 25N5, 35A3 and 35B6) are shown on **Figures 3-57 through 3-60**. As shown for wells 25L3, 35A3 and 35B6, depth-to-water levels are consistently less than 30 feet below the bottom elevations of both potential GDE polygon 93679 (wetlands - wetlands - palustrine, forested, seasonally flooded) and GDE polygon 49326 (vegetation – coast live oak), whereas for well 25N5 (**Figure 3-58**), depth-to-water levels are consistently greater than 30 feet below the bottom elevations of potential GDE polygon 93679. However, screen interval information for 3 of the 4 monitoring wells is not currently available. These potential GDEs will be further evaluated during GSP implementation.

It is also noted that there is anecdotal information suggesting that these two creeks may be fed by springs and/or seeps located in the bedrock areas outside the basin boundaries. If so, the potential GDEs could be supported during dry periods by these surface water flows emanating from outside the basin rather than being dependent on groundwater. However, as noted previously, there are no streamflow monitoring data for either of the two creeks to definitively support this. Historical satellite imagery (Google Earth) was examined, but the available imagery resolution was insufficient to visually determine if surface water has historically been present in Arroyo Paredon and Rincon creeks during dry periods or not. Each of these creeks was subsequently visually inspected in the field at bridges located upstream of the potential GDEs in July 2022. During these field visits, the creek beds were observed to be dry at all locations.

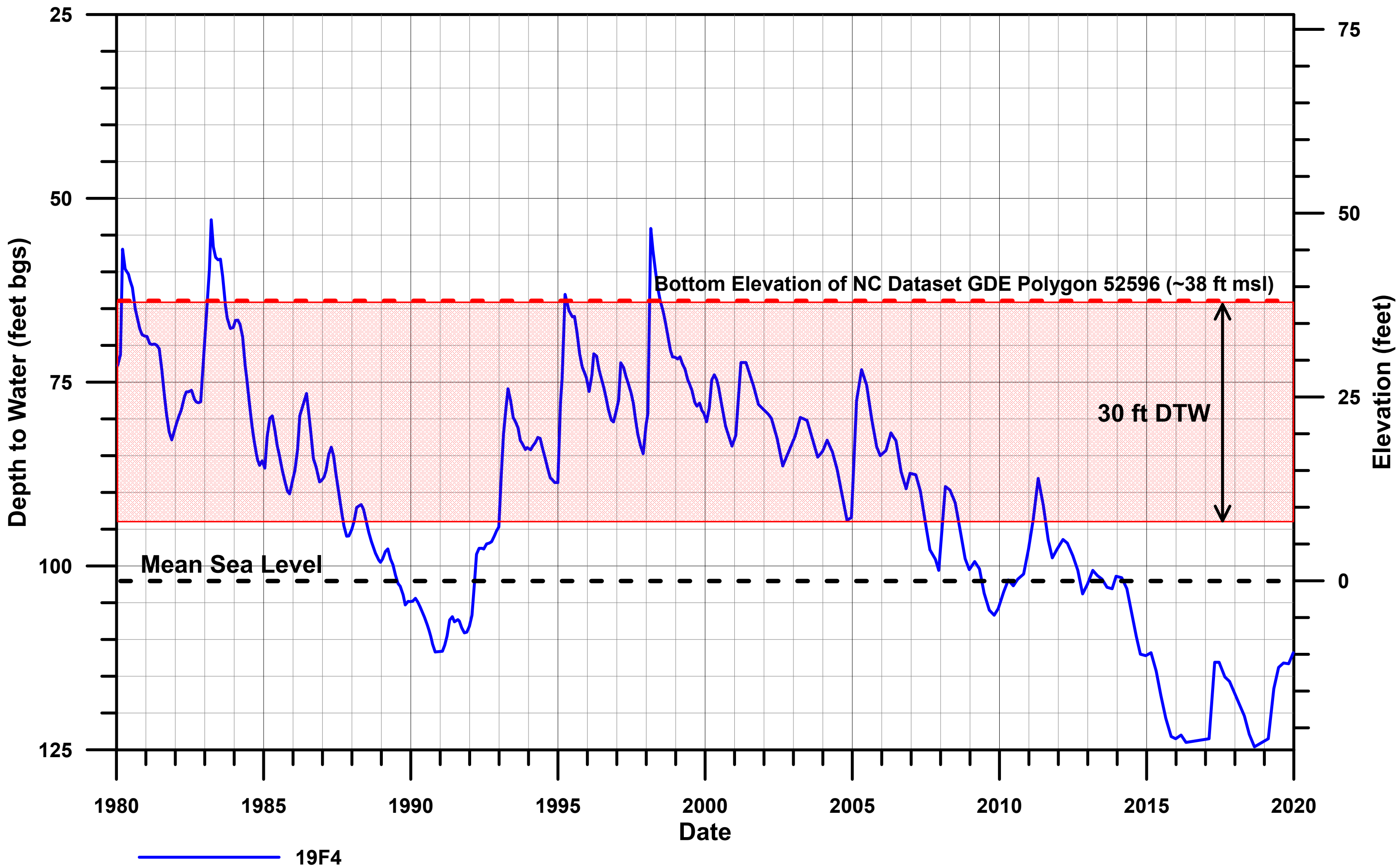

FIGURE 3-53

GDE Screening Water Level Data – 4N/25W-19F4 (relative to GDE Polygon 52596)

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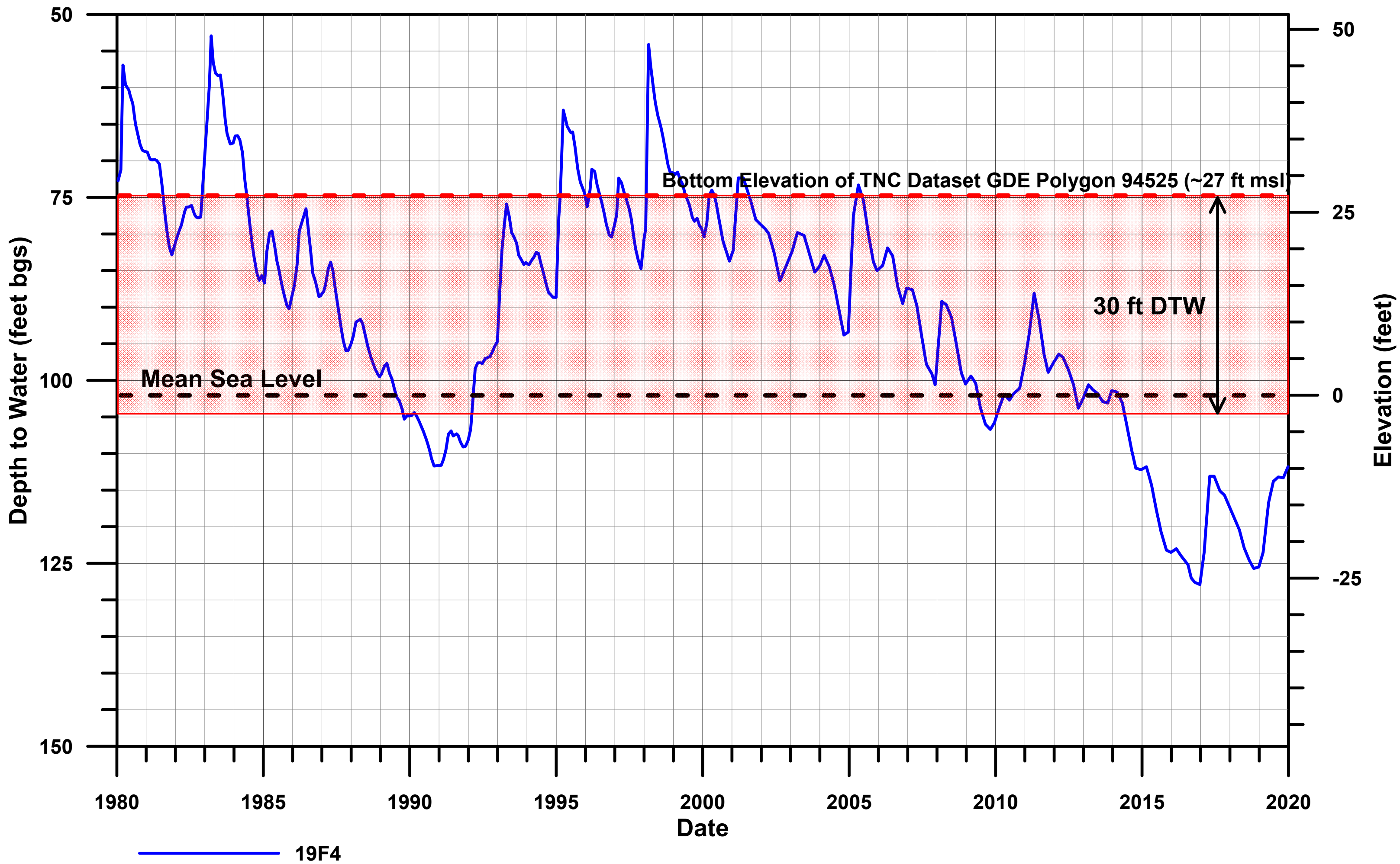

FIGURE 3-54

GDE Screening Water Level Data – 4N/25W-19F4 (relative to GDE Polygon 94525)

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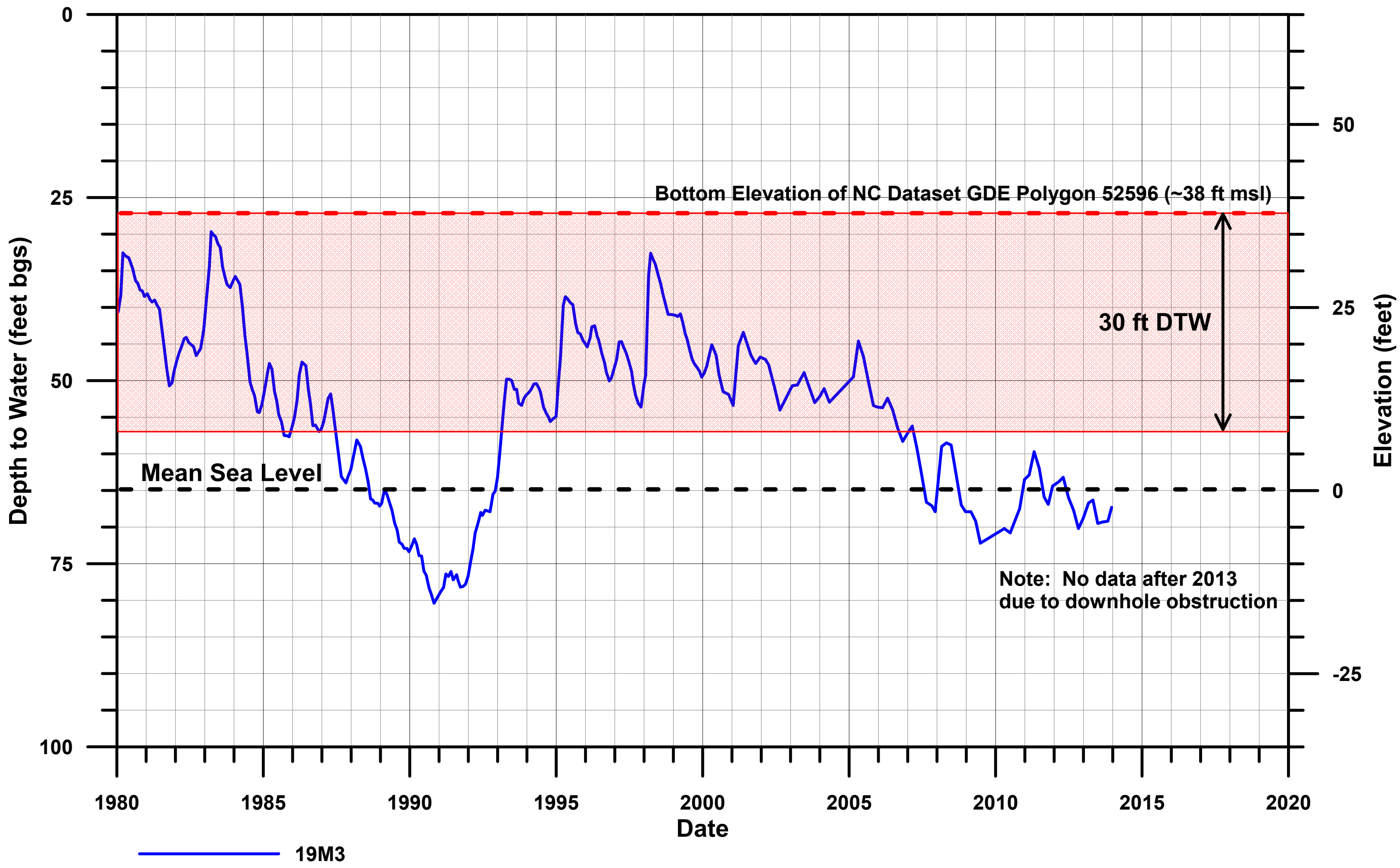

FIGURE 3-55

GDE Screening Water Level Data – 4N/25W-19M3 (relative to GDE Polygon 52596)

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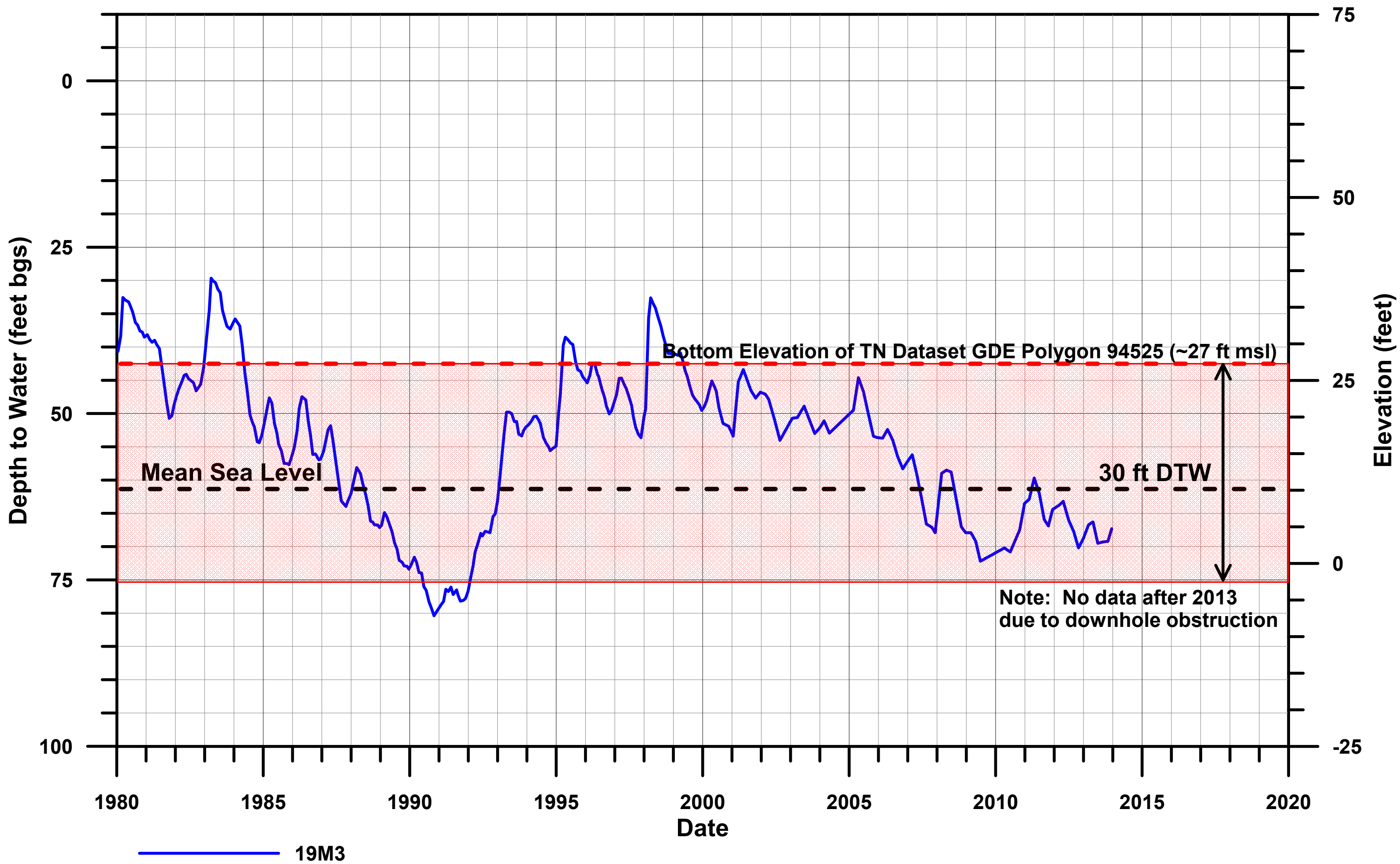

FIGURE 3-56

GDE Screening Water Level Data – 4N/25W-19M3 (relative to GDE Polygon 94525)

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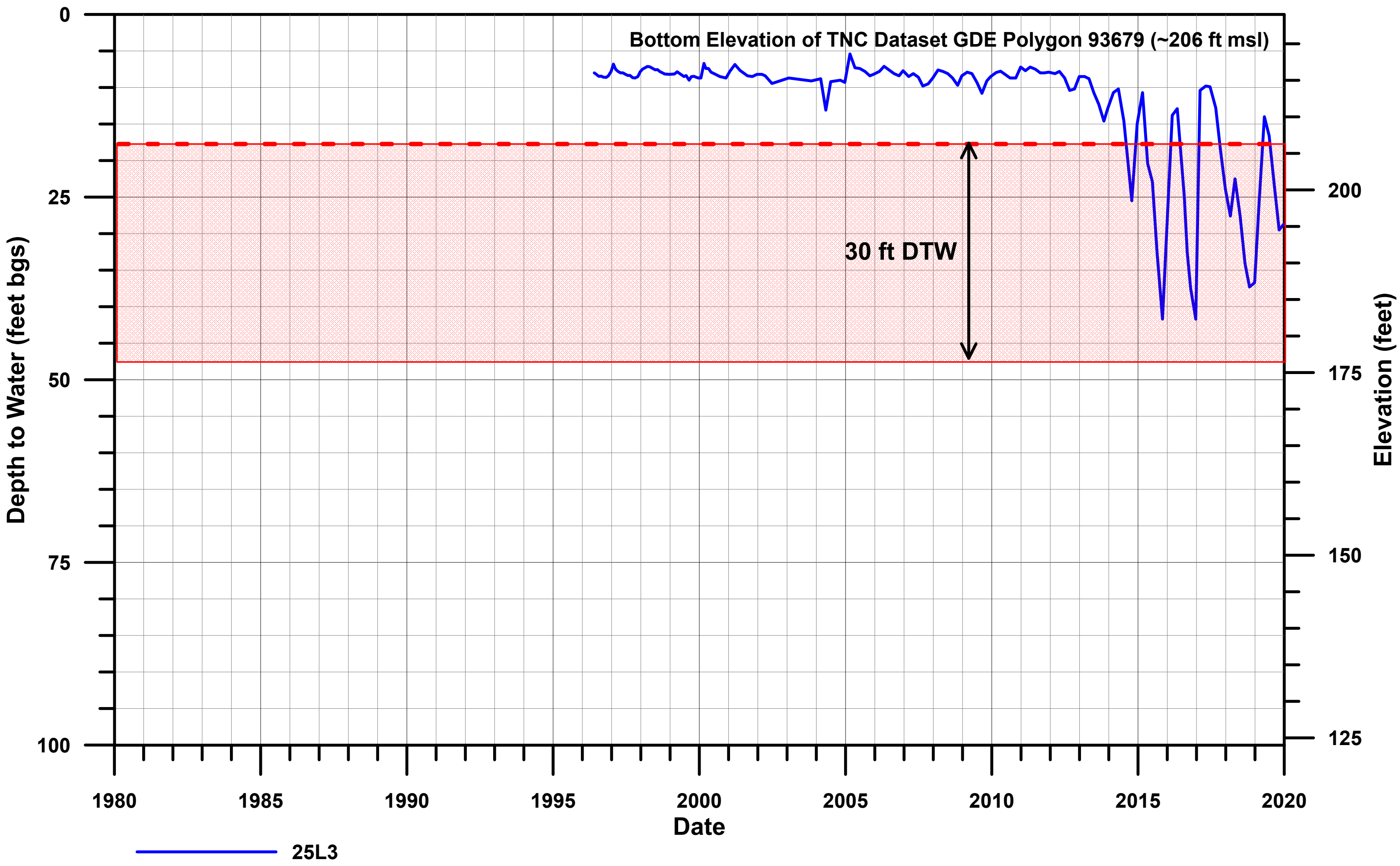

FIGURE 3-57

GDE Screening Water Level Data – 4N/25W-25L3 (relative to GDE Polygon 93679)

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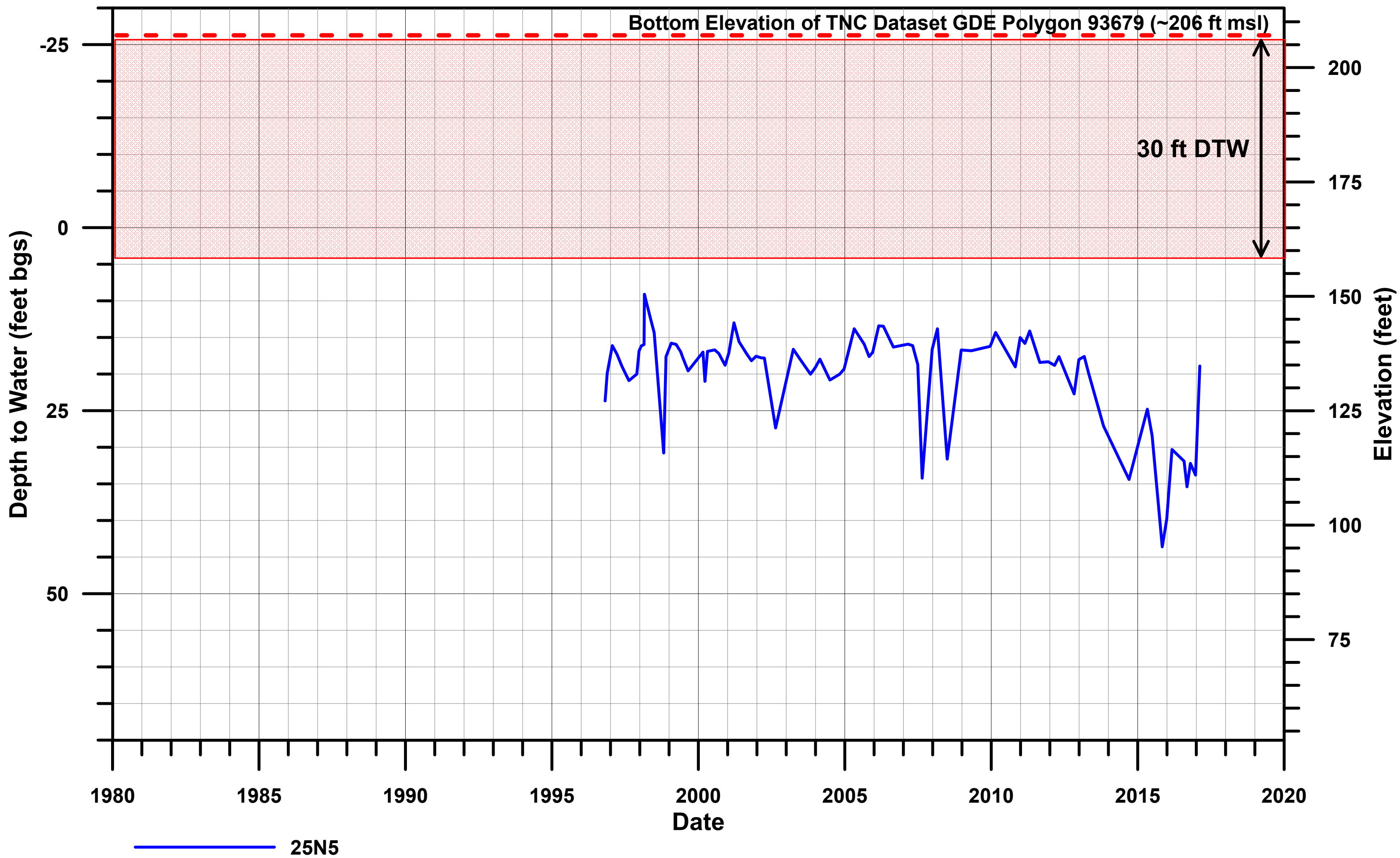

FIGURE 3-58

GDE Screening Water Level Data – 4N/25W-25N5 (relative to GDE Polygon 93679)

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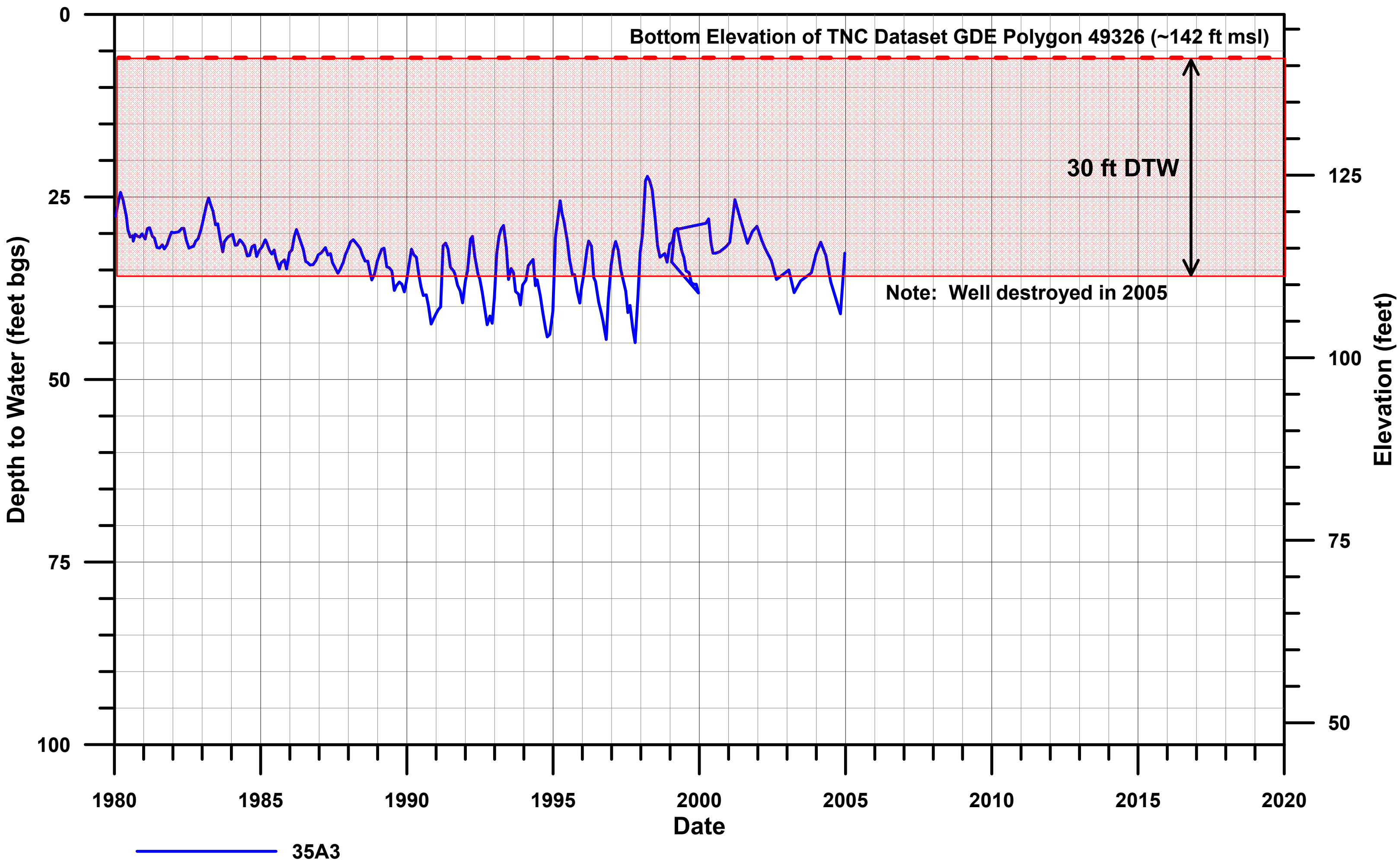

