CHAPTER 3
SUSTAINABLE MANAGEMENT CRITERIA

3.1 INTRODUCTION TO SUSTAINABLE MANAGEMENT CRITERIA

In the Oxnard Subbasin, significant and unreasonable seawater intrusion is the primary undesirable result that occurs when groundwater production exceeds the sustainable yield. This undesirable result can occur even if groundwater production from the Subbasin as a whole is less than the freshwater recharge to the Subbasin, as seawater intrusion is closely related to groundwater production from coastal wells. Infrastructure projects and management actions undertaken in the Oxnard Subbasin have at times limited and even reversed the progress of seawater intrusion (see Section 2.3.3, Seawater Intrusion). However, groundwater elevations declined in all aquifers in the Subbasin in response to the statewide drought that began in 2011. These groundwater elevation declines exacerbated the impacts of seawater intrusion in the Subbasin.

On October 28, 2015, after several consecutive years of drought, the Fox Canyon Groundwater Management Agency (FCGMA) Board of Directors (Board) adopted planning goals for the Oxnard Subbasin, as well as the other basins within its jurisdiction. These goals are as follows:

- 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 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 goal in the Oxnard Subbasin will be measured. Sustainable management of the Oxnard Subbasin does not necessarily mean, however, that springtime high groundwater levels in the Subbasin remain the same year after year. Rather, sustainability can be achieved over cycles of drought and recovery, so long as the impacts to the Subbasin that may occur during periods of drawdown 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, chloride concentrations and land surface elevations—returning to pre-drought levels in the wet years after a drought.

3.2 SUSTAINABILITY GOAL

The primary sustainability goal in the Oxnard Subbasin is to increase groundwater elevations inland of the Pacific coast in the aquifers that compose the Upper Aquifer System (UAS) and the Lower Aquifer System (LAS) to elevations that will prevent the long-term, or climatic cycle net (net), landward migration of the 2015 saline water impact front (see Section 3.3.3); prevent net seawater intrusion in the UAS; and prevent net seawater intrusion in the LAS.

The use of net landward migration, and net seawater intrusion in the sustainability goal reflects that climatic cycles influence groundwater elevations over multi-year periods and requires that assessment of seawater impacts to the Subbasin 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.

In order to achieve the sustainability goal, groundwater production will need to be reduced relative to historical groundwater production rates. At the same time, groundwater production inland from the coast may be allowed to increase as infrastructure is developed to convey inland production to agricultural users on the coast. During the first 5 years following GSP adoption, it is anticipated that the combined groundwater production from both the UAS 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 in the Subbasin, the interference with municipal water supply planning and rate setting, and the uncertainty in the estimated sustainable yield of the Subbasin. The estimated sustainable yield of the Subbasin is 42,000 acre-feet per year (AFY) with an uncertainty estimate of ±9,000 AFY (see Section 2.4.4, General Uncertainties in the Water Budget). The average 2015 groundwater production rate was 69,000 AFY. The difference between the upper estimate of the sustainable yield, 51,000 AFY, and the 2015 production rate is 18,000 AFY. If production is reduced linearly between 2020 and 2040, the estimated groundwater production reduction necessary throughout the geographic extent of the Oxnard Subbasin is approximately 900 AFY. However, the sustainability goal allows for operational flexibility, as groundwater production patterns are anticipated to change during the 20-year GSP implementation period from 2020 through 2039. Progress toward the sustainability goal will be evaluated throughout the 20-year implementation period.

The following sections describe the undesirable results that have occurred and may occur within the Subbasin, the minimum thresholds developed to avoid 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 Subbasin 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, which is FCGMA in the Oxnard Subbasin, using the processes and criteria set forth in the GSP. Each of the sustainability indicators is discussed in this section 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 Oxnard Subbasin. Seawater intrusion occurs in the Subbasin as groundwater levels fall below threshold elevations that maintain sufficient hydrostatic pressure to keep seawater from moving landward. The threshold groundwater elevations differ between the aquifers of the UAS and the LAS, as well as with geographic location in the Subbasin. Groundwater elevation declines can also induce release of connate water brines, reduce the quantity of freshwater in storage, and cause land subsidence in the Subbasin.

The primary cause of groundwater conditions in the Subbasin that would lead to chronic lowering of groundwater levels is groundwater production in excess of natural and artificial recharge. Groundwater production from the Subbasin may result in significant and unreasonable lowering of groundwater levels if the groundwater levels were lowered to an elevation at which they allow net seawater intrusion in the UAS and LAS over climate cycles of drought and recovery. Historically, this condition has occurred within the Oxnard Subbasin.

In the past, groundwater levels in the UAS have declined during periods of drought and recovered during wet periods (Section 2.3.1, Groundwater Elevation Data). In fact, flowing artesian conditions were observed in UAS wells after multiple-year periods of above-average precipitation (UWCD 2016; Appendix C, UWCD Model Report, to this GSP). Groundwater levels in the LAS have also declined during drought and risen during wet periods, although the water levels in many wells in the LAS have remained below sea level since the 1980s (Section 2.3.1). One factor that contributed to the recovery of water levels following periods of drought was the amount of surface water that was diverted from the Santa Clara River and infiltrated through spreading basins to recharge the aquifers. Surface-water flows are available during wetter-than-average precipitation periods. These surface-water diversions and spreading are controlled by the United Water Conservation District (UWCD), which anticipates maintaining the historical volume of water diverted from the Santa Clara River over the next 50 years (UWCD 2018).

In addition to surface-water spreading, seawater intrusion into the aquifers of the Oxnard Subbasin has also sustained groundwater levels. Unlike surface-water spreading, seawater intrusion sustains groundwater levels at the expense of freshwater storage in the Subbasin (Section 2.3.3). Water levels in the aquifers of the LAS have remained below sea level even during drought recovery periods, thereby continuing to allow migration of seawater into the Subbasin near the Mugu and Hueneme Submarine Canyons (Section 2.3, Groundwater Conditions). Continued seawater intrusion has reduced the amount of freshwater in storage in the Subbasin.

Based on the sustainability goals for the Oxnard Subbasin, the criterion used to define undesirable results for chronic lowering of groundwater levels is landward migration of the 2015 saline water impact front during the sustaining period from 2040 through 2069. It is expected that there will be some landward migration of this front between 2020 and 2040 as the FCGMA Board and stakeholders in the Subbasin 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).

In order to effectively manage the groundwater resources of the Oxnard Subbasin, the Subbasin has been divided into five management areas (see Section 2.5, Management Areas; Figure 2-69, Oxnard Subbasin Management Areas). These areas are defined by differences in their hydrogeologic properties, groundwater quality, or historical groundwater elevations. Groundwater elevations within each management area will be used to determine whether significant and unreasonable chronic lowering of groundwater levels is occurring. All of the management areas except the East Oxnard Plain Management Area (EOPMA) have wells in which water levels can be monitored by aquifer.

Until a monitoring well is installed in the EOPMA, the water level thresholds set for the wells closest to the EOPMA are presumed to be protective for the EOPMA, which has considerably less groundwater production than the adjoining management areas. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Chronic lowering of groundwater levels in the Oxnard Subbasin has the potential to impact the beneficial uses and users of groundwater in the Subbasin by (1) exacerbating seawater intrusion in the Subbasin, (2) reducing the volume of freshwater in storage, (3) potentially causing land subsidence, (4) impacting areas of interconnected surface water and groundwater, and (5) causing groundwater levels to drop below current well screens.

3.3.2 Reduction of Groundwater Storage

Significant and unreasonable reduction of groundwater storage is an undesirable result that applies to the Oxnard Subbasin. Seawater intrusion occurs in the Subbasin as groundwater levels fall below threshold levels that maintain sufficient hydrostatic pressure to keep seawater from moving landward. The threshold groundwater levels differ between the UAS and the LAS, and differ with geographic location in the Subbasin.

The primary cause of groundwater conditions in the Subbasin that would lead to reduction in groundwater storage is groundwater production in excess of recharge over a cycle of drought and recovery. Groundwater production from the Subbasin may result in a significant and unreasonable reduction of groundwater in storage if the volume of water produced from the Subbasin exceeds the volume of freshwater recharging the Subbasin over cycles of drought and recovery. Changes in groundwater in storage can be tracked using groundwater elevations and would become significant and unreasonable if groundwater levels were lowered to an elevation below which they allow landward migration of the 2015 saline water impact front over cycles of drought and recovery, which would cause a long-term decline in groundwater storage.

Numerical groundwater model simulations indicate that there has been approximately 101,000 acre-feet (AF) of storage loss in the Oxnard Subbasin over the 31 years from 1985 to 2015 (Section 2.3.2, Estimated Change in Storage; Appendix C). The model results also indicate that between 1985 and 2015, approximately 380,000 AF of seawater intruded into the UAS and LAS under the Oxnard Subbasin. The replacement of freshwater with seawater is a reduction in freshwater storage and is an undesirable result that has already occurred within the Subbasin.

Based on the sustainability goals for the Oxnard Subbasin, the criterion used to define undesirable results for reduction in groundwater storage is landward migration of the 2015 saline water impact front after 2040. The minimum thresholds metric against which reduction of groundwater storage will be measured 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).

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

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

3.3.3 Seawater Intrusion

Significant and unreasonable seawater intrusion is an undesirable result that is present or likely to occur in the Oxnard Subbasin. Seawater intrusion is the primary sustainability indicator in the Oxnard Subbasin. Seawater intrusion occurs in the Subbasin as groundwater levels fall below threshold levels that maintain sufficient hydrostatic pressure to keep seawater from moving landward. The threshold groundwater levels differ between the UAS and the LAS, and differ with geographic location in the Subbasin.

The primary cause of groundwater conditions in the Subbasin that would lead to seawater intrusion is groundwater production. Currently, the area of the 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 (see Section 2.3.3). 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. The saline water impact area was already impacted before 2015, when SGMA was implemented. As a result, the goal of this GSP is not to reverse historical impacts, but rather to limit seawater intrusion to the area that has already been impacted. Therefore, significant and unreasonable seawater intrusion is defined as seawater intrusion that results in a net landward migration of the 2015 saline water impact front beyond the already impacted area west of Highway 1 and south of Hueneme Road from 2040 through 2069.

Chloride concentrations in the Oxnard Subbasin indicate that seawater intrusion has occurred historically, and is currently occurring, in the vicinity of Point Hueneme and Point Mugu. However, seawater is not the only source of chloride to the groundwater of the Oxnard Subbasin (Section 2.3.3, Groundwater Conditions, and Section 2.3.4, Groundwater Quality). Chloride concentrations exceeding 500 mg/L have been measured in the southeastern part of the Subbasin, where there is no direct connection between the inland freshwater aquifer and the Pacific Ocean. Stable isotope studies of the groundwater in these wells have shown that the chloride concentrations are likely not a result of seawater intrusion, but rather originated from release of connate water in the fine-grained lagoonal deposits in the Oxnard and Mugu Aquifers (Izbicki 1996). The connate water is released as groundwater head in the aquifer declines and the fine-grained deposits compress. Additionally, chloride concentrations in the UAS are also impacted by downward migration of brackish water from the semi-perched aquifer via improperly abandoned wells (Izbicki 1996). In the LAS, chloride concentrations above 500 mg/L result from seawater intrusion, as well as from upward migration of brines from the geologic formations that underlie and surround the Subbasin (Izbicki 1991).

The minimum thresholds metric against which seawater intrusion will be measured is water levels that were selected to prevent lateral seawater intrusion. These groundwater elevations are equal to, or higher than, previous historical low water levels (Table 3-1). Some of the minimum threshold groundwater elevations in the LAS are below sea level. These elevations were selected based on model results that indicate groundwater elevations could be this low and still limit seawater intrusion. They were also selected in concert with groundwater elevations in adjacent management areas, and are not expected to negatively impact the ability of the adjacent management areas to meet their sustainability goals.

The groundwater elevations selected in each of the management areas of the Oxnard Subbasin will be used to determine whether seawater intrusion is occurring in the Saline Intrusion Management Area and the West Oxnard Plain Management Area (WOPMA) of the Subbasin (Figure 2-69). Until a monitoring well is installed in the EOPMA, the water level thresholds set for the wells closest to the EOPMA in the WOPMA and the Oxnard Pumping Depression Management Area are presumed to be protective for the EOPMA, which has considerably less groundwater production than the adjoining management areas. This presumption will be revisited as groundwater elevation data are collected from the EOPMA.

Seawater intrusion in the Oxnard Subbasin has the potential to impact the beneficial uses and users of groundwater in the Subbasin by limiting the volume of non-brackish groundwater available for agricultural, municipal, industrial, and domestic use. These impacts will affect all users of groundwater in the Subbasin and continued seawater intrusion could result in changing land use as agricultural land is fallowed due to reduced groundwater supplies.

3.3.4 Degraded Water Quality

3.3.4.1 Chloride and TDS

Significant and unreasonable degraded water quality related to groundwater production is an undesirable result that has the potential to occur in the Oxnard Subbasin. Increases in chloride and total dissolved solids (TDS) have been observed in coastal areas of the Oxnard Subbasin including parts of the WOPMA and the Saline Intrusion Management Area. These increases are associated with seawater intrusion as well as connate water in fine-grained lenses, downward migration of brines from improperly abandoned wells, and upward migration of brines from deeper geologic formations (Izbicki 1991, 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 Subbasin 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.

The primary cause of groundwater conditions in the Subbasin that would lead to degradation of water quality from increased concentrations of TDS and chloride is groundwater production. If groundwater production from the Subbasin results in expansion of areas of the Subbasin impacted by chloride and TDS concentrations that limit agricultural and potable use, significant and unreasonable degradation of water quality may occur.

Based on the sustainability goals for the Oxnard Subbasin, the criterion used to define undesirable results for degraded water quality is the migration of the 2015 saline water impact front during the sustaining period from 2040 through 2069. The minimum thresholds metric against which degradation of water quality will be measured is groundwater levels that were selected to prevent net landward migration of the 2015 saline water impact front. The minimum thresholds metric against which seawater intrusion will be measured is groundwater levels that were selected to prevent net landward seawater migration. These groundwater elevations are equal to, or higher than, previous historical low water levels (Table 3-1).

Water quality will continue to be monitored at monitoring well locations identified by FCGMA and its partner agencies, as identified in Chapter 4, Monitoring Networks. As additional data are collected, the effectiveness of applying a water level proxy to groundwater quality degradation will continue to be assessed.

3.3.4.2 Nitrate

In the Oxnard Forebay area of the Oxnard Subbasin, nitrate concentrations above the water quality objectives (WQOs) and basin management objectives (BMOs) are routinely detected in groundwater (UWCD 2008). These concentrations have resulted in significant and unreasonable impacts to beneficial uses and users of the Oxnard Subbasin, as not all municipal users of groundwater in this area have the ability to blend groundwater with nitrate exceeding the federal maximum contaminant level (MCL) with other water to sufficiently reduce the nitrate concentration for municipal use. Although nitrate concentrations in the Forebay have impacted municipal users of groundwater, the concentrations of nitrate in the Forebay are not caused by groundwater conditions occurring throughout the Subbasin. Rather, nitrate concentrations above WQOs and BMOs in the Forebay are likely a legacy of historical septic discharges and agricultural fertilizer application practices.[1]

Although nitrate concentrations decrease when water levels are high, the decreases are not a result of regional groundwater production patterns. Instead, the reduction in nitrate concentration results from dilution of nitrate in groundwater by lower nitrate concentration surface-water recharge from the Santa Clara River. Operationally, in years when surface-water diversions are lower than the overall demand, UWCD prioritizes surface-water recharge in areas where nitrate concentrations in the groundwater exceed the MCL over deliveries to areas with lower concentrations of nitrate in the groundwater. UWCD currently anticipates maintaining and potentially increasing surface-water recharge from the Santa Clara River in the future. Increases in surface-water recharge, combined with the cessation of septic discharges and modern agronomic fertilization practices, are anticipated to result in long-term declines in nitrate concentration in the Forebay.

