CHAPTER 2
BASIN SETTING

2.1 INTRODUCTION TO BASIN SETTING

Physical Setting and Characteristics

The Pleasant Valley Basin (PVB) is located near the western edge of the Transverse Ranges Geomorphic Province, which extends from the San Bernardino Mountains in the east to the San Miguel, Santa Rosa, and Santa Cruz Islands in the west (Figure 2-1, Pleasant Valley Basin Vicinity Map) (CGS 2002). The Transverse Ranges Geomorphic Province is characterized by a series of east- to west-trending mountain ranges and valleys that are formed by north–south compression across a restraining bend in the San Andreas Fault (Bohannon and Howell 1982; DeVecchio et al. 2012a; Eberhart-Phillips et al. 1990; Hadley and Kanamori 1977; Nicholson et al. 1994; Zoback et al. 1987). Compression across this restraining bend is responsible for rapid, ongoing uplift of the mountain ranges (Feigl et al. 1993; Marshall et al. 2008; Yeats 1988) and extensive folding and faulting of the Pleistocene and older geologic formations in the province (Huftile and Yeats 1995; Rockwell et al. 1988).

The PVB, which underlies the east- to northeast-trending Pleasant Valley in southern Ventura County, is bounded by the Camarillo and Las Posas Hills on the north, the Santa Monica Mountains on the south, the Arroyo Santa Rosa Valley Basin (ASRVB) on the east, and the Oxnard Subbasin (Subbasin) of the Santa Clara River Valley Groundwater Basin on the west (DWR 2003; SWRCB 1956). In general, the PVB is a broad synclinal structure with an east- to west-trending axis that bisects the PVB. The PVB is distinguished from the Oxnard Subbasin by a facies change from generally coarser sediments that host the Oxnard and Mugu Aquifers in the Oxnard Subbasin to generally to finer-grained sediments deposited by Arroyo Las Posas and Calleguas Creek in the PVB (Turner 1975). The Camarillo and Las Posas Hills are part of the Camarillo fold belt, which consists of several active anticlinal folds and faults, including the Camarillo anticline, the Simi–Santa Rosa fault system, and the Springville fault system in Pleasant Valley (DeVecchio et al. 2012a).

The shallowest aquifer in the southern portion of the PVB is a semi-perched aquifer comprising sands and gravels. This unit is underlain by a clay layer, commonly referred to as the “clay cap,” that is nearly continuous throughout much of the Oxnard Subbasin and much of the PVB.

The primary water-bearing formations in the PVB are the San Pedro Formation and the overlying alluvium. The San Pedro Formation is a lower to middle Pleistocene shallow marine deposit that grades upward from a white or gray sand and gravel basal layer into an overlying series of interbedded silts, clays, and gravels (Jakes 1979; SWRCB 1956; Turner 1975; Weber and Kiessling 1976). The lower San Pedro Formation hosts the Fox Canyon Aquifer (FCA) and the Grimes Canyon Aquifer (GCA), the primary aquifers from which the majority of the water in the PVB is produced.

The majority of the PVB lies within the jurisdiction of the Fox Canyon Groundwater Management Agency (FCGMA), although approximately 8.5 square miles, or roughly 25%, of the area of the PVB lies to the southeast of the FCGMA boundary (Figure 2-1). The reason for the discrepancy is that the FCGMA boundary was established by the Fox Canyon Groundwater Management Agency Act in 1982 as the vertical projection of the FCA, whereas the PVB boundary is based on the surface extent of alluvium in Pleasant Valley, and the location of geologic structures and facies changes that impede flow between the PVB and neighboring groundwater basins in the younger sedimentary units (DWR 2003). The trace of the Bailey Fault defines the southern FCGMA boundary in the PVB because the FCA is largely absent in the subsurface to the south and east of this fault. The alluvium, however, extends south and east of the Bailey Fault to the foothills of the Santa Monica Mountains. The geologic and hydrologic descriptions of the PVB in this Groundwater Sustainability Plan (GSP) are based on the boundaries of the PVB, including the area southeast of the Bailey Fault, outside the FCGMA jurisdictional boundary.

2.2 HYDROGEOLOGIC CONCEPTUAL MODEL

The California Department of Water Resources (DWR) defines two water-bearing formations in the PVB: alluvium and the San Pedro Formation (DWR 2003). The medial and basal units of the San Pedro Formation are the FCA and GCA, respectively, which are the primary water-producing units in the PVB (Bachman 2016). Local investigators have identified the underlying Santa Barbara Formation, the upper member of which includes the GCA, and the Shallow Alluvial Aquifer, which comprises alluvial sediments deposited by Arroyo Las Posas, Conejo Creek, and Calleguas Creek as additional water-bearing formations in the PVB (Table 2-1; Bachman 2016). In order to remain consistent with both DWR nomenclature and the work of local investigators (Turner and Mukae 1975; Hanson et al. 2003; Bachman 2016), this GSP includes five hydrostratigraphic units: the Shallow Alluvial Aquifer, older alluvium, the Upper San Pedro Formation, the FCA, and the GCA (Table 2-1).

The majority of the PVB aquifers are confined, and historically it was assumed that little recharge reached the FCA from the north (FCGMA 2007). However, in the vicinity of the Somis Gap in the northern PVB, the Shallow Alluvial Aquifer rests directly on the folded, faulted, and eroded surface of the FCA. Water that recharges the Shallow Alluvial Aquifer via flow in Arroyo Las Posas is able to migrate to the FCA in this area, as demonstrated by rising water levels and rising salinity concentrations measured in two City of Camarillo wells in the northeast PVB (FCGMA 2007; Bachman 2016). However, migration of recharge to the FCA and GCA from Arroyo Las Posas to other parts of the PVB may be limited by extensive faulting and folding in the PVB (Bachman 2016).

Both the stratigraphic units and geologic structures present in the PVB affect the hydrology of the basin. These features are discussed in more detail in Section 2.2.1, Geology.

2.2.1 Geology

The nomenclature of the lower Pleistocene and younger stratigraphic units exposed in outcrop and drilled in the subsurface within the PVB has evolved through time since the first regional-scale mapping was conducted by Kew in 1924 (Table 2-1) (Kew 1924; Jakes 1979; DeVecchio et al. 2012b). Kew (1924) identified the lower Pleistocene stratigraphic unit, which marks the base of the freshwater aquifer in the PVB, as the Saugus Formation. Subsequent investigators identified this unit as either the Las Posas Sand (Pressler 1929, as cited in DeVecchio et al. 2012a; Dibblee 1992a, 1992b; DeVecchio et al. 2012b) or the Santa Barbara Formation (Mukae and Turner 1975). To remain consistent with local investigators (Hanson et al. 2003; Bachman 2016), this GSP refers to the lowermost Pleistocene lithologic unit as the Santa Barbara Formation.

Similarly, the lithologic unit overlying the Santa Barbara Formation is referred to as the San Pedro Formation in this GSP in order to remain consistent with DWR nomenclature. The San Pedro Formation has been referred to in the reviewed literature as both the Las Posas Sand (Pressler 1929, as cited in DeVecchio et al. 2012a; Dibblee 1992a, 1992b; DeVecchio 2012b) and the Saugus Formation (Kew 1924; Jakes 1979). The Saugus Formation is primarily a terrestrial fluvial deposit, whereas the San Pedro Formation is primarily a marine deposit. The older alluvial deposits that overlie the Saugus Formation correspond to the terrace deposits identified by Kew (1924) and are distinguished from the younger, active alluvial deposits by evidence of deformation from ongoing tectonic compression in the region.

The youngest unit, exposed at the surface throughout much of the PVB, is an active alluvial unit that lacks evidence for structural deformation and is called either “recent alluvium” (Kew 1924; Weber and Kiessling 1976; Jakes 1979) or “alluvium” (DeVecchio et al. 2012b). This unit is referred to as recent alluvium in this GSP in order to distinguish it from the underlying, deformed older alluvium.

Tertiary Sedimentary and Igneous Formations

Tertiary sedimentary and igneous rocks that underlie the PVB are generally considered semi-permeable or non-water-bearing (DeVecchio 2012b; Turner 1975). These tertiary formations include the Oligocene/Eocene age Sespe Formation, the lower Miocene Conejo Volcanics, the upper Miocene Modelo and Monterey Formations, and the Pliocene Pico Formation (DeVecchio 2012b; Dibblee 1992a, 1992b; Jakes 1979; Weber and Kiessling 1976). These formations have been sampled in deep wells drilled in the PVB (Weber and Kiessling 1976). These formations are not considered an important source of groundwater in the PVB (Turner 1975).

Quaternary Sedimentary Formations

Santa Barbara Formation (Lower Pleistocene; Marine)

The Santa Barbara Formation typically comprises laminated, poorly indurated blue-gray marine mud and siltstone with sand and gravel (Turner and Mukae 1975). Clay-rich sediments in the Santa Barbara Formation can act as an aquitard between the Santa Barbara Formation and the overlying San Pedro Formation (Weber and Kiessling 1976). The localized basal conglomerate within the upper member of the Santa Barbara Formation hosts the GCA (Weber and Kiessling 1976).

San Pedro Formation (Lower to Middle Pleistocene; Marine and Nonmarine)

The San Pedro Formation is an interbedded, poorly lithified, fine-grained marine, silty sandstone, shale, and mudstone with local pebble conglomerate and an extensive basal consolidated sand unit that thickens to the west (DeVecchio et al. 2012b; Weber and Kiessling 1976). In the PVB, the San Pedro Formation unconformably overlies the Santa Barbara Formation. The pebbles of the San Pedro Formation are plutonic, metamorphic, and metavolcanic clasts. Exposures of the San Pedro Formation are typically poorly consolidated and poorly cemented (Weber and Kiessling 1976).

The lower part of the San Pedro Formation is separated from the upper part of the San Pedro Formation by a regionally extensive clay marker bed (Turner 1975). Below this marker bed, the basal unit of the San Pedro Formation comprises 100- to 600-foot-thick continuous white or gray marine sand and gravel with local silt and clay lenses (Turner 1975).[1] The lower part of the San Pedro Formation hosts the FCA, which is the most important source of groundwater supply in the PVB (Bachman 2016; Turner 1975).

The upper part of the San Pedro Formation in the PVB, corresponds to the Saugus Formation of other investigators (Table 2-1). In the PVB, this unit is characterized by poorly consolidated fluvial deposits of pebbly, coarse sandstone and conglomerate deposited in a nonmarine environment (Weber and Kiessling 1976). Conglomerate clasts are predominantly composed of Miocene Monterey shale and Conejo Volcanics (DeVecchio et al. 2012b). In some locations, the coarse-grained upper fluvial deposits grade downward into a fine-grained estuarine sandstone and siltstone (Weber and Kiessling 1976).

[1] This marine sand has been identified as both the Saugus Formation (Kew 1924; Jakes 1979) and the Las Posas Sand (DeVecchio et al. 2012b; Dibblee 1992a, 1992b; Pressler 1929, as cited in DeVecchio et al. 2012a). The term San Pedro Formation is used here for consistency with DWR (2003) nomenclature.

Older Alluvium (Upper Pleistocene; Terrestrial)

Unconformably overlying the Saugus Formation is the older alluvium, which comprises gravel, sand, silt, and clay. The older alluvium was deposited in river, floodplain, beach, and terrace environments. The older alluvium has been incised and gently folded (DeVecchio et al. 2012b). Coarse-grained horizons in the older alluvium are a source of groundwater in shallower wells in the PVB.

Recent Alluvium (Holocene; Terrestrial)

The recent alluvium comprises surficial deposits of loose sand, silt, clay, and gravel (Weber and Kiessling 1976). The recent alluvium includes colluvium and slopewash, stream channel, valley fill and floodplain, and alluvial fan deposits. These deposits are distinguished from the older alluvium by the lack of soil horizon development and lack of folding. In some areas, this unit serves as a conduit for surface water recharge in the PVB.

Geologic Structure

Boundary Faults

Springville Fault Zone

The Springville Fault Zone, which is part of the Simi–Santa Rosa Fault zone, trends east-northeast along the southern base of the Camarillo Hills. The Springville Fault Zone is divided into two structural domains that together form the boundary between the PVB to the south and the Las Posas Valley Basin (LPVB) to the north (Figure 2-2, Geology of the Pleasant Valley Basin) (DeVecchio et al. 2012a). The southern Springville Domain extends from the western end of the Camarillo Hills to the inferred Spanish Hills Fault between the Camarillo Hills anticline and the Springville anticline (Figure 2-2) (DeVecchio et al. 2012a). The northern Springville Domain extends from the Spanish Hills Fault to the Somis Fault in the vicinity of the Somis Gap. The Spanish Hills Fault offsets the northern section of the Springville Fault to the north of the southern section of the Springville Fault (Figure 2-2) (DeVecchio et al. 2012a).

In both structural domains, the Springville Fault is a high-angle reverse fault with up-to-the-north displacement that juxtaposes the Upper San Pedro Formation on the north side of the fault and older alluvium on the southern side of the fault (Figure 2-3, Cross Section A–A′, and Figure 2-4, Cross Section B–B′) (DeVecchio et al. 2012a). In the southern Springville Domain, deformation in the hanging wall has resulted in the formation of the Springville anticline. In the northern Springville Domain, deformation in the hanging wall has resulted in the formation of the Camarillo Hills anticline. These structures may restrict groundwater flow between the PVB and the LPVB to the north (DWR 2003).

Simi–Santa Rosa Fault Zone

The Simi–Santa Rosa Fault Zone trends east-northeast along the southern base of the Las Posas Hills (Figure 2-2). This fault is a high-angle reverse fault that dips to the north. Deformation in the hanging wall of the fault is related to the uplift of the Las Posas Hills (DeVecchio et al. 2012a). Displacement on the fault juxtaposes outcrops of the Saugus Formation in the Las Posas Hills and active alluvial fan deposits to the south in the PVB. The Simi–Santa Rosa Fault Zone restricts groundwater flow between the PVB and the LPVB to the north.

Internal Faults

Camarillo Fault

The east-trending Camarillo Fault is located south of downtown Camarillo on the south side of a low, narrow ridge that generally trends east-to-west (Figure 2-2). The low, narrow ridge comprises older alluvium uplifted as a pressure ridge on the north side of the steeply dipping reverse fault (Jakes 1979; Turner 1975). The fault dies out to the west of the pressure ridge where the fault transitions to an anticline in the subsurface (Jakes 1979). There is up to 150 feet of displacement of the San Pedro Formation across the fault, and the fault restricts groundwater movement (Turner 1975).

Bailey Fault

The Bailey Fault trends northeast along the southern edge of the PVB near the Santa Monica Mountains (Figure 2-2) (Jakes 1979). The fault is a near-vertical fault with up to 600 feet of displacement that juxtaposes the San Pedro and Santa Barbara Formations to the northwest of the fault with older non-water-bearing volcanic rocks to the southeast of the fault (Turner 1975). As a result of the subsurface displacement, the Bailey Fault acts as a barrier to groundwater flow (Jakes 1979).

Folds

The PVB is located within the Camarillo fold belt, an area characterized by anticlinal and synclinal folds (DeVecchio et al. 2012a). Within the PVB, the Camarillo fold is an east- to west-trending anticline in the hanging wall of the Camarillo Fault (Figure 2-2) (DeVecchio 2012a; Jakes 1979). This fold uplifts the older alluvium and tilts the older alluvium surface to the north (Jakes 1979). To the north of Camarillo, extensive folding and faulting has caused upwarping of the San Pedro and Santa Barbara Formations in the vicinity of Arroyo Las Posas. The folding of the San Pedro and Santa Barbara Formations in the vicinity of Arroyo Las Posas allows for recharge to these largely confined aquifers from flows in the arroyo (Bachman 2016; CMWD 2008).

2.2.2 Boundaries

The northern boundary of the PVB is defined by the Springville and Simi–Santa Rosa Fault Zones. These faults are associated with uplift of the Camarillo and Las Posas Hills and are thought to restrict groundwater flow between the PVB and the LPVB to the north (DWR 2003; SWRCB 1956).

The western boundary of the PVB is associated with the change in character of the recent and older alluvium between the PVB to the east and the Oxnard Subbasin of the Santa Clara River Valley Groundwater Basin to the west (Turner 1975). To the east of the boundary, in the PVB, the recent and older alluvial sediments are more lenticular and finer grained, making them less suitable for groundwater production, although there is still production from these sediments. To the west of the boundary, in the Oxnard Subbasin, the age-equivalent sediments compose the Oxnard and Mugu Aquifers. A similar change is found from west to east in the Upper San Pedro Formation. In the Oxnard Subbasin, the Hueneme Aquifer is found within the Upper San Pedro Formation, but a similar aquifer is not found to the east of the boundary in the PVB. There is no change in the characteristics of the underlying FCA or the GCA across this boundary. The PVB and the Oxnard Subbasin are in hydraulic communication. The boundary between the PVB and the Oxnard Subbasin is based on a change in sediment character, rather than faulting or folding that impedes subsurface flow.

The southern boundary of the PVB is delineated by the contact between the alluvial deposits and surface exposures of bedrock in the Santa Monica Mountains (DWR 2003). The eastern boundary of the PVB is formed by a constriction in Arroyo Santa Rosa (DWR 2003; SWRCB 1956).

2.2.3 Basin Bottom

The bottom of the PVB is defined by either the contact between the Santa Barbara Formation and the underlying Pliocene and older formations or, where the Santa Barbara Formation is absent, the contact between the San Pedro Formation and the underlying Pliocene and older formations. The contact between the Pliocene and older formations and the overlying Pleistocene and younger formations coincides with the base of the freshwater aquifer (Turner 1975). To the west of the Bailey Fault, the base of the freshwater aquifer occurs at the base of the Santa Barbara Formation. East of the Bailey Fault, however, the base of the freshwater aquifer coincides with the base of the alluvium.

In general, the depth to the bottom of the PVB increases from east to west. At the eastern end of the PVB, adjacent to the ASRVB, the PVB is less than 800 feet thick, and the base of the PVB is approximately 400 feet below mean sea level (−400 msl; Turner 1975). To the west, the thickness of the PVB can exceed 1,200 feet, and the base of the PVB is approximately −1,200 feet msl (Turner 1975). Perpendicular to the extensive east- to northeast-trending faulting in the PVB, the depth of the basin is highly variable.

2.2.4 Principal Aquifers and Aquitards

Semi-Perched Aquifer

River-deposited sands and gravels interbedded with minor silt and clay compose the semi-perched aquifer in the Oxnard Subbasin and much of the PVB (DWR 1965; Turner 1975). The term *semi-perched aquifer* is used in this GSP as the name for the uppermost unit of the older alluvium, which overlies the extensive clay cap in much of the PVB. This name was used in the State Water Resources Control Board's Bulletin 12 (SWRCB 1956) to distinguish the water-bearing sedimentary units in the Oxnard Subbasin from those in the Oxnard Forebay area, and this terminology has been adopted by subsequent investigators (Mukae and Turner 1975; Turner 1975; Hanson et al. 2003; DWR 2006). Water-level data indicate that the sediments underlying the semi-perched aquifer are potentially saturated. Therefore, the term *semi-perched aquifer* is used in this GSP to denote the limited migration of water from the uppermost aquifer to the underlying aquifers in the PVB. It is not used to denote a discontinuity in saturation. Furthermore, there is limited groundwater production (<50 acre-feet per year (AFY)) from this unit. Therefore, although this unit is referred to as the *semi-perched aquifer*, it is not considered to be a principal aquifer in the PVB.

This aquifer extends from the base of developed soil horizons to a depth of approximately 75 feet below ground surface (bgs) throughout most of the Oxnard Subbasin and part of the PVB (Turner 1975).

Agricultural return flows affect both groundwater quality and groundwater elevation in the semi-perched aquifer (Mukae and Turner 1975). The highest water levels in the aquifer, which are typically within a few feet of land surface, are found in heavily irrigated areas (Turner 1975). Tile drains are used throughout the Oxnard Subbasin and in part of the PVB to alleviate the high groundwater conditions. Agricultural return flows that cause the high water conditions have resulted in high concentrations of total dissolved solids (TDS) and chloride in the semi-perched aquifer (Turner 1975). Few production wells are screened solely in the semi-perched aquifer. Water quality is highly variable in the semi-perched aquifer (UWCD 1999).

Clay Cap

Underlying the semi-perched aquifer is a clay layer that separates the semi-perched aquifer from the alluvium below. The thickness of the clay cap is approximately 160 feet adjacent to the Pacific Ocean, and thins to nonexistent in the PVB. Although the clay cap functions as an aquitard, water can migrate vertically through the clay cap under conditions of differential head (Turner 1975), and in some cases, through casings of wells that have been improperly abandoned.

Shallow Alluvial Aquifer

The alluvial deposits that compose the Shallow Alluvial Aquifer include loose sand and gravel adjacent to Arroyo Las Posas in the northern PVB, Conejo Creek in southeastern PVB, and Calleguas Creek in southwestern PVB (Bachman 2016; Jakes 1979; SWRCB 1956; Weber and Kiessling 1976). This aquifer coincides with the Holocene-age recent alluvium lithologic unit defined in Section 2.2.1. The maximum thickness of this unit in the PVB is approximately 200 feet adjacent to Arroyo Las Posas (Bachman 2016).

The Shallow Alluvial Aquifer is unconfined (Bachman 2016). Recharge to the Shallow Alluvial Aquifer is typically from native and non-native flows within Arroyo Las Posas, including urban runoff of applied water into upstream branches of Conejo Creek (Bachman 2016; CMWD 2008). The non-native flows also consist of discharges from the Simi Valley Water Quality Control Plant, dewatering wells operated by the City of Simi Valley, and discharges from the Moorpark Wastewater Treatment Plant (MWTP) percolation ponds adjacent to Arroyo Simi–Las Posas in the LPVB (Bachman 2016; CMWD 2008). Recharge from these non-native flows in Arroyo Simi–Las Posas has resulted in degraded water quality in the Shallow Alluvial Aquifer. Groundwater adjacent to Arroyo Las Posas in northern PVB is characterized by concentrations of TDS greater than 1,200 milligrams per liter (mg/L), chloride greater than 150 mg/L, and sulfate greater than 600 mg/L (Bachman 2016).

Flows in Conejo Creek and Calleguas Creek in southern PVB also provide recharge to the Shallow Alluvial Aquifer. This recharge is typically from native and non-native flows. The non-native flows consist of discharges from the Hill Canyon Wastewater Treatment Plant (WWTP) and the Camarillo Sanitary District (CSD) Water Reclamation Plant (WRP).

The Shallow Alluvial Aquifer is not a principal aquifer, with only a few wells that produce water, which is likely a result of the poor-quality water. Well yields within the Shallow Alluvial Aquifer range from less than 100 to 1,000 gallons per minute (gpm). The average well yield is approximately 400 gpm (Turner 1975).

Older Alluvium

The older alluvium underlies the Shallow Alluvial Aquifer. It is found primarily in a northeast- to southwest-trending band through the center of the PVB (Figure 2-5, Cross Section C–C′) (Bachman 2016). On both the northern and southern edges of the PVB, upwarping of the underlying sediment and subsequent erosion have removed the older alluvium (Bachman 2016). This unit is age equivalent to the Mugu and Oxnard Aquifers in the Oxnard Subbasin to the west, which compose the Upper Aquifer System (UAS) in that Subbasin, but is highly lenticular with a large quantity of low-permeability sediments (Turner 1975). The low-permeability sediments were deposited by Calleguas Creek, in the PVB, while the age-equivalent sediments of the Mugu and

Oxnard Aquifers were deposited by the Santa Clara River. Water-bearing sediments within the older alluvium are confined throughout the PVB; the older alluvium has a limited hydraulic connection with the Mugu and Oxnard Aquifers across the western boundary of the PVB.

Because of the lenticular nature of the deposits, and the high percentage of fine-grained material, the older alluvium is not considered a primary aquifer in the PVB. However, there are wells that produce water from this unit, and well yields within the unit are variable, ranging from less than 100 gpm to 1,000 gpm (Turner 1975). The average well yield is approximately 400 gpm (Turner 1975). Water quality is generally poor and has been affected by recharge from non-native flows in Calleguas Creek, characterized by elevated concentrations of TDS, chloride, and sulfate (Bachman 2016).

Upper San Pedro Formation

The sediments that compose the Upper San Pedro Formation are primarily interbedded silts, clays, and gravels with minor sand layers (SWRCB 1956; Weber and Kiessling 1976; Turner 1975; Jakes 1979). The thickness of the Upper San Pedro Formation ranges from less than 200 feet along the boundary between the PVB and the ASRVB to more than 600 feet in the western part of the basin (Turner 1975). This unit is not found to the southeast of the Bailey Fault (Turner 1975). In the Oxnard Subbasin to the west, the Upper San Pedro Formation is age equivalent to the Hueneme Aquifer, which is the uppermost aquifer in the Lower Aquifer System (LAS) of that Subbasin.

Throughout the PVB, the Upper San Pedro Formation is confined because lenses of permeable sediments within the Upper San Pedro Formation are laterally discontinuous and not well connected (Turner 1975). As a result, the Upper San Pedro Formation is not considered an aquifer, and few wells are known to pump from the Upper San Pedro Formation. This formation may, however, function as a leaky aquitard providing additional water to the underlying FCA.

Fox Canyon Aquifer

The FCA is the primary aquifer in the PVB. This aquifer occurs at the base of the Upper San Pedro Formation and is laterally continuous within the boundaries of the PVB, except to the southeast of the Bailey Fault, where it has been removed through uplift and erosion. The FCA also extends to the west into the Oxnard Subbasin, where it is part of the LAS. The water produced from the FCA is used for agricultural, domestic, industrial, and municipal purposes.

The sediments that compose the FCA are white or gray sand and gravel with some clay and silt lenses (SWRCB 1956; Turner 1975). These sediments were deposited under shallow marine conditions and have been extensively folded and faulted since deposition (Turner 1975). In general, the PVB is a broad synclinal structure with an east- to west-trending axis that bisects the PVB. Along the axis of the syncline in the western portion of the PVB, the depth to the upper surface of the FCA is approximately 800 feet bgs, and the thickness of the aquifer reaches approximately 600 feet (Turner 1975; Bachman 2016). At the western boundary of the PVB, the FCA is in hydraulic communication with the Oxnard Subbasin to the west. To the northeast, the FCA is folded and faulted by the Simi–Santa Rosa Fault Zone, where uplift and erosion have placed the FCA in direct communication with the overlying Shallow Alluvial Aquifer (Bachman 2016). To the east, near the boundary with the ASRVB, the FCA shallows and thins. In this area, the FCA is approximately 100 feet thick and the upper surface of the FCA is less than 200 feet bgs. On the south side of the PVB, the FCA is faulted by the Bailey Fault Zone (Turner 1975) and abuts the Conejo Volcanics, which are classified as non-water-bearing rocks by DWR and local investigators (Figure 2-2) (Turner 1975; Bachman 2016).

The FCA occurs under confined conditions in the PVB (Turner 1975). The average specific yield of the FCA is 10.5% and the average yield of wells that are at least partially completed in the FCA is 1,000 gpm (Turner 1975; DWR 2003). Aquifer tests were conducted on the City of Camarillo's production wells A and B, which are located in northern PVB and screened in the FCA (Bachman 2016). The results of these tests indicate the transmissivity of the FCA is 4,000 to 10,300 feet squared per day, the storativity of the FCA is 3.1E-06 to 4.5E-04, and the horizontal hydraulic conductivity of the FCA is 11 to 30 feet per day.

Water quality in the FCA is generally acceptable for most beneficial uses (Turner 1975), although chloride concentrations adjacent to Arroyo Las Posas and in the main part of the PVB exceed 200 mg/L (UWCD 2003; Izbicki et al. 2005a). These concentrations can be problematic for irrigation of several crop types. Additionally, concentrations of TDS exceed 500 mg/L and concentrations of sulfate exceed 250 mg/L in several wells in the FCA (CMWD 2008; Bachman 2016).

Grimes Canyon Aquifer

The GCA is present throughout much of the PVB southwest of the Somis Gap, and northwest of the Bailey Fault (Turner 1975; Bachman 2016). To the southeast of the Bailey Fault, in the eastern part of the PVB, the GCA is absent. This aquifer extends across the western boundary of the PVB into the Oxnard Subbasin, where it is the lowest unit in the LAS in that Subbasin.

In the PVB, the GCA comprises 50 to 500 feet of sand with some gravel and clay within the Santa Barbara Formation (Turner 1975). Similar to the FCA, the GCA has been extensively folded and faulted since deposition (Turner 1975). Faulting and folding of the GCA has resulted in changes to the transmissive properties of the aquifer similar to those described for the FCA. Where present in the PVB, the GCA is in hydraulic communication with the overlying FCA (Turner 1975).

Wells screened in the GCA are typically also screened in the overlying FCA, and groundwater production wells are not solely screened in the GCA. As a result, the yield of the GCA is not well defined (Turner 1975). Depth-discrete flow sampling of wells in the PVB indicates that between

12% and 36% of the flow in wells screened in both the GCA and FCA comes from the GCA, although this percentage varies with groundwater elevation and pumping during drought cycles (CMWD 2008; Izbicki et al. 2005b). Depth-discrete water quality sampling suggests that water in the GCA has higher chloride than that in the overlying FCA, likely as a result of upward vertical migration of brackish water from deeper formations, upwelling of brackish water along fault zones, and release of interstitial water from marine clays (Bachman 2016; CMWD 2008; Izbicki et al. 2005a). Chloride concentrations in the GCA range from 127 to 508 mg/L, with the highest concentrations detected in the deepest intervals (Izbicki et al. 2005b).

2.2.5 Data Gaps and Uncertainty

The primary data gaps in the hydrogeologic conceptual model are as follows:

- Distributed measurements of aquifer properties from wells screened solely in a single aquifer
- Distributed measurements of groundwater quality from wells screened solely in a single aquifer
- Measurements of groundwater quality that distinguish the sources of high TDS concentrations in the FCA and the GCA
- Sufficient water level measurements from wells screened in a single aquifer to delineate the effects of faulting on groundwater flow in northern Pleasant Valley

The data gaps listed above create uncertainty in the understanding of the impacts of water level changes on change in storage in the aquifer. Additional aquifer tests and groundwater quality sampling in the future would help reduce the uncertainty associated with these data gaps. Additional monitoring wells in northern Pleasant Valley would help define the effects of faulting on groundwater elevations.

2.2.6 Maps and Cross Sections

Geologic maps and cross sections are provided in Figures 2-2 through 2-5.

2.3 GROUNDWATER CONDITIONS

2.3.1 Groundwater Elevation Data

Groundwater elevations in the PVB were first measured in agricultural wells in the 1920s. An annual groundwater monitoring program was initiated in the PVB by the County of Ventura (County), the United Water Conservation District (UWCD), and the U.S. Geological Survey in the 1990s (FCGMA 2007). The County's annual groundwater monitoring program includes production wells and multiple-completion nested monitoring wells. Many of the production wells included in the monitoring program are screened across multiple aquifers (Figure 2-6, Upper

Aquifer System 2015 Extraction [acre-feet] in Oxnard and Pleasant Valley, and Figure 2-7, Lower Aquifer System 2015 Extraction [acre-feet] in Oxnard and Pleasant Valley). Historically, the FCGMA annual reports have included potentiometric surface maps for wells screened in the UAS and wells screened in the LAS (FCGMA 2016).

To conform with DWR GSP Regulations, Section 354.14, the following discussion of groundwater elevation is limited to wells screened in a single aquifer. Water level measurements collected between March 2 and March 29, 2015, are used to represent groundwater elevations in the spring of 2015. Water level measurements collected between October 2 and October 29, 2015, are used to represent groundwater elevations in the fall of 2015.

Because many production wells within the PVB are screened across multiple aquifers and there is a limited number of dedicated monitoring wells, the ability to depict representative regional potentiometric surfaces in each aquifer is limited. Groundwater pumping data were mapped to provide context for interpreting the potentiometric surfaces presented in this section (Figures 2-6 and 2-7). Self-reported groundwater extraction data for 2015 are shown in Figures 2-6 and 2-7 for wells screened in the UAS and the LAS, respectively.

The volume of groundwater extracted from the LAS is substantially greater than that extracted from the UAS in the PVB. In 2015, 12,826 acre-feet (AF) was pumped from the LAS and 1,535 AF was pumped from the UAS in the PVB. Groundwater production in the LAS is higher than in the UAS because the aquifers of the UAS are generally absent or much less developed in the PVB compared to the Oxnard Subbasin. In the UAS, extraction occurs to the south of the City of Camarillo (Figure 2-6). The majority of the production from the LAS occurs in the southwestern portion of the basin, near the boundary between the PVB and the Oxnard Subbasin, although some also occurs to the north near the Somis Gap (Figure 2-7).

A pumping depression is evident in the area of highest extraction from the LAS; however, because groundwater elevation measurements are clustered in the northeastern and southwestern areas of the PVB, the impacts of pumping on groundwater elevations in much of central PVB are not entirely clear (see Sections 2.3.1.1 through 2.3.1.4).

Current and historical groundwater elevations are discussed in Sections 2.3.1.1 through 2.3.1.4 by aquifer. Full hydrographs for all Pleasant Valley wells are included in Appendix C, Water Elevation Hydrographs.

2.3.1.1 Shallow Alluvial Aquifer

Spring and Fall 2015 Groundwater Elevations

The Shallow Alluvial Aquifer comprises the recent alluvial deposits that line Arroyo Las Posas, Arroyo Santa Rosa, Conejo Creek, and Calleguas Creek in the PVB. Few wells produce from this aquifer, and no production wells are screened solely within this aquifer. Groundwater elevations were not measured in 2015 for any wells screened solely within the Shallow Alluvial Aquifer in the PVB. Flow in this aquifer is assumed to parallel the creek channels, although monitoring wells would need to be installed to determine the direction and magnitude of flow in the Shallow Alluvial Aquifer.

Vertical Gradient

There are no multiple-completion nested monitoring wells screened in the Shallow Alluvial Aquifer, so vertical gradients cannot be calculated for this aquifer. However, groundwater elevations in this aquifer are below the bottom of Arroyo Las Posas and Conejo Creek and there is no evidence that groundwater discharges from the aquifer to these watercourses. Where permeable pathways exist, water in the Shallow Alluvial Aquifer can move downward to the underlying older alluvium (Bachman 2016).

Historical Groundwater Elevation Trends

Groundwater elevation adjacent to Arroyo Las Posas was measured in a shallow groundwater monitoring well (T0611100253) at the intersection of Highway 101 and Santa Rosa Road from 1993 through 2011 (Figure 2-8, Groundwater Elevation Hydrographs in the Shallow Alluvial Aquifer). The shallow groundwater monitoring well was screened from 51 to 80 feet bgs. The trends in groundwater elevation in this well are similar to the climatic trends in precipitation observed in the PVB (Figure 2-8). The well was destroyed in 2011 (ExxonMobil Environmental Services 2011).

2.3.1.2 Older Alluvium

Spring and Fall 2015 Groundwater Elevations

Groundwater elevations were measured in two wells (02N21W34G05S and 02N21W34G04S) in the older alluvium in the spring and fall of 2015. These wells are two completions within a multiple-completion nested monitoring well in northwestern Pleasant Valley (Figure 2-9, Groundwater Elevation Contours in the Oxnard Aquifer [Older Alluvium], March 2–29, 2015, and Figure 2-10, Groundwater Elevation Contours in the Mugu Aquifer [Older Alluvium], March 2–29, 2015). Well 02N21W34G05S is screened from 170 to 190 feet bgs, and Well 02N21W34G04S is screened from

360 to 380 feet bgs. In the spring of 2015, the groundwater elevations in Wells 02N21W34G05S and 02N21W34G04S were 10.1 feet msl and −56.5 feet msl, respectively (Figures 2-9 and 2-10). In the fall of 2015, the groundwater elevations in Wells 02N21W34G05S and 02N21W34G04S were −14.8 feet msl and −86.6 feet msl, respectively (Figure 2-11, Groundwater Elevation Contours in the Oxnard Aquifer [Older Alluvium], October 2–29, 2015, and Figure 2-12, Groundwater Elevation Contours in the Mugu Aquifer [Older Alluvium], October 2–29, 2015).

Because these wells are the only two wells screened solely within the older alluvium and because both wells are located within a single borehole, the horizontal hydraulic gradient in the older alluvium cannot be calculated for the PVB. The older alluvium is age equivalent to the Oxnard and Mugu Aquifers in the Oxnard Subbasin, west of the PVB. Water levels in the Mugu Aquifer in the Oxnard Subbasin suggest that there may be flow from the Oxnard Subbasin into the PVB (Figure 2-12). There are no wells screened solely in the Mugu Aquifer east of the Revolon Slough and west of Well 02N21W34G04S. Therefore, there is a data gap in this area.

Vertical Gradient

Within the older alluvium there was a downward vertical hydraulic gradient of approximately 0.37 feet/feet in the spring and fall of 2015. This downward gradient within the older alluvium is greater than that between the older alluvium and the underlying FCA. The vertical gradient between Well 02N21W34G04S in the older alluvium and Well 02N21W34G03S in the FCA was approximately 0.07 feet/feet in the spring of 2015 and 0.09 feet/feet in the fall of 2015 (Table 2-2). These two aquifers are separated by the Upper San Pedro Formation (see Section 2.2.4, Principal Aquifers and Aquitards).

Historical Groundwater Elevation Trends

Groundwater elevation in the older alluvium has tracked climatic trends in the PVB (Figure 2-13, Groundwater Elevation Hydrographs in the Older Alluvium). In general, groundwater elevations recovered between 1990 and 2006, a period of above-average precipitation, due to inflow of water along the Arroyo Las Posas and surface water/groundwater/imported water/in-lieu water deliveries, including those associated with the Pleasant Valley Pipeline (PVP), Pumping Trough Pipeline, and Conejo Creek Projects. Groundwater elevations were stable between 2006 and 2011. Between 2012 and 2015, groundwater elevations declined approximately 40 feet in Well 02N21W34G05S and approximately 60 feet in Well 02N21W34G04S (Figure 2-13) in response to the period of drought. Groundwater elevations in both wells remain above the elevations measured in 1990, 1991, and 1992. At this time, groundwater elevations rose in response to increased recharge along Arroyo Las Posas from non-native sources of flow, including WWTP discharges. Perennial surface water flow from WWTP discharges in Arroyo Las Posas no longer reaches Pleasant Valley, cutting off the source of recharge to the groundwater.

2.3.1.3 Fox Canyon Aquifer

Spring and Fall 2015 Groundwater Elevations

In the spring of 2015, recorded groundwater elevations in the PVB within the FCA ranged from –129.3 feet msl to 38.62 feet msl (Figure 2-14, Groundwater Elevation Contours in the Fox Canyon Aquifer, March 2–29, 2015). In the fall of 2015, groundwater elevations ranged from −125.12 feet msl to 15.16 feet msl (Figure 2-15, Groundwater Elevation Contours in the Fox Canyon Aquifer, October 2–29, 2015). The highest groundwater elevation was measured in northeastern PVB, and the lowest groundwater elevation was measured in northwestern PVB. The apparent direction of flow in the spring of 2015 was to the west-southwest, and the hydraulic gradient was approximately 0.008 feet/feet. The apparent direction of flow within the aquifer in the fall of 2015 was to the west/southwest, and the horizontal hydraulic gradient was approximately 0.011 feet/feet. The apparent direction of flow in the FCA reflects the location of the primary pumping area in the western PVB (Figure 2-7). The majority of the groundwater production in the LAS occurs west of Lewis Road and south of Highway 101.

In addition to the location of the groundwater pumping centers, multiple faults in the PVB also influence groundwater elevations and direction of groundwater flow (Bachman 2016). The current distribution of wells screened solely in the FCA is insufficient to determine the influence of many of these faults, although the difference in groundwater elevation between wells in the western PVB (e.g., Wells 02N21W34G03S and 02N21W03C01S) and those in the northern and eastern PVB (e.g., Wells 02N20W19M05S and 02N20W29B02S) likely reflects the cumulative influence of faulting, increased recharge along Arroyo Las Posas, and pumping on groundwater elevations in the PVB (CMWD 2008). The northern wells are the only wells in the FCA in the PVB with groundwater elevations that are above sea level.

Vertical Gradient

Groundwater elevations in the FCA are lower than groundwater elevations in the overlying older alluvium. The downward vertical hydraulic gradient from the older alluvium to the FCA was approximately 0.072 feet/feet in the spring of 2015, and 0.088 feet/feet in the fall of 2015 (Table 2-2). The vertical hydraulic gradients reflect the groundwater depression caused by pumping within the FCA (Figure 2-12).

In contrast, within the FCA, the vertical hydraulic gradient was directed upward in both the spring and fall of 2015. In the spring, the vertical hydraulic gradient within the FCA was approximately 0.043 feet/feet. In the fall, the vertical hydraulic gradient within the FCA was approximately 0.022 feet/feet.

Historical Groundwater Elevation Trends

The historical trends in groundwater elevation in the FCA are similar throughout the PVB, although absolute groundwater elevations vary across the PVB (Figure 2-16, Groundwater Elevation Hydrographs in the Fox Canyon Aquifer). Groundwater elevation trends in Well 01N21W03C01S, the well with the longest historical groundwater elevation record in the FCA, mimic the trends observed in the record of cumulative departure from the mean precipitation for Pleasant Valley. The correlation with the cumulative departure curve occurs for two reasons. First, during periods of above-average rainfall, UWCD is able to recharge groundwater in the Oxnard Subbasin, which is hydraulically connected to the PVB, and is also able to deliver surface water to the PVB to reduce groundwater production in the basin. Second, recharge in the PVB increased in the 1980s and 1990s as perennial wastewater flows in Arroyo Las Posas reached the PVB in 1990. These flows exerted the primary influence on the rising trend in groundwater elevations between 1990 and 2011 (Figure 2-16).

Groundwater elevation in Well 01N21W03C01S declined between 1985 and 1991, coincident with a period of lower-than-average precipitation in Pleasant Valley (Figure 2-16). Groundwater elevations in this well recovered from 1991 to 2006, as a result of wetter-than-average climate conditions and recharge of non-native surface water along Arroyo Las Posas. Groundwater elevations were relatively stable between 2006 and 2011. In 2011, with the onset of the drought, groundwater elevations declined again. In 2015, groundwater elevations remained approximately 50 feet higher than the lowest groundwater elevation recorded in the FCA in 1991, as a result of the additional recharge of surface water along Arroyo Las Posas (Figure 2-16).

Other wells in the western PVB have similar responses to that of Well 01N21W03C01S (Figure 2-16). Groundwater elevations in the northeastern portion of the PVB were influenced by the inflow of water along the Arroyo Las Posas. Groundwater levels in the south and western portions of the basin were influenced by in-lieu water deliveries. The City of Camarillo also received imported water, which impacted groundwater elevations in the PVB.

2.3.1.4 Grimes Canyon Aquifer

There are no wells screened solely within the GCA in the PVB.

2.3.2 Estimated Change in Storage

Estimated monthly change in storage values for the PVB were generated by the numerical groundwater flow model prepared by UWCD (2018, provided with this GSP as Appendix D, UWCD Model Report). Model data for change in storage was reported by aquifer system (semi-perched, UAS, and LAS), and the total change in storage for the PVB was calculated by summing the change in storage for all aquifer systems. It should be noted that the names of the aquifer systems for the

Oxnard Subbasin are carried over to the PVB in the UWCD model for consistency in discussion as well as model continuity. This highlights the interconnectedness of these basins but is not a substitute for the naming conventions of the principal aquifers and aquitards discussed in Section 2.2.4. The semi-perched aquifer is modeled as an area of approximately 14,000 acres with a thickness ranging from approximately 10 to 100 feet in the PVB in order to incorporate the tile drains in the western portion of the PVB that connect with the Oxnard Subbasin. The UAS is also a continuous layer in the UWCD model, although that layer represents the older alluvium of the PVB.

Monthly data reported from the model were summed to reflect the annual change in storage for water year 1986 through water year 2015. The average annual change in storage in the semi-perched aquifer was an increase in storage of approximately 515 AFY, with a maximum increase in storage of approximately 8,000 AF in water year 1998 and a maximum decrease in storage of approximately 7,500 AF in water year 2014. In the UAS, the average annual change in storage was an increase of approximately 1,320 AFY, with a maximum increase in storage of approximately 10,000 AF in water year 1993 and a maximum decrease in storage of approximately 5,440 AF in water year 2014. The LAS had an average annual increase in storage of approximately 445 AFY, with a maximum increase in storage of approximately 4,240 AF in water year 1998 and a maximum decrease in storage of approximately 2,970 AF in water year 1987. The total average annual change in storage for the PVB was an increase in storage of approximately 2,280 AFY, with a maximum increase in storage of approximately 21,850 AF in water year 1998 and a maximum decrease in storage of approximately 15,370 AF in water year 2014 (Figure 2-17, Annual Change in Storage). The cumulative change in storage in the model over the period of record for the semi-perched aquifer, the UAS, and the LAS was an increase of approximately 15,410 AF, 39,600 AF, and 13,390 AF, respectively, for a total cumulative increase in storage of approximately 68,400 AF (Figure 2-18, Cumulative Change in Storage). Pumping in FCGMA jurisdiction is reported on a calendar-year basis, so pumping shown in the figures is per calendar year, while change in storage is per water year.

Modeled change in storage is dependent on several input parameters to the model, which include groundwater pumping, interbasin flows, recharge from precipitation and irrigation returns, stream leakage, and groundwater discharge to streams. The UWCD model inputs were estimated using the best available data and calibrated to measured water levels to the greatest extent possible. Changes in calculations for these input values, along with continued model calibration, will result in changes in the model estimate of change in storage in the future.

2.3.3 Seawater Intrusion (Baseline)

The aquifers of the PVB have not experienced direct seawater intrusion. Although seawater intrusion has not occurred within the PVB, seawater intrusion in the FCA and the GCA in the Oxnard Subbasin is directly related to groundwater pumping in the PVB. Groundwater pumping from the FCA and the GCA in the PVB lowers the potentiometric head in these aquifers, which can result in landward gradients that induce seawater intrusion. Additionally, pumping in the FCA and the GCA in the PVB can increase groundwater flow from the UAS of the Oxnard Subbasin to the FCA and the GCA in both the Oxnard Subbasin and the PVB. This increase in downward groundwater flow decreases the water level in the UAS, thereby potentially inducing seawater intrusion.

2.3.4 Groundwater Quality (Baseline)

FCGMA has adopted Basin Management Objectives for chloride in the PVB (FCGMA 2007; Table 2-3). Additionally, the Water Quality Control Plan: Los Angeles Region (Basin Plan) specifies Water Quality Objectives (WQOs) for TDS, chloride, nitrate (mg/L as nitrate, or NO_3), sulfate (SO_4) and boron (LARWQCB 2013; Table 2-3). The current and historical distribution of these five constituents are discussed below based on aquifer system, rather than individual aquifer. There are too few measurements of water quality in wells screened solely within a single aquifer to allow for meaningful discussion of water quality by aquifer. Additionally, as discussed in Section 2.3.1, Groundwater Elevation Data, the majority of the groundwater production in the PVB occurs in wells that are screened across multiple aquifers. Therefore, impacts to groundwater quality in the PVB should be considered based on aquifer system, rather than individual aquifer.