FIGURE 3-59

GDE Screening Water Level Data – 4N/25W-35A3 (relative to GDE Polygon 49326)

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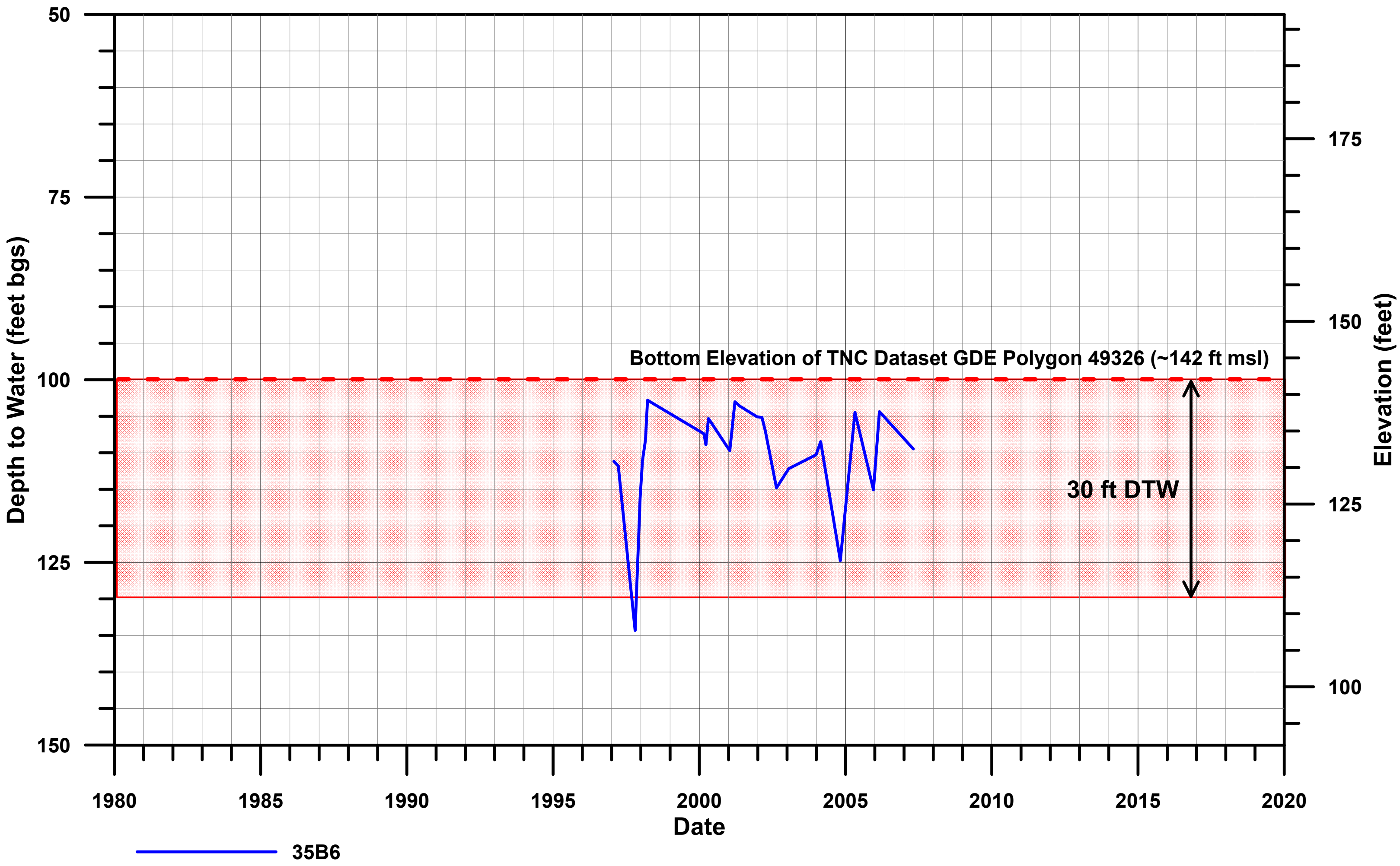

FIGURE 3-60

GDE Screening Water Level Data – 4N/25W-35B6 (relative to GDE Polygon 49326)

Carpinteria Basin Groundwater Sustainability Plan

3.3 Water Budget [§ 354.18]

§354.18 Water Budget.

(a) Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:

(1) Total surface water entering and leaving a basin by water source type.

(2) Inflow to the groundwater system by water source type, including subsurface groundwater inflow and infiltration of precipitation, applied water, and surface water systems, such as lakes, streams, rivers, canals, springs and conveyance systems.

(3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow.

(4) The change in the annual volume of groundwater in storage between seasonal high conditions.

(5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.

(6) The water year type associated with the annual supply, demand, and change in groundwater stored.

A water budget is the key integrating aspect of the basin setting. The HCM (see Section 3.1) and water budgets (this section) form the basis for the numerical flow model used to quantitatively evaluate the management alternatives considered in this Plan.

3.3.1 Overview of Water Budget Development

This section presents the water budgets prepared for the Basin and contains information required by SGMA regulations and information that is important for developing an effective plan to achieve sustainable groundwater management. According to SGMA regulations (§ 354.18), the GSP must include a water budget for the basin that provides an accounting and assessment of the total annual volume of surface water and groundwater entering and leaving the basin, including historical, current, and projected water budget conditions. A water budget accounts for the change in the total volume of water stored in a basin under these different conditions. The regulations require that the water budget be reported in graphical and tabular formats.

This water budget analysis is inextricably tied to the SGMA requirement to ensure the Basin is operated within its sustainable yield. Sustainable yield is defined in SGMA as “the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus that can be withdrawn annually from a groundwater supply without causing an undesirable result." An undesirable result is one or more of the following effects caused by groundwater conditions occurring throughout a basin:

- Chronic lowering of groundwater levels in the aquifer(s) indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if groundwater extractions and recharge are managed as necessary to ensure that reductions of groundwater levels or storage during a period of drought are offset by increases of groundwater levels or storage during other periods.
- Significant and unreasonable reduction of groundwater in storage.
- Significant and unreasonable degradation of water quality, including the migration of contaminant plumes that impair water supplies.
- Seawater intrusion.
- Significant and unreasonable land subsidence that substantially interferes with surface land uses.
- Depletion of interconnected surface water that has significant and unreasonable adverse impacts on beneficial uses of surface water.

Defining the sustainable yield of a groundwater basin based upon a water budget provides a starting point that may be adjusted by considering whether there are undesirable results associated with any of the six sustainability indicators described above. Section 5 presents consideration of the sustainability indicators for defining sustainable yield. Section 354.18 of the SGMA regulations requires development of a water budget that includes both groundwater and surface water components to provide an accounting of the total volume of water entering and leaving a basin. To satisfy the requirements of the regulations, water budgets were prepared for the Basin for each of the three water budget periods.

3.3.2 Water Budget Data Sources, Methodology, and Basin Model

This section describes data sources and methodologies used in the calculation of the historical and current water budgets for the Basin. A description of the data sources and methodologies used in the calculations of the projected water budget is presented later in Section 3.3.5.

In this GSP, the discussion of the water budget periods refers to water years (WY), which run between October 1 and September 30 of the following year. The three water budget periods are as follows:

- The historical water budget period is WY 1985 through 2020.
- The current water budget period is WY 2012 through 2020.
- The projected water budget period is the 52-year period of WY 2021 through 2072 and extends 50 years past the submittal of this GSP as required by SGMA regulations.

The three GSP water budget time frames are illustrated graphically in Figure 3-61 and each of these periods is discussed in further detail in Sections 3.3.3, 3.3.4, and 3.3.5. The 36-year period between WY 1985 and 2020 (inclusive) has been selected for the historical water budget to comply with DWR regulatory requirements, which include the following:

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

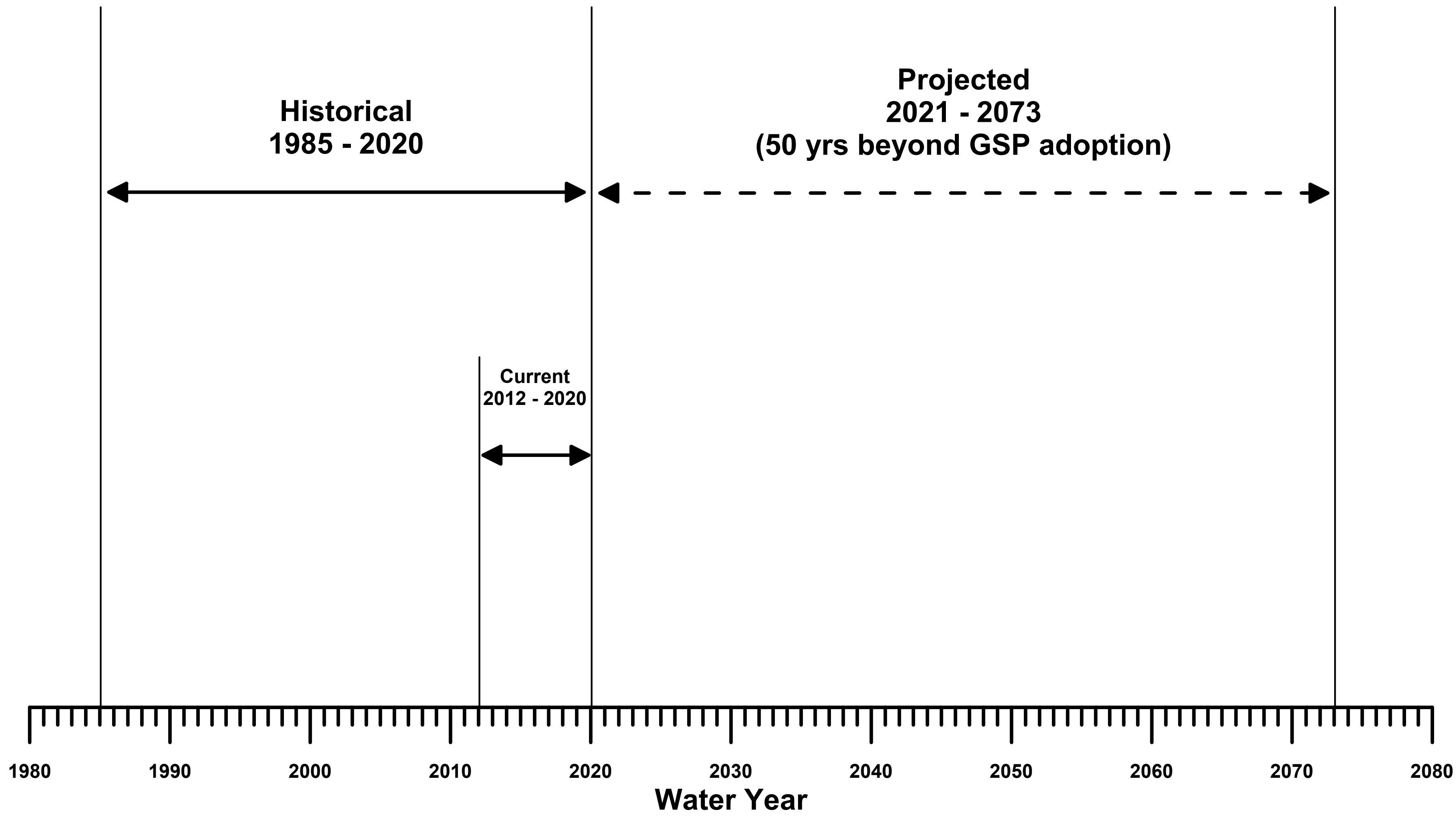

FIGURE 3-61

GSP Water Budget Time Frames

Carpinteria Basin Groundwater Sustainability Plan

The 36-year period selected for the historical water budget includes the most recently available information, two wet and two dry hydrologic cycles, recent changes in imported water supply availability, changes to water demand associated with cropping patterns, and associated land use. The selection of the historical period considered the availability of good-quality data for the principal water budget components, including precipitation water level data, pumping data, and land use information, which will be discussed individually later. The historical water budget period was chosen to define a specific period when all of the elements of recharge and discharge to the Basin may be compared to other periods (e.g., future projected). This historical period allows for the identification of long-term trends in basin supply and demand, water level trends, changes of groundwater in storage, and estimates of the annual components of inflow and outflow to the zone of saturation. This information is fundamental to input into the numerical groundwater flow model (see Appendix F).

Precipitation data was obtained from the gage located at Carpinteria Fire Station No. 1 (see Figure 3-62). Figure 3-63 presents a graph showing the cumulative departure from mean precipitation for precipitation for the period of record from WY 1949 through 2020. Upward trending portions of the line represent wet periods of above-average rainfall, and downward trending portions represent drought periods of below-average rainfall. In the Basin, precipitation occurs primarily as rainfall. The average precipitation, measured at the Carpinteria Fire Station No. 1 is 17.3 inches for the period of record since 1949. The lower portion of the chart shown on Figure 3-63 shows the annual precipitation. Climatic trends (historical wet-dry cycles) are also shown on the graph. Climatic trends were selected in the context of longer-term multi-year climatic periods of wet, normal, and drought conditions within the Basin. Notable aspects of these periods include the following:

- A long, moderate drought occurred between the beginning of the period of record in WY 1945 and lasted through 1960.
- Between 1960 and 1977, rainfall was approximately average.
- Between 1977 and 1986 there was a short but intense wet period of substantially above-average precipitation. After the intense wet period, there was a 4-year drought (1987 to 1990) and a 8-year wet period (1991 to 1998). The wettest month on record occurred during this wet period in February of 1998.

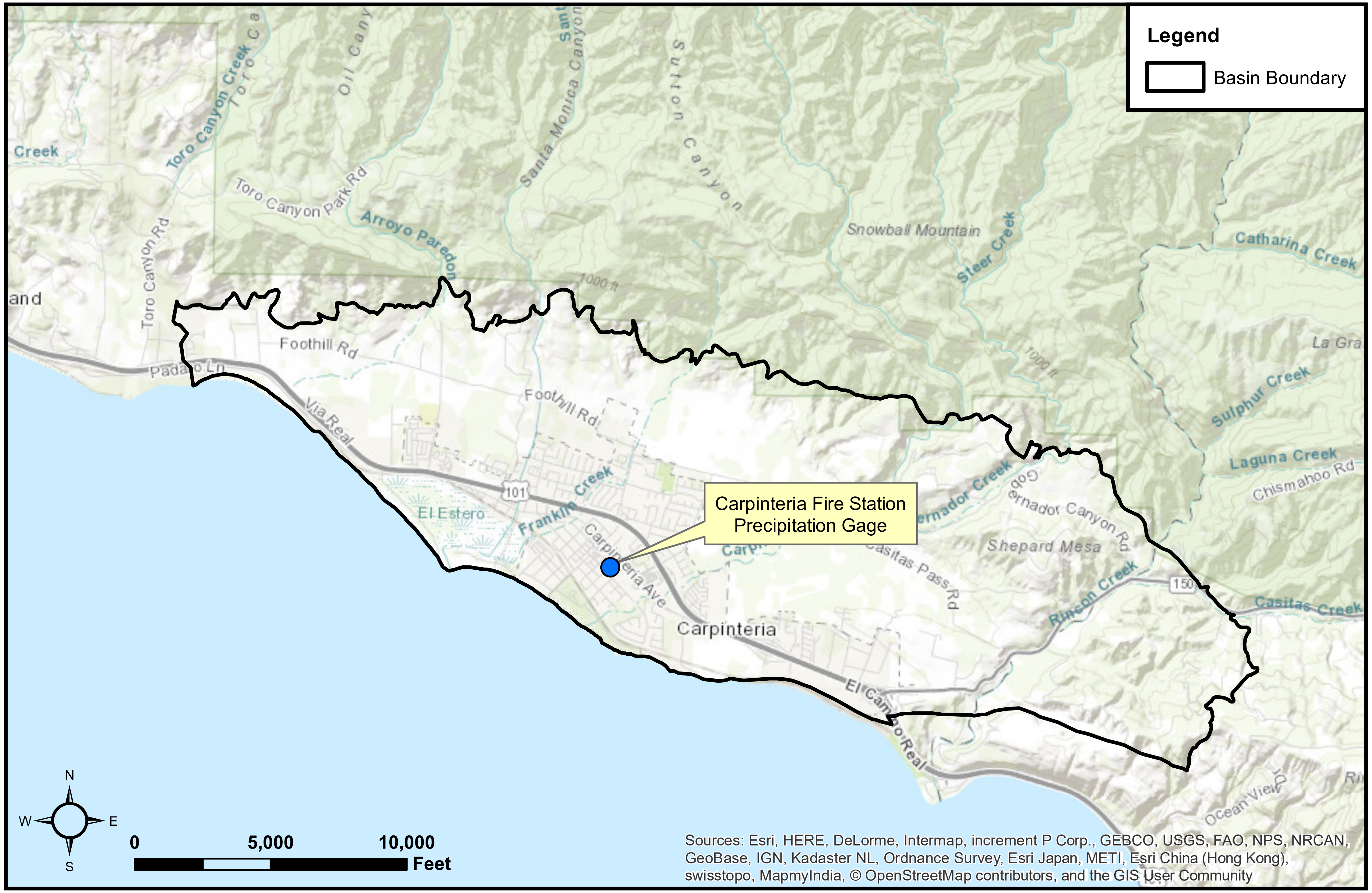

FIGURE 3-62

Rainfall Station Location Map

Carpinteria Basin Groundwater Sustainability Plan

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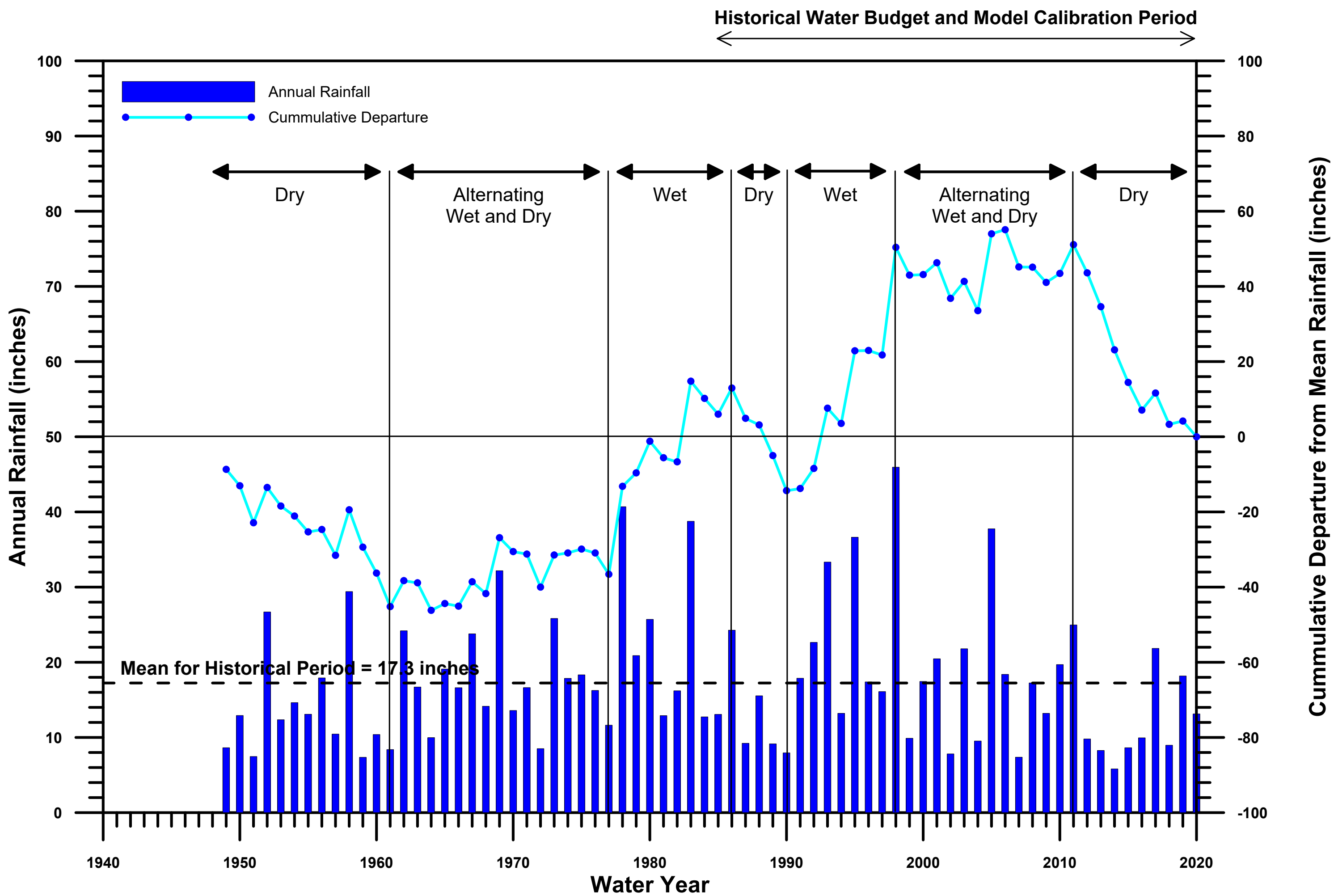


FIGURE 3-63

Historical Annual Rainfall – Carpinteria Fire Station

Carpinteria Basin Groundwater Sustainability Plan

The current drought started in WY 2012 and remains the most severe drought during this period. The period included a single wet year in 2017 and 2019. The current water budget period was selected to be between 2012 and 2020. This period represents a very dry period overall, which—although not as hydrologically balanced as the historical period—is considered representative of the current drought conditions. Precipitation at the Carpinteria Fire Station No. 1 during this period averaged 11.6 inches, which is just 67 percent of the historical period. Section 3.3.4 presents the current water budget information.

The projected water budget for the 53-year period between 2021 and 2072 (inclusive) extends 50 years past the submittal of this GSP. Section 3.3.5 presents the projected water budget information.

Some water budget data are available via direct measurement (e.g., CVWD metered pumping), whereas others require estimation based on commonly used techniques. In general, the techniques used for this GSP are based on methods used by GTC in their 1976 and 1986 water budget inventories, but as modified by PWR in 2012 given the availability of new data and/or analytical tools. The groundwater budget for the Carpinteria Groundwater Basin is expressed by the following equation:

Inflow = Outflow (+/-) Change in Storage

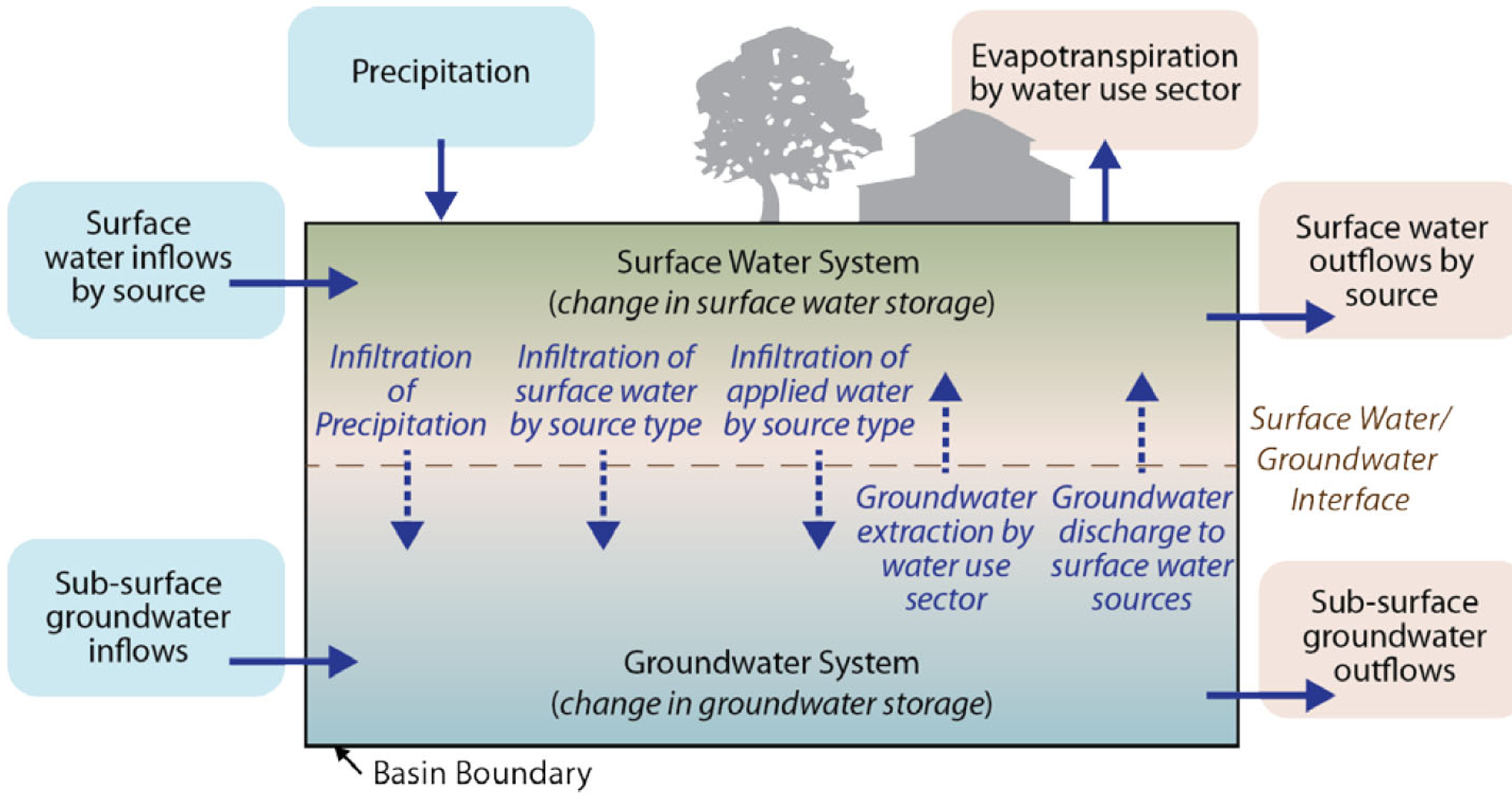
where Inflow equals:

- Percolation of precipitation
- Subsurface inflow from bedrock boundary (mountain front recharge)
- Streambed percolation
- Percolation of irrigation return water (pumped and delivered)
- Subsurface inflow from boundary with Pacific Ocean
- Subsurface inflow from boundary with Montecito Groundwater Basin (MGB)

and Outflow equals:

- Groundwater pumping
- Evapotranspiration by phreatophytes
- Subsurface outflow to boundary with Pacific Ocean
- Subsurface outflow to boundary with MGB

Figure 3-64 presents a general schematic diagram illustrating the hydrologic cycle and various water budget components.