Because nitrate concentrations are not impacted by local or regional groundwater production, and the currently impacted area is not anticipated to get larger in the future, the concentration of nitrate is not considered to be a SGMA sustainability indicator in the Subbasin. Because nitrate impacts are not a sustainability indicator, no minimum threshold concentration for nitrate is proposed at this time. Nitrate concentrations will continue to be monitored and the relationship between groundwater production and nitrate concentrations will be reevaluated during the 5-year evaluation.

3.3.5 Land Subsidence

The undesirable result associated with land subsidence in the Oxnard Subbasin 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 sediments in the aquifers. As water levels decline, the pressure on the sediment matrix increases, and the pore structure of the sediment can collapse, resulting in subsidence. The minimum thresholds metric

1 Ventura County extended sewer lines into this area in the years between 2000 and 2011 to address additional discharges of nitrate.

against which subsidence will be measured is water levels that were selected to prevent lateral seawater intrusion. 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 Subbasin resulting from groundwater withdrawal (Table 3-1).

Groundwater production is only one cause of subsidence in the Oxnard Subbasin. In addition to groundwater production, tectonic forces and oil and gas production can also result in subsidence in the Oxnard Subbasin (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 Subbasin may result in significant and unreasonable land subsidence if the subsidence "substantially interferes with surface land uses" (California Water Code, Section 10721(x)(5)). Using this definition, historical records of land subsidence in the Subbasin do not indicate that land subsidence as a result of groundwater production has caused or is likely to cause undesirable results. Parts of the Oxnard Plain have experienced 2 to 3 feet of subsidence in the past, and future projections of subsidence indicate that areas within the Oxnard Plain may experience an additional 0.1 to 1 feet of subsidence by 2040 (Hanson et al. 2003; DWR 2014).

Land subsidence related to groundwater production has the potential to impact the beneficial uses and users of groundwater in the Oxnard Subbasin by interfering with surface land uses in a way that causes additional costs for releveling fields, replacing surface infrastructure, and otherwise interfering with surface land uses. Additional subsidence of 0.1 to 1 feet is not anticipated to substantially interfere with surface land uses in the Subbasin.

Even though substantial interference with land surface uses is not anticipated, actions to reduce groundwater production to a rate that avoids net seawater intrusion will mitigate future seawater intrusion as well as reducing the potential for additional subsidence in the Subbasin related to groundwater production.

3.3.6 Depletions of Interconnected Surface Water

The undesirable result associated with depletion of interconnected surface water in the Oxnard Subbasin is loss of groundwater-dependent ecosystem (GDE) habitat.

The primary cause of groundwater conditions in the Subbasin that would lead to depletion of interconnected surface water is groundwater production from the semi-perched aquifer. This unit is not currently considered a principal aquifer of the Oxnard Subbasin (Section 2.2.3, Principal Aquifers and Aquitards). Groundwater production from the semi-perched aquifer may result in depletion of interconnected surface water with significant and unreasonable adverse effects on beneficial uses of surface water if the groundwater levels were lowered to an elevation below which the vegetation in the existing GDEs could not access groundwater over a length of time that negatively affected the health of the GDE. Historically, this condition has not occurred within the Oxnard Subbasin, because there has been very minor (<31 AFY) groundwater production from the semi-perched aquifer (Section 2.4.1.2, Imported Water Supplies).

Depletion of interconnected surface water in the Oxnard Subbasin is not currently occurring, as evidenced by lack of production, relatively stable groundwater elevations, and the need for tile drains in the semi-perched aquifer. Groundwater elevations will continue to be monitored in the semi-perched aquifer.

Depletion of interconnected surface water in the Oxnard Subbasin has the potential to impact the uses and users of groundwater in the Subbasin by lowering the groundwater table and negatively impacting the health of GDEs. If future projects involve the use of water from the semi-perched aquifer, depletion of interconnected surface water is possible, and significant and unreasonable impacts may occur. Reevaluation of the effects on existing and potential GDEs should be conducted in conjunction with the project approval process for any such future projects.

3.3.7 Defining Subbasin-Wide Undesirable Results

In order to better manage groundwater production and projects within the Oxnard Subbasin, the Subbasin has been divided into four management areas (Section 2.5, Management Areas). Groundwater production in each of the management areas occurs in both the UAS and LAS (Table 2-14, Oxnard Subbasin Groundwater Used). Although there are groundwater production wells screened in both the UAS and the LAS in the Oxnard Subbasin, there are a sufficient number of wells screened only in one of the two aquifer systems to be able to manage groundwater production in the Subbasin by aquifer system. In contrast, there are few production wells screened only within an individual aquifer in the Subbasin. Therefore, the discussion of Subbasin-wide undesirable results that follows has been separated by aquifer system, but not by individual aquifer.

Upper Aquifer System

Fifteen wells were selected as key wells in the UAS (Table 3-1).[2] Of these, three are in the Forebay Management Area, three are in the West Oxnard Plain Management Area, and nine are in the Saline Intrusion Management Area. None of the UAS key wells are located in the Oxnard Pumping Depression Management Area.

2 Well 02N21W07L05 is screened in multiple aquifers, and has been assigned to the UAS for the purpose of defining undesirable results.

Undesirable results are defined in three ways for the UAS in the Oxnard Subbasin. The first is based on the total number of wells, independent of management area or aquifer. Under this definition, the UAS will be determined to be experiencing undesirable results if, in any single monitoring event, water levels in six of the 15 key wells are below their respective minimum thresholds.

The second definition of undesirable results for the UAS is based on the degree to which a single well exceeds a minimum threshold. Under this definition, the UAS would be determined to be experiencing an undesirable result if the groundwater elevation at any individual key well is below the historical low water level for that well.

The third definition of undesirable results for the UAS is based on the time over which a well may exceed the minimum threshold. Under this definition, the UAS would be determined to be experiencing an undesirable result if the water level in any individual key well was below the minimum threshold 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 UAS meet any of the definitions of undesirable results listed above, the UAS would be considered to be experiencing undesirable results.

Lower Aquifer System

Nineteen wells were selected as key wells in the LAS (Table 3-1).[3] Of these, six are in the Forebay Management Area, five are in the West Oxnard Plain Management Area, six are in the Saline Intrusion Management Area, and two are in the Oxnard Pumping Depression Management Area.

Undesirable results are defined in three ways for the LAS in the Oxnard Subbasin. The first is based on the total number of wells, independent of management area or aquifer. Under this definition, the LAS will be determined to be experiencing undesirable results if, in any single monitoring event, water levels in 8 of the 19 key wells are below their respective minimum thresholds.

The second definition of undesirable results for the LAS is based on the degree to which a single well exceeds a minimum threshold. Under this definition, the LAS would be determined to be experiencing an undesirable result if the groundwater elevation at any individual key well is below the historical low water level for that well.

The third definition of undesirable results for the LAS is based on the time over which a well may exceed the minimum threshold. Under this definition, the LAS would be determined to be experiencing an undesirable result if the water level in any individual key well were below the minimum threshold for either three consecutive monitoring events or in three of five consecutive monitoring events. Monitoring events are scheduled to occur in the spring and fall of each year.

[3] Wells 02N21W07L03, 01N21W07J02, and 01N21W07L03 are screened in multiple aquifers and have been assigned to the LAS for the purpose of defining undesirable results.

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

3.4 MINIMUM THRESHOLDS

The following sections and discussion set forth the minimum thresholds for each of the six sustainability indicators. These thresholds discussed below are the proposed minimum groundwater elevations that would prevent undesirable results, defined as net landward migration of the 2015 saline water impact front, net seawater intrusion in the UAS, or net seawater intrusion in the LAS. When groundwater elevations drop below the proposed minimum threshold, the Subbasin may experience undesirable results (Section 3.3.7, Defining Subbasin-Wide Undesirable Results).

The minimum thresholds for chronic lowering of water levels, change in groundwater storage, seawater intrusion, groundwater quality, and land subsidence are based on the historical record of groundwater elevation in individual aquifers, the documented impacts of seawater intrusion, and the hydrogeologic conceptual model developed for the Oxnard Subbasin. All of these undesirable results are interrelated, and each is directly tied to seawater intrusion. Because groundwater elevations, change in storage, and groundwater quality are directly tied to seawater intrusion, the minimum threshold groundwater levels selected to mitigate the effects of seawater intrusion are also used for the other undesirable results as well (Table 3-1).

The minimum threshold groundwater levels selected to prevent seawater intrusion were based on a review of the historical groundwater elevation data and an analysis of the potential for seawater intrusion under multiple future groundwater production scenarios. Predicted groundwater levels were simulated over a 50-year period from 2020 to 2069 (Section 2.4.5, Projected Future Water Budget and Sustainable Yield). 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 the California Department of Water Resources (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 (Section 2.4.5). The 50-year future simulations were used to assess the rate of groundwater production 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 (Figures 2-67a through 2-67e, UWCD Model Particle Tracks for the Reduction With Projects Simulation, and Figures 2-68a through 2-68e, UWCD Model Particle Tracks for the Reduction Without Projects Simulation 1; Section 2.4). Groundwater production in the first simulation, referred to as the Reduction With Projects Scenario (Section 2.4.5.3), averaged approximately 40,000 AFY, with 27,000 AFY of production in the UAS, and 13,000 AFY in the LAS. This simulation incorporated projects, including temporary fallowing of approximately 500 AFY in the Oxnard Subbasin, and deliveries of approximately 4,000 AFY of recycled water from the City of Oxnard's Groundwater Recovery Enhancement and Treatment (GREAT) Program for irrigation in the coastal area. Groundwater production in the second simulation, referred to as the Reduction Without Projects Scenario 1 (Section 2.4.5.4), averaged approximately 39,000 AFY, with 27,000 AFY of production in the UAS, and 12,000 AFY in the LAS (Section 2.4.5). 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 3-11, Key Well Hydrographs).

The minimum threshold groundwater elevations selected to protect against net seawater intrusion in the UAS and LAS 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 a 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. The rounded groundwater elevation was then raised by 2 feet to account for predicted sea level rise by 2070. The minimum thresholds for each well are presented in Table 3-1 and Figures 3-6 through 3-11.

There are no proposed minimum thresholds in the EOPMA because there are no suitable monitoring wells in the EOPMA (Figure 2-69). The thresholds for the Saline Intrusion Management Area and Oxnard Pumping Depression Management Area, both of which border the EOPMA, are presumed to protect the EOPMA, 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 EOPMA.

It is important to remember that there are several sources of uncertainty in the model predictions. These sources of uncertainty include, but are not limited to, the prediction of future climate, future diversions from the Santa Clara River, groundwater model assumptions and assigned values, and future groundwater production distribution in the Subbasin. The uncertainty in each of these factors is anticipated to decrease with time. As these factors are better understood, the minimum thresholds should be reassessed, and adjustments should be made, when warranted by the assessment.

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 limit migration of the 2015 saline water impact front after 2040, limit net seawater intrusion into the UAS and LAS, and indicate that declines in groundwater elevations during periods of future drought will be offset by recoveries during future periods of above-average rainfall.

These minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by limiting seawater intrusion and chronic lowering of groundwater levels. This allows for long-term use of groundwater supplies in the Subbasin without ongoing loss of storage that would cause economic harm to the users of groundwater in the Subbasin and impair the beneficial uses of groundwater in the Subbasin.

These minimum thresholds may impact groundwater users in the Subbasin by requiring both an overall reduction in groundwater production relative to historical levels, and potentially by requiring a redistribution of groundwater pumping within the Subbasin. A redistribution of groundwater production to shift groundwater production inland may require inland users to deepen existing wells or replace wells, and may require adjustment of the currently proposed minimum thresholds in the future. Furthermore, the minimum threshold groundwater elevations may result in a return to artesian conditions in wells screened in the UAS and LAS adjacent to the coast. In these areas, improperly abandoned wells can act as conduits for flow from the aquifer systems to land surface. Additional efforts may need to be undertaken by FCGMA and stakeholders in the Subbasin to prevent negative impacts from rising water levels and improperly abandoned wells.

The minimum thresholds for chronic lowering of groundwater levels 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 are water levels that were selected based on future groundwater model simulations that limit seawater intrusion in the 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. These minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by allowing for long-term use of groundwater supplies in the Subbasin without replacing freshwater in the UAS and LAS with seawater. Such a replacement would lead to a loss of storage that would cause economic harm to the users of groundwater in the Subbasin and impair the beneficial uses of groundwater in the Subbasin.

The minimum thresholds for reduction of groundwater storage are water levels that will be measured at the key wells two times per year. 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

Because the concentration of chloride is not necessarily the best indicator of modern seawater intrusion, the relationship between seawater intrusion and groundwater elevation was investigated using a numerical groundwater model (Appendix C). Groundwater levels in the Oxnard and Mugu Aquifers in coastal areas have historically fallen below sea level in response to increased production and drought cycles since the 1950s (Figure 2-9a, Groundwater Well Hydrographs in the Oxnard Aquifer – Oxnard Plain, and Figure 2-12, Groundwater Well Hydrographs in the Mugu Aquifer). The groundwater levels below sea level resulted in seasonal seawater intrusion during the fall irrigation season and during droughts in coastal wells in the vicinity of Point Hueneme and Point Mugu (Figure 2-35, Selected Historical Records of Water Elevation and Chloride Concentration).

Modeling by UWCD (2018; see Appendix C to this GSP) indicates that there was flux from the ocean into the Oxnard and Mugu Aquifers in the vicinity of the offshore Mugu and Hueneme Submarine Canyons when the coastal groundwater levels in the UAS fell below 5 to 10 feet above mean sea level. In 1990, FCGMA directed pumpers to decrease production in these aquifers to mitigate seawater intrusion. As a result, production in coastal areas shifted from the Oxnard and Mugu Aquifers to the deeper Hueneme Aquifer, the Fox Canyon Aquifer (FCA), and the Grimes Canyon Aquifer (the aquifers that compose the LAS). Water levels in the FCA and the Grimes Canyon Aquifer near the coast quickly fell below sea level and have remained there since the 1980s, even after periods of above-average precipitation (Figure 2-18, Groundwater Well Hydrographs in the Fox Canyon Aquifer, and Figure 2-21, Groundwater Well Hydrographs in the Grimes Canyon Aquifer). The UWCD model indicates continuous flux from the ocean into these aquifers since 1985 (Figure 2-34, Groundwater Flux along the Coast in the Lower Aquifer System).

Because the model indicates a strong relationship between groundwater elevation and seawater intrusion, the minimum thresholds for addressing seawater intrusion are water levels that were selected based on future groundwater model simulations that limited seawater intrusion in the UAS and LAS (Table 3-1). The model simulations suggest that if water levels fall below the minimum threshold elevations, the Subbasin is likely to experience net landward migration of the 2015 saline water impact front after 2040. These minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by limiting seawater intrusion. This allows for long-term use of groundwater supplies in the Subbasin without ongoing loss of storage that would cause economic harm to the users of groundwater in the Subbasin and impair the beneficial uses of groundwater in the Subbasin.

Groundwater users in the Subbasin may be impacted by the minimum thresholds in several ways. First, an overall reduction in groundwater production relative to historical levels will be required to achieve the minimum thresholds. Such a reduction may impact the value of agricultural land, drive changes in crop types, result in temporary fallowing of agricultural acreage, and cause economic disruption to the regional economy. Second, a redistribution of groundwater pumping may be required to optimize water management in the Subbasin. If groundwater production is reduced at the coast and shifted inland, additional infrastructure may be needed to convey water from the inland areas to the coast, inland users may be required to deepen existing wells, and the currently proposed minimum thresholds may need to be lowered for inland areas in the future. Third, as the minimum thresholds are achieved in the coastal areas, additional economic impacts may occur as improperly abandoned wells may need to be properly sealed so they do not act as a conduit for flow from the underlying aquifers.

