CHAPTER 3
SUSTAINABLE MANAGEMENT CRITERIA

3.1 INTRODUCTION TO SUSTAINABLE MANAGEMENT CRITERIA

In the Pleasant Valley Basin (PVB), significant and unreasonable chronic declines in groundwater levels, along with a corresponding loss of storage and potential for subsidence due to groundwater withdrawal are the primary undesirable results that can occur when groundwater production exceeds the sustainable yield. Groundwater elevations in the Fox Canyon Aquifer (FCA) declined by more than 50 feet throughout the PVB since the onset of drought in 2011 (Chapter 2, Basin Setting). In order to effectively manage the groundwater resources of the PVB, the PVB has been divided into three management areas (see Section 2.5, Management Areas, Figure 2-46, Pleasant Valley Basin Management Areas). These areas are defined by differences in their hydrogeologic properties, relative influence on the Oxnard Subbasin, groundwater quality, or historical groundwater elevations.

Critically, declines in groundwater elevation in the PVB affect the groundwater gradient across the boundary between the PVB and the Oxnard Subbasin of the Santa Clara River Valley Groundwater Basin (Oxnard Subbasin). Changes to this gradient impact seawater intrusion in the Oxnard Subbasin, which is in hydraulic communication with the PVB (Chapter 2). The boundary between the PVB and the Oxnard Subbasin is not a barrier to flow, but rather is based on a change of lithology in the Upper Aquifer System (UAS) (see Chapter 2). In the Lower Aquifer System (LAS), the FCA and the Grimes Canyon Aquifer are continuous across the boundary. Therefore, although the PVB has not experienced direct seawater intrusion historically, determination of the sustainable management criteria for the PVB is coupled to sustainable management of the Oxnard Subbasin.

On October 28, 2015, the Fox Canyon Groundwater Management Agency (FCGMA) Board of Directors (Board) adopted the following planning goals regarding management of the basins within its jurisdiction (FCGMA 2015):

- Control saline water impact front at its current position.
- Do not allow groundwater quality to further degrade without mitigation.
- No net subsidence due to groundwater withdrawal.
- Promote water levels that mitigate or minimize undesirable results (including pumping trough depressions, surface water connectivity, and chronic lowering of water levels).

These goals, which apply to all basins within FCGMA jurisdiction, guide the definition of undesirable results, minimum thresholds, and measurable objectives in the subsequent sections.

Groundwater elevations are the primary metrics by which progress toward meeting the sustainability goals in the PVB will be measured. Sustainable management of the PVB does not necessarily mean, however, that springtime high groundwater levels in the basin remain the same year over year. Rather sustainability can be achieved over cycles of drought and recovery, so long as the impacts to the basins that may occur during periods of drought are not significant or unreasonable. Thus, year over year, groundwater levels may decline during a drought, but sustainable management will result in groundwater levels—and, by extension, land surface elevations and groundwater in storage—returning to pre-drought levels in the wet years following a drought.

3.2 SUSTAINABILITY GOAL

The primary sustainability goal in the PVB is to maintain a sufficient volume of groundwater in storage in the older alluvium and the LAS so that there is no net decline in groundwater elevation or storage over wet and dry climatic cycles. Further, groundwater levels in the PVB should be maintained at elevations that are high enough to not inhibit the ability of the Oxnard Subbasin to prevent net landward migration of the saline water impact front (see Section 3.3.3, Seawater Intrusion) after 2040.

The sustainability goal for the PVB recognizes the influence of climatic cycles on groundwater elevations over multi-year periods and requires that assessment of undesirable results in the PVB be tied to a time period over which net impacts are measured. This Groundwater Sustainability Plan (GSP) assesses net impacts to the Oxnard Subbasin over both a 50-year period beginning in 2020, and a 30-year period beginning in 2040. Undesirable results may occur in the Subbasin between 2020 and 2039, as progress is made toward sustainable management. By 2040, however, management of the Subbasin should achieve the sustainability goal. The 30-year period from 2040 through 2069 is referred to as the sustaining period in this GSP, as it is the period on which the evaluation of sustainability is based.

Historically, groundwater elevations in the PVB have declined and recovered over climatic cycles, assisted in part by additional recharge to the PVB beginning in the late 1980s and early 1990s (Chapter 2). However, groundwater elevations in the Mugu Aquifer equivalent unit in the older alluvium have been below sea level since 1990 (Figure 2-13, Groundwater Elevation Hydrographs in the Older Alluvium) and groundwater elevations in the FCA have been below sea level throughout much of the PVB since 1975 (Figure 2-16, Groundwater Elevation Hydrographs in the Fox Canyon Aquifer). In order to achieve the sustainability goal, groundwater production from the PVB will need to be reduced relative to historical groundwater production rates so that groundwater elevations in the older alluvium and in the UAS are high enough to allow the Oxnard Subbasin to eliminate net migration of the saline water impact front after 2040. During the first 5 years following GSP adoption, it is anticipated that the combined groundwater production from both the older alluvium and the LAS will begin to be reduced toward the estimated sustainable yield, accounting for the uncertainty assessed in the model water budget and sustainable yield predictions (Section 2.4, Water Budget).

Proposed reductions in groundwater production must take into account the potential economic disruption to the agricultural industry, M&I, and the uncertainty in the estimated sustainable yield of the PVB. The estimated sustainable yield of the PVB is approximately 11,600 acre-feet per year (AFY), with an uncertainty estimate of ±1,200 AFY (see Section 2.4.4, Uncertainties in the Water Budget). The average 2015 groundwater production rate was approximately 13,200 AFY. The difference between the upper estimate of the sustainable yield, 12,600 AFY, and the 2015 production rate is 600 AFY. If production is reduced linearly between 2020 and 2040, the estimated groundwater production reduction necessary throughout the geographic extent of the PVB over the first 5 years is approximately 150 AFY. However, the sustainability goal allows for operational flexibility, as groundwater production patterns are anticipated to change during the GSP implementation period. Progress toward sustainability will be evaluated throughout the 20-year implementation period from 2020 through 2039. The estimated sustainable yield may be revised based progress towards sustainability in PVB and the Oxnard Subbasin.

The following sections describe the undesirable results that have occurred and may occur within the PVB, the minimum thresholds developed to avoid future undesirable results, and the measurable objectives that account for the need to continue groundwater production during drought cycles and the associated interim milestones to help gauge progress toward sustainability over the next 20 years.

3.3 UNDESIRABLE RESULTS

Under the Sustainable Groundwater Management Act (SGMA), undesirable results occur when the effects caused by groundwater conditions occurring throughout the basin cause significant and unreasonable impacts to any of the six sustainability indicators. These sustainability indicators are as follows:

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

The definition of what constitutes a significant and unreasonable impact for each sustainability indicator is determined by the Groundwater Sustainability Agency (GSA), which is FCGMA in the PVB, using the processes and criteria set forth in the GSP. Each of the sustainability indicators is discussed below, in the context of undesirable results.

3.3.1 Chronic Lowering of Groundwater Levels

Chronic lowering of groundwater levels resulting in a significant and unreasonable depletion of supply is an undesirable result applicable to the PVB. Chronic lowering of groundwater levels in the PVB is also associated with depletion of groundwater in storage, degradation of groundwater quality, and subsidence. Depletion of groundwater in storage will occur in the PVB if groundwater production exceeds the natural and artificial recharge over a multi-year period that includes both wetter than average and drier than average conditions. Degradation of groundwater quality may occur in the PVB if water levels fall below threshold elevations that maintain sufficient hydrostatic pressure to prevent upwelling of brines along the Bailey Fault and from the geologic formations underlying the PVB. Subsidence can occur in the PVB if groundwater elevations fall below historical low water levels for a sufficient time to allow collapse of the pore structure and settling of geologic formations.

Direct seawater intrusion is not a concern in the PVB (see Section 3.3.3); however, groundwater elevations in the PVB impact groundwater elevations in the Oxnard Subbasin to the west. Consequently, chronic lowering of groundwater levels in the PVB has the potential to exacerbate seawater intrusion in the Oxnard Subbasin and may inhibit the ability of the Oxnard Subbasin to prevent net landward migration of the saline water impact front after 2040. This potential is greatest in the Pleasant Valley Pumping Depression Management Area (PVPDMA), which is adjacent to the Oxnard Subbasin. Declines in groundwater elevation in the eastern part of the North Pleasant Valley Management Area (NPVMA) are less likely to influence seawater intrusion in the Oxnard Subbasin.

The primary cause of groundwater conditions in the PVB that would lead to chronic lowering of groundwater levels is groundwater production in excess of natural and artificial recharge. Groundwater production from the PVB would result in significant and unreasonable lowering of groundwater levels if the groundwater levels were lowered to an elevation below which:

- Groundwater levels do not recover to pre-drought conditions during multi-year periods of above-average precipitation that follow a drought.
- The Oxnard Subbasin is unable to prevent net landward migration of the saline water impact front after 2040.
- The brine migration along the Bailey Fault and from underlying formations is measurably increased.
- Subsidence that substantially interferes with surface land uses is induced.

Of these criteria, chronic lowering of groundwater levels and impacting the landward migration of the saline water impact front are the most likely to occur in the PVB. Historically, the PVB has not experienced subsidence that substantially interfered with surface land uses, and no direct correlation between groundwater elevation and brine concentration has been established.

Groundwater elevations have created low-pressure conditions that have the potential to promote the migration of brines along faults and the upwelling of brines from deeper formations (FCGMA 2007; UWCD 2016).

Historically, groundwater elevations in the PVB have recovered over climate cycles (Section 2.3, Groundwater Conditions). Some of this recovery, however, is related to increased recharge to the PVB since 1990 (see Chapter 2). Since 2010, groundwater elevations in several wells have declined in response to the combined influences of reduced groundwater flow across the boundary with the East Las Posas Management Area (ELPMA), drought, and groundwater production. Continued groundwater production at the current rates may not allow groundwater elevations to recover after the drought, because recharge from the ELPMA has been reduced since 2006 (see Section 2.4).

Additionally, PVB groundwater elevations below sea level in the LAS have impacted groundwater elevations in the LAS in the Oxnard Subbasin where net seawater intrusion has occurred over climate cycles of drought and recovery. In October 2015, groundwater elevations in the FCA in the western part of the PVB adjacent to the Oxnard Subbasin ranged from −125.12 to −117.51 feet above mean sea level (msl) (Figure 2-15, Groundwater Elevation Contours in the Fox Canyon Aquifer, October 2–29, 2015; Section 2.3.1.3, Fox Canyon Aquifer). These elevations are lower than groundwater elevations in the FCA at the coast in the Oxnard Subbasin, which is currently experiencing seawater intrusion. Groundwater elevations in Well 01N21W03C01, in PVB, have been below sea level since they were first measured in the 1970s, corresponding to the time during which seawater intrusion was first detected in the LAS Oxnard Subbasin. Because groundwater elevations in both the older alluvium and the LAS have been below sea level historically, are currently lower than groundwater elevations at coastal wells in the Oxnard Subbasin, and are not separated from the aquifers of the Oxnard Subbasin by subsurface barriers to flow, the current groundwater elevations are contributing to seawater intrusion in the Oxnard Subbasin. Furthermore, groundwater elevations in the Oxnard Subbasin are currently too low to prevent seawater intrusion (FCGMA 2019). The minimum thresholds to prevent seawater intrusion in the Oxnard Subbasin are 10 to 100 feet higher than the groundwater elevations measured in 2015. Consequently, groundwater elevations in the PVB that will allow the Oxnard Subbasin to control seawater intrusion must also be higher than the October 2015 groundwater elevations. Therefore, the minimum thresholds for the PVB are directly tied to the undesirable results in the Oxnard Subbasin.

Based on the FCGMA sustainability goals for the coordinated management of the PVB and the Oxnard Subbasin, the criteria used to define undesirable results for chronic lowering of groundwater levels in the PVPDMA and the western part of the NPVMA are groundwater levels that indicate a long-term decline over periods of drought and recovery, and net landward migration of the 2015 saline water impact front after 2040. It is expected that there will be some landward migration of this front between 2020 and 2040 as the FCGMA Board and stakeholders undertake the necessary projects and management actions toward achieving sustainability in 2040. The minimum thresholds metric against which chronic lowering of groundwater levels will be measured is groundwater levels that were selected to prevent net landward migration of the 2015 saline water impact front, and net seawater intrusion over the 30-year sustaining period from 2040 through 2069. These groundwater elevations are higher than previous historical low water levels, many of which were measured in the fall of 2015 (Table 3-1; Figures 3-1 through 3-5, Minimum Thresholds and Groundwater Elevation Contours).

The criterion used to define undesirable results for chronic lowering of groundwater levels in the eastern part of the NPVMA is groundwater levels that indicate a long-term decline over periods of drought and recovery. The minimum thresholds metric against which chronic lowering of groundwater levels will be measured is groundwater levels from which complete recovery can be achieved over anticipated periods of drought and above average precipitation.

Groundwater elevations within each management area will be used to determine whether significant and unreasonable chronic lowering of groundwater levels is occurring and affecting the Oxnard Subbasin. All of the management areas except the East Pleasant Valley Management Area (EPVMA) have wells in which water levels can be monitored. Until a monitoring well is installed in the EPVMA, the water level thresholds set for the wells closest to the EPVMA are presumed to be protective for the EPVMA, which has considerably less groundwater production than the adjoining management areas. This presumption will be revisited as groundwater elevation data are collected from the EPVMA.