The primary water quality concerns in the PVB are inflows of poor-quality water from discharges from the Simi Valley Water Quality Control Plant, dewatering wells operated by the City of Simi Valley, and discharges from the MWTP percolation ponds adjacent to Arroyo Simi–Las Posas, discharges from the Hill Canyon WWTP and the CSD WRP to Conejo Creek, and saline intrusion in the FCA and the GCA from brine migration along the Bailey Fault. The inflows of poor-quality water percolate through the Shallow Alluvial Aquifer and recharge both the older alluvium and the FCA. Increases in the concentration of TDS and chloride have impaired municipal use of groundwater in the northern part of the PVB (City of Camarillo 2015). Non-marine saline intrusion may affect the FCA and the GCA if groundwater level declines cause compaction of aquitards and create low-pressure conditions that promote the migration of brines along faults and the upwelling of brines from deeper formations (FCGMA 2007; UWCD 2016a). However, a direct correlation between groundwater elevation and TDS concentration has not been established.

Groundwater quality monitoring within the PVB occurs at different intervals for different wells. To assess the current groundwater quality conditions within the PVB, the most recent concentration of each of the constituents listed above was plotted for samples collected from 2011 through 2015 (Figures 2-19 through 2-28).[2] Historical groundwater quality hydrographs are

[2] Note: The Salt Nutrient Management Plan (SNMP) for the Calleguas Creek Watershed uses the median concentration measured at a well over a 5-year period.

presented in Appendix E, Water Quality Hydrographs. Statistics on the most recent sample concentration and date; the maximum, minimum, median, and standard deviations of measured concentrations; the number of times sampled; and the number of samples with concentrations that exceeded the Basin Plan WQOs (LARWQCB 2013) are presented in Appendix F, FCGMA Water Quality Statistics.

2.3.4.1 Total Dissolved Solids

The WQO for TDS is 700 mg/L in the confined aquifers (LARWQCB 2013). There is no WQO for the unconfined aquifers in the PVB (LARWQCB 2013).

Upper Aquifer System

TDS concentration was measured in six UAS wells in the PVB from 2011 through 2015. The concentration of TDS over this period ranged from 704 to 4,340 mg/L (Figure 2-19, Upper Aquifer System – Most Recent Total Dissolved Solids [mg/L] Measured 2011–2015). Of the wells sampled, the southern wells had higher concentrations of TDS than the northern wells (Figure 2-19).

Lower Aquifer System

TDS concentration was measured in 15 wells in the LAS from 2011 through 2015 (Figure 2-20, Lower Aquifer System – Most Recent Total Dissolved Solids [mg/L] Measured 2011–2015). The concentration ranged from 630 to 1,930 mg/L, with the highest concentration measured in Well 02N20W19M06S and the lowest in Well 02N21W33R02S. Well 02N21W33R02S was the only well in the LAS with a TDS concentration below the WQO.

2.3.4.2 Chloride

The WQO for chloride is 150 mg/L in the confined aquifers, and the Basin Management Objective for chloride is less than 150 mg/L (FCGMA 2007; LARWQCB 2013).

Upper Aquifer System

Chloride concentration was measured in seven wells in the UAS from 2011 through 2015. The concentration ranged from 50 to 660 mg/L (Figure 2-21, Upper Aquifer System – Most Recent Chloride [mg/L] Measured 2011–2015). Of the seven wells measured, two had concentrations below 150 mg/L. The highest concentration of chloride was measured in Well 01N21W15H01S in the southwestern PVB (Figure 2-21). Groundwater from this well also had the highest concentration of TDS.

Lower Aquifer System

Chloride concentration was measured in 15 wells in the LAS from 2011 through 2015. The concentration ranged from 59 to 224 mg/L, with eight wells having concentrations less than 150 mg/L (Figure 2-22, Lower Aquifer System – Most Recent Chloride [mg/L] Measured 2011–2015). The highest concentration of chloride was measured in Well 01N21W03R01S in the western PVB (Figure 2-22). The lowest concentration of chloride was measured in Well 02N21W33R02S in the northwestern part of the PVB (Figure 2-22). In general, chloride concentrations in the LAS were lower than those in the UAS.

2.3.4.3 Nitrate

The WQO for nitrate as NO_3 is 45 mg/L for the PVB (LARWQCB 2013).

Upper Aquifer System

Nitrate as NO_3 concentration was measured in seven wells in the UAS from 2011 through 2015 (Figure 2-23, Upper Aquifer System – Most Recent Nitrate [mg/L as nitrate] Measured 2011–2015). Four of the seven wells had concentrations below 45 mg/L, and concentrations in the other three wells ranged from 52 to 171 mg/L. The lowest concentrations of nitrate as NO_3 were found in southwestern PVB (Figure 2-23).

Lower Aquifer System

Nitrate as NO_3 concentration was measured in 15 wells in the LAS from 2011 through 2015. The concentration ranged from below the detection limit to 31 mg/L (Figure 2-24, Lower Aquifer System – Most Recent Nitrate [mg/L as nitrate] Measured 2011–2015). All of the wells measured had concentrations below the WQO for nitrate as NO_3.

2.3.4.4 Sulfate

The WQO for sulfate is 300 mg/L in the confined aquifers (LARWQCB 2013).

Upper Aquifer System

The concentration of sulfate was measured in seven wells in the UAS from 2011 through 2015 (Figure 2-25, Upper Aquifer System – Most Recent Sulfate [mg/L] Measured 2011–2015). Of these, only Well 02N21W34G04S had a sulfate concentration below 300 mg/L. The remaining wells had sulfate concentrations ranging from 350 to 2,130 mg/L.

Lower Aquifer System

The concentration of sulfate was measured in 15 wells in the LAS from 2011 through 2015 (Figure 2-26, Lower Aquifer System – Most Recent Sulfate [mg/L] Measured 2011–2015). The concentration ranged from 155 to 920 mg/L, and 8 of the 15 wells measured concentrations of sulfate exceeding 300 mg/L. These wells are distributed throughout the PVB, with the highest concentration measured in Wells 02N20W19M06S and 02N20W19L05S. The wells with the highest concentration of sulfate are in the area of the recharge mound created by surface water inflows entering the PVB along Arroyo Las Posas. The Northern Pleasant Valley Desalter Project will extract the mounded poor-quality groundwater in this area in an effort to limit migration. The lowest concentration was measured in Well 02N20W29B02S (Figure 2-26).

2.3.4.5 Boron

The WQO for boron is 1 mg/L (LARWQCB 2013).

Upper Aquifer System

Boron concentrations were measured in seven UAS wells from 2011 through 2015 (Figure 2-27, Upper Aquifer System – Most Recent Boron [mg/L] Measured 2011–2015). The concentration ranged from 0.3 to 2.0 mg/L. Two wells, 01N21W02J01S and 01N21W15H01S, had concentrations that exceeded the WQO. The remaining five wells were below the WQO.

Lower Aquifer System

Boron concentrations were measured in 15 LAS wells from 2011 through 2015 (Figure 2-28, Lower Aquifer System – Most Recent Boron [mg/L] Measured 2011–2015). The concentration ranged from 0.3 to 0.9 mg/L. The concentration of boron in all LAS wells was below the WQO.

2.3.4.6 Map of Oil and Gas Deposits

According to records from the County (County of Ventura 2016), two oil fields (the Las Posas and the Conejo) falls partially within the PVB (Figure 2-29, Oil Fields in the Vicinity of FCGMA Groundwater Basins). Petroleum extraction in the FCGMA basins occurs below the deepest freshwater aquifer (Hopkins 2013). While no evidence of impacts of petroleum extraction on beneficial use of groundwater in the FCGMA basins has been identified, there are limited available data. Few wells exist in deep aquifers near oil fields that could be monitored for potential impact. However, trace amounts of organic compounds have been found in deeper wells in the southeastern PVB (Izbicki et al. 2005), and there have been anecdotal reports of trace petroleum hydrocarbons observed in irrigation wells near some oil fields.

2.3.4.7 Maps of Locations of Impacted Surface Water, Soil, and Groundwater

Impaired surface waters (i.e., Clean Water Act Section 303(d) Listed Reaches) that overlie the PVB include Arroyo Las Posas, Calleguas Creek, and Conejo Creek where those surface water bodies fall within the boundaries of the PVB (Figure 2-30, Impaired Surface Waters in the Vicinity of FCGMA Groundwater Basins) (SWRCB 2012). The names of the reaches used by the State Water Resources Control Board, and the impairments listed for each, are included in tabulated form in Appendix G, Pleasant Valley Basin 303(d) List Reaches.

Locations of impacted soil and groundwater were assessed on a basin-wide scale by reviewing information available on the California State Water Resources Control Board's GeoTracker website (SWRCB 2017) and the California Department of Toxic Substances Control's EnviroStor website (DTSC 2017). Cases that were closed by the supervisory agency were not considered.

Of the 290 open cases located within the boundaries of the FCGMA basins, groundwater was impacted in 77. Dudek reviewed and catalogued the constituents of concern (COCs) present on site in these 77 cases, 6 of which fell within the PVB boundary.

Of the six open cases in the PVB in which groundwater is, or is potentially, impacted, the following COCs were identified as present at the following number of sites (Figure 2-31, Constituents of Concern at Open GeoTracker Cases with Impacted Groundwater within FCGMA Groundwater Basin Boundaries; Appendix H, GeoTracker Open Sites):

- Chlorinated volatile organic compounds (VOCs), including COCs marked as *solvents*, *VOCs*, and *chlorinated hydrocarbons* were present at two sites
- Gasoline and diesel, including COCs marked *TPH* and *petroleum*, were present at three sites
- Metals were present at one site
- PCBs were present at zero sites
- Benzene, toluene, ethylbenzene, and/or xylenes (BTEX) were present at one site
- The pesticide chlordane was present at two sites
- Methyl tert-butyl ethylene (MTBE) and/or tert-butyl alcohol (TBA) were present at one site

These cases are under active management by the Department of Toxic Substances Control and/or State Water Resources Control Board. Based on a review of the files available on GeoTracker for each of the cases in the PVB, it appears that in none of the cases were any liable parties required to investigate deeper than 50 feet bgs, indicating that impacts to groundwater in the UAS were not a concern for regulatory agencies.

2.3.5 Subsidence (Baseline)

Inelastic, or irrecoverable, land subsidence (subsidence) can be a concern in areas of active groundwater extraction, including Pleasant Valley. Active causes of land subsidence in Pleasant Valley include tectonic forces, petroleum reservoir compaction, and fine sediment compaction (Hanson et al. 2003). Significant water level declines in the FCGMA groundwater basins since the early 1900s suggest that fluid extraction rather than tectonic activity is the major cause of land subsidence (Hanson et al. 2003). Subsidence resulting from any of these sources can cause increased flood risk, well casing collapse, and a permanent reduction in specific storage.

Direct measurement of historical subsidence in Pleasant Valley is limited geographically and temporally. UNAVCO monument CSCI (California State Channel Islands) is located immediately adjacent to the southern boundary of PVB in the foothills of the Santa Monica Mountains (Figure 2-2).[3] There has been no net subsidence at this monument since its installation in November 2000. Because of the placement of this monument in the foothills of the Santa Monica Mountains, elevations measured there reflect tectonic forces rather than the influence of groundwater withdrawals.

Potential subsidence was modeled for southwestern Pleasant Valley and for the west part of the East Las Posas Management Area using different future water production scenarios (Hanson et al. 2003). The scenarios included consideration of proposed water projects and ordinances for the FCGMA basins. The model results suggest that southwestern Pleasant Valley may experience an additional 0.1 to 1 foot of subsidence by 2040 (Hanson et al. 2003). DWR designated the PVB as an area that has a low potential for future subsidence (DWR 2014). The amount of future subsidence will depend on whether future water levels decline below previous maximum declines for a sufficient time to cause compaction, or remain above these previous low levels (Hanson et al. 2003). Maintaining water levels above the previous low water levels will limit the potential for future subsidence.

From March 2015 to June 2016, the Jet Propulsion Laboratory (JPL) analyzed interferometric synthetic aperture radar (InSAR) data from the European Space Agency's satellite-borne Sentinel-1A and NASA's airborne UAVSAR along with similar previous studies from 2006 to 2015 to examine subsidence in areas of California. The study included the south-central coast of California areas of Ventura and Oxnard (Farr et al. 2017). The map generated from this study for the south-central coast of California area (Farr et al. 2017, Figure 23) showed less than 1 foot of subsidence for the PVB area.

[3] A monument is a physical object for which one is trying to collect data for a determination of position, velocity, and/or acceleration for one or more survey points on or very near that object (UNAVCO 2019).

2.3.6 Groundwater–Surface Water Connections

As discussed in Section 2.2.4, flows in Arroyo Las Posas, Conejo Creek, and Calleguas Creek may be connected to groundwater in the Shallow Alluvial Aquifer. However, shallow groundwater elevation data and information about gaining and losing reaches within the PVB are extremely limited, with no monitoring sites near enough to surface water bodies to provide meaningful information about the connection between surface water and groundwater. Examination of County historical air photos indicated that Arroyo Simi–Las Posas in the LPVB was dry without adjacent vegetation before the 1970s. The best available information comes from model simulated values for groundwater/surface water connections in the UWCD numerical groundwater flow model, which used available data from stream gauges and estimated aquifer properties to estimate the recharge (Appendix D). The UWCD model estimated stream leakage from Arroyo Las Posas, Calleguas Creek, and Conejo Creek into the underlying semi-perched aquifer and Shallow Alluvial Aquifer. Numbers from the model represent net stream leakage, and do not necessarily indicate direct connection between surface water bodies and groundwater in the Shallow Alluvial Aquifer system.

The calculated stream percolation for water years 1986 to 2015 are provided in Table 2-4. These values are from the UWCD groundwater model, which is discussed in greater detail in the water budget section (Section 2.4, Water Budget). Arroyo Las Posas had net recharge to groundwater in all years modeled by UWCD, with an average net recharge to groundwater of approximately 4,400 AFY. Conejo Creek exhibited net recharge to groundwater in all years modeled, with an average net recharge to groundwater of approximately 8,200 AFY. Calleguas Creek exhibited net recharge to groundwater in all years modeled, with an average net recharge to groundwater of approximately 3,600 AFY.

2.3.7 Groundwater-Dependent Ecosystems

The dominant surface water bodies in the PVB are Arroyo Las Posas, Calleguas Creek, and Conejo Creek, all of which drain watersheds that extend beyond the boundaries of the PVB (Figure 2-32, Groundwater-Dependent Ecosystems and Stream Reaches in Pleasant Valley). Within the PVB, Arroyo Las Posas is ephemeral, although upstream of the boundary between the PVB and the LPVB, flow in Arroyo Las Posas is generally perennial (VCWPD 2009). Flow in Arroyo Las Posas is from both native and non-native flow sources (Bachman 2016; CMWD 2008). The non-native flows consist of discharges from the Simi Valley Water Quality Control Plant, dewatering wells operated by the City of Simi Valley, and discharges from the MWTP percolation ponds adjacent to Arroyo Simi–Las Posas in the LPVB (Bachman 2016; CMWD 2008). Perennial flow is observed in Conejo Creek and in Calleguas Creek downstream of the confluence with Conejo Creek. The primary sources of perennial flow to Conejo Creek are urban runoff from Thousand

Oaks in upstream branches of Conejo Creek, the Hill Canyon WWTP, and the CSD WRP.[4] Both the WWTP and the WRP provide non-native sources of flow to the creek. Irrigation water from agriculture and/or landscaping may also serve as a source of flow in both channels during some parts of the year. Water from Conejo Creek is diverted for nonpotable (agricultural and landscaping) uses from a diversion structure near Highway 101 (CWD 2017).

Calleguas Creek, Conejo Creek, and the lower reach of Arroyo Las Posas were identified as potential groundwater-dependent ecosystems (GDEs) on the statewide potential GDE map (TNC 2017). Of these potential GDEs, only lower Arroyo Las Posas north of Pleasant Valley Road lies within FCGMA jurisdiction. All three watercourses are connected to the Shallow Alluvial Aquifer, although the extent of gaining or losing reaches for these streams is not clear in the PVB (see Section 2.2.4).

Calleguas Creek, Arroyo Las Posas, and Conejo Creek include both reaches with natural channel consisting of riparian woodland/wetland habitat and confined channel with riprap on the sides and a soft bottom (VCWPD 2009). The soft bottom in the riprapped reaches is maintained in a largely vegetation-free state by the Ventura County Watershed Protection District (VCWPD 2009). Ecosystem functions and values are lower in the portions of the creeks and tributaries that have been channelized (CMWD 2004).

The Basin Plan (LARWQCB 2011) for the PVB portions of Calleguas Creek (Reaches 3 and 6), the lower reach of Arroyo Las Posas (Reach 6), and Conejo Creek (Reaches 9A and 9B) lists the following beneficial uses (Figure 2-32): groundwater recharge, warm freshwater habitat, and wildlife habitat. Conejo Creek supports the native arroyo chub (*Gila orcuttii*) and northwestern pond turtle (*Actinemys marmorata*) (CDFW 2017). Willow/mulefat riparian scrub with giant reed (*Arundo donax*) along the banks of Conejo Creek, downstream from the CSD WRP provides habitat for the state- and federally listed endangered least Bell's vireo (*Vireo bellii pusillus*) (CDFW 2017). An adult and a juvenile were observed in this area in 2009, and a breeding adult was observed in 2010 (Figure 2-33, Species Occurrences in Pleasant Valley) (CDFW 2017). The vegetation downstream of the CSD WRP is supported by discharges from the WRP that have resulted in perennial flow in Conejo Creek. In addition to the species listed above, in 2013, a single female steelhead (*Oncorhynchus mykiss irideus*) was found, dead, in Conejo Creek, downstream of Howard Road, in a "highly disturbed riparian corridor" (CDFW 2017). Steelhead are a state- and federally listed endangered species. It does not appear, however, that Conejo Creek provides ongoing steelhead habitat, as the California Department of Fish and Wildlife branch biologist found no records for steelhead in Conejo Creek before 2013, and no additional steelhead sightings have been reported since 2013 (CDFW 2017). There is no U.S. Fish and Wildlife Service critical habitat in the PVB (CDFW 2017).

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[4] The Hill Canyon WWTP is located outside the PVB boundaries in Thousand Oaks. The WWTP discharges to Arroyo Conejo, a tributary of Conejo Creek, approximately 3.5 miles upstream of where Conejo Creek enters the PVB.

In general, the connection between surface water and groundwater along Conejo Creek and Calleguas Creek is not well characterized. There was one well screened solely in the Shallow Alluvial Aquifer adjacent to the GDEs (Figure 2-34, Water Level Record for Well Locations Adjacent to Arroyo Las Posas). This well, which was destroyed in 2011, was adjacent to lower Arroyo Las Posas. There are no existing wells screened solely in the Shallow Alluvial Aquifer adjacent to Conejo Creek or Calleguas Creek, and none of the wells are screened shallower than 50 feet bgs. As the depths to groundwater in the Shallow Alluvial Aquifer increase to greater than 30 feet, the riparian vegetation is unlikely to use groundwater to sustain growth during the dry season (Stromberg 2013).

The depth to groundwater adjacent to lower Arroyo Las Posas, downstream of the intersection with Highway 101, has varied from approximately 45 to 65 feet bgs from the early 1990s to 2011 (Figure 2-34). In general, groundwater elevations recovered between 1992 and 2011 (see Section 2.3.1). The shallow groundwater monitoring well was screened from 51 to 80 feet bgs, and has had annual variations in groundwater depth of less than 10 feet since 1992 (Figure 2-33). These data appear to indicate that groundwater does not occur shallowly enough to support riparian habitat in this reach of Arroyo Las Posas.

As described above, the ecohydrology of the lower Arroyo Las Posas, Calleguas Creek, and Conejo Creek potential GDEs is complex, and the connection between these potential GDEs and groundwater in the PVB is not well characterized. The degree to which the vegetation is reliant on groundwater versus unsaturated soil water is unknown. Better understanding of the hydrology along lower Arroyo Las Posas, Calleguas Creek, and Conejo Creek would aid in determining the impacts of decreasing groundwater levels on the riparian habitat. Until this connection between groundwater and the potential GDEs is established, lower Arroyo Las Posas, Calleguas Creek, and Conejo Creek cannot be conclusively determined to be GDEs. The future monitoring network would be improved by including wells dedicated to monitoring water levels in the potential GDEs to assess the degree to which existing habitat is reliant on groundwater (see Section 4.6.5, Shallow Groundwater Monitoring near Surface Water Bodies and GDEs).

2.3.8 Potential Recharge Areas

To evaluate potential future recharge areas within the PVB, soil types were obtained from the Web Soil Survey, available online at https://websoilsurvey.nrcs.usda.gov/ (USDA 2019). Soil Ksat rates (saturated hydraulic conductivity rates) for soils of 92 micrometers per second or greater were plotted. Figure 2-35 (Pleasant Valley Potential Recharge Areas) shows the results of this evaluation and areas with the most favorable soil recharge rates. The most favorable areas are along Arroyo Las Posas, Conejo Creek, and Calleguas Creek.

2.4 WATER BUDGET

This section presents the water budget that has been prepared for the aquifer systems in the PVB. This water budget analysis has been completed in accordance with DWR GSP Regulations. The water budget has been prepared for the 31-year period from 1985 through 2015 and is described in units of AF or AFY. Two water-bearing formations are recognized in the PVB (Section 2.2.4): alluvium and the San Pedro Formation (DWR 2003). The water-bearing alluvium can be divided into a semi-perched aquifer, a Shallow Alluvial Aquifer, and older, low-permeability alluvium (older alluvium), which are not considered to be primary groundwater sources in the PVB. Groundwater in the Upper San Pedro Formation is limited to lenses of permeable sediments that are laterally discontinuous (Turner 1975). As a result, the Upper San Pedro Formation is not considered an aquifer, and few wells are known to pump from the Upper San Pedro Formation (Section 2.2.4). This formation may, however, function as a leaky aquitard providing additional water to the underlying FCA (in the LAS). The medial and basal units of the San Pedro Formation are the FCA and the GCA, respectively, which are primary water-producing units in the PVB.

UWCD (2018; see Appendix D to this GSP) developed the "Ventura Regional Groundwater Flow Model (VRGWFM)," a MODFLOW numerical groundwater flow model, for the Oxnard Subbasin, the Mound Basin, the western part of the LPVB, and the PVB. Details of the UWCD modeling effort are included in Appendix D. The groundwater budget analysis for the PVB is based on the DWR Bulletin 118 basin boundary for the PVB, and does not incorporate the remainder of the model domain. As with all groundwater flow models, the UWCD model has undergone several revisions and will continue to be revised as additional data are collected and the understanding of the hydrogeologic interactions in the model domain improves. This GSP uses the version of the model finalized in June 2018, which was developed in part to support the GSP process. This version of the model was used for the current and historical water budget analysis as well as for the future projected groundwater scenarios discussed in Section 2.4.5, Projected Water Budget and Sustainable Yield.

2.4.1 Sources of Water Supply

The aquifer systems in the PVB receive water from several sources. These include rainfall infiltration within the PVB and along its margins (mountain-front recharge) and subsurface inflows from the adjacent Oxnard Subbasin and the LPVB. Additional sources include streambed seepage from Arroyo Las Posas where it enters the PVB from the adjoining LPVB; streambed seepage from Conejo Creek where it enters the PVB from the adjoining ASRVB; deep percolation of a portion of the irrigation water that is applied to agricultural, commercial, residential, and to public open spaces; and leakage from water distribution systems and septic system return flows.

Water supplies for the PVB consist of locally pumped groundwater; imported water provided by UWCD and CMWD; surface water provided by UWCD from its Freeman Diversion on the Santa

Clara River and delivered to agricultural users in the PVB via the PVP; water supplied by the Camrosa Water District (CWD) to municipal and industrial (M&I) and agriculture users; surface water provided by CWD to the Pleasant Valley County Water District (PVCWD) from a diversion on Conejo Creek; tertiary-treated recycled water produced by CWD and CSD; and fully advanced treated recycled water produced by the City of Oxnard (through the Groundwater Recovery Enhancement and Treatment (GREAT) Program) that began to be delivered to PVCWD in early 2016. CWD also delivers pumped groundwater from Santa Rosa and Tierra Rejada Basins, and from wells at its Round Mountain Desalter Facility, and PVCWD groundwater pumping in the Oxnard Subbasin.

The predominant municipal water suppliers in the PVB are the City of Camarillo and CWD, which service portions of the City of Camarillo, and the Pleasant Valley Mutual Water Company (PVMWC). PVMWC serves a suburban area on the north side of the City, and the Camarillo Utility Enterprise serves the Camarillo Airport.[5] Figure 1-8 shows a map of water purveyors with service areas within the PVB.

- The City of Camarillo's water supplies consist of groundwater pumped from City-owned municipal supply wells located exclusively within the PVB, imported water supplied by the CMWD, and recycled water produced by CSD.
- CWD's sources consist of its Woodcreek and University wells, water imported into the basin consisting of a blend of imported water (purchased from CMWD) and groundwater pumped from wells in the ASRVB and the Tierra Rejada Basin, and nonpotable tertiary-treated recycled water produced at the Camrosa Water Reclamation Facility (CWRF).
- PVMWC's water supplies consist of groundwater pumped from its wells within the PVB, and imported water purchased from CMWD.
- Camarillo Utility Enterprise's water supplies consist of groundwater pumped from its wells within the PVB.

The predominant agricultural water suppliers in the PVB are PVCWD and CWD. PVCWD receives water from the UWCD (via the PVP) and from CWD (surface water from the Conejo Creek Diversion, which began in 2002). Prior to 2002, some farmers diverted directly from Conejo Creek for agricultural uses. CWD also distributes a portion of its diversions from Conejo Creek to other agricultural water users in the PVB and in the ASRVB.

[5] PVMWC's service area extends into the Camarillo Hills and the southern fringe of the LPVB. This portion of the PVMWC service area consists of undeveloped land and contains a large water storage tank for PVMWC's distribution system.

2.4.1.1 Surface Water Flows

Arroyo Las Posas, Conejo Creek, and Calleguas Creek are the primary streams in the PVB. Figure 2-36 (Pleasant Valley Basin Stream Gauges and Water Infrastructure) shows the locations of streams and primary drainage systems in and around the PVB, as well as the locations of stream gauges, and the two diversion structures (Freeman and Conejo Creek) that provide a portion of the water supply for the PVB. Table 2-5 summarizes the available stream flow data in Arroyo Las Posas and Conejo Creek at the stream gauge locations shown on Figure 2-36, the estimated amounts of Conejo Creek surface water diverted for agriculture prior to 2002, and the amounts of surface water diverted by CWD to PVCWD and to others for agriculture and M&I since creek diversions began in 2002 at the Conejo Creek Diversion near Highway 101. Figure 2-37 (Pleasant Valley Basin Stream Flows) shows plots of stream flow data collected at the stream gauge locations in Arroyo Las Posas and Conejo Creek.

Arroyo Las Posas is generally perennial (average or wet years) in its most downstream reach within the LPVB, then fully infiltrates its baseflow upon crossing into the PVB. As described by Bachman (2016), baseflow in Arroyo Simi–Las Posas is a mixture of natural dry-weather flows, discharges from WWTPs, discharge from dewatering wells in Simi Valley, and agricultural tailwaters. The terminus of the baseflow originally occurred in the LPVB, but in the early 1990s it began to move downstream as the LPVB Shallow Alluvial Aquifer began to fill as a result of higher baseflow contributions from Simi Valley. Bachman (2016) reports that the baseflow crossing into the PVB infiltrates along a 1,400-foot-long reach of Arroyo Las Posas at the northern margin of the PVB. Bachman (2016) also estimated that the next 5,500 feet of the creek can infiltrate some or all of the storm flow in the creek that crosses into the PVB during an individual storm event. Bachman (2016) estimated that this lower reach has an infiltration capacity of approximately 89 AF per day. However, surface flows from the LPVB have not occurred during dry weather since about 2012 due to drought conditions.

Conejo Creek is perennial in the upstream adjoining the ASRVB and remains perennial over its entire reach within the PVB. The source of water to Conejo Creek is mostly wastewater discharge from the City of Thousand Oaks Hill Canyon WWTP upstream of the ASRVB, and CSD wastewater discharge flows to Conejo Creek south of the Conejo Creek Diversion near Highway 101 (Figure 2-36). In 2015, CSD discharged 2,274 AFY of tertiary-treated water to lower reaches of Conejo Creek, and provided 1,703 AFY of recycled water supply to agricultural users and urban landscape irrigation (CSD 2016, as cited in DBS&A 2017). CSD has historically discharged an average of about 2,700 AFY (Table 2-5). Urban runoff and seepage, as well as native runoff, contribute to flow in the stream. Since 2002, CWD has operated the Conejo Creek Diversion to provide agricultural and M&I water supplies in the PVB and the ASRVB. CWD is required to maintain 6 cubic feet per second of flow in the stream below the diversion for habitat maintenance purposes. Table 2-5 shows the amounts of water diverted by CWD via the Conejo Creek Diversion and delivered within the PVB based on records presented by CWD, stream flows in Arroyo Las Posas and Conejo Creek, and discharges from CSD into Conejo Creek. Conejo Creek diversions by agricultural users prior to 2002 were estimated by CWD. Figure 2-38 (Conejo Creek Diversions) shows the volume of CWD's diversions from Conejo Creek.

Calleguas Creek extends from the confluence of Arroyo Las Posas and Conejo Creek downstream to the Pacific Ocean at the Mugu Lagoon. Stream flows from Calleguas Creek into the adjacent Oxnard Subbasin are perennial because of treatment discharges, and flow can potentially increase downstream due to inflows from agricultural field tile drains and from the Revolon Slough, which enters Calleguas Creek downstream of Highway 1 in the Oxnard Subbasin.

CWD produces recycled water from its CWRF. During 2015, recycled water deliveries from CWD totaled 1,263 AF for agricultural irrigation on nearby land parcels and landscape irrigation at California State University Channel Islands. Because of high demands and CWD's 300 AFY capacity recycled water storage ponds, CWD has discharged treated water to Calleguas Creek only once since 2000 (approximately 90 AF was discharged during a high-rainfall period in early 2005).

Surface Water Recharge

The UWCD (2018; see Appendix D) groundwater model used the MODFLOW STR stream package to simulate recharge for Arroyo Las Posas, Conejo Creek, and Calleguas Creek in the PVB. Calleguas Creek in the PVB does not have hydraulic communication with the underlying UAS, but modeling indicates that recharge to the semi-perched aquifer from 1985 to 2015 averaged 3,616 AFY (see Tables 2-6a through 2-6c for UWCD water budget data).

According to the UWCD groundwater model stream flow percolation from Conejo Creek and Arroyo Las Posas provide recharge to both the semi-perched aquifer and the Shallow Alluvial Aquifer. Tables 2-6a and 2-6b indicate that from 1985 to 2015 the average inflows from Conejo Creek to the semi-perched aquifer and the Shallow Alluvial Aquifer were 6,320 AFY and 1,831 AFY, respectively, and the average inflows from Arroyo Las Posas to the semi-perched aquifer and the Shallow Alluvial Aquifer were 563 AFY and 3,697 AFY, respectively.

Table 2-6b summarizes the calendar year subsurface inflows from the LPVB in Arroyo Simi–Las Posas as estimated by the CMWD (2018) groundwater model. The average inflow from 1985 to 2015 was 1,646 AFY, and has ranged from 148 AFY to 2,207 AFY (Table 2-6b).

2.4.1.2 Imported Water Supplies

Table 2-7 provides the historical deliveries and uses of imported water purchased from the CMWD by PVB water retailers: the City of Camarillo, CWD, and the PVMWC. CWD provides imported water supplied by CMWD for both M&I and agricultural uses. Figure 2-39 (Imported Water Deliveries) shows the amounts of water imported to the PVB.

Table 2-8 summarizes historical diversions and usage of Santa Clara River water by UWCD. UWCD diverts surface water from the Santa Clara River in the Santa Paula Basin, just upstream of the Oxnard Subbasin and the adjacent Mound Basin. Diverted Santa Clara River water may include imported water held for UWCD in Lake Piru. This water is used for groundwater recharge in UWCD spreading basins within the Oxnard Forebay (the Forebay) and for direct delivery to water users. UWCD-recharged and diverted Santa Clara River water can be supplied via the Pumping Trough Pipeline to service agricultural water users in the Oxnard Plain, or to the PVP for agricultural water users in both the PVB and the Oxnard Plain. As shown in Table 2-8, the water supply delivered in the PVP supply pipeline is a mixture of diverted Santa Clara River water and groundwater pumped by UWCD from its Saticoy wellfield in the Forebay of the Oxnard Subbasin.

PVCWD uses a combination of pumped groundwater from the Oxnard Subbasin and the PVB, delivered UWCD water from the PVP, and CWD-delivered water from Conejo Creek. FCGMA groundwater pumping records indicate that from 1985 to 2015, approximately 41% and 59% of PVCWD's pumped groundwater has come from the PVB and Oxnard Subbasin, respectively. A geographic information system (GIS) calculation of the area of the PVCWD in Figure 1-8 indicates that about 44% of the area is in the PVB and 56% is in the Oxnard Subbasin. For purposes of estimating PVCWD water deliveries, a ratio of 44% PVB and 56% Oxnard Subbasin was used for PVCWD water supplies. As shown in Table 2-8, during some years groundwater pumping in the PVB for PVCWD is less than this ratio, resulting in a positive import from the Oxnard Subbasin. Conversely, in some years, groundwater pumping in the PVB is more than this ratio, resulting in a negative import (an export) to the adjacent Oxnard Subbasin. Figure 2-40 (Other Water Deliveries) shows the amounts of other imported water into the PVB.

In addition to CWD's Conejo Creek Diversion water, imported water deliveries, and groundwater pumped near their Round Mountain Water Treatment Plant, CWD provides water to the PVB for agriculture, M&I, and groundwater storage from other sources, including ASRVB, the Tierra Rejada Basin, and tertiary-treated recycled water produced at the CWRF. These supplies are summarized in Table 2-8. Figure 2-41 (Other Camrosa Water District Water Deliveries) shows the other sources and uses of CWD water in the PVB.

M&I Recharge (Urban Return Flows)

In Tables 2-6a through 2-6c, percolation of M&I applied water is estimated with other recharge. However, the total recharge from M&I is reported separately in Table 2-9. In the UWCD model, it is assumed that 5% of M&I delivered water recharges groundwater. The average return flow from M&I for calendar years 1985 to 2015 was 702 AFY.

2.4.1.3 Recycled Water Supplies

Two sources of recycled water supply are used within the PVB. These sources are provided by CWD and CSD. Section 2.4.1.1, Surface Water Flows, provides a description for recycled water releases to Conejo Creek and Calleguas Creek by CSD and CWD, respectively. Table 2-8 provides the available recycled water amounts used in the PVB.

CWD produces Title 22 recycled water from its 1.5 million gallon per day (mgd) CWRF, which is delivered via a separate distribution system than its nonpotable surface water supply distribution system. As discussed in the Draft 2015 Urban Water Management Plan (CWD 2015), the CWRF produces approximately 1,500 AF of tertiary-treated recycled water annually and provides this recycled water supply to land parcels adjacent to and surrounding the California State University Channel Islands campus, including the campus itself and neighboring farmland.

CSD provides wastewater treatment for most of the City of Camarillo at its Camarillo WRP on Howard Road next to Conejo Creek (and within CWD's jurisdictional boundaries). The WRP currently treats about 4 mgd (approximately 4,480 AFY) for agriculture use and as discharge to Conejo Creek, and has a capacity of 6.75 mgd (CWD 2015).Construction of tertiary-treatment processes at the WRP was completed in 2005. CSD constructed an effluent discharge line that eliminates most, if not all, current discharges to Conejo Creek. This pipeline will connect to CWD's recycled water distribution system to provide additional recycled water supply for agriculture. CSD recycled water deliveries for agriculture are shown in Table 2-8 and CSD discharges to Conejo Creek are presented in Table 2-5.

Recycled Water Recharge

The UWCD model does not have a separate estimate of the amount of recharge from recycled water. Recycled water used for agriculture and M&I purposes was included in the UWCD model. This includes the annual average of 1,587 AFY from the CSD delivered to agriculture and the 669 AFY from the CWD for agriculture and M&I (Table 2-8).

2.4.1.4 Percolation of Precipitation

Much of the rain that falls in the PVB quickly returns to the atmosphere via evaporation, or runs off to creeks, storm drains, and ultimately the ocean; the remainder percolates into the soil, where it is subject to evapotranspiration (ET) and soil absorption. However, some precipitation can percolate into the soil and downward past the plant root zone and reach an underlying aquifer. This recharge process is referred to as deep infiltration (or percolation) of precipitation.

Deep percolation of precipitation depends on many factors, including precipitation rate and duration, evaporation rate, ambient temperature, texture and slope of land surface, soil type and texture, antecedent soil moisture, vegetation cover, seasonal plant activity, and others, and is highly variable over time and location (Appendix D). Thus, estimates of the percolation of precipitation are subject to substantial uncertainty.

UWCD downloaded monthly precipitation data for 180 rainfall gauge stations across the model domain from the Ventura County Watershed Protection District (at http://www.vcwatershed.net/hydrodata/) (Appendix D, p. 80). UWCD used the Kriging method of geostatistical analysis to generate monthly precipitation distributions across model area, and the areal recharge from deep infiltration of precipitation was input to the model using the recharge package, and was calculated as follows:

- If monthly precipitation is less than 0.75 inches, the precipitation is lost to ET.
- If monthly precipitation is 0.75 to 1 inch, then recharge is assigned from 0% to 10% of precipitation (on a sliding scale).
- If monthly precipitation is 1 to 3 inches, then recharge is assigned from 10% to 30% of precipitation.
- If monthly precipitation is greater than 3 inches, then recharge is assigned as 30% of precipitation.
- Urban (non-agricultural) land use, including residential, commercial, and industrial areas: 5% of the total water precipitation.
- Undeveloped land: 10% of the total water precipitation.

Precipitation Recharge

Recharge from the percolation of precipitation is include with recharge in Table 2-6a and Table 2-6b, but identified individually in Table 2-9. Of the average annual recharge shown in Table 2-9 (6,564 AFY), percolation of precipitation accounts for 2,702 AFY, or 41.2%.

2.4.1.5 Basin Groundwater Subsurface Inflow and Outflow

UWCD (2018; see Appendix D) provided model monthly groundwater inflows and outflows between the PVB, the Oxnard Subbasin and the LPVB. These inflows and outflows were combined to generate the annual estimates used for the groundwater budget. Additionally, Table 2-6b shows the subsurface flows between the older alluvium and the semi-perched aquifer as well as between the older alluvium and the LAS.

2.4.1.6 Mountain-Front Recharge

UWCD (2018; see Appendix D) used the MODFLOW WEL package to input mountain-front recharge specified flux amounts into model grid cells adjacent to each small drainage system (sub-watershed) along the margins of the model area, and to the base of elevated bedrock or mountain areas. In the PVB, mountain-front recharge was applied at the base of the Santa Monica Mountains and along the base of the outcrops of San Pedro Formation (in the FCA) in the Camarillo Hills and the eastern margin of the PVB. Recharge rates were calculated from monthly precipitation rates for the area receiving the precipitation. The monthly mountain-front-recharge rate inputs to the model followed the precipitation/recharge-percentage relationship used for agricultural return flows (see Section 2.4.1.9, Percolation of Agricultural Irrigation Water (Agricultural Return Flows)). For the PVB, mountain-front recharge is shown in Table 2-6b and averages 1,599 AFY.

2.4.1.7 Septic Systems Recharge

The number and locations of septic systems in the Oxnard Subbasin were estimated by DBS&A (2017) based on the Ventura County septic database. If septic systems were present within any parcel within a tract, it was assumed that all parcels in the tract contained septic systems. A total of 745 septic systems were assumed in the PVB (DBS&A 2017).

Household water use and annual disposal was estimated to decrease from 0.21 AFY per household for 1985 to 1997, 0.20 AFY per household for 1988 to 2010, and 0.16 AFY per household from 1998 to 2015 based on DeOreo and Mayer (2012, as cited in DBS&A 2017). The resulting estimated percolation from all septic systems was estimated to decrease from 156 AF in 1985 to 115 AFY in 2015 (DBS&A 2017).

The UWCD groundwater model (Appendix D) assumed that septic system recharge was widespread and small relative to other recharge sources and incorporated septic system return flows implicitly as a component of agricultural and municipal return flows.

2.4.1.8 Recharge from Water System Losses

Recharge from leakage of water delivery systems was assumed to be 5% of all deliveries (Sharp 2010, as cited in DBS&A 2017), including locally extracted water and imports. Delivered water included local pumping and water deliveries by CWD, City of Camarillo, PVMWC, Ventura County Waterworks Districts, and Conejo Creek Diversions. DBS&A (2017) estimated the percolation of leakage from distribution systems in the PVB to average 1,146 AFY (DBS&A 2017, Table 12). However, using 5% of the total average water delivery values in Tables 2-7 (8,698 AFY) and Table 2-8 (7,727 AFY), the estimated leakage of water delivery systems is 821 AFY.

The UWCD groundwater model (Appendix D) did not consider water system losses as a distinct source of water separate from other urban return flows.

2.4.1.9 Percolation of Agricultural Irrigation Water (Agricultural Return Flows)

Groundwater pumping is discussed in Section 2.4.2.1; only recharge from agricultural return flow is discussed in this section. The UWCD groundwater model used the following water sources, which were applied to irrigated land, and assumed an agricultural return flow of 14%:

- Extracted groundwater from wells for agricultural use
- Groundwater and surface water delivered via the PVP to PVCWD
- Surface water diverted from Conejo Creek to PVCWD

If the precipitation is more than 1 inch per month, the agricultural return flow ratio is compared with the precipitation recharge ratio. If the precipitation recharge ratio is larger than 14%, the agricultural return flow is replaced by the precipitation recharge ratio.

Agricultural Recharge

Recharge from the agricultural return flow is included with recharge in Tables 2-6a through 2-6c, and identified individually in Table 2-9. Of the total annual recharge shown in Table 2-9 (6,564 AFY), agricultural return flow accounts for 2,118 AFY, or 32.3%.

2.4.2 Sources of Water Discharge

Sources of groundwater discharge predominantly include groundwater pumping, tile drain discharges, and ET. Groundwater pumped and used for agricultural, M&I, and domestic purposes can produce return, and subsurface groundwater flows (interbasin flows) can discharge groundwater from the PVB to the adjacent groundwater (Section 2.4.1.5, Basin Groundwater Subsurface Inflow and Outflow).

2.4.2.1 Groundwater Pumping

Table 2-10 shows the amount of groundwater pumped for agricultural, M&I, and domestic uses by aquifer systems from the UWCD model. The UWCD modeled groundwater withdrawals used the multi-node well package. The FCGMA database provides reported groundwater extraction data for the PVB within the FCGMA boundary. The amount of unreported groundwater extraction within the PVB is not known but is expected to be minor, because the FCA does not occur to the southeast of the Bailey Fault outside the FCGMA boundary, where it has been removed through uplift and erosion (Section 2.4). The extraction amounts in Table 2-10 were combined with well types from the FCGMA database to distinguish the amounts extracted by type. Figure 2-42 (Pleasant Valley Basin Groundwater Pumping) shows the amounts of agricultural, M&I, domestic, and total groundwater pumped from the PVB. Groundwater pumping is also shown in the PVB groundwater budget in Tables 2-6a through 2-6c.

Model input indicates that during the calendar year 2015, a total of 17,849 AF of groundwater was pumped, of which 16,284 AF (or 91%) was for agricultural use, 1,357 AF or (7.6%) was for M&I use, and 209 AF (or 1.2%) was for domestic use. The PVB covers an area of about 19,840 acres and the FCGMA database contains 140 known wells, of which 74 are currently listed as active use, 44 have been destroyed, 21 are inactive, and 1 could not be located.

2.4.2.2 Tile Drain Recharge Losses

Tile drains are used beneath many agricultural lands in the PVB to maintain a sufficiently deep groundwater table in areas where poorly drained soils create perched groundwater conditions or the water table of the semi-perched aquifer is high and saturates the root zone. Tile drains are present beneath many agricultural land parcels in the PVB and the Oxnard Subbasin. These drains discharge to local waterways and then to surface water bodies (Revolon Slough and Calleguas Creek). These flows are not metered. The UWCD model (Appendix D) has calculated losses to tile drains based on groundwater model water levels; the results are provided in Table 2-6a. Average annual loss of groundwater to tile drains was estimated in the model as 1,080 AFY (Table 2-6a).

2.4.2.3 Evapotranspiration

The UWCD model used the U.S. Fish and Wildlife Service's online "Wetlands Mapper" (https://www.fws.gov/wetlands/data/mapper.html) to indicate areas of riparian vegetation along stream channels. These areas, together with parts of the Santa Clara River (including its estuary), Revolon Slough/Beardsley Wash, McGrath Lake, Ormond Beach wetlands, and Mugu Lagoon wetlands, were used to estimate ET (Appendix D). ET is the discharge of groundwater from the saturated zone where the water table is present at very shallow depths. Such conditions mostly occur in the PVB in areas where the semi-perched aquifer and the Shallow Alluvial Aquifer interact with Arroyo Las Posas, Conejo Creek, and Calleguas Creek. Additional detailed discussions about these areas are in Section 2.3.6, Groundwater–Surface Water Connections, and Section 2.3.7, Groundwater-Dependent Ecosystems.

UWCD (2018; see Appendix D) applied U.S. Geological Survey estimates for ET rates from 1.1 to 5.2 feet per year to calculated long-term annual average groundwater discharge as ET. UWCD implemented ET using MODFLOW's ET package, EVT. Model grid cells corresponding to areas of mapped wetlands with shallow groundwater were simulated. The maximum ET flux was 0.010 feet per day (3.65 feet per year) for model grid cells subject to ET over their entire area. The maximum ET flux is scaled down proportionally for grid cells that are only partially occupied by wetlands. The ET surface elevation was set at 3 feet bgs, and the ET extinction depth was set at 5 feet (Appendix D, p. 84).

According UWCD model results, the estimated annual loss from ET is 1,261 AFY, with 280 AFY coming from the semi-perched aquifer (Table 2-6a) and 981 AFY from the Shallow Alluvial Aquifer (Table 2-6b).

Riparian ET losses from the PVB were estimated by DBS&A (2017) for the 274 acres of riparian vegetation estimated by The Nature Conservancy in the PVB. In the absence of basin-specific data, a 20% giant reed coverage was assumed, which was similar to the 23% measured by The Nature Conservancy in the Oxnard Subbasin. The resulting estimated groundwater riparian ET averaged 1,741 AFY and ranged from 1,296 to 2,189 AFY (DBS&A 2017, Table 12).

2.4.3 Current and Historical Water Budget Analysis

2.4.3.1 Water Year Types

Water year type is based on the percentage of the water year precipitation compared to the 30-year precipitation average. Types are defined in this GSP as wet (> 150% of average), above normal (> 100% to <150% of average), below normal (> 75% to <100% of average), dry (> 50% to <75% of average), and critical (<50% of average). Figures 2-17 and 2-18 show the water year type from 1986 to 2015. The water type year for 2015 is dry.

2.4.3.2 Historical Water Budget Analysis

DWR has designated the PVB as a high-priority basin. GSP Regulations, Section 354.18, Water Budget, states: "If overdraft conditions occur, as defined in Bulletin 118, quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions." According to DWR Bulletin 118, "A basin is subject to critical overdraft when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts" (DWR 2006). Bulletin 118 Interim Update 2016 (October 18, 2016) lists the PVB (4-006) as being in critical overdraft (DWR 2016).

Because of the Bulletin 118 listing of the PVB as being in critical overdraft, GSP Regulations, Section 354.18(b)(5), requires a quantification of the overdraft over a period of years during which water years and water supply conditions approximated average conditions. Using the water year types discussed in Section 2.4.3.1, Water Year Types, and the above normal (> 100% to <150% of average) and the below normal (> 75% to <100% of average) water year types to bracket water supply conditions approximating average conditions, the following years have near average conditions: 1988, 1991, 1994, 1996, 1997, 2000, 2001, 2003, 2006, 2008, 2010, and 2011.