The minimum thresholds were selected for each aquifer system in the Oxnard Subbasin, primarily using wells screened in a single aquifer. These wells will be used to monitor groundwater elevations in each aquifer system in the Subbasin. 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.

3.4.4 Degraded Water Quality

Water quality impacts to the aquifer systems of the Oxnard Subbasin are limited to high concentrations of nitrate, chloride, and TDS. The sources and mechanisms controlling the concentration of these constituents differs throughout the Subbasin (Section 2.3). Nitrate concentrations in the Forebay exceed the federal MCL in some wells. However, these concentrations cannot be reduced by altering groundwater production in the Subbasin. For these concentrations, the recharge source water should be of the highest quality possible to maintain or improve future groundwater quality (Section 3.3.4, Degraded Water Quality). Although FCGMA cannot control the quality of the recharge water, the groundwater elevations minimum thresholds to prevent net migration of seawater after 2040 are higher than the historical low groundwater elevations at which nitrate concentrations were observed to exceed the federal MCL. These groundwater elevations will be used as the minimum thresholds to prevent further degradation of groundwater quality in the Forebay until such time that a separate concentration minimum threshold is found to be necessary.

In contrast to concentrations of nitrate in the Forebay, the concentration of chloride and TDS in coastal wells is influenced by groundwater production. Concentrations of chloride and TDS exceed federal, state, and local standards in some wells in the Subbasin (Section 2.3). Groundwater production near the coast induces seawater intrusion, and lowered groundwater elevations induce compaction of fine-grained sediments that release connate brines into the aquifers. Because both of these processes are tied to groundwater elevations in the Subbasin, minimum thresholds for groundwater elevation, rather than concentration, were set to control the additional impacts from seawater and brine migration in the aquifers (Section 3.4.3, Seawater Intrusion). The minimum thresholds selected are the same as the water level thresholds selected to prevent net migration of the 2015 saline water impact front after 2040. These groundwater elevations are higher than historical low elevations, which will prevent further compaction of fine-grained sediments and brine release. They are also designed to prevent further degradation of water quality from direct seawater intrusion.

As discussed previously, the minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by increasing the overall amount of freshwater storage in the Subbasin and limiting the further intrusion of seawater. The minimum thresholds impacts to groundwater users for degraded water quality are anticipated to be the same as those for seawater intrusion, which are described in Section 3.4.3.

The minimum thresholds for degraded water quality are water levels that will be measured at the monitoring wells listed in 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.

3.4.5 Land Subsidence

The minimum thresholds for land subsidence are water levels that were selected based on future groundwater model simulations that limit seawater intrusion in the 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 avoid further seawater intrusion, groundwater elevations in the aquifer systems will rise, and the resulting minimum thresholds are higher than historical low water levels. Because groundwater elevations must be maintained above the minimum threshold in order to avoid undesirable results for seawater intrusion and loss of freshwater storage, water levels in the Subbasin will remain above historical low water levels after 2040. Therefore, water levels in the Subbasin will not induce inelastic subsidence in the Subbasin. If the distribution of pumping is altered to mitigate seawater intrusion by reducing pumping near the coast and increasing pumping in the Forebay, the potential subsidence risk may have to be revisited in inland areas. 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 Subbasin by increasing the overall amount of freshwater storage in the Subbasin and limiting the further intrusion of seawater. These minimum thresholds also will limit future subsidence because currently they 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 seawater intrusion, which are described in Section 3.4.3.

The minimum thresholds for subsidence are water levels that will be measured at the monitoring wells listed in 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

The minimum thresholds for depletions of interconnected surface water are water levels that were selected based on future groundwater model simulations that limit seawater intrusion in the 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 areas of interconnected surface water and groundwater and associated GDEs described in Section 2.3.6, Groundwater–Surface Water Connections, and Section 2.3.7, Groundwater-Dependent Ecosystems, are connected to the semi-perched aquifer, from which there is little current groundwater production. Because the semi-perched aquifer is not considered a principal aquifer, specific minimum thresholds were not selected for this unit. Instead, results of the numerical groundwater model scenarios that prevent net landward migration of the 2015 saline water impact front after 2040 indicate that groundwater elevations in the semi-perched aquifer will be supported by groundwater elevations in the underlying Oxnard Aquifer. The Oxnard Aquifer is the uppermost aquifer of the UAS. The simulated minimum threshold water levels in the Oxnard Aquifer that prevent net migration of the 2015 saline water impact front after 2040 were found to result in higher water levels in the semi-perched aquifer. Therefore, the minimum thresholds for depletions of interconnected surface water are water levels in the Oxnard Aquifer that also prevent net migration of the 2015 saline water impact front after 2040. The minimum thresholds are equal to or higher than the lowest groundwater elevation measured at these wells. The selected groundwater elevations are anticipated to protect against depletion of interconnected surface water, because historical groundwater elevations in the semi-perched aquifer have maintained the documented and potential GDEs in the Subbasin (Section 2.3).

As discussed previously, the minimum thresholds are anticipated to improve the beneficial uses of the Subbasin by increasing the overall amount of freshwater storage in the Subbasin and limiting the further intrusion of seawater. The minimum thresholds set will maintain the existing beneficial uses of the semi-perched aquifer by maintaining groundwater elevations equal to or higher than historical lows. The minimum thresholds impacts to groundwater users for interconnected groundwater and surface water are anticipated to be the same as those for seawater intrusion, which are described in Section 3.4.3.

Currently there is very little groundwater production from the semi-perched aquifer. If water levels in this aquifer rise as a result of reduced groundwater production in the underlying UAS, additional projects may investigate producing water from the semi-perched aquifer. Such 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 semi-perched aquifer are implemented, the need for specific water level minimum thresholds in the semi-perched aquifer should be reevaluated.

The minimum thresholds for interconnected surface water are water levels that will be measured at the monitoring wells listed in 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.

3.5 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 Oxnard Subbasin, the measurable objective is the water level—measured at each of the key wells throughout the Subbasin—at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS. If water levels in the Subbasin 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 Subbasin, because seawater intrusion would be prevented while maintaining the maximum freshwater use from the aquifer systems. However, because groundwater elevations in the Oxnard Subbasin respond to climatic cycles, actual groundwater levels in the Subbasin 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 after 2040, the measurable objectives were selected to work with the minimum thresholds in the Oxnard Subbasin.

To allow for operational flexibility during drought periods, water levels in the Subbasin 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 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. In order 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 to prevent net migration of the 2015 saline water impact front after 2040. The first is not allowing groundwater levels to decline below an elevation at which net seawater intrusion will occur. 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 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 after 2040.

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 Subbasin after 2040, observed groundwater levels 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 to offset seawater intrusion. 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 to offset seawater intrusion.

3.5.1 Chronic Lowering of Groundwater Levels

The measurable objective for the chronic lowering of groundwater levels is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS. This groundwater level is the same groundwater level that is used to protect against seawater intrusion in the 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 Subbasin.

Groundwater elevations within each management area of the Oxnard Subbasin will be used to determine whether chronic lowering of groundwater levels is occurring. All of the management areas except the EOPMA have wells in which water levels can be monitored by aquifer. Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells in the Saline Intrusion Management Area and Oxnard Pumping Depression Management Area, closest to the EOPMA, are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the WOPMA 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 EOPMA.

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 Oxnard Subbasin between 2020 and 2040. The interim milestones for chronic lowering of groundwater levels are the same as the interim milestones for seawater intrusion, because the interim milestones measure progress toward groundwater elevations in the Subbasin that prevent the net migration of the 2015 saline water impact front after 2040.

Two sets of interim milestones were determined for the key wells in the Subbasin (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 3-12, 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 3-12).

Two sets of interim milestones were calculated because the actual groundwater elevation in 2040 will depend both on groundwater production from the Subbasin and the climatic conditions between 2020 and 2040. Groundwater model simulations of future groundwater levels show that groundwater levels throughout the Subbasin vary by tens of feet at constant groundwater production rates over 5-year periods. This variability reflects the variability in annual precipitation, flow in the Santa Clara River, and groundwater recharge through the UWCD spreading grounds. Just as annual climate conditions vary from the calculated long-term historical mean conditions, so do 5-year average climate conditions (Figure 3-13, Distribution of 5-Year Average Climate Conditions in the Historical Record of Precipitation on the Oxnard Plain). Therefore, progress toward the measurable objective, which is the anticipated median groundwater level necessary to prevent net migration of the 2015 saline water impact front after 2040, 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 Oxnard Subbasin, 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 Subbasin 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 six times in the historical record (Figure 3-13), 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 Subbasin 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 progress toward the measurable objective (Figure 3-13). 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 six times in the historical record (Figure 3-13), 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 in Storage

The measurable objective for reduction of groundwater in storage is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS (Table 3-2). The measurable objective groundwater level was selected for each of the key wells based on the median predicted groundwater elevation between 2040 and 2070 from groundwater model simulations that minimized the migration of the 2015 saline water impact front after 2040. This groundwater level is the same groundwater level that is used to protect against seawater intrusion in the Subbasin. 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 Subbasin.

All of the management areas except the EOPMA have wells in which water levels can be monitored by aquifer. Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells in the Saline Intrusion Management Area and Oxnard Pumping Depression Management Area, closest to the EOPMA, are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the WOPMA 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 EOPMA.

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 Oxnard Subbasin between 2020 and 2040 as groundwater production from the Subbasin is reduced. The interim milestones for reduction of groundwater in storage are the same as the interim milestones for seawater intrusion.

3.5.3 Seawater Intrusion

The measurable objective for seawater intrusion is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS (Table 3-2). The measurable objective groundwater level was selected for each of the key wells based on the median predicted groundwater elevation between 2040 and 2070 from groundwater model simulations that minimized the migration of the 2015 saline water impact front after 2040. 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 Subbasin.

All of the management areas except the EOPMA have wells in which water levels can be monitored by aquifer. Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells closest to the EOPMA in the Saline Intrusion Management Area and the Oxnard Pumping Depression Management Area are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the adjoining management areas 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 EOPMA.

Interim Milestones for Seawater Intrusion

Interim milestones for seawater intrusion 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 key well. These interim milestones will be used to assess progress toward sustainable groundwater management in the Oxnard Subbasin between 2020 and 2040 as groundwater production from the Subbasin is reduced.

3.5.4 Degraded Water Quality

The measurable objective for degraded water quality is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS (Table 3-2). The measurable objective groundwater level was selected for each of the key wells based on the median predicted groundwater elevation between 2040 and 2070 from groundwater model simulations that minimized the migration of the 2015 saline water impact front after 2040. This groundwater level is the same groundwater level that is used to protect against seawater intrusion in the Subbasin. 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 Subbasin.

Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells closest to the EOPMA in the Saline Intrusion Management Area and the Oxnard Pumping Depression Management Area are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the adjoining management areas 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 EOPMA.

Interim Milestones for Degraded Water Quality

Interim milestones for degraded water quality 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 key well. These interim milestones will be used to assess progress toward sustainable groundwater management in the Oxnard Subbasin between 2020 and 2040 as groundwater production from the Subbasin is reduced. The interim milestones for degraded water quality are the same as the interim milestones for seawater intrusion.

3.5.5 Land Subsidence

The measurable objective for land subsidence is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS (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 based on the median predicted groundwater elevation between 2040 and 2070 from groundwater model simulations that minimized the migration of the 2015 saline water impact front after 2040. This groundwater level is the same groundwater level that is used to protect against seawater intrusion in the Subbasin. 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 Subbasin.

Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells closest to the EOPMA in the Saline Intrusion Management Area and the Oxnard Pumping Depression Management Area are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the adjoining management areas 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 EOPMA.

Interim Milestones for Land Subsidence

Interim milestones for land subsidence 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 key well. These interim milestones will be used to assess progress toward sustainable groundwater management in the Oxnard Subbasin between 2020 and 2040 as groundwater production from the Subbasin is reduced. The interim milestones for land subsidence are the same as the interim milestones for seawater intrusion.

3.5.6 Depletions of Interconnected Surface Water

The measurable objective for depletions of interconnected surface water is the groundwater level at which there is neither seawater flow into nor freshwater flow out of the UAS or LAS (Table 3-2). This groundwater level is higher than the historical low water level in each key well. Therefore, it will protect against depletions of interconnected surface water related to groundwater withdrawal. The measurable objective groundwater level was selected for each of the key wells based on the median predicted groundwater elevation between 2040 and 2070 from groundwater model simulations that minimized the migration of the 2015 saline water impact front after 2040. This groundwater level is the same groundwater level that is used to protect against seawater intrusion in the Subbasin. 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 Subbasin.

Currently there is very little groundwater production from the semi-perched aquifer. If water levels in this aquifer rise as a result of reduced groundwater production in the underlying UAS, additional projects may investigate producing water from the semi-perched aquifer. Such 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 semi-perched aquifer are implemented, the need for specific water-level measurable objectives in the semi-perched aquifer should be reevaluated.

Until a monitoring well is installed in the EOPMA, the measurable objectives set for the wells closest to the EOPMA in the Oxnard Pumping Depression Management Area are presumed to also protect the EOPMA. The EOPMA has considerably less groundwater production than the Oxnard Pumping Depression Management Area 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 EOPMA.

Interim Milestones for Depletions of Interconnected Surface Water

Interim milestones for depletions of interconnected surface water 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 key well. These interim milestones will be used to assess progress toward sustainable groundwater management in the Oxnard Subbasin between 2020 and 2040 as groundwater production from the Subbasin is reduced. The interim milestones for interconnected surface water are the same as the interim milestones for seawater intrusion.

3.6 REFERENCES CITED

23 CCR (California Code of Regulations), Section 354.28(c)(5). Definition of the minimum threshold for land subsidence.

DWR (California Department of Water Resources). 2014. *Summary of Recent, Historical, and Estimated Potential for Future Land Subsidence in California*. Accessed February 2017. http://www.water.ca.gov/groundwater/docs/Summary_of_Recent_Historical_Potential_Subsidence_in_CA_Final_with_Appendix.pdf.

DWR. 2016. “Map of Basin Boundary Modifications.” Bulletin 118 Basins (2016 Edits) [GIS layer]. https://gis.water.ca.gov/app/bbat/.

Hanson, R.T., P. Martin, and K. Koczot. 2003. *Simulation of Ground-Water/Surface-Water Flow in the Santa Clara-Calleguas Ground-Water Basin, Ventura County, California*. U.S. Geological Survey Water Resources Investigation Report 2002-4136.

Izbicki, J.A. 1991. “Chloride Sources in a California Coastal Aquifer.” In *American Society of Civil Engineers Symposium on Groundwater in the Pacific Rim*, 71–77. Honolulu: American Society of Civil Engineers. Proceedings: July 22–26, 1991.

Izbicki, J.A. 1996. “Use of δ^{18}O and δD to Define Seawater Intrusion.” In *North American Water Congress*, edited by C.T. Bathala. Anaheim, California: New York American Society of Civil Engineers. Proceedings: June 23–28, 1996.

UWCD (United Water Conservation District). 2008. *Nitrate Observations in the Oxnard Forebay and Vicinity, 1995–2006*. Prepared by D. Detmer. Santa Paula, California: UWCD. July 2008.

UWCD. 2016. *Saline Intrusion Update, Oxnard Plain and Pleasant Valley Basins.* United Water Conservation District Open-File Report 2016-04. October 2016.

UWCD. 2018. *United Water Conservation District Multiple Species Habitat Conservation Plan*. Administrative Draft. September 7, 2018. Accessed April 10, 2019. https://www.unitedwater.org/images/stories/Resource-Conservation/MSHCP%202018/UWCD%20Multiple%20Species%20Habitat%20Conservation%20Plan%202018-09-07.pdf.