Source: DWR (2016)

FIGURE 3-64

Water Budget Component Schematic

Carpinteria Basin Groundwater Sustainability Plan

3.3.2.1 Water Budget Data Sources

Rainfall Data. Deep percolation of rainfall precipitation is the primary source of inflow/recharge to the Basin, whether it falls directly on the Basin or on adjacent areas and flows into the Basin via the surface or subsurface inflows. The Santa Barbara County Flood Control District maintains precipitation data from the Carpinteria Fire Station No. 1 with a period of record from 1949 to the present. **Figure 3-62** shows the location of the Carpinteria Fire Station No. 1. **Figure 3-63** presents the annual rainfall during the period of record for the station, which is 17.3 inches.

Figure 3-63 shows the cumulative departure of annual rainfall from the long-term mean. The cumulative departure from mean graphs the sum of annual departures over time, beginning with the first-year departure and adding each subsequent year departure. The climatic trends present in the cumulative departure curve exhibit a cyclical series of dry periods (falling segments) and wet periods (rising segments) in the Basin. The historical water budget period coincides with the beginning of a cumulatively dry period that occurred from about WY 1984 through WY 1991, followed by a wet period from WY 1992 through WY 1998, with alternating wet and dry periods from WY 1999 through WY 2011, followed by a cumulatively dry period extending from WY 2012 through WY 2020 (see **Figure 3-63**). The mean annual rainfall for the water budget historical period is 17.0 inches, which is within 2 percent of the long-term historical mean at the station.

Streamflow Data. There are five principal streams in the Basin: Carpinteria, Gobernador, Santa Monica, Arroyo Paredon, and Rincon Creeks. Additional minor drainages include Toro and Franklin Creeks. Only two of these creeks have runoff records—Carpinteria Creek and Franklin Creek. Stream gages have historically been maintained and monitored by the USGS, and the data is stored on the USGS Water Resources website. The Carpinteria Creek gage is the only currently active gage and has essentially continuous data since 1941 (there is a brief hiatus in the record for WY 1978). **Figure 3-2** shows this gage, which is located just downstream of the confluence with Gobernador Creek. Records for Franklin Creek are limited to WY 1971 through 1978. Available data for the other drainages in the Basin are limited to miscellaneous measurements made by the USGS from 1941 to 1945.

GTC (1976) developed a correlation index for each drainage in the Basin to reflect the variation in precipitation with elevation, drainage area, and runoff lost as seepage based on seepage loss measurements made during the 6-year period of WY 1968 through 1973. Runoff from the ungaged streams was then estimated by GTC for WY 1941 through 1984 using these rainfall-runoff relationships. Similar rainfall-runoff relationships have been used to estimate streamflow in the ungaged streams for the historical water budget period of WY 1985 through 2020 for this GSP.

Figure 3-65 presents graphically the total annual measured and estimated surface water discharge from the Basin for the period of record. Total annual discharges range from 0 to as much as 57,700 AFY. The mean annual stream discharge in the Basin (measured plus estimated) for the period of record is 7,078 AFY.

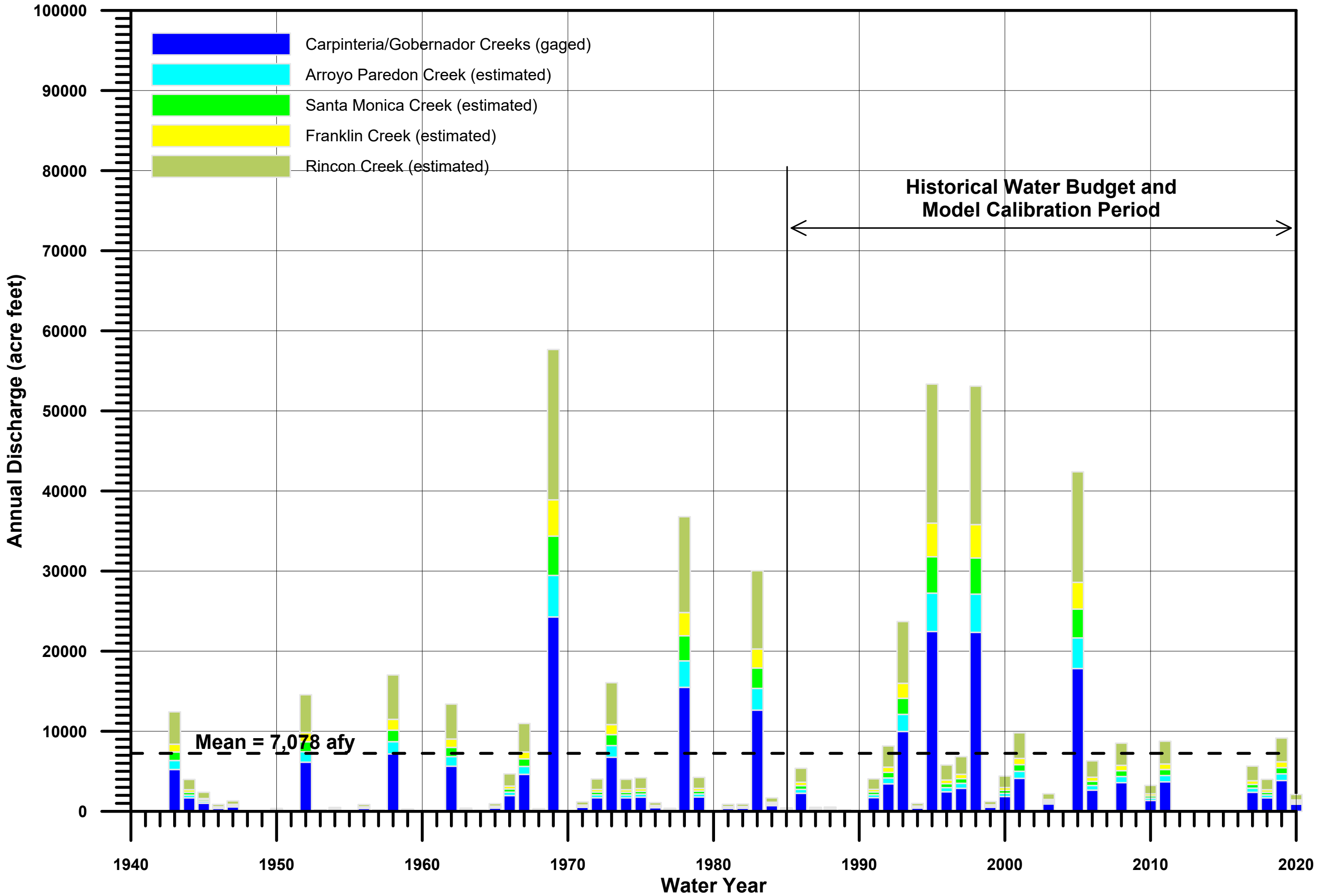


FIGURE 3-65

Historical Annual Streamflow

Carpinteria Basin Groundwater Sustainability Plan

Imported Surface Water Data. Data for surface water imported into the Basin is from CVWD records. The CVWD maintains records on the quantities of water imported into the Basin by CVWD from its Cachuma and State Water Project (SWP) sources.

Numerical Groundwater Flow Model Data. The existing numerical groundwater flow model of the Basin is used to estimate subsurface flows across the basin boundaries with the Pacific Ocean and MGB for the water budgets. The USGS public-domain code MODFLOW-NWT (Niswonger et al., 2011) was used for the basin flow model. MODFLOW-NWT was developed by the USGS as a standalone version of MODFLOW-2005 (Harbaugh, 2005) to better solve nonlinearities of the unconfined groundwater flow equation. The 2012 basin model was calibrated to the period of WY 1985 to 2008 and is documented in the 2012 PWR report. The model has been updated and recalibrated for this GSP by Montgomery & Associates (M&A) for the period of WY 1985 to 2020 and temporally re-discretized from annual to monthly stress periods. The groundwater model update and recalibration results are documented in Appendix F. The water budget has been updated to cover the period of WY 1985 to 2020 and the various components calculated on a monthly basis for the groundwater model input, which have then been aggregated into annual periods for each component discussed in this section.

The majority of the water budget components are calculated outside the model using the approaches to quantify water budget components in the Basin discussed in section 3.3.2.2 and 3.3.2.3, and are implemented in the numerical groundwater model recharge, well, and multi-node well input packages. The recharge (RCH) package is used to define percolation of precipitation, percolation of irrigation water, streambed percolation, and extraction by phreatophytes. The well (WEL) package is used to define the flux of subsurface inflow at the northern boundary. The multi-node well (MNW2) package is used to simulate extraction by groundwater pumping wells. The only components of the water budgets that are calculated by the model are subsurface flows to and from the ocean boundary and across the jurisdictional boundary with the MGB are calculated by the model.

3.3.2.2 Groundwater System Water Budget Methods – Inflows

The methods used to estimate each of the inflow components of the water budget are discussed in the following paragraphs.

Percolation of Precipitation. Percolation of rainfall precipitation is the most important sources of recharge to the Basin. Precipitation recharges the Basin principally through deep percolation to the zone of saturation. The amount of precipitation that percolates downward to the principal aquifer can vary considerably, depending mostly upon the type of soil, density of vegetation, the quantity, intensity and duration of rainfall, the vertical permeability of the soil, and topography. Much of the infiltrating rainfall is held within the root zone because at the beginning of each rainy season there is an initial deficiency of soil moisture. During the summer months the capillary soil moisture is more or less completely depleted from the soil within the root zone by the processes of evaporation and transpiration. No deep percolation of rainfall can occur until the initial fall soil moisture deficiency is exceeded. Many years may pass before any rainfall penetrates beyond the root zone of native vegetation. In irrigated soils, because of the artificial application of water, the initial fall moisture content can be greater and less annual rainfall is required to meet the soil moisture deficiency. Once the soil moisture deficiency within the root zone has been satisfied, the excess precipitation will percolate downward until it eventually reaches the water table.

There are two primary considerations in calculating the volume of precipitation that percolates beyond the root zone and contributes recharge to the Basin’s single principal aquifer: (1) the calculation of deep percolation of rainfall in inches for the various land uses / vegetative covers in the Basin for each year of the period, and (2) the determination of the total area of the various land uses and vegetative covers in the

Basin for each year of the period. The total volume of percolation in acre-feet (AF) is then calculated (i.e., inches of percolation x acreage) for each year of the period.

Deep Percolation. The approach to estimating deep percolation in the Basin uses relationships between annual rainfall and deep percolation made by Blaney (1933) in Ventura County. Although conditions in the Basin are not exactly the same as in Ventura County, it is believed that they are sufficiently similar for the estimates to be valid. Blaney empirically tabulated the amounts of rain that percolated beyond the root zone, depending upon the type of vegetation and amount of seasonal precipitation. Blaney's values of deep percolation (in inches) versus seasonal rainfall have been plotted for land covers similar to those in the Basin, and best-fit curves drawn trough these points (see Figure 3-66). These are referred to as "Blaney Curves." Values of percolation of rainfall corresponding to seasonal rainfall and vegetative cover types in the Basin were calculated from these curves. GTC modified the Blaney Curves to account for deep percolation in years of heavy precipitation when precipitation greatly exceeded the long-term average. Due to the intensity and duration of storms in these years, infiltration can probably not an exceed a maximum amount because of the saturation of the soil within a relatively short period of time and runoff increases greatly; therefore, an upper limit of deep percolation has been fixed at 8 and 15 inches in the unirrigated native and irrigated land use categories, respectively.

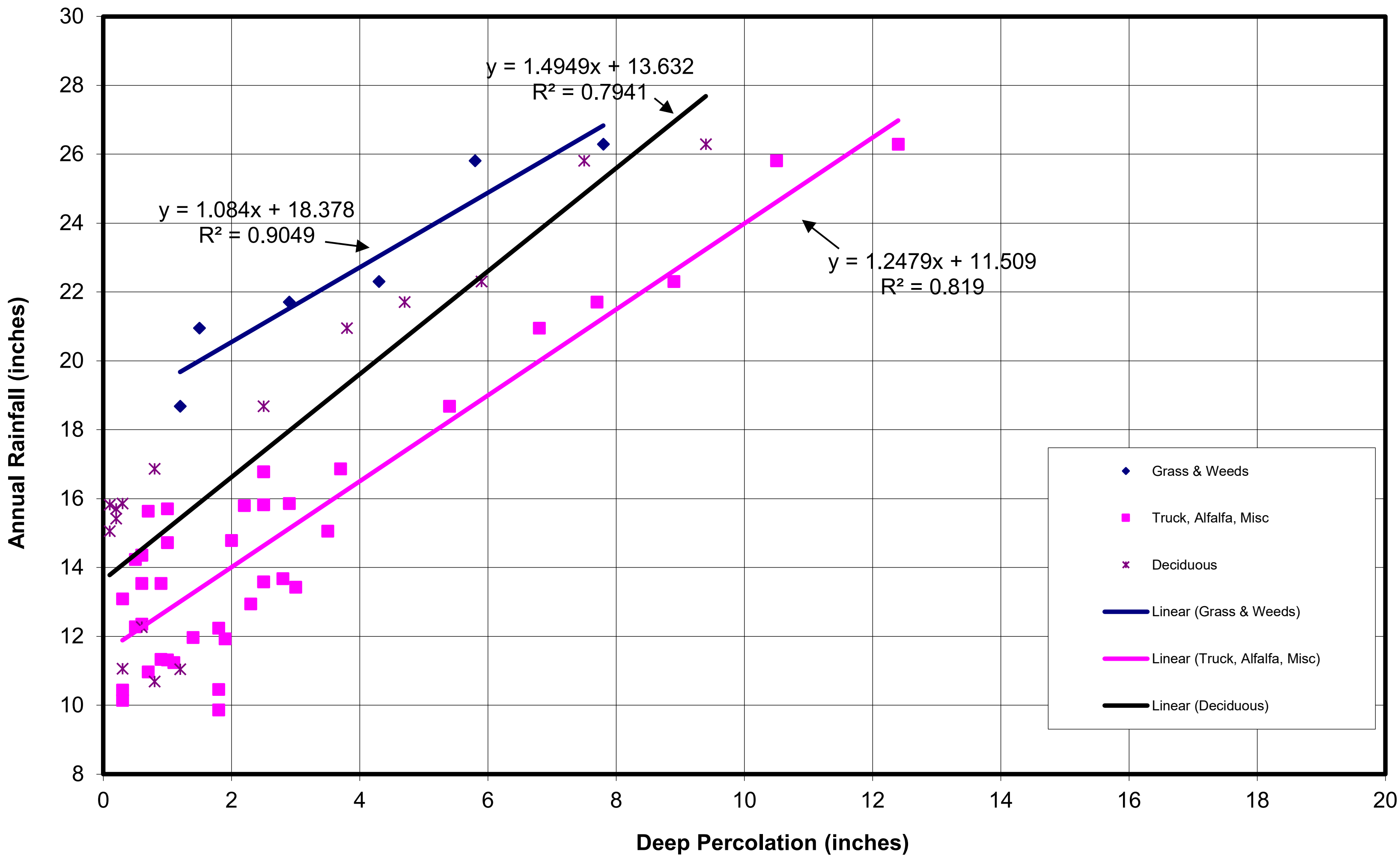


FIGURE 3-66

Annual Rainfall vs Deep Percolation Relationships (Blaney Curves)

Carpinteria Basin Groundwater Sustainability Plan

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Land Use Acreage. The CVWD has estimated land use acreage within its service area boundaries for the period 1984 through 2020. In 2002, the CVWD undertook a comprehensive land use study utilizing a combination of digital imagery, GIS layers of land use and parcel boundaries, and statistical analysis to evaluate land use activities and estimate private well extractions. Prior to 2002, CVWD relied on periodic aerial photography of the Basin and staff to update land use records ("paper cards") when changes in land use activities were noticed as part of other CVWD duties. Since 2002, the land use studies by CVWD have been GIS-based. For the 2012 hydrogeologic update (which covered the period of WY 1985 to 2008), PWR used GIS to intersect land use acreages within the basin boundaries.

Although the CVWD land use surveys do not include areas of the Basin outside its service area boundaries (i.e., the Ventura County portion of the Basin), the land uses in these areas are generally comparable to the land uses present in the Recharge Area within the CVWD service area and are accordingly extrapolated from the CVWD land use data and applied to the entire Recharge Area. For the period WY 1985 to 2001, annual changes in the acreages of each land use category within the Basin were proportioned consistent with annual changes in the percentage of each land use category within the CVWD boundaries as whole. This approach has also been applied to the period of WY 2009 to 2020 as part of annual updates to the basin water budget as part of the Assembly Bill (AB) 3030 program, which are also used for this GSP.

Blaney developed curves for several, but not all of the land cover types that are present in the Basin. **Table 3-5** summarizes the CVWD land use categories and the corresponding Blaney curve used to estimate deep percolation in the Basin.

Table 3-5. Land Use Categories and Blaney Curve Types Summary

Land Use Category	Blaney Curve Used
Native Land	Grass/Weeds
Vacant	
Residential	
Commercial	
Industrial	
Freeway, Railway, Roads, Other	
Irrigated Orchard	Deciduous Crops
Irrigated Crops	Truck Crops, Miscellaneous
Nurseries	
Public Parks, Schools, etc.	
Polo Grounds, Horse Stables	

As shown on **Table 3-5**, Blaney's curve for grass and weeds is used for the residential/commercial/industrial areas. While the actual land use is very different, the grass and weeds curve is considered reasonable because the amount of deep percolation occurring on grass and weeds is the most limited of all the Blaney Curves, due primarily to the large initial soil moisture deficiencies. Due to the presence of impervious surfaces in the residential/commercial/industrial areas where no percolation can occur and much of the rainfall runs off, a relatively limited amount of deep percolation is expected to occur in these areas. The Blaney Curve for irrigated crops land covers was used for the public parks/schools/polo grounds areas in the Basin. Again, it is acknowledged that the actual land use underlying these areas is somewhat different than those shown on **Table 3-5**. The curve for irrigated truck crops was considered to better reflect the deep percolation conditions on irrigated turf, primarily due to the similarly shallow rooting depths, as compared to, for example, deciduous crops with relatively deep rooting depths.

Table 3-6 presents CVWD land use survey data for the various land use categories present in the Basin during the historical water budget period.

Table 3-6. Carpinteria Valley Water District Land Use Survey Data Summary

Water Year	Land Use Acreage within the Basin											
	Native	Irrigated Orchard	Irrigated Crops	Nurseries	Vacant	Residential	Commercial	Industrial	Public Parks, Schools, etc.	Polo Grounds	Roads etc.	Total
1985	1,683	2,465	6	775	650	1,078	129	67	456	0	670	7,980
1986	1,652	2,416	9	772	713	1,082	130	67	463	0	675	7,980
1987	1,646	2,342	8	835	724	1,091	132	67	466	0	668	7,980
1988	1,616	2,275	8	857	770	1,097	132	67	484	0	673	7,980
1989	1,615	2,311	24	841	681	1,110	138	69	486	0	706	7,980
1990	1,571	2,300	58	858	660	1,127	139	69	489	0	707	7,980
1991	1,571	2,272	100	862	628	1,133	139	69	491	0	715	7,980
1992	1,575	2,263	86	859	652	1,137	137	69	498	0	705	7,980
1993	1,578	2,257	58	861	680	1,145	138	69	497	0	696	7,980
1994	1,572	2,223	106	843	693	1,153	141	69	490	0	689	7,980
1995	1,507	2,173	78	948	693	1,188	152	73	446	0	721	7,980
1996	1,504	2,161	95	953	681	1,192	152	73	447	0	722	7,980
1997	1,498	2,127	110	911	735	1,193	146	75	457	0	728	7,980
1998	1,496	2,118	136	887	733	1,200	147	76	457	0	730	7,980
1999	1,496	2,113	137	887	732	1,203	148	77	457	0	730	7,980
2000	1,659	2,087	129	836	619	1,186	148	77	405	40	794	7,980
2001	1,822	2,060	121	784	507	1,169	148	77	353	80	859	7,980
2002	1,986	2,033	114	732	394	1,152	147	77	301	120	924	7,980
2003	2,048	2,011	128	733	365	1,063	147	75	273	127	1,009	7,980
2004	2,048	2,011	128	733	365	1,063	147	75	273	127	1,009	7,980
2005	2,055	2,013	144	716	349	1,063	148	75	352	139	925	7,980
2006	2,055	2,013	144	716	349	1,063	148	75	352	139	925	7,980
2007	2,055	2,013	144	716	349	1,063	148	75	352	139	925	7,980
2008	1,895	1,863	129	720	312	1,033	144	72	322	146	1,344	7,980
2009	1,895	2,053	133	720	339	1,033	144	72	322	146	1,124	7,980
2010	1,895	2,053	133	720	350	1,079	161	78	322	146	1,044	7,980
2011	1,895	2,053	133	720	350	1,079	161	78	322	146	1,044	7,980
2012	1,949	2,055	193	654	350	1,079	161	78	322	146	994	7,980
2013	1,949	2,055	193	654	350	1,079	161	78	322	146	994	7,980
2014	1,949	2,055	193	654	350	1,079	161	78	322	146	994	7,980
2015	1,961	2,041	174	637	319	1,079	161	78	322	165	1,043	7,980
2016	1,961	2,041	174	637	319	1,079	161	78	322	165	1,043	7,980
2017	1,954	1,940	191	590	289	1,079	161	78	322	229	1,147	7,980
2018	1,954	1,940	191	590	289	1,079	161	78	322	229	1,147	7,980
2019	1,954	1,940	191	590	289	1,079	161	78	322	229	1,147	7,980
2020	1,957	2,153	210	504	275	1,044	141	71	420	178	1,028	7,980

Recharge from deep percolation of precipitation in the Confined Area has been included in the numerical model. The HCM and analytic water budget approach balances for all groundwater in the Basin regardless of location: the groundwater model must account for water at every unique location in the model. Therefore, even small amounts of recharge from precipitation in the Confined Area need to be accurately modeled in order to avoid model numerical instability. Accordingly, the deep percolation of precipitation calculations presented in this GSP are consistent with the groundwater model inputs for the entire Basin and are inclusive of both the Recharge and Confined Areas.

Subsurface Inflow (mountain front recharge). The subsurface inflow component is flow from consolidated rocks in the hill and mountain areas generally adjacent to the northern basin boundary (subsurface inflow across the basin boundary with MGB is separate from this component). As discussed by Upson (1951) and Evenson (1962), underflow from the consolidated rocks must be considered as a source of recharge to the Basin. Studies conducted by DWR (Bulletin Nos. 104 and 104-2) similarly concluded that such components of recharge cannot be ignored. Amounts of subsurface inflow to the Basin were estimated in the 1976 GTC report using several interrelated methods of analysis, including:

- Total precipitation less surface runoff and consumptive use
- Natural water loss and recoverable water from mountain basins (the so-called Crippen methodology)
- Base flow regression curves
- Comparison of Tecolote tunnel inflow volumes and Darcy's Law

Data on groundwater gradients, average seasonal volumes of runoff, and consumptive use of native vegetation in the watershed areas tributary to the Basin are subject to considerable uncertainty and interpretation. However, each of the methods of analysis essentially limited the amount of water that can theoretically be available as a source of recharge to the Basin. Based on the GTC analysis, the upper limit of subsurface inflow was estimated to be 1,100 AFY. A direct relationship between subsurface inflow and annual precipitation was developed from the GTC analysis by PWR (2012), and seasonal amounts of subsurface inflow are estimated based on a simple regression curve calculation from the GTC relationships of average annual rainfall to subsurface inflow in any given year. Figure 3-67 presents a graph of the relationship between annual rainfall and estimated subsurface inflow.

This relationship was estimated based on the previous basin boundary and associated groundwater model domain, which includes the Toro Canyon Area. For this GSP water budget, this relationship was adjusted proportionally based on the watershed areas at the northern basin boundary at the present basin boundary (i.e., the Toro Canyon area was removed from the calculations for the Basin presented in this GSP).

Streambed Percolation. Streambed percolation in the Basin is assumed to occur only where the stream reaches cross the Recharge Area (see Figure 3-9). Once streamflow reaches the Confined Area, the amount of deep percolation to the principal groundwater aquifer is assumed to be insignificant. The 1976 GTC study included an analysis of annual runoff and seepage losses for streams in the Basin and developed annual runoff versus streambed percolation relationships for each individual stream in the Basin, and these same relationships are used for this GSP. Figure 3-68 presents a graph of the relationships between annual stream runoff and estimated streambed percolation.