The change in storage during these years was an increase of 1,758 AFY in the older alluvium and an increase of 860 AFY in the LAS (Tables 2-6b and 2-6c). Total groundwater pumping during these years averaged 999 AFY in the older alluvium and 7,145 AFY in the LAS, for a total of 8,144 AFY

(Tables 2-6b and 2-6c). This quantification of the overdraft over a period of years during which water years and water supply conditions approximated average conditions would indicate that PVB was not in overdraft and had a storage increase of about 2,618 AFY (1,758 AFY (older alluvium) + 860 AFY (UAS)). It should be noted that except for 2011, the adjacent Oxnard Subbasin showed net seawater intrusion in the UAS (equivalent to the older alluvium) and in the LAS for each of the years that approximated average conditions (FCGMA 2019). The Oxnard Subbasin seawater intrusion analysis suggests that based on the historical pumping patterns and pumping amounts in the Oxnard Subbasin and the PVB, there was an overdraft in the Oxnard Subbasin.

The above-average water year types from >100% to <150% (above normal) and >75% to <100% (below normal) have a wide range. The increase in storage during these years is also related to the timing of when the PVB started getting additional recharge from Arroyo Las Posas. Water levels increased fairly steadily between 1990 and 2008, coincident with the additional recharge along Arroyo Las Posas. Of the 12 years for the average-year change in storage calculation, only 3 (1988, 2010, and 2011) were outside of the 1990–2008 window. Because the timing of the recharge and the timing of the average years coincide, it is difficult to distinguish a pure climate signal in the observed record.

GSP Regulations, Section 354.18(c)(2), requires that the historical water budget information 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. Historically, the PVB has received surface water supply deliveries directly from several sources: the Santa Clara River by the UWCD PVP; from Calleguas Creek and Arroyo Las Posas streambed percolation; from imported water delivered by the CMWD; and from Conejo Creek diversions and streambed percolation. Table 2-5 shows the average amount of Conejo Creek water delivered by CWD (3,562 AFY). Table 2-7 shows the average amount of imported water delivered by the CMWD (8,698 AFY). Table 2-8 provides the average amounts of Santa Clara River water supplied by the UWCD via the PVP (4,010 AFY), and Tables 2-6a and 2-6b show the amounts of Calleguas Creek, Arroyo Las Posas, and Conejo Creek percolation (3,616 AFY, 4,260 AFY, and 8,151 AFY, respectively). However, some of the Calleguas Creek, Arroyo Las Posas, and Conejo Creek percolation to the semi-perched aquifer is discharged by the tile drains (up to 1,080 AFY; see Table 2-6a) and does not benefit the usable PVB aquifers. The total annual average from these sources is about 32,297 AFY. This would indicate the following surface water contributions to the PVB: Conejo Creek water delivered by CWD (11%); imported water delivered by CMWD (27%); Santa Clara River water (12%); and Calleguas Creek, Arroyo Las Posas, and Conejo Creek percolation (11%, 13%, and 25%, respectively). Figure 2-43 (Total Pleasant Valley Basin Surface Water Supplies) shows the amounts of these water sources from 1985 to 2015. Based on the overall trends in Figure 2-43, the Santa Clara River source is the most variable. It should be noted that the Santa Clara River water supply is used for agricultural uses, and the loss of this water during drought conditions can directly lead to an increase in groundwater pumping.

This similar Section 354.18(c)(2) analysis for the Oxnard Subbasin (FCGMA 2019, Section 2.4.3.2, Historical Water Budget Analysis) indicated that diversions from the Santa Clara River vary widely depending on climate conditions. High-diversion years were wet years and low-diversion years were critical or dry years. Diversions of surface water by UWCD from the Santa Clara River are critical to the surface water supplies of the Oxnard Subbasin, and make up 12% of the surface water sources for the PVB. Dry-weather stream flows into the PVB from Arroyo Las Posas stopped around 2012. This could be permanent because of the significant decrease in discharges from Simi Valley and the MWTP, which has already occurred and is not expected to be reversed.

2.4.3.3 Current (2015) Water Budget Analysis

Groundwater level data presented in Section 2.3, Groundwater Conditions, and the change in storage estimates for the calendar year 2015 from Tables 2-6a through 2-6c indicate that the PVB had greater groundwater outflows than inflows in 2015. The estimated 2015 groundwater change in storage is a loss of about 13,657 AF (a storage decrease; see Tables 2-6a through 2-6c). Groundwater change in storage and cumulative change in storage are discussed in Section 2.3.2, Estimated Change in Storage. Table 2-9 indicates that since 2012, the PVB has had a decline in groundwater storage. Groundwater extractions for calendar years 2012–2015 averaged 17,304 AFY (Table 2-10), which is higher than the average of 15,671 AFY for 1985–2011 and the 15,429 AFY average from 1985–2011. This is because of the dry and critical water years from 2012 to 2015 (Figures 2-17 and 2-18). This corresponds to the decrease in the delivery of Santa Clara River water from an average of 4,382 AFY from 1985 to 2011 (Table 2-8). Except for the percolation of Arroyo Las Posas water, the other water sources listed in Section 2.4.3.2—Conejo Creek water delivered by CWD, imported water, Calleguas Creek, and Conejo Creek percolation—remained about the same from 2012 to 2015. As noted in Section 2.4.3.2, dry weather stream flows into the PVB from Arroyo Las Posas stopped around 2012 and are likely permanently lost due to the significant decrease in discharges from Simi Valley and the MWTP, which has already occurred and is not expected to be reversed.

2.4.3.4 Estimates of Historical Sustainable Yield

Historical estimates for the PVB sustainable yield have also included the Oxnard Subbasin.[6] These historical sustainable yield estimates include the following:

- FCGMA, 1985a, Groundwater Management Plan
- FCGMA, 2007, 2007 Update to the Fox Canyon Groundwater Management Agency Groundwater Management Plan

[6] SGMA requests that an estimate of the "sustainable yield" be made for the PVB based on historical data. However, as used in this section the sustainable yield does not address undesirable results, which are discussed in Chapter 3, Sustainable Management Criteria.

- UWCD and CMWD, 2012, Preliminary Draft Yield Analysis (UWCD 2016b)
- UWCD, 2016, Proposed Method for Estimating Sustainable Yield (UWCD 2016b)

All of these historical estimates for combined PVB and Oxnard Subbasin sustainable yield are about 65,000 AFY, and do not demonstrate that this groundwater pumping rate would prevent seawater intrusion in the Oxnard Subbasin. Even if seawater intrusion is not a problem in the PVB, groundwater pumping in the PVB during drought years contributes to seawater intrusion in the Oxnard Subbasin, and groundwater pumping in the PVB will need to be managed under a coordination agreement with the Oxnard Subbasin to prevent seawater intrusion. Thus, the following discussion is highly relevant to the estimated sustainable yield of the PVB.

The UWCD Open-File Report 2017-02 (UWCD 2017a) Scenario D estimated that if there were no groundwater pumping in what the report refers to as the “Saline Intrusion Management Area,” and that if groundwater pumping were reduced by about 70% in the LAS in the PVB and the Oxnard Plain (excluding the Forebay), and if there was no reduction in UAS pumping, that seawater intrusion would be halted. However, this scenario assumed that groundwater for irrigation in the Saline Intrusion Management Area would be supplied by some type of project to be implemented in the future. The estimated sustainable yield under Scenario D was 59,900 AFY for the PVB and the Oxnard Subbasin (excluding the Saline Intrusion Management Area).

To estimate the sustainable yield under historical conditions where no future project is implemented, the UWCD conducted Scenario F in the Addendum to Open-File Report 2017-02a (2017b). In Scenario F, the Saline Intrusion Management Area was eliminated, and a uniform reduction in groundwater pumping was simulated to achieve sustainable yield. The scenario defined a sustainable yield as maintaining groundwater elevations along the coast at levels sufficiently high to prevent seawater intrusion and other forms of saline water intrusion. In the Port Hueneme area, where the UAS and LAS are believed to have direct hydraulic connection with the Pacific Ocean, they assume minimum thresholds as defined in Open-File Report 2017-02a.[7] However, they assume minimum threshold for the LAS near Mugu Lagoon to be −20 feet msl instead of 18.5 feet msl, as assumed in Open-File Report 2017-02 (UWCD 2017a). This is because the UWCD Saline Intrusion Update Report (UWCD 2016a) interpreted the source of elevated chloride concentrations in the LAS near Mugu Lagoon to be saline water yielded from marine clays and/or from adjacent Tertiary age sedimentary rocks, as a result of large declines in potentiometric head in the LAS over the past several decades, and not directly the result of current seawater intrusion. Both the U.S. Geological Survey and UWCD models included faults in the Mugu Lagoon area that limit the hydraulic connection of the LAS in the Oxnard Basin to the Pacific Ocean (Hanson et al. 2003; Appendix D).

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7 *Minimum threshold* used here is in reference to the Open File Report 2017-02 usage and not to the minimum threshold discussed in Chapter 3 of this GSP.

Based on the results from UWCD Scenario F (2017b, Table 2-2), the sustainable yield under historical conditions with no changes from the current pumping locations (i.e., without water supply or infrastructure projects) for the PVB would be a total of 10,000. Based on the results from UWCD Scenario F (UWCD 2017b, Table 2-2), the sustainable yield under historical conditions with no changes from the current pumping locations (i.e., without water supply or infrastructure projects) for the Oxnard Subbasin would be a total of 39,000 AFY (27,000 AFY from the Oxnard Plain and 12,000 AFY from the Oxnard Forebay area).

2.4.4 Uncertainties in the Water Budget

There are several limitations and uncertainties associated with some historical water budget terms due to necessary simplifying of assumptions and data gaps. Uncertainties about the groundwater models used are discussed in Section 2.4.5.8, Uncertainty Analysis. Some of the general water budget limitations and/or uncertainties include the following:

1. The reporting of groundwater pumping outside the FCGMA boundaries is limited and there is a possibility of underreporting of pumping within the FCGMA boundaries due to metering equipment errors or malfunctions. Additional future data collection is needed to fill this data gap. However, the amount of pumping outside the FCGMA boundary is expected to be minor given the limited number of wells (estimated at fewer than 12).
2. The hydrologic base period (calendar years 1985–2015, DWR's 31-year base period) may not necessarily be representative of long-term average conditions. As shown on Figure 1-6, Long-Term Precipitation Trends in the Oxnard Plain, this was a generally wetter-than-average period. However, the future water budget analysis in Section 2.4.5, which used a model 50-year period with an average precipitation period (1939 to 1979), does not suggest that the historical sustainable yield estimate based on this wetter-than-average period is too high. The sustainable yield for the future water budget ranged from 11,600 AFY to plus or minus 1,200 AFY for the older alluvium and the LAS. The estimated historical sustainable yield using UWCD Scenario F (Section 2.4.3.2) of 10,000 AFY is close to the low end of this range. The uncertainty associated with the future water budget and the sustainable yield are discussed in Section 2.4.5.8, Uncertainty Analysis, and Section 2.4.5.9, Estimates of Future Sustainable Yield, respectively.
3. Conclusions regarding uncertainties in the UWCD model are discussed in Section 2.4.5.8, and in the Dudek peer review of the UWCD model (Appendix I, UWCD Model Peer Review).
4. Subsurface inflows and outflows across basin boundaries are not measurable. The groundwater level data in these areas by themselves do not provide a clear indication of groundwater flow directions because of the limited water level measurements and the variation in time between measurements. The UWCD model provides a significantly

improved understanding of these boundary fluxes and their variability under different pumping and recharge conditions in the region, but checking model values with observations and calculating the gradient with three-point groundwater flow problems should be considered to verify model estimates. Estimating inflows and outflows across basin boundaries using well groundwater level data was attempted for this GSP, but data gaps and limited well locations screened in one aquifer made the results unreliable.

5. Semi-perched groundwater in the PVB is captured by tile drains, rather than recharging the UAS. This uncertainty could be reduced through installation of instrumentation and measurement of discharges from the tile drains.
6. Currently, aquifer-specific water level maps are not reliable to estimate aquifer change in groundwater storage due to the limited number and distribution of aquifer-specific water wells. Dedicated monitoring wells could be installed and equipped with water-level measuring data loggers in all of the aquifers. This would help decrease uncertainty in estimates of future changes in groundwater storage by enabling use of aquifer-specific water-level maps to check groundwater model change in storage calculations.

2.4.5 Projected Water Budget and Sustainable Yield

Several model scenarios were developed in accordance with Sustainable Groundwater Management Act (SGMA) guidelines to assess the future sustainable yield of the PVB, the Oxnard Subbasin, and the West Las Posas Management Area (WLPMA) of the LPVB. Each future scenario covered a 50-year time frame, from 2020 to 2069 (the "model period"). In this GSP, the period from 2020 to 2039 is referred to as the implementation period, and the period from 2040 to 2069 is referred to as the sustaining period. The sustainable yield was determined from the model scenarios that did not result in a net flux of seawater into either the UAS or the LAS in the Oxnard Subbasin, within the level of the model uncertainty, during the 30-year sustaining period (Figure 2-44, Coastal Flux from the UWCD Model Scenarios).

Because the PVB is hydraulically connected to the Oxnard Subbasin, the sustainable yield of the PVB is influenced by groundwater production and projects in the Oxnard Subbasin. The UWCD model used to assess the sustainable yield of the PVB, the Oxnard Subbasin, and the WLPMA in the model domain, and the modeling assumptions associated with each scenario discussed below include the assumptions made for these adjacent basins.

The model scenarios developed for the Oxnard Subbasin, the PVB, and the WLPMA all included existing projects and the 2070 DWR climate-change factor applied to the 1930–1970 historical precipitation and hydrology base period. The model scenarios are the following:

- Future Baseline Simulation (2015–2017 average production rates adjusted for surface water deliveries). Future surface water deliveries were estimated by UWCD using Santa Clara River flows for historical periods, the 1930–1979 climate period adjusted for future

DWR climate-change factors, and estimated diversions based on similar historical Santa Clara River flows. UWCD also considered current allowable diversions, which accounts for current environmental restraints and diversion operating conditions, and optimization of water deliveries for the PVP and spreading basins. Additional details about the UWCD future model scenarios are included in Appendix J.

- Future Baseline Simulation With Projects (2015–2017 average production rates adjusted for surface water deliveries; potential future projects that met the DWR conditions for incorporation in the GSP)
- Reduction With Projects (35% reduction of 2015–2017 average production rates adjusted for surface water deliveries for the UAS and LAS in the Oxnard Subbasin, 20% reduction for the UAS and the LAS in the PVB; and 20% in the LAS in the WLPMA; potential future projects that met the DWR conditions for incorporation in the GSP)
- Reduction Without Projects 1 (reduction of 2015–2017 average production rates adjusted for surface water deliveries by 25% in the UAS, 60% in the LAS, and 45% for wells screened in both aquifer systems in the Oxnard Subbasin; 25% reduction for the UAS and the LAS in the PVB; and 25% in the LAS in the WLPMA)
- Reduction Without Projects 2 (reduction of 2015–2017 average production rates adjusted for surface water deliveries by 55% in the UAS and the LAS in the Oxnard Subbasin; 20% reduction for the UAS and the LAS in the PVB; and 20% in the LAS in the WLPMA)
- Reduction Without Projects 3 (reduction of 2015–2017 average production rates adjusted for surface water deliveries by 55% in the UAS and the LAS in the Oxnard Subbasin; 0% reduction for the UAS and the LAS in the PVB; and 0% in the LAS in the WLPMA)

Two model scenarios listed above, the Future Baseline Simulation With Projects Scenario and the Reduction With Projects Scenario, incorporated projects that were approved for inclusion in the GSP model scenarios by the FCGMA Board. The Board's approval of these projects only indicates that they were sufficiently defined by the project proponent to be analyzed as part of the GSP. It does not indicate that these specific projects will necessarily be constructed or, conversely, that other projects will not be developed in the future. The projects included are discussed in more detail with the description of each scenario below.

An initial set of four modeling simulations were conducted using the future baseline conditions with two 50-year average climate cycles (1930–1979 and 1940–1989), and two DWR climate-change factors (2030 and 2070) applied to each of the 50-year periods. The 1930–1979 50-year period with the 2070 DWR climate-change factor was found to be the most conservative and was used for the comparison with the other modeling simulations conducted. Additional details about the selection of the two 50-year average climate cycles is provided in Section 2.4.5.7, Alternative Climate and Rainfall Patterns.

In addition to the initial set of four modeling simulations and the six model scenarios listed above, the Reduction Without Projects Scenario 1 was simulated with the DWR 2030 climate-change factor and with a historical precipitation and hydrology base period from 1940 to 1989. These simulations were conducted to better understand the potential impact of precipitation patterns and climate change factors on the model results.

Over the next 5 years, as additional projects are developed, the model assumptions discussed below will need to be altered and incorporated into the 5-year GSP evaluation.

2.4.5.1 Future Baseline Model Simulation

SGMA requires that the GSP include an assessment of the "future baseline" conditions. In the Future Baseline Scenario, in order to assess whether or not groundwater extractions from the PVB, the Oxnard Subbasin, and the WLPMA were sustainable at their current rates, the average annual 2015–2017 production rates were simulated. For the PVB, this rate is approximately 14,000 AFY (Table 2-11).

Future Baseline Scenario Model Assumptions

The Future Baseline model simulation included the following:

- Constant pumping at the 2015–2017 average rate of approximately 14,000 AFY in the PVB, 68,000 AFY in the Oxnard Subbasin (39,000 AFY in the UAS; 29,000 AFY in the LAS), and 13,000 AFY in the WLPMA
- Starting water levels equal to the final 2015 water levels from the historical simulations
- Precipitation and streamflow for two 50-year periods (1930–1979 and 1940–1989), with an average precipitation that equaled the average precipitation for the entire historical record
- Estimates of Santa Clara River surface water available for diversion prepared by UWCD staff using climate-change factors provided by DWR and historical measured flow in the river for the 50-year periods
- East Las Posas Management Area outflows to Arroyo Las Posas to the PVB from the CMWD model
- Projects that are currently operating in the PVB or currently under development

The historical measurements of precipitation for the two 50-year periods were modified using the DWR 2030 and 2070 climate-change factors. Stream flows were estimated using the adjusted rainfall. UWCD estimated Santa Clara River flow and the volume of water diverted to direct delivery and spreading. Pumping was decreased where the water is delivered to account for the surface water delivered. Future streamflow in Conejo and Calleguas Creeks in the PVB were estimated by regression.

No projects currently under development were identified in the Oxnard Subbasin, but two projects under development in the PVB were incorporated into the future baseline simulation because these projects affect inflows to the Oxnard Subbasin. The two projects in PVB are the City of Camarillo's North Pleasant Valley Desalter (desalination) Project and Conejo Creek Diversion deliveries to PVCWD. The North Pleasant Valley Desalter Project was simulated by dividing the total project pumping of 4,500 AFY between project extraction wells 02N20W19L05 and 02N20W19F04.

In this scenario, Conejo Creek diversions will increase deliveries to agriculture by an additional 2,200 AFY to make the total deliveries in the PVB 4,500 AFY starting in 2020. The Conejo Creek Project allows CWD to increase pumping by up to 4,500 AFY based on credits for surface water delivered to PVCWD. In running the future simulations, however, it became apparent that the model cells identified for production from the CWD wells were not able to extract the full amount. The amount of simulated CWD pumping that was achievable in the future baseline simulation was therefore limited to 2,816 AFY.

It is important to remember that groundwater extractions are not the only source of water to the PVB. Surface water deliveries vary between the model scenarios because the model adjusts the deliveries of Santa Clara River water based on simulated groundwater elevations in the Oxnard Forebay. Additionally, although the model calculates the groundwater extractions and surface water deliveries with precision, the values reported in Table 2-11 have been rounded to the nearest 1,000 AFY to reflect the uncertainty in the model calculations.

Future Baseline Scenario Model Results

Both the modeled flux of seawater and the particle tracks from the Future Baseline Scenario indicate that continuing the 2015–2017 extraction rate for the PVB and the Oxnard Subbasin over the next 50 years would cause net seawater intrusion in both the UAS and the LAS, as well as ongoing inland migration of the 2015 saline water impact front. Because the model showed the saline water impact front continuing to migrate landward throughout the sustaining period, even during wetter-than-average climate periods, the current areal and aquifer-system distribution of groundwater production at the extraction rates in the PVB and the Oxnard Subbasin was determined not to be sustainable.

2.4.5.2 Future Baseline With Projects Model Simulation

Future Baseline With Projects Scenario Model Assumptions

Modeling of future conditions included all of the assumptions incorporated into the Future Baseline simulation, and also incorporated potential future projects approved for inclusion by the FCGMA Board. Incorporation of the potential future projects in the Future Baseline With

Projects Scenario neither represents a commitment by FCGMA to impose pumping reductions in the amounts specified at the wells identified below nor a commitment to move forward with each project included in the future model scenarios. Assumptions about projects and project implementation may have changed since the modeling was conducted and will continue to change over the next 5 years. These changes should be incorporated into the modeling for the 5-year GSP evaluation.

In the PVB, a proposed temporary fallowing project was simulated near the pumping trough (in Model Parameter Zone 11; Figure 2-45, Pleasant Valley Basin Management Areas). This project would generate a 2,407 AFY reduction in pumping; however, actual simulated fallowing totaled 2,234 AFY due to considerations of existing contracts for the delivery of surface water from the Santa Clara River. Pumping was preferentially reduced in wells in the LAS within the PVB to the extent possible. These projects are discussed in detail in Chapter 5, Projects and Management Actions, of this GSP.

In the Oxnard Subbasin, simulated future projects included delivery of 4,600 AFY of recycled water to farmers in the vicinity of Hueneme Road, expansion of the GREAT Program to increase groundwater recharge by 4,500 AFY in the Saticoy Spreading Grounds, and a 504 AFY reduction of pumping through temporary fallowing.

To simulate the delivery of 4,600 AFY of recycled water to farmers in the vicinity of Hueneme Road, pumping from wells near the coast in the pumping depression area (UWCD Model Parameter Zone 4; Figure 2-45) was reduced uniformly and proportionally by 4,600 AFY. Additionally, pumping from Wells 02N22W23C05S and 02N22W23C07S in the Forebay was adjusted to allow the City of Oxnard to pump up to 8,000 AFY of accumulated credits for 2,600 AF recycled agricultural water delivered annually from the GREAT Program.

To simulate the expansion of the GREAT Program, spreading recharge was increased by 4,500 AFY starting in 2025. To simulate the 504 AFY reduction of pumping through fallowing, pumping from Wells 01N22W26K04S, 01N22W27H02S, 01N22W26M03S, 01N22W26K03S, 01N22W26P02S, 01N22W26Q03S, and 01N22W26D05S was reduced uniformly and proportionally by 504 AFY. It should be noted that these wells were selected for modeling purposes only and use of these wells in the model simulations was not intended to represent any planned pumping restrictions or limitations on these wells.

In the WLPMA, future projects included the purchase of 1,762 AFY of water to be delivered to the eastern portion of WLPMA in lieu of groundwater extraction. Simulated pumping was reduced in Zone Mutual Water Company Wells 02N20W07R03, 02N20W07R02, 02N20W08M01, 02N20W08E01, and 02N20W08F01, as well as Ventura County Waterworks District No. 19 Wells

02N20W06R01 and 02N20W08B01. The pumping reductions of 1,762 AFY were applied uniformly and proportionally across the wells.

After incorporating the potential future projects, the average groundwater production rate for the PVB was 4,300 AFY in the UAS and 7,600 AFY in the LAS. In the WLPMA, the average production rate in the LAS was 11,200 AFY. The average pumping rate for the UAS in the Oxnard Subbasin was 41,000 AFY and the average groundwater production rate for the LAS in the Oxnard Subbasin was 24,000 AFY for the Future Baseline With Projects Scenario.

Because the projects that were incorporated into the Future Baseline With Projects Scenario included temporary fallowing in the PVB and the Oxnard Subbasin, the groundwater extractions in the LAS of the PVB decreased by approximately 1,000 AFY, relative to the Future Baseline Scenario. At the same time, the groundwater extractions from the older alluvium decreased by approximately 2,000 AFY, relative to the Future Baseline Scenario, in the Future Baseline With Projects Scenario (Table 2-11). The total water available to the PVB in the Future Baseline Plus Projects Scenario was approximately 12,000 AFY, with the reduction in groundwater production being offset by the addition of approximately 2,000 AFY of project water.

Future Baseline With Projects Scenario Model Results

Although the shift in groundwater extractions from the LAS to the UAS in the Oxnard Subbasin and the reduction in the total extractions helped reduce the flux of seawater into the Oxnard Subbasin, overall the Future Baseline With Projects Scenario resulted in approximately 3,000 AFY of seawater flux into the UAS and 2,700 AFY into the LAS during the sustaining period (FCGMA 2019). Particle tracks for the Future Baseline With Projects Scenario also showed net landward migration of the saline water impact front during the sustaining period (FCGMA 2019). Based on these factors, the current areal and aquifer-system distribution of groundwater production at the extraction rates modeled in the Future Baseline With Projects Scenario was determined not to be sustainable.

2.4.5.3 Reduction With Projects Scenario

Reduction With Projects Scenario Model Assumptions

The Reduction With Projects Scenario included all of the assumptions incorporated into both the Future Baseline simulation and the Future Baseline With Projects Scenario. The Reduction With Projects Scenario also included a 35% reduction of 2015–2017 average production rates for the UAS and the LAS in the Oxnard Subbasin, 20% reduction for the UAS and the LAS in the PVB, and 20% in the LAS in the WLPMA. Groundwater production rates were reduced linearly over the implementation period and held constant during the sustaining period. In the PVB, the older alluvium simulated groundwater production rate in model year 2020 (the beginning of the implementation period) was 6,800 AFY. The production rate in model year 2040, at the beginning of the sustaining period, was 3,000 AFY.[8] The average production from the older alluvium for the sustaining period was 2,000 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 11,400 AFY and the simulated groundwater production rate in model year 2040 was 9,800 AFY. The average production rate from the LAS for the sustaining period was 7,000 AFY.

Reduction With Projects Model Scenario Results

Reducing groundwater production in the UAS and the LAS, and shifting some groundwater extractions from the LAS to the UAS via the potential future projects in the Reduction With Projects Scenario, resulted in an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 3,300 AFY during the sustaining period. In the LAS, the Reduction With Projects Scenario resulted in an average flux of approximately 1,200 AFY of seawater into the LAS during the sustaining period (FCGMA 2019). Particle tracks for the Reduction With Projects model Scenario indicate that the location of the 2015 saline water impact front would likely migrate toward the Pacific Ocean in the UAS as freshwater diluted saline concentrations, while it would experience some landward migration in the LAS (FCGMA 2019). The continued landward migration of the saline water impact front in the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in this model scenario, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

2.4.5.4 Reduction Without Projects Scenario 1

Reduction Without Projects Scenario 1 Model Assumptions

The Reduction Without Projects Scenario 1 included all of the assumptions incorporated into the future baseline simulation but did not include the projects that were incorporated into the Future Baseline With Projects and Reduction With Projects Scenarios. In the Oxnard Subbasin, the Reduction Without Projects Scenario 1 also included a 25% reduction of 2015–2017 average production rates for wells screened solely in the UAS, a 60% reduction of the 2015–2017 average production rates for wells screened solely in the LAS, and a 45% reduction of the 2015–2017 average production rates for wells screened in both aquifer systems. The 2015–2017 average pumping rate was reduced by 25% in the UAS and the LAS in the PVB, and 25% in the LAS in the WLPMA. Groundwater production rates were reduced linearly over the implementation period and held constant during the sustaining period.

8 Modeled extraction rates depend on climate, surface water availability, and simulated groundwater elevations for each model year. The reductions implemented reflect a reduction in overall water demand for the PVB and the Oxnard Subbasin and are not the exact percentage specified for any given year. Therefore, the extraction rate from the older alluvium in 2040 is 45% of the extraction rate in 2020, rather than the 35% specified in the model scenario description.

In the PVB older alluvium, the simulated groundwater production rate in model year 2020 (the beginning of the implementation period) was 7,500 AFY. The production rate in model year 2040, at the beginning of the sustaining period, was 3,500 AFY.[9] The average production from the older alluvium for the sustaining period was 3,000 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 13,000 AFY and the simulated groundwater production rate in model year 2040 was 10,000 AFY. The average production rate from the LAS for the sustaining period was 7,000 AFY. The resulting average combined extraction rate from the two aquifer systems was approximately 10,000 AFY for the 30-year sustaining period (Table 2-11).

Reduction Without Projects Scenario 1 Model Results

The fluxes in the UAS and the LAS in the Reduction Without Projects Scenario 1 were similar to those simulated in the Reduction With Projects Scenario (Figure 2-44). There was an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 2,800 AFY during the sustaining period in the Reduction Without Projects Scenario 1. In the LAS, the Reduction Without Projects Scenario 1 resulted in an average flux of approximately 1,300 AFY of seawater into the LAS during the sustaining period. Particle tracks for this scenario indicate that the 2015 saline water impact front would likely migrate toward the Pacific Ocean in the UAS as freshwater diluted saline concentrations in the UAS, while it would migrate farther landward in the LAS than in the Reduction With Projects Scenario (FCGMA 2019). As in the Reduction With Projects Scenario, the continued landward migration of the saline water impact front in the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in the Reduction Without Projects Scenario 1, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

2.4.5.5 Reduction Without Projects Scenario 2

Reduction Without Projects Scenario 2 Model Assumptions

The Reduction Without Projects Scenario 2 included all of the assumptions incorporated into the Future Baseline simulation but did not include the projects that were incorporated into the Future Baseline With Projects and Reduction With Projects Scenarios. In the Oxnard Subbasin, the Reduction Without Projects Scenario 2 also included a 55% reduction of 2015–2017 average production rates for the UAS and the LAS. The 2015–2017 average pumping rate was reduced by 20% in the UAS and the LAS in the PVB, and by 20% in the LAS in the WLPMA. Groundwater production rates were reduced linearly over the implementation period and held constant during the sustaining period.

9 Modeled extraction rates depend on climate, surface water availability, and simulated groundwater elevations for each model year. The reductions implemented reflect a reduction in overall water demand for the PVB and the Oxnard Subbasin and are not the exact percentage specified for any given year. Therefore, the extraction rate from the older alluvium in 2040 is 47% of the extraction rate in 2020, rather than the 25% specified in the model scenario description.

In the PVB, the older alluvium simulated groundwater production rate in model year 2020 (the beginning of the implementation period) was 6,800 AFY. The production rate in model year 2040 (at the beginning of the sustaining period) was 3,000 AFY.[10] The average production from the UAS for the sustaining period was 3,000 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 12,000 AFY and the simulated groundwater production rate in model year 2040 was 11,000 AFY. The average production rate from the LAS for the sustaining period was 8,000 AFY. The resulting average combined extraction rate from the two aquifer systems was approximately 11,000 AFY for the 30-year sustaining period (Table 2-11).

Reduction Without Projects Scenario 2 Model Results

Model results indicate that under this scenario, the groundwater flux in the LAS between the PVB and the Oxnard Subbasin is mostly reversed from the above scenarios from about model year 2027 to model year 2055. The groundwater flow during this period (2027–2055) in the LAS is from the Oxnard Subbasin to the PVB. This increased the seawater intrusion in the LAS in the Oxnard Subbasin, exacerbating the Oxnard Subbasin's seawater intrusion problem.

There was an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 4,700 AFY during the sustaining period in the Reduction Without Projects Scenario 2 and an average flux of approximately 900 AFY of seawater into the LAS. As in the Reduction With Projects Scenario 1, the continued inflow of seawater into the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in the Reduction With Projects Scenario 2, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

2.4.5.6 Reduction Without Projects Scenario 3

Reduction Without Projects Scenario 3 Model Assumptions

The Reduction Without Projects Scenario 3 included all of the assumptions incorporated into the Future Baseline simulation but did not include the projects that were incorporated into the Future Baseline With Projects and Reduction With Projects Scenarios. In the Oxnard Subbasin, the Reduction Without Projects Scenario 3 also included a 55% reduction of 2015–2017 average production rates for the UAS and the LAS. The 2015–2017 average pumping rate was not reduced in the UAS and the LAS in the PVB, and was not reduced in the LAS in the WLPMA. Groundwater

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[10] Modeled extraction rates depend on climate, surface water availability, and simulated groundwater elevations for each model year. The reductions implemented reflect a reduction in overall water demand for the PVB and the Oxnard Subbasin and are not the exact percentage specified for any given year. Therefore, the extraction rate from the older alluvium UAS in 2040 is 44% of the extraction rate in 2020, rather than the 55% specified in the model scenario description.

production rates were reduced in the Oxnard Subbasin linearly over the implementation period and held constant during the sustaining period.

In the PVB, the older alluvium simulated groundwater production rate in model year 2020 (at the beginning of the implementation period) was 7,000 AFY. The production rate in model year 2040 (at the beginning of the sustaining period) was 5,000 AFY. The average production from the older alluvium for the sustaining period was 5,000 AFY. In the LAS, the simulated groundwater production rate in model year 2020 was 12,000 AFY and the simulated groundwater production rate in model year 2040 was 13,000 AFY. The average production rate from the LAS for the sustaining period was 9,000 AFY. The resulting average combined extraction rate from the two aquifer systems was approximately 14,000 AFY for the 30-year sustaining period (Table 2-11).

Reduction Without Projects Scenario 3 Model Results

Model results indicate that under this scenario the groundwater flux in the LAS between the PVB and the Oxnard Subbasin is reversed from model year 2027 to the end of the model period (2069). The groundwater flow during this period (after 2027) in the LAS is from the Oxnard Subbasin to the PVB. This significantly increases the seawater intrusion in the LAS in the Oxnard Subbasin, exacerbating the Oxnard Subbasin’s seawater intrusion problem.

There was an average flux of groundwater out of the UAS into the Pacific Ocean of approximately 3,700 AFY during the sustaining period in the Reduction Without Projects Scenario 3, and an average flux of approximately 1,400 AFY of seawater into the LAS. As in the Reduction Without Projects Scenarios 1 and 2, the continued inflow of seawater into the LAS suggests that groundwater production in the LAS may need to be reduced further than it was in the Reduction With Projects Scenario 3, while at the same time the groundwater production rate in the UAS was likely lower than it needed to be, as groundwater left the aquifers of the UAS and entered the Pacific Ocean.

2.4.5.7 Alternative Climate and Rainfall Patterns

To begin to assess the potential impacts on model predictions from alternate climate change assumptions and precipitation patterns, two additional simulations were conducted using the Reduction Without Projects Scenario 1. These additional simulations changed the scenario assumptions in two ways. First, the Reduction Without Projects Scenario 1 was simulated using the DWR 2030 climate-change factors, rather than the more conservative 2070 climate-change factors. This revised scenario is referred to as the Reduction Without Project Scenario 1a. Second, the Reduction Without Projects Scenario 1 was simulated with the DWR 2030 climate-change factors applied to the historical precipitation and hydrology period from 1940 to 1989, rather than the original period from 1930–1979. This revised scenario is referred to as the Reduction Without Projects Scenario 1b.

The 50-year periods from 1930 to 1979 and 1940 to 1989 were selected because they were the two periods from the entire historical record with the closest mean, or average, precipitation to the mean precipitation for the entire historical record of 14.4 inches. The mean precipitation for the historical period from 1930 to 1979 is also 14.4 inches and the mean precipitation from the historical period from 1940 to 1979 is 14.6 inches. These periods also have a similar distribution of precipitation years to the historical record and a similar average drought length to the average drought length in the historical record. The primary difference between the two periods is the timing of the dry periods in the records. The period from 1930 to 1979 begins with a 7-year dry period from 1930 to 1936 (model years 2020–2026), while the period from 1940 to 1989 begins with a 5-year wetter-than-average period (model years 2020–2024). The differences between these scenarios are discussed below.

Reduction Without Projects Scenario 1a

The Reduction Without Projects Scenario 1a had approximately 2,200 AFY of freshwater flowing out of the UAS to the Pacific Ocean and 1,500 AFY of seawater intrusion into the LAS during the sustaining period. Compared to the Reduction With Projects Scenario 1, there was approximately 600 AFY less flow out of the UAS and approximately 200 AFY more flow into the LAS from the Pacific Ocean (Figure 2-44). This is the result of lower water levels in the UAS and the LAS under this scenario than the Reduction With Projects Scenario 1. The 2030 climate-change factor showed lower potential water levels and more seawater intrusion than the 2070 climate-change factor; however, the difference between the simulated fluxes in the two scenarios is within the uncertainty of the model predictions and is not significant compared to other uncertainties in the future simulations, including the actual precipitation pattern that will prevail over the period from 2020 to 2069.

Reduction Without Projects Scenario 1b

The Reduction Without Projects Scenario 1b had approximately 4,300 AFY of freshwater flowing out of the UAS to the Pacific Ocean and 760 AFY of seawater intrusion into the LAS during the sustaining period. Compared to the Reduction Without Projects Scenario 1a discussed above, the Reduction Without Projects Scenario 1b had 2,100 AFY more freshwater leaving the UAS and 800 AFY less seawater intrusion in the LAS during the sustaining period (Figure 2-44). The reduced seawater intrusion and increased freshwater outflow are the result of higher simulated groundwater levels during the sustaining period than in the Reduction Without Projects Scenario 1a. The groundwater elevations in the Reduction Without Projects Scenario 1b rise faster in response to the wetter-than-average precipitation pattern that occurs at the beginning of the model period (model years 2020–2024) and remain higher during the sustaining period (model years 2040–2069) than they do in the Reduction Without Projects Scenario 1a. The differences in seawater intrusion and water levels between the Reduction Without Projects Scenarios 1a and 1b show that the model is more sensitive to actual precipitation patterns than it is to the predicted relative changes in climate between 2030 and 2070. The actual climate and precipitation patterns over the next 5 years should be used to revise the model simulations and refine the estimated potential for net seawater intrusion during the sustaining period.

2.4.5.8 Uncertainty Analysis

A peer review of the UWCD model was conducted to provide an independent evaluation of the model for use in the context of developing a GSP and to quantify the uncertainty associated with the modeling estimates of the sustainable yield for the basins in the model domain (Appendix I). UWCD conducted a *local* sensitivity analysis of its model prior to this review, in order to evaluate how the model input parameters obtained via the model calibration affect the model outputs. The peer review conducted an additional *global* sensitivity analysis that keys off their local sensitivity analysis and allows for a quantitative assessment of uncertainty in seawater flux and sustainable yield.

General Results

Results of the model scenarios discussed above indicate that changes to groundwater production rates or to extraction locations for the Oxnard Subbasin are needed to avoid seawater intrusion in the LAS during the sustaining period. Understanding the uncertainties in the model predictions underscores the desirability of making gradual changes in production rates while additional monitoring and studies help to reduce these uncertainties.

The largest potential sources of uncertainty in the model were found to be hydraulic properties for a given precipitation pattern. As discussed in Section 2.4.3, Current and Historical Water Budget Analysis, precipitation and surface water availability are a critical input parameter for predictive simulations. Critical areas of hydraulic properties were constrained in the historical simulations by aquifer testing. In particular, the model parameters that accounted for the most variance (approximately 37% of total variance) in minimizing error between observed groundwater levels and model simulated heads throughout the model were the horizontal hydraulic conductivities assigned to the Oxnard and Mugu Aquifers in the Forebay. The values assigned in the model were consistent with horizontal hydraulic conductivities determined from aquifer testing in that area. The fact that the most sensitive parameter assignments were well constrained by observations reduces uncertainty and provides good confidence in model predictions of groundwater levels overall.

Additionally and importantly, these same zones of horizontal hydraulic conductivity accounted for approximately 24% of total variance in model calculations of seawater flux across the ocean boundary. In contrast, the conductance of the ocean general head boundaries only accounted for approximately 3% of the variance in seawater flux. This indicates that the movement of artificially recharged groundwater from the Forebay to the coast is key in seawater flux. Additionally, the amount of Forebay recharge that enters the WLPMA rather than moving toward the coast was found to affect the seawater flux more than the conductance of the general head boundaries representing the ocean outcrops at the model boundary.

Stream infiltration, a parameter that was estimated based on the correlation between predicted and observed water levels, accounted for approximately 5% of the variance in seawater flux. Horizontal and vertical hydraulic conductivity of the aquitard separating Layer 5 (Mugu Aquifer) from Layer 7 (the Hueneme Aquifer) in the PVB accounted for approximately 3% of the variance in seawater flux. This sensitivity is associated with the flux across the basin boundary and the flow between the UAS and the LAS. Again, these parameters in the PVB accounted for more seawater flux than that accounted for by the conductance of the aquifer outcrops beneath the ocean.

Quantifying Uncertainty

For the Oxnard Subbasin, the uncertainty associated with model simulations of seawater flux was calculated by determining the relationship between simulated groundwater levels in wells near the coast and simulated seawater flux at the ocean boundary for the six model scenarios described in Section 2.4.5. The relationship was established by calculating the mean errors between observed and simulated groundwater levels at the coastal wells and applying the relationship between simulated groundwater levels and seawater flux to determine what the flux would have been had the model exactly reproduced observed groundwater levels. The analysis was conducted for both the entire model period (from 2020 to 2069) and the sustaining period (from 2040 to 2060).

The Oxnard Subbasin uncertainty analysis indicated that the uncertainty estimate for groundwater pumping in the Oxnard Subbasin was plus or minus 6,000 AFY in the UAS and 3,000 AFY in the LAS, for a total of plus or minus 9,000 AFY. The Oxnard Subbasin uncertainty analysis was used to interpolate the uncertainty for the PVB. This was done by using the uncertainty estimate for the Oxnard Subbasin and the ratio of model pumping in the PVB to the total model pumping for the three model basins: the Oxnard Subbasin, the PVB, and the WLPMA. This produced an uncertainty in PVB pumping of plus or minus 1,200 AFY for both the Shallow Alluvial Aquifer and the LAS.

The relationship between seawater flux and water levels will continue to be refined through data collection and analysis over successive 5-year periods for the GSP evaluations, and these uncertainty estimates are anticipated to contract accordingly.

2.4.5.9 Estimates of Future Sustainable Yield

The sustainable yield for PVB was assessed by examining the modeled flux of seawater into the UWCD future water scenarios over the 50-year model period and the 30-year sustaining period predicted for the UWCD model for the Oxnard Subbasin, the PVB, and the WLPMA. Only the sustaining period was assessed because SGMA recognizes that undesirable results may occur during the 20-year implementation period, as basins move toward sustainable groundwater management. In addition to the flux of seawater, particle tracks from the model runs were analyzed to evaluate the potential migration of the current extent of saline water impact in the UAS and the LAS. The particles were placed along the approximate inland extent of the zone of saline water impact in 2015. Scenarios that minimize the net flux of seawater into the Oxnard Subbasin and the landward migration of the saline water impact front over the 30-year sustaining period are sustainable for the Oxnard Subbasin, while those that allow for net seawater intrusion and landward migration of the saline water impact front are not.

None of the model scenarios described in Section 2.4.5 successfully eliminated seawater intrusion in the LAS of the Oxnard Subbasin during the 50-year model period, or the 30-year sustaining period, while the majority of the model scenarios resulted in net freshwater loss from the UAS to the Pacific Ocean. Therefore, none of the direct model scenarios was used to determine the sustainable yield of the PVB. Instead, the relationship between seawater flux and groundwater production from the model scenarios for both the 50-year period and the 30-year period were plotted graphically and the linear relationship between the seawater flux and groundwater production was used to predict the quantity of groundwater production that would result in no net seawater intrusion over the periods in either the UAS or the LAS. This method is also discussed in Appendix I, Section 2.3.2.2, and the seawater flux and groundwater production plots are provided in Appendix I as Figures 4 and 5. In order to provide separate estimates for the two aquifer systems, independent relationships between groundwater production and seawater intrusion were developed for the UAS and the LAS. It was possible to develop relationships for each aquifer within the UAS and the LAS, but in general wells in the Oxnard Subbasin are screened in multiple aquifers in each aquifer system. Therefore, for management purposes, the sustainable yield estimates were developed for the aquifer systems rather than for independent aquifers.

Based on the scenarios presented in Section 2.4.5 and the uncertainty analysis discussed in Section 2.4.5.8, the PVB sustainable yield for the older alluvium and the LAS was estimated to be 11,600 AFY plus or minus 1,200 AFY. Using the ratio of Shallow Alluvial Aquifer pumping to LAS pumping, this produces an estimate of 4,400 AFY for the Shallow Alluvial Aquifer and 7,200 AFY for the LAS.

It is anticipated that the analysis for the 5-year update to the GSP will focus on differential extractions on the coast and inland, particularly in the LAS. Additional modeling is recommended for the 5-year update process to understand how changes in pumping patterns can increase the overall sustainable yield of the PVB. As this understanding improves, projects to support increases in the overall sustainable yield can be developed.

2.5 MANAGEMENT AREAS

In order to sustainably manage the groundwater resources of the PVB, the PVB has been divided into three management zones: the North Pleasant Valley Management Area (NPVMA), the Pleasant Valley Pumping Depression Management Area (PVPDMA), and the East Pleasant Valley Management Area (EPVMA; Figure 2-46, Pleasant Valley Basin Management Areas).

The NPVMA lies within the PVB northern boundary, the Bailey Fault, and the PVPDMA, which were defined by the lateral extent of the FCA in the PVB. The NPVMA, which includes the City of Camarillo, is east of the PVPDMA and north of the EPVMA (Figure 2-46).

The PVPDMA is west of the NPVMA and north of the EPVMA (Figure 2-46). The boundaries of the PVPDMA include the Bailey Fault, the Oxnard Subbasin, and a northwest-trending line starting at the intersection of Lewis Road and the Bailey Fault. This management area was established based on the historically low groundwater elevations recorded in both the UAS and the LAS in the area.

The EPVMA lies to the east of the Bailey Fault and is predominantly within the jurisdiction of CWD. The FCGMA jurisdictional boundary extends along the Bailey Fault and thus along the boundary with the EPVMA (Figure 2-46). This management area was established based on the Bailey Fault, which acts as a barrier to groundwater flow, and where the FCA is missing (Turner 1975; Section 2.2.1).

This GSP has been prepared for the entire PVB. The PVPDMA and NPVMA defined in this GSP will be managed by FCGMA. The EPVMA lies within the jurisdiction of the Camrosa Water District–Pleasant Valley GSA and the Pleasant Valley Basin Outlying Areas GSA (see Figure 1-2). The minimum thresholds and measurable objectives developed in Chapter 3, Sustainable Management Criteria, are based on the data available in the PVPDMA and the NPVMA. Comparable historical data on groundwater elevation, storage, production, and quality are not available for the EPVMA. Therefore, the minimum thresholds and measurable objectives for the PVPDMA and the NPVMA will be applied to age- and/or depth-equivalent hydrostratigraphic units in the EPVMA. As additional data are collected in the EPVMA, separate minimum thresholds and management objectives may be developed. If changes to the minimum thresholds and management objectives are warranted, justification will be provided in the 5-year GSP updates.