Chronic lowering of groundwater levels in the PVB has the potential to impact the beneficial uses and users of groundwater in the PVB and the adjacent Oxnard Subbasin by (1) exacerbating seawater intrusion in the Oxnard Subbasin, (2) reducing the volume of freshwater in storage, and (3) causing groundwater levels to drop below current well screens.

3.3.2 Reduction of Groundwater Storage

Reduction of groundwater storage resulting in a significant and unreasonable depletion of supply is an undesirable result applicable to the PVB. Reduction of groundwater storage in the PVB is also associated with chronic lowering of groundwater levels, degradation of groundwater quality, and subsidence. Additionally, because reduction of groundwater storage in the PVB is correlated with declines in groundwater elevations, reduction in groundwater storage in the PVB has the potential to exacerbate seawater intrusion in the Oxnard Subbasin and may inhibit the ability of the Oxnard Subbasin to prevent net landward migration of the 2015 saline water impact front after 2040. Landward migration will occur in the Oxnard Subbasin if groundwater levels in the PVB fall below threshold levels that maintain sufficient hydrostatic pressure to keep seawater from moving landward. The threshold groundwater levels differ between the older alluvium and the LAS, as well as with geographic location in the PVB.

The primary cause of groundwater conditions in the PVB that would lead to reduction in groundwater storage is groundwater production in excess of recharge over cycles of drought and recovery. Groundwater production from the PVB may result in a significant and unreasonable reduction of groundwater in storage if the volume of water produced from the basin exceeds the volume of freshwater recharging the basin over a cycle of drought and recovery. Changes in groundwater in storage can be tracked using groundwater elevations and would become significant and unreasonable if (1) groundwater levels were lowered to an elevation below which they could not recover during a multi-year period of above-average precipitation or (2) groundwater levels in the PVB were lowered to elevations below which the Oxnard Subbasin would experience net seawater intrusion in the UAS and LAS over cycles of drought and recovery from 2040 through 2069.

Numerical model groundwater model simulations indicate that since 1985 the volume of groundwater in storage has increased in the older alluvium and the LAS (Section 2.3.2, Estimated Change in Storage; UWCD 2018). This overall increase reflects rising groundwater levels between water years 1991 and 2006 (Figure 2-18, Cumulative Change in Storage). These water levels are independent of water year type because they were driven by increased recharge as perennial flow from wastewater treatment plant (WWTP) discharge and dewatering wells in Simi Valley reached the PVB. As these flows were diminished, groundwater production exceeded recharge in the PVB and the quantity of groundwater in storage decreased. Between water year 2006 and 2015, the older alluvium lost an average of 2,200 AFY from storage and the LAS lost an average of 670 AFY. The rate of storage loss increased during the drought beginning in 2011.

Based on the sustainability goals for the PVB, the criteria used to define undesirable results for reduction in groundwater storage are groundwater levels that indicate a long-term decline over periods of drought and recovery, and landward migration of the 2015 saline water impact front in the Oxnard Subbasin after 2040. The minimum thresholds metric against which reduction in groundwater storage will be measured in the PVPDMA and the western part of the NPVMA is water levels that were selected to prevent net landward migration of the 2015 saline water impact front, and net seawater intrusion after 2040. These groundwater elevations are higher than previous historical low water levels (Table 3-1). The minimum thresholds metric against which reduction in groundwater storage will be measured in the eastern part of the NPVMA is a groundwater level that allows for complete recovery during multi-year periods of above-average precipitation that follow a drought.

Groundwater elevations within each management area of the PVB will be used to determine whether significant and unreasonable reduction of groundwater in storage is occurring. All of the management areas except the EPVMA have wells in which water levels can be monitored. Until a monitoring well is installed in the EPVMA, the water level thresholds set for the wells closest to the EPVMA are presumed to be protective for the EPVMA, which has considerably less groundwater production than the adjoining management areas. This presumption will be revisited as groundwater elevation data are collected from the EPVMA.

Reduction of groundwater storage has the potential to impact the beneficial uses and users of groundwater in the PVB by limiting the volume of groundwater available for agricultural, municipal, industrial, and domestic use. These impacts will affect all users of groundwater in the PVB.

3.3.3 Seawater Intrusion

Seawater intrusion resulting in a significant and unreasonable depletion of supply is not an undesirable result that applies to the PVB. Direct seawater intrusion has not occurred historically in the PVB. Seawater intrusion has impacted the Oxnard Subbasin, which is adjacent to and in hydraulic communication with the PVB. Currently, the area of the Oxnard Subbasin impacted by concentrations of chloride greater than 500 milligrams per liter (mg/L) is generally west of Highway 1 and south of Hueneme Road. Sources of water high in chloride in the Oxnard Subbasin include modern seawater as well as non-marine brines and connate water in fine-grained sediments. Therefore, this area is referred to as the "saline water impact area," rather than the "seawater intrusion impact area," to reflect all the potential sources of chloride to the aquifers in this area.

Because the PVB and the Oxnard Subbasin are in hydraulic communication, it is theoretically possible for seawater intrusion to impact the PVB. However, particle tracks from groundwater model simulations that continue the present groundwater production rates in the PVB and the Oxnard Subbasin over the next 50 years suggest that the current extent of the saline water impact front will not progress farther east than Wood Road in the southeastern part of the Oxnard Subbasin (FCGMA 2019). This is still approximately 2.5 miles southwest of the boundary between the PVB and the Oxnard Subbasin. Additionally, FCGMA is the GSA for both the Oxnard Subbasin and the PVB and has the authority to manage groundwater flows between the Oxnard Subbasin and the PVB to prevent the net landward migration of the 2015 saline water impact front. Therefore, seawater intrusion is unlikely to occur in the PVB in the future. Because seawater intrusion has not occurred historically in the PVB and is not likely to occur in the PVB in the future, specific criteria for undesirable results related to seawater intrusion are not established in this GSP.

3.3.4 Degraded Water Quality

3.3.4.1 Chloride and TDS

Degraded water quality resulting in a significant and unreasonable depletion of supply is an undesirable result applicable to the PVB. Increases in chloride and total dissolved solids (TDS) have been observed in the northern part of the NPVMA, adjacent to the ELPMA, where perennial flows of WWTP and shallow dewatering well discharge along Arroyo Simi–Las Posas have flowed into the PVB both as subsurface recharge in the Shallow Alluvial Aquifer and at times as surface water flow in the Arroyo Simi–Las Posas. Additionally, parts of the PVPDMA have experienced increases in chloride and TDS associated with upward migration of brines from deeper geologic formations (USGS 1996; UWCD 2016).

Degradation of groundwater quality from increased concentrations of chloride and TDS has the potential to impact the beneficial uses and users of groundwater in the PVB by (1) limiting the volume of groundwater available for agricultural, municipal, industrial, and domestic use or (2) requiring construction of treatment facilities to remove the constituents of concern. Existing groundwater quality in the NPVMA has already impaired municipal use by the City of Camarillo (City of Camarillo 2015).

The primary causes of groundwater conditions in the PVB that would lead to degradation of water quality from increased concentrations of TDS and chloride vary geographically within the PVB. In the northern part of the NPVMA, ongoing subsurface inflows from the Las Posas Valley Basin are the primary cause of degradation of water quality. Groundwater production from the NPVMA may result in a significant and unreasonable degradation of water quality if the groundwater gradient causes expansion of the currently impacted area into areas that were not previously impacted, thereby limiting agricultural and potable use.

In the PVPDMA, lowered groundwater elevations from groundwater production may influence the rate of brine migration from underlying formations and along the Bailey Fault. To date, however, no causal effect between groundwater production and chloride concentrations has been established in the PVPDMA. Groundwater production from the PVPDMA may result in a significant and unreasonable degradation of water quality if areas that have not previously been impacted become impacted by chloride and TDS concentrations that limit agricultural and potable use.

Based on the sustainability goals for the PVB, the criteria used to define undesirable results for degraded water quality in the PVPDMA and the NPVMA are groundwater elevations that indicate a long-term decline over periods of drought and recovery, and groundwater elevations in the PVB that impact landward migration of the 2015 saline water impact front in the Oxnard Subbasin after 2040. The minimum thresholds metric against which degradation of water quality will be measured is groundwater levels that were selected to accomplish these dual goals. These groundwater elevations are equal to, or higher than, previous historical low water levels (Table 3-1).

Water quality will continue to be monitored over the next 5 years. As additional data are collected, the effectiveness of applying a water level threshold to groundwater quality degradation will continue to be assessed.

Sustainable groundwater management of the PVB will mitigate or minimize the undesirable result of degraded water quality from migration of brackish water or brines related to groundwater production. The relationship between groundwater quality impacts from flows along Arroyo Simi–Las Posas that originate outside of the PVB and groundwater production within the PVB is not well established. This constitutes a data gap that will be evaluated over the next 5 years.

3.3.4.2 Nitrate, Sulfate, and Boron

Concentrations of nitrate, sulfate, and boron are above the Water Quality Objectives in some wells in the PVB; however, these concentrations are not caused by groundwater conditions occurring throughout the PVB. Rather, these concentrations reflect the influence of past land use practices in both the PVB and adjacent basins, as well as surface water flows to Arroyo Simi–Las Posas and Conejo Creek upstream of the PVB boundary.

Degradation of groundwater quality from increased concentrations of nitrate, sulfate, and boron has the potential to impact the beneficial uses and users of groundwater in the basin by (1) limiting the volume of groundwater available for agricultural, municipal, industrial, and domestic use or (2) requiring construction of treatment facilities to remove the constituents of concern. Existing groundwater quality in the northern part of the NPVMA has already impaired municipal use by the City of Camarillo (City of Camarillo 2015).

The primary cause of groundwater conditions in the PVB that would lead to degradation of water quality from increased concentrations of nitrate, sulfate, and boron is ongoing subsurface inflows from the Las Posas Valley Basin. Groundwater production from the NPVMA may result in a significant and unreasonable degradation of water quality if areas that have not previously been impacted become impacted by nitrate, sulfate, and boron concentrations that limit agricultural and potable use.

Based on the sustainability goals for the PVB, the criteria used to define undesirable results for degraded water quality from nitrate, sulfate, and boron are groundwater elevations that indicate a long-term decline over periods of drought and recovery, and landward migration of the 2015 saline water impact front in the Oxnard Subbasin after 2040. The minimum thresholds metric against which degradation of water quality will be measured is groundwater levels that were selected to prevent long-term declines over periods of drought and recovery. These groundwater elevations are equal to, or higher than, previous historical low water levels (Table 3-1).

The relationship between groundwater quality impacts from flows along Arroyo Simi–Las Posas that originate outside of the PVB and groundwater production within the PVB is not well established. This constitutes a data gap that will be evaluated over the next 5 years. Water quality will continue to be monitored at monitoring well locations identified by FCGMA and its partner agencies. As additional data are collected, the effectiveness of applying a water level threshold to groundwater quality degradation will continue to be assessed.

3.3.5 Land Subsidence

The undesirable result associated with land subsidence in the PVB is subsidence that substantially interferes with surface land uses. The FCGMA Board resolution discussed in Section 3.1, Introduction to Sustainable Management Criteria, calls for groundwater management that will not result in net subsidence due to groundwater withdrawal. Subsidence related to groundwater withdrawal can occur as groundwater elevations decline below previous historical low water levels, because the groundwater acts to reduce the effective stress, or pressure, on the sediment in the Subbasin. As water levels decline, the pressure on the sediment matrix increases, and the pore structure of the sediment can collapse, resulting in subsidence.

Land subsidence related to groundwater production has the potential to impact the beneficial uses and users of groundwater in the PVB by interfering with surface land uses in a way that causes additional costs from releveling fields, replacing surface infrastructure, and other actions necessitated by surface land use interference.

Groundwater production is only one cause of subsidence in the PVB. In addition to groundwater production, tectonic forces and oil and gas production can also result in subsidence in the PVB (Section 2.3.5, Subsidence). Currently there are no monitoring stations that separate the effects of groundwater withdrawal from those of the other causes of subsidence.

Groundwater production from the PVB may result in significant and unreasonable land subsidence if the subsidence "substantially interferes with surface land uses" (California Water Code, Section 10721[x][5]). Direct measurement of historical subsidence in Pleasant Valley is limited geographically and temporally (Section 2.3.5). The California Department of Water Resources (DWR) designated the PVB as an area that has a low potential for future subsidence (DWR 2014).

Even though substantial interference with land surface uses is not anticipated, actions taken in both the Oxnard Subbasin and the PVB to prevent long-term declines in groundwater storage and net landward migration of the 2015 saline water impact front in the Oxnard Subbasin will minimize the potential for subsidence related to groundwater production in the PVB. The minimum thresholds metric against which subsidence will be measured is water levels in the PVPDMA and western part of the NPVMA that allow the Oxnard Subbasin to prevent landward migration of the 2015 saline water impact front after 2040. These groundwater elevations are equal to, or higher than, previous historical low water levels, which will limit the potential for future land subsidence in the PVPDMA and western NPVMA resulting from groundwater withdrawal (Table 3-1).

In the northern part of the NPVMA, the minimum thresholds metric against which subsidence will be measured is a groundwater level that allows for complete recovery during multi-year periods of above-average precipitation that follow a drought. Although the minimum threshold groundwater elevation in a key well is lower than the historical low measured in that well, groundwater elevations in adjacent wells have been lower in the past (see Appendix C, Water Elevation Hydrographs). Additionally, because groundwater elevations will be offset by groundwater recovery over multi-year drought cycles, the potential for future land subsidence in the NPVMA resulting from groundwater withdrawal in the northern NPVMA is limited.