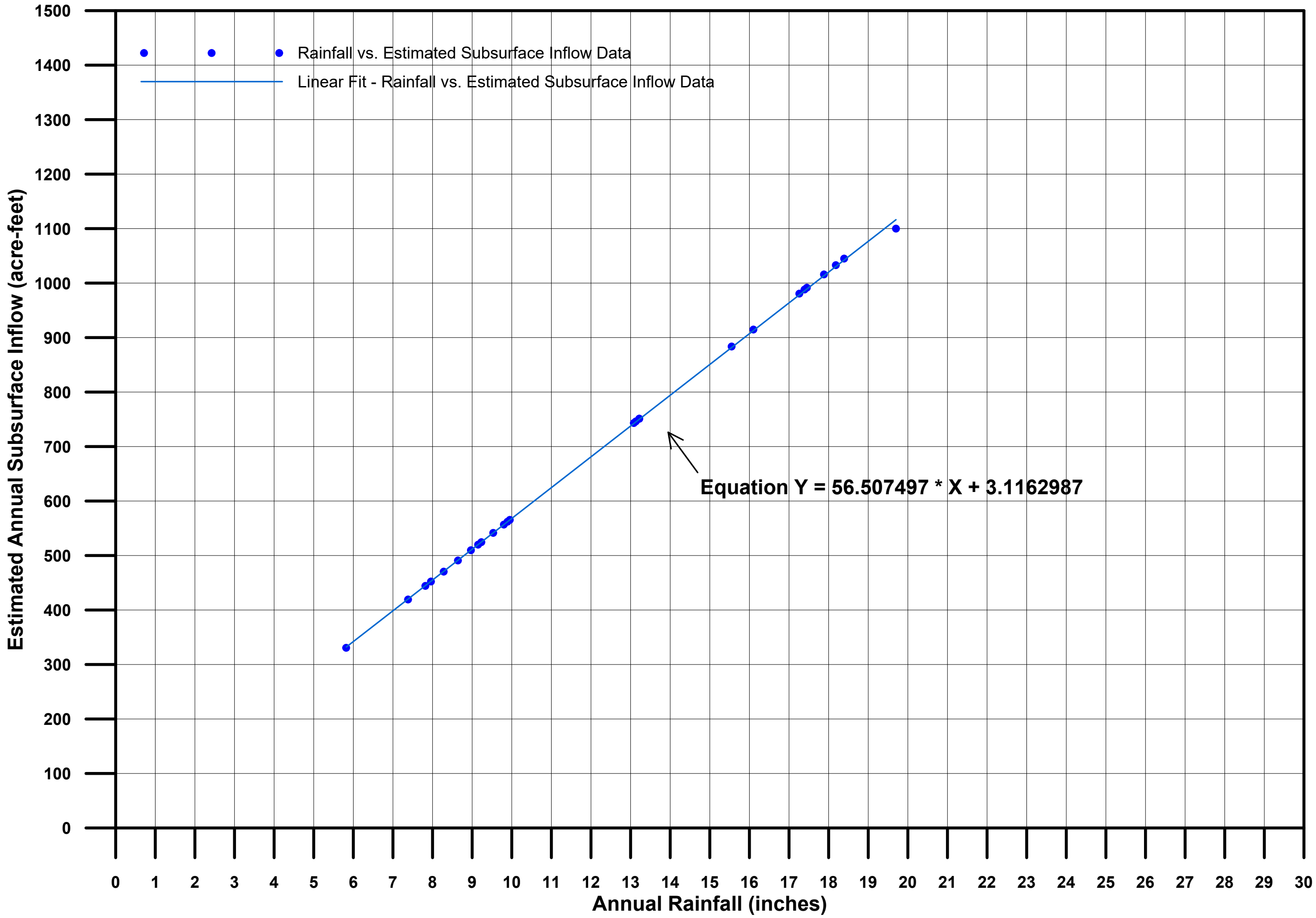

FIGURE 3-67

Annual Rainfall vs. Estimated Subsurface Inflow Relationship

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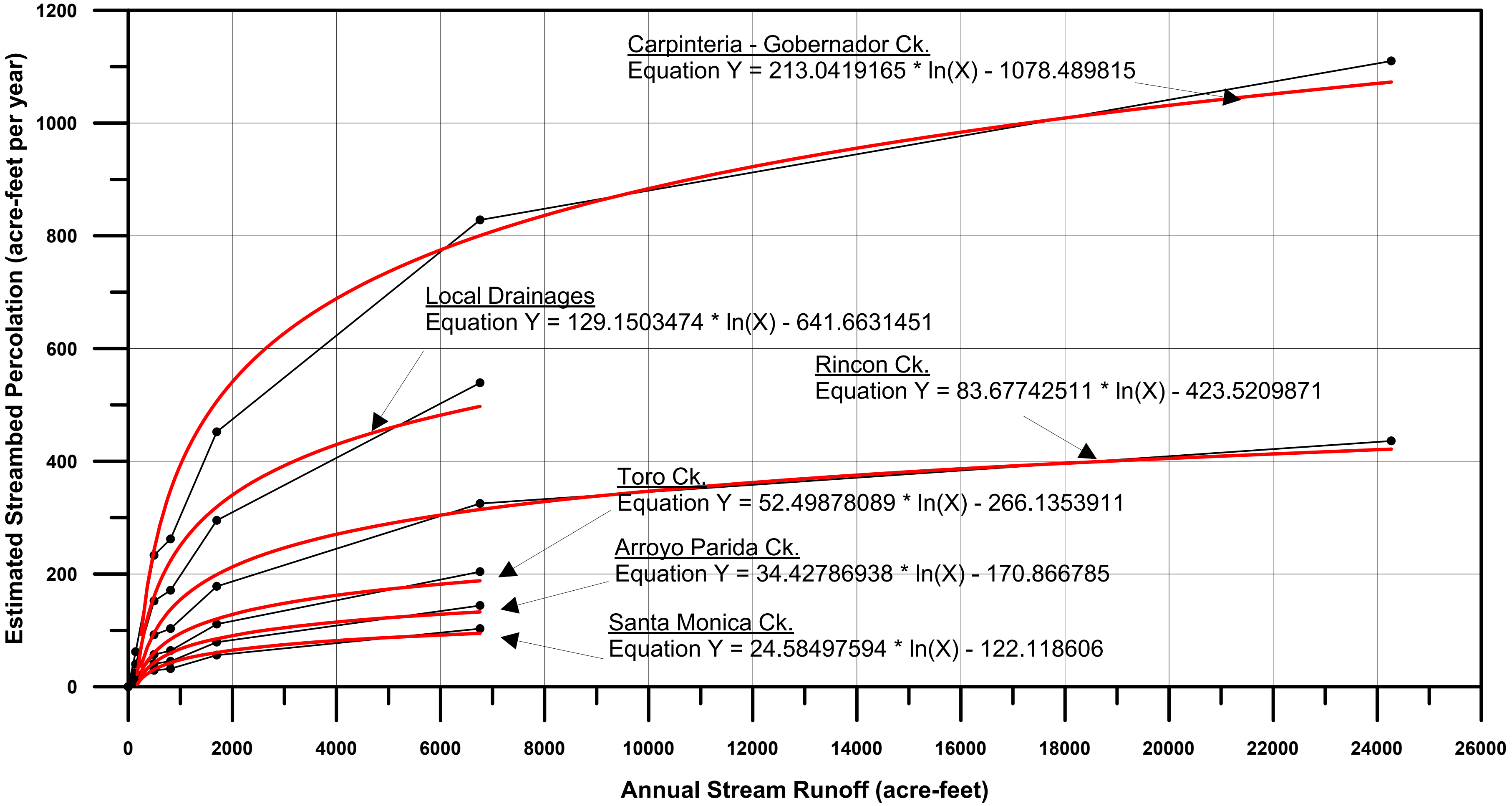

FIGURE 3-68

Estimated Annual Runoff vs. Streambed Percolation Relationships

Carpinteria Basin Groundwater Sustainability Plan

Most of Toro Creek is no longer included in the Basin as a result of the 2018 Basin Boundary Modification. In addition, the reaches of both Santa Monica and Franklin Creeks that cross the Recharge Area were channelized into concrete-lined box channels as part of the Carpinteria Valley Watershed Project in 1974; therefore, these two streams are considered to no longer recharge the Basin in a significant way and are not included in the water budget calculations.

Percolation of Irrigation Water. Percolation of irrigation return water (i.e., "return flows") in the Basin is dependent on a variety of factors, including climatic factors, crop type, and irrigation practices. An estimate of the amount of irrigation return water was one of the primary objectives of studies conducted in the Lompoc area by Blaney in 1962. The study area was within the coastal zone where consumptive use is depressed due to the influence of the coastal fog belt, similar to conditions in the Basin. The studies were also conducted on crops with consumptive use factors similar to those in the Basin. The results indicated irrigation efficiencies ranged varied from 60 to 80 percent. In addition, studies by the U.S. Soil Conversation Service for Santa Barbara County indicate irrigation efficiencies, under good practice, range from 65 to 70 percent. For the purposes of estimating deep percolation of irrigation return water in the Basin, a conservative factor of 20 percent of applied water (both pumped and delivered) is used. This factor takes into account the relatively steeper slopes found in many portions of the Recharge Area within the Basin, and hence greater amounts of runoff, as well as the relatively more efficient sprinkler-type irrigation commonly used in the Basin.

Water provided for residential, municipal, and industrial land uses (and the associated water distribution system losses) occur primarily in the developed area of the City of Carpinteria, which is located in the Confined Area (whereas agricultural land is primarily located in the Recharge Area). As discussed previously, downward percolation of water in the Confined Area is limited due to the presence of fine-grained low-permeability materials overlying the principal aquifer of the Basin; therefore, the approaches to quantifying the water budget in the Basin assume that the contributions of such losses to basin recharge are relatively insignificant and are ignored.

MGB Boundary Inflows. Groundwater inflows across the jurisdictional boundary with the MGB are calculated by the calibrated groundwater flow model of the Basin.

3.3.2.3 Groundwater System Water Budget Methods – Outflows

The methods used to estimate each of the outflow components of the water budget are discussed in the following paragraphs.

Groundwater Pumping. Groundwater extractions from the Basin occur from both CVWD production wells and from approximately 50 to 170 private wells in any given year and constitute the primary source of outflow from the Basin. CVWD well production is metered, and monthly totals of production from each of the five CVWD wells have been obtained for the period of 1985 through 2020, which have been aggregated by water year for the historical water budget for this GSP.

Private pumping in the Basin is not metered and has been estimated on an annual basis by CVWD since 1984 using land use survey and CVWD's water sales records. CVWD supplies imported water and/or local groundwater to numerous agricultural parcels of known acreage and crop type (e.g., avocados, cherimoyas, and open and covered nurseries). From these metered deliveries, unit use values (known by CVWD as "determining factors") for various crop types have been estimated each year since 1984. These unit use values have been combined by CVWD with land use acreage data to estimate private well production in the Basin.

As mentioned previously, in 2002 the CVWD undertook a comprehensive land use study for the first time using a combination of digital imagery, GIS layers of land use and parcel boundaries, and statistical analysis to evaluate land use activities and estimate private well extractions. For this GSP, estimates of monthly pumping were assigned to individual private wells in the Basin by CVWD by intersecting land use "determining factors," acreages of land use per parcel (APN numbers), and well IDs by APN for each month from WY 1985 to 2020.

Subsurface Outflow. Groundwater outflow from the Basin has previously been assumed to occur only through shallow alluvial sediments where they are in contact with the ocean boundary. For previous water budget updates performed for the CVWD (e.g., the PWR 2012 update and subsequent AB 3030 annual updates), the quantity of subsurface outflow has been calculated using Darcy's Law, in which the rate of discharge through a given cross section of saturated material is proportional to the seaward hydraulic gradient. For this GSP, however, subsurface outflow at the basin boundary with the Pacific Ocean as calculated by the updated and re-calibrated groundwater model (see Appendix F) is used in the water budget calculations instead of the values derived from the more simplistic Darcy-based calculations, and includes subsurface outflow for all depths in the Basin at the boundary.

Phreatophyte Transpiration. Phreatophytes are water loving plants (i.e., plants with roots that extend into the water table) that live in the vicinity of stream channels and in areas of high groundwater. Groundwater consumed by phreatophytes is dependent on many factors, including plant species, vegetative density, climate, soil, and depth to groundwater. Direct measurements of consumptive use by phreatophytes in the Basin do not exist. GTC (1976) roughly estimated phreatophyte transpiration for the Basin by applying results of a 5-year study in San Diego County using the Blaney-Criddle formula (Blaney and Criddle, 1963). Phreatophyte transpiration was estimated to be approximately 120 to 130 AFY from the 1930s through 1970, then reduced by GTC to approximately 100 AFY as a result of removal of phreatophytes from the Santa Monica and Franklin Creek channels that occurred as part of the flood control channelization projects in 1974. It has been further reduced for this GSP because most of Toro Creek was eliminated from the Basin as a result of the 2018 Basin Boundary Modification and accordingly assumed that phreatophyte transpiration is 89 AFY.

MGB Boundary Outflows. Groundwater outflows across the jurisdictional boundary with the MGB are calculated by the calibrated groundwater flow model of the Basin.

Evapotranspiration. The only historical evapotranspiration data available in the area is from the California Irrigation Management Information System (CIMIS) Santa Barbara station (Station 107), which has a period of record limited to April 1993 through the present. The missing years of historical data is insignificant for the water budget calculation methodology used here because it accounts for evapotranspiration indirectly, rather than directly. As discussed above, estimates of deep percolation of precipitation in the Basin are made using relationships developed by Blaney (1933). Blaney's values of deep percolation versus annual rainfall mean that the amount of annual rainfall that does not infiltrate as deep percolation is lost to evapotranspiration and/or replenishes deficient soil moisture using this method. In addition, estimates of evapotranspiration from phreatophytes are roughly estimated at 100 AFY and do not vary from year to year, which is acknowledged to be an oversimplification, but is nonetheless based on the best available information.

Summary of Water Budget Data Sources. Table 3-7 presents a summary of the water budget components discussed above, and their associated qualitative uncertainty ratings.

Some minor water budget components that may be present in the Basin are considered to represent relatively insignificant components to the groundwater system ignored by both past approaches and this Plan's approach to the water budget for the Basin, including the following:

- **Rural domestic pumping and septic return flows.** The CVWD land use and private pumping estimation methodology does not consider rural domestic consumption separately from agricultural pumping in the Recharge Area as it is considered to be a de minimis factor. Associated septic return flows are similarly considered a de minimis factor.
- **Losses from potable water and sewer piping systems.** The CVWD potable water distribution system and the Carpinteria Sanitary District sewer piping system are largely associated with urban and industrial land uses that are located primarily within the City of Carpinteria, which overlies the Confined Area of the Basin. As discussed in Section 3.1, in the Confined Area, downward percolation of water is limited due to the presence of fine-grained low-permeability materials overlying most of the area of the principal aquifer; therefore, losses from these systems are considered de minimis factors.
- **Percolation of urban irrigation.** Similar to the consideration of losses from potable water and sewer piping systems, urban land uses occur primarily in the Confined Area; therefore, downward percolation of urban irrigation flows is considered to be limited and represents a de minimis contribution to the principal aquifer of the Basin.

It is also acknowledged that shallow groundwater present in the Confined Area is not considered a principal aquifer of the Basin as discussed in Section 3.1, and for that reason, the details of the inflows/outflows of shallow groundwater in the Confined Area was not further investigated for this GSP.

Table 3-7. Water Budget Data Source Summary

Water Budget Component	Source of Data	Comments	Qualitative Uncertainty
Rainfall	Santa Barbara County	Measured at Carpinteria Fire Station No. 1	Gaged - Low
Subsurface Inflow	GTC (1976) methodology	Methods described in text	Estimated - Medium
Streambed Percolation	GTC (1976) methodology	Methods described in text	Estimated - Medium
Percolation of Precipitation	GTC (1976) methodology	Methods described in text	Estimated - Medium
Percolation of Irrigation Water	GTC (1976) methodology	Methods described in text	Estimated - Medium
MGB Boundary Flows	Numerical Groundwater Flow Model	Simulated from calibrated model	Calibrated Model - Medium
Subsurface Outflow to Ocean	Numerical Groundwater Flow Model	Simulated from calibrated model	Calibrated Model - Medium
CVWD Pumping	CVWD	Metered and recorded by CVWD	Metered - Low
Private Pumping	CVWD	Methods described in text	Estimated - Medium
Transpiration by Phreatophytes	GTC (1976) methodology	Methods described in text	Estimated - High

Notes

CVWD = Carpinteria Valley Water District

GTC = Geotechnical Consultants

MGB = Montecito Groundwater Basin

3.3.3 Historical Water Budget [§ 354.18(c)(2)(B)]

> **§354.18 Water Budget.**
>
> **(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:**
>
> **(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:**
>
> **(B) A quantitative assessment of the historical water budget, starting with the most recently available information and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and project future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon.**

As discussed in Section 3.3.2, WY 1985 to 2020 was selected as the historical water budget period primarily because the data sources needed to support the approach to quantifying water budget components in the Basin are available, in particular, CVWD land use data and private pumping estimates. The 36-year period selected for the historical water budget includes the most recently available information, recent changes in imported water supply availability, changes to water demand associated with cropping patterns, and associated land use. It coincides with the groundwater model calibration period and is long enough to capture typical climate variations (with one wet, two dry and one alternating wet and dry hydrologic cycles) and includes recent changes in imported water supply availability, changes to water demand associated with cropping patterns, and associated land use.

This historical period allows for the identification of long-term trends in basin supply and demand, water level trends, changes of groundwater in storage, and estimates of the annual components of inflow and outflow to the groundwater system. This information is fundamental to input into the numerical groundwater flow model (see Appendix F).

Total Surface Water Entering and Leaving the Basin by Water Source Type. SGMA regulations require an accounting of total surface water entering and leaving the Basin by water source type. The inflow and outflow of surface water to the Basin is required to be annually quantified as a total annual volume according water source type from which water is derived to meet the applied beneficial uses. There are no known surface water diversions from basin creeks; therefore, surface water sources entering the Basin that are applied to beneficial uses are limited to the following sources:

- Imported local supplies from the Cachuma Project
- Imported supplies from the SWP

The CVWD imports surface water supplies from the Cachuma Project and the SWP. Imported water was first made available to the CVWD in 1956 from the Cachuma Project and water from the SWP was first made available in 1997. The CVWD distributes imported water to commercial, industrial, institutional, residential, and agricultural customers within its boundaries. The CVWD's maximum local surface water allocation from the Cachuma Project is currently 2,813 AFY, while the long-term average is estimated to be approximately 1,970 AFY. Maximum allocation from the SWP is 2,200 AFY (including 200 AF of drought buffer), while the long-term average is estimated to be approximately 876 AFY (Woodard & Curran, 2021). Table 3-8 presents a breakdown of the annual deliveries from each of these sources to agricultural users. Application of native surface water sources in the Basin is limited to streambed percolation to the groundwater system.

Table 3-8. Summary of Carpinteria Valley Water District Delivered Water

Water Year	Annual Water Delivered (af)		
	Cachuma Project	State Water Project	Pumped Groundwater
1985	1,110	0	560
1986	865	0	613
1987	1,160	0	785
1988	1,049	0	695
1989	1,064	0	1,008
1990	757	0	1,201
1991	402	0	889
1992	718	0	410
1993	711	0	292
1994	766	0	316
1995	671	0	290
1996	686	0	362
1997	793	0	322
1998	728	0	126
1999	1,009	0	85
2000	869	0	410
2001	949	0	49
2002	989	0	145
2003	821	158	106
2004	761	208	246
2005	744	30	259
2006	745	0	303
2007	790	27	390
2008	989	69	229
2009	751	5	452
2010	737	0	257
2011	638	0	294
2012	939	0	276
2013	1,163	15	192
2014	791	359	317
2015	280	143	818
2016	327	82	865
2017	151	627	383
2018	217	404	726
2019	589	229	289

Water Year	Annual Water Delivered (af)		
	Cachuma Project	State Water Project	Pumped Groundwater
2020	1,000	0	289

SGMA regulations also require that the annual volume of applied surface water be quantified according to the appropriate water use sector. The water use sectors that apply imported surface water to meet beneficial uses in the Basin include the following:

- Urban
- Industrial
- Agricultural

CVWD maintains records of imported supplies and deliveries in the Basin. Table 3-9 summarizes the annual accounting of surface water entering and leaving the Basin (including native local creeks).

Table 3-9. Summary of Surface Water Entering and Leaving the Basin (Water Years 1985 to 2020)

Water Year	Inflows (acre-feet)			Outflows (acre-feet)			
	Local Creeks	Cachuma Project	State Water Project	Local Creeks	Applied Water Use		
					Urban	Industrial	Agricultural
1985	476	3,637	0	424	2,358	164	2,875
1986	6,193	2,868	0	5,382	2,296	136	2,544
1987	581	3,492	0	503	2,536	157	3,349
1988	629	3,533	0	532	2,498	154	3,002
1989	210	3,148	0	186	2,454	160	3,568
1990	36	2,150	0	32	2,151	118	3,231
1991	4,783	1,364	0	4,065	1,821	113	2,186
1992	9,120	2,733	0	8,171	2,065	116	2,099
1993	25,004	3,073	0	23,703	2,131	120	1,972
1994	1,303	3,173	0	992	2,225	139	2,089
1995	54,920	2,983	0	53,349	2,175	129	1,905
1996	6,629	2,946	0	5,794	2,071	144	1,979
1997	7,732	3,245	0	6,842	2,358	138	2,178
1998	54,662	3,325	0	53,093	2,048	124	1,704
1999	1,610	4,026	0	1,227	2,223	139	2,080
2000	5,148	2,991	0	4,404	2,290	128	2,253
2001	10,808	3,550	0	9,799	2,135	121	1,799
2002	55	3,792	0	49	2,207	126	2,035
2003	2,707	3,125	600	2,194	2,165	136	1,945
2004	20	3,090	844	18	2,112	124	2,141
2005	43,884	3,309	132	42,390	2,022	128	1,789
2006	7,170	2,755	0	6,307	1,942	122	1,799
2007	78	2,873	100	70	2,150	134	2,147

Water Year	Inflows (acre-feet)			Outflows (acre-feet)			
					Applied Water Use		
	Local Creeks	Cachuma Project	State Water Project	Local Creeks	Urban	Industrial	Agricultural
2008	9,472	2,853	200	8,509	2,215	109	2,210
2009	124	2,700	17	112	2,086	90	1,929
2010	3,884	3,033	0	3,241	1,956	70	1,634
2011	9,738	2,658	0	8,766	1,933	72	1,573
2012	61	3,448	0	55	2,035	83	1,930
2013	2	3,888	50	2	2,104	83	2,140
2014	58	2,613	1,185	48	1,988	80	2,287
2015	2	889	456	2	1,584	67	1,981
2016	0	1,042	261	0	1,563	64	2,019
2017	6,484	490	2,028	5,656	1,525	60	1,834
2018	4,709	675	1,254	3,997	1,746	71	2,094
2019	10,142	1,925	747	9,156	1,643	73	1,732
2020	2,544	3,077	0	2,110	1,799	65	1,987
Minimum	0	490	0	0	1,525	60	1,573
Maximum	54,920	4,026	2,028	53,349	2,536	164	3,568
Average	8,083	2,791	219	7,533	2,073	113	2,167

Inflows, Outflows and Change in Storage of Groundwater System. A tabular summary of the historical water budget inventory for the WY 1985 to 2020 period by water year is presented in **Table 3-10** and graphically on **Figure 3-69.** A summary of the annual minimum, maximum, and average volumes for each water budget component is presented in **Table 3-11** and the inflow and outflow averages are presented graphically as a paired bar chart on **Figure 3-70.** Mean annual inflow during the historical period was estimated at approximately 3,786 AFY and mean annual outflow estimated at 5,111 AFY, resulting in a mean annual deficit (i.e., groundwater storage reduction) of 1,324 AFY over the 36-year historical water budget period.

Deep percolation of precipitation represents the largest source of inflow to the Basin, constituting approximately 42 percent of the total, averaging approximately 1,572 AFY. During wet years (e.g., 1993, 1995, 1998, and 2005) when average annual rainfall exceeds approximately 30 inches, over 7,000 AF of annual deep percolation can occur; however, during dry years, when average annual rainfall is less than approximately 10 inches, zero deep percolation occurs.

Groundwater pumping represents the largest source of outflow from the Basin, representing approximately 87 percent of the total (28 and 59 percent by the CVWD and private pumpers, respectively). CVWD historical pumping has ranged between a low of 185 AFY to a high of approximately 3,400 AFY, in response to CVWD customer demands and the availability of its other sources of supply (e.g., Cachuma Project water) during the period. Estimated private agricultural pumping has experienced an overall increasing trend during the period, with pumping levels of around 1,000 to 2,000 AFY during the mid-1980s increasing to as much as approximately 4,440 AFY in recent years, reflecting both an increase in overall acreage of irrigated crops in production as well as deficient rainfall conditions, which increased irrigation demands during the drought period of WY 2012 to 2020.

Subsurface outflow across the basin boundary with ocean as calculated by the groundwater model ranges from as little as approximately 190 AFY during dry years to as much as approximately 1,000 AFY during wet years (e.g., WY 1998). Subsurface inflow across the basin boundary with the ocean ranges from as little as approximately 40 AFY to as much as approximately 800 AFY. During extended drought periods, inflows across the basin boundary increase relative to wet periods as result of below sea level water- level conditions in the central portion of the Basin. For example, during the later years of the previous drought (WY 1990 and 1991), inflows across the boundary were as much as approximately 500 AFY, compared to as little as approximately 40 AFY during wet periods such as WY 1998. Similarly, during the later years of the current extended drought period, during WY 2015 through 2020 inflow from across the basin boundary with the ocean ranged between approximately 600 to 800 AFY. As discussed in Section 3.1, basin sediments are known to extend some distance offshore. The location of the freshwater/seawater interface offshore is not known, and while there is undoubtedly some amount of freshwater in groundwater storage offshore, these model results indicate the potential for seawater intrusion into the Basin to occur during these conditions.

Subsurface inflow to the Basin across the western boundary with the MGB is relatively limited, ranging between approximately 50 to 428 AFY, averaging approximately 101 AFY (see Table 3-11).

Variability in the components of the water budget is directly influenced by annual variations in climatic conditions. During the historical period, two full periods of wet and dry climatic cycles were evident. During dry climatic periods (drought), the amount of recharge was relatively low. For example, during the drought between 2012 and 2016, recharge from precipitation and mountain front recharge were reduced significantly, to near zero. The graph indicates that the drought resulted in a substantial net reduction of groundwater in storage. The variability within the water budget generally follows the trends evident in observed groundwater level wells, which are presented as hydrographs in Figures 3-25 through 3-29.

In contrast, wet conditions prevailed in the early 1990s, and the amount of recharge and streamflow percolation was relatively high. The net result during these periods was a gain of groundwater in storage.

The water budget for the historical period is also influenced by the amount of groundwater pumping that occurs. Over the historical period, the total amount of groundwater pumping was variable, with CVWD pumping generally decreasing since the early 1990s, and private well pumping generally increasing since the early 1990s (see Figure 3-69).