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Table 2-1
Pleasant Valley Basin Hydrostratigraphic and Stratigraphic Nomenclature

<table>
<tr><th rowspan="2">Geologic Epoch</th><th>DWR (2003)</th><th>This Report</th><th>Hanson et al. (2003); Bachman (2016)</th><th>Kew (1924); Bailey (1951)[a]</th><th>Jakes (1979)</th><th>Weber and Kiessling (1976)</th><th>Dibblee (1992a, 1992b)</th><th>DeVecchio et al. (2012b)</th></tr>
<tr><th>Water-Bearing Formations</th><th colspan="2">Hydrostratigraphic Units</th><th colspan="5">Lithologic Units and Formations</th></tr>
<tr><td rowspan="1">Holocene</td><td rowspan="3">Alluvium</td><td>Shallow Alluvial Aquifer and Semi-Perched Aquifer</td><td>Shallow Alluvium</td><td colspan="4">Recent Alluvium: Active lagoonal, beach, river, and floodplain, and alluvial deposits</td><td>Alluvium: Active alluvium</td></tr>
<tr><td rowspan="5">Upper Pleistocene</td><td rowspan="2">Older Alluvium</td><td rowspan="2">Upper Aquifer System</td><td rowspan="2">Terrace Deposits: Deformed river deposits</td><td colspan="3" rowspan="2">Older Alluvium: Deformed beach, river, floodplain, and terrace deposits</td><td>Older Alluvium: Incised and gently folded fluvial deposits</td></tr>
<tr><td rowspan="2">Saugus Formation</td></tr>
<tr><td rowspan="5">San Pedro Formation</td><td rowspan="3">Upper San Pedro Formation</td><td rowspan="3">Hueneme Aquifer</td><td colspan="2" rowspan="5">Saugus Formation: Terrestrial and marine sand and gravel</td><td rowspan="2">Saugus Formation: Terrestrial fluvial</td><td rowspan="3">Saugus Formation: Terrestrial</td></tr>
<tr><td rowspan="4">Las Posas Sand: Shallow marine sand thickening westward</td></tr>
<tr><td rowspan="2">San Pedro Formation: Marine clays and sand and terrestrial sediment</td></tr>
<tr><td rowspan="2">Lower Pleistocene</td><td>Fox Canyon Aquifer</td><td>Fox Canyon</td><td rowspan="2">Las Posas Sand: Shallow marine sand</td></tr>
<tr><td>Grimes Canyon Aquifer</td><td>Grimes Canyon</td><td>Santa Barbara Formation: Shallow marine sand</td></tr>
<tr><td>Pliocene</td><td rowspan="4">Non-Water-Bearing</td><td rowspan="4">Non-Water-Bearing</td><td rowspan="4">Non-Water-Bearing</td><td>Fernando Group</td><td colspan="3">Pico Formation</td><td>Absent</td></tr>
<tr><td rowspan="2">Miocene</td><td colspan="3">Modelo Formation: Marine mudstones</td><td colspan="2">Monterey Formation</td></tr>
<tr><td colspan="5">Conejo Volcanics: Terrestrial and marine extrusive and intrusive igneous rocks</td></tr>
<tr><td>Oligocene/ Eocene</td><td colspan="5">Sespe Formation: Sandstone and cobble conglomerate</td></tr>
</table>

Note:
[a] As cited in DeVecchio et al. 2012a.

Table 2-2
Vertical Gradient

Location	SWN	Well	Screen Interval		Spring 2015 Elevation (ft msl)	Gradient (ft/ft)[a]	Fall 2015 Elevation (ft msl)	Gradient (ft/ft)[a]	Aquifer
			Top	*Bottom*					
Western PVB	02N21W34G	5	170	190	10.08	–0.365	–10.19	–0.369	Older Alluvium
		4	360	380	–59.25	–0.072	–80.28	–0.088	Older Alluvium
		3	800	860	–92.53	0.043	–120.62	0.022	Fox Canyon
		2	938	998	–86.65		–117.52		Fox Canyon

Notes: ft/ft = feet per feet; ft msl = feet above mean sea level; PVB = Pleasant Valley Basin; SWN = state well number.
[a] Negative gradients are directed downward.

Table 2-3
Basin Plan and FCGMA Water Quality Thresholds for Groundwater in the PVB (mg/L)

Threshold Source	TDS	Chloride	Nitrate	Sulfate	Boron
LARWQCB Basin Plan WQO	700	150	45	300	1
FCGMA 2007 BMO	—	<150	—	—	—

Sources: LARWQCB 2017; FCGMA 2007.
Notes: BMO = Basin Management Objective; FCGMA = Fox Canyon Groundwater Management Agency; LARWQCB = Los Angeles Regional Water Quality Control Board; mg/L = milligrams per liter; PVB = Pleasant Valley Basin; TDS = total dissolved solids; WQO = Water Quality Objective.

Table 2-4
Modeled Surface Water Percolation from Streams in the Pleasant Valley Basin (AF)

Water Year[a]	Arroyo Las Posas Percolation	Conejo Creek Percolation	Calleguas Creek Percolation
1986	2,434	9,001	3,903
1987	284	8,232	3,365
1988	2,126	8,742	3,659
1989	944	8,404	3,507
1990	797	8,169	3,347
1991	1,463	8,132	3,479
1992	4,308	9,358	4,283
1993	6,197	9,778	4,559
1994	3,349	8,336	3,582
1995	5,411	9,316	4,333
1996	3,373	8,289	3,645
1997	4,594	8,336	3,735
1998	9,946	9,670	4,250
1999	5,659	8,207	3,609
2000	5,208	8,228	3,619
2001	7,064	8,697	3,899
2002[b]	5,489	8,135	3,483

Table 2-4
Modeled Surface Water Percolation from Streams in the Pleasant Valley Basin (AF)

Water Year[a]	Arroyo Las Posas Percolation	Conejo Creek Percolation	Calleguas Creek Percolation
2003	6,993	8,319	3,744
2004	4,266	7,623	3,273
2005	10,417	9,555	3,852
2006	7,309	7,997	3,587
2007	5,082	7,597	3,241
2008	4,924	8,119	3,562
2009	3,877	7,932	3,459
2010	5,750	7,643	3,515
2011	6,125	7,651	3,607
2012	3,883	7,252	3,369
2013	1,734	6,719	3,124
2014	1,663	5,868	3,074
2015	1,264	6,341	3,251
Average	**4,398**	**8,188**	**3,630**

Source: Appendix D.
Note: AF = acre-feet.
a Results presented are in water years, and will not match values presented in Section 2.4 text and tables, which are presented in calendar years.
b Conejo Creek Diversion Project began operating in the year 2002.

Table 2-5
Stream Flows in Arroyo Las Posas and Conejo Creek, Conejo Creek Diversions, Deliveries by CWD, and Discharges from CSD into Conejo Creek (AF)

Calendar Year	Camarillo Sanitary District Discharges to Conejo Creek (AF)[a]	Arroyo Las Posas Subsurface Inflows from East LPVB (CMWD Model, 2018) (AF)	Arroyo Las Posas Flows Measured at Stream Gauge 806 until 1997 and 806A until 2005 (AF)[b]	Conejo Creek Flows Measured at Stream Gauge 800 until 2011 and 800A until 2012 (AF)	Conejo Creek Flows Delivered by CWD for PVB Agriculture (AF)[c]	Conejo Creek Flows Delivered by CWD for Agriculture In PVCWD (AF)[d]	Conejo Creek Flows Delivered by CWD for PVB M&I (AF)	Total Conejo Creek Flow Diversions (AF)
1985	2,375	148	1,174	14,265	2,450	0	0	2,450
1986	2,420	647	11,707	25,621	2,450	0	0	2,450
1987	2,464	695	3,487	16,851	2,450	0	0	2,450
1988	2,565	899	3,256	16,922	2,450	0	0	2,450
1989	2,364	768	840	14,785	2,450	0	0	2,450
1990	1,826	925	1,068	12,608	2,450	0	0	2,450
1991	1,456	1,090	9,715	20,227	2,450	0	0	2,450
1992	1,815	1,597	26,792	44,305	2,450	0	0	2,450
1993	1,512	1,877	27,749	52,306	2,450	0	0	2,450
1994	2,576	1,754	2,956	16,195	2,450	0	0	2,450
1995	3,338	1,991	26,984	45,909	2,450	0	0	2,450
1996	3,730	1,944	9,919	22,862	2,450	0	0	2,450
1997	3,327	1,920	10,742	22,905	2,450	0	0	2,450
1998	4,122	2,091	47,361	49,704	2,450	0	0	2,450
1999	2,307	1,849	923	16,479	2,450	0	0	2,450
2000	2,610	1,855	4,884	18,000	2,450	0	0	2,450
2001	2,722	2,050	18,819	28,092	2,450	0	0	2,450
2002	3,204	1,801	3,003	16,744	2,450	1,153	0	3,603
2003	3,237	2,108	12,973	21,592	1,249	2,644	256	4,149
2004	3,495	2,061	13,757	23,522	1,345	2,353	276	3,974
2005	3,674	2,207	54,549	46,396	1,639	2,447	336	4,422
2006	3,237	2,145	NA	23,175	1,457	2,834	298	4,589
2007	3,215	2,034	NA	17,048	3,288	2,658	674	6,620
2008	2,845	2,064	NA	25,254	2,895	2,136	358	5,389
2009	2,621	1,991	NA	19,099	3,225	1,759	673	5,657
2010	2,767	2,067	NA	20,293	2,554	2,147	594	5,295
2011	2,487	2,057	NA	17,518	2,359	2,827	533	5,719
2012	2,375	1,893	NA	7,612	2,603	1,897	653	5,153
2013	2,240	1,635	NA	NA	2,999	1,432	754	5,185

Table 2-5
Stream Flows in Arroyo Las Posas and Conejo Creek, Conejo Creek Diversions, Deliveries by CWD, and Discharges from CSD into Conejo Creek (AF)

Calendar Year	Camarillo Sanitary District Discharges to Conejo Creek (AF)[a]	Arroyo Las Posas Subsurface Inflows from East LPVB (CMWD Model, 2018) (AF)	Arroyo Las Posas Flows Measured at Stream Gauge 806 until 1997 and 806A until 2005 (AF)[b]	Conejo Creek Flows Measured at Stream Gauge 800 until 2011 and 800A until 2012 (AF)	Conejo Creek Flows Delivered by CWD for PVB Agriculture (AF)[c]	Conejo Creek Flows Delivered by CWD for Agriculture In PVCWD (AF)[d]	Conejo Creek Flows Delivered by CWD for PVB M&I (AF)	Total Conejo Creek Flow Diversions (AF)
2014	2,498	1,503	NA	NA	2,858	904	854	4,616
2015	2,274	1,370	NA	NA	2,555	1,036	794	4,385
Maximum	**4,122**	**2,207**	**54,549**	**52,306**	**3,288**	**2,834**	**854**	**6,620**
Minimum	**1,456**	**148**	**840**	**7,612**	**1,249**	**0**	**0**	**2,450**
Average	**2,700**	**1,646**	**13,936**	**24,153**	**2,423**	**911**	**227**	**3,562**

Notes: AF = acre-feet; CMWD = Calleguas Municipal Water District; CSD = Camarillo Sanitary District; CWD = Camrosa Water District; LPVB = Las Posas Valley Basin; M&I = municipal and industrial; NA = not available; PVB = Pleasant Valley Basin; PVCWD = Pleasant Valley County Water District.

[a] Data from City of Camarillo/Camarillo Sanitary District Annual Reports.

[b] 800A is downstream of Conejo Creek Diversion, whereas 800 was upstream.

[c] 2,450 AFY between 1985 and 2002 accounts for diversions of Conejo Creek water prior to development of CWD's Diversion Facility.

- Between 2003 and 2006, deliveries are less than previous assumptions as not all uses had connected to the CWD system.
- It is fair to assume the difference between those volumes and 2,450 were still applied to land.

[d] For water supplied by CWD to PVCWD, 56% is used in the Oxnard Subbasin and 44% in the PVB.

Table 2-6a
UWCD Water Budget for the Semi-Perched Aquifer

Calendar Year	Groundwater Recharge (AF)					Groundwater Discharge (AF)						Storage Change (AF)
	Recharge	*Calleguas Creek Percolation*	*Conejo Creek Percolation*	*Arroyo Las Posas Percolation*	*Total Inflow*	*Pumping*	*Tile Drains*	*Subsurface Outflow to UAS*	*Evapotranspiration*	*Subsurface Outflow to Oxnard Subbasin*	*Total Outflow*	*Change in Groundwater Storage[a]*
1985	5,089	3,402	6,018	0	14,509	−244	−165	−11,251	0	−1,525	−13,184	−1,325
1986	6,539	3,856	6,815	475	17,684	−270	−233	−11,155	0	−1,720	−13,379	−4,305
1987	5,457	3,523	6,236	0	15,216	−362	−236	−13,833	0	−1,780	−16,212	996
1988	5,406	3,546	6,276	0	15,228	−349	−242	−13,262	0	−1,758	−15,612	383
1989	4,992	3,444	6,107	0	14,543	−384	−222	−14,768	0	−1,641	−17,015	2,472
1990	4,647	3,313	5,839	0	13,799	−457	−161	−16,146	0	−1,312	−18,077	4,278
1991	6,264	3,583	6,188	319	16,353	−433	−133	−14,830	0	−1,074	−16,470	117
1992	7,185	4,324	7,801	1,008	20,318	−336	−209	−12,936	0	−1,448	−14,929	−5,389
1993	6,855	4,524	8,224	1,191	20,794	−254	−329	−10,949	−80	−2,161	−13,774	−7,020
1994	4,908	3,508	6,221	372	15,009	−233	−317	−10,438	0	−2,249	−13,237	−1,772
1995	7,434	4,399	8,012	913	20,759	−163	−743	−8,640	−239	−3,070	−12,854	−7,904
1996	6,131	3,807	6,776	635	17,348	−161	−819	−9,386	−151	−3,281	−13,798	−3,551
1997	6,181	3,763	6,716	670	17,329	−188	−1,085	−10,937	−240	−3,628	−16,078	−1,251
1998	8,032	4,056	8,219	1,785	22,091	−104	−2,241	−8,680	−861	−4,336	−16,222	−5,868
1999	4,964	3,548	6,299	458	15,269	−139	−1,711	−10,502	−317	−4,254	−16,923	1,653
2000	5,218	3,617	6,450	586	15,871	−157	−1,549	−10,579	−314	−4,259	−16,858	988
2001	7,123	3,966	7,218	1,268	19,574	−135	−1,910	−10,319	−551	−4,414	−17,329	−2,245
2002	4,806	3,553	6,324	556	15,238	−173	−1,354	−11,427	−246	−4,219	−17,418	2,179

Table 2-6a
UWCD Water Budget for the Semi-Perched Aquifer

Calendar Year	Groundwater Recharge (AF)					Groundwater Discharge (AF)						Storage Change (AF)
	Recharge	Calleguas Creek Percolation	Conejo Creek Percolation	Arroyo Las Posas Percolation	Total Inflow	Pumping	Tile Drains	Subsurface Outflow to UAS	Evapotranspiration	Subsurface Outflow to Oxnard Subbasin	Total Outflow	Change in Groundwater Storage[a]
2003	5,012	3,534	6,097	725	15,367	−148	−1,322	−9,501	−338	−4,207	−15,516	150
2004	6,165	3,575	6,444	952	17,136	−186	−1,168	−10,423	−254	−4,131	−16,161	−974
2005	6,812	3,610	7,914	1,742	20,078	−120	−2,280	−7,685	−1,081	−4,668	−15,834	−4,245
2006	5,176	3,545	6,231	1,020	15,973	−84	−2,092	−5,857	−658	−4,622	−13,314	−2,659
2007	4,145	3,260	5,758	17	13,181	−122	−1,913	−8,120	−295	−4,673	−15,123	1,942
2008	5,497	3,661	6,561	504	16,224	−140	−2,023	−8,641	−549	−4,791	−16,144	−80
2009	4,928	3,433	6,024	436	14,821	−136	−1,766	−8,604	−437	−4,711	−15,654	833
2010	6,608	3,420	5,607	943	16,579	−124	−1,832	−8,167	−646	−4,706	−15,475	−1,104
2011	4,755	3,668	6,436	603	15,462	−105	−2,052	−6,897	−875	−4,774	−14,703	−758
2012	4,096	3,362	5,343	252	13,053	−129	−1,610	−8,566	−367	−4,651	−15,323	2,270
2013	3,499	3,019	4,196	0	10,713	−204	−942	−11,587	−130	−4,237	−17,100	6,386
2014	4,681	3,251	4,087	13	12,032	−288	−483	−13,703	−37	−3,467	−17,977	5,945
2015	3,308	3,012	3,476	0	9,796	−297	−328	−12,581	−5	−2,760	−15,970	6,174
Maximum	**8,032**	**4,524**	**8,224**	**1,785**	**22,091**	**−84**	**−133**	**−5,857**	**0**	**−1,074**	**−12,854**	**6,386**
Minimum	**3,308**	**3,012**	**3,476**	**0**	**9,796**	**−457**	**−2,280**	**−16,146**	**−1,081**	**−4,791**	**−18,077**	**−7,904**
Average	**5,546**	**3,616**	**6,320**	**563**	**16,044**	**−214**	**−1,080**	**−10,657**	**−280**	**−3,372**	**−15,602**	**−441**

Notes: AF = acre-feet; UAS = Upper Aquifer System; UWCD = United Water Conservation District.
[a] A negative number indicates that water entered storage.

Table 2-6b
UWCD Water Budget for the Older Alluvium

Calendar Year	Groundwater Recharge (AF)								Groundwater Discharge (AF)						Storage Change (AF)
	Mountain-Front Recharge	Recharge	Subsurface Inflow from the Semi-Perched Aquifer	Groundwater Flux from East LPVB by CMWD Model	Conejo Creek Percolation	Arroyo Las Posas Percolation	Subsurface Inflow from the Oxnard Subbasin	Total Inflow	Pumping	Subsurface Outflow to LAS	Evapo-transpiration	Subsurface Outflow to LPVB	Subsurface Outflow to Oxnard Subbasin	Total Outflow	Change in Groundwater Storage[a]
1985	763	558	11,251	148	2,388	222	1,551	16,882	−9,005	−8,623	−692	0	0	−18,320	1,438
1986	2,322	937	11,155	647	2,073	1,880	613	19,627	−8,001	−7,367	−957	−1	0	−16,326	−3,301
1987	1,088	630	13,833	695	2,299	1,067	15	19,628	−10,878	−8,030	−926	0	0	−19,834	205
1988	1,101	670	13,262	899	2,213	1,744	0	19,889	−10,052	−8,585	−966	−11	−142	−19,756	−133
1989	329	510	14,768	768	2,220	530	0	19,126	−11,750	−7,811	−972	−1	−588	−21,122	1,996
1990	261	399	16,146	925	2,254	780	0	20,766	−13,580	−8,947	−922	0	−1,153	−24,601	3,835
1991	2,152	786	14,830	1,090	2,026	1,770	0	22,654	−11,818	−9,510	−963	−1	−956	−23,248	593
1992	3,164	1,042	12,936	1,597	1,656	3,663	73	24,132	−7,967	−9,095	−1,008	−68	0	−18,138	−5,994
1993	2,786	986	10,949	1,877	1,530	4,592	2,107	24,827	−6,440	−7,861	−1,006	−198	0	−15,504	−9,323
1994	887	537	10,438	1,754	1,998	2,714	1,808	20,136	−7,778	−7,876	−1,006	−166	0	−16,826	−3,311

Table 2-6b
UWCD Water Budget for the Older Alluvium

Calendar Year	Groundwater Recharge (AF)								Groundwater Discharge (AF)						Storage Change (AF)
	Mountain-Front Recharge	*Recharge*	*Subsurface Inflow from the Semi-Perched Aquifer*	*Groundwater Flux from East LPVB by CMWD Model*	*Conejo Creek Percolation*	*Arroyo Las Posas Percolation*	*Subsurface Inflow from the Oxnard Subbasin*	*Total Inflow*	*Pumping*	*Subsurface Outflow to LAS*	*Evapo-transpiration*	*Subsurface Outflow to LPVB*	*Subsurface Outflow to Oxnard Subbasin*	*Total Outflow*	*Change in Groundwater Storage[a]*
1995	3,633	1,199	8,640	1,991	1,368	4,767	1,346	22,946	−5,980	−7,726	−1,011	−237	0	−14,955	−7,991
1996	2,281	928	9,386	1,944	1,727	4,092	1,375	21,733	−7,275	−8,069	−1,008	−233	0	−16,584	−5,148
1997	1,968	819	10,937	1,920	1,708	4,007	407	21,765	−8,174	−9,126	−1,006	−308	0	−18,613	−3,153
1998	3,496	1,270	8,680	2,091	1,112	7,338	67	24,054	−5,465	−9,054	−1,025	−994	0	−16,538	−7,516
1999	711	534	10,502	1,849	1,849	4,821	106	20,372	−7,923	−9,029	−1,006	−800	0	−18,758	−1,614
2000	1,351	644	10,579	1,855	1,783	4,627	0	20,839	−7,367	−9,050	−1,008	−715	−1,084	−19,224	−1,615
2001	2,633	922	10,319	2,050	1,532	6,755	0	24,211	−7,138	−8,814	−1,006	−921	−1,233	−19,112	−5,099
2002	1,016	601	11,427	1,801	1,936	5,318	0	22,099	−8,865	−10,040	−1,006	−731	−1,150	−21,791	−307
2003	1,327	651	9,501	2,108	1,743	5,247	0	20,577	−6,480	−9,271	−1,005	−833	−1,803	−19,392	−1,185
2004	2,295	865	10,423	2,061	1,847	4,716	0	22,207	−7,296	−9,503	−1,000	−728	−2,485	−21,012	−1,195
2005	2,929	1,111	7,685	2,207	1,197	7,697	0	22,826	−4,715	−8,357	−1,006	−1,194	−1,757	−17,029	−5,797
2006	1,622	743	5,857	2,145	1,641	5,774	0	17,782	−4,332	−7,719	−1,006	−994	−1,283	−15,333	−2,449
2007	409	445	8,120	2,034	1,972	5,106	0	18,086	−6,281	−8,316	−1,004	−906	−2,419	−18,926	841
2008	1,755	826	8,641	2,064	1,710	4,502	0	19,497	−6,200	−9,210	−1,008	−843	−3,135	−20,396	898
2009	1,182	633	8,604	1,991	1,837	3,686	0	17,935	−5,575	−8,684	−998	−786	−3,515	−19,558	1,623
2010	2,842	1,014	8,167	2,067	1,593	5,177	0	20,860	−5,054	−8,995	−1,000	−1,082	−3,938	−20,069	−791
2011	1,314	739	6,897	2,057	1,610	4,886	0	17,503	−4,127	−8,427	−1,004	−1,196	−3,049	−17,803	299
2012	665	593	8,566	1,893	1,933	3,029	0	16,679	−5,588	−9,010	−994	−870	−3,162	−19,624	2,945
2013	71	331	11,587	1,635	2,050	1,238	0	16,912	−8,172	−9,349	−976	−493	−3,767	−22,757	5,845
2014	1,033	579	13,703	1,503	1,981	1,861	0	20,660	−9,429	−9,999	−971	−265	−4,552	−25,216	4,556
2015	175	337	12,581	1,370	1,989	1,003	0	17,454	−8,290	−8,896	−947	−240	−4,639	−23,012	5,558
Maximum	**3,633**	**1,270**	**16,146**	**2,207**	**2,388**	**7,697**	**2,107**	**24,827**	**−4,127**	**−7,367**	**−692**	**0**	**0**	**−14,955**	**5,845**
Minimum	**71**	**331**	**5,857**	**148**	**1,112**	**222**	**0**	**16,679**	**−13,580**	**−10,040**	**−1,025**	**−1,196**	**−4,639**	**−25,216**	**−9,323**
Average	**1,599**	**737**	**10,657**	**1,646**	**1,831**	**3,697**	**305**	**20,473**	**−7,645**	**−8,721**	**−981**	**−510**	**−1,478**	**−19,335**	**−1,138**

Notes: AF = acre-feet; CMWD = Calleguas Municipal Water District; LAS = Lower Aquifer System; LPVB = Las Posas Valley Basin; UWCD = United Water Conservation District.
[a] A negative number indicates that water entered storage

Table 2-6c
UWCD Water Budget for the Lower Aquifer System

Calendar Year	Groundwater Recharge (AF)					Groundwater Discharge (AF)				Storage Change (AF)
	Recharge	*Subsurface Inflow from the UAS*	*Subsurface Inflow from the LPVB*	*Subsurface Inflow from the Oxnard Subbasin*	*Total Inflow*	*Pumping*	*Subsurface Outflow to the LPVB*	*Subsurface Outflow to the Oxnard Subbasin*	*Total Outflow*	*Change in Groundwater Storage[a]*
1985	196	8,623	1,425	100	10,345	−9,840	0	0	−9,840	−504
1986	378	7,367	686	0	8,430	−7,051	0	−285	−7,336	−1,094

Table 2-6c
UWCD Water Budget for the Lower Aquifer System

Calendar Year	Groundwater Recharge (AF)					Groundwater Discharge (AF)				Storage Change (AF)
	Recharge	*Subsurface Inflow from the UAS*	*Subsurface Inflow from the LPVB*	*Subsurface Inflow from the Oxnard Subbasin*	*Total Inflow*	*Pumping*	*Subsurface Outflow to the LPVB*	*Subsurface Outflow to the Oxnard Subbasin*	*Total Outflow*	*Change in Groundwater Storage*[a]
1987	221	8,030	1,343	0	9,594	−8,822	0	−1,146	−9,968	374
1988	235	8,585	678	0	9,499	−9,247	0	−710	−9,957	458
1989	141	7,811	961	0	8,913	−12,194	0	−43	−12,237	3,324
1990	146	8,947	1,259	0	10,352	−10,951	0	−1,027	−11,979	1,627
1991	313	9,510	830	491	11,144	−8,836	0	0	−8,836	−2,308
1992	409	9,095	0	1,073	10,577	−6,583	−407	0	−6,990	−3,587
1993	407	7,861	0	1,205	9,473	−6,590	−879	0	−7,469	−2,004
1994	203	7,876	0	263	8,342	−7,467	−466	0	−7,933	−410
1995	487	7,726	0	235	8,448	−4,631	−811	0	−5,442	−3,006
1996	363	8,069	0	117	8,549	−7,116	−420	0	−7,536	−1,013
1997	311	9,126	0	0	9,436	−8,019	−314	−167	−8,500	−937
1998	517	9,054	0	0	9,571	−5,430	−1,085	−109	−6,625	−2,946
1999	178	9,029	0	0	9,207	−9,001	−259	−116	−9,376	169
2000	239	9,050	0	0	9,289	−7,442	−39	−546	−8,027	−1,263
2001	348	8,814	0	0	9,161	−5,799	−219	−1,030	−7,048	−2,113
2002	215	10,040	303	0	10,558	−9,801	0	−913	−10,715	147
2003	236	9,271	0	0	9,507	−8,336	−125	−210	−8,671	−836
2004	317	9,503	54	0	9,874	−9,018	0	−353	−9,371	−502
2005	417	8,357	0	0	8,774	−5,337	−614	−819	−6,770	−2,004
2006	275	7,719	0	0	7,994	−4,949	−693	−1,430	−7,071	−923
2007	153	8,316	0	0	8,469	−7,539	−383	−1,266	−9,187	718
2008	324	9,210	0	0	9,535	−7,125	−621	−1,608	−9,355	−180
2009	244	8,684	0	0	8,929	−6,839	−853	−1,657	−9,350	421
2010	399	8,995	0	0	9,394	−5,881	−1,438	−1,162	−8,481	−913
2011	302	8,427	0	0	8,730	−5,525	−1,701	−1,618	−8,845	115
2012	247	9,010	0	0	9,257	−7,500	−1,429	−1,431	−10,360	1,103
2013	127	9,349	0	0	9,477	−10,086	−381	−1,499	−11,966	2,489
2014	236	9,999	73	0	10,308	−9,971	0	−1,346	−11,317	1,009
2015	131	8,896	0	0	9,027	−9,263	−269	−1,420	−10,952	1,925
Maximum	**1,657**	**10,040**	**1,425**	**1,205**	**11,144**	**−4,631**	**0**	**0**	**−5,442**	**3,324**
Minimum	**0**	**7,367**	**0**	**0**	**7,994**	**−12,194**	**−1,701**	**−1,657**	**−12,237**	**−3,587**
Average	**707**	**8,721**	**246**	**112**	**9,360**	**−7,813**	**−432**	**−707**	**−8,952**	**−408**

Notes: AF = acre-feet; LPVB = Las Posas Valley Basin; UAS = Upper Aquifer System; UWCD = United Water Conservation District.
[a] A negative number indicates that water entered storage.

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Table 2-7
Sales and Usage of Imported Water Supplied by CMWD (AF)

Calendar Year	Delivered and Used by the City of Camarillo for M&I	Delivered and Used by CWD for PVB M&I	Delivered and Used by CWD for PVB Agriculture	Delivered and Used by PVMWC for PVB M&I	Total Imported Water Delivered
1985	4,742	2,210	2,155	94	9,201
1986	4,110	2,218	2,163	23	8,514
1987	4,229	2,393	2,335	137	9,093
1988	4,035	2,678	2,613	151	9,477
1989	4,701	2,651	2,586	279	10,217
1990	4,431	3,024	2,950	253	10,657
1991	2,683	1,847	1,634	266	6,430
1992	3,291	1,768	1,419	120	6,599
1993	3,945	1,697	1,234	82	6,958
1994	4,215	1,769	1,163	126	7,274
1995	5,166	1,818	1,079	284	8,347
1996	3,750	1,852	989	303	6,894
1997	4,406	2,201	1,054	494	8,155
1998	4,273	1,792	766	153	6,984
1999	5,436	2,301	874	201	8,812
2000	5,686	2,405	806	187	9,083
2001	5,487	2,256	661	359	8,764
2002	6,169	2,657	674	205	9,704
2003	4,679	2,698	585	194	8,155
2004	5,651	3,044	553	632	9,880
2005	5,468	3,238	482	384	9,573
2006	5,685	3,364	396	279	9,724
2007	6,366	4,823	425	632	12,246
2008	6,328	3,909	235	280	10,751
2009	5,592	3,092	149	313	9,146
2010	4,541	2,700	99	231	7,570
2011	5,057	2,779	96	357	8,288
2012	5,463	2,992	90	249	8,793
2013	5,223	3,046	78	255	8,601
2014	5,091	2,946	63	428	8,527
2015	4,551	2,388	41	233	7,213
Maximum	**6,366**	**4,823**	**2,950**	**632**	**12,246**
Minimum	**2,683**	**1,697**	**41**	**23**	**6,430**
Average	**4,853**	**2,599**	**982**	**264**	**8,698**

Notes: AF = acre-feet; CWD = Camrosa Water District; M&I = municipal and industrial; PVB = Pleasant Valley Basin; PVMWC = Pleasant Valley Mutual Water Company.

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Table 2-8
Other Pleasant Valley Basin Imported Water

Calendar Year	City of Camarillo (AF)	PVCWD (AF)	CWD Water in PVB (AF)						UWCD Water (AF)[a]		Total Other Imported Water
	Camarillo Sanitary District Recycled water Used for Agriculture[b]	*Pumped Groundwater from Oxnard Subbasin Used for Agriculture*[c]	*Pumped Groundwater from Santa Rosa Valley Used for M&I*	*Pumped Groundwater from Santa Rosa Valley Used for Agriculture*	*Groundwater Pumped in Tierra Rejada Basin Used for M&I*	*Groundwater Pumped in Tierra Rejada Basin Used for Agriculture*	*Recycled Water Used for M&I*	*Recycled Water Used for Agriculture*	*Diversions of Santa Clara River Water Used for Agriculture (PVP)*	*Recharged Spreading Water Pumped and Used for Agriculture (Saticoy Wells)*	
1985	1,635	170	513	501	0	0	0	450	3,845	0	7,114
1986	1,613	282	709	692	0	0	0	450	4,334	0	8,080
1987	1,703	231	686	669	0	0	0	450	2,006	0	5,745
1988	1,859	−387	485	473	0	0	0	450	3,046	0	5,926
1989	2,162	−121	382	373	0	0	0	450	2,509	0	5,755
1990	2,644	−273	303	296	0	0	0	450	140	0	3,561
1991	2,487	−708	321	284	0	0	0	450	737	0	3,570
1992	2,229	604	420	337	0	0	0	450	4,101	0	8,140
1993	2,543	197	708	515	0	0	0	450	6,729	0	11,142
1994	1,523	369	749	492	0	0	0	450	5,428	0	9,011
1995	1,400	308	676	401	0	0	0	640	6,166	0	9,591
1996	1,053	1,007	187	100	108	58	0	593	4,117	0	7,221
1997	1,915	425	529	253	124	60	0	497	5,005	0	8,808
1998	1,400	−107	727	311	98	42	0	671	7,068	0	10,210
1999	1,624	119	570	217	115	44	0	501	5,657	0	8,846
2000	1,400	376	750	251	146	49	0	777	5,140	0	8,889
2001	1,299	484	820	240	119	35	0	807	6,879	0	10,684
2002	1,031	145	986	250	113	29	0	617	2,664	0	5,834
2003	941	298	914	198	127	27	0	623	2,777	0	5,904
2004	784	767	954	173	162	30	0	459	2,308	0	5,637
2005	762	1,051	1,100	164	189	28	0	516	5,741	0	9,550
2006	874	−2	1,233	145	288	34	127	506	5,498	0	8,703
2007	930	41	1,692	149	305	27	154	344	4,360	238	8,240
2008	1,434	213	1,374	83	254	15	142	600	4,987	639	9,741
2009	1,624	218	1,013	49	210	10	124	841	6,419	778	11,287
2010	1,479	−77	733	27	218	8	138	835	5,084	166	8,611
2011	1,770	−164	788	27	248	9	167	806	5,576	213	9,439
2012	1,792	5	1,067	32	223	7	223	802	4,480	246	8,876
2013	1,882	−101	1,380	35	189	5	284	893	1,421	57	6,045
2014	1,691	287	1,030	22	171	4	278	1,008	88	0	4,578
2015	1,703	876	862	15	76	1	232	1,031	0	0	4,797
Maximum	**2,644**	**1,051**	**1,692**	**692**	**305**	**60**	**284**	**1,031**	**7,068**	**778**	**11,287**
Minimum	**762**	**−708**	**187**	**15**	**0**	**0**	**0**	**344**	**0**	**0**	**3,561**
Average	**1,587**	**211**	**795**	**251**	**112**	**17**	**60**	**609**	**4,010**	**75**	**7,727**

Notes: AF = acre-feet; CWD = Camrosa Water District; M&I = municipal and industrial; NA = Not Available; PVB = Pleasant Valley Basin; PVCWD = Pleasant Valley County Water District; PVP = Pleasant Valley Pipeline; UWCD = United Water Conservation District.

[a] For water supplied by the PVP to PVCWD, 44% is used in the Pleasant Valley Basin and 56% in the Oxnard Subbasin.
[b] Data from City of Camarillo/Camarillo Sanitary District Annual Reports.
[c] Negative value indicates groundwater pumped in the PVB and used in the Oxnard Subbasin.

Table 2-9
Recharge from Tables 2-6a through 2-6c by Type (AF)

Calendar Year	Precipitation	Pumped Groundwater	Applied Water (M&I and Domestic)	PVB System	Total Recharge
1985	1,560	2,773	732	779	5,843
1986	4,196	2,081	678	897	7,853
1987	2,028	3,123	739	418	6,308
1988	1,959	2,883	834	635	6,312
1989	629	3,508	965	541	5,643
1990	520	3,725	886	61	5,192
1991	3,419	3,172	582	191	7,363
1992	5,135	1,994	604	904	8,636
1993	4,607	1,572	641	1,427	8,247
1994	1,757	2,093	632	1,165	5,648
1995	5,668	1,566	592	1,294	9,121
1996	3,763	2,204	535	921	7,422
1997	3,255	2,280	690	1,085	7,311
1998	6,339	1,401	587	1,491	9,819
1999	1,318	2,452	708	1,199	5,676
2000	2,289	1,982	742	1,087	6,100
2001	4,395	1,770	700	1,528	8,392
2002	1,663	2,593	790	576	5,623
2003	2,528	1,723	683	966	5,900
2004	3,431	2,005	779	1,131	7,347
2005	4,924	966	720	1,730	8,340
2006	2,717	938	728	1,812	6,194
2007	783	1,707	827	1,426	4,744
2008	2,611	1,619	794	1,624	6,647
2009	1,904	1,457	733	1,712	5,806
2010	4,589	1,244	632	1,557	8,021
2011	2,254	1,132	657	1,754	5,797
2012	1,176	1,801	670	1,290	4,936
2013	145	2,524	693	594	3,956
2014	1,791	2,809	652	244	5,496
2015	423	2,555	565	233	3,776
Maximum	**6,339**	**3,725**	**965**	**1,812**	**9,819**
Minimum	**145**	**938**	**535**	**61**	**3,776**
Average	**2,702**	**2,118**	**702**	**1,041**	**6,564**

Notes: AF = acre-feet; M&I = municipal and industrial; PVB = Pleasant Valley Basin.

Table 2-10
Groundwater Extraction

Calendar Year	Agricultural Pumpage (AF)				M&I Pumpage (AF)				Domestic Pumpage (AF)				Totals (AF)			
	Pumping UAS	*Pumping LAS*	*Pumping Semi-Perched*	*Total Agricultural Pumping*	*Pumping UAS*	*Pumping LAS*	*Pumping Semi-Perched*	*Total M&I Pumping*	*Pumping UAS*	*Pumping LAS*	*Pumping Semi-Perched*	*Total Domestic Pumping*	*Total Pumping UAS*	*Total Pumping LAS*	*Total Pumping Semi-Perched*	*Total Pumping*
1985	8,939	9,049	242	18,229	0	364	0	364	66	428	2	495	9,005	9,840	244	19,089
1986	7,944	5,364	269	13,577	0	1,304	0	1,304	56	383	2	442	8,001	7,051	270	15,322
1987	10,794	7,432	359	18,586	0	1,059	0	1,059	83	330	3	416	10,878	8,822	362	20,062
1988	9,905	7,516	344	17,765	0	1,489	0	1,489	147	242	5	394	10,052	9,247	349	19,648
1989	11,630	9,546	380	21,556	0	2,382	0	2,382	120	267	4	390	11,750	12,194	384	24,328
1990	13,471	9,130	454	23,054	0	1,578	0	1,578	109	243	4	356	13,580	10,951	457	24,989
1991	11,692	7,265	428	19,385	0	1,445	0	1,445	126	126	5	256	11,818	8,836	433	21,087
1992	7,844	4,888	331	13,063	0	1,590	0	1,590	123	104	5	232	7,967	6,583	336	14,885
1993	6,308	4,176	249	10,733	0	2,236	0	2,236	132	177	5	315	6,440	6,590	254	13,284
1994	7,684	6,078	231	13,992	0	1,321	0	1,321	95	68	3	165	7,778	7,467	233	15,478
1995	5,893	3,546	161	9,599	0	1,021	0	1,021	88	64	2	154	5,980	4,631	163	10,774
1996	7,112	5,837	157	13,106	0	1,268	0	1,268	163	10	4	177	7,275	7,116	161	14,552
1997	8,018	6,212	184	14,414	0	1,699	0	1,699	156	107	4	266	8,174	8,019	188	16,380
1998	5,337	3,329	102	8,768	0	1,903	0	1,903	128	197	2	328	5,465	5,430	104	11,000
1999	7,734	6,807	135	14,677	0	2,020	0	2,020	189	174	3	366	7,923	9,001	139	17,063
2000	7,096	5,471	151	12,719	0	1,832	0	1,832	271	139	6	416	7,367	7,442	157	14,967
2001	6,683	3,998	127	10,808	0	1,686	0	1,686	455	115	9	579	7,138	5,799	135	13,073
2002	8,353	7,914	163	16,429	0	1,758	0	1,758	512	130	10	652	8,865	9,801	173	18,839
2003	6,084	6,088	139	12,311	0	2,166	0	2,166	396	82	9	487	6,480	8,336	148	14,963
2004	7,133	7,017	182	14,332	0	1,948	0	1,948	163	52	4	220	7,296	9,018	186	16,499
2005	4,541	3,086	115	7,743	0	2,209	0	2,209	174	41	4	220	4,715	5,337	120	10,172
2006	4,119	3,017	80	7,216	0	1,932	0	1,932	213	0	4	218	4,332	4,949	84	9,365
2007	5,983	6,003	116	12,102	0	1,535	0	1,535	299	1	6	305	6,281	7,539	122	13,942
2008	5,872	5,602	133	11,607	0	1,523	0	1,523	328	1	7	336	6,200	7,125	140	13,465
2009	5,248	5,112	128	10,489	0	1,727	0	1,727	327	1	8	335	5,575	6,839	136	12,551
2010	4,488	3,987	110	8,584	0	1,894	0	1,894	566	0	14	580	5,054	5,881	124	11,059
2011	3,912	3,616	100	7,627	0	1,908	0	1,908	215	1	5	221	4,127	5,525	105	9,757
2012	5,286	5,767	122	11,176	0	1,732	0	1,732	302	1	7	309	5,588	7,500	129	13,217
2013	7,810	8,712	195	16,717	0	1,373	0	1,373	362	1	9	371	8,172	10,086	204	18,462
2014	9,309	8,639	285	18,233	0	1,332	0	1,332	120	0	4	124	9,429	9,971	288	19,689
2015	8,089	7,905	289	16,284	0	1,357	0	1,357	201	1	7	209	8,290	9,263	297	17,849
Maximum	**13,471**	**9,546**	**454**	**23,054**	**0**	**2,382**	**0**	**2,382**	**566**	**428**	**14**	**652**	**13,580**	**12,194**	**457**	**24,989**

Table 2-10
Groundwater Extraction

Calendar Year	Agricultural Pumpage (AF)				M&I Pumpage (AF)				Domestic Pumpage (AF)				Totals (AF)			
	Pumping UAS	*Pumping LAS*	*Pumping Semi-Perched*	*Total Agricultural Pumping*	*Pumping UAS*	*Pumping LAS*	*Pumping Semi-Perched*	*Total M&I Pumping*	*Pumping UAS*	*Pumping LAS*	*Pumping Semi-Perched*	*Total Domestic Pumping*	*Total Pumping UAS*	*Total Pumping LAS*	*Total Pumping Semi-Perched*	*Total Pumping*
Minimum	3,912	3,017	80	7,216	0	364	0	364	56	0	2	124	4,127	4,631	84	9,365
Average	7,429	6,068	208	13,706	0	1,632	0	1,632	216	112	5	333	7,645	7,813	214	15,671

Notes: AF = acre-feet; LAS = Lower Aquifer System; M&I = municipal and industrial; UAS = Upper Aquifer System.
Pumping amounts are from the UWCD model and usage type is from the FCGMA well database.

Table 2-11
UWCD Model Scenario Results (AFY)

Model Scenario	UAS Groundwater Extractions	LAS Groundwater Extractions	Total Groundwater Extractions	Project Water	Total Scenario
Future Baseline	6,000	9,000	14,000	0	14,000
Future Baseline With Projects	4,000	8,000	12,000	2,000	14,000
Reduction With Projects	3,000	7,000	10,000	2,000	12,000
Reduction Without Projects Scenario 1	3,000	5,000	8,000	0	8,000
Reduction Without Projects Scenario 2	3,000	7,000	10,000	0	10,000
Reduction Without Projects Scenario 3	5,000	9,000	14,000	0	14,000

Notes: AFY = acre-feet per year; LAS = Lower Aquifer System; UAS = Upper Aquifer System; UWCD = United Water Conservation District.