3.3.6 Depletions of Interconnected Surface Water

The undesirable result associated with depletion of interconnected surface water in the PVB is loss of groundwater-dependent ecosystem (GDE) habitat. Although lower Arroyo Simi–Las Posas, Calleguas Creek, and Conejo Creek were identified as potential GDEs, which are potentially connected to the Shallow Alluvial Aquifer, there are no dedicated monitoring wells that identify groundwater elevations in the vicinity of these potential GDEs.

The primary cause of groundwater conditions in the PVB that could lead to lowering of the groundwater table in the Shallow Alluvial Aquifer is reduced streamflow in these creeks, both upstream and within the boundaries of the PVB. Additionally, groundwater production within the Shallow Alluvial Aquifer can lower the groundwater elevation near the potential GDEs. Few wells produce from the Shallow Alluvial Aquifer, and no production wells are screened solely within this aquifer (Section 2.4.1.2, Imported Water Supplies).

Because lower Arroyo Simi–Las Posas, Calleguas Creek, and Conejo Creek are ephemeral streams; groundwater elevations in the Shallow Alluvial Aquifer, where known, are deeper than 30 feet below land surface; and few wells produce from the Shallow Alluvial Aquifer within the boundaries of the PVB, depletion of interconnected surface water in the PVB is not currently occurring and is unlikely to occur in the future. Installation of monitoring wells screened in the Shallow Alluvial Aquifer in the vicinity of the potential GDEs will help clarify whether the ecosystems along these creeks are using pore water from infiltrating surface water or are accessing shallow groundwater. If future projects propose to use water from the Shallow Alluvial Aquifer, depletion of interconnected surface water may be possible, and significant and unreasonable impacts may occur. Reevaluation of the effects on potential GDEs should be conducted in conjunction with the project approval process for any such future projects.

If the currently identified potential GDEs are found to depend on groundwater in the future, depletion of interconnected surface water in the PVB has the potential to negatively impact the health of the GDEs. However, the link between groundwater in the Shallow Alluvial Aquifer and the location of the potential GDEs must be established before possible impacts to the health of the potential GDEs can be determined.

3.3.7 Defining a Basin-Wide Undesirable Result

To better manage groundwater production and projects within the PVB, the PVB has been divided into three management areas (see Section 2.5). The majority of the groundwater production in the PVB is in the PVPDMA and the NPVMA. The EPVMA supports limited groundwater production, and no groundwater monitoring wells were identified in this management area. Within the PVPDMA and the NPVMA, historical groundwater production is roughly equally divided between the older alluvium and the LAS (Table 2-10, Groundwater Extraction).

There are a limited number of wells in the PVB that can be used to monitor conditions in the older alluvium and the LAS (Table 3-1). Eight wells were selected in the PVPDMA and one well was selected in the NPVMA. Of the eight wells selected in the PVPDMA, three are screened in the older alluvium, three are screened in the LAS, and two are screened in both the older alluvium and the LAS. The only well selected to monitor conditions in the NPVMA is screened in the LAS. The limited number of wells introduces uncertainty in defining basin-wide effects. There are currently too few wells in the PVB to separate out potential undesirable results in the older alluvium from those in the LAS. Therefore, until additional monitoring wells are drilled and additional data are gathered, basin-wide undesirable results will not distinguish between the aquifers. Additionally, the basin-wide effects are not defined based on management area because there is only one suitable key well in the NPVMA.[1]

Basin-wide undesirable results are defined in three ways for the PVB. The first is based on the total number of wells, independent of management area or aquifer. Under this definition, the PVB will be determined to be experiencing undesirable results if, in any single monitoring event, water levels in four of the nine key wells are below their respective minimum thresholds.

The second definition of undesirable results for the PVB is based on the degree to which a single well exceeds a minimum threshold. Under this definition, the PVB would be determined to be experiencing an undesirable result if the groundwater elevation at any individual key well exceeded the historical low groundwater elevation at the individual monitoring site, or in a nearby well if the historical record at the monitoring location is not long enough to capture the historical low water levels in the PVB. This additional criterion reflects the need to increase groundwater elevations relative to their historical lowest values, as well as the unknown potential consequences should groundwater elevations at an individual site drop below the historical low. Two key wells do not have a sufficiently long historical record to capture previous historical low water levels in the PVB. These wells are Well 02N20W19M05S, in the northern part of the NPVMA, and Well 01N32W04K01S, in the PVPDMA. For these wells, the historical low groundwater elevations were selected for nearby wells with longer historical records (Table 3-1). The historical low elevation for Well 02N20W19M05S will be −167.7 feet msl, which is the low water level recoded in Well 02N20W19M04S on October 20, 1988 (see Appendix C). The historical low elevation for Well 01N32W04K01S will be −164.3 feet msl, which is the low water level recorded in Well 1N32W04M01S on November 12, 1991.

The third definition of undesirable results is based on the time over which a well may exceed the minimum threshold. Under this definition, the PVB would be determined to be experiencing an undesirable result if the water level in any individual key well were below the minimum threshold

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1 The City of Camarillo is installing two nested groundwater monitoring wells as part of the development of the North Pleasant Valley Desalter project. These wells will be added to the network of monitoring wells in the NPVMA when they have been completed.

for either three consecutive monitoring events or three of five consecutive monitoring events. Monitoring events are scheduled to occur in the spring and fall of each year.

If conditions in the PVB meet any of the definitions of undesirable results listed above, the PVB would be considered to be experiencing undesirable results.

3.4 MINIMUM THRESHOLDS

The following sections and discussion set forth the minimum thresholds for chronic lowering of groundwater levels, reduction of groundwater storage, degraded water quality, land subsidence, and depletions of interconnected surface water. A minimum threshold is not established for seawater intrusion because direct seawater intrusion has not occurred and is unlikely to occur in the future in the PVB (Section 3.3.3). The thresholds discussed below are the minimum groundwater elevations at individual wells that avoid undesirable results, which have been defined as follows:

- Groundwater levels in the PVB that do not recover to pre-drought levels during multi-year periods of above average precipitation that follow a drought
- Increased rate of brine migration along the Bailey Fault and from underlying formations related to groundwater production
- Induced subsidence that substantially interferes with surface land uses
- Water levels in the PVB that prevent the Oxnard Subbasin from stopping net landward migration of the saline water impact front after 2040

Of the undesirable results listed above, only brine migration from underlying formations and along the Bailey Fault and water levels that contribute to seawater intrusion in the Oxnard Subbasin have occurred historically within the PVB.

The results of groundwater model simulations suggest that groundwater elevations in the PVB will need to be higher than the recorded historical low elevations in order for the Oxnard Subbasin to prevent net migration of the saline water impact front after 2040 (Section 2.4.5, Projected Water Budget). Because the groundwater elevations necessary to prevent net migration of the saline water impact front are higher than those necessary to prevent other undesirable results, the minimum thresholds proposed for the PVPDMA and the western part of the NPVMA are water levels that do not interfere with the ability of the Oxnard Subbasin to prevent net seawater intrusion after 2040 (Table 3-1). These minimum thresholds apply to chronic lowering of water levels, change in groundwater storage, groundwater quality, and land subsidence because all of these undesirable results are interrelated. The minimum thresholds for the northern part of the NPVMA are water levels that allow for complete recovery during multi-year periods of drought and recovery.

The minimum threshold groundwater levels are based on a review of the historical groundwater elevation data, incorporation of potential projects, and an analysis of the potential for seawater intrusion in the Oxnard Subbasin under multiple future groundwater production scenarios. Predicted groundwater levels were simulated over a 50-year period from 2020 to 2069 (Section 2.4.5). The future climate simulated in the model recreated the observed climate from 1930 to 1979 with adjustments to precipitation and streamflow based on climate-change factors provided by DWR. The historical period from 1930 to 1979 includes periods of drought and periods of above-average precipitation, but has the average precipitation of the entire climate record for the Oxnard Subbasin. The 50-year future simulations were used to assess the rate of groundwater production in the PVB, Oxnard Subbasin, and West Las Posas Management Area that results in no net seawater intrusion in either the UAS or the LAS in the Oxnard Subbasin after 2040.

Two simulations were found to minimize net seawater intrusion after 2040 (Figure 2-44, Coastal Flux from the UWCD Model Scenarios; Section 2.4.5). Groundwater production in the first simulation, referred to as the Reduction With Projects scenario, averaged approximately 9,000 AFY, with 2,000 AFY of production in the older alluvium, and 7,000 AFY in the LAS. This simulation incorporated projects, including temporary fallowing of land resulting in an annual extraction reduction of 2,200 AFY in the PVB (Section 2.4.5.3, Reduction With Projects Scenario). Groundwater production in the second simulation, referred to as the Reduction Without Projects Scenario 1, which did not include projects, averaged approximately 8,000 AFY, with 3,000 AFY of production in the older alluvium, and 5,000 AFY in the LAS (Section 2.4.5.4, Reduction Without Projects Scenario 1). In general, the simulated groundwater elevations in the model scenario with projects were close to those in the scenario without projects, with any observed difference between the two limited to less than approximately 10 feet (Figures 3-6 through 3-8, Key Well Hydrographs).

The minimum threshold groundwater elevations in the PVB selected to protect against net seawater intrusion in the UAS and LAS in the Oxnard Subbasin depend on the aquifer system and proximity to the Oxnard Subbasin. For wells within the PVPDMA, the minimum thresholds are based on the lowest simulated groundwater elevation after 2040 for the two model simulations in which net seawater intrusion was minimized. To account for some of the uncertainty in the simulated future groundwater elevations, the lowest simulated value in either of the two simulations was used as starting point for selecting the minimum thresholds. The lowest simulated value was then rounded down to the nearest 5-foot interval to further account for uncertainty in the future simulated groundwater elevations.

For Well 02N20W19M05S, which is located in the NPVMA in an area of the PVB that is extensively faulted and distant from the Oxnard Subbasin, the minimum threshold is based on the lowest simulated groundwater elevation from all of the future simulations investigated. This elevation was selected as the minimum threshold because the water level in this well is heavily influenced by groundwater production from the planned North Pleasant Valley Desalter project in the area. The project has its own set of restrictions on groundwater elevation declines, and was included in the modeling for future conditions in the PVB. The future groundwater model simulations suggest that water levels will recover to pre-project levels even under the highest drawdown scenario (Figure 3-7, Key Well Hydrographs for Wells Screened in the Fox Canyon Aquifer). The minimum thresholds for each well are presented in Table 3-1 and on Figures 3-6 through 3-8.

There are no proposed minimum thresholds in the EPVMA because there are no suitable monitoring wells in the EPVMA. The thresholds for the PVPDMA, which borders the EPVMA, are presumed to protect the EPVMA, which has considerably less groundwater production than the adjoining management areas (see Section 2.5). This presumption will be revisited as groundwater elevation data are collected from the EPVMA.

3.4.1 Chronic Lowering of Groundwater Levels

The selected minimum thresholds for chronic lowering of groundwater levels are presented in Table 3-1. These minimum thresholds are water levels that were selected based on future groundwater model simulations that allow groundwater elevations to recover during multi-year cycles of drought and recovery, and limit migration of the 2015 saline water impact front in the Oxnard Subbasin, after 2040. Numerical groundwater model simulations indicate that, under the conditions modeled, declines in groundwater elevations during periods of future drought will be offset by recoveries during future periods of above-average rainfall throughout all of the management areas of the PVB.

Minimum thresholds were selected for individual wells in the PVPDMA and the NPVMA. The minimum threshold selection was guided by a numerical groundwater model that incorporates production throughout the PVB, the Oxnard Subbasin, and the West Las Posas Management Area. Because the minimum thresholds are based on simulated groundwater elevations from integrated simulations across the PVB, the minimum thresholds selected for the NPVMA are consistent with those selected for the PVPDMA. These minimum thresholds are anticipated to improve the beneficial uses of the PVB by preventing chronic lowering of groundwater levels. This allows for long-term use of groundwater supplies in the PVB without ongoing loss of storage that would cause economic harm to the users of groundwater in the PVB and impair the beneficial uses of groundwater in the PVB.

These minimum thresholds may impact groundwater users in the PVPDMA and the western part of the NPVMA both by requiring an overall reduction in groundwater production relative to historical levels, and potentially by requiring a redistribution of groundwater pumping between the PVB and the adjacent Oxnard Subbasin. A redistribution of groundwater production to shift groundwater production inland may affect users of groundwater in the PVB and may require adjustment of the currently proposed minimum thresholds in the future.

The minimum thresholds for reduction of groundwater storage are water levels that will be measured at the monitoring wells listed in Table 3-1. Groundwater levels in these wells, which are referred to as "key wells," will be reported to DWR in the annual reports that will follow the submittal of this GSP. Additionally, as funding becomes available, it is recommended that each of these monitoring wells be instrumented with a pressure transducer capable of recording hourly water levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-1 to determine whether water levels in individual wells are above the minimum thresholds.