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

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		2015 Spring Water Level (ft msl) and Date Measured		GSP Undesirable Result	Proposed Minimum Threshold (ft msl)
01N21W32Q06S	Saline Intrusion Management Area	Oxnard	180–220	−172.7	−212.7	−25.8	11/22/1991	−12.7	March 2015	SWI, reduction in groundwater storage	2
01N22W20J08S	Saline Intrusion Management Area	Oxnard	155–195	−143.8	−183.8	−14.8	09/28/1991	−7.6	March 2015	SWI, reduction in groundwater storage	7
01N22W26J04S	Saline Intrusion Management Area	Oxnard	185–205	−170.2	−190.2	−28.3	10/26/1990	−14.3	March 2015	SWI, reduction in groundwater storage	2
01N22W27C03S	Saline Intrusion Management Area	Oxnard	175–195	−162.8	−182.8	−18.6	12/13/1990	−9.0	March 2015	SWI, reduction in groundwater storage	7
01N23W01C05S	West Oxnard Plain Management Area	Oxnard	120–145	−105.8	−130.8	−6.9	11/18/1991	1.2	March 2015	SWI, reduction in groundwater storage	7
02N22W36E06S	West Oxnard Plain Management Area	Oxnard	230–320	−211.7	−251.7	−25.0	10/28/2015	−15.3	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	12
01N21W32Q05S	Saline Intrusion Management Area	Mugu	330–370	−322.7	−362.7	−107.4	11/30/2015	−60.7	March 2015	SWI, reduction in groundwater storage	2
01N21W32Q07S	Saline Intrusion Management Area	Mugu	275–285	−268.2	−278.2	−72.5	11/30/2015	−41.2	March 2015	SWI, reduction in groundwater storage	2
01N22W20J07S	Saline Intrusion Management Area	Mugu	310–350	−298.8	−338.8	−16.5	11/13/1991	−10.7	March 2015	SWI, reduction in groundwater storage	7
01N22W26J03S	Saline Intrusion Management Area	Mugu	524–620	−509.2	−605.2	−52.6	10/26/1990	−33.1	March 2015	SWI, reduction in groundwater storage	2
01N22W27C02S	Saline Intrusion Management Area	Mugu	275–295	−262.8	−282.8	−27.3	12/13/1990	−14.3	March 2015	SWI, reduction in groundwater storage	7
02N21W07L06S	Forebay Management Area	Mugu	135–155	11.9	−8.1	−12.2	12/03/2015	8.3	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	25
02N22W23B07S	Forebay Management Area	Mugu	260–300	−150.2	−190.2	−40.8	12/15/1992	−20.7	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	15
02N22W36E05S	West Oxnard Plain Management Area	Mugu	360–420	−288.4	−348.4	−21.0	11/04/2015	−13.6	February 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	10
01N22W20J05S	Saline Intrusion Management Area	Hueneme	640–680	−628.8	−668.8	−29.9	11/30/2015	−19.9	March 2015	SWI, reduction in groundwater storage	2
01N23W01C03S	West Oxnard Plain Management Area	Hueneme	965–1,065	−950.8	−1,050.8	−39.7	01/07/1991	−23.2	March 2015	SWI, reduction in groundwater storage	7
01N23W01C04S	West Oxnard Plain Management Area	Hueneme	630–695	−615.8	−680.8	−34.9	01/07/1991	−20.0	March 2015	SWI, reduction in groundwater storage	7
02N22W23B04S	Forebay Management Area	Hueneme	1,110–1,150	−1,000.2	−1,040.2	−147.1	10/28/2014	−75.6	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	−5
02N22W23B05S	Forebay Management Area	Hueneme	830–870	−720.2	−760.2	−121.0	10/12/1991	−65.5	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	−5

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

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		2015 Spring Water Level (ft msl) and Date Measured		GSP Undesirable Result	Proposed Minimum Threshold (ft msl)
02N22W23B06S	Forebay Management Area	Hueneme	460–500	−350.2	−390.2	−41.7	02/03/1993	−23.2	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	15
02N22W36E03S	West Oxnard Plain Management Area	Hueneme	195–285	−123.1	−213.1	−51.8	12/03/2014	−30.5	June 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	10
02N22W36E04S	West Oxnard Plain Management Area	Hueneme	130–170	−58.9	−98.9	−32.11	11/04/2015	−32.1	November 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	10
01N21W32Q04S	Saline Intrusion Management Area	FCA	600–640	−592.7	−632.7	−116.9	11/30/2015	−66.3	March 2015	SWI, reduction in groundwater storage	−23
01N22W20J04S	Saline Intrusion Management Area	FCA	870–930	−858.8	−918.8	−40.7	11/30/2015	−28.1	March 2015	SWI, reduction in groundwater storage	2
01N22W26K03S	Saline Intrusion Management Area	FCA	470–580	−456.9	−566.9	−71.8	06/16/2015	−65.6	March 2015	SWI, reduction in groundwater storage	−18
01N23W01C02S	West Oxnard Plain Management Area	FCA	1,390–1,490	−1,375.8	−1,475.8	−50.4	01/07/1991	−29.3	March 2015	SWI, reduction in groundwater storage	7
02N21W07L04S	Forebay Management Area	FCA	500–540	−353.1	−393.1	−32.0	10/14/2015	3.9	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	15
02N22W23B03S	Forebay Management Area	FCA	1,210–1,250	−1,100.2	−1,140.2	−128.7	02/28/1991	−77.0	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	−5
01N21W32Q02S	Saline Intrusion Management Area	GCA	930–970	−922.7	−962.7	−115.2	11/30/2015	−64.7	March 2015	SWI, reduction in groundwater storage	−23
01N21W32Q03S	Saline Intrusion Management Area	GCA	800–840	−792.7	−832.7	−125.8	11/30/2015	−75.6	March 2015	SWI, reduction in groundwater storage	−23
01N21W07J02S	Oxnard Pumping Depression Management Area	Multiple	590–1,280	−555.4	−1,245.4	−145.4	10/21/2014	−96.2	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	−40
01N21W21H02S	Oxnard Pumping Depression Management Area	Multiple	503–863	−484.3	−844.3	−149.4	10/20/2014	−101.1	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	−70
02N21W07L03S	Forebay Management Area	Multiple	640–700	−493.1	−553.1	−24.6	10/15/2015	1.8	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	15
02N21W07L05S	Forebay Management Area	Multiple	270–310	−1,23.1	−163.1	−7.4	12/30/2015	20.5	March 2015	SWI, reduction in groundwater storage, chronic lowering of WL, subsidence	25

Notes: FCA = Fox Canyon Aquifer; ft bgs = feet below ground surface; ft msl = feet mean sea level; GCA = Grimes Canyon Aquifer; GSP = Groundwater Sustainability Plan; SWI = seawater intrusion; WL = water level.
Interim milestones are proposed for wells with spring 2015 groundwater elevations that are lower than the minimum threshold groundwater elevation. Wells with spring 2015 groundwater elevations that are higher than the minimum threshold are currently in compliance with the goals of this GSP and do not require milestones to assess progress toward sustainability.

Table 3-2
Measurable Objectives and Interim Milestones

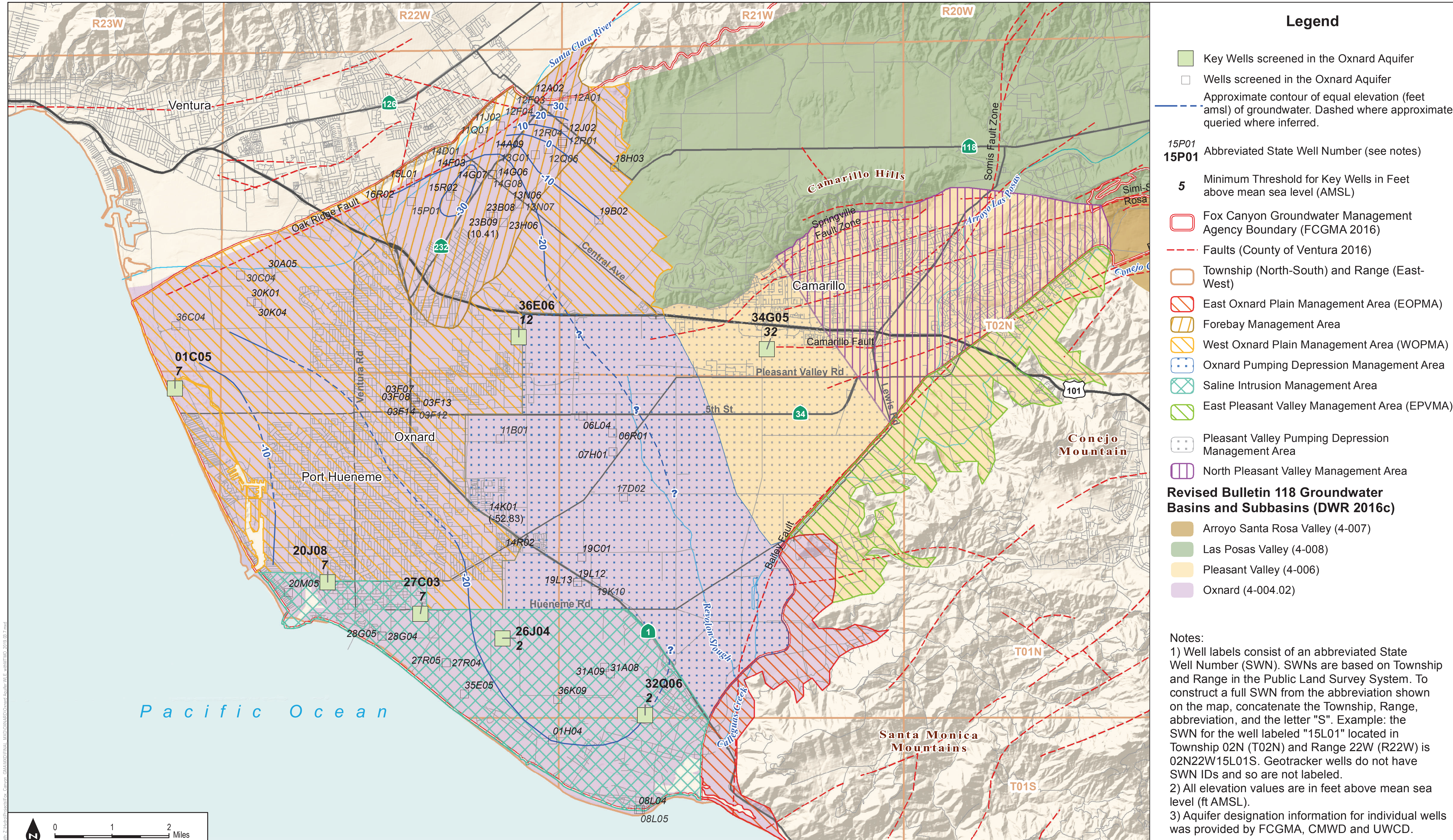
Well Number	Aquifer	Minimum Threshold (ft msl)	Measurable Objective (ft msl)	Fall 2015 Water Level Low (ft msl) and Date Measured		Interim Milestone Average Climate (ft msl)				Interim Milestone Dry Climate (ft msl)			
						2025	*2030[a]*	*2035[a]*	*2040[a]*	*2025*	*2030[a]*	*2035[a]*	*2040[a]*
01N21W32Q06S	Oxnard	2	17	−23.12	11/30/2015	−15	−5	6	17	−18	−11	−4	2
01N22W20J08S	Oxnard	7	17	-14.56	11/2/2015	−7	1	9	17	−10	−5	1	7
01N22W26J04S	Oxnard	2	17	−23.31	10/16/2015	−15	−5	6	17	−18	−11	−4	2
01N22W27C03S	Oxnard	7	17	−14.83	10/6/2015	−7	1	9	17	−10	−5	1	7
01N23W01C05S	Oxnard	7	17	−1.94	11/2/2015	4	8	12	17	2	4	6	7
02N22W36E06S	Oxnard	12	37	−25.03	10/28/2015	−10	6	22	37	−16	−7	2	12
01N21W32Q05S	Mugu	2	17	−107.36	11/2/2015	−78	−46	−14	17	−82	−54	−26	2
01N21W32Q07S	Mugu	2	17	−72.50	11/30/2015	−52	−29	−6	17	−56	−37	−18	2
01N22W20J07S	Mugu	7	17	−16.21	11/2/2015	−7	1	9	17	−10	−5	1	7
01N22W26J03S	Mugu	2	17	−44.39	10/16/2015	−30	−15	1	17	−33	−21	−9	2
01N22W27C02S	Mugu	7	17	−22.57	10/6/2015	−15	−5	6	17	−17	−9	−1	7
02N21W07L06S	Mugu	27	62	−12.21	12/3/2015	8	26	44	62	−1	8	17	27
02N22W23B07S	Mugu	17	47	−31.59	12/30/2015	−11	8	27	47	−18	−6	6	17
02N22W36E05S	Mugu	12	37	−21.01	11/4/2015	−6	8	22	37	−12	−4	4	12
01N22W20J05S	Hueneme	2	17	−29.87	11/30/2015	−18	−6	6	17	−22	−14	−6	2
01N23W01C03S	Hueneme	7	22	−32.26	11/30/2015	−17	−4	9	22	−21	−12	−3	7
01N23W01C04S	Hueneme	7	22	−28.36	11/4/2015	−17	−4	9	22	−21	−12	−3	7
02N22W23B04S	Hueneme	−3	17	−95.68	12/3/2015	−67	−39	−11	17	−72	−49	−26	−3
02N22W23B05S	Hueneme	−3	17	−83.59	12/3/2015	−60	−35	−10	16	−65	−45	−25	−4
02N22W23B06S	Hueneme	17	47	−37.35	12/3/2015	−15	6	27	47	−22	−9	4	17
02N22W36E03S	Hueneme	12	37	−51.77	12/3/2014	−28	−6	16	37	−35	−20	−5	11
02N22W36E04S	Hueneme	12	37	−32.12	11/4/2015	−13	4	21	37	−20	−10	1	12
01N21W32Q04S	FCA	−23	2	–116.94	11/30/2015	−86	−57	−28	2	−92	−69	−46	−23
01N22W20J04S	FCA	2	17	–40.72	11/30/2015	42	34	26	17	38	26	14	2
01N22W26K03S	FCA	−18	2	–71.84	6/16/2015	−52	−34	−16	2	−57	−44	−31	−18
01N23W01C02S	FCA	7	22	–37.63	11/30/2015	−25	−10	6	22	−28	−16	−4	7
02N21W07L04S	FCA	17	42	–32.02	10/14/2015	−12	6	24	42	−18	−6	6	17
02N22W23B03S	FCA	−3	17	–94.26	12/3/2015	−67	−39	−11	17	−72	−49	−26	−3
01N21W32Q02S	GCA	−23	2	–115.19	11/30/2015	−86	−57	−28	2	−92	−69	−46	−23

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]
01N21W32Q03S	GCA	−23	2	–125.76	11/30/2015	−93	−61	−29	2	−100	−75	−50	−24
01N21W07J02S	Multiple	−38	2	–140.02	10/25/2015	−105	−70	−35	1	−115	−90	−65	−39
01N21W21H02S	Multiple	−68	-8	–137.09	9/30/2015	−103	−71	−39	−7	−118	−101	−84	−67
02N21W07L03S	Multiple	17	37	–24.59	10/15/2015	−10	6	22	37	−15	−5	6	17
02N21W07L05S	Multiple	27	57	–7.41	12/30/2015	11	27	43	58	3	11	19	27

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

[a] Interim milestones for 2030, 2035, and 2040 will depend on climate conditions and Subbasin 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.