Table 3-10. Historical Water Budget Inventory (Water Years 1985 to 2020)

Water Year	Water Year Type	Rainfall (inches)	Inflow (AFY)								Outflow (AFY)						Change in Storage (AFY)	
			Subsurface Inflow	Streambed Percolation	Percolation of Precipitation	Percolation of Irrigation Water		MGB Boundary Inflows	Subsurface Inflow from Ocean	Total Inflow	MGB Boundary Outflows	Subsurface Outflow to Ocean	Groundwater Pumping		Phreatophyte Transpiration	Total Outflow		
						Delivered	Pumped						CVWD	Private			Year	Cumulative
1985	Dry	13.08	734	53	119	290	77	428	95	**1,798**	140	1,023	1,836	1,016	89	**4,105**	-2,307	**-2,307**
1986	Below Normal	24.28	1,087	827	4,152	257	111	170	113	**6,716**	75	786	2,032	1,184	89	**4,166**	2,551	**244**
1987	Dry	9.23	518	82	0	338	96	103	152	**1,289**	42	613	2,363	1,057	89	**4,163**	-2,875	**-2,631**
1988	Dry	15.55	873	102	564	303	107	56	194	**2,199**	41	519	2,342	1,193	89	**4,185**	-1,986	**-4,616**
1989	Dry	9.15	514	24	0	360	163	62	327	**1,451**	27	409	2,984	1,703	89	**5,213**	-3,762	**-8,378**
1990	Critical	7.96	447	4	0	341	209	73	485	**1,559**	22	334	3,413	2,249	89	**6,107**	-4,548	**-12,926**
1991	Dry	17.88	1,004	730	1,075	225	243	68	502	**3,846**	41	341	3,014	2,544	89	**6,028**	-2,183	**-15,109**
1992	Above Normal	22.66	1,087	971	3,373	196	249	96	316	**6,288**	57	391	1,560	2,442	89	**4,538**	1,750	**-13,359**
1993	Wet	33.33	1,087	1,340	6,641	174	282	186	106	**9,817**	84	698	1,261	2,744	89	**4,875**	4,942	**-8,417**
1994	Above Normal	13.22	742	323	151	188	318	115	92	**1,929**	49	487	1,307	3,174	89	**5,107**	-3,177	**-11,594**
1995	Wet	36.64	1,087	1,621	6,946	167	256	164	79	**10,320**	91	943	1,291	2,691	89	**5,106**	5,214	**-6,380**
1996	Wet	17.39	976	852	966	182	274	118	53	**3,422**	65	673	1,557	2,826	89	**5,210**	-1,788	**-8,167**
1997	Below Normal	16.10	904	910	693	194	276	71	45	**3,092**	54	574	1,317	2,810	89	**4,843**	-1,751	**-9,918**
1998	Wet	45.95	1,087	1,620	6,920	149	260	139	44	**10,218**	90	1,072	575	2,795	89	**4,621**	5,597	**-4,321**
1999	Wet	9.89	555	398	0	190	315	105	43	**1,606**	50	730	340	3,614	89	**4,823**	-3,217	**-7,538**
2000	Below Normal	17.45	980	757	933	223	303	70	54	**3,319**	53	572	1,410	3,552	89	**5,676**	-2,357	**-9,895**
2001	Wet	20.47	1,087	1,034	2,163	174	329	77	62	**4,926**	60	624	185	3,821	89	**4,778**	148	**-9,747**
2002	Dry	7.82	439	6	0	197	316	57	64	**1,080**	30	509	558	3,682	89	**4,868**	-3,787	**-13,534**
2003	Below Normal	21.81	1,087	516	2,820	189	291	60	61	**5,023**	52	541	402	3,296	89	**4,380**	643	**-12,891**
2004	Dry	9.53	535	2	0	211	302	56	69	**1,175**	30	421	999	3,446	89	**4,985**	-3,810	**-16,701**
2005	Wet	37.76	1,087	1,542	6,793	180	235	135	112	**10,083**	83	849	1,152	2,609	89	**4,781**	5,302	**-11,399**
2006	Wet	18.39	1,033	882	1,078	182	261	110	82	**3,628**	62	603	1,120	2,791	89	**4,665**	-1,037	**-12,436**
2007	Critical	7.38	414	8	0	210	299	72	150	**1,155**	31	466	1,418	3,120	89	**5,125**	-3,970	**-16,407**
2008	Dry	17.26	969	985	820	224	300	56	99	**3,454**	49	440	661	3,296	89	**4,535**	-1,081	**-17,487**
2009	Dry	13.22	742	12	139	210	259	58	283	**1,704**	35	384	1,627	2,679	89	**4,814**	-3,110	**-20,597**
2010	Above Normal	19.70	1,087	651	1,755	173	276	57	228	**4,227**	48	384	1,060	2,820	89	**4,401**	-173	**-20,770**
2011	Wet	24.97	1,087	996	4,491	162	273	104	157	**7,269**	65	564	1,224	2,756	89	**4,698**	2,571	**-18,199**
2012	Below Normal	9.80	550	6	0	211	270	83	143	**1,265**	35	407	1,013	2,829	89	**4,372**	-3,108	**-21,307**
2013	Critical	8.28	465	0	0	238	331	52	135	**1,222**	25	297	641	3,475	89	**4,527**	-3,305	**-24,612**
2014	Critical	5.82	327	10	0	255	392	50	224	**1,259**	20	247	1,048	4,137	89	**5,541**	-4,282	**-28,894**
2015	Critical	8.64	485	0	0	216	398	74	585	**1,757**	22	274	2,598	3,989	89	**6,972**	-5,215	**-34,109**
2016	Dry	9.95	559	0	0	222	382	82	808	**2,053**	23	269	2,759	3,796	89	**6,936**	-4,884	**-38,993**
2017	Above Normal	21.85	1,087	844	2,855	202	417	107	639	**6,151**	52	276	1,239	4,188	89	**5,844**	307	**-38,686**
2018	Below Normal	8.97	504	724	0	234	509	115	751	**2,837**	31	253	2,255	5,141	89	**7,769**	-4,932	**-43,617**
2019	Above Normal	18.18	1,021	1,011	1,009	192	418	112	712	**4,475**	48	232	945	4,283	89	**5,596**	-1,121	**-44,738**
2020	Below Normal	13.13	737	442	130	224	423	100	639	**2,695**	35	186	888	4,437	89	**5,635**	-2,940	**-47,678**

Notes AFY = acre-feet per year CVWD = Carpinteria Valley Water District MGB = Montecito Groundwater Basin

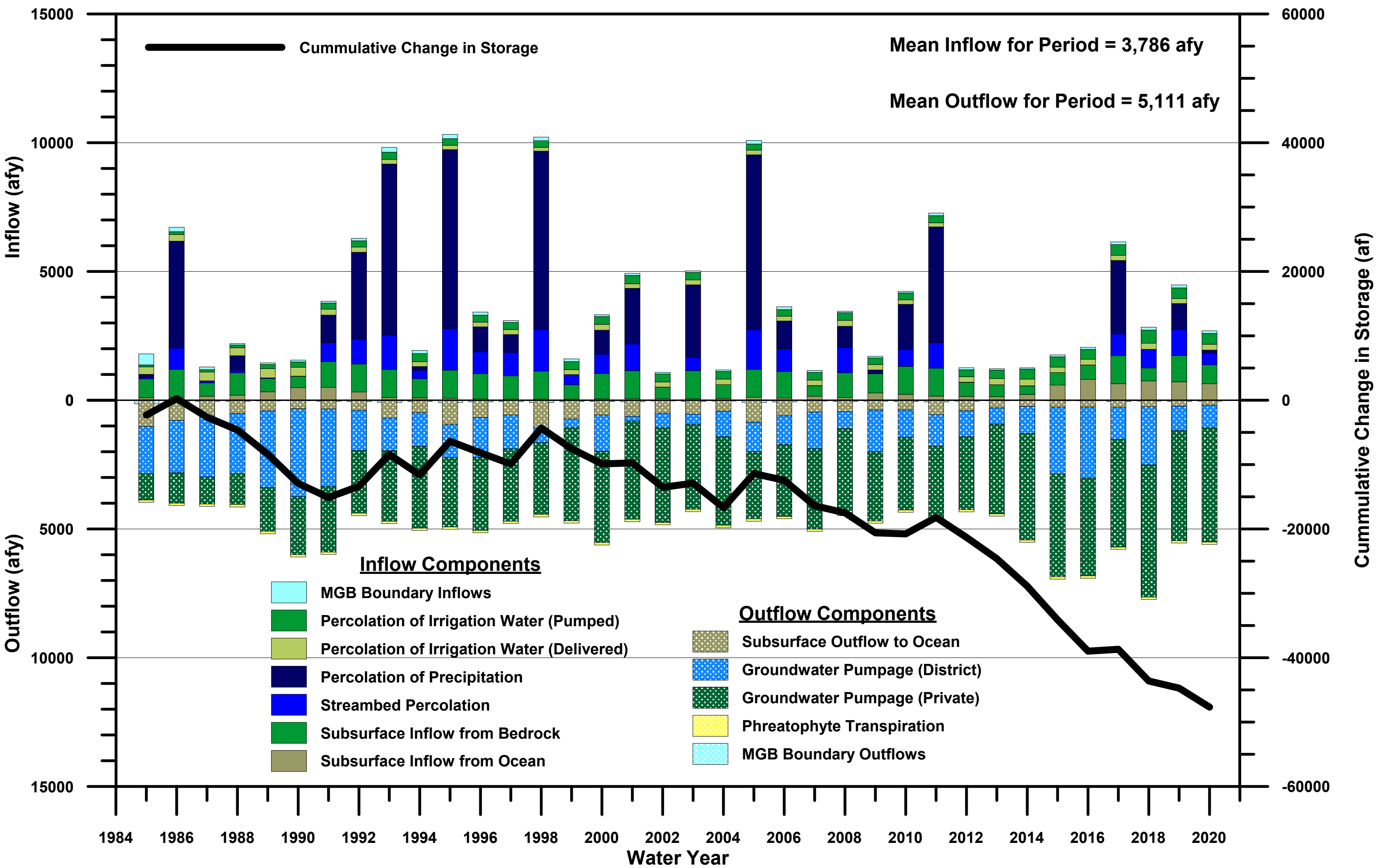

FIGURE 3-69

Historical Water Budget Summary (WY 1985 – 2020)

Carpinteria Basin Groundwater Sustainability Plan

Change in Storage. The change in the amount of groundwater in storage depends on the annual water supply surplus or deficiency, as expressed in the water budget equation. The historical water budget inventory shows the total annual water demand (outflows) was greater than the total recharge (inflows) by 1,324 AFY on average during the 36-year historical period (see **Table 3-11** and **Figure 3-70**). This has resulted in a net depletion of groundwater in storage of approximately 47,678 AF at the end of the historical period, the vast majority of which has occurred during the current drought period of WY 2012 to 2020.

As discussed above, the water budget includes a component of inflow into the Basin from offshore across the boundary with the ocean. While there is likely some unknown volume of freshwater in storage offshore, the location of the seawater/freshwater interface is not known. Conservatively, assuming that any inflow from the offshore area represents seawater intrusion, increases in the volumes of change in storage presented in the water budget inventories (and in the groundwater model) that result from inflow across the boundary with the ocean would, therefore, not represent usable groundwater storage. This issue will be addressed further in the sustainable management criteria (SMC) section presented later in the Plan.

Table 3-11. Historical Water Budget Summary (Water Years 1985 to 2020)

Groundwater Budget Component		Annual Minimum (AFY)	Annual Maximum (AFY)	Annual Average (AFY)	Average %
Inflows					
Subsurface Inflow		327	1,087	805	21
Streambed Percolation		0	1,621	563	15
Percolation of Precipitation		0	6,946	1,572	42
Percolation of Irrigation Water	Delivered	149	360	219	6
	Pumped	77	509	284	7
MGB Boundary Inflow		50	428	101	3
Subsurface Inflow from Ocean Boundary		43	808	242	6
			Total Inflow	**3,786**	**100**
Outflows					
MGB Boundary Outflow		20	140	50	1
Subsurface outflow to Ocean Boundary		186	1,072	511	10
Groundwater Pumping	CVWD	185	3,413	1,455	28
	Private	1,016	5,141	3,005	59
Phreatophyte Transpiration		89	89	89	2
			Total Outflow	**5,111**	**100**
Change in Storage (AFY)		Cumulative		Average	
		-47,678		-1,324	

Notes

AFY = acre-feet per year

CVWD = Carpinteria Valley Water District

MGB = Montecito Groundwater Basin

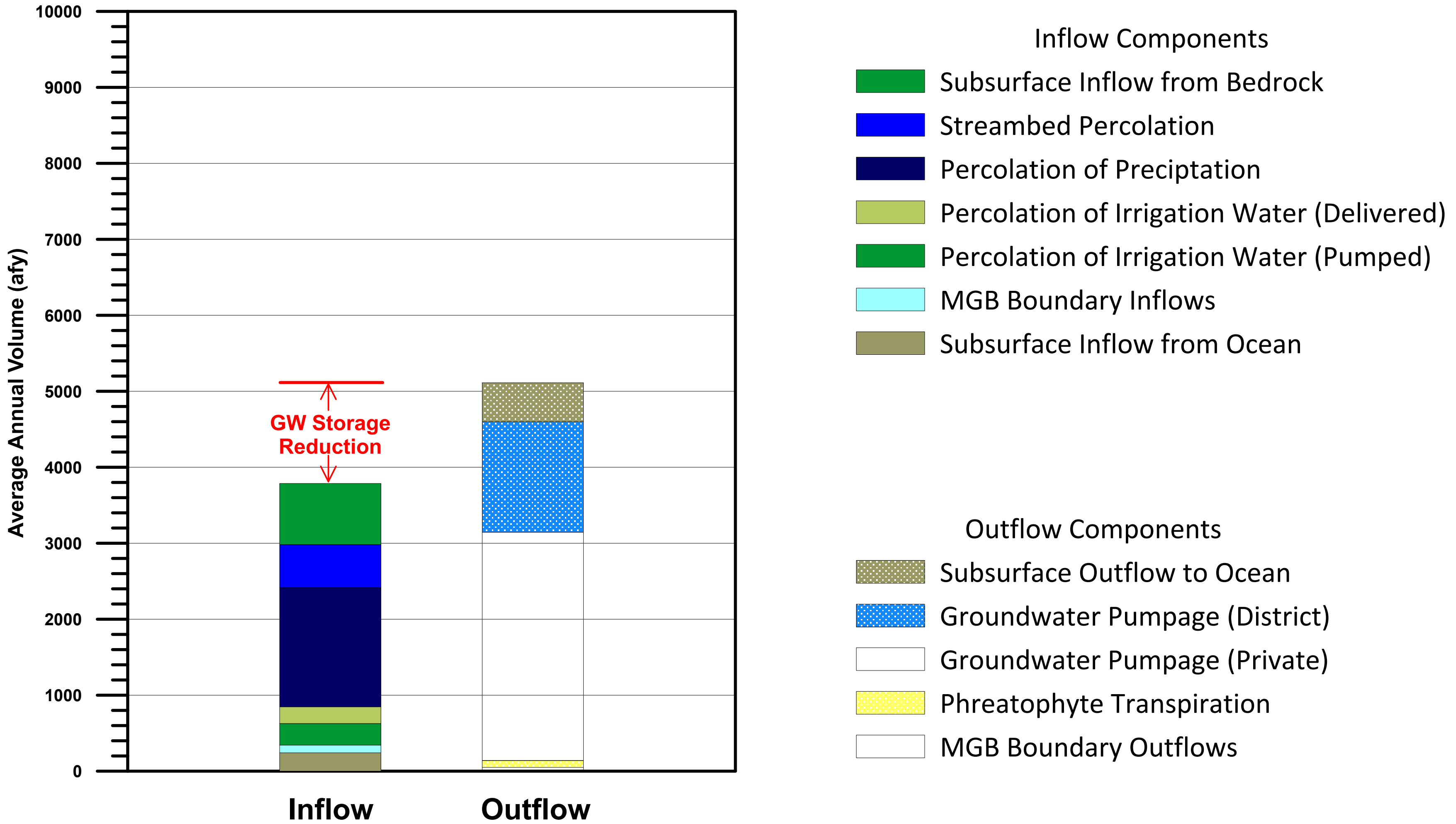

FIGURE 3-70

Historical Water Budget – Groundwater System Averages Paired Bar Chart (WY 1985 – 2020)

Carpinteria Basin Groundwater Sustainability Plan

3.3.3.1 Reliability of Historical Surface Water Supplies [§ 354.18(c)(2)(A)]

§354.18 Water Budget.

(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(2) Historical water budget information shall be used to evaluate availability or reliability of past surface water supply deliveries and aquifer response to water supply and demand trends relative to water year type. The historical water budget shall include the following:

(A) A quantitative evaluation of the availability or reliability of historical surface water supply deliveries as a function of the historical planned versus actual annual surface water deliveries, by surface water source and water year type, and based on the most recent ten years of surface water supply information.

The historical reliability of the surface water supply has been a function of the availability of local and imported surface water, subject to the SWP allocation and operation of the Cachuma Project. The long-term reliability of the surface water from the local sources, including Cachuma Project water, is subject to climatic variability and is subject to requirements for dam releases to meet in-stream habitat and water rights requirements, regulated and determined by terms of the State Board Order (SWRCB, 2019) and NMFS Biological Opinion (NMFS, 2000).

The variability of historical supply was discussed in Section 3.3.2.1, which documents the sources of surface water supply as surface water flows that enter the Basin from precipitation runoff within the watershed; water delivered from the Cachuma Project since 1956; and deliveries of imported SWP supplies since 1997.

The estimated average annual total surface water inflow into the entire Basin from all sources over the historical period is about 11,100 AFY. The largest component of this surface water inflow is local creek flow, which averaged 8,100 AFY during the historical period. The large difference between the minimum and maximum inflows in Table 3-9 reflects the climatic variability and the difference between dry and wet years in the Basin and contributing watershed. The annual average, minimum, and maximum volumes of local surface water sources (native and imported) during the historical period are presented in Table 3-9. The imported surface water averaged 3,010 AFY during the historical period.

During five exceptionally dry years during this period (1990, 2007, 2013, 2014, and 2015) less water was delivered. During these five years, the volume of water delivered from imported sources (Cachuma Project and SWP) was as little as 1,345 AFY delivered (2015) to 3,938 AFY delivered (1993) and averaged 2,841 AFY.

3.3.4 Current Water Budget [§ 354.18(c)(1)]

§354.18 Water Budget.

(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(1) Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, water demand, and land use information.

As discussed previously, the current water budget for the Basin includes the most recent information available and covers the period of WY 2012 to 2020. This period was selected because it encompasses the current and ongoing extended drought period that has resulted in the current groundwater conditions discussed in Section 3.2. The inflow and outflow components for the current water budget are the same as the historical water budget. The current water budget inventory is summarized in Table 3-12 and is presented graphically on Figure 3-71. A summary of the annual minimum, maximum and average volumes for each water budget component is presented in Table 3-13 and the inflow and outflow averages are presented graphically as a paired bar chart on Figure 3-72.

Mean annual rainfall during this period was 11.6 inches, approximately 68 percent of the historical water budget period mean. Mean annual inflow during the current period was estimated at approximately 2,635 AFY, representing approximately 70 percent of the historical period mean. Significant deep percolation of rainfall occurred only in WY 2017, with no deep percolation estimated to occur in WY 2012 to 2016 and in WY 2018.

Mean annual outflow is estimated at 5,910 AFY, representing approximately 116 percent of the historical period mean and approximately 224 percent of the amount of inflow during the period. CVWD mean pumping during the period was 1,487 AFY, consistent with the historical mean of 1,455 AFY. Estimated mean private pumping, however, was 4,030 AFY representing approximately 134 percent of the historical mean of 3,005 AFY.

The significant imbalance between inflows and outflows during the current water budget period has resulted in an estimated cumulative depletion of approximately 29,480 AF of groundwater storage during the period. As discussed in Section 3.2, water level conditions in the Basin reflect this depletion of storage, with current water levels as much as 50 to 60 feet below sea level in the central portion of the Basin (see Figure 3-23). As also discussed above, the groundwater model calculates that under current conditions, subsurface inflow from across the basin boundary with the ocean is believed to be occurring, with approximately 500 AFY of water coming into the Basin from offshore storage during this period.

Table 3-12. Current Water Budget Inventory (Water Years 2012 to 2020)

Water Year	Water Year Type	Rainfall (inches)	Inflow (AFY)								Outflow (AFY)						Change in Storage (AFY)	
			Subsurface Inflow	Streambed Percolation	Percolation of Precipitation	Percolation of Irrigation Water		MGB Boundary Inflows	Subsurface Inflow from Ocean	Total Inflow	MGB Boundary Outflows	Subsurface Outflow to Ocean	Groundwater Pumping		Phreatophyte Transpiration	Total Outflow		
						Delivered	Pumped						CVWD	Private			Year	Cumulative
2012	Below Normal	9.80	550	6	0	211	270	83	143	**1,265**	35	407	1,013	2,829	89	**4,372**	-3,108	**-3,108**
2013	Critical	8.28	465	0	0	238	331	52	135	**1,222**	25	297	641	3,475	89	**4,527**	-3,305	**-6,413**
2014	Critical	5.82	327	10	0	255	392	50	224	**1,259**	20	247	1,048	4,137	89	**5,541**	-4,282	**-10,695**
2015	Critical	8.64	485	0	0	216	398	74	585	**1,757**	22	274	2,598	3,989	89	**6,972**	-5,215	**-15,910**
2016	Dry	9.95	559	0	0	222	382	82	808	**2,053**	23	269	2,759	3,796	89	**6,936**	-4,884	**-20,794**
2017	Above Normal	21.85	1,087	844	2,855	202	417	107	639	**6,151**	52	276	1,239	4,188	89	**5,844**	307	**-20,486**
2018	Below Normal	8.97	504	724	0	234	509	115	751	**2,837**	31	253	2,255	5,141	89	**7,769**	-4,932	**-25,418**
2019	Above Normal	18.18	1,021	1,011	1,009	192	418	112	712	**4,475**	48	232	945	4,283	89	**5,596**	-1,121	**-26,539**
2020	Below Normal	13.13	737	442	130	224	423	100	639	**2,695**	35	186	888	4,437	89	**5,635**	-2,940	**-29,479**

Notes

AFY = acre-feet per year

CVWD = Carpinteria Valley Water District

MGB = Montecito Groundwater Basin

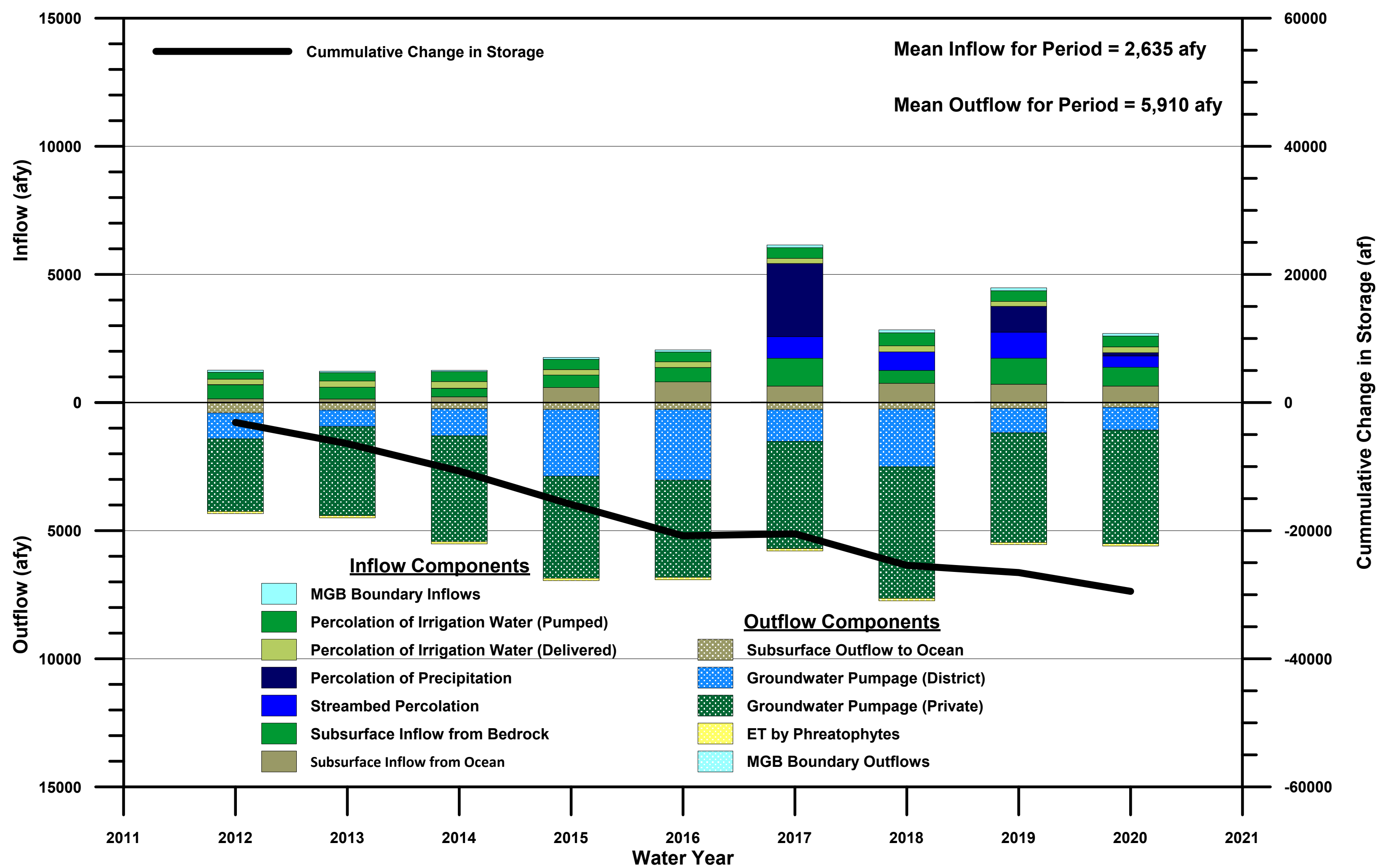

FIGURE 3-71

Current Water Budget Summary (WY 2012 – 2020)

Carpinteria Basin Groundwater Sustainability Plan

Table 3-13. Current Water Budget Summary (Water Years 2012 to 2020)

Groundwater Budget Component		Annual Minimum (AFY)	Annual Maximum (AFY)	Annual Average (AFY)	Average %
Inflows					
Subsurface Inflow		327	1,087	637	24
Streambed Percolation		0	1,011	337	13
Percolation of Precipitation		0	2,855	444	17
Percolation of Irrigation Water	Delivered	192	255	222	8
	Pumped	270	509	393	15
MGB Boundary Inflow		50	115	86	3
Subsurface Inflow from Ocean Boundary		135	808	515	20
			Total Inflow	2,635	100
Outflows					
MGB Boundary Outflow		20	52	32	1
Subsurface outflow to Ocean Boundary		186	407	271	5
Groundwater Pumping	CVWD	641	2,759	1,487	25
	Private	2,829	5,141	4,030	68
Phreatophyte Transpiration		89	89	89	2
			Total Outflow	5,910	100
Change in Storage (AFY)		Cumulative		Average	
		-29,479		-3,275	

Notes

AFY = acre-feet per year

CVWD = Carpinteria Valley Water District

MGB = Montecito Groundwater Basin

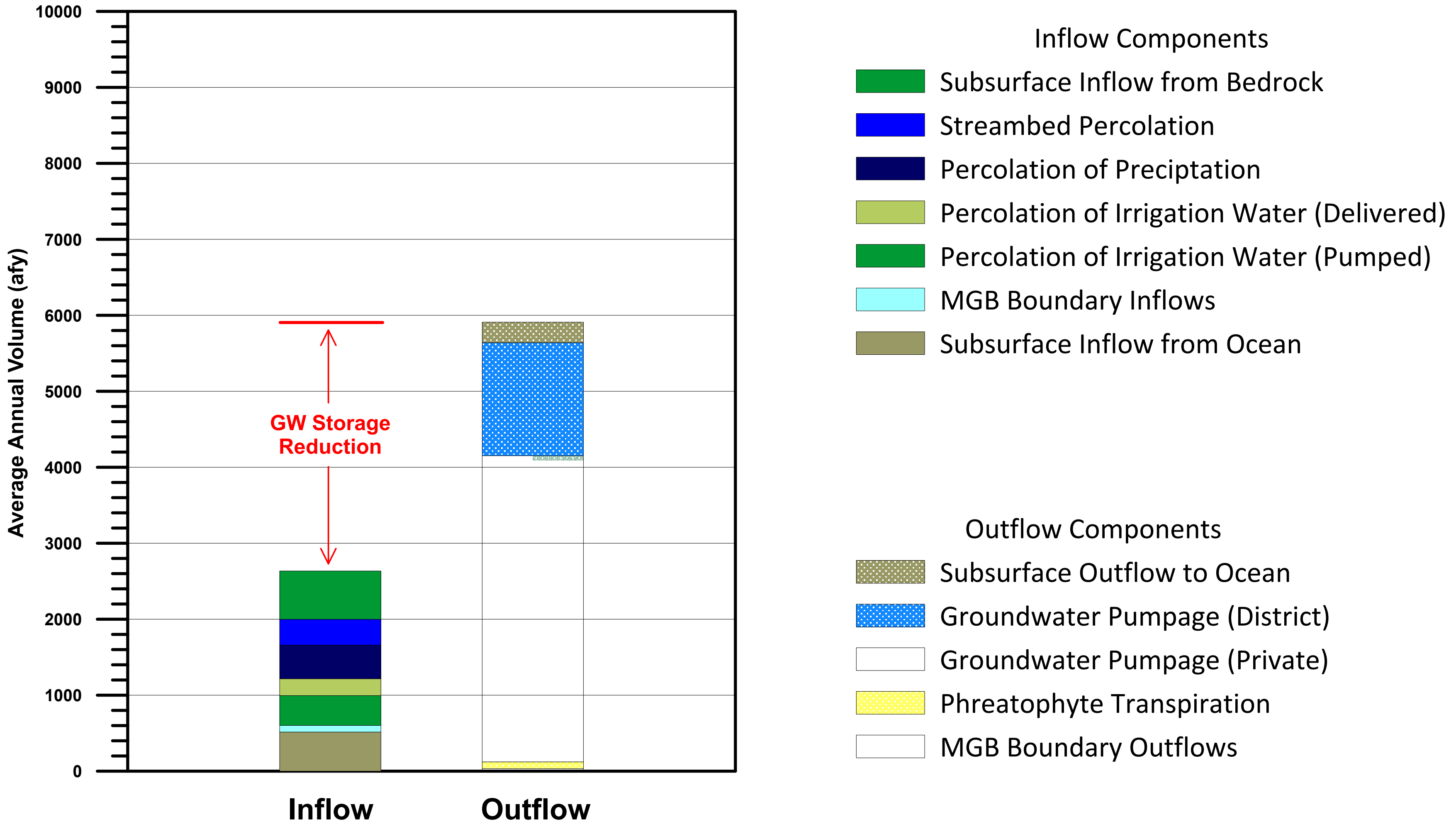

FIGURE 3-72

Current Water Budget – Groundwater System Averages Paired Bar Chart (WY 2012 – 2020)

Carpinteria Basin Groundwater Sustainability Plan

3.3.5 Projected Water Budget

3.3.5.1 Projected Water Budget Calculation Methods [§354.18(d)(1),(d)(2),(d)(3),(e), and (f)]

§354.18 Water Budget.