3.4.2 Reduction of Groundwater Storage

The minimum thresholds for reduction in groundwater storage in the PVB are water levels that were selected based on future groundwater model simulations that limit seawater intrusion in the Oxnard Subbasin, and indicate that declines in groundwater elevations during periods of future drought will be offset by recoveries during future periods of above-average rainfall (Table 3-1). The minimum thresholds impacts to groundwater users for reduction of groundwater storage are the same as those for chronic lowering of groundwater levels (see Section 3.4.1). These minimum thresholds are anticipated to improve the beneficial uses of the PVB by allowing for long-term use of groundwater supplies in the PVB.

The minimum thresholds for reduction of groundwater storage are water levels that will be measured at the key wells. Additionally, as funding becomes available, it is recommended that each key well be instrumented with a pressure transducer capable of recording hourly water levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-1 to determine whether water levels in individual wells are above the minimum thresholds.

3.4.3 Seawater Intrusion

No minimum thresholds are required for seawater intrusion in the PVB because the PVB is not adjacent to the Pacific Ocean (see Section 3.3.3).

3.4.4 Degraded Water Quality

Water quality impacts to the aquifers of the PVB are limited to locally high concentrations of nitrate, sulfate, boron, chloride, and TDS (Section 2.3 and Section 3.3.4, Degraded Water Quality). The sources and mechanisms controlling the concentration of these constituents differs throughout the PVB (Section 2.3). The primary water quality concerns in the PVB are inflows of poor quality surface water and saline intrusion in the FCA and the Grimes Canyon Aquifer from brine migration along the Bailey Fault. Distribution of the poor quality water is influenced by groundwater production, although groundwater production is not the cause of the poor-quality water. Groundwater production may exacerbate upward migration of brines from lower aquifers, but a direct correlation between increased brine migration and groundwater elevation has not yet been established. Additionally, the influence of groundwater production on migration of poor quality water is not well understood in the PVB. As a result, the minimum thresholds for groundwater quality are the same as the water level minimum thresholds for chronic lowering of groundwater levels (Section 3.4.1). They are groundwater elevations, rather than groundwater concentrations, that are higher than historical low elevations in the PVPDMA and the western NPVMA. Maintaining groundwater elevations above the historical low groundwater levels is anticipated to limit any increases in brine migration rates if these rates are related to groundwater elevation. Groundwater quality will continue to be monitored to evaluate the potential connection between groundwater quality and groundwater production. As the understanding of this connection improves, the minimum thresholds may be revised and may incorporate direct concentration minimum thresholds in the future.

The minimum threshold in the northern part of the NPVMA is not expected to exacerbate migration of poor quality water from the ELPMA, because it was selected in connection with a project that is intended to remove the poor quality water and treat it in an area that is already impacted (City of Camarillo 2015). Additionally, the source of the poor quality water is anticipated to decrease in the future. Over the next 5 years, additional work will be done to better understand the potential for pumping to exacerbate groundwater quality concerns in the PVB.

The minimum thresholds impacts to groundwater users for degraded water quality are anticipated to be the same as those for chronic lowering of groundwater levels and reduction of groundwater in storage, which are described in Sections 3.4.1 and 3.4.2.

The minimum thresholds for degraded water quality are water levels that will be measured at the key wells. Additionally, as funding becomes available, it is recommended that each key well be instrumented with a pressure transducer capable of recording hourly water levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-1 to determine whether water levels in individual wells are above the minimum thresholds.

3.4.5 Land Subsidence

The minimum thresholds for land subsidence in the PVB are water levels that were selected based on future groundwater model simulations that limit seawater intrusion in the Oxnard Subbasin, and indicate that declines in groundwater elevations during periods of future drought will be offset by recoveries during future periods of above-average rainfall (Table 3-1). As groundwater withdrawals will be reduced to achieve these goals in the PVPDMA and the western NPVMA, groundwater elevations in the aquifer systems will rise, and the resulting minimum thresholds are higher than historical low water levels. In the northern NPVMA, the minimum threshold groundwater elevation in Well 02N20W19M05 is lower than the historical low groundwater elevation in this well. However, the historical record in this well begins in 1999, after groundwater elevations in this area began to rise. The minimum threshold elevation selected is higher than the historical groundwater elevations for nearby wells.

Because groundwater elevations must be maintained above the minimum threshold in order to avoid undesirable results, water levels in the PVB will remain above historical low water levels after 2040. Therefore, water levels in the PVB will not induce inelastic subsidence. If the distribution of pumping is altered, the potential subsidence risk in the PVB may have to be revisited. This risk evaluation should be tied to areas in which the minimum thresholds are lowered below previous historical low water levels.

As discussed previously, the minimum thresholds are anticipated to improve the beneficial uses of the PVB by increasing the overall amount of freshwater storage in the PVB, and limiting the further intrusion of seawater in the Oxnard Subbasin. These minimum thresholds will also limit future subsidence, because currently the thresholds are greater than the historical low groundwater elevation. The minimum thresholds impacts to groundwater users for land subsidence are anticipated to be the same as those for chronic lowering of groundwater levels and depletion of groundwater storage, which are described in Sections 3.4.1 and 3.4.2.

The minimum thresholds for subsidence are water levels that will be measured at the key wells (Table 3-1). Additionally, as funding becomes available, it is recommended that each key well be instrumented with a pressure transducer capable of recording hourly water levels. The groundwater elevation in each well will be compared to the minimum threshold assigned in Table 3-1 to determine whether water levels in individual wells are above the minimum thresholds.

3.4.6 Depletions of Interconnected Surface Water

No minimum thresholds specific to the depletion of interconnected surface water are proposed at this time. Because lower Arroyo Simi–Las Posas is an ephemeral stream; groundwater elevations in the Shallow Alluvial Aquifer, where known, are deeper than 30 feet below land surface; and the Shallow Alluvial Aquifer is not used for groundwater production within the boundaries of the PVB, depletion of interconnected surface water in the PVB is not currently occurring.

Currently there is very little groundwater production from the Shallow Alluvial Aquifer. If future projects investigate producing water from the Shallow Alluvial Aquifer, these projects will have to evaluate the potential impact to interconnected surface water and GDEs as part of the feasibility and permitting process. Additionally, if projects that produce groundwater from the Shallow Alluvial Aquifer are implemented, the need for specific water-level minimum thresholds in the Shallow Alluvial Aquifer should be reevaluated.

3.5 MEASURABLE OBJECTIVES

The measurable objectives are quantifiable goals for the maintenance or improvement of specified groundwater conditions that have been included in an adopted GSP to achieve the sustainability goal. For the PVB, the measurable objective is the water level, measured at each of the key wells, at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS in the Oxnard Subbasin. If water levels in the PVB remained at the measurable objective in perpetuity, no groundwater would flow from the aquifer systems into the Pacific Ocean, and no ocean water would flow into the aquifer systems. This is the theoretical ideal water level for managing the aquifer systems of the combined PVB/Oxnard Subbasin system, because seawater intrusion would be prevented while maintaining the maximum freshwater use from the aquifer systems. However, because groundwater elevations in the PVB respond to climatic cycles, actual groundwater levels in the PVB cannot be maintained at the measurable objective indefinitely. Therefore, to allow for operational flexibility while still preventing net migration of the 2015 saline water impact front in the Oxnard Subbasin, the measurable objectives were selected to work with the minimum thresholds in the PVB and the Oxnard Subbasin.

To allow for operational flexibility during drought periods, water levels in the PVB are allowed to fall below the measurable objective, so long as they remain above the minimum threshold. As water levels fall below the measurable objective, seawater will flow toward the freshwater aquifer systems in the Oxnard Subbasin, even if the water levels remain above the minimum threshold. The longer groundwater elevations remain between the measurable objective and the minimum threshold, the greater the volume of seawater that will migrate into the aquifer systems of the Oxnard Subbasin. In order to allow the Oxnard Subbasin to prevent net seawater intrusion over periods of drought and recovery, the periods during which seawater intrusion occurs must be offset by periods when the groundwater elevations are higher.

There are two components to balancing groundwater levels over climate cycles. The first is not allowing groundwater levels in the PVB to decline below an elevation at which net seawater intrusion will occur in the Oxnard Subbasin. This elevation is the minimum threshold. The second is ensuring that periods during which groundwater levels are above the minimum threshold but below the measurable objective are offset by equal periods during which groundwater levels are above the measurable objective. Therefore, the measurable objectives for the PVB were selected based on the median groundwater elevation between 2040 and 2070, simulated for each well, in model simulations that prevented net landward migration of the 2015 saline water impact front in the Oxnard Subbasin.

The median groundwater elevation was rounded down to the nearest 5-foot interval to account for uncertainty in the model simulated future groundwater elevations. In order to account for future sea level rise, the rounded groundwater elevations were increased by 2 feet. The median simulated groundwater elevation (from 2040 to 2070) at each well after rounding and accounting for sea level rise is the measurable objective (Table 3-1). In order to prevent net seawater intrusion in the Oxnard Subbasin after 2040, observed groundwater levels in the PVB should be above the measurable objective 50% of the time. Ideally, the periods during which the water levels are above the measurable objectives will coincide with periods of above-average precipitation. If this occurs, additional reductions in groundwater production are not anticipated to be required. If, however, prolonged periods of drought limit the ability to recharge the groundwater aquifers in the Oxnard Subbasin, additional reductions in groundwater production may be required in both the Oxnard Subbasin and the PVB.

3.5.1 Chronic Lowering of Groundwater Levels

The measurable objective for the chronic lowering of groundwater levels in the PVB is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS in the Oxnard Subbasin. The measurable objective groundwater level was selected for each of the key wells (Table 3-2). At each of these wells, the difference between the measurable objective and the minimum threshold is greater than 10 feet, which provides a margin of safety for operational flexibility in the PVB.

Groundwater elevations within each management area of the PVB will be used to determine whether chronic lowering of groundwater levels is occurring. All of the management areas except the EPVMA have monitoring wells. Until a monitoring well is installed in the EPVMA, the measurable objectives set for the wells in the PVPDMA and the NPVMA, are presumed to also protect the EPVMA. The EPVMA has considerably less groundwater production than the NPVMA and does not have an independent suitable monitoring well for selecting a separate measurable objective. This presumption will be revisited as groundwater elevation data are collected from the EPVMA.

Interim Milestones for Chronic Lowering of Groundwater Levels

Interim milestones, which are target groundwater levels in 2025, 2030, and 2035 at key wells, will be used to assess progress toward sustainable groundwater management in the PVB between 2020 and 2040. The interim milestones for chronic lowering of groundwater levels are the same as the interim milestones for the other sustainability indicators, because the interim milestones measure progress toward the groundwater elevations in the PVB that will prevent undesirable results.

Two sets of interim milestones were determined for the key wells in the PVB (Table 3-2). The first set of interim milestones was calculated using linear interpolation between the fall 2015 low groundwater elevation and measurable objective (Figure 3-9, Interim Milestones for Dry and Average Conditions – Linear Interpolation). The second set was calculated using linear interpolation between the fall 2015 low groundwater elevation and the minimum threshold (Figure 3-9).

Two sets of interim milestones were calculated because the actual groundwater elevation in 2040 will depend both on groundwater production from the PVB and the climatic conditions between 2020 and 2040. Groundwater model simulations of future groundwater levels show that groundwater levels throughout the PVB vary by tens of feet at constant groundwater production rates over 5-year periods. This variability reflects the variability in annual precipitation, deliveries of surface water to the PVB, and flow in Arroyo Simi–Las Posas, Calleguas Creek, and Conejo Creek. Just as annual climate conditions vary from the calculated long-term historical mean conditions, so do 5-year average climate conditions (Figure 3-10, Distribution of 5-Year Average Climate Conditions in the Historical Record of Precipitation in the Pleasant Valley Basin). Therefore, progress toward the measurable objective must be evaluated in the context of the climate that occurred during the preceding 5 water years.

If, for example, the average precipitation from water years 2020 through 2024 (October 1, 2019, through September 30, 2024) equals the long-term historical average precipitation for the PVB, then, as groundwater production is reduced, the groundwater level at each key well should reach the interim milestone for average climate conditions shown in Table 3-2. Under these conditions, groundwater levels in the PVB would be expected to reach the measurable objective by 2040. If, however, the precipitation from water years 2020 through 2024 is less than 70% of the average long-term historical precipitation, as has occurred seven times in the historical record (Figure 3-10), reductions in groundwater production anticipated as part of this GSP would not be sufficient for groundwater elevations to reach the interim milestone for average climate conditions. In order for the PVB to be sustainable in 2040 under ongoing dry climate conditions, the interim milestones should reflect progress toward the minimum threshold at each key well, rather than the measurable objective (Figure 3-9). Five-year climate conditions that fall between average and less than 70% of average would be expected to produce interim milestone groundwater elevations between those listed in Table 3-2.

Although specific interim milestones were not selected at each key well for above average climate conditions, a similar analysis should be performed as part of the 5-year assessment process. For example, if the average precipitation from water years 2020 through 2024 exceeds 140% of the average long-term historical precipitation, as has occurred four times in the historical record (Figure 3-10), groundwater elevations in the fall of 2024 should be higher than the interim milestone groundwater elevation for average conditions listed in Table 3-2. Further, although Table 3-2 provides interim milestone groundwater elevations for the years 2030, 2035, and 2040, these interim milestones should be reassessed as part of the 5-year GSP evaluation process because of their climate dependence. The linear interpolation and resultant interim milestones should be updated based on the measured water level in the fall of 2024, 2029, and 2034 at each key well.