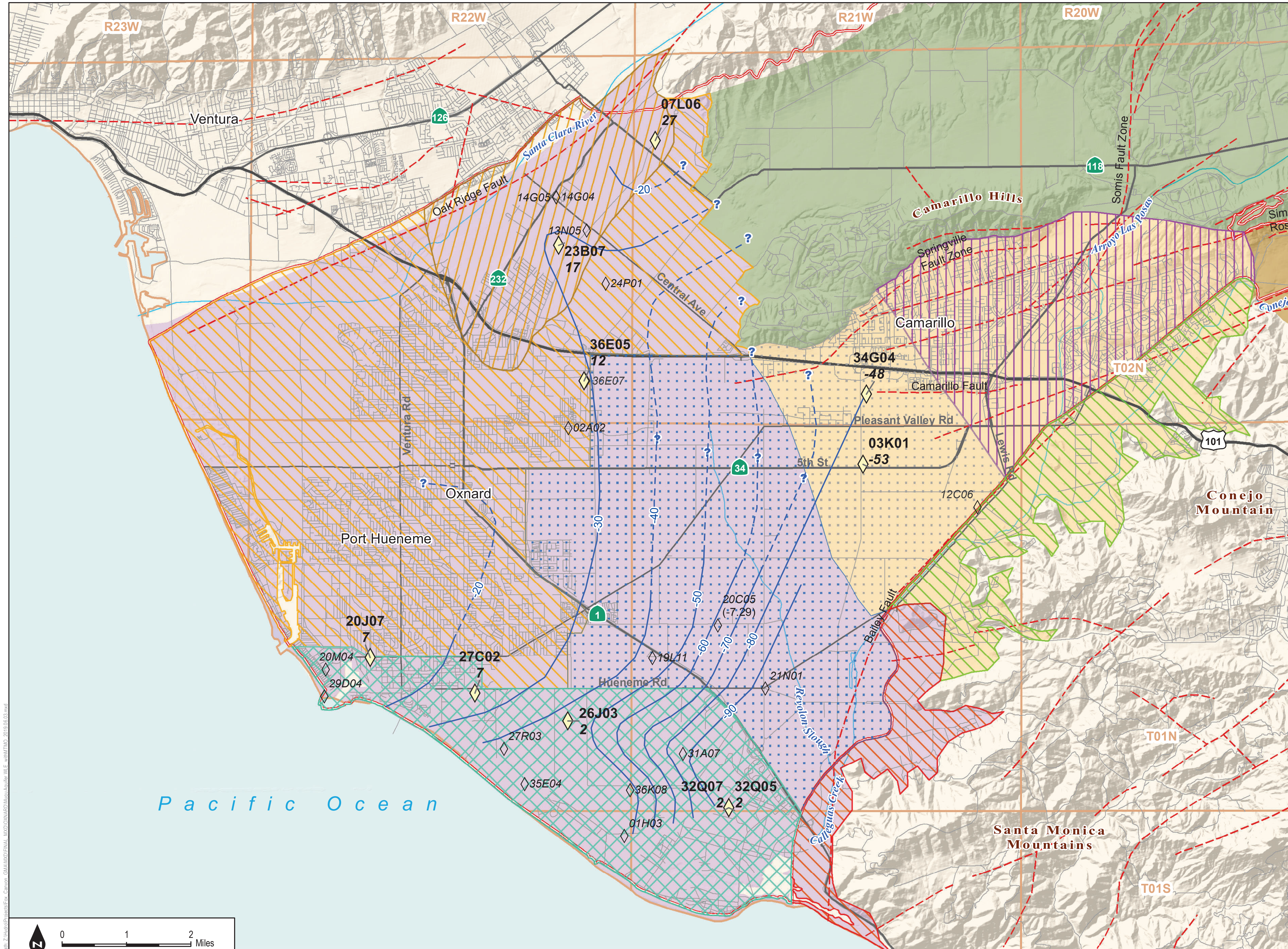
DUDEK

SOURCE: DWR; County of Ventura; UWCD; CMWD

FIGURE 3-1

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

INTENTIONALLY LEFT BLANK



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 (County of Ventura 2016)
- Township (North-South) and Range (East-West)
- East Oxnard Plain Management Area (EOPMA)
- Forebay Management Area
- West Oxnard Plain Management Area (WOPMA)
- Oxnard Pumping Depression Management Area
- Saline Intrusion Management Area
- East Pleasant Valley Management Area (EPVMA)
- Pleasant Valley Pumping Depression Management Area
- North Pleasant Valley Management Area

Revised Bulletin 118 Groundwater Basins and Subbasins (DWR 2016c)

- 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.