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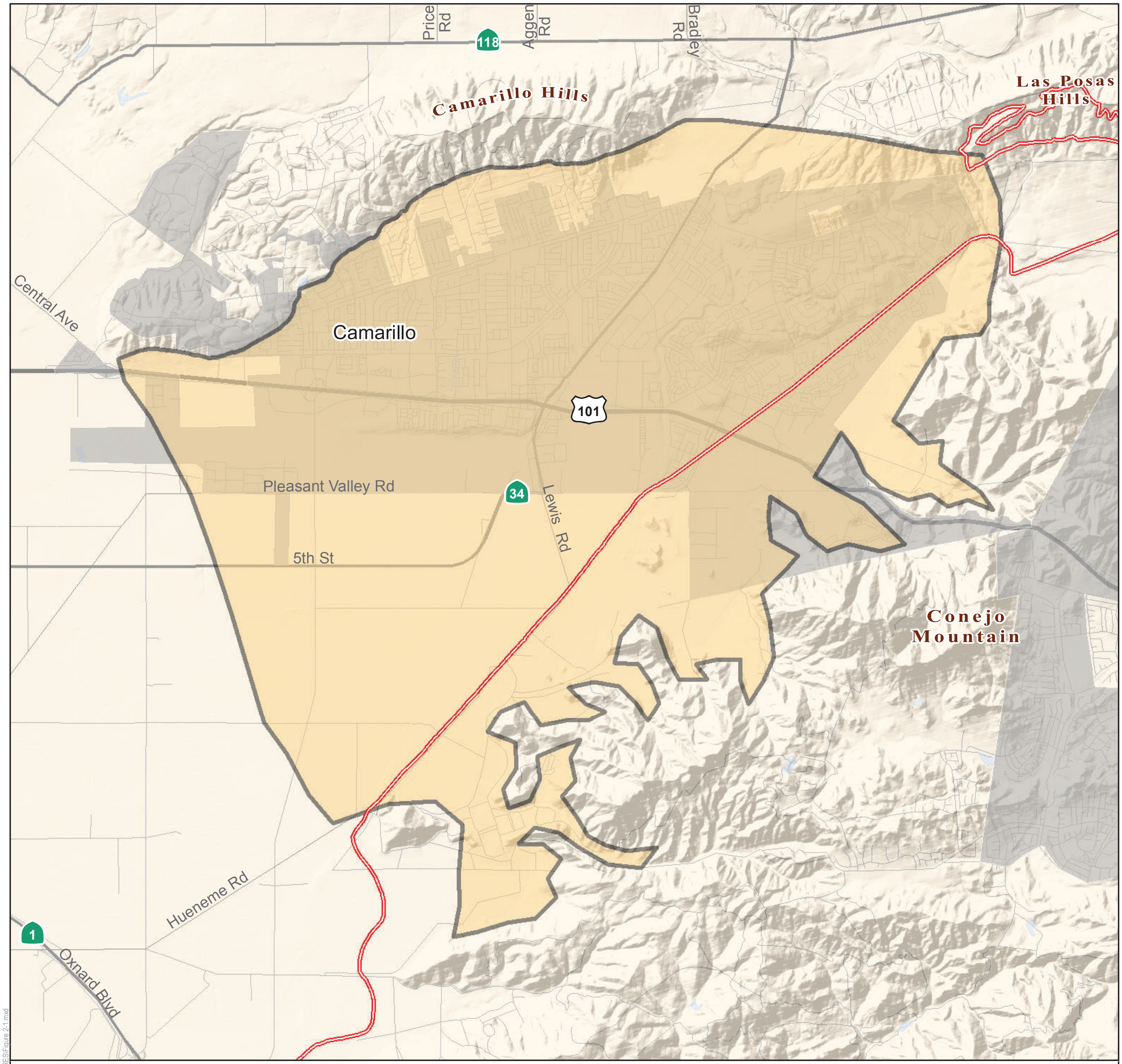
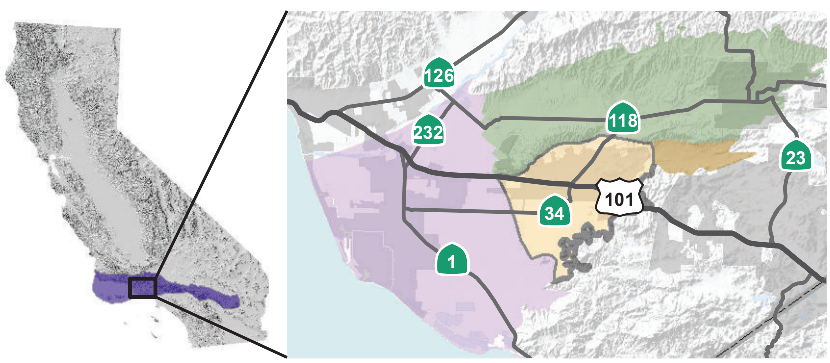


Legend

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Arroyo Santa Rosa Valley (4-007)
- Las Posas Valley (4-008)
- Pleasant Valley (4-006)
- Oxnard (4-004.02)
- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Transverse Ranges Geomorphic Province

0 1 2 3 Miles



DUDEK

SOURCE: CGS 2002; DWR 2016; Cal-Atlas 2016; FCGMA 2016

FIGURE 2-1

Pleasant Valley Basin Vicinity Map

Groundwater Sustainability Plan for the Pleasant Valley Basin

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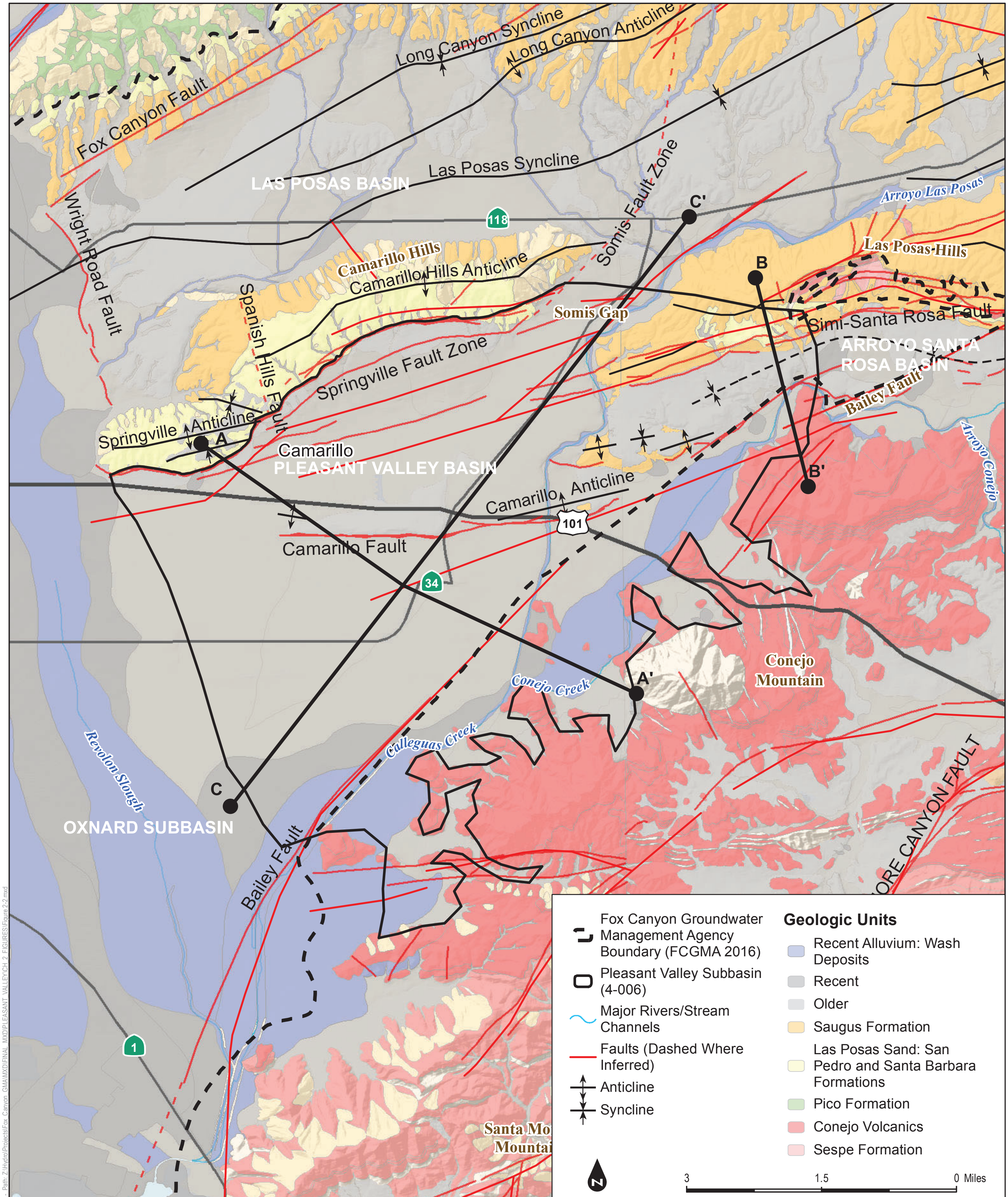

SOURCE: DWR; FCGMA; surficial geology after California Geological Survey; folds after Dibblee 1992a and 1992b, DeVecchio 2012a, Turner 1975; faults after DeVecchio et al. 2012a

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FIGURE 2-2

Geology of the Pleasant Valley Basin

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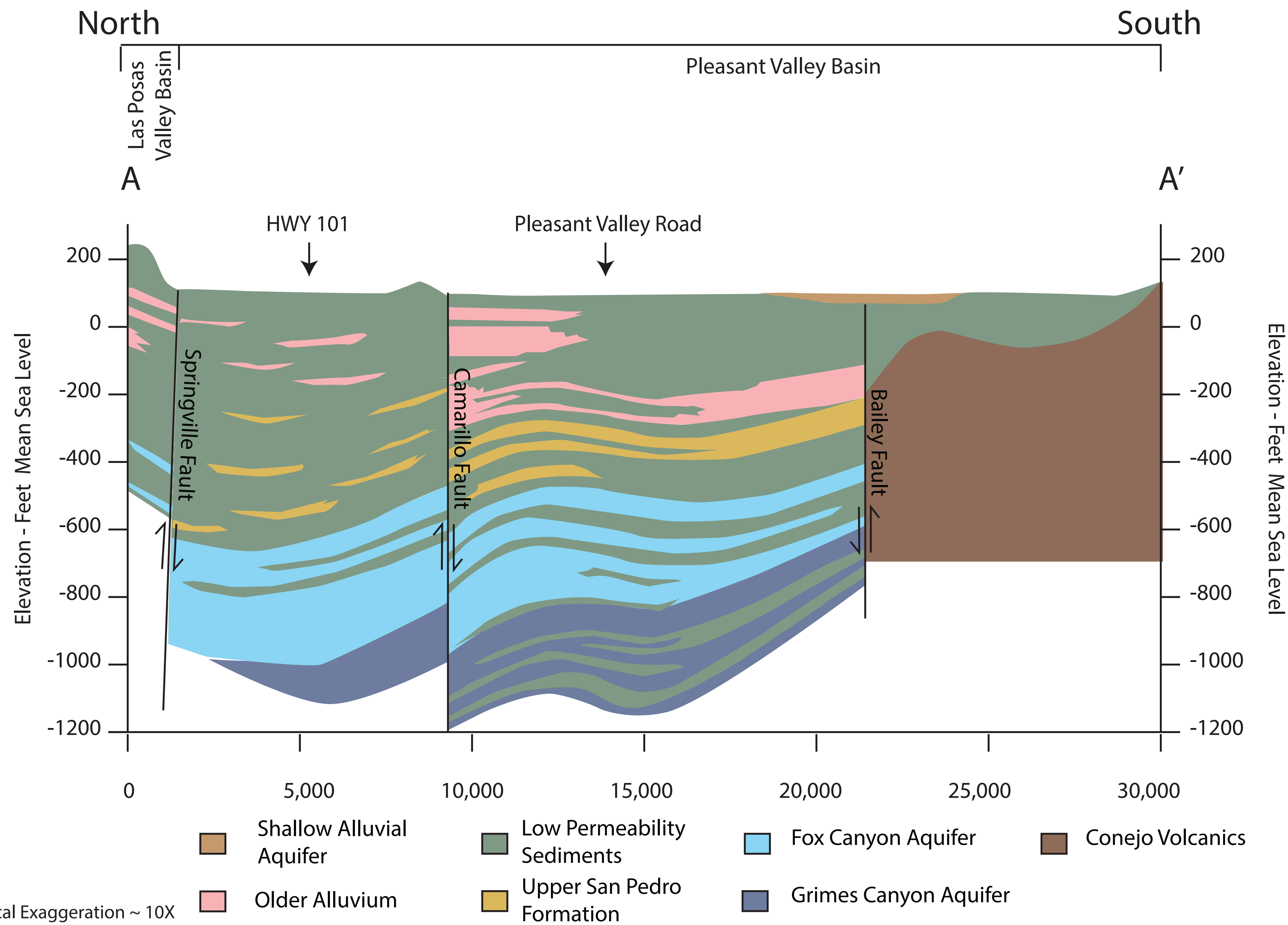

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SOURCE: Turner 1975; Southern Section of Cross section B-B'.

FIGURE 2-3

Cross Section A-A'

Z:\Projects\

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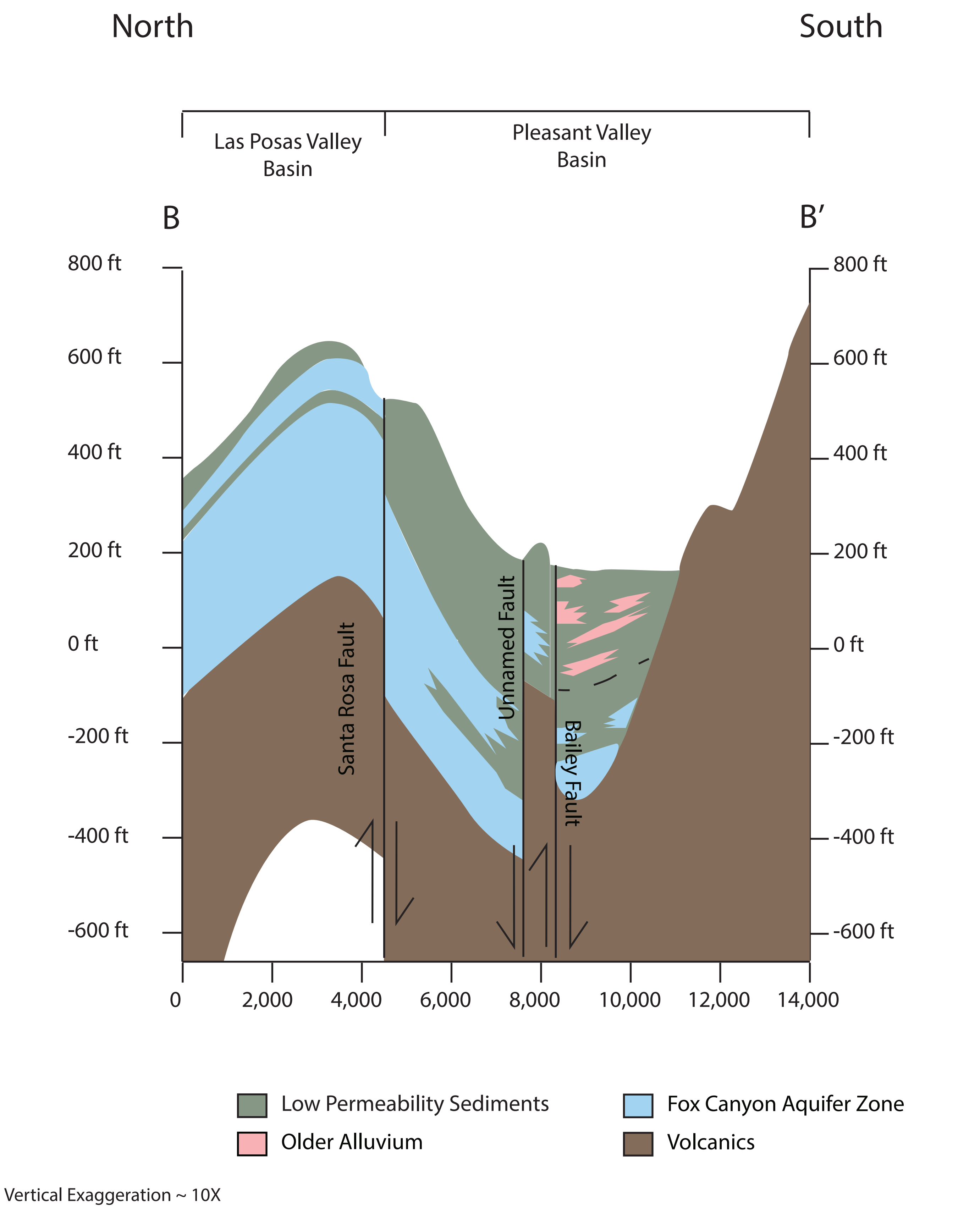

SOURCE: Turner 1975; Southern Section of Cross section D-D'

DUDEK

FIGURE 2-4
Cross Section B-B'

Groundwater Sustainability Plan for the Pleasant Valley Basin

Z:\Projects\

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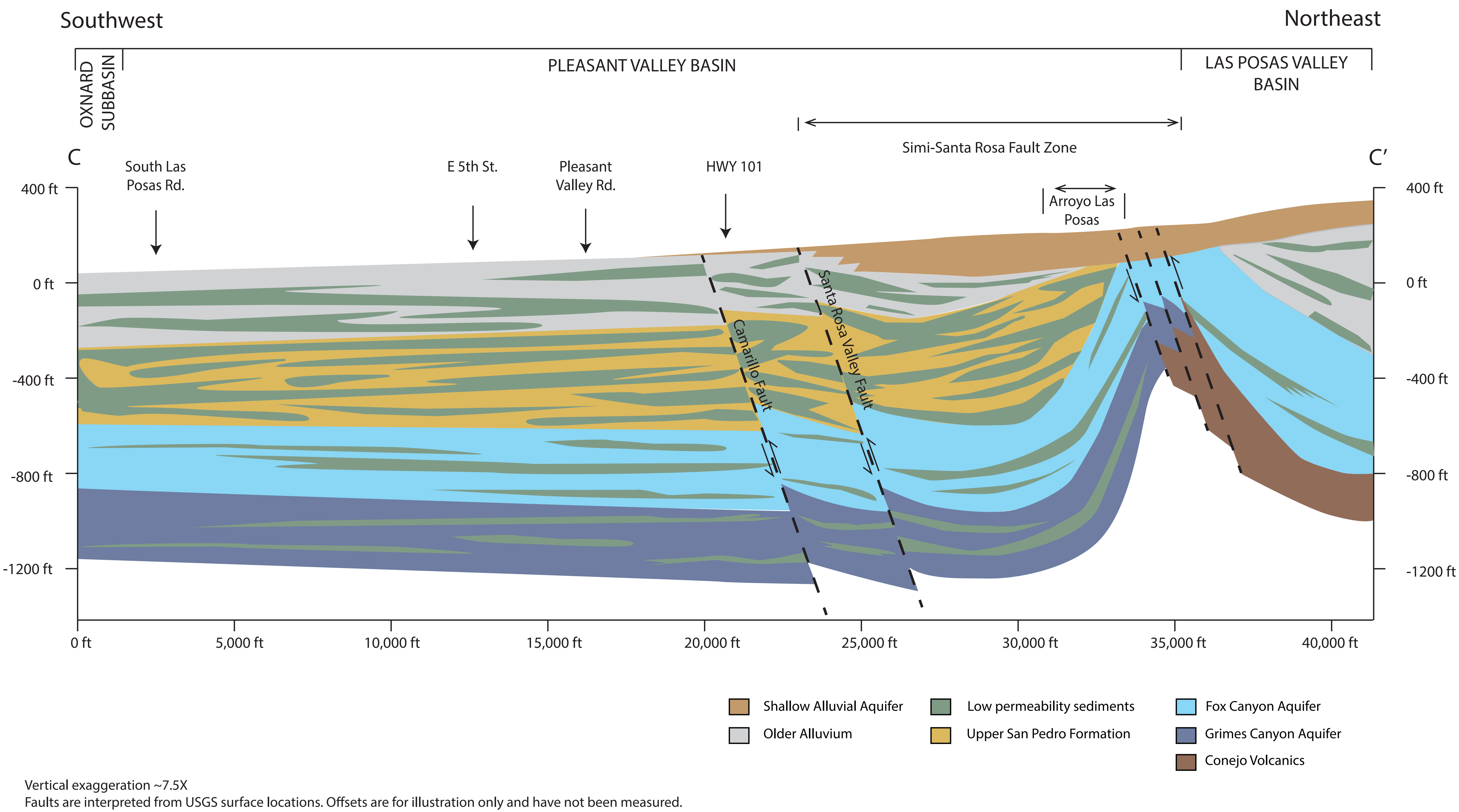

SOURCE: Calleguas 2012; Calleguas 2016a

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FIGURE 2-5
Cross Section C-C’

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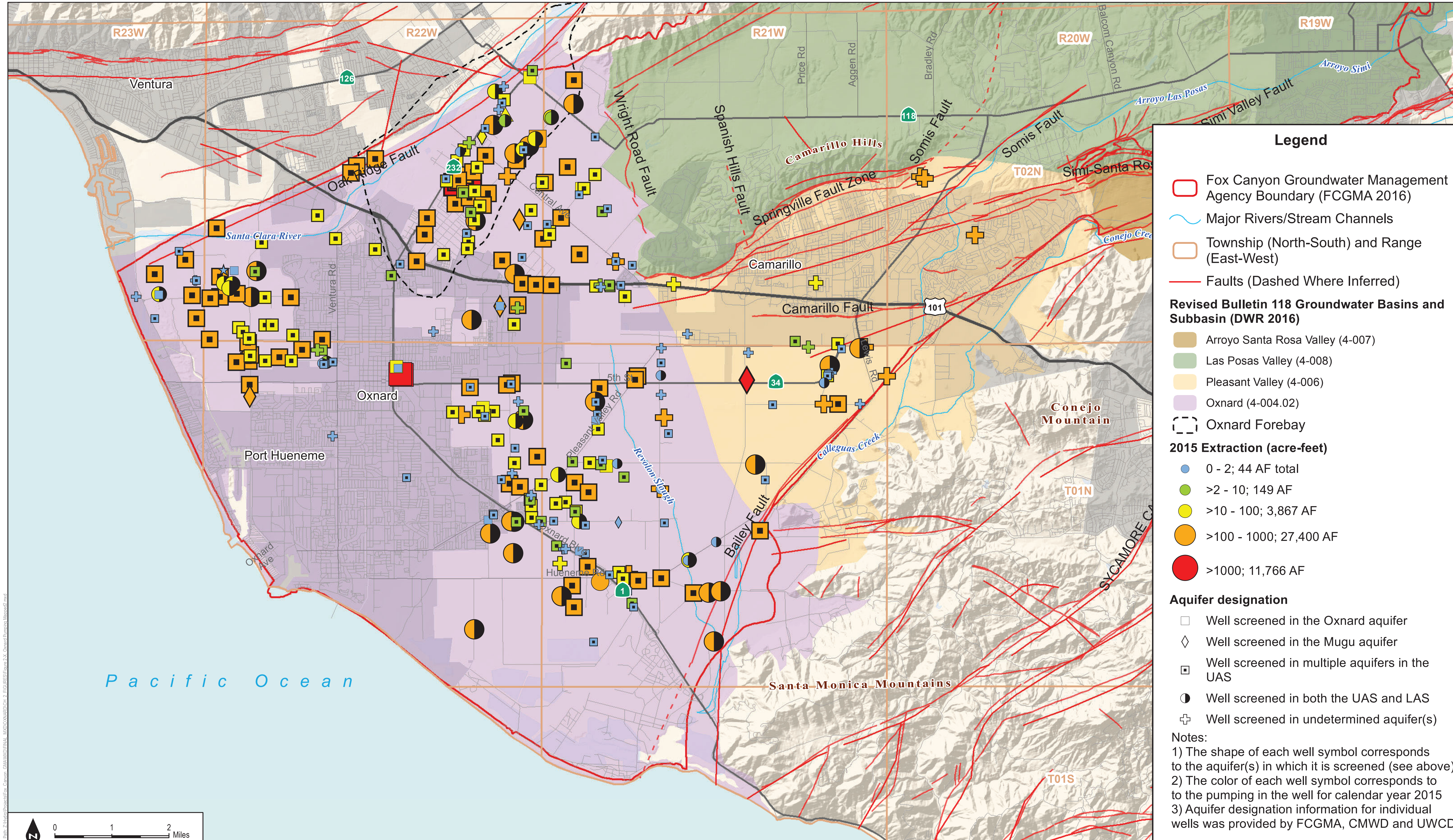

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-6

Upper Aquifer System 2015 Extraction (acre-feet) in Oxnard and Pleasant Valley

DUDEK

Groundwater Sustainability Plan for the Pleasant Valley Basin

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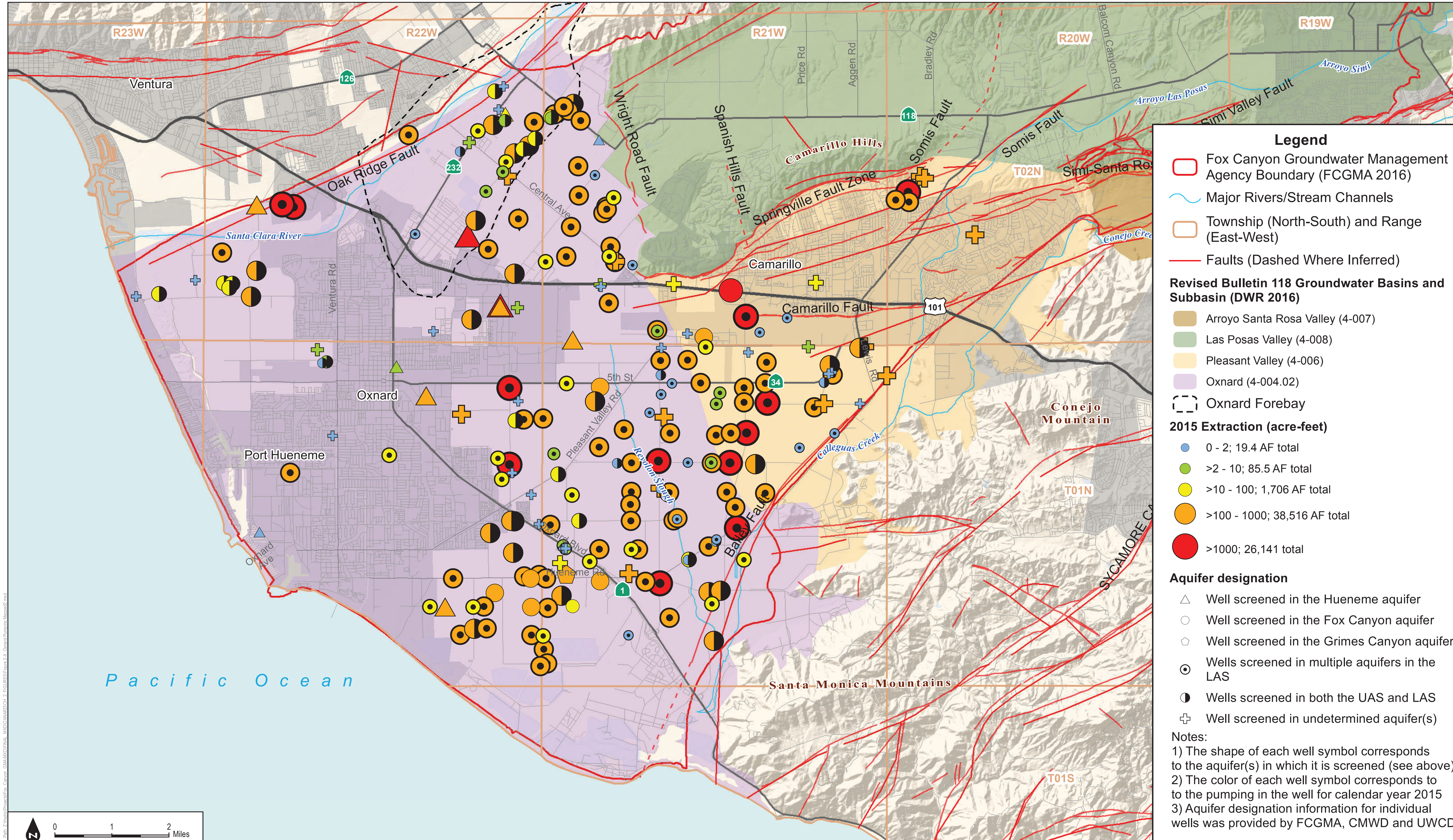

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-7

Lower Aquifer System 2015 Extraction (acre-feet) in Oxnard and Pleasant Valley

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Groundwater Sustainability Plan for the Pleasant Valley Basin

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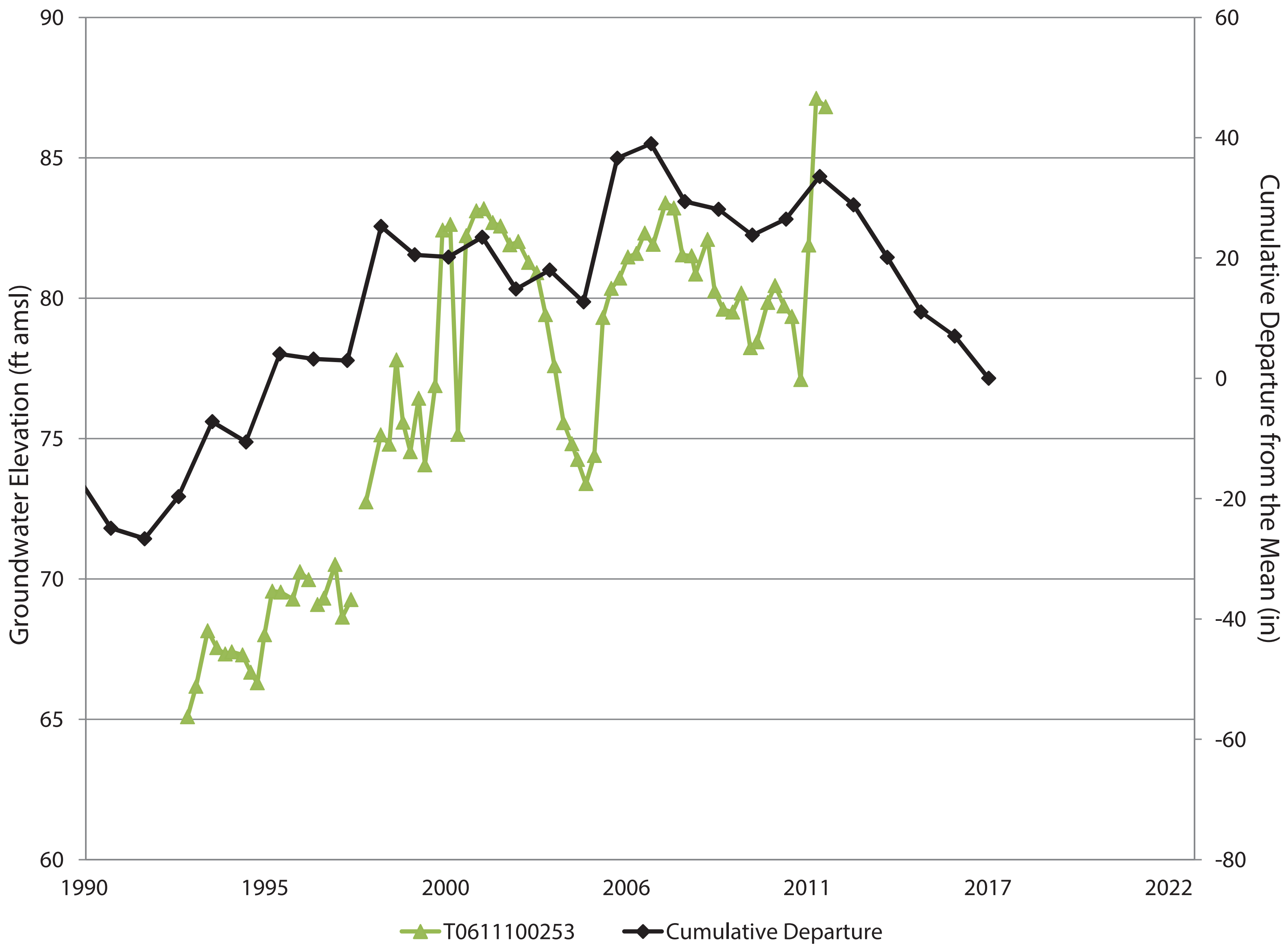

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FIGURE 2-8

Groundwater Elevation Hydrographs in the Shallow Aquifer

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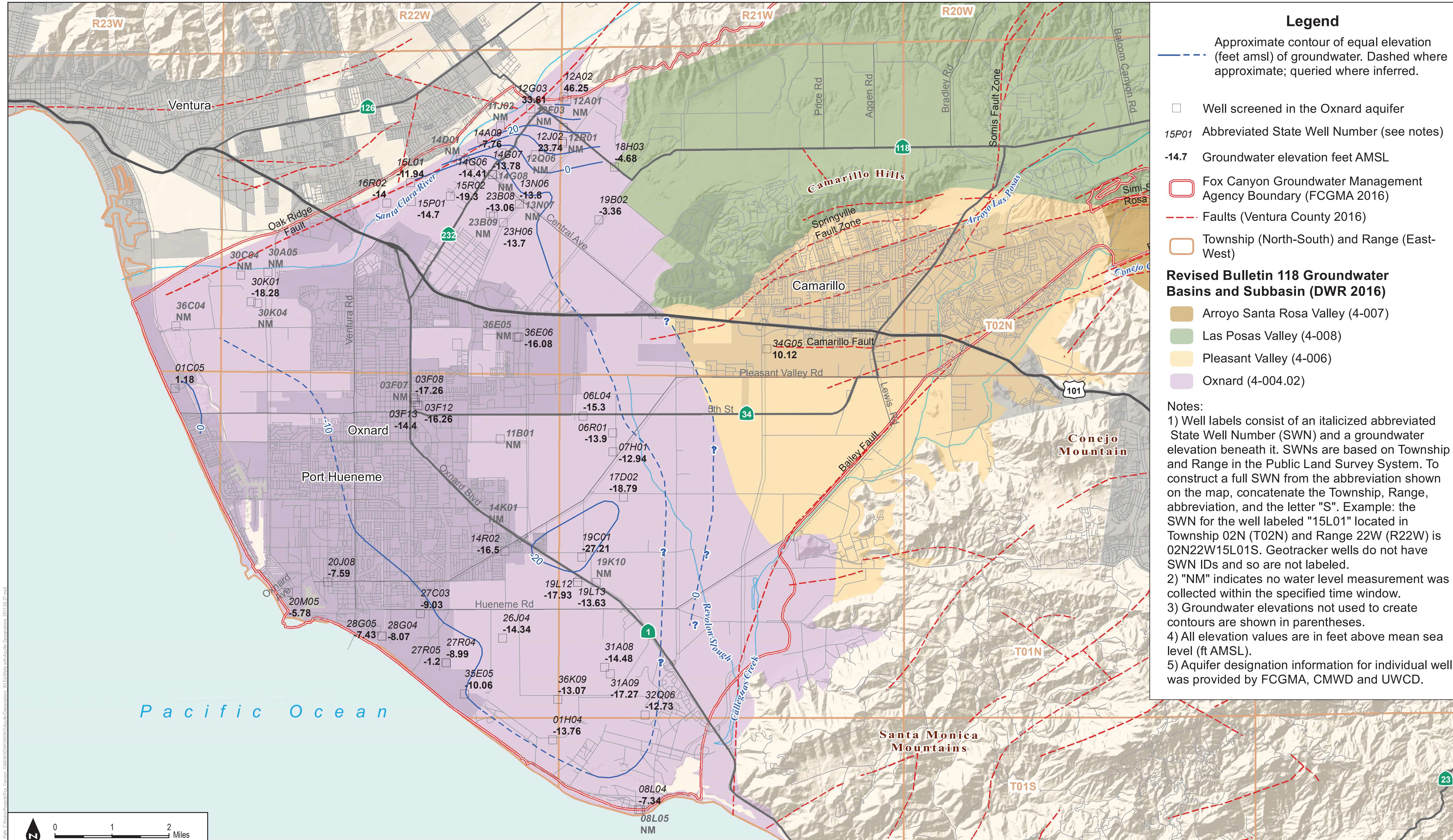

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-9

Groundwater Elevation Contours in the Oxnard Aquifer (Older Alluvium), March 2-29, 2015

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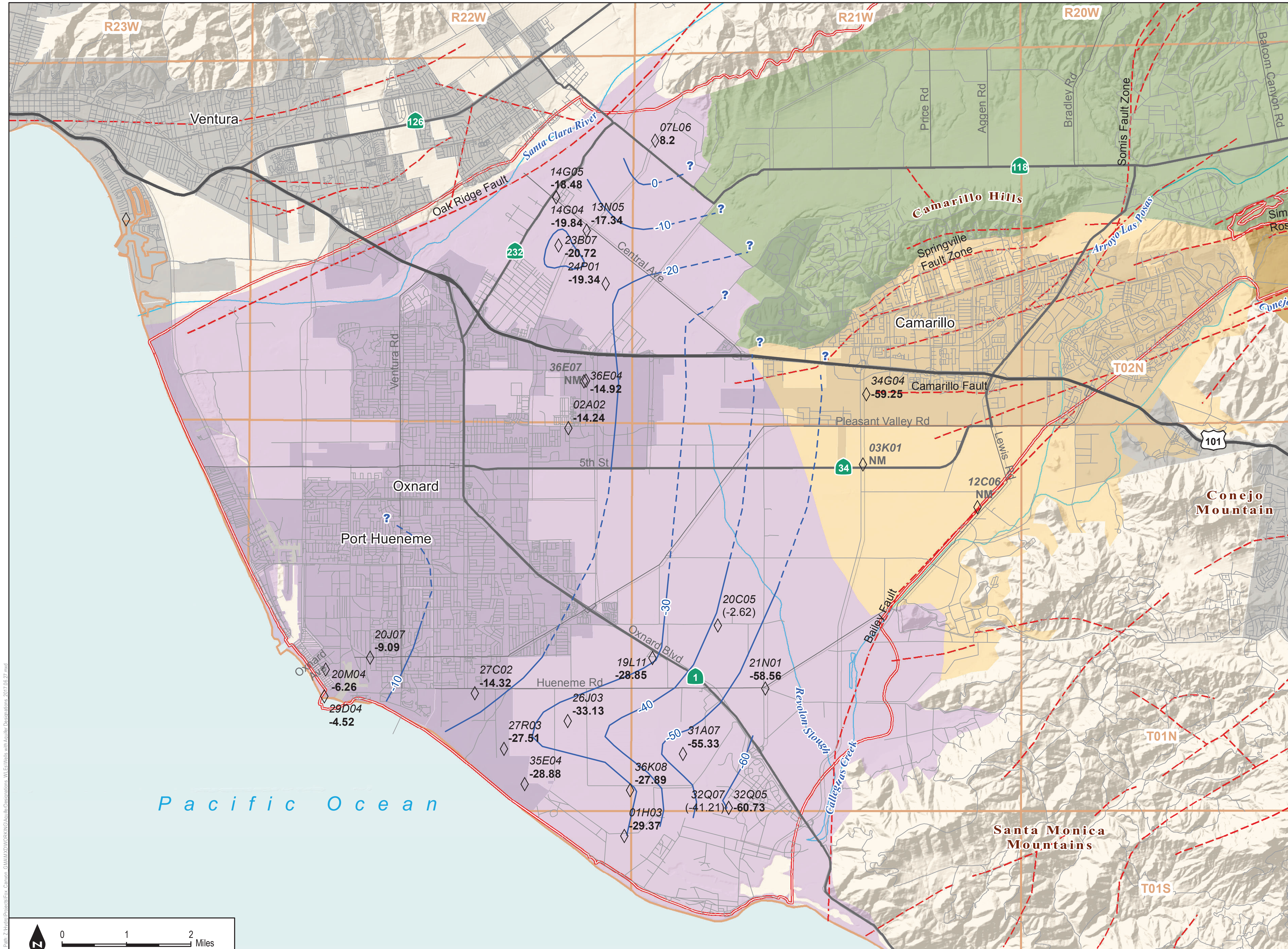

Legend

Approximate contour of equal elevation (feet amsl) of groundwater. Dashed where approximate; queried where inferred.

◊ Well screened in the Mugu aquifer

15P01 Abbreviated State Well Number (see notes)

-14.7 Groundwater elevation feet AMSL

Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)

Faults (Ventura County 2016)

Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Arroyo Santa Rosa Valley (4-007)
- Las Posas Valley (4-008)
- Pleasant Valley (4-006)
- Oxnard (4-004.02)

Notes:

1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a groundwater elevation beneath it. SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map, concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S. Geotracker wells do not have SWN IDs and so are not labeled.
2) "NM" indicates no water level measurement was collected within the specified time window.
3) Groundwater elevations not used to create contours are shown in parentheses.
4) All elevation values are in feet above mean sea level (ft AMSL).
5) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-10

Groundwater Elevation Contours in the Mugu Aquifer (Older Alluvium), March 2-29, 2015

Groundwater Sustainability Plan for the Pleasant Valley Basin

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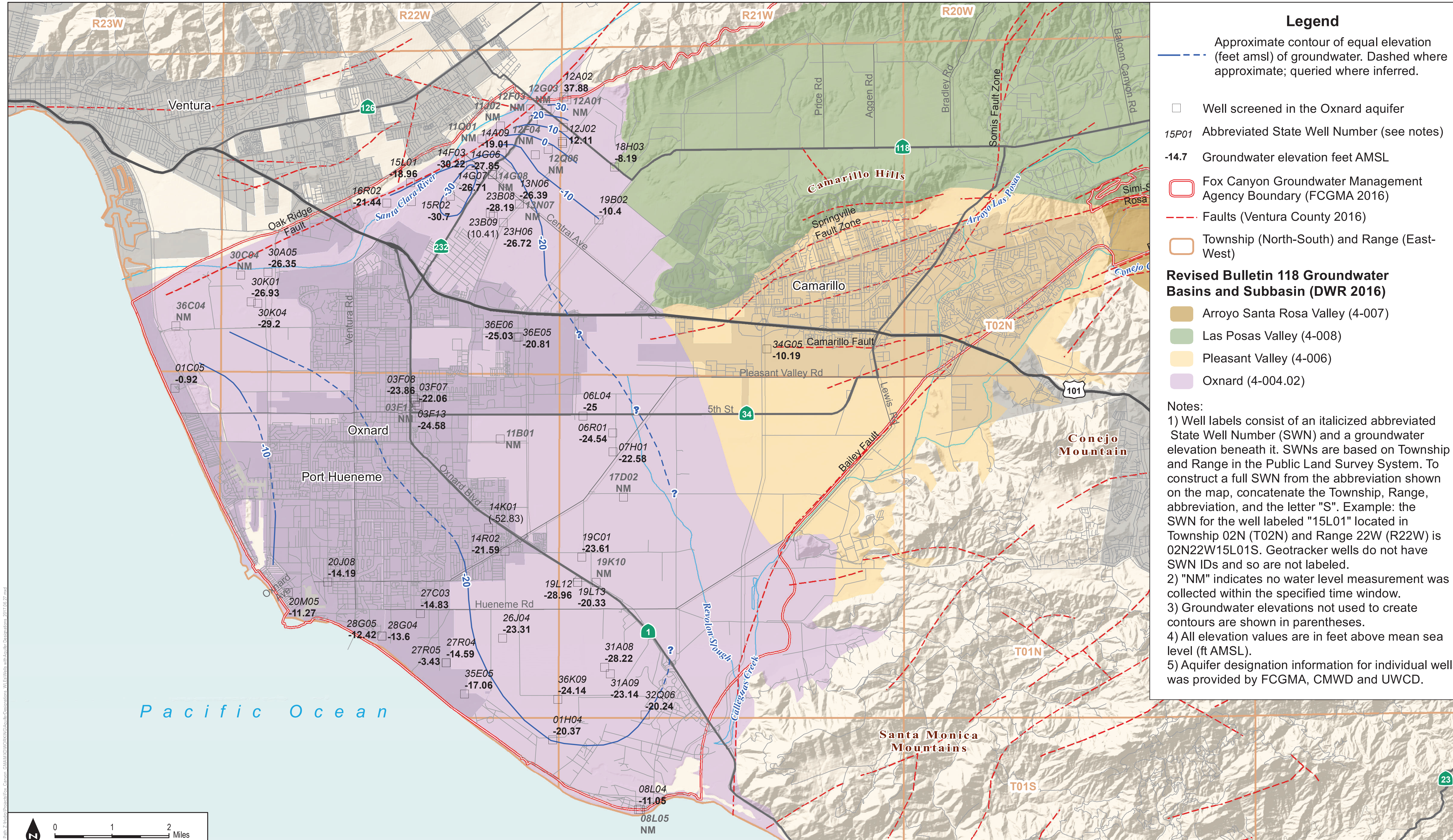

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-11

Groundwater Elevation Contours in the Oxnard Aquifer (Older Alluvium), October 2-29, 2015

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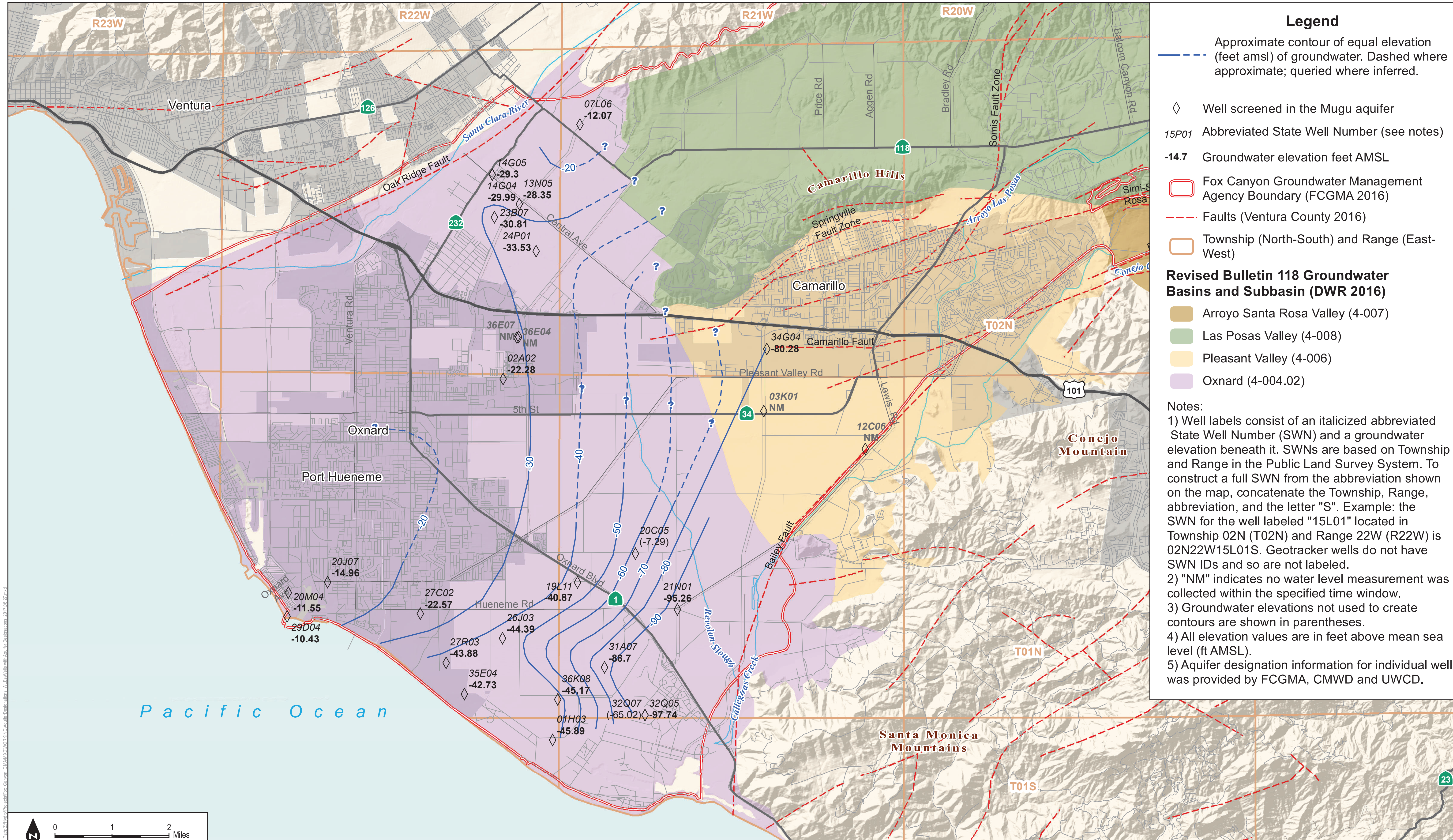

Legend

Approximate contour of equal elevation (feet amsl) of groundwater. Dashed where approximate; queried where inferred.

◊ Well screened in the Mugu aquifer

15P01 Abbreviated State Well Number (see notes)

-14.7 Groundwater elevation feet AMSL

Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)

Faults (Ventura County 2016)

Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

Arroyo Santa Rosa Valley (4-007)

Las Posas Valley (4-008)

Pleasant Valley (4-006)

Oxnard (4-004.02)

Notes:

1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a groundwater elevation beneath it. SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map, concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S. Geotracker wells do not have SWN IDs and so are not labeled.

2) "NM" indicates no water level measurement was collected within the specified time window.

3) Groundwater elevations not used to create contours are shown in parentheses.

4) All elevation values are in feet above mean sea level (ft AMSL).

5) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-12

Groundwater Elevation Contours in the Mugu Aquifer (Older Alluvium), October 2-29, 2015

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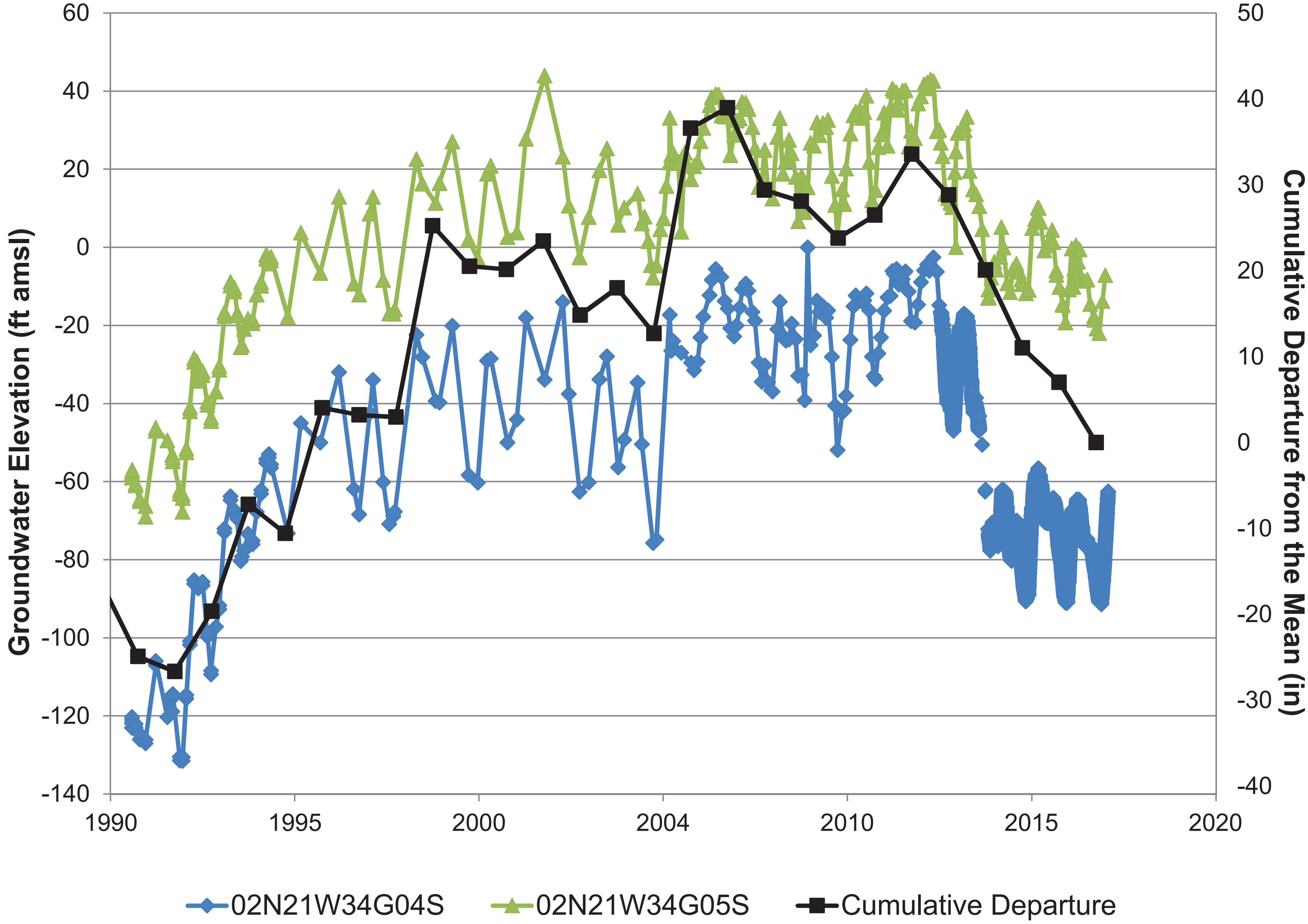

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FIGURE 2-13

Groundwater Elevation Hydrographs in the Older Alluvium

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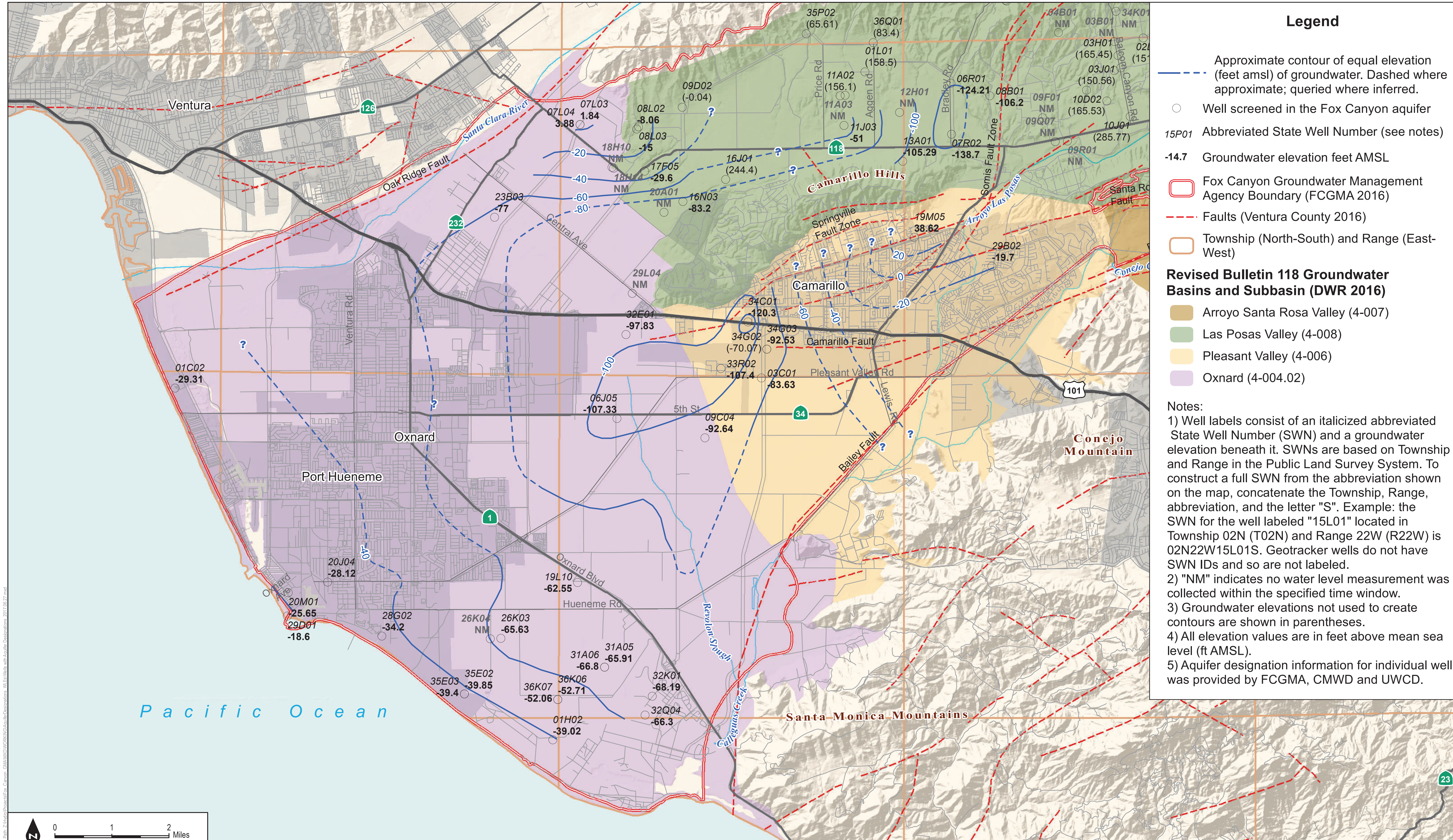

Notes:

1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a groundwater elevation beneath it. SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map, concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S. Geotracker wells do not have SWN IDs and so are not labeled.

2) "NM" indicates no water level measurement was collected within the specified time window.

3) Groundwater elevations not used to create contours are shown in parentheses.

4) All elevation values are in feet above mean sea level (ft AMSL).

5) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

SOURCE: DWR; Ventura County; UWCD; CMWD

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FIGURE 2-14

Groundwater Elevation Contours in the Fox Canyon Aquifer, March 2-29, 2015

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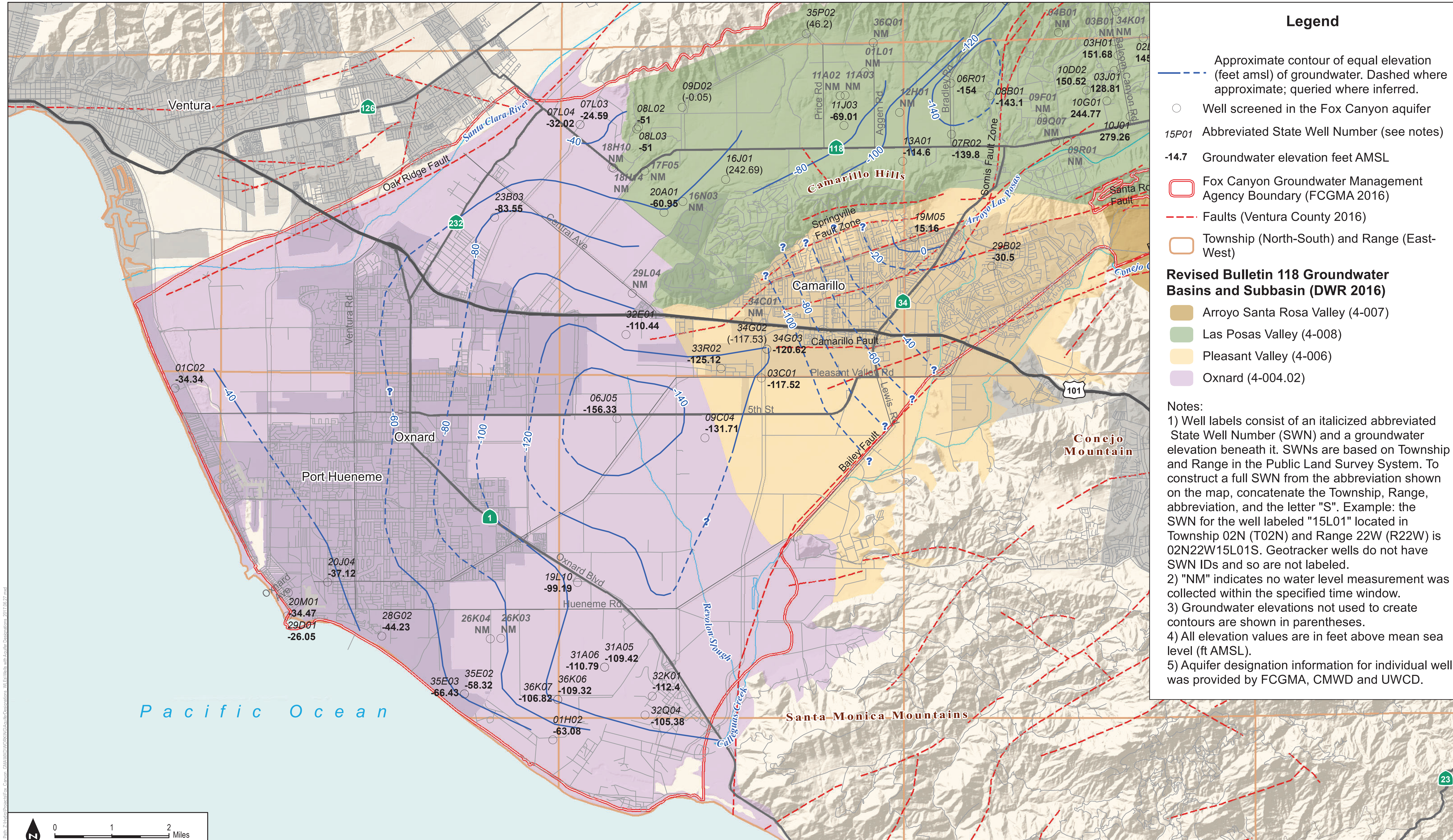

DUDEK

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 2-15

Groundwater Elevation Contours in the Fox Canyon Aquifer, October 2-29, 2015

Groundwater Sustainability Plan for the Pleasant Valley Basin

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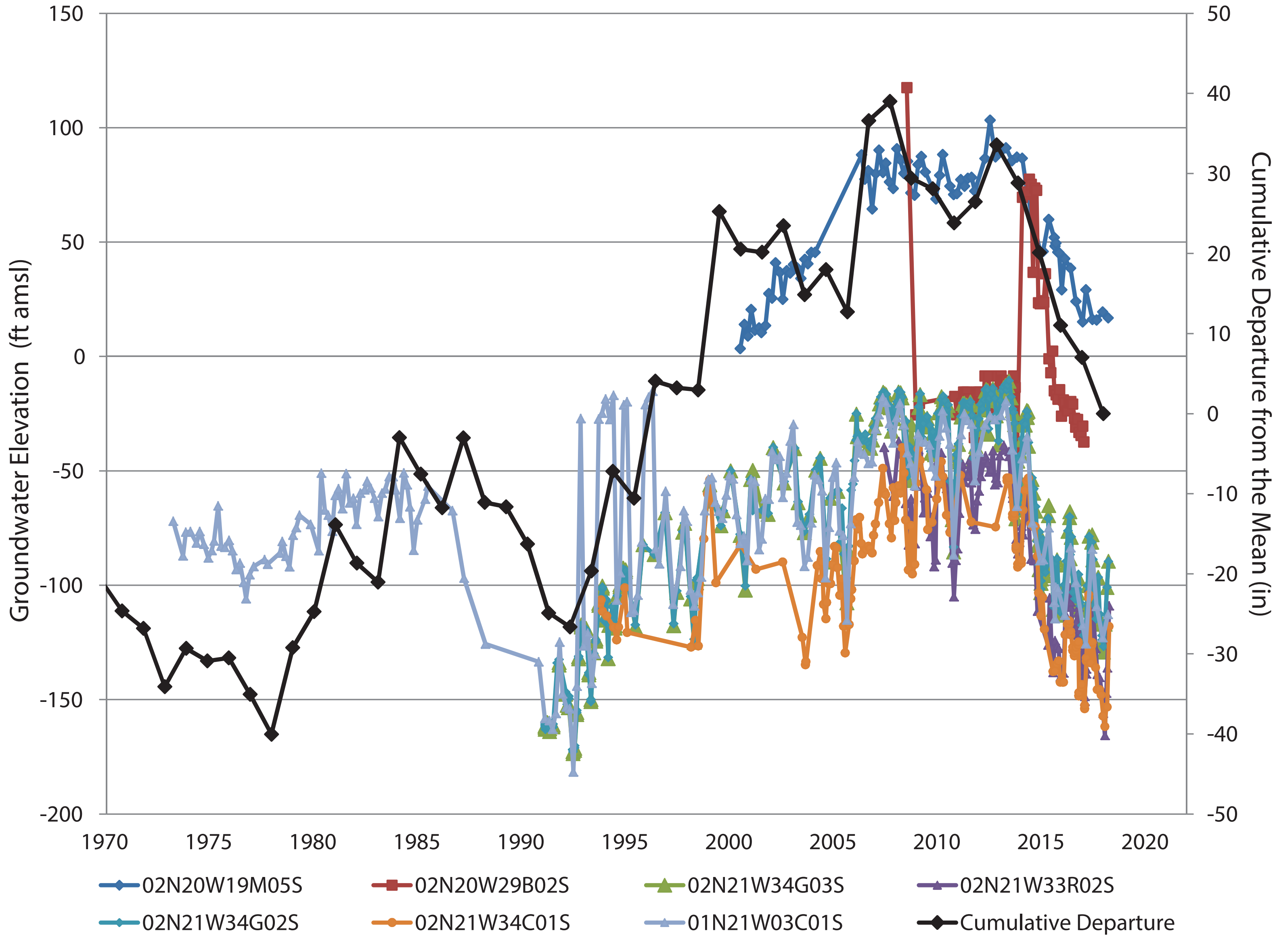

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FIGURE 2-16

Groundwater Elevation Hydrographs in the Fox Canyon Aquifer

Groundwater Sustainability Plan for the Pleasant Valley Basin

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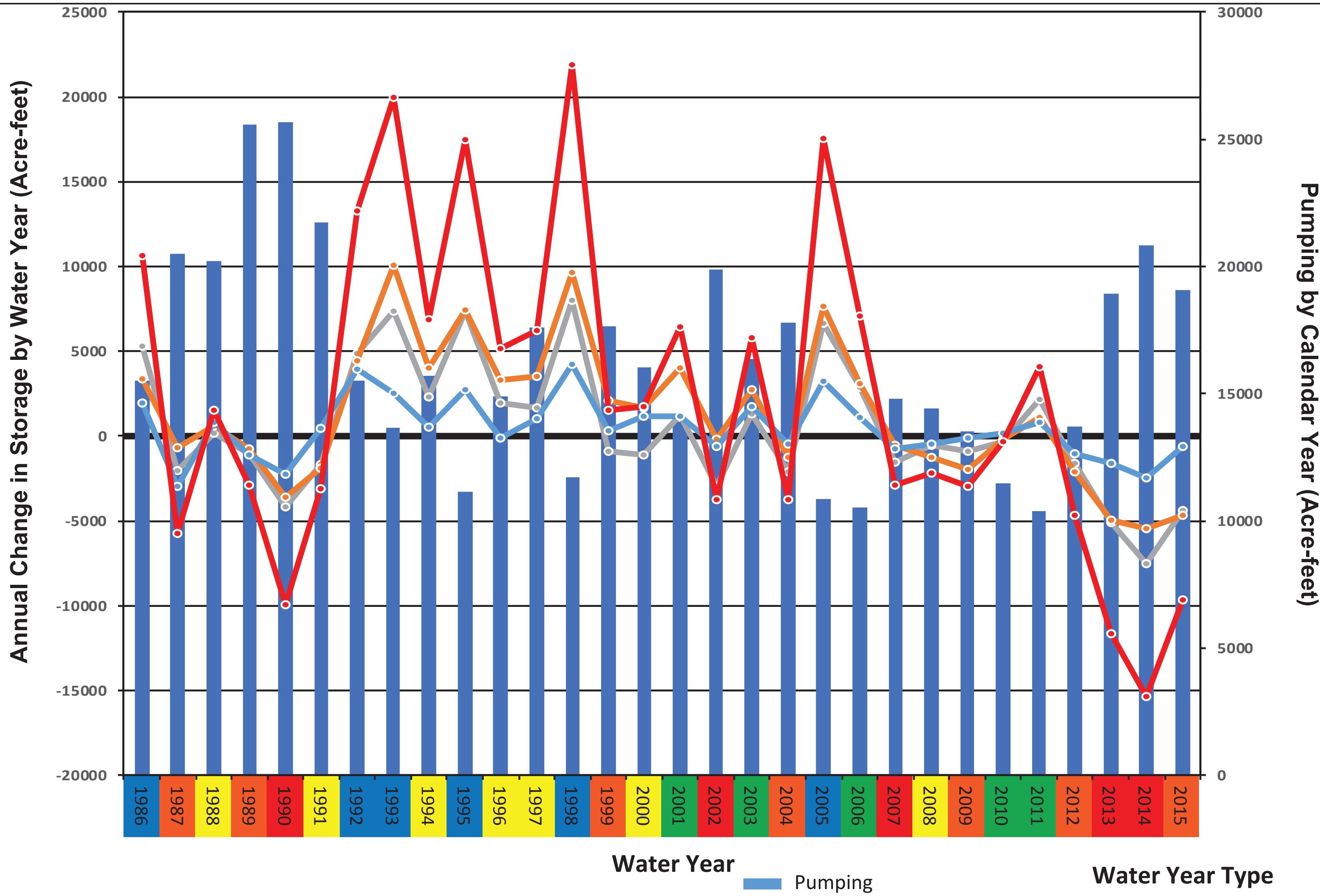

Notes:

1) Estimated Annual Change in Storage is from the United Water Conservation District (UWCD) numerical groundwater model report from July 2018. Total Change in Storage is the sum of the Change in Storage from all aquifers in the basin included in the UWCD numerical groundwater model.

2) Water year is October 1 to September 30 (e.g., water year 2012 is from October 1, 2011, to September 30, 2012)

3) Water year type is based on the percentage of the water year precipitation compared to the 30-year precipitation average. Types are defined as Wet (≥150% of average), Above Normal (≥100% to <150% of average), Below Normal (≥75% to <100% of average), Dry (≥50% to <75% of average), and Critical (<50% of average).

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FIGURE 2-17

Annual Change in Storage

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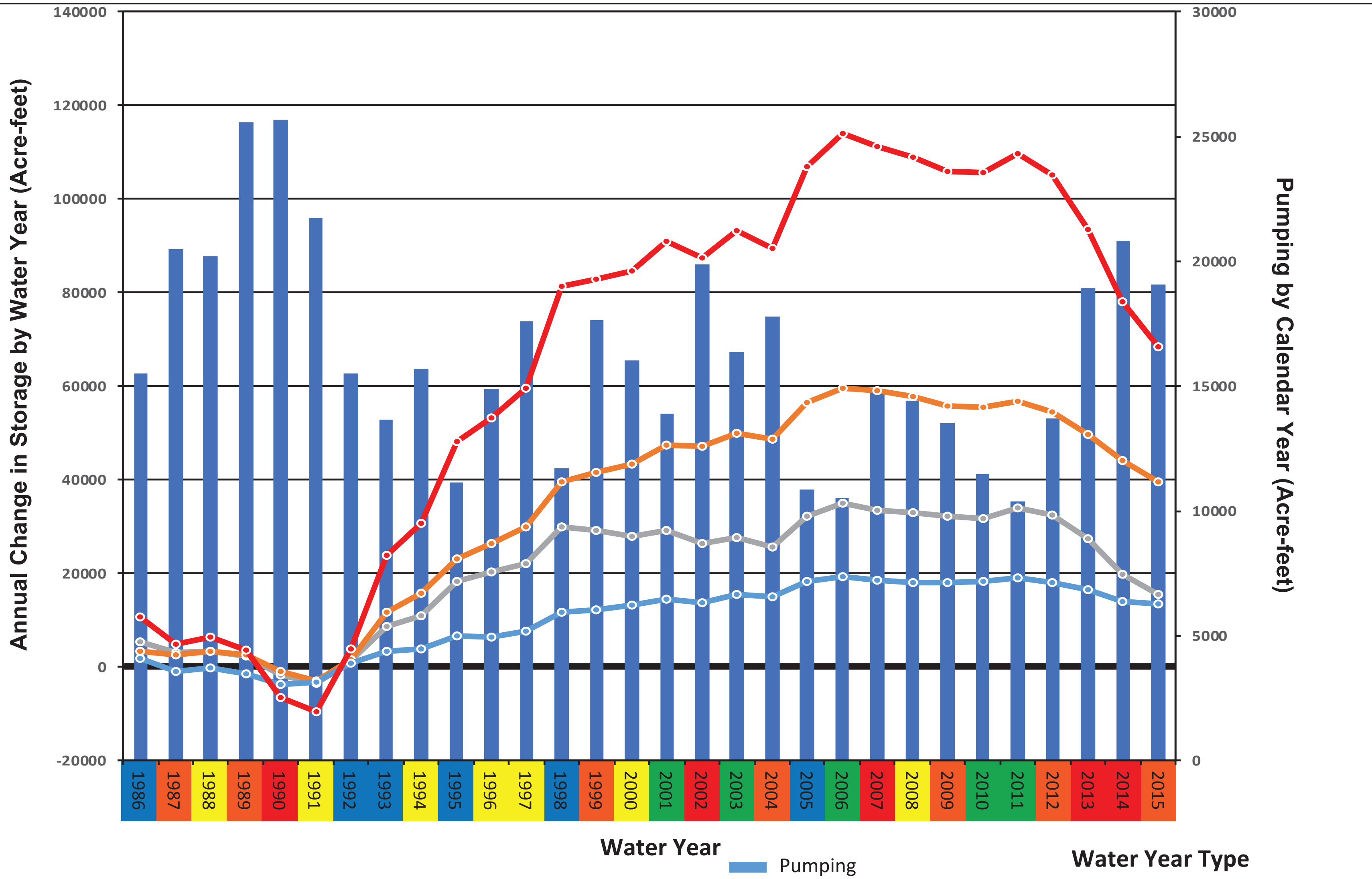

Notes:

1) Estimated Annual Change in Storage is from the United Water Conservation District (UWCD) numerical groundwater model report from July 2018. Total Change in Storage is the sum of the Change in Storage from all aquifers in the basin included in the UWCD numerical groundwater model.

2) Water year is October 1 to September 30 (e.g., water year 2012 is from October 1, 2011, to September 30, 2012)

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FIGURE 2-18

Cumulative Change in Storage

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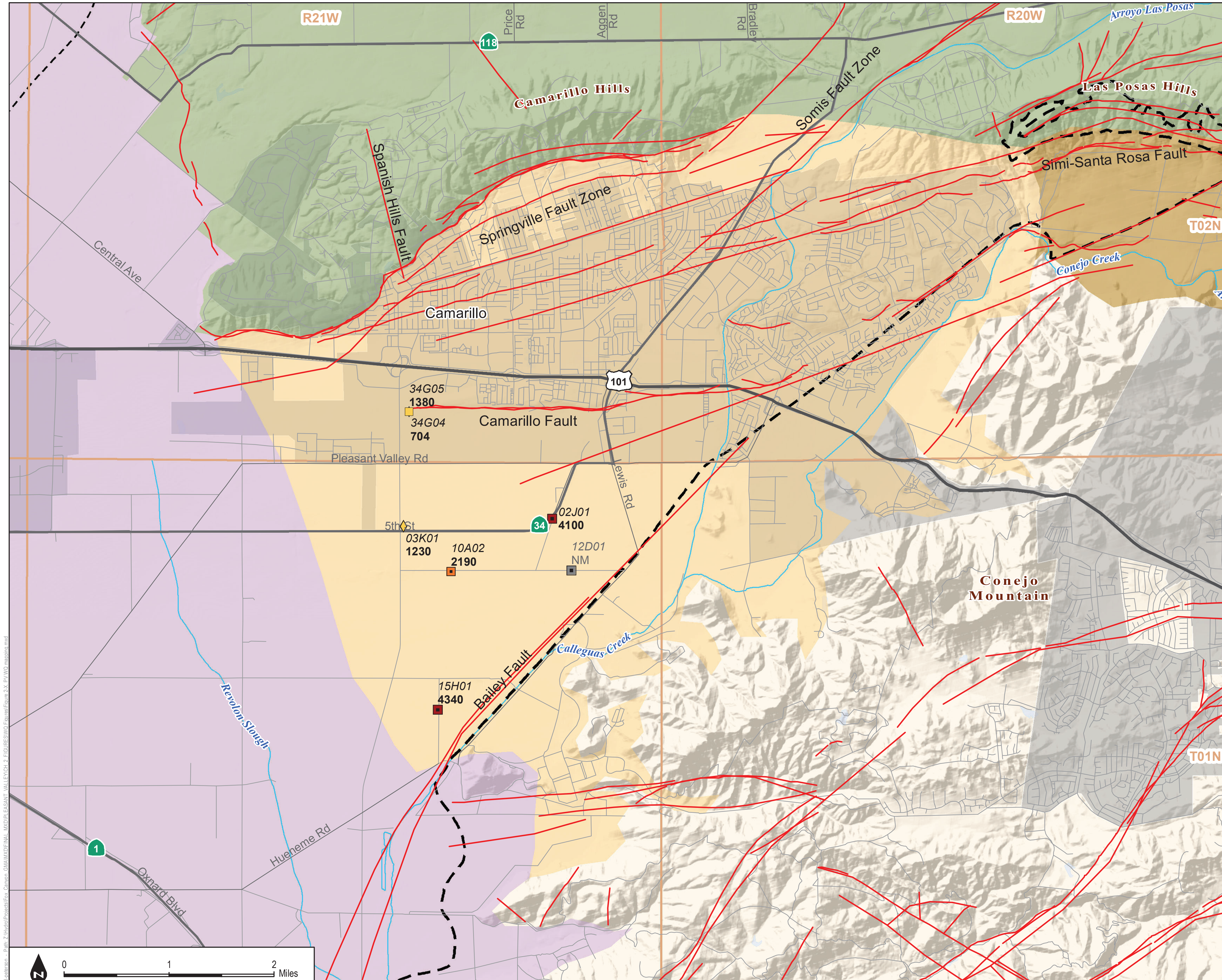

Legend

- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Major Rivers/Stream Channels
- Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Arroyo Santa Rosa Valley (4-007)
- Las Posas Valley (4-008)
- Pleasant Valley (4-006)
- Oxnard (4-004.02)
- Oxnard Forebay

TDS concentration (mg/L), 2011-2015

- 290 - 500
- 500 - 750
- 750 - 1000
- 1000 - 1500
- 1500 - 2500
- 2500 - 49,800
- Not Measured (NM)

Aquifer designation

- Well screened in the Oxnard aquifer
- Well screened in the Mugu aquifer
- Wells screened in multiple aquifers in the UAS

15P01 Abbreviated State Well Number (see notes)
10.5 Concentration (mg/L)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it.The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix F.
2) "ND" signifies non-detect.
3) SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map,concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
4) The shape of each well symbol correspondsto the aquifer(s) in which it is screened (see above).
5) The color of each well symbol corresponds to the most recent concentration measured in a water quality sample from that well.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-19

Upper Aquifer System - Most Recent Total Dissolved Solids (mg/L) Measured 2011-2015

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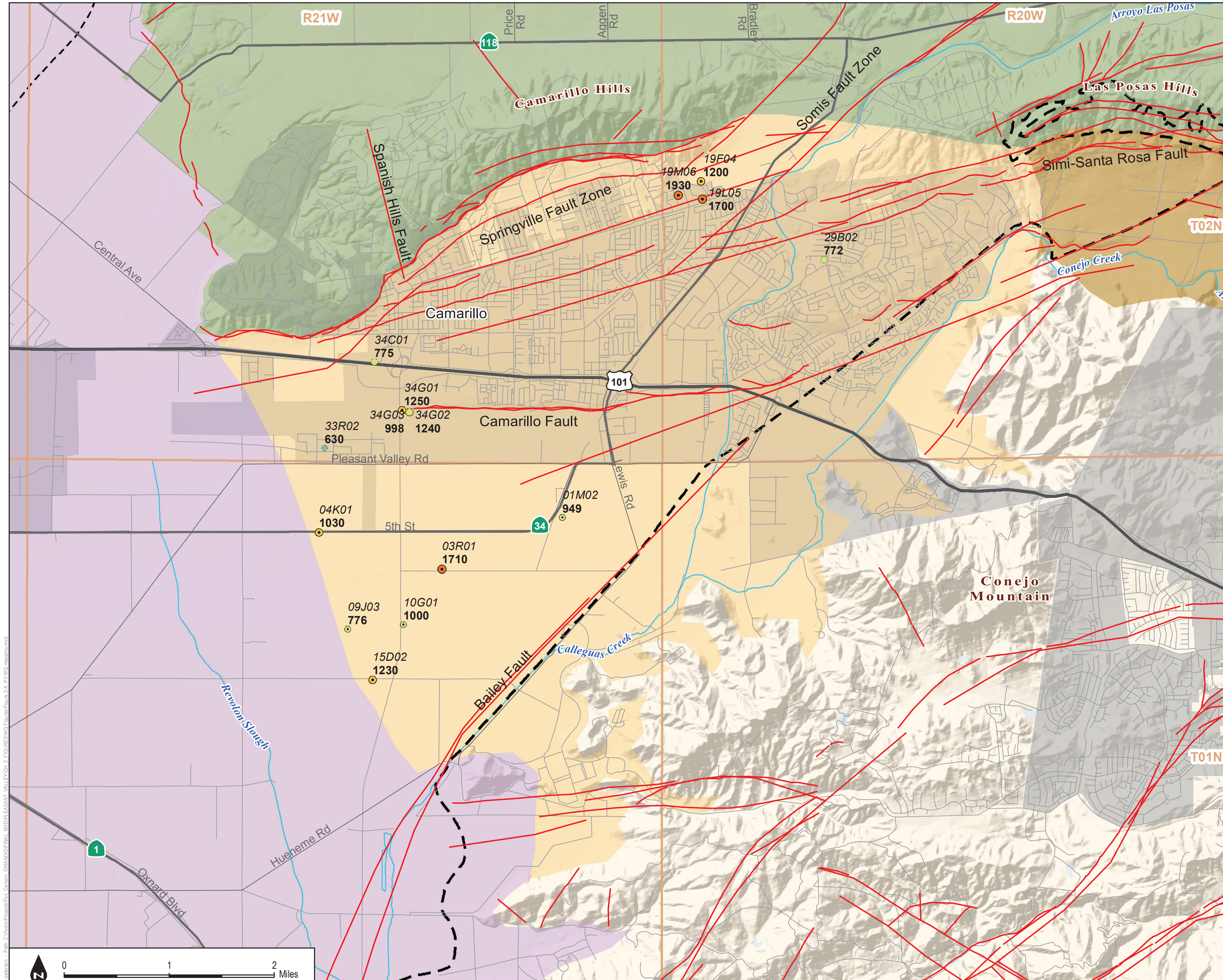

Legend

- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Major Rivers/Stream Channels
- Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Arroyo Santa Rosa Valley (4-007)
- Las Posas Valley (4-008)
- Pleasant Valley (4-006)
- Oxnard (4-004.02)
- Oxnard Forebay

TDS concentration (mg/L), 2011-2015

- 290 - 500
- >500 - 750
- >750 - 1000
- >1000 - 1500
- >1500 - 2500
- >2500 - 49,800

Aquifer designation

- Well screened in the Hueneme aquifer
- Well screened in the Fox Canyon aquifer
- Well screened in the Grimes Canyon aquifer
- Wells screened in multiple aquifers in the LAS

15P01 Abbreviated State Well Number (see notes)
10.5 Concentration (mg/L)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it.The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix F.
2) "ND" signifies non-detect.
3) SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map,concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
4) The shape of each well symbol correspondsto the aquifer(s) in which it is screened (see above).
5) The color of each well symbol corresponds to the most recent concentration measured in a water quality sample from that well.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-20
Lower Aquifer System - Most Recent Total Dissolved Solids (mg/L) Measured 2011-2015

Groundwater Sustainability Plan for the Pleasant Valley Basin

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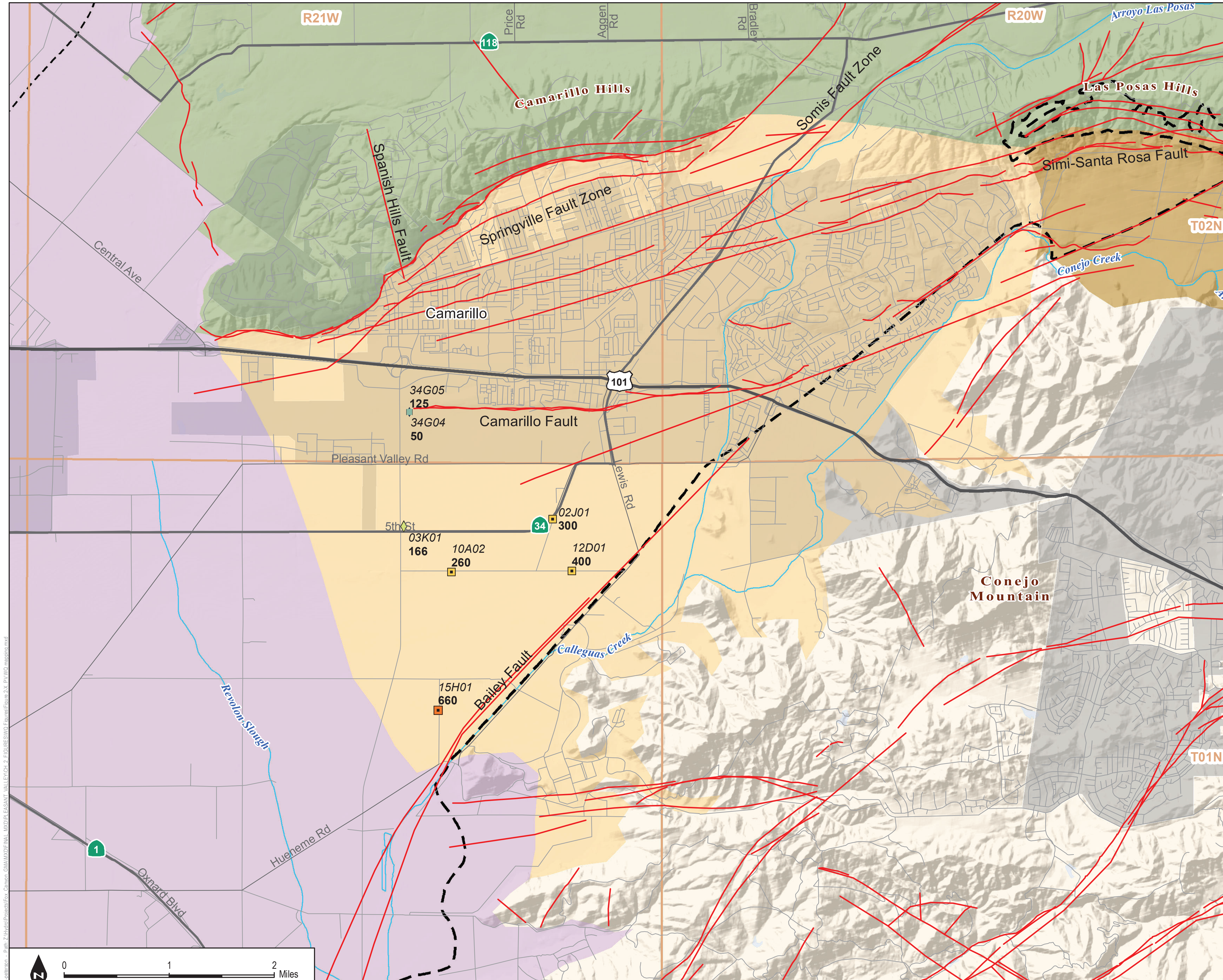

Legend

Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)

Major Rivers/Stream Channels

Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

Arroyo Santa Rosa Valley (4-007)

Las Posas Valley (4-008)

Pleasant Valley (4-006)

Oxnard (4-004.02)

Oxnard Forebay

Chloride concentration (mg/L), 2011-2015

23 - 100

101 - 150

151 - 200

201 - 500

501 - 1000

1001 - 22500

Aquifer designation

Well screened in the Oxnard aquifer

Well screened in the Mugu aquifer

Wells screened in multiple aquifers in the UAS

15P01 Abbreviated State Well Number (see notes)

10.5 Concentration (mg/L)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it.The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix F.
2) "ND" signifies non-detect.
3) SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map,concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
4) The shape of each well symbol correspondsto the aquifer(s) in which it is screened (see above).
5) The color of each well symbol corresponds to the most recent concentration measured in a water quality sample from that well.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-21

Upper Aquifer System - Most Recent Chloride (mg/L) Measured 2011-2015

Groundwater Sustainability Plan for the Pleasant Valley Basin

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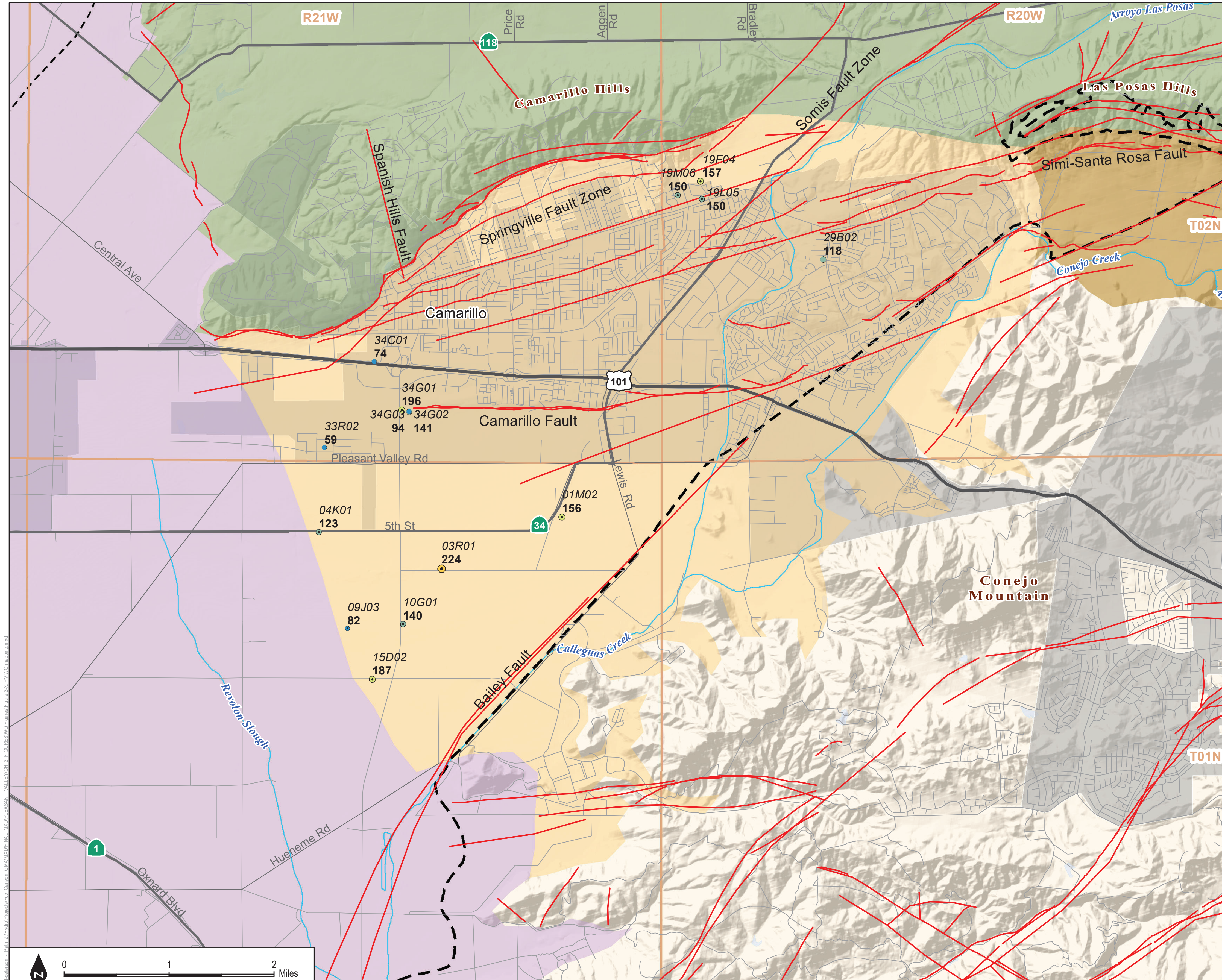

Legend

- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Major Rivers/Stream Channels
- Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Arroyo Santa Rosa Valley (4-007)
- Las Posas Valley (4-008)
- Pleasant Valley (4-006)
- Oxnard (4-004.02)
- Oxnard Forebay

Chloride concentration (mg/L), 2011-2015

- 23 - 100
- 101 - 150
- 151 - 200
- 201 - 500
- 501 - 1000
- 1001 - 22500

Aquifer designation

- Well screened in the Hueneme aquifer
- Well screened in the Fox Canyon aquifer
- Well screened in the Grimes Canyon aquifer
- Wells screened in multiple aquifers in the LAS

15P01 Abbreviated State Well Number (see notes)
10.5 Concentration (mg/L)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it.The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix F.
2) "ND" signifies non-detect.
3) SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map,concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
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5) The color of each well symbol corresponds to the most recent concentration measured in a water quality sample from that well.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-22
Lower Aquifer System - Most Recent Chloride (mg/L) Measured 2011-2015

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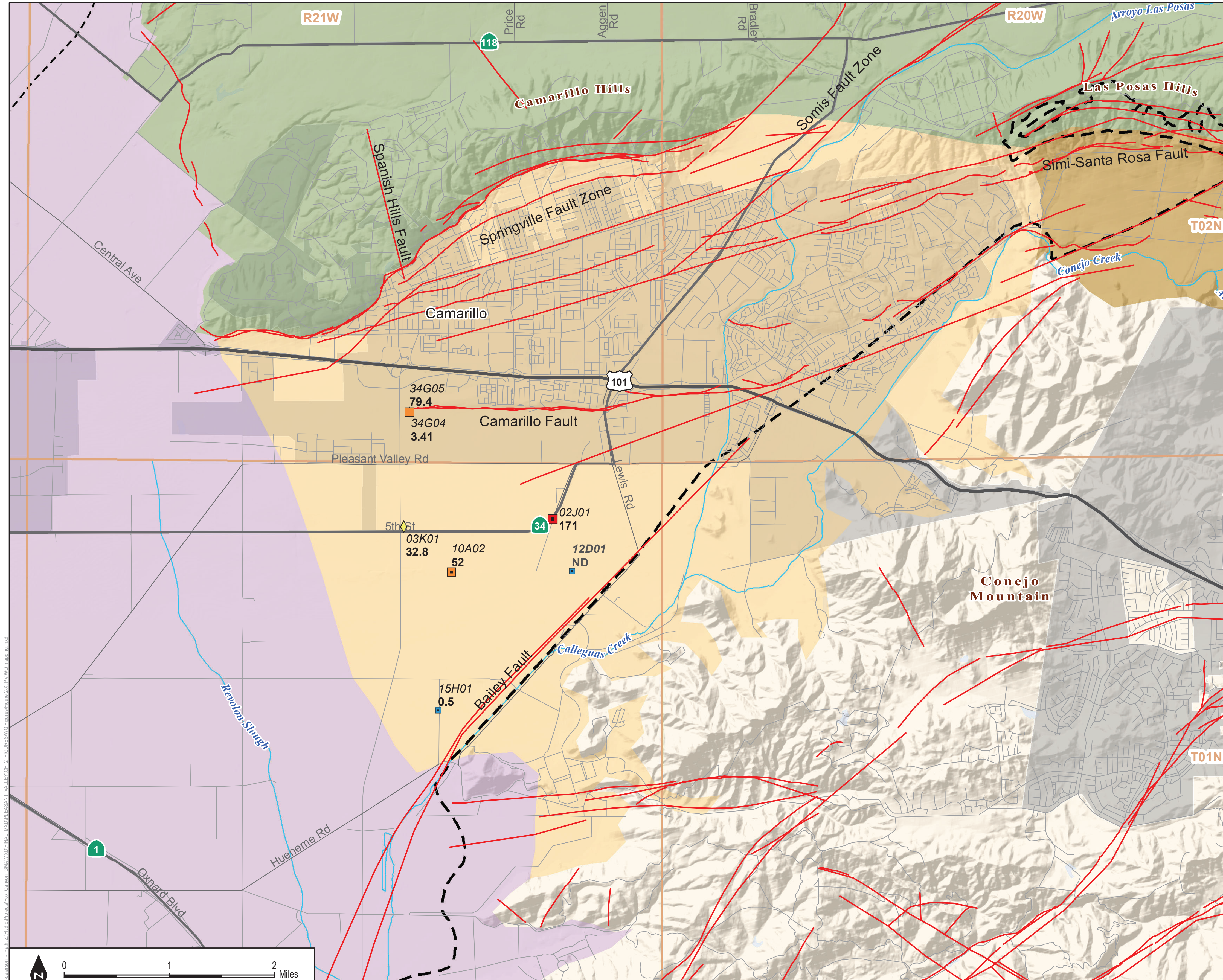

Legend

Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)

Major Rivers/Stream Channels

Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

Arroyo Santa Rosa Valley (4-007)

Las Posas Valley (4-008)

Pleasant Valley (4-006)

Oxnard (4-004.02)

Oxnard Forebay

Nitrate concentration (mg/L as Nitrate), 2011-2015

0 - 10

>10 - 22.5

>22.5 - 45

>45 - 90

>90 - 528

Aquifer designation

Well screened in the Oxnard aquifer

Well screened in the Mugu aquifer

Wells screened in multiple aquifers in the UAS

15P01 Abbreviated State Well Number (see notes)

10.5 Concentration (mg/L)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it.The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix F.
2) "ND" signifies non-detect.
3) SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map,concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
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5) The color of each well symbol corresponds to the most recent concentration measured in a water quality sample from that well.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-23