3.5.2 Reduction of Groundwater Storage

The measurable objective for reduction of groundwater in storage in the PVB is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS in the Oxnard Subbasin (Table 3-2). The measurable objective groundwater level was selected for each of the key wells. This groundwater level is the same groundwater level that is used to protect against undesirable results for the other sustainability indicators. At each of the key wells, the difference between the measurable objective and the minimum threshold is greater than 10 feet, which provides a margin of safety for operational flexibility in the PVB.

Groundwater elevations within each management area of the PVB will be used to determine whether reduction in groundwater storage is occurring. All of the management areas except the EPVMA have monitoring wells. Until a monitoring well is installed in the EPVMA, the measurable objectives set for the wells in the PVPDMA and the NPVMA are presumed to also protect the EPVMA. The EPVMA has considerably less groundwater production than the NPVMA and does not have an independent suitable monitoring well for selecting a separate measurable objective. This presumption will be revisited as groundwater elevation data are collected from the EPVMA.

Interim Milestones for Reduction of Groundwater in Storage

Interim milestones for reduction of groundwater in storage are presented for two climate scenarios in Table 3-2. The two sets of interim milestones were calculated from a linear interpolation between the fall 2015 low groundwater elevation and either the measurable objective or the minimum threshold at each well. These interim milestones will be used to assess progress toward sustainable groundwater management in the PVB between 2020 and 2040. The interim milestones for reduction of groundwater in storage are the same as the interim milestones for chronic lowering of groundwater levels.

3.5.3 Seawater Intrusion

No measurable objectives are required for seawater intrusion in the PVB because the PVB is not adjacent to the Pacific Ocean (Section 3.3.3).

3.5.4 Degraded Water Quality

The measurable objective for degraded water quality in the PVB is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS in the Oxnard Subbasin (Table 3-2). The measurable objective groundwater level was selected for each of the key wells. This groundwater level is the same groundwater level that is used to protect against undesirable results for the other sustainability indicators. At each of the key wells, the difference between the measurable objective and the minimum threshold is greater than 10 feet, which provides a margin of safety for operational flexibility in the PVB.

Groundwater elevations within each management area of the PVB will be used to determine whether reduction in groundwater storage is occurring. All of the management areas except the EPVMA have monitoring wells. Until a monitoring well is installed in the EPVMA, the measurable objectives set for the wells in the PVPDMA and the NPVMA are presumed to also protect the EPVMA. The

EPVMA has considerably less groundwater production than the NPVMA and does not have an independent suitable monitoring well for selecting a separate measurable objective. This presumption will be revisited as groundwater elevation data are collected from the EPVMA.

Interim Milestones for Degraded Water Quality

Interim milestones for degraded water quality are the same as those for chronic lowering of groundwater levels and reduction of groundwater in storage. These interim milestones are presented for two climate scenarios in Table 3-2. The two sets of interim milestones were calculated from a linear interpolation between the fall 2015 low groundwater elevation and either the measurable objective or the minimum threshold at each well. These interim milestones will be used to assess progress toward sustainable groundwater management in the PVB between 2020 and 2040. The interim milestones for reduction of groundwater in storage are the same as the interim milestones for chronic lowering of groundwater levels.

3.5.5 Land Subsidence

The measurable objective for inelastic land subsidence in the PVB is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS in the Oxnard Subbasin (Table 3-2). This groundwater level is higher than the historical low water level in each key well. Therefore, it will protect against land subsidence related to groundwater withdrawal. The measurable objective groundwater level was selected for each of the key wells. This groundwater level is the same groundwater level that is used to protect against undesirable results for the other sustainability indicators. At each of the key wells, the difference between the measurable objective and the minimum threshold is greater than 10 feet, which provides a margin of safety for operational flexibility in the PVB.

Groundwater elevations within each management area of the PVB will be used to determine whether reduction in groundwater storage is occurring. All of the management areas except the EPVMA have monitoring wells. Until a monitoring well is installed in the EPVMA, the measurable objectives set for the wells in the PVPDMA and the NPVMA are presumed to also protect the EPVMA. The EPVMA has considerably less groundwater production than the NPVMA and does not have an independent suitable monitoring well for selecting a separate measurable objective. This presumption will be revisited as groundwater elevation data are collected from the EPVMA.

Interim Milestones for Land Subsidence

Interim milestones for land subsidence are the same as those for chronic lowering of groundwater levels and reduction of groundwater in storage. These interim milestones are presented for two climate scenarios in Table 3-2. The two sets of interim milestones were calculated from a linear interpolation between the fall 2015 low groundwater elevation and either the measurable objective or the minimum threshold at each well. These interim milestones will be used to assess progress toward sustainable groundwater management in the PVB between 2020 and 2040. The interim milestones for land subsidence are the same as the interim milestones for chronic lowering of groundwater levels.

3.5.6 Depletions of Interconnected Surface Water

No measurable objectives or minimum thresholds specific to the depletion of interconnected surface water are proposed at this time. Because lower Arroyo Simi–Las Posas is an ephemeral stream; groundwater elevations in this aquifer, where known, are deeper than 30 feet below land surface; and the Shallow Alluvial Aquifer is not used for groundwater production within the boundaries of the PVB, depletion of interconnected surface water in the PVB is not currently occurring.

Currently there is very little groundwater production from the Shallow Alluvial Aquifer. If future projects investigate producing water from the Shallow Alluvial Aquifer, these projects will have to evaluate the potential impact to interconnected surface water and GDEs as part of the feasibility and permitting process. Additionally, if projects that produce groundwater from the Shallow Alluvial Aquifer are implemented, the need for specific water-level measurable objectives in the Shallow Alluvial Aquifer should be reevaluated.

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Table 3-1
Minimum Threshold Groundwater Elevations by Well, Management Area, and Aquifer for Key Wells in the Pleasant Valley Basin

State Well Number	Management Area	Aquifer	Perforations (ft bgs)	Top Perforations (ft msl)	Bottom Perforations (ft msl)	Historical Water Level Low (ft msl) and Date Measured		Fall 2015 Water Level (ft msl) and Date Measured		GSP Undesirable Result	Minimum Threshold (ft msl)	Historical Low Water Level Used for Undesirable Result (ft msl), Well Name, and Date Measured		
02N21W34G05S	PVPDMA	Older Alluvium (Oxnard)	170–190	−77.55	−97.55	−69	12/14/1990	10.12	3/02/2015	Chronic GW Depletion – Storage Reduction – Subsidence – SWI in Oxnard Subbasin	32	−69	02N21W34G05S	12/14/1990
01N21W03K01S	PVPDMA	Older Alluvium (Mugu)	403–1,433	−345.98	−1,375.98	−107.06	9/04/1996	−72.98	3/31/2015	Chronic GW Depletion – Storage Reduction – Subsidence – SWI in Oxnard Subbasin	−53	−107.06	01N21W03K01S	9/4/1996
02N21W34G04S	PVPDMA	Older Alluvium (Mugu)	360–380	−267.55	−287.55	−131.5	12/18/1991	−59.25	3/15/2015	Chronic GW Depletion – Storage Reduction – Subsidence – SWI in Oxnard Subbasin	−48	−131.5	02N21W34G04S	12/18/1991
01N21W03C01S	PVPDMA	FCA	956–1,216	−883.72	−1,143.72	−162.89	12/04/1990	−83.63	3/18/2015	Chronic GW Depletion – Storage Reduction – Subsidence – SWI in Oxnard Subbasin	−48	−162.89	01N21W03C01S	12/04/1990
02N20W19M05S	NPVMA	FCA	654–990	−453.53	−789.53	3.47	9/24/1999	38.62	3/18/2015	Chronic GW Depletion – Storage Reduction – Subsidence – SWI in Oxnard Subbasin	−135	−167.7	02N20W19M04S	10/20/1988
02N21W34G02S	PVPDMA	FCA	938–998	−845.55	−905.55	−172.8	11/19/1991	−70.06	3/02/2015	Chronic GW Depletion – Storage Reduction – Subsidence – SWI in Oxnard Subbasin	−53	−172.8	02N21W34G02S	11/19/1991
02N21W34G03S	PVPDMA	FCA	800–860	−707.55	−767.55	−173.7	11/19/1991	−92.53	3/15/2015	Chronic GW Depletion – Storage Reduction – Subsidence – SWI in Oxnard Subbasin	−53	−173.7	02N21W34G03S	11/19/1991
01N21W02P01S	PVPDMA	Multiple	117–1,041	−49.02	−973.02	−122.36	12/15/1989	−53.45	3/17/2015	Chronic GW Depletion – Storage Reduction – Subsidence – SWI in Oxnard Subbasin	−43	−122.36	01N21W02P01S	12/15/1989
01N21W04K01S	PVPDMA	Multiple	400–1,220	−352.48	−1,172.48	−145.47	10/30/2014	−92.48	3/31/2015	Chronic GW Depletion – Storage Reduction – Subsidence – SWI in Oxnard Subbasin	−48	−164.3	01N21W04K01S	11/25/1991

Notes: FCA = Fox Canyon Aquifer; ft bgs = feet below ground surface; ft msl = feet above mean sea level; GSP = Groundwater Sustainability Plan; GW = groundwater; NPVMA = North Pleasant Valley Management Area; PVPDMA = Pleasant Valley Pumping Depression Management Area; SWI = seawater intrusion.

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Table 3-2
Measurable Objectives and Interim Milestones

Well Number	Aquifer	Minimum Threshold (ft msl)	Measurable Objective (ft msl)	Fall 2015 Water Level Low (ft msl) and Date Measured		Interim Milestone Average Climate (ft msl)				Interim Milestone Dry Climate (ft msl)			
						2025	*2030*[a]	*2035*[a]	*2040*[a]	*2025*	*2030*[a]	*2035*[a]	*2040*[a]
02N21W34G05S	Older Alluvium (Oxnard)	32	40	−10.19	10/2/2015	2	15	28	40	0	11	22	33
01N21W03K01S	Older Alluvium (Mugu)	−53	5	−79.98	6/30/2015	−59	−38	−17	5	−73	−66	−59	−53
02N21W34G04S	Older Alluvium (Mugu)	−48	5	−80.28	10/15/2015	−59	−38	−17	5	−72	−64	−56	−48
01N21W03C01S	FCA	−48	0	−117.52	10/15/2015	−88	−59	−30	0	−100	−83	−66	−48
02N20W19M05S	FCA	−135	65	15.17	10/13/2015	—	—	—	—	—	—	—	—
02N21W34G02S	FCA	−53	0	−117.53	10/2/2015	−88	−59	−30	0	−101	−85	−69	−53
02N21W34G03S	FCA	−53	0	−120.62	10/15/2015	−90	−60	−30	0	−104	−87	−70	−53
01N21W02P01S	Multiple	−43	5	−91.77	10/13/2015	−68	−44	−20	5	−80	−68	−56	−43
01N21W04K01S	Multiple	−48	0	−133.47	10/29/2015	−100	−67	−34	0	−112	−91	−70	−48

Notes: FCA = Fox Canyon Aquifer; ft msl = feet above mean sea level.

[a] Interim milestones for 2030, 2035, and 2040 will depend on climate conditions and basin water level recoveries between 2020 and 2025. These thresholds are proposed for the current GSP but will be reviewed and revised with each 5-year evaluation.

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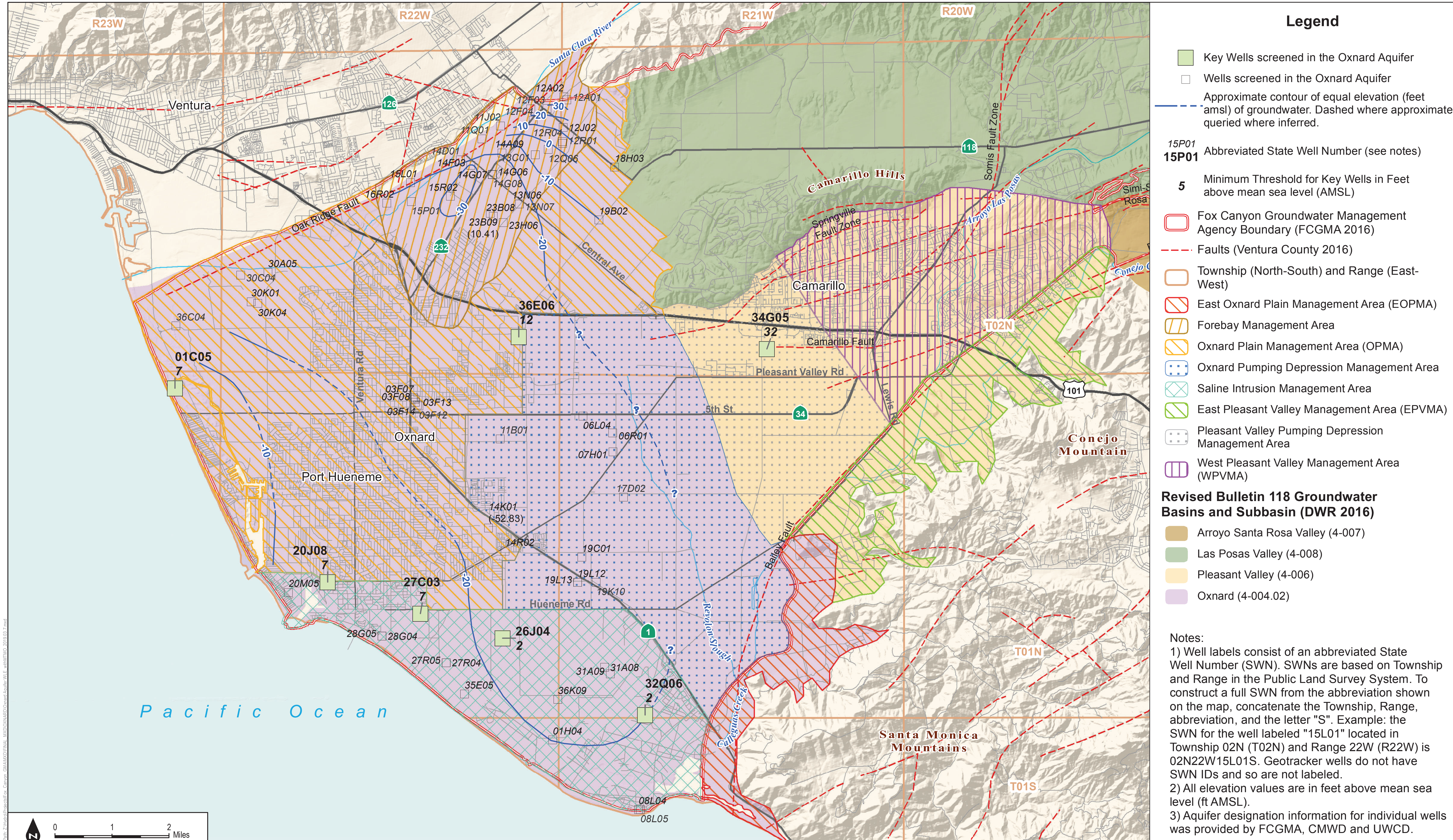

SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 3-1

Minimum Thresholds and Groundwater Elevation Contours in the Oxnard Aquifer, October 2-29, 2015

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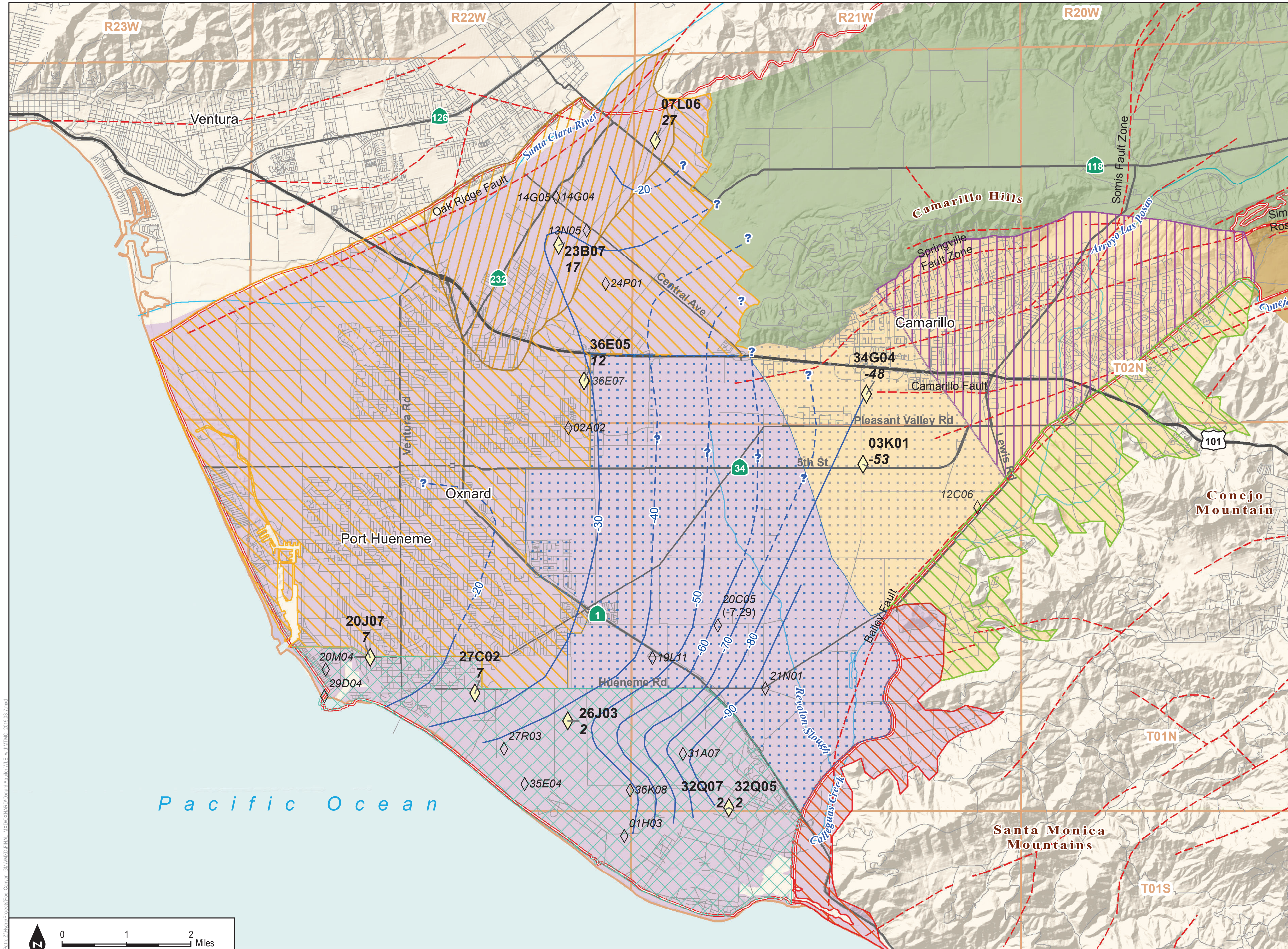

Legend

- Key Wells screened in the Mugu Aquifer
- Well screened in the Mugu Aquifer
- Approximate contour of equal elevation (feet amsl) of groundwater. Dashed where approximate; queried where inferred.
- 15P01 / **15P01** Abbreviated State Well Number (see notes)
- *5* Minimum Threshold for Key Wells in Feet above mean sea level (AMSL)
- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Faults (Ventura County 2016)
- Township (North-South) and Range (East-West)
- East Oxnard Plain Management Area (EOPMA)
- Forebay Management Area
- Oxnard Plain Management Area (OPMA)
- Oxnard Pumping Depression Management Area
- Saline Intrusion Management Area
- East Pleasant Valley Management Area (EPVMA)
- Pleasant Valley Pumping Depression Management Area
- West Pleasant Valley Management Area (WPVMA)

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 abbreviated State Well Number (SWN). 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) All elevation values are in feet above mean sea level (ft AMSL).
3) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

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SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 3-2

Minimum Thresholds and Groundwater Elevation Contours in the Mugu Aquifer, October 2-29, 2015

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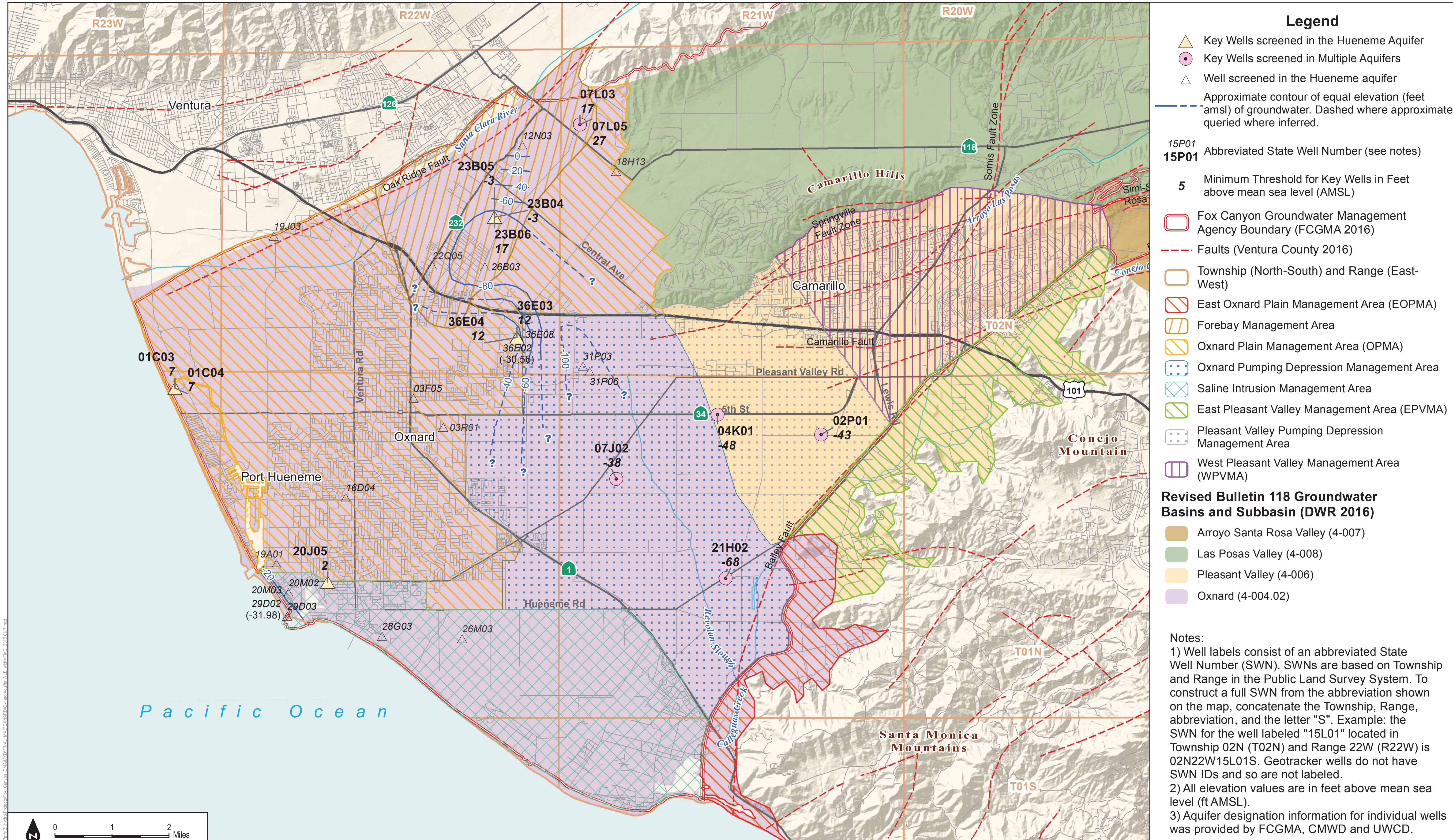

SOURCE: DWR; Ventura County; UWCD; CMWD

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FIGURE 3-3

Minimum Thresholds and Groundwater Elevation Contours in the Hueneme Aquifer, October 2-29, 2015

Groundwater Sustainability Plan for the Pleasant Valley Basin

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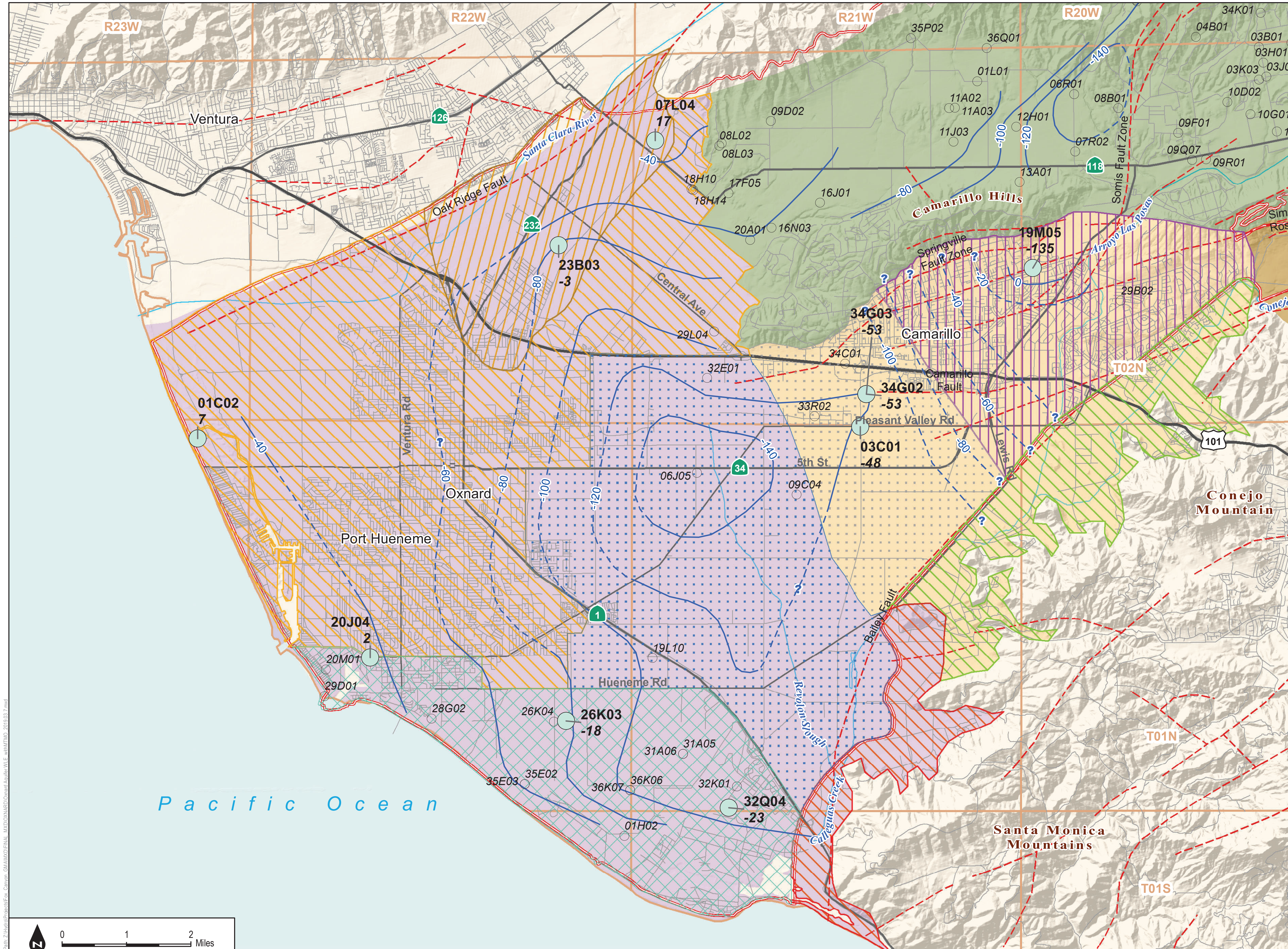