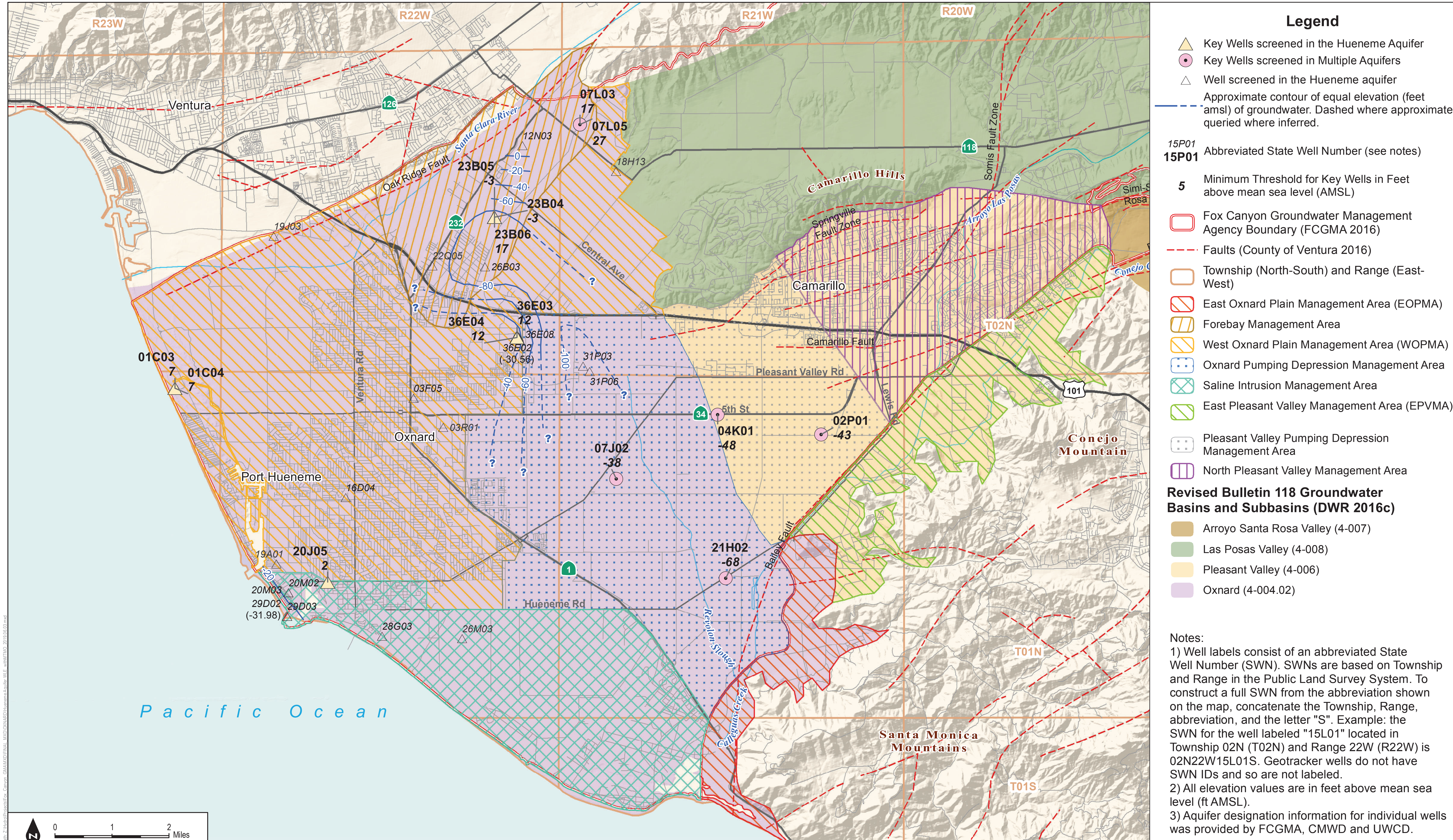
DUDEK

SOURCE: DWR; County of Ventura; UWCD; CMWD

FIGURE 3-2

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

INTENTIONALLY LEFT BLANK



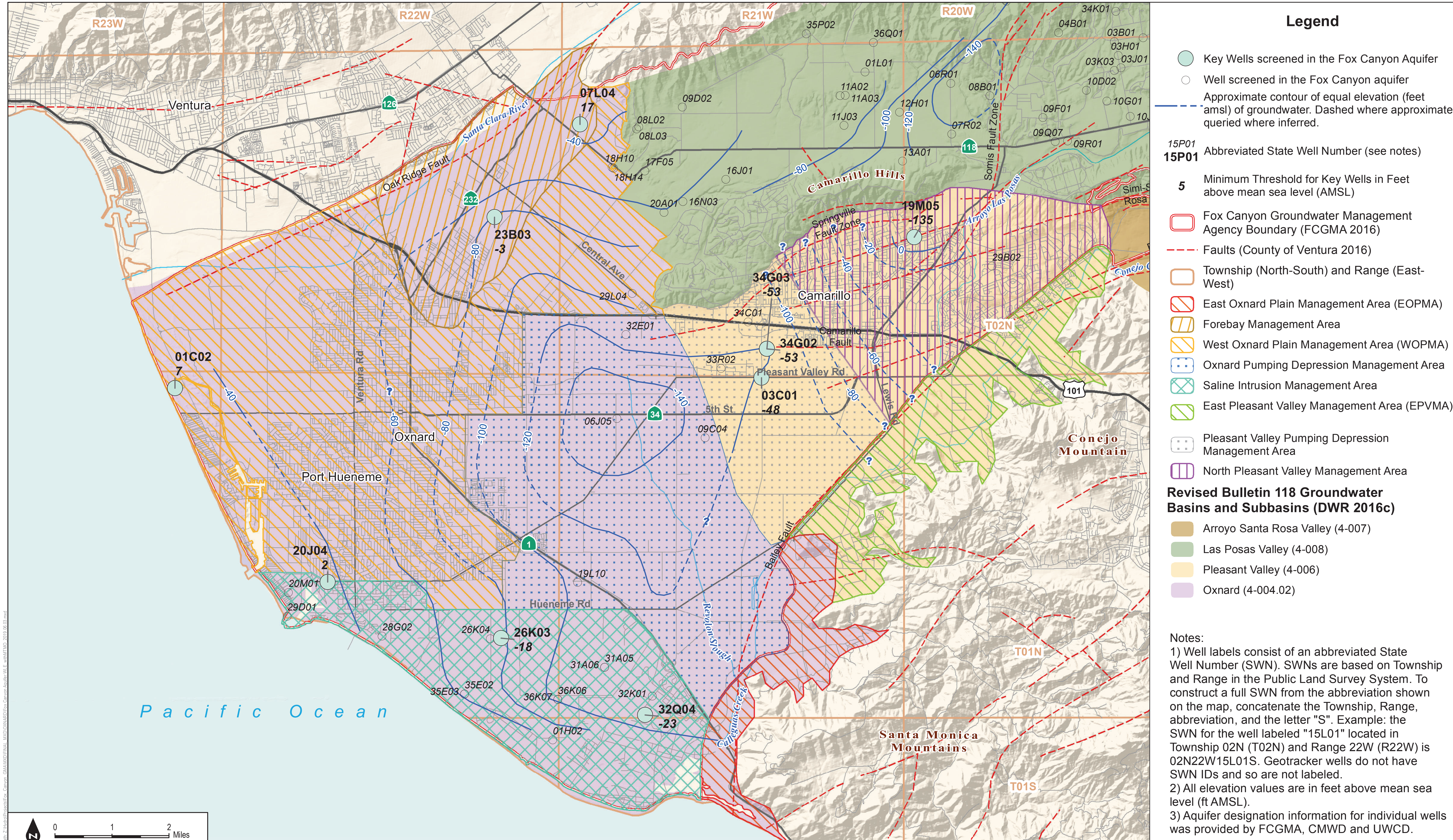
DUDEK

SOURCE: DWR; County of Ventura; UWCD; CMWD

FIGURE 3-3

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

INTENTIONALLY LEFT BLANK

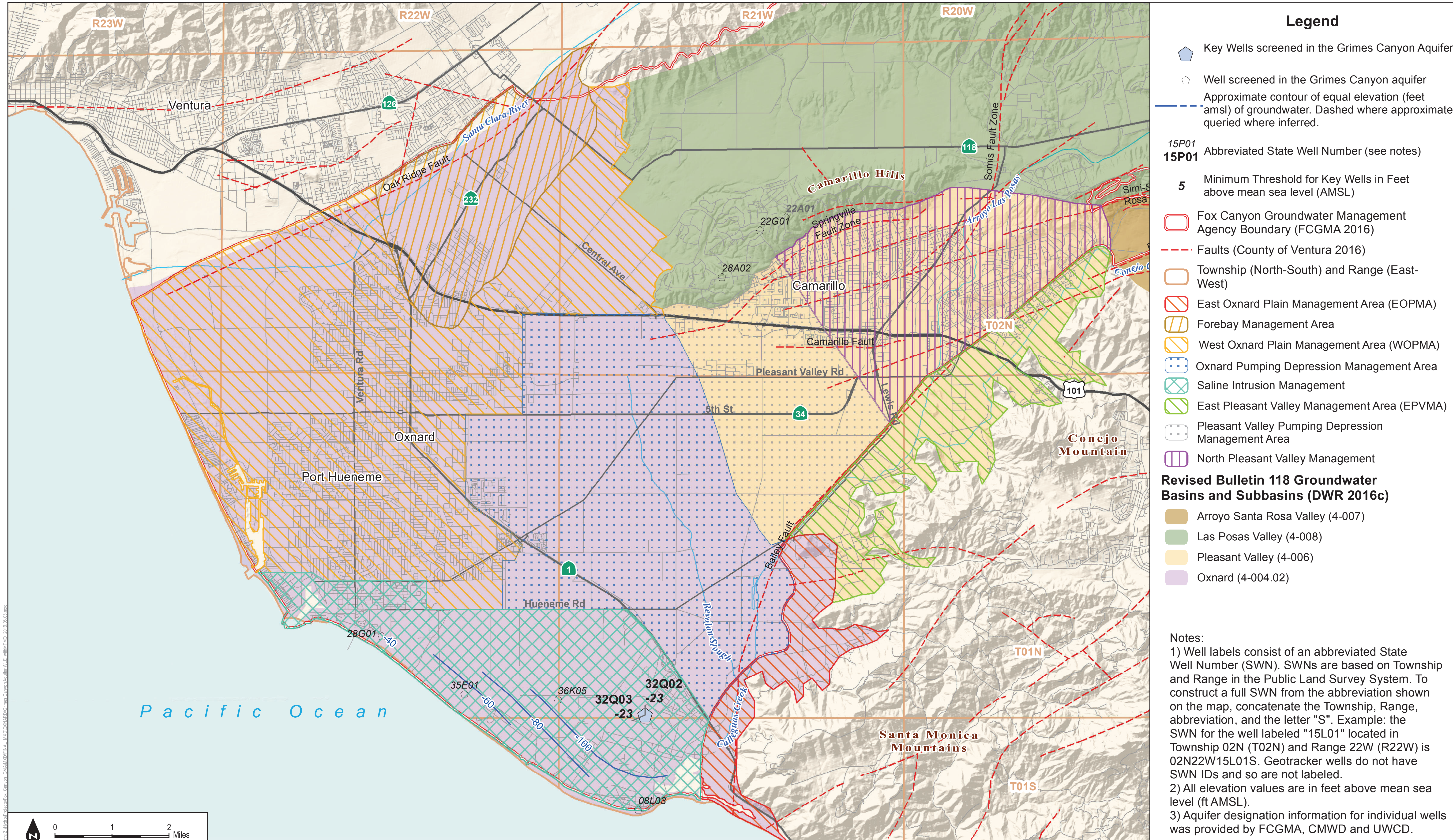


SOURCE: DWR; County of Ventura; UWCD; CMWD

FIGURE 3-4

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

INTENTIONALLY LEFT BLANK



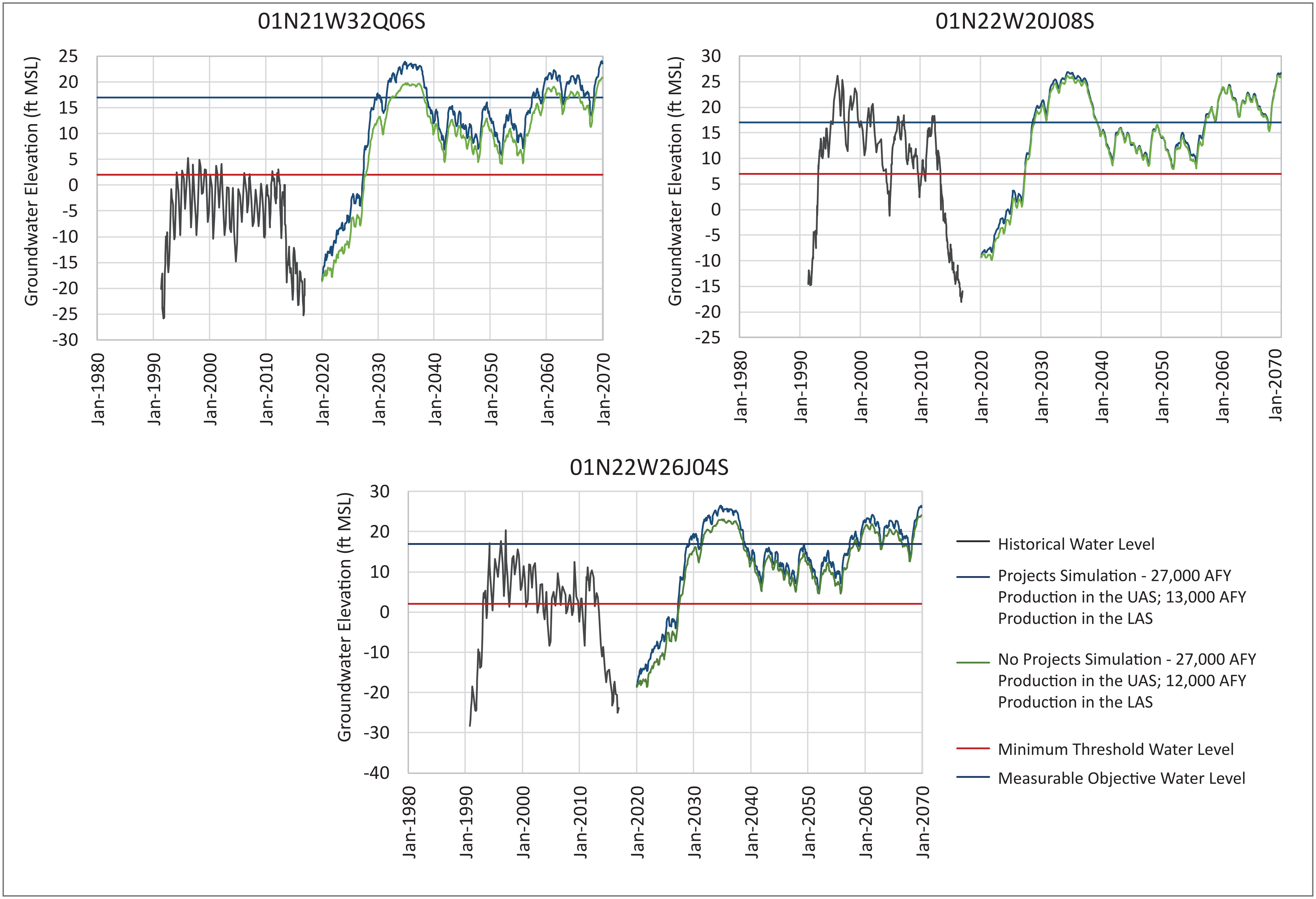
DUDEK

SOURCE: DWR; County of Ventura; UWCD; CMWD

FIGURE 3-5

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

INTENTIONALLY LEFT BLANK



DUDEK

FIGURE 3-6a

Key Well Hydrographs for Wells Screened in the Oxnard Aquifer

INTENTIONALLY LEFT BLANK

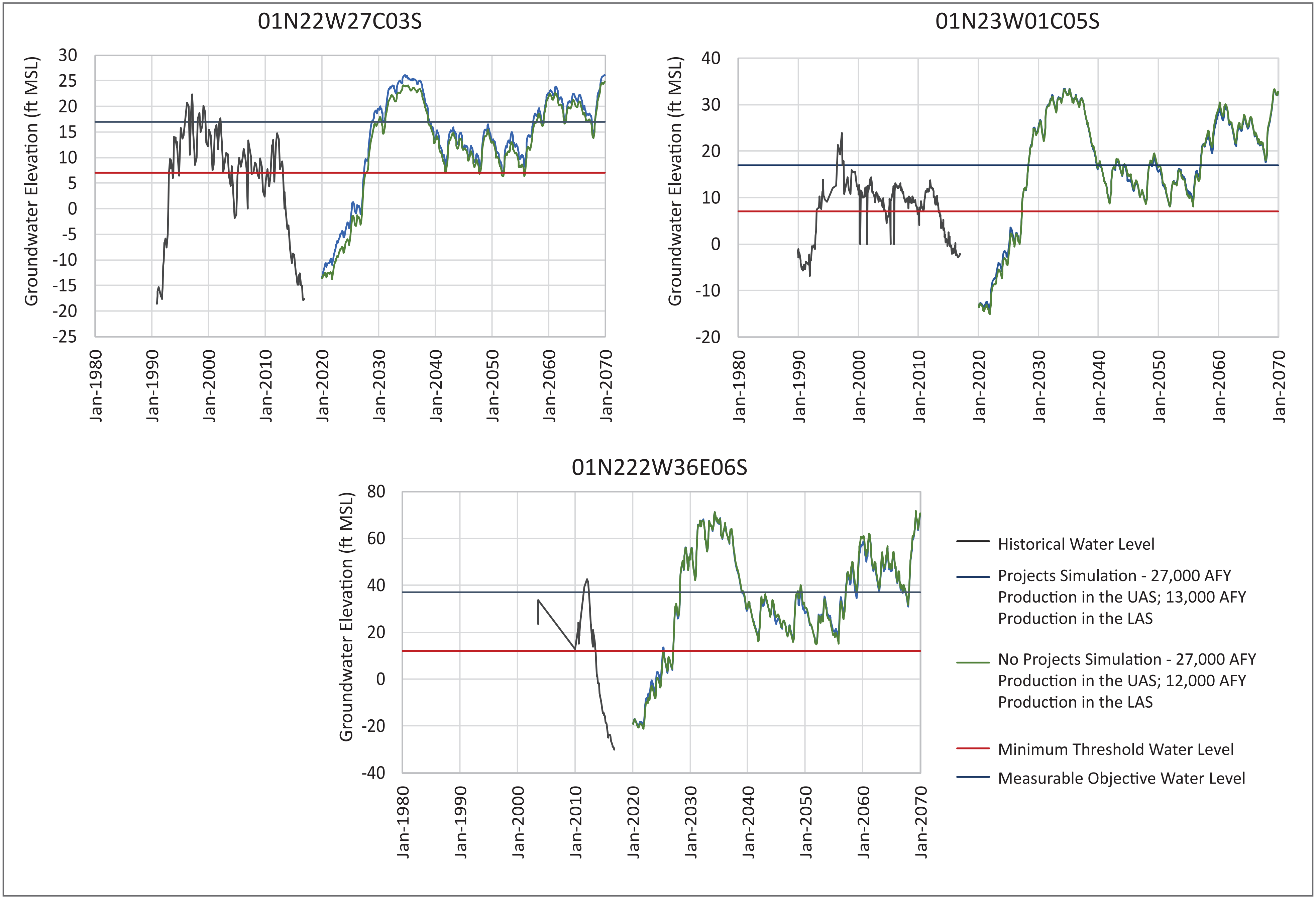
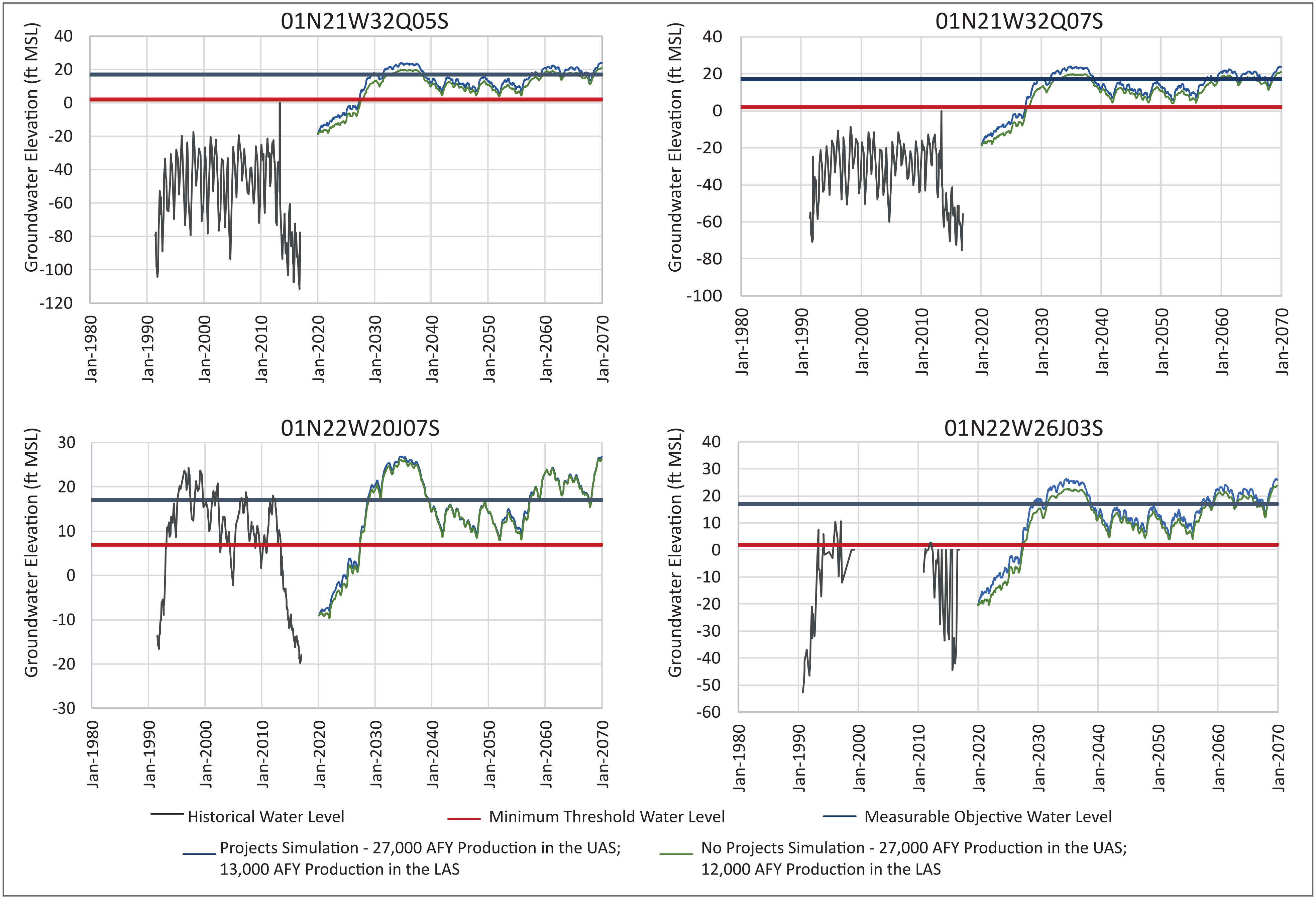