Upper Aquifer System - Most Recent Nitrate (mg/L as Nitrate) Measured 2011-2015

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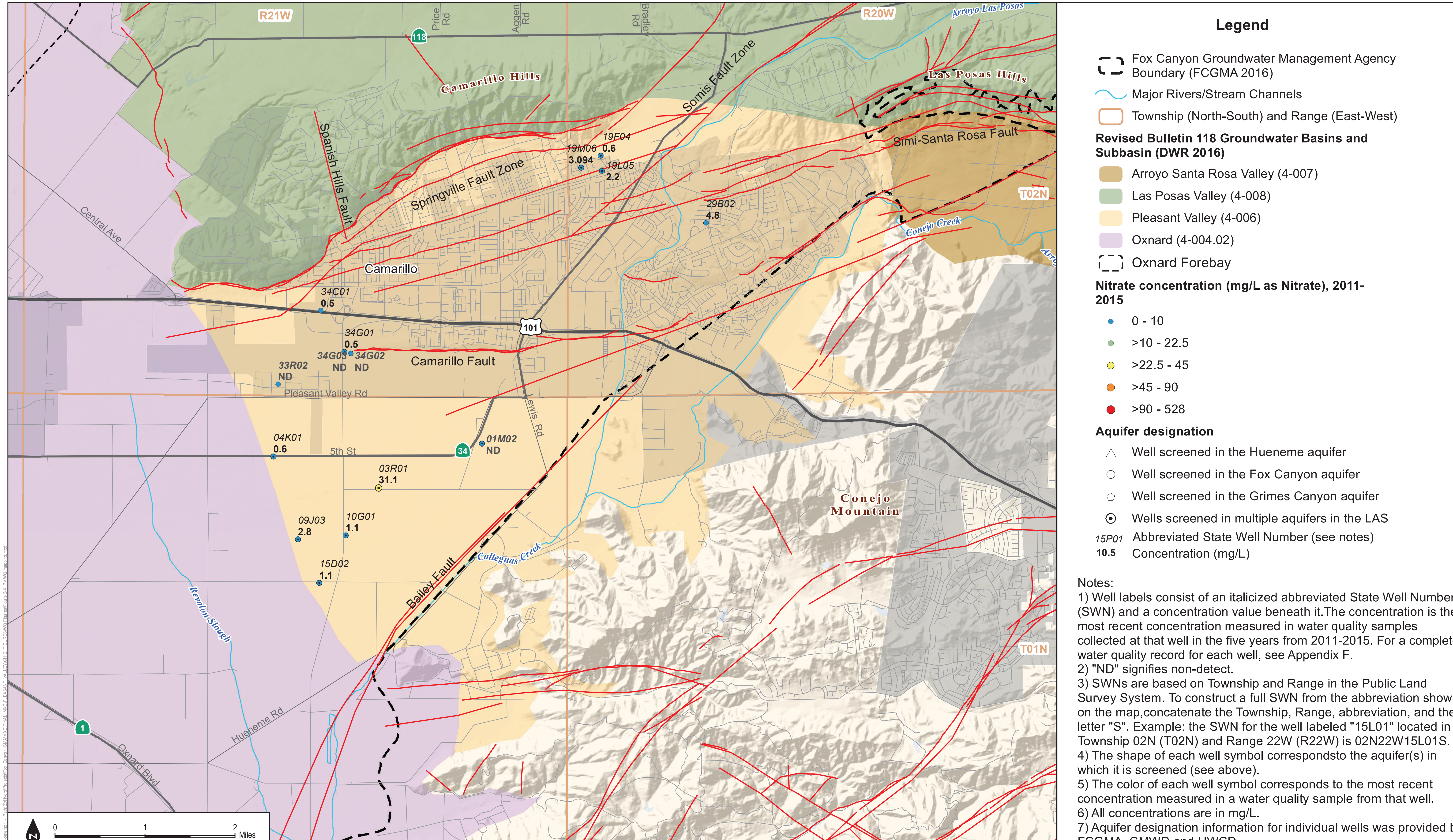

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-24

Lower Aquifer System - Most Recent Nitrate (mg/L as Nitrate) Measured 2011-2015

Groundwater Sustainability Plan for the Pleasant Valley Basin

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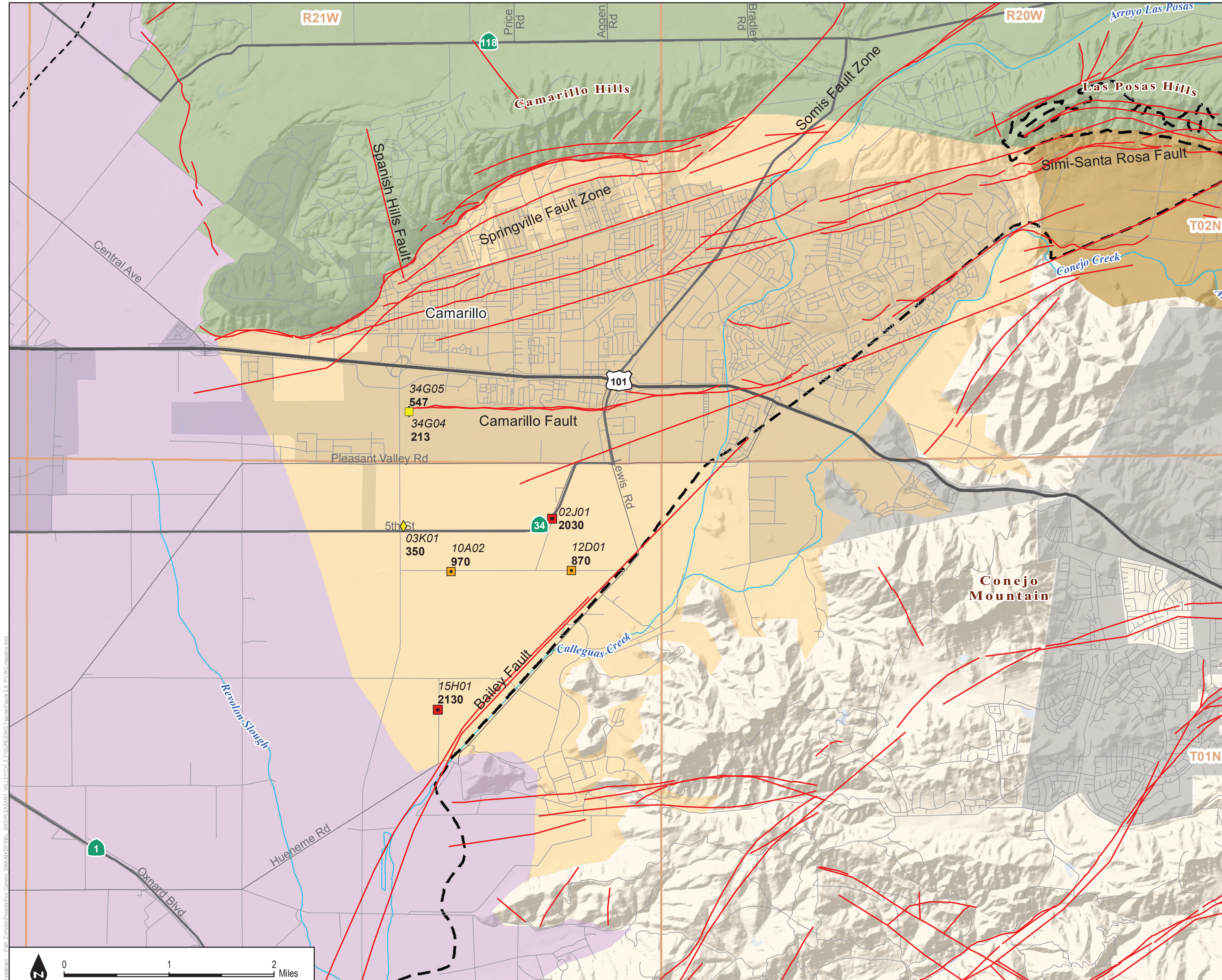

Legend

- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Major Rivers/Stream Channels
- Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

- Arroyo Santa Rosa Valley (4-007)
- Las Posas Valley (4-008)
- Pleasant Valley (4-006)
- Oxnard (4-004.02)
- Oxnard Forebay

Sulfate concentration (mg/L), 2011-2015

- 29 - 300
- 301 - 600
- 601 - 1000
- 1001 - 5740

Aquifer designation

- Well screened in the Oxnard aquifer
- Well screened in the Mugu aquifer
- Wells screened in multiple aquifers in the UAS

15P01 Abbreviated State Well Number (see notes)
10.5 Concentration (mg/L)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it.The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix F.
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5) The color of each well symbol corresponds to the most recent concentration measured in a water quality sample from that well.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-25

Upper Aquifer System - Most Recent Sulfate (mg/L) Measured 2011-2015

Groundwater Sustainability Plan for the Pleasant Valley Basin

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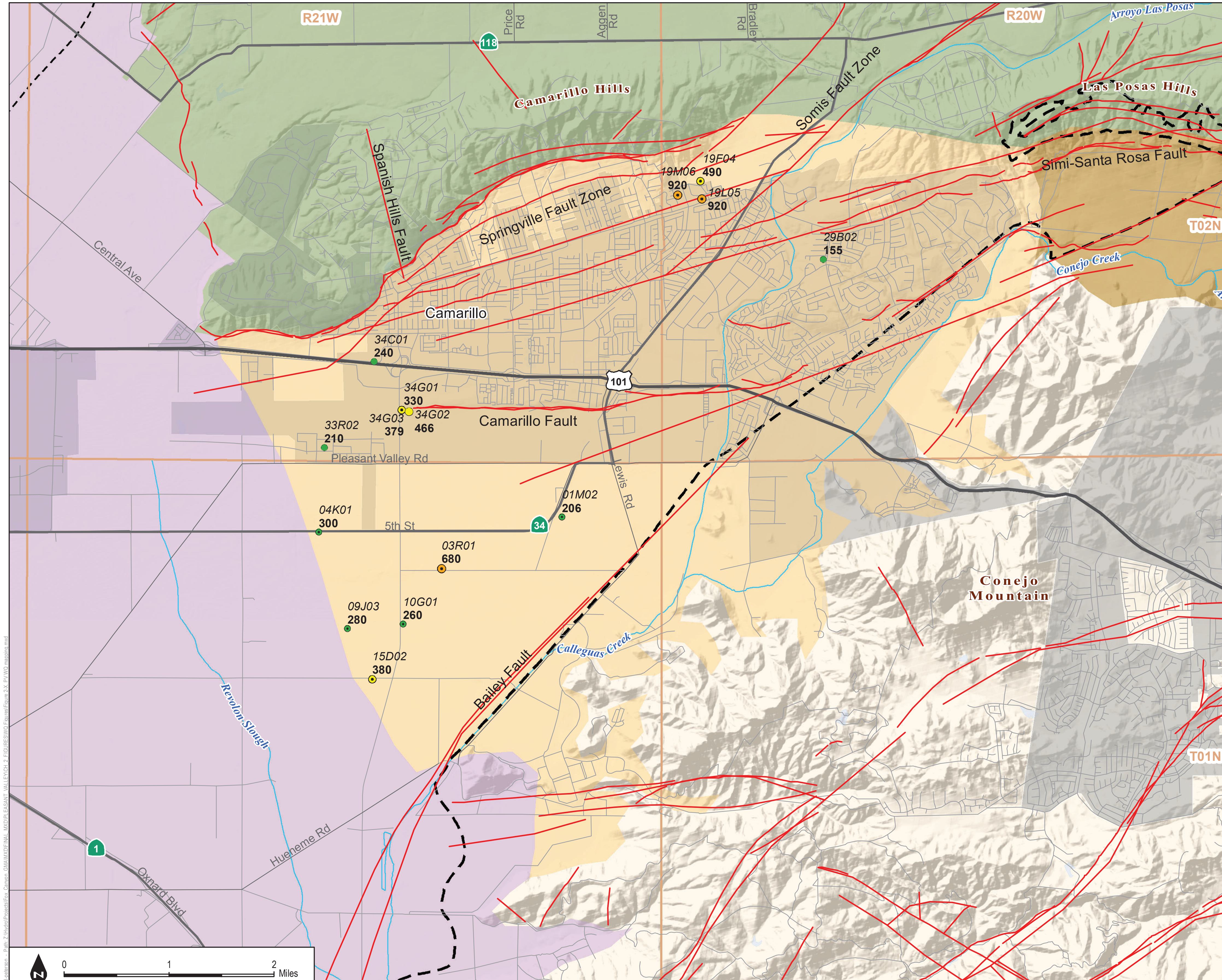

Legend

- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Major Rivers/Stream Channels
- Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

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- Pleasant Valley (4-006)
- Oxnard (4-004.02)
- Oxnard Forebay

Sulfate concentration (mg/L), 2011-2015

- 29 - 300
- 301 - 600
- 601 - 1000
- 1001 - 5740

Aquifer designation

- Well screened in the Hueneme aquifer
- Well screened in the Fox Canyon aquifer
- Well screened in the Grimes Canyon aquifer
- Wells screened in multiple aquifers in the LAS

15P01 Abbreviated State Well Number (see notes)
10.5 Concentration (mg/L)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it.The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix F.
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5) The color of each well symbol corresponds to the most recent concentration measured in a water quality sample from that well.
6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-26

Lower Aquifer System - Most Recent Sulfate (mg/L) Measured 2011-2015

Groundwater Sustainability Plan for the Pleasant Valley Basin

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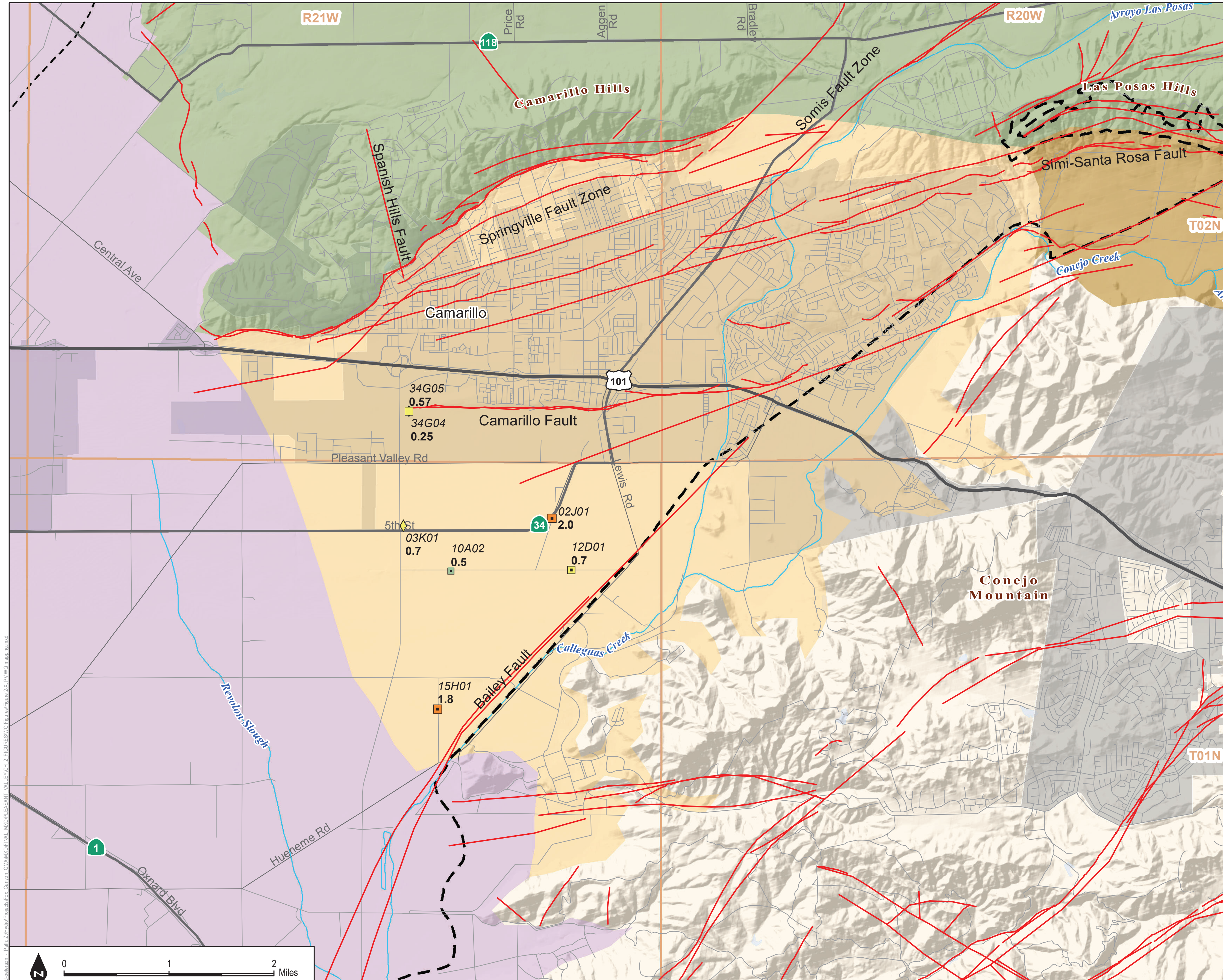

Legend

Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)

Major Rivers/Stream Channels

Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

Arroyo Santa Rosa Valley (4-007)

Las Posas Valley (4-008)

Pleasant Valley (4-006)

Oxnard (4-004.02)

Oxnard Forebay

Boron concentration (mg/L), 2011-2015

0 - 0.2

>0.2 - 0.5

>0.5 - 1.0

>1.0 - 2.0

>2.0 - 6.0

Aquifer designation

Well screened in the Oxnard aquifer

Well screened in the Mugu aquifer

Wells screened in multiple aquifers in the UAS

15P01 Abbreviated State Well Number (see notes)

10.5 Concentration (mg/L)

Notes:

1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it.The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix F.
2) "ND" signifies non-detect.
3) SWNs are based on Township and Range in the Public Land Survey System. To construct a full SWN from the abbreviation shown on the map,concatenate the Township, Range, abbreviation, and the letter "S". Example: the SWN for the well labeled "15L01" located in Township 02N (T02N) and Range 22W (R22W) is 02N22W15L01S.
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6) All concentrations are in mg/L.
7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-27

Upper Aquifer System - Most Recent Boron (mg/L) Measured 2011-2015

Groundwater Sustainability Plan for the Pleasant Valley Basin

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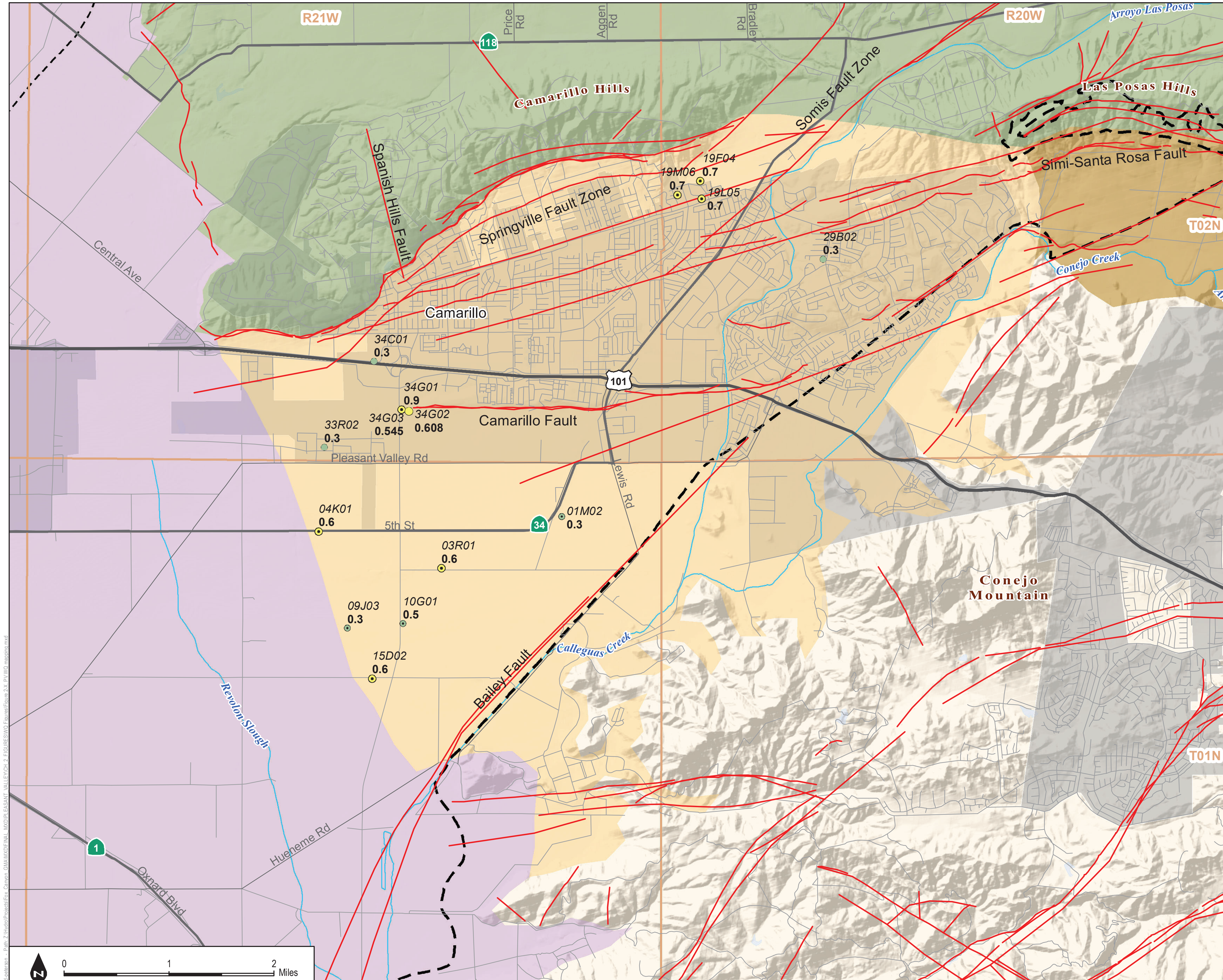

Legend

Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)

Major Rivers/Stream Channels

Township (North-South) and Range (East-West)

Revised Bulletin 118 Groundwater Basins and Subbasin (DWR 2016)

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Las Posas Valley (4-008)

Pleasant Valley (4-006)

Oxnard (4-004.02)

Oxnard Forebay

Boron concentration (mg/L), 2011-2015

0 - 0.2

>0.2 - 0.5

>0.5 - 1.0

>1.0 - 2.0

>2.0 - 6.0

Aquifer designation

Well screened in the Hueneme aquifer

Well screened in the Fox Canyon aquifer

Well screened in the Grimes Canyon aquifer

Wells screened in multiple aquifers in the LAS

15P01 Abbreviated State Well Number (see notes)

10.5 Concentration (mg/L)

Notes:
1) Well labels consist of an italicized abbreviated State Well Number (SWN) and a concentration value beneath it.The concentration is the most recent concentration measured in water quality samples collected at that well in the five years from 2011-2015. For a complete water quality record for each well, see Appendix F.
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7) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

DUDEK

SOURCE: DWR, FCGMA, VCWPD, CMWD, UWCD

FIGURE 2-28

Lower Aquifer System - Most Recent Boron (mg/L) Measured 2011-2015

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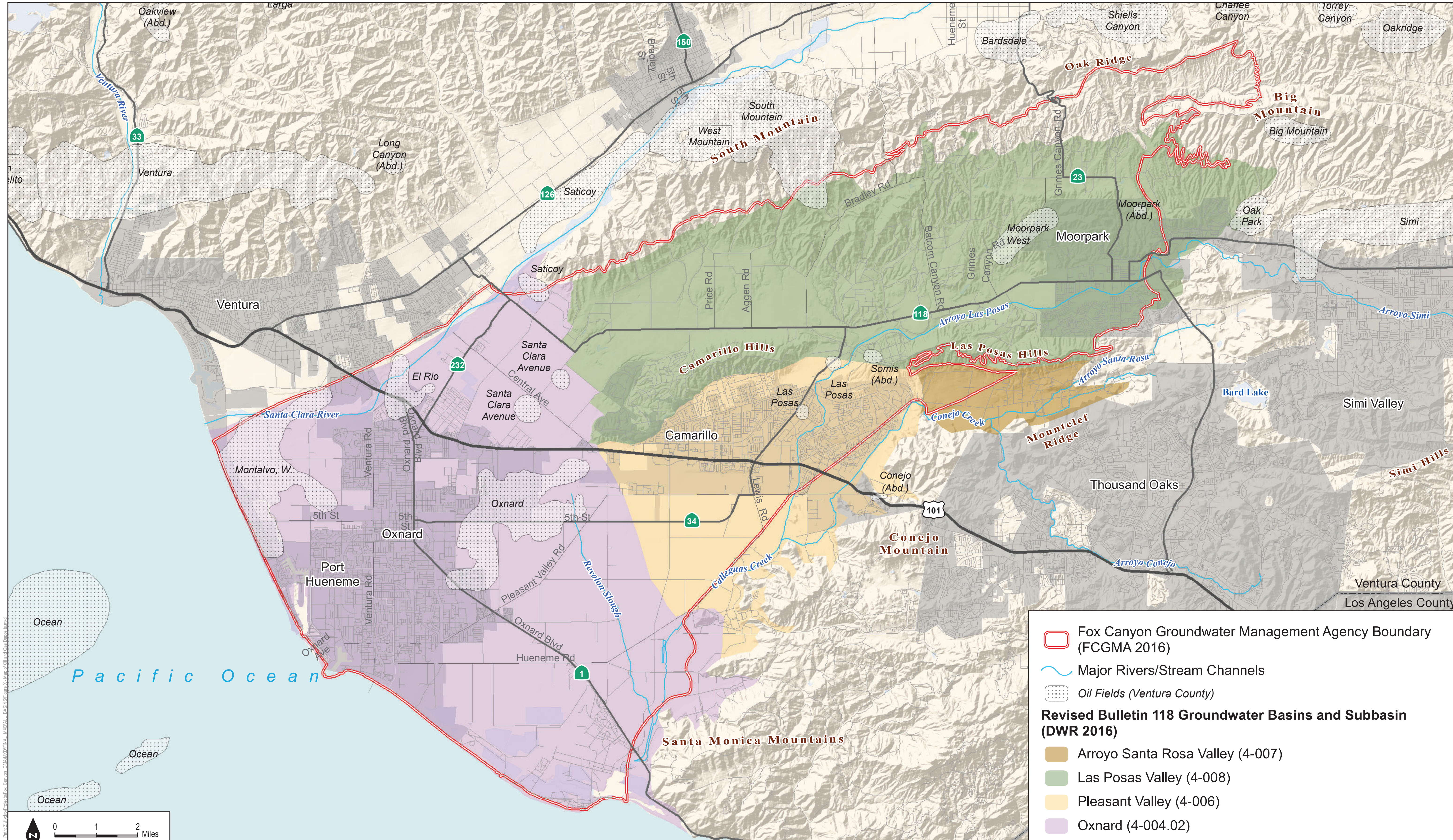

SOURCE: DWR; Ventura County

FIGURE 2-29

Oil Fields in the Vicinity of FCGMA Groundwater Basins

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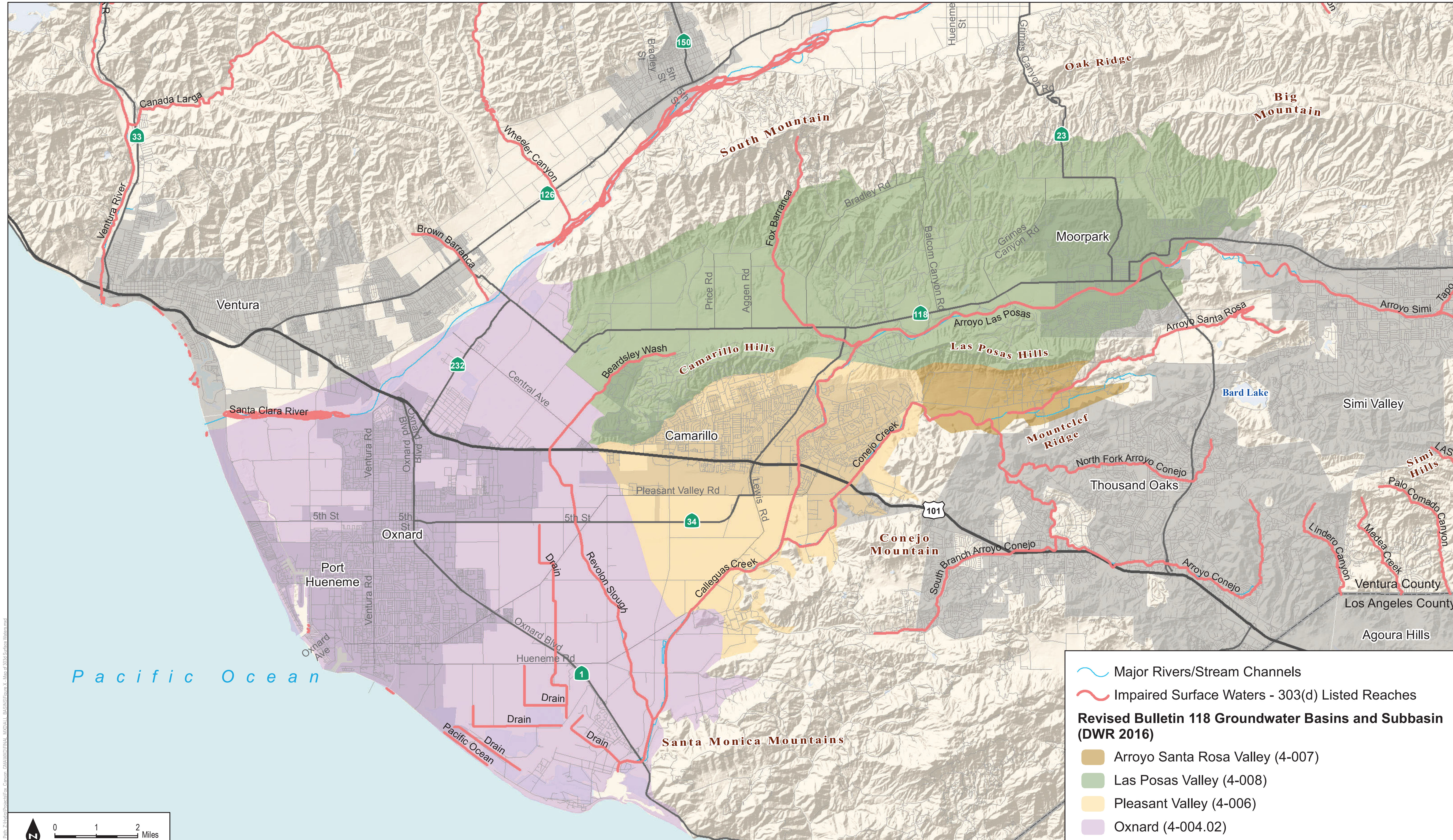

SOURCE: DWR; Ventura County

FIGURE 2-30

Impaired Surface Waters in the Vicinity of FCGMA Groundwater Basins

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Groundwater Sustainability Plan for the Pleasant Valley Basin

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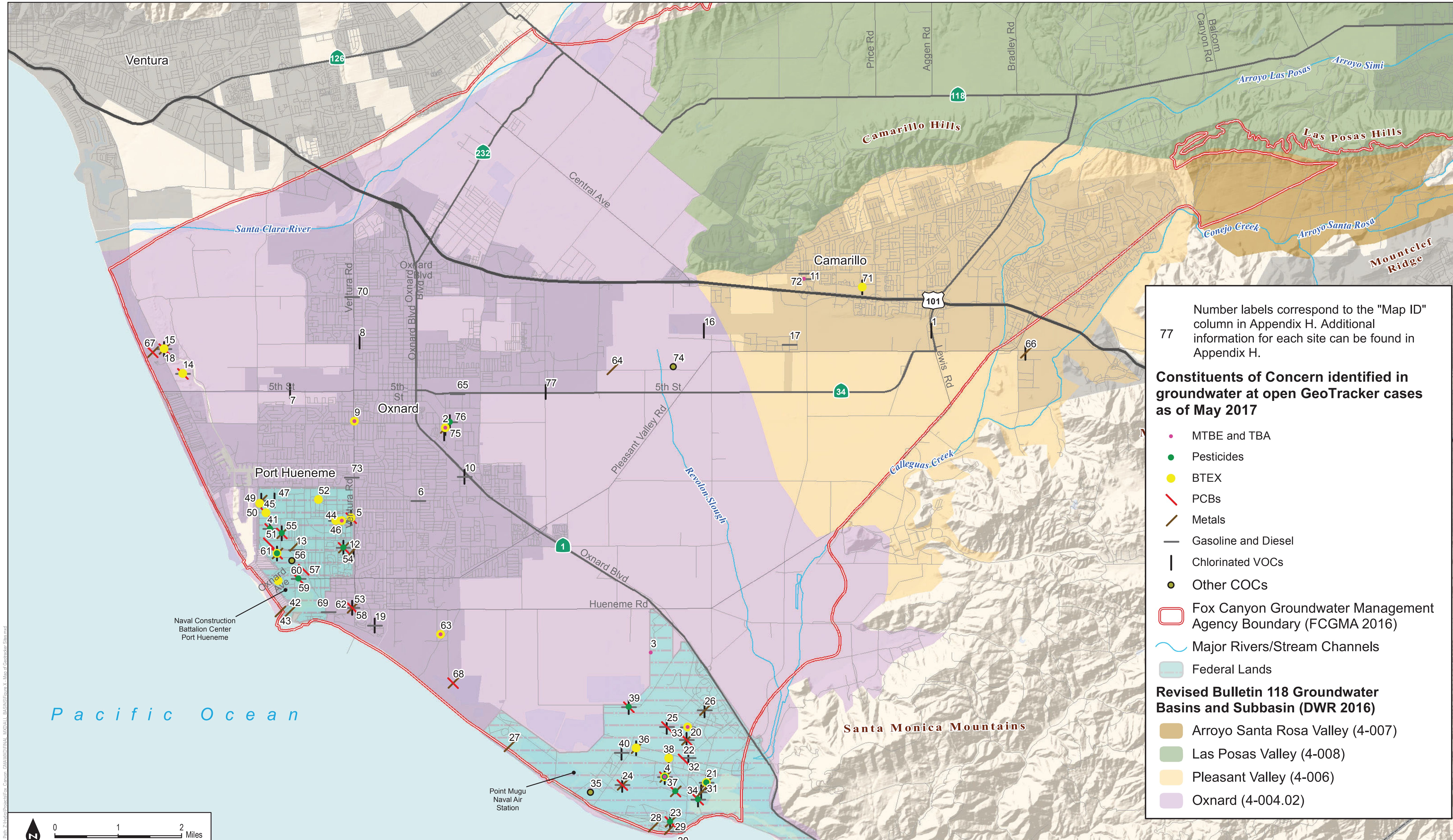

SOURCE: DWR; Ventura County; Geotracker

FIGURE 2-31

Constituents of Concern at Open GeoTracker Cases with Impacted Groundwater within FCGMA Groundwater Basin Boundaries

DUDEK

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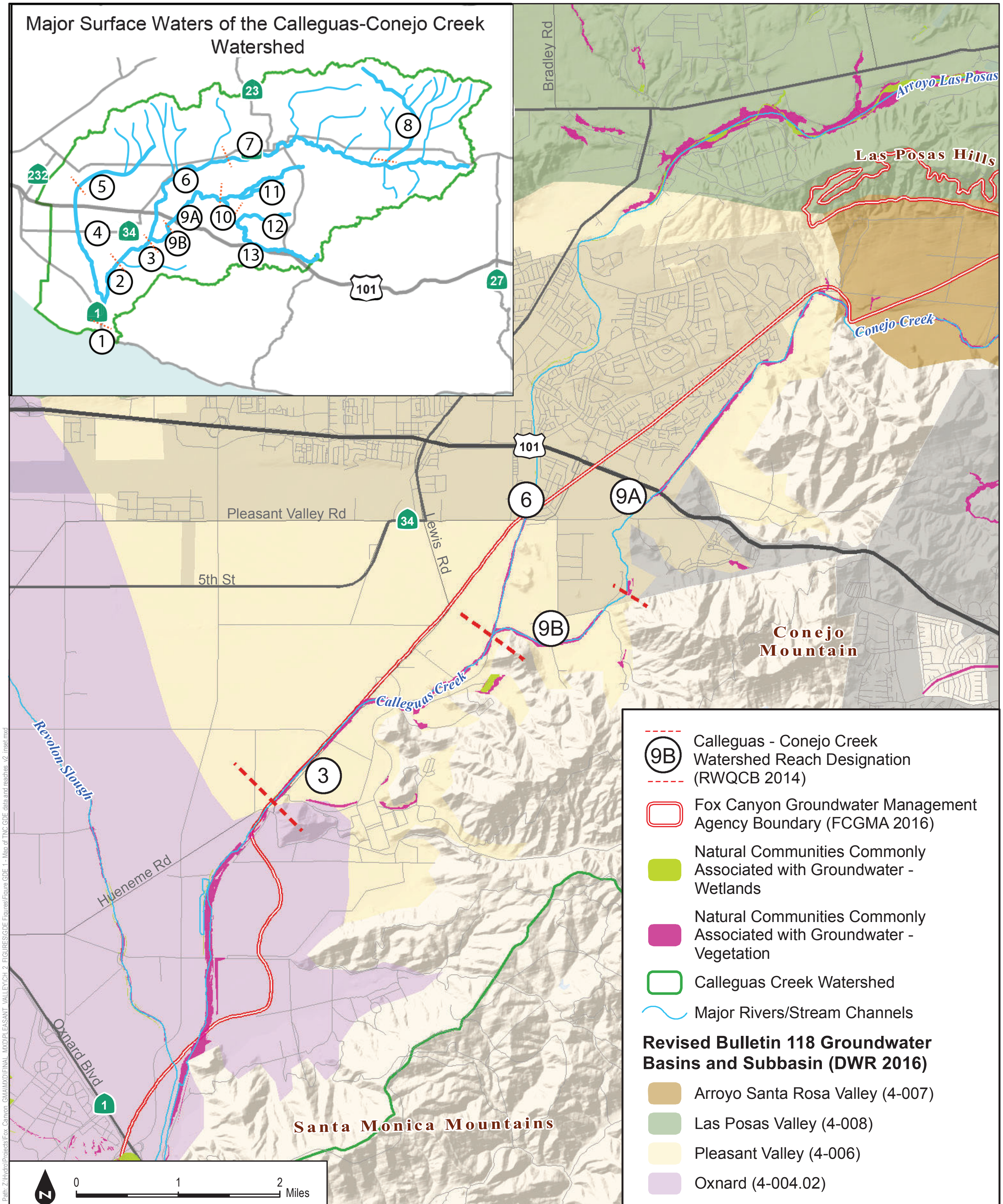

SOURCE: DWR; Ventura County; RWQCB 2014
TNC GDEs Version 0.3.1 (March 2017)

FIGURE 2-32

Groundwater-Dependent Ecosystems and Stream Reaches in Pleasant Valley

DUDEK

Groundwater Sustainability Plan for the Pleasant Valley Basin

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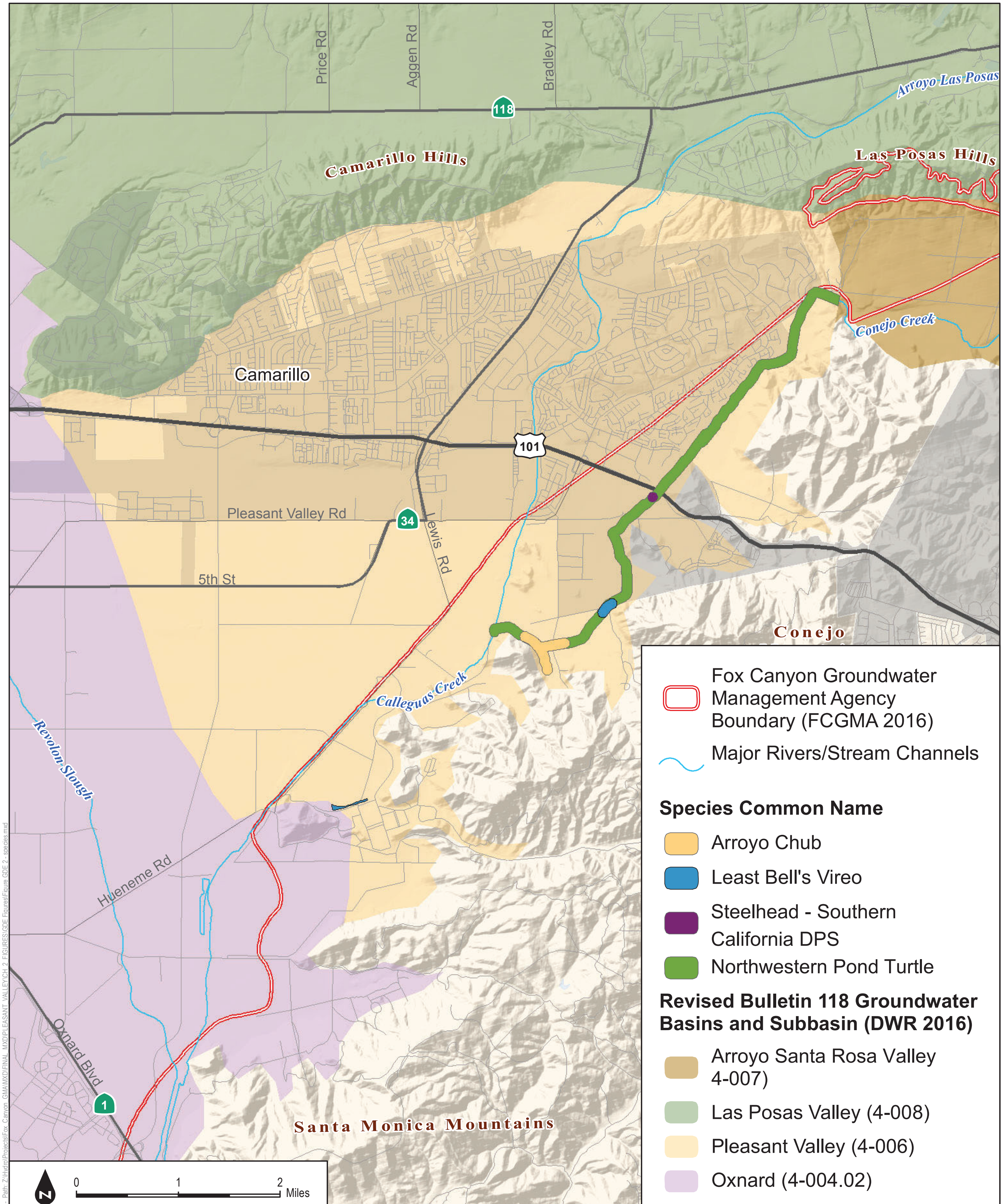

DUDEK

SOURCE: DWR; Ventura County; CNDDB;
TNC GDEs Version 0.3.1 (March 2017)

FIGURE 2-33

Species Occurrences in Pleasant Valley

Groundwater Sustainability Plan for the Pleasant Valley Basin

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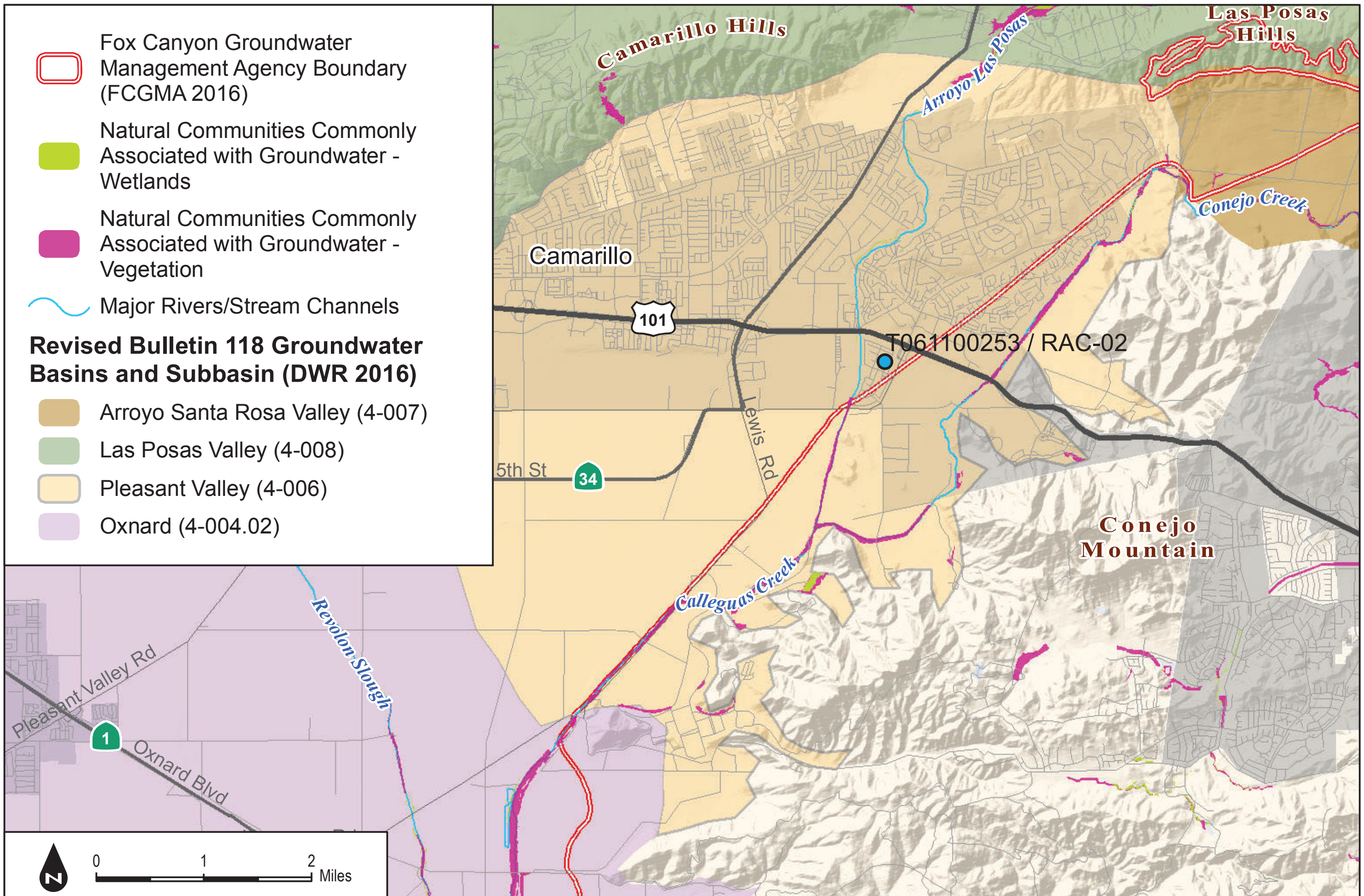