(d) The Agency shall utilize the following information provided, as available, by the Department pursuant to Section 353.2, or other data of comparable quality, to develop the water budget:

(1) Historical water budget information for mean annual temperature, mean annual precipitation, water year type, and land use.

(2) Current water budget information for temperature, water year type, evapotranspiration, and land use.

(3) Projected water budget information for population, population growth, climate change, and sea level rise.

(e) Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow. If a numerical groundwater and surface water model is not used to quantify and evaluate the projected water budget conditions and the potential impacts to beneficial uses and users of groundwater, the Plan shall identify and describe an equally effective method, tool, or analytical model to evaluate projected water budget conditions.

(f) The Department shall provide the California Central Valley Groundwater-Surface Water Simulation Model (C2VSIM) and the Integrated Water Flow Model (IWFM) for use by Agencies in developing the water budget. Each Agency may choose to use a different groundwater and surface water model, pursuant to Section 352.4.

GSP regulations require a water budget for current, historical, and projected basin conditions. Presented in this section is a description of the methodology utilized to prepare a 50-year projected water budget for the Basin. The projected water budget accounting is used to quantify the estimated future baseline conditions of supply, demand and aquifer response to GSP implementation. In general, the methodology involves applying DWR provided climate change data sets to the existing water budget methodology for the basin described in the previous sections.

Historical Base Period Selection Used to Represent Future Conditions

GSP regulations require the use of 50 years of historical precipitation, evapotranspiration, and stream flow information as the future baseline hydrology conditions, while taking into consideration the estimated climate change and sea level rise projections. The available historical data periods for the required information in the CGB are summarized below:

- Precipitation (Santa Barbara County Carpinteria Fire Station): Water Year (WY) 1949–2020
- Evapotranspiration (CIMIS Station 107): WY 1994–2020
- Streamflow (USGS Carpinteria Creek): WY 1941–2020

DWR-provided climate change datasets are used to “perturb” the historical data to represent projected future conditions and have been provided for the period covering WY 1916–2011; therefore, the common hydrology for the historical precipitation record and the DWR climate change datasets is for the 63-year period WY 1949–2011.

Commonly accepted criteria for selection of a base period for groundwater basin analysis is that the selected base period must include at least one period each of overall wet conditions and overall dry conditions (relative to average annual conditions) and have an average precipitation that is close to the average precipitation for the entire period of record (Theis, 1940, Bredehoeft, 1982). In addition, the beginning of the base period should be during a period of relatively dry conditions to eliminate the potential for any “in-transit” recharge water that might otherwise not be reflected in storage condition changes (Theis, 1940, Bredehoeft, 1982). Finally, to the extent possible, the selected base period should begin and end at comparable points on the historical cumulative departure from the mean annual precipitation in order to represent average precipitation over the base period.

The average annual precipitation for the entire period of record at the Carpinteria Fire Station gauge is 17.3 inches. Table 3-14 summarizes the available 50-year historical periods during the 63-year common period and their corresponding average annual precipitation values.

Table 3-14. 50-Year Base Period Annual Average Precipitation Summary

50-Year Period (Water Year)		Average Annual Precipitation (inches)
Start	End	
1949	1998	18.3
1950	1999	18.3
1951	2000	18.4
1952	2001	18.7
1953	**2002**	**18.3**
1954	2003	18.3
1955	2004	18.2
1956	2005	18.6
1957	2006	18.7
1958	2007	18.6
1959	2008	18.4
1960	2009	18.5
1961	2010	18.7
1962	2011	19.0

Note

Bold type indicates the selected 50-year historical base period.

As shown, there are fourteen 50-year periods within the common historical period to choose from. Plots of annual precipitation for both the historical period of record and the WY 1953–2002 period, and their respective cumulative departure from the mean curves, are presented on Figure 3-73 for comparison. As shown, the 1953–2002 period begins with a dry period and includes periods of overall dry, wet and alternating wet and dry conditions. In addition, of the fourteen available 50-year periods, the selected base period most closely begins and ends at comparable points on the historical cumulative departure curve; therefore, the 50-year period of WY 1953–2002 best satisfies the criteria for base period selection and it has been selected as the historical base period for the projected water budget calculations.

DWR Climate Change Datasets

DWR has provided climate change datasets related to the climatology, hydrology and water system operations for the entire state, packaged in the form of change factors for precipitation, reference evapotranspiration, streamflow and seal level rise centered around two future climate periods: 2030 and 2070. The datasets are based on climate projections for these two climate periods and include one central tendency scenario for 2030 and three scenarios for 2070: a central tendency and two extreme scenarios (one drier with extreme warming and one wetter with moderate warming). The central tendency scenarios for both 2030 and 2070 have been pre-selected by the Technical Committee as being reasonable and suitable for this projected water budget, rather than either of the extreme 2070 scenarios.

To use the DWR-provided monthly change factors, the corresponding historical data are multiplied by the change factors to obtain climate change perturbed data for use in the projected water budget calculations. DWR guidance indicates that the projected 2030 data are useful to evaluate projects and management actions to achieve sustainability in the early future, whereas the 2070 data are useful to show that sustainability will be maintained into the planning and implementation horizon (i.e., late future); therefore, 2030 change factors are applied to the future projected WY 2024–2043 period (20 years) and the 2070 change factors applied to the WY 2044–2073 period (30 years).

Precipitation. DWR precipitation change factors are provided statewide on a 6 km by 6 km grid resolution. The Basin boundaries intersect two of the grid cells: VICGrid_ID_10149 and VICGrid_ID_10150. In accordance with DWR guidance, an area-weighted time-series of monthly change factors was developed based on the relative areas of the basin covered by each grid cell (ID 10149 covers 51.2 percent and ID 10150 covers 48.8 percent). The 2030 and 2070 area-weighted change factors were then applied as described above to the historical monthly precipitation for the base period to create a perturbed precipitation record for the projected water budget calculations (discussed in a following section).

Evapotranspiration. DWR evapotranspiration (ET) change factors are also provided statewide on the same 6 km by 6 km grid resolution as the precipitation factors, and an area-weighted time-series of monthly change factors was also developed for ET as described above for precipitation. The average annual ET climate change factor for the WY 2021–2030 period was 1.03 (increase of 3.1%) and for the WY 2031–2070 period was 1.08 (increase of 7.9%). It is noted that the only historical evapotranspiration data available in the area is from the California Irrigation Management Information System (CIMIS) Santa Barbara station (Station 107), which has a historical period of record limited to April 1993 through current; however, as described in the previous section, evapotranspiration information is used indirectly, rather than directly, in the existing water budget calculation methodology for the Basin (e.g., for calculations of deep percolation of precipitation); therefore, the lack of historical ET data in the basin to directly apply change factors to is not problematic for the projected water budget calculations.

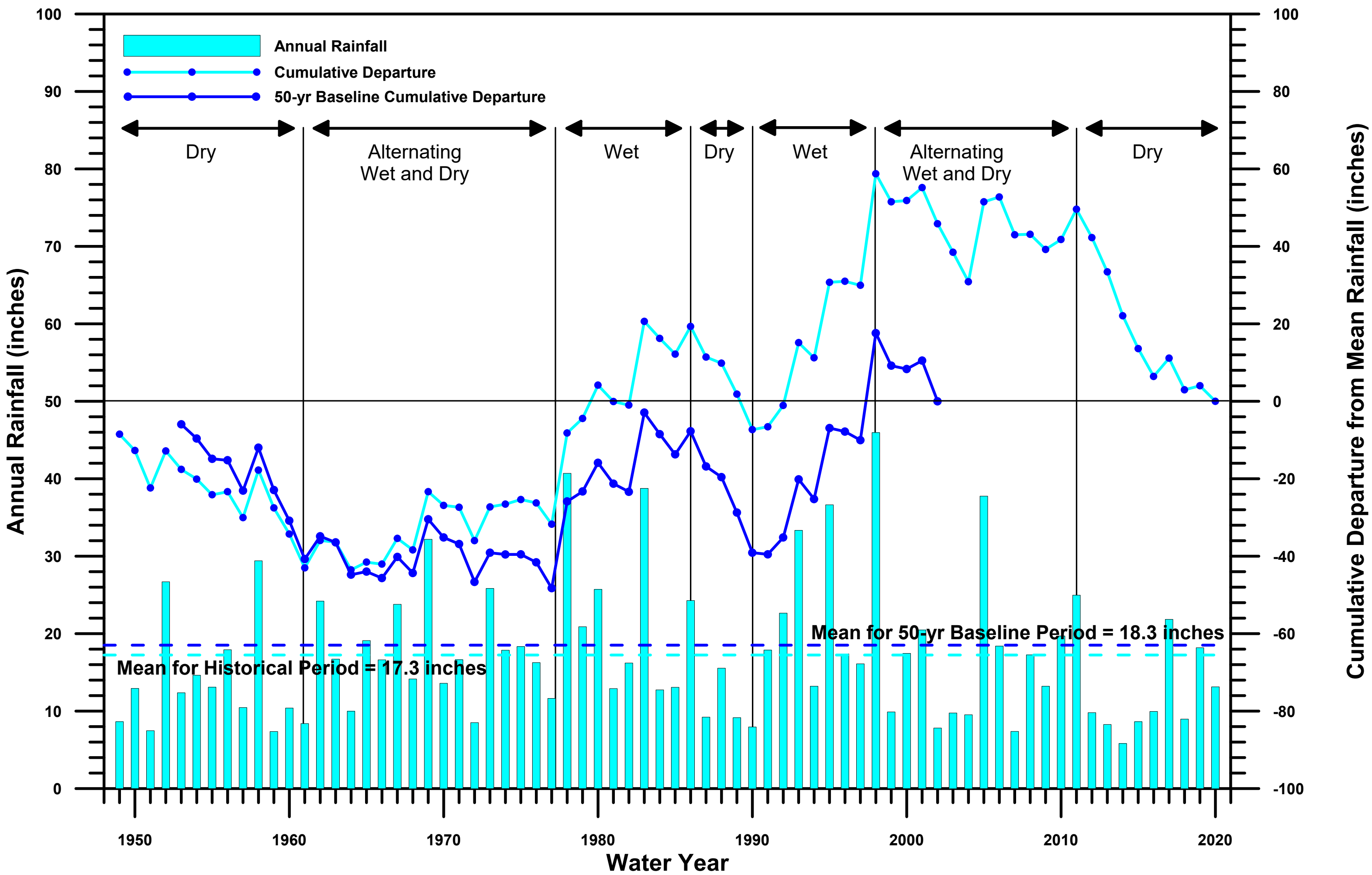

FIGURE 3-73

Historical Annual Rainfall – Carpinteria Station (WY 1949–2020)

Carpinteria Basin Groundwater Sustainability Plan

Streamflow. In addition to the precipitation and ET datasets, DWR provides both monthly and annual unimpaired streamflow change factors for basins outside of the Central Valley. The only stream gauge in the CGB with a substantial period of record is the United States Geological Survey (USGS) Carpinteria Creek gauge, located just downstream of the confluence of Carpinteria and Gobernador Creeks, with a period of record of WY 1941–2021. As described in the DWR Climate Change Guidance document, when applying monthly timeseries change factors, there is an assumption that an aspect of climate change will have a shifting effect on the timing of the streamflow hydrograph, which can result in changes in the annual discharge volume of the hydrograph. Accordingly, in addition to the monthly streamflow change factors, DWR has provided a spreadsheet-based second-order correction tool for unimpaired monthly streamflow to ensure that the total annual volume changes are consistent with the DWR climate change modeling results.

The monthly streamflow change factors and second-order correction tool have been applied to the Carpinteria Gauge monthly data to create a perturbed monthly time series for the projected water budget calculations. The monthly data have been aggregated annually and are plotted on Figure 3-74 along with the unperturbed historical data hydrograph for comparison. As shown, the perturbed streamflow data is only slightly greater than the unperturbed historical data, with a base-period mean of 3,161 acre-feet per year (AFY) versus 3,126 AFY, respectively (an approximate 1 percent increase), with most of the increases occurring in wet years and little changes in normal and dry years.

Sea-Level Rise. The sea-level rise estimates developed by the National Research Council (NRC) have been adopted by DWR as guidance for incorporating sea-level rise into projected groundwater modeling simulations. By 2030 and 2070, sea level rise projections of 15 and 45 centimeters (approximately 5.9 and 17.7 inches, respectively), respectively, have been established. For the projected water budget, this information is incorporated into the ocean boundary conditions in the groundwater model projected future scenario (see Appendix F) and as with the historical water budget calculations discussed previously, subsurface inflows and outflows across the Basin boundary with the Pacific Ocean are calculated by the groundwater model.

SWP Contractor Deliveries. The CVWD imports surface water supplies from the Cachuma Project and the State Water Project (SWP, Table A). In addition to the unimpaired streamflow change factors for watershed outside the Central Valley, DWR has provided datasets on climate-transformed State Water Project (SWP) deliveries to SWP contractors. It is noted that the DWR-provided datasets are not in the form of change factors, as provided for the other parameters, but rather estimated total monthly deliveries to the Table A contractors. Furthermore, the Table A contractors includes all of the member agencies of the Cachuma Project, not just the CVWD; however, the 2020 UWMP developed estimates for anticipated SWP imports by the CVWD and associated deliveries to agricultural customers through 2045, which are used in the projected water budget calculations.

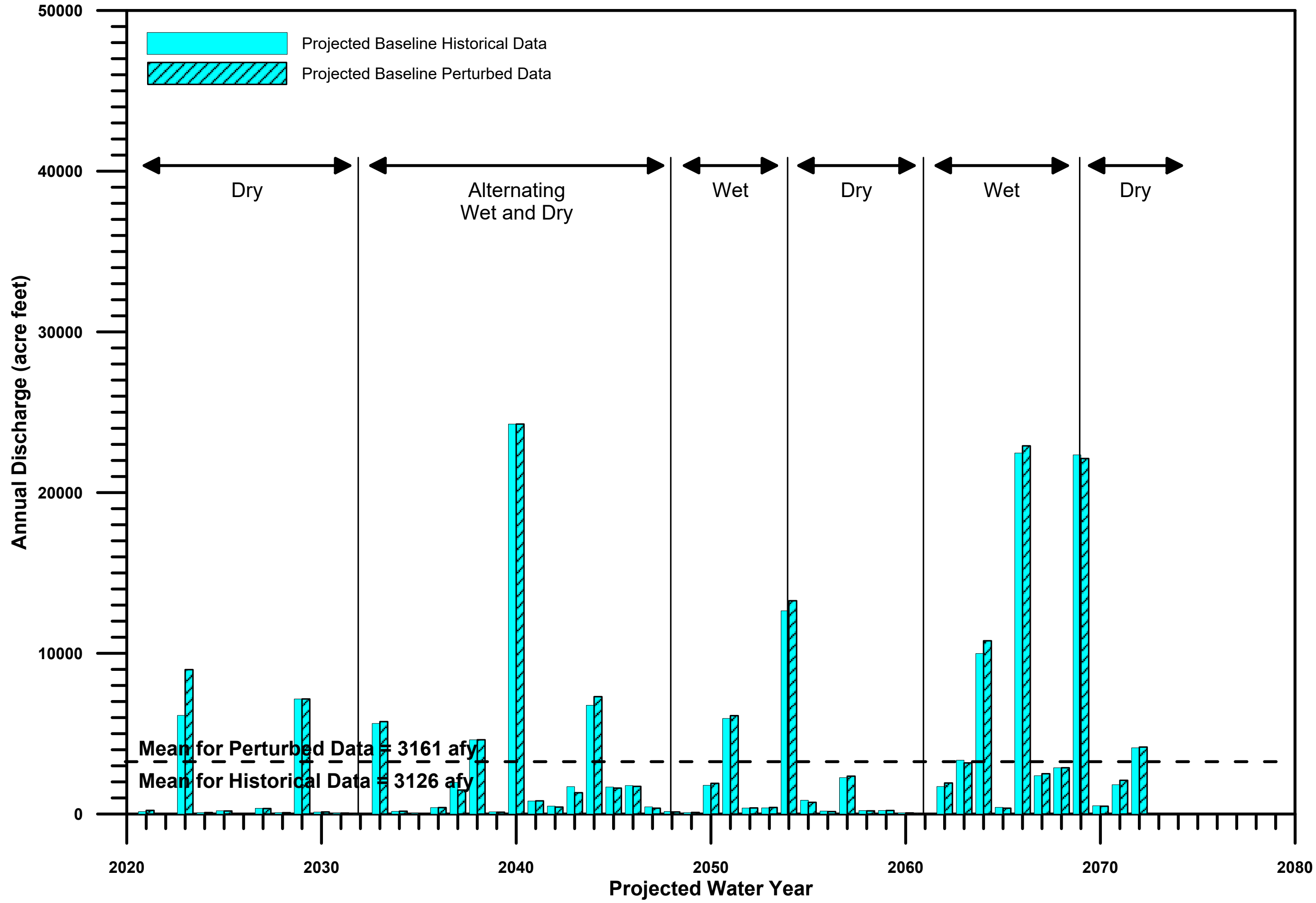

FIGURE 3-74

Projected Baseline Annual Streamflow at USGS Carpinteria Gage

Carpinteria Basin Groundwater Sustainability Plan

Incorporation of Climate Change Factors into Projected Water Budget

The application of the DWR climate change datasets to the various components of existing CGB water budget methodology for creating the 50-year projected water project is summarized in the following sections.

Subsurface Inflow. Subsurface inflow is flow from consolidated rocks in the hill and mountain areas adjacent to the Basin's northern boundary. As discussed in the previous section, a direct relationship between subsurface inflow and annual precipitation was developed by GTC (1976) and has been adopted for the existing methodology. The perturbed monthly precipitation data is aggregated annually, and annual subsurface inflow calculated using the existing relationships. Monthly subsurface inflow is then calculated proportionally based on the monthly precipitation totals in relation to the estimated annual totals.

Deep Percolation of Precipitation. Percolation of precipitation is the most important source of recharge to the basin, historically accounting for approximately 45 percent of the total inflow. There are two primary considerations in calculating the volume of precipitation that percolates beyond the root zone and contributes to the CGB groundwater body:

1. The total area of the various land uses and vegetative covers for each year of the base period, and
2. The calculation of deep percolation of precipitation in inches for each of the various land uses / vegetative covers for each year of the base period.

The total volume of deep percolation in acre-feet is then calculated (i.e., inches of percolation x acreage) for each year of the base period.

Based on the above-noted recent Agricultural Water Management Plan and UWMP, projected land uses in the basin are not anticipated to change appreciably from the current land uses; therefore, the land uses present in WY 2020 are assumed to exist for the projected water budget calculations.

Estimates of deep percolation in the Basin are made using relationships developed by Blaney (1933). Blaney empirically tabulated the amounts of rain that percolated beyond the root zone, depending upon the land use, type of vegetation and amount of annual precipitation. Blaney's values of deep percolation versus annual rainfall have been plotted for land covers (i.e., Blaney Curves) similar to those in the CGB, and best-fit linear regression curves drawn through these points. Values of percolation of precipitation corresponding to annual rainfall and vegetative cover types in the CGB are then calculated using the regression curve equations.

Much of the infiltrating precipitation is held within the root zone because at the beginning of each rainy season there is an initial deficiency of soil moisture. During the summer months the capillary soil moisture is more or less completely depleted from the soil within the root zone by the processes of evaporation and transpiration. No deep percolation of rainfall can occur until the initial fall soil moisture deficiency is exceeded, which is represented as the y-intercept value in the Blaney regression curve equations. Once the initial soil moisture deficiency within the root zone has been satisfied, the excess precipitation will percolate downward until it eventually reaches the water table. To account for the effects of DWR-projected changes in ET on deep percolation, the monthly ET change factors are aggregated to develop annual average change factors, which are then applied to the y-intercept value in each Blaney curve equation (i.e., the y-intercept value represents the amount of annual precipitation that must be exceeded before any deep percolation occurs) for each year of the projected water budget.

Figures 3-75 through 3-77 show comparisons of the unperturbed Blaney-curve calculated percolation of precipitation (in inches) versus the using the perturbed precipitation data and Blaney regression curve equations described above for the three Blaney land use types used in the basin; native grass and weeds, irrigated deciduous crops and irrigated truck crops, respectively. As shown, the net effect of the perturbed data and Blaney equations is an overall reduction in the amount of estimated deep percolation in every year of the projected base period.

For the projected monthly time series water budget calculations, the perturbed annual precipitation data are utilized directly in the perturbed Blaney curve equations to determine the annual volume of deep percolation, which is then distributed monthly based on the monthly proportion of the annual totals each year after the y-intercept value for each Blaney regression curve equation has been exceeded (i.e., deep percolation is assumed to occur during any given year only after the initial soil moisture deficiency has been exceeded).

Streambed Percolation. There are five principal streams in the Basin: Carpinteria, Gobernador, Santa Monica, Arroyo Parida, and Rincon Creeks. As discussed above, the USGS Carpinteria Creek gauge is the only relevant gauge in the basin and has essentially continuous data since 1941 (there is a brief hiatus in the record for WY 1978). Records for Franklin Creek are limited to Water Years 1971 through 1978. Available data for the other drainages in the Basin are limited to miscellaneous measurements made by the USGS from 1941 to 1945.

Streambed percolation is assumed to occur only where the stream reaches cross the Recharge Area of the basin. Once streamflow reaches the Confined Area, the amount of deep percolation to the main groundwater system is assumed to be insignificant. The 1976 GTC study included an analysis of annual runoff at the Carpinteria Creek gauge and seepage losses for streams in the basin and developed annual runoff vs. streambed percolation relationships for each individual stream. These same relationships are utilized for the projected water budget utilizing the perturbed annual Carpinteria Creek gauge data. The monthly time series percolation values are distributed proportionally based on the amount of gauged monthly runoff each year.

Percolation of Irrigation Return Water. Percolation of irrigation return water in the Basin is dependent on a variety of factors, including climatic conditions, crop type, and irrigation practices. Studies by the U.S. Soil Conversation Service for Santa Barbara County indicate irrigation efficiencies range from 65 to 70 percent. For purposes of estimating deep percolation of irrigation return water in the Basin, the existing conservative estimate is that 20 percent of applied water (both pumped and delivered) percolates into the basin (GTC, 1976). This conservative factor takes into account the relatively steeper slopes found in many portions of the Recharge Area, and hence greater percentages/amounts of runoff, as well as the relatively more efficient sprinkler-type irrigation commonly used in the basin at the present time.

The irrigation totals include both pumped and delivered water. In this context, pumped water is the estimated private pumping. Delivered water is water that the CVWD delivers to irrigators in the basin and is a combination of imported water from both the Cachuma Project and the SWP, and groundwater pumped by CVWD wells. It is noted that from a groundwater system mass-balance standpoint, the volumes of water delivered to agricultural parcels accounts for water that is imported into the basin and contributes to basin recharge.