FIGURE 3-6b

Key Well Hydrographs for Wells Screened in the Oxnard Aquifer

INTENTIONALLY LEFT BLANK

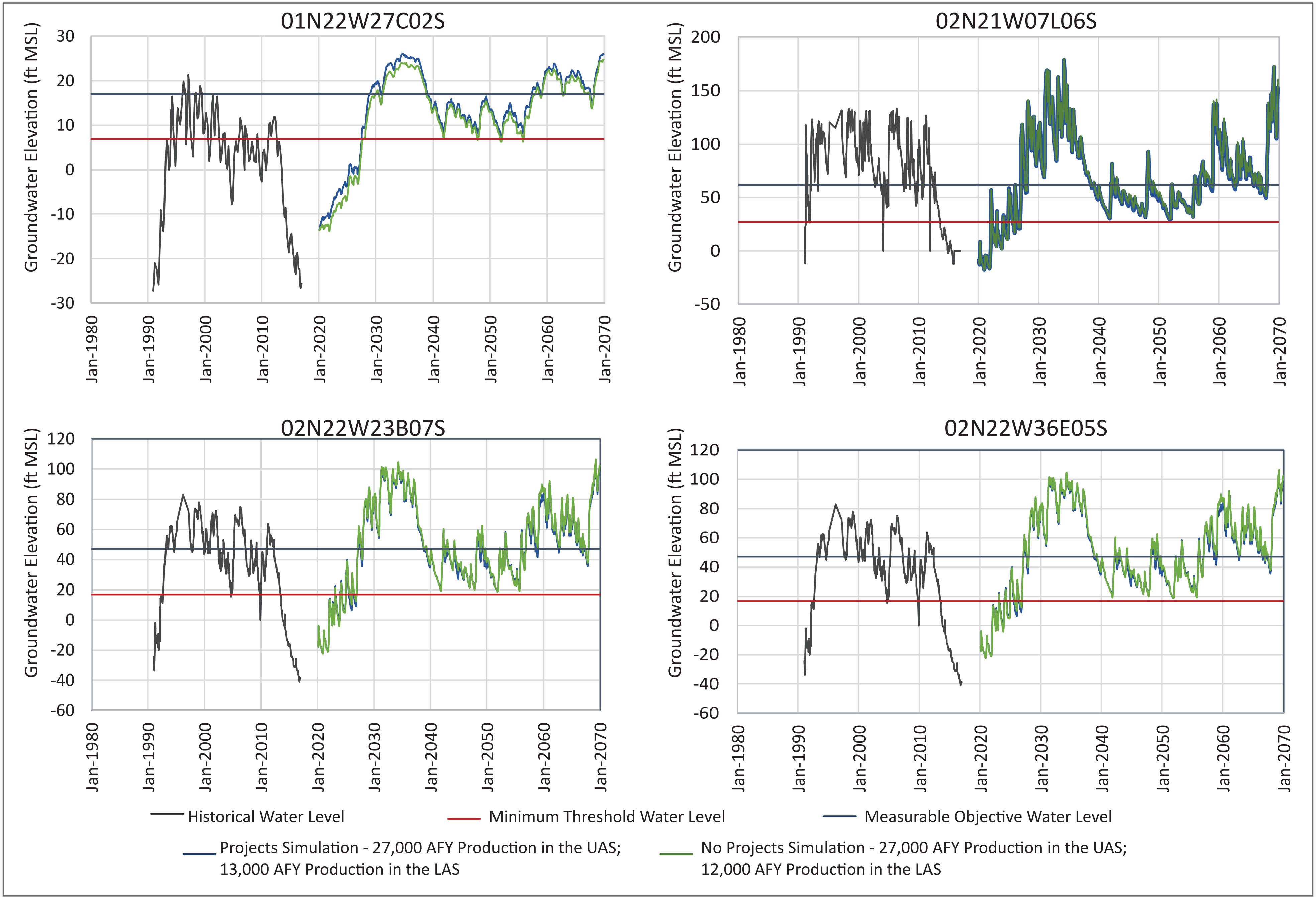


DUDEK

FIGURE 3-7a

Key Well Hydrographs for Wells Screened in the Mugu Aquifer

INTENTIONALLY LEFT BLANK

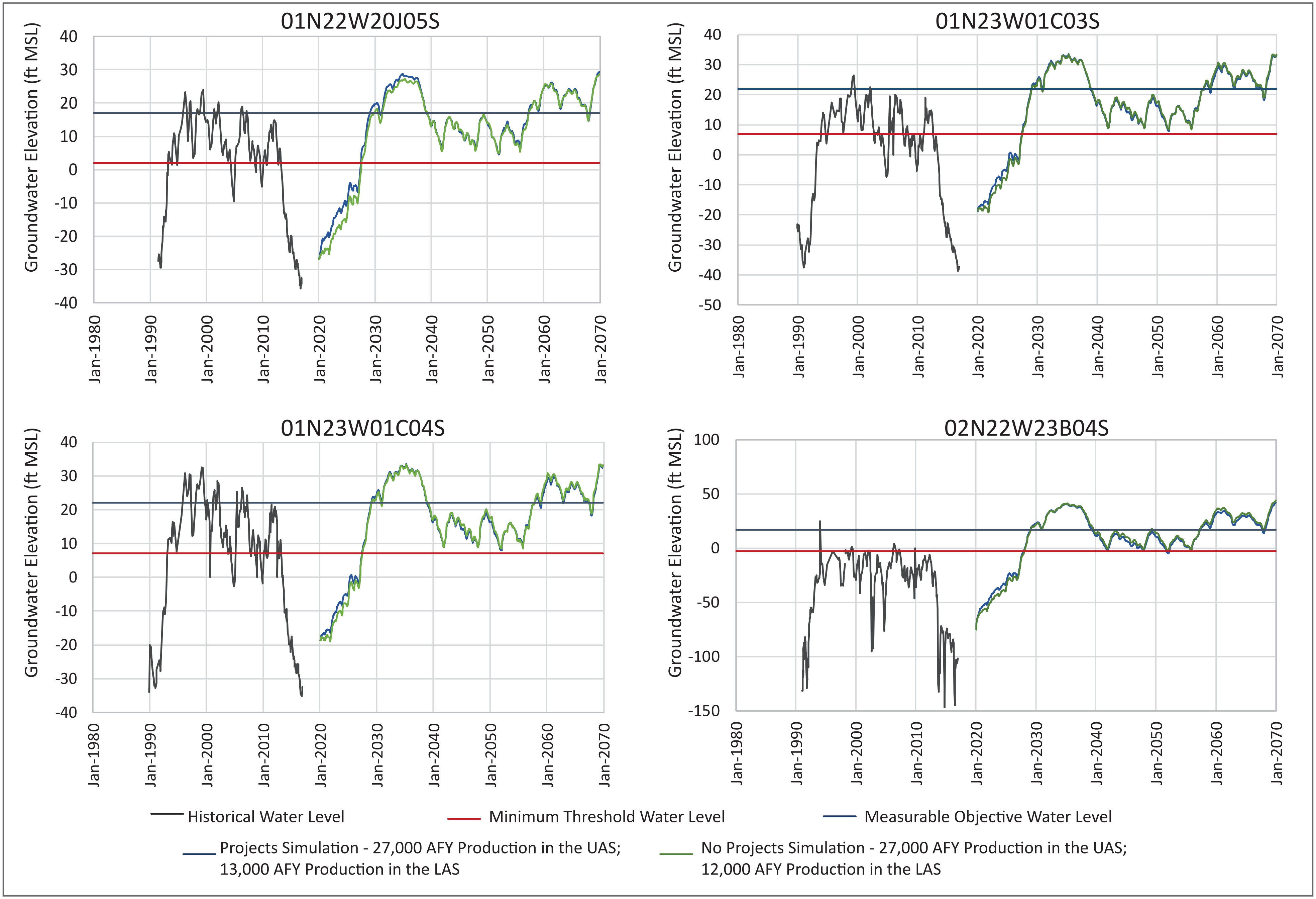


DUDEK

FIGURE 3-7b

Key Well Hydrographs for Wells Screened in the Mugu Aquifer

INTENTIONALLY LEFT BLANK

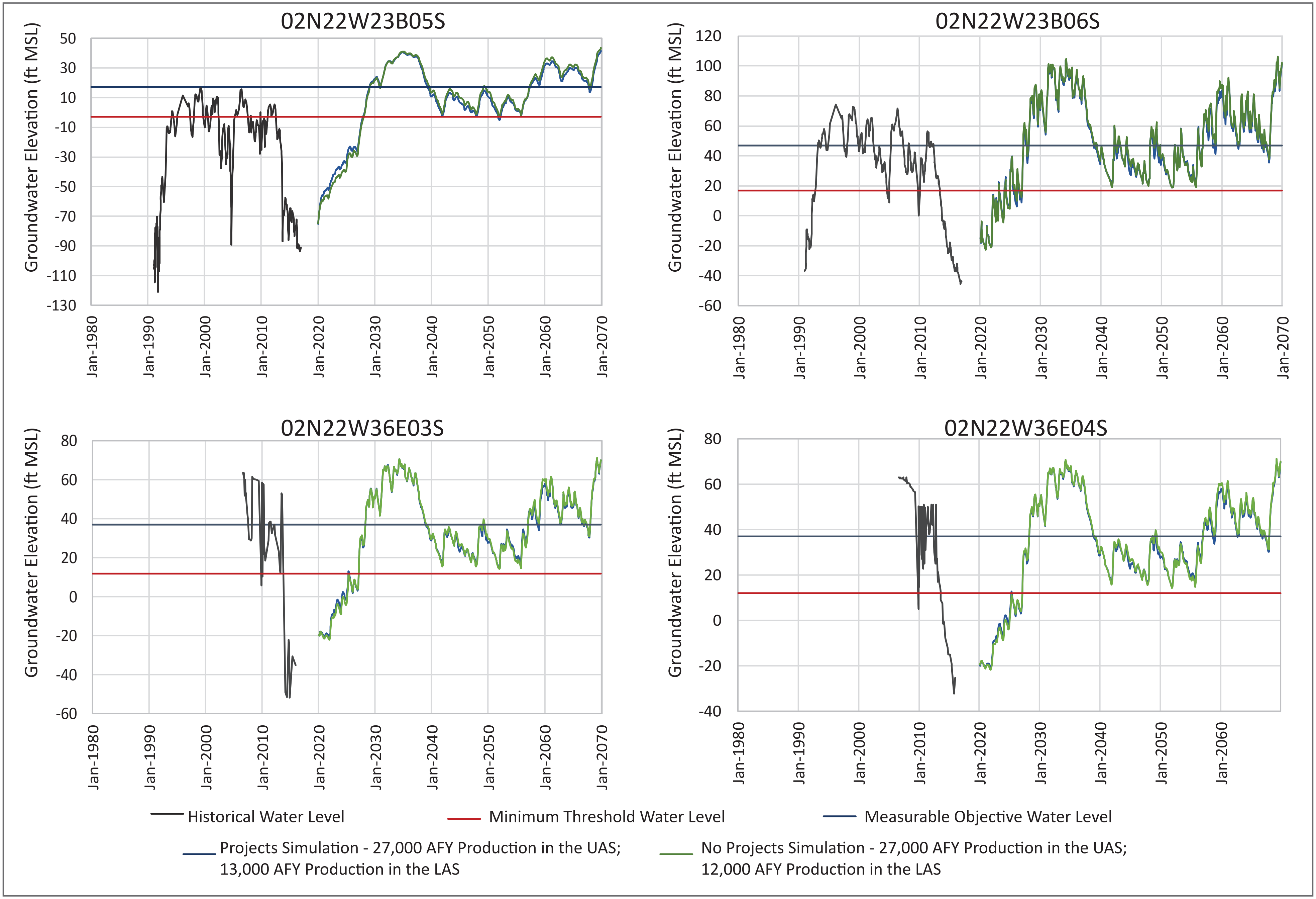


DUDEK

FIGURE 3-8a

Key Well Hydrographs for Wells Screened in the Hueneme Aquifer

INTENTIONALLY LEFT BLANK



DUDEK

FIGURE 3-8b

Key Well Hydrographs for Wells Screened in the Hueneme Aquifer

INTENTIONALLY LEFT BLANK

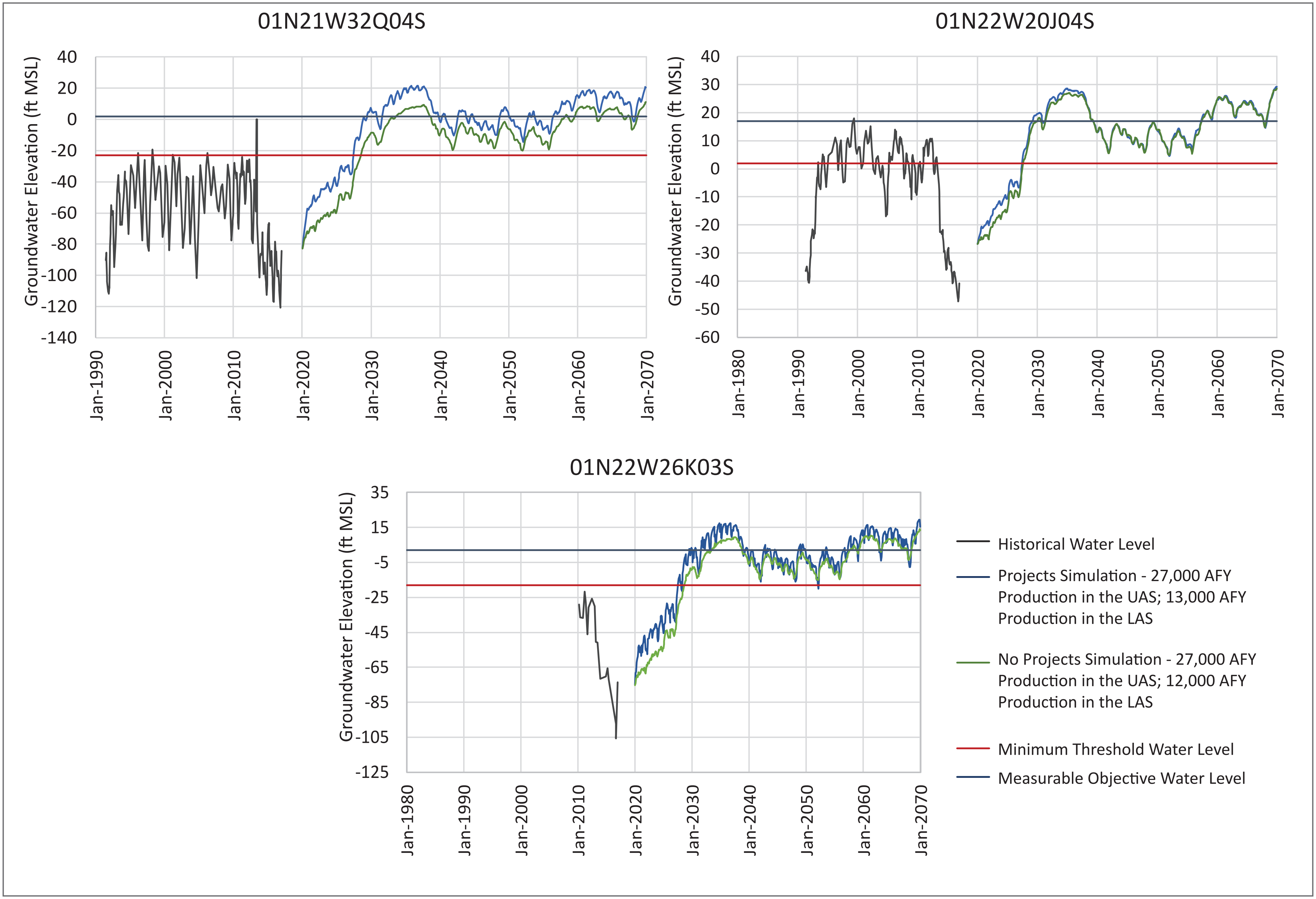


FIGURE 3-9a

Key Well Hydrographs for Wells Screened in the Fox Canyon Aquifer

INTENTIONALLY LEFT BLANK

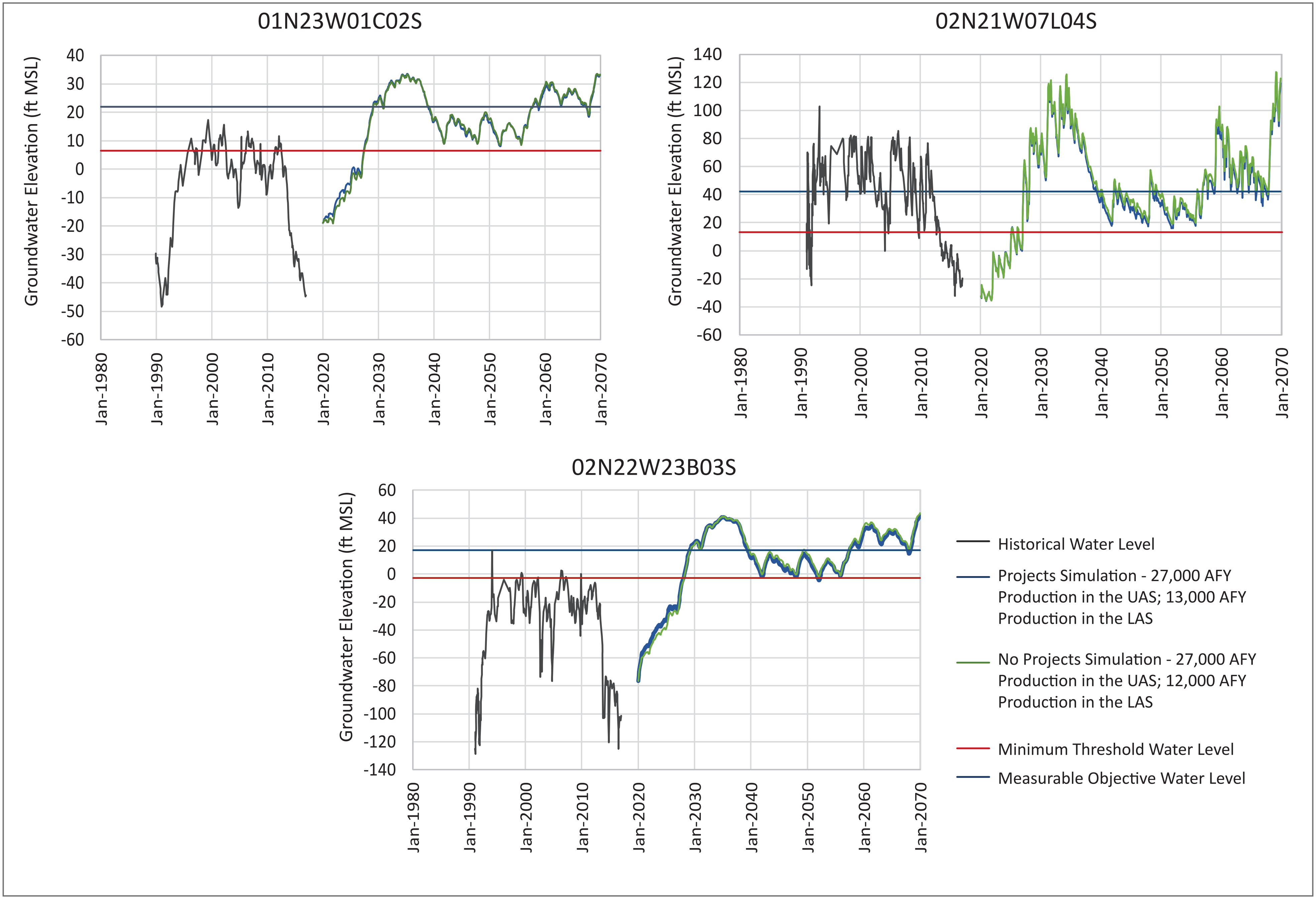
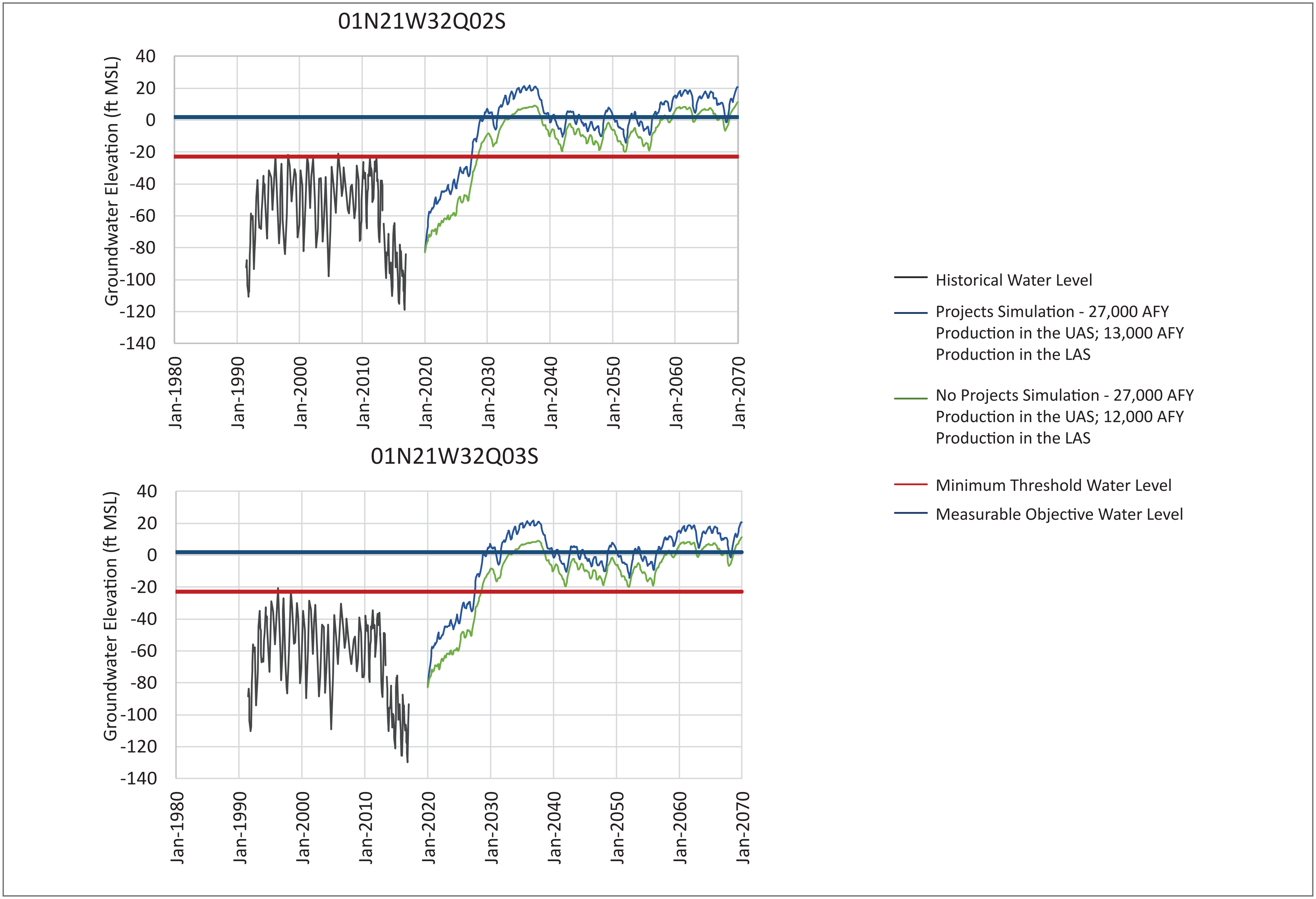