Legend

- Key Wells screened in the Fox Canyon Aquifer
- Well screened in the Fox Canyon
- Approximate contour of equal elevation (feet amsl) of groundwater. Dashed where approximate; queried where inferred.
- *15P01* **15P01** Abbreviated State Well Number (see notes)
- *5* Minimum Threshold for Key Wells in Feet above mean sea level (AMSL)
- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Faults (Ventura County 2016)
- Township (North-South) and Range (East-West)
- East Oxnard Plain Management Area (EOPMA)
- Forebay Management Area
- Oxnard Plain Management Area (OPMA)
- Oxnard Pumping Depression Management Area
- Saline Intrusion Management Area
- East Pleasant Valley Management Area (EPVMA)
- Pleasant Valley Pumping Depression Management Area
- West Pleasant Valley Management Area (WPVMA)

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 abbreviated State Well Number (SWN). 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) All elevation values are in feet above mean sea level (ft AMSL).
3) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

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SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 3-4

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

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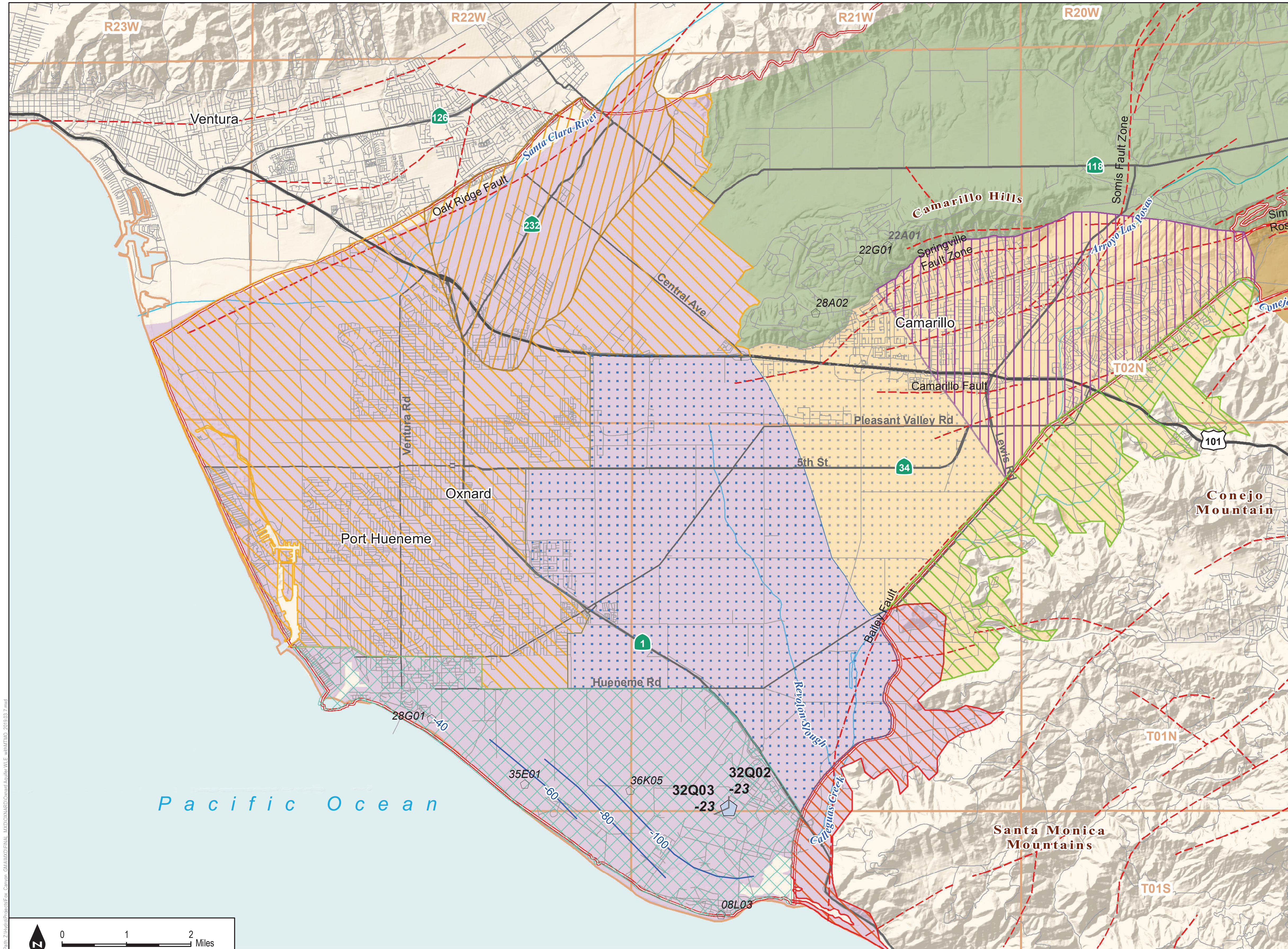

Legend

- Key Wells screened in the Grimes Canyon
- Well screened in the Grimes Canyon aquifer
- Approximate contour of equal elevation (feet amsl) of groundwater. Dashed where approximate; queried where inferred.
- *15P01* / **15P01** Abbreviated State Well Number (see notes)
- *5* Minimum Threshold for Key Wells in Feet above mean sea level (AMSL)
- Fox Canyon Groundwater Management Agency Boundary (FCGMA 2016)
- Faults (Ventura County 2016)
- Township (North-South) and Range (East-West)
- East Oxnard Plain Management Area (EOPMA)
- Forebay Management Area
- Oxnard Plain Management Area (OPMA)
- Oxnard Pumping Depression Management Area
- Saline Intrusion Management Area
- East Pleasant Valley Management Area (EPVMA)
- Pleasant Valley Pumping Depression Management Area
- West Pleasant Valley Management Area (WPVMA)

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 abbreviated State Well Number (SWN). 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) All elevation values are in feet above mean sea level (ft AMSL).
3) Aquifer designation information for individual wells was provided by FCGMA, CMWD and UWCD.

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SOURCE: DWR; Ventura County; UWCD; CMWD

FIGURE 3-5

Minimum Thresholds and Groundwater Elevation Contours in the Grimes Canyon Aquifer, October 2-29, 2015

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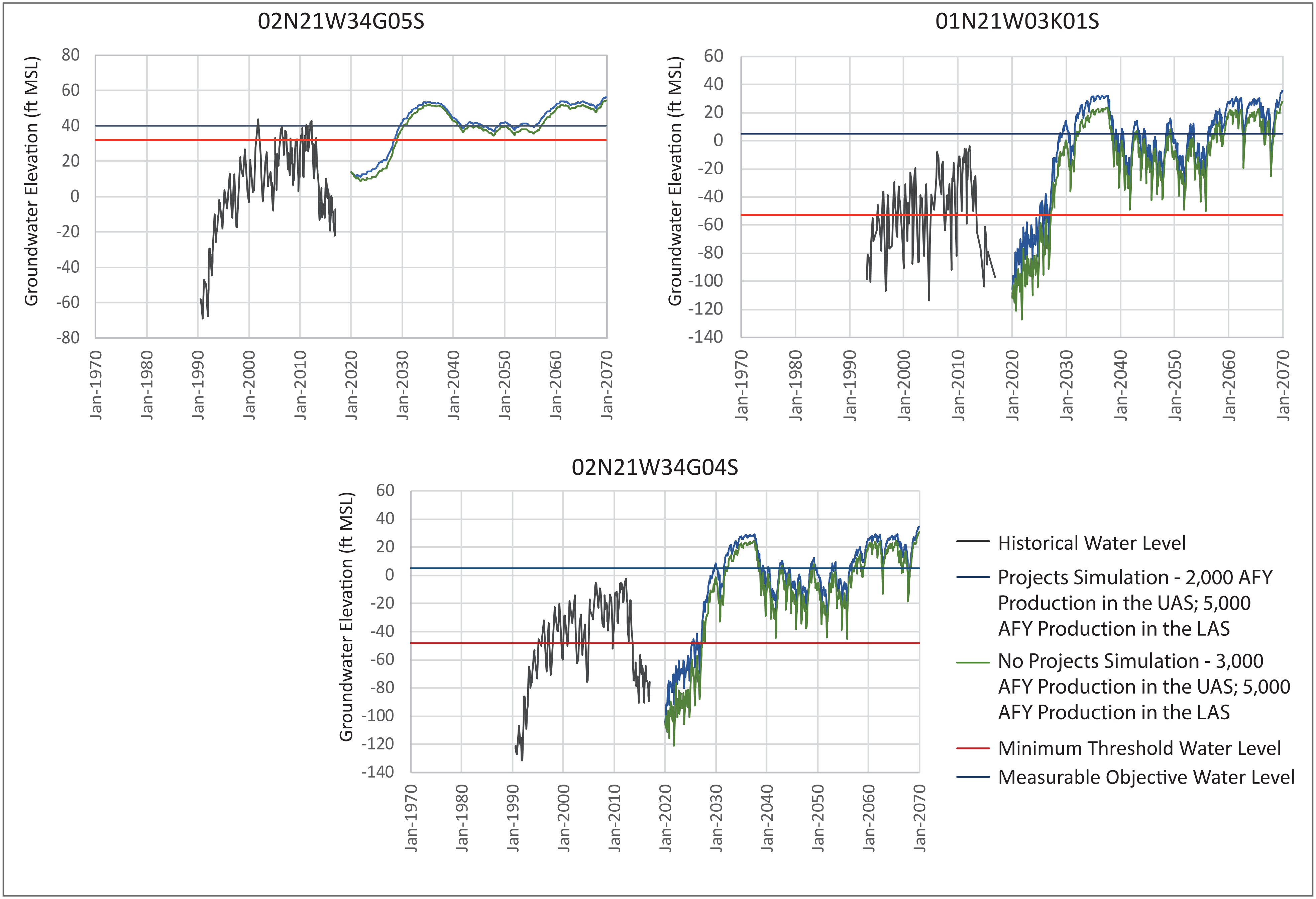

FIGURE 3-6

Key Well Hydrographs for Wells Screened in the Older Alluvium

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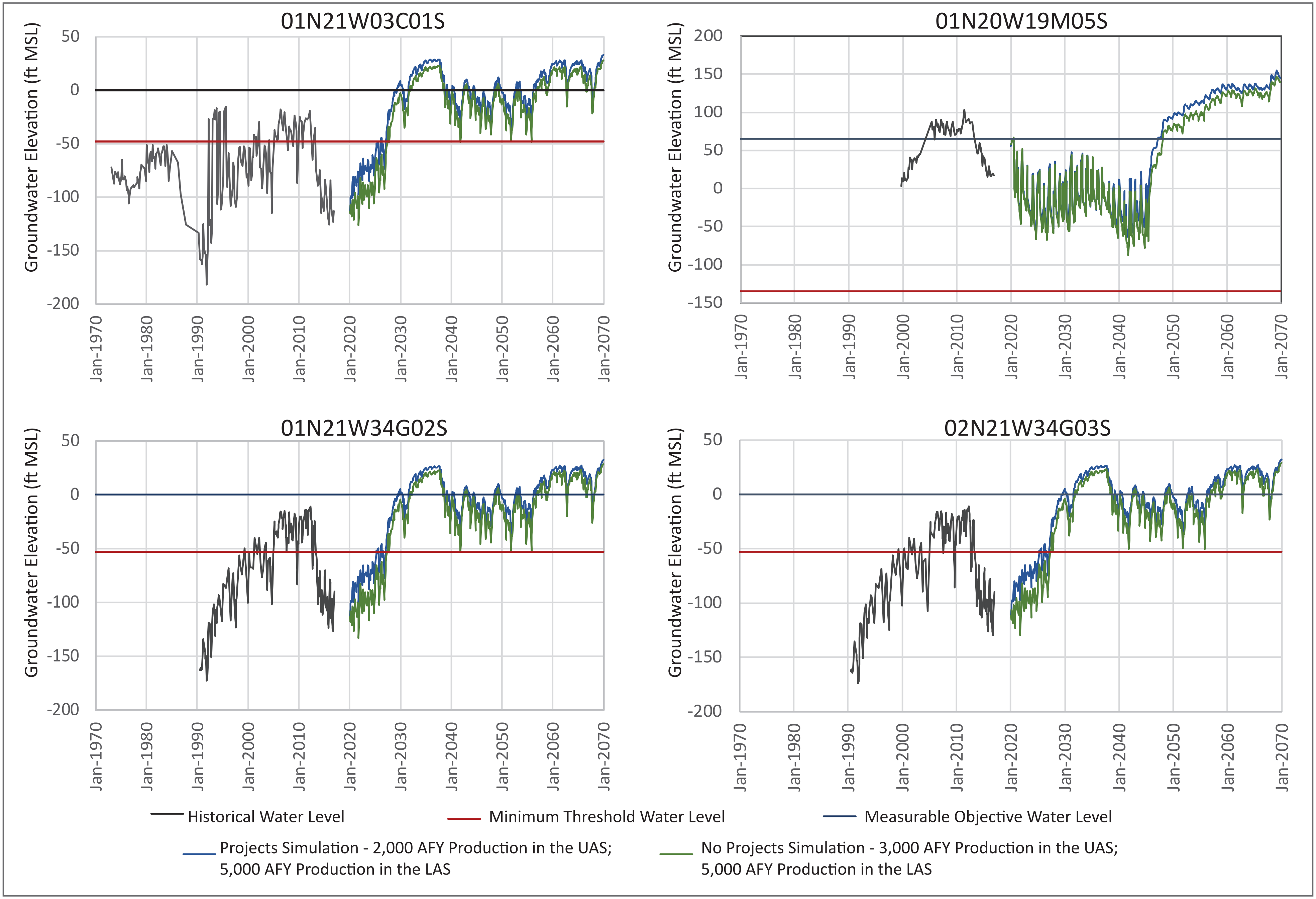