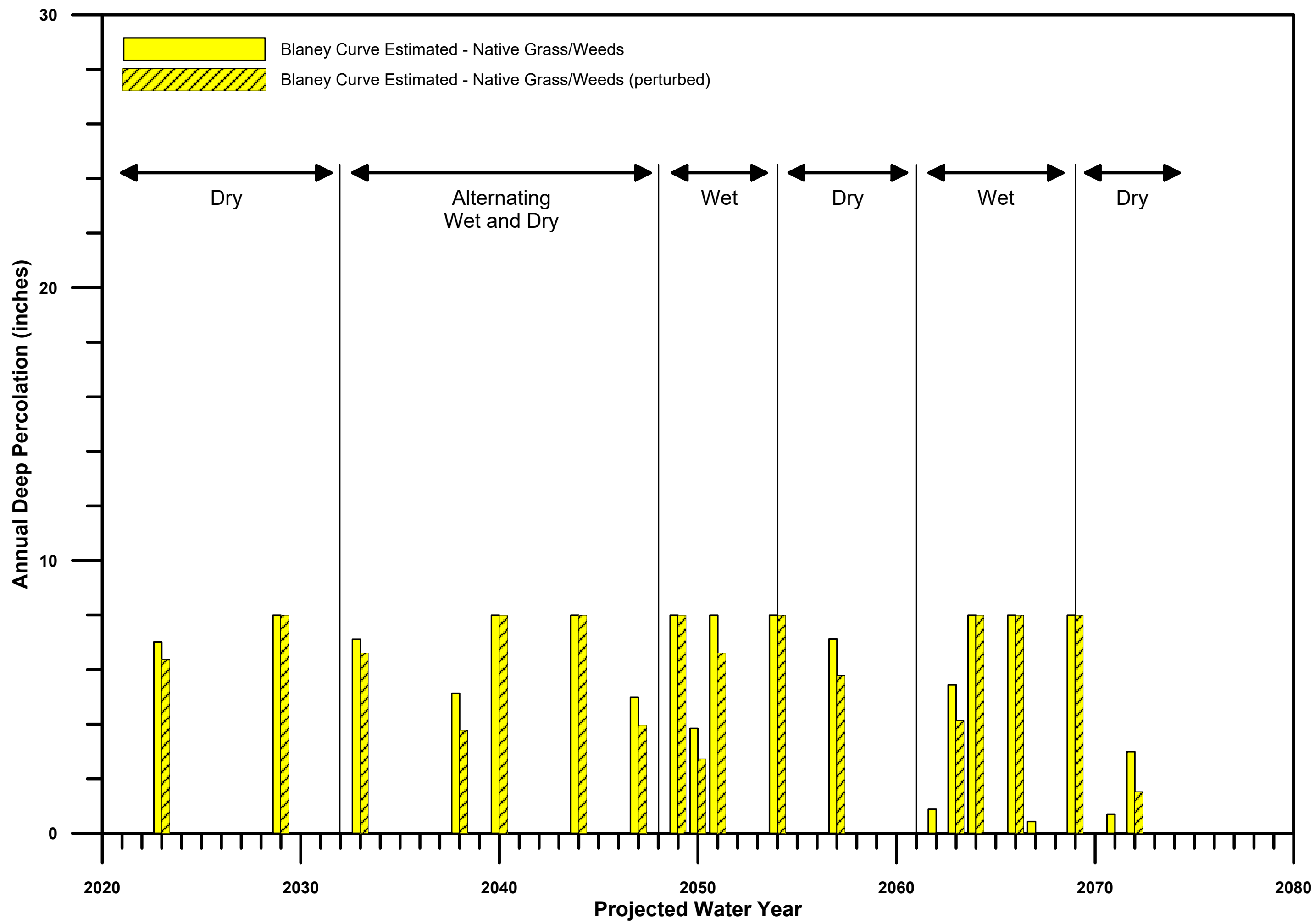

FIGURE 3-75

Projected Baseline Annual Deep Percolation Comparison – Native Grass/Weeds

Carpinteria Basin Groundwater Sustainability Plan

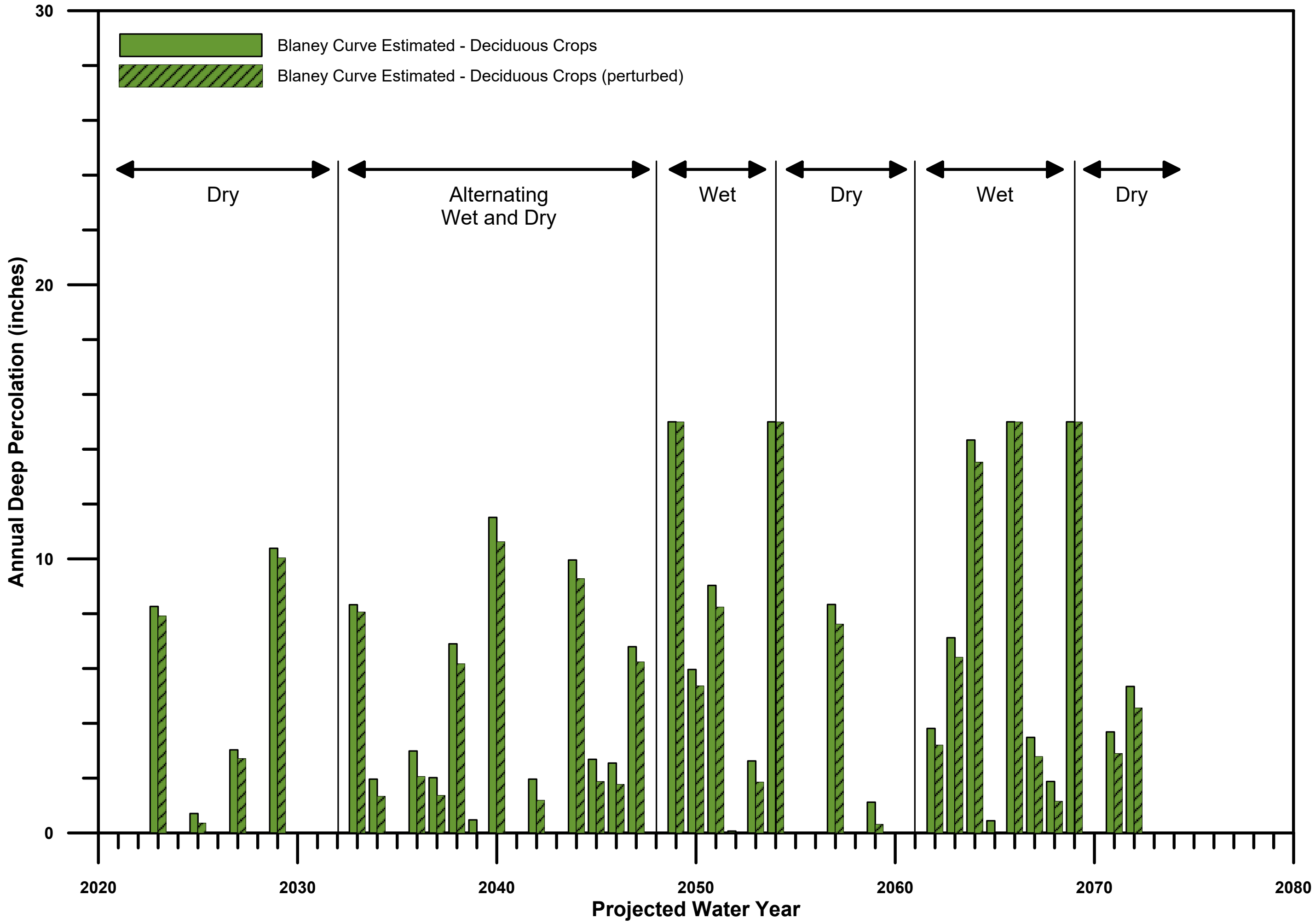

FIGURE 3-76

Projected Baseline Annual Deep Percolation Comparison – Deciduous Crops

Carpinteria Basin Groundwater Sustainability Plan

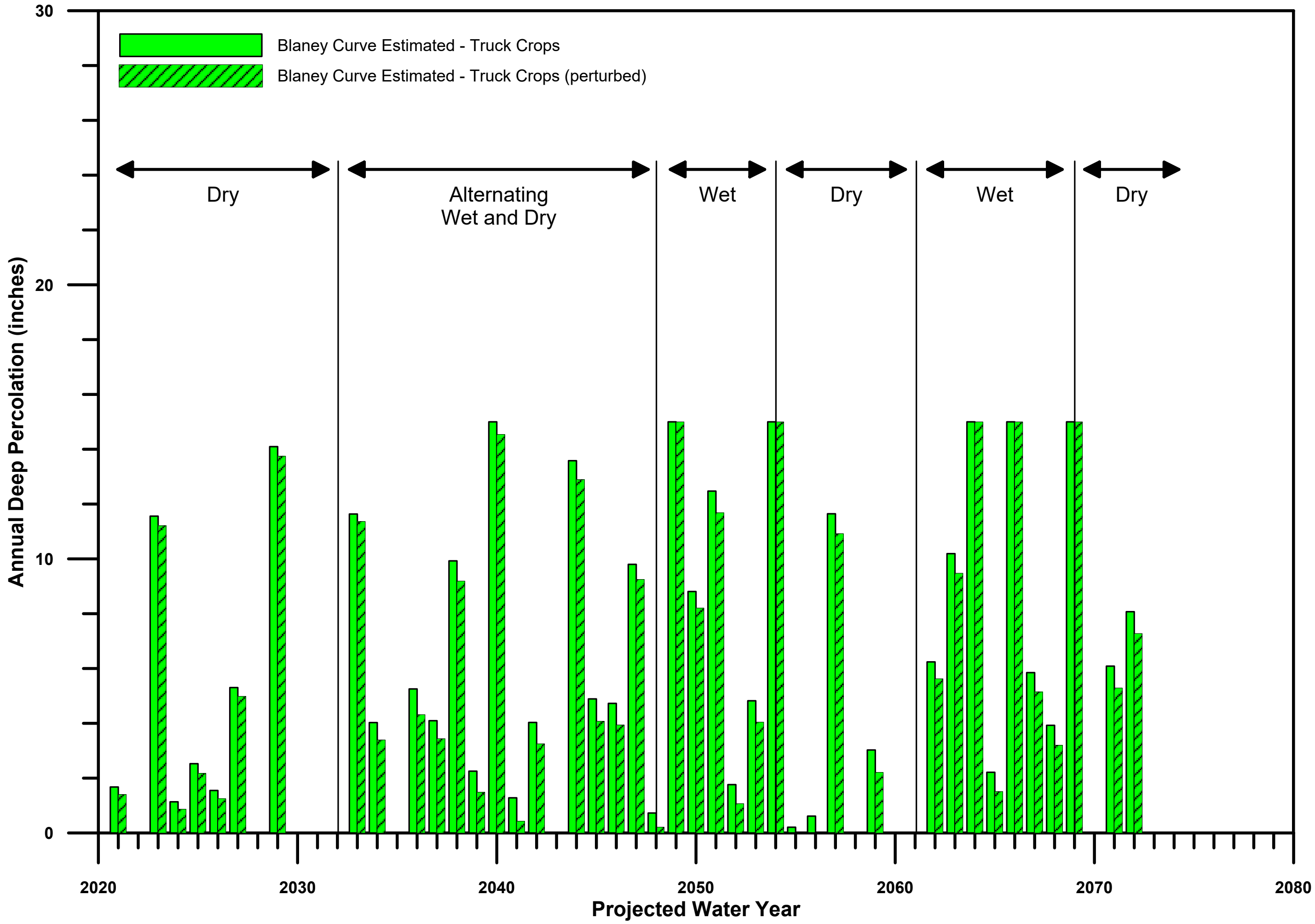

FIGURE 3-77

Projected Baseline Annual Deep Percolation Comparison – Truck Crops

Carpinteria Basin Groundwater Sustainability Plan

As discussed previously, the 50-year historical period being utilized as baseline for the projected water budget is WY 1953–2002, whereas the historical water budget period for the GSP is WY 1985–2020; therefore, the common period for baseline pumping is limited to the 18-yr period of WY 1985–2002. As described in the DWR guidance document, when necessary, projected water budget components can be developed utilizing historical water year type averaging; therefore, for the Basin projected water budget, baseline annual estimates of private agricultural pumping based on water-year type averaging is developed from statistical analysis of the historical data. Similarly, the monthly time series data are distributed proportionally based on statistical analysis of the historical distributions for each water-year type. The effects of changes in ET on crop demands and associated pumping and delivered water is accounted for by applying DWR ET change factors to the baseline agricultural pumping and delivered water values to create a monthly time series of ET perturbed private pumping values.

The 2020 UWMP provides estimates of imported water deliveries to agricultural customers for normal, dry and multiple dry water year scenarios through 2045, which are used for the projected water budget calculations for delivered water based on water-year type. The UWMP estimates for 2045 are carried through WY 2073.

Evapotranspiration by Phreatophytes. Phreatophytes are plants whose roots extend into the water table and typically live in the vicinity of stream channels and in areas of high groundwater. Groundwater consumed by phreatophytes is dependent on many factors, including plant species, vegetative density, climate, soil types and conditions, and depth to groundwater. As discussed previously, direct measurements or detailed studies of consumptive use by phreatophytes in the CGB have not occurred to date; however, GTC (1976) roughly estimated phreatophyte extractions for the CGB by applying results of a 5-year study in San Diego County utilizing the Blaney-Criddle formula (Blaney and Criddle, 1963). Extractions by phreatophytes were estimated to be approximately 120 to 130 AFY from the 1930s through 1970, then reduced to approximately 100 AFY as a result of removal of phreatophytes from the Santa Monica and Franklin Creek channels as part of the flood control channelization projects. The existing water budget methodology for the basin (inclusive of the Toro Canyon area) similarly assumes that extraction by phreatophytes is 100 AFY (and distributed evenly through each year). For the baseline projected water budget for the basin, the same assumptions are made (but not including the Toro Canyon area because it is no longer in the basin as defined by Bulletin 118), with projected increases in ET accounted for by applying DWR change factors to the monthly time series values.

Boundary Subsurface Inflows and Outflows. Groundwater inflows and outflows across the jurisdictional boundary with the MGB and the basin boundary with the Pacific Ocean are calculated by the re-calibrated groundwater flow model of the Basin from the projected future model scenario (see Appendix F).

Projected Hydrology [§354.18(c)(3)(A)]

> **§354.18 Water Budget.**
>
> **(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:**
>
> **(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:**
>
> **(A) Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.**

The monthly historical and perturbed precipitation data discussed above were aggregated to the annual level and plotted on Figure 3-78 for comparison. As shown, the historical inter-annual variability of precipitation is preserved in the perturbed data set, with some years having slightly less, and others having slightly more, precipitation than the historical. The long-term annual average for the perturbed data is slightly (4 percent) greater than the historical average at 19.1 inches versus 18.3 inches, respectively, reflecting the predicted overall slightly wetter future climate conditions.

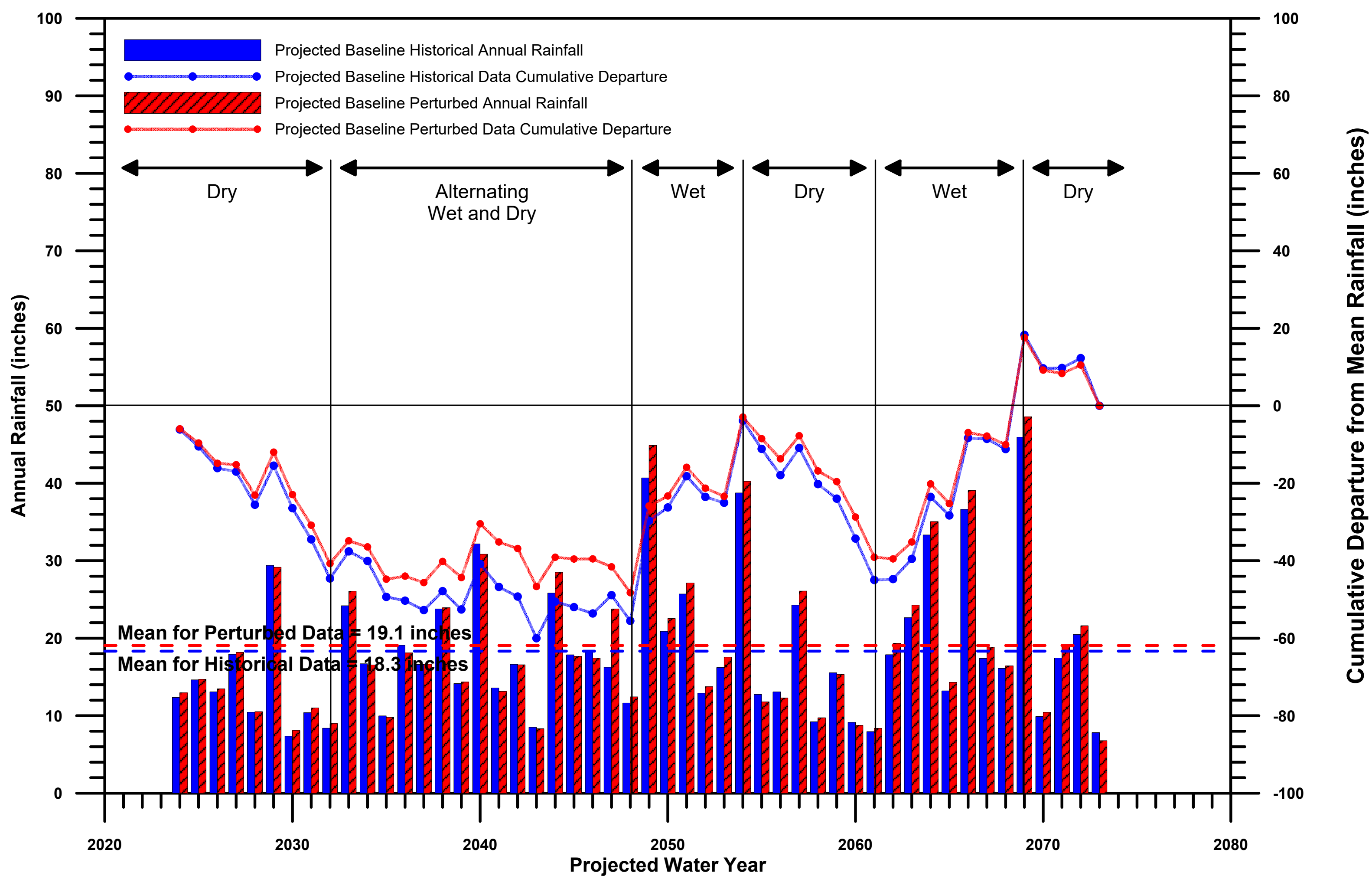

FIGURE 3-78

Projected Baseline Annual Rainfall

Carpinteria Basin Groundwater Sustainability Plan

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Projected Water Demand [§354.18(c)(3)(B)]

§354.18 Water Budget.

(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:

(B) Projected water demand shall utilize the most recent land use, evapotranspiration, and crop coefficient information as the baseline condition for estimating future water demand. The projected water demand information shall also be applied as the baseline condition used to evaluate future scenarios of water demand uncertainty associated with projected changes in local land use planning, population growth, and climate.

Projected municipal pumping by the CVWD is based on the 2020 UWMP, which incorporates projected growth in demands through 2045. The UWMP provides estimated CVWD pumping during normal, single-dry, and multiple-dry water years, which are summarized in Table 3-15.

Table 3-15. Projected CVWD Pumping Summary

Water Year Type	Pumping per Projected Year (acre-feet)				
	2025	2030	2035	2040	2045
Normal	1,200	1,200	1,200	1,200	1,200
Single Dry	2,017	1,200	1,307	1,385	1,455
Multiple Dry					
Year 1	2,012	1,173	1,326	1,394	1,463
Year 2	2,152	1,255	1,418	1,492	1,565
Year 3	2,009	1,185	1,323	1,392	1,461
Year 4	1,835	1,070	1,209	1,272	1,335
Year 5	1,709	997	1,126	1,185	1,243

As shown, projected annual CVWD pumping through 2045 ranges between approximately 1,000 to 2,150 AFY, depending on the hydrologic conditions and planned use of the CVWD water supply portfolio. For purposes of the 50-year projected water budget, the UWMP projected pumping for 2045 is carried forward through 2073.

The annual time-series of CVWD pumping is accordingly based on water-year type averaging and distributed by well proportionally according the estimated per-well pumping capacities. Monthly pumping distribution curves developed from the historical pumping data by water-year type are used to distribute the estimated annual pumping on a monthly basis.

The 2016 Agricultural Water Management Plan does not provide useful information regarding projected agricultural pumping in the Basin; however, the UWMP indicates that significant changes in land use are not projected to occur, and agricultural demands have been kept flat at 2020 use in the UWMP; therefore, projected annual agricultural pumping is based on water-year type averaging from the historical data, using 2020 use as the baseline. Table 3-16 summarizes projected unperturbed baseline private pumping by water type.

Table 3-16. Projected Baseline Private Pumping Summary

Water Year Type	Projected Baseline Pumping (acre-feet per year)
Wet	2,676
Above Normal	2,840
Below Normal	3,005
Dry	3,134
Critical	3,333

To account for future increases in temperatures due to climate change, the projected annual irrigation demands for private pumping are scaled by a factor representing the average annual increase in future ET as calculated from ET climate change factors provided by DWR. As discussed previously, the average ET climate change factor for the WY 2020–2030 period was 1.03 (increase of 3.1%) and for the WY 2031–2070 period was 1.08 (increase of 7.9%); therefore, monthly agricultural irrigation demand is perturbed (increased) by the corresponding change factors to account for higher ET uptake (demand) of irrigation water. Projected monthly pumping is proportionally distributed to individual private wells that existed during the last year of the historical period (2020) based on each well's estimated monthly pumping during that period.

Projected Surface Water Supply [§354.18(c)(3)(C)]

§354.18 Water Budget.

(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:

(3) Projected water budgets shall be used to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:

(C) Projected hydrology shall utilize 50 years of historical precipitation, evapotranspiration, and streamflow information as the baseline condition for estimating future hydrology. The projected hydrology information shall also be applied as the baseline condition used to evaluate future scenarios of hydrologic uncertainty associated with projections of climate change and sea level rise.

Projected surface water supplies imported into the basin by the CVWD are provided in the 2020 UWMP, which incorporates projected water supplies available to meet demands through 2045. As noted previously, the UWMP provides estimated CVWD pumping during normal, single-dry and multiple-dry water years, which considers the available surface water supplies to meet projected demands. As such, available surface water supplies are incorporated into the CVWD pumping estimates are not directly utilized in the water budget calculations for the groundwater system. **Table 3-17** summarizes projected surface water supplies.

Table 3-17. Projected Surface Water Supplies

Water Year Type	Surface Water Source	Projected Year (acre-feet)				
		2025	2030	2035	2040	2045
Normal	Cachuma Project	2,110	2,110	2,110	2,110	2,110
	State Water Project	876	876	876	876	876
Single Dry	Cachuma Project	2,110	2,110	2,110	2,110	2,110
	State Water Project	154	154	154	154	154
Multiple Dry						
Year 1	Cachuma Project	2,097	2,042	2,103	2,092	2,124
	State Water Project	171	174	137	139	142
Year 2	Cachuma Project	2,243	2,184	2,245	2,237	2,271
	State Water Project	183	186	147	149	151
Year 3	Cachuma Project	2,094	2,039	2,099	2,089	2,120
	State Water Project	171	174	137	139	141
Year 4	Cachuma Project	1,913	1,863	1,918	1,909	1,938
	State Water Project	156	159	125	127	129
Year 5	Cachuma Project	1,782	1,735	1,786	1,777	1,805
	State Water Project	145	148	117	119	120

3.3.5.2 Projected Water Budget

The inflow and outflow components for the projected water budget are the same as the historical and current water budgets discussed in previous sections. Based on the methodology described above, the resulting 50-year projected annual water budget for the Basin is summarized in **Table 3-18** and is presented graphically on **Figure 3-79**. A summary of the annual minimum, maximum and average volumes for each water budget component is presented in **Table 3-19** and the inflow and outflow averages are presented graphically as a paired bar chart on **Figure 3-80**.