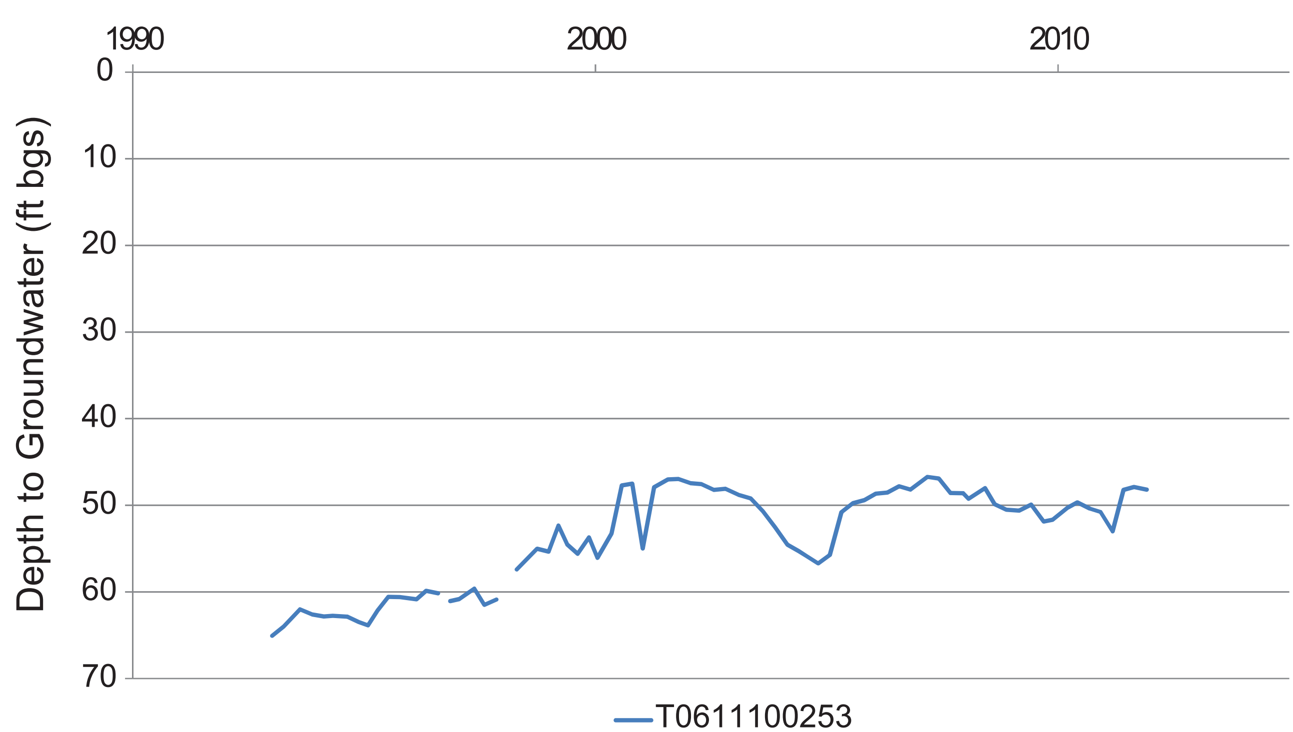

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SOURCE: DWR; Ventura County

FIGURE 2-34

Water Level Record for Well Locations Adjacent to Arroyo Las Posas

Groundwater Sustainability Plan for the Pleasant Valley Basin

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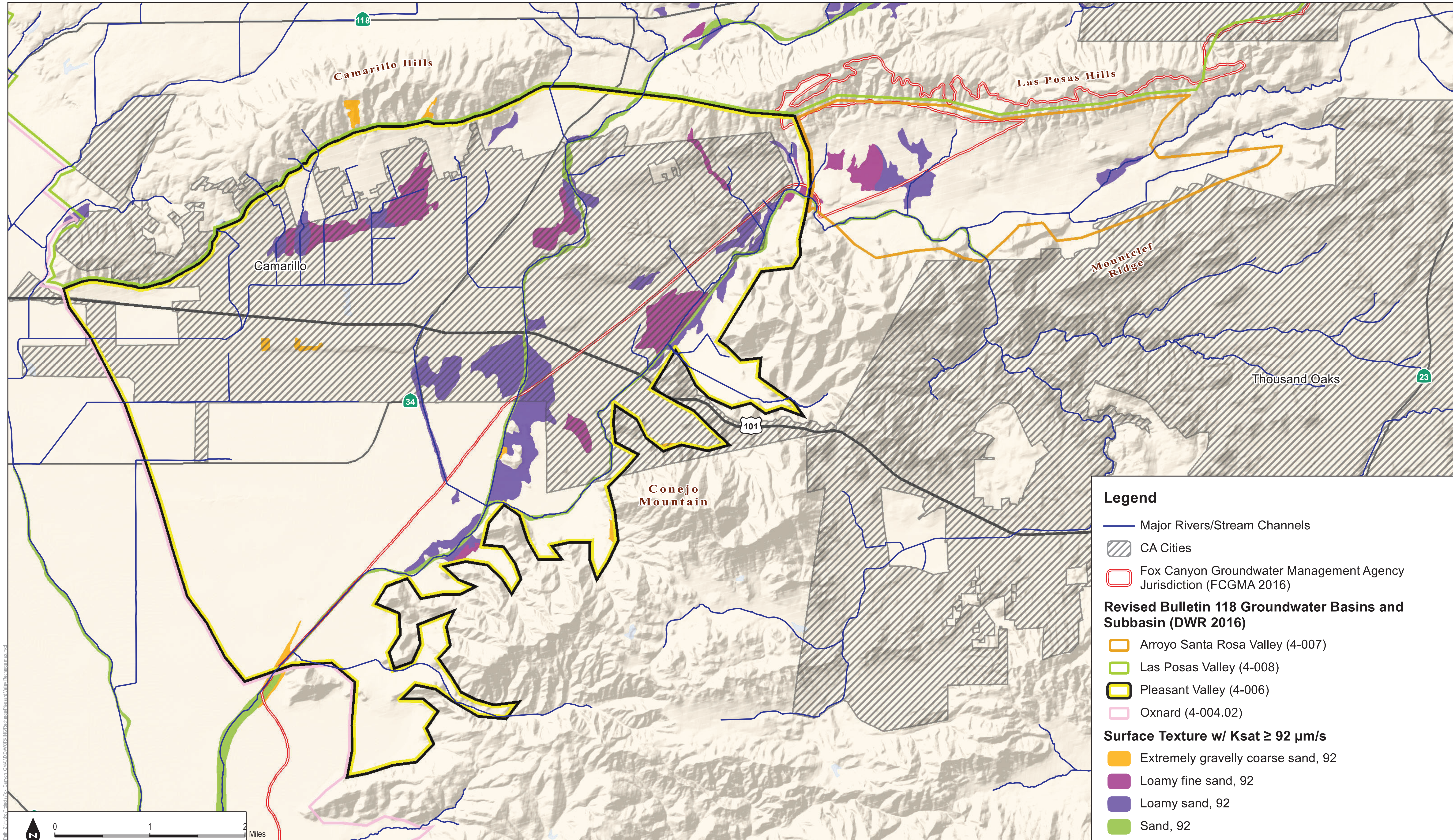

DUDEK

SOURCE: DWR, USGS, NRCS

FIGURE 2-35

Pleasant Valley Potential Recharge Areas

Groundwater Sustainability Plan for the Pleasant Valley Basin

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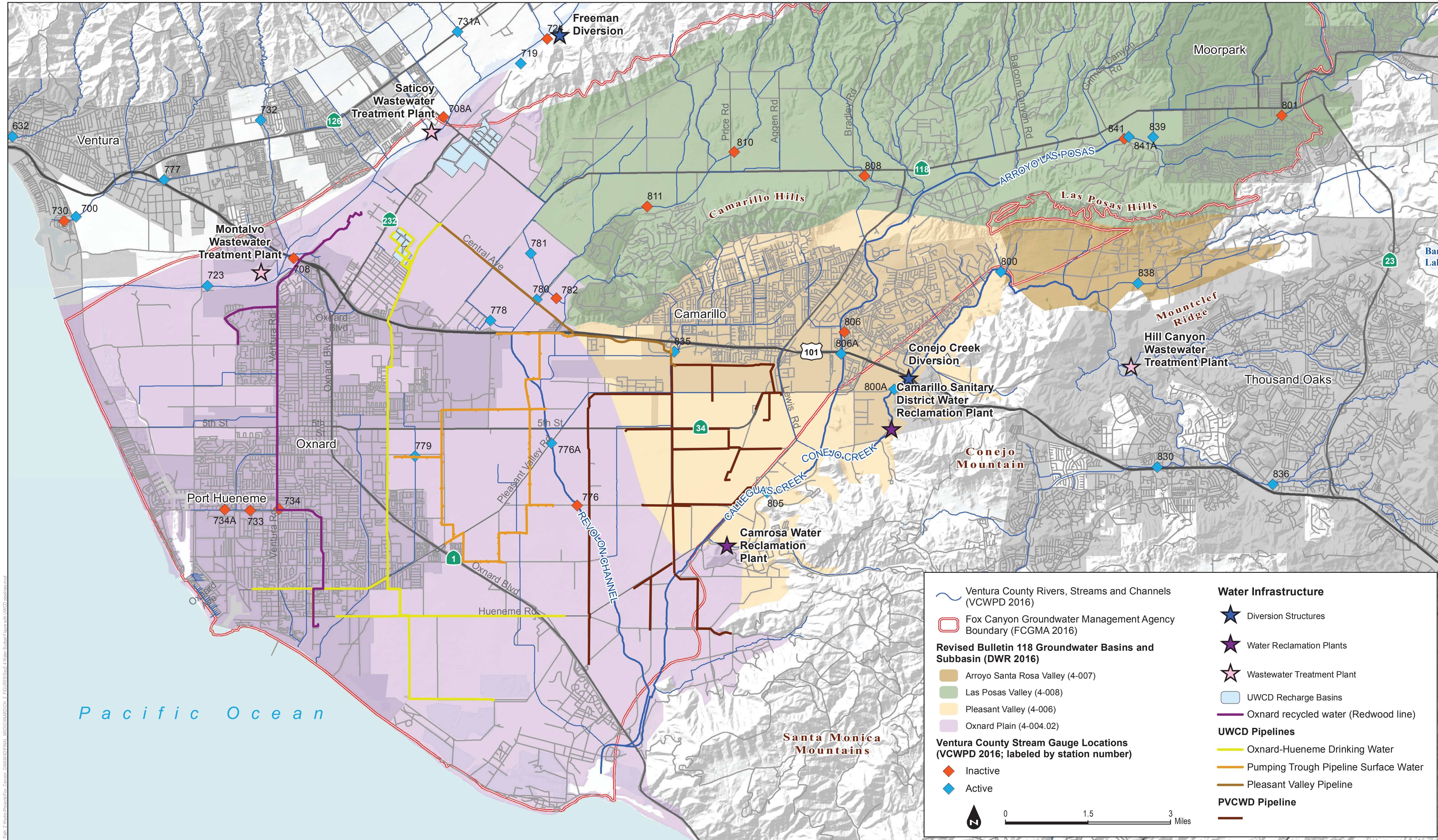

SOURCE: DWR; Ventura County; VCWPD

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FIGURE 2-36

Pleasant Valley Basin Stream Gauges and Water Infrastructure

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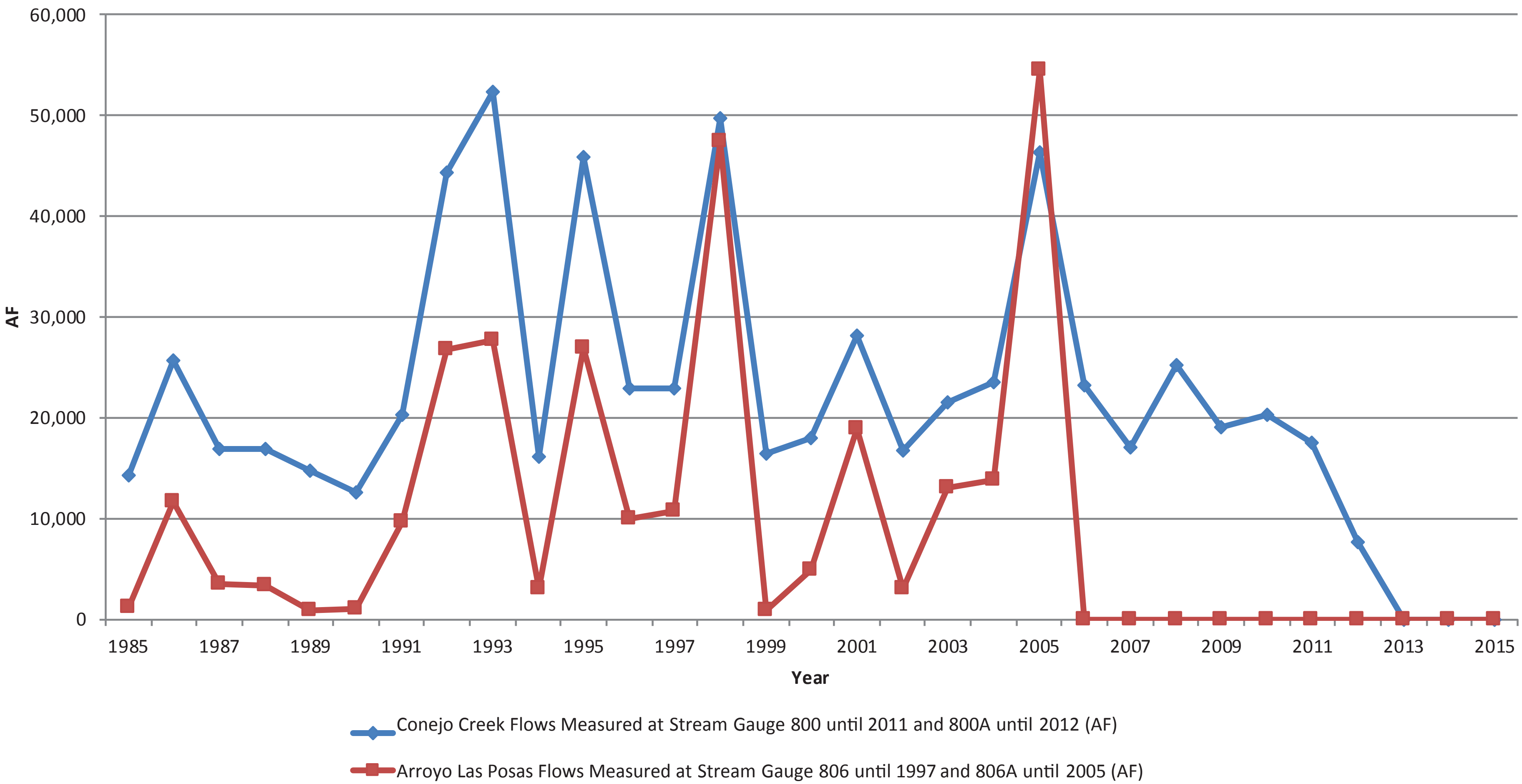

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FIGURE 2-37

Pleasant Valley Basin Stream Flows

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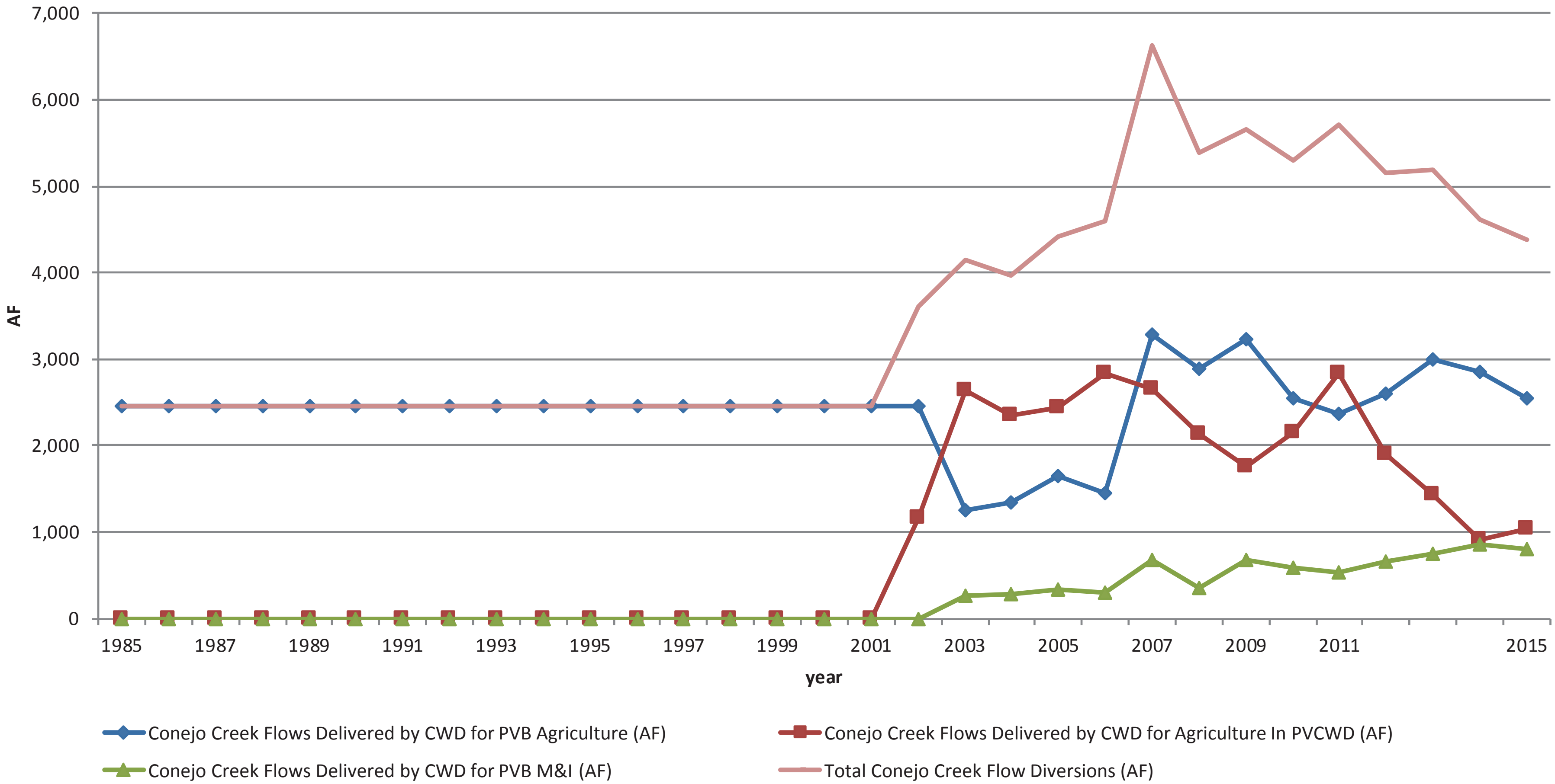

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FIGURE 2-38
Conejo Creek Diversions

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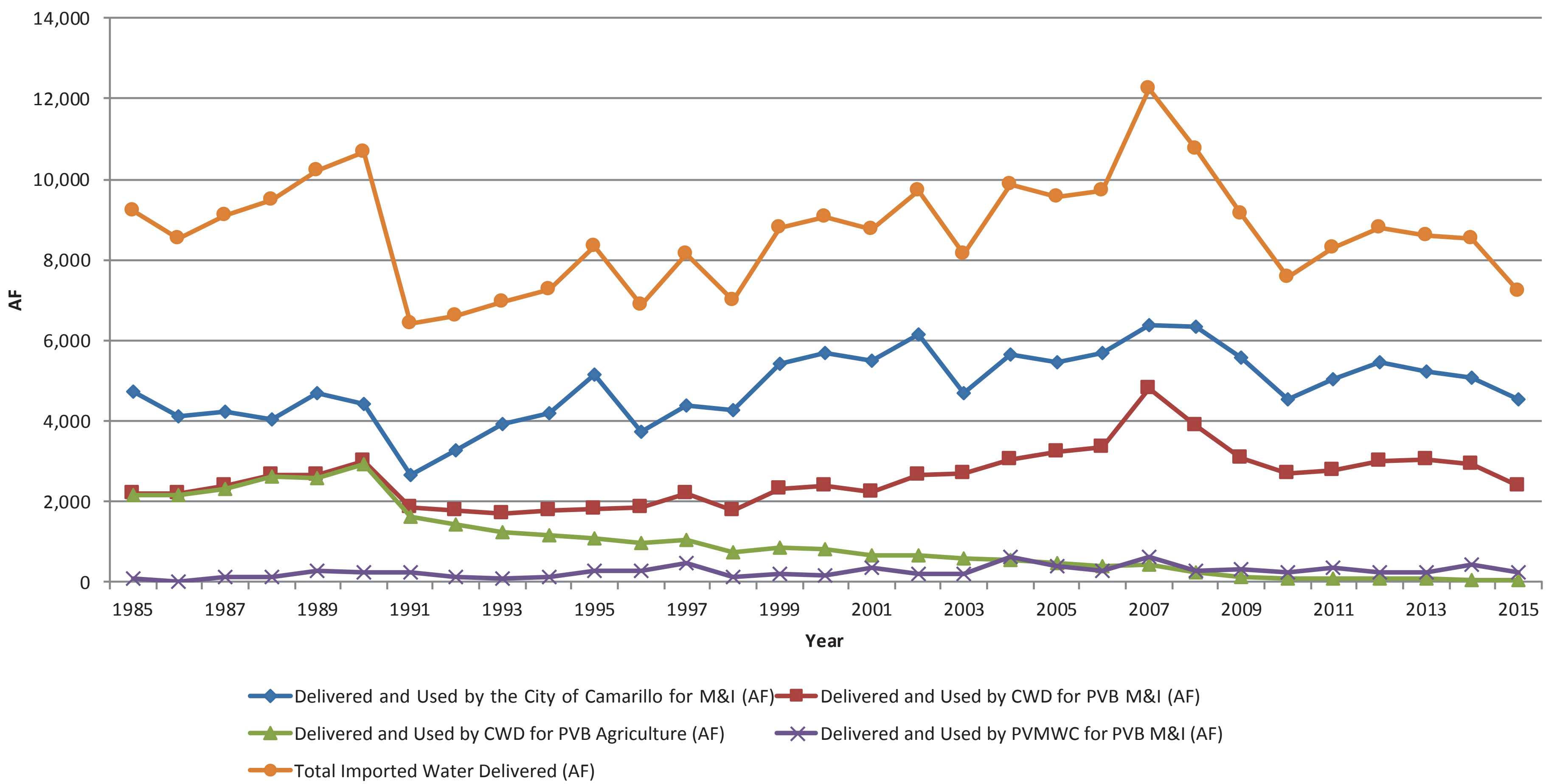

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FIGURE 2-39
Imported Water Deliveries

Groundwater Sustainability Plan for the Pleasant Valley Basin

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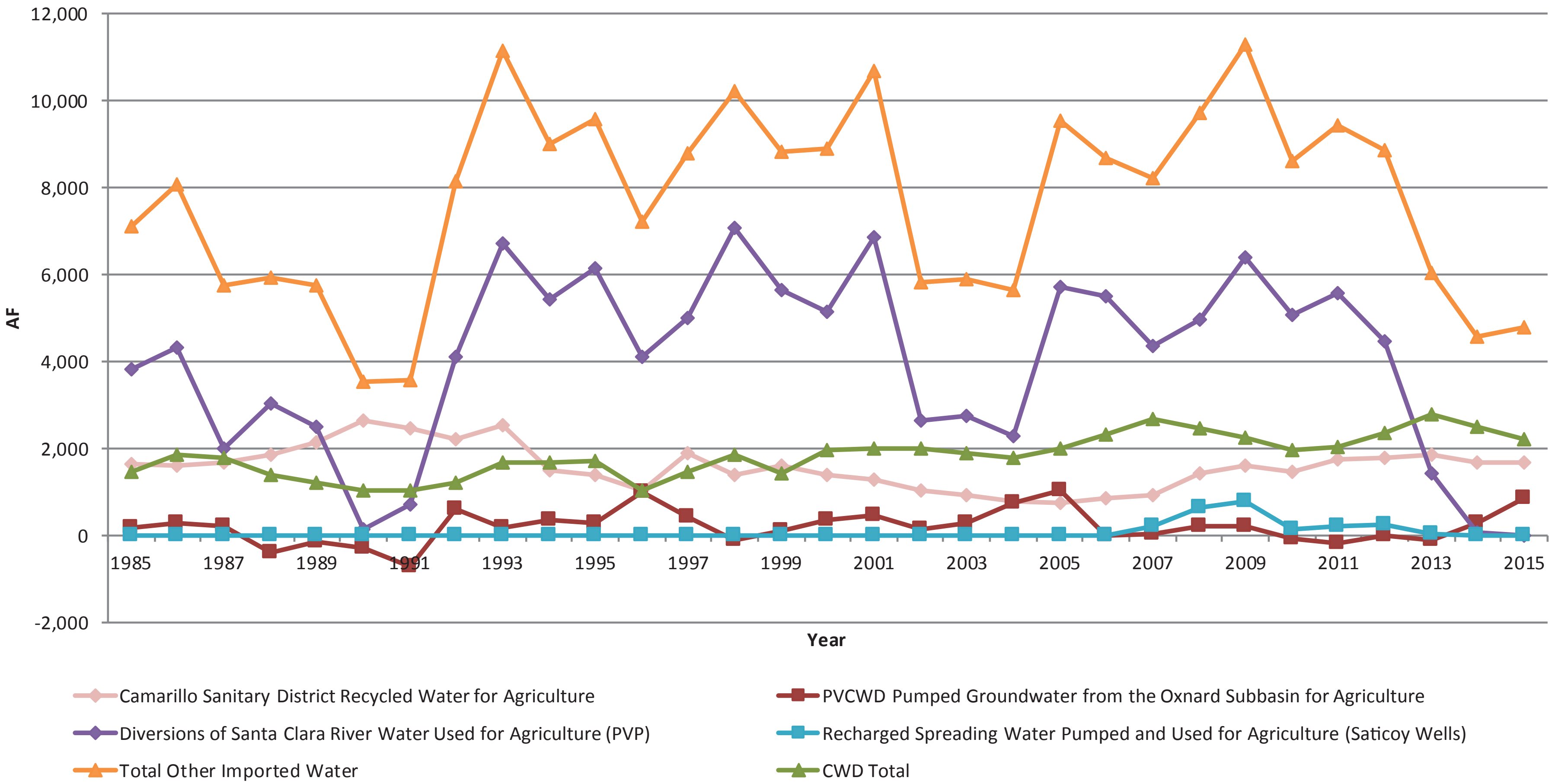

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FIGURE 2-40

Other Water Deliveries

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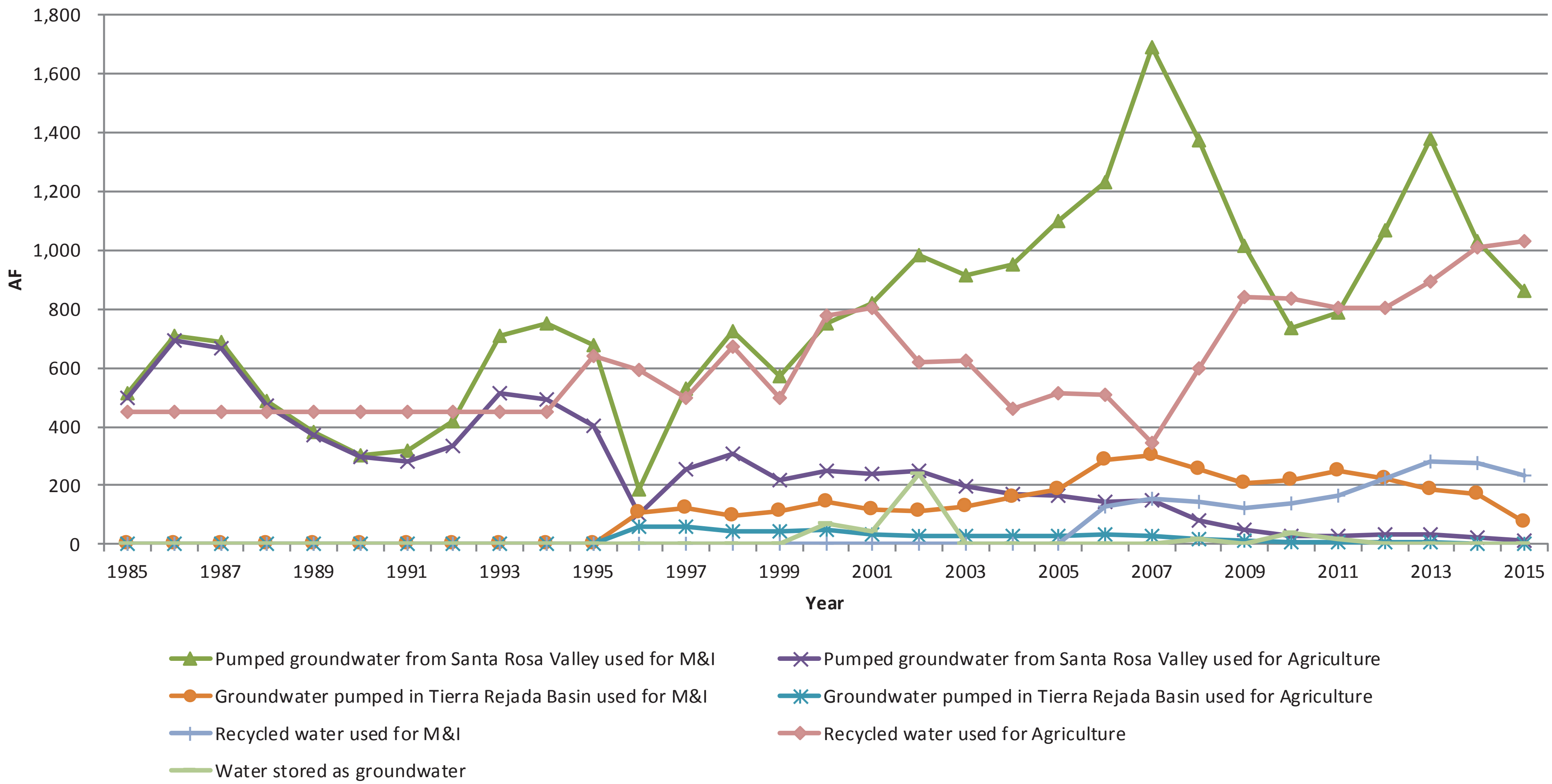

DUDEK

FIGURE 2-41

Other Camrosa Water District Water Deliveries

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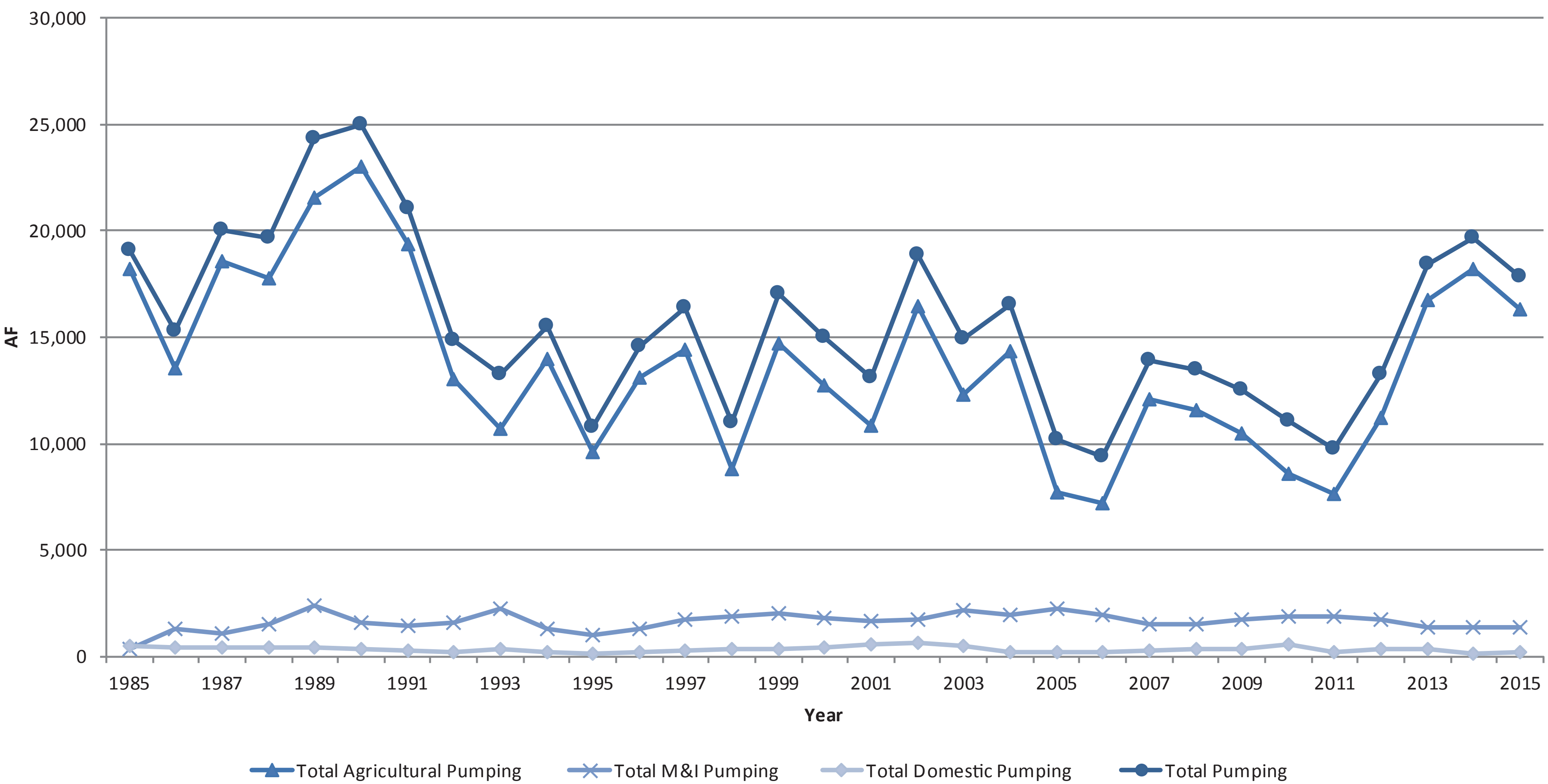

DUDEK

FIGURE 2-42
Pleasant Valley Basin Groundwater Pumping

Groundwater Sustainability Plan for the Pleasant Valley Basin

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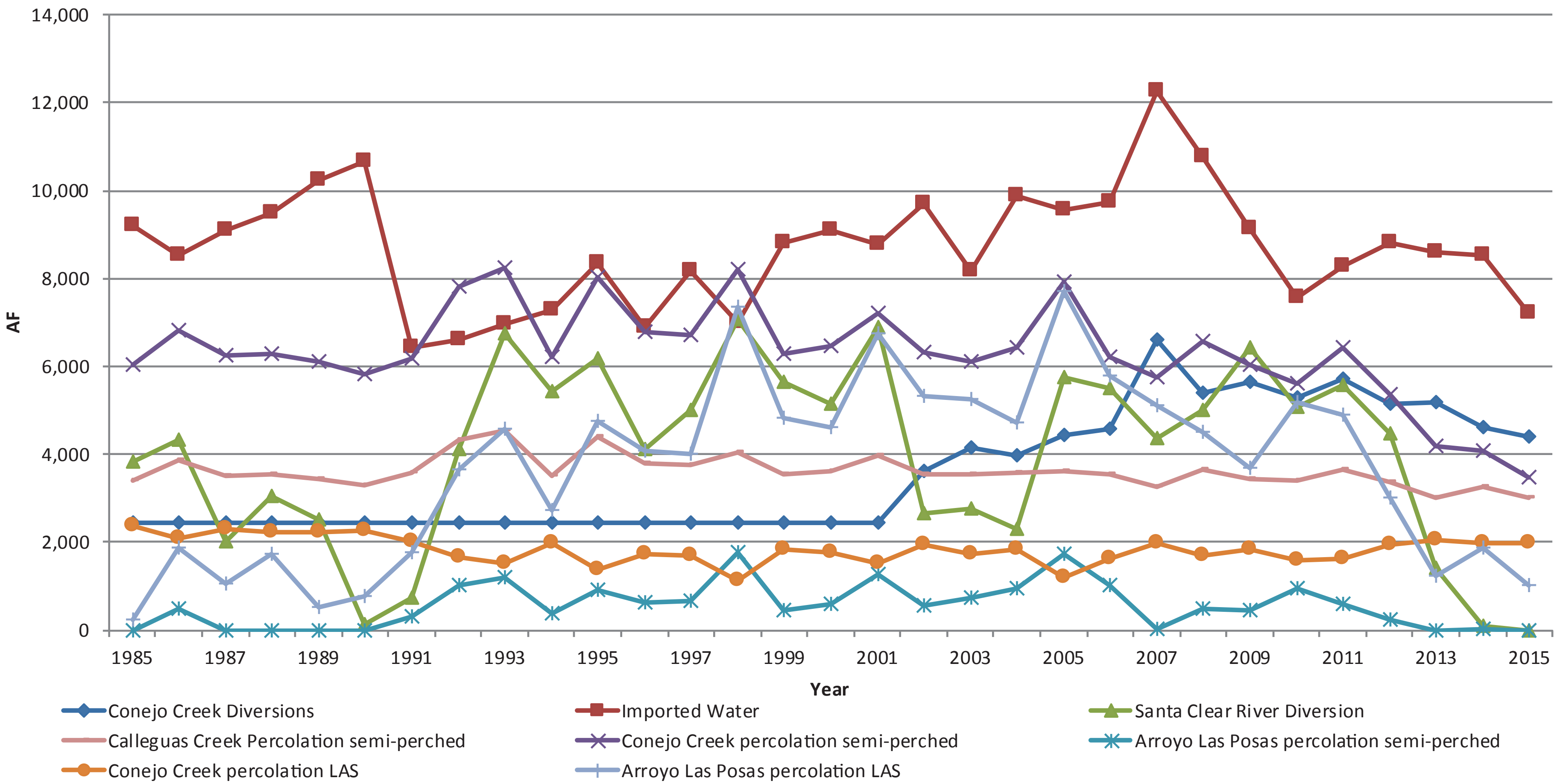

DUDEK

FIGURE 2-43

Total Pleasant Valley Basin Surface Water Supplies

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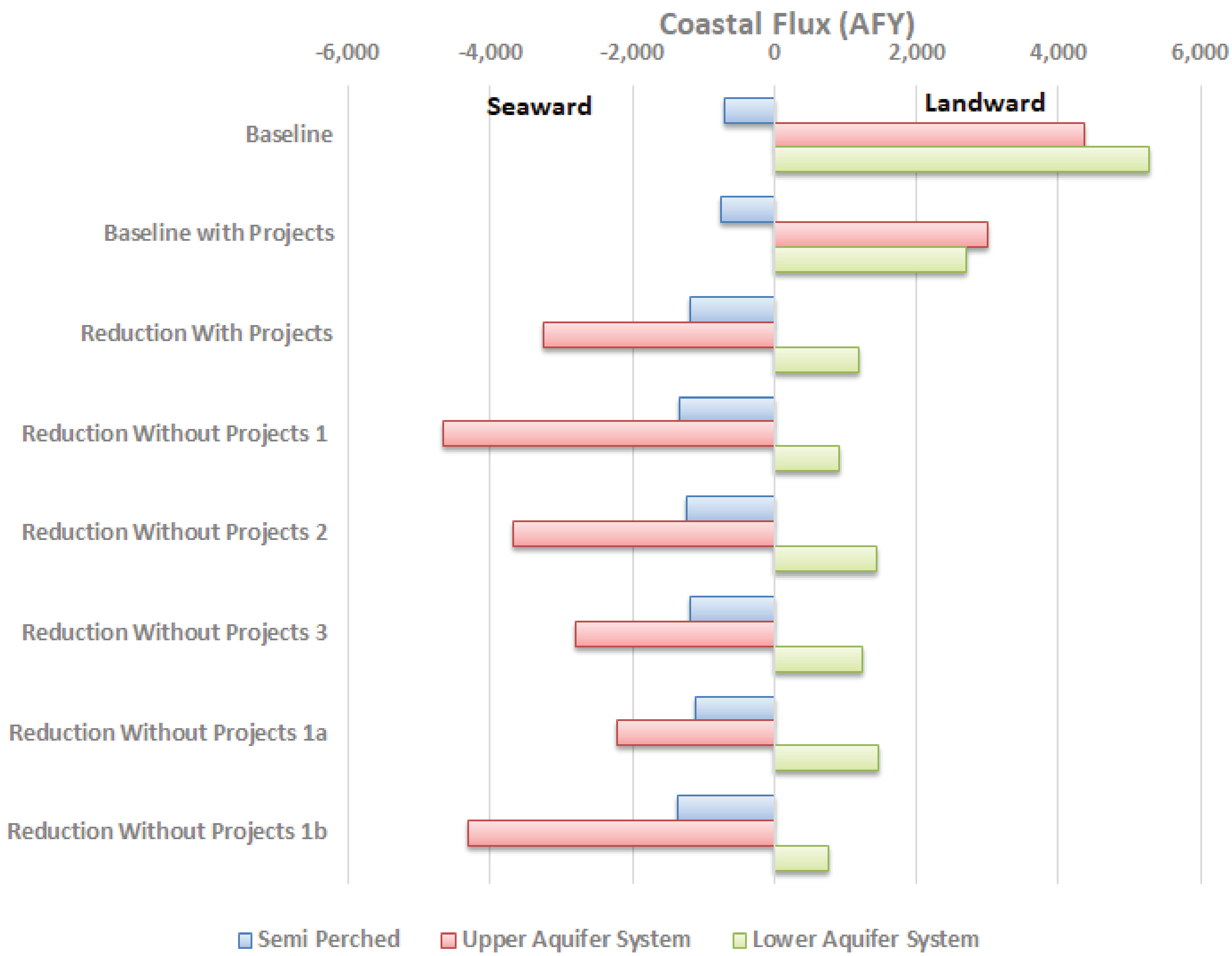

FIGURE 2-44

Coastal Flux From the UWCD Model Scenarios

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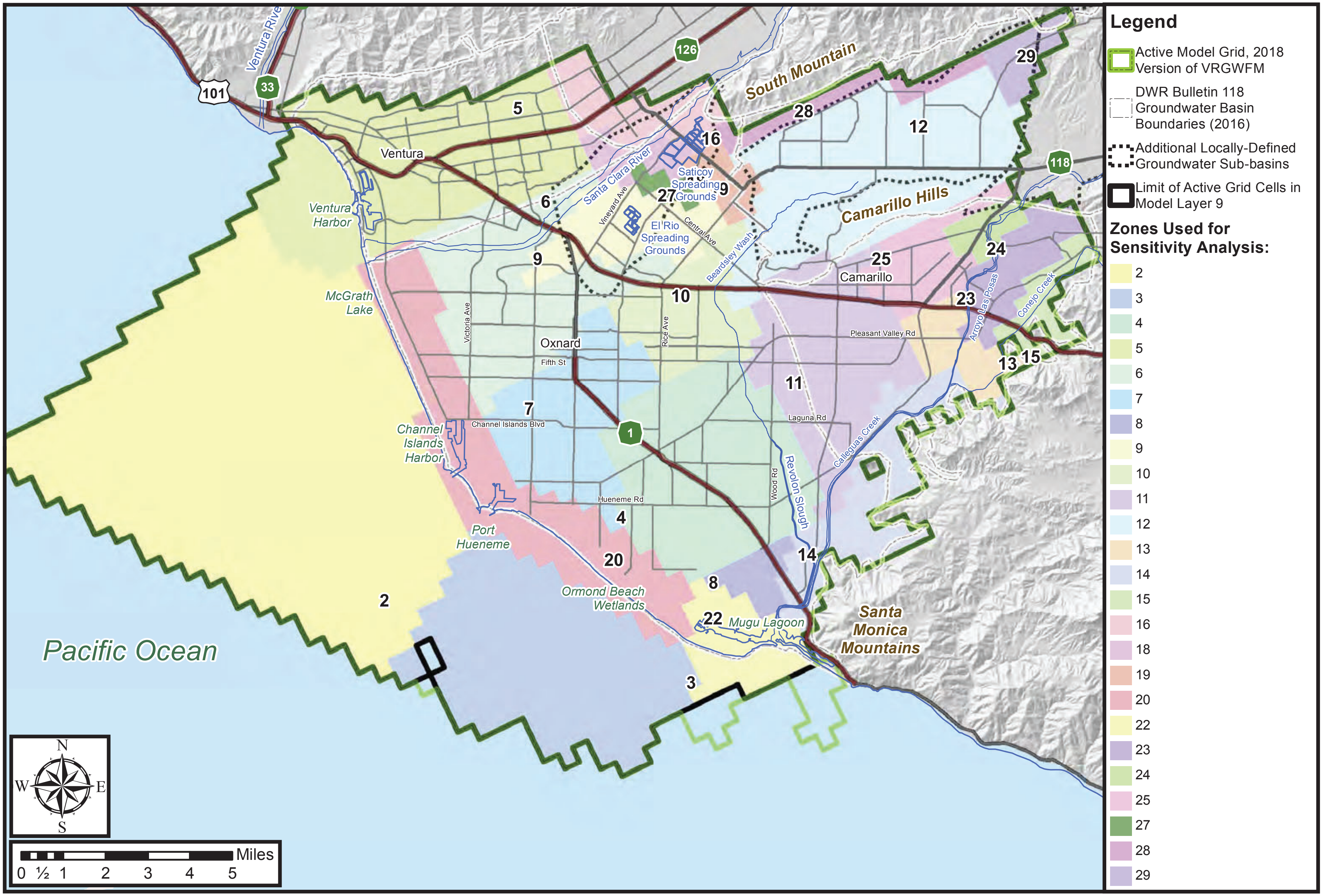

SOURCE: Figure 4-53; UWCD, 2018

DUDEK

Groundwater Sustainability Plan for the Pleasant Valley Basin

FIGURE 2-45

UWCD Model Zones

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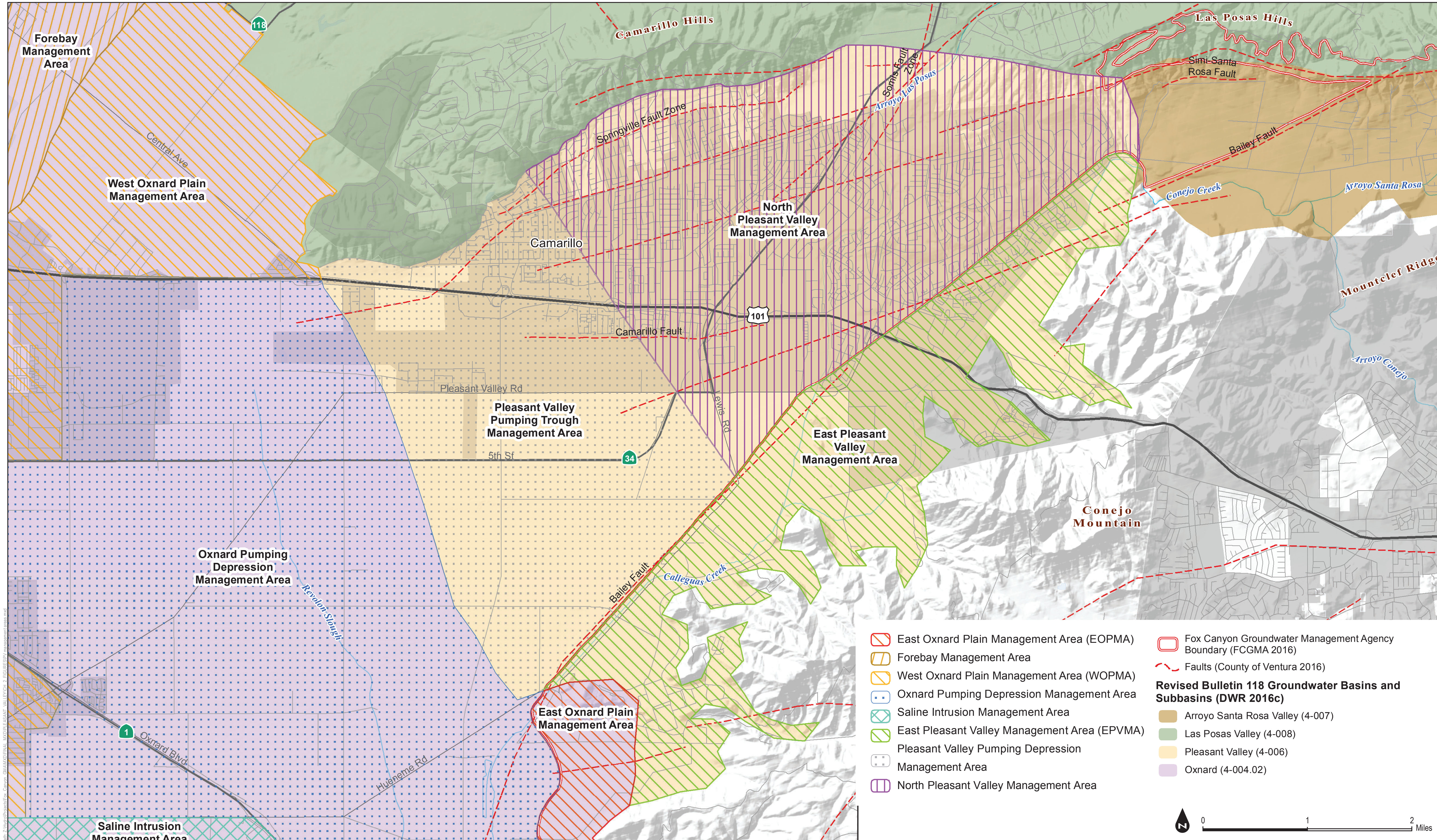

SOURCE: DWR; County of Ventura

FIGURE 2-46

Pleasant Valley Basin Management Areas

DUDEK

Groundwater Sustainability Plan for the Pleasant Valley Basin

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