FIGURE 3-9b

Key Well Hydrographs for Wells Screened in the Fox Canyon Aquifer

DUDEK

INTENTIONALLY LEFT BLANK



DUDEK

FIGURE 3-10

Key Well Hydrographs for Wells Screened in the Grimes Canyon Aquifer

INTENTIONALLY LEFT BLANK

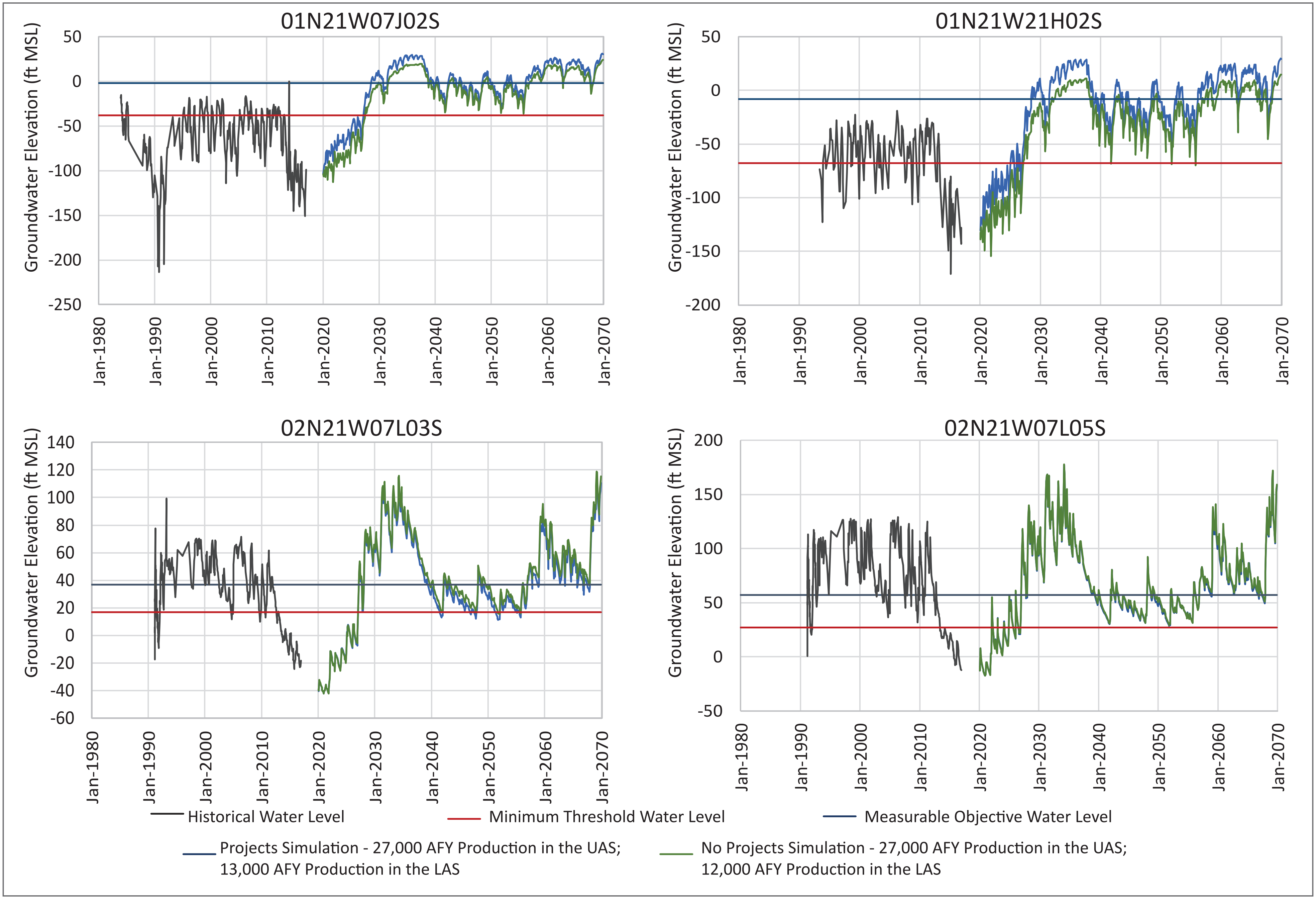


FIGURE 3-11

Key Well Hydrographs for Wells Screened in Multiple Aquifers

INTENTIONALLY LEFT BLANK

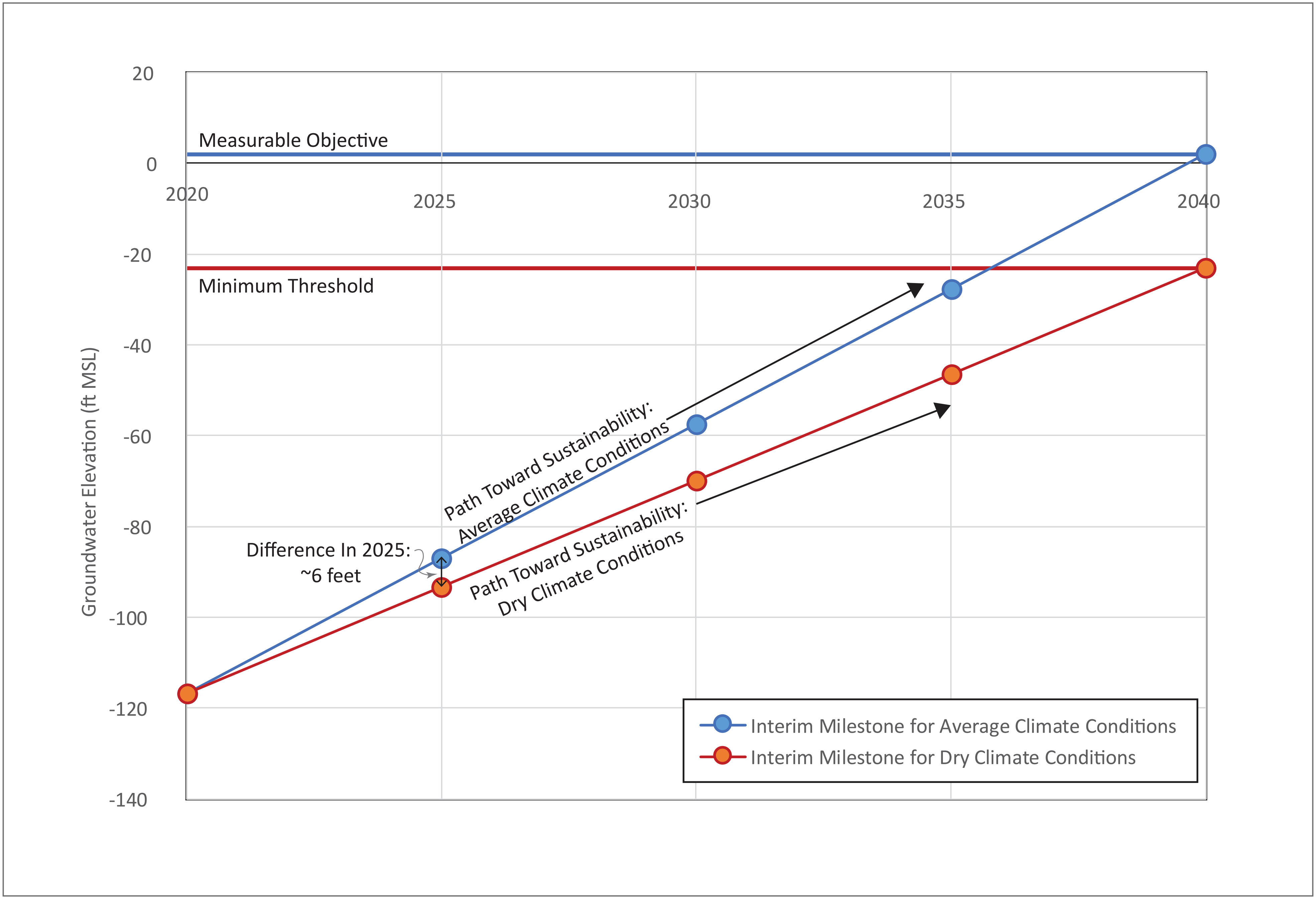


FIGURE 3-12

Interim Milestones for Dry and Average Conditions - Linear Interpolation

DUDEK

INTENTIONALLY LEFT BLANK

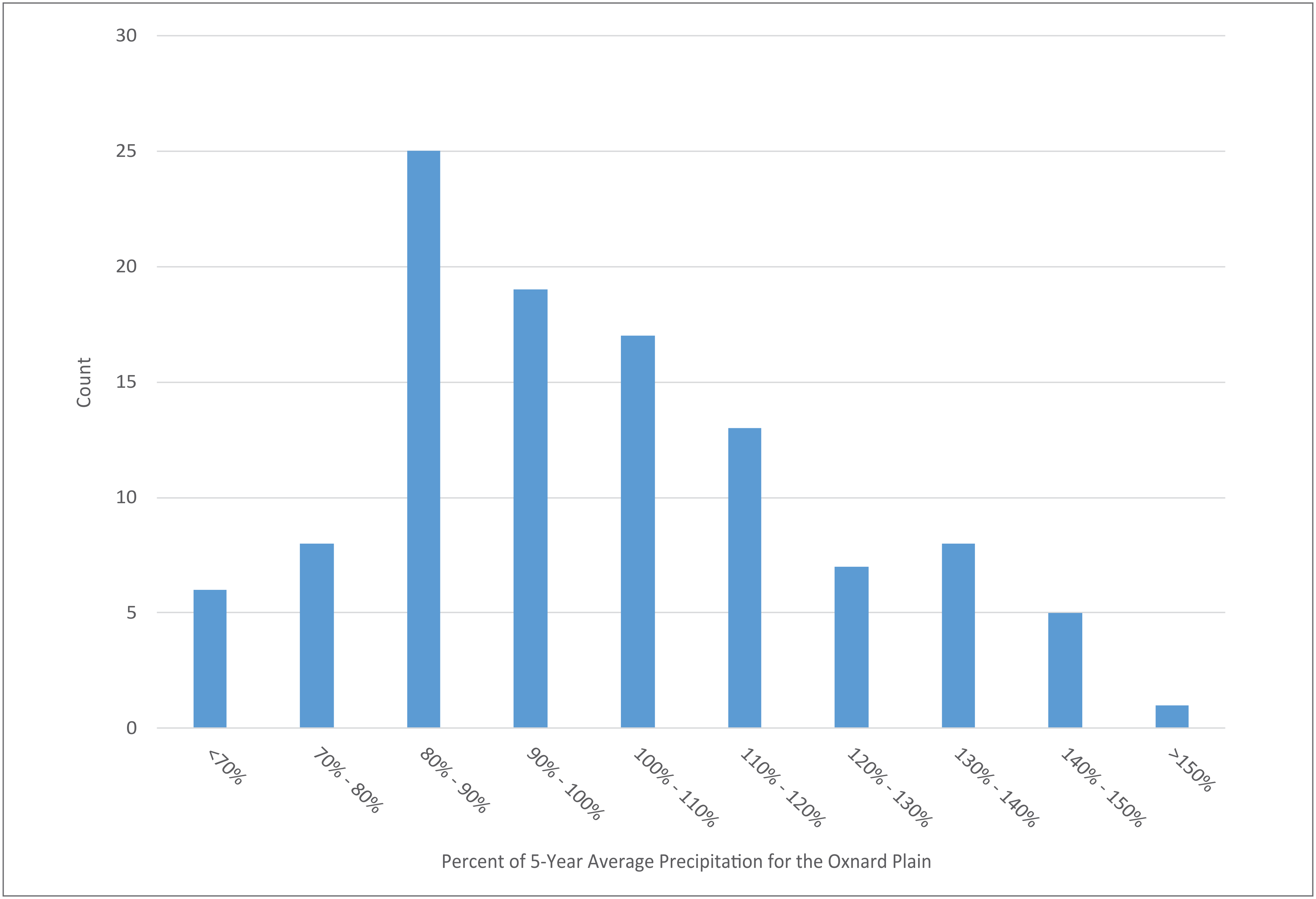


FIGURE 3-13

Distribution of 5-Year Average Climate Conditions in the Historical Record of Precipitation on the Oxnard Plain

DUDEK

INTENTIONALLY LEFT BLANK