Table 3-18. 50-Year Projected Water Budget Inventory (Water Years 2024–2073)

Water Year	Water Year Type	Rainfall (in)	Inflow (acre-feet per year)								Outflow (acre-feet per year)						Change in Storage	
			Subsurface Inflow	Streambed Percolation	Percolation of Precipitation	Percolation of Irrigation Water: Delivered	Percolation of Irrigation Water: Pumped	MGB Boundary Inflows	Subsurface Inflow from Ocean	Total Inflow	MGB Boundary Outflows	Subsurface Outflow to Ocean	Groundwater Pumping: CVWD	Groundwater Pumping: Private	Phreatophyte ET	Total Outflow	Year	Cumulative
2024	Below Normal	12.95	727	0	151	173	398	118	618	**2,186**	45	226	1,200	3,099	91	**4,660**	-2,474	**-2,474**
2025	Below Normal	14.69	825	79	430	177	401	92	662	**2,666**	43	197	1,200	3,122	92	**4,655**	-1,989	**-4,463**
2026	Below Normal	13.47	756	0	217	178	399	81	701	**2,332**	37	177	1,200	3,107	92	**4,614**	-2,282	**-6,745**
2027	Above Normal	18.17	1,020	337	1,263	179	475	88	688	**4,050**	52	203	1,200	2,945	92	**4,492**	-442	**–7,187**
2028	Below Normal	10.53	591	0	0	180	399	84	732	**1,986**	31	170	1,200	3,108	92	**4,601**	-2,615	**-9,803**
2029	Wet	29.16	1,087	1,656	5,619	181	394	134	621	**9,690**	77	318	1,200	2,786	92	**4,473**	5,217	**-4,585**
2030	Critical	8.10	455	0	0	182	484	135	569	**1,824**	39	237	1,200	3,425	91	**4,992**	-3,168	**-7,753**
2031	Below Normal	11.02	619	0	0	183	399	95	671	**1,966**	35	196	1,307	3,108	92	**4,738**	-2,771	**–10,524**
2032	Dry	8.99	504	0	0	184	454	85	784	**2,011**	28	183	1,624	3,210	91	**5,135**	-3,124	**-13,648**
2033	Wet	26.08	1,087	1,561	4,610	185	389	132	645	**8,609**	75	326	1,200	2,752	91	**4,444**	4,165	**-9,483**
2034	Below Normal	16.57	930	48	890	186	399	119	591	**3,164**	52	241	1,200	3,111	92	**4,696**	-1,533	**-11,016**
2035	Below Normal	9.81	551	0	0	187	401	99	654	**1,893**	36	205	1,307	3,122	92	**4,762**	-2,869	**-13,885**
2036	Above Normal	18.10	1,016	403	1,225	189	477	90	673	**4,074**	53	215	1,200	2,960	92	**4,520**	-446	**-14,331**
2037	Below Normal	16.65	935	976	910	190	399	110	651	**4,171**	57	235	1,200	3,109	92	**4,692**	-521	**-14,852**
2038	Wet	23.95	1,087	1,466	3,620	191	393	136	571	**7,464**	76	313	1,200	2,778	92	**4,459**	3,005	**-11,848**
2039	Below Normal	14.35	806	0	351	192	400	118	561	**2,428**	49	248	1,200	3,119	92	**4,709**	-2,281	**-14,128**
2040	Wet	30.85	1,087	2,186	6,004	193	394	178	468	**10,511**	94	538	1,200	2,791	92	**4,716**	5,795	**-8,333**
2041	Below Normal	13.13	737	715	160	194	401	139	406	**2,753**	58	299	1,200	3,125	92	**4,774**	-2,022	**-10,355**
2042	Below Normal	16.57	930	436	881	195	400	108	476	**3,427**	57	262	1,385	3,119	92	**4,915**	-1,489	**-11,844**
2043	Dry	8.33	468	925	0	197	460	106	600	**2,754**	41	231	1,709	3,253	92	**5,325**	-2,571	**-14,415**

Water Year	Water Year Type	Rainfall (in)	Inflow (acre-feet per year)								Outflow (acre-feet per year)						Change in Storage	
			Subsurface Inflow	Streambed Percolation	Percolation of Precipitation	Percolation of Irrigation Water		MGB Boundary Inflows	Subsurface Inflow from Ocean	Total Inflow	MGB Boundary Outflows	Subsurface Outflow to Ocean	Groundwater Pumping		Phreatophyte ET	Total Outflow	Year	Cumulative
						Delivered	Pumped						CVWD	Private				
2044	Wet	28.52	1,087	1,665	5,360	198	406	153	487	**9,356**	85	463	1,200	2,876	96	**4,720**	4,636	**-9,779**
2045	Above Normal	17.65	991	1,010	983	199	497	144	386	**4,210**	72	337	1,200	3,083	96	**4,789**	-579	**-10,358**
2046	Above Normal	17.44	979	1,036	944	199	496	119	408	**4,182**	66	288	1,200	3,077	96	**4,727**	-546	**-10,904**
2047	Below Normal	23.79	1,087	364	3,395	199	408	101	457	**6,011**	58	287	1,200	3,180	94	**4,820**	1,191	**-9,713**
2048	Below Normal	12.44	698	0	37	199	408	121	429	**1,892**	55	327	1,455	3,180	94	**5,111**	-3,219	**-12,932**
2049	Wet	44.89	1,087	0	6,559	199	401	141	378	**8,765**	77	583	1,200	2,837	94	**4,792**	3,973	**-8,958**
2050	Wet	22.55	1,087	1,082	2,813	199	400	150	282	**6,012**	81	537	1,200	2,828	95	**4,740**	1,272	**-7,686**
2051	Wet	27.13	1,087	1,588	4,692	199	411	179	236	**8,391**	96	757	1,200	2,908	96	**5,057**	3,334	**-4,352**
2052	Below Normal	13.74	771	379	186	199	415	130	221	**2,300**	60	372	1,200	3,233	96	**4,961**	-2,661	**-7,013**
2053	Below Normal	17.56	986	415	974	199	416	91	272	**3,353**	58	287	1,200	3,239	96	**4,880**	-1,527	**-8,540**
2054	Wet	40.26	1,087	1,924	6,559	199	401	157	236	**10,564**	95	753	1,200	2,841	95	**4,985**	5,579	**-2,961**
2055	Below Normal	11.79	662	663	0	199	414	141	193	**2,272**	61	419	1,200	3,224	95	**5,000**	-2,728	**-5,689**
2056	Below Normal	12.29	690	0	0	199	415	89	281	**1,674**	45	273	1,455	3,235	96	**5,104**	-3,431	**-9,119**
2057	Wet	26.09	1,087	1,174	4,287	199	408	108	280	**7,543**	73	455	1,200	2,888	96	**4,712**	2,831	**-6,289**
2058	Dry	9.75	547	100	0	199	468	111	295	**1,720**	45	318	1,455	3,314	94	**5,226**	-3,507	**-9,795**
2059	Below Normal	15.31	860	139	431	199	420	88	383	**2,519**	48	244	1,556	3,270	96	**5,214**	-2,695	**-12,490**
2060	Dry	8.75	491	0	0	199	479	79	469	**1,717**	30	187	1,461	3,393	96	**5,168**	-3,451	**-15,941**
2061	Critical	8.37	470	0	0	199	508	75	566	**1,818**	27	166	1,335	3,593	96	**5,217**	-3,399	**-19,340**
2062	Above Normal	19.34	1,086	1,088	1,445	199	489	87	555	**4,948**	60	219	1,243	3,032	95	**4,649**	299	**-19,040**
2063	Wet	24.28	1,087	1,304	3,494	199	407	131	471	**7,093**	75	333	1,200	2,877	96	**4,581**	2,512	**-16,528**
2064	Wet	35.06	1,087	1,834	6,344	199	411	206	345	**10,427**	101	712	1,200	2,911	96	**5,020**	5,407	**-11,121**
2065	Below Normal	14.30	803	362	263	199	415	142	292	**2,476**	61	340	1,200	3,233	95	**4,930**	-2,454	**-13,575**

Water Year	Water Year Type	Rainfall (in)	Inflow (acre-feet per year)								Outflow (acre-feet per year)						Change in Storage	
			Subsurface Inflow	Streambed Percolation	Percolation of Precipitation	Percolation of Irrigation Water		MGB Boundary Inflows	Subsurface Inflow from Ocean	Total Inflow	MGB Boundary Outflows	Subsurface Outflow to Ocean	Groundwater Pumping		Phreatophyte ET	Total Outflow	Year	Cumulative
						Delivered	Pumped						CVWD	Private				
2066	Wet	39.06	1,087	2,161	6,559	199	415	188	260	**10,869**	104	825	1,200	2,938	97	**5,164**	5,705	**-7,870**
2067	Above Normal	18.85	1,058	1,200	1,301	199	493	155	193	**4,598**	83	504	1,200	3,057	96	**4,940**	-342	**-8,213**
2068	Below Normal	16.44	923	1,260	725	199	416	125	211	**3,860**	71	391	1,200	3,242	95	**4,999**	-1,140	**-9,352**
2069	Wet	48.56	1,087	2,146	6,559	199	408	175	187	**10,760**	103	885	1,200	2,885	96	**5,168**	5,593	**-3,760**
2070	Dry	10.44	586	487	0	199	479	137	155	**2,044**	58	416	1,200	3,390	96	**5,160**	-3,116	**-6,876**
2071	Above Normal	19.14	1,075	1,124	1,343	199	496	104	191	**4,531**	72	401	1,200	3,075	96	**4,843**	-313	**-7,188**
2072	Above Normal	21.63	1,087	1,421	2,268	199	498	119	188	**5,779**	78	483	1,200	3,085	96	**4,943**	836	**-6,353**
2073	Critical	6.78	381	0	0	199	510	106	260	**1,455**	38	295	1,455	3,607	96	**5,490**	-4,035	**-10,388**
50-year period 2024–2073	**Avg.**	19.07	866	734	1,877	194	430	122	438	**4,662**	61	358	1,263	3,094	94	**4,870**	-208	
	High	48.56	1,087	2,186	6,559	199	510	206	784	**10,869**	104	885	1,709	3,607	97	**5,490**	5,795	
	Low	6.78	381	0	0	173	389	75	155	**1,455**	27	166	1,200	2,752	91	**4,444**	-4,035	
	% of Total		19	16	40	4	9	3	9	**100**	1	7	26	64	2	**100**		

Notes

CVWD = Carpinteria Valley Water District

ET = Evapotranspiration

in = inches

MGB = Montecito Groundwater Basin

Table 3-19. 50-Year Projected Water Budget Summary (Water Years 2024–2073)

Groundwater Budget Component		Annual Minimum	Annual Maximum	Annual Average	Average %
Inflows (acre-feet per year)					
Subsurface Inflow		381	1,087	866	19
Streambed Percolation		0	2,186	734	16
Percolation of Precipitation		0	6,559	1,877	40
Percolation of Irrigation Water	Delivered	173	199	194	4
	Pumped	389	510	430	9
MGB Boundary Inflow		75	206	122	3
Subsurface Inflow from Ocean Boundary		155	784	438	9
			Total Inflow	4,662	100
Outflows (acre-feet per year)					
MGB Boundary Outflow		27	104	61	1
Subsurface outflow to Ocean Boundary		166	885	358	7
Groundwater Pumping	CVWD	1,200	1,709	1,263	26
	Private	2,752	3,607	3,094	64
Phreatophyte Transpiration		91	97	94	2
			Total Outflow	4,870	100

Change in Storage (acre-feet)	Cumulative	Average
	-10,388	-208

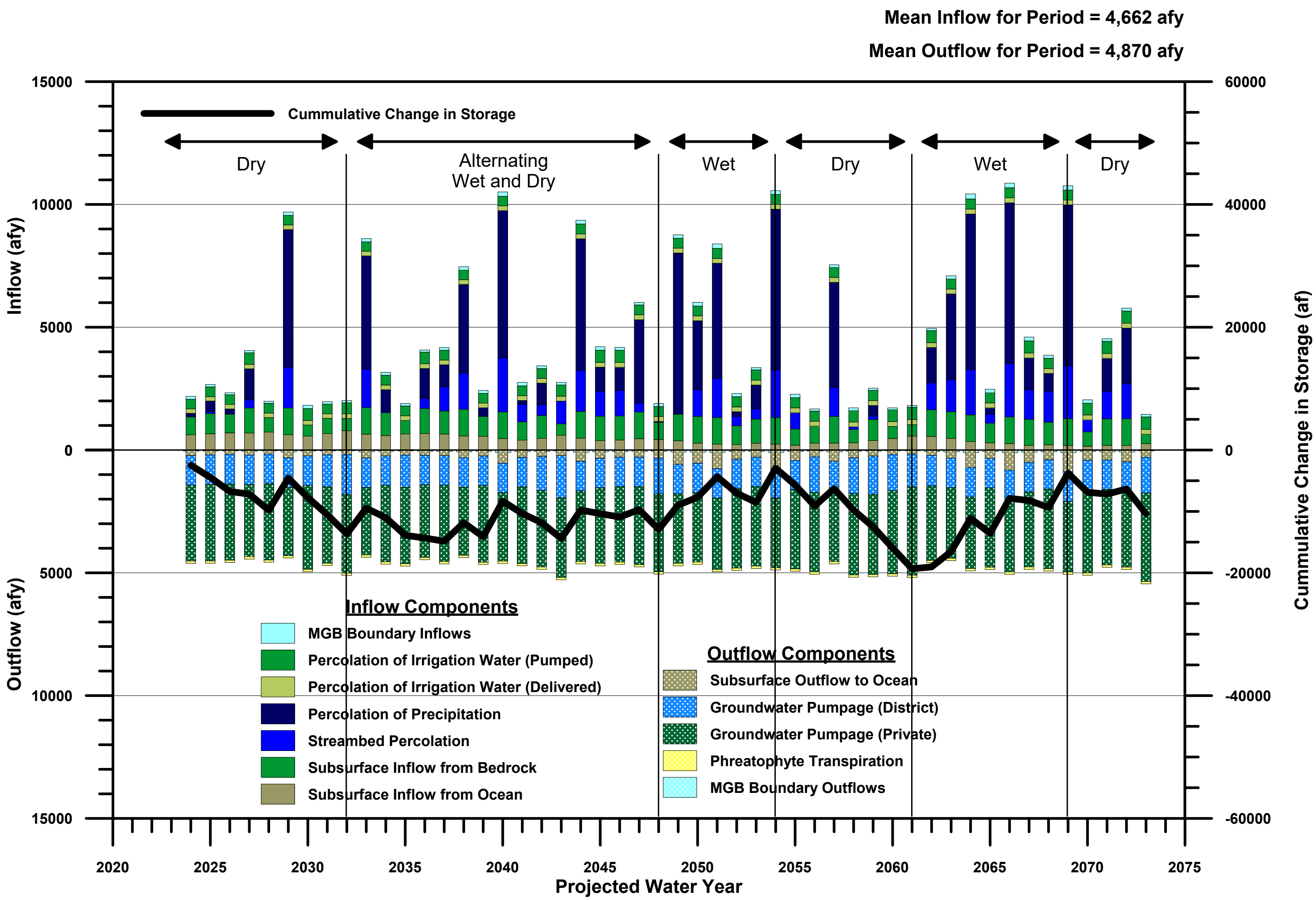

FIGURE 3-79

Projected Water Budget Summary (WY 2024–2073)

Carpinteria Basin Groundwater Sustainability Plan

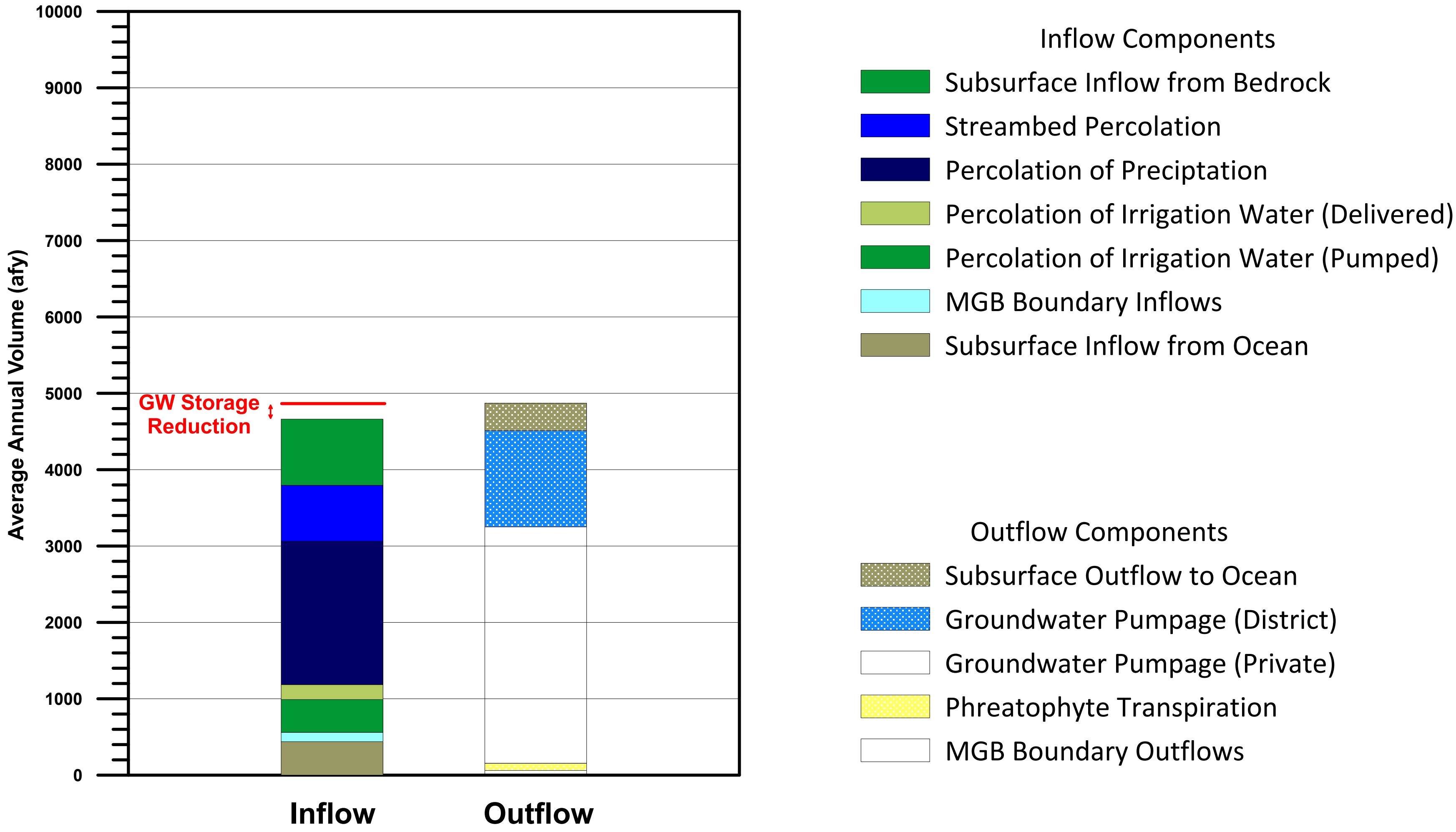

FIGURE 3-80

Projected Water Budget – Groundwater System Averages Paired Bar Chart (WY 2024–2073)

Carpinteria Basin Groundwater Sustainability Plan

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Projected mean annual rainfall for this 50-year period is 19.1 inches, which is approximately 12 percent greater than the 35-year historical water budget period mean of 17.0 inches. Mean annual inflow during the projected period is estimated at approximately 4,662 AFY, which is approximately 23 percent greater than the historical period mean.

Mean annual outflow is estimated at 4,870 AFY, representing approximately 95 percent of the historical period mean. Projected CVWD mean pumping is 1,263 AFY, which is 15 percent less than the historical mean of 1,455 AFY. Projected mean private pumping, however, is 3,094 AFY, which is slightly (3 percent) greater than the historical mean of 3,005 AFY.

The average imbalance between inflows and outflows of 208 AFY during the projected water budget period results in an estimated cumulative depletion of approximately 10,388 acre-feet (AF) of groundwater storage during the 50-year period. As also discussed above for the historical and current water budget periods, the groundwater model calculates that under projected conditions, subsurface inflow from across the basin boundary with the ocean is simulated to be occurring, with approximately 440 AFY of water coming into the Basin from offshore areas during this period.

It is noted that the estimated imbalance between average annual inflows and outflows for the 50-year projected period of 208 AFY is significantly less than the 1,324 AFY imbalance estimated to have occurred during the 35-year historical period of WY 1985–2020. There are a couple key reasons for this:

- The average annual rainfall during the historical period of WY 1953–2002 that is being projected was 18.3 inches, which is approximately 8 percent greater than occurred during the WY 1985–2020 period of 17.0 inches. This is in part an artifact of the longer 50-year projected period having slightly more above normal and wet years less below normal and dry years than occurred during the shorter 35-year historical water budget period. DWR change factors for precipitation result in a further increase in the perturbed projected precipitation to 19.1 inches. The overall increased level of projected precipitation translates into commensurately increased levels of estimated Basin recharge for the period.
- Projected CVWD pumping based on the UWMP averages 1,263 AFY, which is slightly (15 percent) less than the 1,455 AFY that occurred during the historical period. This reflects changes in how the CVWD plans to utilize groundwater in the Basin as part of its overall water supply portfolio compared to past practices.

3.3.6 Basin Safe Yield Estimate [§354.18(b)(7)]

§354.18 Water Budget.

(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:

(7) An estimate of sustainable yield for the basin.

The sustainable yield of a groundwater basin is typically defined as the annual quantity of groundwater that on average can be extracted from a groundwater basin without creating undesirable results, given existing land use conditions and existing wells in the basin. Undesirable results include long-term declining water levels and depletion of groundwater storage. In a coastal basin such as the Carpinteria Groundwater Basin, long-term declining water levels are of particular concern due to the potential for seawater intrusion (as discussed previously, the southwestern portion of SU-1 is in believed to be in hydraulic contact with the Pacific Ocean.

3.3.6.1 Base Period Selection

The sustainable yield calculation is often based on a historical water budget "base period", which should represent long-term, average hydrologic conditions in the basin as much as possible. Criteria for selection of an appropriate base period include at least one period each of overall wet conditions and overall dry conditions (relative to average annual conditions) and have an average precipitation that is close to the average precipitation for the entire period of record. In addition, the beginning of the base period should be during a period of relatively dry conditions to eliminate the potential for any "in-transit" recharge water that might otherwise not be reflected in storage condition changes. Finally, the base period should begin and end at comparable points on the cumulative departure from the mean annual precipitation curve in order to represent average precipitation over the base period.

The WY 1986–2015 historical period best satisfies these criteria. Mean annual rainfall for this selected base period was 17.6 inches compared to the long-term mean of 17.3 inches. This WY 1986–2015 base period (30 years) also reasonably represents current cultural conditions in the Basin. In addition, this period benefits from water-level data collection and relatively sophisticated analysis and quantification of private groundwater pumping in the basin conducted by the CVWD during this period.

3.3.6.2 Water Budget for Base Period

As discussed in the previous section, the historical water budget for the Basin was prepared for the GSP to quantify the various sources of inflow and outflow in the Basin for the historical period of WY 1985–2020. The selected base period for sustainable yield of WY 1986–2015 is therefore a subset of the historical water budget period, and the average annual inflows, outflows and change in storage for this base period are summarized in Table 3-20.

Table 3-20. Sustainable Yield Base Period Water Budget Summary

Groundwater Budget Component		Annual Minimum	Annual Maximum	Annual Average	Average %
Inflows (acre-feet per year)					
Subsurface Inflow		327	1,087	811	22
Streambed Percolation		0	1,621	574	15
Percolation of Precipitation		0	6,946	1,749	47
Percolation of Irrigation Water	Delivered	149	360	217	6
	Pumped	96	398	267	7
MGB Boundary Inflow		50	186	90	2
Subsurface Inflow from Ocean Boundary		0	0	0	0
			Total Inflow	**3,708**	**100**
Outflows (acre-feet per year)					
MGB Boundary Outflow		20	91	50	1
Subsurface outflow to Ocean Boundary		247	1,072	538	11
Groundwater Pumping	CVWD	185	3,413	1,416	29
	Private	1,057	4,137	2,844	58
Phreatophyte Transpiration		89	89	89	2
			Total Outflow	**4,937**	**100**

Change in Storage (acre-feet per year)	-1,229

As shown, average inflow during the 30-year period is approximately 3,710 AFY. It is noted that inflows from the Basin boundary with the Pacific Ocean are not included in the sustainable yield calculation, as it is conservatively assumed that such inflows (estimated at approximately 240 AFY) are saline and, therefore, do not represent usable water in the Basin. Average annual outflow during this period is approximately 4,940 AFY, indicating an average annual **overdraft of approximately 1,230 AFY** during this period.

A common approach is to assume that the sustainable yield of a groundwater basin is equal to the rate of average annual recharge. From a basin mass-balance standpoint, this makes intuitive sense, i.e., pumping must not exceed recharge on a long-term average basis in order to be sustainable; however, as addressed by Theis (1940) and Bredehoeft (1982 and 2002), the sustainable yield of a basin is not necessarily equal to the rate of recharge, but rather is actually dependent on the ability to *capture* recharge without causing undesirable results, such as seawater intrusion.

Projected Sustainable Yield

For the purpose of defining the projected sustainable yield under SGMA in conformance with this GSP, the following methodology is presented. As will be discussed in detail in Chapter 6, Projects and Management Actions, the CVWD is in the process of implementing a major water supply project named the Carpinteria Advanced Purification Project (CAPP). The CAPP is an indirect potable reuse project, that will inject highly treated recycled water into the Basin aquifer for recovery by District production wells. Funding has been procured, project design is substantially completed, and construction is scheduled such that the project is expected to come on line in 2026 to 2027. This project will inject 1,100 AFY of highly treated wastewater into the aquifer through the Headquarters and El Caro municipal wells. Because this project will be implemented during the SGMA horizon, it is appropriate to consider the effects of the CAPP when estimating future sustainable yield in the Basin.

Previous estimates performed for the Basin over past decades have ranged from about 3,600 to 4,000 AFY (PWR, 2012).

The methodology used to estimate the future sustainable yield is as follows. The newly updated Carpinteria Basin Groundwater Model was used to perform two forward 50-year simulations over the 2024-2073 simulation period, and water budget results are evaluated. In the baseline run, expected quantities of municipal and agricultural pumping were simulated consistent assumptions inherent the CVWD Urban Water Management Plan (UWMP) for municipal pumping, and consistent with assumptions about agricultural pumping documented in the future water budget methodology technical memo (PWR, 2022). The Sustainable Yield is calculated by summing the average annual pumping and subtracting any negative change in storage, as well as subtracting any inflow from the ocean (since this water is assumed to be brackish, representative of seawater intrusion, and not appropriate for use in a sustainable yield estimate). Thus sustainable yield is calculated using the following equation:

Sustainable Yield = Total Pumping +/- Change in Storage – Inflow from the Ocean.

Table 3-21 presents the water budget results of the No project Baseline simulation, and the results of the simulation including the expected operation of the CAPP (labelled as CAPP 6 Scenario). Inspection of **Table 3-21** indicates that the hydrologically-based inputs such as subsurface inflow, streambed percolation, irrigation return flow, and percolation of precipitation are unchanged; this is intuitive, since pumping operations will have no effect on meteorologically-based system inflows. The most significant difference between the baseline and CAPP project inflows is the inclusion of 1,054 AFY inflow from CAPP injection. This new source of inflow also leads to a reduction of CVWD pumping of native groundwater; this implies that during wet periods, CVWD will reduce pumping of native groundwater because of the new inflow source from CAPP. Another significant observation is that the subsurface inflow from the Ocean Boundary is reduced from 438 AFY to 323 AFY, a reduction of 26 percent. The quantity of inflow from the ocean boundary can be viewed as a proxy for conditions conducive to seawater intrusion. The increased water levels associated with the injection and operation of CAPP result in conditions that help mitigate against conditions leading to seawater intrusion. It is not expected that CAPP alone will prevent seawater intrusion, but it will help in the management of water levels along the coast.

Table 3-22 presents the comparison of sustainable yield calculations with and without implementation of CAPP. The no project sustainable yield calculation is 3,711 AFY; this is consistent sustainable yield estimates calculated by various researchers over the past decades, which have ranged between 3,600 AFY and 4,000 AFY (PWR, 2012). Significantly, the results indicate that implementation of CAPP will result in an increase in the sustainable yield of the Basin of over 1,000AFY (from 3,711 to 4,757 AFY). This result is not unexpected, since CAPP effectively adds nearly 1,100 AFY of recharge to the Basin that did not exist when the treated wastewater was simply allowed to outfall into the ocean.

Table 3-21. Water Budget Comparison: Baseline (No Project) vs. CAPP

Groundwater Budget Component		No Project Baseline	CAPP Scenario 6	Differences	
				acre-feet per year	%
Inflows (acre-feet per year)					
Subsurface Inflow		866	866	0	0%
Streambed Percolation		734	734	0	0%
Percolation of Precipitation		1,877	1,877	0	0%
Percolation of Irrigation Water	Delivered	194	194	0	0%
	Pumped	430	430	0	0%
MGB Boundary Inflow		122	115	-7	-6%
Subsurface Inflow from Ocean Boundary		438	323	-115	-26%
CAPP Injection		0	1,054	1,054	—
	Total Inflow	4,662	5,593	931	20%
Outflows (acre-feet per year)					
MGB Boundary Outflow		61	61	0	0%
Subsurface Outflow to Ocean Boundary		358	357	0	0%
Groundwater Pumping	CVWD	1,263	1,156	-107	-8%
	Private	3,094	3,094	0	0%
	CAPP Recovery	0	1,034	1,034	—
	Total	4,357	5,284	927	21%
Phreatophyte Transpiration		94	94	0	0%
	Total Outflow	4,870	5,797	927	19%
Inflows – Outflows (acre-feet per year)		(208)	(204)	4	1%

Table 3-22. Sustainable Yield Comparison: Baseline (No project) vs. CAPP

	Total Pumping	Change in Storage	Inflow from Ocean	Sustainable Yield
Baseline	4,357	208	438	3,711
CAPP	5,284	204	323	4,757