FIGURE 3-7

Key Well Hydrographs for Wells Screened in the Fox Canyon Aquifer

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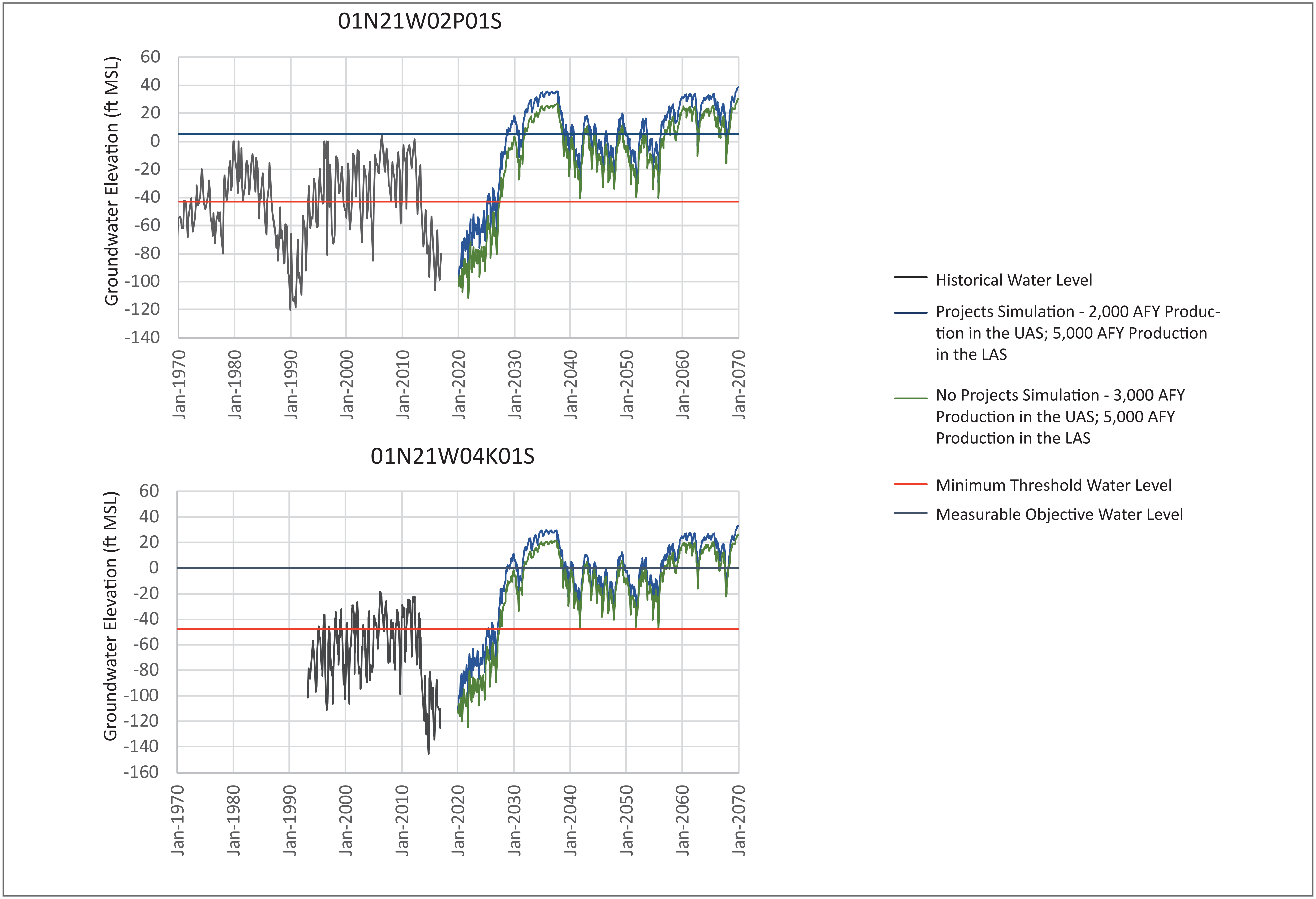

FIGURE 3-8

Key Well Hydrographs for Wells Screened in Multiple Aquifers

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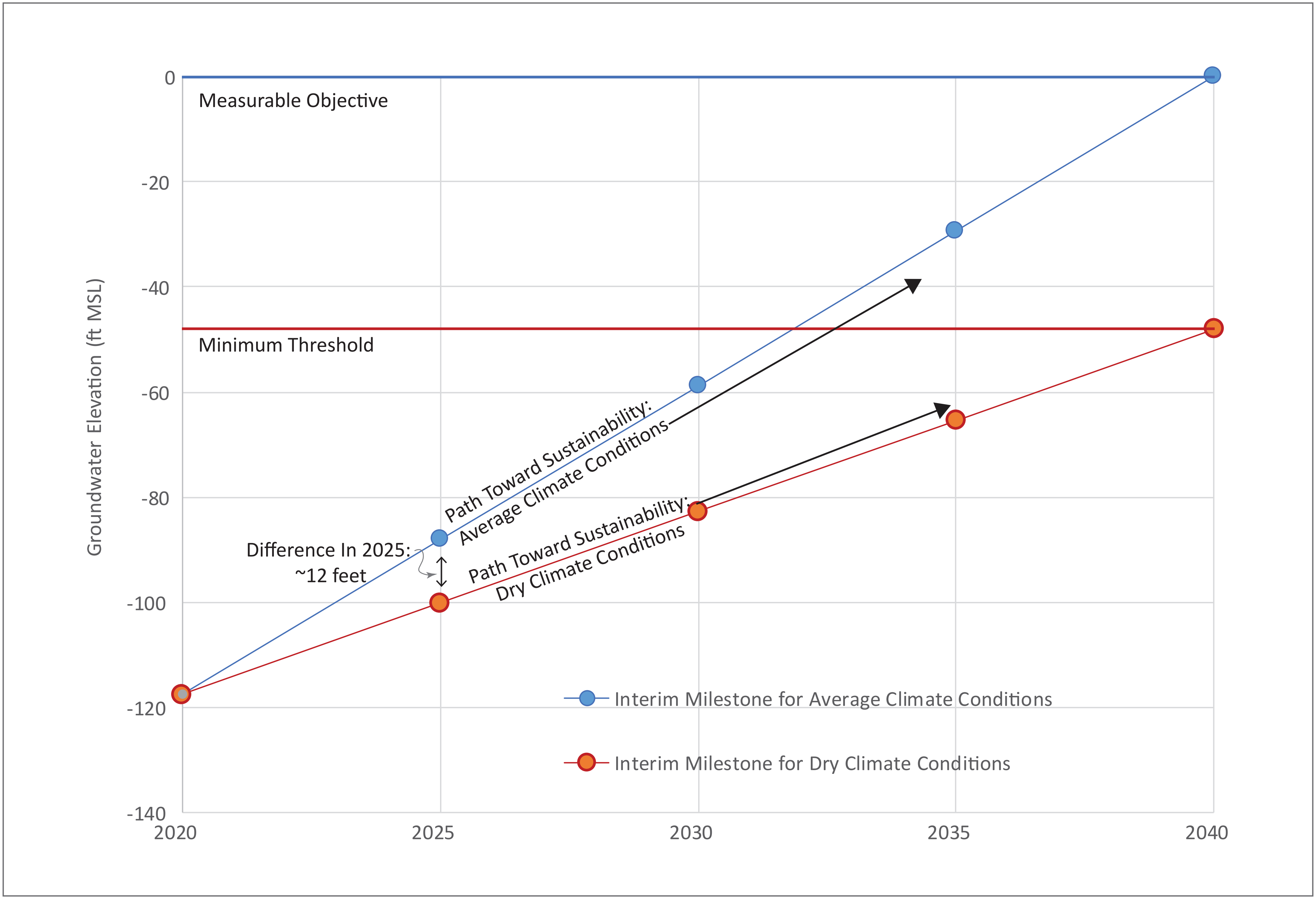

FIGURE 3-9

Interim Milestones for Dry and Average Conditions - Linear Interpolation

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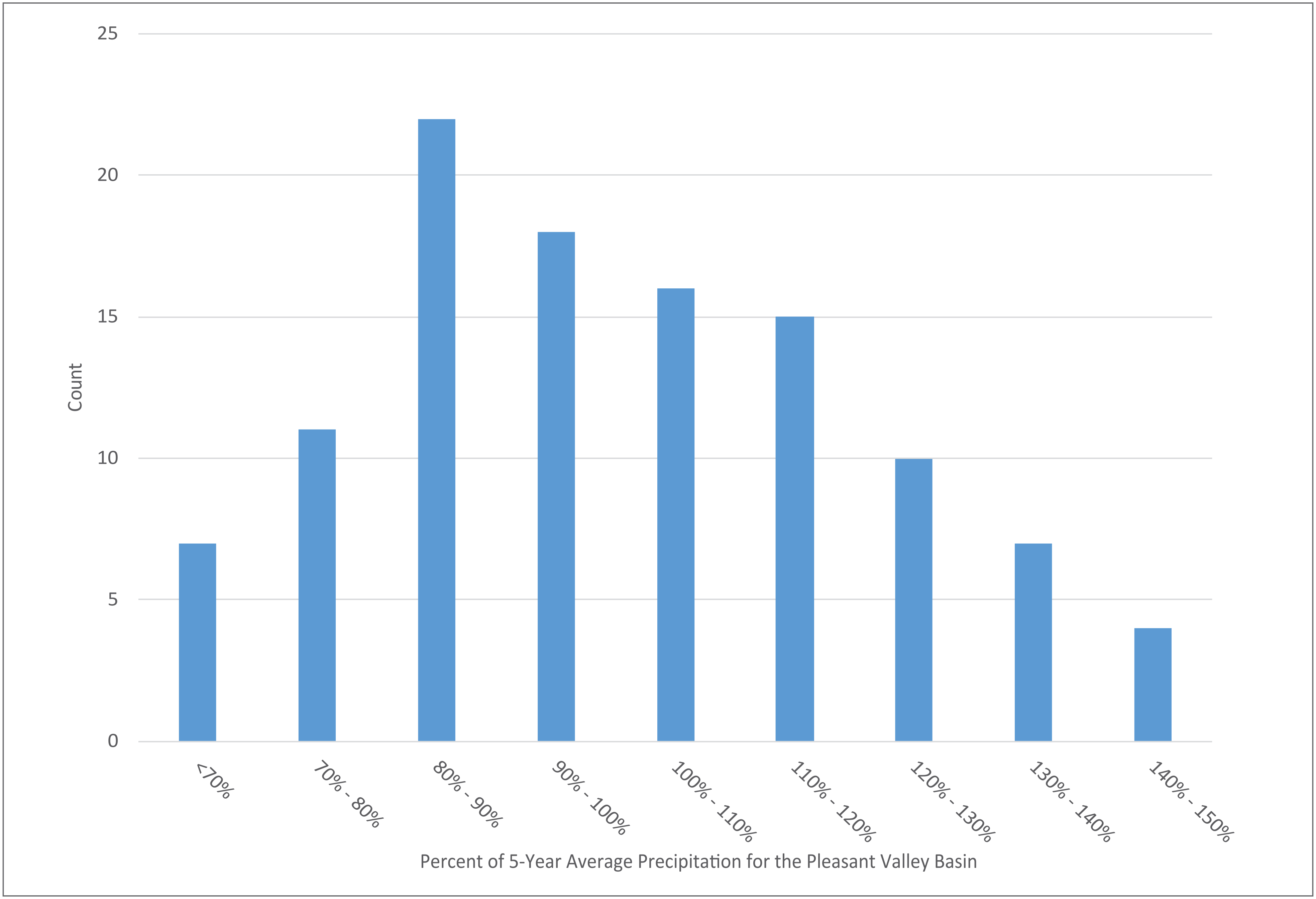

FIGURE 3-10

Distribution of 5-Year Average Climate Conditions in the Historical Record of Precipitation in the Pleasant Valley Basin

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